MASTER THESIS

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PATHWAYS FOR CLIMATE-ADAPTIVE HAVEN-STAD

Spatial Adaptive Policy Pathways approach
for Climate Adaptation Planning
in Haven-Stad, Amsterdam

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TU Delft

COLOPHON

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Figure Frontpage:
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ABSTRACT

Due to population growth, a growing housing shortage, and a space shortage, it is expected that new urban developments in the Netherlands will mainly take place inside existing city boundaries and in high densities. At the same time, it is projected that the effects of climate change will increase, as climate change is expected to intensify. These two trends cause an increased climate risk for the liveability in these new urban areas. Climate adaptation is essential to reduce this risk. Climate adaptation planning is crucial to ensure the development of sustainable urban areas with high liveability standards for future and far-future inhabitants. However, traditional spatial design and -planning practice does not match with the climate adaptation task. If no climate adaptation action is taken now by spatial actors, the problems could be passed on to future generations. Hence, there is a need for a different way of working. A paradigm shift towards adaptive planning is needed to plan for climate adaptation and adaptive pathways are promising approaches to support this.

The objective of this research is to contribute to the search for new approaches that support climate adaptation planning. This research aims to investigate the usability of the Spatial Adaptive Policy Pathways (SAPP) approach for climate adaptation planning in new urban areas in the Netherlands.This research explores this approach to define the possibilities and points for improvement, through four main stages: analysis, identification, development, and application. To test the approach, Haven-Stad in Amsterdam has been selected as a case study area. The evaluation of the output and approach provide input to answer the main research question of this thesis: *How can the Spatial Adaptive Policy Pathways approach support climate adaptation planning for new urban areas in the Netherlands?*

The research has shown that the Spatial Adaptive Policy Pathways (SAPP) can support climate adaptation planning for new urban areas in the Netherlands. The SAPP approach brings forward a paradigm in which uncertainty is embraced and adaptivity is central. SAPPs do not show which trajectory is best to follow, but can address certain options, decision points, and consequences. In addition, it can bring different actors together through spatial- and governance elaborations. Thereby, SAPPs can form a basis for a broad dialogue about the future of an area in the short-term and long-term. It supports the development of adaptive designs and can address potential future governance challenges. The SAPP approach could thus be a promising approach to apply in practice. However, it would have to be further developed first.

Further development of the approach requires more testing at different case study locations and testing in practice. More research needs to be done on the applicability of the approach at different scales and the potential integration of scales and climate stresses.

Keywords: Spatial Adaptive Policy Pathways (SAPP) approach; climate adaptation planning; adaptive design and -planning; Haven-Stad; Urbanism and Water Management

PREFACE

Before you lies the report 'Pathways for Climate-Adaptive Haven-Stad'; the result of my full year graduation project. This research is conducted to fulfill my double degree in Civil Engineering, track Water Management, and Architecture, Urbanism & Building Sciences, track Urbanism, at the TU Delft. The project is connected to the Urbanism studio 'Urban Metabolism & Climate', the Delta Futures Lab, and my graduation internship at Waternet.

For me, climate adaptation is one of the most interesting and important challenges we face. Climate change affects the whole world and will extend over long timescales. With a growing part of the population living in cities and the great importance of water, the integration of spatial design & planning and water management is crucial for climate adaptation. Due to this research, I am convinced that adaptive approaches are needed to deal with the ever-changing cities and climate.

My graduation was a long process, but I have never learned so much. In addition to the content, it taught me to do research independently. It sometimes made me insecure that I did not know where it was all going, but I also found out that this is exactly the core of research. If you already know exactly what needs to be done, there is nothing left to discover. Next to that, working during the pandemic has taught me the value of personal contact, informal learning, and sharing experiences with fellow students.

> *If we knew what it was we were doing, it would not be called research, would it?*
>
> - Albert Einstein -

I would like to thank all my mentors for their support, encouragement, time, and expertise. Martine, I would like to thank you for your open-minded and always enthusiastic mentorship and our nice brainstorm-sessions. Kristel, I would like to thank you for your kindness, support, and all your explanatory drawings during the mentor sessions (I still have them all!). Verena, I would like to thank you for all your help for the governance part and your always supporting and encouraging words. Erik, I would like to thank you for your always critical, but hugely constructive criticism, and the kindness and humor with which you can convey it. Kasper, I would like to thank you for sharing your insights from practice, for your passionate guidance and all interesting meetings at Waternet. I also would like to thank all other experts that participated in my interview series and helped me to get a better view of practice. Finally, I would like to thank my boyfriend Ivar, my family, and my friends for all their support during this year.

I hope you enjoy reading my thesis and get excited to work on adaptive approaches to climate adaptation planning!

Unless otherwise indicated, all figures and drawings are made by the author.

SUMMARY

INTRODUCTION

Due to population growth, a growing housing shortage, and lack of space in the Netherlands, major new urban developments in high densities are expected. At the same time, climate change is expected to intensify, leading to more severe impacts in urban environments. These two trends increase the climate risk in new urban areas. For instance, the consequences of a flood are larger if the flood depths are higher (due to climate change) and if there are more people and assets in the areas (high densities). To reduce the climate risk, climate adaptation is essential.

However, there is a **mismatch** between the climate adaptation task and current spatial design and planning practice. Climate change is dynamic, extends over long timescales (decades to centuries), and is uncertain. Traditional spatial plans are often static, reactive, and short-term plans (max. 30 years) that do not sufficiently take uncertainties into account. Moreover, the coherence between spatial planning and water domains is not strong, yet crucial for climate adaptation. Water management can offer solutions to cope with heat, drought, pluvial flooding and fluvial flooding, but often has too little say in decisions about urban developments.

Hence, there is a need for a different way of working: **Climate adaptation planning**. Climate adaptation planning connects to the idea that both the city and the climate are subject to continuous change. This contrasts with the current paradigm, which is based on the idea that the city is malleable and that 'climate-adaptive' is a fixed status. Climate adaptation cannot be achieved with a single design, it needs series of design options over time to continue to adapt to changing climate. In addition, climate adaptation should be seen as both a design and a governance challenge. To support climate adaptation planning, new approaches are needed, including greater flexibility and proactiveness. Furthermore, longer time horizons, uncertainties and the integration of water management and spatial design and planning must be taken into account.

The **adaptive pathways approach** is a promising approach to support climate adaptation planning. Haasnoot et al. (2012) and Zandvoort et al. (2019) researched the use of pathways for water management policy and spatial design in an existing urban area respectively. But there is a knowledge gap about using adaptive pathways for both design and governance in the context of climate adaptation in new urban areas. The aim of this research was to contribute to the search for approaches that support climate adaptation planning.

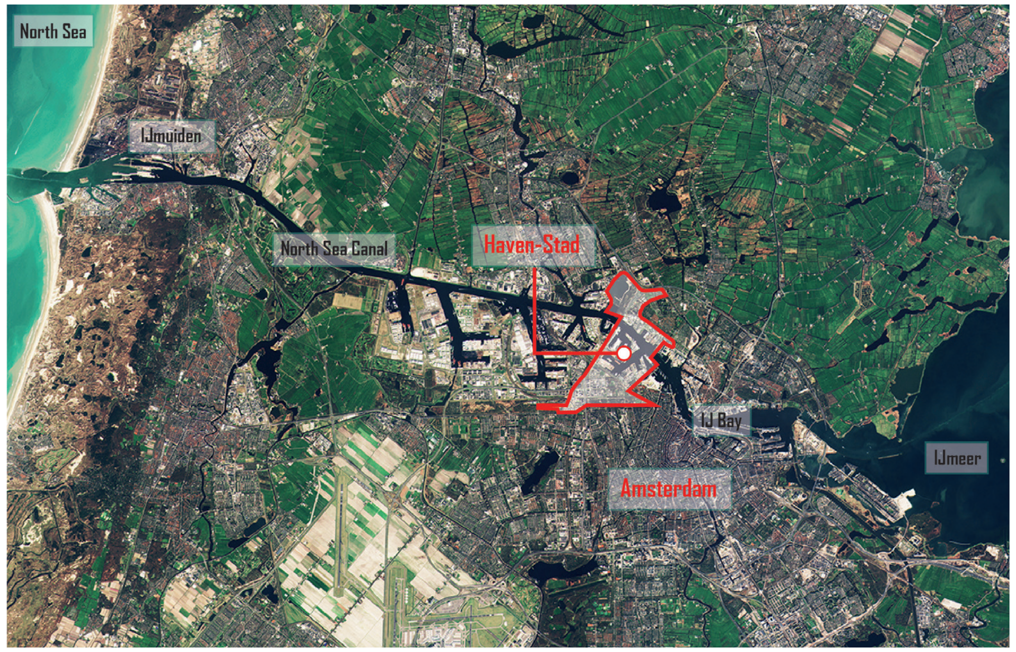


Figure 1. Location of the case study area Haven-Stad, Amsterdam. Background from "The European Space Agency", by ESA, 2017 (https://www.esa.int/ESA_Multimedia/Images/2017/05/Amsterdam_Netherlands). Copyright 2017 by ESA.

RESEARCH APPROACH

Because climate adaptation is both a design and a governance challenge, the two approaches mentioned before (Haasnoot & Zandvoort) were combined in this study. This combined approach is called the **Spatial Adaptive Policy Pathways (SAPP) approach**. The SAPP approach integrates design and governance aspects and the disciplines of water management and urbanism. The implementation of the SAPP approach was investigated for climate adaptation planning in new urban areas in the Netherlands.

To test the SAPP approach, **Haven-Stad** was selected as case study area (see Figure 1). Haven-Stad is an industrial area in Amsterdam-West that will be transformed into a high-density living and working environment.

Evaluation of the Haven-Stad outputs and the SAPP approach itself provided input to answer the main research question of this project:

How can the Spatial Adaptive Policy Pathways approach support climate adaptation planning for new urban areas in the Netherlands?

By applying a **research-by-design** approach, design methods were used to explore how the SAPP approach can support climate adaptation planning. To develop and test the SAPP approach, four research stages were defined, as visualized in Figure 2: Analysis, identification, development, and application. Through multiple iterations, the SAPP approach was developed, tested on the case study area Haven-Stad, and adjusted.

In the analysis stage, a site analysis about the climate change effects (heat, pluvial flooding, drought, fluvial flooding) in Haven-Stad and an analysis about climate adaptation governance were conducted. In the identification stage, the key components of the SAPP framework were identified, including the climate adaptation measures. In the development stage, a SAPP map was developed for fluvial flooding in the Coenhaven Waterfront, the selected focus area within Haven-Stad. In the application stage, it was elaborated how SAPPs can contribute to design and governance for climate adaptation in practice.

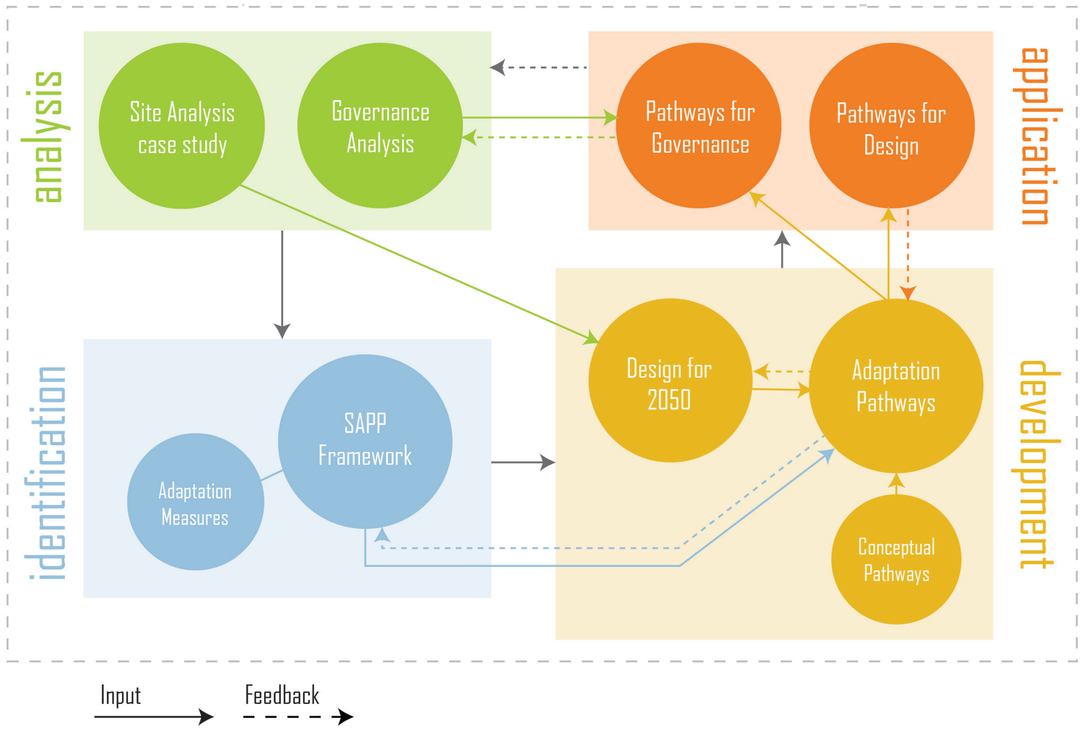


Figure 2. The four research stages and the connections between the stages.

RESULTS

The SAPP Approach

The SAPP approach, like other adaptive pathway approaches, supports adaptive thinking and planning. It brings forward a new paradigm in which uncertainty is embraced and adaptivity is central. That is why it fits well with the climate adaptation planning task, in which uncertainties play a role and adaptivity over the longer term is important. A plan is not seen as fixed, but as a continuous development. This continuous development is visualized in the main output of the SAPP approach: the **SAPP map** (see Figure 4).

By multiple iterations, the steps of the SAPP approach and components of the SAPP map were defined (see Figure 3). The most important insights from each research stage are discussed below.

Analysis (Step 1)

The SAPP approach includes both a site and a governance analysis to get a comprehensive view of the climate adaptation challenge. For the site analysis, the climate vulnerabilities need to be defined. However, the available stress tests do not reflect the future situation of the new urban development. It is therefore important to make a sketch of the future, by analysing the plans and climate projections. The governance analysis examines the actors, policies, collaborations and main challenges for climate adaptation. The governance analysis is important to connect the conceptual SAPP approach to the practical challenges, and to stay up to date with the developments in climate adaptation governance.

Identification (Step 2 & 3)

To make a readable SAPP map, it is important to reduce the complexity. The first step is to select the right scale and level of conceptualization (step 2: scope). In this study, a focus area (neighbourhood scale) and dominant stressor (fluvial flooding) were selected for the SAPP map. This was needed because of the heterogeneity on the district scale; including different kind of neighbourhoods with different adaptation measures made the SAPP map in this case unreadable. The scale of the focus area and the scale of the measures must be determined in conjunction.

The SAPP approach offers a **framework** for the SAPP map with four key components (the grey boxes in Figure 4). The framework is customizable, as the key components can be defined based on the case study location and scope. The **starting point** is the initial design for new urban areas or the current situation in existing areas. Currently, the climate projections for 2050 are often used to make this initial design, so 2050 is a logical starting point for the SAPP map for Haven-Stad.

The **climate objectives and climate trends** are used to define the x-axis. The main axis is defined by the objectives (e.g. flood depth), instead of the climate trend (e.g. sea level rise). This makes it easier to link the effect of adaptation measures to the x-axis. Next to the objectives, **transition phases** are part of the x-axis of the SAPP map. The transition phases support spatial explorations about the development of climate adaptation over time and encourage thinking about long-term and drastic developments. Relevant **adaptation measures** are used to make the designs and are placed on the y-axis. To structure the abundance of adaptation measures, the SAPP approach introduces adaptation principles, design layers, and adaptation tiles. **Adaptation principles** are different options to anticipate or respond to climate change. The definition of **design layers** (soil, water, vegetation, urban design, flood defences) helps to explicitly consider the potential of all layers of the urban environment for climate adaptation. The **adaptation tiles** summarize the most important information about single adaptation measures and can be used to explore, discuss, and select relevant measures for the case study area.

Development (Step 4 & 5)

For the development of SAPPs for a specific area, research-by-design is the most important method. Through sketching and trial-and-error, the content of the SAPP map can be developed with the key components as base. The development involves multiple iterations between the design of the starting point, the design of the area over time (the pathways) and the design of the SAPP map. The approach stimulates to explore the possibilities for climate adaptation in space and time. These design explorations form input for the development of the SAPP map. For the spatial exploration, the adaptation principles are translated to the case study site for each design layer. For the exploration over space and time, conceptual pathways are added to the approach. **Conceptual pathways** explore how each design layer can adjust to a changing climate over time. The conceptual pathways can be seen as design exercises to generate ideas that can be used as input for the SAPP map. Next to the explorations, the approach contains steps that guide the development of the SAPP map. These steps (5b, 5c, 5d, 5e) are closely connected to the key components as defined in the identification stage. The transition phases turned out to be an important integrating component. Both the possible future developments and the x-axis can be linked to the transition phases. This provides a guiding structure to build the SAPP map. The selection of relevant adaptation measures is mainly fed from the design explorations.

The design layers can help to unravel the spatial complexity of the city and the transition phases contribute to the conceptualization of the time component.

Application (Step 6 & 7)

The SAPP approach includes both a design and a governance elaboration of the created SAPP map. For both design and governance, SAPPs support thinking about different phases of climate adaptation in the future and about linking the short- and long term. For design, pathways help to create a climate-adaptive initial design and can provide arguments by displaying the flexibility. For governance, the pathways can address future challenges and can be used to set up a dialogue about the current and possible future governance.

In addition, the SAPP map (and design visualizations) can contribute to the communication of possible future developments towards, for instance, designers, project developers, and inhabitants.

Practice (Step 8, 9 & 10)

The last three steps can only be applied in practice and were thus not conducted during this research. The definition and implementation of a strategy (a selection of certain pathways from the SAPP map) is in the end mainly a political choice. The most important notion is that the SAPP map needs periodic updating to incorporate changing insights, techniques, and societal wishes. The strategy should therefore not be mapped out immediately into the far future.

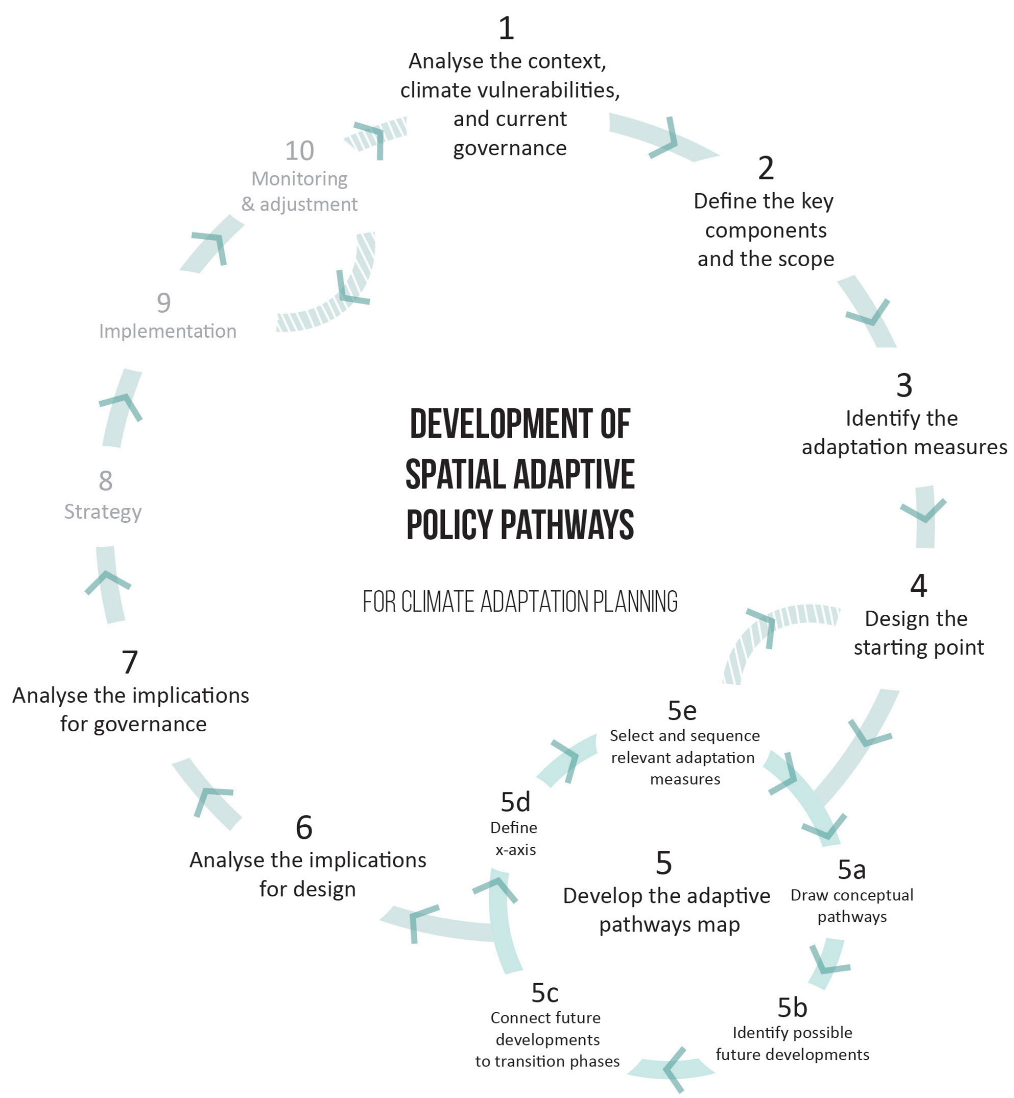


Figure 3. Steps of the Spatial Adaptive Policy Pathways approach for climate adaptation planning. Inspired by (Haasnoot et al., 2013).

Outputs for Haven-Stad

The site analysis showed that Haven-Stad already faces climate change effects and that it can be expected that these effects increase if no adaptation measures will be implemented. The interviewed spatial planning and water management experts from the Amsterdam region made the following suggestions for improving climate adaptation governance: consideration of a longer time horizon, more flexibility of the designs and processes, more integral collaboration, sharing of the climate adaptation task, more national coordination, and more clarity about responsibilities and acceptable risks.

The spatial design explorations brought forward how the adaptation principles can be translated to Haven-Stad. For example, differentiations can be made in the water systems, vegetation, and building typologies, based on the different soil types. Possible future dike trajectories can also be considered, and vertical evacuation can be combined with public and recreational functions. Due to the heterogeneity of the areas in Haven-Stad and to reduce the complexity of the SAPP map, the Coenhaven waterfront and fluvial flooding were selected as focus. This waterfront is selected as it would face the most changes if the protection strategy of Haven-Stad would change in the future.

An exploration of possible future developments revealed that Haven-Stad depends on national and regional decisions about the Dutch delta strategy. In the SAPP approach, these developments were translated into different futures for Haven-Stad, in which choices could also be made on a local scale. The Coenhaven waterfront should be prepared for two main scenarios: An open and a closed system. A decision for one of these scenarios would mean a transition (and potentially later a transformation) for the Coenhaven area.

The SAPP map for the Coenhaven waterfront is presented in Figure 4. The x-axis connects the sea level rise trend to the potential flood depth in the Coenhaven and to a best-case and worst-case climate scenario. The map shows the (non-exhaustive) options for adaptation to a rising sea level over four main transition phases (and a second incremental phase). In the best-case scenario only local incremental measures are needed till 2100. In the worst-case scenario the need for a transition and transformation before 2100 is very likely. The starting point, the design for the Coenhaven in 2050, contains several measures that make the Coenhaven climate-adaptive, such as a waterfront park and flexible plinths. These measures make it possible to adjust the area in the future.

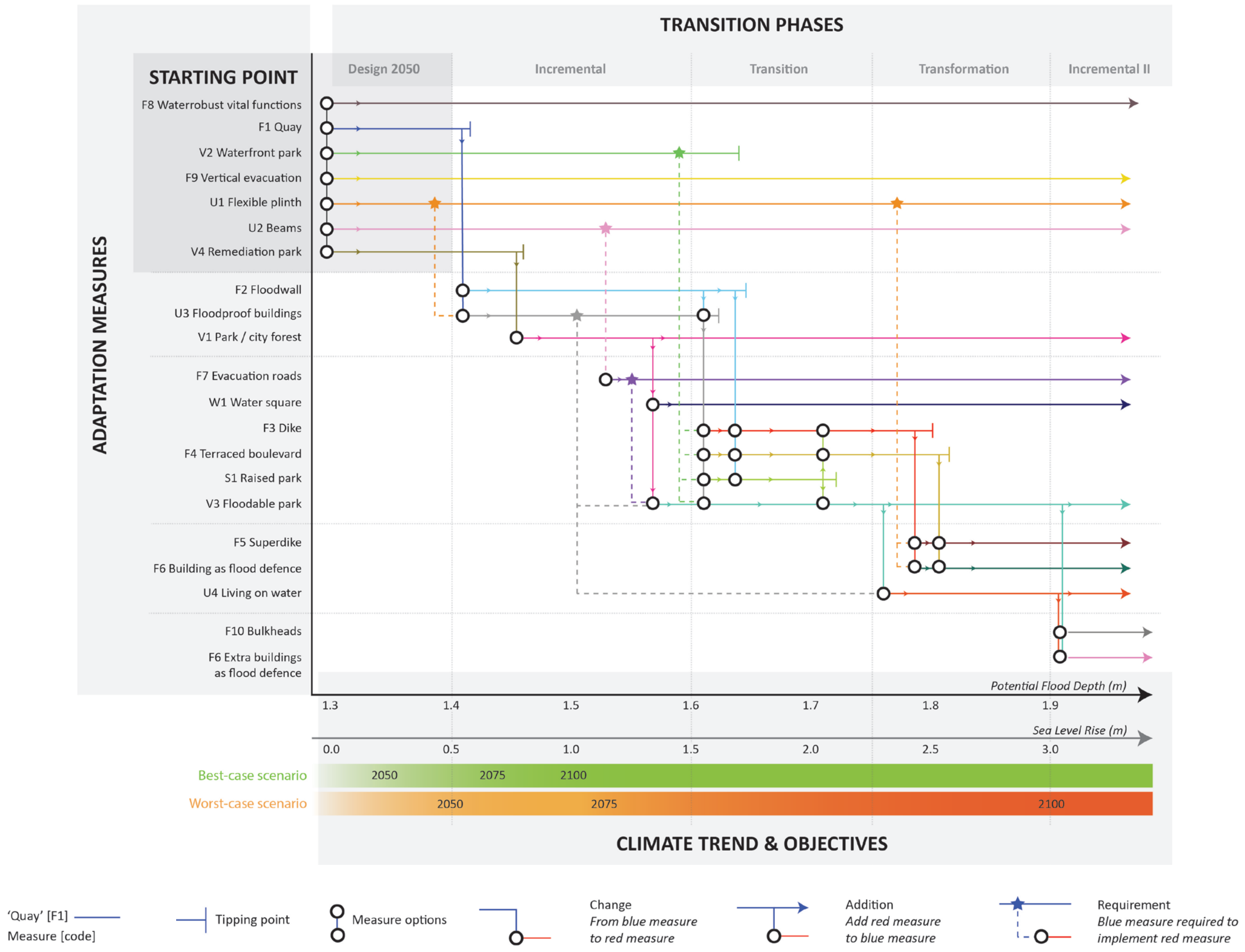


Figure 4. Spatial Adaptive Policy Pathways map for the Coenhaven waterfront.

Two trajectories towards two different futures of the Coenhaven were selected and worked out spatially: The 'living with water' future and the 'protective' future. Figure 5 shows the initial design and the two trajectories in the transformative phase. The SAPP approach helped to create a climate-adaptive initial design, which is important as it defines the future possibilities of the site. For the Coenhaven it is crucial to reserve space along the waterfront. The space reservations can be used for parks or temporal functions. Secondly, it is important that the buildings, or at least the plinths, have a flexible design. The above-ground and underground infrastructures also need to be considered. As can be seen in Figure 5, it could be possible that roads are (re)moved. Underground infrastructure with long lifetimes should be placed as much as possible under 'stable' roads, such as the middle road. Or it could be investigated if the infrastructure can be integrated in the buildings. Secondly, the SAPP map can be used to provide transparency towards investors, project developers, and inhabitants about possible future changes, as the changes can affect market values and functions.

The governance analysis of the SAPP map for the Coenhaven shows that several major decisions will have to be made in the future. These decisions are getting more complex and require strong cooperation between many different actors. The current sectoral focus on prevention for water safety would need to shift to a more integral approach including robust urban design and disaster management policy. This shift would also mean that decentral and private actors, such as the municipality and building owners, are getting more important roles for water safety. An adaptive plan also requires long-term coordination. On the decentral level, the municipality is the logical actor as it is involved in all measures. At the central level, the national government plays a major role in the coordination of the national delta strategy. A collaboration of the regional water authority and the province could be of great importance to form the link between the different scales (local and national) and focuses (spatial planning and water management) of the municipality and national government respectively.

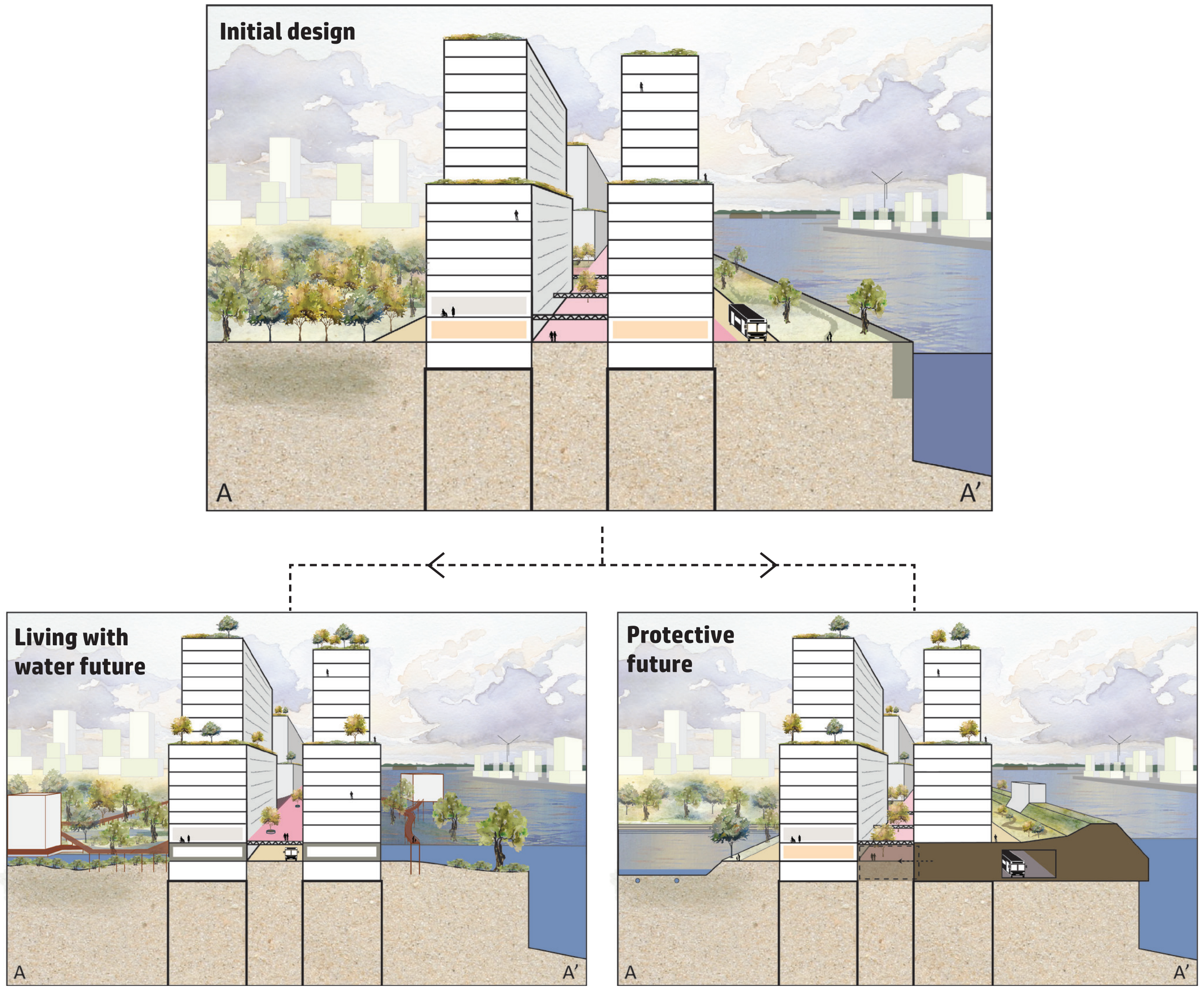


Figure 5. Flexibility in the initial design for the Coenhaven.

Evaluation

Advantages and Limitations
An advantage of the SAPP approach is that it consists of a flexible framework with structuring elements. In addition, an advantage of the SAPP approach is that it includes a spatial elaboration as well as a governance elaboration. As a result, in practice more actors will have to work together, and the created SAPPs can be communicated more easily to different types of actors. However, the SAPP approach also has limitations and challenges. One of the biggest limitations of the approach is the limited space that the SAPP map offers for the representation of a complex environment such as the city. One of the challenges is to find the balance between readability of the SAPP map and grasping the complexity (reality). This also results in limited ability to integrate different scales and themes. Another challenge is the definition of the x-axis and the tipping points. This is mainly caused by the uncertainty about the link between the climate trends and the consequences. Another limitation is that climate change insights, techniques, and societal wishes (or objectives) can change over time. This asks for a periodic updating of the SAPP map.

Implications for Spatial Planning & Water Management practice
The SAPP approach can offer a new way of looking at long-term climate adaptation planning and a starting point for discussion and the development of an action perspective. It could be the first step in the development of new strategies and a governance dialogue. The approach is especially interesting for all governments, because they are responsible for the (long-term) spatial planning and water management in the Netherlands. SAPPs could be integrated in the development of environmental visions and area developments, such as Haven-Stad. The SAPP approach requires a strong collaboration of spatial planning and water management actors. Therefore, it can stimulate the integration of the two domains. It supports the development of adaptive designs, which better anticipate on the uncertain future. By making possible choices and consequences explicit (and spatial), the SAPP map provides transparency for all actors involved. One of the biggest limitations of the approach for practice is that it can take more time to make multiple designs for different phases instead of one fixed plan. Nevertheless, the approach is worth considering, because it could prevent that large and unexpected adjustments must be made later (again). A second limitation is the focus on climate adaptation. In practice, all (transition) issues come together, and integration and smart combinations must be sought. SAPPs can still be used for climate adaptation, but it is important to link the SAPP map to the bigger picture.

Transferability of the SAPP approach
Due to the level of conceptualization and the possibility to customize the framework, the approach is widely applicable. The steps of the SAPP approach, as presented in Figure 3, can be generally used. Besides the use for climate adaptation in new urban areas in the Netherlands (the scope of this research), the SAPP approach can be transferred to other locations, scales, and themes. With small adjustments, such as the addition of a participation process, it can be used for the existing built environment. The approach can be applied to other urban areas around the world, and possibly even to rural areas. The SAPP approach has the potential to support the planning of transition challenges, such as climate adaptation, on different scales.

Contribution to Adaptive Planning Science
The largest differences between the SAPP approach and existing adaptive approaches is the combination between water management and spatial planning and the focus on both design and governance. The SAPP approach introduces some new components to the existing approaches, such as transition phases, adaptation principles, and design layers. These components make it easier to work with the complex urban environment and the time component. The transition phases also support transformative thinking, which is not always integrated in existing adaptive approaches. The lessons learned from the development of the SAPP approach can be used to develop adaptive planning approaches further.

CONCLUSION

How can the Spatial Adaptive Policy Pathways approach support climate adaptation planning for new urban areas in the Netherlands?

This research has shown that Spatial Adaptive Policy Pathways (SAPP) can support climate adaptation planning for new urban areas in the Netherlands. The SAPP approach brings forward a paradigm in which uncertainty is embraced and adaptivity is central. As the climate keeps changing at uncertain rates and with uncertain effects, climate adaptation should be seen as a continuous process of adjustment. The SAPP approach can be used to apply adaptive thinking and planning for this continuous process of climate adaptation. SAPPs do not show which trajectory is best to follow, but can address certain options, decision points, and consequences. In addition, it can bring different actors together due to the spatial and governance elaborations. With this, SAPPs can be a basis for a broad dialogue about the short-term and long-term future of an area. It supports the development of adaptive designs and can address potential future governance challenges.

The SAPP approach can support climate adaptation planning by the provision of a clear step-by-step plan and a framework with structuring elements. In addition, it requires a research-by-design approach and stimulates design explorations of space over time. The approach includes explorative and diverging steps and offers a framework to converge the ideas into adaptive pathways. The outputs of the approach are a SAPP map and design- and governance elaborations, which can be used for the development of adaptive designs and as a base for discussions.

For spatial planning and water management, the SAPP approach can provide multiple advantages. First, it supports the development of adaptive designs, that can better anticipate on the uncertain future. Second, the SAPP map can clarify choices and their consequences. The SAPP map can also be used to provide transparency about possible future changes in the area for all actors involved. Lastly, the SAPP approach can address (future) governance challenges, for instance the need for an integral approach to climate adaptation planning.

The SAPP approach could thus be a promising approach to apply in practice. It would, however, first need further development. One of the biggest challenges for the SAPP approach in practice would be to create support for it, because it requires a different way of thinking and working. A plan can no longer be seen as fixed and should be connected to different long-term futures. The SAPP approach needs updating and thus requires a long-term commitment to adaptive plans.

Nevertheless, the approach is worth considering, because it could prevent that large and unexpected adjustments must be made later (again). In the long term, the approach can therefore be more sustainable than the current way of working.

Ultimately, the SAPP approach has the potential to support climate adaptation planning in practice, as it can generate a discussion about the current way of working and as it offers a new way of looking at the ever-changing city and climate.

Recommendations
Although the SAPP approach is promising for climate adaptation planning, it needs further exploration and development. The SAPP approach was tested and adjusted in this explorative and conceptual research. However, it was not tested on different case studies, nor in practice. The next recommendations are given for further development of the SAPP approach:

- Test the approach on different case study locations;
- Test the approach in practice and involve various experts;
- Test if the approach could be used as strategic workshop tool for multi-actor discussions;
- Explore the applicability of the approach on different scales and the potential integration of scales;
- Explore the potential integration of the four climate stresses (heat, pluvial flooding, drought, fluvial flooding);
- Explore if backcasting could be integrated better in the framework and approach (for instance with the use of normative scenarios);
- Explore if SAPPs can be used for other transition challenges (such as the energy transition) or for the integration of multiple transitions ('koppelkansen').

CONTENT

1

INTRODUCTION

In this research an approach for climate adaptation planning is proposed and tested: The Spatial Adaptive Policy Pathways approach. This first chapter gives an introduction to the relevant trends and the need for climate adaptation, to the identified problem, and into the project and case-study. The chapter ends with the reading guide.

Froma, N. (2015)

1.1 CLIMATE CHANGE & HIGHER DENSITIES

The problem field of this research originates from two trends: climate change and building in higher densities. In the context of the Netherlands, both trends have a significant impact on the Dutch delta. It is expected that in the future more people will live in the same area, and that these areas will increasingly have to deal with the negative effects of climate change.

1.1.1 Climate Change

Climate change is undeniable. After many studies, led by the IPCC (Intergovernmental Panel on Climate Change), it has been proven that the global climate has been changing (IPCC, 2021). Climate change will also be part of the future, because the affected components of the climate system react over decades to centuries and many changes are irreversible for centuries to millennia (IPCC, 2021). In addition, climate change is expected to intensify in the future (IPCC, 2021), meaning greater changes will occur in a shorter amount of time.

KNMI'14 projections for the Netherlands
The KNMI (Royal Netherlands Meteorological Institute) has translated the results of the IPCC into climate scenarios for the Netherlands. Although the projections differ, some main trends are projected in each scenario (see Figure 1.1): the sea level at the North Sea coast continues to rise (at a faster rate); precipitation generally increases and extreme summer events become more intense; and the average temperature continues to rise. In two of the four scenarios drier summers are projected (KNMI, 2015).

Climate change effects in urban areas
Climate change is already negatively impacting urban areas and these impacts are expected to increase as climate change continues. Four main effects of climate change in urban areas can be distinguished: Heat, drought, fluvial flooding, and pluvial flooding. These four effects have different levels of scale, both in time and in space. Drought and fluvial flooding often occur on regional scales and over longer periods, whereas heat and pluvial flooding occur more on a local scale and over shorter time periods. Not only climate change itself, but also certain characteristics of urban areas determine the impact of climate change on the city. Figure 1.2 shows these characteristics and the climate change effects in urban areas.

> *Climate change already negatively influences urban areas and is expected to intensify in the future.*

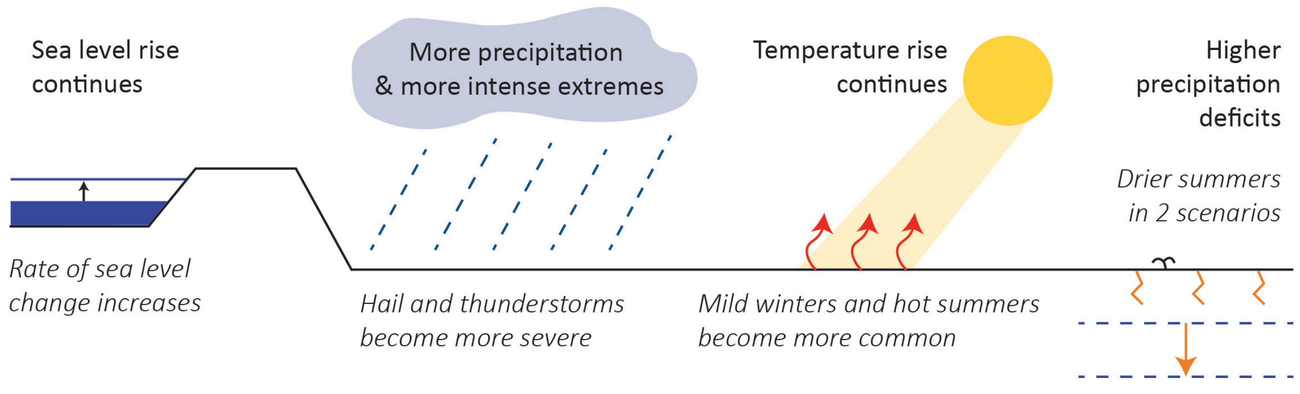


Figure 1.1. Climate change trends in the Netherlands, as projected in the KNMI'14 scenarios. Information from (KNMI, 2015).

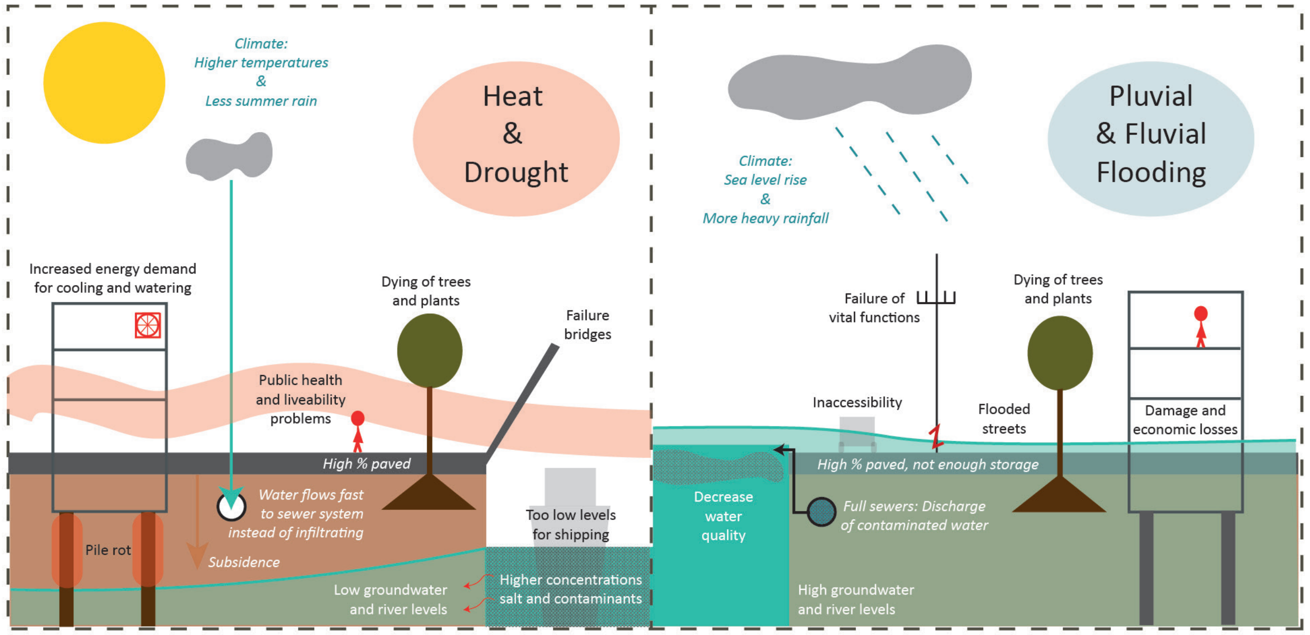


Figure 1.2. Climate change effects in urban areas.

BOX 1.1: THE LASTEST IPCC-REPORT

In this research the KNMI'14 scenarios are used, as these are currently the most recent climate scenario publications for the Netherlands. However, the fields of climate change and climate adaptation are developing at a rapid pace and more and more new insights being added. As well as the latest IPCC sub-report, AR6, which was released on August 9, 2021. This box provides a brief overview of the main points from the sub-report (IPCC, 2021):

- It is certain that human influence has led to global warming and many changes are irreversible for centuries to millennia.
- Since the previous report AR5, the evidence of observed changes in extremes (heatwaves, heavy precipitation, droughts, tropical cyclones) has been strengthened.
- In all scenarios, global surface temperature continues to rise until at least the mid-century.
- During the 21st century global warming will exceed 1.5 and 2 degrees Celcius, unless the greenhouse gas emissions are heavily reduced the next decades.
- Continued global warming is exacerbating many changes in the climate system.
- Since AR5, the evidence of further intensification of the global water cycle due to continued global warming is enhanced.

Appendix 1.1
For more information about the problem field

1.1.2 Higher Building Densities

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

Population Growth
The Netherlands has a population of 17.4 million citizens (CBS, 2020). This is expected to grow till 18.5 million in 2050, due to both natural growth and migration. The growth will be concentrated in the Randstad, Noord-Brabant and parts of Gelderland and Overijssel.

Housing Shortage
The Netherlands is facing a housing shortage and the demand continues to grow as the population grows. It is expected that up to 2035 there will be a need for housing for 750.000 households (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 fill the housing shortage. And next to climate adaptation, there are more space claims; for instance for the energy transition and for a transition to more sustainable agriculture (NOS Nieuws, 2020).

Figure 1.3 shows the current and future space claims in the Netherlands. According to researchers at the University of Wageningen, the Netherlands needs 10 percent more space to execute all plans (NOS Nieuws, 2020). One of the consequences of this space shortage is that new housing developments will take place within the existing city borders (Rijksoverheid, 2020).

Building in Higher Densities
Due to the lack of space, the focus is on inner-city housing developments. As space is often also scarce in the exising cities, this will lead to the development of high-density neighbourhoods. This means that more people will live on the same surface area.

> *It is expected that new urban developments in the Netherlands will mainly and firstly take place within existing city boundaries and in high densities*

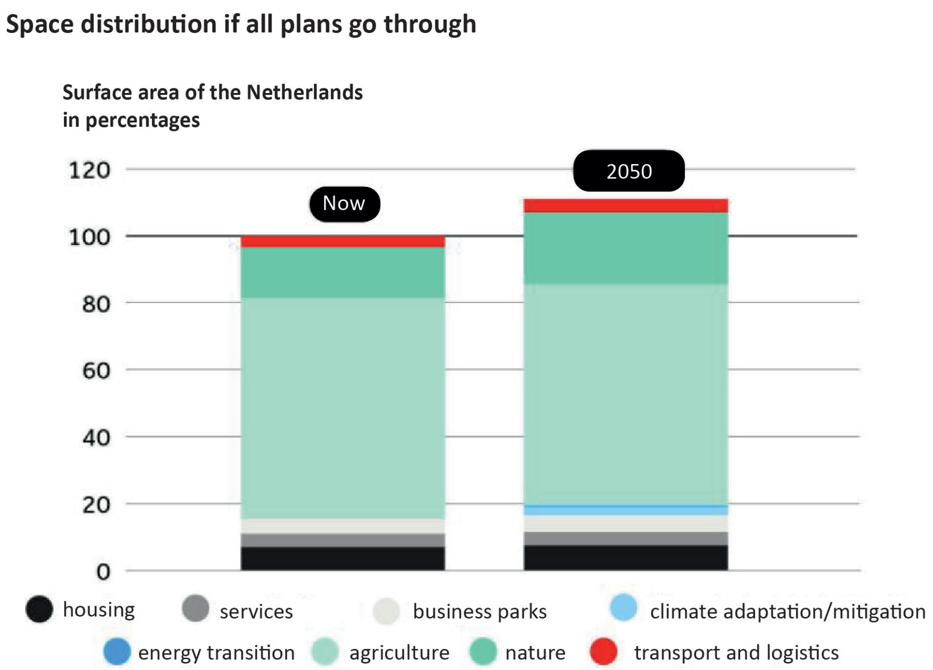


Figure 1.3. Space shortage in the Netherlands in 2050 if all plans go through. Adapted from "NOS Nieuws", by NOS Nieuws, 2020 (https://nos.nl/artikel/2347876-ruimtetekort-in-nederland-minister-gaat-weer-meebeslissen.html). Copyright by Wageningen University.

1.2 CLIMATE ADAPTATION PLANNING

The consequence of the two trends discussed is an increased liveablity risk. As the weather becomes more extreme (KNMI, 2015) and densities increase, so will the need to create neighbourhoods that can cope with and adapt to the effects of climate change. To achieve this, climate change adaptation is essential.

Climate change 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, p.542). In the context of this research, climate change adaptation is about the process of adapting to the effects of climate change in urban areas. The task of planning and realizing these adjustments can be defined as the climate adaptation task.

But, the question is also how to adapt. In the past, climate adaptation was often reactive. Changes were only made when problems occurred. Another option is planned adaptation, which is a more pro-active approach to climate adaptation. Planned adaptation is expected to become more important as climate change intensifies and the time to response becomes shorter. Because the climate keeps changing, but the climate projections are uncertain, climate adaptation is a long term development process. Therefore, climate adaptation planning is needed to explore current and future adaptation options and to steer the adjustment process in the planned direction. Climate adaptation planning is a planned approach to adaptation and is needed to work with the ever changing climate and the associated uncertainties.

> *Climate adaptation planning is needed to work with the ever changing climate and the associated uncertainties*

Current spatial planning practice shows a growing focus on climate change adaptation (Roggema, 2012). However, *'the question is whether spatial planning frameworks and approaches are sufficiently equipped to include strategies that deal with uncertainty and that are capable of anticipating an unpredictable future'* (Roggema, 2012, p.261). Climate adaptation planning is crucial to the development of sustainable urban areas with high liveability standards for future generations. If spatial does not intervene now for climate adaptation, the problems will be passed on to future generations. Hence, there is a need for a different way of working.

1.3 MISMATCH

The problem focus of this graduation project is that traditional spatial design and planning do not match with the climate adaptation task.

1.3.1 Disconnections

The mismatch can be described by four disconnections, as also visualized in Figure 1.4:

1. Dynamic climate & Static (reactive) planning
Climate change is a dynamic process and a dynamic problem, but traditional spatial planning and especially water management are often static (Bothof, 2020). In urban developments, water managers often use the stand-still principle. This principle means that the situation should not get worse, and indirectly implies that improvement is not necessary (Bothof, 2020). Only when problems arise, a change is made; this is reactive planning. As climate change intensifies, this reactive behaviour will eventually lead to problems as the time to make decisions and implement measures becomes shorter (IV2; One Architecture et al., 2020). Climate adaptiveness is too often seen as a fixed status that can be achieved (IV1). But as the climate is constantly changing, climate adaptiveness is a constant process of becoming (ZUS, SLIKC, TU Delft, & Arcadis, 2020).

2. Long-term climate change & Short-term planning
Climate change is a continuous and therefore long-term process. However, in urban development processes the timescale is often relatively short and the long-term climate is not enough considered (One Architecture et al., 2020). A 30-year perspective is common in development plans, while the lifetime of the urban area is at least 60 years, and often even longer. Roggema even talks about a maximal spatial planning horizon of ten years in practice (Roggema, 2012). Climate projections for the year 2050 are currently often used to test designs. But as climate change intensifies, the difference grows between what is needed in 30 years and what is needed in 60 years. One of the main challenges in climate adaptation planning is dealing with the long term (IV1) and forward-looking decisions are not yet self-evident (Pot, 2020).

There is a mismatch between the current spatial design & planning practice and the climate adaptation task

3. Climate uncertainty & Fixed paths and goals in planning
One of the characteristics of climate change is uncertainty (Van Buuren, et al., 2013) and working with this uncertainty is one of the other main challenges of climate adaptation (IV1). Traditional spatial planning assumes control over events, and is based on stability and linear developments (Timmermans, Koolen, Van Dorp, & Branderhorst, 2012). Traditional spatial planning often attempts to reduce uncertainty with better models or data, and to predict or project the future (Balducci, Boelens, Hillier, Nyseth, & Wilkinson, 2011). However, it is impossible to predict the future, so it is necessary to consider a range of futures and to deal with uncertainties. In urban development processes at area-level, multiple futures are insufficiently considered (One Architecture et al., 2020). Traditional strategic plans try to ensure pre-specified goals or end-states within a given timeframe (Balducci et al., 2011), but this does not work for climate adaptation planning.

4. Growing importance of water & Lack of integration with spatial planning
The coherence between the spatial planning and water domain is not yet strong enough (OECD, 2014), but this is crucial for climate adaptation. Water management can offer solutions to cope with heat, drought, pluvial flooding and fluvial flooding, but often has too little say in decisions about urban developments (Bothof, 2020). Traditionally, the regional water authorities have a facilitating attitude towards spatial developments (Spaan, 2021) and are sometimes still involved in spatial choices at a late stage (Bothof, 2020) . But lately, there has been an increasingly loud call to make the soil-water system the starting point for spatial choices (PBL, 2021; Deltares, BoschSlabbers, & Sweco, 2021; Meijer, 2021). To do this, water management should become more directing towards spatial planning.

Figure 1.4. Problem focus:
The mismatch between traditional spatial planning and the climate adaptation task.

1. Introduction

1.3.2 The Result of the Mismatch

The result of the mismatch is that the problems are pushed to the future (One Architecture et al., 2020). Due to a too short time horizon, urban developments are not prepared for the future climate conditions (One Architecture et al., 2020). This means that there is a good chance that adjustments will be necessary in the future. These adjustments are more expensive, as the space required for the adjustments is already in use. It is expected that most costs will fall in the public domain (One Architecture et al., 2020).

1.3.3 What is Missing?

What is currently missing are working approaches to climate adaptation planning, which close the gap between spatial planning and the climate adaptation task. A new way of working should include:

What is currently missing are working approaches to climate adaptation planning, which resolve the disconnections between spatial planning and the climate adaptation task

1. More Flexibility and Pro-activity
The dynamic nature of climate change asks for spatial plans that are more flexible and pro-active (One Architecture et al., 2020; ZUS et al., 2020). It is important to design and build a longer time horizon, or to build in flexibility to increase the adaptive capacity (One Architecture et al., 2020). Strategic maneuverability and flexibility are key when coping with uncertain future conditions (Pot, 2020).

2. Longer Time Horizons
For climate adaptation it is important to consider a timescale that reflects the lifetime of the decisions made (IV1). With a lifetime of more than 60 years, the time horizons for urban developments must exceed the usual 30 years. There is a need for more forward-looking instruments (Pot, 2020) and a stronger connection between short-term and long-term goals and benefits (IV1).

3. Working with Uncertainties
The uncertainties about climate change will not disappear, but there are not many approaches in spatial planning that are suitable for dealing with uncertainty in the program or problem (Roggema, 2012). Therefore, it is important to find ways to deal with uncertainties, instead of ignoring them and planning for a single future. Design tools can be used to cope with the climate uncertainties (One Architecture et al., 2020) and to explore different futures and development trajectories towards those futures.

4. Integration of Water & Spatial Planning
Climate adaptation should be more integrated with urban developments (One Architecture et al., 2020). And considering the importance of water for climate adaptation, it is key to integrate water more into spatial planning. An integral approach is therefore important (IV1) and design can be used to increase the capacity for climate adaptation (One Architecture et al., 2020).

1.4 PROBLEM STATEMENT

Due to population growth, a growing housing shortage, and a space shortage, it is expected that urban developments in the Netherlands will mainly take place within existing city boundaries and in high densities. At the same time, the effects of climate change are expected to increase, as climate change is expected to accelerate and intensify. These two trends pose an increased risk to the liveability in these new urban areas. To reduce this risk, climate adaptation is essential.

However, traditional spatial planning does not match with the climate adaptation task. Climate change is dynamic and uncertain and extends over long time scales. Traditional spatial plans, however, are often static, short-term plans, that do not sufficiently take uncertainties into account. In addition, climate adaptation is not always sufficiently integrated into spatial planning and it is often still the task of the water sector. This means that water, which is crucial for climate adaptation, not always have enough say in decisions about urban developments.

Hence, there is a need for a different way of working: Climate adaptation planning. Climate adaptation planning connects to the idea that both the city and the climate are subject to continuous change. To support climate adaptation planning, new approaches are needed, including greater flexibility and proactiveness. Furthermore, longer time horizons, uncertainties and the integration of water management and spatial design and planning must be taken into account.

If spatial planning fails to act now for climate adaptation, the problems are passed on to future generations. As the liveability of urban areas for future and far-future inhabitants will depend on the success of climate change adaptation planning, it is key to find new working approaches.

1. Introduction

1.5 THE PROJECT

The objective of this research is to contribute to the search for new approaches that support climate adaptation planning. This research aims to investigate the usability of the Spatial Adaptive Policy Pathways (SAPP) approach for climate adaptation planning in new urban areas in the Netherlands. The SAPP approach is a combination of existing adaptive approaches, as further explained in Section 2.3. This research explores the approach to define the possibilities and points of improvement, through four main stages: analysis, identification, development, and application. To test the approach, Haven-Stad is selected as case study area. The evaluation of the output and approach provide input to answer the main research question of this project:

How can the Spatial Adaptive Policy Pathways approach support climate adaptation planning for new urban areas in the Netherlands?

1.5.1 Case Study Area: Haven-Stad

The municipality of Amsterdam is facing one of the largest housing shortages in the Netherlands. At the beginning of 2020 the percentual shortage in the Metropolitan Region Amsterdam was 7.4% (Capital Value, 2020). The ambition of the municipality of Amsterdam is to build 52.500 new houses by 2025. The municipality strives for densification within the existing city (Gemeente Amsterdam, 2018). Along with the task of building comes the task of preserving and increasing the liveability of the city.

Haven-Stad is selected as development area in order to achieve the building targets (see Figure 1.5 and 1.6). Haven-Stad is an industrial (harbor) area in the west of Amsterdam, which will be redeveloped into a mixed living and working area. This is in line with the need for more housing and the aim to stay within the city borders. Haven-Stad will be the largest new housing district ever built (Niewold, 2017); the intention is to build new neighbourhoods with 40.000-70.000 houses and 45.000-58.000 jobs (Gemeente Amsterdam, 2017).

Haven-Stad is selected as the case-study area for this research, because it is a typical example of an inner-city high-density urban development with a challenging climate adaptation task, which corresponds to the described problem field. The intention is to build in high densities and at the same time, the effects of climate change are becoming increasingly apparent in the city of Amsterdam (Gemeente Amsterdam, 2020a). It can be expected that the weather becomes even more extreme in the future (KNMI, 2015) and due to the high densities, it is even more important to prepare the district for the effects of climate change. Climate adaptation planning is essential to ensure liveability for the (next) generations of Haven-Stad,

1.5.2 Reading Guide

The reading guide can be found on the next page. This report is the main report. The appendix of this study is given in a separate document. The chapters and paragraphs in the appendix are named in the same way as the corresponding chapters and paragraphs in this main report.

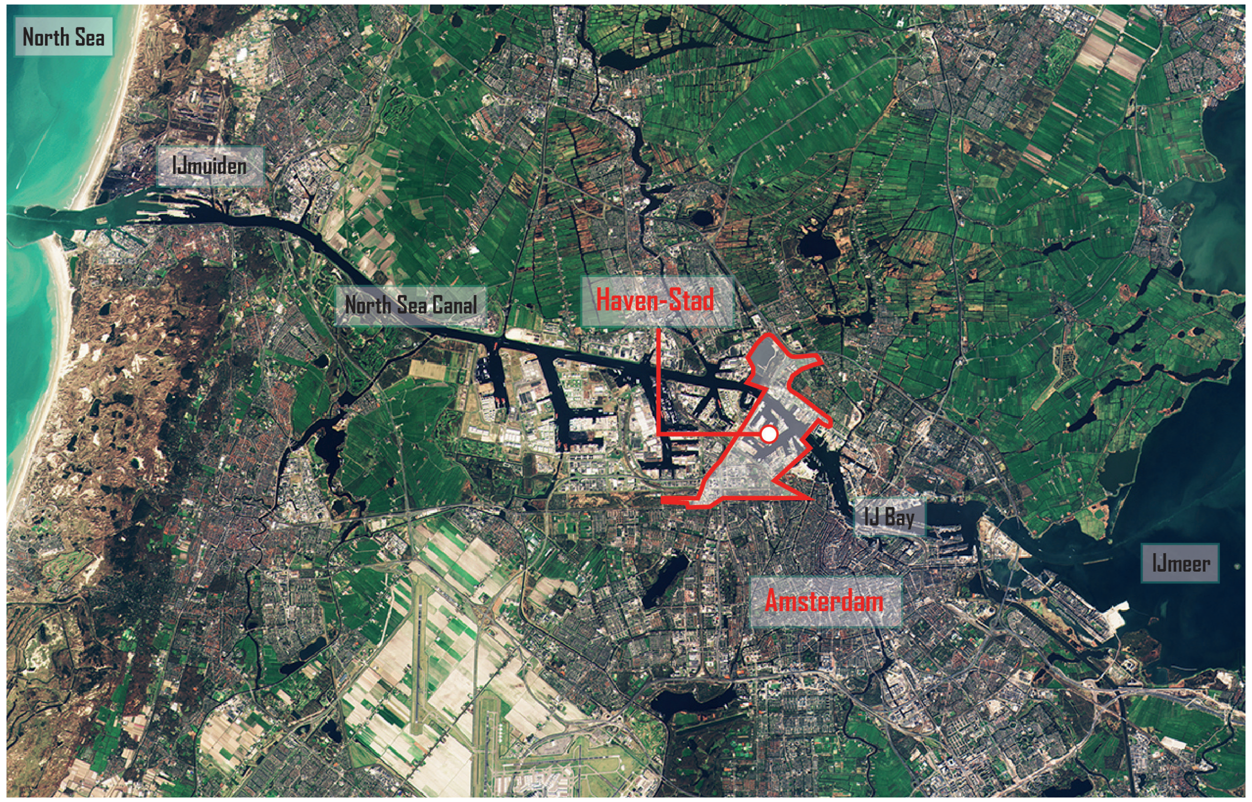


Figure 1.5. Location of Haven-Stad. Background from "The European Space Agency", by ESA, 2017 (https://www.esa.int/ESA_Multimedia/Images/2017/05/Amsterdam_Netherlands). Copyright 2017 by ESA.

Figure 1.6. A part of Haven-Stad from the air. Reprinted from "Haven-Stad: veranderen van gebied", by Gemeente Amsterdam, n.d. (https://www.amsterdam.nl/projecten/haven-stad/). Copyright by Gemeente Amsterdam.

base

1 INTRODUCTION

2 RESEARCH CONCEPTS

3 RESEARCH SET-UP

The first three chapters form the base of this research. Chapter 1 gives an introduction into the problem: A mismatch between the climate adaptation task and the current way of spatial design and planning. In Chapter 2 Spatial Adaptive Policy Pathways (SAPP) are proposed as a possible approach to support climate adaptation planning. Chapter 3 presents the research set-up.

results

12 EVALUATION

13 CONCLUSION & REFLECTION

What can be learned from the process and outputs?

The results of this research answer the question above in two chapters. In Chapter 12 an evaluation is made on the outputs for Haven-Stad and the SAPP approach, based on the trial made during this research. In Chapter 13 answer is given to the research questions and a reflection is made on the research.

analysis

4 HAVEN-STAD & CLIMATE CHANGE

5 CLIMATE ADAPTATION GOVERNANCE

Which analyses are needed to get a comprehensive view of the climate adaptation task?

The Analysis stage gives answer to the research question above and consists of two chapters. Chapter 4 presents the current and projected climate vulnerabilities of Haven-Stad, and discusses the uncertainties of the climate projections. Chapter 5 presents an analysis of the Dutch planning system and current climate adaptation governance, supported by interviews.

application

How can Spatial Adaptive Policy Pathways be used to support design and governance for climate adaptation planning?

The Application stage answers the research question above and consists of two chapters. In Chapter 10 a selection of two trajectories is visualized, to show the link with urban design. Chapter 11 shows how the SAPP map can be used to explore what kind of climate adaptation governance might be needed in the future.

10 PATHWAYS FOR DESIGN

11 PATHWAYS FOR GOVERNANCE

identification

What are the key components needed for the development of Spatial Adaptive Policy Pathways?

The Identification stage gives answer to the question above and consists of two chapters. In Chapter 6 the framework of the SAPP approach, and the scope and objectives are presented. Chapter 7 introduces the adaptation measures and underlying principles.

6 FRAMEWORK

7 ADAPTATION MEASURES

development

9 ADAPTATION PATHWAYS

8 DESIGN FOR 2050

How can Spatial Adaptive Policy Pathways be developed for climate adaptation planning?

The Development stage answers the research question above and consists of two chapters. Chapter 8 presents design principles and ideas for Haven-Stad, based on the climate in 2050. Chapter 9 describes how Spatial Adaptive Policy Pathways are developed for a focus area in Haven-Stad and presents the final SAPP map.

2

RESEARCH CONCEPTS

The research concepts are the theoretical inputs and interpretations that are used for this research. This chapter starts with the relevant theoretical concepts of climate resilience, adaptive planning, and adaptive pathway approaches. The conceptual framework shows the connection between the problem definition, the theories and the selected approach. At the end the Spatial Adaptive Policy Pathways (SAPP) approach is presented, which is the proposed approach for climate adaptation planning.

RTL Nieuws (2019)

2.1 THEORETICAL CONCEPTS

2.1.1 Climate Risk

Risk is determined by the interaction of hazard, exposure and vulnerability (Viner, et al., 2020), as visualized in Figure 2.1. The IPCC defined the components as follows (IPCC, 2018):

Hazard: *'The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources'* (IPCC, 2018, p.551).

Exposure: *'The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected'* (IPCC, 2018, p.549).

Vulnerability: *'The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt'* (IPCC, 2018, p.560).

The two trends discussed in Section 1.1 affect the climate risk. Due to climate change, it is expected that the hazard will increase (more extreme weather events). And high-density developments, will increase the exposure, as there will be more people present on the same area. The result is an increasing climate risk for society.

To reduce climate risk, all three aspects could be reduced. However, for this project it is assumed that the exposure will not decrease quickly, as the Netherlands is faced with a space- and housing shortage. In addition, it is predicted that climate change will continue, despite the mitigation actions. Reducing the vulnerability is thus crucial to reduce the climate risk.

Reducing the vulnerability is crucial to reduce the climate risk

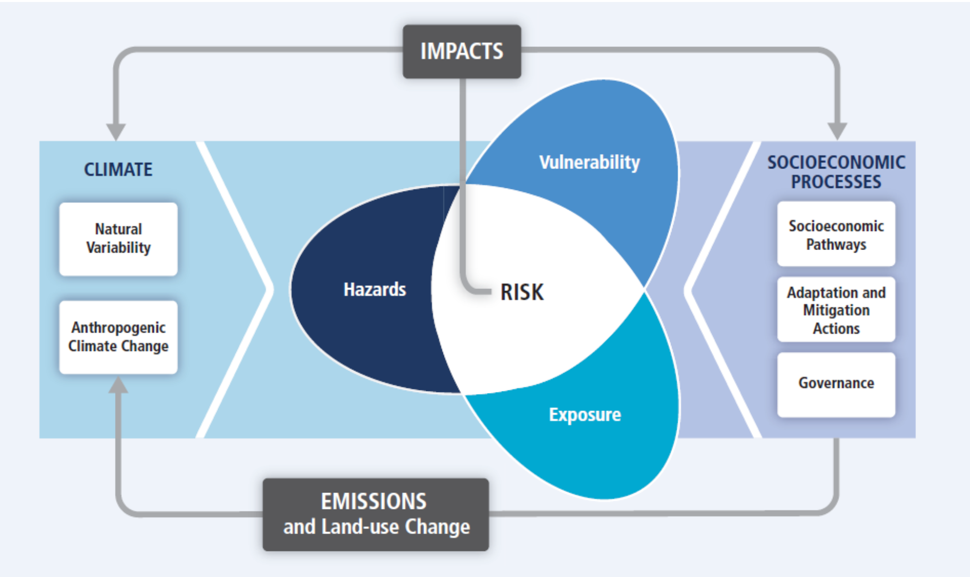


Figure 2.1. The Risk framework of the IPCC, 2014. Reprinted from "*Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*" (p.3), by IPCC, 2014, Cambridge: Cambridge University Press. Copyright 2014 by IPCC.

2.1.2 Climate Resilience

'Vulnerability and resilience are two sides of the same coin' (SOPAC, n.d., p.1). A system that is more resilient is less vulnerable (SOPAC, n.d). The IPCC defines resilience as: *'The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation'* (IPCC, 2018, p.557). Translated into this research, the system refers to the urban system and the event/trend/disturbance refers to the climate change effects.

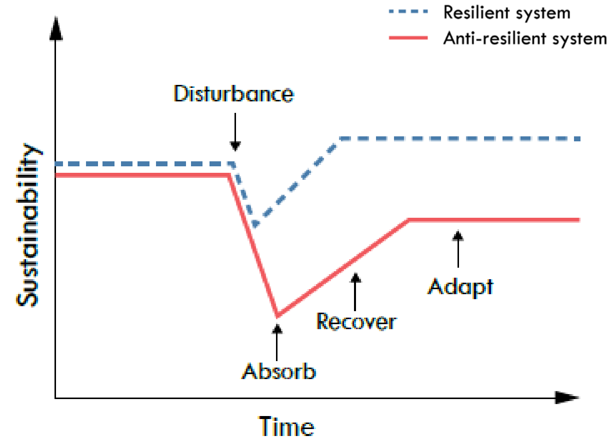


Figure 2.2. Resilient and anti-resilient systems. Reprinted from *"Resilience by Design Metropoolregio Amsterdam"* (p.32), by One Architecture et al., 2020. Copyright 2020 by One Architecture.

Figure 2.2 shows the difference between a resilient and a non-resilient system in response to a shock. The anti-resilient system is unable to absorb the shock and shows reduced system performance after recovery and adaptation. The resilient system absorbs the shock better and has a greater recovery and adaptive capacity. This results in a more transformative recovery and a more sustainable system (One Architecture et al., 2020).

Davoudi, Brooks, & Mehmood presented a framework for resilience building. As can be seen in Figure 2.3, the framework consists of four dimensions: Persistence, adaptability, transformability, and preparedness (Davoudi, Brooks, & Mehmood, 2013).

Vulnerability and resilience are two sides of the same coin

These all four dimensions are relevant for climate change adaptation. Persistence can be explained as being robust; the capacity to resist disturbances. A dike is an example of a robust structure that offers protection against disturbances caused by high water levels. Adaptability can be explained as being flexible; the capacity *'to adjust to potential damage, to take advantage of opportunities, or to respond to consequences'* (IPCC, 2018, p.542). A floating building can absorb the disturbance of high water by moving flexible with te water levels. Transformability can be explained as being innovative; the ability to change towards a different, more preferred, future. An example could be the transformation of a neighbourhood built on peat in a low polder into a swamp landscape, to prevent further soil subsidence (BNA Onderzoek, 2020, p.89). Preparedness connects to the capacity of humans to learn and to intentionally intervene. By learning, people can *'enhance their chances'* to be (more) robust, flexible or innovative (Davoudi, Brooks, & Mehmood, 2013). It is important to note that resilience is a continuous process of becoming; it is not a fixed asset (Davoudi et al., 2012). As long as the climate keeps changing, 'being' climate resilient is not a possible attainable status for long term. It is about becoming climate resilient.

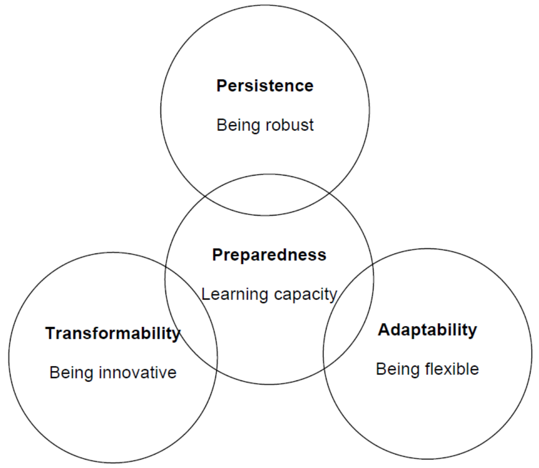


Figure 2.3. Four-dimensional framework for resilience building. Reprinted from "Evolutionary Resilience and Strategies for Climate Adaptation", by Davoudi, Brooks, & Mehmood, 2013, *Planning Practice & Research, 28*, p.311. Copyright 2013 by Taylor & Francis.

2. Research Concepts

2.1.3 Climate Adaptation Planning

Increasing climate resilience can be achieved through climate adaptation (Davidson, 2010; Leichenko, 2011). 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, p.542). In the context of this research, climate change adaptation is about the process of adjustment to climate change effects in urban areas. In particular, decisions with a long-term commitment, such as urbanization plans, can be very sensitive to climate change (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.

But the question is also how to adapt. In the past, climate adaptation was often reactive. Changes were only made in case of problems. Another option is planned adaptation, which is a more pro-active approach. It is expected that planned adaptation gets more important as climate change intensifies and the time to react becomes shorter. Because the climate keeps changing, climate adaptation will be a long term development process. Therefore, climate adaptation planning is needed to explore future adaptation options and to steer the adjustment process.

The enhancement of climate resilience can be reached with climate adaptation

2.1.4 Uncertainty

Van Buuren et al. (2013) defined uncertainty as one of the characteristics of climate change. Both the development of climate change itself, and 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 that 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 the 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. This type is about uncertainty in human actions, behaviours, and policies. The third type concerns 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 the best strategies are to prevent negative local impacts (Stults & Larsen, 2018).

Figure 2.4 shows the relationships between the main sources of uncertainty (Deser et al., 2012) and the resulting uncertainties (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 it is decided toimmediately ban all CO_2 emissions, the CO_2 emissions will go down and will influence the climate system. This change in forcing will again feed uncertainty about future climate conditions.

The uncertainty of climate developments makes adaptation planning a lot more challenging (Van Buuren et al., 2013; Woodruff, 2016). It is not entirely clear whether adaptation measures are needed, how many adaptation measures are needed, and whether the adaptation measures will work as planned (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).

Dealing with climate uncertainty is a challenge for climate adaptation planning

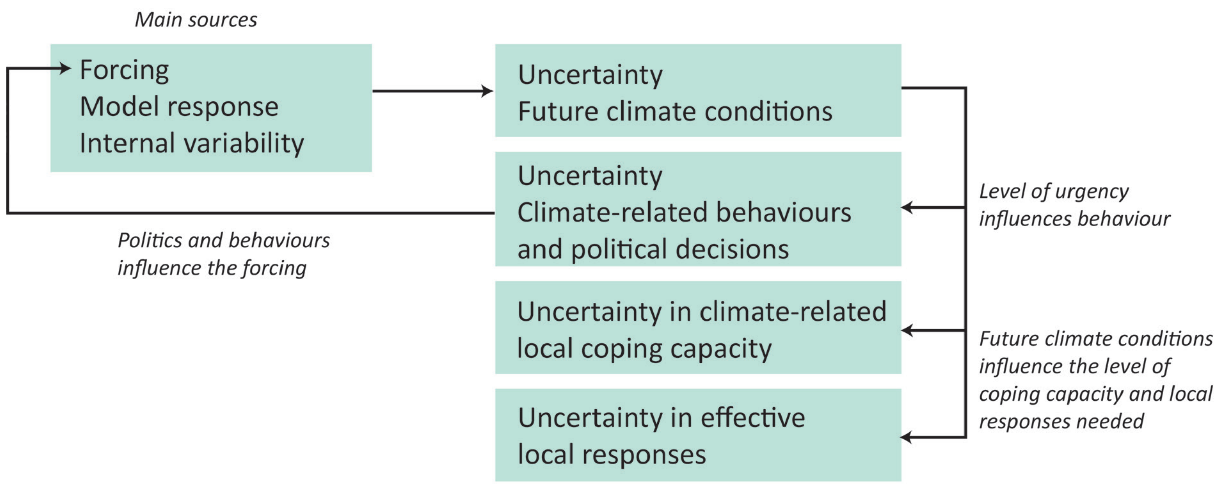


Figure 2.4. Relations between the main sources of uncertainty and the types of resulting uncertainties. Information from (Deser et al., 2012) & (Stults & Larsen, 2018).

Appendix 2.1
For the academic paper:
'The Embracement of Uncertainty'

2.1.5 Adaptive Planning

The perspective of resilience and the embracing of uncertainties asks for a paradigm shift towards adaptive planning.

According to Roggema, *'many spatial planning frameworks are not equipped to deal with uncertainty in the program or in the problem'* (Roggema, 2012). This is supported by the results of Woodruff, who found that urban plans often recognize climate uncertainties, but few apply approaches to tackle them (Woodruff, 2016).

Traditional spatial planning assumes control over events, and is based on stability and linear developments (Timmermans, Koolen, Van Dorp, & Branderhorst, 2012). Traditional strategic plans try to ensure pre-specified goals or end-states within a given timeframe (Balducci et al., 2011). Often attempts are made to reduce uncertainty with better models or data, and to predict or project the future (Balducci et al., 2011). In traditional planning, a static 'optimal' plan is made on the assumption that the future can be predicted. The problem with this traditional approach is that the plan is likely to fail if the future develops differently from the predicted future (Haasnoot et al., 2013).

As future climate uncertainties will not (quickly and completely) dissapear, ignoring or avoiding them in adaptation planning is not an option (Woodruff, 2016). There is a need for new planning approaches that discover, assess, and address uncertainties (Woodruff, 2016). The approaches must give way to all aspects of resilience building: persistence, adaptability, transformability, and preparedness (Davoudi, Brooks, & Mehmood, 2013). Adaptive planning allows changes to be planned more gradually and controlled, rather than extreme and unexpected (Timmermans et al., 2012).

Haasnoot et al. (2013) mention the emergence of a new paradigm for planning under deep uncertainties. 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 resulting plan is adaptive as it can change over time to cope with changing circumstances, such as climate change (Haasnoot et al., 2013).

Van Buuren et al. (2013) agree that climate adaptation requires adaptive spatial planning. They explain that innovation in the spatial planning system is necessary to fulfil two ambitions associated with an 'adaptive spatial planning' paradigm. The first ambition is that planning facilitates the society ' s socio-economic ambitions and the second ambition is that planning meets uncertain climate constraints. The authors argue for an adaptive approach with a central role for learning, experimentation, dialogue, and flexibility. (Van Buuren et al., 2013).

Rauws (2017) also argues for an adaptive planning approach that embraces uncertainty. According to the author, such an approach *'strengthens the responsiveness of urban areas to both expected and unexpected changes'* (Rauws, 2017, p. 32). As traditional planning instruments are usually made for stable situations (Albrechts, 2010; Albrechts & Balducci, 2013, as cited in Rauws, 2017) he claims that adaptive planning instruments can complement planning for an uncertain future.

A paradigm shift towards adaptive planning is needed to plan for climate adaptation

2.1.6 Adaptive Pathways Approach

The adaptive pathways approach is a promising approach to support adaptive planning. The approach is fairly new and was first introduced in the Netherlands 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) have often worked with only a few plausible futures and one or two projection years (Haasnoot et al., 2012). The end-product of this approach, the Adaptation Pathways map (see Figure 2.5), is a tool to discuss uncertainty, multiple possible futures, and the deployment of actions over time. The map can also clarify the relationship between long-term visions and short-term actions. Figure 2.5 shows an example of an Adaptation Pathways map (Haasnoot et al., 2013). On the y-axis, possible actions, or adaptation measures, are listed.

The adaptive pathways approach is a promising approach to support adaptive planning

In this case the x-axis shows the time, but this can be replaced by a changing condition, for example, sea level rise in meters. The figure shows how the current policy (grey) will reach the adaptation tipping point (vertical black line) fairly quickly. Action A, B, C, and D are options for adaptation. Action A and D are expected to achieve the objectives for the next 100 years; the horizontal lines extend up to 100 years on the map. Action B, however, already reaches the adaptation tipping point after 8 years. This means that it is necessary to change the measure to action A, C, or D to achieve the objectives. This transformation must be decided before the 8 years are up to allow time for policy change and implementation (Haasnoot et al., 2012).

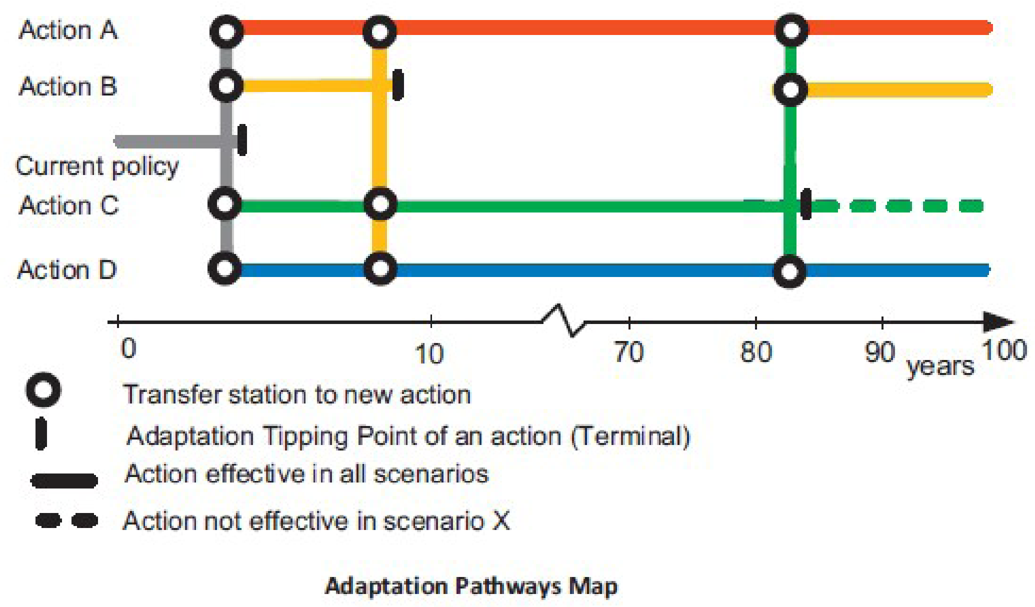


Figure 2.5. 'An example of an Adaptation Pathways map'. Adapted from "Exploring pathways for sustainable water management in river deltas in a changing environment", by M. Haasnoot, H. Middelkoop, A. Offermans, E. Van Beek, & W. Van Deursen, 2012, *Climatic Change, 115*, p.811. Copyright 2012 by Springer.

Appendix 2.1
For the academic paper:
'The embracement of Uncertainty'

There are five ways in which the adaptive pathways approach can support decision-making under uncertainty (Zandvoort et al., 2017). Firstly, by addressing multiple scenarios and by selecting multiple pathways, that accommodate uncertainty. Secondly, through the use of objective-based thresholds, which indicate when adaptation is needed to achieve the policy objectives. As third, the approach structures the abundance of adaptation measures. As fourth, the approach can help to identify potential lock-ins. Lock-ins are actions or policy measures that ultimately do not achieve the objectives and that are difficult to transfer to other actions or policies. Finally, the approach takes into account the preferences of multiple actors (Zandvoort et al., 2017).

The adaptive pathways approach is also promising for the resilience enhancement, as aligns with the previously explained framework for resilience building from Davoudi, Brooks, & Mehmood (2013). The approach incorporates persistence, by checking to what extent a system is robust (adaptation tipping points). It also includes adaptability, by defining multiple pathways that can be followed flexibly. Transformability is incorporated, because the approach provides insights into when incremental measures can no longer achieve the objectives anymore, and it supports thinking about transitions. Finally, the approach incorporates preparedness, because it supports thinking about the (long-term) future. The approach also includes monitoring and adjustment, so that the pathways are adapted to the latest insights.

Thus, adaptive pathways may be a promising approach for climate adaptation planning. The adaptive pathways map can be a supporting tool to move the conversation from 'when and how will the climate change?' to 'what is the action perspective in the longer run?'. While the adaptive pathways approach has been around for nearly 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 spatial translation (Van Veelen, Stone, & Jeuken, 2015; Zandvoort et al., 2017).

In this literature review, only one paper was 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 create an adaptive landscape design for East Boston (Zandvoort et al., 2019). The researchers agree that the spatial translation of adaptive pathways is far understudied. The article shows 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 with the standard pathways approach, they first created conceptual pathways to investigate the goals and possible measures. The researchers added a landscape analysis to map the possible effects of the different measures and to get an idea of how these measures could fit spatially into 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 untill they were sufficient enough to add to the final pathways map (see Figure 2.6). Then, the pathways were made visual, as can be seen in Figure 2.7. In conceptual drawings, the researchers showed how the landscape could evolve over time by adding adaptation measures. Finally, they translated these conceptual drawings to the case study location of East Boston and made a phased 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 enriches the standard process, as it makes the consequences of pathways more transparent. Moreover, it provides more insight into the feasibility and timing of the implementation of the adaptation measures (Zandvoort et al., 2019).

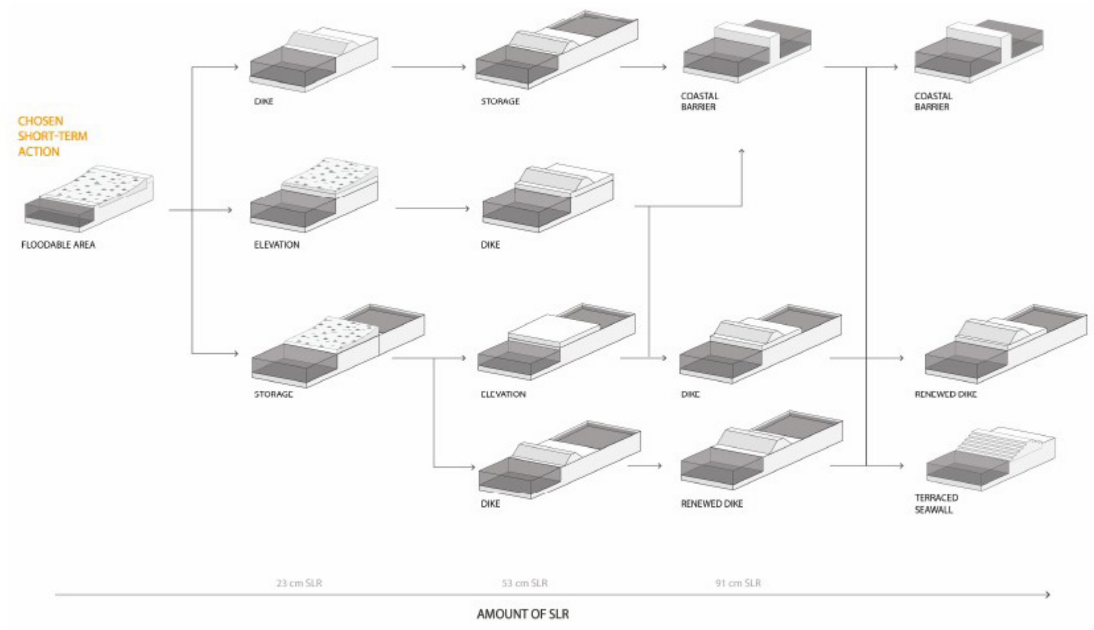


Figure 2.6. Conceptual drawings visualizing the trajectory of change for the multifunctional strategy. Reprinted from "Designing with Pathways: A Spatial Design Approach for Adaptive and Sustainable Landscapes", by M. Zandvoort, N. Kooijmans, P. Kirshen, & A. Van den Brink, 2019, *Sustainability, 11*, p.16. Copyright 2019 by Zandvoort et al.

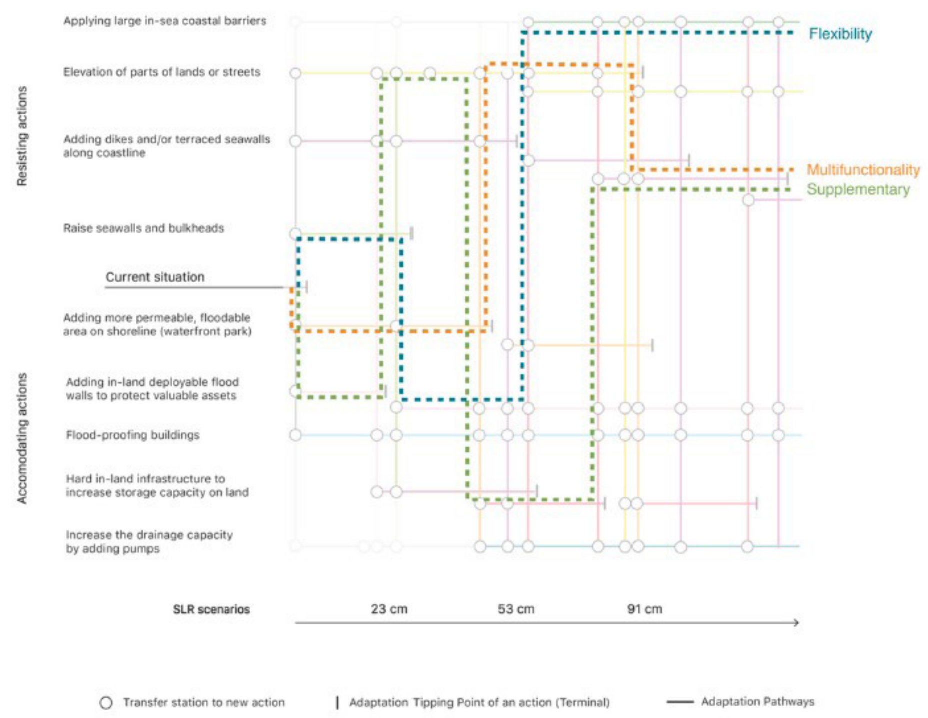


Figure 2.7. The final adaptation pathways map and three different trajectories of change, based on three strategies (flexibility, multifunctionality, and supplementary). Reprinted from "Designing with Pathways: A Spatial Design Approach for Adaptive and Sustainable Landscapes", by M. Zandvoort, N. Kooijmans, P. Kirshen, & A. Van den Brink, 2019, *Sustainability, 11*, p.14. Copyright 2019 by Zandvoort et al.

2.2 CONCEPTUAL FRAMEWORK

The conceptual framework is visualised in Figure 2.8. It shows the links between the observations, theories, and concepts used in this research.

Trends
The two main trends are climate change and higher building densities, as discussed in Section 1.1. The higher building density is caused by the lack of space, the housing shortage, and the population growth in the Netherlands. Climate change causes a.o. rising temperatures, rising sea levels, and higher precipitation intensities.

Risk
Risk is defined by vulnerability x exposure x hazard. Due to climate change the hazards will increase, because of more extreme weather events and higher sea levels. And by building in higher densities, exposure will increase, as more people (and assets) are present in the same area. Together, these two lead to an increased climate risk. *See Section 2.1. for more information about the climate risk.*

Goal
Assuming that the hazards and exposure will not decrease, climate risk can only be reduced by reducing the vulnerability. Or the same: Increasing the climate resilience. *See Section 2.1. for more explanation about climate resilience.*

Means
The means of increasing climate resilience is climate adaptation. As the climate continuous to change, climate adaptation will be a long-term development process. Therefore, climate adaptation planning is needed to explore future adaptation options and to steer the adjustment process in the right direction. *See Section 2.1. for more explanation about climate adaptation planning.*

Problem
The problem for climate adaptation planning is that traditional spatial planning does not match with the climate adaptation task. Traditional spatial planning is often static, short-term, with one future vision, and climate adaptation is mainly connected to the water sector. This while climate change is dynamic, long-term, uncertain, and requires an integral approach. *See Section 1.3. for more explanation about the mismatch.*

Need for
Climate adaptation planning requires flexibility and pro-activity, a long time horizon, working with uncertainties, and the integration of water management and urbanism. This comes together in adaptive planning. See Section 1.3. for more explanation about the needs and Section 2.1 for more information about adaptive planning.

Approach
The adaptive pathways approach is a promising approach to support adaptive planning. Haasnoot et al. (2012) and Zandvoort et al. (2019) have already studied the use of these pathways for spatial design (Zandvoort) and water management (Haasnoot). However, there is a knowledge gap on the use of adaptive pathways for both design and governance in the context of climate adaptation in urban areas. Therefore, in this research a combination of the above two approaches, the Spatial Adaptive Policy Pathways (SAPP) approach, has been tested. *See Section 2.1. for more explanation about the adaptive pathways approach. The SAPP approach is explained in Section 2.3.*

There exists a knowledge gap about the use of adaptive pathways for both design and governance in the context of climate adaptation in urban areas

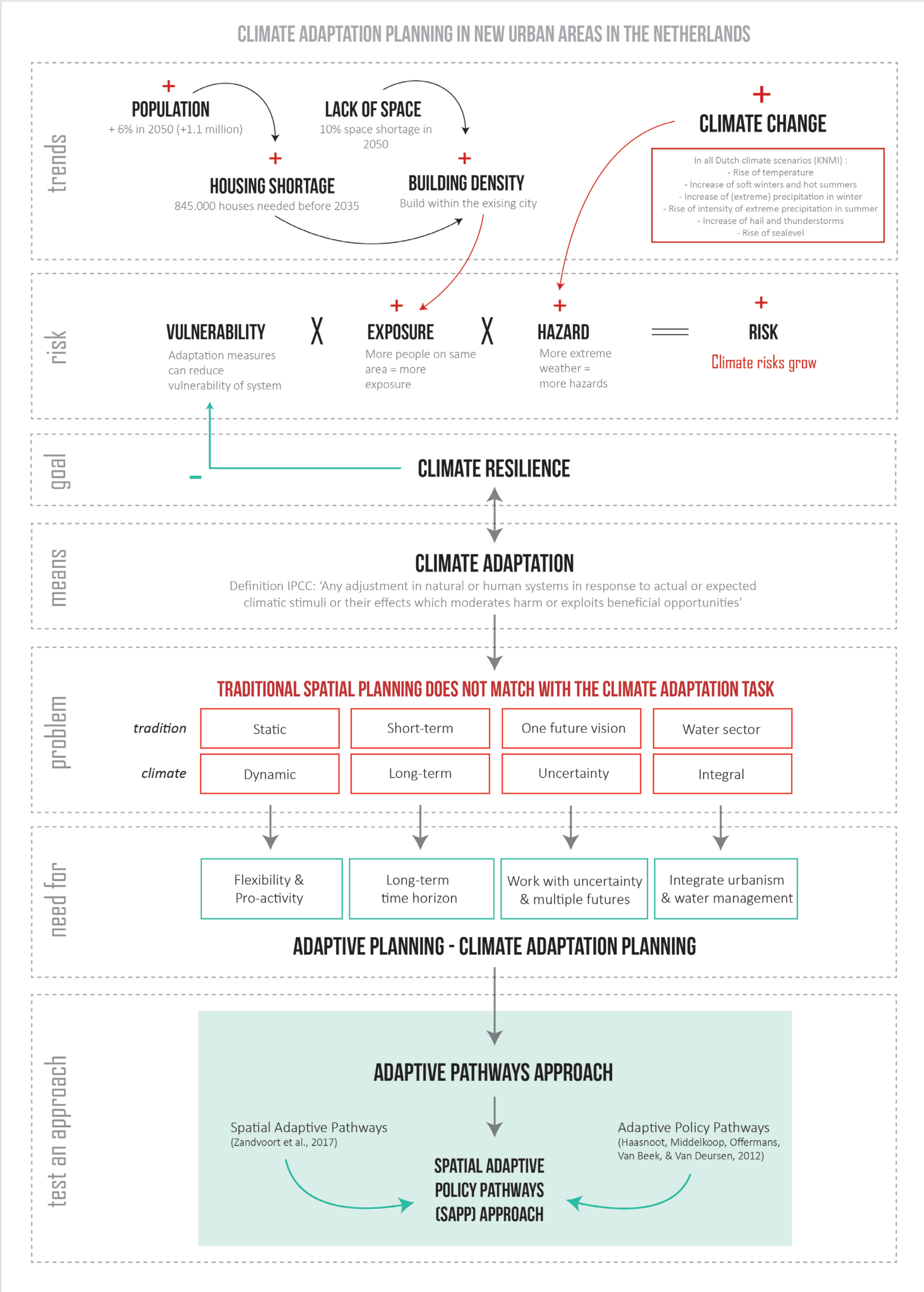


Figure 2.8. Conceptual Framework.

2.3 SPATIAL ADAPTIVE POLICY PATHWAYS (SAPP) APPROACH

Figure 2.9 shows the steps of the SAPP approach to climate adaptation planning. The steps are inspired by the steps of the study of Haasnoot et al. (2013) and the study of Zandvoort et al. (2019), and adjusted during the research process.

Step 1 - Analyse the context, climate vulnerabilities and current governance
In the first step, analyses must be made of the current site and its context (from the site to the regional/national scale), the development plans, the climate vulnerabilities and the current governance for climate adaptation (planning). The climate vulnerabilities need to be analysed for each of the four climate stresses (heat, drought, pluvial flooding, fluvial flooding) and the current governance must also be addressed to get a good overview of the climate adaptation task.

Step 2 - Define the key components and scope
In the second step, the key components and scope must be defined. The key components (starting point, climate objectives & climate trends, transition phases, adaptation measures) form the framework for the development of the SAPP map. The SAPP map presents with adaptive pathways how an area could change over time. The scope needs to be defined to set a focus (theme, spatial scale, time scale, governance scope).

Step 3 - Identify the adaptation measures
In the third step, the adaptation measures need to be identified. The abundance of adaptation measures is structured with adaptation principles, design layers, and adaptation tiles.

Step 4 - Design the starting point
In the fourth step, the starting point needs to be designed. This starting point is the initial design for the new development, and thus the starting point of the adaptive pathways map. This design is also used as spatial exploration (research by design) to discover opportunities and potential problems of the site. The design is created with the design layers, as defined in step 2. This step (4) is iterated with step 5, because new insights from the pathways can be implemented in the start design.

Step 5 - Develop the adaptive pathways map
In the fifth step, the SAPP map must be developed. Steps 1-4 give the input for the pathways. First, conceptual pathways are drawn for each design layer to explore the possibilities of change over time. After that, possible future developments must be identified and linked to the transition phases. The x-axis is defined and relevant adaptation measures are selected and sequenced. This step (5) is an iterative research-by-design processs and ends with the definition of the final pathways in the SAPP map.

Step 6 - Analyse the implications for design
In the sixth step, the final pathways are visualized. In this step the pathways are made spatial to show the spatial integration of the adaptation measures on the site. This step is needed to analyse the implications of the created SAPP for design practice.

Step 7 - Analyse the implications for governance
In the seventh step, an analysis is made of the governance for the pathways. This analysis is needed to address the governance implications of the created pathways. It can address crucial decision points and potential conflicts with the current governance system.

Step 8, 9 and 10
The last three steps are: the development of a climate adaptation planning strategy (8), the implementation of this strategy (9), and monitoring and adjustment of the strategy and pathways (10). These steps can only be followed in practice, and are therefore not performed during this research.

Figure 2.9 shows the steps of the Spatial Adaptive Policy Pathways approach for climate adaptation planning

2. Research Concepts

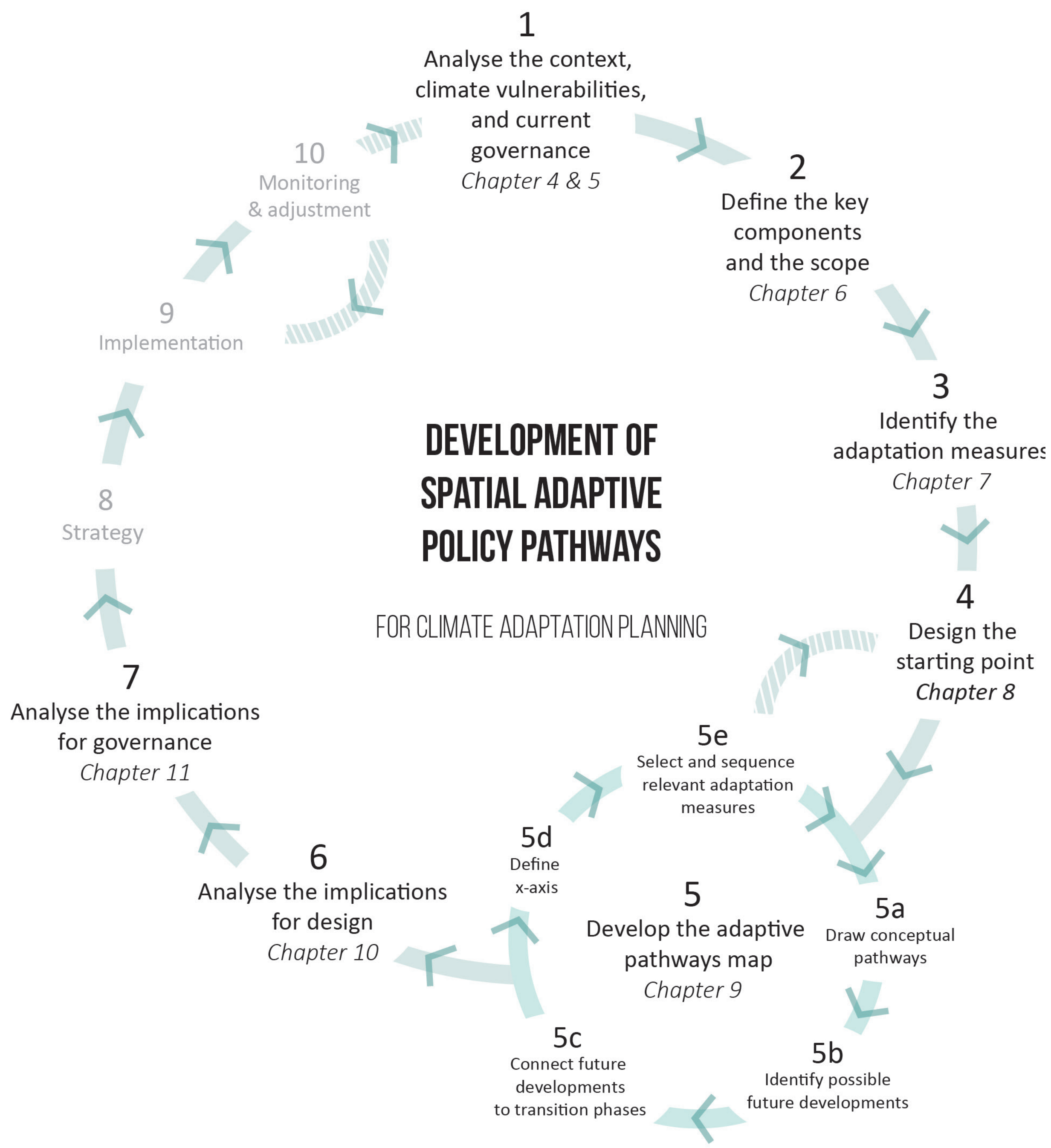


Figure 2.9. Steps of the Spatial Adaptive Policy Pathways approach for climate adaptation planning.
Inspired by: "Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world", by M. Haasnoot, J. Kwakkel, W. Walker, & J. Ter Maat, 2013, *Global Environmental Change*, p.489. Copyright 2012 by Elsevier Ltd.

3

RESEARCH SET-UP

In this chapter the research set-up is presented. The chapter opens with an elaboration of the project backbone. This section 3.1 makes the link between the problem statement, the research aim, the intended outputs, and the research questions. Afterwards, the research approach, including the research framework, is presented. Followed by a description of the used methods.

Driessen, M. (2016)

3. Research Set-up

3.1 PROJECT BACKBONE

3.1.1 Problem Statement - Summary

In Chapter 1 it is explained that there is an increased liveability risk in urban areas due to two trends: Climate change and building at higher densities. To reduce this risk, climate adaptation is essential. However, traditional spatial planning is not in line with the climate adaptation task. Hence, there is a need for a different way of working. Climate adaptation asks for more pro-active and flexible planning, to take into account a longer timescale, and to work with uncertainties. In addition, urbanism and water management should be integrated to fulfill the climate adaptation task. Since the liveability of urban areas for next generations will depend on the success of climate adaptation planning, it is critical to find new approaches. *See Section 1.4 for the full problem statement.*

3.1.2 Research Aim

The objective of this research is to contribute to the search for new approaches that support climate adaptation planning. This research aims to investigate the usability of the Spatial Adaptive Policy Pathways (SAPP) approach, as explained in Section 2.3, for climate adaptation planning in new urban areas in the Netherlands. This research studies the SAPP approach in more detail, to define the possibilities and points for improvement. The research contributes to the ongoing learning process and exploration of planning approaches: that address climate change uncertainties, and the implementation of climate change adaptation in urban developments. The ultimate goal of this exploration is to find suitable working approaches that support decision-making, planning, and design related to climate change adaptation. These new approaches are neccesary beacause the traditional spatial planning does not match with the climate adaptation task. This mismatch must be solved to ensure the development of sustainable living environments with high livability standards for next generations.

This research aims to investigate the usability of the SAPP approach for climate adaptation planning

3.1.3 Intended Research Outputs

The intended final research outputs are two intertwined products, namely the outputs of the SAPP approach for the Haven-Stad case study and an evaluation of the SAPP approach itself. The outputs for Haven-Stad contain pathway maps and elaborations of these maps with a focus on design and governance. The pathway maps show how Haven-Stad could adapt to climate change over time. The evaluation examines the usability of the approach for climate adaptation planning in urban areas and the lessons learned during the research process. Figure 3.1 shows the intended final outputs of this research.

3.1.4 Scope

The scope of the project is defined by multiple aspects (see Figure 3.2). First of all, by the domain: climate adaptation planning is the main focus. Secondly, by the case study. This project focuses on the single case study of the development of Haven-Stad in Amsterdam, the Netherlands. This implies a fixed location and focus on new urban developments, instead of existing neighbourhoods. In addition, the research focuses only on climate adaptation, not on climate change mitigation. And within climate adaptation, the focus is on adaptation to heat, drought, pluvial flooding, and fluvial flooding. The spatial scale of the research is from block/building to neighbourhood/street to district, with an eye for regional developments. The time scale is continuous to connect the short term with the long term.

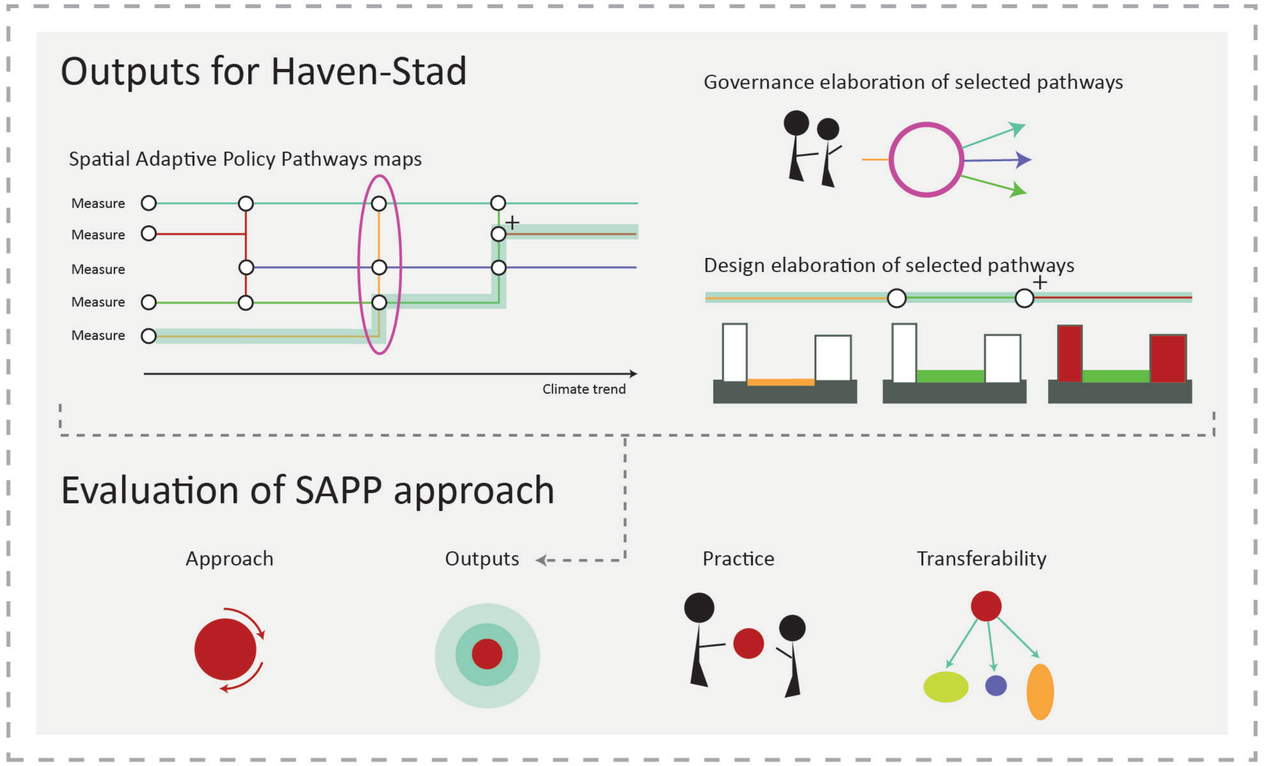


Figure 3.1. Intended Research Outputs.

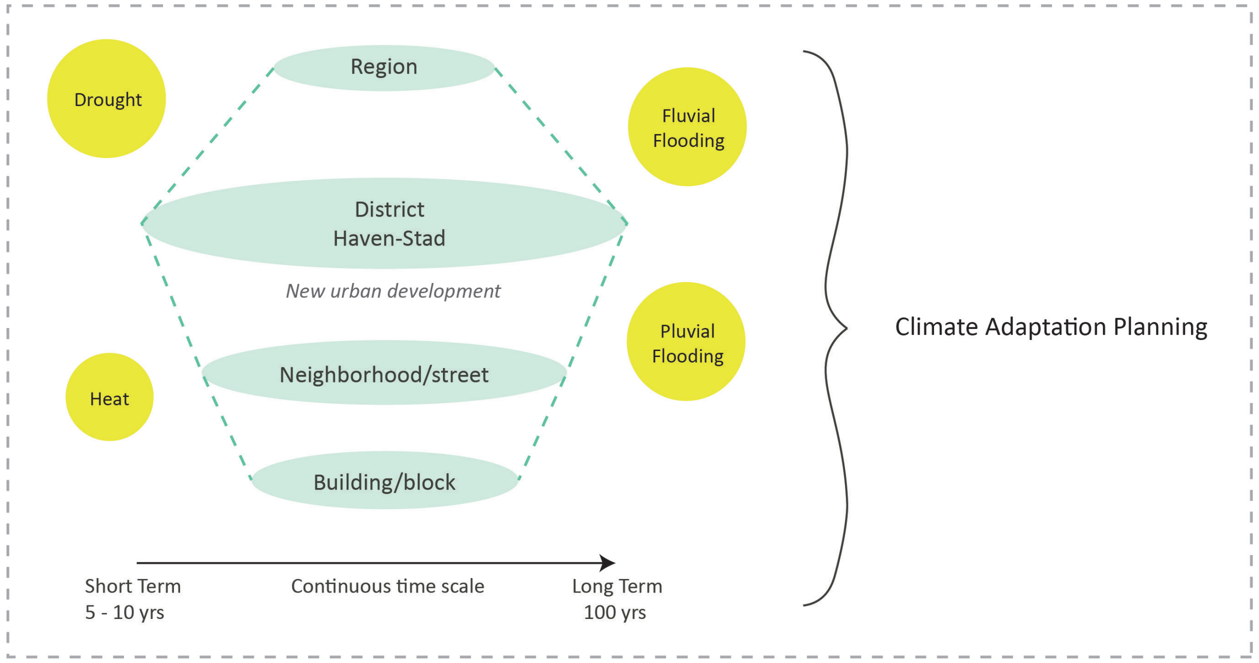


Figure 3.2. Research Scope.

3.1.5 Main Research Question

The main research question of this research is given below:

How can the Spatial Adaptive Policy Pathways approach
support climate adaptation planning
for new urban areas in the Netherlands?

The research question contains the following keywords:

Spatial Adaptive Policy Pathways (SAPP) approach
This research explores the applicability of the SAPP approach for climate adaptation planning in urban areas. *See Section 2.3 for more information about the Spatial Adaptive Policy Pathways approach.*

Climate adaptation planning
Climate adaptation planning is the process in which designers, engineers, and policy makers work together to plan (and implement) measures to adapt to climate change. The goal is to create and maintain climate-adaptive areas. A climate-adaptive area can cope with and adapt itself to climate change effects, now and in the future. This research is focused on four climate change themes: heat, drought, pluvial flooding, and fluvial flooding. *See Section 1.2 and 2.1 for more information about climate adaptation planning.*

New urban areas in the Netherlands
The approach has been tested in the context of new urban developments in the Netherlands. The case-study area is Haven-Stad in West-Amsterdam. Haven-Stad is a redevelopment of an industrial area into a mixed living-working area. It was selected because it is an example of a high-density urban development in the Dutch Delta, which is and will be affected by climate change. *See Section 1.5 and 4.1 for more information about the case study area Haven-Stad.*

Section 2.3
For more information about the
Spatial Adaptive Policy Pathways approach

3. Research Set-up

3.1.6 Sub-Research Questions

Sub-question 1 - Analysis:
Which analyses are needed to get a comprehensive view of the climate adaptation task?

The first question requires to select the most important analyses to obtain a comprehensive view of the climate adaptation task. The climate adaptation task is the task of urban designers, engineers, and policy makers to adapt to climate change. It has both a technical component (what are the climate effects?) and a governance component (how is climate adaptation arranged?).

Sub-question 2 - Identification:
What are the key components needed for the development of Spatial Adaptive Policy Pathways?

The second question is to find the most important components needed to develop Spatial Adaptive Policy Pathways. The key components have to be defined to use them as input for the development. The key components are linked together in a SAPP framework.

Sub-question 3 - Development:
How can Spatial Adaptive Policy Pathways be developed for climate adaptation planning?

The third question concerns finding a way to develop Spatial Adaptive Policy Pathways. Spatial Adaptive Policy Pathways show how an area could adapt over time to a changing climate and can be visualized in a pathways map. The steps required to create the pathways were not clear and had to be explored.

Sub-question 4 - Application
How can Spatial Adaptive Policy Pathways be used to support design and governance for climate adaptation planning?

The fourth question concerns describing and demonstrating the potential of Spatial Adaptive Policy Pathways to support climate adaptation planning. Two applications of the approach for climate adaptation planning are given, both for design and governance.

Sub-question 5 - Evaluation:
What can be learned from the process and outputs?

The last question asks to evaluate the SAPP approach by evaluating the research process and the research outputs. In the research process the SAPP approach is explored and tested for Haven-Stad. The outputs are the Spatial Adaptive Policy Pathways and the associated design- and governance implications for Haven-Stad.

3.2 RESEARCH APPROACH

3.2.1 Type of Research

The research approach can be summarized as an exploratory, iterative, applied single-case-study approach, integrating the disciplines of Urbanism and Water Management (See Figure 3.3).

Testing an Approach: Iterative & Exploratory
Testing the approach is the overall aim of this research. The tested approach (SAPP) is a combination of two existing approaches and has not been studied before. The research is therefore exploratory, as an important part consists of investigating how the approach itself might work. The research is also iterative, which is in line with both its exploratory nature and the tested approach itself.

Applied: Case study
This research is an applied research, as it aims to contribute to a practical, real-life challenge (climate adaptation planning). A single case study (Haven-Stad, Amsterdam) is used to test the approach for a real-life situation. Due to time limitations and the need to go in-depth, a single case study is conducted. Two focus areas within Haven-Stad are selected for the development of SAPP maps.

The research approach can be summarized as an exploratory, iterative, applied single-case-study approach

Integration of Disciplines & Mixed Methods
This graduation project is a combined project for the track Urbanism (Architecture, Urbanism and Building Sciences) and the track Water Management (Civil Engineering). The project therefore integrates two disciplines. By integrating of the disciplines and the nature of the problem, the research combines qualitative and quantitative data, methods, and outputs. Qualitative data, methods, and outputs are for instance spatial configurations, research by design, and a design. Quantitative data, methods, and outputs are for instance climate data, calculations, and water storage requirements.

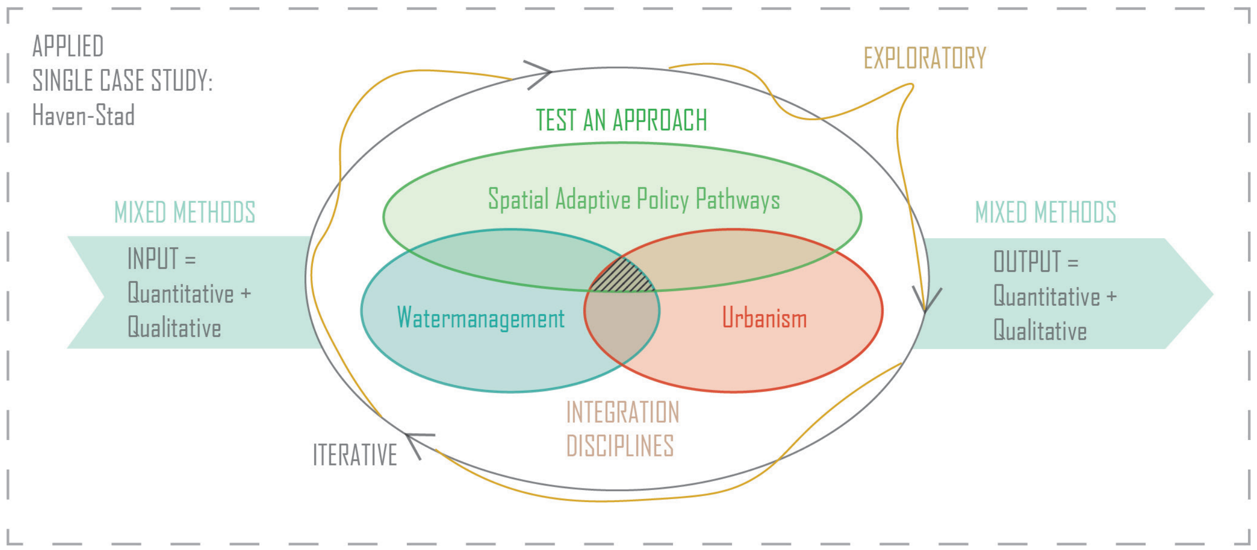


Figure 3.3. Type of Research Approach.

3.2.2 Research Framework

The research framework is presented in Figure 3.4. First, an exploration is done to find the research focus. The problem is defined through the problem field and problem statement. Based on the problem definition, important concepts and theories are explored and incorporated into the conceptual framework. The combined SAPP approach was selected to test in this research.

The SAPP approach is tested in four iterative stages, which are related to the sub-research questions: Analysis, Identification, Development, and Application. After the test, an evaluation is made, which leads to an answer to the main research question in the conclusion. Ultimately, the research itself is reflected.

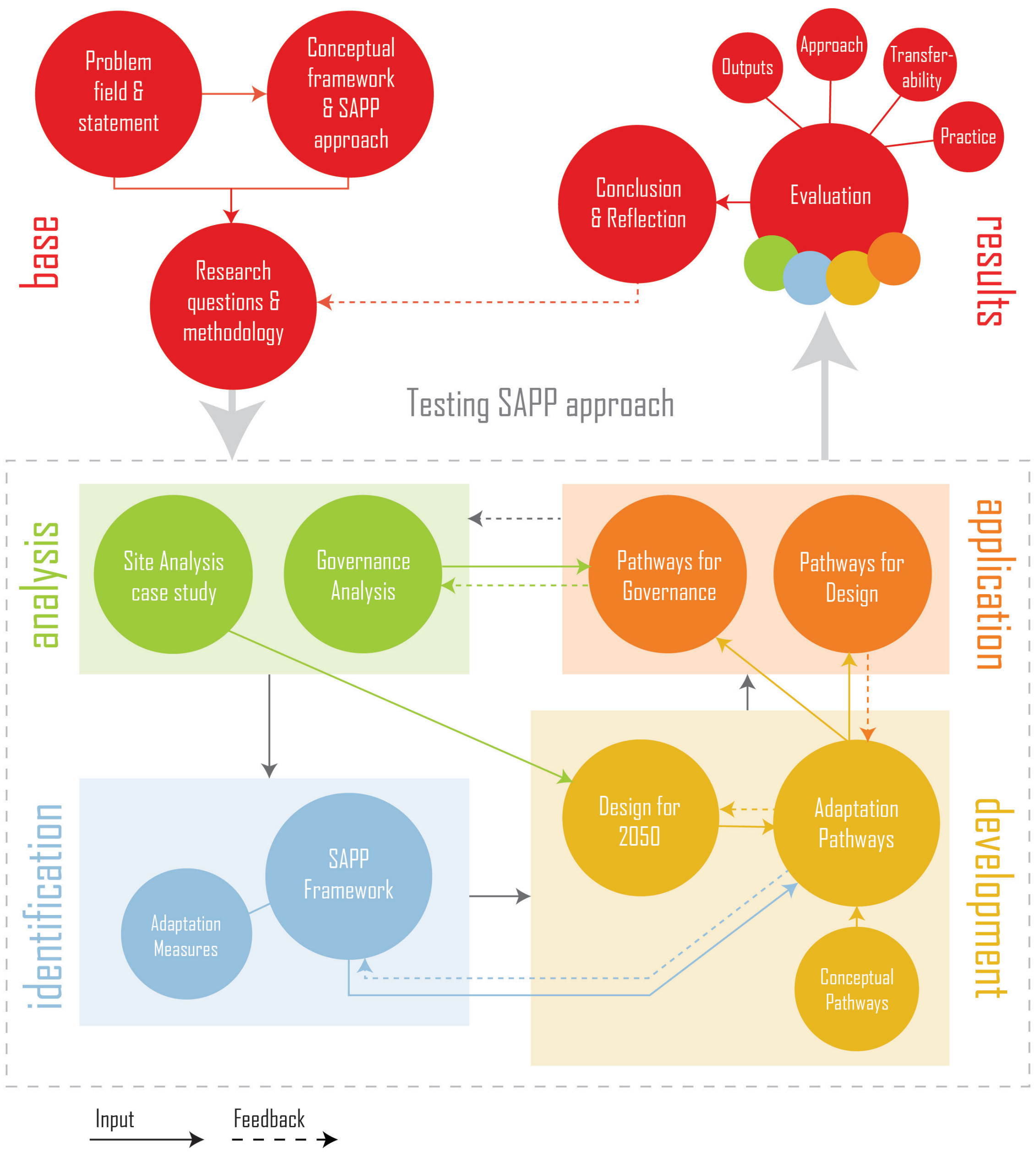


Figure 3.4. Research Framework.

3.3 METHODS

The following seven methods are used in this research to answer the research questions:

- Literature review & Document analysis
- Observation & Participation
- Interviews
- Mapping
- Research by Design

Figure 3.5 presents the analytical framework. This framework shows which research methods were used to make the first exploration (Chapter 1 & 2) and to answer the sub-questions. The following pages describe each method and explain its purpose, data collection, and procedure.

Figure 3.5. Analytical Framework.

Literature Review & Document Analysis

Description of Method
Searching, scanning, selecting, reading, and processing relevant literature and documents.

Relevant literature is found by using the below mentioned keywords and search engines. Relevant documents are found on (governmental) websites and provided by Waternet. Because the field of climate adaptation is in a high dynamic state, new insights and reports came available during the research. Literature and documents are first scanned, to determine the relevance for the project. Selected relevant literature and documents are read and important information is highlighted. In addition, the reference lists of the literature and documents are scanned to find new relevant sources. The collected information is summarized and synthesised, and processed (cited/paraphrased) to add to the project.

Data Collection

Literature:	
Data types	Books and peer-reviewed journals
Data sources	Search engines (TU Delft Library, Google Scholar, Research Gate)
Keywords	- (Urban) climate (change) adaptation; - (climate) adaptation planning; - planning with uncertainty; - adaptive planning; - adaptive approach; - adaptive pathways; - climate adaptation governance; - sustainable urban development
Documents:	
Data types	Government reports and research reports, newspaper articles
Data sources	- Websites of government- and research institutes (Kennisportaal Klimaatadaptatie, Gemeente Amsterdam, Waternet, Provincie Noord-Holland, MRA, KNMI, Deltares); - Waternet (through supervisor)

Observation & Participation

Description of Method
Observing and participating in meetings of Waternet (internship), TU Delft, and online conferences/webinars. The meetings of Waternet consisted of team meetings (gebiedsteams) and meetings related to the work of my supervisor (Advisor Climate Adaptation and Spatial Development), which included the case Haven-Stad. The meetings of the TU Delft consisted of meetings with the Delta Futures Lab (Urban Climate Adaptation group) and an urbanism studio workshop. The online conferences/webinars all related to climate adaptation.

In consultation with my Waternet supervisor, relevant work meetings were selected to participate. Through Waternet and LinkedIn relevant webinars were found. Being a member of the Delta Futures Lab and Urban Metabolism & Climate studio gave the opportunity to follow the lectures and workshops. A logbook is kept, in which notes are made for each work meeting, webinar and workshop. This logbook describes the name of the meeting, the date and the important notions. Afterwards, information relevant for the graduation project is selected, processed, and used for the project.

Data Collection
Data types:
Conversations and discussions, presentations, workshops (knowledge, opinions, ideas) about a.o. (urban) climate adaptation, Haven-Stad, sustainable urban development, climate change.

Data sources:
- Internship meetings:
Waternet, Municipality of Amsterdam, SKG (Stichting Kennis Gebiedsontwikkeling)
- Webinars:
On the road to CAS, KNMI Climate Scenarios, National Delta Congres, Resilience by Design, Integrale aanpak openbare ruimte, etc.
- Lectures/workshops:
Delta Futures Lab, workshops urbanism studio (TU Delft)

Appendix 3.3
For the list of attended webinars, lectures, and meetings

3. Research Set-up

Interviews

Description of Method
Semi-structured interviews with experts in the field of climate adaptation. The discussed themes and some questions are predefined. However, the conducted questions and final focus can differ per interview, because there is room left for other (relevant) questions and conversations, often led by the expertise and interests of the interviewee.

An interview format was created in which important actions (asking consent), and relevant themes, and questions are summarized. Most interviewees are found through the internship at Waternet, others through governmental websites or recommendations from other interviewees. All interviews took place online and lasted an hour on average. One interviewee answered some additional questions by mail after the interview. Prior to the interview, information is collected about the interviewee and his/her expertise. At the start of the meeting, consent is asked for audio/video recording and referencing. During the interview, notes are made. Afterwards, the interviews are processed and summarized, based on the notes and/or recording. The summaries are sent to the interviewees for review. Important information is highlighted and processed for use in the graduation report (indicated with 'IV'). In addition to the interviews, there were six meetings with TU Delft lecturers/pHds to learn more about adaptive pathways or to ask specific questions.

Data Collection
Data types: Interviews - Knowledge, opinions, ideas about the themes below.

Themes:
- Governance of climate adaptation
- Challenges in climate adaptation planning
- Adaptive pathways
- Long-term planning and adaptive planning
- Climate adaptive design
- Haven-Stad/MRA region water system

Interviewees:
- Employees Waternet (advisors climate adaptation / Haven-Stad)
- Employees Municipality of Amsterdam (advisors sustainability / urbanists / Haven-Stad)
- Employees Province of North Holland (advisor climate adaptation)
- Other experts (Researcher WUR, &Flux, MRA)

Appendix 3.3
For the interview format and list of interviewees

Mapping

Description of Method
Visualizing data, (designed) relations, (designed) situations, and adaptive pathways in maps and sections.

All maps and sections are made in Adobe Illustrator. Three main types of mapping can be distinguished in this graduation research. The first type is related to the site analysis. Spatial, technical and climate vulnerability data is collected and visualized in maps. The conclusions of the analysis are presented in sections. The second type of mapping is in line with the development of the 2050 design and the SAPP map. The 2050 design principles and the SAPP map present the results of the research-by-design process. The third type of mapping connects to the application. Maps and sections are used to visualize a selection of trajectories from the SAPP map.

Data Collection
Data types:
- Existing maps or spatial data (spatial context, technical situation, climate vulnerabilities)
- Hydrological data (climate projections, water levels, etc.)

Data sources:
- Documents
Government reports and research reports, such as the MER for Haven-Stad
- Websites
AHN Viewer, DINOloket, maps Amsterdam, Klimaateffectenatlas, Atlas van de Regio, KNMI)
- Waternet Geoloket

Research by Design

Description of Method
In Research by Design, design is used as a research method by developing a project and exploring design materials, such as sketches and mapping (Roggema, 2017). Design is thus used as a creative process to test ideas, materials and technologies (Roggema, 2017). It is used to explore options and possible futures, and to generate new relevant questions for research.

In this research, research by design is used for the development of the SAPP approach itself and for the application on the Haven-Stad case study. The SAPP approach is adjusted over time based on insights from the test on the case study. Multiple iterations are done to define the final SAPP approach, as presented in Section 2.3. Also the framework and lay-out of the SAPP map are made during a research-by-design process. For the Haven-Stad case study, spatial design explorations and temporal design explorations (conceptual pathways) are made. These are brought together in the development of the SAPP for Haven-Stad.

Data Collection
Data types:
- Examples of adaptive pathway (approaches)
- Design of SAPP framework (input for development)
- Reflection on SAPP framework (input for update identification)
- Design of SAPP map (input for application)
- Reflection on SAPP design (input for update development)

Data sources:
- Examples
Research documents (Peer-reviewed journals, Resilience by Design)
- Designs/Reflections
Own intermediate research outputs

ANALYSIS

Which analyses are needed
to get a comprehensive view
of the climate adaptation task?

HAVEN-STAD & CLIMATE CHANGE

CLIMATE ADAPTATION GOVERNANCE

4

HAVEN-STAD & CLIMATE CHANGE

This chapter presents the analysis of the current situation and the future plans of the case study area Haven-Stad in relation to climate change. The site analysis shows how the area is affected by heat, pluvial flooding, drought, and fluvial flooding. The climate change projections and future plans are used to study possible changes in the future of Haven-Stad.

SAPP Approach - Step 1

By author (2021)

4. Haven-Stad & Climate Change

4.1 CURRENT SITUATION & PLANS

4.1.1 Context

A large part of the Netherlands is the Rhine delta, as can be seen in Figure 4.1. This delta made the place interesting to settle, but a delta area is also a vulnerable area. The Rhine rises in the Swiss Alps and flows through the Netherlands to the North Sea. Amsterdam is also located in this Rhine Delta. The water flows through the Amsterdam-Rijnkanaal, meets Amsterdam on the IJ-river, and flows further through the North Sea Canal to the North Sea.

Figure 4.2 shows the red (urban), green (nature) and blue (water) context of Haven-Stad. Haven-Stad is located in west-Amsterdam and close to the city center. Westerpark is located in the south of Haven-Stad, which is part of the green connection between the city center and the rural area in the west. Haven-Stad is divided into a northern and southern part by the IJ-River. The IJ-River is connected to both the Amsterdam-Rhine canal and the IJmeer (IJ Lake). Just west of Haven-Stad, the IJ-River flows into the North Sea Canal. This canal ends at the IJmuiden flood defence, where the water is discharged to the North Sea. Haven-Stad is partly located in the 'boezem system' and partly in polder areas.

4.1.2 Current Situation

Haven-Stad is currently an industrial area, with high percentages of paved surface and large industrial buildings. The north and south side of the area are seperated by the IJ-River, which is still an important shipping route between the North Sea and the Amsterdam-Rhine-canal. The Port of Amsterdam's harbor basins penetrate the Haven-Stad area. The only green spots can be found in the far north and south of Haven-Stad. In the north is the Noorder-IJ Lake with a park around it, and sportfields on the east. To the south is the Westerpark and a large park with allotment gardens. The boundary of the area in the west is the highway A10 (see Figure 4.3).

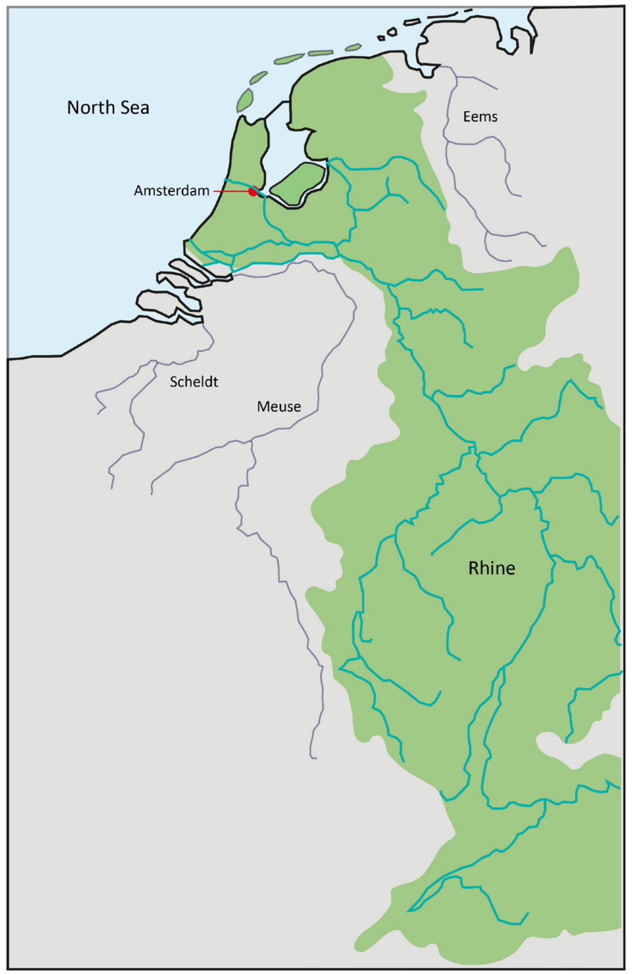


Figure 4.1. Amsterdam in the Rhine Delta. Adapted from *"Hoogwater op de Rijn en de Maas"* (p.2), by L. Bolwidt, M. Schoor, L. Van Hal, M. Roukema, 2006, Rijkswaterstaat. Copyright 2006 by Ministerie van Verkeer en Waterstaat, Rijkswaterstaat.

> *Currently Haven-Stad is an industrial area in the west of Amsterdam, along the IJ River*

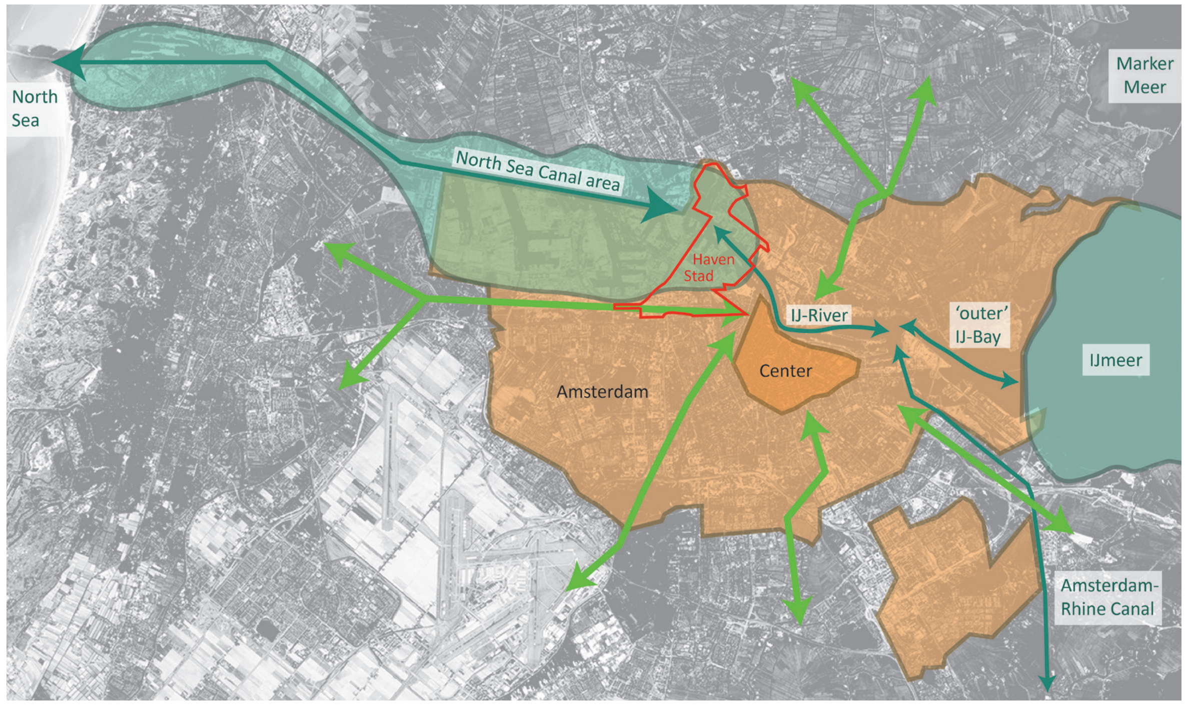


Figure 4.2. Green, blue and red context. Adapted from *"Milieueffectrapportage Haven-Stad"* (p.15), by Antea Group, 2017. Copyright 2017 by Gemeente Amsterdam.

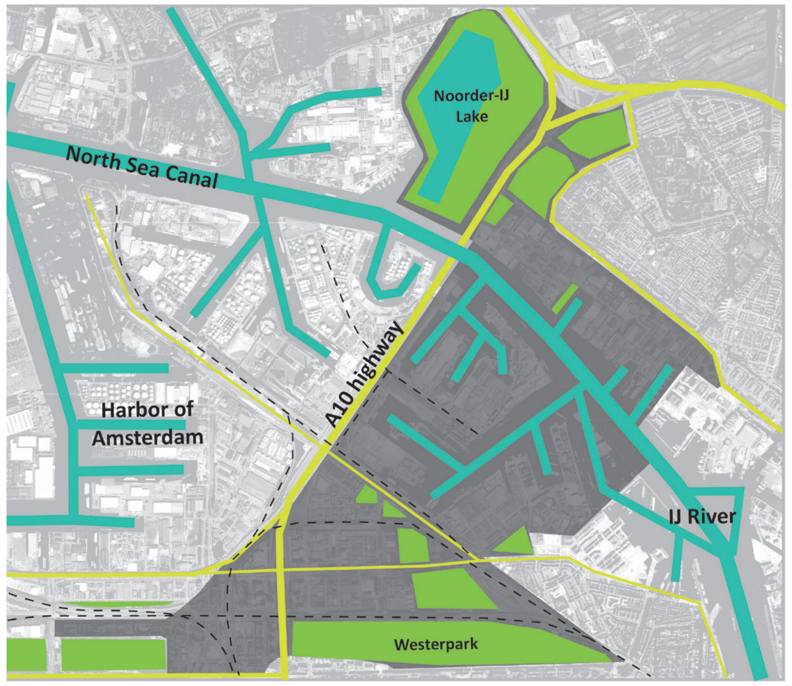


Figure 4.3. Current situation Haven-Stad. Background from "Google Maps", by Google, n.d. (https://www.google.com/maps/place/Amsterdam/). Copyright by Google Maps.

4.1.3 Plans

Vision

Figure 4.4 shows the vision map of Haven-Stad, as part of the spatial framework created by the municipality of Amsterdam. Haven-Stad should be green, accessible, sustainable and with most services within reach. In addition, the municipality has defined the following six mottos as a guideline for the development of the identity of the area (Gemeente Amsterdam, 2021a):

- *'A characteristic green and water-rich, cool, and urban (stedelijk) area';*
- *'An urban (hoogstedelijke) and inclusive environment';*
- *'A district with attractive, and versatile usable green and public space';*
- *'A district where priority is given to cyclists, pedestrians, and public transport';*
- *'A city of the future where sustainability is more than a technical challenge';*
- *'Working together and living together: for and by people.'* (Gemeente Amsterdam, 2021a)

Climate adaptation is recognized as an important aspect of sustainability and the municipality wants to make a climate-adaptive design for a robust Haven-Stad. The design should ensure that water is stored longer, that there is less warming, and that the area can withstand extremes in rainfall, drought, and heat (Gemeente Amsterdam, 2020b).

Neighbourhoods

The area consists of twelve neighbourhoods, all with different characteristics and functions (see Figure 4.5). The neighbourhoods will be built around Sloterdijk station, the Western Harbor area, and across the IJ Bay (Amsterdam North). The municipality of Amsterdam aims for *'differentiated living environments in high densities with a mix of facilities and workspaces'* (Gemeente Amsterdam, 2016).

Figure 4.4. Vision map for Haven-Stad. Reprinted from *"Haven-Stad Integraal Raamwerk. Transformatie van 12 deelgebieden"* (p.14-15), by Gemeente Amsterdam, 2021a, Amsterdam: Gemeente Amsterdam. Copyright 2021 by Gemeente Amsterdam

Density and Building Typology

Haven-Stad will become an urban area with a high density. The plan is to build 40.000-70.000 houses on 650 ha for 150.000 inhabitants and 45.000-58.000 workspaces (Gemeente Amsterdam, 2017). Appendix 4.1 gives extra information, including a figure showing the plans for the building typology and density in Haven-Stad.

Phasing

Haven-Stad will be re-developed in multiple phases, from now to 2055 (Gemeente Amsterdam, n.d.). Because the transformation will be a long-term process, the transformations will be continuously adapted to new insights, wishes and challenges (Gemeente Amsterdam, 2017).

The plan is to redevelop the area into a high-density mixed living-working area

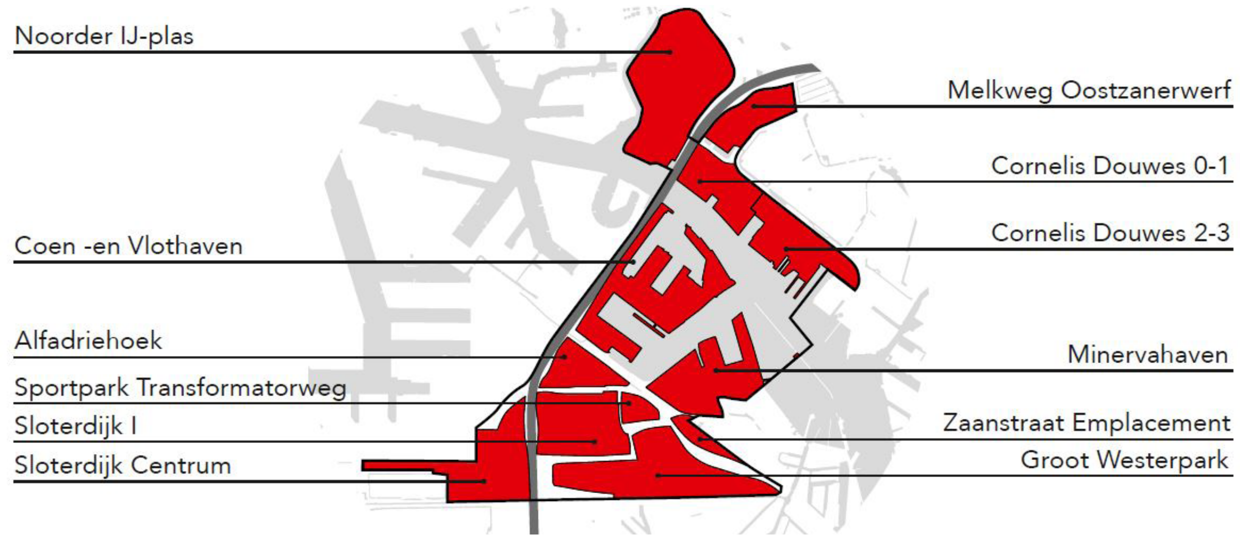


Figure 4.5. Neighbourhoods of Haven-Stad. Reprinted from *"Ontwikkelstrategie Haven-Stad. Transformatie van 12 deelgebieden"* (p.10), by Gemeente Amsterdam, 2017, Amsterdam: Gemeente Amsterdam. Copyright 2017 by Gemeente Amsterdam.

Appendix 4.1
For more information about the building typology and density

4.2 CLIMATE STRESSES

This section presents the summary of the analysis of the climate stresses in Haven-Stad. It shows the vulnerability of the current situation and reflects on the future of the new urban development. The full analysis can be found in Appendix 4.2.

The four climate stresses are:

Heat
Heat is caused by high temperatures. In urban areas the urban heat island (UHI) effect contributes to the heat. The UHI is the average difference in air temperature between urban areas and surrounding rural areas. These higher temperatures in the city are caused by high percentages of paved surface, high densities, and a shortage of open water and green (Gemeente Rotterdam, 2013).

Pluvial flooding
Pluvial flooding is caused by extreme rainfall events and is independent of an overflowing water body (Maddox, 2014). It occurs when the soil cannot infiltrate enough water and/or when the sewage systems are full. Alternatively, the rainwater is stored on the surface, causing pluvial flooding.

Drought
Droughts occur when less rain falls than normal in combination with high evaporation rates over a longer period of time (KNMI, n.d.). In the Netherlands, the indicator is the 'potential precipitation deficit': the difference between the precipitation and the Makkink reference crop evaporation (STOWA, n.d.).

Fluvial flooding
Fluvial flooding is flooding caused by high water levels in water bodies such as rivers. In the context of Haven-Stad, fluvial flooding can be caused by two types of disturbances. Flooding can originate from a dike breach due to high river discharges or due to a failure of the IJmuiden complex due to high water levels in the North Sea (or technical failures).

For each climate stress, four aspects are analysed:

Vulnerability
The vulnerability of Haven-Stad to the climate stresses is analysed using stresstest maps. These stresstests show what can happen in Haven-Stad during a certain event. Note that the stresstests are based on the current situation of Haven-Stad as an industrial area, and not on the new situation as high-density living and working area. Most stresstests can be found on governmental websites or research organisation websites, such as:

https://maps.amsterdam.nl/klimaatadaptatie/
https://agv.klimaatatlas.net/
https://mra.klimaatatlas.net/
https://www.klimaateffectatlas.nl/nl/
https://themasites.pbl.nl/atlas-regio/kaarten/index.php

Consequences
The consequences of climate stresses can be found with the NAS-adaptation tool (https://nas-adaptatietool.nl/). Climate change can have a wide range of negative effects on urban areas. It can affect people (health, safety), ecology (habitat conditions), and objects (vital functions, infrastructures).

Projections & Uncertainties
The climate forecasts of KNMI'14 (KNMI, 2015) are used to analyse the expected trends that influence climate stresses (i.e., temperature rise, increase in heavy rain intensity, increase in precipitation deficit, sea level rise). In addition, the uncertainties of these trends are analysed, by identifying the differences between the climate projections.

Future of Haven-Stad
The (possible) future of Haven-Stad under the influence of the climate stresses is discussed. Due to the changing climate and the new developments in Haven-Stad, changes can be expected.

4. Haven-Stad & Climate Change

Figure 4.6. The four climate stresses.
The sources of the photos can be found in the List of Figures

Appendix 4.2
For the complete analysis

4.2.1 Heat

Vulnerability
Figure 4.7 shows the average wind chill temperature (Physiological Equivalent Temperature (PET)) on 1 july 2015 between 12:00 and 18:00. The RIVM has selected this day, because it is a representative of a 1:1000 heatday for the summer period April till September. A PET between 29-35 °C indicates moderate heat stress, a PET between 35-41 °C represents high heat stess, and a PET above 41 °C indicates extreme heatstress (RIVM, 2019). Figure 4.7 shows that the wind chill temperature can rise to 46 °C Haven-Stad (extreme heat stress). The local parks are a lot cooler, with wind chill temperatures between 34-37 °C.

Consequences
Heat can have negative effects on people, nature, and technology. Public health and quality of life are affected by heat stress, for example it leads to a decrease in sleep, and an increase in air pollution (Gemeente Amsterdam, 2020a; Gemeente Rotterdam, 2013). Nature and biodiversity are affected by the changing growing seasons and surface water temperatures. In addition, heat can lead to power blackouts, ICT failures, melting asphalt, and failing bridges.

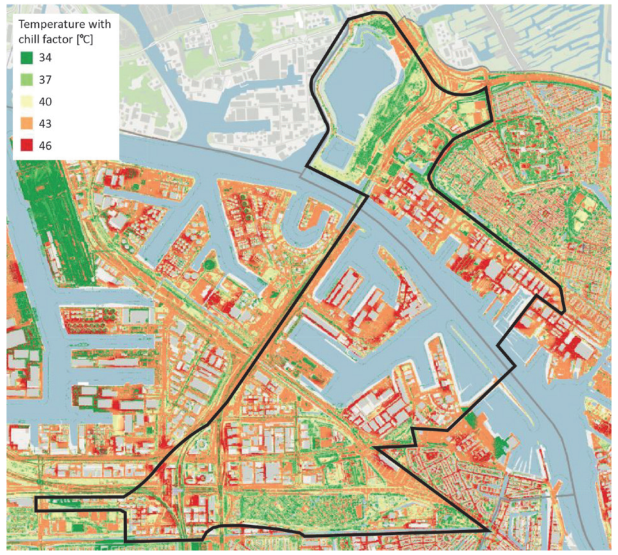


Figure 4.7. Average wind chill temperature (PET) on 1 july 2015, 12:00-18:00. Adapted from "Maps Amsterdam Klimaatadaptatie", by Gemeente Amsterdam, n.d. (https://maps.amsterdam.nl/klimaatadaptatie/). Copyright by Gemeente Amsterdam.

Projections & Uncertainties
In each KNMI'14 scenario the mean summer temperature and number of summer days (Figure 4.8) will increase. The increasing trend is clear, but 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.

Heat in future Haven-Stad
In the future, temperatures are expected to be higher and the number of summer days to increase. Due to the development of Haven-Stad, stone masses are added to the area. These masses absorb heat, causing the area to warm up more and to cool down slower. Without climate adaptation measures, temperatures in Haven-Stad could rise above the current 46 °C during heat days, causing extreme heat stress for the inhabitants, nature, and technologies.

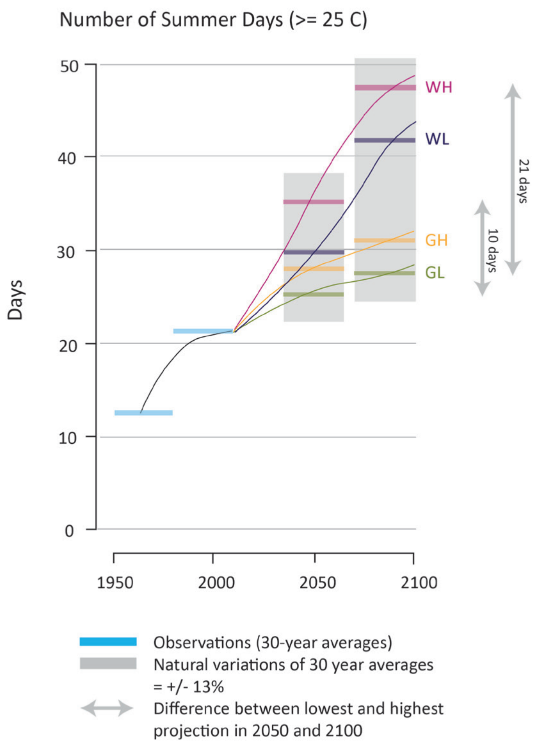


Figure 4.8. Projections of the number of summer days. Information from (KNMI, 2015).

4.2.2 Pluvial Flooding

Vulnerability
Figure 4.9 shows the model result of precipitation 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). Small local depths to 0.10 m can be found in all areas. The low-lying peat polders show the most pluvial flooding and the highest waterdepths, from 0.30 m. Around the Coenhaven and Sloterdijk station, high depths (from 0.30m) can be found on the main roads. Figure 4.11 in Appendix 4.2 shows that the clay areas will also flood (> 0.3 m) after an event of 120 mm/h.

Consequences
Pluvial flooding can negatively affect nature, assets, and people. The water can drown plants and trees and can reduce the quality of the surface water due to more sewage overflow events. This is bad for the health of ecosystems and of people. The condition of (frequently) flooded streets can detoriate faster and buildings can also be damaged. The streets can also become inaccessible (also for emergency services). The risk of power outages increases.

Figure 4.9. 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.

Projections & Uncertainties
Figure 4.10 shows the projections for the maximum hourly precipitation intensity per year in summer (KNMI, 2015). It is projected that the total precipitation in summer decreases, but that the intensity of rain fall increases (more severe summer storms). The projections are given as a range of percentages (e.g. 5-15%). This indicates that it is difficult to project the increases for these short events. If the natural variations are added, which are quite significant (-/+14%), then the projected intensities are very uncertain.

Pluvial flooding in future Haven-Stad
In the future, both the frequency and the intensities of rainfall are expected to increase (Gemeente Rotterdam, 2013). Pluvial flooding will therefore occure more often. The development of Haven-Stad offers opportunities to reduce pluvial flooding by reducing the paved surface and by adding infiltration and storage facilities. An expansion of the watersystem and soil elevations can also contribute to reduce pluvial flooding.

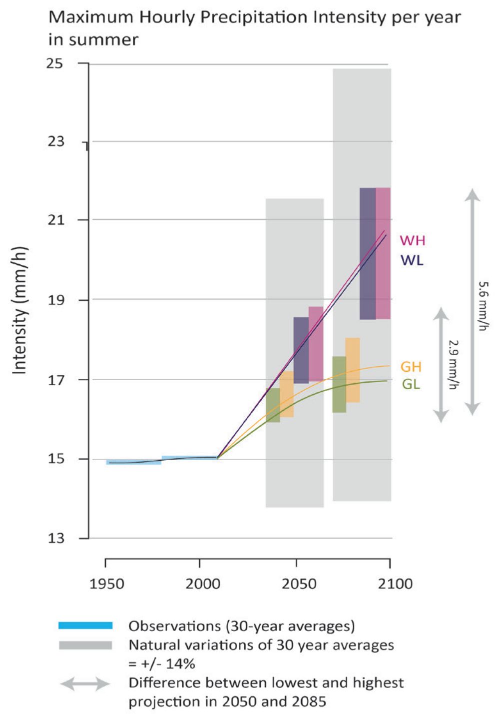


Figure 4.10. Projections of the maximum hourly precipitation intensity per year in summer. Information from (KNMI, 2015).

Appendix 4.2
For the complete analysis

4.2.3 Drought

Vulnerability
Figure 4.11 shows the precipitation deficit in the Netherlands during the heavy drought of 2020. Compared to the rest of the Netherlands, the precipitation deficit in and around Haven-Stad is low (60-90 mm). However, droughts and sea level rise can increase the salinization of the groundwater and surface water.

Consequences
Droughts lead to lower groundwater levels and groundwater shortages, and to lower river levels (Gemeente Rotterdam, 2013). Lower groundwater levels can lead to: water shortages for the vegetation, pile rot of wooden foundations, and an increase of subsidence of peatlands. Lower levels in the IJ river are detrimental to the ecology and shipping. The water quality can decrease if the contiminants are less diluted. Increasing the salinity reduce the freshwater availability, increases the chance of concrete rot in foundations, and can increase corosion.

Projections & Uncertainties
In all KNMI'14 scenarios, droughts are projected to increase untill 2050. However, drought is difficult to predict and this is reflected in the uncertainty margins of the projections, as can be seen in Figure 4.12. After 2050, precipitation deficits can decrease (GL-scenario), but they may also steeply increase. Due to the high uncertainties, the differences between the lowest and highest scenario are quite large. The differences for the mean precipitation deficit are 42 mm in 2050 and 71 mm in 2085.

Drought in future Haven-Stad
Three of the four scenarios show a steep increase in precipitation deficit in the future. 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 closing areas of the sewer system, more water can infiltrate and supplement the groundwater over time.

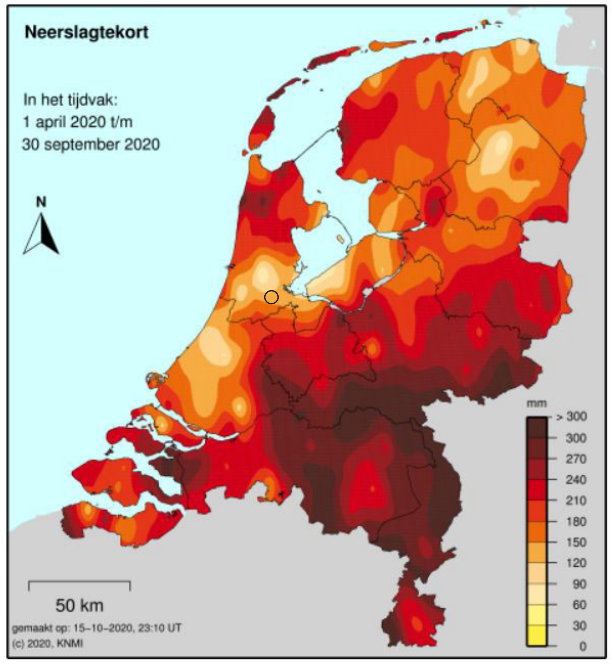


Figure 4.11. Precipitation Deficit in the Netherlands in 2020 (positive = less precipitation than evaporation). Reprinted from "Neerslagtekort/Droogte", by KNMI, n.d. (https://www.knmi.nl/nederland-nu/klimatologie/geografische-overzichten/neerslagtekort_droogte). Copyright by KNMI.

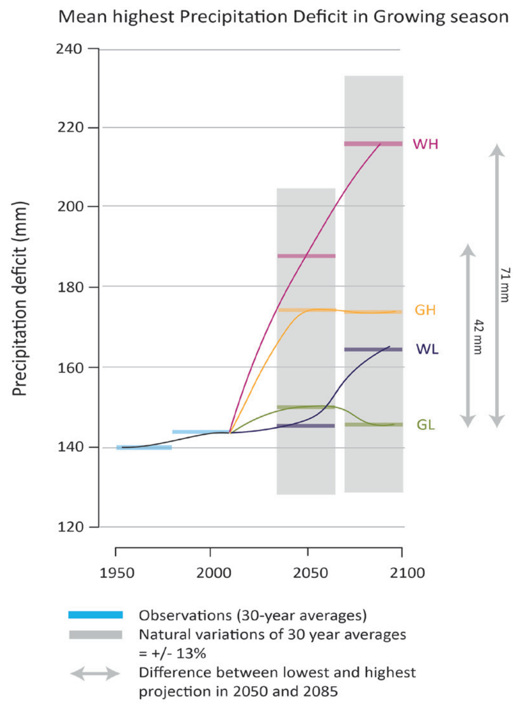


Figure 4.12. Projections of the mean highest precipitation deficit in growing season. Information from (KNMI, 2015).

4.2.4 Fluvial Flooding

Vulnerability
Figure 4.13 shows the maximum flood depths in Haven-Stad for extremely small probabilities (1/100.000-year event). The map combines different flooding scenarios, which are unlikely to occur simultaneously (Defacto Stedenbouw & RHDHV, 2021). Examples of such scenarios are the failures of the Lekdijk and the IJmuiden complex. A flood with a probability of 1/100.000 years causes flood depths of more than 1 m at multiple locations. The areas with the greatest risks (highest chances and depths) are: the north and south of Haven-Stad (polders), secondly the harbor areas along the North Sea canal. The Haven-Stad area is elevated in relation to the surrounding areas and could therefore be used as a shelter for surrounding low-lying neighbourhoods.

Consequences
In addition to the increase of salinization and the need for more pumping, higher sea levels can cause higher flooding probabilities. Fluvial flooding can cause social disruption (Gemeente Amsterdam, 2020a; Gemeente Rotterdam, 2013) through the failure of vital and vulnerable infrastructures, through damage to buildings and infrastructures (economic losses, inaccessibility), and through victims. Recovery times after floods can be long.

Projections & Uncertainties
Figure 4.14 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). However, new forecasts for the accelerated sea level rise scenario (orange in figure) provide a new perspective on the future. Instead of a maximum of 80 cm in 2085 (KNMI'14), a maximum of 150 cm is projected, which is almost double.

Fluvial flooding in future Haven-Stad
In all forecasts, the sea level will continue to rise. Higher sea levels may increase the chances of fluvial flooding and flood depths. Haven-Stad will change into a residential area with a high density of people and economic value. The flood risk will therefore increase, as both the flood probability and the consequences (flood depth and exposure) increase. Vertical evacuation can easily be implemented, as most buildings will have multiple floors on top of the plinths. The area may also be used as shelter area for surrounding low-lying neighbourhoods.

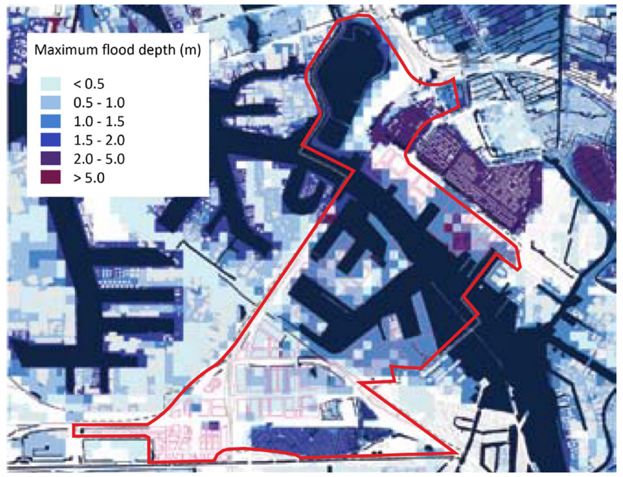


Figure 4.13. Maximum flood depth with a probability of 1/100.000 year. Adapted from *"Kansen voor Meerlaagsveiligheid in Amsterdam. Thematische studie waterveiligheid" (p.92)*, by Defacto Stedenbouw & RHDHV, 2021. Copyright 2021 by Defacto Stedenbouw.

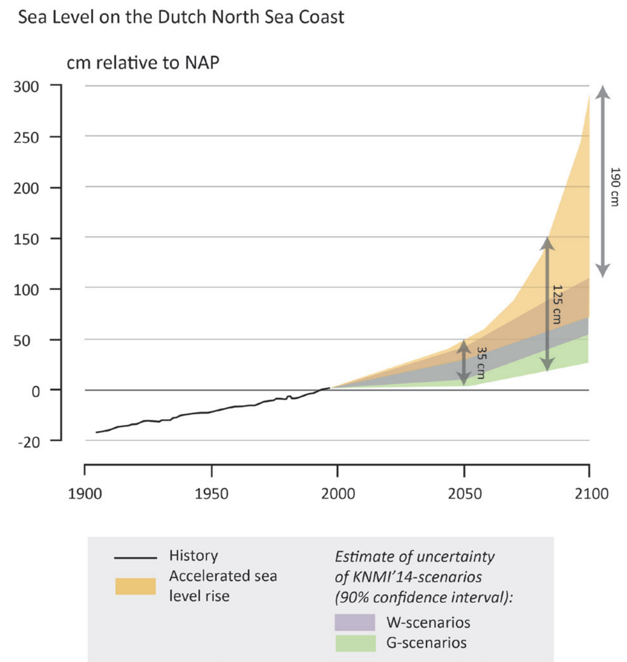


Figure 4.14. Projections of sea level rise at the Dutch North Sea coast. Information from (KNMI, 2015) & (Defacto Stedenbouw & RHDHV, 2021).

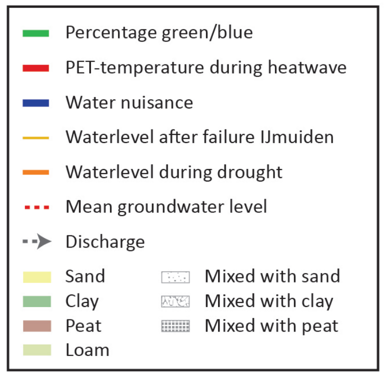
4. Haven-Stad & Climate Change

4.3 SYNTHESIS

4.3.1 Current Situation

Figure 4.15 provides an overview of the current situation of Haven-Stad. Most neighbourhoods have a high percentage of paved surface (low percentage green/blue), which causes water nuisance after heavy rainfall and high temperatures during heat waves. In the harbors, the topsoil is mostly sand, which makes infiltration easy. But in the other areas, infiltration will be more difficult due to clay and peat layers. The high PET temperatures during heat waves cause strong (35-41 °C) and extreme (>41 °C) heat stress. The Westerpark, the North Sea Canal and the sport fields at Melkweg Oostzanerwerf are the cooler (and greener) places in the area. Because a large part of Haven-Stad is part of the boezem system, the North Sea Canal influences the area. In the worst case, a large part of Haven-Stad could be flooded if the IJmuiden complex or a dike fails. During drought, salt intrusion can be a problem. At low groundwater levels, brackish water from the North Sea Canal can penetrate the dry soils.

Currently Haven-Stad is already facing climate change effects



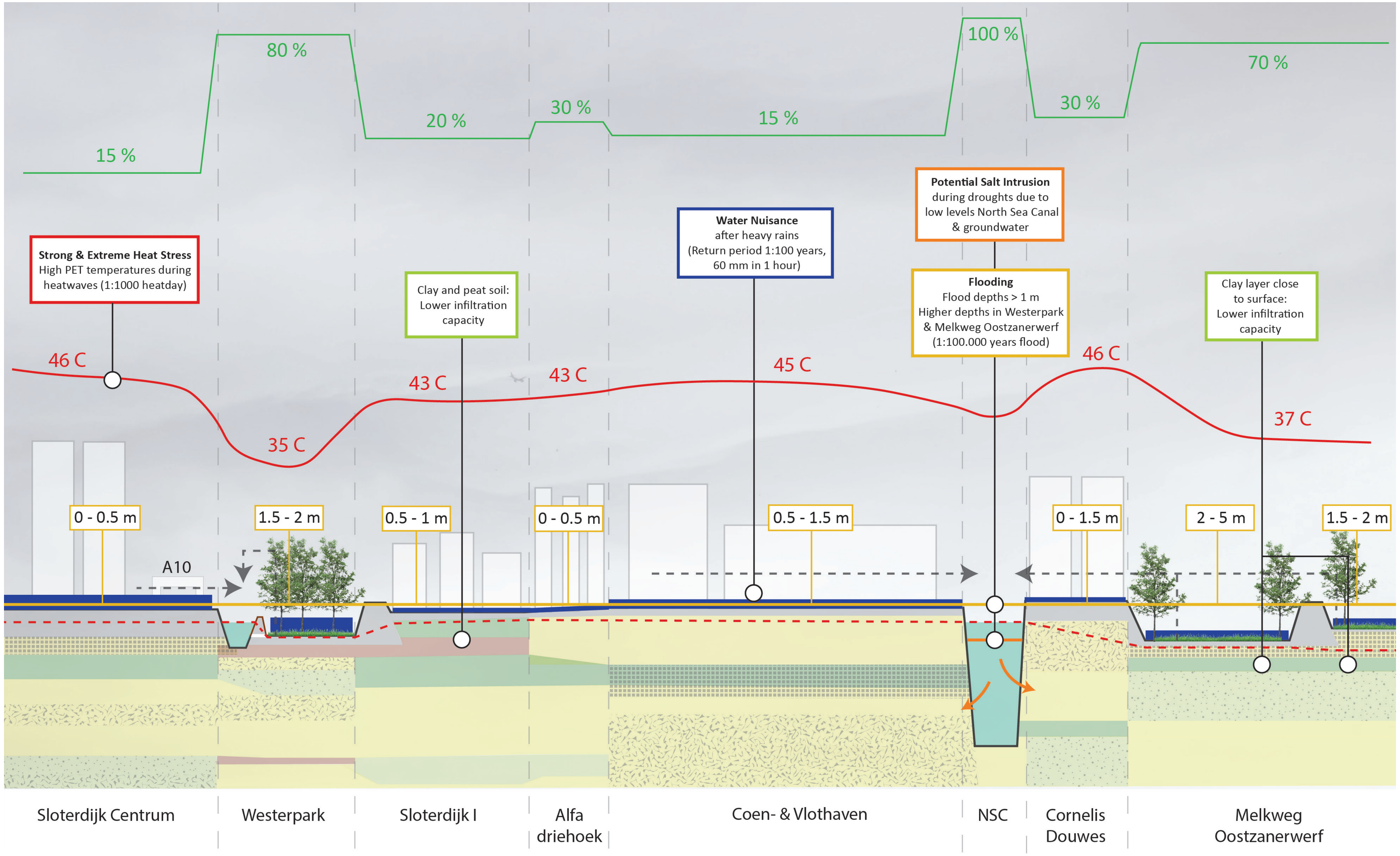


Figure 4.15. The possible future situation, cross-section of Haven-Stad area

4.3.2 Possible Future Situation

Figure 4.16 shows the possible situation of Haven-Stad in 2050, with the new developments and the projected climate changes. Due to the new development, the density of the area will increase and the liveability risk grows as the exposure grows (more people on the same area). The percentage of green/blue will increase slightly in most districts, but it is expected to decrease in Melkweg Oostzanerwerf. Due to climate change, temperatures are expected to rise, making temperatures even more extreme during heat waves. In addition, the sea level will rise, making it more difficult to discharge water to the sea at IJmuiden. A failure of the IJmuiden complex would also cause higher flood depths. Due to more frequent and heavier rainstorms, water nuisance can still be a problem in Haven-Stad. Droughts are difficult to predict, but are likely to increase. This can cause salt intrusion and dying of plants and trees. The climate change effects are expected to increase even further after 2050.

It can be expected that the climate change effects increase in the future if no climate adaptation measures are implemented

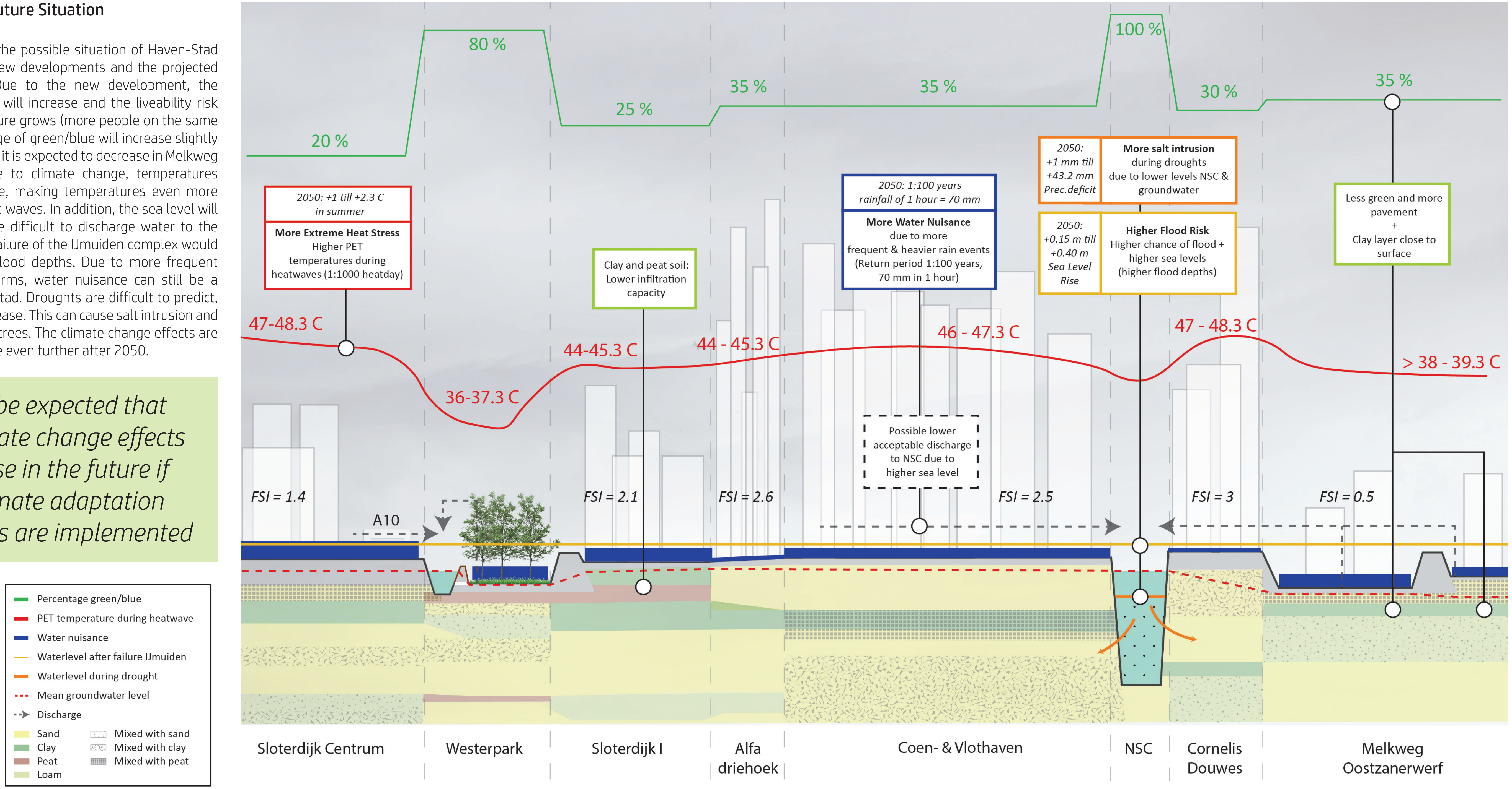


Figure 4.16. The possible future situation, cross-section of Haven-Stad area

5

CLIMATE ADAPTATION GOVERNANCE

Climate adaptation governance is essential to realize climate adaptation planning. This chapter analyses the current status of climate adaptation governance in the Netherlands, with a focus on the Haven-Stad case. It describes the current main actors, policies and collaborations. Expert interviews support the literature review on the main challenges of climate adaptation planning.

SAPP Approach - Step 1

Barends, M. (2014)

5. Climate Adaptation Governance

5.1 PLANNING SYSTEM FOR CLIMATE ADAPTATION

5.1.1 Actors for Climate Adaptation

Due to the spatial nature and the great importance of water, spatial planning and water management are the suitable sectors for tackling the climate adaptation task together. Figure 5.1 shows the distribution of responsibilities in both sectors in the Netherlands.

National Government
- Rijksoverheid & Rijkswaterstaat
At the national level, there are two separate ministries that are responsible for water management and spatial planning. The Ministry of the Interior and Kingdom Relations is responsible for the spatial policy. The Ministry of Infrastructure and Water Management is responsible for national water policy and the management of the main water system. Rijkswaterstaat is the executive department of the Ministery of Infrastructure and Water Management and is responsible of the 'Rijkswateren': major rivers and canals, the IJsselmeer, the Wadden Sea and the North Sea (Mostert, 2019).

Provinces
At the provincial level, 12 provinces are responsible for a wide variety of tasks, including water management and spatial planning tasks. It is the task of the province to translate national policy into regional measures (Rijksoverheid, n.d.). The provinces draw up provincial structural visions and ensure regional spatial- and water policy. The provinces are also responsible for the waterway management (for shipping) of the regional water bodies (Mostert, 2019) and the supervision of the regional water authorities.

Regional water authorities
At regional level, the regional water authorities are responsible for water management. The regional water authorities are decentralized, functional governmental bodies, that are responsible for the water management of a certain area (Al, 2020). Due to the importance of water management in the Netherlands, the regional water authorities are separate and independent organizations, with their own tariff system (Al, 2020). The regional water authorities are responsible for the management of the regional water system and the flood defences, for wastewater treatment and water quality management, and for the regulation of groundwater extractions (Mostert, 2019).

Municipalities
At the local level, the municipalities are responsible for both spatial planning and water management tasks. Municipalities make zoning plans (bestemmingsplannen) and spatial regulations for spatial planning. The municipalities are also responsible for the design and maintainance of the public space. The water management tasks of the municipalities are the management of the sewer system (sewage + rainwater) and groundwater management in the urban area. In addition, the municipalities draw up urban water policy.

Market & Civil Society
In the Netherlands, it is considered important to involve the market and residents in the planning (informal planning culture). Citizen participation is integrated in the administrative processes, so that residents have a say in the plans. Market parties are also consulted and possibilities are discussed. Investors, social housing associations, and project developers are important actors in the context of climate adaptation and new developments.

The Environment and Planning Act
The new Dutch Environmental and Planning Act [Omgevingswet] will be introduced in 2022. The act was created to simplify and merge spatial planning rules and combines 26 existing acts, including those about water and construction, into one (Stichting CAS, n.d.-c). The act aims to create a coherent approach for the living environment, room for local customization (rule = decentralized, unless), and better and faster decision-making. In addition, participation is promoted (Stichting CAS, n.d.-c). The new act is more based on livability and health as spearheads for policy and regulation, in which climate adaptation will become an important part (Stichting CAS, n.d.-c).

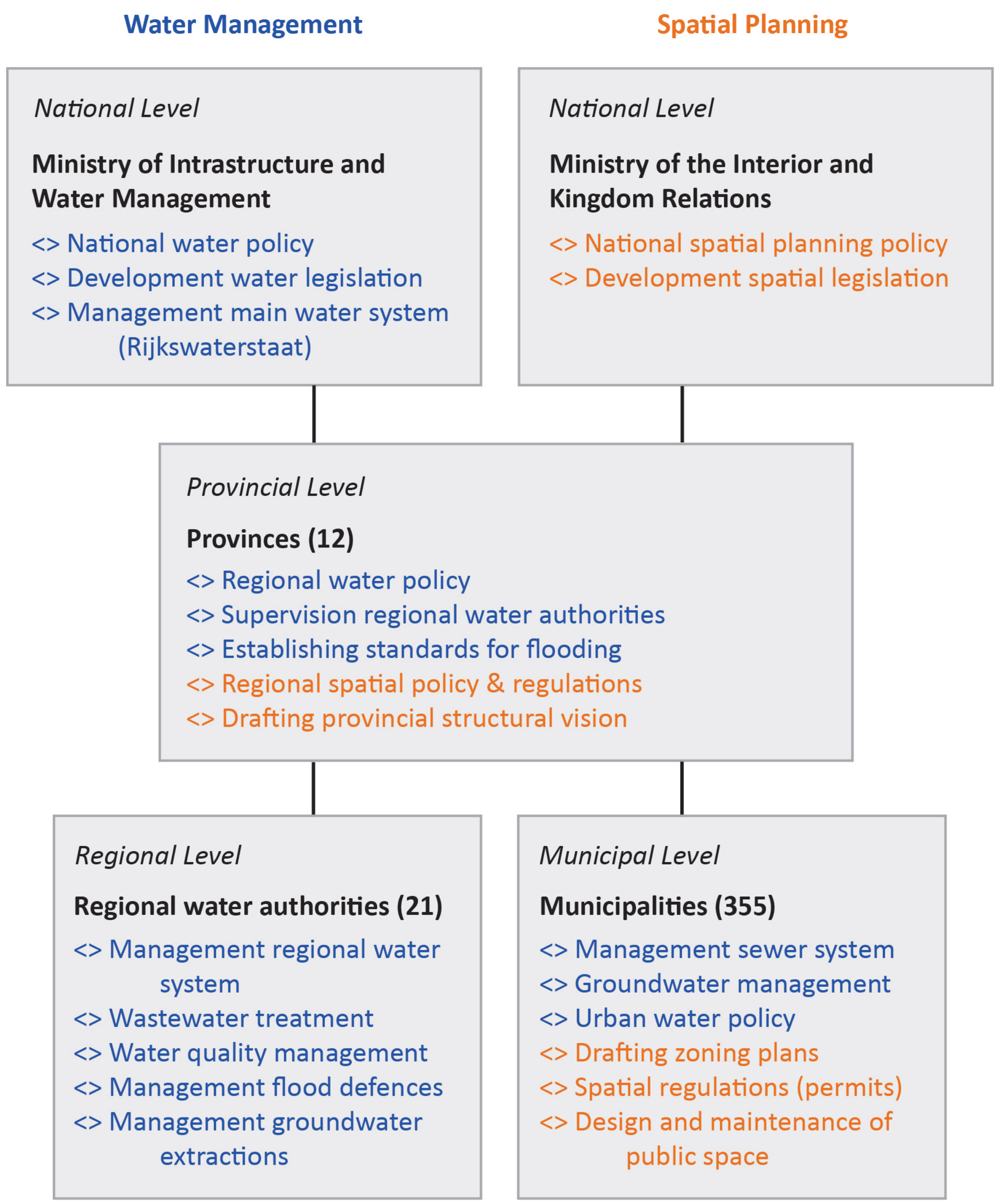


Figure 5.1. Division of responsibilities in Water Management and Spatial Planning in the Netherlands.
Adapted from "*Bruggen slaan tussen water en ruimte: De relatie tussen het waterbeheer en de ruimelijke ordening nader beschouwd*" (p.52), by N.M. Al, 2020. Copyright 2020 by N.M. Al.

5. Climate Adaptation Governance

5.1.2 Climate Adaptation Policies

Two programs form the base of the national approach to climate adaptation: National Climate Adaptation Strategy (NAS) and the National Delta Programme. Climate adaptation policies do also exist on the local and regional scale. These policies are discussed specifically for the Haven-Stad case in Section 5.2.

National Climate Adaptation Strategy (NAS)
The NAS [Nationale Adaptatie Strategie] (2016) is the Dutch strategy to climate adaptation. It describes the climate risks for the Netherlands and the course of action. The implementation program (2018-2019) translates the course into plans and actions (Stichting CAS, n.d.-a). The six spearheads are: heat stress; infrastructure; agriculture; nature; built environment; and 'working together on provincial and regional strategies and visions' (Ministerie van I&M, 2016). The program consists of six action lines: 1. Raising awareness of the need for climate adaptation; 2. Stimulating the implementation of climate adaptation; 3. Using and expanding the knowledge base; 4. Addressing urgent climate risks; 5. Embedding climate adaptation in policy, legislation and regulations; 6. Monitoring the progress and effectiveness of the adaptation policy. (Ministerie van I&M, 2016).

National Delta Programme
The goal of the National Delta programme [Nationaal Deltaprogramma] (2018) is to make the Netherlands climate-resilient and water-robust in 2050. It is a collaboration between the national government, provincies, municipalities, regional water authorities, and civil society organizations. The National Deltaprogram consists of three programs with a focus on water safety, fresh water and spatial adaptation (Stichting CAS, n.d.-a). The Delta Programme on Spatial Adaptation is the most relevant for climate adaptation in urban areas. This program describes how the Netherlands should be organized to cope with the consequences of climate change; increasing heat, drought, heavy precipitation, and flooding (Stichting CAS, n.d.-a). The program contains a Delta 'decision' and a Deltaplan. The Delta decision contains national frameworks (general policy) and the Deltaplan contains specific measures for the implementation of the policy. The program has 7 ambitions, which are depicted in Figure 5.2 (Ministerie van I&M & EZ, 2017).

Administrative Agreement Climate Adaptation
The Administrative Agreement Climate Adaptation [Bestuursakkoord Klimaatadaptatie] (2018) determines that all governments together will invest 600 million euros in climate adaptation in the coming years. 200 Million euro is for the Impulse Regulation Climate Adaptation [Impulsregeling Klimaatadaptatie], which aims to give an impulse to the climate adaptation approach and the implementation of measures from the Deltaplan Spatial Adaptation. In addition, governments can receive financial contributions for impactprojects, living labs, financial incentives for private actors, and implementation projects. (Stichting CAS, n.d.-a)

Figure 5.2. Ambitions of the Deltaplan Spatial Adaptation. Adapted from *"Deltaprogramma 2018"* (p.128), by Ministerie van I&M & EZ, 2017. Copyright 2017 by Ministerie van I&M & EZ.

5.1.3 Climate Adaptation Governance

Collaboration is essential to work on climate adaptation (IV9). Working regions are being set up at the national level, linked to the Delta Plan on Spatial Adaptation. Governmental actors within these working regions discuss their ambitions, policies, and actions together (Stichting CAS, 2018). Because the climate adaptation task is decentralized, municipalities and regional water authorities are primarily at the forefront when it comes to working together on local climate adaptation (IV9). The insight is growing that, in addition to collaboration between governments, it is also important to pay more attention to cooperation with private parties (IV9). Provinces and metropolitan regions can facilitate, stimulate and support the interaction and cooperation of regional partners and governments (IV7;IV8;IV9). In South-Holland, for instance, this has led to the Convenant for Climate Adaptive Building [Convenant Klimaatadaptief Bouwen], in which joint ambitions are set about climate adaptive developments. In addition, national partnerships are being set up to promote collaboration between (public and private) actors. These are, for instance, the networks 'Samen Klimaatbestendig', 'City Deals' and 'Platform KAN' (Stichting CAS, n.d.-a).

Heat in the city
Heat has no apparent problem owner. But because of the local scale of heat and its potential health effects, municipalities are the appropriate governmental actors to take actions for adaptation to heat. Heat plays an increasingly important role in the municipal design of public space. However, a large part of the urban areas are private. Therefore it is important that the municipalities work together with building developers and building owners to create cooler living environments. For the regional water authorities, solving the heat problem is not part of their main tasks, because it has no direct link with water. Of the four themes, the least is known about heat. It is therefore important that municipalities continue to learn about heat in collaboration with other municipalities, research institutes, private actors, and with the regional water authorities.

Pluvial Flooding in the city
The municipalities are responsible for the collection of rainwater from the public spaces, for the sewer systems, and for the groundwater levels. Building owners are responsible for the rainwater and groundwater on their own plot. The municipality and building developers and owners must therefore work together to prevent pluvial flooding. Regional water authorities can provide advice.

Drought in the city
Due to the large (regional-national) scale of drought and the direct link with water, the regional water authorities and Rijkswaterstaat are most involved in adaptation to drought. In the city, municipalities, regional water authorities and inhabitants can work together to store and re-use water to limit the consequences.

Fluvial Flooding in the city
The regional water authorities and Rijkswaterstaat are responsible for preventing fluvial flooding. However, in 2009 it was recognized that prevention alone is not enough. The multi-level safety concept has been introduced, which combines: prevention (layer 1), robust urban design (layer 2) and disaster management (layer 3) (Van Buuren, Ellen, Van Leeuwen & Van Popering - Verkerk, 2015). Rijkswaterstaat and the regional water authorities are the main executing actors for prevention. They are responsible for the construction, management, and maintenance of the flood defence systems. The national government and the provinces draw up, national and regional standards for these systems respectively (Deltares, 2017). In the second layer, the national government, provinces, and municipalities are the main actors. They influence the location choice and urban design through their structural visions. In the third layer, the safety regions (veiligheidsregio's) are the main actors. They are responsible for the risk inventory, planning, and practice of disasters. A crucial notion of the multi-level safety concept is the coherence between the three layers, through strong collaboration. However, this is not always the case, as the governments of the three layers operate according their own logic and are not confident that their interests are represented in complicated collaboration processes (Van Buuren & Ellen, 2013). This can lead to a lack of cohesion and measures taken separately in the layers (Van Zuijlen, 2012).

5.2 CLIMATE ADAPTATION IN THE HAVEN-STAD CONTEXT

5.2.1 Actors in Haven-Stad

In Amsterdam, the division of tasks and responsibilities for spatial planning and water management deviates slightly from the standard Dutch division as depicted in Figure 5.1. Figure 5.3 explains the division in Amsterdam. The main difference arises from the existance of Waternet, the water company of the Amsterdam region. Waternet carries out several water-relating tasks on behalf of both the municipality of Amsterdam and of the regional water authority Amstel, Gooi and Vecht (AGV). One of the advantages is that Waternet takes care of the entire watercycle, which creates opportunities and more cohesion in the plans. The second difference stems from the informal partnership of the MRA, the Metropolitan Region of Amsterdam. The MRA is a partnership of the provinces of North-Holland and Flevoland, 32 municipalities (including Amsterdam), and the Transportregion (Vervoerregio) Amsterdam. Being an informal partnership, the MRA does not change the formal planning system, but can still be seen as an important influencial factor for spatial planning. In addition, the municipality of Amsterdam is considered very strong and independent compared to municipalities of other (smaller) cities and towns. The municipality has a lot of capacity, own experts, and relatively easy access to national levels (IV5; IV7).

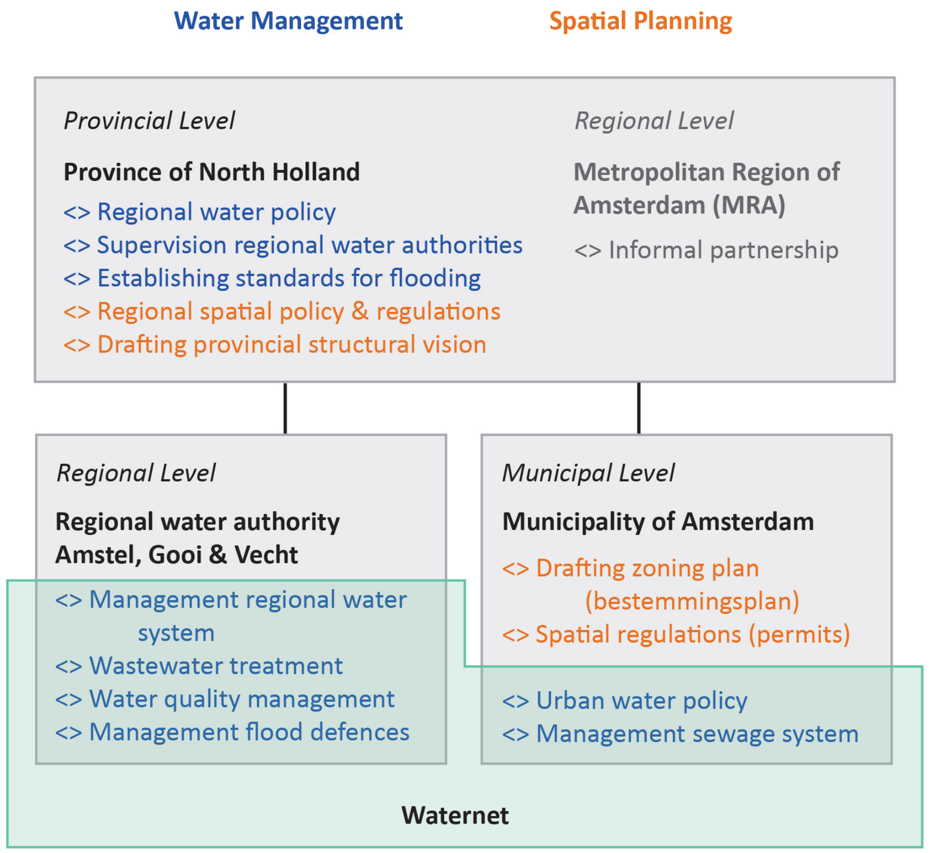


Figure 5.3. Division of responsibilities in Water Management and Spatial Planning in areas in Amsterdam. Adapted from *"Bruggen slaan tussen water en ruimte: De relatie tussen het waterbeheer en de ruimelijke ordening nader beschouwd"* (p.52), by N.M. Al, 2020. Copyright 2020 by N.M. Al.

Several actors are important for the development of Haven-Stad. Figure 5.4 shows the main actors. First, Haven-Stad is part of the municipality of Amsterdam. For spatial planning, the municipality has the leading role in developing Haven-Stad. Figure 5.5 shows the working borders of the two regional water authorities that are responsible within the Haven-Stad borders. It also shows which part of Haven-Stad is still part of the Harbor of Amsterdam (so not owned by the municipality). The water management of Haven-Stad is largely in the hands of the regional water authority 'Amstel, Gooi and Vecht' and is carried out by Waternet. Waternet also carries out water management tasks for the municipality. In addition, Rijkswaterstaat is an important actor in water management for the North Sea Canal. Investors and project developers are responsible for the development and maintenance of their own plot.

> *Waternet, the MRA, and the strong municipality of Amsterdam determine the unique governance context of Haven-Stad.*

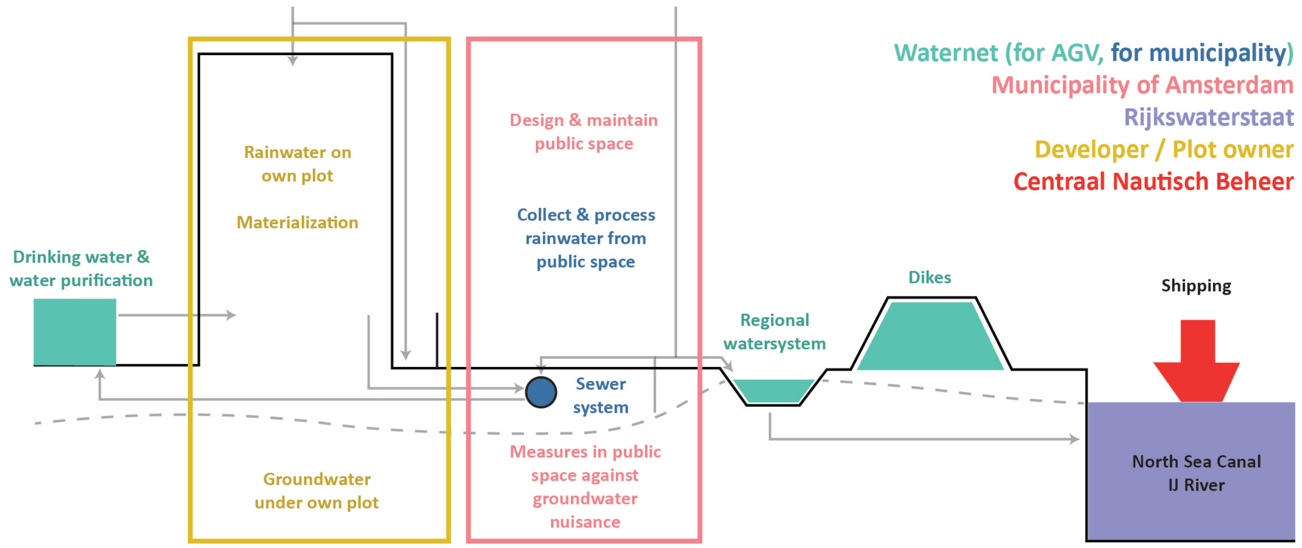


Figure 5.4. Haven-Stad actors. By author, 2021.
Information from: Mostert (2019)

5. Climate Adaptation Governance

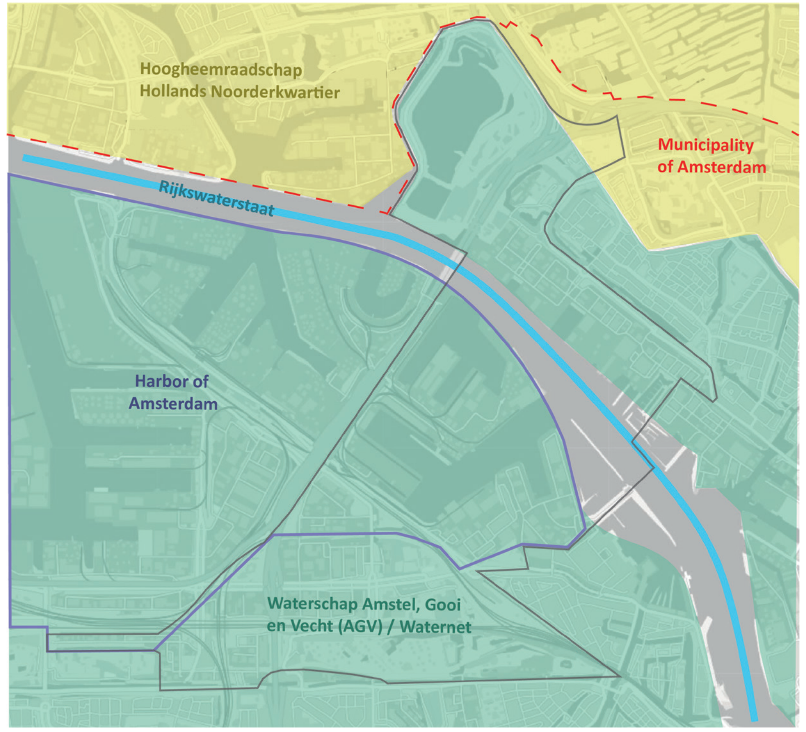


Figure 5.5. Haven-Stad: Administrative boundaries. Information from: Waternet GeoWeb (2020).

5.2.2 Climate Adaptation Policies in the Haven-Stad context

Climate Adaptation Strategy & Execution Agenda
The municipality of Amsterdam has drawn up a strategy and execution agenda for climate adaptation. The strategy describes the risks of climate change in Amsterdam, now and in the future. In line with the Deltaprogram Spatial Adaptation, the municipality also sets the ambition to prepare the city as best as possible for the changing climate in 2050 and to make climate adaptation 'the new normal'. For each theme (heat, drought, pluvial flooding, fluvial flooding) it is described which actions are needed (Gemeente Amsterdam, 2020a). The implementation agenda contains concrete actions for the coming years. The agenda aims to put climate adaptation on the agenda, to inform and inspire, and to provide tools for a wide range of actors (Gemeente Amsterdam, 2021b).

Water Management Plan Amstel Gooi & Vecht (AGV)
The water management plan of the regional water authority AGV also pays attention to climate adaptation. A climate-proof and water-robust area is mentioned as one of the strategic points for 2030. AGV also states that the consequences of climate change increasingly require an integrated approach and that the regional water authority wants to focus more on cooperation with security regions and municipalities, for example when it comes to the climate-proof city (AGV, 2015).

Climate Adaptation Note Noord-Holland
The province of Noord-Holland has drawn up a note for the provincial approach to climate adaptation. The aim of this note is to define the ambition and to form a starting point for renewed cooperation with its partners. For urban areas, the most relevant themes are 'robust vital and vulnerable functions' and 'future-proof built environments'. In both themes the province drawn that new developments must be tested against the effects of climate change. For future-proof built environments, the province facilitates projects in which climate adaptation and health, biodiversity, the energy transition, and the circular economy come together [meekoppel-projecten] (Provincie Noord-Holland, 2020).

MRA Climate Adaptation Program
In 2018, the informal partnership of the MRA started with the program Climate Adaptation. The focus of the program is on supra-regional challenges of climate-resilient area developments and of vital and vulnerable functions. The ambition has been set that a climate test will be carried out at an early stage for all new-build developments. The MRA is now working on a letter of intent between governments, private actors and social actors, for climate resilient new contructions (MRA, n.d.).

5.2.3 Climate Adaptation Governance in the Haven-Stad context

The interviews revealed that it was never agreed which actor would take on which role in climate adaptation (IV7). Nevertheless, the actors have taken on certain roles, because it is in line with their existing tasks and ambitions. In Amsterdam, the municipality and regional water authorities are taking the lead in climate adaptation. For the municipality, climate adaptation is essential to provide a safe and healthy living environment for its inhabitants (IV5; IV6). The regional water authorities have the task of taking care of the water systems. Because this is a crucial aspect for climate adaptation, the regional water authorities also bear their responsibility. The regional water authority AGV therefore mentions 'tackling climate problems' as one of their main tasks (Waterschap Amstel Gooi en Vecht (AGV), n.d.).

Policy documents on climate adaptation, such as the 'Climate Adaptation Execution Agenda' are drawn up in collaboration between the municipality and the regional water authorities. And when developing Haven-Stad, advisors from the municipality and from Waternet regularly discuss water and climate adaptation. Waternet also set up 'Amsterdam Rainproof' together with the municipality: a network organisation that aims to make Amsterdam resilient against rainstorms (rainproof) together with inhabitants, entrepreneurs, and knowledge workers.

The province of North Holland is also working on climate adaptation. However, the focus is more on the rural areas (IV7). In the urban areas they also work on climate resilient vital and vulnerable functions, which are in line with the regional perspective (Provincie Noord-Holland, 2020). The province also has a role in the choice of location and the determination of housing quantities and types. However, the province is not directly involved in climate adaptation in city developments such as Haven-Stad. The province can set requirements, but the municipality chooses which measures are taken to achieve them. One of the interviewees indicated there is less control from the province in Amsterdam, because the municipality does not need the province as much as smaller municipalities do. It is an independent municipality with strong administrative power, its own water authority (Waternet) and it has ties to the national government (IV7).

In the informal partnership of the MRA, climate adaptation is approached from different scales and in collaboration with various actors. It aims to approach supra-local climate challenges in a integrated manner with water management, spatial developments and economy (MRA, 2020). The MRA does try to exert influence on the smaller scales of urban developments. For instance with the 'Basic Safety Level Climate Resilient New Developments' [Basisveiligheidsniveau Klimaatbestendige Nieuwbouw], which includes minimum norms for climate resilient new contructions.

There is also an influence at the national level on Haven-Stad. In 2020, Haven-Stad has been designated as one of the fourteen large-scale building developments in the NOVI (National Environmental Vision [Nationale Omgevingsvisie]), which are necessary to reduce the housing shortage (Bayer, 2021). Due to the size and the complexity of the Haven-Stad development, it requires an integrated approach, long-term involvement of the national government, and strong collaboration between the three government layers. The focus is not only on housing and mobility, but also on climate adaptation, the energy transition, inclusiveness and economic structure reinforcement (Bayer, 2021). At a national level, research is being conducted into the future of the Amsterdam Rhine Canal - North Sea Canal (ARK-NZK) system (Slim Watermanagement, n.d.).

5. Climate Adaptation Governance

5.3 MAIN CHALLENGES FOR CLIMATE ADAPTATION

As explained in Chapter 1, climate adaptation planning is crucial to ensure safe and liveable (urban) environments for now and for the future. However, there is a mismatch between traditional spatial planning and the climate adaptation task. Climate change adaptation is a fairly new policy field (Mees, 2014) and is still under development (IV8). Appropriate governance is of great importance for realizing climate adaptation, but knows its challenges. Davoudi et al. explain it in short:

'Climate change adaptation poses challenges of a different kind for decision-makers. It requires navigating a raft of information generated at different scales, and involving a diverse range of actors in translating these into adaptation options that are socially and politically acceptable despite significant degrees of uncertainty' (Davoudi et al., 2012, p.325).

To learn more about the main challenges of climate adaptation in practice, ten expert interviews were conducted. Eight interviewees are working on climate adaptation in the context of the Amsterdam region; at the municipality of Amsterdam, Waternet, the province of Noord-Holland, and the MRA. The other two are a researcher in the field of governance for resilience and a network professional working on public-private collaborations for sustainability.

Afterwards, the interviews were analysed through the lens of the demands for climate adaptation governance. Van Buuren & Teisman described the demands placed on climate adaptation governance by the characteristics of climate change. According to the writers, the characteristics to be taken into account are: Uncertainty, contentiousness, multiplicity, and complexity (Van Buuren & Teisman, 2010). The results of the interviews are presented per characteristic in the following sub-sections.

5.3.1 Uncertainty

Literature

First of all, it is not known exactly how the climate will change. In addition, it is not yet clear what the effects and consequences of climate change are. Nor can the effect of the applied adaptation measures be fully predicted. Policy must therefore be able to deal with uncertainties and ignorance (Van Buuren & Teisman, 2010).

Interviews

The biggest challenge is *'dealing with the long term* (IV1) *and the uncertainty in decisions that have to be made now'* (IV1; IV3). But what is that long term? According to IV1, the horizon should be linked to the lifespan of the decisions made now (IV1); for new urban areas this would be at least 100 years. In practice, however, often no longer than 30 years is considered (IV1). Following the Deltaplan Spatial Adaptation, the horizon is set to 2050 (IV1;IV2;IV9). However, this horizon is not far enough (IV1; IV7;IV9), because the larger challenges of climate change are expected after 2050 (IV7). But in the administrative system, 2050 is considered a long way off (IV1) and the focus is on coalition agreements of 4 years (IV7;IV10). The province, for example, lacks a real long-term vision, a dot on the horizon (IV10). And the municipality and Waternet often have too short time horizons as well (IV1).

What plays an important role is the action perspective, which gets more complicated further you look in time (IV9). The uncertainty margins in climate projections are increasing sharply after 2050, making it more difficult to determine and argue whether measures are really necessary (IV9). It is often not yet clear how robust and how extreme preparations need to be made for adapting to the changing climate (IV3). This is also because the government does not make it sufficiently clear what is and is not acceptable (IV7). Because the consequences are not yet completely transparent, certainly not in the longer term, society does not yet determine what is acceptable (IV7). This also creates uncertainty for the market. Market parties have indicated that they need a level playing field, because different requirements are often set in different municipalities (IV9). A ministry of space could perhaps provide this clarity, but this is diametrically opposed to the upcoming environmental law (omgevingswet), in which decentralization and customization are central (IV7).

That is why it is important to learn to deal with uncertainty. In practice, however, there is little said about uncertainties and flexibility (IV4). Uncertainty is not really embraced yet and leaving room for letting go and flexibility is still in its infancy (IV4). *'There is often still too much "looking through the glasses of today" and too little thought is given to the future society with the coming climate challenges'* (IV7). The world is constantly evolving, but urban planners and developers still think too little about possible urban changes in the future (IV10).

> *'Dealing with the long term and uncertainty is the biggest challenge for climate adaptation'*

5.3.2 Contentiousness

Literature

The uncertainty and long-term character, and different interpretations about the urgency of adaptation, cause climate adaptation measures that can be controversial. To reach consensus on the measures to be taken, consultation and interaction are crucial (Van Buuren & Teisman, 2010).

Interviews

'One of the biggest challenges for climate adaptation is that for many people it is still something far away [een ver-van-mijn-bed show]' (IV7). Certainly when looking at the longer term, people often still think that *'nothing needs to be done today'* and that there is *'still enough time'* (IV9). *'This has to do with a major lack of ownership, because who has a serious problem if we don't think about the long term? Not current politics.'* (IV9). The urgency of climate adaptation is sometimes not clear enough, but it has increased in recent years (IV6). The urgency of pluvial flooding is often clear, because it is already occurring (IV2). The urgency of heat and drought is also starting to become more apparent after the past hot and dry summers (IV2). Impact mitigation for fluvial floods, however, has not yet landed well (IV2).

'There is still no overview of the actual urgencies, certainly after 2050, and what we as joint governments consider to be the most important tasks' (IV7). The OECD research shows that there is also a lack of awareness among the population in the Netherlands and that all responsibility lies with the government (IV2).

Consultation and interaction are important to address the contentiousness of climate adaptation. However, there is surprisingly little communication between public actors, and especially between public and private actors (IV9). Everyone sits *'in their own little world'* and does *'their own things'* (IV9). Citizens are also involved in planning too late, namely when a problem has to be solved (IV10).

In addition, climate adaptation is still seen too much as a water task and water people are often more aware of the task than others (IV1). Some people therefore believe that the regional water authorities should be more proactive (IV1). In the past, Waternet determined climate adaptation in Amsterdam (IV8). But three years ago, *'it was decided that the municipality took the lead in the collaboration, because of the need of deeper roots in the municipalitan organization to deal with it'* (IV8). Nowadays, climate adaptation is a collaboration between Waternet and the municipality (IV3; IV5; IV8). But in addition to public cooperation, consultation with private parties (such as builders, developers and civil society organizations) is also important (IV9). *'Municipalities are very careful and point to the market, but the market says: "Can it go a little faster?"'* (IV9). It is therefore important that people sit together and that public-private agreements are made (IV9).

Finances are also mentioned as a major barrier to climate adaptation (IV5;IV6;IV7). And especially the question of who will pay for it is often discussed (IV5;IV6). The question is who is prepared to invest now to prevent higher costs in the future (IV9). In addition to the government, there is also a role for investors here. Institutional real estate investors, who invest for the longer term, are becoming increasingly aware of the climate risks in their investment portfolio and want to limit the risks (IV9). Climate adaptation is therefore likely to play an increasingly important role in investment decisions (IV9).

> *'One of the biggest challenges for climate adaptation is that it is still something far away for many people'*

Appendix 5.3
For the interview summaries

5.3.3 Multiplicity

Literature
Climate adaptation affects all scales and many disciplines. Policy systems are often separate, but knowledge and action from the various disciplines are coming together more and more. Many actors with different ambitions are involved in the decision-making process about adaptation measures. Therefore, measures should be chosenon the basis of an integral assessment. (Van Buuren & Teisman, 2010).

Climate adaptation is challenging because it *'cuts right across the demarcations of scientific disciplines and sectorally focused government departments'* (Davoudi et al., 2012). The challenge of climate adaptation is not really a technical issue, but more a collaboration issue. This collaboration issue consists both of the internal collaboration within municipalities and regional water authorities, and of the collaboration with regional partners (Stichting CAS, 2018). *'Climate adaptation asks for new forms of collaboration to ensure the necessary integrated solutions'* (H2O, 2020).

Interviews
One of the other biggest challenges is that *'climate adaptation is still insufficiently seen as an integral task'* (IV7). It is a joint task of all governments, private actors, and consumers (IV5). However, there is still insufficient cooperation and no consensus on the responsibilities (IV7). But working from *'our own bubbels'* will no longer work for the coming climate adaptation challenges (IV8).

Moreover, *'climate adaptation is not the only task that requires space, time, money and attention'* (IV1). The biggest challenge is to combine climate adaptation with other major tasks, such as housing development and the energy transition (IV1;IV2:IV10). All tasks together lead to an accumulation of ambitions (IV5;IV8) and requirements for developers (IV7). Developers often indicate that it will quickly become unprofitable if all requirements must be met while keeping the homes affordable (IV7).

The governance of climate adaptation also has an organizational issue (IV1). At the moment, the task of climate adaptation still mainly lies with the people of water and sustainability (IV1). *'Climate adaptation is not only an issue of the water system, but also concerns the connection with the spatial system'* (IV1). At the national level, climate adaptation remains mainly in the water domain, partly because the NAS strategy has now been integrated into the Delta Plan on Spatial Adaptation, which is a water-related task (IV7). In regional implementation, too, the emphasis is still on the water domain (IV7).

In addition to the lack of public and public-private partnerships, more integration is also needed in the organizations themselves. At the municipality there are different teams that work at different scales. Ideally these teams can find and complement each other well, but in practice this is not always the case (IV6). It is not always easy for colleagues working at the Province in the field of climate adaptation (in the field of water) and spatial development to find each other (IV7). However, the governance of climate adaptation is still developing and climate adaptation is becoming more embedded in organizations (IV8). Integration offers opportunities, but also risks (IV7;IV8). Because more and more people are taking ownership of the climate adaptation task, more coordination is needed before action can be taken (IV8). Consensus can often be reached about the ambition, but there can be a lot of discussion about who is responsible for what in safeguarding and implementation (IV7).

Because large choices and combinations have to be made in the limited space in the Netherlands, more national control is needed (IV2;IV7). For example, it can help if the Ministry of BZK (in addition to I&W) also focuses on climate adaptation (IV8), or if a Ministry is established for Spatial Planning and Climate (IV2;IV7). However, this is diametrically opposed to the current decentralized approach and the forthcoming environmental law (IV7).

Climate adaptation strategies are still translated to a limited extent in urban development projects (IV5). The municipality mainly works on plot-scale (IV5) and the ambitions for the area are translated into requirements for the lots (IV5). For themes such as water, mobility and energy, the municipality works on the scale of the area (IV5). All projects within Haven-Stad have their own boundaries and project teams (IV3). *'Perhaps more attention should be paid to the intermediate scale'* (IV3), because some integral assignments fall outside the scope of the project (lots) or area (whole Haven-Stad).

> *'Climate adaptation is still insufficiently seen as an integral task'*

5.3.4 Complexity

Literature
Climate change is complex because it behaves non-linear and dynamic. In addition, the effects of climate change can differ locally. This also makes the climate adaptation process complex. The policy strategies must therefore be able to learn and adapt over time. Therefore, policy should be customized, flexible, and adjustable (Van Buuren & Teisman, 2010).

Interviews
Climate adaptation is complex because it involves four themes, the public space and buildings, and multiple departments and processes (IV6). At the same time, the governance of climate adaptation is still developing (IV7;IV8). Climate adaptation affects everything and it has never been agreed who is really in charge (IV7). The task is not clear and manageable and is getting bigger and more complicated (IV7). And in large cities such as Amsterdam the complexity is extra high and climate adaptation touches on many other themes (IV8). In addition, climate adaptation is complex because the climate continues to change. Being climate resilient is therefore a continuous process, but it is still too often assumed to be a status (IV1).

Due to this complexity and development of the policy field, it is important that the policy is customized, flexible, and adjustable. However, this is not often the case yet. For example, standards are often used, which by definition lag behind new insights (IV3).

For example, the stormwater regulation (hemelwater-verordening) of the municipality of Amsterdam now sets the standard of 60 mm, but there is no rule about building in flexibility to absorb more in the future (IV5). In addition, processes and budgets are fixed. Investment budgets are fixed far in advance and are difficult to deviate (IV4). The provincial coalition agreement is also very binding (IV10). In addition, area development processes are not flexible enough (IV6). People are used to the fact that nothing is allowed to change once the contract has been concluded or a phase has been completed (IV6;IV8). Recalibration is not possible (IV6) and this inflexibility is not possible with this assignment (IV8).

> *'It is still too often assumed that climate resilience is a status'*

5.3.5 Suggestions for Improvement

All interviewees were asked to make suggestions for improving climate adaptation governance.

A longer time horizon
Multiple interviewees mentioned the need for a longer time horizon (IV1;IV3;IV5;IV6;IV9;IV10). The province needs a long-term vision and/or adaptive planning approach (IV10). In addition, coalition agreements can be accompanied by a long-term outlook (IV10). Future thinking could be anchored in decision-making, for instance by making rules in preparation of investment decisions, with substantiation based on future scenarios or monitoring and recalibration (IV4).

More flexibility
The interviews revealed the need for more flexibility, both in the designs and in the process. Designs and measures should be more flexible (IV3;IV5;IV10). In addition, two interviewees mentioned that it would be good to combine minimum norms with bandwidths to show future ambitions and to stimulate innovation (IV3;IV7). Two other interviewees also addressed the need for a more flexible area development process (IV6;IV8).

More integration
Climate adaptation should be tackled more integrally (IV5) and should extend to the capillaries of the organizations (IV8). Urban development processes should be less project-oriented and more area-oriented (IV5). It is also suggested to bridge the gap from the strategy to the area development process and to connect sustainability experts to urbanization professionals (IV9).

A shared task
The climate adaptation task should be seen as everyone's task (IV1). Both private actors (IV9) and citizens (IV10) should be more involved. In addition, awareness should be promoted (IV2).

More national direction
Several interviewees also indicated that there is a need for more direction from the national government (IV2;IV5;IV7). For resources and national coordination of larger decisions. However, this would be diametrically opposed to the environmental law (omgevingwet) that has a focus on decentralization and customization.

More clarity
Clarity is also needed about which risks governments do and do not accept and who has the role to reduce the risk (IV7). In addition, more clarity is needed about the costs of climate adaptation and the action perspective (IV9).

5. Climate Adaptation Governance

5.3.6 Summary

Figure 5.6 shows the relations between the climate change characteristics, the demands for climate adaptation governance, and the challenges and suggestions for improvement that emerged from the interviews.

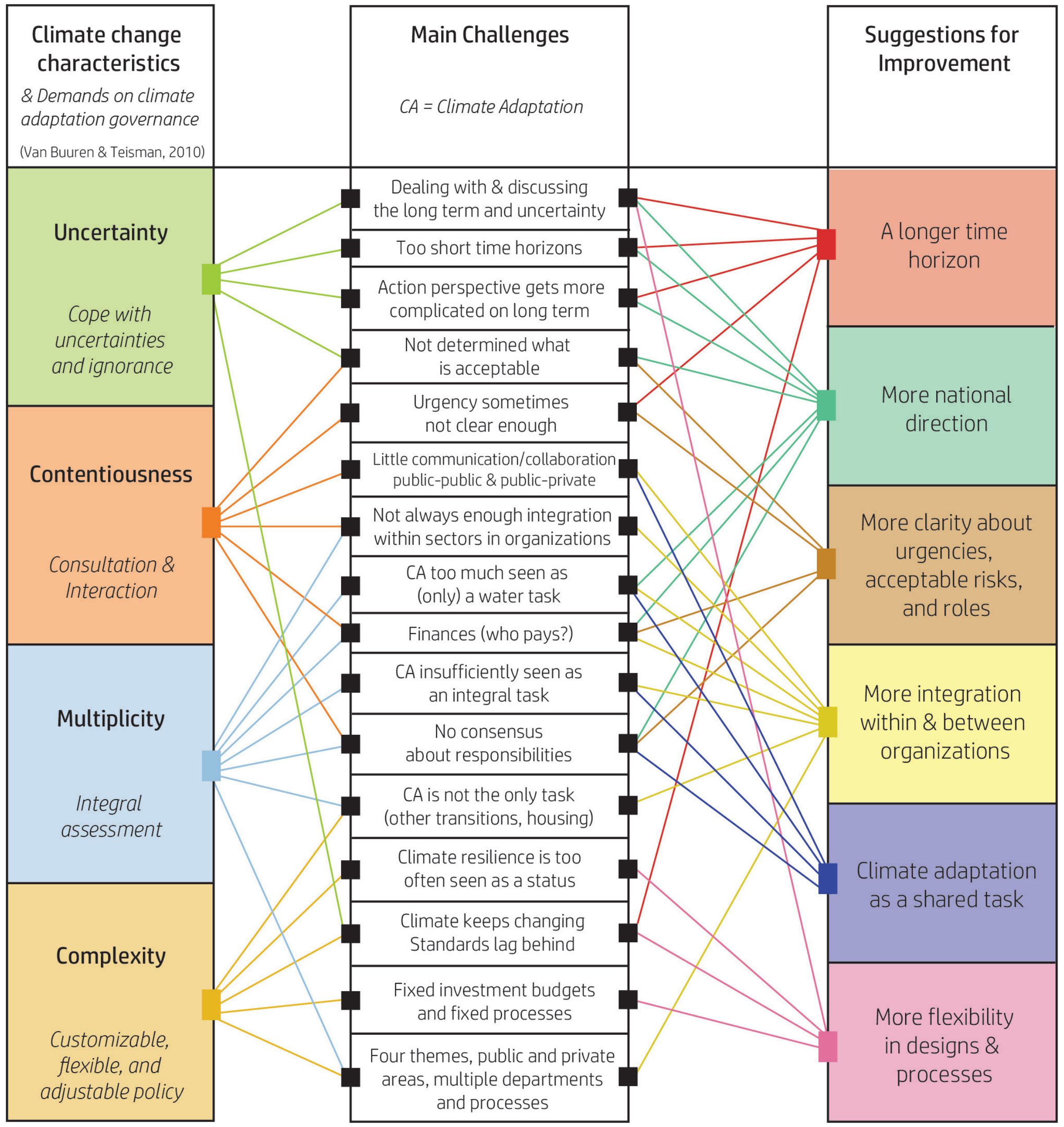


Figure 5.6. Relations between the climate change characteristics and the demands, challenges, and suggestions for improvement for climate adaptation governance.

5.4 CONCLUSION

Climate adaptation governance is key for realizing long-term climate adaptation planning. However, the characteristics of climate change put specific demands on climate adaptation governance. Due to the uncertainties, policy must be able to deal with uncertainties and ignorance. Because of contentiousness, adaptation measures should be created by consultation and interaction. Due to the multiplicity, measures should be chosen on the basis of an integral assessment. And because of the complexity, policy should be customized, flexible, and adjustable (Van Buuren & Teisman, 2010). However, these demands are not always met, according to the interviews.

Spatial Adaptive Policy Pathways may provide support to meet these governance demands. It can offer a way to work with uncertainty by addressing multiple pathways that adapt to climate change and can lead to different futures. In addition, it can support consultation and interaction, as the SAPP map can be used for explanation and discussion with different actors. It may also contribute to strengthening the urgency of actors, because the climate scenarios and pathways show which adjustments may be needed in the future. As the map can bring different spatial scales, time scales and disciplines together, it can also be used as a tool for integral assessments. Finally, the SAPP approach emphasizes the flexibility and adjustability of the design and planning. This can address the need to align flexible and adjustable policy strategies.

Spatial Adaptive Policy Pathways can potentially give support to met the demands for climate adaptation governance

CONCLUSION
ANALYSIS

Which analyses are needed to get a comprehensive view of the climate adaptation task?

HAVEN-STAD OUTPUTS

- Currently Haven-Stad is already facing climate change effects.
- It can be expected that the climate change effects increase in the future if no climate adaptation measures are implemented.
- Waternet, the MRA, and the strong municipality of Amsterdam determine the unique governance context of Haven-Stad.
- The main challenges for (the still developing) climate adaptation governance arise from characteristics of climate change: Uncertainty, contentiousness, multiplicity, and complexity.
- Suggestions for improved climate adaptation governance include the consideration of a longer time horizon, more flexibility of the designs and processes, more integral collaboration, sharing of the climate adaptation task, more national coordination, and more clarity about responsibilities and acceptable risks.

SAPP APPROACH

- A site analysis and a governance analysis are necessary to obtain a comprehensive view of the climate adaptation challenge.
- The site analysis must include an analysis of the future plans and of all four climate stresses (heat, pluvial flooding, drought, fluvial flooding). The analysis of the climate stresses should address the following points: The vulnerability, the consequences, the projections and uncertainties, and an outline of the future.
- The governance analysis must include an analysis of the actors, policies, and collaborations. In addition, it should contain an analysis of the main challenges (preferably supported by expert interviews).
- Spatial Adaptive Policy Pathways may provide support to meet the demands for climate adaptation governance.

IDENTIFICATION

What are the key components needed
for the development of
Spatial Adaptive Policy Pathways?

FRAMEWORK

ADAPTATION MEASURES

6

FRAMEWORK

This chapter presents the framework for the Spatial Adaptive Policy Pathways. The key components of the framework are introduced and the scope of the pathways for Haven-Stad is set out. Additional information is about the objectives is given at the end of the chapter. The elaboration of the other components can be found throughout the report.

SAPP Approach - Step 2

V/d Graaf, F. (2018)

6.1 FRAMEWORK

To develop Spatial Adaptive Policy Pathways, the framework for the SAPP map needs to be set up. The SAPP map shows which adaptation measures can succeed each other over time. The framework consists of four key components which can be adjusted based on the case study and the goal of the research. Figure 6.1 shows the framework and key components for the SAPP map.

The following components are identified as the key components for the development of Spatial Adaptive Policy Pathways:

Starting point
In adaptive pathways maps, the starting point is often the current policy (or current urban situation). However, this starting point does not exist yet for new urban areas. The starting point must therefore be part of the design research. Different starting points can lead to different options in the SAPP map. *Chapter 8 shows the starting point in this research (a 2050 design for Haven-Stad).*

Climate Objectives & Climate Trends (x-axis)
Objectives are needed to determine the 'tipping points'. *'An adaptation tipping point is reached when the magnitude of the external change is such that a policy can no longer meet its objectives, and new actions are needed to achieve the objectives'* (Kwadijk et al., 2010). The climate objective describes the goal in relation to climate adaptation (for instance a certain amount of storage) and is linked to a target value. This target value may change over time, as the climate changes. *Section 6.3 describes which climate objectives are defined in this research.*

The x-axis of the SAPP map is a continuous axis and aligns with the objectives. For instance, an increasing amount of rainwater storage can be placed on the x-axis. The relevant climate trend is shown below, for example an increase in rainfall intensity. The objectives describe how the increase in rainfall intensity is related to an increased objective for rainwater storage. Climate scenarios can be displayed below the two axes, to show how the climate trend is expected to increase in different scenarios. This study uses the KNMI'14 scenarios for the Netherlands (KNMI, 2015). *Section 9.2 describes how the x-axis is set up in this research.*

The key components of the framework are the starting point, the climate objectives and climate trends, the transition phases, and the adaptation measures

Transition phases (x-axis)
Transition phases are added to the framework to make it possible to think about different steps in the future (and the trajectories between them), without too much quantification needed on the x-axis. Information about future developments can be linked to the transition phases and can be used for backcasting. *Section 9.2 shows how this is done for a focus area in Haven-Stad. Future strategies for the Dutch delta are used as inspiration for possible future transitions and transformations in Haven-Stad.*

The transition phases (start, incremental, transition, transformation) are based on the policy phases from the study of Abunnasr, Hamin, & Brabec (Abunnasr, Hamin, & Brabec, 2015). In the SAPP framework, the phases are not directly connected to policy change, but more to the physical changes that can be made in different steps to adapt to (different levels of) climate change.

In this research, the start phase is about the initial design for the new urban area (for Haven-Stad a design for 2050, also the starting point). In the initial design, no measures should be introduced that hamper further climate adaptation later on. In the incremental phase incremental measures are implemented to deal with small changes in the climate. The implementation of these measures usually does not require major adjustments. In the transition phase radical changes are made in the urban area to adapt to the changing climate. In the transformative phase the transition continues to be carried out and becomes part of the new normal.

Adaptation Measures (y-axis)
In order to design adaptation pathways, relevant adaptation measures need to be identified. Adaptation principles, design layers, and adaptation tiles structure the options. This research includes adaptation measures for: heat, pluvial flooding, fluvial flooding, and drought. Combinations of adaptation measures shape the design of an urban area. The adaptation measures are displayed on the y-axis of the SAPP map. The horizontal lines (the pathways) indicate which measures can be selected successively. *Chapter 7 explains the adaptation principles, design layers, and adaptation tiles.*

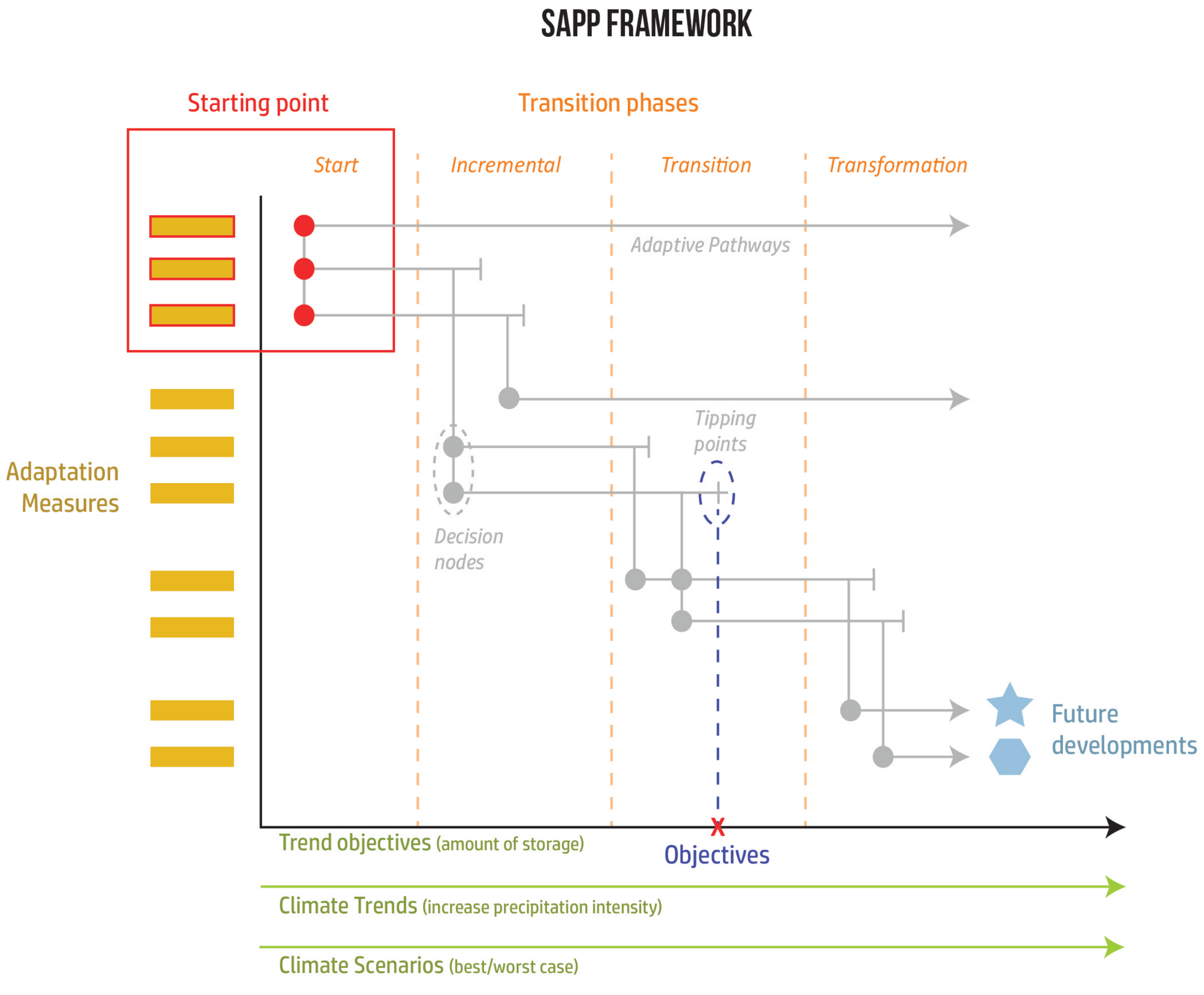


Figure 6.1. Framework of the SAPP map.

Section 2.3
For more information about the SAPP approach

6. Framework

6.2 SCOPE

In addition to defining the key components, it is important to define the scope of the SAPP map. The scope includes the theme of the map, the spatial scales, the time scales, and the governance scope. In addition, focus areas and dominant stressors can be defined if needed. Figure 6.2 shows the scope of this research.

Theme: 4 Climate Adaptation Pillars
The Delta Plan Spatial Adaptation (Ministry of I&M & EZ, 2017) of the Dutch government identifies four adaptation pillars (heat, flooding, river flooding, drought), these cover the most important aspects of climate adaptation. It has been decided to adopt these pillars to link the research with the current (governmental) goals and focus points in practice. In this research, it was decided to create SAPP maps with the focus on one of these adaptation pillars at the time. This is done to reduce the complexity of the process and to keep the final SAPP maps readable.

Spatial Scales
For climate adaptation, multiple spatial scales are relevant. In this research, the most important spatial scale is the district, since Haven-Stad can be considered as a district. However, the adaptation measures considered, vary from the building scale to the regional scale. Where heat and pluvial flooding can often be solved locally, a regional approach may be necessary in the event of drought and flooding. It is important for climate adaptation and water management that interventions at different scale levels are compatible, because water is always part of a larger system and has no boundaries. Design is used to bring the spatial scales together.

Time Scales
The use of adaptation pathway approaches implies that the timescale is continuous. In this research, the timescale runs from 2050 (the year in which Haven-Stad is assumed to be fully developed) to the long-term future (2100 or beyond). In current practice, 2050 is often used as the focus point for future developments. Because the ambition of the government is that the Netherlands should be climate-proof and water-robust by 2050 (Ministry van I&M & EZ, 2017). However, climate change will not stop after 2050. Therefore, the long-term future is set at 2100 in this study. The pathways follow the continuous timescale to connect the short term (initial design in 2050) with the long term. The phases in the development of Haven-Stad (from 2020-2040) are not considered in this research.

Governance Scope
SAPP could potentially support governance for climate adaptation planning. Research into governance is therefore also part of this project. To narrow the scope, governmental actors are the main actors involved in this research as *'governments appear to be the primary actors in adaptation planning'* (Mees, Driessen, & Runhaar, 2012, p.305). The main actors considered are the national government (ministries and Rijkswaterstaat), the provinces, the regional water authorities, and the municipalities. The focus is on government decisions and actions concerning climate adaptation planning. This also includes how the government acts towards, and collaborates with private parties (market) and civil organisations (civil society).

> *Definition of the scope includes definition of the theme, spatial scales, time scales, and governance scope*

Focus areas and dominant stressors
To make a readable SAPP map, it is important to reduce the complexity. The first step is to select the right scale and level of conceptualization. This selection can be made in advance, but can certainly also be adapted to new insights during the process. In this study, focus areas and dominant stressors are selected for the SAPP map. This was needed because of the heterogeneity on the district scale; including different kind of neighbourhoods with different adaptation measures made the SAPP map in this case unreadable.

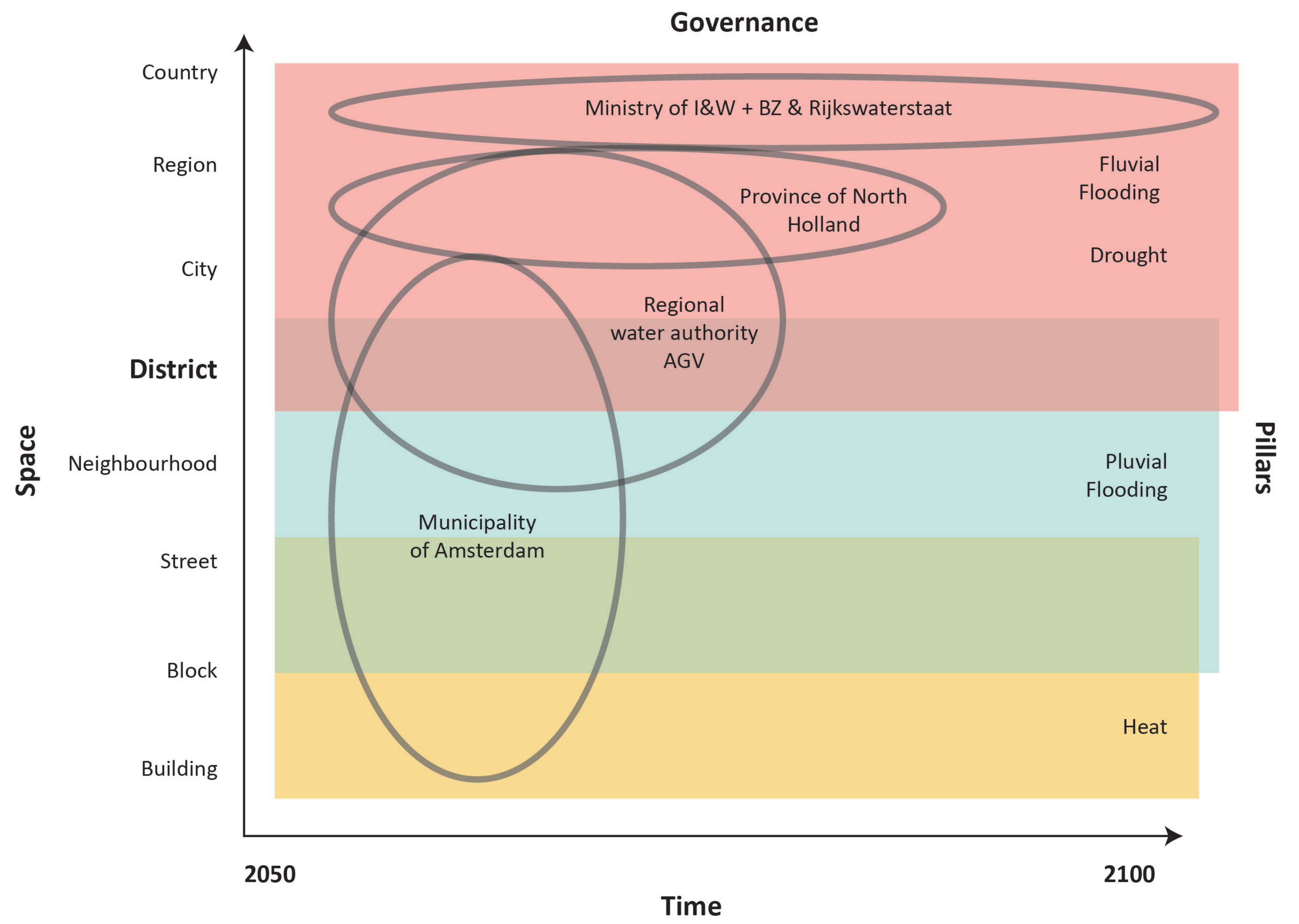


Figure 6.2. Scope for this research. (The circles indicate governance boundaries)

6. Framework

6.3 CLIMATE OBJECTIVES

To develop SAPP and define tipping points, objectives need to be defined. The climate objectives are part of the x-axis of the SAPP map and change with the changing climate trends. For instance, an increasing amount of storage is needed if the precipitation intensities increase. The objectives form the link between the climate trends on the x-axis and the (needed) effects of the adaptation measures.

This section presents the selected climate objectives and the calculations that are used to define the future climate, the effects of the measures, and the tipping points.

6.3.1 Pluvial Flooding

The goal
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. Such a storm may '*not cause damage in and to buildings, infrastructure and services*' (MRA & Inbo, 2021). Vital roads cannot be flooded. In this research, the 1/100 years event has been 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, rapid storage is required. The required storage capacity depends on future rainfall intensities.

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

The calculation
The table from the STOWA statistics (Beersma et al., 2019) is used to calculate the intensity of the future 1/100 precipitation event, see Figure 6.1 in Appendix 6.3. The fast storage objective (m^3) is the product of the future intensity (m/h) and the total area (m^2). The fast storage is the product of the length, width and depth (and soil porosity) of measures. *The full calculation and the assumptions can be found in Appendix 6.3.*

The climate objectives are not fixed; they change with the changing climate

6.3.2 Drought

The goal
The goal 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 study, it has been assumed that the acceptable return period of exceedance is therefore 1/10 years. The KNMI has also made forecasts about the increase in the highest precipitation deficit that is exceeded once every 10 years. Slow storage is necessary to prevent drought. The required storage capacity depends on the future precipitation deficits.

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

The calculation
The KNMI' 14 scenarios are used to calculate the future precipitation deficit of 1/10 (KNMI, 2015). The calculations are based on the 'highest precipitation deficit exceeded once in 10 years'. The slow storage objective is the product of the future precipitation deficit (m) and the total green area (m^2). The total green area is used, as most evaporation takes place through plants and open soils. The slow storage is the product of the length, width and depth (and soil porosity) of measures. *The full calculation and the assumptions can be found in Appendix 6.3.*

6.3.3 Heat

The goal
For the 'basic safety level' (basisveiligheidsniveau) the MRA defined the following objective with regard to heat: *'During heat (minimum 1 heat day) the plan area provides a healthy and attractive living environment and microclimate.'* (MRA & Inbo, 2021, p.11). In this research, the comfort temperature was selected as the temperature to work with, because it reflects the impact on humans better than just the air temperature (Goede, 2020). The comfort temperature is often expressed as the PET-value (Physiological Equivalent Temperature; in degrees Celcius) and the PET value is selected in the Netherlands as the main indicator for heat stress (Brolsma, 2020). Moderate heat stress starts at a PET value of 29 °C. A PET value of 29 °C therefore seems a logical objective. However, the Amsterdam heatmap shows that this value is exceeded almost everywhere during a hot day (Brouwer et al., 2020). Kluck et al. indicate that a maximum of 35 °C is a logical objective, because 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 temperature at which strong heat stress starts to occur. To prevent heat stress, cooling measures are needed. The needed temperature reduction depends on the future temperature rise.

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

The calculation
Three steps are taken to calculate the future PET values. First, the future PET-value without measures is calculated by adding 1.25 × the temperature rise to the historic PET temperature. The temperature rise is adopted from the KNMI projections about the temperature on the warmest summer day (KNMI, 2015). Secondly, the effect of the implementation of adaptation measures (PET reduction) is calculated using the KBS Toolbox (Deltares et al., n.d.). The future PET-value after implementation of adaptation measures is the future PET value minus the PET reduction. *The full calculation and the assumptions can be found in Appendix 6.3.*

6.3.4 Fluvial Flooding

The goal
The goals and objective are adopted from the principles of the 'basic safety level' (basisveiligheidsniveau) of the Metropoolregio Amsterdam (MRA). The goals for flooding are the prevention of damage, the limitation of damage and/or the prevention of casualties (MRA & Inbo, 2021). Floods in Haven-Stad can have multiple causes, including the collapse of the IJmuiden complex and the collapse of the Lek dike. In this research, the focus is on the link between flood depths and sea level rise, and therefore especially on the failure of the IJmuiden complex.

The objective
Depending on the flood depth and probability of flooding, different objectives are relevant. The MRA has developed a table with flood depths and flood probabilities, which also indicates which objectives are reasonable (see Figure 6.4 in Appendix 6.3).

The 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). The flood depth is calculated by substracting the height of the area from the water level in the North Sea Canal. The calculation is based on 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 up (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 by using the heights of the area. Based on these flood depths, the table can be used to determine the reasonable objectives. *The full calculation and the assumptions can be found in Appendix 6.3.*

Appendix 6.3
For more information about the objectives & calculations

7

ADAPTATION MEASURES

What are the options to make a climate-adaptive design? In this chapter 11 adaptation principles are introduced, which can be used to adapt to heat, drought, pluvial flooding, and fluvial flooding. In addition, five design layers are distinguished. The adaptation principles and design layers are connected to the adaptation measures presented in the last section.

SAPP Approach - Step 3

NRC (2019)

7.1 ADAPTATION PRINCIPLES

Eleven principles are identified for climate adaptation (see Figure 7.1). These are the most important options that can be used to adapt to heat, drought, pluvial flooding and/or fluvial flooding.

The concept of multi-layer safety is used for river flooding. The concept of Multi-Layer Safety consists of working on three layers to provide water safety (Deltares, 2017), as illustrated in Figure 7.2. Layer 1 concerns flood prevention, for example by means of dikes. In layer 2, the spatial planning is designed in such a way that the consequences of a flood are limited. Layer 3 is about disaster management, for example crisis management (Deltares, 2017). The concept is in line with the three principles protection (layer 1), robust urban design (layer 2), and evacuation (layer 3).

Adaptation principles are different options to respond or anticipate to climate change

The concept of a Sponge-City is used for flooding and drought. According to this concept, water in the city must be stored, delayed, retained, reused, and drained (only when necessary), as illustrated in Figure 7.3 (De Urbanisten, 2016). The principles materialization, storage, flexible waterlevels, infiltration, and reuse are all connected to the sponge-city concept.

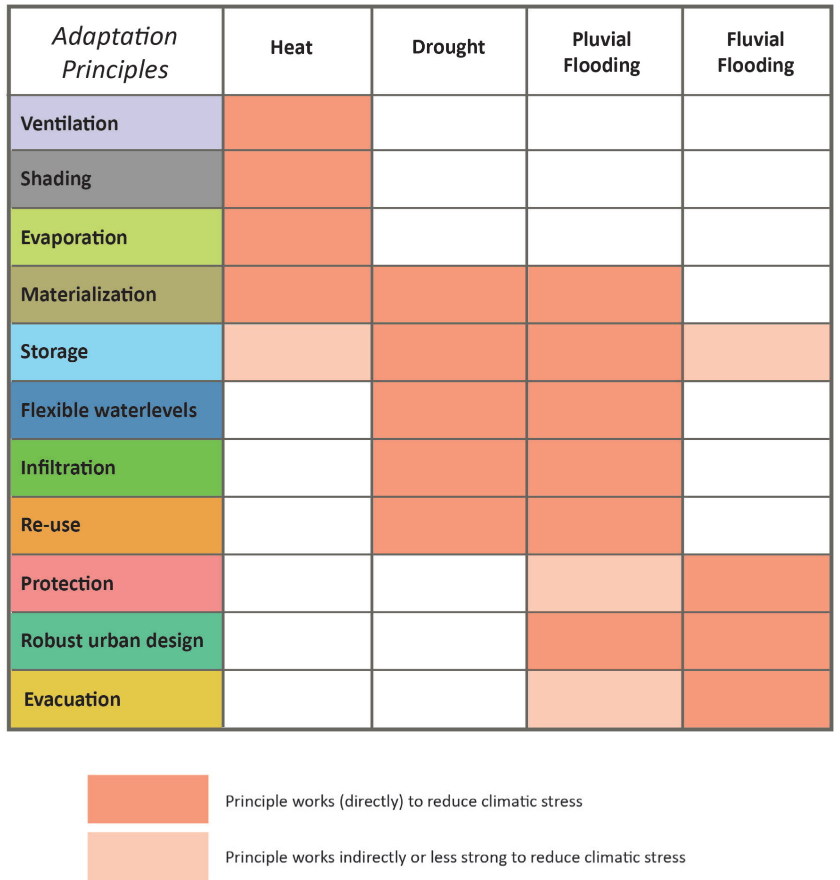


Figure 7.1. Climate Adaptation Principles.

For heat, the four cooling-principles defined in the research 'De hittebestendige stad' are used (Kluck et al., 2020). Ventilation, shading and evaporation are mentioned by the authors as three of the four important principles of heat measures. The last principle in their research is 'reflection', which is classified under the 'materialization' principle in this research. Materialization is thus broader than only reflection for heat, and does also include drought resistant planting for instance.

The adaptation principles are tabulated in Figure 7.1, it shows for which climatic stresses the principles can be used. Some principles can be used to adapt to multiple climatic stressors.

The principles for drought and pluvial flooding are almost all the same, because it concerns the fresh water balance of the area (too much in the event of flooding and too little in the event of drought). The principles for fluvial flooding can sometimes also work for pluvial flooding, because the water rises above street level in both cases. However, principles for pluvial flooding have to do with measures that are often too slow or too small to counteract the consequences of fluvial flooding. Most principles for heat do not work for adaptation to other three climatic stressors. The principles for heat have more influence on the energy balance, and the energy balance is not only influenced by water. Storage is defined as the only principle that could work for all four climatic stressors.

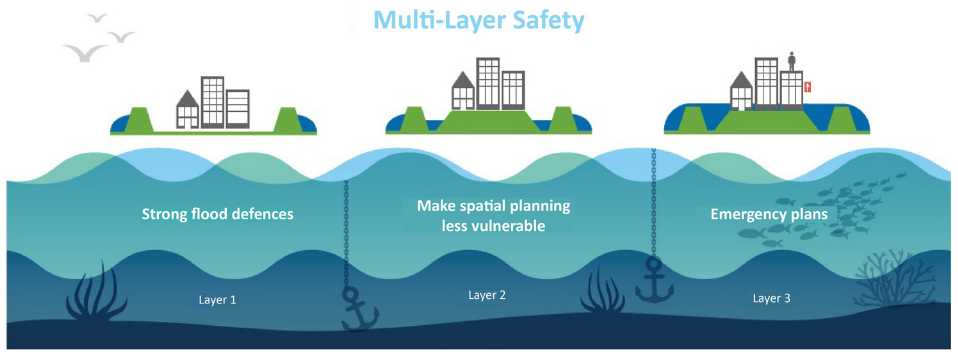


Figure 7.2. The Multi-Layer Safety concept. Adapted from "Delta Expertise voor een leefbare delta", by EVM, n.d. (https://www.zeeweringenwiki.nl/wiki/index.php/RWS_Zorgen_voor_waterveiligheid). Copyright by EVM.

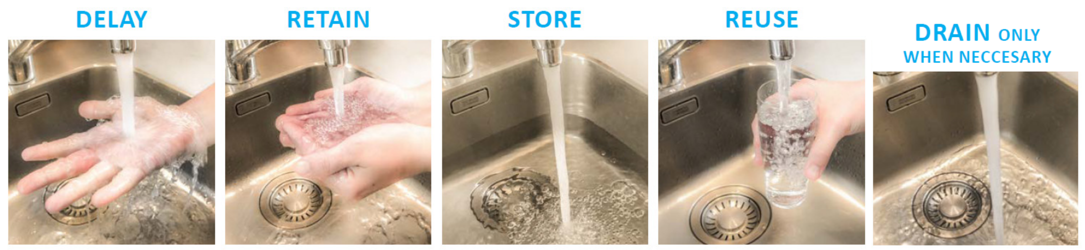


Figure 7.3. Principles of the Sponge-City concept. Reprinted from *"Towards a watersensitive Mexico City. Public space as a rain management strategy"* (p.11), by De Urbanisten et al., 2016, Rotterdam: De Urbanisten. Copyright 2016 by De Urbanisten et al.

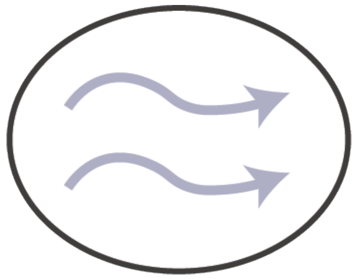
Appendix 7.1
For more information about the connection between the principles

7.1.1 Ventilation

Ventilation reduces heat by pushing out warm air away and allowing colder air (typically from green/blue areas) to enter the area. The colder air is also drier, which can increase the evaporation rate and thus the cooling. This ventilation principle is visualized in Figure 7.4. An additional advantage of good ventilation is that polluted air flows away more easily and is replaced or mixed with fresh air more quickly. In general, ventilation can contribute to better air quality and thermal comfort in urban areas.

To reduce heat, the prevailing wind direction in summer (during hot days) is important. In the Netherlands, however, the wind direction is approximately the same during heat waves and during cold period. During heat waves, there is often little wind, so the designed wind corridors in cities can have a small effect. Another point of contestation is that wind corridors can have a negative effect during cold periods in winter (HvA & KuiperCompagnons, n.d.).

Ventilation promotes the air (heat) exchange between different areas/objects/etc. Urban ventilation can be designed at different scales as shown in Figure 7.5. Orientation is essential for good ventilation. At district, street and building scale the orientation and buildings can be optimized so that the wind can flow through it.



At street and district level, urban ventilation can be boosted by street configuration and avoiding the blockage of existing wind corridors. On a larger scale, connected green-blue networks or green ventilation grids can help to cool the air before it flows into the neighborhoods. The ventilation is promoted by large open green-blue structures in cities. (HvA & KuiperCompagnons, n.d.).

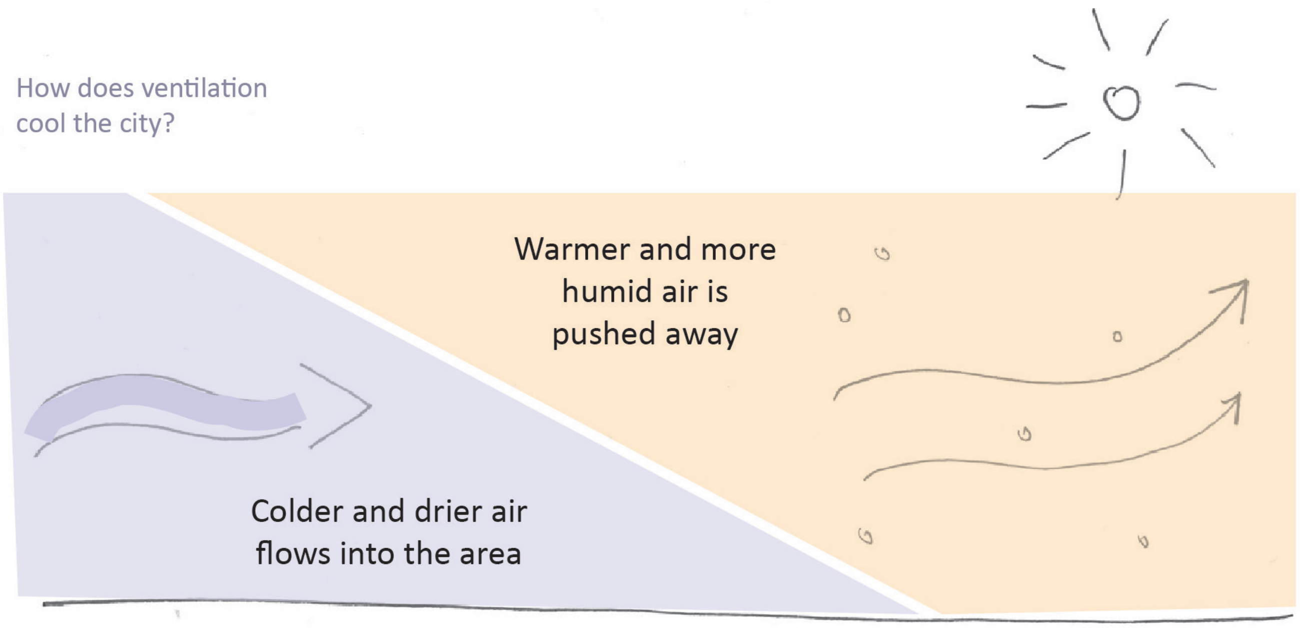


Figure 7.4. Ventilation Principle.

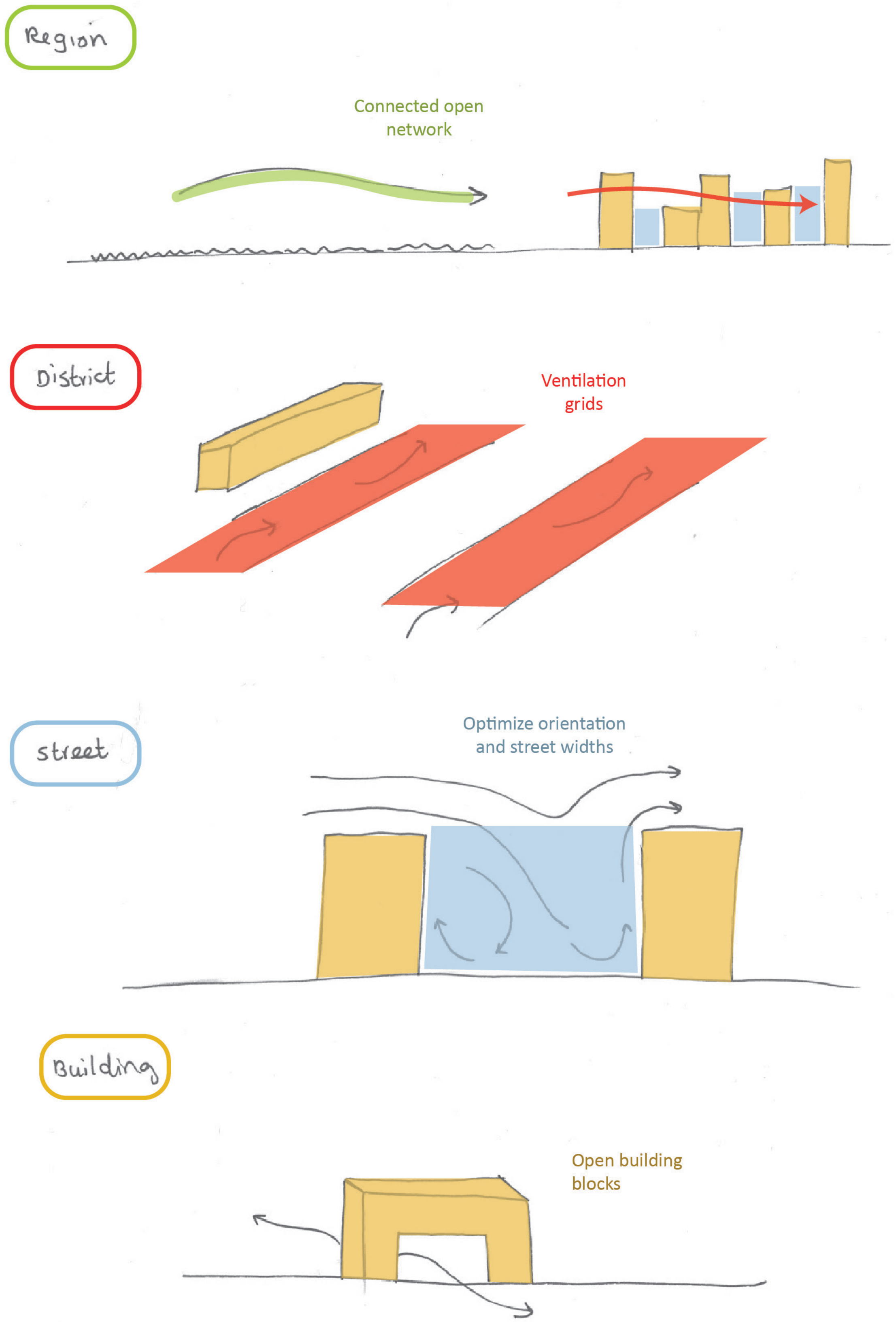


Figure 7.5. Ventilation measures through 4 scales. By author, 2021.

7.1.2 Shading

Shading reduces heat because it prevents surfaces from heating up. Unshaded surfaces can be heated up more easily by the sun and store this thermal energy. The sunlit surfaces radiate heat back to the air, thereby raising the air temperature in cities. The principle of shadow is that constructions/trees capture solar radiation. Thereby, the (short-wave) solar radiation can be reduced to the shaded surface by a factor of 10 (Shahidan et al., 2010). This shading principle is visualized in Figure 7.6.

Shadow has a major effect on lowering the wind chill (HvA & KuiperCompagnons, n.d.). Guidelines created by Kluck et al. (2020) recommend a minimum shade of 40% on important walking areas to reach essential functions. Furthermore 30% shade is recommended on walking routes in neighbourhouds (Kluck et al., 2020). However, too much shadow is not desirable for the quality of urban life. Furthermore, it can hinder the ability of biodiversity to grow in too shady urban areas.

Shadow measures can be implemented at different scales as shown in Figure 7.7. Shadow rich urban forest or shaded squares can be created on a neighborhood and regional scale. These spaces form nice hideaways to escape from overheated urban areas. At street-scale, sheets or pergolas are effective measures to create (temporary) shadow. An advantage of removable shading facilities is that they can be removed in the night, allowing the saved heat to leave in the soil and other surfaces. In addition, temporary shading facilities can be removed in colder periods when there are few warm hours of sunshine, then sunlight is much appreciated. On building-scale, most of the shadow is created by buildings themselves. However, trees can be more effective because they not only provide shade, but also contribute to evaporation cooling of air temperature (HvA & KuiperCompagnons, n.d).

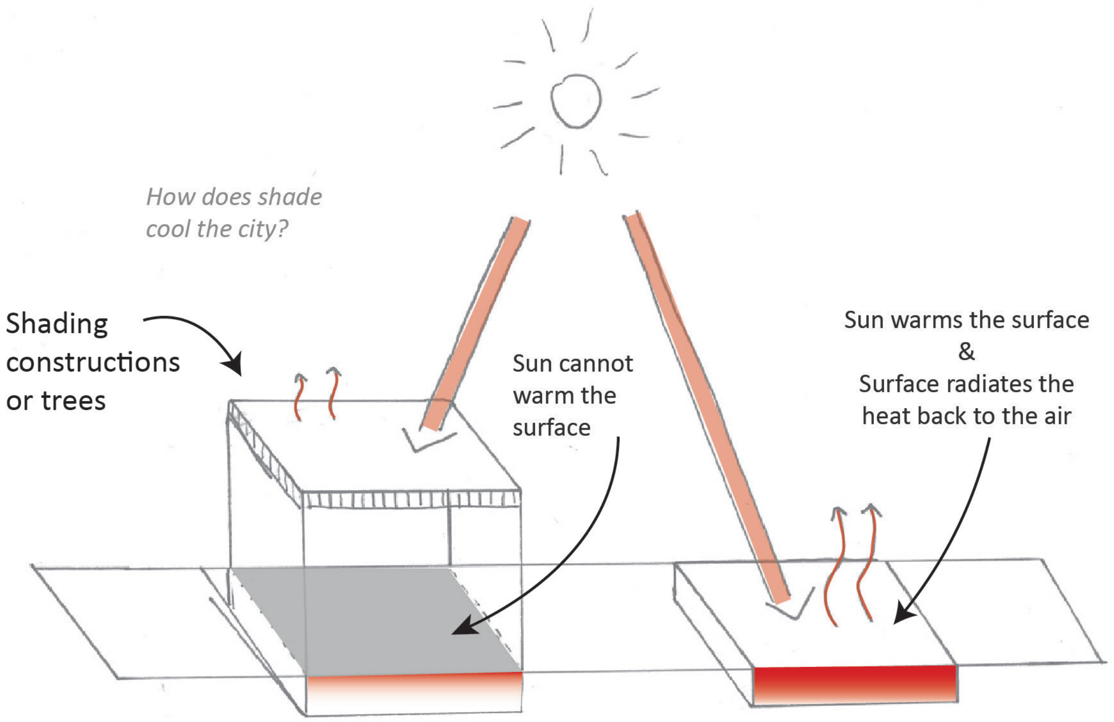


Figure 7.6. Shading Principle.

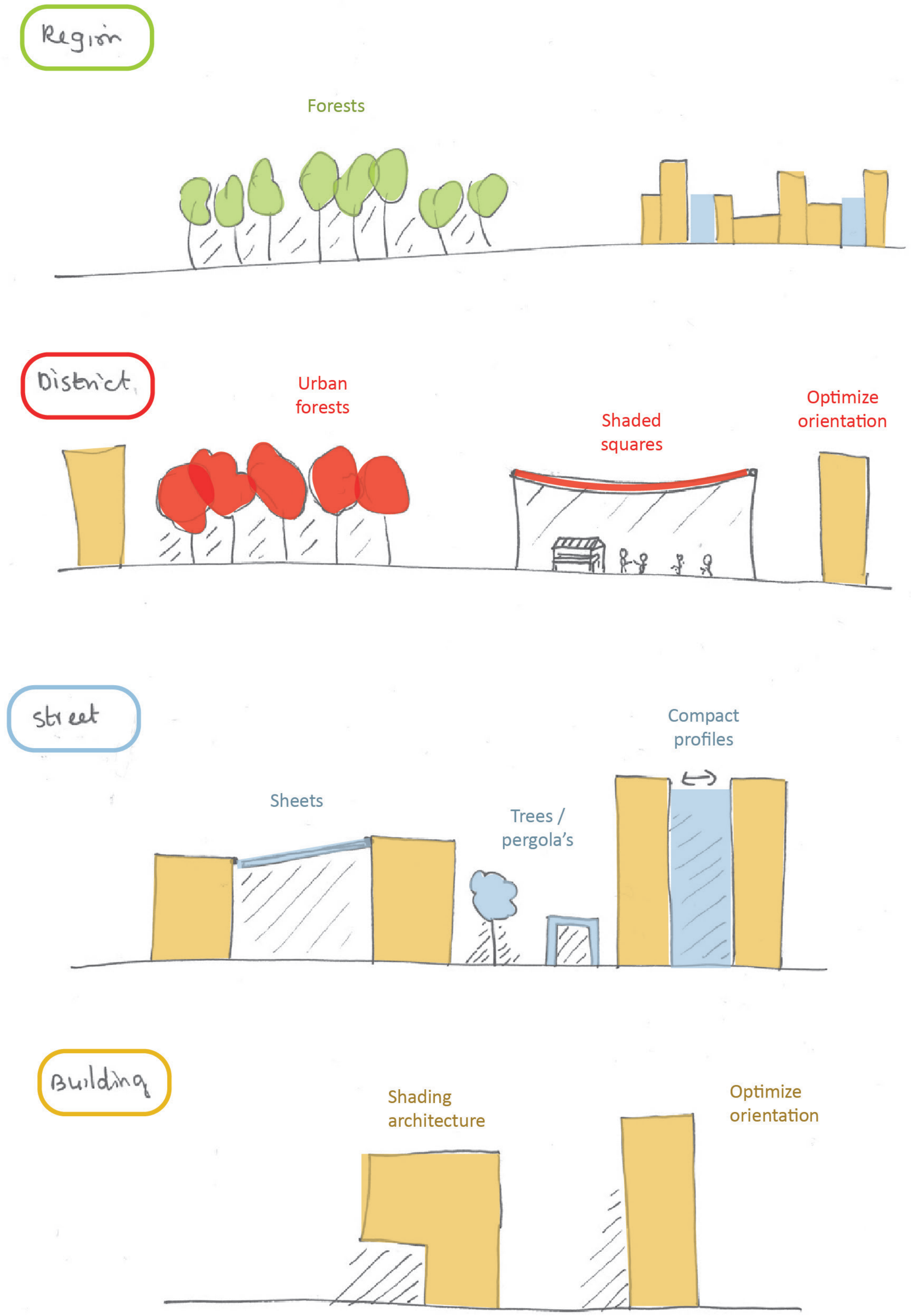


Figure 7.7. Shading measures through 4 scales.

7.1.3 Evaporation

The evaporation principle is schematized in Figure 7.8. Evaporation is the transition from the liquid phase (water/ rainfall) to the gaseous phase. This transition costs energy. The same energy that is used for evaporation (LE) cannot be used for heating up the air (H) or the soil (G). Evaporative cooling is strongest during the day because transpiration (evaporation within plants) is influenced by the incoming solar radiation. This solar radiation absorbed by plants leaves less energy to heat the air (H) or urban surfaces (G) (HvA & KuiperCompagnons, n.d.).

The amount of evaporation tends to be lower in dense urban areas, because water runs off into drainage systems, rather than being absorbed by soils and plants from which it later can evaporate. Kluck et al. (2020) recommend a percentage of green per neighborhood for evaporative cooling. This percentage depends on the type of the neighborhood. For example, in urban high-rise centers 20-40% vegetation is recommended (Kluck et al., 2020). However, during periods of drought, the large water requirement of vegetation is not desirable, the vegetation can then dry out. Another concern is that if it gets too hot, evaporation can stop.

The evaporative area of cities can be increased on different scales. In general, as much as possible green and water bodies can be created. The variety of measures is shown

in Figure 7.9. Connected green-blue networks can be created at regional level. In addition, urban forests and parks, and water playgrounds can be developed.

The evaporative cooling effect of small water bodies is relatively small compared to larger blue and green structures. However, small-scale interventions can still lower local temperature and contribute to the quality of urban life through various social or aesthetic functionalities. At street level, fountains/wadis and grass verges can contribute to evaporative cooling. At the building level, effective measures can be green/water roofs and green facades.

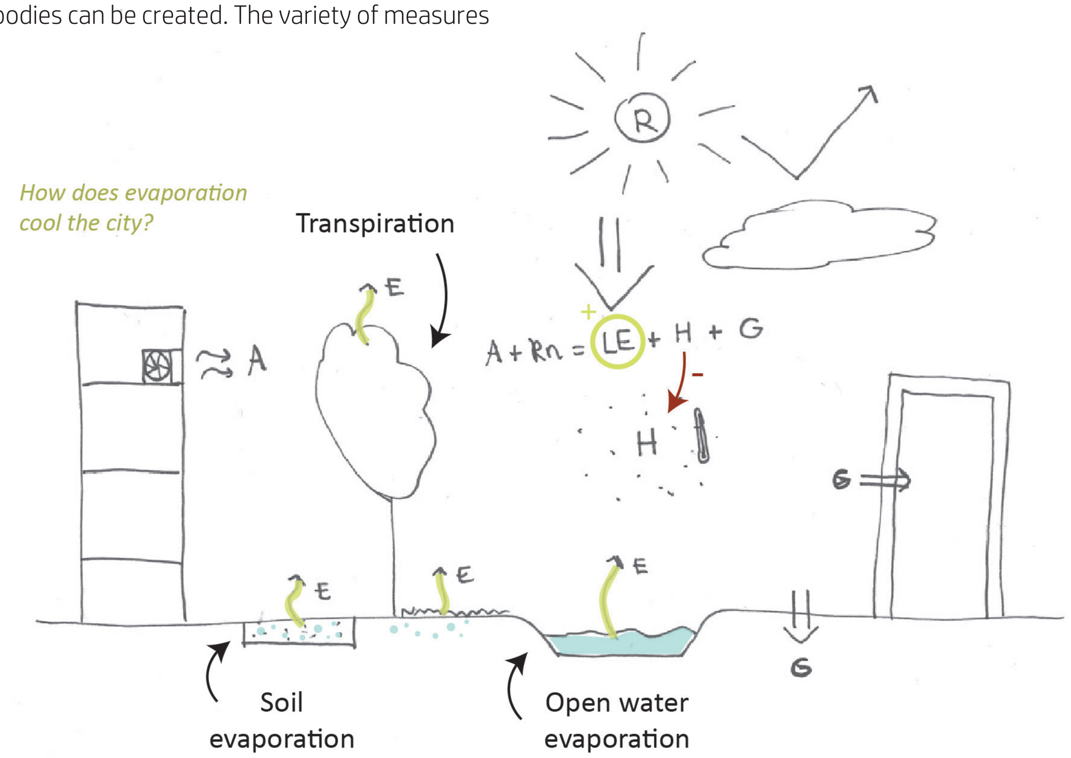


Figure 7.8. Evaporation Principle. With: R=Radiation, Rn=Netto radiation, A=Lateral heat exchange , H=Convective heat transfer to atmosphere, G=Ground heat flux, LE=Latent heat flux (energy for evaporation E).

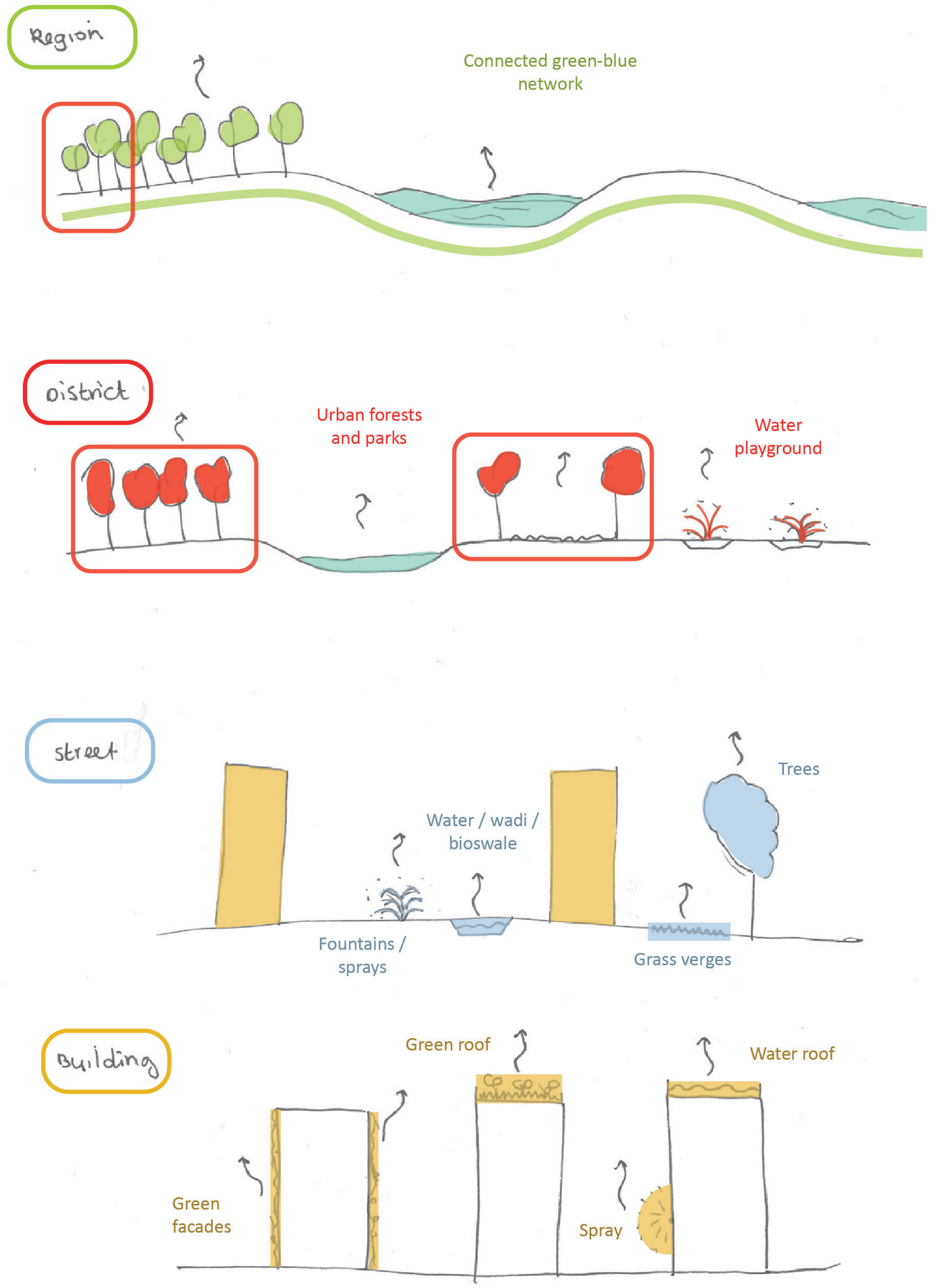


Figure 7.9. Evaporation measures through 4 scales. By author, 2021.

7.1.4 Materialization

Climate adaptation can also be realized through different types of building materials or building methods. There are various measures with different principles to mitigate impacts and to optimize the urban environment, e.g., in terms of thermal comfort and life quality. Some materialization principles are visualized in Figure 7.10.

For example, buildings with cool materials that have a low thermal conductivity. Another important cooling principle is albedo, also known as the reflection factor. It represents the percentage of solar radiation that the surface reflects. Urban surfaces have an average Albedo of only 5%, while rural areas have an average around 25% (Okay et al., 2017). Urban areas are also called heat islands, because of this temperature difference.

A variety of materialization measures at different scales are shown in Figure 7.11. At regional scale, zones of saline vegetation can be constructed. This saline vegetation is resistant to drought and salt water.

Furthermore, different types of pavements or streets can be created. For example, permeable parking lots or sidewalks. Or promoting open surfaces where feasible. These (semi-) permeable measures absorb more precipitation and allow it to flow to the groundwater table. Albedo measures can be implemented typically on asmall-scale. The albedo of urban areas can be increased on horizontal surfaces such as roofs and streets. (HvA & KuiperCompagnons, n.d.).

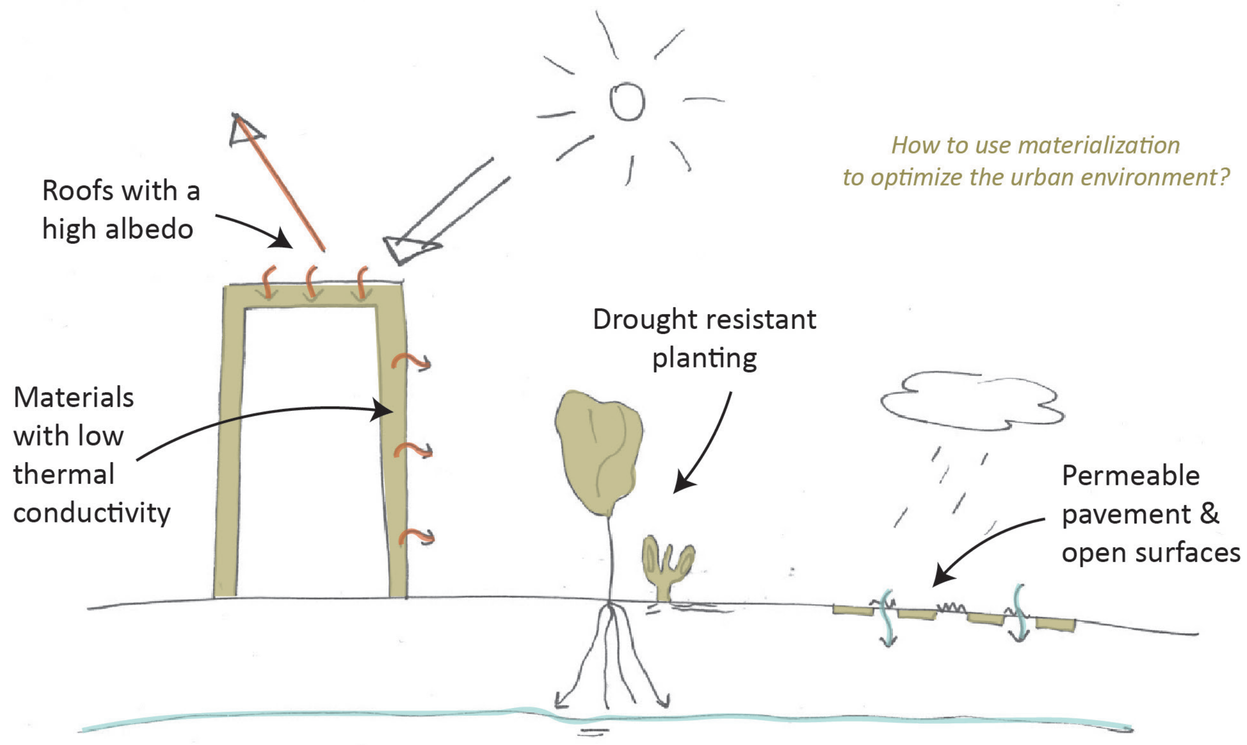


Figure 7.10. Materialization Principle.

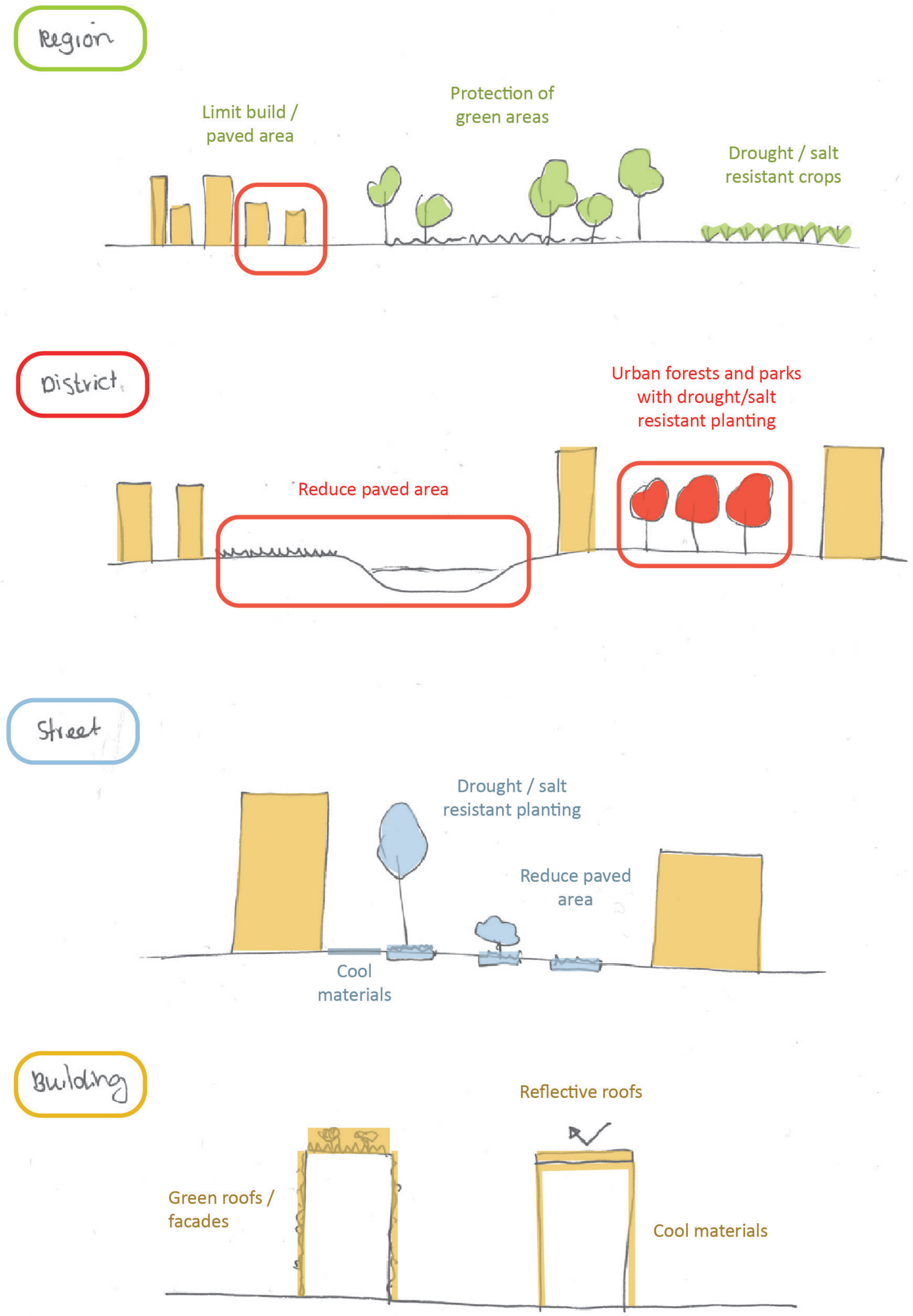


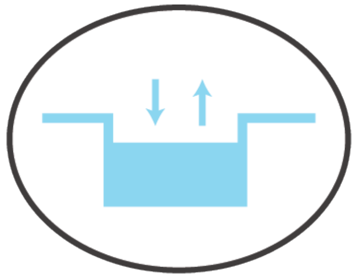
Figure 7.11. Materialization measures through 4 scales. By author, 2021.

7.1.5 Storage

Water storage is a good measure in case of heavy rainfall and to slow down the discharge of rainwater into the drainage system. Traditionally, the Netherlands built dikes against water and designed the water systems for rapid drainage of rainwater. However, this vision has changed from raising (river) dikes and increasing dimensions of drain pumps to other types of measures. Storage is important to balance out the water availability in wet and dry periods. It is therefore important to balance the storage volumes to connect these wet and dry periods. A simplified principle of water storage is shown in Figure 7.12.

Water storage is becoming increasingly important in densely populated urban areas. Especially because the water systems have to be relieved, because they can no longer handle the more heavy rainfalls. However, water storage typically requires space and space is scarce in the Netherlands.

Water storage can be realized on different scales, as shown in Figure 7.13. On a regional scale, water can be stored in retention polders or urban wetlands to relieve the river systems. On a smaller scale, urban parks and large underground water buffers can be created at district level.



Wadis and different sizes of water basins/crates/storages can be implemented on a street and building scale to collect rainwater. Moreover, a lot can be achieved with the height strategy of urban street profiles. For example, some streets can be used temporarily as water storage. In addition, water buffers can be created under roads.

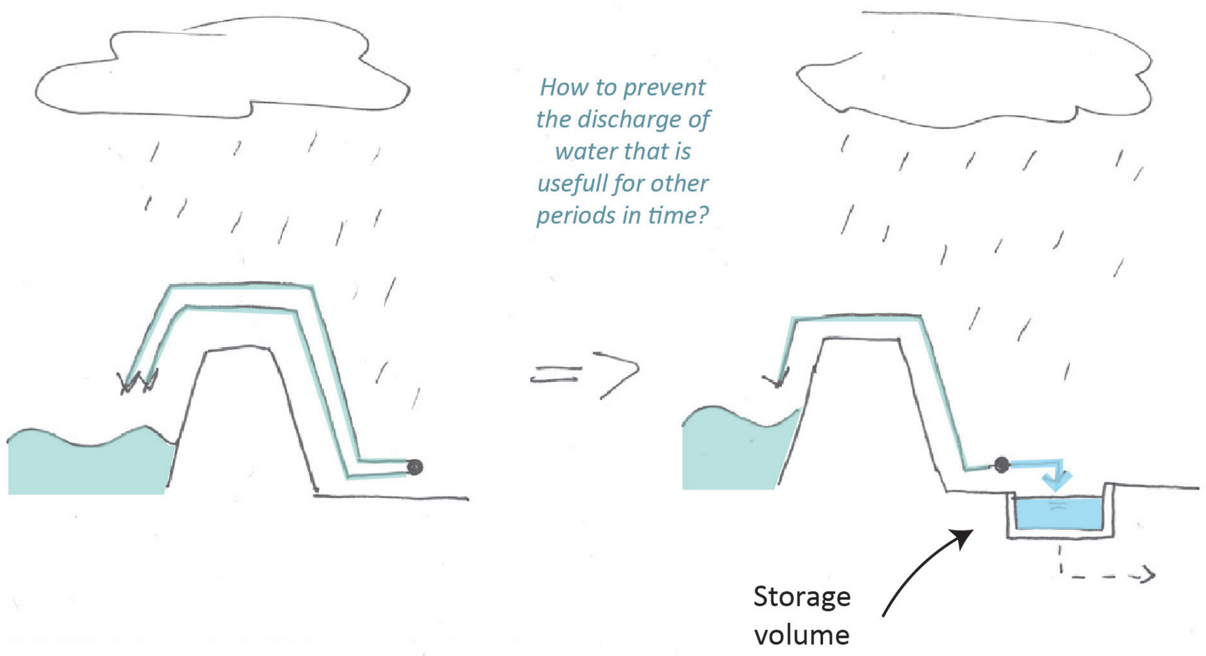


Figure 7.12. Storage Principle.

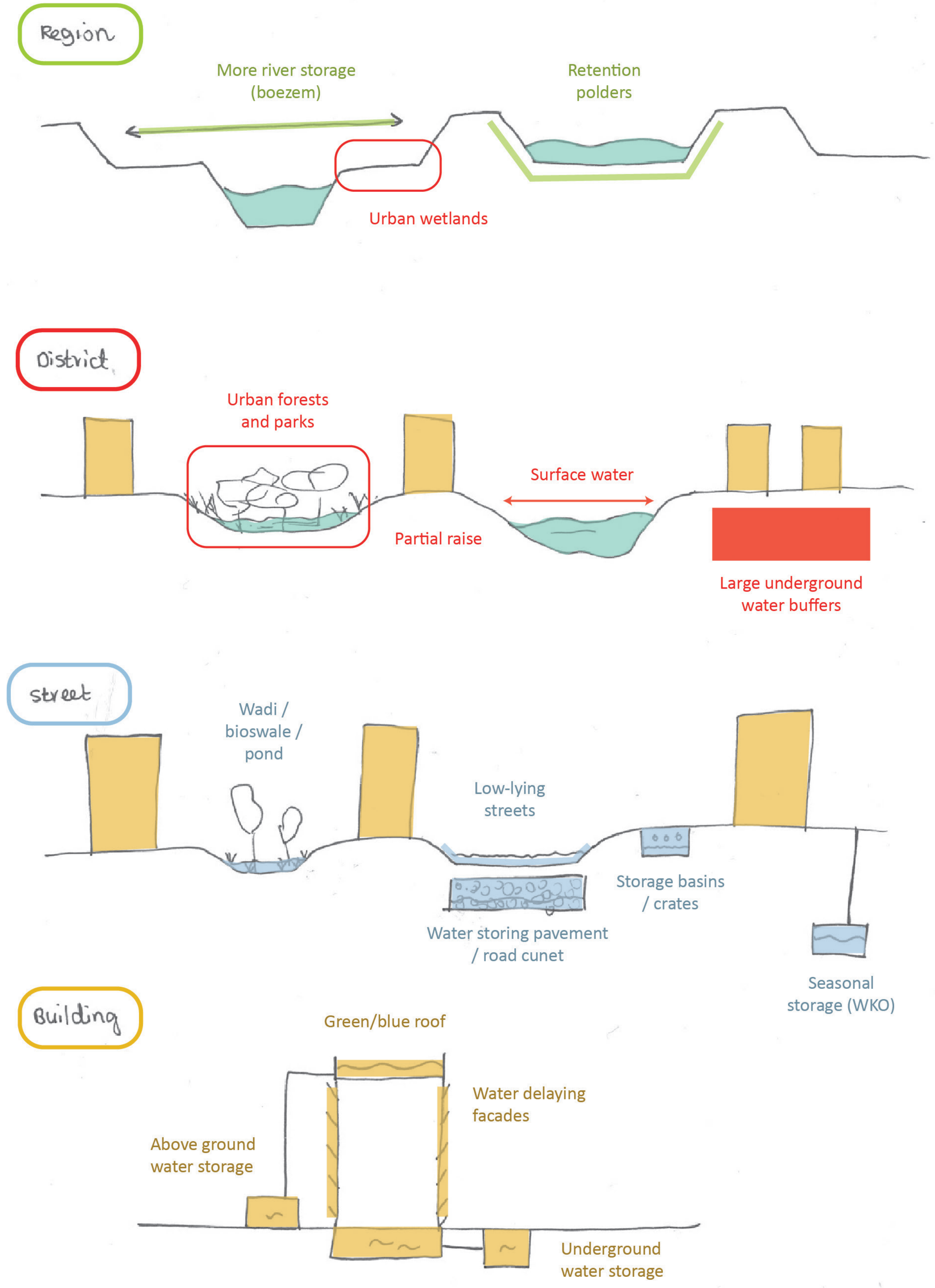
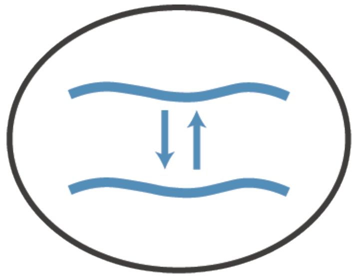


Figure 7.13. Storage measures through 4 scales. By author, 2021.

7.1.6 Flexible Waterlevels

Flexible water levels can be used as an adaptive principle to cope with different (more intense) climate conditions. In Netherlands there are often fixed water levels. But it is becoming increasingly difficult to maintain fixed levels in changing conditions. Flexible water levels can offers some advantages as illustrated in Figure 7.14.



On the one hand, the water levels can be raised if a dry period is expected, so that the soil and plants dry out less quickly. On the other hand, the water level can be lowered if a wet period is expected. In that case, the groundwater level can be dropped, reducing the risk of pluvial flooding after a period of intense rainfall.

Flexible water level management can be carried out at different scale levels, as shown in Figure 7.15. It is now being investigated how the level of the North Sea Canal can be made more flexible in the future. However, the dikes and areas must be designed accordingly. The urban designs can change on smaller scale, at street and building level.

In the public space in the surrounding of water, for example, stair types of quays/slopes can be realized. Flexible water management can also have consequences for the use of buildings, as they have to be designed to function with different water levels.

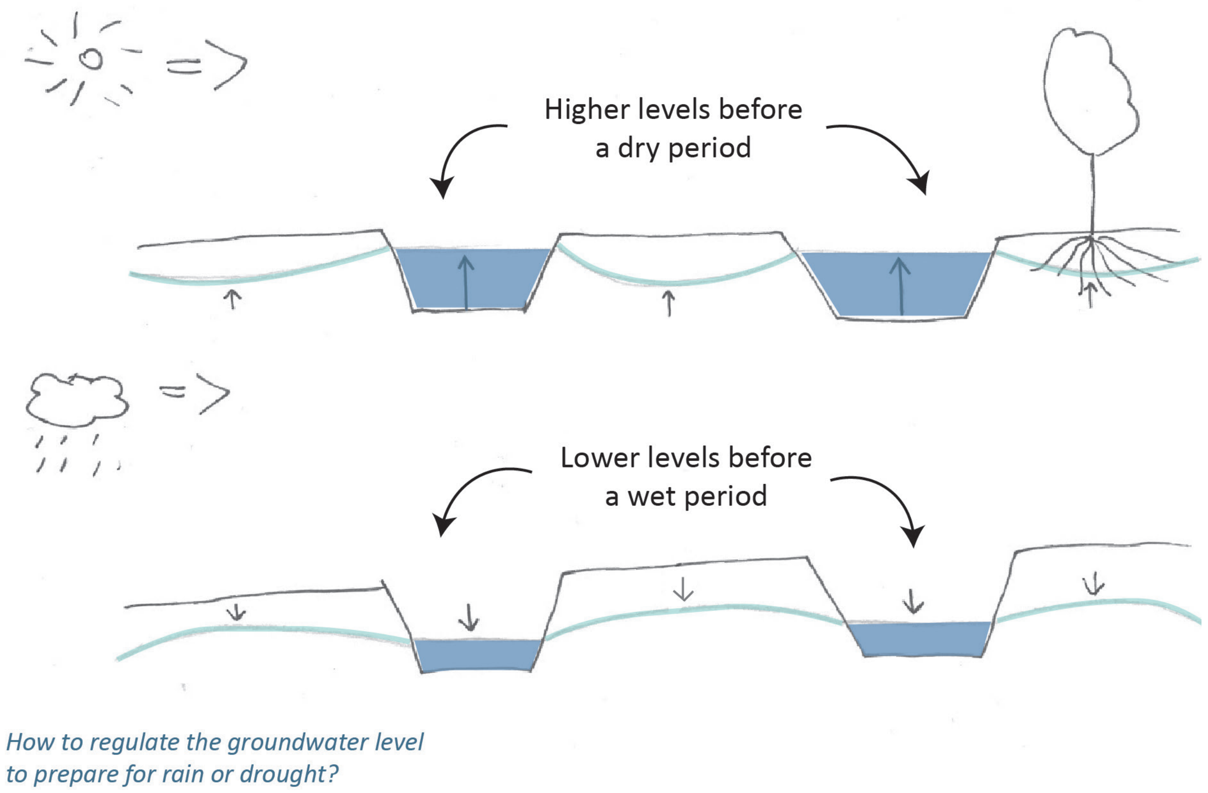


Figure 7.14. Flexible Waterlevels Principle.

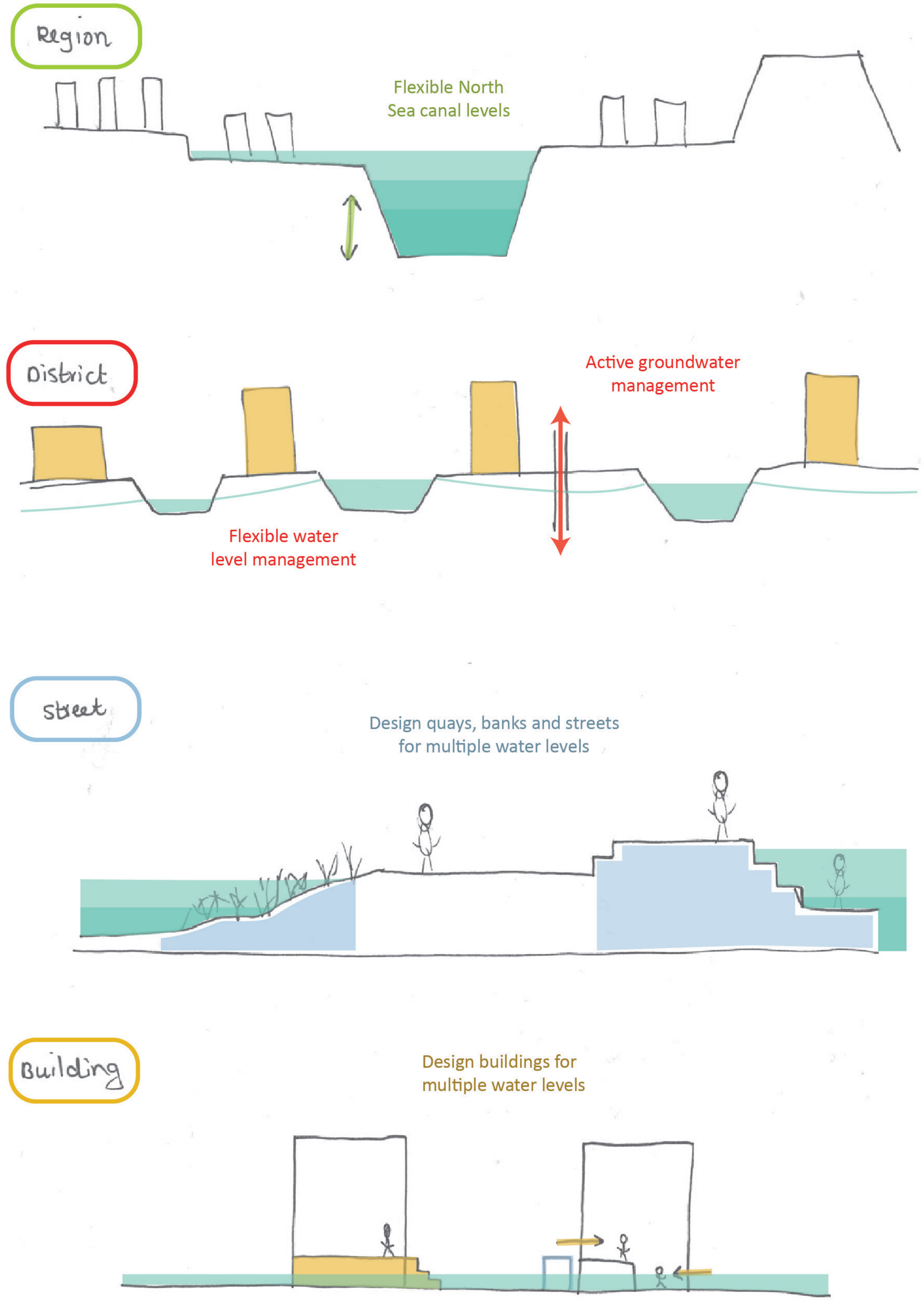


Figure 7.15. Flexible waterlevels measures through 4 scales. By author, 2021.

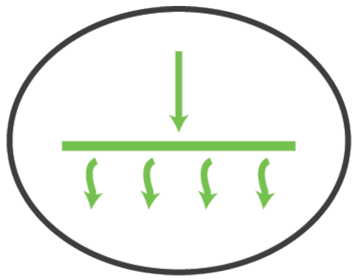
7. Adaptation Measures

7.1.7 Infiltration

Infiltration is the principle that water on the ground surface penetrates the soil below the surface. Infiltration mainly depends on the surface layer and the soil type, as shown in Figure 7.16.

When the surfaces is sealed, the water drains quickly and has no time to infiltrate into the soil. The water then often ends up in the sewage system and not in the groundwater. An open surface makes infiltration easier and if the rainfall intensity is too high, water pools form more easily from which the water can infiltrate later. In addition, the soil type is important. Sand has a high infiltration capacity, but this also means that water drains faster towards the groundwater table. The soil itself stays drier (for plants). Clay and peat have lower infiltration capacities, but they do buffer water, which can be beneficial for (certain types of) plants.

The infiltration capacity can be increased on different scales as shown in the overview of Figure 7.17. At regional scale and district level, paved and dense built areas can be reduced.



Furthermore, parts of land can be elevated and thereby improving ground for infiltration. Deep infiltration can be used to store water a longer period of time (seasonal storage). On street scale, paved areas can be reduced and the soil can be improved for infiltration. Rainwater from the roofs can be disconnected from the sewer system and locally infiltrated into the soil.

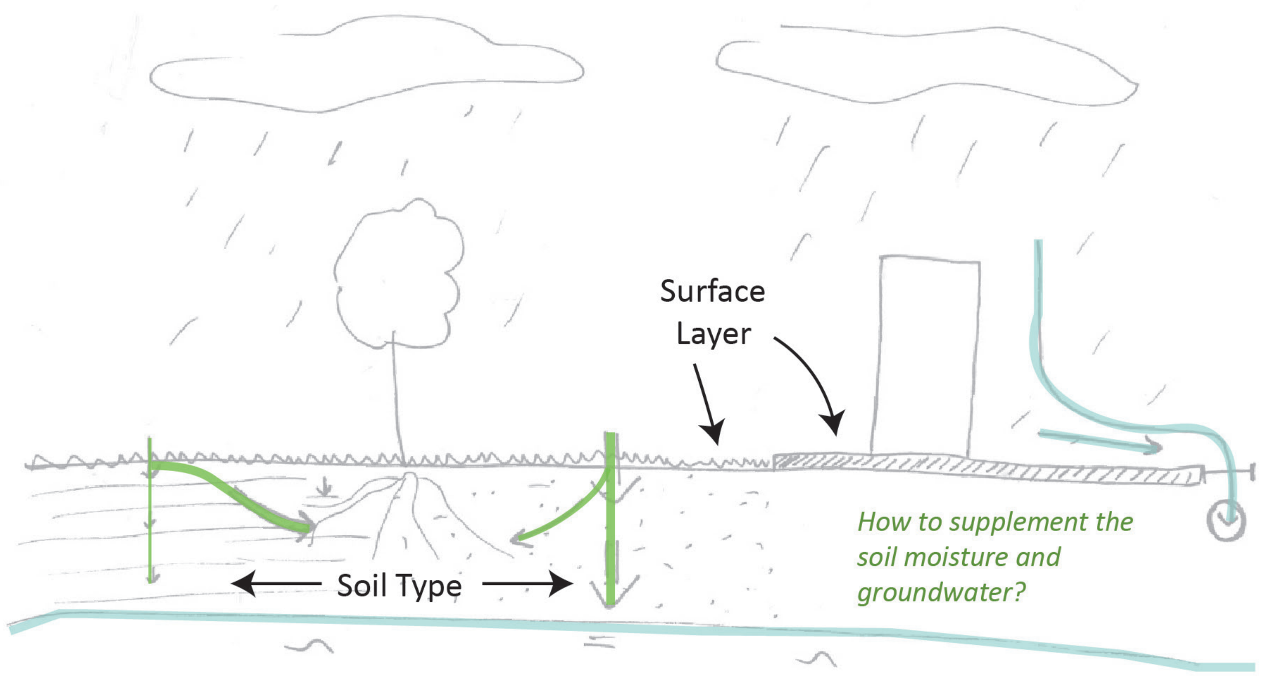


Figure 7.16. Infiltration Principle.

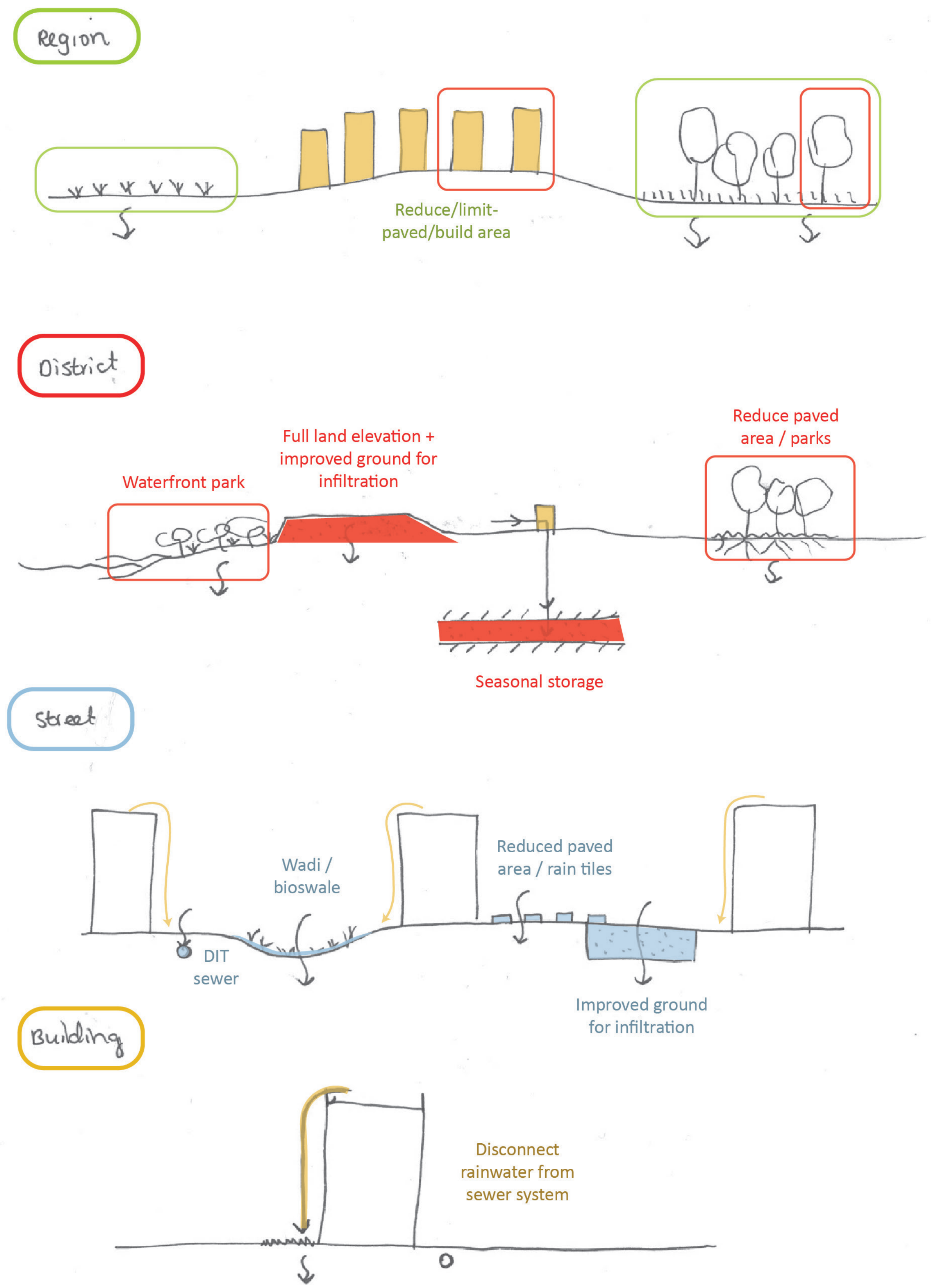


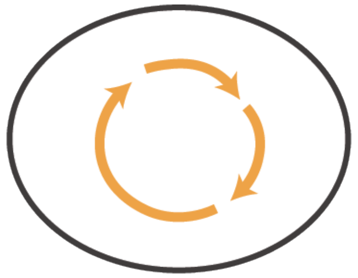
Figure 7.17. Shading measures through 4 scales. By author, 2021.

7.1.8 Re-use

The principle of re-use is about the capturing, the storing, and the use of water. Rainwater, but also grey household water can be filtered and redistributed for use. Figure 7.18 shows this re-use principle.

The figure shows how rainfall can be filtered and stored in underground water storages. This filtered water can then be redistributed, for example to use in houses for the flushing of toilets, or to water the plants in the gardens. This requires separate water systems, one for filtered rainwater and one for drinkable water.

Measures can be implemented at different scales as shown in Figure 7.19. On the regional scale drinking water is produced and sewage treatment plants purify the wastewater.



However, also on smaller scales, re-use measures can be implemented. On the district scale, a central circular water system can be designed to purify the water from the area. At street and building level, rainwater can be locally treated for re-use in households or public areas.

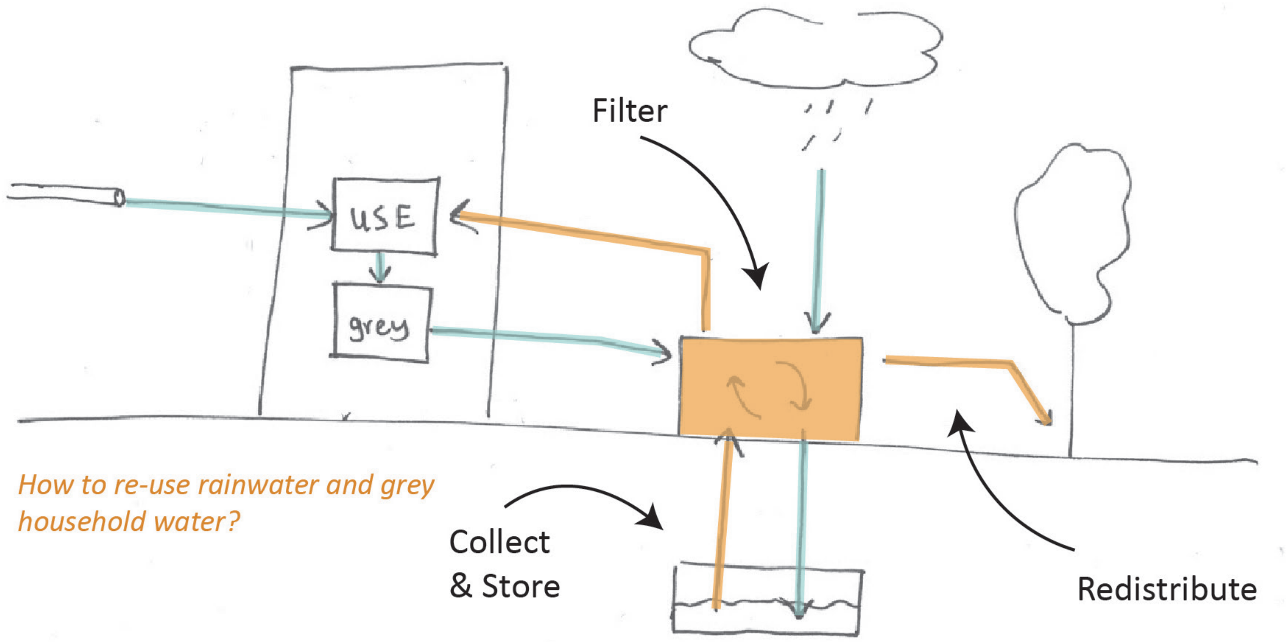


Figure 7.18. Re-use Principle.

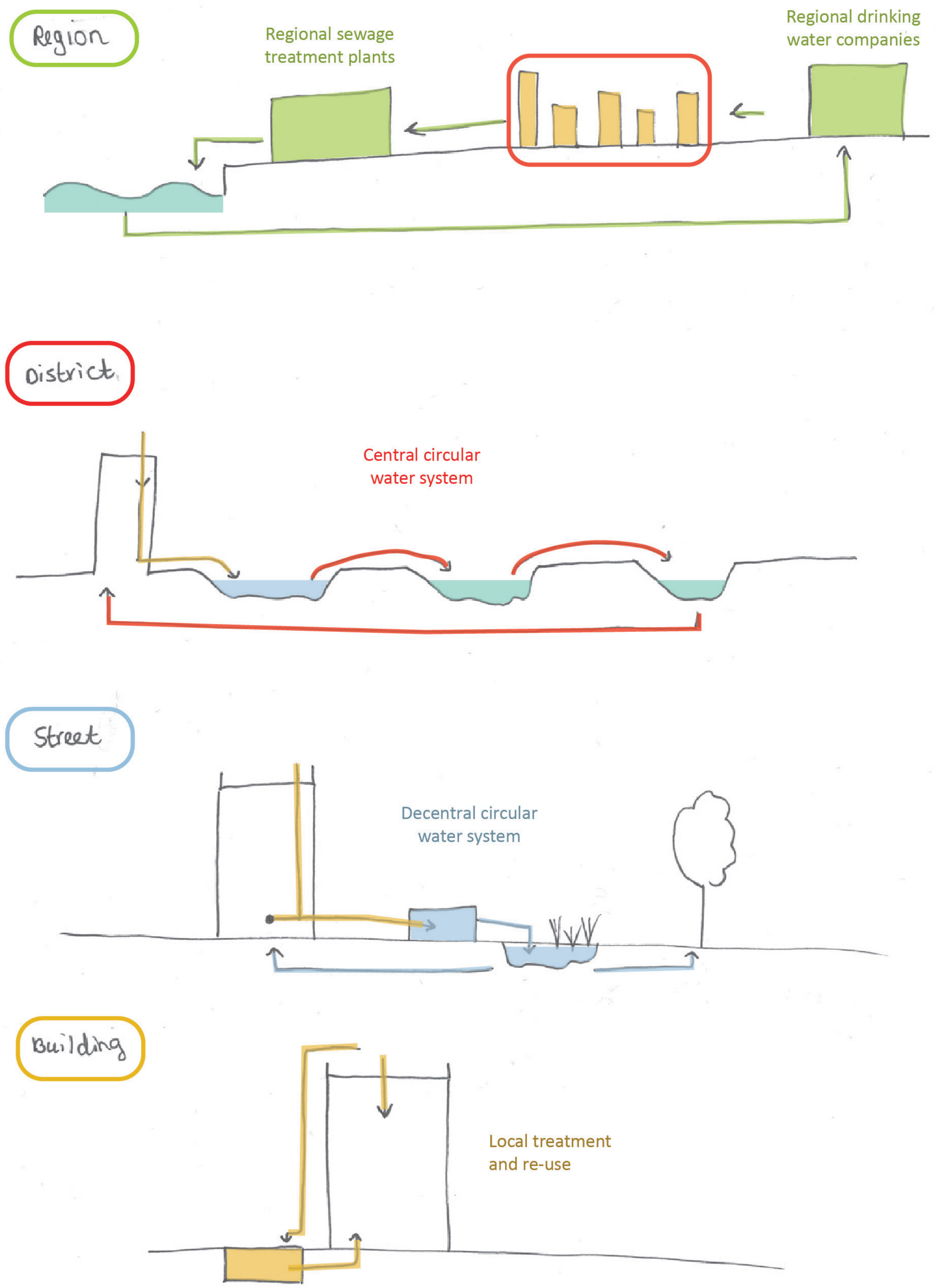


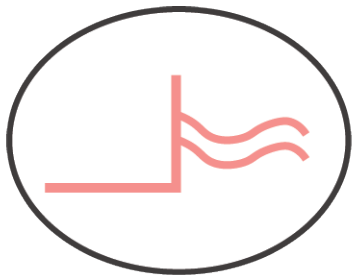
Figure 7.19. Re-use measures through 4 scales. By author, 2021.

7.1.9 Protection

Protection is the first layer of multi-layer safety and includes measures that try to reduce the risk of a flood. Such as dunes, dikes and dams. Protection is of great importance to the Netherlands, since a large part of the country is below sea level. The dikes and dunes protect the land against flooding and excess water is discharged into the rivers and sea with pumps.

Figure 7.20 shows the main concept of the Dutch protection principle, with dunes along the coast to protect the land from the sea, and dikes along the rivers.

Figure 7.21 shows how protection can be implemented at different scales. On a regional scale, the dikes and dunes form closed rings that protect a certain area. Districts located in such a ring are protected by a dike. Another form of protection on district scale is raising the area (integral raise), so that the water depths remain low in the event of a flood. On a street scale, temporary or flexible measures are especially recommended in order not to limit the function of the street too much in normal situations.



For example, deployable bulkheads can be placed. On a building scale, protection can also be incorporated. For example, the building can have a minimum floor level, so that the water (up to certain depths) does not affect important functions. A building can also be made dry-proof, so that water cannot enter during a flood.

The disadvantage of the protection measures is that it gives a strong sense of safety and can therefore prevent people from preparing themselves or their belongings for a possible flood. In addition, protection measures are very robust, but not very flexible.

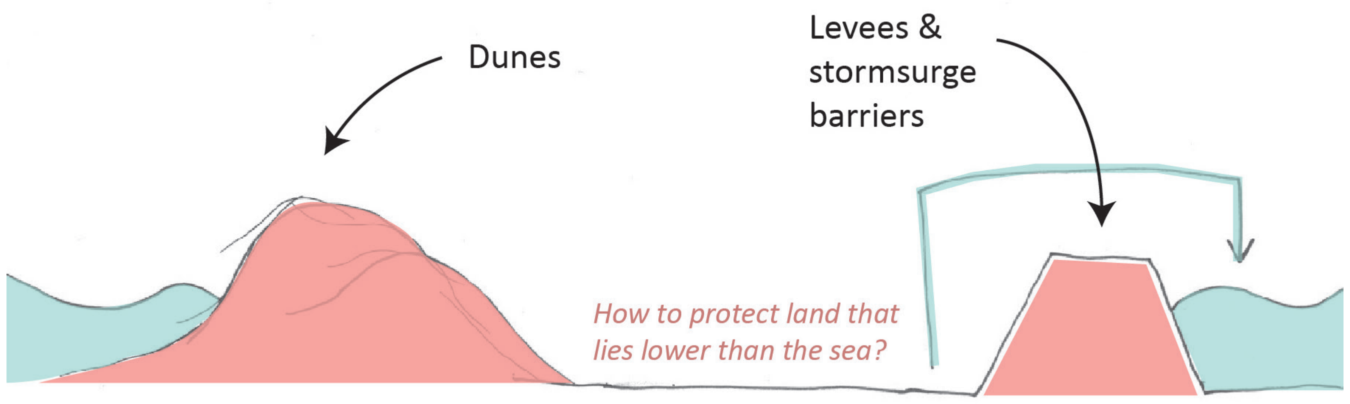


Figure 7.20. Protection Principle.

7. Adaptation Measures

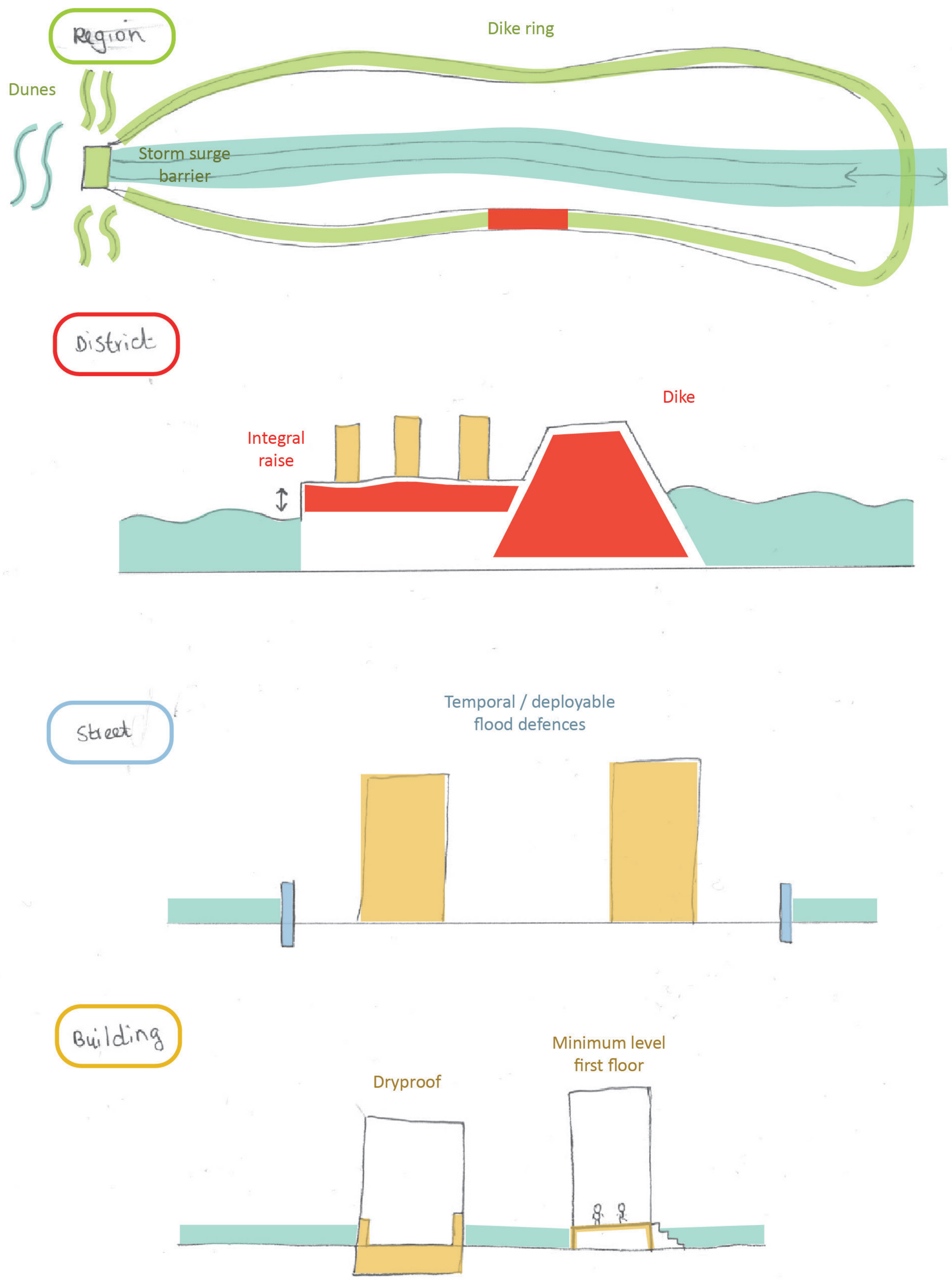


Figure 7.21. Protection measures through 4 scales. By author, 2021.

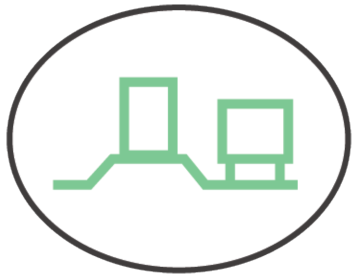
7. Adaptation Measures

7.1.10 Robust Urban Design

Robust urban design is the second layer of multi-layer safety and aims to prevent and limit damage if the first layer of protection fails. The city is designed in such a way that the consequences of a flood are limited.

Figure 7.22 shows the robust urban design principle. This concerns, for example, the protection of vital infrastructure, adapted construction, compartmentalisation and risk zoning (STOWA, n.d.). Vital functions such as energy networks, for example, can be installed higher up, making them less likely to fail and easier to recover. Vulnerable functions are, for example, hospitals, retirement homes, or schools. These functions can also be protected by, placing them in the higher parts of an area or on higher floors of a building. In addition, buildings can also be designed to withstand a flood.

Figure 7.23 shows possible measures of robust urban design at different scales. On a regional scale, robust urban design is mainly related to the location choice. For example, buildings on high ground are a lot safer than in deep polders.



A height strategy can be applied to the scale of the district and the street. The most important or most vulnerable functions are placed higher, and functions such as parks can be flooded in an emergency. Buildings can be built robust (for example on piles), flexible (for example a plinth that can be raised), or floating. This allows them to handle higher water levels.

The downside of a robust urban design can be that it sometimes requires extra investments, which may never be recovered without extensive flooding. Therefore it can be difficult to argue for robust design, if there is also a lot of confidence in the protection layer.

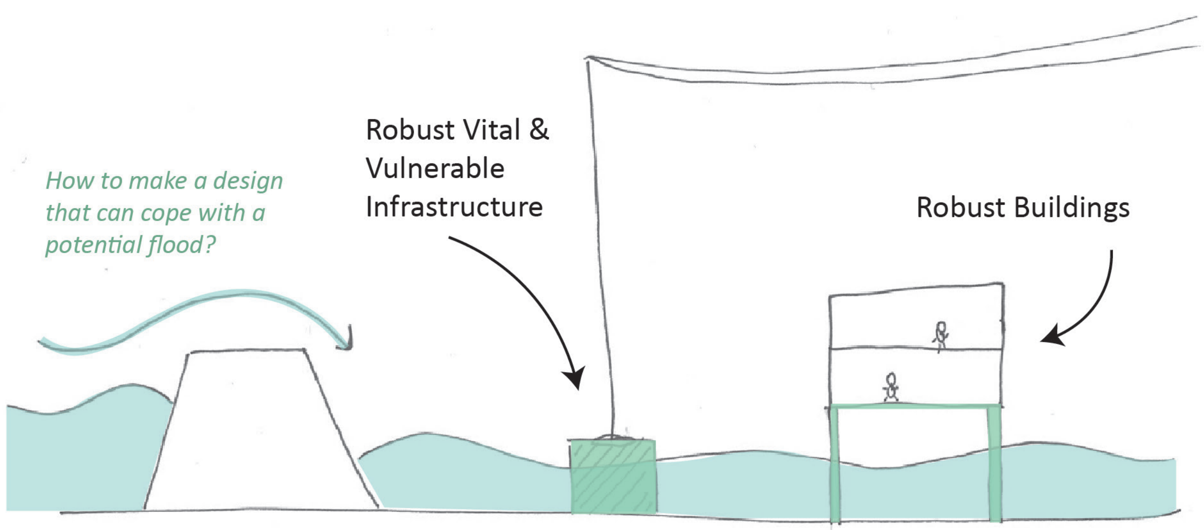


Figure 7.22. Robust urban design Principle.

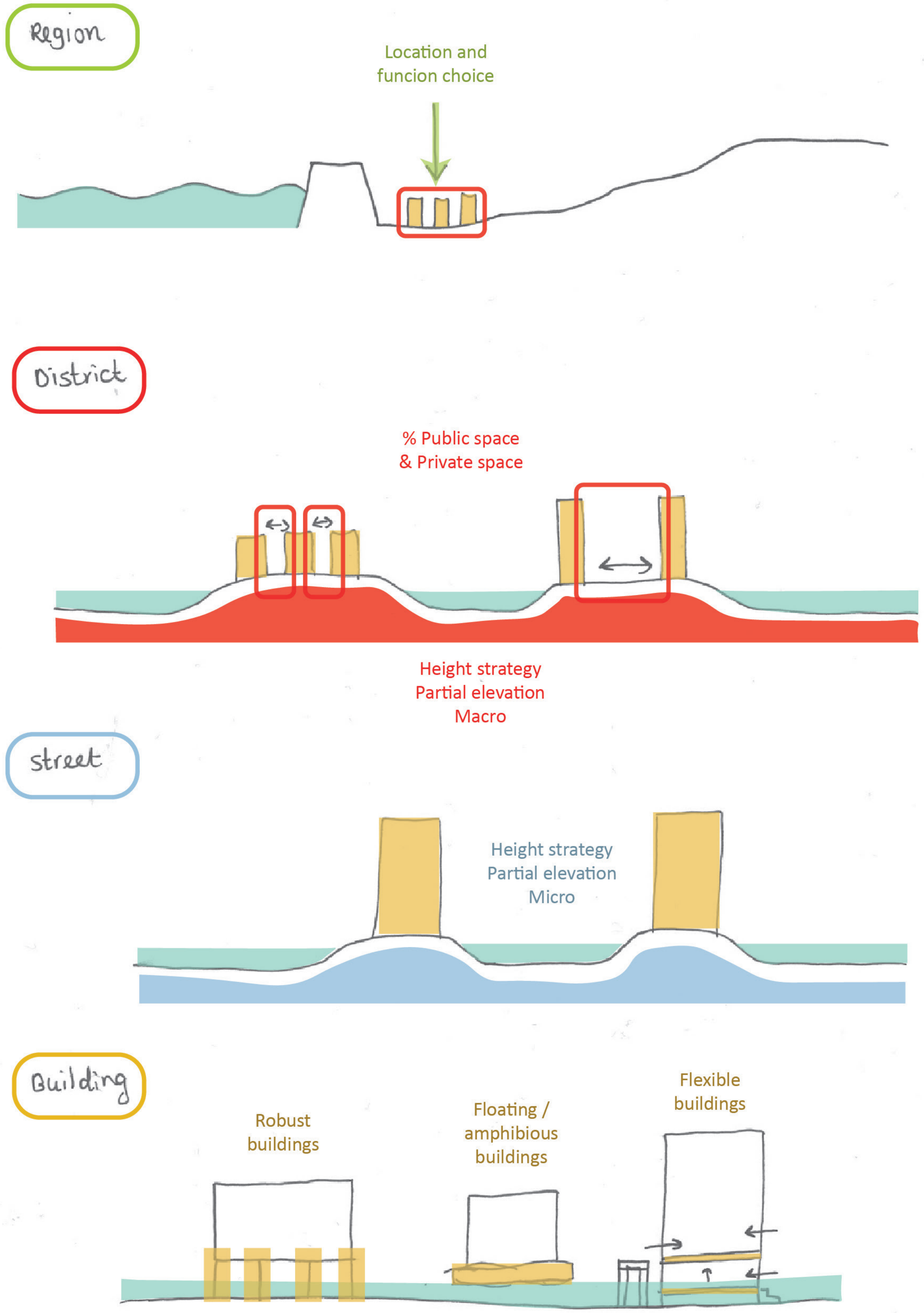


Figure 7.23. Robust urban design measures through 4 scales. By author, 2021.

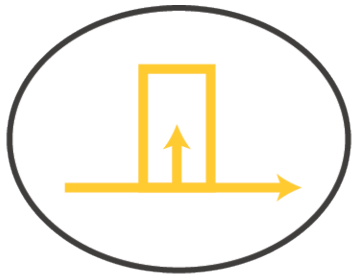
7. Adaptation Measures

7.1.11 Evacuation

Evacuation is an important part of disaster management, the third layer of multi-level safety. Measures can be implemented that improve disaster management during flooding (STOWA, n.d.). Evacuation ensures that lives can be saved and can take place both horizontally (to another place) and vertically (to higher altitudes).

Figure 7.24 shows the evacuation principle, with evacuation routes being most important for horizontal evacuation and shelters for vertical evacuation.

Figure 7.25 shows what an integral evacuation plan can look like conceptually. On a regional scale, this mainly involves facilitating horizontal evacuation from low-lying areas such as polders to higher-lying areas. At the district scale, a network of main evacuation routes, elevated streets and local shelters can be established.



As soon as the area is flooded, there are a number of (public) buildings in each district in which vertical evacuation can take place. These buildings must be accessible to emergency services. Shelters can therefore be designated on a building scale and attention must be paid to, for example, roof access. Buildings in the higher streets can be connected at height to surrounding buildings that are lower situated.

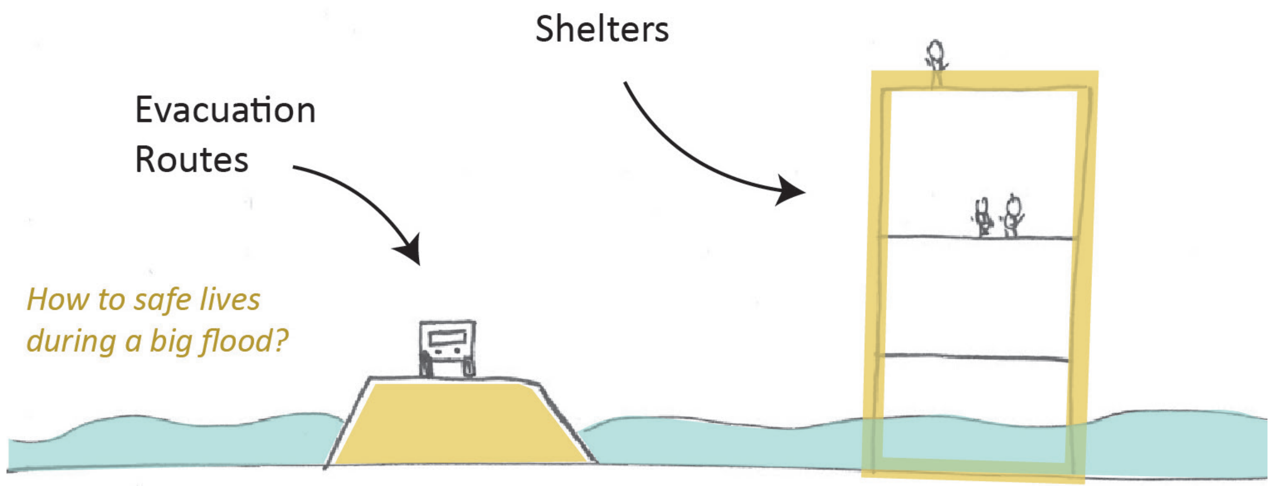


Figure 7.24. Evacuation Principle.

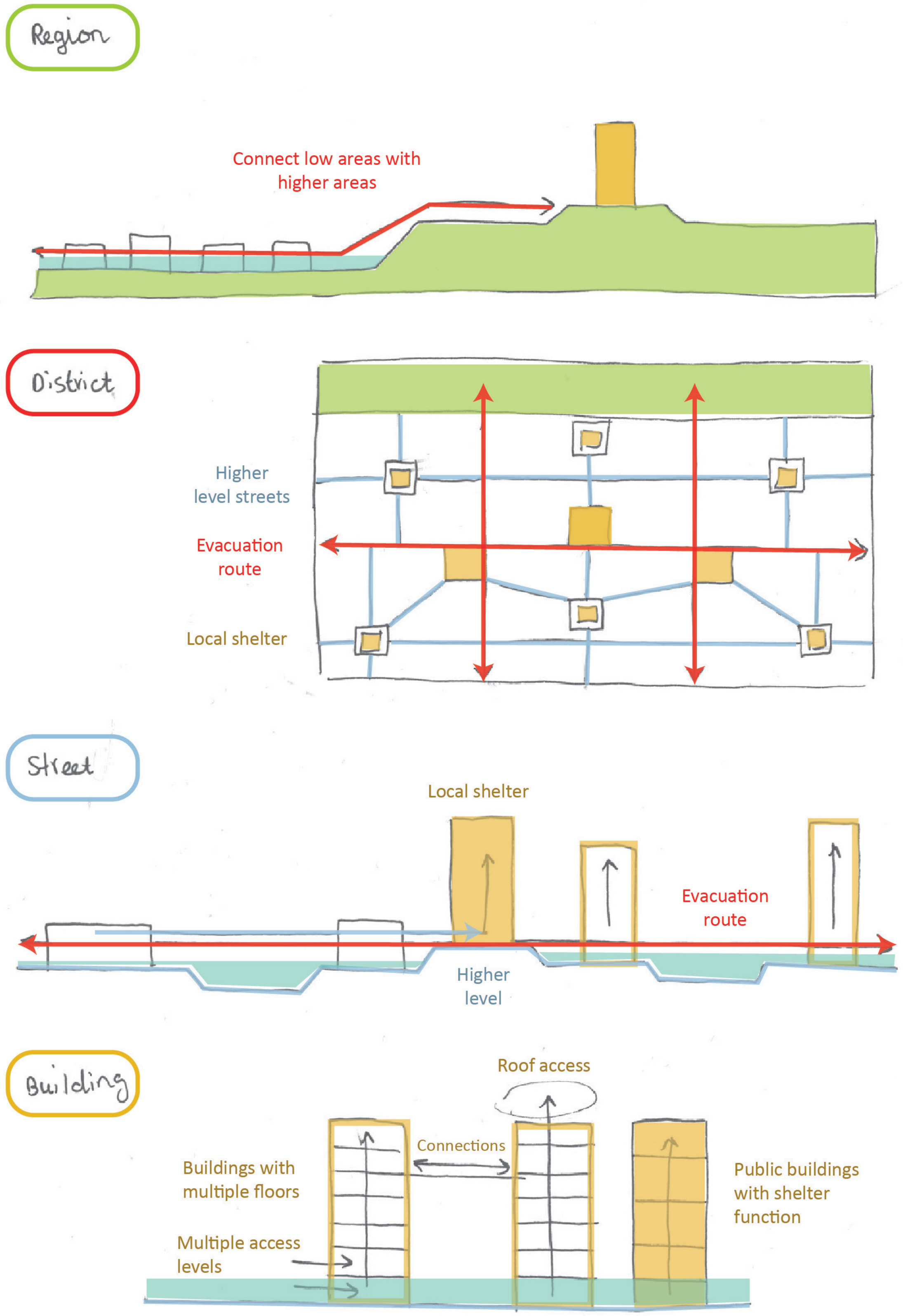


Figure 7.25. Evacuation measures through 4 scales.

7.2 DESIGN LAYERS

For a climate adaptive design, multiple design layers must be taken into account. In this research, the design layers are derived from the Maatregelenmatrix, which was part of the sub-program 'New Construction and Restructuring' from the Delta Program (MWH, 2012). The matrix contains a long-list of climate adaptation measures, which are subdivided in clusters. The main clusters are used to define the design layers of this research. Figure 7.26 shows the design layers and the associated adaptation principles.

Soil
The soil layer is literally and figuratively the basis for all other design layers. The soil layer is strongly linked to the vegetation and water system layers, via the groundwater level and the soil storage capacity. Strong soil layers are required for the foundations of buildings and flood defences. Multiple adaptation principles are related to the soil layer. Robust urban design and evacuation (routes) can be achieved with a (partial) raise of the groundlevel. In addition, the soil type and layering (materialization of the soil) largely determine what is possible for infiltration and storage of water in the soil. The soil layer includes measures in the field of adjustment of the soil and subsoil, infiltration, the reduction or greening of paved areas, and height strategies.

Vegetation
The vegetation layer includes all greenery and nature in the area (in soil, water, and on buildings). This layer has strong links with the soil and watersystem layers, which are habitats for the vegetation. It also connects to urban design as parks and lanes are part of the urban grid, and vegetation can be placed on buildings. Vegetation is most related to the adaptation principles evaporation (evaporative cooling) and shading (trees). In addition, infiltration is promoted, since green areas have a higher infiltration capacity than paved areas. Vegetation can also be used to purify water (for re-use). The vegetation layer includes measures relating to the construction of greenery and nature, and to urban agriculture and crop choice.

Watersystem
The watersystem layer relates to the water storage and -discharge of the area. This includes open water and groundwater. The layer connects closely to the soil and vegetation layer, and can be connected to urban design (water storage in/on buildings). Flood defences

The design layers help to unravel the complex urban area and to explicitly take into account all layers for climate adaptation

can also influence the type of watersystem needed. The layer relates to the adaptation principles storage, flexible waterlevels and re-use. The layer includes measures in the field of waterstorage (in the water system and urban area), rainwater drainage, optimization of the water system, and water purification.

Flood Defences & Calamities
The layer of flood defences & calamities includes the constructions necessary to keep high water out of the area and to ensure the possibility for evacuation and accessibility for emergency vehicles. Elevated evacuation routes are in line with the soil layer (height strategy) and with spatial design (connect evacuation-routes to -shelters). The layer of flood defences and calamities mainly relates to the adaptation principles protection and evacuation.It includes measures relating to flood defence, the protection of vulnerable and vital functions, and the preparation for calamities.

Urban Design
The urban design layer is diverse and relates to the overall design of the public space and buildings. As described above, the layer could connect to all other layers. The adaptation principles ventilation and shading can be influenced by grid orientation and architectural rules. Buildings can also be part of systems for water storage and re-use. The adaptation principle robust urban design connects to the choice of building typologies, and some buildings can be arranged as shelters for evacuation. Finally, sprays can contribute to evaporation. The layer thus includes measures related to the area layout, building typologies, the promotion of wind circulation, the creation of shade, and cooling with sprays.

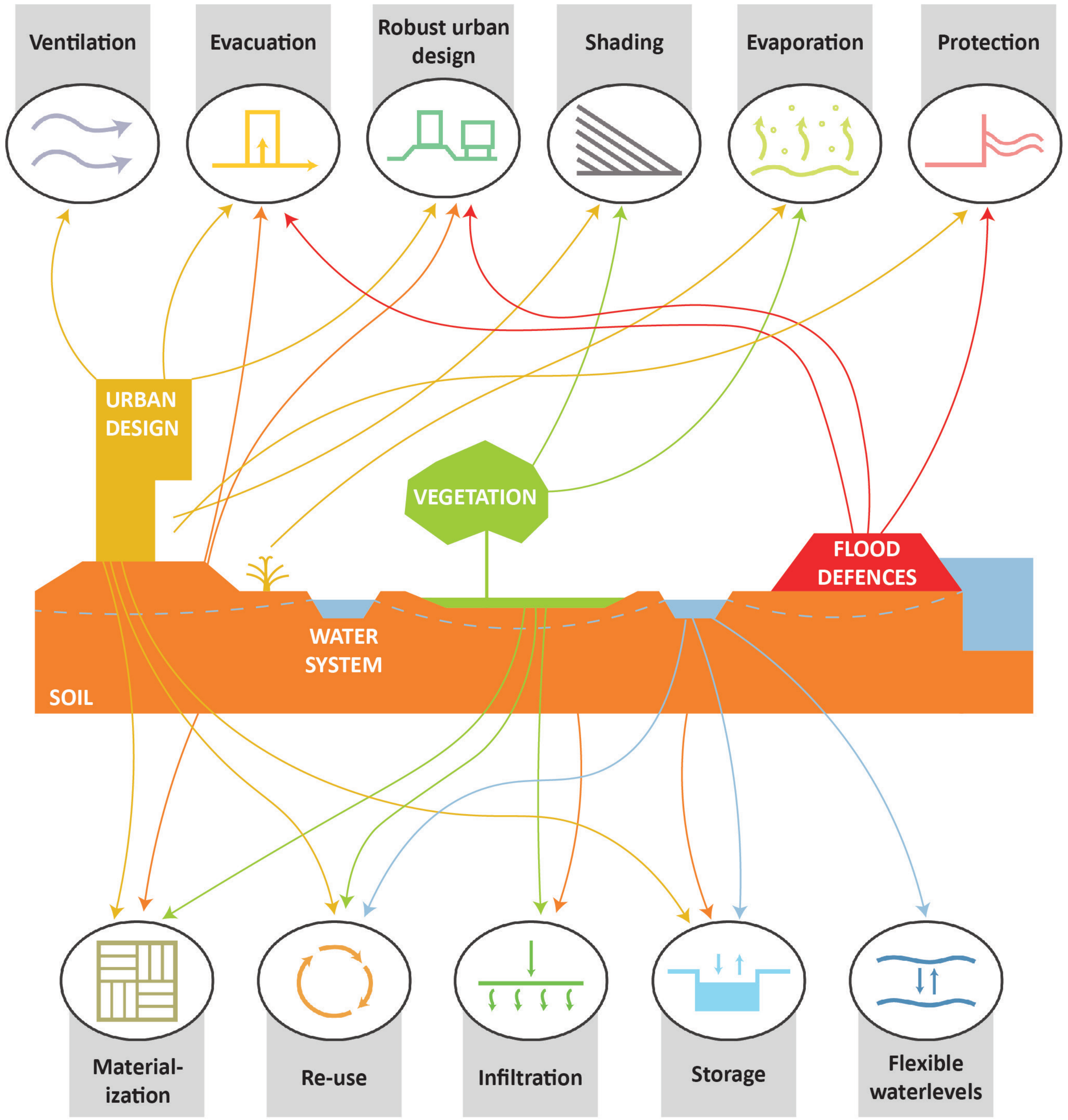


Figure 7.26. Design Layers and connection to Adaptation Principles.
The corresponding table can be found in Appendix 7.2.

Appendix 7.2
For more information about the design layers & Maatregelenmatrix

7. Adaptation Measures

7.3 ADAPTATION TILES

Many climate adaptation measures already exist, 155 climate adaptation measures are presented in the Measures Matrix (MWH, 2012). Because this number is too high to include them all, measures have been clustered for this study. In addition, only measures that are relevant to the Haven-Stad case are selected. For other locations, other relevant groupings and selections can be made.

For each selected adaptation measure, an adaptation tile is developed. The adaptation tile is a 'card' that summarizes the most important information about an adaptation measure. The collection of tiles can be used to take the first steps in developing adaptive pathways. For example, by placing cards one after the other that can follow each other in time. The information from the tiles is also used in Chapter 11, which zooms in on the governance implications of SAPP.

The adaptation tile is a 'card' which summarizes the most important information about an adaptation measure

Planning instruments can be classified into: Shaping instruments, regulatory instruments, stimulus instruments, and capacity building instruments. (Heurkens, Adams, & Hobma, 2015). Figure 7.27 explains these four instrument types. Heurkens, Adams & Hobma argue that it is the role of planners to connect these planning instruments, planning actions and market effects (Heurkens, Adams, & Hobma, 2015).

The final SAPP map can be used as an instrument for soft steering; shaping the decision context and bringing actors together. The adaptation tiles are more focused on the hard steering instruments that can be used for each measure; regulations and stimulations (investments). By the use of adaptation tiles, the SAPP approach brings together the four planning instrument types.

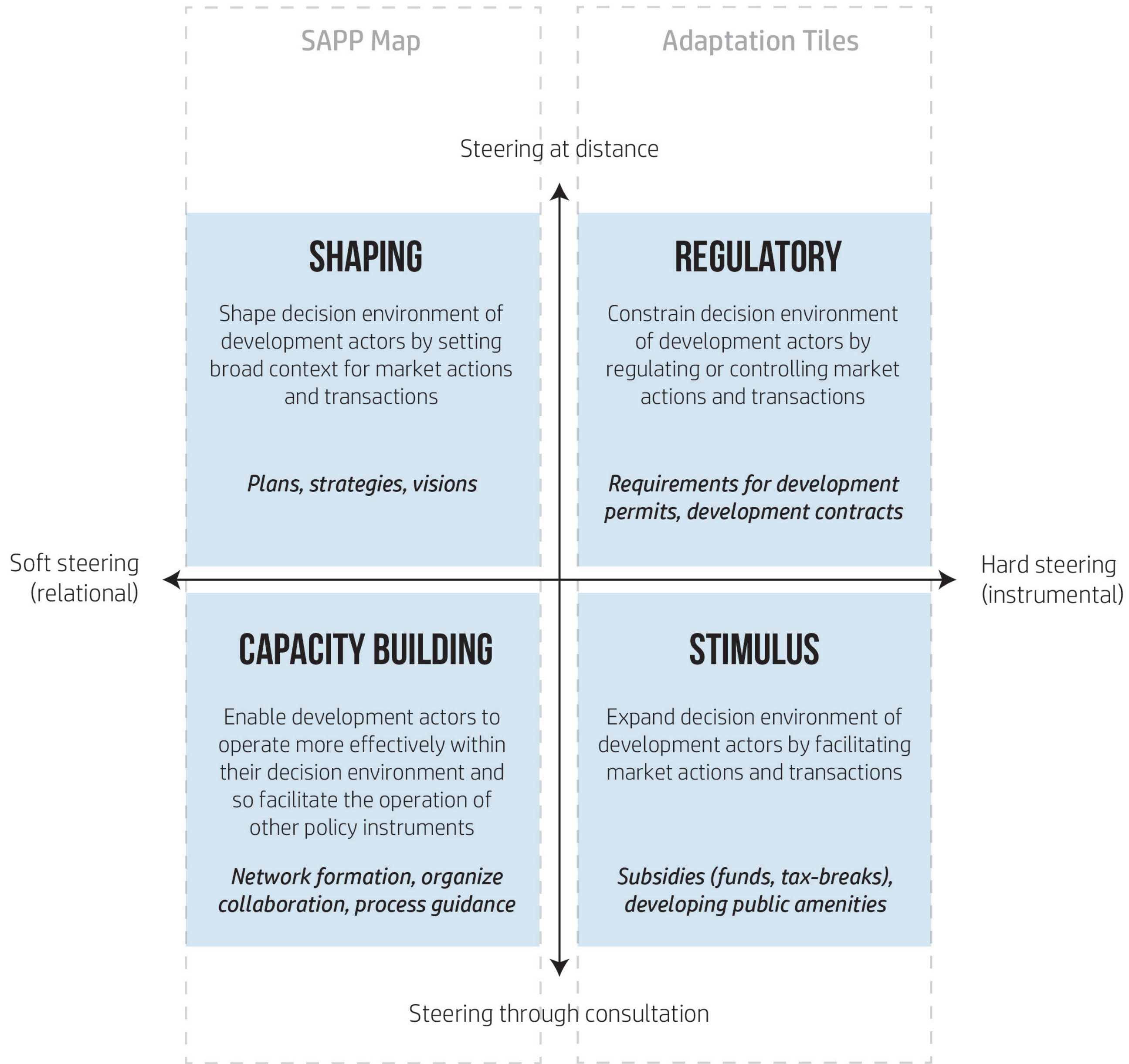


Figure 7.27. Planning Instruments.
Based on: (Heurkens, Adams, & Hobma, 2015).

Figure 7.28 shows an example of an adaptation tile. The top part can be seen as the frontside of the card, with the basic information. The bottom part can be seen as the backside of the card and contains extra information about the measure. For other (case)studies, the information on the tiles can be adjusted or added.

The adaptation tiles of this research contain the following information:

1. The name of the measure and a code;
In the example: F3. Dike
The code is used in the SAPP map (Chapter 9) and the design elaboration (Chapter 10) to refer to the tiles in the appendix.

2. A color to indicate which design layer the measure (most strongly) relates to;
In the example: red, Flood Defences & Calamities
See Section 7.2 for all design layers.

3. The effect of the measure (low +, medium ++, high +++) on the climate stressor(s);
The circle diagram is derived from the information in the Maatregelenmatrix.
In the example: A high (+++) effect for water safety.

4. An illustration of the measure and potential changes to the measure;
In the example: the raise (and broadening) of the dike.

5. General information about the measure;
The scale (region, city, district, neighbourhood, street, building)
The type (robust, flexible, resilient, ad-hoc)

6. Information about time;
Realisation time, payback period, monitoring

7. Information about the organisation;
- Investment costs (cheaper, low additional costs, medium, high)
- Cooperation (public/private/civil, local/regional/national, water management/spatial planning)
- Actors & Collaborations (public/private, decentral/central, sectoral/integral)
- Policies (public investment, private investment, new regulations/agreements needed)

This information is used for the governance elaboration of the SAPP map (Chapter 11).

8. The adaptation principles (icons) related to the measure
In the example: The protection principle.

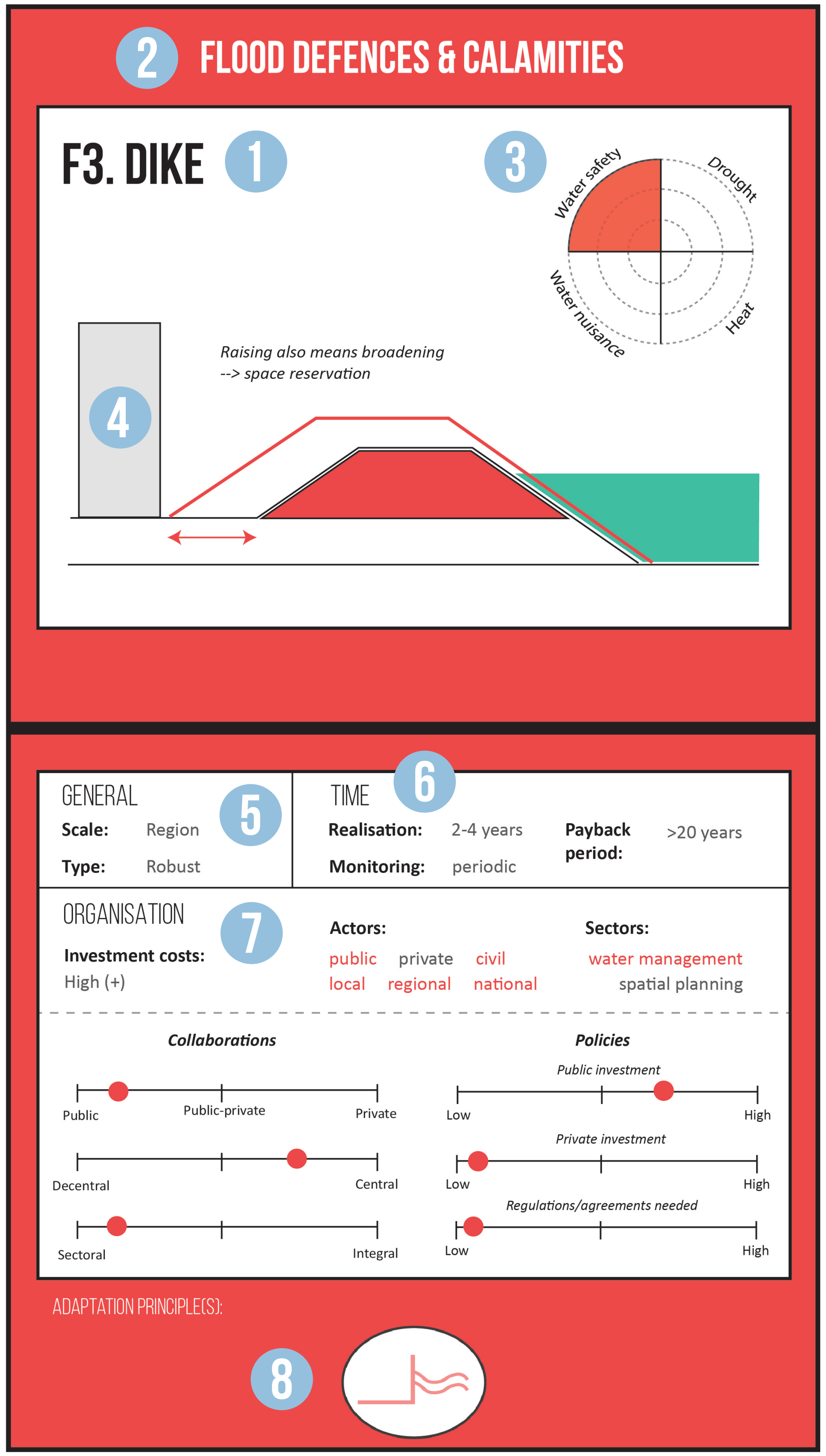


Figure 7.28. Example of an adaptation tile.

Appendix 7.3
For the other adaptation tiles

CONCLUSION IDENTIFICATION

What are the key components needed for the development of Spatial Adaptive Policy Pathways?

HAVEN-STAD OUTPUTS

- The scope for the Haven-Stad case study includes the four climate adaptation pillars (heat, drought, pluvial flooding, fluvial flooding), the spatial scale of the district, a time scale of 2050 till around 2100, and a focus on governmental actors.
- For Haven-Stad, focus areas and dominant stressors are selected for the development of the SAPP map. This is done to reduce the complexity of the process and to keep the final SAPP maps readable.
- The key components as defined in Chapter 6, and the adaptation measures as defined in Chapter 7 are used as input for the development of SAPPs for Haven-Stad.
- The starting point should be developed simultaneously with the development of the SAPPs (Chapter 8 + 9), because Haven-Stad is not developed yet.

SAPP APPROACH

- The key components of the framework are the starting point, the climate objectives and scenarios, the transition phases, and the adaptation measures.
- The transition phases are a new component for the development of adaptive pathways. The phases support spatial explorations about the development of climate adaptation over time and encourage thinking about long-term and drastic developments.
- The abundance of adaptation measures is structured by eleven adaptation principles, five design layers, and adaptation tiles. The adaptation tiles include information about the effects and the governance of a measure.
- The definition of the scope includes definition of the theme, spatial scales, time scales, governance scope, and focus areas and dominant stressors.

DEVELOPMENT

How can Spatial Adaptive Policy Pathways
be developed
for climate adaptation planning?

DESIGN FOR 2050

ADAPTATION PATHWAYS

8

DESIGN FOR 2050

A starting point is needed for the development of Spatial Adaptive Policy Pathways for new urban areas. In this study, the starting point has been defined in a design for 2050. The chapter presents design principles for each design layer in Haven-Stad and explains what could happen if the designs for new urban developments are based on 2050. Finally, two focus areas were presented to test the development of the SAPP map.

SAPP Approach - Step 4

admin (2019)

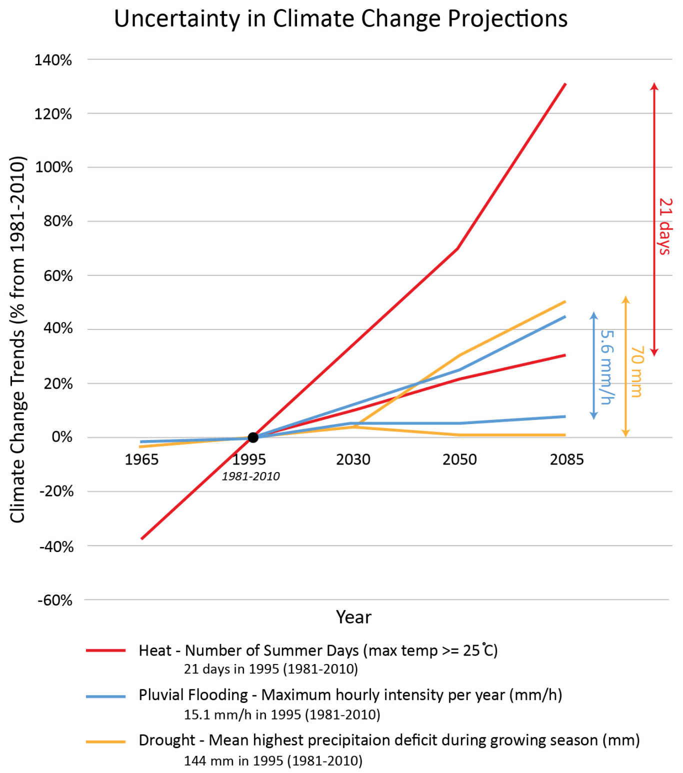
8.1 A DESIGN FOR 2050

8.1.1 Starting Point

The starting point for the development of the adaptation pathways is a design for Haven-Stad, based on the projected climate in 2050. The year 2050 was selected for four main reasons. First of all, because 2050 is currently often used as a target year for climate-resilience goals. The time path, after 2050, is mentioned in the objectives of the Delta Programme and has been adopted by many actors (IV1). Starting with a design for 2050 thus reflects the current way of working. Secondly, climate change is expected to intensify after 2050 (IPCC, 2021). By reflecting a design for 2050 on a changed climate after 2050, it is possible to analyze which changes are likely to be necessary. In addition, the uncertainty of the climate projections after 2050 is also increasing, as can be seen in Figure 8.1. These uncertainties increase the importance of an adaptive design and planning approach.

Finally, it can be assumed that Haven-Stad will be fully developed around 2050, as the final phase will start in 2040 (Gemeente Amsterdam, 2017). In this way, the design does not have to take into account the long development process from now untill 2050, which is out of the scope of this research.

2050 is currently often used as target year for climate resilience goals



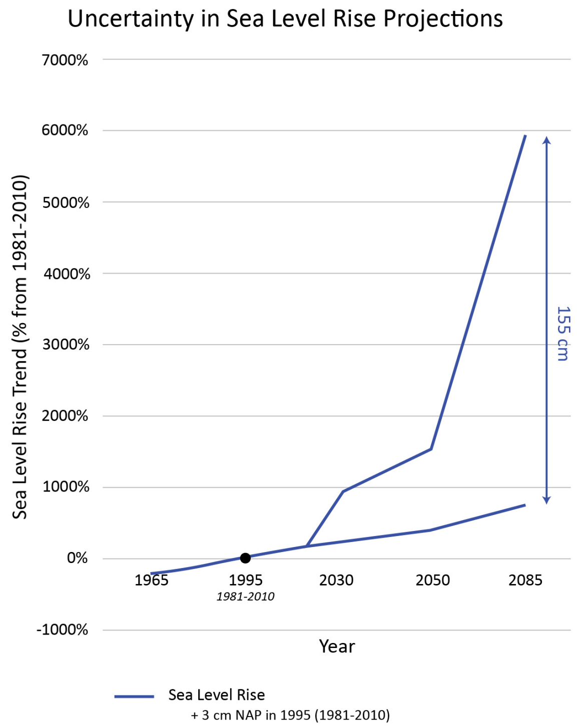


Figure 8.1. Climate change trends & uncertainties.
The top line of each colour shows the highest projection, the bottom line shows the lowest projection, from the KNMI'14 Climate Scenarios for the Netherlands.
Information from: (KNMI, 2015) & (Defacto Stedenbouw & RHDHV, 2021).

8.1.2 Objectives for 2050

The predicted climate in 2050 is considered, in order to determine the design objectives for 2050. A description of the KNMI projections for 2050 can be found in Appendix 8.1. Figure 8.2 shows the assumptions based on the projections. These assumptions are used to define the objectives for 2050 (see Figure 8.3). The description and calculation of the objectives can also be found in Appendix 8.1. More information about the background of the objectives can be found in Section 6.3.

Related to the temperature rise is the cooling objective, which is set at 3 - 15 ºC (PET) in 2050. The range is large because temperatures can vary greatly locally. The objective of fast storage is related to the higher precipitation intensities. It must be possible to quickly store 308,000 m³ for entire Haven-Stad. Related to droughts is the objective of slow storage. This target depends on the amount of green area in Haven-Stad. The rise in sea level is related to the water safety objective. This goal depends on the possible flood depths and return periods, but the main goal is to prevent victims.

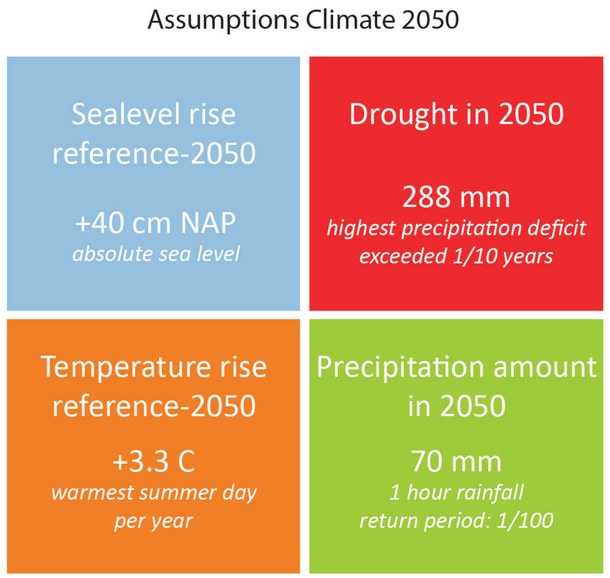


Figure 8.2. Assumptions for the climate in 2050.

Figure 8.3. Objectives for 2050.

Appendix 8.1
For more information about the 2050 climate projections and objectives

8. Design for 2050

8.2 DESIGN LAYERS & PRINCIPLES

8.2.1 Areas

Figure 8.4 shows the five areas of Haven-Stad that are distinguished on the basis of the analysis in Chapter 4. An area has approximately the same soil type, height, water system, and (future) function.

8.2.2 Design Principles

For each design layer, as identified in Section 7.2, design principles are made. These principles are the rules that are followed during the making of a design. The following pages indicate for each design layer what should be considered in a climate-adaptive design.

The design principles are partly derived from the guides 'Bodem als Basis' (Maas, Stichting CAS, & Wageningen University & Research, 2021) and 'Bouwstenen voor een duurzame stedebouw' (BOOM, 1996).

Soil
1. Utilize the soil potential (carrying capacity, gradients, infiltration)
2. Maintain structures, patterns, and elements in the landscape
3. Consider the soil as base for the other layers
4. Take soil quality into account
5. Implement a height strategy

Watersystem
1. Follow the principles of the sponge-city concept:
Delay, retain, store, reuse, drain
2. Let the watersystem follow the soil
    Infiltration in higher sandy soils
    Open water / wadis in lower clay soils
3. Let the water circulate to improve water quality
4. Design banks and quays that handle different water levels

Vegetation
1. Create an ecological network and connect it to the regional/national ecological structure
2. Use the existing 'natural situation' (soil, relief, watermanagement) and connect vegetation typologies with it
3. Maintain the existing valuable elements

For each design layer, it is indicated what should be considered for a climate-adaptive design

Flood Defences & Calamities
1. Make space reservations for possible future flood defences
2. Make flood defences multifunctional
3. Make at least vertical evacuation possible
4. Protect vital & vulnerable functions

Urban Design
1. Let the building typology follow the natural system (soil/water)
2. Treat the building as part of the water- and green-system
3. Take care of the orientation and materialization.
4. Assure flexibility to the plinth or whole building.

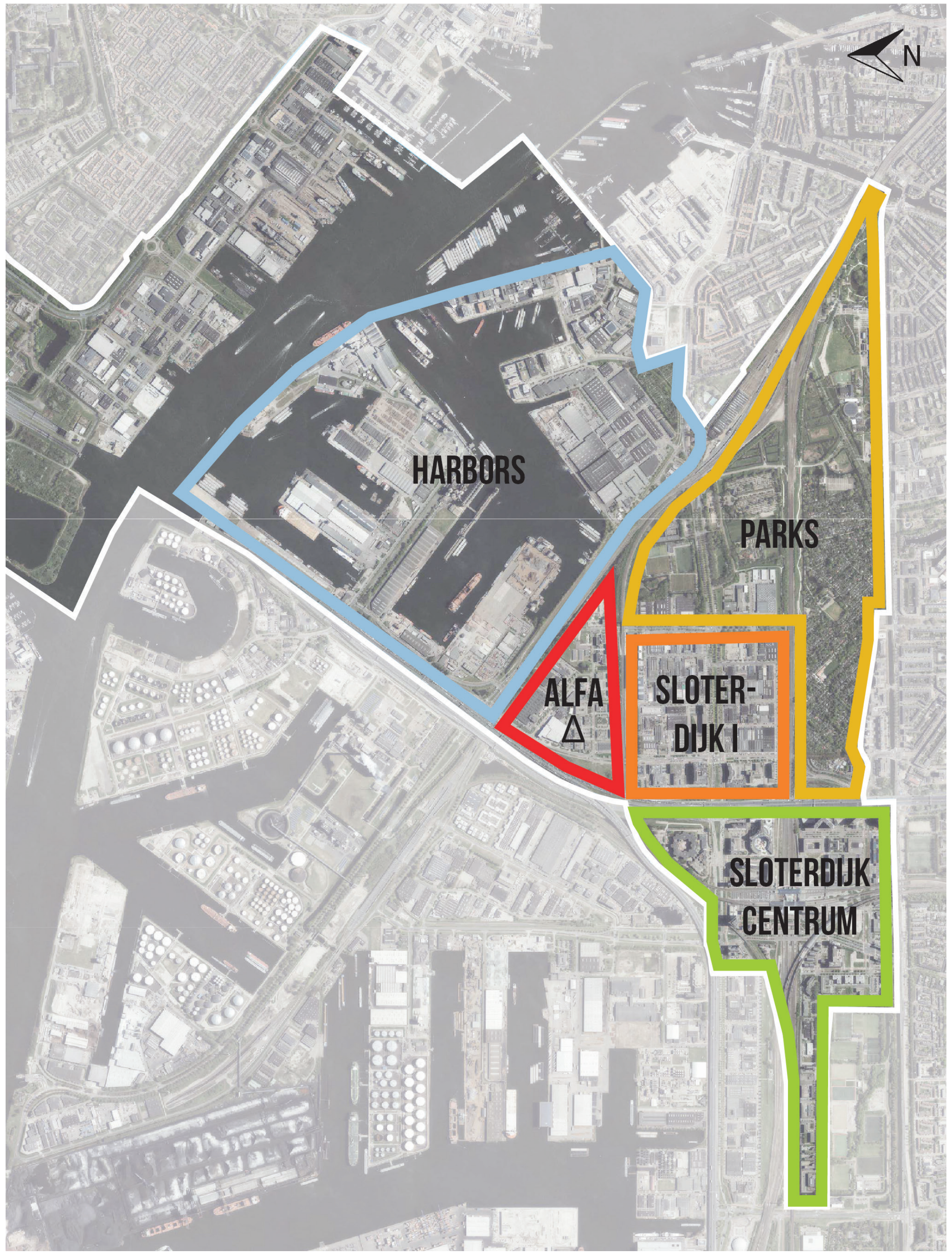


Figure 8.4. Areas within Haven-Stad. Background from "Google Maps", by Google, n.d. (https://www.google.com/maps/place/Amsterdam/). Copyright by Google Maps.

Appendix 8.2
For more information about the design layers in Haven-Stad

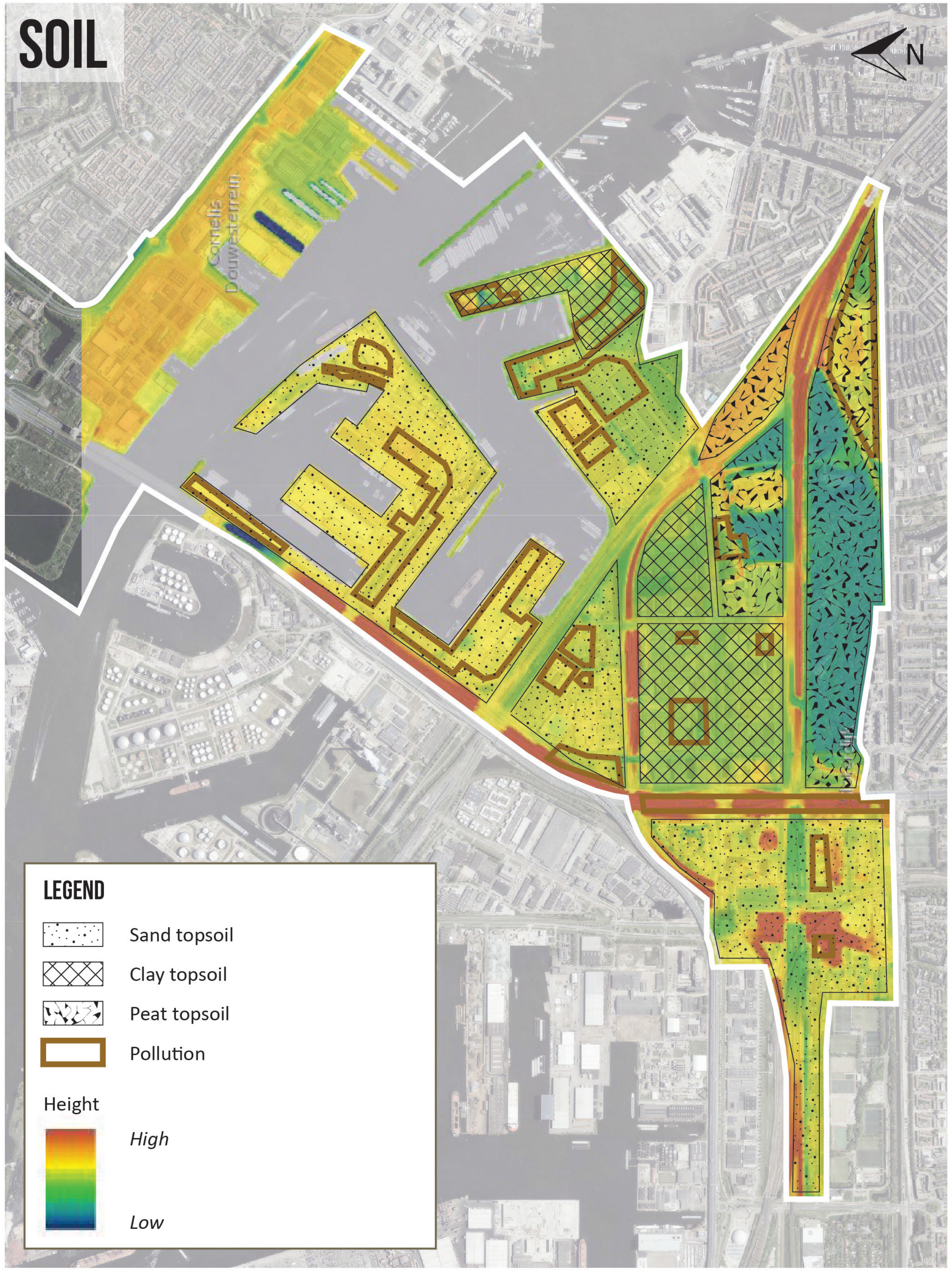
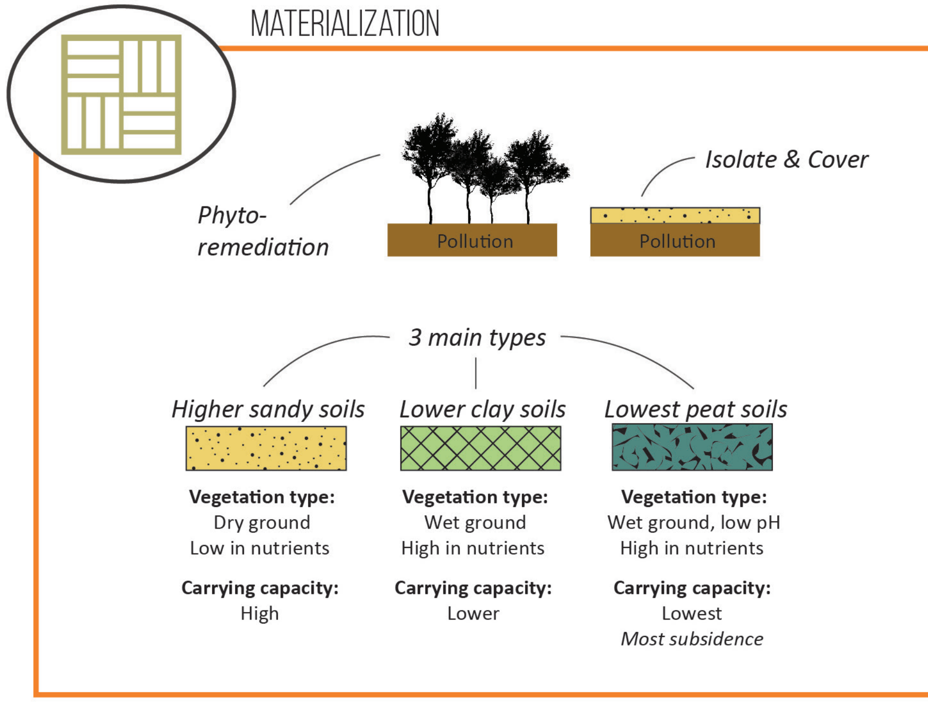


Figure 8.5. Soil Layer in Haven-Stad. Background from "AHN-Viewer", by Actueel Hoogtebestand Nederland, 2018. (https://ahn.arcgisonline.nl/ahnviewer/). Copyright 2018 by Actueel Hoogtebestand Nederland.

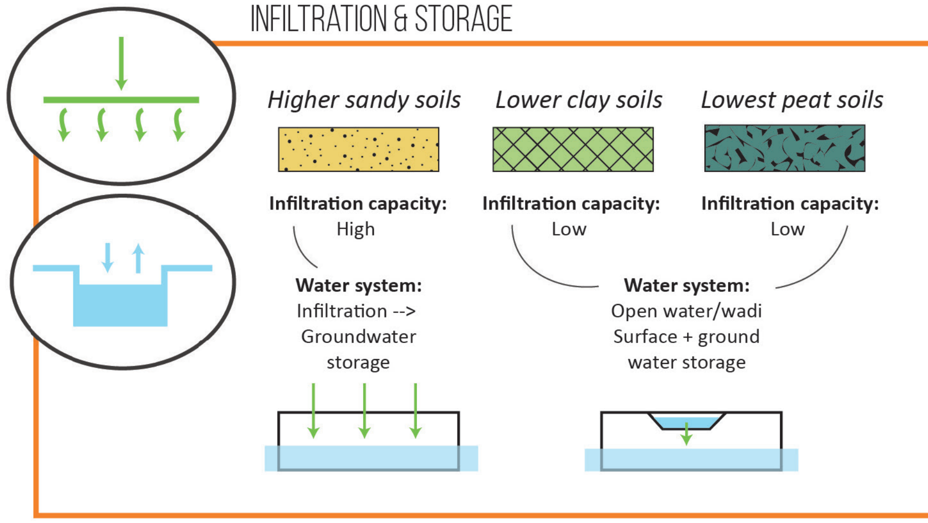
8. Design for 2050

MATERIALIZATION



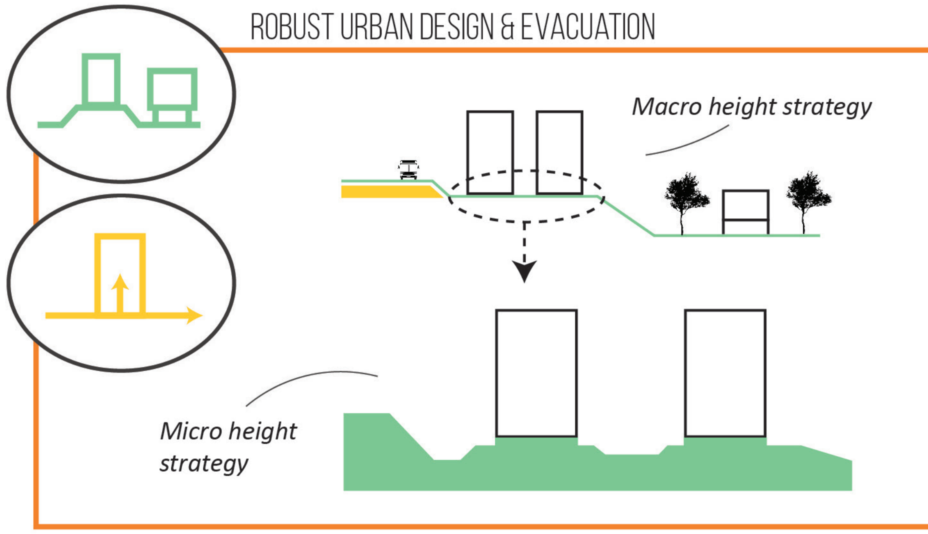
The type and condition of the soil are important, because the soil determines the conditions of water systems, vegetation types and building typologies. Three main types can be distinguished in Haven-Stad: Higher sandy soils, lower clay soils, and the lowest peat soils. One of the design principles is to work with the existing soil types to create diversity in the design and vegetation options. Haven-Stad also has some polluted areas. These areas can be covered or remediated (for instance with phyto-remediation, where the plants remove the toxics).

INFILTRATION & STORAGE



The soil type influences the infiltration capacity and storage capacity of a certain area. The sandy soils have a high infiltration capacity. Water sinks quickly and replenishes the water table again. The clay and peat soils have lower infiltration capacities, water sinks more slowly to the water table. This requires a water system that provides extra storage capacity and optionally drainage capacity.

ROBUST URBAN DESIGN & EVACUATION



The soil layer also influences the heights in the area. A differentiation in height can be applied for a robust urban design and evacuation plans. In a macro height strategy, functions can be subdivided over areas of different heights, based on their importance or vulnerability. In a micro height strategy, smaller height differences can be created within an area. Water is stored at the lowest points (for instance roads), keeping functions at higher levels dry.

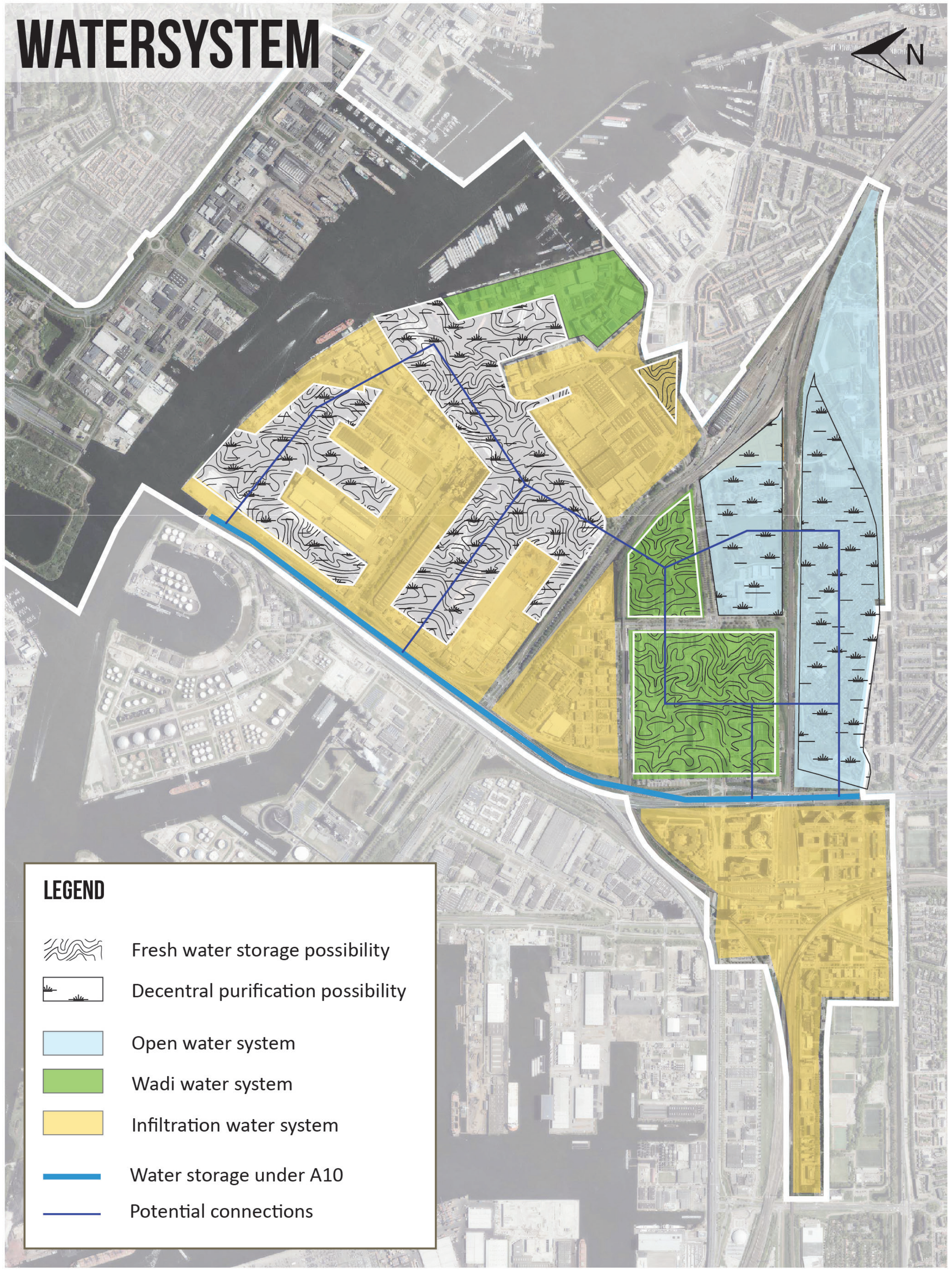
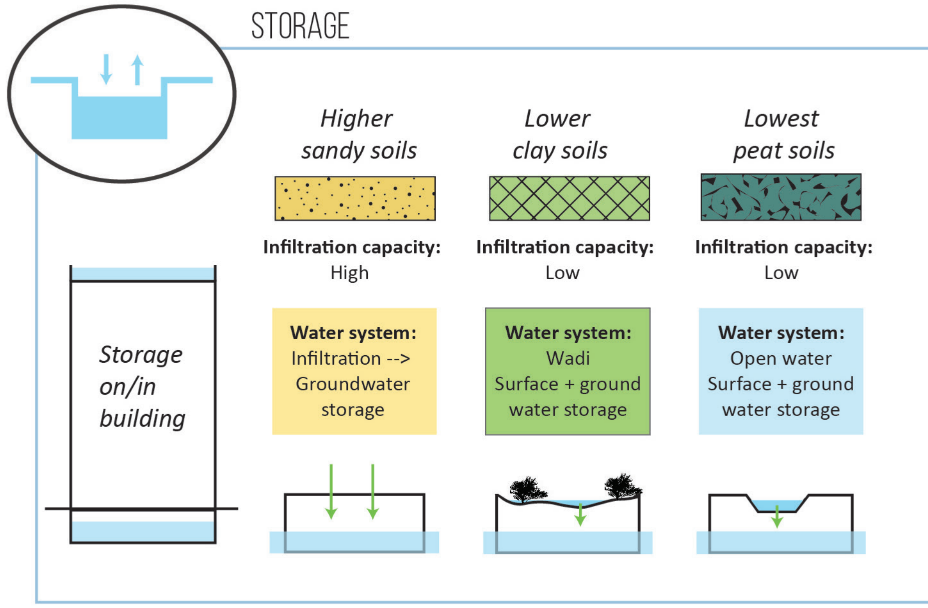


Figure 8.6. Watersystem Layer in Haven-Stad

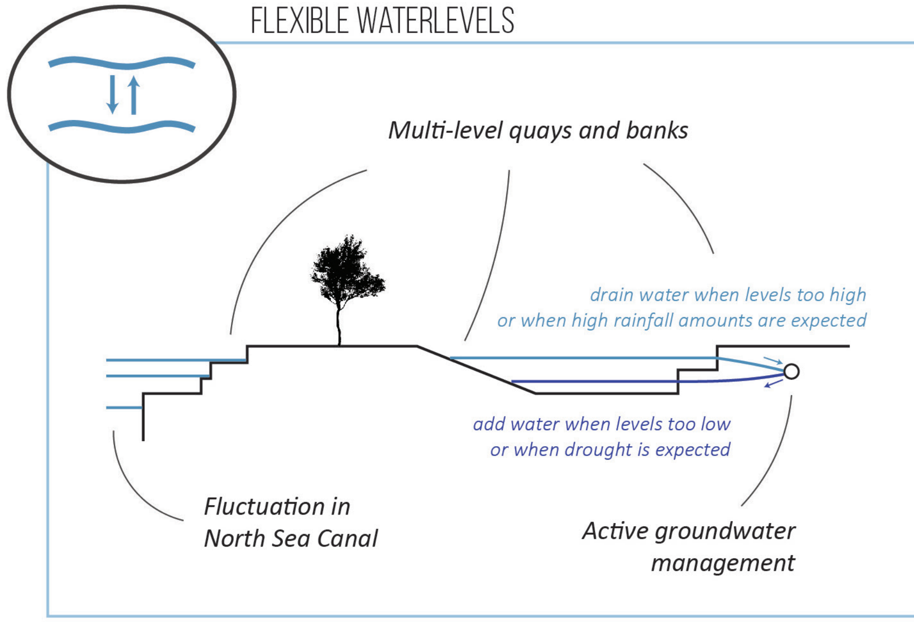
8. Design for 2050

STORAGE



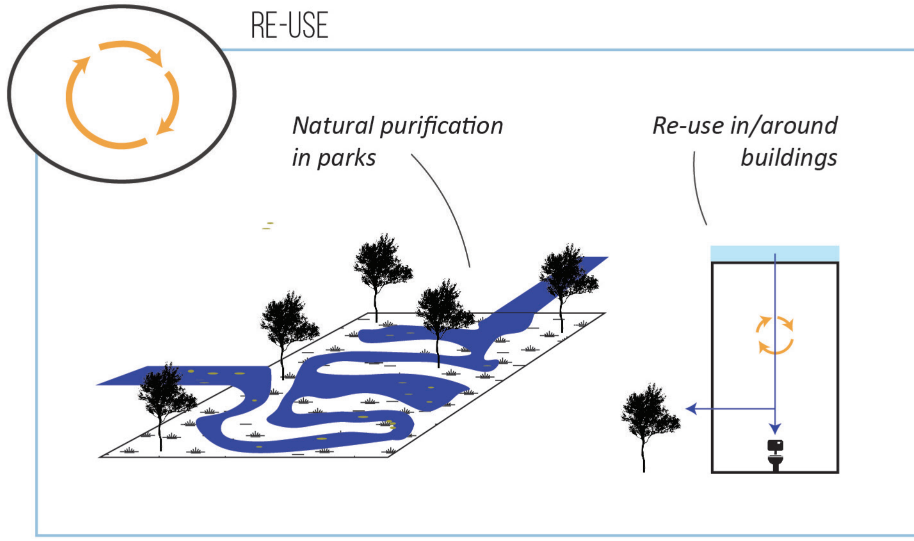
The suitability of water systems for different Haven-Stad areas can be based on the soil types. In the sandy areas, the water flows easily to the water table, where it is stored naturally. In the peat and clay areas, water cannot infiltrate so quickly, which requires (wadi/open water) storage. All private plots should be water neutral and parks are used for extra water storage. In the future, the harbor basins may serve as a storage area for Haven-Stad if the basins are closed off from the canal.

FLEXIBLE WATERLEVELS



Flexible water levels must be taken into account in the design for Haven-Stad. IThe level of the North Sea Canal is expected to fluctuate more in the future, which also has consequences for the water levels in Haven-Stad.In addition, active groundwater management can be used to prepare the area for a wet period (lowering the water table) or for a dry period (increasing the water table). This asks a design of quays and banks that can handle different water levels.

RE-USE



Linked to the storage of water is the re-use of water. Within Haven-Stad, opportunities can be sought to locally purify and reuse the water. The parks could be used to naturally purify the water for Haven-Stad. The water stored in buildings can be re-used for flushing of toilets or watering plants. In a future in which the harbor basins are closed off from the North Sea canal, the basins offer new opportunities for the storage, purification, and re-use of water.

8. Design for 2050

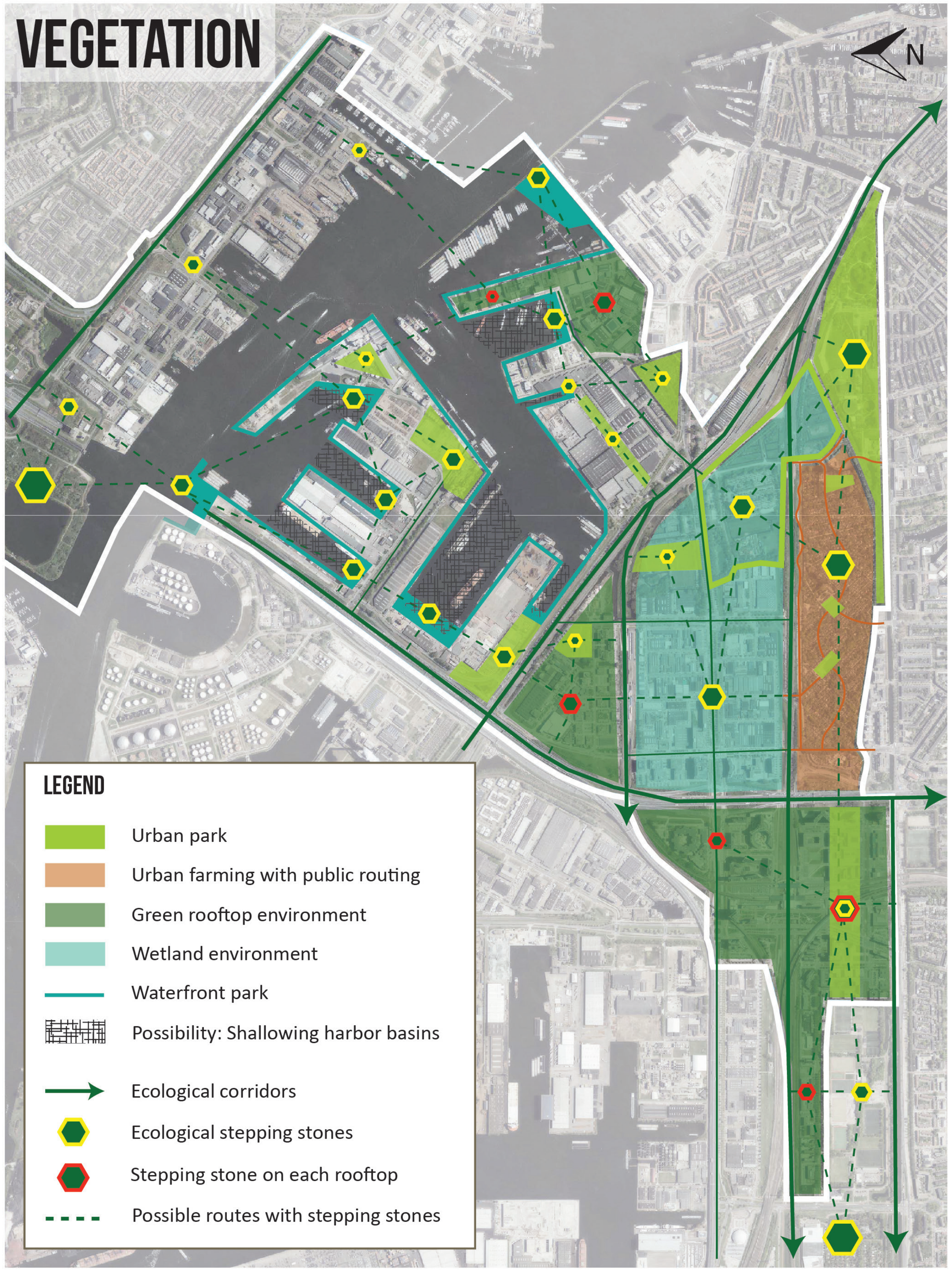
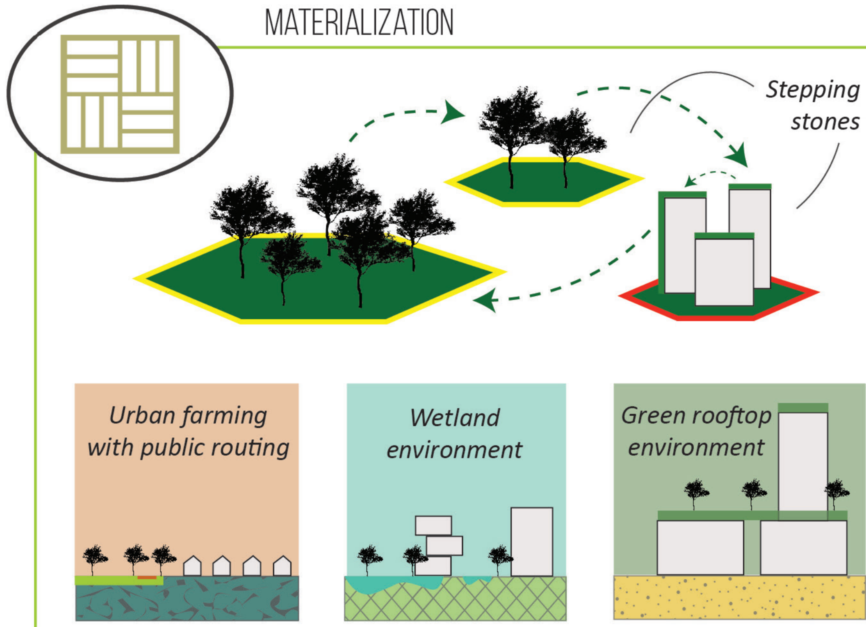


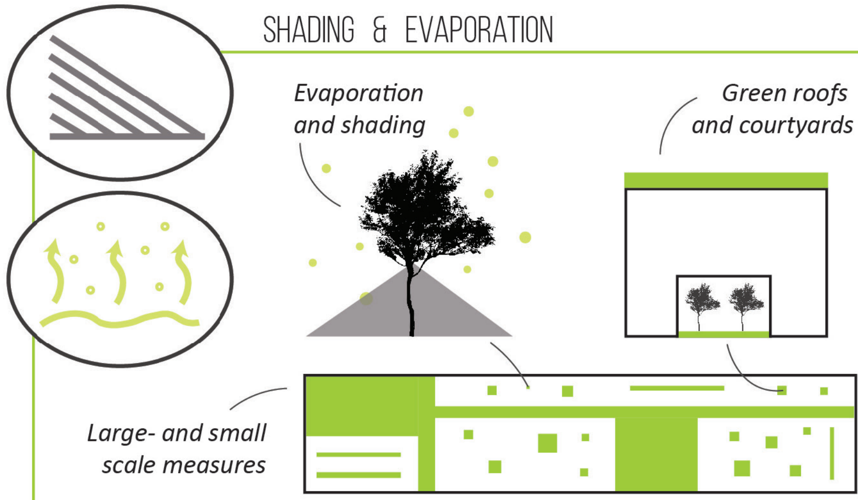
Figure 8.7. Vegetation Layer in Haven-Stad

MATERIALIZATION



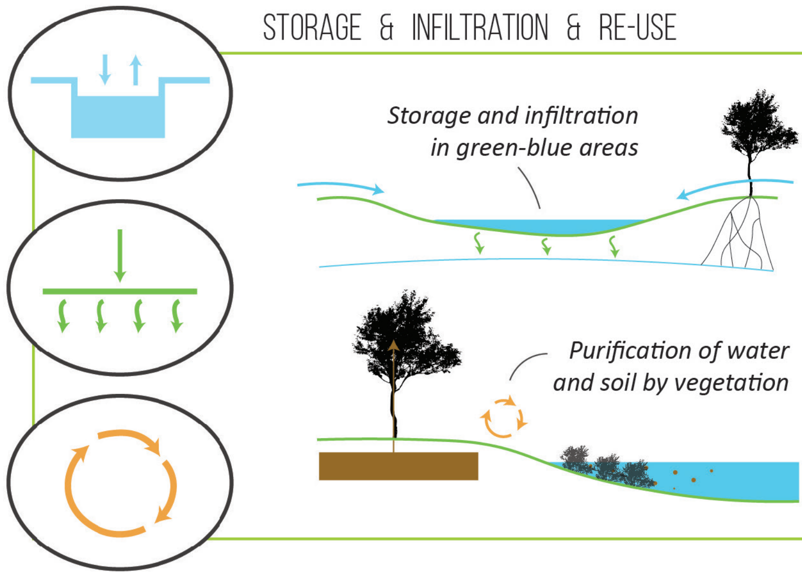
Due to the differentiation in soil types and building density, different types of green can be developed in Haven-Stad. Wetland environments can be created on the wetter clay soils and a landscape of green rooftops can be used as stepping stones in high-density areas. A public route and public parks can be integrated into the allotment park. The harbor basins can be made shallow to create more gradients in water depths. The green areas form stepping stones and together with the ecological corridors a network is formed.

SHADING & EVAPORATION



Trees and other plants cool the area through shading and transpiration (evaporation). However, the cooling effects are not very far-reaching and the cooling needs can differ on a local scale. It is therefore important to provide large-scale parks, green boulevards and small-scale green measures in each street and on every block. Think of street trees, green courtyards, and green roofs and facades.

STORAGE & INFILTRATION & RE-USE



Green areas infiltrate water better than paved areas (with the same soil) and are therefore ideal for sending extra water. The water replenishes the water table and nourishes the plants. Vegetation can also play a role in re-use. Water purifying plants can be used as natural filters to purify the water (helofyten filters) before it is re-used. With phyto-remediation, plans purify the soil, making it possible to 're-use' the soil again for new functions.

8. Design for 2050

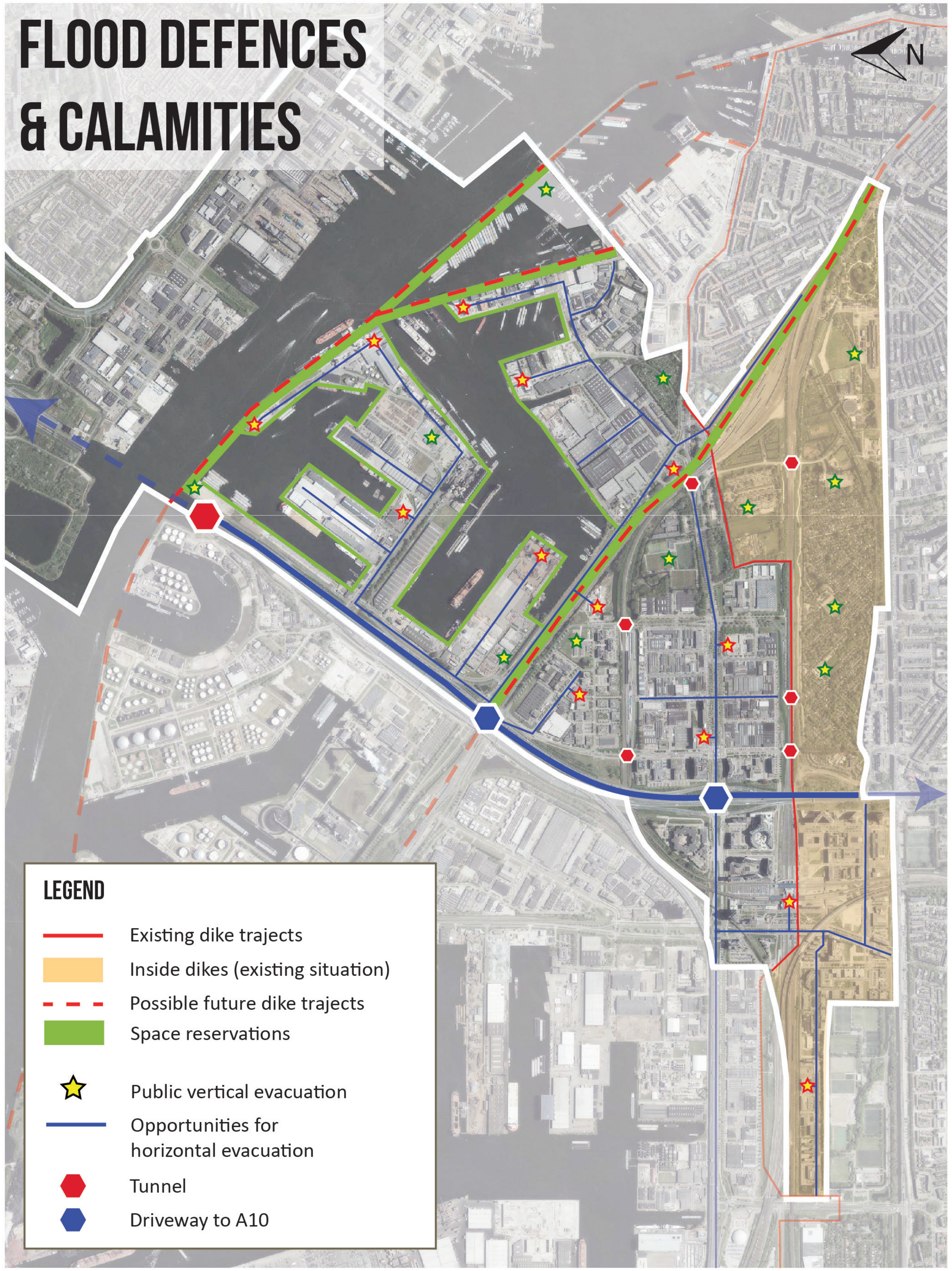
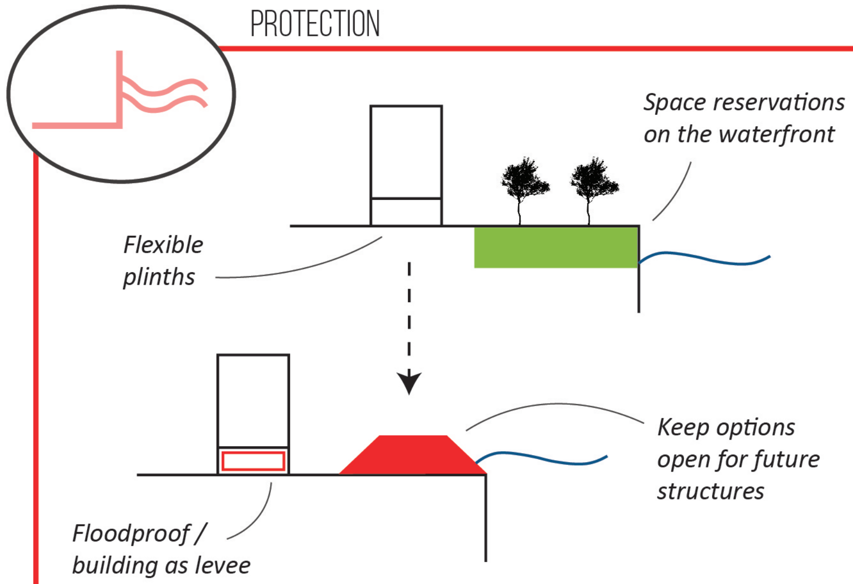


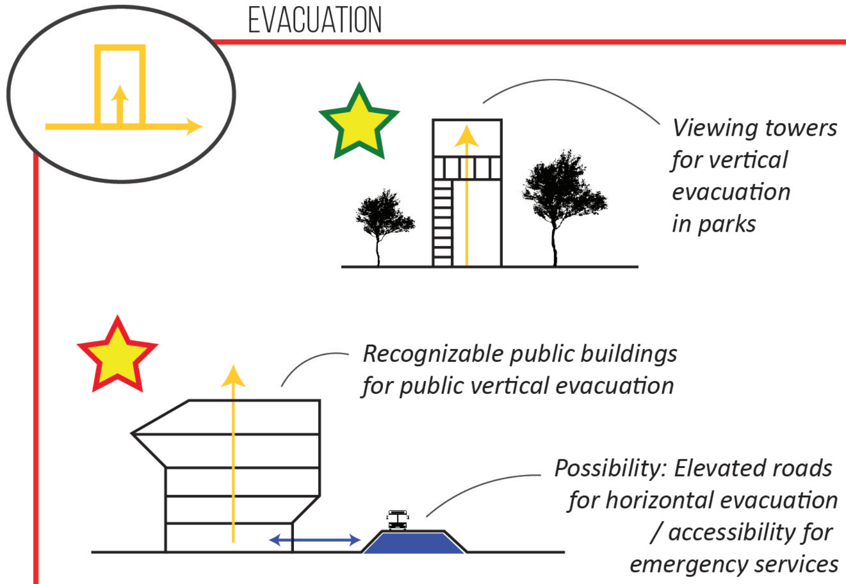
Figure 8.8. Flood Defences & Calamities Layer in Haven-Stad

PROTECTION



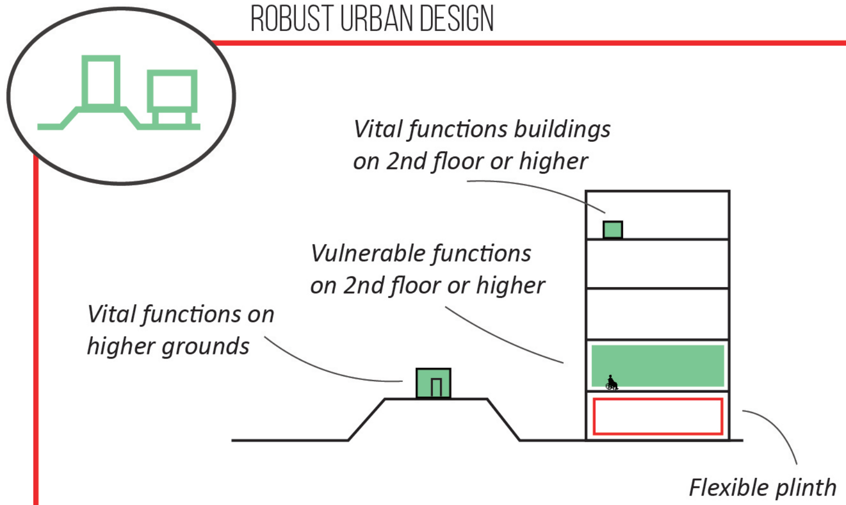
For the protection principle, it is important to analyse where changes in the flood protection can take place in the future. Especially on the waterfront it is wise to reserve some space for unforeseen futures (such as a shifted dike traject). Parks or other temporary functions can be located in these areas, to make reserve space for possible future flood defences. Flexible plinths for the buildings along the waterfront offer the possibility to make the buildings floodproof or to form part of a flood defence in the future.

EVACUATION



An evacuation strategy must be part of urban designs in the delta, and at least vertical evacuation should be taken into account in Haven-Stad. An extra function of vertical evacuation can be realized in 'recognizable' public buildings. In the parks, vertical evacuation can be provided with small watch towers. The blue lines indicate how horizontal evacuation could be planned. All routes are connected to the public evacuation buildings and to the high-altitude highway. However, the tunnels in the area are a weak spot.

ROBUST URBAN DESIGN



To prevent or minimize the consequences of a flood, attention must also be paid to vulnerable and vital functions. Vital functions (such as the energy supply) should be placed on higher grounds and on higher floors. Vulnerable people can best get a place on the 2nd floor or higher. A flexible plinth is also part of a robust urban design, as it can be transformed into a floodproof floor if required.

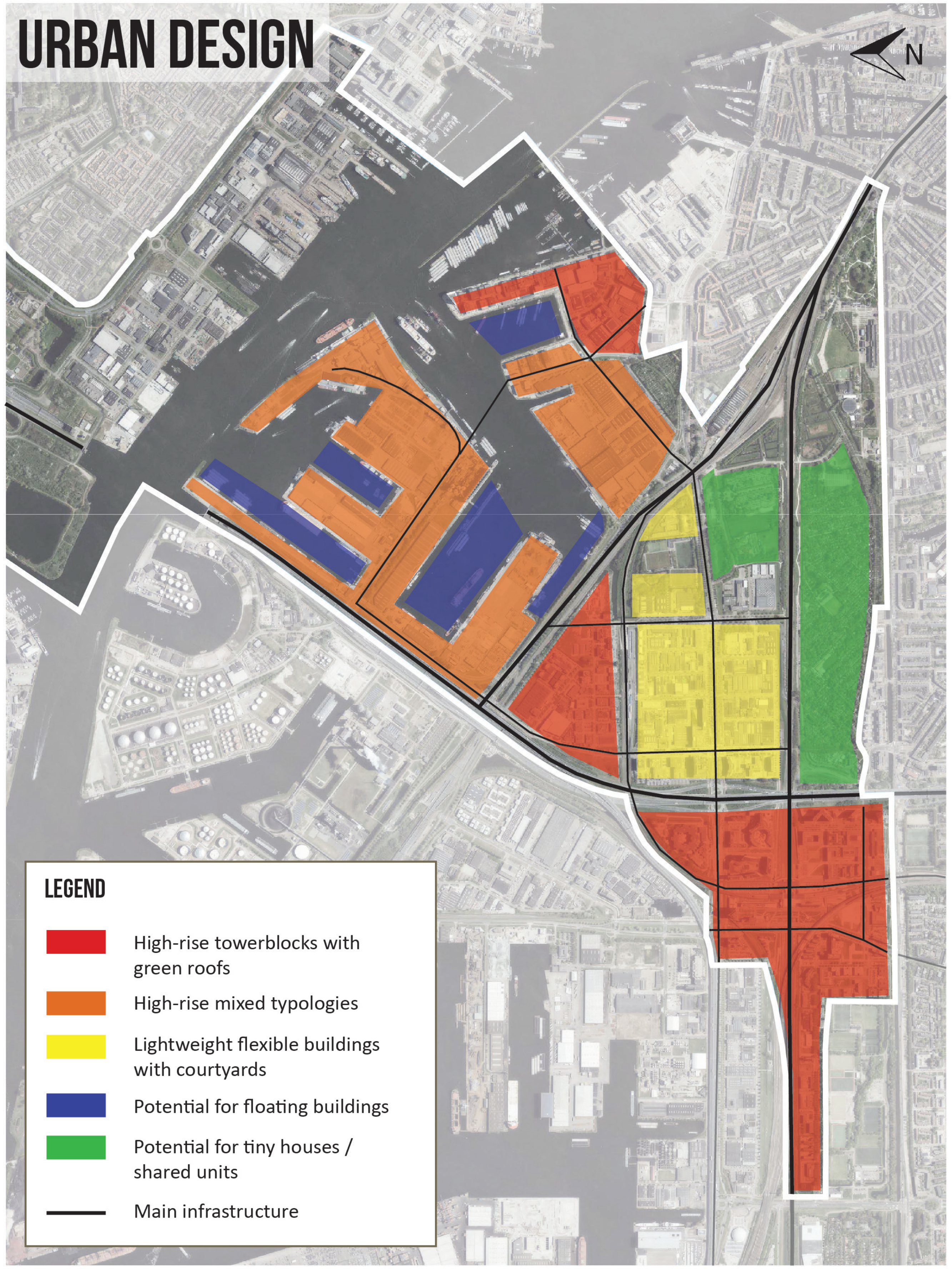
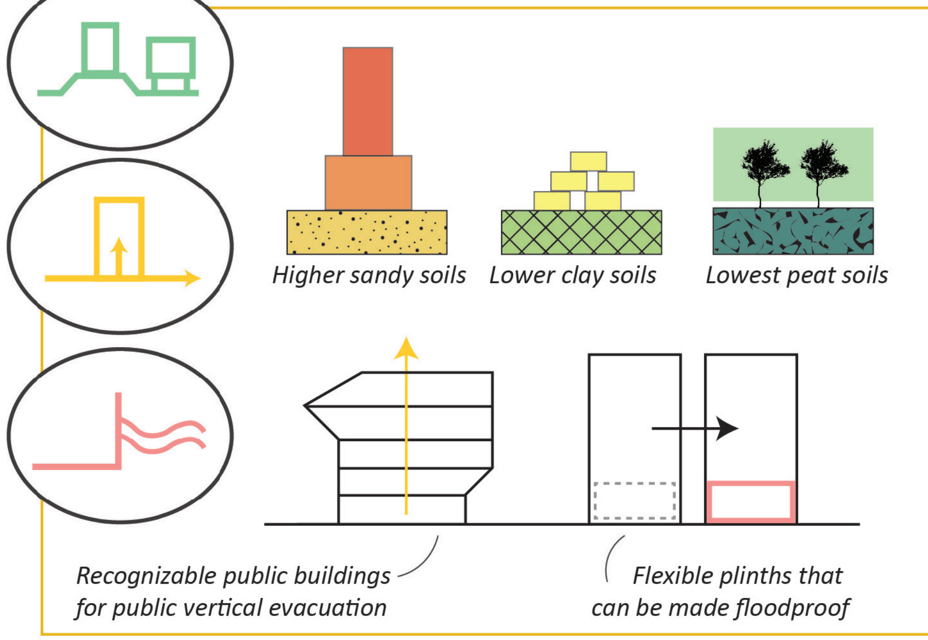


Figure 8.9. Urban Design Layer in Haven-Stad.

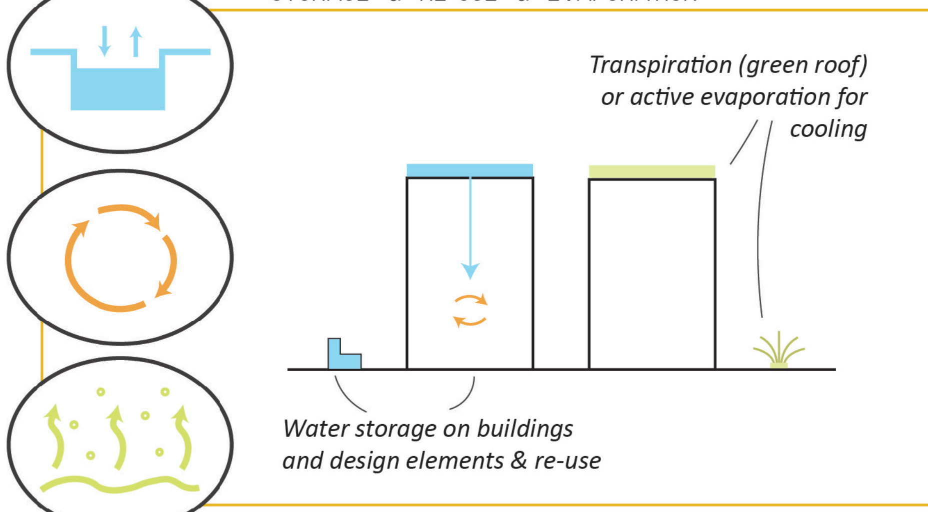
8. Design for 2050

ROBUST URBAN DESIGN & EVACUATION & PROTECTION



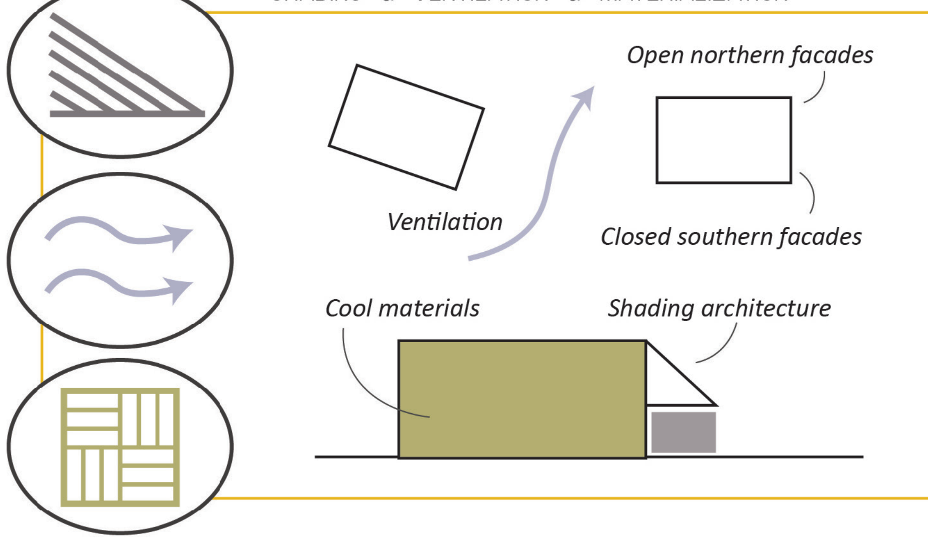
Due to the different conditions of the areas within Haven-Stad, different building typologies have to be created. Flexible lightweight buildings are suitable on clay soils with a lower bearing capacity. Heavy typologies such as tower blocks are possible on the higher sandy soils. (Large and heavy) developments on the low and soft peat soils are not recommended; a park is a logical function for these soils. A selection of public buildings should allow for public vertical evacuation, as this is not guaranteed in the private buildings. The plinths can be made flexible to allow for floodproof adjustments.

STORAGE & RE-USE & EVAPORATION



Buildings and urban design elements should contribute to the storage of water. Think of green roofs or benches with storage space inside. Ideally all water that falls on the roof is stored or infiltrated on the plot. The stored water can also be re-used in or around the building (for instance for watering the plants or flushing the toilets). Green roofs or active evaporation systems (fountains, sprays) can contribute to the cooling of the air through evaporation.

SHADING & VENTILATION & MATERIALIZATION



The architecture and orientation of buildings can influence the temperature of the surrounding public area. During hot days, areas can be left open to let in wind. Building materials should not be dark to prevent too much heat being stored and radiated. Buildings and urban design elements (such as pergolas) can provide shade. Urbanists can indicate certain plots on which the architecture should provide shade.

8. Design for 2050

8.2.3 Linking the Layers

All design layers are interconnected and influence each other. Figure 8.10 shows an example of how different connections can be made between the design layers in Haven-Stad. It shows for instance how high-rise buildings with a high weight (urban design) can best be placed on sandy soils with a large carrying capacity (soil).

The sandy soils have high infiltration capacity and supplement the groundwater (water system). Sandy soils are often dryer and have low nutrient values. This influences which vegetation is able to grow in the area (vegetation). In an area with high densities and high-rise, vegetation can also be added to roofs and courtyards.

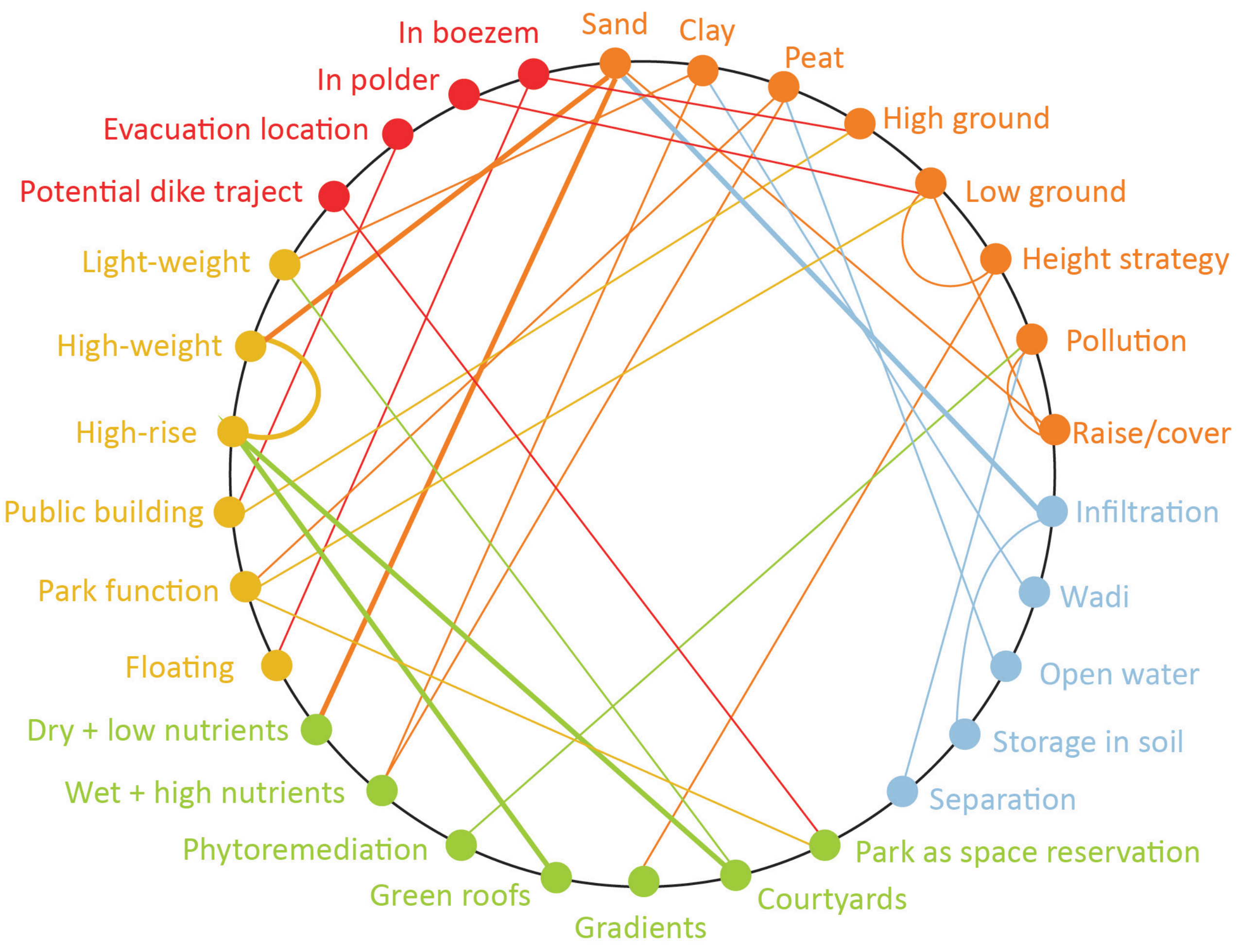


Figure 8.10. Linking the Layers.

8. Design for 2050

8.3 2050-DESIGN IN THE FUTURE

8.3.1 Haven-Stad after 2050

The design for Haven-Stad can be based on the objectives related to the climate projections for 2050. However, Haven-Stad will exist way longer than until 2050. The lifetime of this built environment is expected to be at least 100 years. Since Haven-Stad will be built in the period of 2020-2040, the built area will probably still exist in 2120-2140. One of the interviewees said it is wise to look as far into the future as the longevity of the decision you are making (IV1). The climate of 2120-2140 must therefore also be included in the design. However, climate projections for the Netherlands are now only available untill 2085 (climate 2071-2100).

An analysis has been made of the consequences if a design is based on a projected climate in 2050 or 2085. The objectives for the 2050 design are compared with the objectives for a design in 2085. Figure 8.11 shows the differences between the objectives. The projected climate and objectives for 2085 are described in Appendix 8.3.

Differences Objectives 2050-2085

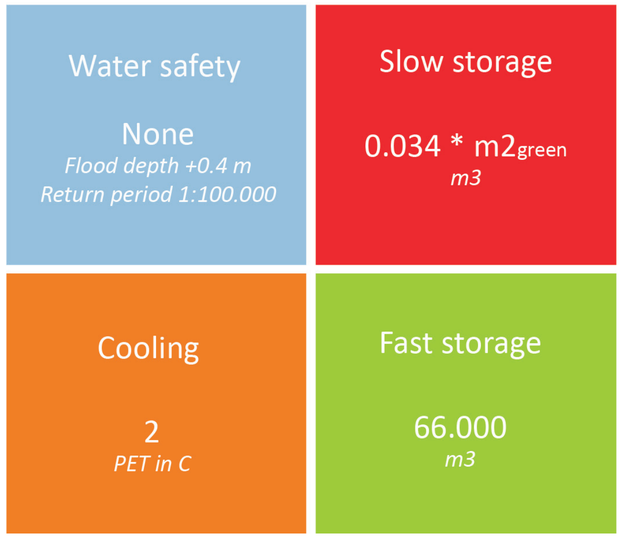


Figure 8.11. Difference between the objectives for 2050 and for 2085.

8.3.2 Expected problems

A design based on 2050 could create problems in the future, if the area is not flexible enough to adapt to new objectives. Figure 8.12 shows the KNMI'14 climate projections and associated differences between the objectives for 2050 and for 2085.

Fluvial Flooding
Sea level rise will not stop after 2050 and is likely to intensify. A higher sea level is putting more pressure on the IJmuiden complex, which is already under pressure. This increases the flood risk (if the complex is not updated). And if a disturbance does occur, the consequences are greater because flood depths are likely to increase and the saltwater can reach further. Haven-Stad is also dependent on the larger regional and national strategic choices regarding flood protection. If the strategy changes, Haven-Stad must be able to adapt.

Pluvial Flooding
Precipitation intensities are also expected to increase after 2050. It is expected that in 2085 there will be a need for 66,000 m^3 of extra fast storage in Haven-Stad (compared to the 2050 design). This requires space reservations or an adjustments of functions.

Drought
An increase in drought intensities is also expected after 2050. In 2085, 0.034 m^2 of extra storage space will be required per m^2 of green space. If this can not be achieved, the amount of green area can be reduced or drought resistant species can be used. However, this is not preferred for biodiversity and heat reduction.

Heat
From 2050 to 2085, the PET temperature is expected to rise by 2 °C. This means that 2 °C extra cooling is needed. Extra green could lower the temperatures, but this can only be done if there is sufficient water storage to feed the plants during hot and dry periods. Alternatively, technical measures can be used for cooling (sprays, shading facilities).

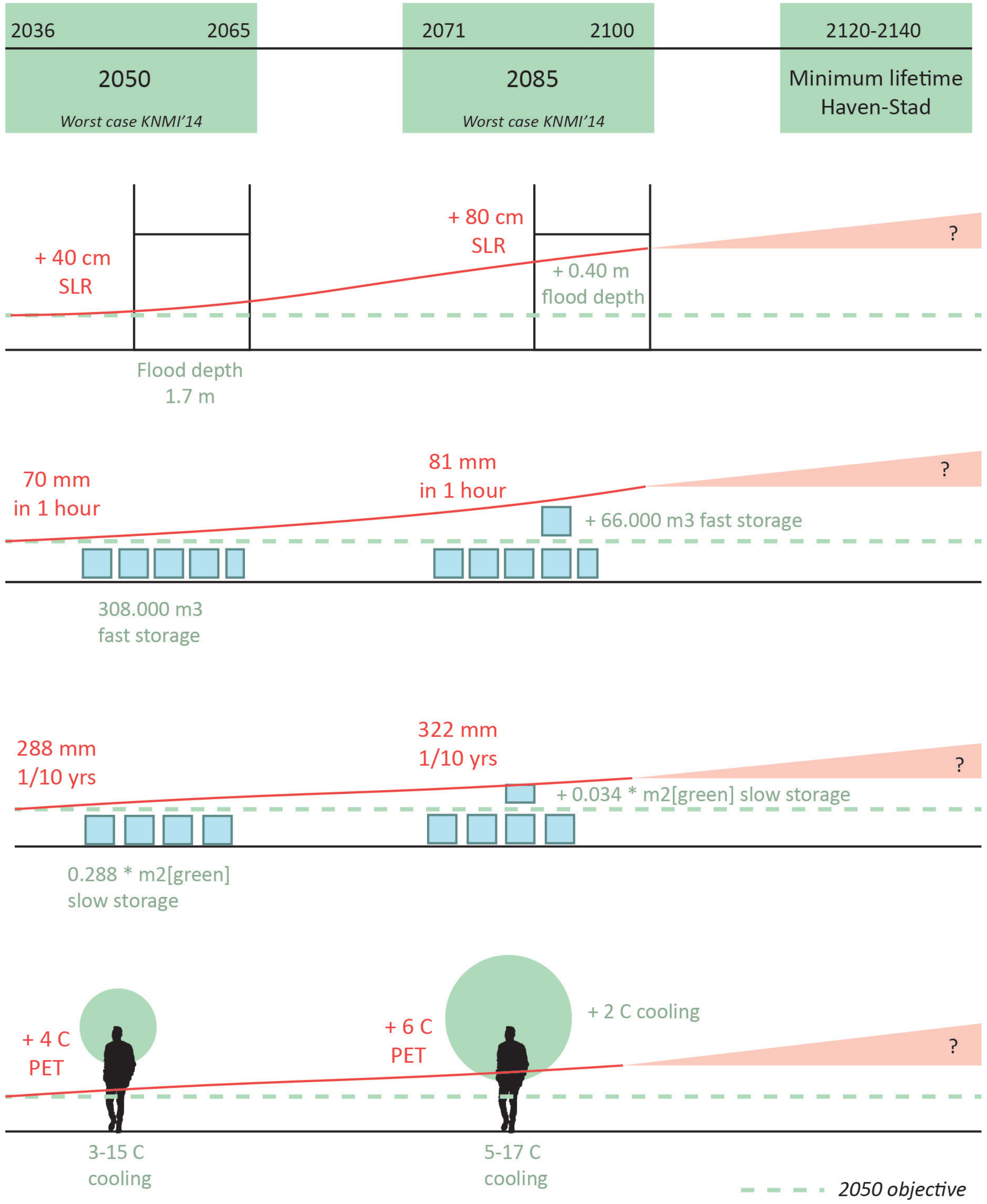
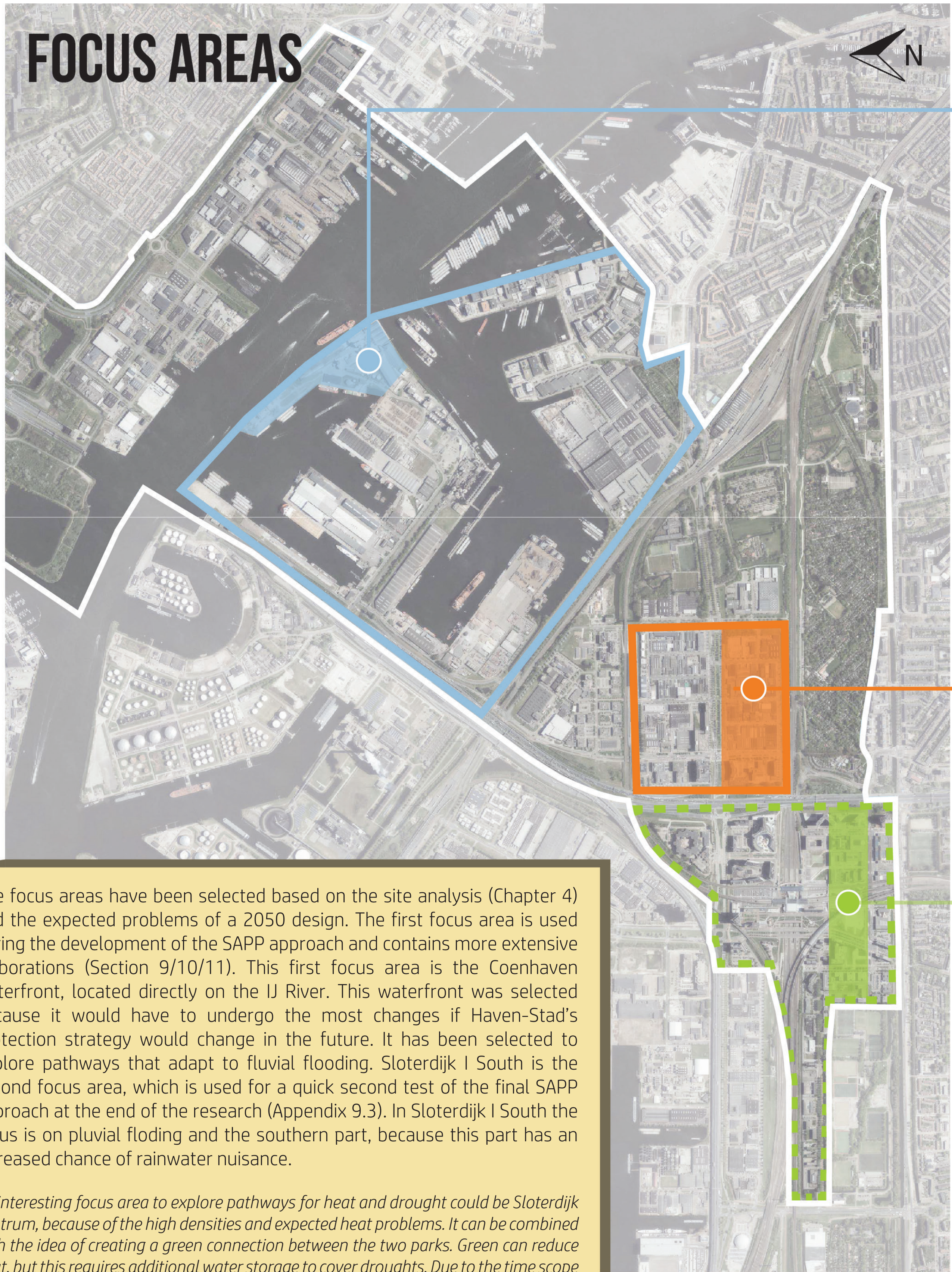


Figure 8.12. The KNMI'14 climate projections (worst case scenario) and related differences between the objectives for 2050 and for 2085.

Appendix 8.3
For more information about the 2085 climate projections and objectives



The focus areas have been selected based on the site analysis (Chapter 4) and the expected problems of a 2050 design. The first focus area is used during the development of the SAPP approach and contains more extensive elaborations (Section 9/10/11). This first focus area is the Coenhaven waterfront, located directly on the IJ River. This waterfront was selected because it would have to undergo the most changes if Haven-Stad's protection strategy would change in the future. It has been selected to explore pathways that adapt to fluvial flooding. Sloterdijk I South is the second focus area, which is used for a quick second test of the final SAPP approach at the end of the research (Appendix 9.3). In Sloterdijk I South the focus is on pluvial floding and the southern part, because this part has an increased chance of rainwater nuisance.

An interesting focus area to explore pathways for heat and drought could be Sloterdijk Centrum, because of the high densities and expected heat problems. It can be combined with the idea of creating a green connection between the two parks. Green can reduce heat, but this requires additional water storage to cover droughts. Due to the time scope and desired level of detail, Sloterdijk Centrum has not been included in this research.

Figure 8.13. Focus Areas.

8. Design for 2050

HARBORS — FLUVIAL FLOODING

COENHAVEN WATERFRONT

SLOTERDIJK I — PLUVIAL FLOODING

SOUTHERN BLOCKS

SLOTERDIJK CENTRUM — HEAT & DROUGHT

PARK CONNECTION

9

ADAPTATION PATHWAYS

This chapter presents the steps in the development of Spatial Adaptive Policy Pathways for the focus areas of Haven-Stad. The result is a SAPP map for climate adaptation planning from the starting point (the 2050 design) to the long-term future.

SAPP Approach - Step 5

NRC (2018)

9. Adaptation Pathways

9.1 CONCEPTUAL PATHWAYS

One of the most important aspects of adaptive pathways is the changing (in this case spatial) elements over time. Conceptual trajectories have been developed to explore the possible changes over time. This is done for each design layer individually, to diverge and discover what each layer can contribute to climate adaptation.

The idea of using conceptual pathways for this kind of exploration stems from the study of Zandvoort et al. (Zandvoort et al., 2019). The main difference is that the conceptual pathways are developed for each design layer separately (as defined in Section 7.2), whereas the study of Zandvoort et al. does not distinguish a distinction between layers. By looking at each layer individually, flexibility in time per layer can become more explicit. And by analyzing all layers at once, there is a chance that paths (or flexibility opportunities) will be missed.

In addition, in contrast to the Zandvoort study, it was decided to not add a climatic trend to the figures (Zandvoort: sea level rise). Firstly, it is not considered necessary for this conceptual level and secondly it is not always possible to connect one particular trend to the changes in the layers. The different layers can all (to a greater and lesser extent) respond to changes in temperature, rainfall, droughts, and floodings. In this research, the conceptual pathways are mainly used as a design exercise to find flexibility in all layers, under the general assumption of a changing climate.

In order to integrate an idea of time into the conceptual pathways (without addition of a climatic trend), transition phases have been added. These phases are: No regret (2050 design), Incremental, Transition, and Transformation. The conceptual pathways on the following pages show how spatial elements within the design layers (soil; watersystem; vegetation; flood defences & calamities; urban design) can change from one phase to the other.

Please note that the conceptual pathways cannot be considered exhaustive.

> *Conceptual pathways can help to explore the possibilities of change over time*

SOIL

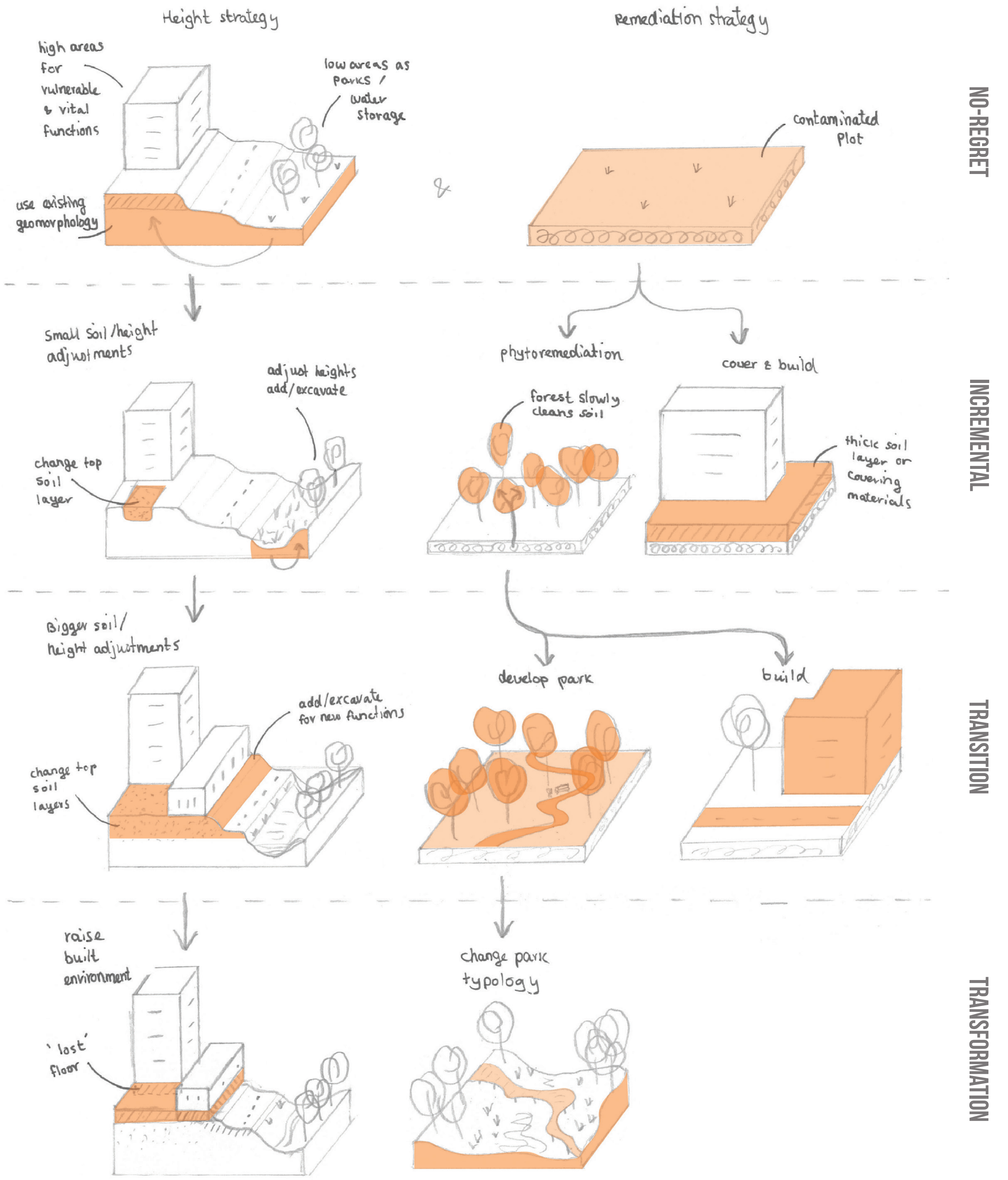


Figure 9.1. Conceptual Pathways for the Soil layer.

WATERSYSTEM

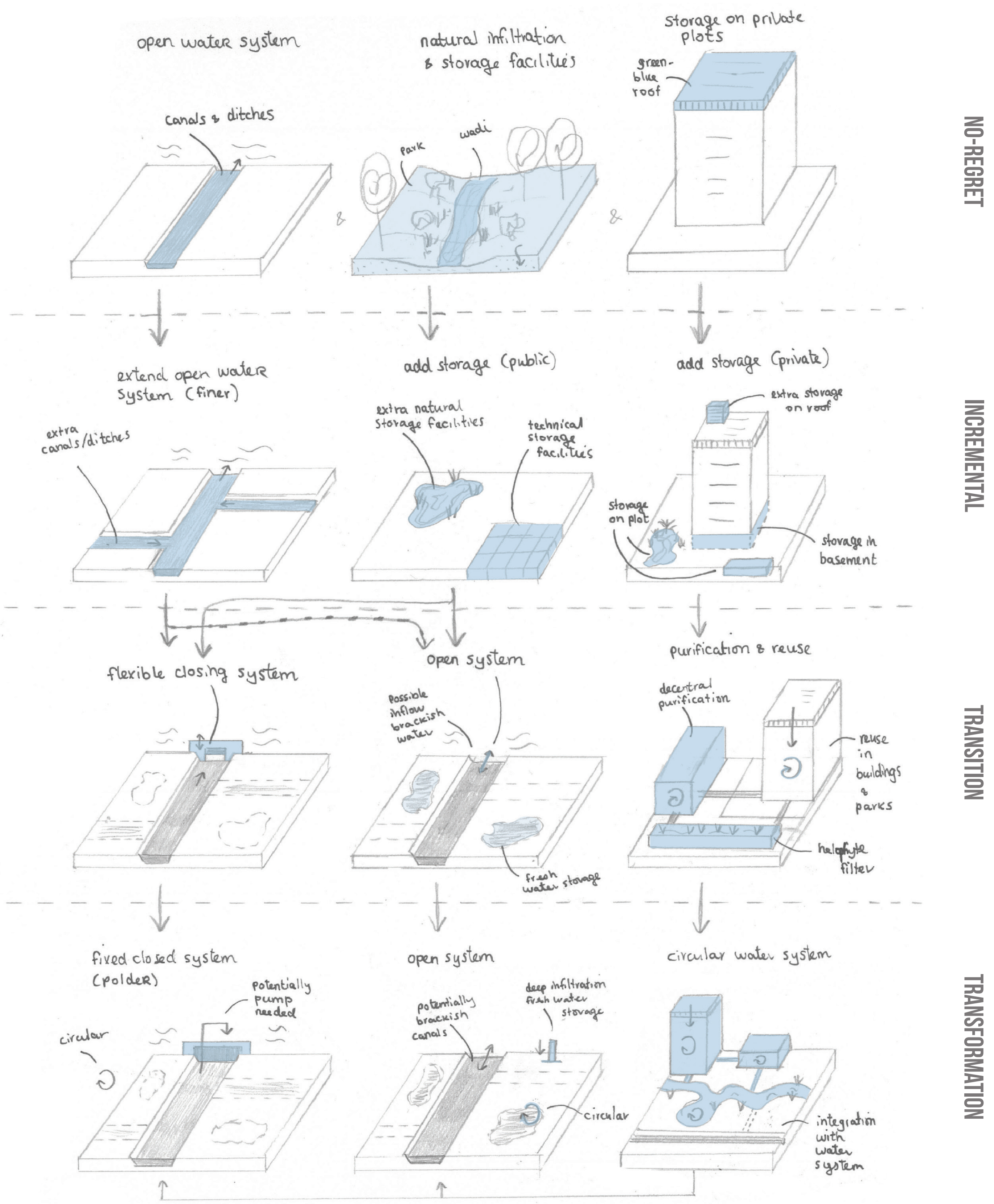


Figure 9.2. Conceptual Pathways for the Watersystem layer.

VEGETATION

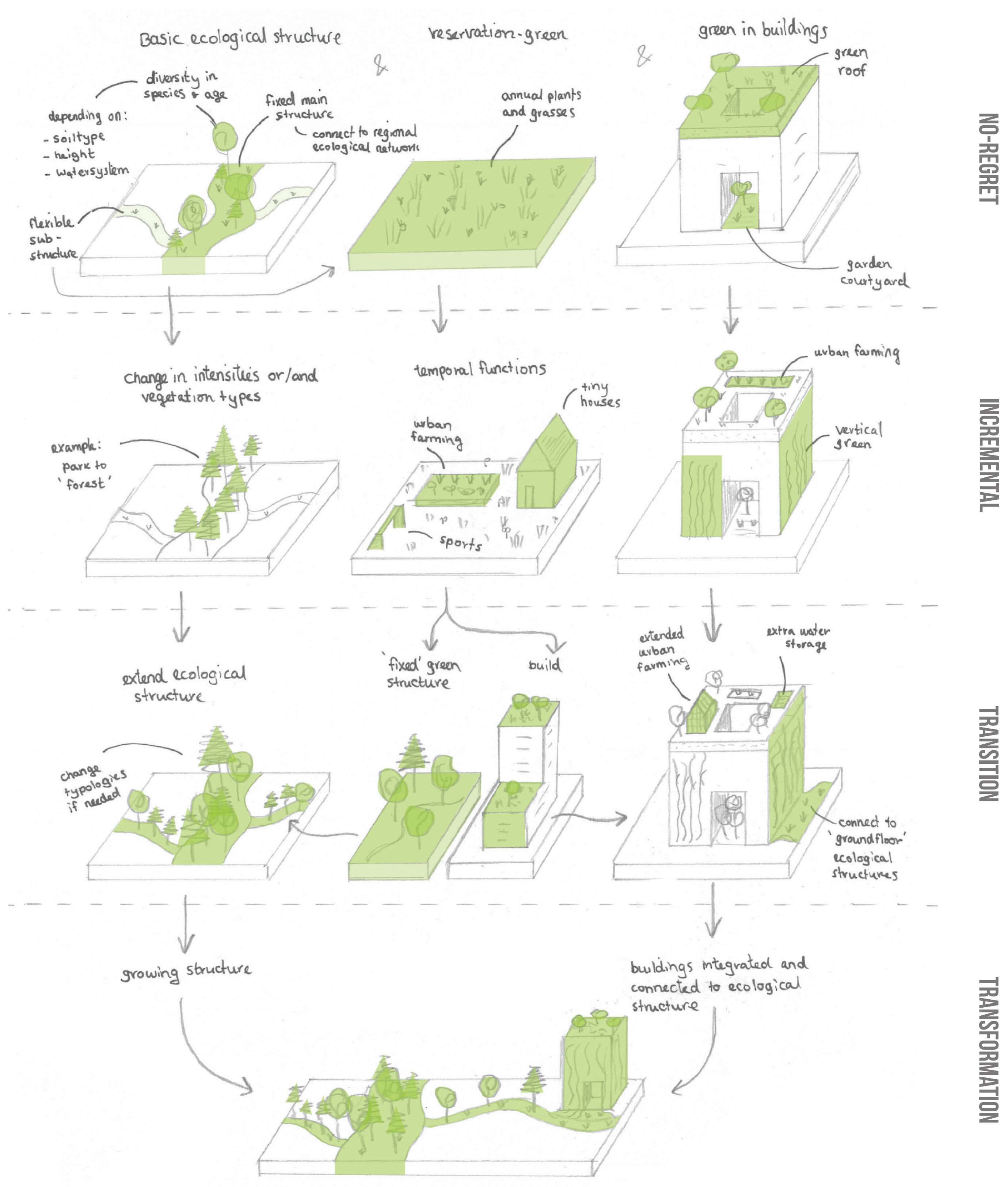


Figure 9.3. Conceptual Pathways for the Vegetation layer.

9. Adaptation Pathways

FLOOD DEFENCES & CALAMITIES

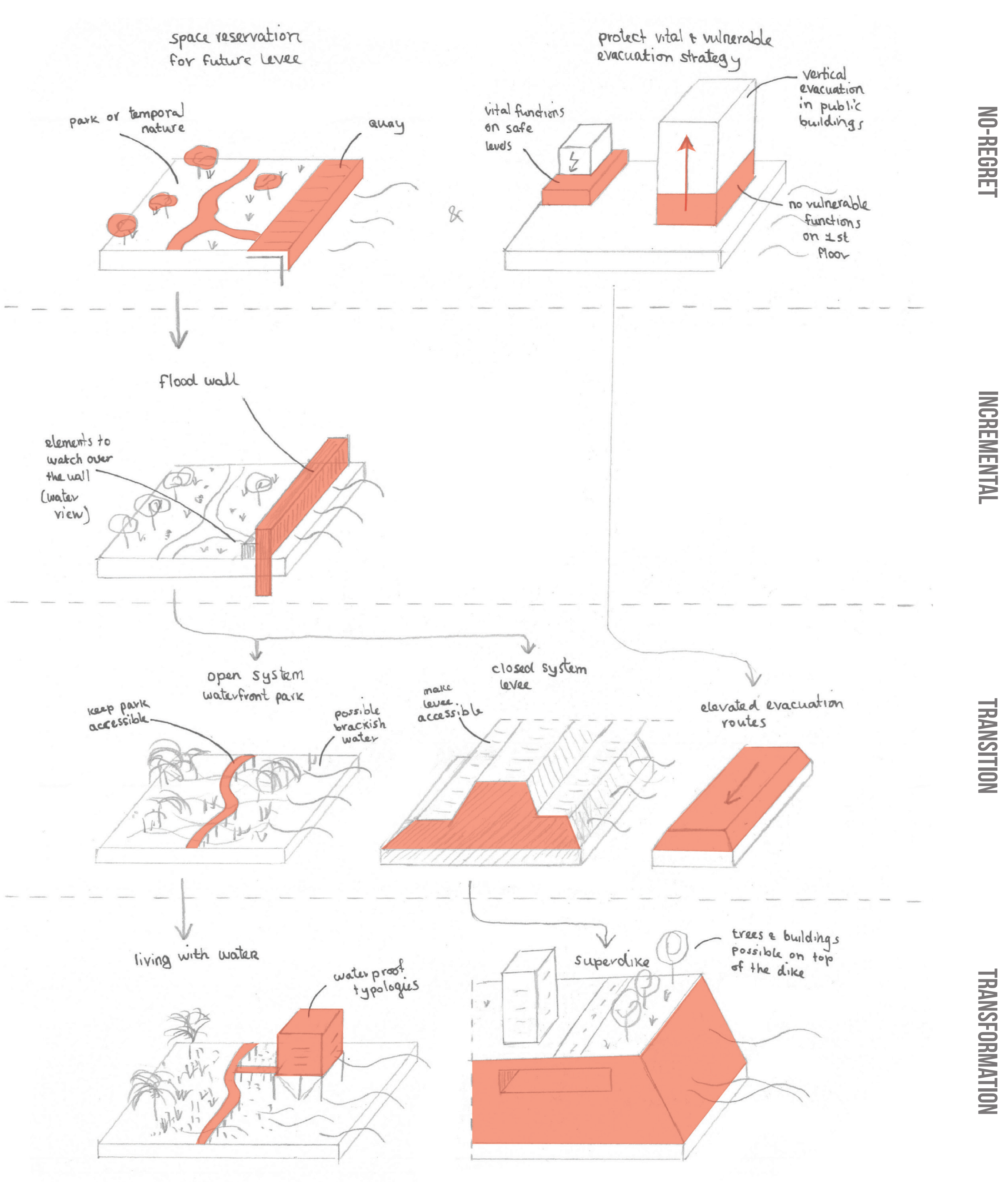


Figure 9.4. Conceptual Pathways for the Flood Defences & Calamities layer.

URBAN DESIGN

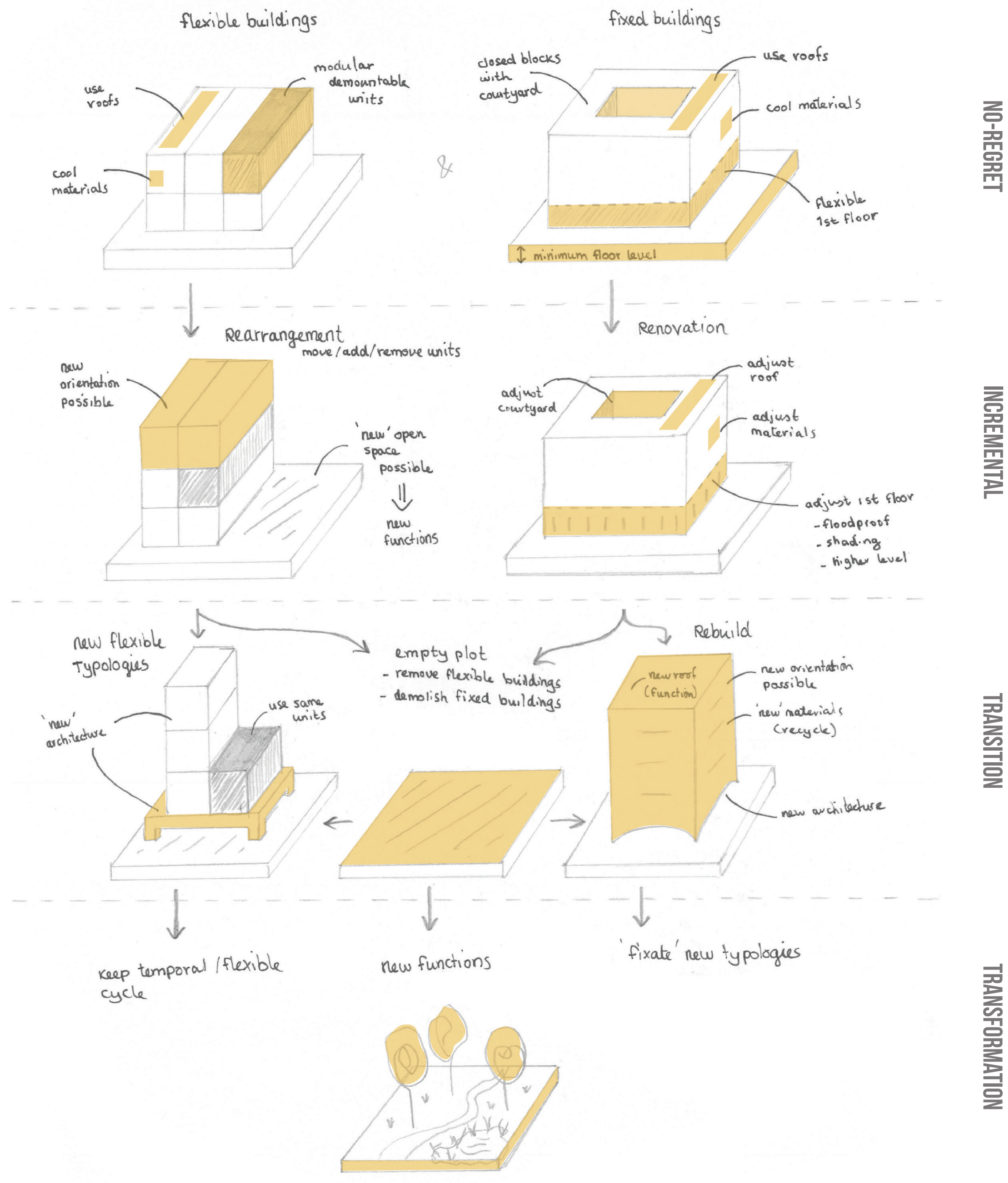


Figure 9.5. Conceptual Pathways for the Urban Design layer.

9. Adaptation Pathways

9.2 FOCUS AREA 1 : COENHAVEN WATERFRONT

The Coenhaven waterfront has been selected to explore pathways related to fluvial flooding. The waterfront is located directly on the North Sea Canal and would undergo the most changes if the protection strategy of Haven-Stad (or the region) changes in the future.

9.2.1 Possible Future Developments

Various future developments could have consequences for the waterfront of the Coenhaven, which would require an adaptation of the area. Due to possible developments on the regional and national scale, the local scale of the Coenhaven can be influenced.

Short-term

The Coenhaven is located in the boezem of the North Sea Canal system. This system is currently already very close to its limits. Due to higher sea levels, less water can be discharged through the sluice gates and more water has be pumped (and higher). As the system is expected to be more difficult to control in the future, plans are being made to make the canal's water level more flexible. This means that the maximum waterlevel can rise to +0.2/+0.5 m NAP (the current maximum is 0.0 m NAP) (Defacto Stedenbouw & RHDHV, 2021). The Coenhaven must able to handle these fluctuations and new maximums. However, because the maximum value of +0.5 m cannot cause flooding in the Coenhaven (minimal +1.0 m NAP), this case is less relevant for this pathway map about fluvial flooding.

Long-term

Deltares has created four strategies to adapt the Dutch delta in the long term to a high and accelerated sea level rise: 'closed protection', 'open protection', 'seaward' and 'moving along', see figure 9.6 (Haasnoot, Diermanse, Kwadijk, De Winter, & Winter, 2019). These scenarios have been translated for the Amsterdam region in the 'Thematic study Flood risk management (Defacto Stedenbouw & RHDHV, 2021). These translations are used as inspiration for the possible futures for Haven-Stad in each of the Deltares scenarios. Figure 9.7 summarizes these possible futures for Haven-Stad.

The current strategy in the Amsterdam region is 'protection-closed', as the IJmuiden complex seperates the North Sea Canal from the North Sea. However, the system is already very close to its limits. In a future with rising sea levels, it is necessary to keep updating the flood defences. Less water can be discharged under gravity, requiring more pumping. However, this makes the discharge system more vulnerable to calamities and the North Sea Canal is expected to reach its maximum level more often (Defacto Stedenbouw & RHDHV, 2021). This means that Haven-Stad would be very dependent on the (renewal of) the regional water system. To reduce dependency, it could be decided to add flood protection to separate Haven-Stad from the canal (closed), or to prepare the urban area for potential floods (open).

The 'protection-open' strategy implies an open connection with the sea. In the Amsterdam region, this would mean that the IJmuiden complex will be removed. However, this is not considered realistic (Defacto Stedenbouw & RHDHV, 2021), because this would require the entire water system in the region to change. In the 'Thematische studie Waterveiligheid' the IJmuiden complex is not removed in this strategy, but also no longer updated (no extra pumps). When the pump capacity is not sufficient, the levels of the North Sea Canal can be increased to discharge more water (Defacto Stedenbouw & RHDHV, 2021). In this strategy, Haven-Stad areas that are part of the boezem (such as the Coenhaven) could be protected against the higher levels in two ways: by increasing the groundlevels of the area (open) or by building a flood defence (closed).

The 'seawards' strategy is based on manu-facturability. Reclaimed islands form the new primary sea defence and an intermediate lake keeps the rising sea level at a distance from the IJmuiden complex. As a result, less updating of the complex is needed and less salinization occurs (Defacto Stedenbouw & RHDHV, 2021). For Haven-Stad the situation approach the 'protection-closed' strategy, but with less chance of higher water levels in the North Sea Canal and flooding.

In the 'move along' strategy, the focus is on living with water. Flood defences are no longer being updated on a large scale and the focus is shifting to limitation of the consequences of flooding. In addition, the storage capacity of the system will be greatly expanded (Defacto Stedenbouw & RHDHV, 2021). Haven-Stad will also be part of the 'living with water' concept and will contribute to the storage capacity of the system, by letting in water. A more extreme version of 'move along' would be to give up most of the polders and flood defences (see Figure 9.6). If Amsterdam, including Haven-Stad, will become city islands, large flood defenses (or extreme land expansions) will probably be needed for these islands.

In conclusion, the Coenhaven must be prepared for two main scenarios: an open and a closed system. In the 'protection-closed' strategy, Haven-Stad can be either open or closed, depending on flood probabilities and regional flood defence updates. In the 'protection-open' strategy, Haven-Stad can also be open (land increase) or closed (flood defence). Not many changes are expected for the area in the 'seaward' strategy. Haven-Stad would depend on the regional system, but this would be a very reliable system. In the 'move along' strategy, Haven-Stad could be open or closed again. In a less extreme version of the strategy, the area would be open and water will be let into the area. In a more extreme scenario, Amsterdam becomes a super protected island (closed).

The Coenhaven should be prepared for two main scenarios: An open and a closed system.

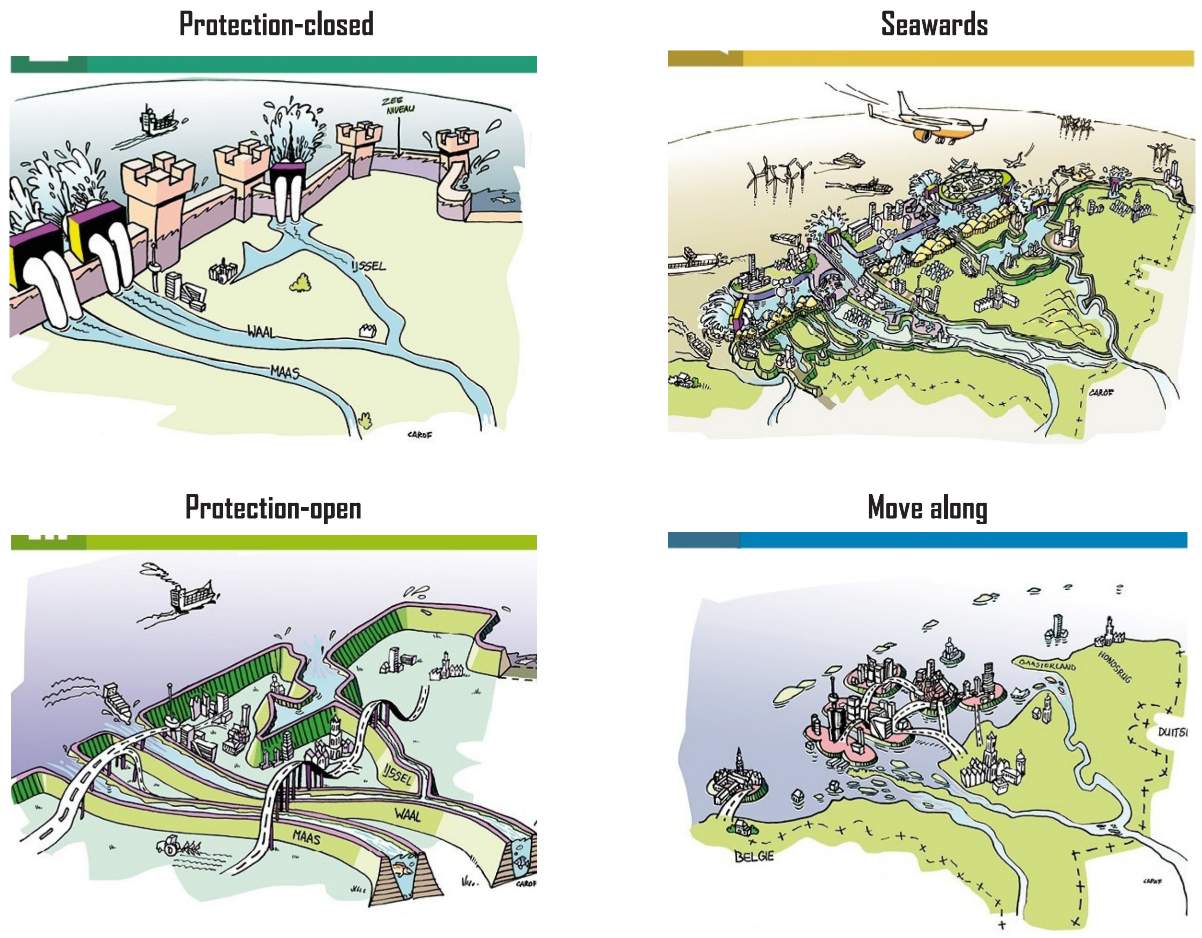


Figure 9.6. Strategies for the Dutch delta to adapt to high and accelerated sea level rise.
Reprinted from *"Strategieen voor adaptatie aan hoge en versnelde zeespiegelstijging. Een verkenning"* (p.21), by Haasnoot et al., 2019, Deltares. Copyright 2019 by Beeldleveranciers-Carof

9. Adaptation Pathways

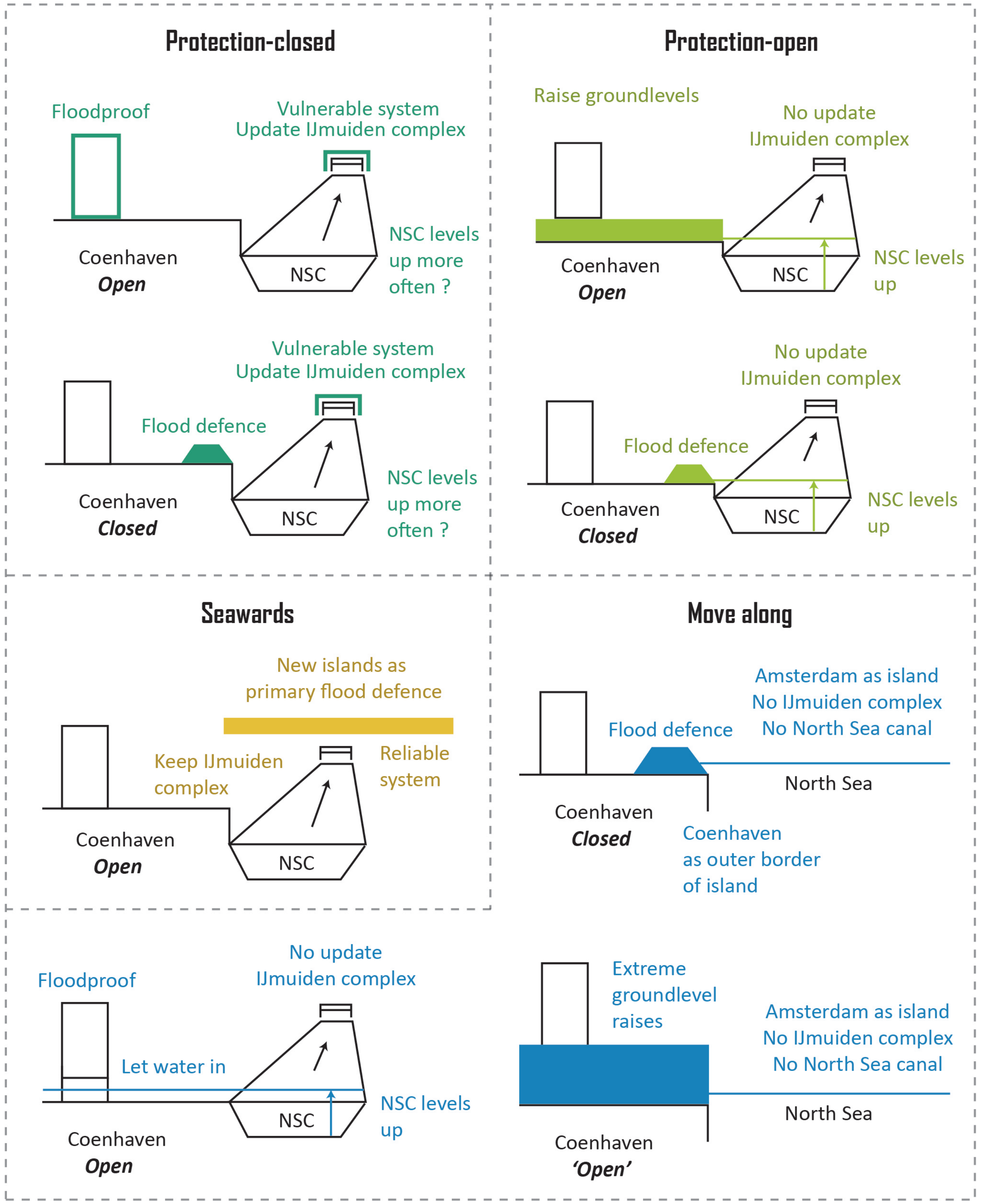


Figure 9.7. Possible futures for Haven-Stad (Coenhaven) in each strategy for the Dutch delta to adapt to high and accelerated sea level rise.

9.2.2 Transition Phases

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 for the future. It is uncertain how the trend of sea level rise will continue and Haven-Stad must still be able to evolve towards an open or closed system if neccesary.

Incremental phase
In the incremental phase, incremental measures can be taken to protect the area from small flood depths (closed) or to make the assets in the area floodproof (open). The incremental measures must be reversible or no-regret. A measure that closes Haven-Stad off from the canal should therefore not mean that a transition to an open system is no longer possible.

Transition phase
In the transition phase, the decision is made for an open or closed system. This decision depends on national and regional decisions on the Delta strategy. However, as described earlier, in Haven-Stad it is still possible to opt for an open or closed system in any of the Deltares strategies. The final decision will thus depend on national, regional and local circumstances and preferences.

Transformation phase
In the transformation phase, the chosen strategy is enhanced and further developed. This can be triggered by more sea level rise and/or by societal needs. With an open system, new developments could be made on the water. With a closed system, new developments could be made on multifunctional flood defences.

9.2.3 Trend (x-axis)

Figure 9.8 explains the leads used for the x-axis development of the SAPP map.

Sea level rise & Flood depths
The flood depth was selected as main axis, because this is often used to determine the severity of a flood and the necessary measures. The trend of sea level rise is shown below the main axis. This axis has been added to show the relationship between the climate change trend (sea level rise) and the possible consequences for Haven-Stad (flooding with a certain flood depth). Connected to the axis with sealevel rise are two lines that reflect the best-case and worst-case scenarios. This component adds two timescales to the adaptive pathways map.

Section 6.3 describes the assumption of this research that the flood depth increases linearly with (a percentage of) the sea level rise. However, the coupling of the sea level rise axis and the flood depth axis is complex. First of all, several different flood events, with different flood probabilities, can cause a flood in Haven-Stad. And some of these events, for instance the failure of the Lekdijk, are actually more related to heavy rainfall events than to sea level rise (although sea level rise also affects the discharge possibilities of the system). Secondly, it is unclear how exactly sea level rise affects the flood depths in Haven-Stad. Water levels during storm surges will increase due to sea level rise, but this does not imply a linear increase of the flood depths in the North Sea Canal and Haven-Stad (Defacto Stedenbouw & RHDHV, 2021). The greatest probability of failure is overtopping (overslag), but this only causes small amounts of extra water in the canal. However, the return time of certain flood depths will increase due to sea level rise (Defacto Stedenbouw & RHDHV, 2021). But updates of technology and dikes can shorten this return time again, as can be seen in Figure 9.3 in Appendix 9.2.

An extensive research into this complex coupling is outside the scope of this research. However, experts can adjust this axis and associate new values with the phase shifts. To reduce the complexity for this research, it is assumed that the flood depths increase linearly with sea level rise. For each 0.5 m sea level rise, the flood depth is assumed to increase by 0.1 m. These steps have arisen from the defined starting point and endpoint, whereby a link is made between the sea level rise and flood depths.

Starting point & Endpoint (blue in Figure 9.8)
The starting point is the current situation. The current sea level rise (compared to 1995) is 0.03 m (see Figure 9.4 in Appendix 9.2). The current flood depth has been set on 1.3 m, this is the value taken into account for Haven-Stad (Defacto Stedenbouw & RHDHV, 2021). It also connects to the data from Figure 9.3 in Appendix 9.2. The endpoint is determined by the maximum value in the worst case scenario; a sea level rise of 3.0 m (see Figure 9.5 in Appendix 9.2). This is in line with the note made in the 'thematische studie waterveiligheid' that a maximum flood depth of 2.0 m NAP can occur in Haven-Stad around 2100 (Defacto Stedenbouw & RHDHV, 2021). The value is set on 1.9 m to avoid the need for two decimals on the x-axis, while the values are indicative and not precise.

Best-case & Worst-case scenario
Figure 9.5 in Appendix 9.2 is used to find the years that are coupled to certain sea levels in the best-case and worst -case scenario. This figure includes the newest scenarios of accelerated sea level rise.

Phase shifts (yellow in Figure 9.8)
The starting design is assumed to be dimensioned for the climate in the worst-case scenario for 2050 (as is often the practice). This corresponds to a sea level rise of 0.5 m (see Figure 9.5 in Appendix 9.2). When the sea level rise starts to reach 0.5 m, a shift to the incremental phase is necessary. The shift from the incremental to the transition phase is related to a 1.5 m rise in sea level. The IJmuiden complex is dimensioned for a sea level rise of 1.52 m (1:10.000) (Defacto Stedenbouw & RHDHV, 2021). Above 1.5 m the probability of failure increases (<1:10.000), which is (currently) not acceptable for such a high-value area. This point is thus selected as a crucial moment to make new decisions about the protection strategy. The shift from the transition to the transformation phase is difficult to project, as it depends on the transition that has taken place, the dimensioning of measures, and the needs of society. However, the shift could be set in motion if the accelerated sea level rise scenario is assumed or proven to become a reality.

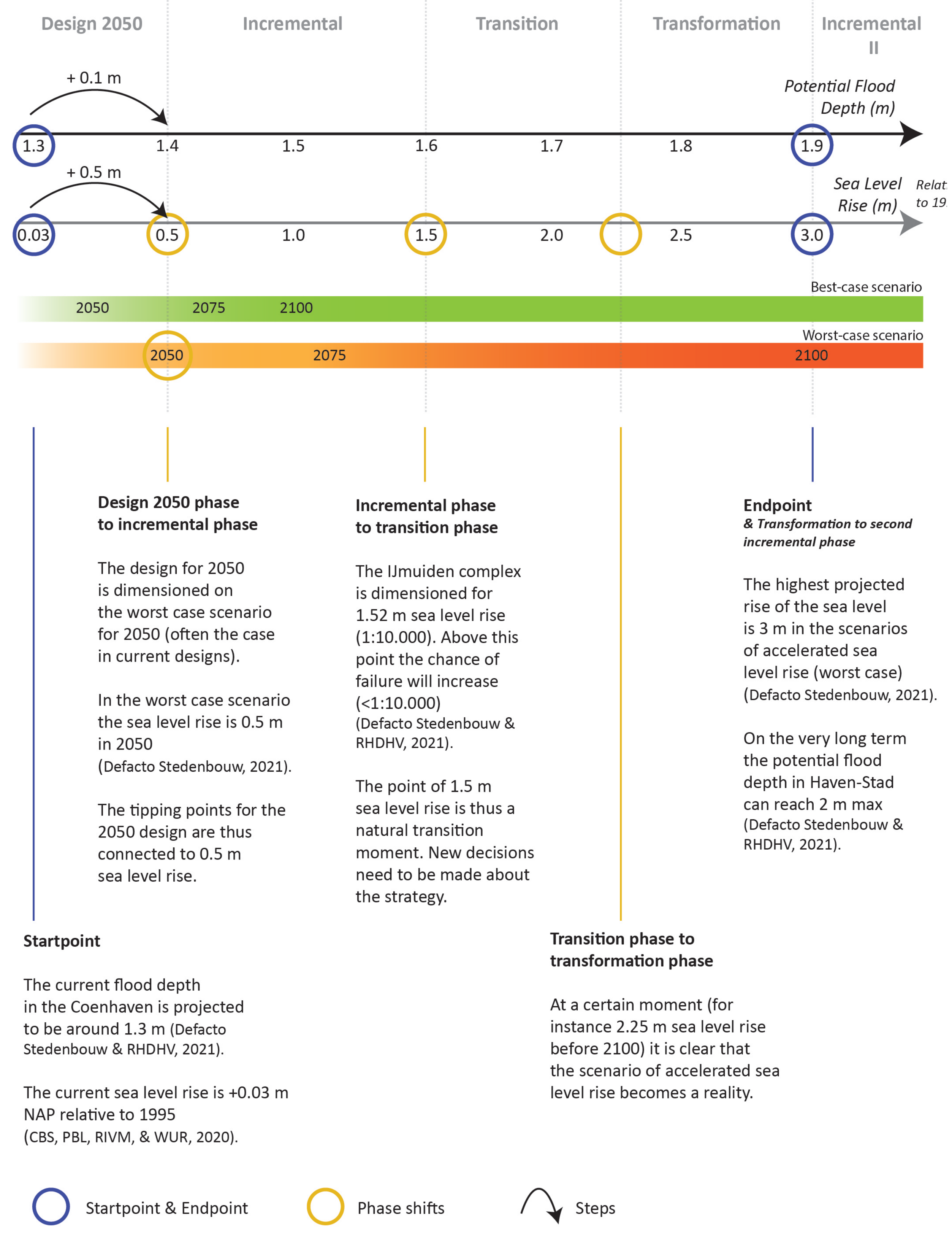


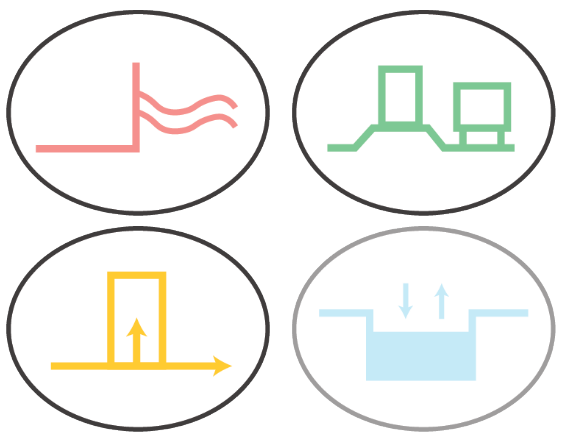
Figure 9.8. Leads for the development of the x-axis.

Appendix 9.2
For more information about the development of the x-axis

9.2.4 Adaptation Measures (y-axis)

Relevant adaptation principles, design layers and adaptation measures have been selected for the design of adaptive pathways for fluvial flooding in the Coenhaven (as identified in chapter 7).

Adaptation Principles
For fluvial flooding, the most relevant adaptation principles are 'protection', 'robust urban design', and 'evacuation'. These principles stem from the multi-layer safety concept, which indicates that each layer must be taken into account in the design. All principles also apply for the Coenhaven waterfront. The principle 'storage' can also be considered, but will have less effect on a flood, because Haven-Stad is not large enough to store a significant amount of water to lower the water depths. Regional measures can have these effects.



Design Layers
Each design layer must be considered, as each design layer can potentially contribute to water safety. The 'flood defences' layer can contribute to protection (with an actual flood defence), evacuation (on top of an uneffected flood defence), and robust urban design (a building as flood defence). The 'soil' layer can contribute to evacuation (elevated evacuation routes) and robust urban design (buildings on higher grounds or terps). The layer 'urban design' also contributes to evacuation (evacuation shelters) and robust urban design (floodproof typologies). The 'vegetation' layer seems to be less relevant, but can play an important role in space reservation (for instance, to build a dike in the future). The 'water system' layer can play a role in creating storage.

Adaptation Tiles
Based on the adaptation principles and design layers, relevant adaptation measures have been selected for fluvial flooding in the Coenhaven Waterfront (see figure 9.9). Please note that the adaptation measures cannot be considered exhaustive.

The measures are divided over the four transition fases:

- No-regret measures / Start measures (design 2050)
The starting measures are the measures that are part of the 2050 design and are directly implemented in the development of Haven-Stad. For the Coenhaven waterfront, the measures concern the design of the quay(park), the creation of vertical evacuation locations, and the development of buildings with a flexible 1st floor and external beams. The design also includes waterrobust vulnerable and vital functions and a remediation park.

- Incremental measures
The incremental measures are the measures that can be implemented if the first problems occur after 2050. In this case: small flood depths. A (flexible) floodwall can keep the water out of the area, or floodproof buildings (plinths) can handle small flood depths. The remediation park can be changed into a 'normal' park.

- Transitional measures
The transitional measures are used as part of a transition. In the case of the Coenhaven, the transition can go two ways. Towards a protective (closed) strategy, with a dike or terraced boulevard. Or towards a more open strategy, with a floodable waterfront park.

- Transformational measures
The transformational measures are a reinforced continuation of the chosen transition direction. A transition to a closed strategy (with a dike) can further develop into an integrated super dike or buildings as flood defences. A transition to a more open strategy can be continued to an area where living with the water is further explored.

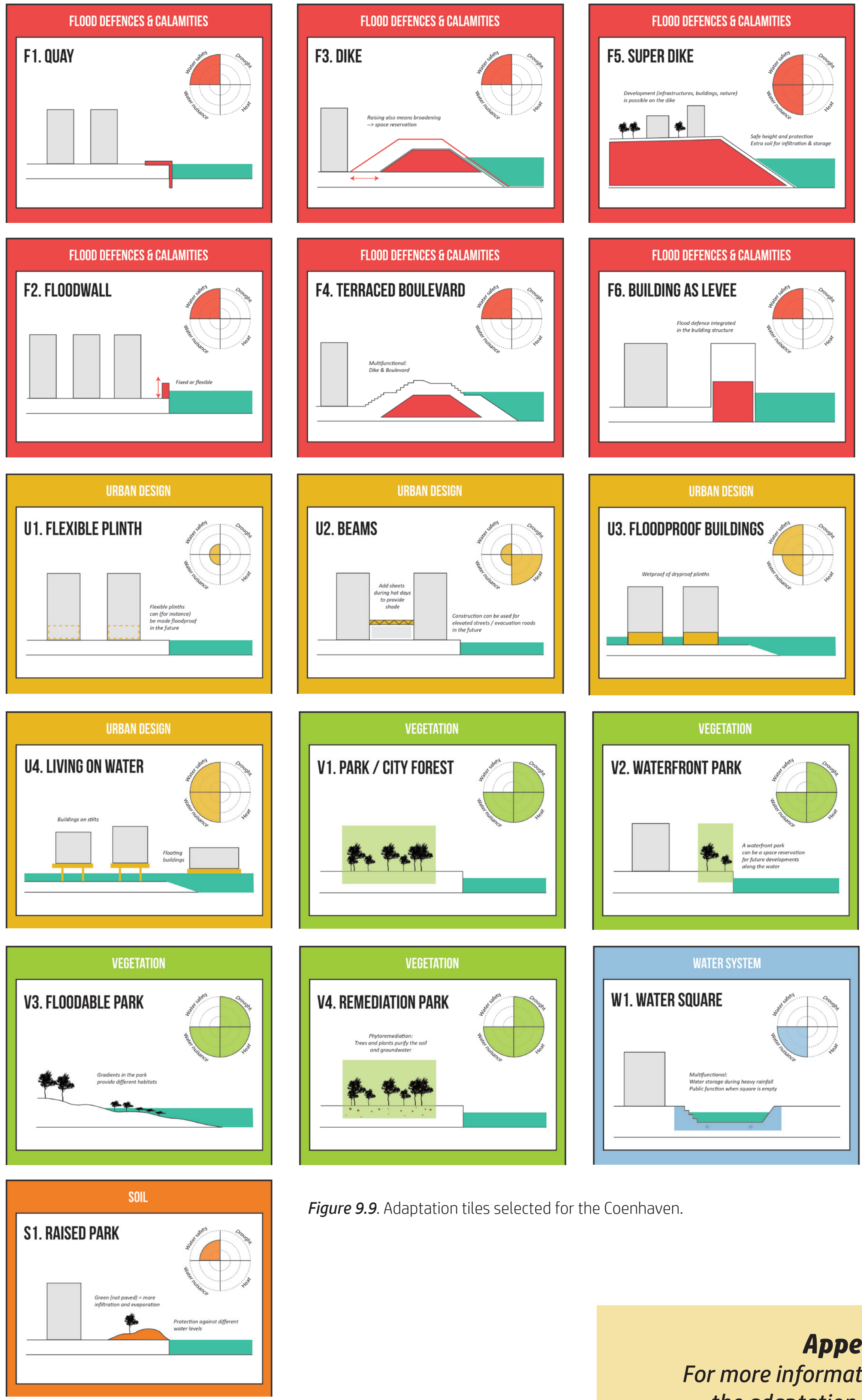
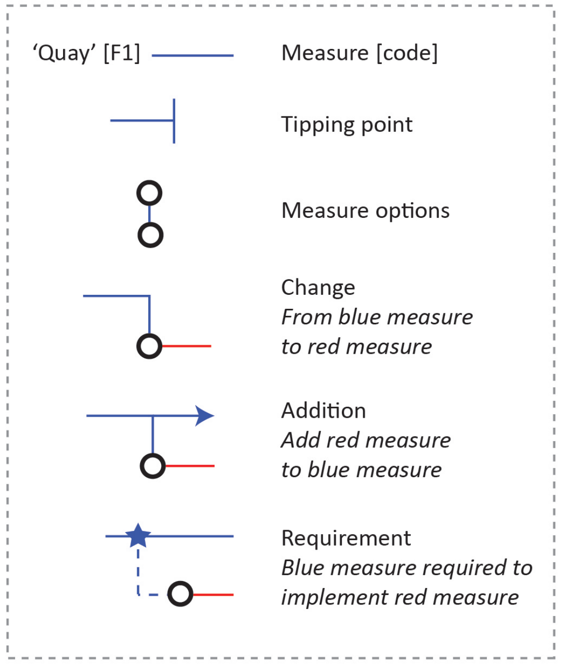


Figure 9.9. Adaptation tiles selected for the Coenhaven.

Appendix 7.3
For more information about the adaptation measures

9. Adaptation Pathways

Legend



9.2.5 Adaptive Pathways map

Figure 9.10 shows the adaptive pathways map for the Coenhaven waterfront. The map shows the adaptation options in the course of the four transition phases (and an additional second incremental phase). The x-axis shows the trend of sea level rise and the associated increase in potential flood depth. The best-case and worst-case scenarios show in which years which sea level rise is projected. The y-axis shows the adaptation measures, that have been selected for adaptation to fluvial flooding in the Coenhaven. The colored lines are the different pathways that can be followed in time (trajectories). The pathways per phase are explained on the following pages.

Please note that the pathways cannot be considered exhaustive.

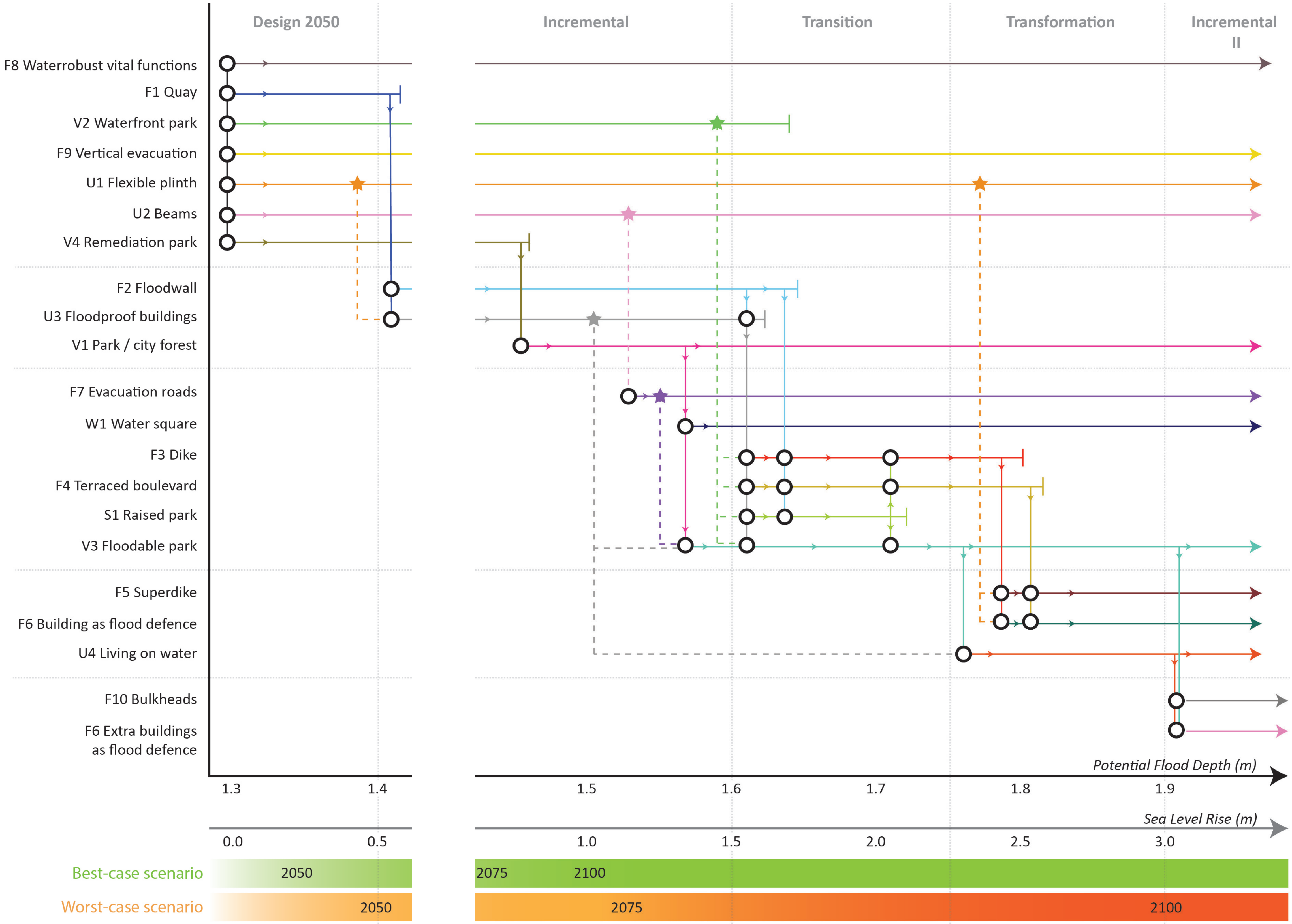


Figure 9.10. Adaptive Pathways map for the Coenhaven waterfront

Explanation of the SAPP map per phase

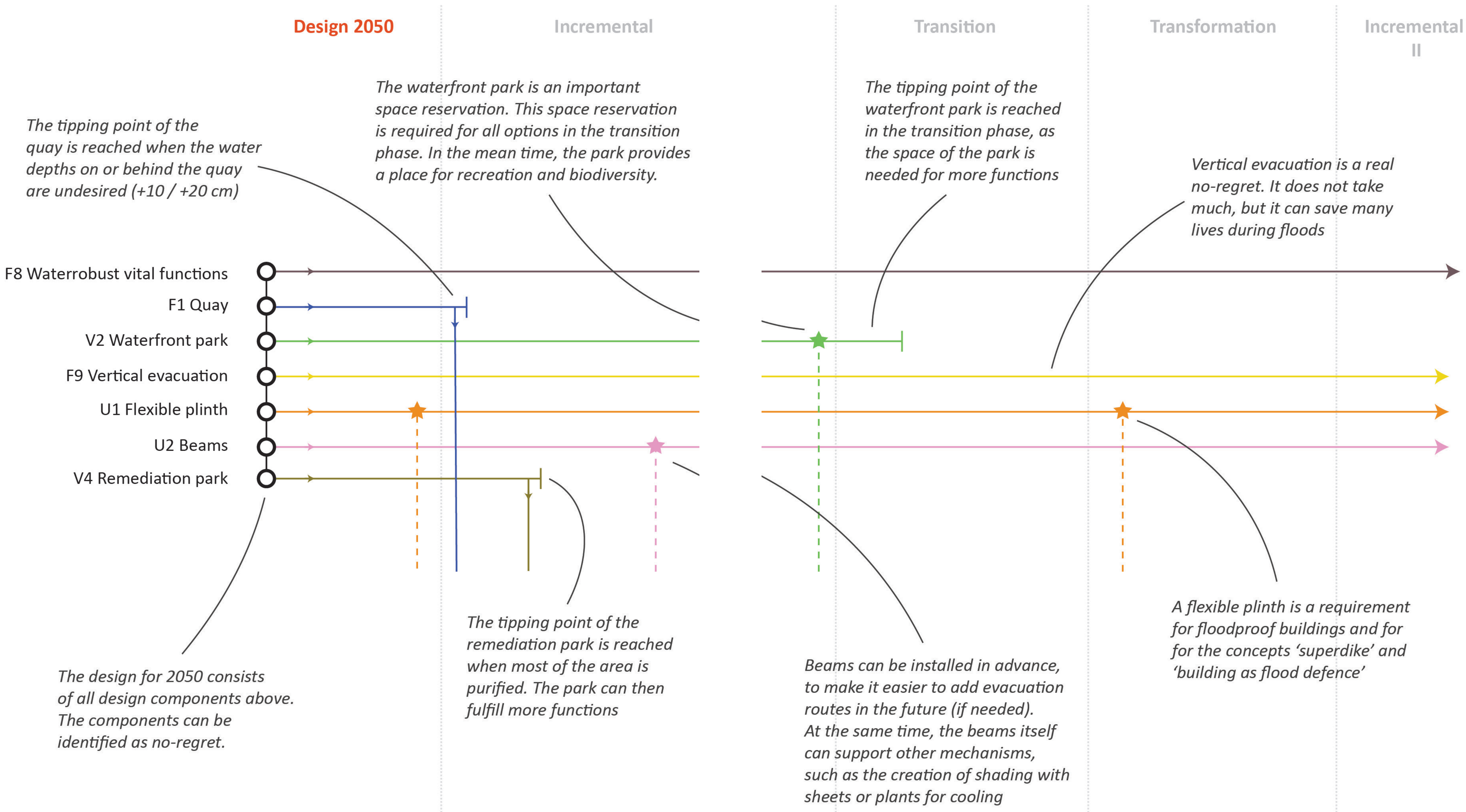


Figure 9.11. Explanation of the No-regret (design 2050) phase.

9. Adaptation Pathways

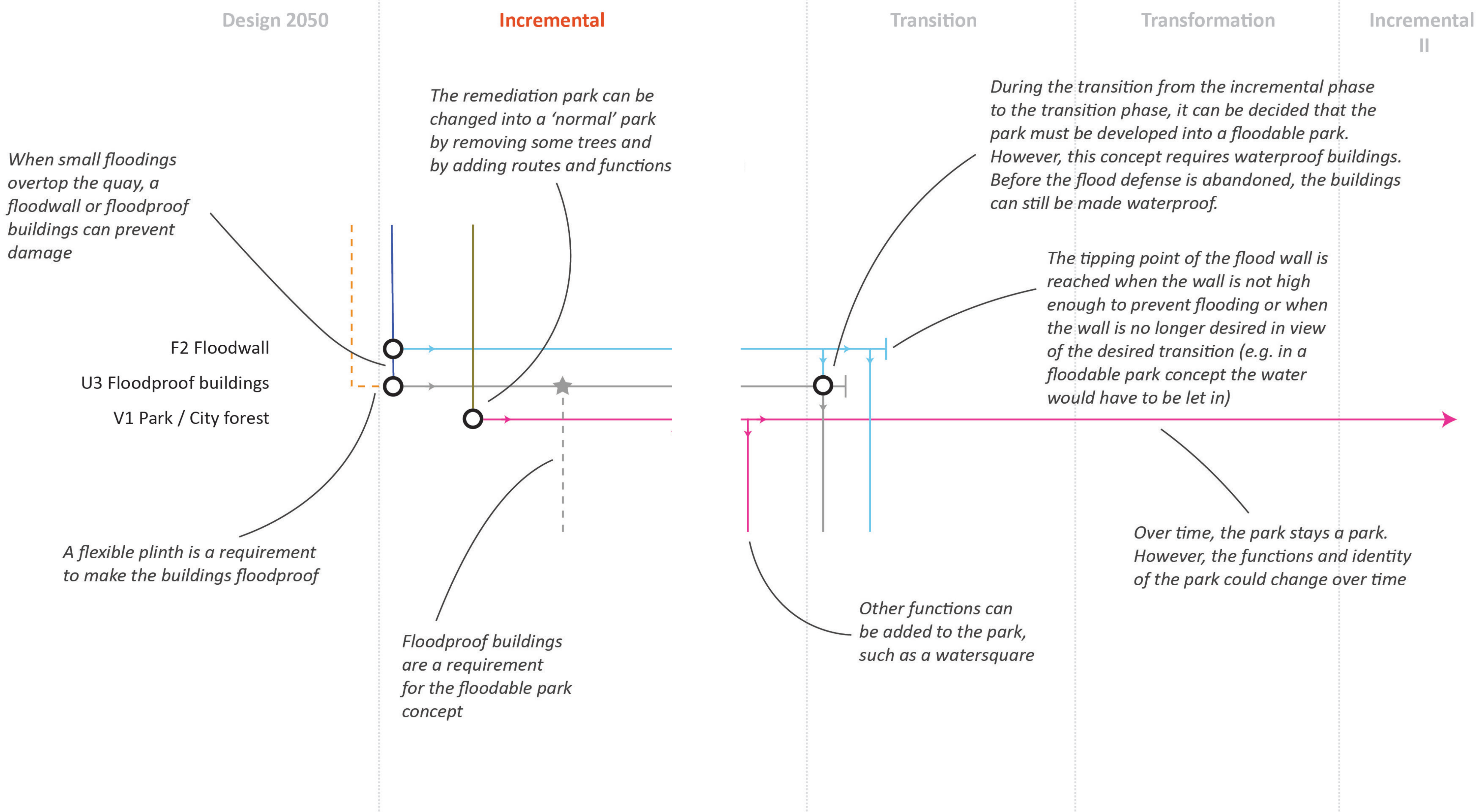
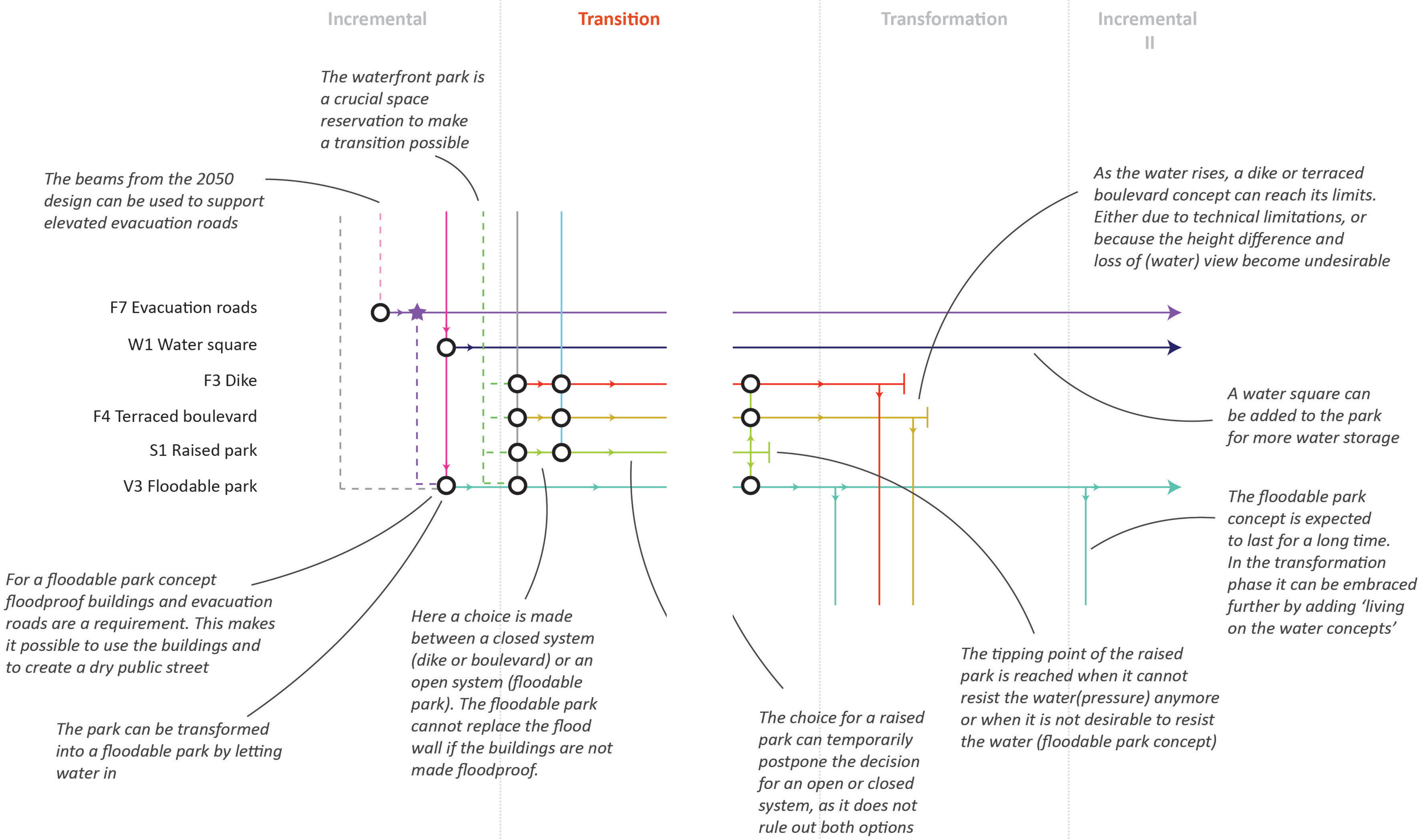
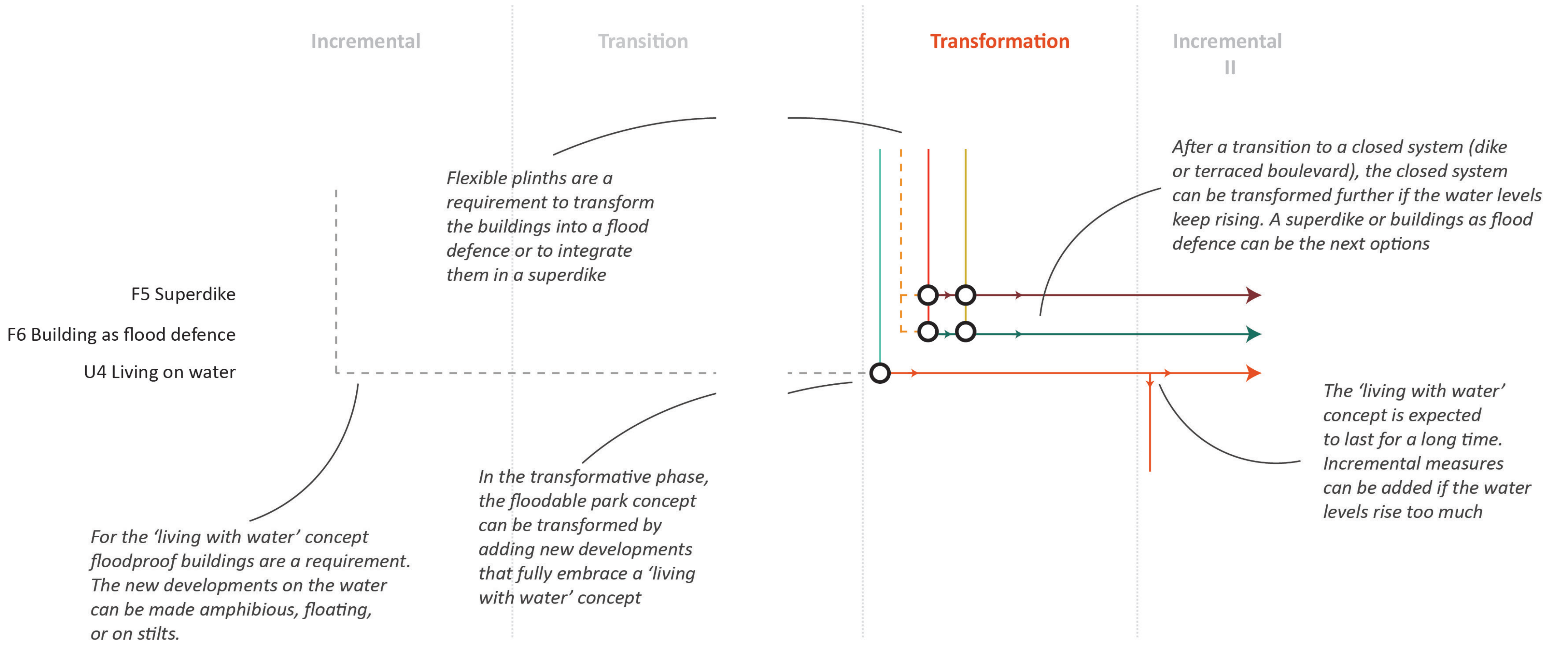


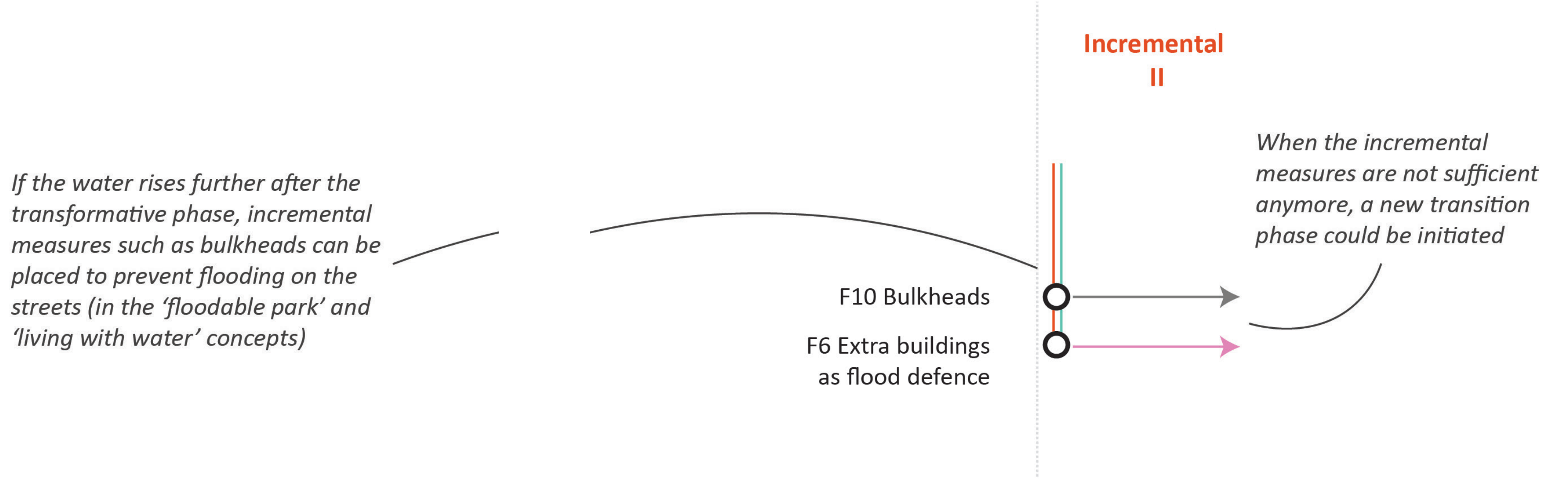
Figure 9.12. Explanation of the Incremental phase.

9. Adaptation Pathways



9. Adaptation Pathways





9. Adaptation Pathways

9.2.6 Reflection on the Coenhaven SAPP map

Comparable areas
The SAPP map of the Coenhaven waterfront can be used for comparable areas (Figure 9.16), but with adjustments. For the harbor areas in the north of Haven-Stad (Cornelis Douwes), the created SAPP map could be used with minor adjustments. Also in the rest of the harbor area in Haven-Stad South (Coenhaven & Minervahaven) the same pathways could be used. However, a new dike trajectory will probably only be constructed along the canal and not along the entire harbor edge. Yet it is also important to make space reservations along the harbor edges for other measures, such as the flood wall or waterfront park (in the living with water future). For the rest of the boezem area of Haven-Stad (Alfa Driehoek & Sloterdijk I) the created SAPP map is less relevant. The SAPP map could also give inspiration for other urban developments in harbors. It should be taken into account that the SAPP map assumes a closure (IJmuiden complex) between the canal and the sea. The x-axis of the SAPP map in particular would look different for areas outside the dikes in Rotterdam, for example, where there is still an open connection with the sea.

Alternative starting points (design 2050)
The created SAPP map contains one single starting point for the design of the Coenhaven, that enables the different pathways. However, this initial design is not the only possible starting point. The created SAPP map can provide insight into which pathways are not possible anymore if they are not anticipated in the initial design. For example, it is a lot more difficult to build a dike if the area has been allocated to private actors and there are buildings there. In addition to (variations on) the created starting point, more extreme starting points can also be made. For example, the choice for a very robust initial design. This could be, for example, raising the entire area by a couple of meters, so that it can also serve as an evacuation location and safe area for vital and vulnerable functions. However, this is not advisable if the national delta strategy is not yet clear, because then another major investment may be needed in the future. A large raise would rule out the move along scenario. A more extreme flexible initial design (for example with fully modular buildings) would be a possibility because it does not rule out any scenarios.

Connection to the region
The SAPP map shows that the future of the Coenhaven depends on the regional and national delta strategy. The choice for a new flood defence trajectory (closed system) is a regional and national choice. But also the choice to not add a new dike trajectory and to focus on living with water concepts (open system) is a regional decision. The implementation of a new dike trajectory requires regional coordination. The implementation of living with water concepts can be more locally customized.

Connection to other climate adaptation pillars
The SAPP map of the Coenhaven is focussed on water safety (fluvial flooding). But some measures can also affect the other climate adaptation pillars heat, drought and pluvial flooding, for example:

- A raise of groundlevels (in the case of the superdike) can increase the infiltration (and storage) capacity of the soil. The extra layer also increases the distance to the groundwater table, which can be positive during wet periods but negative during dry periods (pluvial flooding, drought).
- A flood defence along the North Sea Canal can create fresh water basins in the old harbor basins. This storage can be filled in wet periods and used in dry periods (pluvial flooding, drought).
- High flood defences (dike/superdike) can potentially block cooling winds (heat). Living on the water can potentially cool down the living environment (heat).
- Letting the (brackish) water from the North Sea Canal into the water system of Haven-Stad can influence the local freshwater availability (drought).
- A flood defence changes the water system of Haven-Stad. The boezem areas change into polders and pumping may be needed. This gives more control on the water levels (pluvial flooding, drought).
- Living with water asks for floodproof buildings, which also protect the buildings from pluvial flooding.

Best-case & Worst-case scenario
In the best case scenario only local incremental measures are probably needed till 2100 for the Coenhaven. If the sea level increases further after 2100, the transition can still be set in. If not, the area does not need new measures. In the worst case scenario the need for a transition and transformation before 2100 are very likely. The worst case scenario thus asks for bigger decisions, not only for the Coenhaven, but also on regional and national scale.

Deltares strategies
See Figure 9.7 for possible futures for Haven-Stad (Coenhaven) in each strategy for the Dutch delta to adapt to high and accelerated sea level rise.

The 'protection closed' strategy is covered in the SAPP map, with open options (floodproof) and closed options (dike trajectory). If the IJmuiden complex is updated over time, some measures may be considered unnecessary. However, it remains a vulnerable system and has major consequences in the event of failure. Depending on the flood probabilities and the risk perception, it can be decided whether or not to take measures.

The 'protection open' strategy is partly covered in the SAPP map. The closed version (dike/superdike) is integrated the map, but the open version (raise groundlevels) not. The open version is not integrated in the SAPP map, because it should be incorporated into the initial design right away (it is hard to raise the groundlevels after construction), excluding other strategies.

The 'seawards' strategy is only indirectly covered in the SAPP map. With this strategy, Haven-Stad is given extra protection and at most incremental measures are needed in the district. Due to the islands and the lake off the coast, flood probabilities will change and so will the relationship between sea level rise and flood depths. Therefore an adjusted x-axis would be needed to fully include this strategy in the SAPP map.

The less extreme option of the 'move along' strategy is covered in the pathways (living with water future). The more extreme scenario in which IJmuiden and polders are given up is not really covered. The SAPP map can potentially be used with an adjusted x-axis (direct relation between sea level and flood depths) and an extended version of the superdike. Extreme groundlevel rise not included, as it is not part of the no-regret 2050 design.

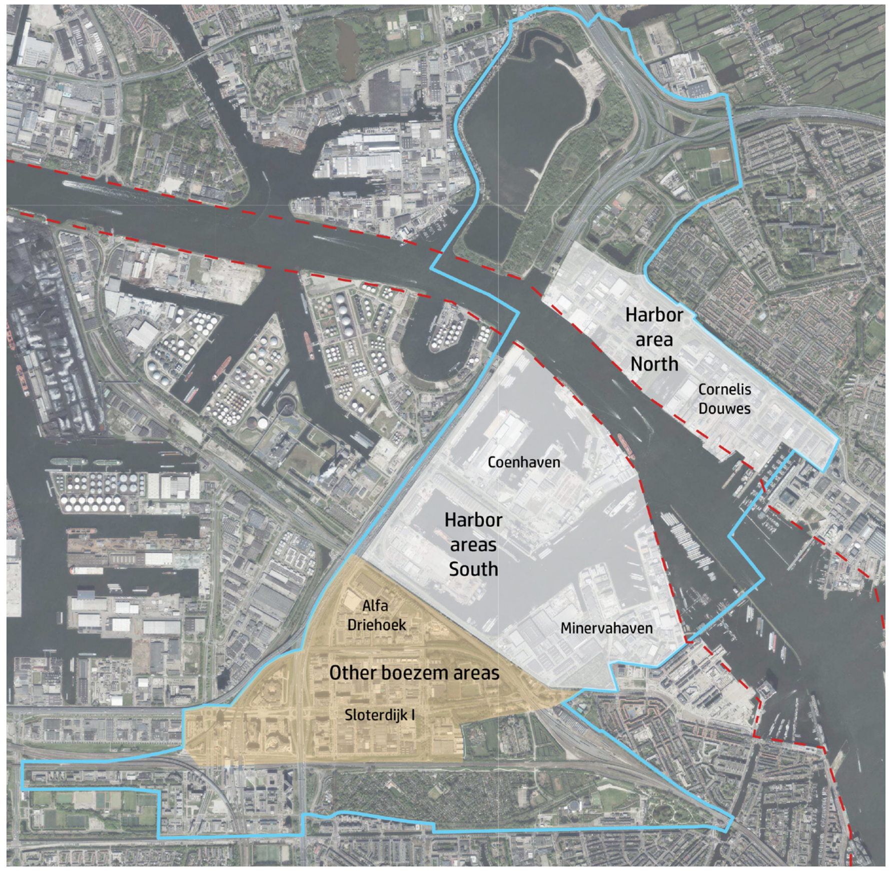


Figure 9.16. Comparable areas. Background from "Google Maps", by Google, n.d. (https://www.google.com/maps/place/Amsterdam/). Copyright by Google Maps.

9.3 FOCUS AREA 2 : SLOTERDIJK I SOUTH

Sloterdijk I South is selected as focus area to do a quick second test of the SAPP approach. Sloterdijk I South is identified as an area in which water nuisance occurs and is therefore selected as focus area to explore pathways that adapt to pluvial flooding. This second test is conducted to find the differences with the development of SAPPs for the Coenhaven, and to explicitly share the questions that emerged during the process to make the research-by-design process more tangible. In Appendix 9.3, all steps of the SAPP approach are discussed.

9.3.1 Differences in development of SAPPs

Design of the starting point (Step 4)
No detailed plans have yet been made for the Coenhaven, because it will only be developed at a later stage. Sloterdijk I South is one of the first areas to be developed, which means that the municipality has already filled in more details. These plans can be used in step 4, the design of the starting point (initial design). The plans make it clearer what is expected of the area (for example in terms of typology and density). This can make it easier to create an initial design. However, the plans must be critically examined and, if necessary, adjusted.

Link between climate objective and climate trend (Step 2 & 5d)
For fluvial flooding (Coenhaven), it was not easy to link the climate trend (sea level rise) to the climate objective (flood depth). Ultimately, this is simplified with an assumption (linear relationship). For pluvial flooding (Sloterdijk I South) this is a lot easier. The link between the climate trend (precipitation intensity in mm/h) and the climate objective (m3 storage) can be made much more directly (intensity*area = m3 needed storage). Also the effect of the adaptation measures (m3 storage) can be easily linked to the climate objective (m3 storage), allowing the tipping points to be calculated more precisely. In the Coenhaven focus area, no sharp link has been made between the flood depth and the effects of the measures, because the measures ultimately cannot reduce the height of the flood itself, but are focused on protection and damage limitation.

Appendix 9.3
For the quick second test of the SAPP approach for Sloterdijk I South

Future perspective (Step 5b & 5c)
Identifying possible future developments was strongly guided by the national delta strategies of Deltares for the Coenhaven. This turned out to be more difficult for pluvial flooding, because no scenarios have yet been developed for this on a regional or national scale. However, changes in the North Sea Canal area can be expected, which could be linked to the SAPP map to some extent (for example, if Sloterdijk I South is allowed to discharge less or no more water to the canal). In addition, pluvial flooding is often a local issue, which makes it harder to connect to transitions on a larger scale. Because the possible futures are not very clear, it has also been more difficult to link these to the transition phases. However, because the tipping points for fluvial flooding can be calculated more precisely, the transition phases are less important than in the Coenhaven case. Nevertheless, the phases can be important to stimulate thinking about more extreme adaptations (transition/transformation).

Defining the endpoint (Step 5d)
For the Coenhaven it was easy to determine the endpoint of the x-axis. This was the highest predicted sea level in the furthest climate projection (2100). This sea level rise could also be linked to necessary transformations. For pluvial flooding it is more difficult to determine exactly at which point a transition and transformation are needed. In the worst-case scenario for 2085, the precipitation intensity is 80 mm/h, 20 mm/h more than now. This 80 mm/h could be chosen as the endpoint, but the question is whether this intensity is high enough to stimulate thinking about more extreme adaptations (transition/transformation). Objectives from RIONED for a climate-adaptive design are eventually used to determine the phase shifts and endpoint (150 mm/h - very climate adaptive) on the x-axis.

Combinations of measures (Step 3 & 5e)
In the SAPP map for the Coenhaven, the effects of the measures that occur together in a design do not have to be combined, because they have no direct effect on the objective itself (flood depth). In the case of pluvial flooding, all the storage capacities of the different measures in a design must be added together to determine the total storage of the focus area (objective). 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.

9. Adaptation Pathways

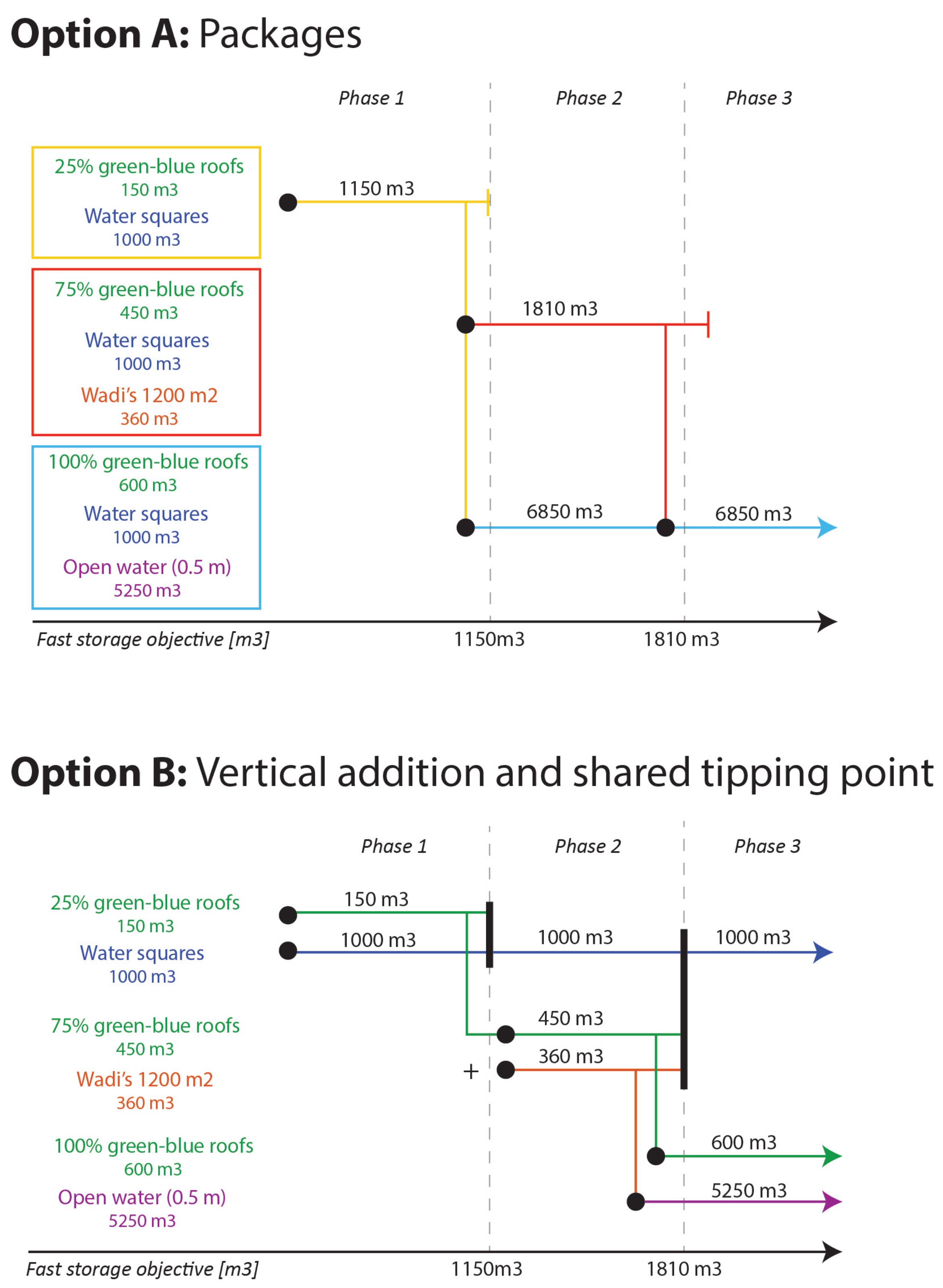


Figure 9.17. Different options to show both the individual measures and the combinations of measures on the y-axis. Note: The storage values and tipping points/phase shifts are indicative.

CONCLUSION
DEVELOPMENT

How can Spatial Adaptive Policy Pathways
be developed
for climate adaptation planning?

HAVEN-STAD OUTPUTS

- For each design layer, it is indicated how the adaptation principles can be translated to Haven-Stad.
- The Coenhaven waterfront and Sloterdijk I South are selected as focus areas for the exploration of SAPPs for fluvial flooding and pluvial flooding, respectively.
- The Coenhaven should be prepared for two main scenarios: An open and a closed system. A decision for one of these scenarios would mean a transition (and potentially later a transformation) for the Coenhaven area.
- The x-axis connects the trend of sea level rise to the potential flood depth in the Coenhaven and to a best-case and worst-case climate scenario.
- The SAPP map for the Coenhaven shows the (non-exhaustive) options for adaptation to a rising sea level over four transition phases. In the best case scenario, until 2100 only local incremental measures are likely to be needed. In the worst case scenario, the need for a transition and transformation before 2100 is very likely.
- Sloterdijk I South (pluvial flooding) is used for a quick second test of the SAPP approach and has revealed multiple differences with the development of SAPP for the Coenhaven (fluvial flooding). For pluvial flooding, the y-axis needs another set-up, in which both the individual measures and the combinations of measures are shown.

SAPP APPROACH

- Research-by-design is the most important method for the development of SAPPs. The development involves multiple iterations between the design of the starting point, the design of the area over time (the pathways), and the design of the SAPP map.
- The SAPP approach stimulates to explore the possibilities for climate adaptation in space and time. For the spatial exploration, adaptive pathways are translated to the case study site for each design layer. The conceptual pathways can help to explore the possibilities of change over time.
- The selection of focus areas with one climate stressor proved necessary to reduce the complexity and to keep the SAPP map readable.
- The transition phases contribute to the conceptualization of the time component and form the connection between the conceptual pathways, the possible future developments and the x-axis.
- The design layers help to unravel the complexity of the city and to explicitly consider different options for climate adaptation.
- The final product of the development is the SAPP map, which shows how the urban area can adapt to climate change over time.

APPLICATION

How can Spatial Adaptive Policy Pathways be used to support design and governance for climate adaptation planning?

PATHWAYS FOR DESIGN

PATHWAYS FOR GOVERNANCE

10

PATHWAYS FOR DESIGN

How can the Spatial Adaptive Policy Pathways be used for climate-adaptive design? This chapter shows the spatial elaboration of a selection of the pathways for the Coenhaven waterfront, developed in Chapter 9. A conclusion is drawn on the use of SAPP for design, and the use of design for the development of SAPP.

SAPP Approach - Step 6

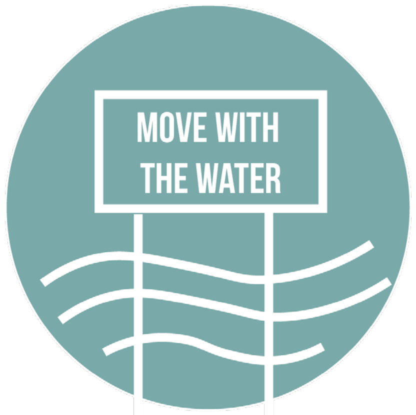
Chororos, J. (n.d.)

10. Pathways for Design

10.1 FOCUS AREA 1 : COENHAVEN WATERFRONT

10.1.1 Selection for Demonstration

Two trajectories of the pathway map for the Coenhaven have been selected for demonstration, as shown in Figure 10.1 & 10.2. Both trajectories start from the same design based on 2050. The first trajectory leads to a 'Living with Water' Future, in which water is accepted and valued as a large part of the living environment. The second trajectory leads to a 'Protective' Future, where water is kept out of the area. See Section 9.2 for more information about the pathway map.



The following spread presents the general design for 2050 in a map and section. The top left corner shows the measures that are part of the 2050 design. The pages after that show the part in each transition phase. On the left page, the 'Living with Water' Future is shown, on the right page the 'Protective' Future. The relevant trajectories are presented above the paragraphs.

LIVING WITH WATER FUTURE

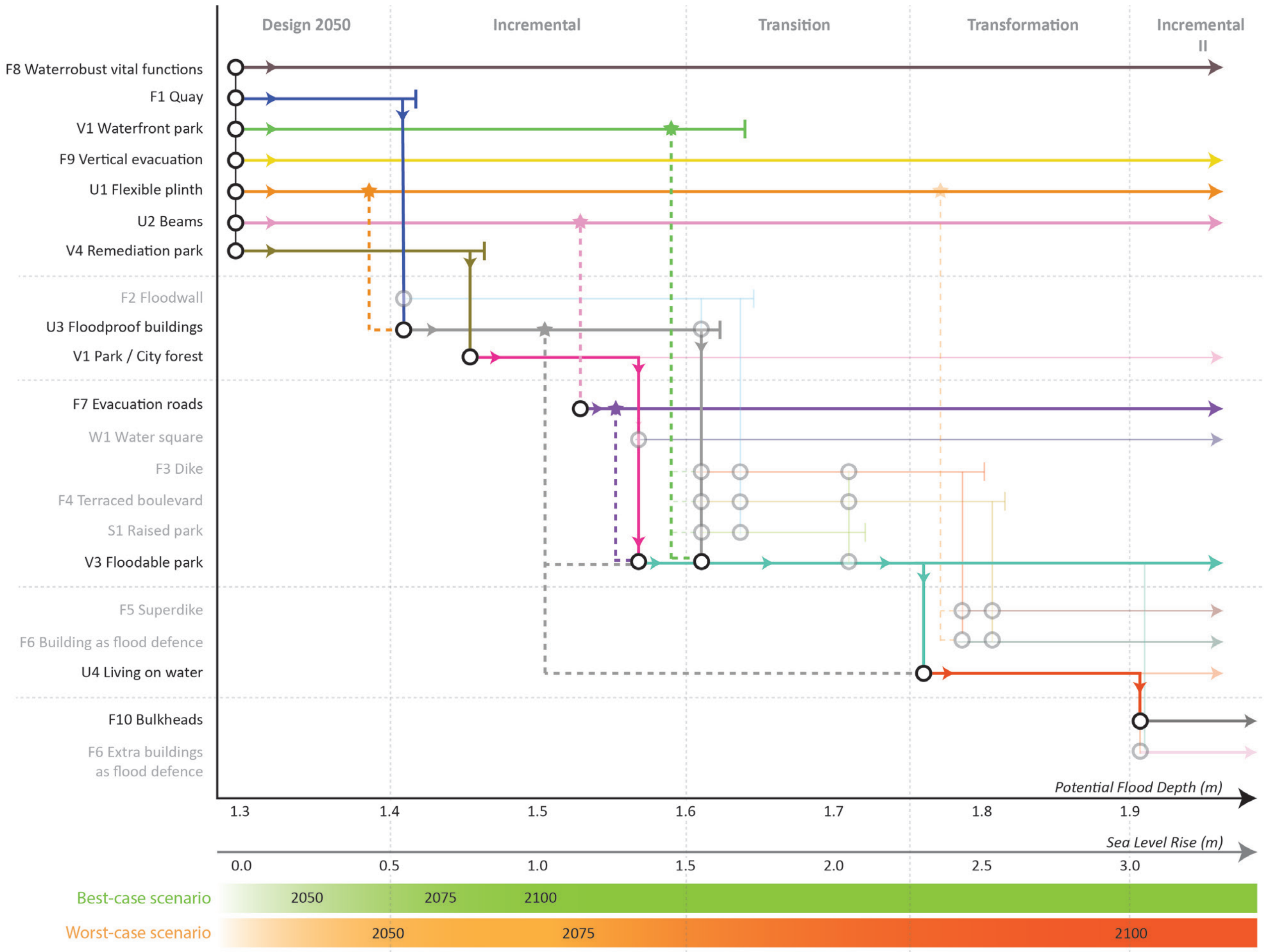


Figure 10.1. Trajectories towards a 'Living with Water' future

PROTECTIVE FUTURE

Figure 10.2. Trajectories towards a 'Protective' future

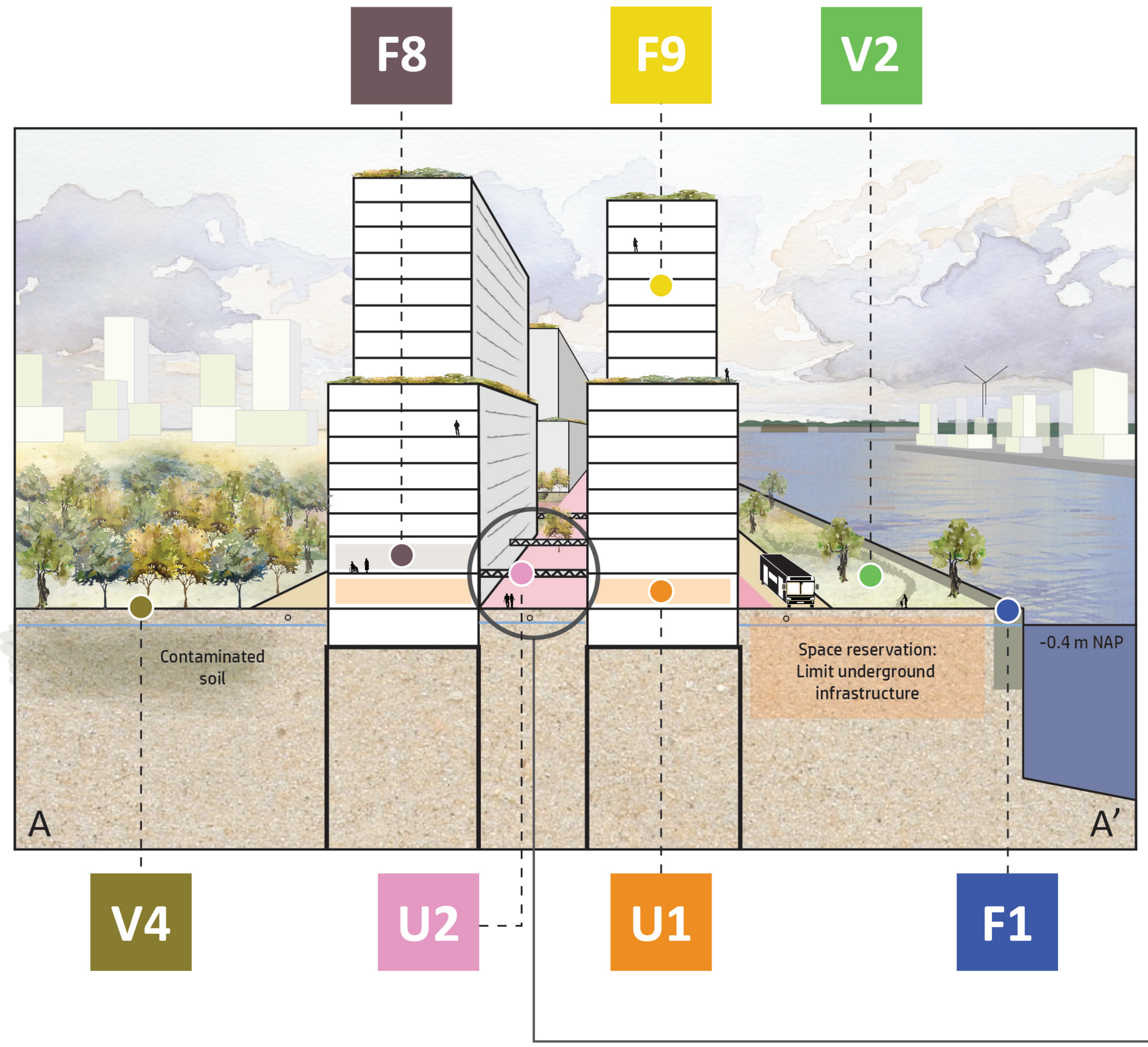
10. Pathways for Design

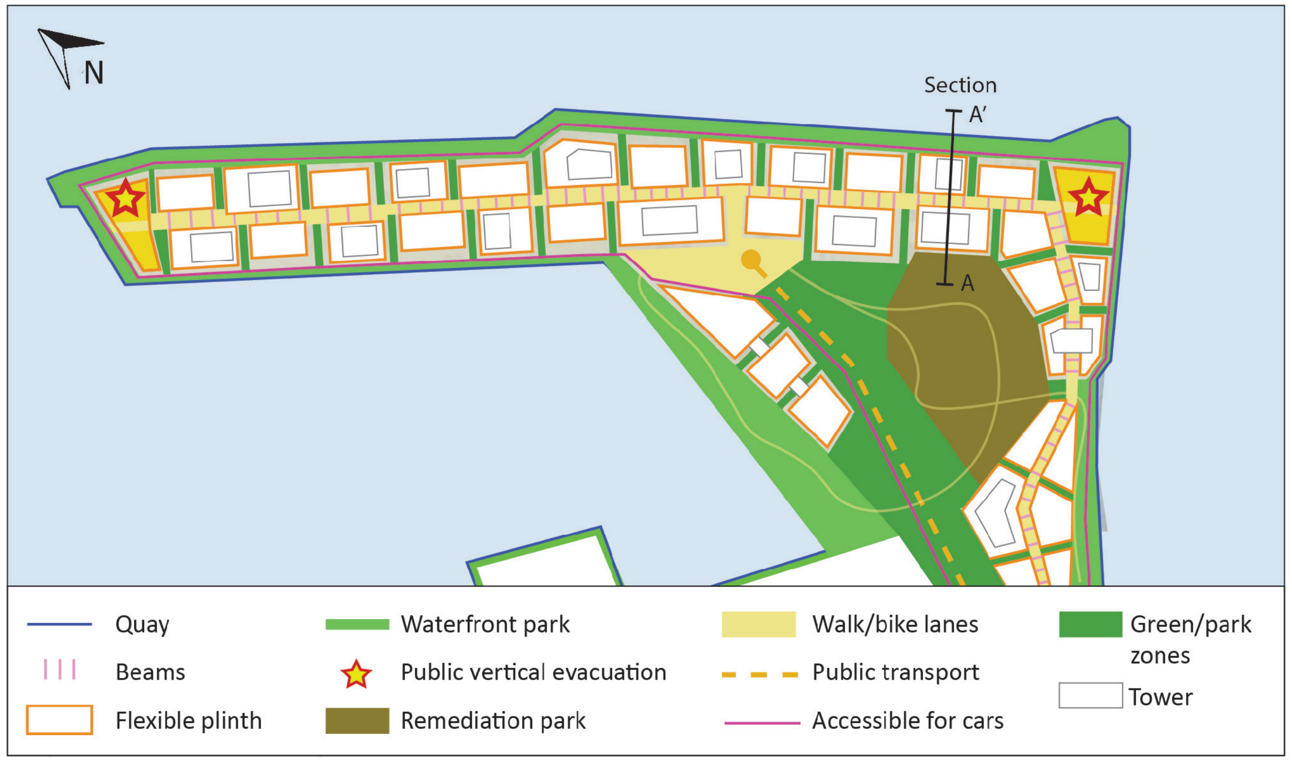
2050 Design - General startpoint

MOVE WITH THE WATER

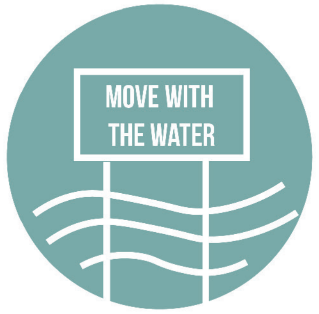
RESIST THE WATER

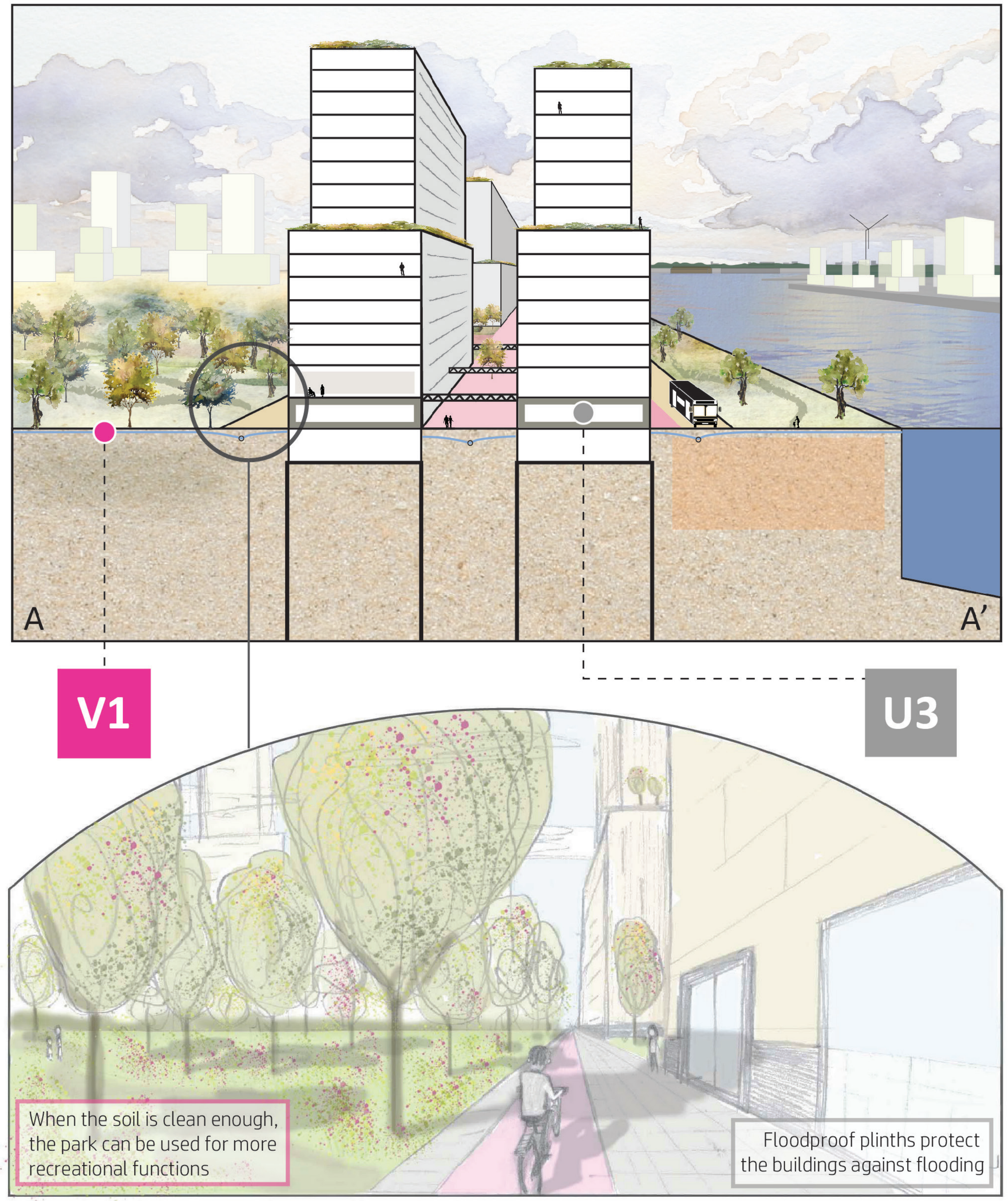
- F8 Waterrobust vital functions
- F1 Quay
- V2 Waterfront park
- F9 Vertical evacuation
- U1 Flexible plinth
- U2 Beams
- V4 Remediation park



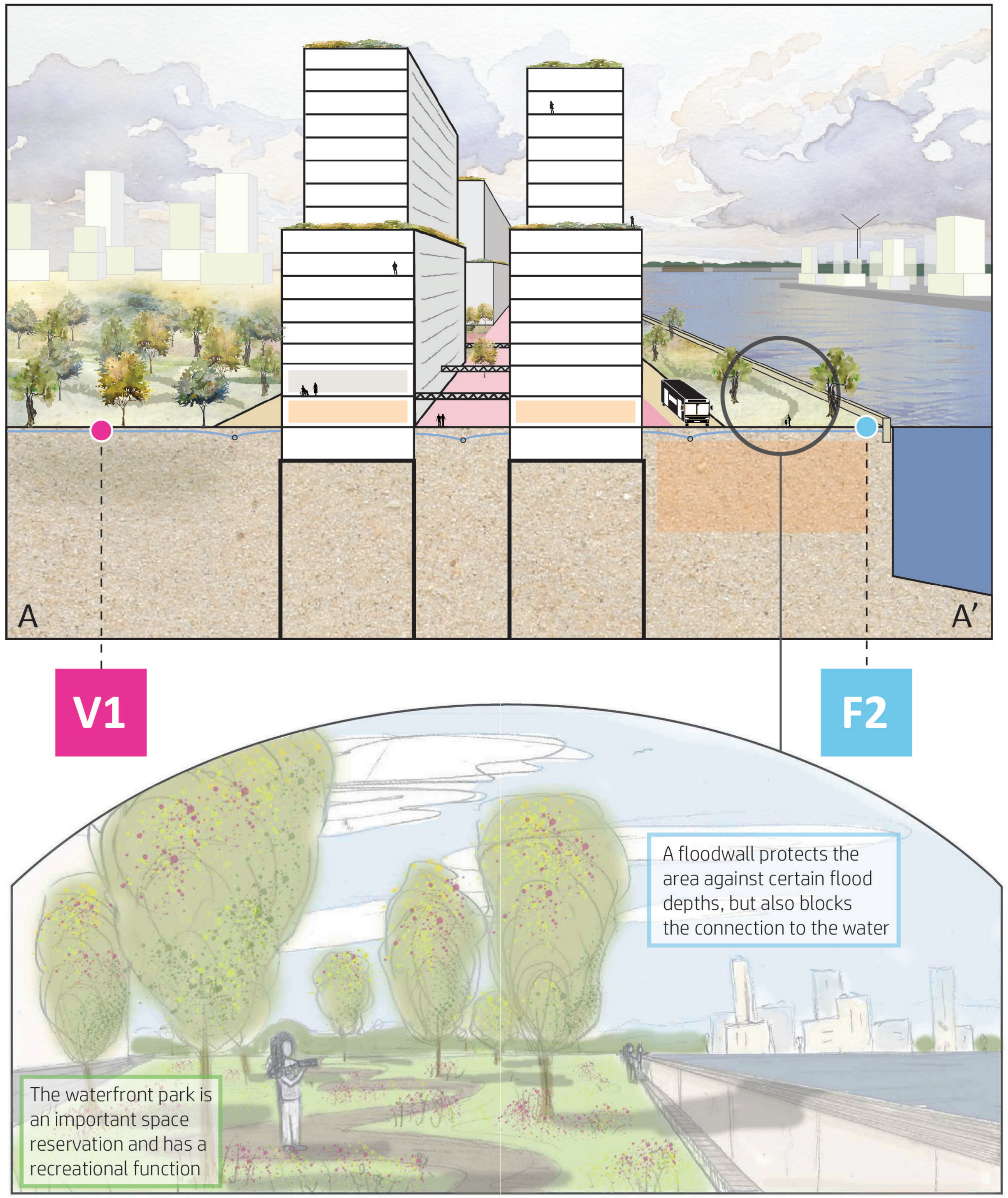


Incremental - Living with Water Future

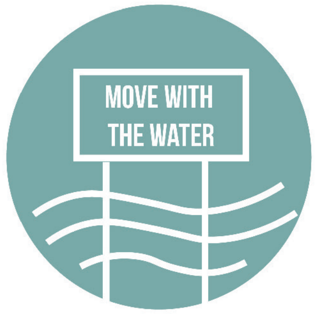




Incremental - Protective Future

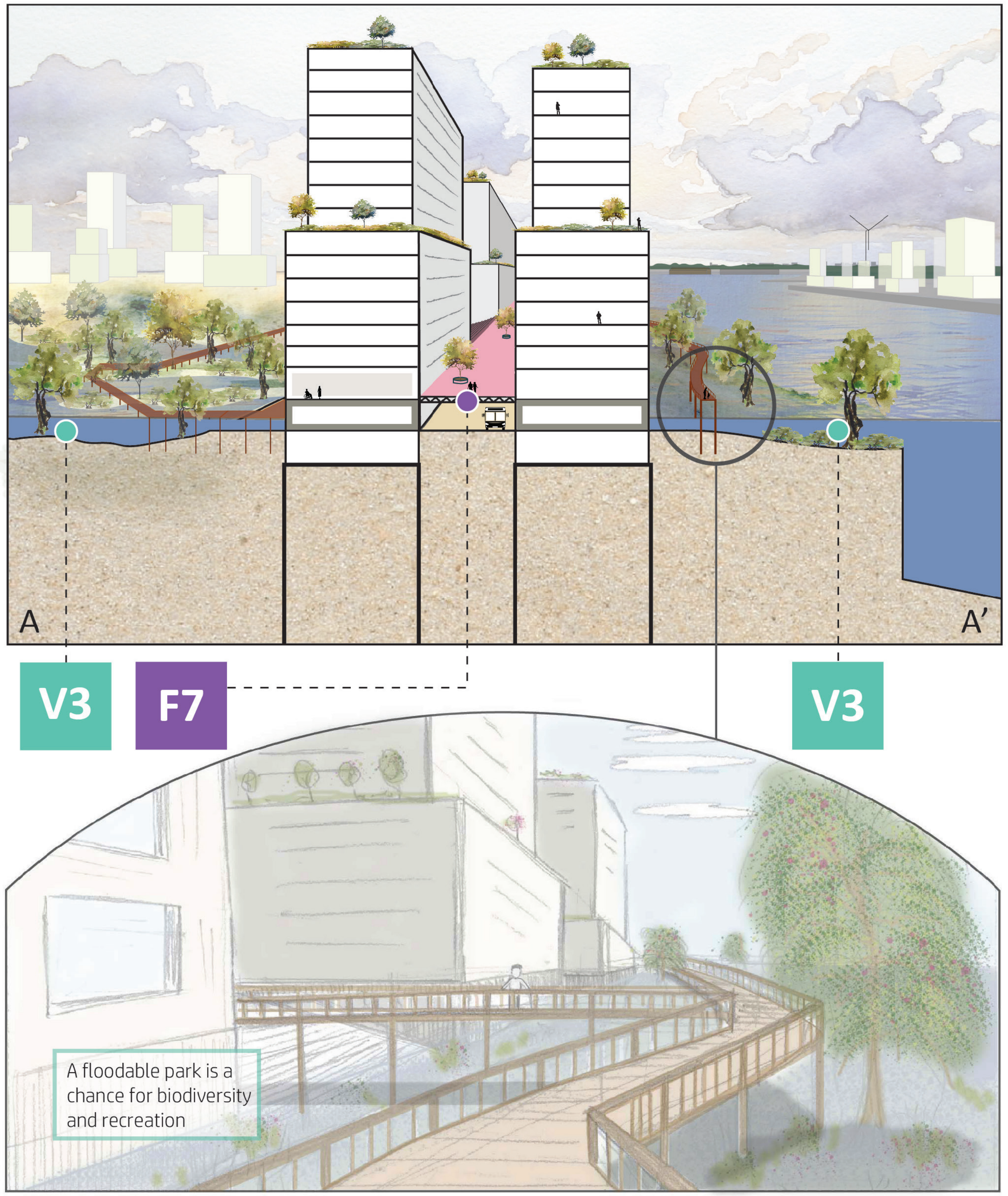


Transition - Living with Water Future



F7 Evacuation roads

V3 Floodable park

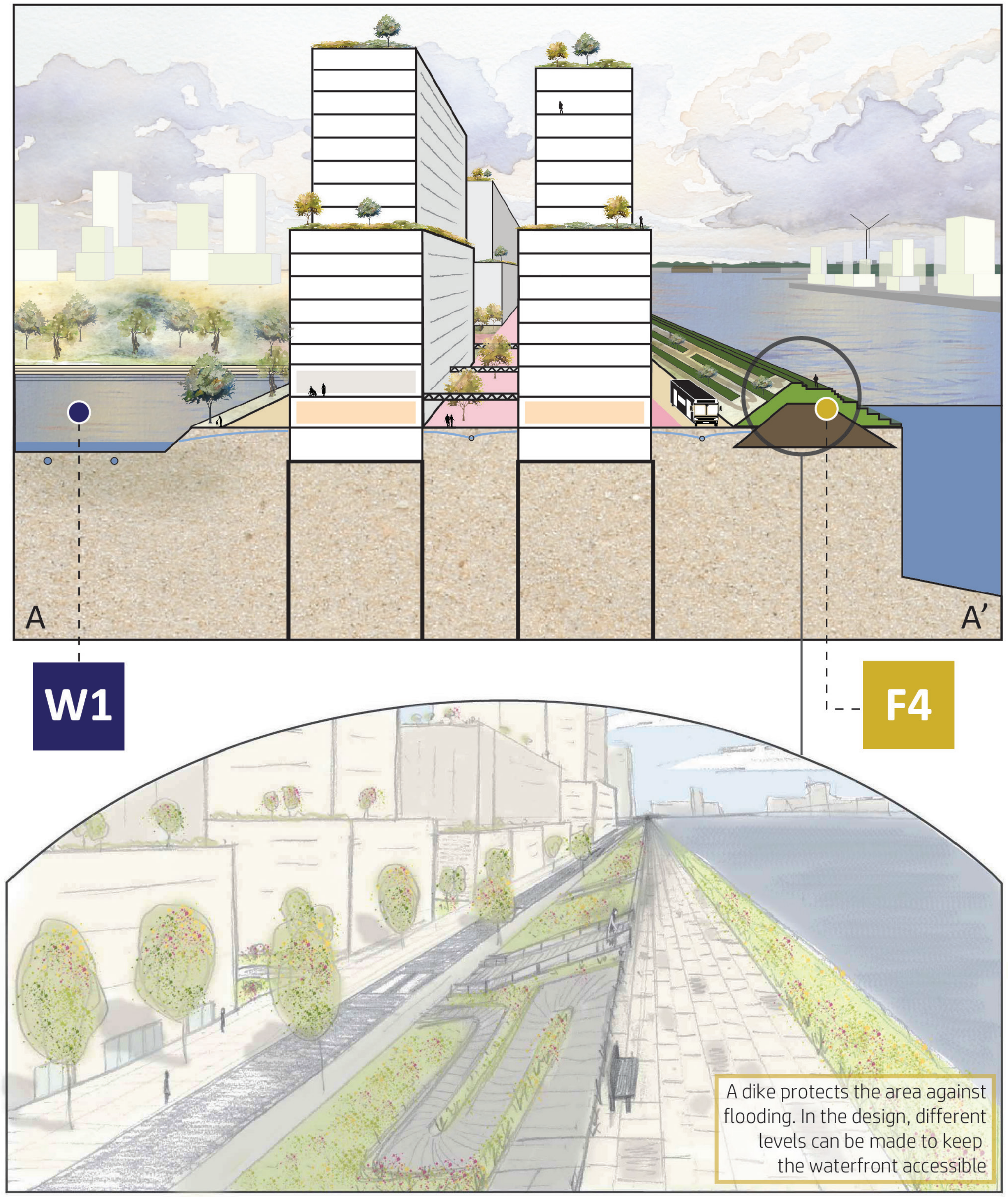


A floodable park is a chance for biodiversity and recreation

Transition - Protective Future

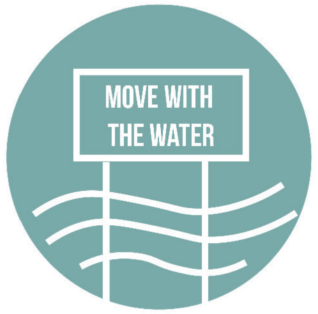
F4 Terraced boulevard

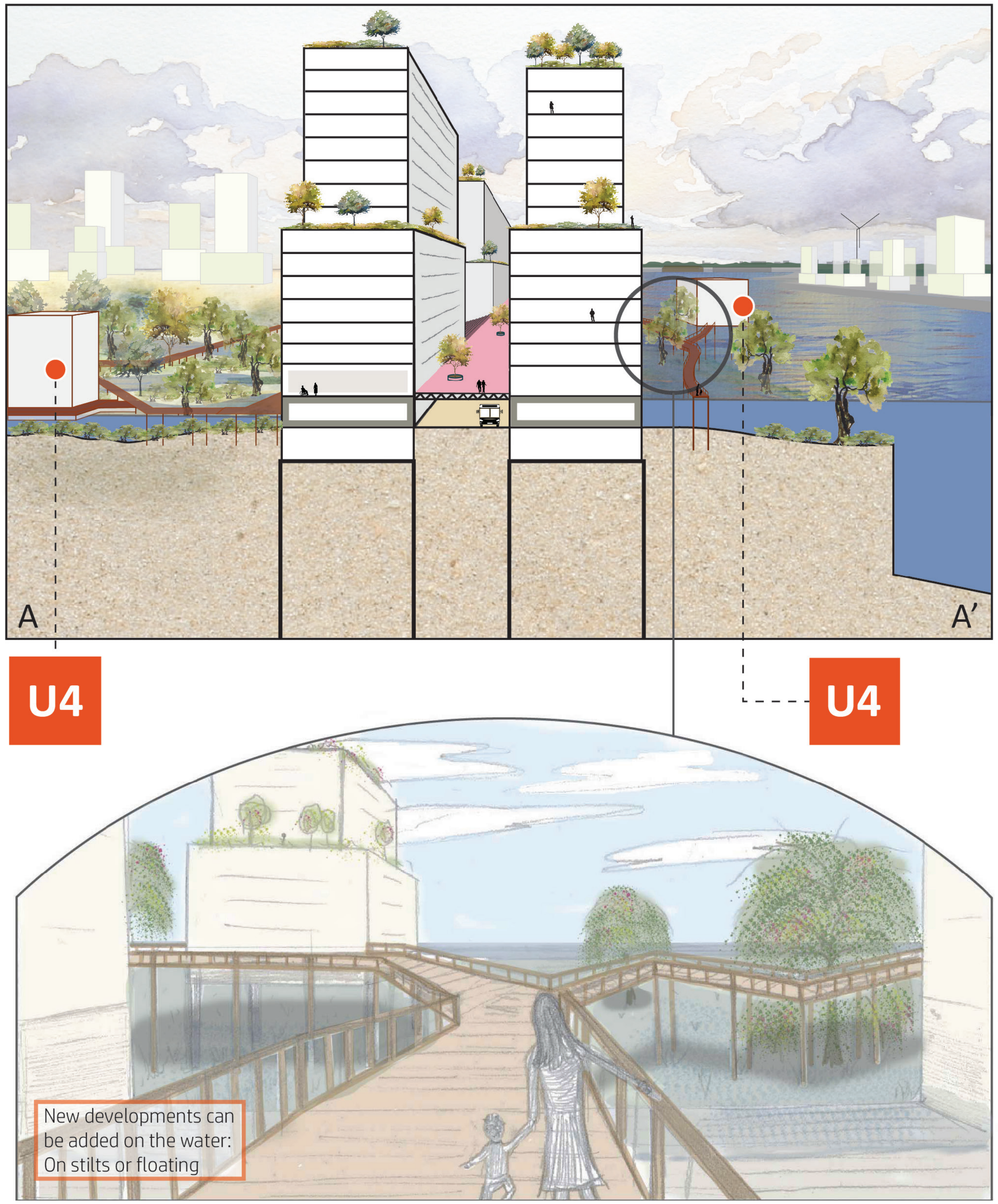
+ W1 Water square



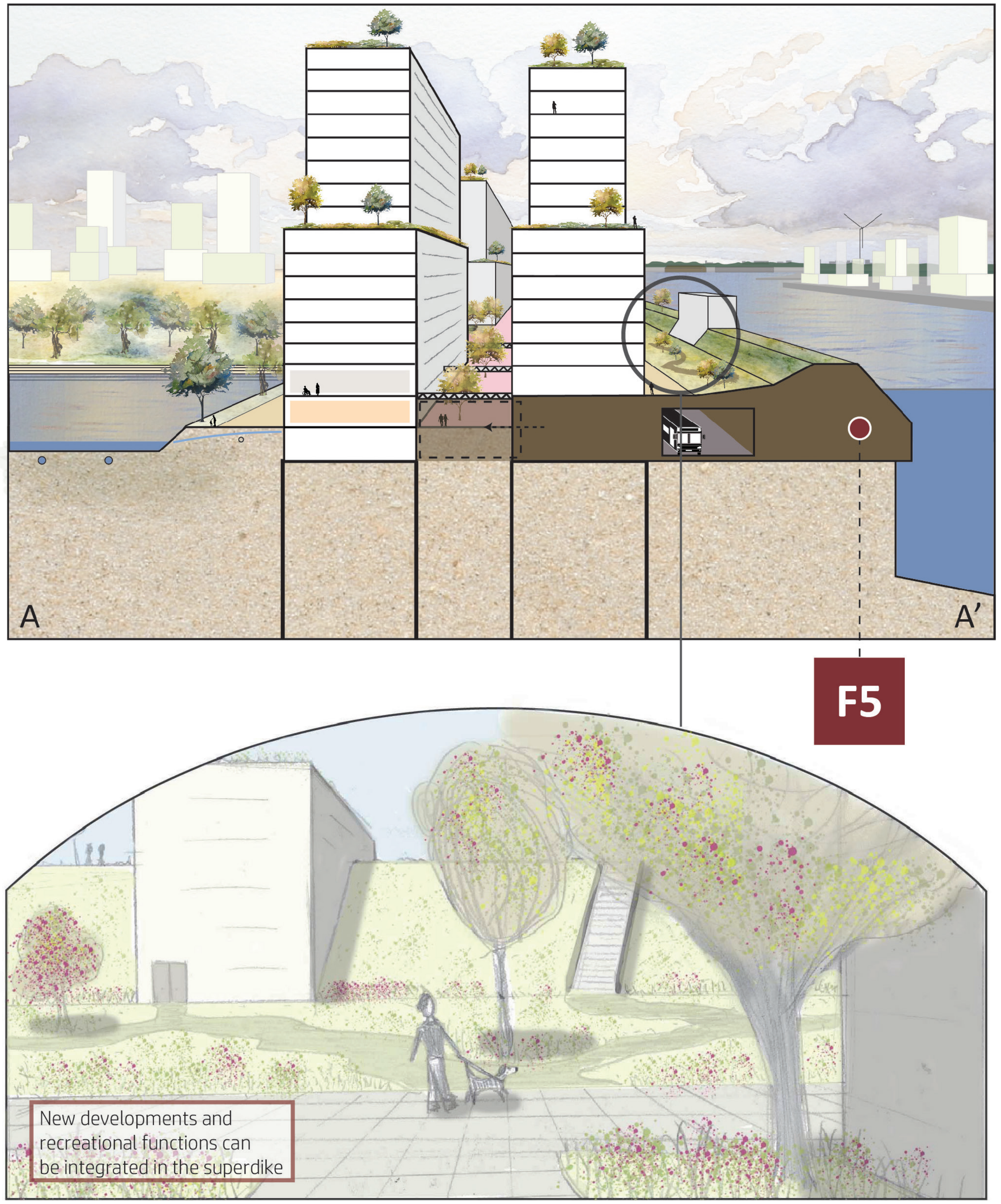
A dike protects the area against flooding. In the design, different levels can be made to keep the waterfront accessible

Transformation - Living with Water Future



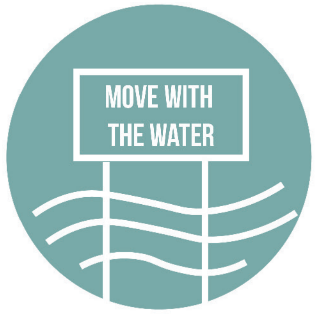


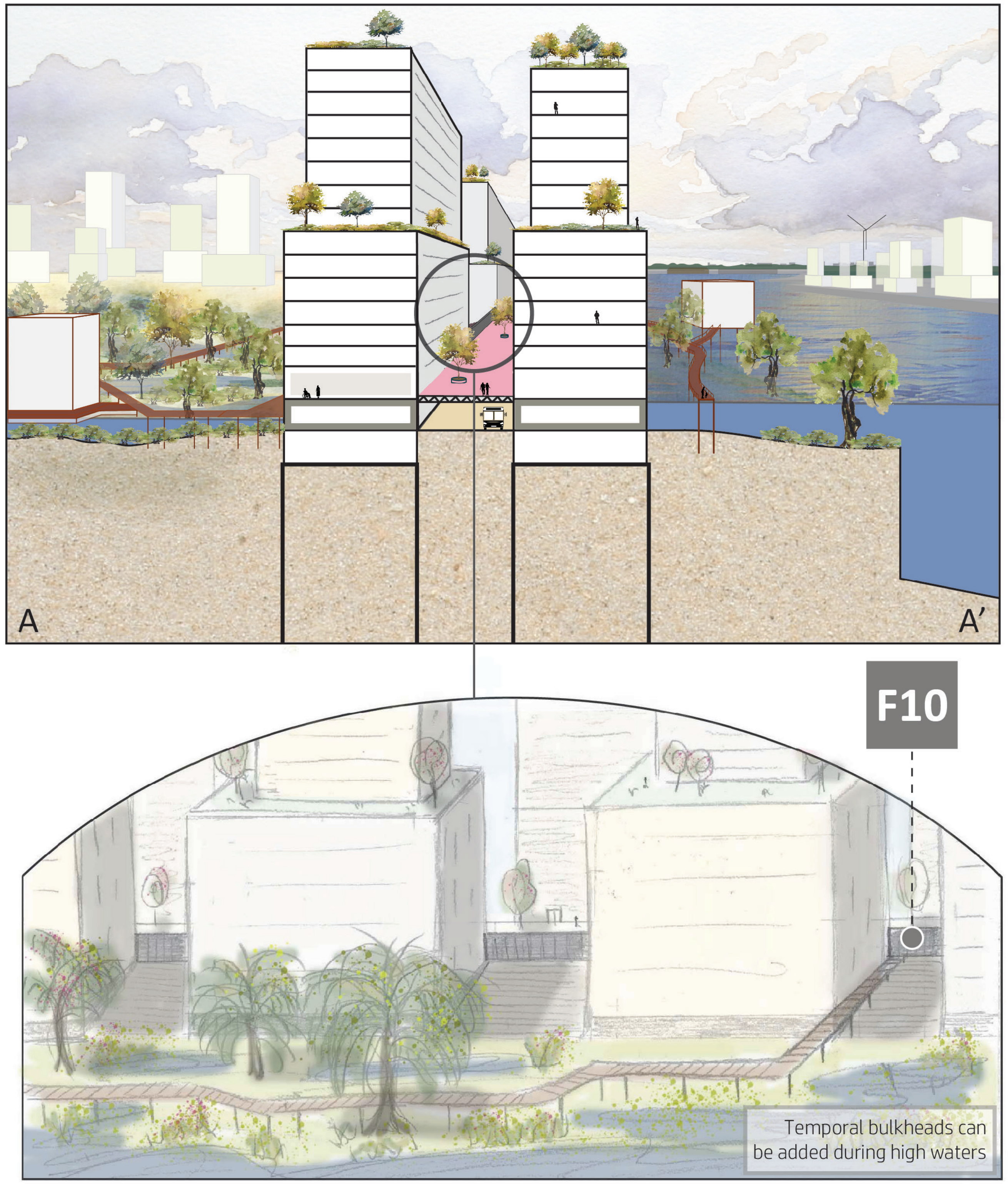
Transformation - Protective Future



10. Pathways for Design

Incremental II - Living with Water Future





10.2 CONCLUSION PATHWAYS FOR DESIGN

Insights for the Coenhaven waterfront
For the Coenhaven it is crucial to reserve space along the waterfront. The space reservations can be used for parks or temporal functions. Secondly, it is important that the buildings, or at least the plinths, have a flexible design. The above-ground and underground infrastructures also need to be considered. It could be possible that roads are (re)moved. Underground infrastructure with long lifetimes should be placed as much as possible under 'stable' roads, such as the middle road. Or it could be investigated if the infrastructure can be integrated in the buildings.

Pathways for Design
First of all, the SAPP approach provides a new way of thinking about design. Not as one single fixed plan, but as an ever developing plan. The approach supports thinking about different phases of climate adaptation in the future and about linking the short- and long term in design. Insights from the SAPPs can contribute to the creation of climate-adaptive initial designs and can provide arguments for the designs, as it displays the flexibility. In addition, SAPPs can be used to provide transparency about possible future developments, towards designers, project developers, and inhabitants. The designers and project developers can in this way anticipate on these possible future adjustments with flexible designs.

Design for Pathways
In addition, design does also support the development and communication of SAPPs. In the development of SAPPs, research-by-design is the most important method. Through sketching and trial-and-error, both the content of the SAPP map as the SAPP map itself are developed. The spatial elaboration makes the abstract SAPP map easier to communicate to a wide range of actors. The spatial elaboration does also show how big the differences between the phases and trajectories can be.

Appendix 9.3
Focus Area 2 - Sloterdijk I South
Step 6 - Pathways for Design

11

PATHWAYS FOR GOVERNANCE

How can the adaptive pathways be used for climate adaptation governance? This chapter shows how the pathways for the Coenhaven waterfront of Chapter 9 can be used for elaboration of potential future needs in climate adaptation governance. In the end a conclusion is made about the use of SAPP for governance.

SAPP Approach - Step 7

'Flock of birds' (n.d.)

11.1 FOCUS AREA 1 : COENHAVEN WATERFRONT

The adaptive pathways for the Coenhaven are used to explore governance questions regarding adaptation to fluvial flooding. The created pathway map and the previously selected pathways ('living with water' pathways & 'protective' pathways) are analysed to find out which governance is needed for the implementation of the pathways. This is compared to the existing governance situation to determine what changes are needed.

11.1.1 Current governance in relation to fluvial flooding

The strategy for water safety in the Netherlands can be related to the multi-level safety (MLS) concept. This concept was introduced in the National Waterplan [Nationaal Waterplan] (2009) for sustainable water safety policy for fluvial flooding and works with three layers: 1. Prevention; 2. Robust urban design; 3. Disaster management (Deltares, 2017). For a long time, however, Dutch policy focused mainly on flood prevention (Raadgever, Hegger, Wiering, & Gersonius, 2013). And that is often still strongly intertwined in the governance for water safety. Figure 11.1 shows the actors, collaborations, and policies related to the current governance for water safety. The government plays a very important role in watermanagement of the Netherlands and is considered responsible. Meanwhile, awareness of flood risks and the involvement in management is low among inhabitants (Dik & Wagemans, 2012).

Due to the focus on prevention, the water safety task lies mainly with the regional water authorities and Rijkswaterstaat, and is therefore sectoral and fairly centrally regulated. Preventive measures, such as strengthening of dikes, are paid for with public funds, mainly from the Flood Protection Programme (Hoogwaterbeschermingsprogramma). In this way, the government makes it possible for private parties to invest safely behind the dikes. This system with a focus on prevention and full government responsibility may no longer be tenable in the future. Due to climate change and the limitations of technical manufacturability, layers 2 and 3 can become increasingly important. Especially in layer 2, many actors play a role, including individuals and private parties. A shift from the focus on layer 1 to the focus on layer 1, 2, and 3 could therefore also mean a shift of responsibilities. The financial system is also expected to respond to this. As awareness grows, a certain flood risk can affect the insurability of assets and even mortgages. To limit risks, investors are therefore increasingly focusing on climate-resilient developments. Provinces and municipalities are also gradually focusing on robust urban design for water safety, for example with themes such as vital and vulnerable functions.

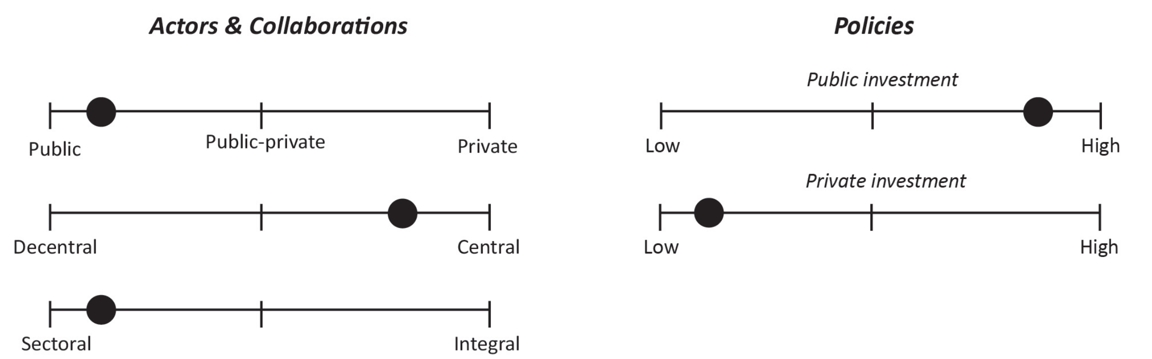


Figure 11.1. Current governance related to water safety.

Chapter 5
For more information about current climate adaptation governance

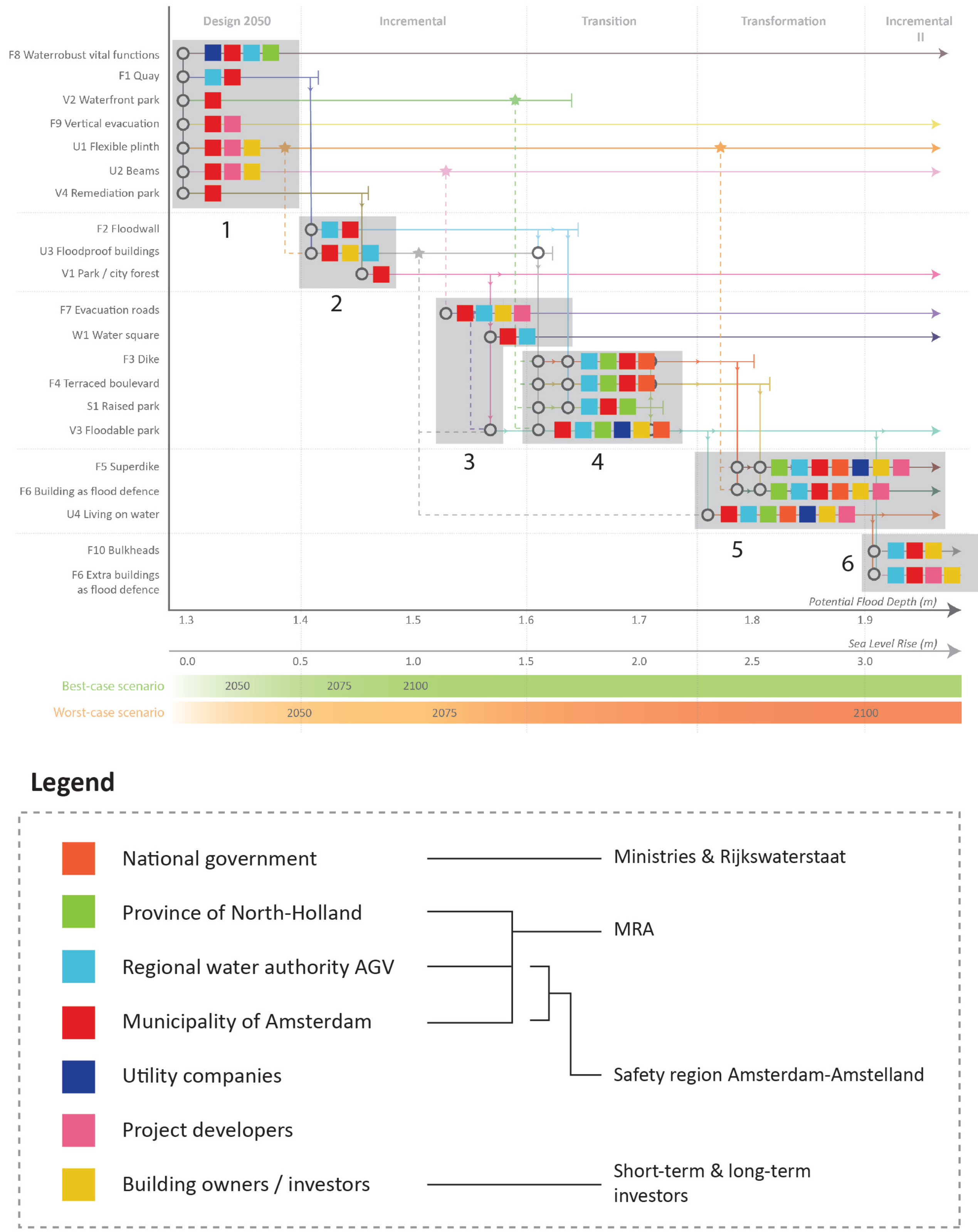


Figure 11.2. Actors involved in the adaptive pathways for the Coenhaven waterfront.

11.1.2 Decision Clusters

Six decision clusters have been distinguished in the Coenhaven Waterfront roadmap (see Figure 11.2). The clusters show the most important moments for decision-making and the (potential) options to select. Most decision clusters (2, 3+4, 5, 6) are associated with a shift in transition phases. The first decision cluster determines which measures will be implemented in the first development of Haven-Stad (design 2050).

11.1.3 Actors & Collaborations

Figure 11.2 shows the main actors that play a role in the adaptive pathways for the Coenhaven Waterfront. For each measure (y-axis), the most important actors are placed on the corresponding horizontal line. It can be noted that in general, the number of actors per phase increases. This is due to the increasing complexity of the adaptation measures. More actors means that the decision process is also more complex and possibly longer. Especially in cluster 4 and 5, many actors have to work together to make strategic decisions about the national and regional protection strategy of the delta and the implementation in Amsterdam and Haven-Stad. In the first three clusters, local actors in particular have to work together and current networks seem to be sufficient. Regional and national actors play a role in the transition and transformation phase and an integrated approach across nation, region, city and Haven-Stad is crucial. The municipality is involved in each adaptation measure. In the first three clusters, the municipality works most closely with the regional water authority AGV for public measures and with project developers and building owners for private measures. In cluster 4 and 5, the municipality still has a crucial role in coordinating developments on city scale, but now there is a strong need to cooperate with the province and national government. The province and the MRA (Metropolitan Region of Amsterdam) can play a coordinating role in the collaboration between all governmental and private actors. It can also be noted that private actors are involved in almost all decision clusters.

11.1.4 Policies

Figure 11.3 shows the investments and leading decision points associated with the adaptive pathways for the Coenhaven waterfront. The green boxes show the leading decision points; a decision whether or not to implement a certain measure influences the choices that can be made in the future. For example: Not implementing flexible first floors at the start (design 2050) make it a lot more difficult and more expensive later on to make the buildings floodproof. If the buildings cannot be made floodproof (technically or financially), the trajectory to a floodable park will be less likely to be followed, because this evokes resistance from private actors. It is noticeable that the number of investments per phase is growing and that most of the leading decision points also require medium to large investments. Cluster 3, 4, and 5 require the most investments, but also bring the most actors together. The high costs could thus be shared with more actors. In the first three clusters, the investments will mainly be local investments, made by the municipality, AGV, and project investors. In cluster 4, the development will be part of regional or national developments that are in line with the protection strategy for the delta. It can therefore be expected that the national government will contribute to these investments, because this serves the national interest. This is also the only cluster in which no private investment is expected. Cluster 5 and 6 require major investments from both public and private actors.

11.1.5 Crucial Decision Clusters

Important decisions have to be made in all decision clusters. In three clusters, however, the decisions are leading for the future of the Coenhaven. Cluster 4 is the most crucial decision cluster, in this cluster, many actors decide for which transition high investments will be made. This decision requires regional and central coordination. Cluster 5 is also a crucial decision cluster, because it requires new investments and openness to new concepts, such as a super dike or living on the water.In addition, cluster 1 is crucial because it sets the boundaries for the possibilities in the future.

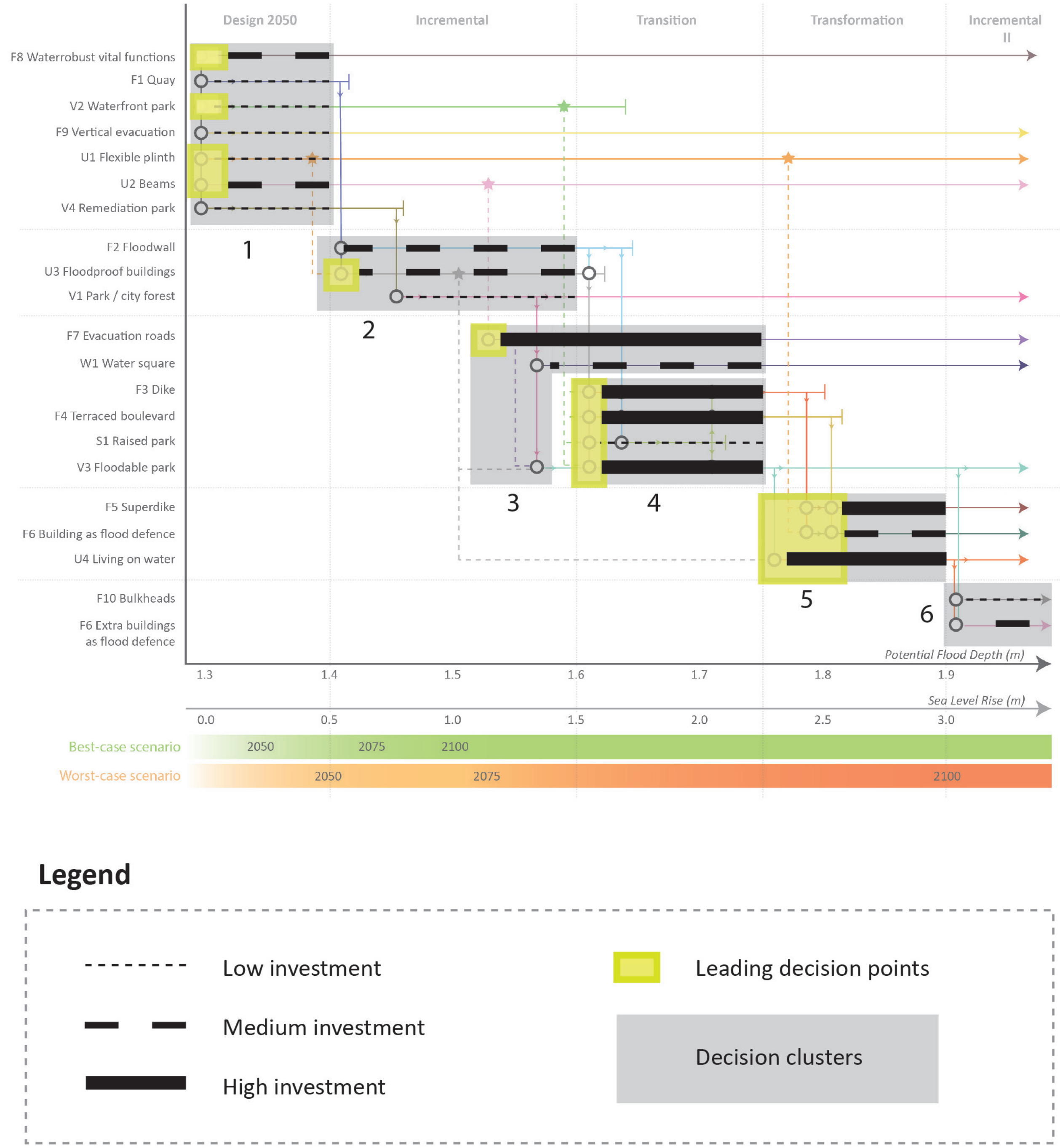


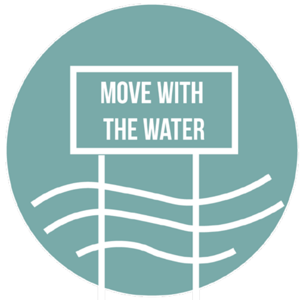
Figure 11.3. Investments and leading decision points in the adaptive pathways for the Coenhaven waterfront.

11.1.6 Selected Trajectories

The same trajectories as in Section 10.1 are used to zoom in more on governance. Figure 11.4 shows the trajectory of the 'living with water' future and Figure 11.5 shows the trajectory of the protective future. Both trajectories per transition phase are discussed on the following pages. On every left page is the future of 'living with water', on every right page the protective future. The first spread shows the common starting point (2050 design). The measures associated with the phase are displayed at the top of the page. The colored dots correspond to the measures. The circle diagram gives an indication of the most important collaborations per phase, based on the current governance systems.

■ Actors

● Measures



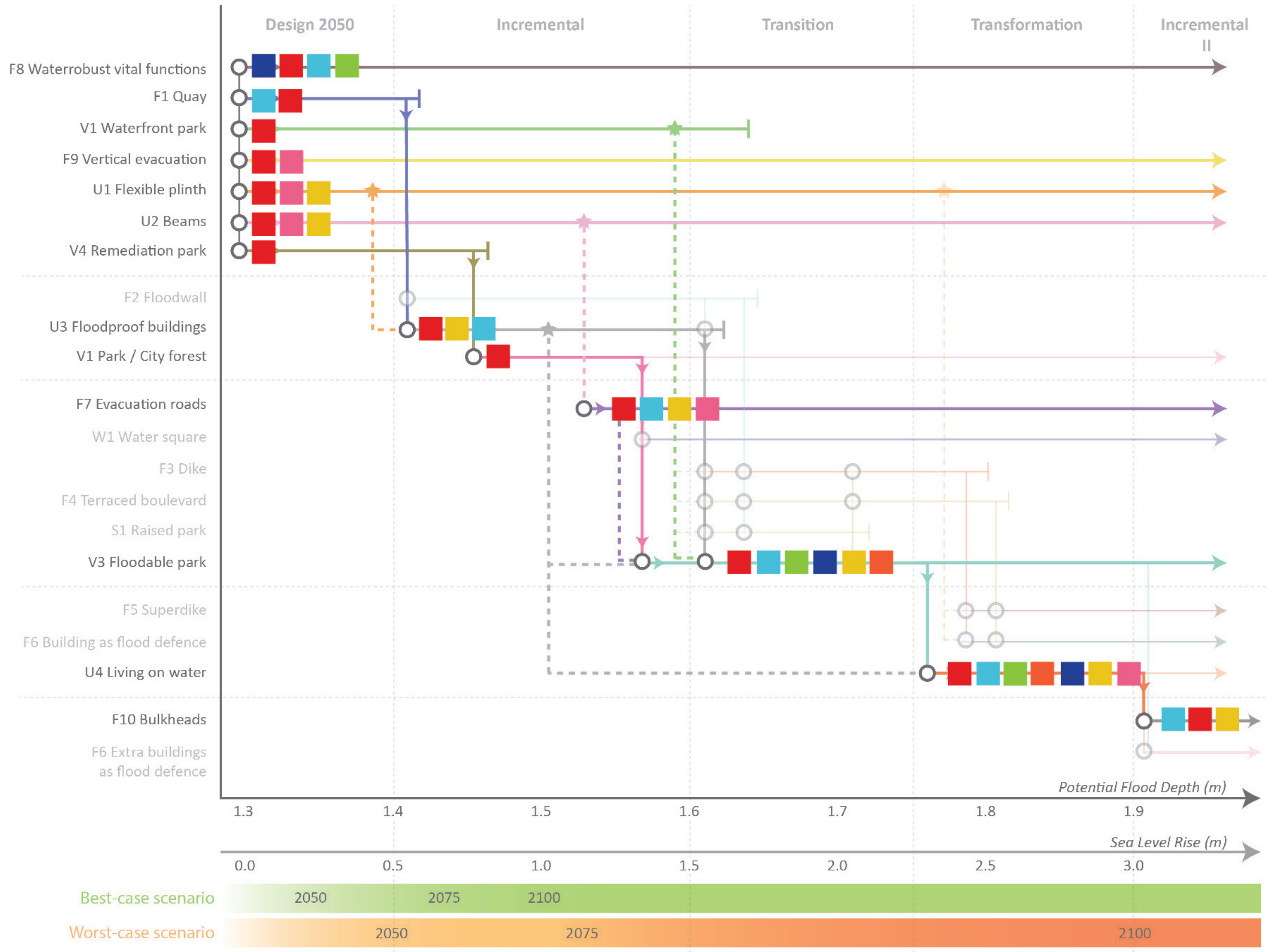


Figure 11.4. Actors involved for the 'living with water' pathways

Legend

- National government
- Province of North-Holland
- Regional water authority AGV
- Municipality of Amsterdam
- Utility companies
- Project developers
- Building owners / investors

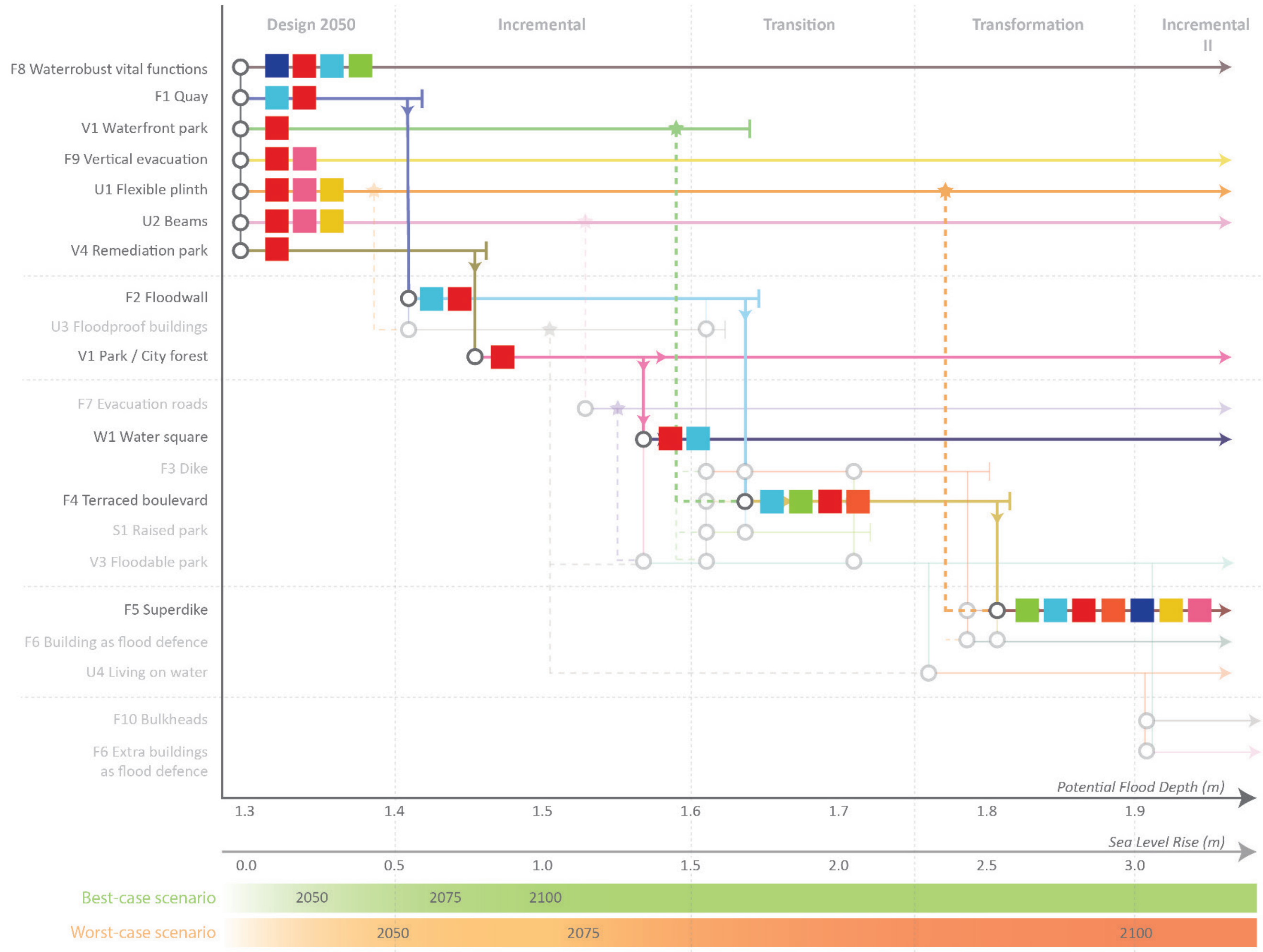
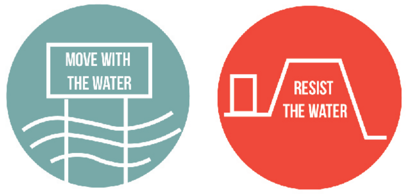
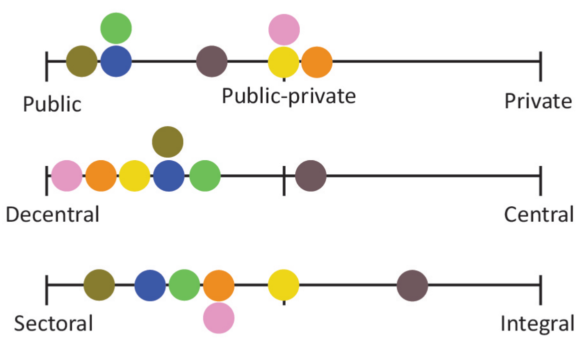


Figure 11.5. Actors involved for the 'protective' pathways

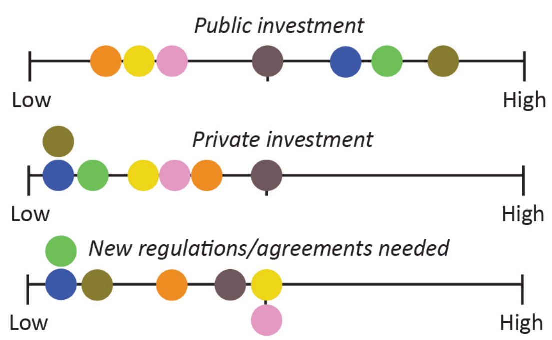
2050 Design - General startpoint



Actors & Collaborations



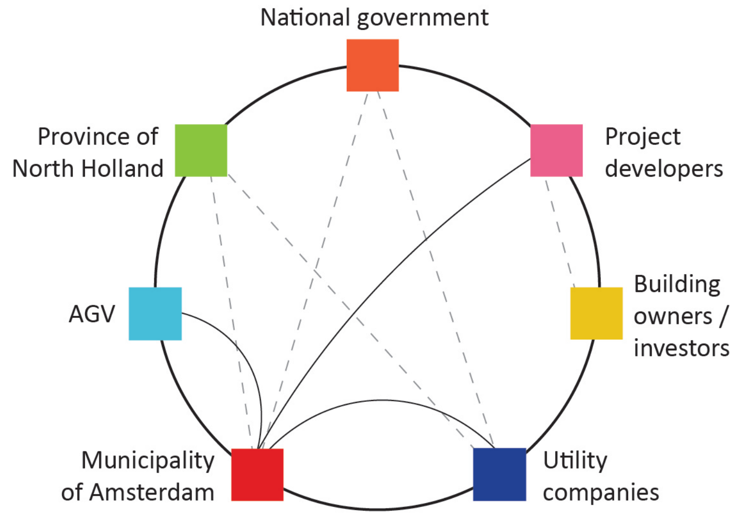
Policies



The 2050 design is the general starting point for both trajectories and contains a wide selection of measures. These are the measures that will be implemented in the development of Haven-Stad. As can be seen above, all measures require different collaborations and policies. Most measures are decentralized and can taken without regional or national control. The water-robust vital functions could be discussed with the province. Most measures are public investments for the development of a climate-adaptive public space. For example, the waterfront park can now function as a park, but it is also a space reservation for future functions (such as a dike). Vertical evacuation does not require high additional investments, but public-private collaboration and agreements between the municipality and project developers. Water-robust functions are a shared responsibility of the municipality and the utility companies.

Private actors should invest in the development of the buildings, which should contain flexible plinths and open beams crossing the street. The municipality can set these points as requirements for the zoning plan change (or tender). However, in addition to these regulations, it is important to explain the need for these measures. The SAPP map can be used to show and discuss possible future developments in the area. In this way, the municipality is transparant about the uncertainties and possible changes. With this information, investors and project developers can create designs that respond to the uncertainties. Flexible plinths make the buildings more sustainable, as they can adapt to different futures. And now that climate vulnerabilities are increasingly included in the valuation of real estate, a flexible building will probably also be valued higher.

The municipality has the leading role in the development of Haven-Stad and is the link between all actors and an integral plan. The national and provincial government will also be involved in the development, as Haven-Stad has been selected as one of the large-scale building developments in the NOVI (Bayer, 2021). Investors, utility companies and project developers will also play a crucial role as executive actors of the private developments. The municipality and AGV are working together for the development of public space, including the waterways. The province can be the connecting factor between the national government, project developers, utility companies, and the municipality. The municipality is responsible for consultations with AGV and possibly the safety region about space reservations for future flood protection or evacuation. As indicated earlier, the municipality should also discuss the future scenarios with the private actors involved.



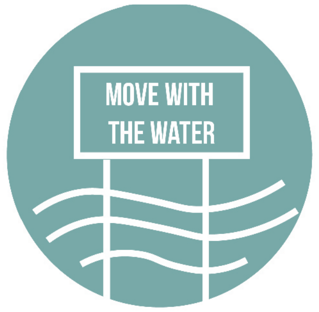
Example 1: Waterfront park

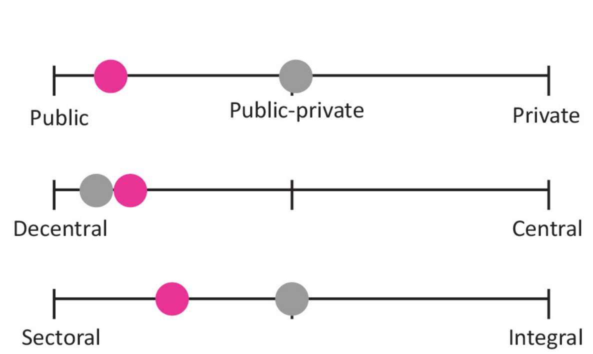
The waterfront park is the park that will be developed along the entire waterfront of Haven-Stad. The park has a recreational function, but also serves as a space reservation. The space reservation is part of the spatial design, so this is the second layer of multi-level safety (MLS-II). The park will be developed and the costs will be borne by the municipality. The space reservation can also lead to less land being sold, if the public space has to be expanded for a certain width of the space reservation. One of the questions that arise is: Who should invest in space reservations? And in this case specific: Who should invest in space reservations for possible future flood defences (MLS-I)? Can regional water authorities contribute financially to these kind of reservations? Can it be considered part of their core task? Or is a climate adaptation fund needed to reserve space?

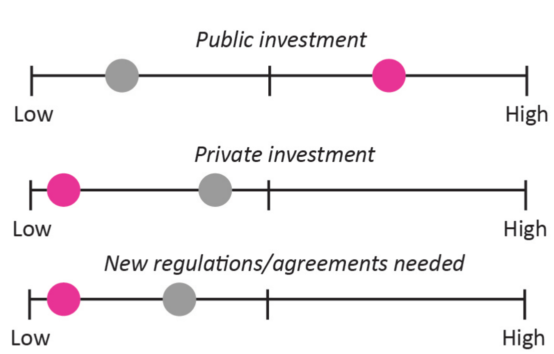
Example 2: Flexible Plinth

All buildings at the Coenhaven waterfront should have a flexible plinth. In this way, the heavy high-rise buildings can still adapt to future changes. If the water level rises and an open strategy is chosen, the flexible plinths must be made waterproof. The municipality can include the flexible plinth in the requirements for amending the zoning plan (or, if possible tendering) or draw up a public-private agreement. Together with AGV, the municipality must explain the possible future climate effects and adaptation strategies to the private actors. In this way, the private actors can make their own assessment (a flexible plinth or a floodproof plinth from the start). However, if the assets are sold to other actors (the ultimate owners of the building), the modification plans and the condition of the building will have to be communicated again, as this will likely also play a role in the valuation of the property.

Incremental - Living with Water Future



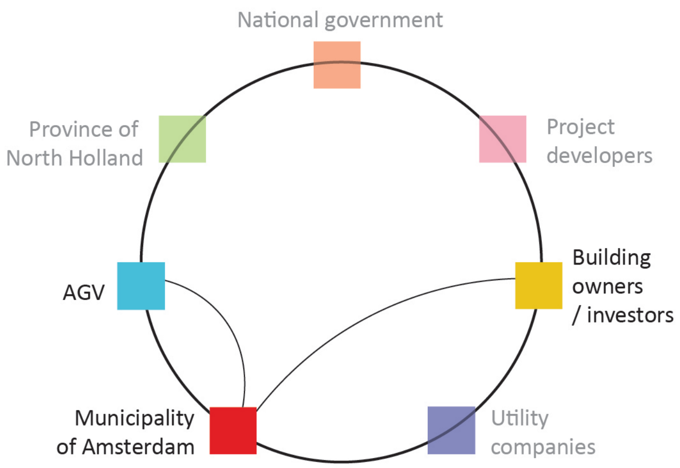




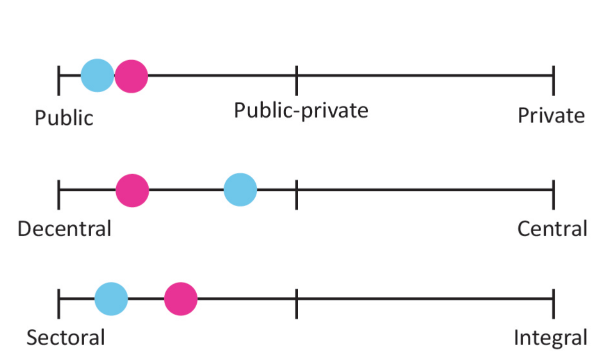
Floodproof Buildings

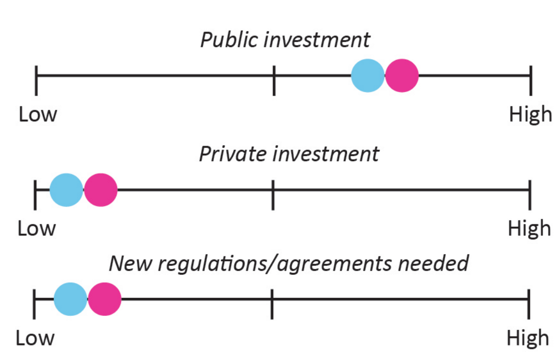
In the incremental phase, the flexible plinths of the buildings are made floodproof. This action will probably be pro-active and initiated by the municipality or AGV. The investment is likely to be solely a private investment. However, the building owners have their own responsibility for their assets and cannot be forced to make these adjustments. However, floodproofing the buildings increases and protects the value of the assets. Certainly now that climate vulnerability is increasingly included in the valuation (and insurability) of real estate. However, the government must have been transparent about the possible adaptation processes. It can be surprising for private parties to suddenly bear responsibility for the water safety of their own assets, because this responsibility often still lies entirely with the governments. If it has not been made clear in the development that additional private investment may be needed in the future, then it may be up to the municipality to also contribute financially for flood protection. However, it is debatable whether public money can be used to flood-proof private buildings. This is currently not possible.

The municipality should take the lead in this phase and form the link between AGV and the building owners. AGV often has an advisory role and can emphasize the need for floodproof buildings at the municipality. However, the municipality should translate this information to the building owners and explain the need for flood-proof buildings. The building owners are responsible for their own asset and can be influenced by the information from the municipality and AGV, and the financial consequences.



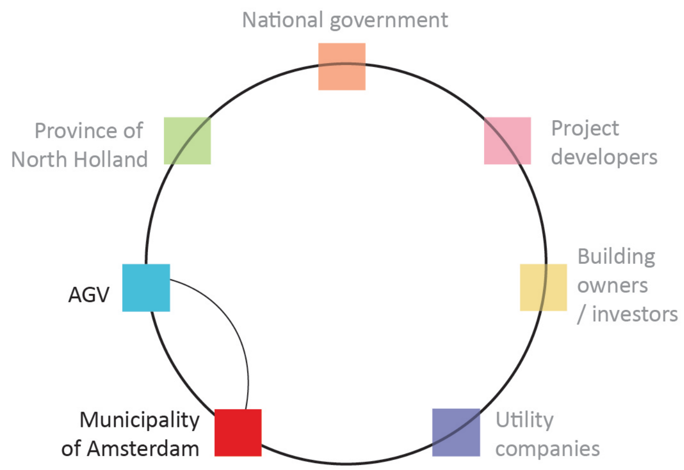
Incremental - Protective Future



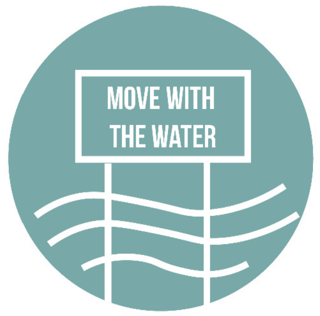


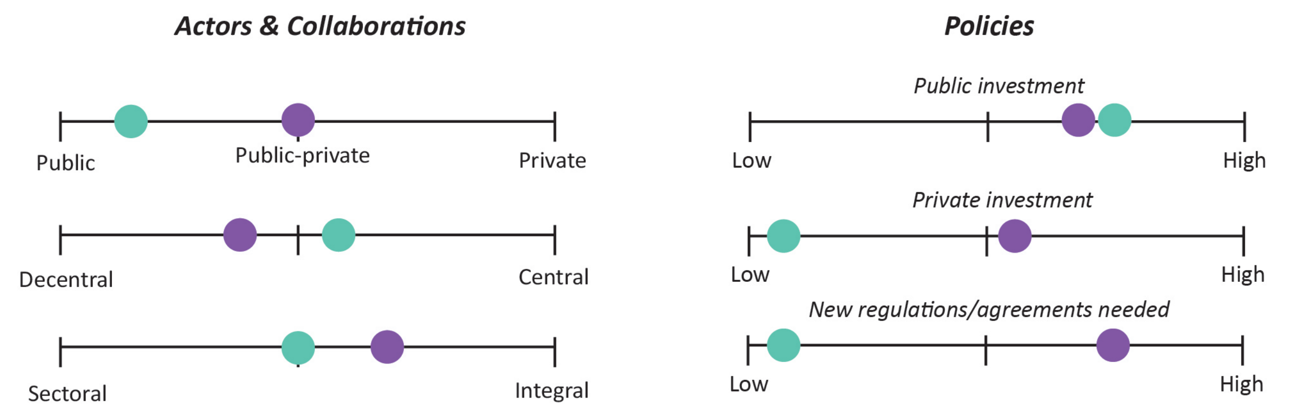
Floodwall

In the incremental phase, a floodwall will be placed. The floodwall is a wall on the quay of the Coenhaven that protects the area against certain flood depths. As can be seen above, the development of the floodwall is public and decentralized. Only the municipality and AGV need to be involved and have to work together. The floodwall is also a very sectoral (watermanagement) solution, which can be partly adapted to the wishes of the municipality. It is a fully public investment and saves private money compared to the trajectory of floodproof buildings. The floodwall is part of the first layer of multi-level safety and can probably be covered with resources from the Hoogwaterbeschermingsprogramma (public protection from public money). No governance changes are needed for the implementation of the flood wall as it is very close to current practices. However, the municipality should invest in an extensive participation program, because this wall blocks the connection to the water and may obstruct views. It should be explained why the wall is needed and residents can be involved in the design of the wall (integration of seating, watching points, information signs, etc.). Both AGV and the municipality can be regarded as frontrunners in this development. AGV takes the lead in the technical design and the municipality in the participation process. The final design must be realized in collaboration. The choice of a floodwall places the responsibility for flood safety on the governments. The building owners are less involved and may feel less responsible for flood safety, compared to the scenario with the floodproof buildings. The wall saves the private actors money, as they don't have to floodproof their buildings.



Transition - Living with Water Future

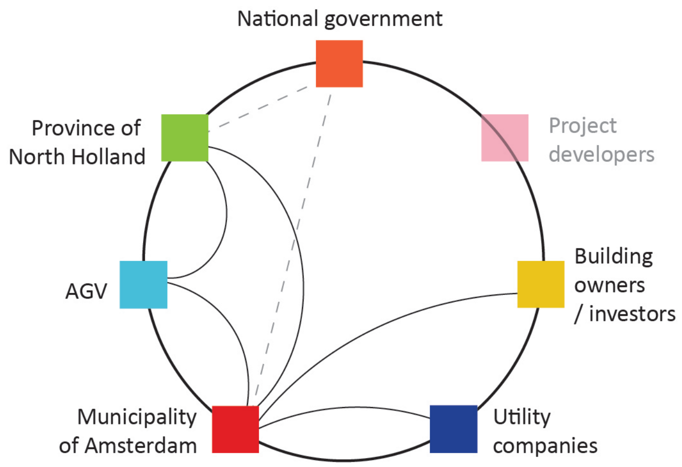




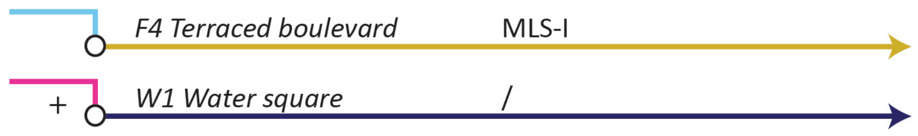
Floodable park & Evacuation Roads

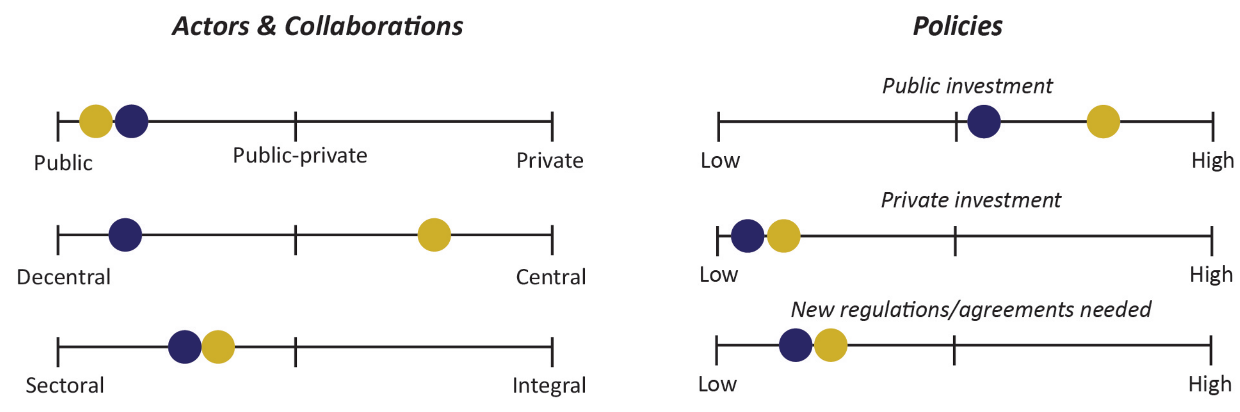
In the transition phase, a floodable park is developed. Evacuation roads will be made prior to the development of this park. These roads rest on the beams of the buildings and form an elevated street. The area below the evacuation roads can remain open or can be used for infrastructure or water storage. The evacuation roads and the floodable park are primarily public investments, but also require consultation with building owners. Because the entrance of the buildings has to rise with the new street, private investments are necessary. In the previous phase the building owners are asked to make the plinths of the buildings floodproof. However, the private assets are the responsibility of the building owners and the investments to make the buildings floodproof cannot be enforced. But if the floodable park is realized, these private investments are really necessary to guarantee the quality of the living environment. It is not possible to invest public money in private buildings (for example with the money saved by not building a flood defence, as in the protective future). However, it may be possible to make public-private agreements in advance or, for example, to make the plinth of the buildings to be adapted public.

A decision for a floodable park shifts the responsibility for flood risk management even more to a public-private responsibility. The government does not protect the area with flood defences and the water is let in. It is the responsibility of the building owners to be prepared for this water on the private lots. However, it remains crucial that the government remains a reliable partner. It must address the private actors' own responsibility for flood safety and must offer perspectives for action and cooperation incentives.



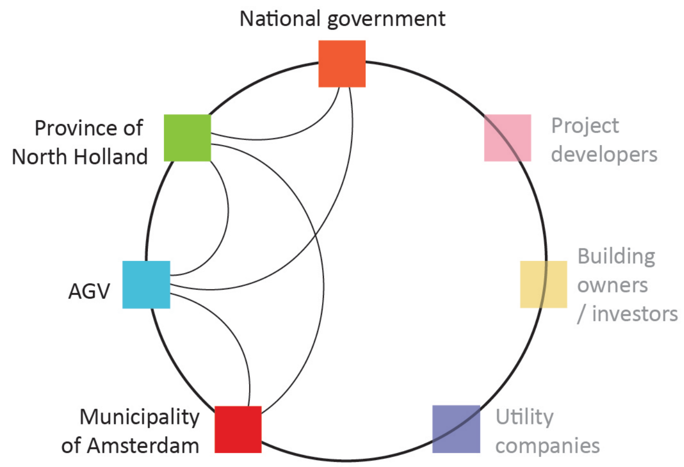
Transition - Protective Future



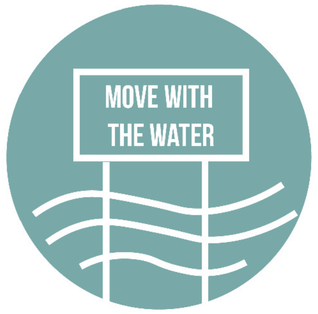


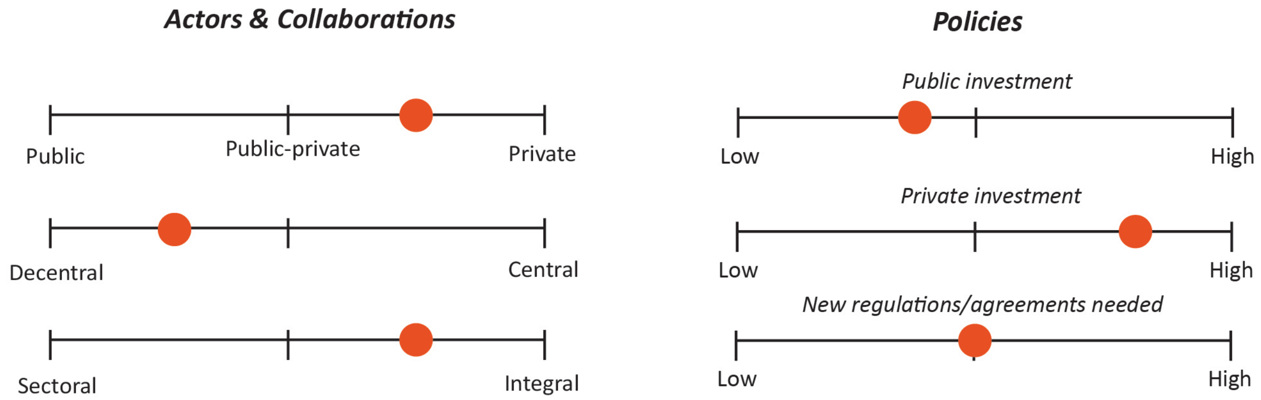
Terraced boulevard

In the transition phase, the floodwall will be replaced by a terraced boulevard. This is a dike structure with terraces on top for recreation. The dike is part of a new regional dike trajectory, in which regional and national actors will also play a role. The trajectory must fit within the national delta plan and within the guidelines of the province. This makes the dike a fairly central project. In addition, it is mainly a public development and is covered by funds from the 'Hoogwaterbeschermingsprogramma' (HWBP). Because this development does not deviate far from current practice, few or no new rules or agreements are needed. At the most, agreements are needed between AGV and the municipality about management and possible functions on the dike. AGV and the municipality must work closely together to combine the function of the dike with the recreational function of the boulevard. AGV works together with Rijkswaterstaat, because the North Sea Canal falls under their management. The province is working on 'water safety with spatial quality' and can seek cooperation with the municipality. Certainly if the recreational function extends beyond the municipality of Amsterdam, an integral regional recreational route can be created. In comparison with the floodable park, water safety remains mainly the responsibility of the governments. This can also be a challenge, as the urgency of the dike may not be clear to the inhabitants. Especially if it blocks their view of the water. This makes it even more important to provide information about the need for the dike and to involve inhabitants in the design of the boulevard.



Transformation - Living with Water Future

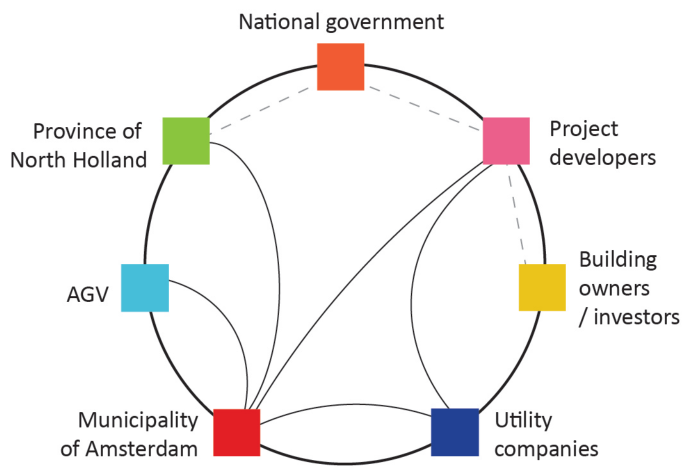




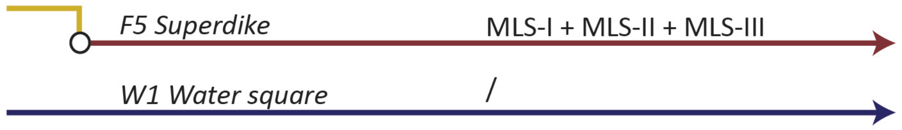
Living on water

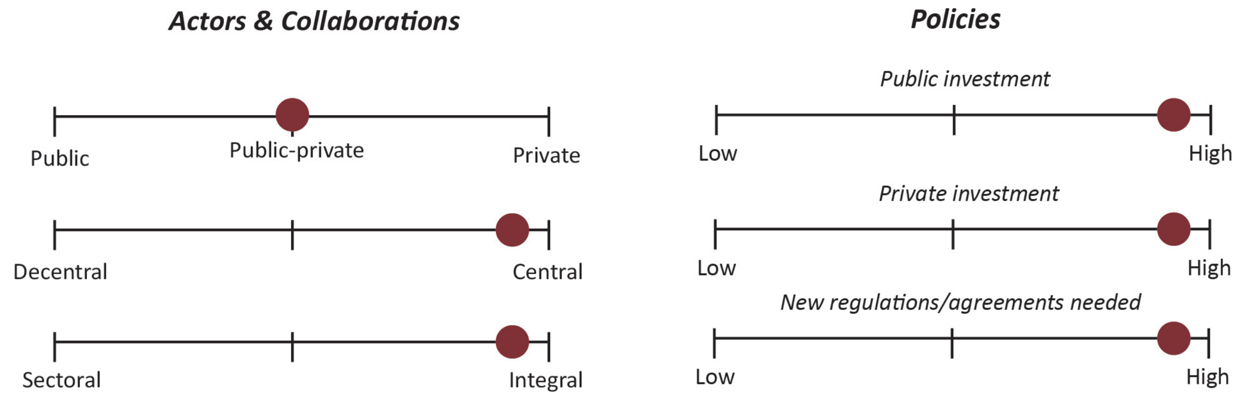
In the transformation phase, the floodable park is extended to a 'living with water' concept. New developments will take place on the water. As can be seen above, these developments require an integral public-private collaboration. Investors as well as developers, utility companies and governmental actors at different levels need to work together. The province and AGV are also included, because it involves building on the water and building in an existing (potential regional) floodable (waterfront) park. The developments require both public and private investments. The municipality must invest in the extension of public space and utilities over the water (platforms). New building regulations for building on water could be drawn up on a national level (Bouwbesluit). If this is not the case, the province and municipality can draw up their own rules for these developments. These rules can, for instance, be set as requirements for adjusting the zoning plan. The floodable park, a public area, will be changed into a public-private area. This is necessary to give new development a chance, but also reduces the influence of the municipality on the waterfront area. It is therefore crucial to make public-private agreements or regulations about the do's and don'ts on the water.

The development is a complex public-private process which requires an integrated approach involving all actors. The municipality is the driving force behind the developments and works together with the regional governments and private actors. The province forms the link with possible national development plans and AGV can provide advice and requirements about the developments on the water. The project developers are influenced by the investors and the national government (Bouwbesluit).



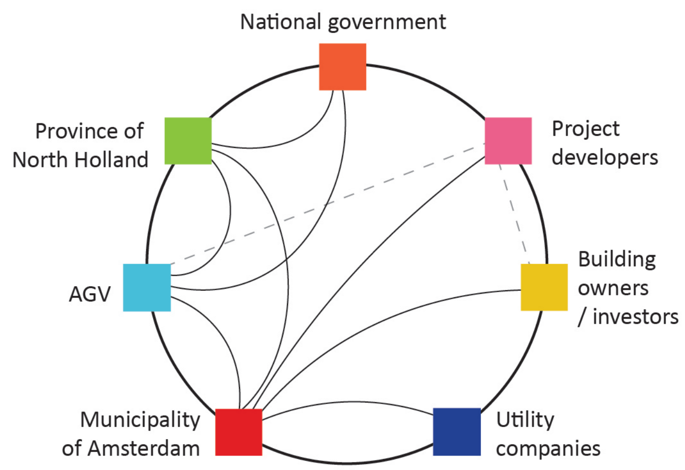
Transformation - Protective Future





Superdike

In the transformation phase, the dike is extended into a superdike. This superdike combines the amplification and magnification of the dike with new developments. The plinths of the existing buildings are integrated into the superdike. This can be seen as optimizing land use, because the monofunctional dike can become a very multifunctional superdike. Similar to the 'living with water' concept, this needs an integral public-private collaboration. However, the super-dike also requires strong management from the regional and national governments, as the dike will become part of a regional dike trajectory and national delta strategy. The superdike requires major investments from both governments and private actors (investors). It also requires strong public-private agreements. The sectoral dike, managed by AGV (or Rijkswaterstaat), will be transformed into an integral object. All layers of multilevel safety come together: The dike protects against flooding, the dike contains urban developments, and the dike can be used as an evacuation location for surrounding areas. However, this integration of all layers also results in an integration of responsibilities. With a normal dike, all responsibility lies with the regional water authority. With a superdike however, many more actors are involved in the dike and all actors share the responsibility for flood safety. Because AGV has the knowledge about flood protection, AGV should play a strong role and should be able to set rules for the municipality and project developers. The municipality coordinates the local implementation of the superdike and the province and regional water authority must coordinate the regional implementation.



11. Pathways for Governance

11.1.7 Differences with current governance

The adaptive pathways for the Coenhaven address a number of aspects of water safety governance that will likely need to change if larger decisions have to be made in the future:

From sectoral to more integral
The current policy focus lies mainly on the first layer of water safety, prevention. It is therefore entrusted fairly to the regional water authorities and Rijkswaterstaat. The financial resources of the water sector and urban development are separated.The adaptive pathways show that more integration is needed in the future, especially towards a transition and transformation. This may involve the full integration of the three layers of multi-level safety, such as with a super dike. But also an exchange of the focus on the prevention layer (1) with a focus on the robust urban design and disaster management layers (2+3). A transition and transformation will probably require more investments, but also more actors are involved. Integral investment budgets may therefore be required. For the initial design of Haven-Stad, it is also important that actors from all levels (in this case the municipality, Waternet and the Amsterdam-Amstelland security region) come together to discuss future developments, possible space reservations and the required flexibility. Bringing together the three layers of multi-level safety therefore also requires bringing actors together. A collaboration between the province and regional water authority can play an important role in this, as a link between the central and decentralized scale and as a link between spatial planning and water management.

From central to central + decentral control
Water safety is currently mainly managed centrally by regional water authorities and Rijkswaterstaat. The adaptive pathways show, however, that decentralized actors will also play an increasingly important role for flood risk management, especially when the multi-level safety layers are integrated. For example, municipalities (and private actors) will become more involved in water safety, especially with layer 2 (and 3), but certainly also with the integration of the three layers. The upcoming environmental law is aimed at decentralization of, a.o., the climate adaptation task. In addition, it emerged from the interviews that there is a need for central control. These two sides do not necessarily have to conflict, especially since control from both layers appears to be necessary. In transition and transformation, central management will certainly be necessary. But decentralized control is also crucial to realize integration between the layers of multi-level safety.

From public to public-private responsibility
The adaptive pathways show that private actors are involved in almost every phase. With a shift from a focus on protection to an integral focus, public responsibilities for water safety will also shift more towards public-private. This also means that private actors must invest in flood risk management together with public actors. Because awareness is still relatively low (but growing!), it is important that governments emphasize the responsibility of private actors. In addition, governments can support private actors by providing knowledge.It is increasingly more important to involve private actors in the planning process, so that there is transparency about any future developments. Private responsibility may have to be imposed from the government, for example through public-private agreements. At the same time, investors are expected to increasingly focus on climate adaptation for risk reduction.

From fixed to flexible processes and agreements
The adaptive pathways address the uncertainty that lies in the future. It is not yet certain which decisions will be made later. In addition, the required governance and processes cannot be predicted. As also emerged from the interviews, the current processes, investment budgets and agreements are not yet flexible enough to be able to anticipate changes. It is therefore important that the design, but also the processes and agreements become more flexible.

Long-term coordination
An adaptive plan also requires long-term coordination. Certainly because the plan will also have to be updated in the meantime as a result of new developments. At the decentral level, the municipality is the actor involved in each measure. That is why the municipality is a logical coordinator. At a central level, the national government plays a major role in the long-term coordination of the national delta strategy. It is also important that the coordination on a decentralized and central scale is consistent. This can still be difficult because there is still a lot of space between the municipality and national government in terms of both scale and focus. For example, the municipality focuses mainly on the urban scale and on layer 2 (robust urban design) and possibly layer 3 (disaster management). The national government is still mainly focused on prevention. Both the regional water authority / Waternet and the province can be of great importance here to form the link between the scales and points of attention. At the moment it seems logical for the regional water authority to be the link for layer 1 (prevention) and the province to be the link for for layer 2 (robust urban design). However, it would probably be better if these links also come together to really integrate the layers of multi-level safety. The province could work together with the regional water authority on a joint adaptive pathways plan for the region, in which spatial planning and water planning are integrated.

Differences between the best-case & worst-case scenarios
The best-case and worst-case climate scenarios are linked to the x-axis. They show in which year a certain sea level rise can be expected in the two scenarios. It can be noticed that the different scenarios also require different governance actions. In the best-case scenario, there is more time to act and incremental measures until 2100 seem sufficient. In the worst-case scenario, the sea level will rise faster and higher, requiring governance to achieve more in less time. In the worst-case, a transition and transformation may be necessary before 2100.

Differences between the two selected trajectories
The main difference between the two trajectories is the choice of an open or closed system. Both systems require more integration and a larger role for private actors, compared to the current governance. When opting for the closed system, central control is much more important than with the open system, because a dike and super dike will become part of a regional trajectory. In addition, there will be a greater shift of responsibilities when opting for the open system. In this case, the private actors have a lot of responsibility for flood risk management compared to the private actors behind the dike or super dike in the closed scenario.

BOX 11.1: WHICH TRAJECTORY TO CHOOSE?

The answer to the above question cannot be found in the pathways map. However, the pathway map can address certain options, decision points, and consequences. The selection of a trajectory is ultimately a political (and a design) choice. It depends on the technical, financial, and organisational possibilities at certain decision moments. In addition, the trajectory selection for the Coenhaven depends on regional and central decisions about the projection strategy for the Dutch Delta and the development of climate change. In the worst-case scenario, more and bigger decisions have to be taken in a shorter time frame than in the best-case scenario. Finally, it is important to note that the pathways map should be updated over time, as new challenges and solutions may arise in the future.Unexpected developments, new climate change insights, or new measures (new technologies) should be implemented in the pathway map. It is therefore not possible to select a complete trajectory through all phases in advance.

11. Pathways for Governance

11.2 CONCLUSION PATHWAYS FOR GOVERNANCE

The SAPP approach supports thinking about different futures and what those futures would require from climate adaptation governance. The adaptive pathways can, at this point, be used mainly as an explorative exercise. It does not outline a plan for a full governance transition, for example. The pathways can address future challenges and can be used to initiate a dialogue on the current and possible future governance. Because governance change can take a long time, it may be necessary to start now with conversations and adjustments, to enable future developments. The SAPPs can highlight several options to consider and certain expected trends, such as:

- From fixed to flexible agreements and processes
- From public to public-private responsibility
- From central to central + decentral control (water safety)
- From a sectoral to an integral approach
- The need for long term coordination of adaptive plans

In addition, the SAPP approach can contribute to the communication of possible future developments towards residents and private actors, and thus contribute to a transparent government.

CONCLUSION
APPLICATION

How can Spatial Adaptive Policy Pathways be used to support design and governance for climate adaptation planning?

HAVEN-STAD OUTPUTS

- ***SAPPs for design***
  Two trajectories towards two different futures of the Coenhaven are selected and worked out spatially: The 'living with water' future and the 'protective' future. The spatial elaboration shows how big the differences between the phases (and the two trajectories) are. For the Coenhaven it is crucial to reserve space along the waterfront. Secondly, the buildings, or at least the plinths need to have a flexible design. Lastly, the above-ground and underground infrastructure need to be considered.

- ***SAPPs for governance***
  The governance analysis of the Coenhaven pathways showed that it could be expected that a number of major decisions will have to be made in the future. These decisions are more complex than until now and also require strong cooperation between many different actors. Control for water safety would shift from centralized to centralized + decentralized and the responsibility from public to public-private.

SAPP APPROACH

- ***SAPPs for design***
  The SAPP approach supports thinking about different phases of climate adaptation in the future and about linking the short- and long term in design. For design, pathways help to create a climate-adaptive initial design and can provide arguments by displaying the flexibility. Design also supports the SAPP approach as the development consists of a research-by-design process and as the spatial elaboration makes the abstract SAPP map easier to communicate.

- ***SAPPs for governance***
  SAPPs support thinking about different futures and what those futures ask from climate adaptation governance (explorative). The pathways can address future challenges and can be used to set up a dialogue about the current and possible future climate adaptation governance. Climate adaptation may require different governance at each stage. As a result, climate adaptation governance itself probably also needs to become more adaptive.

- ***Applications of the SAPP approach***
  The SAPP map is an explorative and strategic tool. It does not give answer to which decision is the best, but it shows options for climate adaptation over time. The map can be used to address and discuss design and governance for climate adaptation over time.

RESULTS

What can be learned
from the process and outputs?

EVALUATION

CONCLUSION & REFLECTION

12

EVALUATION

To assess the Spatial Adaptive Policy Pathways approach for climate adaptation planning, evaluations are made of the outputs for Haven-Stad, of the SAPP approach itself, of the transferability, and of the potentials of the SAPP approach in practice.

By author. (2021)

12.1 OUTPUTS

In this section the outputs of the SAPP approach for the case study area Haven-Stad, Amsterdam are evaluated.

In this research Haven-Stad is mainly used as case study to test the approach. The outputs are not expected to be adopted or executed, but can be a starting point for discussion. Moreover, the outputs can always be improved later through input from the experts involved.

The outputs are not expected to be adopted or executed, but can be a starting point for discussion

Analysis
The site analysis showed that Haven-Stad already faces climate change effects and that it can be expected that these effects increase if no adaptation measures will be implemented. The governance analysis showed that there are still several challenges with regard to climate adaptation, mainly caused by the uncertainty, contentiousness, multiplicity, and complexity of climate change. The interviewed spatial planning and water management experts from the Amsterdam region made the following suggestions for improving climate adaptation governance: consideration of a longer time horizon, more flexibility of the designs and processes, more integral collaboration, sharing of the climate adaptation task, more national coordination, and more clarity about responsibilities and acceptable risks.

Design explorations & Focus areas
The spatial design explorations brought forward how the adaptation principles can be translated to Haven-Stad. For example, differentiations can be made in the water systems, vegetation, and building typologies, based on the different soil types. Possible future dike trajectories can also be considered, and vertical evacuation can be combined with public and recreational functions. Due to the heterogeneity of the areas in Haven-Stad and to reduce the complexity of the SAPP map, two focus areas were selected to test the development of the SAPP map. The Coenhaven waterfront and fluvial flooding were selected as main focus area. Sloterdijk I South and pluvial flooding were selected to do a quick second test.

Coenhaven Waterfront
The Coenhaven waterfront is selected to explore pathways for fluvial flooding in Haven-Stad, as it would face the most changes if the protection strategy of Haven-Stad would change in the future.

An exploration of possible future developments revealed that Haven-Stad depends on national and regional decisions about the Dutch delta strategy. In the SAPP approach, these developments were translated into different futures for Haven-Stad, in which choices could also be made on a local scale. The Coenhaven waterfront should be prepared for two main scenarios: An open and a closed system. A decision for one of these scenarios would mean a transition (and potentially later a transformation) for the Coenhaven area.

In the SAPP map, the x-axis connects the sea level rise trend to the potential flood depth in the Coenhaven and to a best-case and worst-case climate scenario. The map shows the (non-exhaustive) options for adaptation to a rising sea level over four main transition phases (and a second incremental phase). In the best-case scenario only local incremental measures are needed till 2100. In the worst-case scenario the need for a transition and transformation before 2100 is very likely. The starting point, the design for the Coenhaven in 2050, contains several measures that make the Coenhaven climate-adaptive, such as a waterfront park and flexible plinths. These measures make it possible to adjust the area in the future.

Two trajectories towards two different futures of the Coenhaven were selected and worked out spatially: The 'living with water' future and the 'protective' future. Figure 5 shows the initial design and the two trajectories in the transformative phase. The SAPP approach helped to create a climate-adaptive initial design, which is important as it defines the future possibilities of the site. For the Coenhaven it is crucial to reserve space along the waterfront. The space reservations can be used for parks or temporal functions. Secondly, it is important that the buildings, or at least the plinths, have a flexible design. The above-ground and underground infrastructures also need to be considered. It could for instance be possible that roads are (re)moved. Underground infrastructure with long lifetimes should be placed as much as possible under 'stable' roads, such as the middle road. Or it could be investigated if the infrastructure can be integrated in the buildings. Secondly, the SAPP map can be used to provide transparency towards investors, project developers, and inhabitants about possible future changes, as the changes can affect market values and functions.

The governance analysis of the SAPP map for the Coenhaven shows that several major decisions will have to be made in the future. These decisions are getting more complex and require strong cooperation between many different actors. The current sectoral focus on prevention for water safety would need to shift to a more integral approach including robust urban design and disaster management policy. This shift would also mean that decentral and private actors, such as the municipality and building owners, are getting more important roles for water safety. An adaptive plan also requires long-term coordination. On the decentral level, the municipality is the logical actor as it is involved in all measures. At the central level, the national government plays a major role in the coordination of the national delta strategy. A collaboration of the regional water authority and the province could be of great importance to form the link between the different scales (local and national) and focuses (spatial planning and water management) of the municipality and national government respectively.

Sloterdijk I South
Sloterdijk I South is selected to do a quick second test of the SAPP approach for pluvial flooding in Haven-Stad, as it has an increased chance of rainwater nuisance.The quick test has mainly provided new insights about the SAPP approach, but because no pathways have been developed, fewer insights have been gained about the area itself. However, it is advisable to further investigate these pathways. Especially to find out how the area can be adjusted if the precipitation intensity rises above the current municipal standard of 60 mm/h. Some flexibility must therefore be built into the initial design. The governance for pluvial flooding in this area may also be interesting to investigate further, as the private actors are responsible for the development of the whole lot, including the publicly accessible intermediate streets. And it is precisely these areas that have a lot of potential to be flexible and to integrate water storage.

Transferability of the outputs
Because the effects of climate change and also the desired and appropriate climate adaptation measures can be very location-specific, the outputs for Haven-Stad cannot be used 1 on 1 for other locations. Nor can it be assumed that the governance for climate adaptation in other cities is the same as the governance in the Amsterdam region. However, some notions about the governance for climate adaptation planning could be more general. For instance the shift from public to public-private and from sectoral to integral. In addition, the outputs serve as an example of an elaboration of the SAPP approach.

12. Evaluation

12.2 SAPP APPROACH

In this section an evaluation is made of the SAPP approach.

Differences with existing adaptive approaches
The main differences between the SAPP approach and existing adaptive approaches is the combination between water management and spatial planning and the focus on both design and governance. In addition, the SAPP approach introduces some new components to the existing approaches. These components make it easier to work with the complex urban environment and the time component.

Firstly, design layers and adaptation principles are added. These have been especially important to explore more thoroughly the options for adaptation. The design layers structure the adaptation measures (classified per design layer) and the spatial design exploration (2050 design). The design layers are also used for the conceptual pathways and connecting the explorations in time and space.

Second, transition phases are added to the approach. Working with the phases has the advantage that the conceptual and adaptive pathways can already be tested without much clarity about the values on the x-axis. The transition phases provide a guiding structure to link the possible future developments, the adaptation measures, and the x-axis. In addition, the transition phases support transformative thinking, which is not always integrated in existing adaptive approaches. Finally, the transition phases can be the link between designers and engineers that work together on the SAPP map. Designers can think about different steps of the design (per phase) and the engineers can connect tipping points for the phases with the x-axis.

The SAPP map also has differences from other adaptation pathway maps. For example, 'requirement measures' have been added to the SAPP legend, indicated by a dotted line and an asterisk. These measures are a requirement for the implementation of other measures. In addition, the SAPP map combines different scales, from beams on a building to a complete super dike. Such multi-scale adaptation pathways are not often found. Also, not all adaptation pathway maps allow to follow different pathways at the same time. However, this is important for SAPP, because (a design for) an urban area always consists of several components. *Because it is impossible to check all existing adaptation pathway maps, it can not be guaranteed that these features of the SAPP maps are unique.*

What the approach offers
First, the SAPP approach, like other adaptive pathway approaches, supports adaptive thinking and planning. It brings forward a new paradigm in which uncertainty is embraced and adaptivity is central. That is why it also fits well with the climate adaptation planning task, in which uncertainties play a role and adaptivity is important in the longer term. A plan is not seen as fixed, but as continuous development.

As described in Section 2.1, adaptive pathway approaches align well with the resilience framework. The SAPP approach also incorporates persistence (robustness), adaptability (flexibility), transformability (transitions and transformations), and preparedness (a long-term perspective and insight to lock-in principles). In addition, the approach can provide support for meeting the requirements for climate adaptation governance, as described in Section 5.3. It provides a way to deal with uncertainty by addressing multiple pathways that adapt to climate change. In addition, it supports consultation and interaction, as the SAPP map can be used for explanation and discussion with different actors. It may also contribute to strengthening the urgency of actors, as the climate scenarios and pathways show which adjustments may be needed in the future. Because the map can bring together different spatial scales, time scales and disciplines, it can also be used as a tool for integral assessments. Finally, the SAPP approach emphasizes the flexibility and adjustability of the design and planning. This meets the need to align flexible and adjustable policy strategies.

The SAPP approach offers a clear step-by-step plan and framework for working with adaptive pathways. It can be used for making (design) explorations about the future of an area. SAPPs do not show which path is best to follow, but can address certain options, decision points, and consequences. This allows the SAPP map to form a basis for a broad dialogue about the short and long term future, both in design and governance. In addition, the SAPP approach can offer a perspective for action, if it is used for the development of a strategy. Both public and private actors can therefore anticipate to (the different options in) the future when making short-term decisions.

What the approach does not offer
The approach does not provide the answer to which trajectory should be followed or which governance there to implement in the future. The selection of trajectories is ultimately a political (and a design) choice. It depends on the technical, financial, and organisational possibilities at certain decision moments. And also on dependencies on other (for instance national) decisions and the development of climate change. Finally, it is important to note that the pathways map needs to be updated over time, as new challenges and solutions may arise in the future. Unexpected developments, new insights into climate change, or new measures (new technologies) must be implemented in the pathway map. It is therefore not possible to select a complete trajectory through all phases in advance.

Advantages of the approach
An advantage of the SAPP approach is that it consists of a flexible framework with structuring elements. Due to the flexible framework, the approach can be used for various issues. The design layers structure the spatial exploration and the transition phases structure the exploration in time. This provides structure, but also a link between space and time (these come together for the first time in the conceptual pathways). In addition, an advantage of the SAPP approach is that it requires both a spatial elaboration and a governance elaboration. As a result, in practice more actors will have to work together and the created SAPP can be communicated more easily to different types of actors.

The SAPP approach can be a basis for a dialogue about the short-term and long-term future

Limitations and challenges of the approach
However, the SAPP approach also has limitations and challenges. One of the main limitations of the approach is the limited space that the SAPP map offers for a complex environment such as the city. One of the challenges is therefore finding the balance between readability of the SAPP map and grasping the complexity (reality). This also affects the ability to integrate different scales and themes. Although a designer can conceptually link these themes in a complex way, it proves difficult to process this in the SAPP map. If too many measures have to come together, the map quickly becomes cluttered. In addition, the level of detail must be attuned to the scale. For example, it can be a problem if there is a large spatial heterogeneity on a district scale. It can then be difficult to integrate different sub-areas into one map, without getting too conceptual. In this study this problem is solved by decreasing the scale and selecting focus areas. Two other challenges in the development are defining the starting point (in the case study the 2050 design) and defining the x-axis. With a new development there is no starting point yet and it can be difficult to develop the starting point simultaneously with the SAPP map. This requires several iterations. At the same time, this is also a very good design exercise that establishes a strong link between the initial design and the possibilities in the future. Defining the x-axis and tipping points is also one of the challenges. Especially because there is uncertainty about the relationship between climate trends and the consequences. Another limitation is that both techniques and societal wishes (or objectives) can change over time. As a result, the SAPP map sometimes addresses future challenges with current techniques, or indirect assumptions are made about social desirability. And also governance can change over time. This requires periodic updating of the SAPP map.

12. Evaluation

12.3 TRANSFERABILITY

In this section an evaluation is made of the transferability of the SAPP approach. *The evaluation of the transferability of the research can be found in Section 13.2.*

Due to the level of conceptualization and the possibility to customize the framework, the approach is widely applicable. The steps of the SAPP approach, as presented in Section 2.3, can generally be used. Step 1, the analyses, is important because the climate adaptation task generally differs for different (urban) areas. In step 2, the framework has to be defined; this means that the framework can be adjusted to the scope and objectives of the pathways research. The adaptation measures in step 3 can also be adjusted on the basis of the (new) possibilities. Step 4 to 7 can be followed, with this case study as an example, but with own inputs from step 1 to 3.

Existing built environment
In this research, the focus was on new urban areas. However, the approach can also be applied to the existing built environment. While this part of the city is changing more slowly, it is also changing. In addition, the climate adaptation task is also of great importance for the existing city. The starting point is already there and does not need to be designed first. Because the existing city is already inhabited, it is extra important to involve the inhabitants in the process. For example, they can be involved in the analysis (what are they bothered by?), in defining the objectives (what is desirable?) and in the selection of adaptation measures. They can also be involved in the development of the pathways, so that they are aware of the adjustments that will take place over time. Making the pathways spatial can be a good means of communication for this. In addition, the adaptation pathways for the existing city can be linked to management cycles of the city, so that with each management the city is adapted to the changing climate.

Other locations
In this research, the focus was on urban areas in the Netherlands. The climate adaptation task is however not unique for the Netherlands. The whole world faces climate change effects, and a lot of urban areas are in deltas such as the urban areas in the Netherlands. The approach is transferable to other urban areas around the world, as it offers a flexible framework (adjustable scope, objectives, and adaptation measures) and site-specific analyses. The approach could also be used for rural areas to explore the options for climate adaptation over the years.

Other spatial scales
In this research, the spatial scale has been set on the district (Haven-Stad) and the pathways zoomed in on the neighbourhoods. The measures include the building scale and the regional delta strategy has been included in the follow-up studies. As a result, many different scales come together in the SAPP approach. The approach is also transferable to other spatial scales. Adaptive pathways are already being explored for the national Delta Program and can certainly also be interesting on a regional or city scale. However, two things must be considered here. Firstly, about the fact that climate adaptation must be location specific. For example, the necessary adaptations can already differ greatly from region to region (for instance the east and west of the Netherlands). The national scale therefore seems less suitable for climate adaptation. Secondly, the scale of the measures and the level of abstraction must also be adapted to the scale of the adaptation pathways. In an adaptation path map for the region, for example, it is not possible to zoom in on a very specific measure for a certain neighbourhood. This would make the map too complex and unreadable. For scales smaller than the neighbourhood (block/building) the approach is less relevant for spatial design and planning for climate adaptation. The block or building is often owned by a private actor and is too small to make a significant difference to the environment.

Other time scales
In this research, the time scale was set on 2050 to (around) 2100. At this moment, it would be hard to use an even longer timescale. It could be, but many assumptions are needed about the climate and urban areas after 2100. However, interesting design exercises can still be done with the approach. The time axis is not the most important axis. The most important axis is the axis that represents the climate trend or its effect. It is thus possible to set up a fictitious axis and to define and design transition phases as an exercise. A shorter time frame than in this study would also be possible, but the danger of this is that the horizon is set too close and that the changes after 2050 in particular are insufficiently analyzed.

Other sectors and themes
The focus of this research was on climate adaptation planning. The approach can broadly be applied to all transition challenges, which have to deal with uncertainties and a long-term development. The ideal would be to combine all transitions in one pathway map, because they all have to be tackled integrally. However, this requires a strong simplification of all challenges, in order to keep the complexity of the pathway map manageable.

Due to the level of conceptualization and the customizable framework, the approach is widely applicable

12. Evaluation

12.4 SAPP IN PRACTICE

In this section an evaluation is made of the transferability of the SAPP approach to practice.

In practice, the SAPP approach would probably differ from this experimental, more conceptual, and theoretical study.

Why

The first question for practice is: why should you use the SAPP approach? The advantages and disadvantages of the approach have already been explained in Section 12.2. The most important thing that the approach can offer in practice is a new view at long-term climate adaptation planning and a starting point for discussion. The SAPP approach requires a strong collaboration of spatial planning and water management actors. Therefore, it can stimulate the integration of the two domains. It supports the development of adaptive designs, which better anticipate on the uncertain future. By making possible choices and consequences explicit (and spatial), the SAPP map provides transparency for all actors involved. The idea that the Netherlands is finished is already outdated, but now we have to look for new ways to deal with the idea that it will never be finished. The SAPP approach can provide support for this, or at least open up the conversation. It could be the first step towards the development of new strategies and policy development, and to a governance dialogue.

Who

The main difference between this research and practice is that the SAPP approach has to be implemented in practice by a multidisciplinary team with different experts (in any case: water management, spatial design and planning, urban development, governance/policy). The approach can be particularly interesting for all authorities: the municipalities, provinces, regional water authorities, and the ministries. These actors are in fact responsible for the (long-term) spatial planning and water management of the country. This also includes the climate adaptation task. Governments can collaborate with experts in the field and with academics to develop the adaptive pathways. The advantage of developing the pathways is that experts from different sectors (such as water and spatial planning) have to come together and have discussions.

How

To put adaptive planning into practice, the SAPP approach could be given a central place in spatial planning issues at different scale levels. For example, it could be integrated into the (processes for making) the environmental visions. In the beginning, it could mainly be used as an exploration and discussion tool. After further development, the approach may also provide input for strategy and policy-making. For example, to introduce the approach to all government authorities, it could be integrated into the Delta Plan on Spatial Adaptation. Figure 12.1 shows the ambitions of this plan. The SAPP approach could support the top three ambitions. However, this research does not show all steps of the SAPP approach. The last three steps, strategy formulation, implementation, and monitoring and adjustment, are only possible in practice. Drawing up a strategy and selecting the desired trajectories is a choice that will have to be made by the experts in practice and politics. In addition, it is important to emphasize that adaptation pathways will have to be adjusted over time. For example, when there are new insights about climate change or when new technologies have been developed. This updating of the pathways could be combined with updating of the environmental visions (omgevingsvisies).

When

It is also a question in which phase of the planning process the adaptive pathways can best be deployed. The approach can probably be used at two points in the process. Firstly, it can be used in the development of the environmental visions (omgevingsvisies), to broaden horizons and explore different pathways to the future. This can also provide input for the measures that are needed in the short term. The approach brings different sectors together to discuss the long-term future and to link it to short-term actions. Secondly, the approach can be used in area developments, such as Haven-Stad. This is on a smaller scale and will involve other actors, such as project developers. Suppose the municipality in question has developed adaptation pathways for the environmental vision, then these pathways can give direction to the area-specific pathways.

The SAPP approach could be a promising approach to apply in practice

Limitations & Challenges

One of the main limitations of the approach for practice is that it can take more time to make multiple designs for different phases instead of one fixed plan. The process of developing a fixed climate adaptation strategy can already take a lot of time, and creating adaptation pathways makes the process more complicated and therefore longer. There is also a risk that decisions will be postponed. Because the adaptation pathways show the consequences of certain decisions (for instance, excluding a particular scenario) and because the uncertainty is still present, it can be difficult for decision makers to decide to go left or right. Nevertheless, the approach is worth considering, because it could prevent that large and unexpected adjustments have to be made later (again). In the long term, the approach can therefore be more sustainable than the current way of working. A second limitation is the focus on climate adaptation. In practice, all (transition) issues come together and integration and smart combinations must be sought. SAPPs can still be used for climate adaptation, but it is important to link the SAPP map to the bigger picture. One of the biggest challenges for SAPP in practice would be to create support for it, because it requires a different way of thinking and working. A plan can no longer be seen as fixed and should be connected to different long-term futures. The SAPP approach needs updating and thus requires a long-term commitment to adaptive plans.

Figure 12.1. Ambitions of the Deltaplan Spatial Adaptation. Adapted from *"Deltaprogramma 2018"* (p.128), by Ministerie van I&M & EZ, 2017. Copyright 2017 by Ministerie van I&M & EZ.

CONCLUSION
EVALUATION

What can be learned
from the process and outputs?

EVALUATIONS

- The outputs for Haven-Stad are not expected to be adopted or executed, but can serve as a starting point for discussion. In addition the outputs provide an example of an elaboration of the SAPP approach.
- The largest differences between the SAPP approach and existing adaptive approaches is the combination between water management and spatial planning and the focus on both design and governance. The SAPP approach introduces new components to the existing approaches, such as transition phases, adaptation principles, and design layers.
- The SAPP approach provides support to adaptive thinking and planning, and provides a step-by-step plan and framework. The approach is in line with the resilience framework and the demands for climate adaptation governance. SAPPs do not provide the answer on which trajectory to follow , but can be the basis for a dialogue about the short-term and long-term future of an area.
- Advantages of the SAPP approach are the flexible framework with structuring elements and the spatial and governance elaborations.
- The biggest limitation is the limited space the SAPP map offers to capture the complexity of the city. The challenge is to find a balance between readability and grasping of the complexity. Therefore, the approach also offers a limited ability to integrate themes and scales. In addition, the SAPP map needs periodic updating to incorporate changing insights, techniques and societal wishes.
- Due to the level of conceptualization and the customizable framework, the approach is widely applicable. It can be applied to the existing built environment, other spatial scales, other time scales, other locations, and other sectors and themes.
- The SAPP approach could be a promising approach to apply in practice. However, it would have to be further developed first. It can provide a new way of looking at long-term climate adaptation planning and a starting point for discussion.

13

CONCLUSION & REFLECTION

In this chapter, the answer is given to the sub-research questions and the main question: *Can & how can the Spatial Adaptive Policy Pathways approach support climate adaptation planning for new urban areas in the Netherlands?* Afterwards a reflection of the research is presented.

Willard, J. (2012)

13. Conclusion & Reflection

13.1 CONCLUSION

Climate adaptation planning is crucial to ensure the development of sustainable urban areas with high liveability standards for future and far-future inhabitants. However, traditional spatial planning does not match with the climate adaptation task. This is caused by the long-term, dynamic, and uncertain nature of climate change and a lack of integration of water and climate adaptation in spatial planning. Hence, there is a need for a different way of working.

The objective of this research is to contribute to the search for new approaches that support climate adaptation planning. This research aims to investigate the usability of the Spatial Adaptive Policy Pathways (SAPP) approach for climate adaptation planning in new urban areas in the Netherlands, by giving answer to the question:

How can the Spatial Adaptive Policy Pathways approach support climate adaptation planning for new urban areas in the Netherlands?

To answer the main question, five sub-questions are set up.

13.1.1 Answers to the Sub-questions

Which analyses are needed to get a comprehensive view of the climate adaptation task?

A site analysis (Chapter 4) and a governance analysis (Chapter 5) are needed to get a comprehensive view of the climate adaptation task. The site analysis is important to gain insight into the current, but especially the future climate change effects (heat, pluvial flooding, drought, fluvial flooding) on the site. Since many stresstest maps are based on the current situation, it is important to also set a future perspective. For this it is important to have insight into the climate projections and future developments on the site. In addition, the governance analysis is important, since climate adaptation planning is also a governance issue. Insight into the actors, policies, collaborations, and the main challenges experienced in practice is crucial to understand the climate adaptation task. The SAPP approach can give support to meet the demands for climate adaptation governance, which arise from the uncertainty, contentiousness, multiplicity, and complexity of climate change.

What are the key components needed for the development of Spatial Adaptive Policy Pathways?

The framework consists of four key components, which can be customized based on the case study and scope. The key components of the framework (Chapter 6) are the starting point, the climate objectives & climate trends, the transition phases, and the adaptation measures (Chapter 7). The transition phases are a new component for the development of adaptive pathways. The phases support spatial explorations about the development of climate adaptation over time and encourage thinking about long-term and drastic developments. To structure the abundance of adaptation measures, the SAPP approach introduces adaptation principles, design layers, and adaptation tiles. In addition to the framework, the scope needs to be defined. This includes the definition of the theme, spatial scales, time scales, governance scope, and focus areas & dominant stressors.

How can Spatial Adaptive Policy Pathways be developed for climate adaptation planning?

For the development of SAPPs for a specific area, research-by-design is the most important method. Through sketching and trial-and-error, the content of the SAPP map can be developed with the key components as base. The development involves multiple iterations between the design of the starting point, the design of the area over time (the pathways) and the design of the SAPP map. The approach stimulates to explore the possibilities for climate adaptation in space and time. These design explorations form input for the development of the SAPP map. For the spatial exploration, the adaptation principles are translated to the case study site for each design layer. For the exploration over space and time, conceptual pathways are added to the approach. Next to the explorations, the approach contains steps that guide the development of the SAPP map. The transition phases turned out to be an important integrating component. The phases contribute to the conceptualization of the time component and form the connection between the conceptual pathways, the possible future developments, and the x-axis. Design layers help to unravel the complexity of the city and to explicitly consider different options for climate adaptation. The final product of the process is the SAPP map, which shows how the urban area can adapt to climate change over time.

How can Spatial Adaptive Policy Pathways be used to support design and governance for climate adaptation planning?

SAPPs can support climate adaptive design (Chapter 10) as it supports thinking about different phases of climate adaptation in the future and about linking the short- and long term in design. For design, pathways help to create a climate-adaptive initial design and can provide arguments by displaying the flexibility. Design also supports the SAPP approach as the development consists of a research-by-design process and as the spatial elaboration makes the abstract SAPP map easier to communicate. In addition, SAPP can support climate adaptation governance (Chapter 11) as it supports thinking about different futures and what those futures ask from climate adaptation governance (explorative). Pathways can address future governance challenges and can be used to stimulate a dialogue about the current and possible future climate adaptation governance. Climate adaptation may require different governance at each stage. As a result, climate adaptation governance itself probably also needs to become more adaptive. The SAPP map is an explorative and strategic tool. It does not give answer to which decision is the best, but it shows options for climate adaptation over time. The map can be used to address and discuss design and governance for climate adaptation over time.

What can be learned from the process and outputs?

The outputs of the SAPP approach, the SAPP approach itself, the transferability, and the SAPP approach in practice (Chapter 12) were evaluated. The outputs for Haven-Stad are not expected to be adopted or executed, but can be a starting point for discussion. In addition, the outputs provide an example of an elaboration of the SAPP approach.

The largest differences between the SAPP approach and existing adaptive approaches is the combination between water management and spatial planning and the focus on both design and governance. The SAPP approach introduces some new components to the existing approaches, such as transition phases, adaptation principles, and design layers. These components make it easier to work with the complex urban environment and the time component. The transition phases also support transformative thinking, which is not always integrated in existing adaptive approaches.

The SAPP approach offers support for adaptive thinking and planning, and provides a step-by-step plan and framework. The approach connects to the resilience framework and the demands for climate adaptation governance. SAPPs do not provide the answer to which trajectory should be followed , but can be the basis for a dialogue about the short-term and long-term future of an area. The advantages of the SAPP approach are the flexible framework with structuring elements, and the spatial- and governance elaboration. However, the approach also has its limitations and challenges. The biggest limitation is the limited space the SAPP map provides to capture the complexity of the city. The challenge is to find a balance between the readability and grasping of the complexity. Therefore, the approach also offers a limited ability to integrate themes and scales. In addition, the SAPP map needs periodic updating to incorporate changing insights, techniques and societal wishes.

Due to the level of conceptualization and the customizable framework, the approach is widely applicable. It can be applied to the existing built environment, other spatial scales, other time scales, other locations, and other sectors and themes.

The SAPP approach could be a promising approach to apply in practice. It would however, first need further development. It can offer a new way of looking at long-term climate adaptation planning and a starting point for discussion.

13.1.2 Answer to the Main Question

How can the Spatial Adaptive Policy Pathways approach support climate adaptation planning for new urban areas in the Netherlands?

This research has shown that Spatial Adaptive Policy Pathways (SAPP) can support climate adaptation planning for new urban areas in the Netherlands. The SAPP approach brings forward a paradigm in which uncertainty is embraced and adaptivity is central. As the climate keeps changing at uncertain rates and with uncertain effects, climate adaptation should be seen as a continuous process of adjustment. The SAPP approach can be used to apply adaptive thinking and planning for this continuous process of climate adaptation. SAPPs do not show which trajectory is best to follow, but can address certain options, decision points, and consequences. In addition, it can bring different actors together due to the spatial and governance elaborations. With this, SAPPs can be a basis for a broad dialogue about the short-term and long-term future of an area. It supports the development of adaptive designs and can address potential future governance challenges.

The SAPP approach can support climate adaptiation planning by the provision of a clear step-by-step plan and a framework with structuring elements. In addition, it requires a research-by-design approach and stimulates design explorations of space over time. The approach includes explorative and diverging steps and offers a framework to converge the ideas into adaptive pathways. The outputs of the approach are a SAPP map and design- and governance elaborations, which can all be used for explorations and discussions.

The SAPP approach can be applied by going through four stages: analysis, identification, development, and application. To get a comprehensive view of the climate adaptation task, both a site analysis and a governance analysis are required, as climate adaptation planning is both a design and governance issue. The framework is customizable and consists of four key components: the starting point, the climate objectives and -trends, the transition phases, and the adaptation measures. For the development of SAPPs, research by design is the most important method. The selection of focus areas with a single climate change pillar turned out te be necessary to reduce the complexity and to keep the SAPP map readable. SAPPs can be developed through iterative design processes and interaction with the development of the starting point (the initial design).

The application of SAPPs requires both a spatial elaboration and a governance analysis. SAPPs can support climate adaptive design as it supports thinking about different phases of climate adaptation in the future and about linking the short- and long term in design. In addition, the governance analysis supports thinking about possible future governance changes and can therefore address possible challenges. As climate adaptation may require different governance over time, not only the designs, but also the governance should become more adaptive.

The approach has both its advantages and limitations. The main advantages are the flexible framework with structuring elements and the design and governance elaborations. The biggest limitation is the limited space the SAPP map provides to capture the complexity of the city. The challenge is to find a balance between the readability and grasping of the complexity (reality). This also results in limited ability to integrate different scales and themes. In addition, SAPPs need periodic updating to incorporate changing insights, techniques and societal wishes.

Due to the level of conceptualization and the customizable framework, the approach is widely applicable. It can be applied to the existing built environment, other spatial scales, other time scales, other locations, and other sectors and themes.

For spatial planning and water management, the SAPP approach can provide multiple advantages. First, it supports the development of adaptive designs, that can better anticipate on the uncertain future. Second, the SAPP map can clarify choices and their consequences. The SAPP map can also be used to provide transparency about possible future changes in the area for all actors involved. Lastly, the SAPP approach can address (future) governance challenges, for instance the need for an integral approach to climate adaptation planning.

The SAPP approach could thus be a promising approach to apply in practice. It would, however, first need further development. One of the biggest challenges for SAPP in practice would be to create support for it, because it requires a different way of thinking and working. A plan can no longer be seen as fixed and should be connected to different long-term futures. The SAPP approach needs updating and thus requires a long-term commitment to adaptive plans. Nevertheless, the approach is worth considering, because it could prevent that large and unexpected adjustments have to be made later (again). In the long term, the approach can therefore be more sustainable than the current way of working.

In the end, the SAPP approach has the potential to support climate adaptation planning in practice, as it can generate a discussion about the current way of working and as it offers a new way of looking at the ever-changing city and climate.

13.1.3 Recommendations

Although the SAPP approach is promising for climate adaptation planning, it needs further exploration and development. The SAPP approach was tested and adjusted in this explorative and conceptual research. However, it was not tested on different case studies, nor in practice. The next recommendations are given for further development of the SAPP approach:

- Test the approach on different case study locations;
- Test the approach in practice and involve various experts;
- Test if the approach could be used as strategic workshop tool for multi-actor discussions;
- Explore the applicability of the approach on different scales and the potential integration of scales;
- Explore the potential integration of the four climate stresses (heat, pluvial flooding, drought, fluvial flooding);
- Explore if backcasting could be integrated better in the framework and approach (for instance with the use of normative scenarios);
- Explore if SAPPs can be used for other transition challenges (such as the energy transition) or for the integration of multiple transitions ('koppelkansen').

13. Conclusion & Reflection

13.2 REFLECTION

13.2.1 Methodology

Theory & Conceptual framework
The theory as described in Section 2.1 has been important to understand the context of climate adaptation planning and current notions of adaptive planning and adaptive pathway approaches. Especially the research of Zandvoort et al. (2019) has supported this research, as it described the development of the adaptive pathways well (Zandvoort et al., 2019). The conceptual framework is in this research mainly used to show the connection between the problem definition, the theory, and the approach (adaptive pathways). As a result, the conceptual framework has not been of great importance for the further research process.

Scope
The scope of the project has changed over time. Originally the plan was to integrate all climate stresses and to work mainly on the scale of the district. During the research it turned out to be difficult to make a readable SAPP map that combined all four climate stresses as well as the different neighborhoods within Haven-Stad. Due to the differences between the neighborhoods (spatial heterogeneity) and the multitude of adaptation measures, the complexity was too big to be captured in the SAPP map. A conscious choice was then made to reduce the complexity and to keep the map readable. This was done by zooming in on focus areas and selecting one climate stress per focus area.

Research approach
Figure 13.1 shows the research approach. The research stages analysis, identification, development, and application were used quite early in the process. These stages have been important for structuring the research and the report. They are also linked to the research questions. The chapters were subsequently created within these guidelines. The arrows in Figure 13.1 show the relationships between the chapters. The research approach consisted of several iterations between the stages. Especially between the identification and development stage there have been many iterations. But the analysis and application stage have also been updated several times based on new insights. Figure 13.2 shows (a simplification of) the diverging and converging stages of this research.

Research methods & data collection
Figure 13.3 shows the research methods. The literature review and document analysis have mainly been important for defining the problem, finding the adaptive pathway approaches, and for the governance-related parts. This method has been less important for the development of the pathways and designs, although the research by Zandvoort et al. (2019) has served as an important example. It was very easy to find the necessary government documents, but more difficult to find a wide range of studies on adaptive pathways. Observation and participation have been of great importance, because this established the link with practice and brought the potential interviewees to the fore. Here too, it was made easy to collect information thanks to the many Waternet meetings. The interviews were also an important method, as it provided a lot of insight into the current governance and different perspectives of the interviewees. In addition, the interviews ensured that notions from the literature could be linked to notions from practice. Many interviewees were contacted via Waternet, the others were easily accessible by email. Mapping is a method that is always important in spatial analysis and design. Many websites about climate change and stress tests already exist for the Amsterdam region, making it easy to find this information. In addition, MER's (milieueffectenrapportages) have already been prepared for Haven-Stad and contain a lot of information. Research by design has been the most important method in this exploring research. Both the SAPP approach itself and the details for Haven-Stad were not yet known in advance. As a result, a large part of the research was dominated by testing and the constant interaction between the design and the approach.

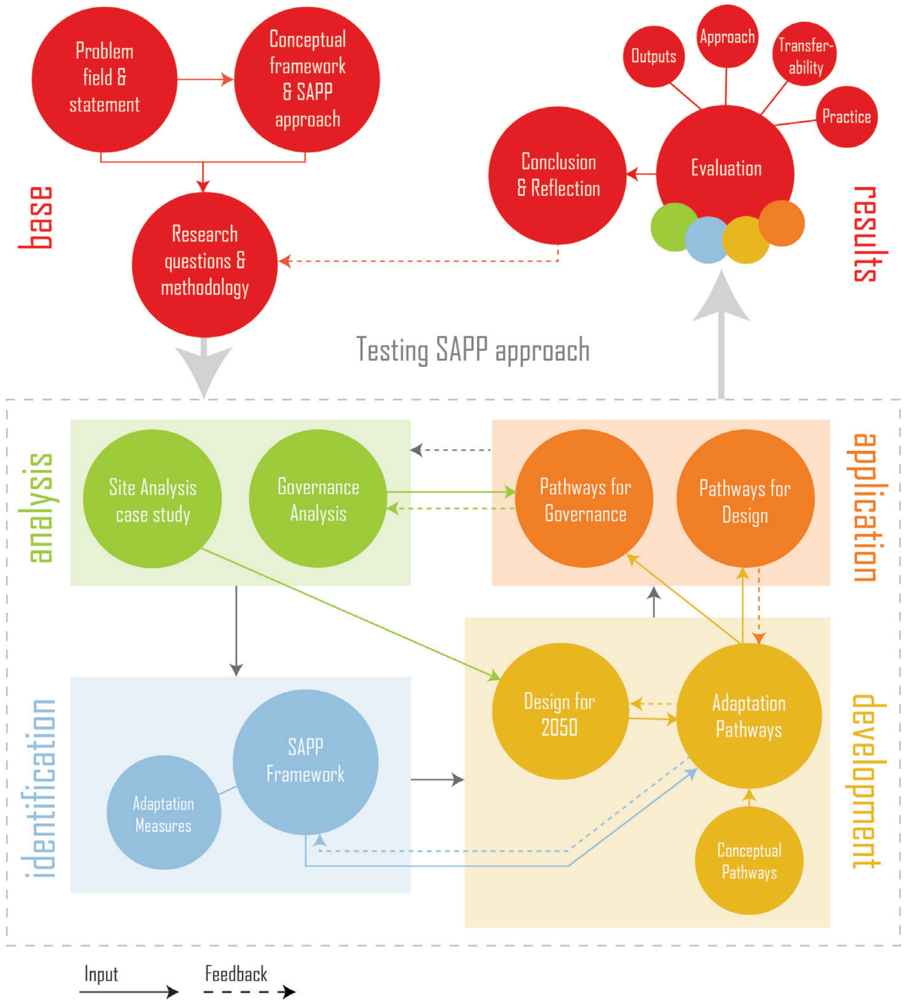


Figure 13.1. Research Approach.

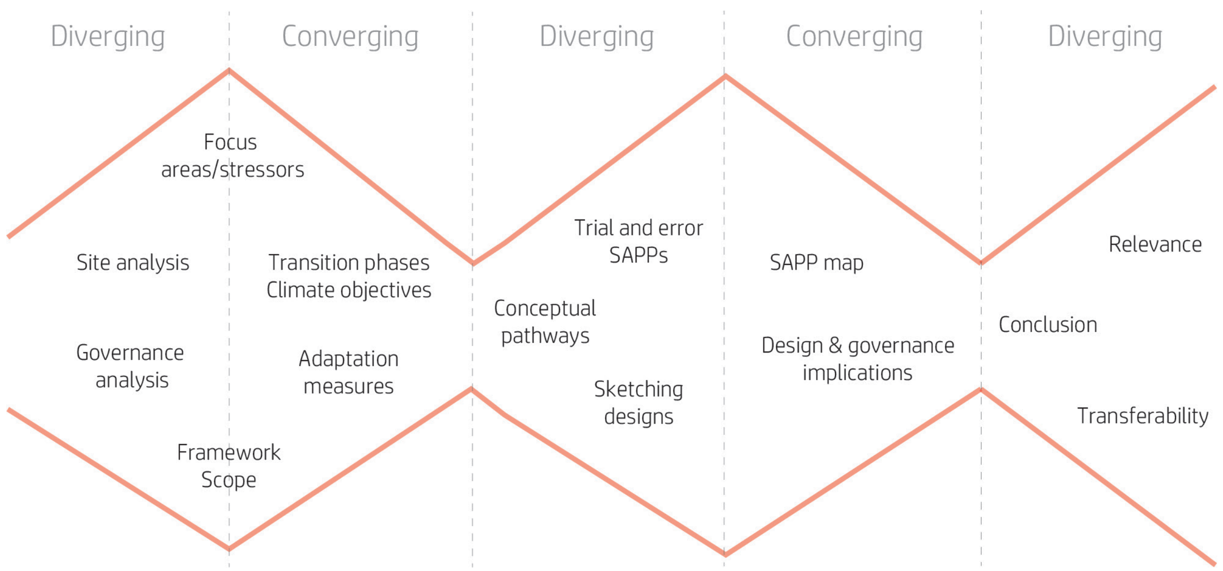


Figure 13.2. Converging & Diverging stages of the research.

Advantages & Limitations
The greatest advantage of the chosen methodology is the combination of the fixed structure of research stages (analysis, identification, development, application) with the flexibility of the methods. In particular the methods research by design, the interviews, and observation & participation contributed to the explorative nature of the research. One of the limitations is that only one case study has been used, which means that no comparisons can be made in the conclusions. In addition, the research has remained quite academic. Expert sessions could have been used to test the SAPP approach in practice and to possibly make more suitable designs for Haven-Stad.
The advantages and limitations of the SAPP approach are discussed in Section 12.2.

Transferability of the Research Approach
The research approach is transferable to other studies. The step-by-step plan, as described in Section 2.3, can provide support here. The description of the research approach itself in Chapter 3 and the example of Haven-City can also be helpful. However, the development of SAPPs was mainly a research-by-design process, which is difficult to pin down exactly. This is however not a problem as it can also be interesting to see what kind of outcomes come from other research-by-design processes. Each researcher or research group will probably come up with different results. Comparing and discussing the differences could lead to new insights about the approach or case study. In addition, the different outputs also reflect what would happen if the approach were used in practice. *The evaluation of the transferability of the SAPP approach can be found in Section 12.3.*

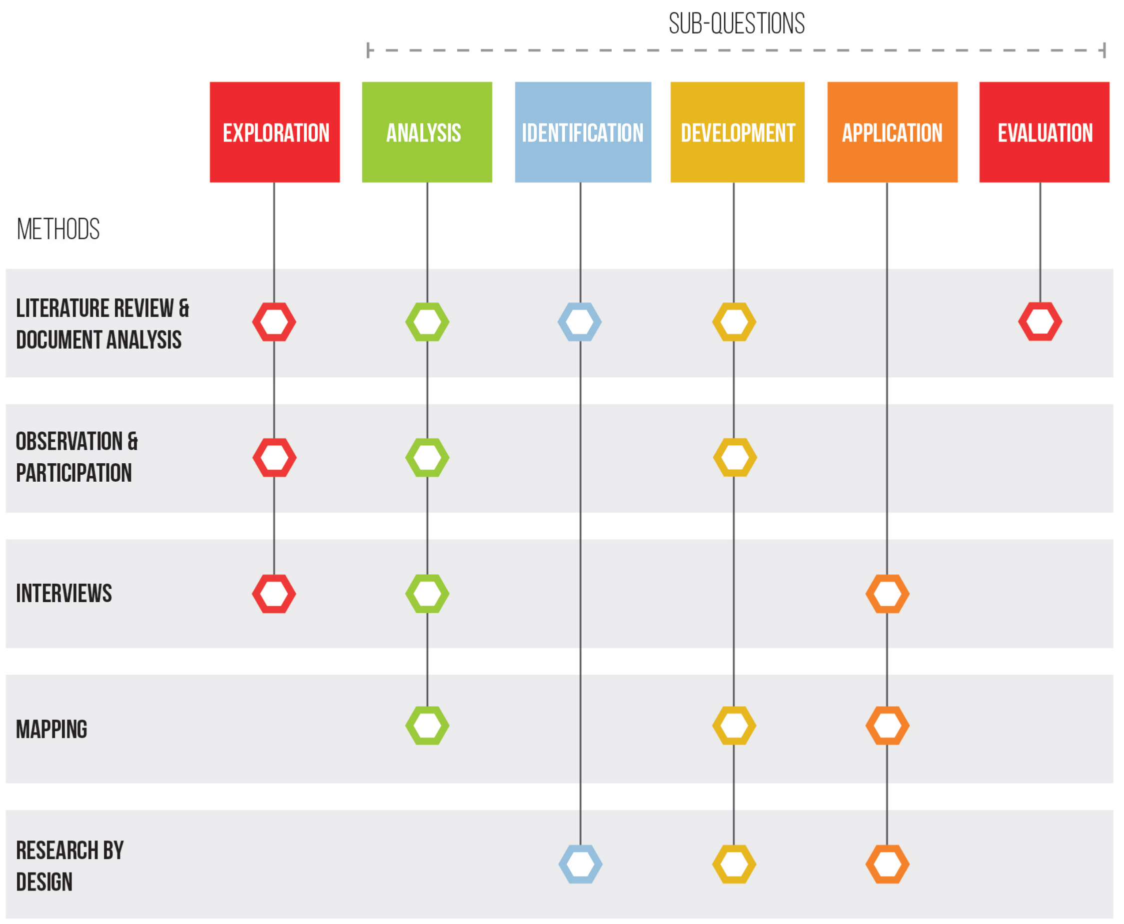


Figure 13.3. Research Methods.

13.2.2 Project Relevance

Societal Relevance
This project tries to contribute to the exploration of approaches which support climate adaptation planning. New urban developments are made to ensure the societal need for more housing, due to the housing shortage and population growth. As densities are getting higher and climate change is getting more intense, the liveability risk and the need for climate resilient neighborhoods increases. Climate adaptation planning is needed to ensure sustainable developments in which the liveability standards are high for the future and far-future inhabitants. If spatial planning fails to act now for climate adaptation, the society is threatened on a social level (more inequality and livability treats), but also on an economic level (losses and damages). This will not only affect the current generation but will also be passed on to future generations. The SAPP approach can stimulate and support climate adaptation planning and thus contribute to climate-resilient living environments.

Scientific Relevance
This project is of scientific relevance, as it tests a new combination (Spatial Adaptive Policy Pathways) of existing adaptive pathway approaches described in academic literature. This research explores the usability of the SAPP approach and contributes to the wide exploration of approaches for climate adaptation planning. The SAPP approach adds a new perspective on the adaptive approaches, by integrating the disciplines urbanism and water management, and by the inclusion of both a design and governance elaboration. Also the context of new urban areas in the Netherlands adds another perspective on the possible use of adaptive pathways. In addition, this project tried to explain and show the (research-by-design) development process of spatial adaptive pathways in more detail, through which the information can be assessed, adapted and used by ohers. The evaluation of the SAPP approach itself is the most important research outcome and gives insights in needed adjustments and future research.

Professional Relevance
This project is of professional relevance, because it addresses the mismatch between current spatial design and planning practice and the climate adaptation task. The project focuses on adaptive design and adaptive planning and advocates a paradigm shift. The SAPP approach can offer a new way of looking at long-term climate adaptation planning and a starting point for discussion and an action perspective. The SAPP approach can, after further development, be used in practice to support the dialogue between actors and to make the link between short-term and long-term decisions. The idea that the Netherlands is finished is already crumbling, but now we have to look for new ways of dealing with the idea that it will never be finished. The SAPP approach could provide support for this, or at least open up the conversation. It could be a step towards the development of new strategies and policy developments for climate adaptation.

13. Conclusion & Reflection

13.2.3 Ethical Considerations

Research
Three core values of the TU Delft, which are relevant to this research, are Integrity, Respect, and Trust (TU Delft, 2020). Integrity means *'being independent, responsible, honest, transparent and sincere for its own sake'* (TU Delft, 2020). Respect entails respecting other people; *'people are never treated merely as means towards the attainment of personal or organisational goal'* (TU Delft, 2020). Trust connects to being transparent, and to protect privacy and confidential information (TU Delft, 2020). In this research, integrity is guaranteed by being independent, by referencing all sources, by protecting (personal) data, and by being honest and transparent about the research process, data, and sources (Integrity). Social science research is part of the methodology in the form of 'observation and participation' (internship at Waternet), and interviews. Both for the internship and the interviews confidentiality and data protection are important (Trust). All interviewees were asked for their informed consent (Respect). This means that information about the project is provided to the participants and that the participants voluntarily take part in the research (in this case the interviewees).

Design
An important idea behind adaptive design and planning is that the area is liveable for the inhabitants of this generation, but also for the inhabitants of the next generations. This is called intergenerational justice and has to do with the fact that next generations will be born in the world this generation will leave behind. Due to the uncertainty and contentiousness of climate change, it is always looking for the balance between what needs to be done now and what needs to be done in the future. Maybe the consequences of climate change are not so severe for this generation, hampering the urge for working on climate adaptation. However, the future generations should also be considered, as they will most likely be confronted with even more severe climate changes. If this generation does not adapt in time, future generations will bear the consequences. And that would be ethically wrong.

Practice
Climate adaptation touches upon the notion of environmental justice. Environmental justice can be defined as: *'the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies'* (EPA, n.d.). To achieve this, everyone should get the same degree of protection from environmental and health hazards (distributive justice). A second condition to achieve environmental justice, is the inclusiveness of everyone in the decision-making process about their environments (procedural justice) (EPA, n.d.). Distributive justice can be quite hard to achieve as local conditions and climate change effects can differ greatly from place to place. Some areas, such as deep polders, potentially need more investments for climate adaptation than areas on high grounds. And even with endless investments, some areas will always be less climate resilient than others. The SAPP approach will not contribute to a solution for this problem. The SAPP approach could however potentially contribute to procedural justice. If spatial planning and water management become more adaptive, plans will also become less fixed. The SAPP map and spatial elaborations can then be used as a means of communication to inhabitants and private actors. Another important consideration comes with the implementation of climate adaptation. It is the question of responsibility. At this point, public actors still carry a big part of the responsibility, but it is unsure if their capacity is enough to keep up with the fast-changing climate. More and more attention is given to the importance of including inhabitants and private actors in climate change adaptation. But if some of the responsibility is shifted to inhabitants or private actors, it should be considered if these people are also capable to carry this responsibility. And if responsibility is given to for instance inhabitants, this will probably not be the same amount of responsibility for each inhabitant. Can we expect the inhabitants of vulnerable areas to carry more responsibility than inhabitants of safe areas?

13.2.4 Relation between Research and Design

In this project, research and design have been closely intertwined. In this case, the design includes both the design of the SAPP approach (framework) and the design for the Haven-Stad case study. First, the goal, climate change adaptation in urban developments, asks for an integrated approach of research and design. Research is needed to assess the effects of climate change and to explore working adaptation measures. Design is needed to explore possible futures and to implement climate adaptation in a physical situation. Research-by-design was the most important method used in this research. During the design of the Spatial Adaptive Policy Pathways, research and design were constantly connected. In the beginning, the focus was strongly on the design of the approach and mainly conceptual designs were made to test the approach. For the case study, mainly exploratory designs were made using the design layers. When the approach took more shape, the designs for Haven-Stad also became more concrete. Research, such as analysis, showed what the spatial and technical boundary conditions of the site were. With this information a design was made for the pathways. During this design process, new questions came up, which were needed to make the pathways (better). Research is used to find the answers to these questions, which are again the input for a second design. In this way, research and design were constantly interfering in an iterative research-and-design loop.

13.2.5 Integration of Urbanism & Water Management

This project integrated the disciplines of Water Management and Urbanism. For climate adaptation, this integration is crucial. Climate adaptation lies exactly in between the disciplines. It is strongly related to water management because water is often part of the problem and the solution. But climate adaptation also requires space and therefore spatial design. Due to the long term of climate change and therefore also of adaptation, planning is very important. This concerns spatial planning, but it will have to be increasingly integrated with water planning. Integrated adaptive long-term approaches will be needed. The water managers can contribute the necessary substantive and technical knowledge, and the urbanists can contribute to the research-by-design and planning process. Both sectors will also have to grow towards each other in policy. In this project, the sectors came together very naturally, even to the point where I would find it difficult to distinguish what belongs to what. And that shouldn't be a problem; it just shows that these sectors belong together.

13. Conclusion & Reflection

13.2.6 Relation to the Master Tracks & Studio

Master Civil Engineering
Track Water Management
This project connects to the Water Management track in several ways. First of all, by the focus on water. For climate adaptation, water is very important, as it is both the source of problems (floodings due to heavy rain, droughts due to a lack of rain), and the way to the solutions. Knowledge gained about the delta, the urban water cycle and climate change (effects) supported the design and research. In addition, the definition of the x-as and tipping points were mainly be guided by the Water Management section. The project also connects to the track via through a (water) governance viewpoint. The project did not only focus on what is needed, but also on how (with whom) it can be achieved in practice.

Master Architecture, Urbanism and Building Sciences
Track Urbanism
The project is also embedded in the track Urbanism, which inherently connects it to spatial design and planning. Methods learned in the urbanism track greatly defined the research approach, such as thorough analysis, research-by-design, evidence-base design, and working through the scales. For the project, both the research into the problem, as the design of a solution (in this case an approach) are important aspects. The aim of the SAPP approach is to support design and planning of urban areas which guarantee the liveability of urban areas over time (and climate change). Another important aspect of the project is that it is future-oriented, which also connects to the Urbanism track; urban design and planning are always very future-oriented. In this research I learned more about this future perspective and about handling uncertainties. I think it would be very interesting to put more emphasis on uncertainties, flexibility, and adaptive design and -planning in the track. The cities are continuously changing, which makes the work of an urbanist challenging, but also extra interesting.

Urbanism Studio - Urban Metabolism & Climate
The research took place within the Urbanism studio Urban Metabolism & Climate. In the base it connects to the studio by the challenge to be tackled: Climate change. Both the studio and the project focus on the urban metabolism, and how it can be designed to adapt to current and future climate changes. Flows and systems thinking are important perspectives that are used in the studio and the project. The project also fits the studio through the methods used, by making the combination of analysis, design, and engineering.

13.2.7 The Project & the Pandemic

The project is fully carried out during the Corona pandemic. This has influenced the research in a couple of ways. There were a lot less possibilities than normal to meet fellow students and to discuss each other's work. It made it harder to get out of my own bubble and perspectives. What really helped were the online meetings at Waternet and the webinars, that provided me with new insights each time. Also the sessions of the Delta Futures Lab and the Water Management colloquia contributed to this. Online meetings with fellow urbanism students also made it possible to discuss my work. However, it was a lot harder to explain and discuss designs without pen and paper. Working from home and mainly on the computer made the process more monotonous, but it also offered chances. A lot of meetings and webinars would have been missed if they were not online and it was easier to combine own work, meetings from Waternet, and meetings with the mentors.

Figure 13.4 shows a drawing that emerged during the pandemic. It addresses the bigger challenges, including climate change, which the world will face after the pandemic. It is (justified!) criticism of the current governments that do not (dare to) look far enough into the future. It shows reactive behaviour, we swim us out of the Corona-flood. However, swimming will not save the world from climate change. This bigger challenge asks for pro-active behaviour, the building of boats. Another problem of the reactive behaviour is that is it very strongly focused on one theme. In this case we are now fighting Corona and seem to forget the other challenges. Even after the latest IPCC publication, 'a code red for humanity' according to the UN Secretary-General (United Nations, 2021), and even after flooding in Limburg, not much response came from the politics in the Netherlands. But to end on a positive note: the pandemic has also shown that we as humans are still capable of change, capable to adapt.

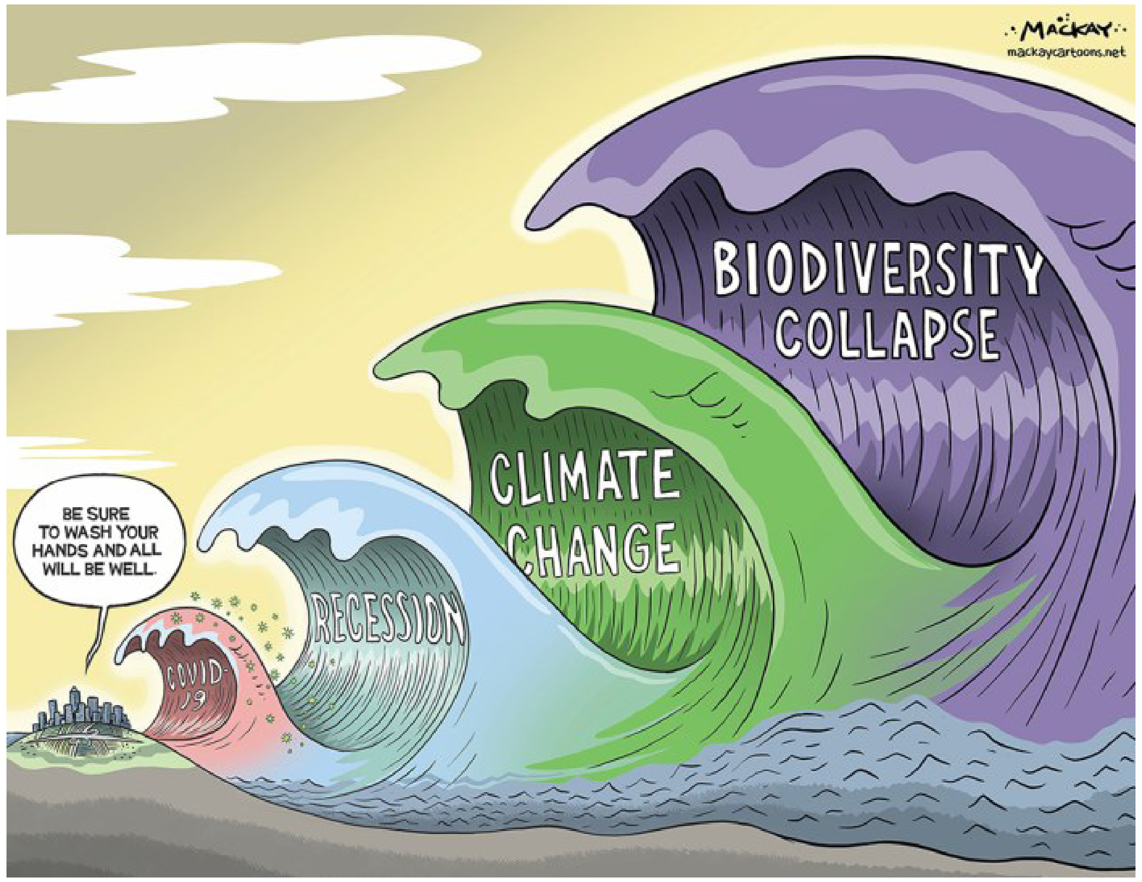


Figure 13.4. 4 Waves cartoon. Reprinted from "MacKay Cartoons", by MacKay, G., 2020 (https://mackaycartoons.net/2020/03/18/wednesday-march-11-2020/). Copyright by MacKay 2020.

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