

Non-parasitic Economy
Towards a symbiosis between coastal cities and water

Jun Chen (4844130)
24-06-2020

Non-parasitic Economy:
Towards a symbiosis between coastal cities and water.

Jun Chen (4844130)

Delft University of Technology
Faculty of Architecture and the Built Environment
Department of Urbanism

Transitional Territories Graduation Studio
2019-2020

First Mentor: Dr. Diego Sepulveda Carmona
Second Mentor: Dr. ir. Luisa Maria Calabrese

P5 report

June 2020

ACKNOWLEDGEMENTS

I want to thank and thank several people for their consistent support throughout the thesis. First of all, I would like to especially thank my mentors Diego Sepulveda Carmona and Luisa Maria Calabrese for their guidance, understanding and a lot of knowledge, and their continuous encouragement and support. I also thank my friends and family who are far away in China for their positive attitude and support for my study abroad in the past two years. I also want to thank all the colleagues from TT studio for making the study time of the last year rich and interesting. Finally, I would like to thank my friends at Delft University of Technology for all the wonderful online discussions, speeches and support during this special period of isolation.

CONTENTS

Parasitism definition 5

0.0 INTRODUCTION 8
0.1 MOTIVATION OF THE STUDY 9
0.2 THE NORTH SEA CONTEXT 10
0.3 THE MRDH CONTEXT 11
0.4 SCALE DEFINITION 12

1.0 PROJECT FIELD
1.1 PROBLEM FIELD 16
1.2 PROBLEM STATEMENT 26
1.3 RESEARCH QUESTION 27
1.4 HYPOTHESIS 28
1.5 OBJECTIVES AND GOALS 30
1.6 EXPECTED OUTPUT 31

2.0 THEORETICAL FRAMEWORK
2.1 BUILDING UP THE THEORETICAL FRAMEWORK 34
2.2 CONCEPTUAL FRAMEWORK 35
2.3 THEORY PAPER 36

3.0 METHODOLOGY
3.1 ABSTRACT 45
3.2 OVERALL RESEARCH DOMAIN 46
3.3 THEORETICAL FRAMEWORK SUMMARY 47
3.4 CONCEPTUAL FRAMEWORK SUMMARY 47
3.5 RESEARCH APPROACH AND PHILOSOPHY 48
3.6 ANALYTICAL AND DESIGN FRAMEWORK 49
3.7 MAIN METHODS AND PROCESSES 52
3.8 EVOLUTIONARY FRAMEWORK 54
3.9 TIME PLANNING 55
3.10 METHODOLOGY FRAMEWORK 56

4.0 ANALYSIS
4.1 ECOSYSTEM ASSESSMENT 60
4.2 CAUSE ASSESSMENT 70
4.3 RISK ASSESSMENT 80
4.4 THE CURRENT CHALLENGES 86
4.5 FLOW ANALYSIS 88

5.0 STRATEGIES
5.1 PROPOSED METABOLIC TYPOLOGIES 107
5.2 NEW FLOW (1X1 KM SCALE) 109
5.3 SPATIAL PRINCIPLES 111
5.4 TWO PRIORITY VISIONS 114
5.5 PRELIMINARY REVISED VISION 2040 116

6.0 DESIGN TESTING
6.1 BUILDING LOCAL SPATIOTEMPORAL 120
6.2 DESIGN TESTING 128
6.3 EVALUATION 200
6.4 GOVERNANCE MODEL 206
6.5 SCALE ADAPTATION 218

7.0 CONCLUSION
7.1 CONCLUSION 224
7.2 BACK TO THE RESEARCH QUESTIONS 225
7.3 RECOMMENDATIONS FOR FUTURE RESEARCH 227

8.0 REFLECTION 230

APPENDIX
A1 BIBLIOGRAPHY 236
A2 OTHER DRAWING 238



Fig. 0.1 Dunkerque coast line, 2019. Source: Photo by the author.

PARASITISM DEFINITION

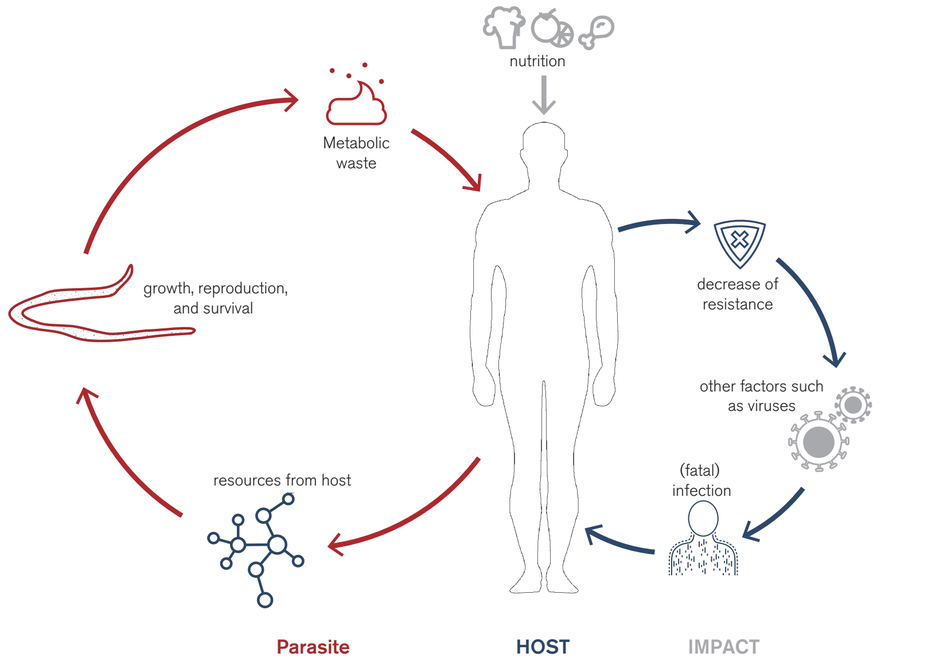


Fig 0.2 Parasitism relationships. Source: made by author

Parasitism is a nonmutual relationship between two organisms in which one benefits at the expense of the other. There are two types of parasites affecting living organisms: ectoparasites (living on the surface of host) and endoparasites (living in the body of the host) (Wu, 2017).

By definition, parasites are costly for their hosts as they divert resources for their growth, reproduction, and survival with no rewards for the hosts (Sorci et al., 2008).

The presence of parasiticides in systems can also lead to healthy individuals experiencing greater mortality from other factors (Bellows et al., 1999).

The parasitic economic relationship we discussed in this thesis is the same as the definition of parasitism above.

Coastal cities continue to transfer or utilize resources in the water to meet the energy needs of everyday life and to achieve urban economic growth.

At the same time, urban development brings a series of negative effects to natural waters, therefore the natural waters become more and more sensitive to external stimuli.

For the coastal ecosystem, the coastal cities are parasites.

0 INTRODUCTION

0.1 MOTIVATION OF THE STUDY
0.2 THE NORTH SEA CONTEXT
0.3 THE MRDH CONTEXT
0.4 SCALE DEFINITION

0 INTRODUCTION

0.0 INTRODUCTION



Fig. 0.3 Knokke-Heist coast line, 2019. Source: Photo by the author.

In almost all parts of the world, coastal areas have a clear process of population concentration, with coastal cities playing an important role (Barbier et al., 2008; Barragán and deAndrés, 2015). This phenomenon is responsible for the loss of services provided by coastal ecosystems for human well-being (UNEP, 2006). Besides, by 2050, about 650 million people will live in delta and coastal cities (Meyer et al., 2015).

With the risks posed by extreme weather, the environment that loses coastal ecosystem services will become more vulnerable. Restoring coastal ecosystems is becoming important in the context of climate change and the expansion of coastal cities, the relationship between city and nature should be symbiotic.

0.1 MOTIVATION OF THE STUDY



Fig 0.4 Chittagong, USA. Source: atlasofplaces.com

For me, I am most interested in urban transformations and sustainability for the reason that I would like to learn the methods of solving the problems in the process of urbanization. For a long time, the concentration of the population in the coastal areas has been continuously increasing. The number and distribution of populations have a serious impact on the coastal landscape.

The coastal landscape has been continuously changed, by increasing the infrastructure to maintain residential, commercial and tourism activities, and these infrastructures encroach on coastal green spaces. The coastal landscape constructed in response to urbanization is not limited to land. The natural habitats on the nearshore are also broken or even lost due to the proliferation of various building structures. The ecological decline of coastal cities has increased the threat of sea-level rise and extreme weather risk. At the same time, coastal urban areas are not only affected by regional climate change but also cause local changes in regional climate, leading to the so-called “urban climate”. In this era of promoting sustainable urban development, how should coastal cities cope with the conflict between urban development and nature? In the context of sea-level rise, what will the future coastal cities look like? How to transform the economy of coastal cities?

0.2 NORTH SEA CONTEXT



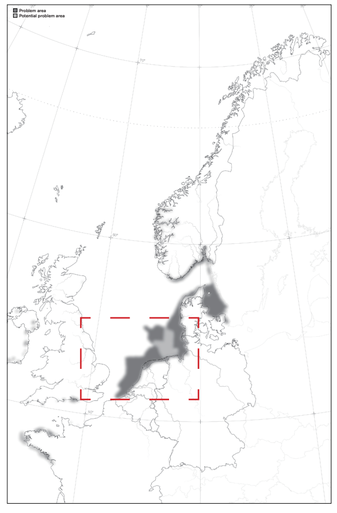
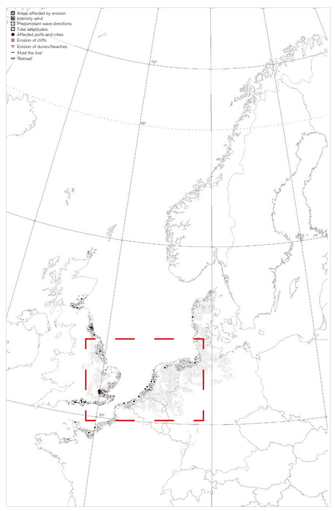


Fig.0.5 Population growth. Source: BBSR Bonn, Group work.

Fig.0.6 Contaminated waterbody. Source: Map created by author. Data from: OSPAR Intermediate Assessment 2017.



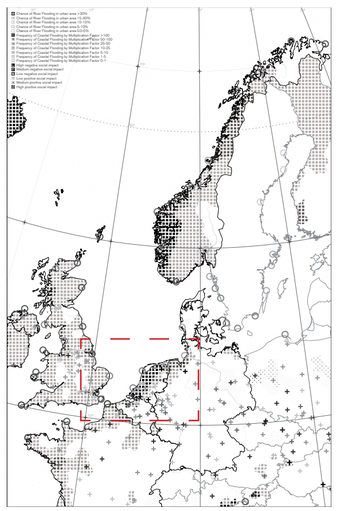


Fig.0.7 Soil erosion. Source: European Environment Agency, Group work.

Fig.0.8 Flood risk. Source: European Environment Agency, Group work.

The coastal cities in the North Sea region have a significant expansion trend, with the exception of Norway, most of which are concentrated in the southern North Sea region.

The most obvious impacts of human activities and climate change on the coastal ecosystems in this region are water pollution and coastal erosion, which lead to eutrophication and the migration or death of species in the region.

Sand dunes and beaches in the Netherlands, Germany and Denmark are affected by long-shore sand erosion caused by transport gradients. This is affected by the direction of the coast and the main (offshore or transoceanic) southwesterly winds. Changes in hydrodynamic conditions and sediment supply are also affected by human activities.

The OSPAR Commission 2017 pointed out that there is also a high water pollution pressure in this area, and the pressure is increasing. This poses a huge challenge to the Netherlands, which is already at high risk of flooding in the southern North Sea region.

0.3 THE METROPOOLREGIO ROTTERDAM DEN HAAG CONTEXT

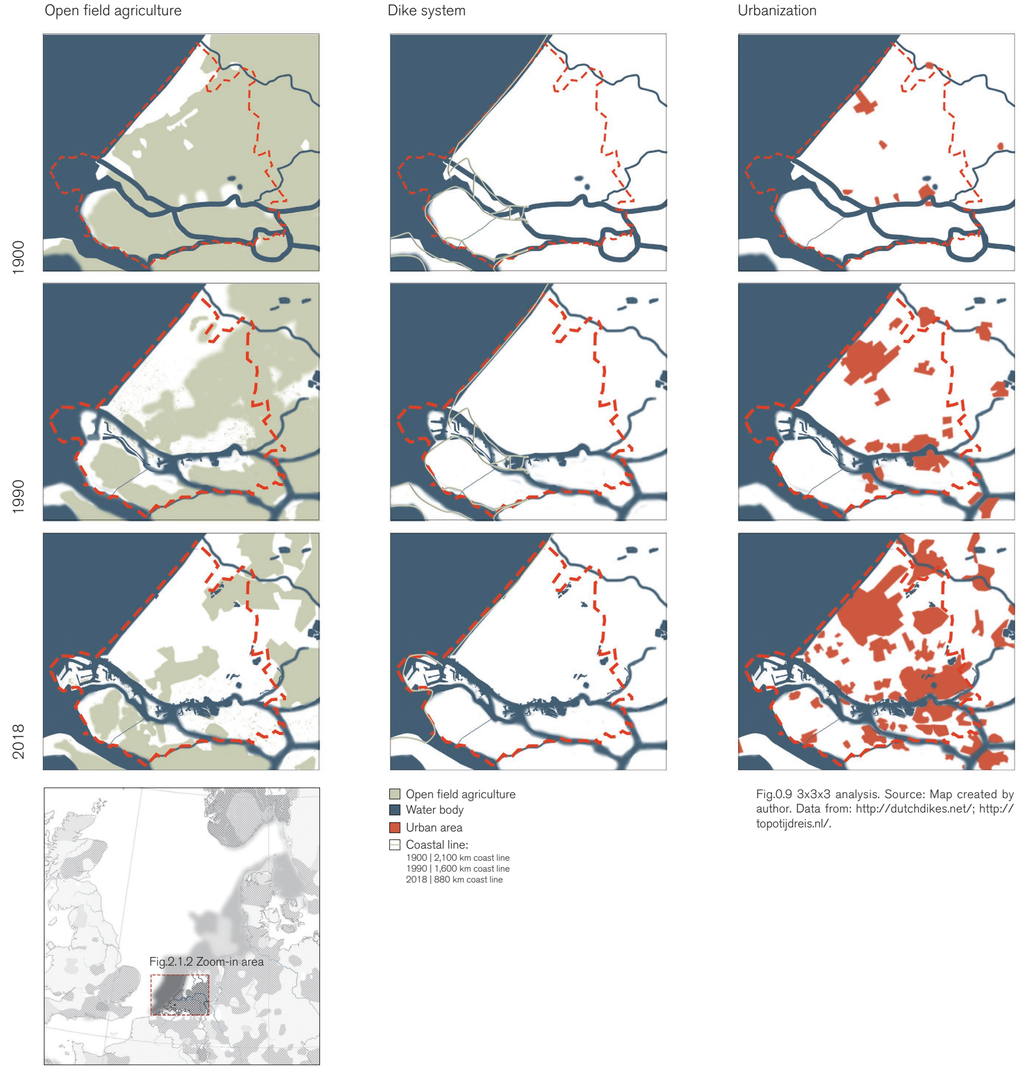


Fig.0.9 3x3x3 analysis. Source: Map created by author. Data from: http://dutchdikes.net/; http://topotijdreis.nl/.

Rotterdam-The Hague Metropolis is an urban area with 23 municipalities, Promoting economic development is the main reason for these municipalities' cooperation. The region is vital, with 2.3 million inhabitants, 1.2 million jobs and 15% of GDP. Oceans, beaches and peat grasses give the area a unique identity.

This area is an important part of the North Sea region in terms of socio-economic or environmental aspects. Due to the urbanization, the ecological landscape of the area has been changing, and open field agricultural has gradually been replaced by hard urban paving and greenhouses. As a consequence, the region was vulnerable to climate change. So the Dutch came out the Delta Plan, it proposes the sea inlets should be closed off, thus making the coastline much shorter and far easier to defend. However, the agricultural leak in 1986 made people realize that large-scale reinforcement of dikes is not the solution. The “River Space” (Ruimte voor de Rivier), which advocated the expansion of the river bed, was formulated. But the contradiction between urban development and natural systems in the region is still increasing, especially between the city and water.

0.4 SCALE DEFINITION

It is divided into two parts: analysis focus scale and design focus scale. In the analysis focus scale, Metropoolregio Rotterdam Den Haag is selected as the analysis object on a macro scale. After analyzing the main challenges in the current region, four patches of 5x5km range were selected as the meso scale analysis object, mainly analyzing the current spatial quality and potential. Last but not least, the four 1x1km patches are selected as the micro scale analysis objects, and a new flow strategy is proposed by analyzing the current local flow.

In design focus scale, the main scale is Pernis area, 3.5x2.0 km area, and design testing is carried out through the design of three conditional areas.

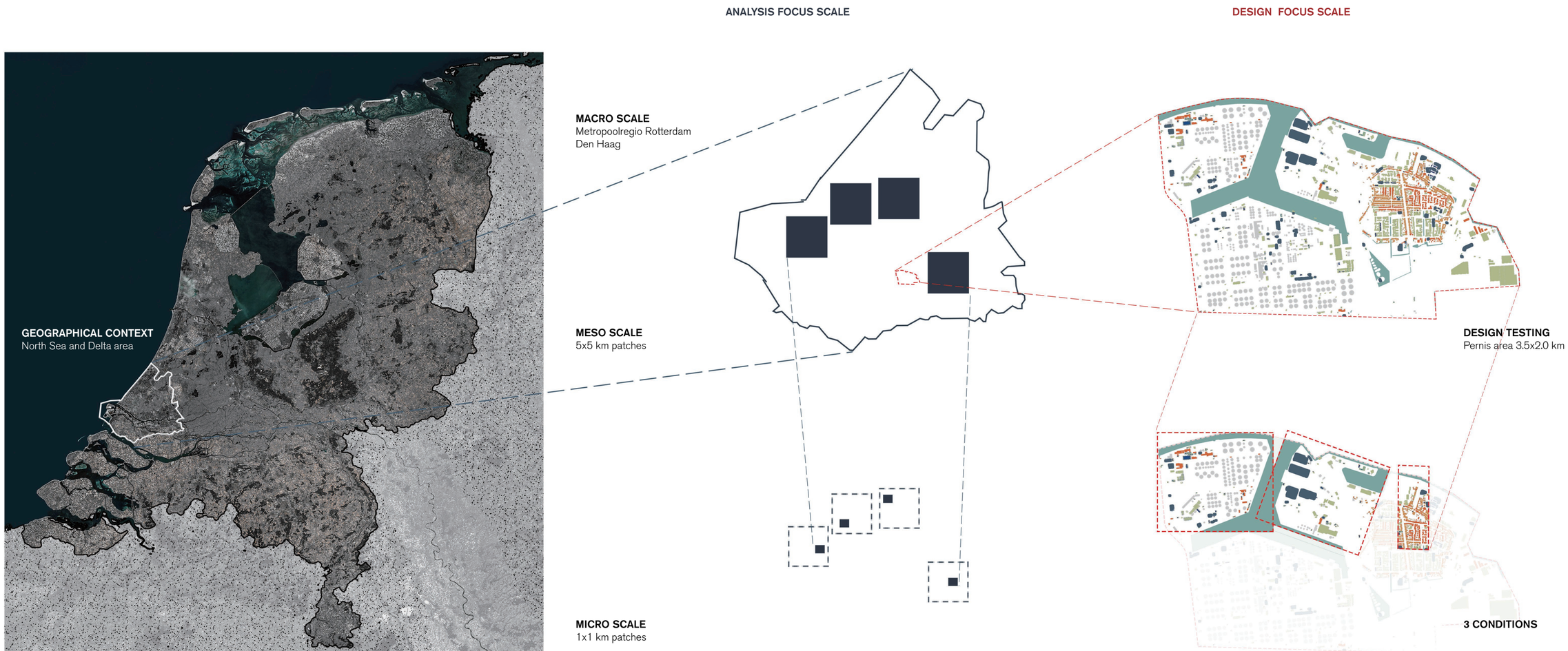


Fig.0.4 Source: Map created by author. Satellite image from Googlemap.

1 PROJECT FIELD

1.1 PROBLEM FIELD
1.2 PROBLEM STATEMENT
1.3 RESEARCH QUESTION
1.4 WORKING HYPOTHESIS
1.5 OBJECTIVES AND GOALS
1.6 EXPECTED OUTPUT

1.1 PROBLEM FIELD

1.1.1 THE DRIVERS FOR ECONOMIC OUTPUT



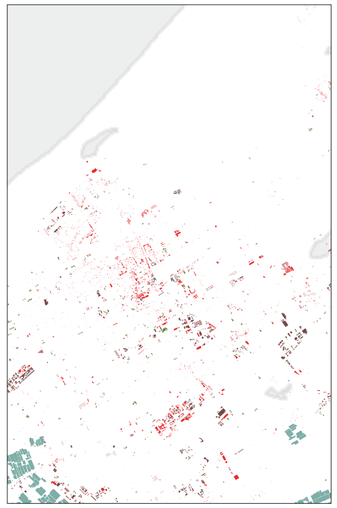


Fig.1.1.1 Drivers for Westeland. Source: Map created by author. Data from: Geofabrik.

Fig.1.1.2 Drivers for The Hague. Source: Map created by author. Data from: Geofabrik.





Building type
- Office
- Industrial&creative
- Recreation
- Servise
- Greenhouse
- Education
- Commercial
- Farm

Fig.1.1.3 Drivers for Rotterdam. Source: Map created by author. Data from: Geofabrik.

Fig.1.1.4 Drivers for Delft. Source: Map created by author. Data from: Geofabrik.

The MRDH generates about 16% of national GDP and is responsible for the majority of economic activity within the Province of Zuid-Holland (which generates about 20% of national GDP), the economic development of the MRDH region is very important for the Netherlands. (OECD report ,2016)

Urban development has transformed open field agricultural land into urban housing, office, commercial, industrial and other lands. Between 2001 and 2006, Westland lost more than 300 hectares of land for farming. By 2005, agricultural land in the Hague had fallen by a third and the number of farms in Rotterdam by 27% (CBS). The rapid land conversion resulted in the landscape pattern of MRDH today.

The port of Rotterdam mainly develops manufacturing and logistics; Westland, whose economy is driven by greenhouse gardening; and The Hague, which mainly develops medical and manufacturing industries. From the perspective of economic drivers, economic drivers in the Hague do the least harm to the environment, while Rotterdam port and Westland, which needs centralized irrigation, are more likely to cause water pollution problems.

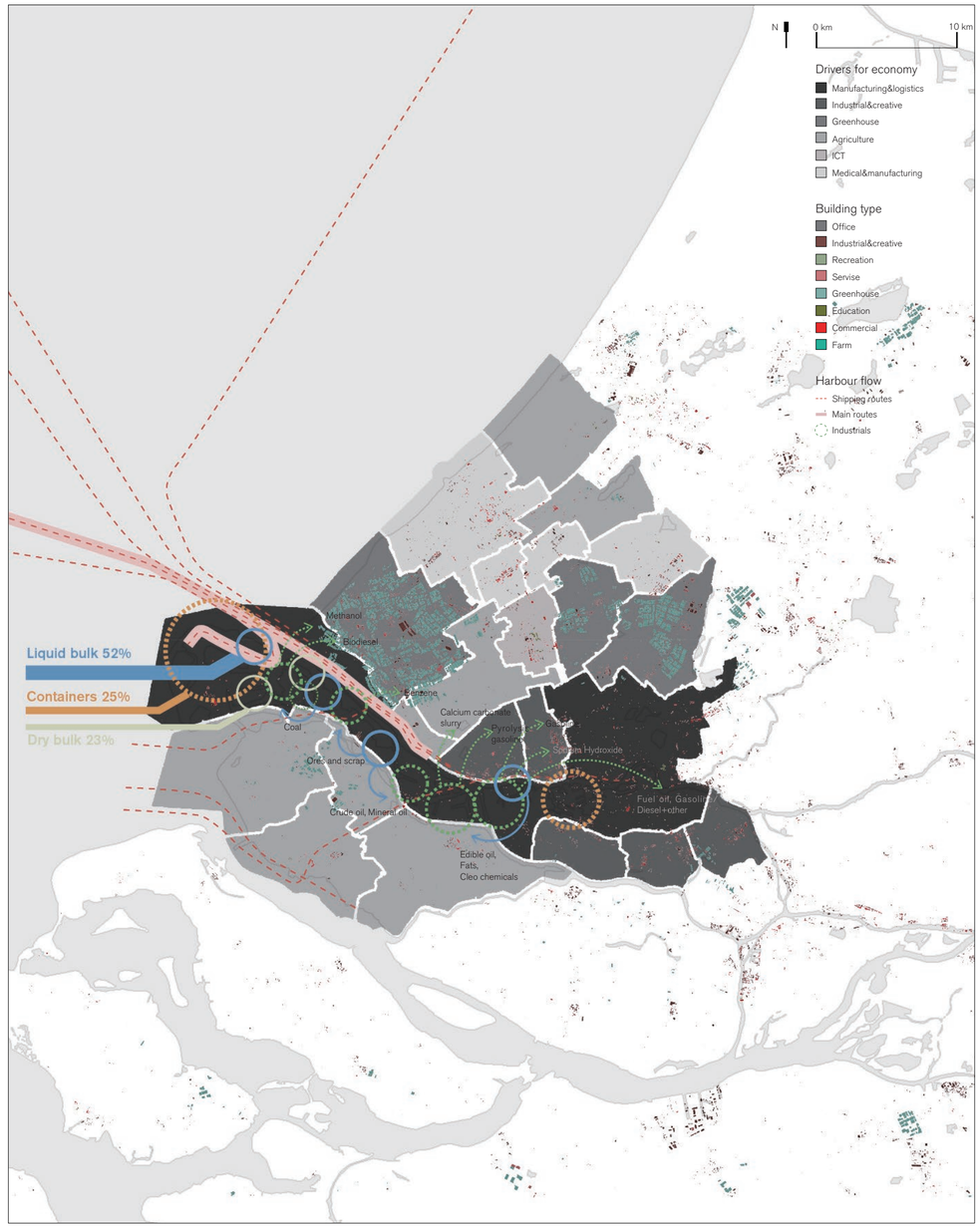


Fig.1.1.5 Drivers for economy. Source: Map created by author. Data from: Geofabrik, CBS, Port of Rotterdam.

1.1 PROBLEM FIELD

1.1.2 WATER POLLUTION THREATENING ECOSYSTEMS

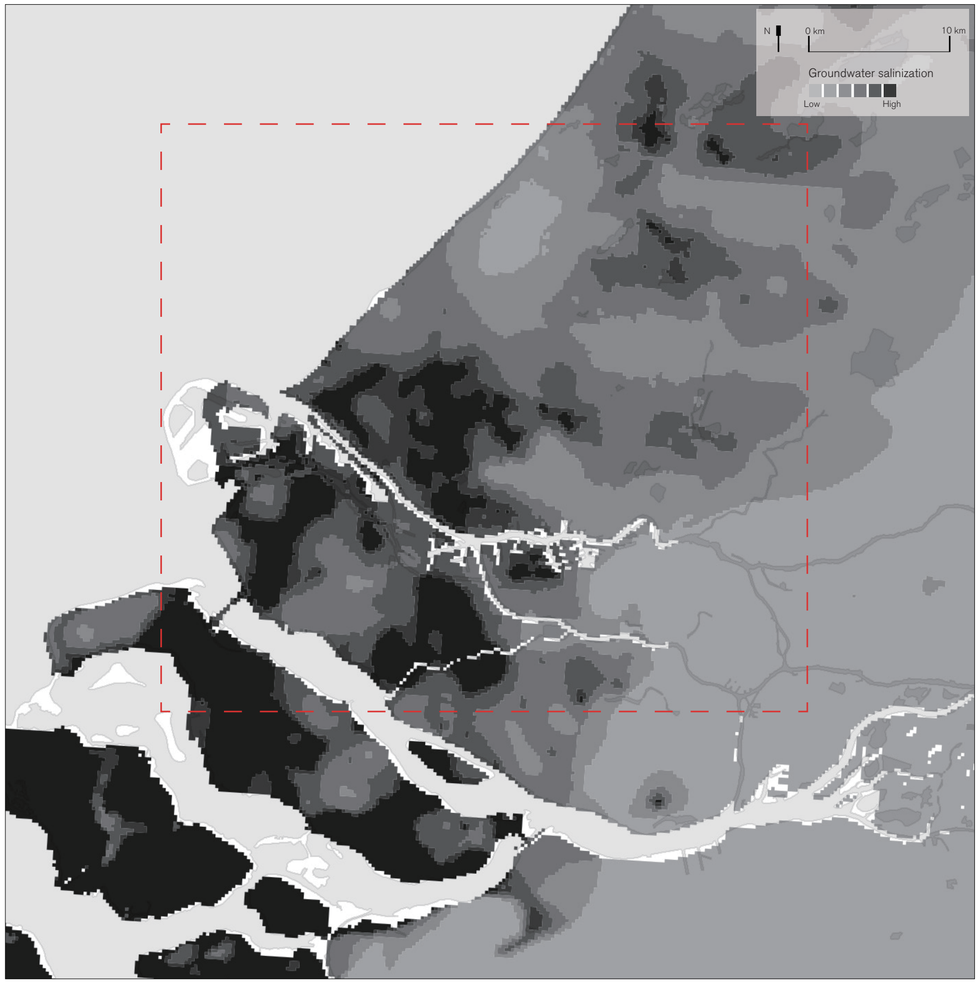


Fig.1.1.6 Groundwater salinization. Source: Map created by author. Data from: nationaalgeoregister.nl.

In the previous chapter, the areas and urgency of the water pollution pressure problem in the southern part of the North Sea have been introduced. Here we will focus on the MRDH area. Fig.1.1.6 and Fig.1.1.7 show that MRDH is mainly affected by groundwater salinization, surface water pollution and salinization. Affected by climate change such as sea level rise, more and more seawater will infiltrate into rivers and groundwater in the MRDH area by means of tidal effects and aggravate the problem of salinity of water bodies.

At the same time, the development of greenhouses and agriculture requires a large amount of fresh water and centralized irrigation. This huge consumption of water resources will increase the pressure on the local water ecosystem. Excessive use of pesticides and fertilizers will eventually lead to excessive amounts of chemical substances such as N and P elements entering nature water bodies, and exacerbating water pollution. This has the consequence of reducing the economic benefits of agriculture, reducing habitats, and increasing the vulnerability of cities and ecosystems.

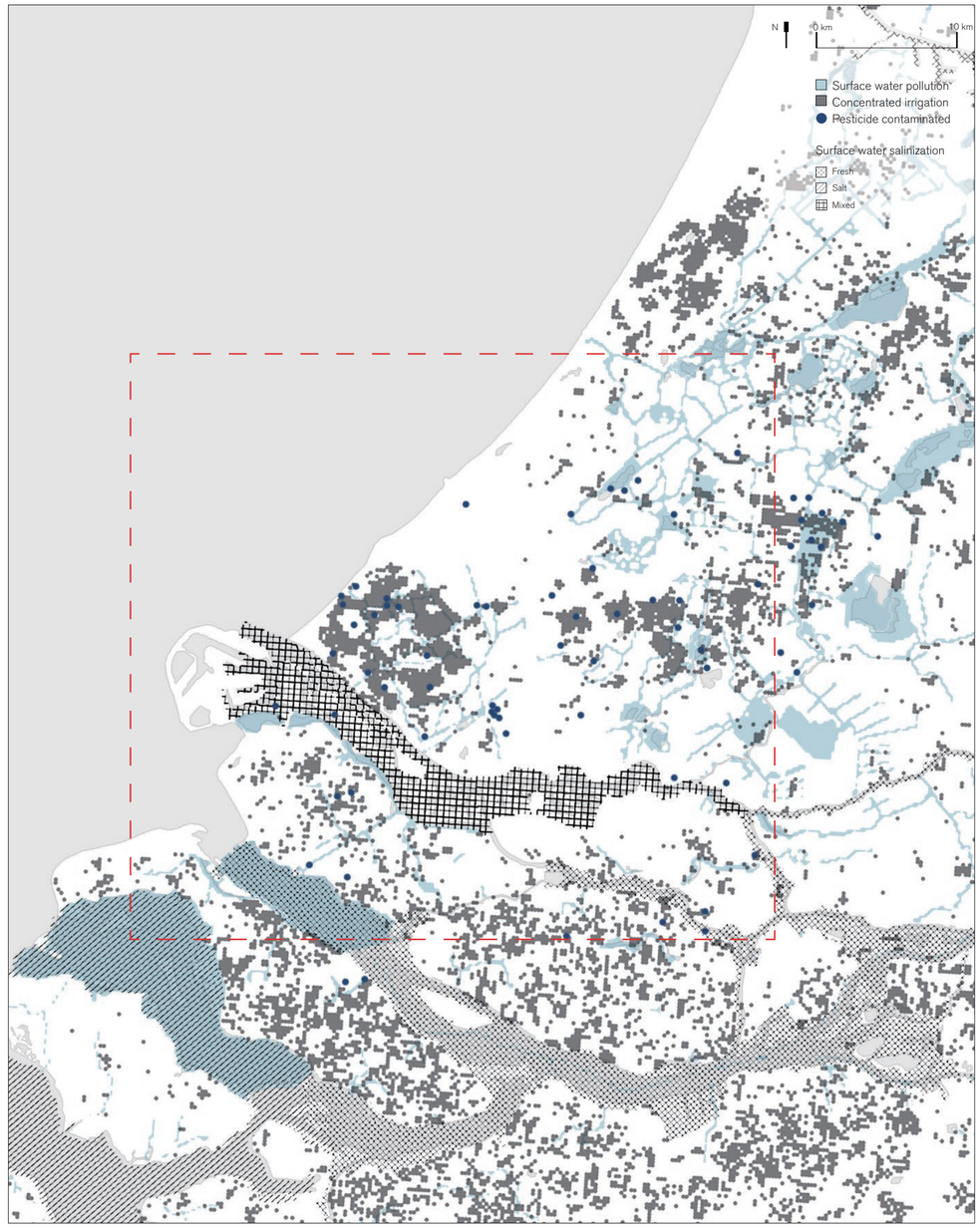


Fig.1.1.7 Surface water quality analysis. Source: Map created by author. Data from: nationaalgeoregister.nl.

1.1 PROBLEM FIELD

1.1.3 SEA-LEVEL RISE AND CLIMATE CHANGE

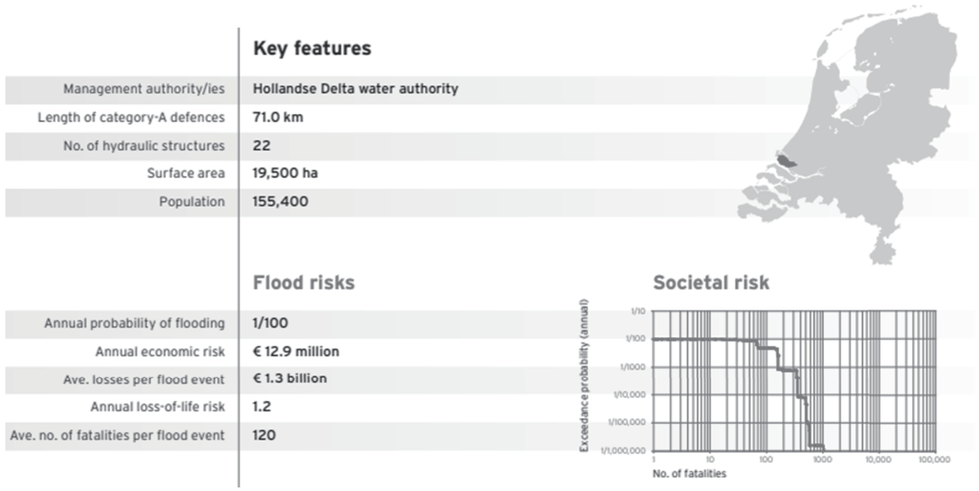


Fig.1.1.8 Risk assessment. Source: The National Flood Risk Analysis for the Netherlands (2017)

Common flood risks come from mainly two sources, one is coast floods caused by sea level rise, and the other is rain floods brought by heavy rainfall caused by climate change. The latter is more common in daily life and is the main problem to be solved in urban areas.

Fig1.1.8 shows the risk assessment carried out by the relevant authorities on the Netherlands (2017). It can be seen that the delta project has two sides. On the one hand, it reduces the flood risk in the region. On the other hand, the rapid socio-economic development puts the region at social risk, if event occurs, cities will suffer unprecedented damage.

Fig1.1.9 shows the current flood risk areas of MRDH. It can be seen that except for the port of Rotterdam, both sides of the river are subject to flood risk. This is due to the development of the city, which has disrupted the inland-river gradient landscape pattern. Because the open natural land is covered by impervious urban land and greenhouses, when heavy rain occurs, existing urban drainage facilities cannot drain rainwater into the system in a timely manner, resulting in floods.

At the same time, the map also shows the current types of coastal defense, which are mainly divided into dunes and dikes. The coastal areas are mainly dunes, such as Scheveningen. The Hague also relies on this resource to further develop tourism, but today's dunes have begun to decay due to human activities, eutrophication of water bodies is also getting worse.

Whether it is a flood disaster caused by rising sea levels or heavy rain, it will cause huge losses to cities and people.

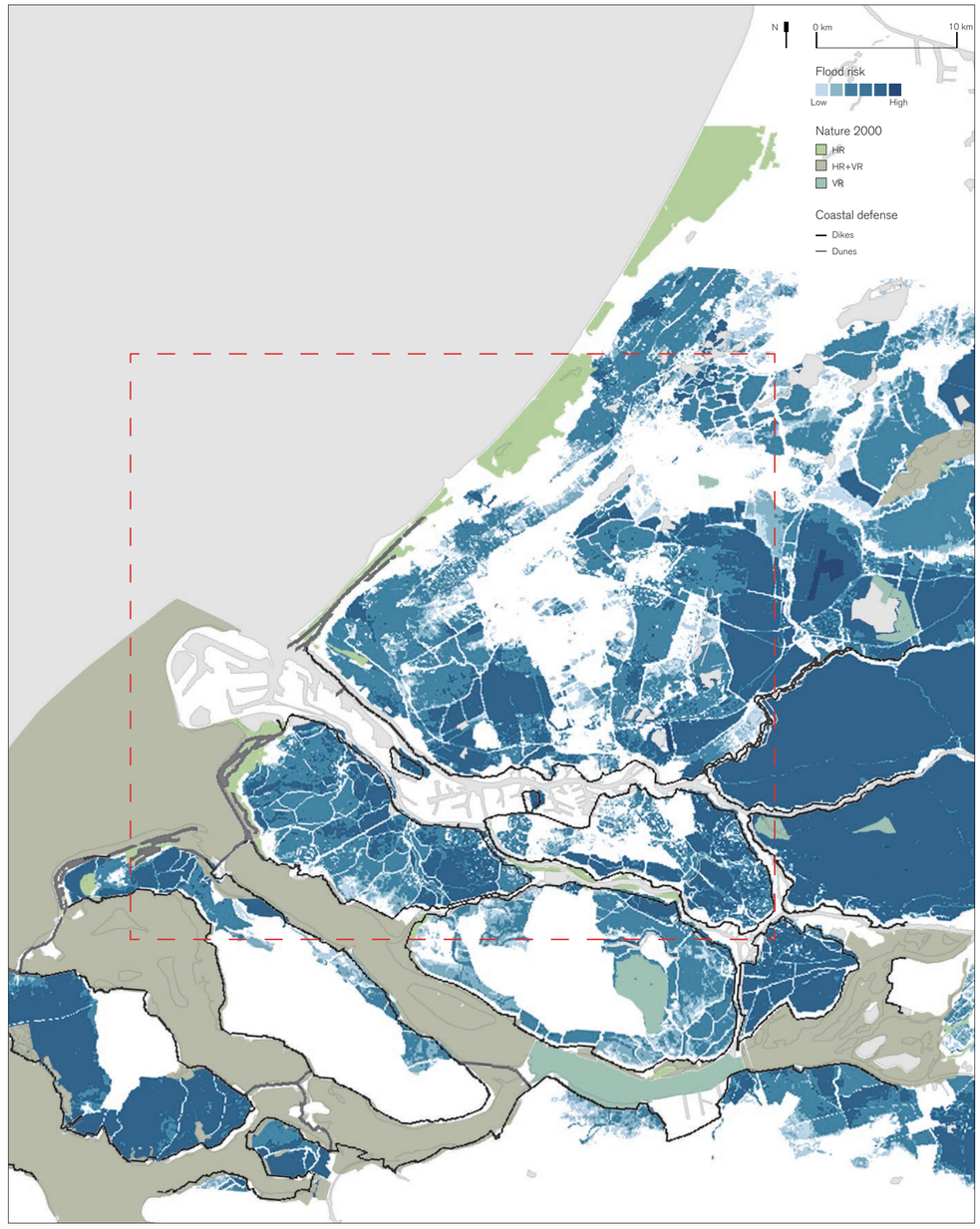


Fig.1.1.9 Flood risk. Source: Map created by author. Data from: nationaalgeoregister.nl, EUDGIS.

1.1 PROBLEM FIELD

1.1.4 THE NEEDS FOR REVISE PRODUCTION SYSTEM AND ECOLOGICAL IMPACT

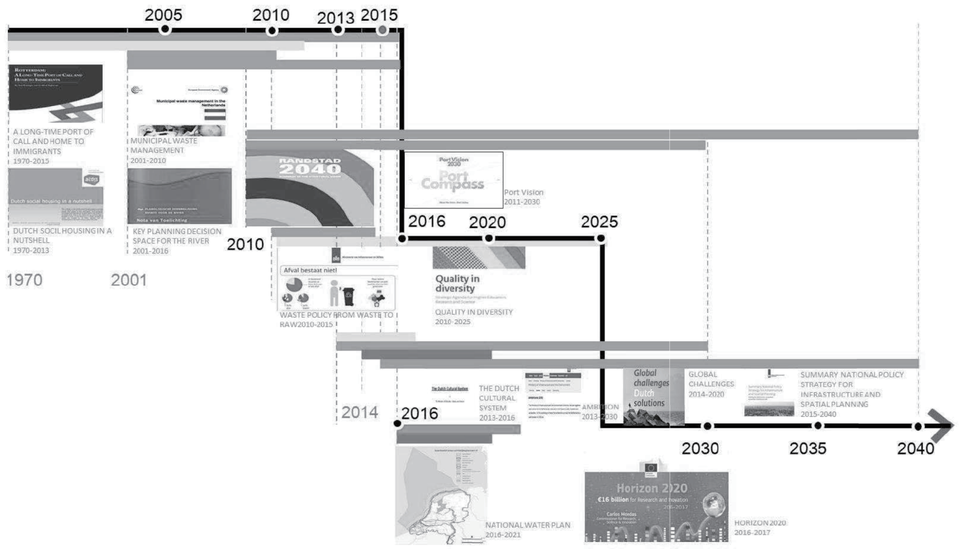
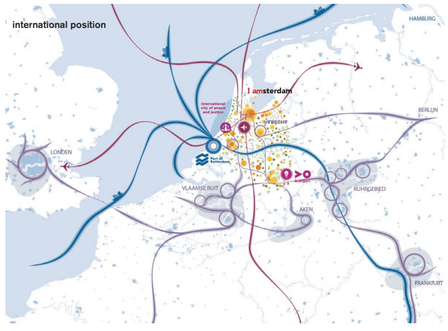


Fig.1.1.10 Existing policies. Source: Next Economy & Urban Region Networks, 2015 TU Delft.



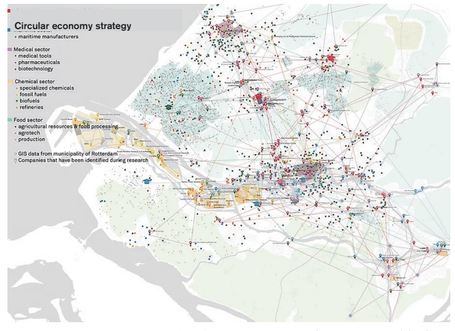


Fig.1.1.11 Existing strategies. Source: NEXT ECONOMY, NEXT CITY, MARCOBROEKMAN.

From the international position, the MRDH region is a port connecting the European to the world. From the national perspective, the MRDH region is an important part of the Dutch economy. At the same time, most of the inland river water will be discharged into the North Sea through the port of Rotterdam. This means that the water quality of the Nieuwe Waterweg is very important for the North Sea. The OECD report (2016) points out that the major work of the metropolitan government system focuses on regional development, transportation and economic development, however, energy and wastewater issues are their last concerns. Therefore, in the circular economy strategy formulated by the next circular economy, most of them focus on the exchange and connection between various industries; In the current relevant policies (environmental aspects), the waste recycling and delta protection plan are more focused on reducing CO2 emissions and creating more space for rivers, which is not enough to solve the complex ecological and environmental problems in the MRDH area.

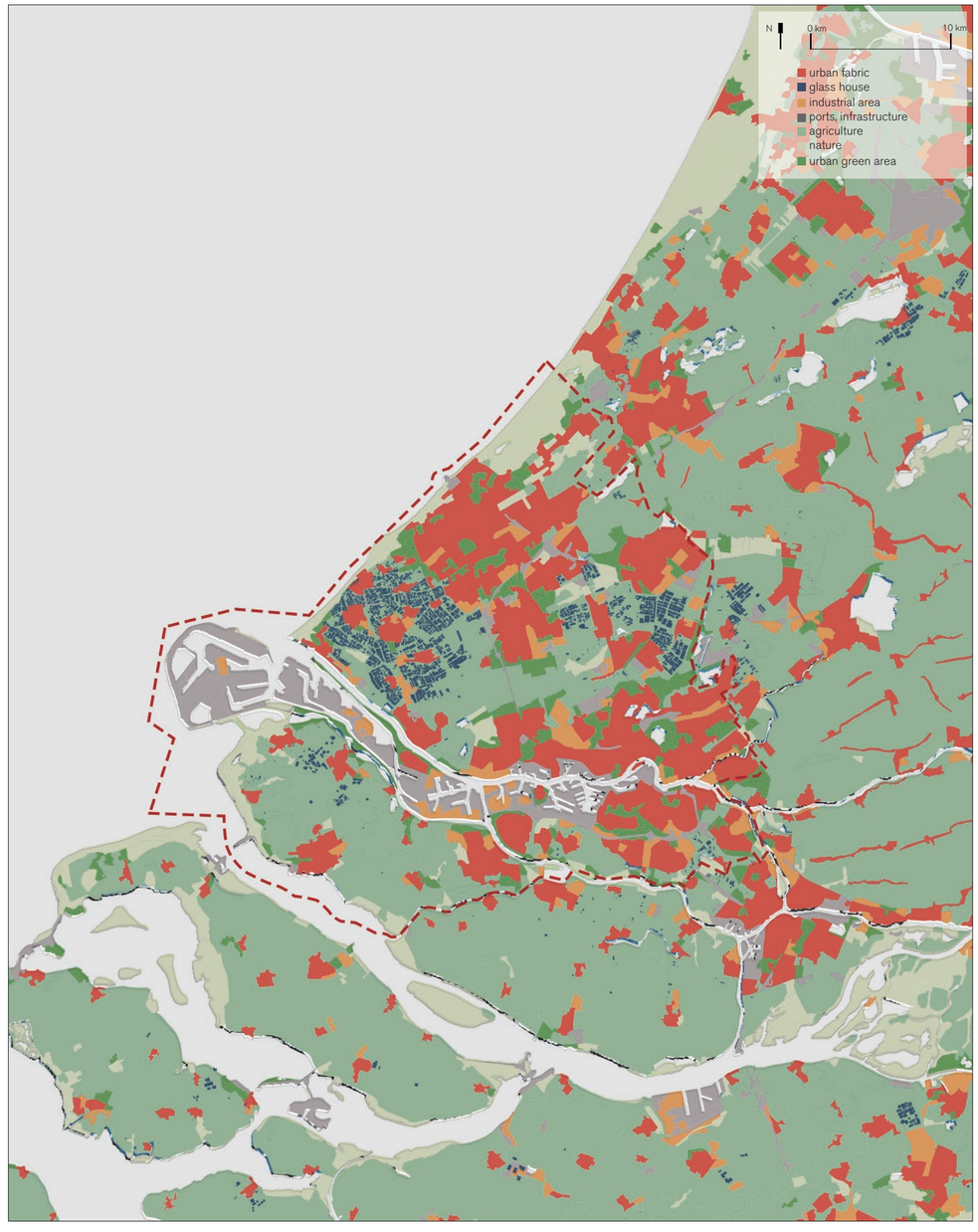


Fig.1.1.12 Current landuse map. Source: Map created by author. Data from: Geofabrik.

1.1 PROBLEM FIELD

1.1.5 BIO-BASED SOLUTION AND CIRCULAR ECONOMY

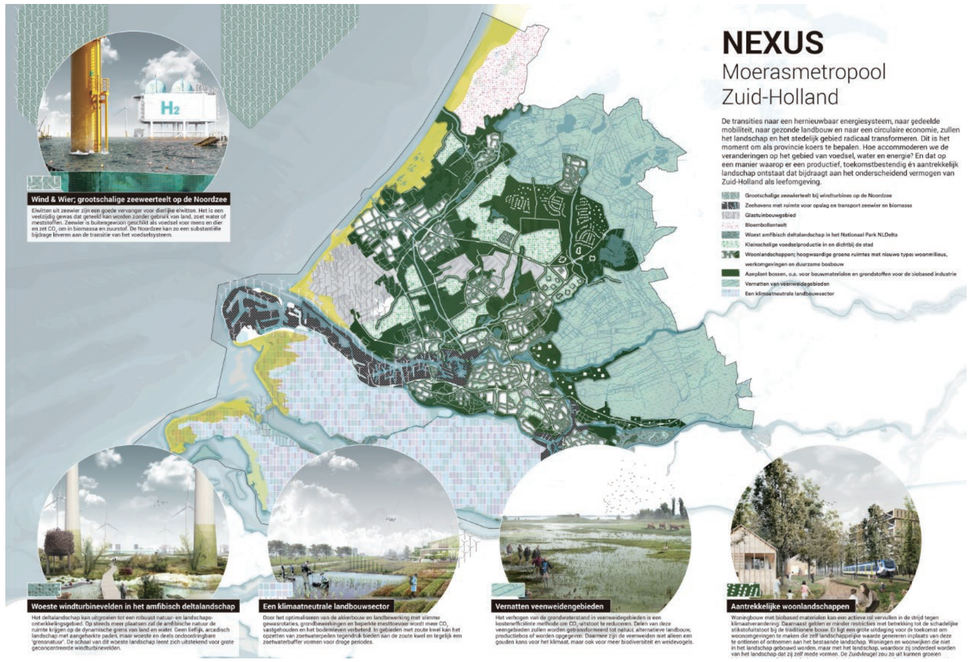


Fig.1.1.13 The landscape of the South Holland water-food-energy nexus. Source: Marcovermeulen.eu, map edited by author.



Fig.1.1.14 Seaweed farm fix the climate. Source: chinadialogue.net, picture edited by author.



Fig.1.1.15 Biogas Energy plant. Source: Youmatter.world, picture edited by author.

The European Commission defines a bio-based economy as: *The respondents support a public goods-oriented global and coherent strategy for a sustainable bio-based economy focusing on a recycling community, conservation of ecosystems and equitable sharing.*

In short, the use of bio-based solutions to achieve sustainable urban development. For example, seaweed cultivation purifies eutrophic seawater, absorbs carbon dioxide in the water, reduces the acidity of the seawater, and realizes the carbon cycle. In the future, fossil fuels will no longer be used, and biomass energy will be on the stage.

However, The Netherlands currently relies heavily on fossil fuels.

In the face of climate change, South Holland is transitioning to a circular economy (Fig1.1.13 and Fig1.1.16 shows future landscape and circular housing strategies). In this transition phase, we can adapt to changes in food, water and energy systems through bio-based solutions, and use these transitions to create productive, multifunctional urban spaces.

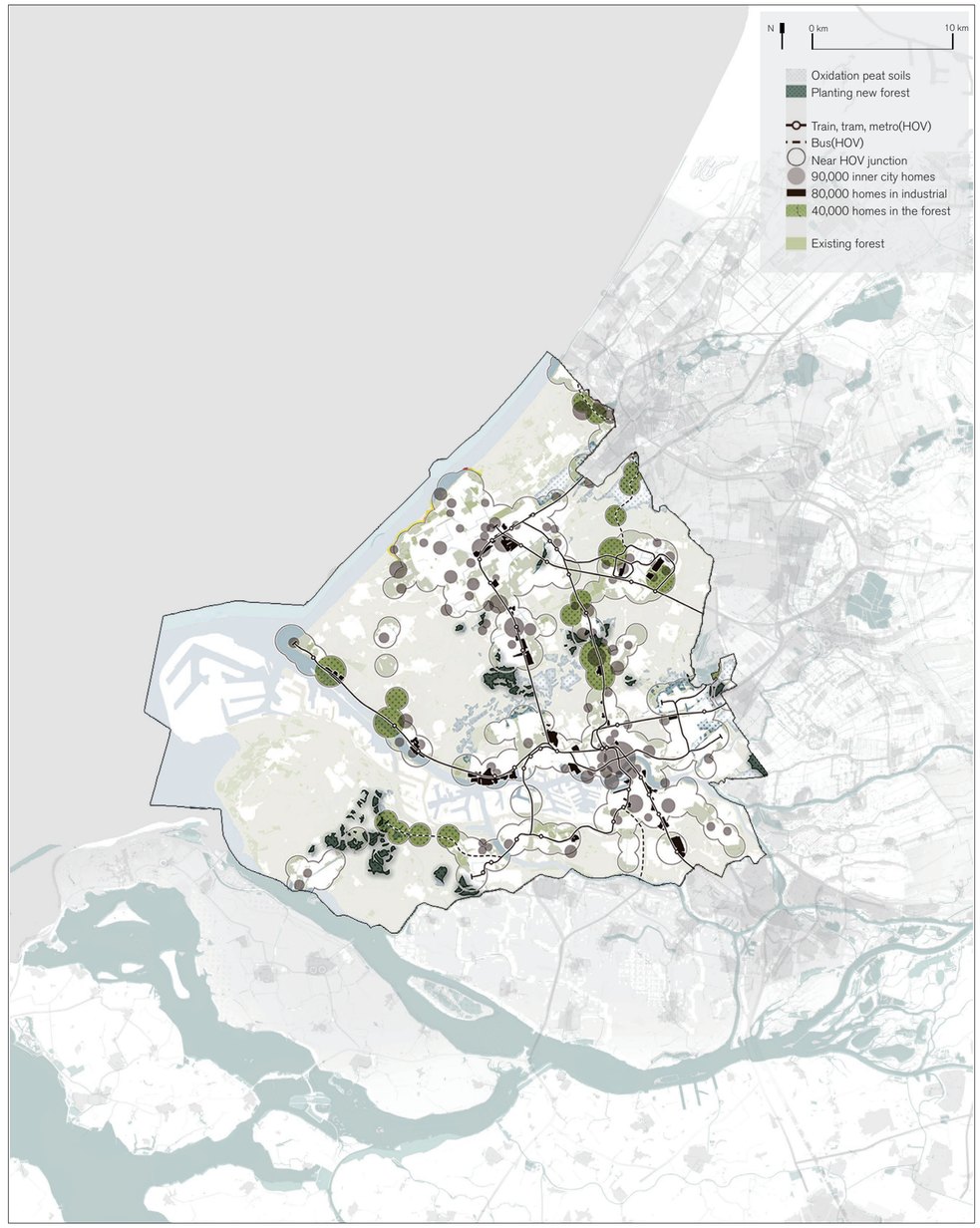


Fig.1.1.16 Circular Housing Strategy. Source: Marcovermeulen.eu, map edited by author.

1.2 PROBLEM STATEMENT

The concentration of the population in the southern coastal areas of the Netherlands has been increasing for a long time. Since 2008, The Hague and Rotterdam have grown faster than the whole of the Netherlands. South Holland is the most densely populated and industrialized region in the Netherlands, and in general, more than 50% of work in South Holland is directly related to the agri-food value chain (CBS). In order to promote economic development, in 2014, the Rotterdam–The Hague metropolitan area with the economic core of The Hague and Rotterdam was formed, to keep and make the area more attractive to international companies and organizations.

However, MRDH's growing urban economy comes at the cost of natural capital. Rotterdam, the second-largest city in the Netherlands, has developed into the largest port in Europe by relying on North Sea logistics. The industrial discharge of busy sea traffic and ports has caused eutrophication of seawater, at the same time, constantly evolving port has also invaded the ocean space in the past few years. Westland, also known as the "glass city", is also in this area, it requires a large amount of water for centralized irrigation every day, and the transfer of agriculture (fertilizer, wastewater, etc.) causes land salinization and eutrophication of water bodies. With its unique features such as ocean, beach and peat grass, The Hague has developed into a popular international tourist destination since the 19th century, however, the over-consumed water body is gradually declining and losing vitality. The natural environment in the MRDH area is under pressure from human activities such as urban expansion, agricultural production, and industrial development.

Human beings constantly transfer resources from the nature, and finally discharge economic metabolic wastes into water bodies, forming an unsustainable production cycle, putting pressure on the coastal ecological environment and destroying ecological services. In the current relevant policies (environmental aspects), the waste recycling and delta protection plan are more focused on reducing CO2 emissions and creating more space for rivers, which is not enough to solve the complex environmental problems in the MRDH area. In the face of sea-level rise, high precipitation condition, and the need for a sustainable economy, especially in the current stage of the energy transition, the use of bio-based solutions is crucial, we need to rethink the economic production patterns of cities and the relationship between cities and nature, so to facilitate areas and conditions for expansion.

1.3 RESEARCH QUESTION + SUB-RESEARCH QUESTIONS

MAIN RESEARCH QUESTION

What kind of shift in the economic production system could change the current waste flows between cities and nature to facilitate a sustainable and resilient economy in the Metropoolregio Rotterdam Den Haag (MRDH)?

SUB-RESEARCH QUESTIONS

SQ1 ASSESSING

1. Why the MRDH area need shift the economic production system?
2. What are the current economic production system in the MRDH area?
3. What is the current state on urban and water systems and its contribution to coastal/ urban pollution?
4. What is the current urbanization chanllenge in the MRDH area?

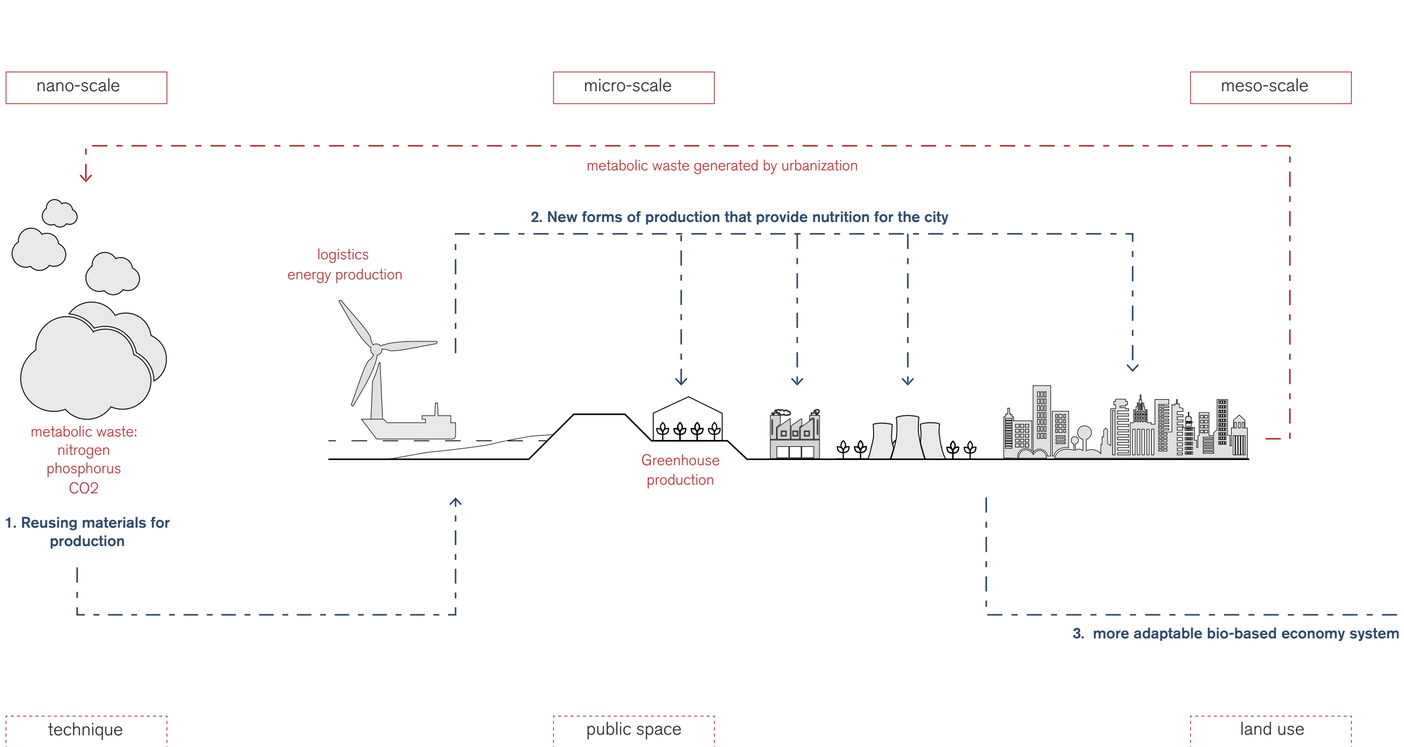
SQ2 INTERRELATING

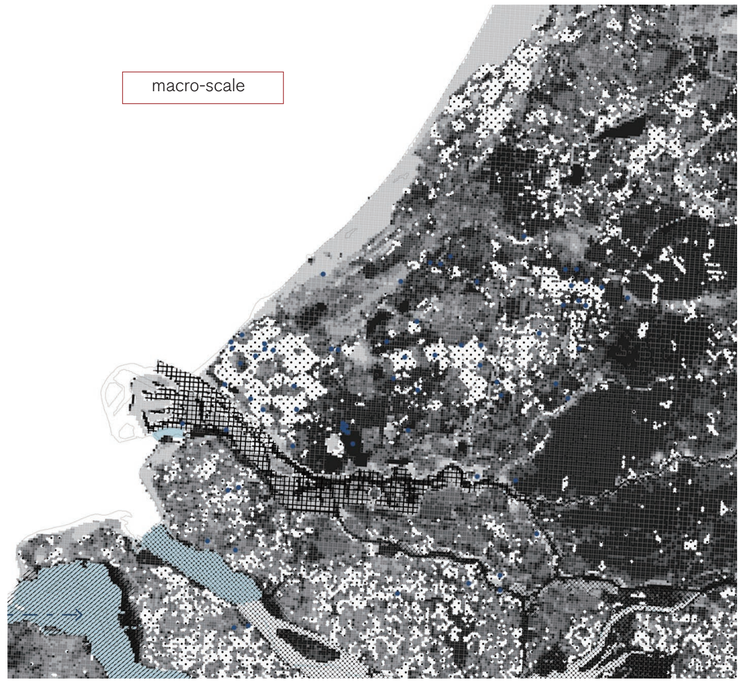
1. What are the limitation and potentialities of applying bio-based solutions in MRDH area?
2. How to use a polluted water body to change the MRDH's economic system and make it a medium for integrating nature and urban?
3. What kind of response measures should be taken to the eutrophication of water bodies while making use of the maximum potential of the North Sea and river forces?
4. How to restore the ecological environment of the MRDH through interventions in the water management system?

SQ3 PLANNING

1. Which method can promote the integration of modern technology and nature and achieve a sustainable economic future in the MRDH areas?
2. What kind of economic and environmental strategies would facilitate a sustainable future for the entire coastal region?

1.4 WORKING HYPOTHESIS





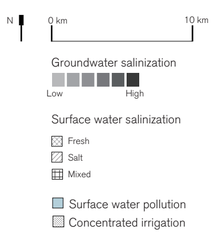


Fig.1.4 Working Hypothesis. Source: Created by author.

What if changes in the current economic production mode could create a different pathway to reuse the economic metabolic waste (nitrogen, phosphorus, carbon dioxide, etc.) in the production process and promote the material exchange process between the urban and nature, to form a virtuous cycle of economic production. This can restore the ecosystem and achieve the purpose of urban development as well. The polluted water body will become the main medium for material exchange between the two, so the more adaptable bio-based solutions will be provided for future climate change and bio-based economy, through interventions in the water management system.

1.5 OBJECTIVES AND GOALS

The key objective is to measure and explore possible changes in the current production structure, introduce a new bio-based economy, and transform towards a sustainable production pattern in coastal areas to achieve a symbiosis between the city and the water. This is based both on the need for a resilient and adaptable local economy as well as on the potential of existing environmental resources support such economic transitions.

Subsequent goals of this proposal would be to:

a. Assess for metabolic changes that have occurred and are still occurring in the economic, environmental and cultural processes of MRDH and correlate them with new flow systems that are generated by bio-based production models.

b. Counteracting negative trends such as eutrophication, the environmental stability of ecological services in coastal areas is restored and economic value is created by converting pollutants in water bodies into production materials.

c. Restore the cultural, social and economic disconnection of the territory's socio-spatial structure with water bodies by using it as a key basis on which to develop these new productive landscapes.

d. Proposing flexible and synergetic strategies for climate change and sea level rise within new production systems.

1.6 EXPECTED OUTPUT

The proposed hypothesis could reveal the potential synergy between various systems' components of metabolic waste, water, existing infrastructure and define the potential to adapt to the bio-based economy principal within certain man-made systems and natural processes based on its interdependencies and symbiotic growth. Assessing the negative externalities of the systematic relationship between the urban system and the biophysical environment, respond to the reduction of ecological services through urban water pollution or poor management, and increase the exploration of measures to cope with the risks of climate change impact. **The final output will be discussed in different scenarios, and reveal the extent to which transformation of the economic production system can achieve the symbiosis between the city and nature, and define possible expansion areas.**

Scale: from the metabolic wastes' nano-scale to regional scale.

2 THEORETICAL FRAMEWORK

2.1 BUILDING UP THE THEORETICAL FRAMEWORK
2.2 CONCEPTUAL FRAMEWORK
2.3 THEORY PAPER

2.1 BUILDING UP THE THEORETICAL FRAMEWORK

First, understand the definition of the main theoretical tools of urban ecosystems, and study the impact of current urbanization on the structure and function of coastal water ecosystems, including the theoretical basis of urban ecology and urban ecosystems. The second is to study the current ecological restoration solutions in coastal areas. In addition, the related theoretical basis of bio-economy is researched, therefore, Urban metabolism can be studied and considered. Comprehensively research the relevant theoretical basis of Adaptation and resilience, and establish the theoretical framework and principles of the biological economic development model of coastal cities.

1. Adaptation and resilience

Resilience as a concept visualizes the dynamics of nature caused by disturbances and change. Thus, nature is not in "balance", but constant change. Holling (1973; 1978) defined resilience as the ability of an ecosystem to absorb disturbances, renew itself and continue within a specific state.

In this case, uncertainty must be accepted, and the management of natural resources should treat uncertain changes as a strategy, not just respond to it (Barthel et al., 2013). Uncertainty shows the need to define the changes and diversity of these environments. In order to adapt to the changes and uncertainties of climate change, it is necessary to focus on several design components of the social ecosystem, that is, green arteries, active ground, and performative buildings(Barthel et al., 2013).

According to Brooks (2003), the vulnerability can be viewed as either social or biophysical. The social vulnerability concerns the impact on specific social groups and depends on the internal characteristics of these groups (Turner et al., 2003) Biophysical vulnerability concerns the ultimate impacts of a hazard event and is often viewed in terms of the amount of damage experienced (Brooks, 2003). Resilience focuses on adaptability and the ability to respond to future uncertainties, providing a dynamic perspective on the processes of change within social and natural systems and the impact of these processes on different temporal and spatial scales (Adger, 2009).

According to Smith and Wandel, the concept of vulnerability is interrelated with the concept of adaptation in the following way; 'Adaptations [...] represent ways of reducing vulnerability' (Smith & Wandel, 2006). Adaptation involves changes in environment, society Or economy by the system itself to alleviate vulnerability (Adger et al., 2004).

2. Urban metabolism

Introduced by Walman (1965), the concept of urban metabolism was first used to study socioeconomic systems. "Urban metabolism" is defined as all tangible stocks that form the material basis of a city and the flow of energy and matter (Baccini and Brunner, 2012). Different research perspectives of industrial ecology, political ecology and urban ecology have been brought together to gain a deeper understanding of urban metabolism, especially the interaction between natural and social systems and resource systems, and their impact on cities.

The framework of urban metabolism consists of two parts, anabolism and catabolism. The former involves the extraction, utilization and production of substances, while the latter involves the decomposition, recovery and reuse of wastes (Hoornweg et al., 2012). Since the urban metabolic framework covers material inputs and waste outputs through equivalent metabolic procedures, it can quantify resources such as food, fuel, water and minerals, and analyze the relationship between material flows and environmental issues. The concept of urban metabolism suggests that cities are not only physical Spaces that depend on planning and management, but also types of "living organisms" that can be controlled and regulated in their metabolic processes (Cui et al., 2019).

Building on these advances, researchers have begun to use the urban metabolic framework to identify sustainable urban solutions that, combined with recycling models, lay the foundation for today's sustainable and resilient approaches.

3. Urban ecology and urban ecosystems

Cities are dependent on the ecosystems beyond the city limits, but also benet from internal urban ecosystems(Bolund et al.,1999). It has been proposed that urban ecosystems are more complex than other types of ecosystems because of their dynamism, their heterogeneity, their nonlinearity, the presence of social–biophysical feedbacks in cities, and the varied actions of thousands or millions of resident humans (Andersson 2006; Alberti 2008; Pickett et al. 2008; Qureshi et al. 2014).

Urban ecology can be defined as the study of spatial and temporal patterns, environmental impacts, and the sustainability of urbanization, with emphasis on biodiversity, ecosystem processes, and ecosystem services. Urban ecology overlaps but differs from the so-called "science of urban sustainability", whose focus is fundamentally dependent on the human well-being of ecosystem services. The science of urban sustainability covers urban ecology but is a much broader field of study. Ecosystem services are the benefits people get from biodiversity and ecosystem functions, which provide a key link between urban ecosystems and sustainability (Wu, 2014). Therefore, the restoration of the urban ecosystem plays an important role in human wellbeing and urban resilience.

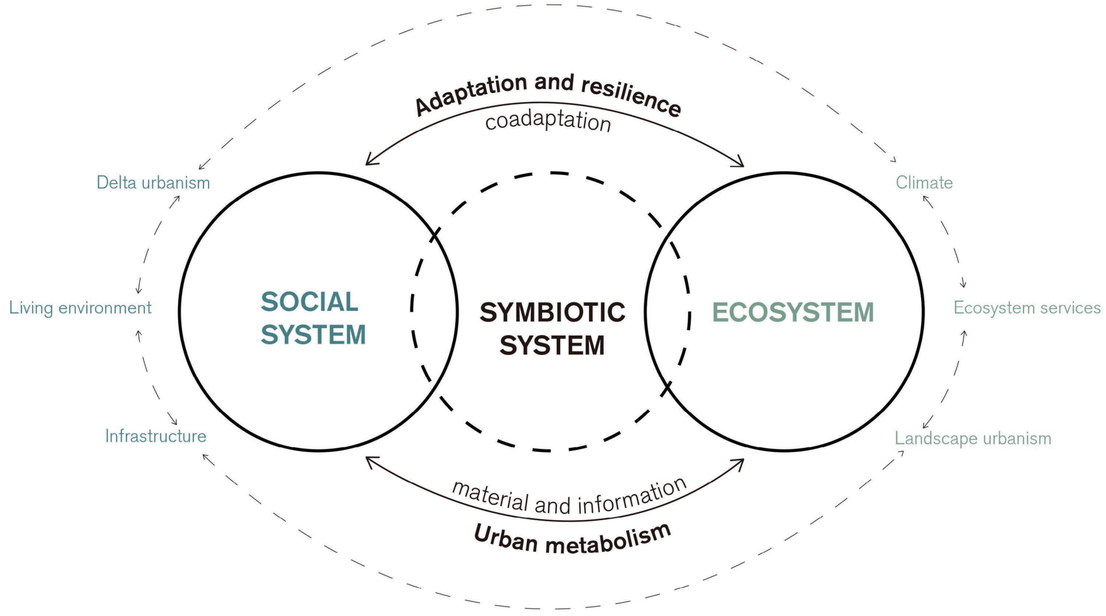


Fig. 2.1 Theoretical framework. Source: Created by author.

2.2 CONCEPTUAL FRAMEWORK

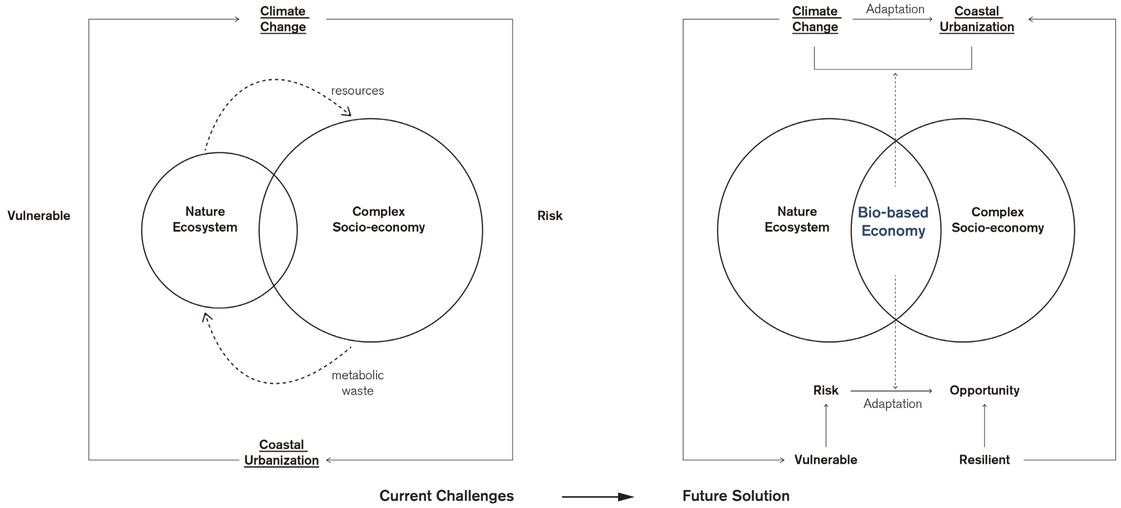


Fig. 2.2 Conceptual framework. Source: Created by author.

The conceptual framework shows that the current socio-economy development is at the expense of natural resources, natural ecosystem is shrinking, and urban is still expanding, which is harmful for urban ecosystems and make coastal areas more vulnerable. Due to the impact of urbanization and climate change, coastal cities will face larger risks.

By adopting bio-economic solutions, linking complex urban socio-economic systems with natural ecosystems, using the characteristics of bio-economics to form a symbiotic system, which could counteract potential risks in coastal areas into opportunities for development, and restore the ecosystem services through this new economic model in coastal areas, thereby increasing urban resilience.

Non-parasitic Economy:
Towards a symbiosis between coastal cities and water

ARU3U023 Theories of urban planning and design
Msc Urbanism, Technische Universiteit Delft

Jun Chen

4844130
j.chenjun0106@gmail.com

25-11-2019

Abstract

Coastal areas have always played a vital role in the economic, social and political development of most countries. They support a diverse and productive coastal ecosystem that provides valuable goods and services (Airoldi et al., 2005). In these areas, urbanization and other land-use activities are rapidly increasing. However, human activities represented by urban expansion, agricultural production, and industrial development have led to the deterioration of ecosystems in coastal areas (Zhai et al., 2019). Climate change and extreme weather events will also pose an increasing threat to coastal ecosystems. In the long run, the current mode of economic development is not suitable for the future development of coastal cities, but it does not mean to stop the urbanization of coastal areas or their development activities. This paper explores the possibility of symbiosis development of human activities and ecosystems in coastal areas, starting with the definition of the main theoretical tools for understanding urban ecosystems, then it expounds the current urbanization impact on coastal water ecosystem structure and function, and reviews the current solutions for ecological restoration in coastal areas. In addition, based on the theoretical research, the possibility of using the bio-based economy to restore the ecology of coastal areas is proposed. The conclusion is to propose a theoretical framework and principles for adopting the model of bio-based economic development in coastal urban areas, laying a solid foundation for enhancing the adaptability of the local economy, ecosystem and social spatial structure.

Key words: **Coastal urbanization; Coastal ecosystem; Ecological restoration; Bio-based economy; Resilient city**

1. Introduction

The coastal area is a transitional zone between the pure land and the pure ocean part of the Earth's surface. From a human perspective, it represents one of the most important regions of the world's oceans (Lu et al., 2018). In almost all parts of the world, coastal areas have a clear process of population concentration, and coastal areas have always played a vital role in the economic, social and political development of most countries. They support a diverse and productive coastal ecosystem that provides valuable goods and services (Airoldi et al., 2005). In addition, by 2050, an estimated 650 million people will live in deltas and coastal cities (Meyer et al., 2015).

However, these coastal areas, which are affected by marine ecosystems and terrestrial ecosystems, are more sensitive and vulnerable than others. Due to population growth and rapid socio-economic development, human activities have exacerbated the frequent exchange of material and energy in coastal areas (Denner et al., 2015). Human activities represented by urban expansion, agricultural production, and industrial development have led to deterioration of ecosystems in coastal areas (Zhai et al., 2019). Sea level rise and extreme precipitation events caused by climate change will also pose an increasing threat to coastal ecosystems.

In the long run, the current mode of economic development is not suitable for the future development of coastal cities, but it does not mean to stop the urbanization of coastal areas or their development activities. On the one hand, the impacts of climate change and human activities on coastal ecosystems have been empirically is interaction (such as accelerating sea level rise, ocean acidification, etc.), and the interaction between the two often causes greater damage to coastal ecosystems. However, there are also literatures pointed out that antagonistic interactions exist in coastal ecosystems (such as metal pollution and agricultural activities can weaken ocean acidification) (He et al., 2019). On the other hand, for professionals in the field of urban design and planning, it is necessary to initiate thinking about the relationship between human systems and natural systems, and to use the interaction between these systems to propose new urban sustainable development strategies.

The aim of this paper is to theoretically explore the possibility of symbiosis development of human activities and ecosystems in coastal areas, and transforming the socio-economic oriented urbanization into the bio-based economic oriented sustainable urbanization scheme. Therefore, the first part begins with the definition of the main theoretical tools for understanding urban ecosystems. Then it expounds the impact of current urbanization on the ecological structure and function of coastal waters, and reviews the current solutions for ecological restoration in coastal areas. Finally, based on the theoretical research, the possibility of using the bio-based economy to restore the ecology of coastal areas is proposed. The conclusion is to propose a theoretical framework and principles for adopting the model of bio-based economic development in coastal urban areas, laying

a solid foundation for enhancing the adaptability of the local economy, ecosystem and social spatial structure.

2. Understanding the Complexity of Urban Ecosystems

In 1987, the World Commission on Environment and Development (WCED, 1987) placed the concept of natural sustainability based on ecology into the wider context of social and economic development. Since then, many partnership approaches between natural and social scientists have improved our understanding of the interactions between human society and natural systems (Ohl et al., 2010). Urban ecosystem is a complex adaptive system in which society and nature interact on multiple spatio-temporal scales. The relationship between society and ecology also points out the mutual dependencies between society and natural components (Ostrom, 2009). Today, the global ecological crisis has triggered critical thinking about human's role and responsibility in the natural environment. There is a growing recognition of human society's dependence on natural systems, so understanding the link between ecosystems and social systems is particularly important for achieving sustainability (Glaser et al., 2012). This chapter will start with defining the main theoretical tools to further explore the interaction between ecosystem and social system in coastal areas.

2.1 Coastal Urban Ecosystems

Coastal urban ecosystem is a special type of ecosystem that consists of complex natural, social, and economic systems in coastal urban areas. It focuses on the interaction between people and the environment through the relationship between economic development and environmental protection (Nathwani et al. 2019). The system is also a relatively fragile, with vulnerable natural ecosystems, high population density, and high economic density, highly concentrated on internal and external flows of energy and material flows. Coastal urban ecosystems combine the characteristics of coastal city, with the ecosystem services that exist at the interface between land and sea. However, these ecosystem services are highly vulnerable to climate change and sea level rise (Osland et al., 2016). This complex hierarchy also brings inevitable uncertainty and structural changes to the ecosystem.

Therefore, analysing the structure and function of coastal urban ecosystems through time and scale is a theoretical tool for understanding the interaction between humans and ecosystems. Analysing local and regional contingencies over time is also important to explain and predict the further impact and development of these systems. Working with layers, times, scales is a way to analyse complex delta through different layers, periods and scales (Courtesy of TU Delft – Nijhuis, Pouderoijen). This method is an important tool to establish the relationship between historical or existing events and projected changes and dynamics in coastal ecosystems. At the same time, this analysis method helps to decompose complex coastal ecosystems and explore problems and opportunities.

2.2 Coastal Ecosystem Services

Coastal ecosystems include brackish, brackish (a mix of brackish and freshwater) and freshwater, as well as coastlines and adjacent land. All these waters and landforms interact as integrated ecological units. Coasts, dunes, offshore islands, isolated islands, headlands, lagoons, and freshwater wetlands within the estuary basin are included in the definition of coastal ecosystems because these interconnected features are critical to coastal wildlife and their habitats (Convertino Et al., 2013). In simple terms, the dynamic interaction between land and sea shapes coastal ecosystems.

Ecosystem services refer to the benefits that humans get from ecosystems. Corresponding urban ecosystem services refer to the benefits that humans get from urban ecosystems (Bolund et al., 1999). According to the Millennium Ecosystem Assessment (MEA, 2005), ecosystem services can be categorized into four major types, and the coastal ecosystem services include: (1) provisioning services, fisheries, building materials; (2) regulating services, carbon sequestration and storage, erosion prevention, wastewater treatment, mitigating extreme events; (3) supporting services, animal and local life cycle maintenance, element and nutrient cycling; (4) cultural services, tourism, entertainment, aesthetics and spiritual interest (MEA, 2005).

The complex structure and diverse service functions also make coastal ecosystems one of the most productive systems on the planet. It not only provides a series of ecosystem services such as habitats for animals, but also brings huge economic benefits to human beings benefits (Iglesias-Campos et al., 2015), and the complexity of the coastal environment makes its own structure and function always dynamic and changing at an alarming rate (Duarte et al., 2009).

The characteristics of coastal ecosystem services are well defined in three main sections: structure, function and change. Structure refers to the interconnected physical characteristics of the above-mentioned coastal ecosystems. Function occurs through structure and represents the movement of plants and animals, the flow of water, energy and materials. Change means dynamic changes in structure and function over time (Iglesias-Campos et al., 2015).

3. Current Urbanization Impact and Restoration Solutions

Urbanization usually refers to as either growth or degree of urban character or natural, it can also refer to the geographic area combining urban and rural areas, or refer to the transformation of an area to greater urban development; Urbanization develops over time at this stage, and as it develops, it becomes one of the main causes of the loss of ecosystem services (Lee et al., 2006). On a global scale, coastal ecosystems are under pressure from the rapid growth of urban population in coastal areas, and the continued growth of population in coastal areas ensures a sustained impact on coastal ecosystems and ecosystem services provided by natural systems to humans (Callaway&Zedler, 2004). In this chapter, the main impacts of current urbanization on the structure and function of coastal ecosystems are described, and solutions for current coastal ecosystem restoration are reviewed.

3.1 Urban Expansion and Hydrological Change

Urban expansion usually involves the conversion of natural habitats to land uses with impervious surfaces that prevent rainfall from infiltrating and causing hydrological changes, which degrade ecosystems downstream in coastal areas

(Faulkner, 2004); and due to urban expansion, the demand for fresh water in urban areas will also increase, and the construction of dams and centralized water withdrawal will also affect the hydrology of coastal areas by changing the flow of the natural environment (Lee et al., 2006). Changes in natural infiltration and flow levels have caused sediments and pollutants in coastal urban areas to enter the drainage network directly, and eventually enter coastal water system. Urban expansion has affected coastal ecosystem services by changing the structure of urban ecosystems.

3.2 Agricultural Production and Eutrophication

Agricultural activities in coastal areas lead to the release of nutrients and organic matter into coastal ecosystems, which is one of the main causes of coastal eutrophication (Lee et al., 2006). Harmful algal blooms and hypoxia are the two most serious consequences of eutrophication, which adversely affects aquatic animals and plants in coastal areas, leading to the loss of biodiversity and the decline of coastal ecosystem services (Carstensen et al., 2011). However, eutrophication also has subtle beneficial effects on coastal ecosystem services. Human nutrients and organic matter have become an increasingly important part of the material budget of urbanized coastal areas. It is estimated that in the Deep Bay of Hong Kong, approximately 50% of all available organic carbon on which fisheries and natural organisms depend is derived from human systems (Li and Lee, 1998). Therefore, human systems should reverse the risks of eutrophication to positive effects before the ecosystem collapses

3.3 Industrial Development and Toxic Pollutants

The development of industry in the port area will also cause pressure on the coastal ecosystem. The discharge of industrial wastewater is one thing, and the other is the increase in the proportion of impervious surface caused by the urbanization mentioned above, and the toxic pollution (such as detergents, heavy metals and petroleum products, etc.) accumulated on land will eventually migrate to coastal waters. In addition, oil spills caused by offshore oil extraction are also an important source of toxic pollutants, which has caused increased soil toxicity in seawater and coastal areas (Lee et al., 2006; Lu et al., 2018), and has also affected creatures living in this area. There is evidence that some of these pollutants can accumulate in the tissues of coastal organisms and biomagnify through food webs, causing range effects (Connell et al., 1999).

3.4 Impacts of Climate Change

At present, climate change issues such as coastal floods, ocean acidification and sea-level rise have affected coastal ecosystem services and climate change is the most widespread threat to coastal ecosystems; In addition, the impact of climate change will be superimposed on other human pressures, and will have a cumulative impact on each of the above environmental issues (He et al., 2019). Increasing greenhouse gas concentrations lead to increased ocean acidification; weakening of biodiversity due to eutrophication increases the sensitivity of coastal waters to acidification; at the same time, algal blooms will consume oxygen in the water and produce carbon dioxide, which eventually increases acidity; Increased precipitation caused by climate change will bring more potential nutrients and industrial pollutants into coastal areas, increasing pressure on coastal ecosystems. It is worth mentioning that some literature points out the antagonistic interaction between the two in coastal ecosystems (such as, lime used in agricultural activities can weaken ocean acidification) (He et al., 2019).

3.5 Current Restoration Solutions

Nowadays, the ecological problems in coastal areas have not been well resolved. We are only slowing down, but not reversing, the degradation of coastal ecosystems affected by global disasters (Chícharo & Zalewski, 2011). In view of the current challenges facing coastal areas, effective and timely governance and management of coastal ecosystems are currently the main means of maintaining the valuable functions and services they provide (Lu et al., 2018). Including: climate-based models and remote sensing tools for assessing coastal ocean capital, the results of which will help policymakers better achieve the sustainable development goals; Integrated management of land-ocean interaction in the coastal zone, focuses on changing the flux of nutrients, sediment, water and air entering coastal areas in response to future climatic conditions (Regnier et al., 2013; Xu et al., 2016); Coastal ecosystem-based management, it focuses on maintaining ecosystem services and functions and managing human activities based on ecosystems (Curtin and Prellezo, 2010).

It can be seen that the main methods for restoring coastal ecosystems are management and control of pollution sources, this is because the resilience of coastal ecosystems has been reduced under the influence of various pressure sources, and it is difficult to reverse the previous state in some damaged areas (Hughes et al., 2017), and the management of point pollution sources, which are relatively easy to control, can help to control the pressure caused by human activities and mitigating the degradation of coastal ecosystems by controlling the pressure.

4. Bio-based Economy as new approach

"A bio-based economy integrates the full range of natural and renewable biological resources—land and sea resources, biodiversity and biological materials (plant, animal and microbial), through to the processing and the consumption of these bio-resources."

——European Commission, 2011

As can be seen from the EU's definition of a bio-based economy, the concept focuses more on raw materials than on the conversion process, and it emphasizes economic sustainability, cleanliness, and renewables of resources. Biomass raw materials can be roughly divided into common major metabolites, secondary metabolites, and plant sources. Transition to a bio-based economy is an important means to achieve sustainable urban development goals (Staffas et al., 2013). The conflict between current urbanization and coastal ecosystems has been discussed above, this chapter will discuss how the bio-based economy can achieve urban resilience goal by restoring coastal ecosystem services.

4.1 Availability of nutrition

As mentioned above, eutrophication has a harmful effect on coastal ecosystem services, but also has subtle beneficial effects, but overall the disadvantages outweigh the benefits. Although eutrophic water is not viable for most aquatic organisms, it may be beneficial for some plants. They can absorb nutrients, especially nitrogen and phosphorus. In coastal Asian area, people have begun to use seaweed to purify eutrophic water bodies. The dissolved nutrients in water bodies are absorbed by seaweed. As a result, the concentration of nutrients is reduced and biodiversity is increased. The method achieves purification of water bodies and increases potential economic value. Bio-based economy can increase biodiversity and strengthen the circulation of materials in coastal urban ecosystems.

4.2 A substitute feedstock economy

In the context of climate change, the European Union has formulated a goal to achieve at least 20% of total energy consumption by 2020. Non-renewable energy such as oil and natural gas will be replaced by renewable energy in the future. The renewable energy currently used is mainly wind and solar energy, which can only generate electricity and is difficult to store or use as transportation fuel. However, biomass can fill the gap left by these energy sources. The biomass currently used is mainly from agricultural residues on land and therefore competes with food (Sanders & Hoeven, 2008). Since the production of seaweed does not require land and freshwater resources, the EU currently supports the development of seaweed biofuels. At the same time, through comparison with conventional bioethanol fuels, it has been found that seaweed biogas may have beneficial effects on climate change, acidification and terrestrial eutrophication (Czyrnek-Delêtre et al, 2017). The development of a bio-based economy can reduce the use of non-renewable energy sources, thereby reducing the ecological problems caused by the leakage of oil and other pollutants in industrial development.

4.3 Non-parasitic economy

The development of bio-based economy will not destroy biodiversity, nor will it compete with food supply. It is not like the current socio-economic development at the expense of natural ecosystems. In addition, the bio-based economy can also strengthen the rural economic structure and use non-food biomass to bring additional income security to farmers. The agricultural sector may also become an energy production sector in the future, increasing the importance of farmland. Future land use limits the possibility of current urban expansion mode. For urban planners and relevant decision makers, new land use forms need to be explored to change the current parasitic economic development model.

4.4 Relationship between Urban Resilience and Bio-based Economy

Ecosystems can mitigate the effects of climate change, thereby providing cities with resilience and enhancing their resilience (Kabisch et al., 2016). The bio-based economy promotes the functions of coastal ecosystems and the services of coastal ecosystems by changing the structure of coastal ecosystems and the material flow in the structures. Improve ecosystem resilience by restoring biodiversity and provide more ecosystem services to cities. These services help increase the long-term pressures and gradual resilience of cities. Compared with engineering adaptation measures, the urban resilience brought by bio-based economic development may be more resilient.

5. Conclusion

Due to the impact of climate change and socio-economic needs, the relationship between cities and nature is currently undergoing transition. Human beings have realized the dangers of the current parasitic relationship of diverting resources from ecosystems to meet socio-economic development.. Human beings depend on ecosystem services, but the current socio-economic development will destroy urban ecosystems, and then destroy ecosystem services. The end result will be that both parties will be destroyed. As complex systems, urban ecosystems should be analysed through time and across scales to understand the dynamics and patterns of such systems.

Based on the above theoretical review and discussion, it is possible to link complex urban systems with natural ecosystems through a bio-based economy, and to restore ecosystems in coastal areas through new economic models, thereby enhancing the resilience of cities.

And what if we change the current economic production mode of natural consumption, to reuse the economic metabolic waste (nitrogen, phosphorus, carbon dioxide, etc.) in the production process and promote the material exchange process between the urban and nature, to form a virtuous cycle of economic production. This can restore the ecosystem and achieve the purpose of urban development as well. In coastal areas, the water body will become the main medium for material exchange between the two, so the more adaptable solutions will be provided for future climate change and bio-based economy through interventions in the water system.

Based on the theoretical framework, the proposal principles are put forward for further study:

1) Projection through extreme scenarios. By making a variety of scenarios, the aim is to cope with the inevitable uncertainties and structural changes due to the complex hierarchical structure of coastal urban ecosystems, so as to make corresponding measures for future climate change and socio-economic transformation.

2) Intervention through multi-scale strategies and local, decentralized methods. Since the impact of ecosystems cannot be confined to a single scale, strategies at different scales are needed. In terms of city scale, the existing blue-green system and underground space can be used to form a small part of the entire ecosystem through small-scale intervention and large-scale connectivity.

3) Targeted stakeholder collaboration. Targeted participation of academic and / or other local authorities, increased policy support for the National Bureau of Statistics / Common National Assessment, and analysis of stakeholders can help policy makers better formulate relevant policies and research new urban development paradigm, to realize the symbiosis of nature and city.

Although the bio-based economy is still developing, more and more countries have supported and invested in research, and it will be more widely used in the future.

Reference:

Airoldi, L., Abbiati, M., Beck, M. W., Hawkins, S. J., Jonsson, P. R., Martin, D., … Åberg, P. (2005). An ecological perspective on the deployment and design of low-crested and other hard coastal defence structures. Coastal Engineering, 52(10), 1073–1087.

Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. Ecological Economics, 29(2), 293–301.

Carstensen, J., Sánchez-Camacho, M., Duarte, C. M., Krause-Jensen, D., & Marbà, N. (2011). Connecting the dots: Responses of coastal ecosystems to changing nutrient concentrations. Environmental Science and Technology, 45(21), 9122–9132.

Callaway J. C. & Zedler J. B. (2004) Restoration of urban salt marshes: lessons from southern California. Urban Ecosys. 7, 107–24.

Czyrnek-Delêtre, M. M., Rocca, S., Agostini, A., Giuntoli, J., & Murphy, J. D. (2017). Life cycle assessment of seaweed biomethane, generated from seaweed sourced from integrated multi-trophic aquaculture in temperate oceanic climates. Applied Energy, 196, 34–50.

Chícharo, L., & Zalewski, M. (2011). 10.01—Introduction to Ecohydrology and Restoration of Estuaries and Coastal Ecosystems. In E. Wolanski & D. McLusky (Eds.), Treatise on Estuarine and Coastal Science (pp. 1–5).

Convertino, M., Nardi, F., Kiker, G. A., Munoz-Carpena, R., Troccolli, A., & Linkov, I. (2013). 5.18—Epitomes of Bottom-Up Hydro-Geo-Climatological Analysis to Face Sea Level Rise in Complex Coastal Ecosystems. In R. A. Pielke (Ed.), Climate Vulnerability (pp. 267–282).

Connell D. , Lam P. , Richardson B. & Wu R. (1999) Introduction to Ecotoxicology. Blackwell Science, Oxford.

Curtin and Prellezo. (2010). Understanding marine ecosystem based management: a literature review. Mar. Pol., 34 (5) (2010), pp. 821-830

Darrel Jenerette, G., & Larsen, L. (2006). A Global Perspective on Changing Sustainable Urban Water Supplies. Global and Planetary Change, 50, 202–211.

Denner, K., Phillips, M. R., Jenkins, R. E., & Thomas, T. (2015). A coastal vulnerability and environmental risk assessment of Loughor Estuary, South Wales. Ocean & Coastal Management, 116, 478–490.

Duarte, C. M. (2009). Coastal eutrophication research: A new awareness. Hydrobiologia, 629(1), 263–269.

Faulkner S. (2004) Urbanization impacts on the structure and function of forested wetlands. Urban Ecosys. 7, 89–106.

Gerry Marten | Human Ecology—Coevolution and Coadaptation of Human Social Systems and Ecosystems. (n.d.). Retrieved 26 November 2019, from http://gerrymarten.com/human-ecology/chapter07.html

Glaser, G. (2012). Base sustainable development goals on science. Nature, 491(7422), 35–35.

He, Q., & Silliman, B. R. (2019). Climate Change, Human Impacts, and Coastal Ecosystems in the Anthropocene. Current Biology, 29(19), R1021–R1035.

Hughes, T. P., Kerry, J. T., Álvarez-Noriega, M., Álvarez-Romero, J. G., Anderson, K. D., Baird, A. H., … Wilson, S. K. (2017). Global warming and recurrent mass bleaching of corals. Nature, 543(7645), 373–377.

Iglesias-Campos, A., Meiner, A., Bowen, K., & Ansong, J. O. (2015). Chapter 3 - Coastal Population and Land Use Changes in Europe: Challenges for a Sustainable Future. In J. Baztan, O. Chouinard, B. Jorgensen, P. Tett, J.-P. Vanderlinden, & L. Vasseur (Eds.), Coastal Zones (pp. 29–49).

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., … Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society, 21(2).

Lee, S. Y., Dunn, R. J. K., Young, R. A., Connolly, R. M., Dale, P. E. R., Dehayr, R., … Welsh, D. T. (2006). Impact of urbanization on coastal wetland structure and function. Austral Ecology, 31(2), 149–163.

Li M. S. & Lee S. Y. (1998) Carbon budget for Deep Bay, eastern Pearl River estuary, China I: a mass balance study and implications for shorebird conservation. Mar. Ecol. Prog. Ser. 172, 73– 87.

Lu, Y., Yuan, J., Lu, X., Su, C., Zhang, Y., Wang, C., … Sweijd, N. (2018). Major threats of pollution and climate change to global coastal ecosystems and enhanced management for sustainability. Environmental Pollution, 239, 670–680.

Meyer, H., Bregt, A. K., Dammers, E., & Edelenbos, J. (2015). New perspectives on urbanizing deltas: a complex adaptive systems approach to planning and design. Amsterdam: MUST Publishers.

Millennium Ecosystem Assessment (Program) (Ed.). (2005). Ecosystems and human well-being: Wetlands and water synthesis: a report of the Millennium Ecosystem Assessment. Washington, DC: World Resources Institute.

N. Kabisch, N. Frantzeskaki, S. Pauleit, S. Naumann, M. Davis, M. Artmann, A. Bonn. Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society, 21 (2) (2016), p. 39, 10.5751/ES-08373-210239.

Nathwani, J., Lu, X., Wu, C., Fu, G., & Qin, X. (2019). Quantifying security and resilience of Chinese coastal urban ecosystems. Science of The Total Environment, 672, 51–60.

Ohl, C., Johst, K., Meyerhoff, J., Beckenkamp, M., Grüsgen, V., & Drechsler, M. (2010). Long-term socio-ecological research (LTSER) for biodiversity protection – A complex systems approach for the study of dynamic human–nature interactions. Ecological Complexity, 7(2), 170–178.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. Science, 325(5939), 419–422.

Osland, M. J., Enwright, N. M., Day, R. H., Gabler, C. A., Stagg, C. L., & Grace, J. B. (2016). Beyond just sea-level rise: Considering macroclimatic drivers within coastal wetland vulnerability assessments to climate change. Global Change Biology, 22(1), 1–11.

P. Regnier, P. Friedlingstein, P. Ciais, F.T. Mackenzie, N. Gruber, I.A. Janssens, G.G. Laruelle, R. Lauerwald, S. Luyssaert, A.J. Andersson, S. Arndt, C. Arnosti, A.V. Borges, A.W. Dale, A. Gallego-Sala, Y. Godderis, N. Goossens, J. Hartmann, C. Heinze, T. Ilyina, F. Joos, D.E. LaRowe, J. Leifeld, F.J.R. Meysman, G. Munhoven, P.A. Raymond, R. Spahni, P. Suntharalingam, M. Thullner. (2013). Anthropogenic perturbation of the carbon fluxes from land to ocean. Nat. Geosci., 6 (8) (2013), pp. 597-607.

Sanders, J., & Van der Hoeven, D. (2008). Opportunities for a Bio-based Economy in the Netherlands. Energies, 1(3), 105–119. https://doi.org/10.3390/en1030105

Staffas, L., Gustavsson, M., & McCormick, K. (2013). Strategies and Policies for the Bioeconomy and Bio-Based Economy: An Analysis of Official National Approaches. Sustainability, 5(6), 2751–2769.

WCED, 1987. WCED Our Common Future. World Commission on Environment and Development. Oxford University Press, Oxford (1987)

Xiao, X., Agusti, S., Lin, F., Li, K., Pan, Y., Yu, Y., … Duarte, C. M. (2017). Nutrient removal from Chinese coastal waters by large-scale seaweed aquaculture. Scientific Reports, 7(1), 1–6.

X.G. Xu, X. Li, M.C. Chen, X.Y. Li, X.F. Duan, G.R. Zhu, Z. Feng, Z.G. Ma. (2016). Land-ocean-human interactions in intensively developing coastal zone: demonstration of case studies Ocean Coast Manag., 133 (2016), pp. 28-36.

Yi, L., Chen, J., Jin, Z., Quan, Y., Han, P., Guan, S., & Jiang, X. (2018). Impacts of human activities on coastal ecological environment during the rapid urbanization process in Shenzhen, China. Ocean & Coastal Management, 154, 121–132.

Zhai, T., Wang, J., Fang, Y., Qin, Y., Huang, L., & Chen, Y. (2019). Assessing ecological risks caused by human activities in rapid urbanization coastal areas: Towards an integrated approach to determining key areas of terrestrial-oceanic ecosystems preservation and restoration. Science of The Total Environment, 135153.

3 METHODOLOGY

3.1 ABSTRACT
3.2 OVERALL RESEARCH DOMAIN
3.3 THEORETICAL FRAMEWORK SUMMARY
3.4 CONCEPTUAL FRAMEWORK SUMMARY
3.5 RESEARCH APPROACH AND PHILOSOPHY
3.6 ANALYTICAL AND DESIGN FRAMEWORK
3.7 MAIN METHODS AND PROCESSES
3.8 EVOLUTIONARY FRAMEWORK
3.9 TIME PLANNING
3.10 METHODOLOGY FRAMEWORK



Fig. 3.1 Hoek van Holland, 2019. Source: Photo by the author.

3.1 ABSTRACT

The coastal area is a transitional zone between the pure land and the pure ocean part of the Earth's surface. From a human perspective, it represents one of the most important regions of the world's oceans (Lu et al., 2018). In almost all parts of the world, coastal areas have a clear process of population concentration, and coastal areas have always played a vital role in the economic, social and political development of most countries. They support a diverse and productive coastal ecosystem that provides valuable goods and services (Airoldi et al., 2005). In addition, by 2050, an estimated 650 million people will live in deltas and coastal cities (Meyer et al., 2015).

However, these coastal areas, which are affected by marine ecosystems and terrestrial ecosystems, are more sensitive and vulnerable than others. Due to population growth and rapid socio-economic development, human activities have exacerbated the frequent exchange of material and energy in coastal areas (Denner et al., 2015). Human activities represented by urban expansion, agricultural production, and industrial development have led to the deterioration of ecosystems in coastal areas (Zhai et al., 2019). Sea level rise and extreme precipitation events caused by climate change will also pose an increasing threat to coastal ecosystems.

In order to cover the scope of the thesis, the methodology chapter contains a defined set of frameworks were created as a backbone for the research. This chapter further elaborates the initial methods, relational methods, techniques, and analysis necessary to explore research issues. In addition, the construction of the framework is essential, because the design will be carried out through a series of theories. The narrative of each framework will be further elaborated within the report and are divided into several frameworks.

3.2 OVERALL RESEARCH DOMAIN

PARASITISM DEFINITION	Urban development brings a series of negative effects to natural waters, therefore the natural waters become more and more sensitive to external stimuli. For the coastal ecosystem, the coastal cities are parasites.
PROBLEM FIELD	Symbiotic ecosystem services and socio-economics
KEYWORDS	Water management, socio-economic, urban ecology, South Holland
SCALE DEFINITION	Metropoolregio Rotterdam Den Haag (MRDH), 5x5km Patches, Pernis area
PROBLEM STATEMENT	Human beings constantly transfer resources from the nature, and finally discharge economic metabolic wastes into water bodies, forming an unsustainable production cycle, putting pressure on the coastal ecological environment and destroying ecological services. In the current relevant policies (environmental aspects), the waste recycling and delta protection plan are more focused on reducing CO2 emissions and creating more space for rivers, which is not enough to solve the complex environmental problems in the MRDH area. In the face of sea-level rise, high precipitation condition, and the need for a sustainable economy, especially in the current stage of the energy transition, we need to rethink the economic production patterns of cities and the relationship between cities and nature, so to facilitate areas and conditions for expansion.
HYPOTHESIS	What if we change the current economic production mode of natural consumption, to reuse the economic metabolic waste (nitrogen, phosphorus, carbon dioxide, etc.) in the production process and promote the material exchange process between the urban and nature, to form a virtuous cycle of economic production. This can restore the ecosystem and achieve the purpose of urban development as well. The water body will become the main medium for material exchange between the two, so the more adaptable solutions will be provided for future climate change and bio-based economy through interventions in the water management system.
RESEARCH QUESTION	What kind of shift in the economic production system could change the current waste flows between cities and nature to facilitate a sustainable and resilient economy in the Metropoolregio Rotterdam Den Haag (MRDH)?
RESEARCH APPROACH	Deductive approach
CONCEPTUAL FRAMEWORK	By adopting bio-economic solutions, linking complex urban socio-economic systems with natural ecosystems, using the characteristics of bio-economics to form a symbiotic system, which could counteract potential risks in coastal areas into opportunities for development, and restore the ecosystem services through this new economic model in coastal areas, thereby increasing urban resilience.
METHODS	Literature review; Policy readying; Transect; GIS analysis; Flow analysis; Design testing; Mapping; 3x3x3 analysis
DESIGN OUTCOMES	Macro scale: Guidelines for revise the structure of existing region vision, including identify urban expansion areas and bio-based economic development frameworks. Meso scale: New spatial principles and flows. Micro scale: Housing and landscape typologies design. Nano scale: Engineering design
CONCLUSION	A symbiosis bio-based economic production system strategy for the MRDH area.

3.3 THEORETICAL FRAMEWORK SUMMARY

With the identification of the problem statement in section 1.0 and a pre-defined set of research questions, the theoretical framework lays the foundation for the body of knowledge related to concepts and theories in regards to the research. The theoretical framework describes a set of definitions to give direction to the research and builds upon the different stages of the project. The construction of the framework includes scientific justification for the research investigation and offers a grounded perspective tied to scientific theory. To understand the problem statement and position of the research in detail , the initial discourse and literature review aims to establish and explore in detail several notions:

- Adaptation and resilience
- Urban metabolism approach
- Urban ecology and urban ecosystems

The main theoretical basis of the thesis is to link complex urban socio-economic systems with natural ecosystems by adopting bio-economic solutions. And using the characteristics of bio-economics, which could counteract potential risks in coastal areas into opportunities for development, and restore the ecosystem services through this new economic model in coastal areas, thereby increasing urban resilience.

First, understand the definition of the main theoretical tools of urban ecosystems, and study the impact of current urbanization on the structure and function of coastal water ecosystems, including the theoretical basis of urban ecology and urban ecosystems. The second is to study the current ecological restoration solutions in coastal areas. In addition, the related theoretical basis of bio-economy is researched, therefore, Urban metabolism can be studied and considered. Comprehensively research the relevant theoretical basis of Adaptation and resilience, and establish the theoretical framework and principles of the biological economic development model of coastal cities.

3.4 CONCEPTUAL FRAMEWORK SUMMARY

The conceptual framework is based on "coadaptation" (Fig.3.2) development. As human society systems develop, they need to adapt to their environment and ecosystems. At the same time, ecosystems also need to adapt to human society systems. Natural ecosystems and the natural parts of urban ecosystems respond to human intervention by making adjustments to promote survival. The important factor to achieve coadaptation is the connection between the two parts of the system. By changing the current connection method, using bio-based economic, enhancing the connection and adaptability between the systems, the risks under climate change are reversed into opportunities.

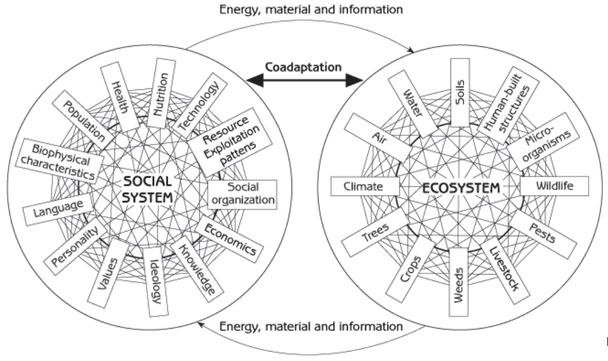


Fig. 3.4 Coevolution and coadaptation. Source: Marten, 2001.

3.5 RESEARCH APPROACH AND PHILOSOPHY

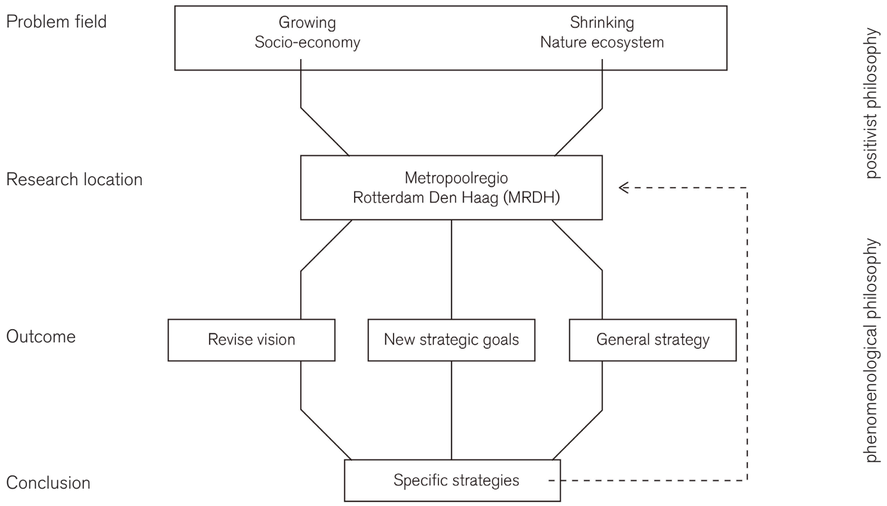


Fig.3.5 Research approach. Source: Created by author.

The overall research method that guided my thesis is deductive method, and the research philosophies include positivist and phenomenological. First, establishing my own theoretical basis and research questions through literature review, and understanding the existing relevant literature and cases can help me better understand the object. Based on previous experience and theoretical knowledge, focus on my research problem and propose new problem solutions.

Use quantitative methods to collect empirical data. On the one hand, empirical data may lead to research questions and provide strong support for problem statements. On the other hand, the conclusions drawn from analyzing large amounts of data are more convincing and reliable.

In the analysis phase, positivist will be used, the conclusions drawn from this will be reliable by using empirical data to reflect the current situation and the causes of these problems. In the design phase, it is more inclined to use phenomenological philosophy, based on the conclusions drawn in the previous paragraph and the phenomena observed in the field survey, to propose design strategies and evaluation standards.

In general, the paper will start from general theories, draw detailed conclusions through design research processes such as classification, assembly, and reorganization, and carry out specific tests to finally reach specific strategies.

3.6 ANALYTICAL AND DESIGN FRAMEWORK

SPATIAL ANALYSIS

While using the deductive method, the hierarchy of scale and time was also emphasized throughout the research process. Use multi-scale analysis to explore spatial narratives that occupy the time domain.

- Macro scale:
The main objective of this scale is to understand the main challenges between the current ecosystem and socio-economic systems, the causes of these problems, and the risks faced in the context of climate change. Therefore, an ecosystem assessment, cause assessment and risk assessment will be analysised on this scale, the main indicators include:

· water quality;
· soil condition;
· vegetation typology;
· pollution source;
· degree of soil sealing;
· water-related infrastructure;
· coasral risk;
· pluvial risk;
The analysis of this scale is the key to formulating the direction of urban expansion and revising the regional economic system, and the main tools are GIS analysis, mapping, policy reading.

- Meso scale:
Select four representative patches for analysis (5x5 km). The objective of this scale is to explore the current flows of the area and the potential for adaptation to biobased solutions, to understand the interaction between socio-economic and ecosystems from the micro to meso scale, and to propose meso scale adaptation strategies. The main indicators include:

· Spatial qualities;
· Flow analysis;
· Flow strategies;
· Spatial intervention strategies;
The analysis at this scale is the key to formulating the spatial principles, the main tools are mapping, transect and flow analysis.

- Micro scale:
Zoom in meso scale, select four patches (1x1 km) for detailed analysis. The purpose of this scale is to study the typologies of current vision, and to propose new typology strategies, and to propose spatial intervention strategies from a micro scale perspective. The main indicators include:

· Typology analysis;

Analysis of this scale is the key to developing bio-based solution typologies for design testing. The main tools are 3D modelling, transect analysis.

GOVERNANCE SYSTEM ANALYSIS

The objective of the governance system analysis is to understand the operational systems for project development in the current region and to identify stakeholders. In addition, the analysis of the governance system can help identify the constraints of the project at each scale and provide a design basis for the governance model design in the design phase. By identifying the range of stakeholders, it is also possible to identify the actors involved in achieving the vision, and then assign relevant interventions to these actors. The process of achieving the vision is also the process of labor force transformation, which will provide more jobs in the region. By analyzing the power of the stakeholders, we can understand the internal relationships between different stakeholders when formulating policies, and provide a basis for triggering the project.

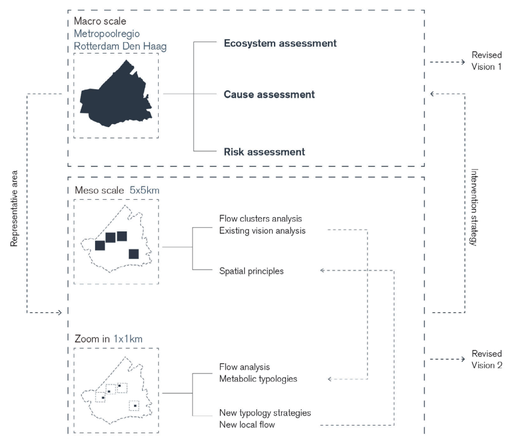


Fig. 3.6.1 Analytical framework. Source: Created by author.

DESIGN FRAMEWORK

In order to place bio-based economic solutions in a multi-scalar framework and build a bridge between macro scale system, meso scale system and micro scale system, working with layers, time and scales approach is essential. In order to develop a vision for the MRDH region and develop an effective strategic framework, it is important to understand and address the relationship between large regional strategies and more detailed local design solutions. In the face of uncertainty, the time dimension is crucial, ecosystem services are declining and it is becoming a reality, and socio-economic is also in transition. Therefore, we can propose different reasonable scenarios based on the analysis outcomes, and design under these scenarios to deal with the future change.

- Macro scale:
The scope of the first stage of the macro assessment is to preliminary revise the structure of existing region vision, include:
1. Identify the direction of urban expansion in the region and positioning of each city's main functions.
2. Identify the green and blue corridors in the area.
3. Identify the range and relationships of stakeholders.
4. Governance model to support the bio-based economy.

- Micro scale:
First, design strategies are proposed through micro and meso scale typology and flow analysis, and then applied the strategies to selected area for design testing. The micro-scale design is mainly for urban design in three conditions: industrial port, logistics port and port city. So to verify the feasibility of the strategy by micro scale design testing. The design should include:
1. spatiotemporal and intervention schemes (Fig.3.6.3).
2. Urban design.
3. New flows strategy.

- Nano scale:
This scale will focus on engineering design, strengthen the feasibility of the project. Including subsoil design, building water cycle system design, vegetation type design, pipeline and material nano scale design.

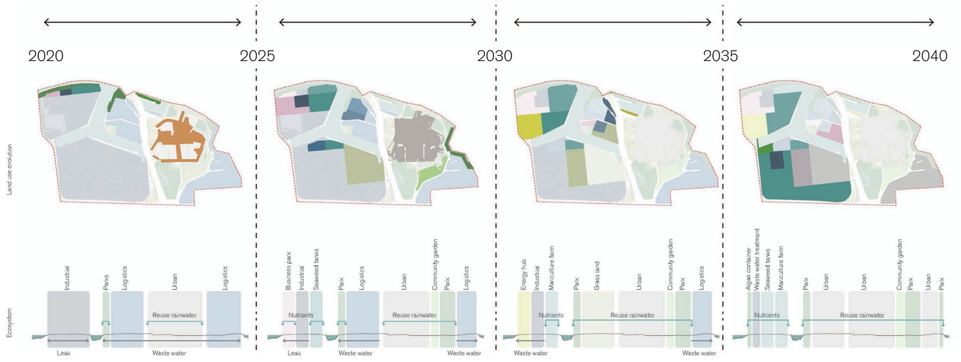


Fig. 3.6.2 Period scheme. Source: Created by author.

EVALUATION FRAMEWORK SUMMARY

In the matrix, the path from Parasitic to Symbiosis represents the evolution from the present to the vision, facing uncertainty (mainly from the flood risk brought by climate change), a series of spatial strategies will be proposed to deal with these uncertaintes, and at the same time, different stakeholders will be interconnected to implement these spatial strategies.

The avaluation will mainly be carried out from the ecosystem services and the interest of the major stakeholders. Through the ecosystem service assessment, you can determine the ecosystem services that the project can provide in each period and which of the stakeholders involved. By evaluating the interests of stakeholders, it can reflect the benefits of the project to different major stakeholders and possible adaptation scenarios in the future.

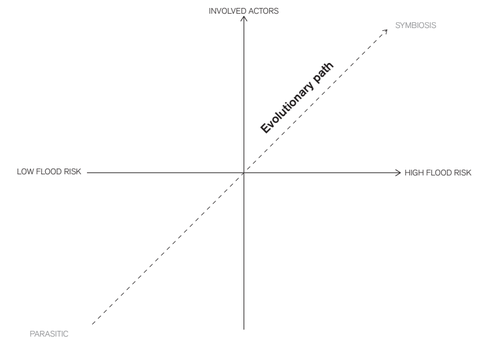


Fig. 3.6.3 Scenario matrix. Source: Created by author.

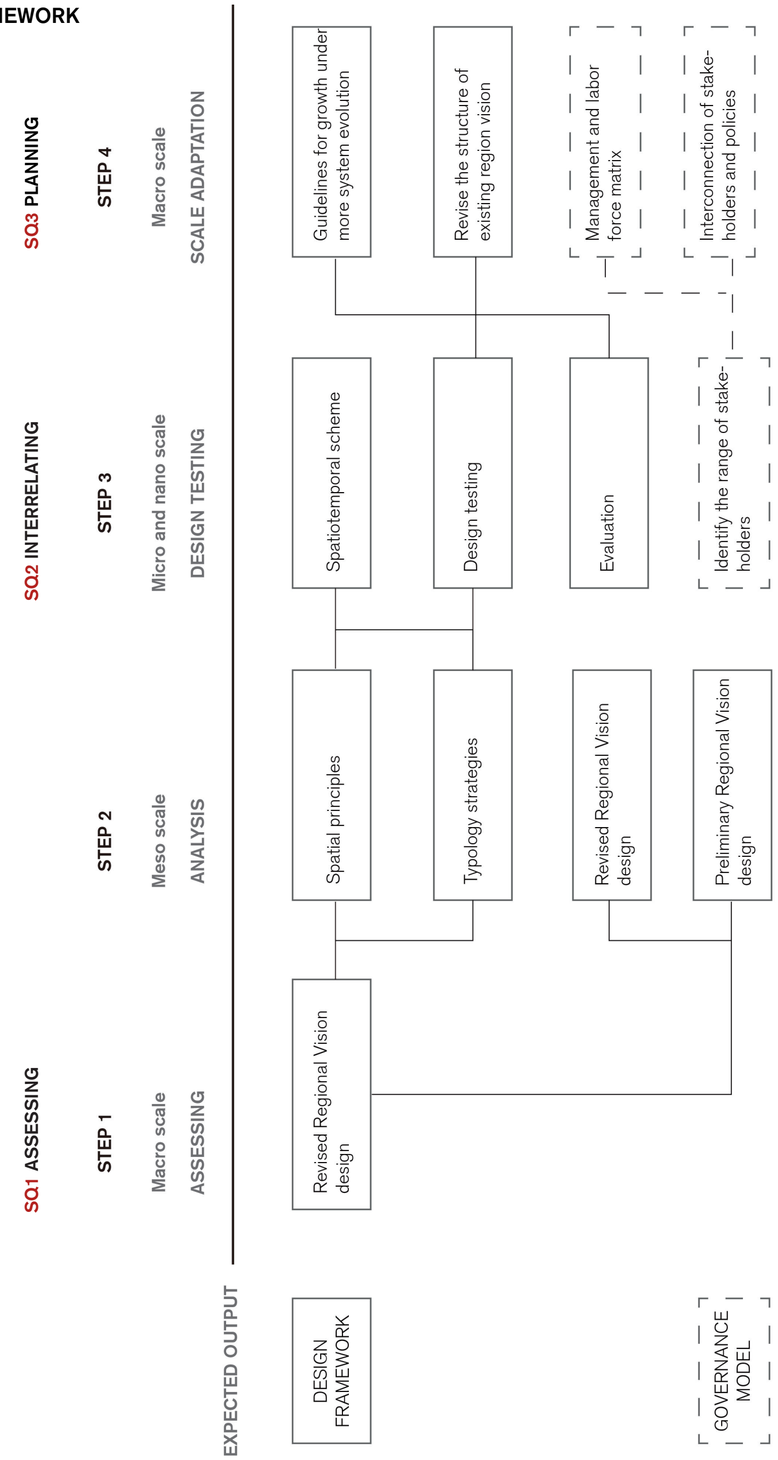
3.7 MAIN METHODS AND PROCESSES

This thesis aims to study changing the current production structure, introducing a new bio-based economy, and transforming it into a sustainable production model in coastal areas, in order to realize the possibility of symbiosis between cities and oceans, and to provide new opportunities for urban expansion. The main research methods used are listed below, although each method and its relation to the various stages and themes of the project will be expanded in the following report. This section will briefly provide the main research methods and tools and their logical interactions with the research questions and objectives.

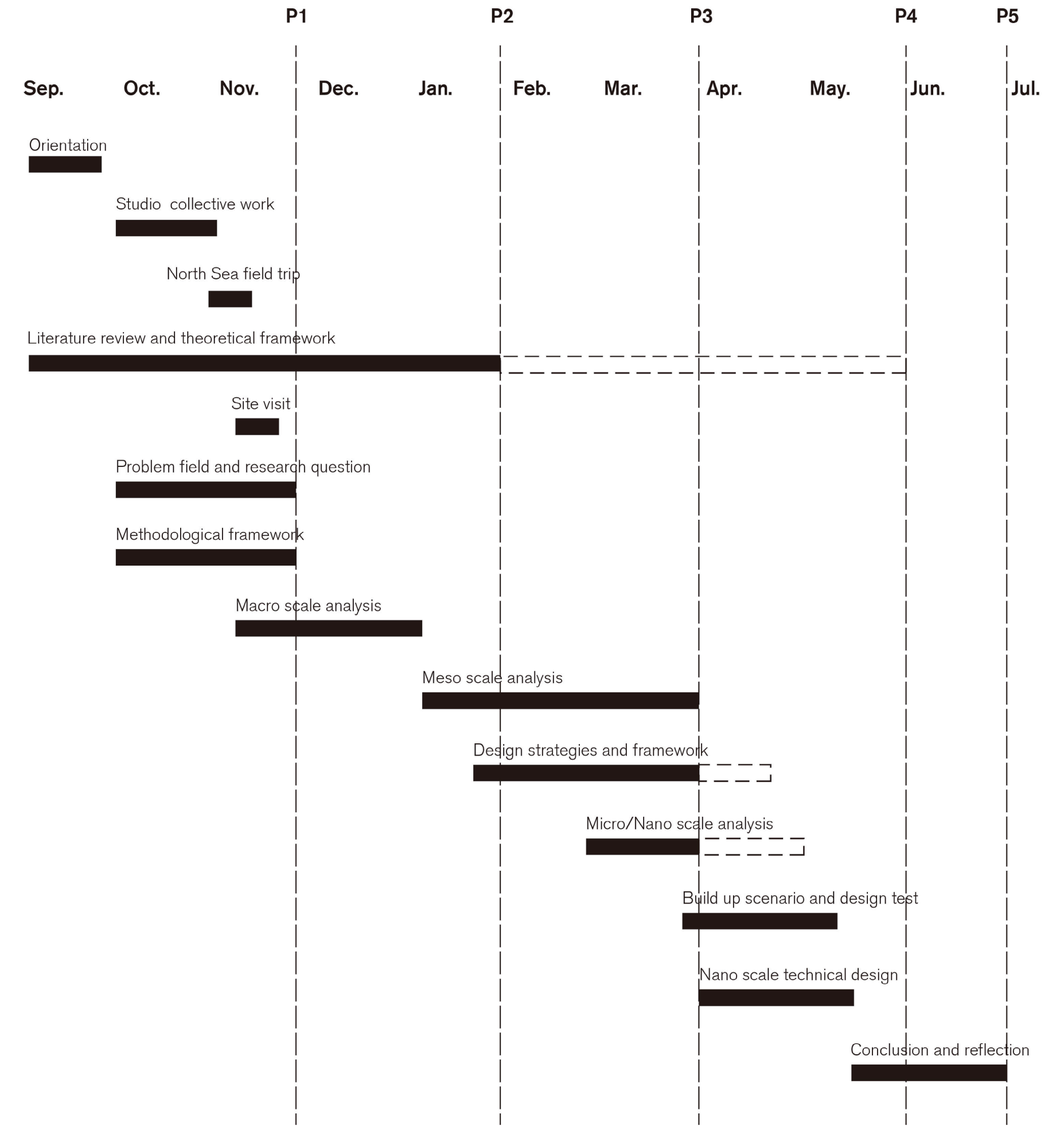
- 3 **3*3*3 Analysis**
- T **Transect**
- D **Design Testing**
- F **Flow Analysis**
- L **Literature Review**
- M **Mapping**
- G **GIS Analysis**
- P **Policy Reading**

Sub-Research Questions	Scale	Method	Tool	Product	Rationale & Aims
Why the MRDH area need shift the economy economic production system?	Macro	L M G P	Reports, online database and GIS	Series of maps	To understand the current negative effects of regional economic development on the environment。
What are the current economic production system in the MRDH area?	Macro	L M G	Reports, online database and GIS	Series of maps	To learn about the current industries in the region and the environmental hazards of different industries.
What is the current state on urban and water systems and its contribution to coastal/urban pollution?	Macro	P M G	Reports, online database and GIS	Series of maps and diagrams	To understand the location of critical areas, vulnerabilities, and hazards.
What is the current urbanization chanllenge in the MRDH area?	Macro	M G	References, online database and GIS	Series of maps and diagrams	To understand and critique the existing vision. Opportunities and constraints for interventions could be observed.
What are the limitation and potentialities of applying bio-based solutions in MRDH area?	Meso Micro	T M F	References and 3D modelling	Series of analysis and diagrams	To develop a series of spatial strategies to deal with different waste flows.
How to use a polluted water body to change the MRDH's economic system and make it a medium for integrating nature and urban?	All scales	T M D F	References and 3D modelling	Series of analysis, Urban design	To understand and develop dynamic and flexible interventions.
What kind of response measures should be taken to the eutrophication of water bodies while making use of the maximum potential of the North Sea and river forces?	All scales	T M D F	References and 3D modelling	Series of analysis, spatial interventions	To develop a series of spatial strategies to deal with different kind of water pollution.
How to restore the ecological environment of the MRDH through interventions in the water management system?	All scales	T D	References and 3D modelling	Series of analysis, spatial interventions	To evaluate the feasibility of the model in different scenarios.
Which method can promote the integration of modern technology and nature and achieve a sustainable economic future in the MRDH areas?	All scales	L D	Reports and journal articles	Governance model	To Builde a government model to achieve the new vision.
What kind of economic and environmental strategies would facilitate a sustainable future for the entire coastal region?	Macro	L D	Reports and journal articles	Scale adaptation	Extract general principles and adapt to large scale.

3.8 EVOLUTIONARY FRAMEWORK



3.9 TIME PLANNING



3.10 METHODOLOGY FRAMEWORK

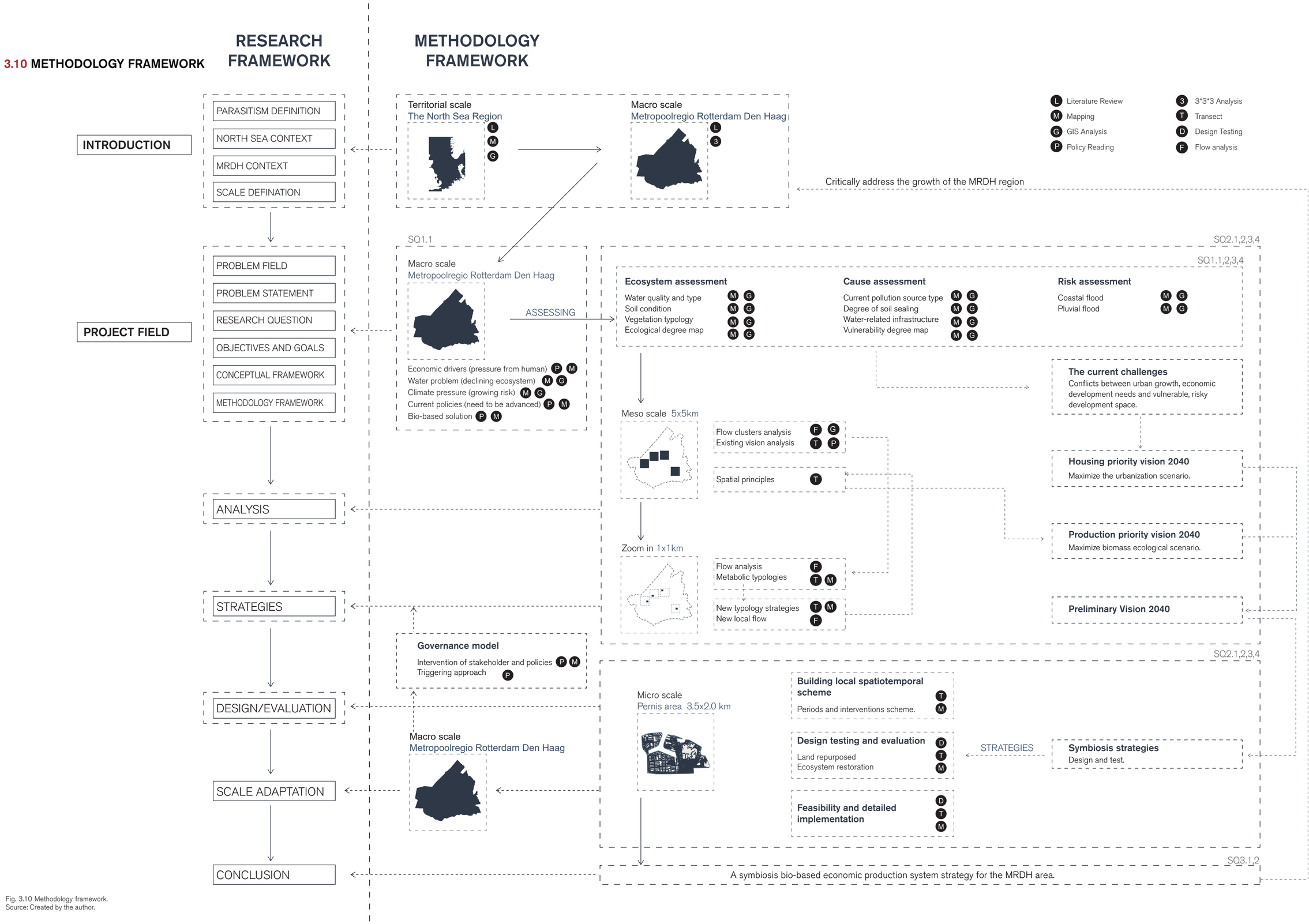


Fig. 3.10 Methodology framework.
Source: Created by the author.

4 ANALYSIS

4.1 ECOSYSTEM ASSESSMENT
4.2 CAUSE ASSESSMENT
4.3 RISK ASSESSMENT
4.4 THE CURRENT CHALLENGES
4.5 FLOW ANALYSIS

4.1 ECOSYSTEM ASSESSMENT (MACRO SCALE)

Water quality and type

The availability of fresh and surface water is crucial for agriculture, industry, drinking water and nature. Due to anticipated climate change and future sea level rise, salt leakage and salt infiltration in seawater will increase, and human activities will exacerbate this phenomenon, and also will cause surface water pollution. The availability of fresh groundwater and surface water will decrease.

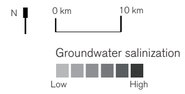


Fig.4.1.1 Groundwater salinization. Source: Map created by author. Data from: nationaalgeoregister.nl.

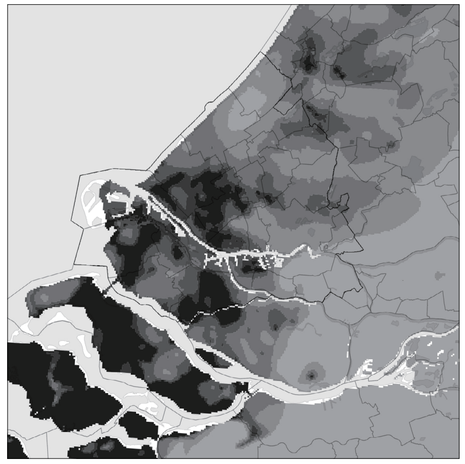
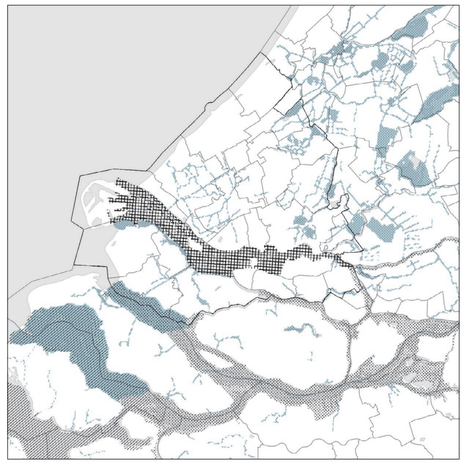




Fig.4.1.2 Surface water pollution and type. Source: Map created by author. Data from: nationaalgeoregister.nl.



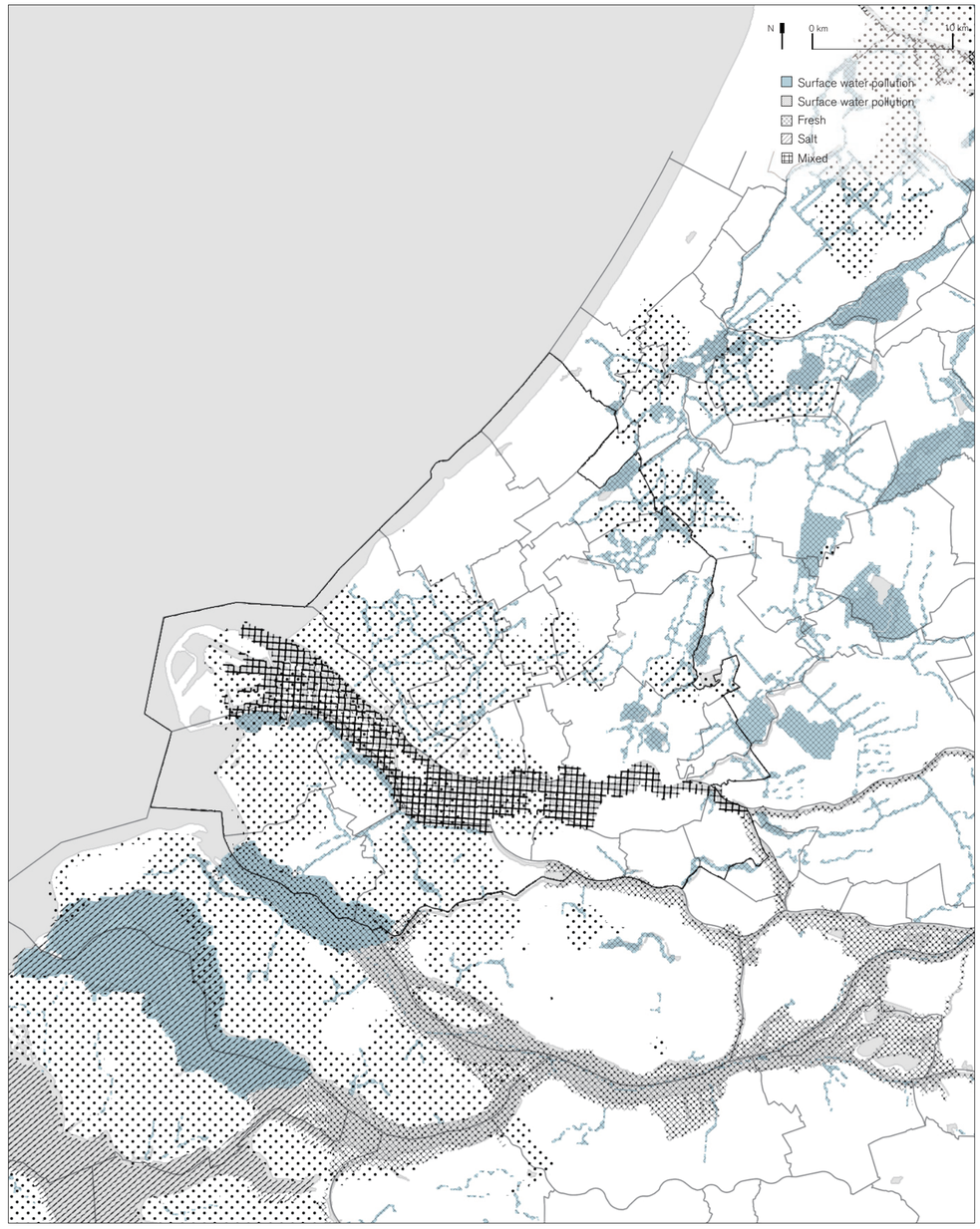


Fig.4.1.3 Water assessment map. Source: Map created by author. Data from: nationaalgeoregister.nl.

4.1 ECOSYSTEM ASSESSMENT (MACRO SCALE)

Soil condition

Soil conditions are important for urban development and nature. At the same time, soil and water affect each other, so it is necessary to assess soils. And shows the presence of soil subsidence, pollution and salinization areas.

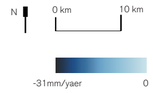
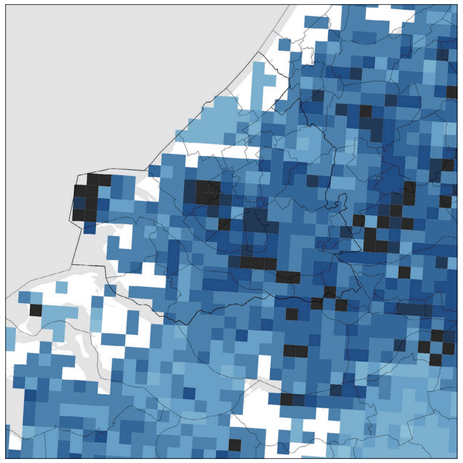
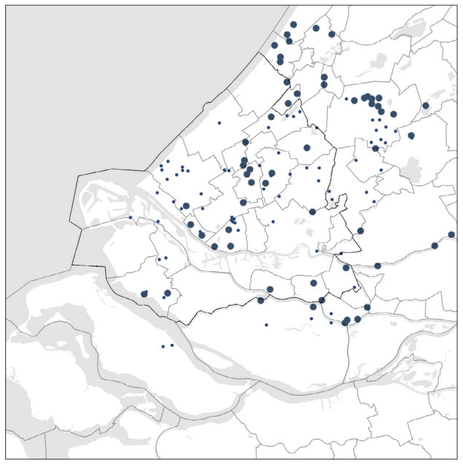


Fig.4.1.4 Soil subsidence. Source: Map created by author. Data from: nationaalgeoregister.nl.





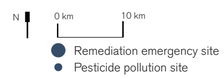


Fig.4.1.5 Surface soil pollution. Source: Map created by author. Data from: nationaalgeoregister.nl.



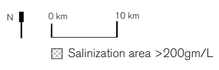


Fig.4.1.6 Groundsoil salinization. Source: Map created by author. Data from: nationaalgeoregister.nl.

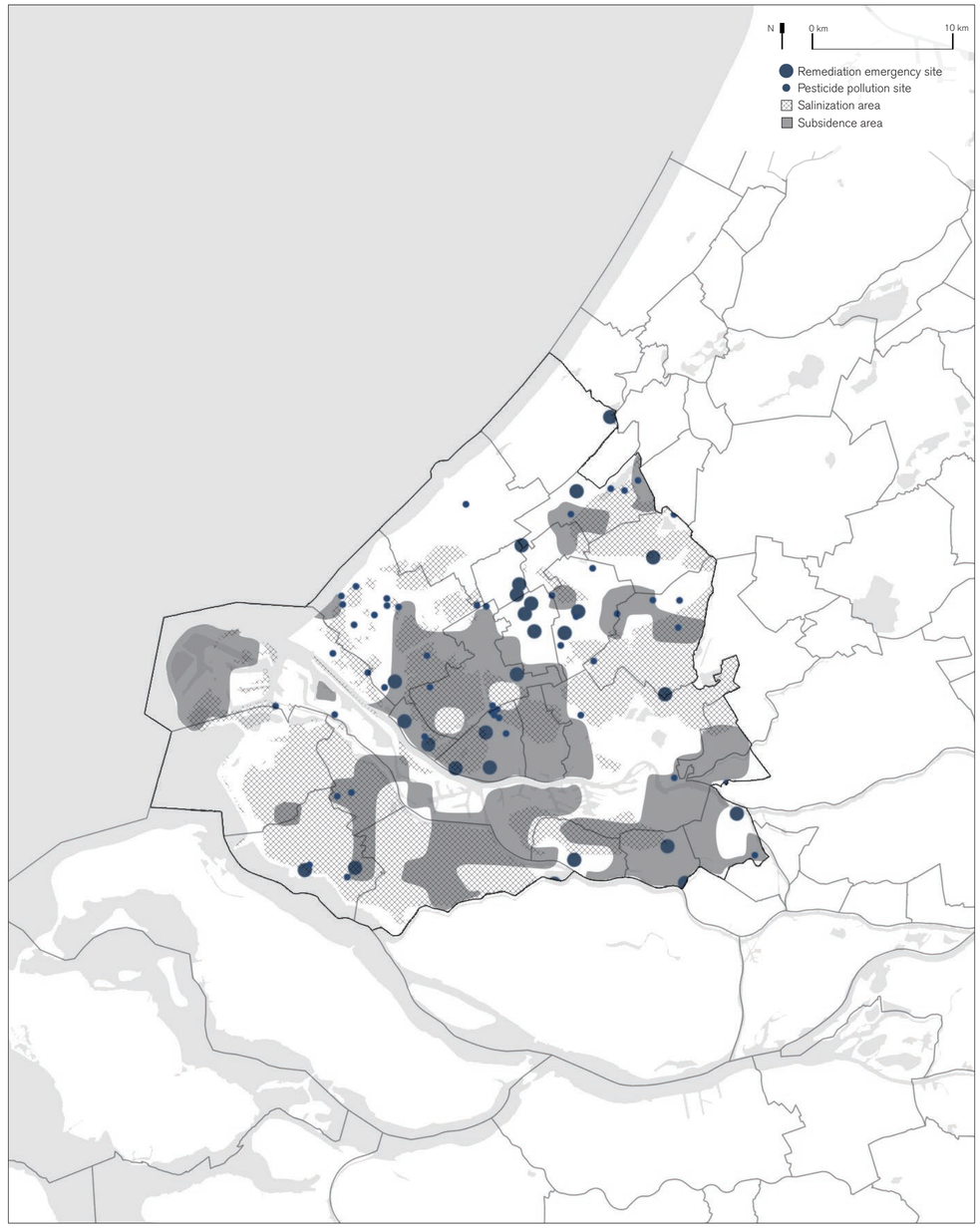


Fig.4.1.7 Soil assessment map. Source: Map created by author. Data from: nationaalgeoregister.nl.

4.1 ECOSYSTEM ASSESSMENT (MACRO SCALE)

Vegetation typology (Weight)



Fig.4.1.8 Allotments (5%). Source: Map created by author. Data from: Geofabrik.



Fig.4.1.9 Recreation (5%). Source: Map created by author. Data from: Geofabrik.

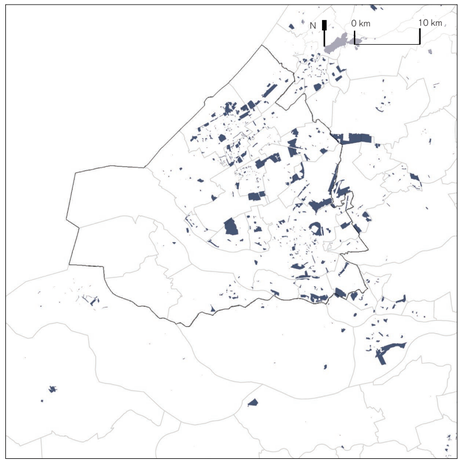


Fig.4.1.10 Park (15%). Source: Map created by author. Data from: Geofabrik.

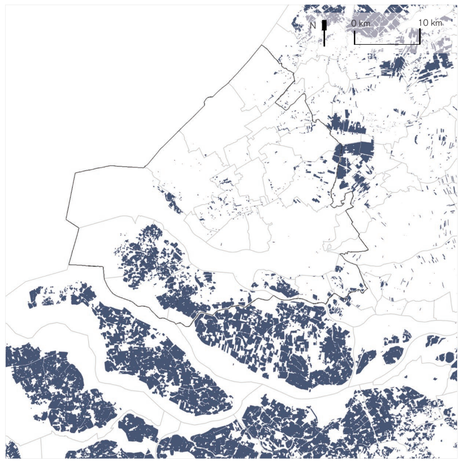


Fig.4.1.11 Farm (5%). Source: Map created by author. Data from: Geofabrik.

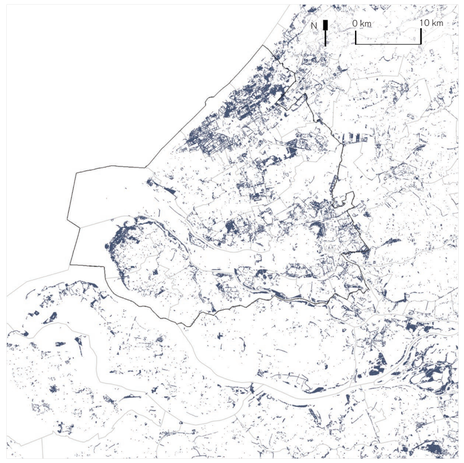


Fig.4.1.12 Forest (15%). Source: Map created by author. Data from: Geofabrik.

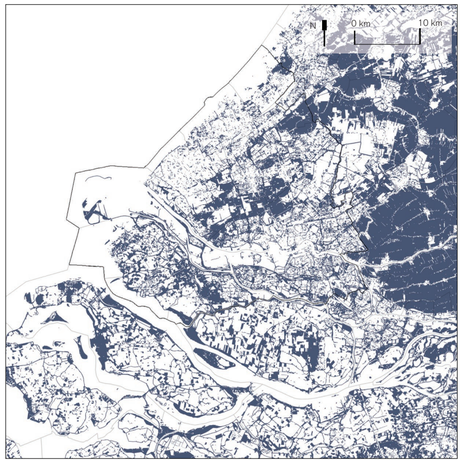


Fig.4.1.13 Grass (5%). Source: Map created by author. Data from: Geofabrik.



Fig.4.1.14 Meadow (10%). Source: Map created by author. Data from: Geofabrik.

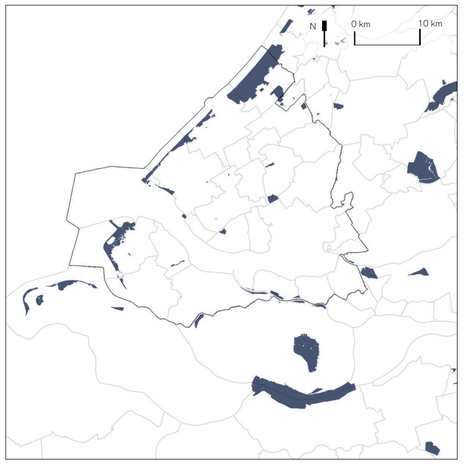


Fig.4.1.15 Nature reserve (25%). Source: Map created by author. Data from: Geofabrik.



Fig.4.1.16 Scrub (10%). Source: Map created by author. Data from: Geofabrik.



Fig.4.1.17 Orchard (5%). Source: Map created by author. Data from: Geofabrik.

4.1 ECOSYSTEM ASSESSMENT (MACRO SCALE)

Vegetation typology

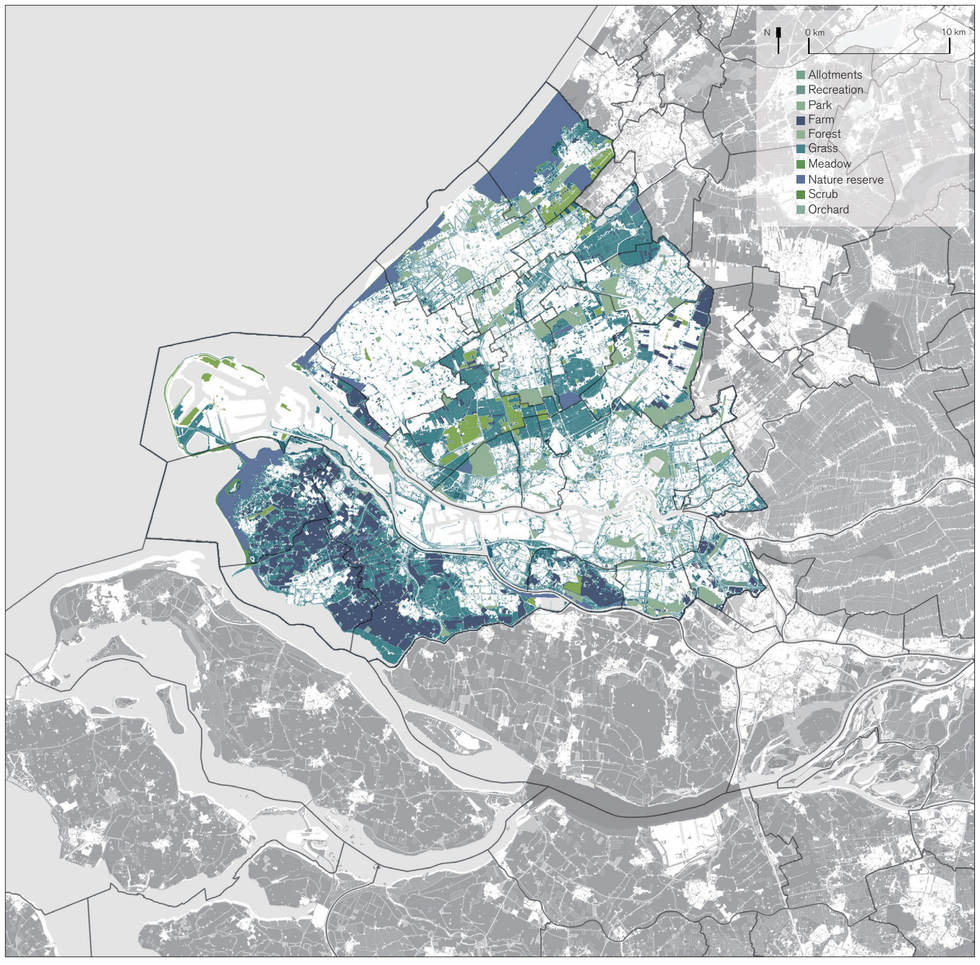


Fig.4.1.18 Vegetation map. Source: Map created by author. Data from: Geofabrik.

Vegetation in coastal areas has important international significance for wildlife, especially for migratory animals. At the same time, the condition of vegetation also affects local water quality and soil.

Rich vegetation is conducive to improving local species diversity. The analysis of vegetation is helpful for understanding the ecosystem status in different subregions, and provides a basis for subsequent ecological degree assessment.

By assigning different weights to the diversity and area of the vegetation in each area, and scoring each subregion, a vegetation degree map is obtained. The weight is showed from Fig.4.1.8-4.1.17.

$$\text{Vegetation degree}_{(\text{city } 1)} = \frac{\text{Area(factor1)} \times \text{Weight(1)} + \ldots + \text{Area(factor n)} \times \text{Weight(n)}}{\text{Area(city 1)}}$$

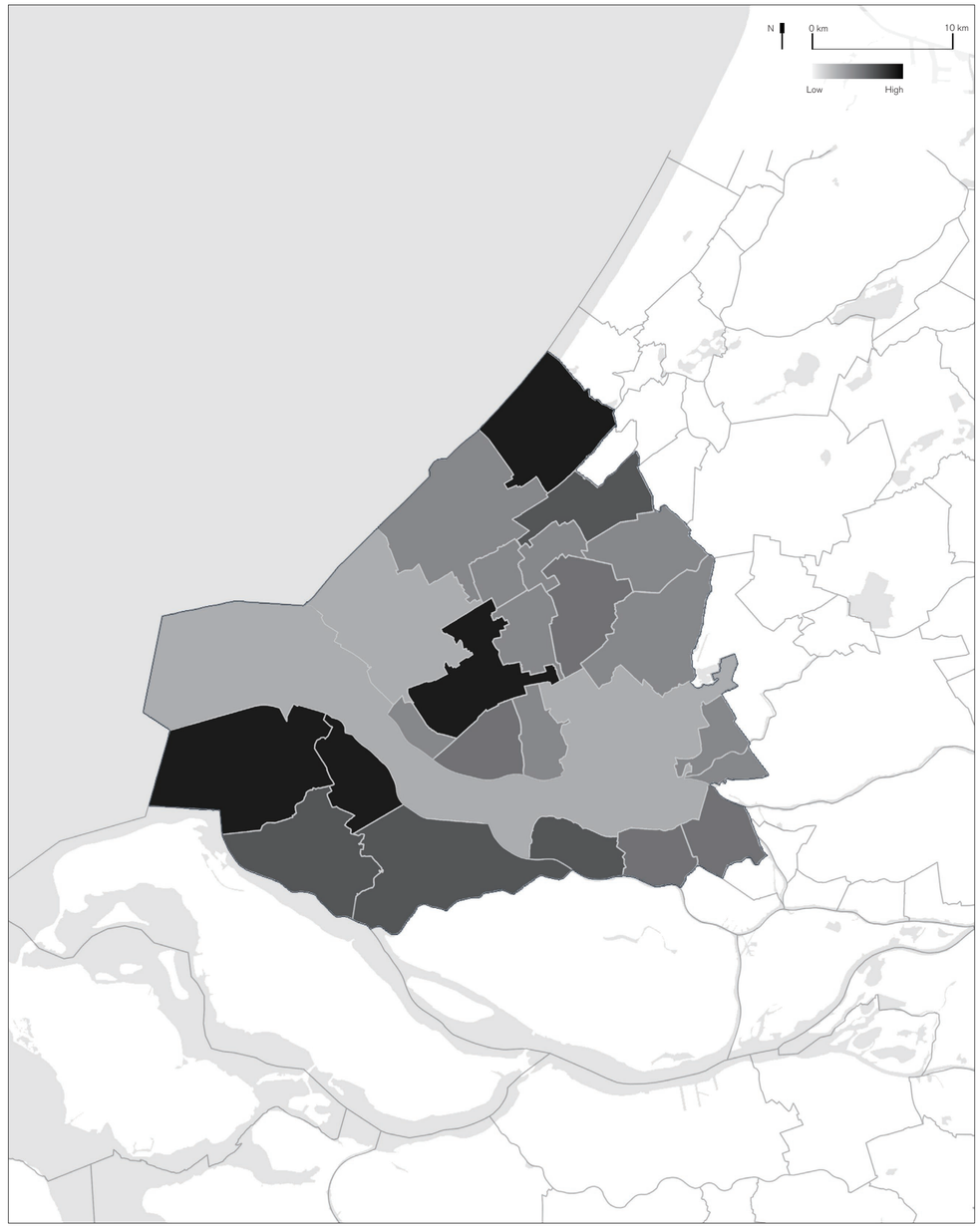


Fig.4.1.19 Vegetation degree map. Source: Map created by author. Data from: Geofabrik.

4.1 ECOSYSTEM ASSESSMENT (MACRO SCALE)

ground water salinization (-1)
surface water salinization (-1)
water quality (-1)

+

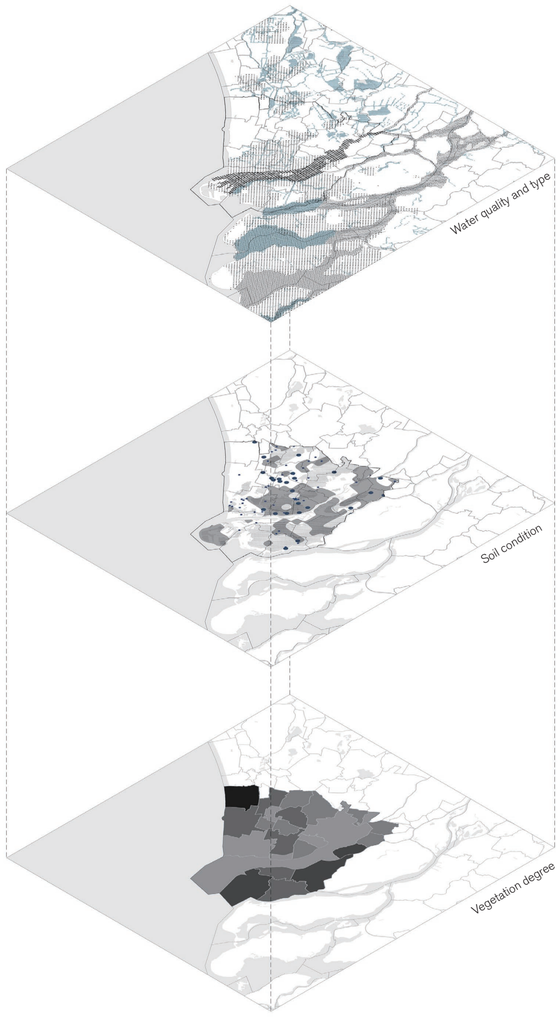
soil salinization (-1)
soil pollution (-1)

+

Vegetation degree
(city n)

II

Ecological degree
(city n)



The three assessment conclusion layers are overlayed and scored for each municipal district. Since water and soil problems are difficult to quantify, we will process the numbers based on the vegetation degree we gained from the last section. If the above-mentioned soil or water problems exist in the municipal area (groundwater salinization, soil salinization, etc.), it is recorded as -1 points on this classification, and the ecological degrees are obtained by adding the points. Use this to evaluate the ecology of the area, through this overlay scoring method, the ecology of each municipality can be intuitively displayed on the map.

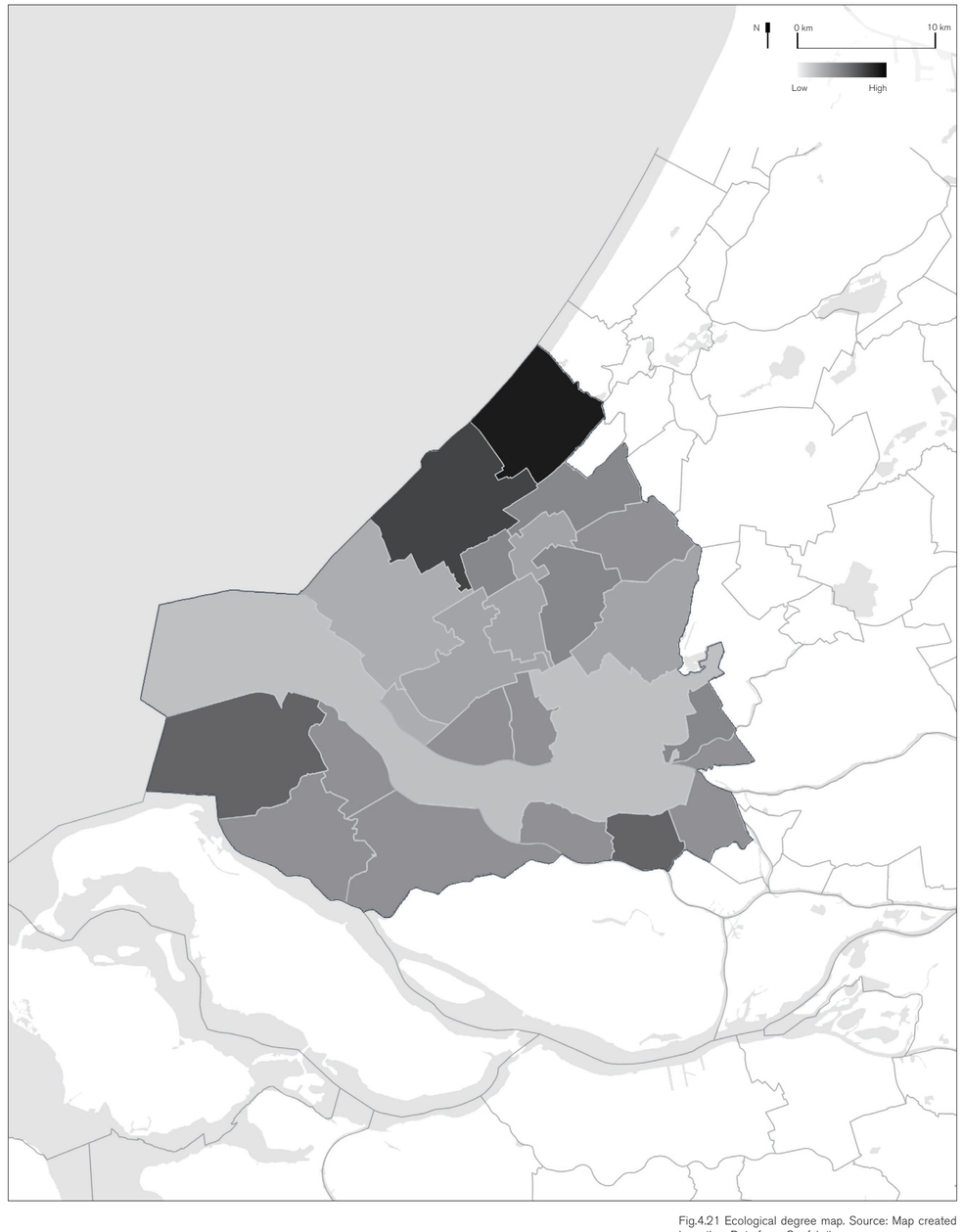


Fig.4.21 Ecological degree map. Source: Map created by author. Data from: Geofabrik.

4.2 CAUSE ASSESSMENT

Current pollution source type

The pressure on the environment in urban areas mainly comes from residential pollution. Pollutants such as sewage and garbage have a direct impact on water bodies in cities. Industrial activities have also caused huge threats to water sources in port areas, oil spills and processing of some chemical substances which have increased toxic pollutants in the environment; fertilizers and pesticides used in agriculture and greenhouses aggravated the phenomenon of eutrophication, and the large demand for water also accelerated the phenomenon of soil salinization.

In addition, transportation infrastructure is also one of the causes. The development of the economy depends on the frequent logistics. The pressure on the environment caused by infrastructure is mainly form noise pollution and air pollution. A large amount of exhaust emissions will cause acidification of surrounding water bodies.

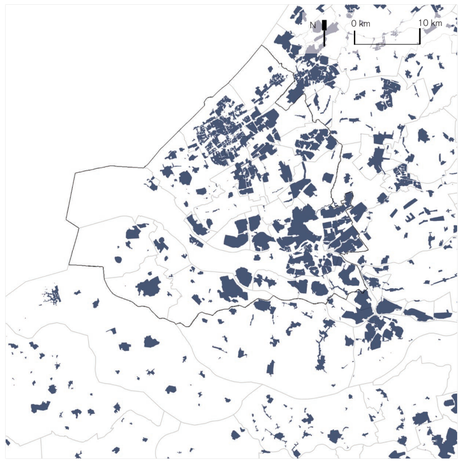


Fig.4.2.1 Residential. Source: Map created by author. Data from: Geofabrik.

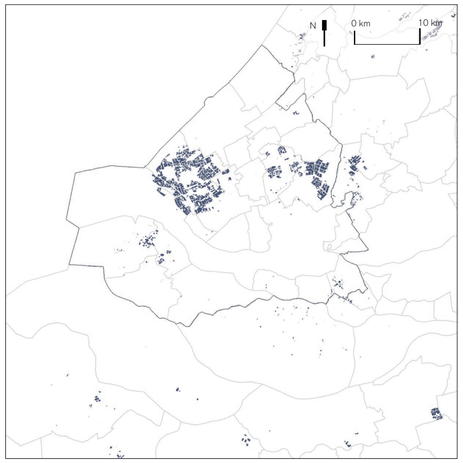


Fig.4.2.2 Greenhouse. Source: Map created by author. Data from: Geofabrik.



Fig.4.2.3 Industrial. Source: Map created by author. Data from: Geofabrik.



Fig.4.2.4 Commercial and retail. Source: Map created by author. Data from: Geofabrik.

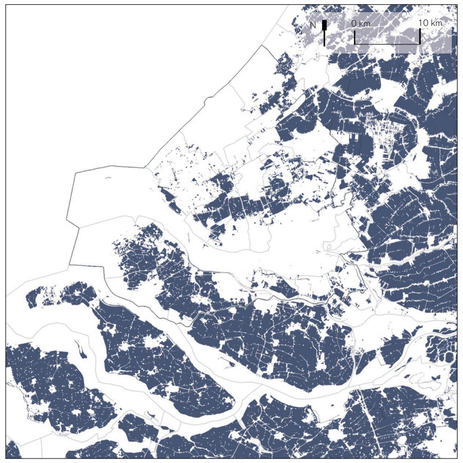


Fig.4.2.5 Open field agriculture. Source: Map created by author. Data from: nationaalgeoregister.nl.



Fig.4.2.6 Infrastructure on land. Source: Map created by author. Data from: Geofabrik.

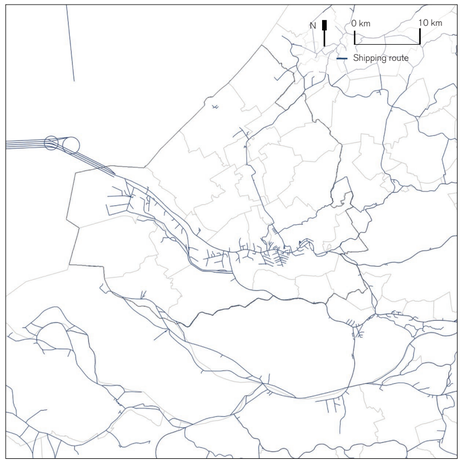


Fig.4.2.7 Infrastructure on water. Source: Map created by author. Data from: nationaalgeoregister.nl.

4.2 CAUSE ASSESSMENT

Current pollution source type

We can divide the pollution sources into residential, industrial, agriculture, greenhouse, and transportation infrastructure.

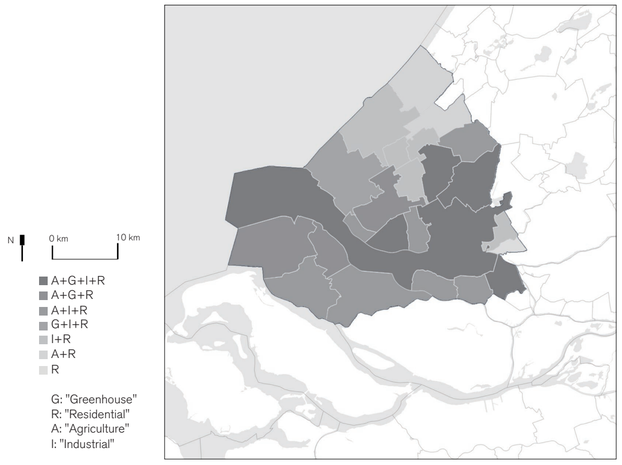


Fig.4.2.8 Pollution from production. Source: Map created by author. Data from: nationaalgeoregister.nl.

Each city is classified according to the different key sectors of its economy. Cities in the south of the port of Rotterdam (such as Vierpolders, Zuidland) are mainly suffered from environmental pollution caused by agriculture and residential. Pollution problems in The Hague and surrounding areas are mainly caused by industrial and / or residential environmental pollution.

Rotterdam consists of the urban area of Rotterdam and the port area of Rotterdam. It is subject to pollution pressure from four key economic sectors, as well as transportation and environmental pollution caused by logistics.

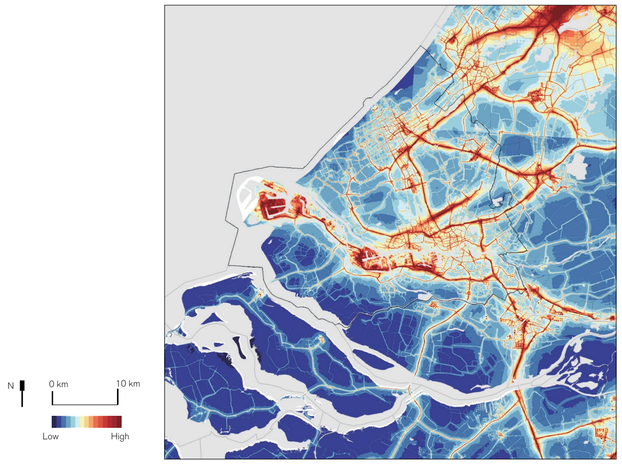


Fig.4.2.9 Pollution from infrastructure. Source: Map created by author. Data from: nationaalgeoregister.nl.

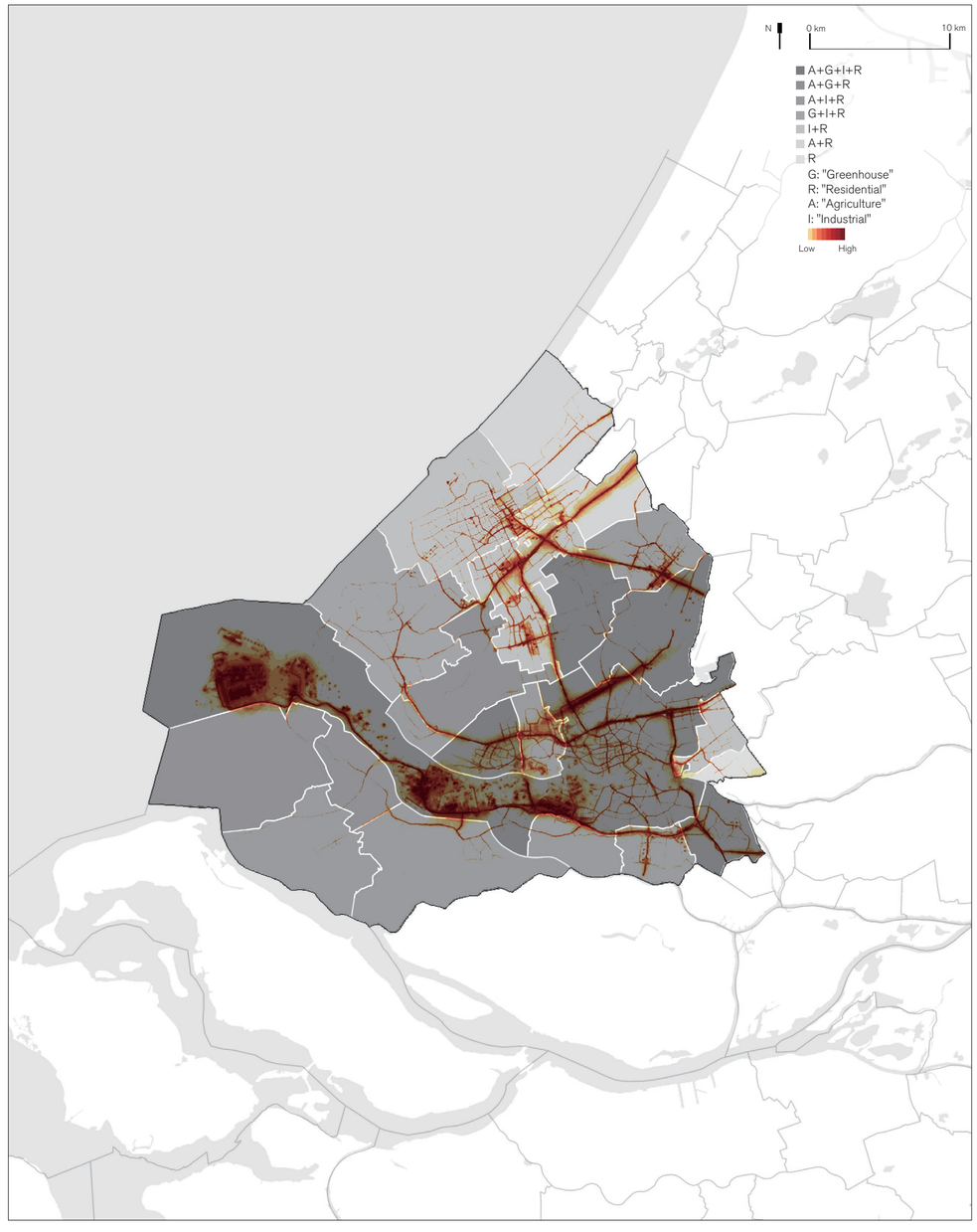


Fig.4.2.10 Current pollution source type. Source: Map created by author. Data from: Geofabrik, nationaalgeoregister.nl.

4.2 CAUSE ASSESSMENT

Degree of soil sealing

Soil sealing can be defined as the destruction or covering of soils by buildings, constructions and layers of completely or partly impermeable artificial material such as asphalt, concrete, etc. (European Environment Agency, 2019). High degree of soil sealing will block the various natural processes which happen in the soil, and also also affect the survival path of wildlife.



Fig.4.2.11 Westland. Source: Map edited by author, satellite image from Bing Map.

Considering the degree of soil sealing in the MRDH area, the enclosed area reduces the water infiltration potential of the soil, which increases the run-off of water and the risk of river flood. In the event of heavy rain falls, in cities with a high soil sealing, also the capacity of the sewage system might no longer be able to cope with the high run-off of water and cause surface flooding.

At the same time, soil sealing also affects soil storage / filtration / transformation functions. Soil sealing will reduce the function of soil as a filter and diluent for pollutants, as well as its ability to store water, causing surfacewater to be discharged directly into the river through the surface or engineering sewage system, causing ecological problems such as water pollution.



Fig.4.2.12 Port of rotterdam. Source: Map edited by author, satellite image from Bing Map.

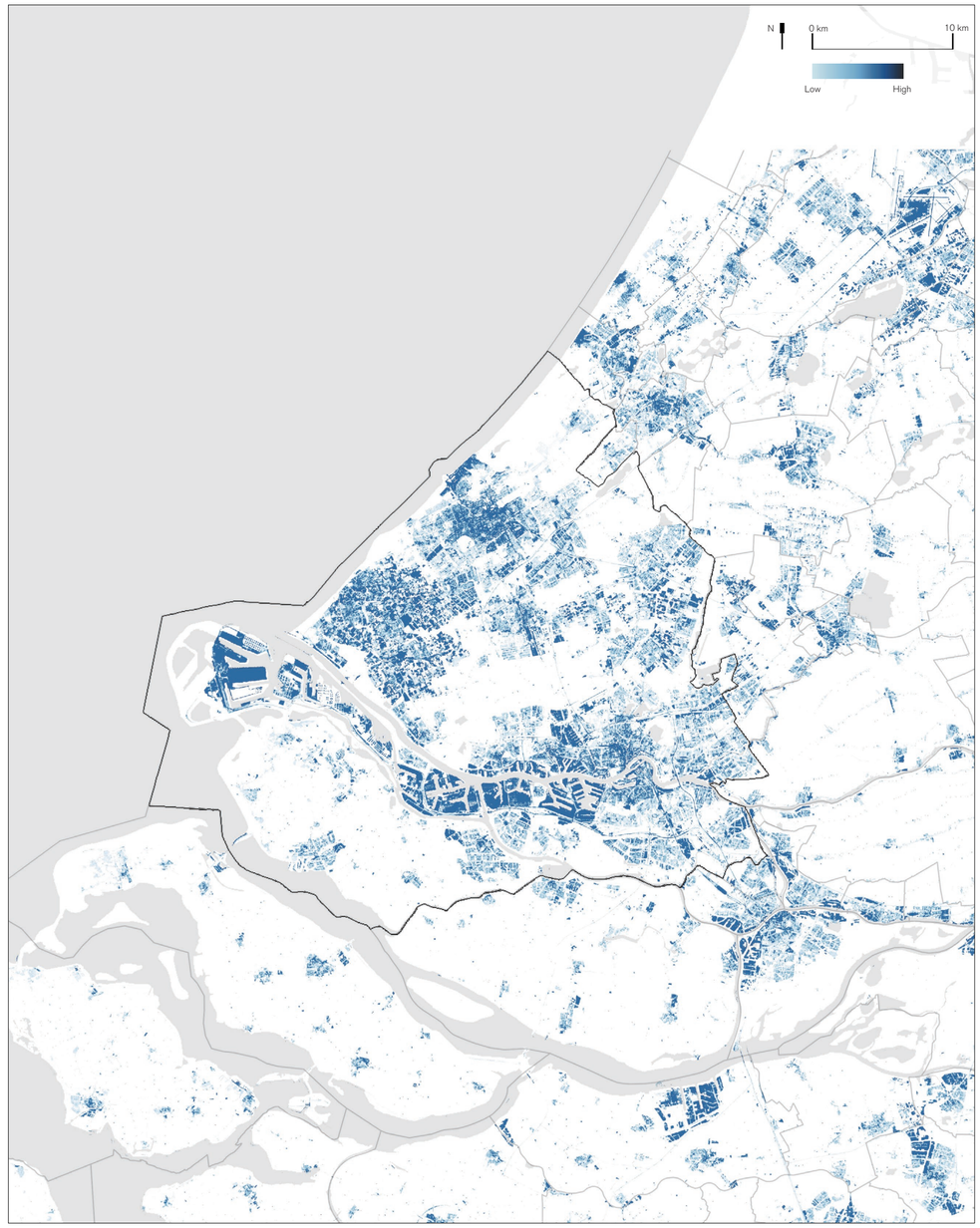


Fig.4.2.13 Degree of soil sealing. Source: Map created by author. Data from: land.copernicus.eu.

4.2 CAUSE ASSESSMENT

Water-related infrastructure

Most of the domestic water in this area comes from surface water extracted from rivers, including Haringvliet, Hollande Ijssel and Waal / Merwede. The sewage treatment plant discharges water into the river through purification treatment. Currently, only 6 sewage treatment plants in the area use digestion, and the sewage has the potential to provide bio-gas during the purification process.

At the same time, because some cities (such as Rotterdam) did not separate the rainwater pipeline and the sewage pipeline, the treatment effect of the sewage treatment plant is lower. In stormy weather, when the drainage pipe reaches its limit, sewage will overflow the ground and pollute the surface water source.

The development of greenhouse agriculture in areas such as Westland and Vierpolders requires centralized irrigation, which has also exacerbated water and soil salinity.



Fig.4.2.14 Coastal defense system. Source: Map created by author. Data from: edugis.nl.



Fig.4.2.15 Water treatment company. Source: Map created by author. Data from: Google Map.

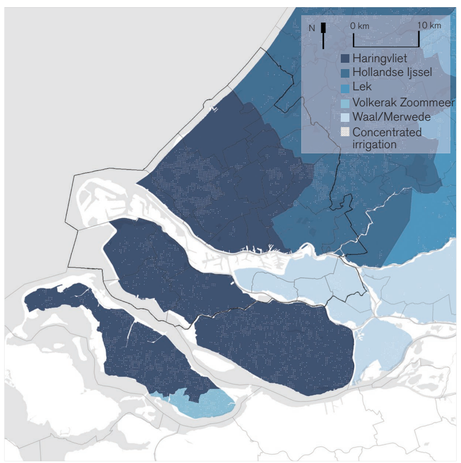


Fig.4.2.16 Source of clean water and concentrated use. Source: Map created by author. Data from: Nationaalgeoregister.nl.

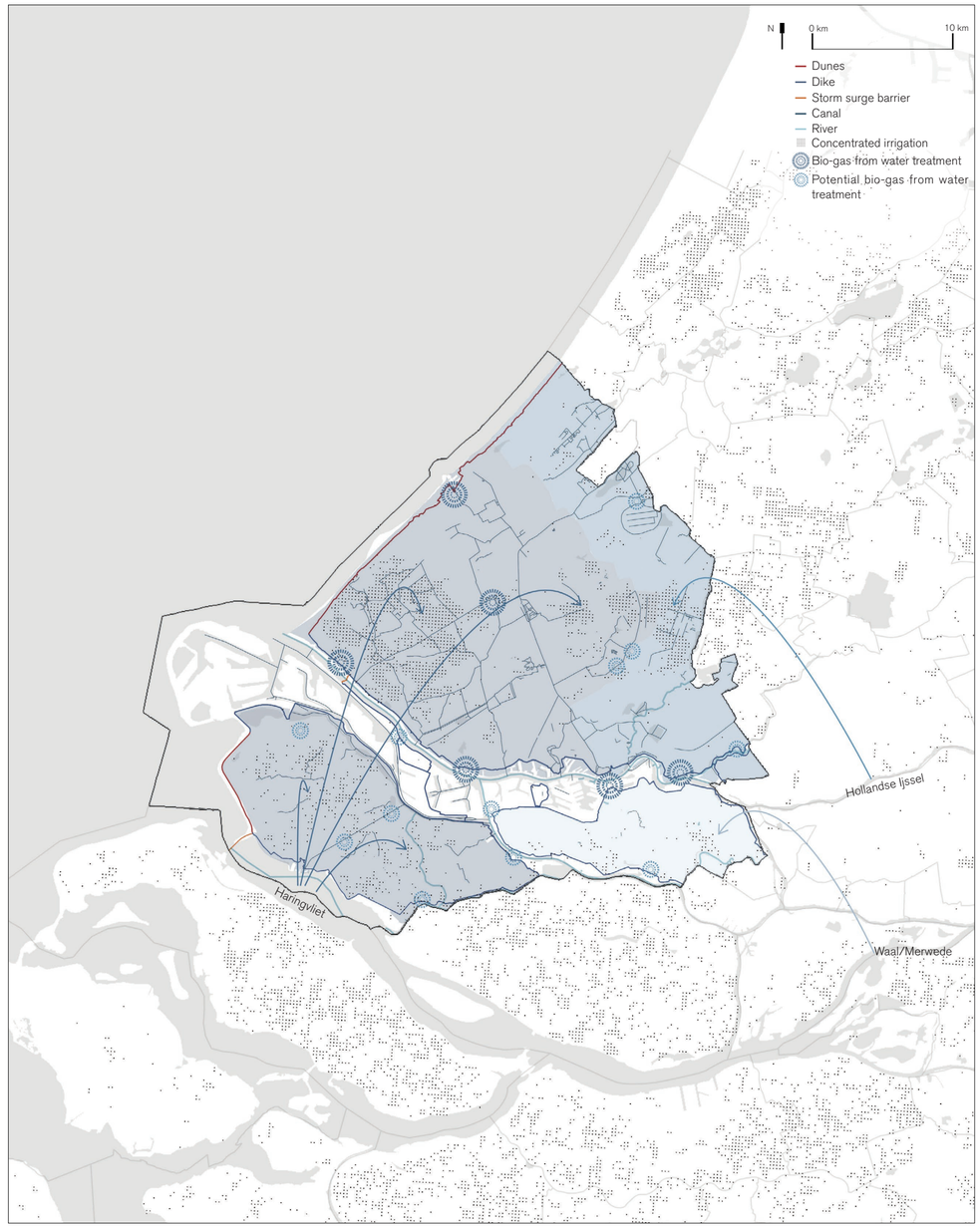


Fig.4.2.17 Water-related infrastructure. Source: Map created by author. Data from: Nationaalgeoregister.nl, edugis.nl, google map.

4.2 CAUSE ASSESSMENT

Vulnerability degree map

By synthesis of cause assessment, the Rotterdam area is a relatively vulnerable area in the MDHR area.

The rapid development of industry, ports and cities has also brought long-term risks to the Rotterdam area.

The MRDH covers about 36% of the Province of Zuid-Holland, but more than 60% of its population, and it is one of the most densely populated areas in the Netherlands. By 2015, Rotterdam has become the most populous city in MRDH, accounting for 27.9% of the MRDH population, while The Hague accounting for 22.9%.(OECD report ,2016)

The continuous population accumulation has led to the increase in soil sealing and the loss of landscape in these two areas, which are the main reasons for the decline in urban ecology. The development of port logistics and industry in Rotterdam has further aggravated air and water pollution in the region, making the region a vulnerable city.

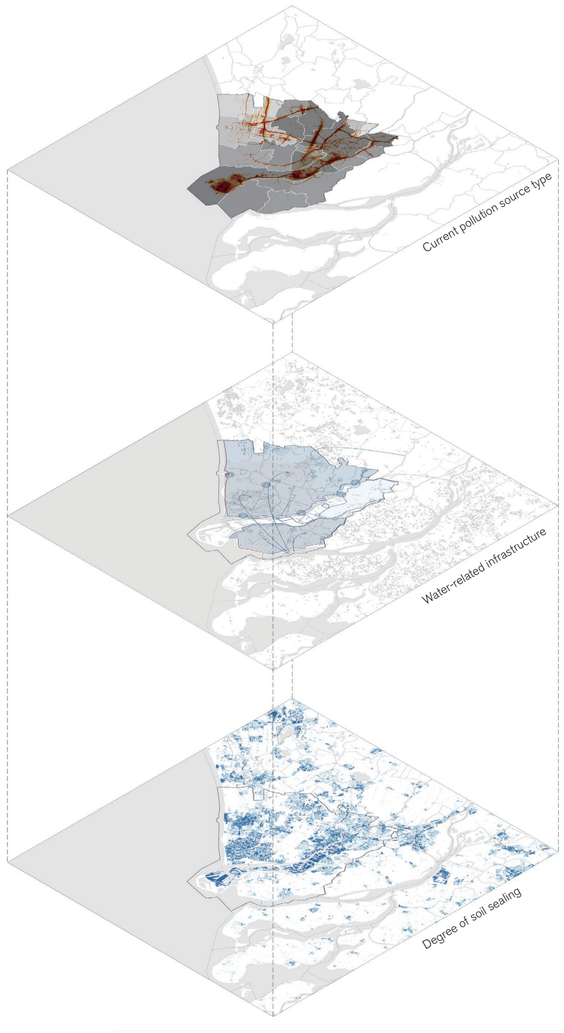


Fig.4.2.18 Synthesis of cause assessment. Source: Map created by author based on cause assessment.

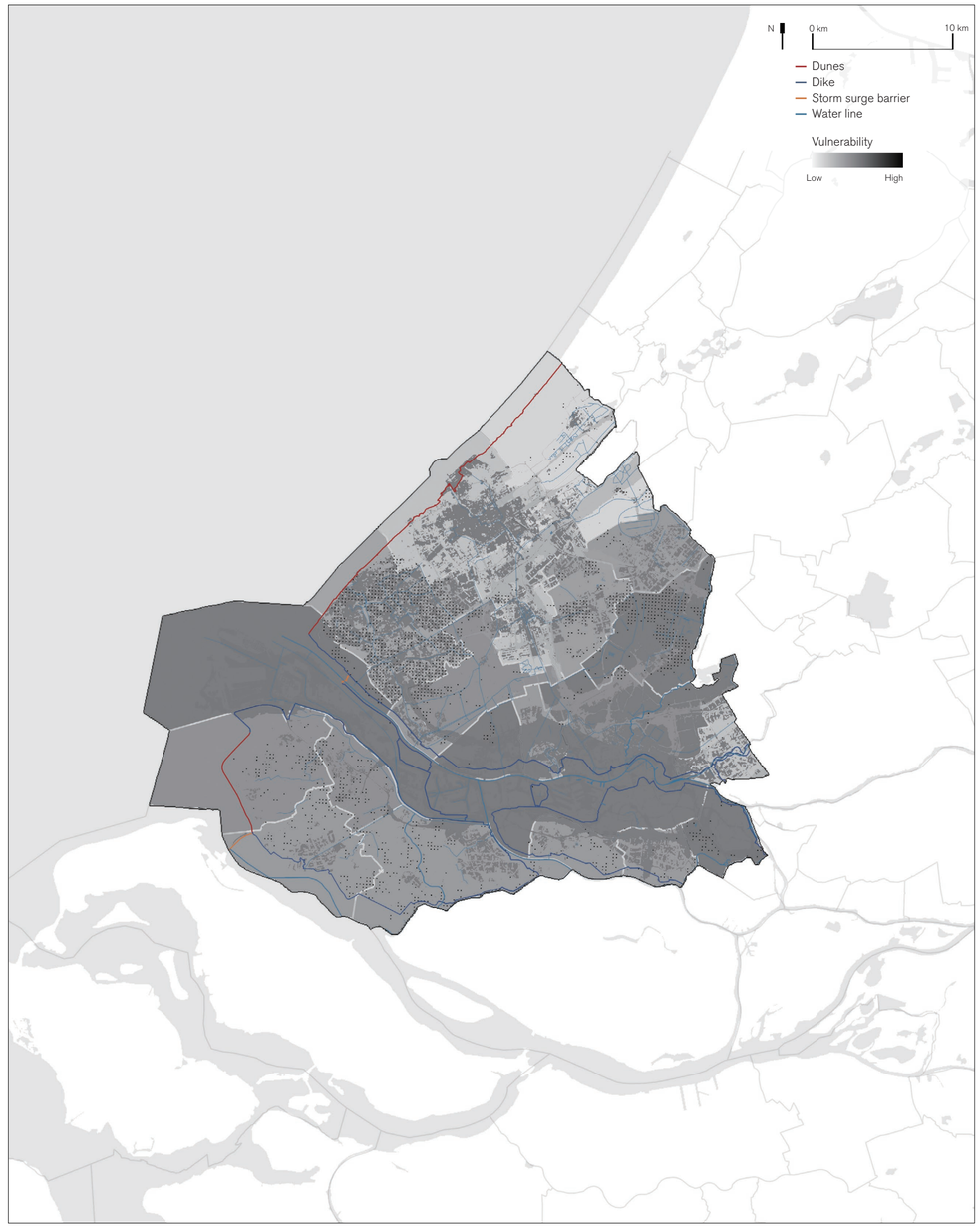


Fig.4.2.19 Vulnerability degree map. Source: Map created by author based on cause assessment.

4.3 RISK ASSESSMENT

Coastal flood

According to the most recent scenarios of the Royal Netherlands Meteorological Institute, sea-level on the Southern North Sea will be 25 to 80 cm higher in 2071-2100 (averaged year 2085) than in 1981-2010. For 2100 an upper level of sea- level rise is projected of 100 cm.

Since the last flood in southwestern Holland in 1953, the chance of encountering a marine flood has been greatly reduced. However, the economic losses caused by floods will become even greater. Most of the cities in The RDHM are below sea level, including The Hague and Rotterdam city. The existing standards for coastal defense facilities were formulated in 1960. The design standards for the height and strength of coastal defense facilities are increasingly different from the current social and economic development.

In general, the impact of coastal floods in the short term is not urgent, but in the long run, it is necessary to recommend that the area use higher safety standards while adopting more ecological flood defence measures.



Fig.4.3.1 Flood-prone areas. Source: Map created by author. Data from: PBL Netherlands Environmental Assessment Agency.

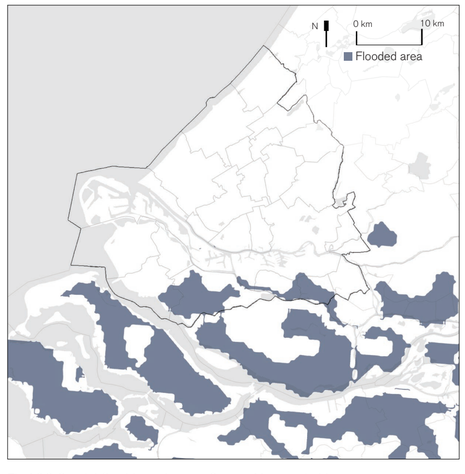


Fig.4.3.2 Coastal flood hazard zones. Source: Map created by author. Data from: Deltawerken.

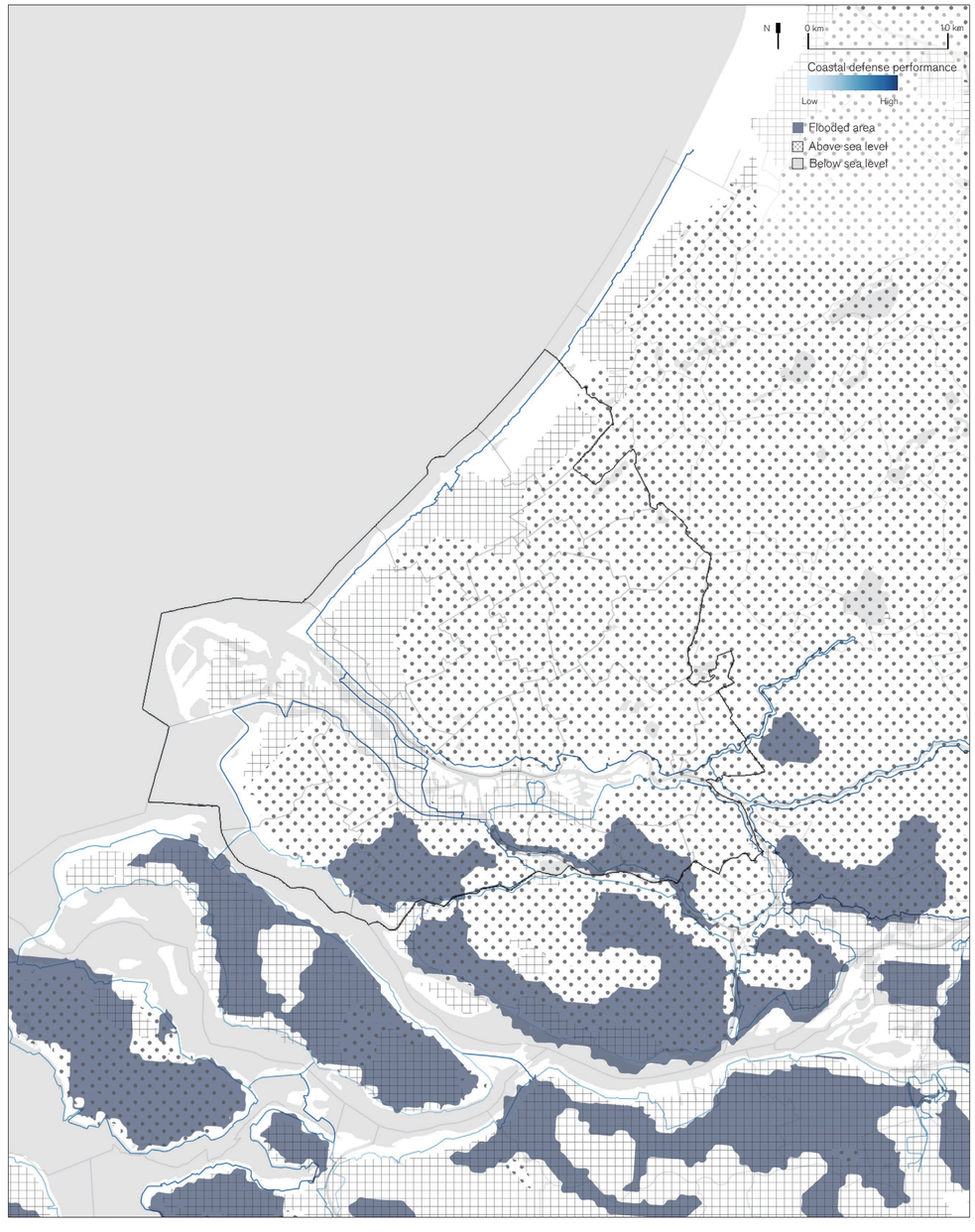


Fig.4.3.3 Risk level of coastal flood areas. Source: Map created by author. Data from: Nationaalgeoregister.nl, PBL Netherlands Environmental Assessment Agency, Deltawerken.

4.3 RISK ASSESSMENT

Pluvial flood

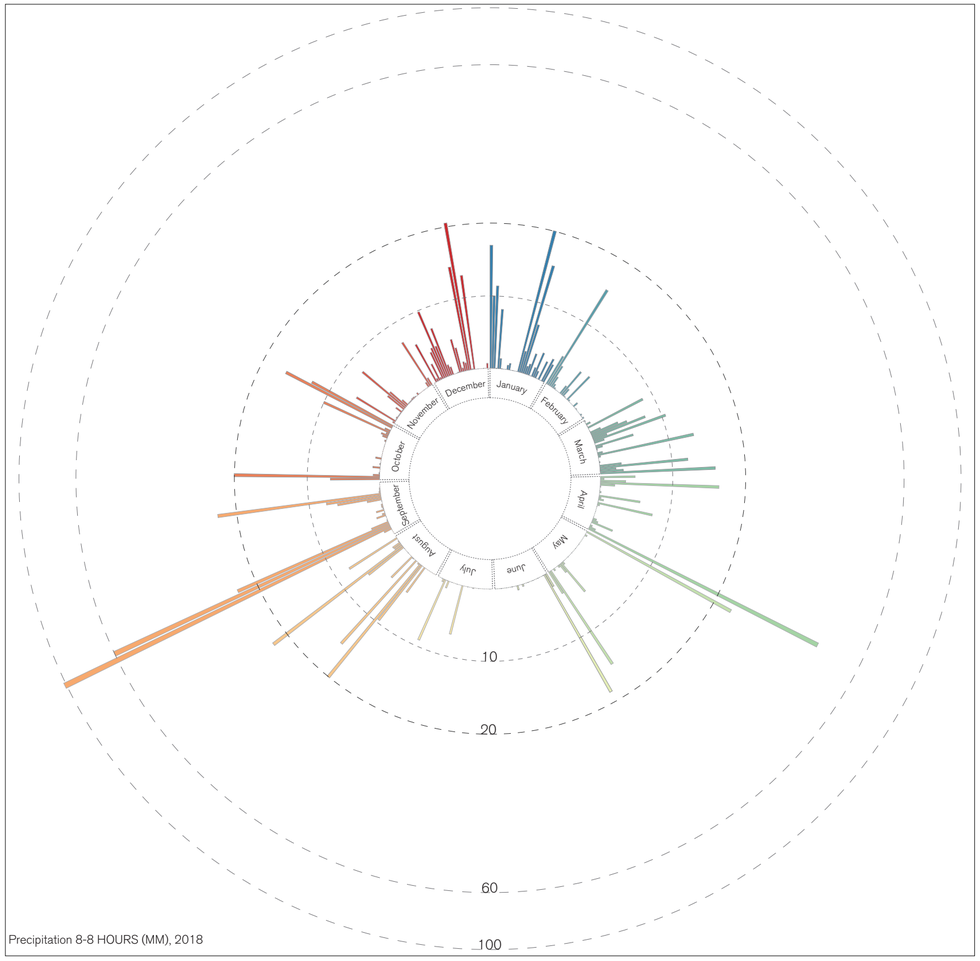


Fig.4.3.4 Study on precipitation pattern in South Holland. Source: Map created by author. Data from: KNMI.nl.

Between 1910 and 2017, the annual rainfall in the Netherlands increased evenly from 690 mm to 874 mm, increased by 27%. The increase in coastal areas is the largest, ranging from 30% to 35% (200-250 mm increase).

In terms of trends, the annual precipitation in the Netherlands increased linearly throughout the period 1910-2017. At the same time, the increase in annual average temperature and the resulting warming in the North Sea will bring more humid air to coastal areas. Therefore, future precipitation will reach even greater.

By studying the precipitation patterns in South Holland in 2018, we can find that the number of days with precipitation exceeding 20mm in August to December is much more than that in January to July, and the maximum rainfall is even reach to 100mm. A large amount of precipitation in a short period of time will cause significant economic losses and social disruption, while continuous heavy rain for several hours or days can cause significant damage to the agricultural sector, as well as congestion of public spaces in cities. In general, the impact of pluvial flood is more pressing than coastal floods in the short term.

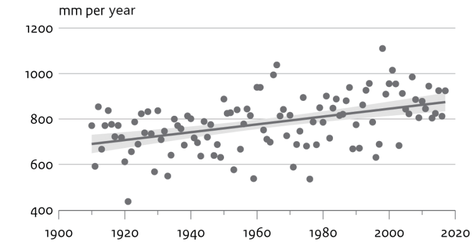


Fig.4.3.5 Annual precipitation trends. Source: www.clo.nl/indicatoren/nl0508-jaarlijkse-hoeveelheid-neerslag-in-nederland.



Fig.4.3.6 River discharge. Source: Map created by author based on New perspectives on urbanizing deltas.

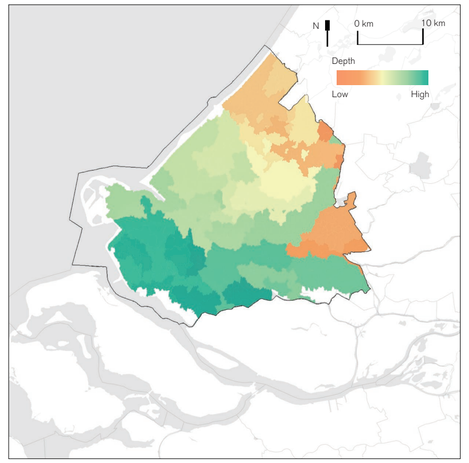


Fig.4.3.7 Basin area. Source: Map created by author. Data from: webgis.com

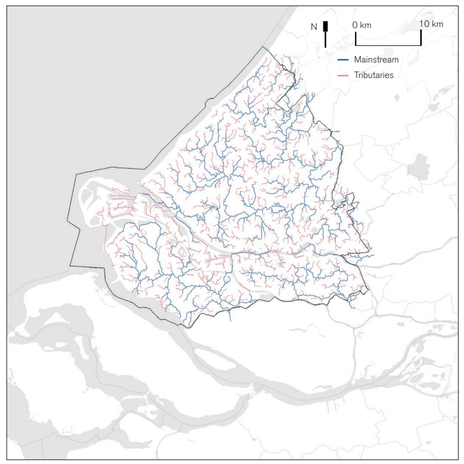


Fig.4.3.8 Runoff. Source: Map created by author. Data from: webgis.com

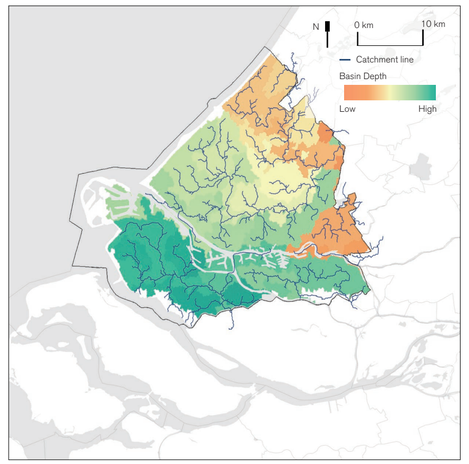


Fig.4.3.9 Runoff area. Source: Map created by author. Data from: webgis.com

4.3 RISK ASSESSMENT

Pluvial flood



Fig.4.3.10 Pluvial flood area. Source: Map created by author. Data from: webgis.com

While the delta project has improved coastal defense, it has also changed river discharge in the MRDH area. Nieuwe Waterweg needs to bear at least 75% of river discharge from Mass and Rijn.

Pluvial flood, also know as surface water flooding, occurs when high intensity rainfall causes runoff which flows over the surface of the ground and accumulates in low lying areas. The presence of impermeable surfaces, saturated soil and insufficient capacity within the drainage network can further exacerbate surface water flooding.

Through the QGIS analysis, the MRDH area is divided into different depth basins, and then catchment areas are made for each area to obtain surface runoff, pluvial flood area and pluvial flood risks due to the rainfall.



Fig.4.3.11 Pluvial flood risk. Source: Map created by author. Data from: webgis.com

4.4 THE CURRENT CHALLENGES

Synthesis of assessment

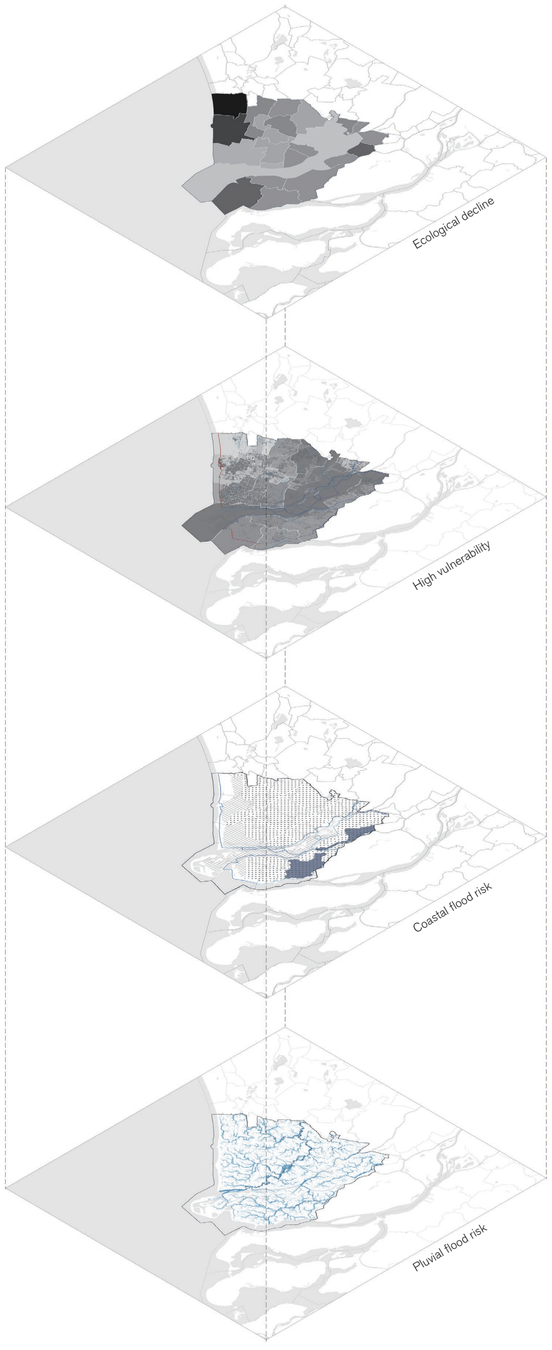


Fig.4.4.1 Synthesis of cause assessment. Source: Map created by author based on cause assessment.

It can be seen from Fig.4.4.1 and Fig.4.4.2 that the MRDH urban area has been almost covered by high-density buildings, especially the waterfront area has almost no open vegetation.

High urbanization has caused the ecological decline of the MRDH area, and the urban ecosystem is important for the urban resilience, which is one of the reasons for the vulnerability of the area.

As a port, Nieuwe Waterweg is the most important and largest water body in the region. Natural water on both sides of the river will almost merge into this river channel and eventually discharge into the North Sea. At the same time affected by the tide, seawater will also flow into the river through it. It is not only an important economic zone in Rotterdam, but also an important part of the natural system. Secondly, the special location of Rotterdam is also affected by the complex effects of river and seawater.

According to the OECD report (2016), the population of the region will increase until 2040, while limited open space restricts the construction of cities. At the same time, cities are facing the risk of pluvial flood caused by high soil sealing and long-term coustal flood risk .

In summary, the main challenges facing the region come from the conflicts between the urban growth, economic development needs and the vulnerable, risky space.

This conclusion will also be used in the "Housing priority vision 2040" later.

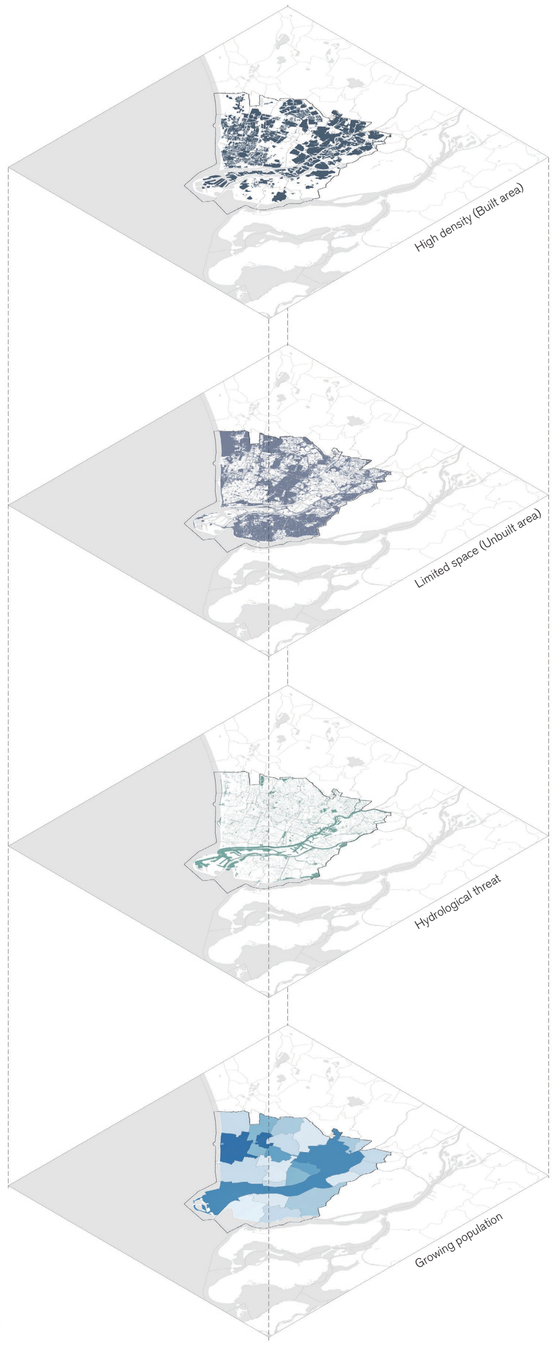


Fig.4.4.2 Synthesis of current challenges. Source: Map created by author based on cause assessment.

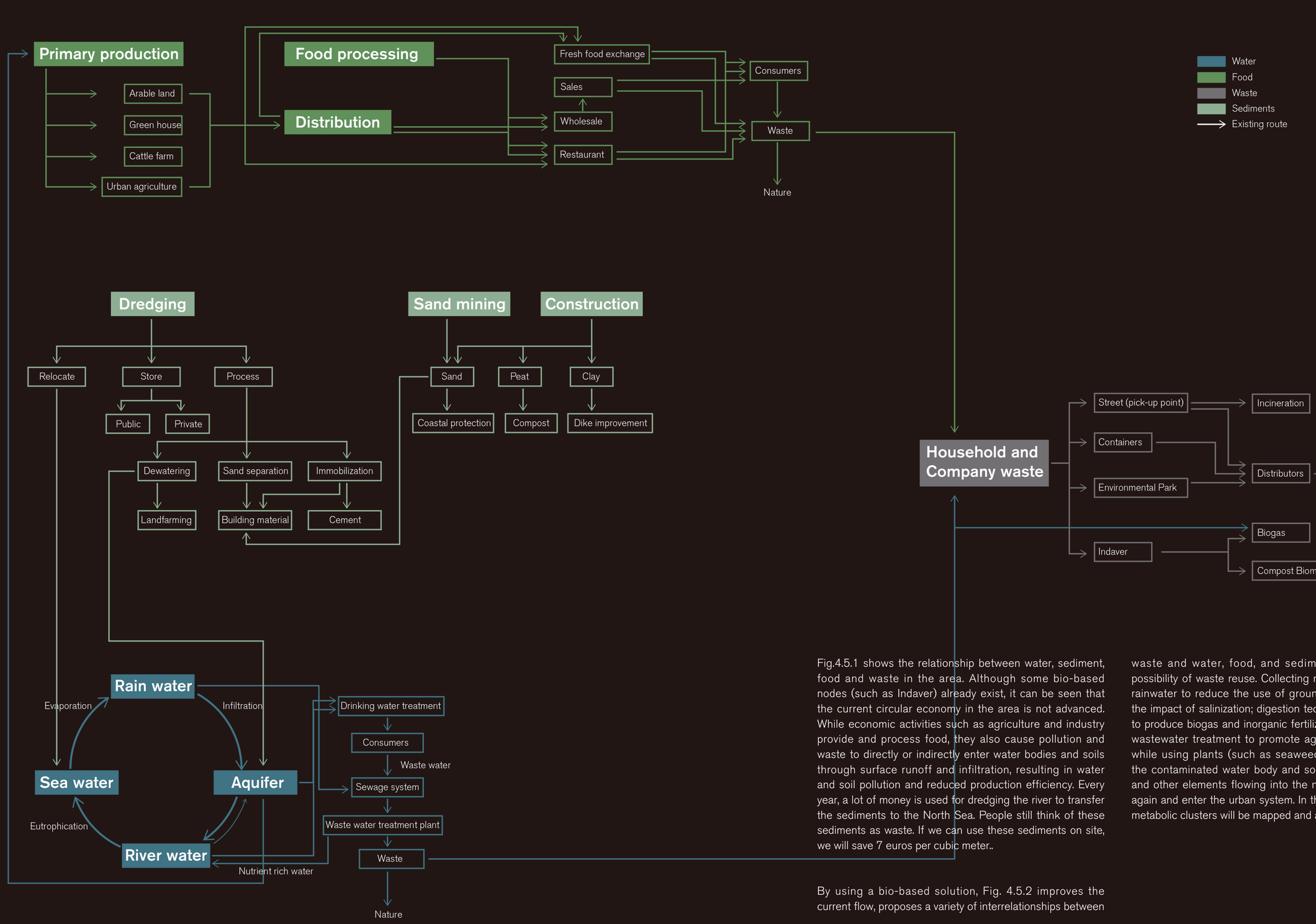


Fig.4.5.1 Existing flow. Source: Map created by author based on study of *Urban Metabolism Rotterdam*.

Fig.4.5.1 shows the relationship between water, sediment, food and waste in the area. Although some bio-based nodes (such as Indaver) already exist, it can be seen that the current circular economy in the area is not advanced. While economic activities such as agriculture and industry provide and process food, they also cause pollution and waste to directly or indirectly enter water bodies and soils through surface runoff and infiltration, resulting in water and soil pollution and reduced production efficiency. Every year, a lot of money is used for dredging the river to transfer the sediments to the North Sea. People still think of these sediments as waste. If we can use these sediments on site, we will save 7 euros per cubic meter..

By using a bio-based solution, Fig. 4.5.2 improves the current flow, proposes a variety of interrelationships between waste and water, food, and sediment, increasing the possibility of waste reuse. Collecting rainwater and reusing rainwater to reduce the use of groundwater so to reduce the impact of salinization; digestion technology can be used to produce biogas and inorganic fertilizers in the process of wastewater treatment to promote agricultural production, while using plants (such as seaweed, algae, etc.) purify the contaminated water body and soil so that the N, P, C and other elements flowing into the natural could be fixed again and enter the urban system. In the next section, these metabolic clusters will be mapped and analyzed in depth.

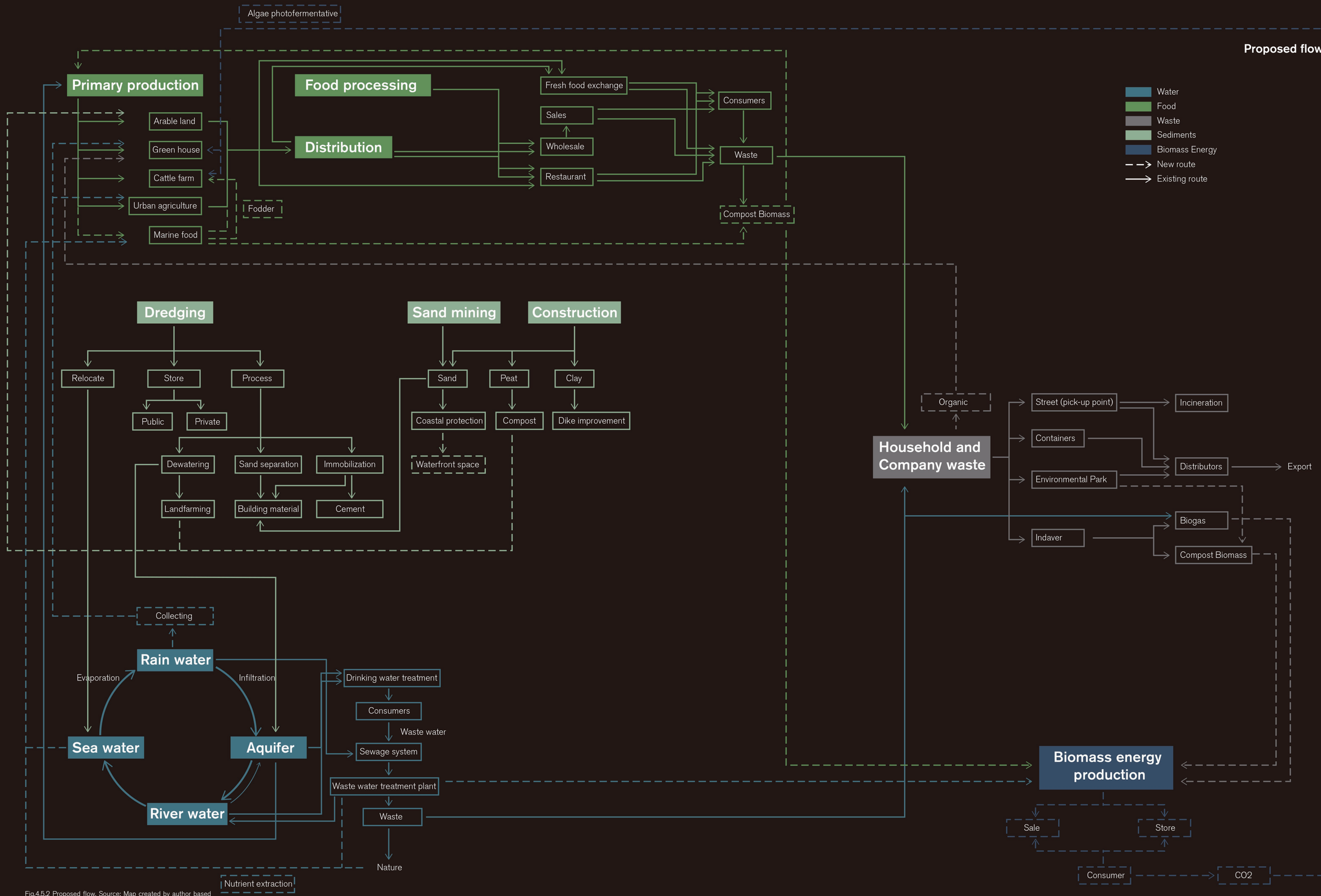


Fig.4.5.2 Proposed flow. Source: Map created by author based on study of *Urban Metabolism Rotterdam*.

4.5 FLOW ANALYSIS

4.5.1 Existing related metabolism cluster layers



Fig.4.5.3 Blue structure. Source: Map created by author.



Fig.4.5.4 Green structure. Source: Map created by author.

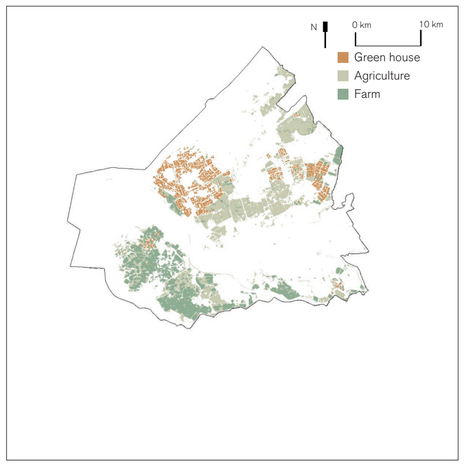


Fig.4.5.5 Food production layer. Source: Map created by author.

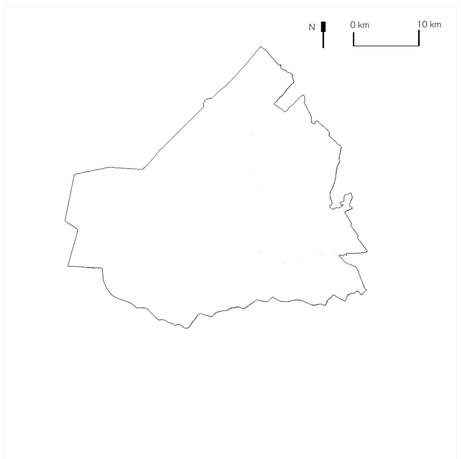


Fig.4.5.6 Dredging company. Source: Map created by author.



Fig.4.5.7 Major water consumers. Source: Map created by author.

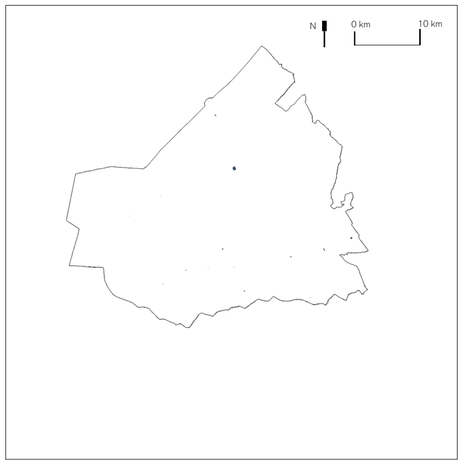


Fig.4.5.8 Waste water treatment layer. Source: Map created by author.



Fig.4.5.9 Waste treatment layer. Source: Map created by author.

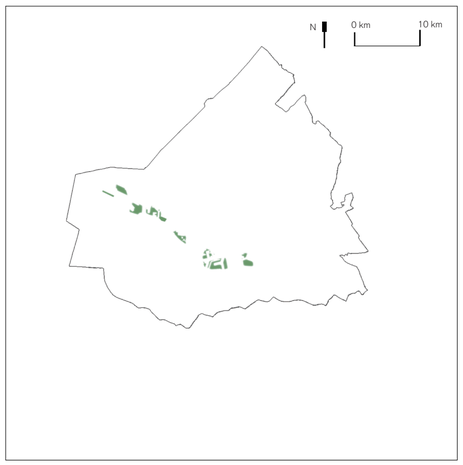


Fig.4.5.10 Fossil fuel tanks. Source: Map created by author.

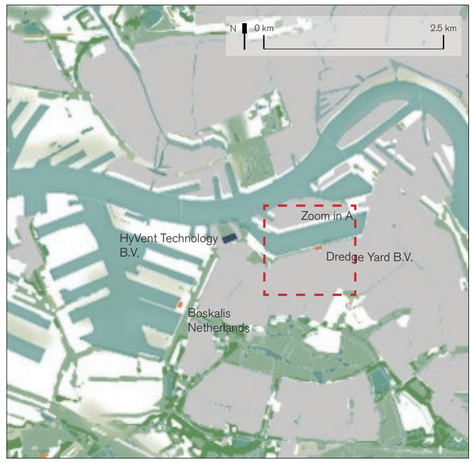


Fig.4.5.11 Zoom in 1. Source: Map created by author.



Fig.4.5.12 Zoom in 2. Source: Map created by author.



Fig.4.5.13 Zoom in 3. Source: Map created by author.



Fig.4.5.14 Zoom in 4. Source: Map created by author.

By mapping the theoretical flow, we can see the spatial distribution of these metabolic clusters, and by overlay them to obtain the existing urban-natural metabolic structure.

I selected four representative and different types of patches as meso scale analysis cases, and each 5km x 5 km patch contained a different part of the flow.

In the next section, I will first perform a multi-scale analysis of each patch in combination with the existing Vision (2020).

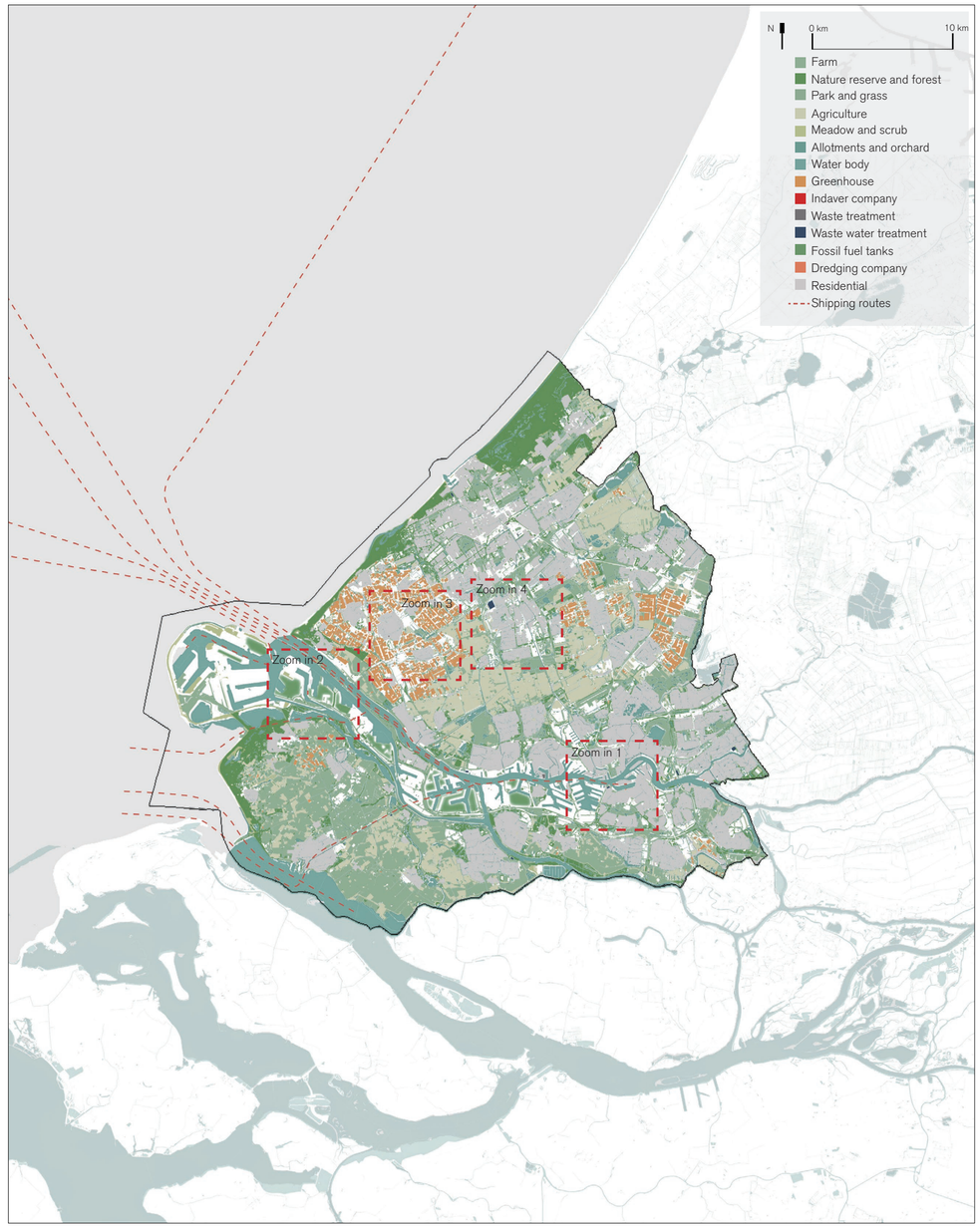
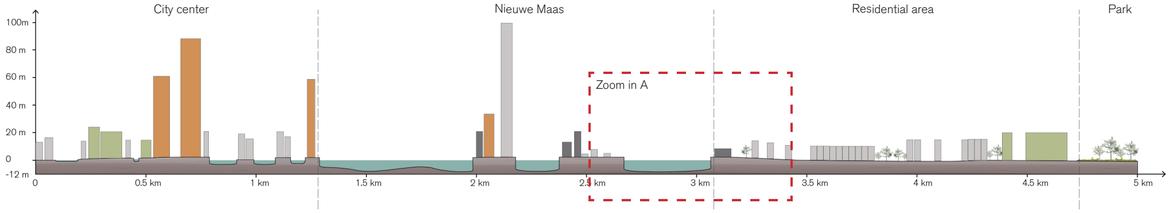
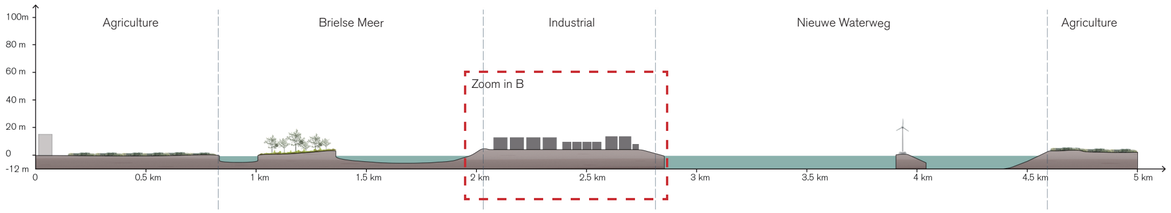


Fig.4.5.15 Existing urban-nature metabolic structure. Source: Map created by author based on the flow analysis.

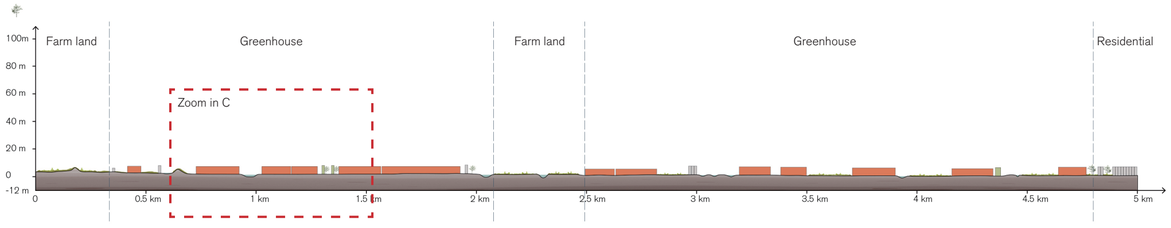
4.5.2 Existing Vison analysis



Section 1-1. Source: Created by author.



Section 2-2. Source: Created by author.



Section 3-3. Source: Created by author.

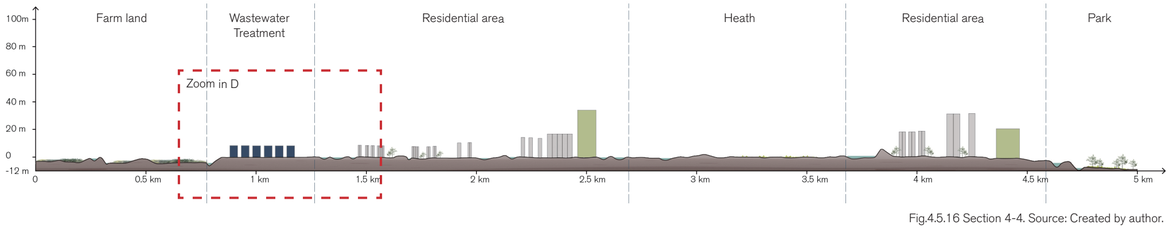


Fig.4.5.16 Section 4-4. Source: Created by author.

- Residential
- Industrial
- Greenhouse
- Water
- Commercial
- Business
- Wastewater treatment

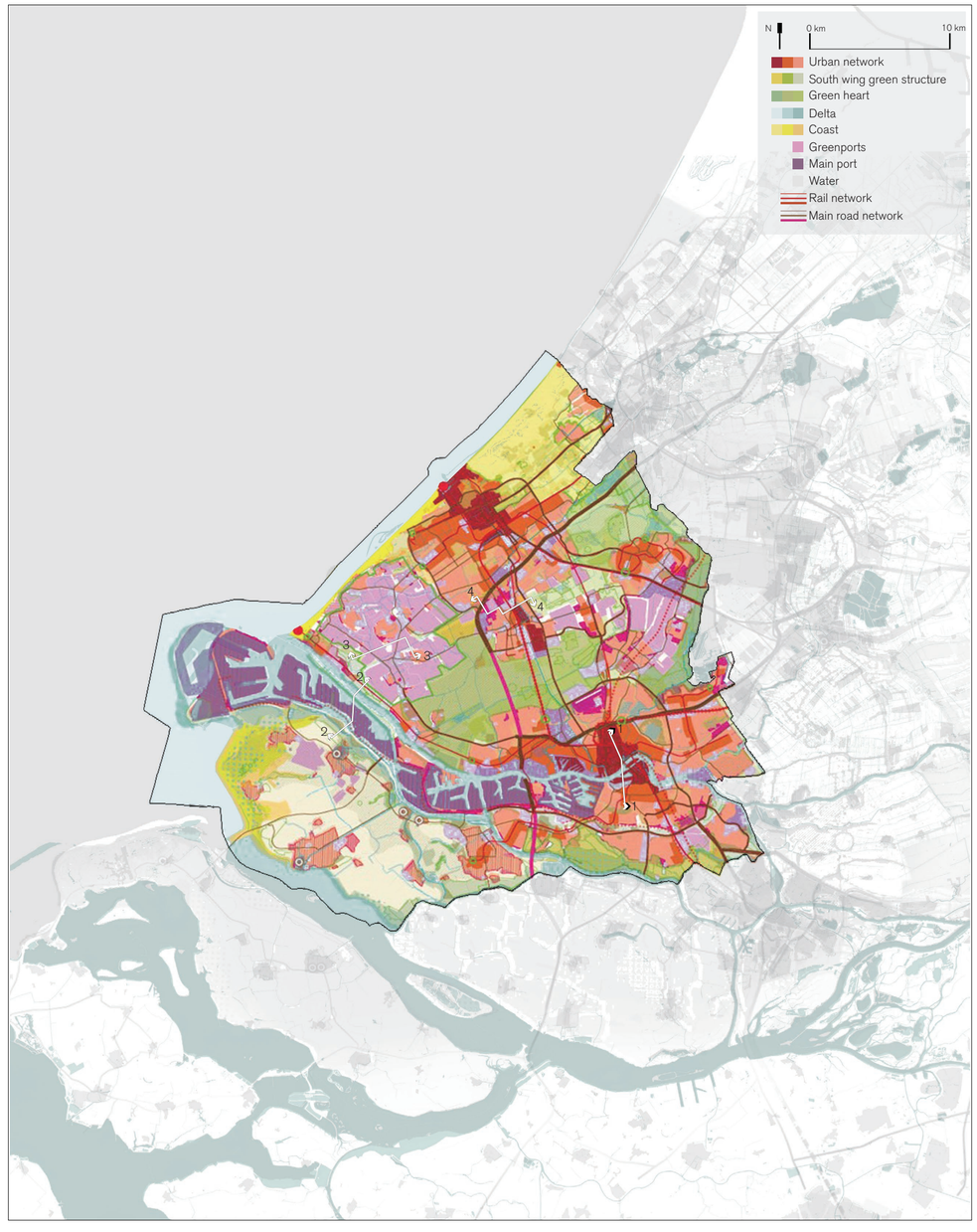


Fig.4.5.13 Existing spatial structure vision 2020. Source: Visie op Zuid-Holland, edited by author.

Zoom in flow analysis (1x1km scale)

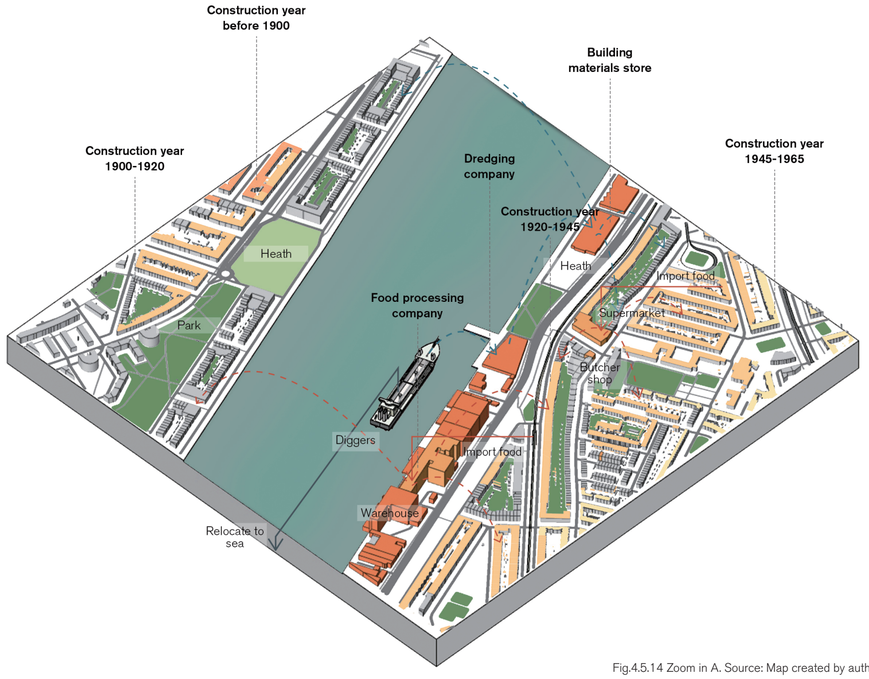


Fig.4.5.14 Zoom in A. Source: Map created by author.

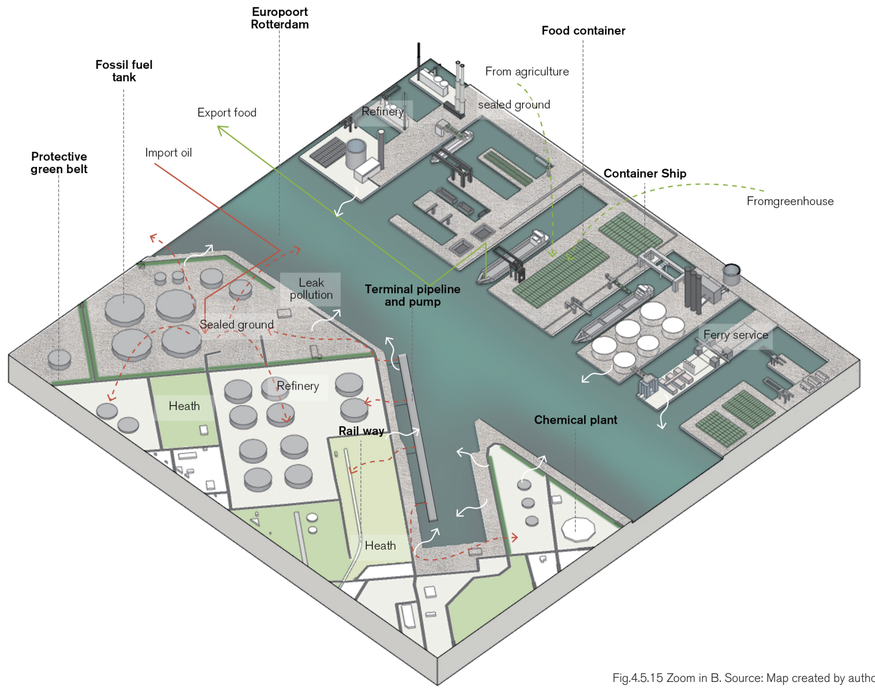


Fig.4.5.15 Zoom in B. Source: Map created by author.



Fig.4.5.16 Zoom in C. Source: Map created by author.

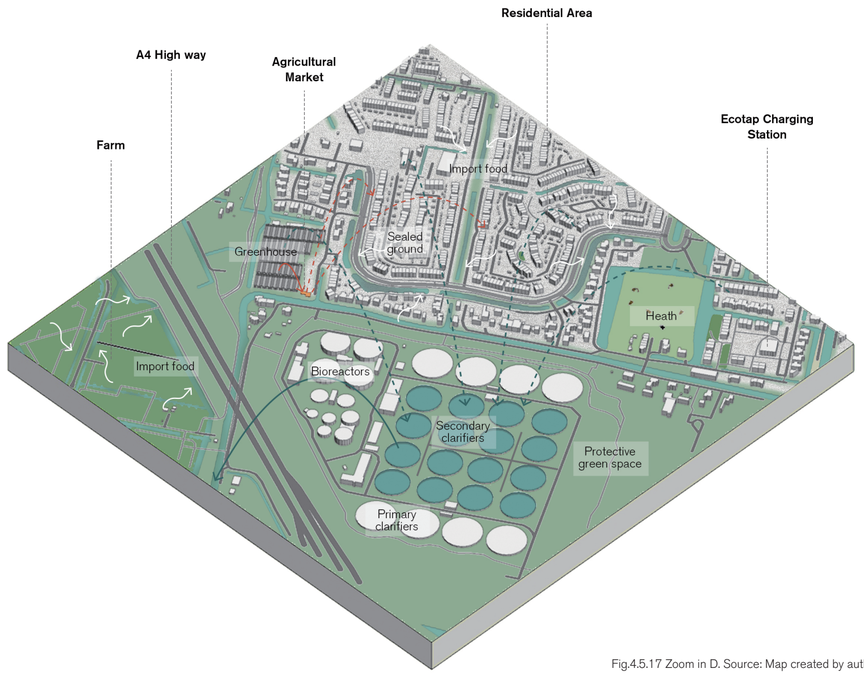
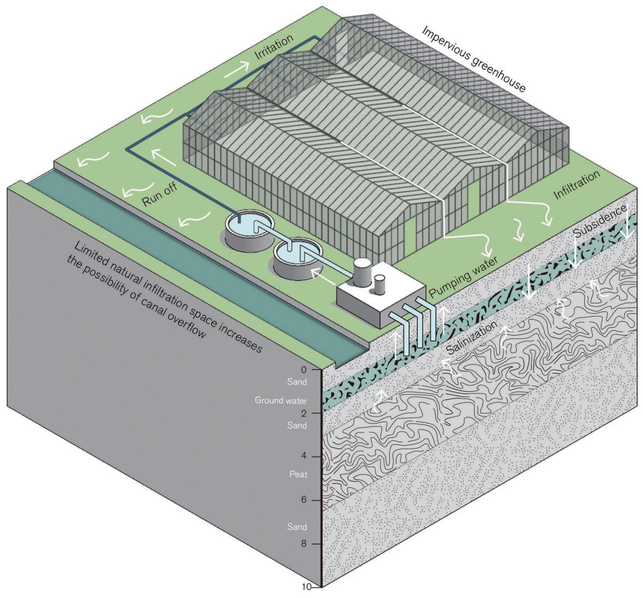
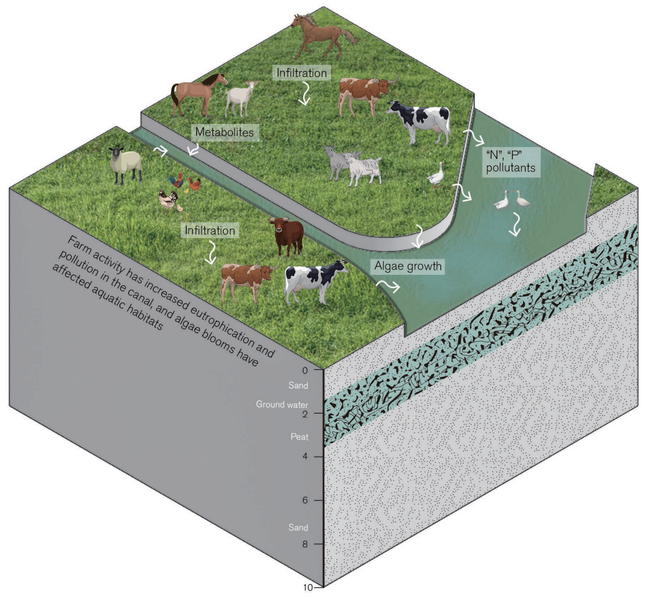
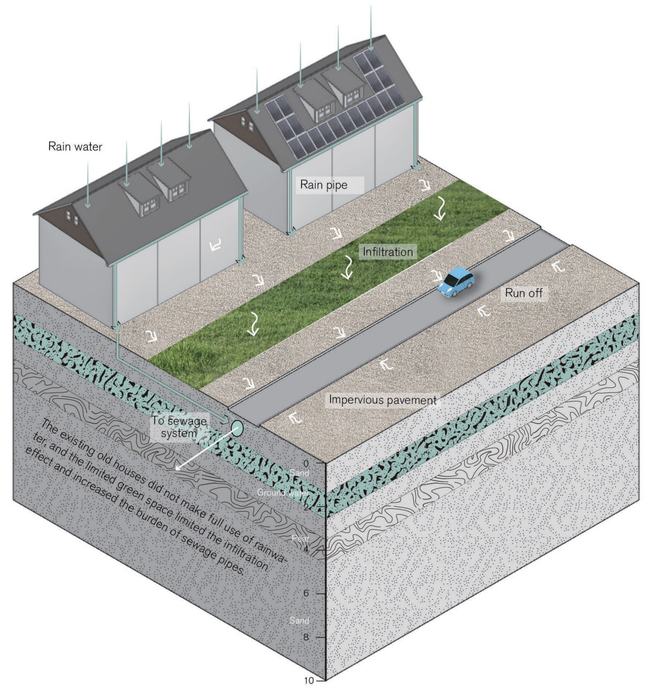


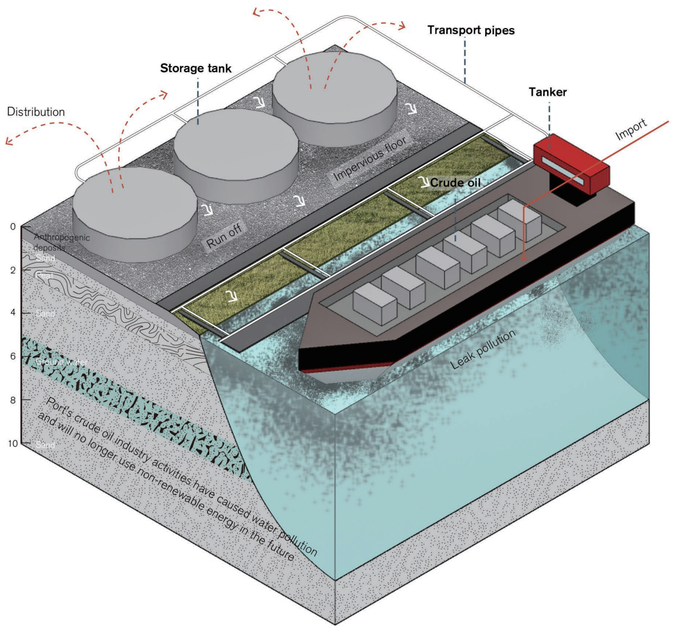
Fig.4.5.17 Zoom in D. Source: Map created by author.

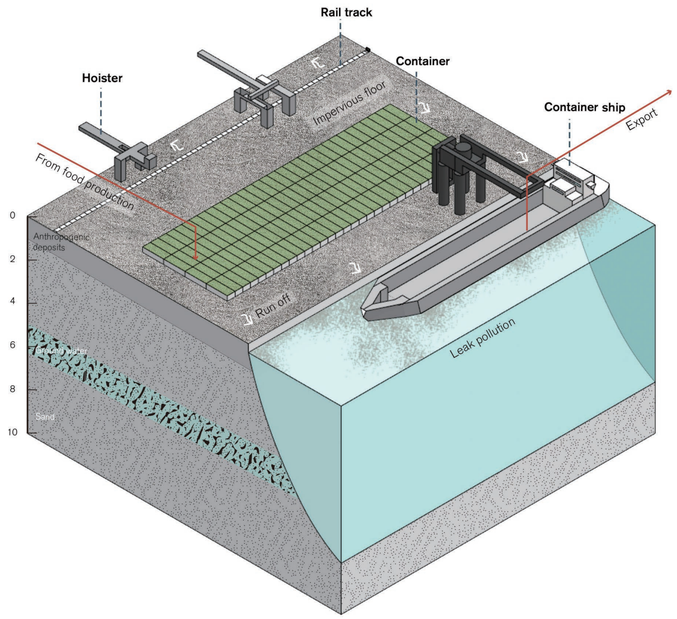
Metabolic typologies











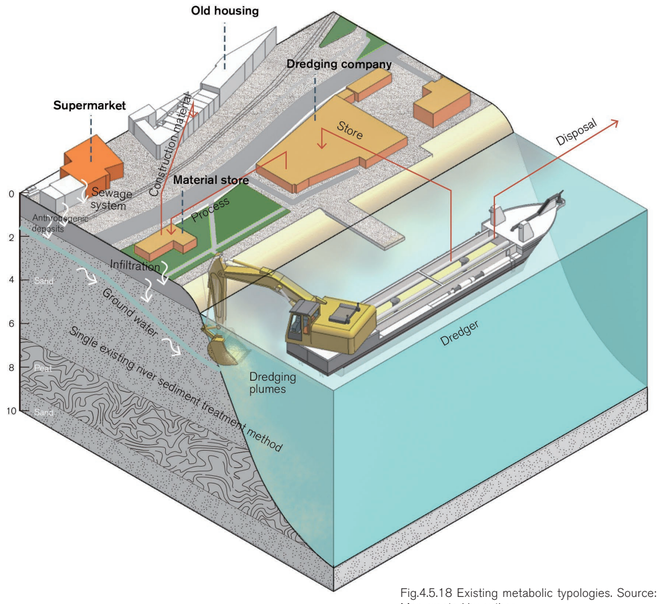


Fig.4.5.18 Existing metabolic typologies. Source: Map created by author.

Fig.4.5.16 and Fig.4.5.17 shows the spatial quality of the four patches and the current 2020 vision. Urban areas are aggregated through a network of regional public transport lines. Rotterdam and The Hague form an economic and urban contact point.

The urban area will use the land more centrally. The suburban areas will mainly be used for leisure and green functions. And Green heart and farmlands in the South Wing are preserved in rural areas, also strengthened the development of Green port.

Fig.4.5.16 also shows the current relationship between different spaces, the rigid relationship in urban waterfront areas, and the separation relationship between buildings and green space. At the same time, there are many unused gray areas in the urban areas.

In each 5km x 5km patch, I selected four 1km x 1km micro-scale patches to perform local flow analysis and explore the possibility of improving the local flow structure and ecology through different typologies.

For example, Fig.4.5.14, the dredging work transferred the sediments to the North Sea, which provided navigational conditions for large ships and destroyed the continuity of the waterfront landscape. At the same time, the sediments were not used locally. Older houses in urban areas make it less likely to collect and reuse of rainwater, and impervious paved areas in the community will increase the risk of pluvial flood.

The Fig.4.5.18 shows the different existing metabolic typologies, and how these activities affect local water and soil issues. For example, the groundwater and soil salinity and the decline of groundwater levels, caused by the extraction of groundwater in the green port area, the pollution of soil and water caused by industrial activities such as fossil fuel industry, and the eutrophication of water caused by agricultural activities.

In response to these issues, strategies will be proposed in the next section.

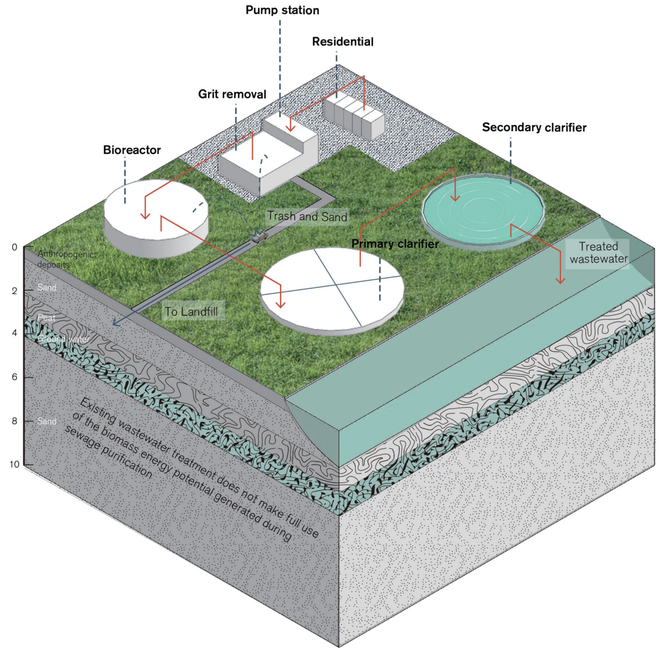


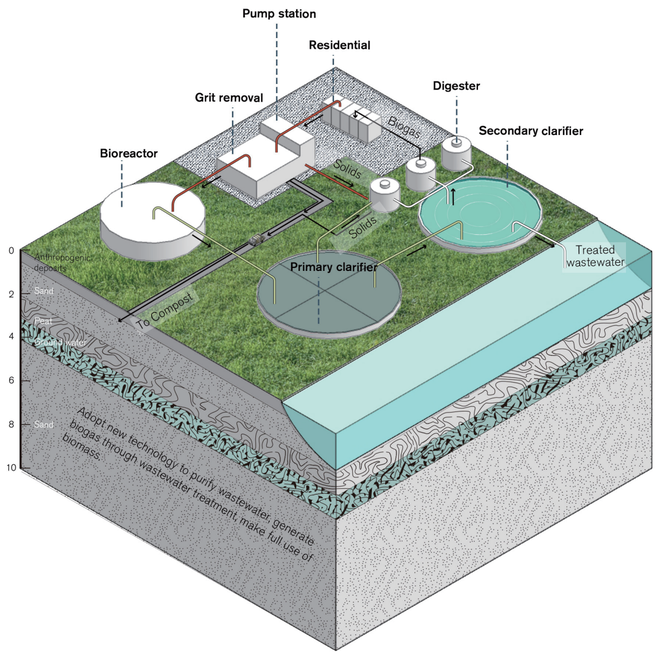
Fig.4.5.18 Existing metabolic typologies. Source: Map created by author.

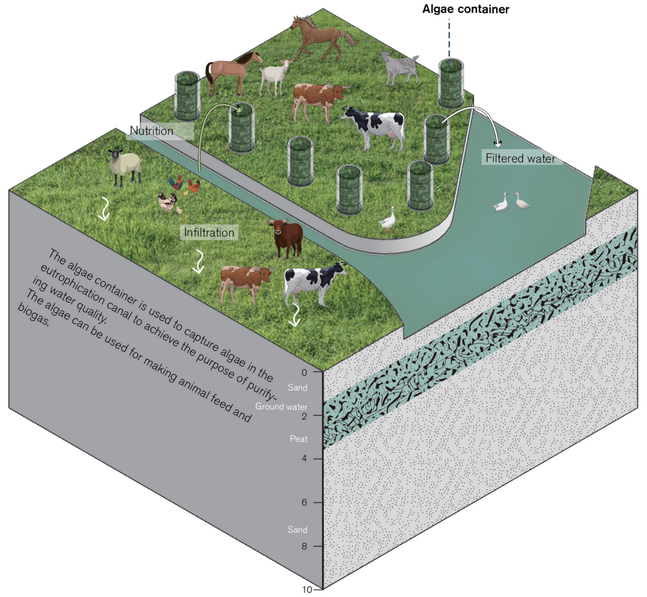
5 STRATEGIES

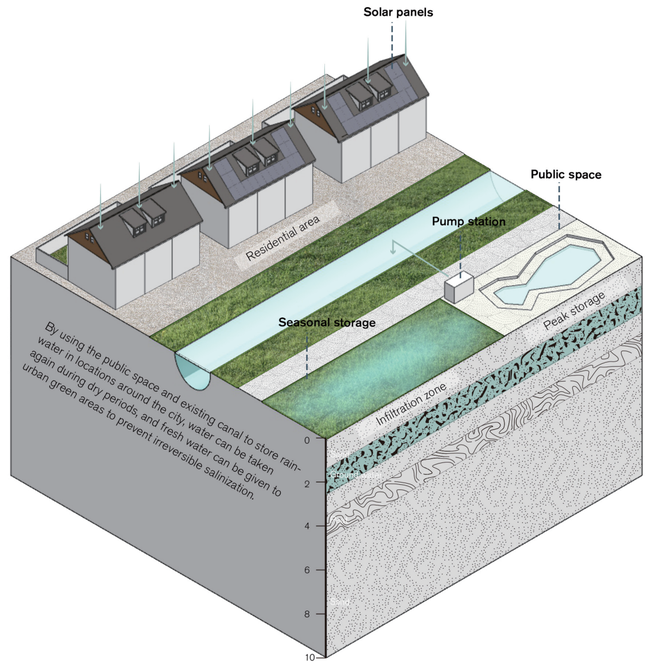
5.1 PROPOSED METABOLIC TYPOLOGIES
5.2 NEW FLOW (1X1 KM SCALE)
5.3 SPATIAL PRINCIPLES
5.4 TWO PRIORITY VISIONS
5.5 PRELIMINARY REVISED VISION 2040

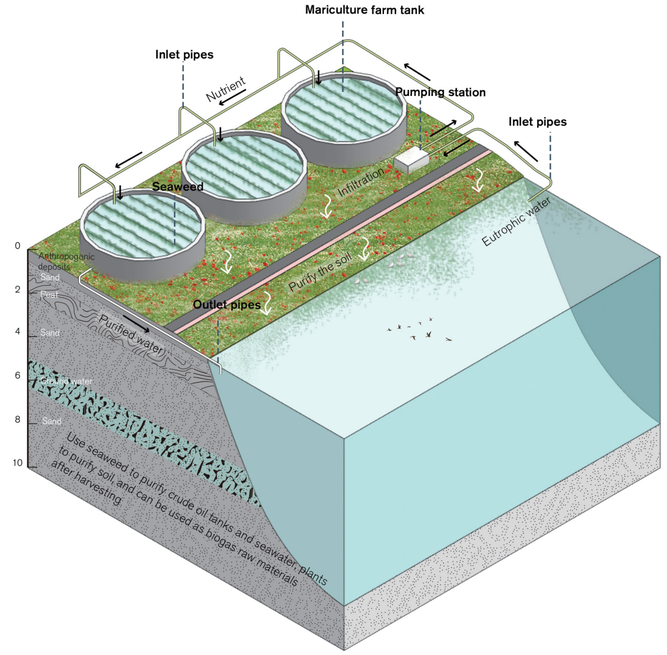
5.1 PROPOSED METABOLIC TYPOLOGIES

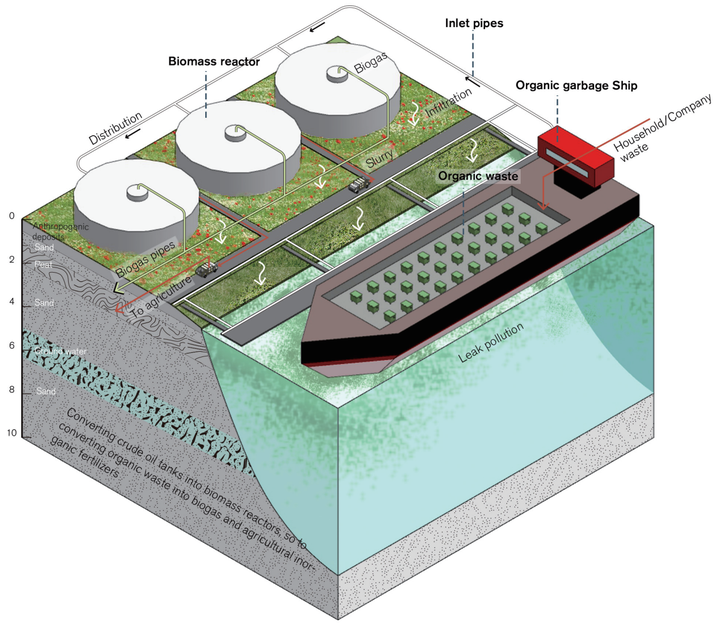
Proposed metabolic typologies











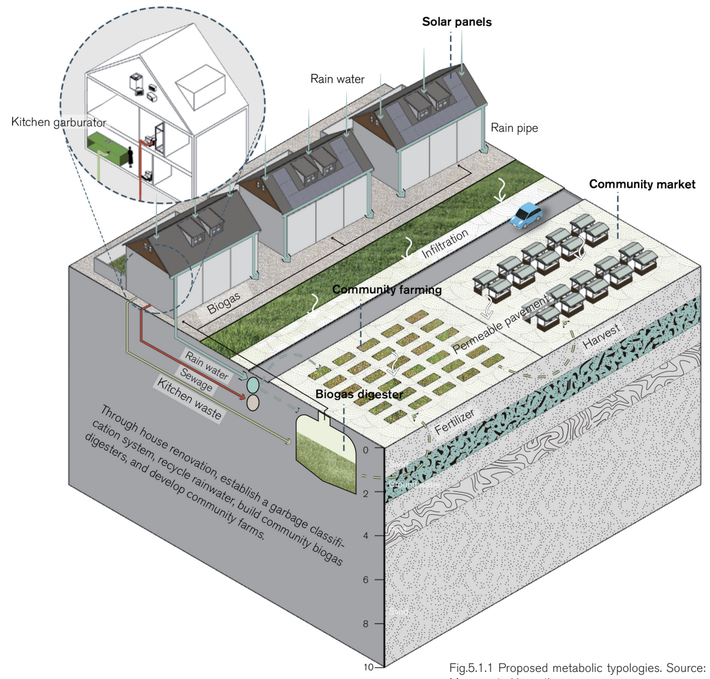
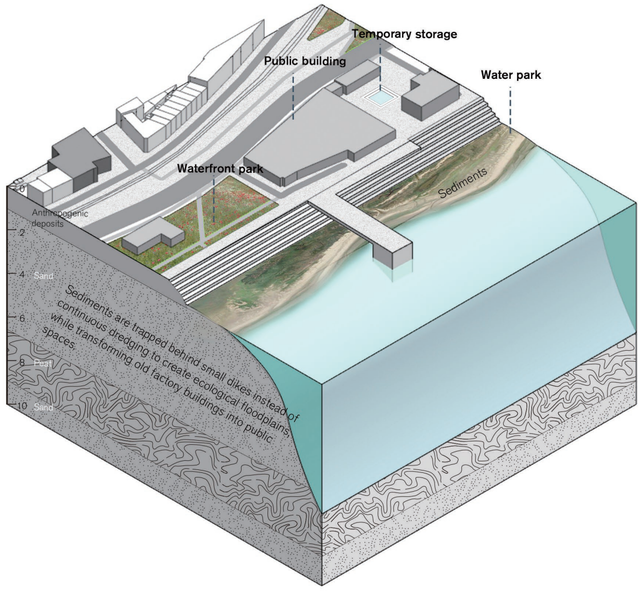


Fig.5.1.1 Proposed metabolic typologies. Source: Map created by author.



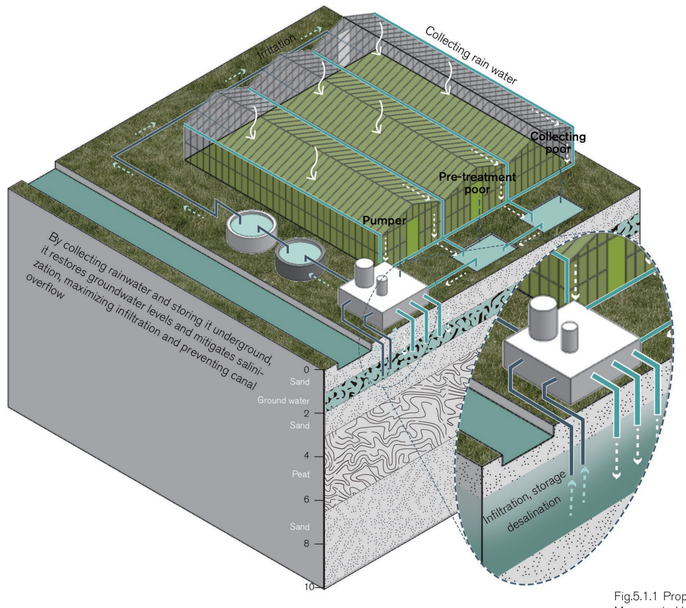


Fig.5.1.1 Proposed metabolic typologies. Source: Map created by author.

5.2 NEW FLOW (1x1 KM SCALE)

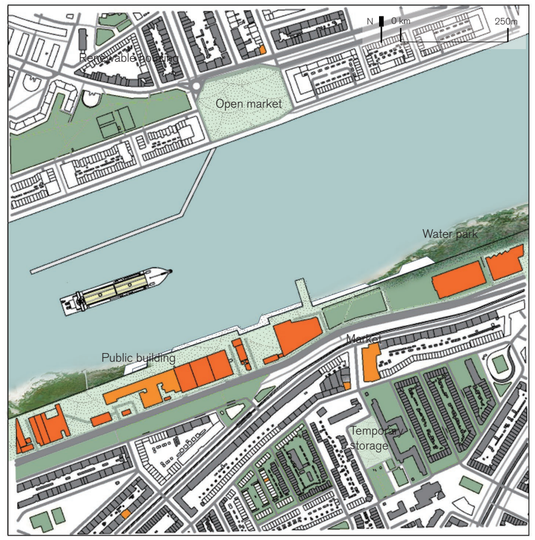


Fig.5.2.1 Zoom in A. Source: Map created by author.

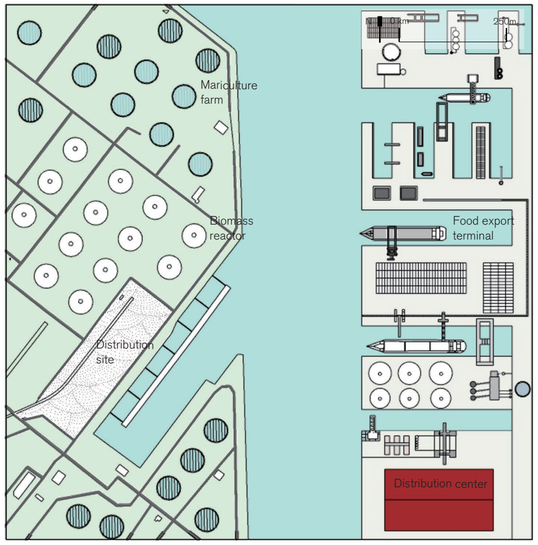


Fig.5.2.2 Zoom in B. Source: Map created by author.

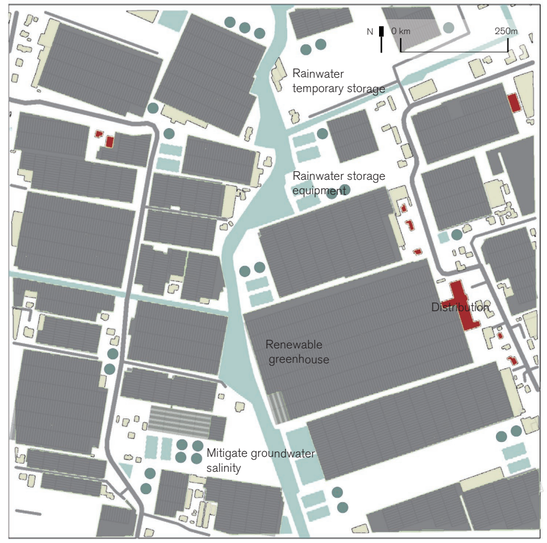


Fig.5.2.3 Zoom in C. Source: Map created by author.



Fig.5.2.4 Zoom in D. Source: Map created by author.

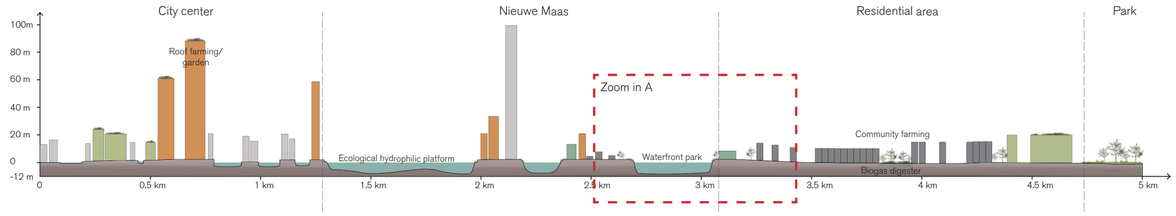
Fig. 5.1.1 shows the strategies to improve the ecological environment and increase economic benefits by changing the local flow. The strategies maximizes the potential of the water cycle.

Through the application of digestion technology, the purification process of domestic sewage can produce biogas and inorganic fertilizers; the algae container on the side of the canal can capture the nutrients in the canal, purify the water, and provide raw materials for biomass; the open space in the residential area can be transformed into community farms and community markets, which reduces the pollution caused by transportation of food, and green waste can be provided to the community's biogas digesters; for the design of open public space, the surface should be lower than the hard paving as much as possible, which is conducive to the natural infiltration of ground runoff and reduces the risk of flooding.

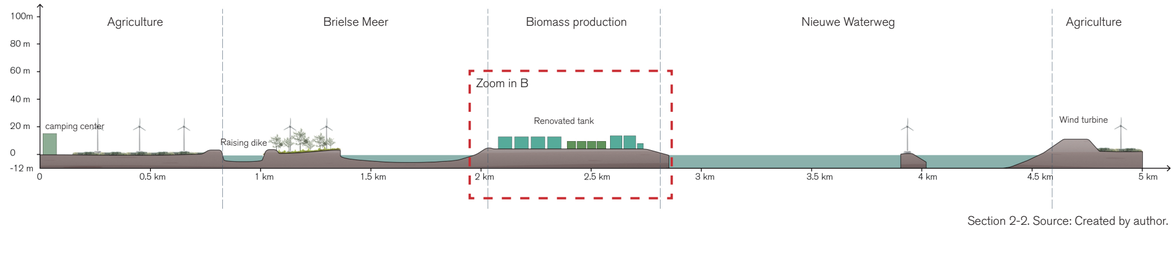
At the same time, the house should also add rainwater collection devices for secondary use and irrigation. ; In the future, fossil fuels will no longer be used, and related facilities in the port area will be modified for seaweed and fish farming, and also as biomass reactors. Use sediments to build waterfront parks and wetlands in the waterfront to create a biological environment. In the green port, rainwater is collected and stored underneath, which reduces the extraction of groundwater, mitigate salinity, and restores the groundwater level.

Propose new spatial principles based on local strategies. Roof farms/gardens are added in urban areas, and old buildings can be renewed to serve as new homes, improving the quality and density of housing. Waterfront areas should also create ecological waterfront environments, such as hydrophilic platforms, parks, etc. Port areas should make maximum use of wind energy, biomass energy, etc., and increase dikes to increse the flood control capabilities. Rainwater collection devices are added to greenhouses to make use of rainwater. Agricultural canals should incorporate algae container devices to achieve the purpose of utilizing the potential of eutrophic water quality.

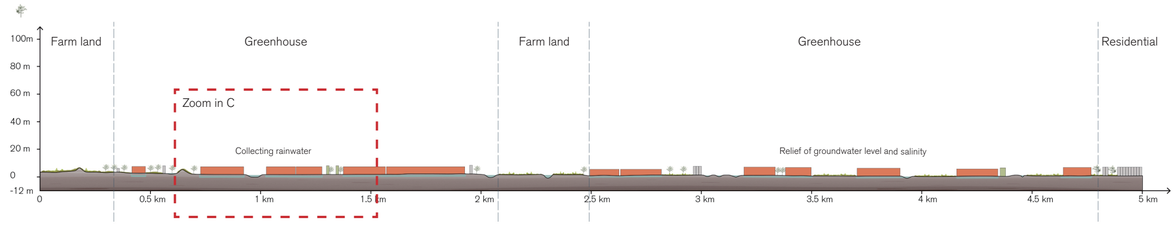
5.3 NEW SPATIAL PRINCIPLES



Section 1-1. Source: Created by author.



Section 2-2. Source: Created by author.



Section 3-3. Source: Created by author.

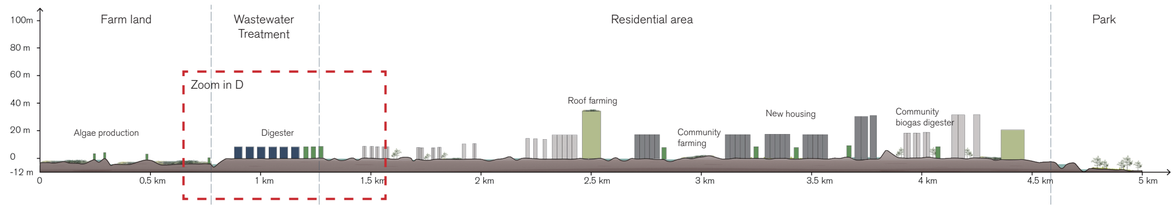
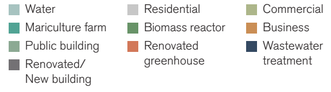


Fig.5.3.1 Section 4-4. Source: Created by author.



NEW SPATIAL PRINCIPLES

	Open Space		Constructions	Water Related Facility			Description
	Spatial Form and Configurations		Circulatory Elements	Storage /Retention	Infiltration	Mixed	
Urban area	City core area Waterfront area O1		C1 Rooftop agricultural collection to purify rainwater Residents use rainwater Excess discharge into rainwater pipes			M1 Waterscape: filtering cycle Square as temporary storage Infiltration evaporation Rainwater goes into rainwater system Separate waterscape and rainwater system	The city core area encourages the development of public buildings to high-rises, and the layout of buildings to clusters, so to form a rich urban space. At the same time, the roof greening of the building should be strengthened. In the construction land, public passages leading to open spaces along the riverside should be encouraged, and sight corridors should be guaranteed.
Rural area	O2		C2 Building private biogas digesters to reuse agricultural waste	S2 Increase secondary dike, use the agriculture plain as water storage place	I2 Increase primary dike, more space can be provide for natural infiltration		In rural areas, large-scale farmland cultivation is maintained, and agricultural waste is processed through biogas digesters, combined with wind power generation to achieve sustainable energy use. Through different means of changing the dikes, the purpose of ecological flood defence is achieved.
Green port	O3		C3 Building biogas digester and greenhouse rainwater collection system	S3			Integrate the rainwater management system with the irrigation system to reduce the extraction of groundwater. At the same time, establish a cooperative biogas digester to utilize greenhouse waste.
Suburban/Park	O4		C4 Excess discharge into rainwater pipes	S4 Filtration of rainwater in biological retention depressions	I4 Extend rainwater runoff and increase infiltration		Buildings in suburban areas should be multi-level or low-level. Areas around the park should maintain a clear line of sight with the park. Outdoor ground parking lots should be paved with grass-grown bricks. Low-lying areas should be maintained and transformed into biological retention depressions, so that natural landscapes have the role of rainwater treatment and management.
Industrial harbour	O5		C5 Purified water quality in marine aquaculture	S5	I5	M5	Industrial areas will no longer be dangerous in the future, but more open areas, so more waterfront spaces should be opened and become urban public spaces. Some industrial areas can be transformed into industrial heritage tourist areas, marine aquaculture demonstration areas and other public urban spaces.

5.4 TWO PRIORITY VISIONS

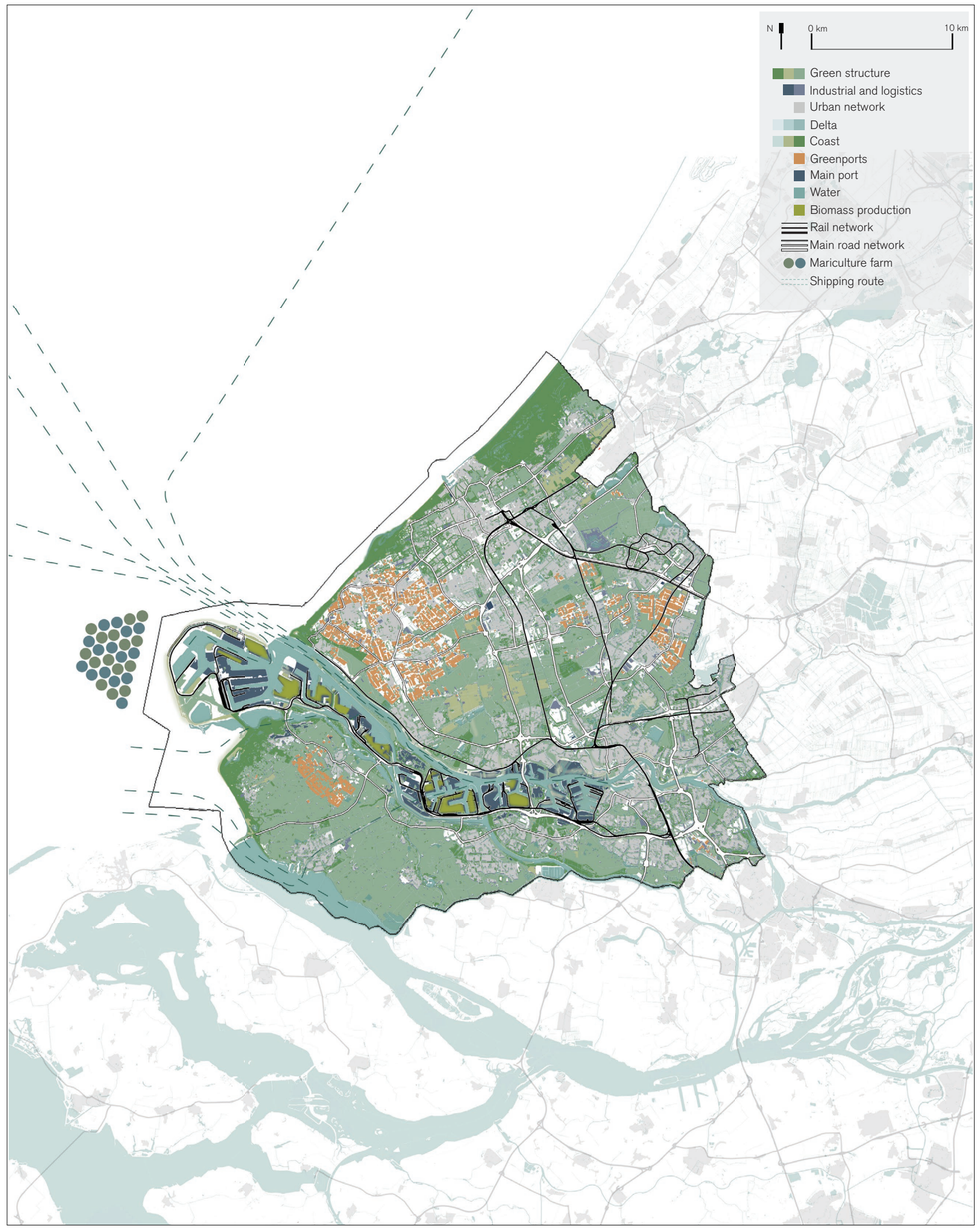


Fig.5.4.1 Production priority vision 2040. Source: map created by author based on Flow analysis.

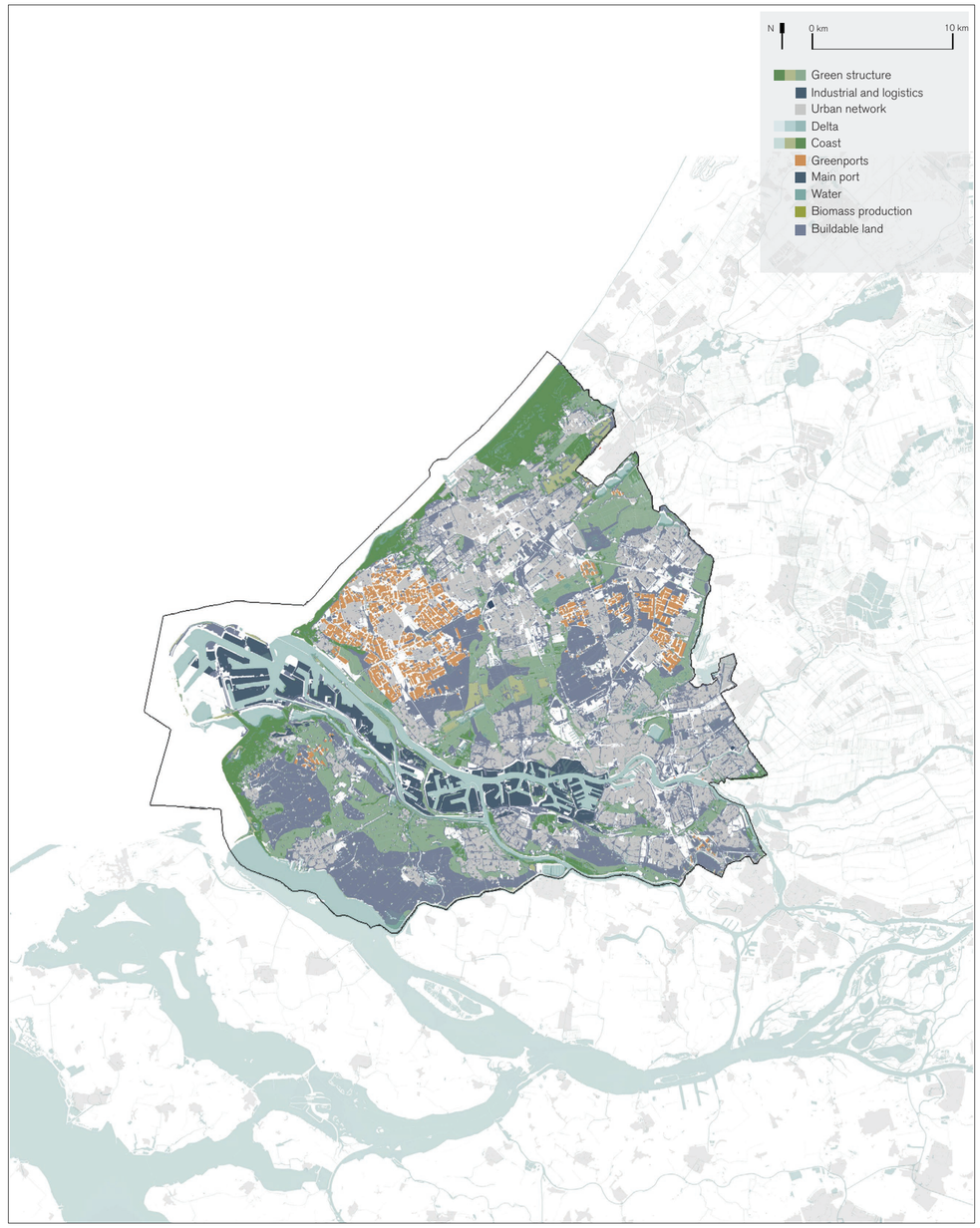


Fig.5.4.2 Housing priority vision 2040. Source: Visie op Zuid-Holland, edited by author based on The current challenges.

5.5 PRELIMINARY REVISED VISION 2040

Fig.5.4.1 shows the scenario of maximizing ecology, that is, biomass production priority vision 2040. According to the flow analysis and the proposed strategies, agriculture and greenport will be developed in the future, and diverse landscapes will be embedded in the city. Rotterdam and The Hague, as attractive international prime locations, continue to develop in terms of cooperation. The connection will also be closer. At the same time, the port of Rotterdam will be transformed into an ecological port integrating logistics, biomass and renewable energy.

Fig.5.4.1 shows the scenario of maximizing urbanization, called housing priority vision 2040. According to the macro scale assessment and the conclusion, we can assume that by 2040 the scenario of maximizing urbanization, housing density in urban areas will increase, and suburban areas will also be urbanized, except for areas with high flood risk and Nature 2000, all unbuilt land can be used as constructable land, and the port of Rotterdam will be completely transformed into a port area for logistics and industry. At the same time, increase the coastal defense engineering coefficient to ensure the safety of the city.

Fig.5.5.1 combines the two scenarios, improve the regional infrastructure and landscape network, so as to strengthen the connections between various industries in the region, also strengthen the flow structure, and achieve the goal of reducing waste. Improve the water cycle through new flow structures, use the potential of water cycle, and create a diverse landscape and economic diversity in the region. This will address climate adaptation and biodiversity issues. The MRDH region will become a region that fully realizes a bio-based economy.

In the next chapter, we will combine design testing to explain how to implement this vision.

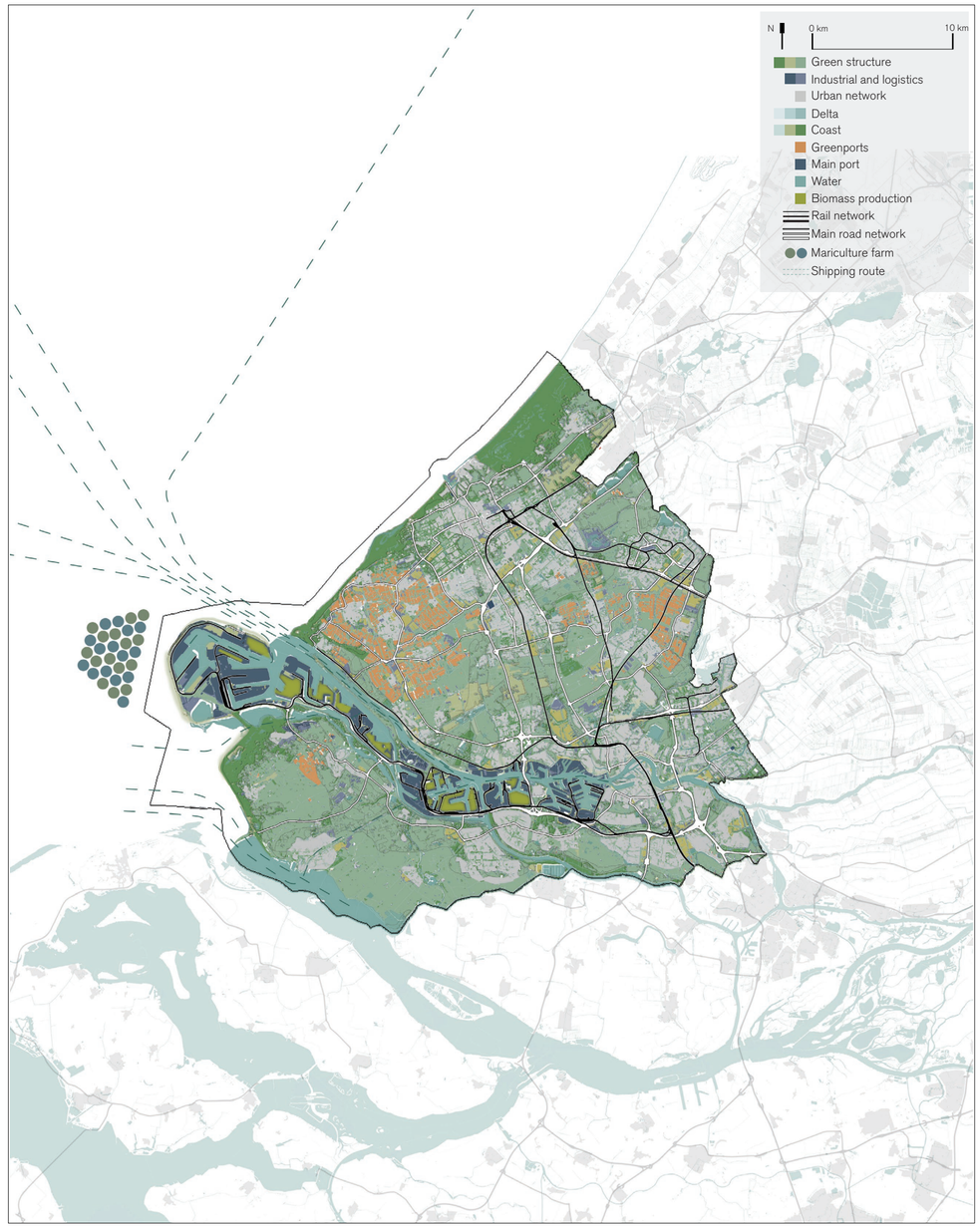


Fig.5.5.1 Preliminary Vision 2040. Source: map created by author.

6 DESIGN TESTING

6.1 BUILDING LOCAL SPATIOTEMPORAL
6.2 DESIGN TESTING
6.3 EVALUATION
6.4 GOVERNANCE MODEL
6.5 SCALE ADAPTATION

6.1 BUILDING LOCAL SPATIOTEMPORAL

Design testing area



Fig.6.1.1 Design testing area. Source: map created by author.

Contextual information



Fig.6.1.2 Land use. Source: map created by author.

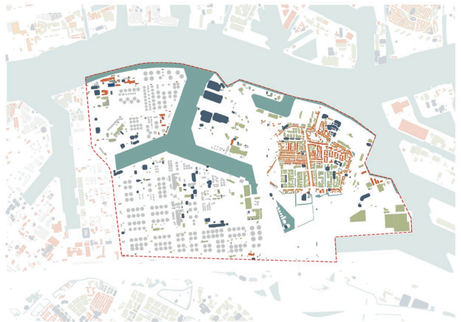


Fig.6.1.3 Building year. Source: map created by author.



Fig.6.1.4 Infrastructure. Source: map created by author.

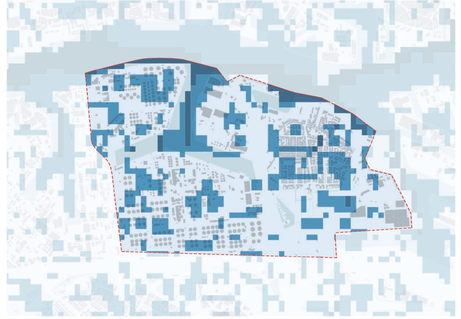


Fig.6.1.5 Pluvial flood area. Source: map created by author.

The design test site was selected as the Pernis area (3.5x2.0 km), including the port and Pernis. The area has a population of 4,845 (2018). Pernis is best known for its petrochemical industry. And Shell's sprawling complex located there is the largest oil refinery in Europe, and one of the largest in the world. And the green space around Pernis has been used to make parks and farms. Pernis city area has good traffic condition, but there is a risk of pluvial flood, and there are many old houses at the same time, making daily energy efficiency inefficient. The motor way connects the north and south banks of the river, and it also becomes the main route to enter the area. Active industrial activities also make the area poor in soil, water and air quality.

These conditions make this area an ideal location for design testing.

Identifying the range of stakeholders

As mentioned before, the design testing is located mainly in three condition areas, the industrial port, logistics port , and urban area, which will show the transformation process of the three condition areas in 20 years, and how to form a new economic chain.

There is no doubt that this process will affect many stakeholders. By identifying and classifying existing main stakeholders, it will be more helpful to show how these stakeholders will be within a 20-year time frame, and How do they participate in these designs.

Condition1

Industrial port

Condition 2

Logistics port

Condition 3

Urban area



Fig.6.1.6 Three condition areas. Source: map created by author.

Proposed stakeholders

- BEP Biomass energy plants
- DP Digester plants
- BC Bio-fuel companies

- LSF Localised seaweed farms
- FC Fishing company
- ACC Algae crops container
- CFO Community farm organization

- TH Transfer hub
- SMC Storage managing companies
- OMO Open market organization
- BPO Business park organization

- SPC Soil purification companies
- ITC Industrial tourist companies
- BHC Bio-adaptive housing construction

Public

- BDP Biobased Delta Platform

- EU European Union
- R Rijkswaterstraat
- NG National government
- PSH Province of South-Holland
- MHP Municipalities (Pernis)
- PR Port of Rotterdam
- BEA NL-BEA Netherlands Bio-energy Association
- ANF Ministry of Agriculture, Nature and Food Quality
- RBC Rotterdam Biomass Commodities Network Foundation (RBCN)

Private

- WG Westland Green port
- BG Bleiswijk Green port
- Y Yara
- F Farmers
- S Seafarm
- CTG CTG Logistics BV
- MRT Matrans Rotterdam Terminal (previous SCA Logistics)
- WTP Wastewater treatment plant
- WTC Waste treatment companies(Indaver)

- IBPR Flagship Iso-butanol Platform Rotterdam (IBPR)

- SH SHELL Nederland Verkoopmaatschappij B.V.
- AN Akzo Nonel
- AER Alco Energy Rotterdam
- LCN Lyondell Chemical Netherlands BV
  Euroliquids

R&D

- U The Universities of Delft, Eindhoven, and Wageningen.
- BBE The Centre of Expertise Biobased Economy (CoE BBE)
- ECN ECN
- TNO TNO
- KEMA KEMA

Civil Society

- R Residents
- LE Local entrepreneurs
- LC Local co-operatives
- LO Local open markets

Fig.6.1.7 Involved stakeholders. Source: map created by author, data from: Bioeconomy Factsheet The Netherlands(2018); Biomass in the Netherlands(2009); Business plan Biobased Delta Foundation 2018-2020 .

Periods scheme

In order to realize the vision, changes in land use are inevitable, Fig. 6.1.8 shows the evolution of land use in the area, with each cycle of change being five years. From a port city dominated by the petrochemical industry to a sustainable city dominated by a bio-based economy, a region for urban expansion has also been identified. The purpose of establishing a period scheme is to clarify the transformation goals of each period, and to make the uncertainty in the transition period under control.

Through the transition of land use, some of the urban functions will also be changed, the flow between the city and nature will become more cyclic, waste will be reused instead of flowing from the city into nature, and the ecology of the area can be restored by time.

Fig.6.1.9 shows the intervention scheme. The goals of each period need to be achieved through spatial and policy interventions. Therefore, it is necessary to specify the actions to achieve typology strategies in each period, and refine the spatial intervention measures in each period from the typology scale. The implementation of the action is inseparable from the actors, so it is also important to identify the stakeholders involved in each period. This is the basis for the governance model to be developed later.



Fig.6.1.8 Periods scheme. Source: map created by author.

Intervention scheme

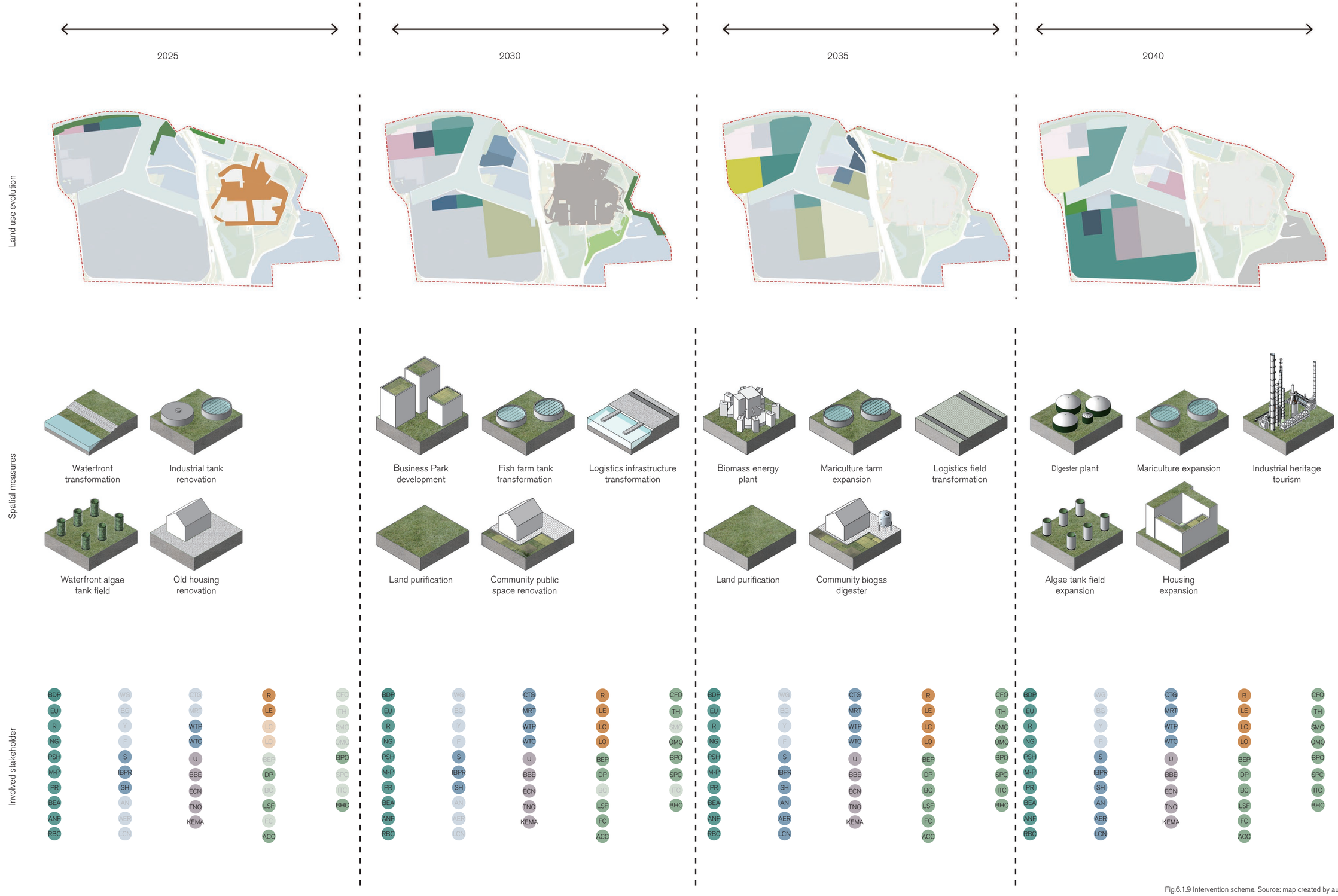
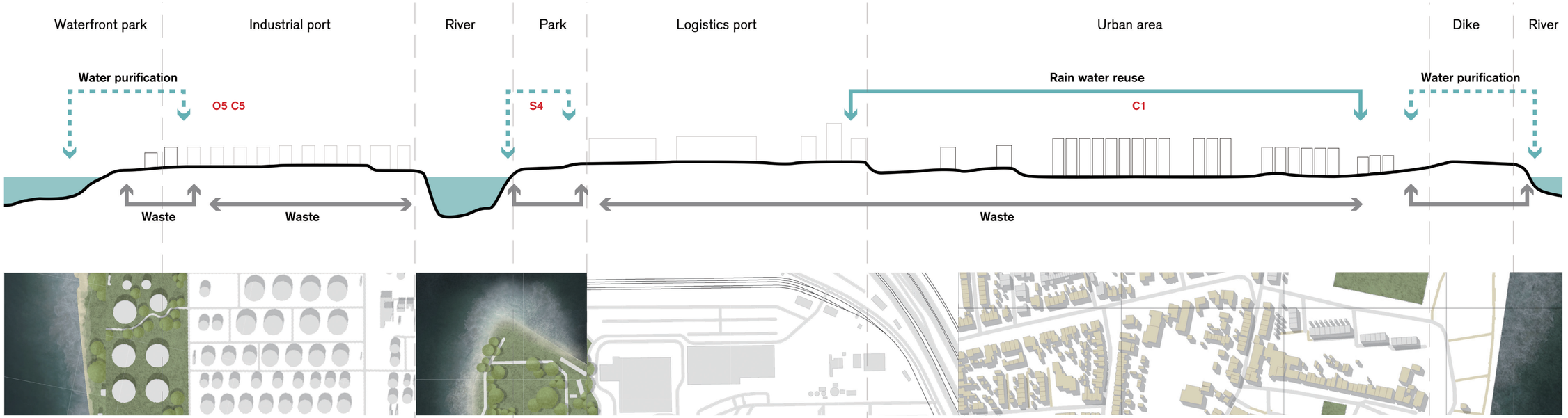


Fig.6.1.9 Intervention scheme. Source: map created by author.

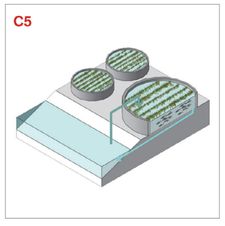
6.2 DESIGN TESTING

6.2.1 2020 - 2025

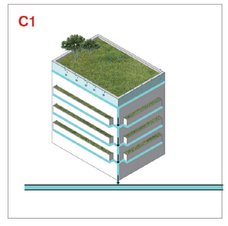
Overall input of intervention



Spatial principle and intervention







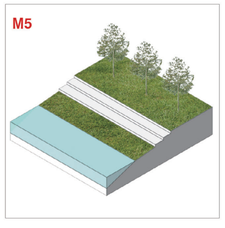


Fig.6.2.0. Source: map created by author.

Condition 1

Due to the particularity of the industrial area and the requirements for safety, the entire area is in a relatively unaccessible situation. In order to gradually restore the local ecosystem, the first step is to open the waterfront space and restore the continuity between land and water.

The transformation of the traditional stone-built dike to a stepped dike allows sediment to accumulate well and provides habitat for plants and animals. After improvement, it not only could provide a flood defence effect, but also provides better ecosystem services to the local area, creating a public space, and at the same time, rich vegetation can also improve the air quality of industrial areas.

At the same time, the bio-digester center is established and test the possibility of reusing oil storage tanks.

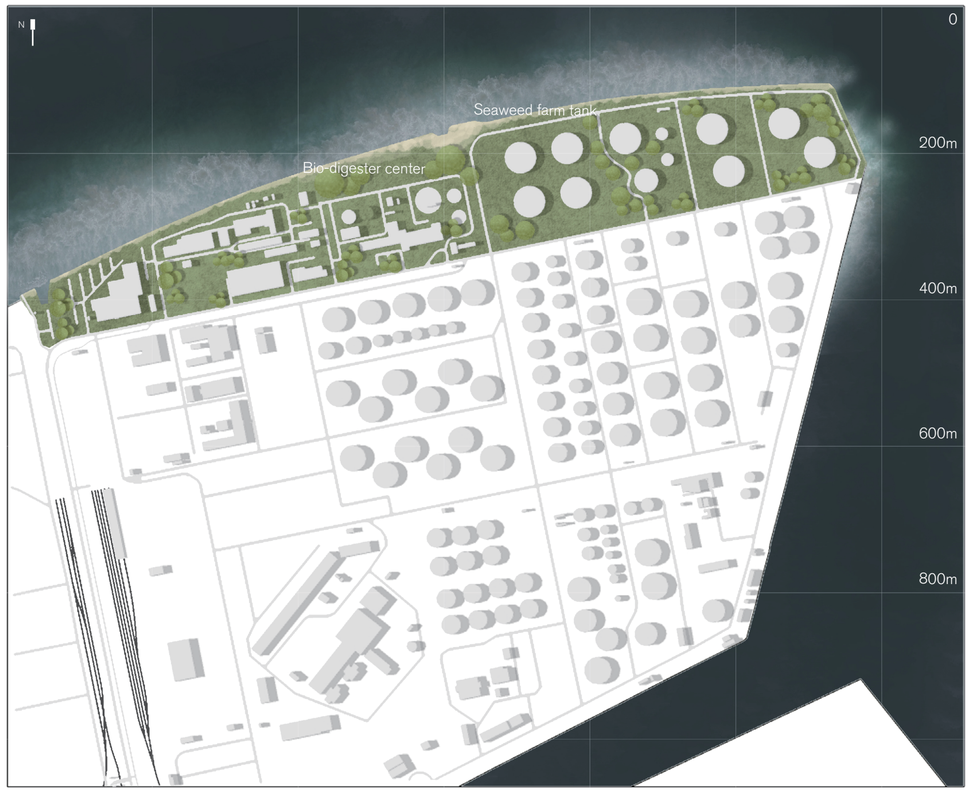
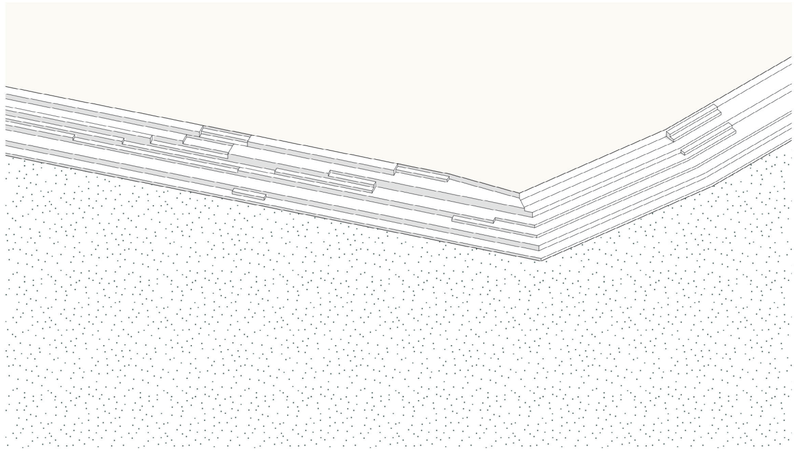
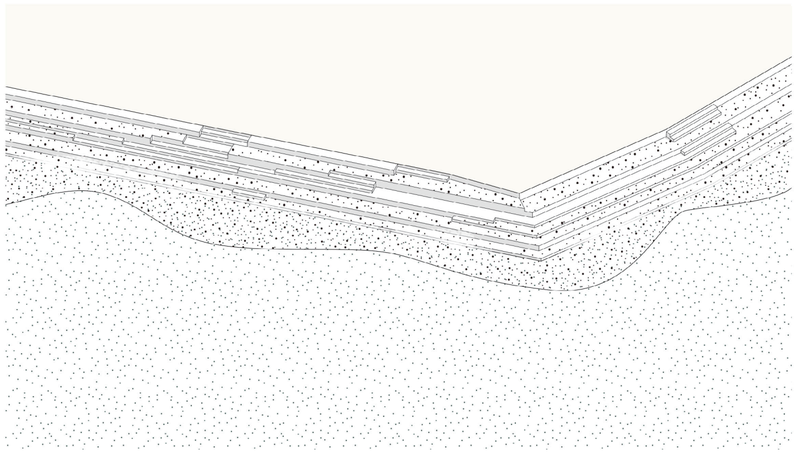


Fig.6.2.1. Source: map created by author.

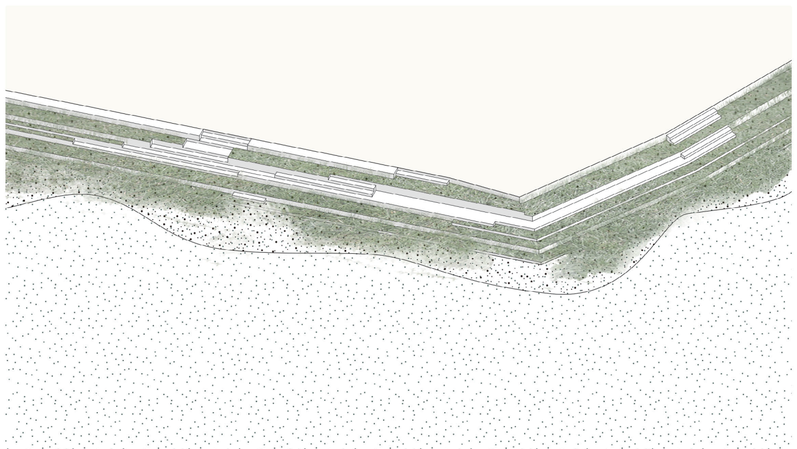
Waterfront transformation



Step 1
Hydrophilic step



Step 2
Sediment retention

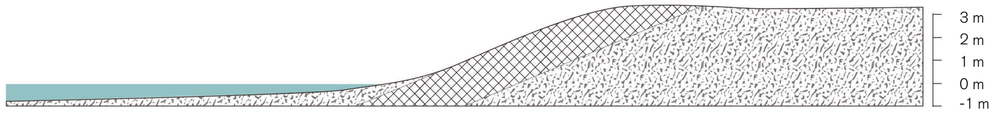


Step 3
Plant growth

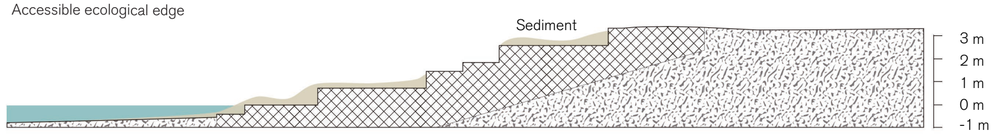
Fig.6.2.2. Source: diagram created by author.

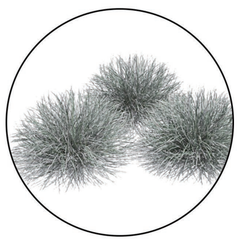
Landscape

Before
Unaccessible stony river edge

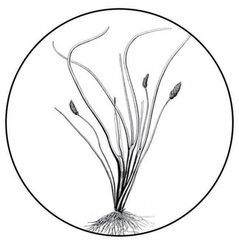


After
Accessible ecological edge





Festuca



Triglochin



Spartina



Field maple



Phragmites



Salicornia



Ligustrum lucidum



White Spruce

Fig.6.2.3. Source: diagram created by author.

Seaweed farm tank techniques

The ecological environment conditions for seaweed growth and development mainly include temperature, light, nutrients, water flow and so on. The characteristics of seaweed cultivation that require minimal external nutritional requirements make it have great potential for carbon capture and bio-energy raw materials. (Han et al., 2007)

According to the lecture held by Willem Brandenburg and Joost Wouters, the seaweed has great potential as a biomass for purifying seawater and providing food, so it is possible to reuse the oil storage tank as seaweed farm tanks.

By studying the structure of the oil storage tank, it can be found that the oil storage tank is likely to be reused as a seaweed farm tank. The seawater is introduced into the tank through the pumping station. The pipes at the top and bottom of the tank body could make the seawater flow in the tank, forming a water flow. The top of the tank is opened and transformed into a rope that allows seaweed to attach. This could solve the problem of material waste caused by functional transformation on the site, and seaweed can purify seawater and absorb carbon dioxide.

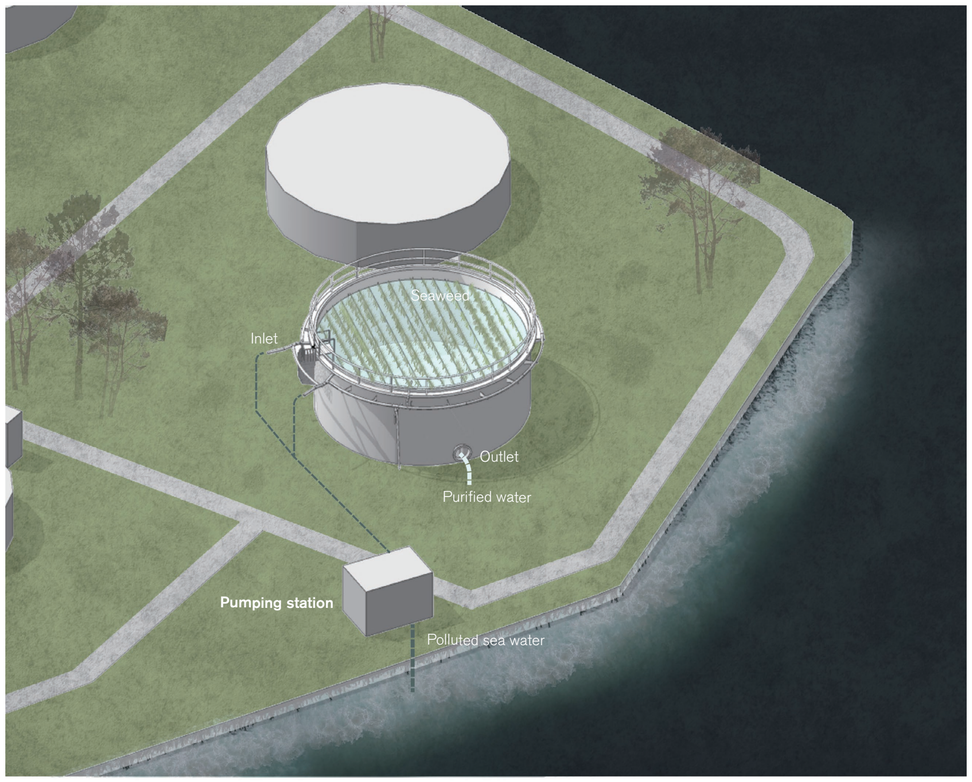


Fig.6.2.4. Source: map created by author.

Rope
The seaweed can attach and grow on the rope

Seaweed
Seaweed absorbs nutrients in water and purifies water quality

Harvest platform
For harvesting and daily observation

Inlet tube
The pipeline through which seawater enters provides the environment and nutrients for seaweed growth

Seaweed farm tank
Renovate from oil storage tank, keeping the local identity and ensuring material reuse

Outlet tube
Located at the bottom of the tank, the purified seawater is discharged to form circulating water

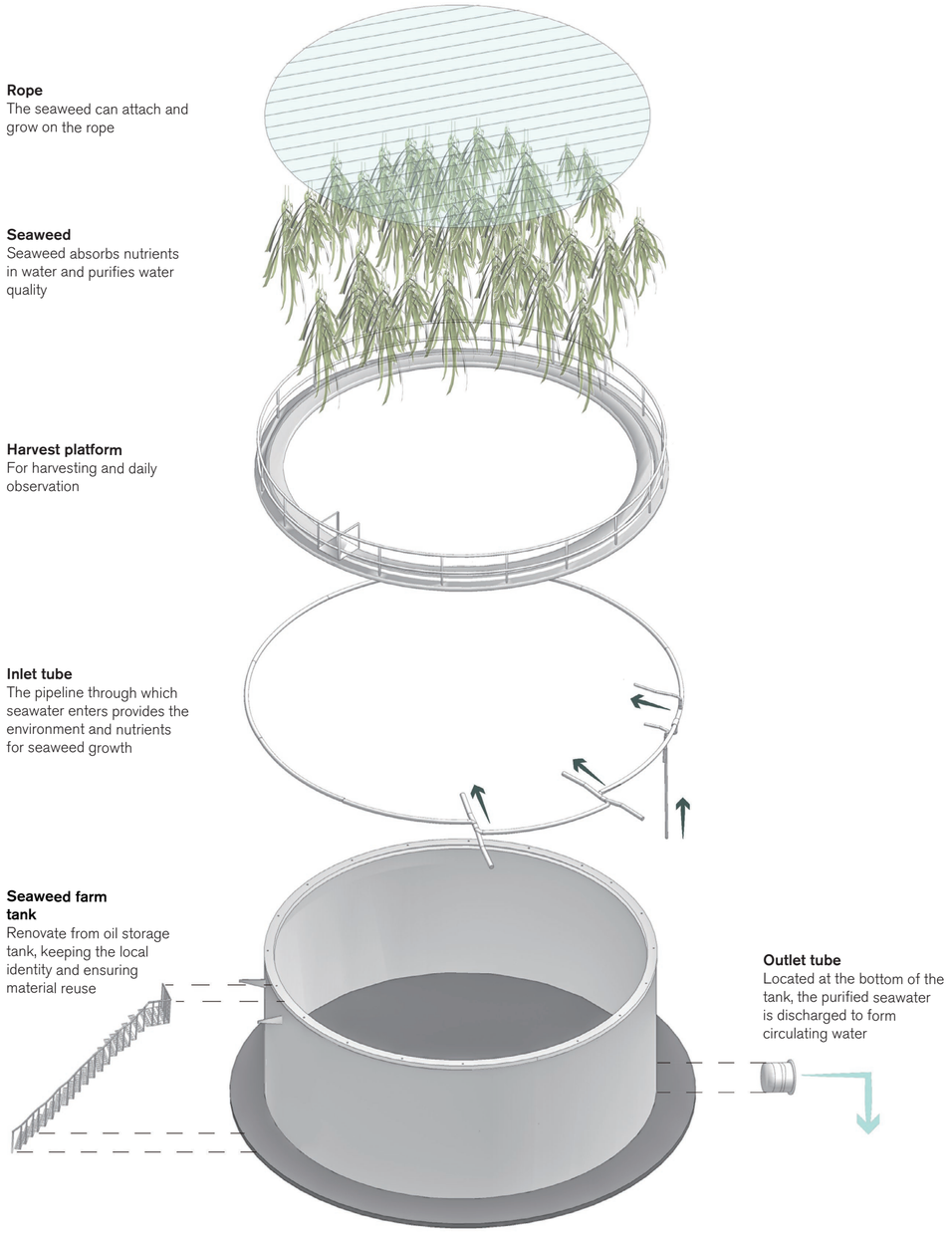


Fig.6.2.5. Source: diagram created by author.

Condition 2

The waste stacking station on the island will become an algae container site. According to Oladapo Adeniyi, Algae can absorb carbon dioxide and live in wastewater, and can be used to produce biofuels.

Therefore, the original Ecoloss project center in the site will study the algae's biomass benefits and promote it in the future. Through different industrial processes, algae can not only be used to produce biomass energy, but also can be processed into protein for human and animal consumption, so it is also a potential eco-economic product. (Myserli, 2018)

Also, the northwest corner of the site is a pluvial flood risk area, besides, the Rotterdam Port area has a high soil seal. So, it is one of an ideal choice to transform it into a waterfront park.

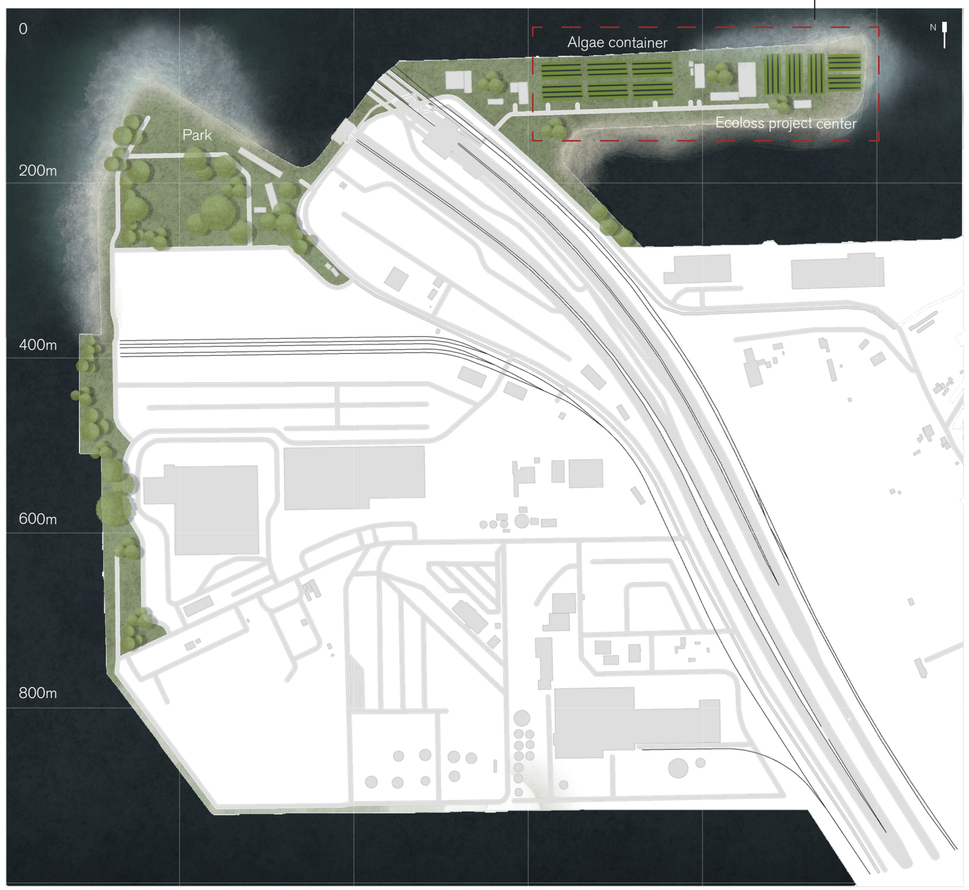


Fig.6.2.6. Source: map created by author.

Algae container techniques

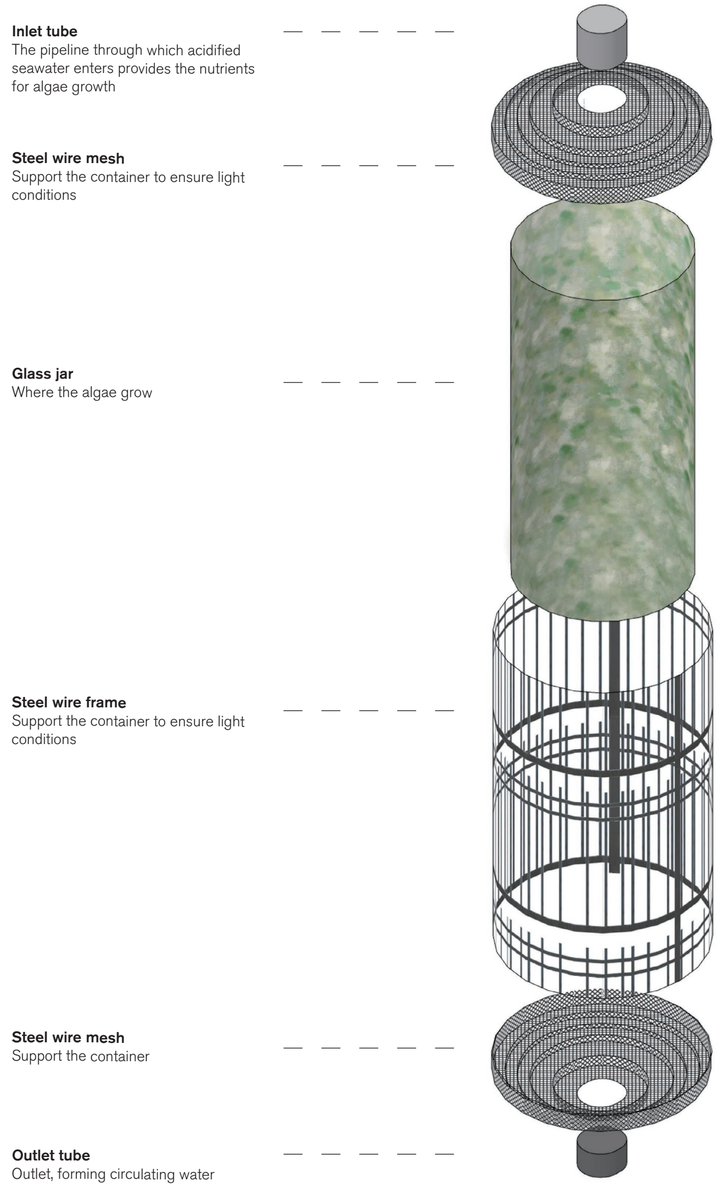
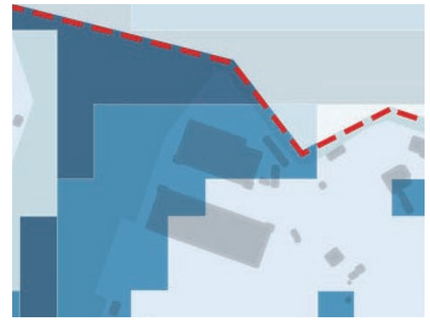


Fig.6.2.7. Source: diagram created by author.

Waterfront Park

Open the soil seal and keep the original terrain, use dredged sediments to create a waterfront park. When stormy weather occurs, rainwater would gather in these low-lying areas and form a biological retention pools, where wetland plants will grow and provide habitat.

The ecosystem services provided could purify the surface water flowing from the warehouse area into the river, and also provide citizens with a good place for daily leisure.



Pluvial flood area



Waterfront park

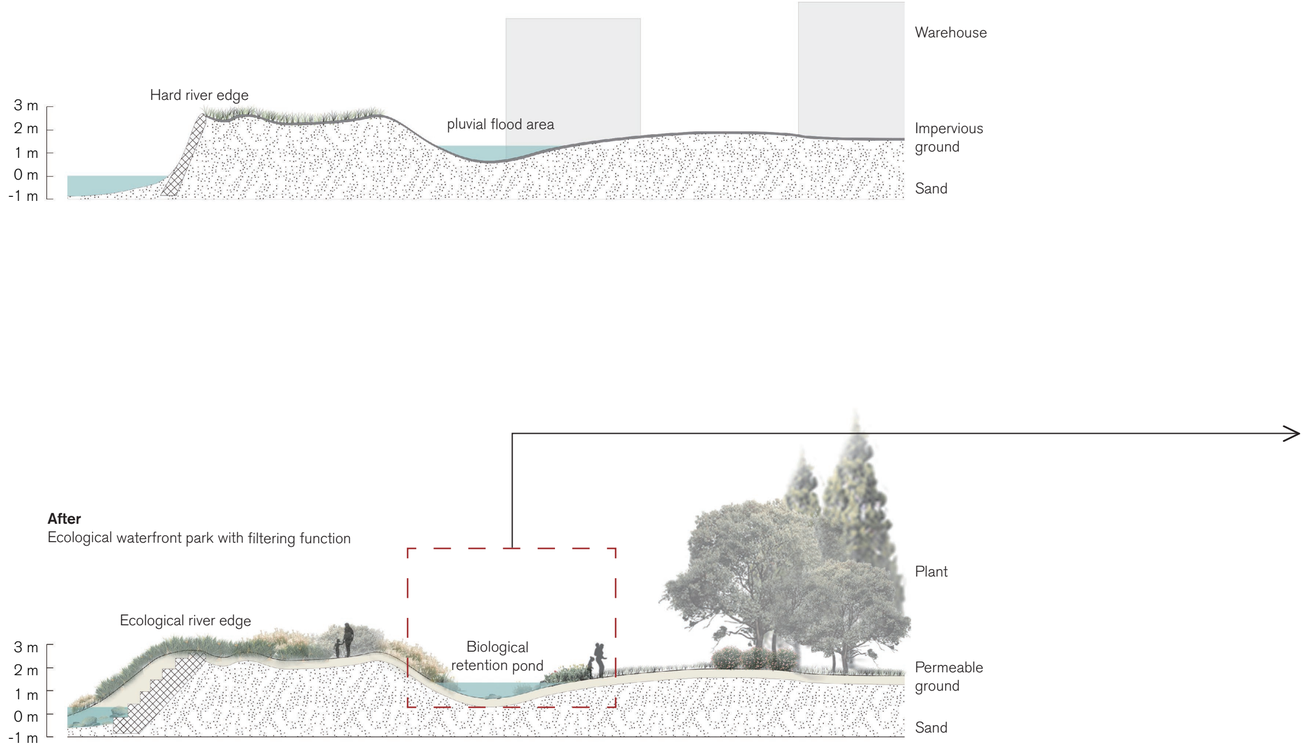


Fig.6.2.8. Source: map created by author.



Fig.6.2.9. Image of the park. Source: Created by author based on image from SJ-Cloud.

Condition 3

One of the main ideas of this period is to the renovate old houses. The renovated houses can collect and reuse rainwater. The green roof can be used as a shared public space or as a roof farm, and at the same time play a role of heat insulation.

The collected rainwater can be stored in underground storage tanks for household cleaning and garden irrigation, and the excess will be discharged into the rainwater pipe. At the same time, some families install private biogas digesters to recycle green garbage in the home and provide biogas for the households.

In public roads, the main idea is to creat sunken vegetation lane. In normal times, it is a road green belt that provides a better community environment. During heavy rain time, these green belts can help transport rainwater and reduce the current pluvial flood risk.



Fig.6.2.10. Source: map created by author.

Old housing renovation

Fig.6.2.11. Collect and reuse rain water, Source: Created by author.

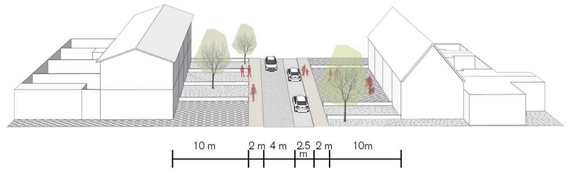
Main road
Remove parking lane
Add bike lanes and sunken vegetation lane
Use permeable materials
Increase house density and green roof



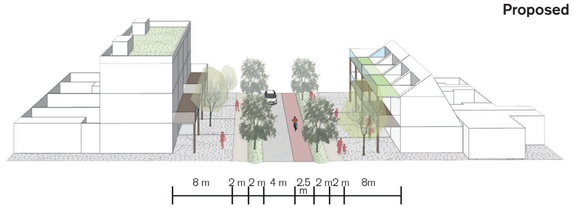
Secondary road
Remove parking lane
Add sunken vegetation lane
Use permeable materials
Increase house density and green roof
Ground floor as public use



Before



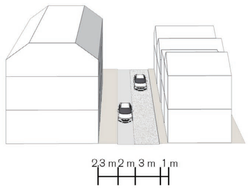
Proposed



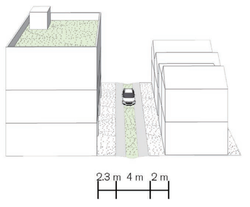
During heavy precipitation



Before



Proposed



During heavy precipitation

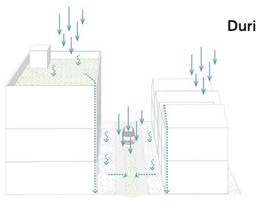
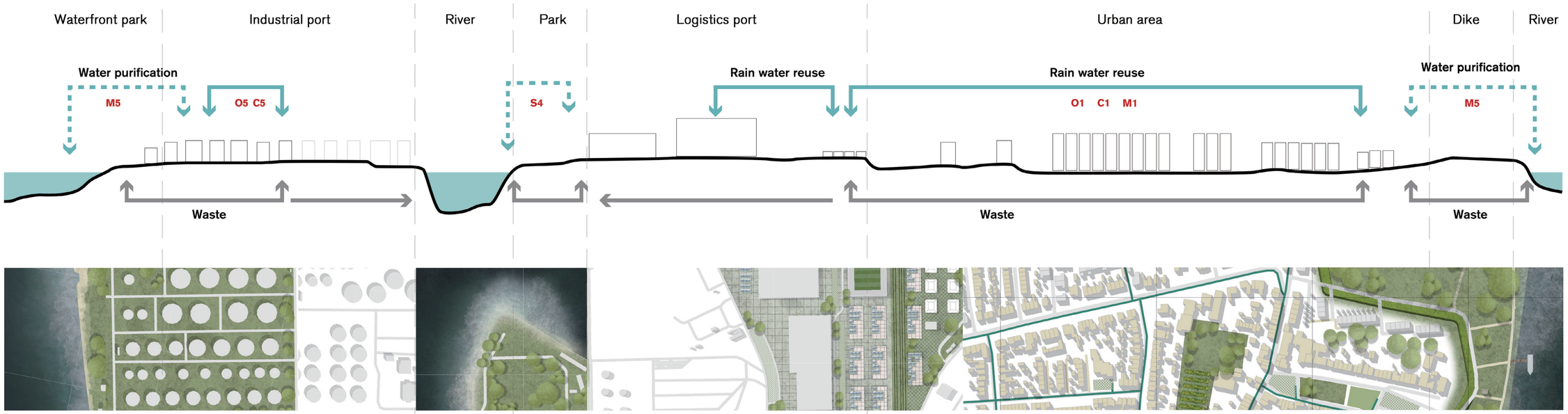




Fig.6.2.12. Cycle technology in housing. Source: Created by author.

6.2.2 2025 - 2030

Overall input of intervention



Spatial principle and intervention

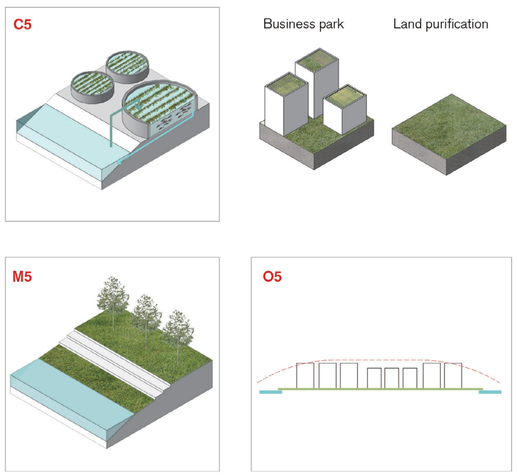


Fig.6.2.13. Source: map created by author.

Condition 1

The main intervention during this period was to expand the reuse of oil storage tanks. More tanks will be used to grow seaweed. At the same time, the tanks used to grow seaweed in the first stage can be used as fish farm tank after being purified. Also the pavement will be replaced by vegetation to purify the soil.

The digester plant can process these harvested seaweed and other green plants to produce biogas and ethanol, provide renewable energy. (Philippsen et al., 2014)

Due to the energy transition, the original local petrochemical enterprises will also be relocated or transformed, so another major intervention is to re-plan the industrial park into business park. The possibility of future office diversification will require diverse office space. At the same time, the rich vegetation will also improve the local microclimate.



Fig.6.2.14. Source: map created by author.

Business park development

Use the fifth facade of the building
The roof can be used as a public space, the terrace can provide a place for workers to communicate and rest, and the green roof can reduce the heat island effect, purify the air, and also provide biomass raw materials.

Diversified office
Diversified office areas provide people with many possibilities for office work. In the future, office space will move towards smart and digital, shared and flexible, green and healthy development.

Room for water
Permeable materials and vegetation can reduce the risk of flooding during heavy rainfall, while filtering surface runoff.

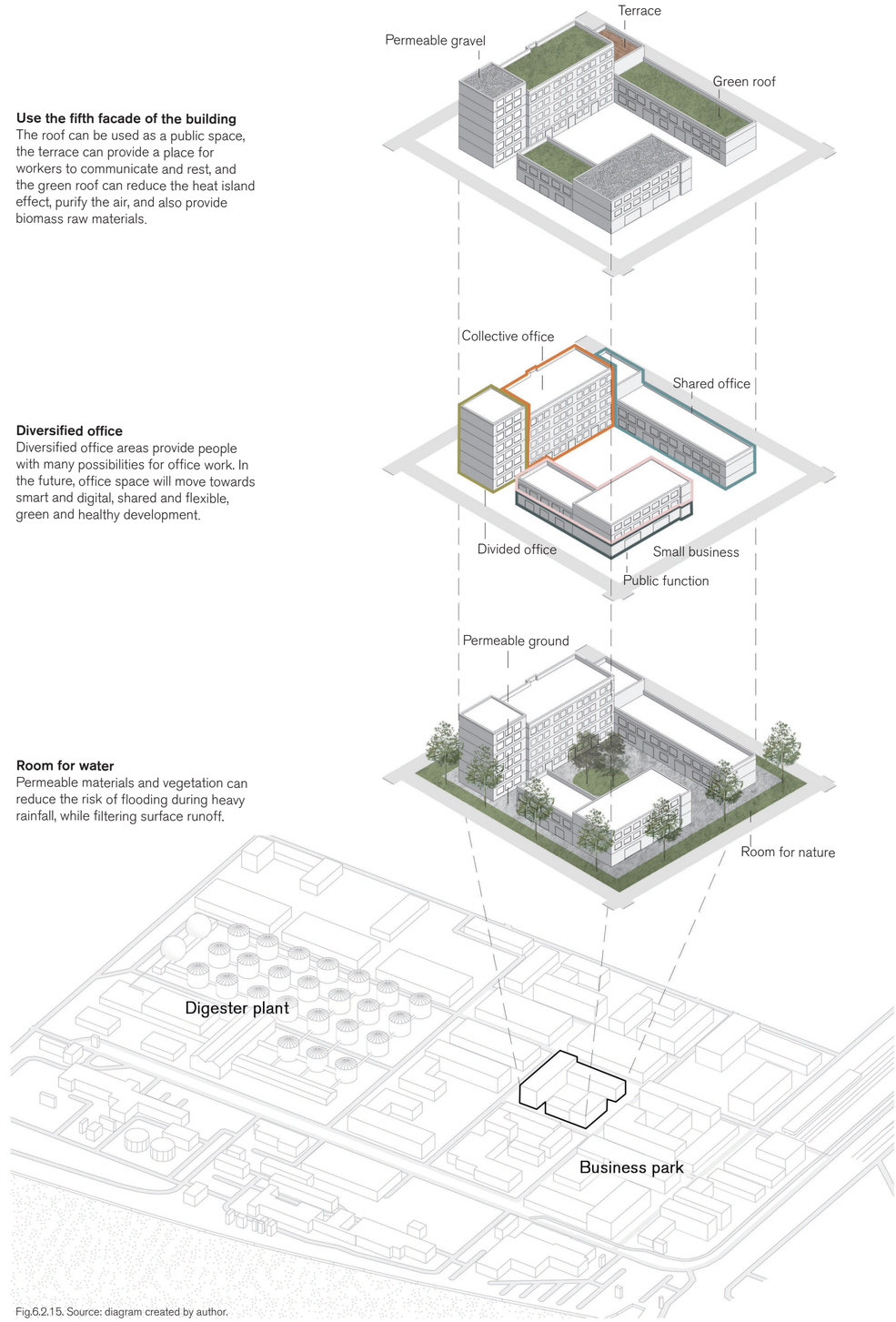
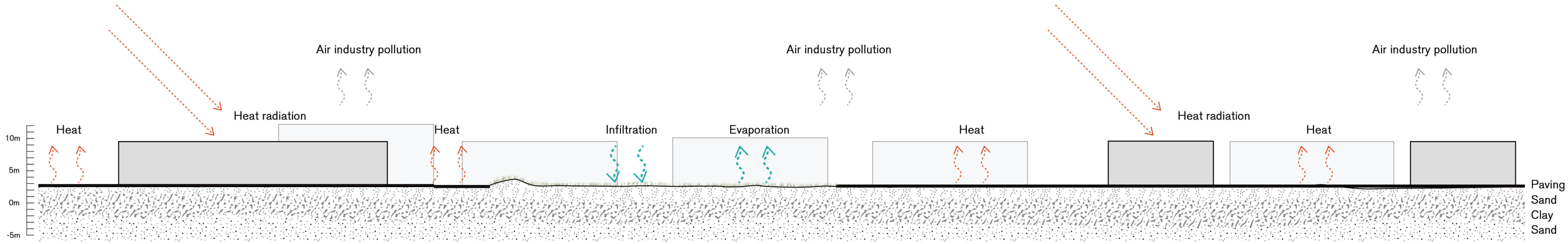


Fig.6.2.15. Source: diagram created by author.

Microclimate change

Before



After

O5 C4

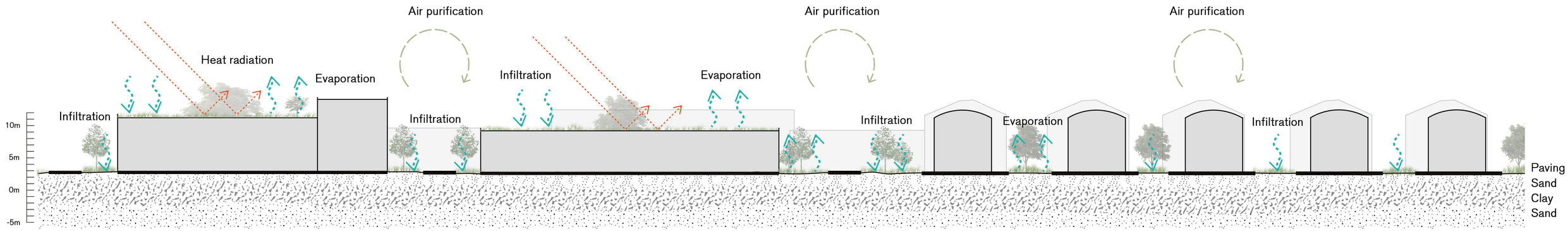


Fig.6.2.16. Source: Section diagram created by author.

Condition 2

According to the strategies proposed above, some goods can be sold directly at the terminal, and the condition2 area is very close to the urban area, so this strategy is feasible in this area.

The transformed warehouse is inspired by IKEA. Goods can be displayed and experienced in the warehouse and open-air market. The transformed warehouse is no longer a single-function storage space, but a multi-functional building with multiple economic benefits. Created a new type of cargo terminal place.

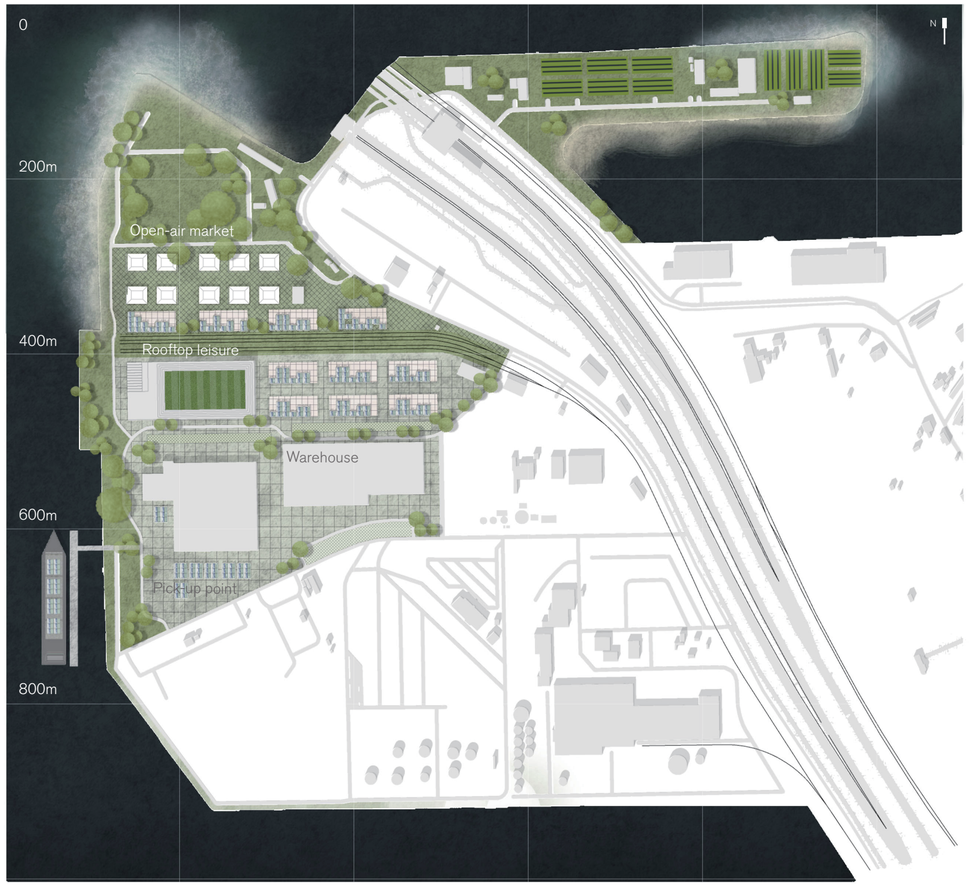


Fig.6.2.17. Source: map created by author.

New flow for people and cargo

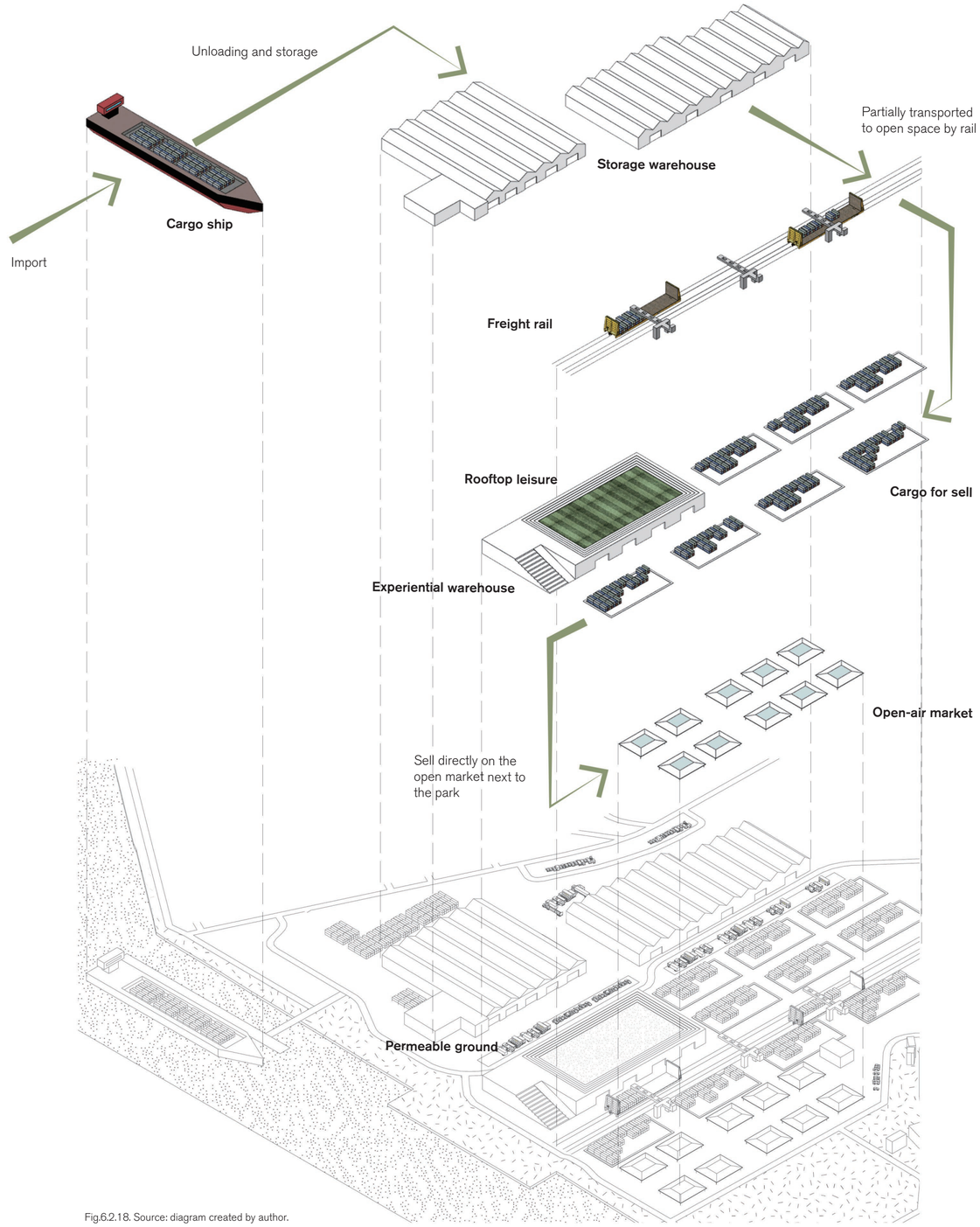


Fig.6.2.18. Source: diagram created by author.

Condition 3

According to the analysis of pluvial flood risk, there is a risk of pluvial flood in some areas of the condition 3 area. Therefore, one of the main ideas of this period is to build multilayer buffer zone to improve the quality of public space and flood defence performance.

Increased dike and vegetation can defent river flooding. The diverse sunken public spaces and permeable floors in the community could mitigate the risk of rain and floods during heavy rain. These public spaces can be community farms, amusement parks, green spaces or parking lots, connected by sunken vegetation lane to better play a role in drainage.

In the normal time, they together form the landscape network in the community and the public space network. During storms season, the network can help transport water and temporarily store rainwater.



Fig.6.2.19. Source: map created by author.

Multilayer buffering zone

Outside the dike
Sufficient natural space for water, tidal and transportation

Inside the dike
Multiple temporary storage spaces, mitigating the risk of flooding

Buffer network
Using sunken vegetation as buffer line, accelerating the discharge and infiltration of surface water, also connecting to a temporary storage space

Overlapping

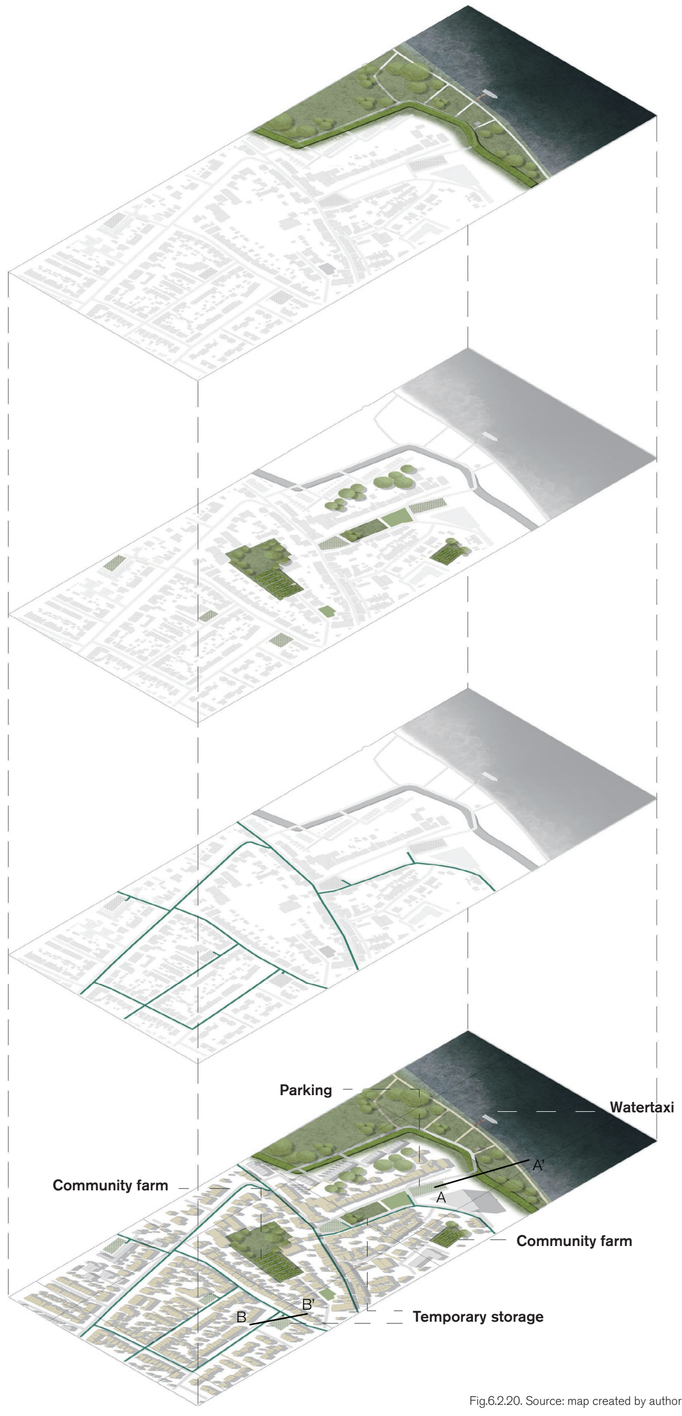
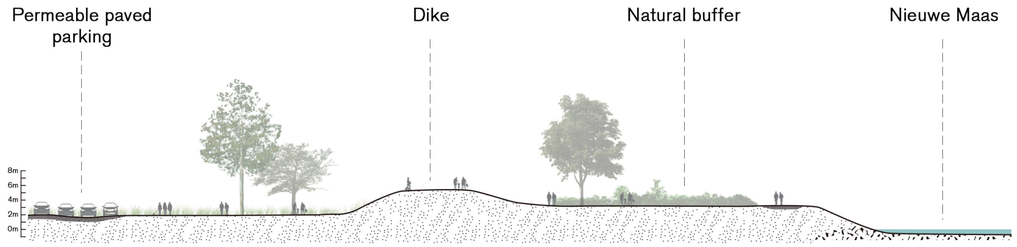


Fig.6.2.20. Source: map created by author.

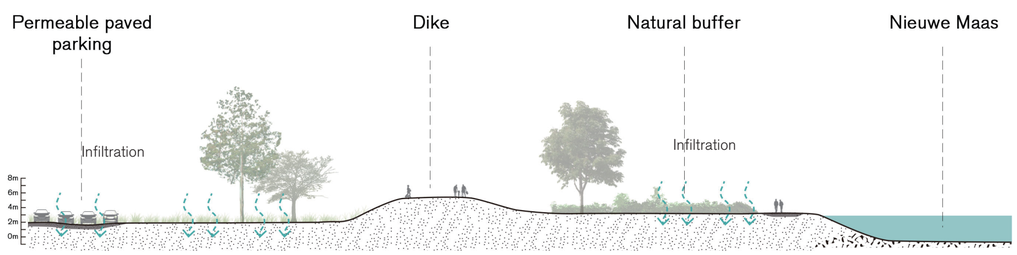
Water management performance

Section A - A’

Normal time



Wet season



Storm events

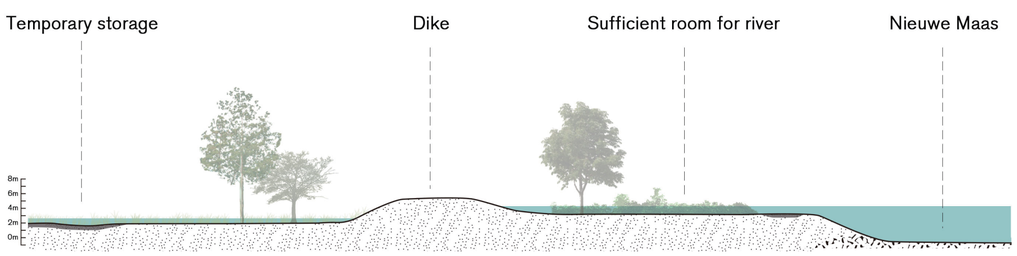
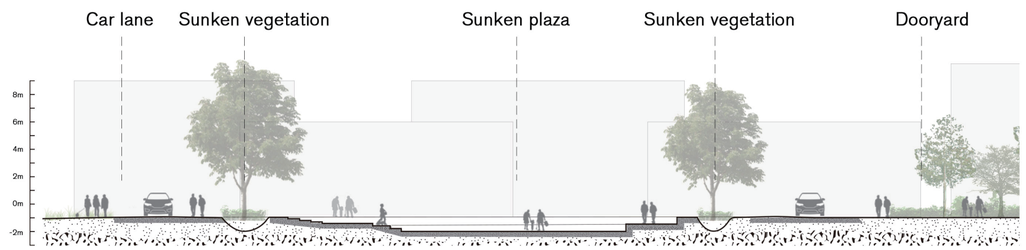


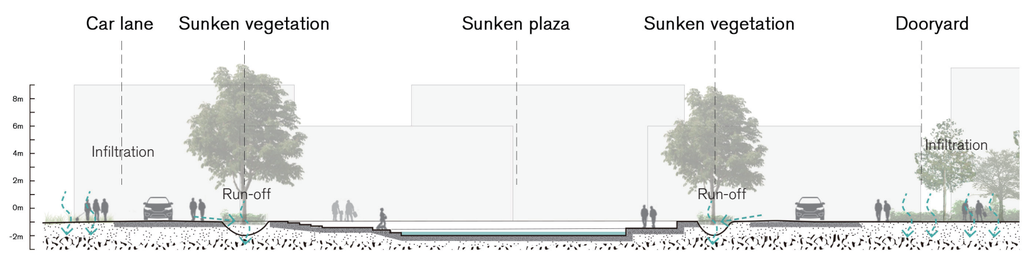
Fig.6.2.21. Section A-A'. Source: created by author.

Section B - B’

Normal time



Wet season



Storm events

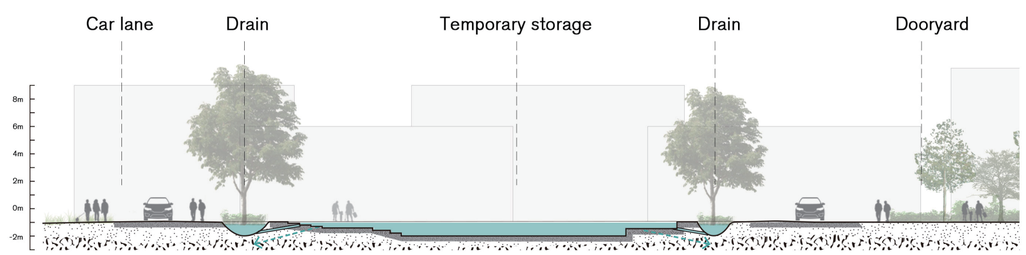


Fig.6.2.22. Section B-B'. Source: created by author.

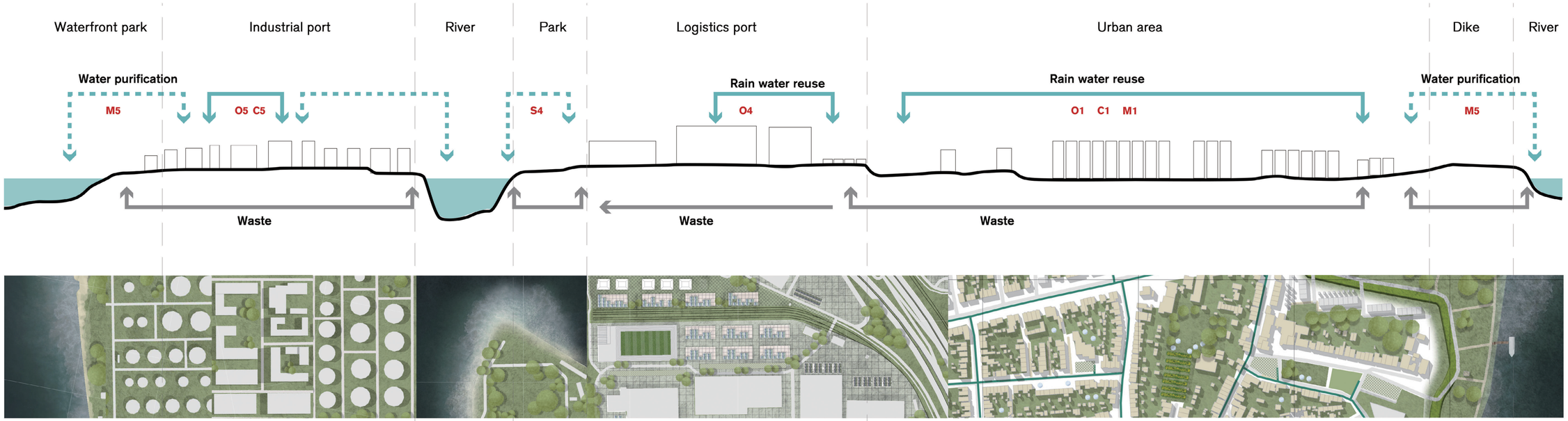
Public space transformation



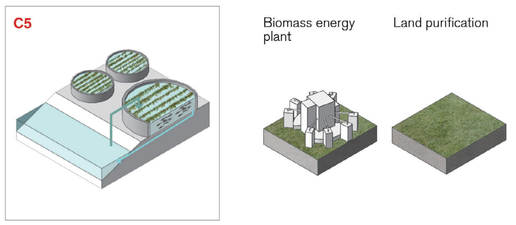
Fig.6.2.23. Sunken public space. Source: Created by author.

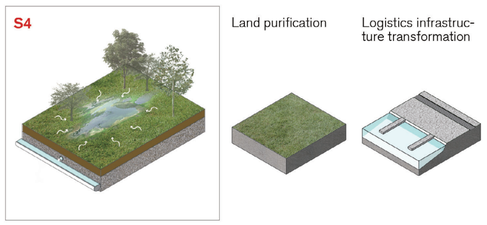
6.2.3 2030 - 2035

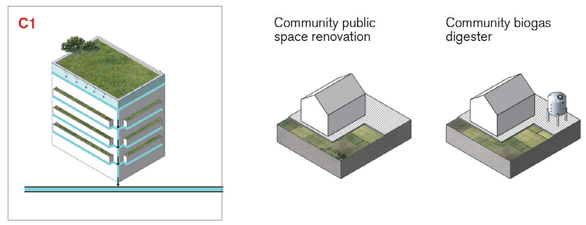
Overall input of intervention

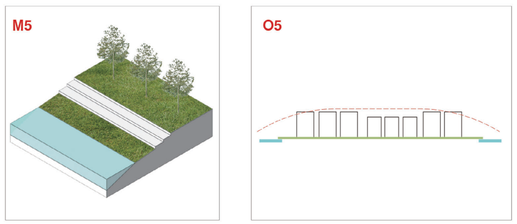


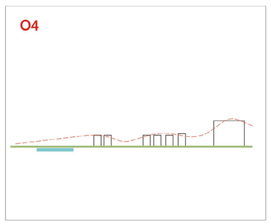
Spatial principle and intervention











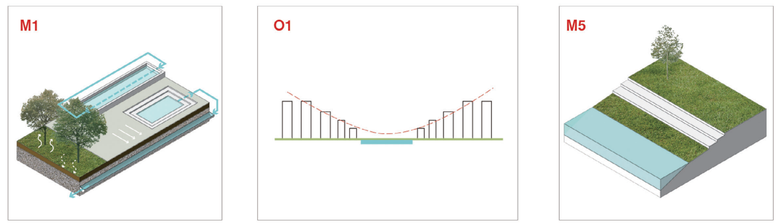


Fig.6.2.24. Source: map created by author.

Condition 1

One of the main ideas of this period is to improve the flow of biomass raw materials, energy and water circulation in this area. First, proposed more possible transformation of oil storage tanks, through the growth of seaweed, purified oil storage tanks can be used for more seafood farming, including fish farming, cold water shrimp and mussels, and other seafood farming, create diverse economic industries in this area.

The power station using natural gas at the site now will also be transformed, and the cost of power generation can be saved by using methane generated in the digestion tank for power generation.(Wu et al., 2009)



Fig.6.2.25. Source: map created by author.

Oil storage tank transformation

Original

Oil storage tank

Possible transformation

Seaweed fatm tank

Biological purification

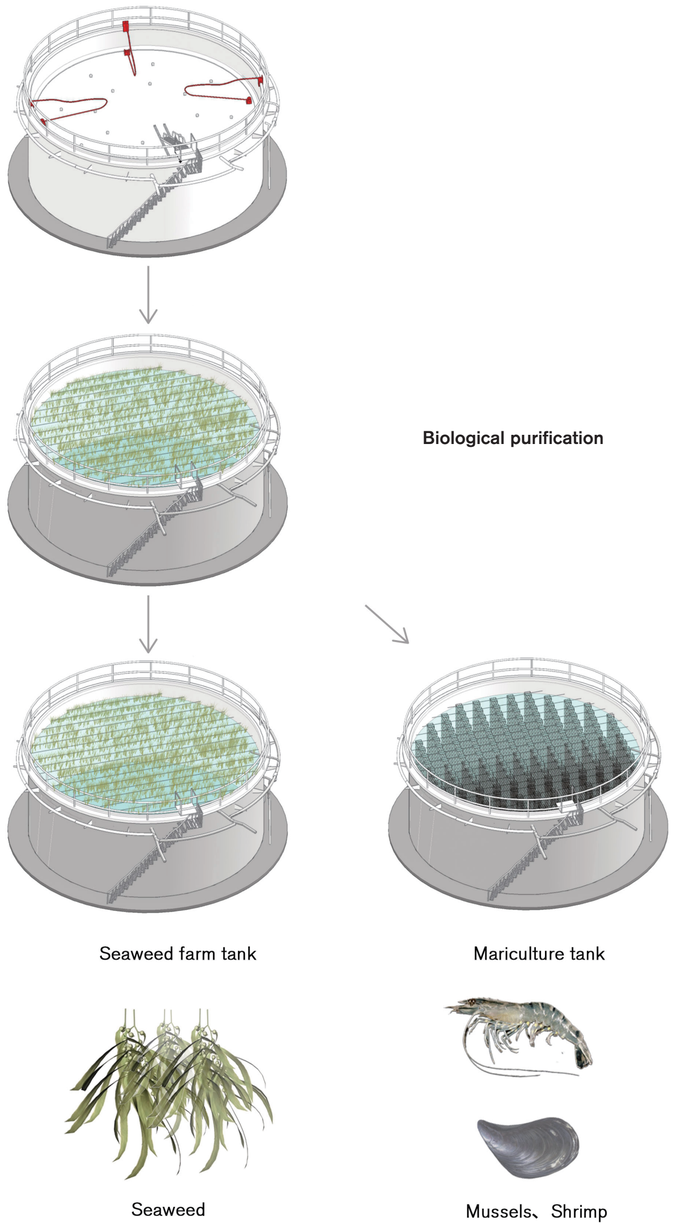
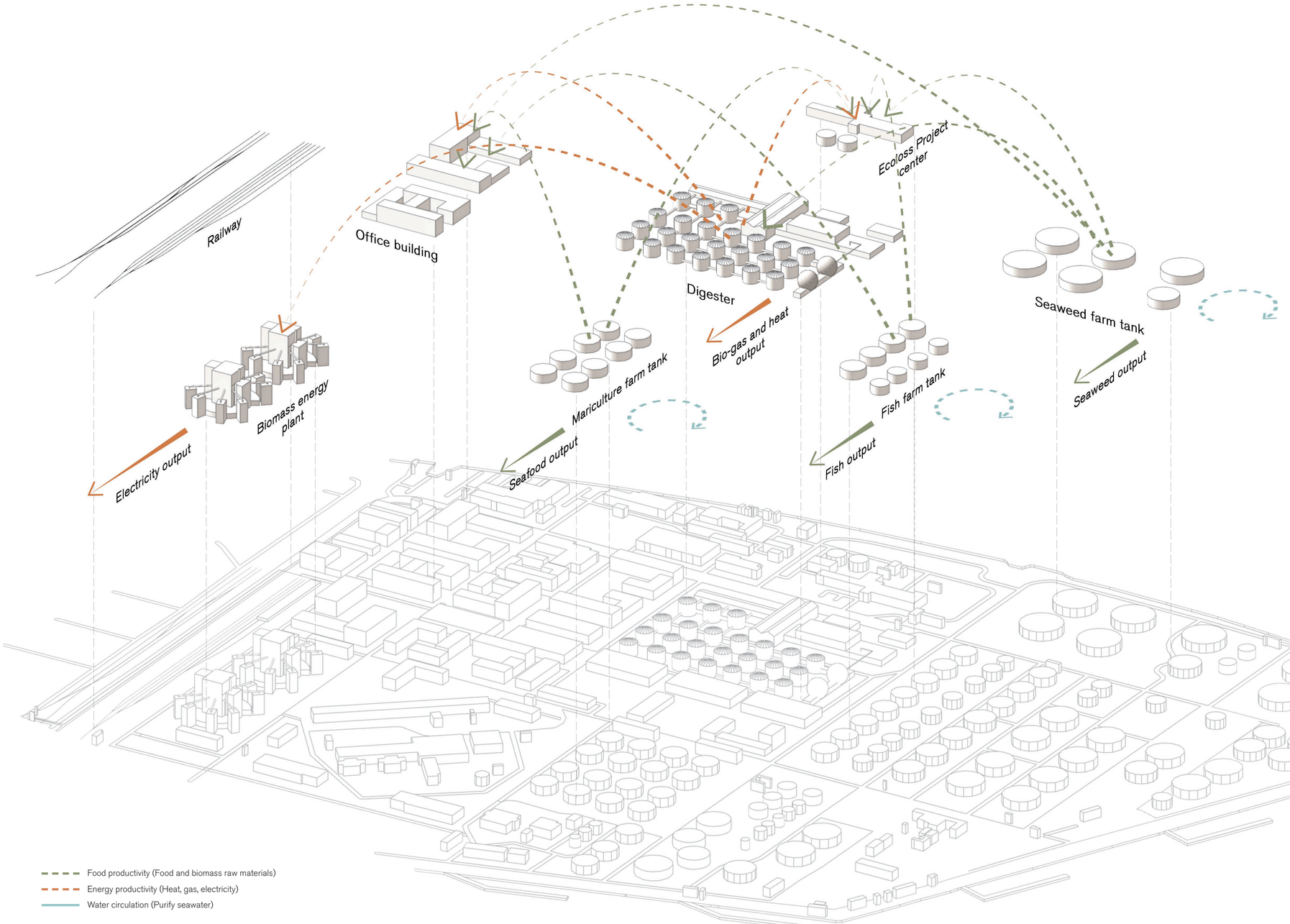


Fig.6.2.26. Source: created by author.

Biomass productivity



This picture shows the improved flow structure. Its biomass productivity mainly includes food and energy.

The seaweed in the farm tank can absorb nutrients and harmful substances in the water, and capture the carbon in the air.

Part of the harvested seaweed can be processed into food, and the other part can be processed in a digester to generate heat and biogas for people to use. Fish and other aquatic products can be exported for sale.

Methane, ethanol and other fuels produced by digesters can be used in power stations to achieve clean electricity generation.

Fig.6.2.27. Source: map created by author.

Condition 2

In order to strengthen the connection between the dock and the city, the areas on both sides of the highway are connected by roads, so that people in the city could more easily reach the waterfront area of the dock and use the waterfront natural space and cargo sales space.

At the same time, in order to reduce the pressure caused by logistics on the highway to the city, a dedicated lane for logistics vehicles can be set up on this section to increase the efficiency of road use and reduce congestion, thereby reducing greenhouse gas emissions.

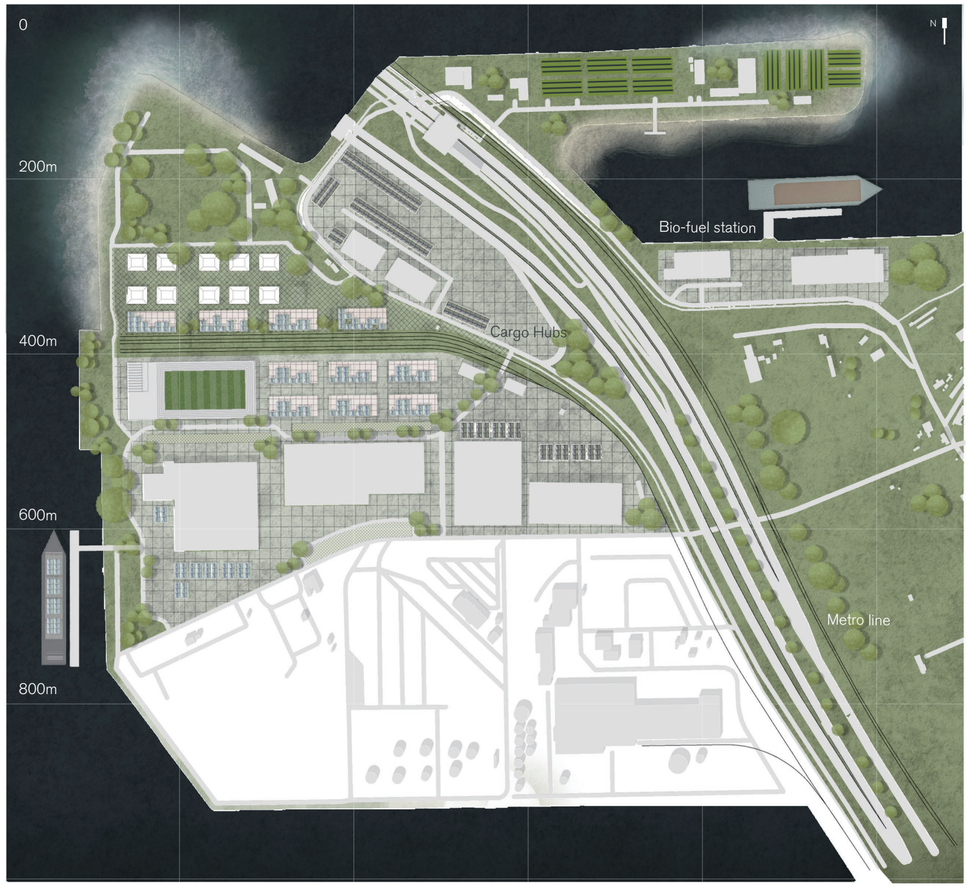
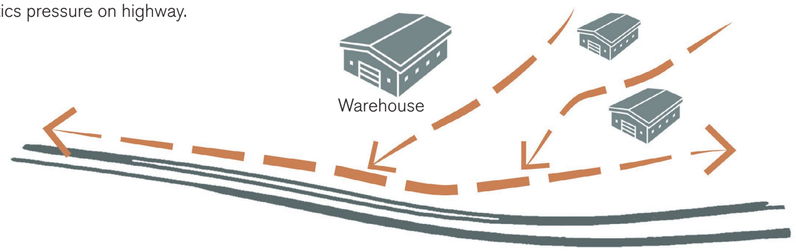


Fig.6.2.28. Source: map created by author.

New accessibility for people and cargo

Design new cargo roads to reduce logistics pressure on highway.



Connect roads to residential areas and waterfront parks, increase accessibility to nature.

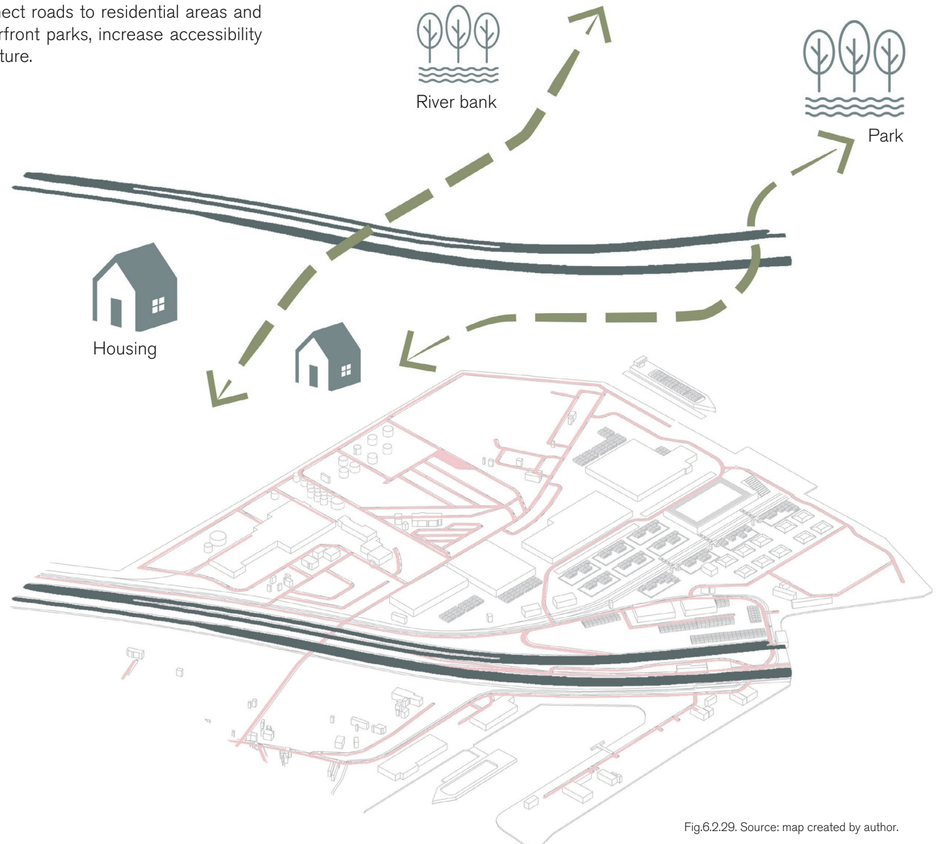


Fig.6.2.29. Source: map created by author.

Condition 3

One of the main ideas of this period is to improve the flow in the community. In the first two periods, the buildings and public spaces were intervened. The main intervention in this period was the establishment of community bio-gas digesters. Provide biomass energy for households that cannot build private biogas digesters.

As shown in the picture on the right, the collected rainwater can be used to irrigate the community farm. The community farm is jointly maintained by the residents of the community and provides fresh vegetables to the local residents.

The green waste in the entire community, such as food, fallen leaves, spoiled fruits and vegetables all can be used in bio-gas digesters to produce bio-gas. The bio-gas produced can be used by residents. Last but not least, the digested residue can be used as fertilizer and returned to the community farm to form a material cycle.



Fig.6.2.30. Source: map created by author.

New flows for community

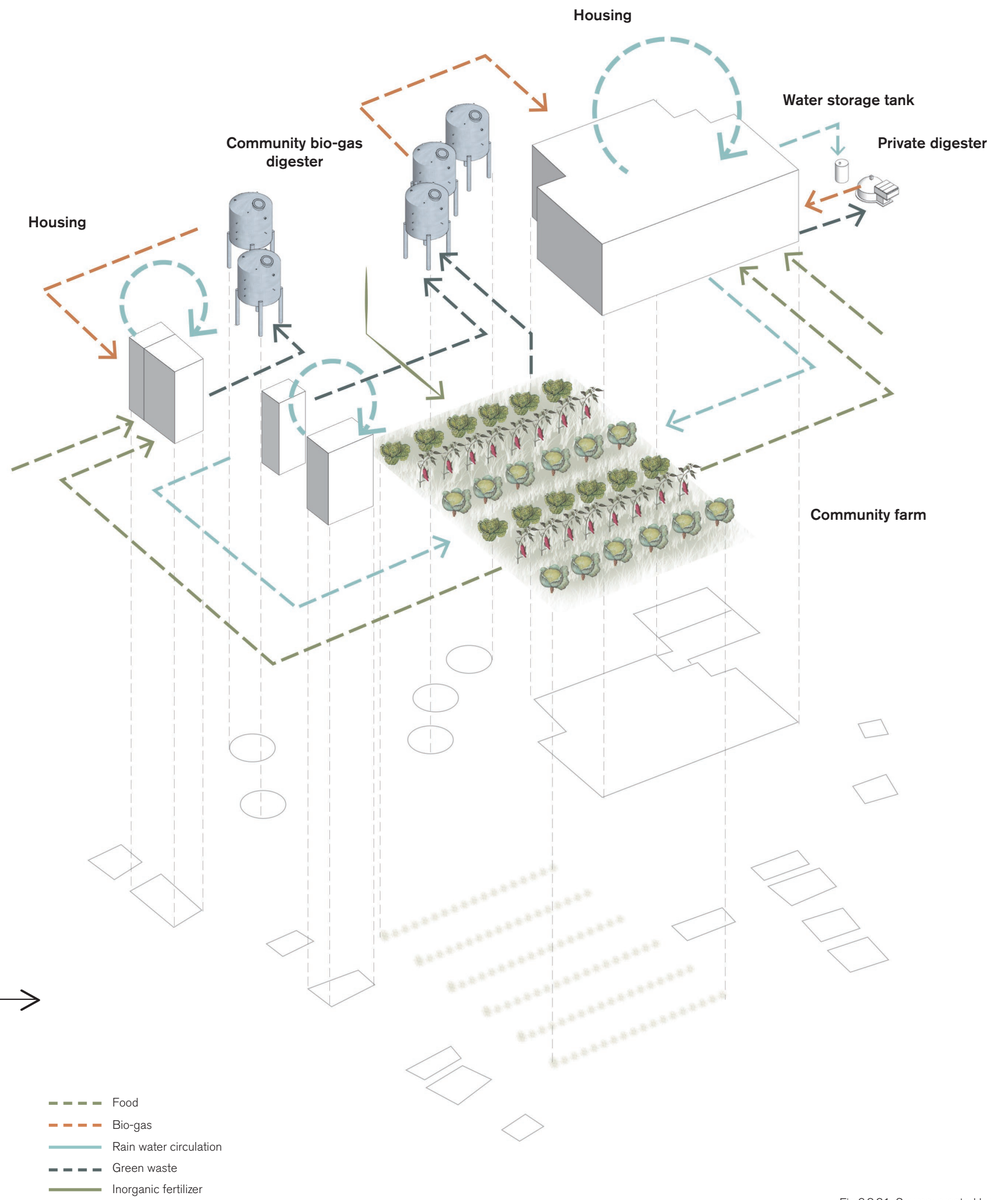
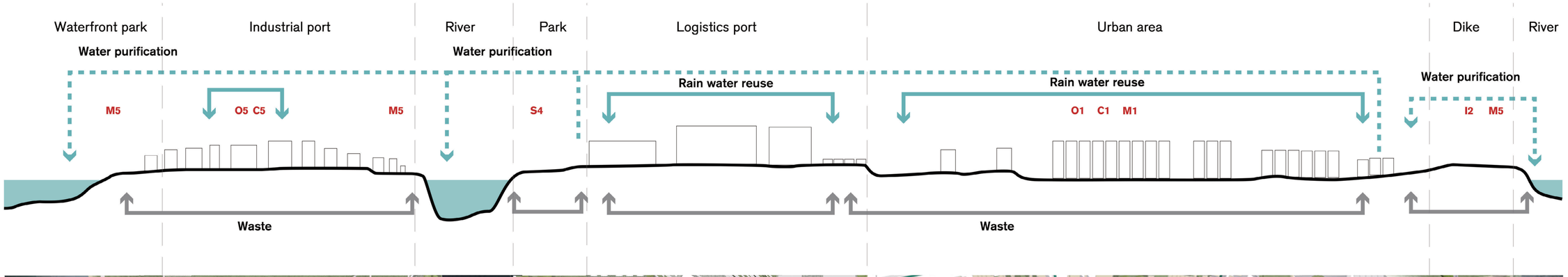


Fig.6.2.31. Source: created by author.

6.2.4 2035 - 2040

Overall input of intervention



Spatial principle and intervention

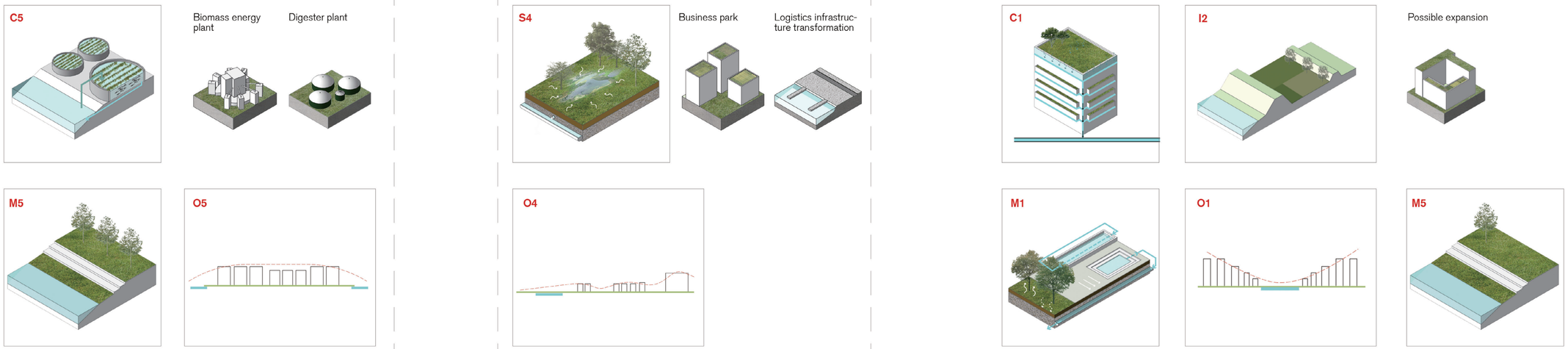


Fig.6.2.32. Source: map created by author.

Condition 1

The idea during this period is to reopen the condition 1 area, so there is a need to improve the accessibility inside and outside the site.

As far as external accessibility is concerned, the cargo terminal of the site can be transformed into a passenger terminal, and some water taxi docks can be added on the river bank. In the port area, water transportation will be more convenient than road traffic.

At the same time, the original freight track is almost connected to the industrial area of the region. During this period, they can be transformed into trams or manned trains to form a local rail transportation network.

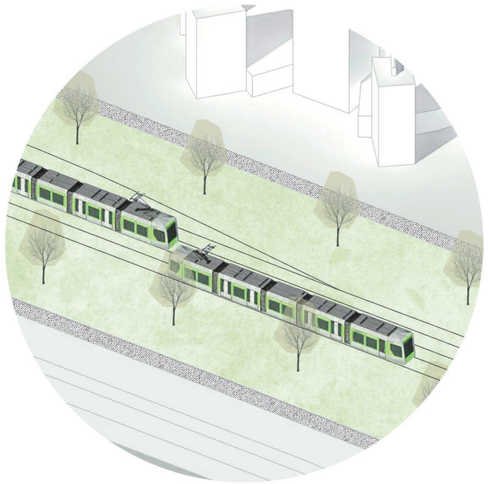
Inside the site, it is the ground pipeline infrastructure that has the greatest impact on accessibility. By replacing part of the pipelines, they could be formed into arches, which broke the original closed pipelines arranged like a wall.



Fig.6.2.33. Source: map created by author.

Increase accessibility

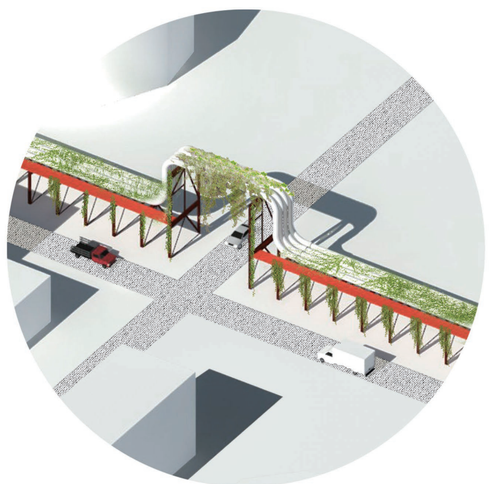
Fig.6.2.34. Multiple transportation. Source: created by author.



A. Tram line
After the transformation of the industrial zone, the rails that were originally used for cargo transportation can be transformed into tram tracks for public transportation



B. Ferry Terminal
The connectivity of the banks of the Nieuwe Maas River mainly depends on highways, and ferry terminals increase the connectivity between the two banks, and people can also reach here in more ways



C. New gate
The oil pipeline in the industrial zone originally used as a barrier to separate the entire area. By partially rebuilding the pipeline at the intersection to form a new gate, also the pipeline can be retained for transportation of bio-gas or bio-fue

Industrial port transformation



Fig.6.2.35. Source: Created by author.

Condition 2

As in the condition1 area, during this period, interventions in the region also included improving accessibility. At the same time, it also increases the functionality of the land. The improvement of internal and external accessibility makes it easier for people to reach the area. The geographical location adjacent to the city makes it possible to develop business office in this areas.

At the same time preserve the vegetation in the southwest corner and transform into a waterfront park to provide ecosystem services. The expanded building should meet the previously proposed spatial principles.



Fig.6.2.36. Source: map created by author.

Increase accessibility and functionality

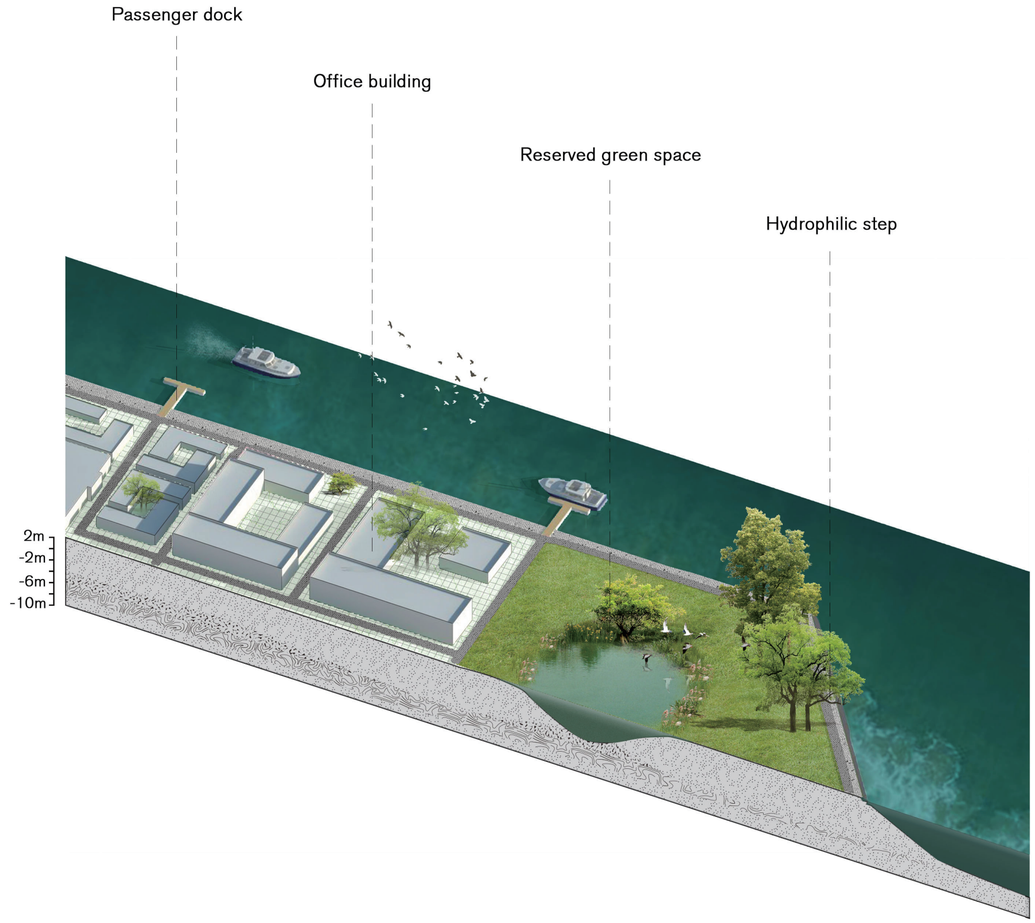


Fig.6.2.37. Retain green vegetation and transform warehouse buildings. Source: map created by author.

Logistic port transformation

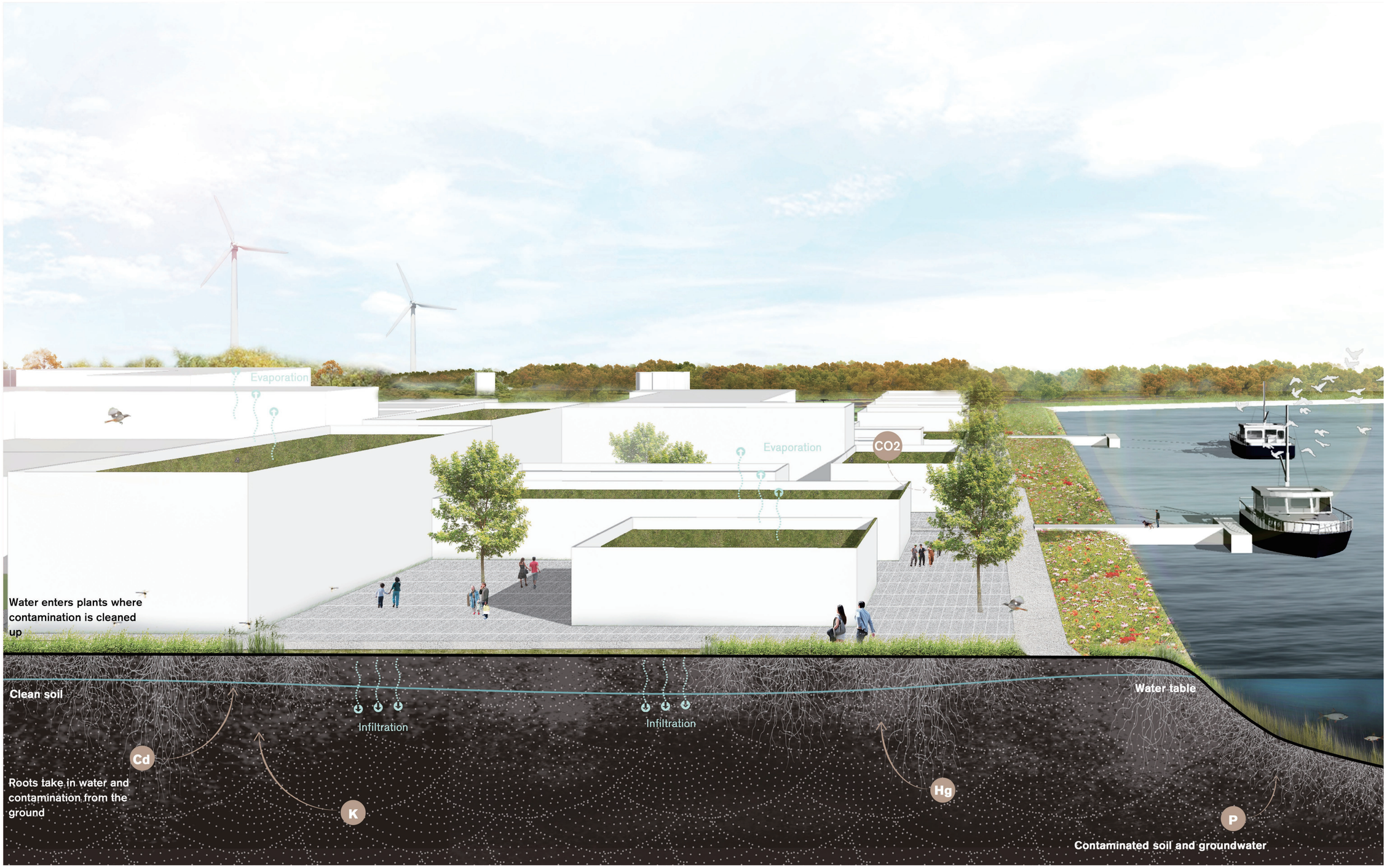


Fig.6.2.38. Water taxi and ecological restoration. Source: Created by author.

Condition 3

According to the research, this area has the possibility of becoming an urban expansion area in the future, so two scenarios for possible future development are proposed.

Under the low-density scenario, there will be more natural space to provide the ecosystem services and biomass energy that people need. In the high-density scenario, there will be more artificial natural spaces, including roof greening and other measures to ensure the maintenance of natural ecosystem services.

All expansion principles include the spatial principles proposed before and connect the current urban infrastructure.

Possible expansion for housing



Possible future expansion - Low density



Fig.6.2.39. Source: map created by author.

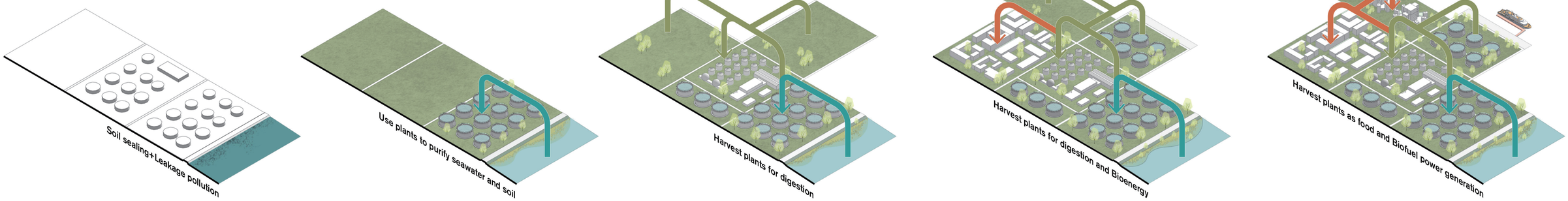
Possible future expansion - High density



Fig.6.2.40. Source: map created by author.

6.2.5 BIOPHYSICAL SYSTEM ADAPTATION IN EACH CONDITION OVERVIEW

Condition 1



Synergy of bio-physical space and ecosystem services

2020

Oil storage and chemicals — Antagonism → **Ecosystem services**

2025

Seaweed farm tanks	Purifying water	Regulating services
Land preparation	Purifying soil	Regulating services
Hydrophilic step	Restoring species	Supporting services

2030

Seaweed farm tanks	Raw materials	Provisioning services
Land preparation	Purifying soil	Regulating services
Hydrophilic step	Restoring species	Supporting services
Digester	Raw materials	Provisioning services

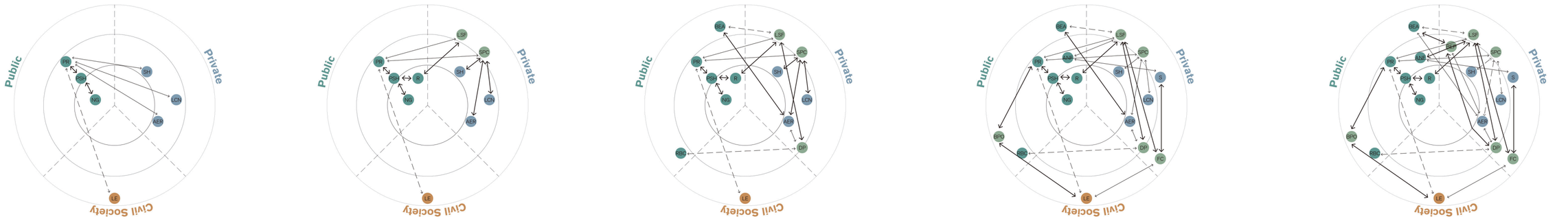
2035

Seaweed farm tanks	Raw materials	Provisioning services
Land preparation	Purifying soil	Regulating services
Hydrophilic step	Recreation, education	Cultural services
Digester	Raw materials	Regulating services
Business park	Climate regulation	Provisioning services

2040

Seaweed farm tanks	Raw materials / Food	Provisioning services
Hydrophilic step	Recreation / Education	Cultural services
Digester	Raw materials	Provisioning services
Business park	Climate regulation	Regulating services
Biopower station	Energy	Provisioning services

Key stakeholder engagement

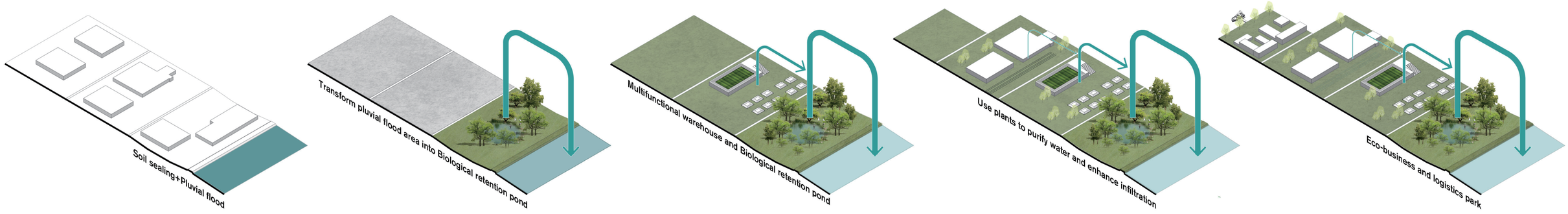




Stakeholders full name see chapter 6.1

Strong relationship
Ad-hoc relationship
Indirect relationship

Condition 2



Synergy of bio-physical space and ecosystem services

2020

Logistics harbour --- Antagonism ---> Ecosystem services

2025

Waterfront park ⟷ Regulating runoff / Purifing water ⟷ Regulating services

2030

Waterfront park ⟷ Regulating runoff / Purifing water ⟷ Provisioning services

Open-air market ⟷ Recreation, education ⟷ Cultural services

2035

Waterfront park ⟷ Regulating runoff / Purifing water ⟷ Provisioning services

Open-air market ⟷ Recreation, education ⟷ Cultural services

Multifunctional warehouse ⟷ Recreation, education ⟷ Cultural services

2040

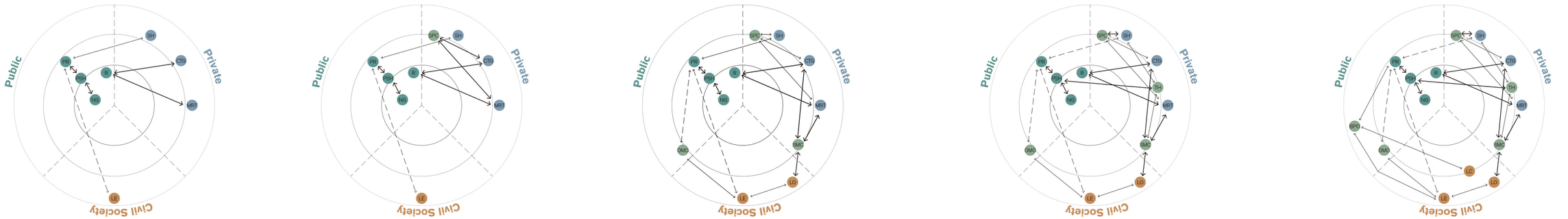
Waterfront park ⟷ Regulating runoff / Purifing water ⟷ Provisioning services

Open-air market ⟷ Recreation, education ⟷ Cultural services

Multifunctional warehouse ⟷ Recreation, education ⟷ Cultural services

Business park ⟷ Regulating microclimate ⟷ Provisioning services

Key stakeholder engagement

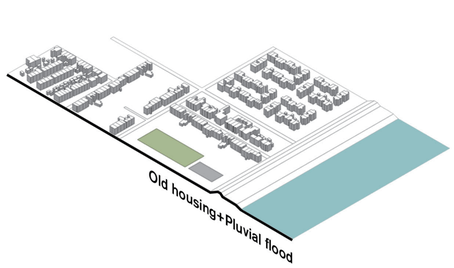


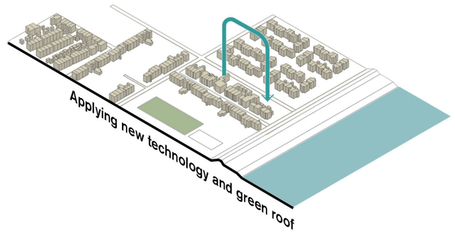


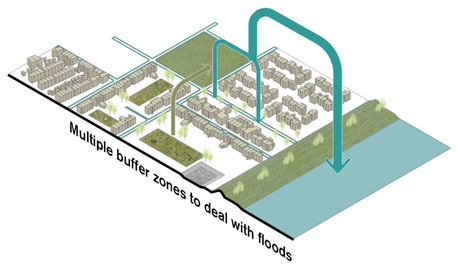
Stakeholders full name see chapter 6.1

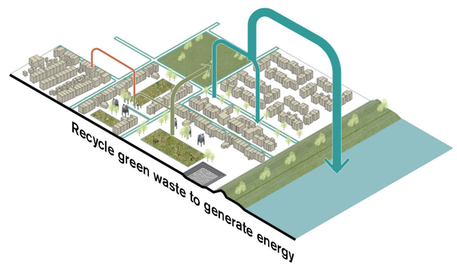
⟷ Strong relationship
⟶ Ad-hoc relationship
⇠⇢ Indirect relationship

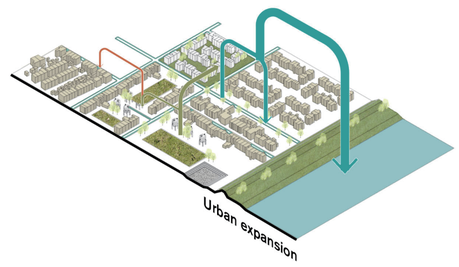
Condition 3











Synergy of bio-physical space and ecosystem services

2020

Old housing facilities	Antagonism	**Ecosystem services**

2025

Greenroof	Reuse rain water Regulation microclimate	**Regulating services**

2030

Greenroof	Reuse rain water Regulation microclimate	**Regulating services**
Community garden	Food	**Provisioning services**
Sunken lane	Regulating runoff	**Regulating services**
Land preparation	Purify the soil	**Supporting services**

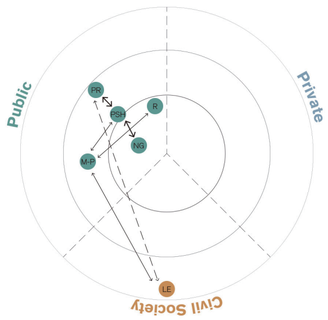
2035

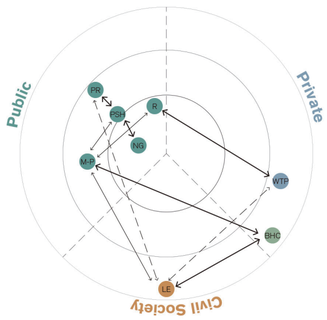
Greenroof	Reuse rain water Regulation microclimate	**Regulating services**
Community garden	Food	**Provisioning services**
Sunken lane	Regulating runoff	**Regulating services**
Land preparation	Purify the soil	**Supporting services**
Digester	Raw materials	**Provisioning services**

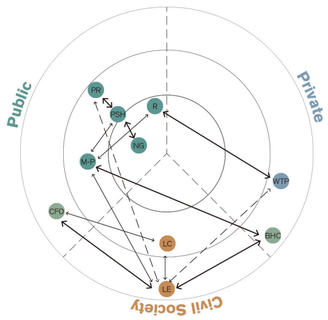
2040

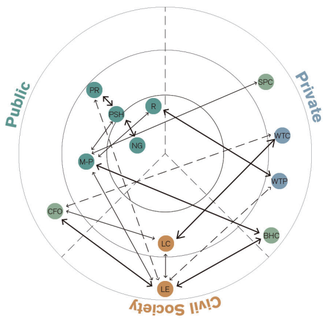
Greenroof	Reuse rain water Regulation microclimate	**Regulating services**
Community garden	Food	**Provisioning services**
Sunken lane	Regulating runoff	**Regulating services**
Land preparation	Purify the soil	**Supporting services**
Digester	Raw materials	**Provisioning services**

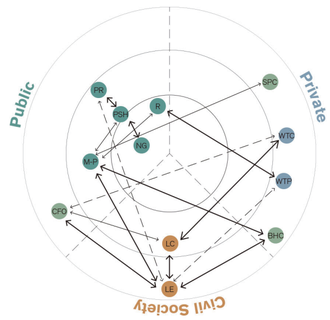
Key stakeholder engagement













Stakeholders full name see chapter 6.1

Strong relationship
Ad-hoc relationship
Indirect relationship

6.2.5 ECO-SERVICE PERFORMANCE

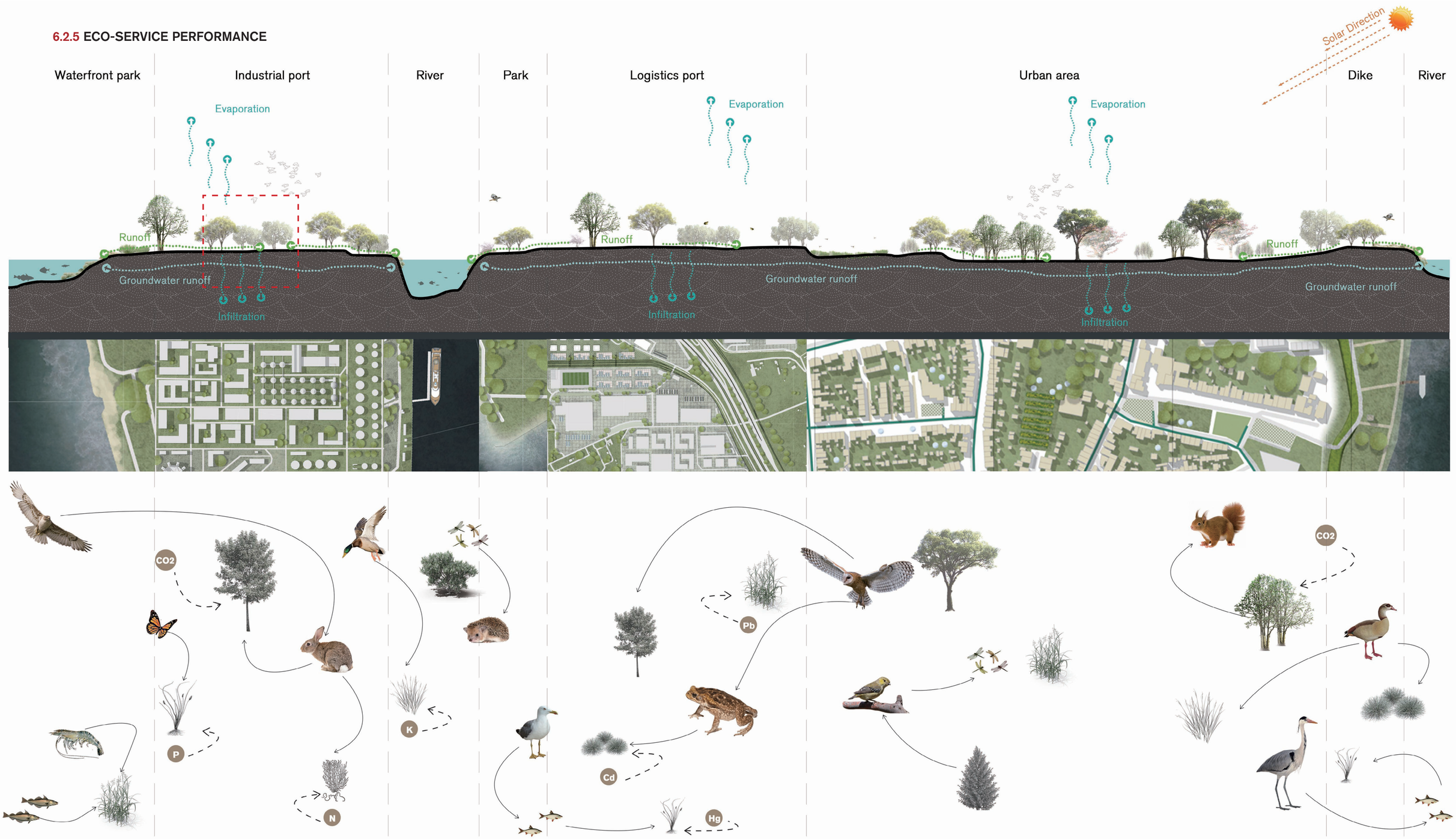


Fig.6.2.41. Source: map created by author.

6.2.6 FLOW ANALYSIS

Natural scale

After

Before

Evaporation

CO_2

Water enters tree where contamination is cleaned up

Evaporation

Industrial emissions

Impervious ground

Flood area

Clean soil

Infiltration

Cd

Industrial emissions

Water table

Roots take in water and contamination from the ground

K

Hg

P

N

Pb

Contaminated soil and groundwater

Fig.6.2.42, Source: map created by author.

2020-2025

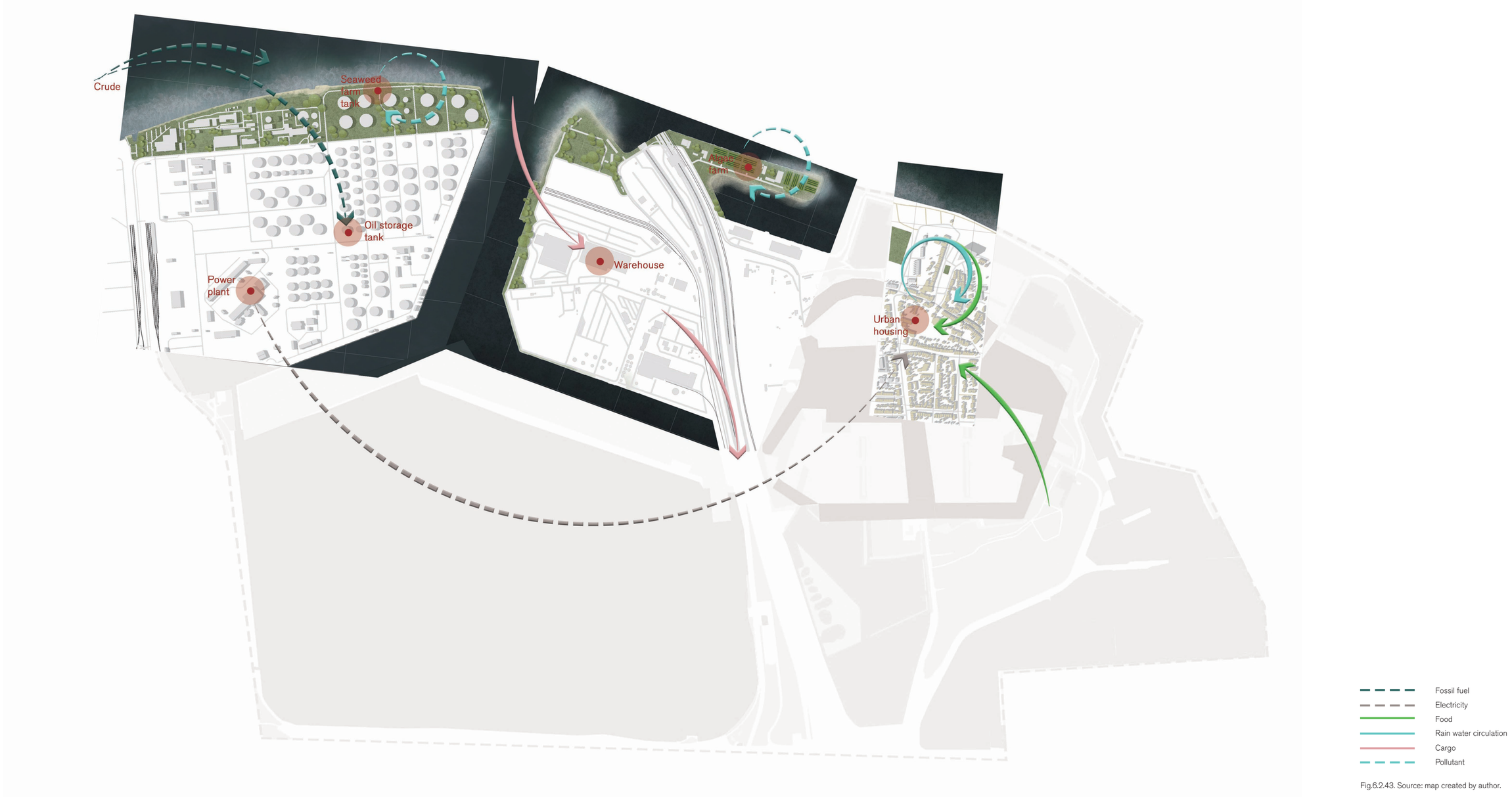


Fig.6.2.43. Source: map created by author.

2025-2030

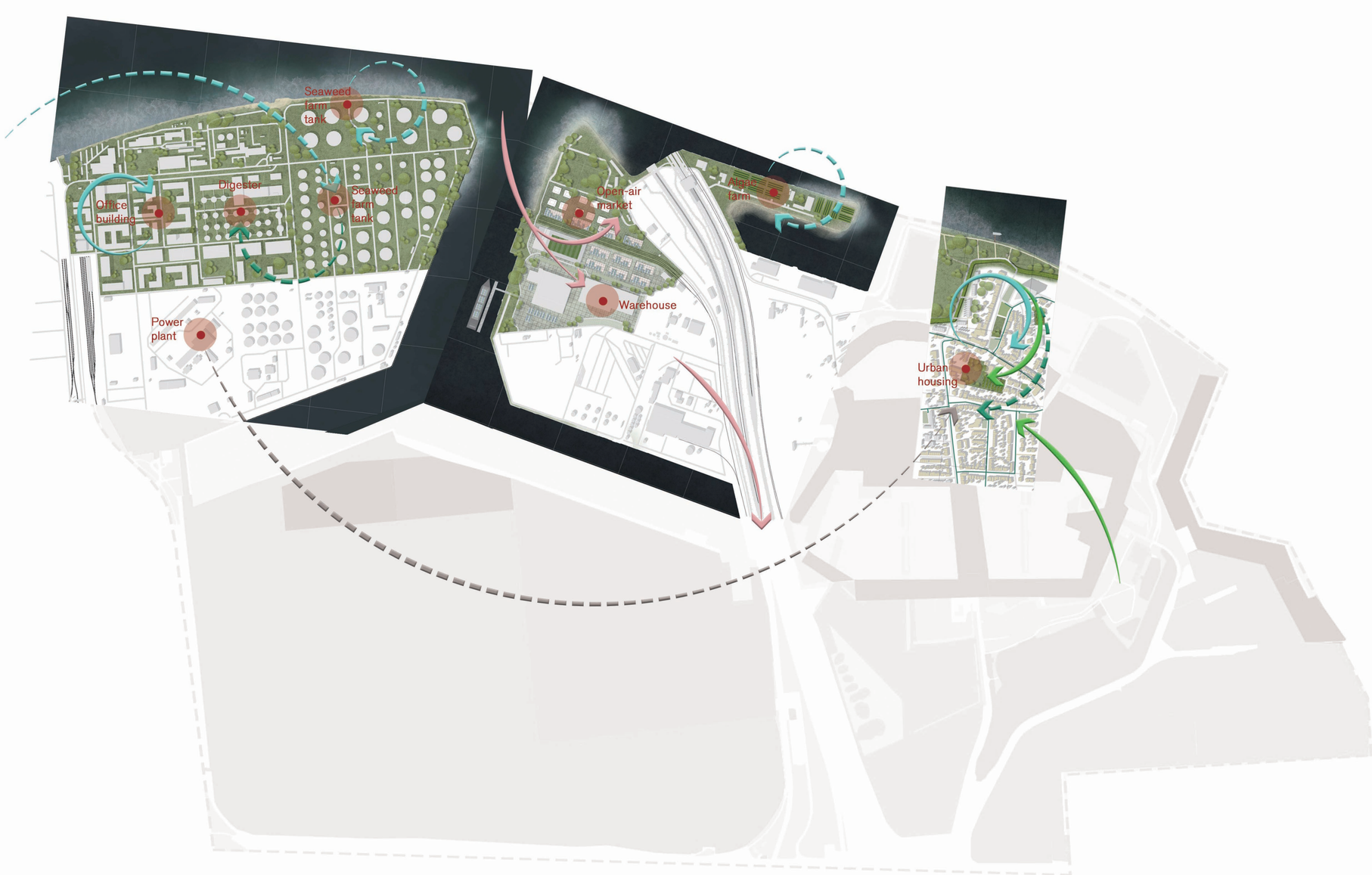


Fig.6.2.44. Source: map created by author.

2030-2035

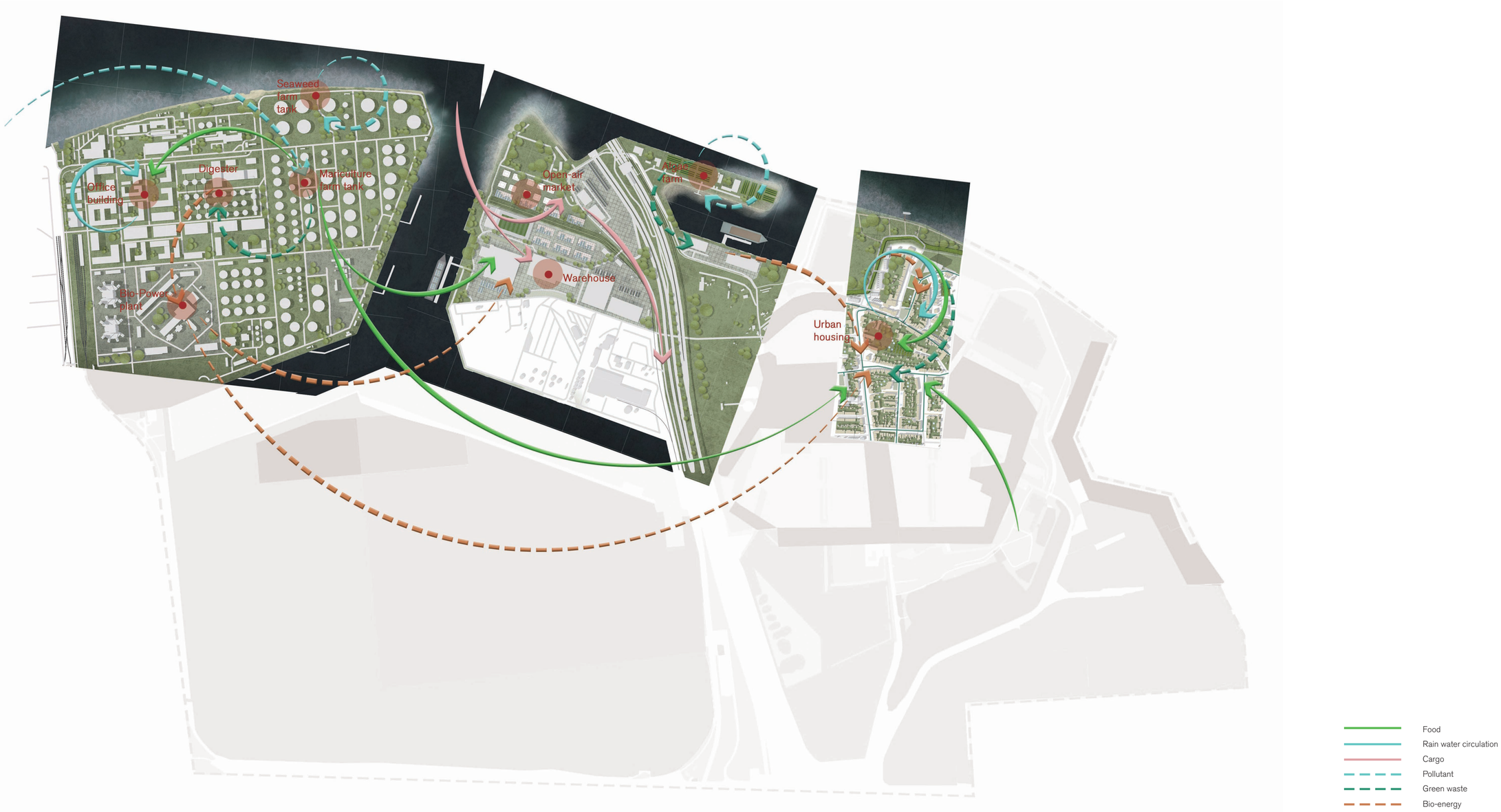


Fig.6.2.45 . Source: map created by author.

2035-2040

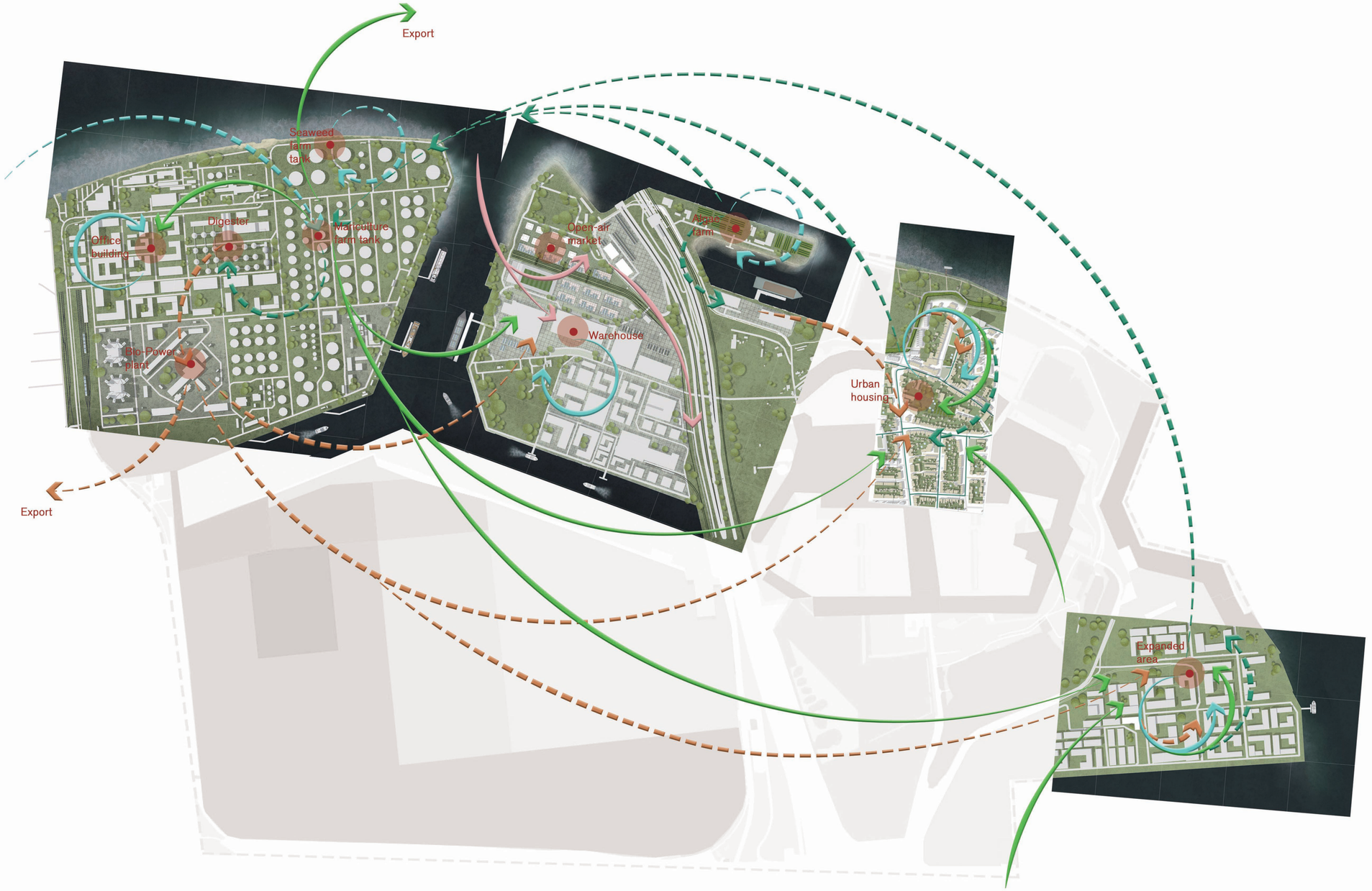


Fig.6.2.46. Source: map created by author.

Zoom out (2035-2040)

Occupation layer

Transportation network layer

Food production layer

Biome landscape layer

Water network layer

Over layer

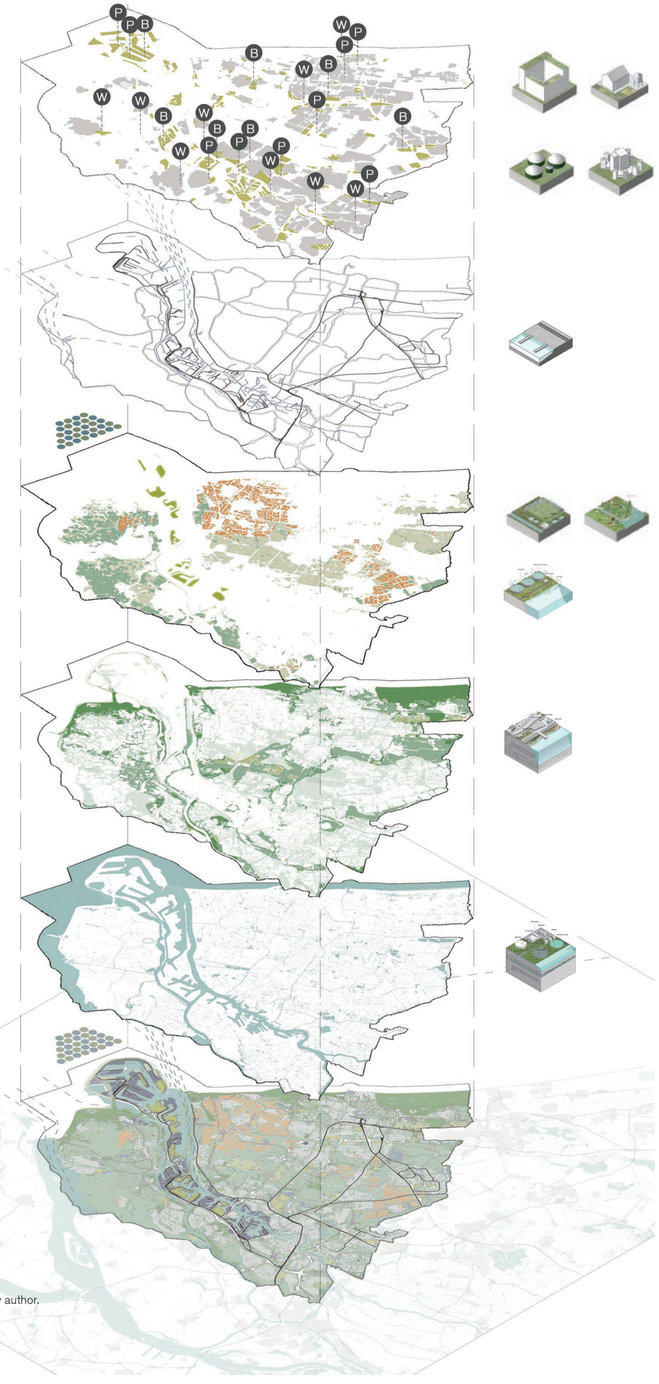


Fig.6.2.47. Regional scale flow layer. Source: map created by author.

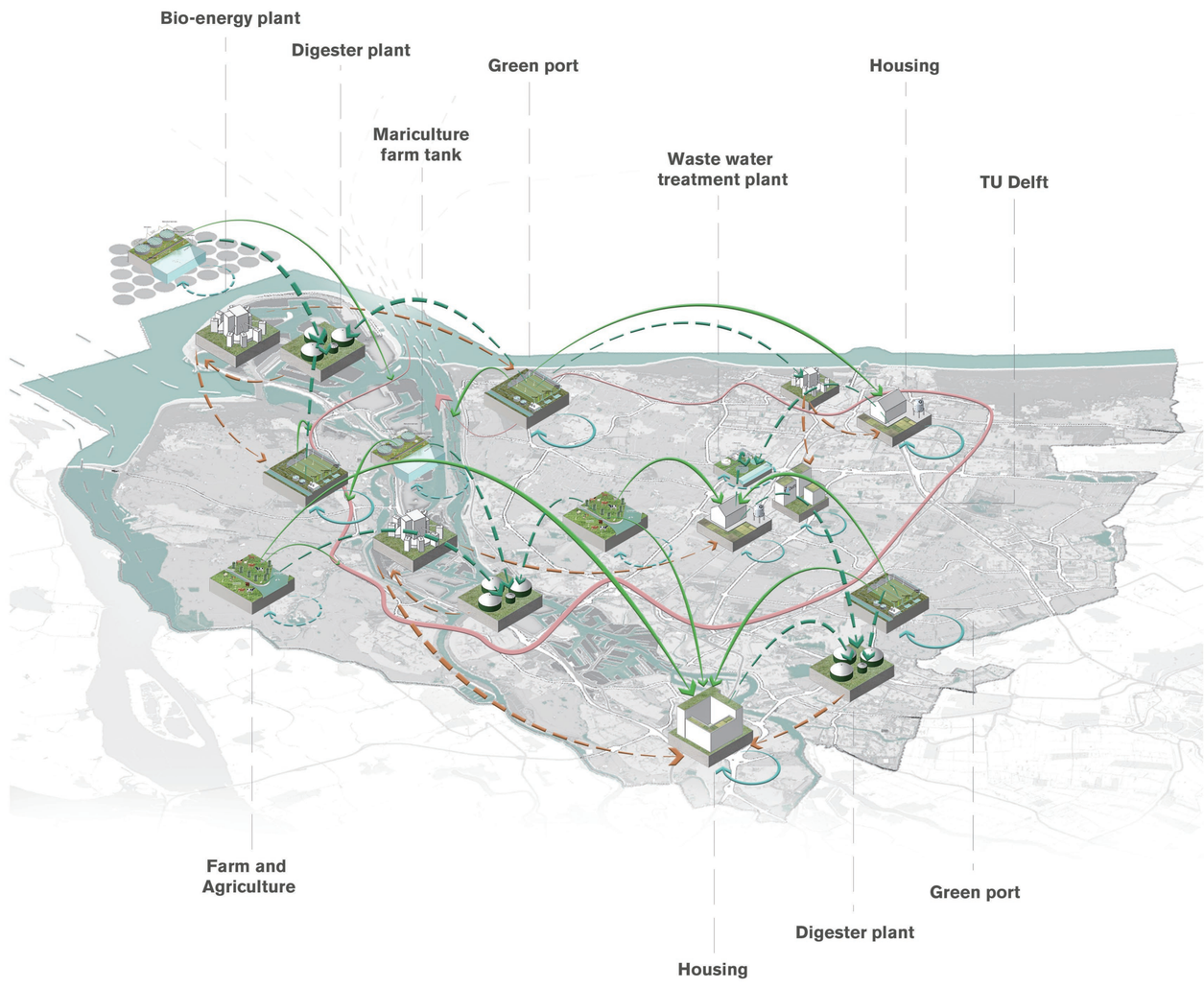


Fig.6.2.48. Regional scale flow. Source: map created by author.

6.3 EVALUATION

6.3.1 Ecosystem services through time

Provided Ecosystem Services

1. Recreation

1.1 Tourism
1.2 Water sports
1.3 Fishing
1.4 Accessibility of water

2. Educational environment

2.1 Awareness of climate change
2.2 Awareness of bio-based economy
2.3 Characteristic landscape: improving identity of MRDH as coastal region

3. Natural values and biodiversity

3.1 Water purification
3.2 Create refugia for migratory and resident species
3.3 Species recovery

4. Water safety

4.1 Use sediment to reduce current and waves
4.2 Reduce groundwater salinity
4.3 Create bio-based dikes and reduce maintenance costs
4.4 Reduce water acidification

5. Food productivity

5.1 Crop productiom
5.2 Seaweed production
5.3 Fish production
5.4 Algae production

6. Contribute to circular economy

6.1 Reuse of sediment
6.2 Reuse of rain water
6.3 Reuse of green residual material

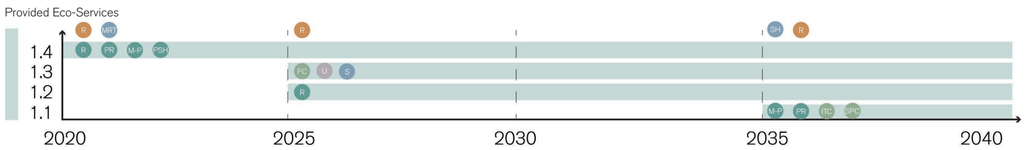
7. Contribute to climate regulation

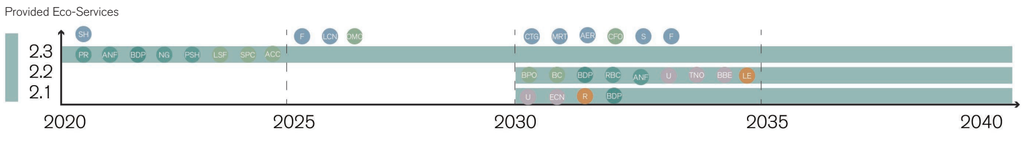
7.1 Temperature regulation
7.2 Air purification
7.3 Carbon sequestration

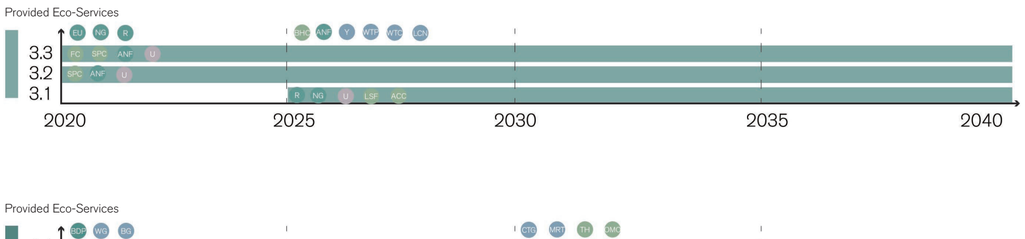
Involved stakeholders (see Fig.6.1.7)

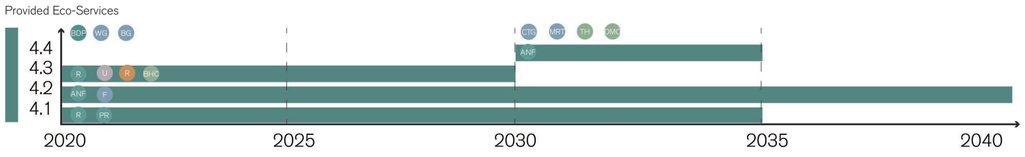
Short term process

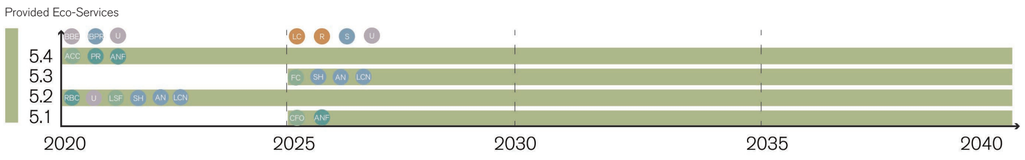
Long term process

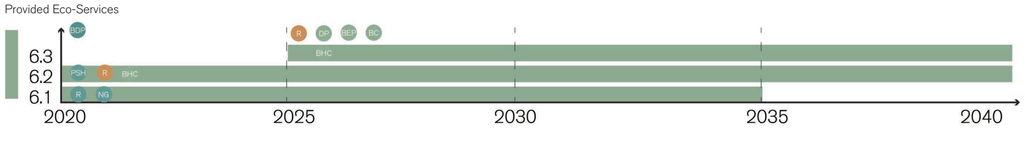


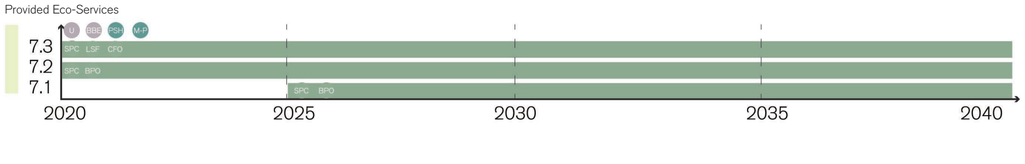












6.3.2 Comparing interest of major stakeholders

Explanation to read the diagram

The chart summarizes the results of the ecosystem services provided at each stage of the project process. This information is combined with the timeline and provides a possible development path for each subservice. And finally pointed to the scenarios that may be adapted.

For each sub-service, the range of values provided by the ecosystem service is represented by a colored bar. The center of each service represents a zero value, and the outside of the service represents the highest value of "high flood risk" or "low flood risk". Different stages of the diagram can be read from the inside, the existing situation is closest to the center, and the final state is outside the diagram.

Use this form to evaluate the ecosystem services received by major stakeholders throughout the project, which is more intuitive to show stakeholders the benefits of the program.

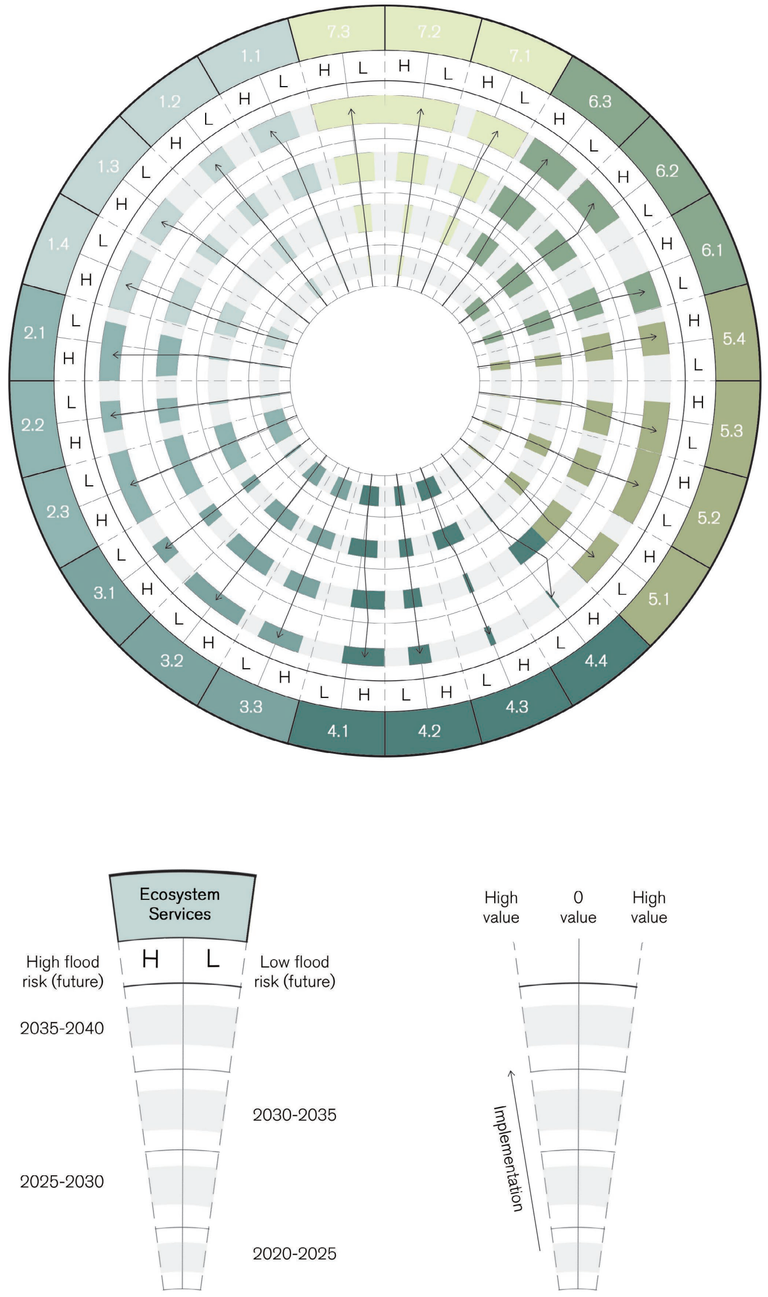
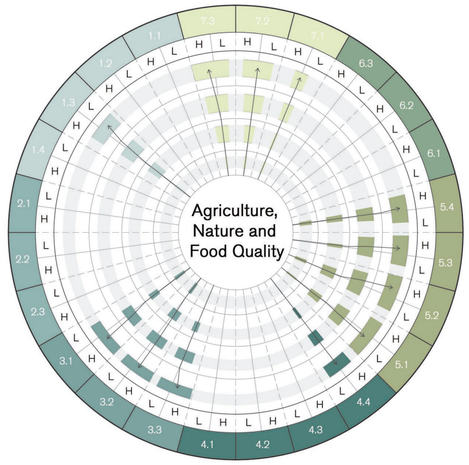
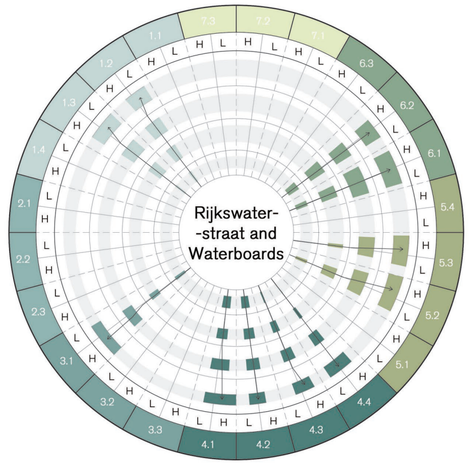


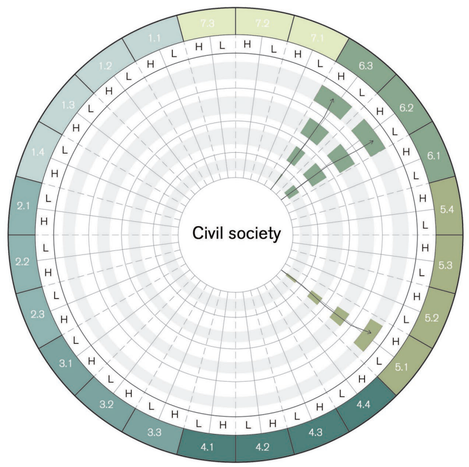
Fig.6.3.1. Explanation to read the diagram. Source: created by author based on report '*Turning the tide*'.

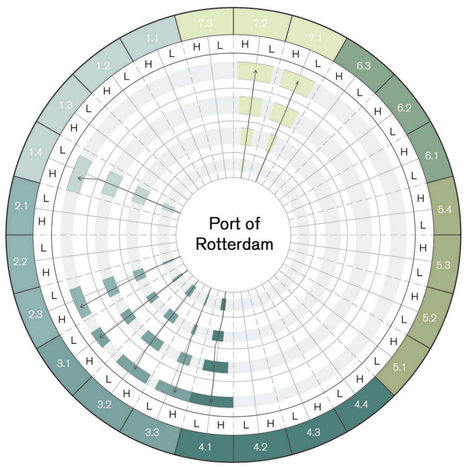
Comparing interest of major stakeholders

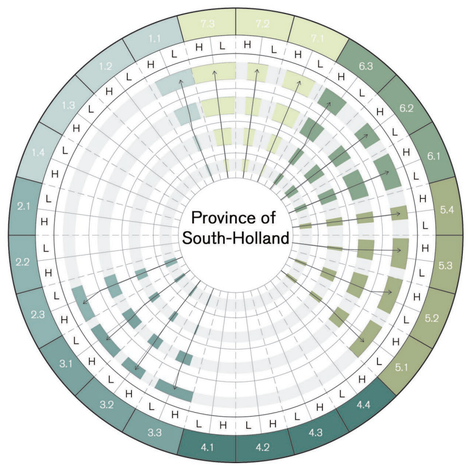
Fig.6.3.2. Interest of major stakeholders. Source: created by author.

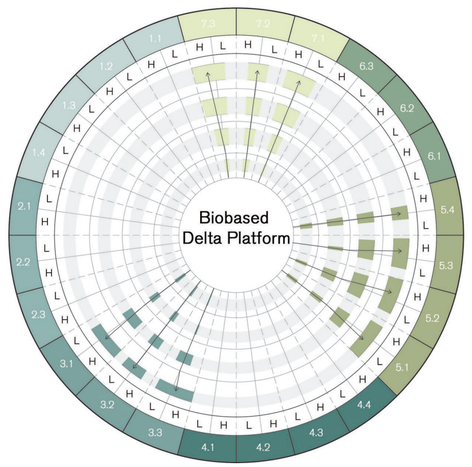


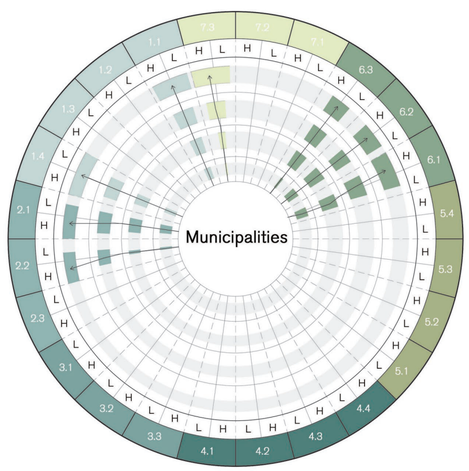


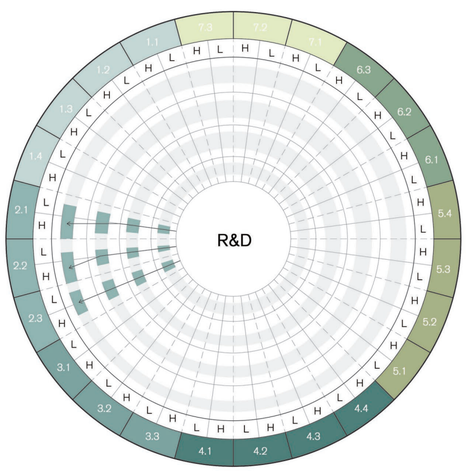


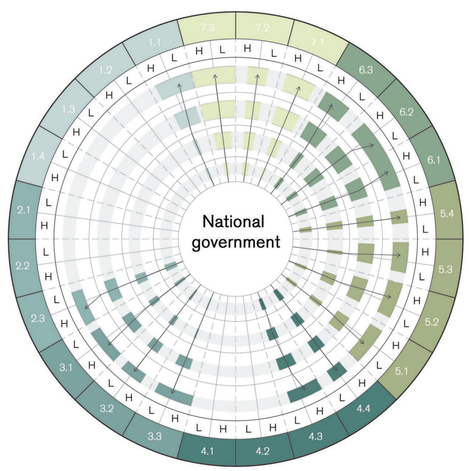


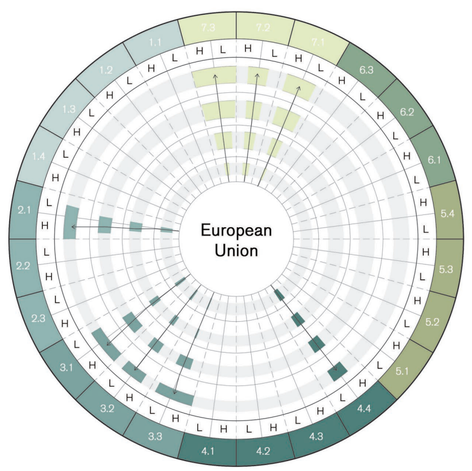












6.4 GOVERNANCE MODEL

6.4.1 Interconnection of stakeholders

Existing goals and interconnection

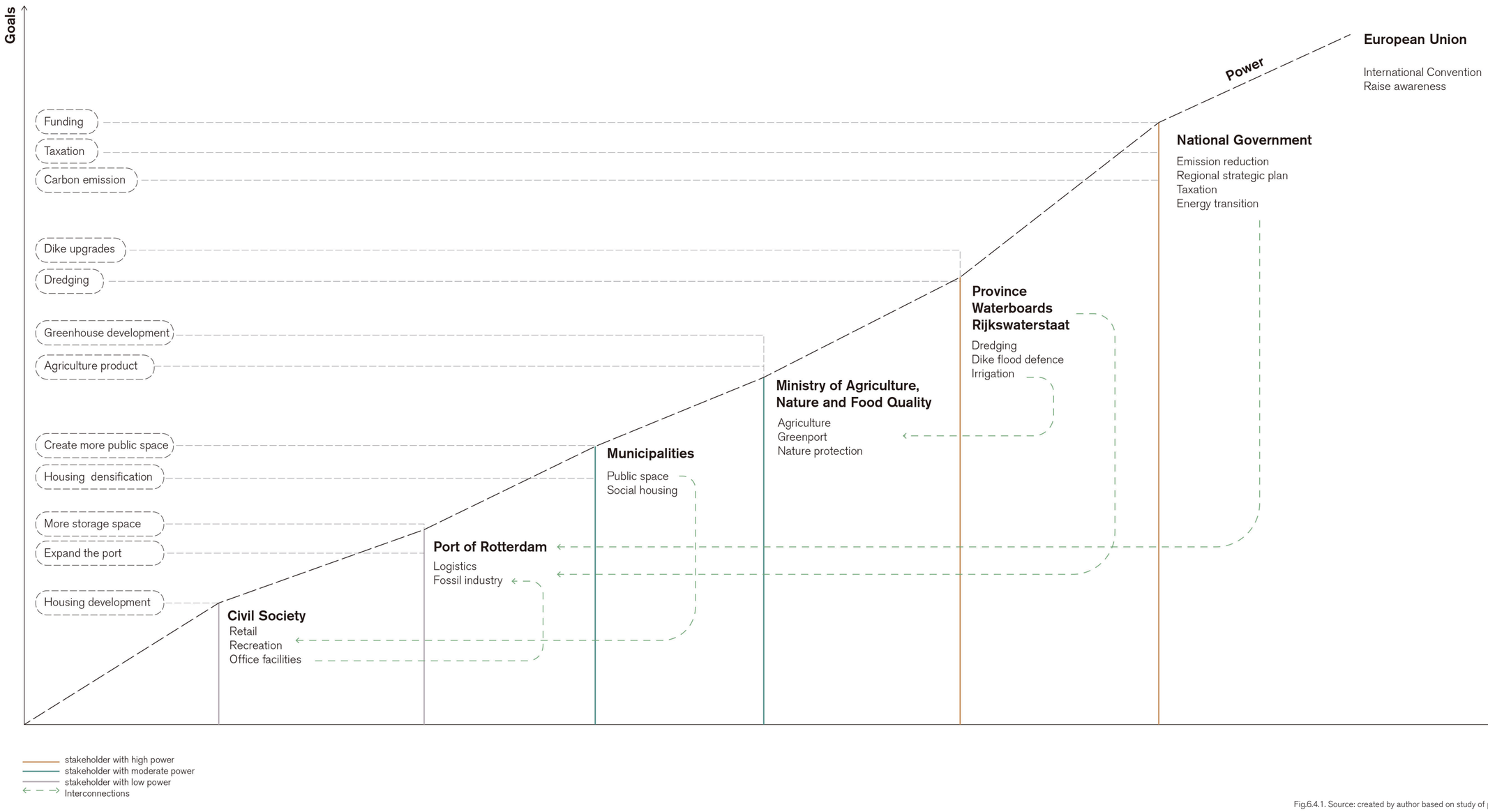


Fig.6.4.1. Source: created by author based on study of policy reading.

Proposed goals and interconnection

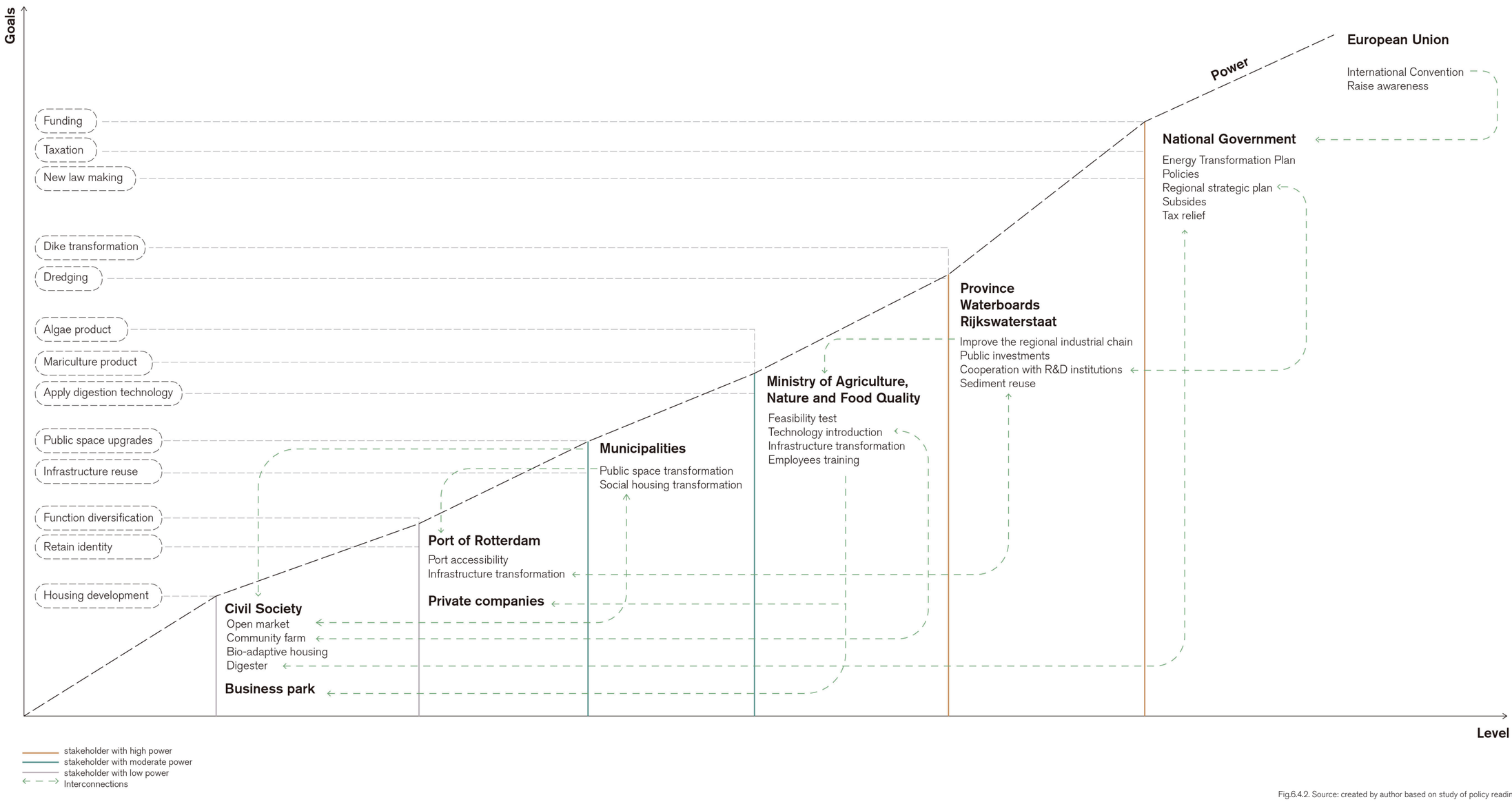


Fig.6.4.2. Source: created by author based on study of policy reading.

6.4.2 Management and labour force transformation matrix

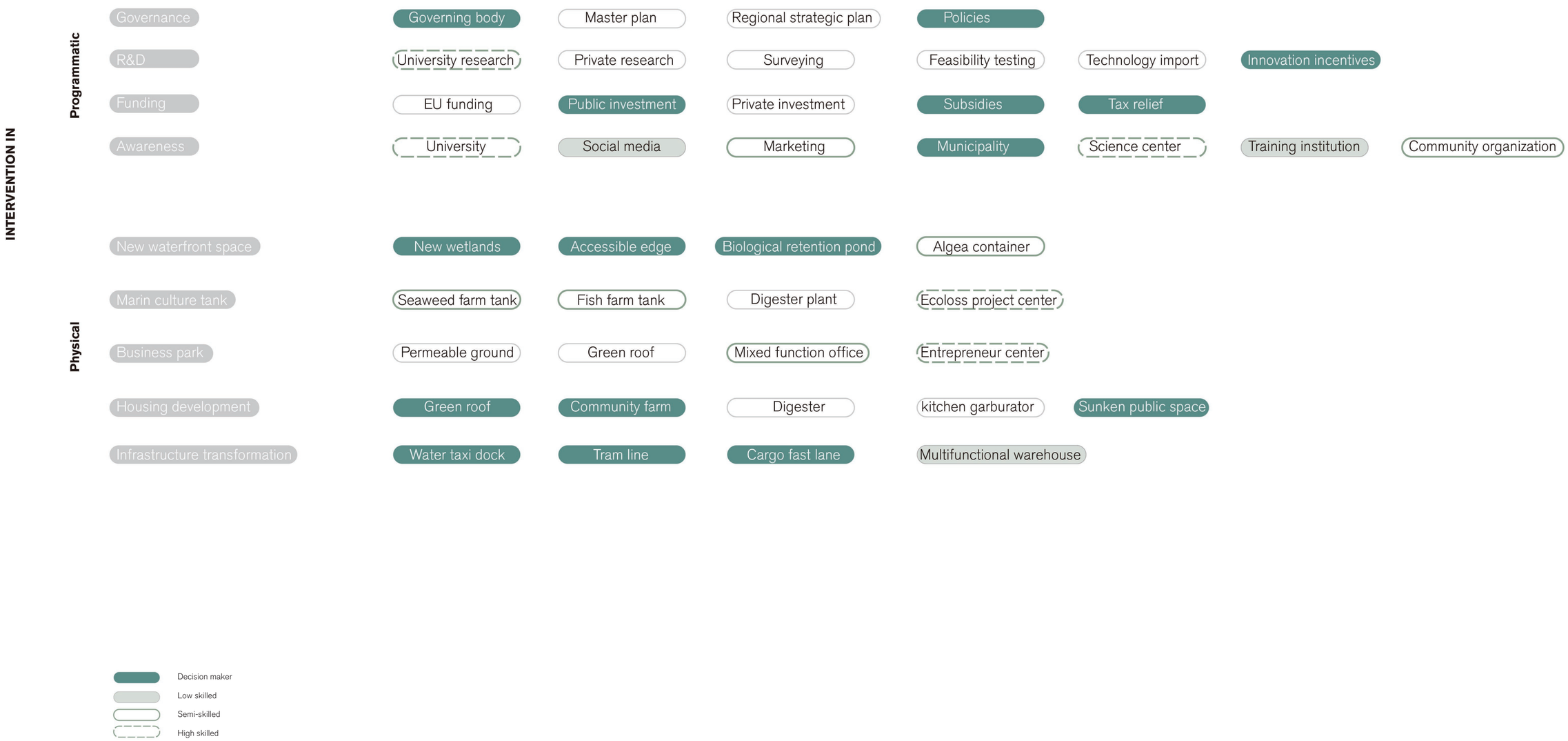
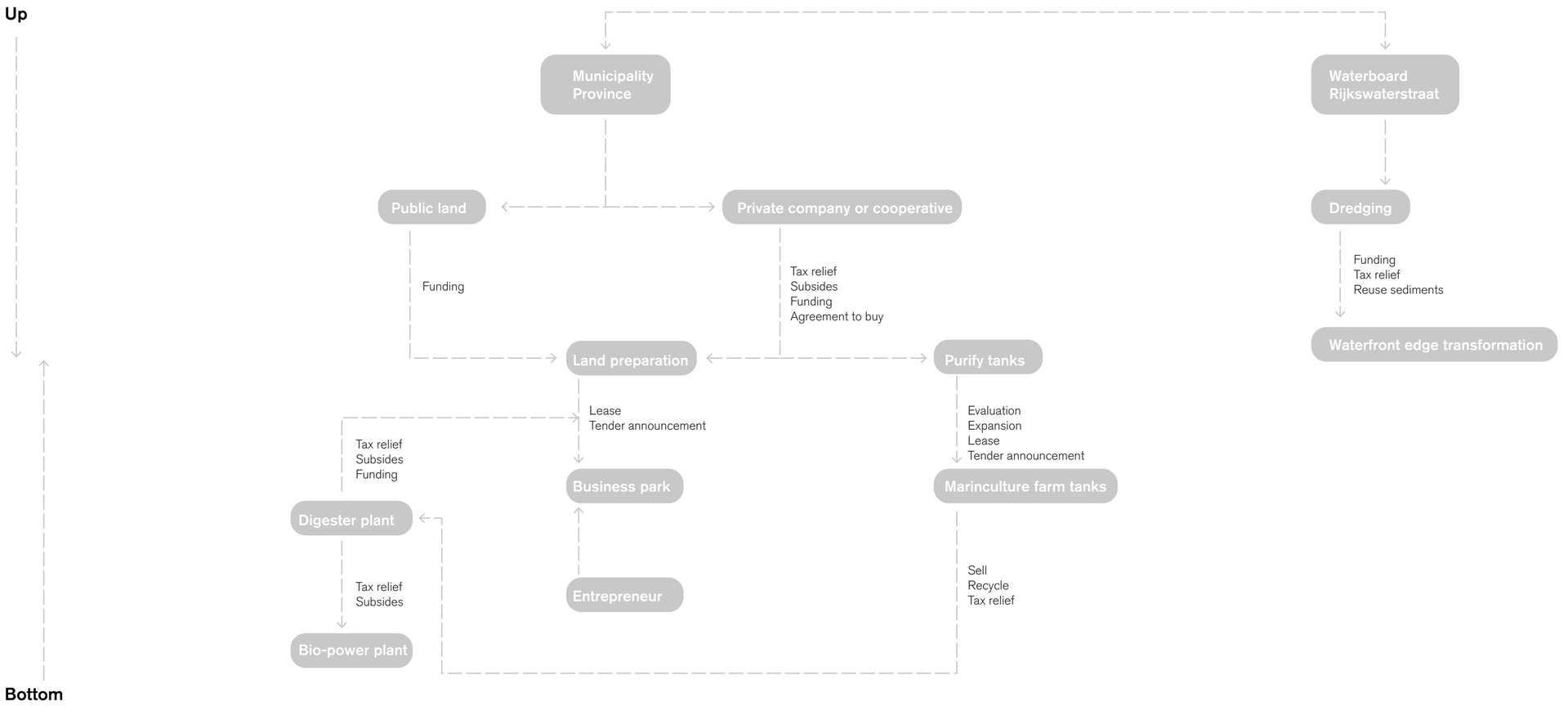


Fig.6.4.3. Source: created by author based on study of policy reading.

6.4.3 Implementation approach

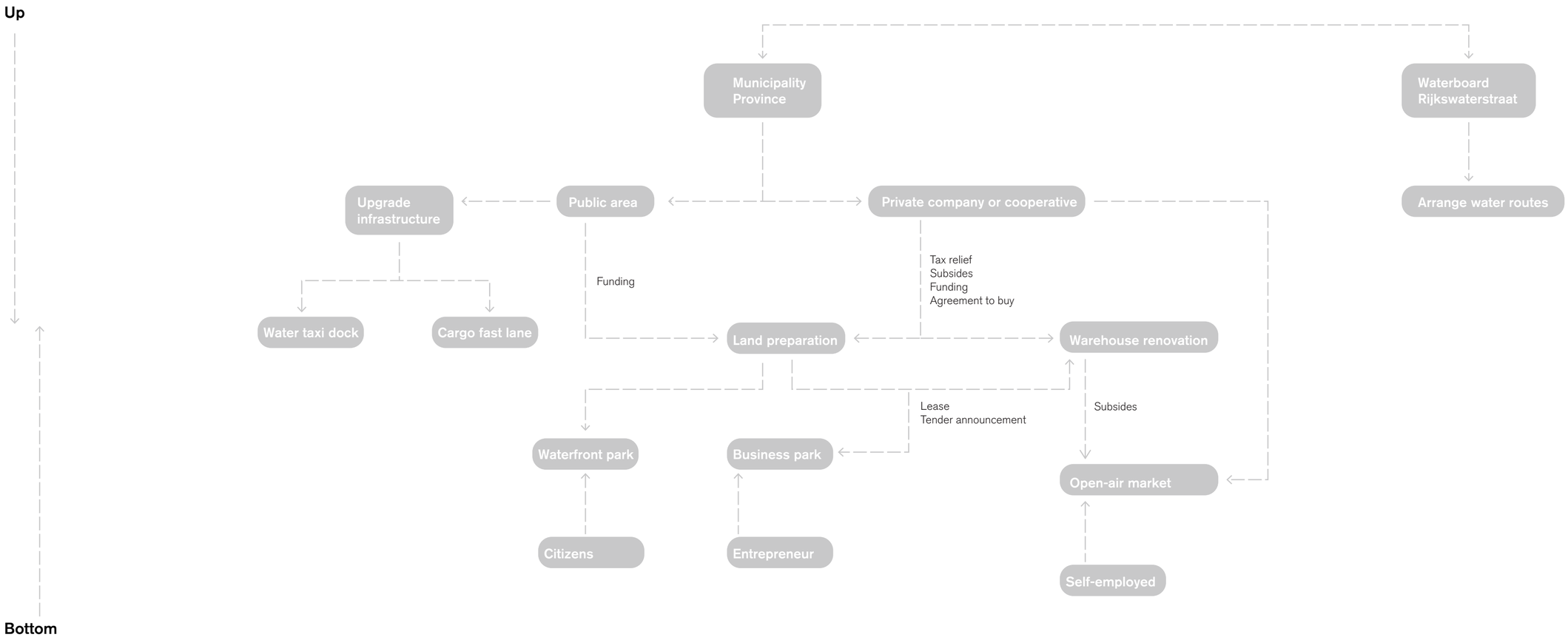
Condition 1



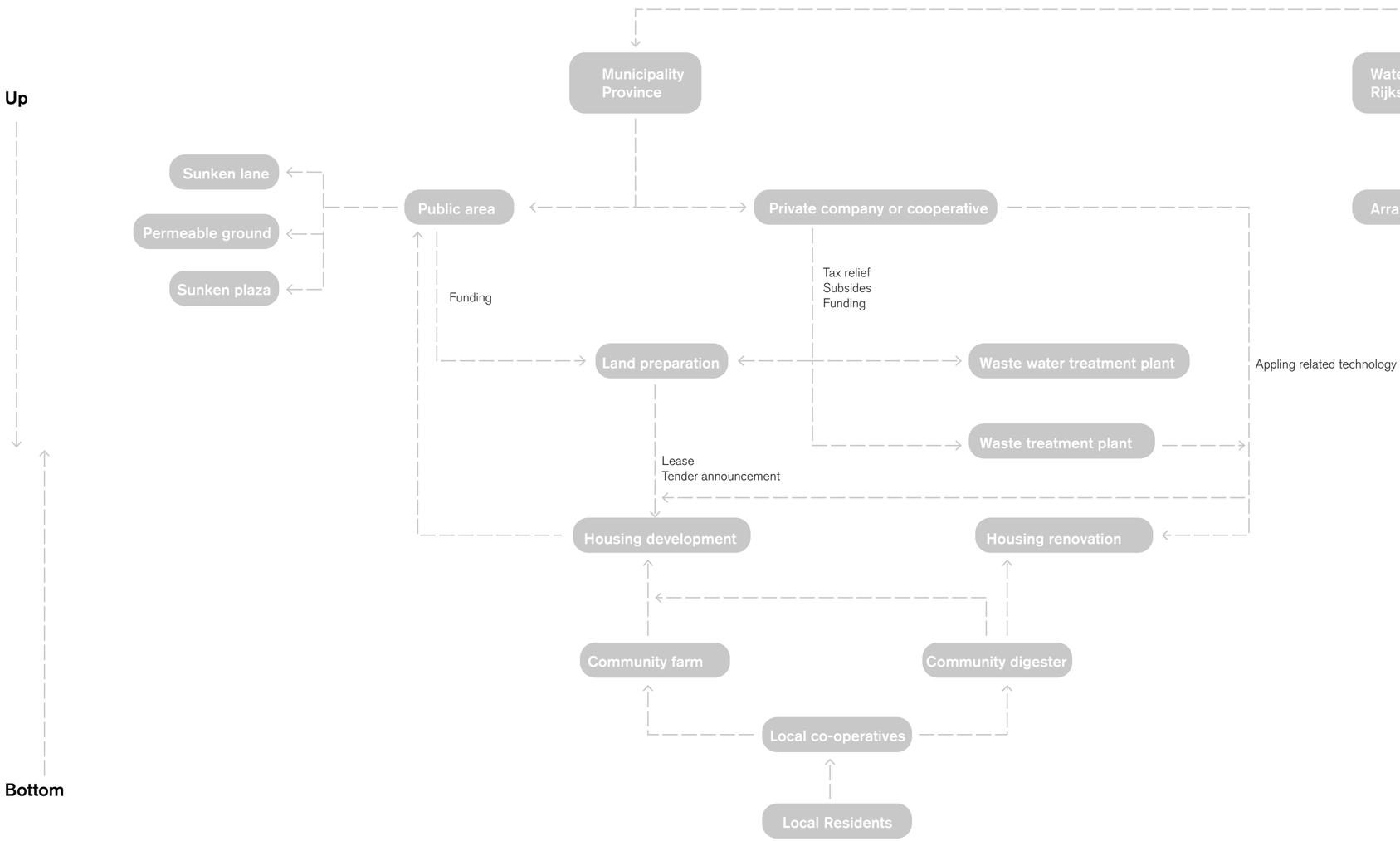
The proposed implementation approach shows the development of the three condition areas and the actions that can be taken. Traditional top-down planning methods may be outdated in this era, and uncertainty may not be adapted.

To achieve the goals of this project, cooperation and participation among stakeholders must be strengthened, which will also lead to bottom activities become more active, therefore, the promotion of program implementation will mainly be carried out from two aspects: top-down, promoted by key decision makers and national policies; bottom-up, development from local residents or public-private partnerships, and upward promotion economic development.

Condition 2


Up
Municipality
Province
Waterboard
Rijkswaterstraat
Upgrade
infrastructure
Public area
Private company or cooperative
Arrange water routes
Tax relief
Subsides
Funding
Agreement to buy
Funding
Water taxi dock
Cargo fast lane
Land preparation
Warehouse renovation
Lease
Tender announcement
Subsides
Waterfront park
Business park
Open-air market
Citizens
Entrepreneur
Self-employed
Bottom

Condition 3


Up
Municipality
Province
Waterboard
Rijkswaterstraat
Sunken lane
Permeable ground
Sunken plaza
Public area
Private company or cooperative
Arrange water routes
Funding
Water related infrastructure
Funding
Tax relief
Subsides
Funding
Land preparation
Waste water treatment plant
Appling related technology
Waste treatment plant
Lease
Tender announcement
Housing development
Housing renovation
Community farm
Community digester
Local co-operatives
Local Residents
Bottom

6.5 SCALE ADAPTATION, TRANSFERABILITY OF RESULTS

The strategies can be adapt from Natural scale to meso scale and to regional scale, and also could adapt to national scale in Zealand delta area, Ijsselmeer area and Waddenzee area. Because these area have similar conditions.

At the natural scale, mainly through restoration of vegetation, the use of plants to restore natural processes, and thus the biophysical space becomes available. This method can be adapted to a wide range of areas, but the species needs to be selected according to local conditions.

On the meso scale, through the adaptation of natural systems and biophysical spaces, the functions of the area has changed. The new spatial functions will work synergistically with natural systems and generate new economic benefits.

By applying the design strategy to the regional scale and adapting the meso scale flow to the regional scale, a new circular economy model is formed.

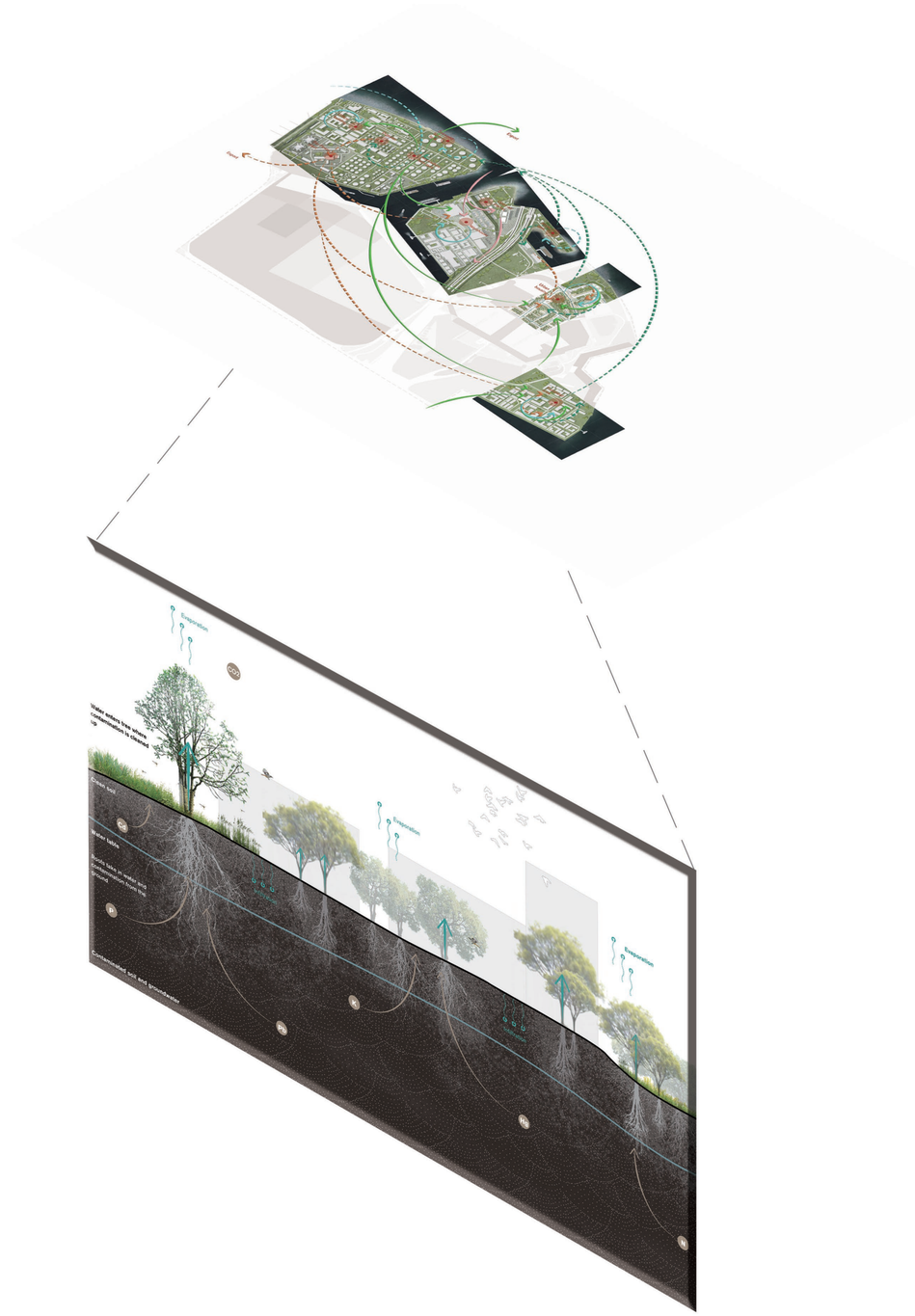


Fig.6.5.1. From the natural scale to the meso scale. Source: created by author.

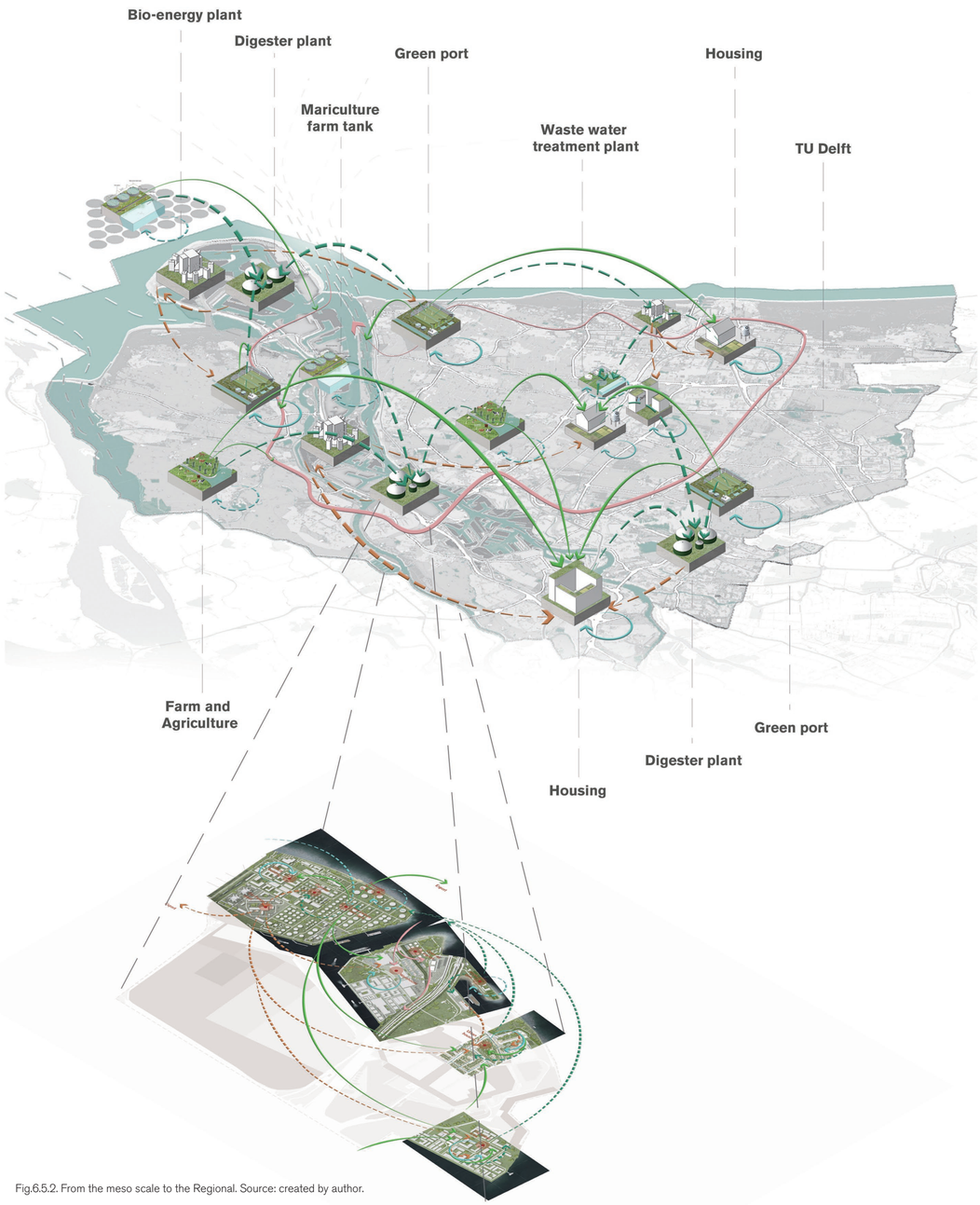


Fig.6.5.2. From the meso scale to the Regional. Source: created by author.

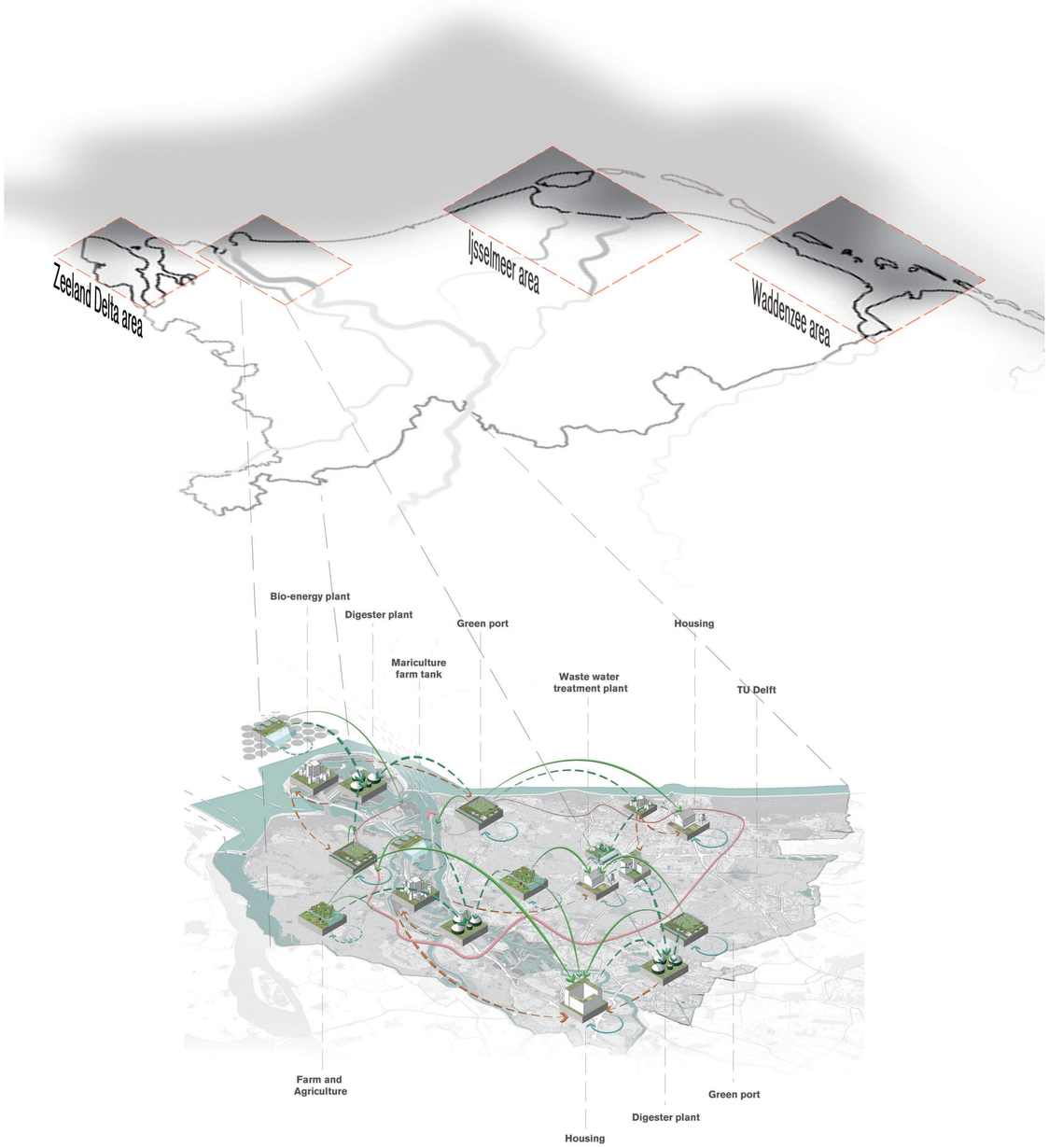


Fig.6.5.3. From the Regional to the National. Source: created by author.

7 CONCLUSION

7.1 CONCLUSION
7.2 BACK TO THE RESEARCH QUESTIONS
7.3 RECOMMENDATIONS FOR FUTURE RESEARCH

7.1 CONCLUSION

The main proposed change is to establish a more circular and more interconnected framework that focuses on recycling current waste and restoring local ecosystems while changing the flow, this will bring stability to the environment of the Metropoolregio Rotterdam Den Haag (MRDH), and at the same time form a new bio-based economy to achieve symbiosis between the city and water.

Although biomass technologies are proving to be commercially viable, they have the potential to provide a flexible and diverse way to produce a range of products (including food, biomass fuels, medicines, etc.) and to repair contaminated soil and water body. From a technical point of view, research and projects in some countries have demonstrated the wide feasibility of producing biomass products, such as the use of seaweed, fungi and algae.

There is no doubt that the development of biomass economy needs to occupy more space, but it is relatively easy to implement in coastal areas, one is because of the climatic conditions in the coastal area, and the other is because of the vast water space, last but not least, the port area has a large amount of infrastructure in the port area can be recycled and reused.

Through the use of biomass, the pollutants in the air and water and soil in coastal areas are absorbed and fixed, and converted into new biomass energy and economy. In order to change the flow in the area, relevant spatial intervention is needed. The space after the intervention will change the landscape and restore the unique landscape of the coastal area. Not only provides visual and functional enrichment, but also improves the existing animal and plant community structure, and may have new migratory animals in the future.

Since the focus of the intervention measures is on some relatively unaccessible areas, it can be used as an open public space after the intervention to strengthen the activities of local community groups to provide a favorable social environment for decision makers, at the same time, the restored ecosystem services will help policy makers achieve the relevant climate goals. Bio-based economic transformation is based not only on the need for adaptability and adaptability to the local economy, but also on the potential of existing environmental resources to support such economic transformation.

In the post-transformation biomass economic framework, farmers, residents and governments can develop a cooperative relationship through the new food industry chain and energy structure, and gradually implement the plan. By stimulating the collaborative relationship between various stakeholders, a stable economic system is formed.

On the other hand, the development of the urban economy must consider the ecological environment. The urban economy at the expense of the ecological environment will be irrecyclable and vulnerable. Therefore, when decision-makers make relevant decisions, need to strengthen the cooperation between various stakeholders, and stakeholders should also actively participate in it.

Although in the short term, the biomass economy has no economic advantages compared with the traditional economy, but with the development of technology and the pressure of climate change, people will gradually accept. At the same time, the biomass economy has broader benefits in the medium and long term, such as improved health, ecological restoration, and reduced flood risk. Therefore, the long-term economic growth of bio-based economy may take over the strategy of profit-oriented parasitic economy.

7.2 BACK TO THE RESEARCH QUESTIONS

SQ1 ASSESSING

1. Why the MRDH area need shift the economic production system?
Because the current economic system is unsustainable and causes great damage to the environment, facing the climate change and energy transition, the current economy cannot adapt.

2. What are the current economic production system in the MRDH area?
The current economy is in a parasitic state, dominated by industrial and agriculture, and the waste generated by them cannot be processed well and is directly discharged into nature, causing damage to the ecosystem.

3. What is the current state on urban and water systems and its contribution to coastal/urban pollution?
Current urban activities have caused great pollution to local water resources, including domestic water pollution, eutrophication caused by agricultural spills, and hazardous substance leakage caused by industrial activities, etc..

4. What is the current urbanization chanllenge in the MRDH area?
The main challenges facing the region come from the conflicts between the urban growth, economic development needs and the vulnerable, risky space.

SQ2 INTERRELATING

1. What are the limitation and potentialities of applying bio-based solutions in MRDH area?
The limitation mainly comes from two aspects. One is the technology factor. Through the combination with technology, the production of biomass can become more diversified and low-cost, which cannot be achieved at present. Anther is time, ecosystem services may not be reflected in the short term. The potential is mainly reflected in the MRDH area has a lot of room for development, and many biomass projects have been tested locally.

2. How to use a polluted water body to change the MRDH's economic system and make it a medium for integrating nature and urban?
The nutrients in the water body are needed for biomass growth. At the same time, the water body is used to cultivate biomass without occupying other occupational space on the land. Through the medium of water, habitats can be created, and the harvested biomass can provide biological food and energy on land,

3. What kind of response measures should be taken to the eutrophication of water bodies while making use of the maximum potential of the North Sea and river forces?
Purify the water body and absorb the nutrients in the water body through the offshore farm and seaweed cultivation tank and algae cultivation tank.

4. How to restore the ecological environment of the MRDH through interventions in the water management system?
Through the intervention of the water management system, the sediment can be reused, the continuity between the land and the water body is restored, and the living environment of plants and animals is created, and the ecological environment is restored.

SQ3 PLANNING

1. Which method can promote the integration of modern technology and nature and achieve a sustainable economic future in the MRDH areas?
Promote synergy among stakeholders by constructing (modifying) a new government framework.

2. What kind of economic and environmental strategies would facilitate a sustainable future for the entire coastal region?
Multi-stakeholder collaborative, sustainable and resilient biomass economy.

MAIN RESEARCH QUESTION

What kind of shift in the economic production system could change the current waste flows between cities and nature to facilitate a sustainable and resilient economy in the Metropoolregio Rotterdam Den Haag (MRDH)?

The economic system needs to change from a profit-oriented parasitic economy to a natural-oriented bio-based economy.

In order to achieve this goal, the landscape of the MRDH area needs to be transformed, and the additional benefit brought by it is the restoration of the natural ecosystem. In the current parasitic economy, waste flows are out of the industrial chain and enters nature, the ecosystem cannot deal with these wastes by itself, thereby causing ecosystem damage.

In the new economic system, the waste flows will change. The first perspective is to recycle the metabolic waste generated in the economic production system. The second perspective is to recycle the waste that has flowed into the natural system and return it to the industrial chain. Through different spatial interventions and policy formulation, the ecosystem will be restored, and the ecosystem services provided will also increase, forming a virtuous circle within the region.

Of course, in order to achieve this goal, more stakeholders are needed to work together. enhancing stakeholder involvement and collaboration, to change and reinforce of the bio-physical space requires policies guidance, so participation and collaboration among stakeholders is essential.

7.3 RECOMMENDATIONS FOR FUTURE RESEARCH

The project proposed a method of using bio-based economy to achieve the symbiosis of urban economy and natural system. I will propose the following points as recommendations for future research.

First of all, to study more bio-based technologies, there will be more available ways to produce biomass in the future, which will also have impact on future urban spaces and natural systems.

Second, more social cost-benefit assessments can be conducted, which will make the benefits of bio-based economies more intuitive and credible.

then, the program also involves research on possible future urban growth, but lack of research on population and other resources, future research should enhance this aspect.

Last but not least, we should strengthen communication and discussion with the stakeholders involved in this thesis, which will help the evolution and feasibility of the program.

8 REFLECTION

Aspect 1 The relationship between the project, the topic of Studio and Urbanism track

The topic of the Transitional Territories Studio this year is 'North Sea: Landscapes of Coexistence: A Topography of Chance', which looks at the interrelationship between land and oceans, studies and discusses the dynamics of nature and human society, and discussions leading to the current critical and means of various processes of the risk statement, and through research and design of buildings and urban projects to respond to today's biophysical, socio-economic, cultural and political changes and related risks.

My research project aims to explore the possible changes in the current economic production structure of coastal cities, introduce new bio-based economies, and transform it into sustainable production models in coastal areas so to achieve the systemic symbiosis between cities and water. From a topic perspective, it is closely related to the research theme of the entire studio.

Through the study and research of urbanism, I have deepened my understanding of the complexity of the city. In the past two years of study, I have been upgraded and supplemented with both theoretical knowledge and analytical methods. These learning experiences have helped me explore the complexity of coastal areas and proposed measures to deal with uncertainty in my project. Through the internship project on Urbanism track, I learned the possibility of improving the spatial form and structure of cities and metropolitan deltas through the combination of landscape design and spatial planning. I was attracted by this method of combining urban and nature, this is also one of the reasons why I choose this studio.

In addition, my project also provided relevant research groups with a new perspective on “bio-based solutions”. By applying bio-based solutions in water management, the water recycling in the region is improved to achieve the improvement of other cluster flows related to water, so to achieve a circular economy, and to gradually restore ecology in the area. Therefore, in my project, the issue of adapting to "bio-based solutions" in coastal urban environments was discussed, and some possible potentials were proposed, which could complement current research.

Aspect 2 The relation between the research and design

Climate change has and will continue to affect people's lives, and we can clearly feel that the impact of climate change is increasing. The risks faced by coastal cities will also increase in the future, but the unique characteristics of the North Sea environment continue to attract people gathering in these coastal cities, creating urban economic vitality. South Holland is a typical case. In order to promote economic development, the South Holland Province established MetropoolRegio Rotterdam Den Haag (MRDH), which is also the project location. A series of economic activities deployments (port industry, green port, agriculture, etc.) caused damage to the local ecosystem, although many nature-based solutions have been discussed and tested in the Rotterdam region in recent years, the environmental problems are indeed severe, especially in water management. This phenomenon led me to rethink the relationship between the urban economy and the natural ecosystem. How to use polluted water as a medium through bio-based solutions to change the relationship between cities and nature to promote sustainable economic development and improve the adaptability of cities towards a systemic equilibrium . This is the original idea of the project.

In order to address my graduation project, several research processes were employed to build up the framework of my research. The research process includes three aspects. First, the Macro scale (MRDH) assessment is conducted. The ecological problems caused by water pollution in the area are studied, and the causes of pollution and the risks brought by climate change are identified. The main contradiction between city and water dynamics was found through the assessment, and then four representative meso scale patches were selected for the second aspect of research. The second aspect is mainly to study the urban metabolism (flows) in contradictory areas. Bio-based solutions usually involve the concept of circular economy. Therefore, it is necessary to study the diverse systemic flows, by studying the flows in the area, it is possible to clarify the reasons for the contradiction in economic production and the adaptation potential of bio-based solutions. At the same time, in the second aspect, the space quality of the current vision was also evaluated and it was found that its space was not well adapted to bio-based solutions. The third aspect is to study the typology of contradictory areas from micro scale patches, a more detailed study of the types of water pollution in different typologies and the specific causes of these problems can be studied. This step of research is also the key to propose design strategies, because by design typology, bio-based solutions can be easily adapted at this scale.

As the conclusion of the research, three outcomes will be used to guide design testing, including: a preliminary revised regional vision, new spatial principles, and new typologies to be considered at planning and adapting the region. The design testing includes three conditions, industrial port conditions, logistics port conditions, and urban area conditions. Through the design of a period scheme for land use, the goals of each transition period are determined. At the same time, it guides how to realize each new typology and the new urban space formed by integrating the typologies through the phased urban design of the three conditions. And the stakeholders who carry out the actions in each period will be identified. Last but not least, the feasibility of the design testing is verified by analyzing the design's ability to respond to risks under different scenarios.

From this point of view, the relationship between the research and design in this thesis is directly integrated. The conclusions of the research can guide the direction of the design, and the design shows the process of realizing the research conclusion. At the same time, the research conclusions can also help to evaluate the design results.

Aspect 3 Methods assessment, Scientific relevance

The methods used in the research process and design section shows the scientific relevance of the project.

In the research part, the method mainly uses GIS analysis and mapping to assess the ecological problems and the causes of the problems in the region, and the risks they face, to understand the main contradictions in the current region, and to revise the current vision in conjunction with policy reading. In addition, transects analysis, flow analysis, typology analysis also helped me to understand the current urban spatial structure and urban metabolism in MRDH area, through these research methods, I have a better grasp of the possibilities to application bio-based solutions in the region, later, a more reasonable design strategy is proposed.

In the design part, the period scheme of land use and the technical design integrated in the urban design can reflect the scientific relevance, such as the use of aquaculture to reuse and purify the port industrial facilities, digestion technology to treat community wastewater and other new scientific and technological interventions, also proposed new spatial principles.

Aspect 4 The transferability of the project results, Societal and Ethical relevance

Under the situation of variability on the climate change effects, coastal cities are undoubtedly facing the greatest risk. Due to the current socio-economic characteristics, not all coastal areas can meet the transition conditions, and the transferability of the project results expands the "bio-based solution ", and provides new possibilities for guiding the transition of coastal urban areas. Just as the testing site of my graduation project, it has designed the transition process of each of the three conditions, as well as the symbiotic system of circular economy formed together.

For undeveloped land in the area, such as wasteland, grassland, etc., it is possible to allocate space resources in newly developed land directly based on space principles and typology strategies, build ecological networks, and integrate into the symbiotic system. However, for the adjustment or change of urban areas that have formed a spatial structure, more energy and time are needed to adapt to the new solution, and more stakeholders need to be considered.

Besides, the project provides possibilities for more jobs in the future, which can make up for the unemployment caused by the energy transition. For example, the marine culture in the port area, biogas energy stations, and the development of some emerging technologies all require a large number of people to complete. The proposal of the project not only solved the problem of local economic transformation, but also proposed a strategy to gradually restore the local ecosystems. Therefore, the landscape structure of the city could also be changed, which may also cause some social equality issues. A better living environment and facilities will increase land prices and rents and cause pressure on low-income people. Of course, the project has also considered changes on people 's lives to a certain extent. People no longer discard food waste, but collect it and put it into community biogas digesters to generate biogas; the rooftop agriculture and community agriculture allow people to get food more conveniently, which could reduce the cost of food transportation and pollution impact, but also promoted the interaction of people in the community.

From this perspective, the project has a strong societal and ethical relevance.

Aspect 5 Summary and limitation

The project also presents some limitations. Due to the limited space, bio-based solutions may cause conflicts between natural landscape, agriculture and housing development in the future. At the same time, in the early stage of project implementation, some stakeholders may not be able to accept these emerging technologies and lifestyle changes; at the same time, due to technological dishonesty, the price of renewable energy will be higher than traditional energy during the energy transition which will limit the development of the project. But in the long run, the project has greater flexibility that can deal with the uncertainties in the context of climate change.

Overall, throughout the thesis process, all the discussions and feedback have allowed me to critically reflect on my research and design process. The guidance and encouragement by Diego and Luisa, have kept me passionate and confident about the project. In addition, I also realized the importance of clear narrative, which is also the aspect that Diego emphasizes in each discussion, which can help the audience better understand the main idea of the project. Through the thesis, not only has I improved my academic research skills, but also laid the foundation for my future career.

APPENDIX

A1 BIBLIOGRAPHY
A2 OTHER DRAWINGS

A1 BIBLIOGRAPHY

Airoldi, L., Abbiati, M., Beck, M. W., Hawkins, S. J., Jonsson, P. R., Martin, D., … Åberg, P. (2005). An ecological perspective on the deployment and design of low-crested and other hard coastal defence structures. Coastal Engineering, 52(10), 1073–1087.

Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. Ecological Economics, 29(2), 293–301.

Carstensen, J., Sánchez-Camacho, M., Duarte, C. M., Krause-Jensen, D., & Marbà, N. (2011). Connecting the dots: Responses of coastal ecosystems to changing nutrient concentrations. Environmental Science and Technology, 45(21), 9122–9132.

Callaway J. C. & Zedler J. B. (2004) Restoration of urban salt marshes: lessons from southern California. Urban Ecosys. 7, 107–24.

Czyrnek-Delêtre, M. M., Rocca, S., Agostini, A., Giuntoli, J., & Murphy, J. D. (2017). Life cycle assessment of seaweed biomethane, generated from seaweed sourced from integrated multi-trophic aquaculture in temperate oceanic climates. Applied Energy, 196, 34–50.

Chícharo, L., & Zalewski, M. (2011). 10.01—Introduction to Ecohydrology and Restoration of Estuaries and Coastal Ecosystems. In E. Wolanski & D. McLusky (Eds.), Treatise on Estuarine and Coastal Science (pp. 1–5).

Convertino, M., Nardi, F., Kiker, G. A., Munoz-Carpena, R., Troccolli, A., & Linkov, I. (2013). 5.18—Epitomes of Bottom-Up Hydro-Geo-Climatological Analysis to Face Sea Level Rise in Complex Coastal Ecosystems. In R. A. Pielke (Ed.), Climate Vulnerability (pp. 267–282).

Connell D. , Lam P. , Richardson B. & Wu R. (1999) Introduction to Ecotoxicology. Blackwell Science, Oxford.

Curtin and Prellezo. (2010). Understanding marine ecosystem based management: a literature review. Mar. Pol., 34 (5) (2010), pp. 821-830

Darrel Jenerette, G., & Larsen, L. (2006). A Global Perspective on Changing Sustainable Urban Water Supplies. Global and Planetary Change, 50, 202–211.

Denner, K., Phillips, M. R., Jenkins, R. E., & Thomas, T. (2015). A coastal vulnerability and environmental risk assessment of Loughor Estuary, South Wales. Ocean & Coastal Management, 116, 478–490.

Duarte, C. M. (2009). Coastal eutrophication research: A new awareness. Hydrobiologia, 629(1), 263–269.

Faulkner S. (2004) Urbanization impacts on the structure and function of forested wetlands. Urban Ecosys. 7, 89–106.

Gerry Marten | Human Ecology—Coevolution and Coadaptation of Human Social Systems and Ecosystems. (n.d.). Retrieved 26 November 2019, from http://gerrymarten.com/human-ecology/chapter07.html

Glaser, G. (2012). Base sustainable development goals on science. Nature, 491(7422), 35–35.

He, Q., & Silliman, B. R. (2019). Climate Change, Human Impacts, and Coastal Ecosystems in the Anthropocene. Current Biology, 29(19), R1021–R1035.

Hughes, T. P., Kerry, J. T., Álvarez-Noriega, M., Álvarez-Romero, J. G., Anderson, K. D., Baird, A. H., … Wilson, S. K. (2017). Global warming and recurrent mass bleaching of corals. Nature, 543(7645), 373–377.

Iglesias-Campos, A., Meiner, A., Bowen, K., & Ansong, J. O. (2015). Chapter 3 - Coastal Population and Land Use Changes in Europe: Challenges for a Sustainable Future. In J. Baztan, O. Chouinard, B. Jorgensen, P. Tett, J.-P. Vanderlinden, & L. Vasseur (Eds.), Coastal Zones (pp. 29–49).

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., … Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society, 21(2).

Lee, S. Y., Dunn, R. J. K., Young, R. A., Connolly, R. M., Dale, P. E. R., Dehayr, R., … Welsh, D. T. (2006). Impact of urbanization on coastal wetland structure and function. Austral Ecology, 31(2), 149–163.

Li M. S. & Lee S. Y. (1998) Carbon budget for Deep Bay, eastern Pearl River estuary, China I: a mass balance study and implications for shorebird conservation. Mar. Ecol. Prog. Ser. 172, 73– 87.

Lu, Y., Yuan, J., Lu, X., Su, C., Zhang, Y., Wang, C., … Sweijd, N. (2018). Major threats of pollution and climate change to global coastal ecosystems and enhanced management for sustainability. Environmental Pollution, 239, 670–680.

Meyer, H., Bregt, A. K., Dammers, E., & Edelenbos, J. (2015). New perspectives on urbanizing deltas: a complex adaptive systems approach to planning and design. Amsterdam: MUST Publishers.

Millennium Ecosystem Assessment (Program) (Ed.). (2005). Ecosystems and human well-being: Wetlands and water synthesis: a report of the Millennium Ecosystem Assessment. Washington, DC: World Resources Institute.

N. Kabisch, N. Frantzeskaki, S. Pauleit, S. Naumann, M. Davis, M. Artmann, A. Bonn. Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society, 21 (2) (2016), p. 39, 10.5751/ES-08373-210239.

Nathwani, J., Lu, X., Wu, C., Fu, G., & Qin, X. (2019). Quantifying security and resilience of Chinese coastal urban ecosystems. Science of The Total Environment, 672, 51–60.

Ohl, C., Johst, K., Meyerhoff, J., Beckenkamp, M., Grüsgen, V., & Drechsler, M. (2010). Long-term socio-ecological research (LTSER) for biodiversity protection – A complex systems approach for the study of dynamic human–nature interactions. Ecological Complexity, 7(2), 170–178.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. Science, 325(5939), 419–422.

Osland, M. J., Enwright, N. M., Day, R. H., Gabler, C. A., Stagg, C. L., & Grace, J. B. (2016). Beyond just sea-level rise: Considering macroclimatic drivers within coastal wetland vulnerability assessments to climate change. Global Change Biology, 22(1), 1–11.

P. Regnier, P. Friedlingstein, P. Ciais, F.T. Mackenzie, N. Gruber, I.A. Janssens, G.G. Laruelle, R. Lauerwald, S. Luyssaert, A.J. Andersson, S. Arndt, C. Arnosti, A.V. Borges, A.W. Dale, A. Gallego-Sala, Y. Godderis, N. Goossens, J. Hartmann, C. Heinze, T. Ilyina, F. Joos, D.E. LaRowe, J. Leifeld, F.J.R. Meysman, G. Munhoven, P.A. Raymond, R. Spahni, P. Suntharalingam, M. Thullner. (2013). Anthropogenic perturbation of the carbon fluxes from land to ocean. Nat. Geosci., 6 (8) (2013), pp. 597-607.

Sanders, J., & Van der Hoeven, D. (2008). Opportunities for a Bio-based Economy in the Netherlands. Energies, 1(3), 105–119. https://doi.org/10.3390/en1030105

Staffas, L., Gustavsson, M., & McCormick, K. (2013). Strategies and Policies for the Bioeconomy and Bio-Based Economy: An Analysis of Official National Approaches. Sustainability, 5(6), 2751–2769.

WCED, 1987. WCED Our Common Future. World Commission on Environment and Development. Oxford University Press, Oxford (1987)

Xiao, X., Agusti, S., Lin, F., Li, K., Pan, Y., Yu, Y., … Duarte, C. M. (2017). Nutrient removal from Chinese coastal waters by large-scale seaweed aquaculture. Scientific Reports, 7(1), 1–6.

X.G. Xu, X. Li, M.C. Chen, X.Y. Li, X.F. Duan, G.R. Zhu, Z. Feng, Z.G. Ma. (2016). Land-ocean-human interactions in intensively developing coastal zone: demonstration of case studies Ocean Coast Manag., 133 (2016), pp. 28-36.

Yi, L., Chen, J., Jin, Z., Quan, Y., Han, P., Guan, S., & Jiang, X. (2018). Impacts of human activities on coastal ecological environment during the rapid urbanization process in Shenzhen, China. Ocean & Coastal Management, 154, 121–132.

Zhai, T., Wang, J., Fang, Y., Qin, Y., Huang, L., & Chen, Y. (2019). Assessing ecological risks caused by human activities in rapid urbanization coastal areas: Towards an integrated approach to determining key areas of terrestrial-oceanic ecosystems preservation and restoration. Science of The Total Environment, 135153.

Website:

http://kaart.edugis.nl/.
https://www.atlasleefomgeving.nl/.
https://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/home.
https://www.copernicus.eu/en.
https://mrdh.nl/over-mrdh.
https://www.rotterdam.nl/.
https://www.portofrotterdam.com/en.

Report:

A. Myserli, [Re]Natured Economy: From pollutants to productive landscapes, 2018.

C. Liu, From resistance to coexistence:Towards a more integrated coastal defence system in city of Ostend by adapting nature-based solutions, 2019.

L. Lijdsman, Turning the tide: Inverting Ecosystem Service Assessment as a Planning and Design Instrument for Decision-Makers to Develop Sustainable Eco-Based Solutions in an Uncertain Region, 2019.

A2 OTHER DRAWINGS

RESEARCH ON ROTTERDAM

Urban growth

Rotterdam's history is one of creation and destruction, with generous doses of innovation and experimentation thrown into the mix. The Netherlands' second city has come a long way since its establishment as a fishing village: from being one of the bases of the Dutch East India Company, the world's first multinational corporation, to developing into Europe's busiest shipping port.

Overall, the rapid expansion of Rotterdam is inseparable from the opening of the Nieuwe Waterweg and the railway crossing the Maas River (connecting Rotterdam with the southern Netherlands in 1877). The connection of Maas's south bank has allowed more development in the south.

From the collage, we can see the process of Rotterdam from the original small island to the largest port city in Europe. Until the 20th century, the port and city were expanding rapidly, the river landscape had undergone tremendous changes, and the process of soil and land sealing had been accelerating. Now that traditionally strong sectors of the Dutch economy, such as the chemical industry, are moving to low-wage countries, the port of Rotterdam is no longer welcomed by investors. While urbanization continues, limited space, fragile ecosystem performance, and hydrological threats have become major obstacles, and Rotterdam faces challenges at the crossroads of economic transformation.

3x3x3 analysis

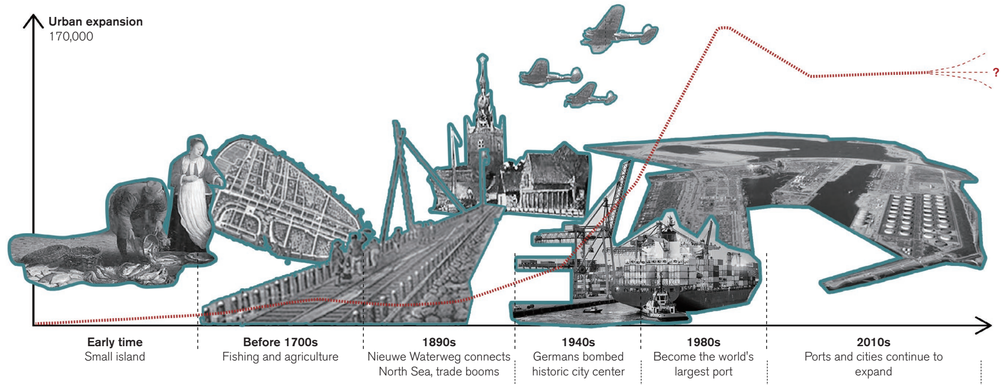
On the mesoscale, I chose the years 1900, 1990 and 2018 to analyze the temporal-spatial process and dynamics of Rotterdam's development, as the city expanded the fastest during this period. Fig.4.5.1shows the matrix of the layers of the landscape, infrastructure and occupation in three different time. In general, from all levels of the landscape, we can see how the landscape was eroded by the urban growth.

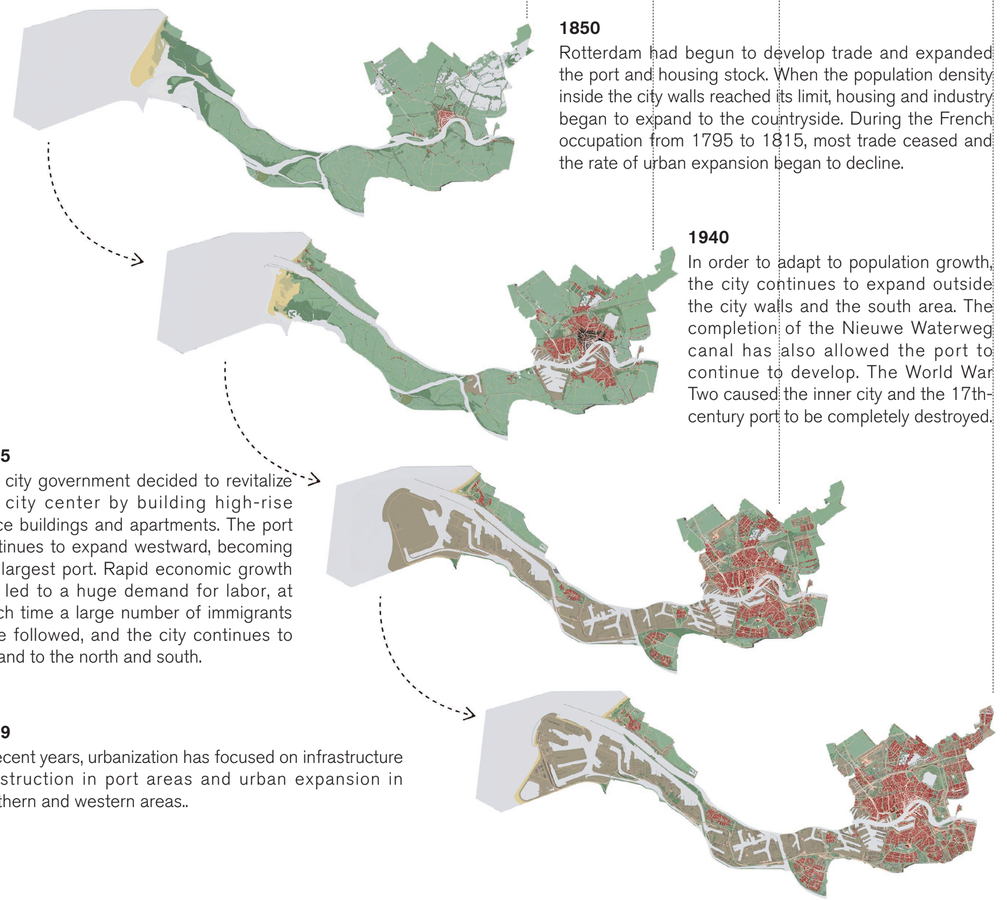
In 1900, the landscape and water bodies around Rotterdam were generally continuous. The surface was dominated by open fields grassland and agricultural vegetation, and there were still many water bodies around the city. By 1990, the landscape layer had become significantly dispersed. In the process, the area of vegetation (port area) on both sides of the river bank had fallen sharply and transformed into infrastructure and occupation layers.

By 2018, the landscape layer had further eroded, and the landscape and water in the city was replaced by closed urban paving, and more waterway was introduced in the port. As for the evolution of Infrastructure and occupation layer, the former section already has a detailed explanation. Here will not repeat it.

Overall, the Rotterdam area is almost completely occupied by these two layers. The continuous landscape change from inland to coastal has been completely broken. Landscape erosion and large-scale industrial activities in the port area have also reduced the quality of water discharged into the North Sea through the Nieuwe Waterweg. The crowded built-up area around the waterfront made the city exposed to the sea without buffer area, and the soil sealing in the occupation layer caused more frequent surface water flood.

Urban growth





1850
Rotterdam had begun to develop trade and expanded the port and housing stock. When the population density inside the city walls reached its limit, housing and industry began to expand to the countryside. During the French occupation from 1795 to 1815, most trade ceased and the rate of urban expansion began to decline.

1940
In order to adapt to population growth, the city continues to expand outside the city walls and the south area. The completion of the Nieuwe Waterweg canal has also allowed the port to continue to develop. The World War Two caused the inner city and the 17th-century port to be completely destroyed.

1975
The city government decided to revitalize the city center by building high-rise office buildings and apartments. The port continues to expand westward, becoming the largest port. Rapid economic growth has led to a huge demand for labor, at which time a large number of immigrants have followed, and the city continues to expand to the north and south.

2009
In recent years, urbanization has focused on infrastructure construction in port areas and urban expansion in southern and western areas..

Source: Map created by author. Based on Mapping History and Archipelago of Knowledge, Openfabric.

3x3x3 analysis

Occupation

1900

1990

2018

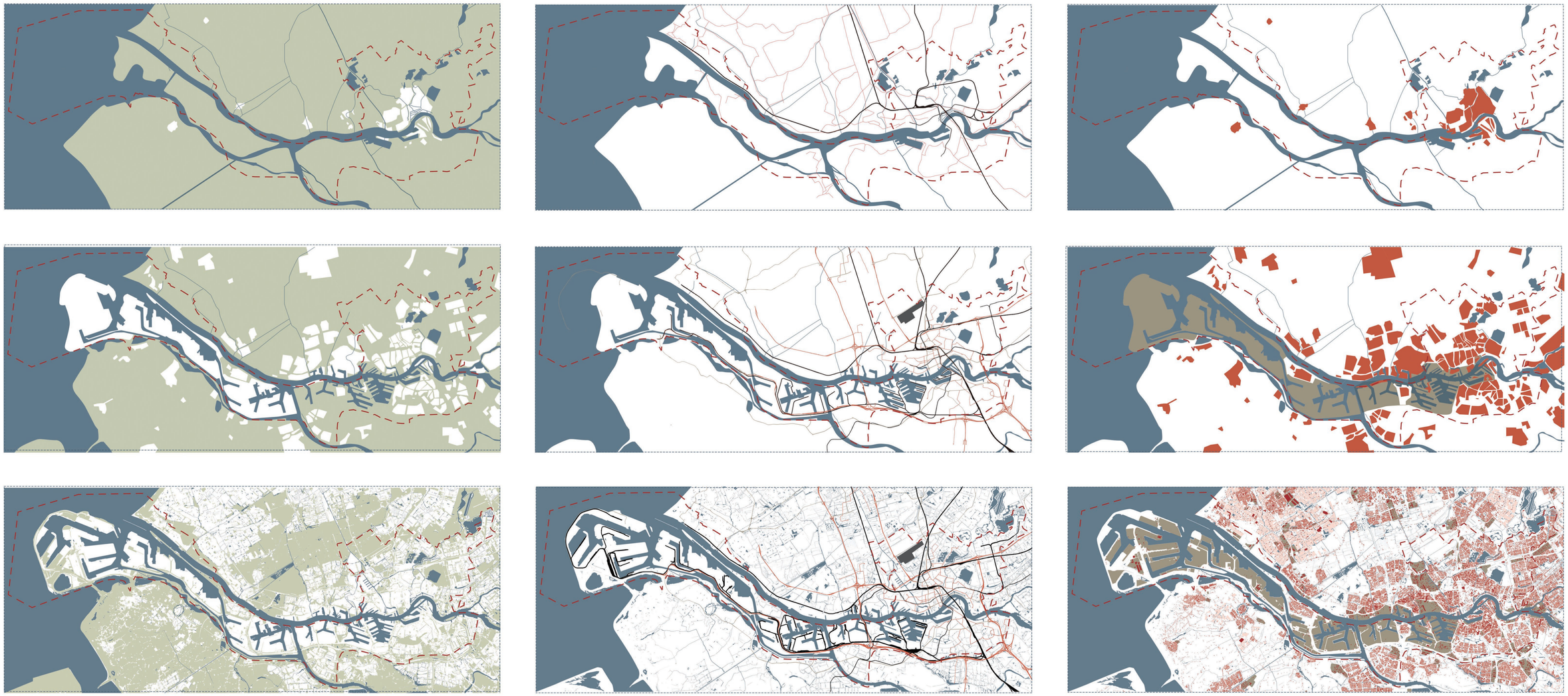
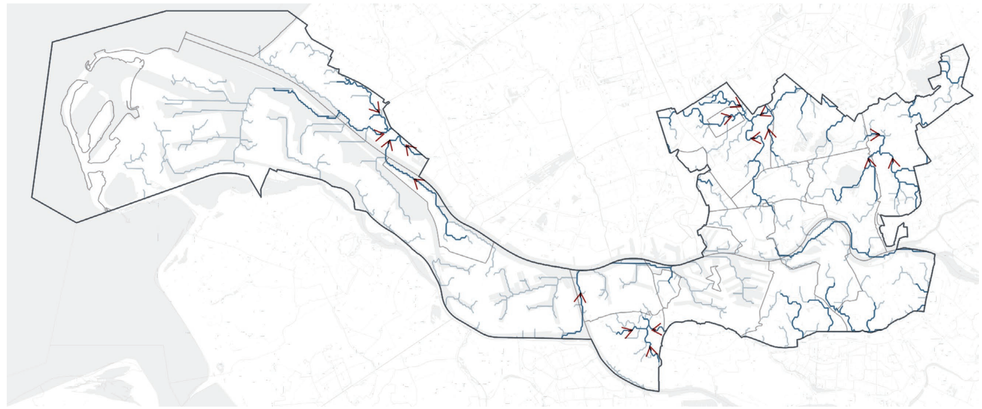


Fig.5.1.2 3x3x3 analysis. Source: Map created by author. Based on the information from topotijdreis.nl, online maps and spatial data.

Pluvial flood



N 0 km 5 km

Collection runoff
Runoff

Runoff. Source: Map created by author. Data from: webgis.com



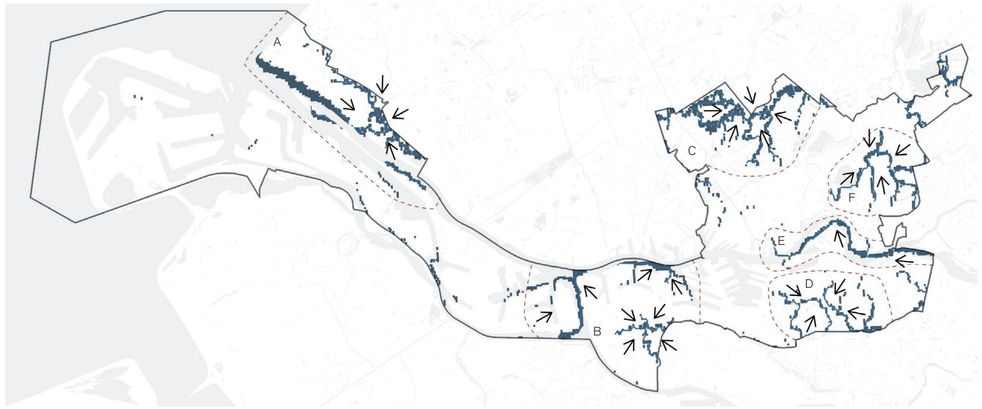
N 0 km 5 km

Water accumulation
Low High

Flood area

pluvial flood area. Source: Map created by author. Data from: webgis.com

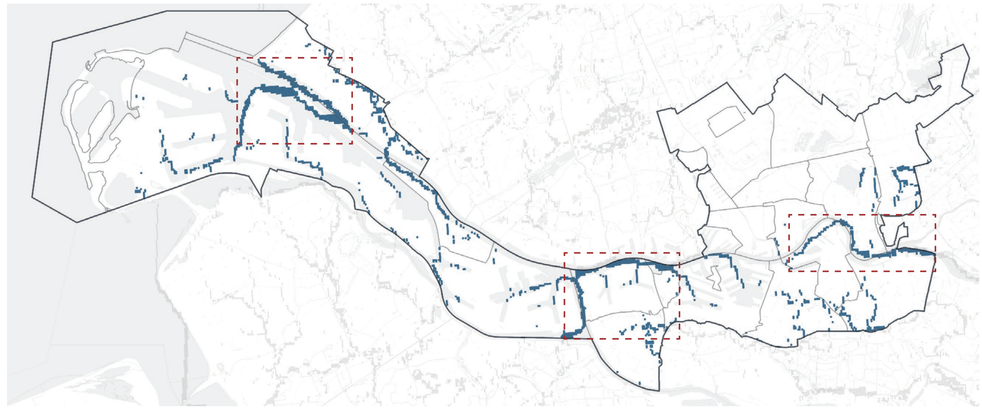
Summary: Catchment Units



N 0 km 5 km

Catchment units
Surface water flow direction
Flood risk area

Define the catchment units: Map created by author based on the study of Rotterdam hydrology.



N 0 km 5 km

Flood area

Fluvial flood area. Source: Map created by author. Based on the information from online maps and spatial data.

Jun Chen
MSc Architecture, Urbanism and Building Sciences - Track Urbanism
Faculty of Architecture and the Built Environment
TU Delft, The Netherlands