DISSOLVING DISTINCTION

Making the city of Rotterdam part of nature

Master Graduation Thesis by Sanne Francissen

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Thesis Report P5

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FIG. 1.1 Before and after developing the city as part of nature

ABSTRACT

Challenges such as urbanization and climate change effect our urban environments. There is an urge to deal with these challenges and develop climate resilient cities. The natural environment is able to adapt to changing circumstances and creating a city as part of nature could contribute to resilience. The city of Rotterdam has lost its connection with nature as the city expanded over the years. As a result, the ecological values of the city environments are low, as well as the awareness among citizens on the values and importance of nature.

By conducting spatial research, this thesis aims to create an evidence informed design strategy for (a certain location within) Rotterdam in which this city is part of nature, using the following research question to guide the project: "How could the citizens of Rotterdam be reconnected to nature, while improving the urban ecosystems, creating a resilient city?"

Three key topics were identified to address the whole scope of a nature inclusive city. Each of the three topics consists of a few criteria, which were defined using literature, that contribute to the research aim. First, the ecological perspective focusses on the natural systems of the landscape. Creating ecological connectivity and increasing the biodiversity and amount of open green space help to strengthen the urban ecosystems.

Secondly, the human perspective consists of creating a connection, both physically and mentally, with nature in order to make it a part of daily urban life. This includes integrating green in the urban environments and making it accessible for residents in order to improve the quality of life.

Thirdly, the climate perspective focusses on tackling issues such as water nuisance, Urban Heat Island effect and risk of flooding to develop a climate resilient city. Making the city part of nature means dealing with these issues in order to develop a climate resilient city.

Using a case study, the urban centre of Rotterdam, research is done on possible interventions to create this nature inclusive city. Using the pattern language approach, all three perspectives are strongly integrated with each other in the design typologies (patterns) which are explained in the pattern atlas and tested on the site. This has resulted in a strategy that consists of a stakeholder analysis and phasing for a specific route, from front door to river, in which is explained how on local scale the city could be transformed into part of nature. The different components of the route: street, boulevard and waterfront, are highlighted using the patterns as design interventions. Furthermore, this is complemented with an exploration on how to implement the concept within the whole city and even region of Rotterdam.

This research shows how, considering the urban ecology, human connection and climate resilience, the quality of life for all living things in Rotterdam could be improved.
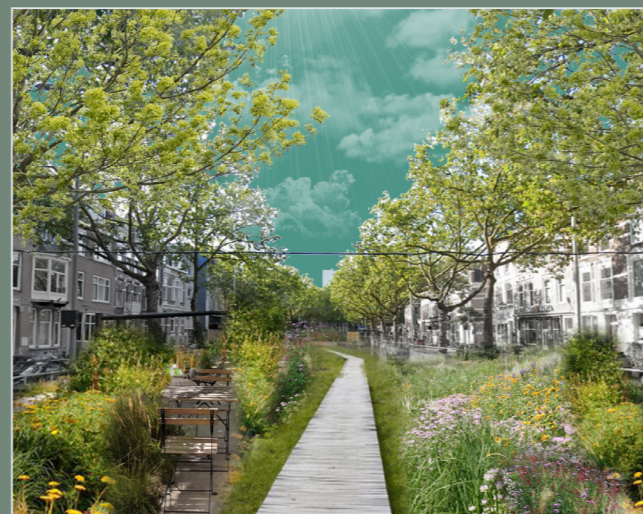
PREFACE

This report is a result of 9 months research on Rotterdam, The Netherlands, and is part of the graduation lab Urban Ecology & Ecocities at the Delft University of Technology.

The city of Rotterdam has always fascinated me. Growing up in a nearby city, Vlaardingen, has resulted in a daily experience of urban life. During my studies at the Delft University of Technology, I developed my fascination for the changing climate and the lack of awareness among other people on this trend and the values of nature. This has motivated me to explore the opportunities of creating an urban environment which is part of the natural. A city in which humans live together with other flora and fauna, for the good of the living environment.

It has been a valuable process from which I gained a lot of learning experiences. I am grateful for Remon and Nico, who have guided me during the project. I would like to thank my grandfather Ed, for providing me with the beautiful photos. And I would like to thank my parents, friends and fellow students for supporting me throughout the whole process. Without all of you I could not have accomplished this.

FIG. 1.2 Witte Huis, Rotterdam

CONTENTS

1 DEFINING

The first section of this report will be introducing the project. It will consist of the motivation and problem field to explain the context of this research. This will be followed by the research questions and aims, which create a guidance through the process.

1.1 MOTIVATION

With the development of urbanized areas, the socio-ecological aspect has been neglected, leading to a lack of nature within cities and a separation of human and nature (Elmqvist et al., 2013). Staatsbosbeheer is an organization that protects and develops green heritage of The Netherlands in order to let future generations experience the values of nature (Staatsbosbeheer, n.d.). With their program "Groene Metropool" (Green Metropolis) they aim to create a nature inclusive urban living environment where every resident of The Netherlands has easy access to high quality nature (Staatsbosbeheer, n.d.). In a collaboration between Delft University of Technology and Staatsbosbeheer, the Urban Ecology and Ecocities graduation lab carries out research on multiple cities in The Netherlands that consist of opportunities to develop the Green Metropolis. Rotterdam is a good example of a metropolitan area that is developing quickly and where opportunities arise to create a nature inclusive environment. This research and design project will explore the opportunities of making Rotterdam part of the Green Metropolis while focusing on creating a city that is part of nature.

1.2 PROBLEM FIELD

Global scale

Urbanization

The world population has grown rapidly and will continue to do so for the next decades (Koop & van Leeuwen, 2016). We are already with 7.7 billion people on the planet, and by 2050 this number is expected to reach almost 10 billion (UN, 2019). This goes together with the trend of urbanization and by 2050 it is expected that two third of the world population will be living in cities (Ritchie & Roser, 2018).

However, humanity is still dependent on nature, even if it is increasingly urban (Bolund, & Hunhammar, 1999). Besides this, urbanization causes multiple environmental challenges, such as soil, water, and air pollution, but also pressure on water supply, waste recycling and wastewater treatment (Koop & van Leeuwen, 2016). This results in cities being increasingly dependent on rural areas and therefore extending the consequences of urbanization far beyond the city (Koop & van Leeuwen, 2016). And as cities are growing, more and more land around it will serve the urban, effecting habitats, biodiversity, and other ecosystems (Elmqvist et al., 2013). Therefore, restoring urban ecosystems is crucial to limit the negative and stimulate the positive consequences of urbanization. Cities can be regarded as a global network of ecosystems, when considering humanity as part of nature (Bolund, & Hunhammar, 1999).

"The benefits human populations derive, directly or indirectly, from ecosystem functions" is what we call ecosystem services (Costanza et al., 1997, p. 253). These ecosystems services occur on different scales, including the local scale within the city. The services we gain from our urban ecosystems are beneficial for the quality of life, making the presence of the natural systems crucial (Bolund & Hunhammar, 1999). In chapter 3 the ecosystem services relevant for this research will be elaborated upon.

Climate Change

Another trend with major consequences is climate change. The average temperature of the earth is rising and will continue to rise leading to an increasing temperature of 1.5 °C, compared to 1990, by 2030. This temperature rise will be met 10 years earlier than expected by the IPCC (KNMI, 2021). As a result, the sea-level will rise, threatening our living environment as it increases the risk of flooding (KNMI, 2021). The changing climate also causes regional an local weather change, affecting human health and local flora and fauna. This occurs in extreme weather such as periods of extreme precipitations and periods of extreme heat and drought. Especially on the long-term climate change causes a threat for the quality of life (Haines, 2004).

Rotterdam

Urbanization

Rotterdam is the second largest city in the Netherlands, with 650,000 inhabitants (CBS, 2021), and is located in the province of South Holland, The Netherlands. The city is mostly known for its large port, which is an important reason for its growth and development (Zweerink, 2017). As can be seen in figure 1.3, Rotterdam has grown exponentially since 1815. In this period the port of Rotterdam grew rapidly, which is due to the construction of The New Waterway, that created a direct connection to the North Sea (Zweerink, 2017). Other alterations of the landscape, such as the drainage of the Rotte and digging harbours, also contributed to the growth of Rotterdam (Zweerink, 2017). The development of the city has caused the natural surroundings to make room for urban environment and as can be seen in figure 1.3, nature returned in the city in a different form, mainly public parks.

However, biodiversity has been lost in urban environments (LaPoint et al., 2015), as well as the human connection with nature. Nature is not embedded into the daily life of citizens, leading to people feeling disconnected from nature (Vining et al., 2008; Tam, 2013). Besides this, as The Netherlands are facing a housing crisis, with a shortage of 279,000 homes (MBZK, 2021), the pressure on open space remains. In order to prevent nature from disappearing completely, there is an urge to treat the natural in an equal way and consider the city as part of nature.
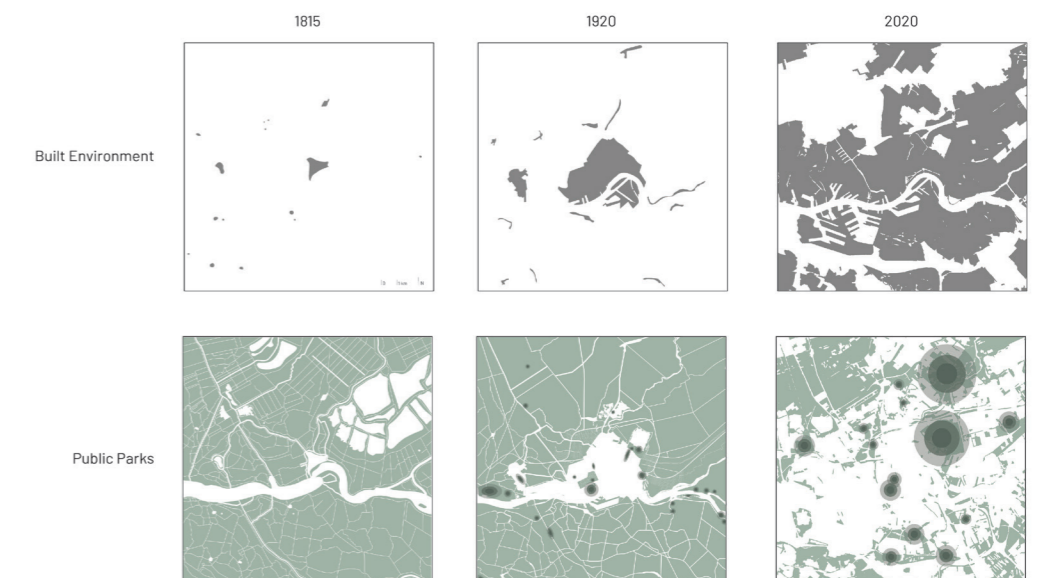

FIG. 1.3 Development Rotterdam

Climate Change

The changing climate has negative effects on the urban living environment. Extreme weather such as heat and excessive precipitation are occurring more often, and Rotterdam will have to deal with these effects as well, see figures (1.4-1.7). These maps show the challenges that Rotterdam faces. First of all, the Urban Heat Island effect occurs mainly in high density urban environments as a result of highly paved areas and lack of shadow (Wijbenga - Van Nieuwenhuizen & Bonte, 2019). Especially the urban centre of Rotterdam suffers from heat stress. Second of all, water nuisance occurs because of extreme precipitation, which urges the city to be able to absorb, store, purify and release precipitation water when necessary (Wijbenga - Van Nieuwenhuizen & Bonte, 2019). Third of all, as a result of the rising sea level, the risk of flooding is increasing, which makes the city vulnerable. It is crucial to protect the city from the water and work with it rather than against it (Wijbenga - Van Nieuwenhuizen & Bonte, 2019). Fourth of all, extreme weather leads to periods of drought, effecting the green structures. Therefore, it is important to store excessive water (Wijbenga - Van Nieuwenhuizen & Bonte, 2019). Another challenge is the high ground water level, with which some districts struggle, while other districts face a low ground water level. This effect goes together with soil subsidence and therefore needs an integral approach (Wijbenga - Van Nieuwenhuizen & Bonte, 2019).

Despite all the environmental problems in cities, they also provide opportunities and solutions as the urban environment is a hotspot of human industry and creativity (Grimm et al., 2008). The current trends can be summarized in the following problem statement.

Problem Statement

"The city of Rotterdam has lost its connection with nature as the city expanded over the years. As a result the ecological values of the city environments are low, as well as the awareness among citizens on the values and importance of nature. Besides this, the changing climate causes negative effects and future treats for the urban environment."

City as Part of Nature

A nature inclusive city is beneficial for the quality of life as it contributes to the ecosystem services and climate resiliency (Monti, 2020). In a city that is part of nature, both the urban and natural systems are integrated, the right conditions
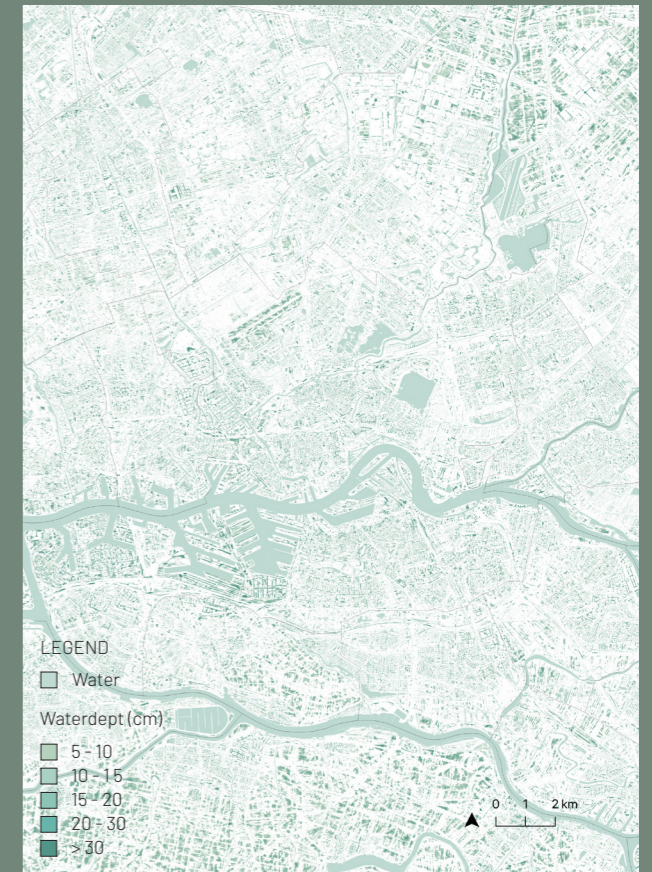

LEGEND
☐ Water
UHI (°C)
☐ < 0,7
☐ 0,7 - 1,4
☐ 1,4 - 2,1
☐ 2,1 - 2,8
☐ > 2,8

0 1 2 km

FIG. 1.4 Urban Heat Island Effect

LEGEND
☐ Water
Waterdept (cm)
☐ 5 - 10
☐ 10 - 15
☐ 15 - 20
☐ 20 - 30
☐ > 30

0 1 2 km

FIG. 1.6 Water Nuisance

LEGEND
☐ Water
Lowest groundwater level (m below groundlevel)
☐ <1,35
☐ 1,35 - 1,71
☐ 1,71 - 2,09
☐ 2,09 - 2,93
☐ > 2,94=3

0 1 2 km

FIG. 1.5 Drought

LEGEND
☐ Water
☐ Buildings
Risk of flooding > 0 cm
☐ Extreme unlikely
☐ Very Unlikely
☐ Unlikely
☐ Likely
☐ Very likely

0 1 2 km
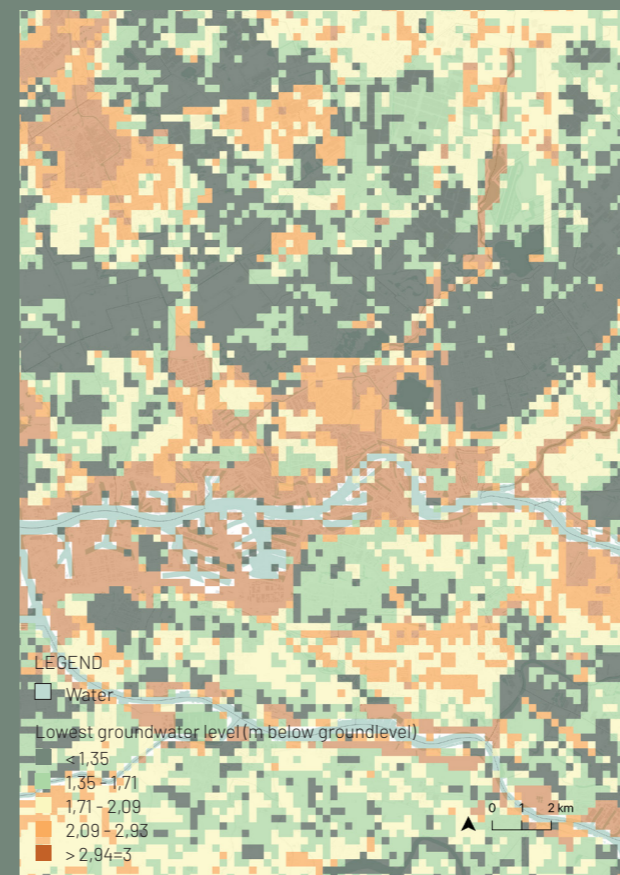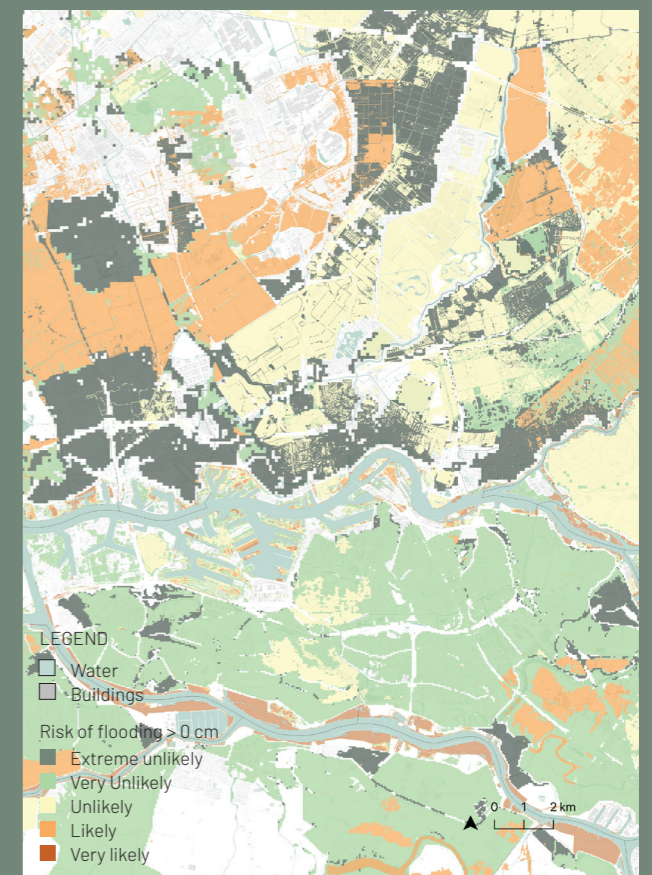
FIG. 1.7 Flooding Risk

for human and nature life is provided, and the distinctions are dissolved. This means urban planning where the natural environment is considered an important stakeholder (Starik, 1995).

1.3 RESEARCH AIMS & QUESTIONS

The aim of this research is to create an evidence informed design strategy for the city of Rotterdam, and a specific urban zones in particular: Urban Centre, in which this city is part of nature. This aim is approached from three different perspectives. Within the first perspective a physical and mental connection will be created between residents of the city and nature. The second perspective focusses on expanding and improving the natural green structures within Rotterdam to improve ecosystems. And the third perspective consists of creating climate resilience within the city. The research question guiding this process is:

"How could the citizens of Rotterdam be reconnected to nature, while improving the urban ecosystems, creating a resilient city?"

In order to achieve the research aim, nine sub-questions are formulated within the three perspectives of the project, see figure 1.8. These sub-questions are structured to each contribute to the final outcome.
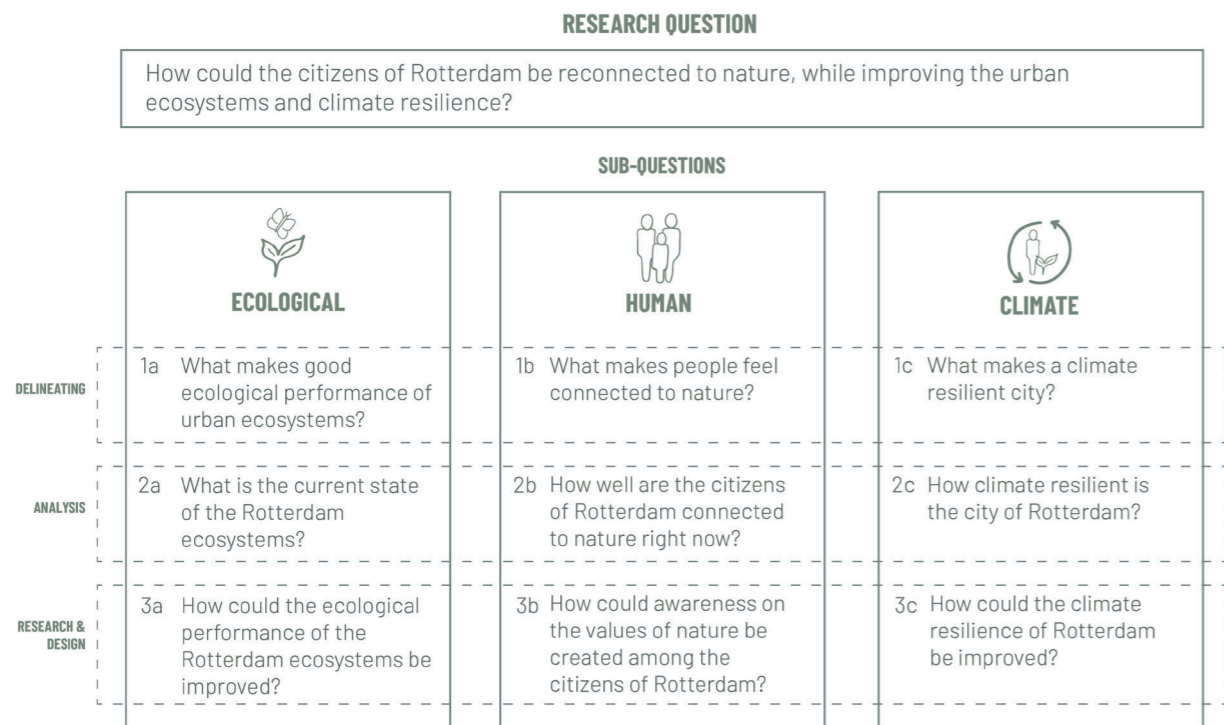
RESEARCH QUESTION

How could the citizens of Rotterdam be reconnected to nature, while improving the urban ecosystems and climate resilience?

SUB-QUESTIONS

	ECOLOGICAL	HUMAN	CLIMATE
DELINEATING	1a What makes good ecological performance of urban ecosystems?	1b What makes people feel connected to nature?	1c What makes a climate resilient city?
ANALYSIS	2a What is the current state of the Rotterdam ecosystems?	2b How well are the citizens of Rotterdam connected to nature right now?	2c How climate resilient is the city of Rotterdam?
RESEARCH & DESIGN	3a How could the ecological performance of the Rotterdam ecosystems be improved?	3b How could awareness on the values of nature be created among the citizens of Rotterdam?	3c How could the climate resilience of Rotterdam be improved?

FIG. 1.8 Research Questions

FIG. 1.9 Illustration City as Part of Nature

2 APPROACHING

Within the approaching phase, the structure of the project, which consists of the project approach and its methods, will be defined. The project approach is a dynamic structure that provides guidance and that will continuously be improved and adjusted throughout the duration of the project. The methods defined explain the approach of different tasks and phases.

2.1 PROJECT APPROACH

The project consists of different phases, that all contribute to answering the research question and therefore achieving the research aim. The process will not be linear, however, some phases lead to an outcome that is helpful for another phase. The phases of delineating, analyzing, and generalizing will consider the sub questions, formulated in chapter 1, and come together in the visioning and strategyzing phase, in which an answer to the main research question will be formed. Finally, the phase of reflecting will be considered during the entire process, but especially within the end.
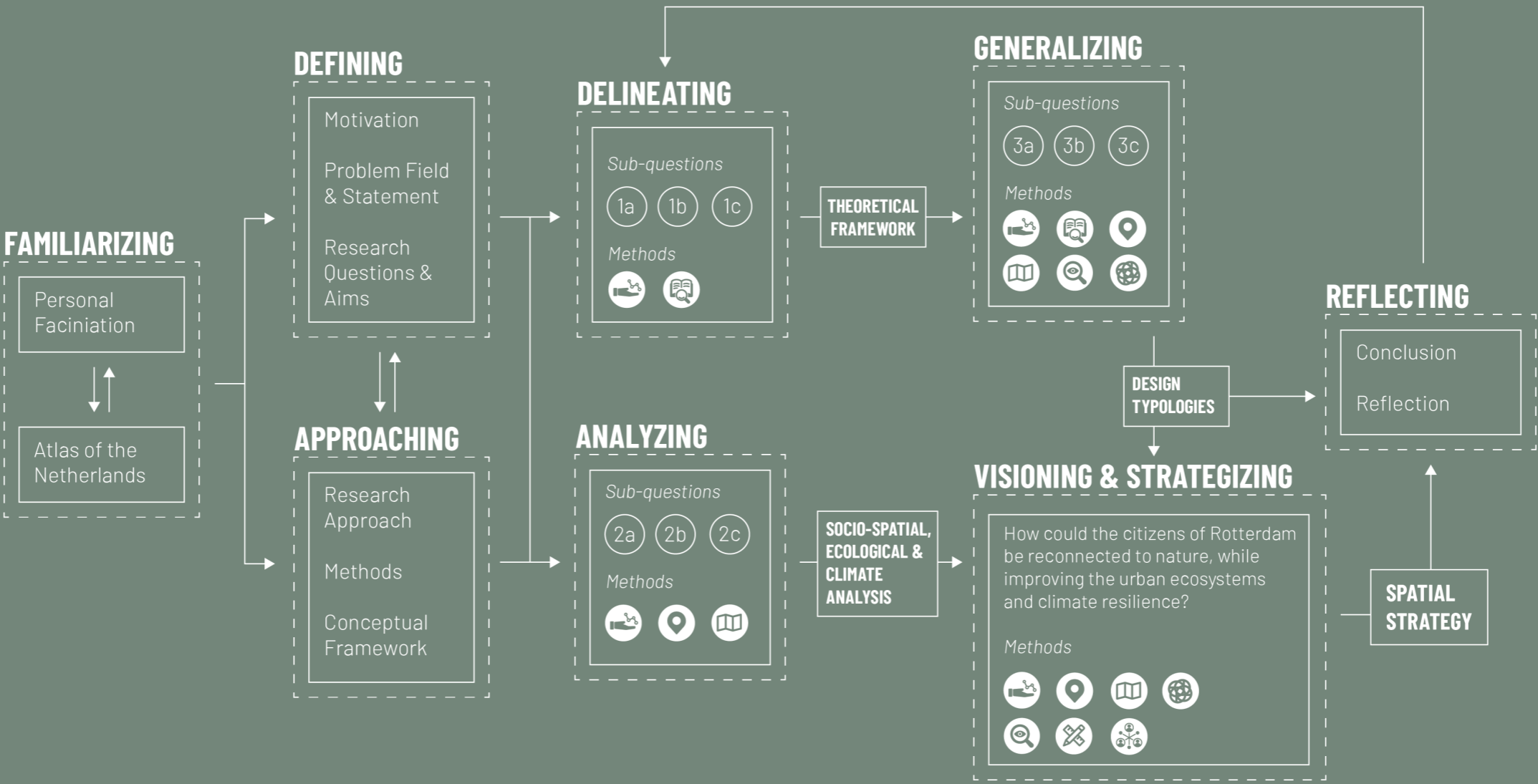
FIG. 2.10 Research Approach

2.2 METHODS

In order to answer the research questions, and get to the outcome of the phases, several methods will be used. Table 2.1 elaborates on the different methods, explaining the aim and the used sources, scales or tools. The source describes where the knowledge and data will be gathered from using this method. The scale elaborates that the methods go through the scale. The tools explain what is used to carry out the method. Depending on the method, an elaboration on either one of these elements is provided. Different methods will be used in the different phases, see figure 2.10.

2.3 CONCEPTUAL FRAMEWORK

Figure 2.11 shows the conceptual framework. It explains that in order to achieve a city that is part of nature, a few aspects are important: human, ecology and climate perspective. The comprehensive theme of the project is to make sure each perspective is resilient. This means a mental and physical connection between human and nature, healthy urban ecosystems and a city that is able to adapt to the consequences of climate change. In the next chapter, this will be elaborated upon as part of the theoretical framework.

METHOD	AIM	SOURCE/SCALE/TOOLS
DATA COLLECTION	to collect qualitative and quantitative data that can be used in other methods	Source: literature, policy documents, QGIS, websites, news
LITERATURE REVIEW	to delineate and substantiate the project	Source: literature, policy documents, websites
SITE VISITS	to understand the dynamics of the location from eye perspective	Tools: photography, filming, sketching
MAPPING	to understand the composition of the landscape and use it as a design tool	Scales: regional, city and district
PATTERN LANGUAGE APPROACH	to link research to design and create a set of design typologies	Sources: literature, reference projects
REFERENCE ANALYSIS	to get inspired	Sources: literature, websites, surroundings
DESIGN	to create an evidence informed spatial design for two different types of locations within Rotterdam	Scales: regional, city and district
STRATEGY MAKING	to understand the feasibility of the project and how to implement the idea	Tools: stakeholder analysis and phasing

TABLE 2.1 Methods

FIG. 2.11 Conceptual Framework

3 DELINEATING

The delineating phase aims to define the scope of the thesis and create a theoretical framework that forms guidance through the research. This will be done by trying to answer the following sub-questions, each focusing on one of the perspectives: human, ecology and climate.

1a   What makes good ecological performance of urban ecosystems?

1b   What makes people feel connected to nature?

1c   What makes a climate resilient city?

3.1 URBAN ECOSYSTEMS

The ecology of cities consists of the overall characteristics of organism (Douglas, 2012). The trend of urbanization changes the composition of the landscape, leading to possible elimination of organisms or change in the conditions of its habitat (Elmqvist et al., 2013). Urban biodiversity is "the variety or richness and abundance of living organisms (including genetic variation) and habitats found in and on the edge of human settlements" (Elmqvist et al., 2013, p. 125). It contributes to "human security, resiliency, health and freedom of choices and actions" as urban biodiversity is an essential component of ecosystem services (Elmqvist et al., 2013, p. 35).

Ecosystem Services
Understanding the structure of the ecosystems helps to understand the values and benefits for the quality of life. Ecosystems are made up of different components, either abiotic (non-living) or biotic (living), see figure 3.12. These assets are a result of ecosystem drivers and pressures that vary from being natural to anthropogenic.

The ecosystem components provide ecosystem services, and as mentioned in chapter 1, these are very valuable for the quality of life. Therefore, it is important to preserve the urban ecosystem and restore urban biodiversity. These services can be distinguished by cultural, regulation and maintenance and provision services, which all are beneficial in a different way.

Within the scope of this research, a few of these ecosystem services are especially relevant to improve the urban quality of life. First, the cultural services: nature-based recreations and ecotourism, such as Kralingse Bos in Rotterdam, and aesthetic values, which improve the quality of public space, are of importance in the urban living environment. Second, the regulation and maintenance services are especially important in the climate change perspective: water, air quality and climate regulation. Third, the provision of support for biodiversity and human infrastructures is in line with the scope of this project.

Biodiversity
Biodiversity is an important component of the ecosystem and therefore the loss of biodiversity and its consequences lead to a growing concern (Elmqvist et al., 2013; Jansson, 2013). Even though biodiversity is lost in urban environments, these areas consist of possibilities to conserve biodiversity and provision ecosystem services (LaPoint et al., 2015). In order to create a rich biodiversity that contributes to the urban ecosystem services, the functional aspect appears to be more important than the species number (Jansson, 2013). The functional aspect consists of "the identity, abundance and range of species traits" (Jansson, 2013, p. 289).

Ecological Connection
As a result of urbanization, green space in the city is often fragmented, leading to a loss of ecological connection. Despite this fragmentation, the green spaces provide habitat, food sources and connectivity between groups and therefore contribute to conserving biodiversity (Nor et al., 2017). In order to create healthy urban ecosystems, an ecological network, consisting of 'ecological components such as core areas, ecological corridors and buffer zones' (Nor et al., 2017; McHugh
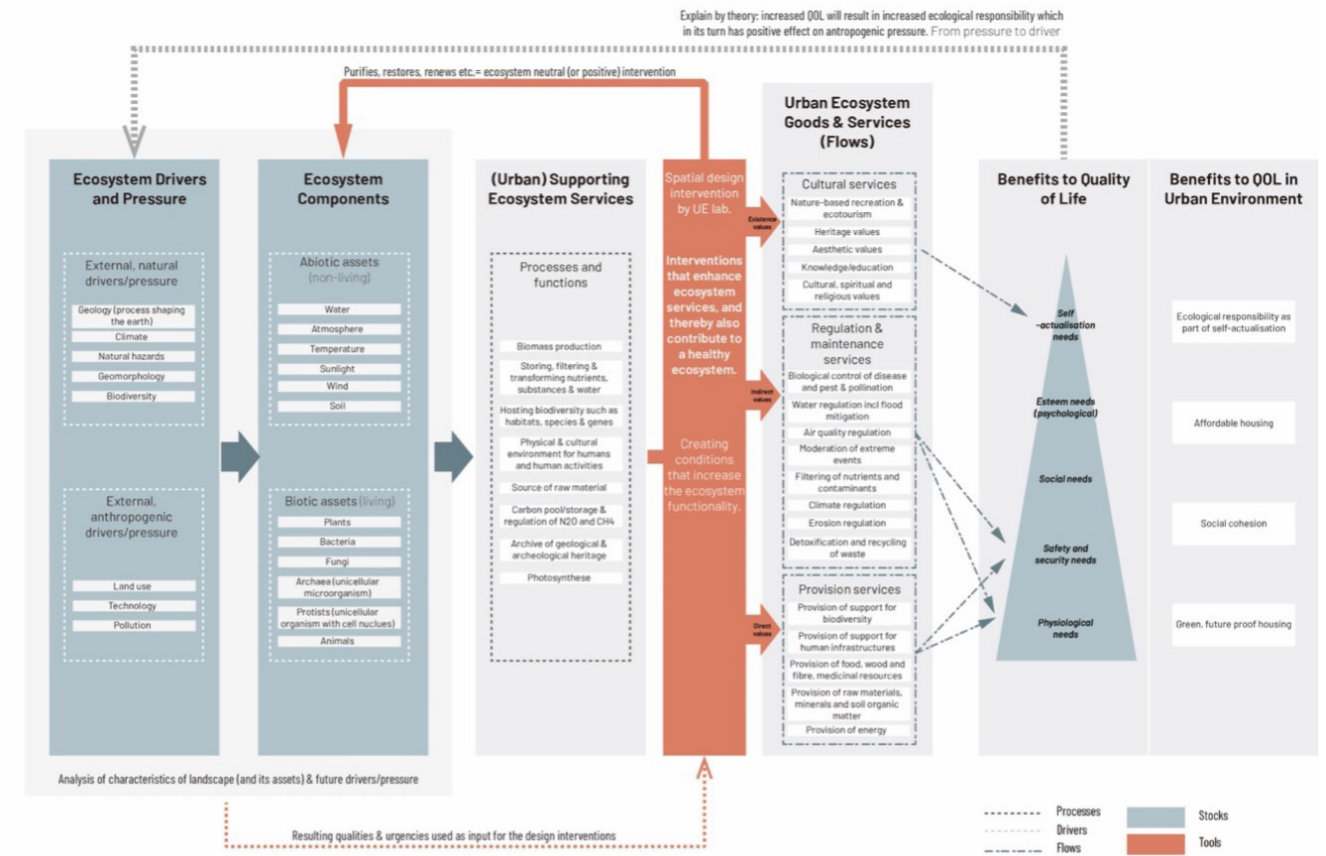

FIG. 3.12 Ecosystem Services (Urban Ecology & Ecocities, 2022)

& Thompson, 2011) is crucial. These networks are able to facilitate "movement, migration, dispersal, distribution and recolonisation" that determine the survival and persistence of species (Nor et al., 2017).

Ecological Restoration
Ecological restoration could be done in multiple ways. Standish et al. (2012) distinguish four main restoration options:
1. Conserve and restore nature at the urban fringes ;
2. Restore remnant patches of urban nature;
3. Manage novel ecosystems: where to manage and where to transform to green space?;
4. Gardening with iconic species for sense of place.

Within chapter 5, these restoration options will be further explored, in order to decide what works best for the context of Rotterdam.

Conclusion
Preserving and maintaining urban ecosystem is important in order to benefit from ecosystem services. Multiple aspects play a role in this, such as biodiversity, ecological connection, and ecological restoration.

3.2 CONNECTION TO NATURE

Residents of western industrialized countries find themselves increasingly separate from nature (Vining et al., 2008) and living in urban environments might prevent people to gain an intimate relationship with nature (Tam, 2013). Interesting is that people consider themselves as part of nature, while their idea of nature consists of natural environments that excludes people. And a lack of contact with natural environments leads to an increasing feeling of separation from nature (Vining et al., 2008; Whitburn et al., 2019).

However, connecting individuals to nature could motivate their pro-environmental behavior and therefore contribute to mitigating the environmental crisis (Tam, 2013; Whitburn et al., 2019). Besides this, interaction between people and nature is beneficial for both biological diversity and human wellbeing (Standish et al., 2012). Ecological restoration could be considered connecting people to nature as much as restoring biodiversity (Standish et al., 2013).

Concepts of Connecting

Within literature, multiple concepts on human-nature connection can be found, among which emotional affinity toward nature (EATN), connectedness to nature (CTN), inclusion of nature in the self (INS), commitment to nature (COM), environmental identity (EID), nature relatedness (NR) and connectivity with nature (CWN) (Tam, 2013). An overview of the concepts is made by Tam (2013) and the most relevant concepts for this research are projected in table 3.1.

CONCEPTS	SAMPLE ITEMS
Environmental identity (EID)	Being a part of the ecosystem is an important part of who I am. I think of myself as a part of nature, not separate from it.
Nature relatedness (NR)	I am not separate from nature, but a part of nature. I always thinks about how my actions affect the environment.

TABLE 3.1 Concepts related to connection to nature (Tam, 2013)

Within the concepts EID and NR humans consider themselves as part of nature and these are therefore very much in line with the scope of this thesis. A connection to nature can be perceived differently over time, depending on the frequency of exposure to nature. In order to change this connection, long-term or repeated exposure is required (Vining et al., 2008; Whitburn et al., 2019). In this thesis, a few criteria are identified that contribute to the exposure to nature.

Accessibility

First, public green should be easily accessible for people. As a result of urbanization, there are limited opportunities within the city to connect with nature, due to the few urban green spaces (Lopoukhine et al., 2014). Accessible green within the living environment is considered more important than large outdoor recreation outside the urban boundaries (Keil, 2005), which supports the idea of making the city part of nature.

Sense of Place

Second, the ability to perceive urban green spaces and its biodiversity is an important aspect, as exposure to nature is beneficial for human health (Dearborn & Kark, 2010). Invoking a sense of place is a crucial component of connecting to nature, increasing awareness of the consequences of urbanization on local biodiversity (Standish et al., 2012). Flora and fauna that occurs in most cities contributes little to a sense of place, while native iconic species do (Standish et al., 2012). Another aspect of perceiving nature is the aesthetic emotional function of an environment. For example, transforming an abandoned industrial environment to accessible green space, where the industrial remnants interact with nature (Keil, 2005).

Interaction

Third, interaction with nature contributes to better connection. Within the media, nature is often projected in a negative way: loss of biodiversity and negative effects of climate change. This leads to a "conscious and subconscious aversion to the outdoors" that has become a feared place (Lopoukhine et al., 2014). Besides this, the domination of screens in our lives leads to a decreasing interaction with nature, and therefore to a decreasing feeling of connection. However, tools such as citizen science provide the interaction with nature, while including technology and social media (Lopoukhine et al., 2014). Interaction with nature is something that could also be established by for example, gardening, natural playgrounds and educational environments (Standish et al., 2012).

Conclusion

Improving the human connection with nature is beneficial for the natural environment. Multiple factors play a role in the degree of feeling connected to nature. These can be united within the topics as described above: accessibility, sense of place and interaction.

3.3 CLIMATE RESILIENT CITY

As described within the problem field, the effects of global warming are a threat for the urban environment and therefore, cities will have to become more resilient (Jabareen, 2013, Lomba-Fernández et al., 2019). However, resilience is a complex concept that can have multiple perspectives. Especially in the urban context it is difficult to operationalize resilience due to the diversity of stakeholders and areas (Lomba-Fernández et al., 2019).

Resilience

In literature, many different definitions for the term resilience can be found, which can be distinguished in two main perspectives. The first one focusses on "the capacity of a system to restore to its previous state of equilibrium after a disaster" (Lomba-Fernández et al., 2019). In the second perspective resilience is defined as "the system capacity to adapt and adjust to changes, both internal and external" (Lomba-Fernández et al., 2019). Resilience is defined by IPCC as "the capacity of social, economic and environmental systems to cope with a hazardous event or

trend or disturbance, responding or reorganising in ways that maintain the essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation" (IPCC, 2014, p. 5). This will be the guiding definition throughout this thesis, with a focus on risk reduction, vulnerability reduction and sustainable development (Lomba-Fernández et al., 2019) concerning climate change effects.

Adaptivity
With respect to the objectives of this research, the context of Rotterdam as a city that is part of nature, must be considered in order to define a climate resilient city. Nature is able to adapt well to changing circumstances, of course to a certain extent, while urban environments struggle more with the effects of the changing climate. Rotterdam will develop as a climate resilient city, when the effects of climate change that are described in chapter 1, especially water nuisance, heat, and drought, are mitigated. Approaching the city as part of nature, and valuing the ecosystem services within the city, will contribute to this development.

Resilient city Frameworks
Within literature, frameworks are developed that can be used to assess the current state of a city concerning resilience and as a guide towards building resilience. These frameworks could be used during the research to define the state of resilience of Rotterdam and work towards a climate resilient design.

The conceptual framework for resilient city and resilient community by Jabareen (2013) consists of four components: Vulnerability Analysis Matrix, Urban Governance, Prevention and Uncertainty Oriented Planning.

The Guide for climate resilient cities by Lomba-Fernández et al. (2019), consists of three steps, that include activities, outcomes, and stakeholders:

1. Understand the urban context and climate change related crises.
2. Understand urban critical infrastructure networks, sectors and services.
3. Assess and improve resilience.

The Framework by Jabareen (2013), focusses on the whole scope of resilient city planning, while the steps of Lomba-Fernández et al. (2019) focus specifically on climate change which is more in line with the scope of this research. Both these frameworks could be helpful in this project to make Rotterdam climate resilient. However, one must keep in mind that a set of climate adaptation measures will need to be followed by another, due to the changing trajectory of climate change (Tyler & Moench, 2012).

Conclusion
Rotterdam will have to deal with multiple effects as a result of global warming and the changing climate. In order to create climate resilience, the city will either have to be able to return to the previous state or adapt to the changing circumstances. In the current situation a few issues affect the city of Rotterdam the most: urban heat stress, water nuisance and risk of flooding. Therefore, these challenges must be dealt with intensively in order to develop climate resiliency.

3.4 SYNTHESIS

The previous sections have explained the scope of the project, based upon literature. This has resulted in knowledge on the variables that influence the extend to which the urban environment is part of the natural. These together form the theoretical framework, which can be used as an assessment framework for the rest of this project. Figure 3.13 shows this framework and the indicators of the three perspectives that are of importance in developing a city that is part of nature.

FIG. 3.13 Assessment Framework

4 ANALYSING

During the analysis phase, an inventory will be made of the current spatial structures of Rotterdam, concerning the different perspectives. The following questions will guide this phase:

2a   What is the current state of Rotterdam ecosystems?

Ecosystem analysis

2b   How well are the citizens of Rotterdam connected to nature right now?

Socio-spatial analysis

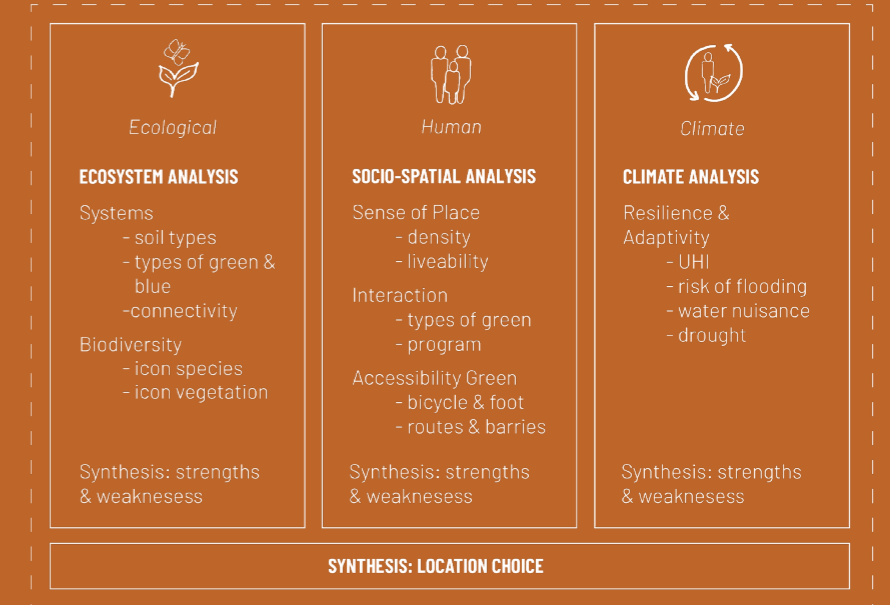*2c   How climate resilient is the city of Rotterdam?*

Climate analysis

ANALYZING

Ecological	Human	Climate
ECOSYSTEM ANALYSIS	**SOCIO-SPATIAL ANALYSIS**	**CLIMATE ANALYSIS**

Systems
    - soil types
    - types of green &
    blue
    -connectivity
Biodiversity
    - icon species
    - icon vegetation
	Sense of Place
	    - density
	    - liveability
	Interaction
	    - types of green
	    - program
	Accessibility Green
	    - bicycle & foot
	    - routes & barries
		Resilience &
		Adaptivity
		    - UHI
		    - risk of flooding
		    - water nuisance
		    - drought

Synthesis: strengths & weaknesess	Synthesis: strengths & weaknesess	Synthesis: strengths & weaknesess

SYNTHESIS: LOCATION CHOICE

FIG. 4.14 Topics to Analyse

4.1 ECOLOGICAL ANALYSIS

During the ecological analysis, research will be done on how well the ecosystems of Rotterdam function currently.

Systems

Soil

The soil map shows the different soil types around the city, which consists mainly of sea clay. In the eastern side the soil consists of peat. The soil types are the base of the ecological conditions and in the peat and clay area, multiple terrestrial vegetation types can be distinguished: dry clay landscape, humid clay landscape, dried out peat landscape, clay wetland, peat wetland, brackish wetland and salt marsh. These ecosystem types each consist of different conditions for flora and fauna.

Connectivity

Looking at the blue/green structure of Rotterdam, a system around the urban boundaries occurs. On the north side of the river banks there are two main water structures in north south direction: De Schie and De Rotte. Outside the city boundaries, these waters are part of large natural structures, while within the urban core, they are hardly surrounded by green.

On the southern side of the river, the east-west structures a very strong, formed by a series of parks. However, the north south connections are missing, especially towards the residential areas.

LEGEND

☐ Water

■ Low peat area
■ Marine clay area

FIG. 4.15 Ecological Analysis | soil

Rotterdam North

Rotterdam South

LEGEND

⬚ Municipal Boundary
☐ Water

■ Forest
■ 'Grienden'
■ Orchard
■ Graveyard
■ Grassland
☐ Crop land

FIG. 4.16 Ecological Analysis | connectivity

Biodiversity

The urban setting offers a lot of potential living environment for biodiversity. However, the threats of a city, such as a lot pavement and traffic, cause biodiversity to disappear. The municipality of Rotterdam has defined a few iconic species and vegetation, to create awareness among citizens. These are elaborated upon in either characteristics or distribution over the province of South Holland.

Red Mason Bee
Bees provide 80% of our food supply and therefore are crucial for (urban) life. They can be found in urban gardens, but also in trees with splits and walls with crack. Wild vegetated rooftops with a lot of flowers are also a favourable place to settle.

Song thrush
The Son thrush is a bird that settles in dense green environments such as forest and park where it lives in high trees. Besides this, it needs dense vegetation on street level to find food and shelter.

Serotine bat
Laatvlieger
Eptesicus serotinus
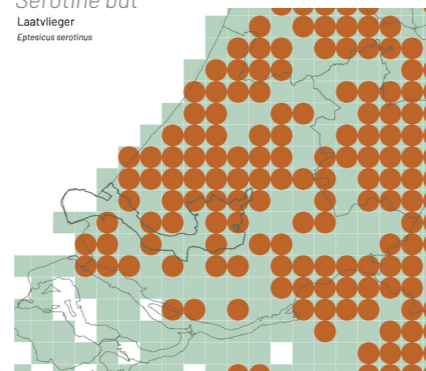
LEGEND
● 1990 - 2024
▪ <1990

FIG. 4.17 Serotine bat

Northern pike
Snoek
Esox lucius
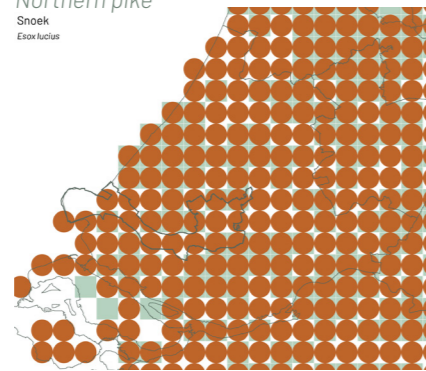
LEGEND
● 1990 - 2024
▪ <1990

FIG. 4.18 Northern pike

Small copper
Kleine vuurvlinder
Lycaena phlaeas
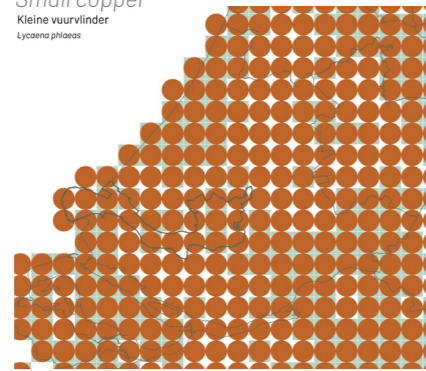
LEGEND
● 1990 - 2024
▪ <1990

FIG. 4.19 Small copper

European hedgehog
Egel
Erinaceus europaeus
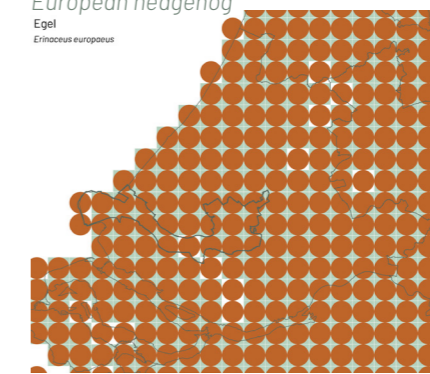
LEGEND
● 1990 - 2024
▪ <1990

FIG. 4.20 European hedgehog

Red fox
Vos
Vulpes vulpes
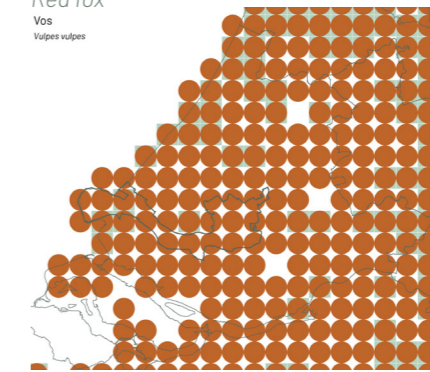
LEGEND
● 1990 - 2024
▪ <1990

FIG. 4.21 Red fox

Sweet Cherry
Zoete kers
Prunus avium
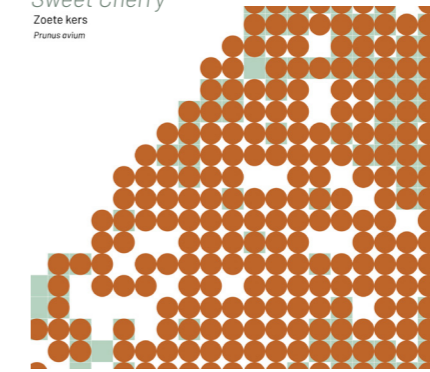
LEGEND
● 1990 - 2024
▪ <1990

FIG. 4.22 Sweet Cherry
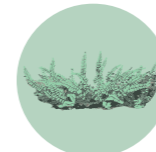
Maidenhair spleenwort
Steenbreekvaren
Asplenium trichomanes
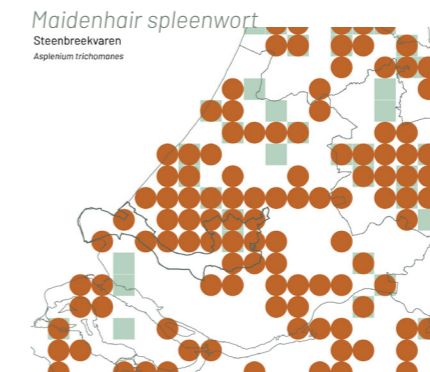
LEGEND
● 1990 - 2024
▪ <1990

FIG. 4.23 Maidenhair spleenwort

Synthesis

To conclude the ecological analysis, a synthesis map is made using the three main indicators.

Amount of green

The amount of public green is lacking in the urban centre of Rotterdam. Remarkable is that the districts consisting of <30% green are also the locations with a low liveability score (see section 4.1). Therefore, opportunities arise to create a network of green in the inner city and to increase the amount of green.

Biodiversity

The key species and vegetation as defined by the city represent the biodiversity in Rotterdam. By focussing on improving the living environment for these plants and animals, the whole biodiversity can be increased.

Connectivity

The northern and southern side of the river Meuse in Rotterdam consist of a different ecological structure. In the north side, opportunities arise to strengthen the waterways going inside the city and creating connection in between those. In the southern side, the main goal is to improve the north south connections, going from the old to the new river Meuse. These would result in the ideal ecological structure, see figure 4.25.

LEGEND

- Water
- Forest
- Grassland
- Main structure
- <30% green
- Missing connections

FIG. 4.24 Ecological Analysis | synthesis

Rotterdam South   *Rotterdam North*   *Rotterdam Vision*
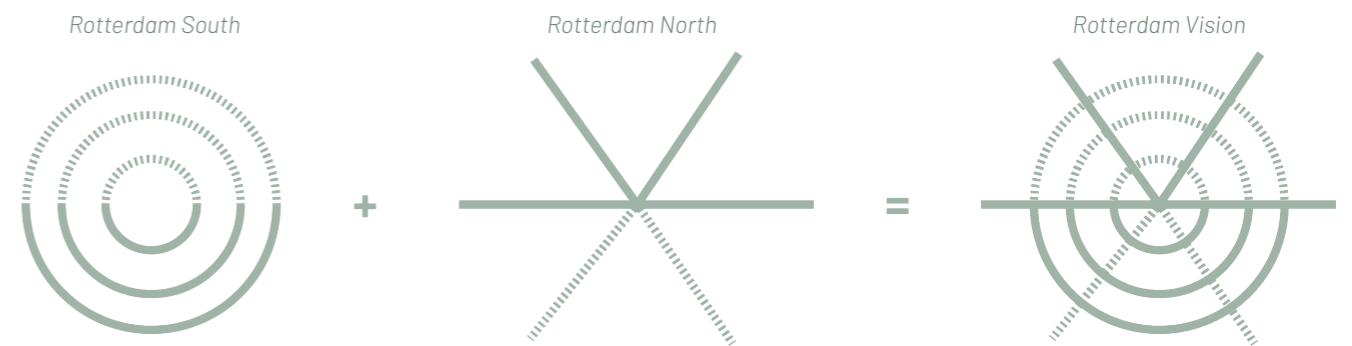
FIG. 4.25 Concept Natural Structure

4.2 SOCIO-SPATIAL ANALYSIS

During the socio-spatial analysis, research will be done on how well the residents of Rotterdam are currently connected to nature.

Sense of Place

Density
The city of Rotterdam is a high density urban area, as shown in de map below. Especially in the city centre, the density is very high. This is of course not a surprise as it is the second largest city of the Netherlands. The information in the map is especially interesting when combining it with other layers of the analysis.

Liveability
The liveability in the city of Rotterdam does not score very high. Especially in the western and southern districts, the liveability scores insufficient. The score is based upon the extent to which the neighbourhood meets the needs of the people living and/or working there. This consists of multiple variables among which demographics, criminality rates, building types, facilities and public parks (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2018).

One of the aspects of improving the liveability and therefore health and well-being of the citizens is adding green and blue, and improving public (green) space.

LEGEND
☐ Water
⬚ Municipal Border

Density (FSI)
■ > 4.2
■ 3.5 - 4.2
■ 2.8 - 3.5
■ 2.1 - 2.8
■ 1.4 - 2.1
■ 0.7 - 1.4
■ <0.7

FIG. 4.26 Socio-Spatial Analysis | density

LEGEND
⬚ Municipal Boundary
☐ Water
■ Buildings

Liveability (score)
■ > 8
■ 6 - 8
■ 4 - 6
■ 2 - 4
■ < 2
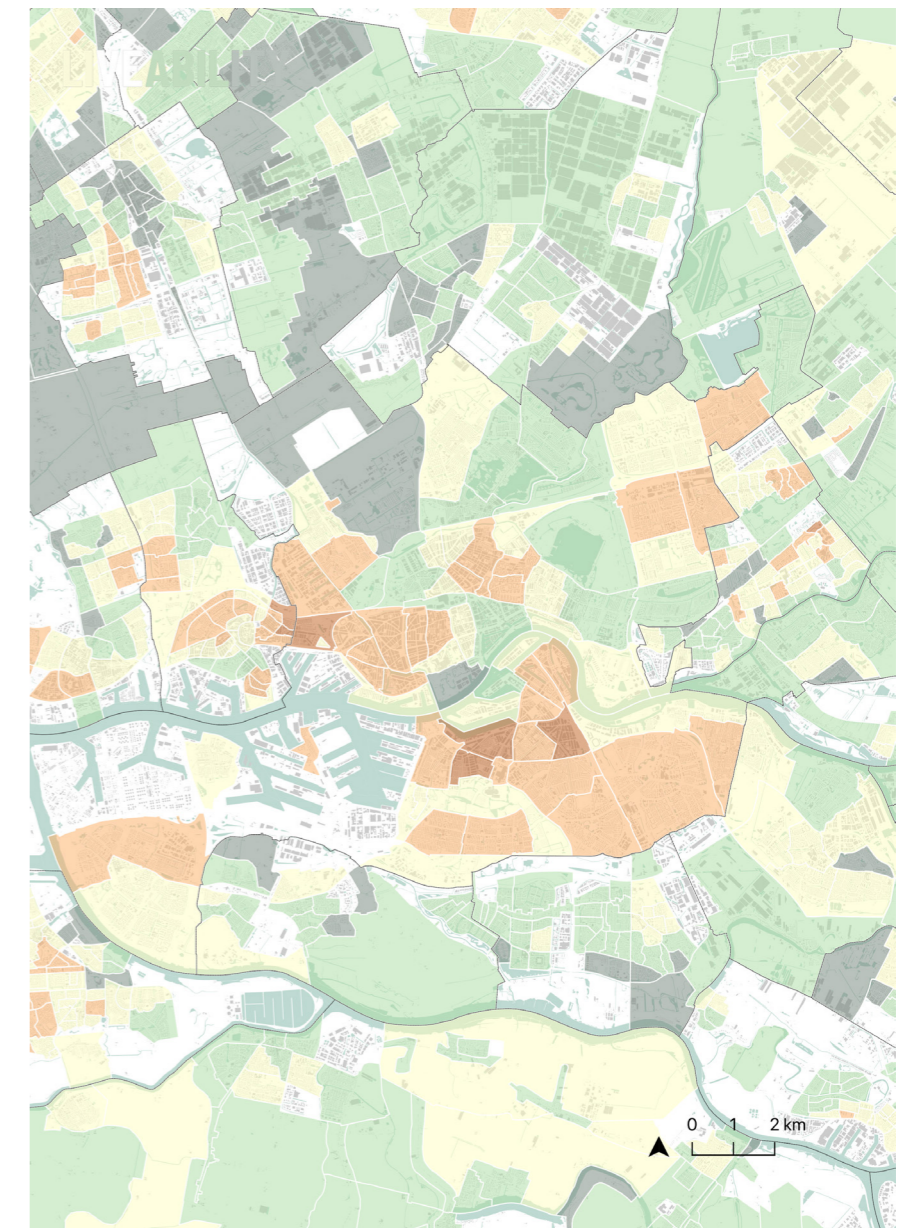
FIG. 4.27 Socio-Spatial Analysis | liveability

Interaction

Types of Green
The map below shows the different types of green in Rotterdam and its surroundings. The city edges consist of some forest areas, while further away from the urban, more grassland occurs. Within the urban centre, there is little green, except for a few small strips and Kralingse Bos.

Program
The amount of green only says something about the connection with nature to a certain extend. Even though the urban centre does not have a lot of green space, the ones present, mainly Kralinsge Bos, consist of program, which supports the interaction between human and nature. However, the larger nature areas located outside the urban boundaries have little program. Besides adding recreational green space in the city center, it is also preferable to add program to the regional parks.
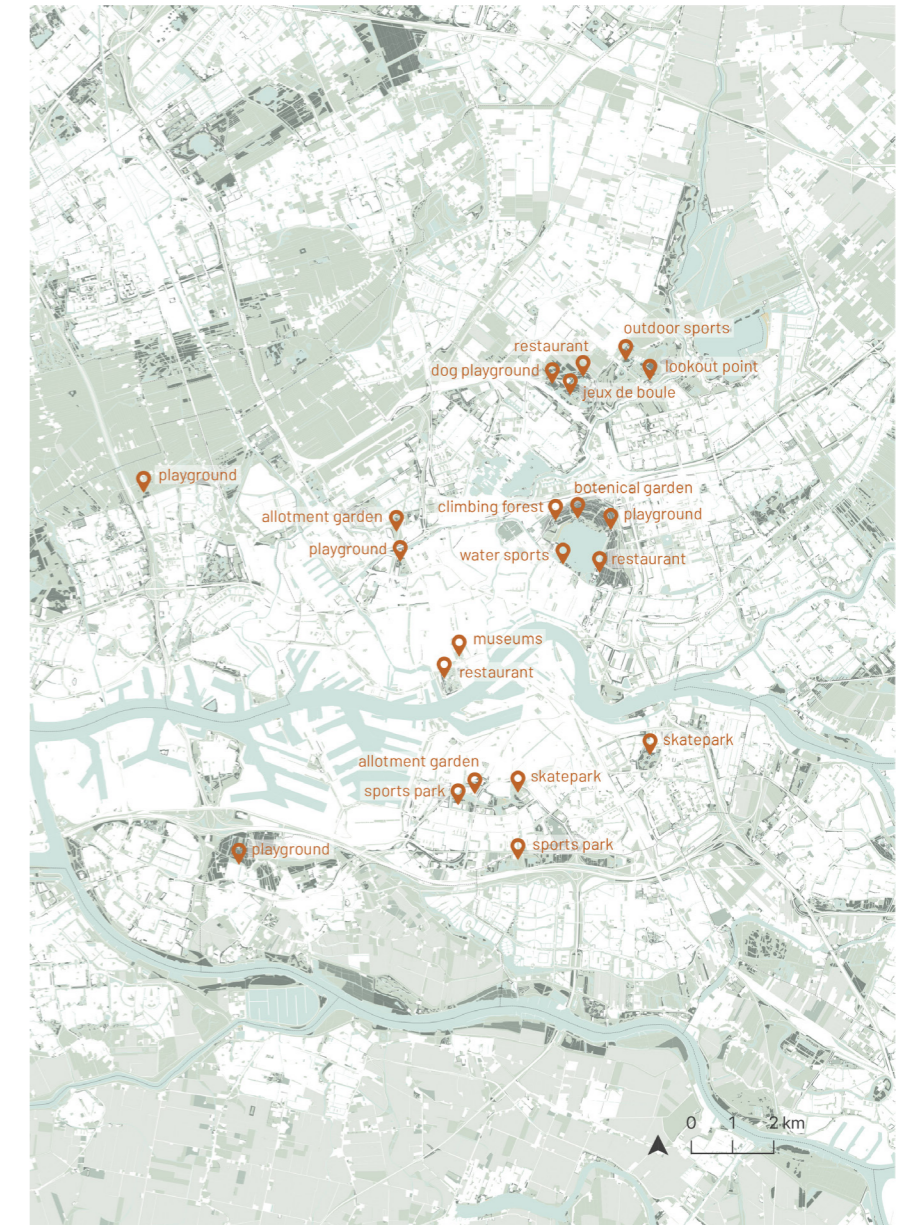
LEGEND

⬚ Municipal Boundary
▢ Water

■ Forest
■ 'Grienden'
■ Orchard
■ Graveyard
■ Grassland
▢ Cropland

0 1 2 km

FIG. 4.28 Socio-Spatial Analysis | types of green

outdoor sports
restaurant
dog playground
lookout point
jeux de boule
playground
botenical garden
allotment garden
climbing forest
playground
playground
water sports
restaurant
museums
restaurant
skatepark
allotment garden
skatepark
sports park
playground
sports park

LEGEND

⬚ Municipal Boundary
▢ Water

■ Forest
■ 'Grienden'
■ Orchard
■ Graveyard
■ Grassland
▢ Cropland

0 1 2 km

FIG. 4.29 Socio-Spatial Analysis | program

Accessibility

Bicycle & Foot
The maps below show the accessibility of green areas by foot and by bicycle. Within 10 minutes by bike, the whole city of Rotterdam can be reached from nature areas. However, by foot it shows that the inner city is not well connected to green spaces.

Besides this, the maps shows us how well the city of Rotterdam is accessible by bicycle. This suggests that car mobility is not necessary for all mobility within the city boundaries as bicycle mobility has a lot of potential. However, the bicycle routes should be improved and car traffic reduced in order to stimulate alternative mobility.

Route & Barriers
When combining the accessibility of Staatsbosbeheer properties by bicycle with the possible boundaries, it gives a better indication of the accessibility. The route from the residential areas towards the nature consist of multiple possible barriers. Especially the ring highway and industrial areas form this barrier, which might influence the willpower to visit the locations. Therefore, the possible barriers should be taken into account in improving the accessibility of public green.

LEGEND

☐ Green
┊ Municipal Border
☐ Buildings
☐ Water

■ 5 minutes
■ 10 minutes
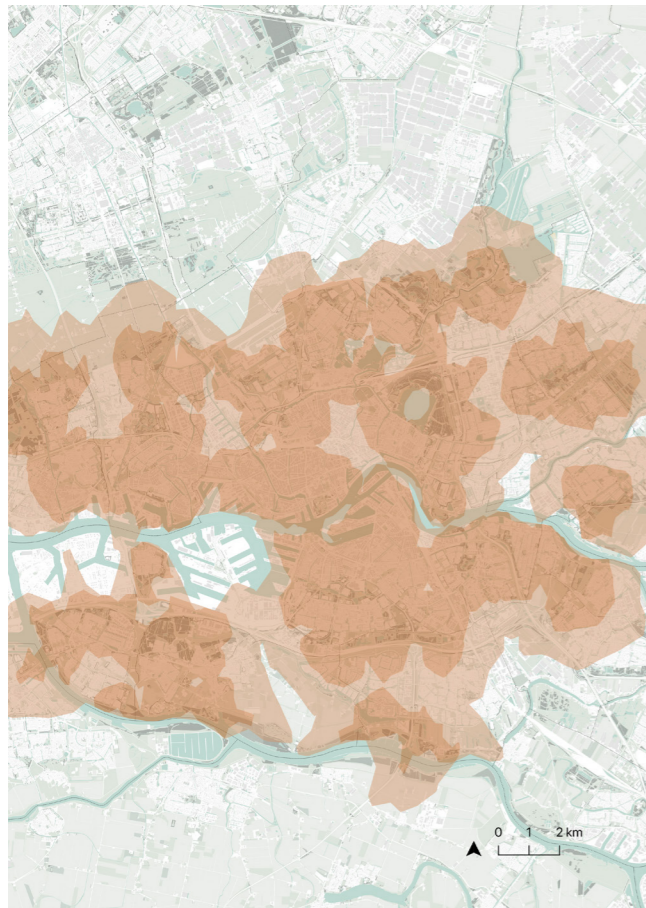
FIG. 4.30 Socio-Spatial Analysis | accessibility by bicycle

FIG. 4.31 Socio-Spatial Analysis | accessibility by foot

LEGEND

☐ SBB property
┊ Municipal Border
☐ Buildings
☐ Water

╱ Train
╱ Highway
╱ Main road
╱ Regional Road

FIG. 4.32 Socio-Spatial Analysis | barriers
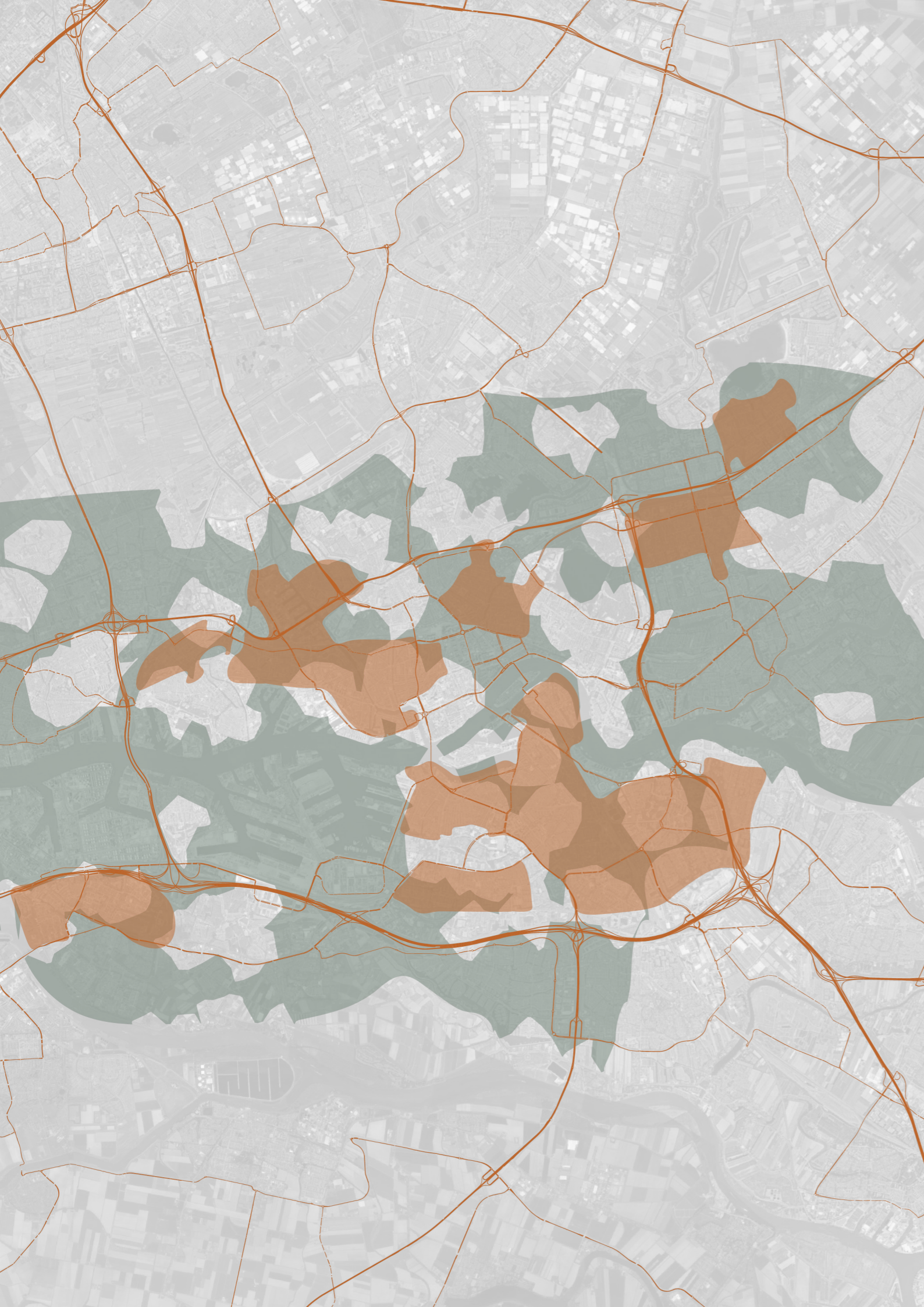
Synthesis

By combining different layers of the analysis, a conclusion of the socio-spatial analysis can be made using the three main indicators that influence the connection with nature.

Accessibility

The main goal concerning accessibility is to connect every resident of Rotterdam physically to nature. Especially in the high density urban areas of the city, access to green is limited. Herewith it is important to break down possible barriers on the routes.

Opportunities arise to reduce car mobility within the urban core of Rotterdam and focus on slow mobility. As a result of limiting car accessibility in the centre, space opens up which can be used to create high quality public green space.

Interaction

Currently the nature areas do not have a lot of program, which results in a lack of reason to visit these places. Opportunities arise to create program in the larger nature parks, to make it attractive to visit, whilst making the local scale green spaces part of daily life, by creating routes.

Sense of place

In certain districts, especially in the western and southern side of the city, the liveability is relatively low. In these areas, chances lie in using the integration of nature to improve the liveability. Especially by facilitating co-creation of the neighbourhoods, social cohesion can be stimulated which contributes to the liveability.

LEGEND

▢ Poor accessibility to public green by foot
▢ Poor liveability
╱ Physical barriers

FIG. 4.33 Socio-Spatial Analysis | synthesis

4.3 CLIMATE ANALYSIS

During the climate analysis, research will be done on the capacity of the city of Rotterdam to deal with the consequences of the changing climate and be climate resilient.

Urban Heat Island
The urban heat island effect indicates the difference in temperature in the city as a result of modification of the landscape. Especially in the city centre and around the ports, this effect is strongly visible because of all the paved area, even though there is a river flowing through the city.

Drought
The dropping ground water level as a result of little precipitation in the city causes treats for the natural systems (Klimaateffectatlas, 2021). The lack of water leads to unsuitable circumstances for flora and fauna. Especially in the urban centre this challenge occurs, causing vegetation to disappear.

LEGEND

Water

UHI (ºC)
- < 0,7
- 0,7 - 1,4
- 1,4 - 2,1
- 2,1 - 2,8
- > 2,8

0   1   2 km
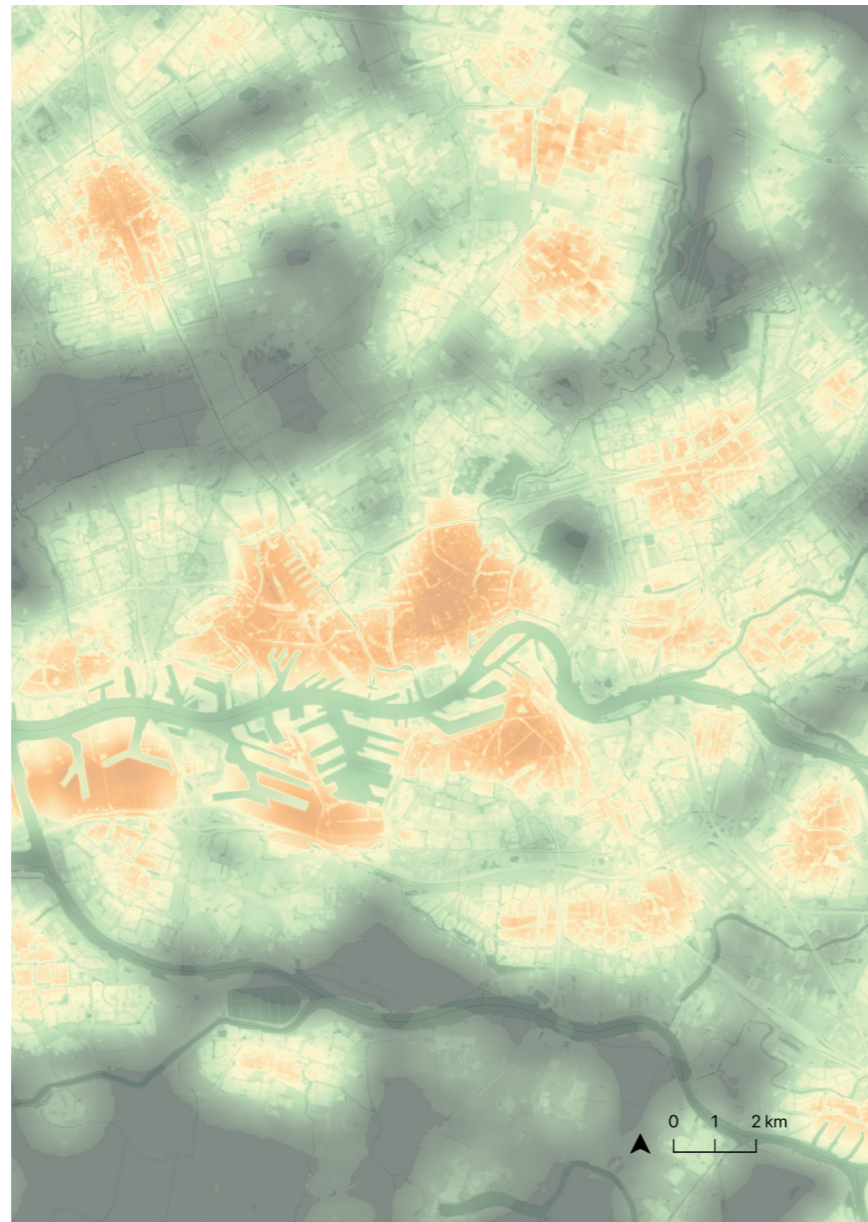
FIG. 4.34 Climate Analysis | UHI

LEGEND

Water
Buildings

Lowest groundwater level (m below groundlevel)
- < 1,35
- 1,35 - 1,71
- 1,71 - 2,09
- 2,09 - 2,93
- > 2,94

0   1   2 km
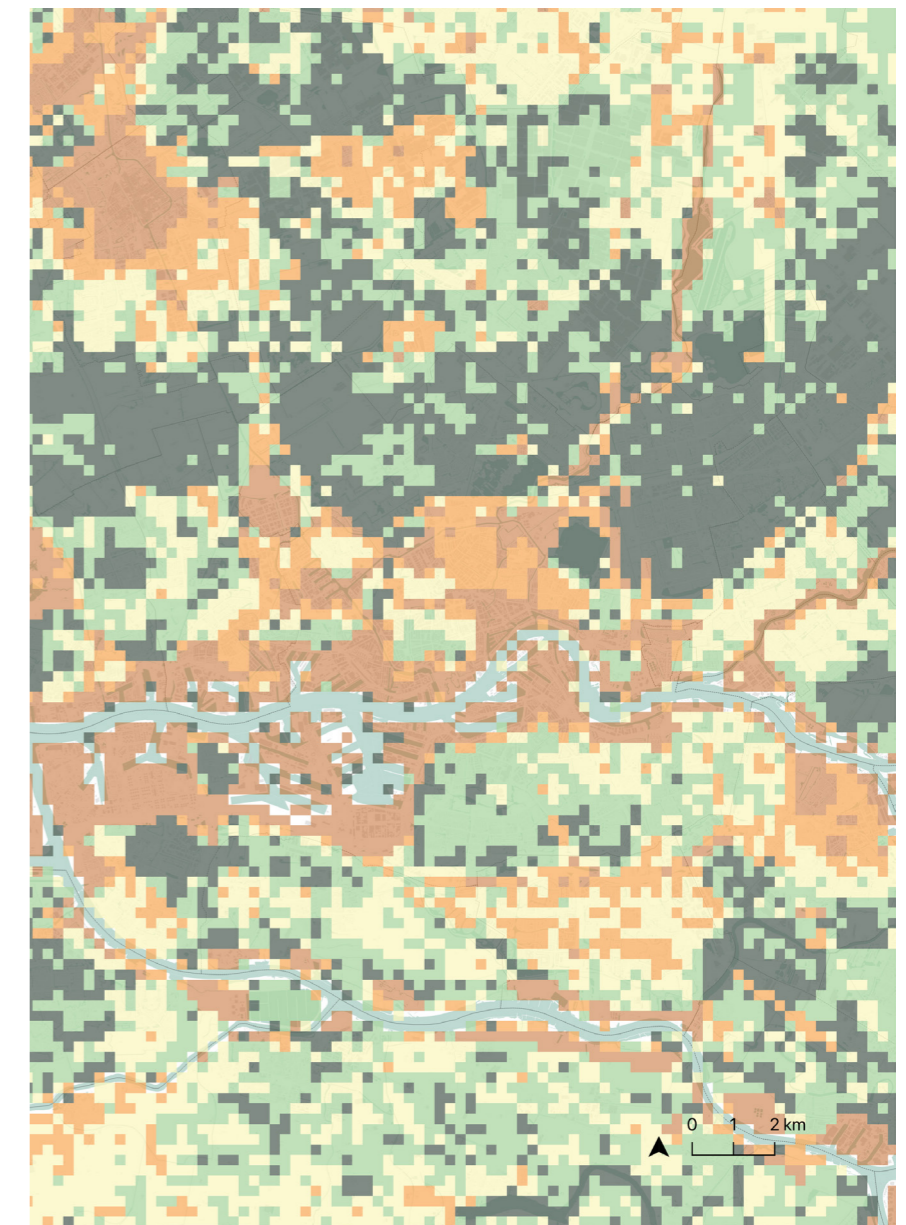
FIG. 4.35 Climate Analysis | drought

As a result of the changing climate, extreme precipitation occurs more often leading to water nuisance. Long periods of drought are alternated with periods of heavy rainfall. As there is little unpaved area in the urban environment, this water is not able to infiltrate into the ground, causing a lot of pressure on the sewage systems. This challenge affects the whole urban area, especially in streets.

Risk of Flooding
Global warming causes the sea level to rise, whilst the soil in the western part of The Netherlands is subsiding. The chances that the river will overflow and cause flooding in the city of Rotterdam is still limited, due to the advanced water protection of The Netherlands. However, the risks keep increasing in this lower part of The Netherlands, especially for areas located outside the dikes.
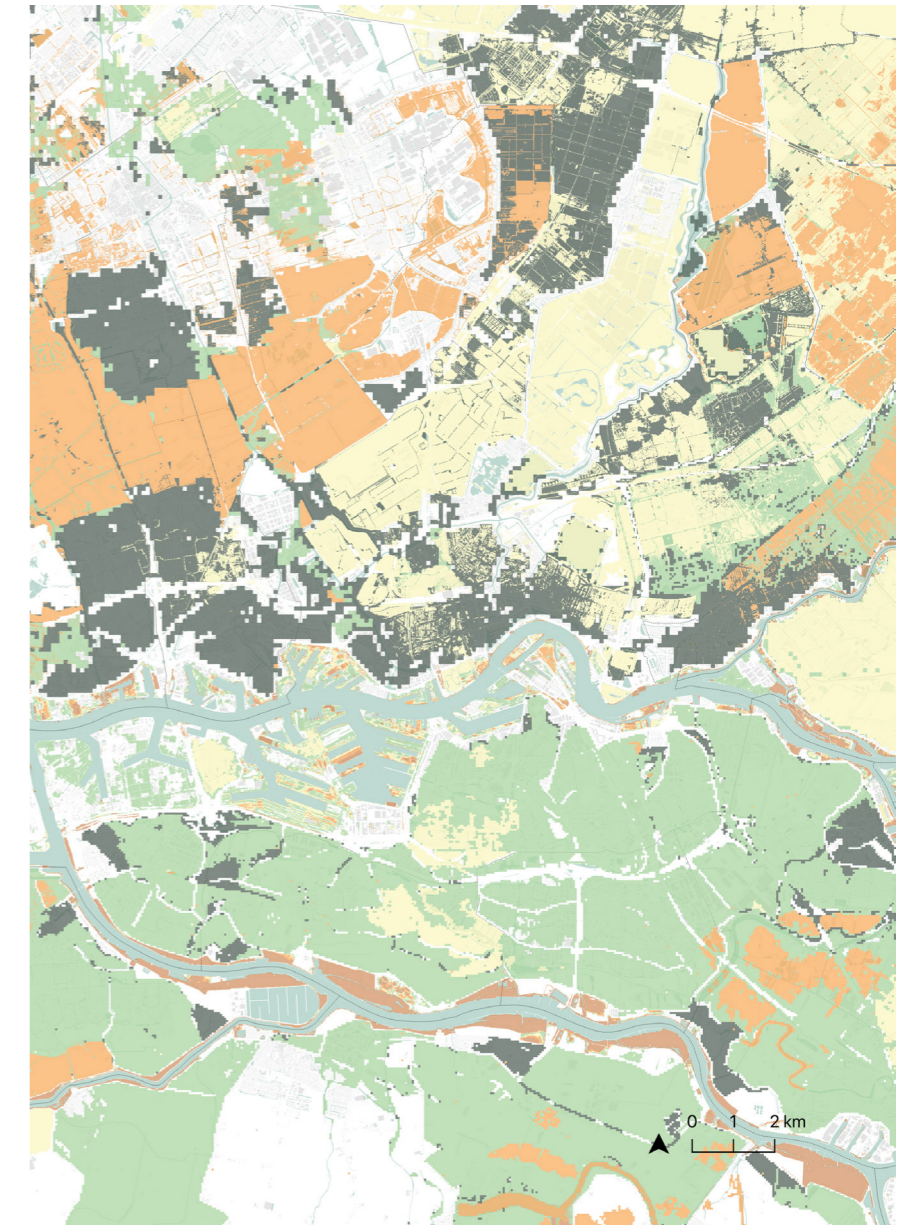
LEGEND

◻ Water

Waterdept (cm)
◻ 5 - 10
◻ 10 - 15
◻ 15 - 20
◻ 20 - 30
◻ > 30

FIG. 4.36 Climate Analysis | water nuisance

LEGEND
◻ Water
◻ Buildings

Risk of flooding > 0 cm
◼ Extreme unlikely
◼ Very Unlikely
◻ Unlikely
◼ Likely
◼ Very likely

FIG. 4.37 Climate Analysis | risk of flooding

Synthesis

The three main indicators of climate change in Rotterdam are Urban Heat Island, Water Nuisance and Risk of Flooding. This synthesis concludes the main treats these effects have on the city life.

Urban Heat Island
The rising temperature of the city is occurring especially in the urban cores, where little unpaved areas and green can be found. The main goal is to limit the urban heat island effect in these areas by increasing the amount of nature.

Water Nuisance
In order to tackle the nuisance of water in the urban areas, more places of infiltration are needed. The city must be able to absorb, store and release the water in times of drought. This can be combined with tackling the effect of UHI as well, by decreasing paved areas.

Risk of Flooding
The risk of flooding is especially relevant along the river shores. Tackling this challenge should be focussed on this part of the city.

To conclude, all effects of the changing climate are very much integrated and affect especially the urban cores. Creating a city as part of nature could contribute to limiting all these consequences.

LEGEND

▣ Risk of flooding
▣ Drought
▣ UHI
▣ Water Nuisance

FIG. 4.38 **Climate Analysis** | synthesis

4.4 LOCATION CHOICE

As described in the previous analysis, the city of Rotterdam is dealing with quite some challenges concerning all three aspects. The areas where multiple issues occur are highlighted in figure 4.40. First, the socio-spatial analysis leads to the places with a low liveability score and poor access to nature. Second, the ecological analysis shows the missing connections in the ecological network and places with little green. Third, the climate analysis emphasizes the areas vulnerable for flood, drought, heat stress and water nuisance. Synthesizing these different analyses shows that the urban centre of the city is facing challenges on all aspects, see figure 4.39.

Besides this, the urban centre is the district with a high population density, making this area even more vulnerable. Therefore, during this project this district will be scrutinized and used as a case study to examine how it could be developed into an urban environment that is part of nature, in order to improve the urban quality of life.
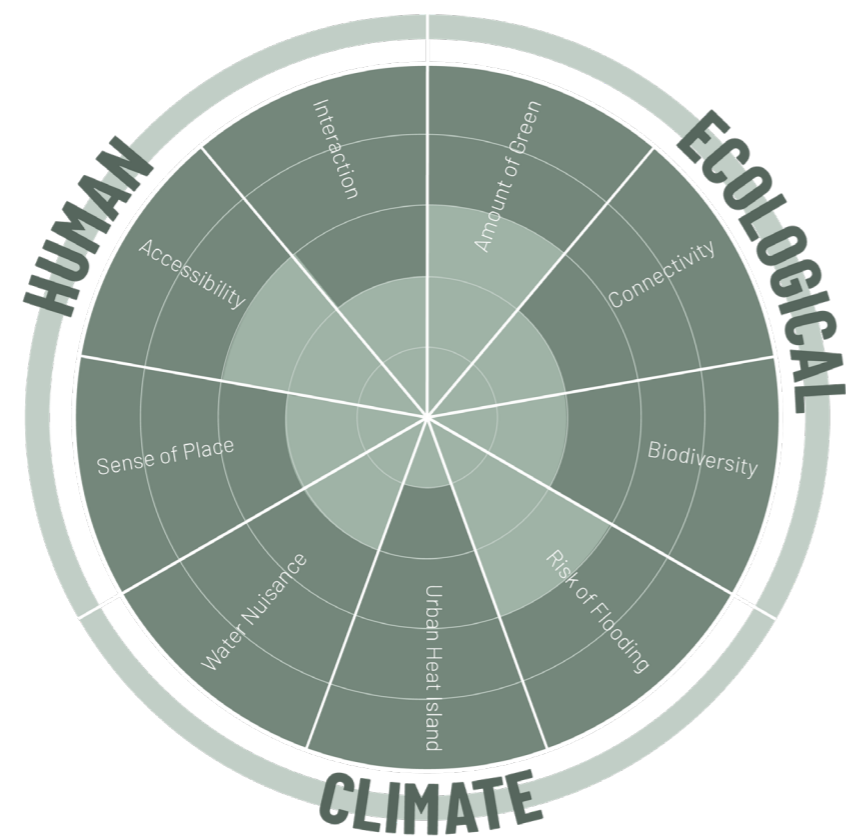
FIG. 4.39 Synthesis Analysis | assessment

LEGEND

▪ Water
▪ Vulnerable places ecological perspective
▪ Vulnerable places human perspective
▪ Vulnerable places climate perspective
⚑ Missing ecological connections
○ Case study

FIG. 4.40 Synthesis Analysis | location choice

0   0.5   1 km

5 GENERALIZING

During the researching phase, a pattern language is developed. This consists of a set of patterns that describe solution orientated design typologies, supported by a pattern field, which explains the relations between the patterns. The pattern language aims to answer the following research questions:

3a   How could the ecological performance of the Rotterdam ecosystems be improved?

3b   How could awareness on the values of nature be created among the citizens of Rotterdam?

3c   How could the climate resilience of Rotterdam be improved?

5.1 PATTERN LANGUAGE APPROACH

The pattern language is a method in which problem solution descriptions are developed, called patterns, to suggest guidelines for creating place (Hendriquez et al., 2013; Park, 2015). The pattern language approach is developed by Christopher Alexander (Alexander, 1977) and can be used as a tool in urban planning and design. The individual patterns describe a spatial problem and a possible solution to this problem. Together, the patterns, that all have the same format (figure 5.41), make up a language that can be used in multiple ways. It is a way of collecting and organizing data that can be used in different projects and situations.

5.2 PATTERN ATLAS

The developed pattern language on a city as part of nature can be found in the pattern atlas (Francissen, 2022). This atlas consists of a set of 28 patterns, all related to this research objective, and pattern fields, which explain the relationships between the patterns. The pattern field can be organized in multiple ways, of which one is shown in figure 5.42.

Each individual pattern consists of a few elements that can bee seen in the example pattern in figure 5.41. The framework developed in the delineating phase (see chapter 3), is included as well. This framework is filled based upon own estimations, in order to highlight the main focus and influence of the pattern.

The development of the patterns is based upon own research on the relevance for this project. However, other pattern languages by De Roode (2021), Van Dorst (2013) have been an inspiration for these topics.

The pattern language is applied within the designing and strategizing phase (see chapter 6 and 7). A full overview of the patterns can be found on the next pages.

FIG. 5.41 Example Pattern Atlas
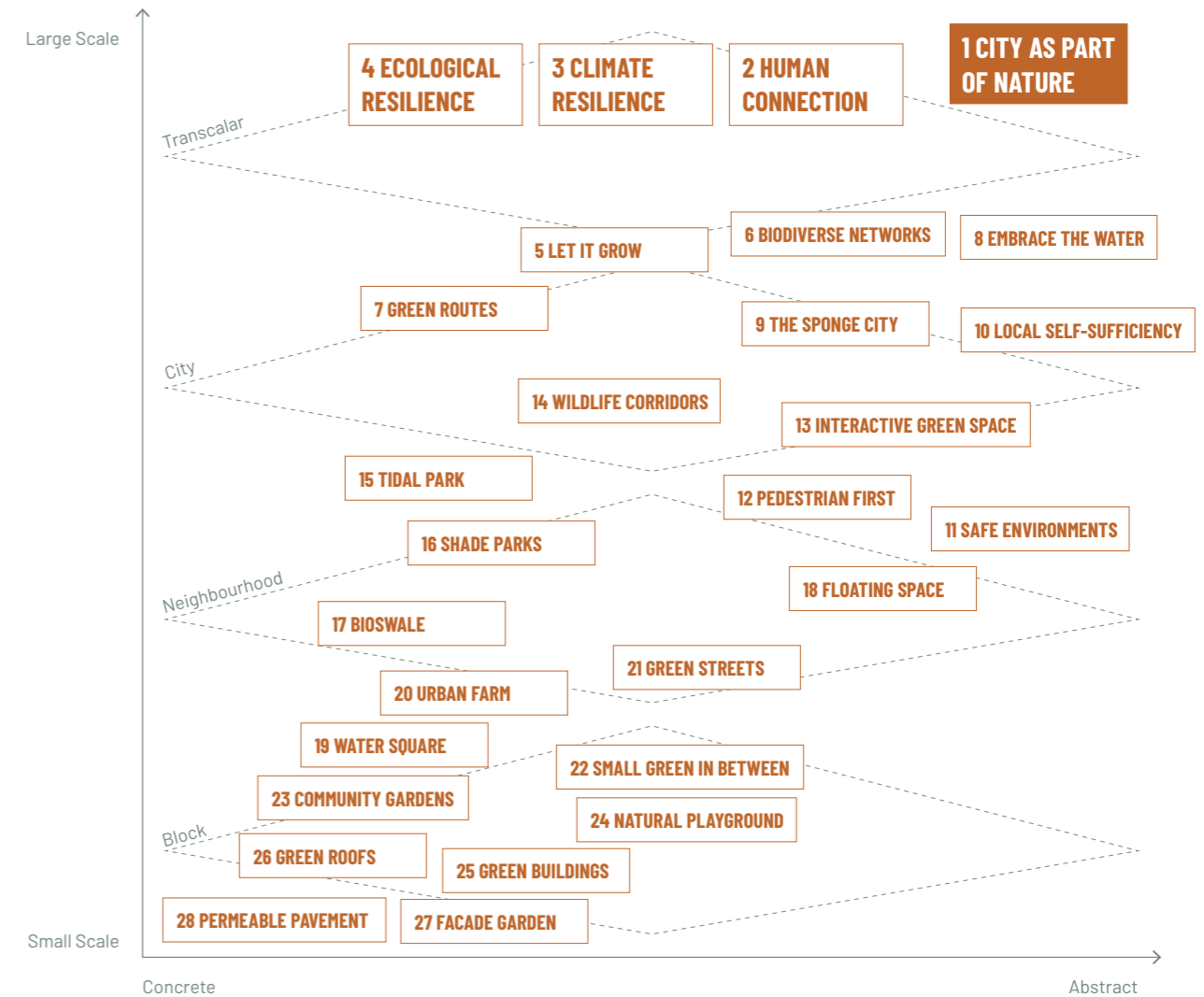
FIG. 5.42 Pattern Field by Scale & Nature

1 CITY AS PART OF NATURE

2 SOCIAL RESILIENCE

3 CLIMATE RESILIENCE

4 ECOLOGICAL RESILIENCE

5 LET IT GROW

6 BIODIVERSE NETWORK

7 GREEN ROUTES

8 EMBRACE THE WATER

9 SPONGE CITY

10 LOCAL SELF-SUFFICIENCY

11 SAFE ENVIRONMENT

12 PEDESTRIAN FIRST

13 INTERACTIVE GREEN SPACE

14 WILDLIFE CORRIDORS

15 TIDAL PARK

16 SHADE PARK

17 BIOSWALE

18 FLOATING SPACE

19 WATER SQUARE

20 URBAN FARM

21 GREEN STREETS

22 SMALL GREEN IN BETWEEN

23 COMMUNITY GARDEN

24 NATURAL PLAYGROUND

25 GREEN BUILDINGS

26 GREEN ROOFS

27 FACADE GARDENS

28 PERMEABLE PAVEMENT

FIG. 5.43 Overview of the Patterns
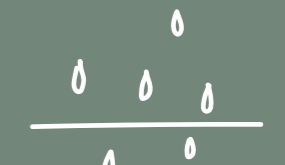
6 VISIONING

During the visioning phase, the knowledge gathered from the previous phases will be used to develop a design proposal for (a location within) the city of Rotterdam. The main object of the project to create a the city as part of nature is aimed to achieve in this design, using the main research question as a guideline:

How could the citizens of Rotterdam be reconnected to nature, while improving the urban ecosystems, creating a resilient city?

FIG. 6.44 Vision Map Rotterdam

6.1 CITY VISION

In the vision for Rotterdam, the aim is to dissolve the distinctions between the natural and urban environment in order to create a nature inclusive city. Starting from the natural systems, the aim is to create a network of green going into the urban centre, using the waterways of De Schie and De Rotte on the northern side of the river Meuse, and green infrastructures on the southern side of the Meuse.

Creating space to open up the natural systems results in reducing car mobility in the inner city. This leads to a slow mobility focussed city where public green space is an integrated party of city life. Transfer locations will transform into convenient places to stay with the main focus to improve the quality of life.

With a network of green that flows through the port city every resident is able the experience nature especially now biodiversity is increasing and interaction with the natural systems is provided. Specific interventions contribute to dealing with climate change effects and by letting the city landscape develop from a natural perspective, resiliency is created.

The site that will be used for the case study, see figure 6.45, show how this spatially will work out.

LEGEND

- Water
- Grassland
- Forest
- Buildings
- Roads

LEGEND

- Main Water Structure
- Strengthen Current Structure
- New Connections
- Hotspots: places to visit
- Case Studies

FIG. 6.45 Abstract Vision Map and Case Study Location
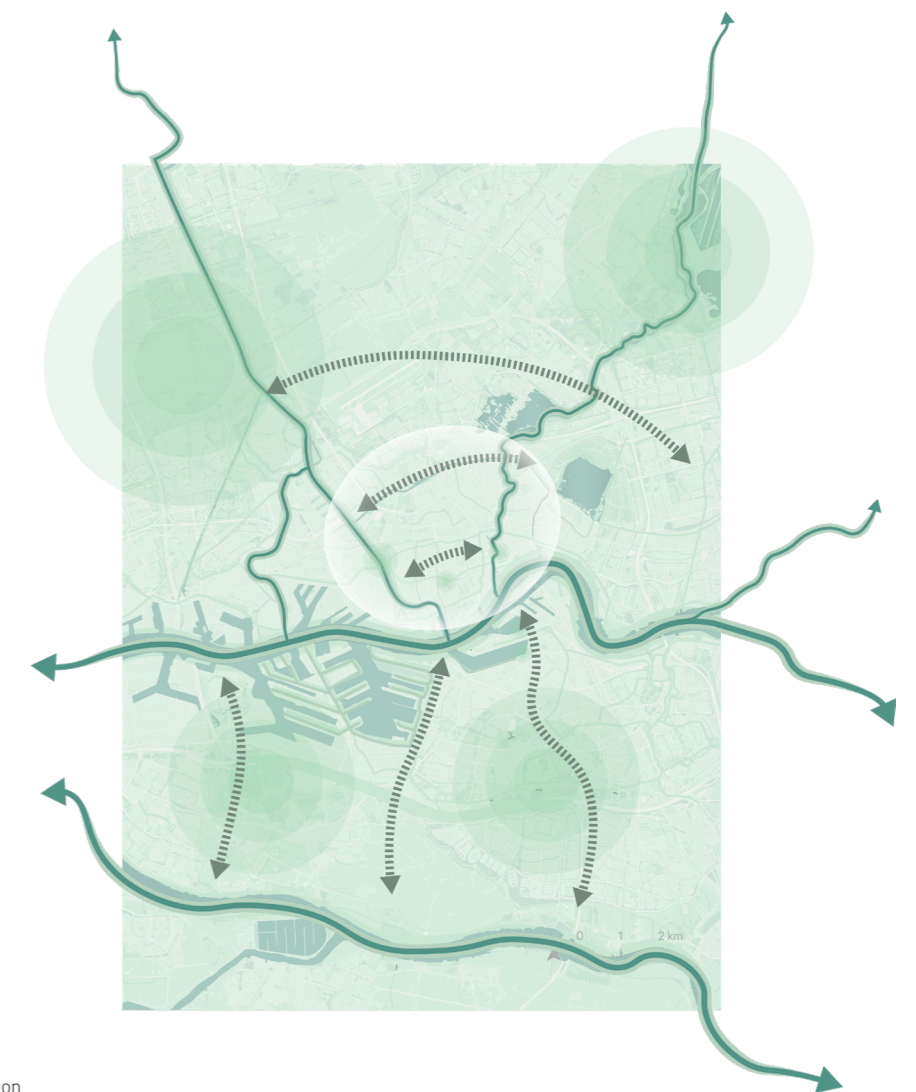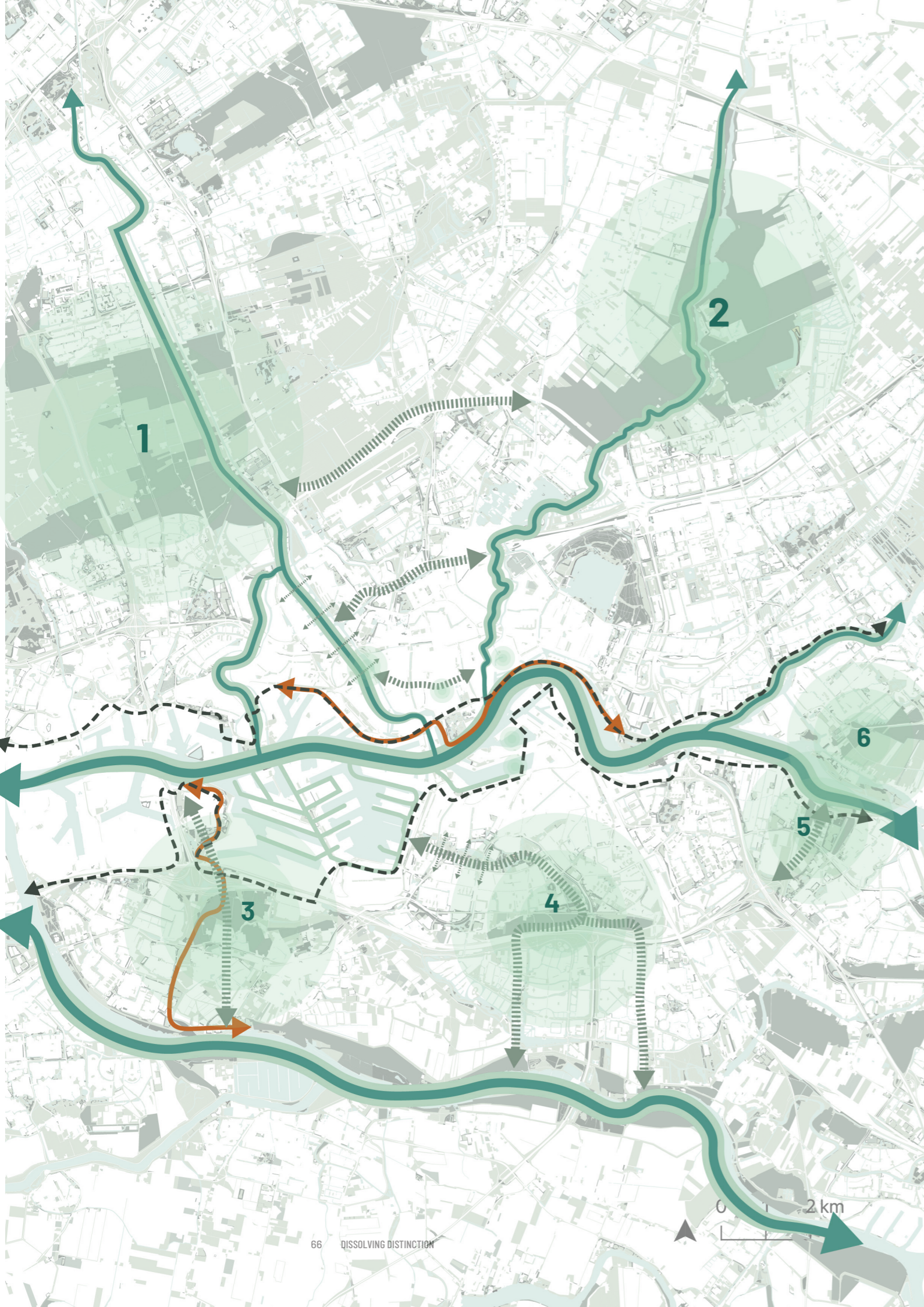
6.2 STRATEGIC INTERVENTIONS

In Rotterdam, developments take place that support the ambitions of the Green Metropolis. However, opportunities arise to strengthen this network in order to improve the quality of life in Rotterdam. Figure 6.46 shows strategic interventions that contribute to the vision.

First of all, a distinction in green structure can be made in the northern and southern banks. On the north side there is a need for east-west connections, especially connecting the Schie to the Rotte, while on the south there is a need for green wedges.

Second of all, the 6 main locations of Staatsbosbeheer can play an important role in the Green Metropolis: Midden Delfland (1), Rottermeren (2), Valckensteynse Bos (3), IJsselmonde (4 & 5) and Krimpenerhout (6). Numbers 1 and 2 are already part of ongoing developments. However, numbers 3, 4, 5 and 6 can be transformed into hotspots, places to visit, by adding program for recreation and strengthening the ecological values.

3: Create a connection from river to river through the Valckesteynse Bos. This consists of a unique section, crossing multiple landscape types (port, residential, forest and "grienden" tidal river). A route can be developed from north to south, adding recreational functions and a connection to the rest of the city through the Watertaxi. A challenging location is crossing the highway, which could be done through a biking bridge or ecoduct.

4: This location could function as a recreational hotspot, linked to the Zuiderpark and even all the way to the port. Improving the intrinsic quality of the area could contribute to the liveability of the surrounding neighbourhoods.

5 & 6: Connect these locations to the river, and add recreational functions to make it an attractive place to visit, also considering the to be developed business park close to here. Transform this into a tidal river park and connect them using a bicycle ferry.

Third of all, the inner city will have to be greenified. The dike structure could be used as a starting point for this, expanding especially towards port areas. In former ports, parks or city beaches could be developed. On the north bank this could be linked to the Schie.

LEGEND

▢ Municipal Border
▢ Water
▢ Agriculture
▢ Nature

↗ Main water structure
✎ Greening
✎ Green Connections
● Hotspots
✎ Dike Structure
↗ Recreational route

FIG. 6.46 Strategic interventions Rotterdam

6.3 URBAN CENTRE -

SCHIE TO ROTTE

Rotterdam has a high density urban centre which is mainly located on the northern side of the river. Two main waterways De Schie, a natural creek constructed for water transport, and De Rotte, a natural creek, flow trough the urban core of the city. The aim is to develop a network of green in between these waterways and make them an integral part of urban life, to create an ecological and spatial connection.

The research is approached from three different perspectives, and so is this vision. Each layer consists of a few criteria that contribute to a nature inclusive city. Each point of criteria will be highlighted showing an exploration on how to improve the spatial compositions for the benefit of that certain aspect. This will be done using the patterns from the pattern language, see chapter 5. These patterns further explain the practical implication and propose a design solution.

Together, all the criteria and layers make up a vision for this site, see figure 6.47 and 6.48. A nature grid is developed, with different hierarchies, both for human as ecological activities. Each layer will be elaborated upon within the following few pages.

Climate Perspective

Human Perspective

Ecological Perspective

FIG. 6.47 Urban Centre | layered vision map

LEGEND

■ Main water structure
■ Strengthen existing green
⁄ Greening
⁄ Performative waterfront
■ Network of green roofs

FIG. 6.48 Urban Centre | vision map

Urban Heat Island

3 CLIMATE RESILIENT CITY

6 BIODIVERSE NETWORKS

9 SPONGE CITY

14 WILDLIFE CORRIDORS

26 GREEN ROOFS

FIG. 6.49 Urban Centre | UHI map

FIG. 6.50 Urban Centre | UHI impression

Water Nuisance
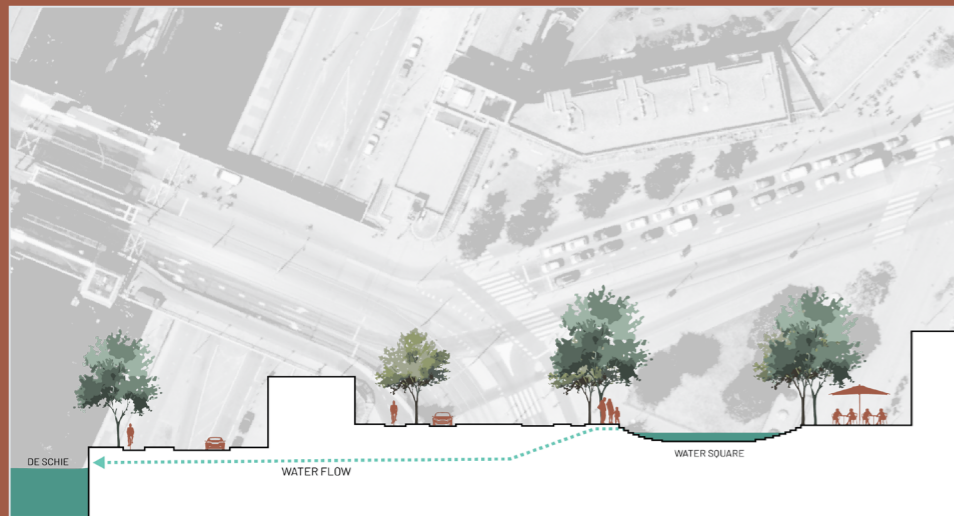
3 CLIMATE RESILIENT CITY

8 EMBRACE THE WATER

9 SPONGE CITY

13 INTERACTIVE GREEN SPACE

19 WATER SQUARE

FIG. 6.51 Urban Centre | water nuisance section

Risk of Flooding

3 CLIMATE RESILIENT CITY

7 GREEN ROUTES

8 EMBRACE THE WATER

9 SPONGE CITY

15 TIDAL PARK
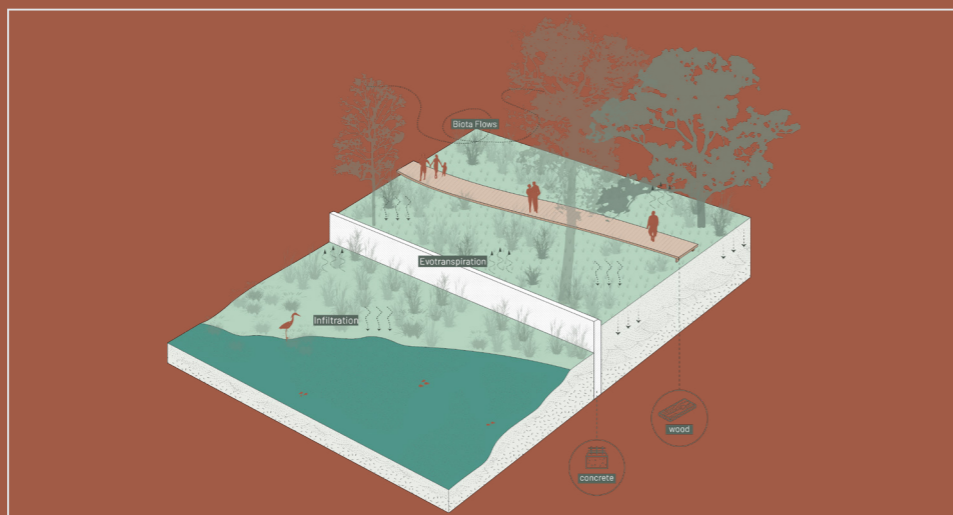
FIG. 6.52 Urban Centre | risk of flooding 3D

Climate Perspective

Urban Heat Island
In a city that has a high density and little unpaved area, the temperature rises. By decreasing the unpaved area, this challenge can be dealt with. In Rotterdam opportunities arise to create a network of environmental friendly roofs. This could be realized in the form of green, blue, brown and white roofs (Gee, 2021). Not only does this contribute in decreasing the Urban Heat Island effect, it also increases the biodiversity and water storage capacity of a city.

Water Nuisance
As a result of extreme rainfall and little area for water to infiltrate in the ground the sewage systems cannot deal with the amount of water. As can be seen in chapter 4, water nuisance occurs in the streets. By implementing water squares, the excessive water can be temporarily stored before entering the sewage system. Of course, reducing the amount of paved area contributes to reducing the nuisance as well.

Risk of Flooding
To limit the risk of flooding in districts outside the dykes, as a result of the rising sea level, buffer zones will be established in the form of tidal parks. These parks are also part of a recreational route, and emphasize the tides of the river.

Water Nuisance

Risk of Flooding

LEGEND

○ Highlighted location
▮ Soft quays
▮ Water square

Potential green/grey roofs
▮ Completely flat
▮ Mostly flat
▮ More than half flat

FIG. 6.53 Urban Centre | climate perspective map

Accessibility

12 PEDESTRIAN FIRST

21 GREEN STREETS

22 SMALL GREEN IN BETWEEN

23 COMMUNITY GARDEN

25 GREEN BUILDINGS

FIG. 6.54 Urban Centre | accessibility map

FIG. 6.55 Urban Centre | accessibility impression

Sense of Place

FIG. 6.56 Urban Centre | sense of place section

FIG. 6.57 Urban Centre | sense of place impression

7 GREEN ROUTES

12 PEDESTRIAN FIRST

16 SHADE PARK

21 GREEN STREETS

28 PERMEABLE PAVEMENT

Interaction

8 EMBRACE THE WATER

9 SPONGE CITY

13 INTERACTIVE GREEN SPACE

19 WATER SQUARE

28 PERMEABLE PAVEMENT
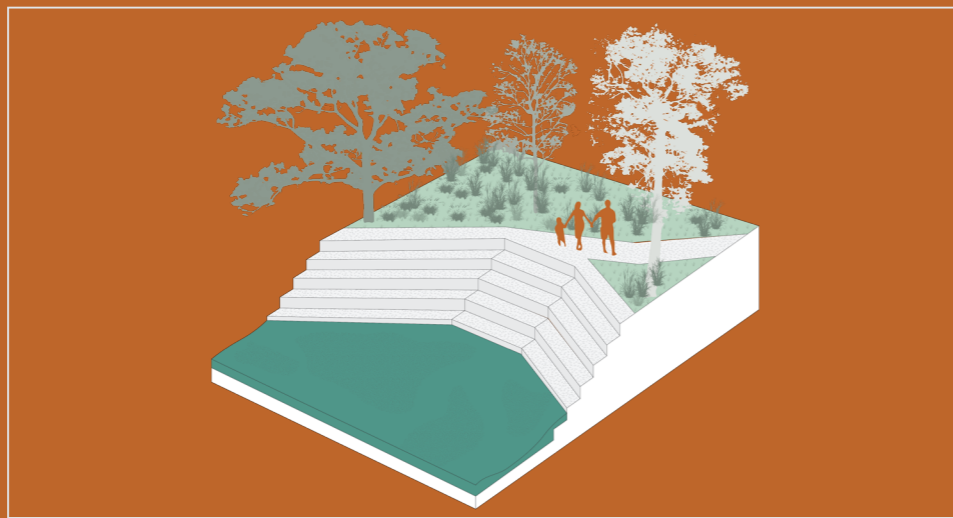
FIG. 6.58 Urban Centre | interaction 3D

Human Perspective

Accessibility

By greening streets and buildings, and transforming paved playgrounds in to natural ones, nature will be accessible for every citizen. Besides this, car mobility will be reduces leading to a safer environment for pedestrians and bicyclists and more attractive routes through the city.

Sense of Place

Creating attractive public space for recreation in the form of parks contribute to the sense of place. By making it part of a bigger route and adding some program the quality increases. The 's Gravendijkwal, which today is a busy main road, causes a lot nuisance in the surrounding environment. By lowering the road (at some parts this is already done) and covering it with a park, the quality of the area increases, as well as the quality of life.

Interaction

Spaces that contribute to climate and ecological resilience can also contribute to the connection with nature and quality of life. A multifunctional water square, that stores excessive rainwater, could also function as a playground, or a square for events.

LEGEND

○ Highlighted location
▫ Green route
▪ Tidal park
▪ Existing public green
▪ New public green
⦿ Rotterdam hotspots
▫ City centre

FIG. 6.59 Urban Centre | human perspective map

Amount of Green

FIG. 6.60 Urban Centre | amount of green map

FIG. 6.61 Urban Centre | amount of green impression

Biodiversity

FIG. 6.62 Urban Centre | biodiversity section
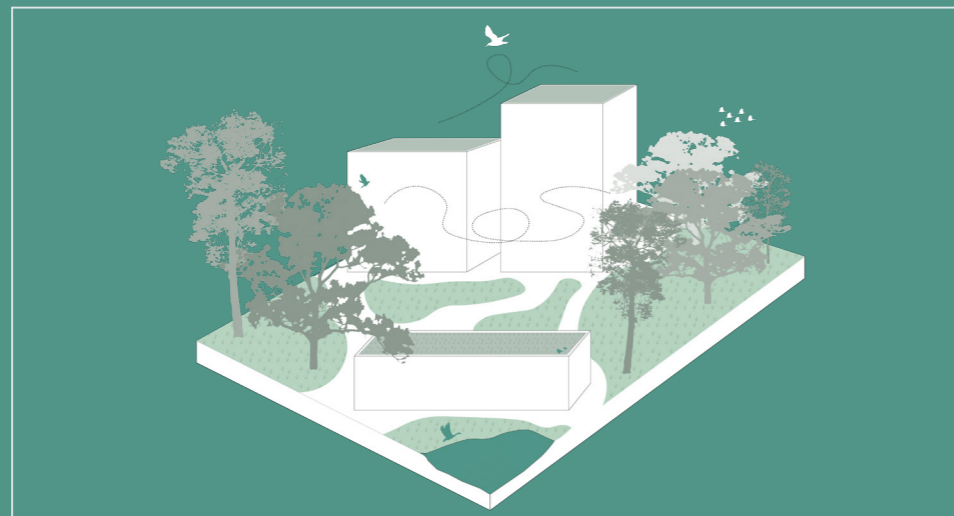
Connectivity

FIG. 6.63 Urban Centre | connectivity 3D

Ecological Perspective

Amount of Green
In order to strengthen the ecological systems an create a nature inclusive city, the amount of green will be increased by greening streets, façades and buildings.

Biodiversity
In order to increase biodiversity in a city the circumstances for settlement must be optimised, consisting of the provision of food, place for sleep, good soil conditions, shelters for safety and possibility to reproduce (Vollaard et al., 2017). Rotterdam has identified 10 key species to be highlighted, in order to create more awareness among citizens (Gemeente Rotterdam, n.d.).

Connectivity
Creating ecological connectivity by connecting green patches helps to develop the network and support the urban biodiversity. This aspect is strongly connected with biodiversity and the amount of green.

LEGEND

☐ Highlighted location
■ Water
■ Existing green structure
■ New green structure

FIG. 6.64 Urban Centre | ecological perspective map

7 STRATEGIZING

As an addition to the designing phase, a certain location is highlighted to show how the implementation of a city as part of nature can be approached. This will be done by taking a look at the involved stakeholders and possible phasing of the implementation. In the strategizing phase, the main research question will again be considered:

How could the citizens of Rotterdam be reconnected to nature, while improving the urban ecosystems, creating a resilient city?

7.1 STAKEHOLDERS

In order to develop a complete strategy, it is important to identify the parties that are involved in the spatial development. Conducting a stakeholder analysis in order to determine in what way the parties are involved and should be engaged, gives a better understanding of how to approach these. Involving and engaging the stakeholders in the right way within the process, helps to gain support for the developments. And without support, it will be difficult to achieve success (Pichler, 2015).

Developing the city as part of nature requires local support. On the one hand, there are small scale interventions. Creating facade gardens, for example, is a good way to contribute to a nature inclusive city. However, not everyone might want this in front of their house, as it requires some maintenance. Therefore, engaging the local citizens and using a participative approach could lead to understanding of the vision and support for the implementation (Waterschap Schieland en Krimpenerwaard, 2020).On the other hand, larger scale interventions such as creating a park on the 's Gravendijkwal requires political support, as the financial aspect is quite large, as well as the impact of the intervention on car mobility within the city. For these type of

interventions, more stakeholders are involved and will have to be engaged in order to achieve the implementation.

The role of the stakeholder depends on their power and interest. In this way, four different groups can be identified, that all require a different approach: player, subject, context setter and crowd, see figure 7.65 (Pichler 2015). First, the players are the stakeholders with the most power and interest, such as the municipality of Rotterdam. Therefore, it important to manage them closely and preserve a good relationships with them. Second, the subject has a high interest but little power, and should be involved and informed during the process (Pichler 2015). A good example of a subject are the citizens. As mentioned earlier, a participatory approach is beneficial for the projects support. Third, the context setters are the stakeholders that have a lot of power, but little interest and should be kept satisfied. If not, the project feasibility could be at risk (Pichler, 2015). Fourth, the crowd does not have a lot of interest nor power and keeping them informed might be enough (Pichler, 2015).

The stakeholders defined for the city vision and the strategic project, see section 7.3, are based upon first estimations. When diving further into the stakeholder analysis, this will be more accurate.
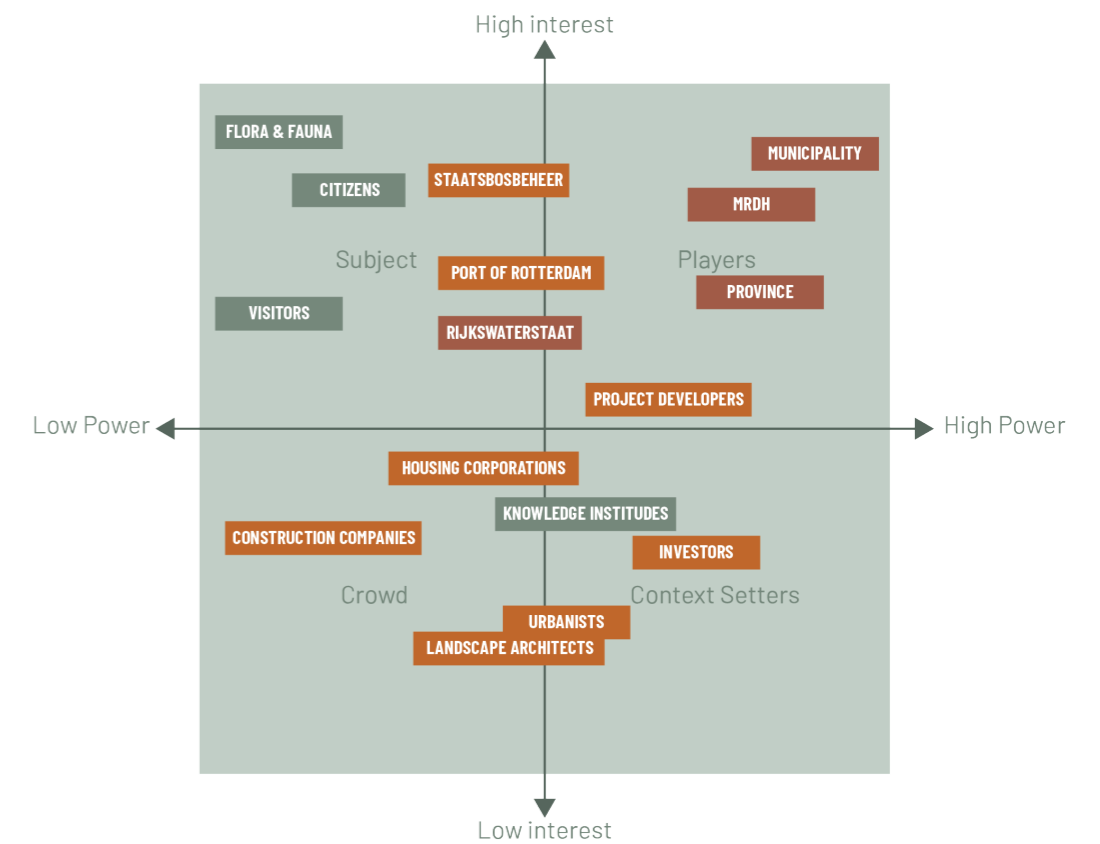
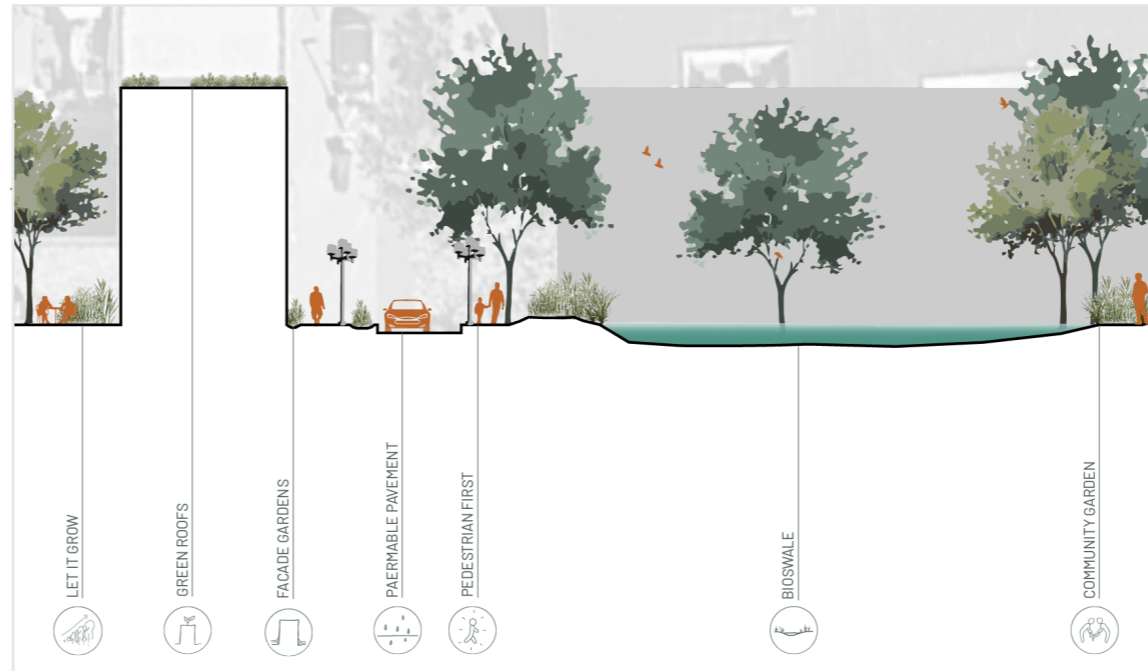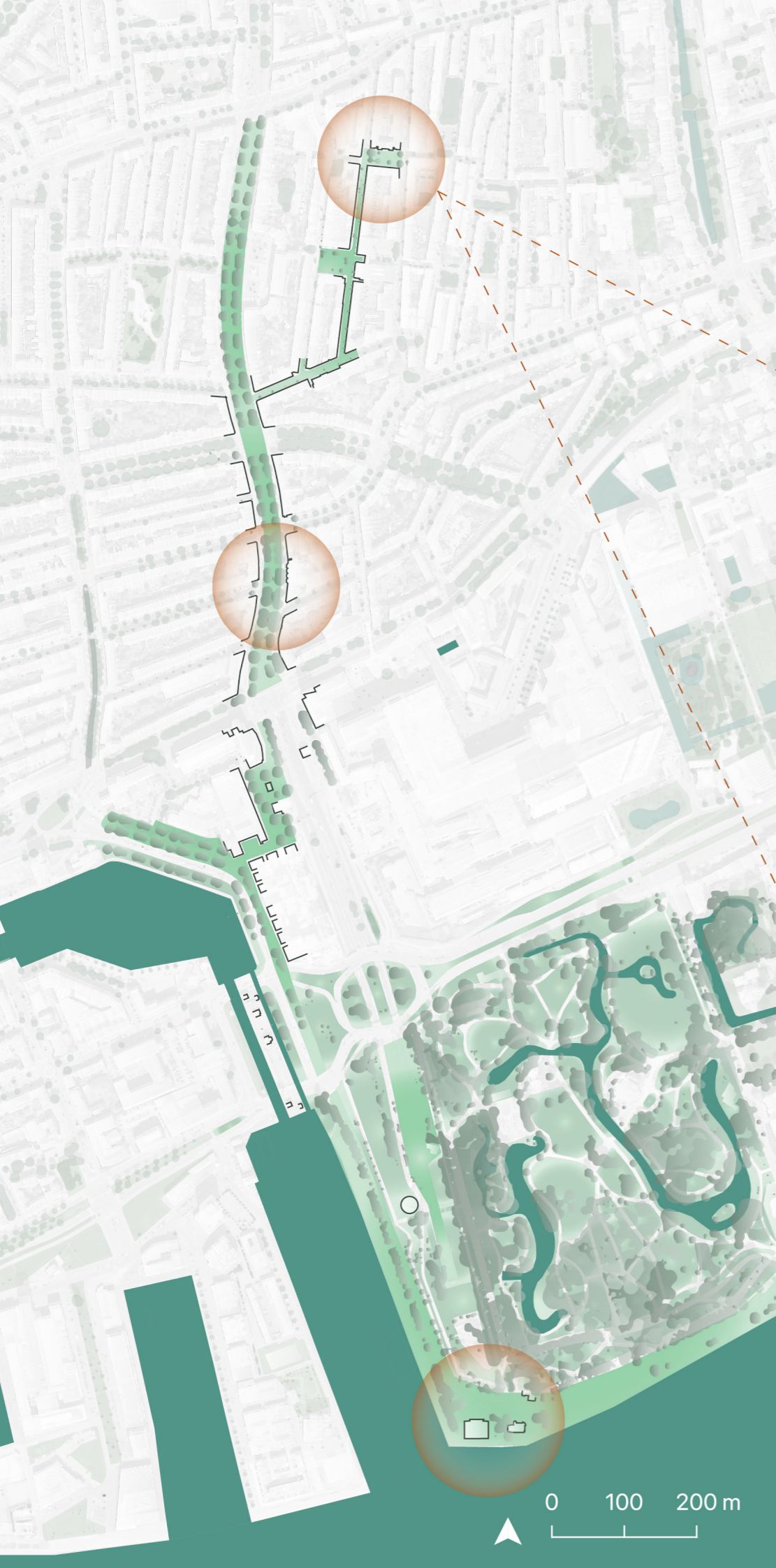| ACTOR	INTERESTS	PROBLEM PERCEPTION	GOALS
Province of South Holland	Strengthened nature, strong cities and villages, healthy and safe environment	Decreased car accessibility	Manage the relationship and keep involved in the process
Metropolitan Region Rotterdam The Hague	Increased urban quality of life	Decreased car accessibility and costs	Manage the relationship and keep involved in the process
Municipality of Rotterdam	Attractive city, well-being citizens, economic growth, climate resilient, reduced traffic	Costs/feasibility	Increasing urban liveability, involve in the process and manage the relationship
Citizens	Health & well-being, access to nature, attractive recreation/public space, decrease of climate effects, pedestrian friendly, less traffic	Decreased car accessibility, constructions in living environment, increasing housing prices, uncertain of the benefits	Increasing urban liveability for all citizens: accessible nature, climate safety and connecting to ecosystems, involve in process and engage in local initiatives
Staatsbosbeheer	Accessible nature for all citizens, attractive Staatsbosbeheer areas	Involvement of Staatsbosbeheer properties	Contribute to the Green Metropolis, involve and inform in the process
Visitors	Attractive urban environment, recreational green space, inspiring city, pedestrian friendly	Decreased car accessibility	Create an inspiring nature inclusive city, inform about the developments.
Project Developers	Employment opportunities and job security	Restrictions and regulations	Manage the relationship and keep involved in the process
Investors	Increasing value of the land, climate (and ecological) resilient, possibility of densification	Costs, uncertain of the benefits	Convince of the benefits, values and feasibility, engage and involve in process
Housing corporations	Possibilities for urban densification, creating sustainable housing	Costs, restrictions and regulations	Keep informed on the project
Construction Companies	Employment opportunities and job security	Restrictions and regulations	Keep informed on the project
Urbanists/landscape architects	Employment opportunities and job security, contributing to a sustainable and resilient urban environment.	Limitations of possibilities	Keep informed and involved in the process
Knowledge institutes	Contribution with research and technology, possibilities to test pilots.	Limitations of possibilities	Keep informed and facilitate involvement
Rijkswaterstaat	Increased liveability, decreased risk of flooding, more green space, less traffic	Costs of tunneling roads	Convince of the benefits, values and feasibility, engage and involve in process
Port of Rotterdam	Improvement of health, safety and resilience of port	Costs of transforming, not wanting to move	Convince of the benefits, values and feasibility, engage and involve in process
Flora & Fauna	Improved conditions for settlement		Create resilient urban ecosystems and improved conditions for settlement

TABLE 7.1 Stakeholder Analysis

FIG. 7.65 Stakeholder analysis

7.2 FRONT-DOOR TO PARK

The objectives of a city that is part of nature considers multiple scales. This strategic project highlights the different scales of experiencing nature within the city as a resident: street, boulevard and urban park.

Street
On street scale, quick wins can be achieved. Small scale interventions can transform the environment right outside the front door into a biodiverse and climate resilient area.

Interventions such as greening roofs and constructing a community garden can be easily achieved while contributing to a nature inclusive city. The improvements are especially beneficial for the human connection with the ecosystems.

FIG. 7.66 Section street

FIG. 7.67 Impression street

FIG. 7.68 Strategic Project
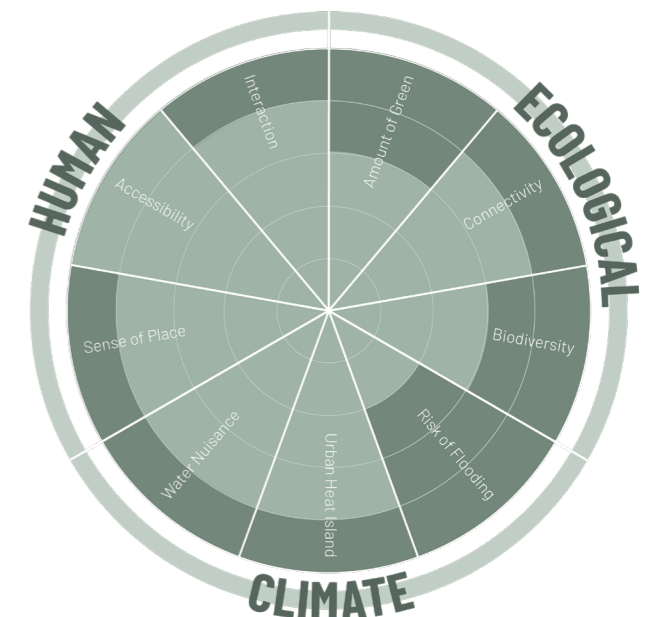
FIG. 7.69 Assessment street

Boulevard - 's Gravendijkwal

Moving from one place to the other, residents will come across larger streets such as a boulevard. 's Gravendijkwal is a perfect example of a large street type that forms a barrier for local scale movement for both humans and other living organisms.

Covering the car lanes, which are already partly located below ground level, could provide new open space with a lot of potential. Instead of a barrier, 's Gravendijkwal could function as a connection within the inner city, by creating a multifunctional park on top of it. This type of intervention has a bigger impact and requires political support, but would contribute to improving the quality of open space and urban life.

FIG. 7.70 Section 's Gravendijkwal

FIG. 7.71 Impression 's Gravendijkwal

FIG. 7.72 Strategic Project
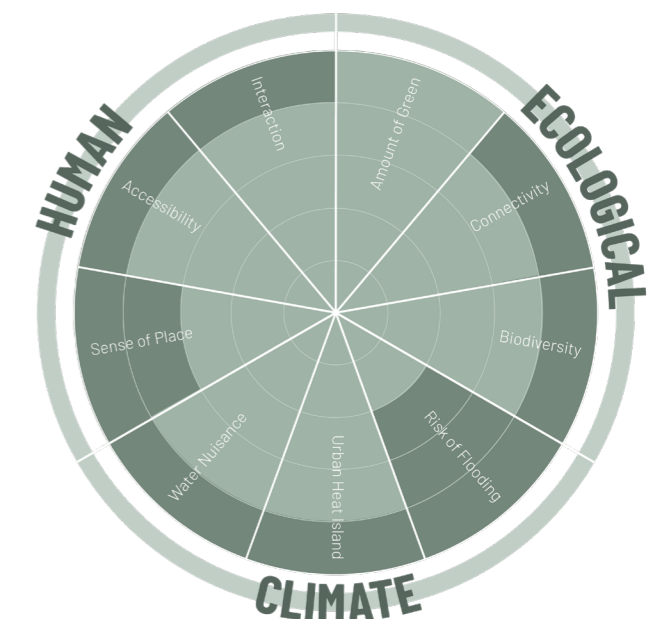
FIG. 7.73 Assessment 's Gravendijkwal
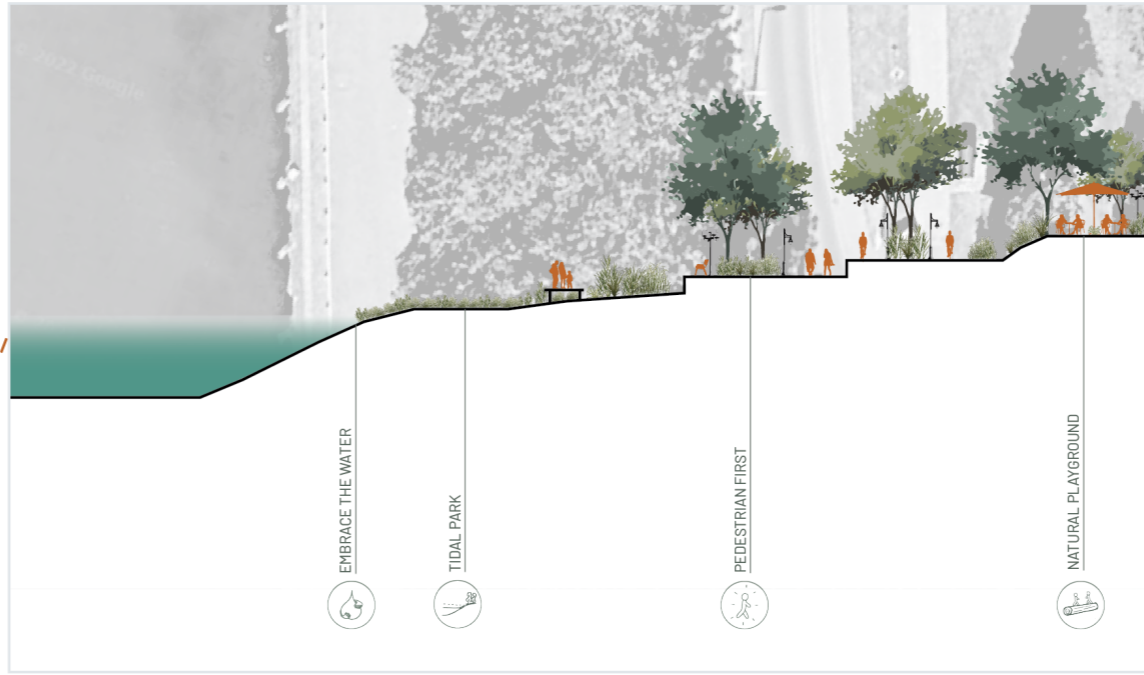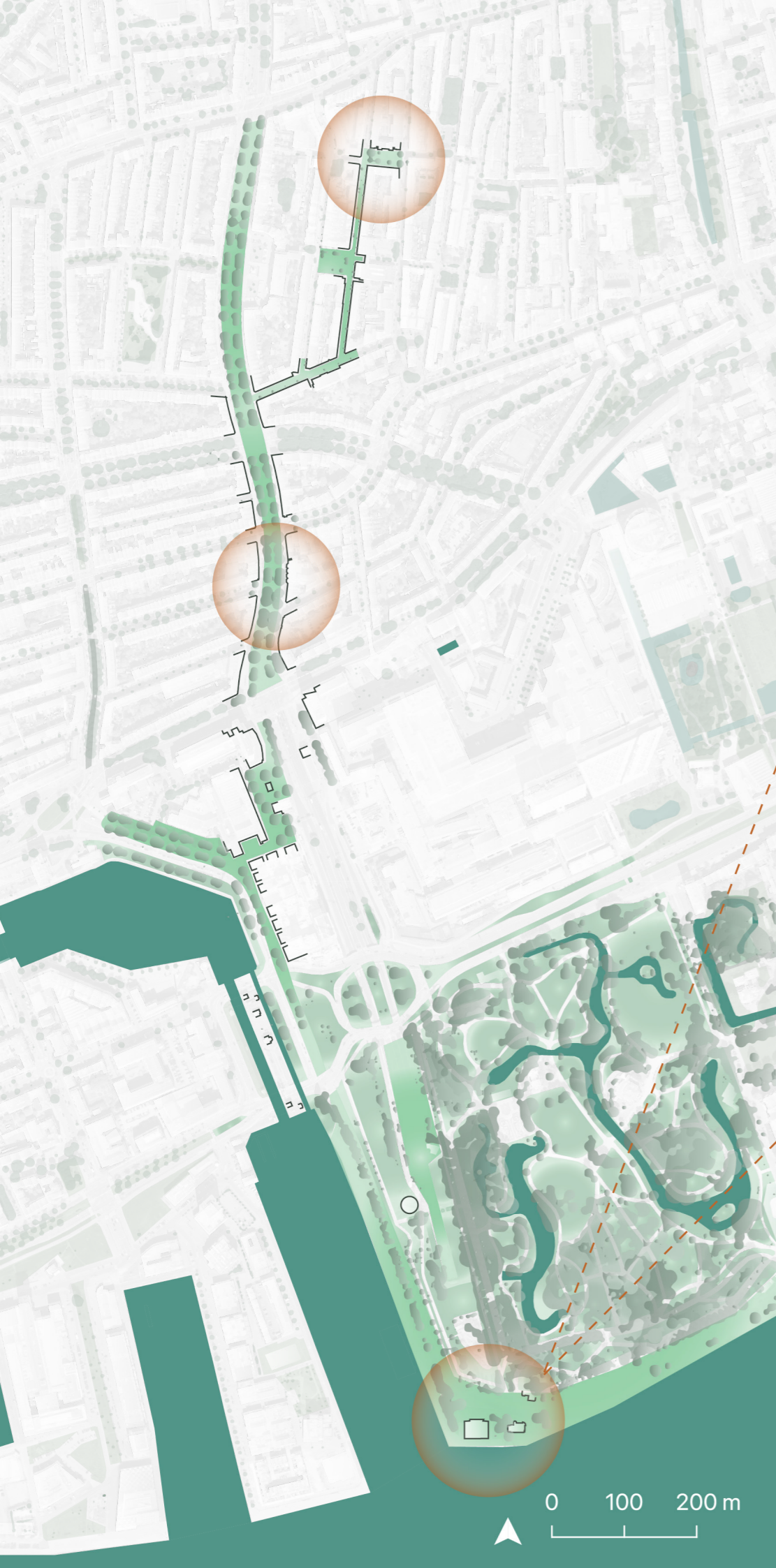
FIG. 7.74 Section tidal park

Tidal Park

A larger scale green environment such as a park, that is part of a recreational route, functions more as a destination rather than every day environment. This type of intervention contributes to all three perspectives of the city as part of nature, by bringing back the natural tides of the river.

The tidal park requires more open space compared to the street and boulevard. However, in this situation, implementation is very feasible and requires less effort than the 's Gravendijkwal.

FIG. 7.76 Strategic Project

FIG. 7.75 Impression tidal park
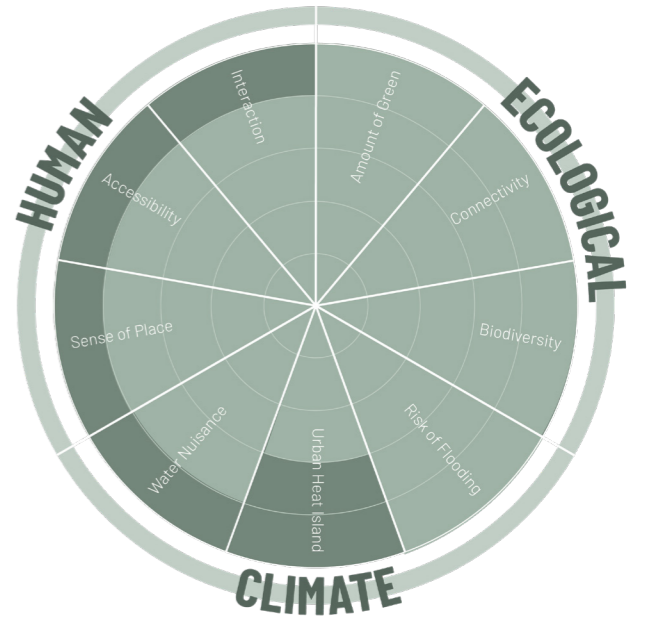
FIG. 7.77 Assessment tidal park

0   100   200 m

ROOFTOP HABITAT
grass

LINEAR PARK HABITAT
grass - forest

URBAN PARK HABITAT
grass - forest - water

RIPARIAN HABITAT
forest - water

RIVER HABITAT
water

0   100   200 m
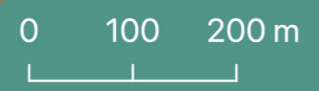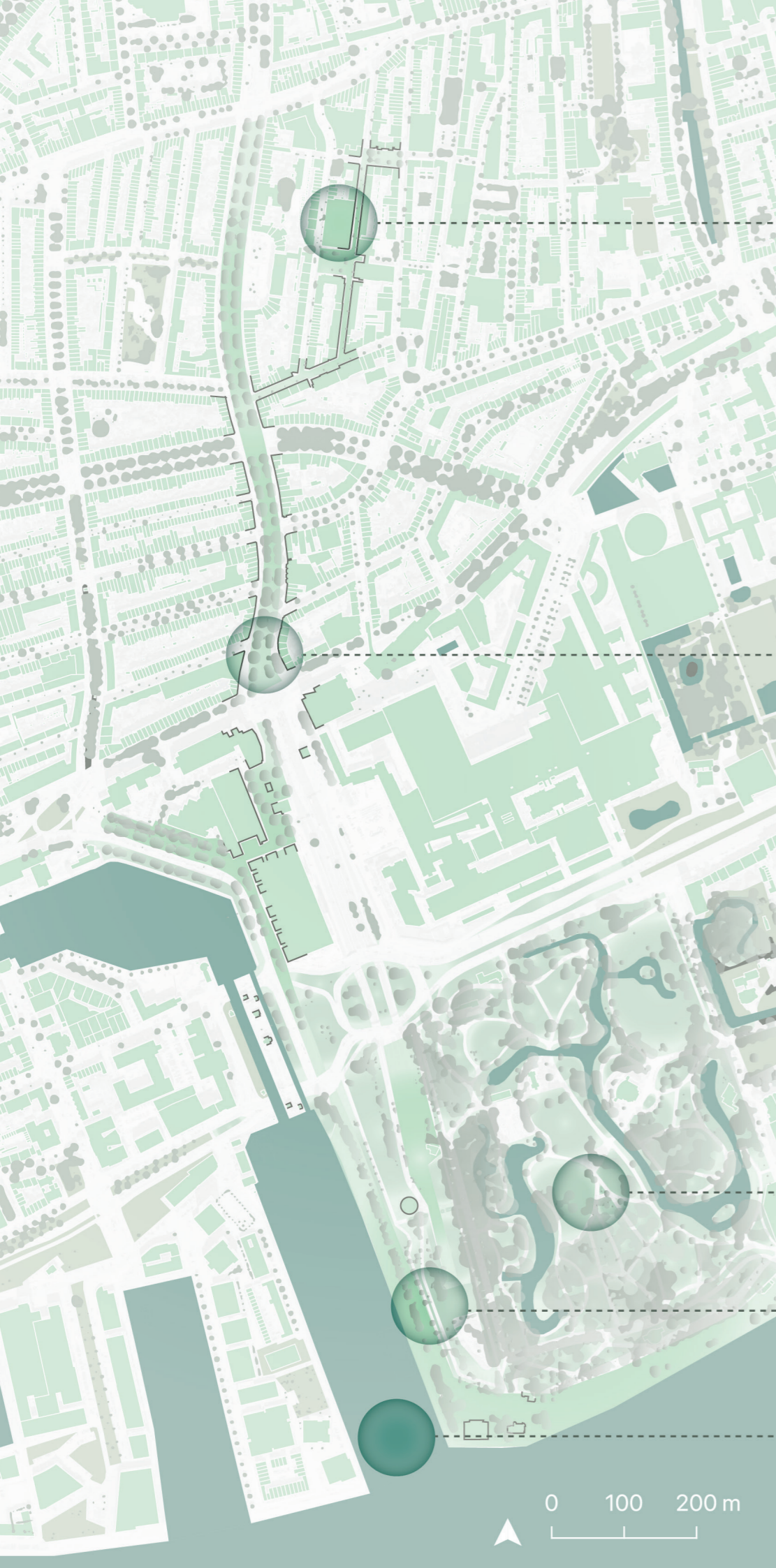
Ecological value
By transforming the urban environment, multiple habitats occur providing convenient circumstances for different flora and fauna. This gradient of habitats varies from dry to wet circumstances, increasing the urban biodiversity.

Rooftop Habitat
The highest located habitat is also the driest one. Rooftop habitats consisting of wild vegetation form an attractive environment for the Red Mason Bee.

Linear Park Habitat
As the former traffic barrier is transformed into a nature inclusive environment, there is little danger from car mobility, making it convenient for the European Hedgehog. Also population of the Serotine Bat could get a boost, as there are a lot of places to settle.

Urban Park Habitat
Within the habitat of the urban park, all the different circumstances can be found. The Song Thrust prefers high trees and low dense vegetation, which both occur in the urban park. This is also an ideal environment for the large tree: Sweet Cherry.

Riparian Habitat
The riparian park habitat consists of a tidal park that partly overflows in cases of high river water level, creating a soft transition from water to land. With some stones and herbs, this is a nice environment for the Saxifrage Fern and the Small Copper.

River Habitat
The final and wettest habitat is located in the waterways. As the quays of the river Maas and Schie are soft with a lot of vegetation, this is a convenient environment for the Pike to settle.
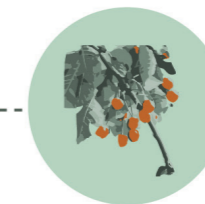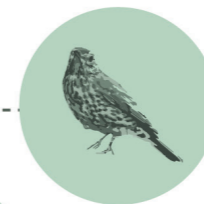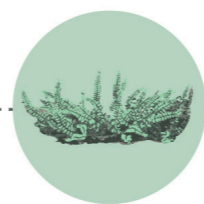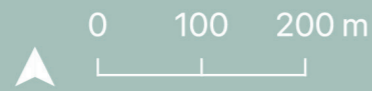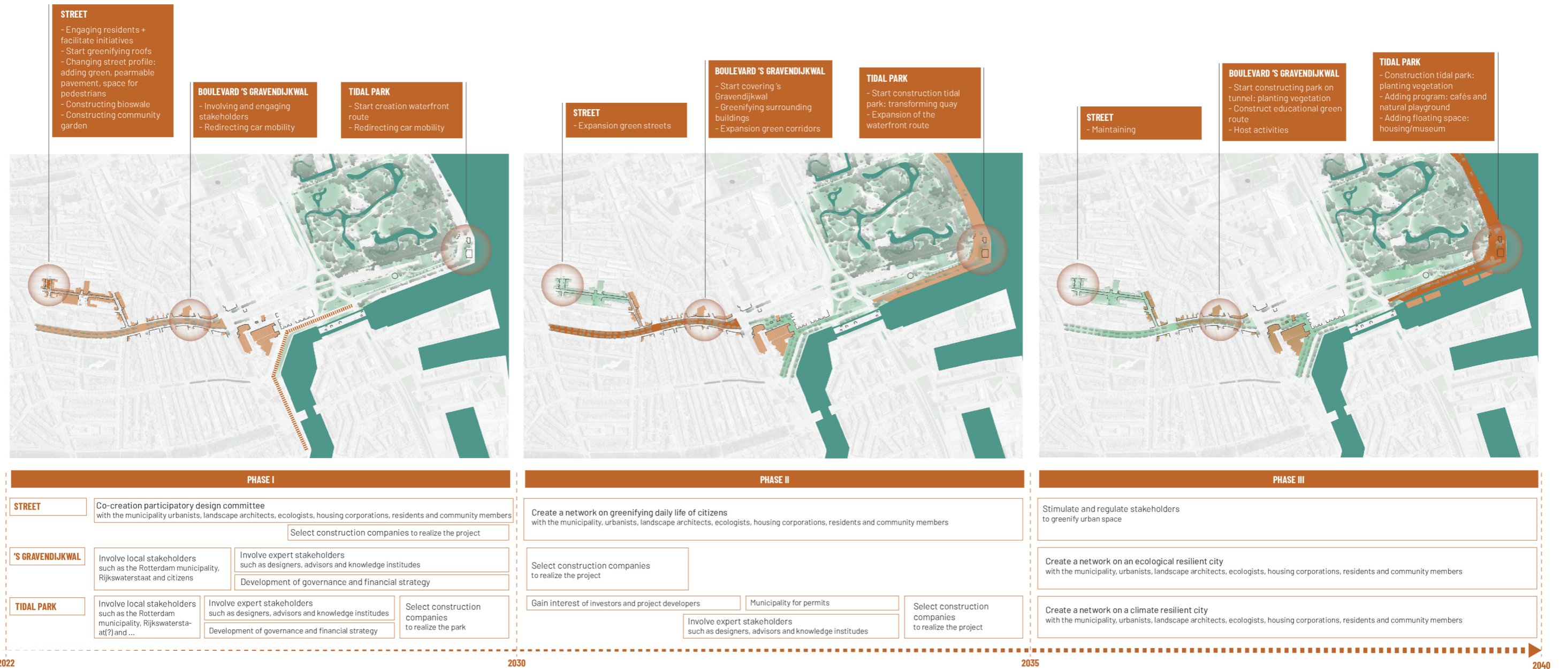
STREET
- Engaging residents + facilitate initiatives
- Start greenifying roofs
- Changing street profile: adding green, pearmable pavement, space for pedestrians
- Constructing bioswale
- Constructing community garden

BOULEVARD 'S GRAVENDIJKWAL
- Involving and engaging stakeholders
- Redirecting car mobility

TIDAL PARK
- Start creation waterfront route
- Redirecting car mobility

STREET
- Expansion green streets

BOULEVARD 'S GRAVENDIJKWAL
- Start covering 's Gravendijkwal
- Greenifying surrounding buildings
- Expansion green corridors

TIDAL PARK
- Start construction tidal park: transforming quay
- Expansion of the waterfront route

STREET
- Maintaining

BOULEVARD 'S GRAVENDIJKWAL
- Start constructing park on tunnel: planting vegetation
- Construct educational green route
- Host activities

TIDAL PARK
- Construction tidal park: planting vegetation
- Adding program: cafés and natural playground
- Adding floating space: housing/museum

PHASE I		
STREET	Co-creation participatory design committee with the municipality urbanists, landscape architects, ecologists, housing corporations, residents and community members	
		Select construction companies to realize the project
'S GRAVENDIJKWAL	Involve local stakeholders such as the Rotterdam municipality, Rijkswaterstaat and citizens	Involve expert stakeholders such as designers, advisors and knowledge institudes
		Development of governance and financial strategy
TIDAL PARK	Involve local stakeholders such as the Rotterdam municipality, Rijkswaterstaat(?) and ...	Involve expert stakeholders such as designers, advisors and knowledge institudes
		Development of governance and financial strategy

Select construction companies to realize the park

PHASE II		
Create a network on greenifying daily life of citizens with the municipality, urbanists, landscape architects, ecologists, housing corporations, residents and community members		
Select construction companies to realize the project		
Gain interest of investors and project developers	Municipality for permits	Select construction companies to realize the project
	Involve expert stakeholders such as designers, advisors and knowledge institudes	

PHASE III		
Stimulate and regulate stakeholders to greenify urban space		
Create a network on an ecological resilient city with the municipality, urbanists, landscape architects, ecologists, housing corporations, residents and community members		
Create a network on a climate resilient city with the municipality, urbanists, landscape architects, ecologists, housing corporations, residents and community members		

2022   2030   2035   2040

FIG. 7.78 Complete phasing

7.3 PHASING

Transforming the city does not happen over night. This requires some time and effort. This section will take a look at the phasing of the project. A distinction is made between the phasing of the complete route from front door to tidal park and the quick wins that can be achieved within the first few years.

Complete Phasing

Figure 7.78 shows the specific interventions of Frontdoor to Park and the order in which the steps will be taken. It shows how the area transforms over time into a nature inclusive environment through three scales and how the stakeholders are engaged during the process. For an overview of the involved stakeholders see figure 7.79. In order to transform the whole area into a nature inclusive one, a timespan of 30 years is proposed.

First, the interventions on street scale can be implemented quite easily and can be considered as quick wins. Within the first phase most of the transformation can be done on this scale by facilitating a co-creation design committee. Using a participatory approach could stimulate the sustainability and maintenance of the

LEGEND
- Public stakeholders
- Private stakeholders
- Civil stakeholders

FIG. 7.79 Stakeholders Frontdoor to Park

High interest

FLORA & FAUNA   MUNICIPALITY

CITIZENS

Subject   STAATSBOSBEHEER   Players

VISITORS   MRDH

RIJKSWATERSTAAT   PROJECT DEVELOPERS

Low Power   HOUSING CORPORATIONS   PROVINCE   High Power

CONSTRUCTION COMPANIES

PORT OF ROTTERDAM

INVESTORS

KNOWLEDGE INSTITUDES

Crowd   Context Setters

URBANISTS

LANDSCAPE ARCHITECTS

Low interest

measures as a feeling of joined ownership is created (Waterschap Schieland en Krimpenerwaard, 2020).

Second, the development of the boulevard 's Gravendijkwal, requires a relative long process of negotiations with local authorities before the implementation can be started in phase 2.

Third, the creation of a tidal park along the river edges is the largest scale transformation. However, this does not require the amount of negotiations as the boulevard as the impact for the surroundings is not as large. Therfore, the implementation can be started sooner.

First steps

In order to achieve the implementation of the complete proposal, quite some time is required. However, as mentioned in the previous section, on street scale a lot can be achieved within the first phase. Figure 7.80 shows which quick wins can be achieved within the first three years. On street scale, all the interventions can be implemented, transforming the entire street scape in to a nature inclusive one.

In short, even if the larger interventions such as covering the 's Gravendijkwal can not be realized, or takes some time in order to be implemented, the daily environment of the residents can be transformed towards a part of nature by making relatively small alterations to the open space.

YEAR 0
Current situation

YEAR 1

A Flipping tiles
B Start greening the rooftops

YEAR 2

Planting vegetation on the rooftops
C Changing street profile
D Transforming playground

YEAR 3

Construction bioswale
E Planting community garden

FACADE GARDENS GREEN ROOFS

PAERMABLE PAVEMENT PEDESTRIAN FIRST

BIOSWALE COMMUNITY GARDEN
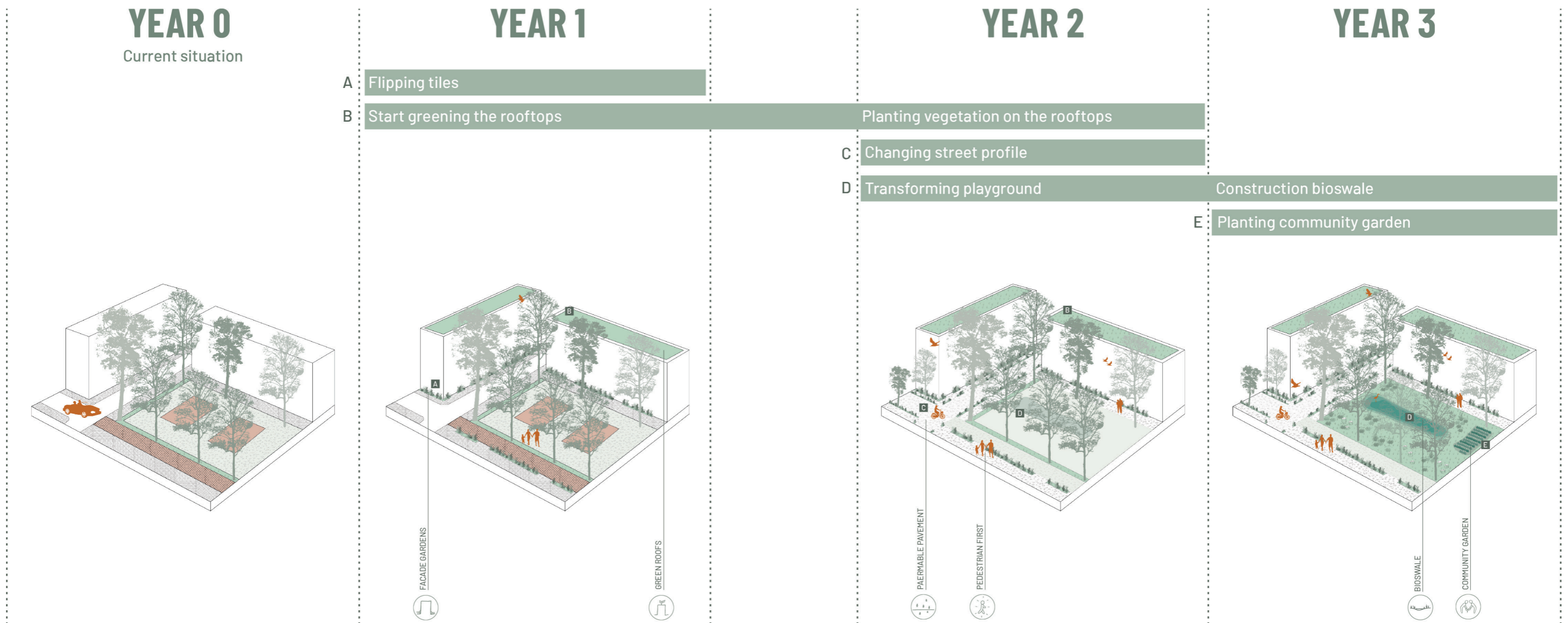
FIG. 7.80 Phasing first 3 years

7.4 EXPANSION

District Scale

The strategic project presented in sections 7.2 and 7.3 is an example route of how the urban environment transforms from the front door of a home, to large green area. The route consists of three typologies: the street, boulevard and park, see figure 7.81a. Each of these typologies nature in implemented within the urban environment using different patterns. From this location, multiple routes can be walked, while experiencing the same typologies, see figure 7.81b.

Not only from this point, a city that is part of nature can be experienced. Throughout the whole urban centre of Rotterdam, similar routes can be walked, consisting of the same three typologies, see figure 7.81c The starting points have been taken based upon the following criteria: distance to a park, liveability and amount of green in the environment. The locations that score low on the extend to which they are part of nature are taken as an example, see figure 7.82. This shows that no matter where in the urban centre one works or lives, every citizen has access to nature on different levels. Besides this, the larger green spaces can be accessed within a 10 minute walk from all the locations. By implementing this strategy, a whole network of routes is developed, shown in figure 7.81d, consisting of the three main typologies. In this way, Rotterdam could strategically be developed into a nature inclusive city.

Further away from a park
Stoney environment & further away from a park

Stoney environment

Further away from a park

Stoney environment

Further away from a park

Further away from a park & low liveability score
Low liveability score

FIG. 7.82 Criteria locations

A One highlighted route

B Multiple route from same starting point
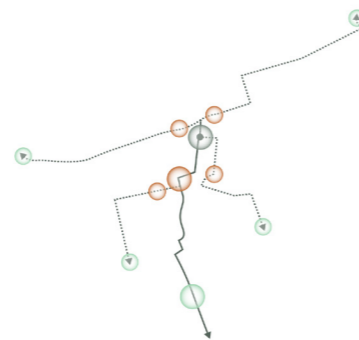
C Multiple routes from multiple starting points

D Network of routes

LEGEND

○ Street
○ Boulevard
○ Park
↙ Route
╱ Street
╱ Boulevard
◢ Park

FIG. 7.81 Expanding

FIG. 7.83 City Structures

0 1 2 km

City Scale

Developing a strong green/blue network in an urban environment could be done in multiple ways. One of those is to create natural 'fingers', going inwards the city. Anther option is to create 'rings' of green within the city, expanding towards the urban fringes. Both of these structures occur in the city of Rotterdam, see figure 7.84. However, they do not form an integral system as the systems differ on both sides of the river Meuse. The northern structures consist of two peat rivers going inwards the city, while the southern structure is formed by east west green structures. In the preferred situation, the ring structure expands on the north side, while the natural fingers go in to city on the southern side.

As also explained in the previous chapters, this would result in adding east-west connections in Rotterdam north, and north-south connections in Rotterdam south. During this project, a study has been done on the missing links in the urban centre, see number 1 in figure 7.83, for which a strategy has been developed connecting the urban centre of Rotterdam with the natural systems, both in and outside the city boundaries. In order to develop the complete preferred ecological structure, multiple additional connections will have to be developed, leading to new projects. For project number 2, a first attempt has been made to develop the missing ecological connection between the new and old river Meuse, which focusses on breaking down the ecological and physical barriers.

FIG. 7.84 Concept Natural Structure

Rotterdam South   *Rotterdam North*   *Rotterdam Vision*

Regional Scale

By implementing the concept of the city as part of nature on multiple scales results in a strong ecological network. In the Metropolitan Region Rotterdam The Hague there is the opportunity to expand the ecological structures. Starting from greening within the urban cores, these could be connected through the existing water structure.

On this scale, there is the opportunity to expand the current pattern language in order to make it comprehensive. This might include patterns such as regional routes, metropolitan park and transitional territories.

Rotterdam   *Including the whole region of Rotterdam*

FIG. 7.85 Regional Structures

8 CONCLUDING & REFLECTING

The final phase will be used to conclude and discuss the findings of the graduation research and reflect on it and its process. The predetermined research aims will be revised to check whether or not these have been achieved.

8.1 CONCLUSION & DISCUSSION

Currently there is the urge to deal with the (arising) effects of climate change, as well as the consequences of urbanizations. The city of Rotterdam has lost its connection with nature as the city expanded over the years. As a result, the ecological values of the city environments are low, as well as the awareness among citizens on the values and importance of nature. This graduation research was conducted with the key objective to create an evidence informed design strategy for (a certain location within) Rotterdam in which this city is part of nature. The aim was to formulate an answer on the following question:

"How could the citizens of Rotterdam be reconnected to nature, while improving the urban ecosystems, creating a resilient city?"

Three key topics were identified to address the whole scope of a nature inclusive city. Each of the three topics consists of a few criteria that contribute to the research aim.

Ecological Perspective
First, the ecological perspective focusses on the natural systems of the landscape, considering sub-questions 1a, 2a and 3a. In Rotterdam, the amount of green and ecological connectivity was a point of improvement. Creating ecological connectivity and amount of open green space using diverse vegetation helps to increase biodiversity and strengthen the urban ecosystems. Opportunities lie within the city to use urban components to achieve this.

Human Perspective
Secondly, the human perspective consists of creating a connection, both physically and mentally, with nature in order to make it a part of daily urban life, considering sub-questions 1b, 2b and 3b. This includes integrating green in the urban environments and making it accessible for all residents. By adding program and routes to the (added) qualitative public green space the connection with nature could be improved leading to an increased quality of life.

Climate Perspective
Thirdly, the climate perspective focusses on tackling issues such as water nuisance, Urban Heat Island effect and risk of flooding, to develop a climate resilient city considering sub-questions 1c, 2c and 3c. Making the city part of nature and emphasizing on the natural landscape structure helps dealing with these issues as the natural landscape is able to adapt to changing circumstances. Besides this, artificial interventions such as water squares support the climate resilience.

Using a case studies, in the city centre, research is done on possible interventions to create this nature inclusive city. All three perspectives are strongly integrated with each other in the design typologies (patterns) which are explained in the pattern atlas and tested on the site. This has resulted in a strategy that shows how, considering the urban ecology, human connection and climate resilience, the quality of life for all living things in Rotterdam could be improved through the scales. However, only one test site was used to develop the strategy. In order to develop the complete storyline for the city an refine the strategy, other areas with different conditions should be tested as well.

During this research, Rotterdam was studied carefully. However, the strategy is applicable to other (Dutch) cities as well, due to the developed pattern atlas. The

ECOLOGICAL

1a What makes good ecological performance of urban ecosystems?

2a What is the current state of the Rotterdam ecosystems?

3a How could the ecological performance of the Rotterdam ecosystems be improved?

HUMAN

1b What makes people feel connected to nature?

2b How well are the citizens of Rotterdam connected to nature right now?

3b How could awareness on the values of nature be created among the citizens of Rotterdam?

CLIMATE

1c What makes a climate resilient city?

2c How climate resilient is the city of Rotterdam?

3c How could the climate resilience of Rotterdam be improved?

FIG. 8.86 Research Questions

patterns created for the city as part of nature are not location specific, making the research in combination with the pattern language transferable to other locations that are dealing with the same challenges.

Recommendations
In order to upgrade the study and strengthen the strategy, further research should be done on the following topics. First of all, as mentioned in section 7.4, the site of the urban centre is only one aspect of the whole ecological structure. Multiple sites and connections should be studied and established to develop the ideal green network in Rotterdam. Second of all, this strategy is an outcome of theoretical and spatial research. However, the political and economical feasibility of the project is not looked into in detail. A feasibility study on these aspects is necessary to make the strategy ready for implementation. Third of all, the values for the ecosystems is based upon an estimation. This could be studied in more detail and further expanded with indications of the species that would be able to settle in certain areas, and the types of vegetation that would be growing there.

8.2 REFLECTION

Relationship between research methodology and studio approach
This graduation research started with the motivation to address the lack of a connection with nature within a city as well as the urge to deal with the consequences of climate change. As part of the Urban Ecology and Ecocities lab, which is a cross domain lab between Urbanism and Landscape Architecture, exploration has been done on how to develop Rotterdam as a city that is part of nature. Within the Urbanism masters track, a landscape architecture perspective has not necessarily been very prominent, but I learned that approaching the assignment from this perspective could result in a future proof result. As Gülgün et al. (2014) explain, it is necessary to consider all aspects of ecological planning

in order to reach a sustainable city concept. However, this does not entail that the society needs should be neglected. "Indeed, landscape planning activities should not only take the physical facts of an area as their starting point, but also deal with the social situation of the people whom the planning affects"(Frieder, 2000). Especially in this graduation project, where the dynamics between the urban and natural systems are central, this approach is very valuable. Besides this, today's spatial challenges are very much related to the natural systems, which makes it even more relevant.

During the first phase of the graduation year, a group analysis of the Dutch landscape has been conducted with the graduation lab. New methods and research approaches such as the layer and lenses approach were introduced. Especially the method of approaching the landscape through different layers, the natural, cultural and urban layer, helped me to understand the systems and morphology of the national landscape. However, during my individual research I did not implement this method which, looking back at the project, is a loss. This could have increased the understanding of the natural systems and therefore strengthened the outcome. This is something I intend to improve during future projects.

Relationship between graduation topic, graduation lab and master track
Current challenges such as climate change and urbanization have consequences for the spatial configuration of urban environments. Finding integrated solutions for the built environment in a multi-disciplinary way is the main objective of the Master Architecture, Urbanism and Building Sciences (Delft University of Technology, n.d.) and conducting urban research and design for this graduation project is in line with the end terms for the master track Urbanism (Aalbers et al., 2021). The main objective of the research, to create a climate resilient city with improved urban ecosystems and a connection between residents and nature, touches upon the spatial challenges and is in line with the objective of the lab: to improve the environmental performance and quality of life from an urban ecology perspective (Aalbers et al., 2021).

Relationship between research and design
The project approach was developed well in an early stage of the project and consisted of different phases. However, the pitfall was to follow these phases in a linear way as a result to avoid dealing with the complexity of the process. The pattern language method was helpful in switching between doing research and design, in order to deal with the complexity (Rooij & Van Dorst, 2020). It has taught me a new way of linking research to design, while structuring my thoughts and ideas and therefore formed "a building block of knowledge which can work as a framework" (Hendriquez et al., 2013).

On the one side, coming up with new patterns was something which I enjoyed and it motivated me to further develop the project. On the other side, it made be enthusiastic of more topic than I was able to address. During the process of this research, a struggle was to define and delineate the project and its outcomes well, as I have experienced that there are many aspects I find important to address. In previous design projects, the project boundaries were set clearly whilst this project was limitless (up to a certain extend). Having realised the importance of clearly defining the project, I can now understand that addressing all the issues is not possible. As a result of this experience, I am aware of this pitfall and in future situations, I will be able to recognize this, and I will have to respond on this by making decisions on what to address and what not to. Even though developing patterns contributed to this struggle, it could also be used to deal with this. Creating a pattern field and understanding the relationships between the developed patterns could help making decisions on the specific target of the project. And without designing

for specific topics, these could be touched upon by referring to patterns. Within future projects, this method is one that I will apply and get more familiar with. Besides that, the already developed patterns can be reached out to as well. This avoids doing the same research multiple times.

Ethical reflections
The aim of the project was to add a positive environmental and social impact on society, by considering nature on an equal level as humans. This might not be interpreted in the right way, and some people might not understand or agree with this objective and the resulting spatial interventions. However, considering the natural environment as a stakeholder makes sense, as it affects or is affected by all organizations using stakeholders (Starik, 1995). Besides this, it is important to consider all stakeholders involved, also the ones without any voice or power, as explained as advocacy planning (Davidoff,1965). In order to gain support amongst all stakeholders, it is important to clarify the motivation for such idea of a nature inclusive city and facilitate a participative approach.

Transferability
As part of the Urban Ecology and Ecocities lab the process started with a group analysis on the landscape of The Netherlands in relation to the properties of Staatsbosbeheer and proposing spatial developments to achieve the ambitions of the Green Metropolis (Urban Ecology & Ecocities et al., 2022). Reflecting upon the outcome of this research, we can state that it is consistent with the main goal of connecting every Dutch resident to nature. Besides this, the issues being addressed are relevant for other areas of The Netherlands as well and the research is conducted through different scales. The case study shows how the objective of a city as part of nature could be implemented in Rotterdam and herewith function as an inspiration for other Dutch cities.

The pattern atlas ensures that the outcomes can be transferable to other cases as it focusses on the city as part of nature and everything that falls under this concept. The design typologies suggest a spatial solution to a problem and can be applied in different ways and projects. Besides this, new patterns could be developed to further expand the pattern language in order to make in even more comprehensive and transferable. A distinction could be made in patterns that could transcalar be applied, whilst others are scale specific. The current pattern language focusses mainly on transcalar patterns with a few concrete scale suggestions, and could therefore be supplemented with local scale patterns, as well as regional scale patterns.

Relationship between graduation thesis and city plans Rotterdam
Rotterdam is a city of change and the municipality is making plans to keep on developing. Currently, there are multiple plans and policy documents that describe the sustainable development of the city, including the values and importance of green and biodiversity. The municipality is already focussing on greening the city and acknowledges the contribution of nature to the quality of life. It is positive to read all the plans for the different projects that focus on adding green to the urban environment. In that way, this research is very much in line with the ambitions of the city. However, what is missing in the current plans and policy is the integral approach from the landscape perspective and considering the natural systems in an equal way as the urban systems. The different perspectives do feature within this research, and therefore it could be of value to the municipality.

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