Reconnect Green and Blue Highways of Nature Flows

A new urban landscape for renewable energy systems and biodiversity in Rotterdam

Master Graduation Thesis 2020-2021
P5 Report

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Delft, The Netherlands 2020

I would like to thank my tutors Nico and Arjan, for their guidance, encouragement, and support during the project. They always support me with constructive feedback and patience. I couldn't have done it if it weren't for their help.
Thank you to my priceless family for standing next to me in this journey, especially my sister, who supported and trusted me when I was weak. Thanks to Niek for all the advice regarding my project and my future. Also, I would like to thank my beautiful friend Stanislaus who has been my strength since 2019. Thank you to Bogum, Francesca, and Suxin for inspiring me every time!

https://www.portofrotterdam.com/nl/nieuws-en-persberichten/windpark-landtong-rozenburg

Contents

Abstract

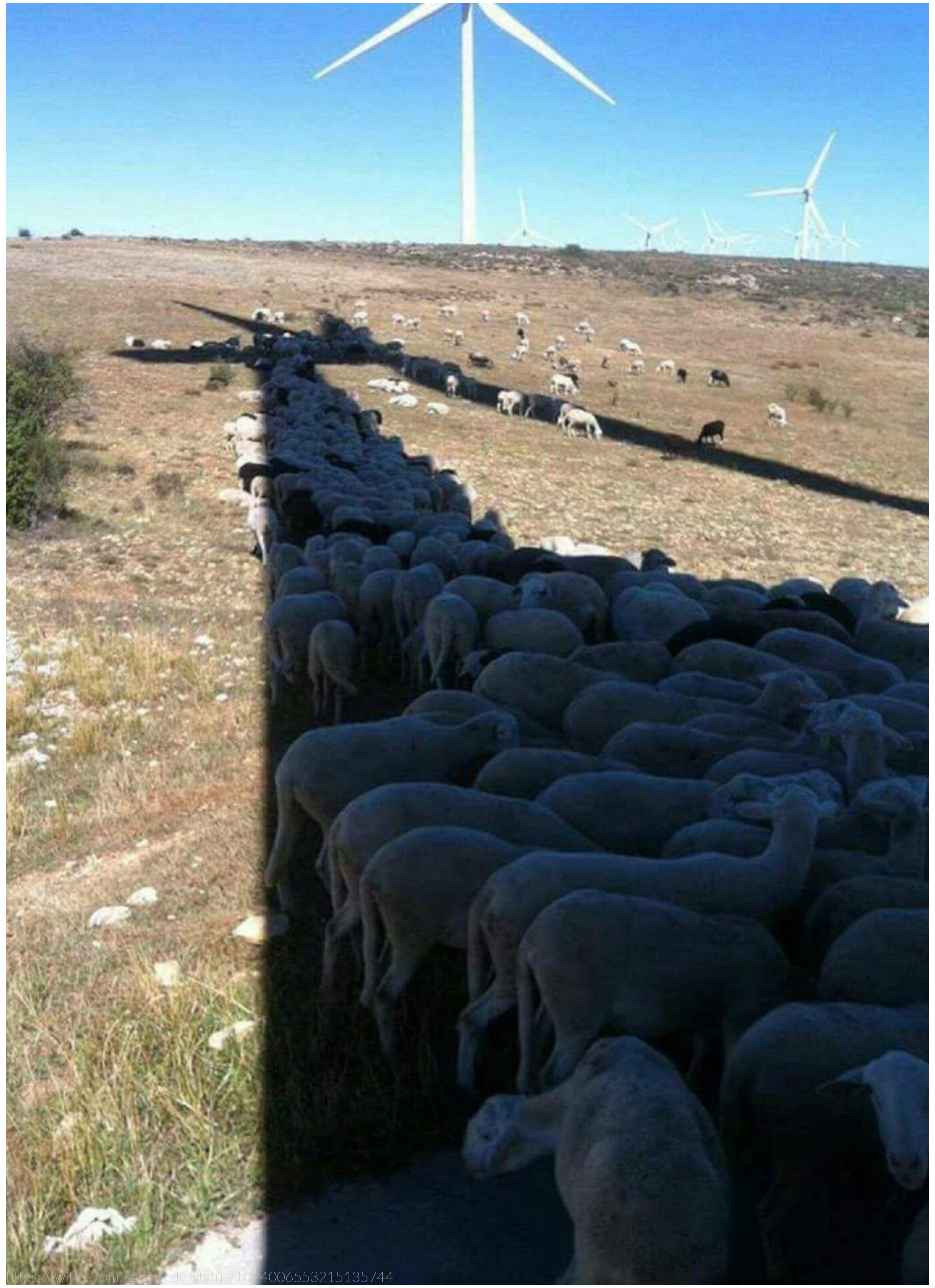
Renewable energy is beneficial to human life. According to the International Renewable Energy Agency, renewable energy provides not only environmental benefits but also societal advantages, namely lower carbon emissions/ reducing air pollution and employment. However, these systems require a substantial scale of infrastructures which take up large areas of land. In addition, developing such infrastructures can cause biodiversity loss and ecosystem change such as habitat loss/ change, pollution, overexploitation, climate change and introduction of invasive species (Gasparatos et al., 2017). The negative effects of the energy infrastructures can be triggered by almost every renewable energy pathway. Hence, we need to consider the true 'sustainable' ways of the renewable energy landscape.

Rotterdam aims to be a carbon-neutral city by reducing 95% of CO2 emissions, and therefore the city introduces various renewable energy systems. In particular, Waalhaven has been a hotspot of many industries regarding renewable energy systems due to its geographical and industrial values. Waalhaven is in a transitional stage of actively altering energy production ways to make the system more sustainable. However, the port area has eight endangered species which are registered in the red list of The International Union for Conservation of Nature. In this regard, one may note that Waalhaven's plant could produce threats to the current ecosystem.

Based on the above findings, this thesis suggests a spatial framework for a renewable energy landscape that can (1) strengthen the ecosystem, (2) bring robust biodiversity, and (3) provide sustainable energy production methods through utilising local resources. Other cities sharing similar environmental conditions and societal issues may also consider adopting this framework to resolve the problems. The final outcomes and goals present a vision for improving the environment and energy circularity in Waalhaven. The project describes a series of spatial interventions and detailed methods for integrating biodiversity and energy infrastructure and further introduces a scenario to build resilient planning for both human/non-human stakeholders.

An unexpected meeting with a ladybug at Waalhaven

We all know renewable energy system is beneficial to human life. It provides power generation without greenhouse gas and enhances fuel diversification and lower risk of a fuel spill. However, in terms of biodiversity, what will it look like? Can we honestly say renewable energy improves ecosystem?



INTRODUCTION

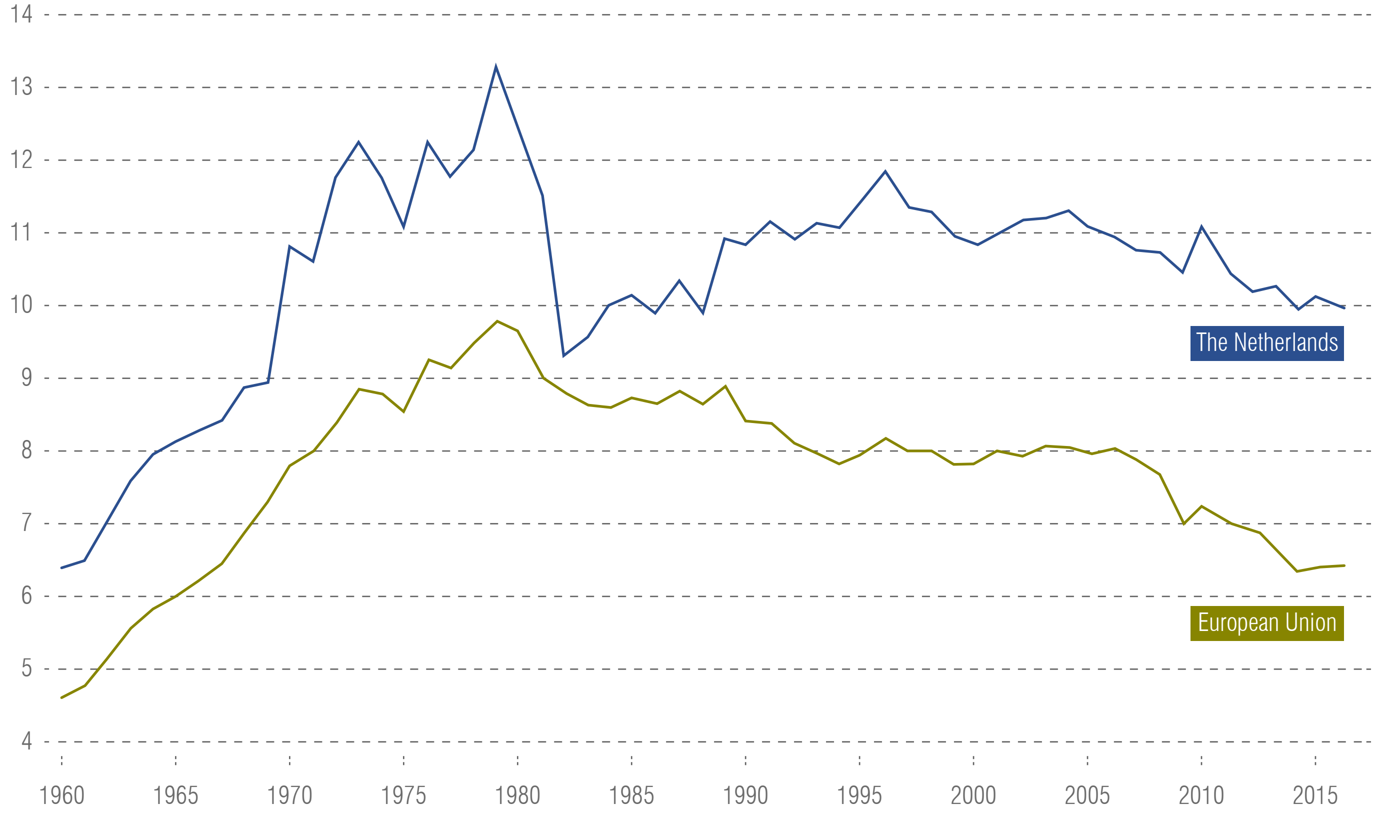
Problem Field
Problem Statement
Research Question
Research Objective

Global Warming & the Netherlands

As global warming has come up as a big challenge for the world, many countries try to reduce greenhouse gas (GHG). The main factor of GHG is carbon dioxide (CO_2) which is responsible for 64% of anthropocentric activities: heat, electricity, and transportation. Its concentration is 40% higher than the pre-industrialisation period.

According to the Intergovernmental Panel on Climate Change (IPCC), the global sea level is rising, reaching 1.2m in 2100 (IPCC, 2014). If the earth's temperature reaches 2C°, 70% of coastlines foresee sea level rise higher than 0.2 meters (Watts, 2020). Since 1/3 of the Netherlands lies below sea level, results of global warming such as flooding, erosion, salinisation of drinking water are very critical on humans and ecological systems. Under the Paris Climate Agreement, the EU aims to reduce global warming, preferably 1.5C° to a maximum of 2C°. Since the Netherlands signed the agreement, the Dutch government aims to lessen 49% of GHG by 2030 and 95% by 2050 (Gementee Rotterdam, 2019)

Figure. 1
CO2 emissions of the Netherlands and European Union
(metric tons per capita).
(Modified by author)



CO2 emissions in Rotterdam

CO_2 emissions from the Netherlands in 2016 were 163, 419, 285 metric tons (MT), 9.62 MT per capita and its' ranking was the third-highest among European countries. 17% of CO_2 emissions in the Netherlands are from Rotterdam, and most of them (33.1 MT in 2017) produced by port industries. The most significant part is from coal-fired plants (10.7 MT), and the second largest is oil refineries (8.5 MT) (Port of Rotterdam, 2018).

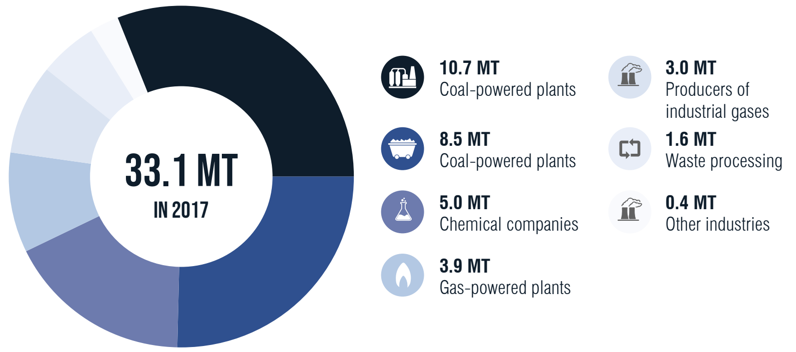
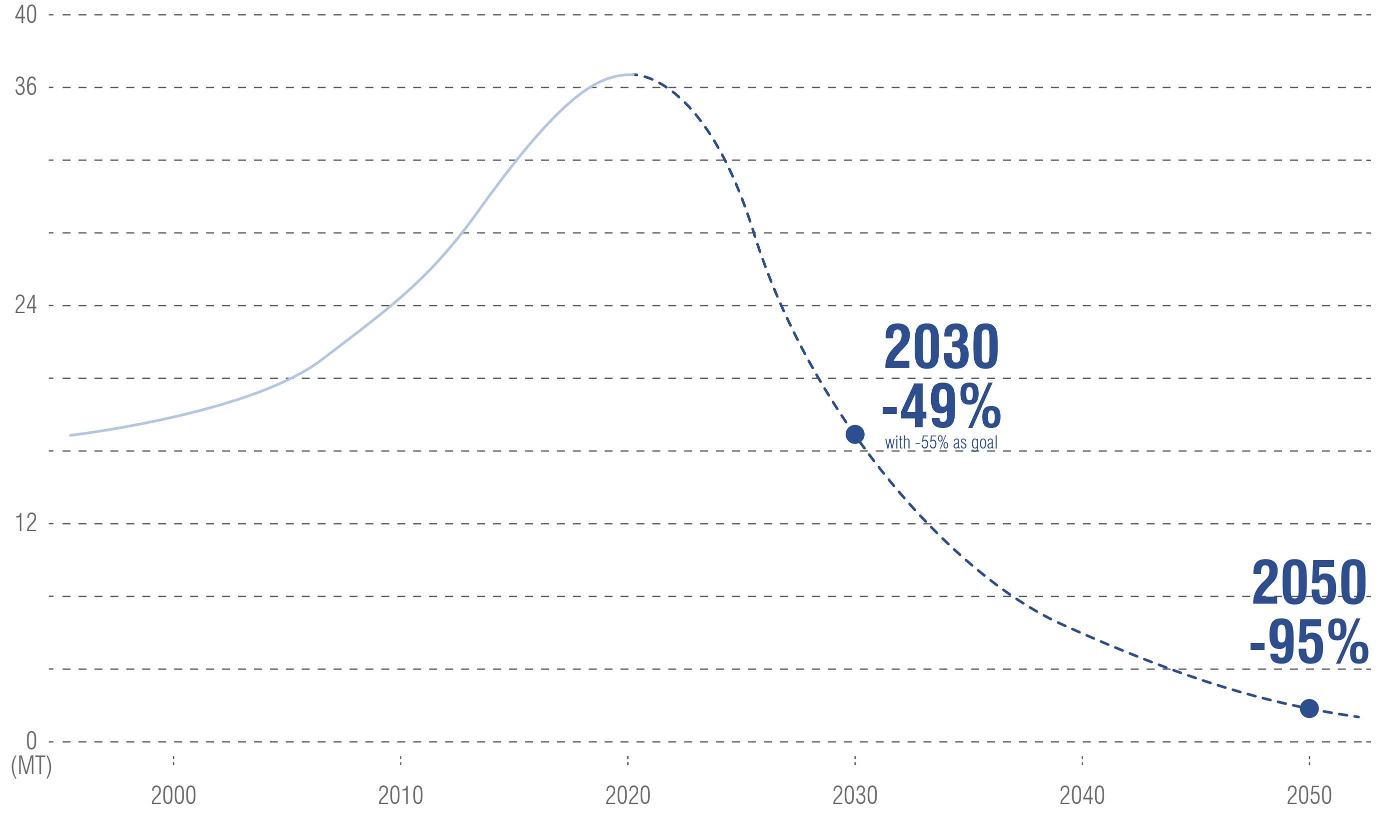


Figure. 2
CO2 emissions by industry based in the port.
Figures for Rotterdam/ Moerdijk combination
(Modified by author)

Figure. 3
Rotterdam ambition: Energy transition leader
(Modified by author)



Renewable Energy for a Carbon-neutral City

Below, the map shows SE infrastructures in Rotterdam. Since the municipality manages the 'Park the Sun' project in the city ports, solar panels occupy the majority of Rotterdam north and south. These places are residential areas or are very close. Waalhaven and Eemhaven, which are moderately close to residential areas, are running solar energy and biomass energy systems. On the other hand, newly built ports such as Maasvlakte or Europort have wind turbines and biomass, which are considered large-scale infrastructures.

Figure. 4
SE infrastructures in Rotterdam
(Modified by author)

- Solar panels
- Wind turbines to be removed
- Wind turbines to be installed
- Existing wind turbines
- Industrial gas& water
- Biofuel, edible oil
- Oil products
- Gas power, coal, biomass

Figure. 5
Energy landscape around port industries
(taken from Google map street view)


A. Maasvlakte


B. Europoort


C. Botlek


D. Eemhaven


E. Waalhaven


F. Waalhaven

Surrounding Environment of Renewable Energy Infrastructures

Images show the current SE landscape in Rotterdam. Generally, every area has a slight green hierarchy, mainly lawn, which means fewer hiding spaces and habitats for animals. Maasvlakte, Europort, and Botlek have less accessibility, mostly covered with lawn without trees or shrubs. There are high human-made infrastructures like wind turbines and cranes, but they can be harmful to avian species. Heijplaat, Eemhaven, and Waalhaven have a slight green hierarchy, but they are located at the edge of the port. Except for the edge, most spaces are paved and are covered with concrete buildings or containers.

Disadvantage of RE Infrastructures

In the paper 'Renewable energy and biodiversity: Implications for transitioning to a Green Economy (Gasparatos et al., 2017)', the authors said 'the existing knowledge at the interface of renewable energy and biodiversity across the five drivers of ecosystem change and biodiversity loss of the Millennium Ecosystem Assessment (MA) framework (i.e. habitat loss/change, pollution, overexploitation, climate change and introduction of invasive species). It identifies the main impact mechanisms for different renewable energy pathways, including solar, wind, hydro, ocean, geothermal and bioenergy (Gasparatos et al., 2017).' According to the below table, almost every SE system can bring habitat loss and change in Rotterdam.

	Habitat loss/change	Pollution	Invasive-Alien Species	Over-exploitation	Climate change
Wind (Section 2.2)	✓	?*	X	X	X
Solar (Section 3.2)	✓	?	X	X	?
Hydro (Section 4.2)	✓	✓*	?	?	?
Biomass energy (Section 5.2.1)	✓	✓	✓	?	✓
Biofuels (Section 5.2.2)	✓	✓	?	?	✓
Ocean energy (Section 6.2)	✓	?*	X	X	X
Geothermal (Section 7.2)	✓	✓*	X	X	X

✓ – Strong evidence for the existence of a causal link.

X – Lack or minimal evidence for the existence of a causal link.

? – Theoretically possible causal link, but inconclusive or contextual evidence.

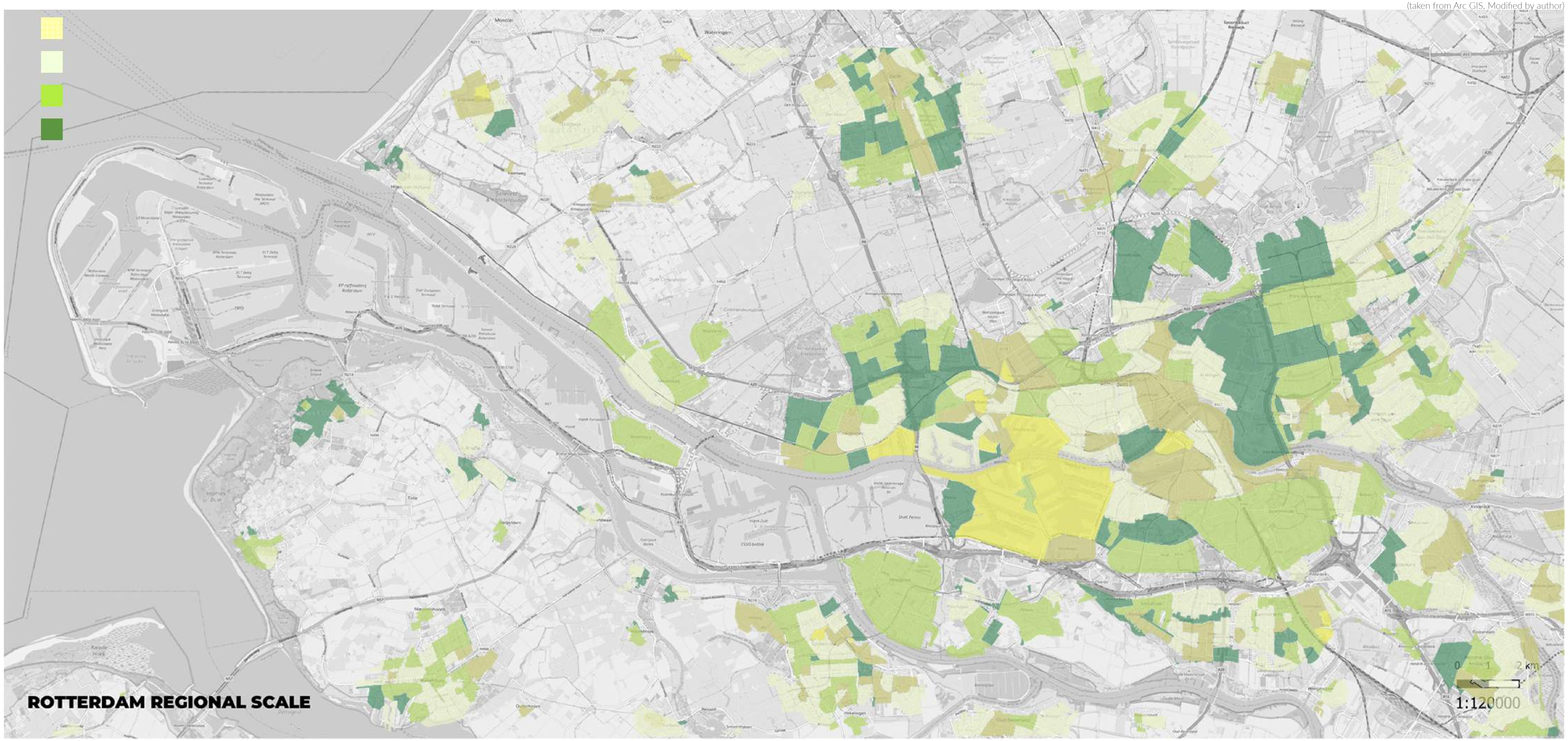
* – Includes non-chemical pollution such as sound, heat and light pollution.

Figure. 6
Drivers of biodiversity loss for different RE pathways
(Gasparatos et al., 2017)

Green Percentage of Rotterdam

Urban nature offers many functions; recreation, social interaction, community cohesion (Jennings & Bamkole,2019). Furthermore, public green spaces are psychologically helpful for people. Urban nature resolves social or personal problems and environmental issues such as water restoration, heat island effects, and pollutions regarding water, soil, and air (Willemsen& Tillie, 2018). However, below the map show, Rotterdam South has fewer green spaces compared to Rotterdam North. Especially, Waalhaven is surrounded by residential areas that do not possess enough nature. As mentioned above, urban nature is the essential element; fostering more green spaces is crucial.

Figure. 7
Green spaces per neighbourhood
(taken from Arc GIS. Modified by author)

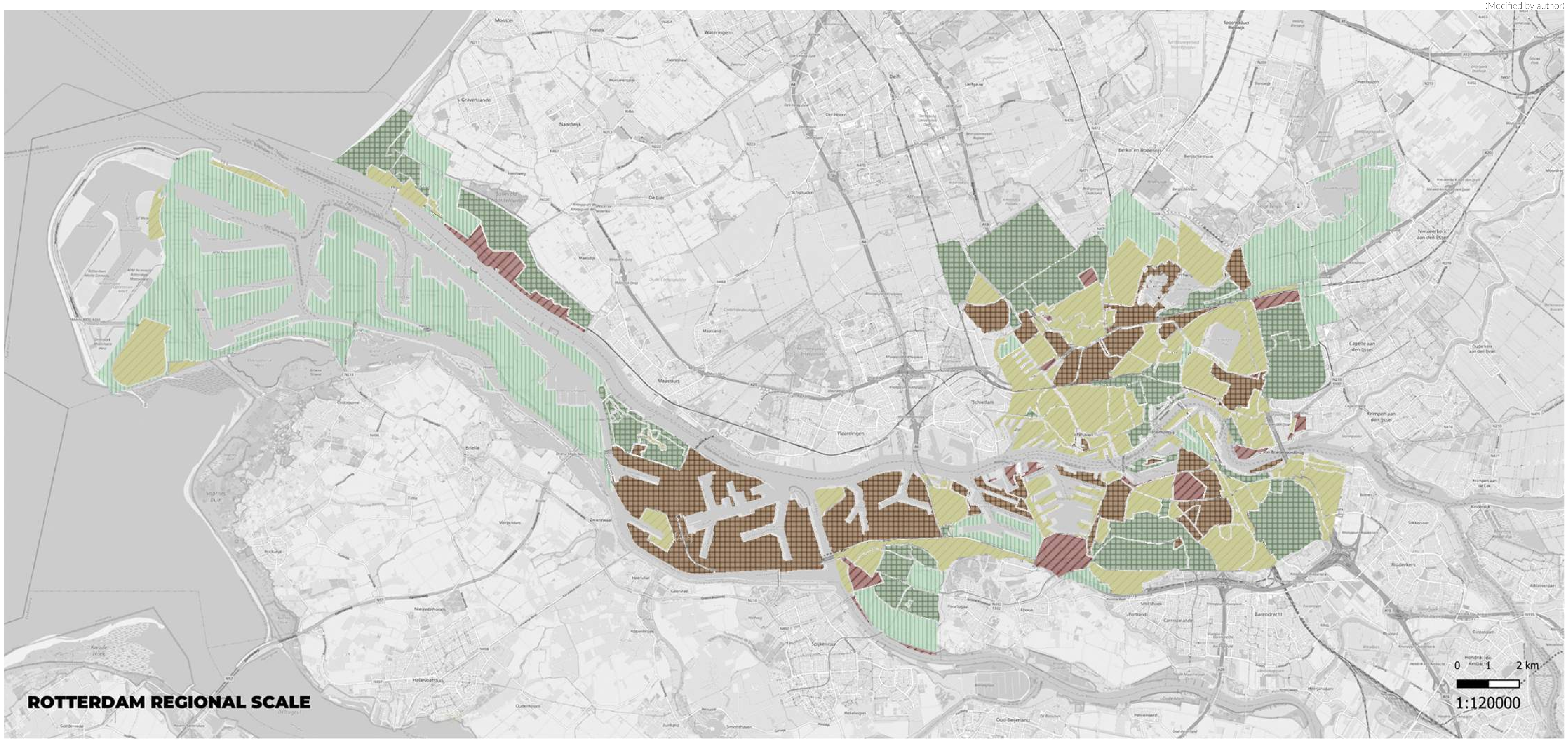


<10%
10-20%
20-30%
30-40%
40-50%
< 50%

Pollution from Industries

Unlike other ports, contamination of Botlek is very high due to bio industries and transportations. Europort and Maasvlakte possess bio port, but they have more green spaces than Botlek and are inaccessible. At the same time, Eemhaven and Waalhaven partially contaminated, which is a severe issue since they are close to residential areas. The contamination can affect residential areas and near green spaces. Furthermore, many animals and plants here are defined as endangered species by the Dutch government. Hence, it is crucial to remediate the port and surrounding residential areas to improve urban nature for animals, plants and provide ecosystem services.

Figure. 8
Contamination of Rotterdam
(Modified by author)

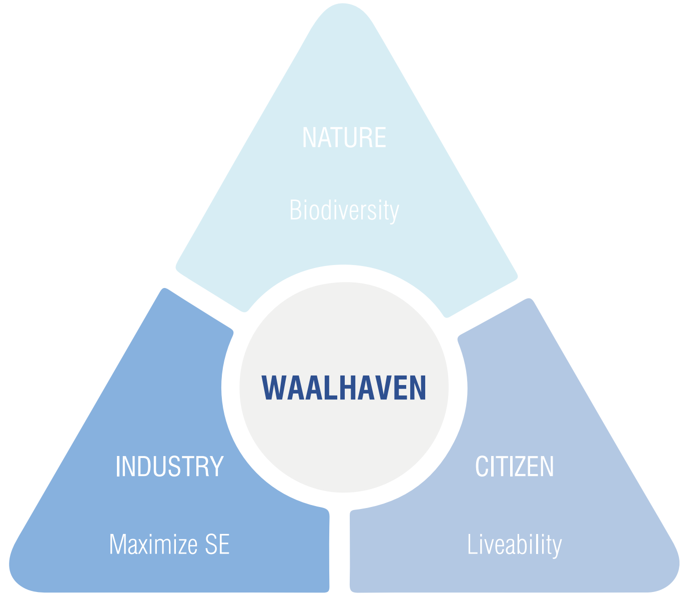


- Nature (clean)
- Agriculture (very light contaminated)
- Living (light contaminated)
- Industry (moderately contaminated)
- Strongly contaminated

Problem Statement

A resilient port of industries, residents, and nature

Rotterdam South, especially Waalhaven, is a resilient city that has various properties: port industries, sustainable energy companies, houses for human, and habitats for animals and plants. However, the current and future landscape of sustainable energy systems is not suitable for biodiversity since their demand for land and resource use can bring loss of habitat and contamination. At the same time, these are problems not only for biodiversity but also for human. If the urban ecosystem breaks down, ecosystem services from it get lost, resulting in the demolition of benefits of urban nature. Therefore, the sustainable energy landscape should be developed from the perspective of animals and plants.



Problem triangle of Waalhaven

Research Questions

Rotterdam South, especially Waalhaven, can be a resilient port city by balancing nature, citizens, and industries. However, the industries' current movement to expand the sustainable energy landscape is not desirable for biodiversity because they didnt take into account spatial design for biodiversity and ecosystem, which can break down urban nature.

Main research question

What is a possible spatial framework to create a renewable energy landscape that improves urban biodiversity and provides ecosystem services while enhancing recreational values for citizens?

- What is RE landscape in terms of non-human species?
- What spatial interventions are needed for different landscape typology?
- How can REL which contains large-scale energy infrastructures can work with residential areas?
- How industries & companies and RE landscape compromise together without any loss?
- What position/ strategy should RE industries take into account during a planning stage (e.g. wind farm, solar park)?

Research Objective

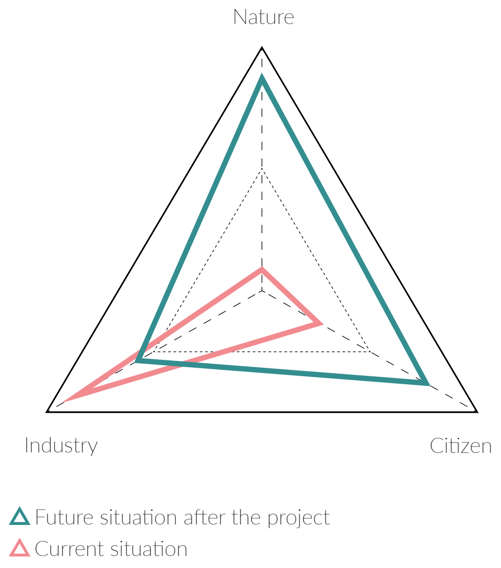
Build a spatial plan and design for SEL to protect and enhance biodiversity and provides ecosystem services

The goal of the project is protecting and improving biodiversity and ecosystem in Waalhaven by fostering a new resilient energy landscape through integration of nature-based solutions and industrial infrastructures.

Scientific Relevance
This project can provide
1. A new resilient landscape for SE and urban ecosystem
2. An environment-oriented design solution which responds to global warming and climate change
3. Spatial interventions that improve biodiversity/ ecosystem and quality of urban/ industry life
4. Blue/ green infrastructures for domestic resources of industries
5. A way for living organisms to strengthen self-regenerating abilities

Social Relevance
This project can provide
1. Social interaction to the public by providing recreational and public areas where people can improve mental and physical health
2. Job opportunities for local people

Ethical Issues
This project should consider
1. Existing ecosystem to minimize the undesirable side effects from the project
2. The value and improving the quality of existing SE industries
3. Daily behaviours (e.g. consumption, the scope of movement) of local people to improve their quality of life



METHODOLOGY

Abstract

This chapter illustrates the research and design methodology related to the previous chapter. After a quick revision of the Introduction part within the research framework, I explained several concepts and theories from literature and lectures how I applied them to theoretical and conceptual frameworks. Possible methods are describing within research that will be used for different purposes in each stage.

RESEARCH FRAMEWORK

Problem Field	Lack of spatial design and planning for biodiversity/ecosystem around SEL
Keywords	Renewable energ landscape · ecological infrastructures · ecosystem-based adaptation · urban nature
Location	Waalhaven in Rotterdam South
Problem Statement	Waalhaven has the potential to be a resilient port city by balancing between nature, citizens, and industries. However, the industries' current movement to expand the renewable energ landscape is not desirable for biodiversity because they did not take account spatial design for biodiversity and ecosystem, which can break down urban nature.
Research Question	What is a possible spatial framework to create a RE landscape that improves urban biodiversity and provides ecosystem services while enhancing recreational values for citizens?
Research Aim	Build a spatial plan and design for SEL to protect and improve biodiversity and provides ecosystem services

Methodology

Theoretical Framework

Nature-based solutions

+Ecosystem-based adaptation

+ Green infrastructures

Lanscape Urbanism

+ Integration

+ Remediation

Conceptual Framework

$$REL = f\left(\frac{\text{Management + Design + Space}}{\text{Human Impact on Environment}}\right)$$

Methods

Literature Review
Site Visit
Data Collection
Multiscalar/ Critical Mapping

Scenario / Calculation
Rotterdam matrix / Ecocity 18 standards
Stakeholder Analysis

Outcomes

Ecological multi-scale spatial design and planning for SEL

Regional scale	City scale	District scale
Spatial strategies for SE production and consumption in Rotterdam South	Relationship between ecological infrastructural landscape and human life	Pilot projects in various neighbourhood typologies

Design strategies that improve biodiversity/ ecosystem and quality of human life
Definition of a Sustainable Infrastructure from non-human organisms perspective

Conclusion

Assessment — Reflection

Limitations/ Discussion/ Scientific Relevance/ Social Relevance/ Ethical Relevance

I used the theoretical framework and academic paper to find approaches and to set criteria from several concepts deriving from two theories in terms of spatial planning and design. Approaches and criteria are deducted from several global examples of each theory, but I analyzed them in Rotterdam.

The project focuses on RE landscape for biodiversity and ecosystem in a highly urbanized area, and I extracted two approaches (ecosystem-based adaptation and green infrastructures) from NBS to understand it in socio-ecological ways. Then I found NBS should be considered a multi-scale solution to deal with social, political, and environmental problems instead of a single environmental solution. Furthermore, at the beginning of NBS, political intervention is crucial to set fair land distribution.

Likewise, Rotterdam South has to highlight the positive outcomes of green infrastructure so that people can understand the future outcomes and spontaneously participate. Because installing and improving the big scale of green infrastructure needs many times to be a solid-state (Shacham et al., 2016). Political regulation can settle a fair land use. Furthermore, the new landscape design should be used as multi-methods. (Hanvit Lee, 2020)

The project site is the hub of transportation and several SE industries which require many infrastructures. Hence I referenced 'Landscape Urbanism' theory to identify the relationship of hard infrastructures of industries and urban nature. I learned that understanding the properties of animal or plant species can help choose resources and typologies of infrastructure for spatial design and planning.

...show the potential of infrastructures (ALLEN, 1999) in an urban fabric as a method to show a diverse landscape. In this regard, when we design a green space in an urban area, we do not have to mimic the typical image of 'nature' (Waldheim, 2016). If we take into account biodiversity properties and unique characteristics of the site, we could come up with various urban landscape designs. However, during the process of utilizing infrastructures, an ecological way to remedy the environment is crucial because it motivates us to use local resources. (Hanvit Lee, 2020)

From Human to Nature

Socio-ecological approaches toward a balanced landscape in Rotterdam South

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Abstract

As climate change becomes a global issue, the municipality of Rotterdam has been adopting renewable energy systems, and its wind farm and solar park in Port of Rotterdam, on the surface, appear sustainable in view of renewable energy-use. However, the city's infrastructure which has been developed on the basis of its human-oriented process is less-sustainable in terms of preserving the ecosystem and further promoting the biodiversity (Gasparatos et al., 2017).

In this regard, the present research addresses the human-oriented planning of renewable energy landscape and its impacts on the existing ecosystem within the city, through the following framework: habitat loss/change, pollution, and over-exploitation (Gasparatos et al., 2017). In order to prevent the ecosystem from degradation, approaches of 'renewable energy landscape' in a point of non-human species,such as life on earth and under-water, are provided.

The theoretical foundation of the present research relies on the concept of the 'nature-based solutions' introduced by IUCN . Based on their concept, the paper provides innovative approaches for ecocentric design in urbanised areas and suggests roles of modern industries and people. Hence, the research contributes nature-based solutions to have a symbiotic relationship with industries in society, focusing on reintegration and remediation of the industrial infrastructures and environment of 'Landscape Urbanism' (Waldheim, 2016).
The paper concludes that a new approach of nature-based solutions and landscape urbanism help the society to achieve resilience, restoration, and adaptation for promoting biodiversity in an urban environment.

Keywords: ecosystem-based adaptation · green infrastructures · industrial infrastructures · urban nature · urban biodiversity

"Nature seems to bring out the best in us (Beatley, 2011). As it turns out, even small nature places can help just do that (Kaplan& Kaplan, 2005)."

`As global warming has come up with a worldwide challenge, many cities have started to use renewable energ systems to reduce greenhouse gas (GHG) emission. Carbon dioxide takes the most significant part of GHG production, which is coming from anthropogenic activities such as fossil fuel use, coal, or refined oil industries. Hence, people come up with renewable energy systems as a low carbon alternative. However, the transition from the non-renewable to renewable energy systems have triggered unexpected outcomes in a natural environment. Renewable energ systems are not 'sustainable' any more in the field of an ecosystem and biodiversity (Gasparatos et al., 2017). The new energy systems can leave negative results on nature by disrupting their ecological structure, and the main contributor is human-oriented planning and infrastructures (Katzner et al., 2013). For example, Rotterdam municipality planned to build large scale wind farms and solar parks in Maasvlakte. However, these new energy landscapes are complicated to hide (Stremke, & Dobbelsteen, 2013) because of their size which can evoke habitat loss. Because every wind turbine and solar panel needs a vegetation clearing, and makes the land barren. Also, they require human- oriented infrastructures, which support energy production, such as roads to access (McDonald et al., 2009) and electrical equipment (Johnson & Stephens, 2011). This kind of planning can sever existing nature where animals and plants are living (Liu et al., 2016). The fragmented habitats can halt the movement of animals, reduce hiding spaces, and lessen food availability (Northrup & Wittemyer, 2012). These phenomenons happen not only in the wind energy system but also in other types of renewable energ systems as well. Therefore, we need to change our perspective from human-oriented to nature when it comes to building a renewable energy landscape. In this regard, since Rotterdam South is the hub of transportation and has multiple fossil fuel- based industries, the city has the potential to be a new renewable energy production area.

The main objective of this paper is suggesting approaches to make a 'renewable energy landscape' as a way to protect urban biodiversity and ecosystems in Rotterdam South by compromising with the city's surrounding social environment. Hence, the paper explains the theories about 'nature-based solutions' and 'landscape urbanism'. These theories are related to an ecosystem and biodiversity in highly urbanised areas. This paper also aims to understand possible concepts to define the renewable energy landscape in the context of Rotterdam South. As mentioned above, the theories are mainly about the restoration of the urban ecosystem, but the fundamental focus is on how to enhance benefits for both natural and human environments.

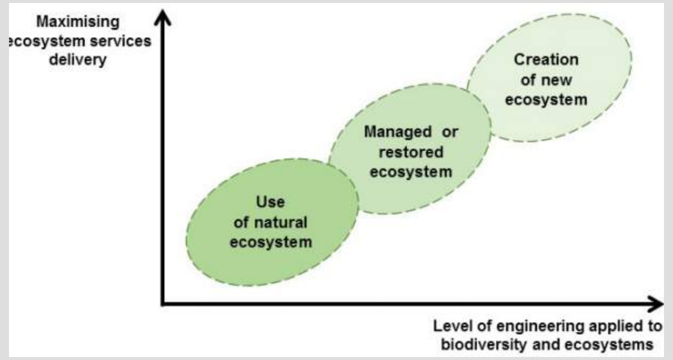
In the end, the paper will be a part of the process to answer the research question of the research project, what is a spatial framework to create a renewable energy landscape which improves urban biodiversity and provides ecosystem services while enhancing the quality of human life.

1. NATURE-BASED SOLUTIONS

According to the International Union for Conservation of Nature (IUCN), nature-based solutions (NbS) are "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. (Shacham et al., 2016)" Usually, NbS are used in terms of well-managed conservation and restoration which can be presented by following examples: developing green infrastructures in urbanised areas with spatial interventions such as green walls or roof gardens, creating urban forests to support local foods and resources for renewable energy. The examples are a part of the following three categories.

Use of natural ecosystem
Managed or restored ecosystem
The creation of a new ecosystem.
(Filho, 2015)

They are based on two gradients; the level of engineering of biodiversity and ecosystem, and the level of plausible enhancement of ecosystem services (Eggermont et al., 2015). When the parameter goes to a higher level, the solutions are more adaptable in highly urbanised areas because they require small scale NbS interventions such as green buildings with green walls and green roofs (Shacham et al., 2016). The below graph shows how the system and the typologies can explain which NbS approach and concept is adaptable.



[Fig 1] A typology of Nbs interventions and three main categories
Source: adapted from Eggermont et al., 2015.

Based on a typology of NbS applications, people can choose methods which are suitable for the environmental condition of their cities. There are several ecosystem related approaches which compose the current NbS. However, this paper discusses two approaches: issue-specific ecosystem related approaches, green infrastructure approach, and they can accommodate the situation of Rotterdam South.

1.1. ECOSYSTEM-BASED ADAPTATION

Issue-specific ecosystem related approaches have four types of detailed approaches; ecosystem-based adaptation (EbA), ecosystem-based mitigation (EbM), climate adaptation services (CAS), ecosystem-based disaster risk reduction (Eco-DRR). In this paper, we only discuss EbA. Because, compared to other NbS approaches, EbA requires an active engagement of the community to increase awareness about the environmental resource and its sustainable management (Shacham et al., 2016).

Ecosystem- based adaptation (EbA) is the "sustainable management, conservation and restoration of ecosystems, as part of an overall adaptation strategy that takes into account the multiple social, economic and cultural co-benefits for local communities (CBD, 2010)". An example of EbA is well explained by 'Nature-Based Solution for Balancing the Food, Energy, and Environment Trilemma: Lessons from Indonesia (Rhaman & Baral, 2020)'. This study case shows how people in Indonesia restored and used degraded land through linking biofuel crops for renewable energy production to local agriculture for food production. At the same time, biofuel crop agriculture helped to remediate soil pollution as well. All these positive results are favourable for local farmers which motivated them to actively participate in the project (Rhaman & Baral, 2020). The critical point of the project is land use for bioenergy production. Because it does not interrupt a space for agriculture. Usually, the agricultural bioenergy crops require a lot of lands (Vasile et al., 2015) and pollute soil and groundwater (Barnabè et al., 2013). Hence, there is a negative assumption that local people would be against sharing land for biofuel crops of energy resource production. However, since the crops used in the project are represented as the most adaptive local species in Indonesia which can easily survive in a tropical environment, it mitigates the relationship of food industries and renewable energy landscape.

With the case of Indonesia, Rotterdam South needs to find social problems of the surrounding port industries and residential areas. The renewable energy landscape can be a sub-solution for other problems. Since Rotterdam South, especially Eemhaven and Waalhaven are close to logistics, industrial, maritime, business services, and residential areas. The industries are struggling with the transition from non-renewable to renewable energy systems and residential areas have less public green spaces compared to other neighbourhoods. At the same time, the existing industries have a low green hierarchy. Based on these problems, we can understand Rotterdam South needs to come up with spatial design which can mitigate problems of surrounding industries to have a strong support. Also, since the ports have high potential to be a habitat for their local fauna and flora, they need to consider the way to protect environmental resources.

1.2. GREEN INFRASTRUCTURE

Green Infrastructure approach is 'a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services (European Commission, 2013)'. As the word shows, green infrastructure includes green and blue spaces that protect ecosystems with biodiversity and provides ecosystem services to humans. Unlike conventional approaches, open space planning, a green infrastructure approach considers anthropocentric development. Because this approach is often used for land development, growth management and built infrastructure planning (Benedict & McMahon, 2002) in an urban and a landscape scale. Consequently, green infrastructure needs to combine hard infrastructure, physically built infrastructure such as roads or bridges that require assets to make them functional (Portugal-Perez & Wilson, 2010), and ecosystem- based infrastructure. A difference between green infrastructure and ecosystem- based infrastructure, according to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), ecosystem- based infrastructure supports and improves agricultural pollination services for natural or semi- natural patches (Dunkley et al., 2018). On the other hand, green infrastructure tends to be used in urban aspects such as policy, practice and scientific research (Tzoulas et al., 2007).

As explained before, green infrastructure represents not only the ecological aspect but also the social aspect. Urbanisation in Spain shows how they use green infrastructure within social circumstances. In Spain, rapid urbanisation of the metropolitan area in Barcelona fragmented ecological habitats and landscape. It led to uncountable isolated natural patches with impaired ecological function. This is due to the fact that the municipality did not consider ecological processes when they integrated natural areas in urban planning (Muarulli & Mallarch, 2005). Hence, they announced the Barcelona Green Infrastructure and Biodiversity Plan in 2020 to restore and enhance urban nature. Furthermore, the project offers ecosystem services like reduction in energy consumption and CO2 emissions for humans, provides habitat for biodiversity, and creates an ecological connection (Ajuntament de Barcelona, 2013; URBES, 2014; Baró et al., 2014). The planning involved small interventions such as parks and gardens and even street trees. In the beginning, they were small scale spatial interventions, but they brought a significant change in the city by alleviating climate change and improving green infrastructure strategies, urban biodiversity and values. In the end, the project promoted participation from citizens to obtain green spaces for well-being.

The study case of Barcelona can teach Rotterdam South how to deal with the challenges and impacts of green infrastructure approach. If the Rotterdam municipality wants to proceed with the green infrastructure strategy, they need to acquire possession of the land and integrate public green spaces in highly urbanised areas (Hansen, 2015). Otherwise, competitive land use can make port industries confused about land resources and lead to indiscriminate land development(Kanianska, 2016). Because without the strict regulation on land use can break the balance of urban green spaces, maintenance, and conservation (Shacham et al., 2016). Besides, Rotterdam South should not only focus on the municipal level because the efficacy of green infrastructure would be confined to a municipal level. The city and the government have to strongly cooperate to manage environmental quality and urban planning (Baró et al., 2014). It will bring various ecosystem services such as improvement of local air quality and low production of greenhouse gas emissions on multiple levels (Shacham et al., 2016).

From a social viewpoint, the Barcelona Green Infrastructure and Biodiversity Plan was successful. Political support and desire from the city helped to make the project successful (Hansen, 2015) and managing urban biodiversity and ecosystem services in multi- scale motivated various stakeholders and citizens participation (Schewenius et al., 2014). Moreover, as citizens spontaneously participated, people understood the importance of urban nature and its following consequences, ecosystem services, from green infrastructure such as reducing urban heat stress, alleviating stormwater runoff, and offering public entertainment spaces (Baró et al., 2014). Likewise, Rotterdam South has to highlight the positive outcomes of green infrastructure so that people can understand the future outcomes and spontaneously participate. Because installing and improving the big scale of green infrastructure needs many times to be a solid-state (Shacham et al., 2016).

In the context of Rotterdam South port areas, there are many port industries alongside the river, but the municipality and the port authority did not consider urban nature for biodiversity and ecosystem. Nevertheless, the port city has various flora and fauna, and some of them are even endangered species. This area is located close to the blue and green infrastructures; it has the potential to restore the ecosystem by improving the quality of ecological infrastructure. Therefore, based on the two concepts of NbS, the municipality should take a strong position for industries to consider the urban ecosystem in multi-scale. With the integration of EbA and green infrastructure approaches, it can help biodiversity to coexist with the surrounding social environment in Rotterdam South.

2. LANDSCAPE URBANISM

There are many industrial infrastructures in Rotterdam South since the ports were established in the early 1900s (Gijt, 2008). In consequence, it is hard to make a new space for urban biodiversity and ecosystem due to existing facilities. Since demolishing those brownfields is not a sustainable way, modern urbanists had to come up with a resilient alternative. The theory of landscape urbanism helped to build an idea about the transition of existing urban or industrial architecture, which is out of use, into a sustainable urban landscape for citizens and nature. To be specific, it is about utilising landscape as a medium to integrate anthropocentric spaces and natural environments. The integration adds multiple values to a city because the design of a landscape can plan and organise a city in a better way. Therefore, it beautifies the city with several methods: revegetation, conservation of water, and restoration of the natural system.

The traditional way of a landscape is following ecological systems by a realisation of 'nature'. Unlike its pastoral image of nature, contemporary urbanists had come up with a new way of the landscape as a part of urban planning; landscape urbanism. The four strategies of landscape urbanism tend to use efficacies of the landscape: integration, remediation, heritage, and renovation (Waldheim, 2016). The paper shows integration and remediation. Brief explanations about study cases of each strategy in the real world explain how urban biodiversity and ecosystems come along with industrial and urban infrastructures that were built in modern times.

2.1. INTEGRATION OF URBAN NATURE AND INFRASTRUCTURES

In the field about 'integration' of landscape urbanism, the study case in Barcelona explained how the integration of landscape urbanism had been achieved. During the late 1900s, the city focused on a large scale landscape rather than public infrastructures. Primary project sites were metropolitan riverways, an airport, industrial areas, and water-treatment facilities (Waldheim, 2016). Trinitat Cloverleaf Park by Enric Battle, and Joan Roig built public parks are main projects. Because unlike the primary sites as mentioned earlier, the park is in the junction of a circular highway which is a peculiar location. The urbanists tried integration of transportation and public spaces. The project proves the topographic and relational value of the park within the city and the relationship.

Another example of integration is inducing the ecological transition from industrial infrastructure. To be specific, it is about letting nature show a new form of landscape. Adriaan Geuze of West 8 has worked on a project under the name of Shell Project to create several aspects of the landscape in contemporary hard infrastructures. The project is about a landscape design in eastern Scheldt storm surge barrier and a highway. He aimed to show different aspects of landscape within urban infrastructures for drivers.

[Fig 2] Trinitat Cloverleaf Park by Enric Battle
Source: https://alchetron.com/Nus-de-la-Trinitat

His project gave less attention to the middle scale of architectural/ urban projects and tried to work on the large scale infrastructures with small materials (Waldheim, 2016).
In consequence, he decided to utilize natural selection, coastal birds' habits. Different coloured mussel shells allow white birds choose white mussels, and black coloured birds choose black shells. Because the birds are prone to disguies feather colours. As he intended, the project has brought attention not only from animals but also from the people on the highway. First, the geometric stripes capture humans and the bird's eyes. After then, a flock of the birds attracts attention when they are going over the site.

[Fig 3] Scheldt storm surge barrier by west8
Source: https://www.west8.com/projects/landscape_design_eastern_scheldt_storm_surge_barrier/

City planning has worked on the design of architecture. For example, buildings, blocks, and streets were objects of the design under the name of urban development. However, the aforementioned projects reveal the potential of infrastructures (ALLEN, 1999) in an urban fabric as a method to show a diverse landscape. In this regard, when we design a green space in an urban area, we do not have to mimic the typical image of 'nature' (Waldheim, 2016). If we take into account biodiversity properties and unique characteristics of the site, we could come up with various urban landscape designs.

2.2. REMEDIATION OF URBAN NATURE AND INFRASTRUCTURES

Remediation means reducing exposure from contaminated environments such as polluted soil or groundwater. It aims to protect people and the environment from harmful elements (Stein & Kerle, 2008). Usually, these harmful elements come from human activities, especially industrial residues (Begum, 2019). The consequences of human- oriented industries reminded modern urban planners to think about the importance of urban regeneration through the rehabilitation of existing industrial facilities in cities and reusing their structures (Encyclopedia Britannica Ultimate Reference Suite, 2012). This idea led to the ecological transition from industrial infrastructures (Dulić & Krklješ, 2013). In this sense, Richard Weller, an Australian landscape architect, said "Post-modern landscape architecture has done a boom trade in cleaning up after modern infrastructure as societies shift from primary industry to post-industrial, information societies (Waldheim, 2016)....the landscape itself is a medium through which all ecological transactions must pass: it is the infrastructure of the future." Because ecology has received a lot of attention as an essential strategy in the design field of urban infrastructures and urban economies (MUMFORD, 1959).
Following two study cases, Duisburg Nord Steelworks Park which is designed by Peter Latz and Gas Works Park of Richard Haag explained how they worked in the sense of renovation and remediation. The former is in Germany, and the latter is located in Seattle. Both of them used old buildings and left existing structures for public use. Also, they tried to restore the contaminated soil by phytoremediation. Through the design of Duisburg Nord Steelworks park, the urbanist decided to change abandoned buildings into open green spaces, to make more nature in the city, instead of demolishing them (Weilacher, 2009). The concrete bunkers and the boiler house have become spaces for people to enjoy the infrastructures which is not used anymore. In addition, Peter Latz aimed to achieve ecological restoration by vegetation succession with planting pioneer species and phytoremediation (Keli, 2019).

[Fig 4] Duisburg Nord Steelworks Park by Peter Latz
Source:https://green.uw.edu/blog/2015-11/uw-professor-pushed-revolutionary-design-gas-works-park

Looking at Rotterdam South in a point of nature-based solutions and landscape urbanism, an integration of both theories can be a plausible strategy to build a resilient landscape for the prevailing circumstances. Specific methods to integrate theories are explained below.

1. The municipality and the government should support sustainable energy landscape design. Political regulation can settle a fair land use. Furthermore, the new landscape design should be used as multi-methods. If it is used only for the renewable energy industries, other industries which do not use them can be left. In that sense, the renewable energy landscape should cover economic, social, and environmental benefits.

2. Rotterdam South, especially Eemhaven and Waalhaven are located on the edge of Nieuwe Maas, is covered with containers and private industrial buildings. Therefore, we need to figure out animals and plants in these unique industrial typologies to understand their distributions. It will help to design habitat in the port areas by using infrastructures instead of removing them. However, during the process of utilizing infrastructures, an ecological way to remedy the environment is crucial because it motivates us to use local resources.

3. The scale of urban landscape design can be various. However, we need to consider surrounding anthropocentric environments. But the material for the design can be various.

By following the methods, Rotterdam South can achieve resilience, restoration, and adaptation for promoting biodiversity as shown by study cases mentioned before.

CONCLUSION

In this paper, we explained the impact of renewable energy systems on biodiversity and possible approaches to achieve a renewable energy landscape in Rotterdam South. The negative impacts on ecosystems from renewable energy systems have allowed us to consider the concept of ecosystem-based adaptation and green infrastructure. The two concepts let us understand that a nature-based solution is not a solution for a single problem but strategies for mixed problems in political, social, and environmental ways. Additionally, setting multiple scales for urban landscape design is essential to expand the efficacy of green infrastructures. The concept of landscape urbanism helped to come up with the idea that industrial typologies and its infrastructure can be a new chance for urban biodiversity and ecosystem.

This paper can help further research and design for the project. Because the theories and concepts mentioned above will be a guideline to add more values of what design or methods can create a renewable energy landscape.

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The conceptual framework explains how renewable energy landscape is formed by four parameters which can bring positive or negative impacts by the formula. In problem statement, I focused on liveability of human, biodiversity of nature, and maximization of nature. I found space, design, and management are the requirements which based on theoretical framework of the key points from the problem triangle. (See Figure.9) Space, design, and management are positive parts of SEL which boost speed and quality to build SEL. On the other hand, human impact on environment can negatively influence on REL.

In management, the project aims to achieve co-benefits through multiple aspects (social, economic, cultural, and environmental) and local-based governance to improve the city in Rotterdam South context. Design is focused on ecological approach. The four variables will help to understand how the concept of landscape ecology (Dramstad & Forman, 1996) can be applied to the project. Space is related to design which is concentrated on typology of infrastrucutres that can help to choose what resources are adaptable. Human impact on environment means side effects which can be produced during the building of REL.

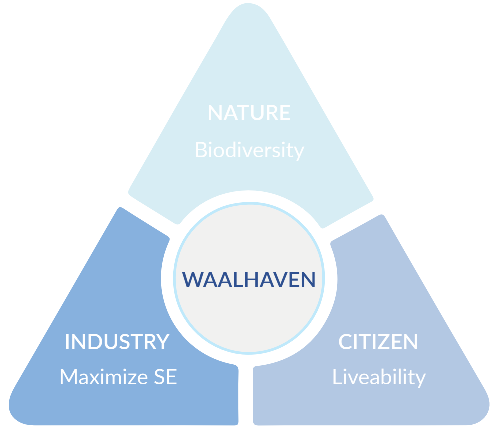

Figure. 9
Current green areas of Waalhaven and flora/ fauna species list and the numbers

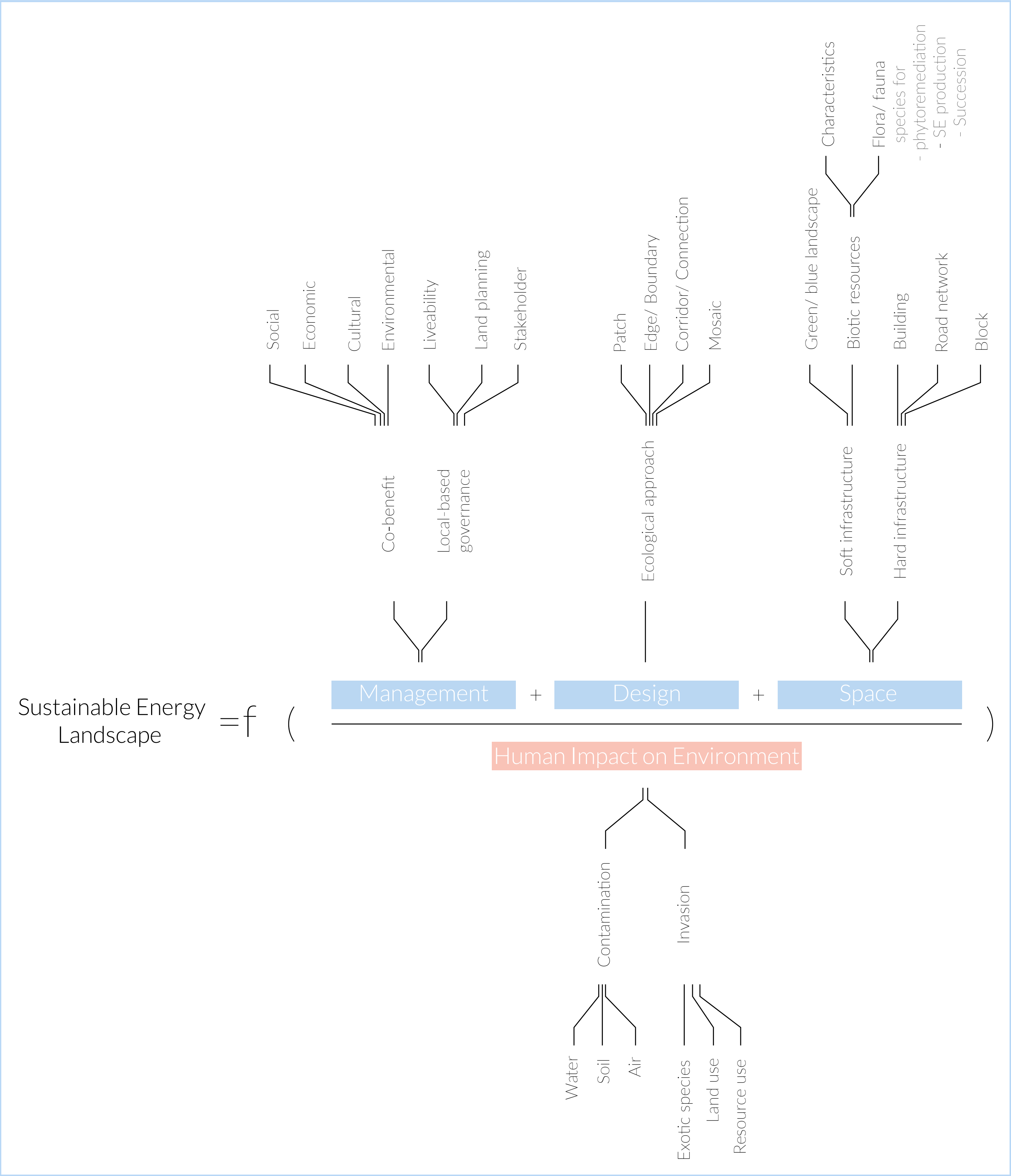

Figure. 10
Conceptual framework is taken from senior graduation project.
Modified by author (Garcia Vogt, 2020)

Data Collection

Aim: To collect qualitative and quantative information

Source: Literature, report, paper, website, documentary, and news

Multiscalar/ Critical Mapping

Aim: To understand and identify three key points (space, management, design) through multiple scale

Scales: National (XL) - Regional (L) - City (M) - District (S)

Scenario / Calculation

Aim: To understand relationship between SE demand in Rotterdam and its impacts on surrounding landscape, and to propose resilient spatial planning in worst situations

Source: Literature, report, paper, website, documentary, and news

Rotterdam Matrix / Ecocity 18 Standards

Aim: To evaluate ecological aspect of the project, to understand synergies with surrounding environments, and evaluate project potential

Scales: City (M) - District (S)

Stakeholder Analysis

Aim: To understand opinions from various actors, to assess the power and the interest, and to suggest alternative strategies

Parameters: Public sector - Private sector - Civil society - Non human species

	Literature Review	Site Visit	Data Collection	Multiscalar Mapping	Scenario / Calculation	Rotterdam matrix/ Ecocity 18 standards	Stakeholder Analysis
Foundation							
Motivation	●		●				
Context	●	●	●	●			
Problem Statement	●	●	●	●			
Research Question	●		●	●			
Research Aim	●		●	●			
Methodology							
Theoretical Framework	●		●				
Conceptual Framework	●		●				
Analysis							
Analysis	●	●	●	●	●		●
Scenarios	●		●	●	●		
Design and Outcomes							
Scenario	●		●	●	●		
Regional Design	●		●	●	●		
City Design	●	●	●	●	●		
District Design	●	●	●	●	●		
Phasing					●	●	●
Assessment						●	●
Relevance							
Societal/ Scientific Relevance			●			●	●
Ethical considerations			●			●	●

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ANALYSIS

Mapping RDM South
RE Aspect
Environmental Aspect

Location of RE Industries in RDM

- Solar panels
- Wind turbines to be removed
- Wind turbines to be installed
- Existing wind turbines
- Industrial gas& water
- Biofuel, edible oil
- Oil products
- Gas power, coal, biomass

Four main ports which have RE are Maasvlakte, Europoort, Botlek, and Eemhaven~Waalhaven. Ports in the west have larger-scale energy infrastructures compared to the ports in the east. Four main ports which have RE are Maasvlakte, Europoort, Botlek, and Eemhaven~Waalhaven. Ports in the west have larger-scale energy infrastructures compared to the ports in the east.

‘Official’ Green Areas around RE Industries

- Meadow
- Allotments
- Wetland
- Heath
- Shrub
- Farmland
- Grassland
- Beach
- Forest
- Park
- Garden

Official green areas mean green areas which are officially defined places for recreational values. Based on QGIS, Rotterdam's current official green areas are meadow, allotments, wetland, heath, shrub, farmland, grassland, beach, forest, park, and garden.

However, the four-port areas have fewer green spaces compared to other cities and waterfront areas.

Potential Green and Blue for RE landscape

River, canal, waterway
Official green areas
Grassland

The previous page described the main four ports have fewer green spaces. However, by including the unofficial green areas such as linear green buffer zone, canal, and grassland, the ports can be more green and blue.

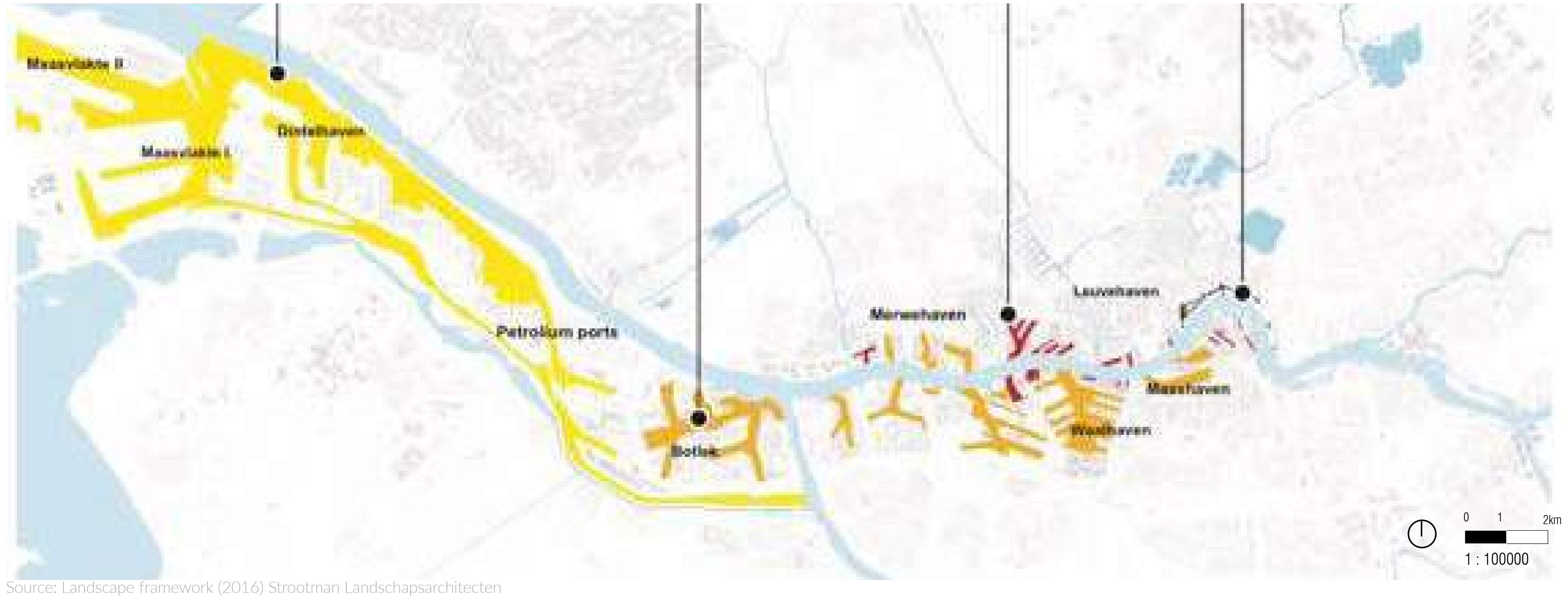
Closeness to Residential Areas + Green Percentage of Waalhaven

XL
Built in 19/20c
Less urban life

L
Built in 19/20 c

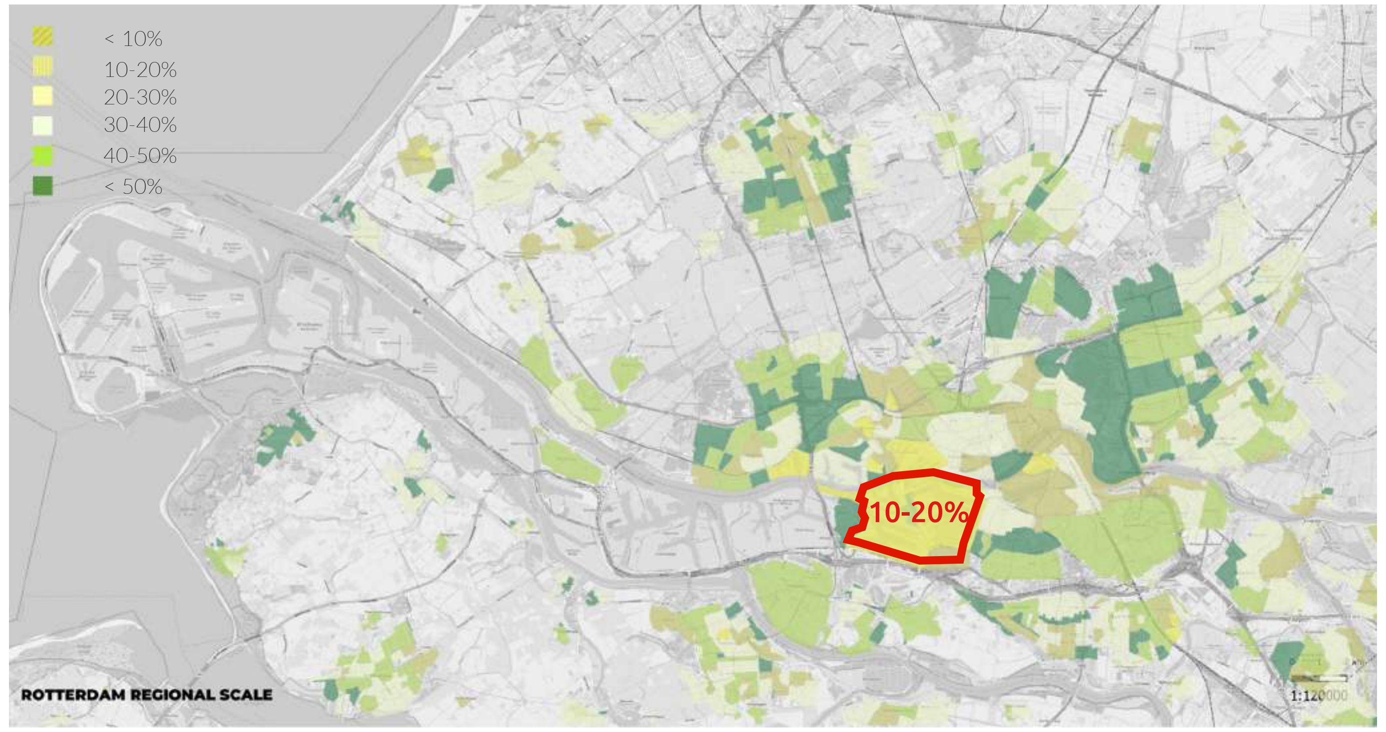
M
Built in 18/19c
Mix of urban life and industry

S
Built in 16/17c
Mix of urban life and port activity



Source: Landscape framework (2016) Strootman Landschapsarchitecten

As the project regarding the recreational value for people, the project site should include urban life. Based on Landscape famework and the green percentage of neighbourhood, I chose Waalhaven for my project site as it has mix of urban life and industry and at the same time, the port has only 10 to 20 percent of green.



Potential RE

Approximately industries and residents of Waalhaven require 4,2,000,000kWh per day, from coal-fired power stations, biomass power station and gas-fired power stations in the port. Several projects regarding renewable energy are progressing in Rotterdam by many private/ public stakeholders. Figure 00 shows the locations of the potential RE systems at spatial niches by producing energy with an extreme amount. Extreme amount means using every space in Waalhaven to calculate the maximum amount of energy production. For example, 'Wind energy on buildings' mean installing wind turbines on every building in Waalhaven.

However, the RE systems mentioned above cannot offset the energy requirement of Waalhaven. For example, one of the projects, Solar panels in parking lots, proved PV panels at parking lots, 132,280km^, can produce 7,830kWh per day, and the amount can meet 0.018% of Waalhaven energy consumption. Even though including other RE systems that can produce more energy by utilizing spatial niches (parking lots, rooftop...), an uncountable land amount is required (Figure 11).

Figure. 11
How much surface of Waalhaven would be required?

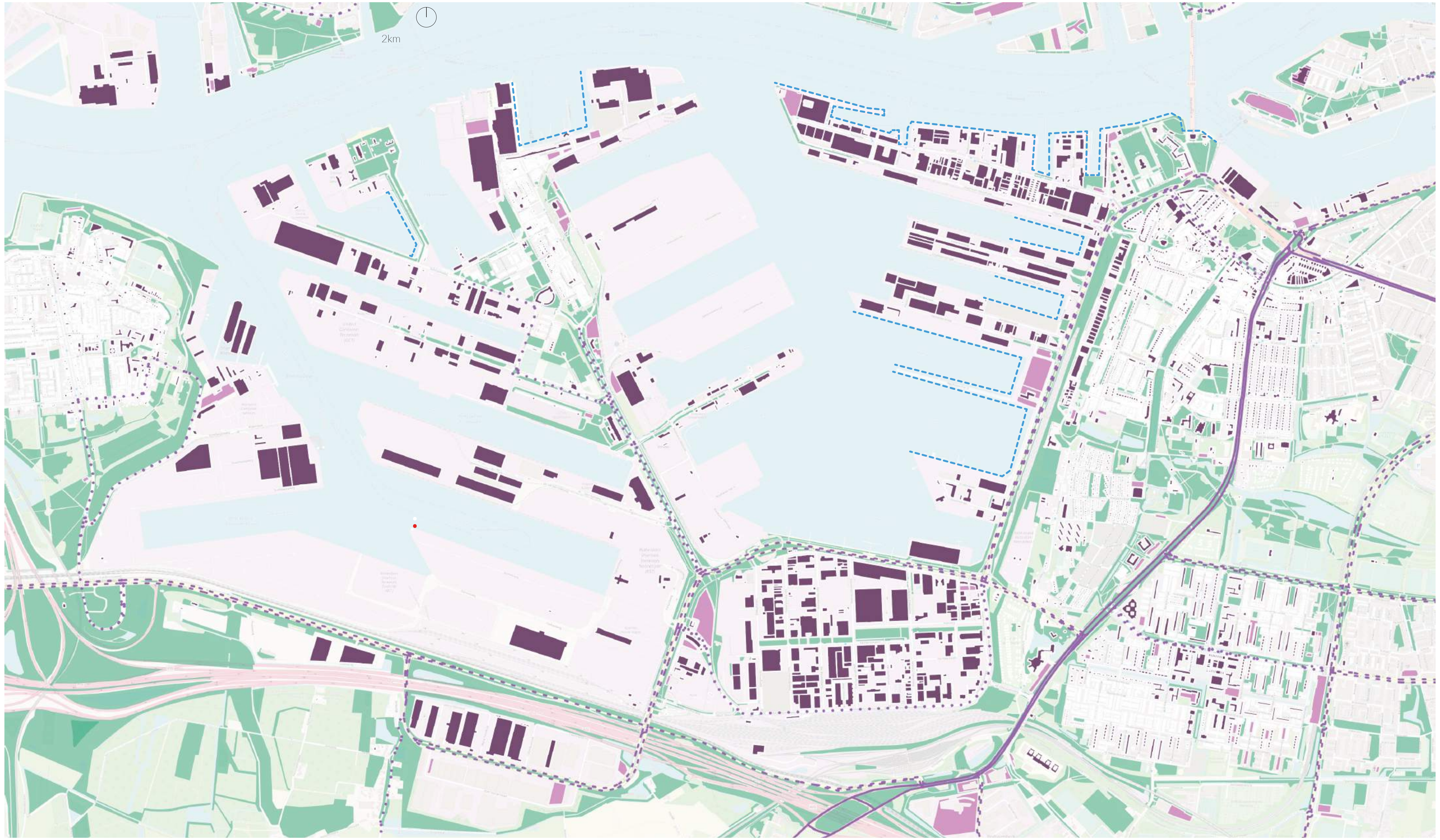
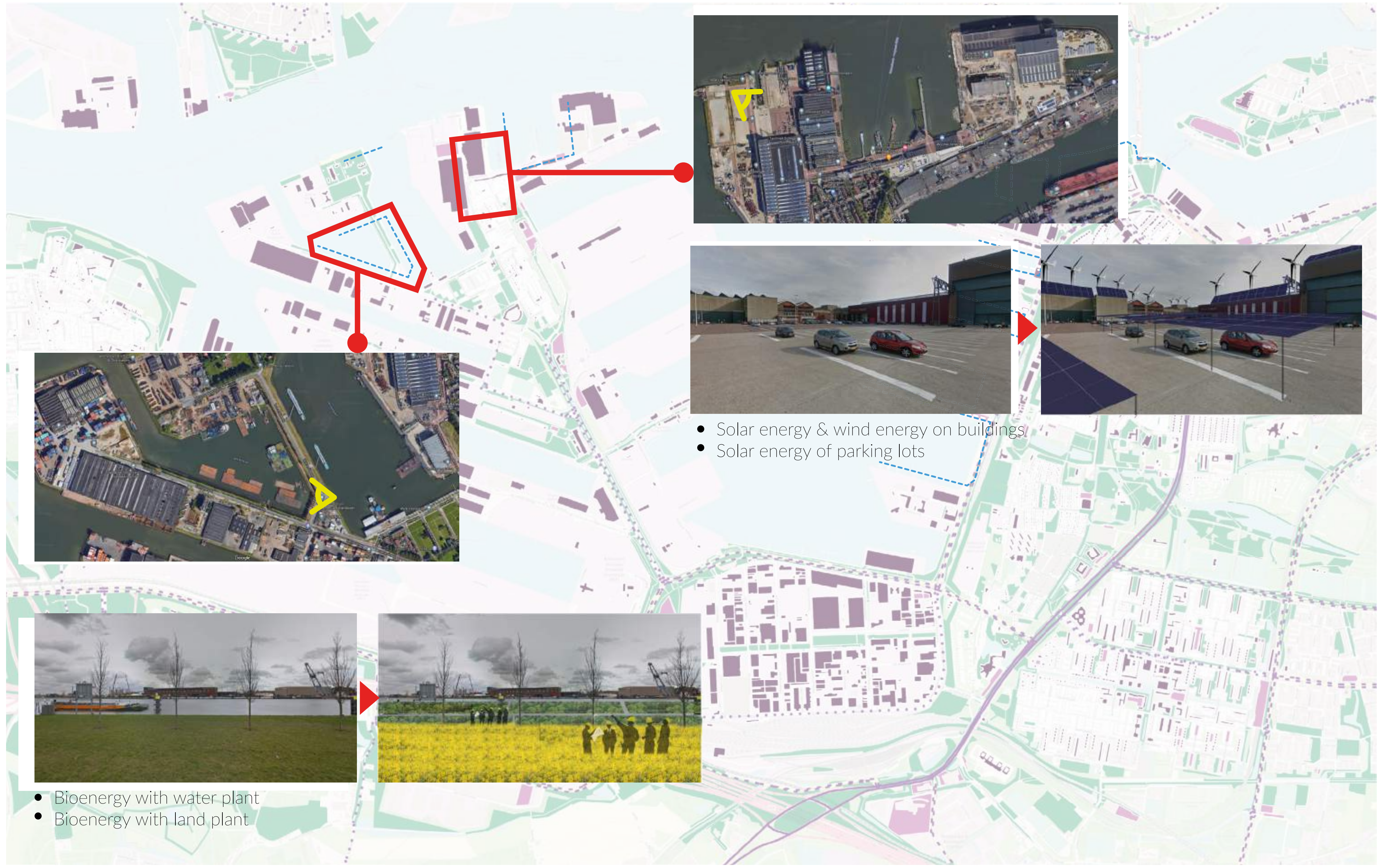


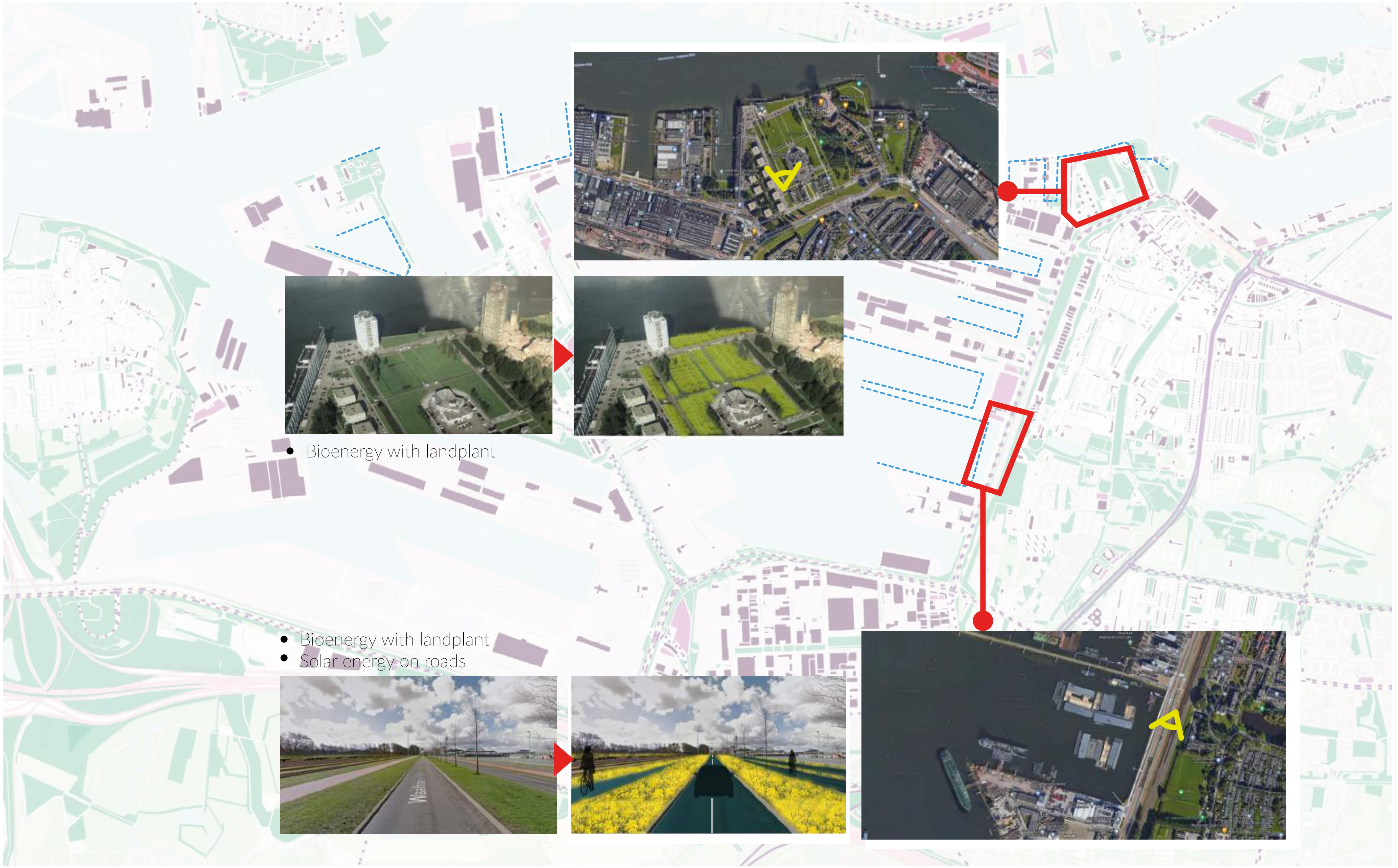
Figure. 12
Location of RE systems

Potential RE infrastructures (extreme amount)

- Wind turbines on buildings
- PV panels on buildings
- PV panels at parking lots
- PV panels on roads
- Land type biomass plants
- Water type biomass plants

Exploring Potential RE





Nanji Ecological Park, Seoul, South Korea

As described on the previous page, more energy production is needed. The following two references show how to produce enough energy amount to meet the requirement. These two study cases will let Waalhaven adopt new RE systems which are beneficial to human and biodiversity.

MOUNTAIN COVERED WITH WASTE
As Seoul has experienced rapid urbanization and economic growth, the city faced increased waste from household and industries. However, the city suffered from a lack of waste disposal sites, and the municipality has disposed of them at landfill sites (e.g. residential areas and low marsh). It turned the beautiful island into the land of death. The land released odor and harmful gases like methane, and the islands destroyed the surrounding ecosystem by polluting air and water (Seoul Institute, 2014). Hence, the government decided to turn the landfill into a park.

TURNING LANDFILL GAS TO ENERGY
Methane was one of the major and the most dangerous gases released from the landfill. The municipality installed gas extraction wells, then the gas was channelled into wells to provide heating for public sites and surrounding residential areas. For example, the gas was enough to heat 16,335 households, 40 office buildings, and three public areas (Seoul Institute, 2014). The collected gas from the landfill is supplied to a district heating facility located in the park. An incineration plant of the park is used for dealing with the domestic waste of the neighbourhood.

RECOVERECOSYSTEM
One of the most popular areas of the park is Nanjicheon park. As it was built in the lowlands between the waste layer and Sangam area, the areas suffered from water pollution. Leachate from the landfill and waste was buried in the centre and the stream (Seoul Institute, 2014). Hence the plan was to improve the quality of stream and park to achieve ecological recovery.

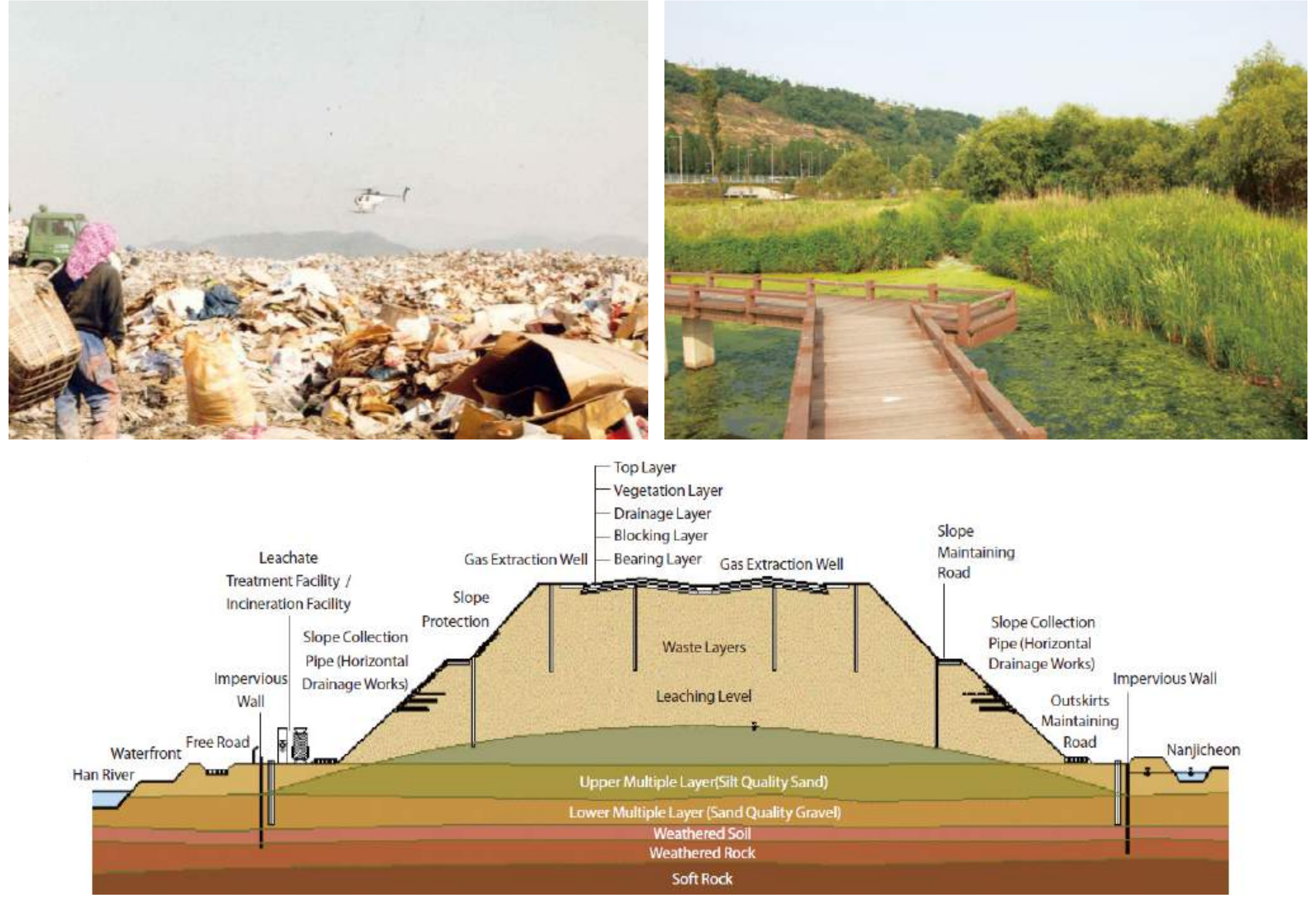


Figure. 13
Left top: Nanjido as a landfill
Right top: Nanjido as a ecological park. The area is wetland
Bottom: Section view of Nanjido

Water	■
Heat	■■■
Energy	■■■
Biodiversity	■■■■
Social and economic importance	■■■■
Multifunctional space usage	■■
Costs	■■

Bio energy : Heat from waste
Wind energy : Wind turbine
Solar energy : Building, parking lot

Hammarby Sjöstad, Stockholm, Sweden

Figure. 14
Left top: Dagvatten canal
Right top: Resource flow model
Left bottom: GlashusEtt
Right bottom: GlashusEtt energy flow

Water	■■■
Heat	■
Air quality	■
Energy	■■■
Biodiversity	■■
Social and economic importance	■■■
Costs	■■

Bio energy
- Biogas from purified water sludge
- Combustible household waste

In the 1990s, Hammarby Sjöstad was notorious for contaminated and unsafe residential and industrial area. However, now it is the most desirable district for residents as the most successful urban renewal districts.

Hammarby Sjöstad considered sustainability as the priority. District heating is the primary source of heating in the town. According to 2002 figures, 34% of the heat comes from purified wastewater, 47% is from local waste, which is combustible. 16% is from biofuel. The heat is extracted from the purified wastewater, and the remaining cold water is used for cooling for grocery stores, office buildings as a replacement for energy-guzzling air conditioning systems.

ENERGY PRODUCTION
There are several types of solutions for energy supply. First, solar cells on Sickla Kanalgata supply energy for public areas of buildings. Solar panels on a residential building can supply 50% of the hot water annually. In GlashusEtt, an Environmental Information Centre in the area, the Fuel cell can generate electricity and heat by running on fuel like hydrogen gas. With this energy supply, 900 flats in the town are using biogas cookers and biogas from sludge formed from the wastewater treatment. These biogas cookers have reduced electricity consumption by 20%.

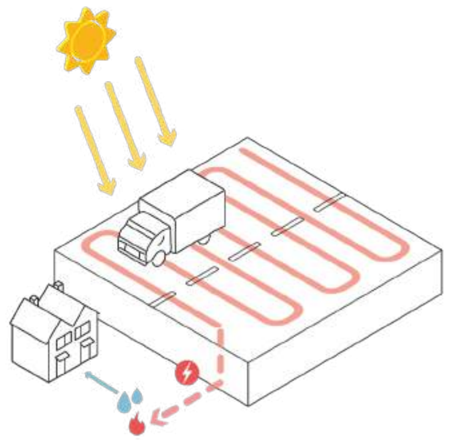
ENERGY GOALS
With all these RE systems, Hammarby Sjöstad aimed to achieve the following lists.

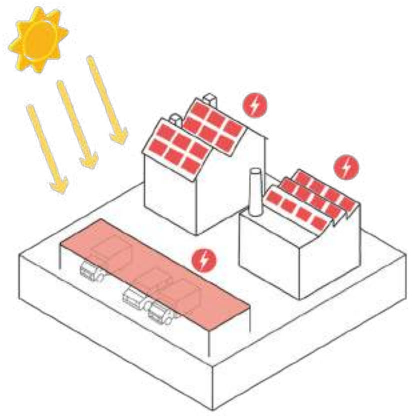
District heating connection with exhaust air systems: 100, of which 20 kWh electricity/m2 UFA (Buxton, 2015).
District heating connection with heat extraction systems: 80, of which 25 kWh electricity/m2 UFA (Buxton, 2015).
The entire heating supply shall be based on waste energy or renewable energy sources (Buxton, 2015).
Electricity shall be "Good Environmental Choice"-labelled, or equivalent (Buxton, 2015).

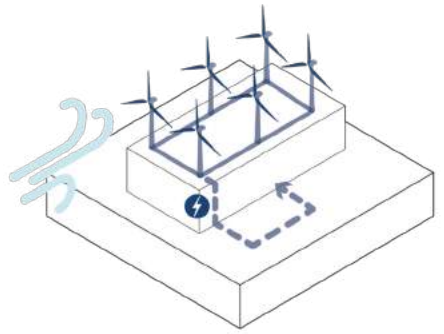
WASTEWATER
The sludge from the water treatment process is sent to farmland and forestry land as a fertilizer. When the sludge release biogas during fertilising, the gas is used for transportation as fuel and to heat households. Extracted heat from the treated water is used fo district heating and during summet, the cold water is used for cooling down.

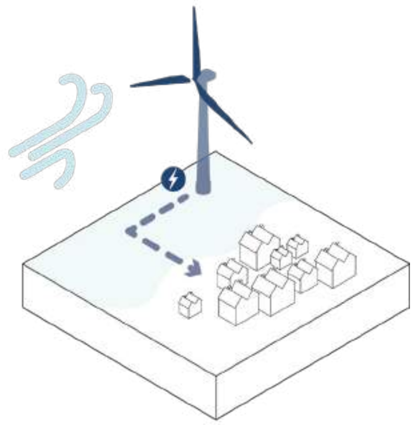
The Hammarby Sjöstad model shows that wastewater can be treated in multiple ways by recycling, in the end, the whole process is not only beneficial to human life but also to the natural cycle.

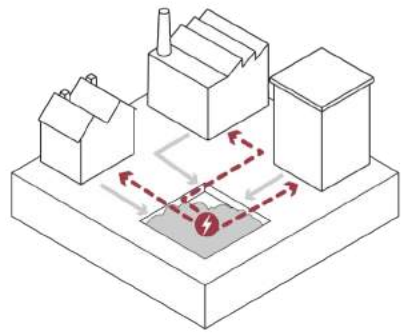
Spatial Interventions of RE System

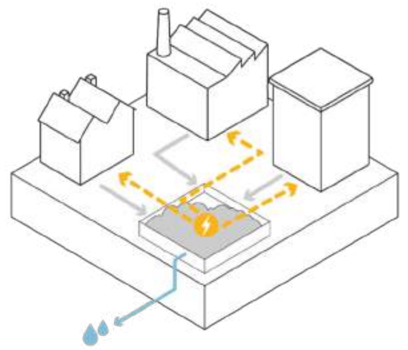

Asphalt heat collectors beneath road

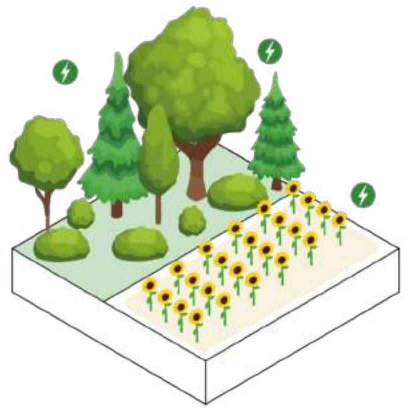

PV panels

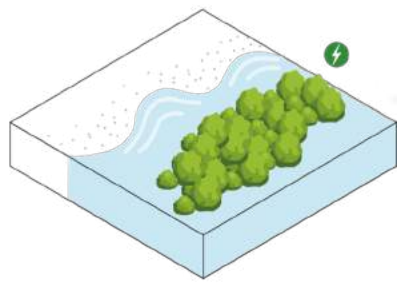

Small scale wind turbines

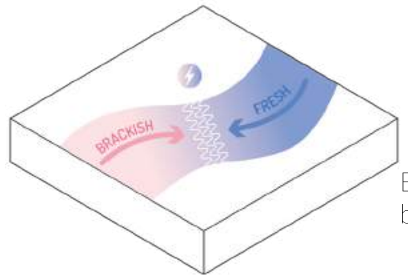

Large scale wind turbines


Heat from local waste


Heat/gas from wastewater treatment


Bioplant landscape


Algae farm



Blue energy: Membrane of brackish & fresh water

Based on the case studies and analysis, entire nine spatial interventions were selected. However, some of them (Blue energy) are not eligible for theproject site due to its scale.

Possible RE interventions will be describe in Design chapter.

Flora and Fauna of Green areas in Waalhaven

In Waalhaven, various plants and animals are living. I used 'Waarneming.nl' to make a species list and investigate what species have been found and dominant. By doing this, I was able to understand their habitat conditions and preference.

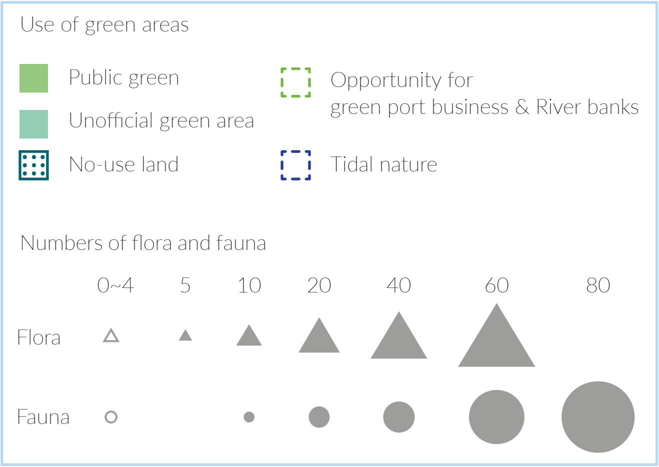
Fauna

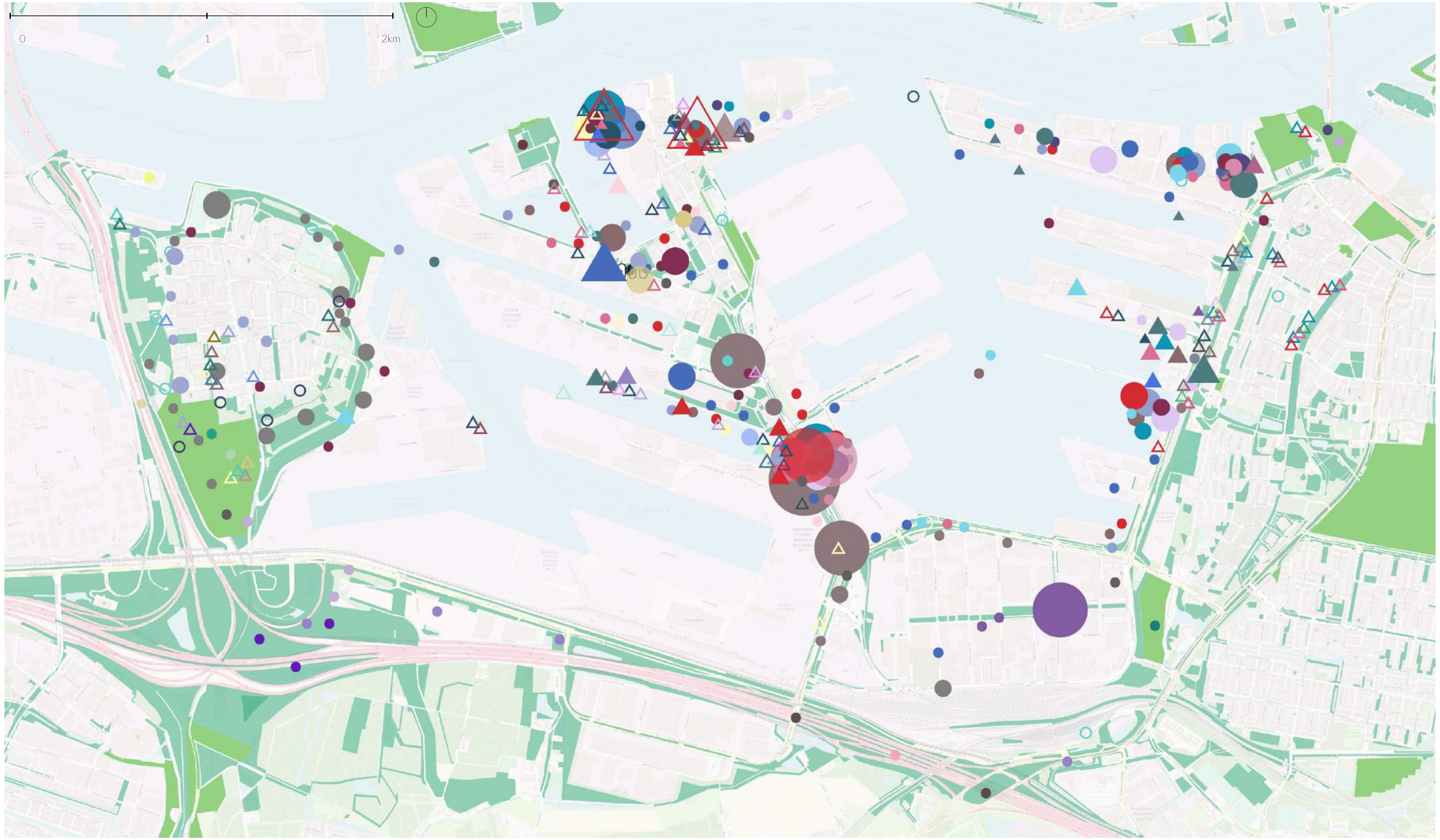
The most frequently observed faunas are birds and mammals. Few underwater species and insects have been found. Most insects are pollinators, such as butterflies and bees. Interestingly, they have been found alongside the unofficial green areas, a green buffer zone between industrial sites and roads because there are few green spaces due to industries.

Flora

A flora list contains trees, shrubs and thickets to observe natural vegetation gradient. However, most green spaces in Waalhaven are green buffer zone, and they are covered with mowed lawn and some trees. Furthermore, according to 'Waarneming.nl', many florae are trees, shrubs, and thickets are excluded from the list.

Figure. 15
Current green areas of Waalhaven and flora/ fauna species list and the numbers





Flora and Fauna list

Flora rare species

01. Amaranthus retroflexus
02. Anisantha tectorum
03. Asplenium scolopendrium
04. Caltha palustris subsp. radicans05.
06. Catapodium rigidum
07. Chaenorhinum minus
08. Crepis foetida
09. Echium vulgare
10. Epipactis helleborine
11. Galeopsis angustifolia
12. Gnaphalium luteoalbum
13. Lepidium ruderale
14. Lycium barbarum
15. Medicago arabica
16. Ononis repens
17. Parietaria judaica
18. Plantago coronopus
19. Potentilla intermedia
20. Potentilla supina
21. Saponaria officinalis
22. Silene conica
23. Saxifraga tridactylites
24. Sedum rupestre
25. Setaria viridis
26. Sisymbrium orientale
27. Torilis nodosa
28. Tripolium pannonicum
29. Ulmus glabra
30. Verbascum lychnitis
31. Verbascum nigrum
32. Vicia villosa
33. Xanthium orientale sl+Xanthium strumarium

Flora common species

01. Arabidopsis thaliana
02. Arenaria leptoclados + Arenaria serpyllifolia
03. Artemisia spec.
04. Artemisia spec.
05. Diplotaxis tenuifolia
06. Erigeron canadensis
07. Erodium cicutarium
08. Geranium pusillum
09. Geranium robertianum
10. Glechoma hederacea
11. Lamium amplexicaule
12. Lotus corniculatus
13. Hypochaeris radicata
14. Linaria vulgaris
15. Plantago lanceolata
16. Poa compressa
17. Polygonum aviculare
18. Prunella vulgaris
19. Pulicaria dysenterics
20. Rumex acetosella
21. Silene latifolia
22. Senecio vulgaris
23. Stellaria apetala
24. Taraxacum spec.
25. Urtica dioica
26. Veronica hederifolia
27. Viola arvensis

Fauna rare species

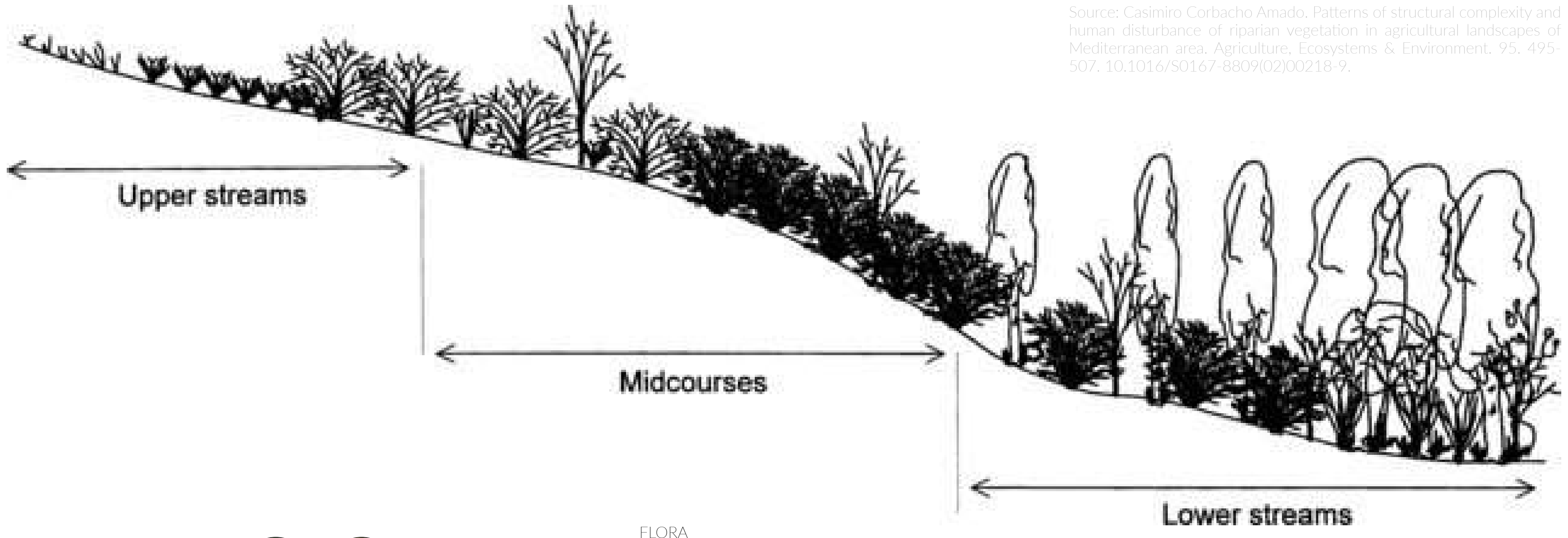
01. Buteo buteo
02. Ciconia ciconia
03. Corvus cornix
04. Crepis foetida
05. Cyprinus carpio
06. Falco peregrinus
07. Galeopsis angustifolia
08. Haematopus ostralegus!!!
09. Larus cachinnans
10. Larus michahellis
11. Motacilla cinerea
12. Oryctolagus cuniculus
13. Passer domesticus
14. Phalacrocorax carbo carbo
15. Phoenicurus ochruros
16. Stone marten
17. Nyctalus noctula

Fauna common species

01. Allium ursinum
02. Catapodium rigidum
03. Chroicocephalus ridibundus
04. Coloeus monedula
05. Cygnus olor
06. Falco tinnunculus
07. Fringilla coelebs
08. Fulica atra
09. Larus argentatus
10. Larus fuscus
11. Larus marinus
12. Linaria cannabina
13. Mareca strepera
14. Motacilla alba
15. Pipistrellus nathusii
16. Pipistrellus pipistrellus
17. Platichthys flesus
18. Podiceps cristatus
19. Spatula clypeata
20. Sturnus vulgaris
21. Turdus iliacus
21. Anthus prantensis
22. Aricia agestis
23. Corvus frugilegus
24. Ononis repens subsp. spinosa
25. Anguilla anguilla

*Waarneming.nl is the largest nature platform in the Netherlands.
*Species seen period is from 01.January.2015 to 01.January. 2021.
*The list include all species group but top 15 species are prioritized.

Natural Vegetation Gradient



Source: Casimiro Corbacho Amado. Patterns of structural complexity and human disturbance of riparian vegetation in agricultural landscapes of Mediterranean area. Agriculture, Ecosystems & Environment. 95. 495-507. 10.1016/S0167-8809(02)00218-9.

Figure. 16
Current green areas of Waalhaven and flora/ fauna species list and the numbers

Natural vegetation gradient means a plant community. The community has grown without any interventions from human and has been remained undisturbed for a long time. It controls erosion by protecting soils and riverbanks. Especially vegetation of riverbanks can reduce land degradation and salinity that will improve water quality and availability. Rich natural vegetation will provide habitats for local biodiversity and bring unique species.

The flora list of figure 17 will be useful to strengthen natural vegetation gradient. Plants are selected which are against pollution, tolerant to wind, and sandy/ loamy soils. The paltns are divided with four categories based on the vegetation gradient: wetland, grassland, shrubland, and forest

Figure. 17
Selected species in Waalhaven area
(Source: Francesca Mazza)

FLORA
Forest:
1. Quercus Robur
2. Salix Nigra
3. Populus x canescens
Shrubland:
4. Taxus baccata
5. Crataegus monogyna
6. Berberis vulgaris
7. Amelanchier rotundifolia
8. Rosa canina
9. Salix nigra
Grassland:
10. Helianthus rigidus
11. Brassica Juncea
12. Typha angustifolia
13. Phragmites australis
14. Lythrum salicaria
15. Hypericum calycinum
16. Phalaris arundinacea
17. Chrysopogon zizanioides
Wetland:
(Underwater plants)
18. Ranunculus aquatilis
19. Hottonia Palustris
20. Callitriche palustris
21. Elodea canadensis
(Plants with floating leaves)
22. Eichhornia crassipes
23. Patamogeton natans
24. Polygonum amphibium
25. Phragmites australis
(Floating plants)
26. Stratiotes aloides
27. Ceratophyllum demersum

FAUNA - Target species (endangered)
29. Rabbit - Oryctolagus cuniculus
30. EU Eel - Anguilla anguilla
31. Bone - Platichthys flesus
32. Carp -Cyprinus carpio
33. Common Coot - Fulica atra
34. Meadow Pipit - Anthus pratensis
35. Bumble bee - Bombus
36. Redwing - Turdus iliacus
37. Noctule bat - Nyctalus noctula

Current Environmental Situation of Habitats in Waalhaven

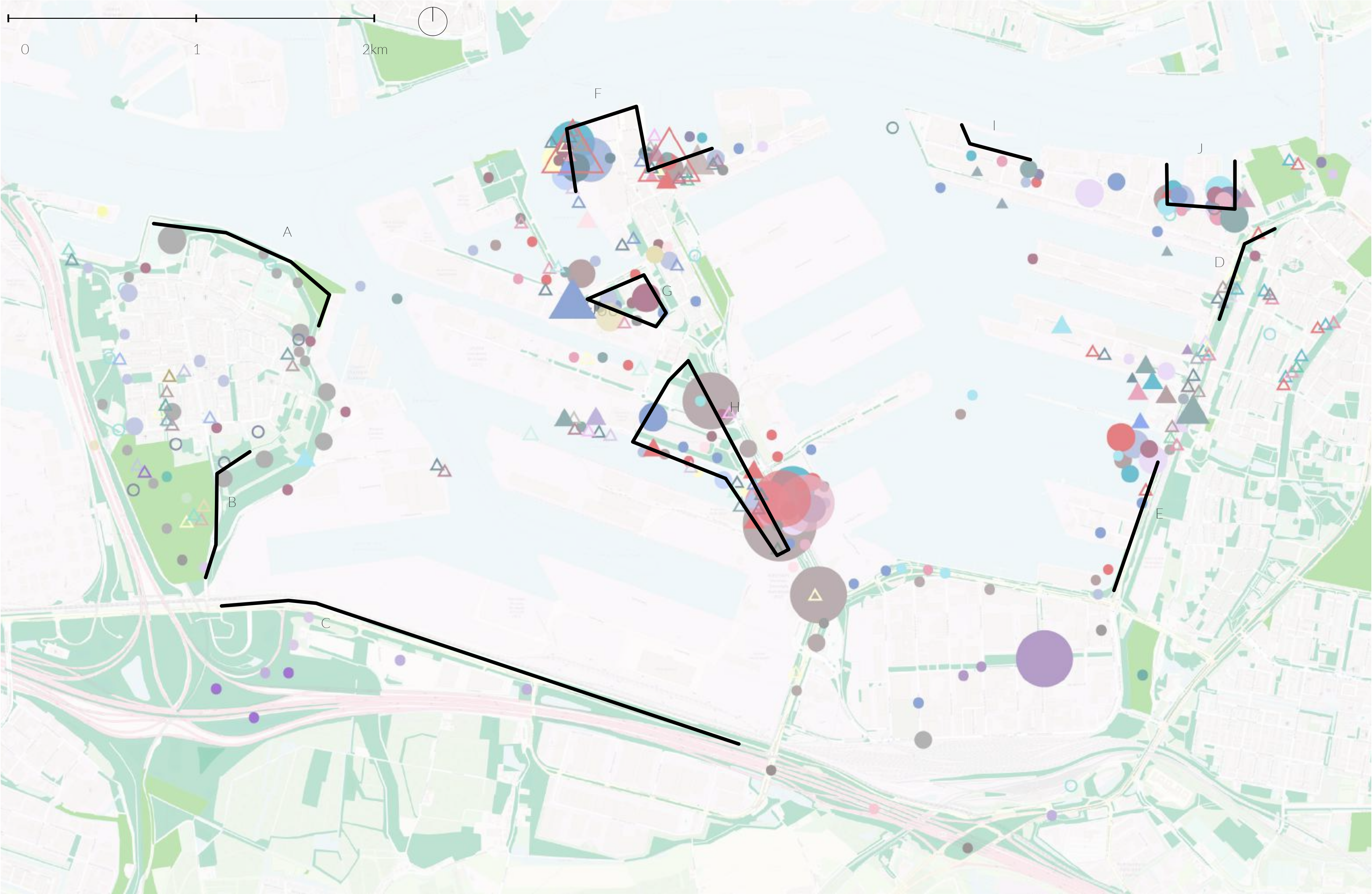
Based on Natuurkart (Gemeente Rotterdam, 2014), there are 14 natural typologies in Rotterdam. However, Waalhaven has four typologies: dry ribbon, the opportunity for green port businesses and riverbanks, and tidal nature. When I overlayed the typologies and the species map, I found they are correlated. Hence, I analysed current environmental situations which surround habitats by an excursion.

From A to F are linear green areas. Since A and B are close to the residential areas, they are adjacent to the public green, allowing them to embrace more diverse landscapes. However, C and D are green buffer zones between roads, railways, and industrial sites. Therefore, and environmental situation is very harsh for biodiversity due to lack of hiding spaces and noise/ air pollutions. E and F are waterfront areas in industrial zones. 70% of them are covered with urbanised embankments and quays from the construction of harbours and industries(De Urbanisten and Strootman Landschaps Architecten, 2016), which can prove that anthropocentric activities could have degraded soil quality. Furthermore, the surrounding areas are covered with impermeable pavements.

G is Heijplaat, a residential area, and has several natural areas such as lakes and unofficial green areas. However, most of them are less-use. Since many small scales, green areas are not in use, if they would be changed into public green areas, Heijplaat has many potentials to be more biodiverse.

H and I are industries and logistic blocks. Green buffer zone locates alongside roads, disused railways and bike lanes.

In conclusion, most habitats have low vegetation level, and over 50% of them are covered with impermeable pavements.



Use of green areas

- Public green
- Unofficial green area
- No-use land
- Opportunity for green port business & River banks
- Tidal nature

Numbers of flora and fauna

	0–4	5	10	20	40	60	80
Flora	△	▲	▲	▲	▲	▲	
Fauna	○		●	●	●	●	●

Selected Species from the Fauna List

Among the fauna species, I selected eight animals that are registered as endangered species in IUCN. Their extermination threat degree is from 'Nearly Threatened' to 'Vulnerable' on a European scale. Some of them are common species in the Netherlands; however, they have been threatened in other countries.

Some of them are beneficial to the environment. For example, Oryctolagus cuniculus can enhance soil fertility by digging a hole. When they improve the soil quality, it can be an opportunity to introduce other animals and plants.

NT Rabbit - Oryctolagus cuniculus

CE EU Eel - Anguilla anguilla

LC Bone - Platichthys flesus

VU Carp - Cyprinus carpio

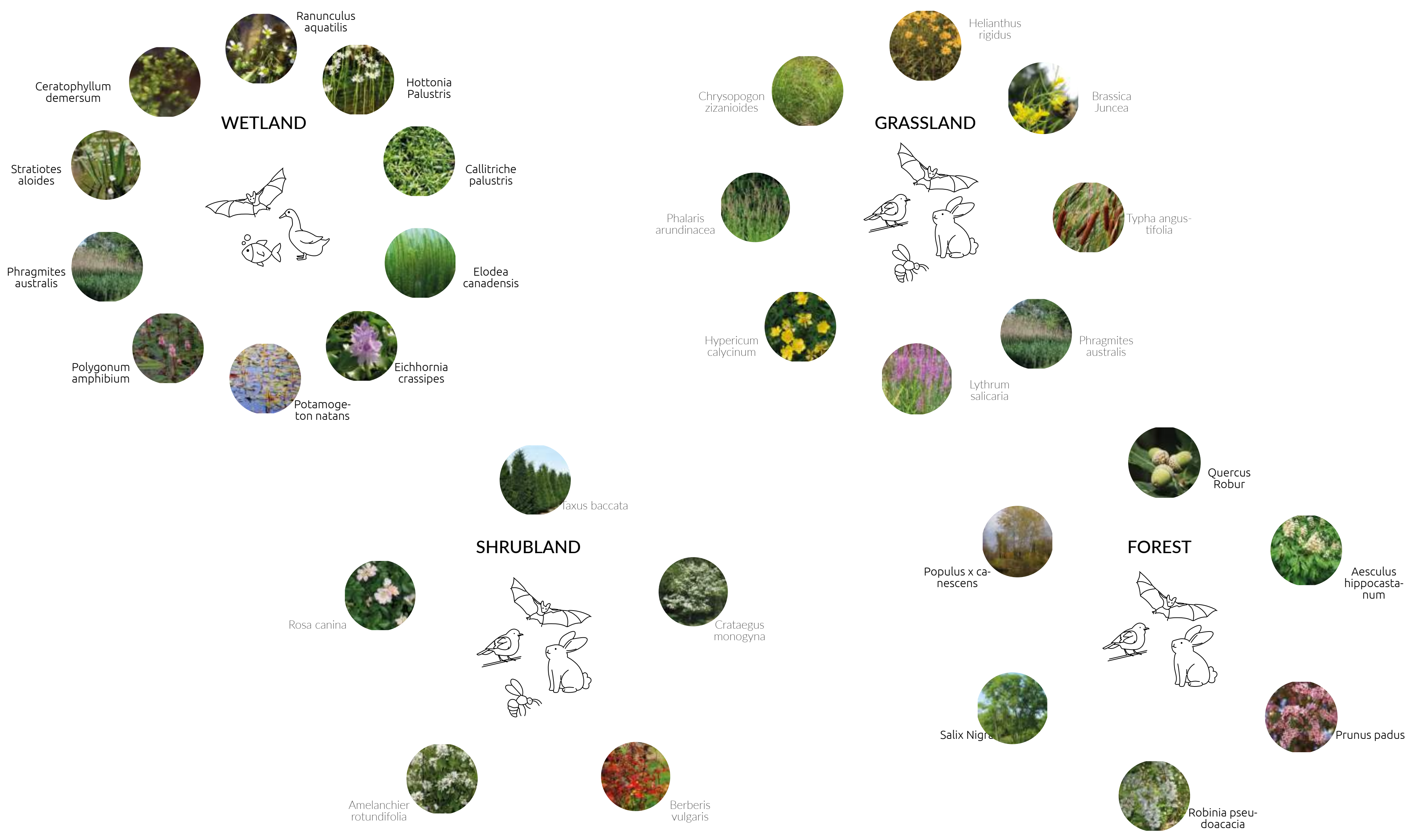
NT Common Coot - Fulica atra

NT Meadow Pipit - Anthus pratensis

NT Redwing - Turdus iliacus

LC Noctule - Nyctalus noctula

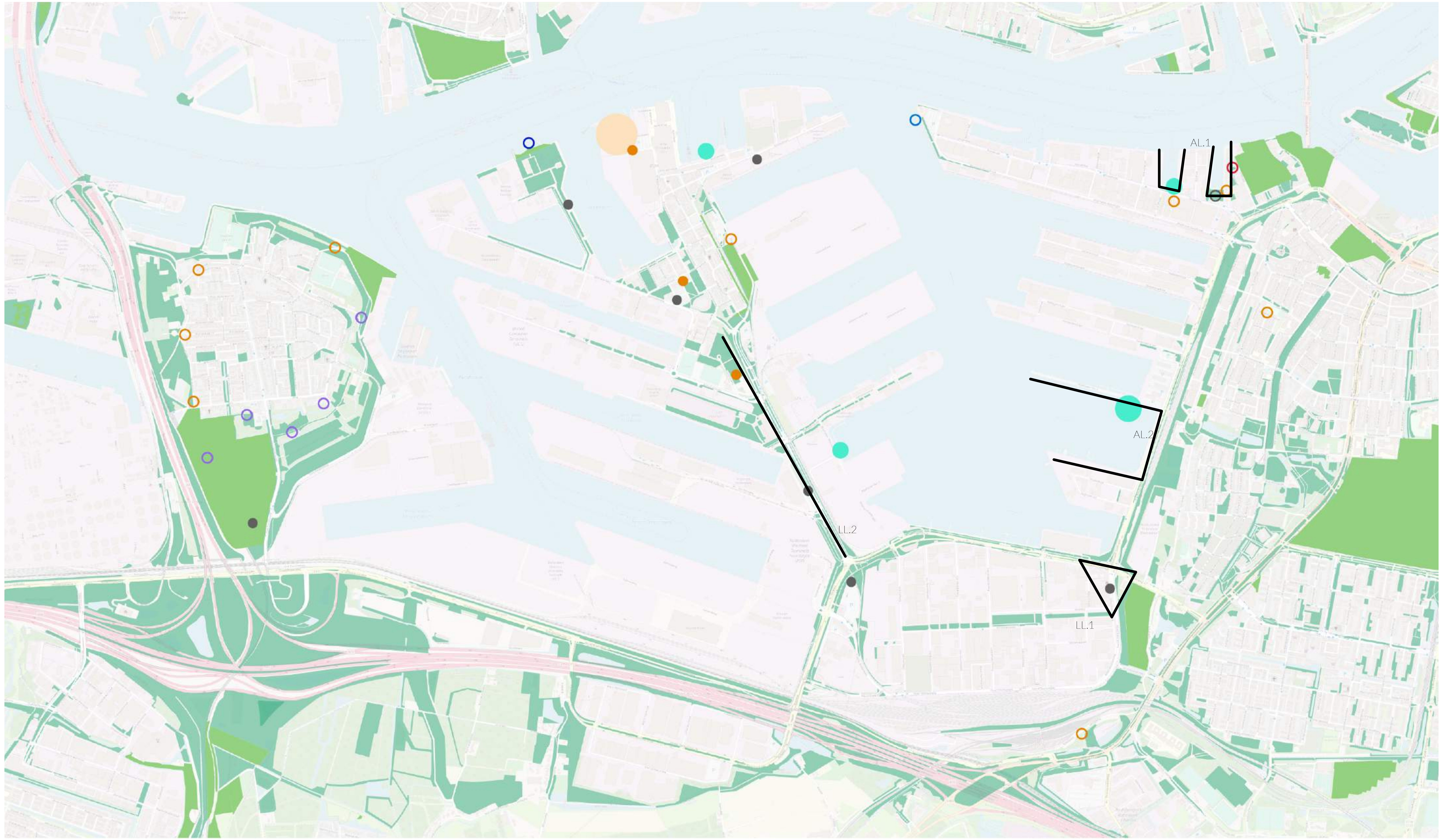
Figure. 18
Flora species for each area and for fauna

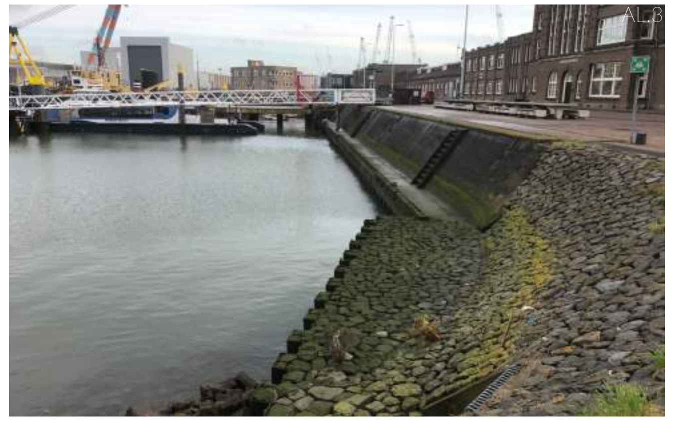


NT : Near Threatened
CE : Critically Endangered
LC : Least Concern
VU : Vulnerable
*European scale

Current Environmental Situation of Selected Species Habitats

Figure. 19
LL: Linear landscape
AL: Artificial waterfront landscape
NL: Natural waterfront landscape



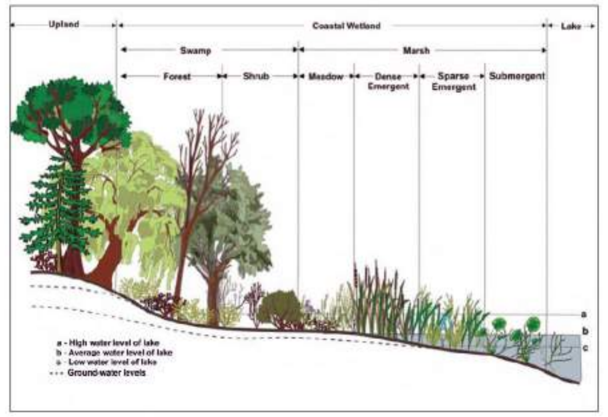


Spatial Interventions

To improve the current environmental problems, low vegetation level and impermeable pavements, Waalhaven needs to increase natural vegetation gradient. However, current Waalhaven plant species are not diverse and are not enough to make rich gradience. As shown before (Figure 17), 29 plant species are divided into four categories based on the wetland gradient. The selected flora species can make an ideal ecosystem by being a provision or as hiding spaces.

The aforementioned selected flora/ fauna species and wet/dry gradient can be realized by following spatial interventions. Most of them are focused on improving the quality of the ecosystem, but the benefits can be shared with human.

Since the spatial interventions require a different scale and period, they worked as an approximate guide.



Source: Douglas A. Wilcox, Todd A. Thompson, Robert K. Booth, and J.R. Nicholas - USGS Document, Circular 1311, Lake-Level Variability and Water Availability in the Great Lakes

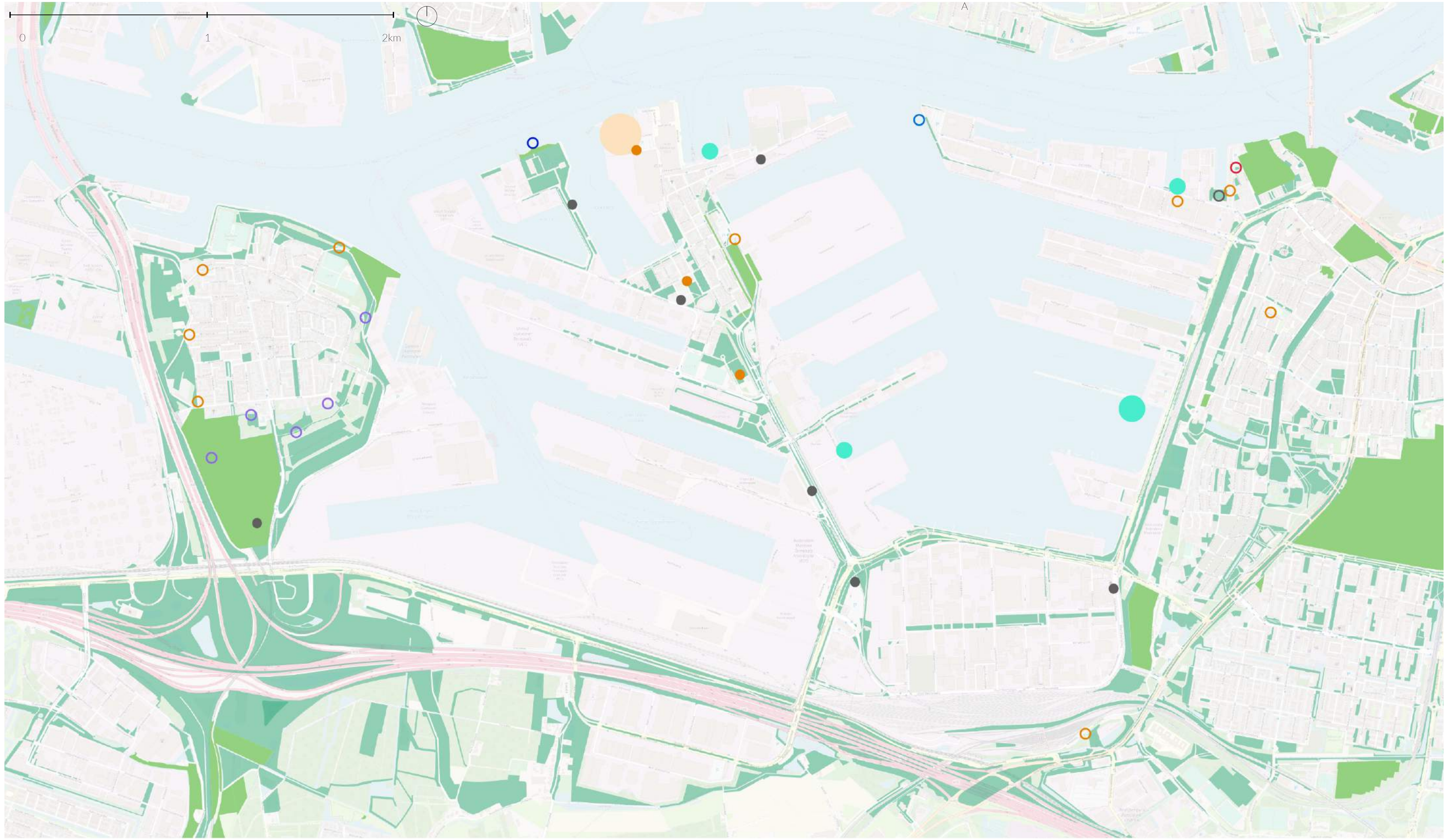


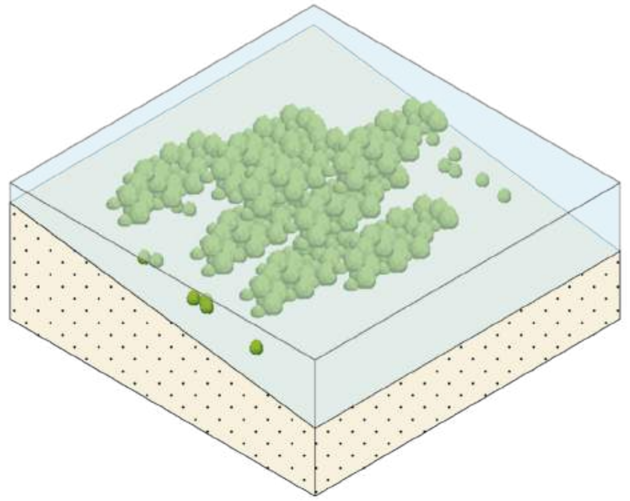
Figure. 20
Location of spatial interventions

Selected species

- Rabbit - Oryctolagus cuniculus
- EU Eel - Anguilla anguilla
- Bone - Platichthys flesus
- Carp - Cyprinus carpio
- Common Coot - Fulica atra
- Meadow Pipit - Anthus pratensis
- Redwing - Turdus iliacus
- Noctule - Nyctalus noctula

A. Bioswale

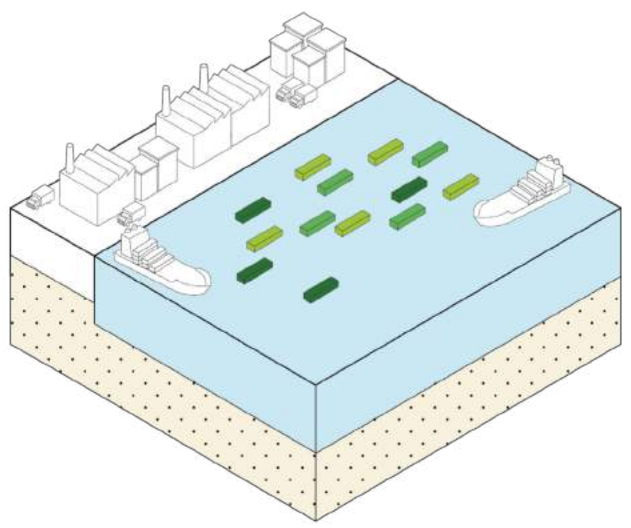
- can lower speed and filter stormwater runoff by rooting out pollutants and contaminants (Feit, 2018).
- can be used in any site (parking lots, streets...) by incorporating local plants.
- require low maintenance and costs.
- can offer aesthetic values.



B. Waterplant

- can hold sediments and reduce soil erosion which helps to grasp algae growth.
- can provide habitats and food sources

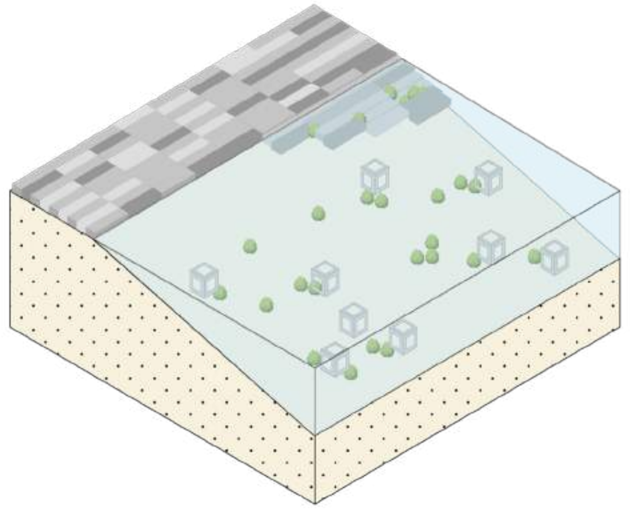
Spatial Interventions



C. Hanging/ floating structure

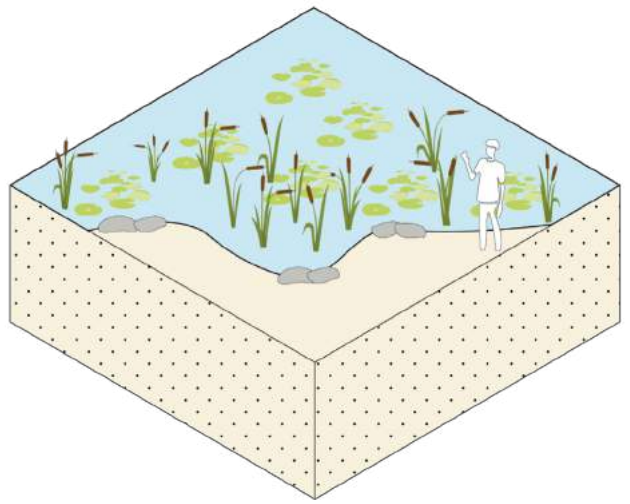
- can control wave attenuation and offer artificial substrates for creating habitats (Paalvast, 2007).
- can develop underwater biodiversity by increasing the population of plants (Paalvast, 2015).
- Will be settlements for algae, mussels, and sponges.

*These structures have already applied to port areas in Rotterdam with different types, as the harbour areas usually have artificial infrastructures.



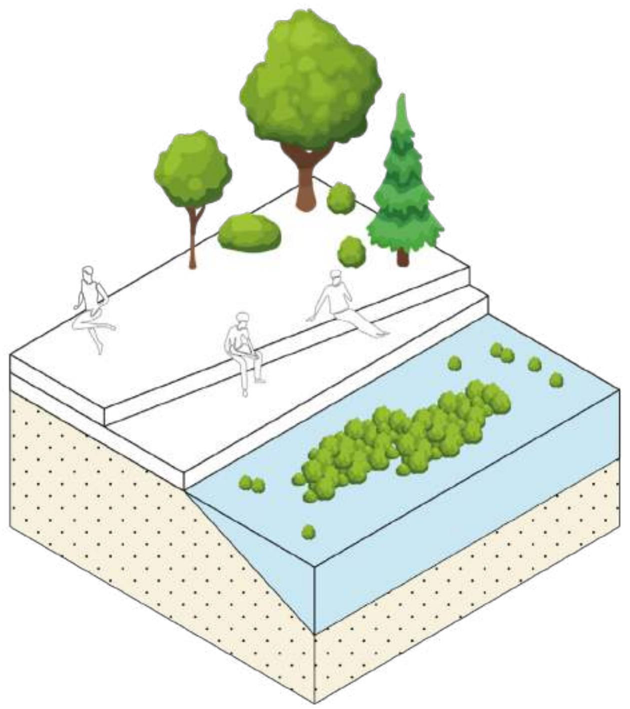
D. Rich revetments

- help algae, seagrass, corals, and other organisms to settle and grow, becoming a food source that attracts shellfish, fish, and birds
- provide habitats with spatial niches such as cracks and holes of revetments
- improve water quality and can be used for an educational purpose



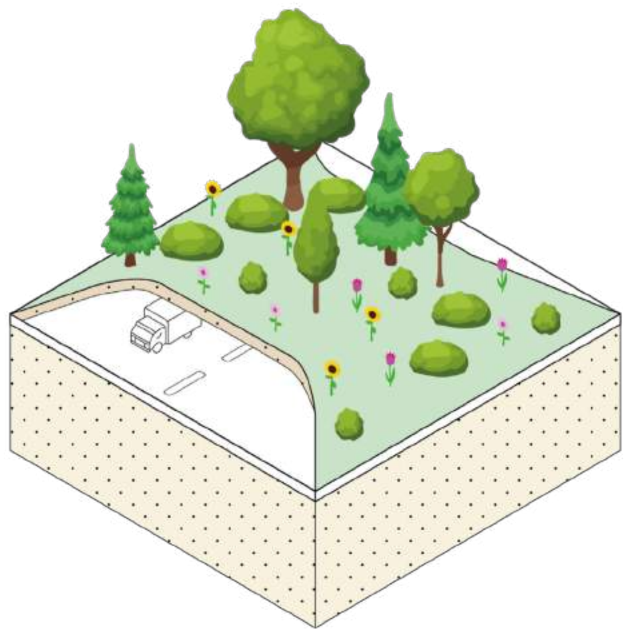
E. Helophyte pond

- can purify the polluted water from industries.
- can accept different types of plants (emergent, floating or submerged).
- can provide habitats and food for organisms.
- can release and transport oxygen (Stottmeister et al., 2004)



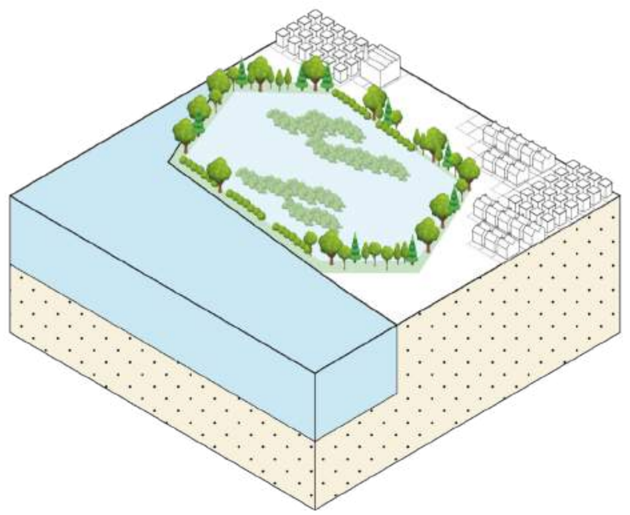
F. Urban promenade

- provide public spaces for residents.
- can achieve the role of waterscape by increasing the ecological and recreational benefits of the city.



G. Eco-bridge

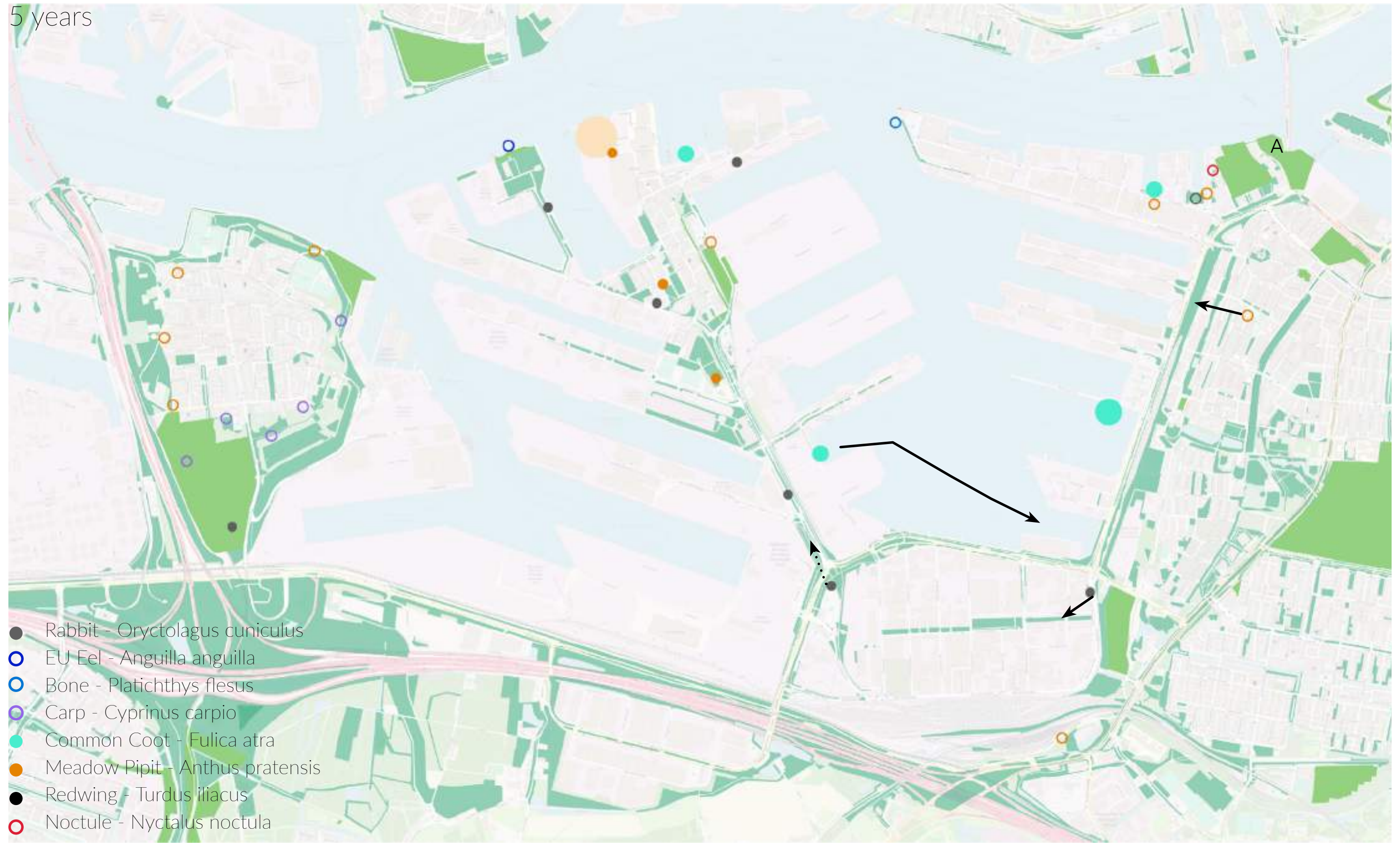
- connect wildlife that was separated by hard infrastructures.
- allow animals to over pass and increase the chances of pollination and dispersion (Wang et al., 2021).
- can prevent genetic isolation of fragmented biodiversity (Natural England, 2015).

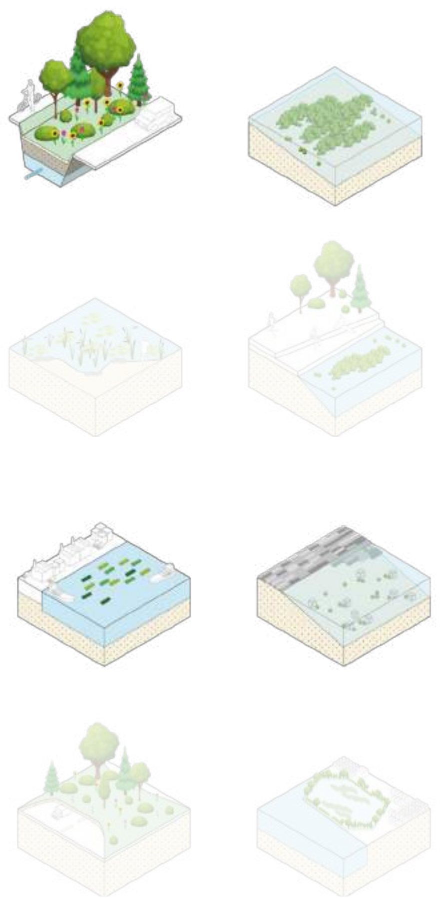


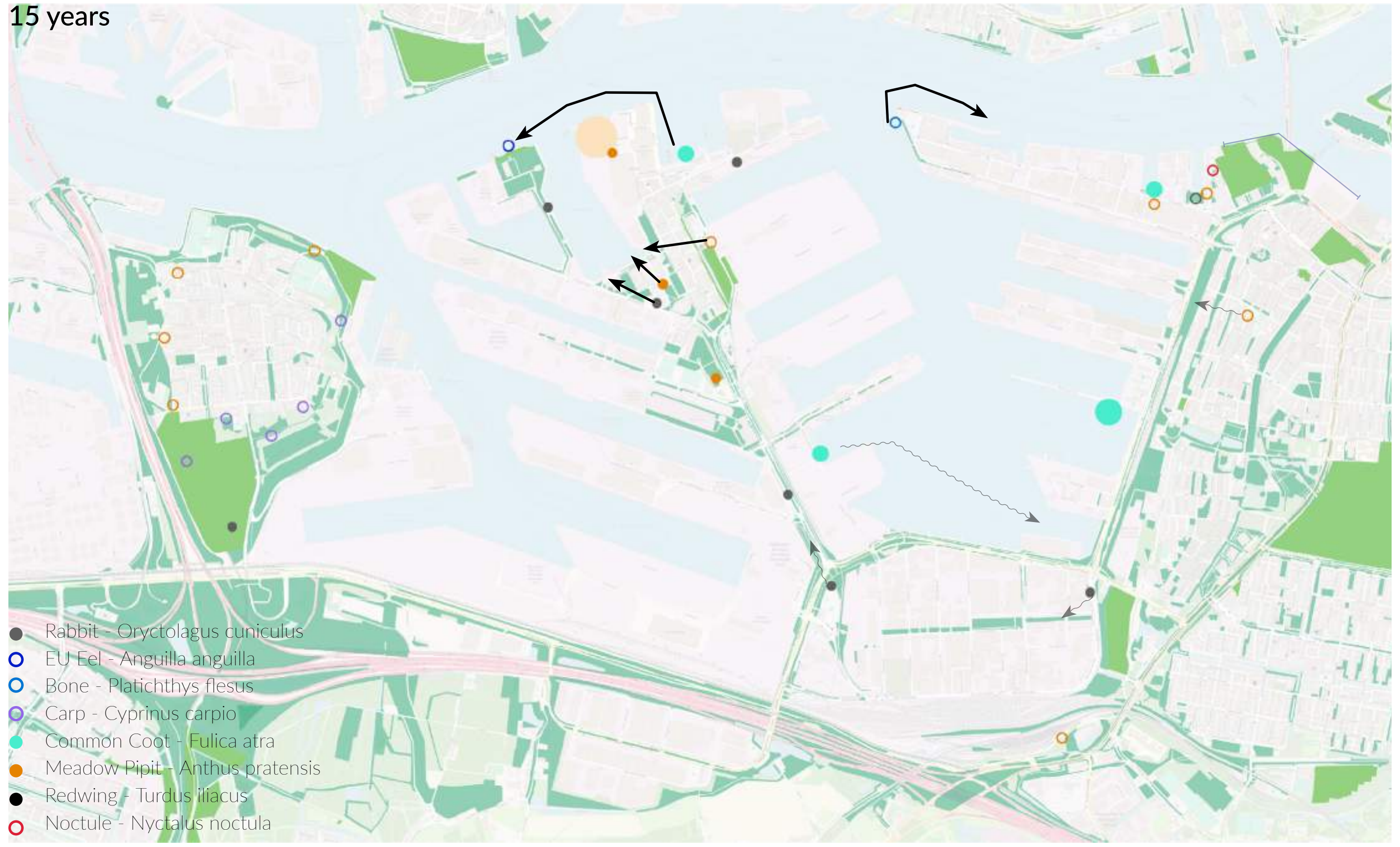
H. Inland buffer zones

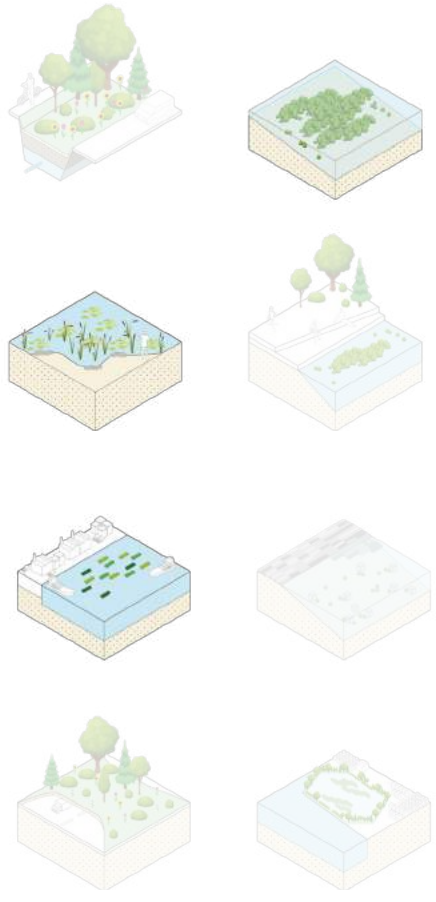
- can hold stormwater surpluses
- control water levels during flooding and shortage
- provide open space, recreational values for fishing and aquaculture, experiments on floating developments and sustainable energy production
- are possible along with large water bodies where the water level is higher than the hinterland
- use renewable energy sources for pumping water back into the water body and for controlling the water level fluctuation in the inland shore

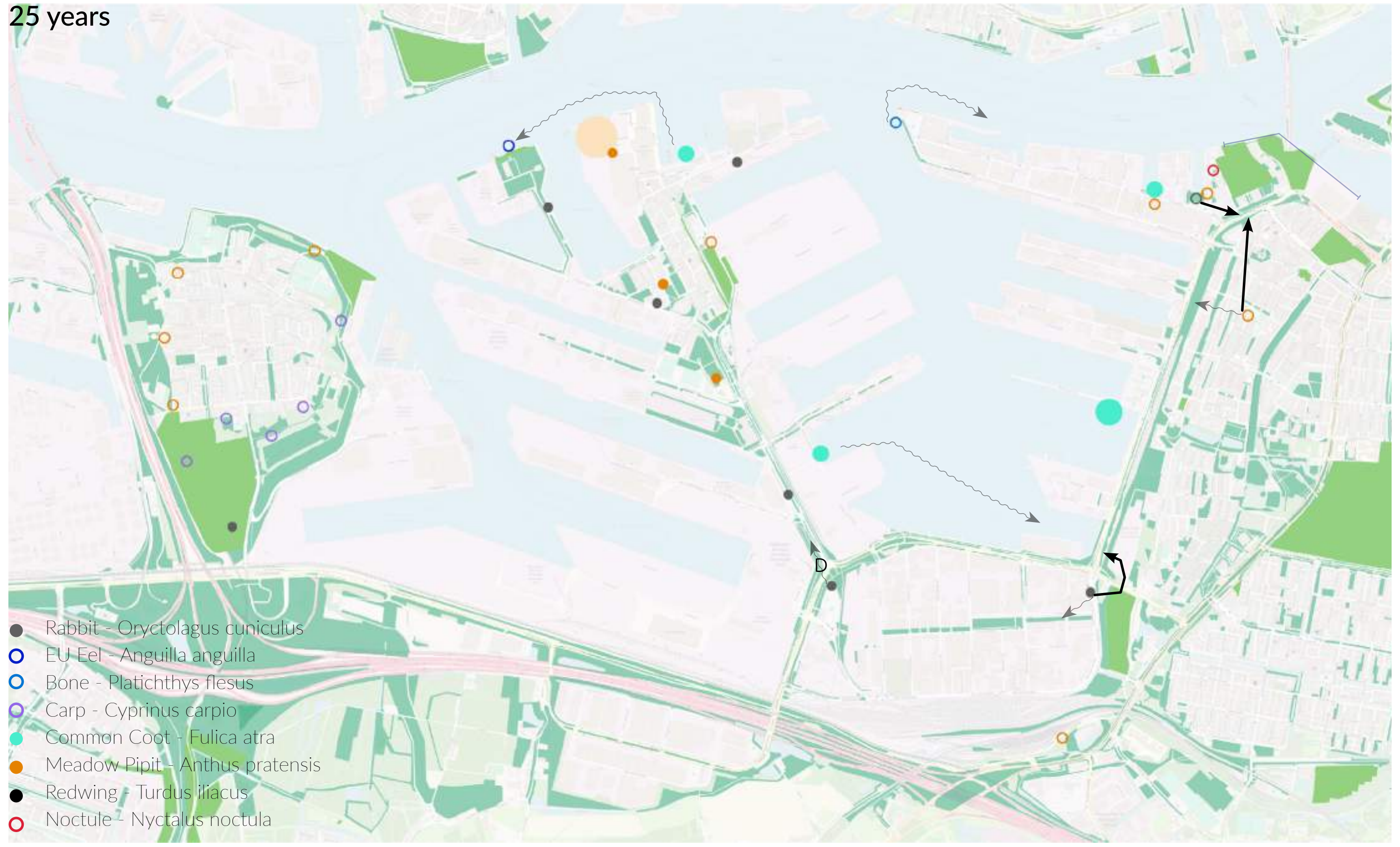
Fauna Movement

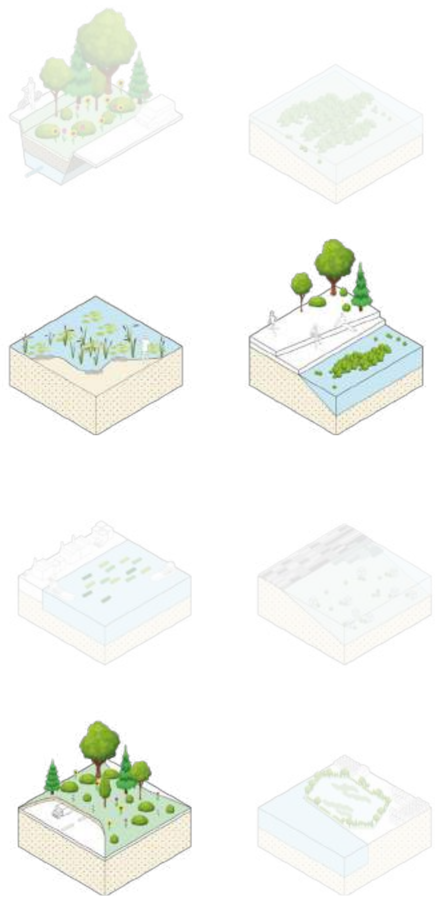












DESIGN

Target Areas Selection

Eight target areas are the hotspots of faunas in Waalhaven. They are chosen based on analysis of biodiversity, landscape typologies, and RE systems. Some of them included Pernis, Heijplaat, and Oud-Charlois. These neighbourhoods are in the administrative boundary of Waalhaven.

Target areas with light blue lines cover residential/ industrial areas that include public green spaces (e.g. park and forest). On the other hand, target areas with red-dotted lines have linear typologies that include inofficial green spaces such as buffer zones (see figure.00).

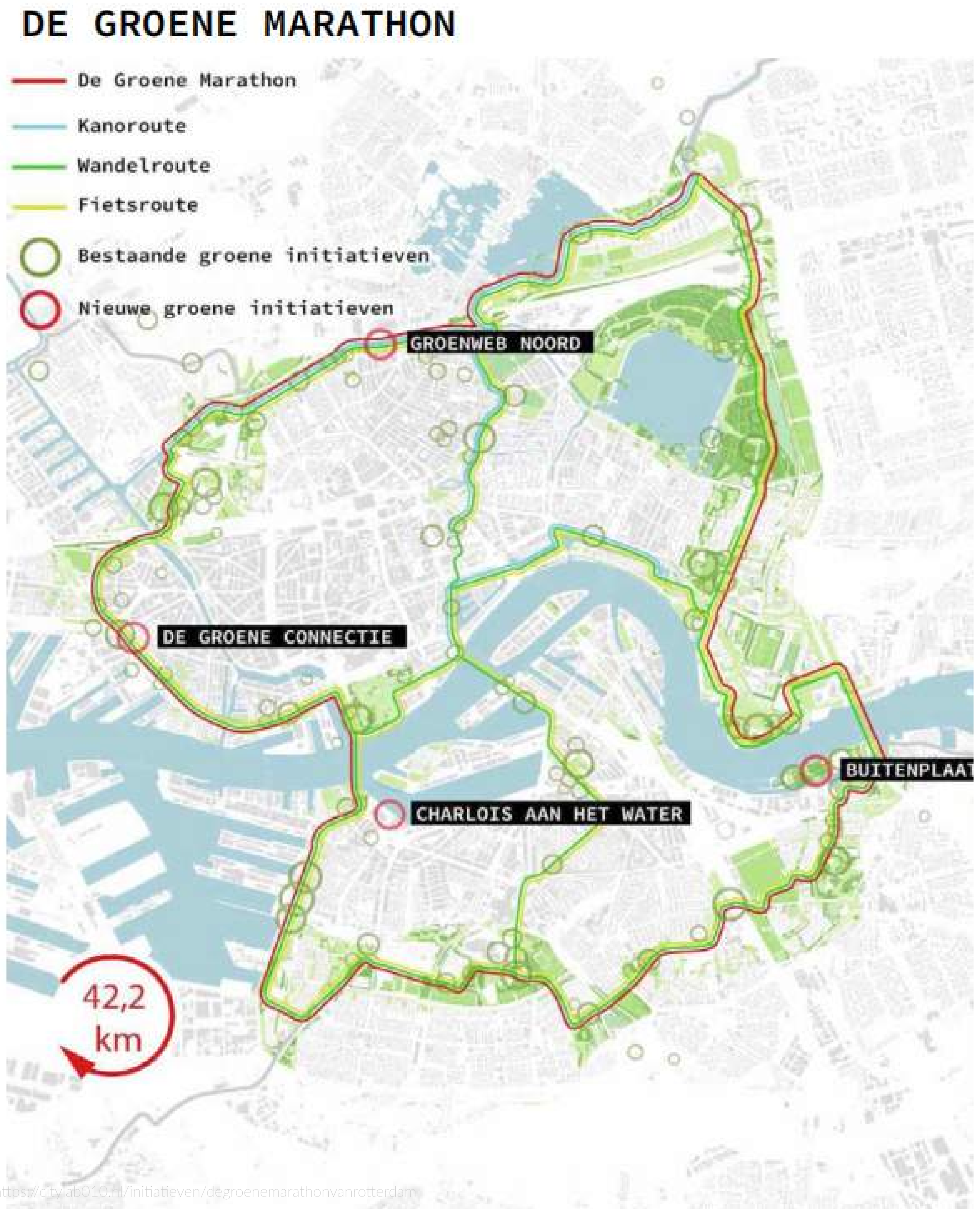
Most of them are adjacent to the riverside and are highly related to the green harbour and riverbanks project of the Rotterdam Municipality. Especially riverside of Waalhven is approximately 33km, and 70% of riverbanks are impermeable due to stone embankments and quays (De Urbanisten and Strootman Landschaps Architecten, 2016). Furthermore, Waalhaven is a logistic hub that requires high transportation and urbanization, and the riverbanks are four meters above sea level due to accretion.

Source: Landscape framework (2016) Strootman Landschapsarchitecten

Among the eight target areas, I chose Oud-Charlois (a red-dotted line on the right) for two reasons. First, from the perspective of biodiversity, the area is a part of the green harbour and riverbank project. If the target area turns into a more green place, it can be a hotspot of selected eight animals. The environmental quality will be improved, then more faunas and florae from Zuider park of Charolois can be introduced. Significantly, the target area is a part of DE GROENE MARATHON, which aims to connect the green areas of Rotterdam to enhance the recreational value of nature. It correlates to the graduation project aim.

Second, in terms of RE, the target area is close to local plants such as a wastewater treatment plant and incineration plants. Furthermore, the area includes a junction of transportation, which means that many industries require much electricity for transportation and production. Therefore, nearby industries will leave fewer carbon footprints if the area turns into an energy resource-producing spot.

"The Green Marathon ***connects the green*** *parts of the city into a permanent* ***recreational nature*** *route..." (Gementee Rotterdam)*



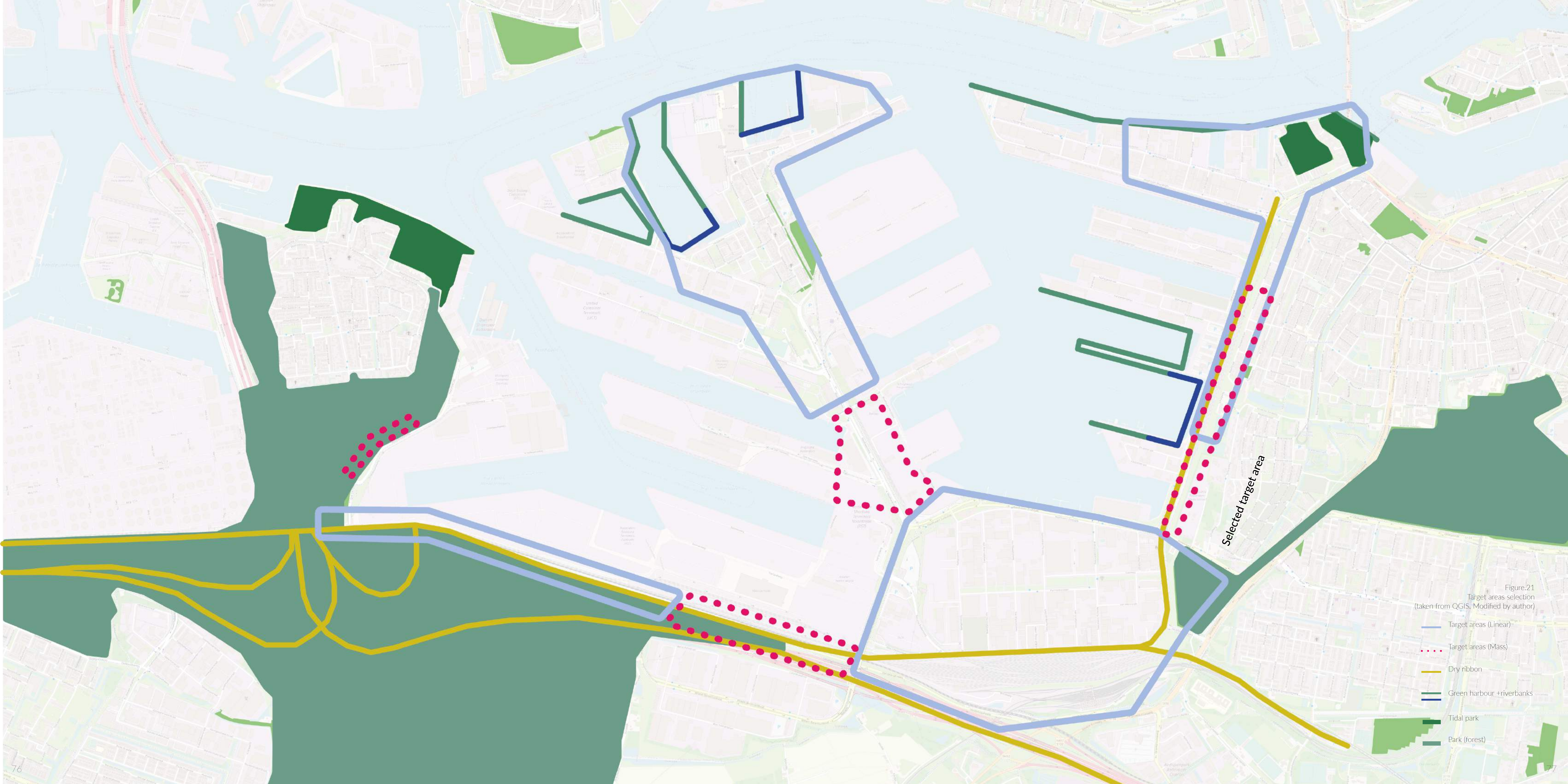


Figure.21
Target areas selection
(taken from QGIS. Modified by author)

Locations of Spatial Interventions

Through site visit and spatial analysis, I understood that Waalhaven has a low natural vegetation gradient which can weaken biodiversity and is not easy to access. Compared to the centre of Rotterdam, where the river and banks are easy to access from everywhere, the port area on the south between the Maashaven and the point where the Oude Maas and the Nieuwe Maas meet is not accessible (De Urbanisten and Strootman Landschaps Architecten, 2016). Therefore, spatial interventions will be installed following locations to increase the level of green and attract people.

A.1 is an industrial area. It is close to a residential area, Oud-charlois. The centre of A.1 has two spacious green areas which are not used. However, A.1 is accompanied by a continuous cycle/ pedestrian path. If this place can be connected to Dokhavenpark, it will bring more people as a linear park.

A.2 is a place where the RDM campus is located. This area has many initiative and circular industries and produces energy with PV panels. Significantly, the corner of A.2 is a hotspot of meadow pipit. However, the point is covered with impermeable pavements and fewer spaces for green. It is also the same at A.3. A.3 is a part of the Green harbour and riverbank projects of Rotterdam municipality (Natuurkaart, 2014). Currently, the riverbank is occupied by industrial infrastructures. The green buffer zone has only grass, so it does not navigate animals.

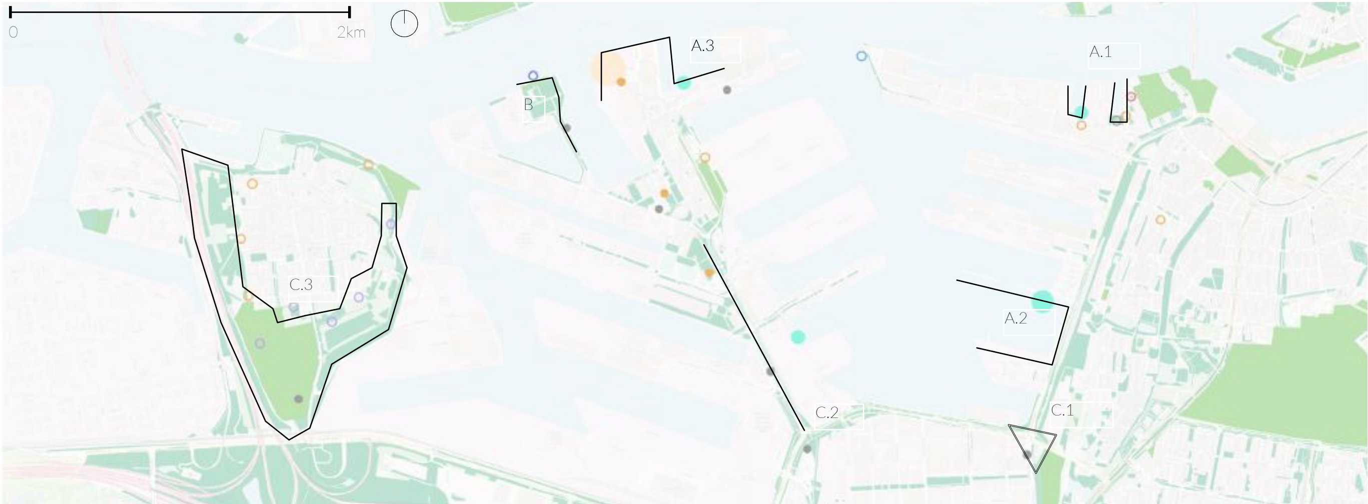
B is a Quarantaine-Terrein. B has a natural beach which is the only one in Rotterdam. Fortunately, this area is keeping as a historical site; the environment and natural vegetation gradient are in good condition compared to other areas.

C.1 is at a crossroads. Southeast of C.1 is Volkstuinvereniging De Wielewaal which is a community garden . Hence, it is assumed that the community garden will introduce more biodiversity. Also, European rabbits have often been found southwest. In this respect, C.1 has many potentials to be biodiverse. However, there is no infrastructure for the connection. If C.1 works as a connection of Volkstuinvereniging De Wielewaal and the southwest, the animals will move their habitats to a safer place, Waalhaven.

C.2 has pedestrian road, roadway, bike lane, buffer zone and railway. The railway is not used any longer. If the railway and buffer zone are integrated, they will work as navigators for animals to a Quarantaine-Terrein.

C.3 is a residential area, Pernis. Compared to Waalhaven, the neighbourhood has a higher natural vegetation gradient.

*The next page shows how this area can be changed with spatial interventions by integrating RE and BD.



- Rabbit - Oryctolagus cuniculus
- EU Eel - Anguilla anguilla
- Bone - Platichthys flesus
- Carp - Cyprinus carpio
- Common Coot - Fulica atra
- Meadow Pipit - Anthus pratensis
- Redwing - Turdus iliacus
- Noctule - Nyctalus noctula

A.1


A.1


A.1. No-use green area


A.1. Dokhavenpark (Now)
Source: Nimh-beeldbank.defensie.nl object 2011-0066 Homepage nimh-beeldbank.defensie.nl


A.2


A.2


A.3

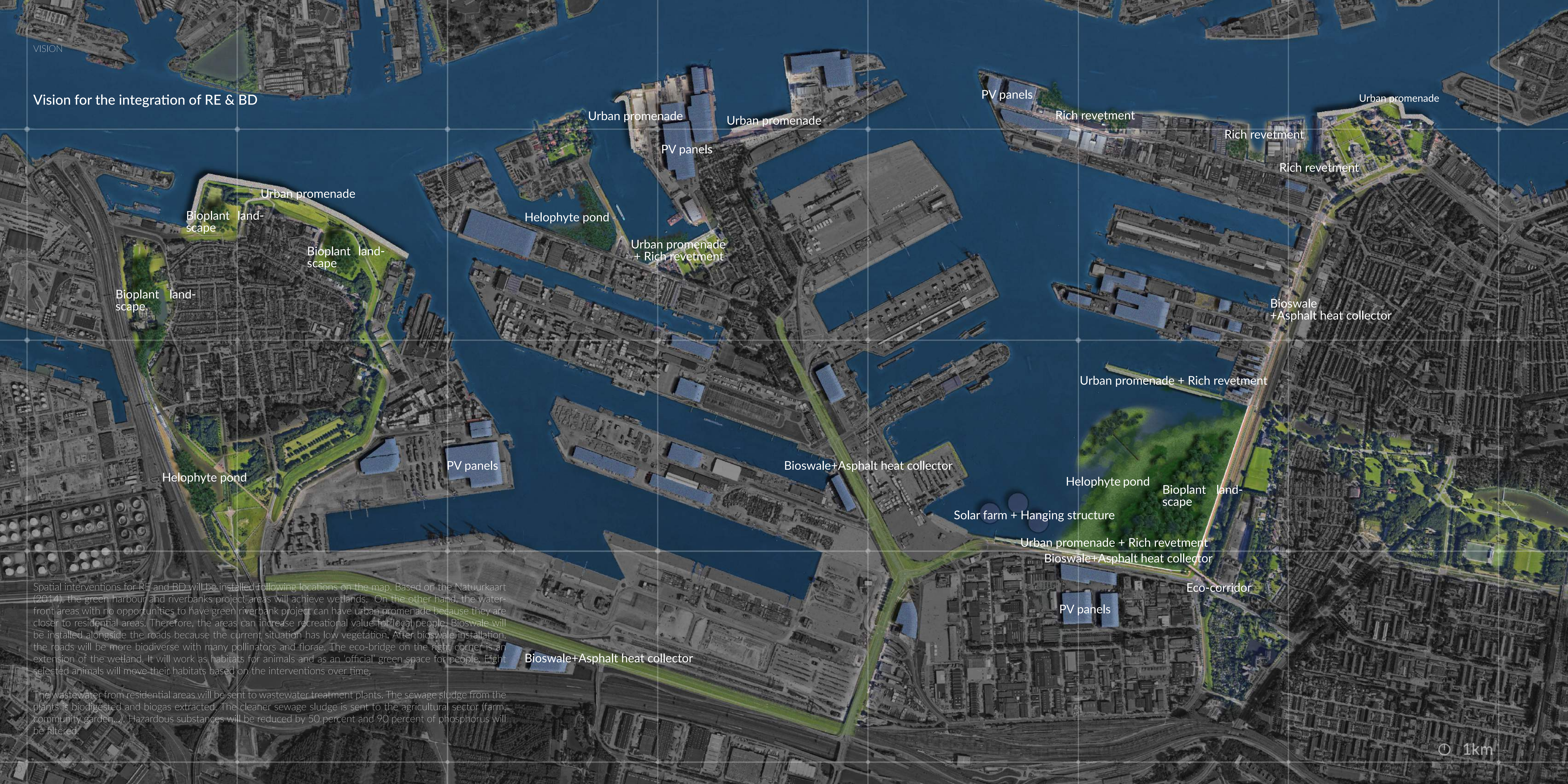

B


C.1


C.2


C.3


Vision for the integration of RE & BD

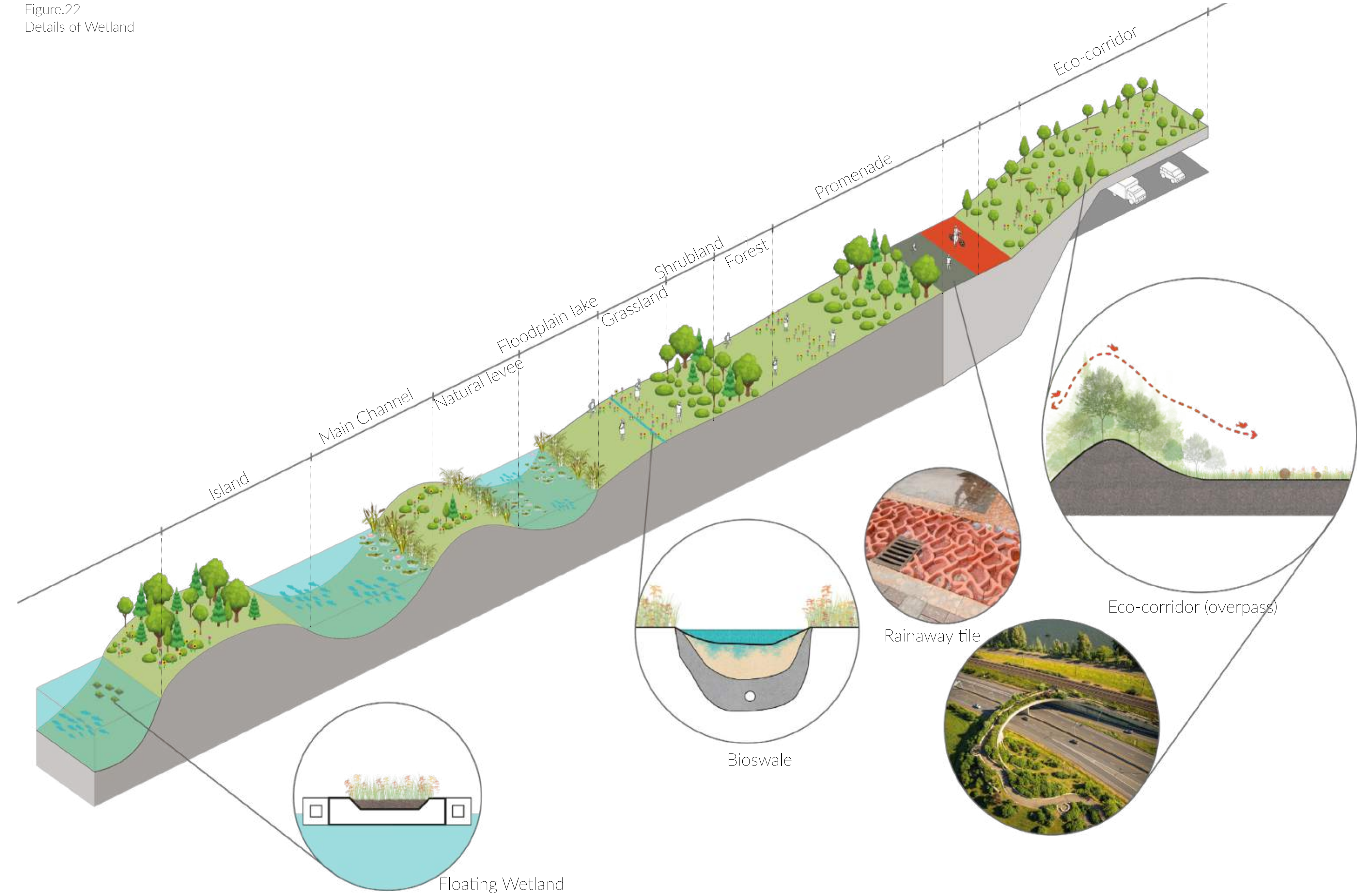


Spatial interventions for RE and BD will be installed following locations on the map. Based on the Natuurkaart (2014), the green harbour and riverbanks project areas will achieve wetlands. On the other hand, the waterfront areas with no opportunities to have green riverbank project can have urban promenade because they are closer to residential areas. Therefore, the areas can increase recreational value for local people. Bioswale will be installed alongside the roads because the current situation has low vegetation. After bioswale installation, the roads will be more biodiverse with many pollinators and florae. The eco-bridge on the right corner is an extension of the wetland. It will work as habitats for animals and as an ‘official' green space for people. Eight selected animals will move their habitats based on the interventions over time.

The wastewater from residential areas will be sent to wastewater treatment plants. The sewage sludge from the plants is biodigested and biogas extracted. The cleaner sewage sludge is sent to the agricultural sector (farm, community garden...). Hazardous substances will be reduced by 50 percent and 90 percent of phosphorus will be filtered.

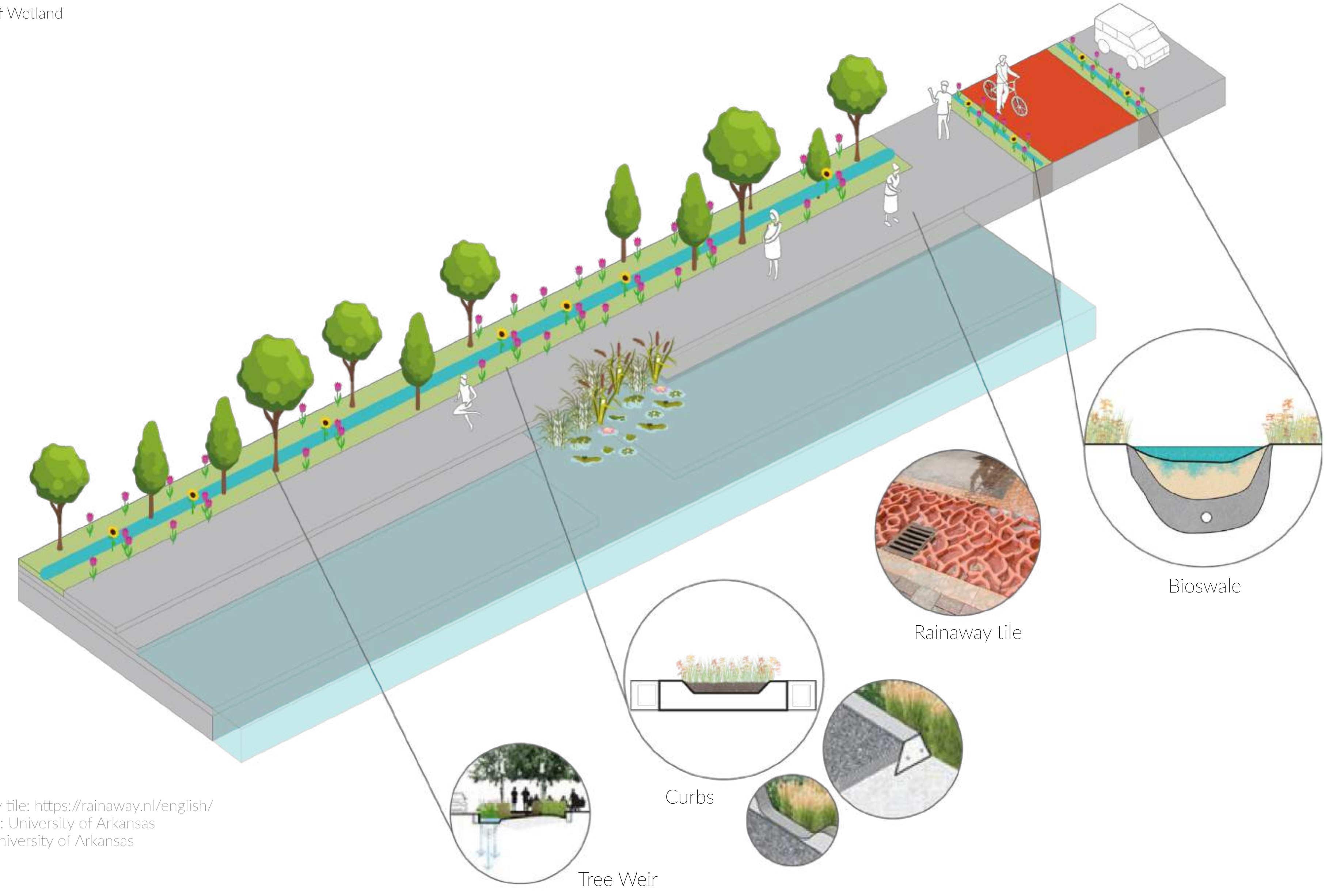
Design for RE & BD

Figure.22
Details of Wetland



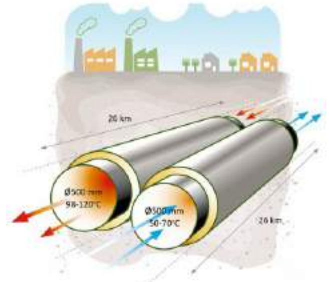
Source
Rainaway tile: https://rainaway.nl/english/
Vancouver land bridge: https://land8.comland-bridge-is-an-ecological-masterpiece/

Figure.23
Details of Wetland



Source
Rainaway tile: https://rainaway.nl/english/
Tree weir: University of Arkansas
Curbs: University of Arkansas

Figure.24
Details of heat network
Asphalt heat collector will join at 3: the Waal-Eemhaven area



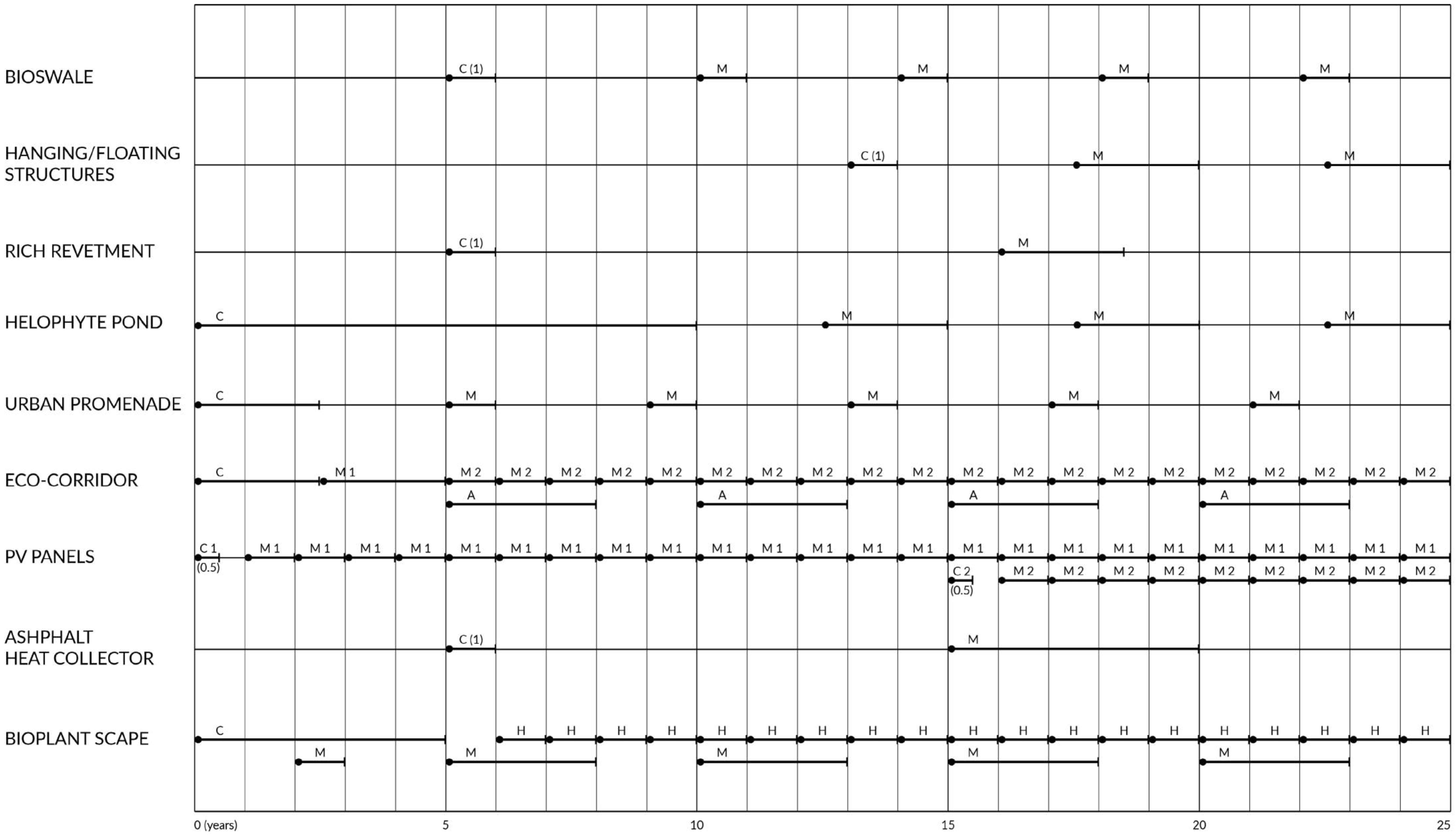
Source: Warmtebedrijf Rotterdam

Figure.25
Ecological bridge
The logs navigate animals to a safer place

Figure.26.
Dryland hill is a bio plant landscape where sunflowers and rapeseeds can grow. Reducing (car) roads offer broader pedestrian ways and bike lanes.

Figure.27.
Part of wetland. Solar farms are behind the island.

Design for RE & BD



C - Construction
M - Maintenance (might be different per interventions)
H - Harvest
A - Analysis

M Replenish and redistribute mulch to a total three inches at least every three years

M Equipment repair/maintenance/ replacement/ water / replenishment of products

C Step 1: Plant native species (1~2years)
Step 2: Form colonys (1~2years)

M Monitor/ repair signs/ equipment/ filtration systems

M M 1: Seasonal monitoring first three years
M 2: Once per year
A Analysis for equipment

C C 1: Solar panels on buildings
C 2: Solar farm
M1/2 Clean at least once a year. Cleaning improves 12% of efficiency

M Equipment repair/maintenance/ replacement/ water / replenishment of products

H Harvest herbaceous plant(rapeseed, sunflower...) every year

Spatial interventions for the design site require different period for construction and maintenance. The left graph shows the timeline of the spatial interventions and their requirement.

Development of the Project (5 years)

Development of the Project (15 years)

Development of the Project (25 years)

Stakeholder Analysis

Crew

Ecosystem of Waalhaven

Public vs private

Public — Private

What they do?

- Build strong environment for habitat
- Offer recreational/ educational value

Level of Importance

★★★★★

Level of Influence

★☆

Level of Interests

☺☺☺☺☺

Crew

Citizen

Public vs private

Public — Private

What they do?

- Receive increased recreational value and get more job opportunities
- Responsible energy/ waste consumption

Level of Importance

★★☆

Level of Influence

★★☆

Level of Interests

☺☺☺☺☺

Crew

Farmers Association

Public vs private

Public — Private

What they do?

- Receive treated compost from the waste/ wastewater treatment plants

Level of Importance

★

Level of Influence

★

Level of Interests

☺☺

DESIGN DETAILS

Stakeholder Analysis

Crew

Knowledge Hub

Public vs private

Public — Private

What they do?

- Collaborate with circular initiatives Research, test, design, offer information to local workers

Level of Importance

★★

Level of Influence

★★★☆

Level of Interests

☺☺☺

Crew

Waste/ Wastewater Treatment

Public vs private

Public — Private

What they do?

- Collect, sort, waste. Send non-recyclable waste to incineration center
- Supply energy to shareholders

Level of Importance

★★★☆

Level of Influence

★★☆

Level of Interests

☺☺☺☺☺

Crew

Environment-related Enterprise

Public vs private

Public — Private

What they do?

- Offer circular ways of waste treatment Provide resource of renewable energy

Level of Importance

★★★★☆

Level of Influence

★★★

Level of Interests

☺☺☺☺

Stakeholder Analysis

Crew

Port of Rotterdam

Public vs private

Public Private

What they do?

- Collaborate with circular inititiatives
- Change energy production/ consumption to be more sustainable

Level of Importance

Level of Influence

Level of Interests

Crew

Municipality of Rotterdam

Public vs private

Public Private

What they do?

- Maintain the spatial interventions
- Offer subsidy to stakeholders to increase participation

Level of Importance

Level of Influence

Level of Interests

Crew

Government Agency

Public vs private

Public Private

What they do?

- Offer sustainable planning and policy, land/ water management

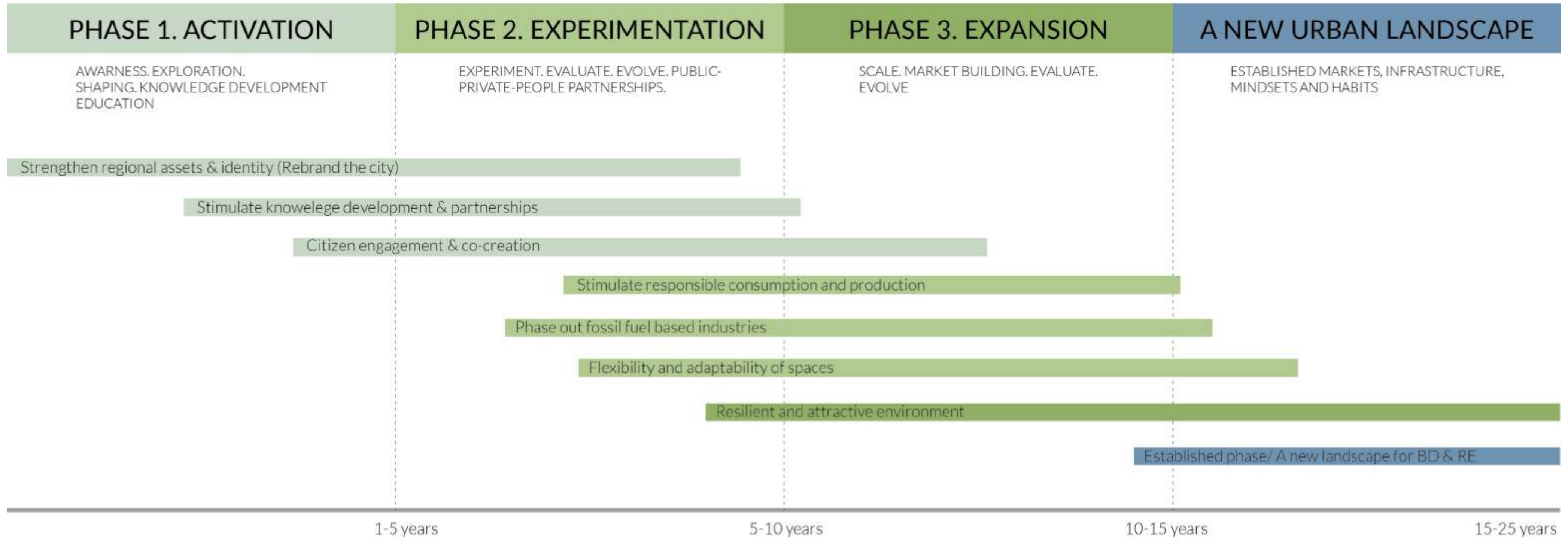
Level of Importance

Level of Influence

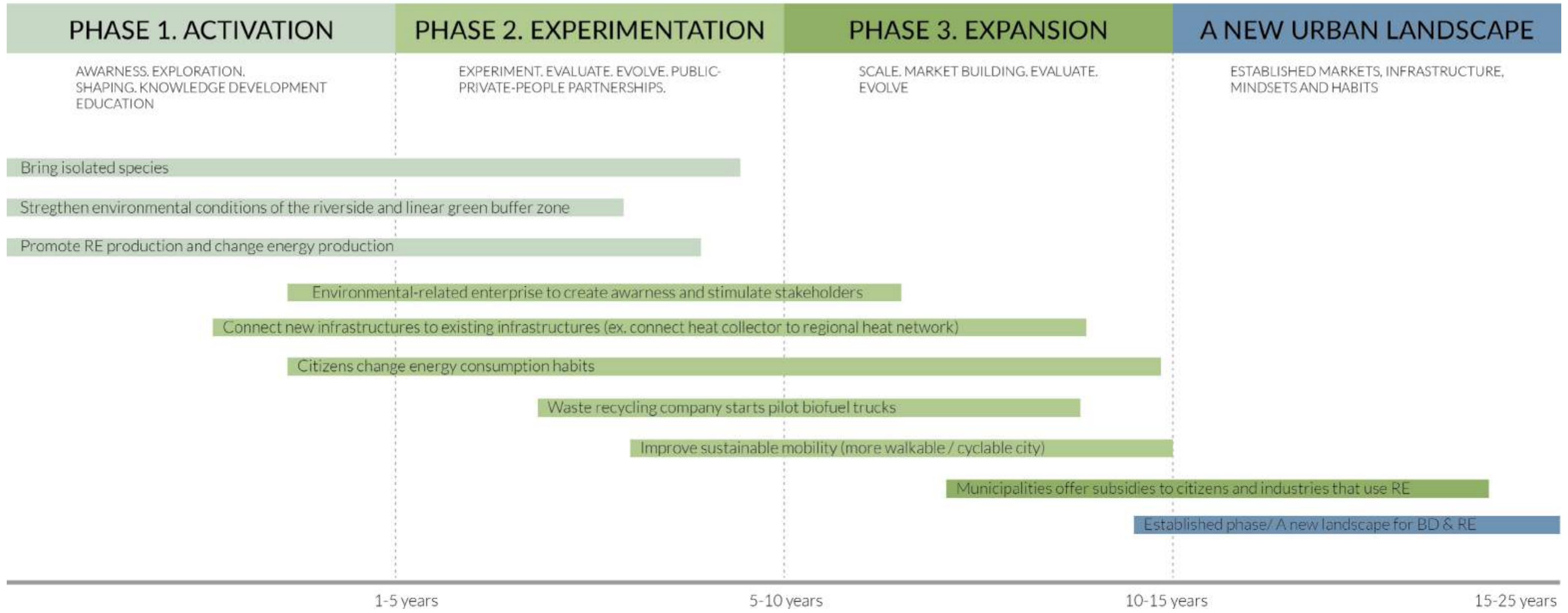
Level of Interests

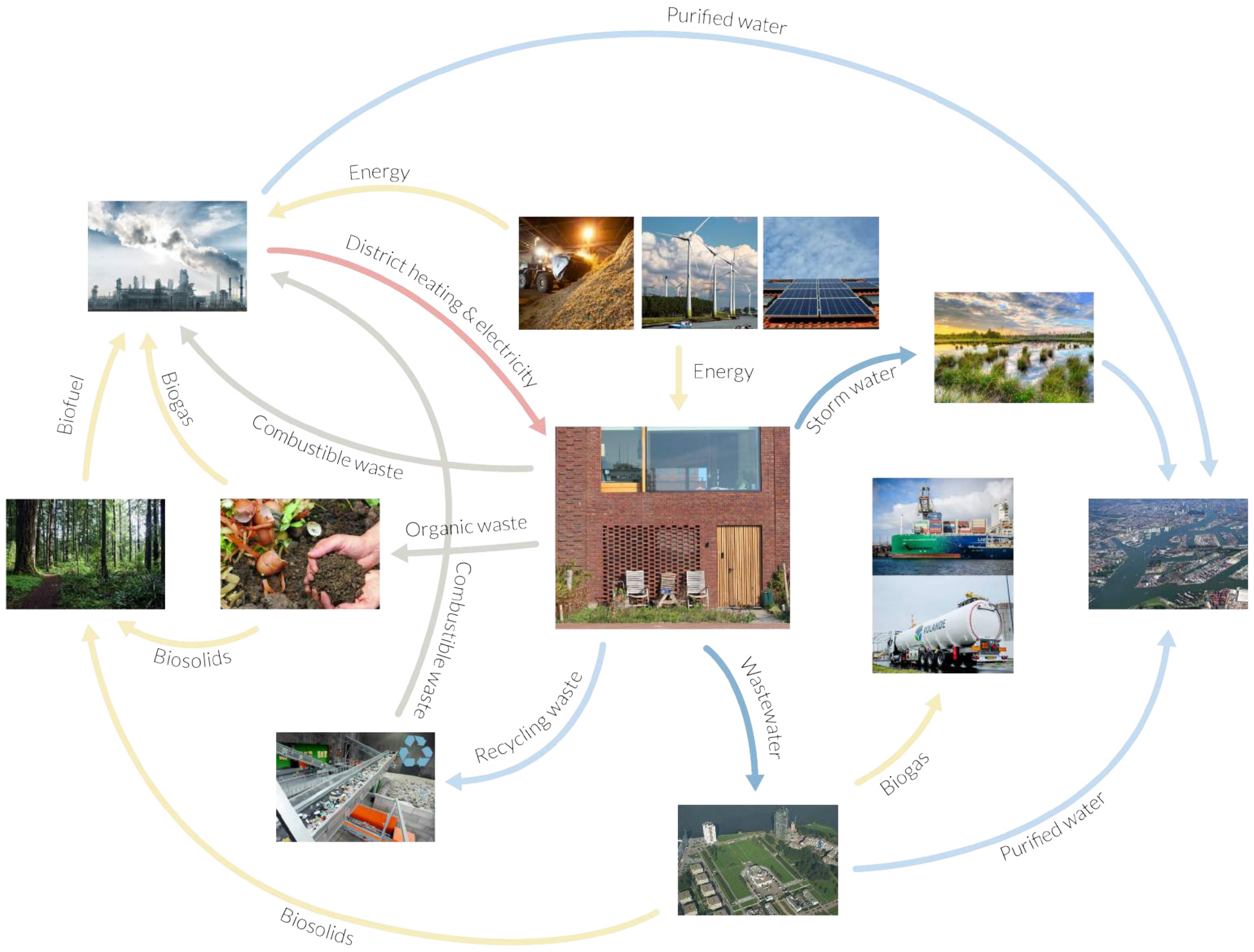
Phase with main stakeholders

General Timeline



Design Site Timeline





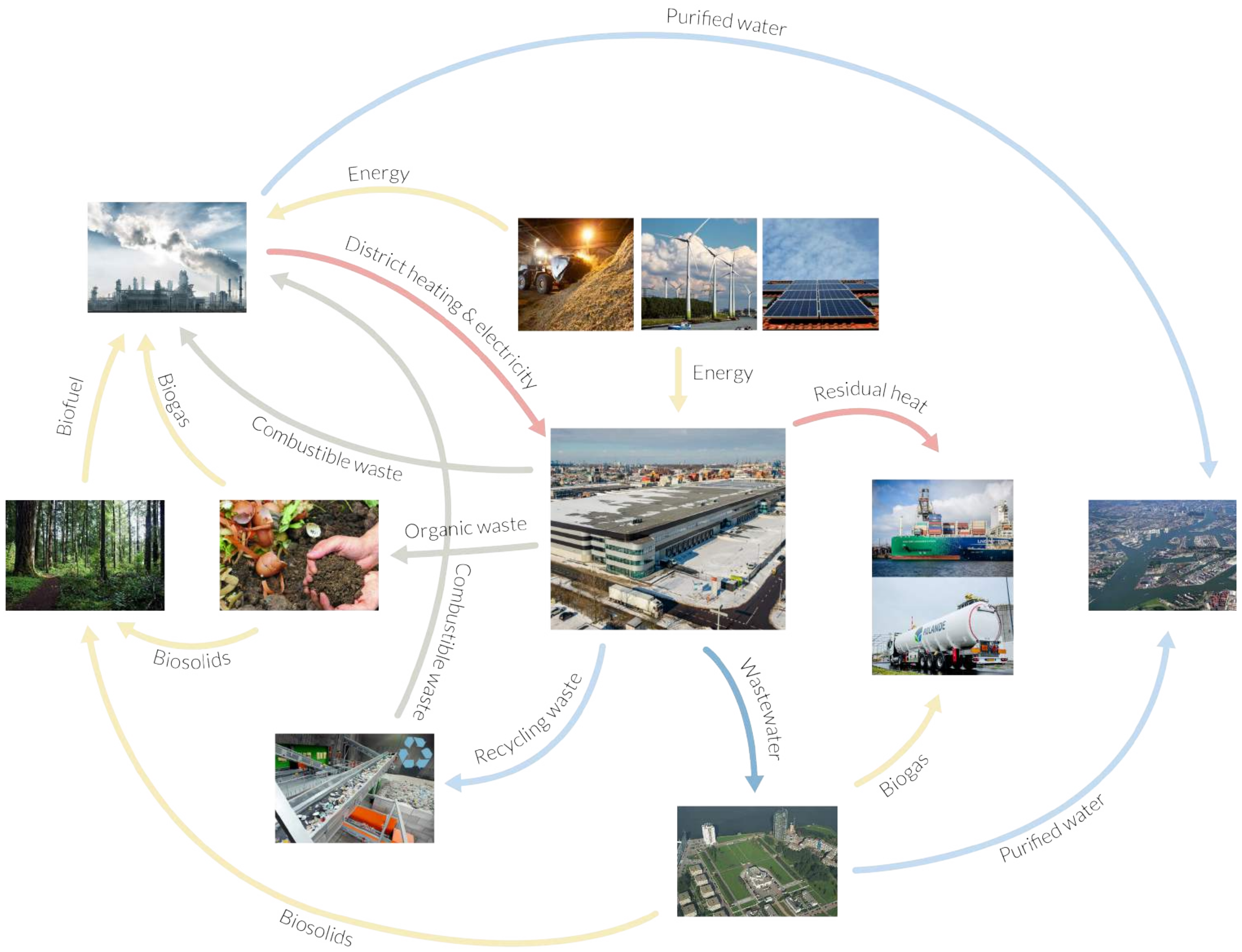


Figure.28
Circularity of the design area
(L) Circularity of household
(R) Circularity of industries
(Design by URBAN GREEN BLUE GRIDS for resilient cities. Photos are modified by author)

INT. / ACC.	Heat collector	PV panels	Wind turbines (S)	Wind turbines (L)	Heat from local waste	Heat/gas from wastewater	Bioplant scape	Algae farm	Blue energy
High	○	○	△	×	○	○	△	△	×
Medium	○	○	△	△	○	○	○	△	×
Low	○	○	○	○	△	△	○	○	△
	Bioswale	Water plants	Hanging/floating structures	Rich revetment	Helophyte pond	Urban promenade	Eco-bridge	Inland buffer zones	
High	○	○	○	○	△	○	△	×	
Medium	○	○	○	○	△	△	△	×	
Low	○	○	○	○	○	×	△	△	

Figure.21
Four main ports regarding RE

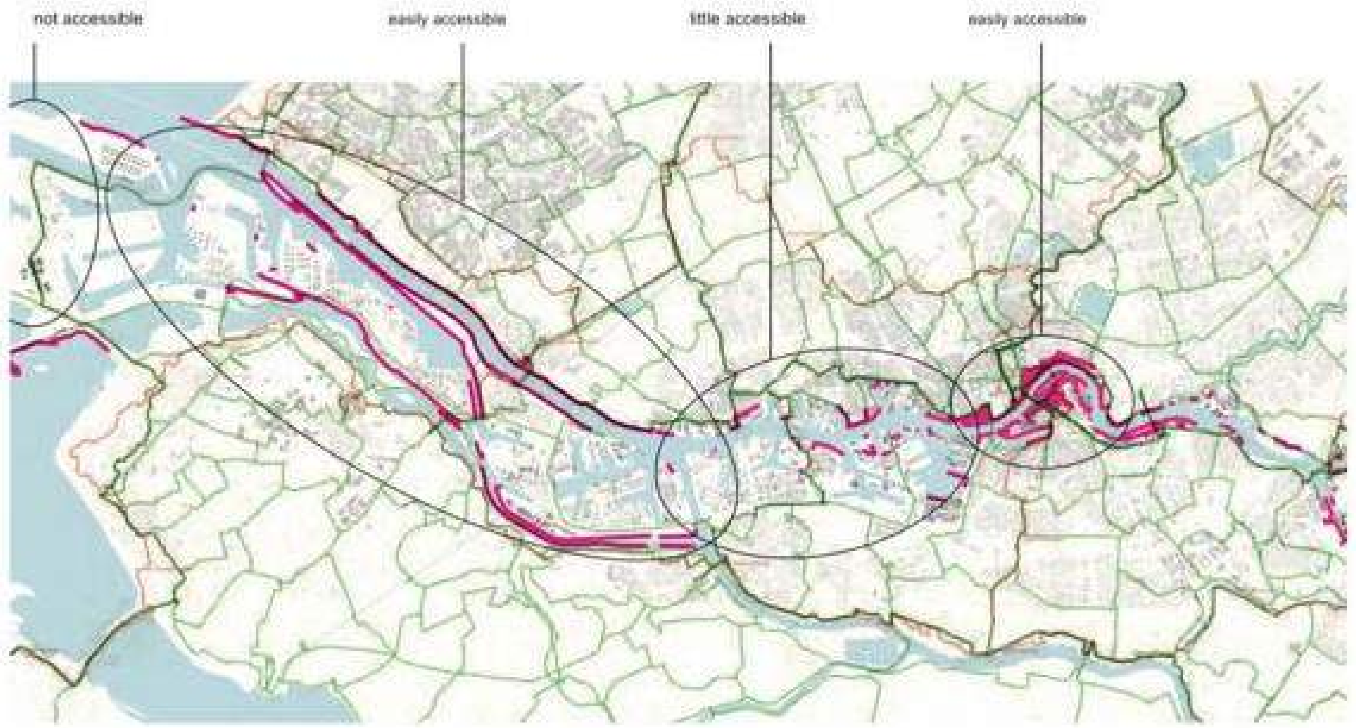


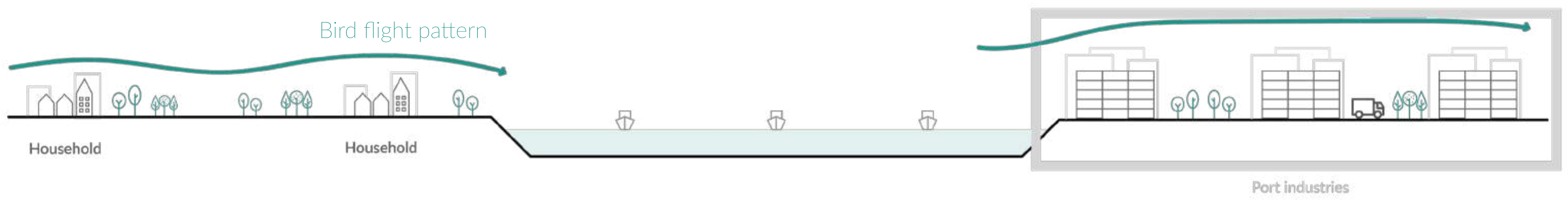
Figure.22
Accessibility for cyclists and pedestrians

Source: Landscape framework (2016) Strootman Landschapsarchitecten

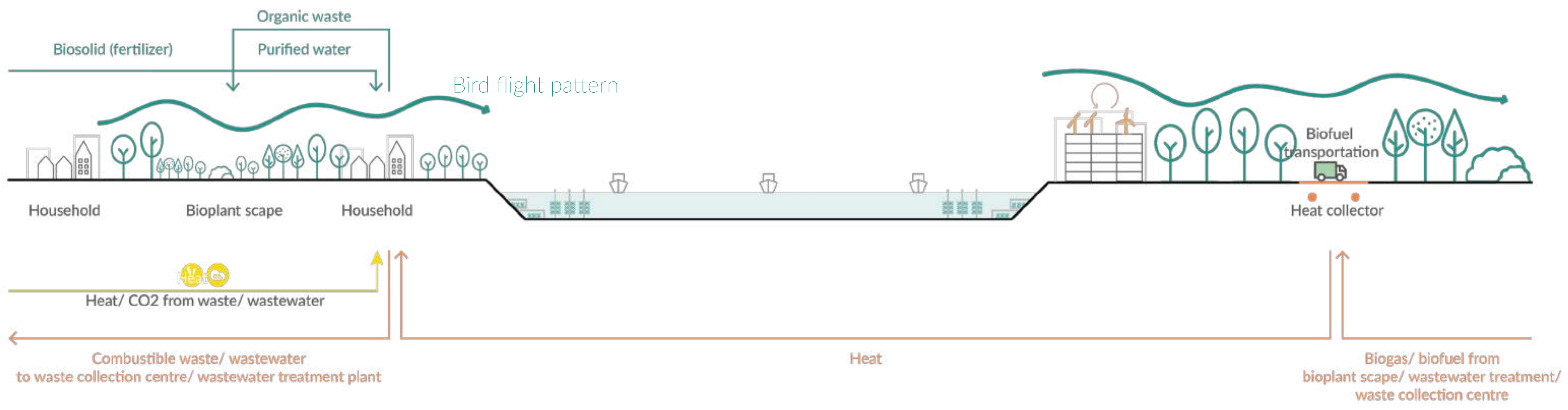
Aforementioned, four main ports (Maasvlakte, Europoort, Botlek, Eemhaven~Waalhaven) possess RE systems. Each port area has different characteristics. Regarding the project objective, enhancing recreational values for people, I made a comparison framework to understand what spatial interventions can form a new type of integration of BD and RE. The ports are divided based on accessibility (Figure 22).

For instance, the high accessibility ports are close to residential areas, requiring a small energy intervention scale. However, this area has many potentials to increase recreational values for educational purpose. For example, according to BioForest, bio plant landscape provide innovative strategies and products for tree care, tree nursery, and commercial use. It will play a role in increasing community awareness, engagement and education.

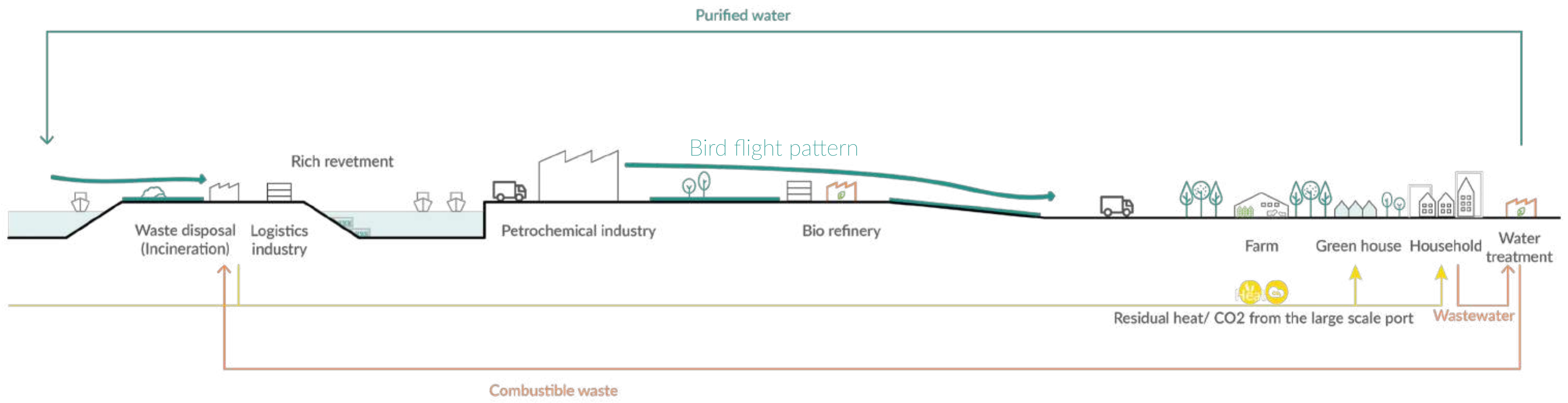
The next page shows how circularity can be achieved in different scale ports.



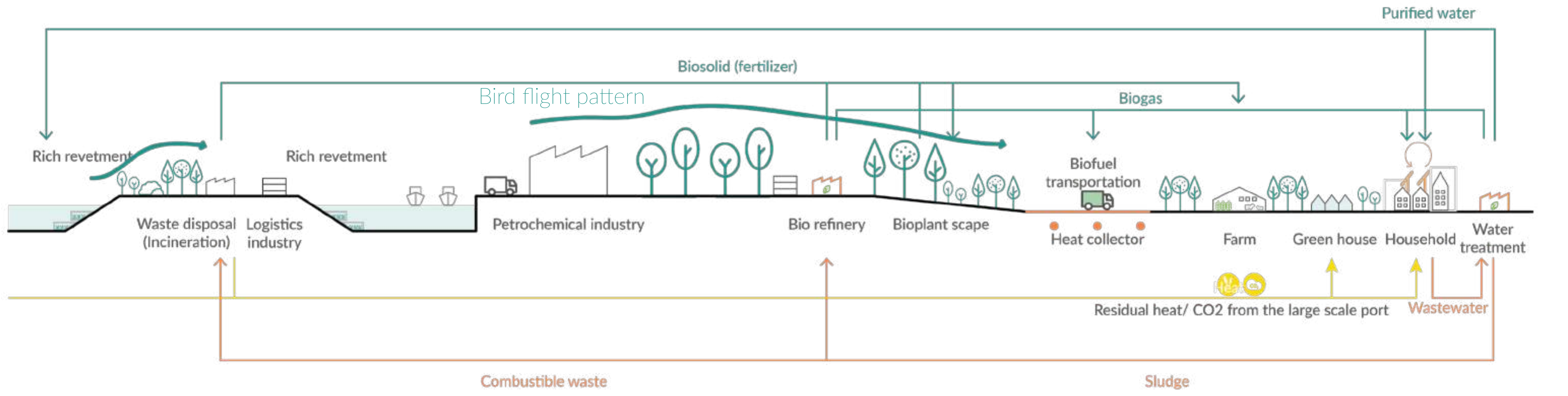
Circularity of RE & BD in high accessibility port
(Before)



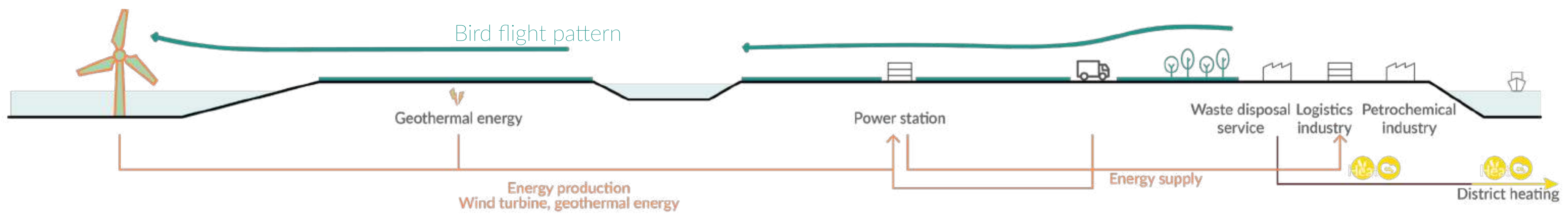
Circularity of RE & BD in high accessibility port
(After)



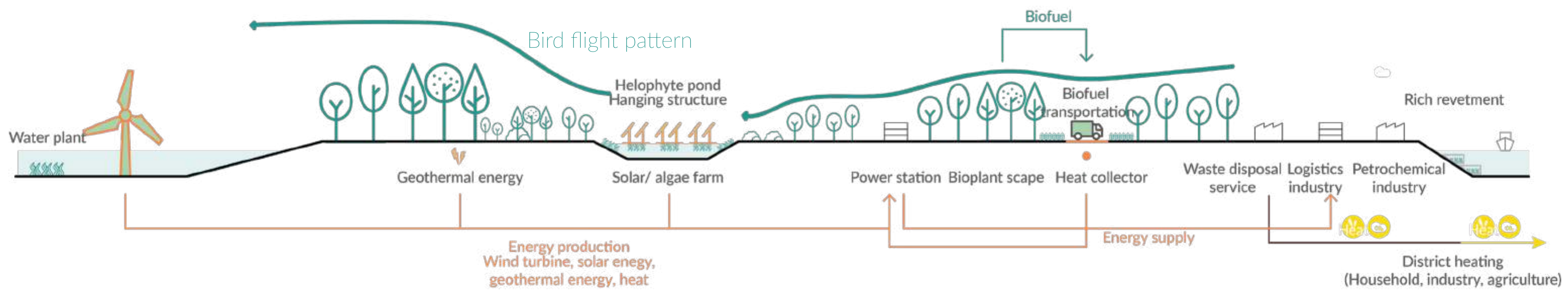
Circularity of RE & BD in medium accessibility port
(Before)



Circularity of RE & BD in medium accessibility port
(After)



Circularity of RE & BD in low accessibility port
(Before)



Circularity of RE & BD in low accessibility port
(After)

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Conclusion

Overall conclusion

The project aimed to achieve ecosystem services, and it achieved. Ecosystem services have four types; provisioning services, regulating services, supporting services, regulating services, and cultural services. The project mainly obtained provisioning services and cultural services. The bio plant landscape and local waste treatment process offer a source of biomass. At the same time, as the bio plant landscape functions as a public green area, it offers aesthetic experience, recreation and tourism for people. Furthermore, the integration of bio plant landscape (RE) and wetland (BD) educate people to arouse attention on the importance of their consumption habits.

The framework reflects the current environmental situations and energy systems. Especially, it suggested utilising local waste from households and industries, and connecting local plants (e.g. water treatment plants and incineration plants). Neighbourhoods of Waalhaven have similar conditions, and it will be transferred well to other locations.

Affordable and clean energy (SDG 7) & Industry, innovation and infrastructure (SDG 9)

Ban Ki-moon, the former Secretary-General of the United Nations, mentioned, "Energy is the golden thread that connects economic growth, social equity, and environmental sustainability." This statement's focus on energy as a core factor impacting changes in its surrounding environment can also be reflected on this project site, Waalhaven. Waalhaven is one of the most active ports in Rotterdam as it is located between other ports and Rotterdam centre. However, the geographical position makes industries require more energy and resources. As the Rotterdam municipality and Port of Rotterdam Authority want to reduce CO2 emissions from their energy consumption, the industries need to develop ways of energy production/consumption. The project suggests several ways of renewable energy by using local resources that reduce resource import and distribute the energy to industries and residential areas. Also, new energy production systems consist of biodiversity by giving spaces to them.

Sustainable cities and communities (SDG 11)

The United Nations explains that providing access to safe and accessible public green spaces is essential (United Nations, 2015). However, the current Waalhven has fewer green spaces compared to its neighbourhood as they are fragmented. Hence, the graduation project suggested new big public spaces for residents and industries by incorporating the fragmented green spaces and increasing the vegetation.

Climate action (SDG 13)

As the current greenhouse gas emissions are 50% higher than in the early 1900s, more attention has been given to the impacts of climate change. The project suggested climate change-related planning and management (e.g. wetland/ dryland gradient, spatial interventions for mitigating the water flow), and it will raise the capacity for a sustainable urban landscape.

APPENDIX

Reflection

Research Methods

Historical and typo-morphological research was conducted to understand the current context of the site initially. As an urbanist, I tried to understand the relationship between urban development and spatial factors (e.g. impacts on the surrounding environment, landscape typology, land use).

The theories I used for my project were mainly Nature-based solutions and Landscape Urbanism. They were used for the structural background and formed the basis of the research. The theories sorted the information I gathered through mapping and field trip under the following five categories: (1)historical aspect, (2)social aspect, (3)environmental aspect, (4) flora & fauna properties, (5)hard & soft infrastructure typologies. The methods efficiently divided the five subjects and supported ecology-related concepts that I used for the strategies to reason the design. This process worked throughout the overall design stage and the spatial strategies. However, the theories mainly focused on gathering information and data, not as a decisive element for the design. Because the project has two main subjects (biodiversity and renewable energy systems) and the theories are more focused on the natural part instead of integrating biodiversity and energy. I divided the design into two parts, biodiversity and energy, and they have different strategies and concepts in the design part. Some of them contradict with each other, but I prioritised design elements based on the local contexts and created spatial components. Because of geographical position, the project site has a limited scale. It was not possible to include significant scale design elements. However, on a regional scale, I was able to include large scale spatial interventions. I referred to the 'Ecoshape - Building with Nature' because 'Ecoshape' is a foundation under Dutch law, hence their suggestions for design were highly suitable to my project site. However, as the graduation project site has confined geographical features, the urbanised port area of the river, few spatial interventions were possible to apply.

Fieldwork and geographical research were the main methods to understand the correlation of anthropocentric activities and their effects on nature. I went to Waalhaven twice, December 2020 and March 2021, it was precious to look around the area at different times. I was able to observe aspects of action from people and animals depending on the meteorological condition. Especially, exploring the most crowded part of residents/ industries/ and animals was helpful to understand the landscape typologies. However, it was dissatisfaction that I could not interview people, so I could not reflect what local people wanted due to the lockdown.

Social relevance

The graduation project intends to "Re-connect green and blue highways of nature flows," focusing on a new urban landscape for renewable energy systems and biodiversity in Waalhaven, Rotterdam. It tackles the common ethical issues brought by anthropocentric activities on biodiversity, such as habitat loss and the depletion of natural resources. The project aims to create a spatial framework to bring a renewable energy landscape for urban biodiversity, ecosystem services and recreational values for residents, reducing the negative human impacts on nature. By doing this, the project reflects on Sustainable Development Goals (SDGs), which are developed by the United Nations (United Nations, 2015).

- Affordable and clean energy (SDG 7) & Industry, innovation and infrastructure (SDG 9)
  Ban Ki-moon, the former Secretary-General of the United Nations, mentioned, "Energy is the golden thread that connects economic growth, social equity, and environmental sustainability." This statement's focus on energy as a core factor impacting changes in its surrounding environment can also be reflected on this project site, Waalhaven. Waalhaven is one of the most active ports in Rotterdam as it is located between other ports and Rotterdam centre. However, the geographical position makes industries require more energy and resources. As the Rotterdam municipality and Port of Rotterdam Authority want to reduce CO2 emissions from their energy consumption, the industries need to develop ways of energy production/consumption. The project suggests several ways of renewable energy by using local resources that reduce resource import and distribute the energy to industries and residential areas. Also, new energy production systems consist of biodiversity by giving spaces to them.

- Sustainable cities and communities (SDG 11)
  The United Nations explains that providing access to safe and accessible public green spaces is essential (United Nations, 2015). However, the current Waalhven has fewer green spaces compared to its neighbourhood as they are fragmented. Hence, the graduation project suggested new big public spaces for residents and industries by incorporating the fragmented green spaces and increasing the vegetation.

- Climate action (SDG 13)
  As the current greenhouse gas emissions are 50% higher than in the early 1900s, more attention has been given to the impacts of climate change. The project suggested climate change-related planning and management (e.g. wetland/ dryland gradient, spatial interventions for mitigating the water flow), and it will raise the capacity for a sustainable urban landscape.

Scientific relevance

There are two knowledge gaps in terms of the landscape. First, most renewable energy infrastructures have limitations in terms of scale and location. Many case studies from 'Sustainable Energy Landscapes: Designing, Planning, and Development (Stremke et al., 2013)' are complicated to apply in highly urbanised areas. Most energy infrastructures are large scales, such as wind turbines and solar farms on mountains or the ocean. On a city scale, many sustainable energy projects are related to solar energy systems. However, solar energy has many restrictions that depend on meteorological and architectural conditions (Wiel et al., 2019). Second, these infrastructures can deteriorate surrounding ecosystems (Gasparatos et al., 2016). However, biodiversity has been often excluded during the planning stage.

Transferability of the results

The main focus of the Urban Ecology studio was to think of how to design eco-cities by using eco components and urban ecosystem resaturation strategies.I explored spatial, societal and environmental problems through multiple scales and times. The graduation project tackles the common ethical issues brought by anthropocentric activities on biodiversity, such as habitat loss and the depletion of natural resources from a non-human species perspective. The project aims to create a spatial framework to bring a renewable energy landscape for urban biodiversity, ecosystem services and recreational values for residents, which could be used as a study case in other cities. The framework reflects the current environmental situations and energy systems. Especially, it suggested utilising local waste from households and industries, and connecting local plants (e.g. water treatment plants and incineration plants). Neighbourhoods of Waalhaven have similar conditions, and it will be transferred well to other locations. However, the framework focused on specific challenges that Waalhaven face, and it could be complicated to apply in other cases, which has fewer opportunities to use local resources and facilities.

Ethical considerations

The moral dilemmas of my graduation project could be that some areas of the site or the neighbourhood might need to face NIMBY because the project covers transforming energy-producing ways by using local resources (e.g. biogas from local waste). Furthermore, the project site, Waalhaven, is a hub of logistics and marine industries but the project slightly excluded them even though many companies already possess the area. Therefore, the people who reside and work adjacent to the industries would not be hostile to ecological strategies.

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Traffic Noise of RDM 2007

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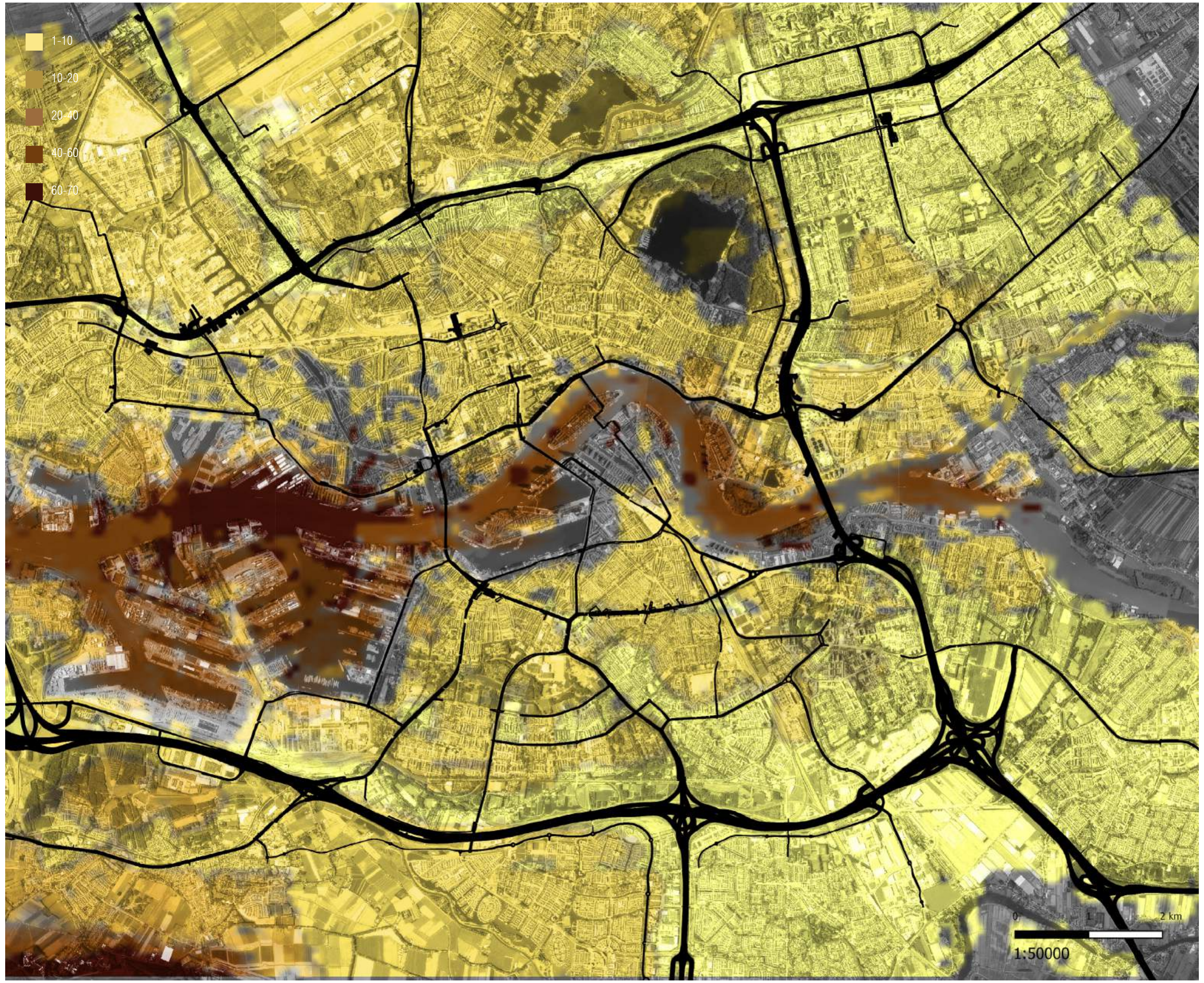
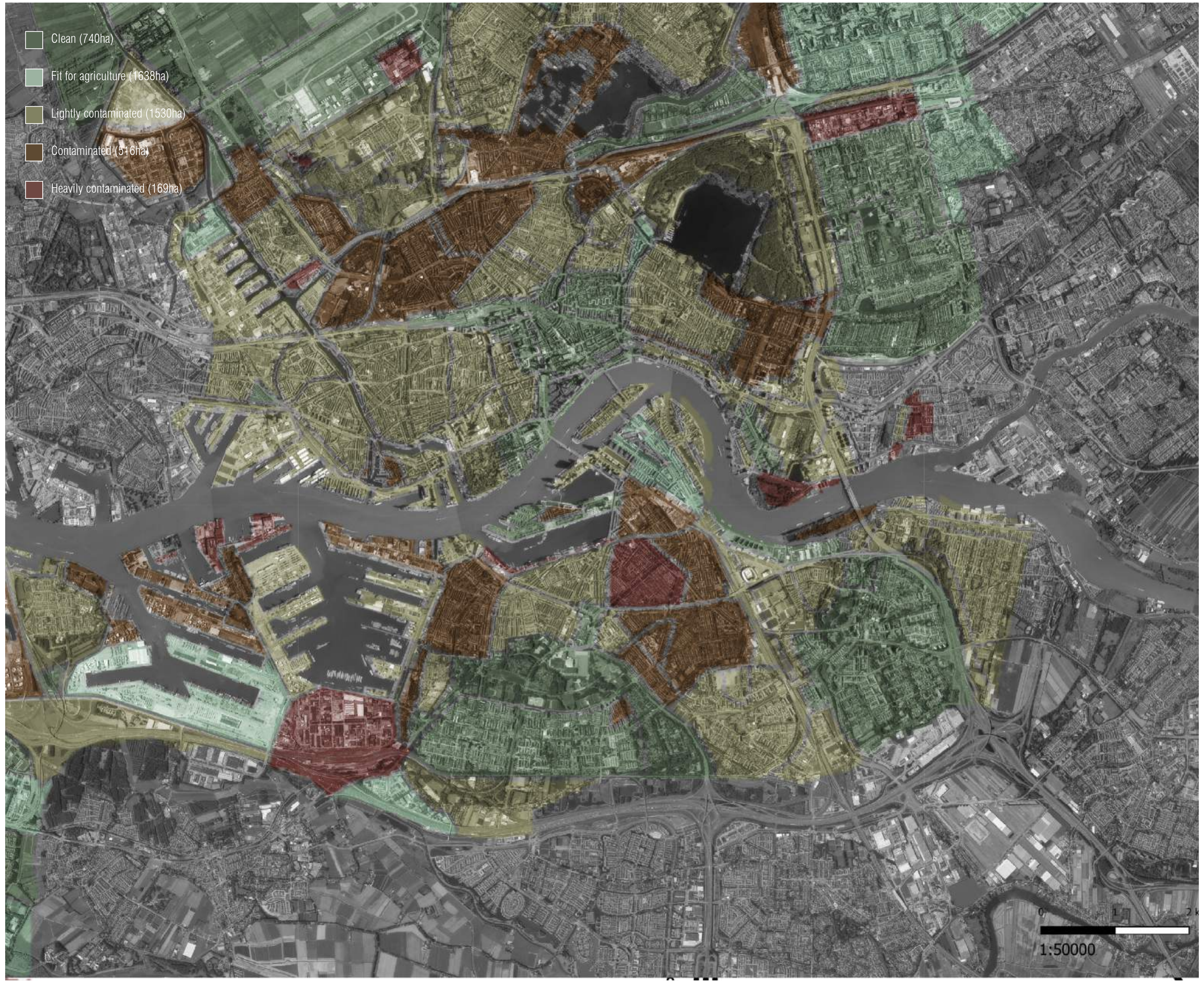


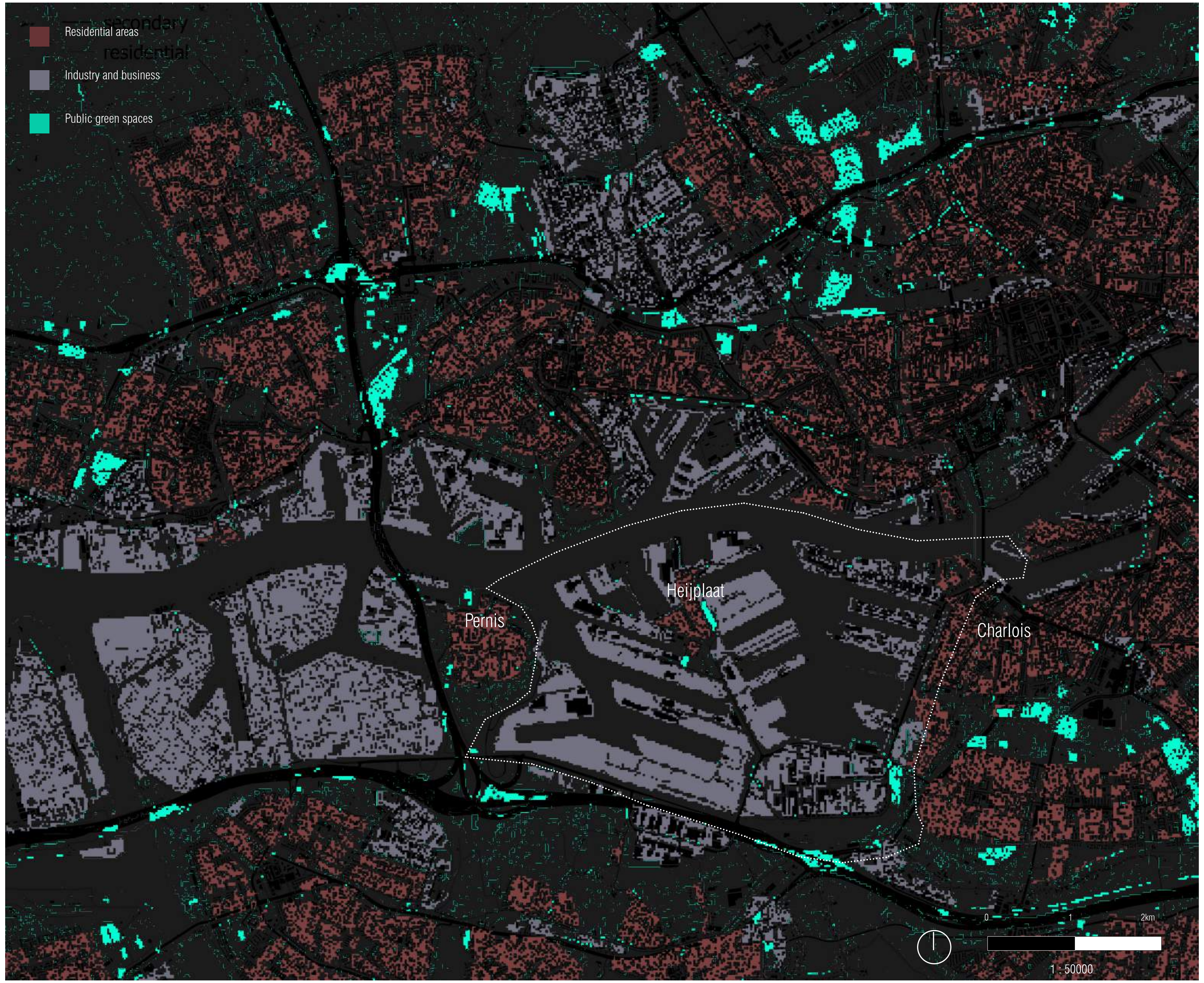
Soil Contamination of RDM (0~1m)



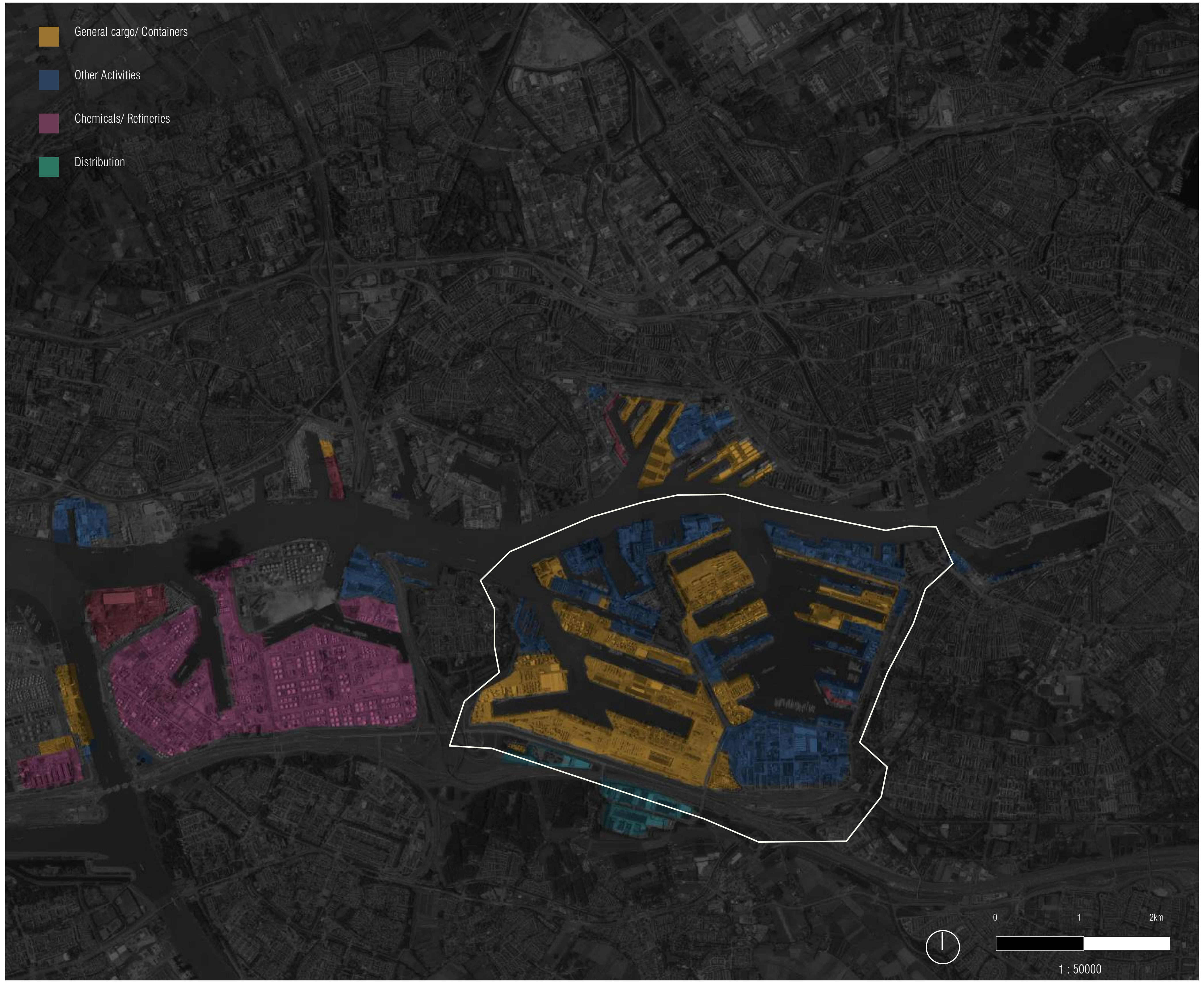
Salinisation of RDM in 2050

Landuse of Waalhaven

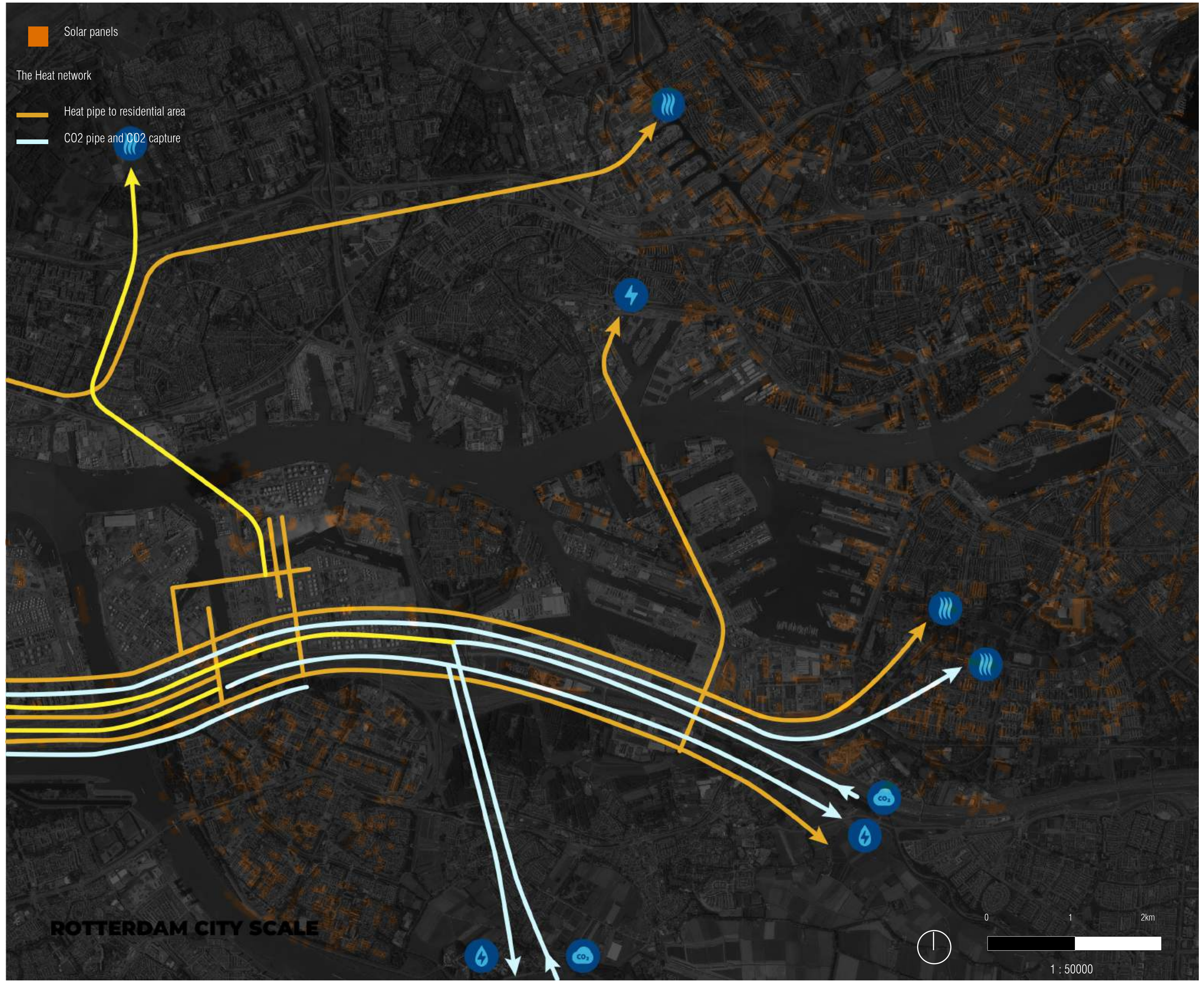
Maritime related industries/ business take over 80% of port areas.



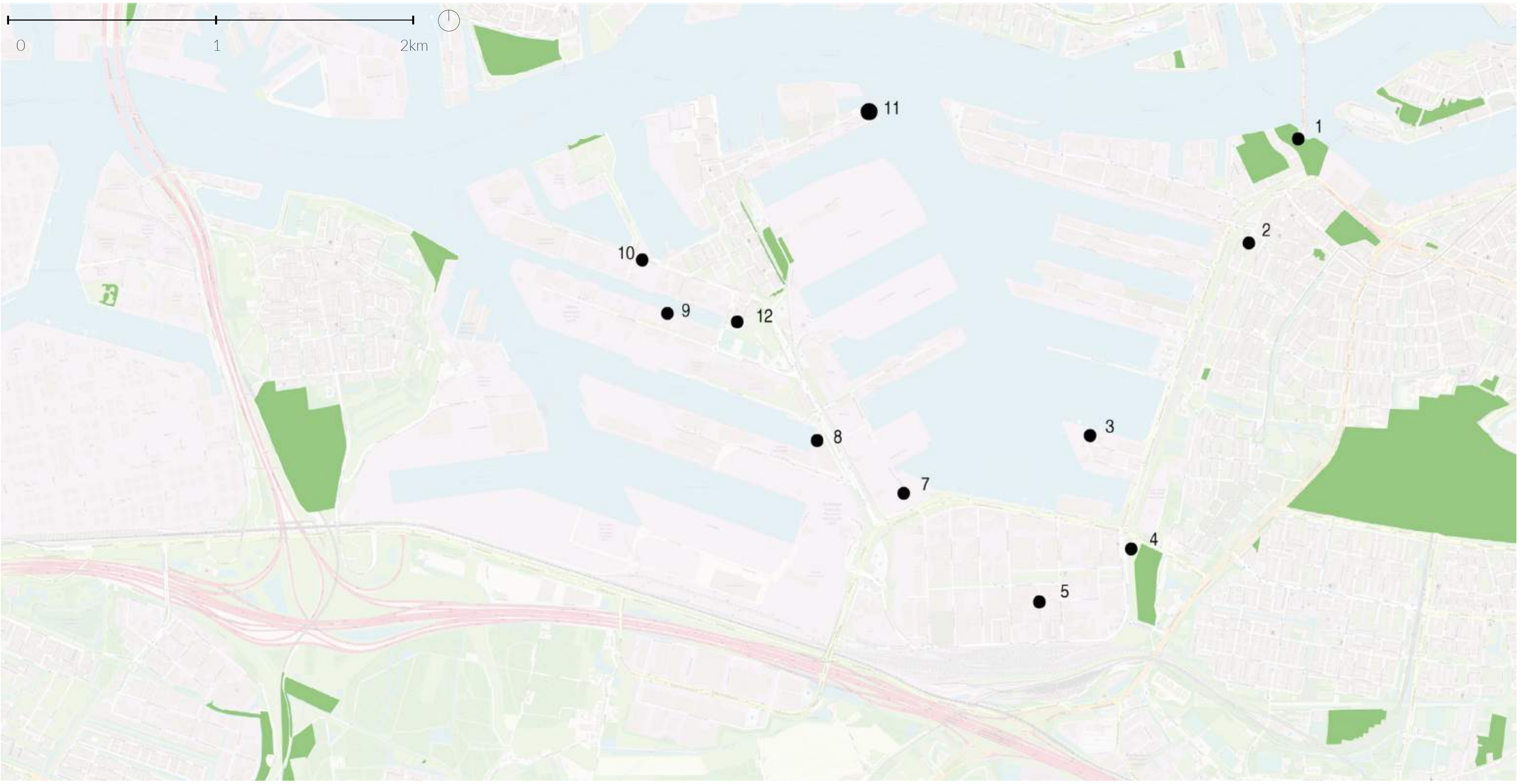
Industry type of Waalhaven



Solar Panels and The Heat Network



Soil Quality and Types



NAWA	1.2 : sand(medium~coarse) from tidal activities. Contains shell
AAOP	4.9 : sand (fine~medium) from anthropocentric activities -> domestic waste, construction material...
AAOP+NAWA	5.7.8.11.12 : sand
AAOP+NIHO	3.10 : sand+peat