THE RESILIENT PORT:
Toward a social-ecological integrated estuary and Rotterdam port transformation

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Image of Rotterdam Port
Author BaokunWei
Source: Google Maps

Resilient Rotterdam Port

Toward a social-ecological integrated estuary and Rotterdam port transformation

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MSc urbanism track
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*All images without source of referenece are drawed by author

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Acknowledgement

The final year project is a quite long journey with feelings of wondering, struggling, happiness and confusion. The journey is about the Rotterdam port. Even though I have done several projects that refer to Rotterdam, I still continuously get new insights from the research and studies. During the process, I have encountered many obstacles and difficulties, and the Covid-19 makes tutorials even harder than ever before. However, I still do enjoy the time that I spent on the Urban ecology and eco-cities studios. I always viewed it as the opportunity for me to bridge the knowledge between urban planning and design and landscape. Thanks to Dr.ir. N.M.J.D. (Nico) Tillie and Ir. F.D. van Loon, it makes my dream of co-working with landscape comes true.

I would give my profound gratitude to my first mentor, Ir. F.D. van Loon for his patient and valuable guidance and suggestion. He is truly in help with the aspects of design and presentation. In addition, he always encourages me to share the insights with other students during Corona time. Without his support and help, the journey will end nowhere. In addition, my gratitude to Dr. D. A. Sepulveda Carmona for his constant support and provision of useful materials. He also provides very critical suggestions on my project directions and pushes me for advances. I do appreciate and remember the time and working experience with him.

I would specially thank my fellow student Ning Cai, for the time we have experienced together in the same lab. The discussion inspired me a lot and relieved my stress. To Yangzi, Chen Gao, Taokong and Zichuan Lu, the online zoom meeting keeps me focusing on my study and finally the time we spent togther will become treasure in the future.

Last but not least, I would like to be with my family and girlfriend. They always trust me and are there for me when I need help. Thanks to my parents providing the financial support for my master. Moreover, my girlfriend accompanied me during the lockdown time and the inspiration, encouragement and help that she offered to me always motivated me to move forward.

Abstract

The project envisioned a social-ecological resilient waterfront for Rotterdam. By focusing on the outer dike area of Rotterdam, it aims to protect the port from flooding ,and at the same time create more nature habitat for biodiversity. With creating a resilient river, it can re-realize the role of industry and reconnect them into resource flows, in the end, it will formulate a healthy and liveable social-ecosystem at New River Mass.

The vision of the River Mass is firstly to restore the riverfront as the place of ecological importance and also aplace for working, living and recreations. It should be a place for people to come and meet together. In order to achieve that, it implies four strategies including protect, restore, reconnect and grow.

Stadhaven is the programmes for applying proposed strategies. In fact, the stadhaven is an area in transition. Over the coming decades, new links between the city and port will be constructed in stadhaven to bridge the port and city, at the same time, develop the economy. It is vulnerable to high water levels since it is part of old harbour complex. The area is on the water which is subject to tidal dynamics and could have transition between River Mass and inner city distcit. Based on that, the systematic strategies could start from the aspects of Nature(sedmiation), densification and open space and access.

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01.

Introduction



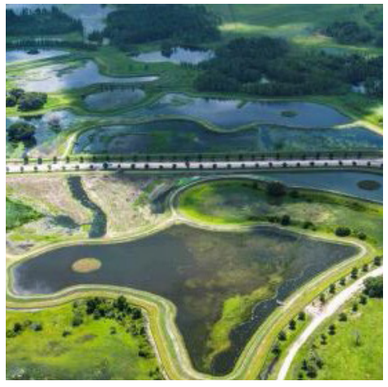
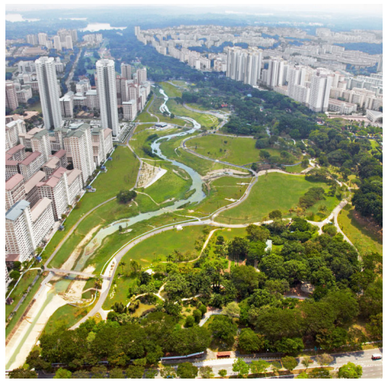



Figure1.1: Examples of Green Infrastructure to Provide Ecosystem Services:

Benthemplein water square, ROTTERDAM (Top Left);TANGHE RIVER PARK - QINHUANGDAO CITY, CHINA(Top Right); Water Reuse - FLORIDA, USA(Bottom Left);Bishan-Ang Mo Kio Park - SINGAPORE(Bottom Right);

Fancination

The coastal urban delta is a place where has highly population concentration and advanced economy. With the acceleration of urbanization, coastal landscape area constantly changed that the infrastructure for housing, commercial, tourism and industry has been increased. The result of that is the loss of coastal green space. Due to that, the nature habitat for biodiversity has sharply decreased. Both of terrestrial and water ecosystem are degraded to varying degrees. Deterioration of the ecosystem and lack of ecosystem services has exacerbated the negative impacts of climate change, including sea-level rise and increased extreme weather.

These changes pose threats to urban growth which formulate a negative cycle as result. Therefore, it is not only beneficial but also necessary to realize a sustainable and resilient urban landscape for future transition.

Personally, I am very interested in how to study the transition of coastal delta city based on nature-based solutions. Taking that as a starting point, it is essential to consider how to realize a social-ecological delta, which containing a sustainable productive landscape, a robust ecosystem, sustainable and shared mobility and circular economy. How to achieve these goals by creating a series of productive, future proof and attractive landscapes, guiding future urban metabolic flows for food, water, energy or sedimentations. It could be a new way and method to develop the urbanism.

Figure 1.2: Delta Environment For Coastal Delta City Rotterdam ,made by author

Context

Rotterdam is the second largest city in the Netherlands and one of the most important cities in the province of South Holland. It is located at the mouth of Nieuwe Mass channel of the Rhine-Meuse delta leading to the North sea. Regionally, the Rhine-Meuse delta is the significant composition of the North sea region in terms of socio-economic and environmental aspects. The long term urbanization process of the delta cities influences the change of landscape and open agricultural field. Gradually, they are covered by urban paving and infrastructure, imposing ecological impact on the region. As the consequence, it is vulnerable to climate change. Rotterdam, as the part of the region, also has the tension between urban development and the natural system. The conflicts are obvious at the interface between water and the city.

Rotterdam is the port city. Most of Rotterdam, including the main port, is located outside the dyke instead of the city center which is behind the dyke and below sea level. According to the relative data, the lowest point in Rotterdam is in the Alexanderpolder area where is 6.67m below NAP.(De Urbanisten,2015).

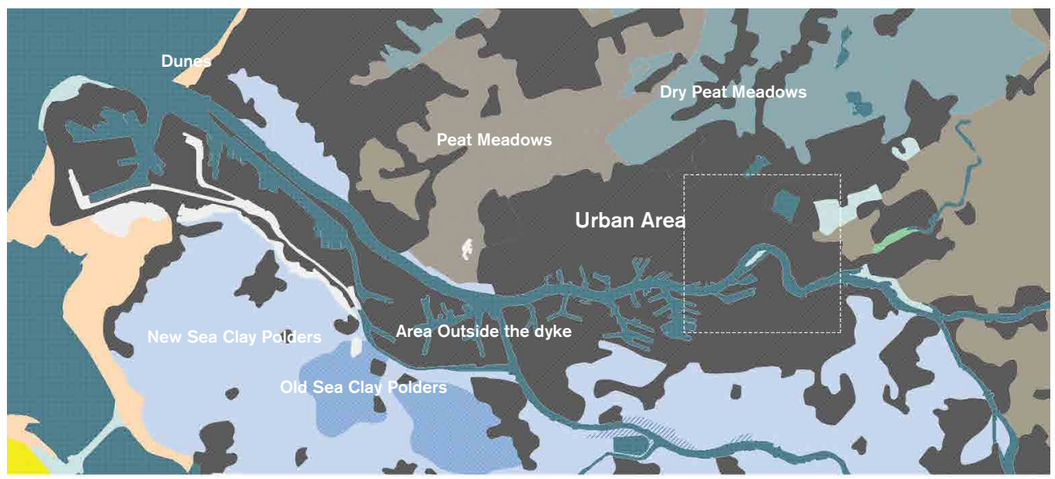


Figure 1.3: The landscape composition of Rotterdam ,Map Made by Gary Gilson. from Rotterdam the story of the landscape

(STAGE1:1850-1940)

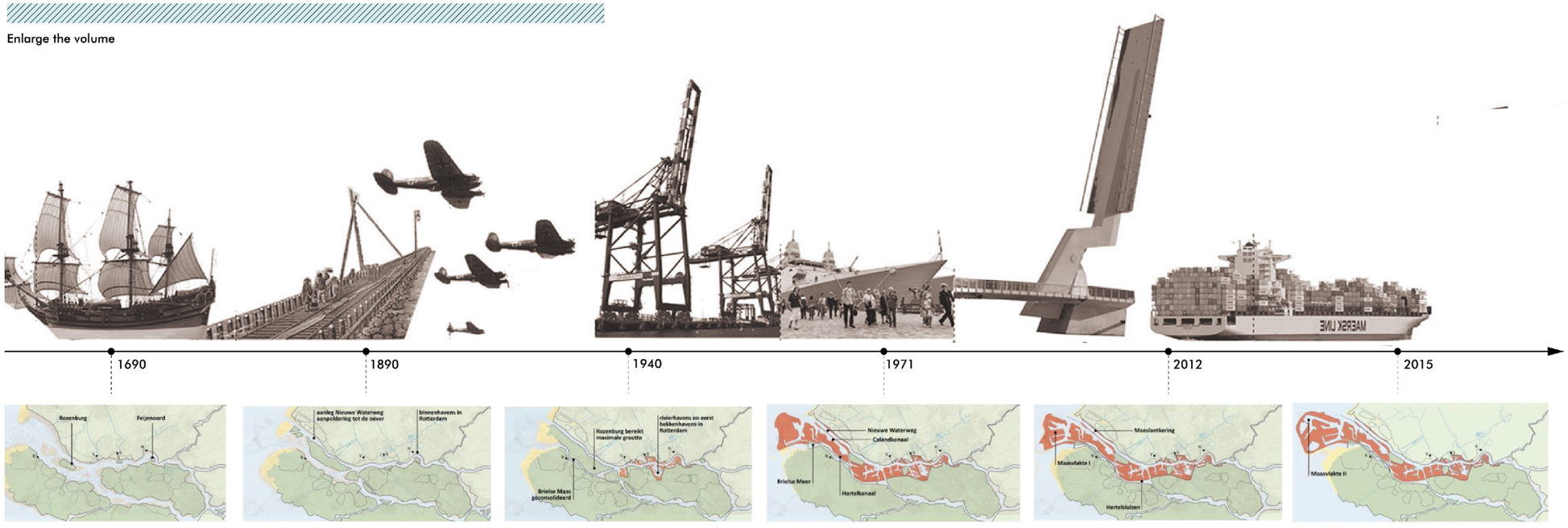
Enlarge the volume

(STAGE2:1940-1975)

Improve the quality

(STAGE3:1975-2015)

Transformation and Integration



Small-scale reclamation, varying influence of sea and river

Construction of a new waterway ,small landfall polders,harbors

Landing polders, canal ports

Completion of Europoort / caland/hartelkanaal,damming Brielse Mass

Expansion of the port with Mass valakte1,Hartelkanaal,damming Brielse Maas

Expansion of the port with Massvlakte2

Rotterdam is the port city. Most of Rotterdam, including the main port, is located outside the dyke instead of the city center which is behind the dyke and below sea level. According to the relative data, the lowest point in Rotterdam is in the Alexanderpolder area where is 6.67m below NAP.(De Urbanisten,2015). In Rotterdam, the water level has been strictly managed in order to keep the polder city dry. In history, the river has played an important role for Rotterdam development. The landscape in Mass-Rhine delta was an estuary. It is a dynamic landscape characterised by gradual transition from saltwater to freshwater. After 1896, the construction of a new waterway opened the largest link to allow the sea-relative activities to reach Rotterdam. In result, the port area has expanded from east to west with the accomplishment of Maasvlakte 2. Nowadays, the port is mainly for oil and cargo operations and manufacturing activities. Originally, the estuary and river are dynamic because they provide varied conditions for flora and fauna due to the erosion and sedimentation under the influence of tide. it has gradually disappeared with the process of Rotterdam port development.

Figure 1.4: the timeline of Rotterdam port and estuary development, made by author

Reference: River as tidal park (De urbanisten,2014)

02.

Problem Field

Promblem statement

Currently, the Rotterdam, especially the port of Rotterdam landscape has been dramatically transformed and changed through a long temporal process. The port expansion, industrial development, and urbanization take place in natural habitats. Besides, these human activities also impose pressure on natural habitat and then destroy the ecosystem services. As a result, the vulnerable ecosystem could not provide services to adapt to climate change(expressed mainly as flooding issues in Rotterdam Port). in fact, the region will be a disaster if flooding happens which also gives threats to city development.

On the other hand, the river Mass service docks and industry and they create enormous economic values. However, other values, such as ecological value, recreational value and densification value have been missed. There are numerous potential for future port development. The Rotterdam port and city authority are seeking the opportunities to develop the stadhaven area as a place for education, technology and living center to link the city with its port. Besides, at the current stage, the port is also at the critical point of energy transition which leaves more space for future development. In summary, we need to consider a systematic transition of the Rotterdam port landscape that combines the city development and nature restoration together toward renewable energy, slow mobility, resilient ecosystem and circular economy. In the long run, a resilient river vision could be realized.

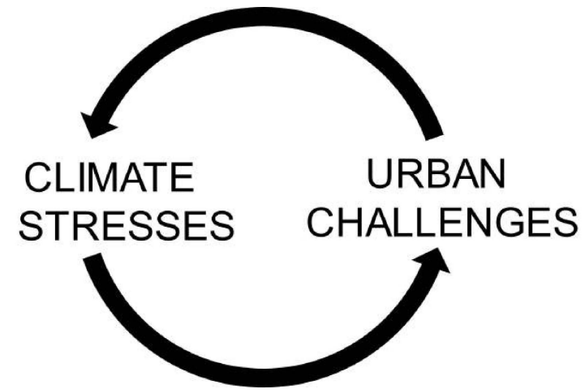


Figure 2.1: the diagram of the problem statement ,made by author

Figure 2.2: Flooding issues caused by climate change in Rotterdam:

pluvial flooding in the urban area (left top); high river discharge problem(left bottom); sea level rise by climate change in Rotterdam(right)

photo from Rotterdam Climate adaptation strategy (De Urbanisten,2015) and Google Images

Threat 1: Climate Change and Flooding Issues

Coastal flooding

The Netherlands is significantly sensitive to the effect of sea level rise. Referring to data, sea level in the Southern part of North Sea will increase by 25cm to 80cm in 2071-2100 than 1981 -2010. Until 2100, it is projected that rising height will reach about 100 cm. After the disastrous floods in 1953, the Netherlands initiated the delta work to protect the entire region from floods and storms. Topographically, the urban areas of the delta are concentrated on the area below sea level and the economic loss will be increased enormously because of that. In that case, the sea defense should be improved in terms of strength and height to accommodate future development. The coastal defensive system need to take more flexible and adaptive measures to deal with threats.

Puvial Floodings

Based on data, the annual rainfall in the Netherlands has increased annually from 690mm to 874mm increased by 27%. Moreover, the coastal areas have taken the largest percentage, from 30%-35%, about 200 to 250mm. From the figure 2.2, it shows the trend that annual precipitation has continually increased during the period of 1910 to 2017. In addition, climate change leads to warmer temperature, which will bring the humid air for high perception in the future. The KNMI reflects that the intensity of rainfall will increase 14% with each degree of temperature rise. In South Holland, the rainfall pattern indicates that the downpour concentrates during August to December. Compared with coastal flooding, the flooding caused by high intense rainfall causes damage to public space and building, and the agricultural sector in the short term. In Rotterdam, the pluvial flooding is normally serious in the compact urban area with hard paving, insufficient drainage network and soil condition. However, it should be noted that New waterway affects the most of the river discharge from Mass and Rhine. the extreme rainfall may cause potential flooding.

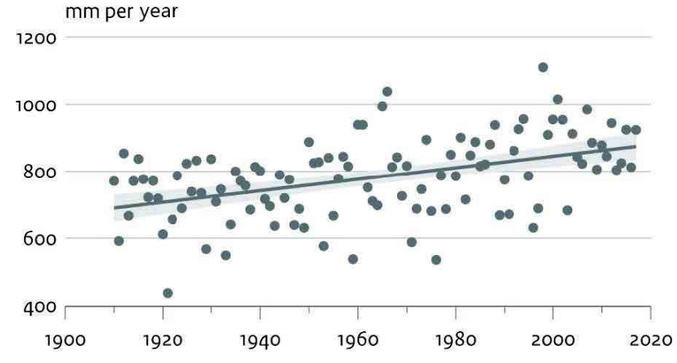


Figure 2.3: Annual precipitation trends in South Holland. Source: www.clo.nl/indicatoren/nl0508-jaarlijkse-hoeveelheid-neerslag-in-nederland.

Topgrahpy

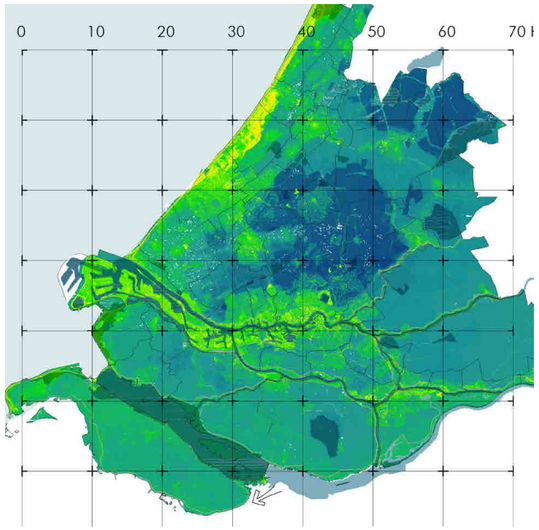
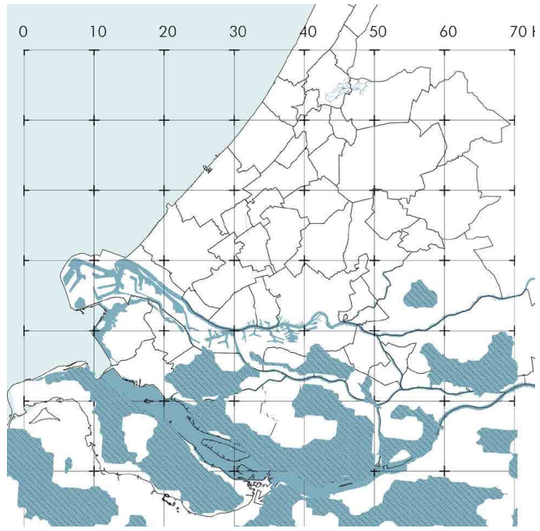


Figure 2.4: The topography of Southholland region,
Map made by auther, Data from:nationaalgeoregister.

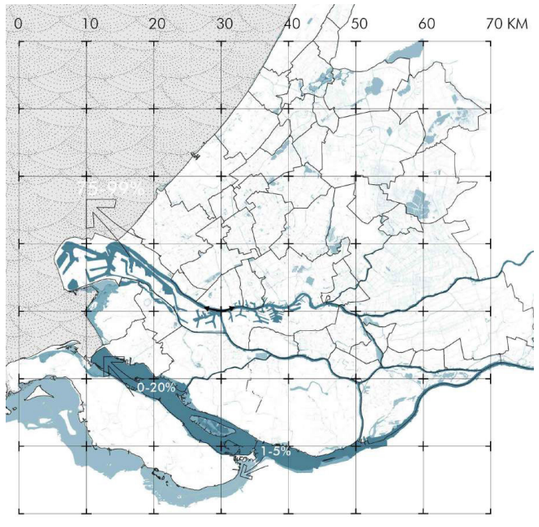
Flood Event



Flooded area from 1953

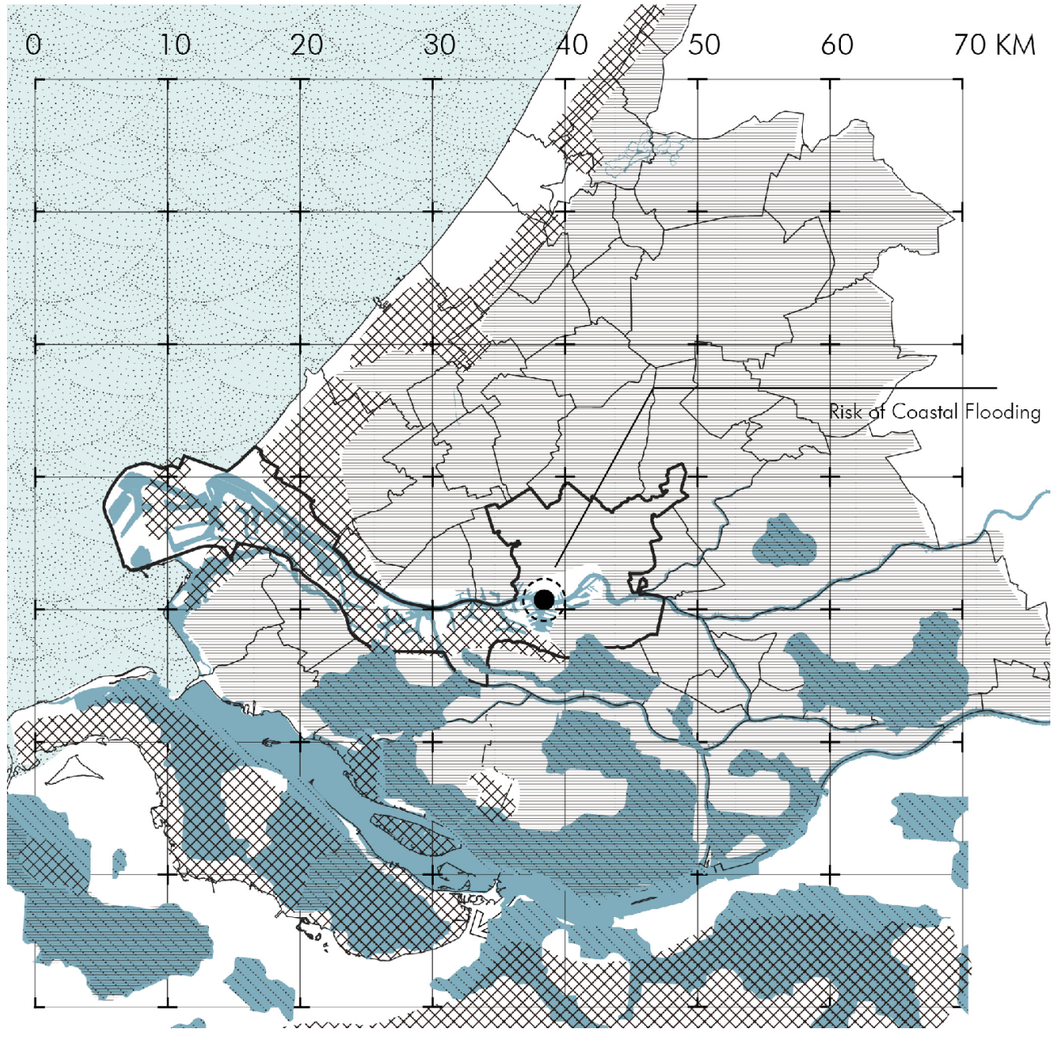
Figure 2.5: the record of flooding event in delta region, Map made by auther, Data from:nationaalgeoregister.nl.

River Discharge



Tidal river in estauary

Figure 2.6: the river discharge in the delta, Map made by author
,Data from:nationaalgeoregister.nl.



Flooded Area
Area above sea level
Area below sea level

Figure 2.7: The conclusion of delta flooding issue, made by author

Figure 2.8: the surface of Rotterdam port, photoed from Google Images

Threat 2: Ecosystem Deterioriation

Human activities and climate change have a negative impact on the natural environment and ecosystems of Delta. These are mainly manifested into two aspects: water pollution and soil condition(these two aspects are interrelated with each other).

Water Quality

The water problems in the delta region are focused on three aspects: salinization of groundwater, surface water pollution and seawater intrusion. Firstly, the groundwater salinization is the result of agricultural development. The green houses and agriculture fields require large amounts of freshwater for irrigation, leading to a shortage of groundwater .Secondly, the excessive use of pesticides and fertilizers leaks the chemical element such as N or P elements to the water bodies. This will cause water eutrophication problems. As mentioned before, the delta region is highly influenced by climate change, one of the most influential factors is sea level rise. In result, the rising sea water will infiltrate into rivers and groundwater with tidal effects. Due to that, the water quality into the urban system will decresed which will directly influence the flora and fauna dependent on it. In conclusion, in the future, the availability of freshwater will decrease and the water problem such as salinization and eutrophication need to be taken countermeasures.

Soil Condition

soil condition combines with water together in the delta region. The soil is also very significant for both nature and urban development. in terms of the soil issues, it could be summarized by soil subsidence, soil sealing, and salinization problem. In terms of soil subsidence, the direct reason for it is insufficient groundwater. In addition, climate change triggers an increase in extreme weather. The high intense precipitation normally concentrates on short term while the dry condition leads to further compaction and subsidence of subsoil. Thus, the excessive rainwater has not enough time to infiltrate in subsoil. In addition to salinization and subsidence, the soil sealing is the essential issue that influences the ecosystem. Based on European Environment Agency(2019), the definition of soil sealing is that covering the ground by an impermeable material. In fact, the hard paving area will block the natural process that occurs in the soil and impacts the path of wildlife. As it shows in the maps, much of the delta, including most of Rotterdam, has been paved by hard surfaces. it damages the various processes, like soil storage, water infiltration, and transformation,causing ecological problems such as flooding, water pollution.

In conclusion, most distinguishable ecological problems happen with water and soils. we need not only to provide space for water but also find ways to remediate and restore the water and soil ecosystem.

Water Quality

Groundwater Salinization

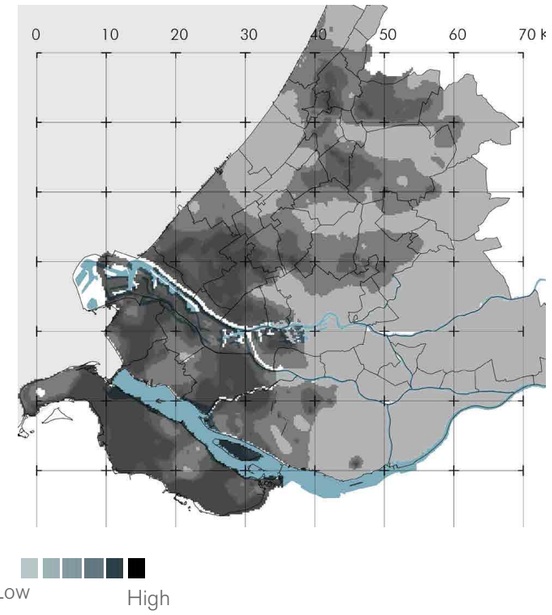


Figure 2.9: Water quality for coastal delta city Rotterdam ,Made by author, Data from:nationaalgeoregister.nl.

Water Pollution

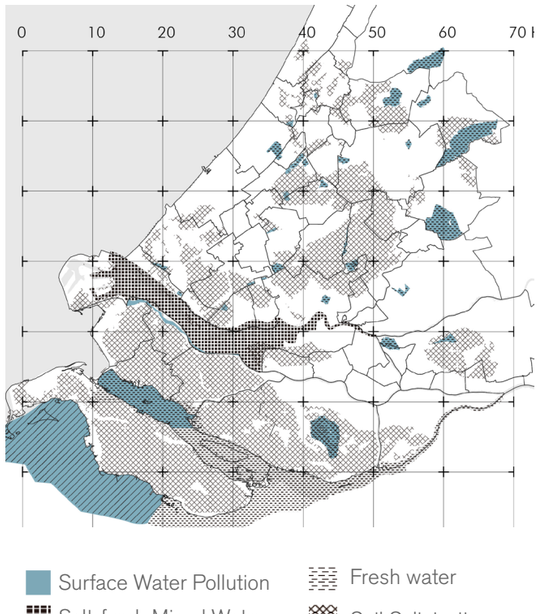


Figure 2.10: Water quality for coastal delta city Rotterdam, Made by author, Data From: nationaalgeoregister.nl.

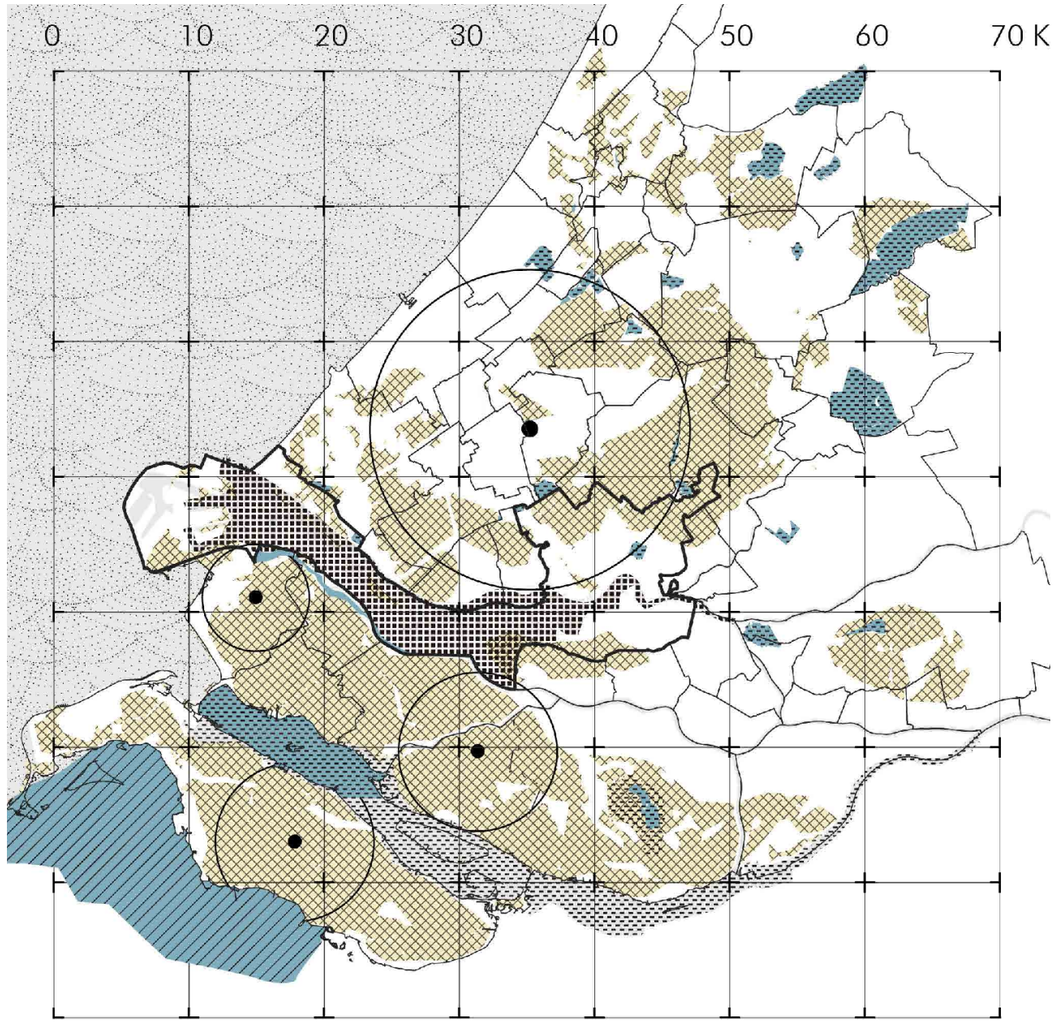


Figure 2.11: Conclusion of water quality, made by author

Soil Condition

Subsidence

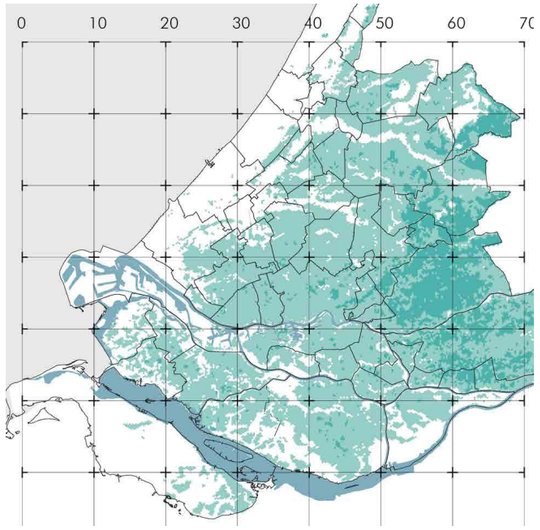


Figure 2.12: Soil condition for coastal delta city Rotterdam, Made by author Data from: nationaalgeoregister.nl.

Soil Sealing

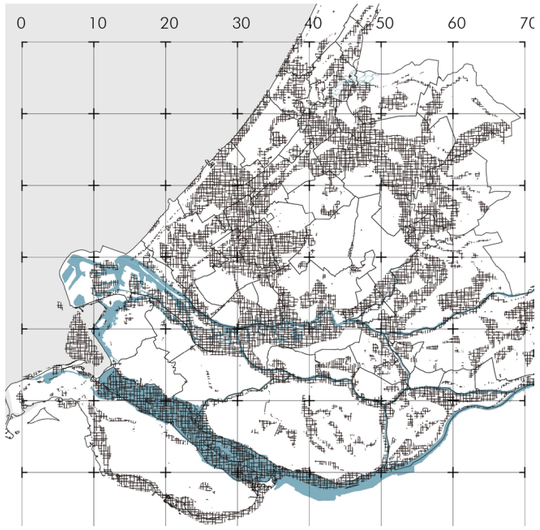


Figure 2.13: Soil condition for coastal delta city Rotterdam, Made by author Data from:nationaalgeoregister.nl.

Salinization

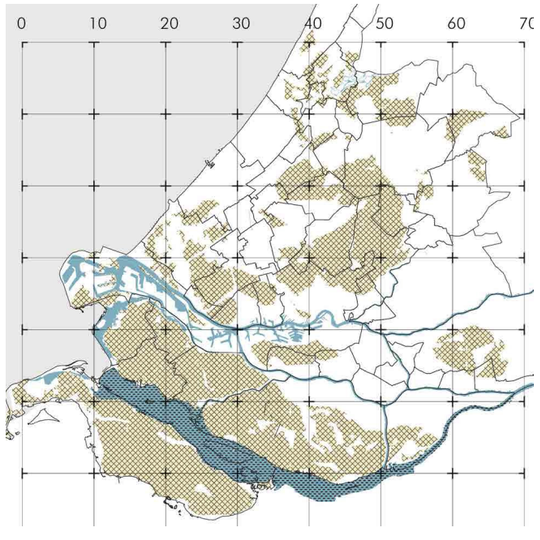


Figure 2.14: Soil condition for coastal delta city Rotterdam, Made by author Data from:nationaalgeoregister.nl.

Soil Pollution

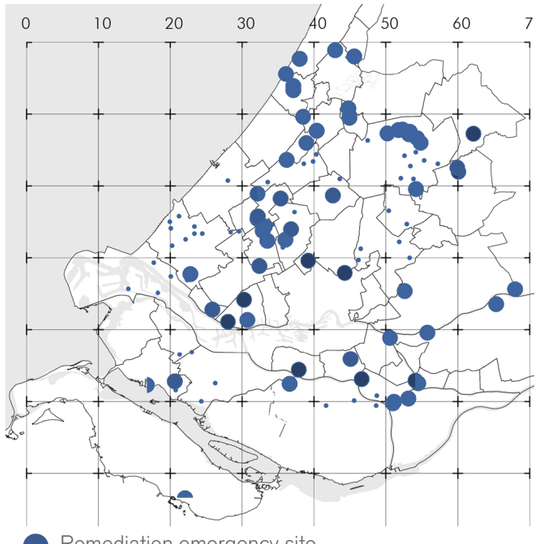


Figure 2.15: Soil pollution for coastal delta city Rotterdam,Made by author, Data from:nationaalgeoregister.nl.

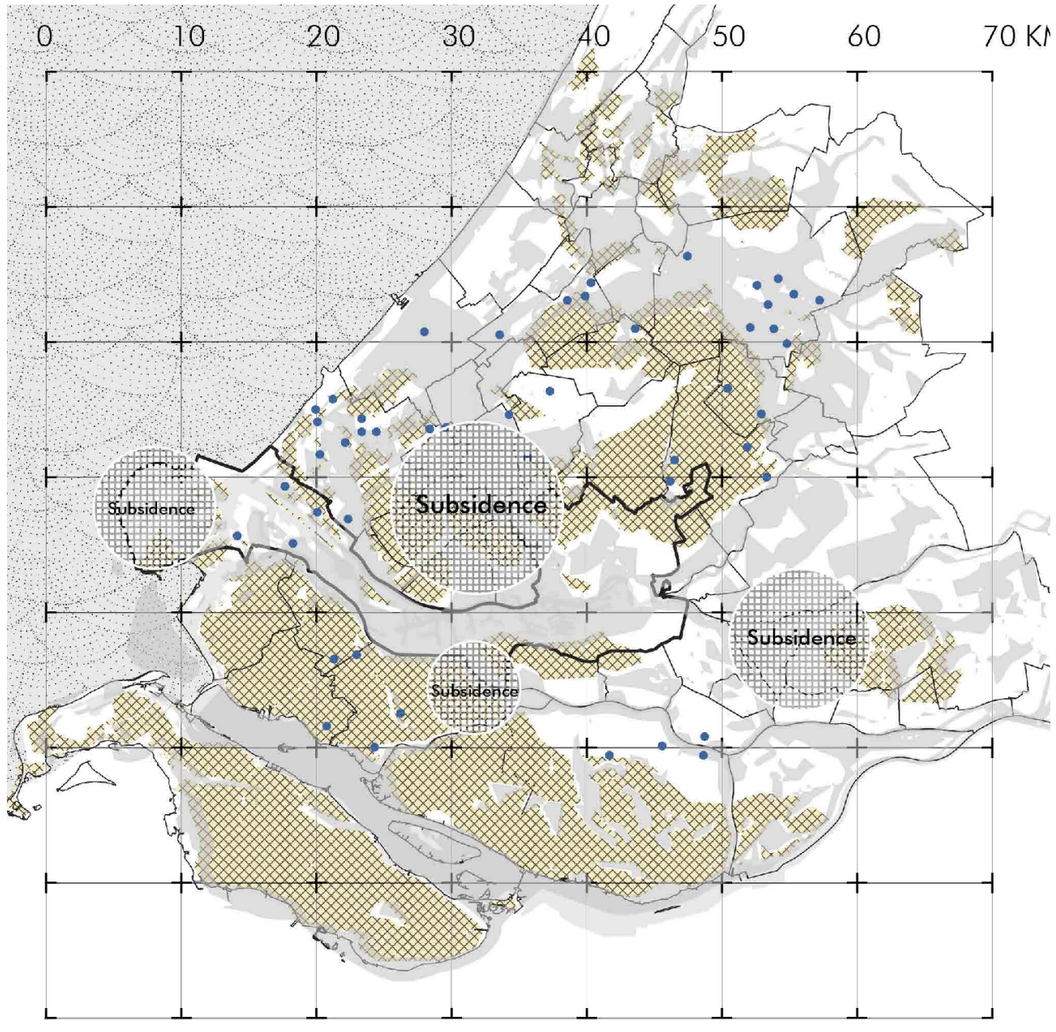


Figure 2.16: Soil condition conclusion map for delta city, made by author

Without Natural system, Rotterdam lacks of ecosystem services, the negative cycle generates

Can we imagine a new resilient, adaptive and sustainable urban development pattern for Rotterdam, so called “Soical-ecological integration”

Figure 2.17: Diagram from the problem statment toward the desired paragidm, made by author

03.

Methodology

Abstract

This chapter will explain how planning approach could be used to apply in this research by framing the research domains that elaborates the research trajectory, designing various methods to explore proposed research questions and considering what kinds of outcomes could be achieved through the process. It adopts design as a tool to help generate the additional knowledge about social-ecological integration in the coastal port area. This research method combines different methods, techniques and analysis from both natural sciences(quantitative nature) and humanities(qualitative nature), rooting in a pragmatic worldview, which is not" committed to any one system of philosophy and reality"(Creswell,2014,p.11). Since the research discusses the transformation of Rotterdam Port, it concentrates on the notions of transformative perspective from transition theory and evolutionary planning and governance to indicate the transformation process of the project.

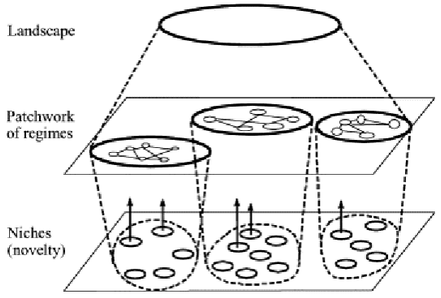


Figure 3.1: Multiple levels as a nested hierarchy(Source: Geels,2002:1261)

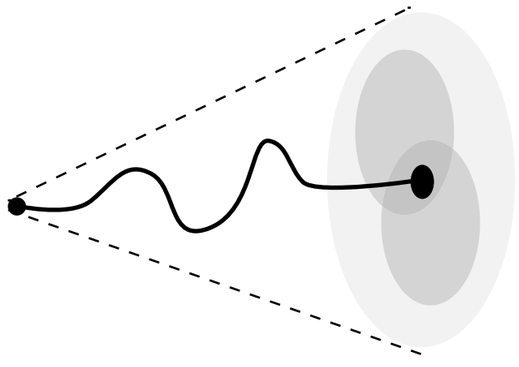


Figure 3.2: Achieving long term goals nowithstanding uncertainties(Source: Agliati,2020)

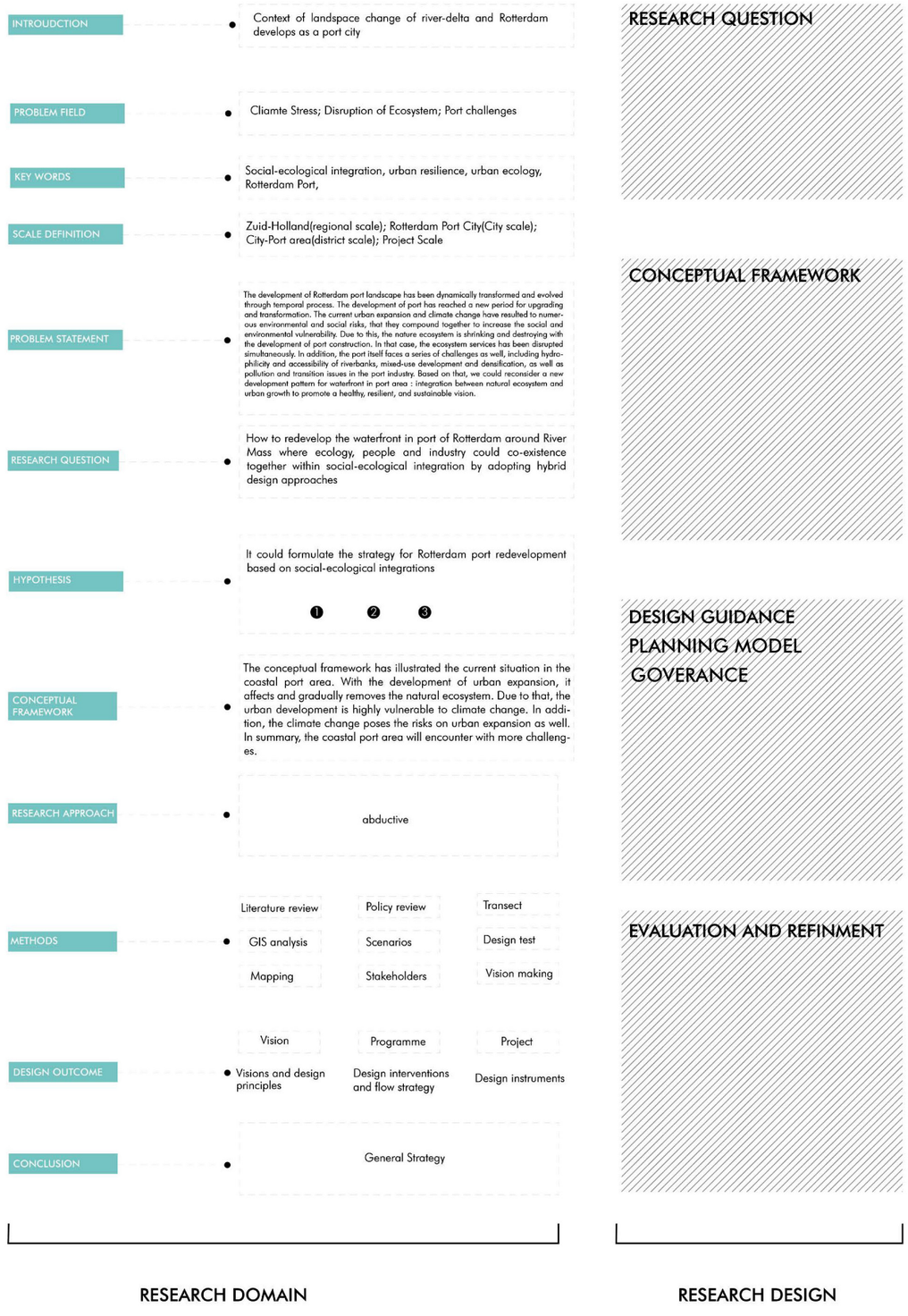


Figure 3.3: Research domain, made by author

Research Aims

The aim of the research is to complete a new social-ecological integrated vision to renew the Estuary and River Mass, and adjacent Rotterdam Port. It aims to “Explore the principle and strategies for water management and port transformation in Rotterdam through the multi-scales ”.

-Concept built-up

At the regional scale, the research will provide a systematic design strategy to integrate the water management, ecosystem restoration and port transformation together following the proposed design principles.

-Governance

To understand the current power and interest of stakeholders and the process of coordinating with different stakeholders. In addition, the management of future uncertainties and how to achieve the goals through time

-Regional planning

In addition to design principles and design strategies, the toolkits that collect water management, ecology, infrastructure and urbanization explore how the natural system and urban development synergy together for Rotterdam port and River Mass estuary.

-Design testing

In addition to design principles and design strategies, the toolkits that collect water management, ecology, infrastructure and urbanization explore how the natural system and urban development synergy together for Rotterdam port and River Mass estuary.

Research Question

Main Research Question

“How to shift the river Mass estuary and port of Rotterdam into a more adaptive and resilient system by synergizing the natural system and urban growth with landscape and urban design intervention?”

Sub Research Question

Understading question:

What is the concept of social-ecological integrations in spatial planning and governance?

What are the current social-ecological system of Rotterdam port and what are the challenges and opptunities?

What to do question:

What are the design principles of social-ecological integrated port transformation in terms of ecological, soical and econonic aspects?

How to summary the guideline principle and how to apply them in the regional plannning of Rotterdam port?

Application question:

What are the stakeholders involved in the current and future process? and then how to facilitate strategic multi-actor collaborations?

Theoretical Framework

Based on the previous problem statement and proposed research questions, the theoretical

framework aims to provide a knowledge basis for relative concepts and theories. Facing the climate stress, disruption of ecosystem and urban challenge and growth, the Rotterdam port needs to find more resilient approaches and new mechanisms for socio-economic development. Therefore, the research will apply the key concepts for major three theories:

1. Urban Ecology

2. Urban Metabolism

3. Urban resilience

The main theoretical foundation of this research is to create the symbiotic development between natural and socio-ecosystems with hybrid approaches. Firstly, urban ecology could provide theoretical tools to understand coastal areas as a complex urban ecosystem, then study the interactions between urbanization and ecosystems. Then, it adopts SES framework and urban resilience theory (social-ecological resilience) to provide the frame and concept of social-ecological integrations. Moreover, the urban metabolism and Nature-based solution (NBS) could provide means to represent, analyze and design the port area. The theoretical framework was to reconstruct the key concepts from theory paper(for both position and literature reviews). In the future, case studies will be combined together with review to offer perspective and tools toward research questions.

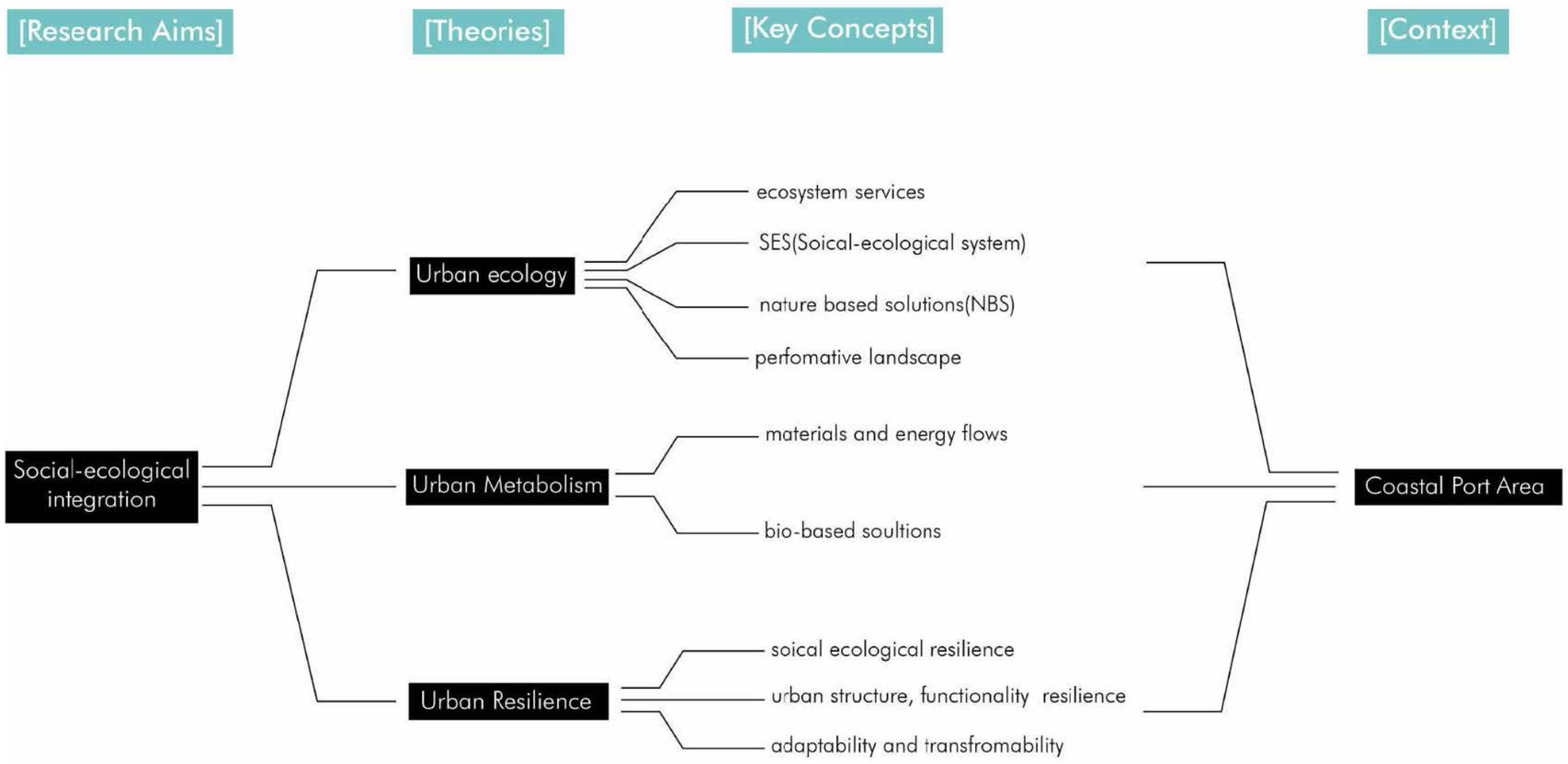


Figure 3.4: Theoretical framework, made by author

Ecosystem services and nature-based solutions

Urban ecology is defined as a cross-domain of sustainability that across social, economic and environmental dimensions. Because social development has neglected the importance of ecosystems and ecosystem services, the urbanization has diminished the resilience of cities which leads to problems in the capacity to cope with arising risks. In urban ecology, the Urban ecosystem is the population growth and its dependent infrastructure in forms of cities, towns and megacities. To be more specific, urban ecosystems examine the relationship between economic development and environment protection in the context of natural, sociaand economic systems. Furthermore, urban agriculture, biodiversity , roads, building typologies, transportation, health, energy flow and other components consist of urban ecosystems.

Verma et al(2020) state the definition of the urban ecosystem is the human population growth and its depended infrastructure that divides into cities, towns, agglomerations and megacities. Shen et al.(2020) state that" urban ecosystem is an open and complex system with multi-dimensional interactive relationships". Moreover, it points out that urban ecosystem consists of a serious of social, economic, biological and ecological components which collaborate to achieve a comprehensive system of providing interactions and feedback loops(Verma et al,2020). Due to that, the coastal urban ecosystem is identified as a "special type of ecosystem that consists of complex natural, social and economic systems in coastal urban areas(Chen,2020).

The broad definition of ecosystem services(ESs) is the ecological processes,characteristics and functions that human-being could benefit from directly or indirectly. In addition, the types of ES are divided into three categories, including provisioning, regulating and cultural services(Li et al, 2020).

'The interactions in the urban ecosystem are recognized and guided by human values, it constitutes the formulation of social-ecological systems (SESs). It requires us to consider and identify and bridge the valuable synergies between different systems. Landscape, especially performative landscape, is able to provide a position that plays a bridging role in the combination of human and nature with urban ecology. In addition, Tillie has described trans disciplinary between landscape architecture and urbanism within urban ecology.

Metabolic flows and bio-based solutions

The concept of urban metabolism is used to appreciate the process of urban water supply, air,and water pollution. In the urban metabolism approach, the urban area is a dynamically functioning organism that it acts like a cell with respect to material and energy flows,transforming energy and moving water out of the city into the natural system. Therefore, it is admitted that the city, as an organism, could be controlled and managed through metabolic processes. Urban metabolism, similar to urban ecology, is a transdisciplinary field of study combining industrial ecology, political ecology and urban ecology. The focus are presented on three aspects: the interactions between natural and social systems, the resource systems and their impact on cities.

The framework of urban metabolism consists of two main components: anabolism and catabolism. Anabolism refers to the extraction, use and production of substance while catabolism, as opposed to the former, incorporates mainly decomposition, recovery and reuse of metabolic waste (Hoornweg et al., 2012). Numerous of paper suggest that UM(urban metabolism) concepts should be introduced to the development of analytic tools to help the designers deepen understanding of a city's material and energy needs, then support the optimization of resource needs through urban design. For instance, the green and blue infrastructure is the important integration of urban metabolism and design in terms of its contribution to recycling of material flows and carbon emission reduction. At present, UM provides theoretical support and foundation for urban solutions, such as bio-based solutions. However, there is still a gap in the closing loop of urban metabolism analysis and the design guiding nature-based solution(NBS).

Social-ecological resilience

In 1973, Holling has firstly brought forth the concept and definition of resilience which is regulated as the opponent of stability as “a measure of the perspective of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables”(Holling.1973). With the extension of these terms to many other aspects, there are different types of resilience that have been proposed such as ecological resilience, social resilience or engineering resilience. Folke(2006) has created social ecological resilience which defines as “the ability of a complex socio-ecological system (SES theory) to change, adapt and crucially, transform in response to stresses and strains”(Davaoudi,2012).

In addition, Forgaci(2018) attributes social-ecological resilience which are adaptability and transformability. Adaptability could be understood as the capacity of SES for response adjustments in terms of changing external factors and internal processes in order to allow the development within current trajectory while transformability is the opposite which refers to the capacity to create a new stability domain for development switching to new trajectory.

In addition, there are three underlying assumptions of social-ecological resilience (1) SES are interrelated. The social system is coupled and part of the ecological system (2).SES are complex adaptive systems and (3).building adaptive capacity is the key of governing SES.

The “dynamic interplay of [resilience as]persistence, adaptability and transformability across multiple scales and multiple attractors in SESs form the framework of resilience thinking”, as the concept of the adaptive cycle.

Adaptive plannning

The concept of urban metabolism is used to appreciate the process of urban water supply, air,and water pollution. In the urban metabolism approach, the urban area is a dynamically functioning organism that it acts like a cell with respect to material and energy flows,transforming energy and moving water out of the city into the natural system. Therefore, it is admitted that the city, as an organism, could be controlled and managed through metabolic processes. Urban metabolism, similar to urban ecology, is a transdisciplinary field of study combining industrial ecology, political ecology and urban ecology. The focus are presented on three aspects: the interactions between natural and social systems, the resource systems and their impact on cities.

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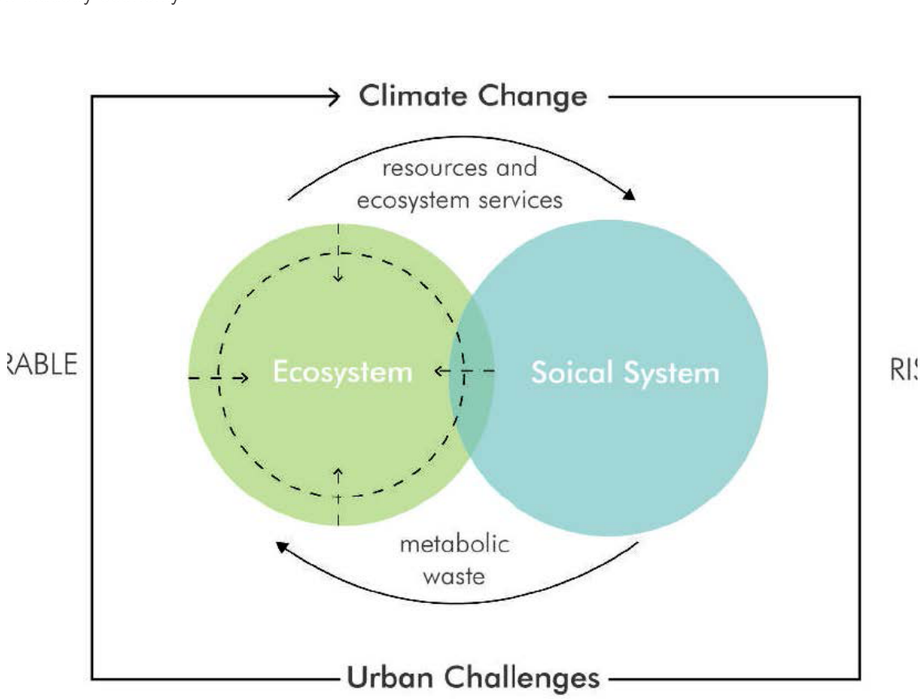
Conceptual Framework

The conceptual framework has illustrated the current situation in Rotterdam area. With the development of urban expansion, it affects and gradually removes the natural ecosystem. Due to that, urban development is highly vulnerable to climate change. In addition, climate change poses the risks of urban expansion as well. In summary, the coastal port area will encounter more challenges. In order to create the symbiotic development linking the socio-economic system and natural system in coastal ports, it identifies the social-ecological integration that the nature, industry, people can exist and grow together. Both natural resilience and urban structure and functionality resilience could be combined to adapt to climate change and the performative landscape. It not only provides benefits for local ecosystem and biodiversity through the restoration of ecosystem services, but also allow for new development by densifying the port with more functions and new industry economy.



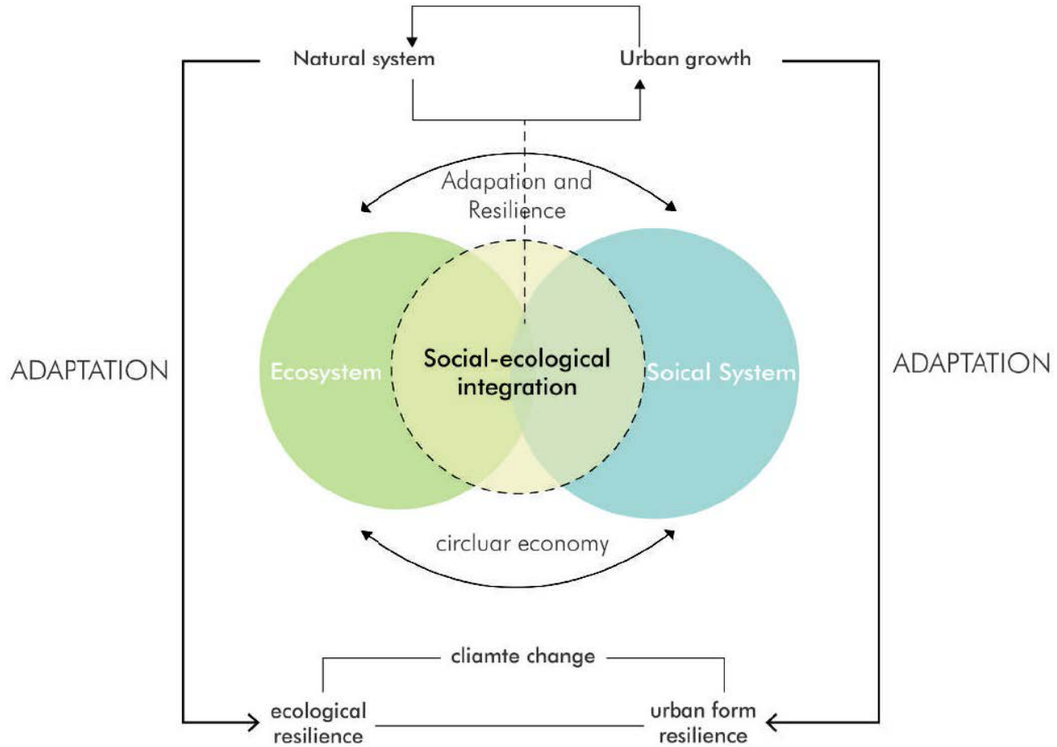


Figure 3.5: conceptual framework, made by author

Research Methods

The main objective of research is to trigger the transition of Rotterdam port, introducing new design strategies to help with realizing the different strategic goals, which in the end achieve the possible synergizes between city, port and estuary, to give a new perspective of the urbanization process. These are the following main research methods that have been used to develop the project and answer the reserach question.

1.Literature review

In the literature review, the research intends to understand and organize the relative theories that could offer knowledge building for the research. furthermore, it gives foundation for the research approach, conceptual framework, and theoretical framework. Through the literature review, the core is to formulate a comprehensive and logical concept of social-ecological integrations for design strategy making.

2.Case study

The case study also provides essential references and knowledge for comparison and knowledge gaining. It gives direction for the application sub questions.

3.Mapping and spatial analysis

This method applies layer analysis of Rotterdam port water management, ecology and industry pattern through the tool of GIS. Mapping is a useful method to analyse the urban landscape and find the right place for interventions. The visualization of data could provide foundation for strategy making.

4.Data Collection

The design test is used as the method to respond to feasibility and relevance of design strategy. The design is not a product but a tool to test the built up conceptual framework to help with the later refining process with conceptual framework and design strategy. the design test should reflect on the main research question and explore whether the outcome is appropriate for the proposed question.

5.Stakeholder Analysis

To understand how the governance works in the planning process. The multiple involved actors should be analyzed based on each one's powers and interests. Furthermore, it analyze the relationship between these actors as well

6.Research through design

The final configuration of the social-ecological integrated Rotterdam port should be expressed through design. The research through design could apply the principles of intervention combing the specific site conditions. It could be a test of different combinations and get more lessons from design.

Expected Outcome

-Desgin Principles

In order to guide the later design strategy of reaching a transition of social-ecological integrated port, the design principles should be summarized from the analysis of Rotterdam port. Based on the analysis of water management, ecosystem, industry and metabolic flows between the river and port, the principles are proposed by following five: firstly, it should synergize the water management and ecosystem restoration together. Instead of continuing using grey infrastructure and to control the water level, it is the time to utilize the ecosystem services to counter the flooding issues with benefits that not only provide the space for water but also for ecological restoration. secondly, to achieve social and urban form resilience in port, the land use should be diversified and at the same time, facilitate multifunctionality and enhance responsive nature to urban development. Then, try to close the resource loop to formulate a resilient social-ecological system. Considering the implementation of transition, it also should consider the scales and process.

-Strategic regional plans

There are three design strategies in total as the product of the research, including build with nature, bio-based economy and city-port integration to guide the Rotterdam port toward social-ecological integration. The design strategy will describe the transition process of Rotterdam port. In addition,the design strategies are applied with different scales based on the situations. As the result of the design strategy, the design toolbox will be formulated and it could be the part of the reflection of three design strategies.

Time schedule

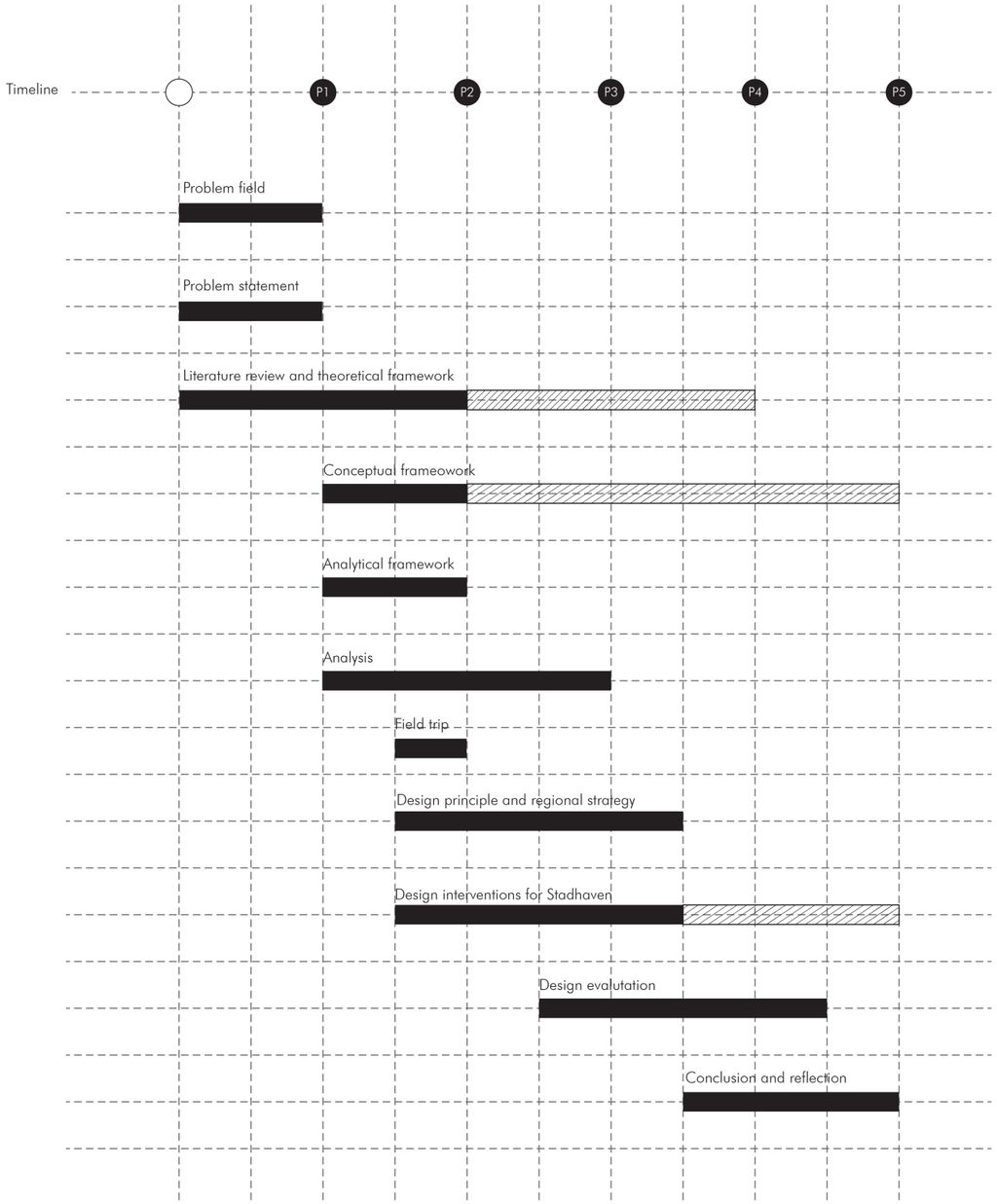


Figure 3.5: Timetable of the project,edited by author

04.

Analysis of Rotterdam Port

Rotterdam Port as the case

River and Estaury(Biophysical Layers)

-Water-related infrastructure

-Indundations

-Sand and Clay

-Biodiversity

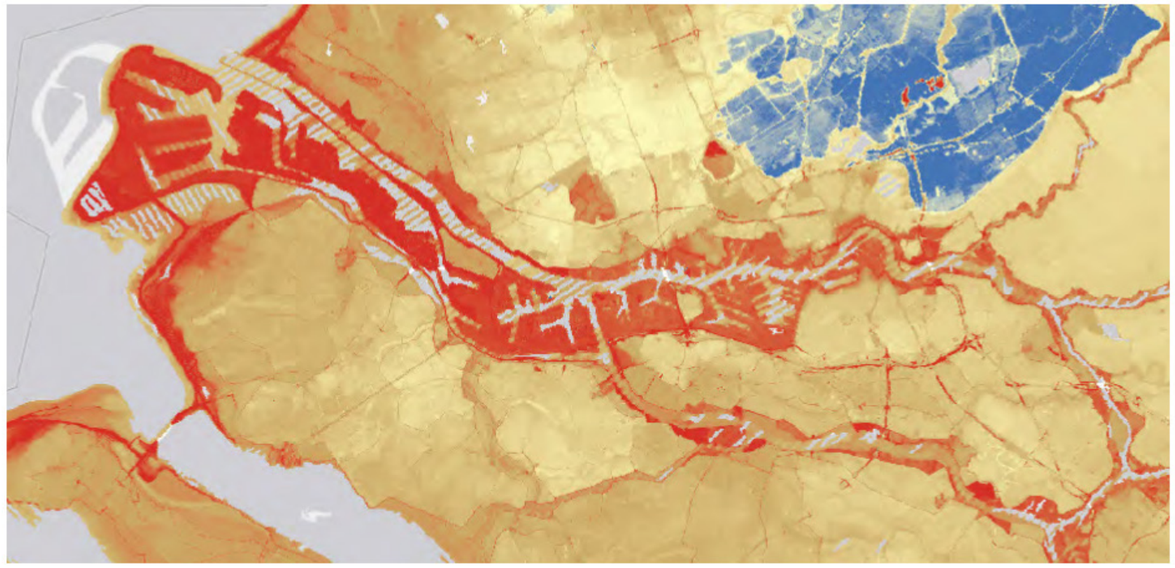
-Esturay ecosystem

Industry(Economic Layers)

-Land use

-Typology study of industry

-City-port layers



The landscape outside the dikes has largely been raised and urbanized

Figure 4.1: the ground of Rotterdam port has been raised and urbanized. source: Landscape framework, the river as the tidal park(De Urbanisten,2014)

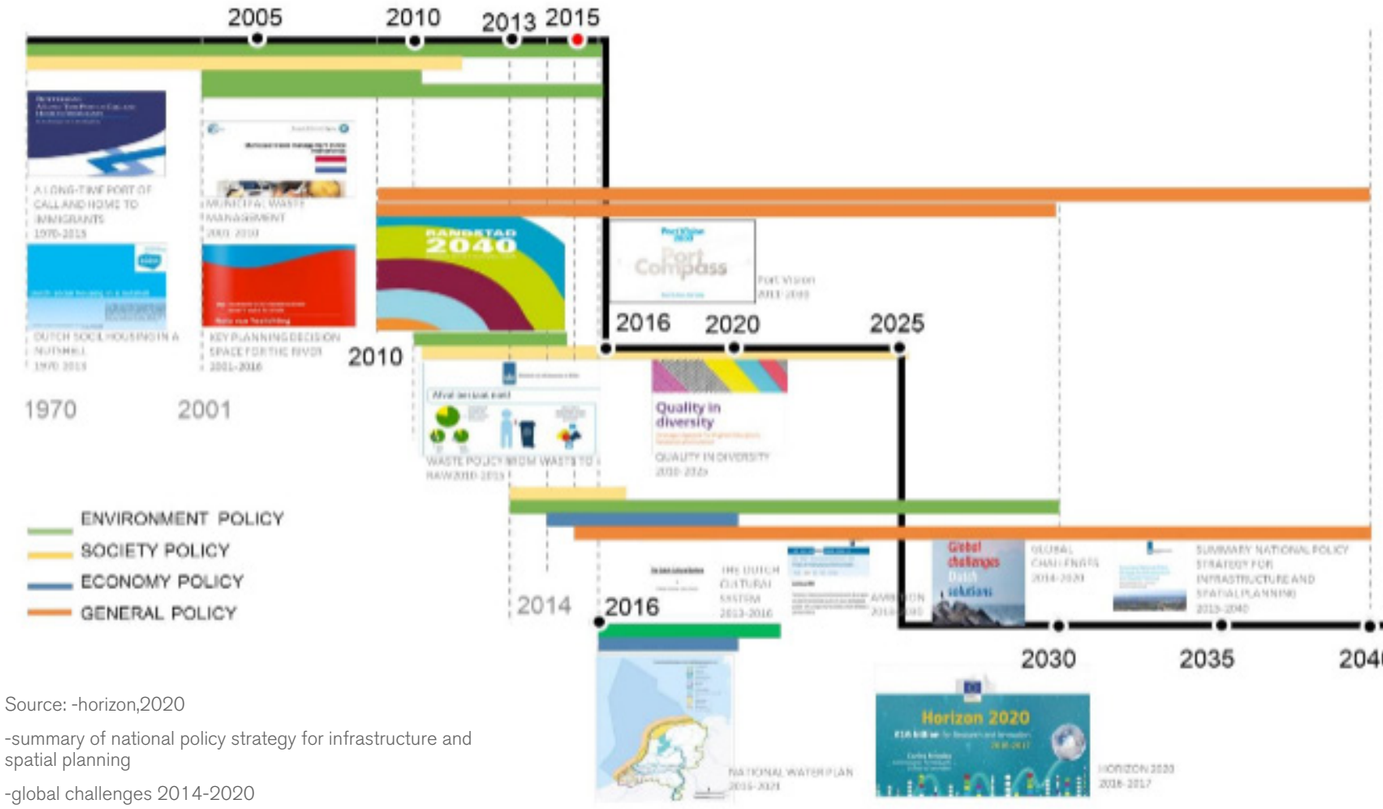
Case: Rotterdam Port Area

Rotterdam port is the main part of Rotterdam, which covers over forty kilometres and about one third of Rotterdam territory (De Urbanisten,2015).

In order to protect the Rotterdam city from the sea, the dykes are constructed as the main infrastructure for protection. Outside the dykes, it was constructed for harbours and industrial areas. The ground level of the harbours and industrial area are highly raised because the outerdyke area is directly influenced by the rising seawater level. In that case, about 70% of the surface of Rotterdam port is paved by the stone embankments and quays. To be more specific, the quaysides elevation are very different in terms of different time phased hours. From the east to west, the city(old harbours) to new development, the rising ground level varies from 3 metres above the NAP to 5.5 meters above NAP (De Urbanisten,2015). Another significant feature of Rotterdam port is that most of the area is highly urbanized, since Rotterdam port is one of the largest logistic and manufacturing centers in Europe. The transport and industrial activities occupy the outer-dyke area. It provides enormous economic values and job opportunities for people while at the same time, it mainly causes the water and soil pollution in the delta.

The research wants to select the Rotterdam port as the case because of three reasons. Firstly, it has diversified landscapes, where the city, port and estuary(river) meet so that it has the great potential to discover. Secondly, the Rotterdam port recently has the ambition to achieve CO2 neutral in 2050. Due to that, the current energy consumption needs to be upgraded and it gives numerous choices for upcoming interventions. Thirdly, the city-port area currently is under the transition process. The municipality and local authority collectively develop the urbanization in this area in order to integrate the port with the city together. In that case, It could apply the social-ecological integration concept in this new redevelopment.

These three starting points and following analysis proposes three design focus questions: 1.How to create a resilient and dynamic river-estuary blue and green system? 2.How to use ecosystem services to develop a circular economy and help with energy transition? 3.How to realize urban development to link the city with port while nurturing and integrating the ecosystem? The three focus questions also guide the principle and strategy making in the following chapters.



Source: -horizon,2020

-summary of national policy strategy for infrastructure and spatial planning

-global challenges 2014-2020

-a long term port of call and home to immgrants 1970-2015

-dutch soical housing in a Nutshell 1970-2013

-quality in diversity 2010-2025

-the dutch cultural system 2013-2016

-Municpal Waste Management report 2001-2010

-key planning decesion space for the river 2001-2016

-port vision

-National water plan

-Quality in diversity

-waste policy from waste to raw

Figure 4.2: Existing strategy to develop Rotterdam Port (Source: Next Economy & Urban Region Networks EMU Stuido,2015)

Potential: New Production System and Circular Economy in Rotterdam Port

In terms of regional perspective, the Rotterdam port is one of the significant components of delta economic development. Recently, the Rotterdam port claims that they want to cooperate with the port business and government to establish a new future proof port to provide more job opportunities and income and reduce the negative environmental impact on the climate and nature. To achieve this, the energy transition is a necessary trend for the future port. Currently, the government is more focused on high mobility and economic development. Even though the circular economy strategy brings forth various connections and exchanges between industries to realize CO2 neutrality, the consideration of ecological and environmental problems is not enough, especially for Rotterdam because most inland rivers discharge into the North sea through Rotterdam Port. for the. It is the opportunity to integrate the new production system and circular economy with development and management of Estuary and river mass.

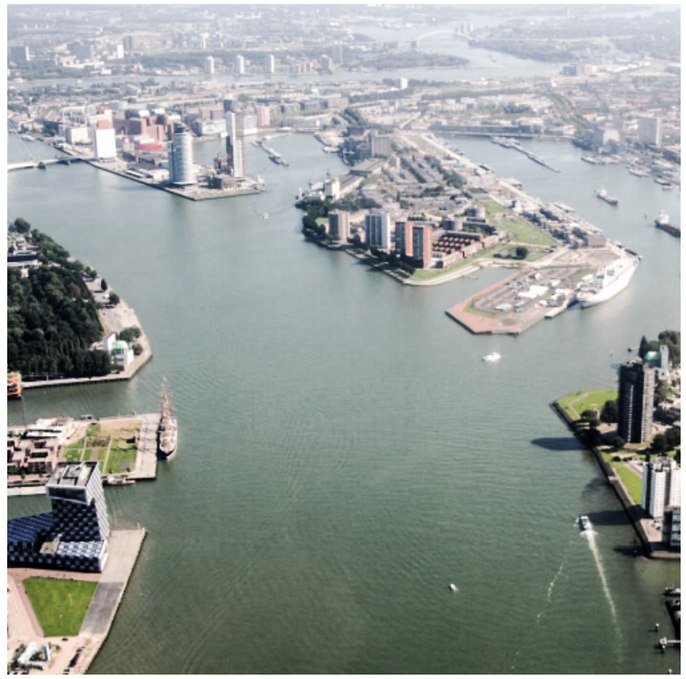


Figure 4.3: Stadhaven area in Rotterdam (Source: Photo from Google Maps)

Potential: Transformation and link city with port

The relationship between the port and city has been changed in terms of urban forms, functions and environment. These changes are ultimately connected to the waterfront development in Rotterdam(Aarts et al., 2012). After 1872, the opening of Nieuwe Waterweg started the port growth. During the process, two developments have changed the relationship between city and port which are port regionalization and geographical migration of port. These two processes have been mentioned and explained in the theory essay. In Rotterdam, there are two orientations for waterfront redevelopment. Firstly , the port and city of Rotterdam, is devoted to invest in the aspect of innovation that can decrease the urban congestion and accessibility. Then, they take measures in renewable energy and bio-based energy sources toward energy transition. Another direction is to develop the advantage of “knowledge”. Both the port and municipality of Rotterdam strength their link with universities and high tech companies in order to generate knowledge. In that case, the research, consultancy and training services for the port have been connected within the framework. In addition, based on the vision and plans, the job creation will bring more high skilled population flow into the port with subsequent rising requirement of housing, retail and leisure functions. The waterfront is also reflected in the socio-cultural aspect as a special way of living.

Stadhaven(City port area)

Currently, the city and port of Rotterdam gradually grow apart from each other. Port functions mainly focus on cargo operation, industry activities and oil transportation. the city and port authority are now launching the city ports project that could achieve the connections. Currently, there are five wild card strategies to redevelop the city port area:(1).volume and value (2). reinventing delta technology (3).crossing border (4) floating community and (5) sustainable mobility. The stadhaven(city port)area aims to remain the port activities but change the current logistic system. Due to that, the recycling industry would be a suitable choice. In addition, in order to manage the risk, the city port area also wants to work with universities such as TU Delft to apply the water mangement technology in the area to keep it clean and safe. In addition to that, the city port area also provides a new vision for floating community and sustainable mobility for transformation in the future. It is inspireful to take this into the new development of the waterfront area in Rotterdam.

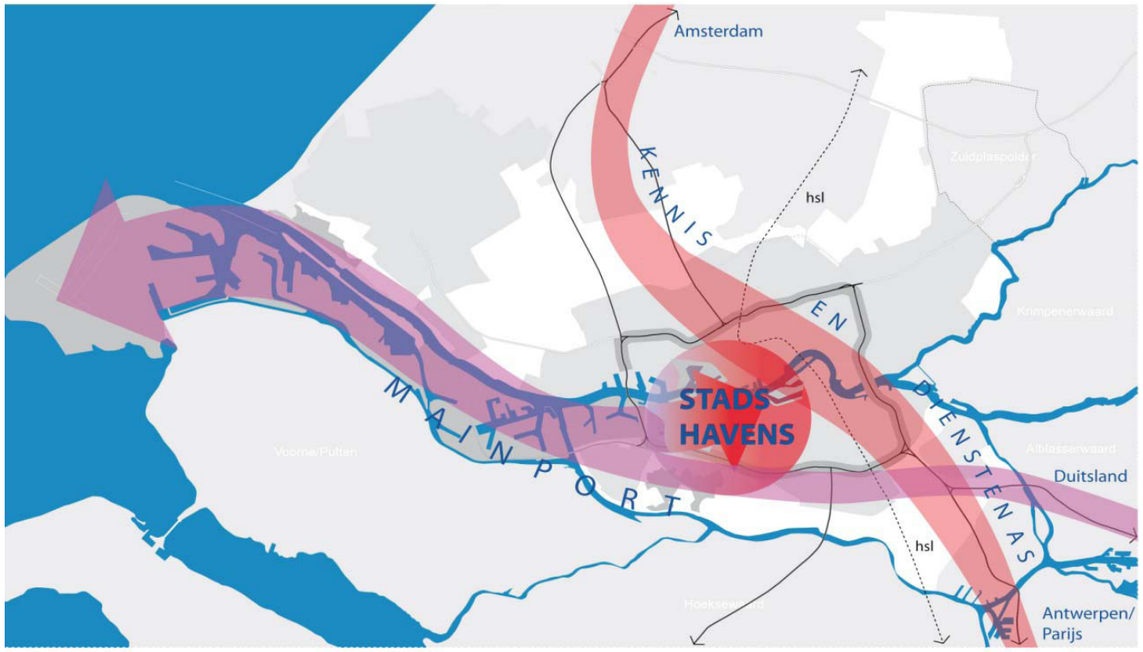


Figure 4.4: CityPorts or CityPorts Rotterdam is the place where city and port meet, spaces have been created to develop new activities for both city and the port (Source:Aarts et al, 2012)

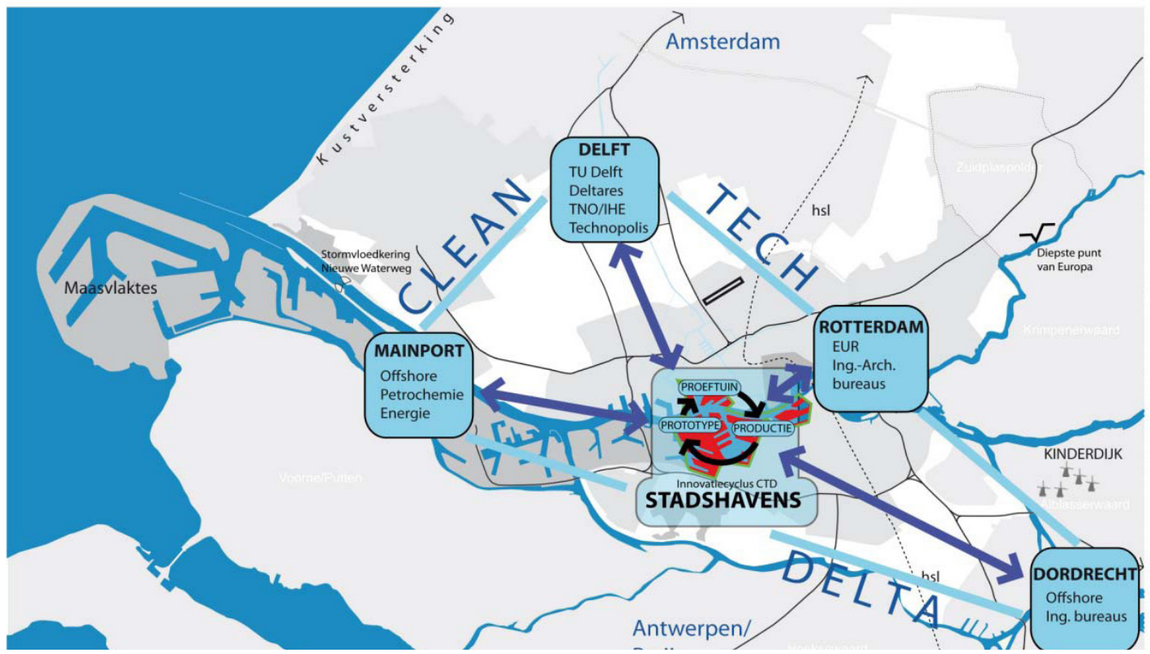


Figure 4.5: Stadhaven area in Rotterdam aims to be clean tech Delta by applying knowlege and techniques in this field in terms of water, climate and energy issues (Source: Aarts et al, 2012)

Estaury and River Landscape(Biophysical Analysis)

As it mentioned before, Rotterdam port is located at the converge of river, industry and city landscape. The estuary condition used to provide enrich conditions for flora and fauna. However, due to the continuing urbanization process, the dynamic of the estuary has been negatively affected by human intervention, for instance, green space fragmentation and intensive farming methods(FABRICation,2014). According to Erik& Matthij(2020), the dynamic of rivers and estuaries has been strongly suppressed because normally the river is confined and estuary is reclaimed. As a result of this, in Rotterdam, especially in the Rotterdam port, the natural habitat and green and blue connections have gradually decreased through the years. With the disappearance of the salty transition, nature process including erosion and sedimentation and gradient transition from land to water, biodiversity has decreased in the area. According to data, the species in peat-meadow landscape have decreased dramatically, reflected by the recorded numbers(FABRICation,2014).

Even though the hard engineering and infrastructure ensure the development of Rotterdam port by allowing the river services the harbours, the port also has the potential issues to deal with. Firstly, the port has a flooding risk due to climate change. In the future, it requires finding space for water in the outer dyke area. The measures should be more flexible and climate adaptive. Moreover, another considerable issue for the port is sedimentation management. The port needs to degrade the sedimentation for shipping large vessels. This process costs high expenditure and limits the natural system of tidal influence. In summary, the nature system shrinked for years and it requires finding the space for nature rehabilitation to restore the tidal nature in Rotterdam port. At the same time, it should combines the issues of climate adaptation and sedimentation control.In the following chapter, the relative analysis will be provided for understanding the mentioned issues.

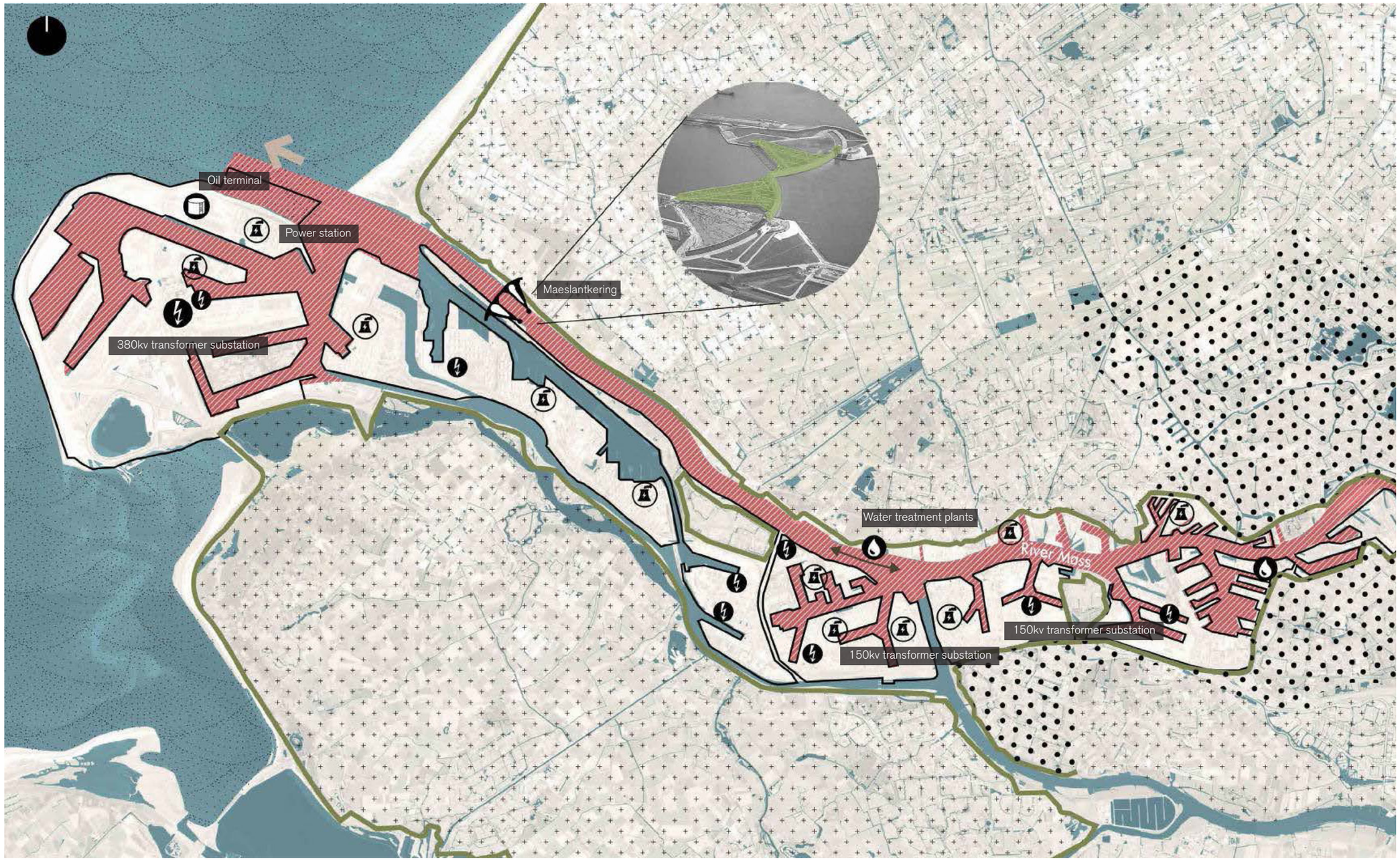


Figure4.6 Water mangement and sedimentations

The water-related infrastructure shows the main infrastructure to prevent the Rotterdam and Rotterdam port from flooding. Compared with the city, the port height has been increased; however, some particular industries and infrastructure at Rotterdam port are vulnerable to flooding. Besdes, the environment has been isolated from the dynamic estuary due to infrastructure expansion, the high sedimentation rates and high cost concerns the sustainable development of Rotterdam port.

Challenge1: Flooding

Flooding is one of the significant issues for the outer dyke area(Rotterdam port). The flooding is mainly from the sea level rise which is affected by climate change. In the Netherlands, there are main factors that determine climate change- global warming and changing air circulation patterns in the west Europe based on the research(De Urbanisten, 2015). Based on that, the KNMI (Royal Meteorological Institute of the Netherlands) has setted up four potential scenarios including Moderate(G), Moderate with changing air circulation currents(G+), warm(W) and warm with changing air circulation current(W+). They aim to indicate the change of rainfall, temperature and wind caused by climate change. In addition, the climate scenarios provide essential references for the policy making and relative research in the Netherlands.

In the future, the chance of flooding risk in Rotterdam port will increase based on the climate scenarios. As it is shown in the figure, the inundation area of the outer-dyke area has been mapped out with a probability of 1 x 1,000 years under the W+ scenarios(De Urbanisten, 2015). Under that scenario, in 2100, the sea level increase will reach 85 cm. The main affected area concentrates on the city center area that is located outside the main dyke, such as Noordereiland, the Scheepvaartkwartier, the Kop vanFeijenoord and Heijplaat . In, addition, the old harbours and docks will be affected as well, including Katendrecht, the

Wilhelmina Pier, the Lloyd Pier and the Muller Pier. By rising 60 cm of sea level, in the historical city center, the frequency of flooding risk will increase to once a year compared to once every 50 years. In the stadhaven area, the flooding risk will increase from once every 10,000 year to once 1,000 year. Furthermore, the New waterway is also heavily affected as it has to bear the main discharge from the river. However, the new ports still will be safe under the extreme scenario. In summary, in the historical outer dyke city center, the flooding risk is extremely high. It needs to be taken into consideration for climate adaptations. In Stadhaven area, flooding in future will become one of the concern to solve while the risk remains extremely low in the new port.

With a frequency of 1x1000 years

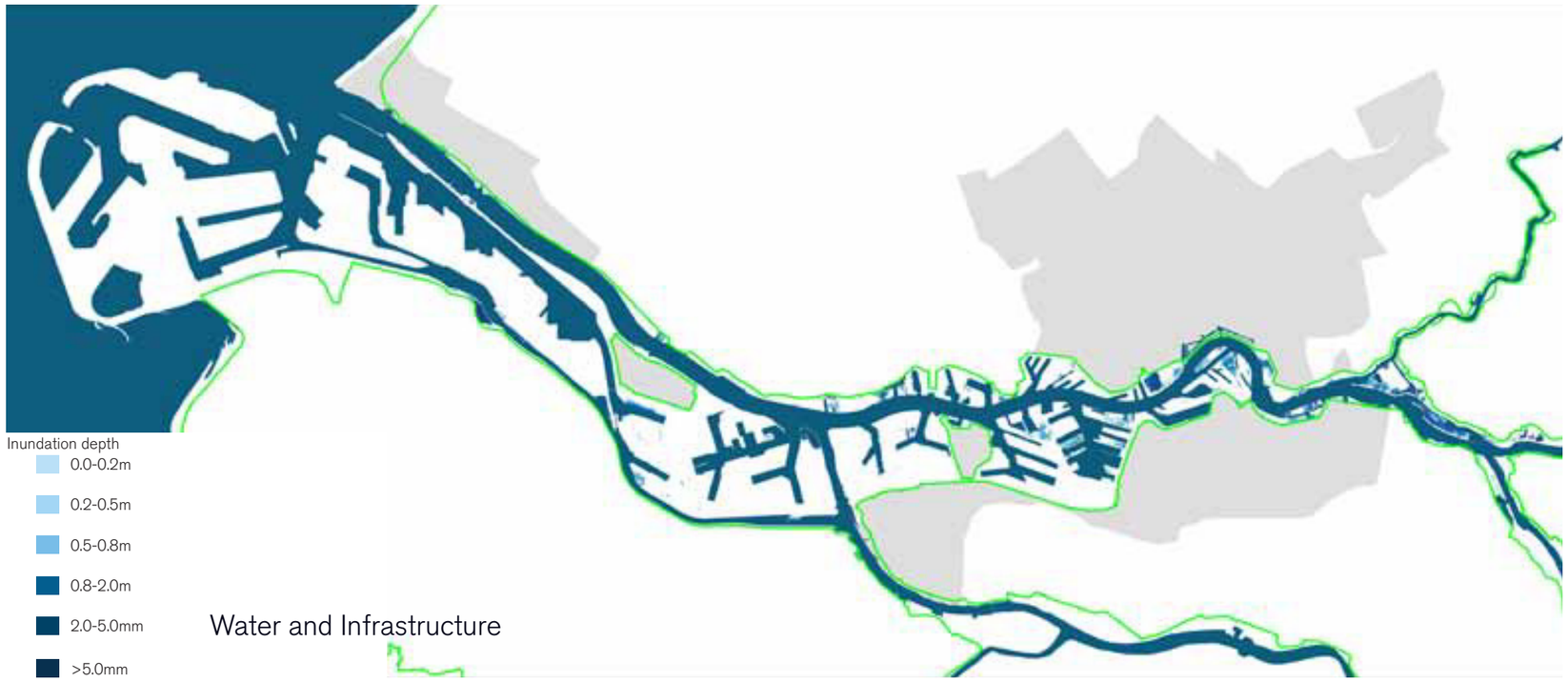


Figure 4.7 Out-dike flooding in outer-diker Rotterdam in 2015,data from: Deltares, Maps created by De Urbanisten, 2015

climate scenario with a frequency of 1x1000 years

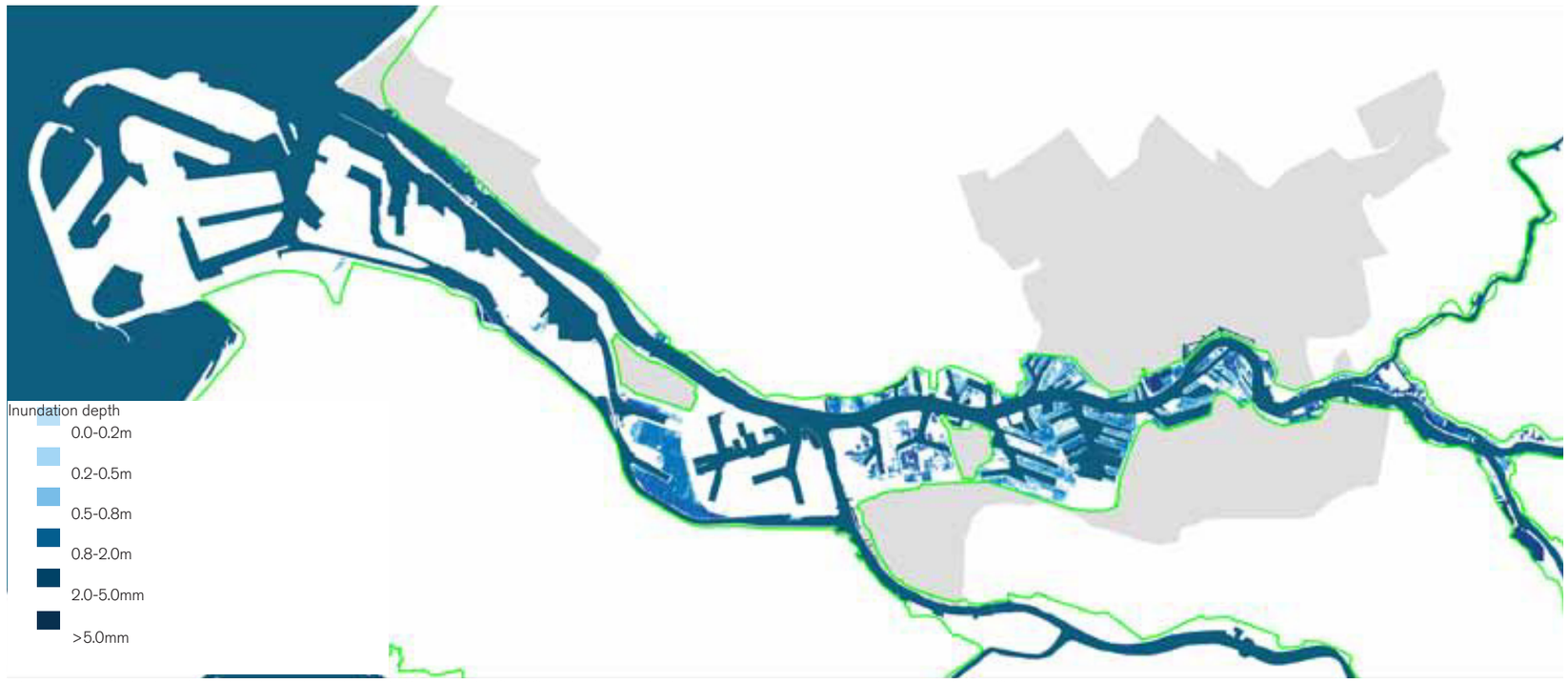


Figure 4.8: Out-dike flooding in outer-diker Rotterdam in 2100 data from: Deltares, Maps created by De Urbanisten,2015

Challenge2: Sand and Clay

The estuary is very dynamic because it has the gradual transition of salinity and depth. Due to the nature process, the landscape is subject to erosion and sedimentation at the riverside. Without human intervention, the watercourse is very shallow. The condition is also the foundation of enriched biodiversity in the intertidal ecosystem.

After centuries, the harbours concentrated at the Rotterdam port. In order to optimize the transport of goods by deeping the channelization.Since the construction of new waterway, the harbour activities started to move toward the west part of Rotterdam port. At the same time, the harbours are required to be continually degraded because of high sedimentation rate. Currently the sedimentation (Mainly consists of sand and clay) has been transported and placed at offshore locations with a long distance. It states that the depth of the New waterway should be guaranteed at least 30 meters for accommodating the large ships. Thus, more than 20 million m3 silt are degraded from Rotterdam port yearly. Main source of sedimentation comes from the North Sea, which takes about 14 million m3 (FABRICation,2014). To clean the accumulated river bed and harbour basin, the sedimentation management is an essential challenge for ports. In addition, the transport cost mainly makes up the total cost. In conclusion, it needs to rethink how to optimize the process to alleviate the degrading and use the siltation locally.

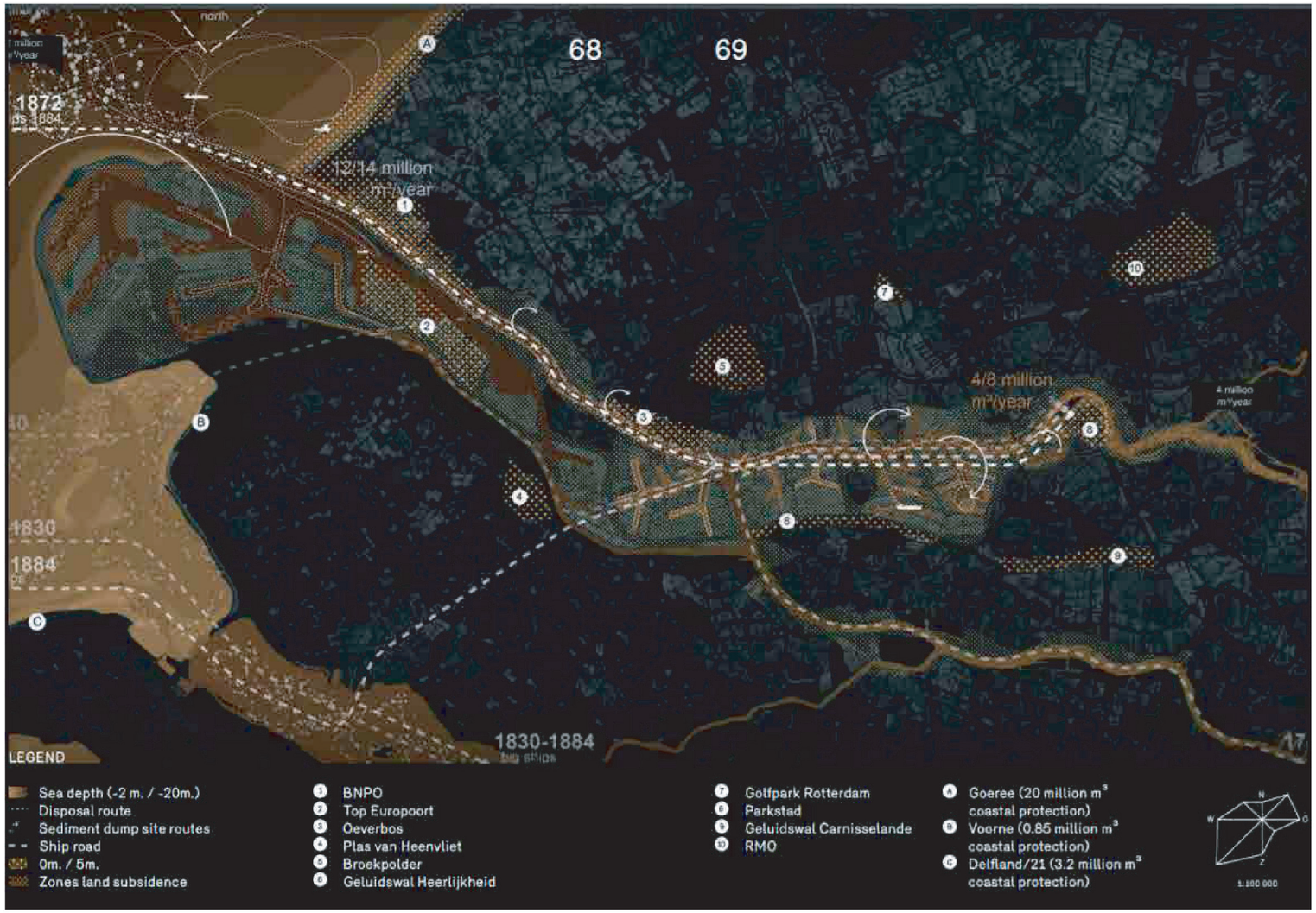


Figure 4.9: the current situation of sand and clay sedimentation in Rotterdam port ,maps created by FABRICATION,2014

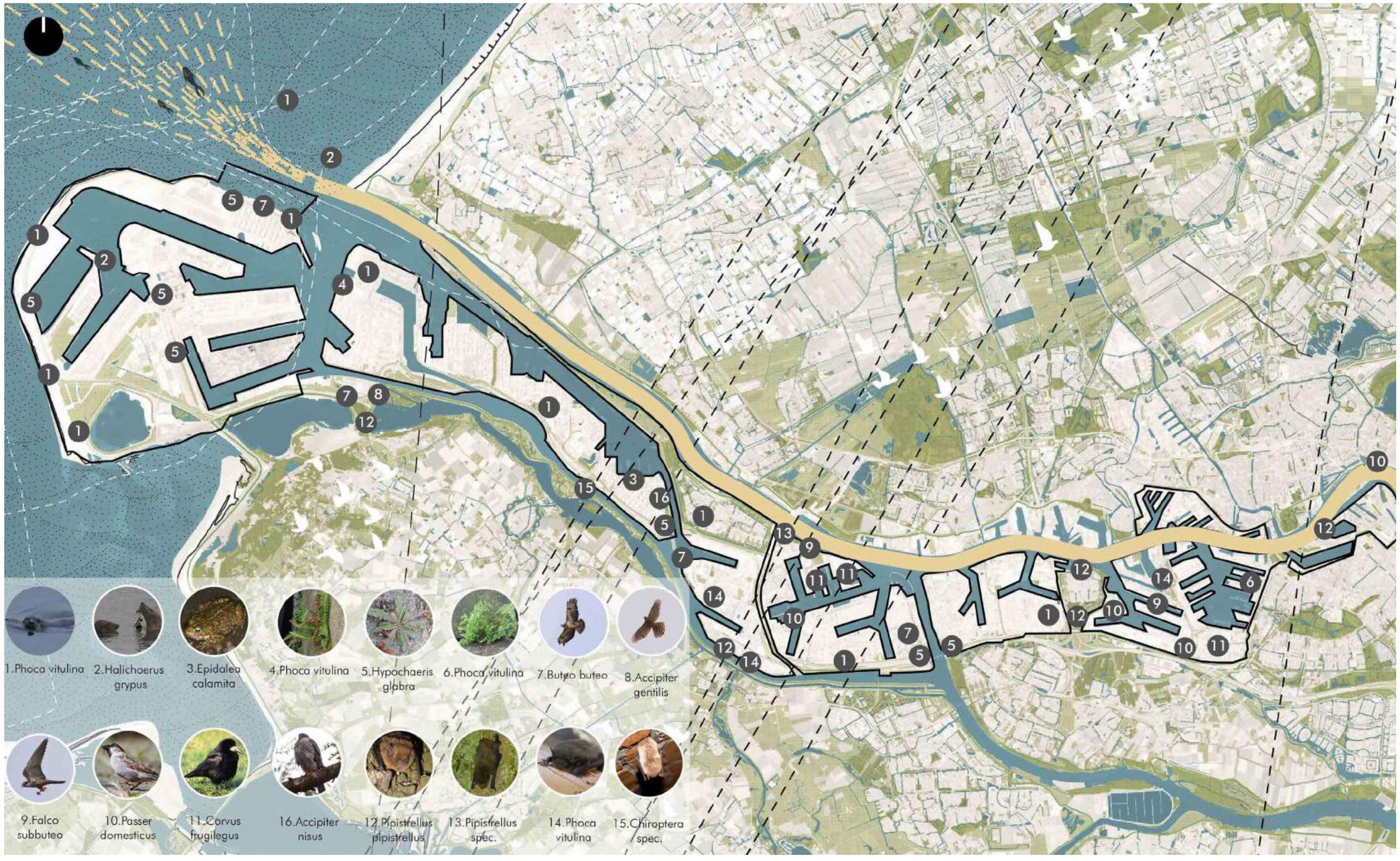


Figure 4.10 Biodiversity and green space

The figure shows the current distribution of flora and fauna in Rotterdam port. The species are distributed at different habitats, including delta river banks, dunes, forest and grassland. The challenge of biodiversity in Rotterdam port is that the trend in species has decreased dramatically in the peat meadow landscape. Rotterdam, and Rotterdam port could only provide limited habitats. Besides, the green corridor and stepping stones for fishes are lacking as well..

- Sea
- River Mass
- Migrate Route of fish
- Green Space

Challeng3: Marsh zones and tidal ecosystems

Originally, the estuary has offered ecological prosperous conditions for flora and fauna. The dynamic landscape is located at transitions between the marine environment and freshwater environment. It is influenced by both the wave and tide conditions and river discharge. The two essential conditions lead to the dynamic change in aspects of salinity and water level in terms of time and space (Ecoshape, 2020). In addition, the river is subject to erosion and sedimentation at the different sides of riverbanks. The gradients provide space for species to grow. The estuarine ecosystem provides significant habitat which is referred to as marsh zone for different species. The species assemblage adapts to marine, freshwater and brackish conditions. According to the fact sheet of the marsh zone(Deltare&Ecoshape,2020), it defines that marsh zone has been characterised by water features and particular vegetation whose roots are submerged permanently or periodically. The marsh zone is important for the estuarine environment because it could provide various ecosystem services.

First, it offers benefits and functions for the animal, such as birds, fishes, amphibians and insects. For the fishes, it is not only the shelter that prevents species from the predictors but also a nursery ground for mating and spawning in the vegetation of marsh zones. Some of the species need to reproduce under the brackish conditions. The examples are plaice (Pleuronectes platessa), flounder (Platichthys flesus) and common dab (Limanda limanda). Kruitwagen and van Deelen (2019) mentioned that Rotterdam port is one of the most important habitats for these species for mating and spawning. In addition to fish, the bird accounts on the marsh zone as well as the breeding ground. Marsh zone also plays the role as the high water shelter and resting place for migratory birds.

Secondly, marsh zones are natural water buffers. During the heavy rainfall season, it could absorb the rainfall and water from the river. In addition, it has the function of attenuating the waves caused by storms. From that, it is an important tool of water management.

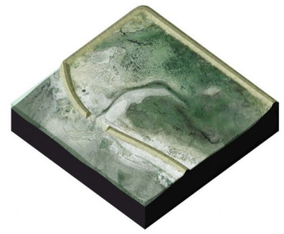
Thirdly, the marsh zones could be used for water purification. It distinguished two types of marsh zones which are water-treatment marsh and natural wetlands. The water treatment marsh, also known as artificial marsh zones, is designed to clean the water. It is a system containing an inlet zone, a macrophyte zone and a channel to flow through the zone. It uses vegetation and soil processes to clean up the water.

Figure 4.12 and 4.13 shows the impression of marsh zone restorations in the estuarine environment and relative flora and fauna compositions in the Rotterdam context. Except for flooding control and sedimentation management, the tidal ecosystem restoration is also an essential topic.

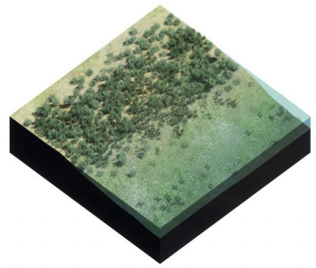
Build with nature strategy

Build with nature concept aims to create, implement and upscaling the nature-based solutions for the water related infrastructure (Eekelen& Bouw, 2021). Shacham, et al (2016) stated that build with nature aligns the natural processes with engineering solutions. Build with nature brings forth four key concepts for estuarine ecosystem restoration, including creating tidel park, restoring the tidal dynamic, restoring the salinity gradients and restoring the connections. Those five concepts give directions and reference of the next step interventions by considering the challenge of creating more habitats and at the same time managing the water and sedimentation better.

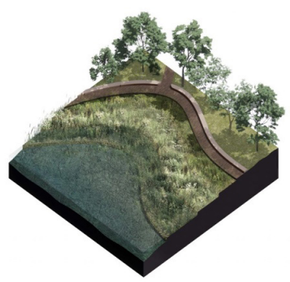
Restoring salinity gradients



Restoring salinity gradients



Growing more salt marshes



Creating tidal park

Restoring connections

4.11Examples of concepts that can help with restoring estuarine ecosystem (Reference: Ecoshape, Build With Nature)

0.Submergent Species

Ranuculus Fluitans

Elodea canadensis

Algae

1.Non vegeta tions

2.Pioneer aquatic and low marsh plants

Salicornia europaea(salt marsh)

Sporobolus anglicus(Common Cordgrass) (salt marsh)

Sesuvium portulacastrum(salt marsh)

Chenopodium rubrum

Typha latifolia

Pulicaria vulgaris

Rumex palustris

Persicaria lapathifolia

3.High Marsh Plants

Elytrigia atherica(salt marsh)

Spartina patens(salt marsh)

Agropyron pungens(salt marsh)

Festuca rubra

Spartina alterniflora

Bromus racemocus

4. Alluvial forest highly influenced by tide

Salix alba

Populus nigra

Phalaris arundinacea

Symphytum officinale

Iris pseudocorus

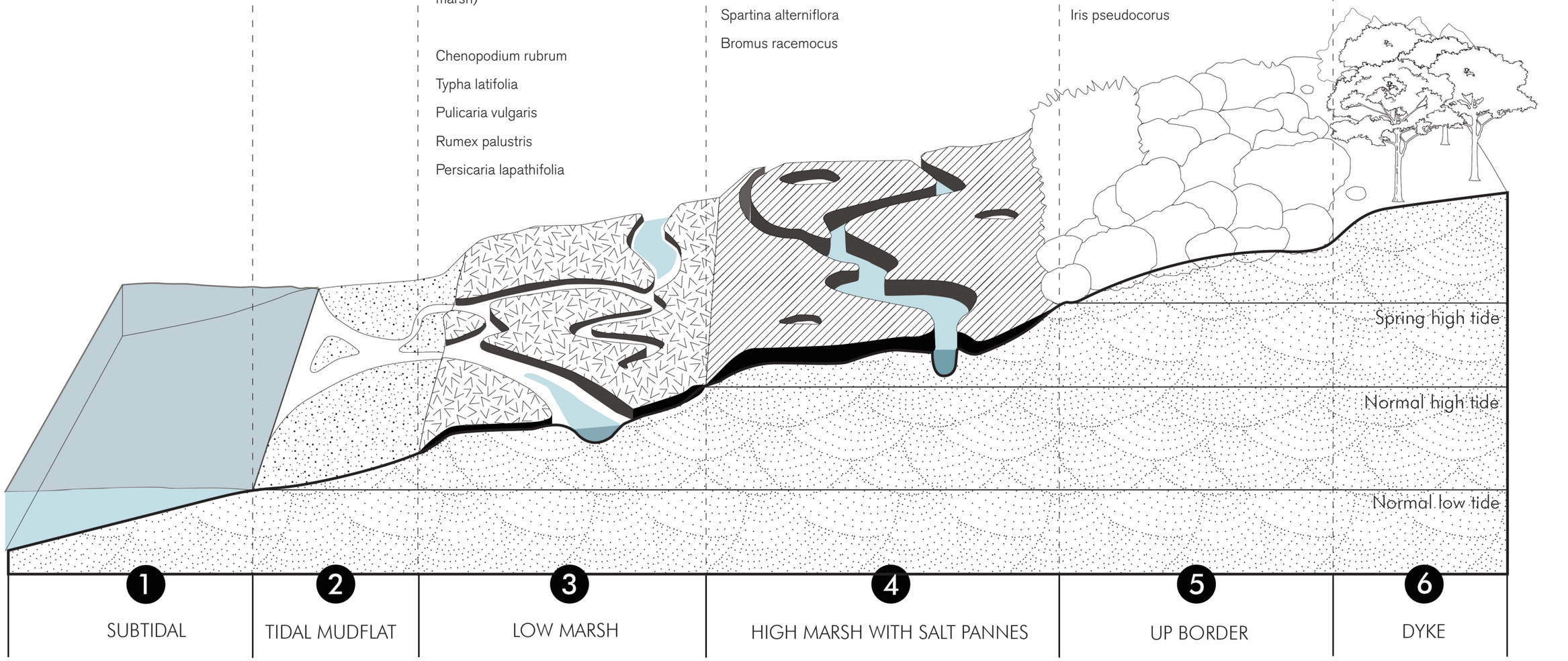
5.Climax coummnity Higher land accretion

Fraxinus ulmetum

prunus padus

Anomodon viticulosus

Homolia trichomonoides



4.12 The restoration of tidal ecosystems, with relative flora and faunna

Fauna

SUBTIDAL


shad


sturgeon


striped bass


clams


flounder

TIDAL MUDFLAT


otters


crabs


mussels


clams


oyster

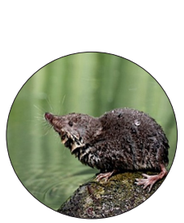
LOW MARSHES


Osprey


heron


sedge warbler


spotted crake


water shrew


Minnows


barnacle goose


marsh harrier


epidalea calamita

HIGH MARSHES


Eurasian hobby

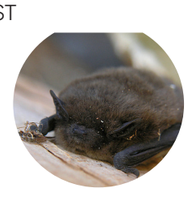

House sparrow


kwartel


thymelicus sylvetris

UPBORDER AND FOREST


Common buzzard


Pipistrellus nathusii


corvus frugilegus


pipistrellus pipistrellus


nightingale


beaver

Figure 4.13 Potential restored fauna in Rotterdam port by creating more marsh zones

By using the method of building with nature, it tries to cope with climate change and ecosystem dynamic restorations. By the systematic analysis of biophysical, social and government, it could help with defining the locations of interventions by linking the typical river elements with potential nature-based solutions. After careful selections, four strategic sites for interventions have been chosen for specific interventions with particular challenges. The four strategic locations are Riverfront Mass, old docks and harbours, port of Maasvlakte2 and New waterway. The interventions focused on different representative challenges. By collecting all of the actions at the river and estuary, it aims at addressing the existing problems and vision of a resilient and sustainable river. The interventions of five site-specific areas have been described in the following part.

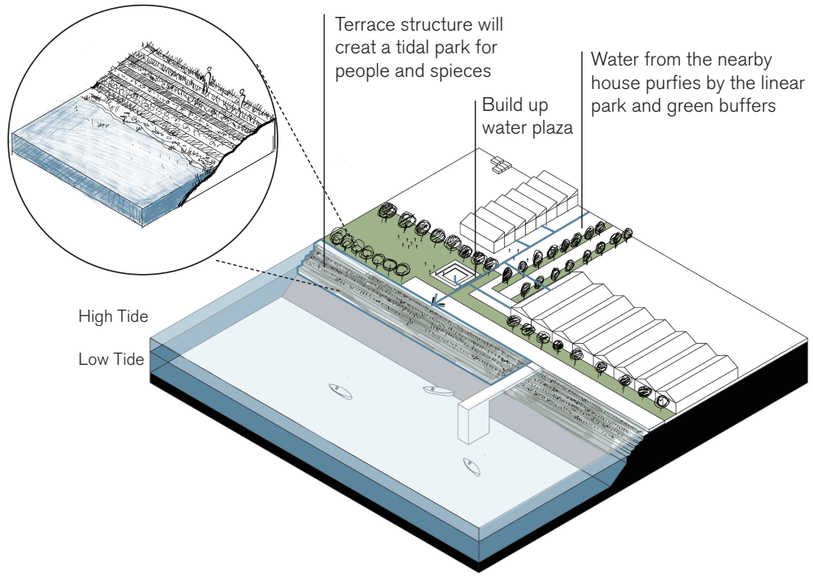
Interventions

-In **Riverfront of Mass(Figure4.14)**, the main challenge is lack of space for ecology and flooding considerations(Especially at the waterfront of the city center). Due to that, the waterfront park consists of tidal terrace and water plaze to enlarge water capacity will be key interventions. By allocating the terrace structure at the sedimentation side, the space for the vegetation growth could be restored. In addition, the flooding issues will be stressed through the water plaza along the waterfront which also provides the leisure values for residents. In addition, the waterfront park is also part of a circular water system by connecting with nearby building blocks.

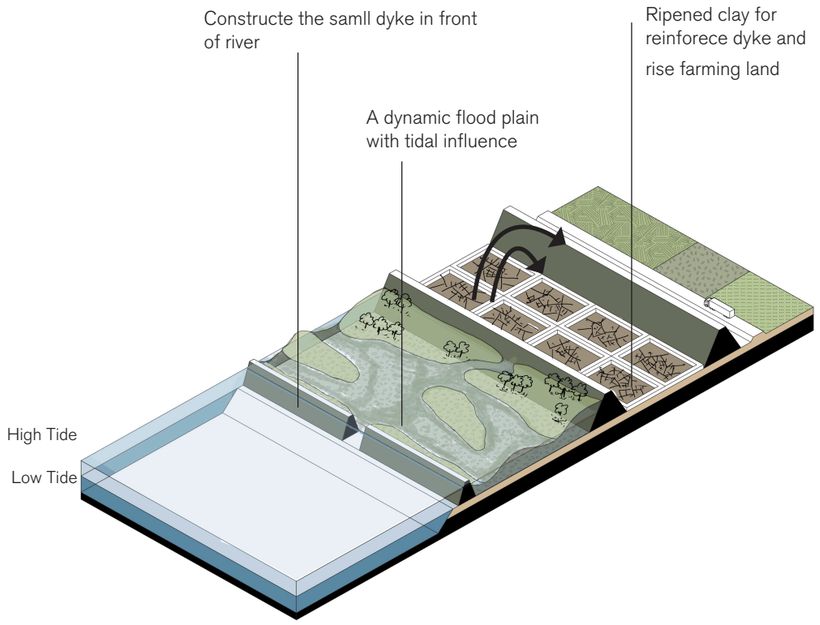
-In **old dock and harbour(Figure4.15, Figure4.16)**, the main challenges are the sedimentation, transportation, flooding and water quality. Based on that, the key interventions would be different types of wetland creations according to the needs and conditions. For instance, the floating structure could be applied to the harbours for the underwater habitat creations to increase biodiversity and increase the water quality. The advantage of this action is that it has less restriction of design and physical conditions. Moreover, the restoration could also use natural wetland creations through the local use of slit. Through the process, the number of new biotopes will increase and grow as the important habitats for the migratory fishes. In addition, the wetlands are also the water buffers for the increasing storms in the future.

-In **New Waterway(Figure 4.17)**, the main challenges are flooding and hard-paving revement. In that case, the flooding plain restoration by constructing the secondary dike is the key intervention. By establishing a small dyke, it could gradually formulate a gradient in front of the main dyke. The new wetland is the natural water buffers and the habitat for species. In addition, the degrading slit could be used for clay ripening that was used to strengthen the main dyke and raise the farmland.

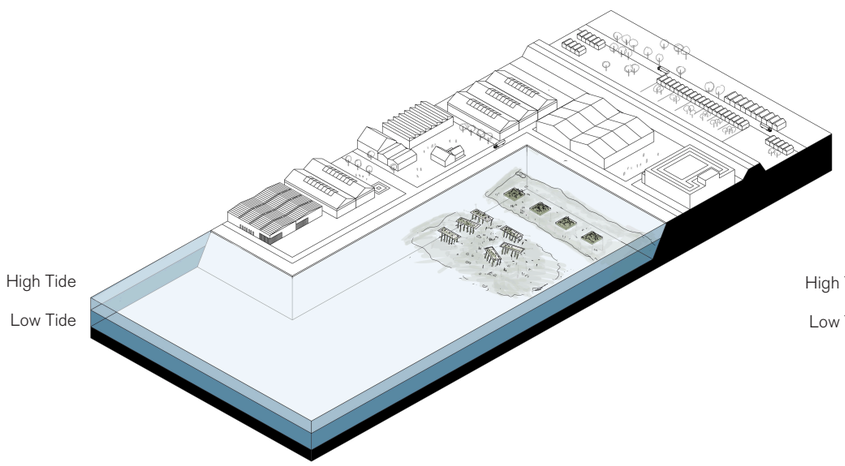
-In **Port of Maasvlakte2(Figure4.18)**, as the place close the coastal area, the main challenge is how to operate the sedimentation. In that case, the sand and mudflat restoration is the key intervention. Using the engineering structure, it could maintain the sedimentation from sea and port. Salt marshes could continue to grow here and thus provide habitat for oysters and fishes. In the long transition, it will be a self growing system(FABRICation,2014).



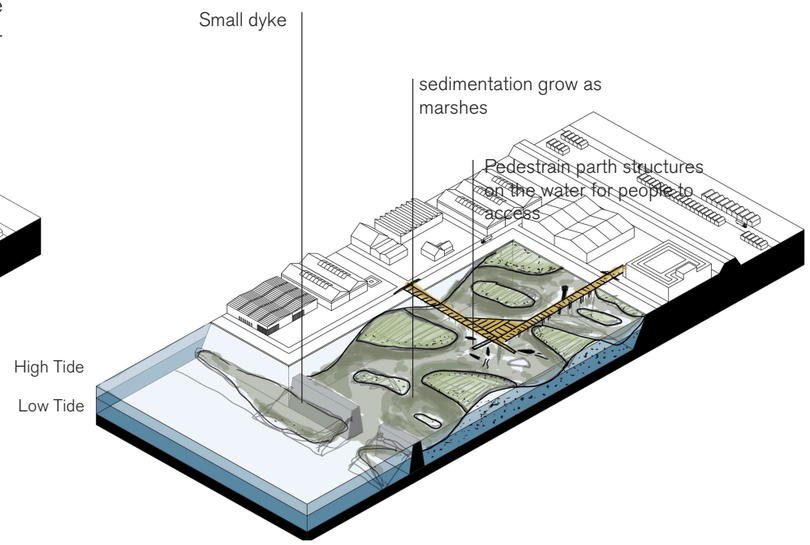
A Interventions of **Riverbank** of Mass
Figure 4.14



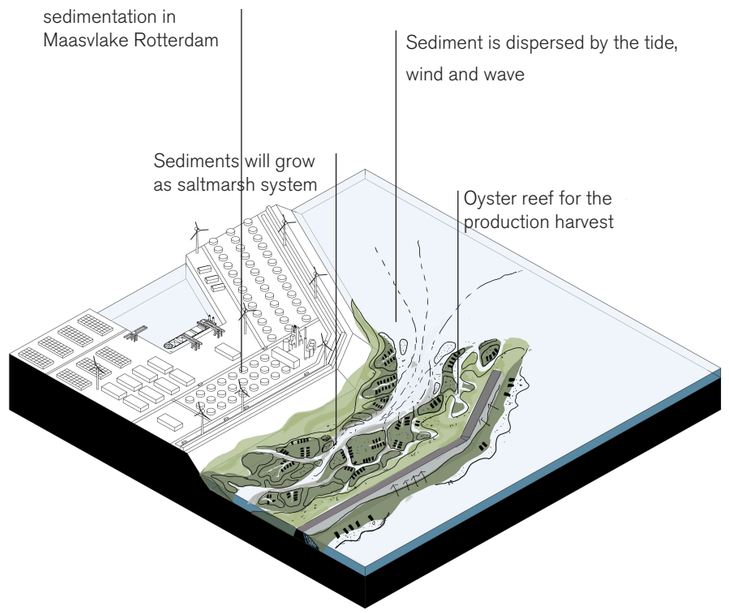
C Intervention of the **New Waterway**
Figure 4.17



B1 Intervention of the **old docks** by using floating structure
Figure 4.15



B2 Intervention of the **old docks** by creating wetlands
Figure 4.16



D Intervention of the **port of Maasvlakte 2**
Figure 4.18

Rotterdam Port Industry(Social-economic)

Rotterdam port is the main industrial, logistic and manufacturing center in Europe. The port of Rotterdam provides economic prosperity for the city and job opportunities for people. Thousands of containers, infrastructures and other goods are stored at Rotterdam port. It is essential to understand the configurations and functions of Rotterdam port which provide the base for later energy transition strategy. Currently, the Rotterdam port is still dominated by the oil-based relative industry. In summary, the oil-based industries have the common features in Rotterdam port. Summarizing them into categories, it expresses as four dominant types: oil transportation, cargo operation, chemical industry and logistics.

The patterns also combine the considerations of metabolic flows with these industrial activities. It shows how the oil-based industry causes damage to the natural system and threatens ecosystem services. For instance, in the oil transportation pattern, the current working flow is that ships transport the oil from overseas to Rotterdam port and store it at the oil tank using the inlet pipes. During the process, the water quality has been threatened because ships will leak pollution into the sea. In addition, in the long run, the Rotterdam port will abandon the use of fossil fuel to achieve the CO2 neutral. The oil terminal as the post-industrial infrastructure could be regenerated and reused. In addition, the pattern catalyzed the design strategy for Rotterdam port industry as the starting points.

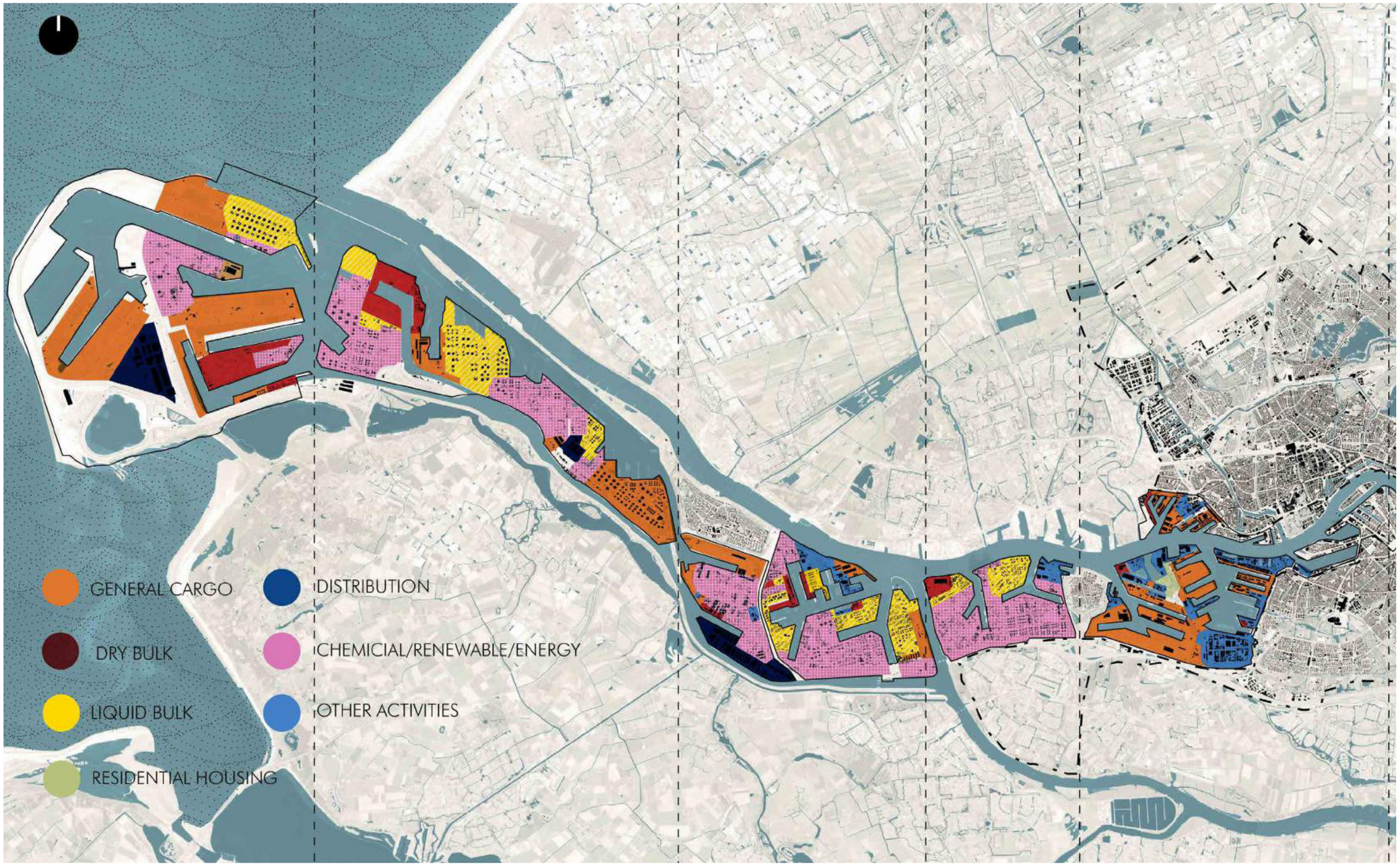


Figure 4.19 Industrial land uses

The Rotterdam port occpuide by different industries with different features. Map shows the distribution of fossil- related industry, by analyzing the industry, the pattern of the industry could be concluded.

- General Cargos
- Dry bulk
- Liquid bulk
- Residential area
- Distribution
- Chemical/renewable/Energy
- Other activities

Categories of Rotterdam port industry

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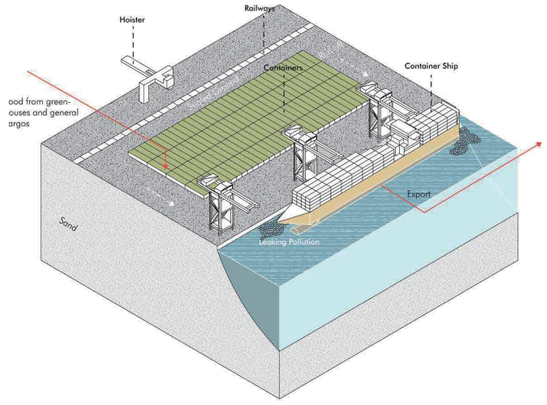
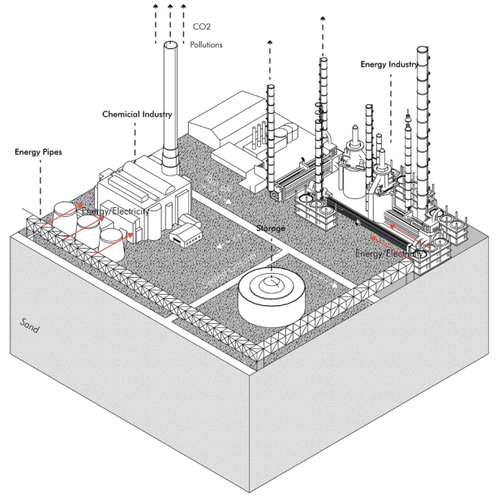
workforce development



Cargo Operations
Figure 4.20



Fossil based -Industry Cluster
Figure 4.21

Challenge1: Polluction of industry

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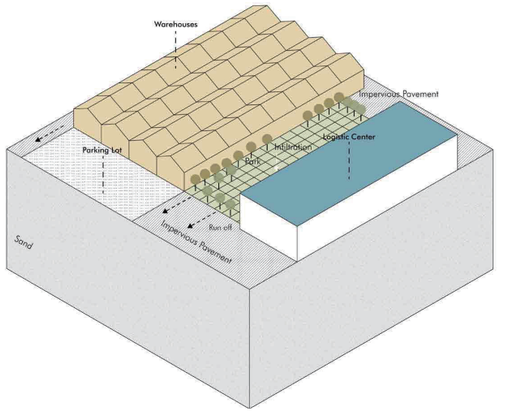
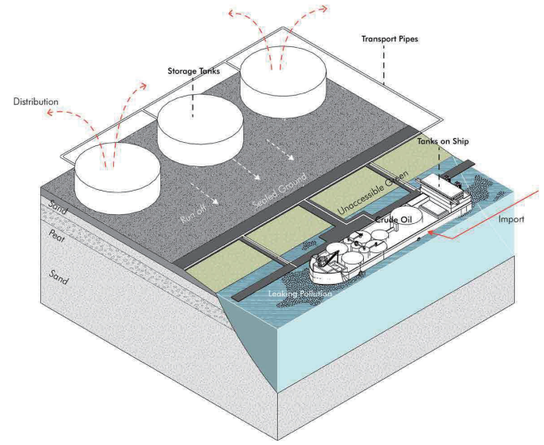
Challenge2: Jobs and benefits creations

Port funding

Enlarge space



Logistics and distribution
Figure 4.23



Oil transportation
Figure 4.22

Interventions

Rotterdam port is the main industrial, logistic and manufacturing center in Europe. The port of Rotterdam provides economic prosperity for the city and job opportunities for people. Thousands of containers, infrastructures and other goods are stored at Rotterdam port. It is essential to understand the configurations and functions of Rotterdam port which provide the base for later energy transition strategy. Currently, the Rotterdam port is still dominated by the oil-based relative industry. In summary, the oil-based industries have the common features in Rotterdam port. Summarizing them into categories, it expresses as four dominant types: oil transportation, cargo operation, chemical industry and logistics.

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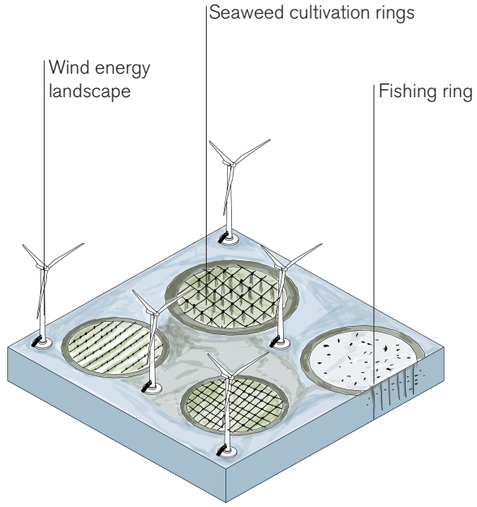
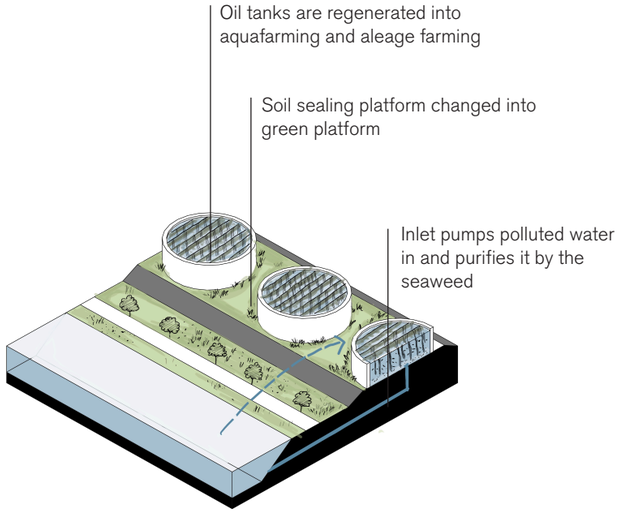
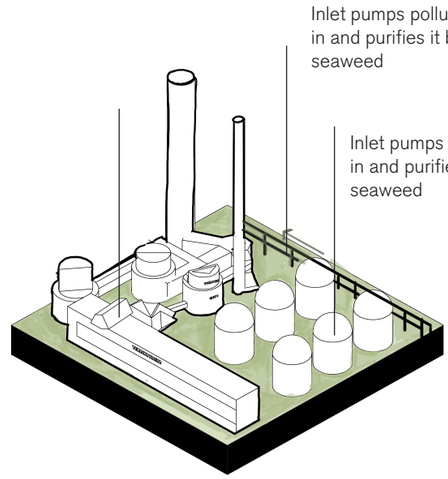


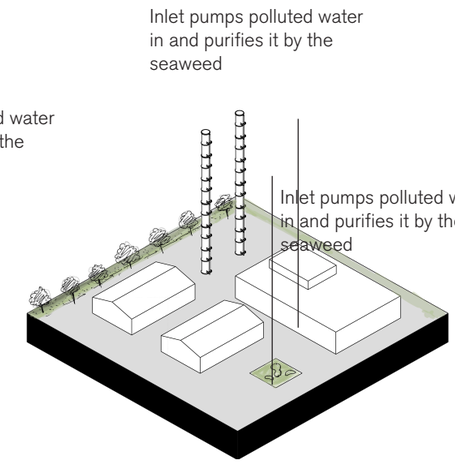
A Seaweed cultivitations in **North Sea**
Figure 4.16



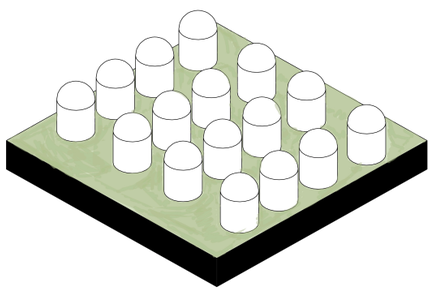
B1 Oil tank regeneration in **Heavy Port**
Figure 4.16



B2 the bio-energy plant in **Heavy Port**
Figure 4.16



B3 bio-tech department in **Heavy Port**
Figure 4.16



B4 bio-digistors creation in **Heavy Port**
Figure 4.16

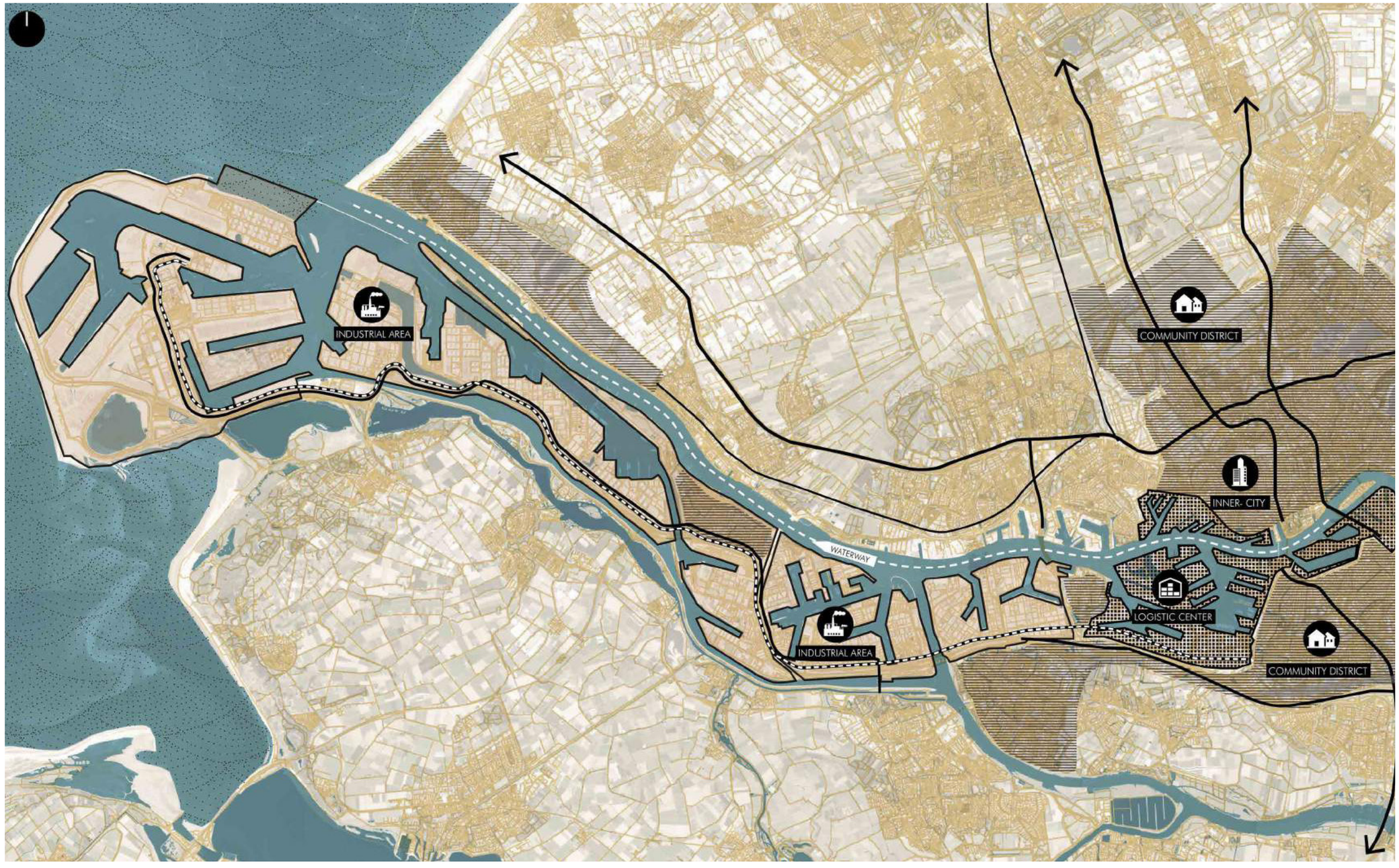


Figure 4.19 Road system and Area Division

In Rotterdam port, the city and port functions have been separated for a very long time, the port could be divided into heavy port, city and city port area. The map shows the primary road and railway across the region.

N

0 5km

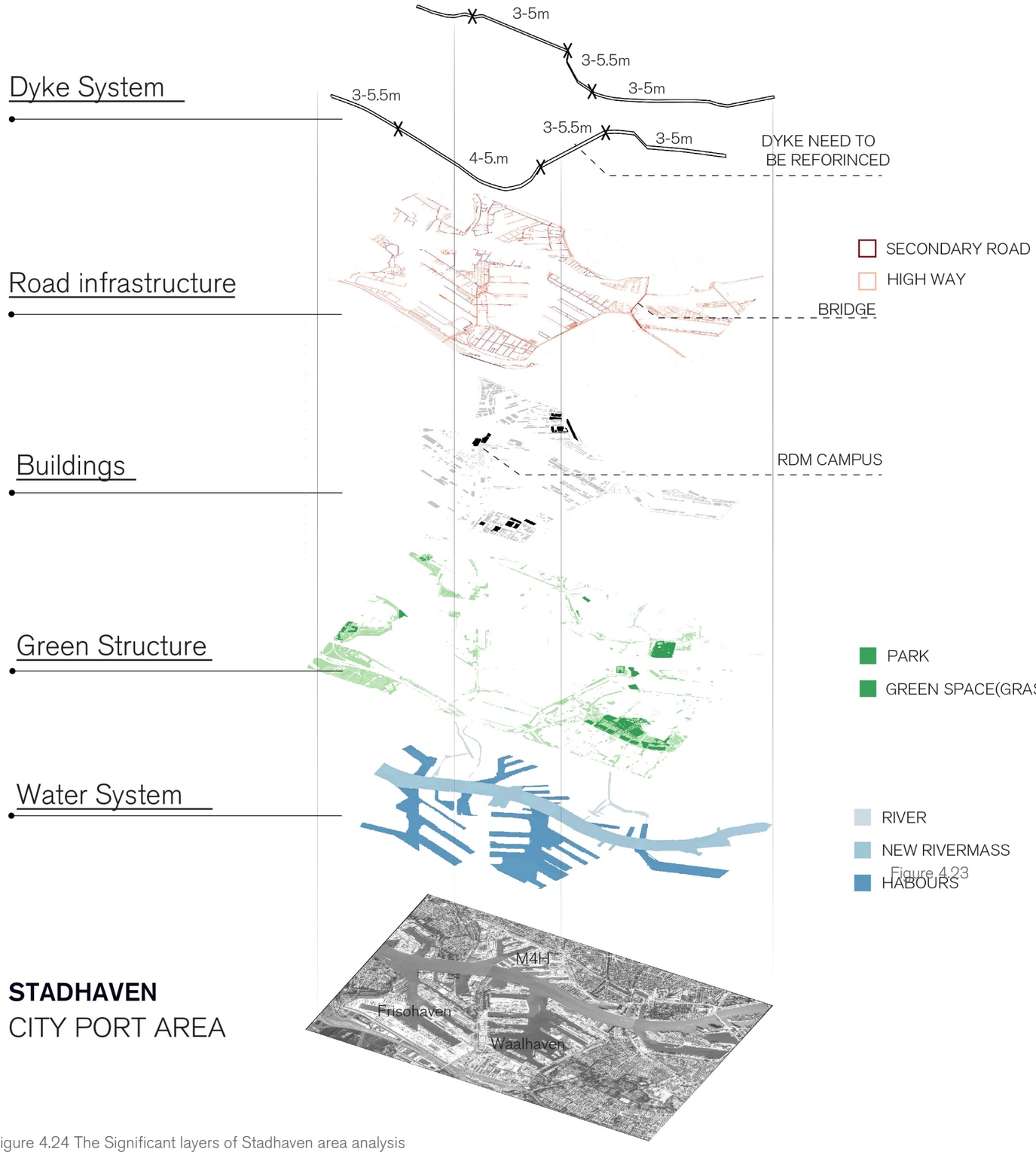


Figure 4.23

Figure 4.24 The Significant layers of Stadhaven area analysis

05.

Design Principle

Principle summary of social-ecological integration

Water Mangement and Ecosystem restoratioon Synergy

Multifunctionality and responsive nature improvment

Land use diversification

Circluarity development

Process and Multi-scales for implementation

Design Principle I

Water managment and ecosystem restoration synergy

To respond to the previous analysis of the biophysical environment in Rotterdam port, a series of measures have been proposed to deal with the challenges. The conceptual approach of nature-based solutions targets based on the strategic area. In order to guide the interventions in principle from the planning perspective, it proposes frameworks to integrate biodiversity, water management and sedimentation management by giving the actions of the framework, starting point of the project and instruments.

Core of the water mangement framework

-A series of tidal parks should be introduced to the city and city port area, the wetlands are the natural purification devices for river Mass recovery.

-Water plaza and the green buffer along the waterfront enlarge the water capacity. In addition, more water could be retained in polder outside the city in the wet season and encounter with salinization problems in the dry season.

-It uses natural flooding plain and hard infrastructure combinations to monitor and mitigate the floodings of storm

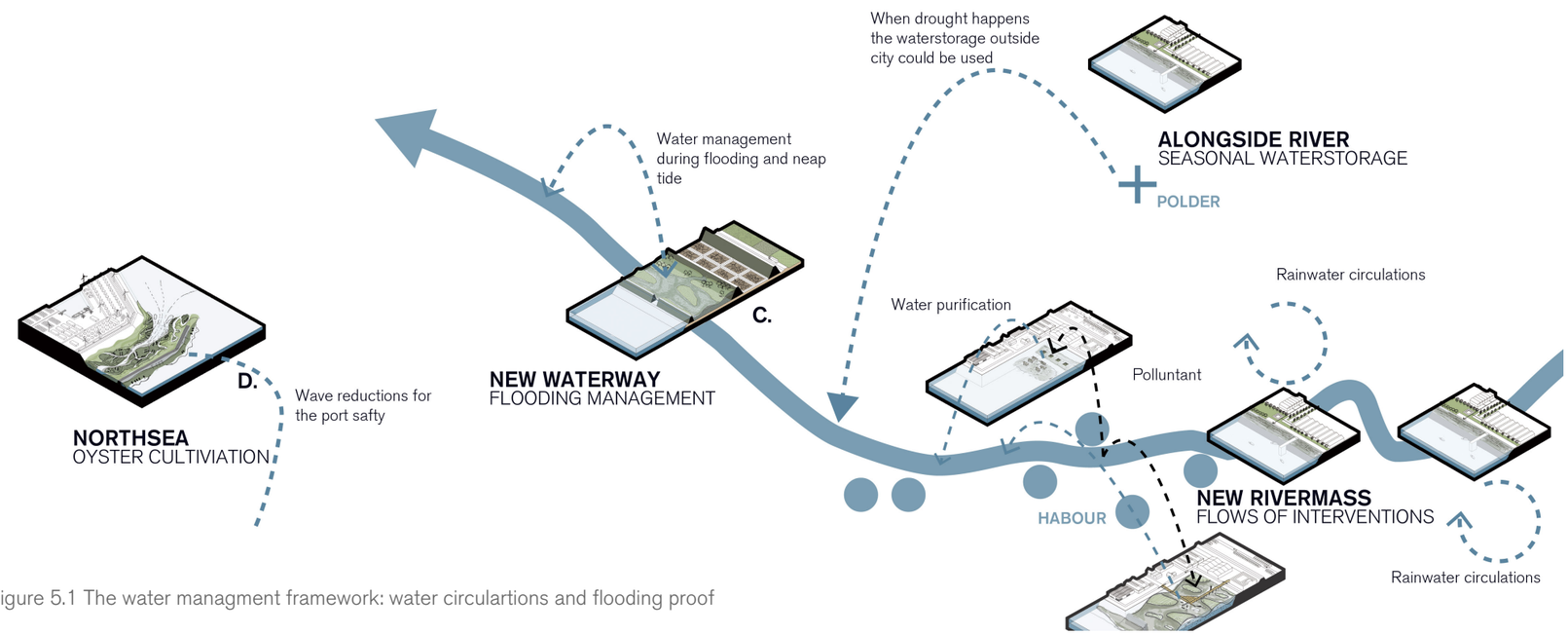


Figure 5.1 The water managment framework: water circulartions and flooding proof

Core of the sedimentation mangement framework

-It aims to decrease the direct transportation of water from the ports to the sea. The sedimentations from the port could be partly spreaded at the strategic locations. It could create the space at the coastal area for sedimentation retention

-Another core is local use of the sedimentations by depositing the degraded sediments at the targeting marshes and wetlands with the process of habitat creations.

-The clay in the sediment is a valuable resource for infrastructure construction and other applications. After the clay ripening process, the sediments from the port area could be used for dyke reinforcement, heightening the farming land and building materials.

Starting point

-Find the space for ecosystem restorations without heavy influence of port operations. The space should fulfill the needs of nature conservation and salt marshes restoration.

-Define the process of nature-based solutions application. It should have the willingness to combine green and grey infrastructure together for water crisis and flooding management .

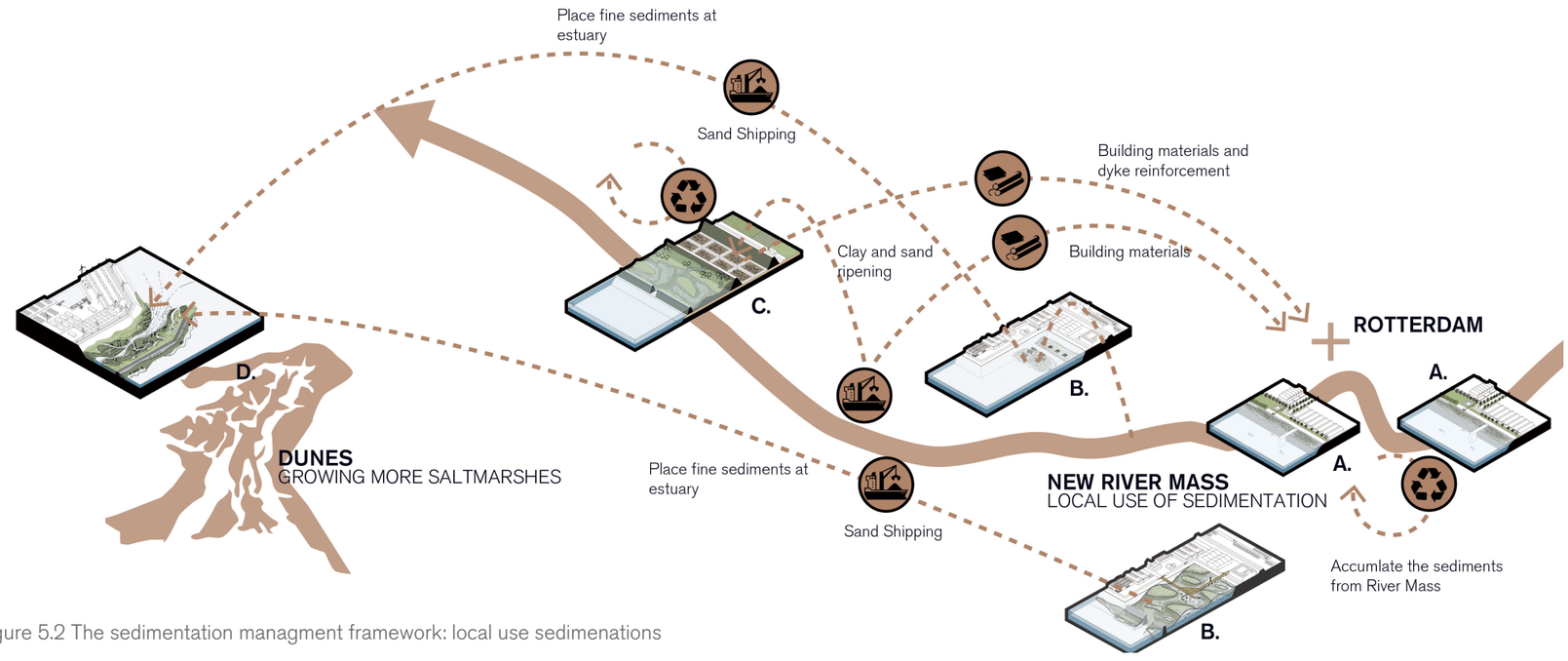


Figure 5.2 The sedimentation managment framework: local use sedimenations port

Design Principle II

Develop the circularity

To respond to the analysis of the resource system in Rotterdam port, the interventions are two essential clusters: energy-production cluster and bio-based material production cluster. The clusters utilize the ecosystem services provided by the seaweed and aquaponics. In this system, the seaweed is mainly obtained as the bio-based materials from the North sea and transferred for the energy use in port, thus the nutrient cycle will be closed. In addition, the nutrient capture process by seaweed will also improve the water quality of River.

Core of bio-based economy

-Encourage the development of aquaponic farming. The seaweed cultivation would be imagined to happen at various places: sea, existing infrastructure and surface of the building. In addition, the wind turbines are a considerable energy landscape on the sea and along the port.

-Develop the bio-based networks, including energy factory, production factory and transport pipelines to formulate energy hubs and business parks in Rotterdam port. Then, the hub, agriculture land and sea will be integrated as the backbone for new circular economy development

- Application and upgrading of innovative technology. The niches of the bio-based economy should be developed from the bottom to move forward the energy transitions.

Starting point

-Decrease and stop the use of fossil energy. The new bio-based economy helps with CO2 neutral and green ports.

-The rich benefits of aqua farming and the River Mass could provide productive ecosystem services for seaweed and bio-based material cultivations.

-The regeneration and upgrading of the current industry infrastructure and the wide use of biomass.

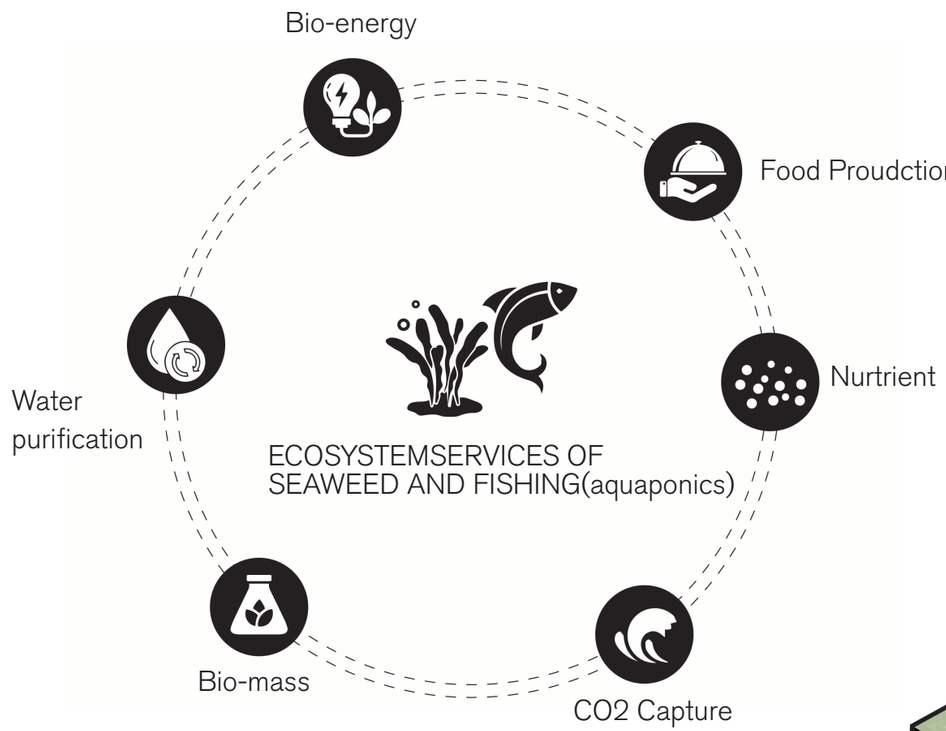


Figure 5.3

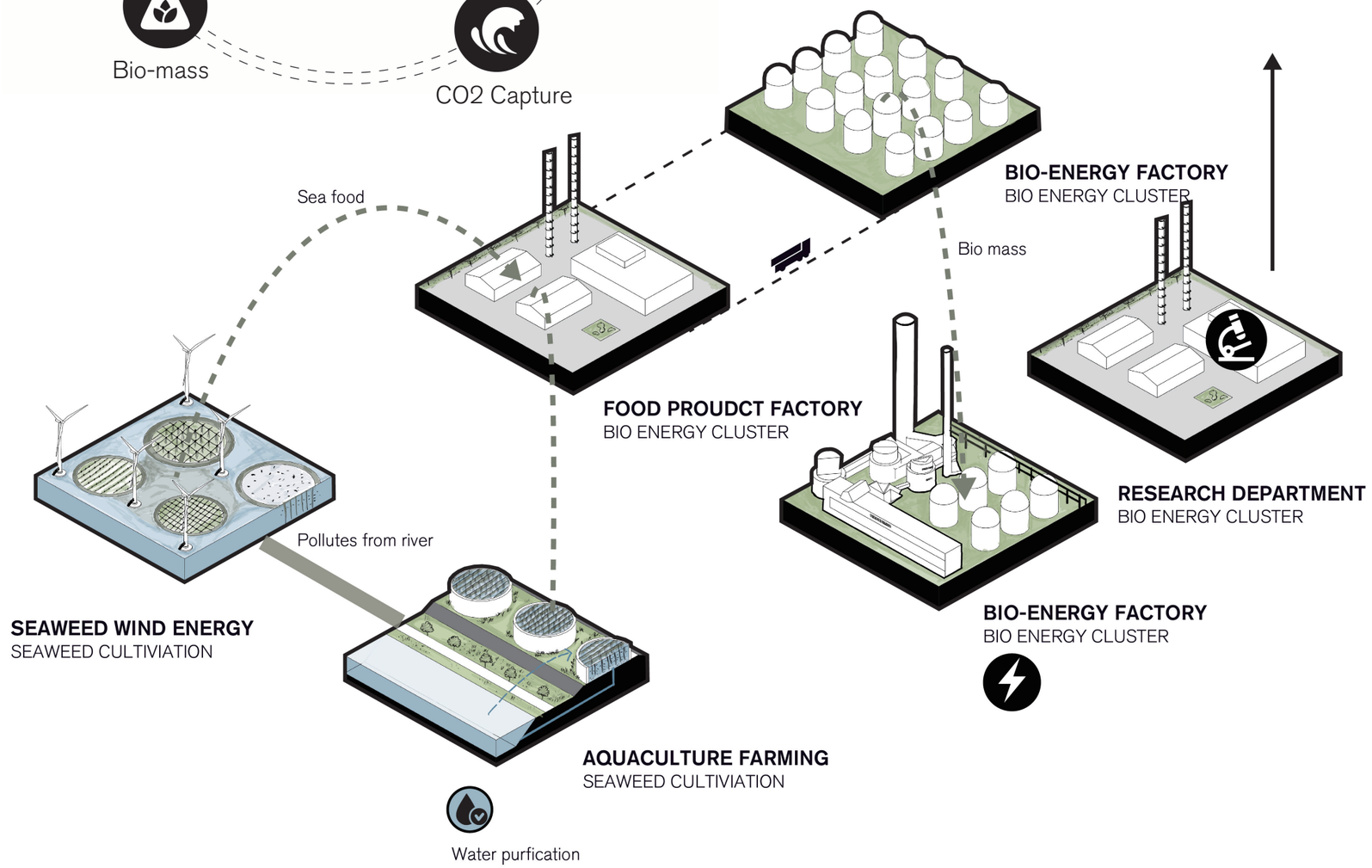


Figure 5.4 New bio-based economy

Design Principle II

Multifunctionality and increase responsive nature

In order to integrate the city growth with the port development, the interventions mainly focused on the city-port area where the port activities are mixed with urban functions. The interventions refers to numerous aspects, such as the landscape, urban functions, mobility, and green spaces. The goal is not only to develop areas to accelerate the integration between city and port by providing job opportunities and living space, but also to develop nature and green space for ecology and people's health. In addition, adaptive development is also taken into consideration for climate adaptations. The landscape framework and nature in city framework focus more on green connections and public space(urban nature) development.

Core of the landscape framework

- the waterfront of the area in the city-port transition is diversified: hard active shoreline and soft restored shorelines for diversified waterfront uses, port value increase and natural environment enhancement. From the ecological perspective, the waterfront and created wetland will be habitats for species. From the social perspective, it will increase the waterfront accessibility and provide entertainment and education for citizens.

-Intense the greenery of the main dykes as it is the main infrastructure to separate the city and port. The greenery could mitigate the sense of boundary. From the ecological perspective, the primary dyke is the green connections to the main parks for birds and other species. From the social perspective, the dyke provides multi-function uses, it could be viewed as a public space, platform for property development and transport and parking space.

-From the city to the river, the stepping stone for migratory species will be created.

Core of Nature in city framework

-Enlarge the green space at the building, street, parks and square, the courtyard of building blocks. It will be part of the landscape framework. In addition, the nature in the city will also grow as ecological hotspots for insects and birds to live in the city. The water sensitive design could also be integrated in the green space for water collections.

- Green space in city are also multifunctional. They are high quality of public space for collective use.

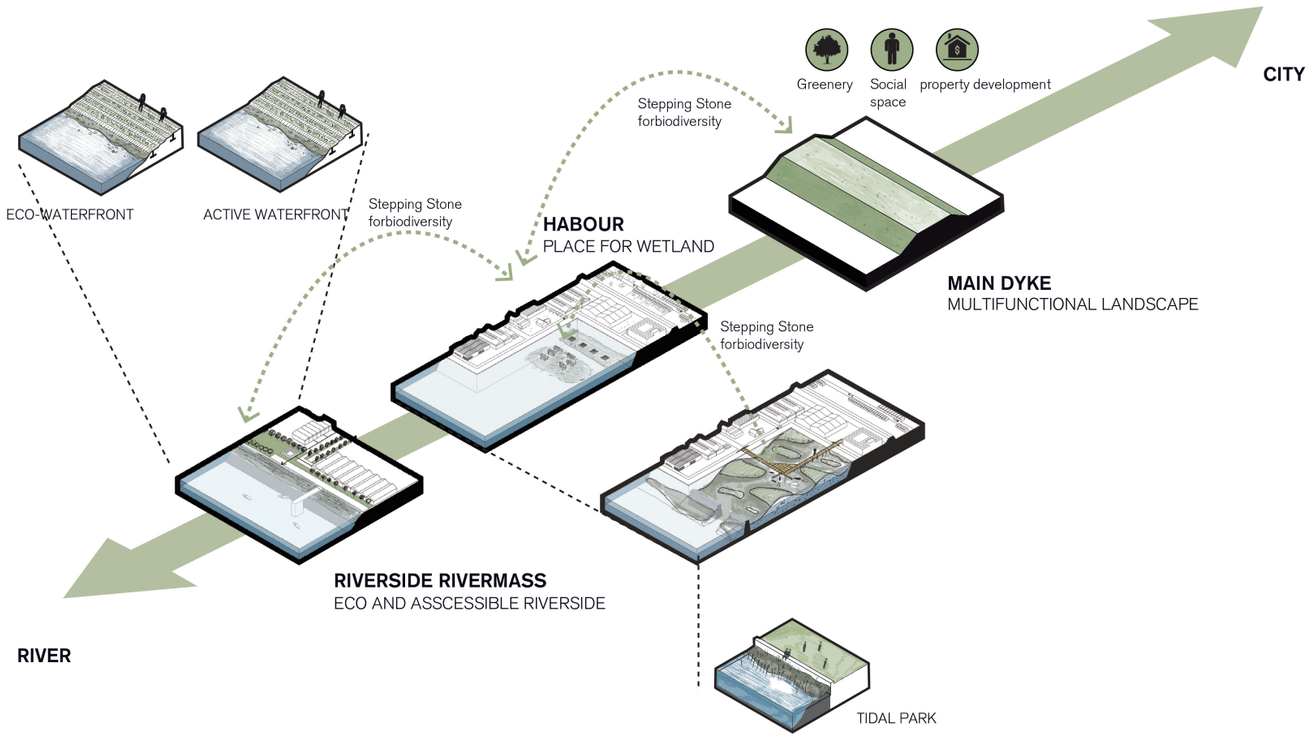


Figure 5.5 Landscape framework

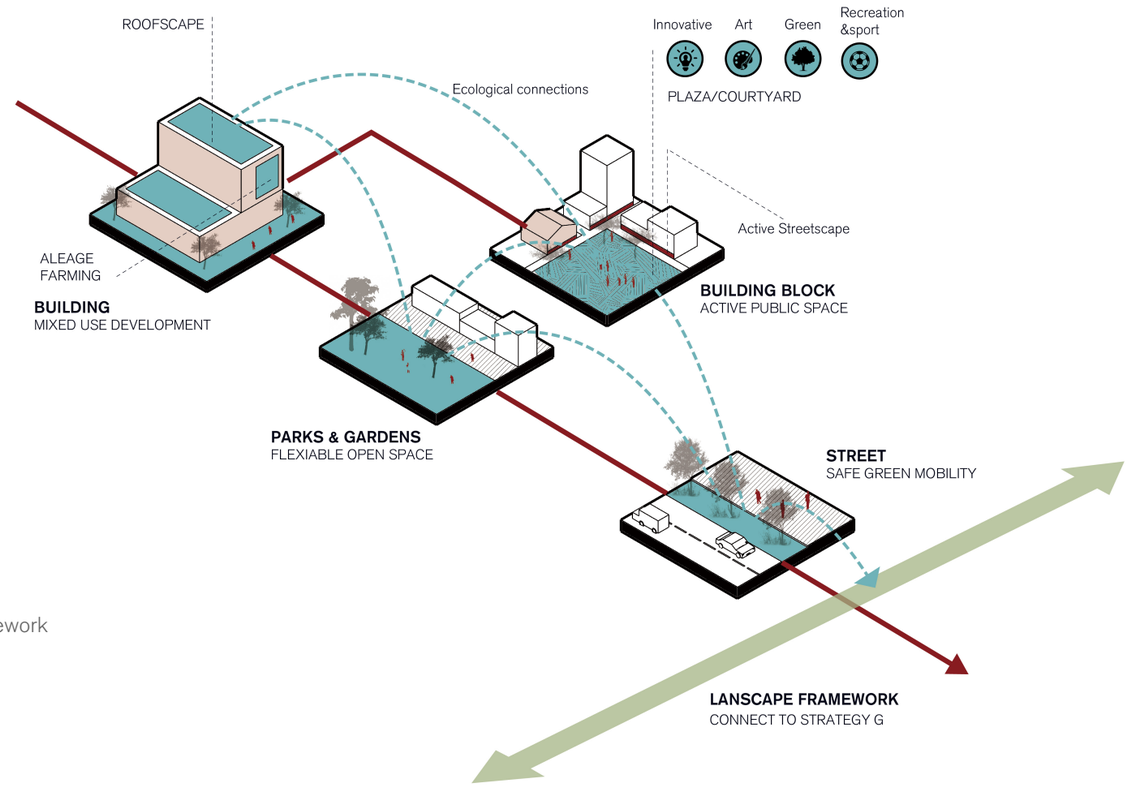


Figure 5.6 Nature in city framework

Design Principle III

Land use diversification

The sustainable mobility framework concentrates on improving the accessibility to the neighborhood and community. It connects the neighborhood to activities, nature space and open spaces at the city-port area in Rotterdam port(taking Stadhaven as example). Moreover, the densification and redevelopment integrate different interventions for facilitating urban development and economic growth in port.

Core of the sustainable mobility

-Enhance the public transit model. The bus, subway, train and water transport provide multiple choices for visitors and workers. The main transport hubs will integrates different public transportation together and the high density bring the opportunity for property development.

-Strengthen the identity of water and port. The choice of water transportation will be diversified from water bus, ferry to kayak, thus the accessibility of the waterfront will be increased.

-Create a safe and green mobility network for pedestrians and cyclists. In addition, the network also improves the port accessibility from the surrounding city and area.

-Organize the car and freight traffic and parking spaces by creating highly collective car parking and integrated cargo hubs.

Core of redevelopment and densification

-Explore the innovative technology application in the port by developing research hubs and education centers.

-The newly developed port should be maker districts by providing more jobs for nearby communities while allowing more companies to come in to formulate industrial ecosystems.-

-The industrial heritage is a valuable source for tourism and art development. Adapting and reuse existing built form is effective way of redevelopment to increase the spatial quality and overcome physical of industrial uses

-Make the densification both on the lands and the water by using different housing typologies. For instance, the floating housing, dyke housing and stilt housing will create a new lifestyle as it adapt the change of climate as well.

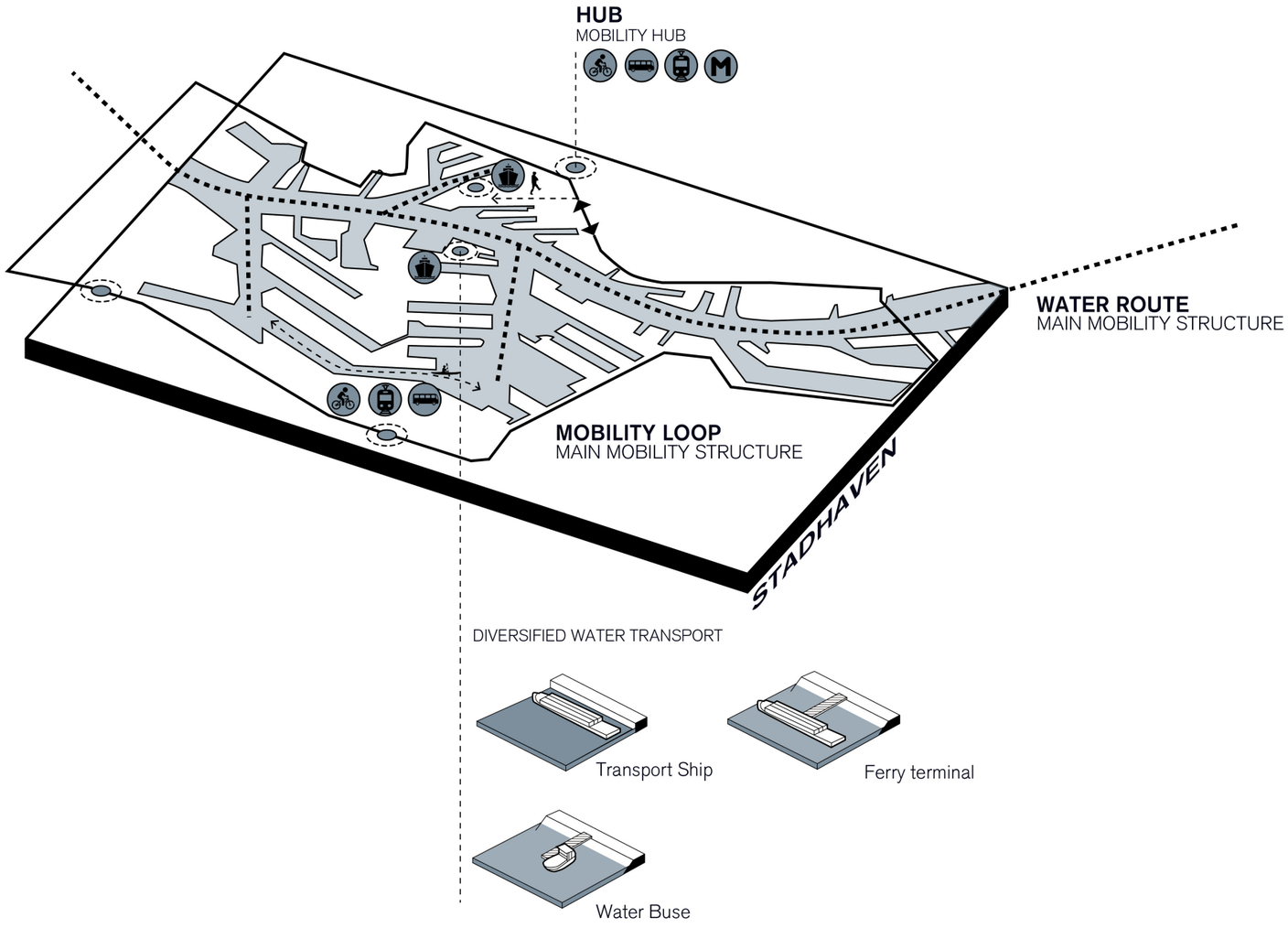
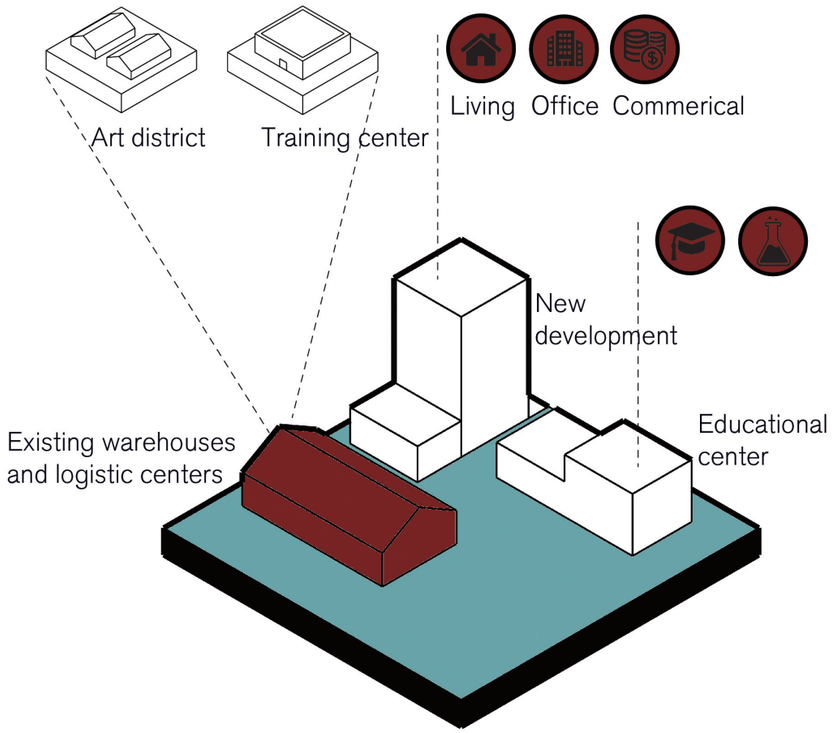


Figure 5.7 Sustainable mobility framework(City-port area)



MAKER DISTRICT
PLACE FOR COMPANY AND PEOPLE

Figure 5.8 Redevelopment and densification framework

Starting points

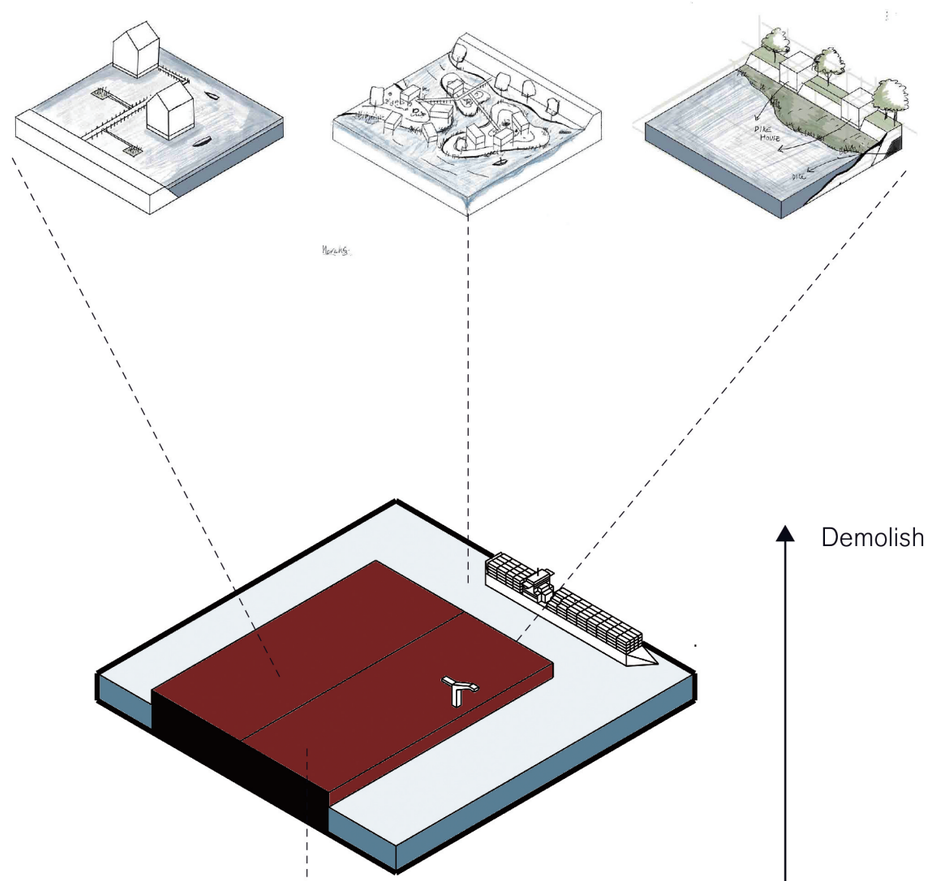
-The upgrading of the cargo transportation. The existing abandoned railway could be transferred into light transits.

- Space for collective uses and well equipped electricity infrastructure.

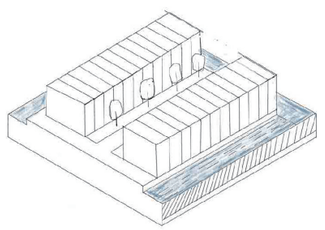
-Identify and make attractive bicycle parking spaces for the local users in the communities to connect the public transit.

-Apply the parking policy of Rotterdam at the area to make less surface parking space as possible.

TYPOLOGIES OF WATER COMMUNITY



WATER COMMUNITY
CHANGE THE HABOURS FOR CARGOS



-balance the demand and supply of housing from different groups of people. The analysis of densification site from different aspects

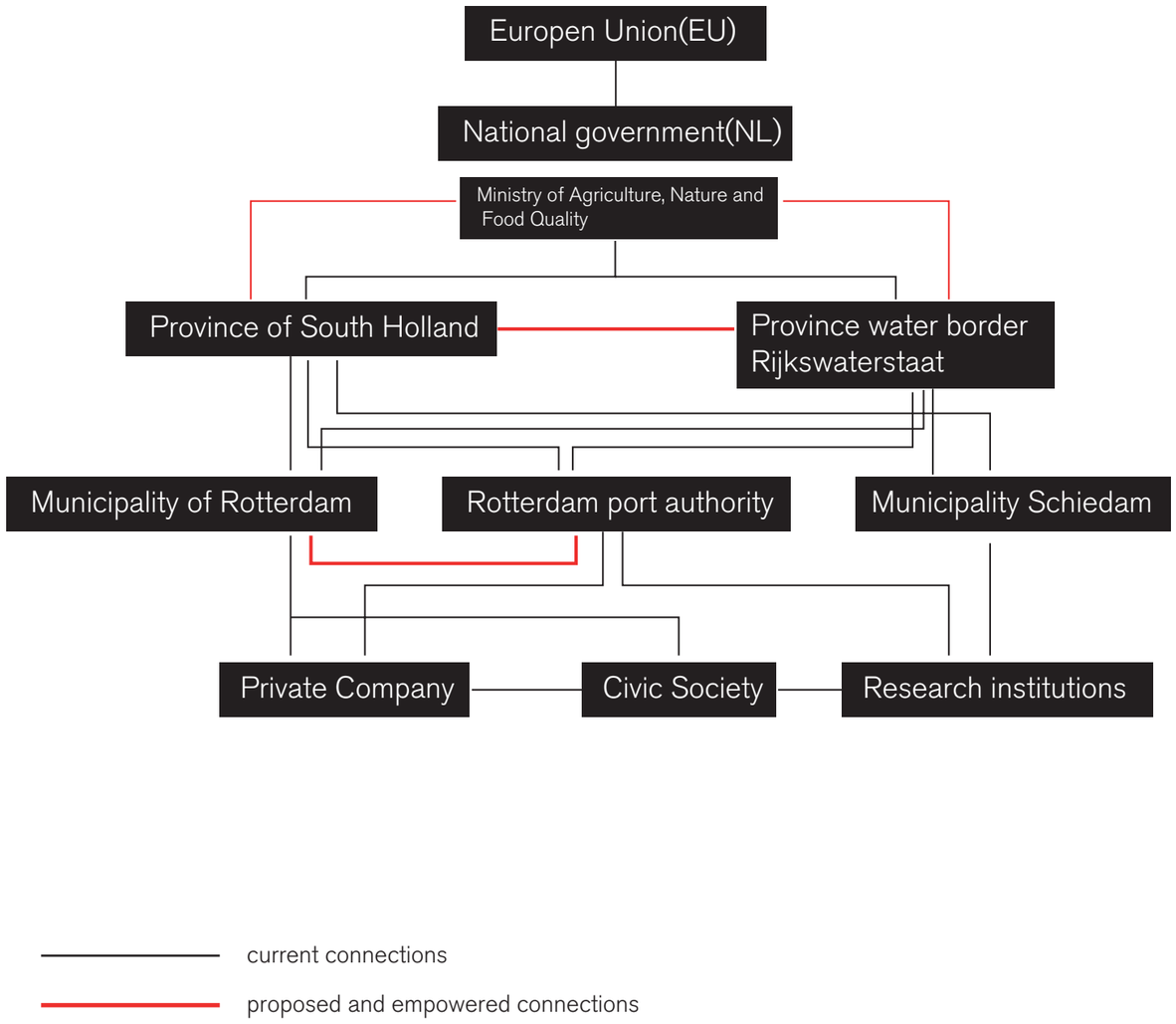
-Mixed used developed building blocks with mixed programs. The flexibility of the building block will adopt the future uses.

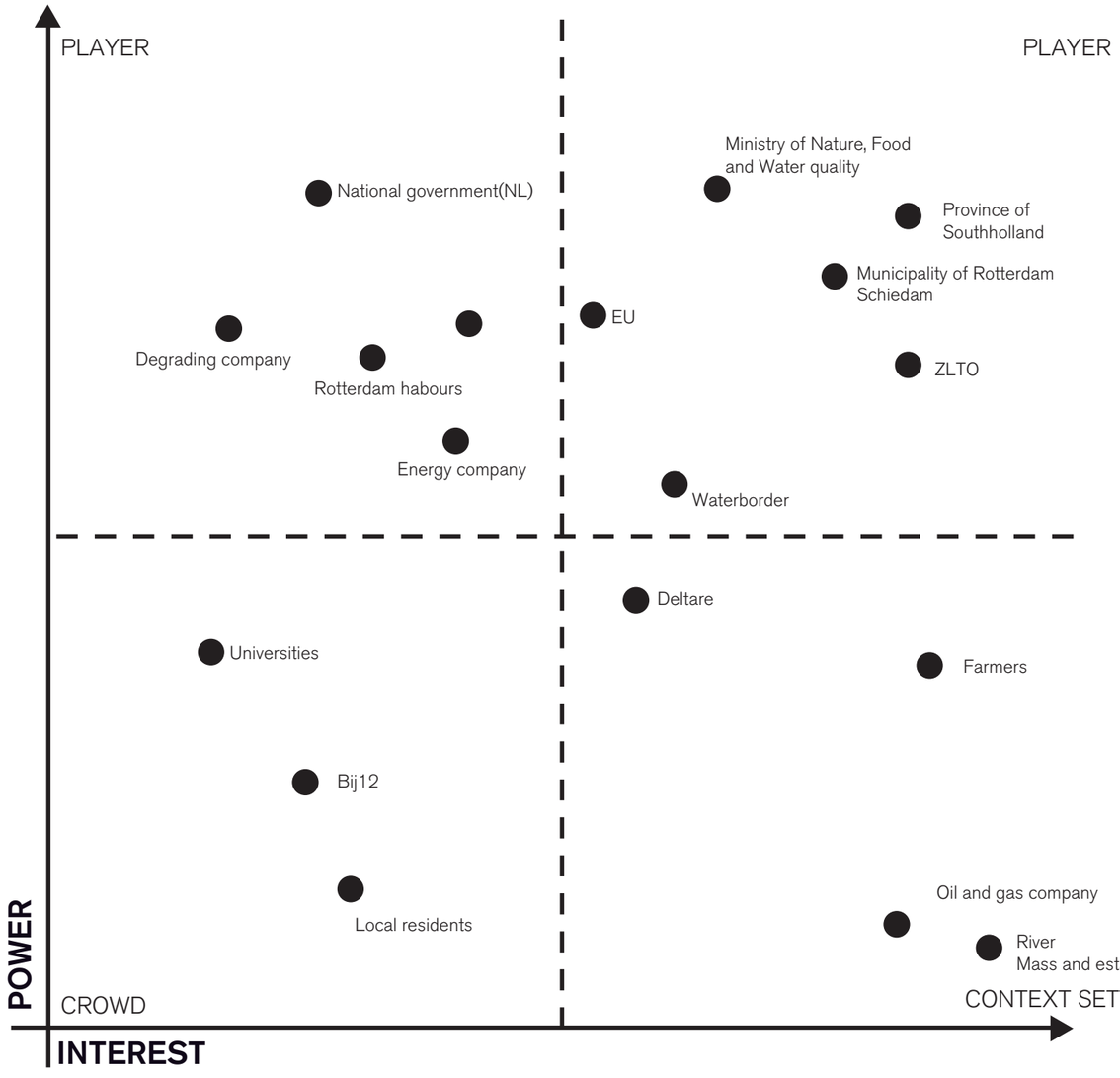
07.

Governance

Goverance

Insititutional framework

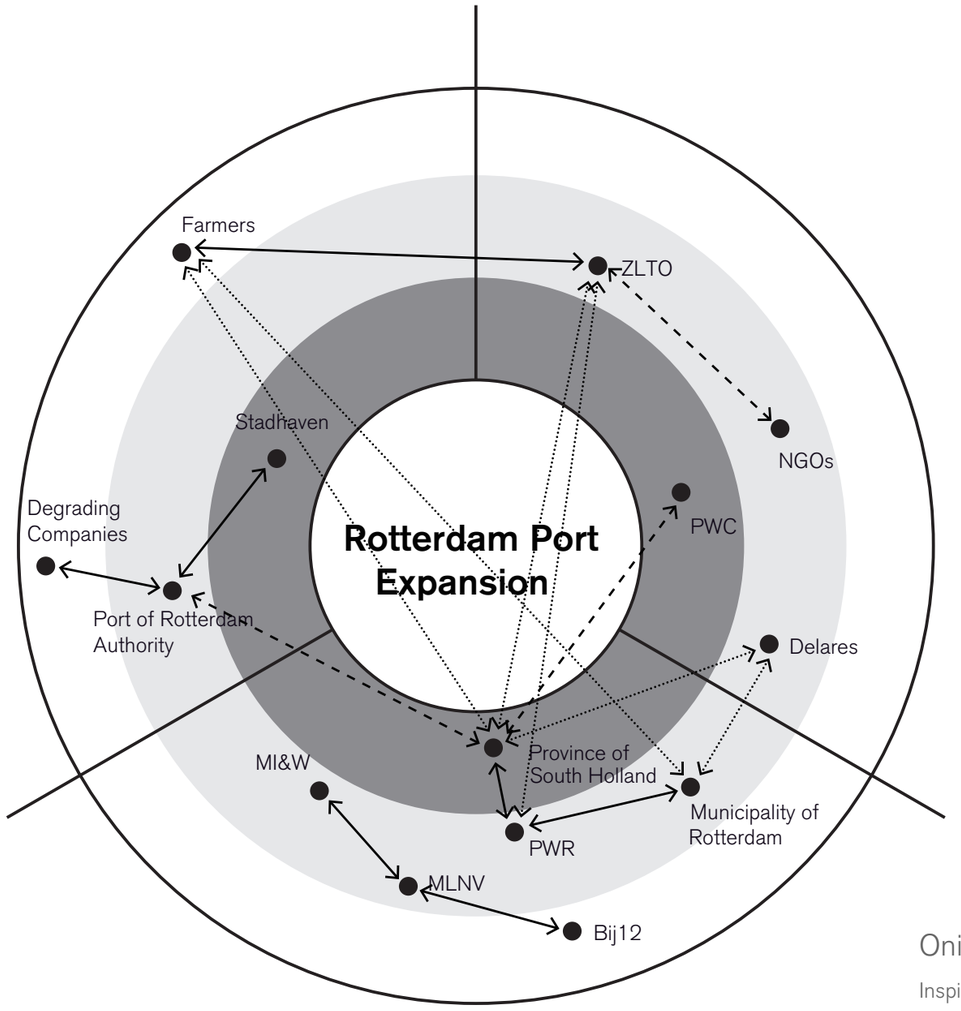




Current Situation

Private

Civic



Public

Wider Environment

Secondary Stakeholders

Primary Stakeholders

Onion diagrams. Based on: Czischke,(2018)

Inspired by:Agliati, (2020)

Actors

- Existing Stakeholders
- Potential Stakeholders

Relationship

- Strong collaboration
- Ad-hoc collaboration
- Indirect inlfuence

Multi-actors interactions

-Encourage the development of aquaponic farming. The seaweed cultivation would be imagined to happen at various places: sea, existing infrastructure and surface of the building. In addition, the wind turbines are a considerable energy landscape on the sea and along the port.

-Develop the bio-based networks, including energy factory, production factory and transport pipelines to formulate energy hubs and business parks in Rotterdam port. Then, the hub, agriculture land and sea will be integrated as the backbone for new circular economy development

- Application and upgrading of innovative technology. The niches of the bio-based economy should be developed from the bottom to move forward the

-Decrease and stop the use of fossil energy. The new bio-based economy helps with CO_2 neutral and green ports.

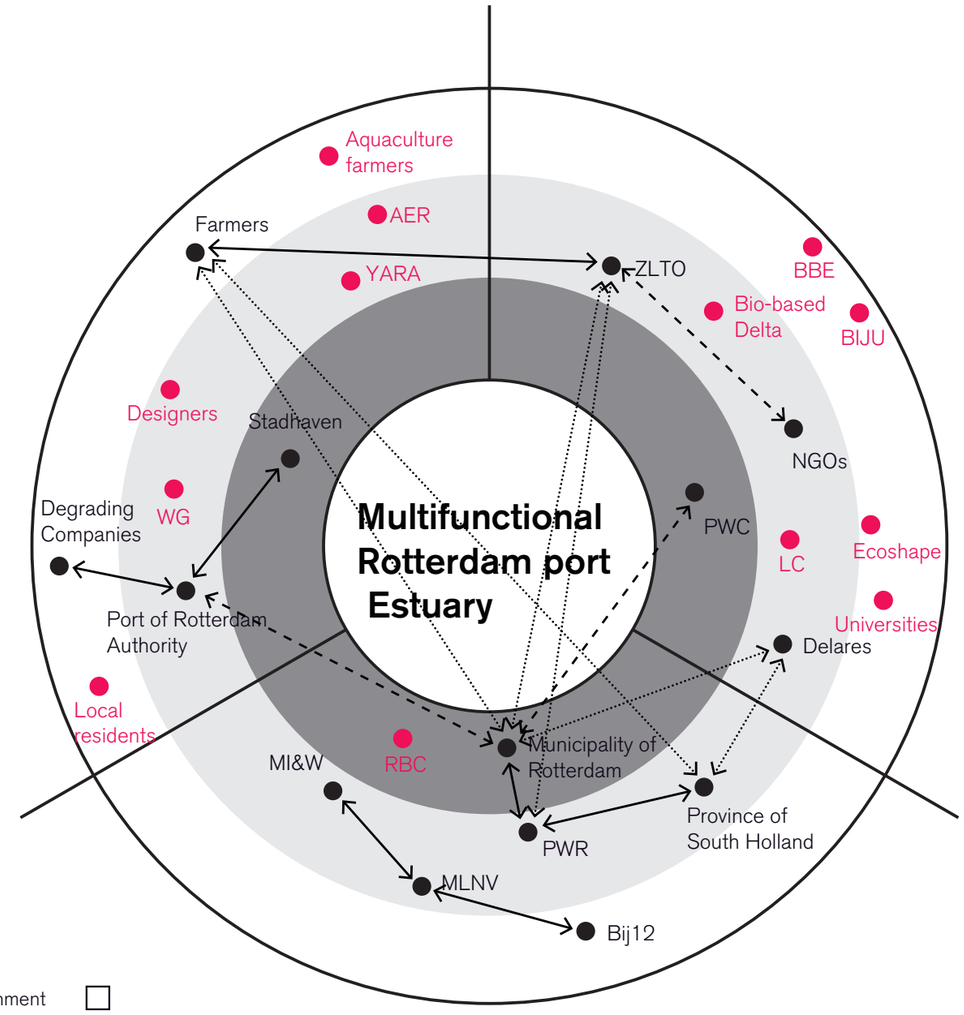
-The rich benefits of aqua farming and the River Mass could provide productive ecosystem services for seaweed and bio-based material cultivations.

-The regeneration and upgrading of the current industry infrastructure and the wide use of biomass.

Desired Situtation

Private

Civic



Wider Environment

Secondary Stakeholders

Primary Stakeholders

Public

Onion diagrams. Based on: Czischke,(2018)

Inspired by:Agliati, (2020)

Actors

- Existing Stakeholders
- Potential Stakeholders

Relationship

- Strong collaboration
- Ad-hoc collaboration
- Indirect inlfuence

Desired situation

-Encourage the development of aquaponic farming. The seaweed cultivation would be imagined to happen at various places: sea, existing infrastructure and surface of the building. In addition, the wind turbines are a considerable energy landscape on the sea and along the port.

-Develop the bio-based networks, including energy factory, production factory and transport pipelines to formulate energy hubs and business parks in Rotterdam port. Then, the hub, agriculture land and sea will be integrated as the backbone for new circular economy development

- Application and upgrading of innovative technology. The niches of the bio-based economy should be developed from the bottom to move forward the

Overaching planning framework

-Decrease and stop the use of fossil energy. The new bio-based economy helps with CO_2 neutral and green ports.

-The rich benefits of aqua farming and the River Mass could provide productive ecosystem services for seaweed and bio-based material cultivations.

-The regeneration and upgrading of the current industry infrastructure and the wide use of biomass.

07.

Strategy

Regional strategy for Rotterdam port

Based on the previous guiding principles of social-ecological integrations, it will propose regional planning to establish a resilient Rotterdam port. The previous analysis of the social-ecological system in Rotterdam will be changed by bridging the connections between different interventions at three mentioned topic layers.

According to the proposed structure, the Rotterdam port plans 2050 will be brought forth based on three significant layers, including biophysical layers, resource layers and social layers. In addition, the roadmap to achieve the transition is provided as part of plans. Then, the Stadhaven area is chosen as one of the important programmes for social-ecological integrations. M4H is illustrated as the example project by the design interventions. The structure of regional planning work inspired by the Agliati (2020) to provide a well defined and structured model to realize the guiding principle of process and multi-scale interventions.

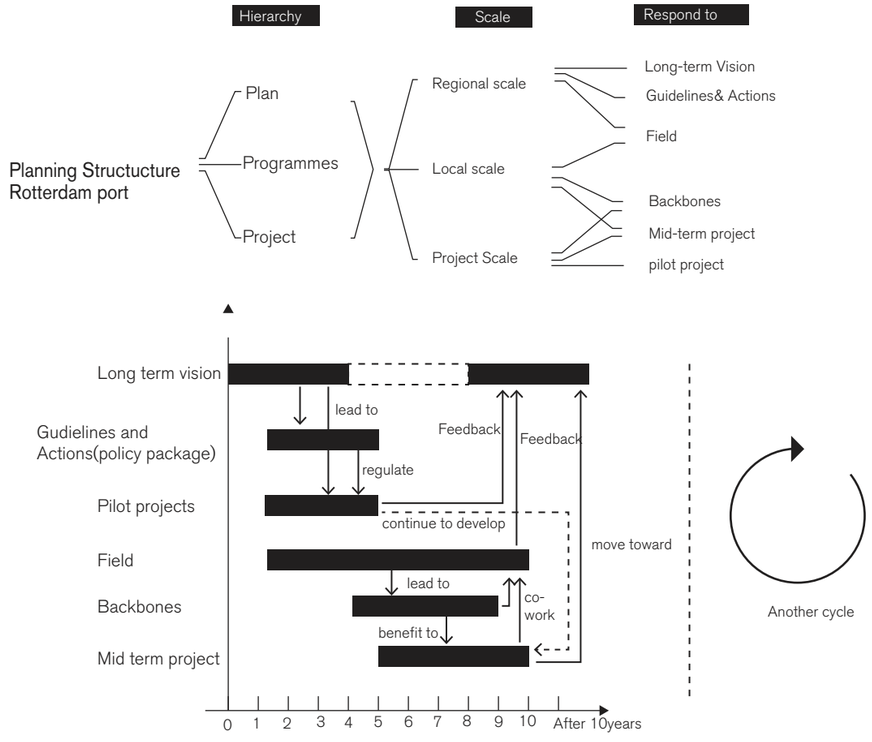


Figure 7.1 Introduce the planning structures and planning cycle(Source:Agliati,2020)

Structure of planning

The strategic planning level has been divided into three elements, including plans, programmes and projects at regional scale, district scale and local scale separately. The three elements involved with the different actions and stakeholders. It will be classified clearly in the following content.

-The strategic **plan** draws the overall vision of the region's development. By prospes specific actions at different layers, the plans manipulate the transition process from the top down perspective.

-The **programmes** could be viewed as a connection of both plans and projects. It is the collection(cluster) of several projects and backbones happening toward a particular field in a certain area. In this thesis, the area in transition called Stadhaven(City-port area) is defined as the programmes for development.

-The lowest level of the scale of the intervention is the **project**. It is the component of the programmes and plans. Most of the project is design-oriented and site specific.

In addition to the planning level, it is significant to understand how to develop and implement the strategy and actions throughout the time as the **planning cycle**. In this thesis, the planning phases have been setted up until 2050 years.

-**Long term vision development(30years)**. The long term vision has been defined by the actions at regional level . It is the top down approach to understand the challenges and opportunities of the Rotterdam port region. In addition, the vision will be evaluated and adjusted every 10 years.

-In every ten years, there will be a **policy package** to define in detail the actions and principles of the long term vision at plans based on the adjustment. From the bottom-up, the programmes will be activated through the development of pilot projects. Furthermore, the pilot projects will formulate the backbones and then the backbones to facilitate the implementation of the project.

-The **backbones** are the large scale infrastructure network development well the **local project** are one or several block designs at small scale.

-**Pilot projects** are the pinooring test solutions of the actions from plan.

Plan1: Build with nature

The build with nature strategy focuses on the **environmental actions** at biophysical layers. It aims at the implementation of the **nature-based solutions** in the river and estuary landscape of Rotterdam port which will increase its ecological resilience and climate adaptability. The build with nature measures is devoted to restore the tidal ecosystem and thus utilize the ecosystem services of it.

Moreover, the strategy moves beyond the Rotterdam port to work with the surrounding regions by strengthening and establishing **ecological connections** to the region. It will eventually grow as a regional park. At the regional scale, the connection is ensured for biodiversity and migratory species.

The ecosystem is the area of the intertidal ecosystems. The habitat of this ecosystem is mainly the marsh zones that originally grows along the waterfront while disparence. The action of the ecosystem restoration is to **restore the water gradients** and let it grow through time. Two examples of restoration have been illustrated as Figure 7.3 and 7.4 along the river.

Last but not least, to solve the flooding problems, the **retention area** of water is mapped out, the water landscape also supplies fresh water to the river during the dry season while store the rainfall during the wet season.

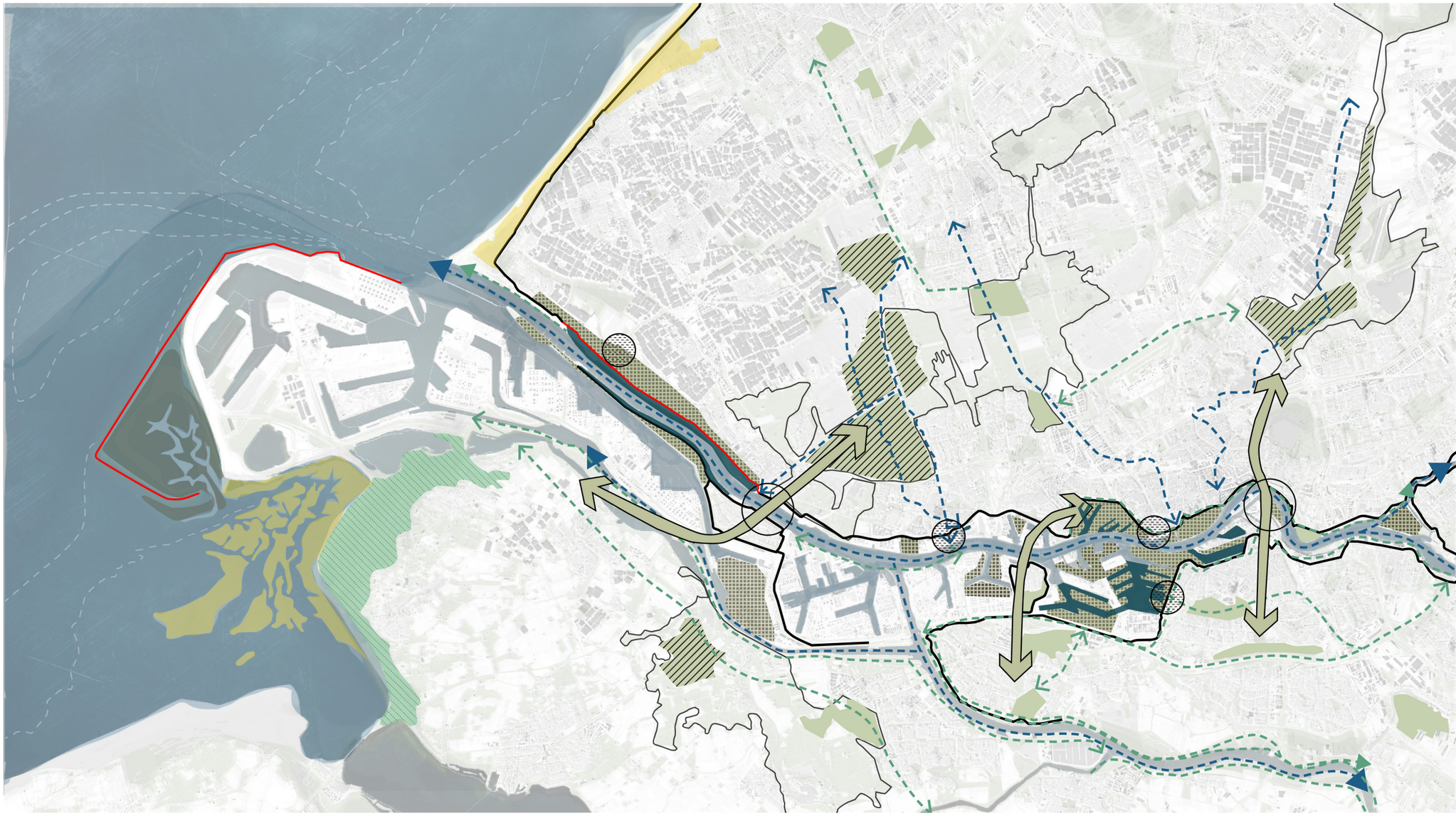


Figure 7.2 Biophysical layer

Growing system:waterfront park

Stakeholder Involvment

- NG National government
- PS Province of South-Holland
- PR Port of Rotterdam
- MR Municipality Rotterdam
- IN Investor
- RH Royal Haskoning DHV
- FA Famers
- WTP Waste water treatment plant
- HKV Lijn in water HKV
- R Residents
- NGO NGOs

2 The green buffer can help with infiltration process and provide benefits for biodiversity

3 Water plaze provide the recreational function as part of park and enlargee the water capcity during rain

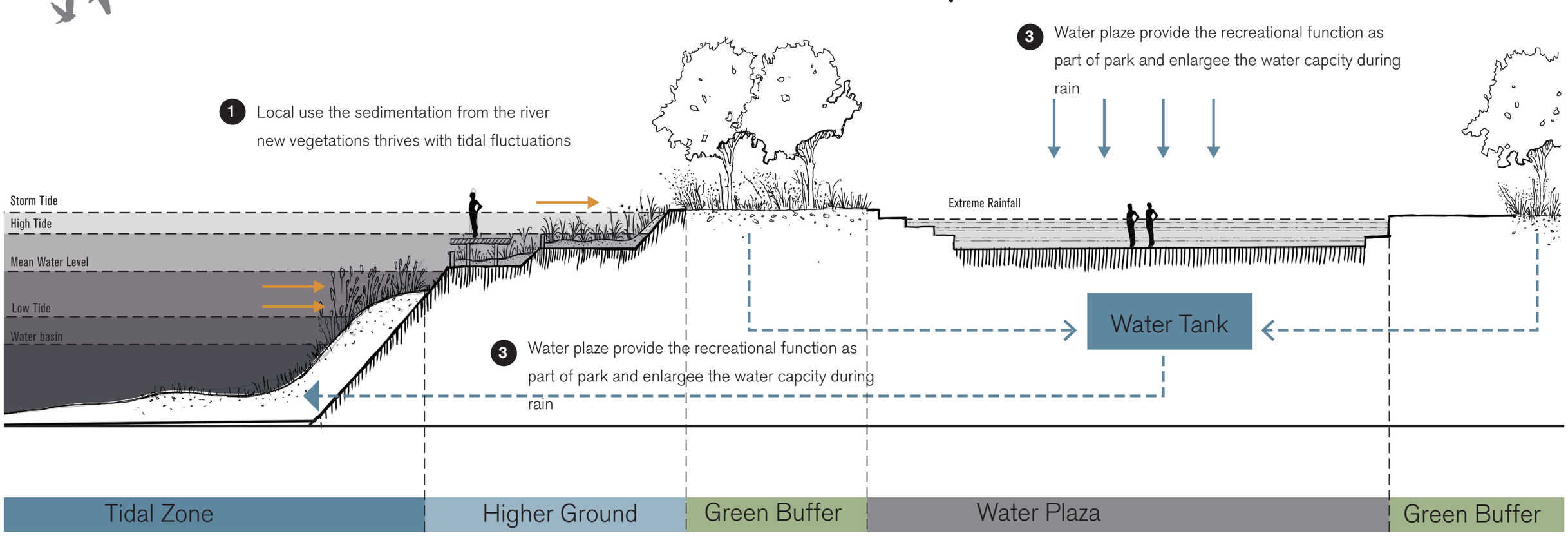


Figure 7.3 Biophysical layer

Growing system:dynamic flooding plain

Stakeholder Involvment

- NG National government
- PS Province of South-Holland
- PR Port of Rotterdam
- MR Municipality Rotterdam
- IN Investor
- RH Royal Haskoning DHV
- FA Famers
- WTP Waste water treatment plant
- HKV Lijn in water HKV
- R Residents
- NGO NGOs

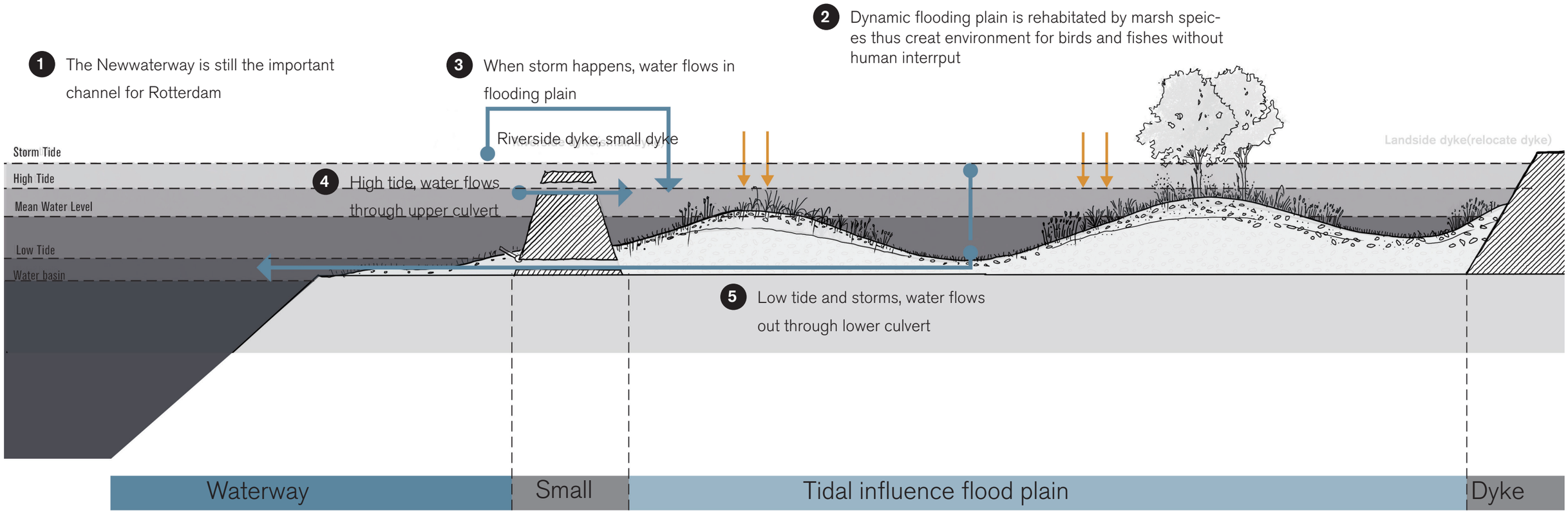


Figure 7.4 Biophysical layer

Plan2: Develop circular economy

Developing the circular economy focuses on **economic actions** at the resource layer. It aims at the implementation of a circular and bio-based economy to the region of Rotterdam port. **Bio-based solutions** will be applied as measures.

The actions are highly related to the previous mentioned cluster interventions in the analysis chapter: bio-based material productions and energy productions and distributions.

For the energy production and distributions, actions are **energy landscapes(wind turbines)**. The port and north sea provide a rich wind resource to capture at shorelines and salines. In addition, the bio-digesters could be solutions for transferring the biomass into heating and electricity.

In addition, the actions responded to the bio-based material productions to use the **seaweed cultivation** and fishing in the North sea and **acaponic farming** in port. Combining horticulture in the westland and agriculture, more bio-circular material will be provided. In addition, the **networks of bio-gas and carbon pipelines** and **network of bio-waste transport and storage space** to supply the development of industrial clusters and grasshoues. in the long run, it moves towards the renewable energy transitions.

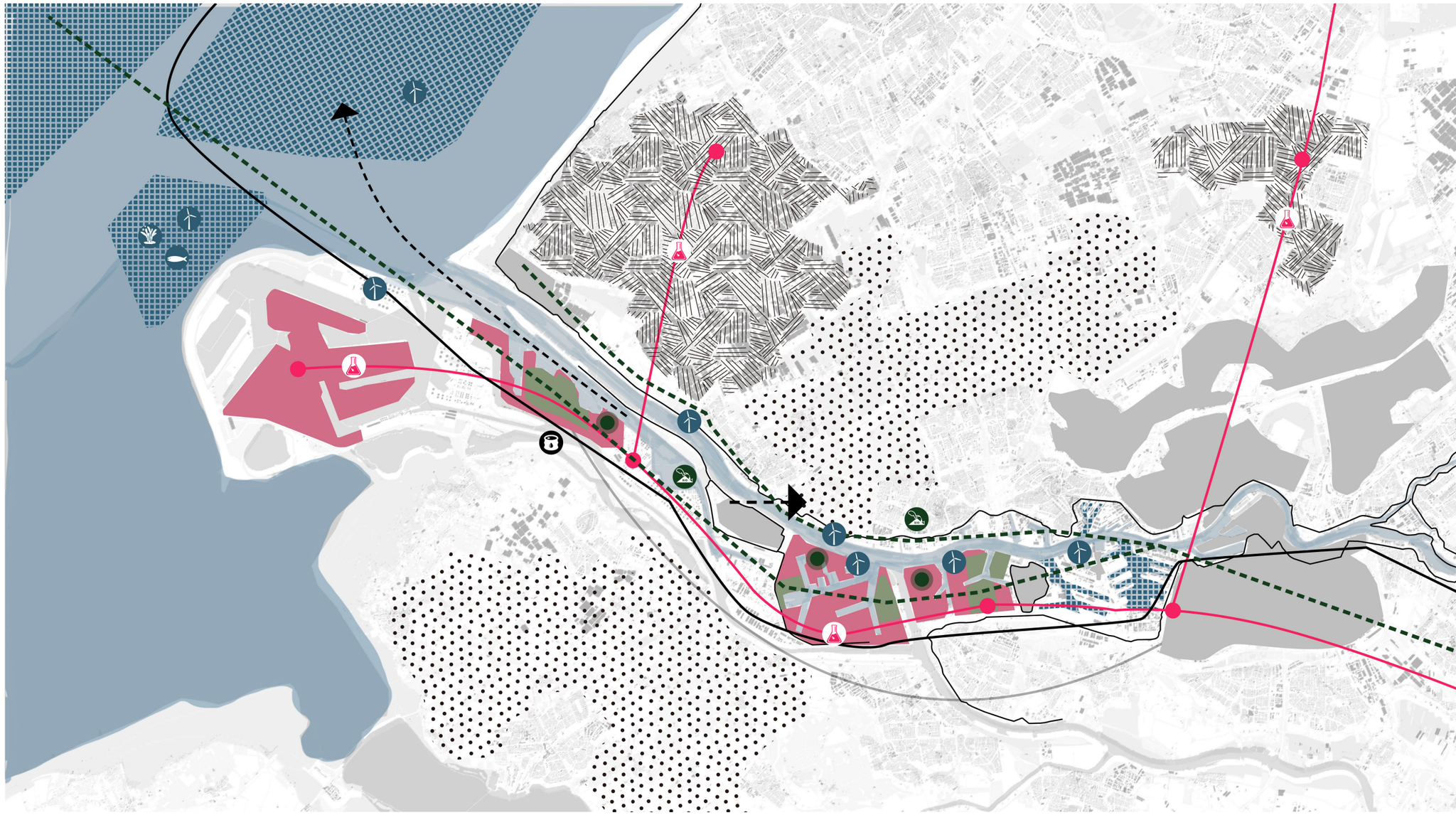


Figure 7.5 Economic and resource layer

Plan3: Muntifunctional port

Multifunctional port strategy focuses on the **social actions** at the social layer. It aims at the implementation of a **city-port integration development** to the region of Rotterdam port. In the future, more land use and property of the port will be transferred in terms of functions and accessibility toward a more inclusive development. In order to realize that, adaptive and flexible actions will be taken into consideration.

There are 4 social actions: First, the public transit in the Rotterdam port must be improved in order to increase the connection with the city. The **transit hubs** that integrate multiple ways of public transportation should be distributed to the whole Rotterdam port. **Water transportation** is another essential way to access the Rotterdam port as well.

In addition to the public transit network, **slow transport** such as regional bicycle routes and pedestrian routes should be developed so that the waterfront will be a continuous and accessible public space. The routes also connect the Rotterdam port with the surrounding area.

Thirdly, the **green port** will take actions to enlarge the green surfaces of the port as the ecological structure will develop along the pipelines and high-voltage. Last but not least, the actions identify the **area of desnifictions** in the city-port transition area. The new marine cluster thus will be given new functions.

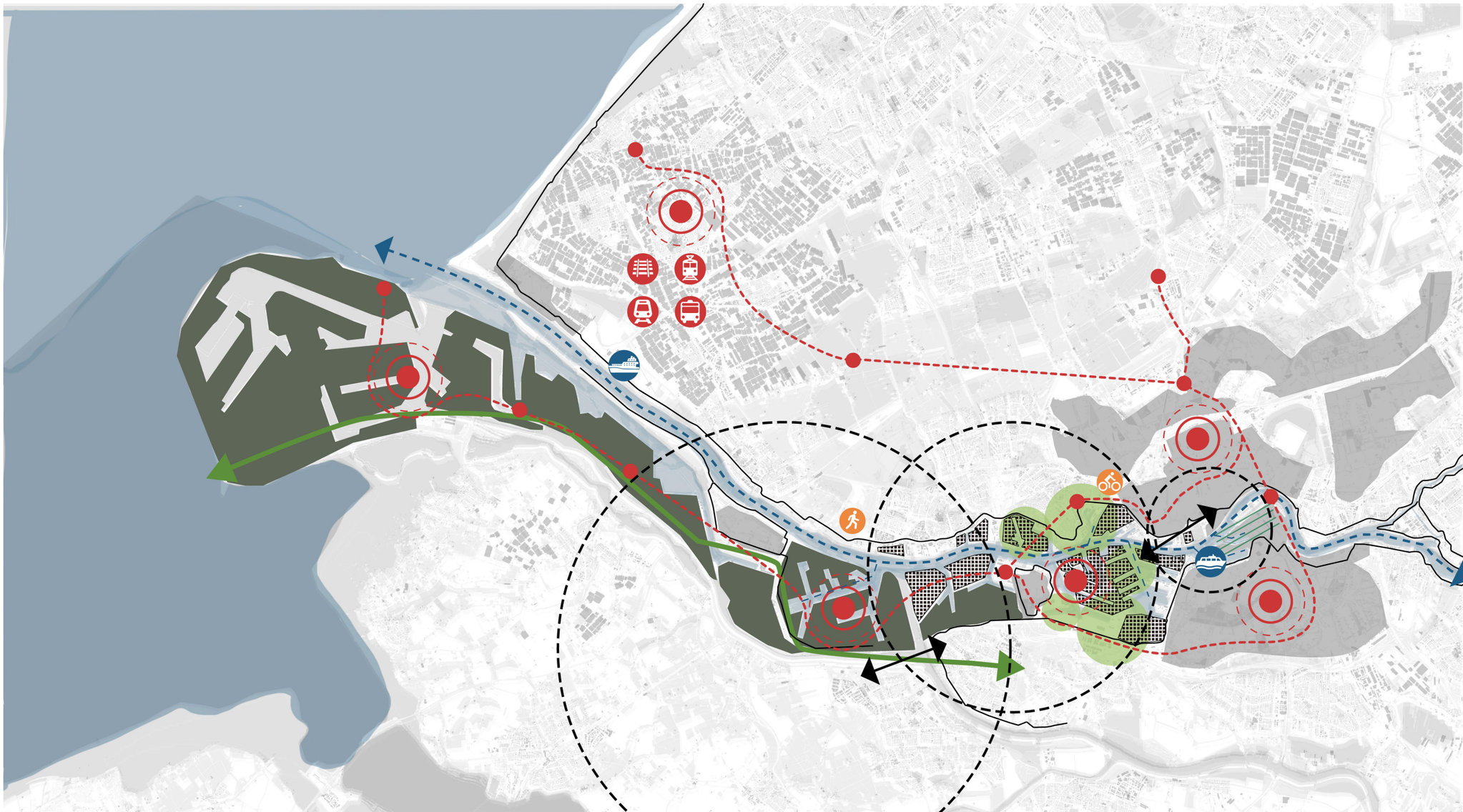


Figure 7.6 Social layer

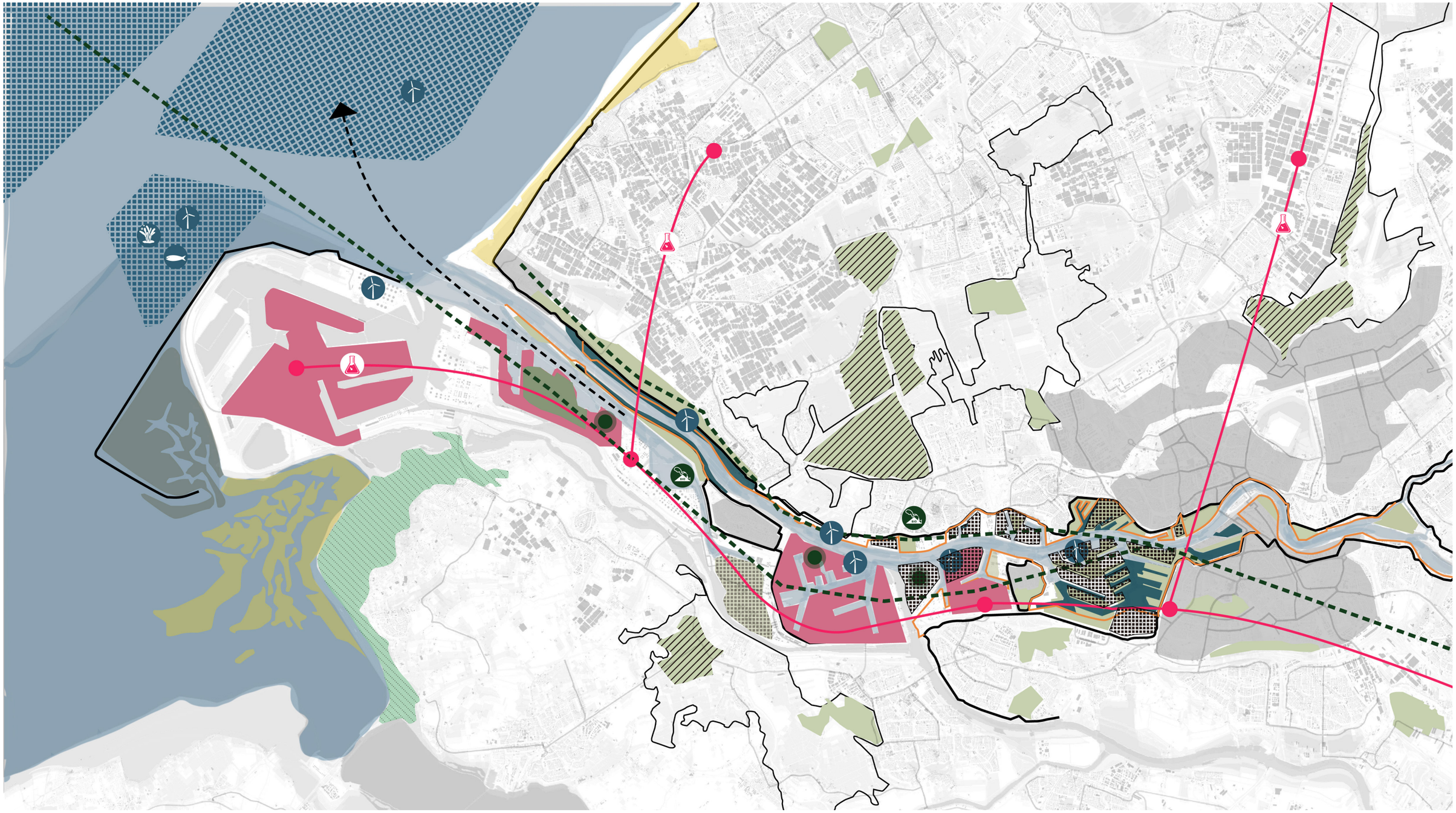


Figure 7.7 Regional plan for the Rotterdam port; Rotterdam port vision 2050

Implementation road maps

When the actions have been proposed and decided on the plans spatially, the implementation plans need to elaborate how it works through a long temporal process. From the top down view to the bottom up, the timeline has been listed in the following figure 7.8.

It moves from the pilot projects, backbones, project and finally the long term vision.

When the actions have been proposed and decided on the plans spatially, the implementation plans need to elaborate how it works through a long temporal process. From the top down view to the bottom up, the timeline has been listed in the following figure 7.8.

It moves from the pilot projects, backbones, project and finally the long term vision. The pilot projects will be a quick win for local stakeholders, and based on that, the backbones will be structured as the priority for the next development. In the next step, more projects will be introduced as infill projects to exacerbate the transition process. In the end, the transition will move toward the **desired scenarios** in the long term vision lasting 2100.

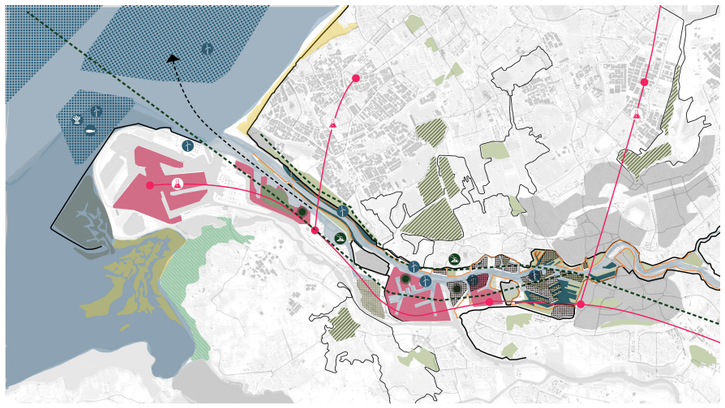


Figure 7.8 2025

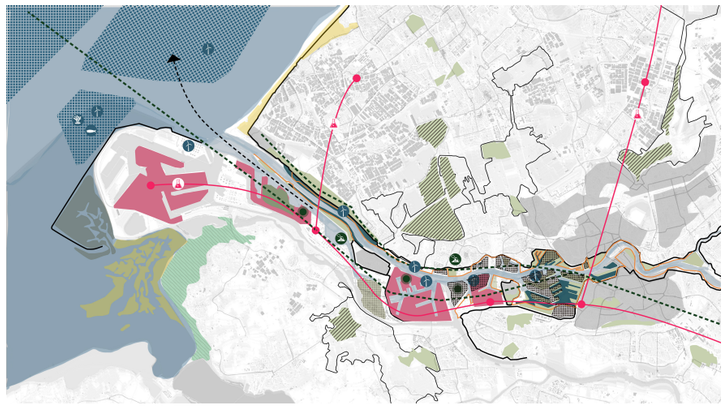


Figure 7.8 2030

Future

Current

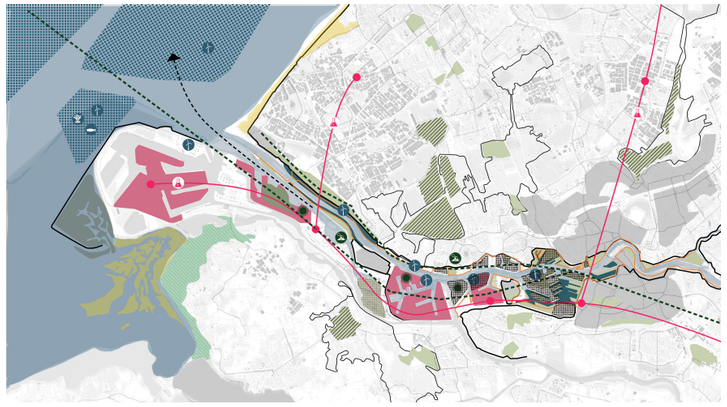


Figure 7.8 2040

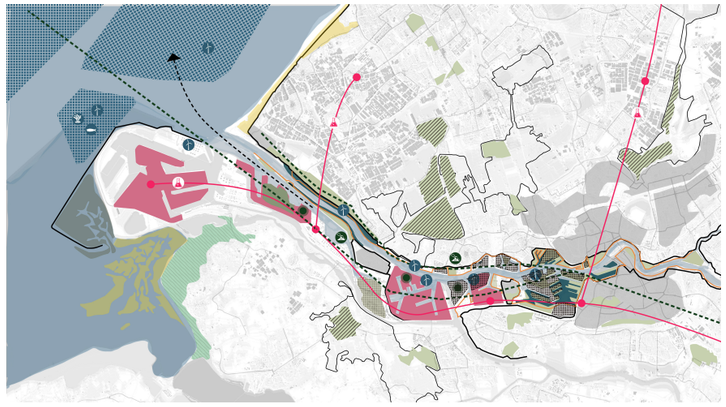


Figure 7.8 2050 and after 2050

Figure 7.8 Regional plan for the Rotterdam port

Strategic programmes: Stadhaven

The programme, as the junction between the plan and project is very significant since the overlapping of the layers of plan with different actions would cause the land use pressure and the risk of conflict (Agliati,2020). The common interest of the development could be addressed through institutions of programme. It could involve multi actors at the local level through the PPP(public-private partnership) to deal with the proposed transaction in the regional plan within certain interesting sites. Why does it adopt the programmes as the intermediate level? The benefit is that it not only bridges the design aspect and planning aspect by considering the implementation of regional guidelines but also gets more local stakeholder involved in the process.

Due to that, the **Stadhaven area**, as we mentioned in the previous chapter, has been identified as the strategic programmes of the Rotterdam port. The area in transition has its prioritized task of redevelopment: **re-integrate the port activities with city development** which concentrates on the land use and economic development. Moreover, there are other opportunities that can help with aligning with other planning frameworks. The Rotterdam port authority and Rotterdam municipality are collaborating together and ready to start the development. Therefore, the programme of Stadhaven needs to define the design and management of projects and conflicts.

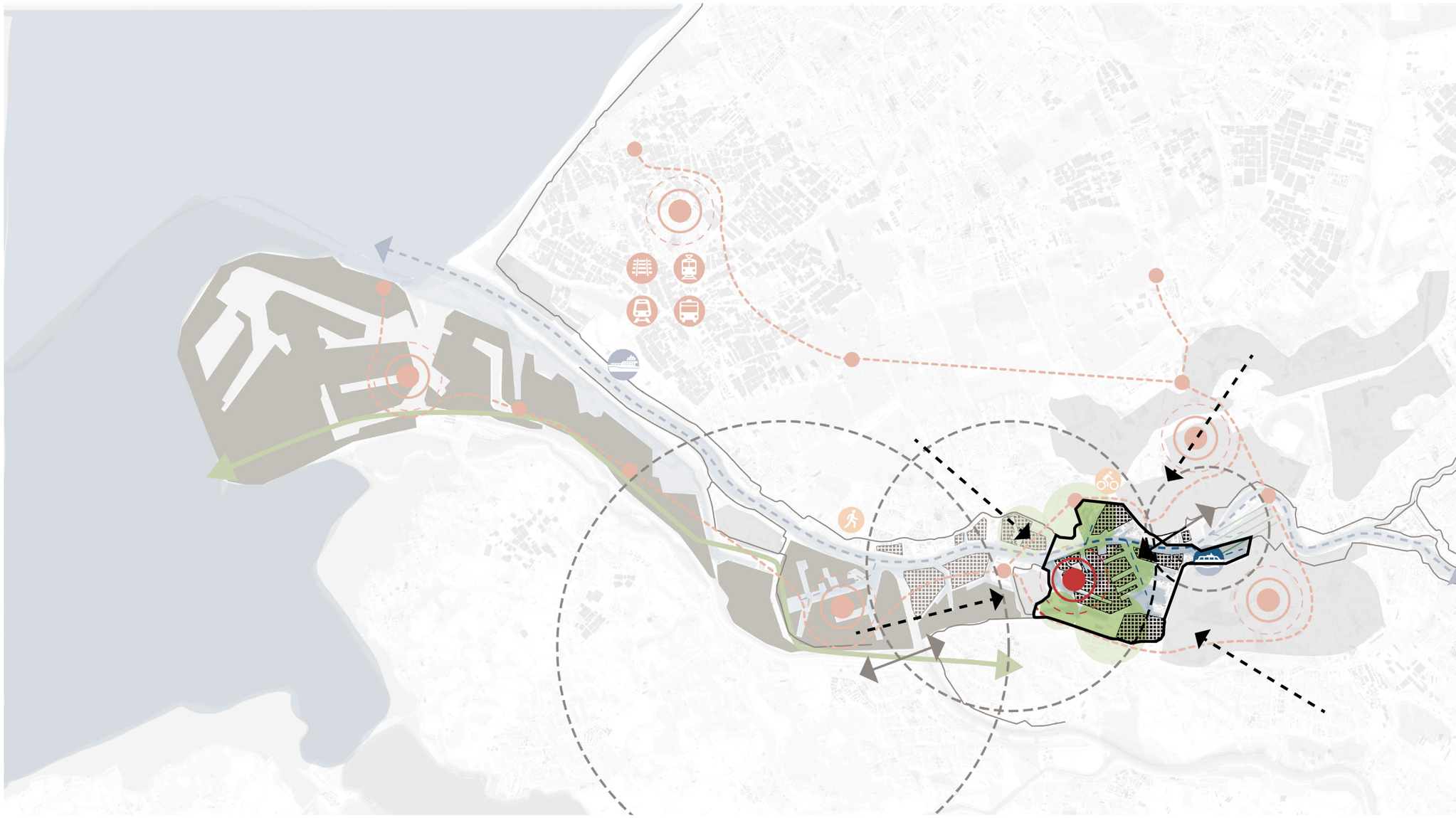


Figure 7.10 Stadhaven as the strategic programme in the Rotterdam port

For the city-port development, the current planners decided to use the planning instrument for five wild cards instead of the traditional master plan which decided the developing programmes and infrastructure. It thinks the five wild cards could be well balanced in the programme's development to make it highly adaptive to the real situations. Five wild cards in Stadhaven are as it mentioned and explained in the analysis:

-Volume& value

- reinventing delta technology

- crossing border

-floating community

-sustainable mobility

Combining these five wild cards, the programmes in Stadhaven contain two types of projects for implementation as described in the planning cycles.

-Backones. The backbone refers to a series of framework development(large scale infrastructure projects) as part of regional plans. For instance, the **landscape framework** and infrastructure framework set up the basis for the lantern on project. Figure 7.11 shows the actions for the construction of a landscape framework with the reference and use of the **green dykes** and introduces **the cluster of tidal parks.** Figure 7.12 indicates a mobility framework while the actions are devoted to tram **transport development** and **slow mobility connections** to each port.

-The local project will devote the further development of the area and it will appear and enlarge with well-structured infrastructure in Stadhaven. Figure 7.13 and Figure 7,14 shows the further develped projects in Stadhaven with **community and floating community development**, the **adaptive landscape** interventions.

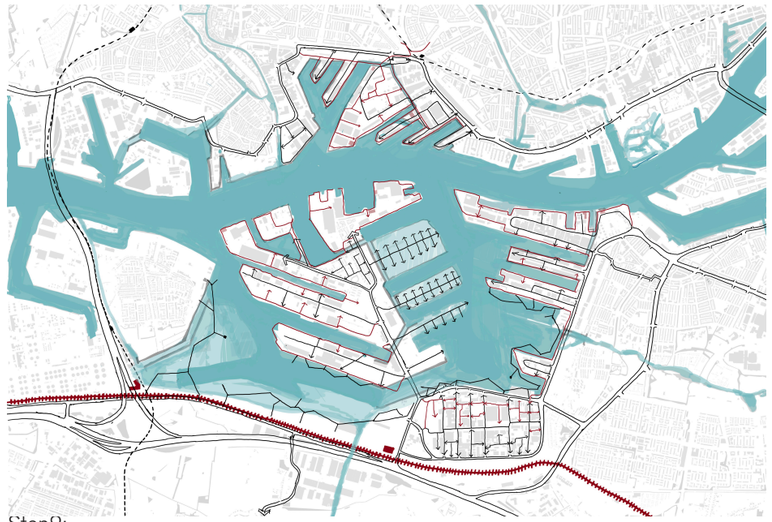
In detail, the pilot projects in M4H will show the transformation from bottom up.

Step1:

LANDSCAPE FRAMEWORK
Figure 7.11

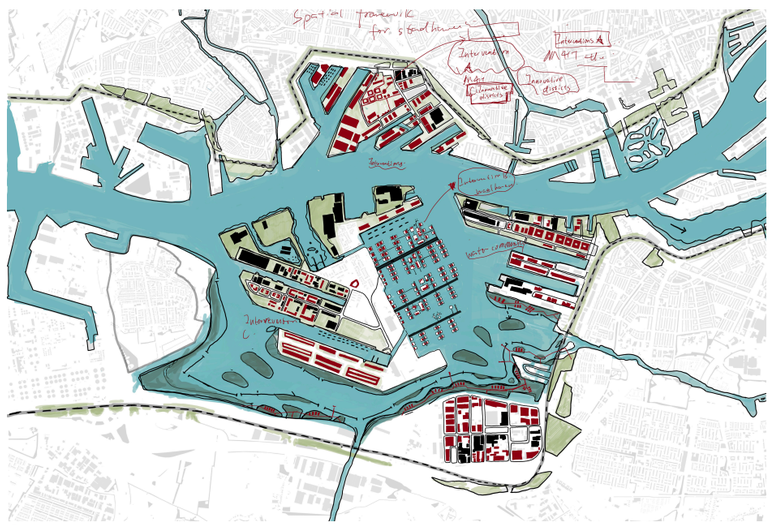
Step 3:

URBANIZATION
Figure 7.13



Step2:

INFRASTRUCTURE
Figure 7.12



Step4:

INTEGRATIONS
Figure 7.14

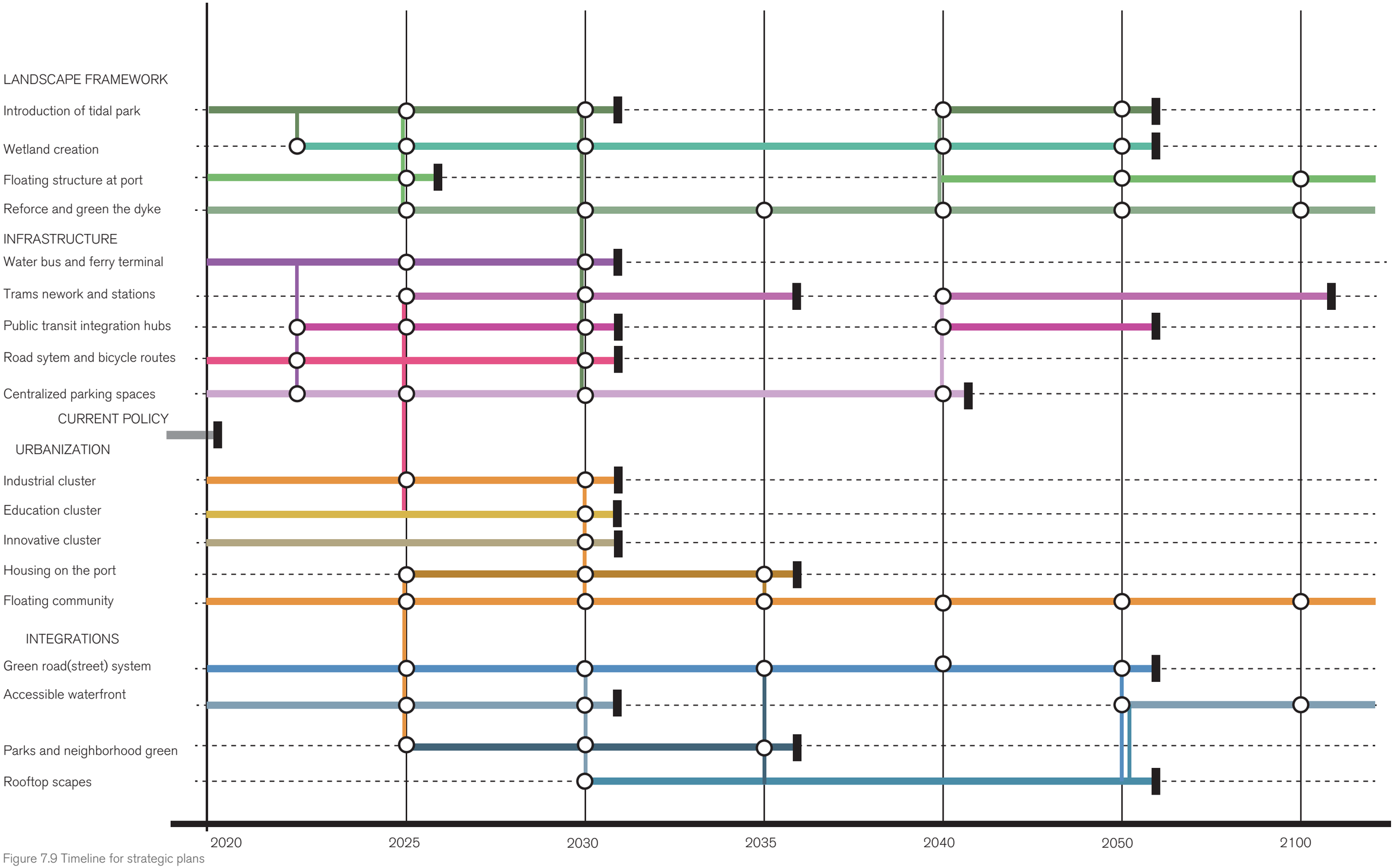
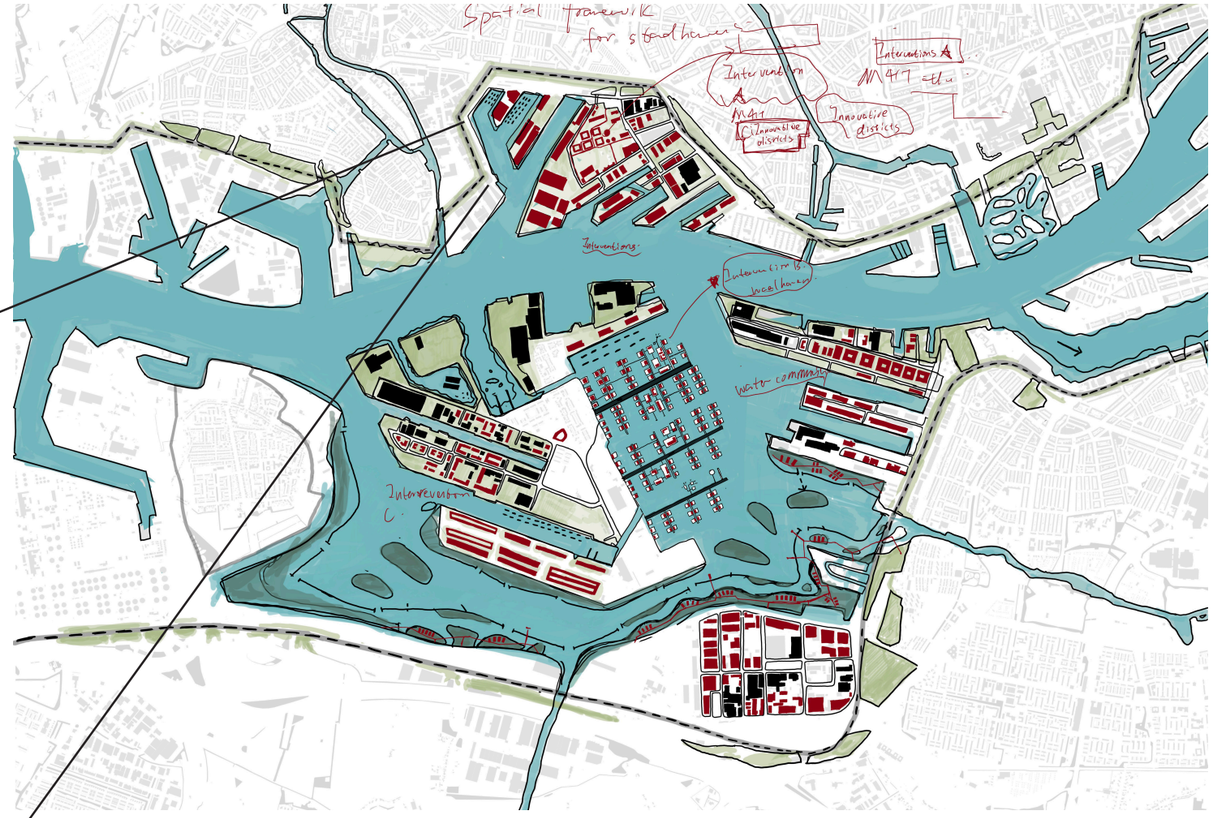


Figure 7.9 Timeline for strategic plans

Pilot projects in M4H

M4H is the essential project of the Stadhaven programmes development. In M4H, the projects will show the transitions toward a maker and innovative districts aligning to the regional plans and proposed principles(Figure7.16). It will show how people work, live and enjoy the healthy lifestyle in this area as a transition example. It is more **design-oriented** with local conditions analysis and stakeholder involvements.

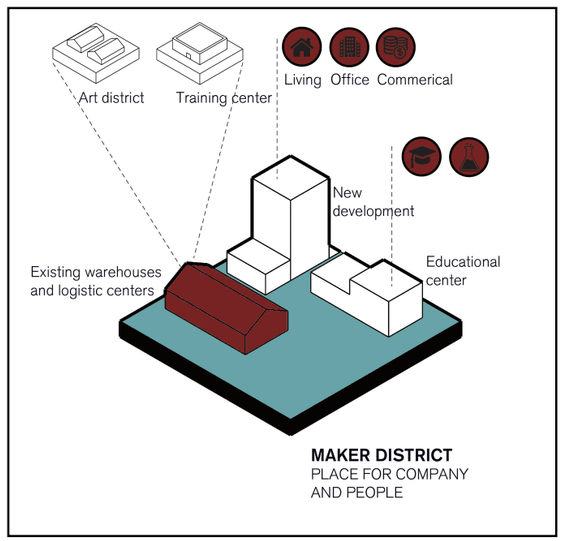
TESTING: M4H



Vision Plan for Stadhaven

Achieve the social-ecological port in 2050

Figure 7.15



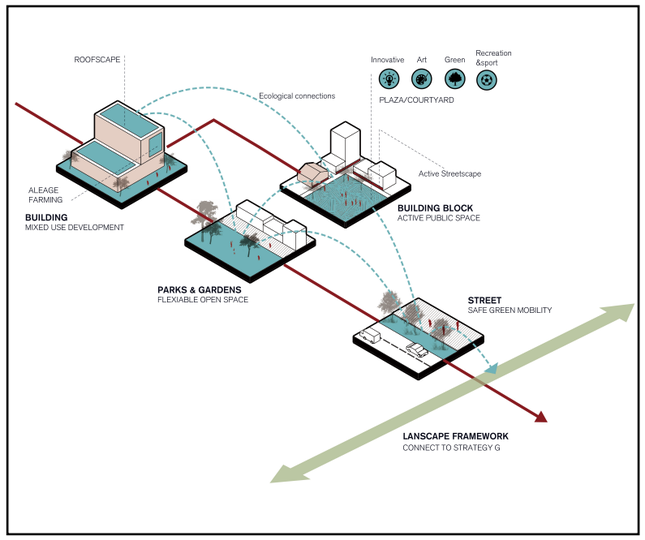


Figure 7.16 Applied the guiding principles for M4H

Design Analysis

M4H Analysis

Buildings

Figure 7.12

Green Space

Figure 7.13

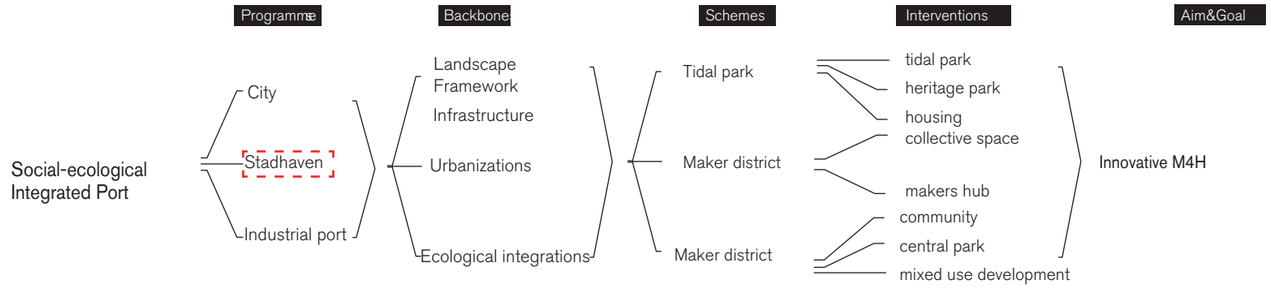
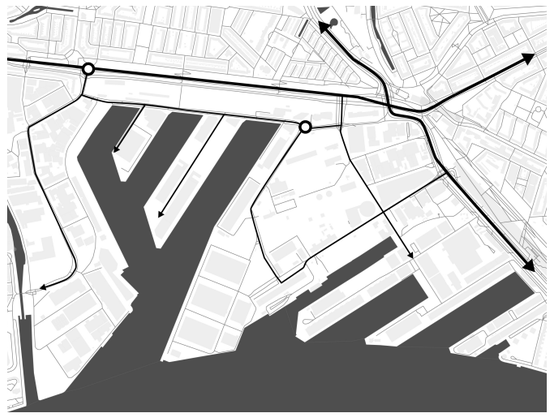


Figure 7.16 flow chart of design intervention in M4H

Dyke Structure

Figure 7.14



Road System

Figure 7.15

In **M4H**, it is the interface with the port and city, currently, the port needs to be regenerated. The conditions provided by the port will furnish the form of an **innovative district**. In the future, it has the potential to create space for education, working and other cultural facilities for new economic development. The M4H area coexists with the challenges and opportunities at the same time.

Opportunty

-It will benefit from the existing infrastructure to surround the area, such as Rotterdam, Schiedam,RDM and Delft. It also provided the platform for attracting the companies, universities, research institutions and light industries(manufacturing).

Challenges

-sea level increase and climate change. The area is where the port, water(nature) and city meet together, it will affect the port with the increased sea level.

-lack of green space and biodiversity. There is no park or any large scale green space within M4H. In addition, the accessibility to nearby parks is not good thus the area is not very attractive for people to come.

Based on analysis, the design interventions could be imagined and pilot projects will happen from the initiatives.

Design phase

M4H//Tidal Park

The first pilot project is the **Tidel Park District** in keileweg. The site used to be the place for the sand storage degraded from the port. The design proposed to stop use it and transfer it into a project that could help with improving the ecology, adaptability, housing development and public realms.

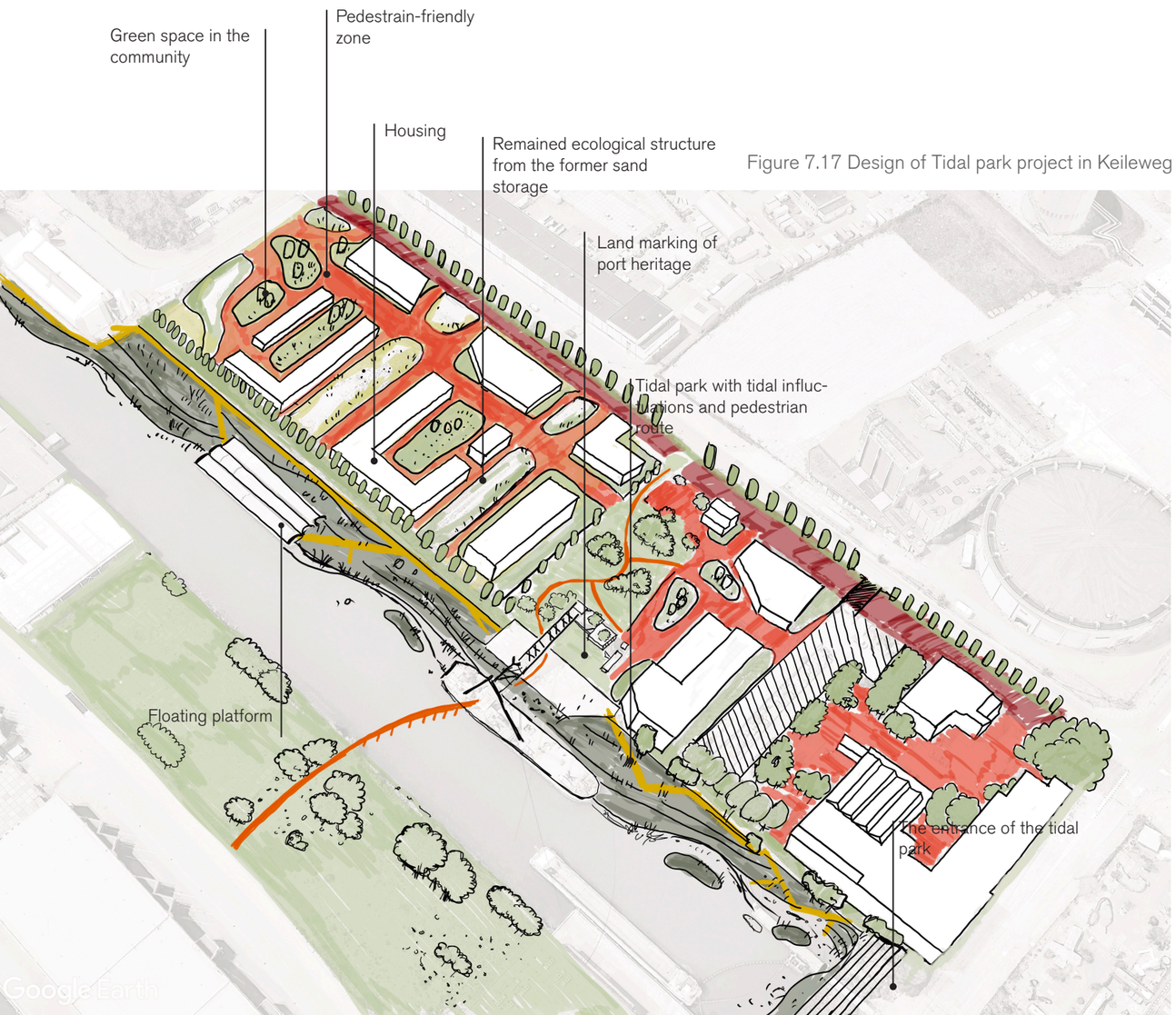


Figure 7.17 Design of Tidal park project in Keileweg

The project will be develped through the temporal process as the part of the M4H tranistion process:

-For the **Short-term development,** the tidal park will be constructed to restore the biosystem and increase the value of property development . In addition, select some of the old elements from storage to let it grow through time.

-As for the **Mid-term development,** it adresses on the acessibility. It considers the parking, pedestrian and biycle access to the waterfront. Then, the housing and retail could be developed as well.

-In **Long-term vision,** the tiadal park district constructed and strength the impact with other district

Eco-system services provision

Improve the cultural identity of the place and preserve the industrial heritage to provide more recreation

Source: Google image (https://www.aivp.org/en/newsroom/how-to-share-and-protect-port-city-culture-and-heritage/)

Water quality improvement and enhancing the biodiversity while provide education s and leisure

Source: De Urbanisten, 2014 River as tidal park

The nature improve the spatial quality for living, working and health

Source Google image (https://www.aivp.org/en/newsroom/how-to-share-and-protect-port-city-culture-and-heritage/)

Design Interventions

M4H// Maker District

The second pilot project is the **Maker District** in the south of NIEUW MATHNESSE. The current site was occupied by the parking space and warehouses. The design proposed to change the land surface to help with accommodating the companies, jobs, identity and cultural facilities.

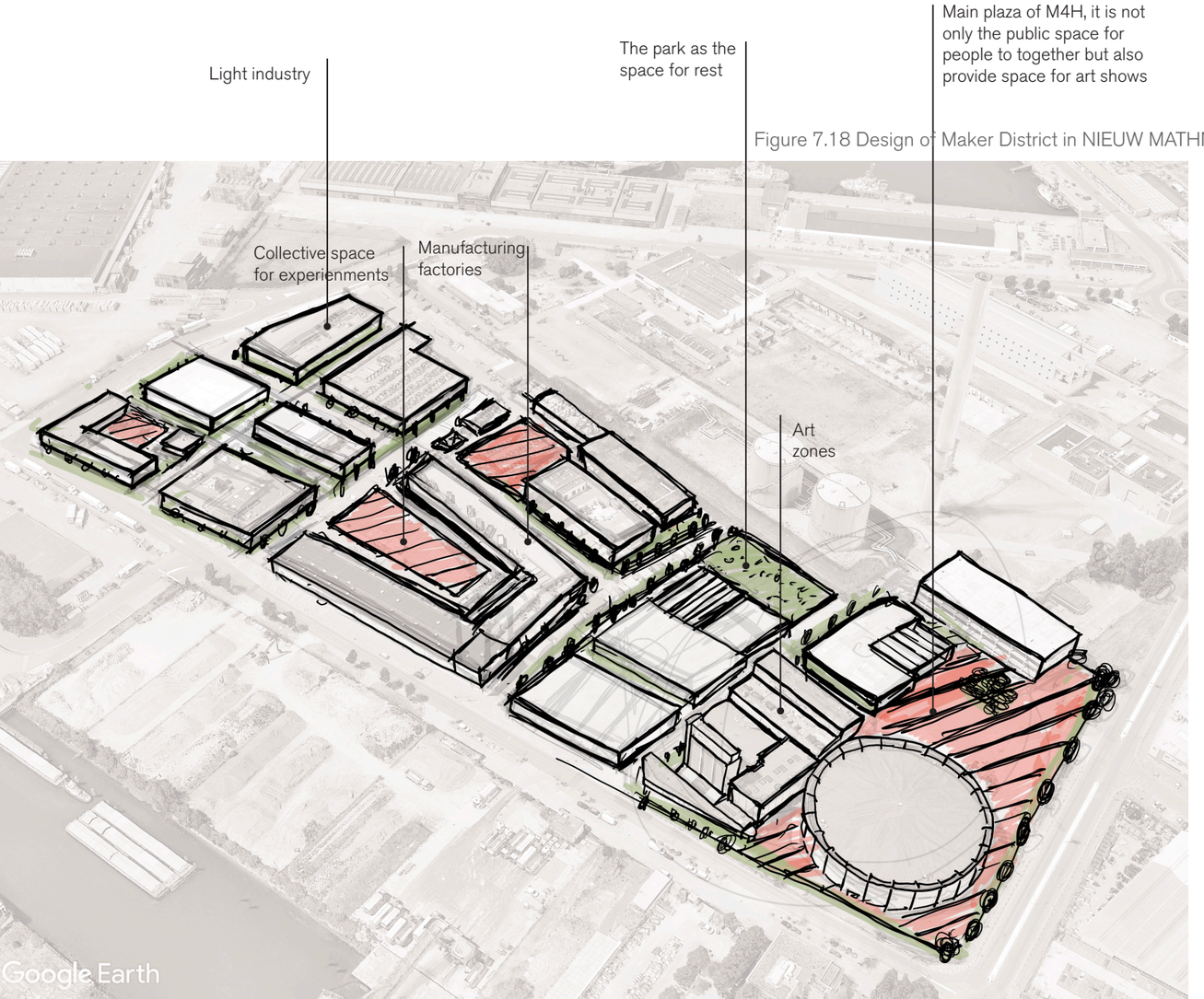


Figure 7.18 Design of Maker District in NIEUW MATHNESSE.

The project will be develped through the temporal process as the part of the M4H tranistion process:

-For the **Short-term development,** the maker district will construct a new art zone with a designated main plaza. The flexale plaza will be the main public realm to fufill with different needs and functions.

-As for the **Mid-term development,** it adresses on the acessibility. It considers how to decrease the car use and let the bicyling and walking as the way to move around. In addition, the manufacturing activities will be introduced.

-In **Long-term vision,** the tiadal park district constructed and strength the impact with other district.

Eco-system services provision

Improve the cultural identity of the place and preserve the industrial heritage to provide more recreation

Source: Sasaki,2013 Midtown Detroit Techtown District

Use the large roofscape for the improvement of urban ecology and with other urban functions

Source: Google image(https://www.resilientrotterdam.nl/)

The innovtive environment create a health indsutrial ecosystem for companies and other insititutions

Source Google image (https://popupcity.net/observations/worlds-smartest-port-in-the-making/)

Design Interventions

M4H// Community

The third pilot project is the **Community District** in the North of NIEUW MATHNESSE. The site has a lot of vacant space and parking space which is possible for the densification. In addition, the green space should be combined in community making to give a high urban life quality. The design proposed to change the land surface to help with housing densification, offices and green space and water storage infrastructure.

Flooding Plains:

CRT techniques:

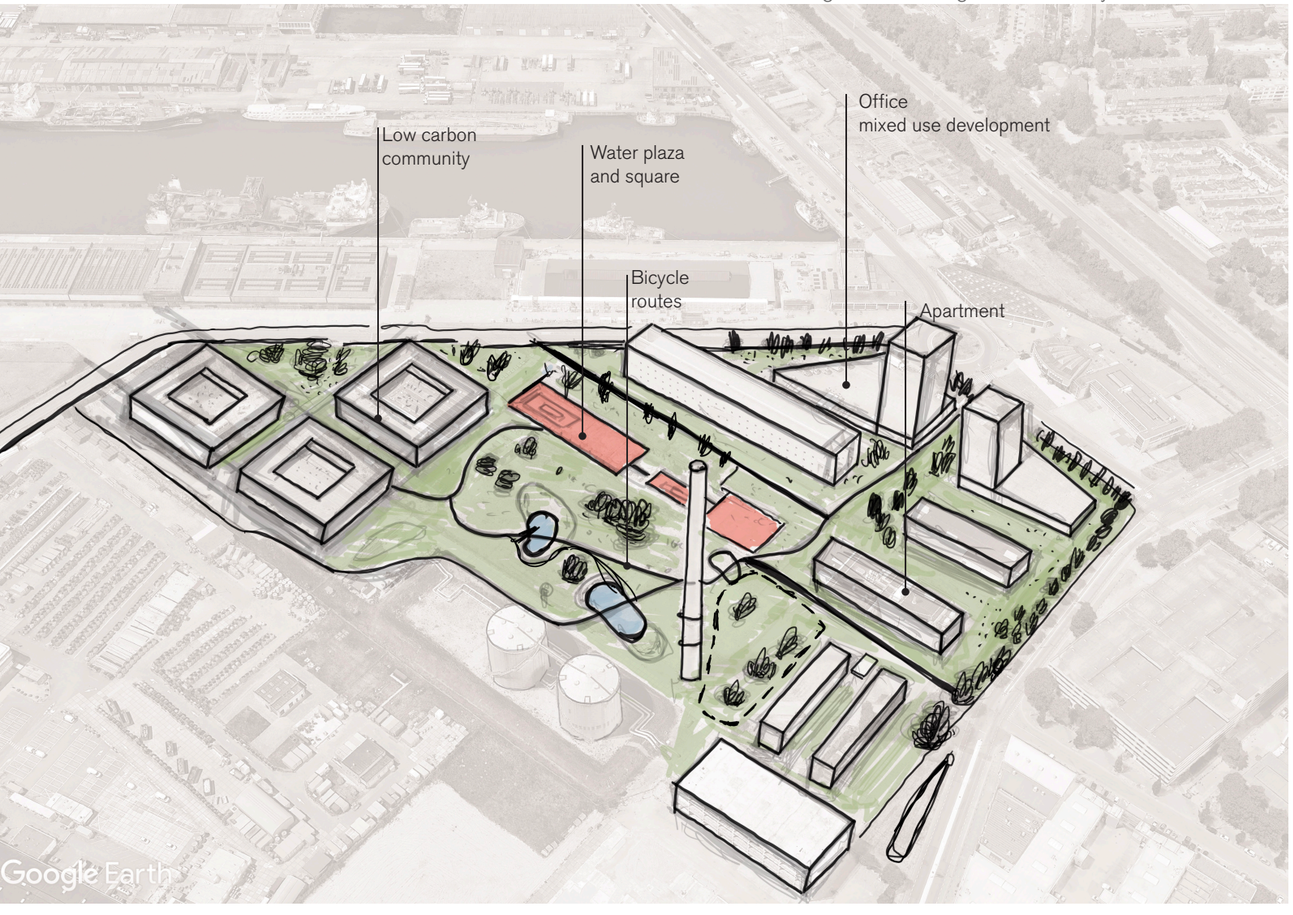
The project will be develped through the temporal process as the part of the M4H tranistion process:

-For the **Short-term development,** more housing and apartment will develop for the densification.

-As for the **Mid-term development,** it addresses on the accessibility. It considers the parking, pedestrian and bicycle access while bridging the wider network. The central park will be developed for collective use and climate adaptation.

-In **Long-term vision,** the **community district** constructed and strength the impact with other district and grows.

Figure 7.19 Design of Community district in NIEUW MATHNESSE.



Eco-system services provision

Enhancement of water infiltration and recycling the water

Source: Google image (https://www.aivp.org/en/newsroom/how-to-share-and-protect-port-city-culture-and-heritage/)

provision of the productive landscape at urban area

Source: Google Image (https://www.urbangreenbluegrids.com/agriculture/)

From paving to the green sufrace and improvement of cliamte adaptability

Source: Google Image (https://www.urbangreenbluegrids.com/agriculture/)

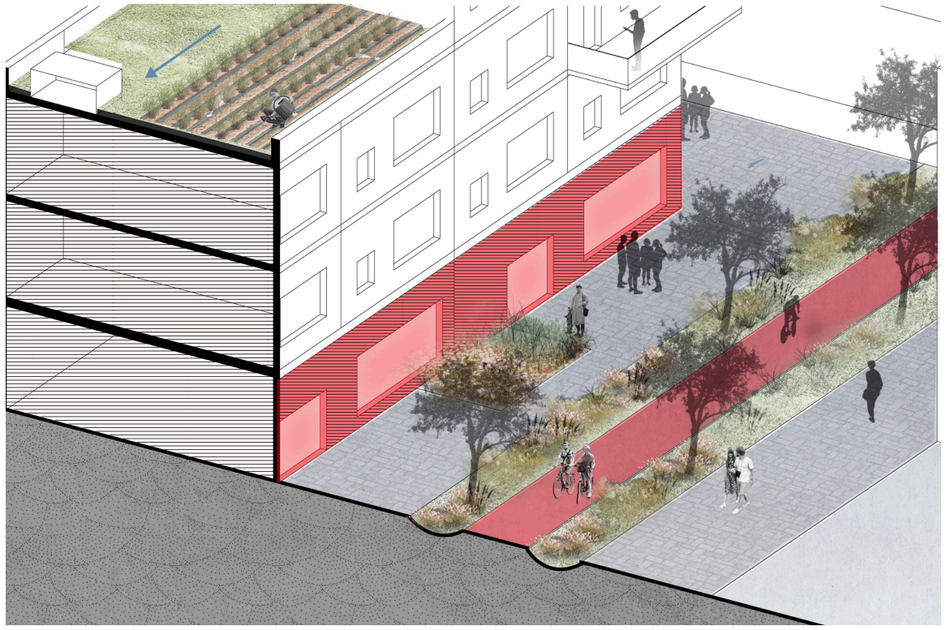


Figure 7.20 Design of Community district of social-ecological integrations

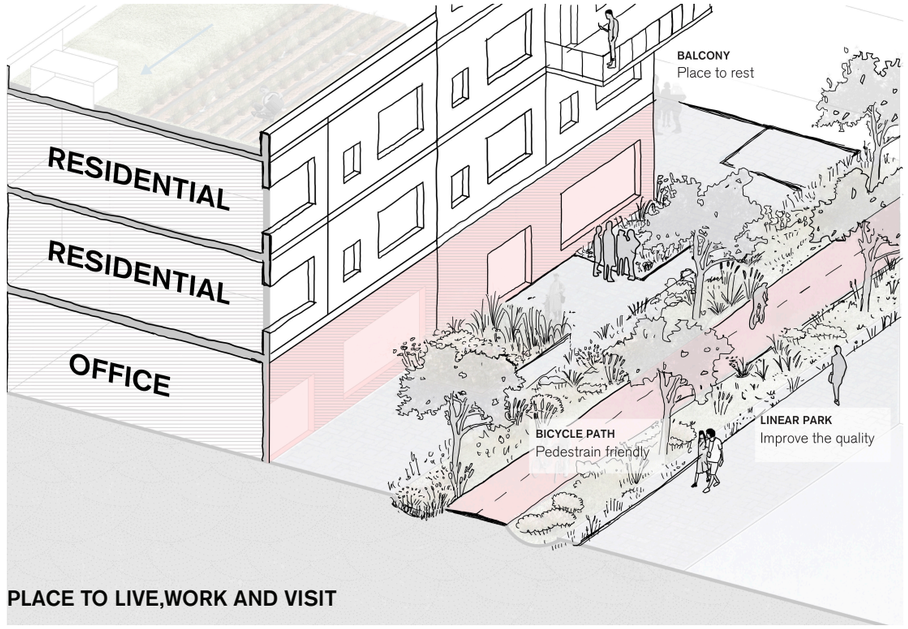


Figure 7.21 Places for the people to work, live and get together

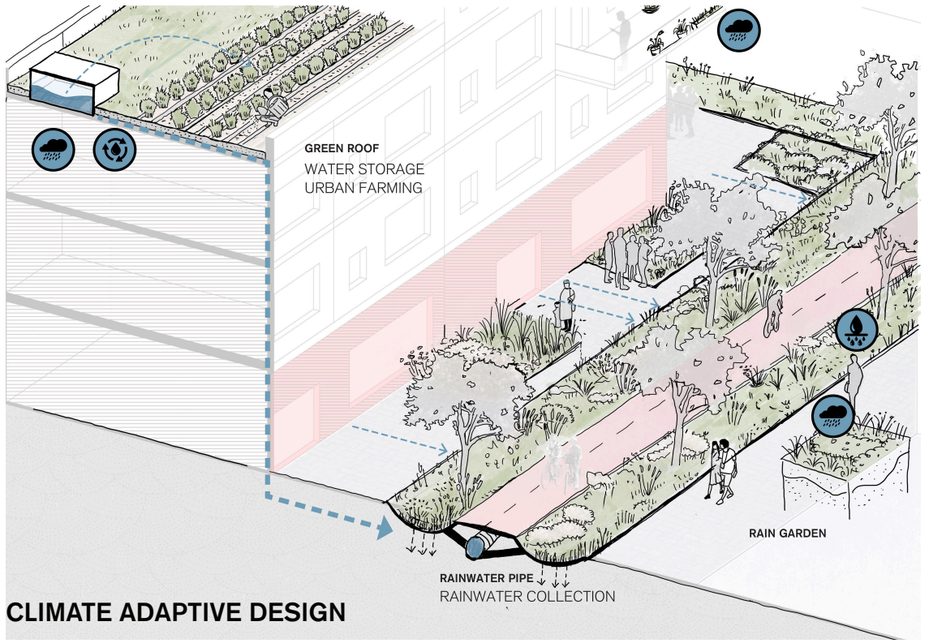


Figure 7.22 Water sensitive design of possible interventions

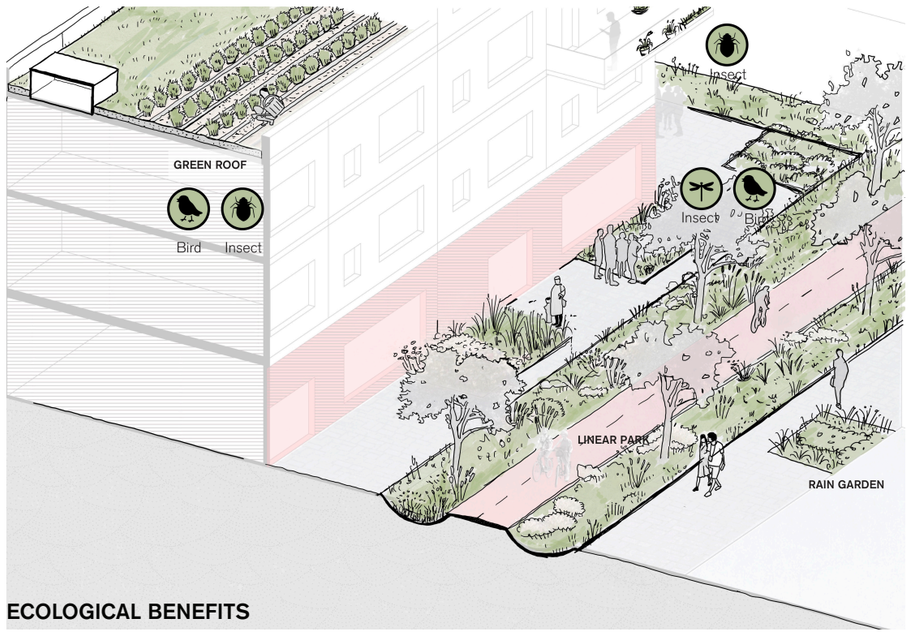


Figure 7.23 Habitat creations in the community

08.

Conclusion

Conclusion

In conclusion, the thesis introduces the adaptive planning approach in Rotterdam port toward the social and-ecological integrations with several building blocks. First, currently, the infrastructure and urban development, which is the socio-economic system, makes the natural habitat in the coastal area shrink and the consequences are serious. Due to that, the new urban development paradigm is needed, a new integration between ecological and social systems.

By understanding the current situation of the social-ecological system in Rotterdam port, it decided to use strategic interventions at different defined layers to mitigate the impacts of human activities and climate change. It visions that the resilient port could be achieved after actions at different scales.

The main research question is:

“How to shift the river Mass estuary and port of Rotterdam into a more adaptive and resilient system by synergizing the natural system and urban growth with landscape and urban design intervention?”

Through the research, the answer of the main question is clear: it could develop a regional strategy based on the guiding principles. The analysis of the essential relative layers within the SES, including biophysical, social and resources systems. Based on the analysis, the challenges will be summarized and then the design interventions could happen within the prototype area in line with the social-ecological integrations.

After outlining the interventions at different layers, it will formulate design principles by bridging the interventions with clusters.

Second, Except for the implementation of the interventions and principles, the multi-actors collaboration is required. By analysis the current stakeholders and their relationship for later on change toward desired scenarios.

Third, with the principle and stakeholders, it could develop the regional strategy for Rotterdam port from short term to long term. The multifunctional development of Rotterdam port will be stated from both top down and bottom up by using the M4H as the local project for development.

Provision of ecoystem services//

The core of social-ecological integration design in Rotterdam port is the ecosystem services provision through different actions and interventions. Taking the stadhaven as an example, it recorded the ecosystem provision after the design of projects. (See Appendix).

Scale adaption//

The strategy of regional planning in Rotterdam could adapt from the project scale to the programmes scale and to the plan scale. Spatially, it moves from local scale to district scale to the regional scale. The strategy will be implemented through both top down and bottom up processes as it mentioned in the previous strategy chapter. The implementation of the plan relies on the development of a field and pilot project which starts as an initiative for mid term development and backbone constructions. Overall, the implementation plan combines both top down and bottom up approaches for transition. It works through the spatial and temporal processes

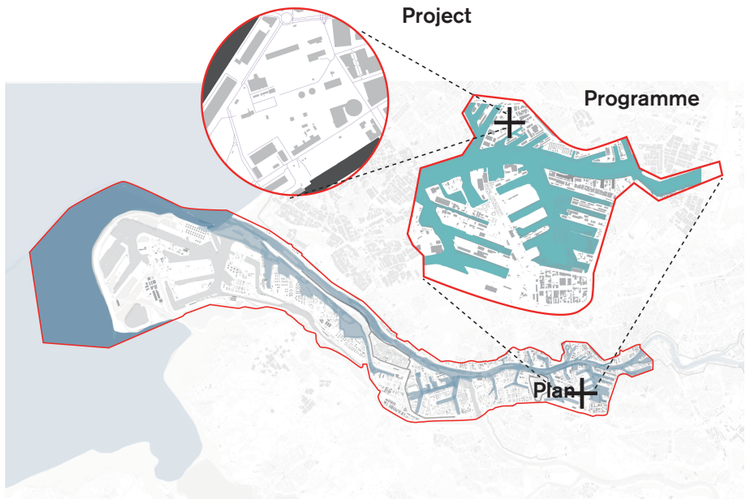


Figure 8.1Scale adaption of “plan, programme, project”

Reflection

The relationship between the proejct, the topic of studio and urbanism track//

The relationship between the project, the topic of studio and urbanism track//

The topic of the studio labs is to develop urban ecology in Rotterdam which aims to restore the ecosystem and increase biodiversity in the process of city making. In the lab, it encourages different approaches for urban ecology practices. For instance, the application of the NBS(nature-based solutions) for community planning and design. In addition, the topic is highly related to climate change and people's health. The labs also collect students' work for publication.

As a member of the lab, the author makes contributions to the urban ecology in Rotterdam while the research is laid on a different orientation. It believed that ecosystem restoration should be realized through large scale to local scale. In addition, the balance between ecosystem restoration and urban development. The thesis tries to find solutions of port development with the growth of nature, social development and application of a new circular economy. Even though the starting point of the project is not design-focused and design-oriented, it does align with the studio topic with the foundation of SES, implementation and upscaling of the NBS(Nature-based solutions) and Bio-based solutions.

The strong and weak side of the choosen methodology//

In the thesis, the project aims to explore the possible changes in the current ur

-ban landscape in Mass River and Rotterdam port toward ecosystem restoration,

climate adaptation, sustainable mobility and circular economy, in a word, "sociale-cological integrated port" to achieve the integration between the natural system and urban growth. In order to achieve the transformation, the frame of reference (Van Koningsveld, 2003) has been referenced to design the methodology with identification of operational objectives and the realization of these goals through steps. In addition, the methdology consideration the relationship between the research, planning and desgin. and this section will reflect its advantages and limitations

-Design and reserach

Design provides the research direction In the research, the design plays the role as the instrument for generating ad - ditional knowledge, in that case, it is reasonable to use design to help with nar - rowing and identifying the concrete targets for research. During p1 to p2, the research was very difficult to carry on because I did not use the design strategy for resilient urban landscape for port transformation as the guidance for my project. A very negative impact of this is that there is no concentrating port for my analy - sis. Due to that, it no doubt causes the loss in the track of the whole storyline. If it is constructed on the strategy, the intention of analysis of water management, ecological condition, industry and flows are crystally clear since they are the foundation for the design principle and strategy. From the analysis, the design principles could be summarized through it, then guide the formulation of design strategy.

-Design and planning

In order to know whether the design principle and strategy created from the theories and data informing has universality and feasibility, the design tool is reflective enough for testing. it could give different visions in combining urban structures and nature together in the Stadhaven detail design.

Scientific relevance//

Since the conceptual framework has been setted up to understand the new paradigm of social-ecological integrations from the SES(social-ecological system), the project adopts the planning as an approach to realize the transition in Rotterdam port. In addition, compared with other similar topic approaches, the project invented the synergy of planning and design for the transition. Furthermore, the project takes the multi-actors collaborations into consideration. The real actors in Rotterdam port have been discussed and engaged in the strategic planning process. Last but not least, the development is from the transformative perspective by viewing the port and estuary landscape as the performative landscape. Together, the design as testing tool for the possible interventions to answer the question about “what to do” and adaptive planning and governance provide the perspective about“ How to imply it and when it happens”. In the end, the project provided strategic planning for Rotterdam port by centering on the notions of SES, transition theory and evolutionary governance.

Societal Relevance//

In summary, the social values of the project could be summarized into three dimensions: (1). the introduction and further explanation to the social-ecological system (SES) to enrich the urban ecology domain. The project refers to multiple disciplines: landscape, urban planning and urban design (2). use the planning model aligned with nature-based solutions and bio-based solutions (3). respond to the city-urban development and energy transition of the port.

First, the project establishes the concept of social-ecological integration through literature review. The concept builds up based on the theoretical terms ”social-ecological system”. In urban ecology, the interaction of both social and ecological systems is where the interventions happen.Compared with other urban ecology projects, the social development of Rotterdam port values as well. The project goes beyond the single design (urban design or landscape)interventions at certain sites. It considers the Rotterdam port as a region, as a social-ecological system. Thus, a holistic insight will be provided in the research of urban ecology.

Secondly, both nature-based solutions and bio-based solutions need a very long process for implementation and maintenance. The planning model that the project explored integrates the interventions with adaptations based on different scenarios(uncertainties). It will provide the reference of phase development.In addition, the planning gives new options of port development to make it more resilient and adaptive to climate change.

Last but not least. it responded to the urban development topic of city and urban integrations and energy transition in Rotterdam port. By providing the conditions and interventions to move forward the transition, more economic benefits and sustainable development will be reached.

Transferability of the project results//

In general, coastal cities have more vulnerability to climate change compared with others. At the same time, urban development and infrastructure development even aggravate the risk by causing damage to the ecosystem. The social-ecological integration planning in Rotterdam port is driven by the plans, programs and projects. It believed that with careful adjustment and adaptation, the planning approach could be applied in the other similar context. In addition, the multi-actors analysis and involvement, the government through time by the adaptive pathway could be adopted to other contexts as well.

Another outcome of design principles, summarized from the proposed interventions is applicable for the development of port. After prototyping a replicable, area-based process for Rotterdam toward climate adaptations, the principles need slight changes based on the local conditions. In addition, the interventions are also the toolbox in cope with different problems

Ethical issues and dilemmas//

There are three ethical issues (moral dilemma)during the development of the thesis as follows:

(1). **The local stakeholder's benefit vs Development**. The transition of Rotterdam provides diversified ways of interventions of implementing the build-with-nature strategy and bio-based economy. Building with nature requires expensive design and maintenance costs . Who will offer the funding for design, construct, monitor and maintain? It is essential to have persuasive reason or evidence to tell the audience the project does provide benefits for them no matter in the short term or in the long run. Another example would be the port development. With the attraction of high skilled labor to work in the Rotterdam port, unemployment will increase. In addition, the situation will also happen when the energy transition process starts.

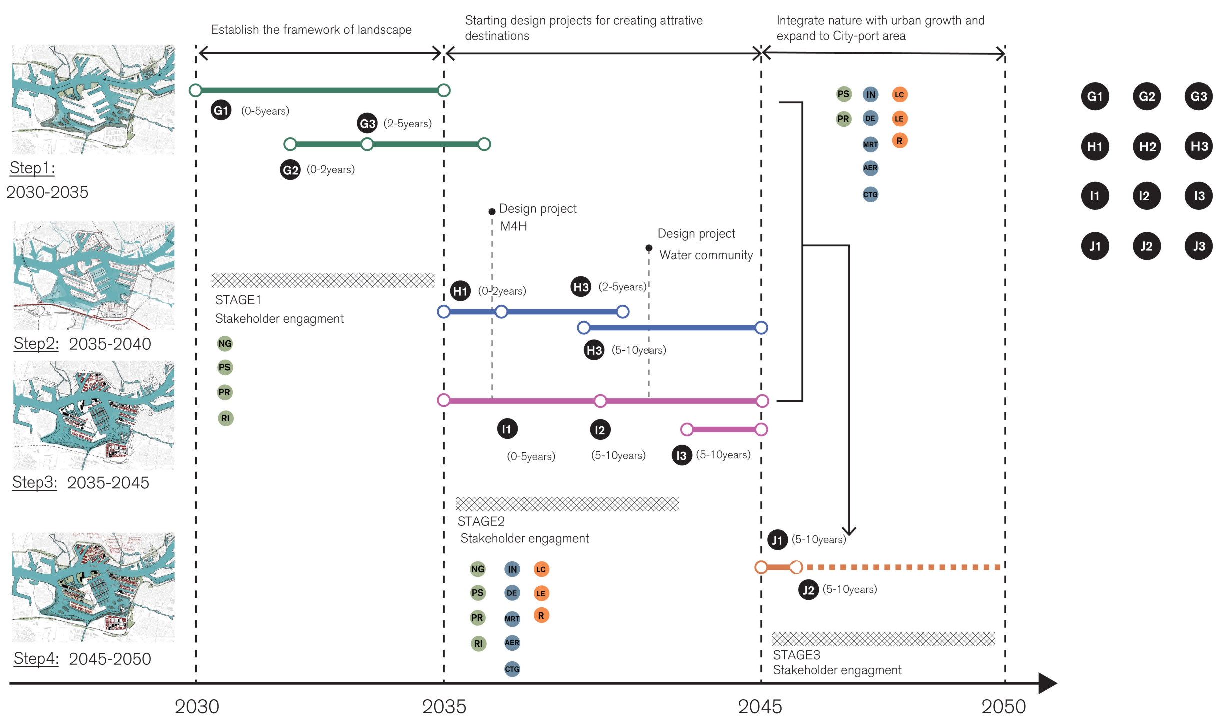
(2).**Design principles vs Feasibility**: Most of the guideline principles proposed by the thesis are referenced from literature and based on the previous analysis. However, the application of the principles need more consideration from wider aspects, such as site-specific physical conditions, the local economy system and initiatives, even with local policies. In addition, the planning needs real community (actors) engagement specifically at the programme level too for the common interest debates, thus the interviews and workshops are needed..

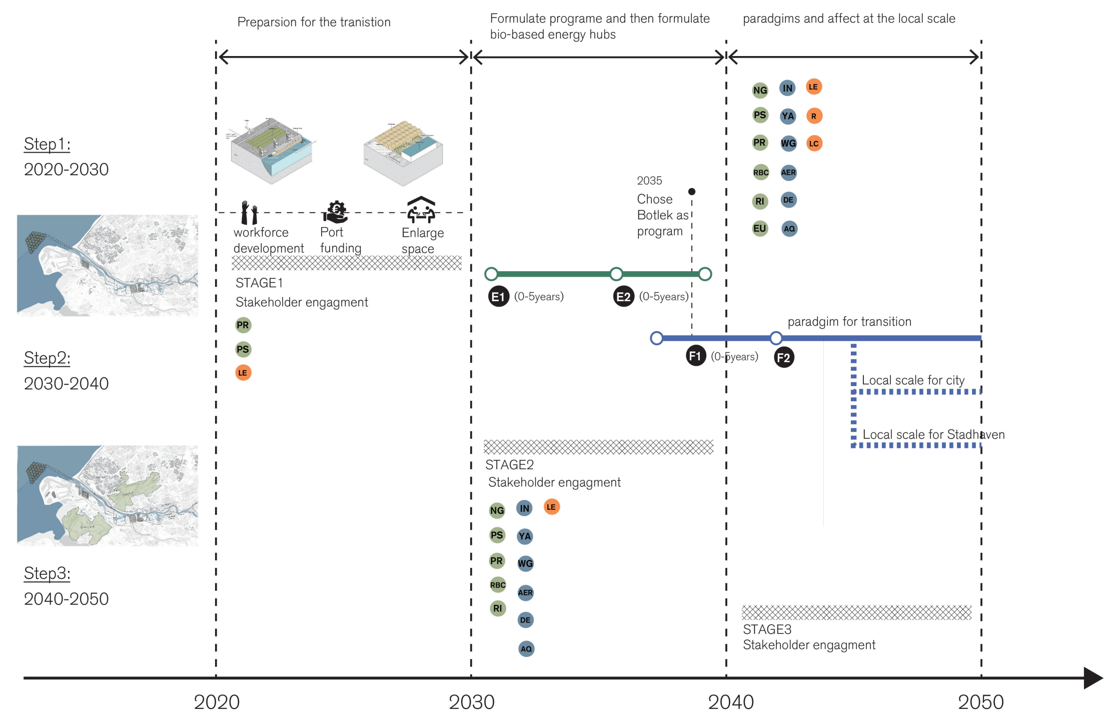
(3).**Nature based solution vs Adaptability**: even though the common agreements on the advance and ecosystem services provided by the nature based solutions, it still needed the hard infrastructure for current future water management. In that case, it needs to be careful when the intervention of NBS takes the spaces of infrastructure. The comparison and evaluation should be provided that the infrastructure outweighs its pros and cons or not..

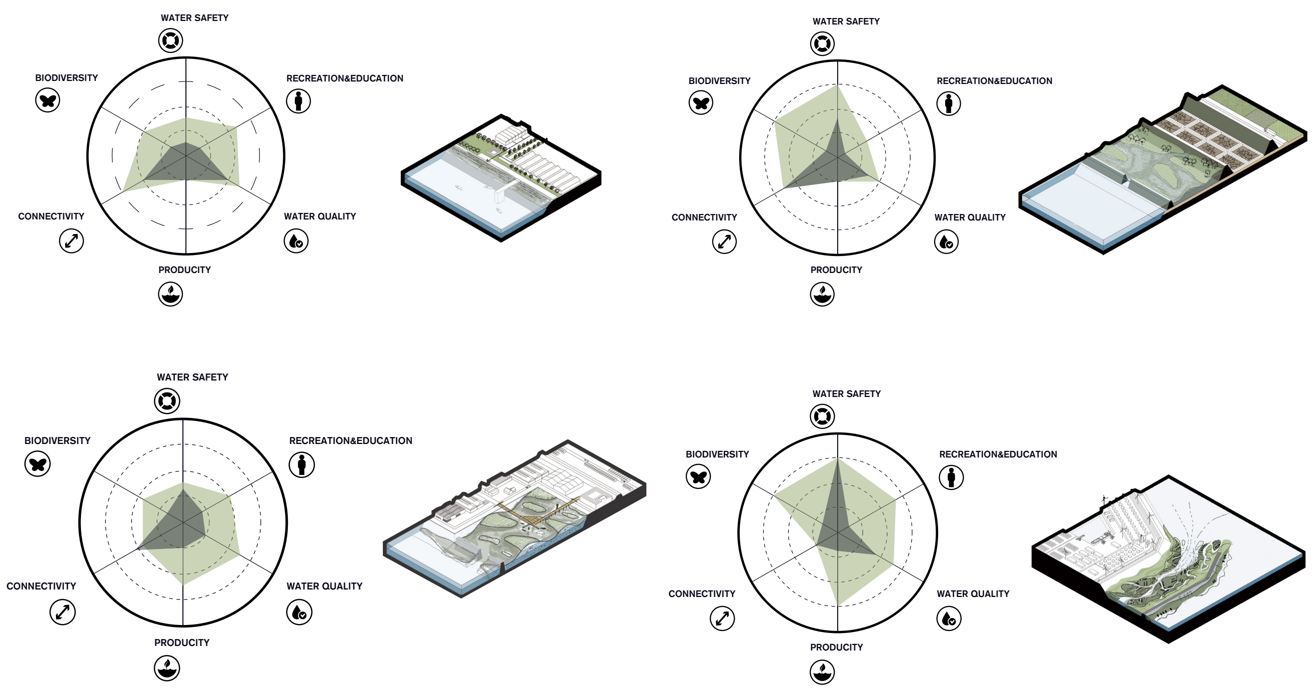
(4). **Cultural indentity vs New developmen.**The fact is that Rotterdam is a water city. During the urban development process. The new urban development will inevitably lose part of the cultural identity while the low impact development could not fulfill the motivation of transitions, which is one of the ethical dilemmas.

Summary of limitations//

Personally, I think it is important to clearly state a logic and comprehensive storyline is always important for your audience to understand your project. Frits always push me to have a more focused narrative in each tutorial which I think helps a lot. In addition, the design is always a good reflective tool to continue the project. Design can propose, solve and refine the problem. In that case, everytime I encounter obstacles, the design could be applied as a tool to explore.


Establish the framework of landscape
Starting design projects for creating attrative destinations
Integrate nature with urban growth and expand to City-port area
Step1: 2030-2035
Step2: 2035-2040
Step3: 2035-2045
Step4: 2045-2050
G1 (0-5years)
G3 (2-5years)
G2 (0-2years)
STAGE1
Stakeholder engagment
Design project M4H
Design project Water community
H1 (0-2years)
H3 (2-5years)
H3 (5-10years)
I1 (0-5years)
I2 (5-10years)
I3 (5-10years)
STAGE2
Stakeholder engagment
J1 (5-10years)
J2 (5-10years)
STAGE3
Stakeholder engagment
2030
2035
2045
2050


Preparsion for the tranistion
Formulate programe and then formulate bio-based energy hubs
paradgims and affect at the local scale
Step1: 2020-2030
Step2: 2030-2040
Step3: 2040-2050
workforce development
Port funding
Enlarge space
STAGE1
Stakeholder engagment
2035
Chose Botlek as program
E1 (0-5years)
E2 (0-5years)
paradgim for transition
F1 (0-5years)
F2
Local scale for city
Local scale for Stadhaven
STAGE2
Stakeholder engagment
STAGE3
Stakeholder engagment
2020
2030
2040
2050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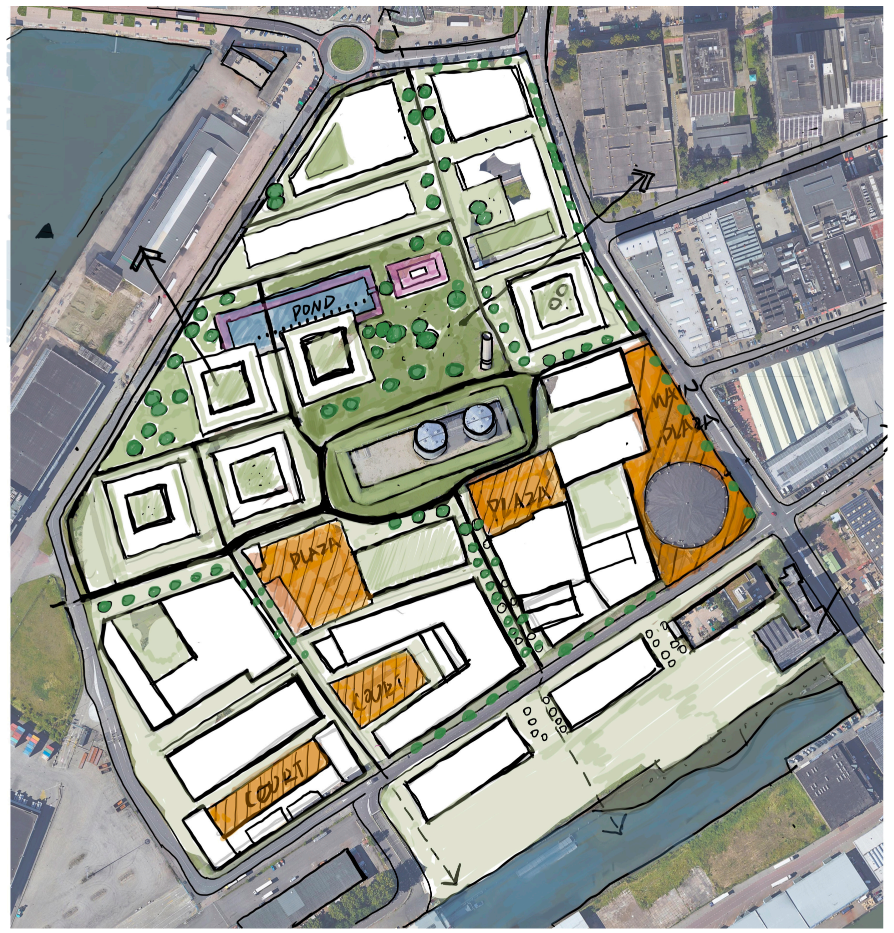
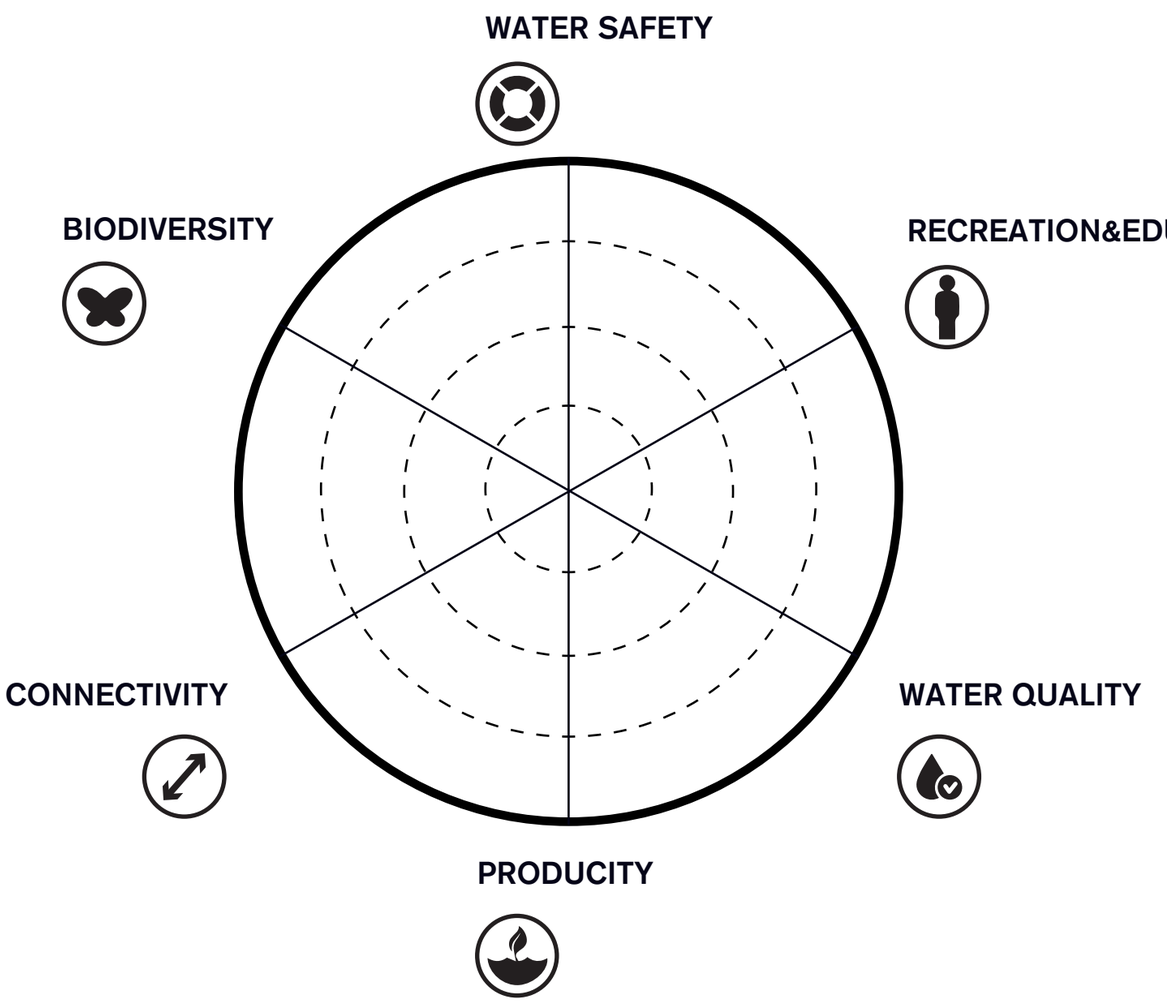
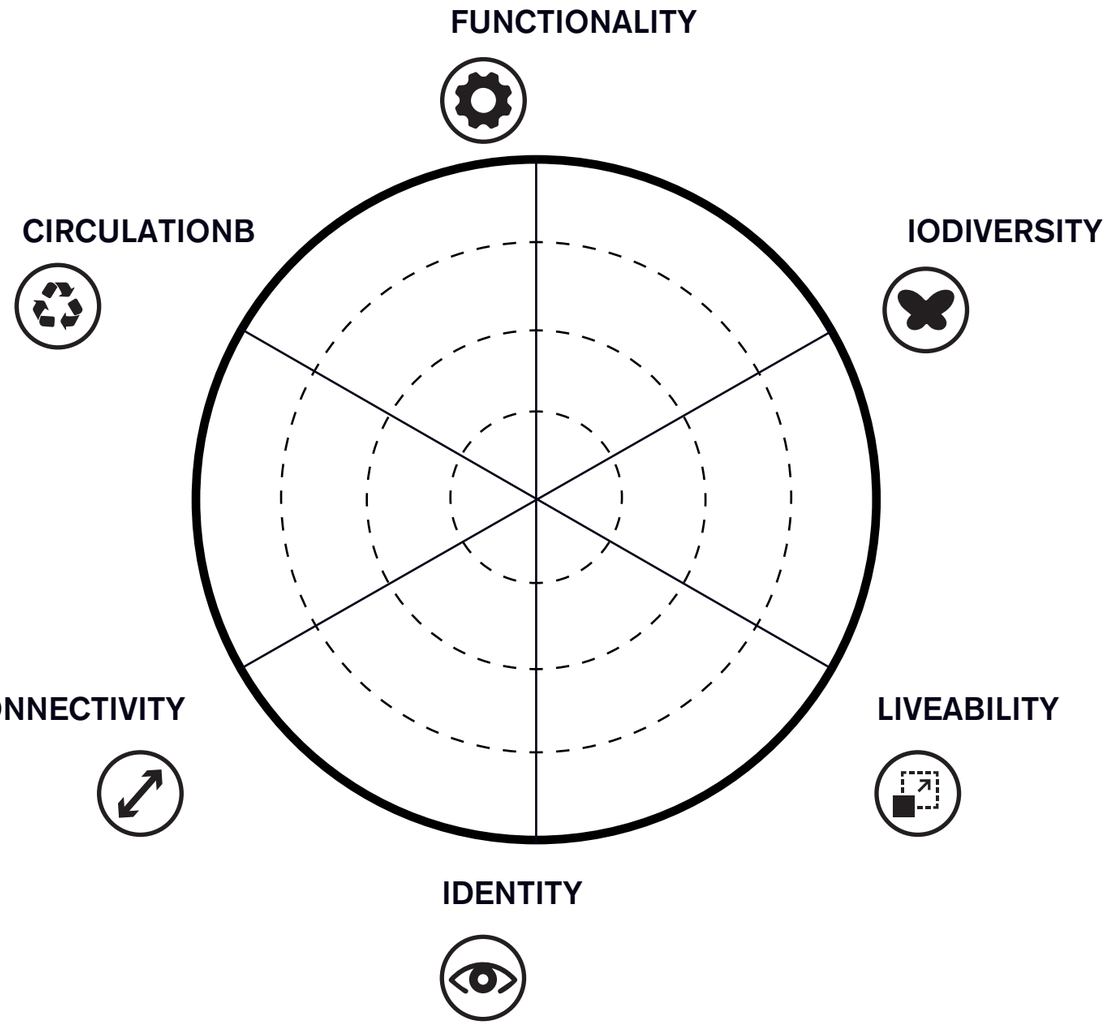
RECREATION&EDUCATION
WATER QUALITY
PRODUCITY
CONNECTIVITY
BIODIVERSITY

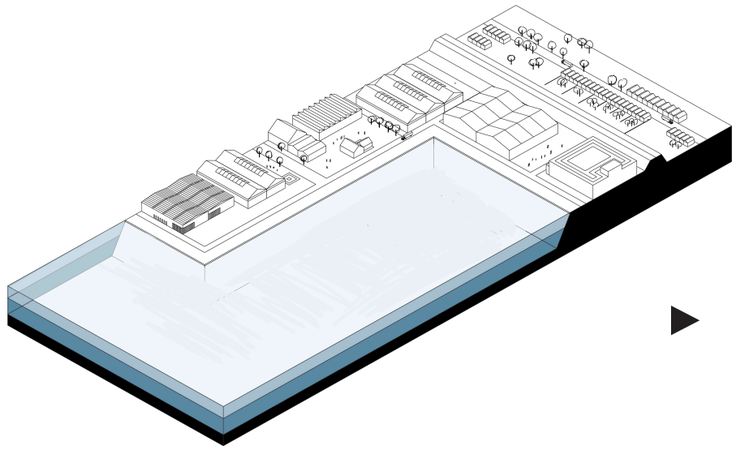

POND
PLAZA
PLAZA


WATER SAFETY
BIODIVERSITY
RECREATION&EDUCATION
CONNECTIVITY
WATER QUALITY
PRODUCITY

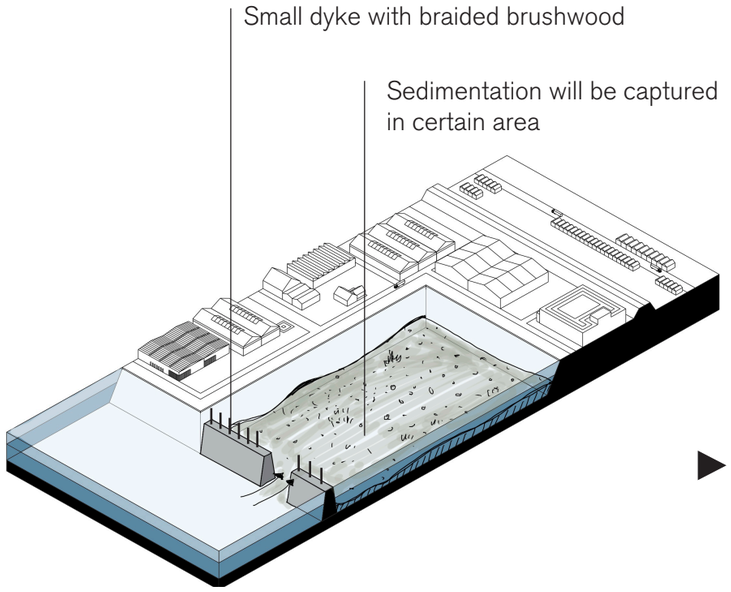

FUNCTIONALITY
CIRCULATIONB
IODIVERSITY
CONNECTIVITY
LIVEABILITY
IDENTITY

B.

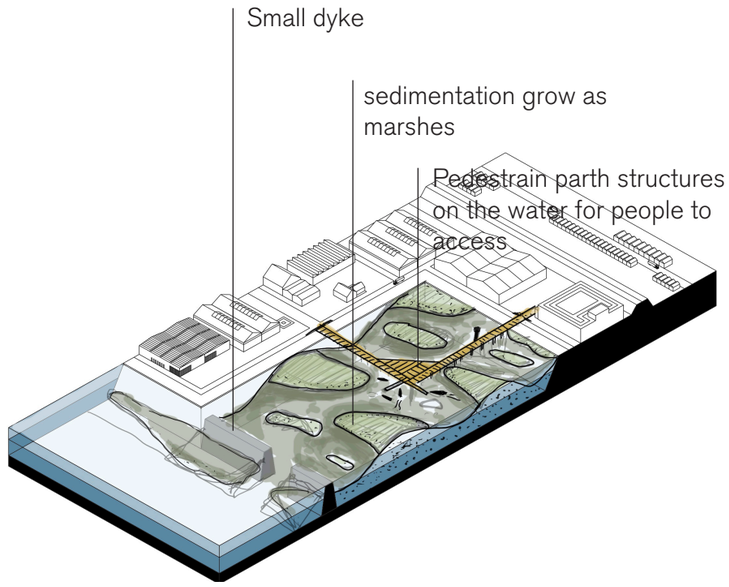
Old docks//Wetland Creations



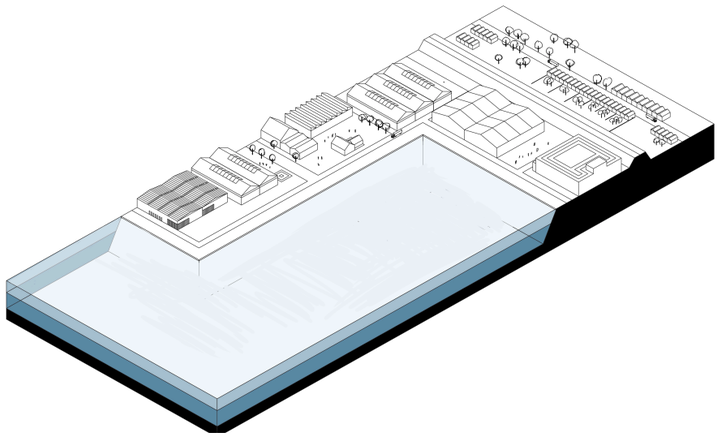
0 Current situation of dock(0 year)



B1 use the structure to define the space for sedimentations and trapping(0-2years)

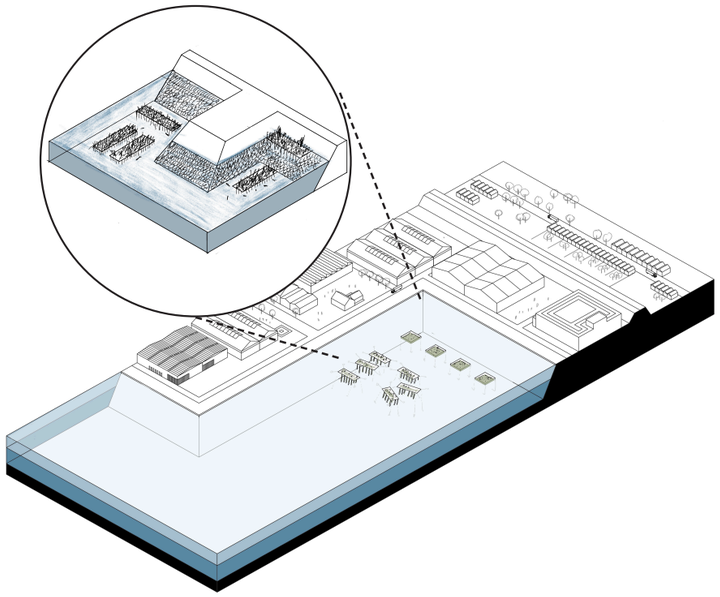


B2 the natural process creates rich habitat for marine life and wetlands, with local adpation, it grows as water park or for densification (2-5years)

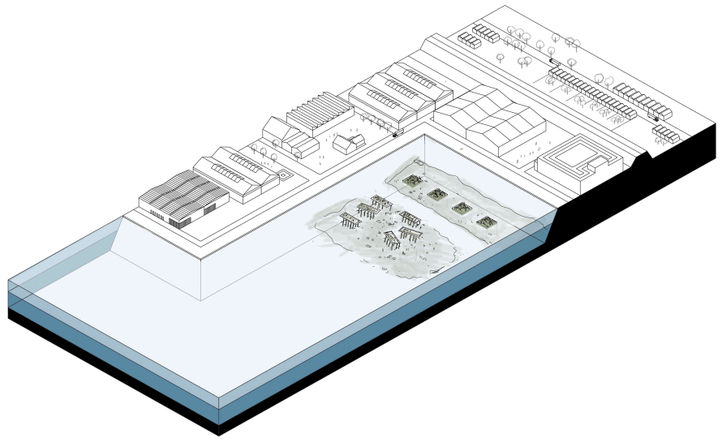


0 Current situation of old habour(0 year)

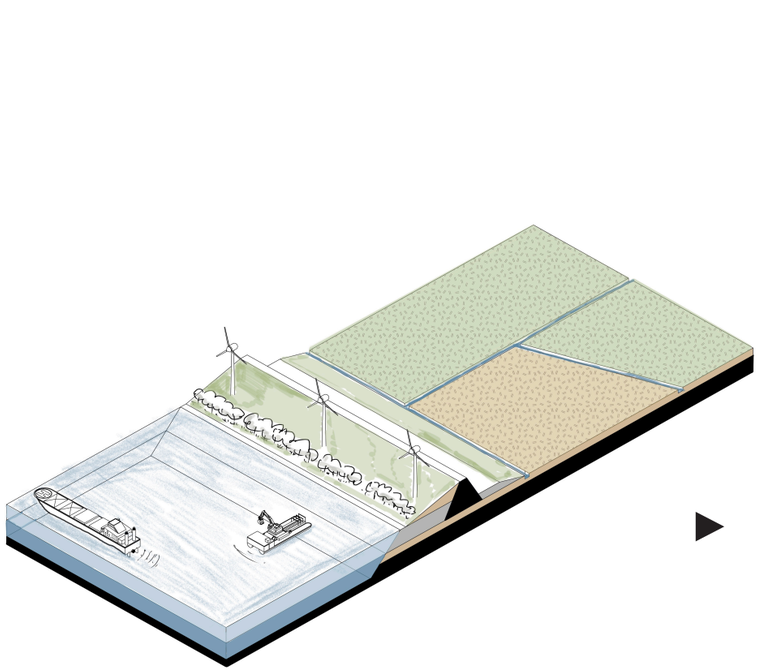
B1 Install the framework with seabed achors (0-1 years)



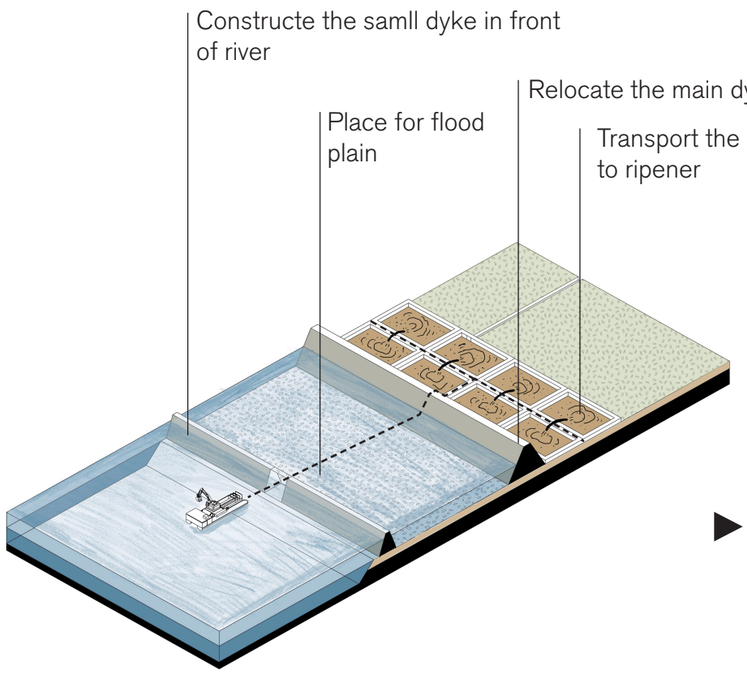
B2 the frame can grow filter feeders and trap sediments for wetland vegetations (1 -3years)



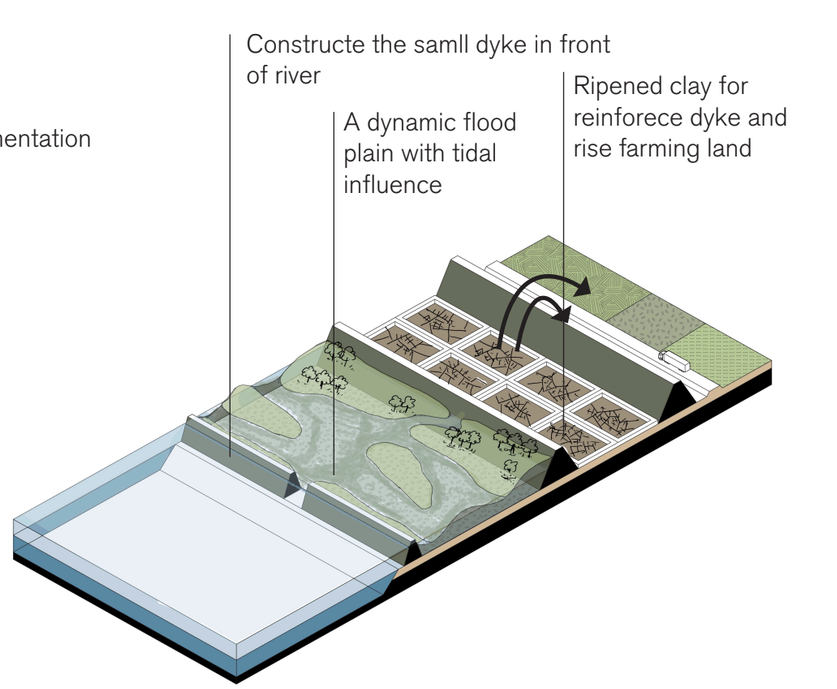
B3 the natural process can create rich habitat for marine life and wetlands(3-5years)



0 Current Situation of New water-way(0 year)



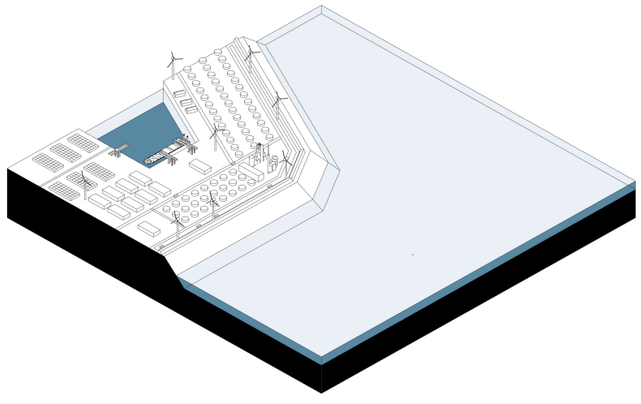
C1 Relocate the main dykes and constructe small dykesuse the sediments for clay repaining(0-5 years)



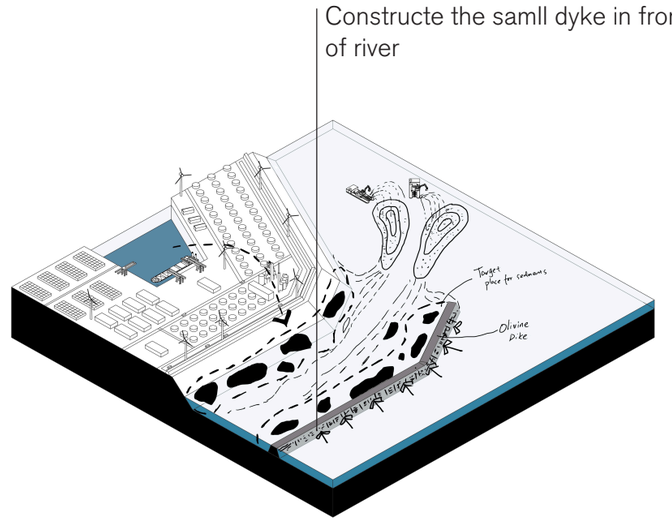
C2 work with nature process to create flooding plain and build the secondary dyke (5-10years)

D.

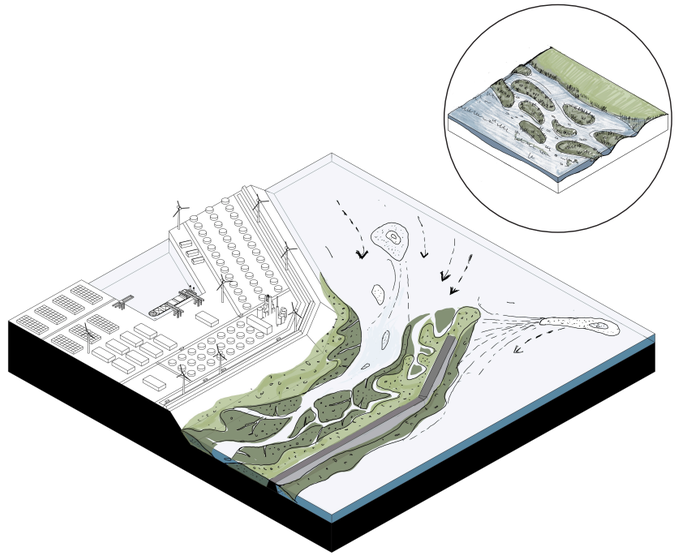
Maasvlakte2// Self Growing System



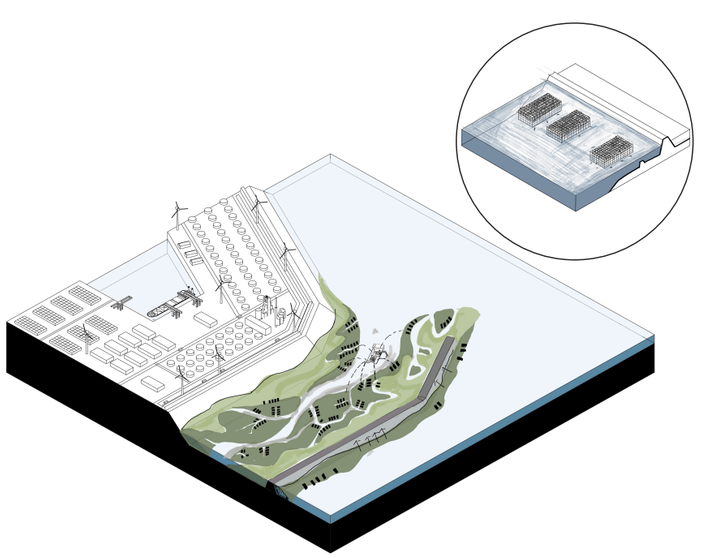
0 Current Stage of Maasvlake2



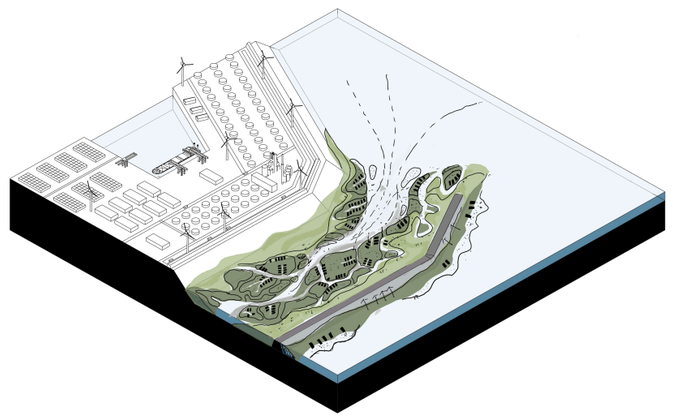
D1 Build up olivine dike and deposits dredged sediments near the target places(0-5 years)



D2 Wind,waves and tide disperse the sediments along the dyke and salt marsh can grow(5-15years)



D3 Place the oyster larave at the low tide and begain to grow with filter feeding(15-20 years)



D4 Oyester reef continue to grow as the sea level grow together with the saltmarsh(after 30 years)

Bibliogaphy

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