ADAPT ME FOR TOMORROW

Towards urban resilience and rainwater adaptation in The Hague by 2050
through public space design

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P5 report
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Colofon

Adapt me for tomorrow:
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Master Thesis P5 Report
MSc. Architecture, Urbanism and the Building Sciences

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"Humans cannot live, nor live in security, unless they assume that the active struggle between earth and water is over, or at least contained."

— Gilles Deleuze

ABSTRACT

The phenomena of climate change interacts with the complexity of urban system, which reflect sptially on the process of urbanization. One of the effects of climate change is an increased flooding hazards, and when floods occur this has a severe impact on human lives and comes with vast economic losses. The city of The Hague aims to achieve the goal of becoming a resilient city in 2050. However, the city is under the threat of extreme precipitation and the challenge of urbanization, which affect the liveability in the city. As an important component of achieving resilience, rainproof adaptation can be transformed as an opportunity.

By taking the complexity of the social and enviromental vulnerabilities into the consideration, the project discusses the possibility of linking the water management process with the public space design to develop a conversation of the techinical, spatial and social process.

The focus of the graduation project is how precipitation flood management can collaborate with public space design to become an opportunity for achieving urban resilience. Taking the case of The Hague, the Netherlands, the project proposes a re-defination of urban development process through public space design with techinical water management approach.

Key words: urban resilience, rainwater flood management, public space design

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Chapter

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PREFACE

Introduction & Executive summary

Figure 1: Dunes in The Hague (Source: photo taken by author, 2019)

Urban areas of the world are witnessing many simultaneous trends, namely the growing number of population (Hammond et al. 2015); increased urban sprawl; climate change and the extreme weather patterns brought by it.

The North Sea region is a major economic entity within Europe and a very busy marine area with respect to human activities. The North Sea plays a key role in one of the world's major economic regions, it is a place for settlement and commerce for millions of people and thus parts of its coastal area are densely populated. As the coastal areas provide many resources and trading opportunities, it also expose residents to various hazards.

As a country in the North Sea region which has been constantly protecting itself from the risk of flooding, the Netherlands will be threated by the water issues brought by the climate change, such as more extreme precipitation and rising sea levels. Like the rest of the western Netherlands, The Hague is particularly sensitive to the effects of climate change due to its low location, subsidence and high degree of urbanization.

Therefore, urgency and necessity to adapt The Hague to the changing climate is increasing. The city is also growing, with approximately 15,000 additional homes expected within the existing city limits until 2050. This means that the pressure on the available space will increase. This creates a tension, because space for water and greenery is important in making the city climate adaptive.

Therefore, this project aims to explore the possibility of linking climate adaptation approaches with public space design. By analysing the possibilities and vulnerabilities and taking the goal of achieving resilience by 2050, a development vision, a set of spatial strategies and designs, this project provides pathways for an liveable, resilient future for The Hague in 2050.

Motivation

Figure 2: Transitional territories studio field trip (Source: Transitional Territorties studio, 2019)

"Our cities must be places where human beings lead fulfilling lives in dignity, good health, safety, happiness and hope." In 1996, UN Commission on Human Settlements released Istanbul Declaration on Human Settlements, in which this sentence was written. It sticks in my mind as I am fascinated by the process of how urban planners develop spaces in cities, and how spaces alter the lives of their inhabitants.

I am passionate about urban design with a strong sense of social responsibility and the aspiration to make people's life better. For me, making places for people to experience is much more important than making forms for their own sakes.

In recent years, the risk of climate change has gripped the European Union. The rapid hazards caused by cliamte change are challenging the livelihood of human-beings and bringing new challenges to the urban areas as the carrier of human economic and social activities.

This research is a result of an interest in the spatial consequence of climate change and the its reflection on socio-cultural-ecological systems.

Chapter

2

PROBLEM FIELD

Coastal regions in the global context: Hotspot of urbanization and economy development

Historically cities have been located along the coastlines due to the benefits of rich resources, which is particularly their supply of subsistence resources, and location, which provides logistical advantage for possible access points to marine trade and transport or their special sense of place at the interface between land and sea proivdes opportunities of development for recreational or cultural activities.

This has set a precedence for populations to naturally migrate towards coastal areas, which results that coastal areas is significantly more densed than non-coastal areas (Barbara Neumann et al., 2015), and there is an ongoing trend of coastal migration, which is associated with global demographic changes (Hugo G., 2011).

Coastal population growth and urbanization rates are outstripping the demographic development of the hinterland, driven by rapid economic growth and coastward migration. According to a recent analysis by CIESIN,over

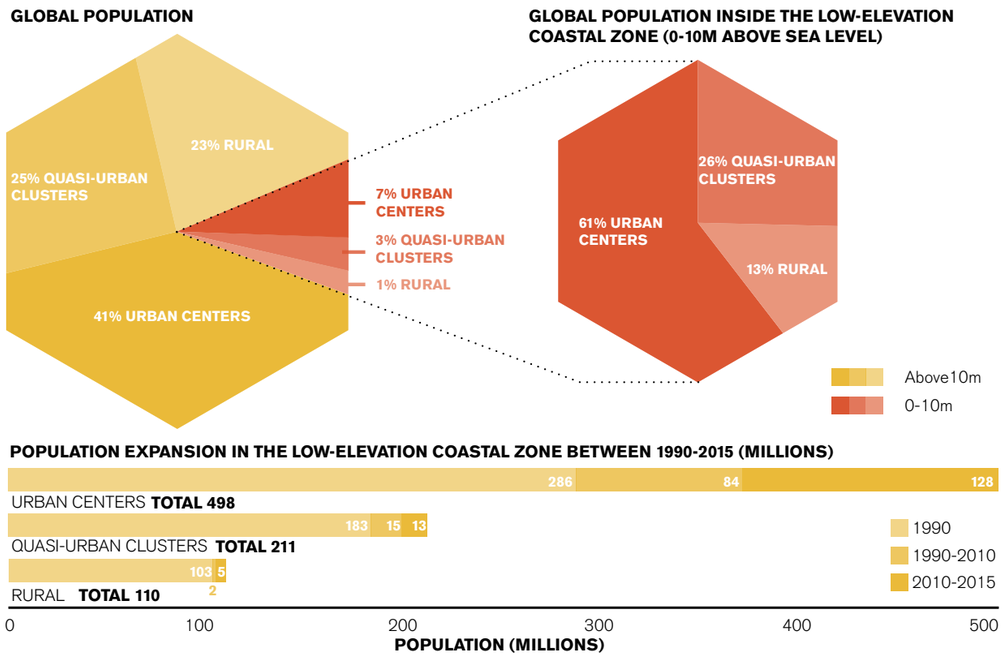


Figure 3: Share of global population outside and inside the low elevation coastal zone, by settlement type
(made by author, adapted from CIESIN, 2015)

10% of the world's population – over 820 million people – lived within 10 metres above sea level in 2015, and 86% of those people lived in urban centres or quasi-urban clusters (which have lower densities than urban centres, and could include peri-urban or suburban areas). Nearly 10% of the land in this low-lying coastal zone is already urban or quasi-urban, compared with less than 2% elsewhere (see Figure 3), which contributes to the fact that coastal population densities are six times higher than the world average (309 versus 56 people per square kilometer). Nowadays, urban areas, like urban residents, are disproportionately located in low-elevation coastal areas. Although just 2 percent of the world's total land is urban, almost 10 percent of coastal land lower than 10 meters above sea level is already urbanized or quasi-urbanized. To this end, 13 percent of the world's total urban land mass is located in low-elevation coastal zones (the Global Human Settlement Layer, 2019).

The North Sea Region context: Crisis in the territories of coastal cities

While the coastal cities are hotspots of urban development, they are also hotspots of vulnerability and crisis, due to their concentration of people, assets and economic activity.

Coastal areas less than 10 metres above sea level are more densely populated than the rest of the world, and growing faster. Since 1990, the growth rates in urban centres are about 20% higher in these areas than elsewhere. Moreover, growth rates in urban centers are highest in the lowest-lying areas where are less than 5 meters above sea level (Colation for urban transitions, 2019). Most of these settlements have developed with little regard for coastal environmental sensitivities, and almost no regard for growing climate risks. This means that storm surges and sea-level rise are now overwhelmingly urban threats.

Most critically, many cities will face multiple climate hazards that interact and reinforce one another, making adaptation still harder. Both urban disasters and fragile ecosystems occur disproportionately in low-lying coastal areas. Floods and saltwater intrusion pose a hazard to coastal populations and infrastructure. Urban development can both exacerbate natural disasters and add environmental pressures. Impervious surfaces such as asphalt and concrete disrupt natural drainage, increasing peak flows and flood risks. Without further action on climate change, sea levels may rise by several metres by the end of the century. This will threaten the very existence of low-lying cities.

As a major economic entity within Europe and a very busy marine area with respect to human activities, the North Sea Region plays a key role in one of the world's major economic regions, it is a place for settlement and commerce for millions of people and thus parts of its coastal area are densely populated.

However, for the North Sea Region, the effects of climate change – more damaging storms, floods and drought – are hard to predict. With so many low-lying areas, the hazards brought by the changing climate could cripple the region's economy and put many lives at risk.

Therefore, the threats and the crisis underscore the importance of pursuing mitigation, adaptation and development simultaneously.

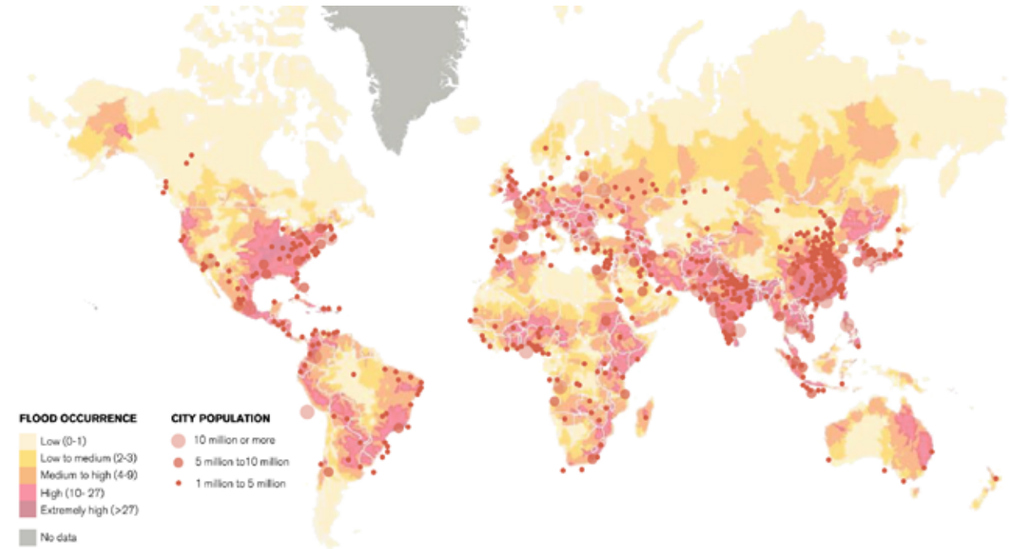


Figure 4: Crisis on coastal territories, made by author
(Data source: United Nations World Urbanization Prospects, 2014; G.R. Brakenridge, 2011)

Population growth, urbanization and crisis of representation

As mentioned above, the attractive location conditions and development prospects of coastal areas continue to attract people from urban inland areas to the coastline. The changes in population lead to other changes in land use, economic activity and culture.

This change has brought opportunities for investment in urban areas, in the meanwhile, it is also challenging the cities to desify for accomdating the increasing population. As a coastal area of developed countries, the population increase combined with a de mand for more houses may also result in competition for urban green infrastructure in the urban area.

This competition may pose the cities to greater challenge. On the one hand, the increasing impermeable surface and the shirking areas of greenery in the city may block the natural water cycle in urban areas. This process will put more stress on the water drainage system and result water run-off that will affect the security of residents. In the face of the challenges posed by climate change, risks are not evenly distributed among different communities, which will cause the inequality and position vulnerable groups to greater vulnerabilities. On the other hand, the decreasing greenery in the city will affect the liveability in the cities and cause segregation among communities.

Under the challenge of urbanization, the city need to be prepared to provide its residents with a safe, pleasant and equal living environment. Therefore, effective ways to integrate newcomers into our society area required.

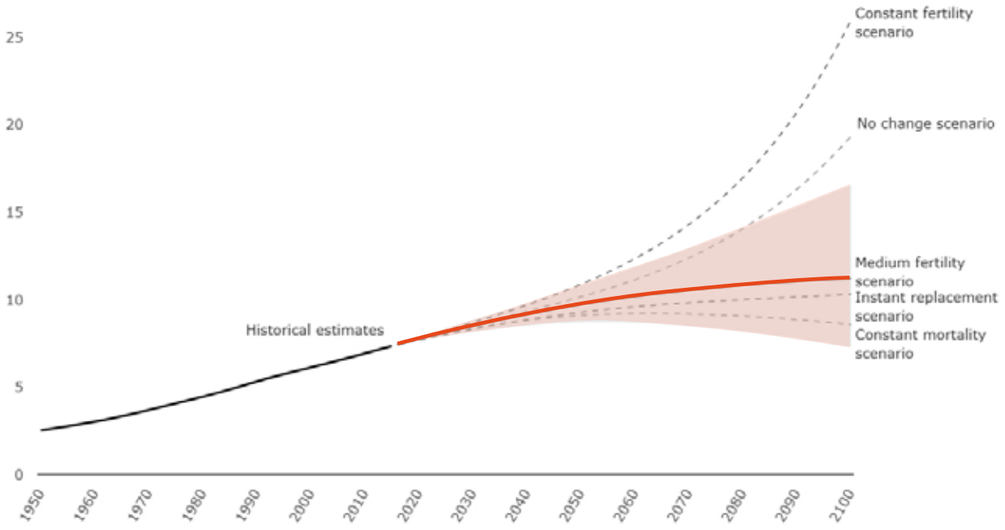
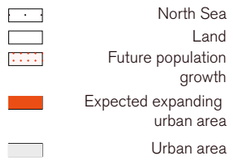


Figure 5: Historical and projected global population (made by author, adapted from UN world population prospects: The 2015 revision)

Population growth and urbanization in North Sea region

The most densely populated regions lie in the lowlands, which are typified by delta areas and polders. Besides, the most population growth is expected to happen along the coastline.



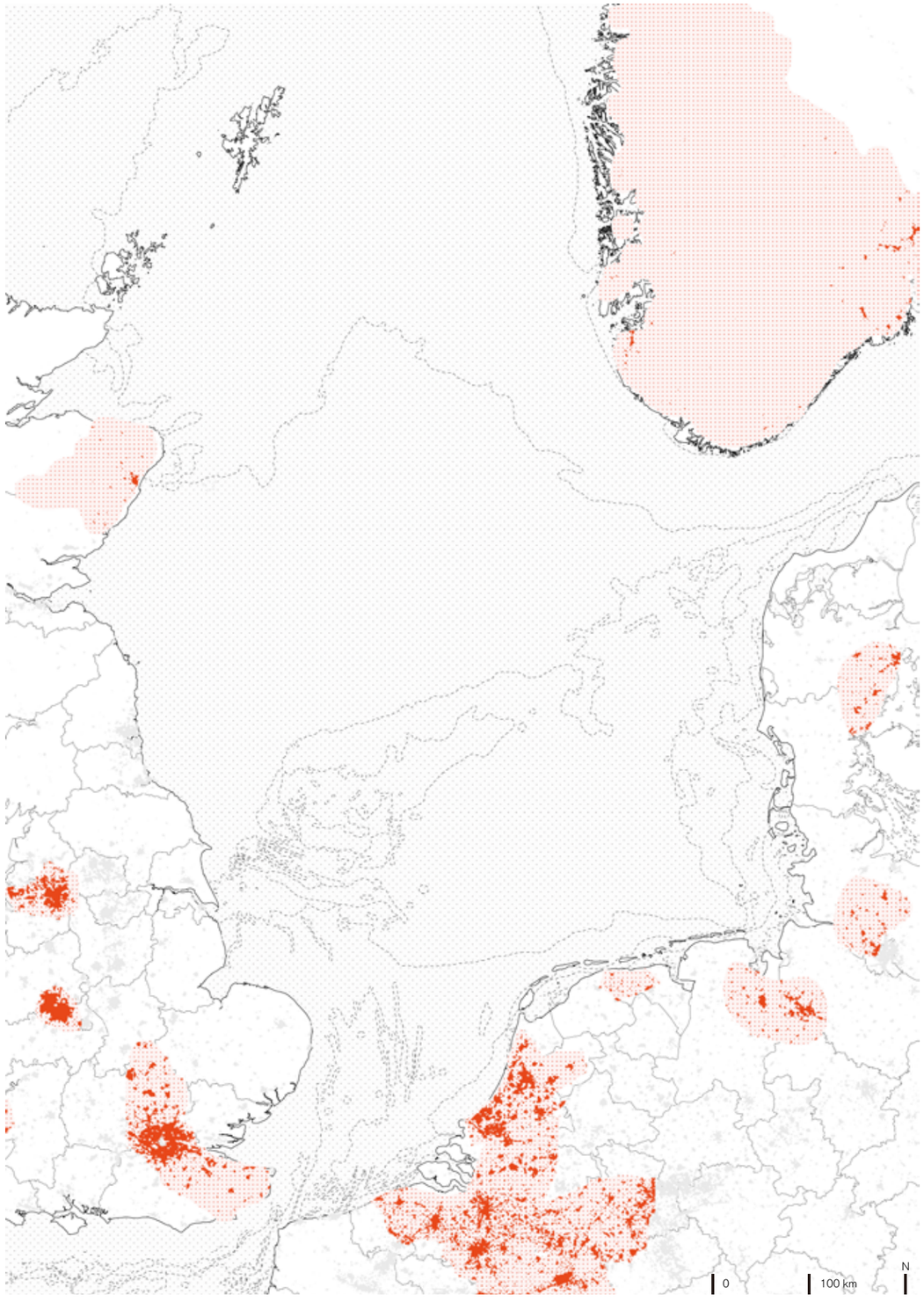


Figure 6: Population growth and urbanization trend 2050 (made by author, data source: TT studio group work, 2017)

Climate crisis and water-related issues

Climate change is defining crisis of our time. The Fifth assessment report by the Intergovernmental Panel on Climate Change (IPCC) predicts a definite average rise of 1.5 degrees Celsius above pre-industrial levels by mid-21st century (IPCC, 2018).

Rising temperatures are fueling environmental degradation, which lead to more extreme and frequent climate events (IPCC,2013). The change of climate patterns manifests itself primarily through water-related issues by means of sea level rise and change of water cycle (United Nations, 2020). Water-related issues affect territorial security in multiple directions. On the one hand, by taking the future scenario described by the IPCC (IPCC, 2014, 2018) RCP 8.5 by 2100, the southern coasts in the North Sea region will be under the threat of inunderation. On the other hand, the likelihood and effects of extreme precipitation are increasing and causing flooding in urban areas.

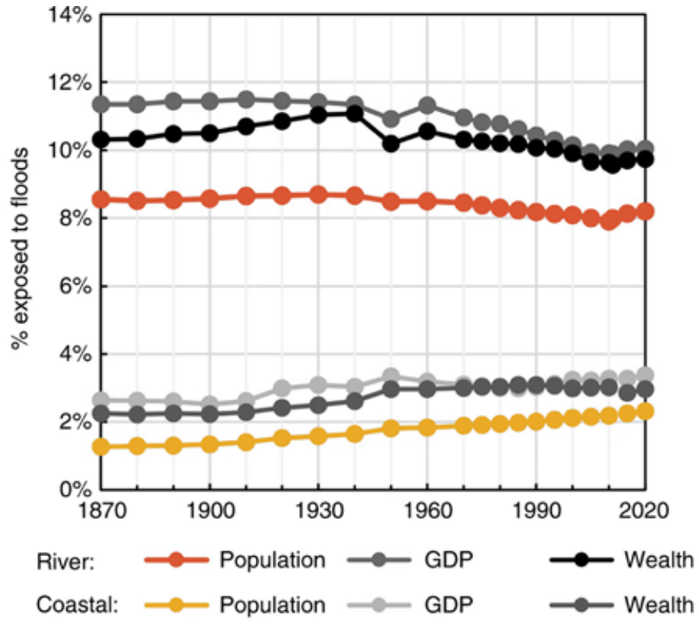
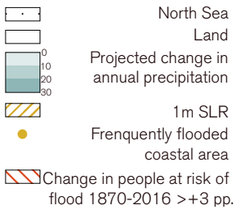


Figure 7: Trends in flood exposure. Percent of the population exposed to the 100-year river and coastal flood in Europe (made by author, adapted from Dominik Paprotny, 2018)

Water-related effects in North Sea region

If the defence infrastructure fails, the sea level rise of 1 meter will flood most of the southern low and subsiding coast of the North Sea region.



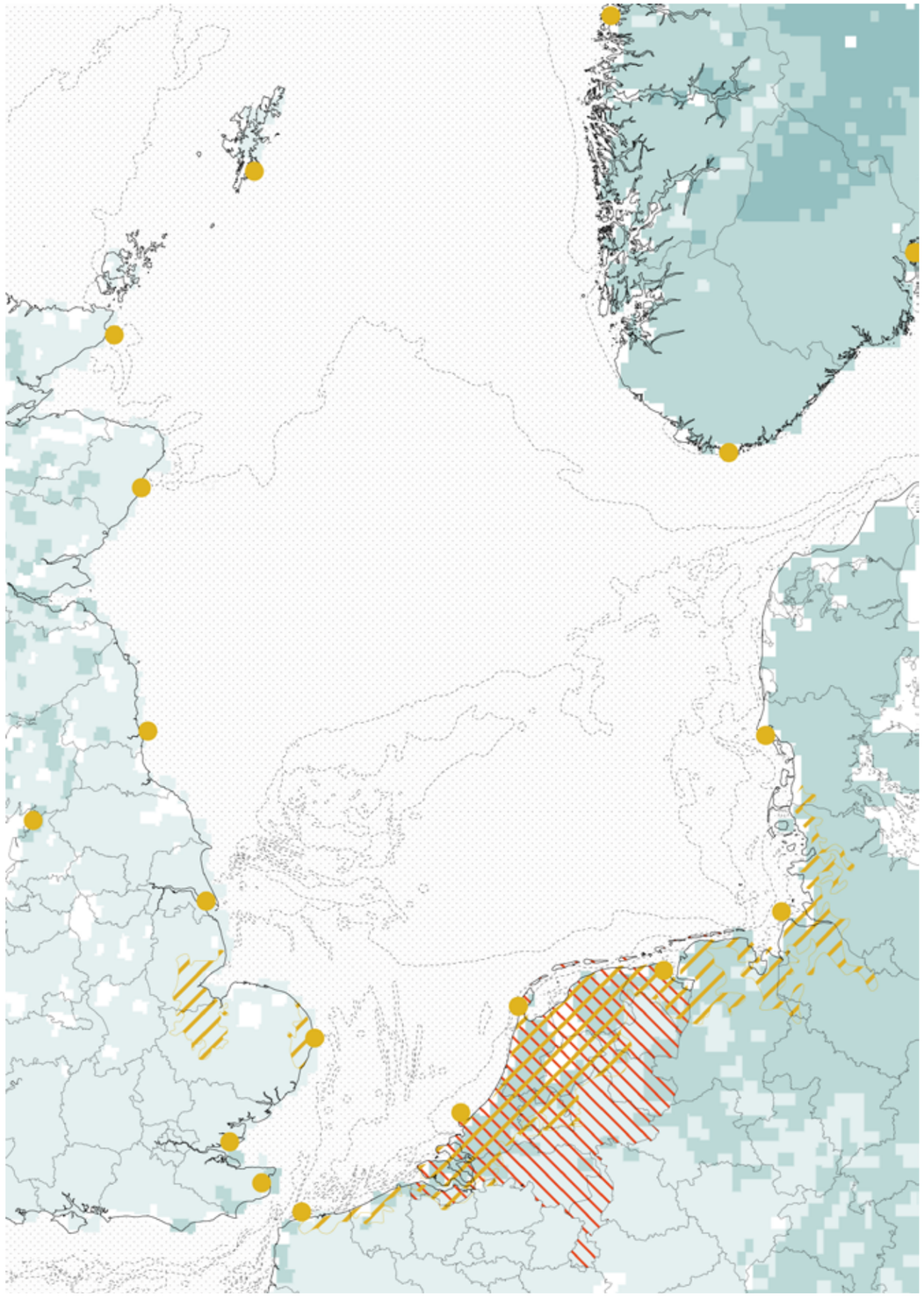


Figure 8: Water related issues (made by author, data source: TT studio group work, 2019)

Metropoolregio Rotterdam Den Haag context: Vulnerable coastal region

By overlapping the selected threats on territories, it helps to determine which areas are most susceptible to the projected conditions. Within the most affected areas, the coastal region of the Netherlands, with Rotterdam-The Hague Metropolis (MRDH) as one of the most urgent locations to look into.

The Rotterdam- The Hague metropolitan area is a metropolitan area encompassing the cities of Rotterdam and The Hague as well as 21 other municipalities. The main reason for the cooperation of these municipalities is for promoting the economy. With 2.3 million inhabitants, the largest European port and many international organizations reside within its borders, this area plays an important role in the socio-economic aspect in both the Netherlands and the North Sea Region.

As other costal regions, MRDH faces the rapid urbanization therefore it's under the stress of accomdating more residents in the limited space. On the other hand, it's also threatened by water-related hazards from multiple directions. However, as a country which is orginally more dependent on water mangement for ensuring the security, the Netherlands has been working on building a robust coastal defence to prevent the sea-level rise. Therefore, the biggest water-related threat is the unpredictable extreme precipitation events.

Figure 9: Rotterdam- The Hague Metropolis (made by author, data source: Mapbox)

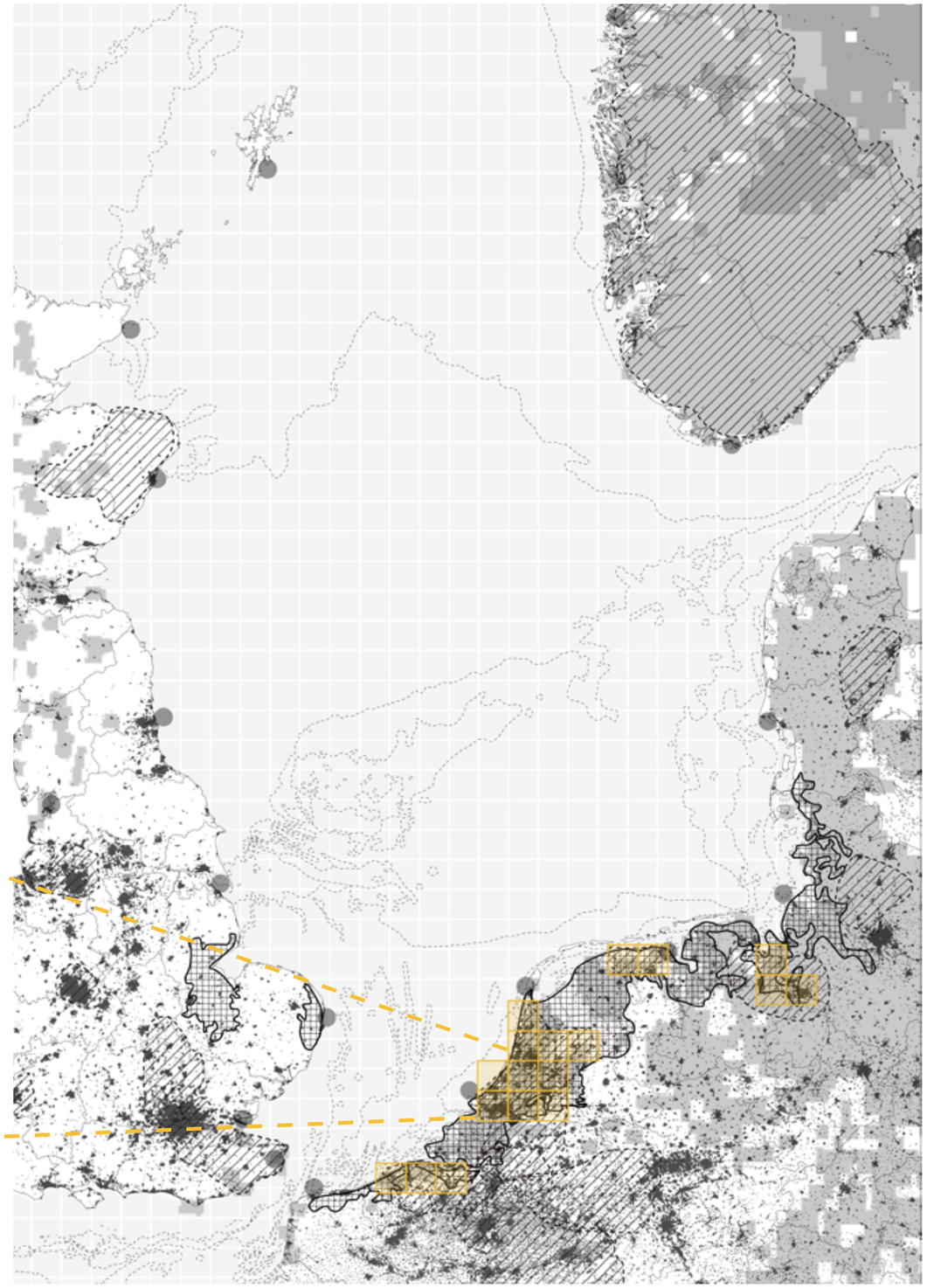


Figure 10: Vulnerable areas in the North Sea Region (made by author)

The Hague context:
A unique coastal city in Metropoolregio Rotterdam Den Haag

With the threat from climate change and urbanization, it is important to protect the important clusters in MRDH.

There are two major nodes in MRDH— Rotterdam and The Hague where the important international and interregional rail connections are located, while they play different roles in the region (See figure 11).

As a city which is closely linked with water, Rotterdam plays an important economic role, as it can provide attractive loctions for the development of industry and logistic areas.

As a coastal city boasting natural beauty, The Hague is also a place with rich culture and social diversity (The Hague Resilience Strategy, 2019). As a political center and one of the and metropolitan centers, but also attraction clusters which are the heritages in the city center. What's more, the dunes along the coastline also play the role of metropolitan recreational areas. Therefore, The Hague plays an important role of socio-cultural functions.

In the meanwhile, the dynamics of the major water system (rivers and sea) and the regional water system have been vital for the reclamation and urbanization of Dutch territory. The water structure played an important role of shaping the cities in The Netherlands. Rotterdam and The Hague can represent two different typologies: river town and coastal town.

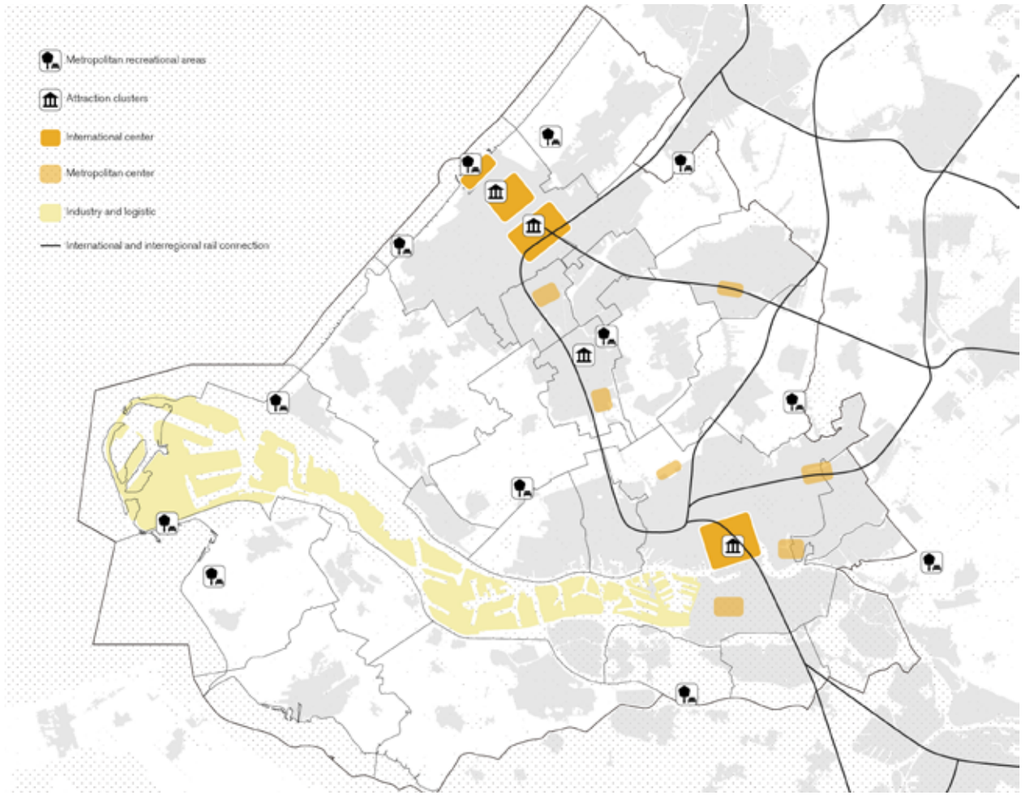


Figure 11: Economic core areas & Recreational crowd pullers in MRDH (made by author, adapted from Verveorsautoriteit Metropoolregio Rotterdam Den Haag, 2013)

The foundation of the built of the two cities are originally different —The Hague is a city built along the oringal aorta of Holland over the dunes, while Rotterdam is built at the convergence of roads and waterways (Hooimeijer et al., 2005).

The different water structure also contributes to the different urban functions.

As a river town, with more outer water allowed into the town and the urban waters found a new role for business locations, Rotterdam gradually develops as a harbour city.

As a coastal city, The Hague is built in the shelter of the dunes, although it's built further from the coast, the evidence of the sand ridges can still be found in its urban pattern (Hooimeijer et al., 2007). The dunes not only play the role of protecting the city, but also provides recreational functions. Therefore, the city of The Hauge is well-known as a beach city, with tourism function in Scheveningen.

As a river city, the city of Rotterdam is more closely linked to the water, therefore, the city is built with robust defense system to protect the safety of the city (Rotterdam climate change strategy, 2013).

For The Hague, the infrastructure which is invested the most in the city is for withstanding unruly weather. The city might be more vulnerable when it is faced with unpredictable precipitation events as the conditions are more extreme and prolonged (The Hague Resilience Strategy, 2019).

Therefore, with its uniqueness of urban typology and function, The Hague is an important area to look into in MRDH.

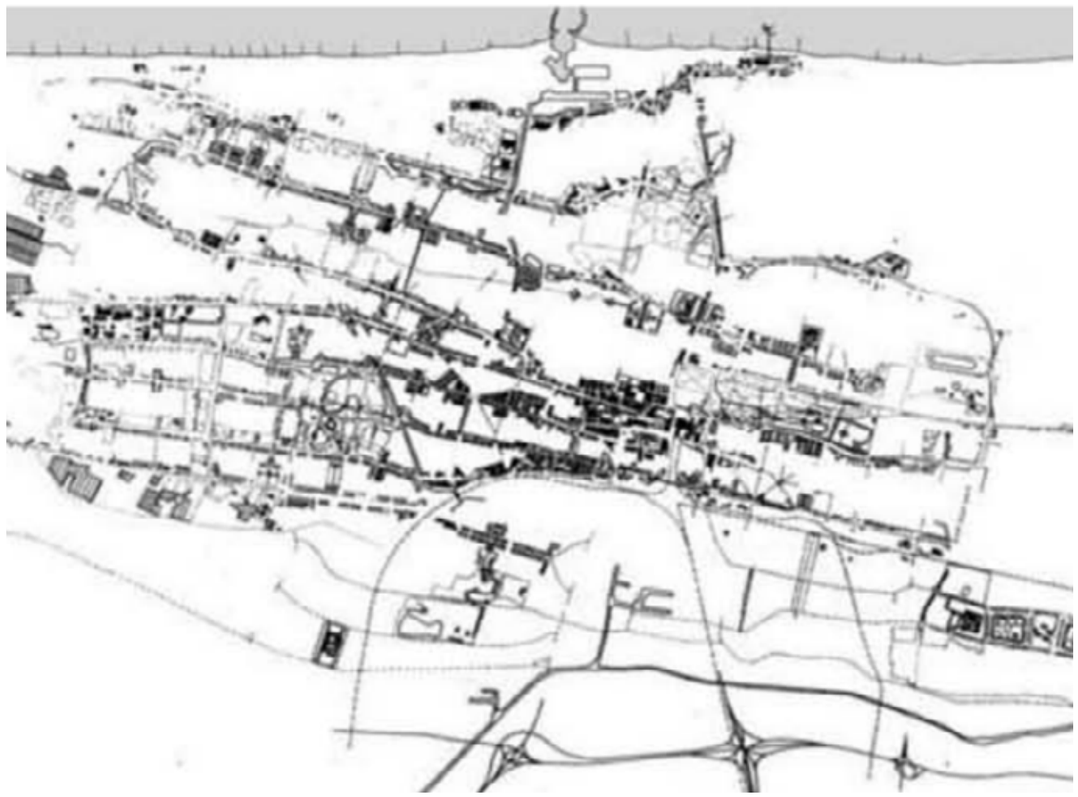


Figure 12: Coastal town on sand ridges The Hauge (Hooimeijer et al., 2005)

Chapter

3

PROBLEM FOCUS

The Hague context:
A territory with stress

As mentioned in the former chapter, as one of the densely populated coastal area, The Hague is under the risk not only due to the threat to territories due to the unpredictable weather, but also due to the amount of vulnerable groups and areas with socio-cultural importance that might be exposed to the risk.

As the political center of The Netherlands and a historical city, The Hague is a well-developed city. This not only shows the political-cultural importance of the city, but also shows the difficulty of maintaince within the city.

In the meanwhile, the city is faced with another challenge of urbanization due to the population growth. As a densly populated and well built-up urban area, the population of The Hague is still expected to grow about 5000 more each year until 2030. As an international city, the residents share diverse cultural background. Therefore, the city is under the challenge for accomodating the newcomers not only physically but also socially.

a. Urgency of territorial stress and liveability

According to the latest forecast by Statistics Netherlands (CBS), the population of the Netherlands will continue to grow over the next few decades. The population is growing on account of two factors: migrant arrivals exceeding departures, and increasing life expectancy (CBS, 2017).

Among the cities of MRDH, the population growth rate of The Hague is expected to be one of the most.

On the one hand, as a well-developed city, the growing population will put pressure on the urban space for densification. On the other hand, as an international city, the newcomers as immigrants will face the problem of segregation. Therefore, the city of The Hague is also under the pressure of providing a pleasant living environment for all population groups.

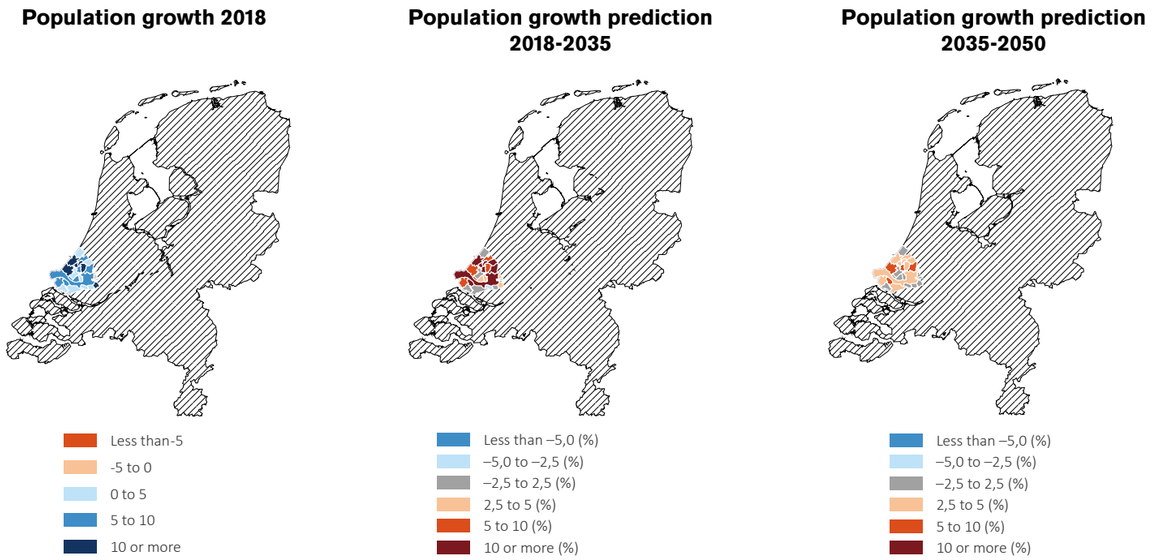


Figure 13: Population growth trend 2018-2050 (made by author, data source: CBS, 2018)

b. Uncertainty of the risk of extreme precipitation

As a result of climate change (increased chance of extreme precipitation) and socio-economic developments (urbanization and economic growth), the likelihood and effects of extreme precipitation are increasing. According to the research of risk of extreme precipitation among the capital cities in the Netherlands, The Hague faces with the most risk in both 2018 and 2050 (Tjerk Krijger, 2018). According to the precipitation index, The Hague has the largest number of buildings affected by extreme precipitation and suffers the greatest economic consequences in the event of pluvial flooding. The index also reveals the main risk – The Hague has a relatively large percentage of paved surface and a high percentage of urbanization.

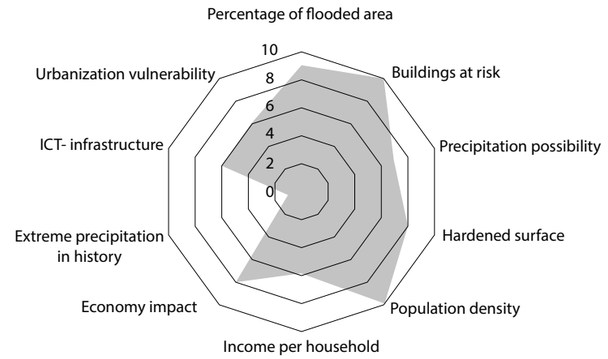


Figure 14: City index of The Hague
(made by author, data source: Tjerk Krijger, 2018)

The Hague

Risk in 2018 (x1 million/ year)	52.7
Risk in 2050 (x1 million/ year)	112

Utrecht

Risk in 2018 (x1 million/ year)	37.3
Risk in 2050 (x1 million/ year)	76.1

Arnhem

Risk in 2018 (x1 million/ year)	26.7
Risk in 2050 (x1 million/ year)	51.4

Maastricht

Risk in 2018 (x1 million/ year)	15.5
Risk in 2050 (x1 million/ year)	29.2

Leeuwarden

Risk in 2018 (x1 million/ year)	12.1
Risk in 2050 (x1 million/ year)	23.1

Den Bosch

Risk in 2018 (x1 million/ year)	10.8
Risk in 2050 (x1 million/ year)	20.8

Zwolle

Risk in 2018 (x1 million/ year)	10.2
Risk in 2050 (x1 million/ year)	19.7

Groningen

Risk in 2018 (x1 million/ year)	10
Risk in 2050 (x1 million/ year)	17.8

Lelystad

Risk in 2018 (x1 million/ year)	8.5
Risk in 2050 (x1 million/ year)	15.7

Haarlem

Risk in 2018 (x1 million/ year)	7.6
Risk in 2050 (x1 million/ year)	15.1

Assen

Risk in 2018 (x1 million/ year)	5.4
Risk in 2050 (x1 million/ year)	10.9

Middelburg

Risk in 2018 (x1 million/ year)	5.3
Risk in 2050 (x1 million/ year)	10

Figure 15: Extreme rainfall risk of capitals in 2018 and 2050 (made by author, data source: Tjerk Krijger, 2018)

The Hague context:
The making of a typical Dutch city

Looking back to the development history of Dutch polder cities, the urbanization process shares a close relation with the technical approaches and the nature. It can be ordered in six phases: natural (-1000), defensive (1000-1500), offensive (1500-1800), early manipulative (1800-1890), manipulative (1890-1990) and adaptive manipulative water management (1990-) (Fransje Hooimeijer, 2014).

In the first two phases, most settlements started on higher lands, along rivers or the coast and expanded for military or economic reasons (Fransje Hooimeijer, 2014). The coexistance shows how tightly the socio-economic construction, water management and landscape are woven due to the importance of physical geographical and hydrological circumstances.

The next phase is the birth and the foundation of Dutch planning tradition. The intervantion of mill marks the transition towards an Anticipative Phase in the attitude towards nature, and the form of social coherence that is characterized by unity and diversity. In this phase, the development of technology gave more power to the city making process and made it possible to make use of nature, thus sometimes the landscape is altered (Fransje Hooimeijer, 2014).

With the need of housing and urban expansion, the urbanization and water management process come to the manipulative phase. At the beginning of this stage, little attention is paid to soil conditions, water system and the landscape (Fransje Hooimeijer, 2014), therefore, the urban context is completely artificial. The expansion of the layers of the city, such as roads, buildings and urban blocks, is in exchange of the disappearance of water from the city. And the water will only be resurfaced for recreational funcitons. This process is regarded as a negative effect on urbanism. With the consciousness of the importance of landscape and ecology and the impact of the cultivated system on the natural system, the perspective of resurfacing the natural system, the perspective of resurfacing nature in the city is raised up. The intervention of 'urbanized landscape' enhanced the connection between natural system, the landscape, the existing urban structures and the new development. With this approach, the relationship between landscape and urbanization is reconnected and consolidated.

Nowadays, under the pressure of the changes in hydrological and urban system, the current artificial water system can't deal with the increase in rainfall. Therefore, the water layer is regarded as a new spatial layer in urban development and included in the adaptive approach. The awareness of the relationship between urban design and physical geography returns and the cities are searching for an approach to balance between adaptation and manipulation. As a direction of the development of Fine Dutch Tradition, the management approach is to address resilience in the future.increase in rainfall. Therefore, the water layer is regarded as a new spatial layer in urban development and included in the adaptive approach. The awareness of the relationship between urban design and physical geography returns and the cities are searching for an approach to balance between adaptation and manipulation. As a direction of the development of Fine Dutch Tradition, the management approach is to address resilience in the future.

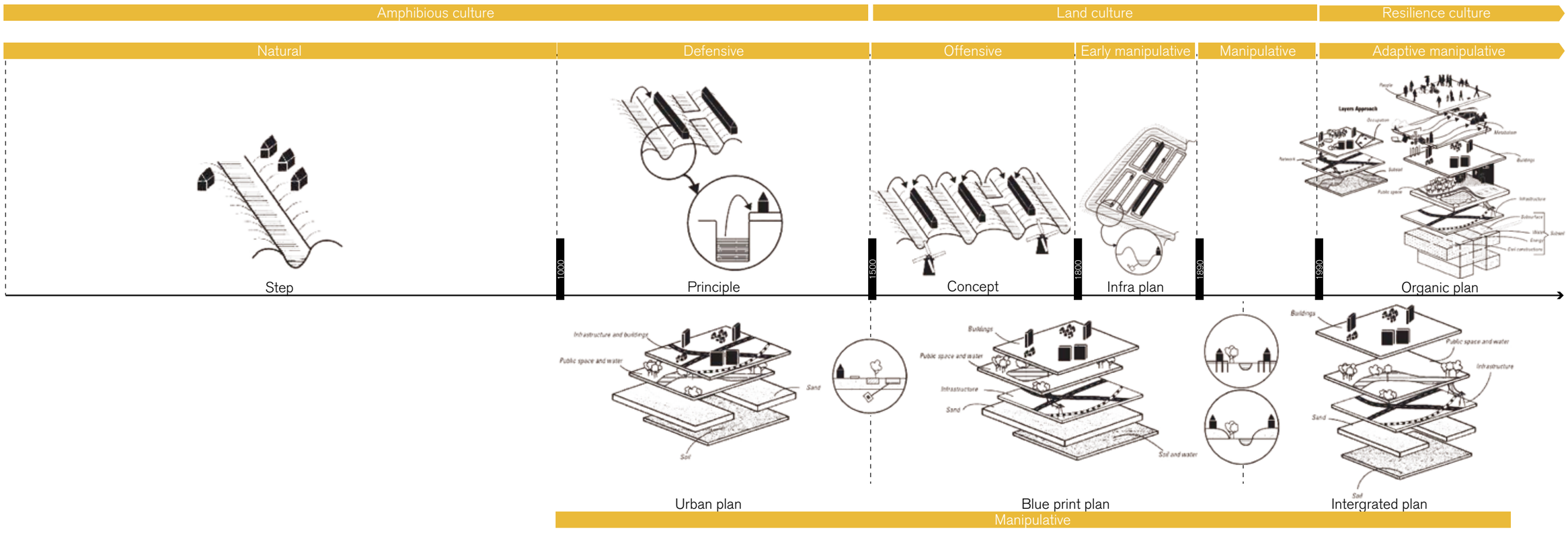


Figure 16: Systematic overview of the making process of Dutch polder cities (made by author, adapted from Fransje Hooimeijer, 2014)

The Hague context:
The making of a typical Dutch city

As a typical Dutch polder city, the six develoment phases can also be applied to the development history of The Hague. The city develops with water and also faces with water challenges.

In the early history of The Hague, as it's largely below the sea level, the development of the city was highly dependent on water management. Thus, the water, the urban development and the inhabitant shared a close interrelathionship. They were never regarded as parellel systems, but were always regarded as an integrated and dynamic system that benefited and affected each other. Polders and dikes were built up due to the need of people to carry out agricultural activities under the challenge of water for living. They prevented the land from being flooded and ensured the effective provision of safe and secure water supplies. In return, they also defined the urban development typology at that time that the residential houses are located near the water for the convenience of farming.

Nowadays, the city mainly rely on the underground drainage system to keep the water security, this also provides the possibility for people to expand their territory and develop cities. With numerous waterways piped and located underground, houses can be constructed far away from the waterways and urban development in floodplain areas can be possible. This development empowered human for managing the land. As a result of urban expansion, the waterways and greeneries in the city became less and less. More and more surfaces are paved and the connection between developed area and the nature is gradually becoming fragmanted. The development of the technique also weakened the consideration of the innerrelationship of climate, spatial and social systems of the urban system. The investment of different problems are taken over by different departments of the municipality. The nature and inhabitants became the victims of fast urban development.

The designed system will reach its limitation and the dependance makes the city vulnerable towards unexpected extreme hazards. And the seperated investments may result the negative effects between each systems and then expose the city to greater vulnerabilities. Learning from the history, the challenges can also be regarded as new opportunity for new form of development and help with intergrating the society. The Hague today is in the fortunate situation that with the investment of building the city resilient by 2050, there's an opportunity that can turn the water and urbanization challenges into opportunities for the city to increase its quality and well-being for its citizens while future proofing the ability of adapting the water challenge.

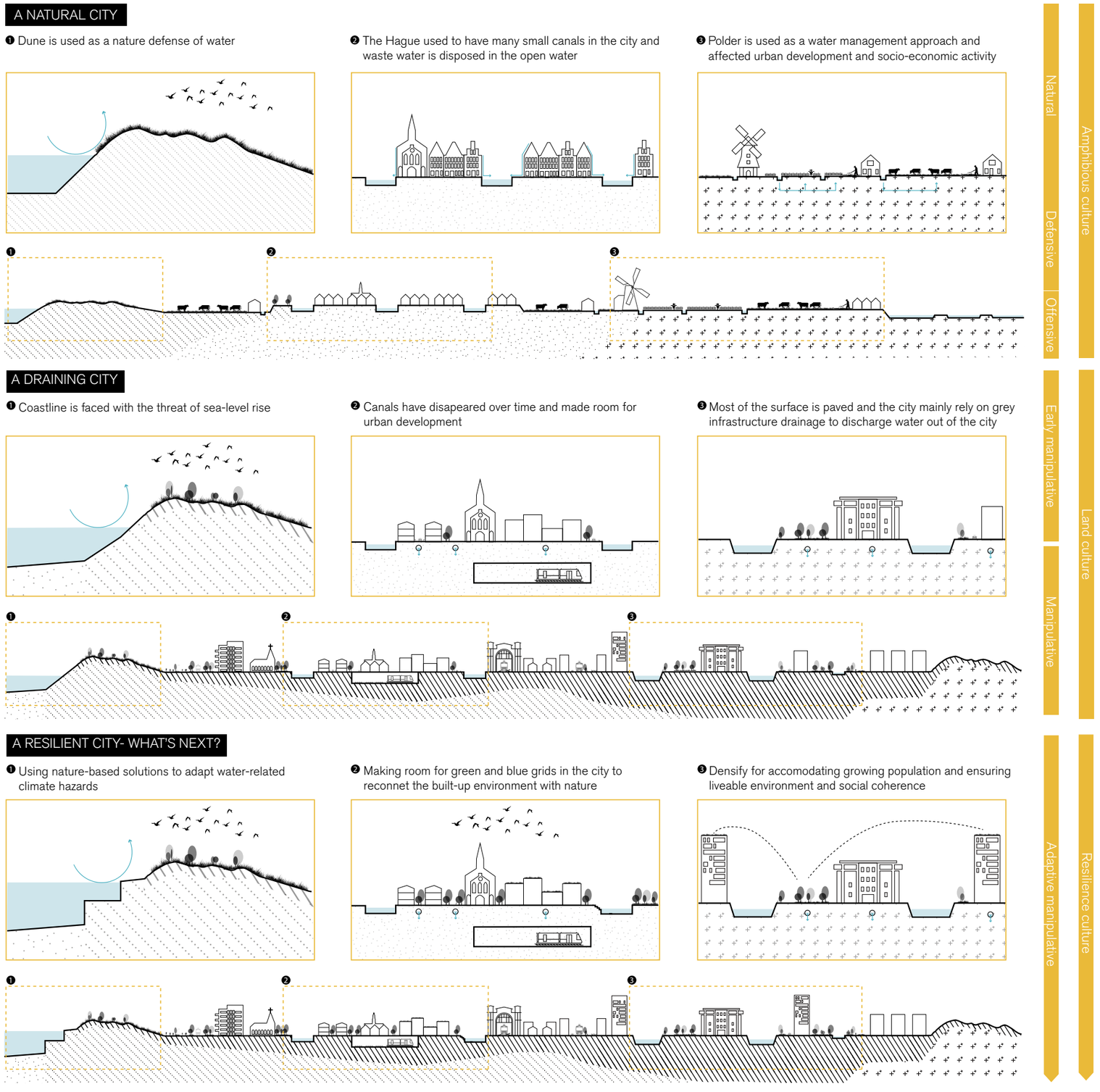


Figure 17: The relationship between water management and urbanization in the development process of The Hague (made by author)

The Hague context:
A city towards resilience

For The Hague, resilience is not only a trend of urban management approach for adapting multiple challenges in the city, but also a goal of the city. Faced with the challenge of rapid urbanization, climate hazards and enhancing social coherance, The Hague participated in the 100 Resilient Cities network (100RC) for adapting and transforming them to new oppoturnities of the city.

This not only requires the city to be able to adapt to future shocks and stresses, but also make it grow and thrive afterwards. According to the 100RC network, the approach that can transform risk to opportunity can be called a 'resilince dividend'. This requires a systematic way of thinking and adaptation approach, which not only solve problems in a multidimensional way but also in a cross-scale way, which meets the research aim of this project and provides an opportunity for the project to collaborate with the development agenda and comfirms the feasibility of the project (The Hague Resilience Strategy, 2019).

The Hague Resilience Strategy takes the entire city to build resilience, without losing sight of the city's population and communities, from working to connect individuals to become more risk prepared; to making neighbourhoods more peaceful; to advancing city-wide policies on procurement; and forging partnerships regionally to understand interdependencies between critical infrastructure (The Hague Resilinece Strategy, 2019). It aims to ensure a connected and inclusive society, get everyone ready for the new economy, adapt to climate change, improve risk awareness and emergency preparedness and collaborate with partners to achieve the resilience in four levels: individual, neighborhood, city and region.

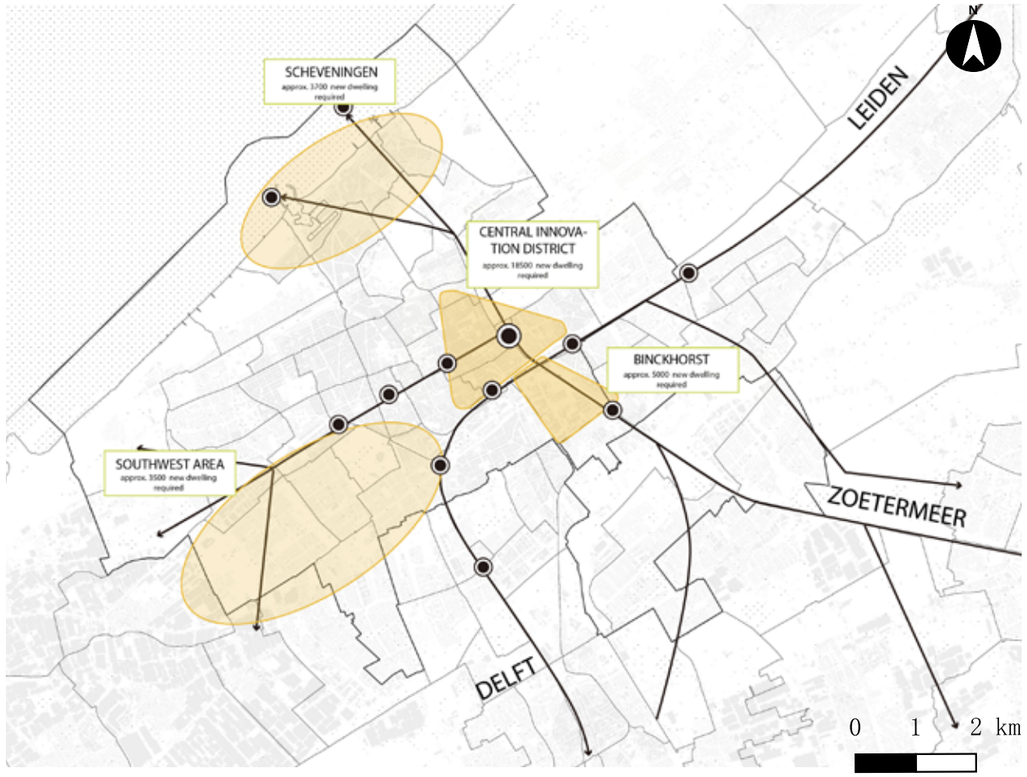


Figure 18: Municipal vision (made by author, adapted from development vision of The Hague Resilience Strategy, 2019)

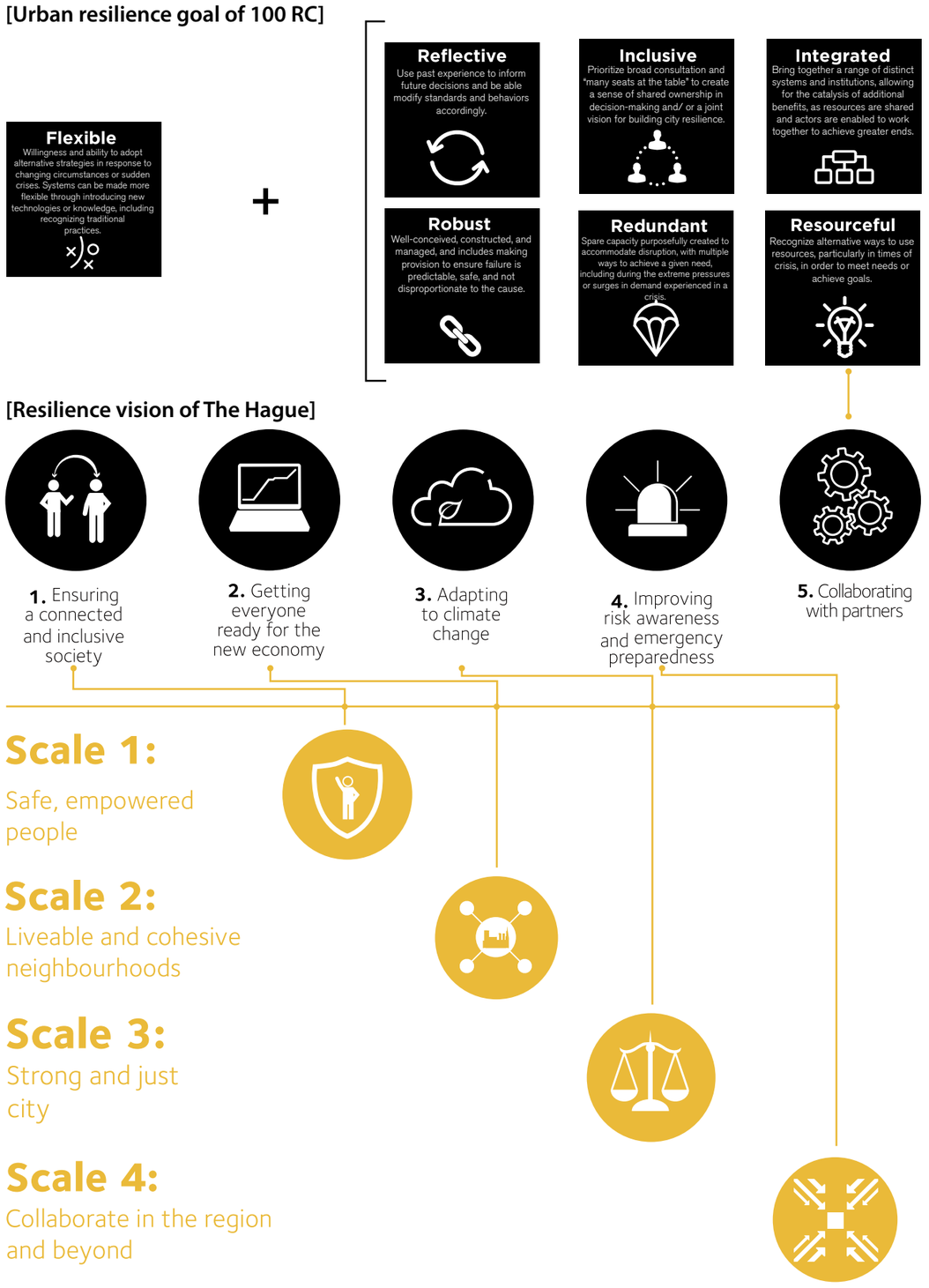


Figure 19: resilience goals (made by author, adapted from resilience vision of The Hague Resilience Strategy)

Problem statement:
The vicious circle

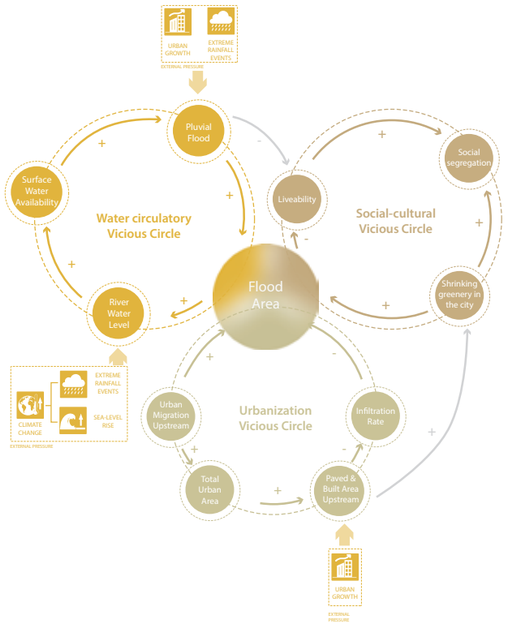


Figure 20: The vicious circle (made by author, 2020)

As stated in the former charpter, the city is faced with multiple challenges at the same time. The diagram depicts the vicious cycles that drive a process of growth of vulnerability of the city as it develops due to the inherent relevance and mutual influence of these challenges.

The vicious circle starts from the expansion of urban areas due to the population growth, which will cause the expansion of the total area of impermeable surface that blocks the natural water cycle process by means of decreasing the infiltration rate, causing higher discharge peaks during extreme precipitation events.

The increasing of total paved area will also result the decreasing of total area of greenery in the city. On the one hand, this will affect the possibility of the urban area to link with the open surface water. As the infiltration of the rainwater is blocked, the conveyance of the water to the rivers and canals in the city will increase, which will lead to the rise of the water level and increasingly cause the water run-off. This will form the second vicous cycle by means of insufficient water flow in the urban area.

The increasing frequency of flood in the city will cause damage to public assets and private property and even hinder the normal functioning of the city and block the implementation of emergency rescue. The damage of public assets might lead to higher damages. More investment will be used for the maintance for the damage of public assets and will further reduce the availability of financial resources for investment of water infrastructure development and maintenance. The damage of private property and the blocked emergency rescue also explore the vulnerable groups to greater vulnerabilities.

They have to spend more for the damage or this will affect their well-beings, and further affect their ability to adapt to the flood risk.

On the other hand, the decreasing of greenery and public space in the city will also affect the liveability. For residents that don't have their private gardens and mostly rely on public spaces, this will also affect their equality of getting resources. Public spaces can also be regarded as a platform for communities with different social background to intergrate and communicate. Without this platform, the segregation between different communities will increase.

Concluding, the current way of the city development is not resilient for the following reasons:

- Flood will cause damage to the public and private properties and hinder the normal functioning of the city
- Urbanization without measures to increase the water retention capacity will further increase flood risk and cause damage to the newly development area, which will cause more damage to the city financially and cause the shortage of resources for investment of water mangement
- The risk will explode the vulnerable groups to greater vulnerabilities and increase the inequality and segregation in the city

Research aim

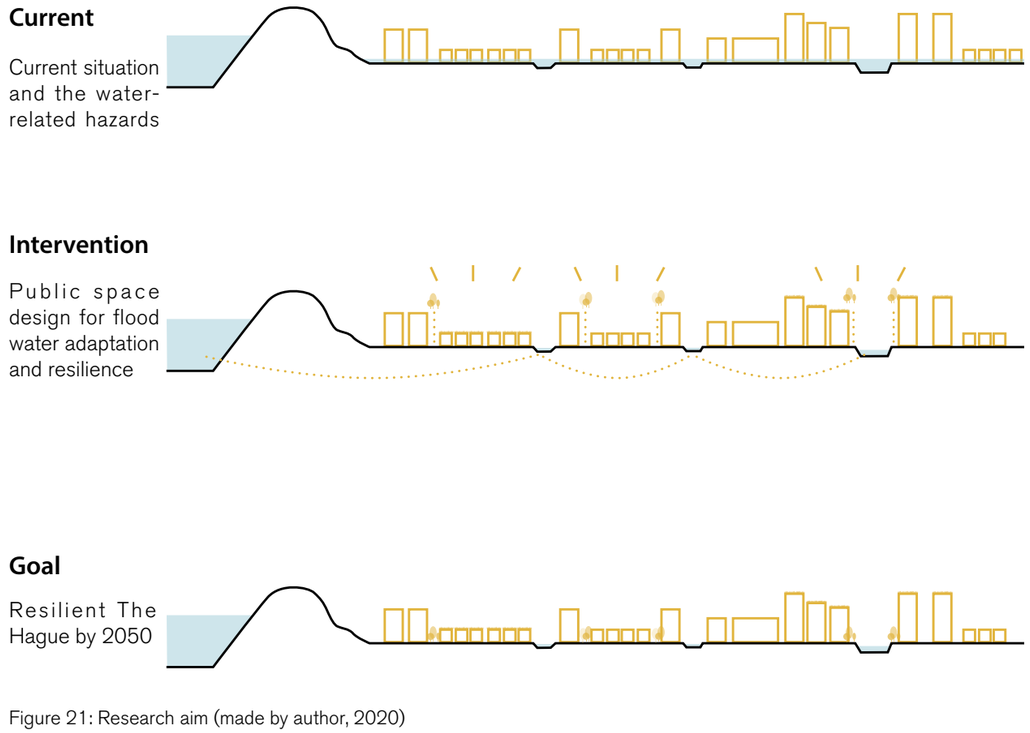


Figure 21: Research aim (made by author, 2020)

The project argues that there is an urgent need to rethink the contribution of green-blue grids and their implications on spatial and social management. The project aims to collaborate with the municipal development agenda of The Hague Resilince Strategy to avoid repeated investment in the same area. It argues that resilient approach for solving spatial,social and climate challenges needs to be accompanied by a systematic strategy that can re-link the interrelationships of water management, urban development and people to create an adaptive, resilient and liveable city of The Hague. The project makes three crucial contributions for the achievement of this goal:

1. Analytical contribution: By studying, analysing and mapping the challenges of climate hazards, social segregation and the inequality of space that brought by urban development, the project can gain scientific knowledge about the existing spatial and social challenges that can contribute to show the interrelationship of the challenges as a backbone.

2. Normative contribution: Based on the analytical knowledge, the project comes up with a spatial vision for resilient climate and spatial development with a set of strategies and governance proposals.

3. Organizational contribution: At last, the project evaluates the organizational logic and the implications of strategies on specific areas. This can show the feasibility and spatial implications of strategies on territories.

Chapter

4

METHODOLOGY

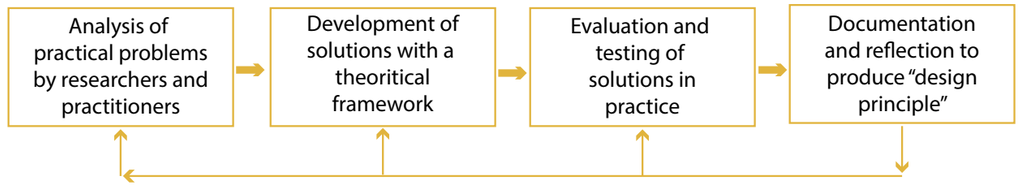


Figure 22: Reeves's phases in the conduct of design-based research (2000)

This chapter explains the research and design methodology by defining its outline, elaborating on the trajectories of exploration of the research, designing the research methods and finally presenting the expected outcomes of the research. The methodology addresses the problem field and context of study, analysis and design phases of the graduation project.

A research framework is firstly constructed as a guiding principle to harmonize the various components of the research framework. The research and methodology approaches for research and design are based on the theoretical and contextual foundations of the project. The methodology approaches are structured in the following steps:

Step 1: State the motivation of research and explore practical problems by research in possible sites. This step essentially clarifies the arguments that lead to research questions and research methods. To this end, the analysis of the problem field and the context of study will firstly be stated. After that, a problem focus will be developed to streamline the project and define its scope. The three branches of the problem field, namely 'cliamte change', 'rapid urbanisation' and 'socio-cultural challenge', and their intersections will give rise to the overarching aim of the project, which is to use green-blue grids as water management strategy and combine it with public space design to adapt the climate change and provide opportunity for realizing climate and social resilience in the city of The Hague. On the basis of the former studies, the section further outlines the hypothesis, research aim and the research questions that guides the project.

Step 2: Elaborate the theorerical foundation, analytical framework and conceptural framework used for research development. The theory paper is for outlining the how can green-blue grids help with avoiding water run-off and helping the city to adapt to extreme precipitation events and how can the extra value of this approach help with solving the urban and social problems of the urban development under the Dutch context. It was written by indepth analysis of existing literature, obtaining expert opinion and applying the theory to the research site. This theoretical foundation gave rise to the conceptual framework of the project, which is a embodiment of linking the theoretical research to practical issues.

Step 3: Outline the design approaches and the expected outcome. This step states the various steps undertaken to evolve the design component of the project. The expected outcomes of the project are: (1) A governance model that defines the roles of stakeholders of different levels in the decision-making process; (2) A set of resilient urban design model that can work systemtically to solve climate, urban and social challenges at the same time and can make the city adaptive, resilient and liveable. The more detailed approaches for realizing the final outcome will be further presented in this section.

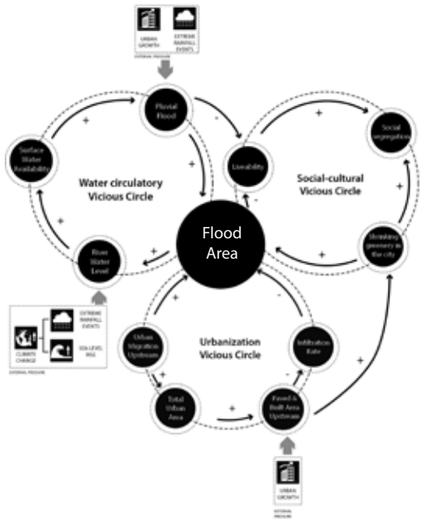
To conclude, the conclusions of the above steps will be used to develop a strategy for the region. These approaches will be further tested against the ethical, societal and scientific considerations and limitations.

Research framework

MOTIVATION and RELEVANCE → **PROBLEM FIELD**

PROBLEM STATEMENT

HYPOTHESIS



RESEARCH QUESTIONS

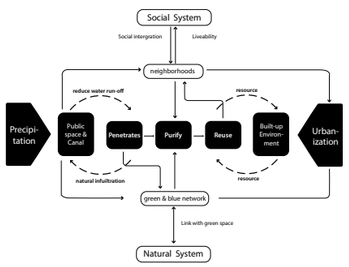
How can public space design contribute to urban resilience in The Hague by 2050 when city is faced with the challenge of extreme precipitation?

SUB RESEARCH QUESTIONS

REFLECTION

RESEARCH FRAMEWORK

CONCENPTUAL FRAMEWORK



ANALYTICAL FRAMEWORK

QUANTITATIVE METHODS

QUALITATIVE METHODS

FIELD TRIP

THEORITICAL FRAMEWORK

HISTORICAL PERSPECTIVE OF DUTCH CITY MANAGEMENT

URBAN RESILIENCE

WATER SUSTAINABLE URBAN DEVELOPMENT

PUBLIC SPACE DESIGN IN THE PROCESS OF WATER MANAGEMENT

EXPECTED OUTCOMES

MULTI-SCALE SPATIAL ADAPTATION STRATEGY

- *A TRANSFERABLE MANAGEMENT APPROACH FOR DIFFERENT TYPOLOGIES IN THE CITY BY MEANS OF PUBLIC SPACE DESIGN TO MAKE THE CITY ADAPTIVE TO EXTREME PRECIPITATION AND ACHIEVE THE GOAL OF BEING RESILIENCE*
- *ZOOM-IN PILOT PUBLIC SPACE DESIGNS AS AN EXAMPLE OF HOW CAN THE STRATEGY WORK SYSTEMTICALLY BY TACKLING CLIMATE AND SOCIO-CULTURAL PROBLEMS AT THE SAME TIME*

SUPPORTING POLICY-MAKING

- *A GOVERNANCE MODEL THAT DEFINES THE ROLES OF STAKEHOLDERS OF DIFFERENT LEVELS IN THE DECISION-MAKING AND EXPLAIN HOW TO ADDRESS DIFFERENT VALUES IN THE PROJECT*
- *LOCAL GOVERNANCE STRUCTURE COOPERATE WITH THE CITIZENS TO DETERMINE AN ADAPTATION STRATEGY*

Figure 23: Research framework (made by author, 2020)

Hypothesis and research questions

The following diagram explains the hypothesis and the research question of the thesis and shows their relationship.

The research questions are structured to guide the analytical, design and evaluation process of the thesis.

[Hypothesis]

The increasing effects of climate change and urbanization has been proportionate to the vulnerability of urban area and socio-cultural inequality. To ensure a resilient and adaptive future for The Hague, new integrative frameworks need to be implemented to decrease risk and improve liveability.

In light of these problems, this research is based on 3 main hypotheses:

1. Rapid and extreme precipitations due to climate change are the cause of loss of liveability.

2. The population growth stimulates, while at the same time, places pressure on urbanization in form of the need of housing. This will result the decrease of greenery in the city as the rapid construction will occupy more land in urban area.

3. Inclusion of adaptive approaches in the spatial planning, by means of public space design, and policy instruments can lead to better socio-cultural development of urban system and promote better intergrations among population.

It attempts to test these hypotheses through a series of research questions.

- To investigate the relationship between public space design, adaptation and urban resilience.
- To develop a spatial and governance response to assist in adapting rainwater flood risk and increasing the liveability and social integration in the city.

Urban resilience:

Urban resilience goals of this project includes the following dimensions:

- Reduced exposure and fragility
- Integrated development planning
- Empowered stakeholders
- Minimal human vulnerability

[Main research question]

How can **public space design** contribute to **urban resilience** in The Hague by 2050 when city is faced with the challenge of **extreme precipitation**?

[Sub research questions]

What are the spatial implications of water-related risk on the communities in the city of The Hague?

Where is the vulnerable area need to be preserved?

How can public space design collaborate with the development vision of The Hague and enable the transformation of the city into a resilient environment?

What population groups are involved in the process of management?

How can the project ensure resident engagement?

How can public space design offer higher social and ecological returns while making the city rainproof?

Figure 24: Hypothesis and research question (made by author, 2020)

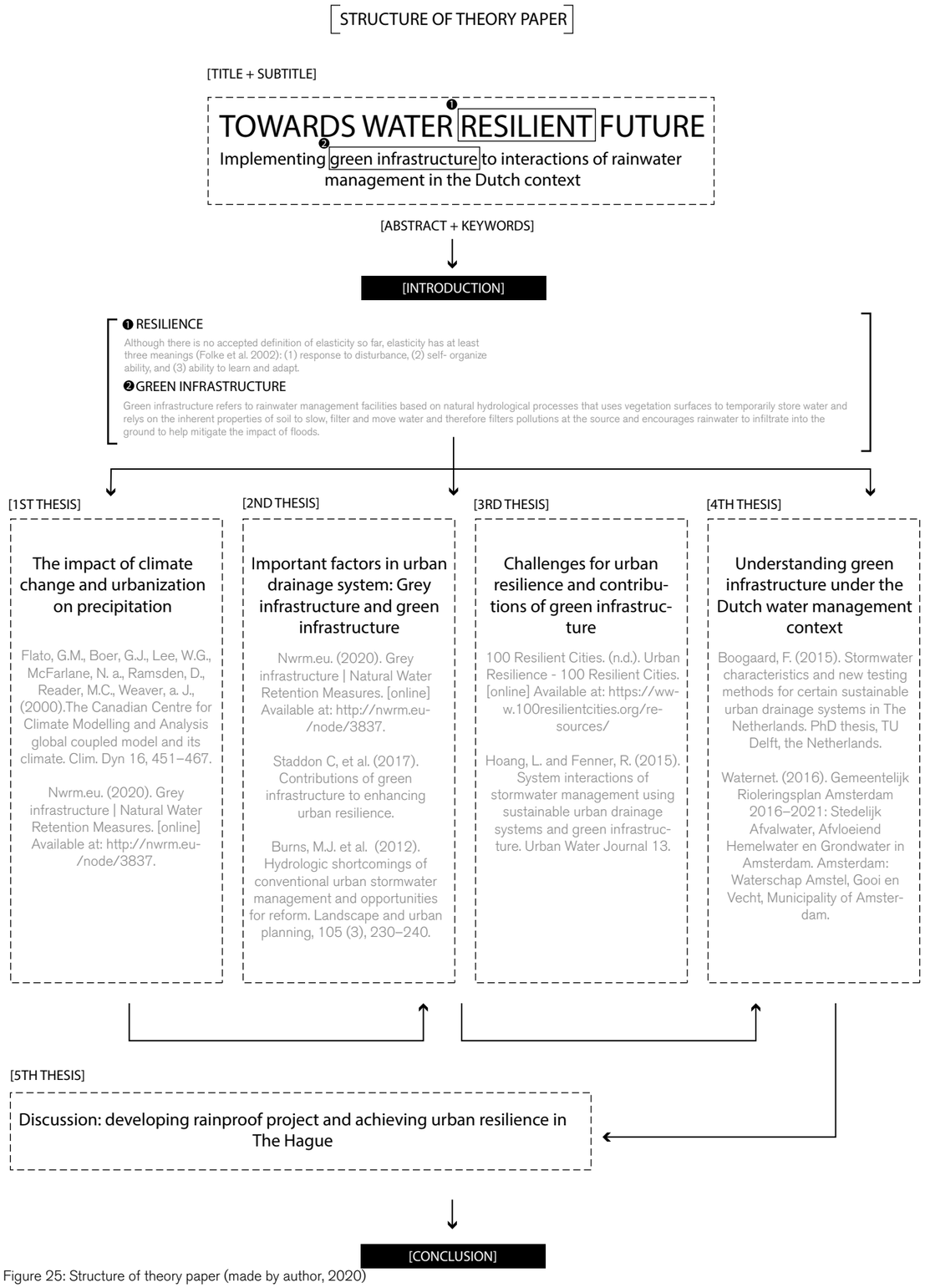


Figure 25: Structure of theory paper (made by author, 2020)

Theoretical framework

The challenges in the city of The Hague has been explained and pointed out in the previous chapter. The city needs a new approach to cope with the upcoming hazards while contributing to urban resilience. Therefore, the design strategy and the frameworks of the research is expected in the future strategy. This research will apply three theories:

1. Urban resilience and its values
2. Water-sensitive urban design as a future trend of urban development when the city is faced with uncertainties of extreme weather hazards
3. How can public space design be applied to water-sensitive urban design framework and contribute to urban resilience values

Urban resilience

As one of the goals of the project is to achieve urban resilience in The Hague by 2050, it is important to understand the defination of urban resilience and its values.

As The Hague is one of the cities of 100 Resilient Cities (100 RC), the definition of urban resilience of 100 RC will be taken. According to 100 RC, “urban resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience." Therefore, a resilient city is one that assesses, plans and acts to prepare for and respond to hazards - natural and human-made, sudden and slow-onset, expected and unexpected (100 RC, 2015).

The resilience theory is built on a notion of cities as highly complex adaptive systems. The implication of this insight is to switch the management approaches of urban planning from conventional approaches based in geometric plans to an approach informed by network science that involves less interference in the functioning of cities.

While the vagueness of the term "resilience" has enabled innovative multi-disciplinary collaboration, it has also made it difficult to operationalize or to develop generalizable metrics. To distinguish a resilient city from a normal sustainable or liveable city, the 100 RC combined different factors and organized them into the four core dimensions of the urban resilience framework (Arup, 2015):

(1) Leadership and strategy:
- Effective leadership and management
- Empowered stakeholders
- Integrated development planning
- Health and well-being

(2) Minimal human vulnerability:
- Diverse livelihoods and employment
- Effective safeguards to human health and life
- Economy and society

(3) Sustainable economy:
- Comprehensive security and rule of law
- Collective identity and community support
- Infrastructure and environment

(4) Reduced exposure and fragility:
- Effective provision of critical services
- Reliable mobility and communications

Water-sensitive urban design (WSUD)

As stated in the former chapter, the challenges in the city are forming a vicious circle. Therefore, for breaking the vicious circle, the city requires an adaptive approach that can tackle multidimensional problems systematically.

The approach chosen for the project is water-sensitive urban design (WSUD).

Over the past decade, as a result of climate change, increasing attention has been drawn to adaptation approaches for rainwater management. As an answer to that, more and more cities are using green infrastructure for adapting extreme precipitation flood. Nowadays, the extra value of this approach provides the opportunity of linking water management approach to urban development for increasing the resilience and liveability in urban areas. Water-sensitive urban design (WSUD) is a land planning and engineering design approach which integrates the urban water cycle, including stormwater , groundwater and wastewater management and water supply , into urban design to minimise environmental degradation and improve aesthetic and recreational appeal. The basic priciple of WSUD is building up linkages between water management, infrastructure planning and urban design.

The development of water mangement approches are following the process of urban development or to meet the needs of the people. Therefore, with the rapid urban development, the function of water management system has developed from simply supplying water for people to protect the territory

from natural hazards. Nowadays, increasingly city planners have recognised the need for an integrated management approach to stormwater management, to enable cities to adapt and become resilient to the pressure which population growth, urban densification and climate change places on population and increasingly expensive water infrastructure. Therefore, the new standard of water management approch is raisen up, which is not only making the city adaptative to the hazards but also providing extra values to the city and the population during the non-hazard scenarios. This standard is called the water sensitive city.

WSUD regards urban stormwater runoff as a resource rather than a nuisance or liability. This represents a paradigm shift in the way environmental resources and water infrastructure are dealt with in the planning and design of towns and cities. WSUD principles regard all streams of water as a resource with diverse impacts on biodiversity, water, land, and the community's recreational and aesthetic enjoyment of waterways. The principles can be concluded as the following:

- Protecting and enhancing creeks, rivers and wetlands within urban environments;
- Protecting and improving the water quality of water draining from urban environments into creeks, rivers and wetlands;
- Restoring the urban water balance by maximizing the reuse of stormwater, recycled water, and grey water;
- Conserving water resources through reuse and system efficiency;
- Integrating stormwater treatment into the landscape so that it offers multiple beneficial uses such as water quality treatment, wildlife habitat, recreation and open public space;
- Reducing peak flows and runoff from the urban environment simultaneously providing for infiltration and groundwater recharge ;
- Integrating water into the landscape to enhance urban design as well as social, visual, cultural and ecological values; and
- Easy and cost effective implementation of WSUD allowing for widespread application.

A water-sensitive city is considered as able to be adaptive and resilient to broad-scale changes (Wong and Brown, 2009). The WSUD measures can be applied step by step gradually transforming a city as it becomes more sustainable and its urban environment resilient. The individual components can work together supporting the broad spectrum of processes, for instance, treatment, retention, infiltration, or conveyance depending on the context and target.

Figure 26: Urban water management transitions framework (made by author, adapted from Brown, et al., 2009)

Public space design and its contribution to a water-sensitive and resilient city

A public space is a place that is generally open and accessible to people. Roads (including the pavement), public squares, parks and beaches are typically considered public space. As the research proposal is using public space design to achieve flood water adaptation and urban resilience, the following chapter will further explain how can public space design to adapted to WSUD measures and meet the urban resilience values.

Public space design, green infrastructure and WSUD

According to the Three Points Approach (Fratini et al., 2012), the designed drainage capacity can cover the maximum of the daily water usage amount. However, due to the climate change, more extreme precipitation will happen, which will cause the needed drainage capacity exceeding the designed one, therefore cause the urban water run-off. The urban water run-off is characterized by more rapid and intensive flow, as well as high discharage into the sewerage system.

This situation is also due to the blocked natural hydrological cycles. With the rapid urbanization, the urban space is more and more occupied by paved surface, which cause the decrease of green areas. The lack of green areas together with the predominance of impermeable surface aggravate the run-off volume and rate in the urban environment. Moreover, this also cause the decrease of liveability in urban areas. On the one hand, it is becoming more and more difficult for people to find shadows in the city that can be used to block sunlight, which exposes citizens to heat waves. On the other hand, with the decrease of green space, it is the city is gradually losing the connection with the surrounding nature, which hinders the diversity of species in the city.

However, redesigning and replacing the grey infrastructure can be a waste of resource and not very flexible for solving the rainwater flood problem in the city. Therefore, public space design which is combined with green infrastructure can be a solution to the problem.

As an important conponent of the hybrid socio-technical engineered systems, green infrastructure refers to rainwater management facilities based on natural hydrological processes that uses vegetation surfaces to temporarily store water and relys on the inherent properties of soil to slow, filter and move water and therefore filters pollutions at the source and encourages rainwater to infiltrate into the ground to help mitigate the impact of floods.

Combining with green infrastructure, the redesigned public spaces can increase the green-blue grids in the city. So that the permeable surface is increased, which can reintroduce the natural water cycle to the city. The natural water infiltration can reduce the total amount of exceed water. On the other hand, the public space itself can be used as a space for temporary water storage and retention. It also helps with increasing total water storage capacity and therefore helps with decreasing the pressure on grey infrastructure for water drainage.

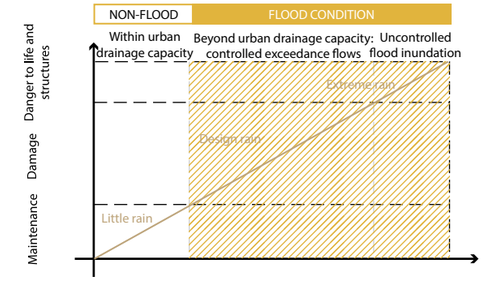
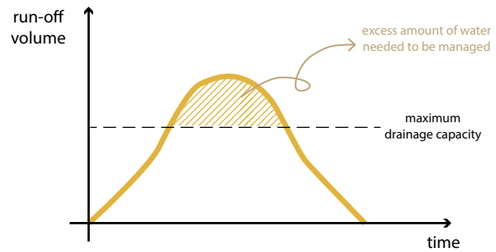


Figure 27: Three Points Approach (made by author, adapted from L. Hoang & Fenner, 2015)



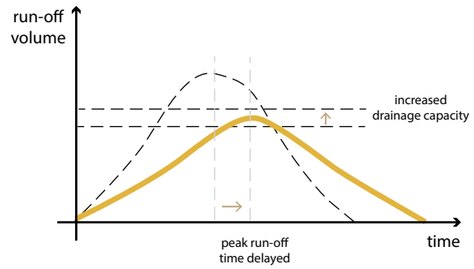


Figure 28: Three Points Approach (made by author, adapted from L. Hoang & Fenner, 2015)

WSUD seeks for the approach for incorporating water management approaches in which the aspirations and values of the local community and urban spaces administrate the place-making and water management approaches. Within the water sensitive city framework, the resilience of different categories of urban system is considered as the key components for decision-making (Wong et al., 2013). The following figure shows that all elements of the water cycle and their interconnections are considered concurrently to achieve an outcome that sustains a healthy natural environment while meeting human needs, and that planning and design processes are considered at various levels (i.e. towns, cities, places) seeking to achieve the expectations and aspirations from design.

The values provided by public space can also be adapted to the framework.

It provides space for community engagement and recreational functions. With the consideration of socio-cultural values, it can also help with enhancing local identity. The green-blue infrastructures can also provide ecological benefits, such as helping with microclimate and provide better liveability.

Concluding, public space which is combined with green-blue infrastructure can contribute to achieving rainwater adpation and urban resilience.

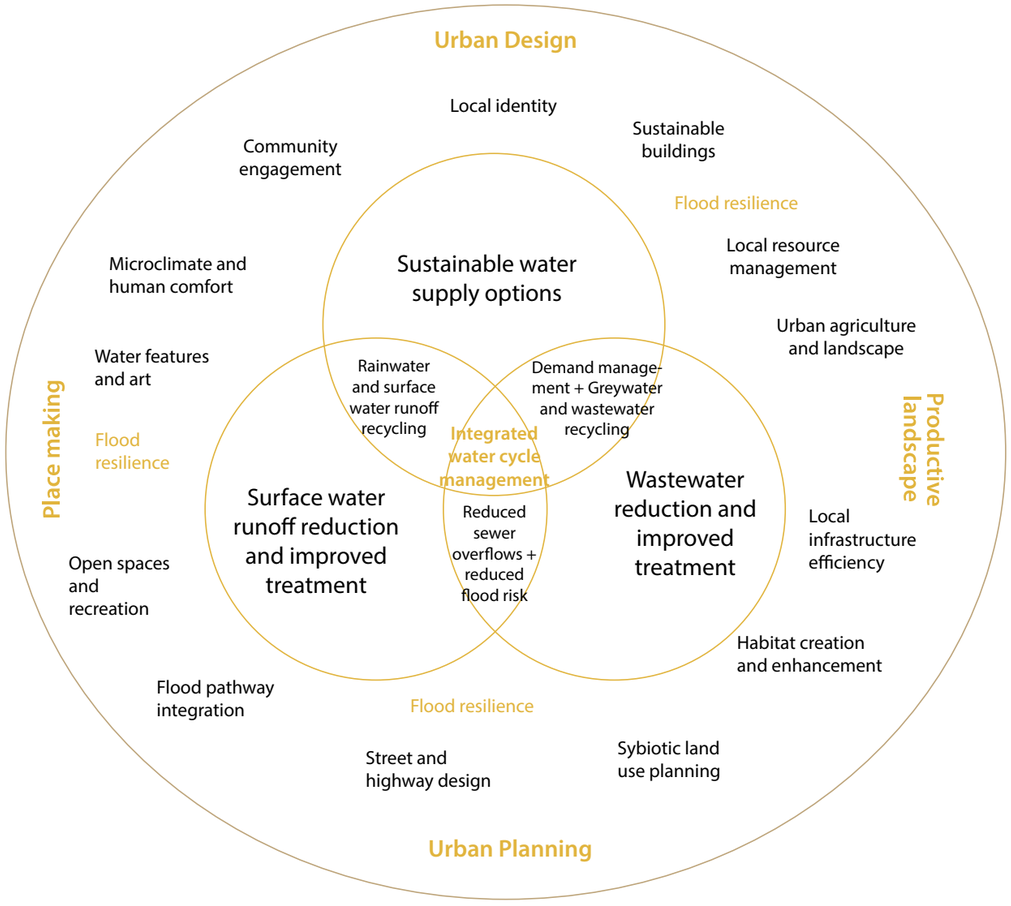


Figure 29: Components of water sensitive urban design and their interactions highlighting the place of flood resilience and other aspects of WSUD (made by author, adapted from Ashley et al., 2013)

Conceptual framework: Breaking the vicious circle

As a complex system, the challenges in the urban area can't be regarded as parellel lines. The approach of combining sptial and technical approaches on public space can redefine the urban, water and inhabitation patterns in the city with new potential and opportunities.

By summerarizing the theoretical foundation, the project aims to tackle the three challenges elaborated in the former charpter in a systemtic system. And it also aims to break the vicious circle. This framework will act as the backbone of the research and design methodology of the project.

The framework posits that for achieving the resilience of The Hague, it is important to understand the complexity of the urban system and embed the approaches in various socio-spatial-techinical relationships across scales and reflect it on the space. It explicitly shows how can public space connect technical, spatial and social dimensions systemtically. On the one hand, a better water cycle process can be achieved through public space. On the other hand, those processes can also bring benefits to the social, spatial and natural systems.

This interdisciplinary research also adds to the body of knowledge on spatial and technical design for climate and urbanzation challenges, and points out a new paradigm of conception of approach for achieving resilience by urban development and climate adaptation, which integrates the multidimensional facets of achieving urban resilience.

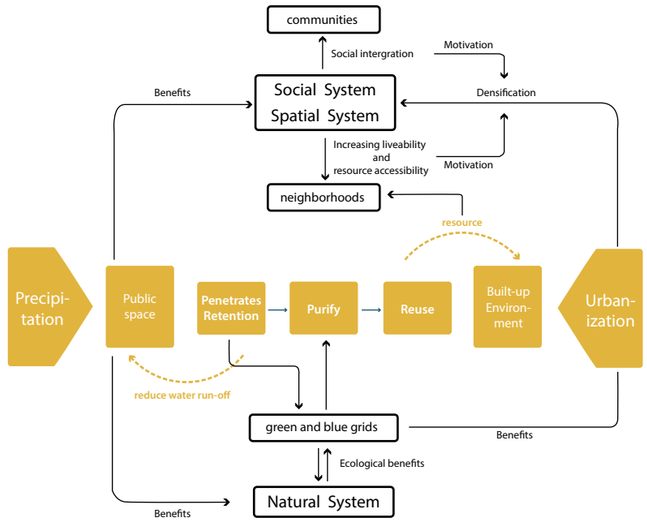


Figure 30: Conceptual framework (made by author, 2020)

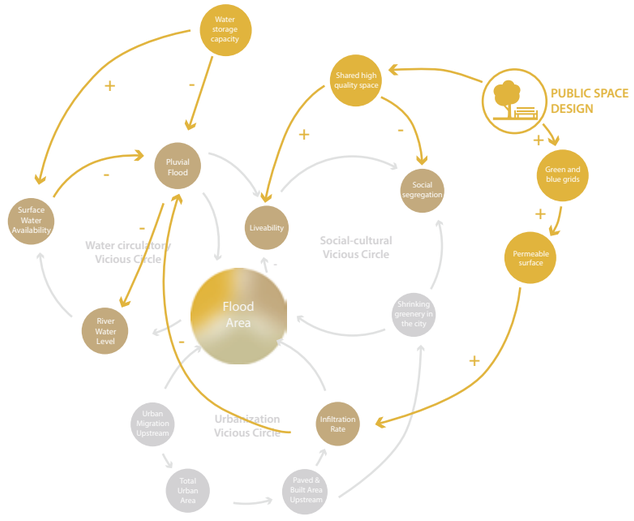


Figure 31: Breaking the vicious circle (made by author, 2020)

Chapter

5

Analysis

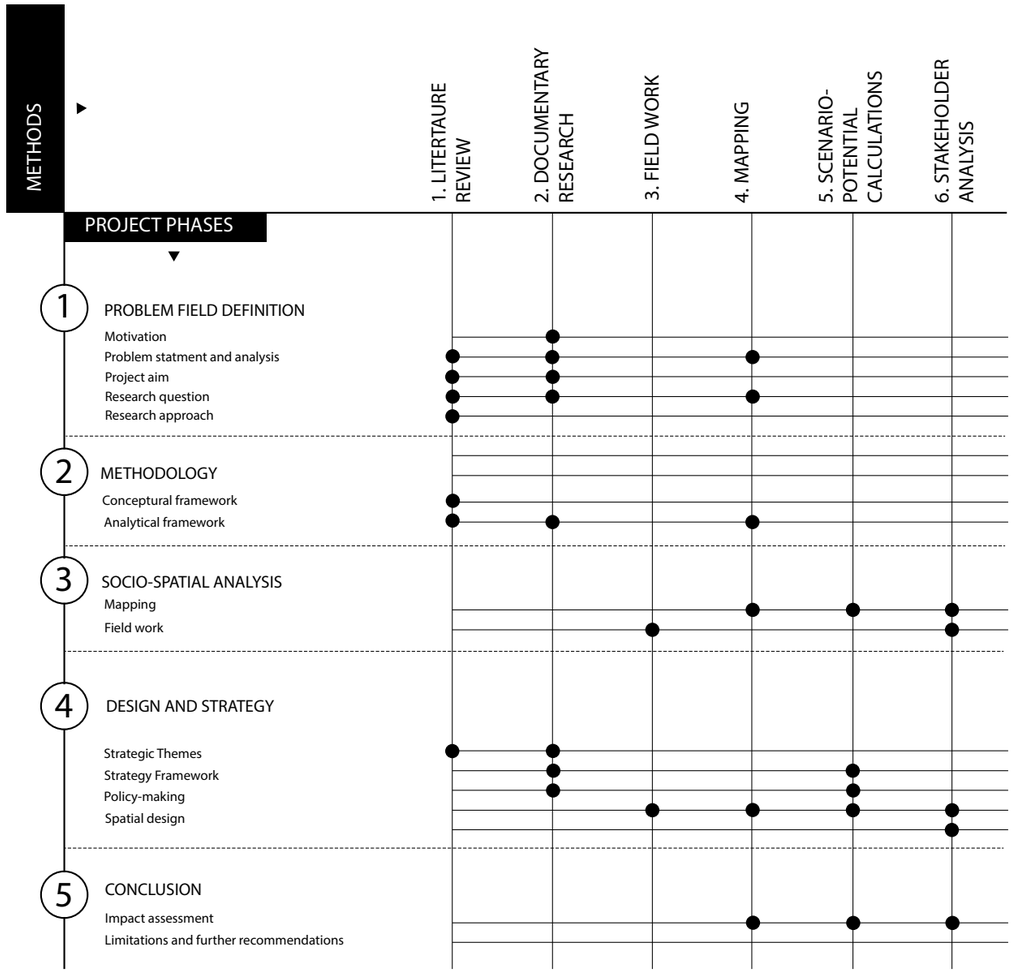


Figure 32: Research methods (made by author, 2020)

Analytical framework

Choosing appropriate methods for research can contribute to the study of intersection of water management and spatial design. The chosen methods are used in different stages of the project separately or combined, according to the need of different themes or topics. The methods of the research are divided into three dimensions- qualitative methods, quantitative methods and the combination of them as the following catagories:

1. Interview
2. Group discussion
3. Documentation/ Observation
4. Mapping
5. Data analysis/ Desk research
6. Literature review

[QUALITATIVE METHODS]

INTERVIEWS : Formal and informal interviews can be used to gain opinions from different perspective of approaches for the research. The interviews can be carried out with people from various backgrounds, such as sociology, governance and non-profit agencies for a fair and comprehensive consequence.

GROUP DISCUSSIONS : The group discussions can be held within the Transitional Territory studio group. The discussions are the different reflections on peer's own research and place it within the lines of inquiry of groupwork perspective. By comparing with these outcomes, the assembleges and dissonances of the project can be revealed. This can be instrumental in improving the approach.

DOCUMENTATION / OBSERVATION : Field trips will be used to collect empirical data by means of surveys and interviewing the experts. Further, the observation of the research site by means of photography, video and recording will be done to understand the spatial impact of the phenomena explored.

[QUANTITATIVE +QUANTITATIVE METHODS]

LITERATURE REVIEW : The critical review of scientific literature, policy documents and reports from local governments is an intrinsic part of this research. Readings can be constantly used to define the necessary terms and reflect on various periods of development.

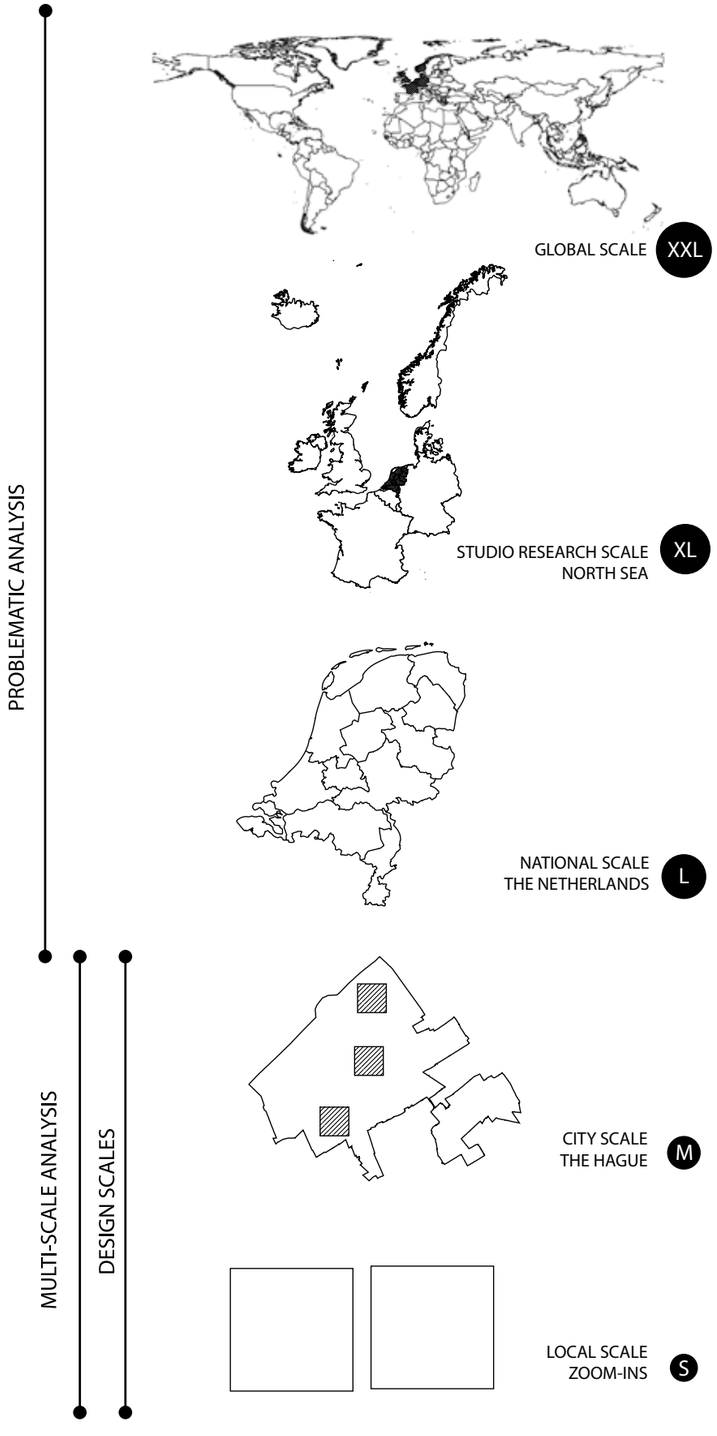
The scientific literature can contribute to discover the theories behind adaptive approaches, multi-disciplinary view on effect of adaptation and the relationship between climate impact adaptation and urban resilience.

On the other hand, policy documents and reports from the local government, informed the research with the ongoing discourse and future plans. They are also a source of valuable data and contacts for the development of the research.

[QUANTITATIVE METHODS]

MAPPING : Mapping can work as an essential method for understanding and analysing the socio-spatial processes related to climate change impacts. GIS analysis and raster mapping can be used to accumulate basic data and represent it in a comprehensive way by overlapping. Besides, some important data can also be extracted from interviews and documentaries.

DATA ANALYSIS / DESK RESEARCH : Due to the unfamiliarity of the context topic and geographical constraints, desk research is the main tool for initial exploration. As part of the desk study, data analysis can be used to explore and test hypotheses spatially and statistically.



[Layered approach analysis]

Analysing world trend to locate the problem field of the project- climate change and flood risk in coastal area; rapid urbanization and the stress on territory; socio-environmental vulnerabilities under climate change scenarios.

By analysing at the studio focus scale- the North Sea region, the problemetic area of the combined problems, which are under the consideration of future projections of flooded area, urbanization trends and population density, can be located.

By analysing at the level, the challenges and the relationship of water mangement and urban development can be revealed, which provides a backbone for coming up with the strategies of the project.

By overlapping the different problem layers, the most vulnerable areas can be located and the emergency level can also be graded.

The most vulnerable areas will be the design areas of the project. Solutions will be put up for increasing climate adaptation ability and urban resilience.

Figure 33: Analytical scales of research and design (made by author, 2020)

Development map

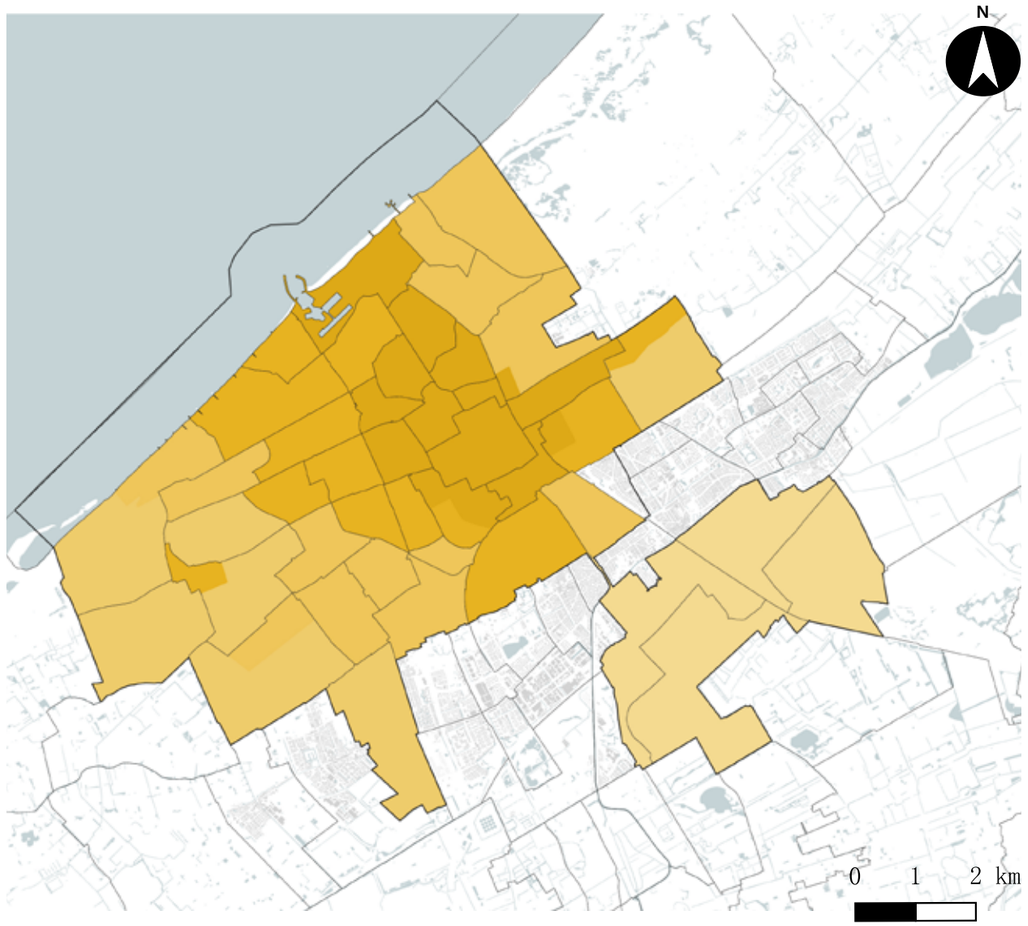
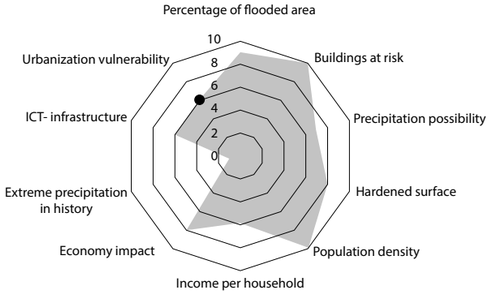


Figure 34: Development map of The Hague (made by author, 2020)

When looking into the history of recent 100 years of The Hague, the development of urbanized areas could be concluded as the above image. After world war II, The Hague witnessed a massive urban expansion to the south-west and in the 21st century the construction of Leidschenveen-Ypenburg has been applied on the southeast of the city.

The oldest area of the city which was built before the 1930s mainly consisting of Centrum and Scheveningen are found to the places with relatively larger vulnerabilities when faced with the extreme precipitation risk. The result can be shown in the following mappings.



Water depth

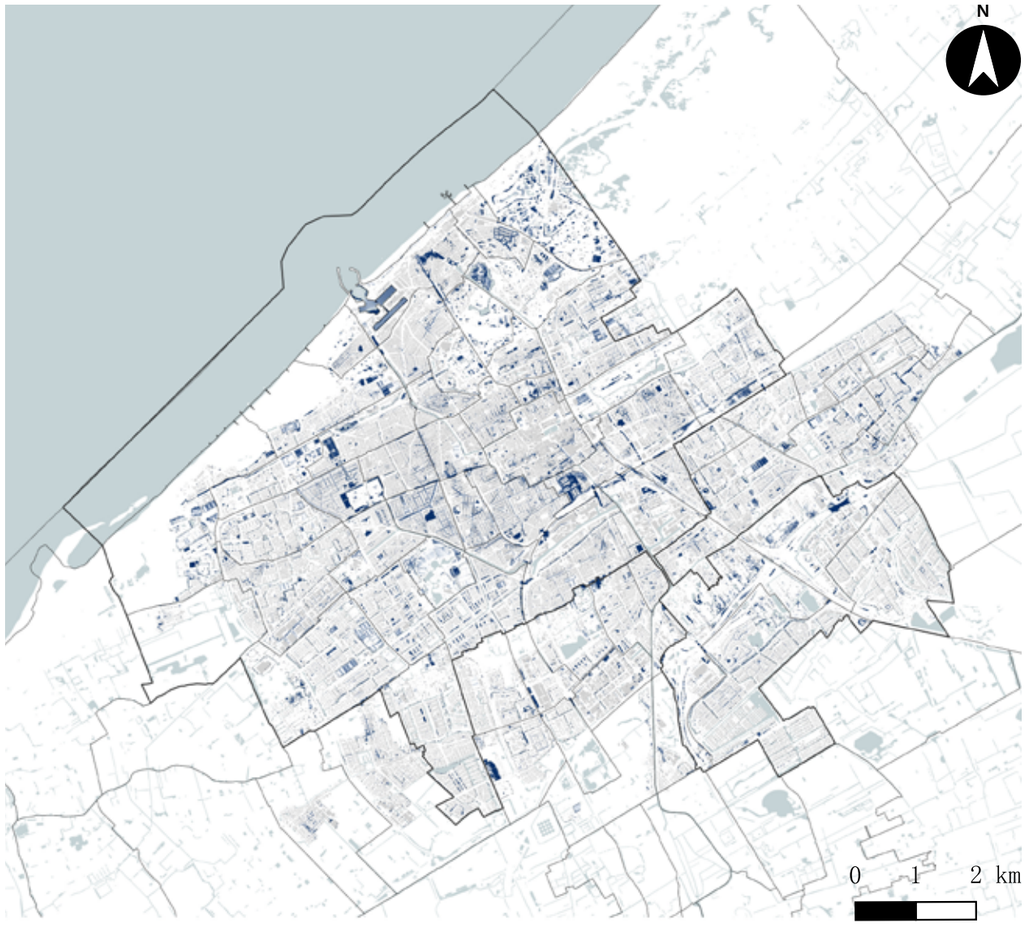
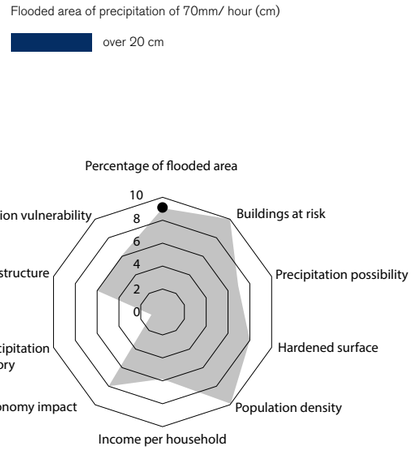


Figure 35: Flooded area of precipitation of 70mm/ hour (cm) (made by author, data source: klimaatatlas)

Extreme precipitation events are expected to become more frequent due to the climate change. The hazards may have a major impact in urban areas. Water nuisance currently can't be prevented during these extreme events. So analysing where the flood will occur and what consequences can be expected is necessary.

Taking precipitation scenario of 70 millimeters per hour, this map shows the flooding locations and the water depth in the city.

As we can see from the map, there are several bottlenecks in the city where the water depth is over 20 cm. These areas might suffer the most damage if they can adapt to this flood.



Drought

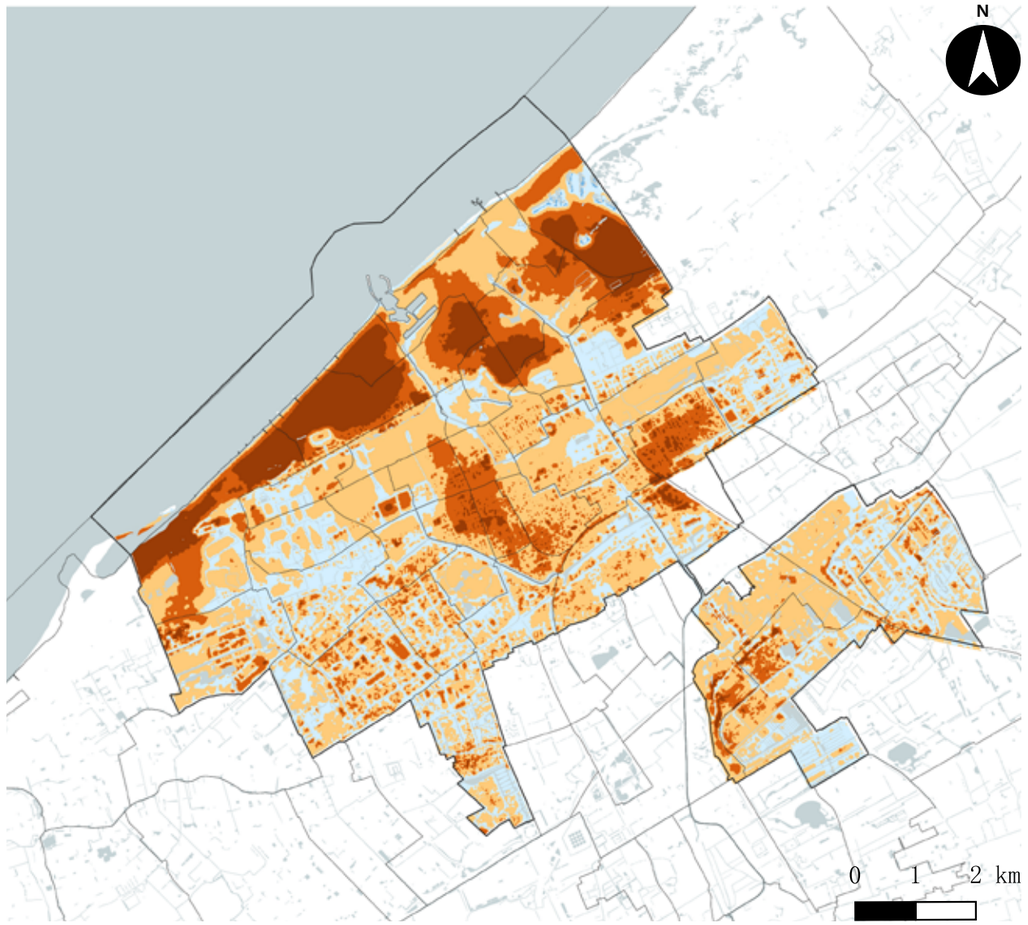
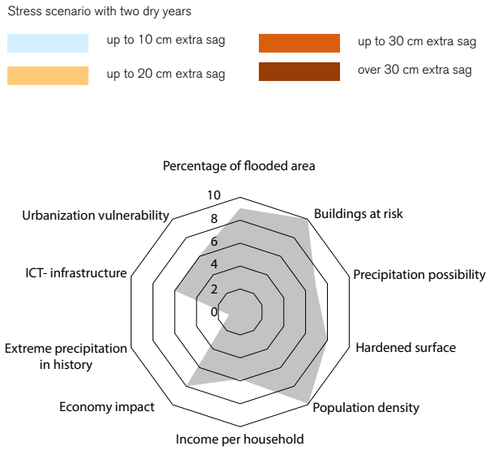


Figure 36: Drought (made by author, data source: klimaatatlas)

The city is not only at risk from too much water, it is also under the threat of not enough water. As more extreme precipitation hazards brought too much water above ground to the city, in the future the city might also be prone to water shortage due to the possibility of droughts. As the areas in the city that can be used for the retention and infiltration of water is usually scarce, the solutions can be costly or conflict with other above ground functions. This maps shows the vulnerable areas in the stress scenario with two dry years drought. As we can see from the map, the most areas of the city will suffer from drought and the most vulnerable area is located in Schveningen and the Dunes.



Greenery

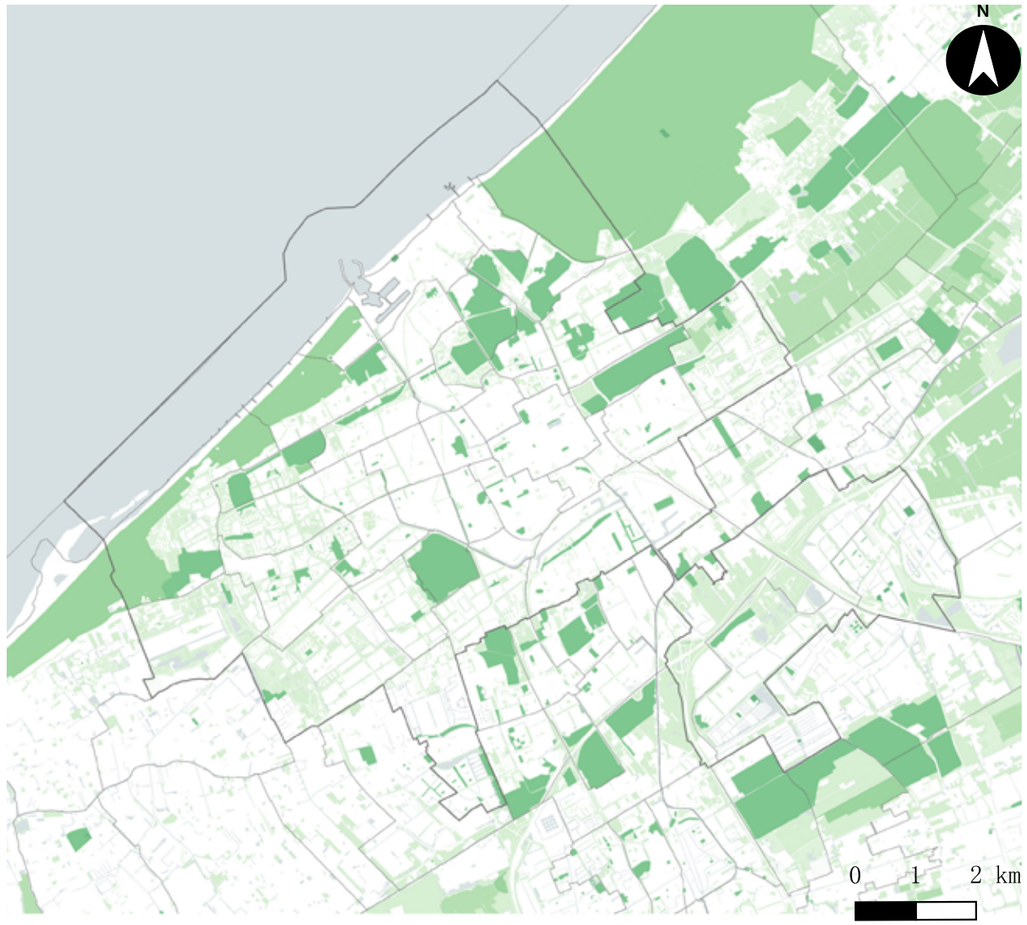
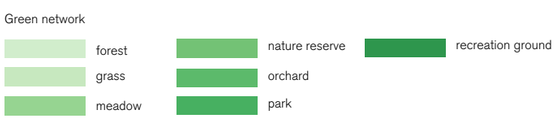


Figure 37: Green network of The Hague
(made by author, data source: EduGis)



The Hague is known as a green city by the sea, with wide beaches, dunes and long green avenues. Based on the typologies of greenery in the city, the city can be divided into three parts: dense city, semi-open city and the surrounding areas. The dense city is the areas with street trees, squares and neighborhood parks and the semi-open city is close to large-scale green structures. Greenery can not only provide a pleasant living environment for the residents, it can also help with the adaptation of water run-off in the city. From this map, we can see that there're several areas with missing accessibility of greeneries, such as Scheveningen, Centrum, Laakhaven and Binckhorst. Therefore, the residents might not only be exposed to greater risk under extreme climate hazards but also suffer from inequality of liveability.

Impermeable surface

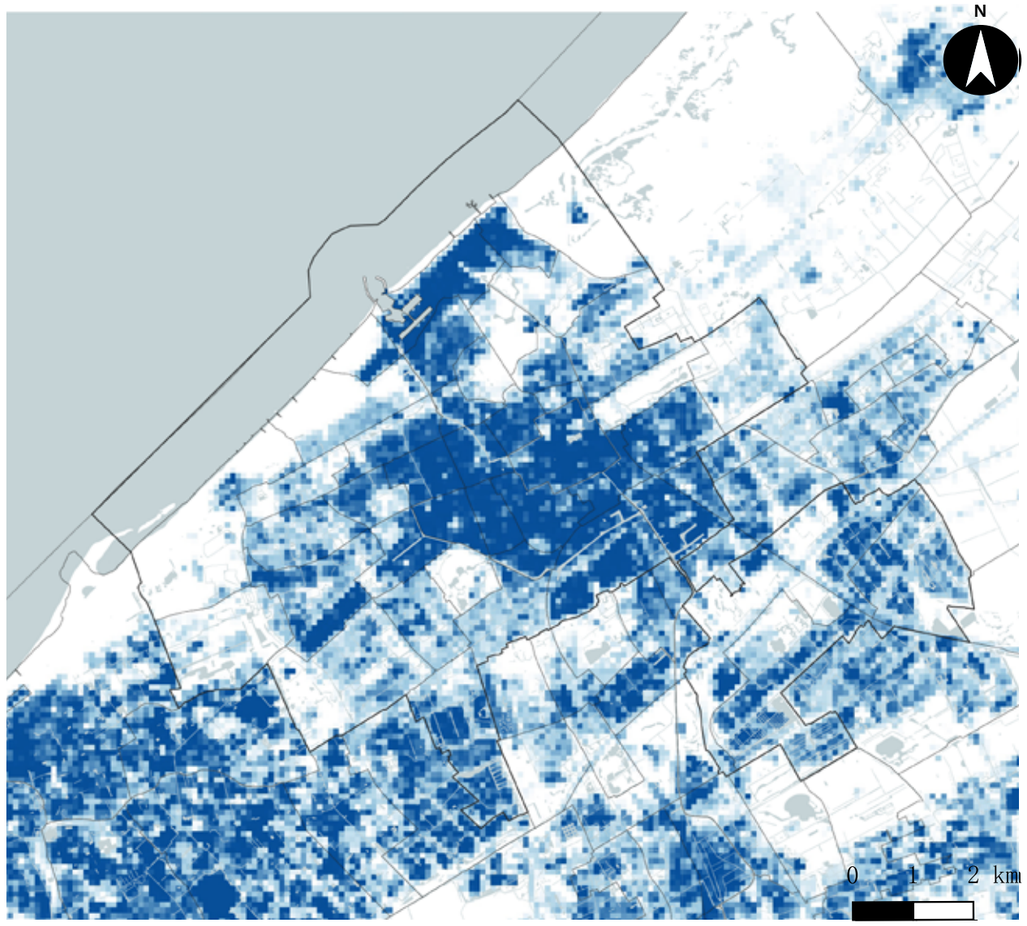
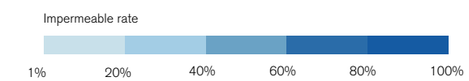
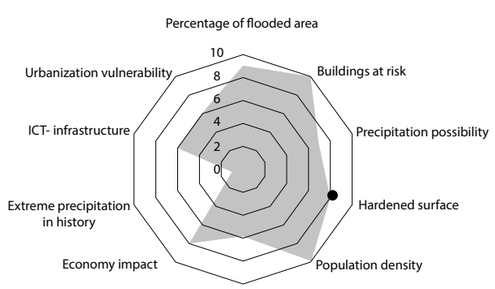


Figure 38: Impermeable surface
(made by author, data source: land.copernicus.eu)



With the rapid urban development construction, the built-up areas are gradually replacing open green spaces in the city. Therefore, the land of urban area is more and more covered by impermeable surface. This will affect the natural water cycle process such as infiltration. Under extreme precipitation, this will cause the increasing amount of water that can't be infiltrated to the ground. It will put stress on water drainage systems. When they reach their drainage capacity, it will cause the water run-off in the city and eventually cause damage to public and private properties or even affect the urban function. As we can see from this map, The Hague is mostly covered by high impermeable rate surface, which makes the city vulnerable under the threat of extreme precipitation.



Typologies

The layout of a Dutch street is often characteristic of a specific period. The technical possibilities and ideas about the design of our residential and living environment in the construction period are reflected in typical, recognizable characteristics of a street or neighborhood. These are, for example, the size of houses and gardens, the space for public greenery and play areas, the width of the street or the architecture of houses. In this research, the housing typologies are defined according to the research of Kleerekoper (2016). The characteristics of a typology determine the adaptation ability of the neighborhood when it's faced with a more extreme precipitation event. For example, the abundance of public green spaces in post-war garden cities can easily be used for climate adaptation, but the densely built urban building blocks and the pre-war building blocks are more demanding for (technical) solutions underground.

The following diagram listed eight typologies which are vulnerable to extreme precipitation events. Understanding different neighborhood typologies can provide a fairly accurate picture of local climate adaptation options.

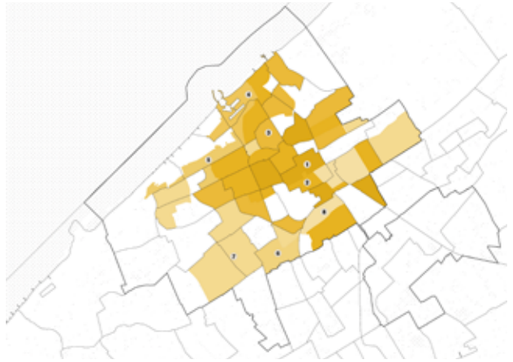


Figure 39: Housing typologies (made by author, data source: klimaatatlas)

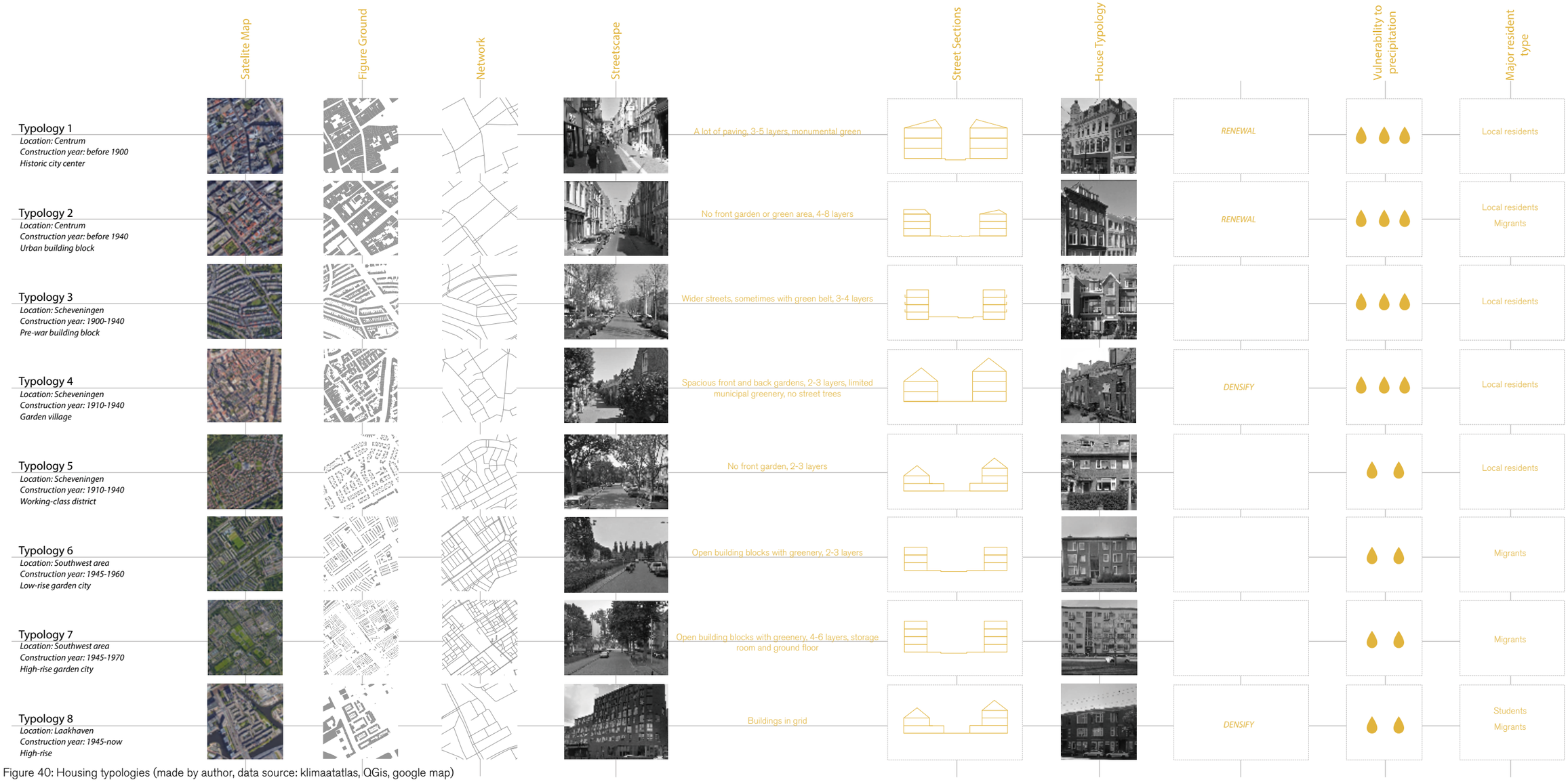


Figure 40: Housing typologies (made by author, data source: klimaatatlas, QGis, google map)

Vulnerable buildings

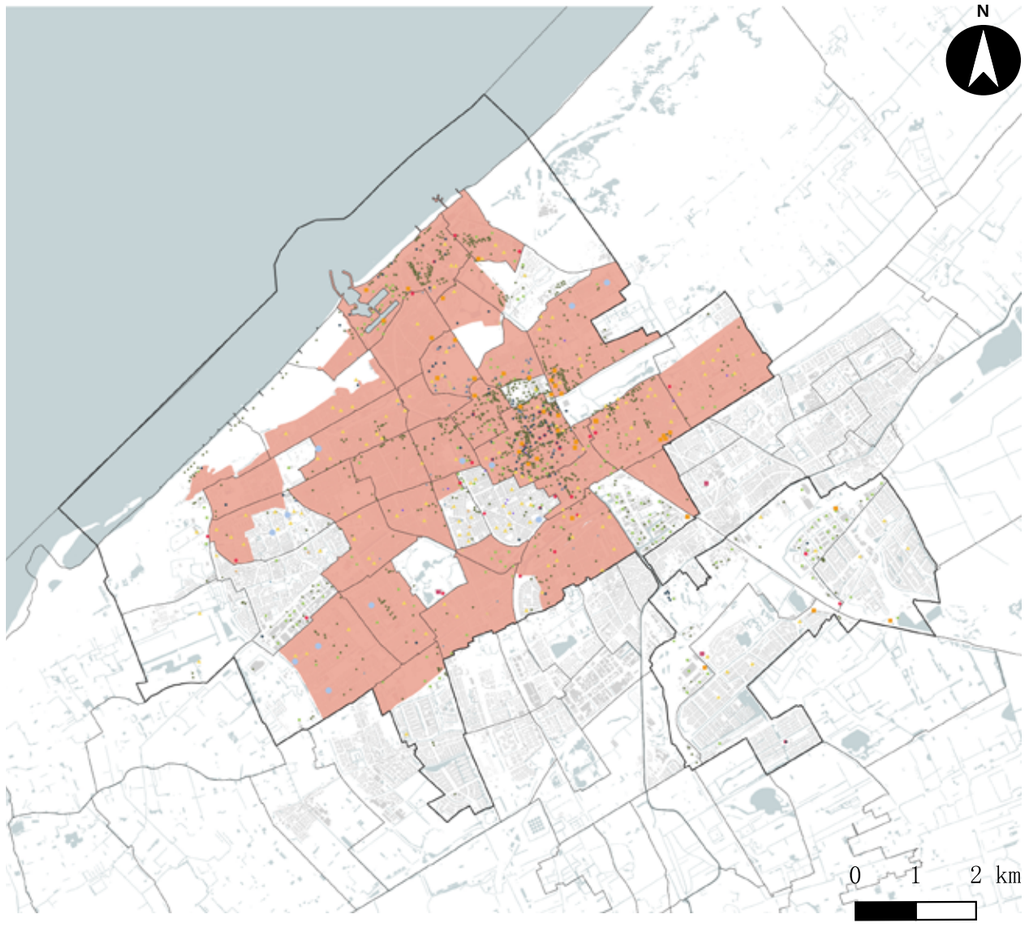
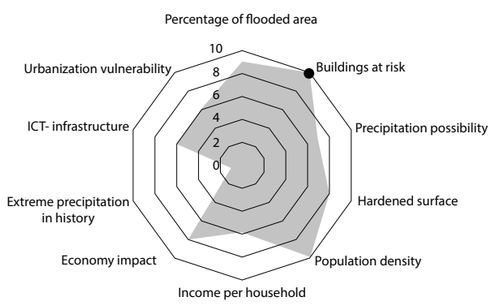


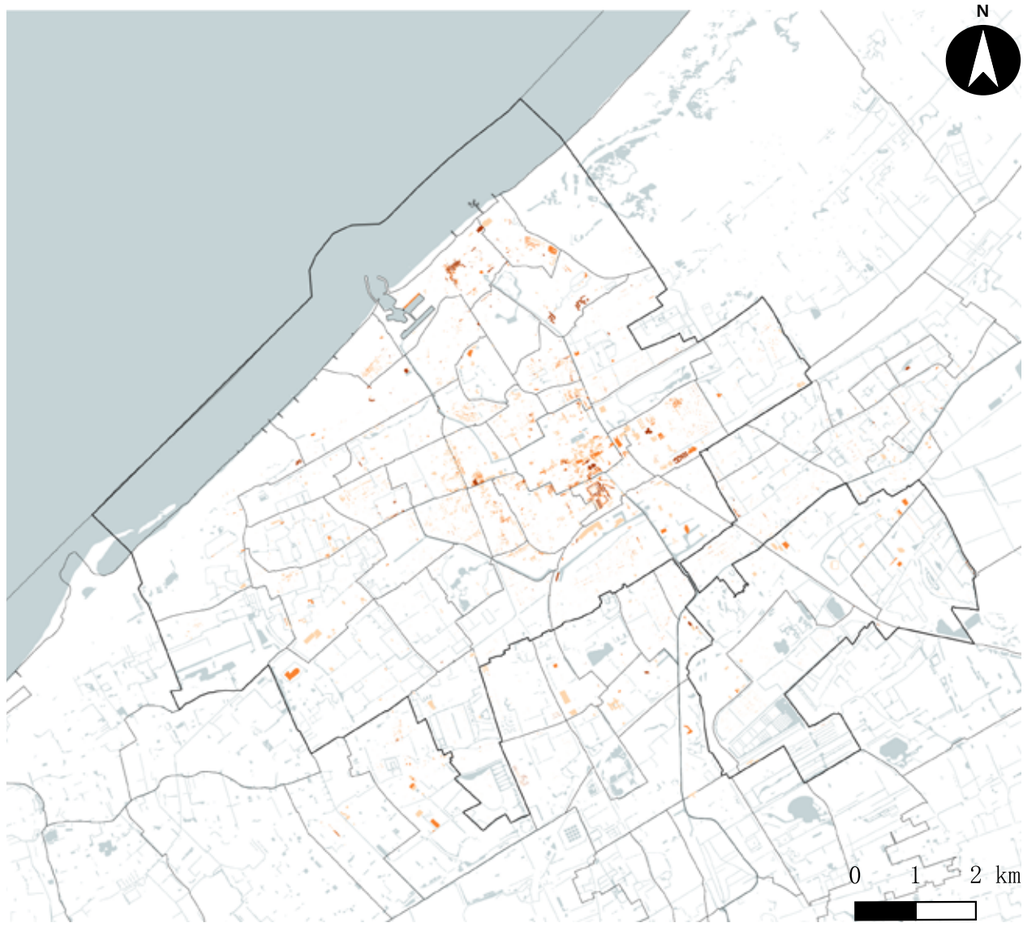
Figure 41: Housing typologies and building functions
(made by author, data source: EduGis, Klimaatatlas)

The vulnerable buildings are defined by two standards: (1) buildings with non-residential urban functions; (2) buildings are less adaptive to flood due to their typologies.

From this map we can see that there's a concentration of vulnerable buildings in the city in Scheveningen and Centrum due to their important position of urban function in the city and the construction typologies of the buildings.



Water damage on buildings



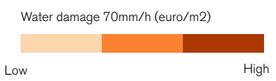
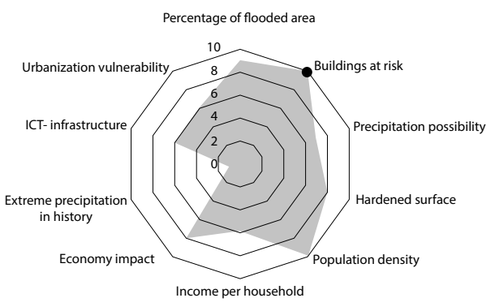


Figure 42: Water damage on buildings
(made by author, data source: klimaatatlas)

Extreme precipitation will cause water run-off in the city, and will cause damage to public and private properties. The water damage map provides an estimate of the water damage in euros per square meter if an extreme rainfall of 70 mm falls in one hour. This module includes damage amounts for direct damage to, for example, floor coverings, but also indirect damage due to costs of replacement housing.

As we can see from the map, Scheveningen and Centrum and surrouding areas suffer the most from the water damage.



Mobility

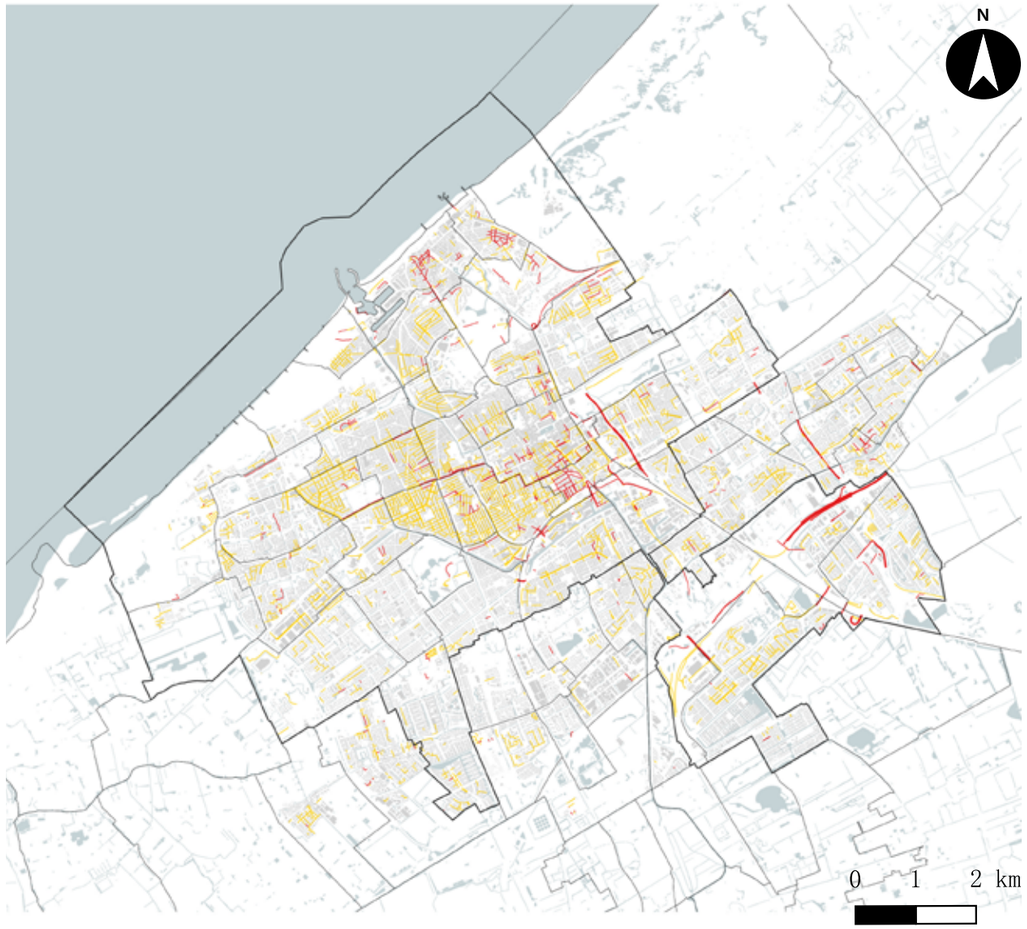
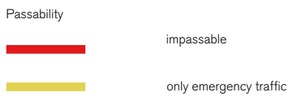
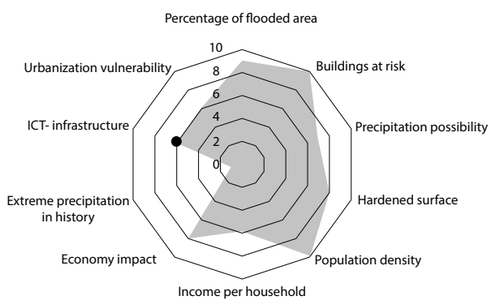


Figure 43: Damage on roads during 70mm/h precipitation (made by author, data source: Klimaatatlas)



The water nuisance can also affect the passability in the city. This might lead to dangerous situations regarding accessibility of not only residents but also emergency services. In a heavy rainstorm, the water on the street can get so high that the road becomes impassable. The passability map shows which roads are impassable at the same storm as on which the flooding map is based: 70 mm in one hour. At water depths between 10 and 30 cm, the roads are classified as 'accessible for emergency traffic' (yellow). Roads with water depths of 30 cm and more are "impassable" (red).



Population group

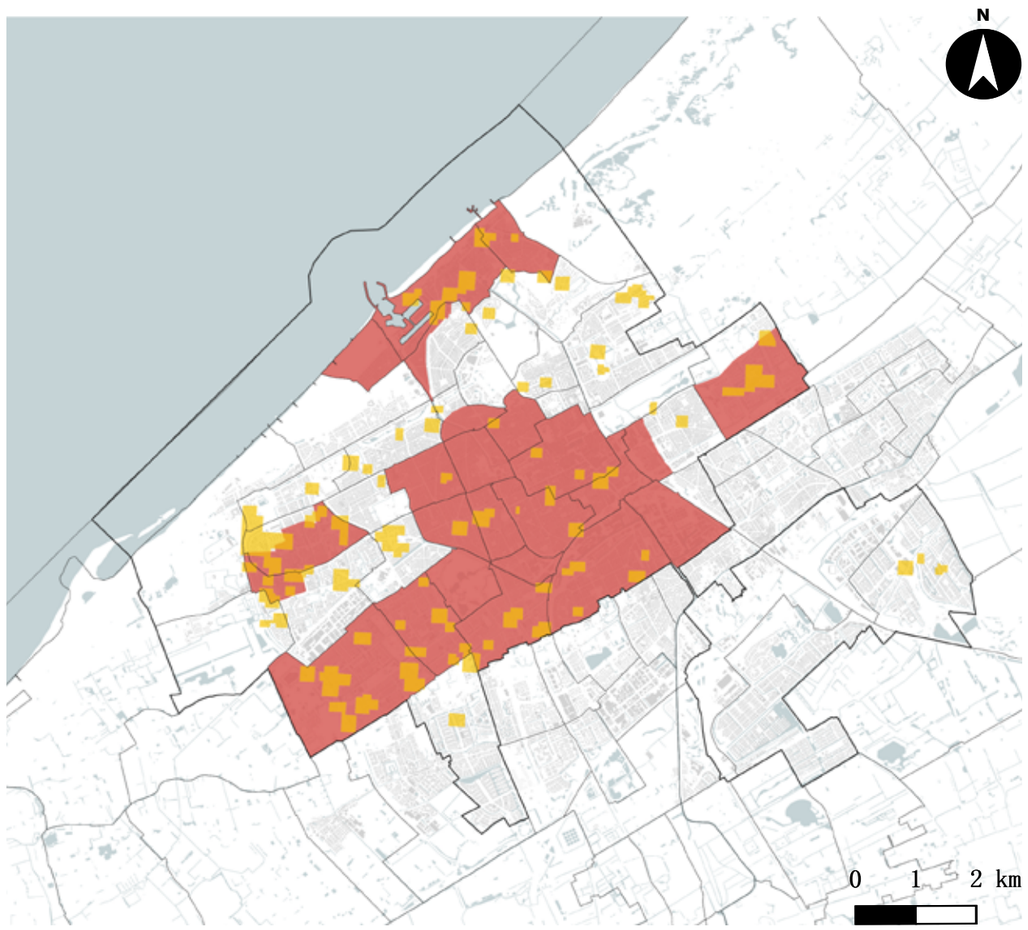
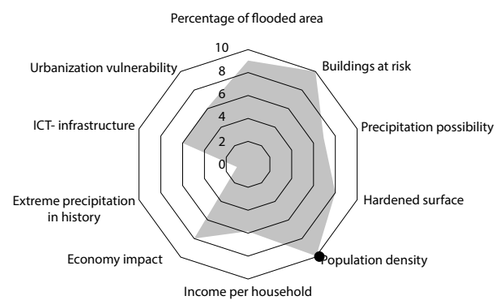


Figure 44: Vulnerable groups (made by author, data source: CBS)

The vulnerable groups in the extreme precipitation flood scenario are identified as groups with low ability of adapting to hazards or will even suffer from the lose of well-beings. Therefore, the vulnerable group map located two groups in the city which are regarded as vulnerable: elderly, people suffer from proverty. They are considered as with low ability of adaptation due to their well-being or finicial situation.



Conclusion

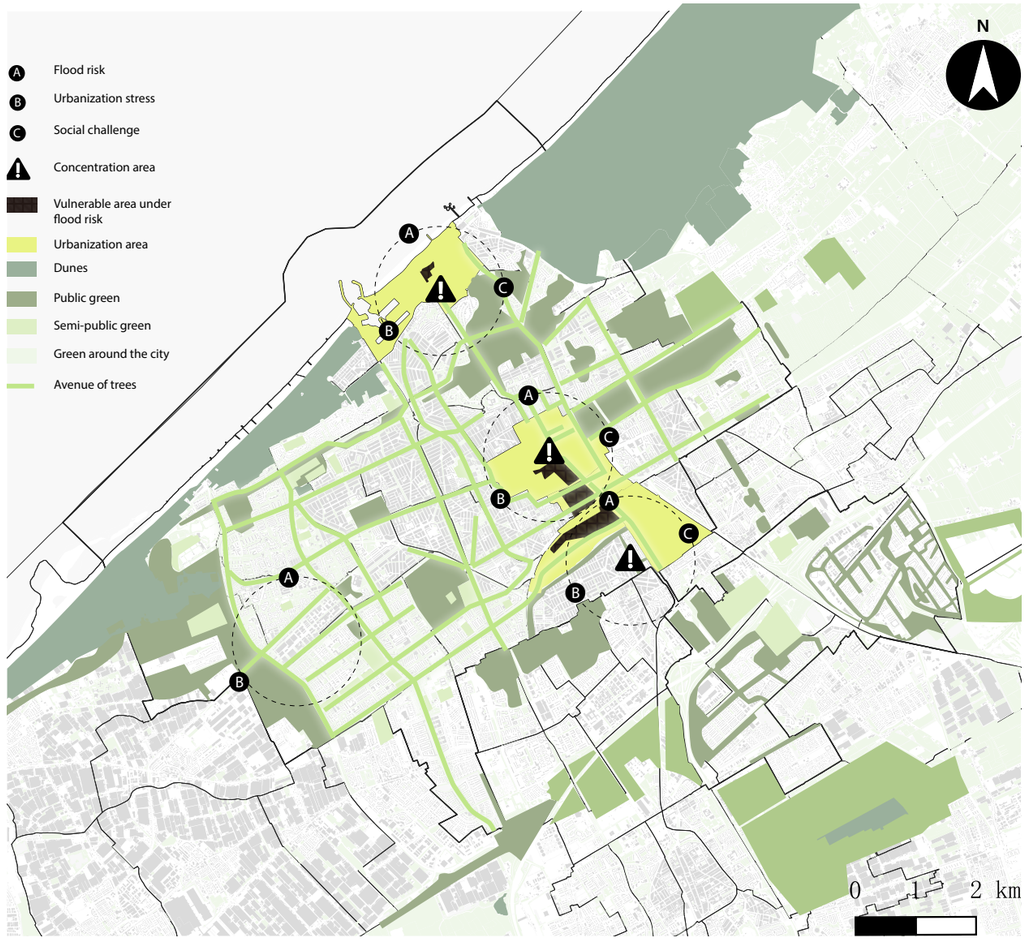


Figure 45: Conclusion map (made by author, 2020)

The Hague is faced with challenges of climate, spatial and social aspects at the same time. It is a city that is growing with growing vulnerabilities and the risk is distributed in the city unevenly. As a complex system, the urban functions in the city is highly connected. Without the proper precautions, a disruption of one service can lead to failure in other services and eventually lead to greater damage to the city. Therefore, the mappings are for understanding what and where are the vulnerabilities in the city. With the use of a layered approach, it helps to overlay the selected vulnerabilities in 70 mm per hour scenarios for determining areas that are most susceptible of the extreme conditions and therefore at risk. The problems are divided into four pillars: urban challenges, water challenges, social challenges and the environment challengs (liveability). A resilient city requires the adpative ability of different scales of communities and can eventually be beneficial for the whole city. Therefore, by taking the climate adaptation and urban development goal into consideration, the city can be divided into four typologies, which are: densification semi-open city, renewal dense city, densification dense city and semi-open rainproof city.

Scheveningen, Centrum, Laakhaven and Southwest are chosen for representing those four different typologies.

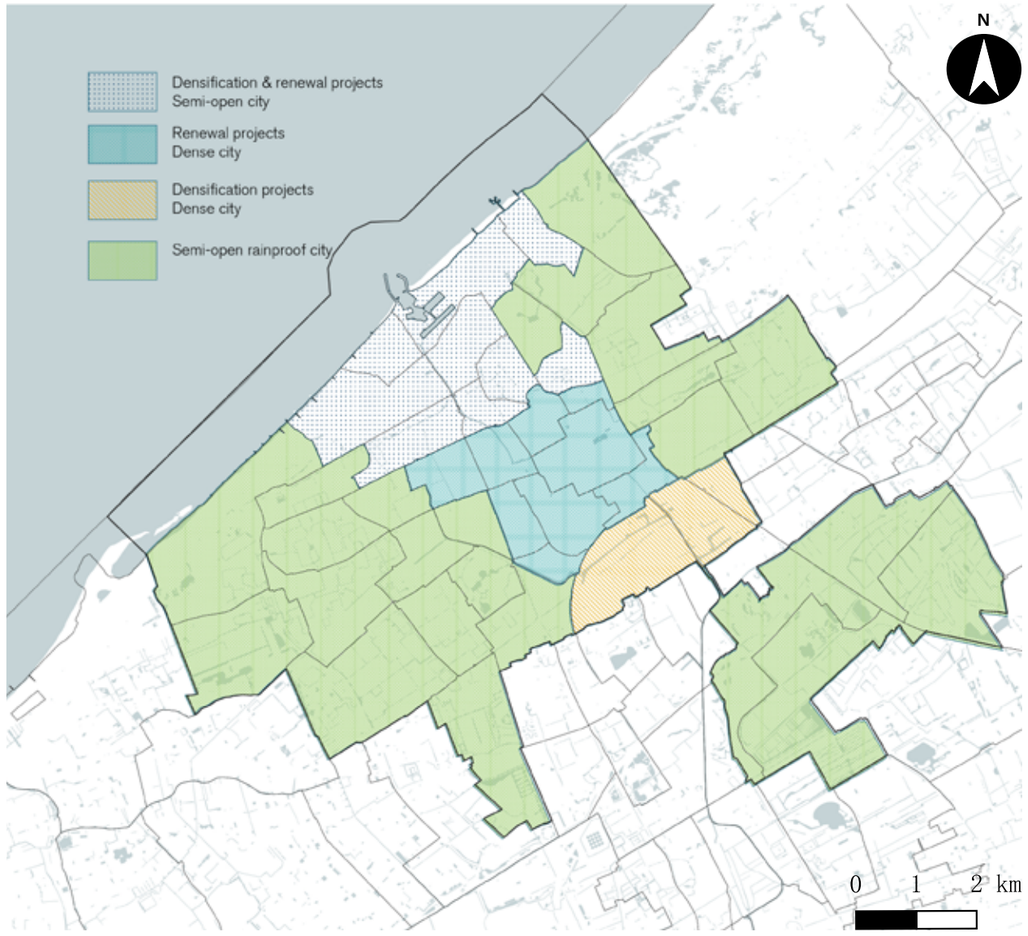


Figure 46: Four research typologies of the neighborhoods in The Hague (made by author, 2020)

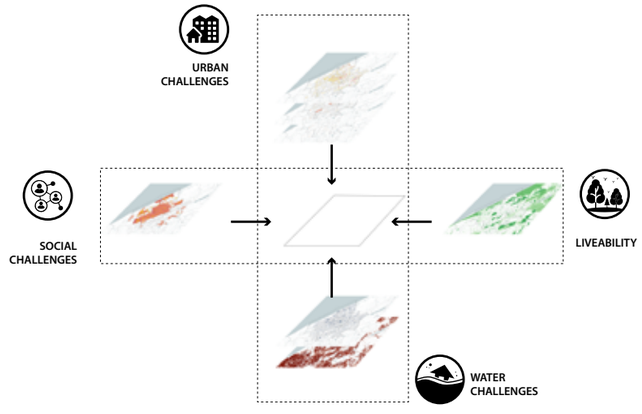


Figure 47: Four pillars of the challenge (made by author, 2020)

Neighborhood typologies analysis

The sections on the right show the spatial context of four different neighborhood typologies of The Hague. Scheveningen, Centrum, Laakhaven and Southwest are chosen for representing the four typologies.

The sections show the consideration of different layers of the urban system: subsoil, housing typology and public space typology. By showing those layers as an intergrated system, the sections show the water cycle and the bottlenecks of the current urban system when faced with the extreme precipitation.

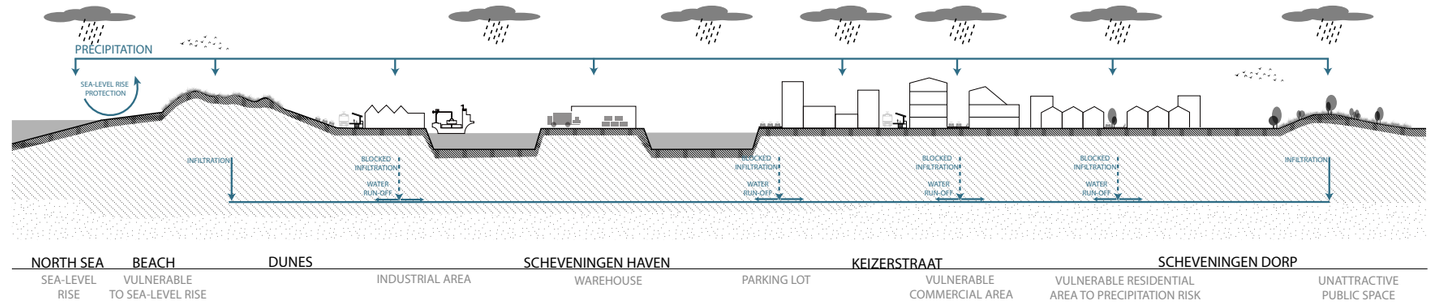


Figure 48: Sechevening section east-west direction (made by author, 2020)

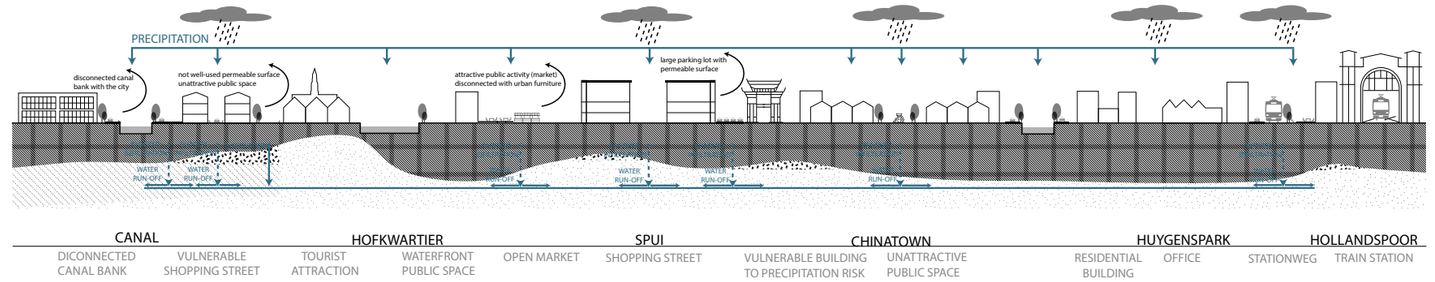


Figure 49: Centrum section east-west direction (made by author, 2020)

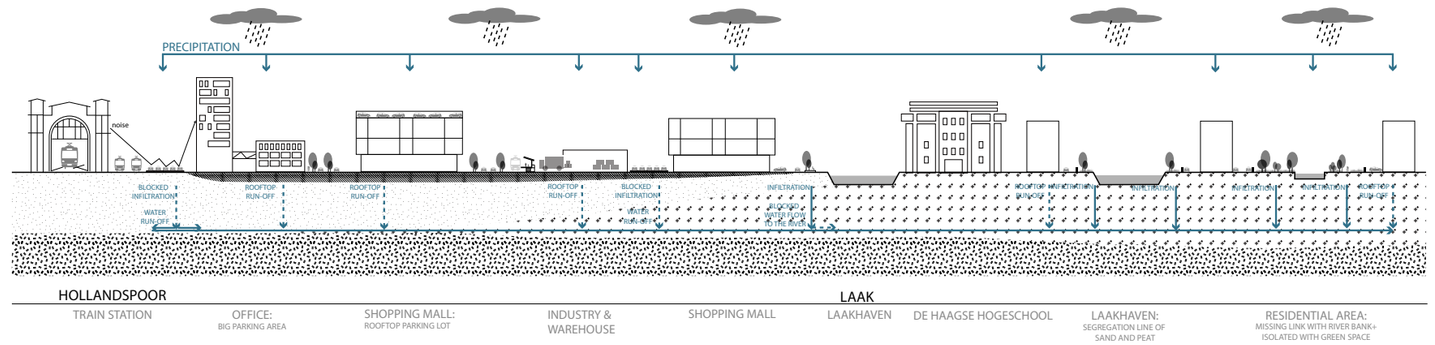


Figure 50: Laakhaven section east-west direction (made by author, 2020)

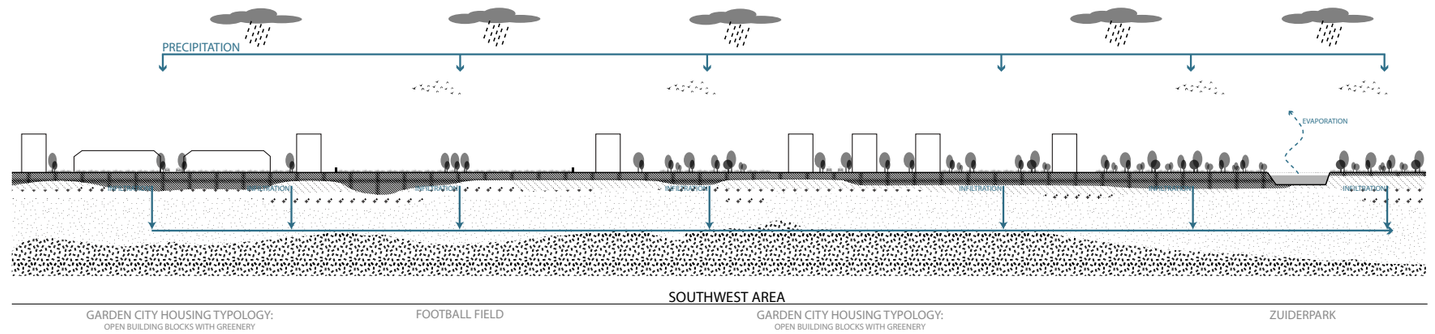


Figure 51: Southwest area section east-west direction (made by author, 2020)

Governance structure analysis

Water management in the Netherlands is regarded as a responsibilitiy shared by public authorities, government and public administrative bodies. As the Netherlands is a decentralized unitary state, the water management implementation is also decentralized from both territorial and functional perspective. While provinces and municipalities takes the responsibilities of territorial functions, functional administrative bodies are responsible for more specific tasks (OECD, 2014). At the national level, different governmental levels share responsibilities of flood risk management. Focusing on spatial planning level, they developed the National Adaptation Strategy and the Delta Programme as climate adaptation strategies. They provide guiding principles for next level. However, when it comes to adaptation of precipitation flood, due to the scale of the problem, currently, the responsibility is shared by local municipality at territorial level and regional water authorities at functional level, which is the project scope.

Zooming into the city of The Hague, the collaboration of local residents and communties is essential at territorial level as 60% of the land is privately owned. Therefore, the primary stakeholders in the water mangement and urban development process are identified below:

The municipality of The Hague:

The municipality is in charge of spatial planning at local level, dealing with sewerage collection system. Urban drainage and stormwater collection in urban areas. It is required to take water management into account in the spatial planning decisions. Throught coordination with regional water authorities, it carries out tasks with its own instruments (Municipality Act).

Water authorities:

The water authorities such as Deltares and Engineering Agency The Hague play important roles in the water management process with functional supports.

Local residents and communities:

Dealing with water run-off is also a shared responsibility of municipality and residents as some approaches such as separating sewerage system might involve private property and maintaining their own land is also a responsibility of residents themselves.

In the current governance model, the main responsibilities and investments are taken by the municipality and IPW and RWZI provide technical supports for the projects. However, most of these investments can only be implemented in public owned space. As large amount of land in The Hague is private owned, although there's already some attempts for collborating with local residents, the power and responsibilities of local residents is still not involved in the current governance model. This shows the most vulnerability of the current system. By analysing the existing governance structure and the involved stakeholders can help to find out the vulnerabilities of the current system and provide references for building up new models.

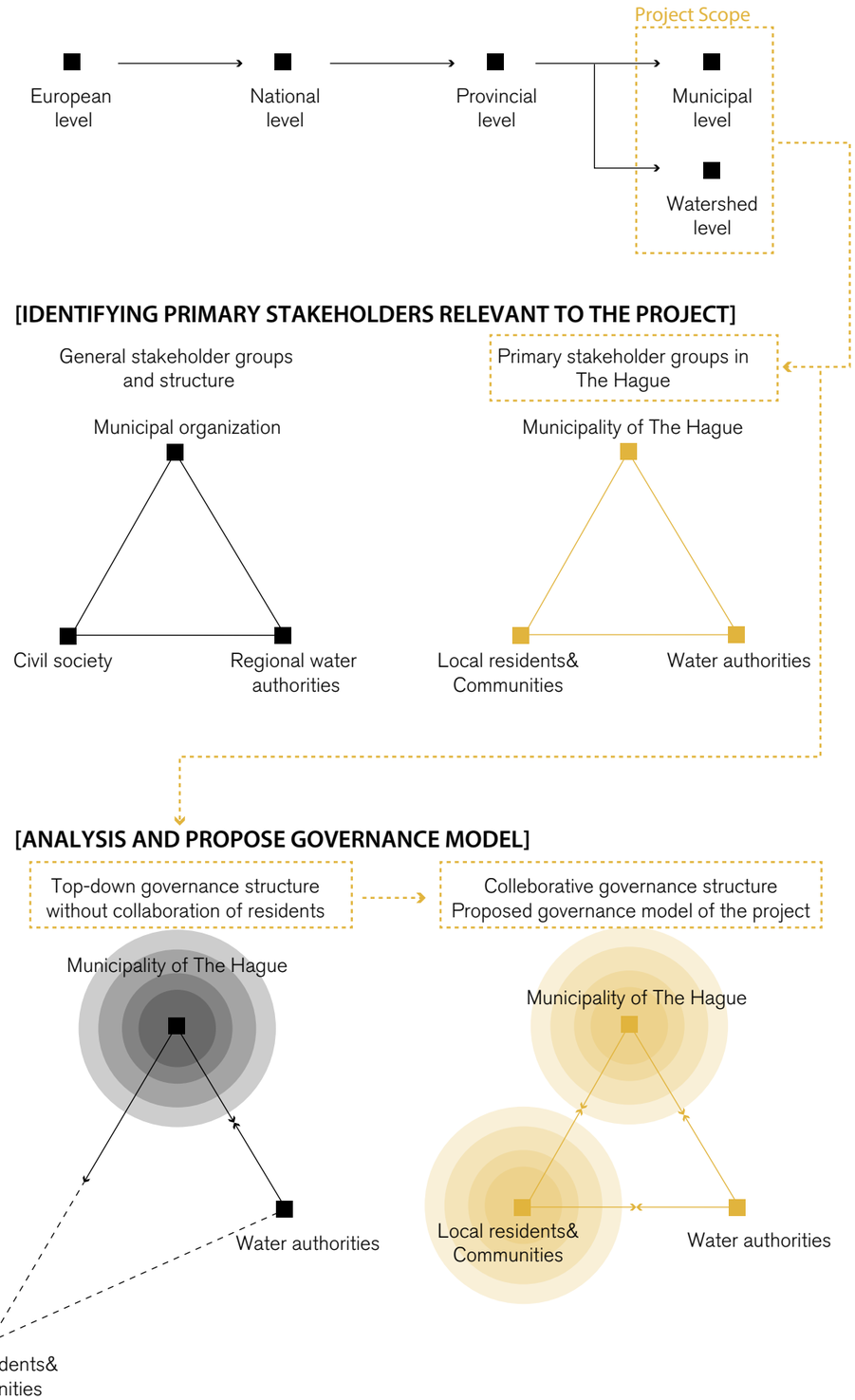


Figure 52: Governance analysis (made by author, 2020)

Stakeholder analysis

Stakeholders involved in climate and spatial resilience management

As elaborated in the methodology chapter, the primary stakeholders of the project are the municipality of The Hague, water authorities such as Deltares and local residents and communities. In the following diagram shows the stakeholders involved in the different stages of technical and spatial management. Based on the identification of different stakeholder groups across sectors, the analysis can be used for analysing their power and interest.

Steps in climate and spatial resilience management	Stakeholders	Stakeholder Group
Identify vulnerable areas under climate and spatial challenges	Resilient The Hague (RTH) Safety Region Haaglanden Municipality of The Hague	Public sector/ Municipality and organizations
	Dunea District Water Control Board of Delfland (HHD) Deltares Municipality of The Hague: 3Di	Public sector/ Water authorities
		Private sector/ Local residents and communities
Public land and drainage system mangement	Municipality of The Hague: Department of City Management (DSB), Engineering Agency The Hague (IbDH), Department of Civilian Affairs (DPZ) Department of Urban Development (DSO) Department of Project Mangement of The Hague (PmDH) Resilient The Hague (RTH)	Public sector/ Municipality and organizations
	Municipality of The Hague:District Water Control Board of Delfland (HHD), 3Di Deltares	Public sector/ Water authorities
		Private sector/ Local residents and communities
Policy-making for involving community collaboration	Municipality of The Hague: Department of City Management (DSB), Department of Civilian Affairs (DPZ) Strategy, Framework Development, Purchase (SKI)	Public sector/ Municipality and organizations
		Public sector/ Water authorities
	residents, community initiatives, property owners	Private sector/ Local residents and communities
Integrate resilience and climate adaptation at private properties	Municipality of The Hague: Department of City Management (DSB), Department of Civilian Affairs (DPZ) Resilient The Hague (RTH)	Public sector/ Municipality and organizations
		Public sector/ Water authorities
	Housing cooperations residents, community initiatives, property owners	Private sector/ Local residents and communities

Figure 53: Stakeholder analysis (made by author, 2020)

Power-interest matrix analysis

The interests and influence of the stakeholders are analysed for coming up with interventions based on the motives of the stakeholder groups. The current relationships of different actors are shown in the Power- Interest matrix. Based on this, desired future collaborations can be identified. The inferences gained from stakeholder analysis is essential for policy-making and the implementation of spatial design.

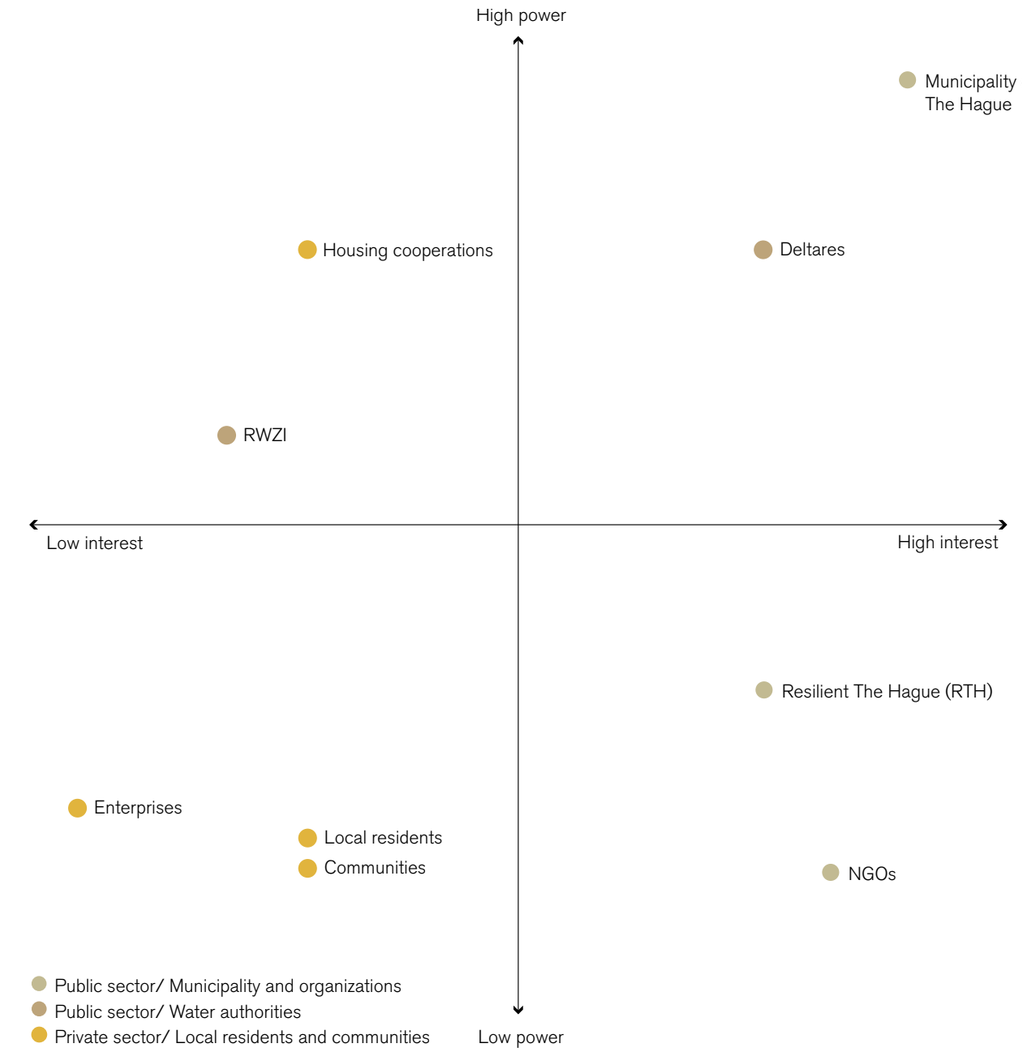


Figure 54: Power-interest matrix (made by author, 2020)

Chapter

6

VISION

The Hague 2050:
A Resilient future

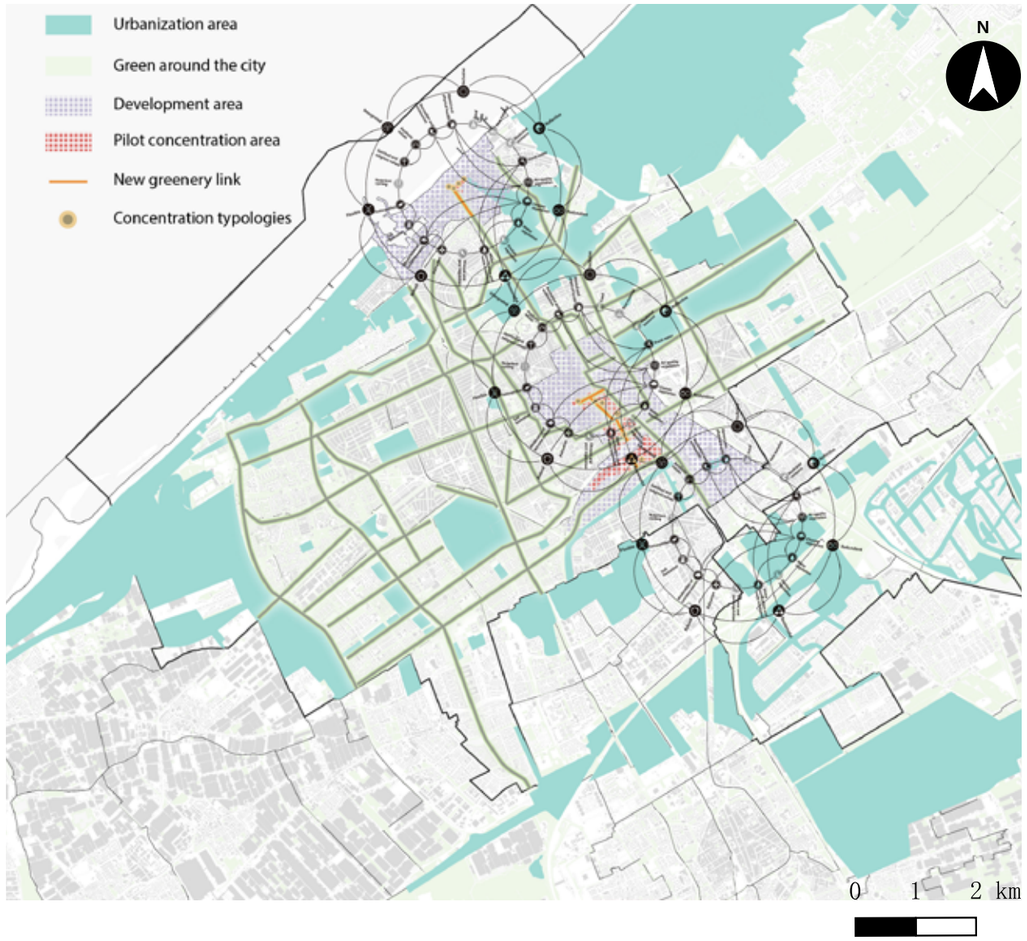


Figure 55: Development vision for The Hague 2050 (made by author, 2020)

In 2050 the city of The Hague will become a more resilient city with adaptive living environments and empowered and cohesive communities through the investment of public space. To ensure a systematic adaptation approach for the integrated challenges, public space will play the role of a platform to intergrate technical, sptatial and social management pathways. Therefore, the most vulnerable clusters of The Hague under the threat- Scheveningen, Centrum and Laakhaven will be taken as pilot research areas. While they also play important roles in urban function, the pilot investment can ensure the normal operation of urban functions will not be affected by a loophole in these areas. On the other hand, as these areas also have diverse communities and will be the focus of urban development, the investment can also provide a better living environment for the residents and more cohesive neighborhoods for the newcomers. Moreover, the homogeneous public space and gradually be improved and enhance the missing links in the city with the surrouding greeneries and offer spaces for the biodiversity, enhance urban resilience and make it more attractive for recreational and cultural functions.

This vision map shows the synergy between different public spaces in the pilot areas and also between the pilot areas and the green network.

Proposed values

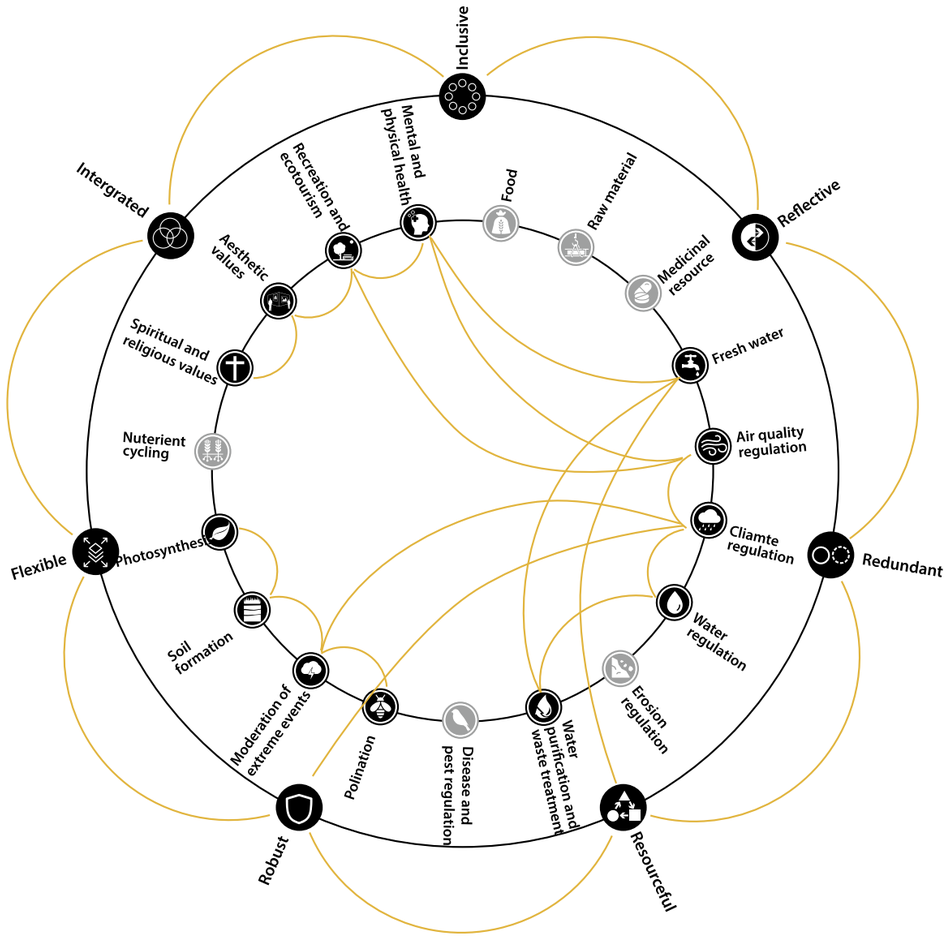


Figure 56: Proposed value for The Hague 2050 (made by author, 2020)

For achieving the goal of urban resilience and climate adaptation by 2050, the proposed vision must be able to provide corresponding value.

The framework aims to show the values can be provided by the proposed vision and their relationships with the qualities of urban resilience.

The values are measured by ecosystem services, which are the benefits people obtain from ecosystems. Combined with green-blue infrastrucuture, the public space design can not only provide regulating services, which can increase the rainwater adaptation capacity of the city, but also brings additional provisioning and cultural services. The black circles show the services can be provided by this project.

The next step is to test the interrelation between those services and urban resilience qualities. The qualities can help to distinguish a resilient city from the ones that are simply liveable or sustainable (Arup, 2015). With the spatial and governance management approaches, the project can achieve the systematic collaboration and empowers people, so that it meets the qualities of urban resilience.

The Hague 2050:
Designing principles

The city is a complex system which will prone to the effect of extreme precipitation events. Using green-blue infrastructures as adaptation measure to address the risk of flood brought by precipitation, inventations at neighbourhood, street and building level need to be matched to the characteristics of the area, rather than applying a single model and expects it to match all the situations. Therefore, for coming up with the adaptation strategy, three layers in the urban system are taken into consideration: inhabitant layer, built-up layer and the underground soil layer. According to the different typologies, different design principles are proposed as the following diagram.

	Public space		Densification		Major water and public space management approach			Description
	Urban and public space configuration		Housing typology	Target resident group	Infiltration	Retention	Conveyance	
Typology 1 : Representative area Scheveningen	Waterfront area Residential area			Elderly	Renewal front yard and back yard for rainwater infiltration			Typology 1 area refers to the coastal neighborhoods with both new development area and traditional Dutch neighborhoods. Urban areas are located close to large green space, therefore it provides opportunities for management the water cycle through infiltration approaches.
Typology 2: Representative area Centrum						Redesign public space as water square for rainwater retention		Typology 2 area refers to the historical city core with valuable heritages and buildings and mixed social groups. In this area, greenery is mainly provided by public space and the urban area is not close to large green space. With the construction of the underground public transportation, the main water management approach is chosen as retention.
Typology 3: Representative area Laakhaven				Student Starter			Canal bank management as public space and for rainwater conveyance	Typology 3 area refers to the new development area of the city. In this area, new highrise residential buildings and offices will be built according to the municipal plan. The urban area is close to the canal, which provides an opportunity for water conveyance. Green roof and facade will also be built along with the housing projects.
Typology 4: Representative area Southwest					Using central green space as biological rainwater pond			Typology 4 area refers to the garden city area. In this area, the buildings are located closely to both community gardens and large green spaces. Therefore, it provides an opportunity for using these green spaces as a sponge, by water infiltration and retention.

Figure 57: Designing principle (made by author, 2020)

The Hague 2050:
Designing principles

The sections on the right show how can the designing principles of different neighborhood typologies be adapted in the spatial context.

The management approaches can be divided in two dimensions: (1) the public square and green space (2) the collective space in residential areas such as green roof, green facade and community gardens.

The management approaches are selected based on the subsoil and urban development typologies.

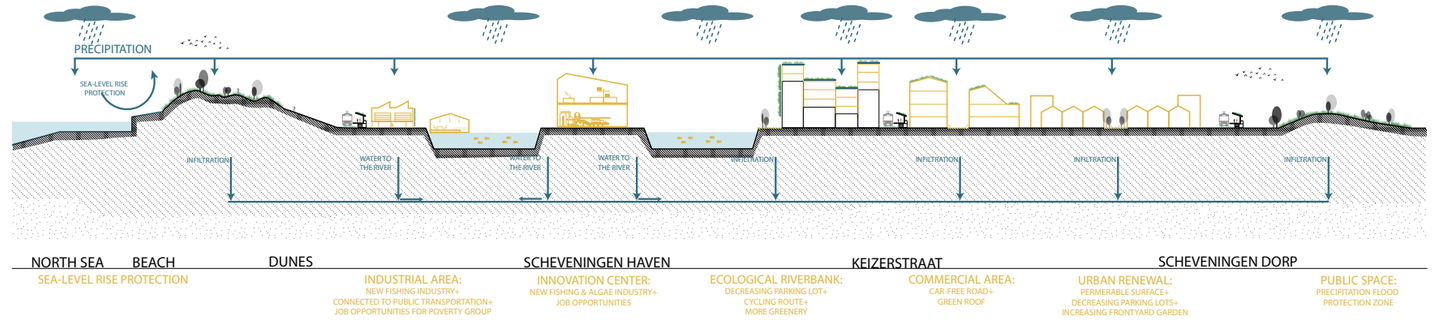


Figure 58: Sechevening section east-west direction (made by author, 2020)

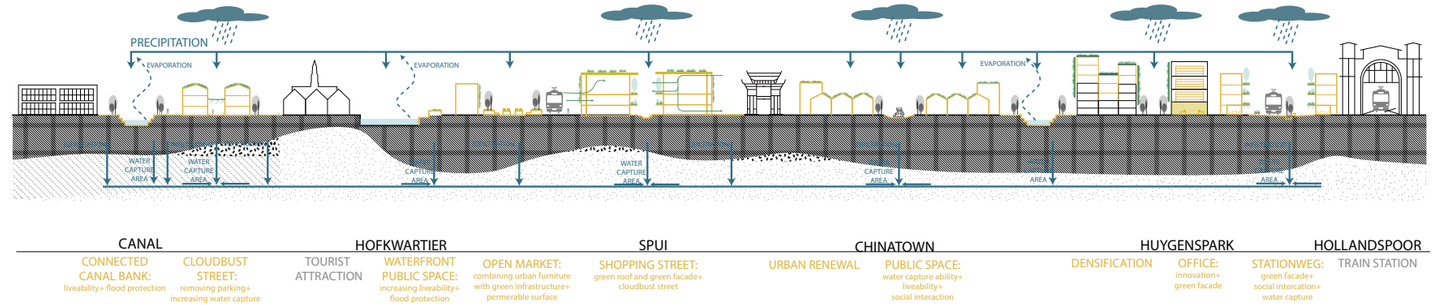


Figure 59: Centrum section east-west direction (made by author, 2020)

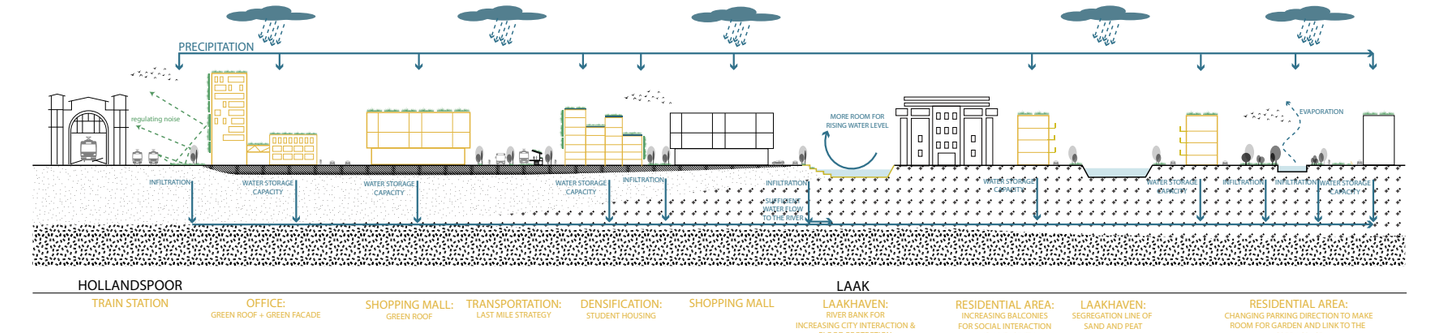


Figure 60: Laakhaven section east-west direction (made by author, 2020)

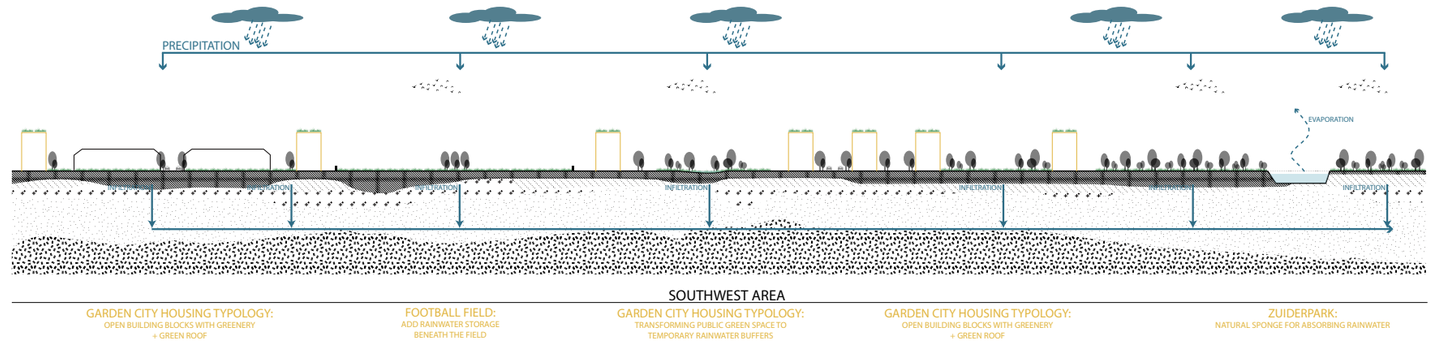


Figure 61: Southwest area section east-west direction (made by author, 2020)

The Hague 2050: An intergrated system

The next step of the project is to look into the three urgent areas, which are Scheveningen, Centrum and Laakhaven. Combined with the proposed designing principles, an intergrated system can be formed.The strategy is divided into three approaches: infiltration in Scheveningen, retention in Centrum and conveyance in Laakhaven.

For Scheveningen, it is better connected with green space. It might also suffer from drought. Therefore, taking these into consideration, the water management strategy is designed as infiltration.

For Centrum and Laakhaven, they both rely on public spaces to provide greenery.

However, due to the different subsoil condition, the adaptation strategies vary in these two areas. In Centrum, the metro lines and underground parking lots contribute to the situation that this area can only rely on water drainage, therefore, taking retention as strategy is for helping to decrease the peak flow to let the water amount not exceed the drainage capacity. In Laakhaven, the public spaces are closer to the large waterbody-Laak River, therefore, connecting the public space to the river can provide the opportunity of conveyancing the water to the river to prevent the flood.

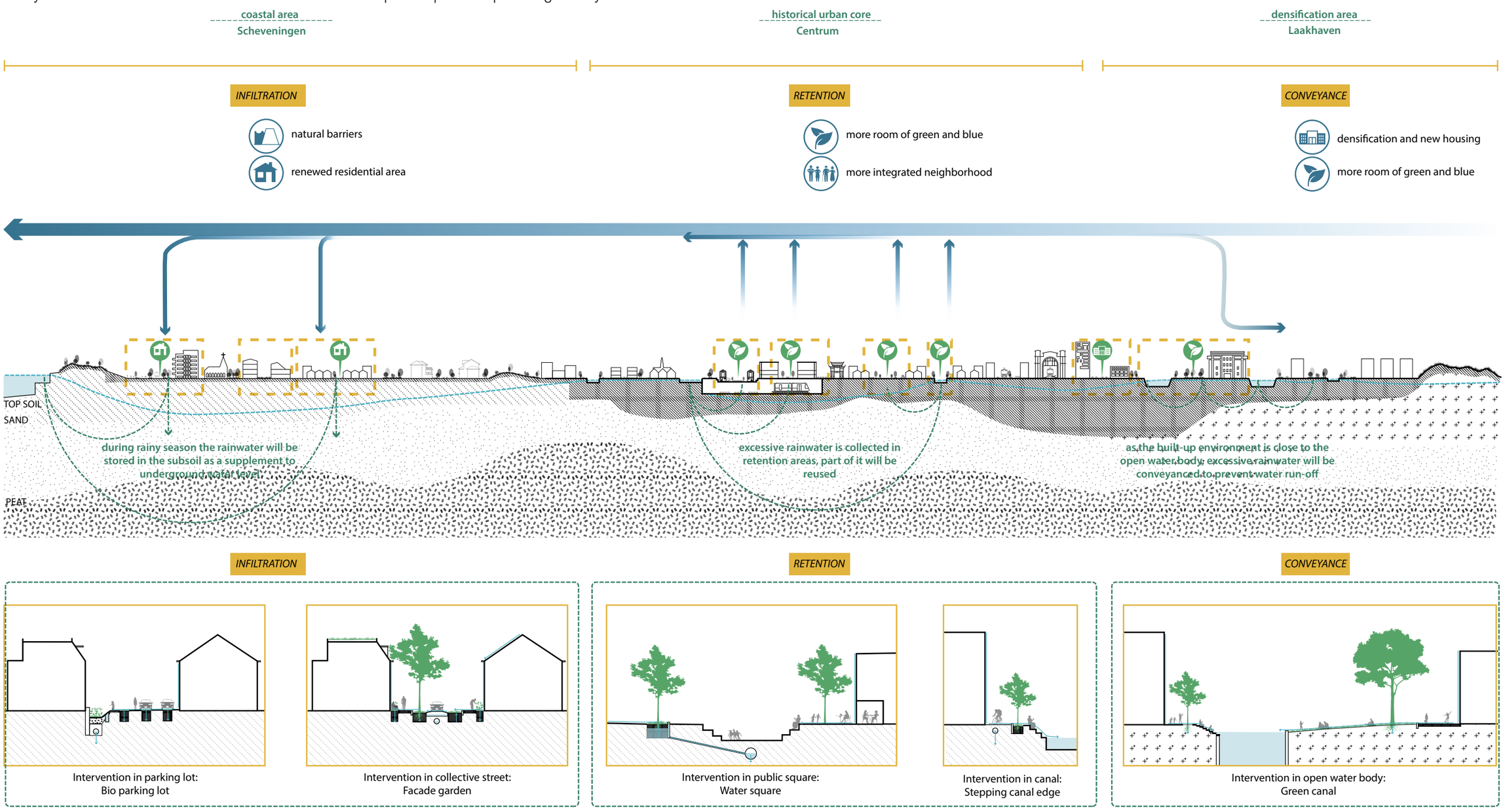


Figure 62: Development vision for The Hague 2050 (made by author, data source: Dinoloket)

Test area 1: Scheveningen

Figure 63: Site location (source: google map)

Test area 1 is located in the Scheveningen Dorp area. In this area, the vulnerable buildings are located in the traditional Dutch neighborhood where the main resident group is elderly.

The water management approach in this area is infiltration through public space. As the built-up area is located close to the large green space, those green spaces can be used as central sponge for water infiltration. By redesigning the paved surface such as parking lot and neighborhood streets as bio parking lot and adding community gardens on the streets, the total amount of impermeable surface will be decreased and the water infiltration process can be improved. Therefore, the total amount of exceed water will be decreased, so that the rainwater flood can be prevented.

By linking the redesigned areas with the central sponge area, a network for adapting rainwater can be established while enhancing the greenery link in the neighborhood and provide a better living environment for the residents.

Figure 64: Test area management structure (made by author, 2020)

Test area 2: Centrum

Figure 65: Site location (source: google map)

Test area 2 is Centrum. As a historical core of the city, this area is well-developed with valuable cultural heritages and historical buildings, which are vulnerable to the rainwater flood.

In this area, the ground surface is mainly paved due to the urban development process, and the green space is mainly provided through public space. The underground space is also taken by the public transportation. The public space also works as a structure for linking the neighborhoods and cultural heritages.

Therefore, the water management approach in this area is selected as retention in public space. The public spaces can temporarily store the exceed rainwater in the vulnerable areas to meet the designed drainage capacity of grey infrastructure, so that the risk of rainwater flood can be decreased.

The public spaces can also enhance the socio-cultural and ecological link in this area to provide better liveability for the residents.

Figure 66: Test area management structure (made by author, 2020)

Test area 3: Laakhaven

Figure 67: Site location (source: google map)

Test area 3 is located in Laakhaven. This area is a new development area with the vision of being a student city. With many newly built highrise office and residential buildings, the main resident groups are students and technical migrants. Therefore, a lively living environment is essential for the social coherence.

As the built-up environment is located close to the large waterbody-Laak, the rainwater management approach can be linked with construction of green roof and facade and later conveyance to the canal.

As this area is still in the process of densification and renewal projects, the adaptation process can collaborate with the construction programs for avoiding repeat investment of the same area.

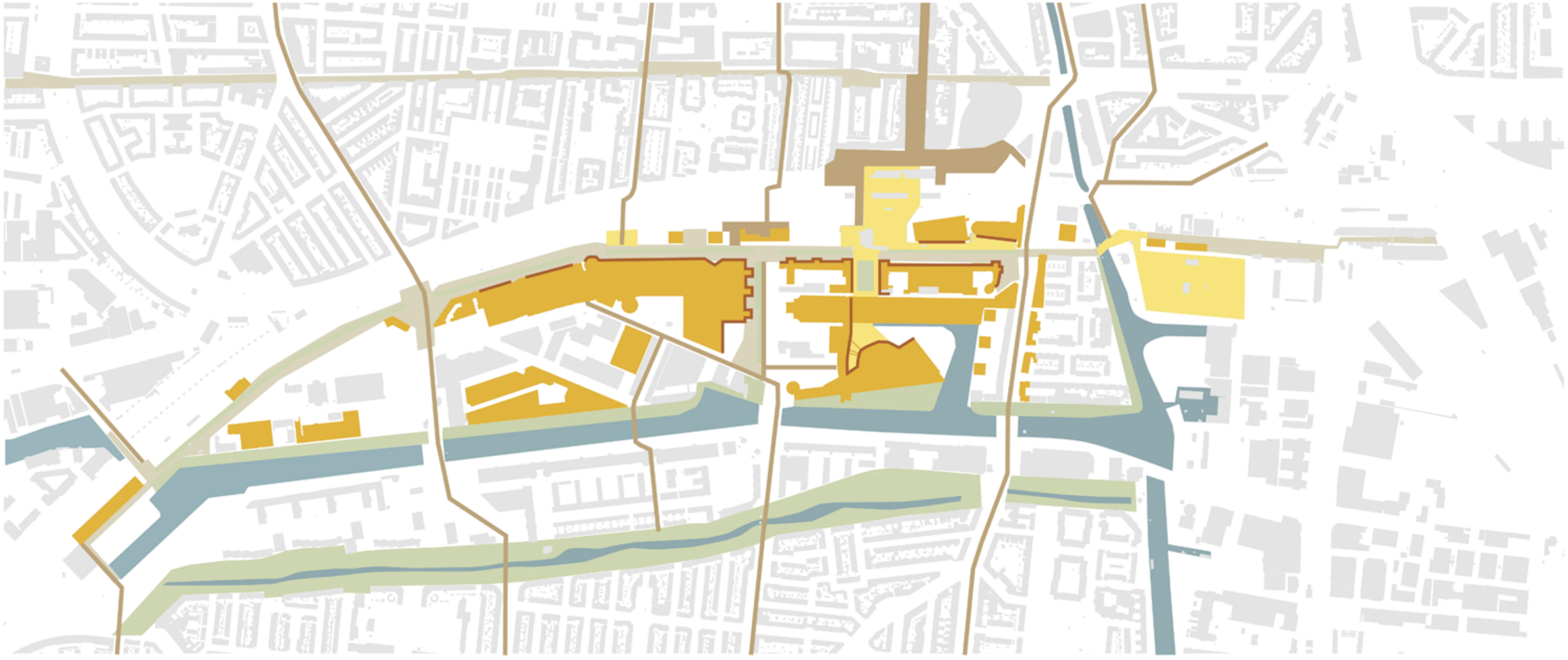


Figure 68: Test area management structure (made by author, 2020)

The Hague 2050:
Stakeholder Engagements

The current governance is a top-down dominated structure. According to the research in the methodology chapter, the project scope is focused on the municiple and water shed level of governance. The most responsibilities and power are concentrated in the municipality of The Hague and shared between different departments. The water authorities can also let their voices be heard and provide technical support. However, this structure is unstable because a very important group of stakeholders- the local residents and communties are not involved into the policy-making. They're now only passively involved in this process. As 60% of the land is privately owned in The Hague, this might hinder the implementation of the adapation approach and arouse complaints of the public.

Nowadays, the governance comes to a stage that need a transition from the top-down dominated structure to a collective structure with both top-down and bottom-up investment. The project aims to contribute to empowering local residents and communities and achieving a more stable collective governance structure.

The project evaluates the performance of the the contribution of the project- collaborative governance structure by highlighting some of the main transformantions in relationships between stakeholders after the implementation of the project.

Public sector/ Municipality and organizations:
1. Improved inter-departmental collaboration between spatial management, engineering agency and civilian affairs and invovement of water management in spatial governance and decision-making
2. More financial and administrative support for bottom-up initiatives from the local residents and communities

Public sector/ Water authorities:
1. Increased technical and knowledge support for private sectors

Private sector/ Local residents and communities:
1. Empowered residents and communities and increased participation of individuals and communities
2. More opportunities for participating in decision-making process due to the contribution to resilience
3. The collaboration between public and private sectors increase the resilience and adaptation ability of local communities

The second contribution of the project is proposing new governance structure by defining critical areas for collaboration between sptial, techinical and social governance. The project defines five stages where climate and civilian management tools aer integrated in spatial development approaches to ensure that the development approaches follow the values defined in the vision. The first figure shows the exisiting model of urban developmen and defines the critical points of intergration between climate and spatial governance. The five points represent ways in which spatial planning knowledge can enrich climate development and improve collaboration of local residents and communities and empower individuals in The Hague:

1. Development of strategic plan: The strategic plan brought up by the municipality of The Hague will be the guiding document for ahieving resilience in the city.

2. Feasibility assessment: Before the approved projects are tendered for development, the vulnerability of the chosen site must be tested according to the vulnerability research.

3. Consideration of land use regulations and local community well-beings: Strict measures need to be taken to ensure that the construction of the project in the land can follow the regulations of land use and the well-being of local community.

4. Collaboration between municipality, water authorities and local residents: This is a very important step of the improvement of the governance structure and empowering individuals. This step aims to creat platforms for community participationin the decision-making and development process and to equip the residents with necessary knowledge.

5. Evaluation: After the completion of the process, regular spatial impact assessment studies are made to inform future projects and improve the quality of performance.

These five steps for the integration of climate and social management in urban development shows how the loopholes between these fields can be fixed.

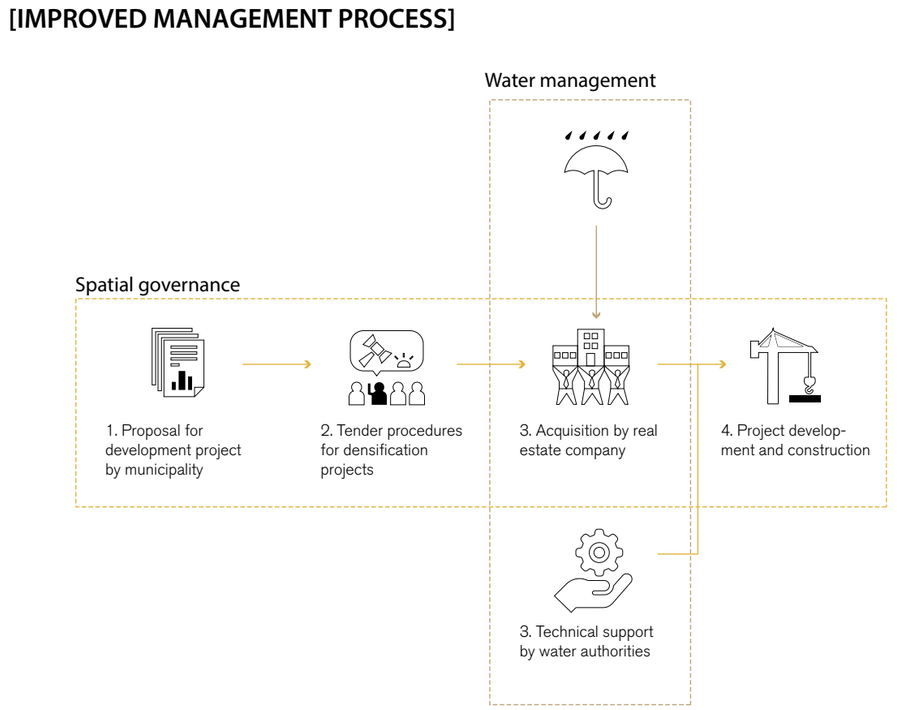


Figure 69: Proposed governance structure (made by author, data source: Dinoloket)

Chapter

7

PILOT PROJECT

Pilot location: Centrum

Historical perspective: De Kern Gezond

As a representative area of the historical core, Centrum is a well-developed and dense area with valuable heritages. It is also an area whose development is closely linked with public space design.

In 1987, the 'De Kern Gezond' plan was designed as a masterplan for the redevelopment of the city center in The Hague. The concept was based on five linear landscape atmospheres. Each atmosphere has its own recognizable identity, fusing the city center into one unit. The Heart Line is the center axis that runs from Spui to the Lange Voorhout and connects the other individual linear atmospheres.

However, after years of construction, the Heart Line couldn't successfully create a sense of cohesion anymore. The previous plan is car centric, and it resulted in a wide and unidentified space, creating no sense of place. Therefore, the municipality started a new project in 2016 to enhance the connection between each spatial linear atmosphere's identity. The spatial atmospheric lines are supplemented with five atmospheric areas that form a functional, economic unit. The Heart Line will be transformed into a pedestrian-friendly area; cars and trams are largely diverted.

This provides a backbone for researching how to achieve urban resilience through public space design in this area.

Figure 70: De Kern Gezond, 1987

Figure 71: De Kern Bijzonder, 2016

Challenge

There are five public spaces are taken as pilot projects: Grote Markt, Bijenkorf, Rabbijn Maarsenplein, canal and Stationsweg. On the one hand, they all play an important role in social interactions and carry important cultural backgrounds. On the other hand, they are located in the low point in Centrum, therefore, when extreme precipitation occurs, the water will flow to their directions and they're more easily be flooded.

Figure 72: Observation in Centrum, photos from Google Map street view

Tools

As stated in the stratgy section, the system of a resilient water mangement network in Centrum focuses on the retention of water for delaying and storing stormwater before it ends up in the main drainage pipes to relieve the stress on grey infrastructure.

In order to apply a coherent and applicable water network, a series of integrated tools must be applied. The techincal approaches will combined with ecological and social functions and then eventually become different public spaces design proposals of different pilot sites.

SOCIAL SYSTEM

NATURAL SYSTEM

TECHNICAL SYSTEM

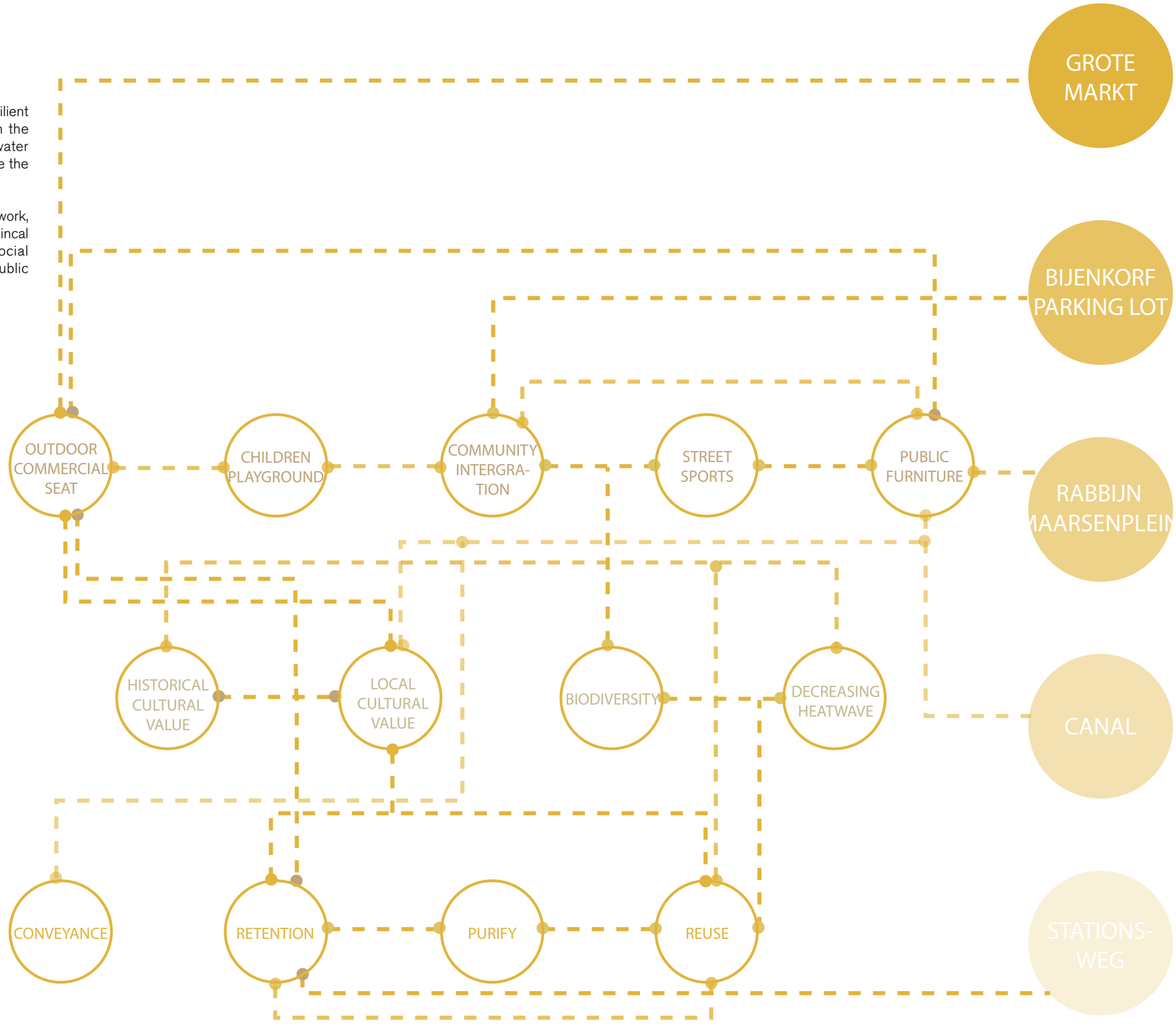


Figure 73: Toolkit (made by author, 2020)

Design vision

Figure 74: Zoom-in areas (made by author, 2020)

Figure 75: Urban water channel (source: https://www.urbangreenbluegrids.com/)

Urban water channel

Urban water channel can not only provide an area for the drainage of stormwater, but also to use the water to form a pleasant landscape in a densed city center. It can also work as a recreational space and provide a cool and airy microclimate.

Figure 76: Skating park (source: pinterest)

Skating park

The skate park combined with surrounding greenery can form a new center for neighborhoods and provide a cool and airy microclimate off from the loud streets. The height distance can also be used for water rentention when extreme precipitation occurs.

Figure 77: Water square (source: De Urbanisten)

Water square

The water square combines water storage with the improvement of the quality of urban public space. The water square can be understood as a twofold strategy. It makes money invested in water storage facilities visible and enjoyable. It also generates opportunities to create environmental quality and identity to central spaces in neighborhoods.

Figure 78: Canal front (source: pinterest)

Canal front

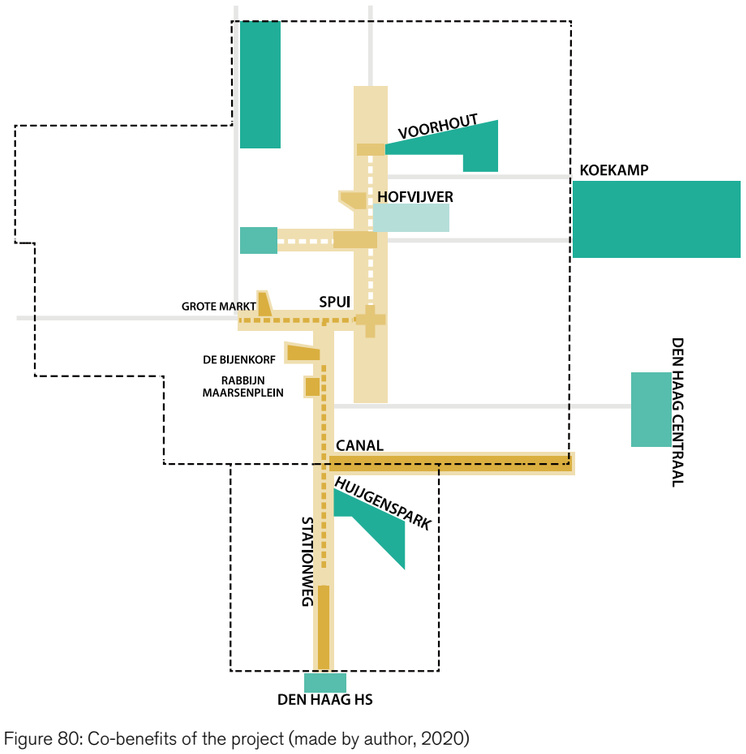
The stepping of the canal edges makes a gradual inundation possible while still maintaining the useability as public space in a dry state. It embraces
the canal as a recreative amenity and gives the city its canals back. The regeneration of the canals offers good development and business opportunities alongside an attractive, public space and offers room for cultural activities.

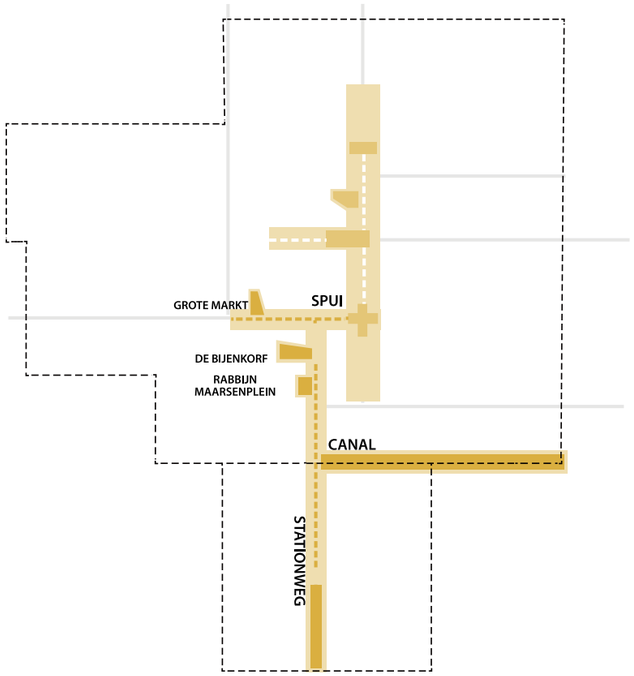
Figure 79: Cloudburst road (source: pinterest)

Cloudburst road

Cloudburst road is established with a combination of stormwater plants and permeable paving in a unique V-shaped profile and raised kerbs to ensure water will flow in the middle of the road, away from the buildings. The green areas can be combined with urban furnitures to provide more urban functions.

Co-benefits of the project





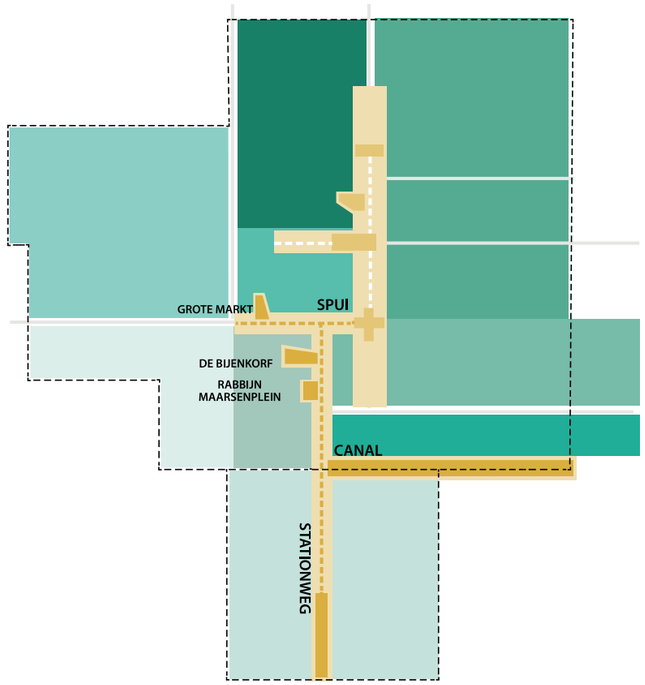


Figure 80: Co-benefits of the project (made by author, 2020)

Healthy living

The Hague is a green city which is surrounded by green spaces and open water. According to the green typology of the city, Centrum belongs to the dense city typology, of which the greenery is mostly the green avenues and public spaces.

On the one hand, the pilot projects are designed with green-blue grids for increasing the adapation of flood, these green-blue grids can also improve the quality of living environment and provide a cool and airy microclimate.

On the other hand, there are some large green areas and parks in Centrum but fragmented located, together with De Kern Bijzonder projects, the pilot projects can form a continous connection of green-blue grids in Centrum. This can help with forming a pathway for increasing biodiversity in the city.

Socio-cultural enhancement

In 1987, the project of De Kern Gezond was designed in The Hague,which is a master plan for the re-design of the city center. The vision is based on five atmospheric lines, each with their own spatial character. The center line connected the different zones. Each atmosphere line was given a recognizable identity, so that the city center was forged into a coherent whole. This line also links the areas with valuable historical backgrounds.

With the rapid urban development, the atmospheric lines become blurry and need to be re-designed. Therefore, in 2016, the project of De Kern Bijzonder was proposed for reconnecting the fragment parts of the inner city.

In respect of that, the pilot projects work as an extention link of the project, which completes the link of different neighborhoods and also links the valuable historical areas in the city.

Equal accessbility to public space

The Hague is an international city which accomdates communities with diverse cultural background. However, this diversity can also result a fragmented neighborhood if there's no platform for these groups to gather together.

The pilot projects extended the link of public spaces. The link connects different neighborhoods of Centrum and provides equal accessibility for the residents of the public services.

Some pilot projects are also located in the edge of different neighborhoods that accomodates various social groups. They can also be a platform between communities of different cultural background to gather together and decrease the segregation between neighborhoods.

Grote Markt

The Grote Markt used be a fruit and vegetable market with the canal of Prinsegracht to make it accessible. Later on, with the construction of the city, the Prinsegracht was filled in along with most other inner canals. From the 1970s, the square turned into an important entertainment area. Nowadays, there is a café in the Boterwaag and many other historic buildings on the square have also received a catering destination, such as the famous café De Zwarte Ruiter. In the summer, the square turns into a large terrace , which is frequently visited not only by local residents but also visitors.

The construction of the underground tram tunnel of The Hague increased the accessibility of Grote Markt but didn't change the character of the square.

Grote Markt is with important historical value and witnessed the development of the city. It always works as a platform for the intergration of different communities from the history to now. Although the historical buildings are successfully combined with new urban functions, the evidence of the existance of a very important canal of the city is fading away.

Faced with unpredictable extreme precipitation, this area is vulnerable and under the risk of being flooded for the following reasons:

(1) Grote Markt is located in the lowest point nearby, therefore when there's a water overflow, the water will flow to this direction and eventually be hoarded here.

(2) The surface of the area is all paved and impermeable, the water can't be infiltrated to the ground but fully rely on drainage system, the current designed capacity can drainage all of the water at the same time.

Due to the socio-cultural importance and the vulnerability of Grote Markt, there's an urgency to look into this area.

Figure 81: Historical scenario (source: google image)

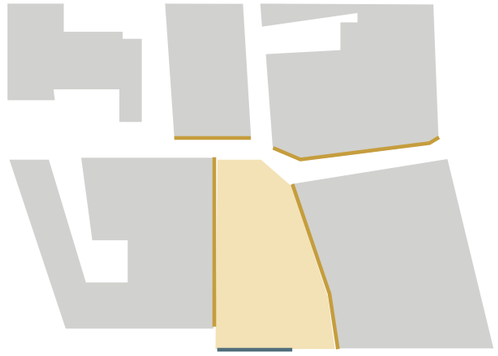
Figure 82: Summer scenario (source: google image)

Figure 83: Winter scenario (source: google image)

Site analysis

Location and service group analysis

The site is surrounded by resturants and cafes, therefore it not only needs to provide functions for commercial usages but also as it lies in the center, it need to provide quick pathways for the accessibility of the shops or for the smooth traffic of this area.



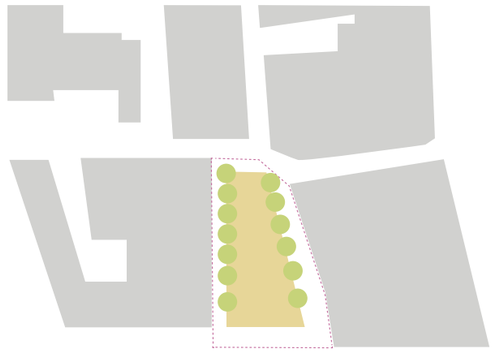
Legend

resturant

transporatation

Exsiting function analysis

The site always acts like a platform for communities to gather together. Nowadays, it become a terrace with multiple usages which vary with the season changes. The most iconic usage of the site is for accomodating outdoor commercial seats during the summer, this will not only interest the local residents but also the tourists. And during the winter, the site will be covered by snow, which makes it a stage for winter related activites, such as placing a Christmas tree or skating.



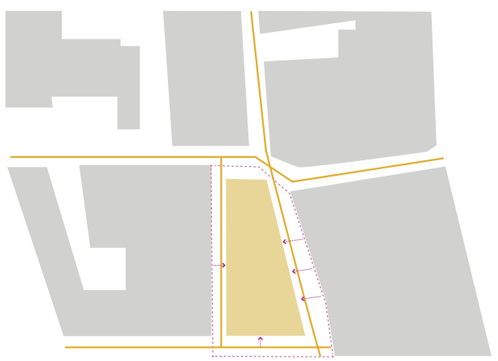
Legend

tree

city terrace

Accessibility analysis

The site need to serve multidimensional mobilities. Firstly, it lies in the center of ground level cafes and resturants, therefore, the sidewalks between the site and the shops need to be clear. What's more, it is also connected with the entrance of the metro station. Therefore, the intersection area need to be clear for the quick pass of the site to get access to the tranportation or for getting into the site.



Legend

sidewalks

entrance from the resturants

Masterplan

By keeping the original function of the site- an urban terrace, the redesign of the Grote Markt combined the original function with urban water channel for not only climate adaptation but also socio-cultural consideration.

The urban water channel is designed in the edge and the surface of the central terrace, and combined with green grids. Choosing to designing urban water channel here is cherish the culture. The site used be linked by the important inner city canal of Centrum-Prinsegracht. However, the evidence of the canal existed in the area has faded away during the rapid urban development process. By designing urban water channels here, it can show the relationship of the water and the site again.

It can also bring socio-ecological benefits for the site.

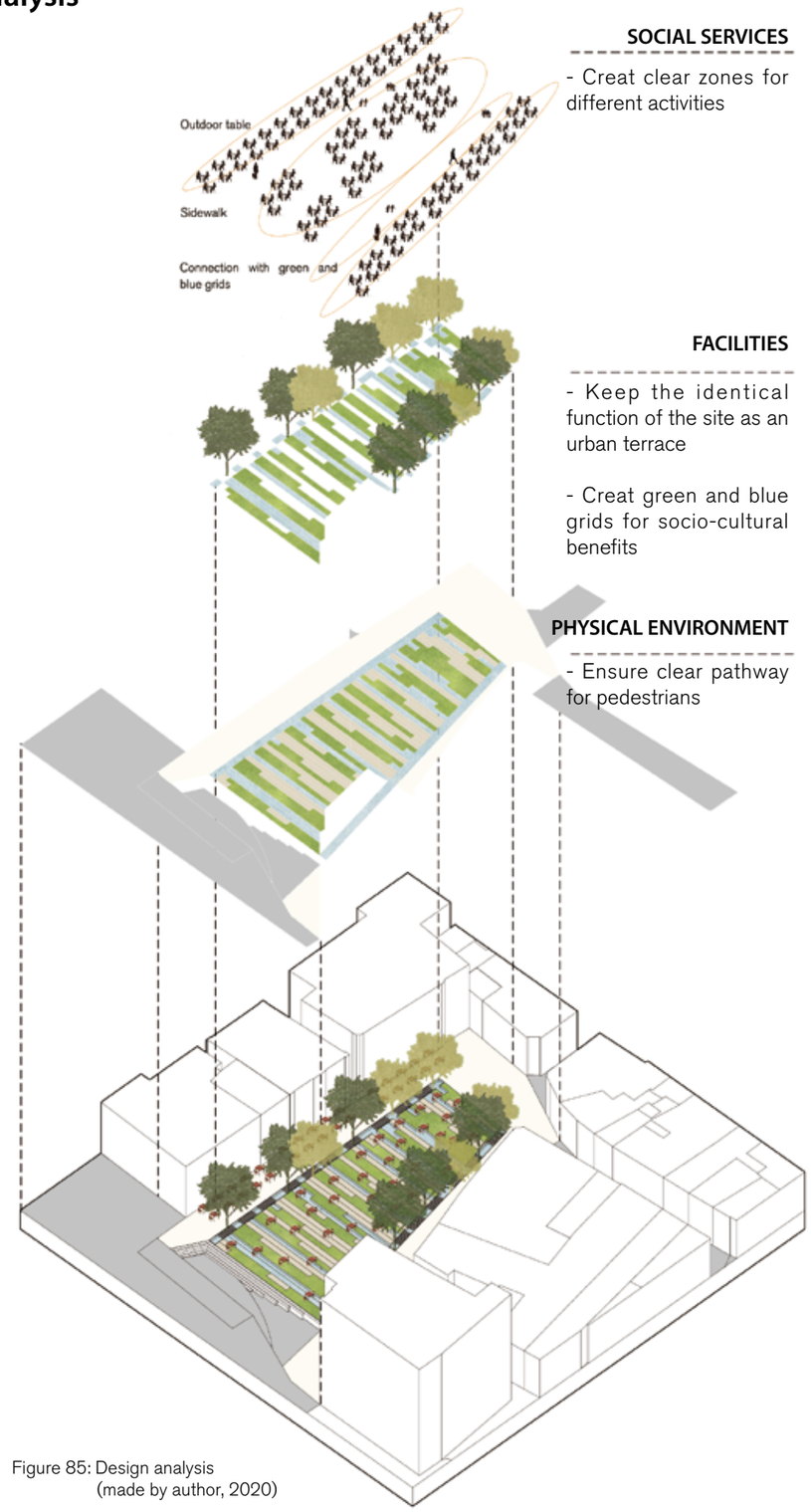
The green and blue grids can enhance the greenery link in the inner city. What's more, it also increases recreational functions of the site and forms a more pleasant visual intersection between the central terrace area and the sidewalks.

The collected water can also be used for improving microclimate. During seasons with high tempretures, the urban water channel can help with cooling down the site and the plants can provide shades.

1 Urban water channel
2 Urban terrace

Figure 84: Masterplan (made by author, 2020)

Design analysis



SOCIAL SERVICES

- Creat clear zones for different activities

FACILITIES

- Keep the identical function of the site as an urban terrace

- Creat green and blue grids for socio-cultural benefits

PHYSICAL ENVIRONMENT

- Ensure clear pathway for pedestrians

Figure 85: Design analysis
(made by author, 2020)

Technical profile

For adding precipitation adaptation capacity, the site designed urban water channel with an underground water tank. The design can not only ensure the security and the accessibility of the site during extreme rainfall events, but also form a more sustainable water cycle.

The following sections show the water management approaches of the site.

Extreme precipitation scenario

As the site is located in the lowest point in the surrounding area, during the extreme precipitation, extra rainwater will flow to the site.

They will firstly flow to the urban water channels in the edge and the fill the branches on the surface of the site. After that, the rainwater will be collected in the water tank under the central terrace for reuse.

Therefore, the security of the properties and the accessibility of the site can be ensured.

Daily use scenario

In sunny days, the central terrace will be filled with outdoor commercial seats. The water collected in the water tank will be reused for refilling the urban water channels. The channels will be covered by a transparent material, therefore the water can be seen while the site can be used. On the one hand, the water can be used for cultural memorizing. On the other hand, the water can help with cooling down the tempreture during heat waves in the summer to improve microclimate of the site.

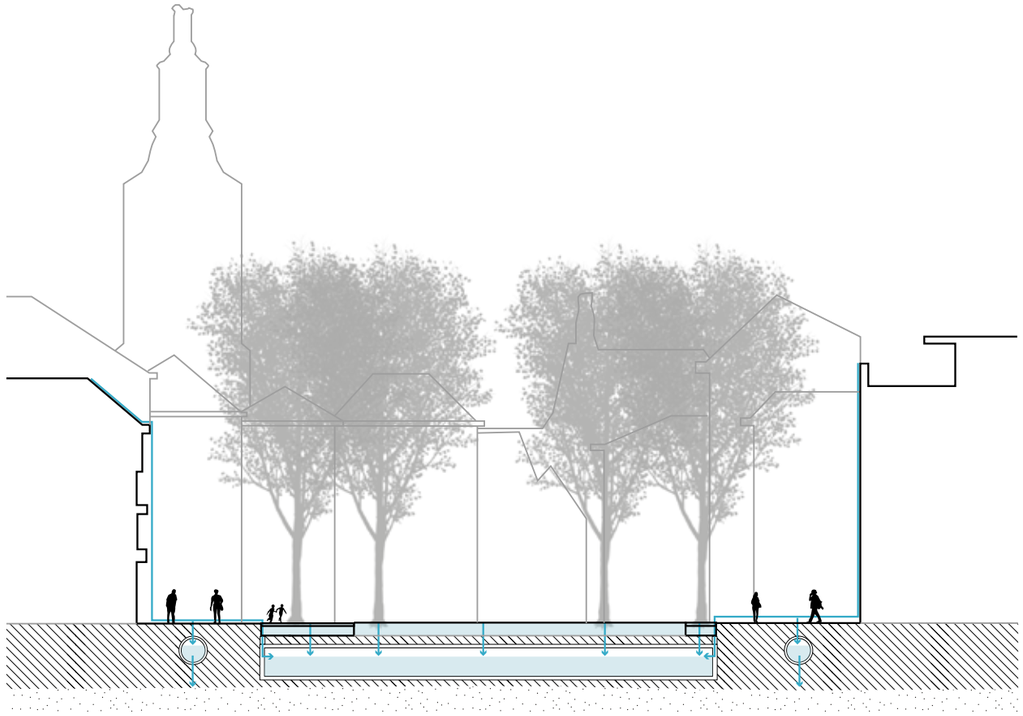


Figure 86: Extreme precipitation scenario section (made by author, 2020)

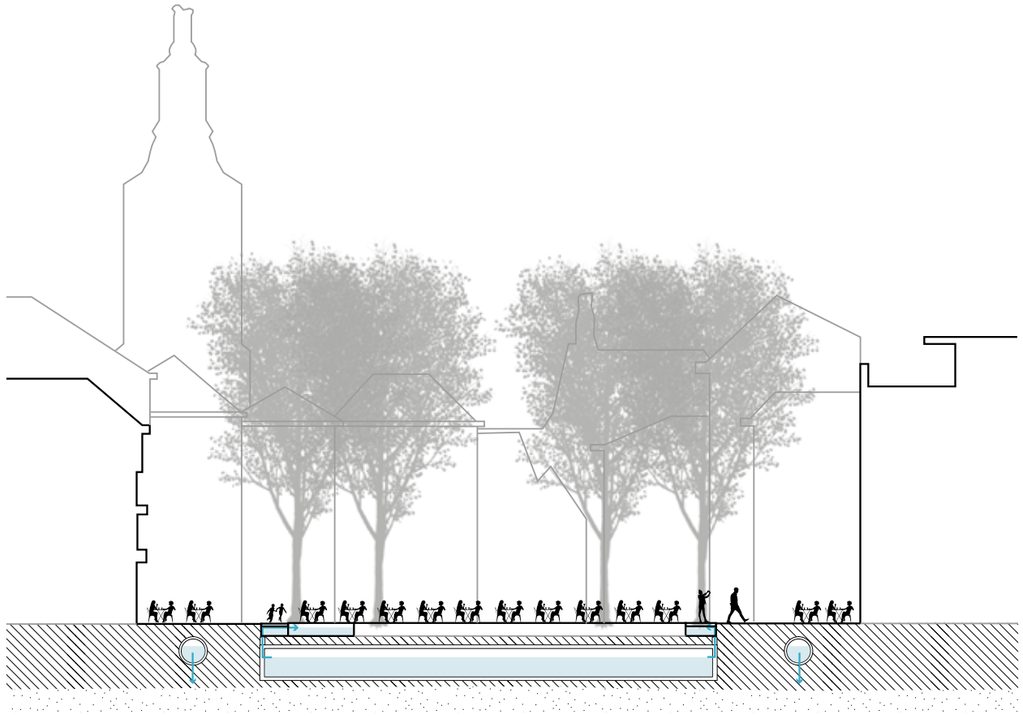


Figure 87: Daily use scenario section (made by author, 2020)

Figure 88: Scenario of the site (made by author, 2020)

Bijenkorf

The Hague Bijenkorf was built to a design by the famous architect Piet Kramer and various artists worked on the building. It is located in the most important commercial axie of The Hague- Spui, and nowadays there is a large Chinese gate next to the Bijenkorf which leads to the Chinatown.

As a important shopping mall, it works as a concentration of population itself. In the meanwhile, it is also a important node that connects two important neighborhoods in the city- Spui and Chinatown, which not only serves different urban functions but also serves different social groups.

Now the connection point of these two areas is a parking lot lies behind Bijenkorf. It forms a negative visual interface of the two iconic landmarks and also decreased the liveability of the residents nearby.

The ground level of this area is also the lowest in the surrounding area. As its surface is all paved and impermeable, it is also a negative area with high possibility of being flooded by extreme precipitation and cause damage to the properties.

With the development of public transportation, the total amount of parking area will be gradually decreased. Therefore, this provides an opportunity of renewal function of this area. This area can be transformed to a platform for visitors to rest and admire the beauty of the landmarks and for local residents to gather together and forms a positive intersurface. It should also have the ability of retention of water to decrease the amount of peak flow and the total amount of water that need to be drained.

Figure 89: Bijenkorf (source: google image)

Figure 90: Gate of Chinatown (source: google image)

Figure 91: Parking lot (source: google image)

Site analysis

Location and service group analysis

The site is behind Bijenkorf and located at the intersection of Spui and Chinatown. It is surrounded by resturants, a shopping mall and residential buildings. Therefore, it needs to provide a space for three groups: residents in Chinatown, tourists in Chinatown and visitors of Spui.

Legend

resturant

residential

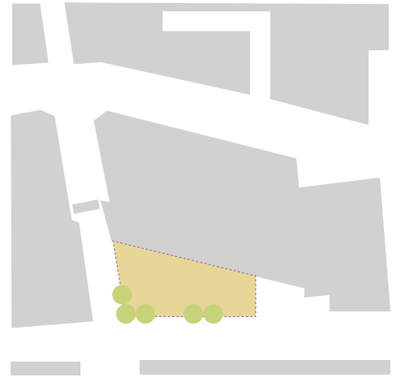
Exsiting function analysis

The site is currently a parking lot with greenery at the edge. With the development of the public transportation, the current function can be replaced. Near the site, there's a need for a public space that can not only serve the visitors of the surrounding areas but also the local residents to bring vitality to the neighborhoods.

Legend

tree

parking

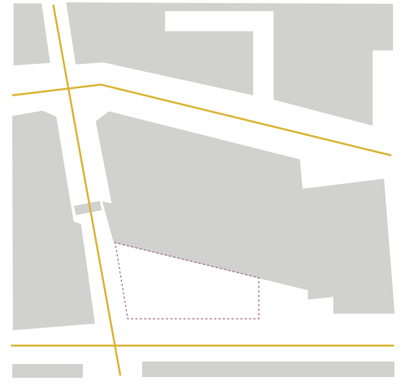


Accessibility analysis

The site is at the corner of two roads that lead to Spui and Chinatown, therefore, two entrances should be placed at the two edges of the site for accessibility for people from different directions.
As the site is next to the access of the truck for delivery for Bijenkorf, there should be a clear edge at this side of the site to prevent the users of the site from being borthered by the traffic noise.

Legend

sidewalks



Masterplan

As a node which connects two important areas of Centrum- Spui and Chinatown, the site needs to provide possibilities for people to rest, to stay and enjoy the view. As it's also surrounded by the neighborhood of Chinatown, it also needs to provide functions for enhancing the intergration of the local residents. Therefore, the site is renewed as a skate park surrounded by greeneries.

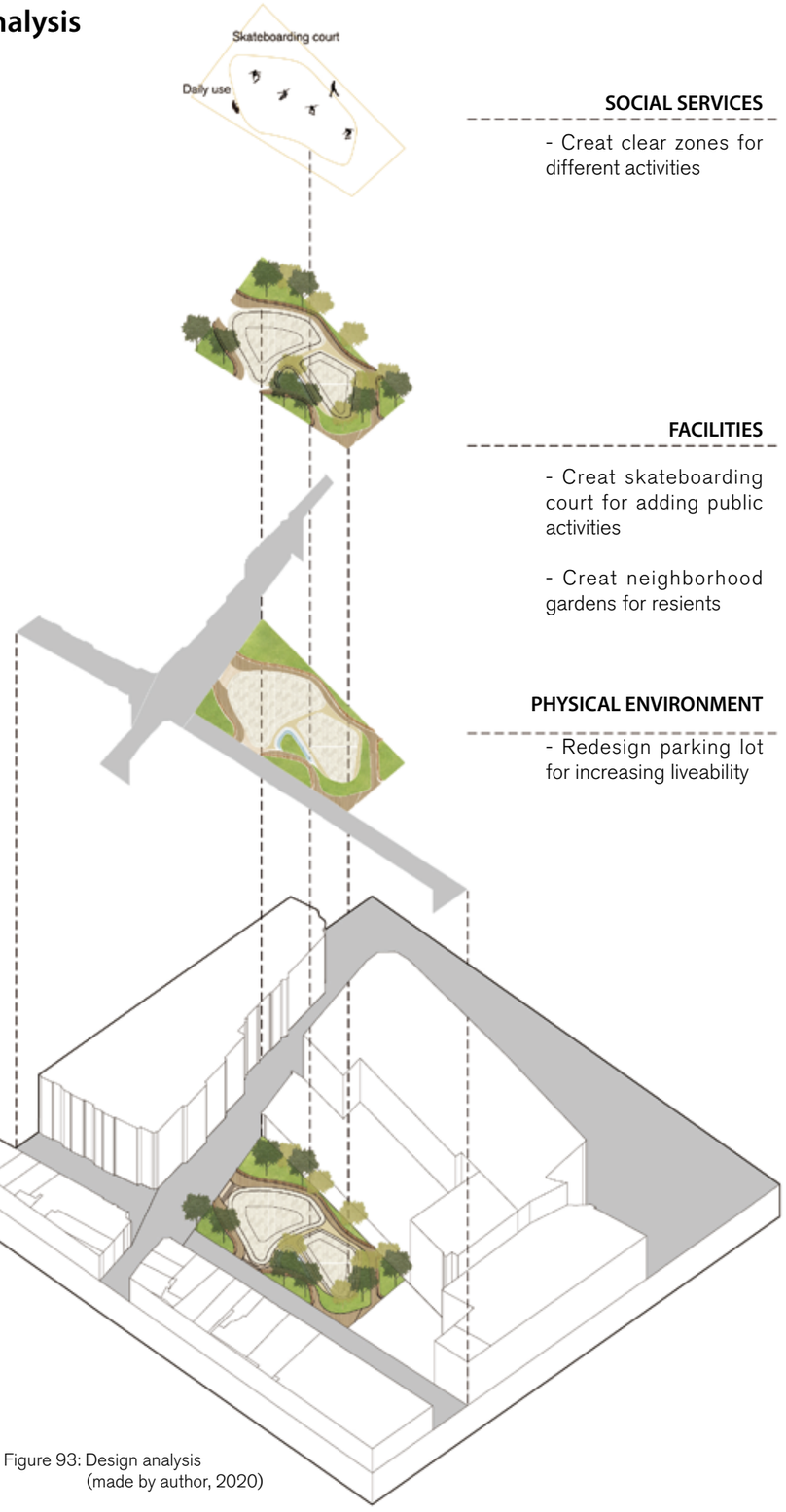
The trees that are originally located at the edge of the site are kept and combined with green space and benches as urban furniture for visitors to get some rest. More green areas are added to the site, they can be the collective garden for the surrounding neighborhoods to increase their liveability and cohesion.

The skateboarding court is located in the middle of the site for ensuring the safety of people and the noise will be prevented by the trees. The entrance of the skating site is located at both sides of the intersections with the roads, so that people come from different neighborhoods have the same accessibility to it.

1. Community garden
2. Public seat
3. Skateboarding court
4. Urban water wall

Figure 92: Masterplan (made by author, 2020)

Design analysis



SOCIAL SERVICES

- Creat clear zones for different activities

FACILITIES

- Creat skateboarding court for adding public activities

- Creat neighborhood gardens for resients

PHYSICAL ENVIRONMENT

- Redesign parking lot for increasing liveability

Figure 93: Design analysis
(made by author, 2020)

Technical approach

Extreme precipitation scenario

During the extreme precipitation, the skateboarding court can work as a water square to firstly collect the exceeded water. The green spaces can also work as a sponge to absorb some water. Therefore, the peak flow of the water and the total amount of water that needs to be drainaged is decreased, so that the flood can be prevented. Even during the extreme scenario, the water will be collected by the site so that the mobility of the surrounding areas and the public and private properties can be protected.

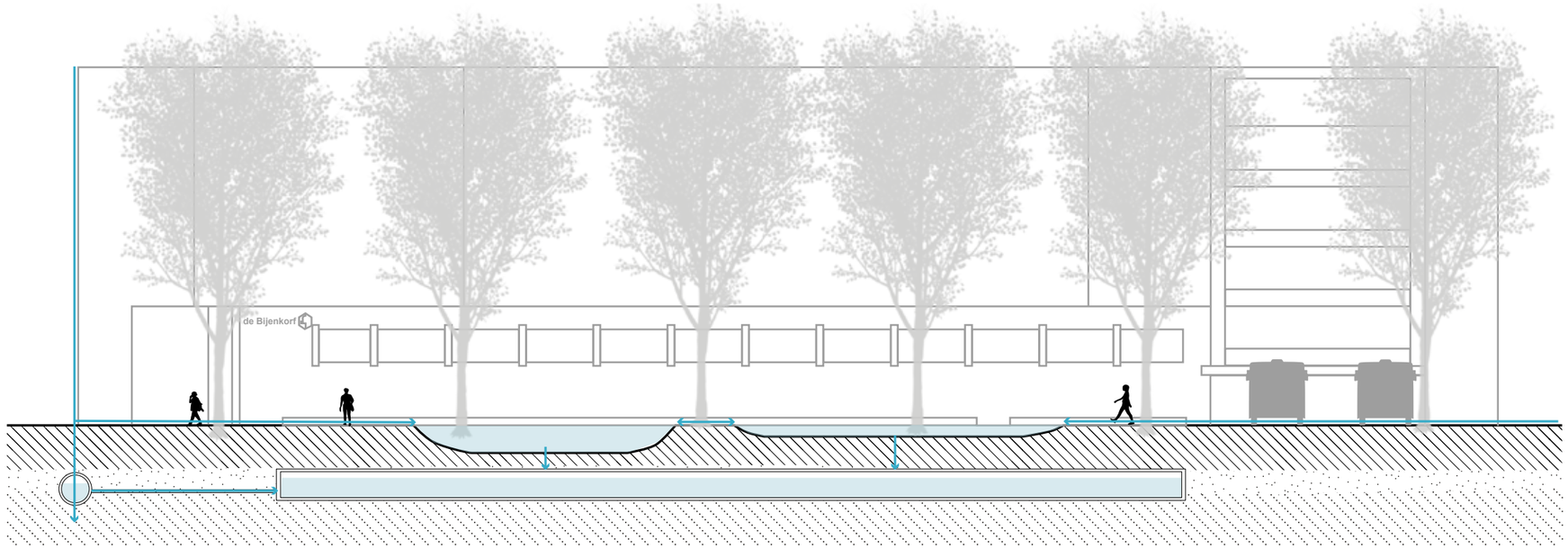


Figure 94: Extreme precipitation scenario section (made by author, 2020)

Daily use scenario

When the rain stops, the collected water in the skateboarding court will flow into the water tank. The water can be reused in two ways: (1) the water can be used for watering the neighborhood gardens, so that it reduces the cost for maintaining; (2) the water can be used in the mini fountain in the site, combined with a public seat. It can help with cooling down the tempreture.

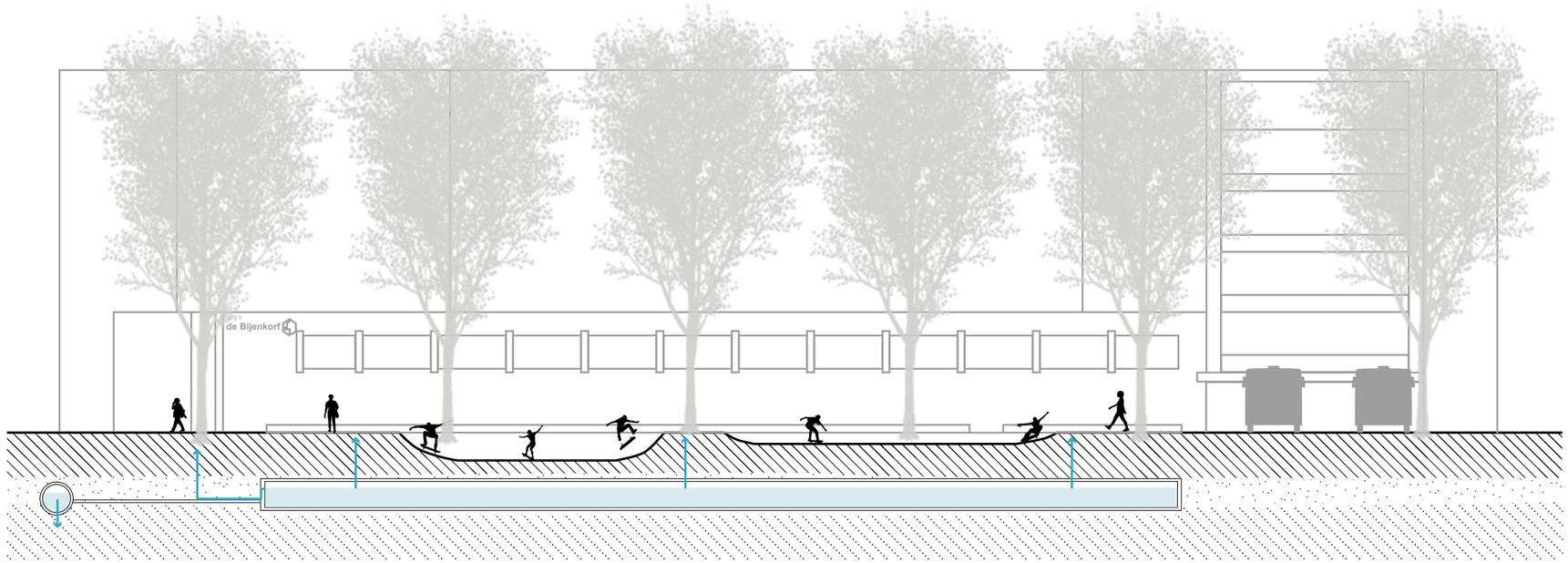


Figure 95: Daily use scenario section (made by author, 2020)

Figure 96: Scenario of the site (made by author, 2020)

Rabbijn Maarsenplein

Rabbijn Maarsenplein is a square located in the Chinatown in Centrum. It is not only a platform for various social activities, it is also a showcase and connection of various cultures and social communities.

The square is named after a Jewish rabbi as it played an important role of accomodating Jewish immigrants during the WW2. For momerizing this history, multiple monuments were built on the square.

This square is also opposite the Nieuwe Kerk, which is one of the ' Top 100 of the National Heritage Agency ' . The church is considered a highlight of early Protestant ecclesiastical architecture in The Netherlands. As Like many churches from the 17th century, the Nieuwe Kerk is a central building . Taking the path from the gate of the church surrounded by green space and going out from the entrance, the first view is the Raabijn Maarsenplein. Therefore, it is also connected with Dutch culture.

At last, it is currently located in the Chinatown of The Hague. Therefore, it also serves the Chinese community.

It also accomodates different functions of social activities: outdoor commercial tables for the resturants surrounding the square, children playground, seats and so on. Old sycamore trees on the square are also iconic and shows the history of the square.However, there's no morphological connection between different urban functions and results the fragmented visual effect of the square.

The paved surface made this area vulnerable under the flood risk. The adaptation approach can also be regarded as an opportunity for improving the quality of this area as a better platform for multi-cultural background and intergration of communities with diverse social background.

Figure 97: Monument (source: google image)

Figure 98: Monument (source: google image)

Figure 99: Monument and the church (source: google image)

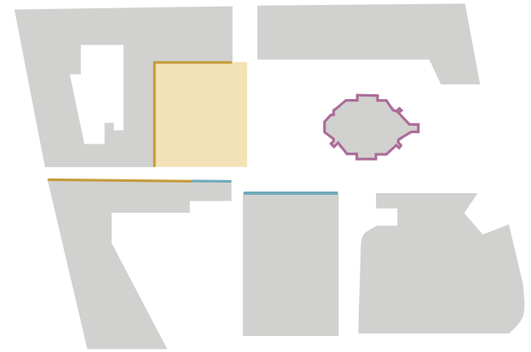
Site analysis

Location and service group analysis

There are diverse functions located around the site: groundfloor resturants, residential buildings and the Nieuw Kerk. Therefore, it challenges the site to provide not only recreational functions for the residents nearby, but also enough space for a quick pass for the customers of the resturants and space for pedastrians to stop and admire the beauty of the church.

Legend

- resturant
- church
- residential

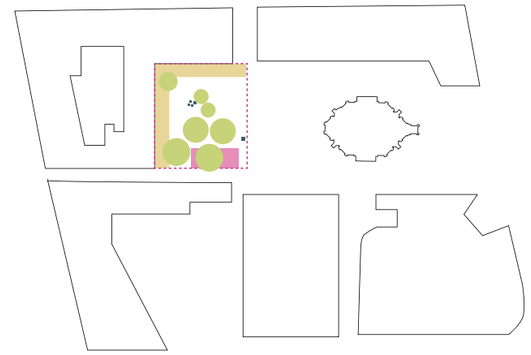


Exsiting function analysis

There are several exsiting functions of the site need to be noticed. Firstly, the valuable cultural-historical functions: the monuments for memorizing the Jewish history and the old sycamore trees. What's more, the social functions: the children playground, the tree benches and the outdoor commercial seats for the resturants. These functions are iconic and important for the site and need to be kept. However, they need to be better visually integrated.

Legend

- tree
- outdoor commercial seats
- monuments
- children playground

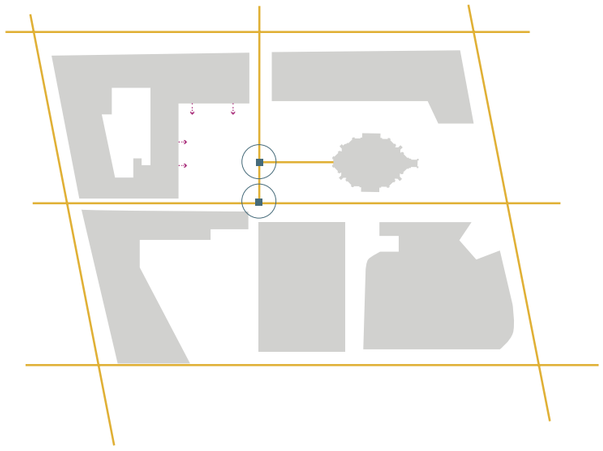


Accessibility analysis

There are multiple entrances of the site. In a bigger picture, it is located at the node of the path to Spui and Chinatown. They bring different social communities with diverse cultural background. As the site is surrounded by resturanats, the entrance of the resturants also defined multiple entrances to the site. The last but also a very important entrance is the intersection of the site and the church.

Legend

- sidewalks
- entrance from the resturants
- intersection



Masterplan

Rabbijn Maarsenplein is re-designed as a water square. The design is in two height levels with two types of functions.

Firstly, the underground level is designed for recreational functions for the residents. The children playground is moved to this level and the stairs are designed combining with benches. This can not only provide a safer environment for the children in case they rush to the road while playing, but also provided a more pleasant place for the parents to watch the kids while they're playing. In the meanwhile, the benches can also provide a space for people to rest and admire the beauty of the church, therefore the visual connection between the site and the church is formed. This also brings different social activities together and formed a more integrated visual effect of the site. Besides. by designing like this, a more clear edge is formed between the recreational functions and the outdoor commercial seats of the resturants, which will satisfy the owners of the resturants and make them more willing to collaborate with the re-design process.

The ground level is redesigned for cultural memorizing functions: the site is with valuable historical identity and therefore there're many monuments designed on the square. However, the current design didn't highlight their importance. Therefore, they're redesigned on the central green island at ground level with the old sycamore trees. The monument near the entrance of the church is designed as another island surrounded by green belts.

1. Monument island
2. Outdoor commercial tables
3. Public seats
4. Water square
5. Community garden
5. Water wall with public seats

Figure 100: Masterplan (made by author, 2020)

Design analysis

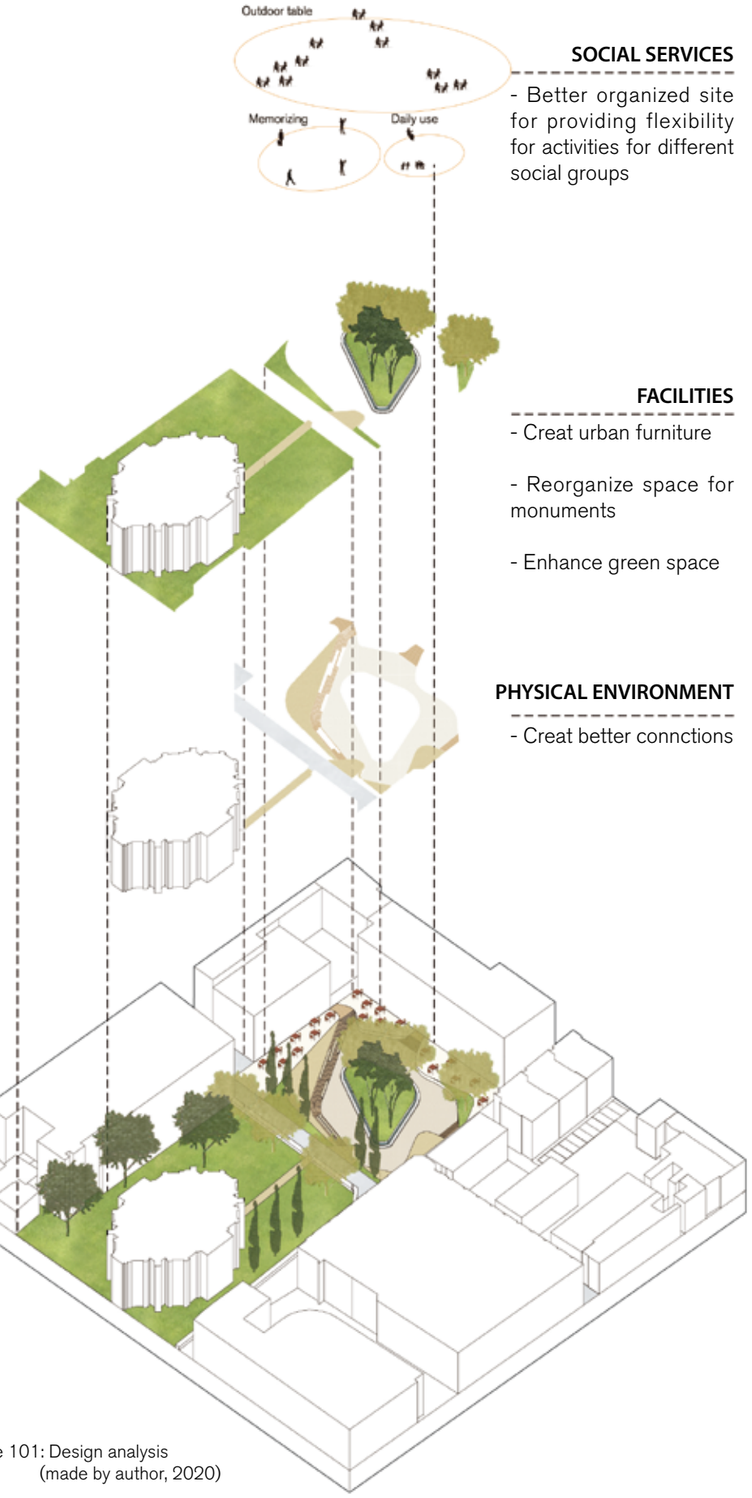


Figure 101: Design analysis
(made by author, 2020)

Technical approach

For adding precipitation adaptation capacity, the site is designed as water square with an underground water tank.

Water facilities are also designed for recreational function and water reuse in the site.

The following sections show the water management approaches of the site.

Extreme precipitation scenario

During the extreme precipitation, the underground layer can be used as a water square to collect the exceeded water. The water in the surrounding area will flow to the underground water square and then extra water will be collected in the water tank for reuse. When the underground level is flooded by rainwater, the monument island can still be safe. When people step outside of the entrance of the church, the two islands of the monuments can be seen as floating on the water, which highlights the iconic spots of the site and adds more poetic atmosphere.

Daily use scenario

When the rain stops, the collected water will be reused for the water wall that surrounds the central island and combined with seats. They can provide a coolder microclimate in the site.

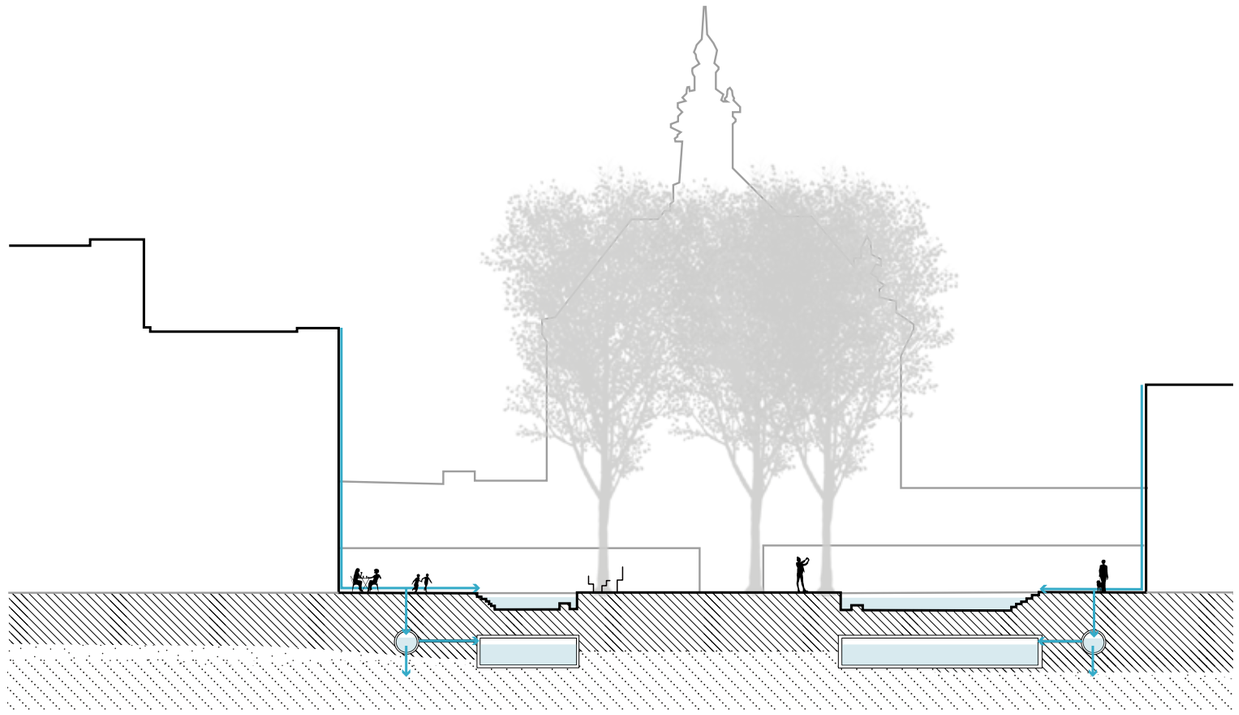


Figure 102: Extreme precipitation scenario section (made by author, 2020)

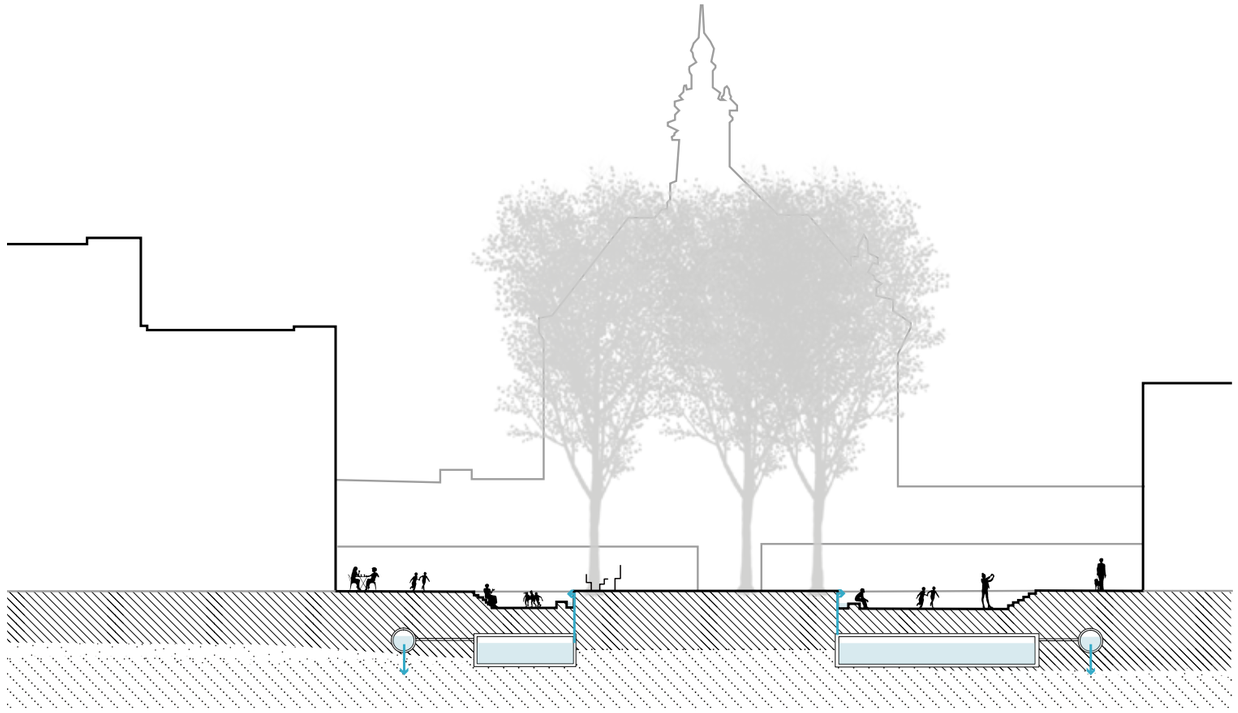


Figure 103: Daily use scenario section (made by author, 2020)

Figure 104: Scenario of the site (made by author, 2020)

Bierkade

As a historical city center, Centrum is surrounded by canals. The canal ring is a unique, coherent and connecting element of the city center.
The current canal system originated in the 16th and 17th centuries. The canals, often lined with trees, made an important contribution to the urban beauty, but were primarily due to the practical purpose of water management, transport or protection of the city.

The function of the canal was fundamentally changed from the 20th century as a result of the decline in activity on and along the water and at the same time the increase in car traffic. Paving of concrete and asphalt made the appearance of car parking in two rows: along the canal side and along the facade side. The cars obscure the view of both the water and the facades. From the beginning of the 20th century, the canal system loses its economic value of the transport of goods by water, but retains its significance for water management: to this day, the drainage of the surplus polder water around the city takes place via the ring of canals to the drainage to the sea. It also works as a platform for social actitivies in the form of interacting with the boats as shown in the picture.

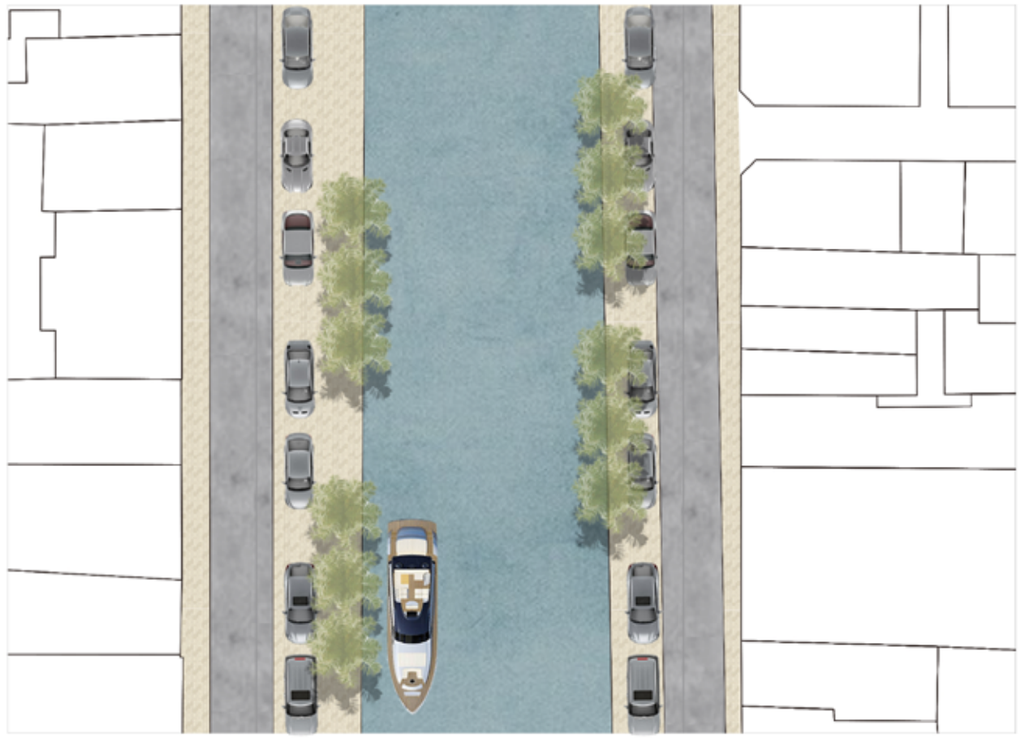
Figure 105 (source: google image)

Figure 106 (source: google image)

Figure 107 (source: google image)

Site analysis

The canal bank is occupied by car parking. This blocked the visual connection between the pedastrians and the water, and also hindered the oppotunity of people to get close to the water. The main greenery is provided by the avenue trees, which is a monotonous type of landscape. The current situation of the canal can't show the unique identity and the importance of it in the city.



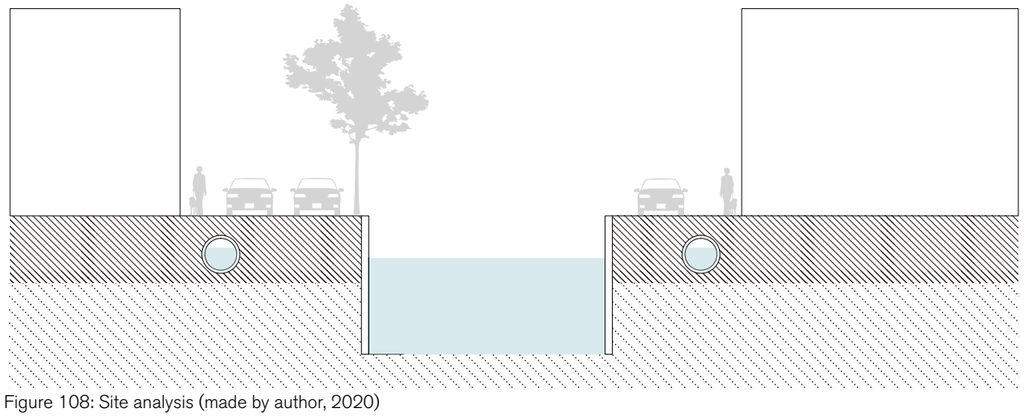


Figure 108: Site analysis (made by author, 2020)

Masterplan

As stated before, the canals in the city still play an important role in the water drainage system to the sea. Therefore, for preparing the area for the extreme weather hazards, one efficient way is to increase the total capacity of the water storage in the canal but at the same time control the water level.

Therefore, investing on the edge of the canal as a transitional area to prevent the flood can be an efficient soluation and can also bring extra values to the site.

As the transportation function of the canal is gradually fading away, it become a place with recreational and cultural value. Humans are naturally willing to get close to the water.However, the development of car usage and car parking blocked the interaction between people and water. With the development of public transportation in the city, the amount of area that used for car parking will be decreased. Therefore, the car parking along the edge of the canal can be removed the this area can be designed as the transitional area between the water and the land.

The edge is designed in three layers with two height differences: a green belt between the road and the canal edge; stairs as transitional area between the land and the sea with two height levels and platforms on the water surface. It is at the lowest design level.

Therefore, people can have different accesses to the water and interact with the boats and the capacity of water storage in the canal can be increased.

1. Green belt
2. Stepped canal bank and public seats
3. Platform

Figure 109: Masterplan (made by author, 2020)

Design analysis

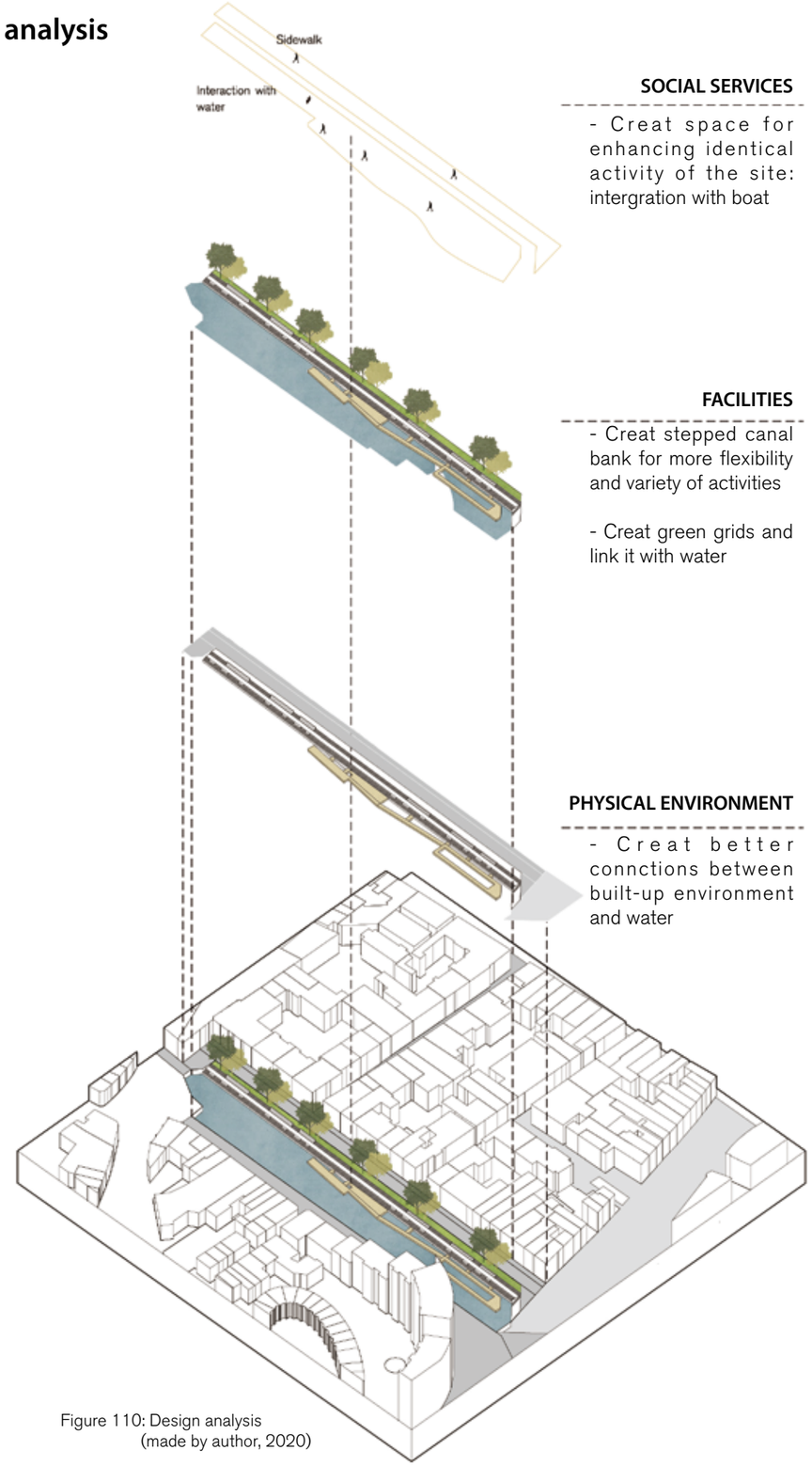


Figure 110: Design analysis
(made by author, 2020)

Technical approach

Extreme precipitation scenario

By designing stepped edge for the canal, the water storage capacity will be increased. During the extreme precipitation, rainwater will flow to the canal and be transported to the sea. The normal mobility and the security of the surrounding properties can be ensured. The stepped stairs will be partly flooded, with different water level, the site can provide different accessibility to the water.

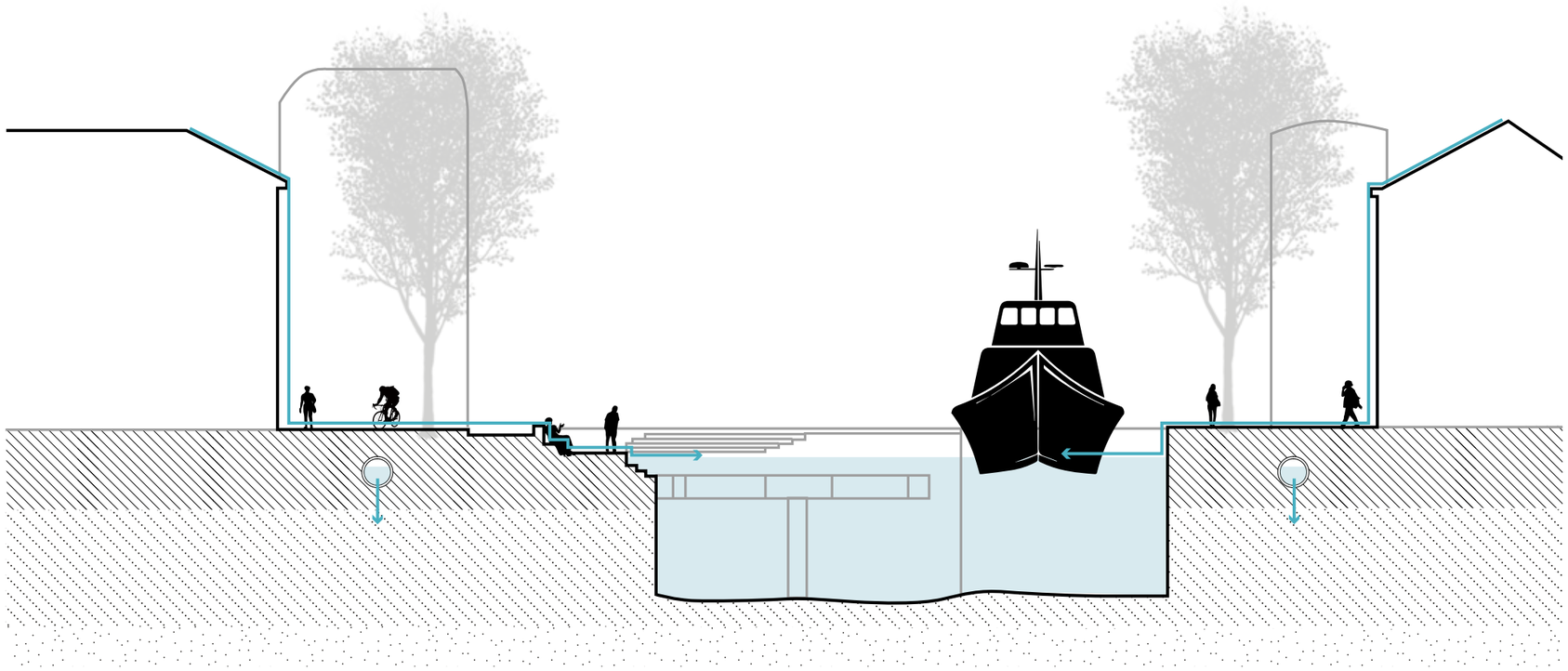


Figure 111: Extreme precipitation scenario section (made by author, 2020)

Daily use scenario

When the rain stops, the stairs can be approached again. The stairs as transitional area between the land and the sea with two height levels. The stairs are combined with benches so that people can have more space to sit and relax by the water. A platform is placed in between as the intersection of the height change, so that with different water level, people will always have chance to get close to the water and more water can be stored.

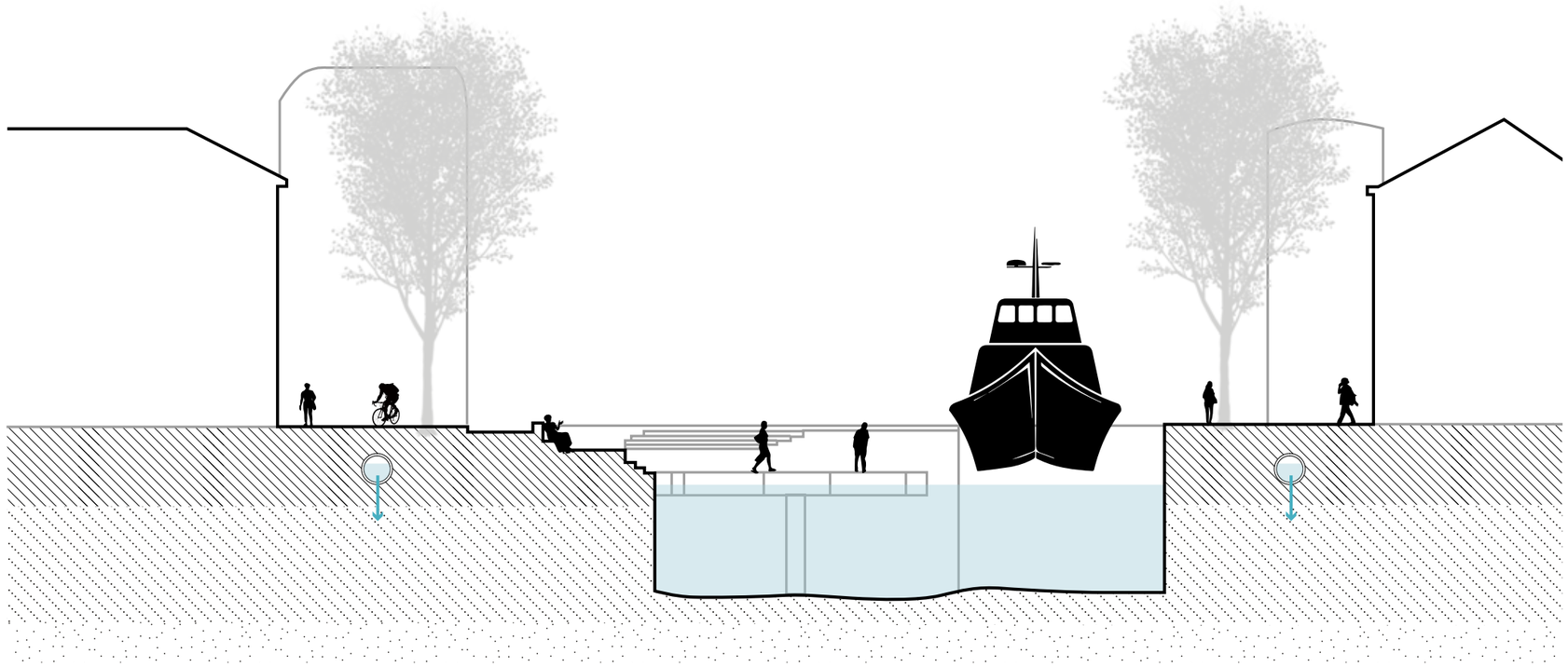


Figure 112: Daily use scenario section (made by author, 2020)

Figure 113: Scenario of the site (made by author, 2020)

Stationsweg

The name of Stationsweg is due to the Holland Spoor station. The street was firstly built by the railway company for ensuring the accessibility to the station. However, due the poor construction, the street is eventually taken over by the government.

The function of this street is also changed, from the mobility dominated function to a multi-functional iconic landmark of the city. As we can see from the photographs of different eras, the area used only for transportation is decreasing and the types of pavement materials are increasing to clarify different functions. The station also works more than a transporation node, but also a beautiful historical building as a landmark.

The function of this street needs to be renewed for the following reasons:

(1) The change of mobility: The Hague wants to increase the use of public transportation and decrease the use of cars, therefore, the areas currently used for car parking can be replaced with other functions.

(2) The street is already suffering from frequent floods due to the soil subsidence.

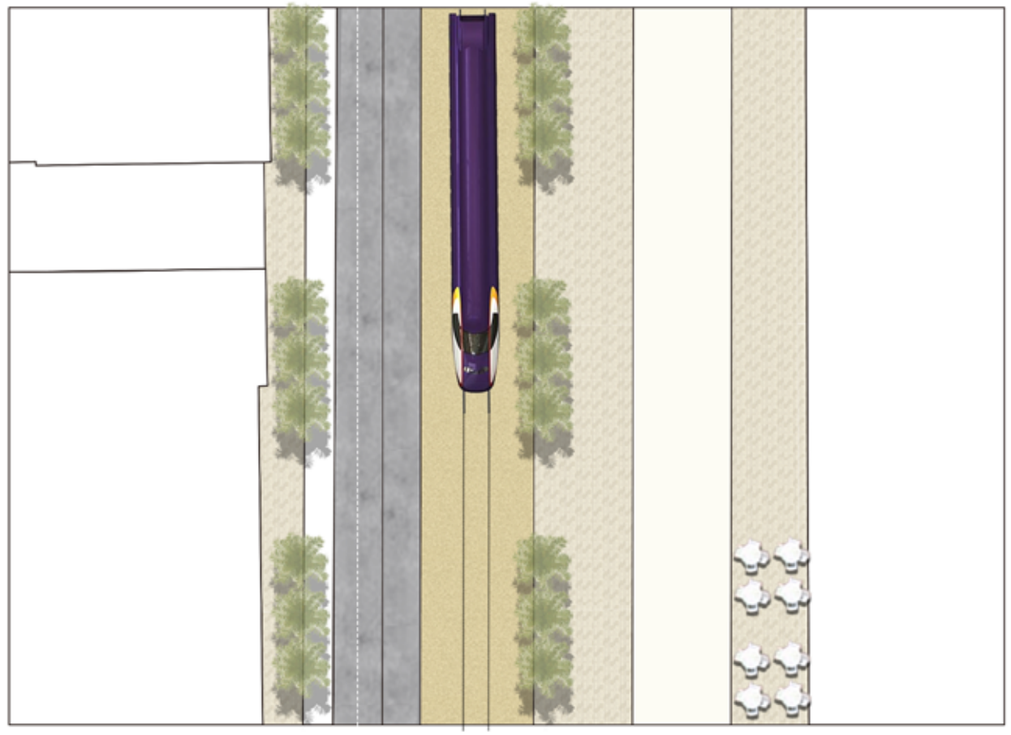
Figure 114 (source: google image)

Figure 115 (source: google image)

Figure 116 (source: google image)

Site analysis

The street is divided into different functions: pedastraian pathway, metroline, motorway and cycle path. The middle of the sidewalk of the right side of the street is paved with different material to hightlight the link between the street and Holland Spoor station. The street is currently totally relying on water drainage, therefore when it's faced with extreme precipitation, it will be flooded.



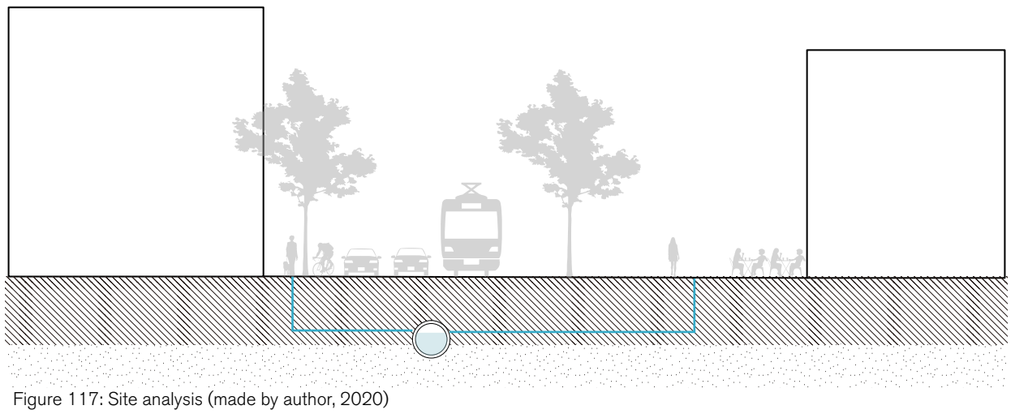


Figure 117: Site analysis (made by author, 2020)

Masterplan

Stationsweg always plays an important role for providing mobility for the surrounding neighborhoods, it is also an important access to the Holland Spoor train station. The function of the street varies with the change of the mobility.

Nowadys, with the purpose of using more public transportation, the area allocation for different usages on this street also needs to be renewed. In the meanwhile, the street is frequently bothered by the water nuisance due to the soil subsidence when faced with extreme precipitation.

The aim of the design is to add the adaptation capacity of the site and to define a more clear sidewalk. The redesign of the site is defined as a cloudburst road.

The parking area is decreased and combined with greenery on the left side of the street. On the right side of the street, a green belt with urban furnictures is designed. The current outdoor commercial seats are also moved to this area and located in the middle of greeneries. Therefore, a more clear line for pedastrian that links to the Holland Spoor station is defined can more green can be seen on the street.

The green belts can add the green-blue grids in the city and provide more space for pedastrian. The re-design also provided a more integrated visual effect of the street profile.

1. Cloudburst road
2. Outdoor commercial table
3. Public seats
4. Urban water fountain

Figure 118: Masterplan (made by author, 2020)

Design analysis

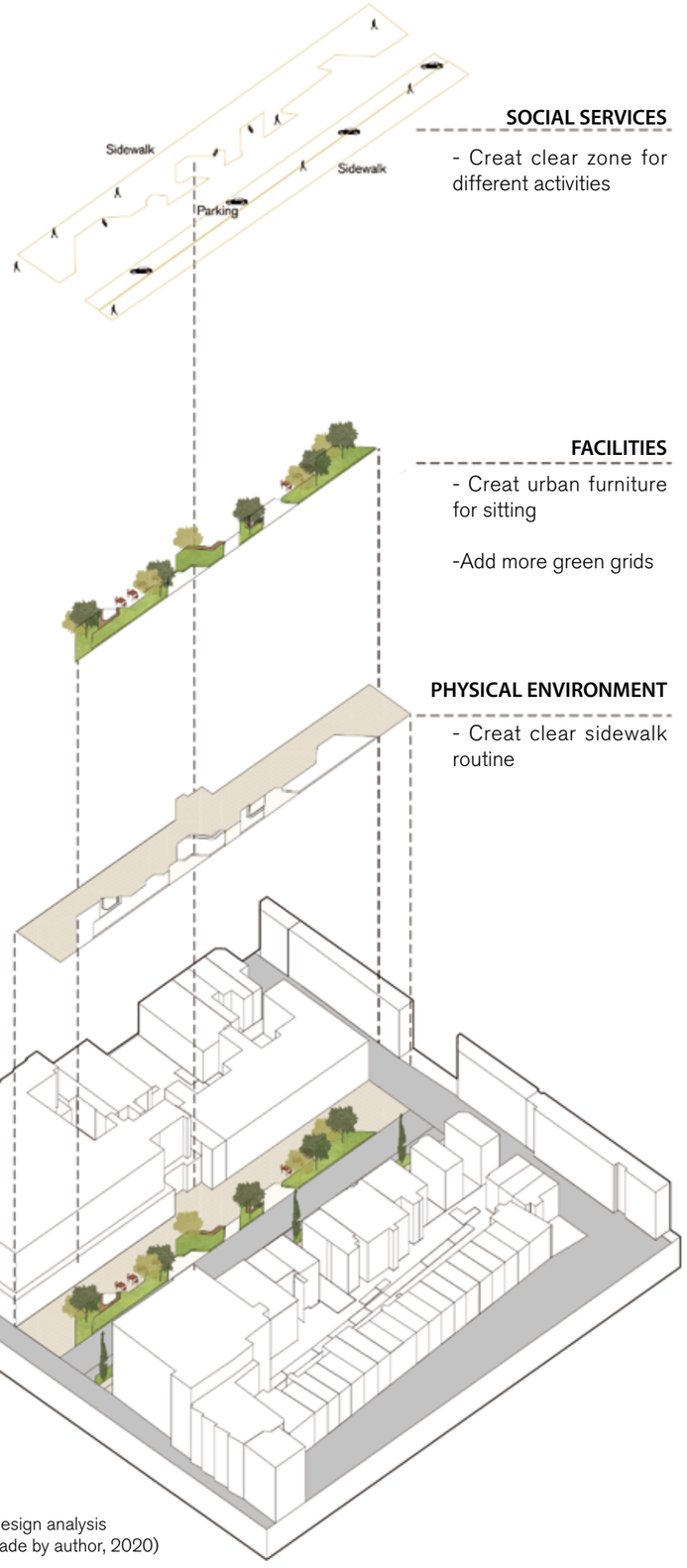


Figure 119: Design analysis
(made by author, 2020)

Technical approach

Extreme precipitation scenario

The green belts can be used as sponge when extreme precipitation occurs. The street profile is desigedn in a V shape, the green belts are located at the lowest point of the street. Therefore when there's water run-off, the water will flow towards the green belt direction and be collected. The sidewalks and the transportation can still be accessible during extreme precipitation and the public and private properties can be protected. A underground water tank is located on the right side of the street and connected with water fountain on the surface of the street.

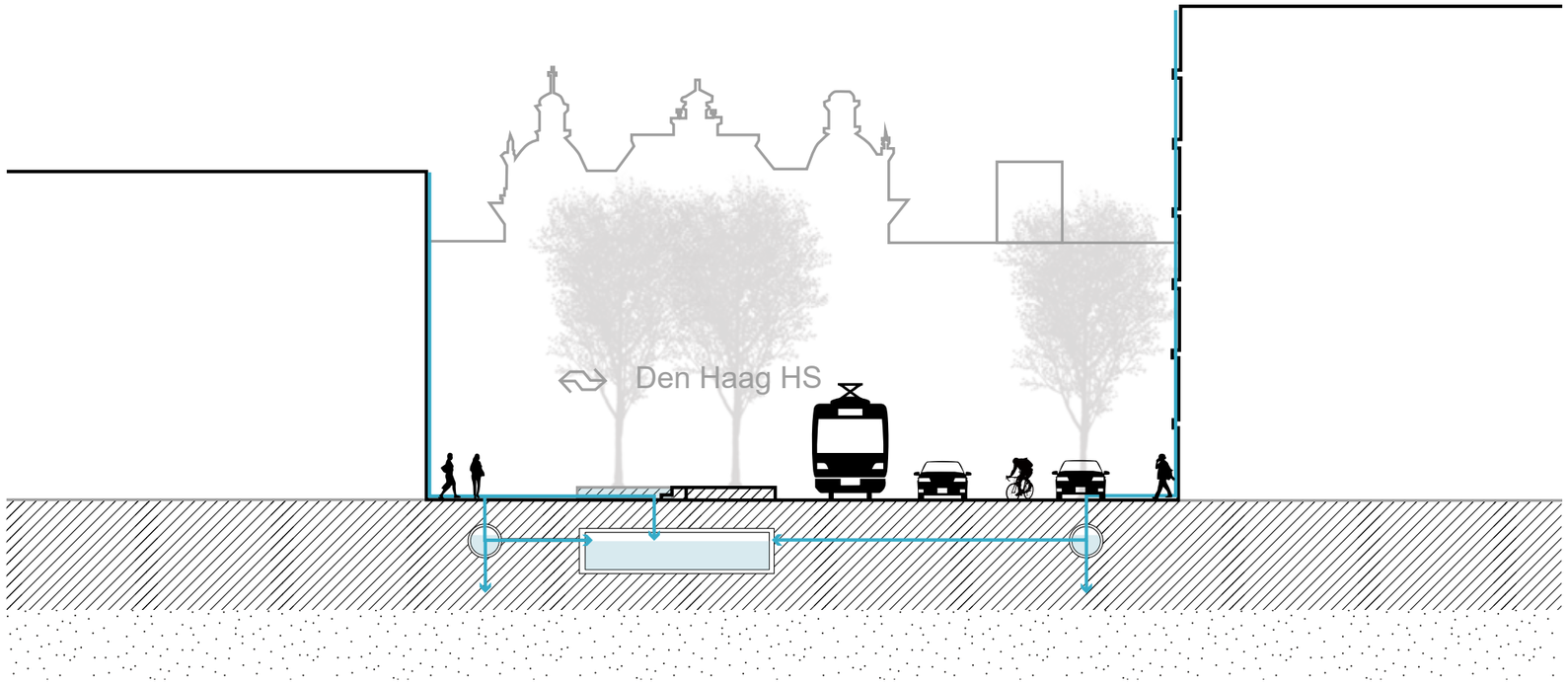


Figure 120: Extreme precipitation scenario section (made by author, 2020)

Daily use scenario

When the rain stops, the water collected in the underground water tank can be reused for water fountain. The view combined with water fountain and Holland Spoor can highlight the beauty of this historical building. The water can creat a more playful and attractive environment.

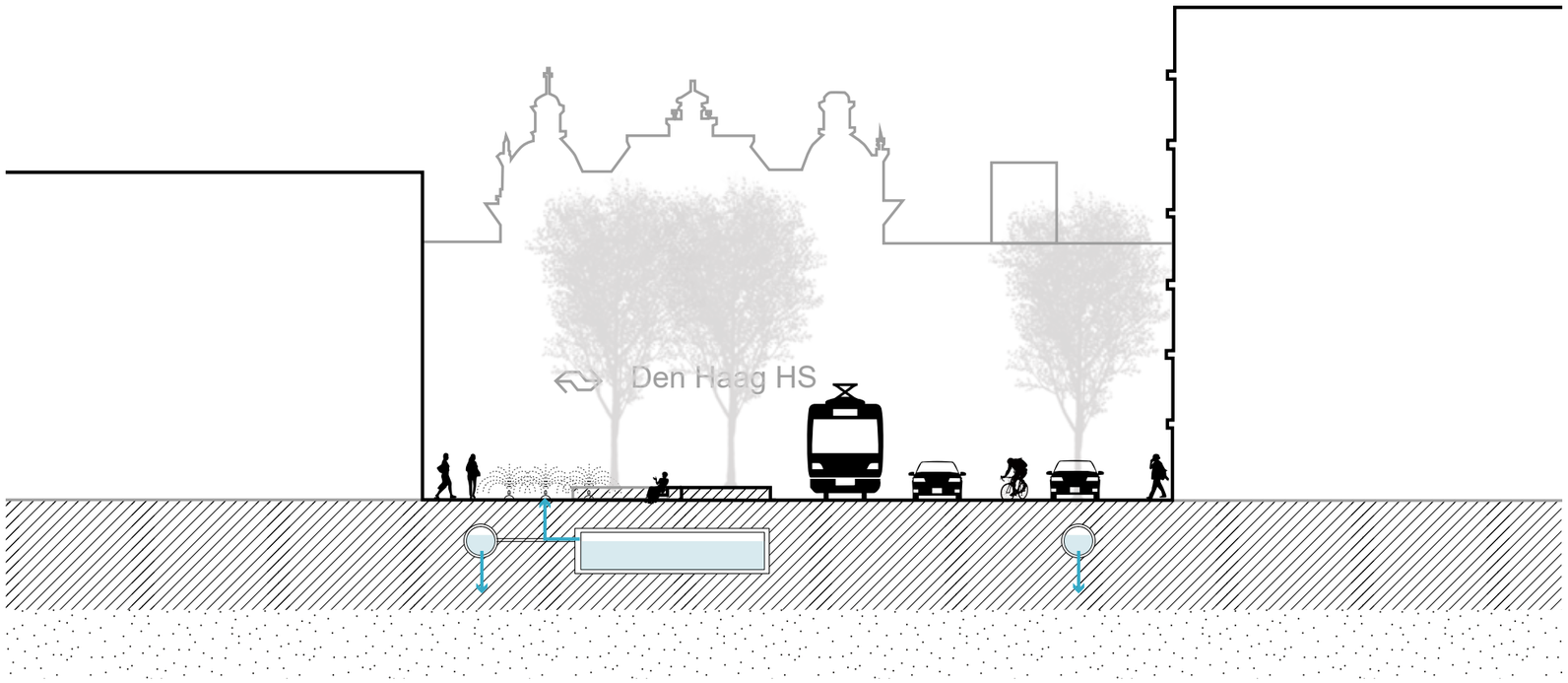


Figure 121: Daily use scenario section (made by author, 2020)

Figure 122: Scenario of the site (made by author, 2020)

Chapter

8

EVALUATION

Aspect 1: Collaborative development approach

The following diagram explains how can stakeholder be engaged in the development process. The development process is divided into seven steps, the participation of different stakeholders of the approaches are firstly shown in the diagram.

As the project aims to change the current top-down governance structure to a collborative structure, the local communities and residents are added to the management process. The relationships between the policy making, conduct duties and the benefits of the local communities are highlighted in the diagram.

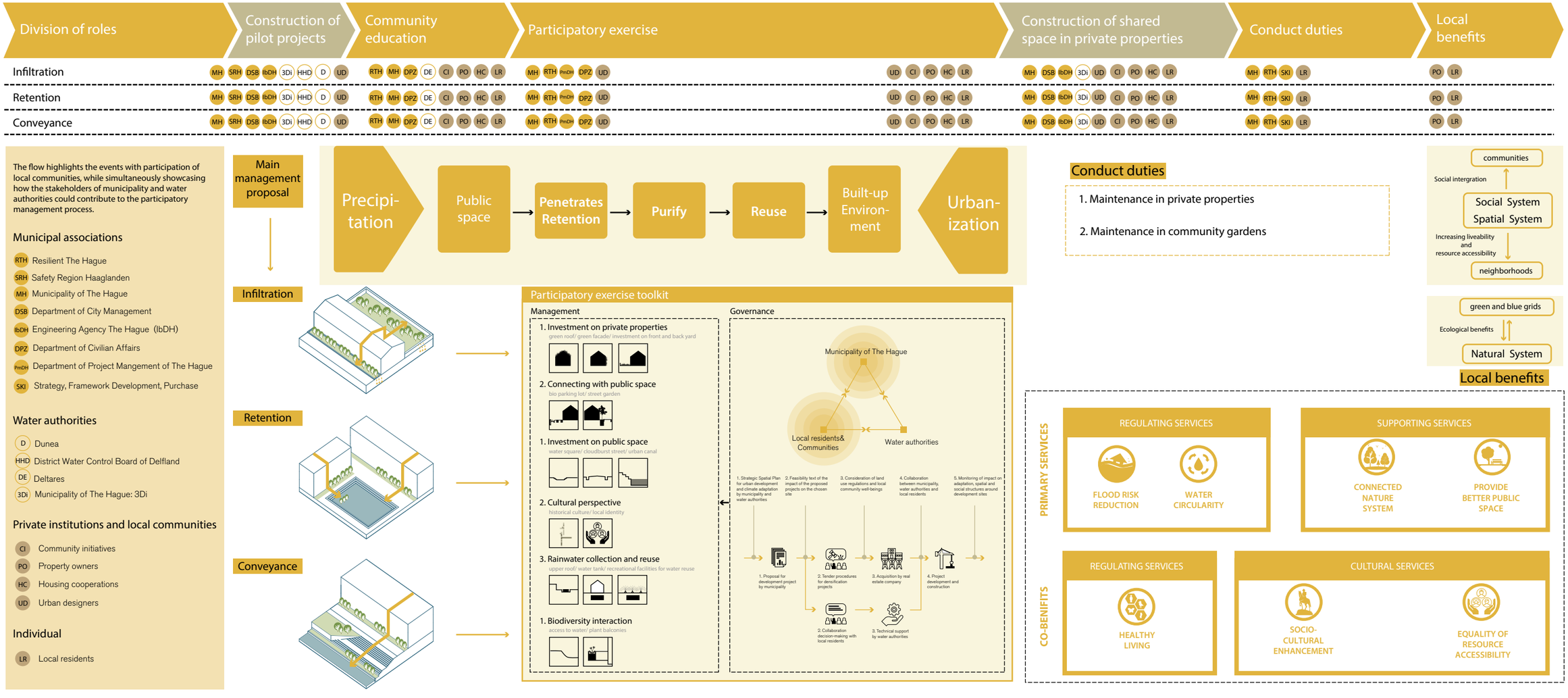


Figure 123: Daily use scenario section (made by author, 2020)

Aspect 2: From proposed values to urban resilience values

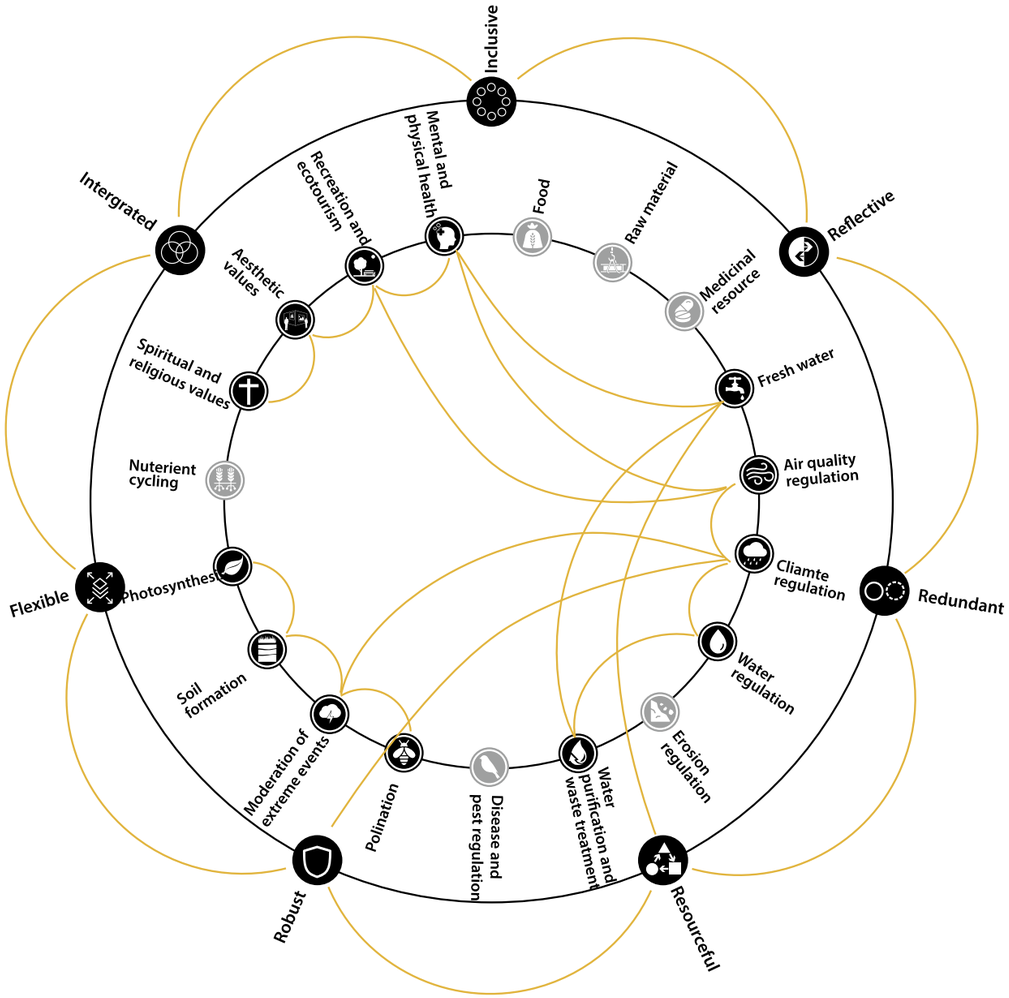


Figure 124: Proposed value for The Hague 2050 (made by author, 2020)

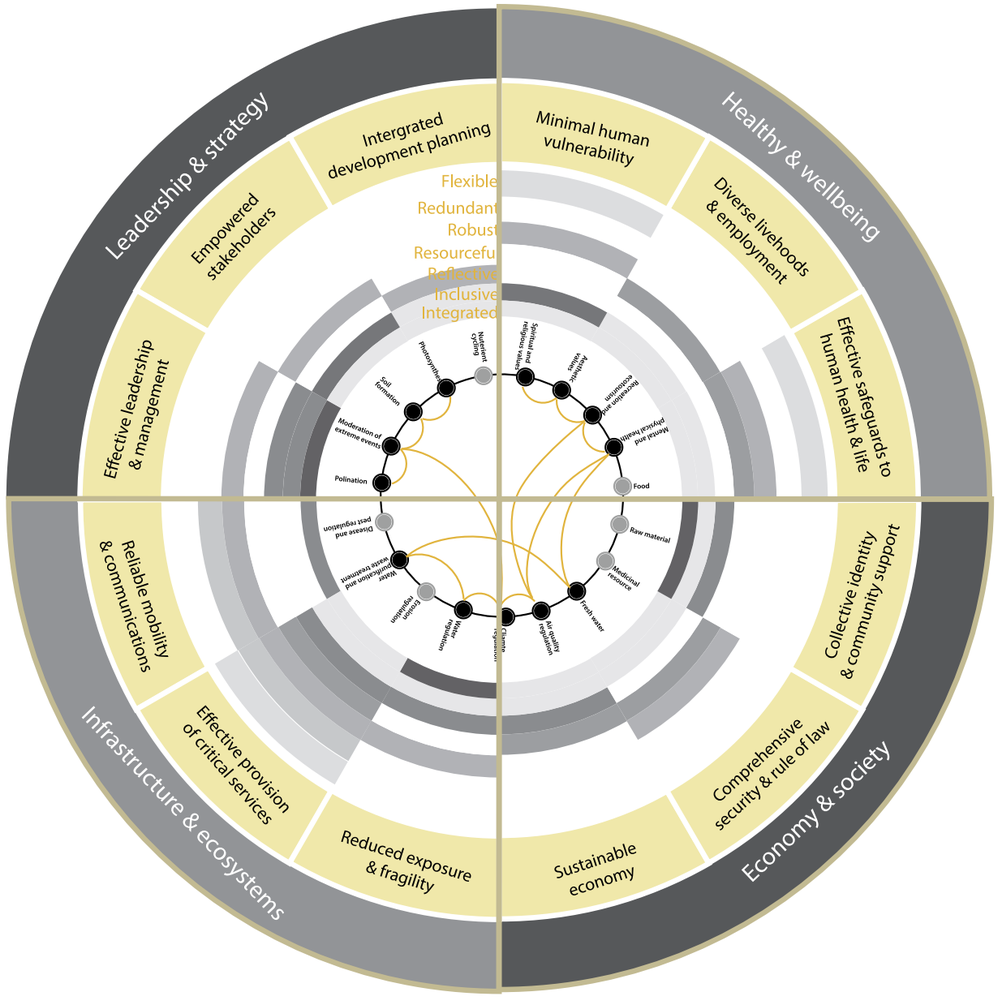


Figure 125: Proposed value and urban resilience values (adapted from urban resilience framework,made by author, 2020)

As stated in the former chapter, the impact of the project can be analysed within the ecosystem service framwork. Four primary services of this project are (1) reducing flood risk by delaying peak runoff amount and reducing total runoff; (2) creat better water circularity by collecting and reusing rainwater; (3) re-connect the inner city with natural system and (4) creat more and better public spaces. At last, the co-benefits of it, which includes healthier living environment and better socio-cultural environment, can make the urban area more resilient, adaptive and inclusive.

Also, by analysing the interrelationships of different services can help to understand the synergy between different systems in this project. It also helps to trace which approach should be firstly set on the timeline.

The urban resilience framework is an essential reference to decribe the complex and interdependent issues that contribute to a resilient city. According to the framework, the urban resilience value can be concluded as four categories: the health and wellbeing of individuals (people); urban systems and services (place); economy and society (organization); and, finally, leadership and strategy (knowledge) (Arup, 2015). The diagram shows that with the spatial implementations, the physical layers of urban resilience, which are the resilience of people, place and organization, can be achieved.

As stated in the collaborative development approach analysis, empowered residents and intergrated development approaches can be achieved through the management process. Therefore, the knowledge layer can also be achieved. Thus, the goal of achieving urban resilience can be achieved through the design proposal.

Aspect 3: Actions timeline

The project aims to investment on designing public spaces in The Hague as adaptation measures for extreme precipitation floods and make full use of the added values to increase the liveability and resilience in the city. However, it doesn't seem possible to implement the whole city at the same time due to the different resistance to change and limited capacity in place. It aims to link climate adaptation projects as much as possible to the development agenda of the city to prevent investing repeatedly in the same area and protect the newly built-up projects from flood risk. In the time management, the project is divided into two phases: (1) pilot projects on the most vulnerable areas that are faced with the possiblity of severe damage due to the flood (2) adaptation projects on buildings following the urban development process and workshops and collaborative decision-making for more empowered individuals.

As 60% of the land in The Hague is privately owned, for achieving the goal of making the city resilient and rainproof, the collaboration of the municipality and the citizens is essential to this project. Therefore, the first phase pilot projects are the investments on public spaces which the municipality will contribute to. They can improve the liveability in the neighborhoods and ensure the safety of the living environment, which will not only make the community more integrated but also add to the land value. This may draw the interest of the community. It can not only help with the densification programs but also make the citizens interested in taking part in the process, which provides the starting point for the second phase adaptation approach on the roof and facade of the buildings.

The second phase of the project aims to build with the housing programs of the city development agenda while empowering individuals and communities. For achieving adaptation with housing projects, the policy-making will firstly intergrate resilience and climate adaptation with tender procedures. Together with the densification and urban renewal projects, investing on roof and facades can not only prevent the new projects from being flooded, but also form new public spaces for residents. This process can also provide a possiblity of linking the green network in the city not only horizontally but also vertically. For the long-term maintance, workshops and collaboration for climate adaptation and resilience should be provided for local residents and communities to empower and educate them about the co-responsibility for the living environment and the benefits.

After the two phases of the programs, from 2020 to 2030 and from 2030 to 2050, the city of The Hague can be more resilient and liveable.

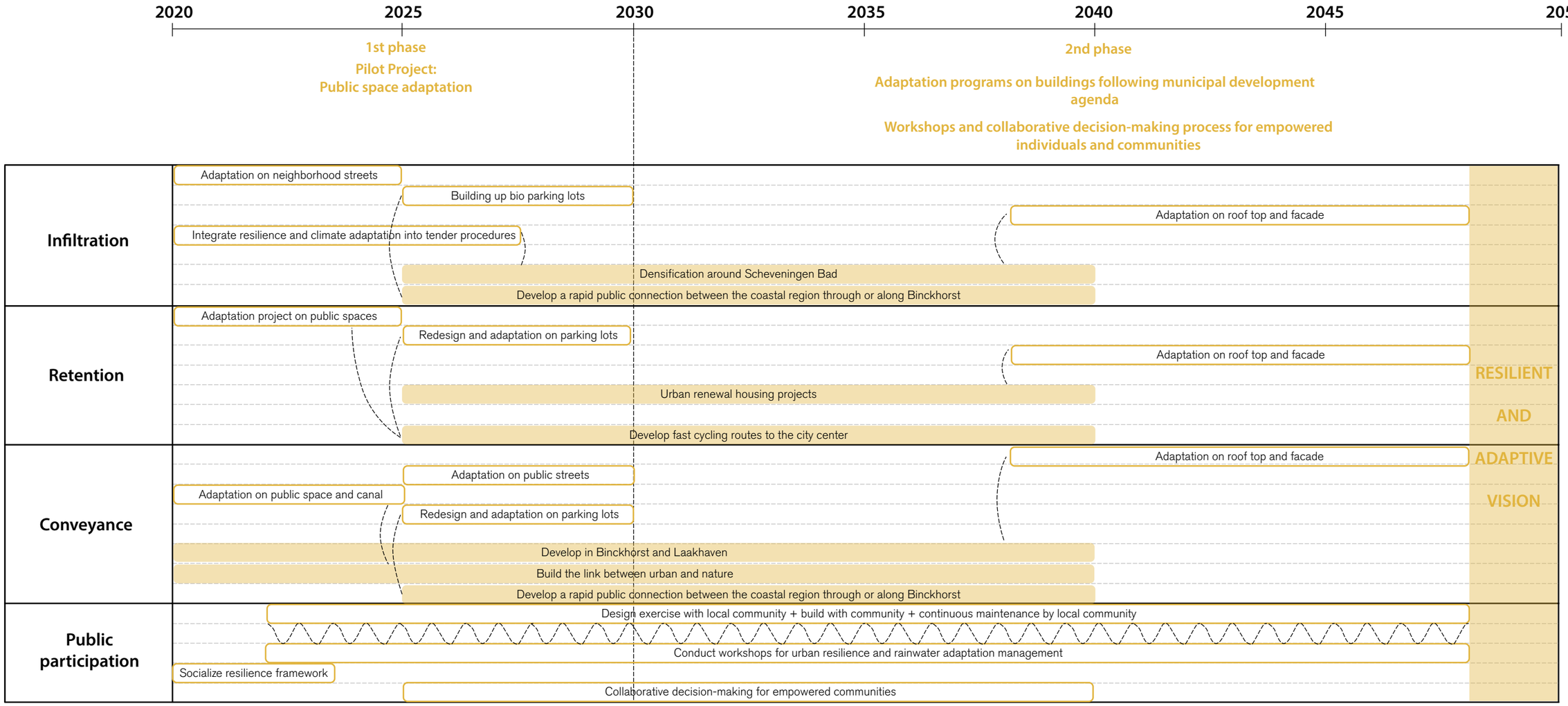


Figure 126: Develop timeline (made by author, 2020)

Aspect 4: Transferability

During the research process, the analysis is made through different scales. Therefore, the research could zoom in from a wide range of issues to in-depth discussion of specific strategies.

As the outcome of the research, the strategies can also be transferable to the analysed scales, either providing practical management experience or contributing to the knowledge body of the framework.

The transferability of the research outcome can cover all the selected scale of the research.The transferability analysis is opposite to the order of the scales of problem research: from the local scale to the city scale, then zoom out to the national scale and eventually come to the global scale.

In the following analysis, the relationships between different scales and the contribution of the transferability experience will be further explained.

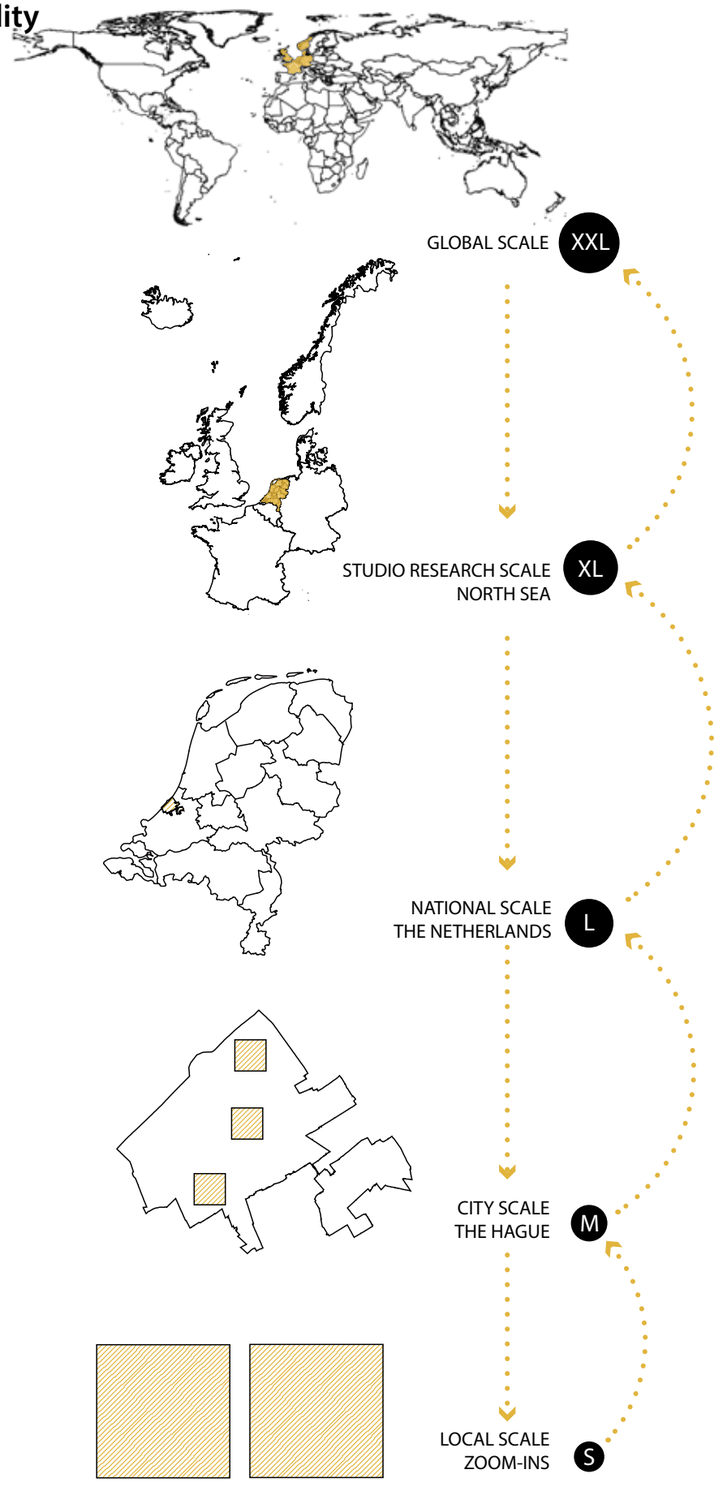


Figure 127: Transferability through scales (made by author, 2020)

Scale 1: from pilot projects to the city

The first scale is from the pilot projects to the city. In this scale, the pilot projects tested how can public space design increase the adaptation capacity in the specific areas. The main water management approach is retention, which is based on the neighborhood typology. During the design process, the social, cultural and ecological values are also took into consideration. The experience of the process can be transferable to the management of other neighborhoods in the city: public space design needs to be adapted to local conditions, the subsoil, social, cultural, ecological layers need to be taken into consideration.

Figure 128: From pilot projects to the city (made by author, 2020)

Scale 2: from the city to the capital cities

As stated in the former chapter, The Hague will suffer the most from precipitation flood risk in both 2018 and 2050 among capital cities in the Netherlands. Therefore, the management approach of The Hague can also contribute to the rainwater flood management of other capital cities in the country in different ways.

On the one hand, the experience can be adapted to other historical cities, which still owns canals in the city center, the redesign of the canal can be adapted to those cities.

On the other hand, cities which are using public space as construction structure, such as Groningen, can take the experience of the management process of Centrum as an example.

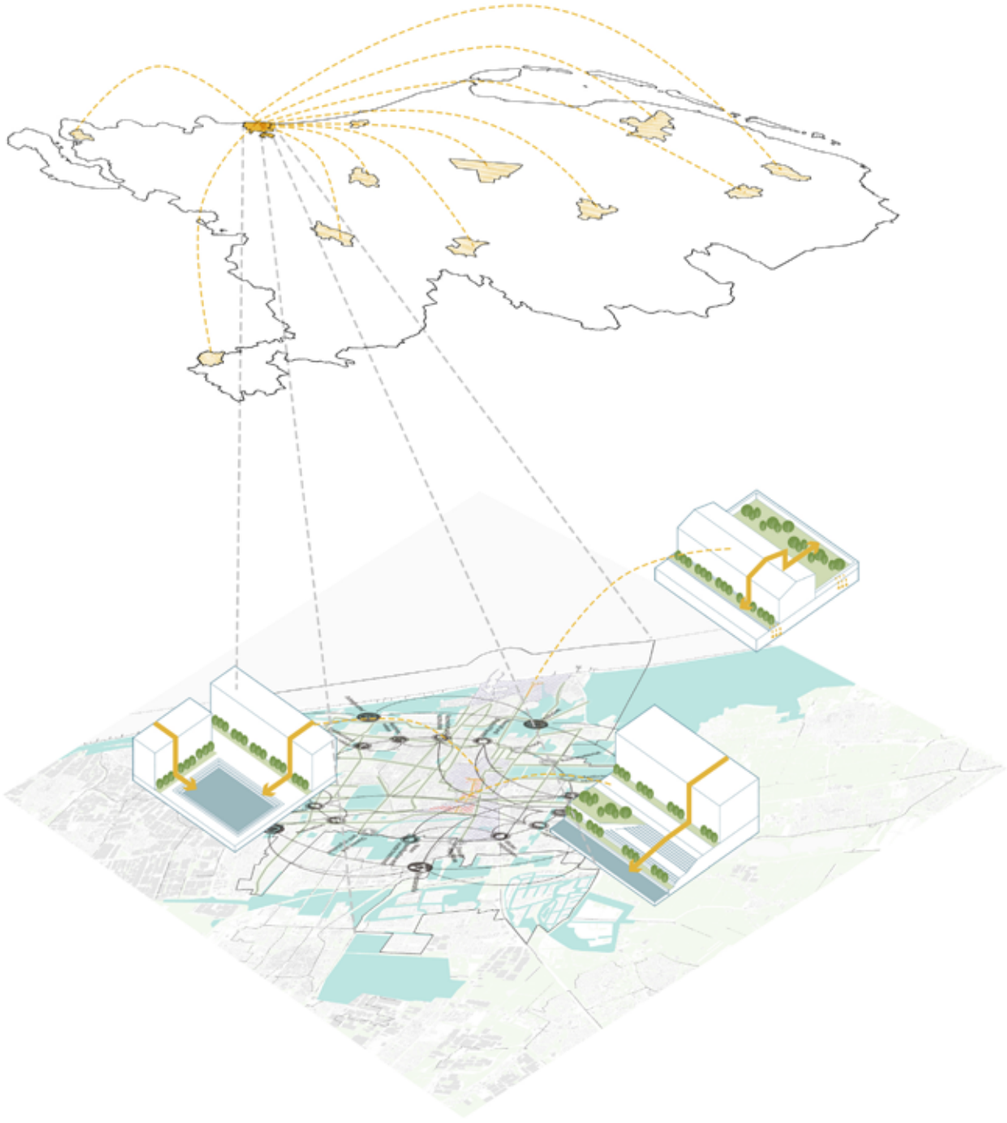


Figure 129: From the city to the capital cities (made by author, 2020)

Scale 3: from the city to 100RC cities

As a member of the 100 RC, the research outcome of The Hague can also be adapted to the urban resilience framework and expand the knowledge body.

The experience of The Hague can be used as a reference for the European cities of 100 RC with the following characteristics:

(1) a well-developed city which is vulnerable to precipitation;

(2) a historical city with valuable public spaces;

(3) an international city with a large amount of migrants with different social backgrounds, which requires solutions for social intergrations.

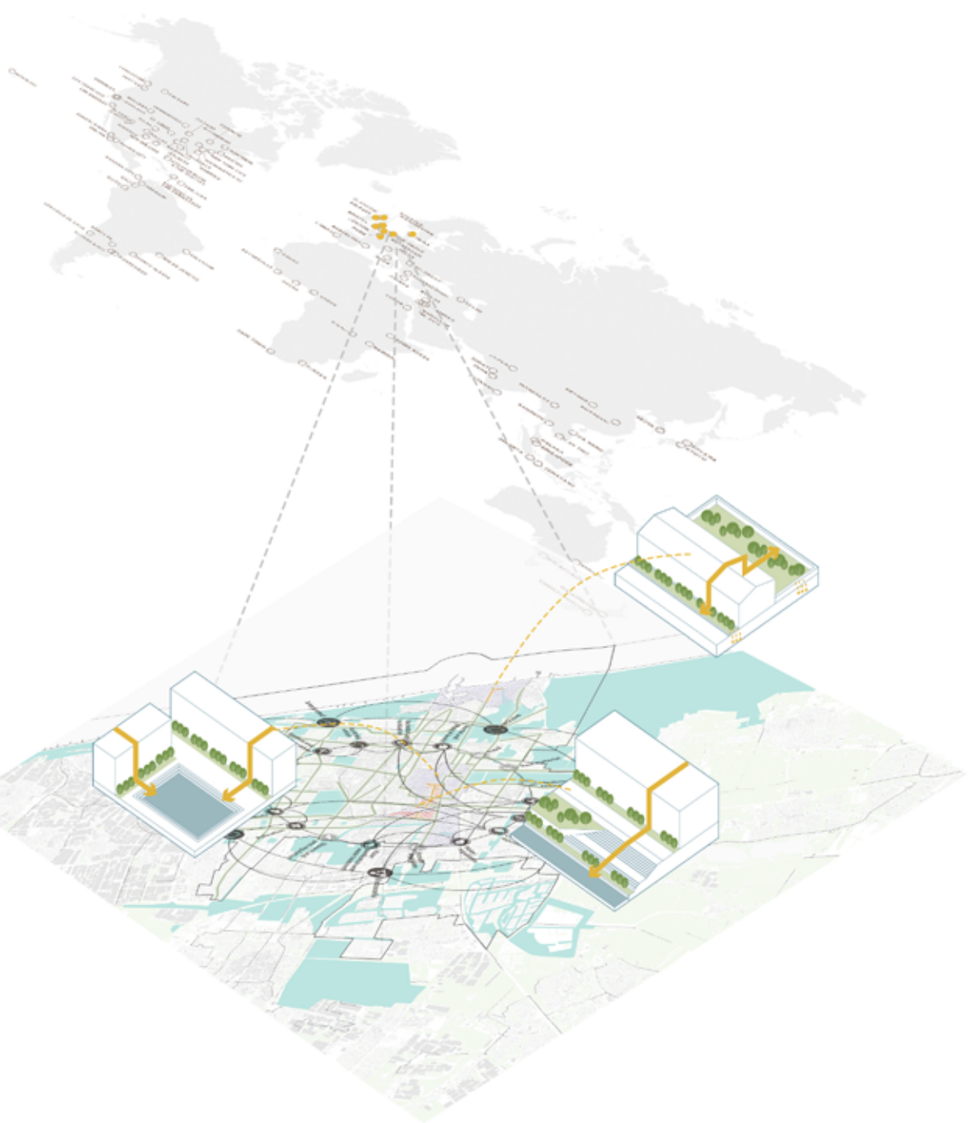


Figure 130: From the city to 100 RC cities (made by author, 2020)

Chapter

9

CONCLUSION

Problem

Based on the problem field and problem focus chapter, the major problems of The Hague are in two dimensions: (1) the uncertainty of extreme precipitation and the related rainwater flood; (2) urbanization trend for accomodating growing population and the results of losing liveability and segregations between different population groups. They're forming a vicious circle and causing larger and more complicated problems in the city. As a well-developed city, the construction structure of the city is closely linked with public space design. Therefore, the research of this thesis aims to study how can public space design help with breaking the vicious circle and achieving rainwater adaptation and urban resilience in the city.

Guiding theory

The conceptual framework of the thesis aims to discuss how to break the vicious circles and form a benign cooperative relationship between water, social and ecological systems. The framework aims to increase the adaptation capacity of the city and further alter it to resilience to let the measures contain additional benefits.

The management approaches must embed the urban resilience values, which are: (1) Leadership and strategy; (2) Minimal human vulnerability; (3) Sustainable economy; (4) Reduced exposure and fragility to act on the project in order to come up with a resilient set of spatial measures.

Design approach

According to the different subsoil and urban layer, the implementation consists of three different water management approaches, which are: infiltration, retention and conveyance. They are combined with public space design and derived into various intervention strategies.

The design approaches consists of three scales, which are: the city scale, the neighborhood scale and the public space scale.

Firstly, in the city scale, by looking into the subsoil, urban and social layer, the city is divided into four typologies. Various toolkits are raised up as designing proposals for different typologies.

Secondly, in the neighborhood scale. an intergrated system is designed for the three urgent areas of the city- Scheveningen, Centrum and Laakhaven by using the proposed designing principles.

In the public space scale, Centrum is chosen as pilot area, as the structure of the area is originally formed by public space design. Five pilot areas are chosen to test how can public space design increase rainwater adaptation capacity and enhance urban resilience locally.

The designing proposals will be adapted into the municipal development visions. By doing so, it can be prevented to investment in the same area repeatedly.

Answers to research questions

The project also provides answers to the raised research questions in the former chapter.

Main research question:

How can public space design contribute to urban resilience in The Hague by 2050 when city is faced with the challenge of extreme precipitation?

When faced with the challenge of extreme precipitation, the management approach needs to be adjusted from a purely techinic-based approach to nature-based approach.

The current water runoff is due to two dimensions of problems: (1) during the extreme precipitation, the designed drainage capacity of the grey infrastructure can't meet the required amount; (2) the largely paved surface blocked the natural water infiltration in the city and adds the total amount of water which is required to be drainaged.

Public space design which is combined with green infrastructure can therefore become a powerful complement to urban drainage systems. On the one hand, it can increase the permeable surface in the city and therefore introduce the natural water cycle back to the city. In the proposal, the total amount of exceed water is decreased. On the other hand, the public space can provide with temporary water storage and retention, therefore, the pressure on grey infrastructure can be decreased, and the drainage time can be extended to meet the designed drainage capacity and prevent water runoff.

The green and blue grids in the public space can also provide additional values. They can not only enhance the green network in the city, increase the biodiversity, and improve the microclimate, but also provide spaces for intergrations between population groups with different social background and increase the liveability.

As urban resilience is defined as the "measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming towards sustainability", public space design meets the values that are highlighted.

Therefore, public space design can contribute to urban resilience when the city is faced with the challenge of extreme precipitation.

SQ 1- Reduced exposure and fragility:

(1) What are the spatial implications of water-related risk on the communities in the city of The Hague?

The spatial implications of water-related risk in The Hague can be divided into two layers: subsoil layer and urban layer.

For the subsoil layer, the extreme precipitation and drought might affect the underground water level.

For the urban layer, the extreme precipitation will on the one hand cause damage to public and private properties, and on the other hand hinder normal urban functions, such as mobility and accessibility to resources and emergency services.

(2)Where is the vulnerable area need to be preserved?

(1) In neighborhood typology perspective:

According to the former analysis, the city of The Hague can be divided into four typologies. There are three typologies that are vulnerable: densification-semi-open city, renewal-dense city and densification-dense city.

(2) In neighborhood perspective:

There are three vulnerable neighborhoods: Scheveningen, Centrum and Laakhaven. When faced with extreme precipitation risk, the most damage will be caused to these three areas.

(3) In housing typology perspective:

According to the analysis, there are eight housing typologies that are vulnerable to extreme precipitation, which are: (1) Historic city center; (2) Urban building block; (3) Pre-war building block; (4) Garden village; (5) Working-class district; (6) Low-rise garden city; (7) High-rise garden city; (8) High-rise.

SQ 2- Integrated development planning:

How can public space design collaborate with the development vision of The Hague and enable the transformation of the city into a resilient environment?

The aim of the research meets the municipal development vision, which is to make the city of The Hague resilient by 2050. The designing principle and the timeline of the project also take the municipal intervention areas into consideration and follows the development time.

The public space designs can improve the quality of the urban environment and the hazard adaptation capacity, so that it provides a precondition for densification projects in the municipal development agenda.

It also collaborates with the densification and housing renewal projects by investing in rooftops, facades and private gardens.

SQ 3- Empowered stakeholders:

(1) What population groups are involved in the process of management?

The population groups include local residents, migrations, students, new residents which will be brought by the densification projects.

(2) How can the project ensure resident engagement?

In the governance management approach, the current top-down governance structure will be improved as a collaborative structure which consists the collaboration of municipality, water authority and local community. So that it provides the possibility to let the voice of resident group be heard. Workshops and collaboration for climate adaptation and resilience would also be provided for local residents and communities to empower and educate them about the co-responsibility for the living environment and the benefits.

With these two approaches, the residents will be empowered and involved in the design-making process.

SQ 4- Minimal human vulnerability:

How can public space design offer higher social and ecological returns while making the city rainproof?

As stated in the answer to the main research question, public space designed with green infrastructure can become a powerful complement to urban drainage systems.

The additional values provided by public space can enhance the green network in the city, increase biodiversity and improve microclimate. Public space can also be a platform for better social intergrations and improve liveability.

Recommendations for future research

The project proposed a method which combines the technical, spatial and socio-cultural management approaches. The following points will be the recommendations for future research:

(1) Multi-layer consideration: the city can be regarded as a collection of different layers- subsoil layer, urban layer and social layer. The project proposed an approach which can solve the different dimensions of problems systematically. The proposed approach can be further developed and adapted to other cities.

(2) Strengthening communication and discussion with the stakeholders involved in the management approach: as a recently proposed approach, the benefits of this approach might not be known by all the involved stakeholders, more communication and discussion will help with the evolution and feasibility of this approach.

(3) Social cost-benefit assessments and branding: as stated in the former chapter, the collaboration of local residents is essential to the project. However, the benefits of the management approach need to be shown to the public so that the residents will be more willing to get involved into the process. There are many cities are positively promoting the outcome of their rainwater management approaches to the public by branding. With websites, workshops and neighborhood activities, the benefits of the approaches can be easily known by the public. It may play an important role in the implementation and improvement of the approach.

Chapter

10

REFLECTION

The starting point of this master thesis was how to transform the challenge of climate change to the opportunity of urban development. As an intuitive embodiment of the consequences of continuous urbanization, climate change in turn affects urbanization. Nowadays people are faced with the new challenge: how to make the city able to provide liveablity, equality and security under the uncertainties brought by climate change. The project focuses on finding the synergies between rainproof resilience and the patterns of inhabitation of public space in the city. By taking the rainproof adaptation as the starting point, the project will also tackle the urban development process simultaneously.

[Aspect 1: Relationship with the studio, Urbanism and master program]

Transitional Territories studio focuses on the agency of design in territories at risk between land and water (maritime, riverine, delta landscapes), and the dialectical (or inseparable) relation between nature and culture. The studio focuses on the North Sea Region, which means the risk of climate change on the coastal cities would be critical. The geographical focus on the costal cities of North Sea Region, faced by the conflicts in the distribution of spatial resources, rapid development and governance, brings my project under the picture of the studio. As the integrated relationship discussed in the stuido requires regional and systematic consideration, my project resonates with the underlying theme of the studio.

Transitional Territories studio focuses on the game between natural territories and urban territories, which is also exploring how to coordinate the relationship between different systems. In this sense, my project aims to build the relation between climate change, urban development and society, which has a strong connection with the aim of the studio.

The study in the Urbanism track deepened my understanding of the complexity of the urban system. It let me change from thinking only about the visible apperance of design results to thinking about the interactions between different urban elements. The study of multi-layer safety approach of the Dutch water management inspired me about this project. The study also equipped me with more research and design methods, such as multi-scale design, research by design and stakeholder analysis.

On the other hand, my project also provides a new perspective of climate resilient urban design. Although the water management methods that are used in this project is nothing new, this design expands the meaning of climate adaptation from simple water management perspective to a carrier that guarantees social and economic equality.

[Aspect 2: The relationship between research and design]

There're already well-developed solutions in water management approaches for urban rainproof measures in response to climate change and the increasing precipitation. However, they are hard to be applied in highly urbanized and densed urban areas for the limitation of space and time. This phenomenon leads to my thinking about the relationship between water management and urban development. Therefore the starting point of my project is to develop a hybrid approach to adapt green infrastructures as rainproof measures in highly urbanized areas by connecting the water management and urban development approach.

This project follows the approch of research by design. Based on a well-developed city with a strong character, The Hague, the project aims to provide an answer to the risks in the city regarding to the complexity of the system while establishing a dialogue between water management and urban development approaches. The design approach can be regarded as a tool for generating problems of different perspectives and visualizing the possible solutions by reflecting them spatially.

In the research part, I divided the objective intro three components: risk, urban and inhabitation. By analysing the respective risks and vulnerabilities I found the overlapping of problemtic areas. Urban development areas are also faced with the challenge of extreme precipitation and the segregation of different popoulation groups. Therefore, as the climate changes, the vicious circle will be formed, resulting the new developed areas are still faced with risks and exposing the vulnerable groups to more vulnerabilities.

Thus, accroding to the conclusions drawn from the research, vision for urban development should consist three aspects: densification, rainproof and equality. Due to the limitation of space, the possibilities of using the public spaces as a buffer of rainproof can be explored.

The conclusions of the research points out the direction of the design, which is how to use natural based solutions in the reconstruction of public space to achieve the goal of being rainproof and providing better liveablity and equality in the urban area. This approach can make the city more resilient and increase the capacity of coping with future risks.

In this perspective, the clear relationship of research and design is stated. Design comes from the conclusion of research and provide the evaluation for it in return.

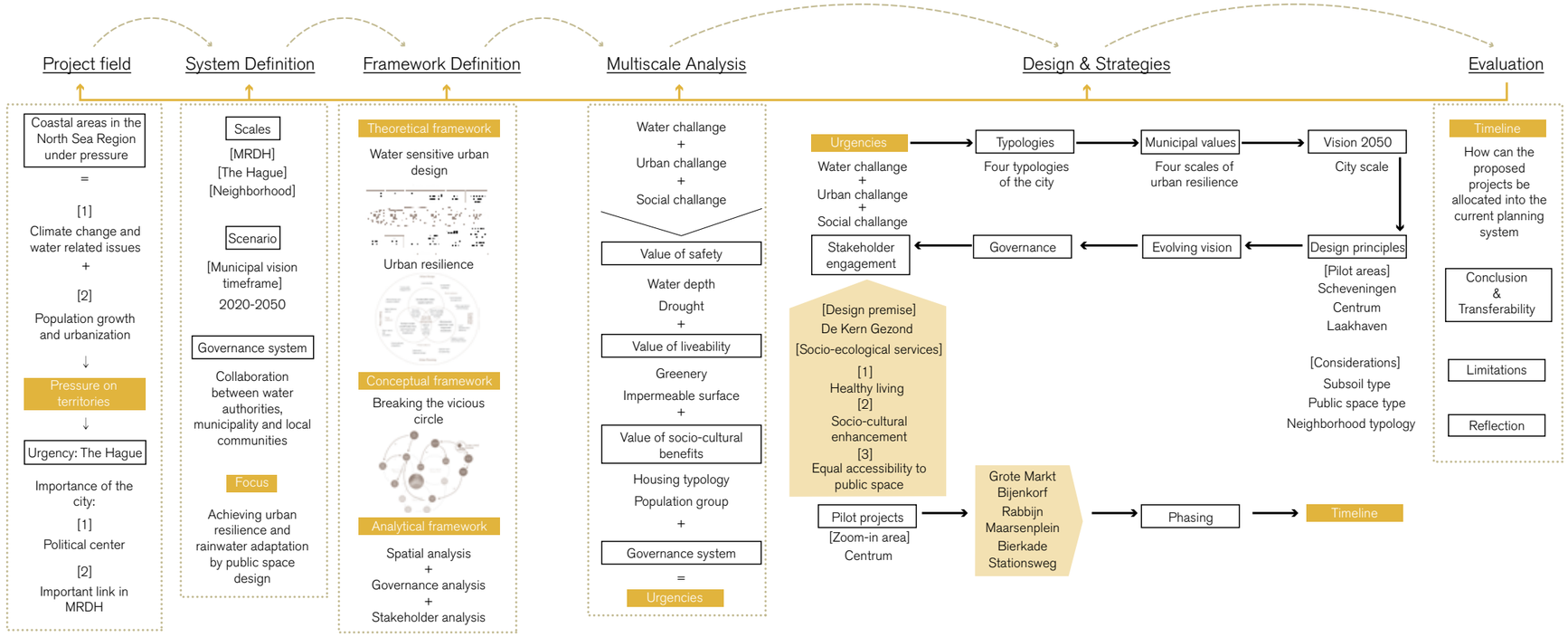


Figure 131: Research approach (made by author, 2020)

[Aspect 3: Elaboration on research method and approach chosen by the student in relation to the graduation studio methodical line of inquiry, reflecting thereby upon the scientific relevance of the work]

In the methodical line of inquiry of Transitional Territories, the notions of the complexity and co-existing of nature and urban form are valued. It proposes a holistic approach where risk management and inhabitation play the role of integrated components of complex urban system rather than dualistic approaches.

In regard of this, my project attempts to position itself as a multi-dimensional method that combines risk adaptation and urban development. This approach can not only solve the problem of each dimensions but can also create more values with the snergy between different systems, which can provide a new vision for urban development of areas under climate risk.

[Aspect 4: Scientific & Societal relevance and transferability]

The past decades there has been a shift in the water management approach; moving from fighting against water to working with nature to give space to the water. The spatial planning and water management strategies which are measured by the engineered approach do not urge the urban development to look for suitable land but made it possible to urbanize areas that are geographically not the most suitable for this land-use. However, the geographical layer is less influential than the topographical layer in determining where to develop urban areas. Therefore, the strategies about adjusting the way risk is approached is being elaborated. The components of vulnerability and adaptation to risk are playing more important roles in the water management approach. This project aims to implement the water sustainable urban design into the city development vision to make the city rainproof. This approach can work as a beneficial complement to the current water management system and is also flexible. Additionally, the contribution of adaptation as an opportunity for promoting urban development and resilience to the 100 Resilience City context is an important marker of the societal relevance of this project. The strong focus of the project on socio-spatial and governance relationships with climate change and the notion of social and spatial justice is an asset to furthering the debate and discussion on equality in society.

The transferability of this project is related to the conceptual base of the research method. The research is based on developing the connection between water management approach and urban development approach to make the city rainproof. As climate change and urbanization are the common challenge all over the world, this approach can provide a possiblity of adapting cliamte change in a well-developed city with strong character.

[Aspect 5: Ethnical considerations]

An increased focus on ethics and justice is the root of shaping how we respond effectively to global pressing issues such as climate change while at the same time tackling diverse social and economic problems in our cities including inequality, marginalization and lack of access to opportunities.

In some areas (such as The Hague Southwest), clear demarcation lines show the spatial separation of different communities. Isolation is more than money and assets. It also deals with livability, cultural diversity and equal opportunity. It must be recognized that some residents strive to meet basic needs and have limited capacity or resources to deal with emergency shocks or cope with long-term stress.

Climate change is a manifestation of the consequence of at the cost of sacrificing the interests of certain communities in the name of the ‘greater good’. The water sustainable urban development approach focuses on small-scale innovations which mainly happens in the neighborhoods. It not only solves spatial the vulnerabilities, but also the social vulnerabilities because of the extra value it brings. Therefore, it can directly tie the techno-dominant field of mitigation approaches of climate change impacts with the social vulnerabilities.

[Aspect 6: Summary & Limitations]

The reflection of hazards due to climate change in The Hague varies in different aspects, such as heat waves, sea-level rise and extreme precipitation. In this project, the main focus is the possible flood risk brought by extreme precipitation.

Adaptation is a continuous stream of activities, actions, decisions and attitudes that informs decisions about all aspects of life, and that reflects existing social norms and processes. There are many classifications of adaptation options (summarised in Smit et al., 2000) based on their purpose, mode of implementation, or on the institutional form they take. In this paper, to better explain adaptation, we have focussed on the intention of the adaptation and the impact of the adaptation.

As elaborated previously, climate adaptation approach has multidimensional impacts on space, society, politics, economy. Here, the project limits its focus to studying the spatial and socio-spatial implications of adaptation in alignment with the main aim of the project, which is to facilitate a humanised urban development and risk prevention.

Climate justice is intrinsically tied to the idea of socio-spatial justice, a concept that emphasises the social and spatial perspectives of inequality. Thus, the adaptation to climate change is not only just a issue of a spatial dimension but also has a socio-economic or political demension. Here, it is important to note that the physical boundaries and problems that delineate locations of vulnerable communities have evolved due to years of negligence and systemic inequality in all socio-spatial fields. Faced with this reality, it is crucial to acknowledge that the outcome of this project can create conditions for equitable accissibility of opportunities and resources to exist, but the systemic inequality in other fields falls outside the scope of this project.

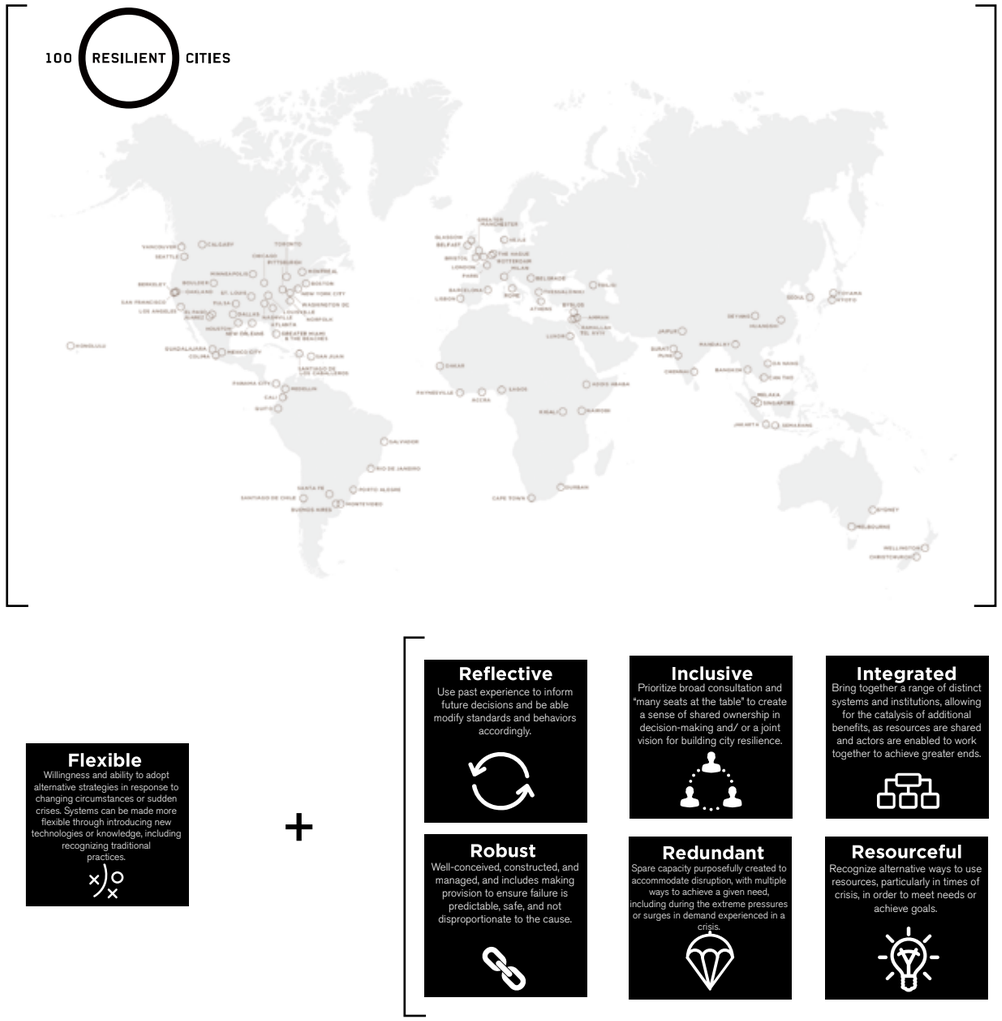


Figure 132: Characteristics of Resilient Systems (made by author, adapted from100 RC)

Chapter

11

APPENDIX

Towards a water resilient future:
Implementing green infrastructure to interactions of rainwater management in the Dutch context

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Throughout the history, the fight against water never ends in the Netherlands. Nowadays, due to the change of precipitation and urbanization patterns, the cities are more exploded to the danger of urban flooding. The more noticable extreme weather conditions and the continuously growing unpermable surface in the city cause undesirable conditions regarding water resilience in cities. The water run-off in the cities caused by extreme precipitation are more and more often, which shows that the current water system in the cities are insufficient under this situation. Therefore the need of a more resilient rain-proof system is gaining momentum in the Dutch water management. The major cities in the Netherlands, such as Amsterdam, Rotterdam and The Hague, are becoming a new victim of the flood caused by extreme precipitation. In light of the dual demands of urbanization and rain water resilience, the interacted system of rainwater management using green infrastructure will analyzed. Amsterdam and Rotterdam will be used as a practical example of how the this strategy can achieve rain water resilience in the process of urbanization under the Dutch context. Last but not least, how these approaches can be implimented in The Hague will be discussed. It concludes that implementing green infrastructure into rainwater mangement would lead to transformation, flexibility and better liveability, which are key to achieve the resilience in the context of the city of The Hague.

Key words
urban flooding, water drainage system, green infrastructure, rainproof, the Netherlands

Introduction

Over centuries, the Netherlands has always been fighting against the water. In recent years, the observed significant increase of precipitation and the incidents of extreme rainfall have sounded the alarm for the Netherlands.

The 26% increment of annual precipitation between 1910 and 2013 (KNMI,2015) and the significant increase of intensity of weather conditions in the Netherlands shows a wetter future. Besides, the continous urbanization in the Netherlands, with an increase of 11% between 1900 and 2000 is predicted that will continue in recent years and reach a growth of approximately 41% by 2040 in the Netherlands (VR Golroudbary et al., 2018).

However, with the increasing density in the urban areas and the amount of precipitation, the traditional infrastructure in Dutch cities, which combines the canals and the sewer draiange system, can't reach the capacity to sufficiently drain off the rainwater (Boer, 2012). This shows the urgency that the changing climate and urbanization pattern may explode more residents to the serious aftermath of flooding.

Urban areas are facing the challenge of providing safe, adequate living space and infrastructure with limited spatial resources while the urban flooding incidents are threatening the safety of both public infrastructures and private properties.

This has led to the acknowledgement of implementing flood management to the spatial planning, which is a reflection of the call for climate adaptation and urban resilience (Showstack, 2014). In this case, instead of narrowly focusing on defending assets or urban functions from the flood risk, we should try to create deeper relationships between spatial planning and flood management, to transfer it as an opportunity for re-connecting the urban and natural systems and creating interactions.

As the focus of this article, making the city rainproof and strengthening resilience not only means equipping the city with the ability to recover from shocks and develop disaster preparedness, but also means to explore its extra value from measures, so that resistance measures can also promote the development of other urban functions.

In the rainwater proof context, adaptation approaches need to be adapted to local conditions, therefore it is hard to come up with a standard which can be generally adapted to all conditions (Anguelovski & Carmin, 2011). As different cities have adopted varying approaches, it is important to take refrences among the Dutch cities. Therefore, adaptation plans of the municipalities of Amsterdam and Rotterdam will be chose as case studies.

By analysing the experience of these two cities, this article will discuss how to archieve rainproof resilience in the city of The Hague through the interacted system of stormwater management using green infrastructure under Dutch context.

1. The impact of climate change and urbanization on precipitation

The complete water cycle consists six components: precipitation, condensation, evaporation, transpiration, surface runoff, infiltration and groundwater flow. As the most significant component of the water cycle on land, precipitation represents the water that descend from the clouds. Precipitation falls on the land and flows over the ground (runoff) or moves from the ground into the soil (infiltration and groundwater) (Flato et al., 2000).

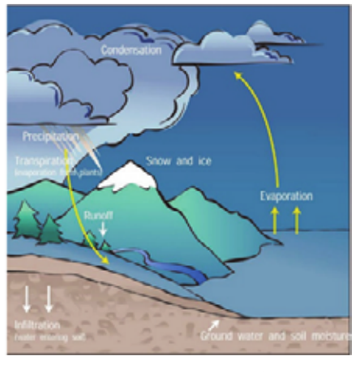


Figure : Natural process of water cycle (Source: Windows of Universe website., 2009)

As the two biggest challenges in the 21st century, the climate change and urbanization are affecting the water cycle, which results the increasing urban flooding caused by extreme precipitation.

On the one hand, the global warming increases the total amount of precipitation. The rising temperature is increasing moisture in the atmosphere and thus making storms wetter (Nature, 2019), which increases the distribution of the precipitation and extreme events.

On the other hand, the urbanization impedes the infiltration of the water. The growing population drives the urbanization in urban areas for providing more habitats for human beings. The constant construction in urban areas are resulting the large percentage of areas covered by sealing materials, which impedes the infiltration movement of the rain water. When the total amount of detained water exceeds the amount of discharge from the sewage system, the water runoff may cause the pluvial flooding.

Therefore, urban areas need to provide two aspects of solutions: on the one hand providing larger capacity of water storage when flood occurs, on the other hand increasing the infiltration of water to the ground to decrease the runoff on the surface.

2. Important factors in urban drainage system: Grey infrastructure and green infrastructure

The current urban drainage system can be approximately divided into two types: sewer drainage systems and hybrid socio-technical engineered systems.

Grey infrastructure refers to the artifical, centralized water management infrastructures, such as water treatment plants, sewers and reservoirs. As a traditional drainage infrastructure, it is often constructed of concrete, thus it is often impermeable to water. As there's no ecosystem can grow on the grey infrastructures as designed, therefore it can't deliver extra benefits for the urban system (NWRM,2015).

Hybrid socio-technical engineered systems refer to solution combining natural and artificial (grey and green) structures which involve both grey systems and their integration with re-discovered green systems (Staddon et al. 2017).

As an important conponent of the hybrid socio-technical engineered systems, green infrastructure (GI) refers to rainwater management facilities based on natural hydrological processes that uses vegetation surfaces to temporarily store water and relys on the inherent properties of soil to slow, filter and move water and therefore filters pollutions at the source and encourages rainwater to infiltrate into the ground to help mitigate the impact of floods.

While both grey infrastructure and green infrastructure can reduce the flood risk by attenuating exceedance to ensure the normal operation of hydrological functions in urban systems, they also have differences and they are distributed in several aspects.

Firstly, their ways of distributing the risk with the urban domain are different. Grey infrastructure Gray infrastructure is by shifting risk out of the protected area, while green infrastructure is by decentralizing the risk within the protected area. Grey infrastructure mainly suppresses the risks by diverting risks out of the protected areas by creating hard barriers or conveyances. It is limited by the designed capacity and when the capacity is exceeded, it is hard to implement adjustments. While green infrastructure tries to attenuate the peak flows by creating a more diffused distributing flood risk over space and time. This is achieved by creating water capture areas vrays in scale, they can both provide more space for water storage and increase the ability of storing water within the space.

Secondly, they have different effects on the reconstruction of the natural water cycle system within the urban domain. Nowadays, due to the rapid urbanization, the areas covered by hardened surface are increasing, which blocks the penetration of water into the soil, thereby affecting the natural water cycle wihtin the urban domain. As the main focus of grey infrastructure is either on the efficiency of water drainage or reducing pollutant load, it not only leaving out the ecological changes but also works as hard

physical barriers and may even encourage impermeable areas and occupy valuable limited space in urban areas (Burns et al., 2012). Meanwhile, green infrastructure creats possiblities for the water movement in terms of precipitation, runoff, infiltration and evaporation and therefore reconnecting the urban ecology to the natural water cycle.

3. Challenges for urban resilience and contributions of green infrastructure

By aiming to develop towards rainproof cities, it asks for decreasing vulnerability and to increasing urban resilience. Urban resilience refers to the capacities of different systems within the urban domain to survive, adapt and grow under the threat of no matter what kinds of chronic or acute stresses they're faced with (100RC, n.d.). Within the flood context, the concept of resilience can be tranlated as the capacities of the systems to resist, absorb and recover when they're under the flood risk. The capacity to resist refers to the strategies of reducing the flood risk. In the meanwhile, by realizing that flood can't always be prevented, we need to prepare flexible measures to absorb and recover from the flood when it occurs.

According to the Three Points Approach proposed by Fratini et al. (2012), urban flooding risk management can be divided into three domains: ① non-flood condition state: it refers to the performance of which there is little or no rainfall. At this state, rainwater management system within the urban space is functioning normally within its designed capacity; r ② flood state: the critical point between non-flood condition and flood condition is the maximum of the designed capacity of sewers and other drainage infrastructure. When the water amount exceeds the full capacity of the drainage system, it comes to the flood state; ③ extreme rainfall: it happens under the condition of 1 in 100 year event when the floods became uncontrolled and submerged.

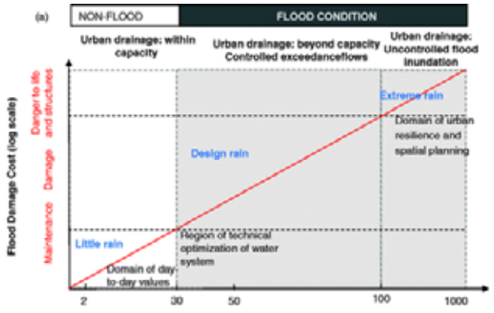


Figure : Three Points Approach (Source: L. Hoang & Fenner, 2015)

Solutions for the first two states are gray infrastructure within the city. With the rapid urbanization and expansion of cities, natural green spaces have disappeared on hard ground, often losing the concrete flood prevention function. Therefore, under non-flood conditions, cities rely on gray infrastructure to provide hydrological functions. However, the traditional method of using gray infrastructure will generate a positive feedback loop, promote more urban development, and thus promote more rainwater infrastructure construction at the expense of environmental systems.

Similarly, it is not practical to build the corresponding gray infrastructure according to the capacity required for extreme 1 in 100 year weather event. Not only because the capacity is difficult to predict, but also such capacity far exceeds the capacity needed in daily life, so it will bring large amount of waste of resources.

Therefore, green infrastructure can be a powerful complement to urban drainage systems. The green infrastructure constructions by making use of residual green space in cities can make them a useful complement to the current gray infrastructure drainage systems, enabling drainage systems in cities to survive extreme rainfall and floods and avoid interrupting the drainage services.

At the same time, the green space can provide extra value in the urban system. Firstly, it can create the opportunity to re-connecting the natural system to the urban areas by means of working as increased habitats to improve biodiversity or public space to decrease the heatwave. Besides, it can also reduce the threat to nature from urban activities by using its ecological properties, such as climate change mitigation through carbon sequestration/storage and reduced greenhouse gas production. By creating interdependencies among different aspects of social-ecological systems, the green infrastructures may foster urban resilience by enabling integrated social–ecological–technical systems to respond and recover in a more positive way.

4.Understanding green infrastructure under the Dutch water management context

Different green infrastructure elements will perform differently in different geographic context. Therefore, the urban storm water management schemes should adapt to local conditions and water management approaches.

4.1 The Three-Step Approach

The Three-Step Approach, which entails the capturing, storing and draining of water (Dai, van Rijswick, Driessen, & Keessen, 2017), is one of the key concepts of Dutch water management.

The first step aims to hold the precipitation in the catchment area as long as possible when it falls. After reaching the capacity, the second step is to store the water temporarily at the designed storage areas. Drainage comes at the last, as the last step when the capacity of former options exceeds. This approach aims to increase the capacity of absorbing rainwater,

and it is more and more applied in urban areas. The key to this strategy is the capture and storage in the first two steps. It can be done through green infrastructures, by means of public infrastructure (such as public space and water square), and measures taken in private land (such as green roof and separated rainwater sewage system).

This will involve different layers of stakeholder collaboration. At the national level, different governmental levels share responsibilities of flood risk management. Focusing on spatial planning level, they developed the National Adaptation Strategy and the Delta Programme as climate adaptation strategies. They provide guiding principles for next level. However, when it comes to adaptation of precipitation flood, due to the scale of the problem, the responsibilities are shared between the municipalities and local residents. If measures are taken blindly to only increase the capacity of the sewage treatment system, the solution will become very expensive. Therefore, the Dutch municipalities wisely chose to introduce 'blue-green grid' measures in the form of cooperation with residents and multi-functional infrastructure. Except for separating the rainwater drainage systems from the sewage treatment systems, they also practiced informal policies such as subsidies and facilitating participatory projects to encourage local residents take more measures in private property.

4.2 Case studies: Amsterdam and Rotterdam

Rainproof approaches are maily focusing on city scale interventions. Therefore, it is important to apply tailor-made strategies and policies that are specific to local circumstances, as every city is unique at their characteristics of landscape, infrastructure and social demographics.

As the final research area of this paper is The Hague, cities with similarities to the characteristics of The Hague will be chose as case studies. The city of Amsterdam and Rotterdam are chosen as case studies for the following reasons: ① These three cities are all part of the Randstad area. They are all highly urbanized and are undergoing the most visible urbanization (CBS, 2018); ② They have all currently experienced incidents of heavy rainfall. Therefore, taking the rainproof projects in these two cities as case studies can provide valuable refrences for discussing the case in The Hague.

4.2.1 Amsterdam

Amsterdam takes the climate change adaptation as an opportunity rather than a obstacle. It aims to reach the goal of coping with rainfall of 60 mm/hour by 2020 without damage to buildings and vital infrastructure, and to be fully rainproof by 2050 by practicing the 'Amsterdam Rainproof' adaptation strategy. This project is developed by Waternet, which is the water management enterprise of Amsterdam and surrounding areas, which mainly uses soft policy instruments and avoids large infrastructural investments. By estabilishing 'Amsterdam Rainproof' website, it created a showcase platform which can inform the local residents, private enterprises, government officers and experts of the current situation and the resposibilities while encouraging and activating them to take part in designing public infrastructures that can better handle intensive rainfall and taking actions in private properties.

4.2.2 Rotterdam

As a delta city, 'protecting itself against and living with water' is one of the core spirits of Rotterdam's urban development. In the rainproof context, the municipality aims to make the city 100% climate-proof by 2025, and developed its unique project: Rotterdam Climate Proof.

While located in the delta of the Rhine and Meuse rivers, the city lies both in the outer-dike and inner-dike areas, and the inner-dike city is largely below the sea level. The measures taken in Rotterdam are also vary according to the location. It takes adaptive constructions and designs, such as flood-proof buildings and public spaces, in the outer-dike areas. While in the inner-dike part, the measure are more about capturing and storing rainwater, such as green roof and façade, water squares and infiltration zones. Rotterdam also transfers climate change as opportunities by engaging in city branding as a safe, climate-proof innovation and climate-knowledge hub and advertising its climate adaptation strategies on 'Rotterdam Climate Initiative' website.

4.2.3 Overview of the approaches and concluding remarks

By comparing with these two cities, although the measures differ from forms, by they are all following the core concept of Three-Step approach by aiming to raise the ability of capturing, storing and draining of water in the urban areas. It can release the pressure on the sewage system by taking measures before directly discharge the water into the pipes. It is a good practice to integrate water-storing facilities in local residents' daily lives and developing multi-functional public spaces such as green roof in private properties and water plazas.

Besides, expect for gaining location-specific risk data, the remarkable part in the policy-making process is that they both proactively initiated city-scale campaigns with their own name and branding strategy. This approach can raise public awareness of the need to make their city rainproof can lead to long-term benefits.

4.2.4 Principles of analysis for policy-making

Good policy-making must be based on a clear defination of the problems at the hand. Therefore, it it important for municipalities to prepare location-specific risk data and sufficient knowledge of practical issues such as soil types, subsidence and housing typologies.

Each cities face different problems. Thus, it is essential to have a good understanding of the physical circumstances,existing infrastructures and social demographics.

① Physical circumstances

In the case of pluvial flooding, local nature conditions can largely affect sensitivity to flooding as well as the development of the most suitable adaptation strategy. For example, the soil type affects the speed of the rain permeating through the surface (Boogaard, 2015). Therefore in the case of Amsterdam and Rotterdam, the strategies are different. Rotterdam is mainly built on clay, so the infiltration of water is limited and the run-off level is higher (van de Ven et al., 2011). Therefore the municipality at first invests and promotes large-scale projects such as the Benthemplein water plaza which can reduce hazards to some extent when run-off occurs. While Amsterdam is based on peat, which makes it hard to extend the drainage system, thus it focuses on the water storage capacity through investing in green roofs and green spaces rather than on drainage.

② Existing infrastructure and capacity

It is also important to have a clear oversight of the city's existing infrastructure and its capacity. The infrastructures include the existing canal, sewage system and permeable surface, which may affect the capacity and speed of dealing with water in the city. For instance, the historical canal systems exist in the traditional city centers in Amsterdam but not in Rotterdam. And the most paved areas also should be identified as it's the root causes of the pluvial flooding. Whether the rainwater drainage is seprated with the sewage treatment is also worth concerns. For example, in Amsterdam, there are two types of sewer systems: a mixed and a separate system. In the mixed sewer system, there is one sewer pipe below the streets where rainwater and waste water from the toilet, shower and washing machine come together. The water flows through the sewer system and a sewage pumping station to the sewage treatment plant (WWTP) in Westpoort. Once the water has been purified, the WWTP discharges the clean water into the North Sea Canal. With a separate system, there are two pipes under the street: one for waste water and one for rainwater. The water is drained separately from each building via two pipes. The waste water is then pumped to the treatment plant. In principle, rainwater flows freely through the (rainwater) sewer pipe to surface water such as a canal or river. If there is enough space underground, the separate system is preferred for the (re) installation of sewer systems. By seperating the pipes, the process of purifying water can be omitted, so that rainwater can flow into natural water bodies faster.

③ Social demographics and public involving

For example, as Rotterdam inhabits more low-income families, it makes sense to firstly arrange climate-proof strategies through spatial planning, which means the municipality will take more responsibilities. By doing so, the city may be turned into a greener and more liveable place, which may attract families with higher incomes and thus provides the premise for practicing small-scale strategies in private properties. While Amsterdam rainproof project emphasises that its responsibilities focus on helping residents take on their own responsibilities (Waternet, 2016).

What's more, since 2000, the municipalities have been increasingly focusing on introducing public participation in projects and stimulating 'bottom-up' projects by collabrating with local residents.

The approaches examined in Amsterdam and Rotterdam show that there are two aspects that are important for involving stakeholders into rainproof projects.

The first one is to stimulate actions in the private-owned lands taken by residents and owners of private enterprises. The most common way is to disseminateby online and traditional media, such as the Amsterdam Rainproof and Rotterdam Climate Initiative websites. This can raise the awareness of climate change and to remind residents that they are responsible for dealing with rainwater on their own plot of land. This sets the backbones for promoting the bottom-up projects led by residents.

The second form happens at the public space designing and constructing phases. By involving stakeholders at the early stage of the project can on the one hand dig out many valuable suggestions and improve the project and on the other hand relieve public concerns and reduce dissatisfaction with the need for space planning projects and water-related infrastructures.

5. Discussion: developing rainproof project and achieving urban resilience in The Hague

In a current graduation thesis at TU Delft (Tjerk Krijger, 2018), the affect of precipitation flood among cities is named as city index, which is consists of two related components, namely the precipitation risk and the precipitation index. Among all provincial capitals, The Hague ranks has the highest city index in both 2018 and 2050. This is mainly due to the high precipitation index in the city, which is contributed by the the relatively large percentage of paved surface and the high percentage of urbanization in The Hague. Therefore, The Hague has the largest number of buildings affected by extreme precipitation and suffers the greatest economic consequences in the event of pluvial flooding, which makes it very vulnerable. However, the Hague is still blank in establishing specific rain protection plans like Amsterdam and Rotterdam.

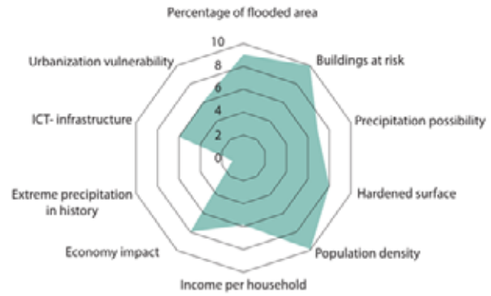


Figure : City index of The Hague (Source: made by author, adapted from Tjerk Krijger, 2018)

But the municipality has already set up a solid basis by joining the 100 resilience cities project and actively developing Resilience The Hague project in the city. The Resilience The Hague website also serves as helpful and recognizable platforms for raising the awareness of residents.

Since more than 60% of the Hague's land is private property, it limits the possibilities for local governments to take action, which means that public-private partnerships are essential for climate disaster prevention in our cities. Therefore, using green infrastructures as a medium is an effective measure to increase the water capacity in the city and achieve the goal of being rainproof.

The vulnerable part in the city is the historical center, which is based on peat soil and with rich historical canals. Therefore, at this point, Amsterdam project is more informative. The project should focus on increasing water storage capacity and invests in green roofs on public buildings, green spaces in residential areas and make use of the historical canals.

Due to complexity of cultural backgrounds of the local residents, which most of them are high-income population, and the importance of the area in the city, it is important to practice spatial planning and small-scale strategies in private properties at the same time to increase the rainproof ability of this area in multiple dimensions.

As a result, the city can benefit from community-based adaptation methods tailored to local conditions. For example, increasing green space in communities lacking green space not only reduces the vulnerability to the impact of heat waves and heavy rain, but also helps to purify the air and improve people's living habits throughout the year. In addition to improving environmental adaptability, it can also encourage people to interact between different parts of the city and with people of different cultures, nationalities, abilities, values, social classes or ages, thereby reducing apartheid and enhancing social adaptability. Therefore, it also promotes the urban resilience.

6.Conclusion

This paper outlines how green infrastructure can be used as a beneficial supplement to the current urban water drainage system, improve the rainproof capacity of the city and promote the urban resilience.

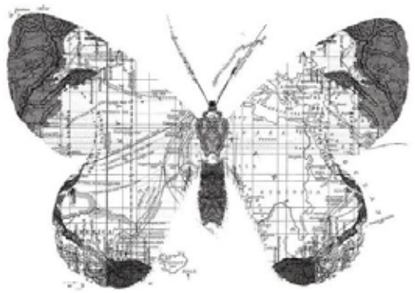
The continous of urbanization results the increasing percentage of the paved ground surface. The impermeable surface blocks the infiltration of the water which disturbs the natural water cycle process in the urban area. Meanwhile, due to the climate change and global warming, precipitation and extreme weather happens more frequently. The drainage system therefore is under great pressure and if excess rainwater can't be drain away in time through grey system, it causes pluvial flooding, which may not only interfer with the normal operation of city functions but also cause property damage. Therefore, the research on improving the city's rain resistance has attracted increasing attention.

As rainproof measures must be adapted to local conditions, this paper combines the general approaches of building up green infrastructure with Dutch local water management policies, and proposes how to evaluate and implement rainproof strategies in the Dutch context.

The applied assessment method in this study provides a systematic way to discuss the relevant elements of policy approaches. As the urban space in the Netherlands is often privately owned and the residents have the responsibilities to collect rainwater in their private properties, it is important to clarity about the public and private responsibility. The lack of awareness of the private responsibilities disturbs the effective adaptation. Thus the municipalities should take measures to raise the public awareness and avoid causing negative emotions among residents.

Overall, the good practices and improved lessons discussed in this paper will certainly support the research of the thesis and may be a useful refrence for other municipalities inside and outside the Netherlands who want to protect their cities from rain.

Notions



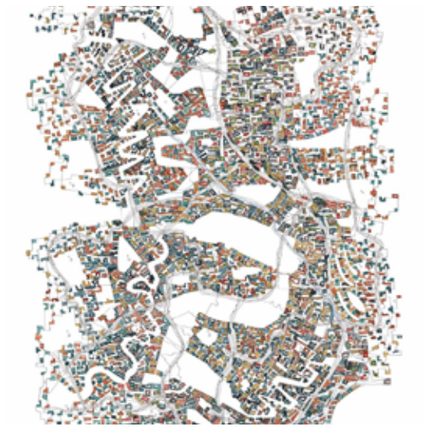
Butterfly effect

Tobias Fonseca

A small change in one state of a deterministic nonlinear system can result in large differences in a later state.

[SYSTEM]
Complexity

An essential quality shared by all living cities is a high degree of organized complexity (Jacobs, 1961). The conditions under which a complex system is likely to change to higher levels of complexity are seen as important when this system needs to deal with and adapt to climatic changes.



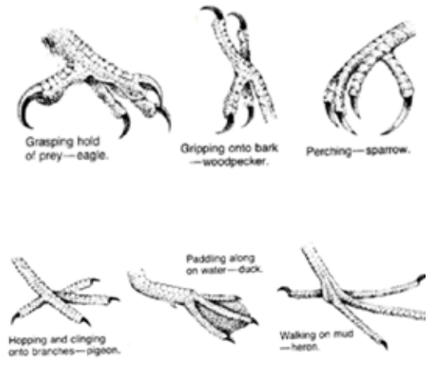
Geographical uncertainty

Fabrice Clapiès (2017)

The city was a fundamentally unknowable and unpredictable environment, uncertainty can be considered as an essential dimension of urban life.

[VARIATE]
Uncertainty

Due to the complex nature of the interaction of atmospheric warming, oceanic warming and ice-sheet,the uncertainties of climate change surround the precise interactions of regional sea-level rise and patterns of urban demography and development.



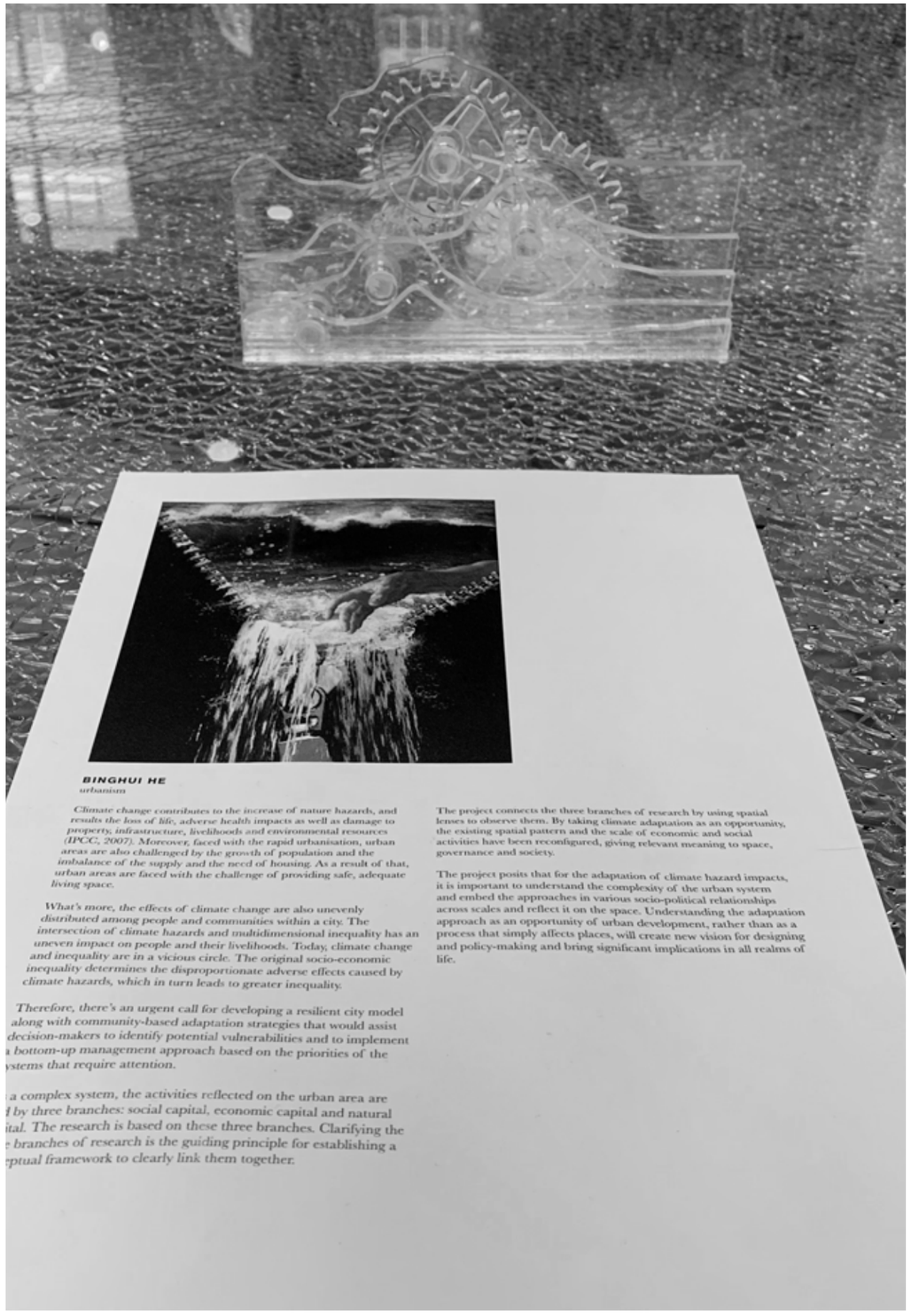
Biology adaptation

In the field of biology, adaptations are those changes to the structure or behaviour of an organism that improve its chances of survival or of successfully raising offspring.

[PROCESS]
Adaptation

Adaptation to climate change is the process whereby society reduces its vulnerability to climate change or whereby it profits from the opportunities provided by a changing climate.

Transitional Territories - Symposium sculpture



BINGHUI HE
urbanism

Climate change contributes to the increase of nature hazards, and results the loss of life, adverse health impacts as well as damage to property, infrastructure, livelihoods and environmental resources (IPCC, 2007). Moreover, faced with the rapid urbanisation, urban areas are also challenged by the growth of population and the imbalance of the supply and the need of housing. As a result of that, urban areas are faced with the challenge of providing safe, adequate living space.

What's more, the effects of climate change are also unevenly distributed among people and communities within a city. The intersection of climate hazards and multidimensional inequality has an uneven impact on people and their livelihoods. Today, climate change and inequality are in a vicious circle. The original socio-economic inequality determines the disproportionate adverse effects caused by climate hazards, which in turn leads to greater inequality.

Therefore, there's an urgent call for developing a resilient city model along with community-based adaptation strategies that would assist decision-makers to identify potential vulnerabilities and to implement a bottom-up management approach based on the priorities of the ystems that require attention.

a complex system, the activities reflected on the urban area are f by three branches: social capital, economic capital and natural ital. The research is based on these three branches. Clarifying the e branches of research is the guiding principle for establishing a eptual framework to clearly link them together.

The project connects the three branches of research by using spatial lenses to observe them. By taking climate adaptation as an opportunity, the existing spatial pattern and the scale of economic and social activities have been reconfigured, giving relevant meaning to space, governance and society.

The project posits that for the adaptation of climate hazard impacts, it is important to understand the complexity of the urban system and embed the approaches in various socio-political relationships across scales and reflect it on the space. Understanding the adaptation approach as an opportunity of urban development, rather than as a process that simply affects places, will create new vision for designing and policy-making and bring significant implications in all realms of life.

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Graduation Studio
Transitional Territories- North Sea: Landscapes of Coexistence.
A Typography of Chance

Mentor team: Luisa Calabrese
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