Lilly Petter

# Accepting the current(s)

## A porous approach for the revitalization of a former port area in the Rhine-Meuse Delta

P5 Report

First mentor: Leo van den Burg

Second Mentor: Carola Hein

M. Sc. Urbanism

Faculty of Architecture and the Built Environment

Technische Universiteit Delft

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**Abstract**

The constant manipulation of the Dutch delta system and the resulting creation of hard borders between the natural river landscape, the harbour and the city has led to a destabilized delta system (Hein, 2021; Meyer et al., 2015). The spatial and ecological challenges resulting from population growth and the resulting urban growth, as well as climate change, are becoming increasingly urgent. To densify already urban areas, municipalities are transforming more and more inner-city port areas, which as a result of the relocation of the port to the North Sea are increasingly becoming available. However, this trend presents increasingly apparent challenges as these areas are outside of dike protection and exposed to natural influences (Breś & Krosnicka, 2021). On the one hand, they offer the opportunity for housing, which is urgently needed in Rotterdam, but on the other hand are highly vulnerable due to the enhanced risk of flooding resulting from sea-level rise and higher river discharge.

The research project "Accepting the current(s) - A porous approach for the revitalization of a former port area in the Rhine-Meuse Delta" explores a new nature-based approach for these areas. The resulting design aims to combine the natural and urban processes in an adaptive and urban tidal landscape, working with and benefiting from the natural processes of the Nieuwe Maas and the Delta. It seeks to balance the various entities by enhancing the natural environment in the urban delta.

The permeable approach enables the provision of a collaborative zones for different flows and connections. This facilitates a transition from water to land and from port to city, where people, resources and ideas can move smoothly (Höller, 2021). Leading to better exploitation of potential and a better activation and integration of the previously segregated outer dike areas into the urban context. An adaptive hotspot is created within the dynamic landscape that is continuously evolving and able to accommodate future changes. In addition, the creation of tidal habitats provides an important natural habitat for different species of animals and plants that have been displaced by the previous water management of the region, thus creating a place of migration. For both humans and animals.

The work includes a design catalog for the creation of an urban tidal landscape to show decision-makers the various options available to create an adaptive wetland neighborhood. It allows the project to be more comprehensible and regionally transferable. In the end the suggested design strategies are applied to the study area of the waterfront of Nieuw Mathenesse/Merwe-Vierhavens to give a more specific outlook and to better demonstrate the potentials the design is intended to offer.

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Figure 1: Man evacuating carrying woman through the water in 1953 in Rotterdam / *Unknown*

# Introduction

*Before delving deep into the subject matter, this chapter is intended to provide a brief introduction to this thesis, its background, and how it came about in the first place. It refers to the personal motivation of the author and illustrates how the field of interest of climate adaptation and urban flood resilience and what this might entail was found.*

This thesis is focused on identifying opportunities for resilient and urban flood protection as well as adaptive development strategies in former port areas. It aims to achieve this by paying more attention to the Delta ecosystem, finding new multifunctional uses and integrating climate adaptation measures into the built environment, i.e. buildings and infrastructure.

Due to the increased risk posed by the climate crisis to the inhabitants of maritime locations, including the Netherlands, there is a great urgency to research long-term solutions that bring urban life and nature into harmony and no longer compete with each other (Kabisch et al., 2016). To do this, it is important to take a closer look at the boundary between both of these very different environments, in this case the waterfront in the Rhine-Meuse Delta, in order to gain a better understanding of the current relationship of the two entities. (Breś & Krosnicka, 2021; Meyer et al., 2015)

The close connection to the water and focus on trade and transportation has made the Dutch cities and port areas what they are today and contributed to the success story of the Randstad area. In recent years, the former Delta landscape has been transformed into a huge and extensive industrial area that stretches from the historic parts of Rotterdam into the North Sea. Instead of a unique marsh landscape, oil refineries, cranes and container ships now dominate the scenery. Now, however, with the increasingly visible effects of climate change, such as salt intrusion, sea level rise or soil subsidence this close connection and current use poses a greater risk than ever and has brought contemporary planning to a turning point. (Meyer, 2014)

The research focuses on a former port area outside the dikes in Schiedam and Rotterdam. It is in a very vulnerable location due to the lack of protection by the primary water protection structures and disconnected of the main urban fabric. The aim of the project is to propose how the Nieuw Mathenesse/Merwe-Vierhavens study area can be made more porous and help to fundamentally change the post-industrial areas along the Nieuwe Waterweg into transitional zones that lead to a substantial and necessary stabilization of the delta. In doing so it is essential for creating a future proof design to not only look at the project area itself but to understand the estuary system and its processes as a whole and see Rotterdam as just a small part of this landscape.

## Motivation

A lot of people in the western world are aware that the Netherlands is particularly vulnerable to climate change and the associated rise in sea level due to its high percentage of land below sea level. However, this always seemed to be far in the future, after all, it has always worked out so far and climate change seemed to threaten much more socially disadvantaged countries than the well-planned Netherlands and the other western countries. How wrong we were was made clear last year by the great flood event in the region in and around the Eifel, in which over a hundred people died in Germany alone. It was a tragic and a wake-up call for many not to underestimate the effects of climate change.

Coming from a port city myself, I feel a fascination from the maritime life near the water and I feel very connected to it. However, I am also becoming more aware of the risks it carries. It is not uncommon for the fish market in Hamburg to be under water, but I am used to being protected by a security system of dunes, dikes, and barriers, just like in the Netherlands. In my case, these have always been able to withstand the floods, but how overwhelming the forces of nature can be is now becoming more and more apparent. A failure of today's safety measures would have devastating consequences. A look at the past shows that this battle against the water has been going on for centuries. Now that we see that the measures taken so far are slowly reaching their limits, it is important to think further into the future and research new long-term solutions. Therefore, I find it all the more interesting to take a closer look at maritime and sustainable construction in port cities.

# 1 foundation

The chapter foundation deals with the basics on which the work is based. It takes a closer look at the trends in the world and **what** moves them today, **what** the problems and challenges, as well as the context in which the project is located. What is discussed in this chapter will consistently be taken up again throughout the thesis.

- Problemfield
    - Challenges of climate change
    - Urbanized delta
- Context
    - Delta context
    - Port city context
- Problemstatement

Figure 2: High water February 2020 / *Flashphoto*

Figure 3: Scale showing the water level in the north of the Netherlands / *Rob Oo*

# Problem field

*Climate change and lack of space are global processes that represent major challenges worldwide. According to Ward and Winsemius (2018) an estimated 39 million people worldwide are currently affected by riverine flooding. This is largely due to climate change, but also to increased urbanization of flood-prone areas. If changes are not made soon to help countries better adapt to and mitigate the impacts, this number could rise to as many as 134 million per year. (Ward & Winsemius, 2018) The Netherlands is not exempt from this problem. On the contrary, with a densely populated landscape, most of which lies below sea level, it holds a unique and highly vulnerable position. This chapter examines this particular problem field in more detail. Here, the main purpose is to demonstrate the relevance of the study and to illustrate the need for action. The discussion of the problems is referred to the national and regional context of the region around the Rhine-Meuse Delta and Rotterdam.*

## Challenges of climate change

Climate change is one of the most far reaching and consequential challenges in the world and has already been predicted and fought for decades. It is due to human activities, especially in developed countries, and is changing the environment and atmospheric configuration. Even though it has been acknowledged for multiple decades, the world hasn't paid enough attention. (UNFCCC, 1992) Climate change is in full process and is irreversible. While projections for the future are not accurate when it comes to time, geography, and magnitude, impacts such as prolonged or extreme heat waves, rising sea levels, and unpredictable flooding are already evident. Although climate change cannot be stopped completely, it is possible to reduce its impact to a level that is less threatening and more sustainable for future generations. However, this will require immediate and long-term adaptation efforts from everyone, be it the private, social, commercial or governmental sectors. These actions should happen precautionary and anticipate to minimize the outcome of possible future disasters. (IPCC, 2022)

Although climate change is a normal phenomenon in world history, human influence has disrupted it, leading to more drastic and rapid impacts. According to the IPCC (2014), human activities are 95% of the reason for it. Increased emissions of greenhouse gases, which have been rising steadily since pre-industrial times and continue to reach record highs, are leading to global warming. Thus, the northern hemisphere is now in the warmest period it has ever been in since the last 1400 years. If humans continue as they are, this will lead to long-term, severe, and irreversible impacts on human and ecological life. Therefor a systematic approach is needed that prioritizes climate adaptation and risk management and sets the goal of achieving a resilient environment. (IPCC, 2014) An important step in this direction was the Paris Agreement adopted in 2015 at the United Nations Climate Change Conference (COP21), which was signed by 196 parties, including the Netherlands. (Shi et al., 2016)

By 2050, according to the Sixth Assessment Report, an additional 2.5 billion people will live in urban regions with increased exposure to climate change impacts. Especially in urban areas the greatest friction are to be expected and will lead to most environmental, social and economic challenges. To date, 50% of the world's population lives in cities and is forecasted to increase to 75% by the middle of this century (United Nations, 2017). The risk that urban areas face in relation to climate change is made up of 3 factors: Hazard, Exposure, and Vulnerability. Without mitigation strategies and adaptations by cities, the impacts will become more extreme and further exacerbate the situation of urban areas (UN-Habitat, 2014). Increased precipitation and sea level rise will lead to increased flood risk where many

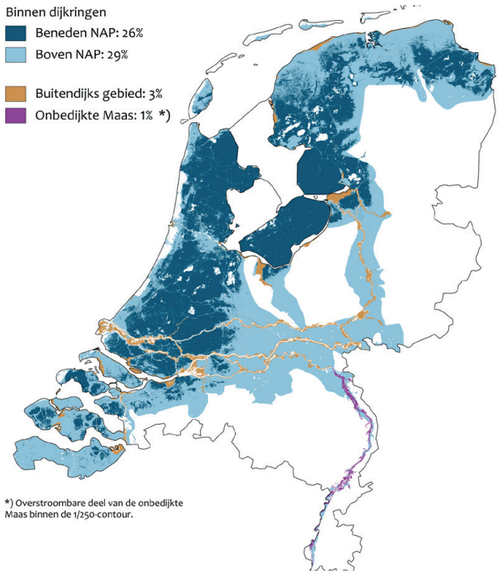



Figure 4: Flood risk in the Netherlands / *Pbl, 2007*

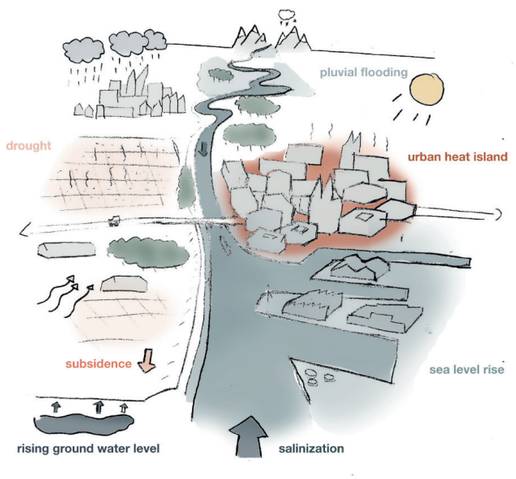
urban areas have settled and most of the urbanization and population growth is happening (Meyer & Bouma, 2017). This affects the Netherlands because of its coastal location on the delta and its special water management. Urban planners can help reduce the degree of delivery and magnitude of the hazard in these cases and help cities and regions adapt to the new circumstances and mitigate the outcome. (IPCC, 2022)

## Climate change in the Netherlands

The Netherlands is a very densely populated country. As indicated before, as a low-lying country it holds a very special and vulnerable position with respect to climate change and its direct and indirect effects. The country is closely interwoven with water and is characterized by various deltas of the rivers Scheldt, Meuse, Rhine, and Ems. Furthermore, it has a 400 km coastline to the North Sea. What makes the Netherlands so vulnerable to flooding, however, is the fact that almost 1/3 of the country lies below sea level (see figure 4) and due to the delta system and the many rivers, the rest of the country must be periodically protected from floods. (Van Koningsveld et al., 2008)

Among the various threatening impacts of climate change on the Netherlands, the greatest hazard is water related. The sea level is rising continuously and with the melting of the glaciers it will continue to do so more rapidly. This increases the pressure on the country's delta, rivers and coastline and the corresponding flood defenses. Another impact of climate change on the nation's water management is the extremization of rainfall patterns. The predicted longer dry seasons and rainstorms favor floods and enhance the river discharge in delta. (Meyer & Bouma, 2017)

The increased vulnerability of the Netherlands to climate change and the direct impact of it on the country has become increasingly clear in recent years. Since the mid-20th century, floods have become more frequent and more severe (Meyer & Bouma, 2017). For example, the most recent flooding of the Rhine in 2021 on the border between Germany, Belgium, and the Netherlands killed over 200 people, completely cut off sections of land from their surroundings, and destroyed important infrastructure. (IPCC, 2022)



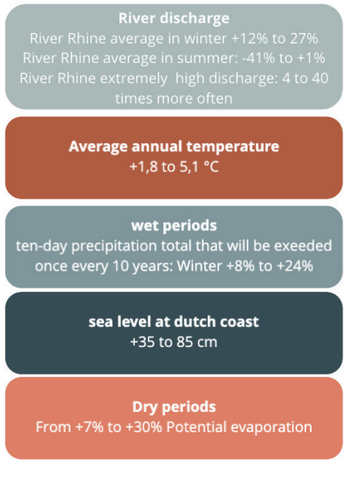




Figure 5: Effects of climate change in the Netherlands / *Data from Meyer & Bouma, 2017*



## Urbanized delta

As already mentioned, urban regions are at increased risk from climate change. This is particularly true for the Netherlands. It is one of the most densely populated countries in the world (Meyer et al., 2017). Much of this density is located in the Randstad the most urbanized area of the country, which stretches in west along the coast via Rotterdam with multiple port cities exposed to high flood risk. It forms the economic engine of the country, generating 60% of its gross national product and attracting many people from all over the world (Meyer & Bouma, 2017). The Randstad is also where most of the population growth and housing demand is expected. The lack of homes in and around major cities such as Amsterdam, Rotterdam, The Hague, and Utrecht increases the pressure on the landscape and the housing market, resulting in high property and rental prices. To be able to create a more sustainable future, the approaching crisis is to be counteracted. (PBL, 2018)

Accordingly, the government has set itself the goal of creating one million new homes by 2030 to make up the current deficit. 230,000 of these are to be realized in the province of South Holland alone (Provincie Zuid-Holland, 2017). In order not to urbanize the delta and the countryside even more than it already is, densification and housing construction should take place within the existing city boundaries. This also includes various industrial (port) areas that are to be converted into mixed or residential areas (see figure 6) (Nabielek, 2012).

This restructuring poses challenges for urban planners and designers due to the special circumstances of such post-industrial areas. The advantages and disadvantages of the intended transformation of post-industrial port areas along the delta, on which this paper focuses, are for example soil pollution, flood risk due to location outside the dams, but also intact infrastructure and inner-city location. However, this will be discussed in more detail later. Although these areas offer a great deal of potential, the government's planning can also be viewed critically. In 2050, up to 100,000 people in the region around Rotterdam are expected to live in elevated flood risk areas that lie outside the dams. That is almost 40,000 more than before. (Kennis voor Klimaat, 2014) Although these areas are located higher than the urban development behind the dike, they are exposed to an increased risk that needs to be responded to with sensitive and sustainable planning, which often turns out to be in the beginning more costly than conservative densification programs (Storbjörk & Hjerpe, 2014).

## Lack of space

The housing crisis and the required adaptation strategies for existing and new urban areas need space and increase pressure on land. Space that the Netherlands does not necessarily have. According to a study by Wageningen University, 100% of the Dutch land mass is already allocated to a specific function. If all current plans are maintained to achieve the government's goals, more than 10% more space will be needed than is available in the Netherlands (see figure 7). Therefore, a rethinking of land use is needed with a new approach that is more multifunctional. Conventional planning as we have known it so far will no longer be possible for spatial reasons. This concerns not only new but also existing spaces that will have to be restructured to meet temporal needs. (Ruimtetekort in Nederland, 2020)

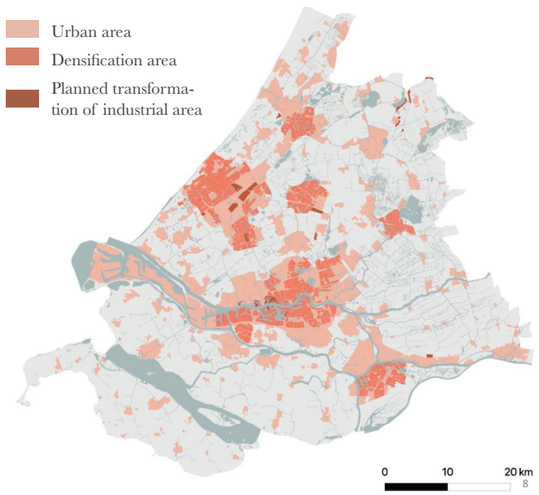



Figure 6: Densification areas in South Holland / *Author*

In detail, the focus of the government's plans is clearly shifitng in favor of the preservation and expansion of the natural environment and its integration into the urban context. A large part of the additional space needed by 2050 will be used for nature to maintain ecological services, strengthen natural capacities, and increase biodiversity in the country. This goes hand in hand with a stronger integration of climate adaptation into public spaces to mitigate the impacts of climate change. (Ruimtetekort in Nederland, 2020)

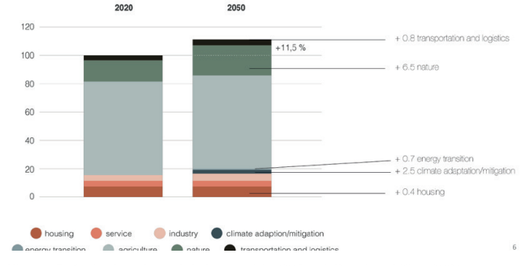



Figure 7: Calculated spatial demand in 2050 / *Based on NOS, 2020*

"Low-lying countries such as the Netherlands, because of their physical characteristics, are highly vulnerable to the consequences of extreme climatic events such as storm surges and periods of extreme precipitation."

- Mark van Koningsveld et.al, 2008

Figure 8: Dike breach in the Netherlands in 2021 / *New York Times*

Figure 9: Aerial view of the Rhine-Meuse-Scheldt river delta in the Netherlands in which Schiedam is located / *NASA Johnson*

# Context

*After examining the general problem field, it is important to get an understanding of the broader context of the study area. This chapter attempts to give a brief introduction and describe the basic contextual features. In a first step, the landscape of the Delta and its current state will be described, including a general outline of the current and past planning approaches that shaped it. This is followed by a brief overview of the port dynamics as the main driver of the current delta system and its specific interrelationship with Schiedam and Rotterdam. A more detailed analysis is provided in a later part of the thesis.*

## Delta context

The Rhine, which originates in Switzerland, is one of the most important and largest rivers in Europe. On its way to its river mouth in the North Sea in the Netherlands, it passes through many cities and towns. Today, more than 58 million people live in its far reaches and along its waterfront. It was and still is used as one of the most important inland waterways, leading to socio-economic growth in different countries. Its industrial and infrastructural importance is reflected in the size category of its port activity. The seaport of Rotterdam is the largest seaport in Europe and Duisburg, further inland on the Rhine in the German Ruhr region, is the largest inland port in the world. (Delta Alliance, n.d.)

The majority of the Delta lies below sea level and is extremely vulnerable to flooding. Despite this, the economic conditions and fertile soils are so appealing that this area has become one of the most densely populated places in the world due to water defense and drainage of the marsh and peat landscape (Meyer et al., 2015; Meyer & Bouma, 2017). This led to a lowering of the ground of up to 6 meters in some places of the Netherlands. Historically, the Rhine-Meuse area has been flooded in several flood events but is now considered the safest urbanized delta in the world. This is due to the delta plan introduced after 1953 and its complex water management, with barriers along the coast, locks and hydropower plants, which have been able to protect the land from catastrophic floods for more than 60 years now. (Meyer & Bouma, 2017) However, according to experience, such planning decisions and large scale interventions take a long time to be fully implemented. The past Delta program was completed 45 years after being adopted in the aftermath of the 1953 flood, and similarly the past Room for River project took a full 20 years before it was fully realized. Therefore, instead of waiting for the next catastrophe to strike, new strategies should be implemented ahead of time to better prepare for the inevitable challenges in the coming future. (van Alphen et al., 2022)

## Paradigm change

However, these extreme interventions in the delta did not occur without consequences for the ecosystem and existing systems. Today, the delta and its hinterland are completely dependent on the functioning of the water management which turned out to be effective until now but are neither resilient, nor sustainable (van Slobbe et al., 2013). The impaired tidal flow altered the flora and fauna of the river. Migrations of species to and from saltwater and within inland waters were prevented by the barriers and locks. Also, the embankment of the river especially in the port of Rotterdam and the artificial water fronts destroyed near-water biotopes and habitats such as wetlands. The water flow and sediment cycle has been thrown out of balance, forcing man to constantly maintain and intervene. Ultimately, human intervention and actions have paradoxically made the land even more vulnerable through “hard” engineering approaches designed to protect it and reduce the risk (Haer et al., 2019). Urbanized delta regions in particular need more resilient and sustainable planning and management approaches that are nonetheless in the economically affordable range. Thus, a paradigm shift has occurred. Increasingly, the previous hard engineering solutions are being questioned by planners and ecologists and new, nature-based approaches are being researched and supported by pol-

icy makers. One example of this is the "Room for the river" project that was launched in 2005 (Peters et al., 2021). Here, more space is to be given to the rivers of the delta in order to protect the hinterland even during floods and in view of climate change. In a collaborative effort to link, nature, engineering, and society in urban and rural areas to provide a new way for water management and built with nature. Currently, the Netherlands is looking for a new national flood protection scheme in which instead of fighting the water, a way is found to work and live with it, allowing new landscapes and urban developments to emerge. (Engel et al., 2021; van Slobbe et al., 2013)

Back then, the Rotterdam region decided against the establishment of the "Room for the river" project, due to its high complexity and intensive port activities. Now it must consider further protection measures in view of climate change and the increasing vulnerability of the urban area. According to the Delta Program, the region is the most problematic in the Delta. This is due to the complex and dense fabric of urban and industrial and port structures where every intervention has an impact on the larger system, ecological or economical, but also due to the existing water management, which is based on the function of the Nieuwe Waterweg. Now the region is standing at crossroads faced with a far-reaching decision. Should it continue to develop the existing hard technical interventions and protection measures, which would lead to a progressive destabilization of the ecosystem, or should it undertake a complete restructuring of the delta by replacing the Nieuwe Waterweg as the main route for the discharge of sediments, thus entailing a relocation of industry and shipping? Meaning a shift of the main flow to the Hollandsche Diep-Haringvliet in the south of the delta, which offers a bigger capacity. (Engel et al., 2021)

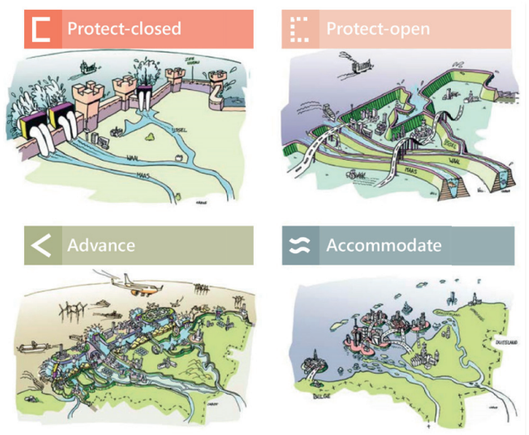



Figure 10: Potential types of strategies for the Netherlands to adapt to accelerated sea level rise / *Carof for Deltares*

Deltares and the delta commission defined 4 different type of strategies (see figure 10) for the Netherlands to respond to the inevitable sea level rise. Two of these (protect-closed and protect-open) retain the existing water management and flood protection policies. Here, hard measures continue to be used and previous practices are reinforced in order to generate previous land use. These "business as usual" approaches may include a closed river system on one side, which enhances protection along the coasts of the Netherlands. This requires enormous pumping facilities that can service the river discharge. On the other hand, the other "Protect" strategy offers the possibility to keep the rivers open. Accordingly, however, flood protection will be reinforced by dikes and dams along the rivers, and saline intrusion of surface water is likely to increase. The "Accommodate" approach is aimed at finding ways to live with the presence of water. This will involve a mix of retreat and adaptation. Here, the previous hard flood protection measures, such as dams, will not be reinforced. Instead, the vulnerable land behind them is largely prepared for more frequent flooding. This involves high social consequences, as areas and inhabitants must adapt horizontally (move away) or vertically (raise). The "Advance" response is the newest of the strategies presented so far. Here, to achieve a more robust coastal protection, the coast is extended seaward. The newly created brackish water area along the old coastline serves as a buffer during high tide periods and can be used for industrial, ecological, residential, and recreational purposes, while allowing the current land use in the hinterland. These measures involve high levels of investment, construction, and social impact, some more than others. Overall, the delta program seeks to find an inclusive solution that balances large- and small-scale interventions and leaves room for flexibility for adaptive measures in the future. (van Alphen et al., 2022)

## Port city context

Climate change has a major impact on port cities. This is due not only to their vulnerable geographical location and physical construction, but also to their important economic role in the global context. As the maritime trade links between international port cities also need to be adapted as a result. (Hein, 2019)

Port cities are unique and complex urban structures that resemble a connection from people to the water. Lying on the border between land and water, they are the link between a hard and fixed infrastructure and the softer and dynamic maritime system. Through the continuous flow of goods, society, and knowledge through these urban environments, they have become important engines and pillars for regional and national economies. Accordingly, the economic assets do not remain local and sharply delineated but extend far beyond the port itself and often blur the boundary with the surrounding area. Thus, a port city becomes a port city region. On the other hand, this effect cannot be transferred to the negative economic and social aspects, which remain mostly local. Historically, they have attracted more and more people and new businesses, enabling an urbanization process and making the city competitive. Not only in national comparison, but also in a global one. The

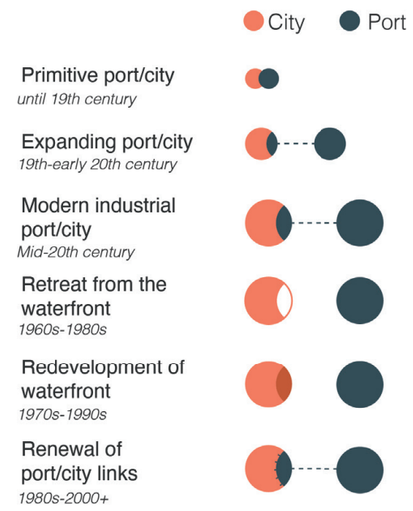



Figure 11: Conception of the port city interface evolution by Holye (2000) / *Author*

special relationship of port cities between the two different entities, port and city, as well as the connection to other (inter-)national cities led to a historical formation and strong identity creation. (Hein, 2019; Wiese et al., 2013) On closer inspection, apart from the general port function, there could be various orientations. Yochum and Agarwal divides them into the following three categories: „port-specific industries that represent transportation and port services necessary for maritime trade; port-related industries that represent firms engaged in import and export trade; and port-induced industries that take advantage of the hub to expand their markets." (Yochum and Agarwal, 1988 in Zhao et al., 2017, p. 120)

The importance of these cities for a region and a country can also be seen in the large and small port cities in the Dutch delta and along the Rhine. The strategically located ports between the sea and the hinterland, such as Rotterdam and Amsterdam, were already flourishing in the Middle Ages. The accompanying economic boom made the Netherlands at that time the heart of Europe. To this date Rotterdam is still one of the largest ports in the world, competing with Shanghai or Singapore and can be called "the gate to Europe". (Port of Rotterdam, n.d.; van Mil & Rutte, 2021) Particularly in the Netherlands, the port cities were important. They were not only a connection from the mainland to international waters, but the main connection of the inland. The port cities developed along the embankments where inland rivers met the main streams, as the place of transfer of goods was attractive to merchants and traders. Thus, the inhabitants of the polder area could sell and transport their goods to the rest of the country, especially when water transport was more accessible than rail transport. (Borger & Ligtendag, 1998)

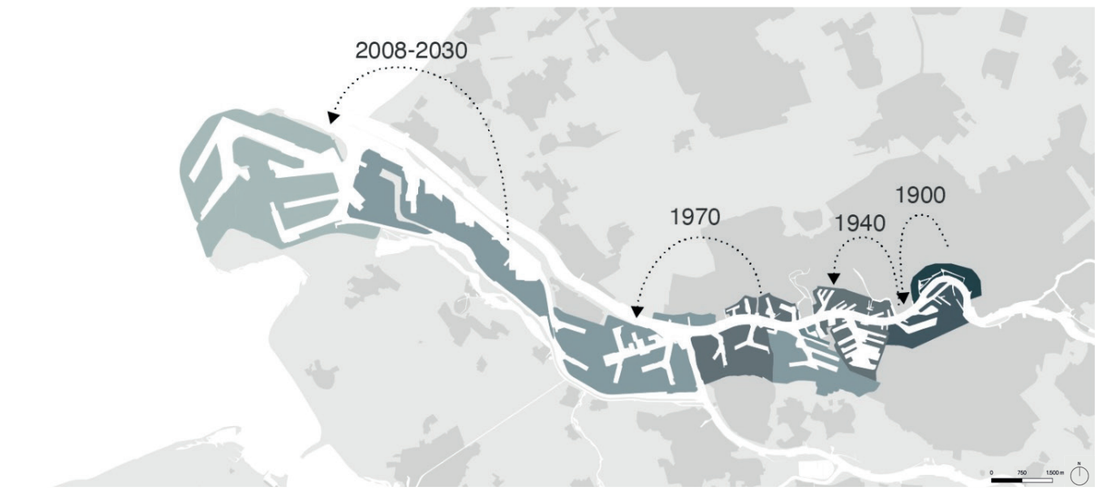



Figure 12: Evolution of the port of Rotterdam / *Author*; *Based on De Gijt et al., 2010*

## Port city interface

Over time, the connection between the city and the port has constantly changed. This evolution has been studied and interpreted by various researchers and planners. Social changes and technological advances have caused the two entities to grow apart. The technological demands on the landscape have changed and the negative effects brought by industrial use, such as pollution and noise have weakened the link and in some cases led to a complete segregation of areas. (Zhao et al., 2017). The boundaries, once blurred beyond recognition and resembling a porous landscape, became increasingly clear, eventually leading to a transformation and emergence of new and old port areas. New areas that corresponded to the larger and heavier infrastructure and ships were developed outside the city limits and old inner-city areas were converted to convertible urban areas. This process was conceptualized by Hoyle as early as 1989 and again in 2000 (see figure 11). Hoyle's concept is one of the best-known representations on the subject. In it he describes how the port was first closely connected to the city, but then became separated from it and is to be more closely connected again in recent years. Hoyle divided the evolution of the relationship in European port cities into five parts: the primitive city port, the expanding port-city, modern industrial port-city, the retreat from the waterfront, and the redevelopment of the waterfront. (B. S. Hoyle, 1989)

Hoyle's conceptualization which was over the course of time, repeatedly overhauled and further developed has been applied worldwide and has led to various transformation and redevelopment projects of post-industrial and inner-city port areas in order to integrate them into the urban fabric. Yet he sees the boundary between the port and the city as a hard line. This view, however, is outdated. According to Moretti (2021) it has led projects around the world on the one hand to a progressive development of infrastructure, but on the other hand to a further separation of port institutions and the city or hard engineered water's edge in transformed urban cityscapes. She criticizes the previous theory for being too one-dimensional and for misunderstanding the actual relationship between the two entities. Viewing the connection as a static interface does not solve the existing conflicts and tensions between urban life and the port as well as the relationship between water and land. Instead, the boundary between the two has many openings, overlaps and intersections that are changing over time. The planning and relation between port and city must be seen as much more flexible and variable, allowing for transition and coexistence of the two. This is the only way to preserve the identity of the port city.

In order to try out the new approach, the planning of small port cities can be particularly instructive and helpful, since they are historically much more malleable and flexible, and their changes, even if small, influence the large systems. (Hein, 2021)

## Waterfront development

The Rotterdam region is strongly influenced by the importance and development of the seaport. Since its foundation around 1250, it has changed a lot and will continue to do so in order to remain competitive and more sustainable. This is related, as briefly mentioned, to technological advances and the restructuring of global shipping and loading technology. During the 20th century, ports moved towards the sea to meet the demands of continuously bigger container ships and loading technologies and to remain competitive with the rest of the world. As a result, space was created for urban expansions. This also happened in Rotterdam, where development proceeded very quickly and some of the replanning is still ongoing. Before the (re)discovery of the potential and the revitalization of the port areas, they were initially disregarded and neglected in many places. Schubert (2010) divides the replanning into four generations, some of which were also realized in Rotterdam. First, the waterfront was activated by tourist facilities such as promenades and hotels. This was followed by a stronger urbanization of the waterfront with the help of tall and architectural office buildings and luxury apartments, which are intended to create a skyline in Kop van Zuid, for example. While this process was very profitable, it led to new conflicts as existing maritime facilities and users were pushed out of the area for the new urban development. This was followed by a greater involvement of the population in the new planning and creation of master plans. At the beginning of the 21st century, the 4th generation began, in which the port areas were replaced by mixed-use developments, often in the upper price category, as is the case in HafenCity in Hamburg, for example. (Schubert, 2010)

Today, in light of climate change, the new approaches are more experimental, and nature based. Their goal is to enable an equitable development that is sustainable and can respond to future changes and is able to bounce back after alterations. (Greef & Nieuwenhuijze, 2005)

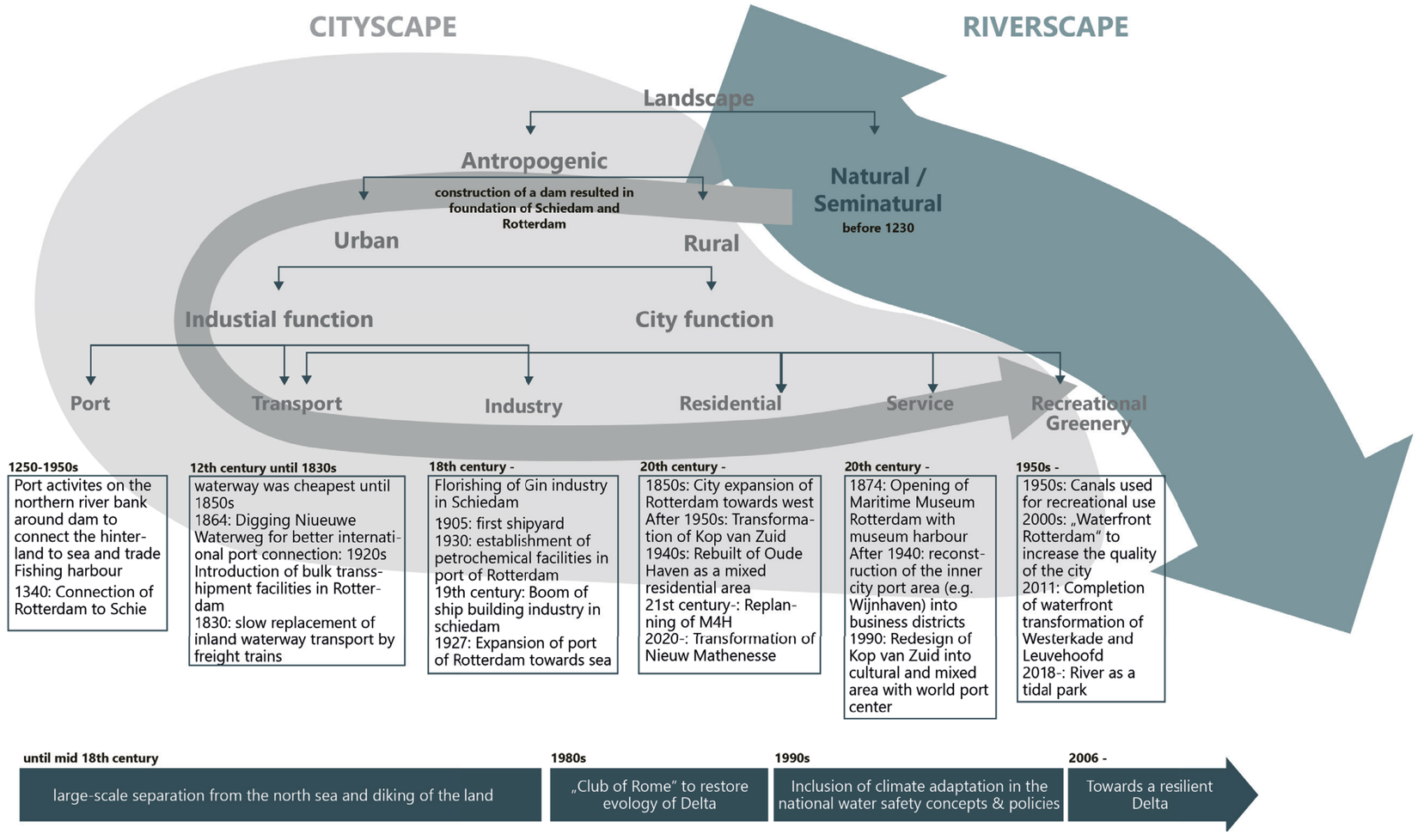



Figure 13: Timeline of the function cycle in the Rijnmond-Drechtesteden Delta / *Author; Illustration based on Breś & Krosnicka, 2021*

# Problem statement

*The problem field and the characteristic of the challenges in the context of the Dutch delta system are summarized in form of the problem statement that will be addressed by the research.*

*The miscomprehension of the interrelationship and the inadequate integration of old port sites to the port city and delta system, as well as the underutilization of climate adaptation measures at sites along the river, result in a vulnerable and destabilized system with limited adaptive capacity of the cities and the delta.*

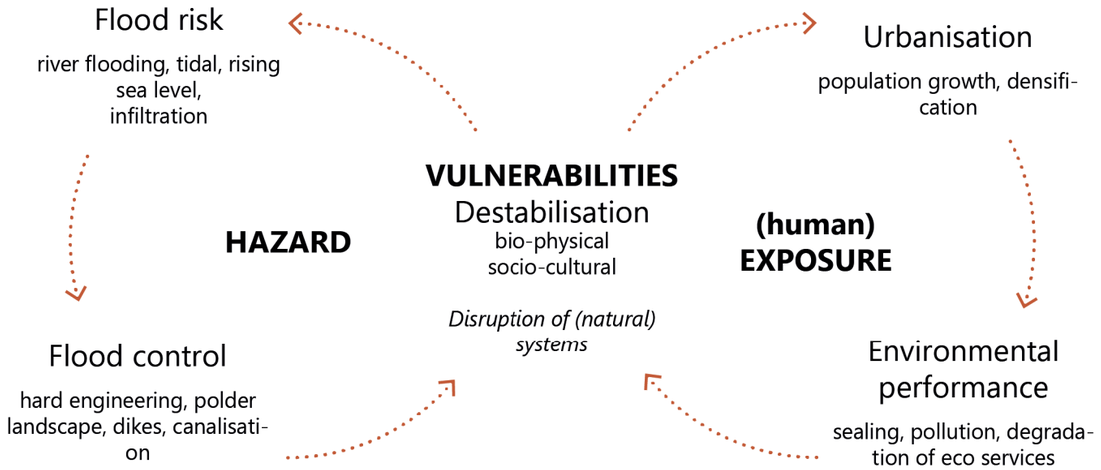



Figure 14: The The destabilized Delta / *Author*

## Conclusion

The delta is currently experiencing an unstable environment as exposure and hazard continue to rise steadily (see figure 14). The uncertainty and incalculability of climate change and its effects make the planning, redeveloping and expansion of urban areas difficult. Especially in view of their impact on the natural environment and its services. The constant urbanization over time, especially in the Rotterdam region along the Nieuwe Waterweg led due to the increased sealing and polution to a lower environmental performance of the delta (IPCC, 2014, 2022; United Nations, 2017). It became clear in the past years that the clear hard separation of the two components of water and land, or port and city, did not solve the issues, but rather lead to further problems (Breś & Krosnicka, 2021). Until now, the Netherlands has worked against the natural processes of the delta and the increasing flood risk, using “hard” techniques for flood control such as dams and locks, and floods have been considered undesirable because of their high vulnerability. The resulting negative impacts and disruption of the (natural) systems, especially on the ecosystem, but also on the social environment of the port cities, were seen as lesser evils (Meyer & Bouma, 2017). With the paradox of the now further increased vulnerability to flooding, it is becoming increasingly clear that these are not to be ignored but must be integrated into the delta system. As long as traditional methods of planning, designing, decision-making, and managing cities and regions are maintained, hazards and exposure to expanding human activities will only increase and only continue to reinforce each other instead of reaching actual long-term solutions. These are crucial for the feasibility of urban development projects in the delta in general and especially in an outer dike area like Merwe-Vierhavens in Schiedam/ Rotterdam as well as the overarching stabilization of the Rhine-Meuse-Delta. (Meyer et al., 2017)

Figure 15: Oosterscheldekering largest dam in the Delta / *Unkown*

# 2 conception

In this chapter, the approach of this project is presented in order to investigate whether and to how far a densification of flood-prone areas is possible. To this end, the purpose of the work is first formulated, and the main questions identified. Furthermore, it is explained how the intended results are to be achieved and which methodology is to be used and when.

- Research approach
    - Aim of the research
    - Research objective and questions
    - Conceptual framework
- Theoretical framework
    - Porosity
    - Urban flood resilience
    - Nature based design
- Methodology
    - Research scales
    - Analytical framework

Figure 16: View from study area to the south / *Author*

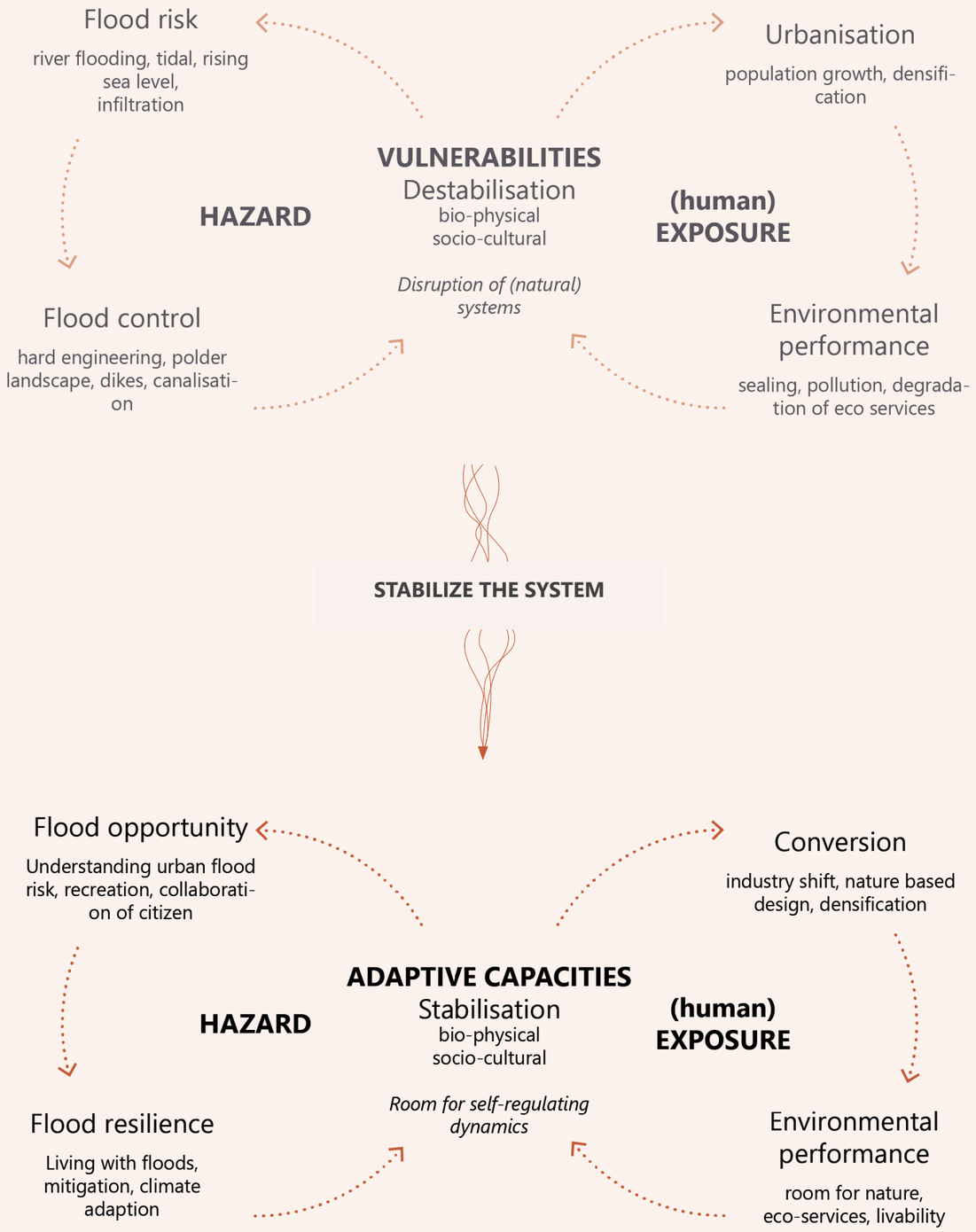



Figure 17: Creation of a stable delta system / *Author*

# Research approach

*The research approach outlines the overarching goal of the thesis. In doing so, this chapter establishes the framework within which the project is situated. It sets out the common thread that runs through it and will guide the reader until the end. The research questions are an essential part of this and concludes with the presentation of the created Conceptual Framework.*

## Stabilization of the system

The instability of the current delta system, as elaborated in the problem statement, must be counteracted, and stabilized. The aim of the design project is to strengthen adaptive capacities and to allow more room for self-regulating dynamics. The knowledge gap is how the two processes, climate change and the resulting increased flood risk, and the housing shortage and densification process, can be combined and sustainably integrated into one design. Therefore, the intention of this work is to clarify to what extent, with the help of expanded natural capacities, it is possible to live with floods in flood-prone postindustrial areas in such a way that no great social and physical damage results from them. The preferred scenario, which will be designed for the study area in Nieuw Mathenesse and Merwe-Vierhavens in Schiedam and Rotterdam, is to create a better integrated, revitalized and particularly resilient environment, first on a small scale, which can subsequently influence the large system in the future.

The revitalization of post-industrial port areas has been talked about for many years, but they are often thought of in too one-dimensional a way and are outdated (Hein, 2021). To create a meaningful design, this thesis will investigate this more and integrate new knowledge and findings from the recent development to find humane solutions to the man-made problems of the past.

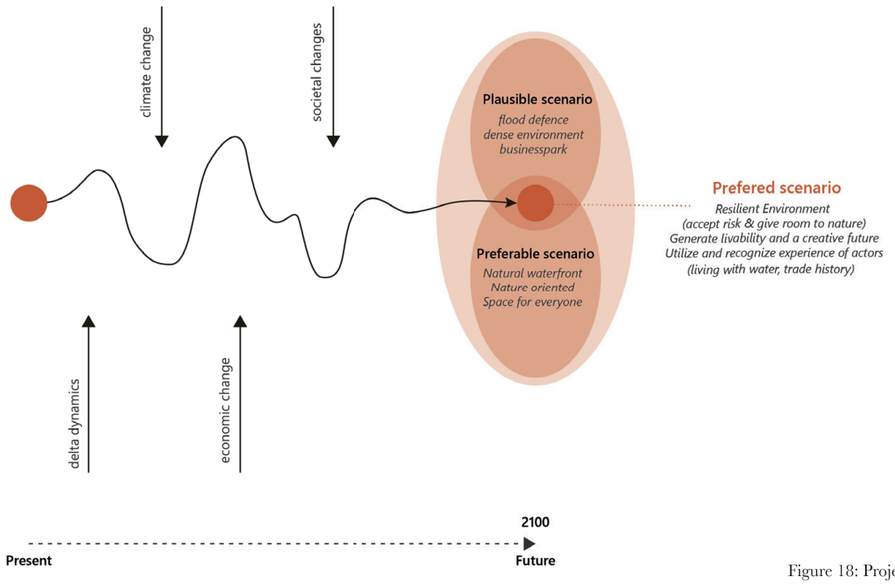



Figure 18: Project aim / *Author*

## Research objective and questions

Leading from the Problematization and Research aim the main research question that is ought to be answered is:

**How can *post-industrial port areas* and project site be *transformed* and used as a catalyst for *sustainable development* to become *resilient to flood risk* and part of an *adaptive delta system*?**

To fully be able to answer this question different steps and objectives are in need to be taken:

- Familiarization within the existing problem area and the application of knowledge and methods on the topic gained in previous research.

- Orientation in the range of existing projects and their approaches and methods regarding the studied problem field.

- To analyze the site-specific trends and problems of the processing area.

- Exploring design options of the site to find solutions and compare them.

- Reflecting on the process and design to test the potential for transferability.

In that progress the following sub questions are supposed to be answered. In doing so they will help create a better understanding and identification of the bigger system and support creating a concept guide to a multi-scalar operationalization (see figure 19).

**SQ 1:** What are the vulnerabilities and transformation challenges in post-industrial port locations along the Meuse and what are their effects?

**SQ 2:** How did the Region of Rotterdam deal with the flood risk and urbanisation process until now and what are the current trends?

**SQ 3:** What are methods and solutions that have been carried out in recent years and to what extent have these transformations contributed to sustainable and climate-adaptive urban development?

**SQ 4:** What are climate adaptation measures, that can be used in the transformation of Merwe-Vierhavens towards a sustainable development?

**SQ 5:** How can the sustainable development of Merwe-Vierhavens translated to principles for planning, design, and decision-making on other locations along the Nieuwe Maas?

## Intended outcomes

These research questions will guide the way through the research, which is defined in two general dimensions, the theoretical or research based, as well as the design dimension, and set certain milestones. In doing so, they will also help to achieve the following objectives:

1. A greater understanding of the dutch watermanagement in the context of southern delta and the effects it had and still has on it. This includes past, current, and future trends.

2. Selection of different methods to achive a more resilient environment in which it is possible to live with floods.

3. A strategy that can help Merwe-Vierhavens lead to a more stable delta and livable environment

4. An extensive and adaptive Desingproposal which will lead to a sustainable development.

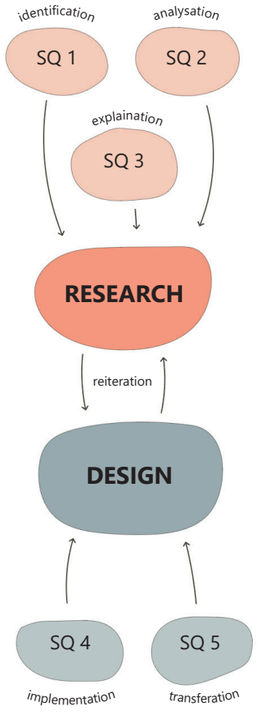



Figure 19: Dimensions of the thesis / *Author*

## Conceptual framework

The increasing vulnerability of the population in the Dutch Delta regarding floods shows that the previous measures and processes are no longer up to date and need to be changed. For this, a new approach is needed that brings together the social, ecological/natural, and physical built systems. The findings of the work so far suggest that this can be achieved with the help of adaptive (urban) planning. So far, in the urban context, the transformation of post-industrial port areas has mostly involved "hard" measures for flood protection and have often served only for urban expansion. The aim of this work is to explore how the ecosystem-based approach can be combined with the densification of the urban landscape.

Figure 20 represents the conceptual framework. It consists of three parts. First, the challenge, which in this work is the increased flood risk, especially for the offshore area. This is amplified by the external and incalculable influence of climate change. In addition, it is also amplified by anthropogenic processes such as urbanization in risk areas, which is related to the industrial transformation and partly to the previous water management, which led to a paradox. The second aspect of the framework concerns the possible solution to the challenge. With the help of adaptive design, the possibility is established to adequately anticipate and address coming changes in the environment and society. Thus a symbiosis between land and water can be created and eco-services as well as the sensitivity of the population to the issue can be strengthened. This leads to increased capacity and flexibility of the area. When these aspects are combined, there is the potential to achieve (urban) resilience and reduce vulnerability. This will be manifested in the sustainable design.

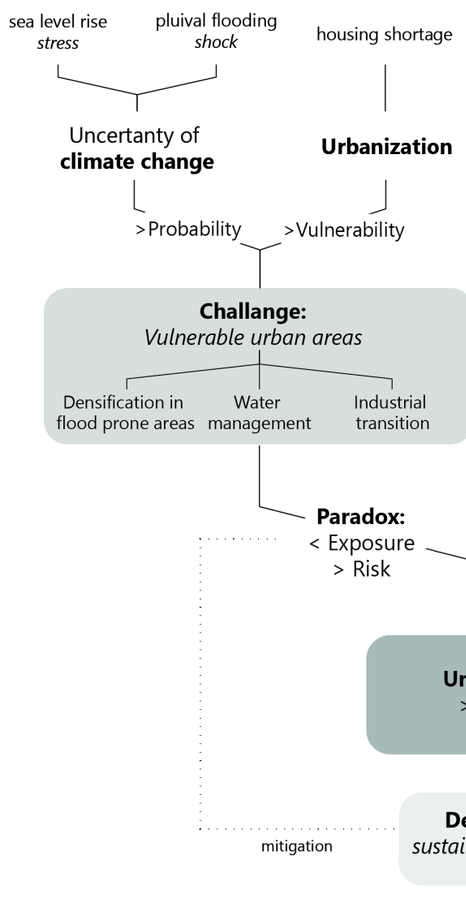



Figure 20: Conceptual framework / *Author*

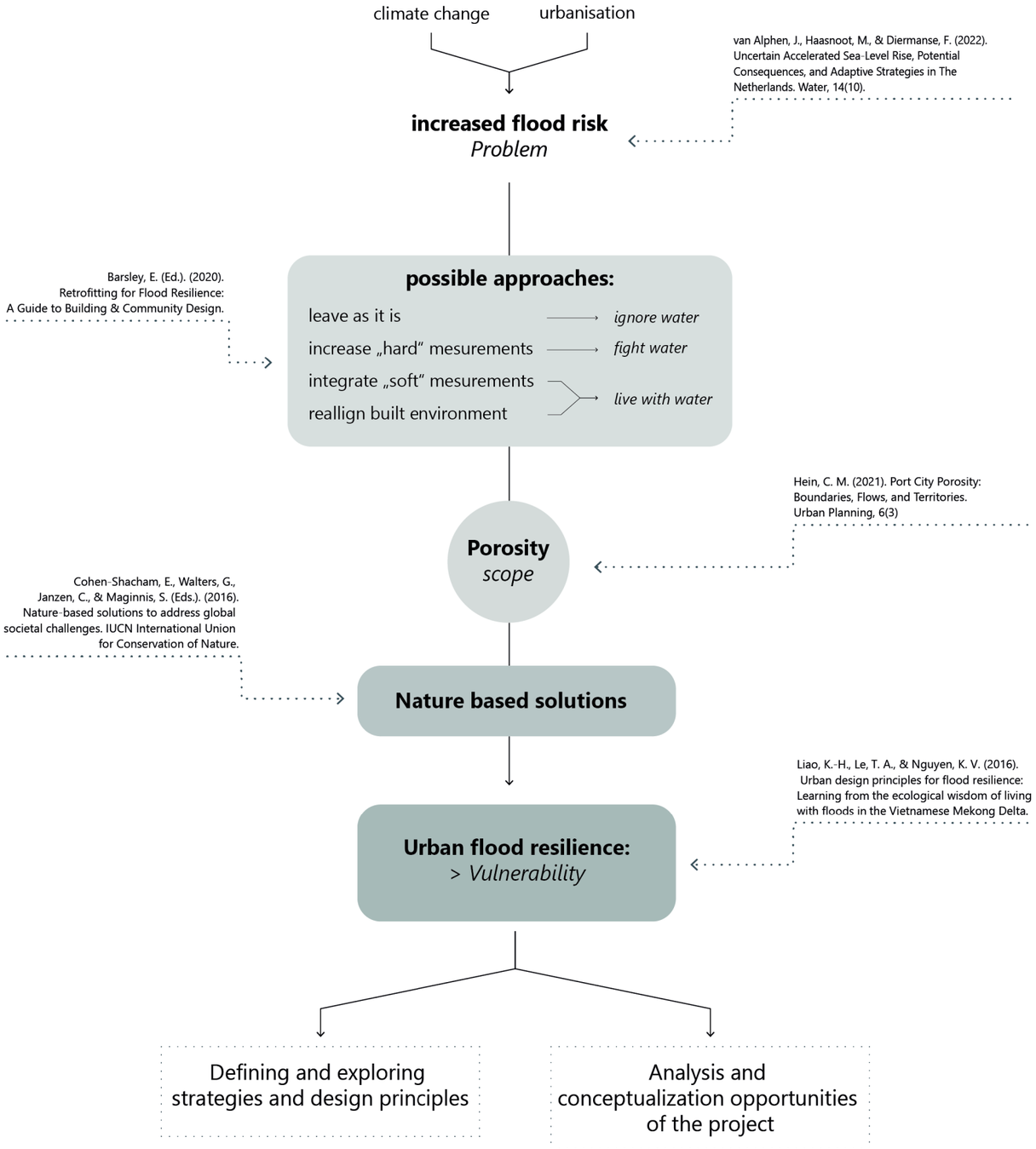



Figure 21: Theoretical framework / *Author*

# Theoretical framework

*There are various approaches on addressing the earlier mentioned problems. Therefore, the theoretical Framework (see figure 21), which is presented in this chapter, provides and basic understanding and outlines the main theories and concepts that are relevant to the topic of this research. It begins by clarifying and briefly outlining basic processes and concepts that are part of the conceptual framework and important for achieving the goal. Then the two main approaches are examined and explained in more detail. The first is going a bit deeper into the goal definition which is flood resilience and visualizing different approaches in doing so, and the second is the solution approach and scope to deal with the defined problem and conceptualize it.*

## Related theories

This section briefly outlines themes and theories associated with the theme that continues to emerge in this thesis and in the Region. These possible planning strategies are regarding the condition and risk it is currently under considering the climate crisis and housing crisis and include vulnerability, adaptation, and resilience.

### Vulnerability

The challenges outlined in the problem statement are addressed differently everywhere. There is no universal solution, because each culture is shaped differently, behaves differently, and has a different vision. Accordingly, one must pay close attention to the relationship of the human environment to the natural environment. (W. Adger et al., 2013) Particular consideration must be paid to the vulnerability of those involved. Vulnerability describes the sensitivity to damage triggered by external disturbances, through ecological or social changes, on a system. It increases as soon as a system has a higher exposure and is at a higher risk, but especially as soon as it lacks adaptive capacity to possible disturbances and changes. Vulnerabilities are generated from site-specific biophysical, social, and cultural characteristics. (W. N. Adger, 2006) There are several ways to plan for increased vulnerability. Adaptation and resilience are two of the most common means of doing so.

### Adaptation

The adaptability of the human environment to changing conditions, such as climate change, defines the vulnerability of a community. There are many different research papers and studies on the subject. Originally, the term comes from the field of biology and describes the behavioral ability and survival mechanism of an organism to adjust to changes in the environment. (Smit & Wandel, 2006) Applied to the built environment, it has a similar meaning. It is considered a possible response to the potential negative impacts of climate change by allowing the both the environmental and anthropogenic systems to accommodate. Although the term has only become more common in recent years, the concept of flexibility in planning is not new. It allows the system to respond to changes over time. The concept is used in all different scales and became one of the main strategies of the IPCC to deal with the climate change. (Dhar & Khirfan, 2017)

### Resilience

Adaptative capacities are often named in the same context and plays a key role in the resilience of a system but has a stronger focus on human induced climate change. Resilience describes a socio-ecological system that can react flexibly to different and unforeseen circumstances and outlast them. Accordingly, it is not rigid, but leaves room for different innovations and new influences. A resilient system is capable of organizing itself and responding to and absorbing stress and disturbances without becoming unbalanced and undergoing major changes in a short time frame. (Dhar & Khirfan, 2017) In this way, it differs from conventional planning, which tends to be seen as static, and can only respond a certain degree to specific and projected events. However, the unpredictability of the future, especially in times of climate crisis, a much more dynamic approach is need-

ed that can respond to and embrace the complexity of the urban context. This has led to the paradigm shift to resilience-oriented planning, which is now used in many processes such as participation, strategy development and empowerment. Although this concept is still relatively new, it has been applied increasingly in the field of urban planning for several years now. Not only there, but is also used in the fields of e.g., engineering and ecology. Initially, its origin is in the domain of psychology. (Sharifi & Yamagata, 2018)

In summary, in order to be able to manage the high vulnerability of the delta especially in urba-nized and increasingly populated areas outside of primary dike protection, a change in planning needs to occur. One that creates a resilient system which is able to continuously respond to small and large alterations and to reduce hazards by means of an increased adaptive capacity and to quickly regain a functioning and balanced condition after disturbances.

## (Urban) flood resilience

The importance of resilience and adaptation in relation to climate change has already been made clear. For each sub-theme of flooding, however, this looks different. Accordingly, for this thesis and the study area of Merwe-Vierhavens, which is directly adjacent to water, it is important to take a closer look at resilience in relation to (urban) floods.

The urbanization process along water veins and rivers, which entails stream alteration and soil compaction, will not be stopped in the coming years. Therefore, it is important for planners to design environments in which it is possible to live with floods by finding long-term solutions that manage to minimize the negative impact. With the help of a resilient system, it is possible to move away from the previous planning structures, which provide a fixed framework and processes, and instead allow for more flexibility. In this way, it is possible not only to survive and adapt to the flood disaster, but also to become functional again in a short time and to learn from them. Thus, resilient flood planning in the Netherlands is not about extending the dikes and working against the water, but much more about dealing with it and mitigating the possible consequences. (Bertilsson et al., 2019; Liao, 2012)

Due to the urgency of rising flood risk globally, several frameworks have emerged in recent years that attempt to assess and conceptualize the resilience of an area. Influenced by local values and perceptions, they differ from each other. In summary, however, a resilient system should have certain characteristics:

The system should be robust and not fail directly after an alteration. Instead, it should be able to respond to problems over time. As soon as individual parts might fail, the system must be spatially and functionally diverse enough to be able to react to this, so that the failure of individual parts does not have a major impact on the large system. The multifunctional design avoids a homogeneous landscape and enhances the partnership advantage and the necessary flexibility. As already mentioned, in resilience it is important to learn from past (flood) events and thus maintain the ability to quickly identify and respond to problems. It is also important to consider the extent of the consequences and how quickly it is possible to become functional again. None of this can be accomplished without the local ecological systems. Accordingly, the blue-green infrastructures in an area must be maintained and promoted. However, it should be noted that the extent and possibility of these features are highly dependent on the specific location. (Barsley, 2020; Bertilsson et al., 2019; Liao, 2012)

The Netherlands is known for its successful water management. Its approach to flood risk in an increasingly vulnerable country has changed and evolved over the years based on new scientific findings and experience. Instead of reactive and short-term approaches, there is an increased focus on more flexible and adaptive planning and policies to increase resilience. (Yu et al., 2020)

Innovative and new planning approaches are sought for creating (urban) flood resilience. Barsley (2020) uses six basic and flexible strategies, which include different tactics and can be adapted context-specifically to the requirement and conditions, to try to summarize the large number of approaches to enhanced flood resilience within new and existing urban structures. They are not just exclusively regional policies, but also include tactics that go to the smallest scale. The strategies will be outlined in the following section to give an impression of possible solutions (see figure 21).

The **first strategy** is to try to attenuate the water masses during floods. For this purpose, artificial or natural structures can be placed in the way of the water, or the water flow can be split into different sections to reduce the speed and volume of the water. In this way, erosion can be limited or avoided altogether, infiltration can be increased, and the water level can be lowered.

In the **second strategy**, more space is given to the water body by floodable areas or additional riverbeds to help minimize the hazard of vulnerable areas. More storage capacity is created and thus the water network is relieved.

In the **third approach**, water infiltration is prevented completely. With the help of soft and hard measures, the exposure of the population and the country is reduced.

Another **strategy (4)** involves relocating sensitive structures to less vulnerable locations. This does not only have to involve land use change but can also happen vertically.

The **fifth strategy** deals with protecting the built and sensitive environment from floods by building new structures and masses. The new configuration and land use thus mitigates exposure.

The **last strategy (6)** listed by Barsley, which can also be seen as the most sustainable of the six strategies, creates an environment in which natural conditions are accepted. Here, a mixture of the previous tactics is used to best adapt to the conditions of a region. It is a flexible framework that makes it possible to take advantage of the potential of the changing (built) environment and create a diverse landscape. Among the strategies, it corresponds the most to the theory of a flood-resilient landscape presented by Liao (2016).

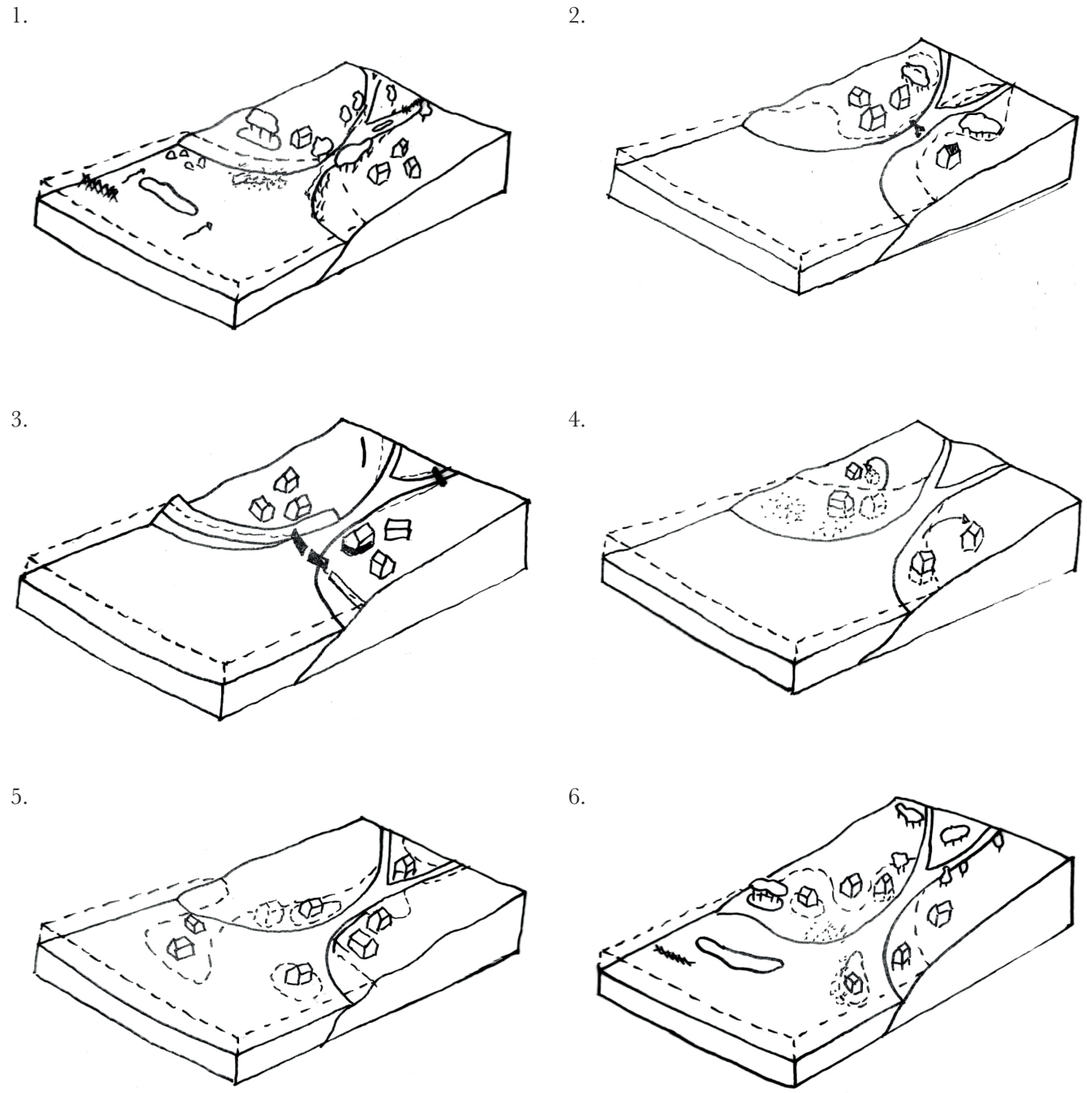



Figure 22: Six strategies to achieve (urban) flood resilience / *Based on Barsley, 2020*

## Porosity

As noted in the problem field and statement, the transition between water and land as well as port and city has historically been seen as a hard line and static boundary. However, this is outdated no longer suitable for encouraging future sustainable development. The system does not consist out of two definable entities, as Hoyle described them in 1983, but rather a large area where parts overlap, cross, and shift. Therefore, a much more long-term, multi-scalar and progressive solution is needed. To give the system the flexibility and space it needs, the concept of porosity can be introduced as one way of approaching it. The paradigm shift allows for the possibility to conceptualize the transition zone and ultimately to integrate different systems better than was the case with previous conservative planning. (Hein, 2021; Moretti, 2021)

In 1924, the German philosopher Walter Benjamin first introduced porosity in the context of cities and their urban planning. In his description of Naples, he used the metaphor of porosity to describe the spatial form and chaos of the city, which to him seemed like an unreadable labyrinth. This idea was subsequently taken up again by several planners and further developed in different thematic fields over time. (Korthals Altes et al., 2015) Among others, architect Stavros Stavrides (2007) uses the concept to describe blurred boundaries. In his approach, he tries to see the city as a collection of different dynamic processes, rather than a static unity. The (in-between) spaces that emerge when they meet represent a connection and relation rather than a boundary. Thus, it can be seen as a contrast to the clear separation of functions practiced in modernity.

With the help of the porosity in urban planning, it is possible to blur hard boundaries between entities to create a fluid and three-dimensional transition and no longer see it as a hard and simple line. To create a resilient environment, not only spatial aspects are addressed, but also socio-economic ones. Porous surfaces are not only empty spaces and gaps in the network, but also potential areas for the coexistence of different systems and self-organizing mechanisms. This removes the enclosing static frames from the dynamic urban and social context and gives it the possibility and flexibility to react to its environment. (Korthals Altes et al., 2015; Wolfrum et al., 2018)

For the waterfront and the transition from water to land, the aspect of porosity in the spatial context means the introduction of urban blue spaces. It is immensely important to include the water and put it on an equal footing with the land. Previously, this was not the case and often the waterfront transformations, which as mentioned before have been very popular worldwide since the late 20th century, took place only from the land perspective. This led to inconsistencies and made it clear that involvement is important to minimize friction between stakeholders. Porosity is defined here as the gaps and transitions between the natural elements of water and the built elements. These gaps can be used by humans and allow a direct connection. The higher the possible human flow and the directly visible connection between the two units, the higher the porosity (See figure 22). The function of these spaces can and have varied over time, for example, from a more commercial program such as a market or cultural sites to a more environmental, urban, or transportation program such as a port or pier, this is dependent on the particular needs of the users, investments, the environment as well as the history of a place. (Breś & Krosnicka, 2021)

To what extent a blue-urban waterfront may look depends on the site-specific characteristics of a place. For example, the waterfront in Nieuw Mathenesse was used for industrial harbour operations until the middle of the 20th century, which is why the water defenses were hard engineered and ecological use was not included. In Merwe-Vierhavens, although the waterfront became more porous and accessible to visitors with the construction of the new industrial area (see chapter 4.1), the planning did not go beyond the land boundary. However, in order to create a unified and rounded system, both units must be respected and integrated into the planning. (Breś & Krosnicka, 2021)

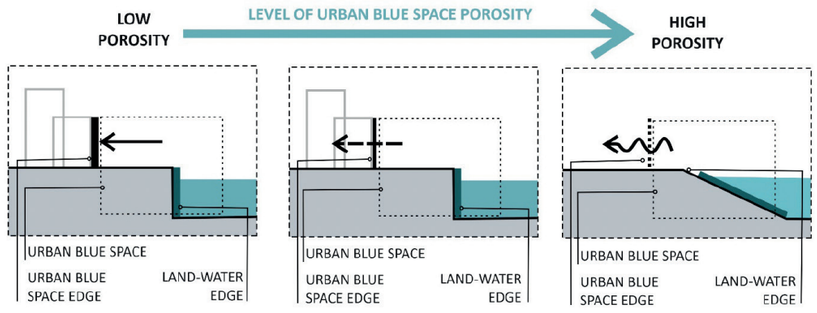



Figure 23: Types of urban blue space edge in terms of their porosity / *Breś & Krosnicka, 2021*

As already mentioned, porosity does not only have to be spatially recognizable, but can also be reflected in the functionality and on the social level. The transition and change of two different use profiles can also be described as porous. Industrial change and the departure of port operations and maritime connectivity from inner-city areas, as was the case in the Rijnmond-Drechtesteden Delta, freed up land that was slowly taken over and appropriated by new users, such as in the M4H area in Rotterdam. However, the goal pursued in many places of creating a creative quarter in the old port areas and thus enhancing the socio-cultural value of the area was rarely fully achieved and rather led to controversial outcomes, such as over-commercialization. However, the possible integration of the area with the help of the creative class offers a lot of potential and is readily accepted by both sides. Due to the complexity of the urban waterfront, it is important to maintain flexibility in the new planning of the waterfront in order to avoid an unwanted homogeneity. Especially a porous planning offers an eloquent transition of use, which manages to keep old character features and to accommodate old as well as new identities. In this way, it remains possible to attract new users without neglecting the existing ones. (Jansen et al., 2021)

All in all, the porosity approach can be used to create an improved transition at different scales. In this way, fragmentation and functional separation can be worked against, which can be seen in many places and especially in port areas outside the dikes. With regard to the waterfront, it is important to move away from the human-drawn line between units and initiate a paradigm shift. Porosity offers a lot of potential and new solutions for this.

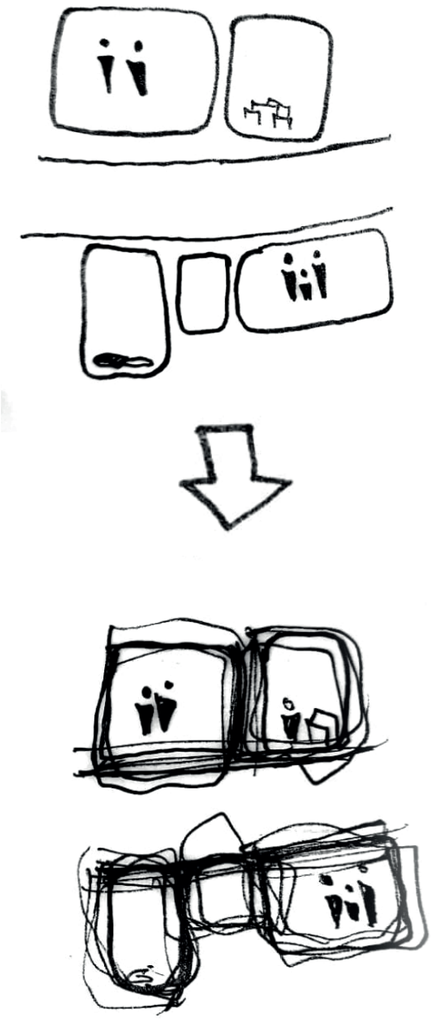


Figure 24: Porous borders as a transitional zone / *Author*

## Nature based design

The manipulation of the Dutch river and delta landscape with, for example, river straightening, damming, and draining of wetlands was intended to reduce the risk of floods and to protect the population. Although these changes have so far averted many dangers, the negative effects of the harsh measures on ecosystem structures and processes are becoming increasingly clear. Climate change will only increase the risk and add to them. To address the paradox, new approaches are now being sought. One of these is nature-based design. (Albert et al., 2022)

Nature-based measures are eco-based approaches to help adapt to the impacts of climate change. One of the most common definitions is from the International Union for the Conservation of Nature (IUCN). They describe them as "actions to protect, sustainably manage and restore natural or modified ecosystems, that address societal challenges (e.g. climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016). They offer the possibility of finding and addressing not only environmental but also societal challenges at the same time. Therefore they offer multiple benefits and the potential to promote the well-being of society by making use of eco services and processes of natural or artificial blue-green infrastructures in urban landscapes. This includes for example the regulation of urban heat islands by using vertical green and provision of green structures such as parks or trees along the street. Nature based solutions are also used to provide more floodplains and room for water to naturally infiltrate to prevent flooding. (Kabisch et al., 2017) The aim is not only to preserve nature but to shape it in a sustainable way for the coming future. In contrast to traditional planning and infrastructure, these solutions focus on large-scale measures. While the interventions may initially appear more expensive and time-consuming than traditional (hydraulic) engineering solutions, they have a long-term effect that lasts longer and are ultimately often more cost-effective. To make them as successful as possible, nature-based solutions require a combination of extensive observation, analysis, and modelling. Only in this way a site-specific and scientifically based concept can be created that is able to respond to local, natural, and cultural dynamics and find multifunctional solutions. For example, by integrating natural processes such as wind, tides or materials, designers can create flexible and above all adaptive designs. (Dumitru et al., 2020; Schröter et al., 2021; 'What Is Building with Nature ?', n.d.)

In his book, Roggema (2020) hypothesizes that the city should be seen as part of the natural landscape and that the two entities should not be separated. In his opinion, this is how they should be planned and promoted. However, this must be done in balance in order not to reinforce the already existing imbalance and to redress it. Nature-based and driven urbanism offers the opportunity to create a richer and more resilient environment. It provides a robust socio-ecological basis for further future planning. It is important to respect and integrate nature and its systems and processes. The aim is to work with nature rather than against it. Nature is used as the basis and heart for urban and infrastructural developments in planning and can accordingly determine the spatial quality and form and is responsible for its functions.

Figure 25: Nature driven urban design / *Author*

# Methodology

*This chapter addresses the methodological approach of this research. It aims to create an understanding of how and when to achieve the previously explained set objectives and answer the research question(s).*

**Mega scale**
Rijnmond-Drechtsteden

**Macro scale**
City of Schiedam and Rotterdam

**Micro scale**
Nieuw Mathenesse and M4H

**Nano scale**
Nieuwe Maas

Figure 22: Definition of the examined scales / *Author*

## Project scales

The project location Merwe-Vierhavens in Schiedam and Rotterdam is part of a bigger delta system. Any alterations to this system entail significant consequences for the greater picture, affecting not only the adjacent urban context, but also regional conditions and, in particular, the broader riverine ecological system and thus the delta. This on the other hand also an effect on the smaller systems in it as well as the in the project area. Accordingly, this work uses a multiscale approach divided into four scales: the Rhine-Meuse Delta region (Mega), the urban network of Schiedam and Rotterdam (Macro) and especially the outer dike area and project site of Merwe-Vierhavens (Micro), as well as smaller detailed individual areas of the design along the waterfront such as Nieuwe Maas (Nano) (See figure 22). This helps also to include the entire landscape system and not to be limited to municipal boundaries. The circumstances of the different scales will be put in relation to the project location and reflected.

### Macro scale

The most extensive scale deals with the large delta system of the Rhine-Meuse Delta, especially with the Rijnmond-Drechtsteden region, which is located in South Holland and is the most urban part of the delta. Especially the ecological and water system are considered and what influence the human changes and prominent industrial port use had and will have. This scale is mainly represented in the theoretical and analytical part and will influence the design. It represents a more abstract level for strategy development and provides a basis and framework for design. However, due to the complexity of the topic and unpredictability of the future flow system, the elaboration will remain rather schematic and will not be dealt with in depth in the design, but rather show the potentials and the influence on the overall system.

### Meso scale

Ecosystems do not know municipal boundaries, so this study will focus on both Rotterdam and Schiedam. The connection between the two cities is particularly important because the study area Merwe-Vierhaven stretches across the official borders of the two cities. Here, not only the ecological context is important, but also the urban and historical context. It is clarified which role the area plays and has played in the urban context of the historic port city. This scale is also primarily represented in the analysis and theory.

### Micro scale

The micro scale, which consists of the outer dike area Merwe-Vierhavens and in particular its riverfront. It is here that the main part of the design will be located. Here the new design will be both integrated and examined for its impact on the built environment, users, and water management. The goal is to implement and spatially shape the previously conceptual ideas.

### Nano scale

The smallest scale in this research is the nano scale, which deals with design details. It is almost on an architectural level and illustrates more precisely the effects on the different actors, connections, and processes. This should make it easier for decision makers and stakeholders to develop an awareness of the design, its values and, above all, the function and importance of the climatic adaptations and possible synergies.

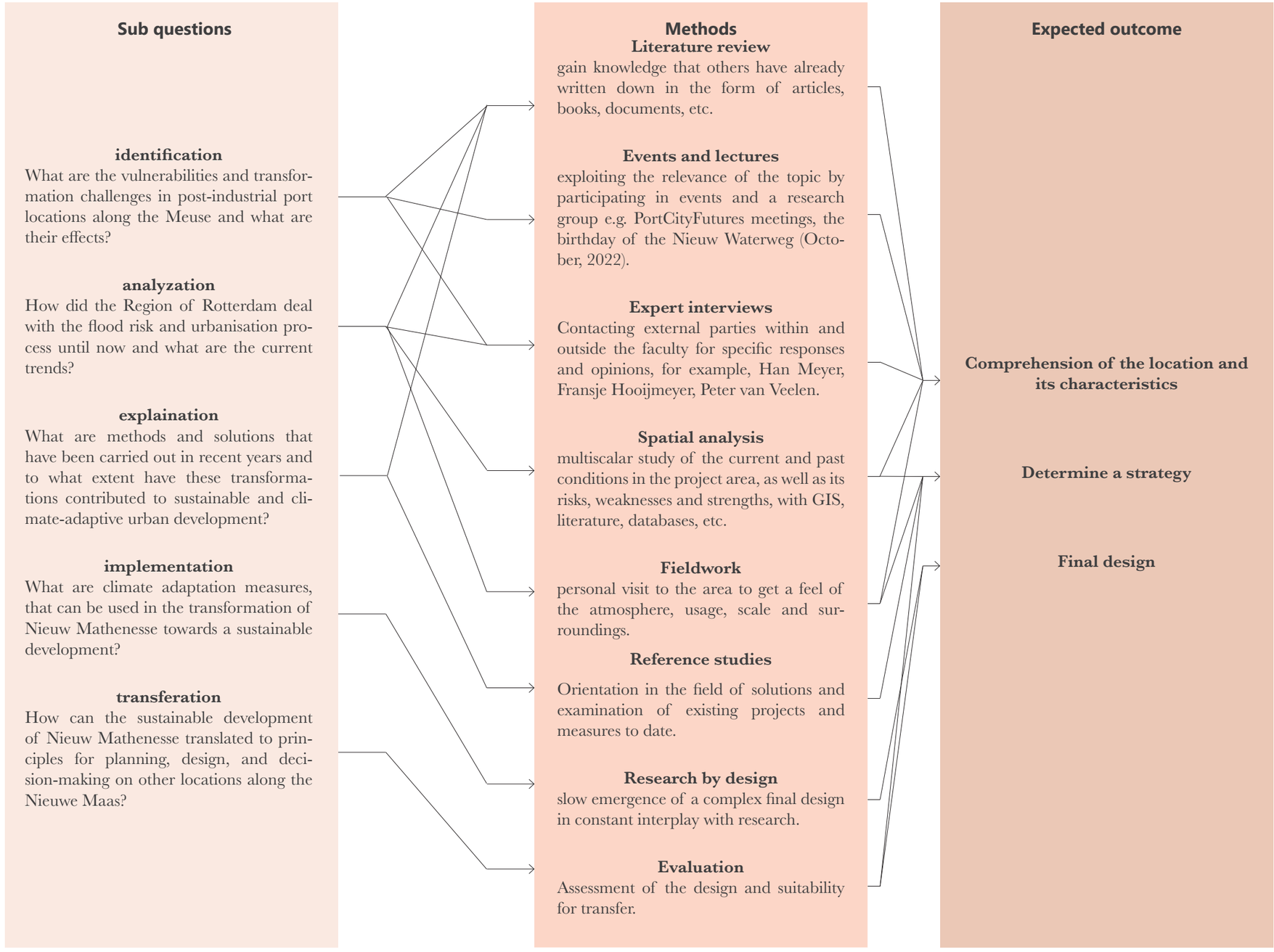
Together, the different scales will create a sustainable and rounded project that does not function in isolation but is reflected and integrated into the larger system.

## Analytical frame work

In this work, different methodologies were applied to help answer the research questions and achieve the objective of the work. These are as follows:

1. literature review
2. events and lectures
3. expert interviews
4. spatial analysis
5. fieldwork
6. reference studies
7. research by design
8. evaluation

The analytical framework on the right shows in more detail what these methods should include and to what extent they are related to the sub-questions and the desired results. This provides an overview of the work and its content. However, the methods do not follow a linear progression as presented in this report, but are intended to be applied in alternation with each other, thus constantly influencing and reflecting on each other. In this way, a coherent content and final design is to be created.



# 3 revision

This chapter deals with the present spatial implementation and explores historical and current technologies. For this purpose, part of the reference studies are presented and tested for the knowledge extracted from the literature. This is intended to provide an orientation as to which methods can be implemented and how, and what effects this entails. Based on this, a typology catalog for climate-adaptive measures in outer dike areas is presented, which was prepared with the help of the previous literature and especially the references.

Reference study

- Residential transformation
- Ecological transformation
- Landscape transformation

Adaption strategies

Figure 26: Port of Hamburg with HafenCity in the Backround / *Creative Commons CC0*

Figure 27: Location of different reference studies / *Author*

# Reference study

*As mentioned before, waterfront development is not a new concept and has been implemented in many ways around the world. With the help of this section, a ground knowledge for more specific techniques for urban flood adaptation will be created. By taking a closer look at reference examples of previous port transformations, implemented or still in the planning stage, the aim is to identify what is outdated, what does not work, what offers potential or what can be replicated.*

## Choice

The case studies were selected based on their handling of the previous port area and their approach to flood adaptation:

*Residential - Hamburg HafenCity*
*Ecological - De Ceuvel*
*Landscape - Tidal park Rotterdam*

Each of them is analyzed and considered using the following approach:

| | |
|---|---|
| Test | Review of the reference study by the ambitions of a climate adaptive an resilient neighbourhood in relation to floods |
| Scope | Investigate conditions and im plementation measures to reivitalise the area |
| Flood management | Understand how the area has been activated and responds to natural conditions |
| Consideration | Assess the (dis-) advantages of the design in order to be able to apply the successfull measurements |

## Test categories

**Increase Biodiversity**
Enhancement of existing habitats and re-establishment of local species to strengthen the delta ecosystem.

**Placemaking**
Attract visitors and new entrepreneurs to become an example of success for similar areas.

**Flood protection**
Risk reduction through sufficient flood protection for the population and landholdings.

**Raising awareness**
Reconnecting the population with water by making it tangible and enjoyable to also gain knowledge.

**Reducing damage**
Easy recovery after floods due to adaptive development, which works with the water and does not suffer any great damage.

**Eco services**
benefit from eco-services, such as infiltration, to create natural flood protection.

## HafenCity

*Urban transformation*

The HafenCity inner-city urban development project is currently the largest in Europe. The new district is outside the city's dikes and surrounded by river and canal courses. The plan, which was drawn up in 2000 and has been revised several times since then, provides housing for 12,000 people and around 40,000 jobs. The project was made possible by the relocation of the previous port and container handling area to the west of the city and the resulting large-scale acquisition of brownfield land from the city. The plan has since been implemented successively from west to east and from north to south and is scheduled for completion in 2030. (KCAP, n.d.)

| | |
|---|---|
| Location: | Hamburg |
| Status: | Ongoing |
| Design: | KCAP, ASTOC Architects and planners |
| Scale: | ca.150 ha |
| Function: | Mixed use spaces |

Figure 28: View over HafenCity / *KCAP*

### Flood management

As already mentioned, the HafenCity area is not diked, despite the increased risk of flooding, and has a very close interaction of land and water. The flood protection concept draws from the waft model and is designed in three dimensions. The public space consisting of quay and waterfront promenades as well as jetties and squares are on the lowest level. This can be flooded without causing major damage and has been built "waterproof". The rest of the area has been raised to about 8-9 m above sea level. Thus, the larger infrastructure and buildings are better protected from the floodwater and the area gets its maritime character through the special urban typography and preservation of historic harbour structures. In addition, parts of the area have additional routes on another level. Buildings are connected on the second floor by bridges and walkways, making it possible to safely exit the area in case of extreme flooding or giving rescue teams further access. (KCAP, n.d.; Serre et al., 2018)

Test


Figure 29: Flood management in HafenCity / *Serre et al., 2018*


Figure 30: Masterplan of Hamburg HafenCity / *KCAP*

### Scope

A lively and mixed district with flats, shops, parks and promenades, offices, kindergartens, schools, leisure, and tourism facilities were planned, divided into different quarters. The varied architecture also reflected this mixture and liveliness.

The area is designed for low traffic use and places greater emphasis on the public area for recreational uses. The links connect to the neighboring and historic "Speicherstadt" and create a close connection with it.

The corners of the area are defined by monumental, architectural buildings that form a frame. The Elbphilharmonie Concert Hall at the forefront of the area, visible from many vantage points in the city and especially from the water, is the activator of the area and its main attraction. (Hafencity, n.d.)

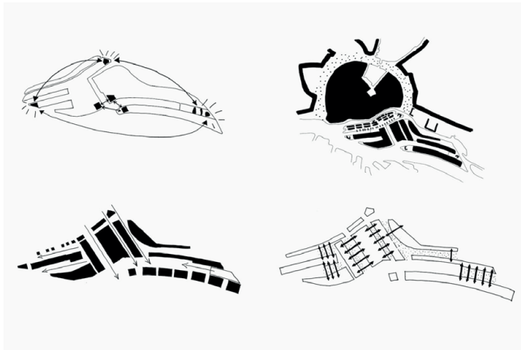


Figure 31: Concept sketches / *KCAP*

Figure 32: Recreational use of the water front / *KCAP*

### Consideration

**Pro**

high ecological value

integration of natural environment

**Con**

giving up urban area, needed densification

## De Ceuvel

*Ecological transformation*

The abandoned former shipyard area of De Ceuvel Volharding in the industrial harbour area of Buiksloterham in Amsterdam Noord has been transformed into a forward-looking and creative hub for young entrepreneurs. In the award-winning sustainable concept, the heavily polluted surface is to be cleaned using simple and natural techniques to restore it and the water to a usable condition. During the cleaning process, which is targeted to last 10 years, old houseboats are placed in the park area, providing space for different workspaces and studios, connected by wooden walkways. After the treatment the area is meant to be given back to the municipality of Amsterdam. (Space&Matter, n.d.)

| | |
|---|---|
| Location: | Amsterdam |
| Status: | Completed |
| Design: | Space and Matter, DELVA |
| | Landscape Architects |
| Scale: | 0,4 ha |
| Function: | Business & creative HUB |

Figure 33: Bird's view on De Ceuvel / *Space&Matter*

### Scope

The design process and establishment of the circular business park took place in close collaboration with specialists, researchers as well as the future community consisting of entrepreneurs and artists.

Using the so-called phytoremediation technique, a sustainable and cost-effective alternative cleaning method is applied in the "forbidden park" of De Ceuvel, in which plants absorb, stabilize, or remove the high concentration of pollutants from the soil to make a later use of the area possible.

The temporary project focuses on flexibility and reuse. While the wasteland and waste materials are converted into valuable resources, the retrofitted houseboats, which would otherwise be demolished, are intended to allow for time-limited use of the area. These relate to the surrounding harbour structures and can be easily removed at the end of the project without impacting the landscape. (De Ceuvel, n.d.; Delva, 2018)

Test

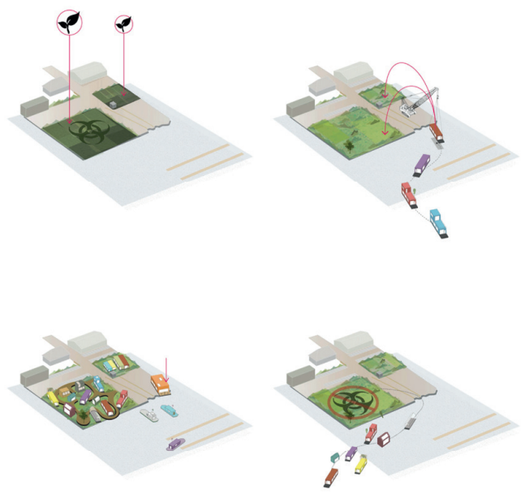


Figure 34: Strategic land recycling and purification plan / *Space&Matter*

Figure 35: Design vision De Ceuvel (Delva)

### Flood management

The design does not directly build on the ground. It consists of partially floating buildings as well as old houseboats standing on wooden piles and wooden jetties that can be used like amphibious structures. They are hybrid and stand on the land during dry season, but are „waterproof" could float on the high water when floods occur. In addition, the park landscape consists entirely of open surface that allows the water to percolate and gives the Ij more space before it endangers the built structures.

### Consideration

**Pro**

cost efficient purification of area

hybrid environment

**Con**

temporal

small scale

Figure 36: Wooden footbridges as path connection through purification park / *Delva*

Figure 37: Old and reused house boats placed on contaminated soil as small studio spaces / *Space&Matter*


Figure 38: Board walks above purification park / *Space&Matter*

## Tidal park Rotterdam

*Landscape transformation*

Rotterdam has set itself the goal of increasing the vegetation in the city and making the banks more open. Through "the river as a tidal park" a program was created in which possibilities are sought to locate different locations that make it possible to give the Meuse more space and to integrate the tides of the river into the city in order to make it possible to experience them. The design was adapted and further developed by the City of Rotterdam and the Province as well as the Ministry of Infrastructure and Environment, but also by the Port Authority as well as the Deltaprogramma Rijmond Drechtsteden and now facilitates multiple projects along the river. (De Urbanisten, 2017)

| | |
|---|---|
| Location: | Rotterdam |
| Status: | Explorative study |
| Design: | De Urbanisten |
| Scale: | n.d. |
| Function: | recreational park landscape |

Figure 39: Impression of Tidal park in Rotterdam as a recreational area for residents and habitat for different species / *De Urbanisten*

### Scope

The concept contributes to the regeneration of the Delta ecosystem. It creates a new and unique habitat by establishing and expanding the room for diverse and endangered local species. (ARK Natuurontwikkeling, n.d.)

The project includes a close and intensive cooperation between planners, communities, researchers and different stakeholders through different information evenings and workshops. This is to guarantee that the resulting project proposals and concepts are all-inclusive, sustainable, and equitable.

It is a large-scale program in which the different parks house various functions, be it recreational, natural, or educational. A green connection will be created along the river, creating a softer transition between the city and the waterscape. (Gemeente Rotterdam, 2018)

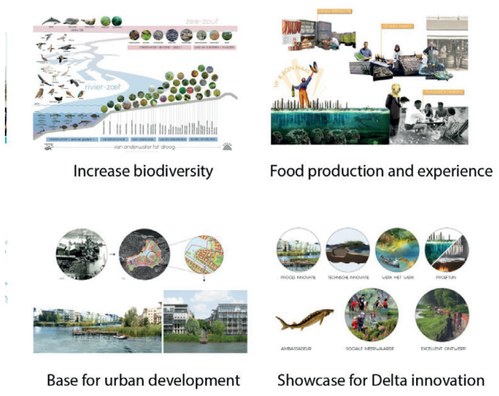



Figure 40: Opportunities and goals of the Tidal park program / *De Urbanisten*

Figure 41: Study Tidal park Brienenoord - De Esch / *De Urbanisten*

### Flood management

The flood protection of the built environment is strengthened by giving more space to the river and its natural tides. Even during floods, a margin to the dikes is maintained, increasing their capacity, and supporting them in their essential function for the subsided surrounding land. The softer shores break the waves of the ships and the tides and by allowing the excess water to percolate on the open and slow-sloping banks rather than overflowing the dikes and endangering millions of people. (Gemeente Rotterdam, n.d., 2018)

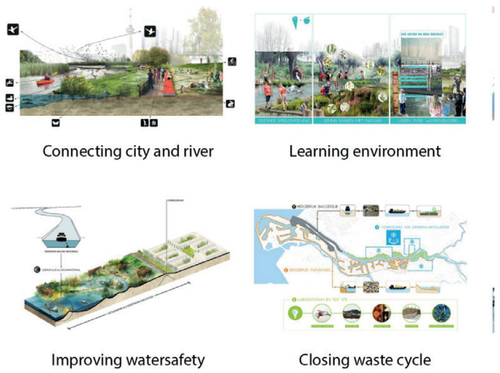



Figure 42: Goals of the Tidal park program / *De Urbanisten*

### Consideration

**Pro**

cost efficient purification of area
hybrid environment
maintaining of port identity
connection to surrounding neighborhood

**Con**

low ecological value
high price range

### Test

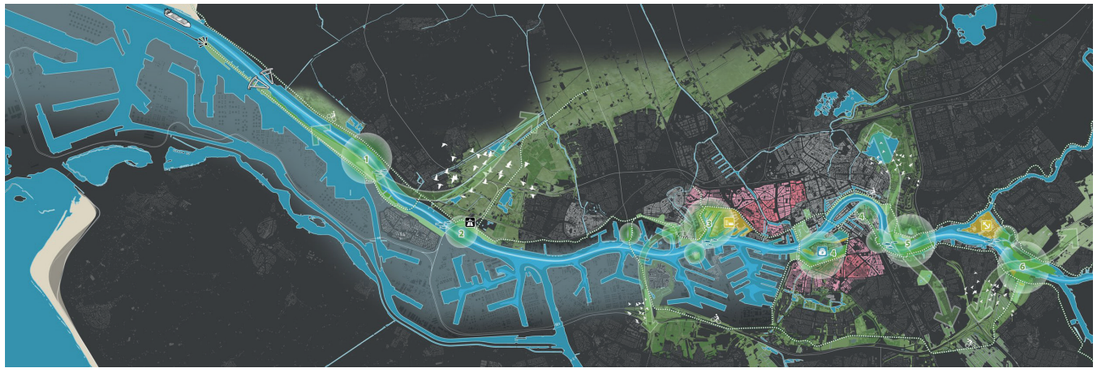
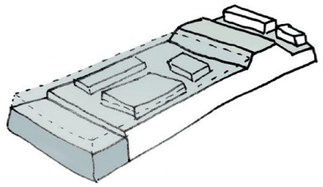
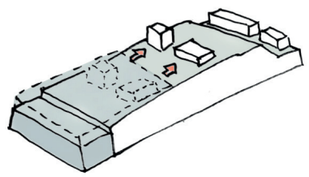


Figure 43: Different location form a regional connection and park / *De Urbanisten*

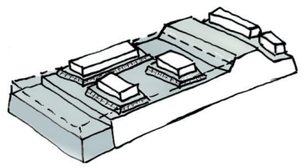
Existing situation



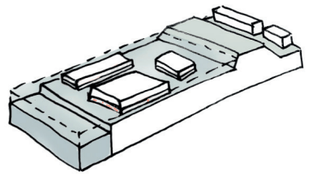
## Climate adaptive buildings



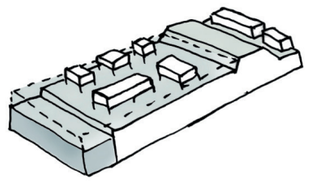
**Temporary building**
Building can be relocated or removed if needed.



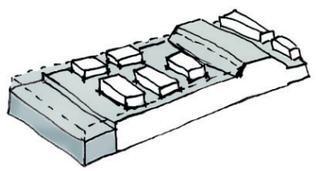
**Raised building**
Parts of the landscape are raised to protect properties and important infrastructure,



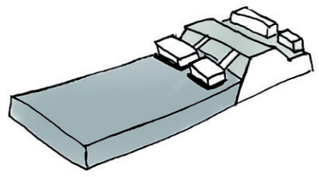
**Floodproofed building**
Building resricts water from entering (dry proof) or are recoverable from flood consequences (wet proof).



**Elevated building**
Building is safe from floods and give space for water & vegetation below them.

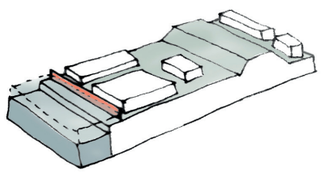


**Amphibic building**
Building is flexible. It rests on a platform on groundlevel but can be temporal vertically adjusted and lifted by higher water.

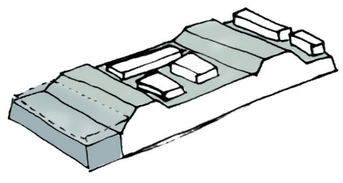


**Floating building**
Building is detached from surface and can therefore adjust to the tides and water.

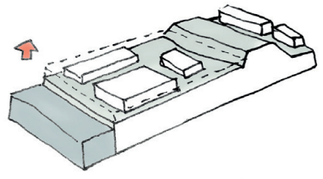
## Climate adaptive public space



**Flexible water defence**
Flexible structure that can be used and put in place if needed.

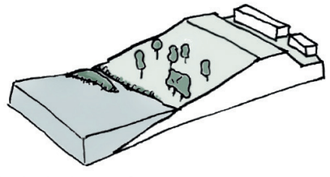


**Multifunctional dike**
A dike is often used to protect the lowlying hinterland. It can offer more functions than just protection, e.g. recreation, infrastructure, etc.

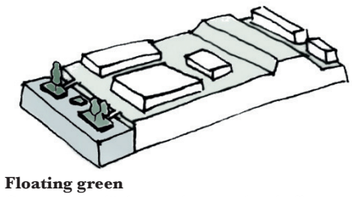


**Elevation of terrain**
Raising the ground level of the area to protect against high water levels.

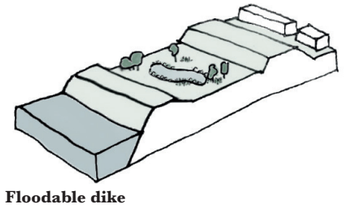
## Climate adaptive green



**Ecological waterfront**
A slow slope to water giving space for river if needed and offers a habitat for different local species.



**Floating green**
Greeen "island" that can be moved and offers multifunctional use. It adds ecological value to river and breaks waves to protect the shoreline.



**Floodable dike**
2 dikes behind each other with wetland inbetween that can be used for water regulation and alleviates the strain on the main dike system.

Figure 44: Possible adaptive implications to achieve a better flood protection in the area / *Author*

# Adaption practices

*As a result of the literature review as well as the detailed examination of existing and planned reference examples described in the chapter before, climate adaptive measures could be identified that represent possible solutions for building in the flood risk area in the Nieuw Mathenesse study area. These are shown on the left (see figure 44) and have been divided into three subcategories: climate adaptive buildings, climate adaptive public space and climate adaptive green. This is shortly described in more detail in the text below. They provide a basis for the upcoming chapter, which deals with the conceptual approach and site-specific design proposal.*

### climate adaptive buildings

In order to protect the personal property of the inhabitants, the buildings itself can adapt and adjust to the water. This can work in different ways. Either buildings are waterproofed and therefore resistant to floods, or they are constructed in such a way that water is allowed to enter but does not cause permanent and major damage, so that the property is able to recover from floods. Another option is to build buildings that are adaptable and minimize exposure by working with water. For example, they can float on the water or move horizontally. These measures can be implemented both in existing buildings and in new buildings.

### climate adaptive public space

Public space could also be adapted to the floods. However, these measures are largely hard-engineered defenses that are already widely used in the Netherlands and globally. Either protection can be provided by temporary or permanent (e.g., dam or dike) structures. Another possible measure is to increase the height of the complete outer dike area, as has been done in the HafenCity, to reduce the risk. However, the measures mentioned here should be combined with others, otherwise the current criticized planning will continue and will not be a long-term solution.

### climate adaptive green

Strengthening the ecological environment offers many benefits to the urban fabric and can provide natural protection from flooding. In doing so, the city gets a sponge function, which can also be seen as vertical porosity. The river is given more space by providing floodable areas along the riverfront where water can infiltrate naturally. Floating greenery can also mitigate storm damage. However, these interventions are very profound in the existing structures and can be expensive, but worthwhile in the longer term.

# 4

# implication

This chapter will be the main part of the thesis. Here, after an in-depth analysis of the project area, the main site-specific challenges and systems will be identified. This is followed by the design vision and the concept coming from that. The phases and technologies associated with and required for this are then explained. At the end, the chapter is concluded with the site-specific design proposal.

- The project area
- Vision
- Spatial concept
- Phasing
- Design catalogue
- Projection

Figure 45: Remains of the sandbank at the Quarantaine-Terrein in Rotterdam */ Author*

# The project area

*One of the densification and transformation areas decided by the municipalities (See figure 6), which shows a high vulnerability to floods, is Nieuw Mathenesse part of Merwe-Vierhavens in Rotterdam and Schiedam. In the next chapter, a preliminary analysis of the area is presented. Here, the current challenges for Nieuw Mathenesse are elaborated. Special attention is given to the area outside the dikes of the Nieuwe Waterweg and along the waterfront of Merwe-Vierhavens. Based on the analysis, a preliminary conclusion is drawn that shows the main challenges of the area.*

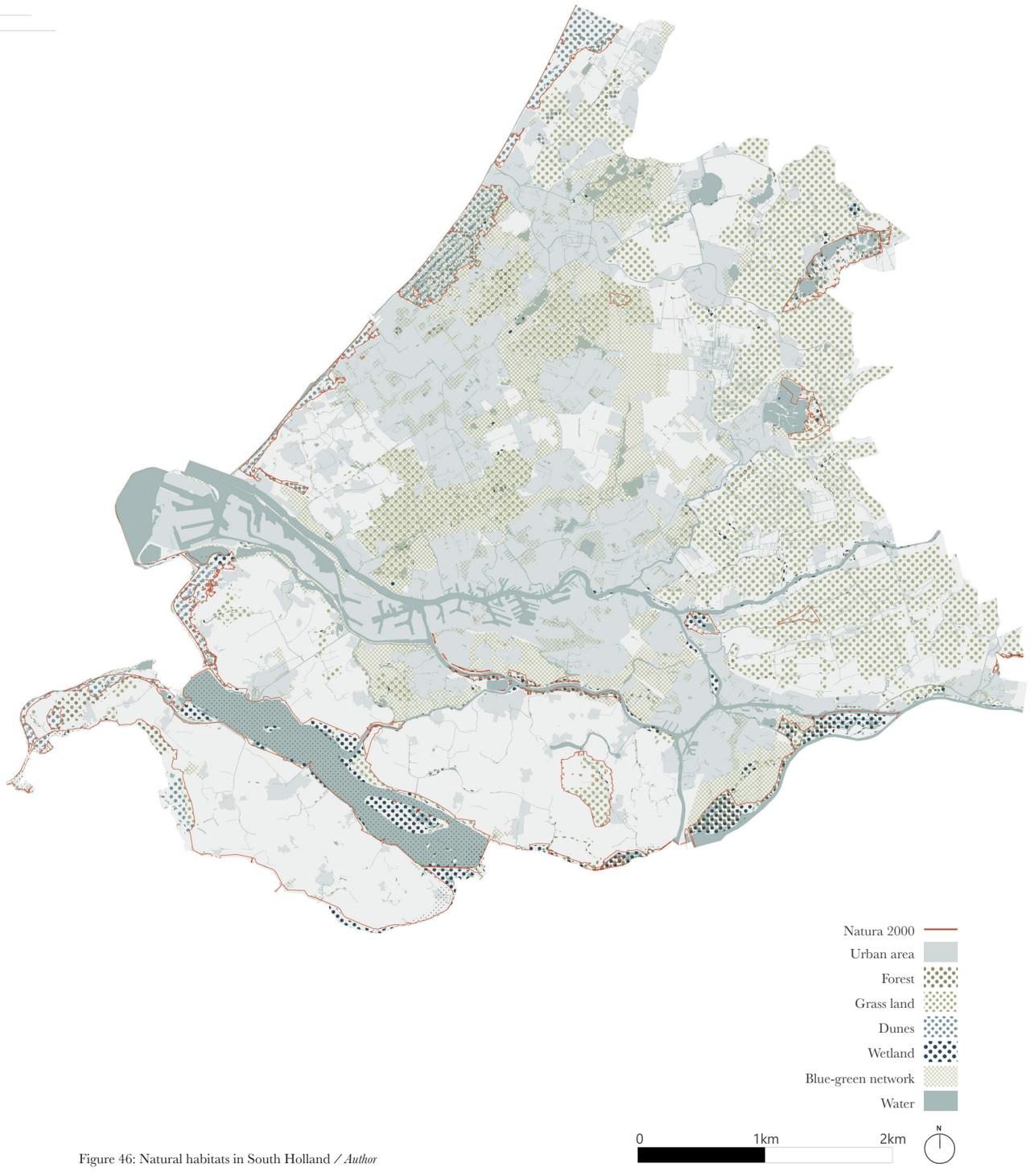



Figure 46: Natural habitats in South Holland / *Author*

## Blue-green network in South Holland

The south of South Holland is strongly influenced by the Rhine-Meuse estuary. It forms the transition from the large freshwater rivers to the salty sea and is therefore under the influence of the tides. Originally, the entire area was formed by the dynamic interplay between sedimentation and erosion of sand and silt and consisted of stream systems, (salt) marshes and floodplains. These were defined by the fluctuating flow velocities of the rivers. The complex and dynamic system provided an adaptive landscape that grew naturally with the sea level and was constantly changing. (Kater et al., 2012; Palmboom, 1995)

The resulting fertile soil provided an ideal basis for agriculture and is the reason for the extensive human settlement along the riverfront. In the course of the past centuries, as already mentioned, the river and delta system has been manipulated and transformed to such an extent that only a small fraction of the natural landscape forms are represented in the current landscape profile. This urbanization of the river was particularly strong in the Rotterdam region. The New Waterway was built to make it possible for (container) ships to enter the Port of Rotterdam, and as a result the formerly natural Merwede River is now largely canalized. Therefore, gentle water edges were transformed into hard quays for industrial activities, ports and residential areas (Stikvoort et al., 2002). Today, as a result of these previous planning paradigms, a high percentage of the river embankment along the Nieuwe Waterweg now consists of hard, often paved and steep quays, which have not only led to a degradation of nature and destabilization of the system but are also often inaccessible and unattractive for local residents. (Paalvast, 2014)

How the riverbed has developed as a result of human manipulation and what effects this has had on the surrounding nature can be seen in the illustration of figure 45. Only a few remnants of the original river landscape can still be recognized today. These include, for example, the river island of Brienenoord, or, especially in the southern part of the Delta, tidal rivers with islands as far as the Merwedes and the lower reaches of the Lek, Maas and Waal. (Kater et al., 2012)

When looking at the regional level, it becomes apparent that the protected and larger natural areas in the Delta are mainly located in the southern part of the estuary, along the arms of the river. An exception to this is the mouth of the Nieuwe Waterweg, which is because of the port usage and related high urban development. Due to the construction and continuous manipulation of the channel, a large part of the river's natural characteristics and thus its function as a habitat for flora and fauna has been lost. This is of concern since the Nieuwe Waterweg is open to the sea and is affected by changes in it and plays a big part of the global migratory system. (Internationaal Symposium: 150 jaar Nieuwe Waterweg)

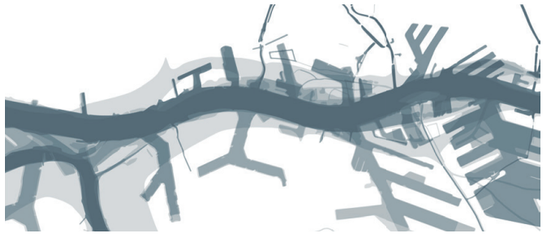


Figure 47: Shape of Nieuwe Maas over time / *Openfabric*

## Tidal habitat

Since early human records, rivers and estuaries have been coveted as settlement sites for human populations due to their ecological and economic advantages. They have been an important transshipment point for trade and transport for humans and are very fertile due to their sediment, nutrient and seed flow and animal migration routes. Because of their complex sedimentation and erosion behavior, tidal rivers are particularly diverse and constantly evolve in their form and support ecosystem dynamics. (Internationaal Symposium: 150 jaar Nieuwe Waterweg)

The Nieuwe Maas, as the only open river arm and thus direct connection to the sea, is one such tidal river, which makes it particularly important for migratory species that depend on its connection and existence. The transition area between the tidal currents of the North Sea and the freshwater inflow of the Rhine-Meuse delta leads to a dynamic morphology and provides space for diverse species of flora and fauna. The changing flows of a tidal river as well as erosion and sedimentation processes give rise to characteristic natural types such as salt marshes, mudflats and creek systems in the floodplains. Formed by the deposition of fine sediments and muddy material retained by vegetation and the ebb tide. As a result, they are brackish tidal landscapes that are influenced by both fresh river water and salty seawater and are biologically valuable and diverse due to this special interdependency. In the Nieuwe Maas, however, as already mentioned, these have largely been lost due to the constant manipulation and dredging of the river and the waves caused by ships. However, the still existing natural dynamics offer a high potential, which can be used to our advantage through nature-oriented construction. (EcoShape, n.d.; van Veelen & Huisman, 2020)

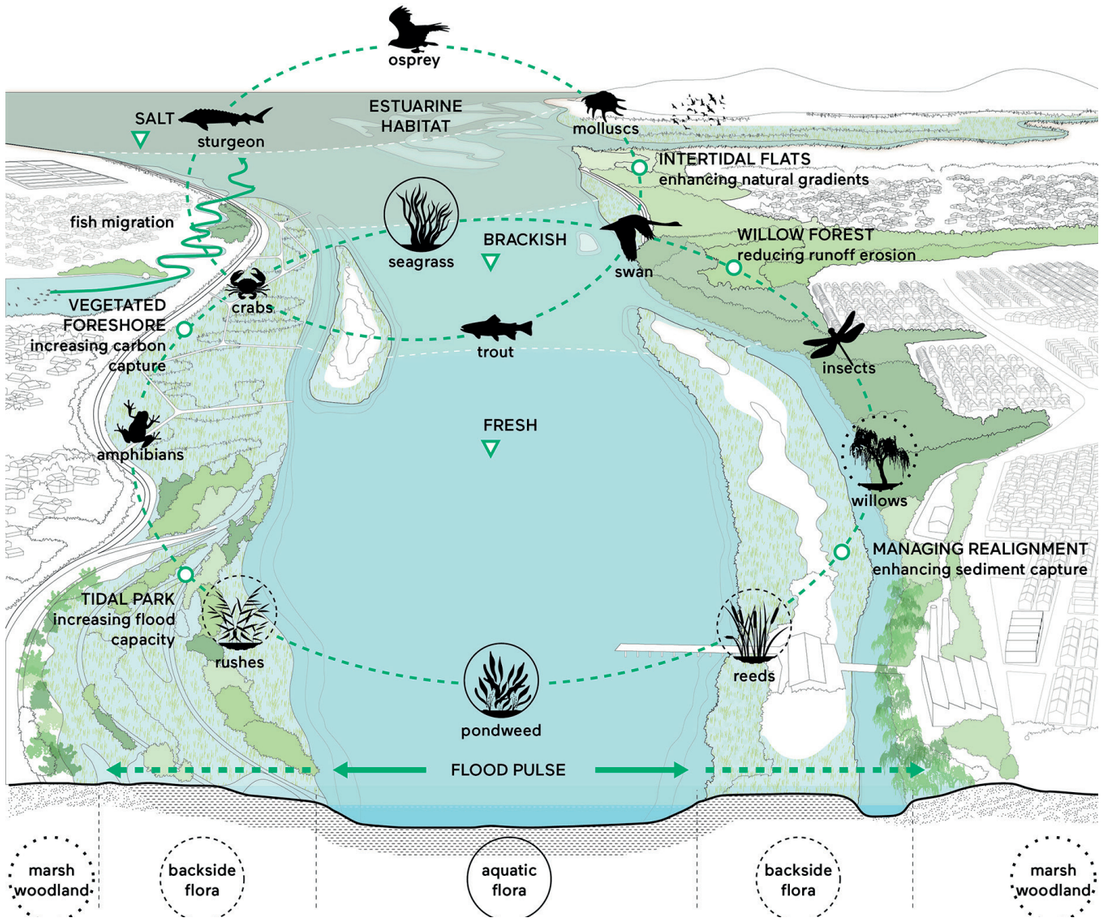



Figure 48: Delta ecosystem / *EcoShape*



Figure 49: Salt marsh habitat / *Author*

In the Rhine-Meuse delta area, before human intervention, the river courses were surrounded by salt marshes, in Dutch called 'Schorren'. They play an important role in flood protection, create a balance of sediment and are a natural and porous transition between water and land. In general they are considered one of the most productive landscape types there is and provide a high value of ecoservices that support and contribute to the surrounding and connected areas. An important benefit of salt marshes is, for example, their ability to filter the water that passes through them. This increases water quality and creates an important marine habitat. Despite their high ecological value, they have been disregarded in the past, leading to a decline of up to an estimated 50% of all global salt marshes. (Baptist et al., 2021; Mcowen et al., 2017)

Typically, salt marshed are vegetated by halophytic plants or plants that can cope with the saline floodwater. These include grasses, shrubs, and herbs. Which specific plant species can be found where is determined by the salinity of the area as well as the recurrence of flooding and differs according to its location. It is not possible to say exactly how a habitat would look and be composed in the study area. Based on the reading, species observed in and around the site and species sighted in the nearby natural salt marsh/sandbank of Brienoord Island, a table (Appendix 1) has been compiled that gives an outlook on possible habitation.

The plants help trap the sediments and stabilize the very dynamic land, protecting it from erosion and waves. This allows the salt marshes to grow naturally with the sea level. Due to their special position between salt and fresh water, they form a diverse and unique habitat. They serve not only as an important source of food but also as a protective refuge and breeding ground for birds and fish. This not only helps the local ecosystem but is also closely interwoven with global networks through the migration patterns of the different species. For example, fisheries, both domestic and commercial, can benefit from their presence. (Baptist et al., 2021; Boesch & Turner, 1984; Mcowen et al., 2017) It is not only in an ecological sense that these unique areas are important. They can also benefit people in urban areas. They contribute to the quality of life by improving water quality, capturing carbon, reducing the impact of urban heat islands as well as generating recreational opportunities. (Alikhani et al., 2021)

## Site location

The area Nieuw Mathenesse is located on the border of the two cities Rotterdam and Schiedam and is bordered in the west by the river opening of the Schie and in the east by the Merwehaven and therefore has a close connection with the water. It is officially part of the Merwevierhaven area, a post-industrial port area of Rotterdam. This area is a development area that has been expressed and supported by the municipality and the port planning for several years, with many potentials for improvement and high sustainable ambitions. However, the part of Schiedam is often not further included in the plans because most development strategies are based on and by Rotterdam and not planned supra-regionally. Accordingly, Nieuw Mathenesse is rarely considered due to its special multi-municipality character. Regionally, it is located in an economically very profitable location. It forms an overlapping point where the urbanized part of the peripheral city and the industrial port area meet and create a special connection. Although part of the study area officially belongs to the city of Schiedam, it can be considered part of the extended port territory of Rotterdam. Due to the expansion of the port to the west by the construction of Maasvlakke I&II, the area no longer has so much economic importance and the port function has been steadily decreasing since then and have been replaced over time. However, it has a key position due to its direct adjacency to the historic mouth of the Schie in the Nieuwe Maas. The area thus embodies the connection to the Dutch hinterland and the entrance to the city of Schiedam.

The study area like most of the port areas, lies outside the primary dike protection. The soil has been artificially heightened over the past centuries to be above sea level to avoid regular flooding and is higher than the area behind the dike. However, in view of the climate crisis it is in a very vulnerable situation and strongly influenced by the river and its behavior. The dike is not only a protective measure but also a hard boundary towards the rest of the urban fabric. Not only is the water separated from the land, but the development area is separated from the rest of the city. Furthermore, the dike in this section needs upgrading and, according to Deltaproamma's projections, will need to be raised further in the near future (De Urbanisten, 2013; De Urbanisten et al., 2014). This increased vulnerability can be seen as an opportunity to generously restructure the area and change the current state.


Figure 50: Location of Nieuw Mathenesse in the regional primary dike protection system / *Author*



## Water network

The water network in the study area is very complex. It is strongly influenced by the Nieuwe Waterweg, which is called Nieuwe Maas in this section. Here the tidal currents of the Delta still have a great influence and lead to water level differences of up to 3 m during the tides. As it turned out in the conversation with Peter van Veelen and Han Meyer, this influence makes the system very complex. The simple erosion and sedimentation processes expected in rivers further upstream are here influenced by the increased movement of the river system, as both the tides and the regular flow of the river carry sediment to the delta. In the estuary, they subsequently settle due to the reduced river flow. As the tides rise, the sediment percentage also increases. This has thrown the system out of balance, resulting in more sediment being carried into the estuary by the tides than is washed out again at low tide. Nevertheless, natural erosion and sedimentation prone areas may still be expected, which have been attempted to be depicted in the accompanying graph (see figure 51). However, the erosion process is not as high as in other arms of the Delta due to the high amount of sediment in the Nieuwe Waterweg which lies around 5.2 cm/year. (Rijkswaterstaat, 2005) This indicates that without regular dredging, the existing river system could silt up.

The study area is located at an important interface with the hinterland due to the historic lock of Schiedam. The Schie is a direct connection to Delft and the villages and cities behind it. However, its industrial importance has been replaced by the Delfshavense Schie. Today, the Schiedamse Schie, which runs through the historic town center, is increasingly used for recreation and only private boats could be observed at the lock.

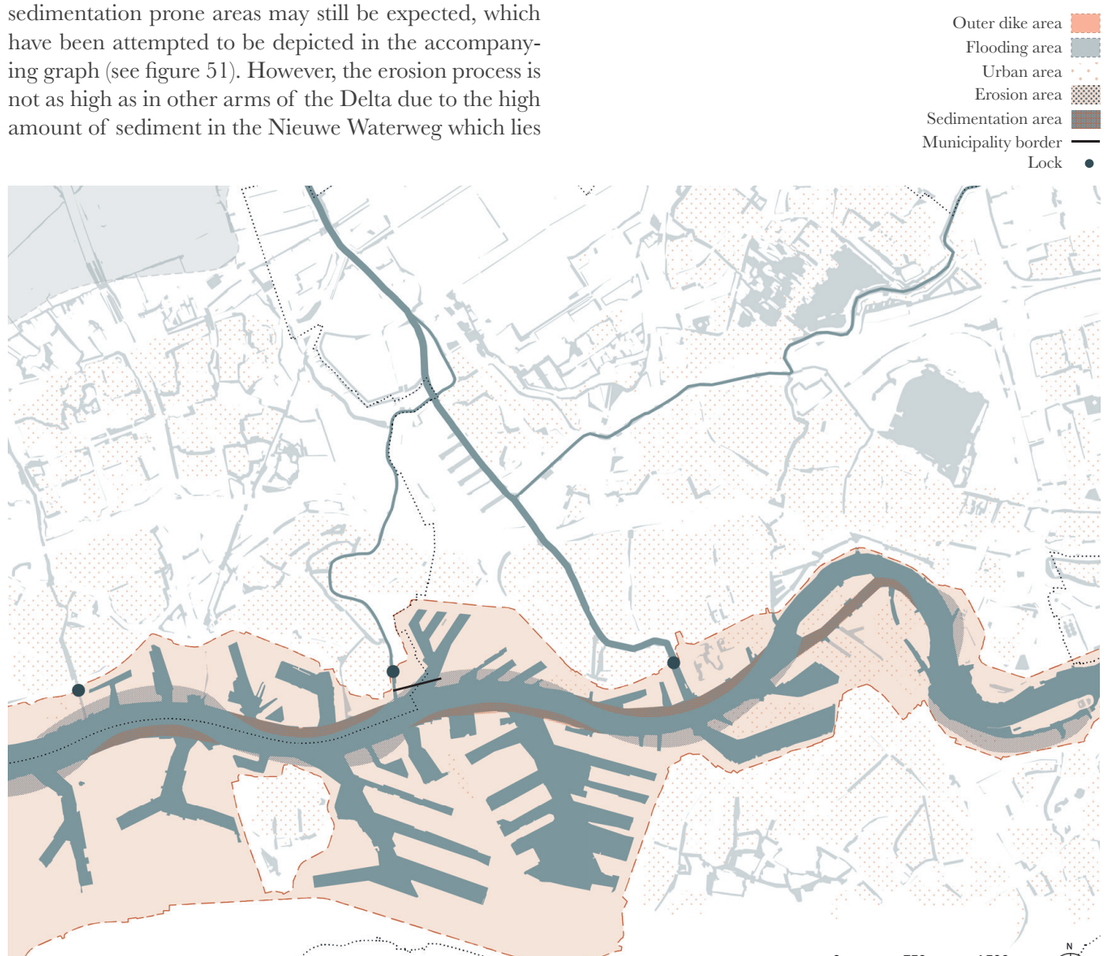



Figure 51: Water network in Rotterdam region / *Author*

## Urban context

The study area is located on the border between Schiedam and Rotterdam. Thereby, it has the appearance of a sort of industrial "island" as compared to the surrounding, almost exclusively residential urban fabric (see figure 52). A closer look at the area reveals its strong contrast. While the (historic) city centers of Rotterdam and Schiedam are clearly more porous and fine-grained, the Merwe Vierhavens is still very monofunctional. In the process of transforming the area, as envisaged by the two municipalities, this could be potentially addressed and reshaped, for example in a similar way as in the Rijnhaven. There is an opportunity to extend, enhance and eventually connect the commercial hotspots and corridors that can now be identified through a repurposing and redeveloping of the area. This would not only make the connection of the so closely neighboring cities more visible and strengthen them, but also better integrate the outer dike areas, i.e. the waterfront, into the context and communal mindset. This would place the design proposal in an optimal and urban location that would encourage initial activation of the area, make it more attractive and highten the awareness of the topic. A leap over the Maas to the RDM would be another potential connection worth exploring further.

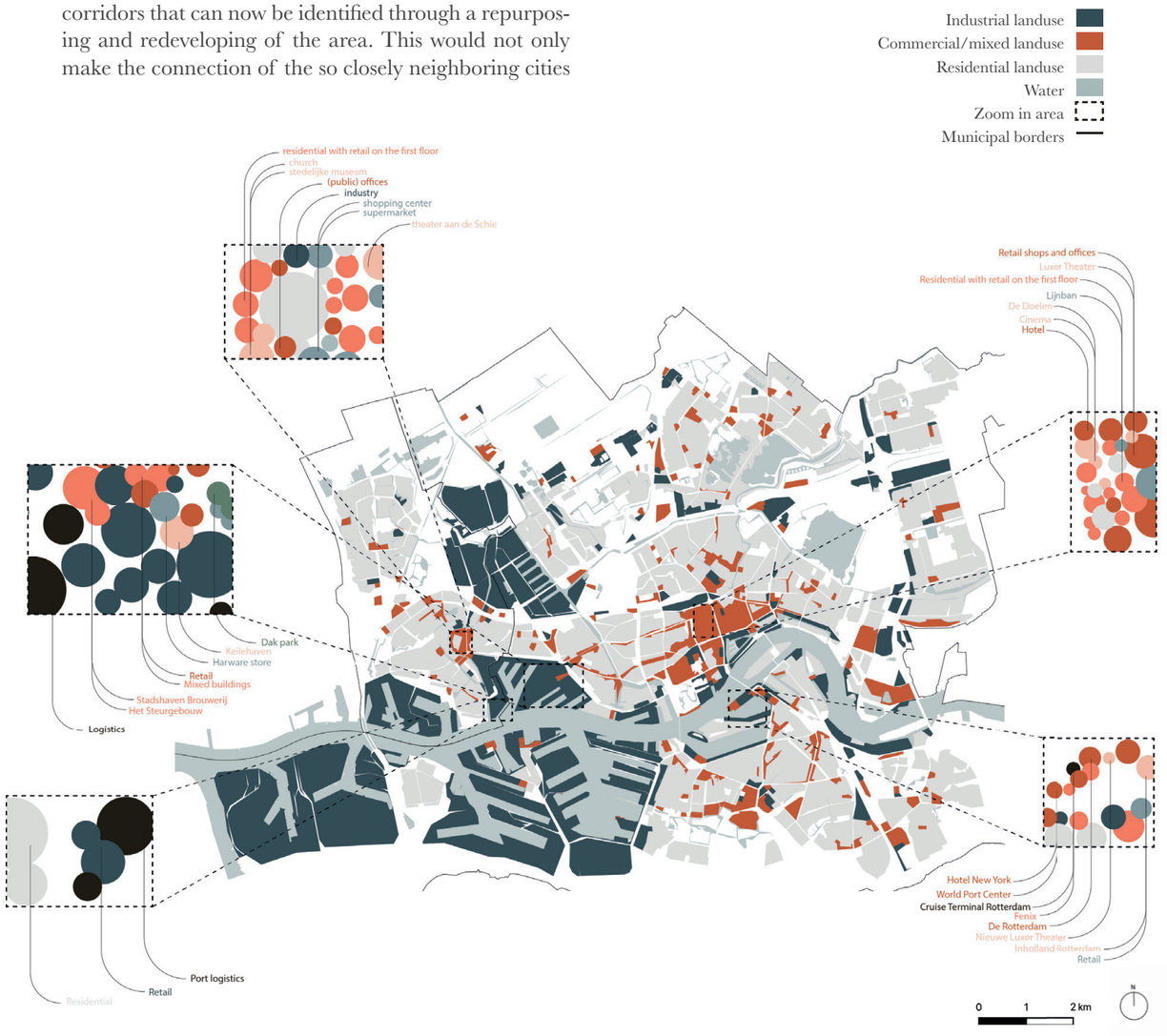



Figure 52: Urban landuse in Rotterdam and Schiedam / *Author*


Figure 53: Context of study area / *Author*

## Direct context

The project focuses on the southern part of Nieuw Mathenesse and partly on the waterfront of Merwe-Vierhavens, which lies outside the primary water barrier "Delflandsdijk". This dike forms the main infrastructure of the area. Behind the dike there is currently a mixed commercial area, which is directly adjacent to the historic old town and city center of Schiedam, with halls, old distilleries, and partly historic. Together the two parts of Nieuw Mathenesse form the oldest industrial area in Schiedam (Gemeente Schiedam, n.d.). The embanked part, however, will be transformed into a mixed-use area in the coming years as part of the redevelopment of Nieuw Mathenesse. First the area around the Glasfabriek. (Nieuw-Mathenesse | Schiedam, n.d.)

The residential areas adjacent to Nieuw Mathenesse are among the poorest in Schiedam (AlleCijfers.nl, 2022b). To the east, a dense residential area in the Zuid district is immediately adjacent. This was considered poorer until a few years ago, but housing prices have increased dramatically (by 24%) in the last three years (AlleCijfers.nl, 2022a). It forms a strong contrast to the commercial area on the other side of the Schie and is much greener than the latter. It consists of small row houses with private gardens in the backyard. On the bank facing the Meuse, adjacent to solitary high-rise buildings overlooking the river, is the Maasboulevard park. This is not only a popular reclamation zone for residents, but also has a pier for Rotterdam water taxis.

West of the Nieuwe Maas design area is the Merwehaven and the rest of the Merwe-Vierhavens (M4H) area. Currently, the docks along the water and large warehouses here are still active in port operations and cause noise and traffic.

On the other side of the Nieuwe Maas and in direct view is the Techniek College Rotterdam RDM, which can be accessed from the north bank by ferry from the Markoniplein. Right next to it is the former Quarantine Terrain, which is now used by artists and a foundation. Here the "naturally" left sandy beach still reminds of the former sandbank reclamation.

Figure 54: Location of adjacent neighborhoods and its morphological appearance / *Author*



## Historical review

The area of Nieuw Mathenesse was established around 1350 with the canalization of the Schie using a sandbank in the river outside the dike. Until the beginning of the nineteenth century, the area remained largely uninhabited. Until then only along the dike urban dwellers settled. Instead, the area was characterized by the polder structures until the twentieth century. At first, the whole area belonged to Schiedam. However, with the construction of the Merwehaven, which was used as a transshipment point for fruits and juice goods, and the relocation of the Rotterdam ports, the municipal boundary was redrawn and has run through the area ever since. Before the entire area was tendered completely as an industrial area during the Second World War, the site behind the dike wall was a mixed area. In addition to workers' housing, factories were built here in the 19th century, producing primarily gin and the bottles that went with it. The area outside was only used for industrial purposes since the first buildings were erected in the 19th century. Here was the first shipyard of Schiedam "de Nijverheid". This was replaced at the end of the 19th century by the much larger Gusto shipyard. In addition, in the southern area on which the projects concentrating on and which today is called Nieuwe Maas, was the candle factory Apollo, which moved in 1931. After the closure of the Gusto shipyard in the 1980s, the entire southern area was demolished and restructured for a new industrial area. Today, almost nothing reminds of the previous appearance and use of the area. (Gemeente Schiedam, n.d.) The only remnants in the new industrial area are concrete and metal structures of the old jetty lying inaccessible in the Nieuwe Maas and the entrance gate commemorating the Gusto shipyard.

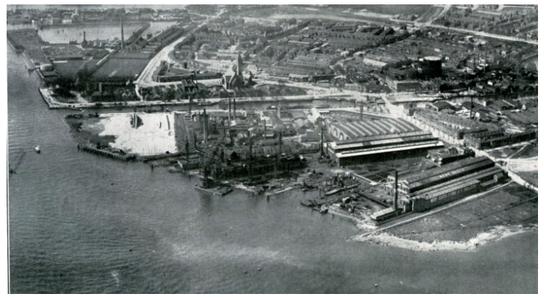


Figure 55: Historical picture of the Gusto werf in Schiedam / *Author*

Figure 56: Last remnants of the shipyard in the water / *Author*

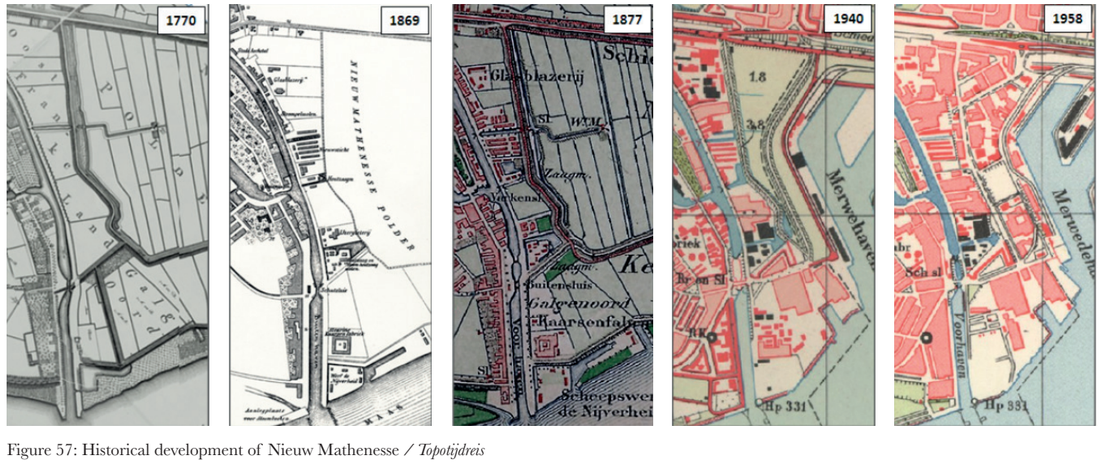



Figure 57: Historical development of Nieuw Mathenesse / *Topotijdreis*

## Future plans

The area is not unknown to many urban planners in the Netherlands. For some time now, the municipalities and the Port of Rotterdam have been researching new potentials for a holistic integration of the inner-city port area by means of various, also experimental, competitions and assignments. So far, the aim is to create a so-called maker district by combining living and working. Creative and innovative initiatives have already been launched here, such as the Keilewerf or the floating farm. (M4H Rotterdam, n.d.) So far, the increased risk of flooding has also been taken into account. Accordingly, a sub-strategy is to find solutions that make it possible to live and work in the hazard zone and to better integrate water into people's everyday lives (see Figure 59). (Port of Rotterdam, n.d.-a)

This approach has also been integrated into the spatial framework currently used by DELVA Landscape Architects, which provides guidelines for the subsequent redevelopment and represents a first possible outcome (see Figure 58). Through various impulses, the aim is to become a test area for circular economy, reconnecting the port with the city through innovative facilities. (DELVA Landscape Architects et al., 2019; M4H Rotterdam, n.d.)

However, it can be concluded that the ecological value of the delta nature as well as the water aspect and the effects of our previous water management were not the main objective of the urban planners. For example, the existing hard borders between the river and the city are maintained. Thus, the proposal does not go far enough to contribute to a stabilization of the current delta system.

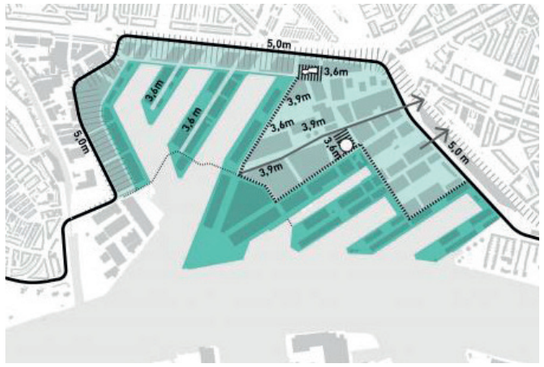



Figure 59: Adaption strategies for M4H / *Port of Rotterdam*

"Water stays outside"
"Life with water"

Furthermore, another weak point becomes visible when looking at the framework. There is no framework plan that deals in depth with the entire area, which extends over two city boundaries. Instead, each city deals with its part of the area individually and partly disregards the other part. To achieve a viable delta system, however, it is necessary to think across municipal boundaries and to conceive the waterfront as a whole, as nature does not recognize these political borders.

Thus, a large-scale design and revision proposal of the spatial framework is needed that goes further than the existing and, at least initially, disregards the political boundaries.

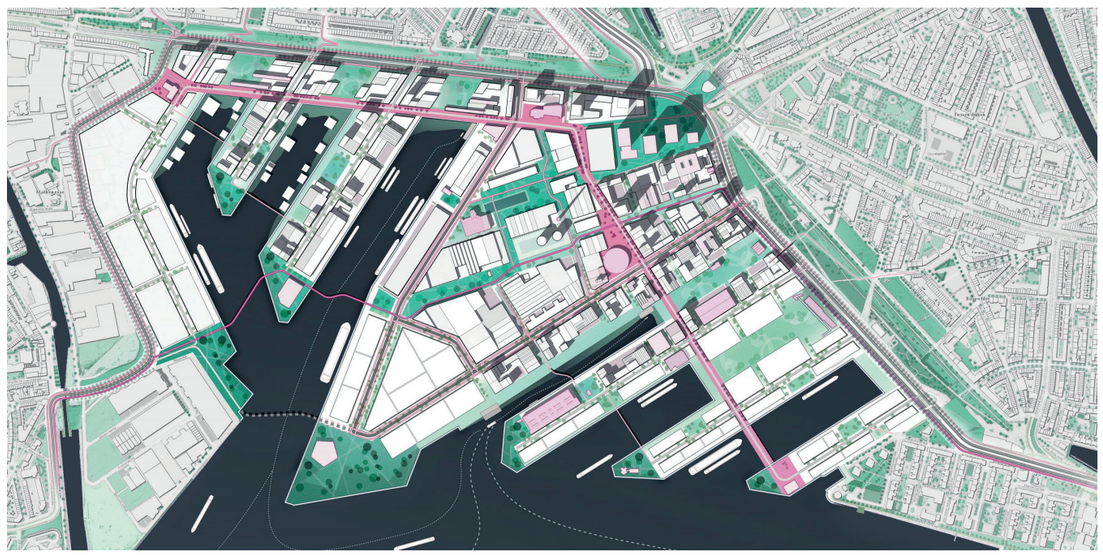


Figure 58: DELVA's spatial framework for M4H / *DELVA*



## Spatial layout

The area outside the dikes of Nieuw Mathenesse is modern and functionally built. The buildings there have a large footprint and scale, as is common in newer more peripheral and industrial areas. They are considerably larger than the commercial buildings behind the dike. Most of the area is no longer directly related to port activities. Instead, the residing facilities are logistics centers, such as the UPS transshipment point or Commercial Wholesale, car workshops or stores for industrial and maritime commodities, such as Hatenboer-Water which is located directly on the waterfront. Especially the wholesale and warehouses are shielded from the public space. The facades are often closed or screened by large parking lots and there is no connection between the private and public areas. Instead, there are many barriers within the areas due to the numerous fences, which make the operational areas inaccessible (see figure 65). The scale of the area is not designed for people, but for cars and trucks. This makes visitors to the area feel small and gives a sense of emptiness. The streetscape, the lack of human activity and especially the lack of visual connections to the buildings through the closed facades and visual barriers through fences, an unsafe feeling and a sense of unease is conveyed. This tends to repel visitors, so that the only actors in the area are the people working there and the transporters.

Merwe-Vierhavens has an older character, but is too functional layouted. It is characterized by large warehouses surrounded by industrial yards, systematically placed one after the other on the docks. These are still used today for the handling and storage of fruit and juices. In turn, these warehouses are connected by long straight roads that run down the middle and ending at the waterfront

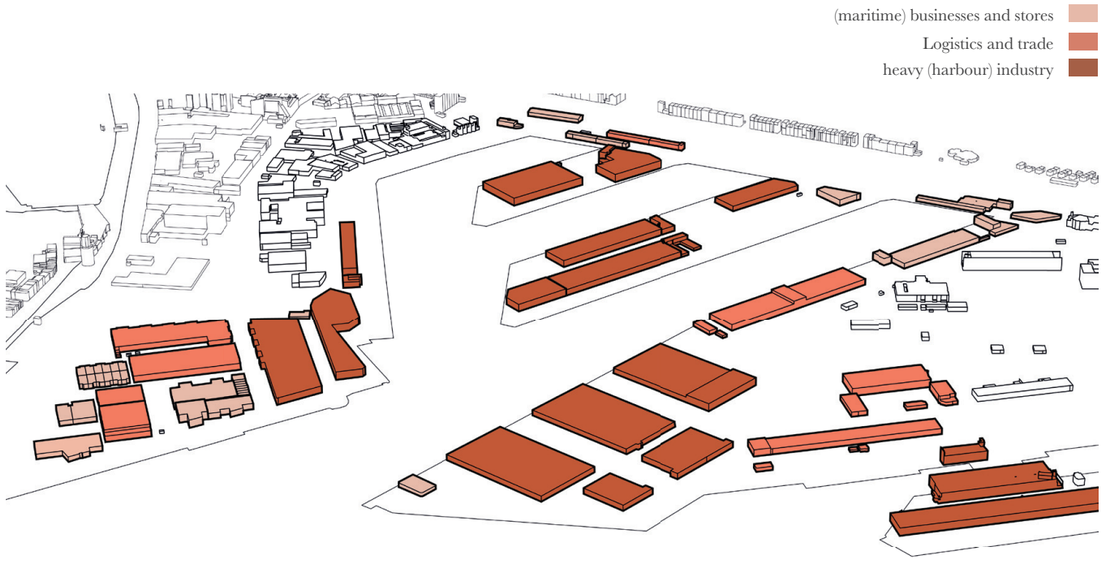



Figure 60: Location of the different commercial uses at water front of the M4H area / *Author*

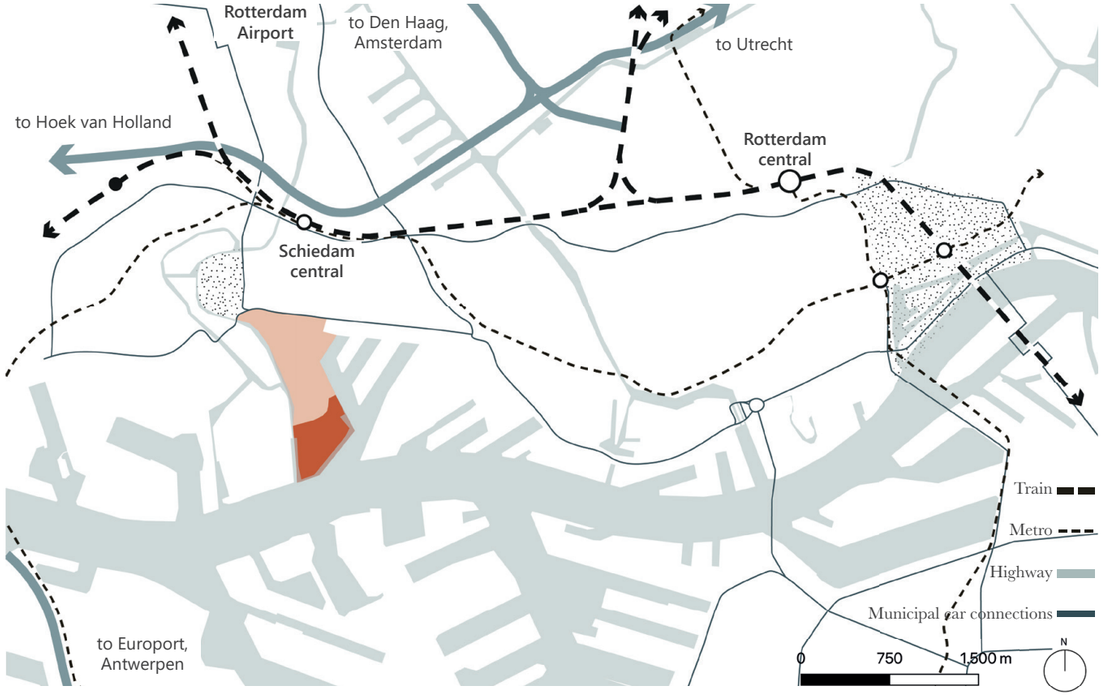



Figure 61: Supraregional connection of Nieuw Mathenesse / *Author*

## Accessibility

A quality of the area is the central location and good connectivity, especially regionally. The city center could be reached on foot without problems, and it is only a few minutes by car from the highways that leads to among others, the Europort, The Hague, Amsterdam, or Antwerp. Furthermore, the airport Rotterdam-The Hague is only 13 minutes away by car. The adjacent metro station at the Marconi plein offers a fast connection to Schiedam's train station or Rotterdam Centraal station, which then connect to the national and international network.

However, when looking at the area in more detail, it can be seen that while the surrounding is relatively well connected, the outer dike areas such as Nieuwe Maas and other old harbour quays are not. Here, there are no bus tram or bus routes and in general no possibilities to cross the basins. Therefore you have to go around the area and can't just move along the waterfront. In total, there are only limited accesses points to the area, which are also often privatized and closed off by barriers. Especially the slow traffic is in need of improvement. The roads are designed for car and truck traffic with only limited pedestrian space (see figure 63) and no bike lane in the entire area. The ferry stop close to the Marconi plein is one of the only possibilities to cross the Meuse and connects directly to RDM.

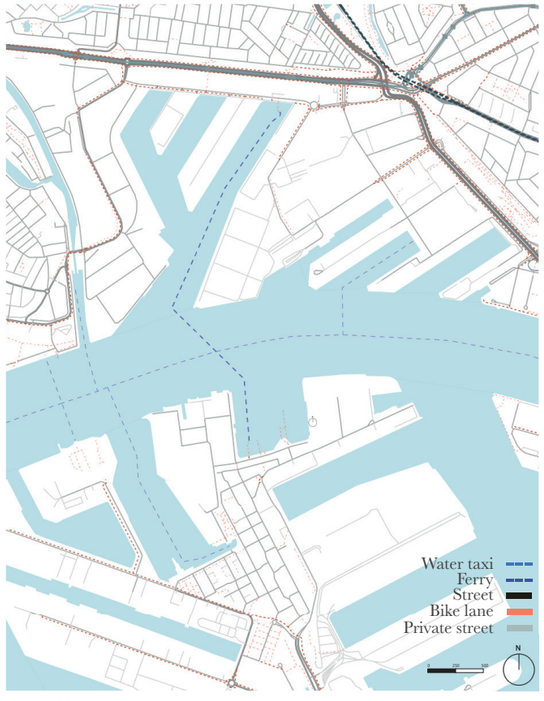



Figure 62: Municipal connection of Merwe-Vierhavens / *Author*



## Green public space

Because of the area's classic industrial character, it has little planned public space, such as a square or park. To the west and on the tip of the land are the only areas that are not built on and do not have sealed soil but instead are covered with grass. However, they do not have a noticeable recreational quality and limited biodiversity. The next recreation area is located on the western bank of the Schie with the Boulevard park. It has a simple design and also offers a relatively low ecological context. Despite the proximity of the two green spaces, they are not connected in any aspect. In the north of the area there is the dike, which is traditionally kept clear and overgrown with grass and shrubs. Behind it there are private commercial areas, which, like the working area, are heavily sealed and have hardly any qualitative areas to stay. In the area, the fitness parkour, which was built next to the lock and is in good condition, stands out. This is used especially by the residents of the neighboring district Zuid and offers potential to move into the area.

In the regional context, the lack of continuous green spaces is particularly noticeable (Fig. 63). The only larger recreational areas are located on the outskirts of the city with Prinses Beatrixpark, Zuiderpark and Kralingse Bos and are not easily accessible on foot from the city centers of Schiedam and Rotterdam. This is particularly noteworthy in relation to the urban heat island effect, which is likely to become more common in the future (Meyer & Bouma, 2017). During hot weather periods, it is not possible for a majority of the city's inhabitants to cool down in the proximity of their neighborhood, and people have to leave the city for "natural" areas. In addition, the water sources like canals and rivers are inaccessible and not suitable for swimming and other recreational activities.

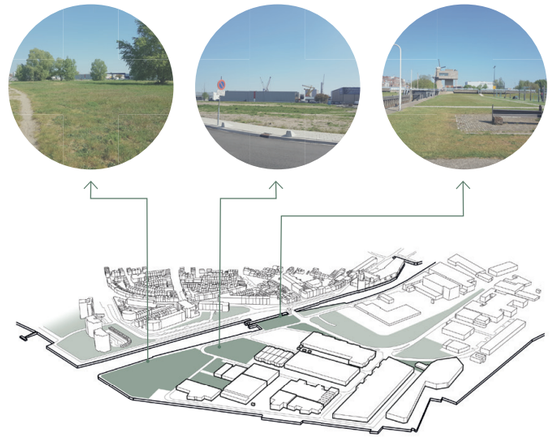


Figure 63: Different public and green spaces in outer dike area / *Author*


Figure 64: Green structures of in the regional context / *Author*

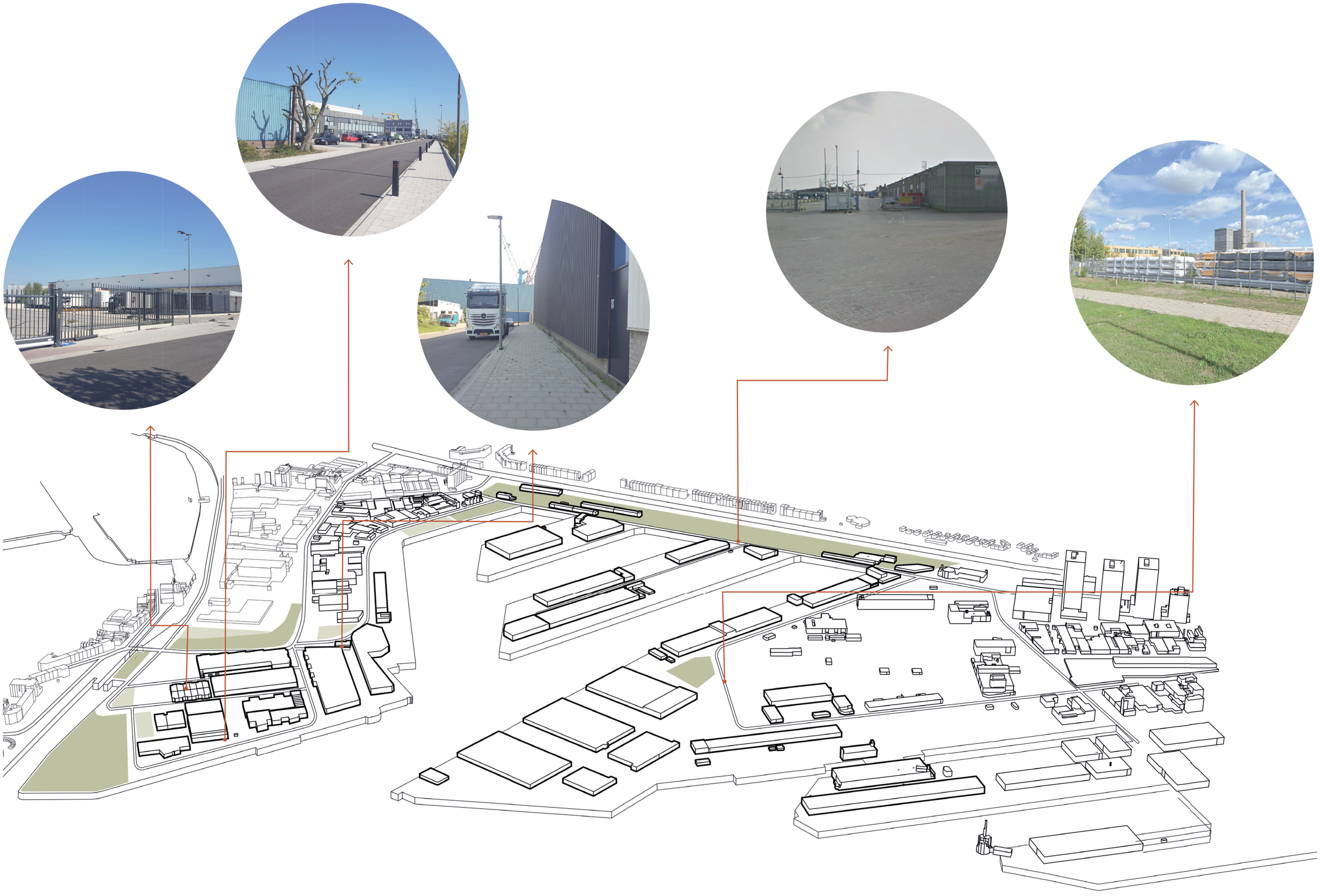


Figure 65: Impressions of street scape in Nieuwe Maas */ Author*


Figure 66: Acessability of waterfront in the area / *Author*

Figure 67: Modeling the elevation of Rotterdam's river front / *Bobbink*

## Relationship between water and land

Merwe-Vierhavens has a strong separation between the river and the mainland eventhough beeing almost completly surrounded by it. The more recent added harbour basins in the area of Rotterdam show a low porosity and are reserved for private and industrial uses. Therefore, the waterfront is in most cases not accessible to the public or even visible from the street. The concrete quay walls are built for unloading and loading ship cargoes and serve only functional purposes. A quay wall has also been built along the entrance to the lock, which also serves to moor ships and is currently screened by shrubs.

Most of the development area at the tip of Nieuw Mathenesse is reinforced by stone slopes of brick and rubble. This has a more natural appearance but is neither accessible nor usable for recreational purposes. So here too is no relationship between the area and the water.

The separation of water and land is intensified by the difference in the difference in height of the two. The areas outside the dikes are reclaimed and higher than the hinterland (see figure 67). This means that they remain dry even at high tide, which is not so pronounced in Rotterdam due to the cur-rent flood defense systems and does not exceed two meters above sea level. At low tide, the difference in elevation between the quays and the river is around 3.5 meters. Due to the early creation of the harbour basin, the area is not as high as the newer port areas of the port of Rotterdam outside the dike protection. The area is therefore particularly vulnerable and, in view of the climate crisis, needs new planning that better protects the site as well as the urban area behind the dike. This is located at the same height as sea level or even below it due to the subsidence of the soil and requires special protection. The dike between the two areas provides protection but also creates a visible barrier between the two urban areas and between the city and the river.

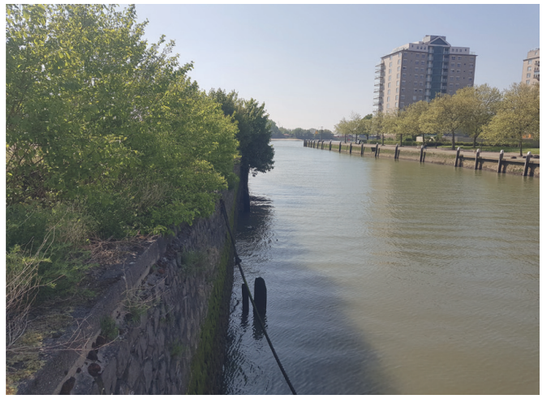


Figure 68: Photography of waterfront in Nieuwe Maas / *Author*

Figure 69: Photography of waterfront in Nieuwe Maas / *Author*

Figure 70: Photography of waterfront in Nieuwe Maas / *Author*

Figure 71: Hight difference of the dike and the urban hinterland / *Author*

## Conclusion

Overall, the relatively young industrial area Nieuwe Maas and waterfront of M4H is a fully functioning area. However, it is currently being used below its potential and especially in view of climate change and its effects, there are significant weaknesses and challenges in the area that need to be solved with the help of a new design. From this, the site survey and data analysis have identified four in particular:

1. **monofunctional environment:** the lack of a diverse character of the area, which is separated from its surroundings by clear boundaries, leads to fragmentation of the area. The lack of mixing makes the area becoming desolated and resulted in a lack of qualitative spaces to stay. Especially in view of the planned densification of the region to respond to the housing crisis. The area has little value due to its current use. In order to make it more responsive and livable for different population groups, it must be fundamentally restructured.

2. **borders:** The city, the port and the river have lost the only close relationship with each other. Although the infrastructure of the area is at a very good level, it is not well integrated into the surrounding area. There are only two entrances, which are controlled by barriers. Especially for slow traffic the area is difficult to reach. disconnection between landscape and built environment: The area is not only infrastructurally but also visually disconnected from the surrounding landscape. The isolation of the area is also visible in the larger context. Until now, it has been an island, separated from the rest of the urban fabric by the dike. Due to the privatization of the riparian zone in the former industrial areas, access to the river is limited and today there is a great lack of recreational spaces that make the river more experiential. Especially with regard to the urban green space shortage, the area offers a chance to create more public open space.

Figure 72: Monofuntional environment of Merwe-Vierhavens / *Author*

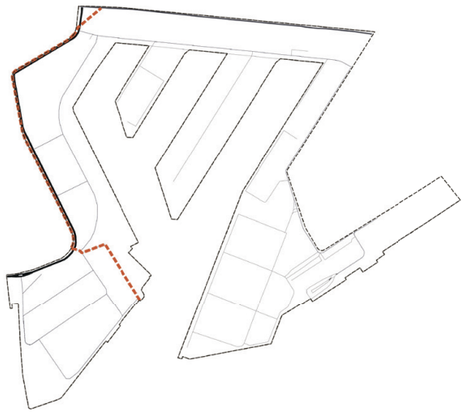


Figure 73: Borders of Merwe-Vierhavens / *Author*

3. **degradation:** The previous use of the area and the high rate of sealing contributed to the loss of its former ecosystem and natural habitat. The areas that have open ground have very low biodiversity and ecological value and are neither connected to the Nieuwe Waterweg nor to the green corridors in the city. Furthermore there is a high chance of pollution in the ground due to the use of the area as a shipyard and for other industrial purposes.

4. **flood risk and disconnect:** The area is exposed to the fluctuations and floods of the river due to its location outside the primary water protection. In view of climate change, this situation is becoming increasingly uncertain. However, not only the area is affected, but also the land behind the dike. Due to the measures taken so far to keep the area dry, the urban areas sank and thus became more vulnerable, especially in view of a possible dike breach, as the existing dike needs to be upgraded.

Furthermore, the current use led to not only infrastructural but also visual disconnection from the surrounding landscape and urban fabric. Even though it is almost fully surrounded by water, it is rarely accessible visually and especially not physically. Therefore there is no connection between the urban fabric and the river, possibly leading to a lower awareness and relationship.

All in all, the above-mentioned challenges lead to a very low porosity in the area. There is no communication not only with the water, but also with the landscape, urban core of Schiedam or the neighboring areas.

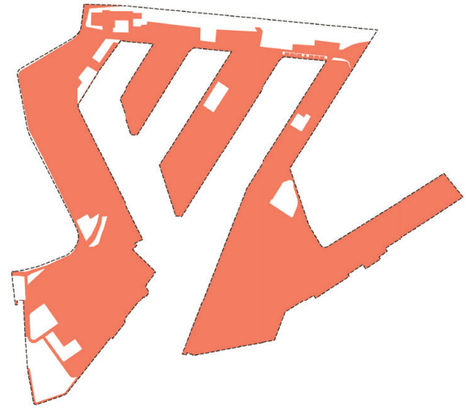


Figure 74: Degradation of Merwe-Vierhavens / *Author*

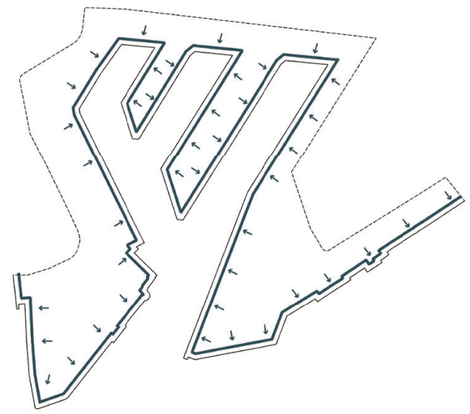


Figure 75: Relationship between river and Merwe-Vierhavens / *Author*

# Vision

*After an in-depth analysis of the area and the context, a preliminary design idea has been identified that provides a first approach to respond to the previously presented challenges and increasingly urgent problems of the delta. For this purpose, this chapter presents the design framework that forms the foundation for the vision and, ultimately, will lead to a more in-depth conceptual design proposal.*

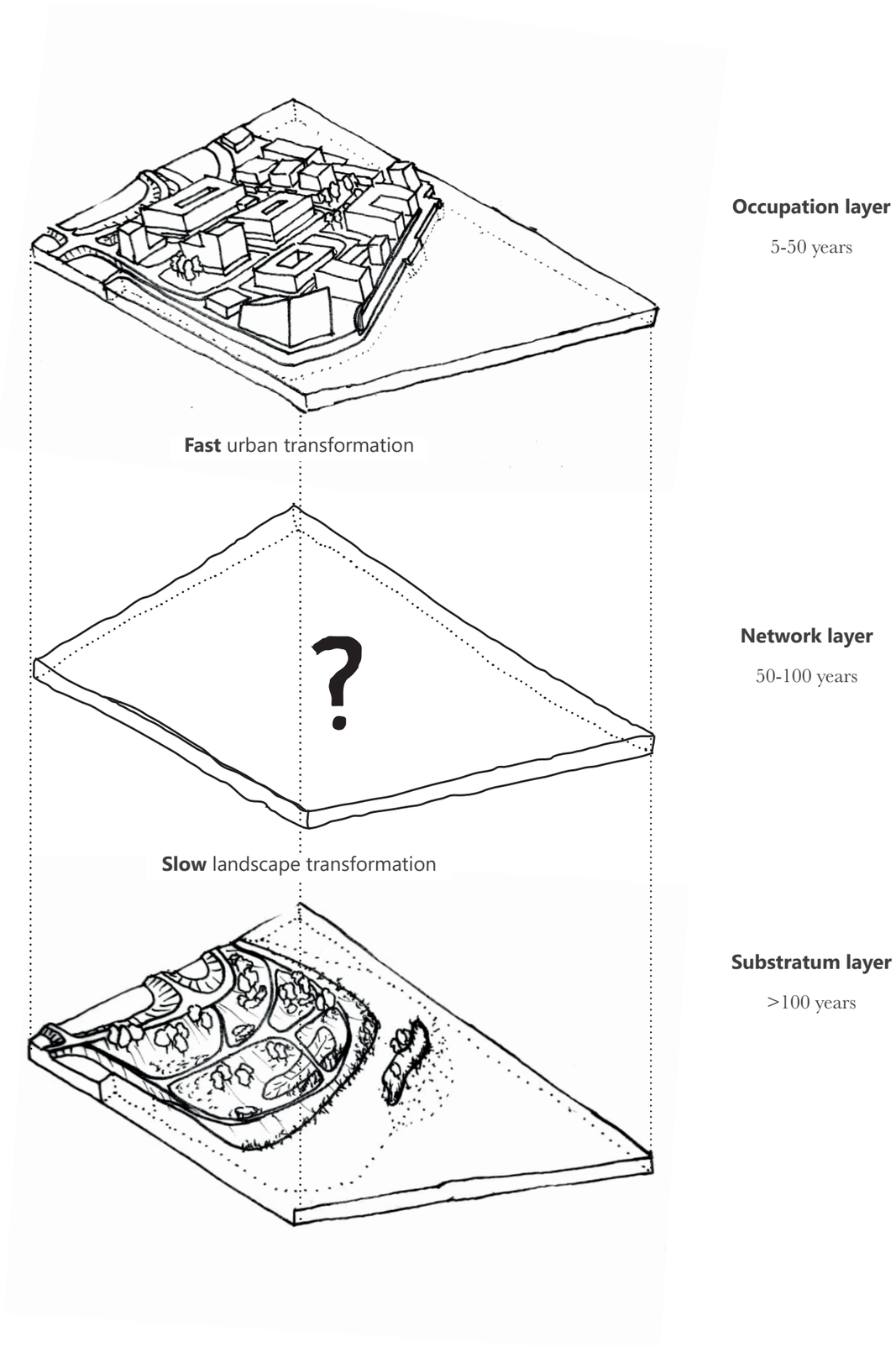



Figure 76: Connecting fast and slow transformation processes / *Author*

## Urban development in the delta context

The project deals with the impact of climate change on the urbanized and increasingly post-industrial areas outside the dike protection along the Nieuwe Maas. The aim of the project is to create a design proposal to achieve the goals of the delta program and to propose an alternative and nature-based way to provide more space for natural processes in a densely urbanized delta like in the Netherlands, while facing the pressure on (living-) space. To this end, the following aspirations shall be considered:

**- Water safety:** Creating a flood resilience that makes it possible to better protect urban areas of the delta in the future.

**- Spatial adaptation:** In the design, the landscape and built environment must be climate compatible.

In Port City Territories like Rotterdam and its surrounding area, there are currently two approaches to how the waterfronts should and can be dealt with and the interface could be changed.

On the one hand, there is the more urban approach, which mainly tries to cope with the housing crisis by creating a more urban front and entrance from the water. Here, there can exist a broad program and generate a mixed and lively district in the immediate vicinity of the water. Forward-looking and adaptive architecture can incorporate the existing buildings and help attract people here.

The other approach is reflected in the proposed tidal park. Here, the focus is on ecology and nature. This creates a green framework around the city, which can connect the hinterland with the waterfront. The green park landscape offers the possibility for city dwellers to experience the delta and its processes directly and to decelerate and escape from city life in the green area.

Both of these approaches have advantages and disadvantages. In order to fulfill the design principles already mentioned in the last chapter and extracted from the literature, the design idea is to combine the two fundamentally different approaches and thus create a porous typology that utilizes the riverbank as a landscape infrastructure. By transforming the river into a communal resource, both the sponge function and ecological quality of a tidal park and new living environment can be experienced by everyone. This is where the challenge of the different dynamics comes in. In order to bring the two such different aspirations together, a solution must be found that both incorporates and responds to the slowly evolving subsurface/substratum layer and, at the same time, works with the comparatively rapidly evolving and changeable occupation layer (see figure 76). In this way, a good porosity should be created in the outer dike area, which not only creates a better transition horizontally to the neighboring neighborhoods, but also has a vertical porosity that allows to live with water, embrace the river and profit from it.

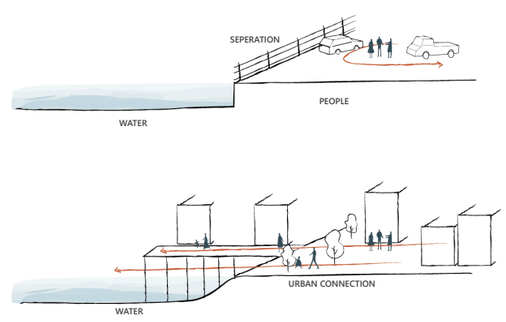



Figure 77: Actual situation and proposed change / *Author*

## Design framework

In the analysis of the delta context as well as the design area, different vulnerabilities and challanges have emerged. These must be dealt with accordingly in the design and sustainable and long-term solutions must be found. The figure below summarizes some of these. It also shows how these challenges can be countered in a design and how the area and its characteristics can be used as an opportunity. The resulting ideas gave rise to the preliminary design idea, which is explained in more detail in this and the coming chapters.

### Vulnerabilities

#### FLOODING

Urban expansion worsens climate change conditions and may increase hazard zones. Rising sea levels and increased precipitation due to climate change make delta populations more vulnerable to flood risks.

*sea level rise*
*located outside of primary flood protection*
*property lost*
*flood mitigation*
*impervious surface*

#### ECOLOGY

The dredging and manipulation of the river and the pollution originating from the port have serious impacts on the local biodiversity. The river velocity has been affected and numerous habitats, such as natural wetlands, marshes and vegetation, have been lost, leading to salinization and ecosystem degeneration.

*urban sprawl*
*Lack of connections*
*habitat lost*
*biodiversity loss*

#### POLLUTION

The port sites in Rotterdam and Schiedam are both heavily affected by flooding and characterized by industrial land uses resulting in pollution of the area which is spread due to tidal flows.

*contaminated soil*
*(industrial) waste water*
*contaminated marine life*
*depletion of wildlife*
*public health*

### Opportunities

#### ECONOMY

Schiedam is expected to grow in the coming future and will have to accommodate the Dutch house crisis. Stimulating sustained economic growth and employment growth is essential for the development of the site

*improve tourism*
*redevelop community*
*affordable housing*
*green infrastructure*
*urban (food) production*
*increase income*

#### KNOWLEDGE

The proximity to the RDM across the river has the potential to expand the existing campus across the river. Science can benefit from the natural environment and the environment can be nurtured and expanded by science.

*on site research opportunities*
*interactive and educational components*
*collaboration*
*living laboratory*

#### LEISURE

The inner cities of Schiedam and Rotterdam are lacking in public recreational space. The area can therefore offer a natural counterbalance to urban stress in the immediate vicinity of the city centers and better connect the cities to each other and to the river.

*water activities*
*cooling location*
*connection and engagement*
*recreational exploration*
*sports and exercise*


Figure 78: Action approach of design / *Author*

## Vision

To counteract the increased risk of flooding in the area, the urban space is to be raised to an elevated level in the design. The basis for this is the delta landscape. With the help of sediment and sand traps and so-called mud motors, an ecological and floodable delta park is to be created with a play of different heights. The urban landscape is built on stilts on top of the dynamic and constantly changing landscape. The lowest level consists of the infrastructures that partly made this landscape possible, such as the platforms and public path systems. But not only walkways should be on this level, but also the commercial base level, which consists of public facilities, services, and other infrastructure. It can also be called the "exchange level." The residential area shall be spread on the most elevated level and shall be flood adaptive.

The resulting dynamic structure should make it possible to stretch like a net over the landscape and adapt to local processes and changes. The resulting amphibious bridge structure, inspired by mangrove forests, represents an intermediate zone between the "natural" delta and the cities of Schiedam and Rotterdam. Creating a new ecosystem that will reduce flood risk, improve water quality, and promote economic growth in the city. It interacts with different periods and seasons and enables the city's residents to experience and feel the effects of tides, floods and droughts (see appendix 2) and is intended as a specifically local space for the people of Rotterdam to enjoy.

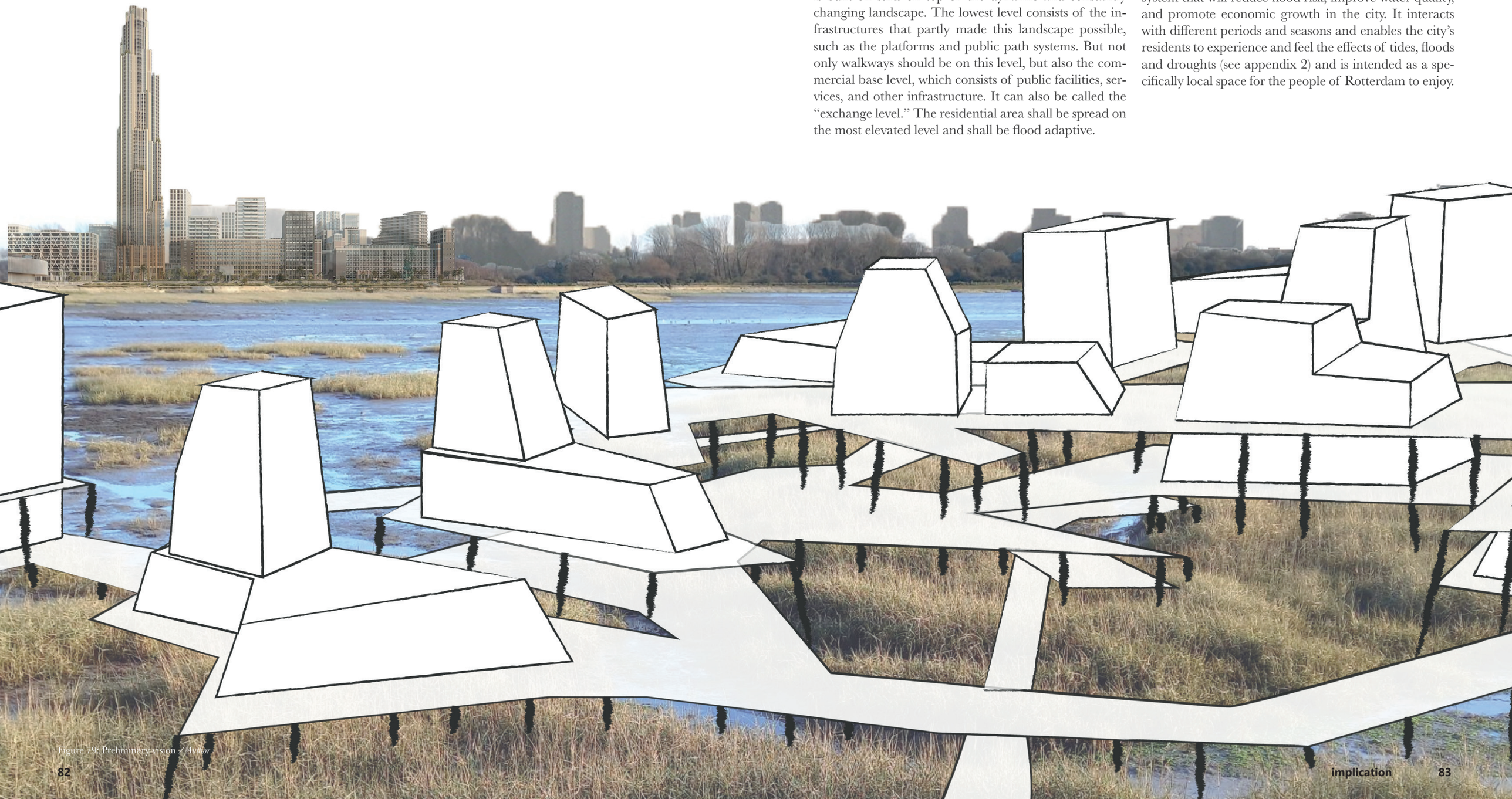


Figure 79: Preliminary vision / *Author*


Figure 80: Design concept / *Author*

# Concept

*The goal of the large, medium and small interventions at the heart of this project is to allow the people of Rotterdam and Schiedam to reconnect with a de-industrialised and porous waterfront. How exactly this could look like in the context of the study area, and what kind of processes this implies, is presented in the following chapter.*

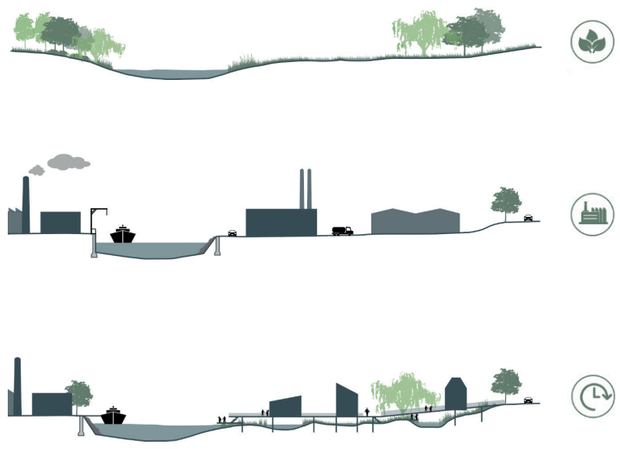
## Embracing natural gradients

The proposal is to create a hybrid landscape between the city and the river, helping both nature and the urban functions and amenities (see graphic below). The goal is to find a way to mimic and trigger, through human incentives, how the river would naturally unfold and develop while actively allowing the area to become part of the urban space. As this is a highly dynamic system, it must be given a certain amount of space. Accordingly, the design should only define framework conditions that remain flexible and not a strict master plan. To achieve this, the following questions must be answered:

- What will be **created**?
- What will **grow** from that?
- What will **change** in the system?

With the use of carefully placed infrastructures it will be possible to capture sediments and create floodable salt marshes and sandbanks in the old harbour basin of the Merwe-Vierhavens district. The new neighborhood can benefit from the reconstructed ecosystem and grow with it. The design is based on the island of Briennoord and its natural features in the west of Rotterdam, which is one of the few remnants of the original river course.

The area is a transitional area that is neither city nor port nor "wilderness". It is intended to be a balance between the 3 entities.



**Past**
Precondition of the river's edge: purely natural state with original resilience. This system has the capacity to adapt to changing conditions and to maintain or regain functionality and vitality in the face of stress or disturbance. It has the capacity to bounce back after a disturbance or interruption.

**Present**
Existing condition of the river's edge in an urban environment: an engineered, impervious, highly channelled, hard-edge flood wall with an artificial ditch or industrial area which separates city from river. This system is based on the conventional static design approach which does not adapt itself over time.

**Future**
Proposed condition of the river's edge in an urban area: a hybrid landscape employing both restorative/natural processes and highly productive municipal serving infrastructure and accessible public space. It aims to create a resilient framework rather than a fixed master plan, and to let the ecological strategy generate corresponding landscape along the water's edge.

Figure 81: Derivation of new waterfront / *Author*

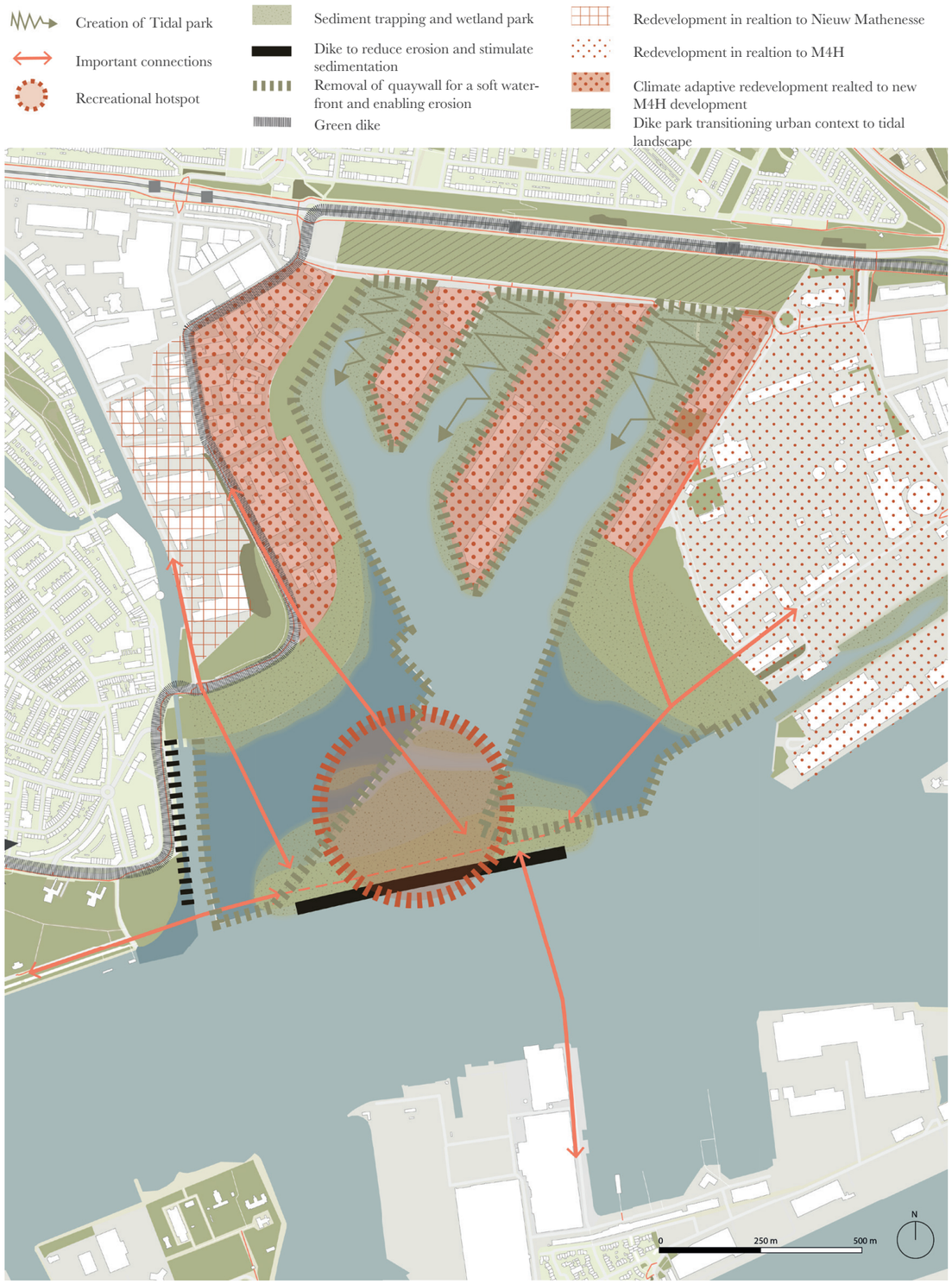


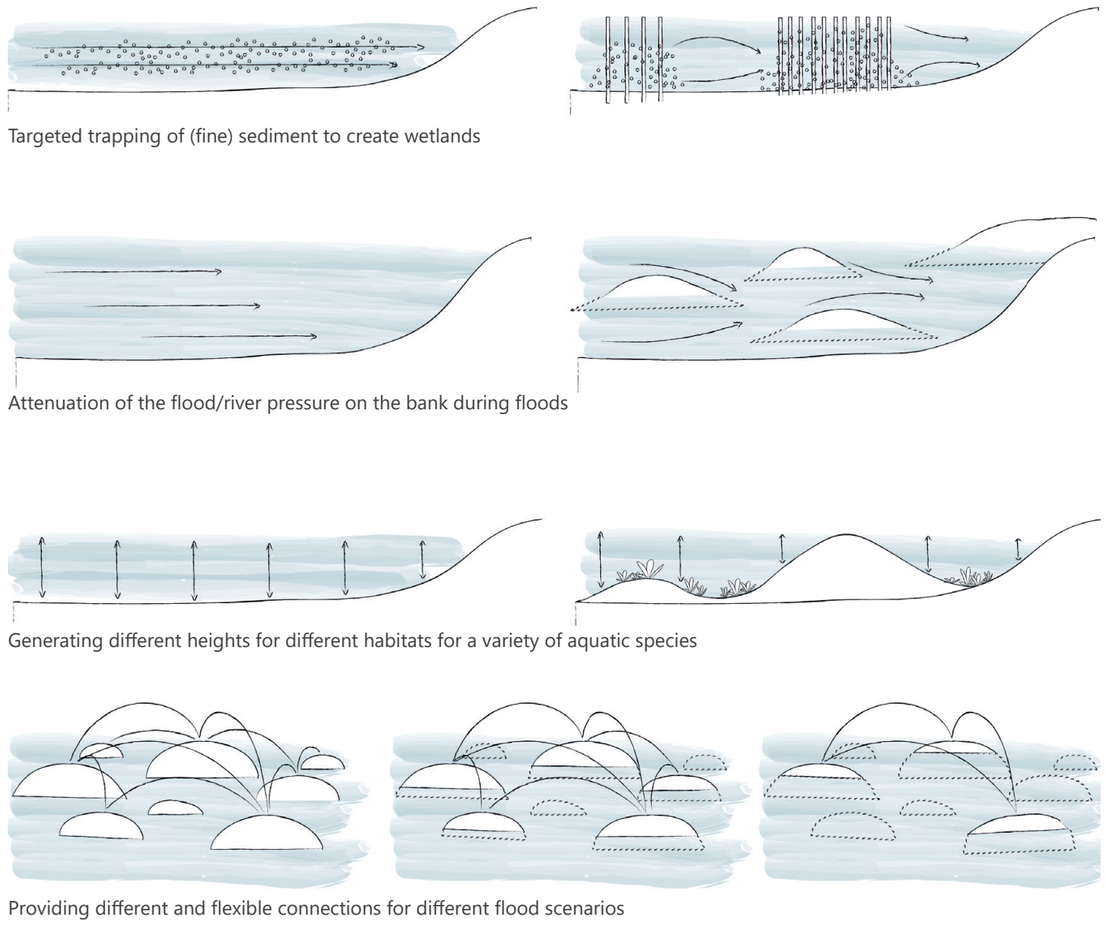

Figure 82: Conceptual plan / *Author*

## From grey to green

In detail, the measures presented are shown in the following map, which provides the basis for the further design. Here you can see the aspirated connections to the surrounding area, as well as the predicted developments in the harbour basin.

## Adaptive strategies

In order to develop an adaptive environment, it is necessary to modify the existing fragile river system in order to stabilize it. It is important to work with the processes and make use of them. The strategies to be implemented in the area to create an urban tidal landscape that is flexible and able to respond to change are briefly summarized in the graphic below. How exactly they are introduced and implemented in the area is shown in more detail in the following structure plan.



Targeted trapping of (fine) sediment to create wetlands

Attenuation of the flood/river pressure on the bank during floods

Generating different heights for different habitats for a variety of aquatic species

Providing different and flexible connections for different flood scenarios

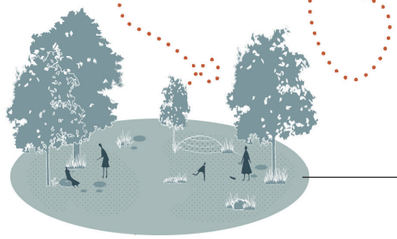
Figure 83: Adaptive strategies / *Author*

# Phasing

*The creation of the designed environment is based on a collection of different strategies and sub-steps/phases, which are intended to form the basis of the system and are based on the aim to work with the water and its natural processes and not against it. They build on each other and are therefore interdependent. The three strategies presented here are related to the site but can also be applied to different "river acupunctures" and adapted to different spatial configurations of river margins. they are, however, flexible enough to be adapted to other specific spatial, social and cultural conditions and to the larger scale concepts.*

## Preperation

Shape and prepare area and community for the new form of use and the increased risk of flooding



## Habitation

Creating the possiblity of co-existence and migration of both human and natural entities and processes

## Expansion

Creation of large scale landscape corridors and connections for the most effective outcome

Figure 84: Project phases / *Author*

## Preperation

The first phase and step is to “prepare” the processing area for the new form of use and the increased risk of flooding. Both socio-economically and spatially. The goal is to create a collective acceptance of living with water instead of fighting it. In doing so, it is a matter of expanding and building the awareness and responsibility of each individual towards the environment. The measures in this phase have a direct influence on the dynamics within the natural river system and are intended to act as the first steps towards adapting to rising sea levels.

Measures can include restructuring of land use, which can lead to relocation, elimination, elimination, or environmental improvement of previous uses, some of which were environmentally harmful and unsustainable. Another measure is the cleaning of the waterfront and the processing area. This not only improves the local system, but also has a positive effect on the rest of the flow and strengthens the connection of the area to the urban (economic) cycle.

## Habitation

In the habitation phase, the aim is to make it possible for people to coexist in the delta or, in this case, in the outer dyke areas. It is not exclusively about making the area suitable for human habitation, but about designing it as a natural landscape infrastructure, based and built on the natural processes. This offers the possibility to create a new perception of the river and the city. The previous hard boundary between the entities will be dissolved and porous, creating a new in-between space with the possibility for symbiotic activities. In this stage it is necessary to work with the dynamic and temporality of the natural processes in place. Accordingly, the flexibility, permeability and fluidity in the new and temporal uses must be particularly considered and incorporated. This offers not only space and attention for nature for example its tidal currents, but offers the possibility to integrate the local community and its needs and habitat structure. During the habitation phase, hybrid adaptation measures must be used to activate the area at different levels and create a productive environment. Both humans and nature can benefit from this in the future.

## Expansion

The final, expansion phase is about working across scales and creating regional connections and corridors to maximise the effectiveness of the project. Through connections and expansions, the aim is to create a resilient, site-specific and adaptive space that works with and benefits from nature. Here, individual steps from different dimensions are combined and linked creating an integrative habitat for humans and animals. In this phase, migration corridors are created and landscape networks are revived. Furthermore, this phase includes the maintenance and promotion of what has been achieved before in order to achieve the best possible effect on the larger system. Here, the coexistence of all stakeholders is made possible on a wide scale.

## Mud becomes habitat

The basis of the concept is to take advantage of the natural sediment flow in the Meuse to create an adaptive ecosystem that grows naturally with the water level and is considered a natural flood protection. Until now, excess sediment flow in the Nieuwe Waterweg has been a nuisance byproduct of increased water flow. The excess silt that settled to the bottom had to be continuously dredged until now to keep the stream navigable for the low-lying vessels. (Kirichek et al., 2018) The approach of intercepting a large portion in the inner-city areas and utilizing the nutrient-rich sludge there not only offers the possibility of relieving the harbour area and minimizing the continuous and ecologically harmful deepening and dredging, but also offers the basis for creating an inner-city ecological system and rehabilitating the former landscape of salt marshes. How exactly this process can take place can be seen in the graphic below:

The mud and fine sediments are trapped by the constructed infrastructure. The resulting sandbanks and marsh plains are planted with native plant species of the marsh to stabilize and fix the still loose sediments. Over time, a qualitative habitat can grow out of this. The expansion of the infrastructure and the slowing down of the river will allow this process to continue and to spread further.

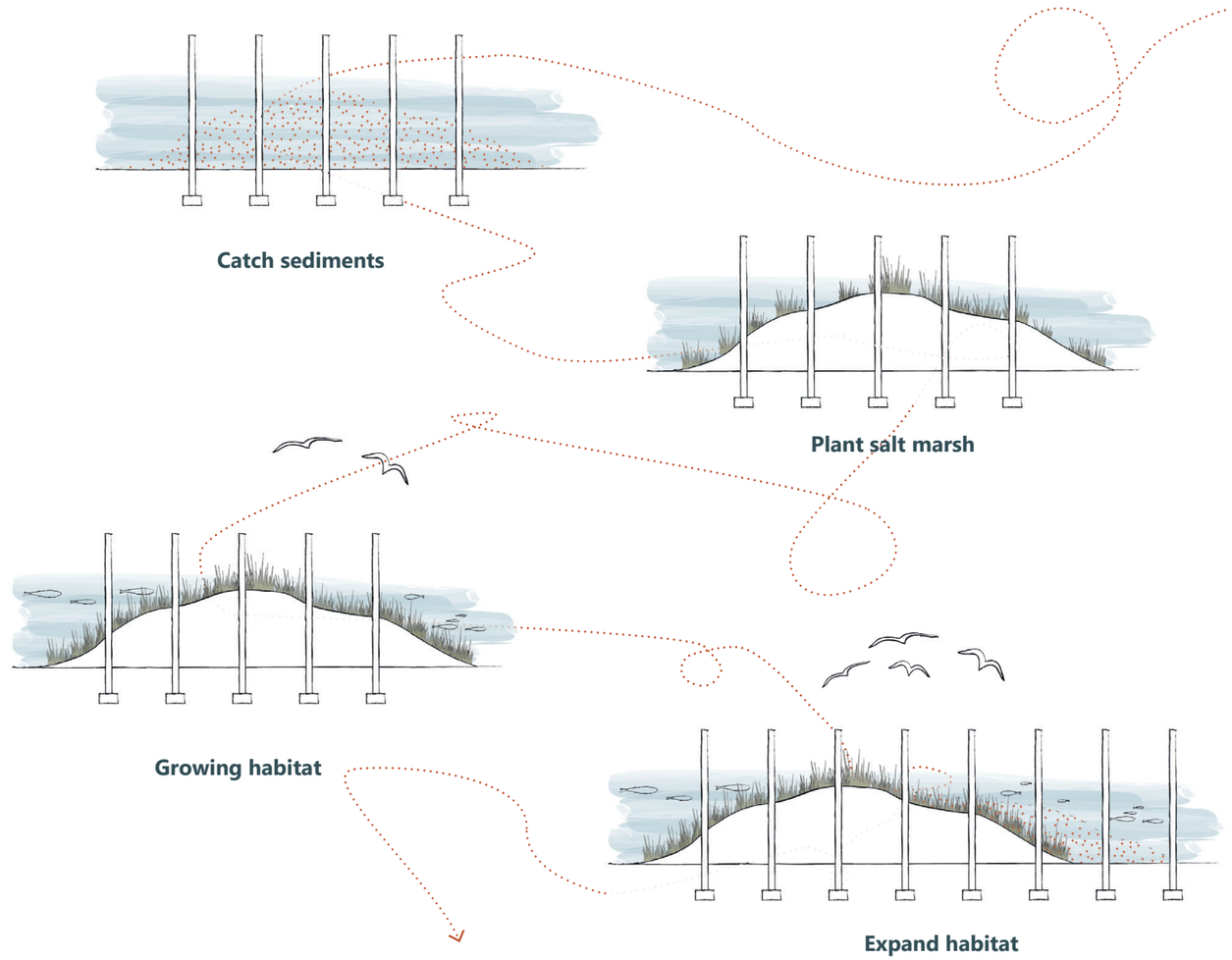



Figure 85: Creation of salt marsh habitat / *Author*

## Terrain restoration concept plan

Based on the previously presented sub-steps of the project, a series of site-specific plans for the area was developed to guide the macro-vision of the potential reconstruction of the wetland and lay the foundation for an urban development. Based on the slow process of natural development, a large part must be prepared before the key intervention of a new neighborhood can be developed on the selected site.

**1 Embankment Breaching**

In the first step, the quay walls and hard waterfronts, as well as the old buildings along the shore, are removed. Instead, the area will be planted with purification plants to clean the partially acidified soil of the area caused by the industry.

**2. Erosion**

The now soft and unprotected riparian edges are now exposed to the natural erosion processes of the river. Especially the entrances to the harbour basins behind are accordingly quickly eroded by the fortex often created there by the tides and river currents. The removed soil is partly drifted downstream or deposited in the old harbour basins of Meerwede-vierhaven. Furthermore, the dredged silt can be used for dike improvement or as a base for construction in Nieuwe Mathenesse.

**3. Permeable dike**

After the old embankments have been eroded to the desired point by erosion, the newly placed, now soft banks must be fortified by planting to prevent further erosion. The river is now wider and slower at this point, which favors sediment deposition, which is already happening by itself in the almost still harbour basins. However, in order to accelerate the large-scale and deliberate creation of salt marsh, a permeable dike is used to protect the inner area from the flow of the river.

**4. Sedimentation**

With the help of the permeable dike, a sandbank could be created and the basic building block for the salt marsh. Now the development of the area can begin. The stilt construction of the paths and buildings also help to trap more sediment and further expand the ecosystem.

**5. Stabilization**

The development can grow organically with the salt marsh and is now part of the urban fabric. The resulting sandbars, islands, and marshes are fortified with the help of additional native plants to support the unfolding of a biodiverse habitat.

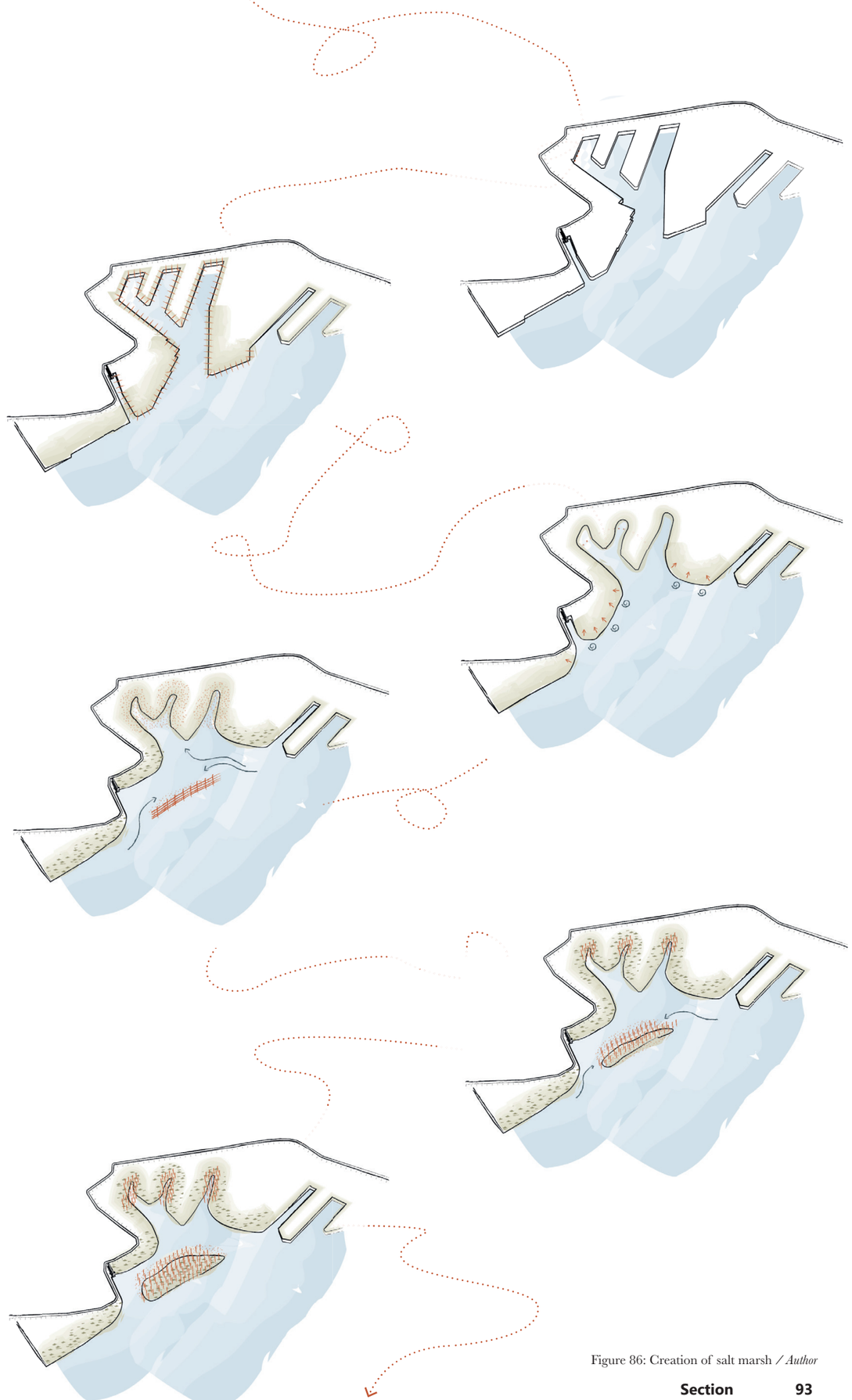



Figure 86: Creation of salt marsh / *Author*

## Settlement concept plan

Outlined in the settlement plans are the general principles of how the new neighborhood will be built. The focus is not on the exact layout of the area, but rather in the principles that form the basis of the neighborhood and allow it to grow in the first place.

### 1 Relocation

In order for the erosion and restoration process described above to occur, some of the development along the water's edge must be relocated and demolished. The areas affected by this are particularly those at the tips of the harbour quays. Meanwhile, the old harbour basins along the dike can already become the basis for a new urban use and the start of the new waterfront neighborhood.

### 2. Densification

As the erosion process occurs along the area peaks and the first sediments settle into the quiet harbour basins, the surrounding existing areas can continue to densify and create a more nature inclusive but dense environment.

### 3. Amphibious connection

The restoration of the salt marsh in the old harbour basins continues to progress. The area is becoming drier, and the original development may need to be adapted. As a better foundation for more static and adaptive development is created there, the floating buildings can be relocated and help create an urban and amphibious connection along the permeable barrier.

### 4. Marsh development

The current-calmed area behind the dike provides the basis for the creation of a sandbank and the rehabilitation of the salt marsh. In order to connect this area with the urban surroundings, new impulses will be created here. The resulting urban development adapts to the surroundings and becomes partly permanently anchored, which in turn helps the sedimentation process.

### 5. Expansion

Through the incentives created, an adaptive neighborhood is developing in and on the marsh and river. This has the potential to spread over time and create further connections.

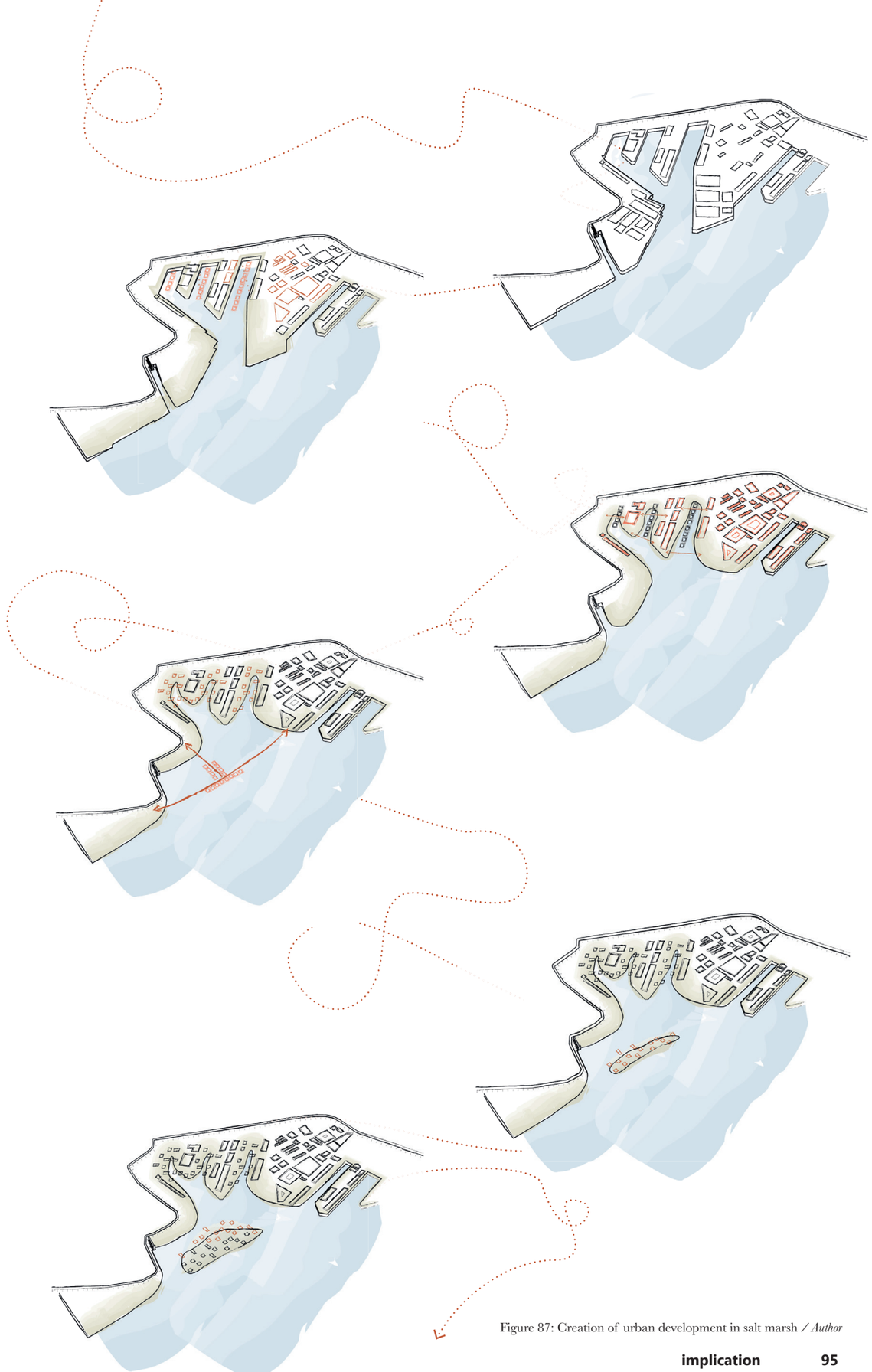



Figure 87: Creation of urban development in salt marsh / *Author*

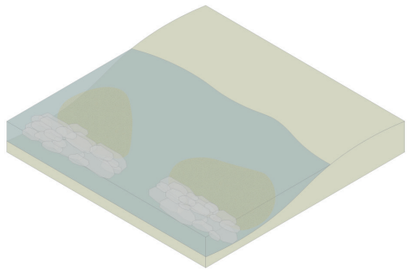
Figure 88: Adaptive building strategies / *Author*

# Design catalouge

Creating an adaptive environment in floodplains and outlying levee areas presents certain difficulties, as discussed previously. To create a concrete mitigation strategy to transform the riverfront into a productive landscape infrastructure, a design catalog based on circular strategies was developed. This will help to increase the living conditions in the outer dike areas; to activate the site and increase the awareness towards the environment; to better integrate the area into the landscape and work with the natural conditions; to generate migration, both for animals as for humans. The design typologies presented here can be implemented sequentially over the development period of the neighborhood and/or city. In doing so, they work both individually, but also in conjunction with others. The application strategies presented here offer the opportunity to improve the basic understanding of the environment and its processes, as well as to enable improved management of scarce resources. This methodology will enable site-specific responses to today's challenges and will enhance the ecological robustness, adaptive capacity, and self-sufficiency of local communities.

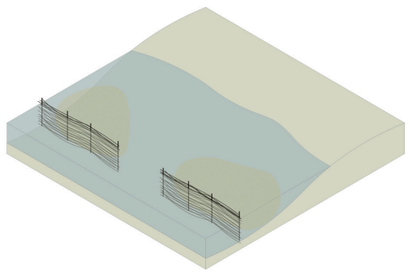
## Techniques to create a salt marsh

To make it possible to return to a "natural" river front and mimic the landscape the river would have historically created itself without interference, human intervention is needed due to the current instability of the river system. Several techniques can be used to enable the restoration of the natural, local ecosystem and to provide room for tidal environments, such as salt marshes. The goal is to find natural solutions that can enhance, accelerate, or mitigate the natural tidal currents and sedimentation and erosion processes and allow development in the area. In the following section, we will present some of these solutions, which will make it possible to attenuate the water currents and allow a "targeted" settlement of sediments. It is worth mentioning that the mentioned measures are related to the treated area. Several other solutions are known to exist, but not suitable for this case study, for instance, location-specific conditions not allowing them, which is why they have been omitted.



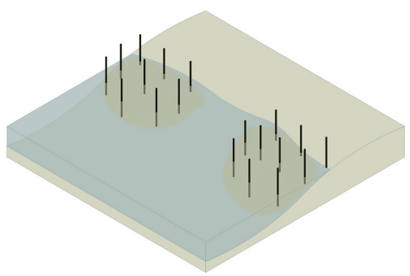
**Living breakwater**

protects the shore and break waves and attenuate backflow. In this way, they create a calm area in which it is possible for sediments to settle. They also provide a habitat for a wide variety of marine animal and plant species, such as mussels and algae, and a refuge for fish. They can be made of different materials, such as shells, stone or concrete and therefore offer the possibility to reuse parts of the former quay wall.



**Permeable dike/dam**

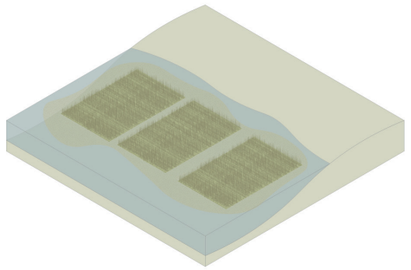
has a similar benefit to living breakwaters and offer a more sustainable alternative to a classic dam or dike by maintaining the flow of water. They also protect the shoreline and provide space for sediment to accumulate behind them. They can also be made from a variety of materials, both organic, such as wood, which has the potential to decompose slowly over time, and static, such as stone.



**Poles**

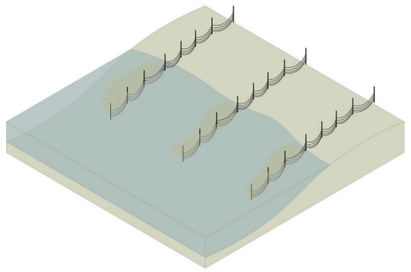
attenuate and minimize the tidal flow and create a protected area in the spaces between them. Their exact arrangement is not particularly important and does not have to follow any particular pattern. However, it can be expected that the closer together they are, the more effectively they trap sediment.

Figure 89: Sedimentation trapping methods / *Author*



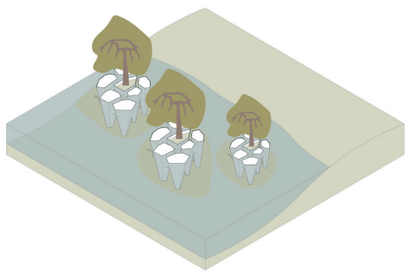
**Planting mats**

help to establish tidal habitat. native and salt marsh species are planted on coconut fiber mats, or other organic and easily settable fabrics that can float on water. This protects the young plants during their growth phase. They fix the substrate with their roots. The organic fibers will dissolve over time, while the stronger plants will remain standing.



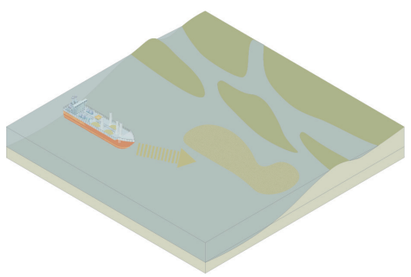
**Sand net**

is often used in the restoration of dunes and minimize the blowing and washing away of sand and sediments and trap them. Accordingly, they accumulate around them, especially in their lee. Once the sediments have collected to a certain extent, the nets can simply be moved somewhere else, where the process is repeated.



**Rizolith island**

is a concrete planter embedded or floating in the ground, planted with wetland plants and/or trees. The plants are protected from tidal currents and waves. Holes in the tub walls allow the roots to emerge, which can stabilize the soil and trap sediments. It also provides a habitat for aquatic life.

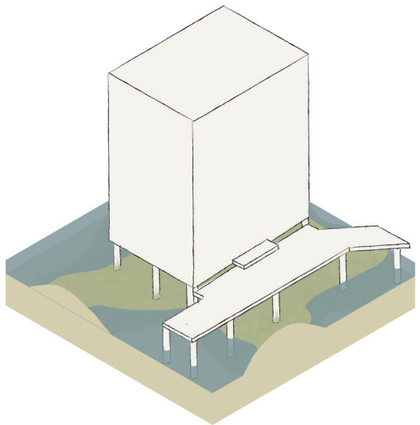


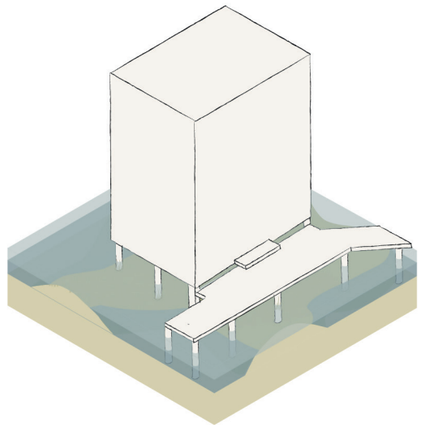
**Mud motor**

is a strategy in which dredged mud from the river and delta basin is dumped in specific locations near the marsh. The tidal current then carries it to the marsh and redistributes it naturally. In this way, the sedimentation process is accelerated by additional material.

## Adaptive architecture

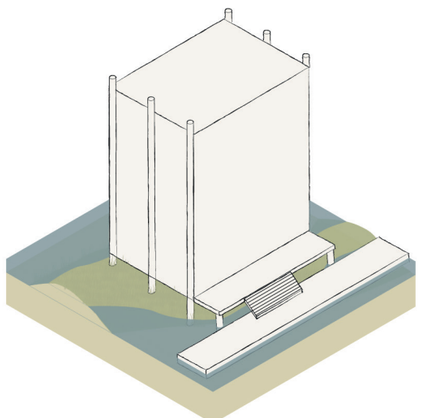
To achieve the goal of a new landscape infrastructure and a new living environment between the river and the urban space, different types of aquatic architecture are used. This makes it possible to create an adaptive urban structure and to react to different flood scenarios in the future. In this way, an urban space can be created that is not only located on the river with a view of it, but becomes part of it and enables an interplay of the two entities. These typologies have been briefly mentioned before and will be described here in terms of their function and influence in the design and are based on Nillesen's (2021) research on aquatic architecture in the Netherlands.

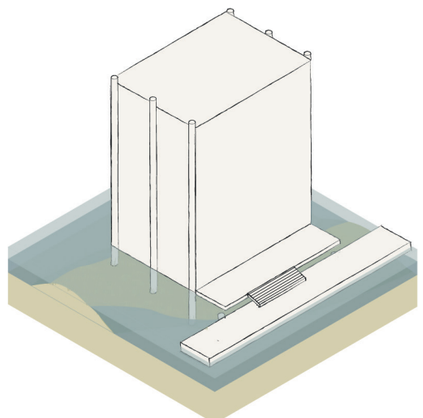




### Stilt/pile buildings

are elevated above sea level and the highest expected water level of the river. There can be a range of elevation levels to play with, with levels that can be flooded if necessary and areas, such as the living compartments, that are at a safe height even in the event of a high tide. The pillars are anchored in the ground and help to trap sediments.

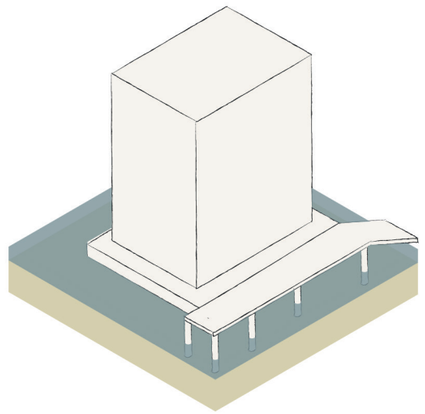


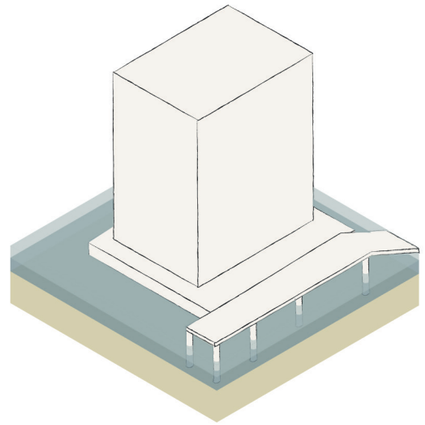


### Amphibic buildings

are similar to stilt buildings and follow the same principle of building above the landscape to give space for the landscape to unfold below. However, amphibious buildings could be built at a lower level because their vertical flexibility. Meaning their structure is designed to adapt to the water level and, if necessary, to detach from their foundation and float.

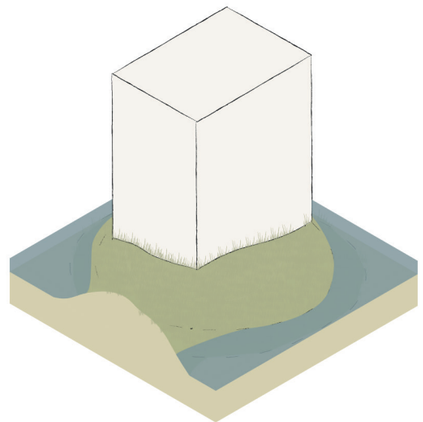


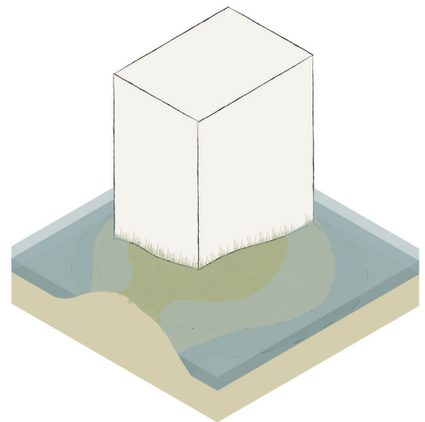




### Floating buildings

is a building that is able to constantly float on the water due to its low mass. It can be held in place by various elements, such as an anchor. Due to the fluctuating plateau height, the access must also be adaptable in hight. It is the most flexible typology and has the possibility of being quickly replaced or relocated.





### Terp building

are built on an (artificial) elevation in or along the river. There they are firmly established, and may have to be additionally water-protected in order to achieve a higher adaptive capacity. The mound can be seen as the starting point of the marsh and can spread out from there or connect with the rest.

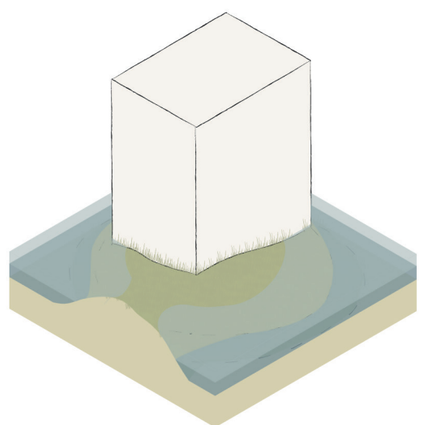


Figure 90: Adaptive architecture typologies / *Author*

### Waterproof building

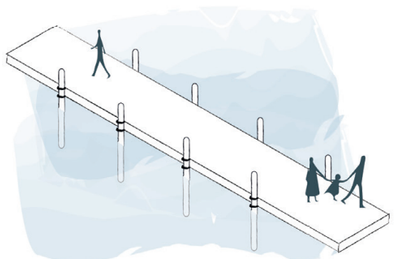
are built on an (artificial) elevation in or along the river. There they are firmly established, and may have to be additionally water-protected in order to achieve a higher adaptive capacity. The mound can be seen as the starting point of the marsh and can spread out from there or connect with the rest.

## Adaptive connections

For a dynamic area undergoing constant change, adaptive infrastructures are required to keep the area connected and accessible under different environmental conditions and flood scenarios. This creates different levels that allow new relationships to emerge not only between different facilities but also to the landscape. Some more and some less flexible. In the following section, a few of these are presented as examples.

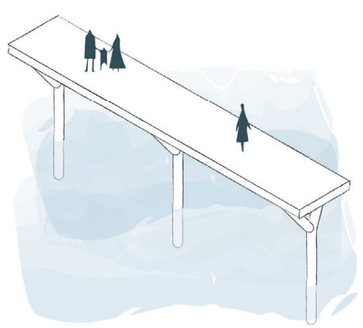
### Floating path

With floating paths, a high degree of flexibility can be achieved. Here, users are guided very close to the water. These paths are completely at the mercy of the tides and water levels and are anchored to the bottom by chains or similar. The modular construction makes them easy to expand and change.



### Amphibic walkway

Amphibious walkways are a smart way to create barrier-free paths on uncertain ground. Due to their stilt structure, among other things, they are durable and less invasive walking platforms, for example suitable for wetlands and marshy environments, which can adapt to the water level if necessary due to their amphibious design and can float if necessary. In this way, they create safe connections in a wide range of scenarios.

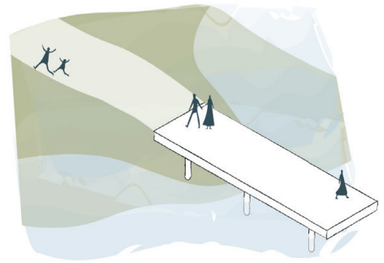


### Lifted street

It is possible to raise paths and roads high enough using columns or stilts so that they remain outside the hazard zone. This strategy is also less invasive to the surrounding landscape and is particularly suitable for essential escape routes and infrastructure, as they are to lift heavy weights and are little impacted by the environmental changes once completed. A disadvantage of these is that they are highly static and therefore not as easily altered.

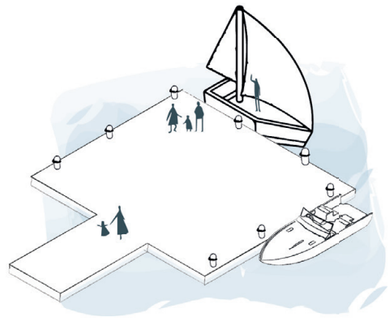
Figure 91: Adaptive connection types / *Author*





### Floodable path

It is also possible to leave pathways exposed to flooding and not move them out of the danger zone. However, these should only be less important routes. It offers the opportunity to visualise and maybe educate users about the impact of tides and floods in the area. Flooding of the paths can be occasional or even permanent, in which case the old paths could be used as a base for marine life (for more on this, see the following page).

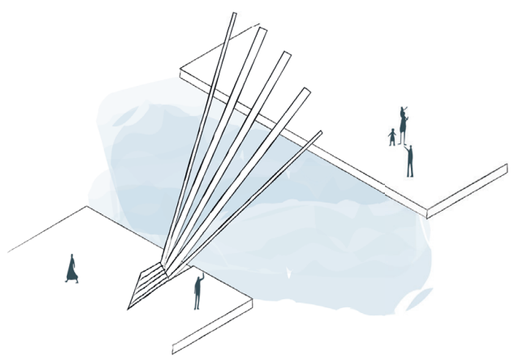


### Boat landing stage

Connections must not only be made from the land side, but also water sideways. Accordingly, the infrastructure of the river should also be improved, for example by means of private and public boat landing facilities, which make water mobility accessible. In this way, interlinking with the river can be further promoted by shifting the river more into the center of a community. Water mobility can be both individual and public transport.

### Movable/floating bridge

It is also possible to provide floating bridges that can be kept mobile allowing pedestrians and users to feel the river as they cross. This makes these installations very flexible and can be used and positioned in different situations and locations, so that connections can be maintained even in extreme situations that could otherwise be interrupted.



### Foldable bridge

With the help of installed foldable bridges, connections can be made that are not constantly needed. For example, such bridges can only be “unfolded” at high tide, as a ground connection is available at low tide. Such bridges can be installed on top of buildings or platforms, for example. In order not to create a visual barrier, there are various ways to make the folded state look more like an art object than a cemented wall as it is currently often the case. Examples of such bridges are “The Rolling Bridge” and “Merchant Square Footbridge” in London.

## Catalysts for an inclusive community

There are different ways to activate an urban area and make it lively. Accordingly, a compilation of different catalysts that can take place in the proposed development has been made. The activities listed include specialized and more site-specific types of functions, as well as everyday ones, such as cafes, restaurants, and supermarkets. Often the different subgroups overlap and list some of the same cultural drivers. This reflects the high and targeted porosity in the area.

When selecting catalysts, the connection with water is particularly important. Accordingly, care was taken to ensure that at least one of the listed activities takes place on water or is at least strongly connected to it.

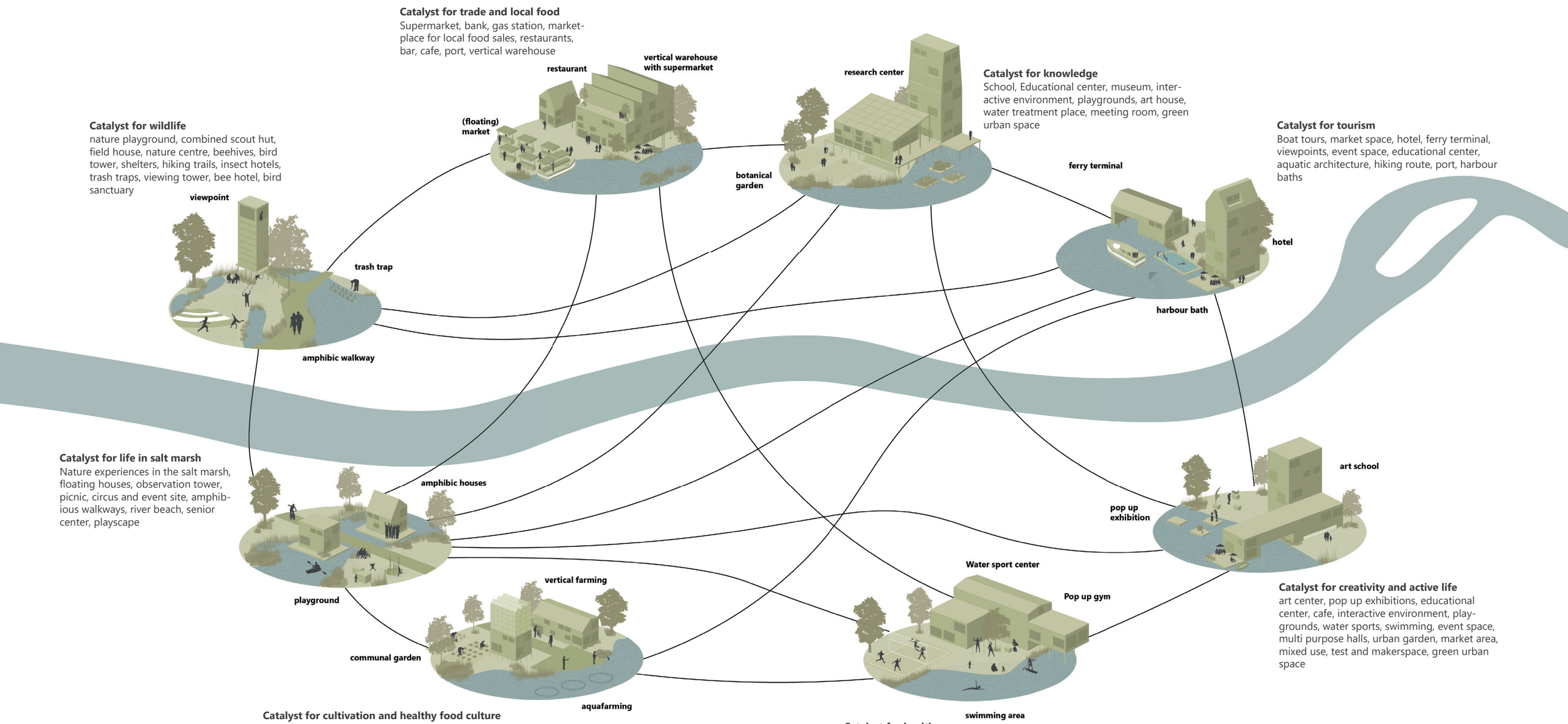


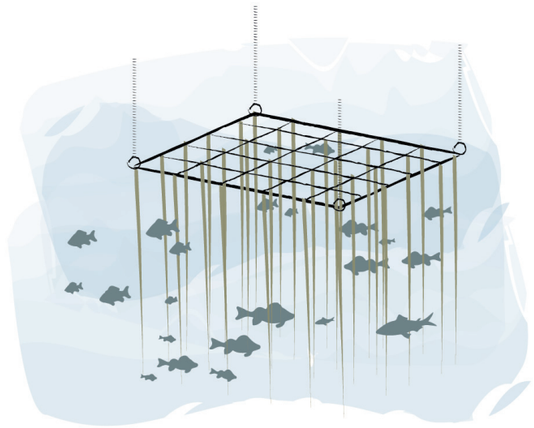

Figure 92: Possible catalysts to achieve an activation of the outer dike area / *Author*

## Promoting maritime habitats

The aim of the project is to reinforce the ecological system of the delta. In order to also support the development of habitats underwater that might not be visible to humans at first, aquatic life promotors can be used that imitate natural conditions and can thus bridge and/or replace "real" natural spaces and/or accelerate the development time of them. They have the opportunity to be installed on their own, in connection to others or be attached directly to the built environment, such as under buildings or walkways, or even on stilts. This allows urban structures to no longer confine the natural environment and suppress it. Instead, they connect the urban with the natural environment and incorporate the maritime habitat. In doing so they could even become the basis of it, if necessary. In this section, some artificial ways are presented that are currently already practiced and aim to attract and preserve wildlife.

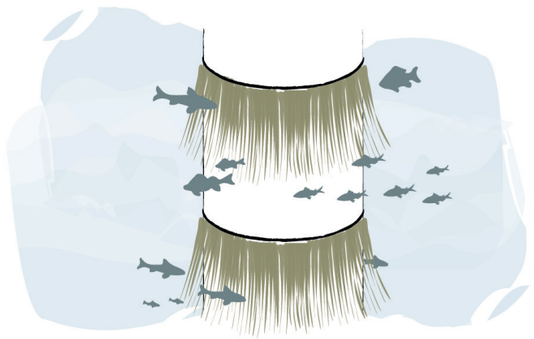
### Limnetic curtain

Limnetic habitat curtains can be installed underneath buildings, platforms, docks, and walkways. The curtains are a steel frame with nylon strands attached to the wire mesh inside of it. The hanging nylon straps provide an opportunity for sessile organisms such as mussels to colonize or an algae growth that serves as food for the fish population in the river. (Al-Kodmany, 2020)



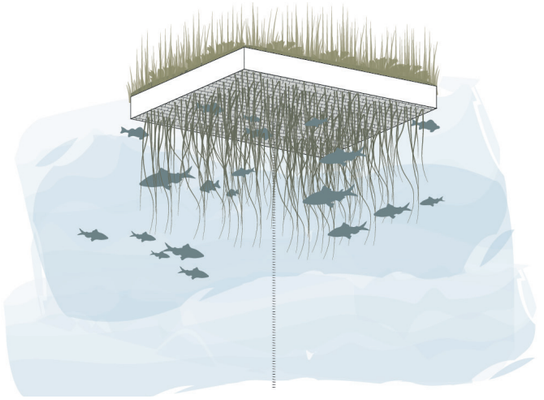
### Pole hula

Pole Hulas are rings with nylon strings that can be attached underwater around the poles of the buildings and walkways. Like the curtains, they are suitable for algae growth. Moreover, they provide a suitable breeding ground for amphibious insects. These are also one of the most im-portant food sources for the local fish and shellfish populations. (Al-Kodmany, 2020)



### Floating wetland/forest

Floating wetlands have several functions and advantages. On the one hand, they offer the possibility to clean and filter the river water through permeable used soil, which functions like a sponge, as well as through the plants and their roots. They work like a natural biological filter. They remove nutriens and lower the nitrogen and phosphorous levels in the water, which improves the living conditions for the fish and wildlife population of the water. On the other hand, they serve as a habitat for animals above and under the water. The roots just below the water's surface can serve as a shelter or food source, while the wetland provides breeding habitat for birds. (Al-Kodmany, 2020)



### Lunker

Lunkers are perforated steel cylinders that can be attached to a variety of underwater objects, such as the piles, but also caissons and the like. They provide shelter for fish and other marine life and protect them from strong tidal currents and predators. (Al-Kodmany, 2020)

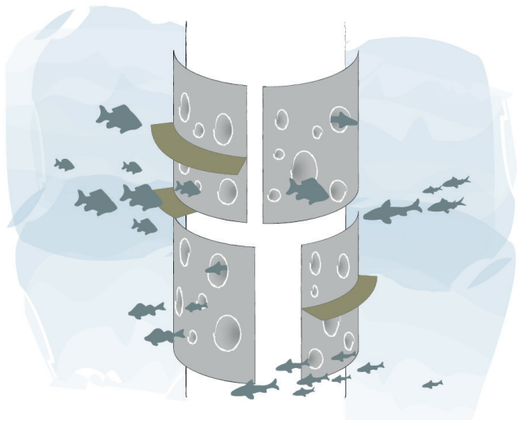


Figure 93: Maritime habitat promotion technologies / *Author*

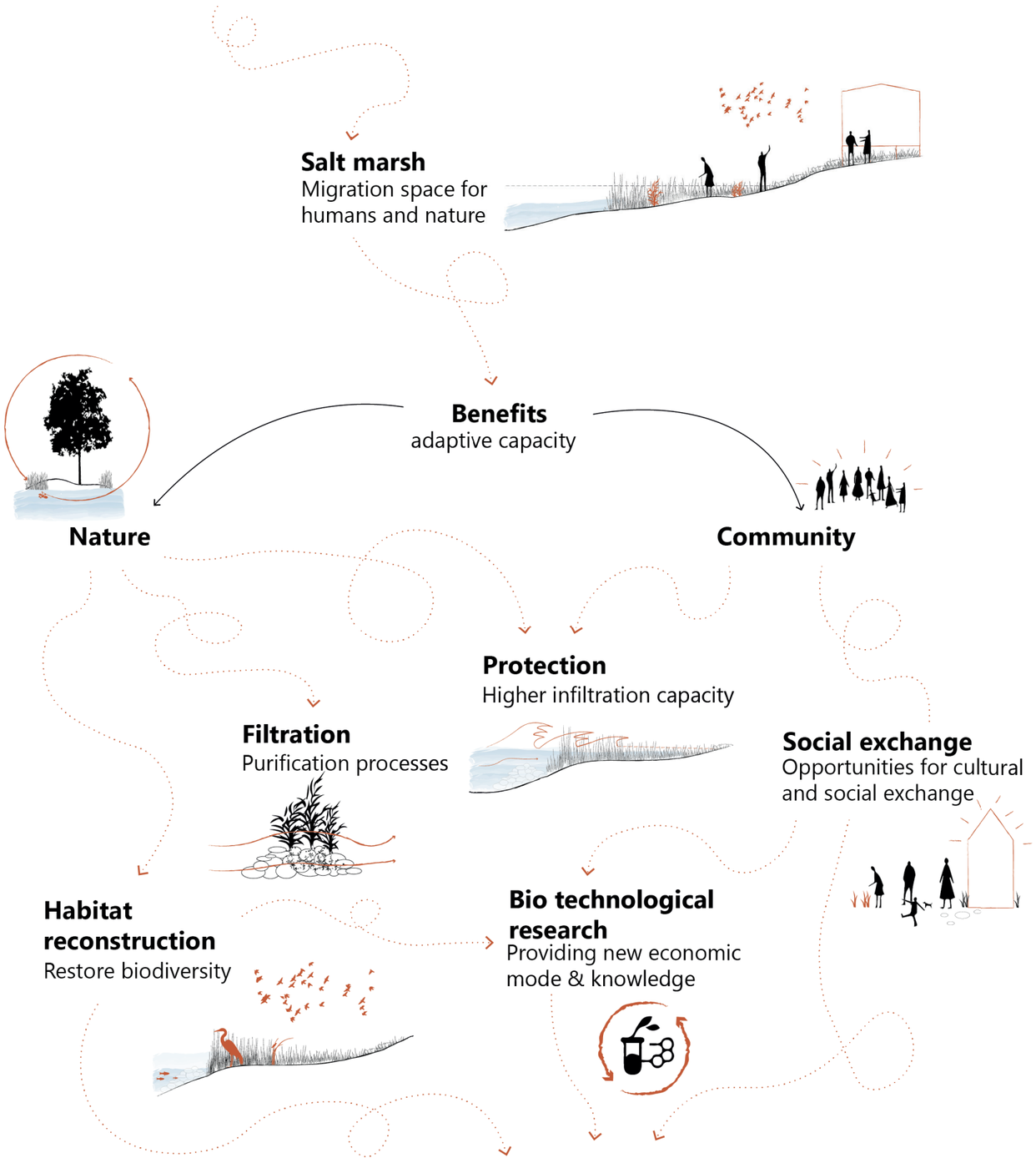



Figure 94: Creation of productive landscape / *Author*

# Projection

*In this chapter, the concept developed, and the related design techniques and development phases compiled earlier are applied to the field of work in concrete terms. This demonstrates their applicability and gives an insight into possible future implementation perspectives.*

By applying the strategies presented earlier, it is possible for the M4H territory to become part of an integrated urban delta system. The creation of a unified identity and rehabilitation of the ecosystem of the salt marsh creates a new relationship between industry, ecology and society. Creating in the former port area a productive ecological waterfront of the new century.

The recreation of the salt marsh not only creates a (ecologically) healthier environment. The dynamic and adaptive landscape offers more space for the river due to the gentle banks and a higher infiltration capacity and can react to different flow scenarios with its infrastructure. The creation of a collective riverfront also creates social benefits and strengthens the community. With the help of new landmarks and opportunities for cultural and social exchange, a socially and spatially porous space is created, which is inclusive of all stakeholders.

The different heights of accumulated sediments in the marsh create different habitats and allow visitors to directly experience and visualize the tides and water currents. The tide regularly creates and shifts a new waterfront in the area. At the same time, access to the area is always secured by a multi-layered infrastructure. Even in a high tide scenario, the primary infrastructure remains intact through elevation and mobility, permanently securing escape routes.

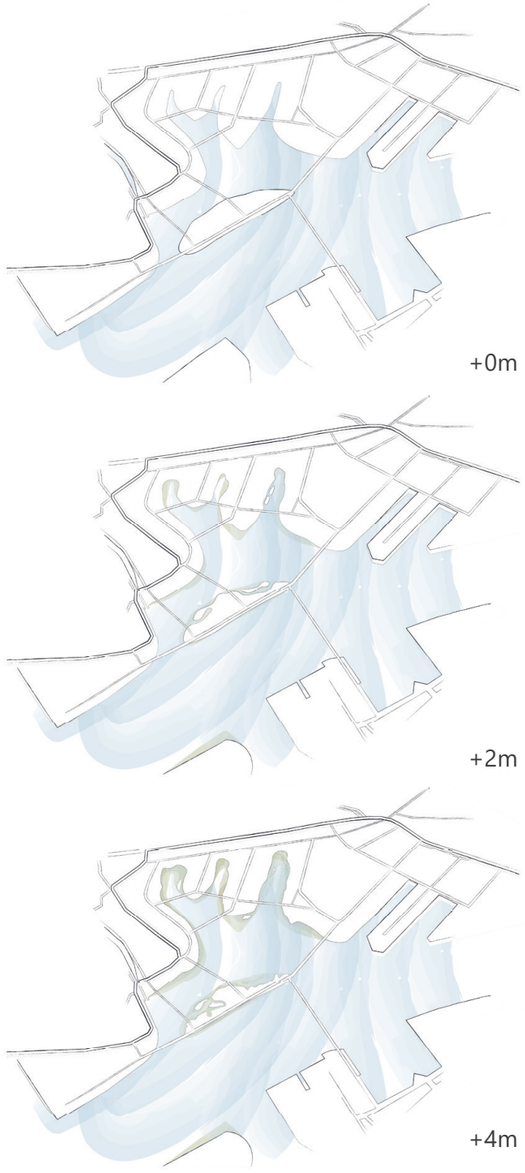



Figure 95: Area in different flood scenarios / *Author*

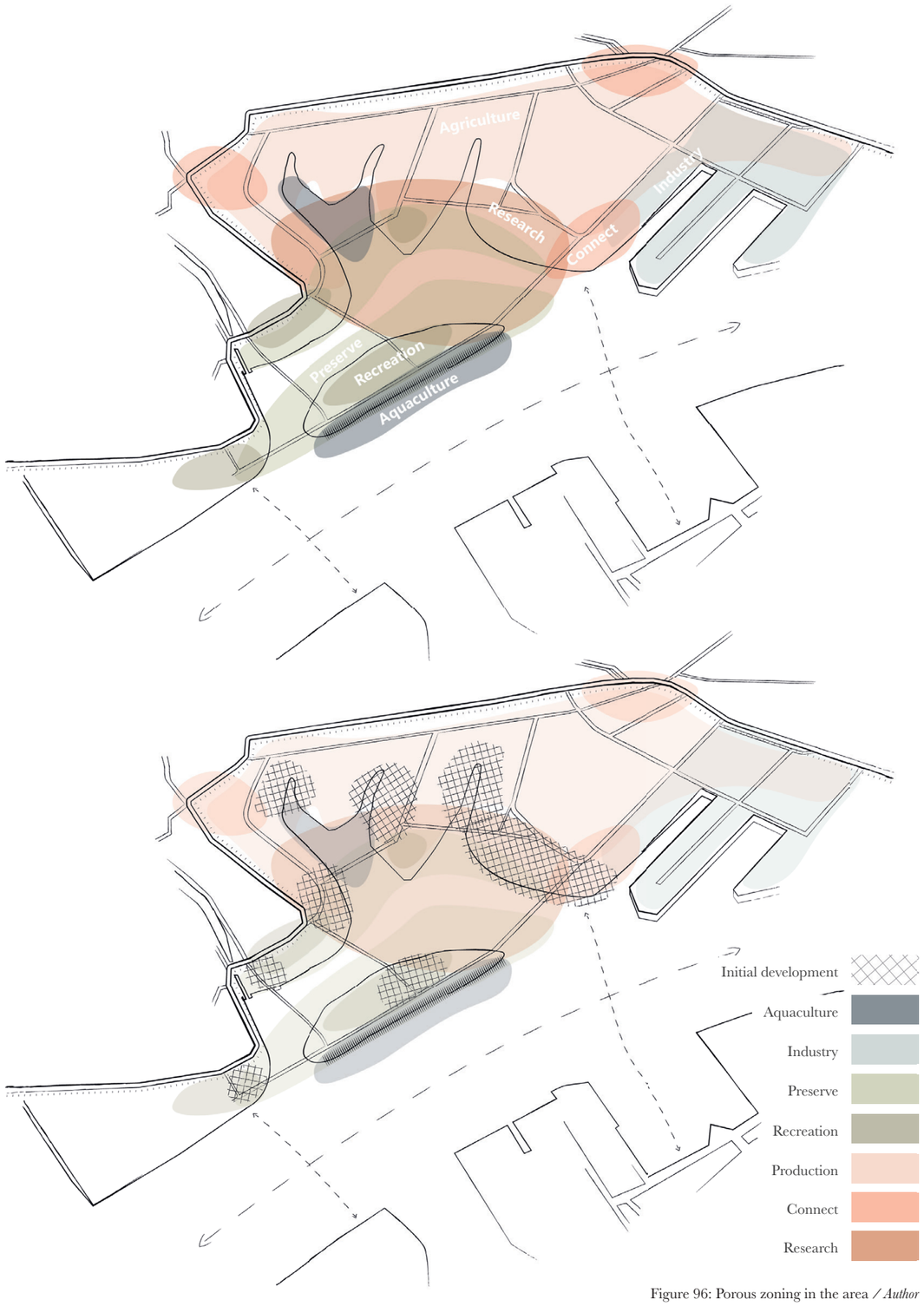



Figure 96: Porous zoning in the area / *Author*

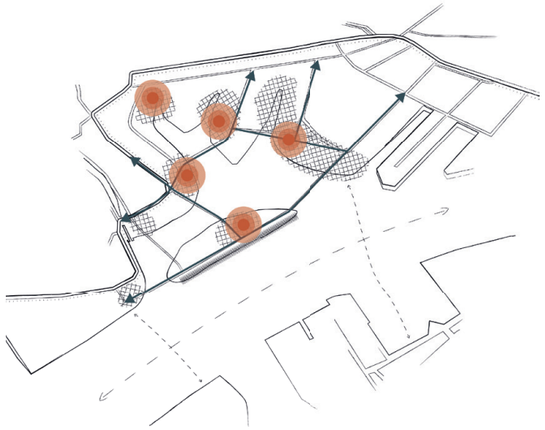


Figure 97: Possible location of cultural drivers in the area / *Author*

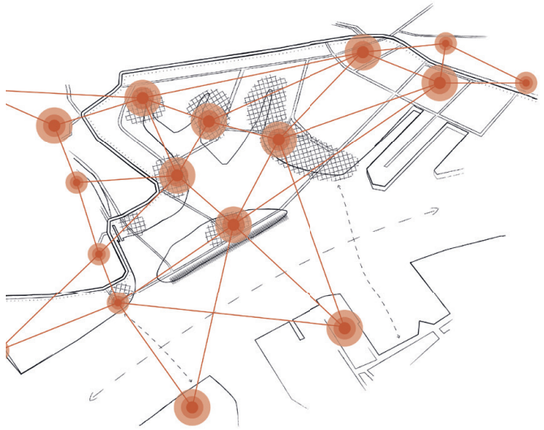


Figure 98: Cultural drivers in the urban context / *Author*

## Development zones

The development of the productive landscape creates various porous zones (Figure 92) that are closely connected and interact with each other.

The higher-density former port areas offer a good location to increase urban productivity and build on and benefit from existing social and spatial potential and development in the area. These new inner-city production sites can replace or relieve floodplains outside the city that are potentially inundated in the future. Urban agriculture in the outer levee areas offers the potential to connect the neighboring residential areas with the recreational space, as well as with the existing port and industrial areas. Furthermore, it harkens back to its historic role as a fruit port, bringing consumers back closer to actual production and regional flows and creating the foundation for long-term community equity and resilience. This productivity does not have to take place only on the land. the healthy and clean ecosystem now provided by the restored salt marsh offers a basis for sustainable and small-scale aquaculture that benefits from algae production as well as water filtration and direct access to the river. The outer dike area thus becomes a collective source of natural products that supports the local community. This may increase the awareness of the general public towards the valuable local ecosystem and encourage them to protect it.

The waterfront education zone builds on its natural surroundings in the salt marsh and provides an ideal location for a field research area that extends the RDM campus across the river. Here, local knowledge can be gathered and shared, new technologies, ideas and innovations can be researched, and the history and characteristics of the unique natural ecosystem can be brought to the attention of society and visitors through outdoor laboratories, nature trails and research farms.

In the heart of the area and the salt marsh lies the recreational hotspot. It is a place of deceleration and green connection. Through various nature and water-related activities, such as floating trails, natural playgrounds, water sports center, visitors and residents are brought closer to the local environment through play. Community actions to keep clean, develop and maintain the area can increase awareness and individual emotional investment in the natural space.

Development of the area will start at the intersections of these different zones, and spread out from there. The cultural drivers presented earlier in the design catalog will help. At special infrastructural points in the development areas, targeted points of attraction can be created. With the help of the catalog, it is possible to filter out different activities that fit the conditions at the respective location. In this way, the area fits smoothly into the surrounding area and it's hotspots and bridges the previous void (see figure 98).

## Strategies through local experiences

The design blends the existing conditions of the area with the new uses of sediment recharge and marsh reconstruction. With the desired activation of the different conditions, as mentioned earlier in the phasing of the project, time plays an important role in the sustainable redevelopment of the urban delta system. As can be seen in the schematic drawing, several new programmes, often water-related, are settling in desired locations (shown in figure 93) and along the waterfront. They coexist with neighbouring industries in the river system and create local and trans-regional connections and synergies, making this river community resilient to change.

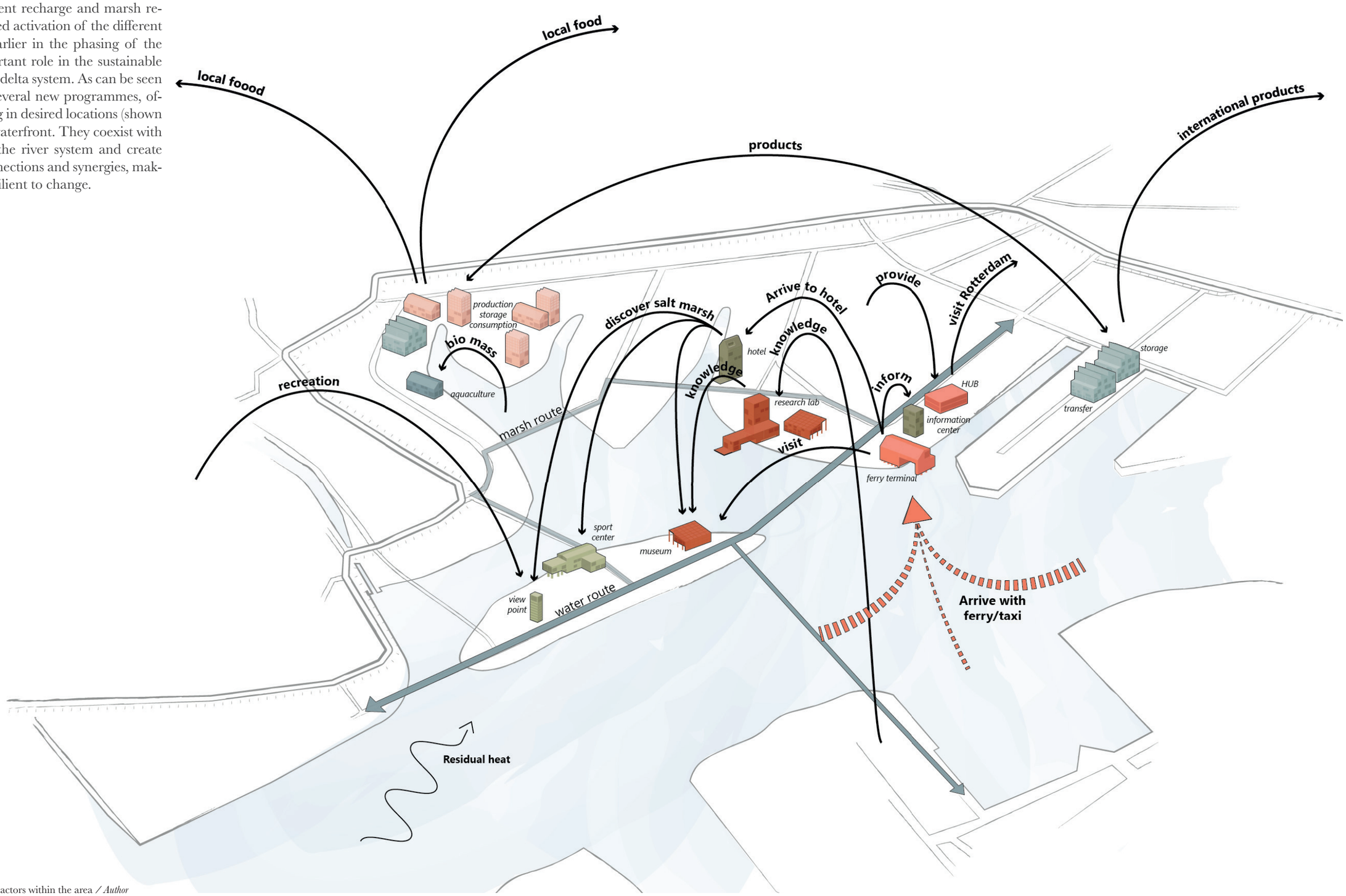



Figure 99: Flows between the different actors within the area / *Author*

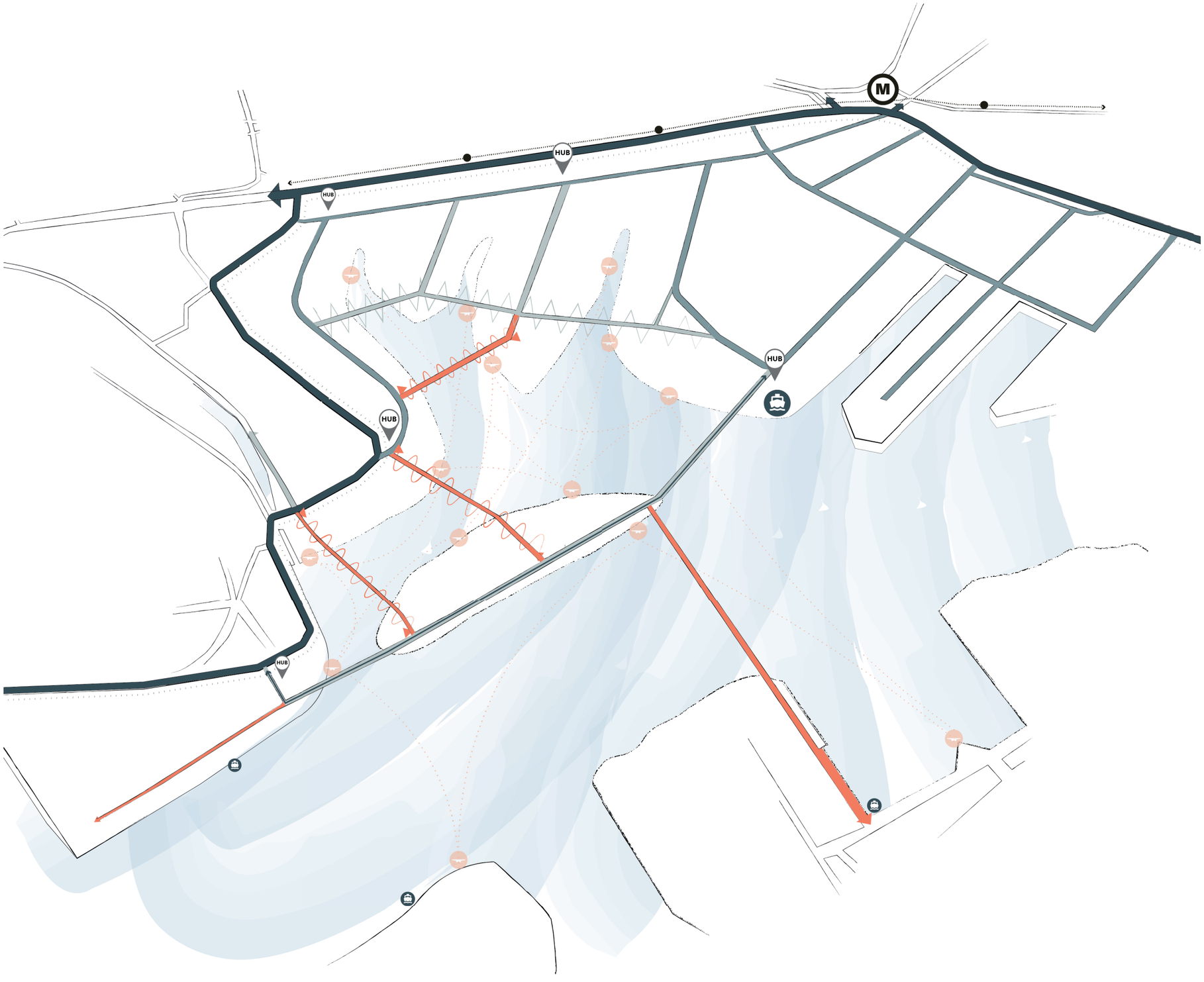



Figure 100: Mobility concept / *Author*

## Mobility

In the draft, the previously strongly car-oriented area is to be calmed down and more space is to be created for slow individual traffic. The existing routes remain as the main routes for automobile-oriented individual traffic. The new routes, however, place a stronger focus on slower traffic and give it a higher priority. Shared spaces are created for this purpose.

The main connection of the marsh island is in connection to the permeable dike. The area is car-free and becomes a fast route for slower traffic, such as electric bikes and boat docks. It thus creates an atmospheric commuter route along the new Meuse, separated from car traffic. The rest of the island will be connected by slow traffic routes, which are mostly oriented towards recreational use.

The car-free area will be served by three shared mobility HUBs located along the regional fast routes. Here, residents can access future common transportation options.

## Typologies

The design incorporates different building systems that create a built environment which respects and supports the marsh landscape. It can be categorized into different subterrains that are determined primarily by their subsoil and habitat condition. In the transition area between the river and land, this can vary from dry to wet. The most elevated and dry areas are old, elevated port areas. They can be partly elevated further and made more fertile by using dredged sediment. Furthermore, the redevelopment of the old quays into a more natural setting will create an attractive neighborhood for not only residents as well as workers but also animals or tourists. (Higher) wetlands will extend along the water's edge in the immediate tidal zones and soften the former hard border between land and water. The salt marsh forms the wettest area and is flooded regularly or sometimes constantly. Where which area and typology could be located can also be seen from the map (see figure 101). The following is a brief outline of the typologies and their specific characteristics.

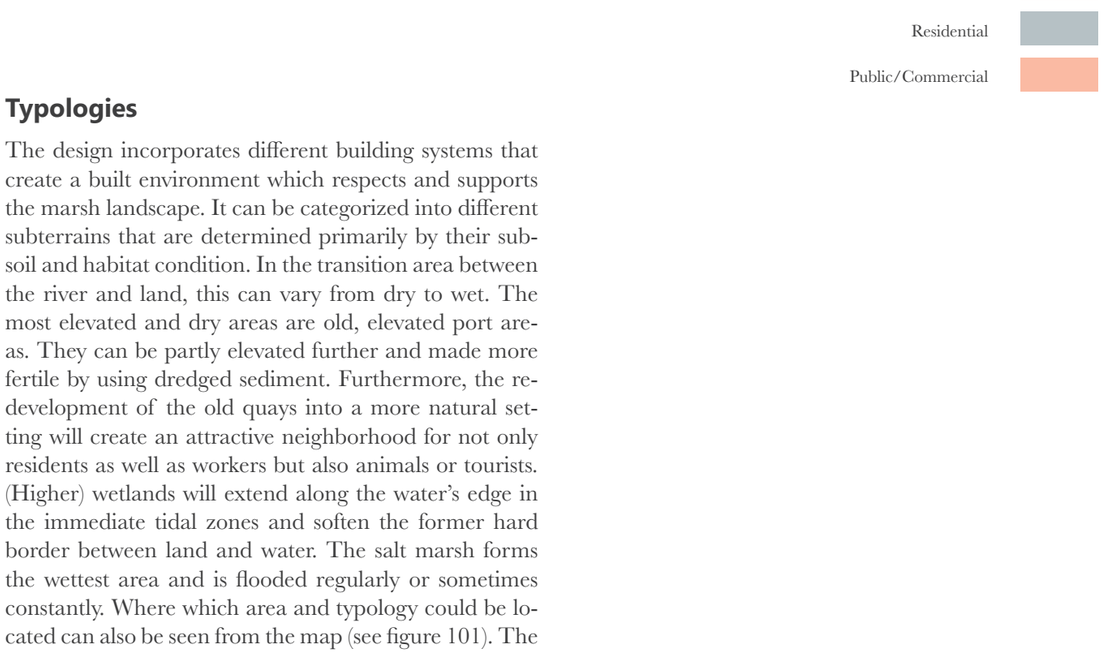
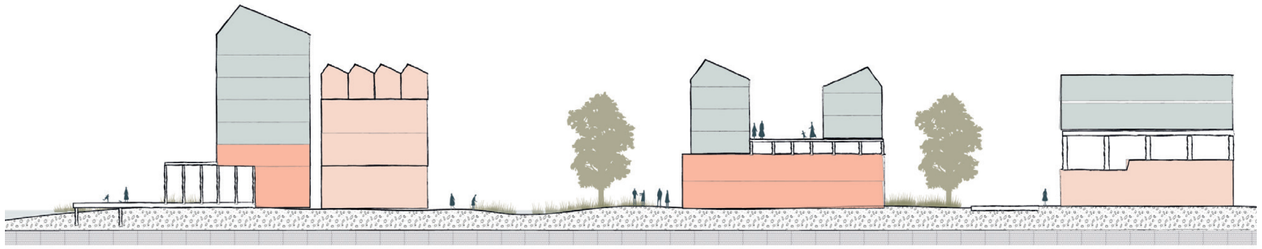


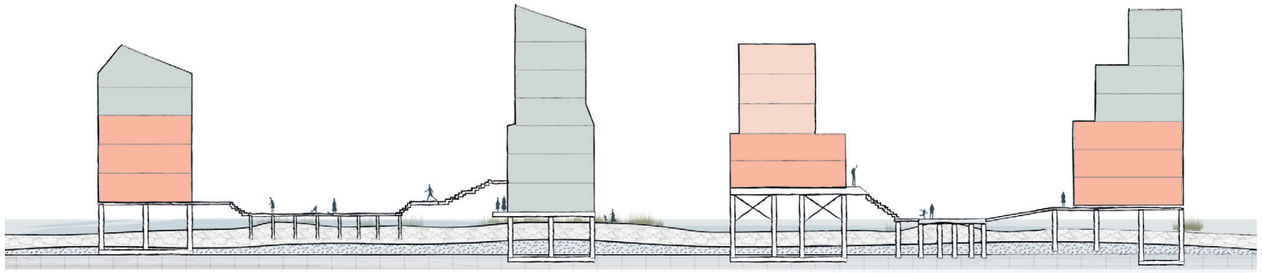

Figure 101: Expected wetness of marsh in site / *Author*





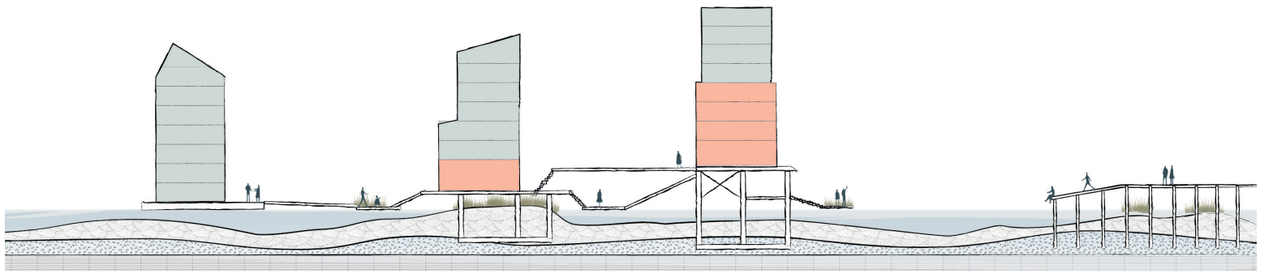

### Dry

In the dry area, the main objective is to densify, adapt and increase the existing buildings. However, enough open space should be maintained to allow water to percolate and increase the quality of the area. The new structures are to be built on existing ones and old industrial land bridging between the scale of industrial halls and mixed and residential buildings in the marsh as well as the surrounding neighborhoods. The ground floors are designed to be waterproof or water-resistant, so that damage is minimised even in the event of exceptional flood events.



### Semi-Dry

The semi-dry area is flooded irregularly and also has partially dry areas due to the small differences in elevation in the tidal park that are not always affected by tidal currents. To reflect the dynamics of the landscape and their uses, a wide variety of adaptive typologies are used, such as waterproof, amphibious or stilted buildings. In this way, the diverse built structures remain responsive and adaptive to water of the Maas, even in the event of flooding.



### Wet

The wettest area, which is mostly located in the salt marsh and at its edge, will be completely accessed by the amphibic and floating structures. In part, it is accessible to via floating docks for boats and jetties and amphibious walkways. This area offers the most space for nature to evolve, which is why the lowest land consumption and a vertical orientation are targeted here. Yet in order to be able to offer an adequate number of accommodation units, the buildings here are higher than in the dry areas, which currently have a horizontal orientation.

Figure 102: Sections showing different typologies in different landscape conditions / *Author*

## Regional applicable areas

If one wants to take the idea of the Merwe-Vierhaven basin further, one can apply it to the other (post-industrial) inner-city port areas in Rotterdam. As in the design case, the other eroded sections of the Nieuwe Waterweg could be used for this purpose. Here, too, gentle measures can relieve the dikes and create sandbanks and salt marshes. In many places, it would no longer be necessary to constantly remove the quay walls outside the dikes, as the natural sedimentation processes used help to keep these areas above sea level. The out-of-dike area in Rotterdam would thus become a play of urban and natural spaces, which would not only provide more water security for the inhabitants, but also much needed recreational and green space. A coherent ecosystem for flora and fauna with wetlands that reconnects the city with the delta. Restructuring into a more natural estuary is a fitting foundation for the port, which desires and is required to transform from a polluting, fossil fuel-based industry to a clean, bio-based economy. By creating more space for the river and therefore being able to benefit from its ecoservices, the Nieuwe Waterweg can evolve into an eco-industrial corridor in which the generated landscape infrastructure provides a framework for a patchwork of new maritime and clean tech industries, research, and educational wetlands, improved urban development in a natural setting, and a publicly accessible waterfront. It takes the pressure off the heated city centers and offers a diversified and rich recreational space to cool down.


Figure 103: Regional application of concept / *Author*

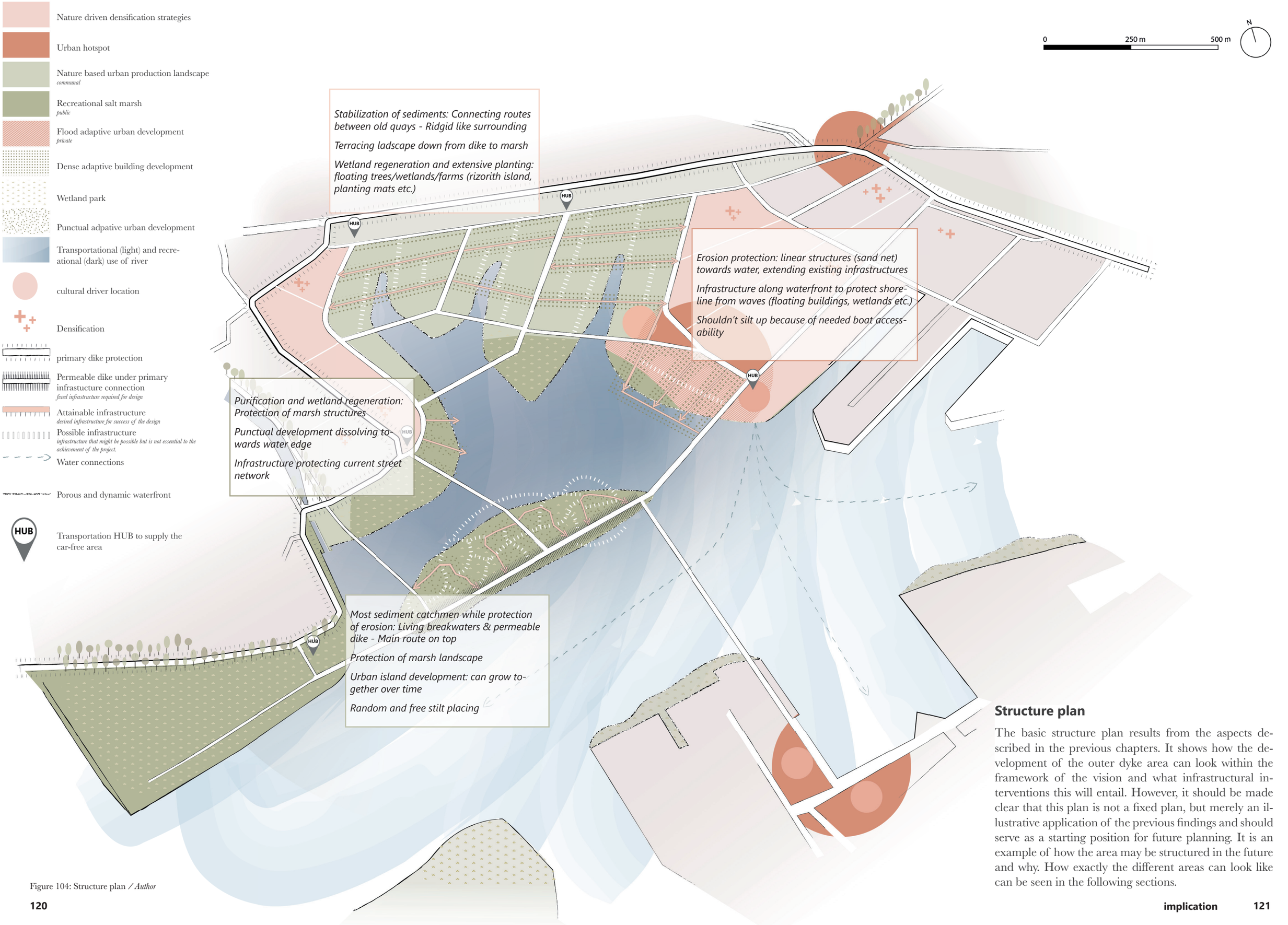



Figure 104: Structure plan / *Author*

## Structure plan

The basic structure plan results from the aspects described in the previous chapters. It shows how the development of the outer dyke area can look within the framework of the vision and what infrastructural interventions this will entail. However, it should be made clear that this plan is not a fixed plan, but merely an illustrative application of the previous findings and should serve as a starting position for future planning. It is an example of how the area may be structured in the future and why. How exactly the different areas can look like can be seen in the following sections.

## Wetland Park

The Wetland Park is located on the sandbank of the Marsh. The focal point here is the main connection route on the Living breakwaters, made from the former quay walls. It serves as a slow traffic highway and connects the salt marsh with the surrounding banks and allows the water to calm and sediments to accumulate. It is an island-like urban development that will allow sediments to settle and grow together organically over time. The amphibious pathways, targeted planting of local vegetation and stilt structures help to reshape the landform of the area and allow the salt marsh to emerge. The infrastructure creates safe zones that allow the community to experience the marsh for themselves and engage with the water.

In fact, it is a landscape interplaying with the river, making it a tangible sensation for residents and visitors alike. Marsh flora and fauna gradually return to the site and enrich the landscape. the outer parts of the marsh are kept free of buildings and used as a bird sanctuary. The construction consists of wetland and water structures,

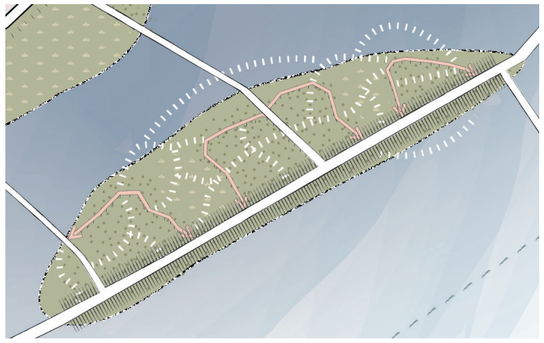


Figure 105: Location of Wetland Park in structure plan / *Author*

which are located at different levels. In the process, the infrastructures will be car-free and may only be used by slow traffic and small electric vehicles, creating a quiet atmosphere and slow commuting route along the water on a bicycle lane. Residents and visitors have parking for their cars and sharing facilities on the mainland. The flexibility of the floating structures, which can be relocated as the marsh grows, is taken advantage of. In general,

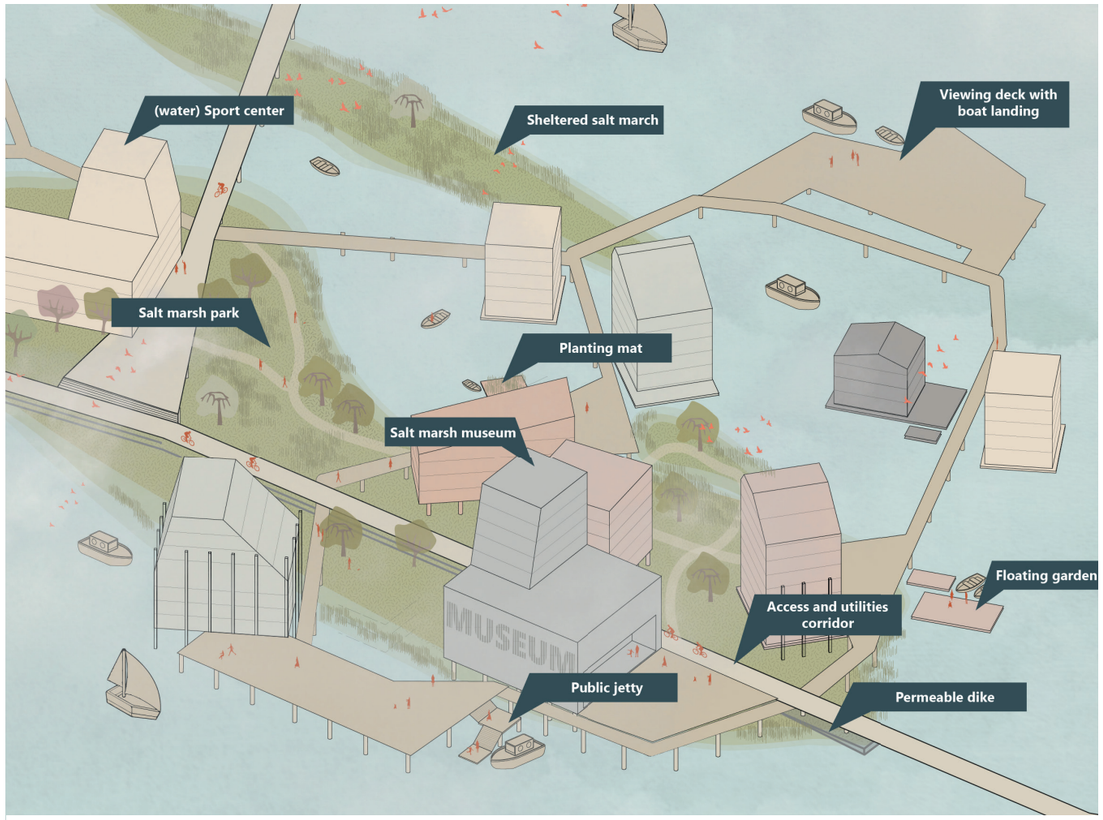



Figure 106: Possible composition of the Wetland Park after implementation of the concept / *Author*

the land use of the different buildings is to be kept low in order to leave as much soil open as possible. To compensate for this, the houses can also be higher than those in the surrounding area. The apartment buildings, which are located in the public space, create a unique urban environment where people can live in harmony with the river and nature.


Figure 108: Landuse concept Wetland Park / *Author*

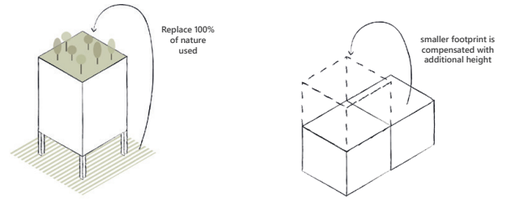



Figure 109: Guidelines for Wetland Park / *Author*

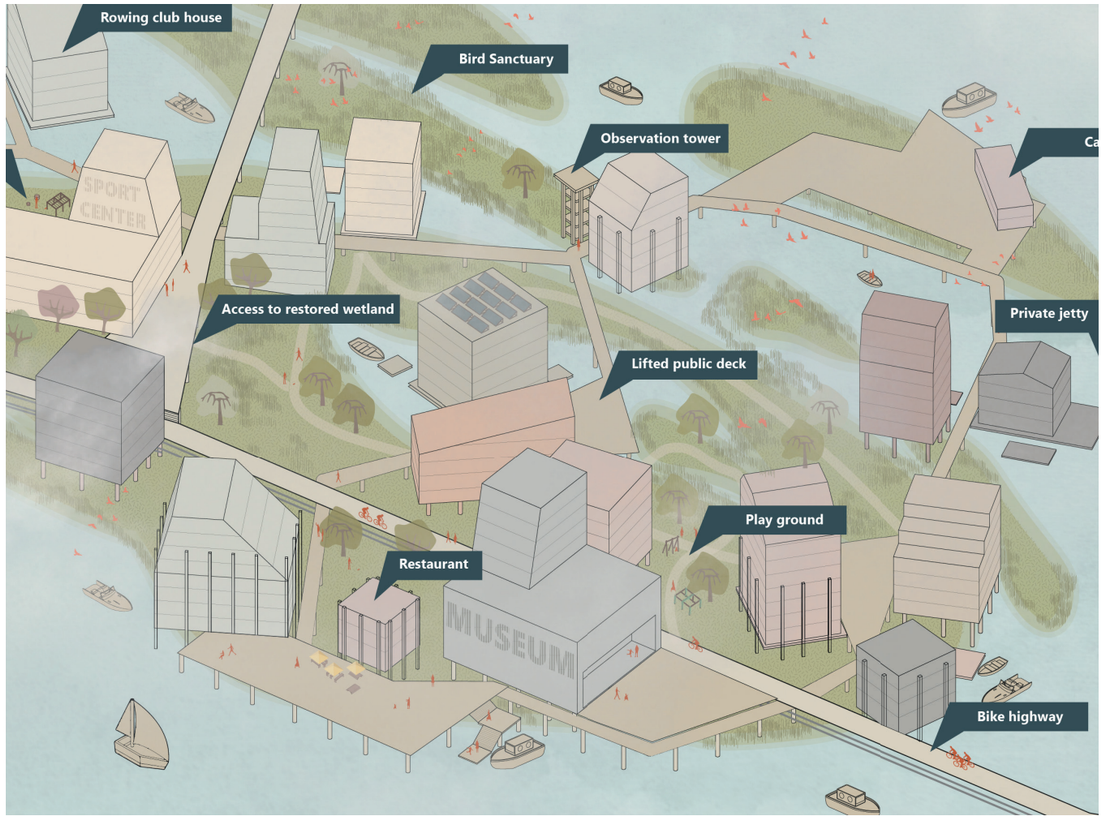



Figure 107: Possible composition of the Wetland Park over time / *Author*

## Productive Terraces

The productive terraces are the interfaces between the old harbour quays and the wetlands developing in the former basins. To stabilize the sediments that naturally settle there and to bridge the high difference in height from the dike to the water's edge, the urban landscape gradually develops in terraces parallel to the dike towards the heart of the salt marsh. This will be helped by stilt and amphibious buildings, as well as floating buildings, gardens, and wetlands.

The area forms the heart of the productive landscape and directly connects the old quaysides to the new tidal landscape. It includes the productive landscape of open green spaces, greenhouses, floating fields and water collection or purification stations, since food is and probably will be a crucial part of the port economy. With this it integrates existing projects such as the floating cow farm in Nieuwe Mathenesse or the urban gardening project. The wetland increases soil quality and fertility, increases the productivity of the surrounding. It is possible to create a circular system between the different types of cultivation and other production sites. For example, the

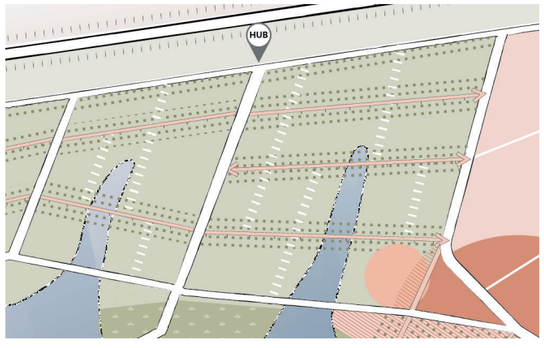



Figure 110: Location of Productive Terraces in structure plan / *Author*

algae and biomass enriched by aquaculture and habitat promoters can serve as fertilizer and naturally increase productivity. To take advantage of this, salt-tolerant crops are needed.

By bringing the production and into the city and former port sites the link between each step will be shortened and products can be produced, traded, stored, sold, and consumed on site. This will be vital to maintane a local production in the region as a lot of the floodplanes in the surrounding of Rotterdam are farm land. In a scenario where these areas are in need of a constant flooding the urban production offers a solution to maintane a local supply. Connecting the visitor stronger to the value of the product. Urban, vertical, and floating farms use the fertile landscape for their purpose and bring the positive characteristics of the salt marsh closer to the population.

The area is collective land. The use of this land must ensure that a balance is maintained between urban development, productive use, and nature. In this way, a continuous green landscape is created through a smooth transition between private green spaces, urban structures, and landscape. Residents are closely connected to the environment and benefit directly from it. Accordingly, they will take the initiative to help keep it intact and maintain it.

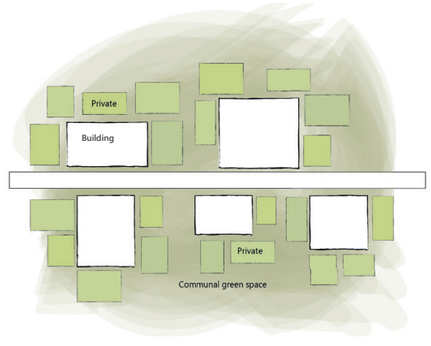



Figure 113: Landuse concept Productive Terraces / *Author*

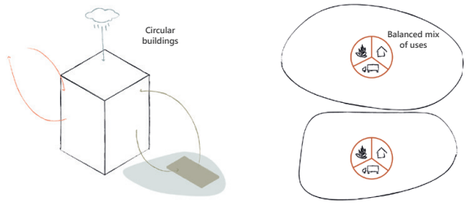



Figure 114: Guidelines for Productive Terraces / *Author*

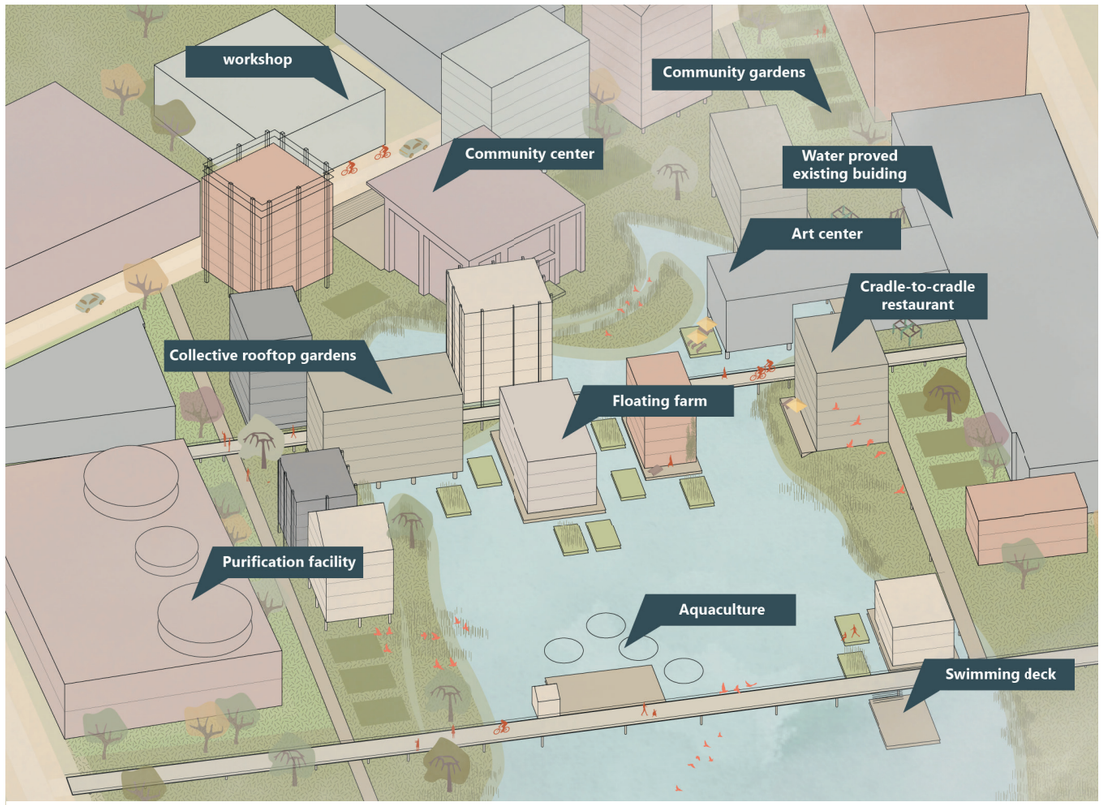



Figure 111: Possible composition of Productive Terraces after implementation of the concept / *Author*

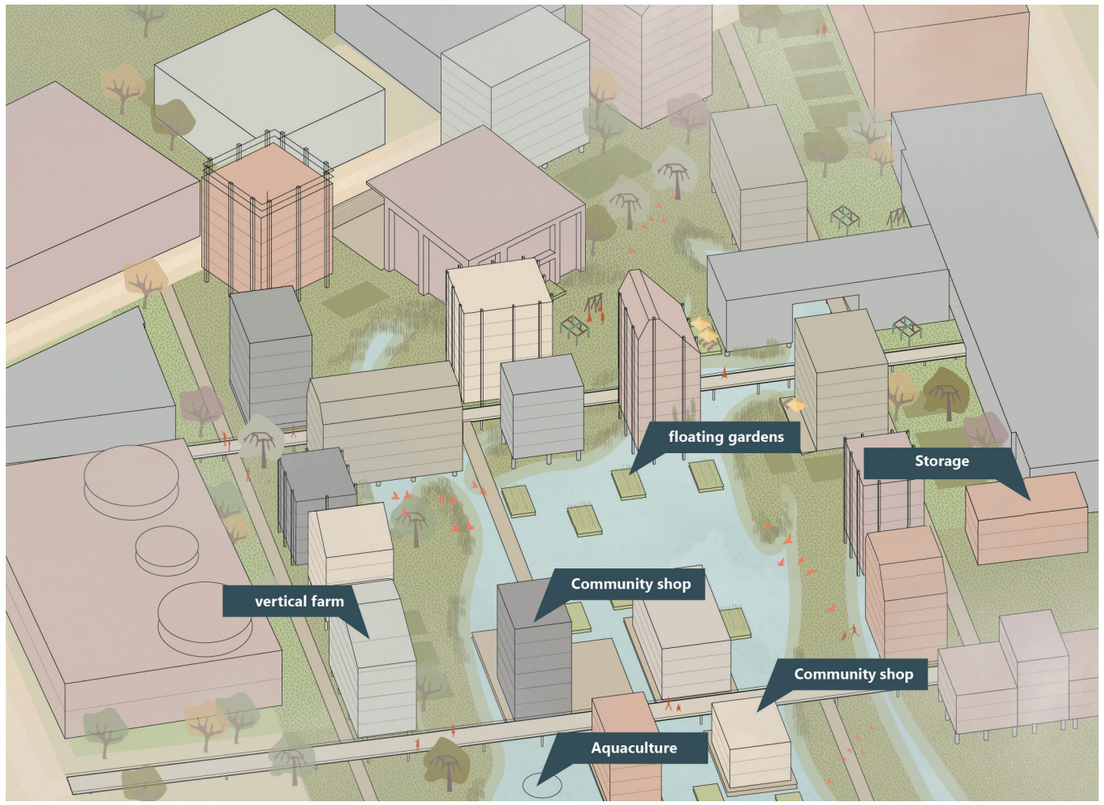



Figure 112: Possible composition of Productive Terraces over time / *Author*

## Cultural-Visitors HUB

The Cultural-Visitors HUB is located at the end of the former tip of the M4H area. Now, with a new ferry terminal providing direct connections to the port area, the city center, and the other shore, it is the arrival point for visitors to the area and Rotterdam and its surroundings. Coming from Rotterdam city center or the metro station to the salt marsh, it offers visitors a panoramic landscape opening onto the marsh.

To prevent further erosion and avoid destruction by flooding, the main infrastructure here runs perpendicular to the water's edge, thus extending the existing linear infrastructures on the slow slope towards the river. These linear structures provide the main infrastructure of the area. They are traffic-calmed shared spaces that can still be used by individual motorized traffic but with less priority than in conventional road systems. After the purification of the contaminated soil, the shore is protected from the tidal flows and waves, partly caused by the ferries, through floating elements such as floating docks, wetlands, or buildings.

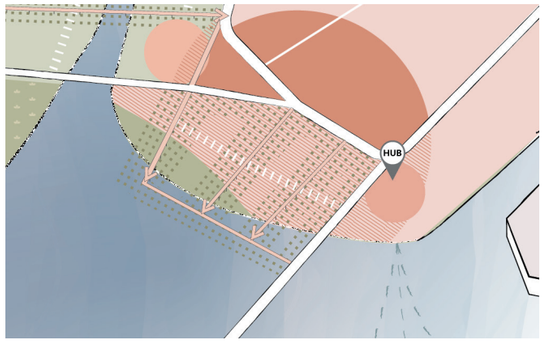



Figure 115: Location of Cultural-Visitors HUB in structure plan / *Author*

Here, driven by the many catalysators placed in this area such as the hotel, the harbour swimming pool, and the research center, which are aimed at the touristic and urban character of the site, a highly urban area is created. Dispite this being the most urban area of the proposal, it is still tightly interwoven with the surrounding natural landscape. Wetland parks form green connections and offer retention basins for rain or even pluvial flooding. It will become a living laboratory for scientists and visitors to witness the new relation the residents of the outer dike areas established over time with the marsh landscape and production.

The urban development is a traditional block layout. However, these are to have a more open character and the private courtyards are to be connected to the surroundings by breaking up the blocks. The area forms in that way a transition from "wilderness" to the city and becomes a community of encounter, promoting the mitigation of climate change through ecology and limiting the impact of human influence.

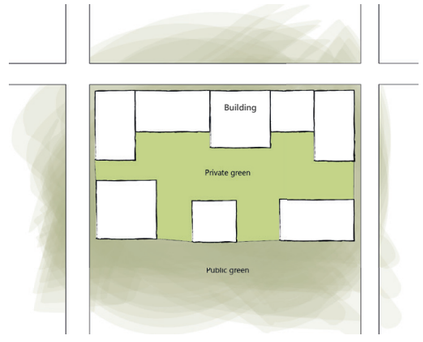



Figure 118: Landuse concept Cultural-Visitors HUB / *Author*

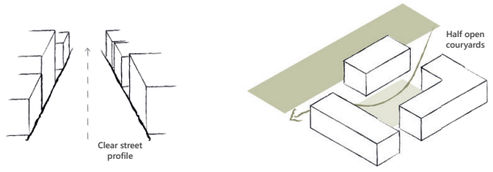



Figure 119: Guidelines for Cultural-Visitors HUB / *Author*


Figure 116: Possible composition of Cultural-Visitors HUB after implementation of the concept / *Author*


Figure 117: Possible composition of Cultural-Visitors HUB over time / *Author*

Based on different design principles and strategies, the outer dike area of Schiedam and Rotterdam becomes a place where urban and maritime life overlap, support each other and flourish together. The dynamic tidal site has an improved connection to the surrounding cities, attracts people from near and far and creates an attractive and adaptive neighborhood. The Diverse buildings, variety of public activities, recreational opportunities as well as modern (maritime) mobilities allow to experience the area in different (exceptional) scenarios and seasons. The bird's eye view on the rght shows what the area might look like in a flood scenario after the proposed design strategies have been implemented (see figure 120). Nevertheless, it should be noted that this is only an exemplary impression and may well change in a more detailed elaboration.

The adaptive solutions allow seasonal and full-time residences and amenities connected by multilevel routes and armatures with only leaving a minimal footprint in the salt marsh. Finally, the measures will create a significant environment of native biodiversity that preserves and enhances the restoration of the natural shoreline and marsh development, providing eco services like including water management, reduction of heat, and cleaning the air and river. This allows a unique living environment and experiential dialogue between human and natural scales, the space we live in and the space beyond the human domain. A space where the intrusion of water beyond the manmade boundary is not seen as a threat to human well-being but is instead a welcomed recourse and gets embraced.

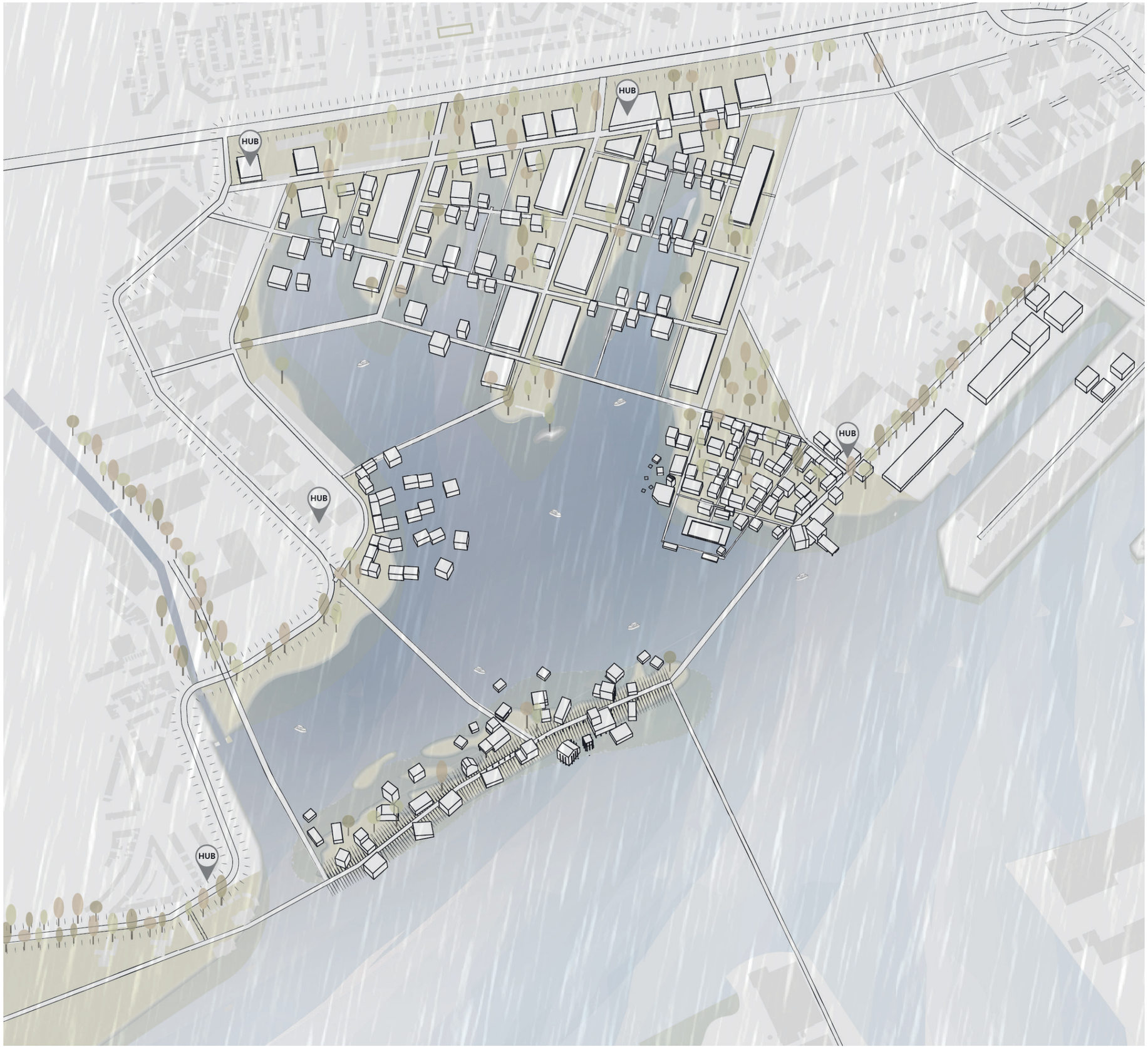



Figure 120: Bird view over possible building configuration in area / *Author*

## Accepting the current(s)

Sea levels will rise in the coming years, putting more and more pressure on the Netherlands. The areas that are outside the primary dike protection and where people will live, and work will have to collaboratively respond to this eventuality. The water of the river will be used as a natural source of both energy and life to transform their waterfront through a transition and porous landscape of salt marshes. It includes a hybrid design of wetlands, industry, agriculture, and housing that naturally evolves in response to the changes in the river and delta system. The idea of the design concept is to create a hybrid development strategy for a new system that can adapt over time to achieve positive social and environmental benefits for residents and stakeholders like .

Figure 121: Possible view from salt marsh / *Author*


Figure 122: View over floating fields and wetlands / *Author*

Merwer-Vierhavens became a flagship project for wetland urbanity. Researchers are encouraging new productivities by exploring new materialities and strategies related to salt marshes and urban food production.

The Reconstruction strategies integrate the participation of the local population from the very beginning.

2028
*Research*

2025
*Planting marsh vegetation*

Water retention

2100
*Reformation of salt marsh and restored habitat*

2030
*trash trap*

Amphibic walk ways

*Purification plants*

2042
*Living breakwaters*

THERE'S ANOTHER NEW SPECIES OF FISH I HAVEN'T SEEN HERE BEFORE!

The river is no longer a border or a barrier, but rather a place of connection. Not only from the natural and human domain, but also from different activities and in the interpersonal sphere.

2038
*River access*

FINALLY I CAN ACCESS THE MAAS AND SPENT SOME QUALITY TIME WITH MY SON HERE AND TEACH HIM MORE ABOUT OUR ENVIRONMENT.

The marshland programme involves species decontamination and maintenance of both the soil as well as the water, thus promoting human and non-human health.

Water mobility

2065
*water sports*

THIS IS THE BEST PLAYGROUND IN THE WORLD! I LOVE COMING HERE WITH MY CLASS.

2035
*Marine architecture*

I LOVE MY NEW FLAT! I NEVER GET BORED LOOKING OUT BECAUSE THERE IS ALWAYS SOMETHING TO WATCH.

The ever present relationship between landscape, urbanity and water is key to the atmosphere in Merwe-Vierhavens. This unique atmosphere has been integrated into the architecture of new maritime buildings. The residential buildings with minimal land consumption are surrounded by a wetland park, which is a largely wild landscape.

2041
*marsh species*

Figure 123: Design conclusion / *Author*

# 5

# reflection

This chapter concludes this thesis. Here, we take a critical look back at the work done and answer any unanswered questions. It attempts to close the framework described at the beginning and to take a look into the future.

- Conclusions
- Discussion

Figure 2: View over current use of the river in the Port of Rotterdam */ Author*

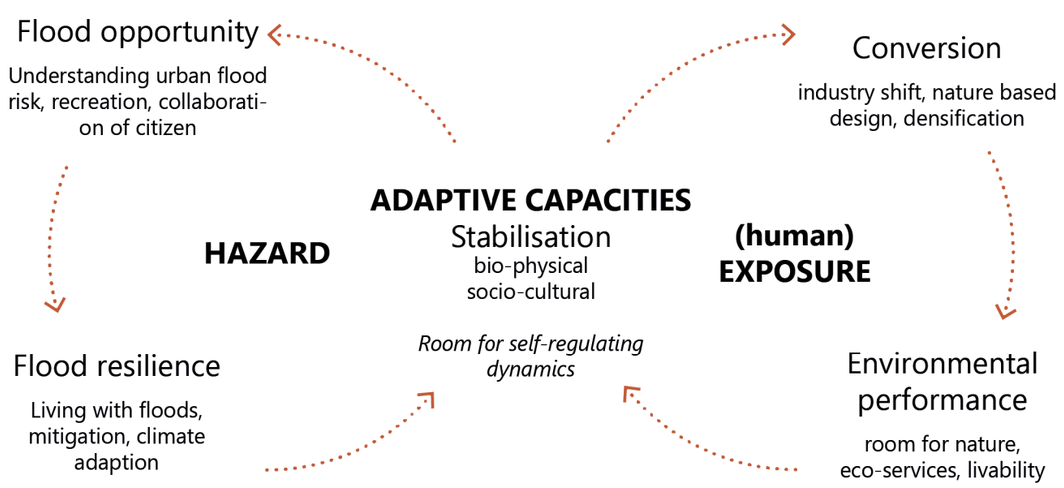



Figure 124: Stabile delta system / *Author*

# Conclusions

*To conclude the thesis, it is important to clarify what can be drawn from this design proposal. At this point, we take a critical look back at the work that has been done and answer the last open questions. Finally, this section aims to close the scope described at the beginning of this thesis and to take a look into the possible future and recommend starting points for further research and needed steps.*

The Nieuw Mathenesse, Nieuwe Waterweg and the Rein-Meuse Delta were incredibly complex and interesting places to study. It was fun to get a deeper understanding of the historical water system and hydraulic knowledge of the Delta and the Netherlands, which skills are recognized and admired worldwide, as well as the cities relationship to Europe's largest seaport. The current shareholders have accepted the need of a paradigm shift and the necessity to change the way we behave so far. This interest and openness of the different stakeholders towards new design attempts for a more sustainable and resilient future has been a strong inspiration for my design. It aims to combine natural elements such as tidal and sedimentary flows as well as migratory processes with economic and social needs and objectives. By integrating the opposing aspects of urbanity and naturality and their contradicting interests, both positive and negative, a complex design concept has been established. With the help of an innovative and audacious vision, an approach for a "game changer" was created that pushes the paradigm shift further and proposes an alternative reality for outer dyke areas in which a balance between nature, society and economy is created that benefits all parties in the long term.

The long-term perspective of the design tackles and tries to work with uncertain problems and processes of the future. For instance, the predictions and impacts of rising sea levels and increased river flows are unpredictable and future scenarios are continually being altered. Accordingly, the project, considering the far future, must have a flexible planning framework in which the initiatives, whether small or large, are adaptable and consider the dynamic system it is based on. Otherwise, there is a risk of creating further conflicts and provoking an unsustainable outcome or even failure of the design. This flexible framework was made possible in this thesis with the help of the nature-based design, inspired by the project "River as a tidal park". The slow development and multi-scalar design process makes it possible to achieve a just distribution between all participants, both silent and not, and thus a higher sustainability. The result is a plan that tries to give a strategic and cross-border suggestion for the delta, based on the fact that nature and the river knows no borders. The research question to be investigated was:

***How can inner city port areas be transformed and used as a catalyst for sustainable development to become resilient to flood risk and part of an adaptive delta system?***

In order to answer these questions, a detailed analysis of the outlying dyke areas, in particular of the study area of Nieuw Mathenesse as an example, was carried out. To gain a deeper understanding of them, the specific composition, historical development as well as their potentials and risks were investigated.

Furthermore, it was important to understand how the (natural) river system and its processes function. Therefore, it was important to take a closer look into the past and to understand how the river would or could have behaved without human intervention and what the natural system would look like. From these results, it was important to clarify which risks and opportunities they offer to be able to conclude specific nature-based solutions.

To answer the question, it was also important to clarify what the future needs and demands of the stakeholders

in the outer dyke areas might be and to what extent they could be addressed.

Finally, it was important to discuss the technological possibilities that could make the area more adaptive. To this end, it was necessary to look at which and to what extent technologies are already being used today, what can be transferred, and for what concepts already exist.

The fundamental aim was to create a transition between different sub-areas and paradoxical elements through using the concept of porosity, not only horizontally but also vertically. The design is about embracing the inner port areas as a transition zone between river and land, port and city, production, and consumption, where urban and natural developments collide and converge. Synergies have been identified that allow the two entities to coexist and intertwine. Therefor porosity provides a flexible framework and a certain amount of freedom so that the different units can develop, unfold, and connect naturally. In this context, a development cannot be defined in concrete terms, but behaves dynamically. In planning for this, the design catalogue helps to consider different solutions and shows the decision-makers ways to deal with the challenges in the area once certain turning points are reached.

The work provides decision-makers with an insight and a design proposal to sustainably change the outer dyke areas. This is very important as the project and related initiatives are costly interventions. Large initial sums of money and investments are needed, which can take many years and only lead to visible benefits at a late stage. This could be deterrent at first. With the help of this thesis, an attempt was made to counteract this by highlighting the urgency as well as the possible consequences of intervening or ignoring the current situation. The different processes and their (partial) results were explained in detail in order to point out the long-term benefits. This should increase interest and acceptance. Only in this way is it possible to achieve widespread support, which will enable the establishment of a delta system that can benefit from its ecosystem services and thus respond to the risks associated with the uncertain future, so that the exposure of future generations can be reduced.

Much of the work and design has been kept general and schematic for this purpose. Not only to maintain flexibility and to be able to respond to the different future scenarios, but also to achieve a broad understanding. This allows a simplified transfer to other areas in the delta or beyond to create a sustainable delta system where we can benefit from the ecoservices. The whole system can only be stabilized by integrating the conceptual approach in several places in the delta, thus creating a region-wide impact. However, this also means that a higher profit can be expected. If only the short-term and locally "isolated" solutions are adopted, the effects are expected to be smaller and only affecting the immediate surroundings.

The conventional economic growth that has determined the development of the Rhine-Meuse-Delta and especially the Nieuwe Waterweg to date should no longer be a top priority in the future. The benefits of nature inclusive long-term design have in the past too often been neglected with decision makers prioritizing faster and more economically efficient approaches over slower nature based ones. It is therefore important to work together with the Port of Rotterdam and to create a synergy that allows us to switch from well fair to wellbeing by giving nature a new value. The aim is to generate a balance between nature, economy, and urban space. However, this takes time and space and could mean shrinkage to become more flexible. The positive aspects and effects must therefore be emphasized again and again, because only with a balanced cooperation of all stakeholders and a paradigm shift is it possible to grow a strong eco-economy that will bring long-lasting benefits for everyone. Only then can we find long-term solutions to water safety and climate mitigation and make a sustainable quality of life possible for future generations.

With this approach, this thesis is in line with the proposals of Han Meyer and ARK for a renaturation of the Nieuwe Maas (Meyer, 2020), which are often referred to in this thesis. However, these are even more far-reaching and require a considerably longer development period before they can be realized. In that respect, this design proposal can be seen as a preliminary step towards enabling the renaturalized outer dike areas to be further used and inhabited by humans. According to Peter van Veelen, it would have been too complicated to engage in their design proposal in its entirety, as the intended shift of the main river flow into the Haringvliet would entail a major change in the current flow system. The already very complex sedimentation pattern on which a significant part of the design is based on would be strongly influenced by this. How exactly, is impossible to say. Accordingly, I have decided to plan with the existing river system instead of inserting the proposal in theirs.

It should be emphasized once again that restructuring should be provided as soon as possible and cannot wait until a disaster occurs, to which we then must react. Particularly in regard to nature-based planning, far-sighted planning is indispensable, as it is much more time-consuming than conventional planning strategies. Failure to do so could have even more drastic consequences for present and future generations. An example of this is the past flood disaster in which the floods in the unprepared Eifel region caused over a hundred human casualties and even higher material damage and from which it has still not recovered.

The urgency for restructuring and paradigm shift was to be elaborated in this work and hopefully succeeded. Especially in highly vulnerable regions, such as the outer dyke areas, in future economic shrinkage must be accepted to generate large-scale well-being and survival.

## Recommendations

The urgency for restructuring and paradigm shift have been elaborated in this work and hopefully succeeded. Especially in highly vulnerable regions, such as the outer dyke areas, in future economic shrinkage must be accepted to generate large-scale well-being and survival.

With the help of the thesis, a promising and nature-based proposal was created addressing the issue of revitalization and transformation of inner-city port areas which lie outside dike protection. Thereby the importance of the interdisciplinary and multi-scalar collaboration of the different subareas was highlighted. It became clear that only by combining and integrating the different disciplines in one comprehensive design, it is possible to provide qualitative solutions to achieve a sustainable and resilient urban delta system. By saying this, it is to say that this project only offers a catalyst for further development in the future. With the help of an interdisciplinary team, it would be possible to deepen the approach through more research and specific expertise. There would be the possibility of expanding the design catalog and adding further technologies.

Furthermore, while this is a conceptual design which is scientifically founded and anchored in reality, it could not be tested in practice due to the limitations. No concrete plan has been created that can be adopted on a one-to-one basis. For this, a further future, more detailed design is needed, for which this work can be used as a starting point and foundation. Accordingly, further research can be conducted with the help of case studies and pilot projects to test and evaluate the proposed rehabilitation strategies within the delta system. This would provide further spatial, technological as well as social insights.

Finally, a further approach would be to examine the conclusions drawn and the design approach in terms of its transferability not only on the regional scale but in a global context. This may help to address the possibility if the work can help to stabilize other delta systems as well.


Figure 125: Recreational use of waterfront in combination with port functions in Hamburg /Author

# Discussion

*In this final chapter of the thesis, the last open questions are clarified and final conclusions are drawn. In doing so, reference will be made to issues that could not be specifically addressed in the thesis or that only played a subliminal role during the process and only became clear at the end. Furthermore, the limitations of the work, the success of the chosen methodology and the applicability of the project design are highlighted and reflected upon.*

## Project relevance

In order to place this academic thesis in its broader context, the following section discusses and examines the relevance of the topic, addressing its social and academic relevance.

## Scientific relevance

With the increasingly drastic effects of climate change, many spatial and social subspaces around the world are now being forced to rethink and radically change their current behaviors and approaches. The Netherlands, a country largely situated below sea level, is very vulnerable to floods. Consequently, they are very interested in creating a delta system for the future and better preparing the country for possible extreme weather events and protecting it from floods. For this purpose, they invest a lot of money and support different research projects in this research field. (Waterstaat, 2014) So far, however, the plans, concepts and measures show a lack of long-term vision, integration and innovation (Eijndhoven et al., 2013). The redevelopment of post-industrial port areas, which has been taking place for a long time, has relied on these solutions. The once vital locations for trade, transport, culture, work and recreation are under increasing pressure to adapt and change due to the impact of the climate crisis (Barsley, 2020). The special connection of these sites to water has been seen too one-dimensionally and conveyed as a hard boundary. This approach is outdated and has been problematic for some time, leading to a paradox that has increased risk. (Haer et al., 2019; Hein, 2021)

This final project will help to demonstrate the need to rethink the current planning system and present a proposal for a flood-prone site in which a transition to an adapted environment and society is created using site-specific typologies. According to statistics, floods are among the most devastating disasters worldwide resulting in severe damage and casualties. This also concerns the countries of the western world. (Bertilsson et al., 2019) The project can identify small-scale and nature-based approaches to address site-specific problem solutions such as for urban resilience to flooding and living with floods, perhaps seeing proximity to water as an opportunity instead of a weakness.

## Societal relevance

Due to the increase in population in the Netherlands and especially in the delta (PBL, 2018) , the exposure of the residents to potential floods is also increasing. On the other hand, urbanization and the associated water management led to a large part of the current (ecological) challenges in the delta. The impact of the exploitation of the delta's fertility, the expansion of industry along the shore, and the alteration of the estuaries show that a paradigm shift is needed (Meyer et al., 2017). For the future, it is important to integrate ecosystems in and around cities, not only to improve the quality of life for residents but also to increase the adaptability of the environment, making cities more sustainable (Keeler et al., 2019). The importance of this can be seen by the increasingly frequent and severe floods along the Rhine.

With the ambition to create a healthy neighborhood for all stakeholders, both humans and other species, that can adapt to climate change and its impacts, the design can contribute to the national effort to make urban areas more adaptive and help to meet the climate adaptation goals. In doing so, it can also serve as a model for other

post-industrial port revitalization projects which will be essential given the growing impact of climate change.

With its objective, the project responds to several Sustainable Development Goals adopted by the United Nations in 2015 (United Nations, 2015). The high potential for achieving the goals is related to the generality of the goals, but is mainly related to the risk of flooding, which can negatively affect and prevent almost all of the SDGs (Vaughan & Norton, 2019). The specific goals that can be achieved through this project include:

Societal:

Sustainable cities and communities (Goal 11), Climate action (Goal 13), Partnerships for the goals (Goal 17)

Economic:

Decent work and economic growth (Goal 8), Industry, innovation and

Infrastructure (Goal 9), Responsible consumption and production (Goal 12)

Environmental:

Good health and well-being (Goal 3), clean water and sanitation (Goal 6), life below water, life on land (Goal 14)


Figure 126: Related SDGs (based on United Nations, 2015)

## Uncertainties

When planning a project that outcomes lie so far in the future, uncertainty plays a major role and should not be disregarded. The goal of the work to change an existing system takes a lot of time and depends on various circumstances. In this context, climate change plays a major role, as has been emphasized many times in this thesis. There is no doubt that the predictions are correct that sea levels will rise, and extreme weather will increase, but no one can say exactly when this will happen and to what extent. The forecasts change depending on how positively or negatively our past and planned behavior and its effects are assessed. What the future will actually look like and how people will react to it is impossible to say. This is precisely why adaptive design is needed, maintaining flexibility in planning to respond to different extremes. The work can be seen much more as a statement than a standing design, showing the urgency and potential of immediate action. Indeed, in the future, today's extreme climate change scenario may turn out to be much lower than reality. On the other hand, there is the possibility that the impacts will be significantly lower than perhaps expected. All this is possible because the predictions are only expectations and not actual processes.

The design attempts to create a common spatial design based on different sub-themes. An attempt was made to predict how the river would naturally behave in order to give it more space and to mimic this. However, this is only an estimation and cannot be concretely defined. When it comes to designing very specific and complex systems in the river such as sediment and water flows, there is no clear answer. As has been shown in interviews and presentations on the subject, even the most nominated experts contradict each other.

But natural space is not the only component of the work that is in constant flux and difficult to assess; social conditions are as well. For example, the democratic political system in the Netherlands is designed to change every four years. This could have a problematic effect on such a lengthy project, as the political orientation can change, and the support needed can dwindle. While nature knows no borders, the municipal system in the Netherlands does. A holistic concept is needed, in which all Delta communities work together across borders. After all, if the alignment and views of some stakeholders change, the whole project could be affected or compromised.

## Port-City without a Port

At the end of the work, it was emphasized how important it is to bring about a system change and to research alternative port developments. However, the importance of the port for Rotterdam and the region should not be underestimated. Its activity has determined much of the region in the past and will probably continue to do so in the future. The restructuring of the river system has had a major impact on its activities and opportunities. These have not been addressed in great enough detail in the thesis, but they are not to be disregarded. The port is the reason why Rotterdam is the way it is today and has always been a great identity generator for the region. But what happens if all of the inner-city port area are to be transformed. What if the river no longer has the capacity for the deep ships and is no longer regularly dredged, and therefore a large part of the port area must be relocated even further outside the river system, as was already the case with the Maasvlakte, and loses its connection to the city completely? How can the cultural assets then be dealt with? What could an alternative harbour look like? All these questions could not be answered within the scope of this work due to lack of time.

What can be said in this small framework is that there are always paradoxes, but also synergies, between the units of city and port in a port-city. Not only the city is in need of change, but the port is as well. The design has been kept flexible and open in such a way that it is not intended to concretely replace all port activities, but to present alternative uses. The aim is to move from a polluting fossil-based industry to a cleaner tech and bio-based economy that can be better integrated into the urban context. This will not only include a big change in the maritime flows but also in the whole structure of the port and transportation network. While still maintaining an operating industry the pollution on the direct environment and estuary will be reduced and enhance harmony within the system. Thus, there is the possibility to create a unique patchwork of different functions along the river and to remain a productive corridor. Only on a different scale than today.

In such a port transformation, however, it is also important to consider who would work in the new industry. Much of the work in the port is done by lower wage workers. The question is whether they would be included in the transformation and receive the appropriate retraining, or whether a large proportion of them would lose their current occupation. If the latter were to come into effect, there would be a need to clarify to what extent this can be compensated for and where further job opportunities can be provided in a similar or different or new sector, so that employees are not completely uprooted from their current environment.

## Architectural limitations

As already mentioned, work should be used as an inspiration and basis for further design and idea development. Due to a lack of time and expertise, it was not possible to delve deeply enough into the architectural aspect of the design. What can the new wetland typologies look like specifically, and what is within the realm of possibility here? This could also allow better conclusions to be drawn about who inhabits the neighborhood. With the large investment needed for the technically demanding buildings, is social housing within the realm of possibility? There is still a need for clarification, especially with regard to the materials. What materials are suitable for such a unique and demanding environment? The degradation of many materials in connection to the vertical water flows, especially organic ones like wood, plays a major role here. A next step in the research would be to determine which materials, especially sustainable ones, are suitable for use in and on the water. This has implications for the longevity and maintenance of the various proposed structures of the design proposal. Since sustainability is a key aspect of this project, this should also be reflected in the materials used and should not be neglected. However, this requirement could lead to a complication of the issue. For example, cement, which can withstand wet conditions a lot longer than wood, is a product of an extremely unsustainable industry. A solution here might be to use new recycling processes to revalue old materials from the area, such as old quay walls or pavement and reuse them in the construction of, for example, the needed stilts. However, to be able to say more precisely to what extent this is possible, I personally do not have the necessary expertise. Maybe even a completely new construction process is needed to facilitate the maritime architecture. Questions like these are very important and should not be overlooked, but as I said before, they go beyond my field of knowledge and need to be addressed in a further investigation.

## Reflection on methodology

In order to create a scientifically sound theoretical framework, comparative case study research was applied. These were compiled from different time periods and thus provided a historical insight as well as an inspiration for possible developments. In order to facilitate their transferability to the study area, they were further selected by their location, being in the immediate vicinity of the Delta and part of the North Sea system. These were the HafenCity in Hamburg, the Tidal Park in Rotterdam, as well as De Ceuvel in Amsterdam. An audit catalogue was created to allow easy understanding, overview, and comparison.

The resulting findings, which were informed by certain biases, were also supplemented, and verified through literature research to provide a scientific basis and validation, and to expand upon them. They are a product of their time and region. Accordingly, they give a good impression of possibilities in the revitalization of post-industrial port areas, but a transfer must always be critically questioned and especially examined in view of the uncertain future.

With the help of "research by design" I built the practical part of the work. In this way, I was able to verify the theoretically founded findings and to test the promising

methodologies for their practical applicability in a concrete space. The design basis was the nature-based approach, which brought a sustainable design. However, it needed the expertise of many different sectors to be able to make a qualitative statement. In addition, it required different data sets. Some of these were easily obtained through the provision of the Dutch government, but others proved to be more challenging. For this purpose, I attended events on the subject and consulted experts who had a better understanding of the natural system in the delta and enriched the project with their hydraulic and ecological expertise. This made the project very complex and elaborative. This sometimes left me frustrated, as I was unable to answer certain questions and advance with my design. Instead, I had to wait for specific answers or meetings that would help me continue. This realization led to a slight restructuring of the work, as the uncertainty of the future was increased and an in-depth research for a concrete plan instead of a strategic design idea would have been beyond the scope of this work.

## Research and design

At the beginning of the work, a concrete adaptive urban plan and design proposal should be developed with the help of the reference projects and literature on the topic of landscape urbanism. The aim was to focus on the context of the port city and its characteristics and interactions. However, this approach and my position on it has been in flux through the development process of the work and has proven to be more difficult than first thought. Through the realization to get away from the classical, static structure of the port areas and to find a more dynamic way, which allows a higher porosity. In the end, the goal was to base the design on the environmental and landscape conditions and to explore a change in the planning system. As the design process progressed and the contextual systems were explored, it became clear that a broader time horizon and therefore greater flexibility was needed for the design layout. A traditional master plan does not provide this flexibility. Instead, it became clear that other design methods were needed to provide a foundation and guide rather than dictate. This interface proved to be the creative design's link to the analysis and theoretical foundation. By detaching the project from the present time, a more creative and innovative design process was made possible. During the constant shift between research and design, new techniques, possibilities and possible synergies were identified. This made it possible to create a more rounded and elaborate project.

## Relation to urbanism track

The main topic of the thesis is the climate adaptive and resilient transformation of Schiedam's and Rotterdam's former port area and riverfront. The studio and the thesis are both related to the premise of landscape urbanism where multi-scalar problems are tried to be solved by nature based solutions. In the design is focused on in cooperating and profiting of ecoservices and tries to facilitate synergies and cooperation for a qualitative future in urban deltas. For both vocal and silent stakeholders of the port city. It looks at the problem from different scales and contexts within the different territories. Be it the relationship between water and land or port and city or even delta and Randstad. The focus is not only on spatial conditions, but also on socio-economic changes and risks. In the final design it was tired to gain insight into the other specialties and in cooperate their knowledge and interests (A, U, LA & MBE). Only in that way it was possible approach the complex systems and understand the site-specific characteristics. Therefore, different goals and participants are planned to be integrated and considered to create a critical and reflective project.

## Ethical dilemmas

The trajectory is a highly sensitive issue in which opposing views collide. The need to protect the environment is a heated issue in which (water-related) environmental threats are assessed and considered differently. In the design, a possible shrinking of the economic strength of the region and the port is accepted in order to give nature a higher value and ultimately to create a balance between the stakeholders. When the waterfront is restructured from an industrial business park to an urbanized wetland, companies must relocate, buildings must be demolished, and workers might lose their jobs and familiar surroundings. These are jobs that may not be replaced in the same sector. Even if the decision to do so is for the greater good, the negative aspects must be taken into account in future designs and Delta decisions. Therefore, an equitable involvement of the different stakeholders is so important to achieve a spatial and socially equitable transformation. By involving the community in the planning and slow development, it is tried to increase the acceptance, to make the circumstances understandable and to integrate the area into the existing environment.

The work has tried to take a clear and unbiased look at the situation and to create an objective plan that manages to strike a balance. At this point, however, it should be noted that a complete independence is hardly possible in my opinion. My personality as a urban planner always has an influence on what I design and decide and is ultimately influenced by my personal views of the world. To say that I have created a completely objective design would be an illusion. Therefore, at this point, my bias and positioning in the design must be acknowledged instead of presenting an impartiality.

Nevertheless, an attempt was made to counteract this with an inclusive planning framework. In it, conflicts, which inevitably arise in this area, should not be avoided, but rather embraced by recognizing their potential. The goal of the strategic plan was to provide an impulse for planners and to inspire them in their future decisions.

# 6

# references

In this last chapter all references can be found. Both those of the used literature, as well as those of the pictures and illustrations, which were not made by the author.

- Bibliography
- List of figures

Figure 127: Picture of viewing deck */ Author*


Figure 128: View from Hoofdplein to study area / *Author*

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