CROSSING THE LINE FOR NATURE:

CROSS BORDER PLANNING COLLABORATION FOR EFFECTIVE ECOSYSTEM-BASED ADAPTATION

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DATE: 27/06/2019

SUMMARY

Climate change is creating alterations and increasing risks to both nature and our built environment. One of the most evident risks is sea level rise. We need to reconsider the way we have been preparing cities to face the climate change related issues. The hard infrastructure that has been used in the past to deal with these issues requires high investment and has very limited adaptive capacity.

Instead of fighting nature, we should understand better the natural processes that take place in the ecosystems and use them in our favour to become more adaptable. The use of these Ecosystem-based Adaptation (EbA) strategies can contribute to the sustainable development of our regions.

The main challenge in this discussion is to acknowledge the dimension of these ecosystems and their processes, which normally does not align with the administrative and political divisions that we have established for our territory. This issue is very apparent in the case of the Western Scheldt, the remaining open arm of the Rhine-Meuse-Scheldt delta that has to satisfy the needs of the Dutch and Belgian development.

Some cross-border initiatives have already been implemented in the region, the most important one being the Western Scheldt Commission. This commission created an outline and long-term vision for the sustainable development of the Western Scheldt. Increasing port activity, dealing with multiple risks associated to flood and maintaining ecological qualities in this tidal estuary were defined as the main functions to be addressed.

Because the systems related to these functions are interdependent, dealing with them separately can have many negative impacts. Port activity is the main driver of change in the Western Scheldt. Until recently, it has mostly developed autonomously and resulted in increasing flood risks and further deterioration of the valuable ecosystems in the region.

Port development has high potential to be integrated with the other functions and will be used as the driving force for the proposal. Port development projects in the Western Scheldt will be paired with the expected local impacts in the values of safety and ecology.

Each of these projects will be addressed through a multi-system approach, taking the Building with Nature (BwN) principles and exposing its potentialities. The pairs not just give way to BWN as technical solution, where systems support each other, but also, will establish pathways for beneficial governance arrangements.

The new governance arrangements will respond to the site specificities and consider the following aspects:
- It identifies the site-specific group of stakeholders that would have an important role in the implementation of the proposed EbA strategies.
- The regional drivers are established and connected to local-scale groups that benefit from the provision of ecosystem services. This contributes to initiate and maintain the conditions of these ecosystems.
- The network highlights synergies between different sectors, facilitates the exchange of interests, knowledge and perspectives and distributes responsibilities to ensure the networks robustness.
These aspects of collaboration will contribute to the implementation of EbA by increasing the overall support, minimizing trade-offs, revealing additional potentialities and channelling resources efficiently.

TABLE OF CONTENTS:

TABLE OF CONTENTS:

1. INTRODUCTION

"Climate change presents the single biggest threat to sustainable development everywhere" (UNFCCC) In coastal areas, some effects of climate change such as sea level rise and more extreme weather conditions make them particularly vulnerable to an increasing risk of flooding.

Dealing with this vulnerability requires special attention, considering that coastal areas are highly populated areas and about 10% of the total world's population lives along the coast under 10 meters above current sea level.
Establishing urban settlements in proximity to the coast has been driven by the diversity of resources and trading opportunities these areas provide (McGranahan et al. 2007). Therefore, improve coastal resilience to these threats is a priority for many countries and a global need (Barbier, 2014).

Considering this vulnerability and uncertainty about how the future will unfold is the starting point of the transitional territories studio. The studio aims to understand better the influence of climate change on the natural and built environment. How can we coexist and cope with these changes in the future? The research is focused around the North Sea and how changing conditions demand for new ways to consider economy, ecology, politics and space.

The focus of this project will be on the challenge for traditional governance structures to plan and manage issues of territorial extension like ecosystems. This is becoming increasingly relevant as ecosystems are being altered by both climate change and human activity, reducing their capacity to provide resources and services. New forms of cross-border spatial planning that respond to the specificity of the area should emerge to bridge this gap and this will be tested with the case study of the Western Scheldt between the Netherlands and Belgium.

Figure 1. Coexistence and vulnerability
(Picture taken and edited by author)

2. PROBLEM FILED: THE NEED TO MAKE OUR BUILT ENVIRONMENT MORE RESILIENT TO CLIMATE CHANGE

In a context where climate change poses a threat to many parts of the world, our built environment needs to improve its adaptive capacity to these changes. This is particularly relevant for low coastal areas. They are vulnerable to increasing flood risks due to sea level rise and more frequent storm events. Not only cities are affected by climate change, but also natural environments. In addition to climate change, natural environments are also disturbed by human activity.

The concentration of urban settlements near the coast has caused severe environmental consequences and has intensified the already altered state of the coastal ecosystems. (McGranahan et al. 2007). By prioritizing economic activities for short-term benefits, urban systems have significantly altered water, energy and other resources flows in existing ecosystems, which results in a decreasing capacity to operate properly (Rakodi et al, 1997). Damaged ecosystems face biodiversity loss, fail to provide the necessary ecosystem services and finally are not able to mitigate the hazards related to climate change.

Even if actions are taken globally to mitigate the effects of climate change (Like reducing Co2 emissions and by that reducing temperature rise), cities still need to adapt to climate change. For this reason, we have to aim for plans and implementations that can be more adaptable to the changing conditions. In the past, we have relied strongly on hard engineered solutions to deal with risks, which have a very limited adaptive capacity and results in high costs and constant intervention. Approaches like seawalls, building dams, levees and channels to control flooding and even relocating infrastructure and settlements may help to some extent, but do not address integrally the climate change impacts. They can contribute to the destruction of fragile ecosystems and even reduce their adaptive capacity. (Hale et al., 2009)

Recently we have rediscovered the potentialities of working with nature to increase our resilience against climate change. Integrating "soft" and "hard" approaches has more potential to achieve adaptation, where structural measures can even aim to protect the ecosystems so they can continue providing their services. (Hale et al., 2009)

Ecosystem based adaptation has been recently introduced in planning as an approach to build with nature and face climate change. It can be defined as *"The use of biodiversity and ecosystem services (BES) as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change"* (CBD, 2009). Ecosystem-based adaptation (EbA) proves to be a more efficient, cost-effective and sustainable approach to respond to climate change (Munang et al. 2013) and the concept is recently being introduced in spatial planning as an approach for to face climate change work towards a sustainable development. (Wamsler, 2014).

2.1. CASE STUDY SELECTION:

Climate change related issues are part of the scope of the Transitional Territories studio (TT), but specifically focused on the North Sea area. A 1-month collective research of the studio on the North Sea (Attached in appendix) helped me to define a critical case study.

The Western Scheldt, which is located in the Southern part of the Netherlands, was identified as a relevant area in the discussion of climate change adaptation. It will be used as the case study for the project for the following reasons:

a) It presents high vulnerability to climate change effects (Particularly flood risks) that affects both nature and the built environment.

b) As the remaining open arm of the Rhine-Meuse-Scheldt delta it has higher natural value that needs to be preserved.

c) It concentrates important port infrastructure that contributes to economy, but further deteriorate the local ecosystems.

d) There is potential to use Ecosystem-based adaptation to increase resiliency of the built environment

e) The Western Scheldt is also located between the southern part of the Netherlands (In the region of Zeeland) and the Northern part of Belgium (in the region of Flanders), which will address the main point of discussion about the potentialities of cross-border collaboration to best manage Ecosystem-based adaptation strategies. In this case, one territorial unity is divided administratively by two countries (Therefore 2 different planning systems and different goals that need to be coordinated to implement effective and efficient EbA across scales)

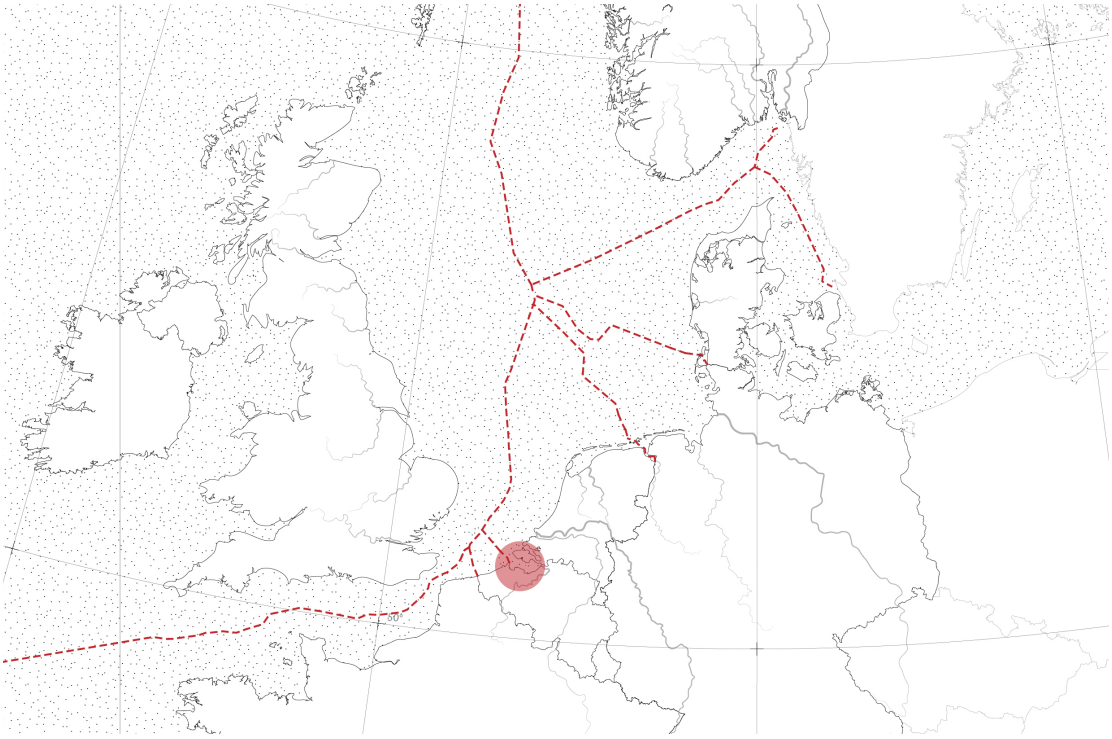


Figure 2. Location of the case study, the Western Scheldt.
(Elaborated by author)

2.2. PROBLEM STATEMENT:

The main challenge in strategic planning to take EbA from a goal to operations is to acknowledge the territorial scale of ecosystems and its dynamics, which is usually not confined by traditional political and administrative boundaries. This means that traditional planning structures do not align with the territorial dimensions of ecosystems and cannot manage them properly. (Andrade et al. 2011, p.8). Ecosystems can cross cities, regions and even countries and therefore be subject to many different and conflictive planning structures. This means that planning systems not only need to coordinate ecosystem management with all the other functions and activities of urban areas, but they also need to coordinate their strategies with the other planning systems involved in the same natural system. Ecosystems are complex and any intervention to improve something can create new problems in other areas. That needs to be taken in consideration in the process of decision making.

EbA requires long term vision, more complex planning and a custom governance system to be implemented.
Researchers, decision makers, economic forces and society need to come together and contribute to an integral approach, which means that new forms of governance need to emerge according to the specificity of the context.

This issue is very apparent in the case of the Western Scheldt, a river delta that has to satisfy the needs of the Dutch and Belgian development. An increasing port activity, multiple risks associated to flood and the deterioration of very valuable ecosystems in this tidal estuary are today's main goals that both countries need to address (Outline 2010 Western Scheldt, 2005). Cross-border coordinating planning is a key factor to combine these goals in an optimal way and allow for more creative solutions for the development of this region. Some cross-border initiatives have already been put forward to manage the Western Scheldt as a natural system. However, port activity still has a dominating autonomous development model (Eker and Houtum. 2013).

If new forms of governance encouraged a higher level of cooperation among the ports of the area, new opportunities could emerge to combine the port development with measures to increase safety and preserve environmental quality of the Western Scheldt. To explore these possibilities, the project will answer this following research question:

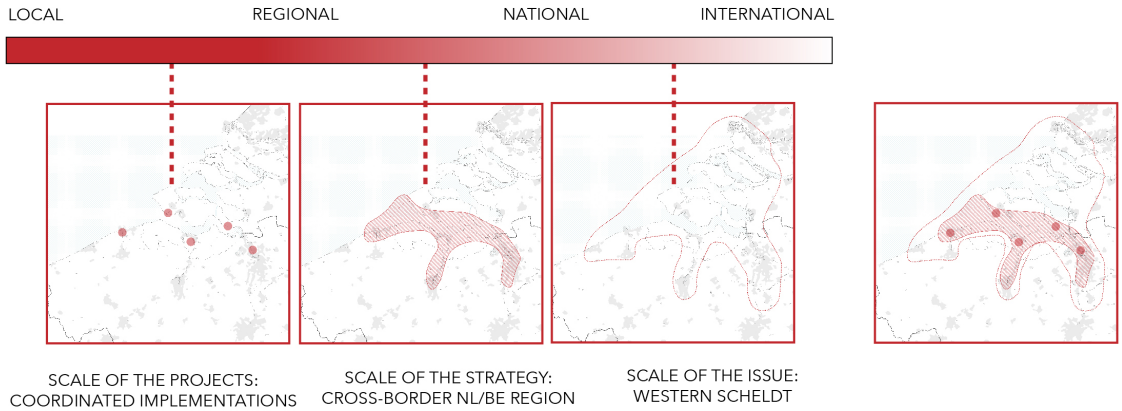


Figure 3. Diagram of issue between scales of governance and scales of natural dynamics (Elaborated by author)

2.3. RESEARCH QUESTIONS:

"How can EbA play a role in the sustainable development of the Western Scheldt, and how can cross-border collaboration in planning be adjusted to facilitate the implementation of EbA strategies?"

SUBQUESTIONS:

DESIGN APPROACH GOVERNANCE BIOPHYSICAL

SQ1: How can an increasing sand demand influence the development of the Western Scheldt area?
SQ2: What are the values, potentialities and limitations of ecosystems in the Western Scheldt area to facilitate adaptation to climate change?
SQ3: What is the relevance of the port function in the Western Scheldt?
SQ4: How do the safety, ecologic and economic systems relate to each other in the Western Scheldt?

SQ5: What is the influence of the 2 planning systems (Dutch and Belgian) in the Western Scheldt?
SQ6: What are the main alignments and conflicts in policies related to the functions of safety, ecology and accessibility in the Western Scheldt area?
SQ7: What are the main opportunities and limitations from a planning perspective to operationalize EbA in the Western Scheldt area?

SQ8: How can the degree of collaboration of the ports in the Western Scheldt influence the possibilities to implement EbA strategies?

SQ9: How does a high degree of planning collaboration create opportunities for local projects that can help manage the ecosystems of the Western Scheldt?
SQ10: How can the Long-term Vision 2030 for the Western Scheldt facilitate cross-border implementations of adaptive strategies like EbA?

RESEARCH AIM:

The aim of this research will be on the potential opportunities that higher collaboration can create in the region. The inclusion of the ports of the Western Scheldt is key in this aspect. They are the main drivers in the development of the area, but they have mostly developed their activities autonomously and separated from other functions. If they were involved in future collaborations, it could result in a reduced impact on the local ecosystems and a proper management that can increase their capacities. We have to consider that with future sea level rise, intertidal marshes are still in danger to disappear in the area. They are not only important for biodiversity, but they also slow water and dissipate waves, which protect us from flooding.
If port-related infrastructure is developed differently, it can contribute to change sediment flows and preserve the marshes for a longer period of time. It would allow for local projects that are also considered part of a system in the larger scale. This will show a way that ecosystem-based adaptation (EbA) could be operationalized in this complex context.

2.4. GOALS AND EXPECTED OUTCOME:

The main goal of the project is to create a more coordinated, comprehensive and flexible governance structure, which can adapt to the requirements of a specific ecosystem-based project to facilitate its implementation.

This will be on the basis of higher level of coordination among the different plans, especially regarding port development on the Western Scheldt.

The project is also framed under the Long-term vision for Western Scheldt (Outline 2010), which has defined goals for 2030. The project aims to use Ecosystem-based adaptation to contribute to these goals as well.

- Safety by reducing the risks of flooding: Projects will reinforce the capacity of mud flats, dunes and other sand formations to dissipate waves and maintain coastal defences
- Good accessibility to the different ports along the Scheldt: Port development and new port infrastructure should not only have a reduced impact on the ecosystem, but contribute to its restauration.
- Preserving the natural systems: In combination with the other goals, the surface of valuable natural areas should increase and provide new economic opportunities.

After different possibilities of the projects are tested, they will be compared based on how effectively they can contribute to these goals. The most successful alternatives will then be studied in terms of governance and what kind of arrangements would be required to implement these projects. The study will result in a set of policies, governance arrangements and investment recommendations to revise the Outline for 2010 of the Western Scheldt and related planning systems of Belgium and the Netherlands.

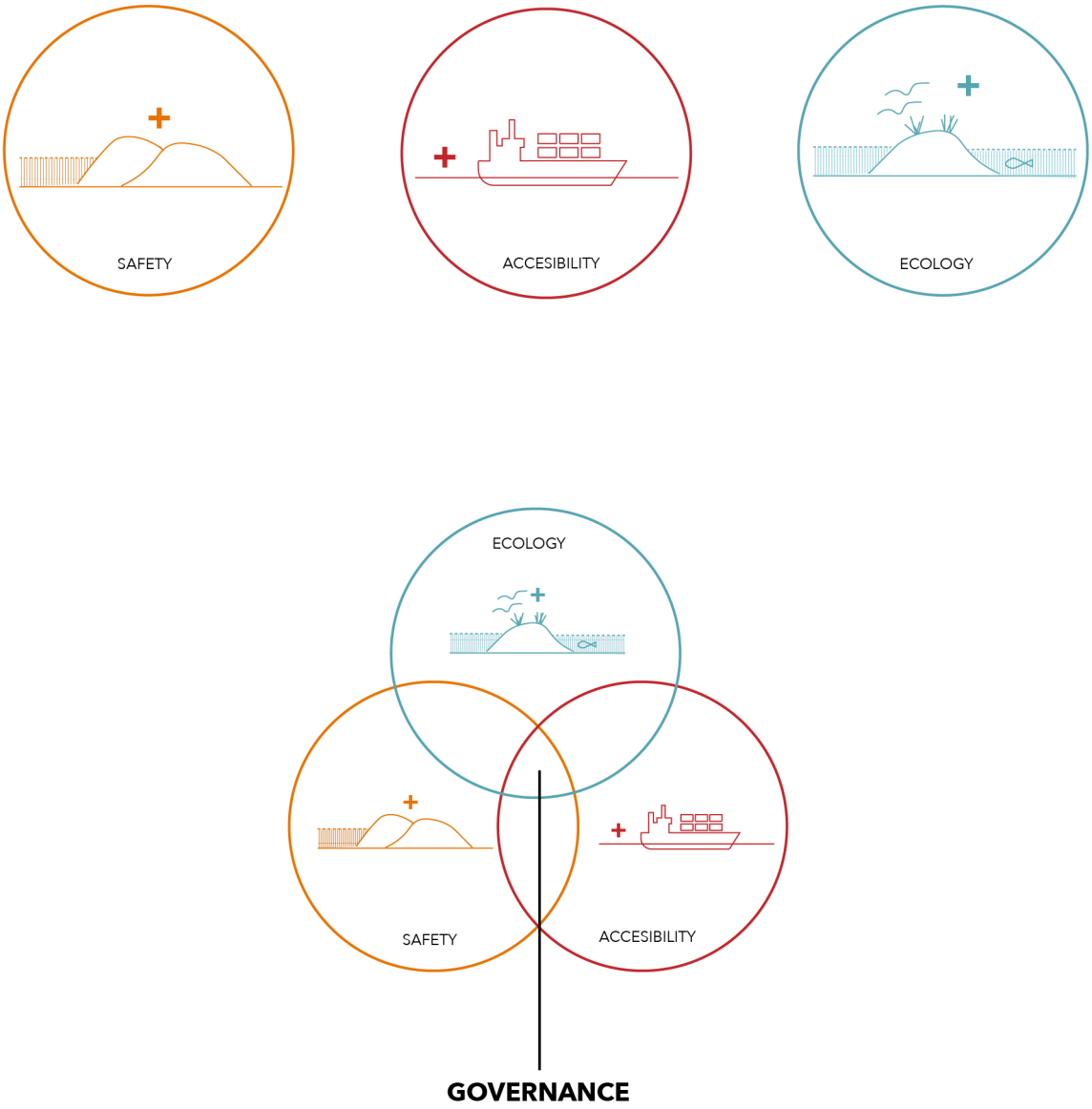


Figure 4. Goals for the Western Scheldt by 2030 and the role of governance. (Elaborated by author)

3. THEORETICAL BACKGROUND:

This chapter will define and relate the key notions of the conceptual framework of the research.

First it will explain the concept of Ecosystem-based Adaptation (EbA) and its relevance in a context of climate change.
Then it will introduce the notion of Sustainable Development and how EbA can contribute to this.
The third part will explain the position of EbA in a strategic planning context
And finally, it will expand on the potentiality of Cross-border collaboration to operationalize EbA in planning. A research paper was developed in relation to this subject and how it applies to the case study of the Western Scheldt (Attached on appendix)

3.1. CONCEPTUAL FRAMEWORK

To reduce this "gap" between EbA as a goal and its operationalist in strategic planning, I explore the role of planning collaboration. The diagram shows cross-border planning collaboration as a pathway to operationalize EbA so it can contribute to sustainable development.

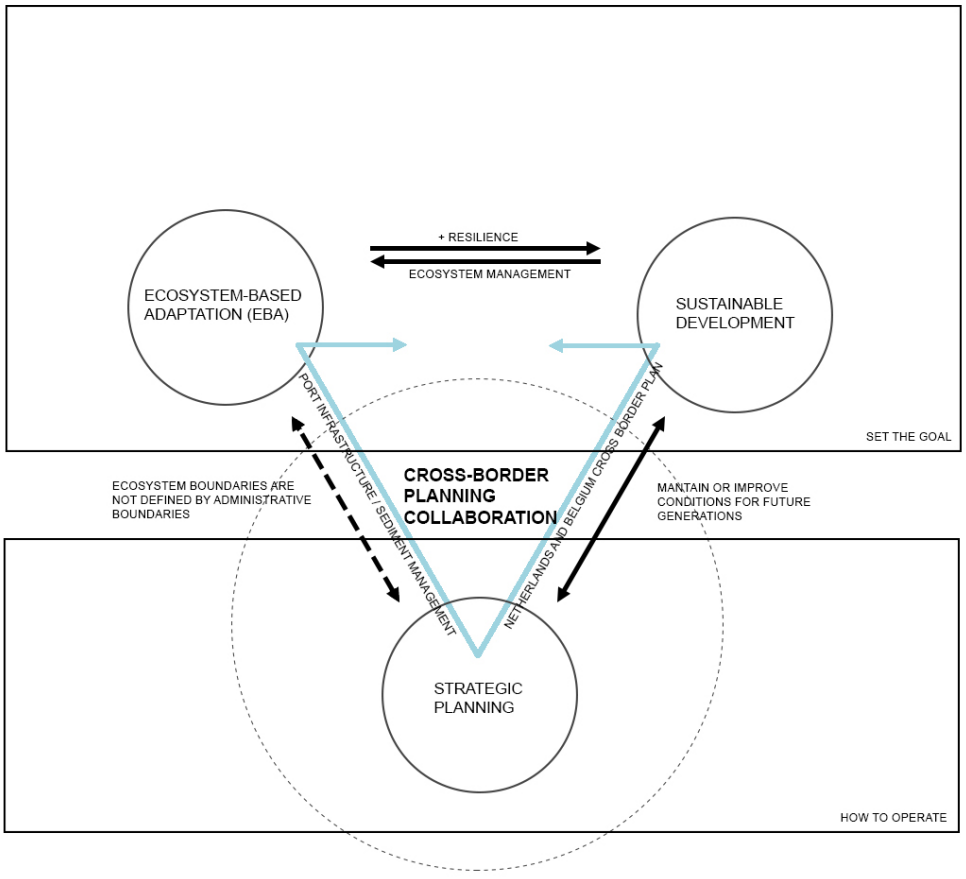


Figure 5. Conceptual framework diagram.
(Elaborated by author)

3.2. KEY NOTIONS:

3.2.1. ECOSYSTEM-BASED ADAPTATION (EBA):

One of the first and most accepted definitions of Ecosystem-based adaptation (EbA) is the one provided by the Convention of Biological Diversity (CBD): "The use of biodiversity and ecosystem services (BES) as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change (CBD, 2009). The idea of "using" biodiversity and ecosystems services implies that humans can benefit from them and therefore, they should ensure that these ecosystems prevail in time.

EbA is an anthropocentric concept, it is centred on meeting people's needs (WWF,2011). The concept also implies that by "using" the ecosystem services, humans are capable to alter to some extent their performative capacities. EbA is considered a multiscale and multisectorial approach to manage ecosystems so they can help reduce the vulnerability that people is facing with climate change (Sierra-Correa and Cantera, 2014). This means that we are responsible to take good care of the ecosystems we rely on if we want them to be more productive.

This idea of merging territory and provision of services is directly related to the theory of "landscape infrastructure". Landscape infrastructure aims for a more integrated infrastructural system within the landscape framework, in other words, more aligned with the natural dynamics of ecosystems (Hung & Aquino, 2013). In landscape infrastructure projects the performance of the ecosystems can be measured, it has a higher potential to remediate negative effects, it can connect dissipated elements in a cohesive manner forming networks and can increase the sustainability of urban growth.
These 4 attributes previously described: Performance, Aggregate, Network and Increment also define EbA, but EbA is specifically defined in a context of climate change and its contribution to increase the resilience of the built environment.

EbA can be framed as "evolutionary resilience". Evolutionary resilience describes a socio-ecological approach to resilience as it identifies people and nature as interdependent systems (Folke et al., 2010, p. 21). In this complexity, several sub-systems that operate at different scales and speeds are constantly interacting with each other, self-organizing and adapting to changes (Davoudi et al. ,2013 p. 310). Evolutionary resilience also embraces flexibility, resourcefulness and cooperative networks at different scales as values in the building capacities of society. (Davoudi et al. ,2013, p. 319)

3.2.2 EBA AND SUSTAINABLE DEVELOPMENT:

The report of the World Commission on Environment and Development of 1987 introduced the famous definition of Sustainable Development, where development "meets the needs of the present without compromising the ability of future generations to meet their needs" (WCED, 1987, p. 43).

Sustainable development is presented as the "ideal" goal that we as society have to achieve. However, the main challenge is to implement the concept in operational terms. EbA can be a key instrument to drive the transition towards a sustainable development (Scarano, 2017, p.66) because it can adapt to this evolving target as we learn and understand better our socio-environmental system (Bagheri et al., 2007, p.84). As Holling (2004) describes, "sustainable" aims to create, test and maintain adaptive capacities and "development" simultaneously aims to create opportunities. EbA can be a link between the socio-economic and environmental issues that sustainable development attempts to combine (Hopwood et al. 2005, p.39). EbA is introduced as an approach that can combine both kinds on issues, but just like sustainable development, needs to transition from goal to implementations.

If ecosystems are preserved and properly managed, they can contribute to a sustainable development by the provision of food, risk reduction, water management and livelihood diversification (Munang et al. 2013). EbA can offer a policy mix to guide this sustainability transition by preserving biodiversity, but also reducing social vulnerability and shaping economic and infrastructural development. (Scarano, 2017, p.67). It can work as a long-term investment to ensure future environmental, social and financial benefits (Munang et al. 2013). This means that long term vision and planning is required, especially considering the speed of change of natural processes.

3.2.3. EBA AND STRATEGIC SPATIAL PLANNING:

There is no univocal definition of strategic spatial planning, there are many perspectives (Albrechts, 2001). A common characteristic in most of these views for strategic spatial planning is to first recognize and define goals and then plan strategies, actions and means for implementation to guide development towards the desired goal. Bryson and Roering (1996) indicate that it is a set of concepts, procedures and tools that are tailored according to a desirable outcome.
Strategic frameworks for the territory are developed, recognizing the place qualities, spatial impacts and integration of investments and creating context for specific projects. (Albrechts et al., 2003).

Often strategic plans demand for new ways of governance, moving away from traditional functional/sectorial organizations and promoting more inclusive relations with other local stakeholders. This promises more integrated economic, environmental, cultural, and social policy agendas and has the potential to "rescale" these different perspectives up or down when required (Albrechts et al., 2003).

Taking such approach in planning may provide the means to operationalize EbA. Once the specific values of ecosystems that need to be managed are defined, frameworks can be created and guide specific projects. Governance will also have to adapt according to the proposed strategies. But frequently territories and ecosystems will not be bounded by traditional administrative boundaries and specific forms of coordination will be required to tackle these issues.

3.2.4. CROSS-BORDER PLANNING COLLABORATION TO IMPLEMENT EBA:

A research paper was elaborated explaining the relation between cross-border collaboration in planning and its potential to operationalize Ecosystem-based Adaptation (EbA) (Attached in appendix)

It first explains that the notion of EBA is being recently introduced in spatial planning and emphasizes the challenge to take EBA from just a goal into implementations. The main reason is that traditional planning structures do not align with the territorial dimensions of ecosystems and cannot manage them properly. (Andrade et al. 2011, p.8).

Then, it explains that planning collaboration is fundamental to deal with cross-border issues such as ecosystem management. EbA strategies are more likely to be implemented if multiple systems at stake are considered simultaneously, if resources are optimized and if the different stakeholders are involved and have something to gain.

3 aspects of collaboration are concluded from the paper:
-Context specific governance
-Vertical relations between scales of planning
-Horizontal inclusion, transdisciplinary involvement

Governance requires to understand the territorial dimension of ecosystems and elaborate custom planning systems that respond to them. This may demand for flexibility in the areas of concern of traditional planning scales and have "fuzzy boundaries" to define possible EbA strategies. Coordination between the multiple scales involved in these ecological dynamics will facilitate recognizing the value of local adaptation strategies and how they can contribute towards the overall systems' adaptive capacity and mitigation of impacts. The involvement of the multiple sectors and stakeholders will facilitate the flow of knowledge and perspectives, increase the benefits and distribute them more equally.

4. METHODOLOGY

In this project, like any other, it is important to frame the research in relation to the issue that is being explored (Problem statement) and what I'm aiming to contribute to knowledge. (Project's outcome)
Defining a proper path between the problem and outcome will ensure that the project answers the question I asked in the first place.

The methodology in the following chapter will explain the steps I will take to research the problem and come up with answers and what kind of tools and methods will be used to collect information during the process. The organization of these tasks throughout the year are indicated on a project's timeline (Attached on appendix.)

As it was previously mentioned, the project addresses the issue of traditional planning structures not being capable to properly deal with the management of the territory and its dynamics. Specifically, it aims to inform the Outline 2010 for the Western Scheldt on what are the values and potentialities of EbA for the sustainable development of the Western Scheldt and what governance arrangements can be introduced to facilitate implementation of EbA strategies.

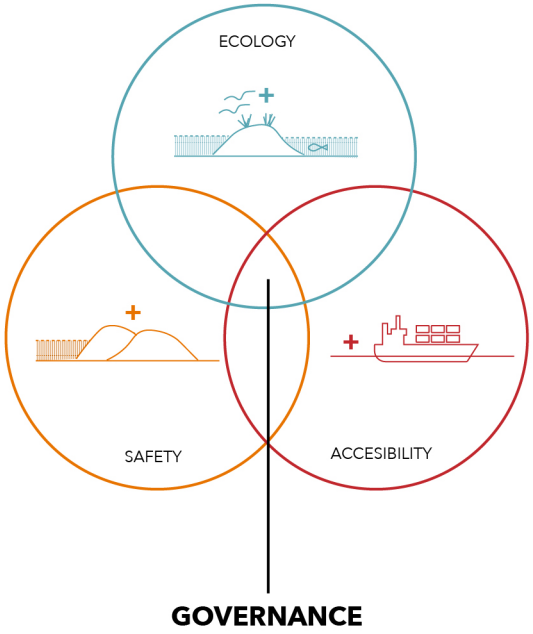


Figure 6. Goals for the Western Scheldt by 2030 and the role of governance. (Elaborated by author)

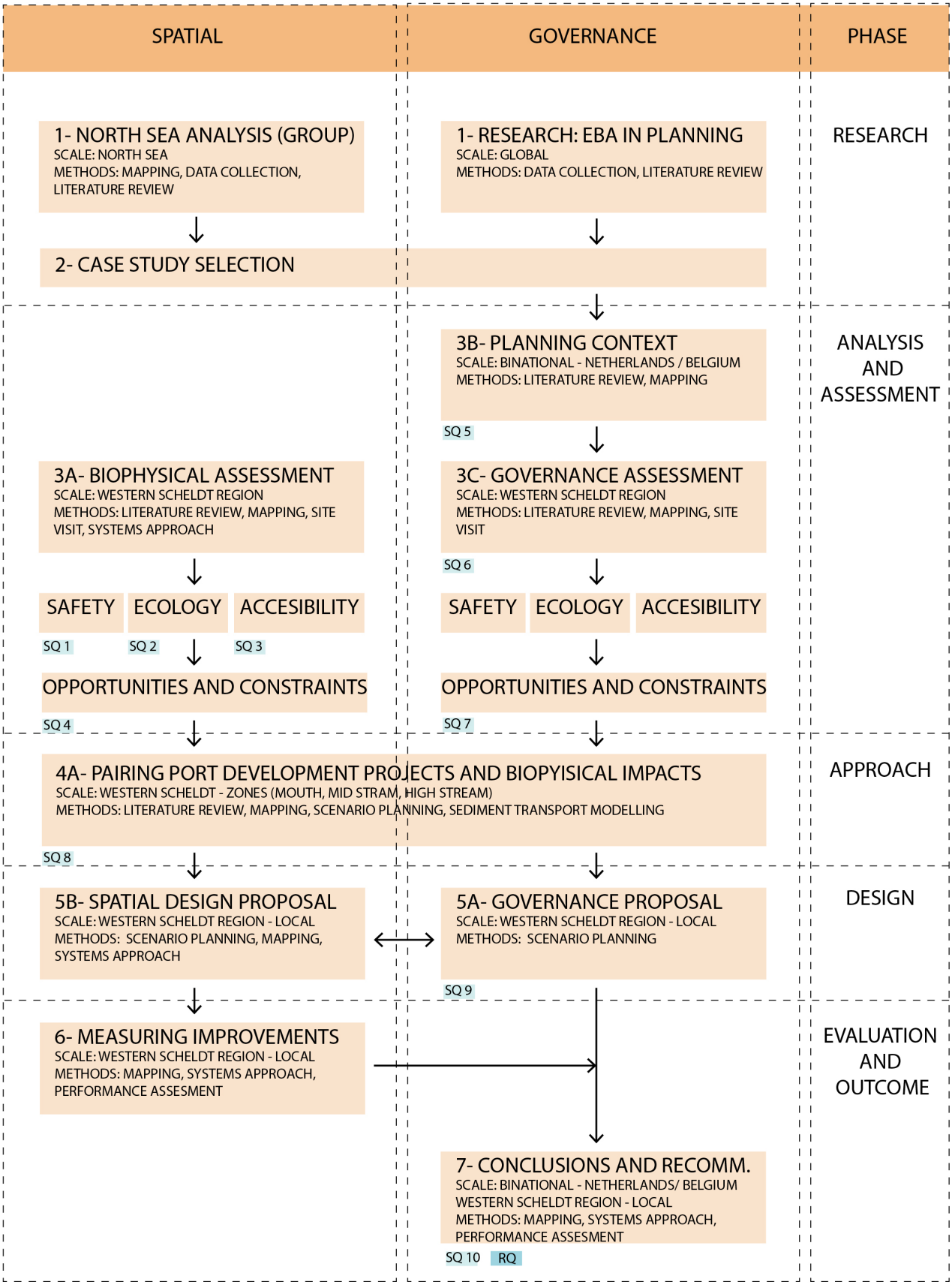


Figure 7. Research framework diagram (Detailed version in appendix)
(Elaborated by author)

4.1. ANALYTICAL FRAMEWORK - PHASES

1a- Group analysis – North Sea
In the scope of the studio, the research is centred around the North Sea and how dynamics in this area could be influenced by the effects of climate change.
This analysis of the geomorphological, economic, politic and biological conditions served as a common base of the studio to identify potential risks and challenges.

1b- Individual research
A theoretical research was developed individually to identify key concepts related with the topics of the studio and "gaps" in existing knowledge that we can contribute to. For my personal research, identifying EbA as a valuable approach to respond to climate change and challenges in planning to put it to practice led me to define the Western Scheldt as the case study.

2- Case study selection: Western Scheldt. Map analysis and data collection of the North Sea revealed that this river delta concentrates high risks related to climate change, high pressure to protect due to the importance of port activity and many governance overlaps resulting in conflictive interests.

3a- Biophysical assessment Western Scheldt
On the case study, a more detailed analysis will be elaborated. First, by mapping the natural dynamics of the delta's ecosystems I will be able to define what is the optimal frame to propose possible interventions. Then, a systems approach will be used to first identify how the functions of safety, ecology and accessibility take place in the Western Scheldt and then how these functions influence each other and the overall infrastructural and morphological development of the river. The focus of this analysis will be to identify sediment dynamics and habitat values related with these activities and project how could they be in the future when sea level rises. The elaboration of these layers will be based on research and other collected data as well as information gathered on a site visit.

3b- Planning context
In addition to the biophysical systems, a governance layer will be included to identify the spatial presence of planning systems in different scales over the area and where overlaps occur. This is important as both the Netherlands and Belgium have influence and interests related to the area. It is first necessary to understand and compare these values.

3c- Governance assessment Western Scheldt
The second part of the analysis in planning is focused on the 3 main functions (Safety, ecology and accessibility) and how are they present in terms of policies that protect those interest and the stakeholders related to these systems. This will highlight the major opportunities and limitations to improve the management of the interdependent systems of the Western Scheldt.

4- Approach
The assessment phase reveals how the different systems are interdependent of each other, but from a governance perspective plans not always take this into consideration. This is especially visible in the case of port authorities, the main drivers of development in the area. The proposal starts by pairing port development projects with the local impacts related to sediment balance and habitat conservation. To deal with the uncertainties of the future (mainly how intense climate change will be and how the trend of collaboration will evolve) the approach includes scenario planning.

These scenarios will explore the possibilities that can arise when planning encourages the ports of the area to collaborate and make strategic alliances or when it continues to promote their autonomous and competitive development. Both scenarios will consider high climate change, resulting in both accelerated sea level rise and increasing sand demands. The 2 scenarios will showcase how these risks can be managed. In the low collaboration scenario, port development continues to have limited involvement in the maintenance of morphological and ecological conditions. The high collaboration scenario will inform until what extent ports are able to grow while contributing to the adaptive capacity of the Western Scheldt.

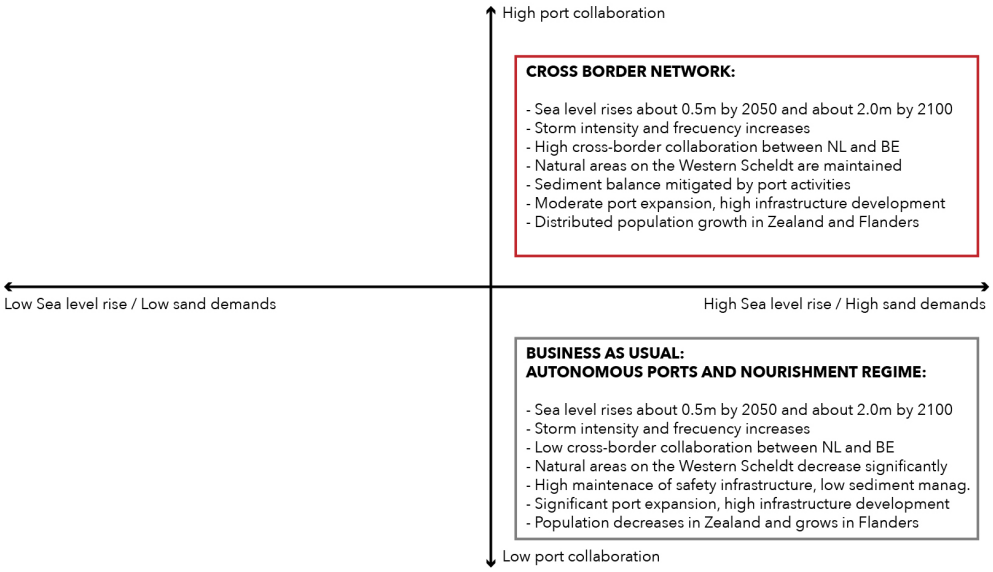


Figure 8. Definition of scenarios
(Elaborated by author)

5ab- Governance and design proposal
To increase the potential for port collaboration, it will be necessary to propose new planning arrangements, policies and governance structures. They aim to increase support for projects that maintain and enhance the ecosystems capacities and create added values and benefits for multiple groups of stakeholders.
Under this collaborative governance, the spatial design proposal highlights the transformation of the Western Scheldt and these added values.

6- Evaluation
Finally, the outcomes of these scenarios will allow me to compare how different levels of coordination in governance (particularly among the ports of the delta) can have an effect on facilitating the implementation of EBA to deal with port accessibility, ecological preservation and flood protection of the Western Scheldt. These 3 variables have been set as the common goals for the Outline 2010 of the Western Scheldt and will be used to measure performance in the scenarios.

7- Conclusions and Recommendations
The added values will indicate the potential of collaboration, responding the main research question and serve as the outcome to make policy and investment recommendations for the Outline 2010 for the Western Scheldt.
Outcomes
- New governance structures and spatial planning proposals to implement EbA based on high degree of port collaboration and accelerated sea level rise (sand demands).
- Policy and investment recommendations to revise the Outline for 2010 of the Western Scheldt and related planning systems of Belgium and the Netherlands.

4.2. RESEARCH METHOD DESCRIPTION

LITERATURE REVIEW:
It provides theoretical input of the concepts that will be analysed throughout the research and how they relate to each other. For example, in order to define that a certain area is under flood risk, it is necessary to clarify first what constitutes risk, what are the direct and indirect attributes, how are they valued in urban contexts to then use this knowledge and establish under which parameters the flood risk of an area will be measured. Another example involves using literature to understand cross-border dynamics and use them to propose how can it operate in the specificity of the case study.
Limitations: In literature, there can be multiple versions of a concept, sometimes the definitions can even be contradictory. This means that I have to be explicit about which definitions and arguments I stand by and why some would not be appropriate for my research.

DATA COLLECTION:
Some historical records about the sea level rise and what are future projections on the North Sea will provide a realistic starting point to develop scenarios on the case study area and what would be required for strategies to adapt as time passes. Other useful data sources include population (Growth, decrease, distribution in space), port growth projections based on size, transported volumes, jobs and sediment volumes, flows and uses.
Limitations: Because I'm dealing with a cross-border issue, data from the Netherlands and Belgium will be required. Each country has their own organizations and researchers that will produce the data. For example, it could happen that one country produces content in relation to sand flows and the other doesn't. I can also happen that both countries study the same topic, but measure with different parameters or different timeframes.
These limitations reinforce one of my arguments of the research the point of the research; fragmented knowledge defined by administrative borders is less useful than an integrated ecosystem analysis.

SYSTEMS APPROACH:
To understand the complex nature of ecosystems, the systems approach can be a good starting point. It organizes information into sub-systems, each one focusing on a specific dynamic. This way, i can reveal the related component that influence the safety, ecology and accessibility of the Western Scheldt, considering both natural processes and human induced changes as a result of their occupation of that space.
For the special conditions of the project, an additional system will be considered. How governance guides the development of the region, how different planning systems spatially recognize climate change adaptation, the alignments and conflicts of their goals and strategies, the role of small scale plans within larger scale frameworks, etc.
Limitations: The high level of interdependency between the systems of an ecosystem demands for some components to be considered multiple times, in most cases no clear boundaries between systems could be drawn.

MAPPING:
Maps can be used to illustrate the quantity and spatial distribution of elements and dynamics. They can provide information about critical areas, spatial networks, land uses, historical evolution of space, etc. Sections provide information on heights, depths and vertical relationships in space. Maps provide the starting point of a design proposal and can show how the proposal creates new conditions in space.
Limitations: Mapping itself is a process of abstraction and synthesis. On every map, the attention is guided to a specific topic, but can selectively ignore other relations and influences.

SITE VISIT:
By visiting the area of study is possible to gain more insight of the operational aspect of the current flood risk management, how the biophysical environment reacts to the flood risk implementations and how urban activities relate to the flood risk functions. It is also an opportunity to go to the different planning departments and interview people involved in the decision-making process to have a better understanding on how are current relations when it comes to defining a combined multi-level strategy.
Limitations: Knowledge gathered on a site visit is influenced by temporary conditions like weather, traffic, events, etc. The visit is like a picture, it captures a fixed moment in time, but is very limited to capture change. In relation to the project, it still provides partial understanding of short span cycles like tidal variation or the intensity of port activity through the day.

SCENARIO PLANNING:
The purpose of this method is to test multiple futures and how climate change effects are dealt with. The scenarios proposed in the project will explore the potential of collaboration, especially of the ports in the area, to develop EbA strategies. Current governance, with low port collaboration in the future will have to deal with frictions between systems. Governance that facilitates collaboration will have an impact on the capacity to manage the ecosystems and an increasing sand demand on the river and estuaries.
Limitations: Scenarios as the name indicates are based on assumptions and not necessarily represent the real future. There are infinite scenario possibilities and scenario planning normally explores very few of them.

SEDIMENT TRANSPORT MODELLING:
With a scaled model of the case study area it is possible to see how morphological alterations on the edges between land and water can influence sediment flows. It shows an approximation of where sand erodes and where is deposited. It informs the impacts of some design proposals and can be used to guide sediments to where is needed.
Limitations: Currents, as any natural dynamic are very complex. It is difficult to reproduce the real water flows, therefore simulations in the model will probably not show the real sediment transport. For the specific case of the project, a computer simulation on the test site is available, which provides more accurate information.

PERFORMANCE ASSESSMENT:
The performance assessment basically compares the capacity of projects in the area to influence safety, ecology and accessibility. It will be used to give an overview of the benefits form a high collaboration approach in the development of the Western Scheldt.
The surface calculation will provide a more accurate indication of the amount of areas of ecological value present in the present and after the proposal.

5. BIOPHYSICAL ANALYSIS

In this chapter, the biophysical systems related with the main functions for the sustainable development of the Western Scheldt will be explained.

The first function related to safety is mostly influenced by the distribution, transport and loss of sediments in the river as well as the infrastructural components to protect land from flooding.

The ecological function highlights the particularities of the ecosystems located in the Western Scheldt, the ecosystem services they can provide and what conditions are threatening their existence.

The third function of port accessibility is related to the main channel that is used for navigation and what are the conflicts between the natural size of that channel and the space required to maintain efficient accessibility for bigger ships.

Each of these functions also indicate some conflict points with the other functions proving how interdependent they are. This leads to the argument why EbA is a desirable option for the development of the Western Scheldt. Ecosystems are capable to provide values for each of the three functions simultaneously as a multi-systems approach.

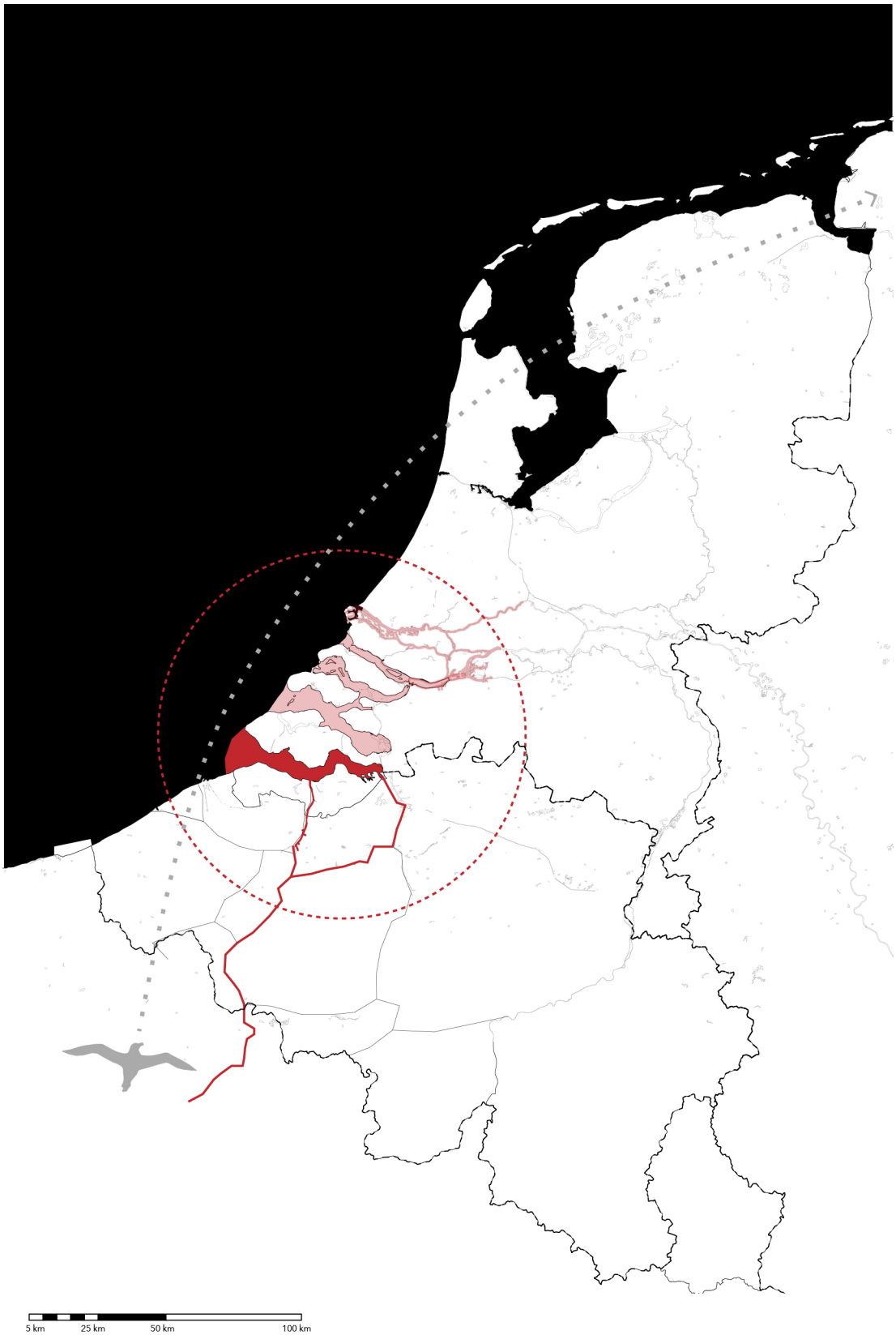


Figure 9. The Rhine - Meuse - Scheldt delta
(Elaborated by author. Source: Vlieger, 2017)

5.1. THE WESTERN SCHELDT - BIOPHYSICAL SYSTEMS

The Western Scheldt is the lowest arm of the Rhine-Meuse-Scheldt delta located in the southern part of the Netherlands and connected to the North Sea.

The Scheldt has a total area 21.000 km2, with 1.000 km2 in the Netherlands, 13.000 km2 in Belgium and 7.000 km2 in France. The total length of the river is about 355 km starting from Gouy (France) and ending near Vlissingen (Netherlands).

Through the Western Scheldt, the river discharges an average of 100-200 m3/s of freshwater and about 50.000 m3/s of tidal water per year. (DELTARES, 2005)

The Western Scheldt, which is the remaining open arm of the Delta, still experiences significant tidal processes. As a result, sea water periodically moves inland and mixes with the fresh water from the river, forming transitional zones of brackish water (Mix of fresh and salt water). The tidal influence on the Western Scheldt extends up to Ghent (km 160) while the salt intrusion to about km 92.

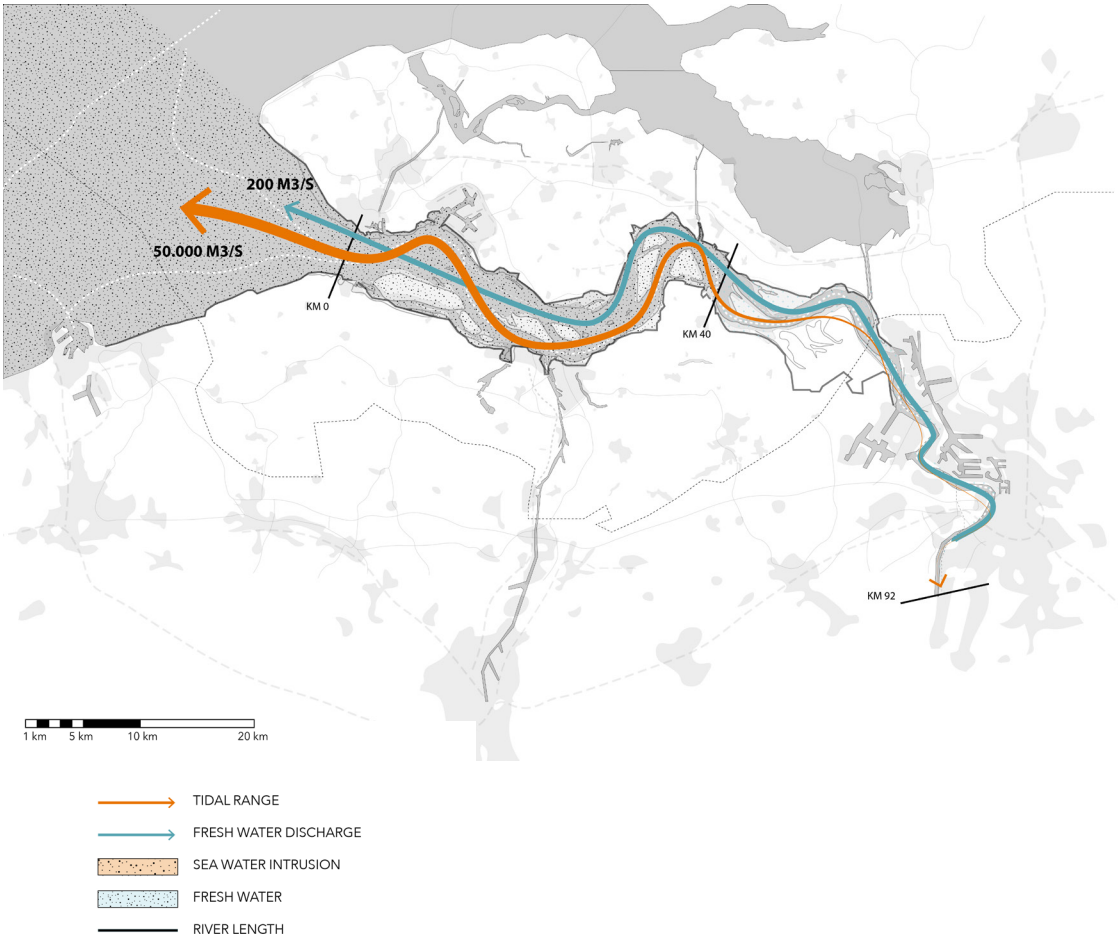


Figure 10. Water Discharges
(Elaborated by author. Source: Hydrological Research division, Waterways and Marine Affairs Administration of the Environment and Infrastructure, Department of the Ministry of the Flemish Community, Belgium, 1996)

5.2. THE WESTERN SCHELDT AND ITS SAFETY VALUE

The presence of the North Sea not only introduces tides and salinity to the Western Scheldt. By being connected to the sea, the river is exposed to risks associated with climate change such as sea level rise and increasing storm frequency and intensity.

The first line of protection is the coastline. Beaches and dunes absorb the wave impacts and they are then stopped by dikes.

As the open arm of the delta, instead of a dam blocking sea inflows, a series of dikes define the limits between the river space and the occupied land. The main strategy considered to date for the safety of the area includes the raise and strengthening of these dikes as sea level rises.

As a complimentary strategy, increasing the amount of controlled flooding areas is being used in combination to the restoration of habitats. This increases the river space in case of strong storm surges and helps to reduce the wave intensity.

Figure 11. Flood safety on the Western Scheldt
(Picture taken by author.)

5.2.1. COASTLINE PROTECTION

From the North Sea perspective, other sediment flows influence the change in the morphology of the coastline. The main superficial currents coming from the English Channel transport sediments in a south-north direction. The movement of these currents near the coast favor the sediment supply in the Dutch and Belgian coastlines, while wind transports them from the shore to the dunes.

However, the beach and dunes are not raising at the same speed than sea level and coastal water are getting deeper. In fact, a mayor part of the coast is experiencing a sediment loss.

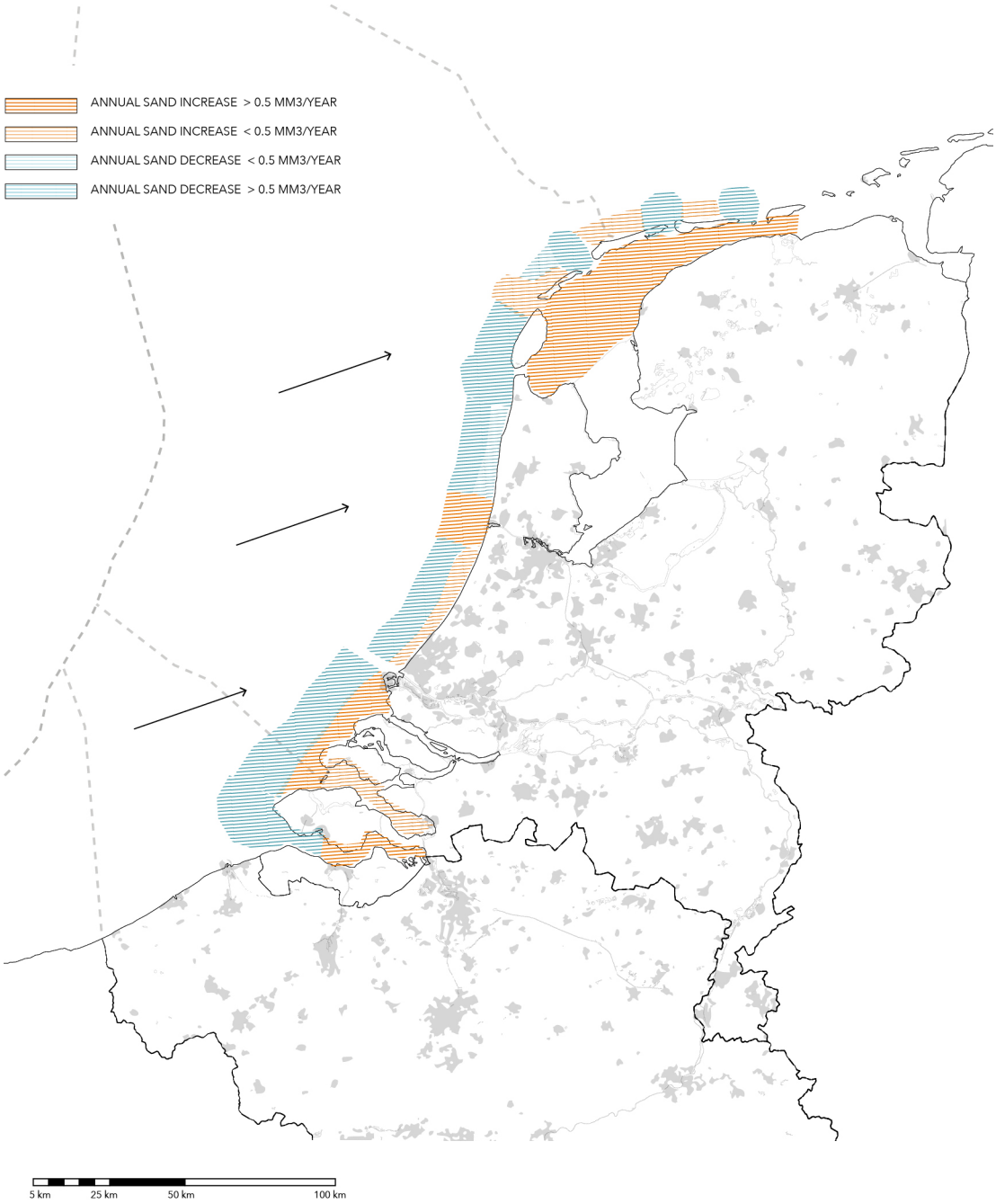


Figure 12. Sand gain and loss in the Netherlands.
(Elaborated by author. Source: Ministry of Transport, Public Works and Water Management, 1996).

Sea level rise increases the demand of sediments required to maintain the coastlines. The sediment deficiency can cause coastline retreat by the degradation of dunes, beaches and foreshores and finally increase flood risks landward. (Stronkhorst et al. 2018)

For this reason, strategies involving sand nourishment are used in order to compensate for the sand deficit caused by climate change and maintain the beaches and dunes.

Traditional beach nourishment includes taking sand from defined extraction sites on the sea and dumped in the beaches. Beach nourishment can also be considered as a nature based approach to manage the coastline. The sand engine for example, besides providing sand for the coastlines, it uses the natural currents of the sea to distribute the sand along the coast in the area, reducing maintenance work.

Every year, the Netherlands and Belgium are increasing the amount of sand used to nourish their beaches and dunes. Sand is becoming increasingly scarce due to this nourishment in addition to the sand used for land reclamation and construction. (UNEP, 2014)

In the case of the Netherlands, an increase in the annually nourished volumes of sand from 12.5 up to 40–85 million m3 of sand for counteracting effects of future sea level rise is anticipated (Deltacommissie, 2008).

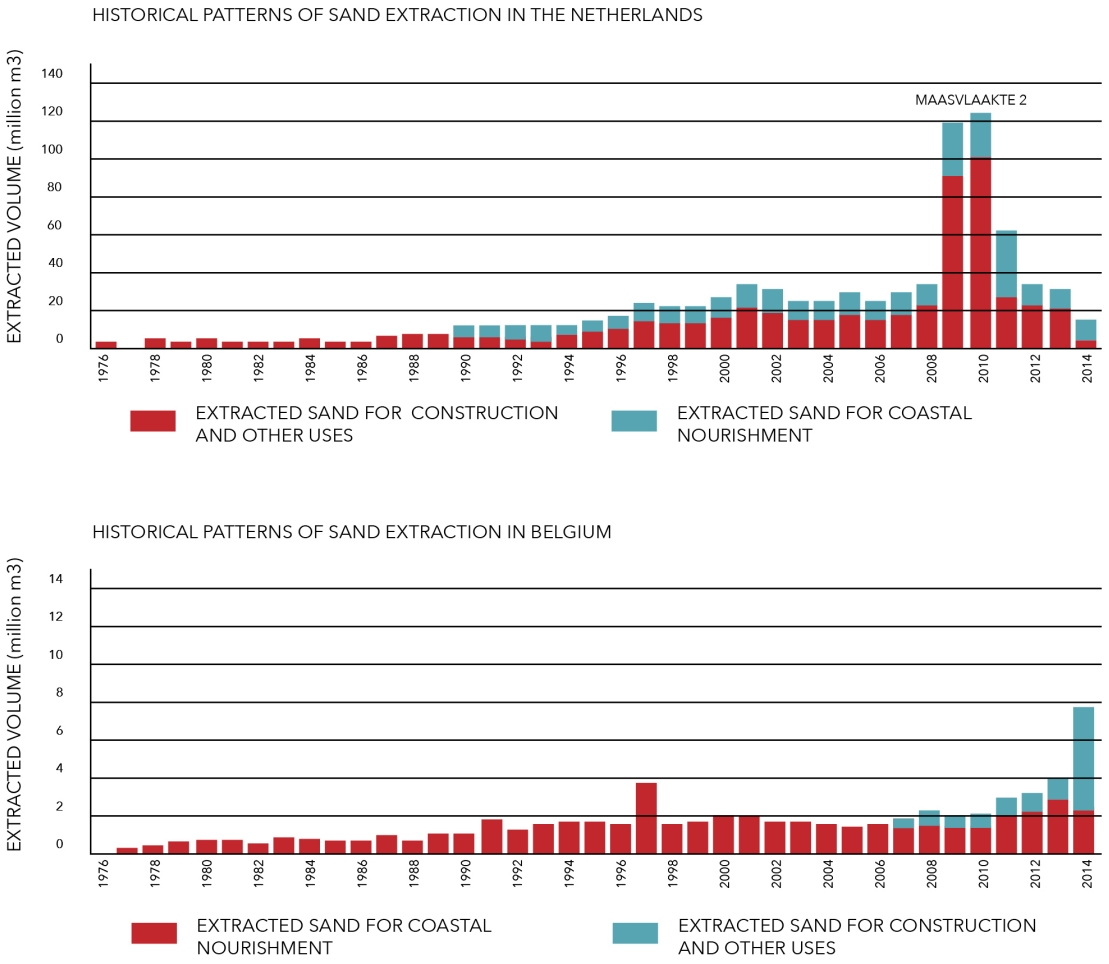


Figure 13. Historical sand extraction volumes.
(Elaborated by author. Source: International Council for exploration of the sea (ICES), 2016).

NATIONAL AGGREGATE EXTRACTION ACTIVITIES IN 2015 (M3)

COUNTRY	CONSTRUC-TION	BEACH REPELISHMENT	LAND FILL RECLAMATION	NON-AGGREGATE	TOTAL EXTRACTED	EXPORTED AGGREGATE
BELGIUM	2.330.000	481.000	0	0	2.180.000	1.079.000
THE NETHERLANDS	6.666.118	17.772.647	1.457.010	204.873	26.100.648	3.182.940

Figure 14. Sand extraction volumes and uses.
(Source: International Council for exploration of the sea (ICES), 2016).

In a context of climate change, not only the coastline is demanding more sand to be maintained. In the lower part of the Western Scheldt, several mudflats are under threat of disappearing as sea level rises. Unfortunately, the estuary has limited sediment exchange of with the North Sea and the sediment volume supplied from the river flows is rather small (Plancke & Ides, 2006).

If sea level rises about 0.6 m during the next 100 years, the Western Scheldt would need 1.7 million of m3 of sand every year to maintain current depths. If sea level rises in a more extreme speed and reaches 2.0 m, the river would require about 5.7 million of m3 per year.

SAND DEMANDS IN RELATION TO SEA LEVEL RISE (NL)

	0.18	0.60	0.85	2.00
1. COASTLINE	+ 7.0	+ 23.0	+ 33.0	+ 77.0
2. WADDEN SEA	+ 4.5	+ 15.0	+ 21.0	+ 50.0
3. WESTERN SCHELDT	+ 0.5	+ 1.7	+ 2.4	+ 5.7
TOTAL SAND REQUIRED	+12.0	+ 39.7	+ 56.4	+ 132.7

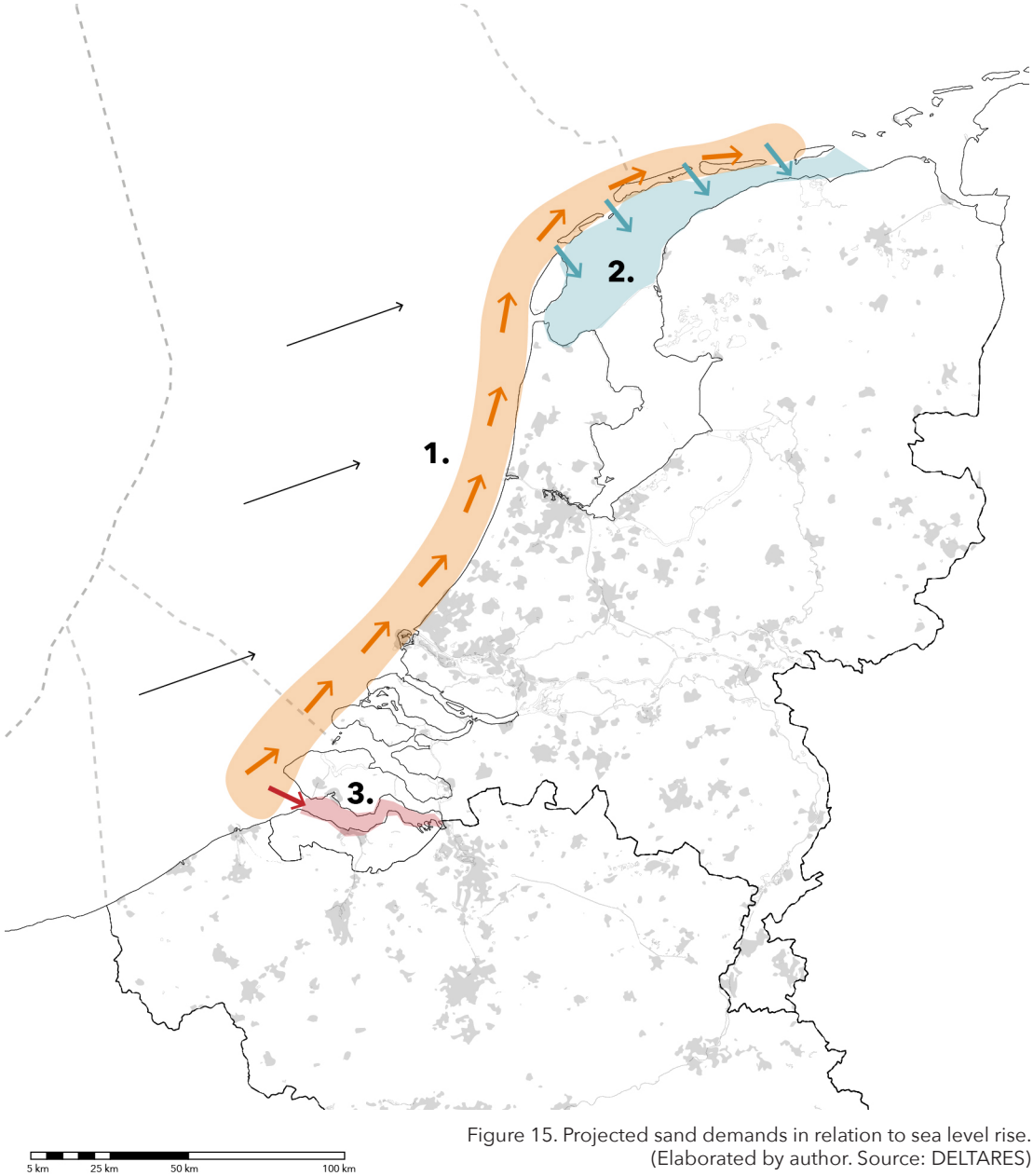


Figure 15. Projected sand demands in relation to sea level rise.
(Elaborated by author. Source: DELTARES)

5.2.2 CHANGE IN MORPHOLOGY OVER TIME - NATURE

Territory is in constant change, and this includes its morphology. On the Western Scheldt, the constant flow between river discharges, incoming sea waves and tidal variations are responsible for transportation of sediments. The tidal hydrodynamics of the river are the main force that influence morphology (Wegen and Roelvink, 2012)
As the sediments move from one place to another, the morphology of the river basin changes, some areas experience erosion while others aggregation.

Over time, the form and depths of the Western Scheldt have changed and will continue to do so in the future.

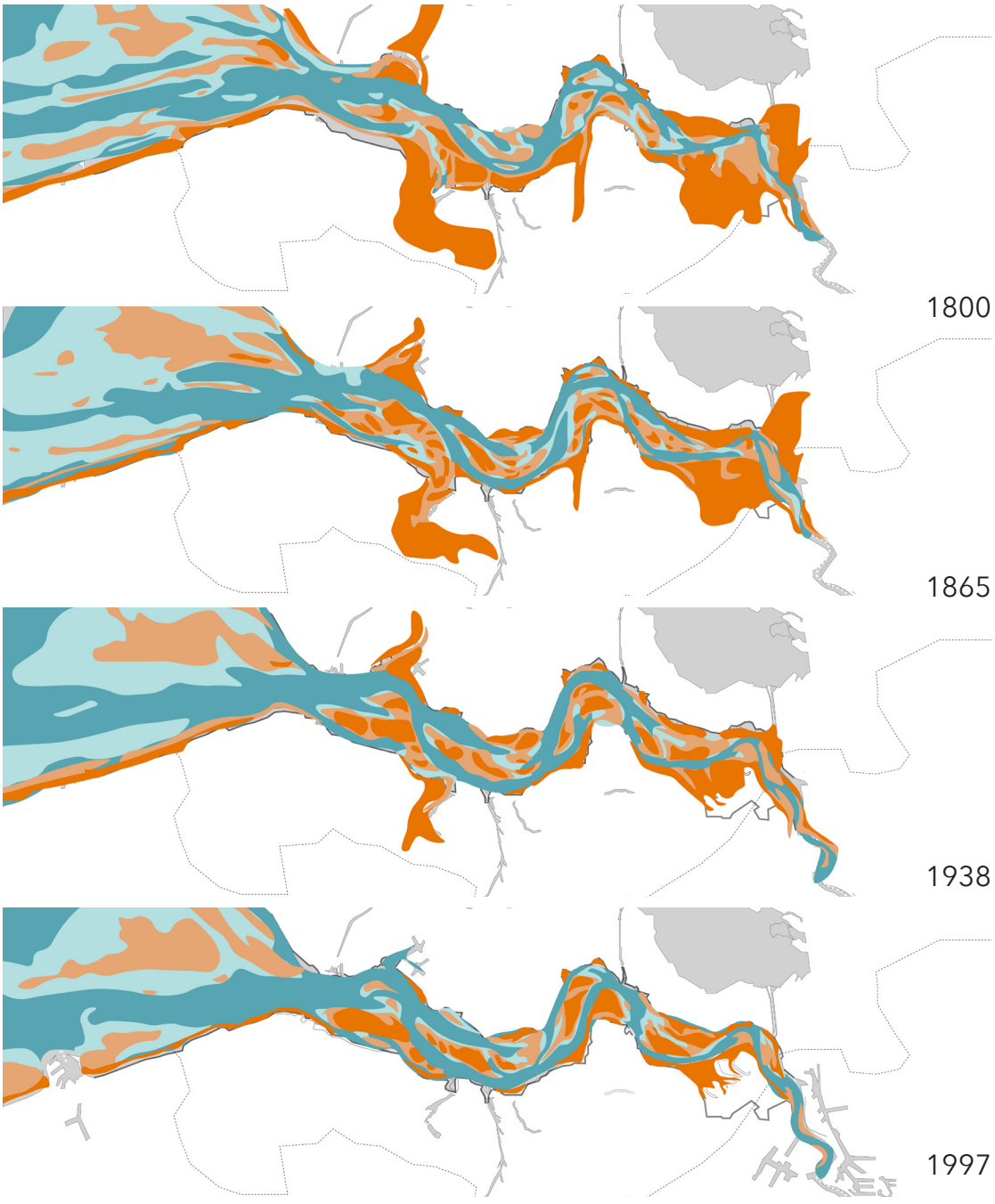


Figure 16. Morphological change of the Western Scheldt in the last 200 years
(Elaborated by author. Source: Plancke et al. 2006)

5.2.3 CHANGE IN MORPHOLOGY OVER TIME - HUMAN INFLUENCE

Human intervention, with processes of land reclamation, dredging and barriers, has gradually reduced the surface of these salt and freshwater marshes and altered the morphological dynamics. Nowadays, the river bank and estuary shore is completely man-made.

From the 11th century onwards, the process of land occupation became more apparent. Initially, when the flood safety techniques were not so sophisticated, some areas were taken by the river during strong storm events. From the 16th century on, more knowledge on poldering allowed for areas to be permanently reclaimed. (Plancke et al. 2006)

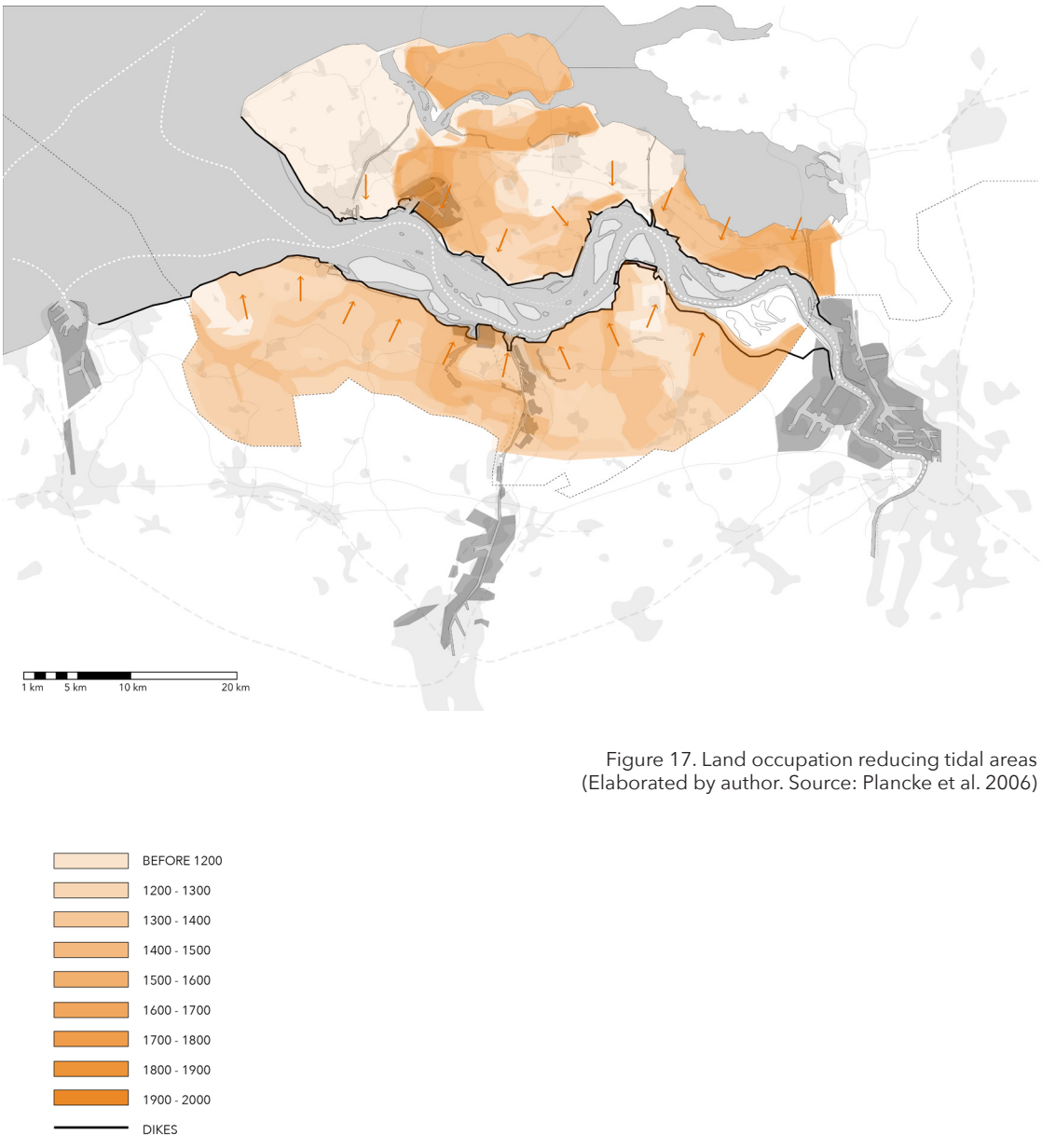


Figure 17. Land occupation reducing tidal areas
(Elaborated by author. Source: Plancke et al. 2006)

5.2.4. TIDAL RANGE

The boundaries of the estuary are all artificial and determined by man-made dikes. Marshes are only present at specific locations along the estuary and are all bordered by dikes as well. (Stark J., 2016)

As a result of the land occupation and the confinement of the borders, the Western Scheldt has lost storage area and sea water now propagates faster and further inland. Water levels have risen 1.3 meters since 1930 in the Western Scheldt around Antwerp, which is about 5 times more than sea level rise at the coast. (Temmermann et al., 2013)

This amplification is increased by the morphology of the Western Scheldt. The river becomes narrower and shallower as water moves inland

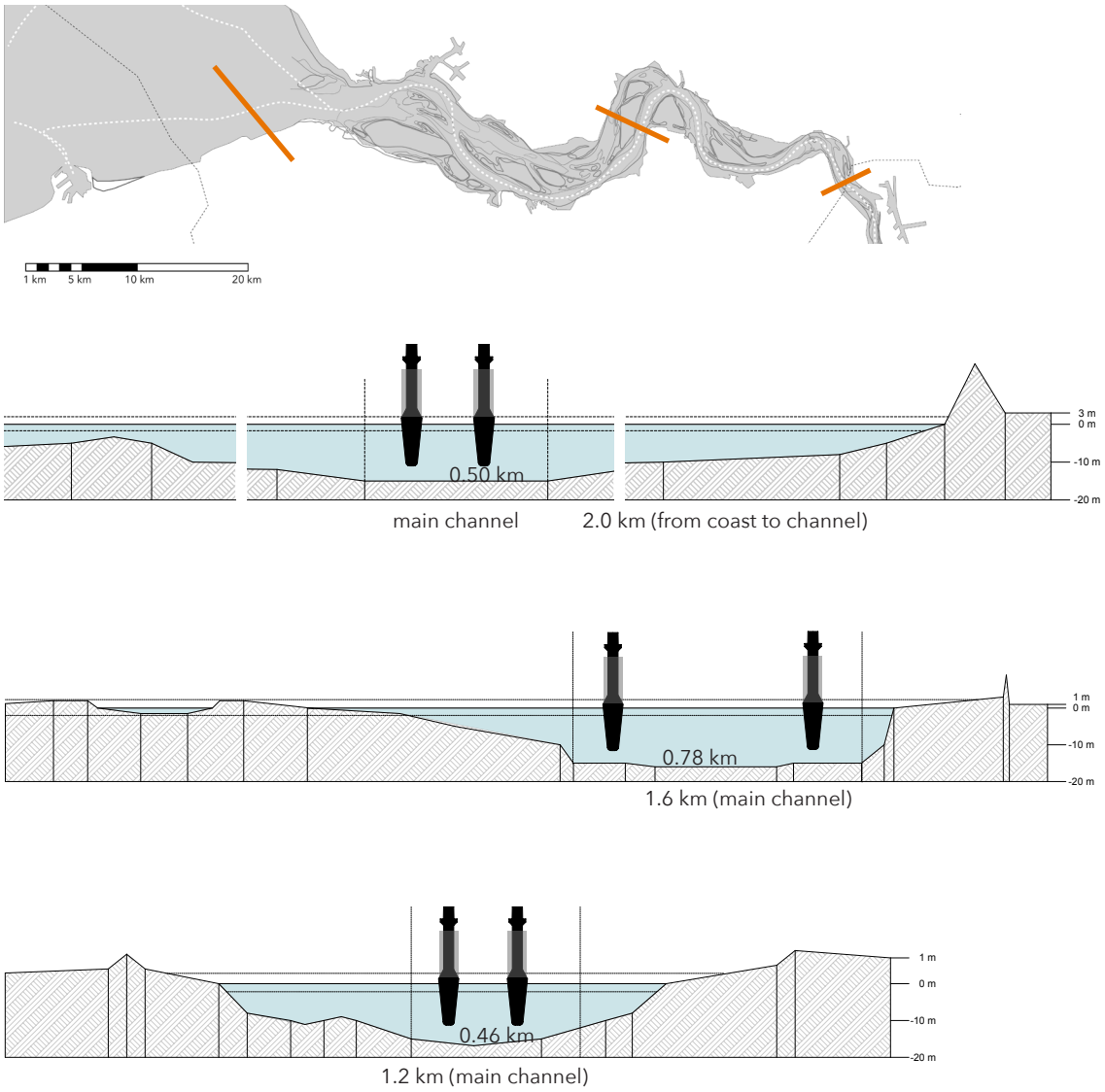


Figure 18. 3 Selected profiles on the Western Scheldt
(Elaborated by author. Source: Warmerdam, 2018)

Tides play a large role in the natural system. The tidal prism at the mouth of the rives is about 1 billion m3. The mean tidal range near Vlissingen is about 3.8 meters, while in the area of Antwerp it can reach 5.2 meters. Due to sea level rise and the morphological changes that the river has experienced, the propagation of the tidal waves and the water levels have increased (Sistermans P. and Nieuwenhuis O., 2004) "In Antwerp, the average high tide level has increased by 56 cm" (European Climate Adaptation Platform, 2014).

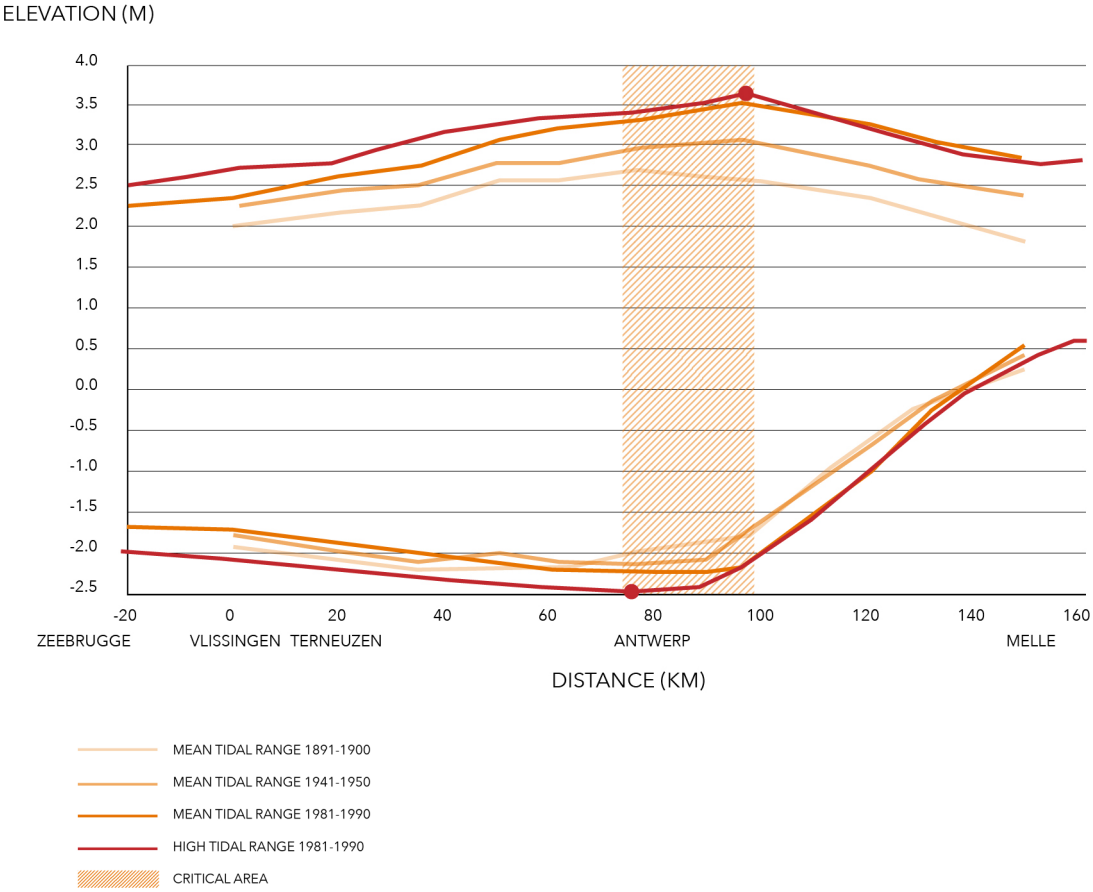


Figure 19. Tidal range along the Western Scheldt.
(Source: DELTARES, Pieters, 2002)

On this diagram, we can see that around the area of the Saeftinghe Marsh and Antwerp (around km 80) the tides range from +3.3 and -2.5 meters on the spring tide (the most extreme). It also shows how the tidal range has been increasing in the past century.

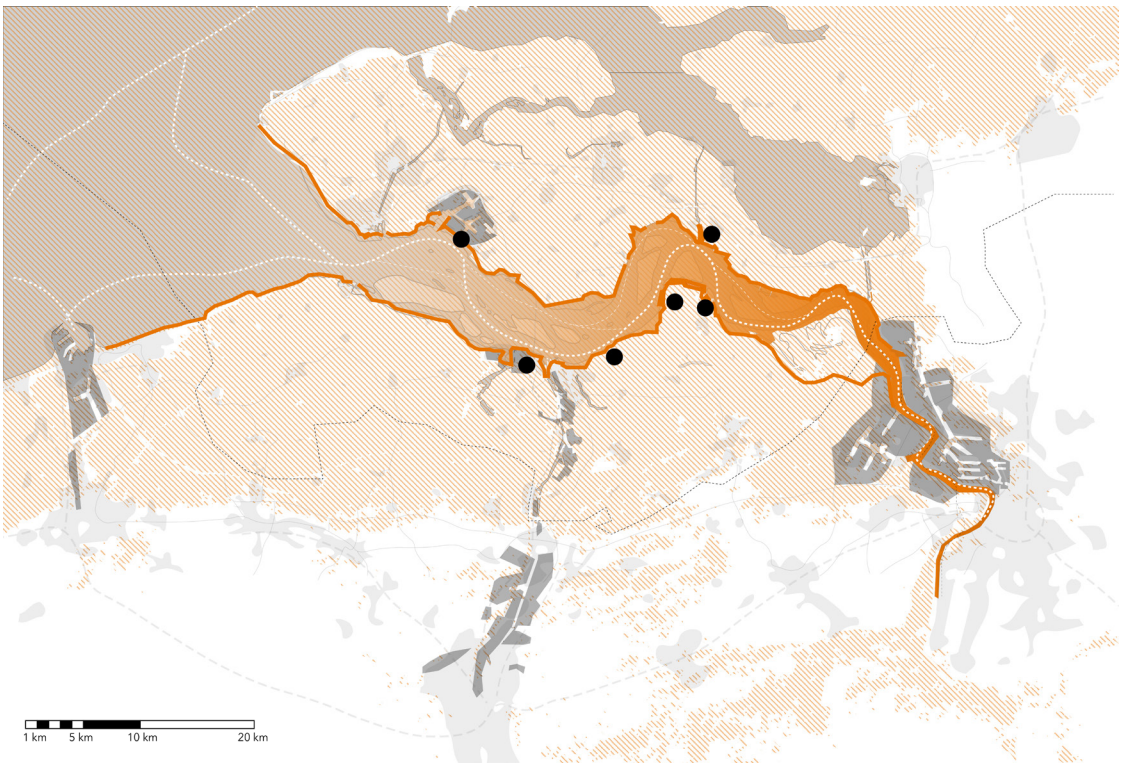
*The NAP is approximated the mean water level used in the Netherlands.

Intense waves also accelerate the deterioration of the defence infrastructure. For example, it increases the erosion on places where the channel curves. The base of the dike, which is less resistant than the dike, suffers then from scouring and the stability of the dike is compromised.

5.2.5. CURRENT STATUS OF SAFETY

The region (specially the Dutch area) is located at very low elevations. If it wasn't for the defence systems almost the whole region around the Western Scheldt would be under water when sea level reaches 2.00 m above current levels. Current dikes have sufficient margin to guarantee flood protection in the medium term, but eventually sea level will increase the risks. In 2007 for example, the project to raise the quays in Antwerp by 0.90m was initiated.

As both the Netherlands and Belgium realized that there is a limit to the dike rise approach (and does not represent the current social context) they aim to increase the natural capacities to support the dikes in flood protection.



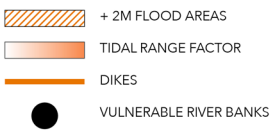


Figure 20. Flood risk areas based on elevation
(Elaborated by author. Source: http://www.floodmap.net)

5.3. THE WESTERN SCHELDT AND ITS ECOLOGICAL VALUE

The interaction between salty and sweet water in the Western Scheldt creates a range of very valuable habitats, being one of the few remaining estuaries in Europe that include the complete range of tidal areas, from sweet to salty (Peeters et al, 2006). "Below Hansweert, the estuary is completely saline, and between Antwerp and Hansweeit the water is brackish - a mixture of fresh and saline" (Report DGW, Prospects for the Scheldt Estuary, 1992)

Around the mouth of the Western Scheldt, there is a higher amount of species that feed on suspended nutrients, while on the estuary there are more deposit feeders (Ysebaert et al., 2003). The changing salinity and water movements along the estuary limits the amount of species that can adapt and live there, but their abundance is very high (Meire et al., 2005). Biodiversity is again very high on the sweet water tidal areas of the river.

The species that are present on the Western Scheldt are very important as they are the food supply for many birds and fishes. (LTV for the Scheldt estuary, 2001) The estuary is located on the NW European bird migration route and it includes up to 230.000 individuals, including 21 species of international importance (Ysebaert et al., 2000).

The Scheldt estuary is where some fish species grow and reach their adult stage before they move downstream. (LTV for the Scheldt estuary, 2001)

Figure 21. Ecosystems present on the Western Scheldt
(Picture taken by author.)

The Western Scheldt and their ecosystems provide a wide range of services. In terms of provision, the coastal areas and mouth of the Western Scheldt are places for fishing (cod, plaice, sole) as well as some shrimp and cockle catching. A current positive sediment balance accumulates around 2 - 2,5 mm3 of sand in the higher parts of the Western Scheldt and around 1,5 - 2 mm3 in the Zeescheldt. Out if this 4,5 mm3 positive balance, current policy allows for a maximum of 2,6 mm3 to be extracted from the river and be used for other purposes. (Long-term vision for the Scheldt estuary, 2001)

These ecosystems provide a wide range of regulating services that add to their value such as natural hazard mitigation, control of erosion temperature regulation and water purification (Munang et al. 2013). Intertidal areas such as estuaries are capable of store excess water and control flooding. They can also attenuate wind waves and storm surges and increase flood protection (Stark, 2017). In terms of water quality, marshes can capture heavy metals or organic particles like nitrogen and even increase the volumes of scarce nutrients like silica (Temmerman et al. 2013). They can capture Co2 from the air contributing to climate change mitigation (Temmerman et al. 2013).

As for recreational activities in the area, angling, deep-water diving, swimming, sailing, motor-boat cruising, relaxing on the beach, camping, visiting the historical towns and eating mussels are popular pastimes (Erasmus University, Rotterdam & Radboud University, Nijmegen, 2004). The infrastructural interventions like storm surge barriers, dams, etc. are also elements that attract visitors to the estuary. The dikes offer places to walk and cycle while viewing nature and the shipping traffic (Long-term vision for the Scheldt estuary, 2001).

In terms of biodiversity, the area not only provides habitat for plants and algae, but also for secondary production such as shrimps, mussels and even some benthic organisms and fish. Some fresh water species die when they enter saline environments and remain in these areas, which then become a nutrient source for the species that are adapted to these habitats. The estuary also creates favourable conditions for many permanent and migrating bird species to live there. (OSPAR, 2010)

If we use the categorization of ecosystem services by the Millennium Ecosystem Assessment, we can classify the previously mentioned services in the Western Scheldt as following:

-PROVISIONING:
Food sources, specially fish, shrimps, mussels, sand for extraction
-REGULATING
Wave dissipation, erosion reduction, soil stabilization, Co2 retention, filter
-CULTURAL
Recreational, educational, heritage
-SUPPORTING
Biodiversity conservation

The capacity of the ecosystems on the Western Scheldt to provide all of these services is dependent on the quantity and quality of them. Both through natural and human induced changes in time, these capacitates have been affected.

5.3.1 HABITAT LOSS

As a result of natural processes such as sediment transport and sea level rise as well as human interventions like land reclamation and dredging, the total area of salt marshes, mud flats and shallow water has decreased significantly in the last couple of centuries. The Dutch part has decreased from 15.000 ha to 7.000 since 1800, while in Flanders the total area has decreased from 700 ha to 550 since 1900 (Peeters et al., 2006, Wageningen University).

Sea level rise also plays a role in the reduction of intertidal habitats. As the mean water level rises, some of these areas start to flood permanently

CHANGES IN NATURAL SURFACE AREA IN WESTERN SCHELDT

	1960	1990	CHANGE
1. INTERTIDAL SALT MARSHES	3.520	2.540	-980
2. INTERTIDAL MUD FLATS	4.260	3.330	-930
3. SHALLOW WATER	4.450	3.170	-1.280
(1 + 2 + 3)	12.230	9.040	-3.190
4. SHOALS	4.480	4.930	+480
5. CHANNELS	16.160	16.960	+800
TOTAL	32.870	30.930	-1.940

Figure 22. Changes in natural surface (Hectares).
(Elaborated by author. Source:Peeters et al. ,2006, based on report from Rijkswaterstaat, 1996)

Human actions have not only reduced the quantity of habitats, but also the quality. The presence of agriculture, industries and ports along the Western Scheldt has caused the release of pollutants to the water. Agriculture is mainly responsible for the large nutrient load, particularly of nitrogen, into the Scheldt estuary (Cabri-Volga Consortium, 2005). Since the 70's the water quality has slowly started to improve, specially by reducing of organic loads in the water (LTV for the Scheldt estuary, 2001).

The constant dredging increases the amount of suspended particles, increasing turbidity of the water, affecting the living conditions for some species as production of phytoplankton is reduced. (Chen et al. 2005)

Among the initiatives to preserve the natural value of the Western Scheldt, some areas have been recognized internationally as nature reserves. The "Verdronken land van Saeftinghe", located near the border between the Netherlands and Belgium has been designated by Natura 2000 and as a Ramsar site to be protected. This is one of the largest brackish water marshes in Europe (3.500 ha). Other protected areas include "Schor van Waarde" (100 ha) and "Verdronken Zwarte Polder" (73 ha) (Sistermans P. and Nieuwenhuis O., 2004)

5.3.2 HABITAT RESTORATION

As concerns regarding ecological conservation increase, the Voordelta area was included in the Natura 2000 protection policy. This comes with a management plan of the delta and regulations for activities that disturbs or kills protected species. Exceptions can be made if compensations measures for the ecological impacts are included in the project.

Within the framework of the Outline 2030, to compensate for the habitat loss caused by the widening and deepening of the navigation channel, 600 ha of mud flats and salt marshes have to be created along the river on the Dutch side and 1.100 ha of wetlands on the Belgian side. (Verdrag tussen het Vlaams Gewest en Het Koninkrijk der Nederlanden betreffende de uitvoering van de ontwikkelingsschets 2010 Schelde-Estuarium. 2005. Het Vlaams Gewest en Het Koninkrijk der Nederlanden.) (Found in EU OURCOAST PROJECT DESCRIPTION)

On the Belgian side, the updated Sigma Plan from 2005 also calls for raising an additional 24 kilometres of dykes and increasing the land set aside solely for flood protection to 1523 hectares (390 ha more than in the original plan). (EEA, 2016)
New projects, (in some cases as compensation requirements) aim to increase the amount of marshes of the Western Scheldt. These large-scale restoration projects are included in the Sigmaplan to both reduce flood risks and increase intertidal habitats along the Scheldt estuary. (Stark J., 2016)

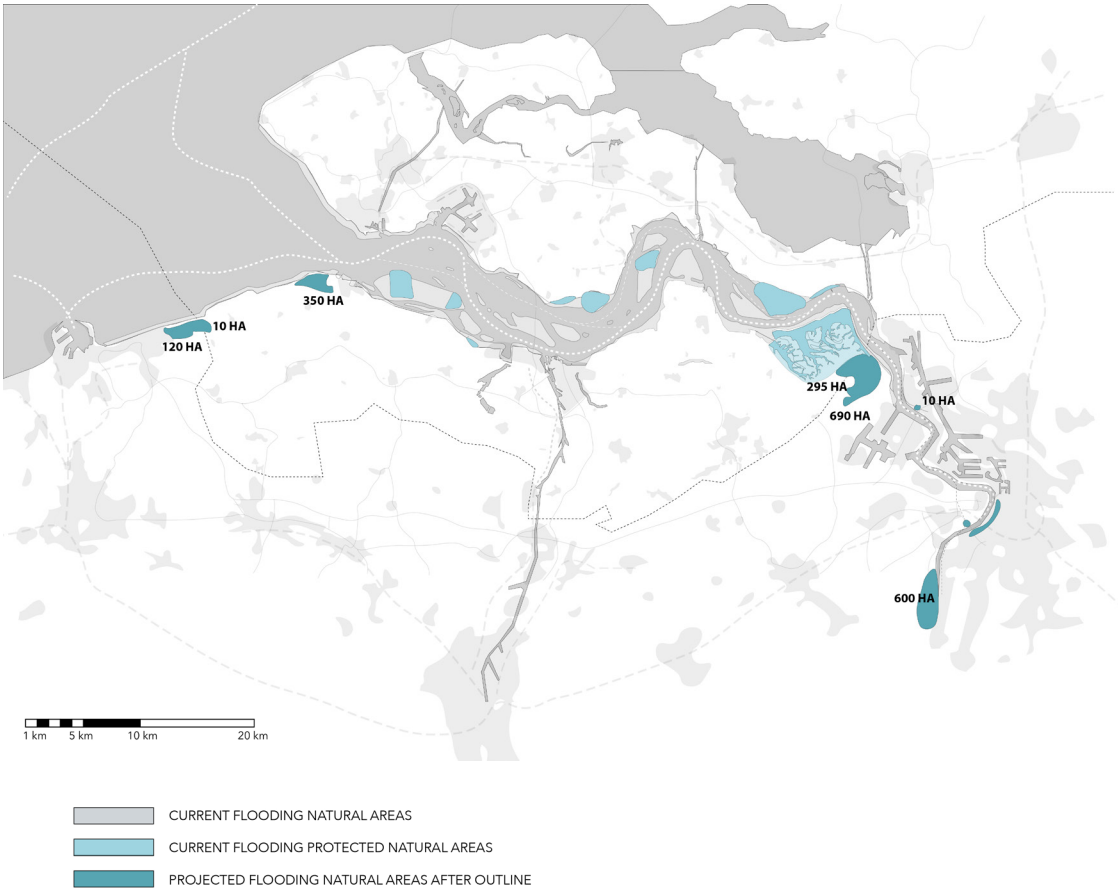


Figure 23. Existing natural areas, protected natural areas and new projects.
(Elaborated by author. Source: Sigmaplan, Deltawerken, Natura 2000)

5.3.3 CURRENT STATUS OF HABITATS

Based on the classification of surfaces on the Western Scheldt made by Rijkswaterstaat, (Fig. 22) I established a current measurement of these surfaces using elevation as a parameter. I considered the -5 m elevation as channel space. Shoals are considered in the water levels between -5 and -2 m. Shallow waters are considered between -2 and 0 m, as they would be exposed to intertidal conditions. Mudflats are considered between 0 and 2 meters, where vegetation can rarely grow and marshes are considered for 2 and higher elevations.

Based on these criteria, the map shows that the trend of losing existing river space and habitats continues (Using the same space of the Western Scheldt used in the 1960 and 1990 surface calculations). The new compensation areas outside the frame would show a slightly positive change in the amount of habitats compared to 1990.

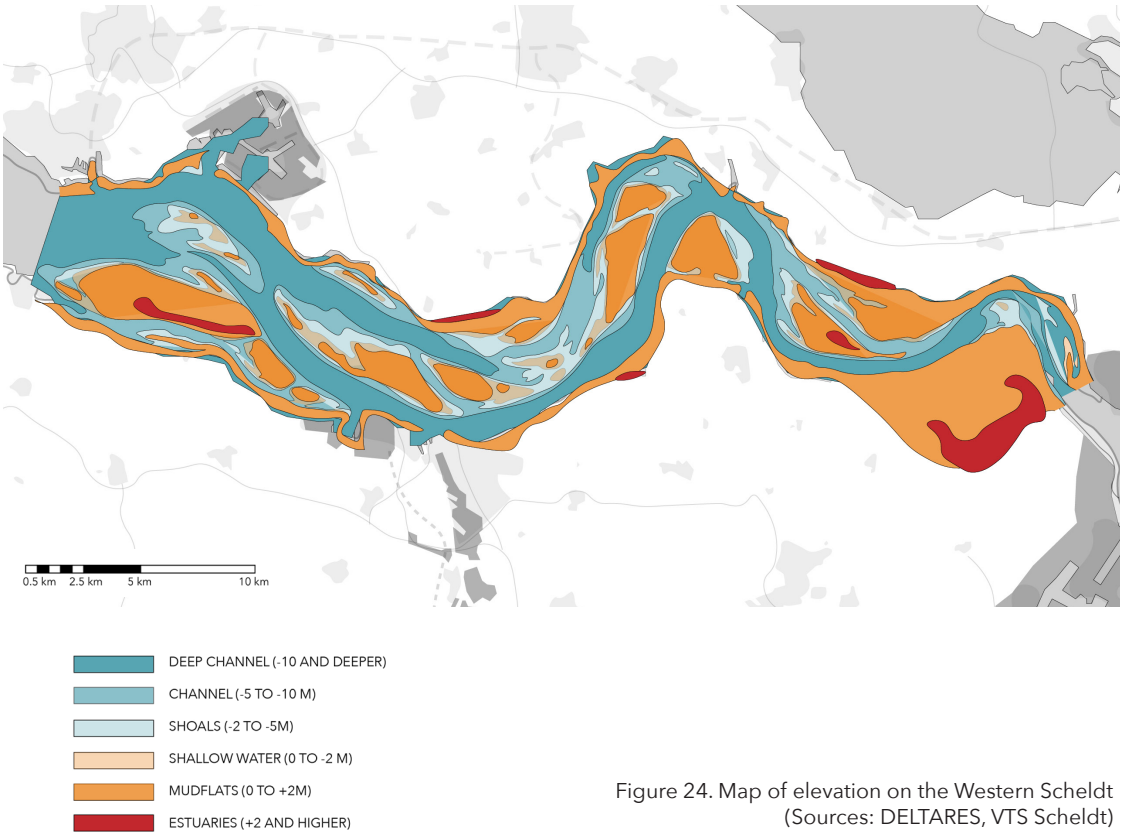


Figure 24. Map of elevation on the Western Scheldt
(Sources: DELTARES, VTS Scheldt)

	1960	1990	2018	CHANGE
1. INTERTIDAL SALT MARSHES	3.520	2.540	2.350	-1.170
2. INTERTIDAL MUD FLATS	4.260	3.330	3.290	-970
3. SHALLOW WATER	4.450	3.170	3.110	-1.360
(1 + 2 + 3)	12.230	9.040	8.750	-3.500
4. SHOALS	4.480	4.930	4.960	+510
5. CHANNELS	16.160	16.960	17.600	+1440
(DEEP CHANNELS)			8.740	
TOTAL	32.870	30.930	30.410	-2.460

Figure 25. Changes in natural surface (Hectares) + Current surface calculation).
(Elaborated by author. Source: Peeters et al. ,2006, based on report from Rijkswaterstaat, 1996)

5.4. THE WESTERN SCHELDT AND ITS ACCESIBILITY VALUE

The Scheldt ports are one of the most important economic poles in the Benelux, making the Scheldt waterways one of the busiest of the world. Around 200.000 vessels movements can be observed every year (Zeebrugge is not considered) including sea-going vessels, inland-going vessels, ferries, work vessels and recreational vessels. Approximately 60% of the total supply of sea-going vessels has destination Antwerp. (LTV for the Scheldt estuary, 2001)

These vessels use of the natural channels of the Western Scheldt for navigation. Morphologically the channels have the lowest bathymetries and as the high hydrodynamics in the channels result in lower habitat values.

Over time, the number of vessels has been rather consistent, but the size and capacity of the ships has increased significantly in the last few decades. To preserve the good accessibility to the inland ports, the navigation channels have been manipulated and enlarged both in depth and width.

This is more challenging on the higher parts of the river (on the Belgian side), where water is shallower and the river space is almost completely occupied by the navigation channel.

Figure 26. Port presence on the Western Scheldt
(Picture taken by author.)

5.4.1 THE SPACE OF THE MAIN NAVIGATION CHANNEL

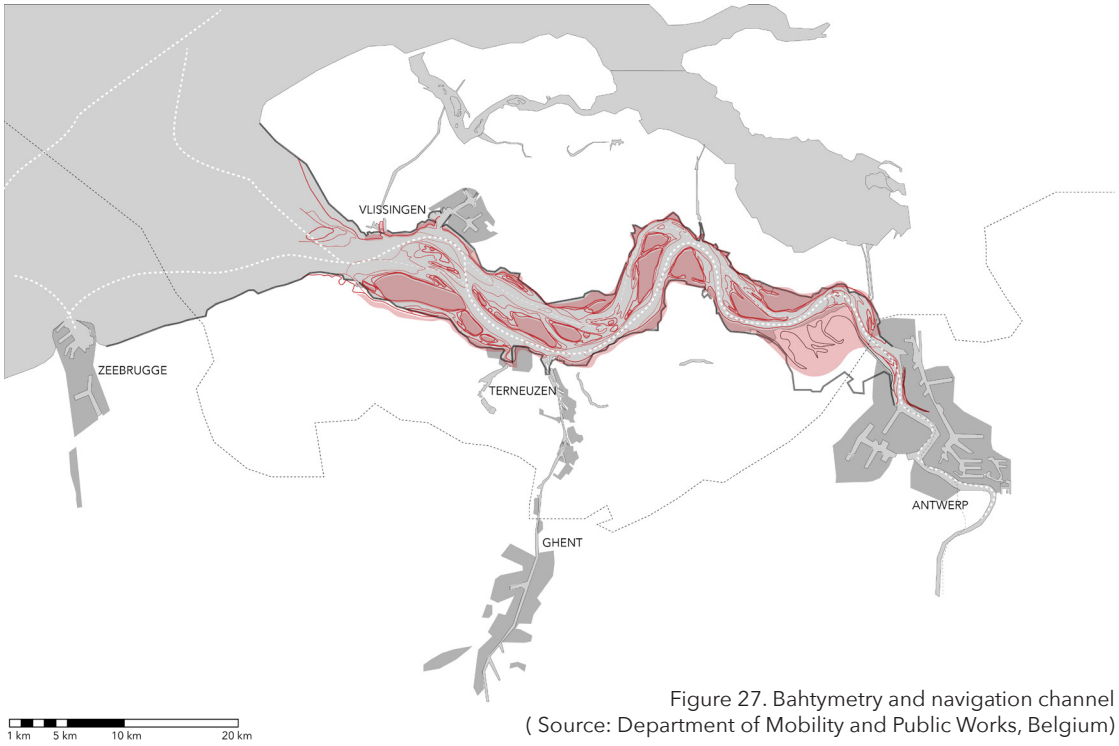


Figure 27. Bahtymetry and navigation channel
(Source: Department of Mobility and Public Works, Belgium)

The current depth of the main channel has been determined to assure tide-independent accessibility for ships with a draught till 13,10 m all the way to the port of Antwerp. Along the channel there are areas that can reach up to a -20 m depth.

As for the width, it varies along the river but becomes narrower in the Belgian side. The current enlargement established minimum width between 370 and 500 meters around the port of Antwerp. The 1/10 slope has been established in the latest enlargement of the channel as a minimum to maintain the banks' stability.

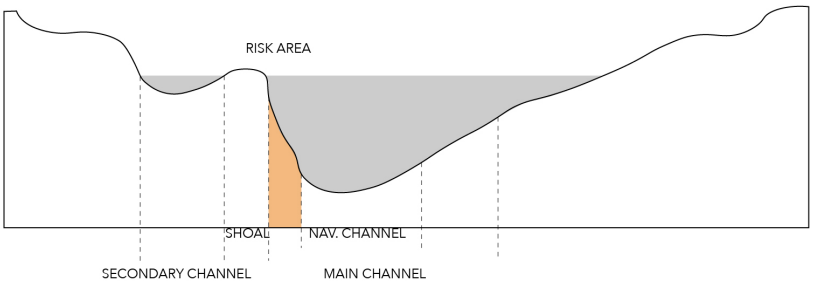


Figure 28. Steep slopes in the Western Scheldt
(Source: De Wit et al., 2007)

In some locations, where the channels are close to the borders or mudflats, trying to increase water depth can destabilize the river bank and the flood defences located in those borders. Dredging for example has altered the slopes between the sandbanks and main channel, which are now too steep for the proper conservation of some intertidal habitats (Report DGW, Prospects for the Scheldt Estuary, 1992) "It was not always recognised that river engineering schemes designed to deal with a localised problem can have far-reaching effects, often requiring remedial measures to be taken elsewhere."

5.4.2 THE SEDIMENT ACCUMULATION AND OBSTRUCTION

In addition to the morphological variations of the channel, the sediment transportation on the Western Scheldt also varies by location. It was previously indicated that the coastal area, mouth and lower part of the river experience a negative sediment balance. On the other hand, the higher areas experience an overall accumulation of sediments, which creates an additional challenge to maintain accessible shipping routes.

As the diagram shows, about 50% of the silt sedimentation takes place around the Saeftinghe marsh in the higher Western Scheldt (Van Eck, 1991)

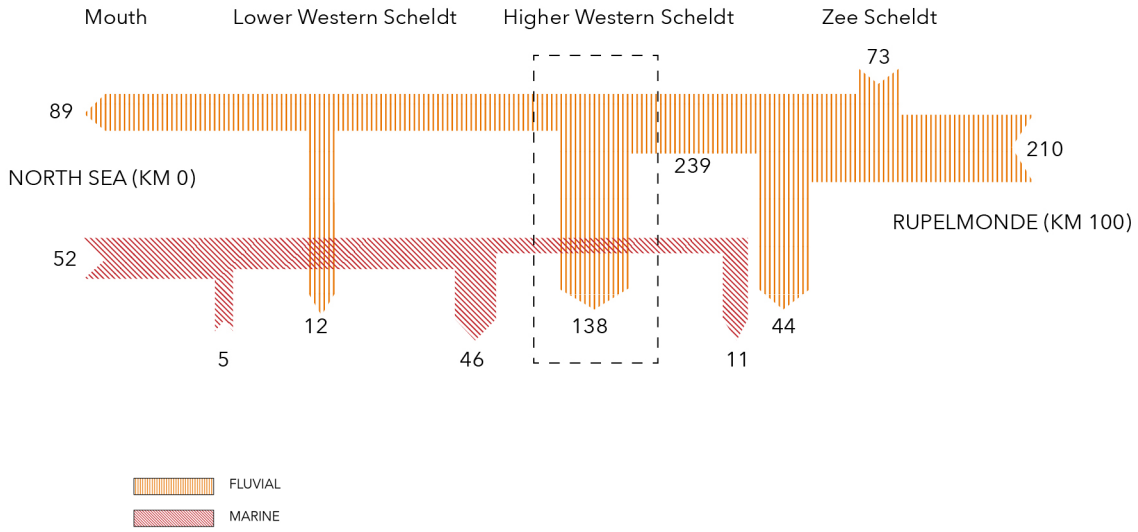
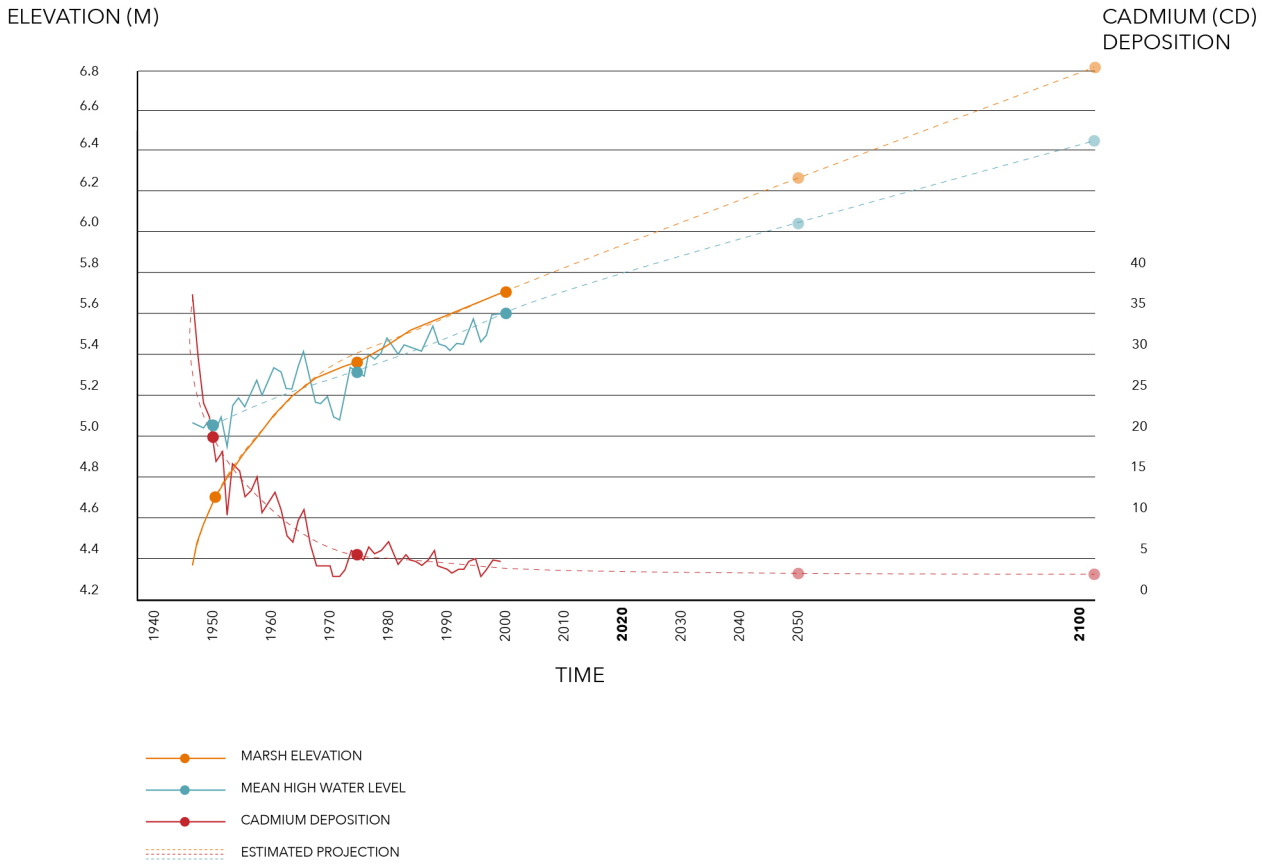


Figure 29. Diagram of silt transport on the Western Scheldt (Elaborated by author. Source: Van Eck, G.T.M. et al., 1991)

Most of the surface of the Saeftinghe marsh is between o and 3 m in relation to the NAP. The mean high-water level in the area is 2.76 m NAP, which is slightly below the mean platform elevation of the Saeftinghe marsh of 2.99 m NAP. (Stark J., 2016). In the last century, the elevation of the marshes has raised about 1.3 meters as result of sedimentation processes. Figure 30 shows that the change of elevation has occurred at a faster rate than sea level rise and some areas of the marsh have now a reduced intertidal influence. This even impacts the marshes capacity to filter pollutants form the water (Teuchies et al. 2013)



ge of mean water level, elevation of the
d volume of Cd deposition in the marsh
/ author. Source: Teuchies, J. et al. 2013)

5.4.3 DREDGING STRATEGIES

There has been a change in the way dredging is executed on the Wester Scheldt. Initially, dredged material was dumped on the sides of the main navigation channel of the mid-Western Scheldt and in the secondary channels (Deltares 2013). The channels are high hydrodynamic areas and sediments return "quickly" back to their original location, which lead to high maintenance efforts. In other cases, an excessive dump of sediment in the secondary channels was resulting in their obstruction and additional accumulation of sediments in those locations.

This constant process of dredging and dumping sediment in the river has also negative effects. The constant dredging of the shipping lines incorporates additional sediment particles into the water, increasing its turbidity and affecting life underwater. Because the sand in the upper part of the Scheldt is polluted, the dredged sand is dumped in the same area. The mud then moves back to the deeper area of the shipping lane, being constantly recirculating. (Report DGW, Prospects for the Scheldt Estuary, 1992)

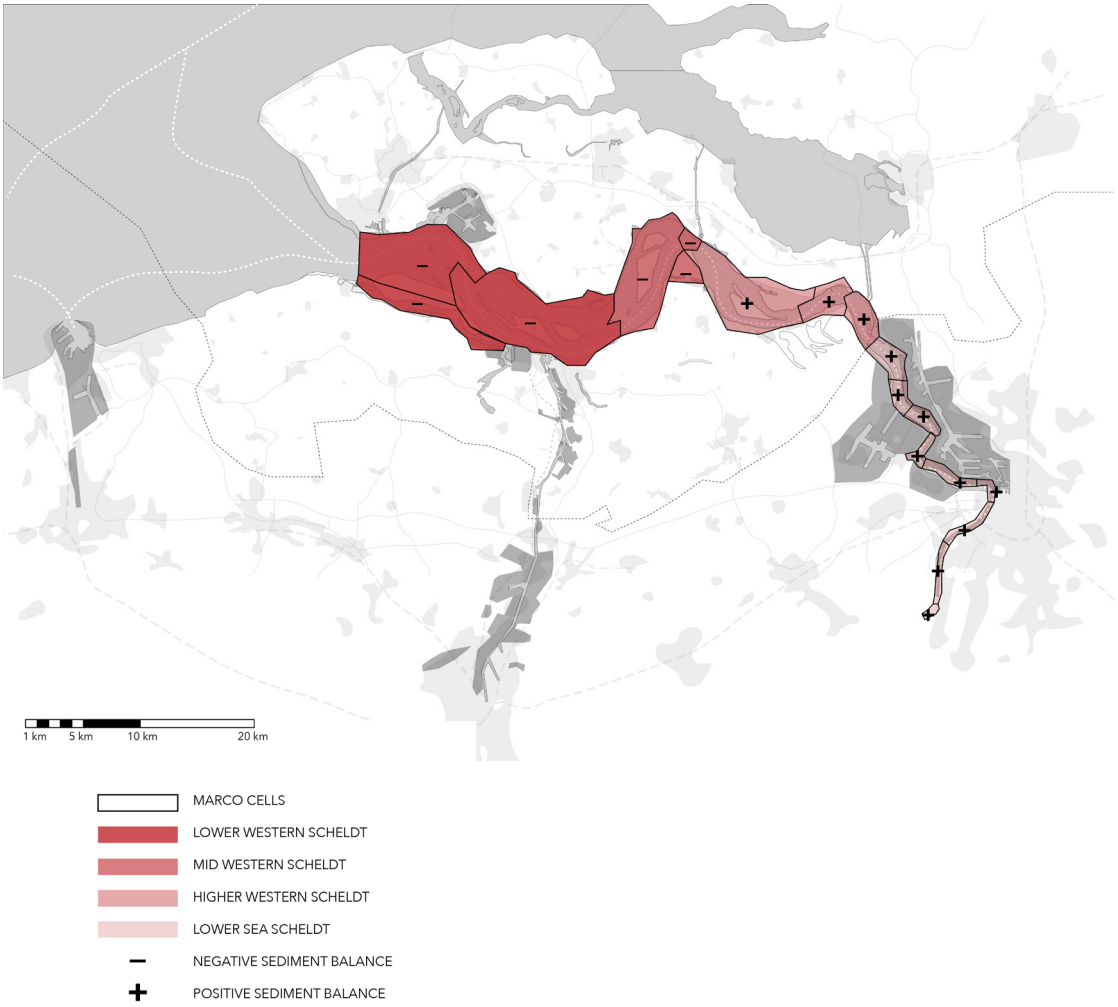


Figure 31. Sediment balance per zone on Western Scheldt
(Elaborated by author. Source: Maritime Access Division, 2010)

To cope with climate change and improve the internal sediment balance of the Western Scheldt, there has been an increasing sand extraction on the higher parts of the river (particularly macro cell 5) and dumped in the mid and lower areas (cells 1-4) (Maritime Access Division, 2010).

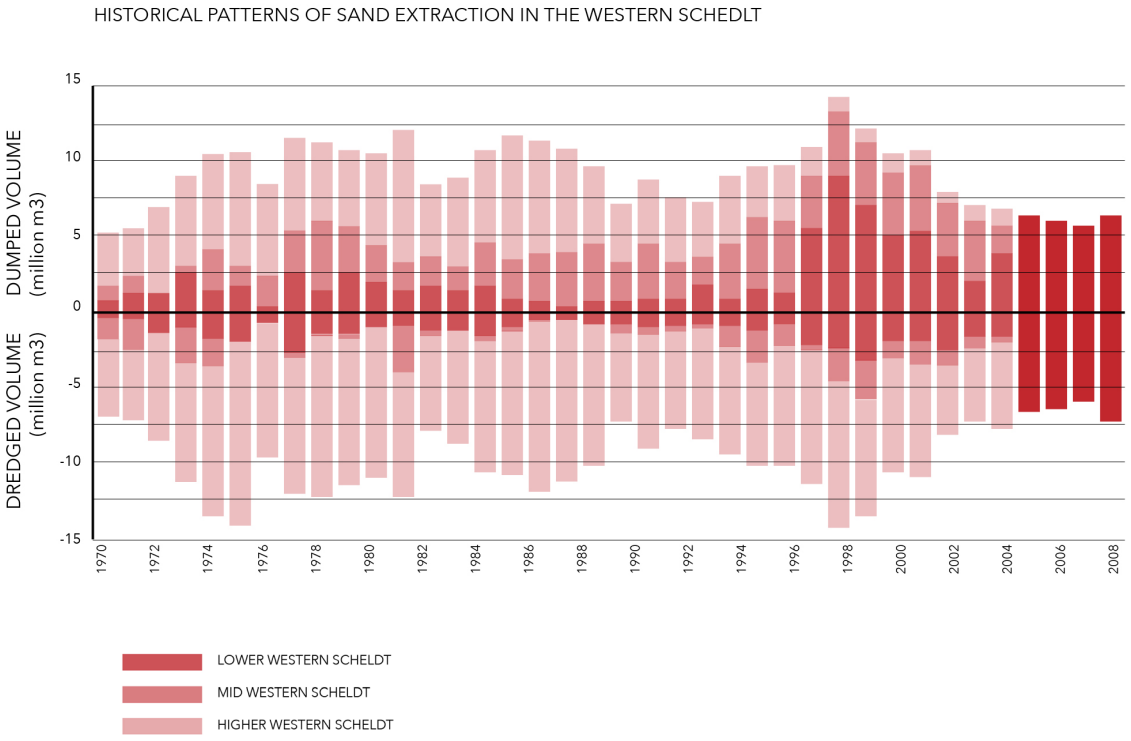


Figure 32. Historical sediment dredging and dumping per zone on Western Scheldt (Elaborated by author. Source: Maritime Access Division, 2010)

The third channel enlargement (2005-2006) estimated a total of 14 mm3 to be dredged form the river. 6,3 mm3 out of the total would be dredged from the Sea Scheldt (cells 8-17), 5,2 mm3 from the higher part of the Western Scheldt (cells 5-7), 1,1 mm3 form the mid Western Scheldt (cell 4) and 1,4 mm3 of the lower Western Scheldt (cells 1-3) (De Wit et al., 2007)

As part of the last agreement to deepen the navigation channels in the Western Scheldt, an environmental assessment was elaborated. The alternative that was chosen (Flexible relocation) proposed using the extracted sand from the dredging and deposit these sediments in strategic areas that would contribute to the maintenance of the mudflats within the estuary (Plancke & Ides, 2006).

In addition to the secondary channels, new sites for dumping include subtidal areas near sandbars and deep parts of the main channel. (TIDE, 2013)

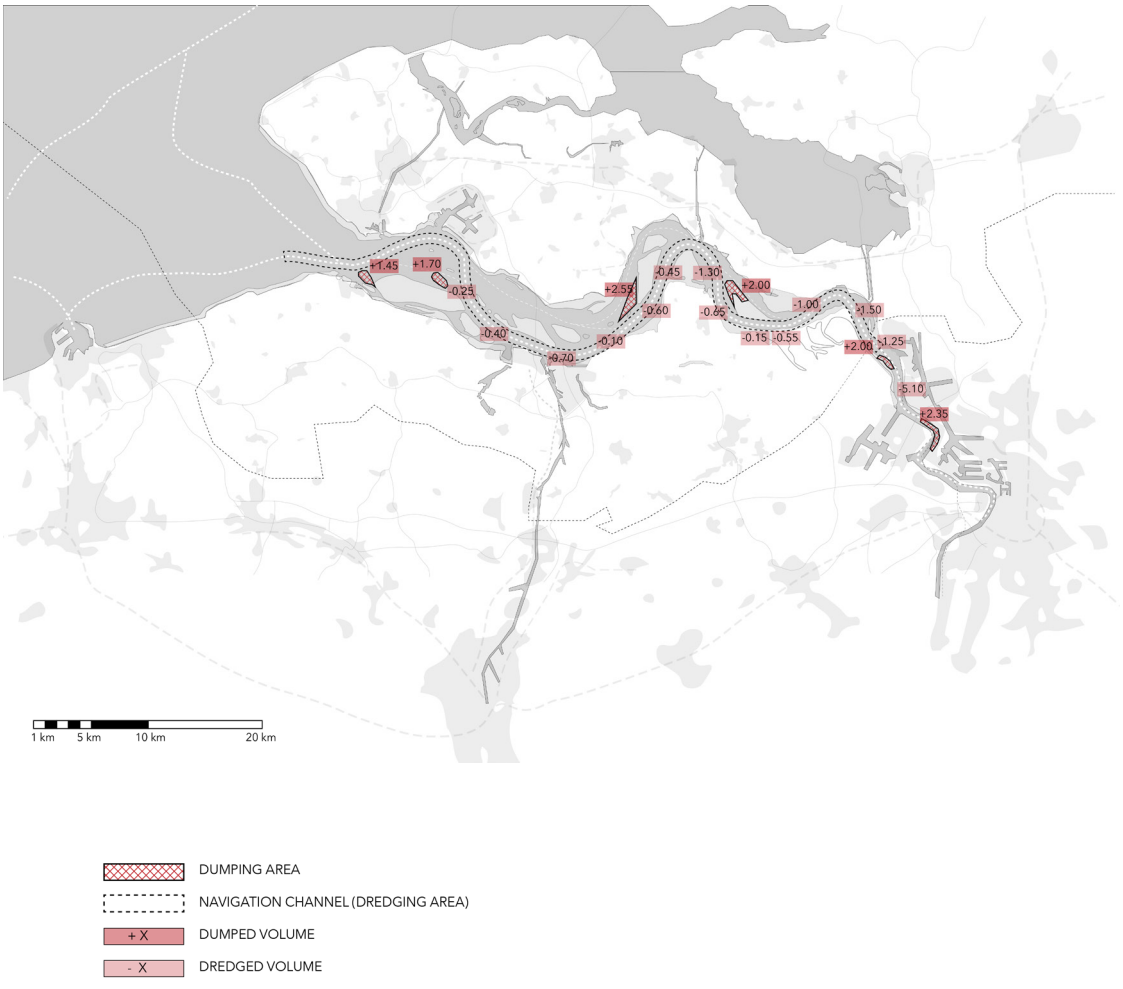


Figure 33. Alternatives to manage dredged sediments.
(Elaborated by author. Source: Environmental Impact Assessment (EIA). Port of Antwerp, 2005)

5.5 FINDINGS: INTERDEPENDENCY OF THE SYSTEMS

The three functions (Safety, Ecology and Accessibility) are considered as priority for the Western Scheldt and need to be managed by both the Netherlands and Belgium.

Each of these functions have competing values, but the components of each of these subsystems are interconnected (Buuren et al.,2008). Planning and managing one of these subsystems separately will quickly face limitation by the other functions.

For example, by confining the borders of the river space with dikes as a safety measure, navigation and ecology have to coexist within those boundaries. By enlarging the navigation channels and performing constant dredging, the resistance of the river bed is reduced and speed of the currents increases (Buuren et al.,2008). It also affects the river and shoal banks, which become less habitable by species. The presence of mudflats and natural water depths are constraints for good navigability. (European Commission, 2003)

In order to deal with the conflicts between functions and contribute to these 3 goals defined on the Outline 2010 for the future of the Western Scheldt (2030), we should aim for multi-system strategies. Luckily, the natural values of the Western Scheldt already show that they can contribute to some extent to each of these functions simultaneously:

-Safety: Wave dissipation by surface and bottom friction, positive sediment transports for river bank stability, Co2 capture and subsequent climate change mitigation.
- Ecology: Water and soil purification, phytoplankton production as key component of the food web.
-Accessibility: Soil stability reduces sediment deposition on navigation channels, accumulation areas of moving particles.

On top of these functions, ecosystems can provide added economic values including food sources (Fish, seafood, algae), energy sources (Biomass, tidal), material sources (rushes, salt, sand, silt) and social values including recreational and educational spaces, identity, scenery, etc.

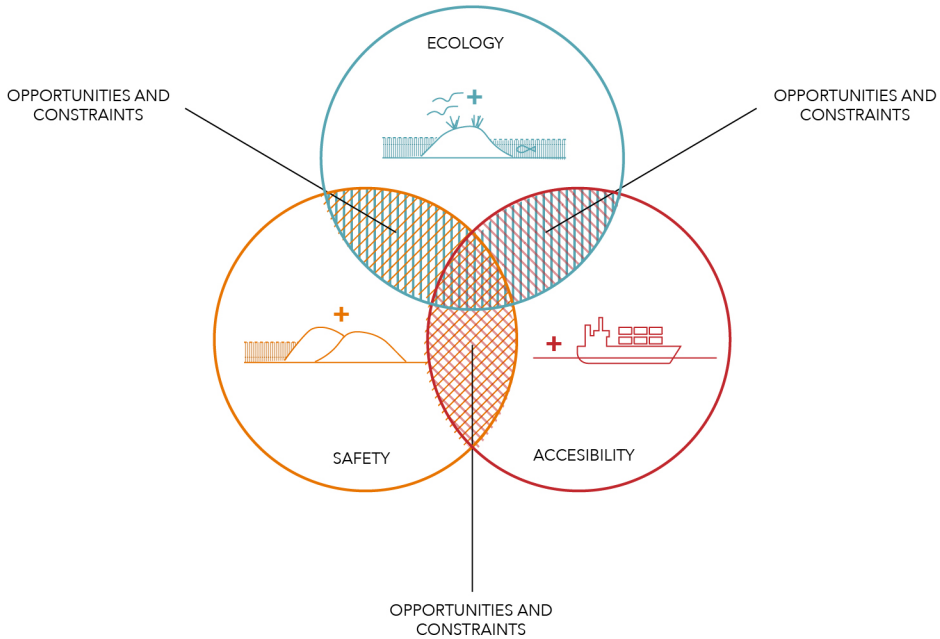


Figure 34. Diagram of systems and interdependency
(Elaborated by author.)

5.5.1. EBA FOR A SUSTAINABLE DEVELOPMENT OF THE WESTERN SCHELDT

There is a high potential to develop multi-systemic strategies if use these ecosystems and manage them to maintain and enhance their capacities. Such strategies would fit in the framework of Ecosystem-based adaptation (EbA) and would be a desirable pathway for the Western Scheldt.

The habitats of the Western Scheldt are valuable even from a European scale. If our interventions on the area not only improve our living conditions, but also have positive effects on the quantity and quality of the ecosystems present in the river, their provision of services will be higher and will create a more sustainable development.

This open arm of the delta is highly exposed to the influence of the sea and the climate change effects such as sea level rise and storm events. To maintain safety, a lot of investment in infrastructure like dikes is required. As Zeeland is a low priority region to invest in, multi-functional solutions can reduce costs. EbA solutions not only are multi-functional, they have high adaptive capacity. This can be combined with the existing infrastructural solutions. For example, it would extend the lifespan of the current dikes and reduce costs for reinforcements in the long term.

5.5.2. BUILDING WITH NATURE AS A PHILOSOPHY THAT PROMOTES EBA

In the area, particularly in the Netherlands, there are already initiatives to research and test the incorporation of nature in infrastructure for more flexible and adaptable solutions. This "Building with Nature (BwN)" philosophy combines the forces of engineering and natural dynamics with innovative solutions.

"Building with Nature begins with the natural system and uses ecosystem services to meet society's need for infrastructure and encourages the development of nature at the same time." (Ecoshape) The focus is to find innovative, sustainable and adaptable solutions to hydraulic engineering.

The Building with Nature approach in the Netherlands has develop pilot projects in the Wadden Sea, Ijselmeer, Rhine, Meuse, Scheldt Delta and The Dutch coastline. The positive results on most of these projects support the feasibility of such strategies.

A very famous example is the "sand engine" located in the coast Ter Heijde. It combines the principle of beach nourishment with the use of natural currents to distribute the sediments in a larger extension of the coast and dunes. Other projects incorporate the action of dredging, used to maintain the navigation channels, and use the dredged material to improve habitat and morphological conditions.

6. GOVERNANCE (SOCIAL) ASSESSMENT

This chapter will explain the "system" of governance that takes place on the Western Scheldt and what are the main opportunities and constraints to increase collaboration.

The first section will reveal the spatial planning context of both countries (The Netherlands and Belgium) and the main differences and similarities of their planning culture, structure and power related to this cross-border region.

The second, third and fourth sections will establish the roles of governance in relation to the main 3 functions (Safety, Ecology and Accessibility). Also, what policies and stakeholder groups are involved in the development of each of these functions in the Western Scheldt.

The final section explains the existing cross-border initiatives in governance, especially the Outline 2010 which defined the 3 main functions in the first place. This includes the confrontation of the goals with the current conditions that influence the development of the area.

6.1. THE ROLE OF GOVERNANCE IN THE WESTERN SCHELDT

The case study of the Western Scheldt represents an extreme case where the scale of biophysical dynamics cannot be managed by the traditional governance and planning structures. We are talking about a delta river that is present in 2 countries, Belgium and the Netherlands.

Even if most of the Western Scheldt is located in the Dutch province of Zeeland, its area of influence expands further than that. The Zee Scheldt is the river located in the Belgian province of Antwerp that that discharges into the Western Scheldt. The western Scheldt is also a concern of the Belgian province of West Flanders for its proximity to the river's mouth and the province of East Flanders for the connection between the river and the Ghent-Terneuzen channel. It can even be a concern of the province of South Holland if we consider the Delta as a whole natural entity.

The cross-border delta also plays a significant role for both countries, but driven by different goals and different planning systems (Eker, 2013).

As it was previously explained, the Western Scheldt is a valuable area for nature conservation. (Maillefert, 2013, p.1). It is part of a delta where 3 major European rivers discharge into the North Sea, resulting in very valuable ecosystems.

For Belgium, port development has a high priority in the decision-making as the waterway related economic activities are important contributors to the region's wealth (Vries, 2001).

"The Scheldt is the entrance to the harbour of Antwerp, an ecological valuable area and a notorious apple of discord between the Netherlands and Flanders." (Leibenath et al., 2008). To maintain the unconditional access to the port for shipping, a treaty was signed by both countries in 1839. Because of this overlap between governance and river space, the management of the Scheldt is more complex. The cross-border condition of the Western Scheldt requires coordination between the two countries to fulfil these different goals in an optimal way.

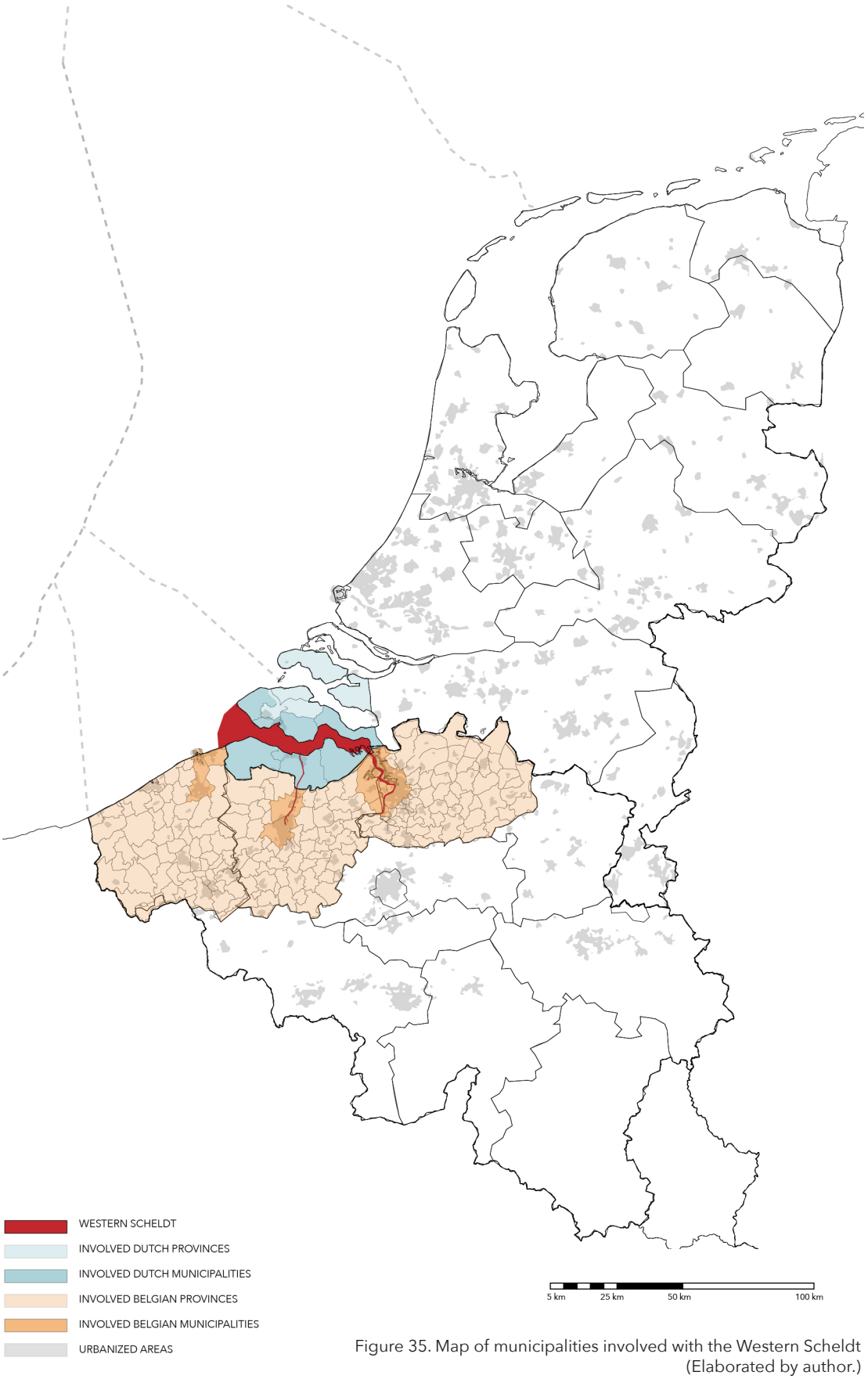


Figure 35. Map of municipalities involved with the Western Scheldt (Elaborated by author.)

6.1.1. THE ADMINISTRATIVE STRUCTURE

Besides the difference of interests and priorities between both countries, there are also structural differences like the number, size and power of the administrative units. (Eker and Houtum, 2013).

In fact, in this case is more accurate to compare the power between The Kingdom of the Netherlands and the Region of Flanders even if it is not the same administrative scale.

The number of municipalities involved in both countries may be similar, but in Belgium they are dispersed and distributed in 3 different provinces. The municipalities in the Dutch province of Zeeland are also larger and less urbanized than the Belgian ones.

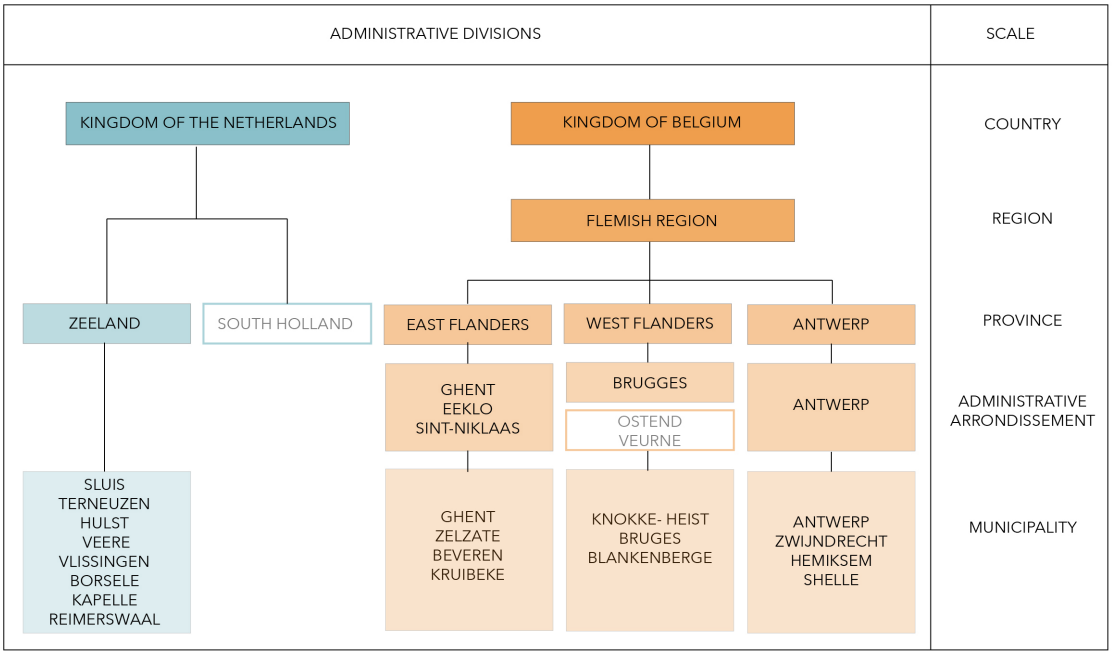


Figure 36. Administrative divisions in Belgium and the Netherlands
(Elaborated by author)

6.1.2. THE PLANNING CONTEXT

Each country has its own planning system, influenced by history, culture, society, etc.
The planning context in the Netherlands and Belgium is different in many ways, which poses an obstacle to collaboration when dealing with related issues. They also have some common traits, which can be seen as opportunities to improve collaboration.

Eker and Houtum (2013) defined some for these differences and similarities in their planning context, which are following described:

	NETHERLANDS	BELGIUM (FLANDERS)
DIFFERENCES	- Long history of using spatial planning to develop the country - Administrative culture based on consensus and high expectation on the problem-solving capacities of the government. - Limited exchange of ideas in planning and related issues with Flanders - High relevance of written material for decision making -More open terms in policy -More presence of planners in the government - Decision-making of the planners aims to be more neutral	- Limited use of spatial planning until the past couple of decades. - Administrative culture based compromise and less trust in the government, a "necessary evil" - Limited exchange of ideas in planning and related issues with the Netherlands - High relevance of agreements between stakeholders for decision making -Desire for precise terms in policy -More presence of consultants in the government -Decision-making is more influenced by political parties
SIMILARITIES	- Both share the same language and some historical roots. - The Netherlands has transitioned from regulative planning to a more decentralized planning, Flanders ambition is also to make this transition. This means that provinces are responsible for the development of their strategic plans. - In both the Netherlands and Flanders, international competition can dominate decision making and spatial planning at the cost of sustainability goals, like the port development.	

Figure 37. Summary chart of similarities and differences in the Dutch and Flemish planning culture (Elaborated by author. Source: Eker and Houtum, 2013. p.313.314)

6.1.3. GEOGRAPHICAL RELEVANCE OF THE REGIONS

The geographical position of the Western Scheldt and the regions that are involved in the decision making over that territory have a different meaning for the 2 countries.

In the Netherlands, we can define the Western Scheldt as part of the "delta region". In this delta region, the northern part is well connected to both the economic heart of the country (the Randstad) and the easy access to the North Sea. For this reason, port of Rotterdam developed as an important economic cornerstone (Vries, 2007). On the other hand, the Western Scheldt is located in the lowest part of this delta region, with limited infrastructural connections between North and South. The river arm is then a distant and peripheral zone.

In Belgium is the opposite case. The Western Scheldt is the access point to the port of Antwerp and port of Ghent. Both cities are part of the "Flemish diamond" which is the Belgian economic heart (Liebenath et al., 2008). This means that the willingness of the Flemish government to be involved in the decision making of the Western Scheldt is high

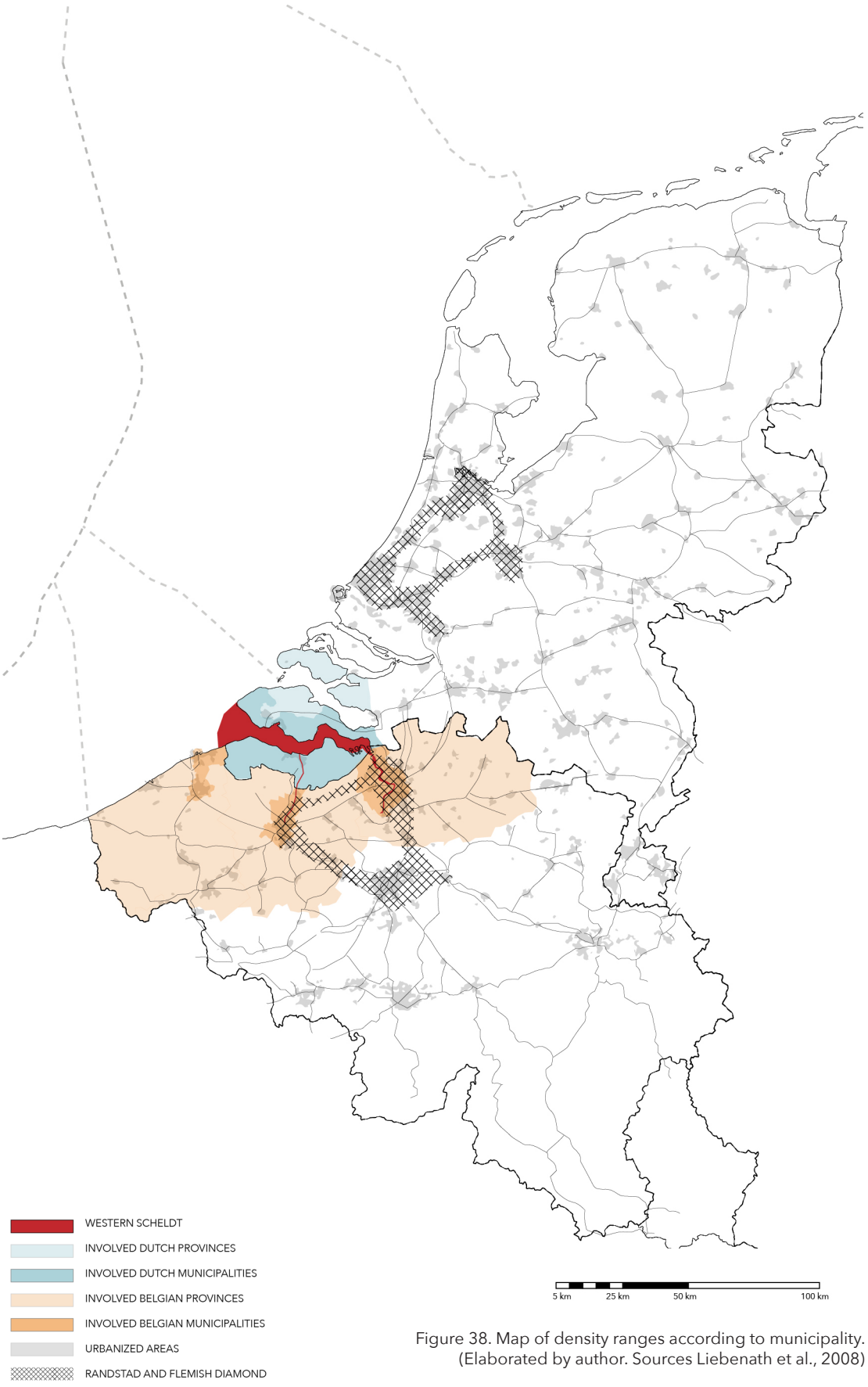


Figure 38. Map of density ranges according to municipality. (Elaborated by author. Sources Liebenath et al., 2008)

6.1.4. SOCIAL RELEVANCE OF THE REGIONS

The position and role of the regions also influence their demography.

The peripheral positon of Zeeland in not attractive for most people to move or establish their business there. Zeeland like the northern provinces of the Netherlands have more agricultural uses and densities below the national average.

In the case of Belgium, the Flemish region of the north is significantly denser than the Walloonian region of the south. The central position of the Flemish provinces of Antwerp and East Flanders attract urbanization and migration and are the densest areas after Brussels.

By 2017, the population in Zeeland represents only 2,2% of the Dutch population, while the Flemish provinces represent 16.3% (Antwerp), 13,2% (East Flanders) and 10,5% (West Flanders) of the Belgian population. This impacts the social representation of the provinces and the level of priority that the countries assign to deal with their problems.

Not only population is low, but the trend shows that most municipalities in Zeeland are shrinking, while the Belgian municipalities related to the Western Scheldt show a moderate grow (With the exception of Knokke-Heist)

DENSITY BY PROVINCES IN THE NETHERLANDS (2018)

PROVINCE	SURFACE	POPULATION	DENSITY
DRENTHE	2.641 km2	492.100	186 p/km2
FLEVOLAND	1.417 km2	411.670	290 p/km2
FRIESLAND	3.341 km2	647.268	194 p/km2
GELDERLAND	4.971 km2	2.060.103	414 p/km2
GRONINGEN	2.333 km2	582.944	250 p/km2
LIMBURG	2.150 km2	1.117.198	520 p/km2
NORTH BRABANT	4.916 km2	2.528.286	514 p/km2
NORTH HOLLAND	2.671 km2	2.831.182	1.060 p/km2
OVERIJSSEL	3.325 km2	1.151.501	346 p/km2
SOUTH HOLLAND	2.814 km2	3.681.044	1.308 p/km2
UTRECHT	1.385 km2	1.295.484	935 p/km2
ZEELAND	1.787 km2	382.304	213 p/km2
TOTAL	33.751 km2	17.181.084	509 p/km2

DENSITY BY PROVINCES IN BELGIUM (2018)

PROVINCE	SURFACE	POPULATION	DENSITY
ANTWERP	2.860 km2	1.847.486	646 p/km2
EAST FLANDERS	2.982 km2	1.505.053	505 p/km2
FLEMISH BRABANT	2.106 km2	1.138.489	194 p/km2
LIMBURG	2.414 km2	870.880	541 p/km2
WAST FLANDERS	3.151 km2	1.191.059	378 p/km2
HAINAUT	3.800 km2	1.341.645	353 p/km2
LIEGE	3.844 km2	1.105.326	288 p/km2
LUXEMBOURG	4.443 km2	283.227	64 p/km2
NAMUR	3.664 km2	493.073	135 p/km2
WALLOON BRABANT	1.093 km2	401.106	367 p/km2
BRUSSELS*	161 km2	1.191.604	7.401 p/km2
TOTAL	30.518 km2	11.368.948	373 p/km2

Figure 39. Density chart by province in NL and BE.
(Elaborated by author. Sources CBS, STATBEL)

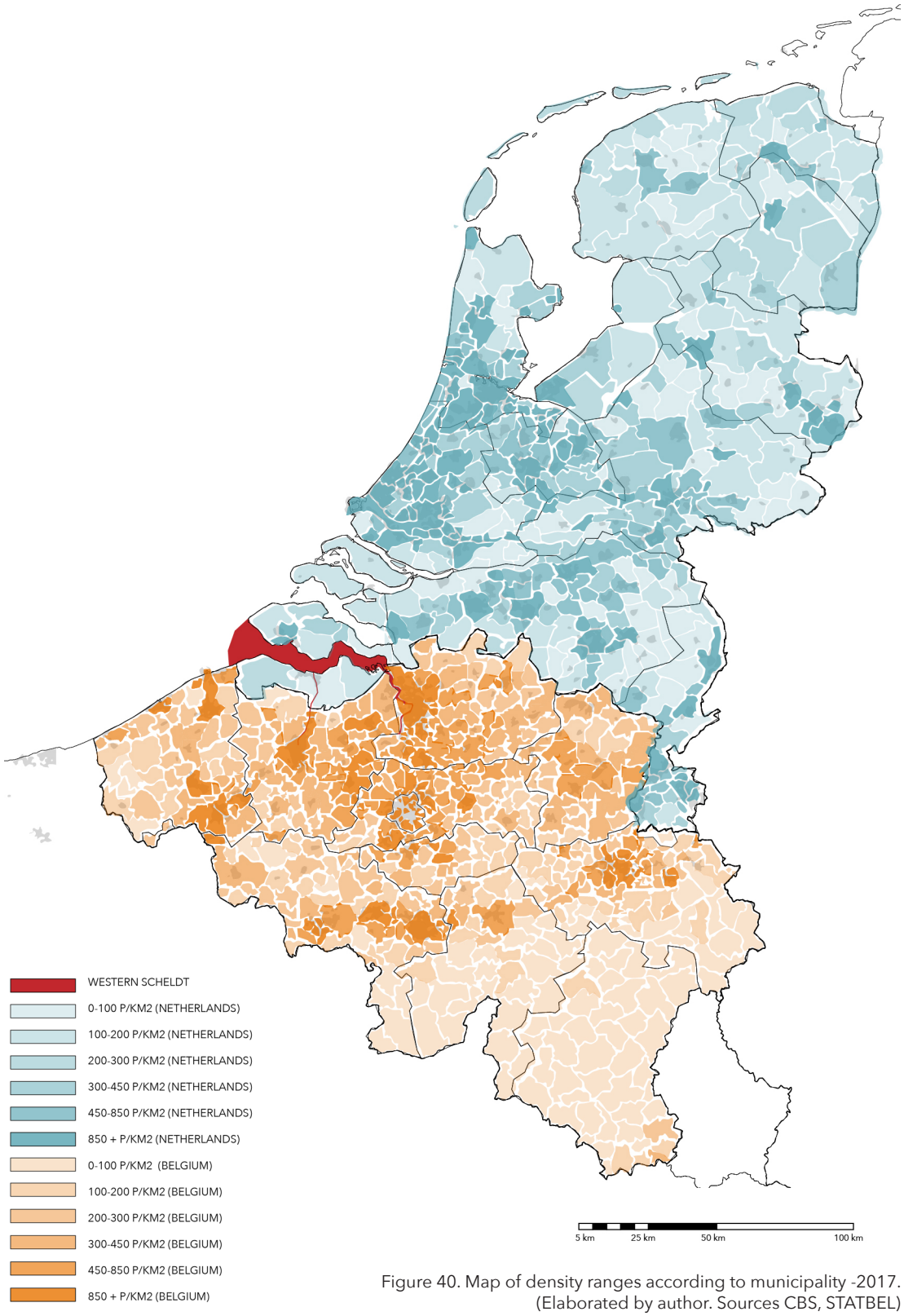


Figure 40. Map of density ranges according to municipality -2017.
(Elaborated by author. Sources CBS, STATBEL)

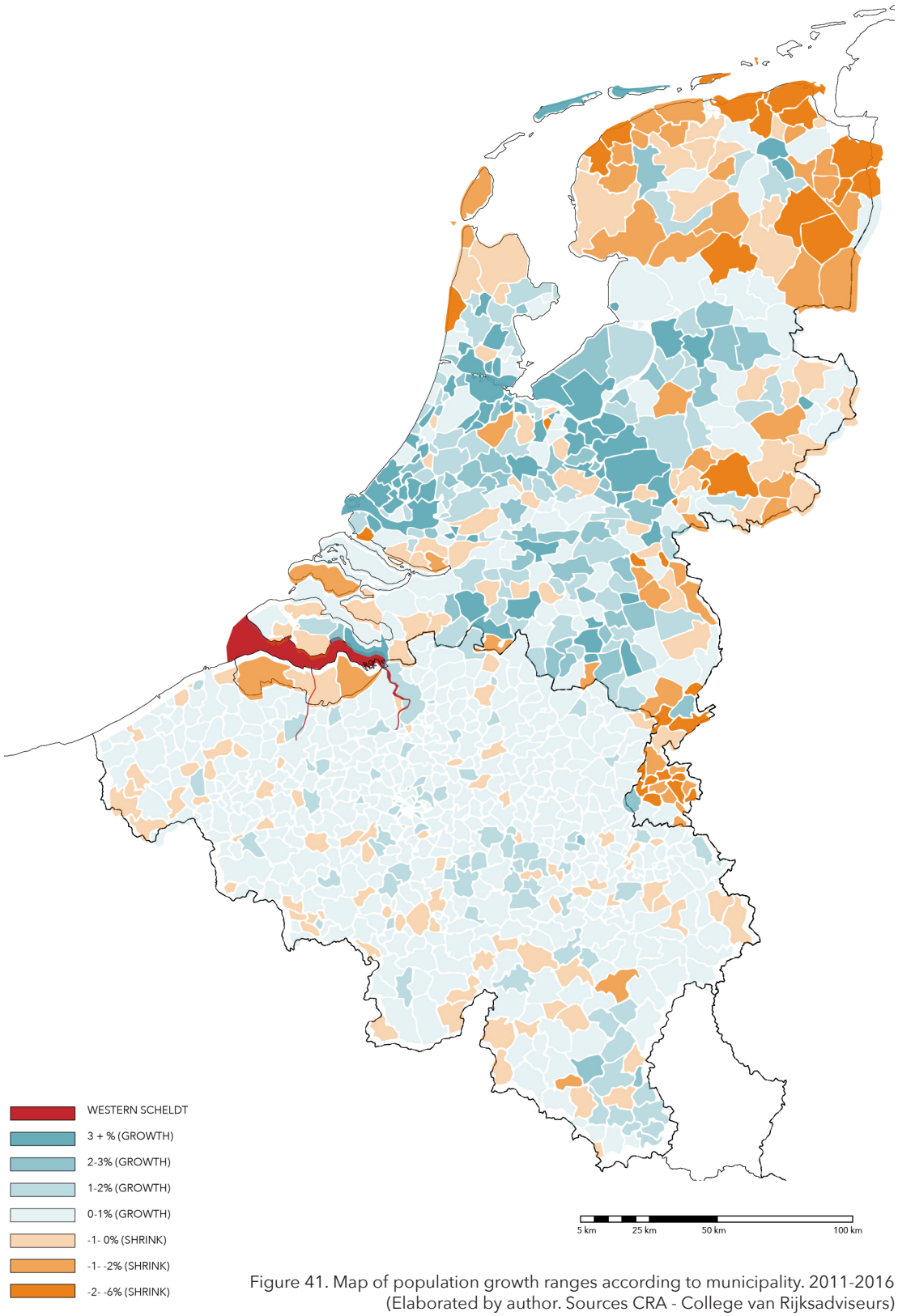


Figure 41. Map of population growth ranges according to municipality. 2011-2016
(Elaborated by author. Sources CRA - College van Rijksadviseurs)

6.1.5. ECONOMIC RELEVANCE OF THE REGIONS

The province of Zeeland is one of the lowest contributors to the global domestic product (GDP) of the Netherlands. This is a common trend for the peripheral and more rural provinces, because the agricultural sector in the Netherlands only contributed to the 1.6% of the national GDP in 2017 (OECD). If the economic contribution is low, the priority and urgency to invest in big, expensive projects is lower and can limit the ambitions of the province to make plans.

On the other hand, the Belgian provinces that are close to the Western Scheldt have the most significant GDP contribution that adds up to 41,4% of the national total of 2016. This can be very influential in decision-making.

In 2013, the ports that are related to the Western Scheldt (Port of Antwerp, Ghent and Zeebrugge) contribute 3.6% of the national GDP and indirectly to 7% of the Belgian GDP. In the Flemish region, their contribution adds to 6.2% directly and 12% indirectly, which shows the economic power of that particular activity. (Van Nieuwenhove, 2015)

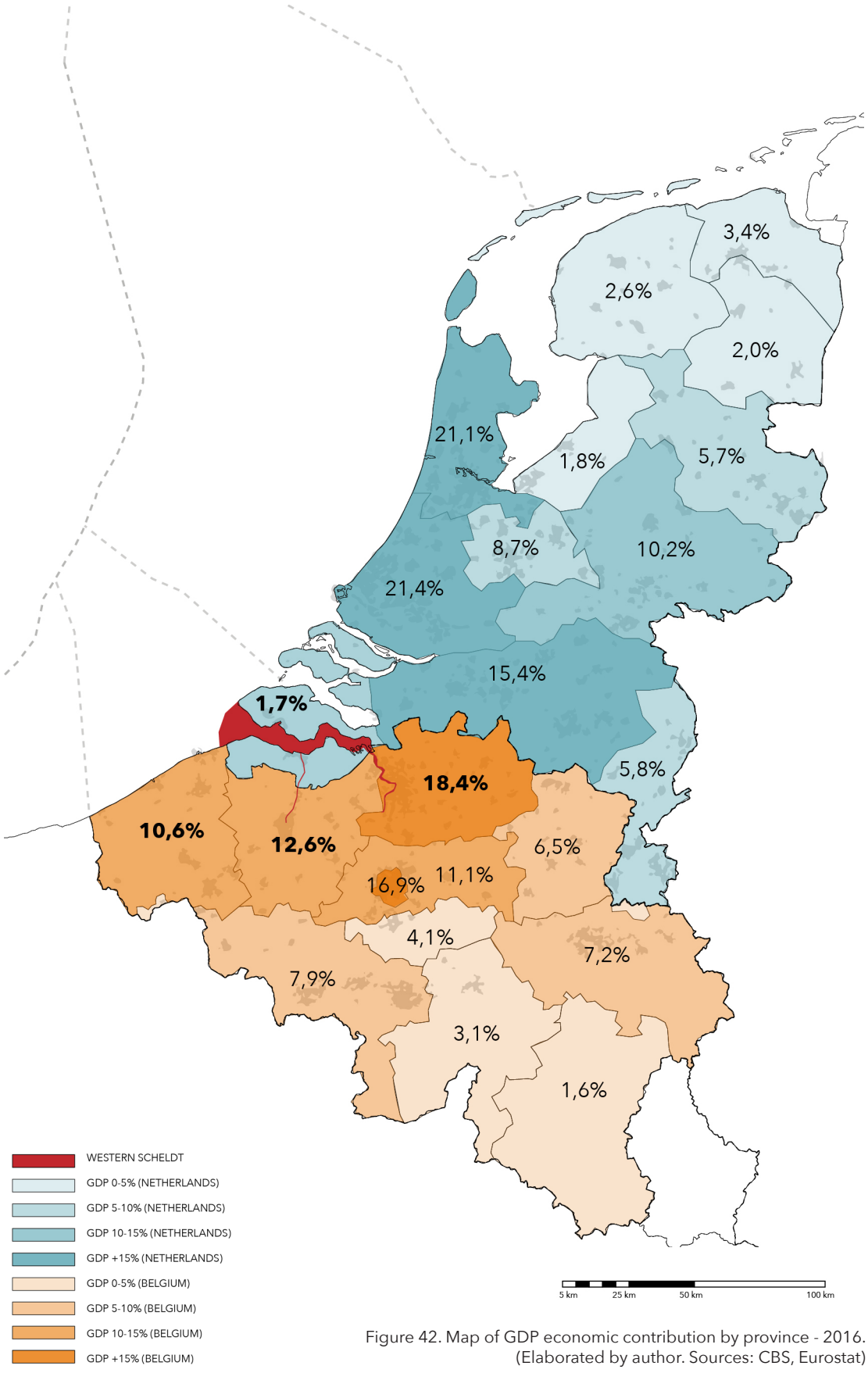


Figure 42. Map of GDP economic contribution by province - 2016.
(Elaborated by author. Sources: CBS, Eurostat)

This first part of the chapter revealed the unbalanced power between the Dutch and Belgian regions in relation to decision-making around the Western Scheldt area. For geographical, social and economic reasons the Flemish region will have a higher capacity to influence development of the area, including the Dutch part of the river.

The following part of the chapter will reveal what is the position of governance in the area in relation to the 3 priority functions established in the Outline 2010 for the Western Scheldt,

6.2. GOVERNANCE AND SAFETY

The Western Scheldt is open to the North Sea and is constantly exposed to flood risks. This creates an urgency to develop plans to protect land from flooding and pushes both countries to make decisions together about this issue. Integrating actors at different scales and sectors has shown positive results in the process of adaptation while dealing with flood risks.

In 1953, high tides combined with a heavy storm resulted in waves that rose up to 4,5 meters above the N.A.P. in the Vlissingen area. This flood event killed 1.836 people and about 200.000 animals.

The reaction to this catastrophe, a Delta Committee was established. They elaborated a plan (Delta Plan) to both protect the land from water and prevent land salinization. The options were to either raise the dikes or to close a number of water inlets. The latter was chosen because it was cheaper, considered less maintenance costs, the dams could also be used as connections and would occupy less space than raising the dikes. (de Vlieger, 2017)

For the project implementation (Delta Works), which started around 1958, Rijkswaterstaat chose to start with the smaller dams and as they learn from experience move to larger and more challenging ones. (de Vlieger, 2017)

This approach was dealing with safety, but with no consideration for ecology. Dams would stop the exchange between the salty water from the sea and sweet water from the rivers and the mussels, oyster and crustaceous farming on the eastern Scheldt would have to disappear. (de Vlieger, 2017)

Rijkswaterstaat however was taking into consideration port activities. They would not close the water inlets that connected the ports of Rotterdam and Antwerp to the North Sea. During that period, they would also build a new waterway between Rotterdam and Antwerp. (de Vlieger, 2017)

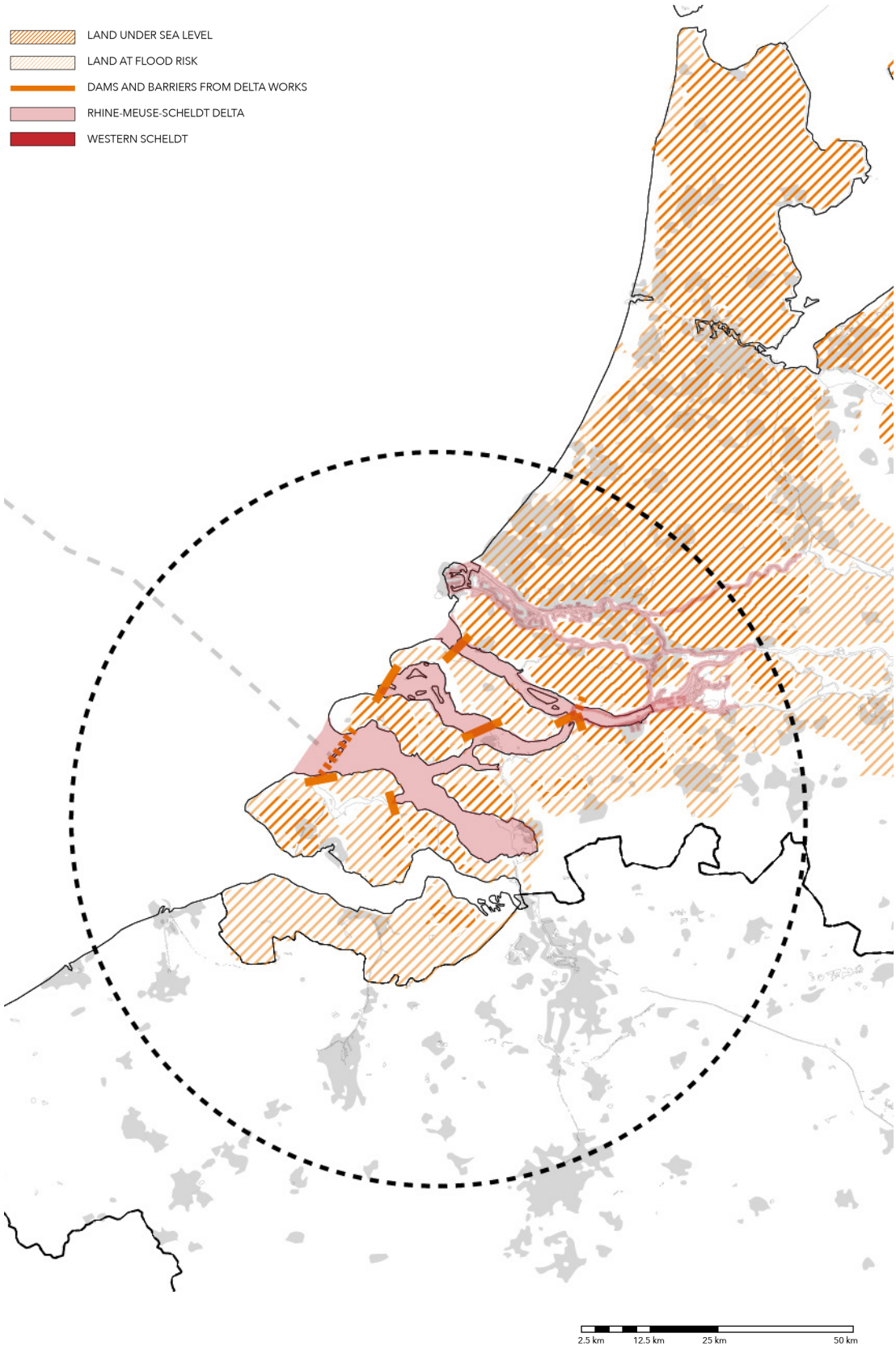


Figure 43. Delta Works in the Rhine-Meuse-Scheldt delta
(Elaborated by author. Source: Vlieger, B. The new delta, 2017, Ministry of Infrastructure and Water Management, NL)

Around the 1970's, concerns about the environment started to grow, which lead to new approaches to deal with flood safety. (de Vlieger, 2017)

Some examples include:
- The resalinization of the Grevelingen to restore bird habitats.
- The Flemish Sigmaplan, that addresses flood risk by not only raising dikes, but also increasing the river space with flooding areas.
- The use of sand to nourish and maintain the coastlines
- The restauration and compensation of habitats as result of projects' negative impacts, including the initial Delta Works.

These more environmentally friendly projects were carried out by different programs.

In 2008, a new Delta Plan was established. The programme is a key element of the Dutch climate adaptation policies and works to protect the country from flooding and to ensure adequate fresh water supplies (Van Eerd et al., 2014).

The main strategies of this plan included to use natural processes whenever possible, because of their high adaptive capacity and to develop multi-functional solutions as they can reduce costs and create social added value (Delta Programme, 2012). The Delta Plan took over the other safety plans that were carried out simultaneously in order to facilitate governance over this aspect. This way, responsibilities are clarified, funds can be better assigned and exchange of information is improved (de Vlieger, 2017).

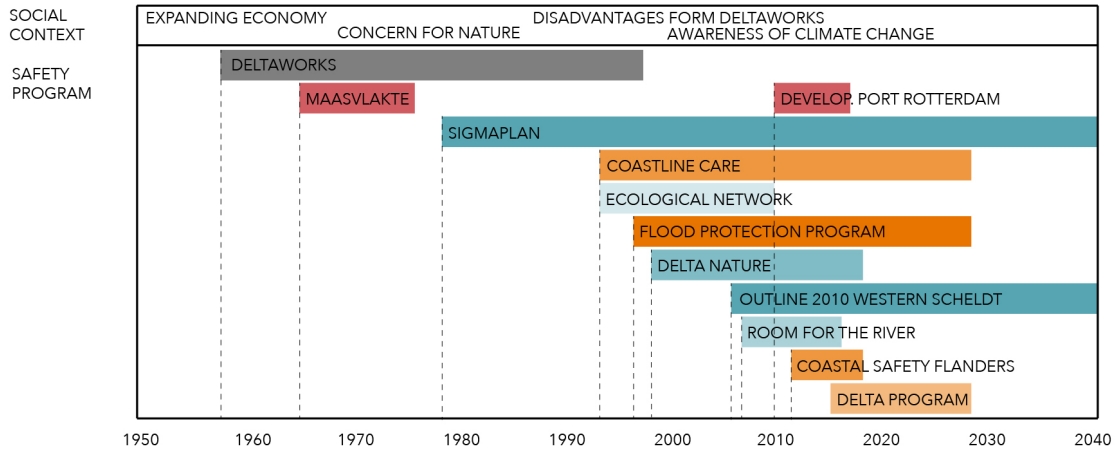


Figure 44. HistoricalWater management plans for safety
(Elaborated by author. Source: Vlieger, B. The new delta, 2017)

Here it's important to mention how governance in relation to safety around the delta region became more aware of the potential of ecosystems to deal with adaptation (EbA) and shifted towards a more integrated ecology - safety approach.

Rijkswaterstaat for example is an important member of the ECOSHAPE Consortium (established in 2008), which researches on "Building with Nature". The value of this stakeholder from a governance perspective is the interdisciplinary approach that links knowledge producers, engineering companies, government, NGOs, etc. to collaborate in innovative multifunctional solutions. On the Flemish side, the Sigmaplan also bridges water management and nature conservation. The collaboration is primarily from the government departments, but has involved other stakeholders to implement their projects (Sigmaplan.be)

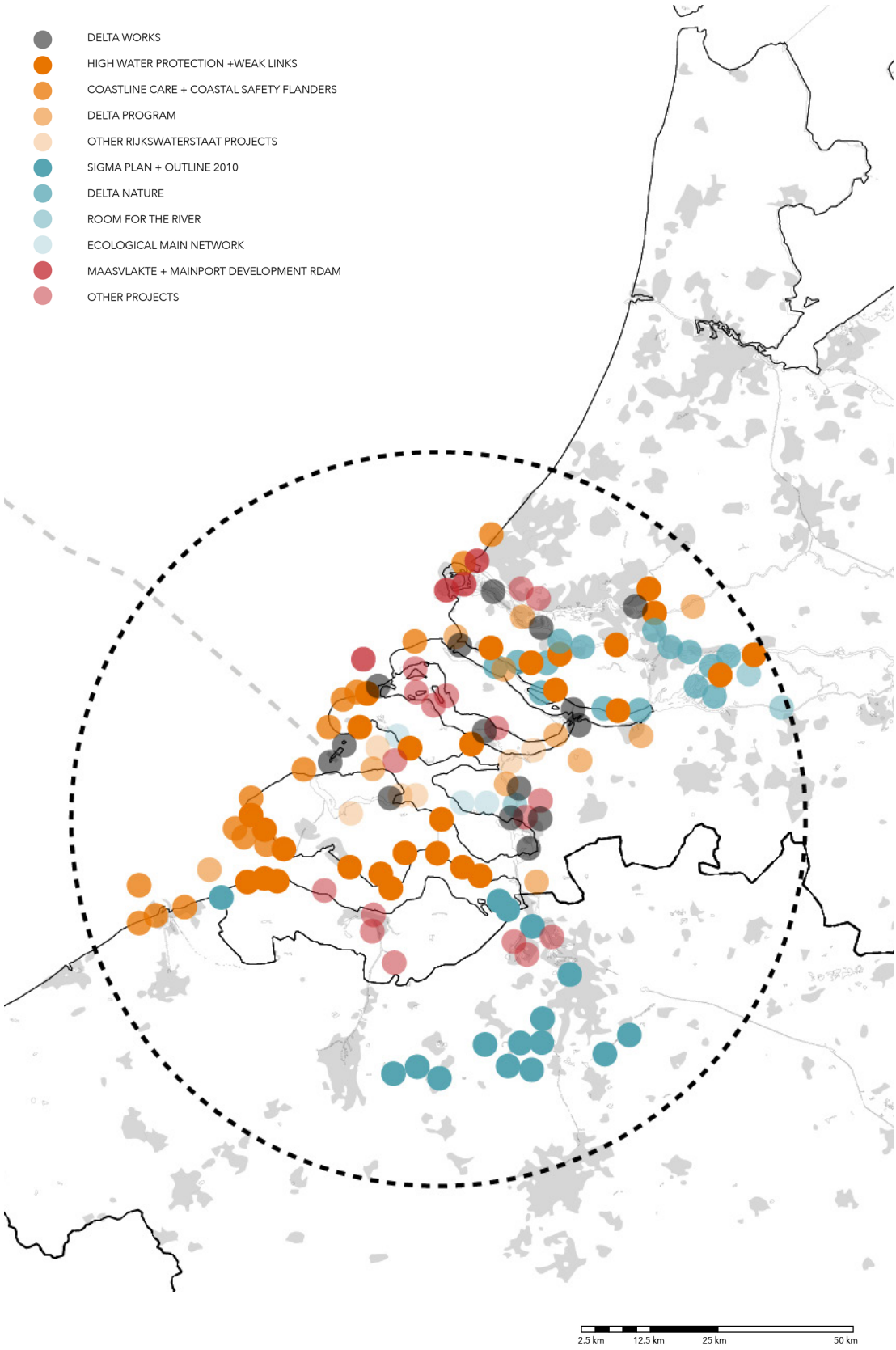


Figure 45. Safety projects in the Rhine-Meuse-Scheldt delta
(Elaborated by author. Source: Vlieger, B. The new delta, 2017)

6.3. GOVERNANCE AND ECOLOGY

Zeeland, as a result of its peripheral location and soil conditions, became a good place to develop agriculture. The Flemish region has sandy soils and a more diverse land use. Here urbanization is high and fragmented, specially between Antwerp and Ghent (Eker and Houtum, 2013)

Despite being a "green" area of the country, the environmental values are very low and the amount of areas of ecological value is limited. Based on the OECD well-being measures, Zeeland has the worst environmental performance of the country, measured by air quality. Intensive agriculture, especially with old practices, cause high stress and affect the quality of the soils. Agriculture and all the industrial activity of the ports have a significant impact on the Co2 emissions to the air. Recent innovative strategies aim to reduce the industrial Co2 emissions of the region by 90% by 2050 (Smart Delta Resources, 2018)

They also are responsible for releasing pollutants (heavy metals by industries, untreated sewage, nutrient load by agriculture) to the water, including the Western Scheldt. (Peeters et al., 2006). The water quality has improved since the 80's, with improved agricultural practices and an increased industrial and municipal water treatment. (Van Damme et al., 2005)

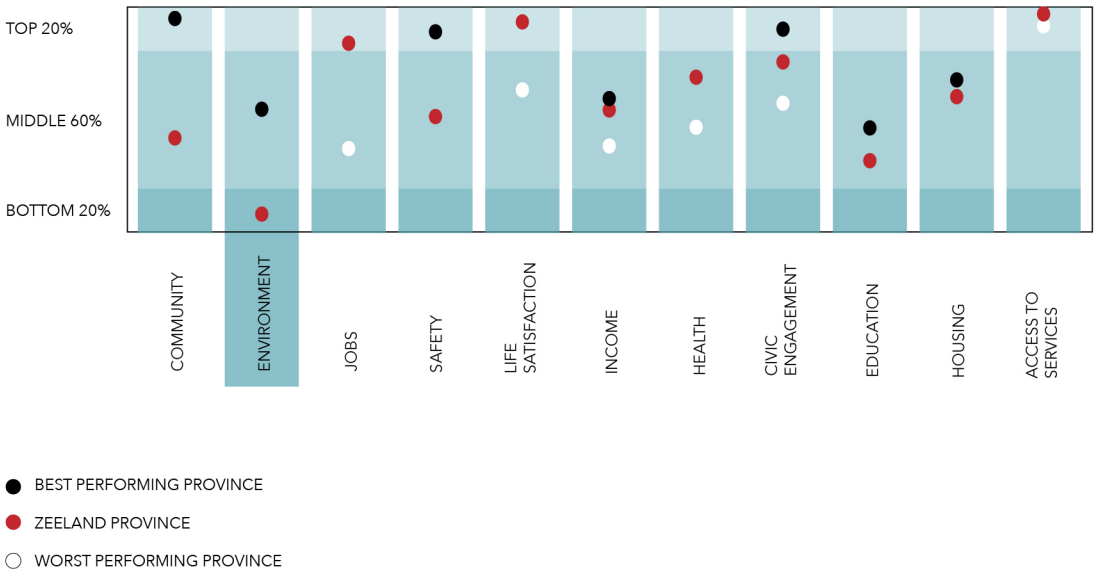


Figure 46. Regional ranking for 11 well-being dimensions
(Elaborated by author. Source: OECD Regional Well-Being Database, 2017)

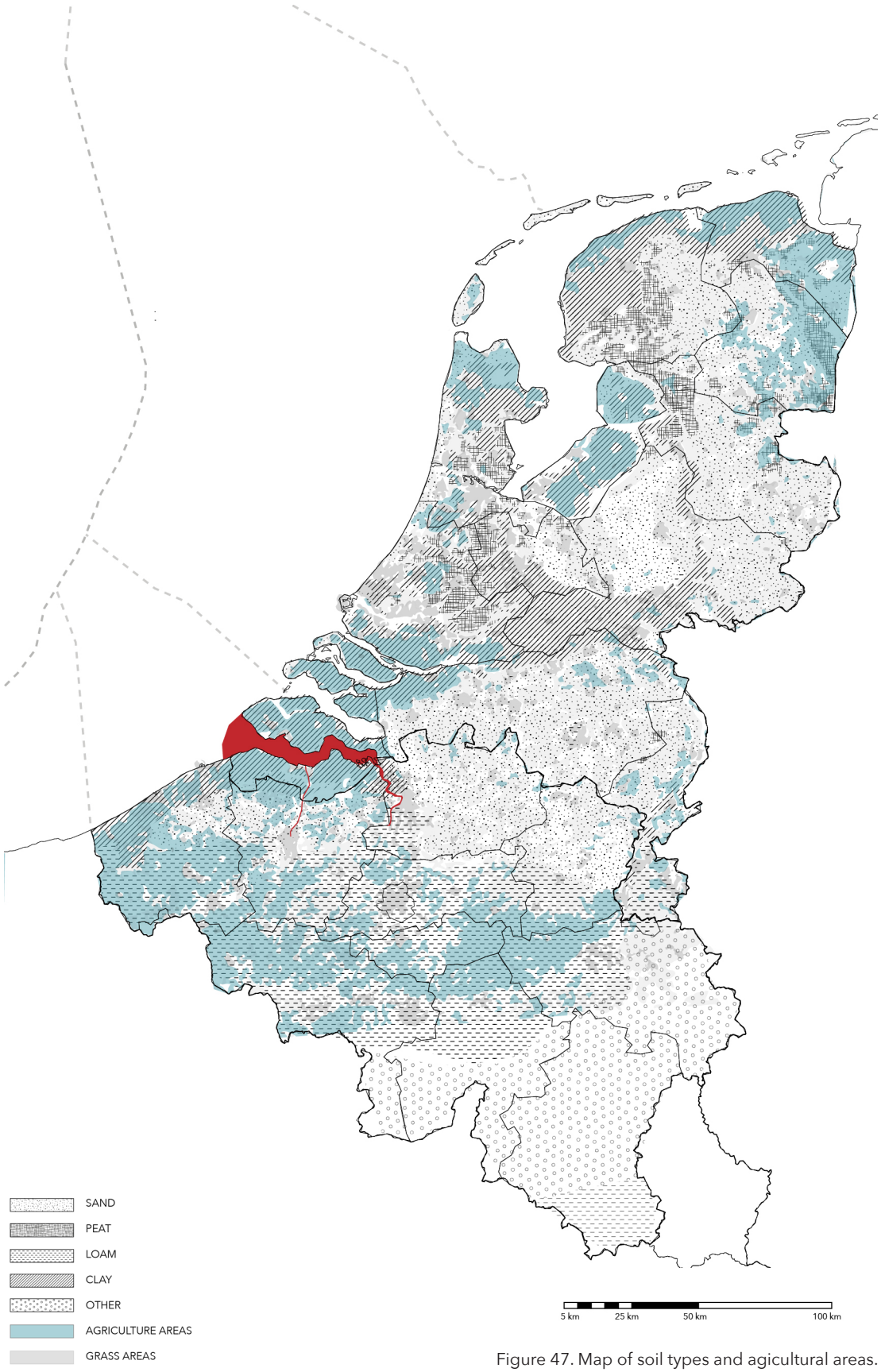


Figure 47. Map of soil types and agicultural areas.
(Elaborated by author. Sources: Agriculture - European Space Agency, 2017,
Soil types - Bofek, 2012)

In relation to policies to preserve and strengthen nature and biodiversity, the National Ecological Network (NEN) in the Netherlands was introduced in the 1990's. This Ecological Main Structure defines corridors of ecological value using existing and planned nature (de Vlieger, 2017).

"The NEN encompasses:

- existing nature conservation areas, including the 20 National Parks;
- areas where new wildlife habitats are being created;
- agricultural land under nature-friendly management;
- over six million hectares of water: lakes, rivers, the North Sea coastal zone and the Wadden Sea;
- all Natura 2000 areas."
(Government.nl - NEN)

In terms of governance, the NEN is defined by the Ministry of Agriculture, Nature and Food Quality, but each province is responsible for the management of these areas.

In Flanders, the Flemish Ecological Network (VEN) is based on the Spatial structural plan for Flanders from 1997. It includes with about 125.000 hectares of areas of ecological value (Agency Nature and Forest, Flemish Government). In this case, management of the VEN areas is mainly responsibility of the municipalities.

The largest area of ecological value in the delta region is the Rhine-Meuse-Scheldt delta, which was assigned the protection by the European Natura 2000 policy in 2008. This protection prohibits human activities that cause negative impact on the ecosystem or demands for management or compensation plans. This is the case of the third enlargement of the navigation channel on the Western Scheldt. The project could not be rejected because of the unconditional access treaty between The Netherlands and Belgium. The project had to include compensations, including 600 hectares of estuarine habitats in the Dutch territory and 1100 hectares of wetlands in the Belgian side. (EEA, 2016)

Because the areas of natural value in the province of Zeeland are limited, there is additional relevance in maintaining the quality and quantity of habitats on the delta. They are valuable for a number of reasons, including their capacity to improve the environmental qualities of the region (Co2 capture, water and soil purification).

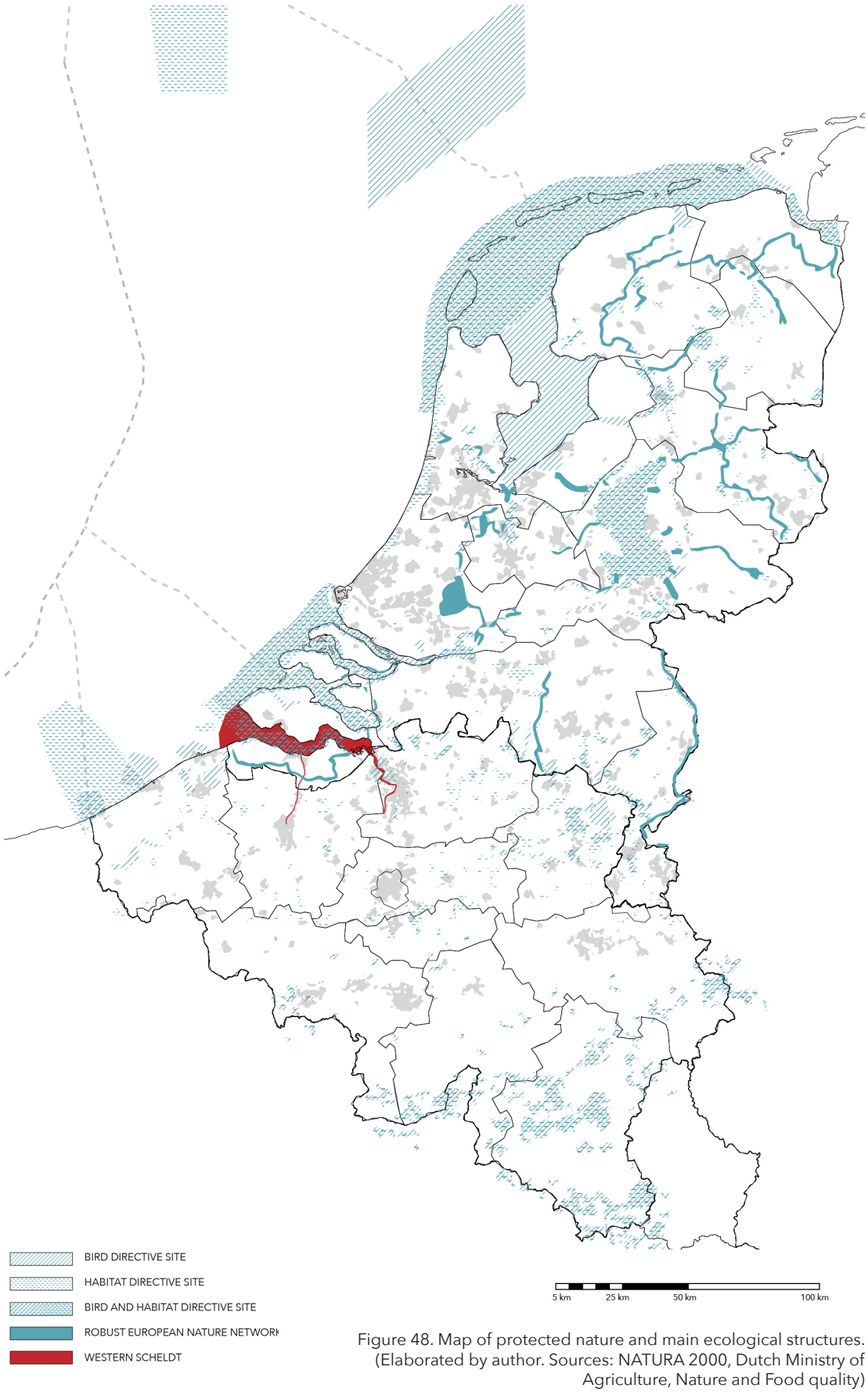


Figure 48. Map of protected nature and main ecological structures. (Elaborated by author. Sources: NATURA 2000, Dutch Ministry of Agriculture, Nature and Food quality)

The following map shows the ownership of natural areas in the province of Zeeland. Here we can see that the natural areas located on land (COLOR) are owned or administrated by privates or organizations. On the other hand, the majority of natural areas located on the delta space such as foreshores and mudflats are owned and administrated by the government. This facilitates proposing and implementing projects that make use of these spaces.

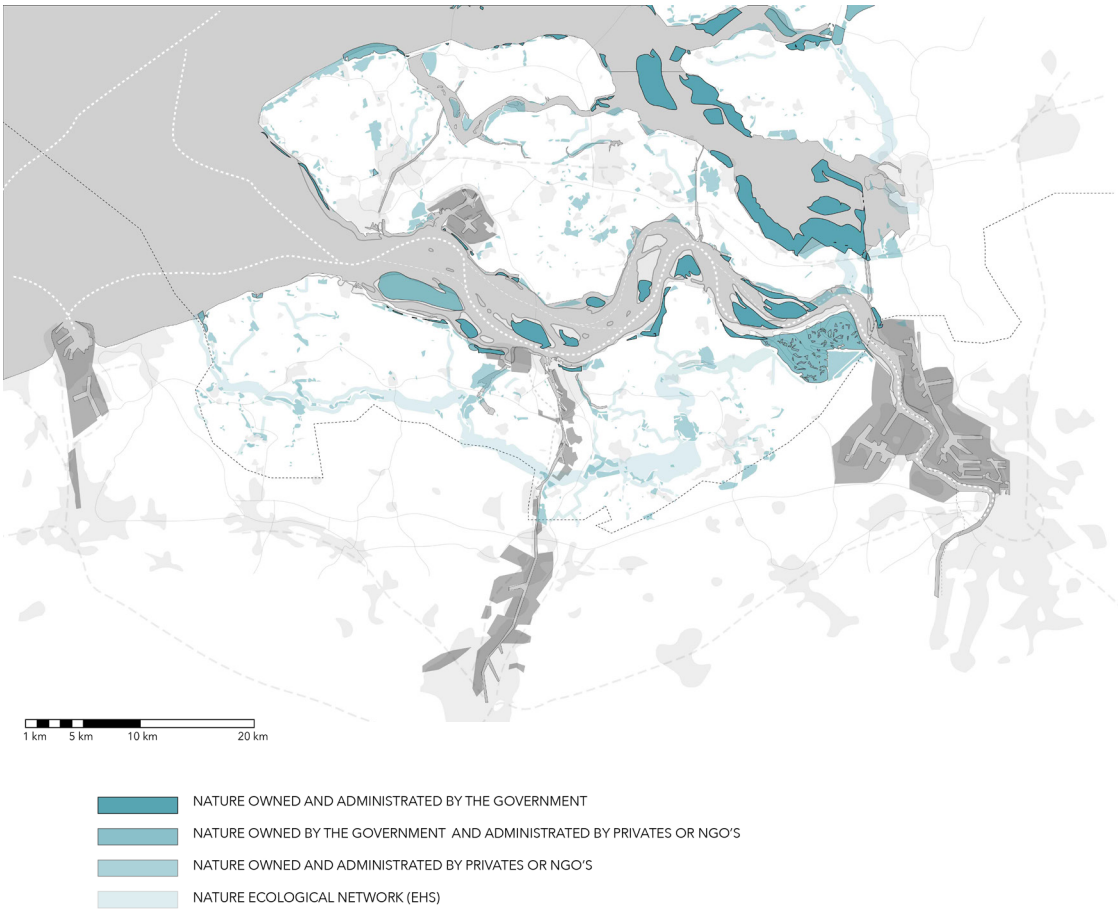


Figure 49. Map of ownership of natural areas in Zeeland
(Elaborated by author, Sources: Dutch Ministry of Infrastructure and Water Management)

6.4. GOVERNANCE AND ACCESSIBILITY

Along the Western Scheldt, port activity has developed because of its direct connection to the North Sea. The river provides access to many ports including the port of Vlissingen, Terneuzen, Ghent, and Antwerp. Most influential port on the river is the port of Antwerp, which is located about 90 km inland from the North Sea

The presence of the ports has strongly influenced the spatial development along the Western Scheldt. This includes constant dredging to make the river deeper and allow bigger ships to access the port, the straightening of the river to facilitate the transportation flows, the transformation of quays to build new port infrastructure and the diversion of water into multiple canals (Sustainability report Antwerp, 2017).

In 2017, 14,223 seagoing ships navigated the river to access port of Antwerp. Antwerp's sea access was improved with the deepening of the river Scheldt, so that even the largest container vessels in the world can now call at Antwerp. (Sustainability report 2017, Port of Antwerp). Including the other ports on the Western Scheldt (Vlissingen, Terneuzen and Ghent) the number of sea going ships exceeds the 25.000.

The number of vessels that navigate the Scheldt increases slowly and even decreases in some periods. However, the capacity of those ships and their size has been increasing at a fast paste in the last couple of decades

Maintaining good accessibility to the port in the Western Scheldt presents a challenge, mainly because bigger ships require more free space to move through the river.

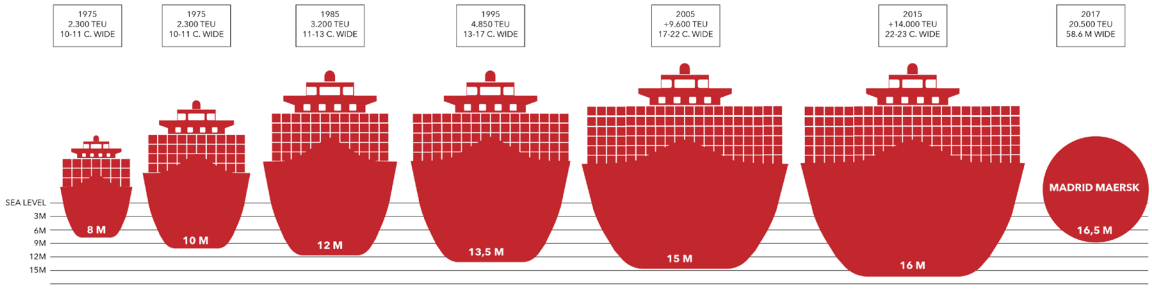


Figure 50. Evolution of ships by sizes
(Source: http://www.vesseltracking.net/article/biggest-container-ship)

To ensure that accessibility is maintained and ports can continue to grow and be competitive, the Flemish government has requested 3 times the enlargement of the navigation channel (1970, 1995 and 2005). Since the 3rd enlargement, ships with a maximum draught that exceeds 15 m can navigate through the Western Scheldt.

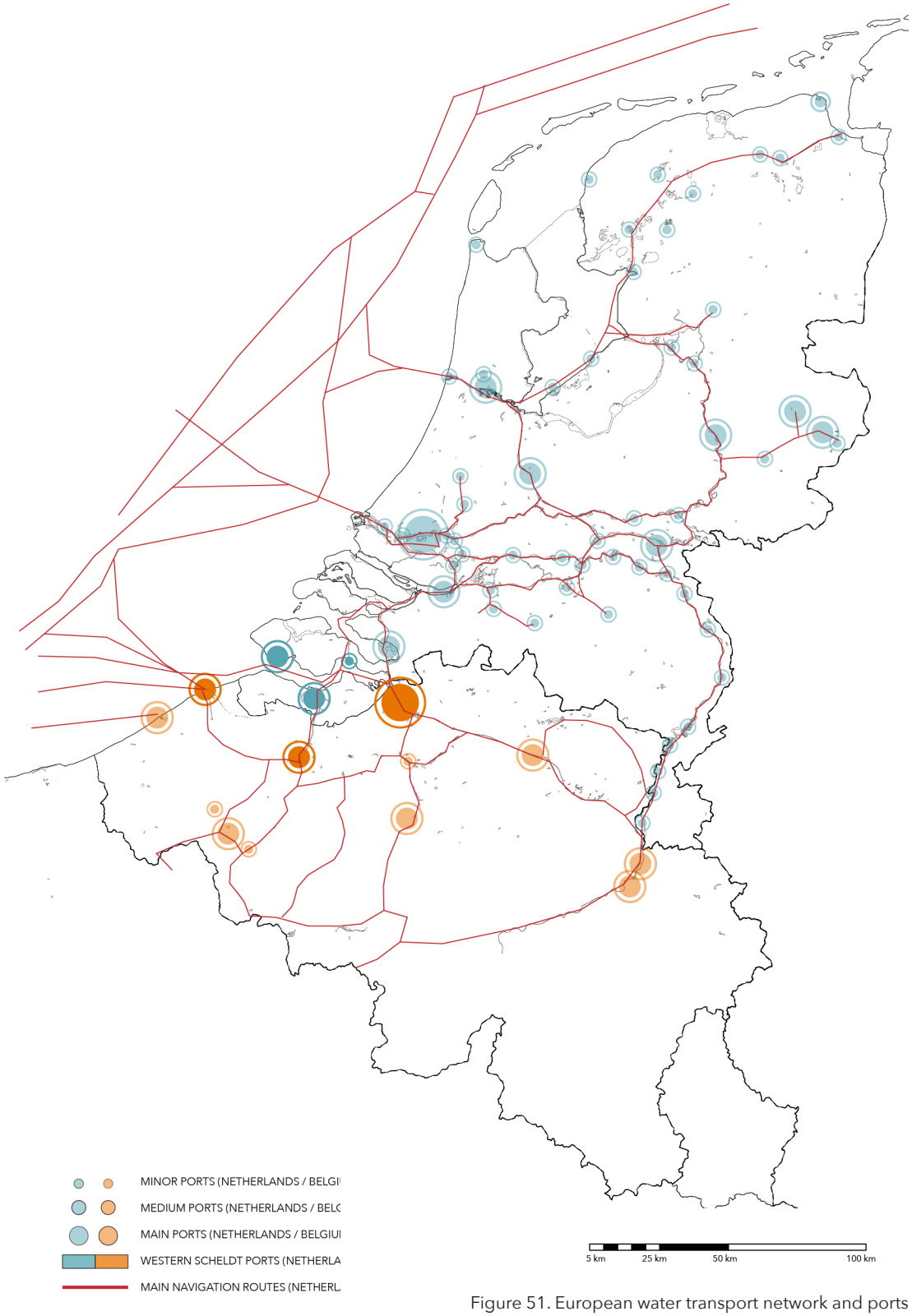


Figure 51. European water transport network and ports
(Elaborated by author. Sources Rijksoverheid)

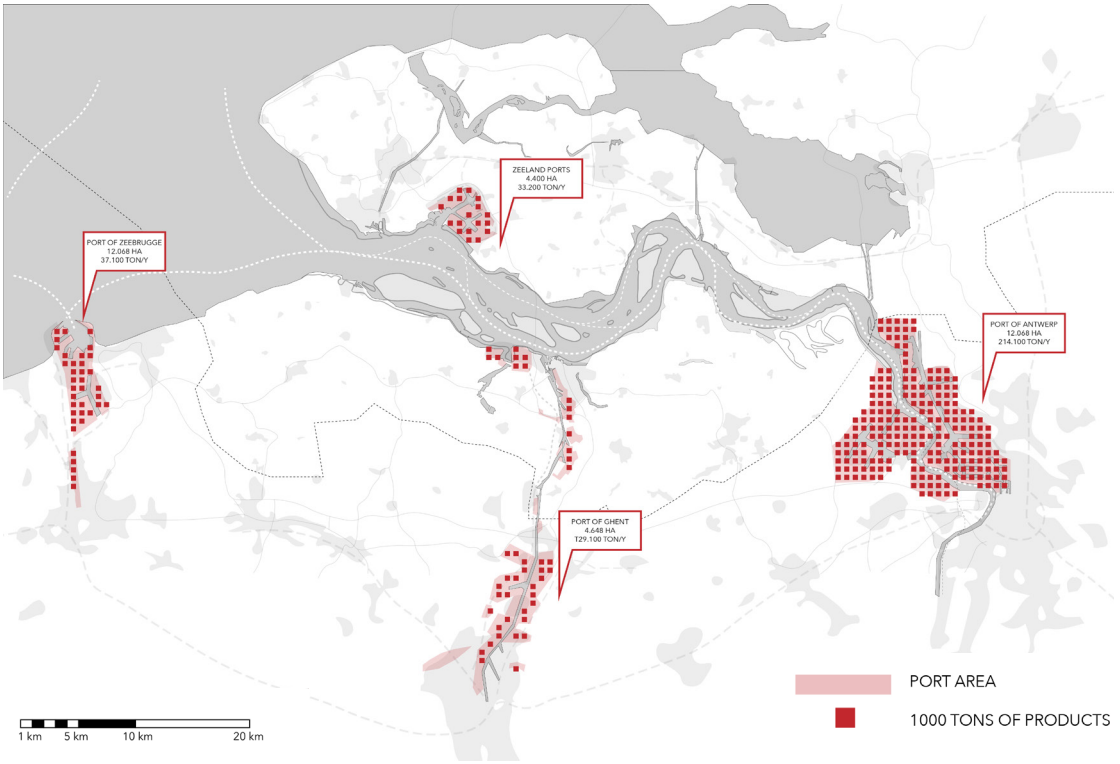


Figure 52. Intensity of port activity by Tons of material
(Sources: Port of Antwerp, Vlaamse Haven Commissie, Vesselfinder, Port of Zeebrugge)

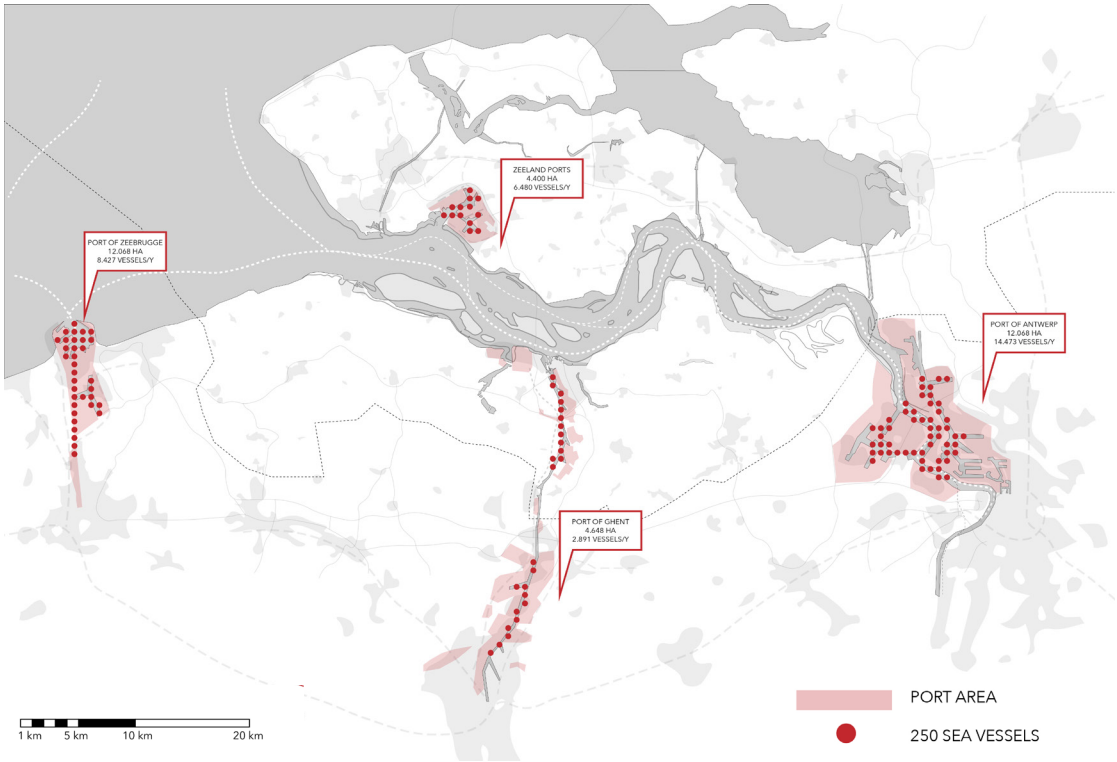


Figure 53. Intensity of port activity by Sea Vessels
(Sources: Port of Antwerp, Vlaamse Haven Commissie, Vesselfinder, Port of Zeebrugge)

Ports are a very influential activity in the region. In 2013, the contribution of the ports on the Western Scheldt represented 6.2% of the GDP of the Flemish region directly and 12% indirectly (With added values)

The port of Antwerp is currently the second largest container port in Europe. The port has an extension of 120,68 ha, which represents about 60% of the city's surface. They also planned a 940-ha expansion on the left riverbank that would be finished by 2021. The port host about 900 companies and provides about 150.000 jobs

The current Flemish port decree from 1999 establishes that Port Authorities are public yet autonomous authorities. Only they can exercise the port management powers and they cannot be transferred. (Vlaamse Havendecreet, 1999)

As we can see on the image, the Port Authority of Antwerp has a separated planning department than the municipality of Antwerp.

Figure 54. City of Antwerp and Port of Antwerp presenting their developemnt plans separately. (Photo by author)

The Flemish government has very limited capacity to influence decision-making of the daily activities of the ports. However, they can finance part of the port activity (Hooydonk, 2010). They have for example financed most of the maintenance costs associated with navigation channels, including the ones on the Dutch part and projects like new locks (Meersman et al., 2006). The Kieldrecht lock located in the port of Antwerp is currently the largest lock of the world (500 m long, 68 m wide 17,8 m deep). The cost of the lock was 382 million euros and the Belgian government paid 75% of the project. (Port of Antwerp, 2016)

The port authorities of Antwerp are highly supported by the powerful Flemish Government and together they are constantly trying to improve the port's accessibility. (Buuren et al., 2008)

The Flemish Port Decree from 1999 also established that the Flemish government would develop a long-term vision for the port policy, with a time horizon at 2030. This long-term vision started in 2002 and was carried out by the intermediate scale of decision making, the provinces. (Dooms, 2006)

This document reveals the awareness of the Flemish Government that social support is declining because society is paying more attention to non-economic values such as the environment, nature and quality of life. On the other hand, the seaport policy is focused on economic interests and no longer matches the social objectives. This has led to longer and more difficult processes to get plans and implementations approved. (Een langetermijnvisie voor het Vlaamse zeehaven beleid, 2005)

In the document, they acknowledge that the focus should expand from only economic efficiency and competitiveness to maximizing social added value (Een langetermijnvisie voor het Vlaamse zeehaven beleid, 2005).

In some cases, an increased involvement of the port Authorities can be identified. The third enlargement of the navigation channel on the Western Scheldt was considered necessary, but it included an environmental impact assessment to define the least negative option. The chosen option also included an experimental approach to dredging (morphological dredging) (van Buuren et al., 2010).

In some other cases, the port authorities still show low collaboration. The expansion of port of Antwerp in 2012 for example would take place in areas with environmental protection (Natura 2000 sites). The project initially ignored this protection policy, which then resulted in the project being objected at the court. Plans had to be rewritten and adjusted to include environmental compensations, causing delays and additional costs. (Vikolainen et al., 2014)

Recently, the discussion of merging port of Antwerp and port of Zeebrugge is being evaluated. This decision could benefit the limited growth on Port of Zeebrugge and reduce the intensity in the Port of Antwerp that has limited space to grow (Logiestiek.be). This will also reduce the intensity of use of the Western Scheldt by large ships.

6.5. CROSS-BORDER GOVERNANCE

In an attempt to coordinate all the things that happen around the Western Scheldt, some cross-border initiatives have emerged. Some examples are the Border Commission (VlaNed), the Euroregions, the Rhine-Scheldt Delta cooperation and Project Team Development Perspective Scheldt Estuary (PROSES) (Leibenath et al, 2008).

PROSES has been the most effective cross-border collaboration, with strong involvement of the Flemish regional and Dutch national governments for large scale physical transformations. (Leibenath et al, 2008). Within PROSES, an outline plan for the long-term vision (2030) of the Western Scheldt was developed. The Outline 2010 envisions the future of the river as accessible, safe and natural. This means that the development of the area should contribute to maintain and improve these functions.

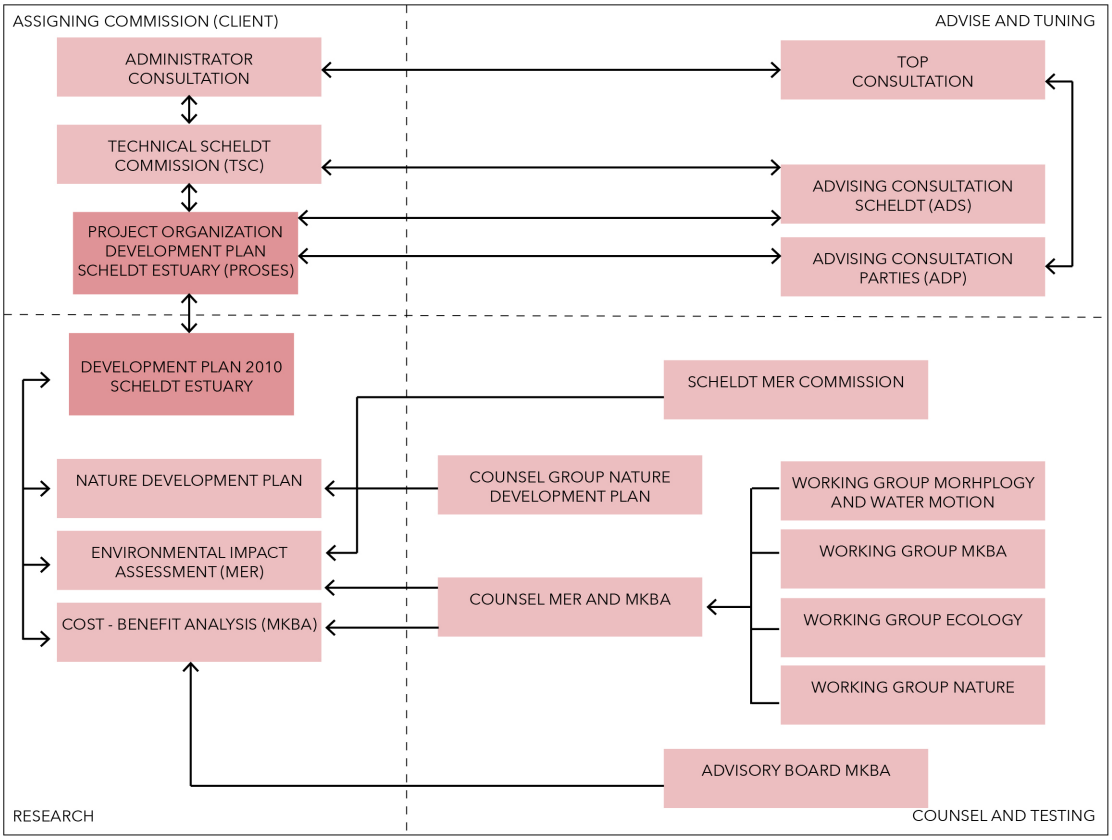


Figure 55. Institutional framework for the development of the Scheldt Estuary Development Outline 2010. (Elaborated by author. Source: Cabri-Volga Consortium, 2005)

In the governance structure behind the development of the Long-term vision there are 3 important components:

- The 'Technical Scheldt Commission' does the overall management and involves ministries of Infrastructure, Water management, Agriculture and Nature from both the Netherlands and Flanders as well as the provincial government of Zeeland (Vanoutrive, 2007).
-The 'Advising Consultation parties' that involve other stakeholders like farmers, port authorities, NGO's, municipalities in the decision-making (Vanoutrive, 2007).
- The 'Research' component, informing the plans with a Nature development plan, environmental impact assessment (EIA), and cost - benefit analysis

6.6. POTENTIAL TO INCREASE COLLABORATION IN THE WESTERN SCHELDT

OPPORTUNITIES	CONSTRAINTS
- The relationship between the Netherlands and Belgium is relatively good - There is important knowledge development of the area to help decision-making. - There is previous experience with cross-border initiatives in the area and the definitions of common goals. - Previous experiences combining ecology and water safety (Deltaplan, Sigmaplan) - Nature protection policies demand for management and /or compensation for negative impacts in their sites. - The Paris Agreement to reduce Co2 emissions is a common climate change mitigation goal for the Delta region. - ECOSHAPE is a Dutch consortium that brings together different sectors for innovative solutions using nature - New forms of collaboration between ports including the merge between Zeeland ports and port of Ghent and the Flemish Port Area	- Both regions have different priorities in relation to the future of the Western Scheldt - The decisions by the Dutch government are primarily made by consensus and in Belgium by agreements between stakeholders - Flemish port decree encourages competitive and autonomous development of the regional ports. - The importance of ports in Flanders influences decision-making - The treaty of 1863 for unconditional accessibility demands for unnatural enlargement of the main channel - Unequal availability of resources between the Dutch and Flemish region - There is not a Flemish or cross-border ECOSHAPE

Figure 56. Summary chart of opportunities and constraints for cross-border collaboration (Elaborated by author.)

6.6.1. IN THE SEARCH OF CONSENSUS IN GOVERNANCE

The three functions previously explained, as well as many others, take place in a shared territory, with high stakes for both the Netherlands and Flanders (Belgium). Each of these dynamics influence the other and decisions made in one side have effects on the other. Therefore, decision making should aim for strategies that can address multiple problems at the same time. By doing so, the support among stakeholders can increase and facilitate implementation. (Buuren et al., 2008)

These functions are not only in constant friction with each other, they are also represented by different and powerful stakeholders (Buuren et al., 2008), which adds to the complexity of reaching consensus.

There is heavy competition to defend the interest of each of these functions in the Western Scheldt, however we have seen the functions of safety and nature quality becoming increasingly integrated in the past couple of decades. Newer approaches included in the Delta Plan and Sigmaplan have shown some potentialities of working with multiple systems.

On the other hand, the accessibility function is still managed separately. Port authorities have until recently developed in a very autonomous and competitive way. Port activity is very powerful for the Flemish economy, which results in high support from the Flemish government.

In this case, the friction between the functions demands a more complex form of cross-border collaboration. The interest of nature conservation and safety in the Western Scheldt are primarily managed by the Netherlands, while port accessibility is managed primarily by the Flemish government.

As the ports are the main drivers in the development of the Western Scheldt, there is high potential in integrating their actions with the other functions. There are already discussions to build ships with twice the capacity of the current largest ships before 2067 (50.00 TEU). What could that mean for the future of the Western Scheldt? especially if it's managed with limited collaboration.

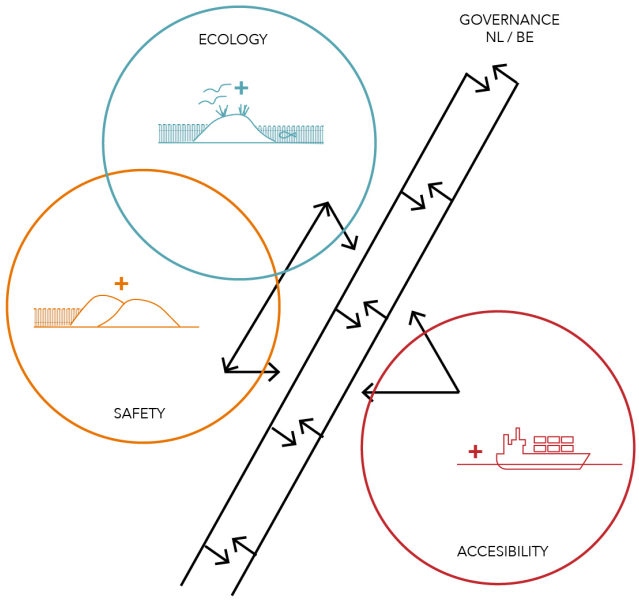


Figure 57. Governance in relation to the 3 main functions for the Western Scheldt (Elaborated by author.)

7. APPROACH

The approach chapter describes how the knowledge obtained from both the biophysical and governance assessment is linked into a planning and design proposal.

First, it indicates what is the main opportunity that can be used to bring closer governance structures and the scale of the biophysical systems in the Western Scheldt.
Then, it explains the use of scenario planning and how it conditions the proposal
And finally, what is the expected value of the approach for the Western Scheldt area.

7.1. PROPOSED APPROACH: PAIRING PORT DEVELOPMENT AND IMPACTS

Taking into consideration how influential the ports can be in the development of the Western Scheldt, how they can impact the nature and safety values and how limited their engagement in collaborative plans has been until very recently, their position will be shifted and they will be used as drivers for an integrated collaborative strategy.

3 port development projects that will have an impact on the Western Scheldt were identified. My proposal takes as a starting point to pair each of these projects with the expected local impacts on the values of safety and ecology.

The projects and expected impacts are:

1- Expansion of the Port of Zeebrugge - Additional erosion on a coastline with negative sediment balance

2- Maintenance dredging after the 3rd enlargement of the navigation channel - Stability of the river banks

3- Expansion of Port of Antwerp over protected habitats - Nature compensation and flood risk reduction

Each of these projects will be addressed through a multi-system approach, taking the Building with Nature (BwN) principles and exposing its potentialities. BwN is still most cases as a pilot stage, but this is a good opportunity to implement them in real scale with management strategies that define responsibilities.

The pairs not just give way to BWN as technical solution, where systems support each other, but also, will establish pathways for beneficial governance arrangements.

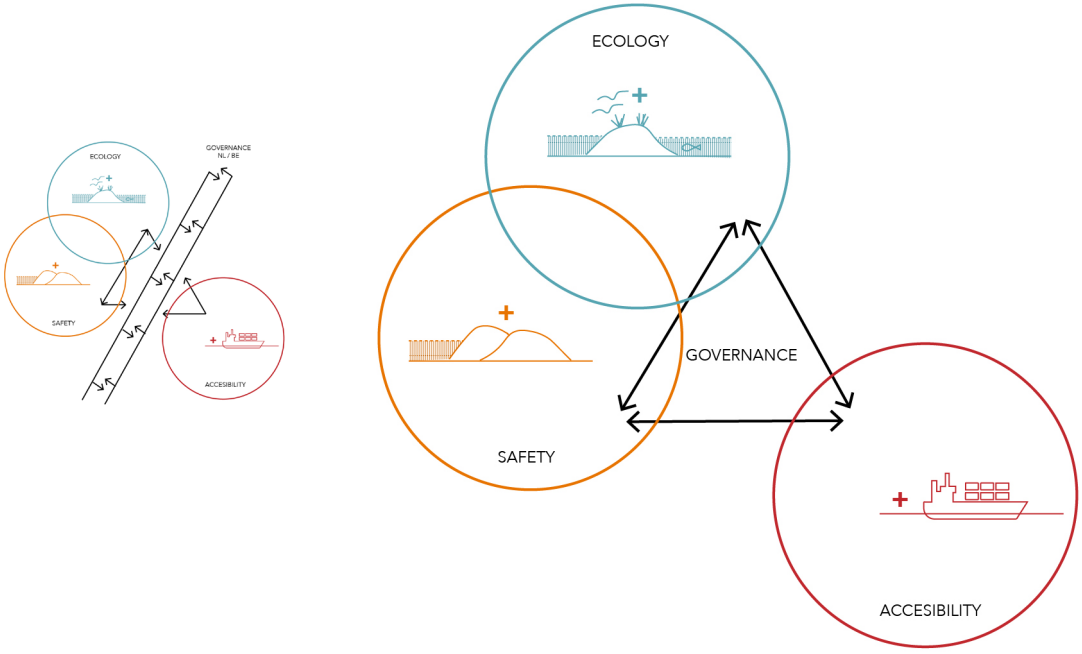


Figure 58. Approach for governance in proposal
(Elaborated by author.)

7.2. SCENARIO PLANNING. DESIGN POSSIBILITIES FOR UNCERTAIN FUTURES

The design proposal will be based on scenario planning. Scenario planning can be an effective way to propose strategies when dealing with high uncertainties. It allows to plan for possible future conditions. As time unfolds and new knowledge is gained, the chosen path and strategies can be adjusted. This can help for more flexibility and adaptability in planning.

To be able to project the performance of the future Western Scheldt, 2 axis will be defined based on major uncertainties in the area:
-The intensity of climate change, which translates into sea level rise and demands for sand.
-The level of collaboration in planning, represented in the involvement of the regional ports.

In a context of climate change, the intensity of the impacts is very difficult to predict. Until recently, projections for sea level rise in the Netherlands estimated an increase between 35 and 85 cm by 2100 (DELTARES 2012; KNMI, 2006). As new information is revealed, estimations also consider that sea level can rise more than 2 meters by 2100 (DELTARES 2018). The intensity of sea level rise will influence on which measures need to be taken in order to keep the area safe and also what can be done to preserve the ecological qualities of the Western Scheldt.

Another aspect that is challenging to predict is politics. Globalization has made divisions between countries less dominant, like in the case of the EU. However, economies are still competitive, and this is very apparent in the case of the ports of Belgium and the Netherlands. (Eker and Houtum, 2013; de Goey, 2004). The level of collaboration and coordination in the plans to develop the ports can provide different possibilities and outcomes, which should be explored.

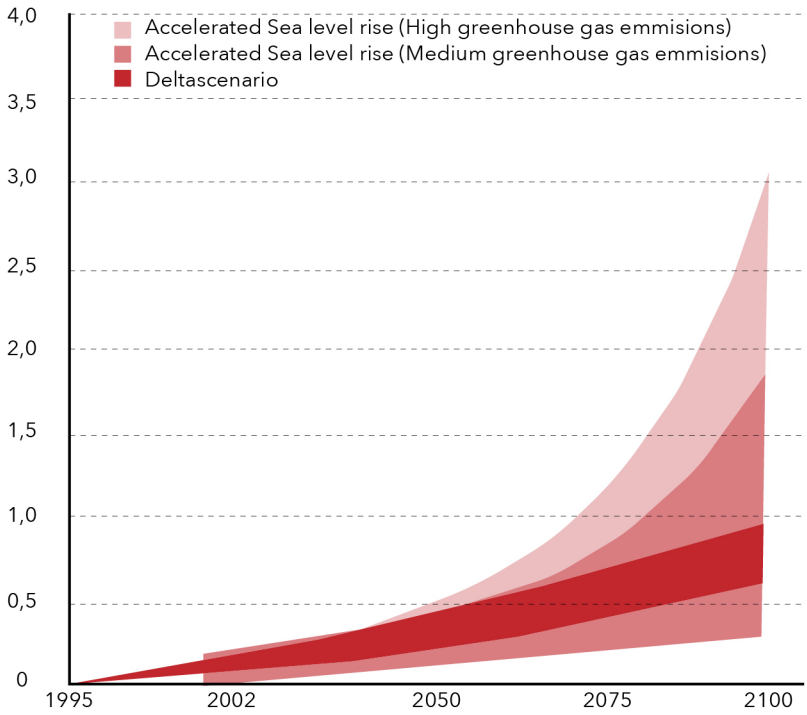


Figure 59. New sea level rise projections
(Elaborated by author. Source: KNMI. DELTARES)

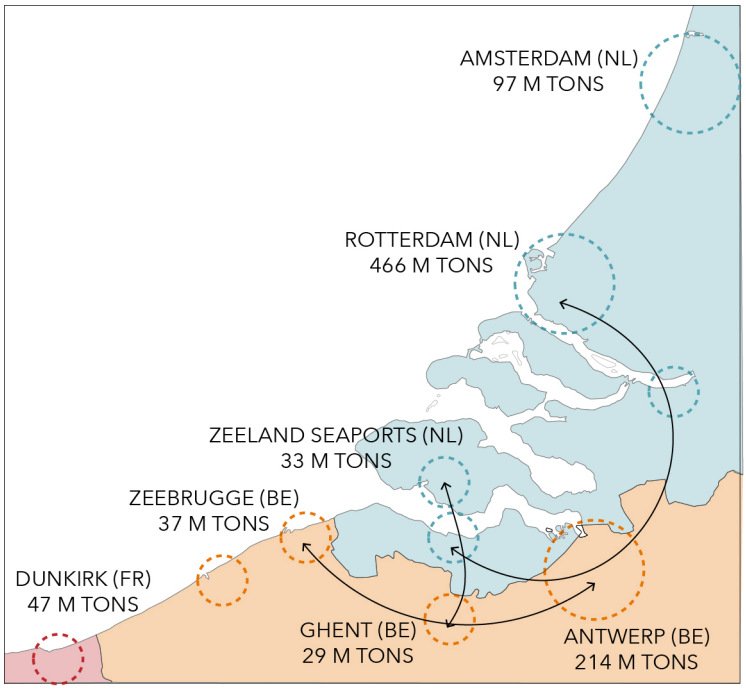


Figure 60. Recent collaborations between ports in the region
(Elaborated by author. Source: Goey F, 2004. Comparative Port History of Rotterdam and Antwerp (1880-2000))

7.2.1. THE SCENARIO FOR THE FUTURE WESTERN SCHELDT

The 3 selected projects in the area will be developed in the high sea level rise / high collaboration scenario to expand on the potentialities it provides for the 3 main goals defined in the Outline 2030 for the Western Scheldt: Safe, accessible and natural.
And then reflect on how increase in collaboration (specially by the regional ports) can result in a more sustainable development compared to the current trends.

The high sea level rise component will emphasize the urgency to address the potential flood risks and habitat loses in the area, while the high collaboration component will assume that different stakeholders are willing to make combined efforts, especially when there are expected benefits.

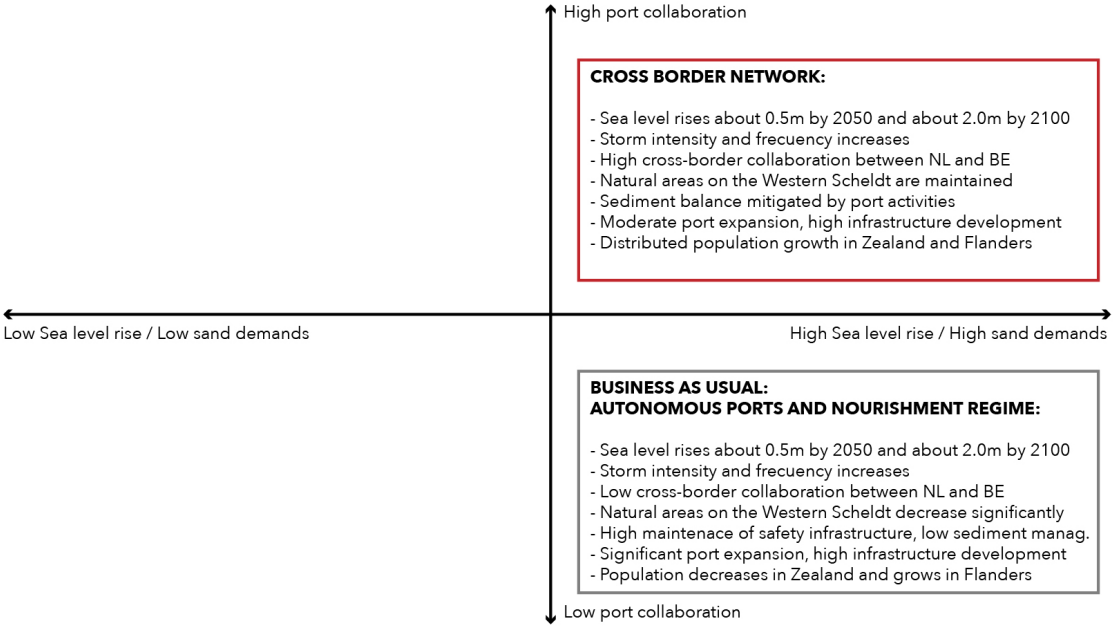


Figure 61. Scenarios
(Elaborated by author.)

7.3. THE VALUE OF THE APPROACH

From a planning perspective, high collaboration is expected to increase the capacity to manage ecosystems and develop EbA. This is particularly important in a cross-border territory like the Western Scheldt.

The previously identified values of ecosystems can be connected with potential benefits for the different stakeholders and that way assign responsibilities in their management.

The governance arrangements of each zone will take in consideration the 3 aspects of collaboration for EbA highlighted on the research paper:

-Flexible governance structures and new forms of governance that are context, site and even project-specific.
-Vertical coordination among scales, where goals are reached by higher levels of administration that initiate, regulate and supervise and supported by local levels of action and maintenance of the biophysical systems
-Horizontal inclusion of stakeholders, to facilitate the flow of knowledge and perspectives and to develop innovative multi-systemic solutions.

From a spatial perspective, the port development would contribute to a more positive ecological and morphological evolution of the Western Scheldt. The associated BwN projects will enhance the capacities of the different systems over time and allow for EbA to be more effective in the area.

There is an evolutionary component of the proposal. As ecosystems are positively intervened, they will perform better and also create added values at local scales. This will then result in an expansion of the stakeholder network involved in the management.

8. THE INTERVENTION AREAS

This chapter explains the 3 selected port development projects and valuates the impacts on the biophysical dynamics that are undesirable for the sustainable development of the Western Scheldt.

Then, it explains the BwN projects that are applicable in these areas. These projects can potentially counter these negative impacts by using the adaptive capacities of the ecosystem (EbA).

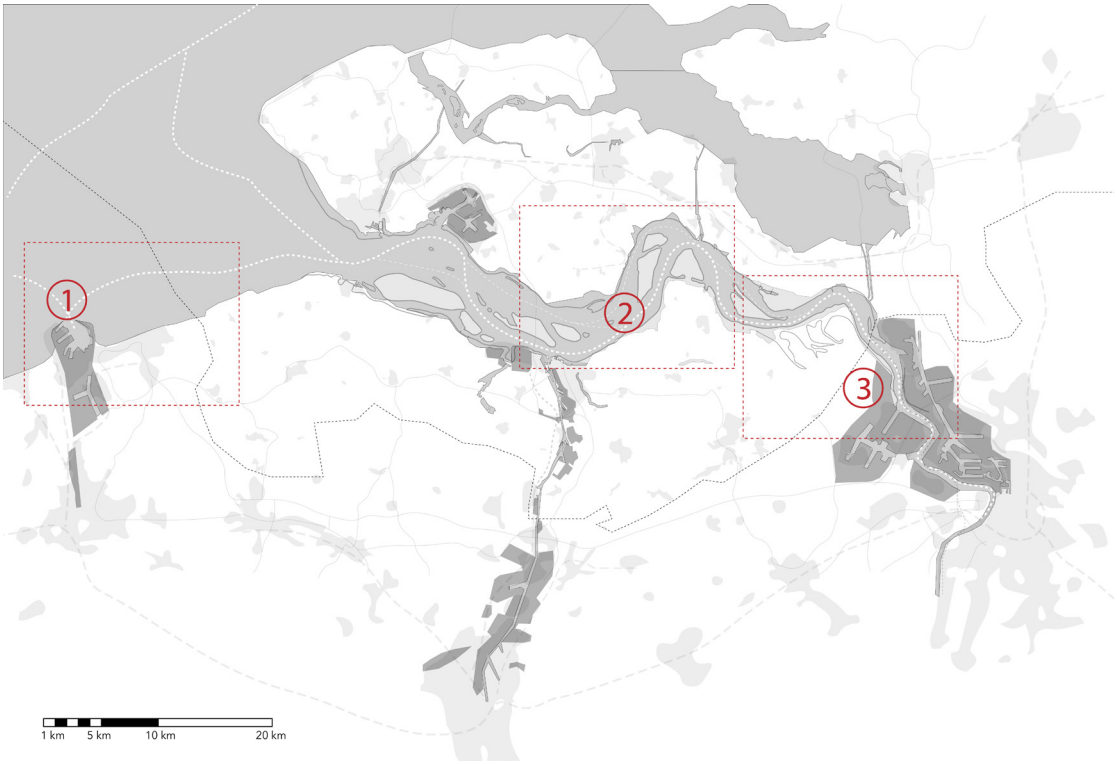


Figure 62: 3 Intervention areas
(Elaborated by author.)

8.1. THE PORT DEVELOPMENT PROJECTS AND THE SYSTEMS AT STAKE

3 projects that will be developed by the ports in the coming years will define the starting point of the proposal:

1- The expansion of port of Zeebrugge in the river mouth area

2- The maintenance dredging for the navigation channel on the mid-stream area.

3- The expansion of port of Antwerp in the high stream area.

8.1.1. RIVER MOUTH AREA:
EXPANSION PORT OF ZEEBRUGGE - ADDITIONAL COASTAL EROSION

The trend already shows that the coastlines of both Belgium and the Netherlands are suffering a loss in their sediment balance. For this reason, every year the volumes of sand that is used to nourish the beaches and maintain the current coastline is increasing. As sea level gets higher, it's expected this sediment loss to increase further.

In addition to this, the coastline at the mouth of the Western Scheldt suffers from erosion as a result of stronger residual currents in an east-west direction and dragging sediments out of the coast. In order to reduce this erosion patterns, a system of groins is present on the coastline of this area.

At the same time, the *Zwin* marsh, which is located in the border of the two countries and directly behind the coastline, is being restored. This X ha marshland has a positive sediment balance and silts up over time, losing its intertidal qualities.

Based on the sea level rise projections made by Deltares (2018), if the sea level rises at a speed of 20mm per year (projection used on the high climate change scenarios), the Netherlands would require around 80 mm3 of sand every year to maintain the current coastlines.

The stretch of coast between the port of Zeebrugge and Nieuwesluis is about 20 km long, divided almost in half between Belgium (9 km) and the Netherlands (11 km).

Taking in consideration that the exterior coastline of the Netherlands is 451 km long (Worldatlas) and making an assumption that the required beach nourishment along the Dutch coastline is equally needed, the 11 km of Dutch coast between the national border and Nieuwesluis will require about 1,9 mm3 per year in the 20-mm sea level rise projection. A similar amount should be expected on the Belgian coastline between Zeebrugge and the national border. As a total, the 20-km coastline will require about 3,4 mm3 every year to maintain the current position.

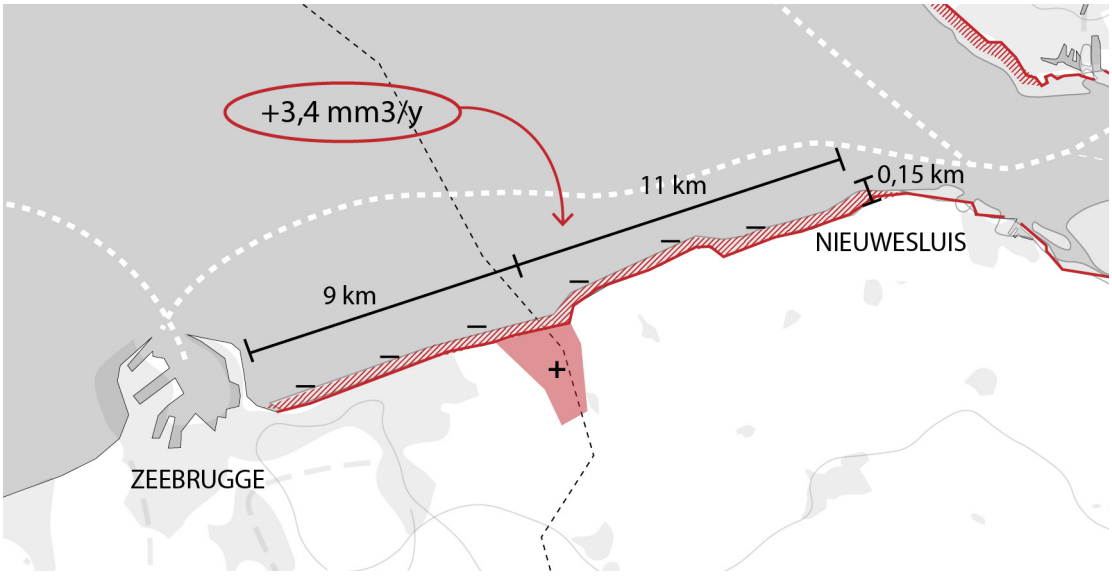


Figure 63: Coastal sediment balance area 1
(Elaborated by author. Source: Estimation based on DELTARES, 2018)

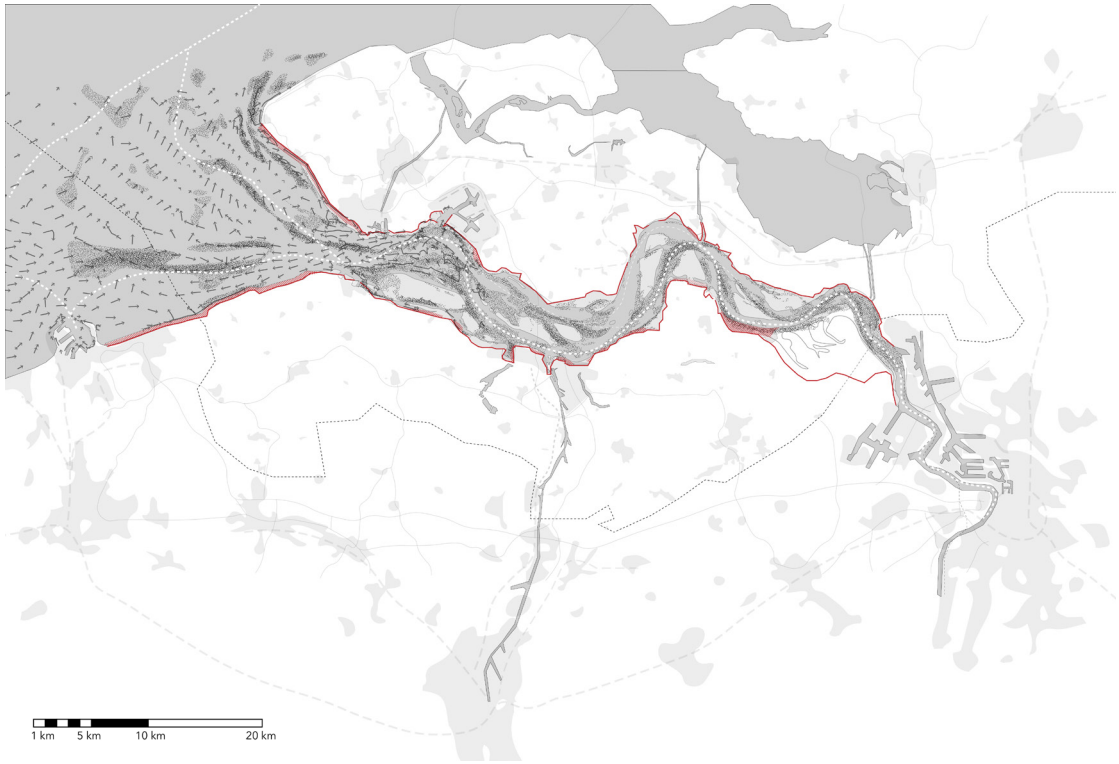


Figure 64: Expanded port and new coastal erosion
(Elaborated by author. Source: Currents, De Vries., S. 2016, DELTARES,)

The presence of the Port of Zeebrugge in the Flemish coastline has also an influence on the sea currents. As a fixed element, it deviates currents out of the coast when they reach the port, and then they move back to the coastline.

A seaward expansion of the Port of Zeebrugge is already a project in discussion to increase the port's capacity and attract new investors.

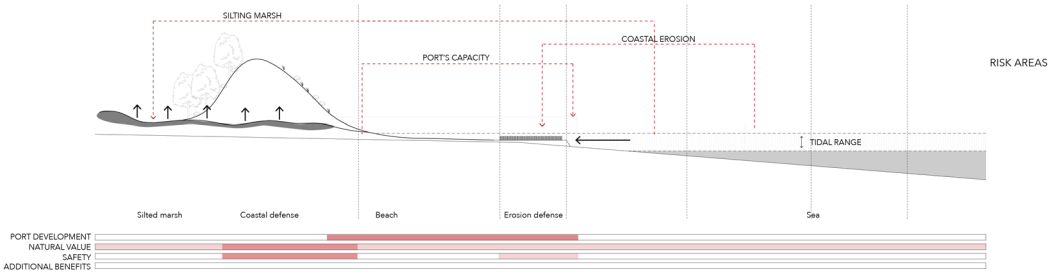
This expansion will again change current movements at a local scale and the resulting sediment flows. It is expected that currents will accelerate in front of the port and have a higher impact on the coasts of Knokke-Heist and even part of the Dutch coasts in the municipality of Sluis.

Similar effects have been experienced with the latest expansion of the Port of Rotterdam in surrounding areas, which means that a project of similar conditions should include a plan to mitigate the additional coastal erosion

Based on a research made by Port of Rotterdam & National Institute for Coastal and Marine Management RIKZ (2005) they modelled the effects of the port expansion and the impacts of additional erosion in the coastline further north. The model showed a decrease of mud flux that varied between 5 and 25% after the port was built.

For the purpose of estimating the impact of the expansion of Port of Zeebrugge in the sediment flows, the average of 15% decrease will be used. In such case, the sediment demand in the 20 km stretch of coastline will increase by 0,5 mm3/year. The total nourishment that will be required to maintain the coastline will be about 3,9 mm3/year.

In addition to the sediment impacts, the Port expansion will occupy 700 ha of sea space that is under the Natura 2000 bird protection status.



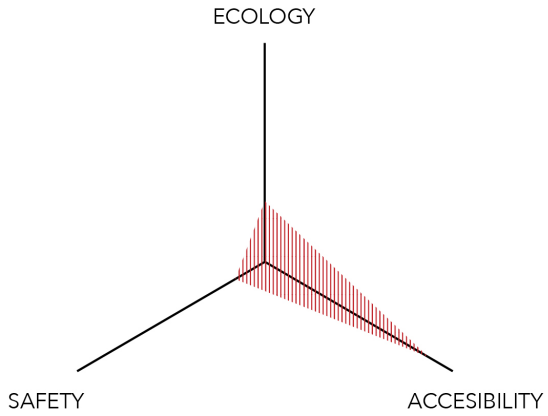


Figure 65: Zone 1 - Expanded port project risks and performance
(Elaborated by author)

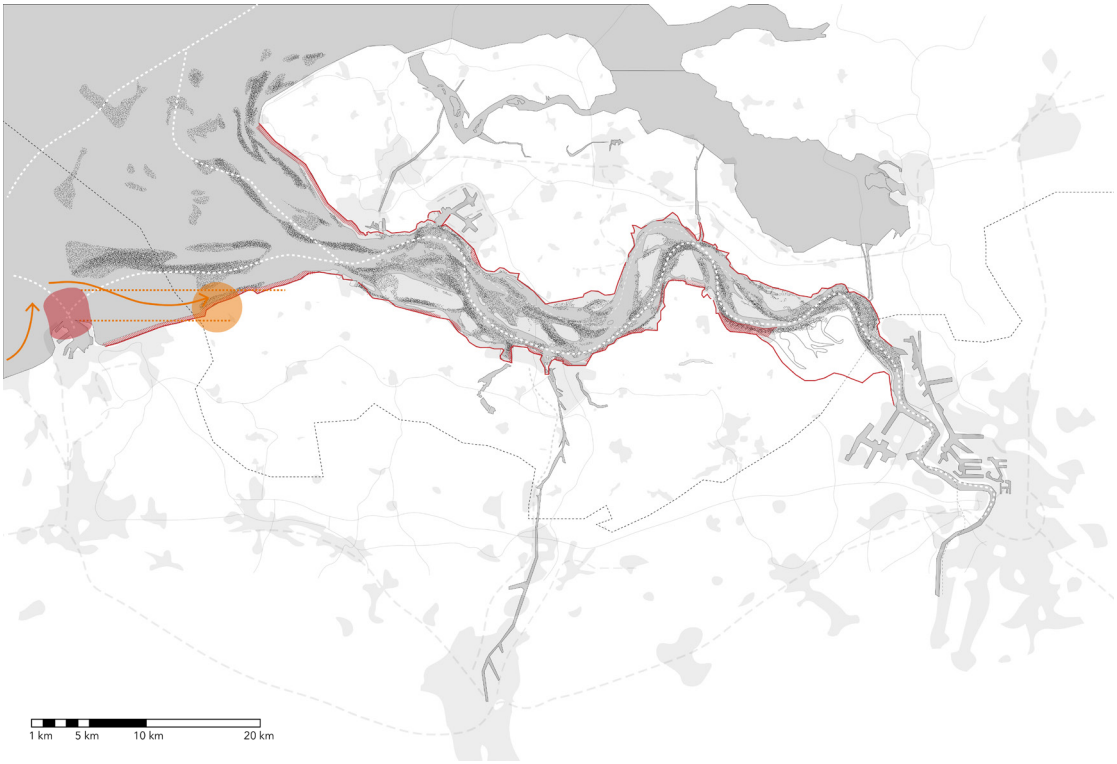


Figure 66: Expanded port and new coastal erosion
(Elaborated by author. Source: Currents, De Vries., S. 2016, DELTARES, Bank protection, Van Dijk, M. 2018)

8.1.2 MID-STREAM:
MAINTENANCE DREDGING - SHOAL AND BANK MARGIN COLLAPSE

The main and secondary channels on the Western Scheldt are a result of an interaction of the currents and their subsequent sediment transport. The position of these channels has changed over time. Some areas are very exposed to the currents and eroding while others areas experience less dynamics and accumulate sediments.

The borders of the river have been fixed by the dikes, affecting the capacity of the channels to move to new positions. In some cases, the channels have moved closer to the borders and created a problem.

The bank slopes between channel and border have become too steep and more vulnerable to collapse as sediments can easily run down to the channel bed. The most common mechanism that causes failure of a channel bank is the loss of sand at the toe of the bank (van Dijk et al., 2018), also known as “scouring”.

This problem not only affects the channel banks, but also the inner mudflats. Mudflats or shoals on the Western Scheldt are not protected against erosion. If the margin of the shoals becomes too steep it can collapse as well.

If a shoal or bank margin collapses, it will obstruct the navigation channel, cause significant alterations to the local environment and could even destabilize dikes and other safety related infrastructure.

As sea level rises, the traditional approach to maintain safety relies on raising the dikes. This will further increase the steepness of these areas and the risk of collapse.

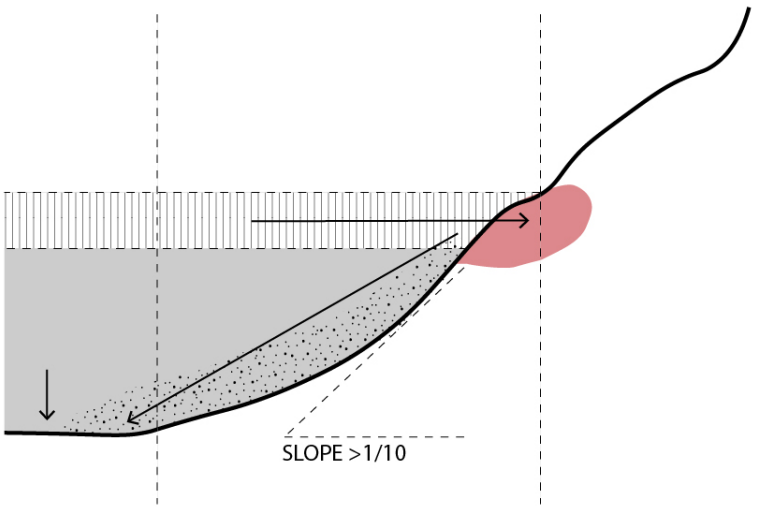


Figure 67: Diagram of bank margin erosion area 2
(Elaborated by author. Source: Van Dijk et al., 2018)

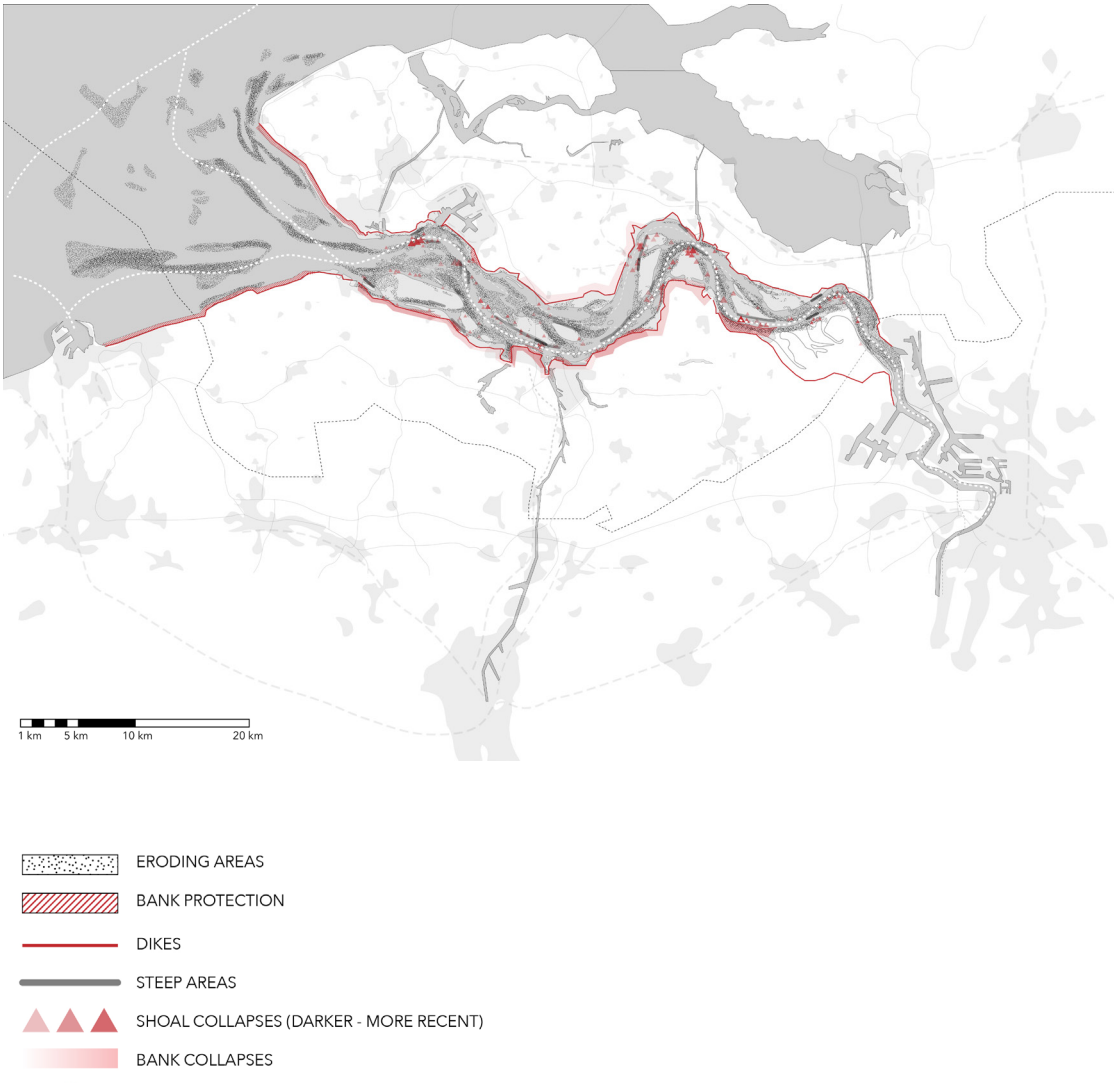


Figure 68: Eroding areas and historical collapses
(Elaborated by author. Source: Van Dijk, M. et al. 2018, VTS Scheldt, EUROSION, 2004)

To maintain good accessibility for the ships, additional dredging takes place in the main channel. Since the last enlargement agreement in 2005, tide unconditional accessibility is assured for depths up to 13.1 m. This additional deepening needs constant maintenance dredging as sediment transport is high in many of these areas and return to the river bed rather quickly.

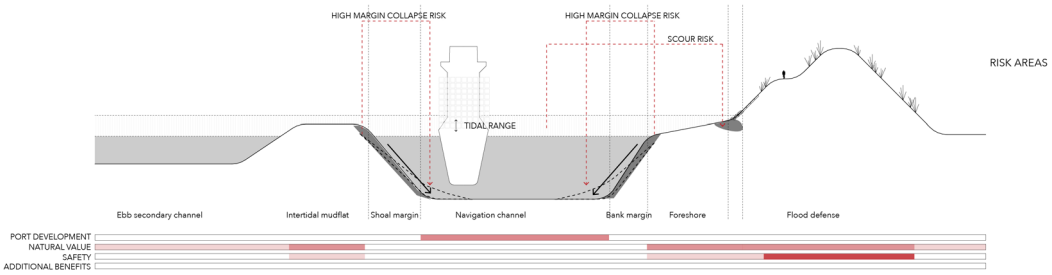
Previous dredging strategies (Which took place until 2007) defined main dumping sites on secondary channels and eroding sides of the channel. As too much material was being deposited on the secondary channels, some to these areas started to get obstructed, affecting the multichannel system of the Western Scheldt. The dumping sites on the sides of the channel are not stable areas and this increases the risk of shoal and bank margin collapse.

The “morphological dredging” strategy that is currently being tested can help to maintain the mudflats and redoing areas, but steep banks will maintain their less stable condition.

As the channel is maintain at an “unnatural” depth, it increases the slopes of the banks even more. Sediments will be transported faster to the bottom of the river from these steep, less stable areas and the banks will erode faster.

In addition to this, a deeper channel reduces the bottom friction and waves will enter the river with more intensity. This will also add to the scouring to the channel banks.

On the map (Figure x) the orange areas indicate channel banks which exceed the 1/10 slopes and are more likely to collapse. As a reference, if the depth of the navigation channel is close to 15 m below the N.A.P., the distance between the navigation channel and the shore should be at least 150 m wide. This banks in this vulnerable condition (slopes over 1/10) add up to about 28 km along the Western Scheldt.



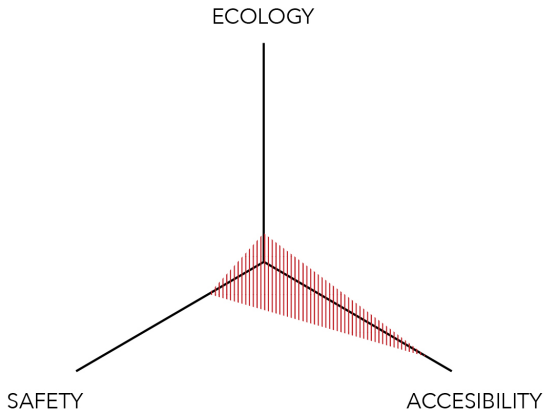


Figure 69: Zone 2 -Maintenance dredging project risks and performance
(Elaborated by author)

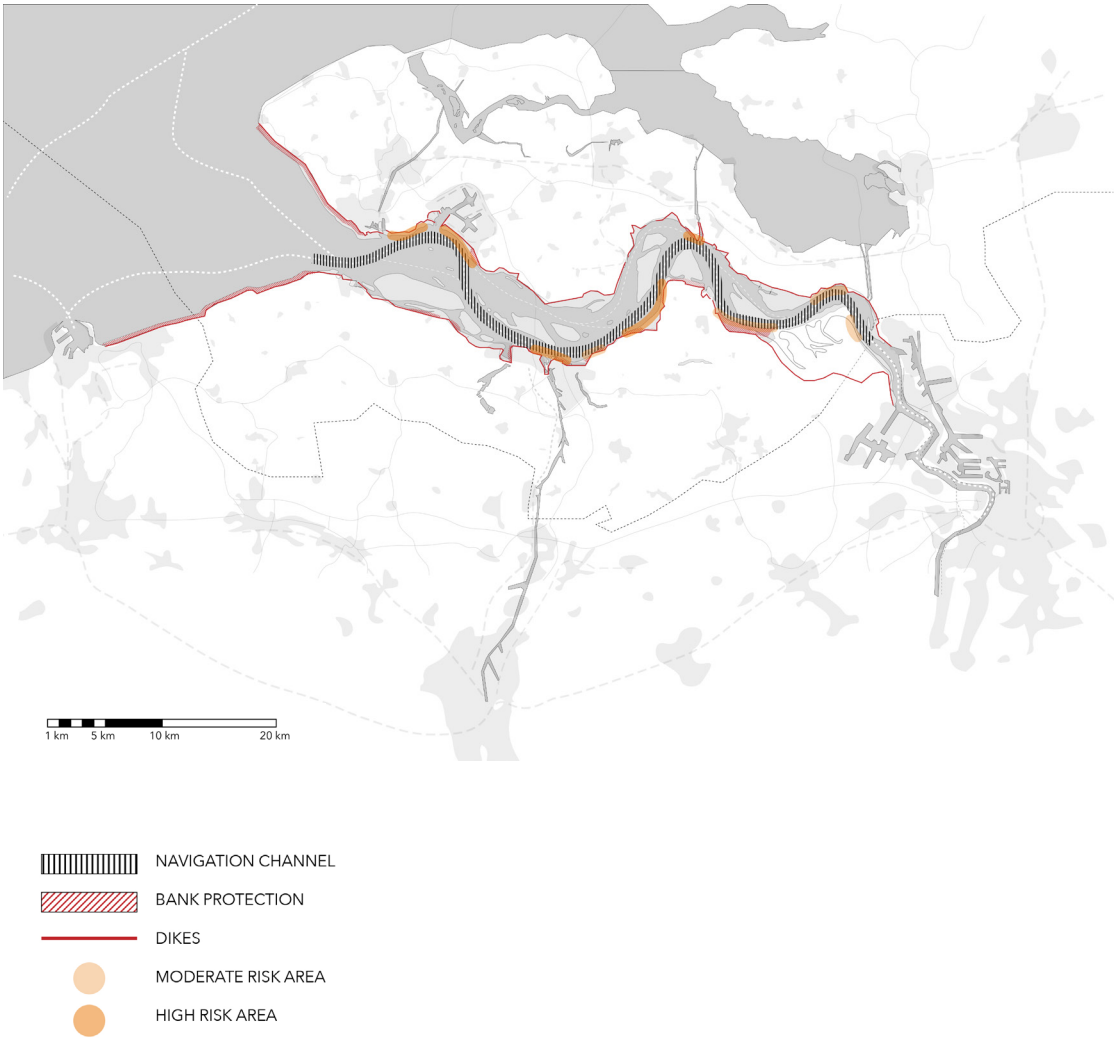


Figure 70: Navigation channel and margin collapse isk areas
(Elaborated by author. Source: Van Dijk et al. 2018, VTS Scheldt)

8.1.3. HIGH STREAM:
EXPANSION PORT OF ANTWERP - OCCUPATION OF PROTECTED AREAS

As it was mentioned before, the quantity and quality of habitats on the Western Scheldt has decreased over time. The Natura 2000 environmental policy has given protection to habitats and birds on the Western Scheldt. It also has given protection for birds in some adjacent areas, because they feed and breed near the river and estuaries.

This included areas near the ports of Antwerp and Zeebrugge, before their future expansion plans were defined. *"In many cases, the port authority's opinion had no influence on the designation of a site as a valuable nature area, and the planned future use of an expanded facility had not been taken into consideration."* (Vikolainen V. et al, 2014)

Not having clearly defined plans to deal with the environmental impacts has caused frequent delays in port infrastructure projects, significant increase in costs during the project development stage and even cancellations. This has already happened with the expansion "Maasvlakte II" in Rotterdam or the Deurganck Dock in port of Antwerp, where the projects delayed for more than a year for avoiding the Natura 2000 regulations. (Vikolainen V. et al, 2014)

Figure 71: Port of Antwerp expansion over Natura 2000 bird site
(Elaborated by author. Source Port of Antwerp, Natura 2000)

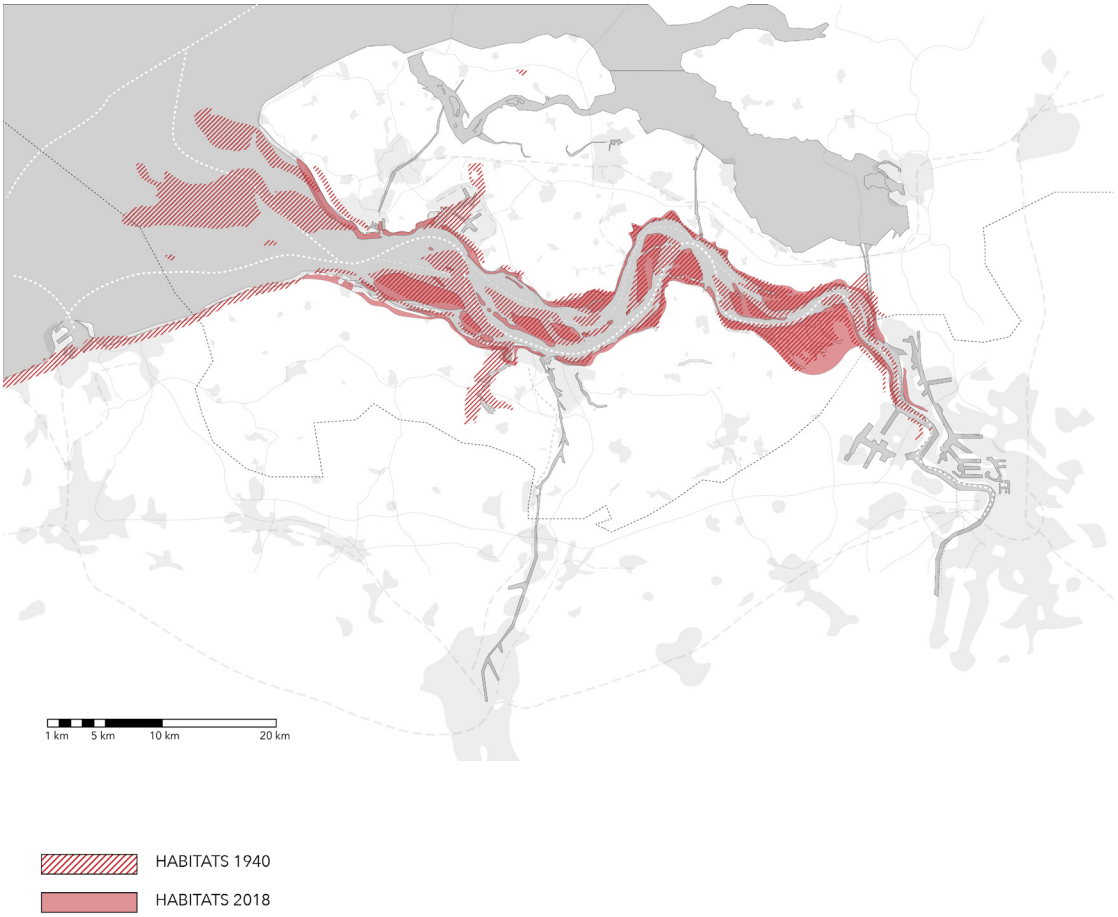


Figure 72: Habitat loss
(Elaborated by author. Sources: Plancke et al., 2006)

To be competitive and attract new clients, ports aim to increase their services and capacity. In most of these cases, such increase requires a physical expansion.

For both the Port of Antwerp and Port of Zeebrugge, the areas of planned expansion take place in Natura 2000 sites for bird protection.

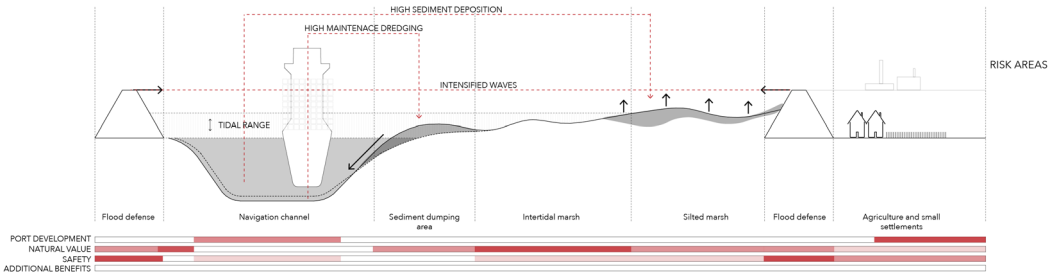
These expansion projects will have to then incorporate a management and/or compensation plan to deal with the environmental impact as required by the Natura 2000 regulations and avoid the issues of previous port projects.

Other rural areas, adjacent to these ports, have high potential to be used for future expansions, but will also have to deal with the same regulations.

Most of the compensation projects executed by Port of Antwerp take place near the port, but disconnected from the Western Scheldt or further upstream outside the city. In both cases the compensation sites may have reduced disturbance, but the habitat conditions change significantly if there is no tidal influence or much lower salinity.

The latest expansion will not only develop over 940 hectares of bird protected sites, it also impacts the 3 hectares of foreshore habitat and to some extent the water flows.

It is also worth mentioning that this expansion will include demolishing the town of Doel. Most inhabitants have moved out already.



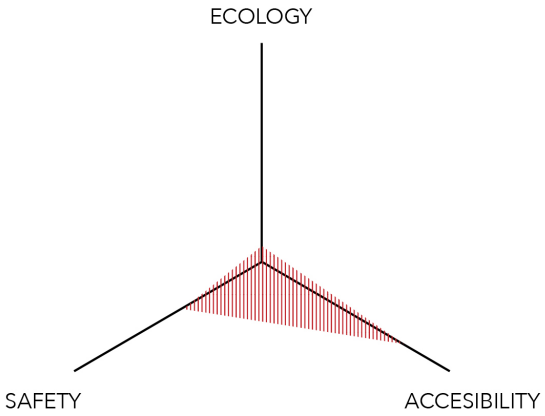


Figure 73: Zone 3 -Expansion port of Antwerp project, local risks and performance (Elaborated by author)

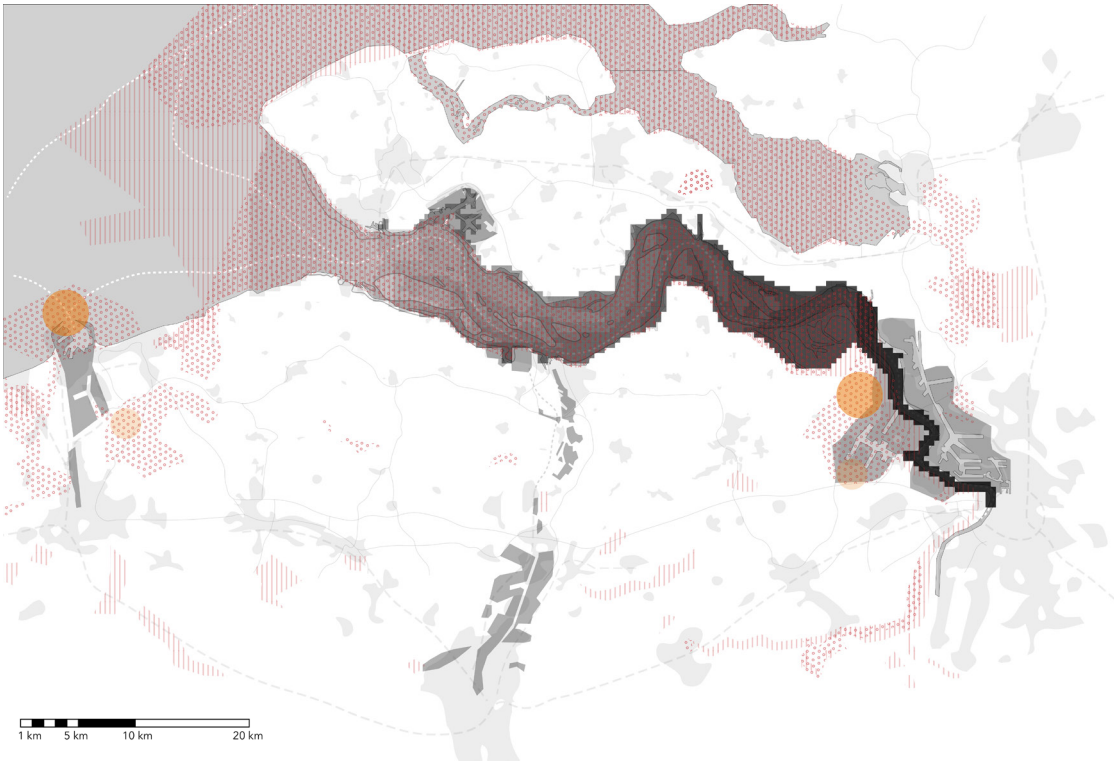


Figure 74: Port expansions and conflicts with Natura 2000 areas
(Elaborated by author. Sources: Water quality, DELTARES 3d simulator, Natura 2000. Port expansions, Port of Zeebrugge, Port oF Antwerp)

8.2. PROJECTED IMPACTS - 2100

If the ecosystems of the Western Scheldt are not managed and the impacts of climate change and human interventions continue to affect their values, risks will increase, habitats will be lost, and the sustainability of the system will be compromised.

If collaboration is limited, the management of the ecosystems is of interest of few stakeholders and resources are not sufficient for the required tasks.

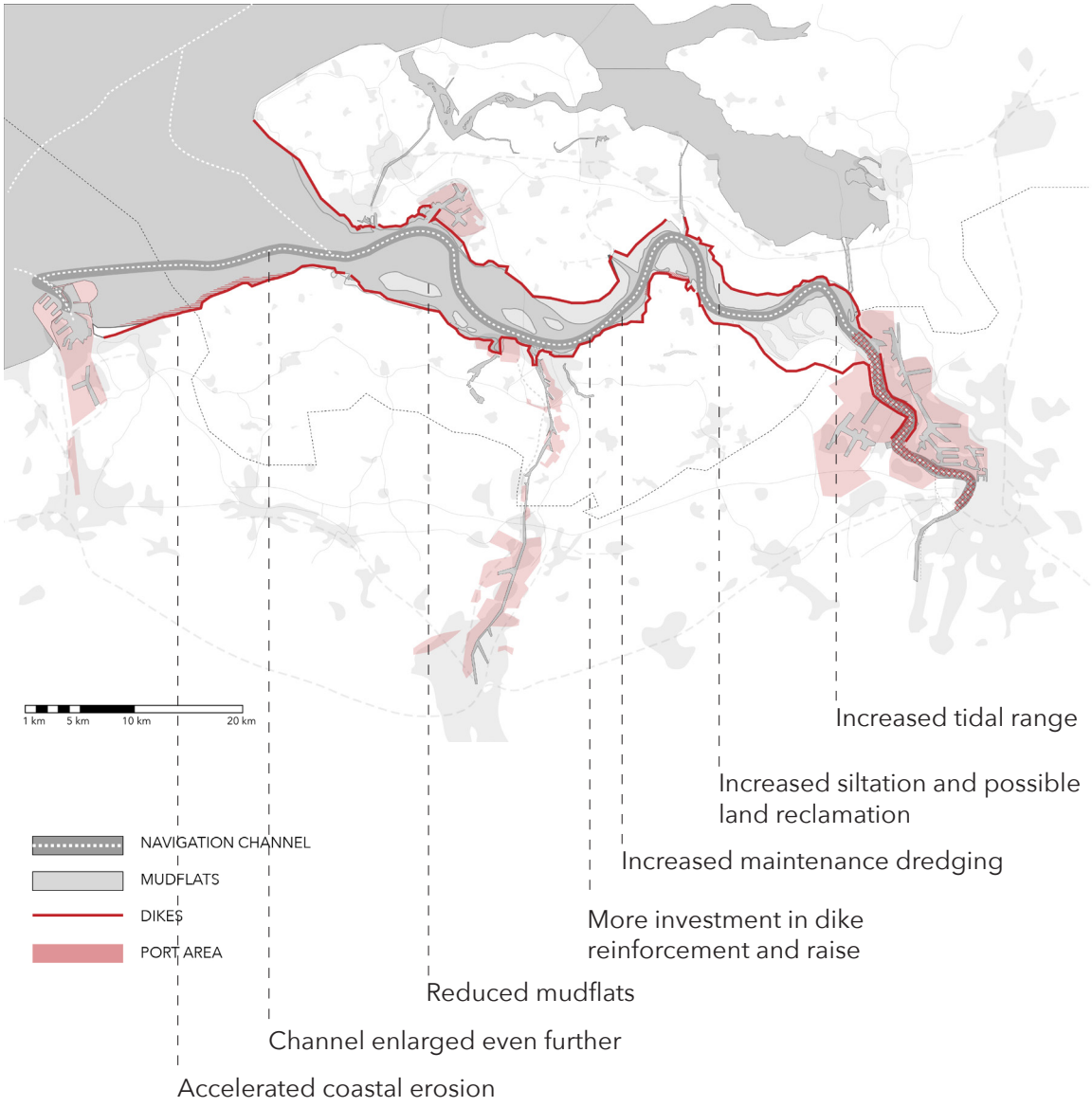


Figure 75: Projected Western Scheldt by 2100 in a low collaboration/ high climate change scenario (Elaborated by author)

8.3. GOALS:

Port development should not come at the cost of increased ecosystem deterioration.
As framed under the Long-term vision 2030 for Western Scheldt (Outline 2010), the three main functions need to coexist the sustainable development of the area.

Ecology: Maintain the physical conditions of the Western Scheldt, including the multi-channel system and the intertidal mudflats as well as the quality of the water and habitats.

Safety: Maximize the protection against flooding for both countries

Accessibility: To be optimal for ports

The theoretical research of the project reveals the value of Ecosystem-based adaptation (EbA) as a pathway for sustainable development, which is also applicable in the Western Scheldt. Ecosystems are capable to contribute to the three goals simultaneously, but the challenge in spatial planning is to implement strategies to manage such complex systems.

For this reason, the proposed strategies along the Western Scheldt will promote interdisciplinary and cross-border collaboration to integrate the values of each system. The Building with Nature (BwN) principles and projects will then be used to intervene and enhance the ecosystem's capacities to contribute to a safe, natural and accessible Western Scheldt.

8.3.1. GENERAL EBA GOALS FOR THE WESTERN SCHELDT

- Safety by reducing the risks of flooding: Projects will reinforce the capacity of mud flats, dunes and other sand formations to dissipate waves and maintain coastal defences
- Good accessibility to the different ports along the Scheldt: Port development and new port infrastructure should not only have a reduced impact on the ecosystem, but contribute to its restauration.
- Preserving the natural systems: In combination with the other goals, the surface of valuable natural areas should increase and provide new economic opportunities.

8.3.2. ZONE-SPECIFIC EBA GOALS FOR THE WESTERN SCHELDT

For Zone 1: River Mouth

Ecology: The port expansion will compensate the altered bird protection area with the same amount of valuable intertidal habitats (like salty marshes) that will be then be added to the Natura 2000 protection sites.

Safety: The coastline at the mouth of the Western Scheldt will raise at the same rate than sea level.

Accessibility: Port of Zeebrugge will increase i's capacity and its connections with port of Antwerp and the hinterland.

Others: The potential of the coastal character of Knokke-Heist will be enhanced and will provide new forms of local economies based on recreation, tourism and aquaculture.

For Zone 2: Mid-Stream

Ecology: The current surface of the mudflats will be maintained or increased if possible. The foreshores will develop more stable and rich habitats and the water and soil quality will be improved.

Safety: Elevation of the mudflats will be maintained at a 0-1 m over the mean sea level to maximize its wave dissipation capacities. The river banks will be stabilized from collapse risks.

Accessibility: The navigation channel will have a decrease in the number of vessels, which facilitates navigability. This will be achieved without reducing the current freight volumes. The maintenance dredging will be reduced as well

Others: Innovation will be encouraged and local economies based on biofuel and biomass production as well as aquaculture will be developed.

For Zone 3: High Stream

Ecology: The current surface of the estuaries will be increased. The levels of existing and new estuary areas will be controlled and maintained for optimal tidal influence and habitat development.

Safety: The river space in the high stream area will be expanded to reduce tidal range in critical area. Elevation of the mudflats and estuaries will be maintained at a 0-1 m over the mean sea level to maximize its wave dissipation capacities.

Accessibility: Capacity of port of Antwerp is expanded in a responsible way. Infrastructure connecting with port of Zeebrugge including pipelines and railroads will compliment efficient sea - land transfer of goods.

Others: Positive sediment balance in the high stream area will not only compensate in lower areas, but serve as resource for new economic sectors based on aggregates and construction materials.

8.4. APPLICABLE BWN PROJECTS

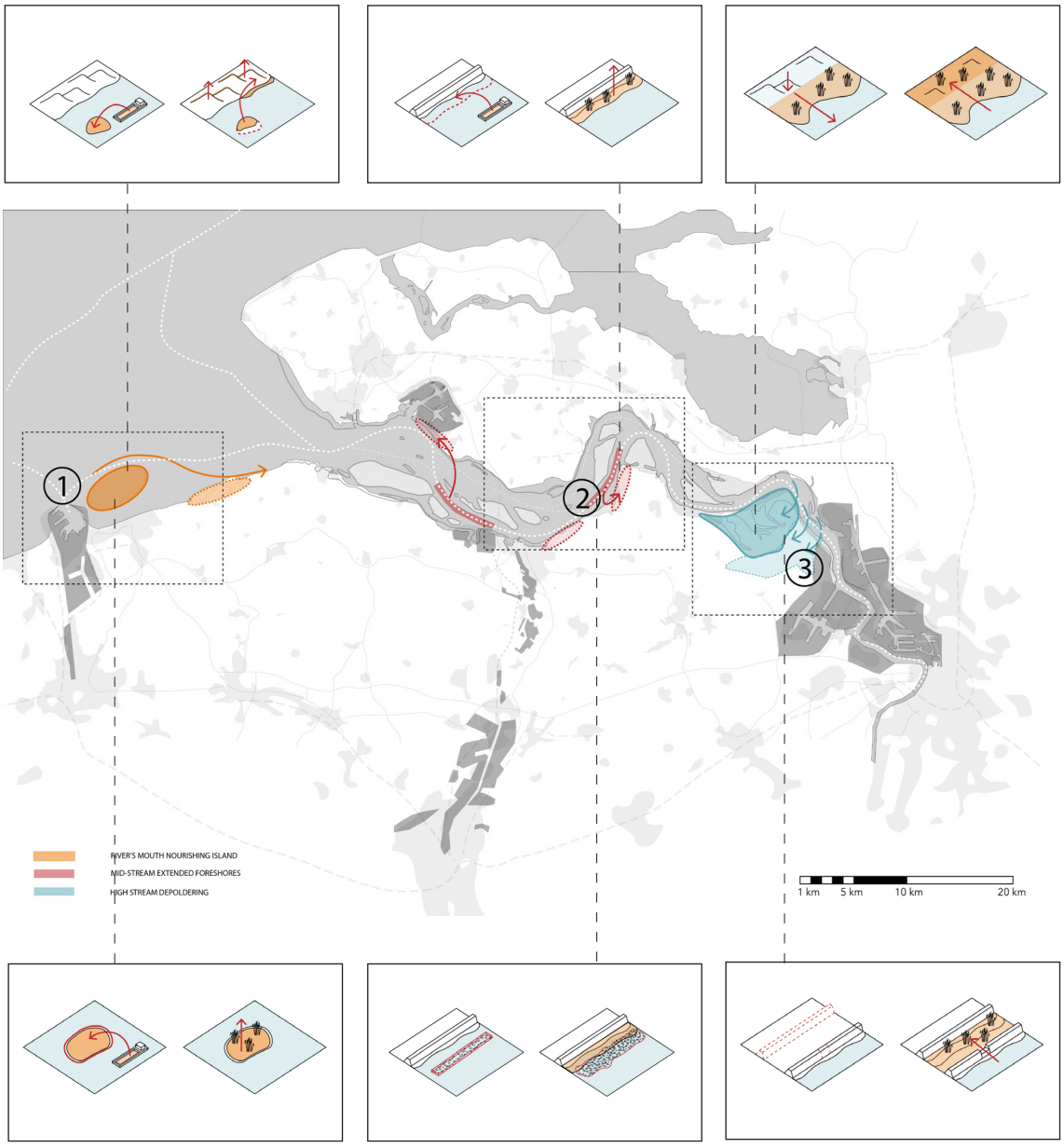


Figure 76: Applicable BwN projects in Western Scheldt
(Elaborated by author)

8.4.1 ZONE 1: RIVER MOUTH - NOURISHING ISLAND

There has already been discussion of "building" artificial islands on the coast of the Netherlands and Belgium to protect the coastline. The Belgian marine spatial plan even assigned an area for a future island. The main points that need to be considered for the definitive position of the island are the impacts on the currents, sediment flows, views and tourism. (On the news, focus wtv, December 2017).

In the proposal, the island is attached to the port of Zeebrugge. This way, the island becomes responsibility of the port and the Flemish region. (Separated islands are responsibility of the Belgian government). The island will include a fixed part for habitat development and a flexible part that will serve as a sand engine for the eroding coasts. De Vries (2016) for example, has already modelled the impacts on erosion and residual currents with the introduction of an island in the area and shows that sediment transport would likely nourish the coastlines.

8.4.2 ZONE 2: MID-STREAM - EXTENDED FORESHORES

This principle uses sediments and vegetation to protect land and dikes from wave impacts. This will take into consideration the steep slopes on the Western Scheldt and make room for these stabilizing areas by either displacing the navigation channel when possible or in some cases by moving the dikes back. The morphological approach for dredging and dumping will contribute to these changes.

The foreshores will be combined with another BwN project of oyster reefs. They can be used as natural wave breakers, which grow over time. The oyster reefs protect the foreshores, purify water and increase sedimentation. This way, the foreshores will raise along the water level.

8.4.2 ZONE 3: HIGH-STREAM - DOUBLE DIKE FOR DEPOLDERING

In the last few decades there have been projects that aim to restore habitats by creating flooding areas or even controlled flooding areas. These areas can combine natural values and other uses. For example. the *Waterdunen* near Breskens is a depoldered area that serves as recreational site for camping as well as laboratory for salty crops and educational activities (de Vlieger, 2017)

Stark (2017) elaborated a model of the effects on the tidal range of depoldering in different areas of the Western Scheldt. The results showed that depoldering in high-stream areas had a bigger impact. In the proposed area, depoldering 1km further the Saeftinghe marsh would reduce tidal range between 12 and 16 cm around the Antwerp area.

In the area, sediment vacuuming will be used to regulate siltation of the marshes to maintain their optimal tidal influence.

8.5. IDENTIFYING SYNERGIES BETWEEN THE MAIN FUNCTIONS FOR THE SUSTAINABLE DEVELOPMENT OF THE WESTERN SCHELDT

The proposal deals with the 3 main functions simultaneously by enhancing the capacities of ecosystems. This contributes to maintain the sufficiency of the functions over time.

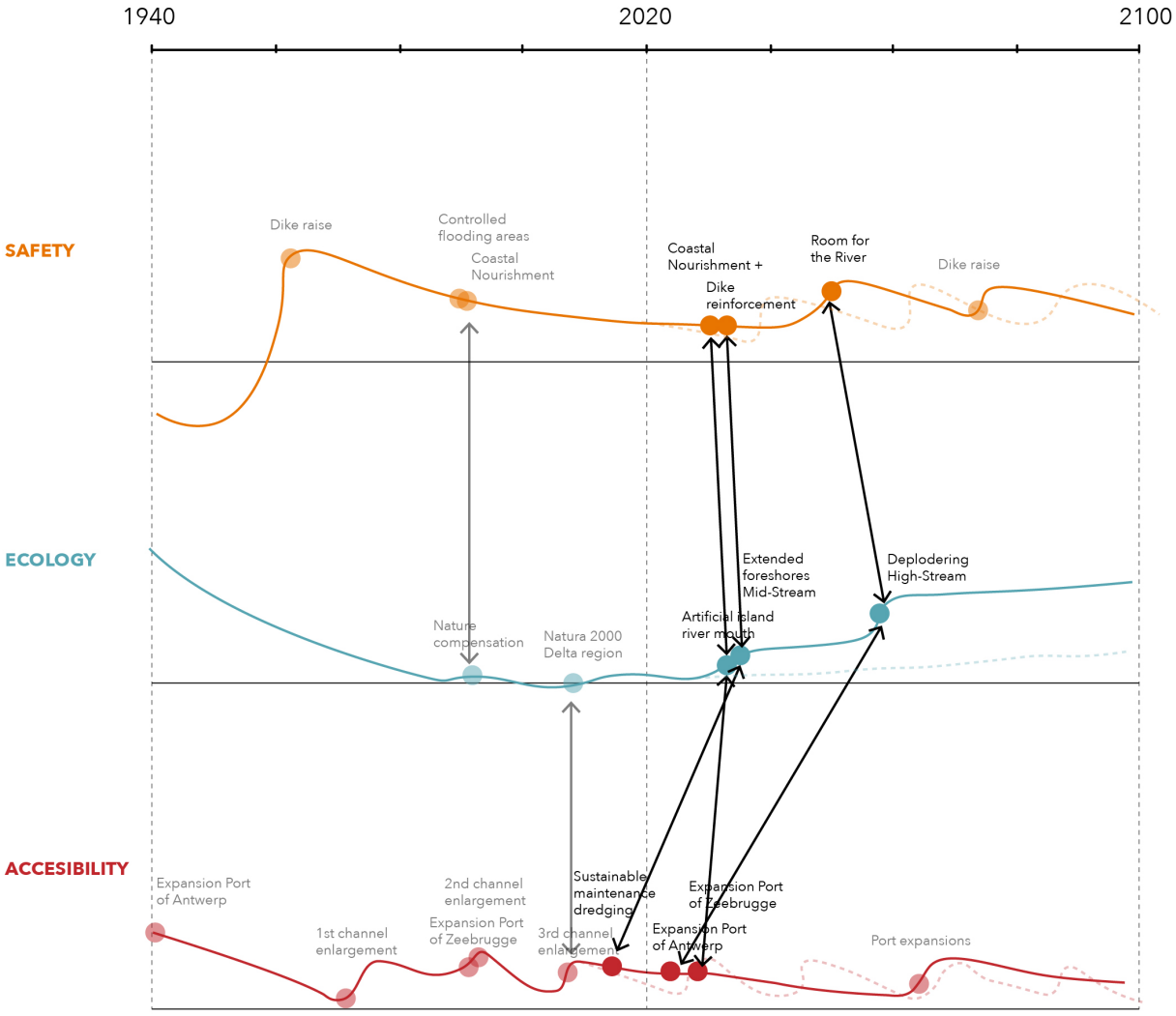


Figure 77: Synergies between the main functions in the timeline of the Western Scheldt (Elaborated by author)

9. GOVERNANCE ARRANGEMENT PROPOSAL

In this chapter, the governance proposal of the project will be explained. The proposal in this high collaboration scenario will reveal the potentialities of incorporating ports and their projects into a multi-systemic EbA strategy for the Western Scheldt.

The collaborative approach will facilitate the implementation of the port projects and at the same time create opportunities to manage the biophysical conditions of the Western Scheldt.

The governance arrangements are presented through "Onion diagrams". They show a stakeholder network that could be involved in the management of each BwN project. The first ring indicates the main drivers, the second ring shows supporters and the outer ring shows potential beneficiaries.

The new governance arrangements align the values of the ecosystems with the interests of different stakeholders in the region. Stakeholders have a role to fulfil and potential benefits for their collaboration. This will also create opportunities for combine resources and increase the general support for the projects.

The governance arrangements of each zone will take in consideration the 3 aspects of collaboration for EbA highlighted on the research paper:

-Flexible governance structures and new forms of governance that are context, site and even project-specific.

-Vertical coordination among scales, where goals are reached by higher levels of administration that initiate, regulate and supervise and supported by local levels of action and maintenance of the biophysical systems

-Horizontal inclusion of stakeholders, to facilitate the flow of knowledge and perspectives and to develop innovative multi-systemic solutions.

9.1. ZONE 1 - RIVER'S MOUTH

STAKEHOLDER POSITION: LOW COLLABORATION ZONE 1

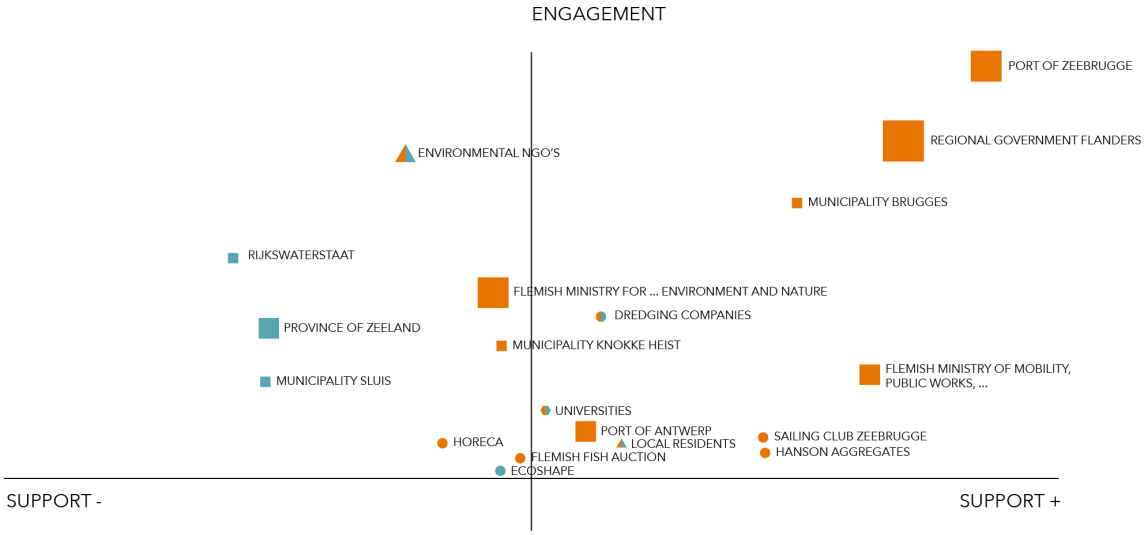


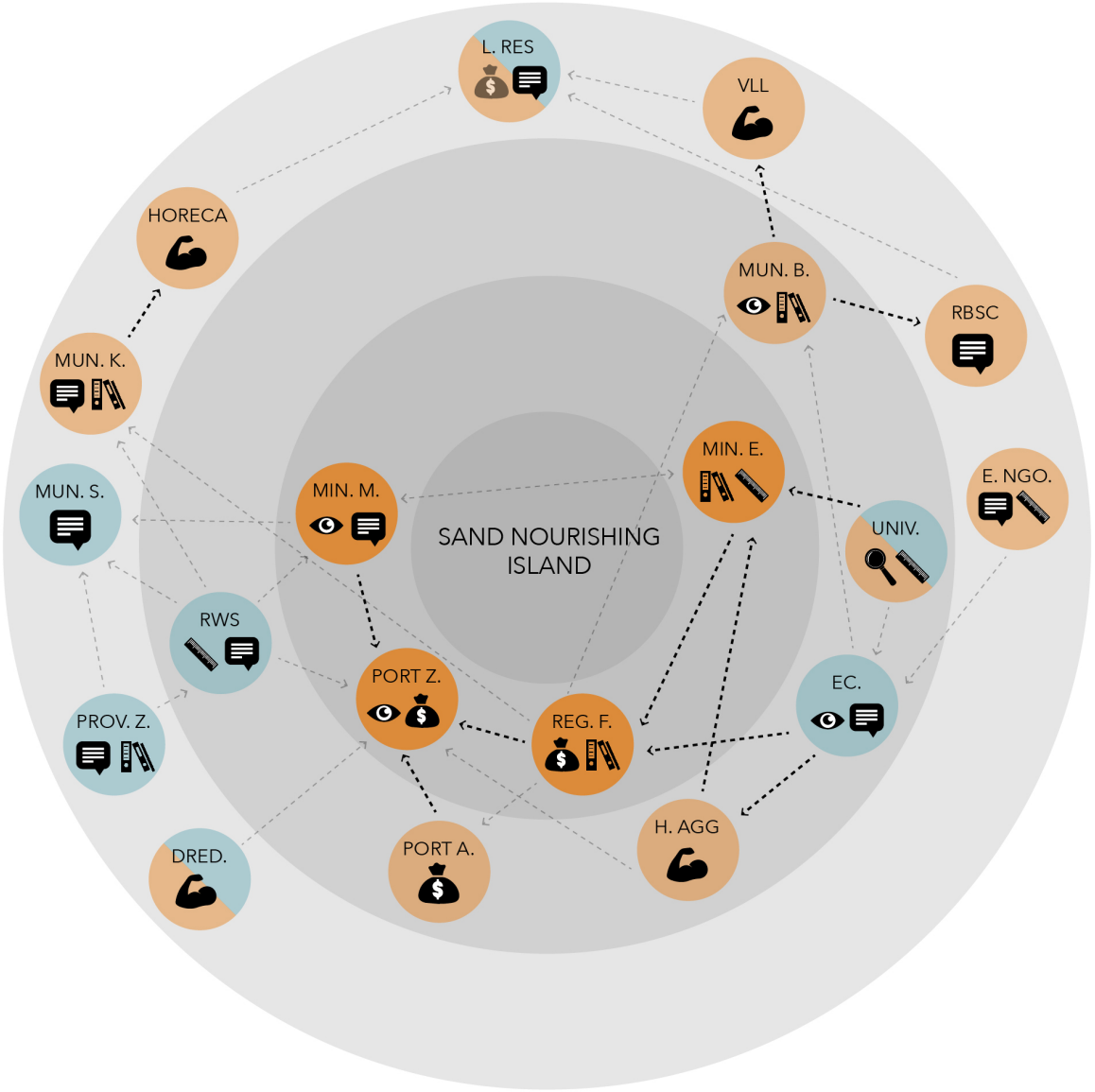
Figure 78: Stakeholder matrix "business as usual" scenario Zone 1 (Elaborated by author)

In this area, Port of Antwerp will be the most interested party in the port expansion project to be more competitive. It will need important support of the Flemish government to make it possible.

There will be opposing groups fighting for the altered bird protected sites and the additional coastal erosion caused by the port project. There would be particularly a lot of opposition from the Dutch side, because they won't get benefits and suffer additional erosion. As an isolated port project, many stakeholder groups have little involvement and power to influence decision-making. (Detailed chart of stakeholders and main interests attached on appendix)

The proposal in this area combines the port expansion with an artificial island and the management of the *Zwin* polder to compensate their impacts.

ONION DIAGRAM ZONE 1



PORT Z.	Port of Zeebrugge	Labor force
REG. F.	Regional Government Flanders	Economic support
MIN. M.	Ministry Mobility, Public Works, ...	Regulation (Policies)
MIN. E.	Ministry For ... Environment And Nature	Supervision
RWS	Rijswaterstaat Zee and Delta	Consultation
PORT A.	Port Antwerp	Monitoring
H. AGG	Hanson Aggregates	Research
EC.	Ecoshape	
UNIV.	Universities	
MUN. B.	Municipality Brugges	
MUN. K.	Municipality Knokke-heist	
MUN. S.	Municipality Sluis	
PROV. Z	Province Of Zeeland	
DRED.	Dredging Companies	
E. NGO	Environmental Ngo's	
RBSC	Sailing Club Zeebrugge	
VLL	Flemish Fishauction - Aquaculture	
L. RES.	Local Residents	
HORECA	Hotels, Restaurants, Catering	

Figure 79: Onion diagram for governance proposal Zone 1 (Elaborated by author. Based on D. Czischke 2018)

MAIN STAKEHOLDER ARRANGEMENTS ZONE 1

1- The expansion of the Port of Zeebrugge will incorporate areas of natural value to compensate for the impacts on a Natura 2000 site for birds. These new habitat sites provide ecological benefits, but can also expand to local economies including ecotourism, aquaculture, recreation, water sports, etc. This improves the support of the local residents and environmental groups.

2- Port of Zebrugge will not only compensate for possible coastal erosion that the port extension may cause. The flexible part of the island will provide additional sediments to maintain and raise the beaches and dunes of the 15 km stretch to the river mouth. This will benefit both the Belgian and Dutch coasts. The Netherlands will receive "free" nourishment in their coasts as a trade-off for the depoldering around Emmadorp (Area 3)

3- Port of Zeebrugge and Port of Antwerp will develop joint infrastructure in port of Zeebrugge for the future extra-large Vessels. The costs and profits of this activities will be divided. That way, port of Antwerp will have more resources for the port expansion. More liquid bulk vessels will also arrive to port of Zeebrugge and will transfer the bulk through the pipeline infrastructure to partially moderate the traffic on the Western Scheldt.

4- The new morphology would likely cause some beach areas to expand, especially next to the Port of Zeebrugge in the municipality of Knokke-Heist. This will increase the capacity of these beaches and expand the opportunities in that beach front, including gastronomy, accommodation and recreation.

5- Port of Zeebrugge will manage the sediment balance on the *Zwin* polder. The polder levels should be lowered to increase the tidal influence and increase the ecological value. The extracted materials can be used as material for further infrastructural projects in the area.

6-ECOSHAPE will supervise the nourishment capacities of the island and the natural sediment treatment on the *Zwin* polder and inform if changes need to be made.

(The complete chart of stakeholders with responsibilities and benefits is attached on appendix)

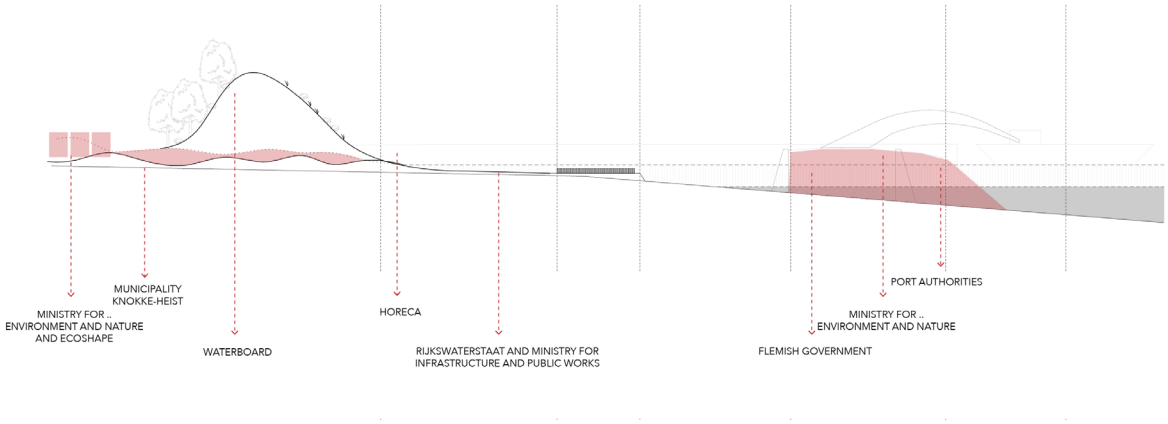
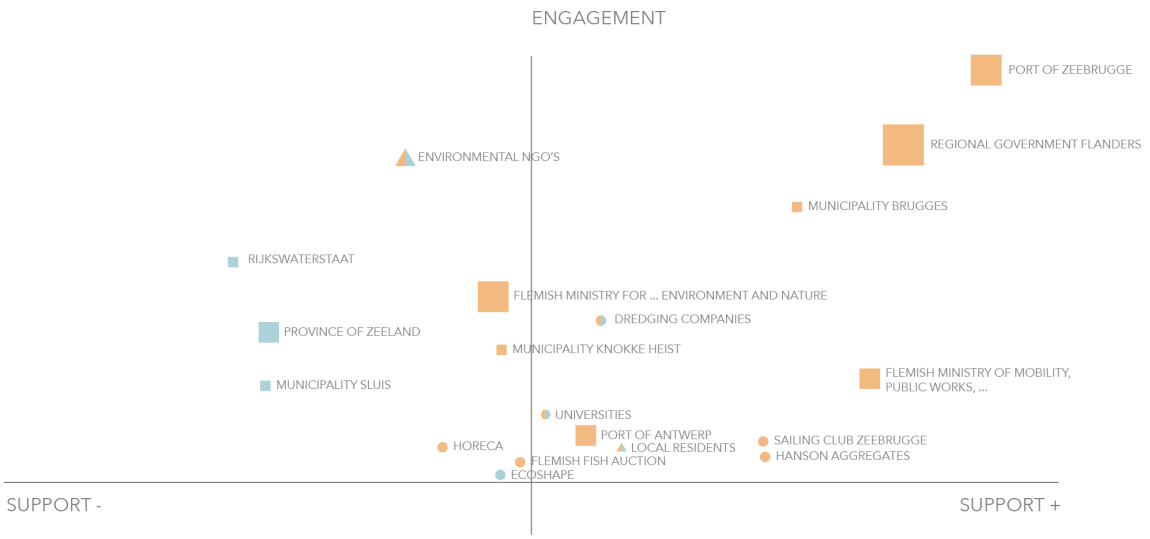


Figure 80: Governance in space Zone 1
(Elaborated by author)

SHIFTS IN STAKEHOLDER'S POSITION ZONE 1

LOW COLLABORATION PROJECT ZONE 1



HIGH COLLABORATION PROJECT ZONE 1

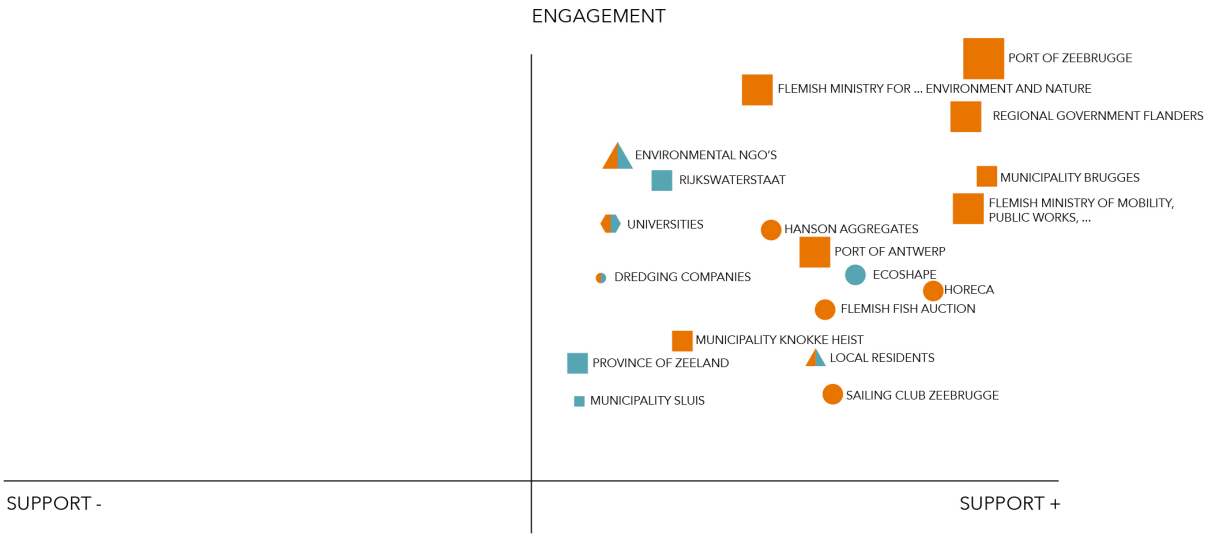


Figure 81: Stakeholder matrix and shift in positions for high collaboration scenario Zone 1 (Elaborated by author)

9.2. ZONE 2 - MID STREAM

STAKEHOLDER POSITION: LOW COLLABORATION ZONE 2

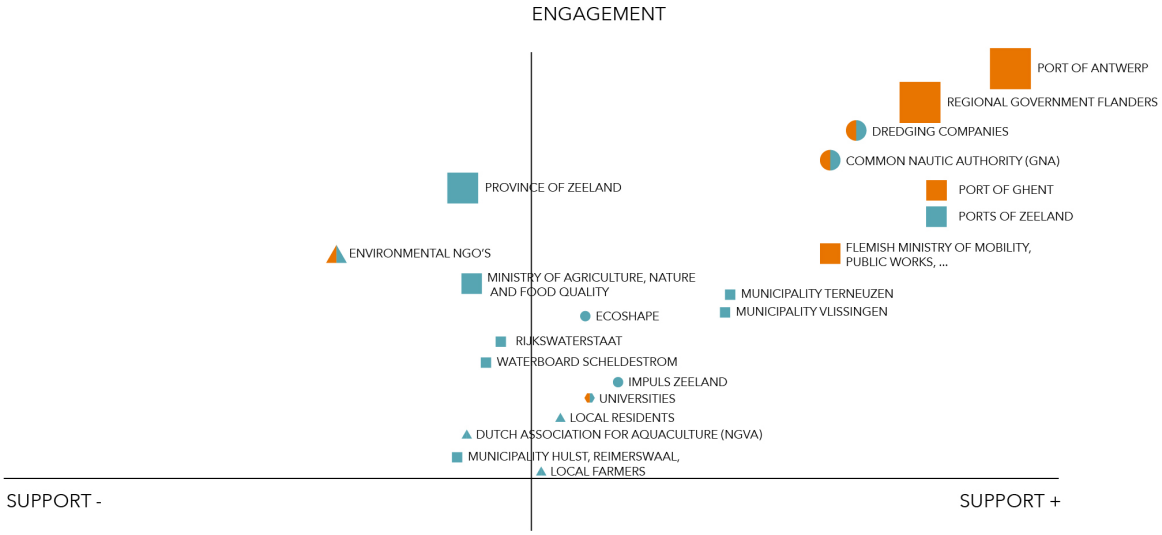


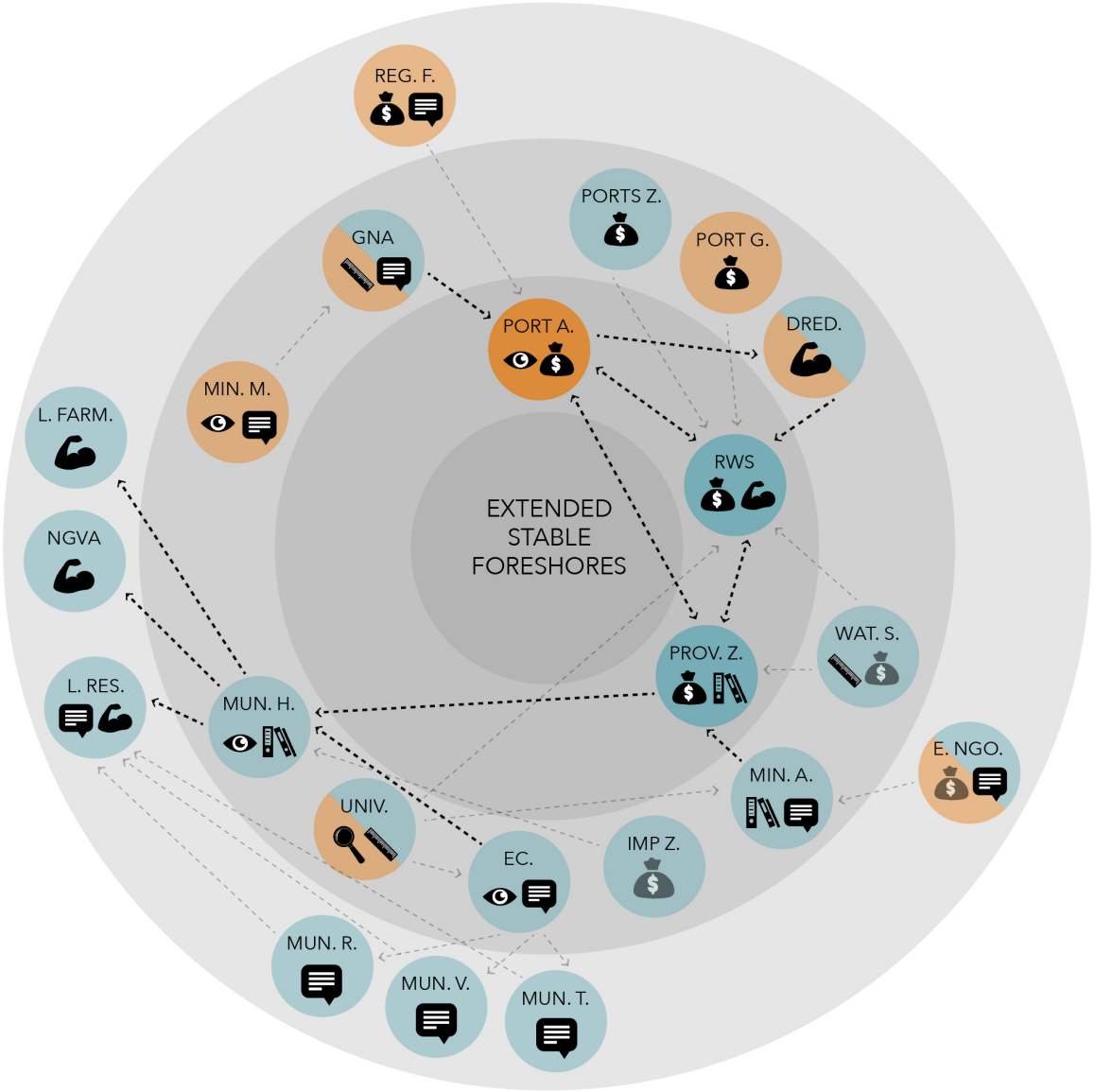
Figure 82: Stakeholder matrix "business as usual" scenario Zone 2 (Elaborated by author)

In this area, ports (especially port of Antwerp) will expect that the navigation channel can allow even the largest ships to reach the port area. Almost all the costs associated to dredging and maintenance of the navigation channel are borne by the Flemish government (even om the Dutch side) (Meersman et al. 2007).

Most of the Dutch stakeholders (with the exception of Dutch ports in the area) show limited support or even opposition to this. The environmental and safety values on Zeeland are compromised by the enlargement of the navigation channel and the constant high-maintenance dredging activities

The proposal of extended foreshores aims to counter the negative impacts on ecological qualities and stability of the flood defence systems.

ONION DIAGRAM ZONE 2



PORT A.	Port of Antwerp
PROV. Z	Province of Zeeland
RWS	Rijswaterstaat Zee and Delta
MIN. A.	Ministry of Agriculture, Nature and Food Q.
WAT. S.	Waterboard Scheldestromen
DRED.	Dredging Companies
PORT G.	Port of Ghent
PORTS Z.	Ports of Zeeland
GNA	Common Nautic Authority Western Scheldt
MIN . M.	Ministry Mobility, Public Works, ...
MUN. H.	Municipality Hulst
UNIV.	Universities
EC.	Ecoshape
IMP. Z.	Impuls Zeeland
E. NGO.	Environmental Ngo's
REG. F.	Regional Government Flanders
L. FARM.	Local Farmers
NGVA	Dutch Association for Aquaculture
L. RES	Local Residents
MUN. R.	Municipality Reimerswaal
MUN. V.	Municipality Vlissingen
MUN. T.	Municipality Terneuzen

- Labor force
- Economic support
- Regulation (Policies)
- Supervision
- Consultation
- Monitoring
- Research

Figure 83: Onion diagram for governance proposal Zone 2 (Elaborated by author. Based on D. Czischke 2018)

MAIN STAKEHOLDER ARRANGEMENTS ZONE 2

1- The dredged material from the navigation channel will be dumped in the mudflats to maintain their optimal height of 0 to 1 m above water level and optimize wave dissipation. Other dredged sediments will be used to create extended foreshores in the areas of high collapse risk. To do this properly, dredging companies and the Flemish government will be assessed by Rijkswaterstaat and Ecoshape on where to dump and how the basin evolves morphologically.

2- In some cases, to make room for the foreshores, displacements and reductions of the navigation channel may be requited. Taking into consideration that around Antwerp the width of the channel is between 370 and 500 meters, some parts of the navigation channel are wider than necessary. The Common Nautical Authority of the Western Scheldt will be a key player in defining where and how much can be adjusted without compromising the current accessibility.

3- Region of Zeeland will create regulations for the uses and maintenance of the foreshore areas. Rijkswaterstaat and the Ministry of Agriculture, Nature and Food Quality will co-supervise the foreshores as spaces for bank reinforcement, habitat development and later food producing areas.

4- The pilot project will be developed in the municipality of Hulst (medium collapse risk, medium tidal range, medium salinity). The expected development of the foreshore will be used for biofuel crops initially and later other forms of food production like muscle farming. These activities will be executed by local farmers and supported by aquaculture associations.

5- Once the pilot has reached an advanced stage (5 years) universities and research facilities will study the effects and inform for improvement in the other locations along the river.

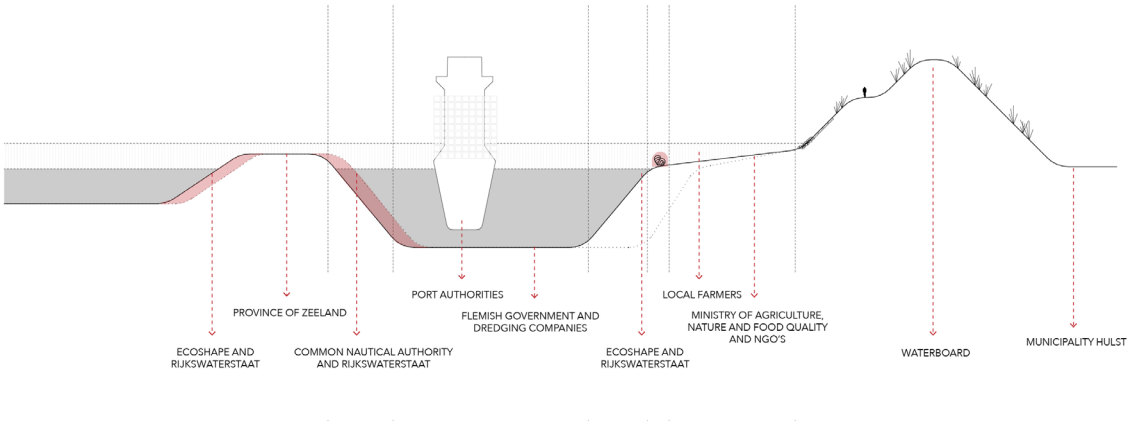
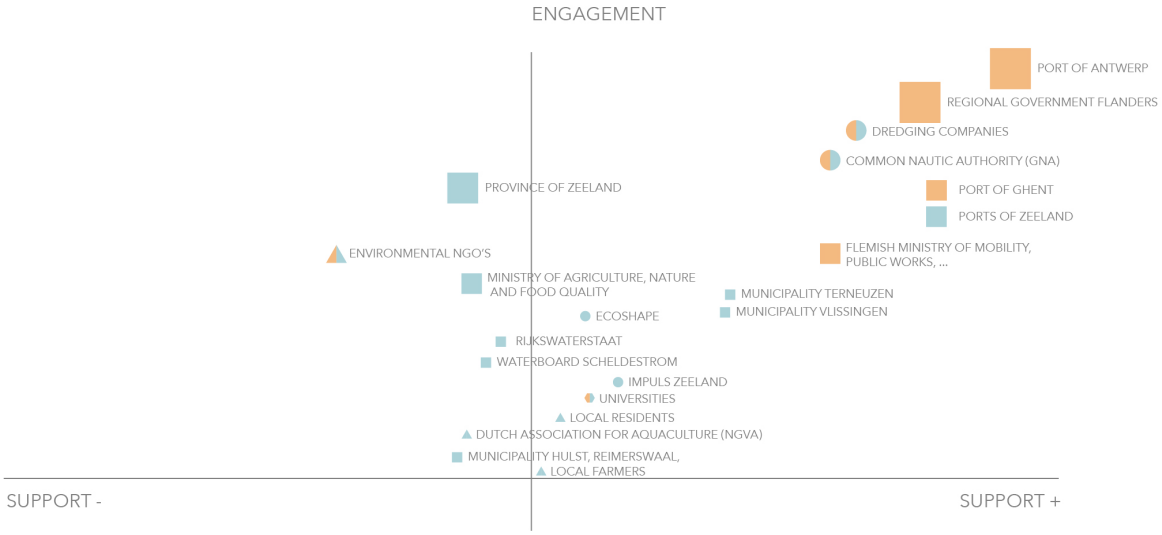


Figure 84: Governance in space Zone 2
(Elaborated by author)

SHIFTS IN STAKEHOLDER'S POSITION ZONE 2

LOW COLLABORATION PROJECT ZONE 2



HIGH COLLABORATION PROJECT ZONE 2

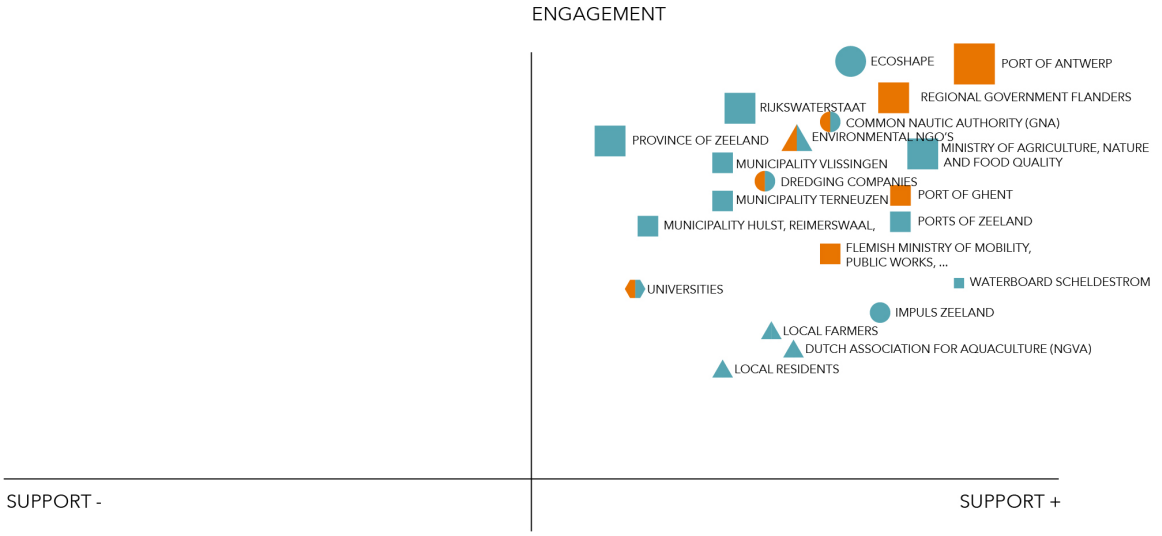


Figure 85: Stakeholder matrix and shift in positions for high collaboration scenario Zone 2 (Elaborated by author)

9.3. ZONE 3 - HIGH STREAM

STAKEHOLDER POSITION: LOW COLLABORATION ZONE 3

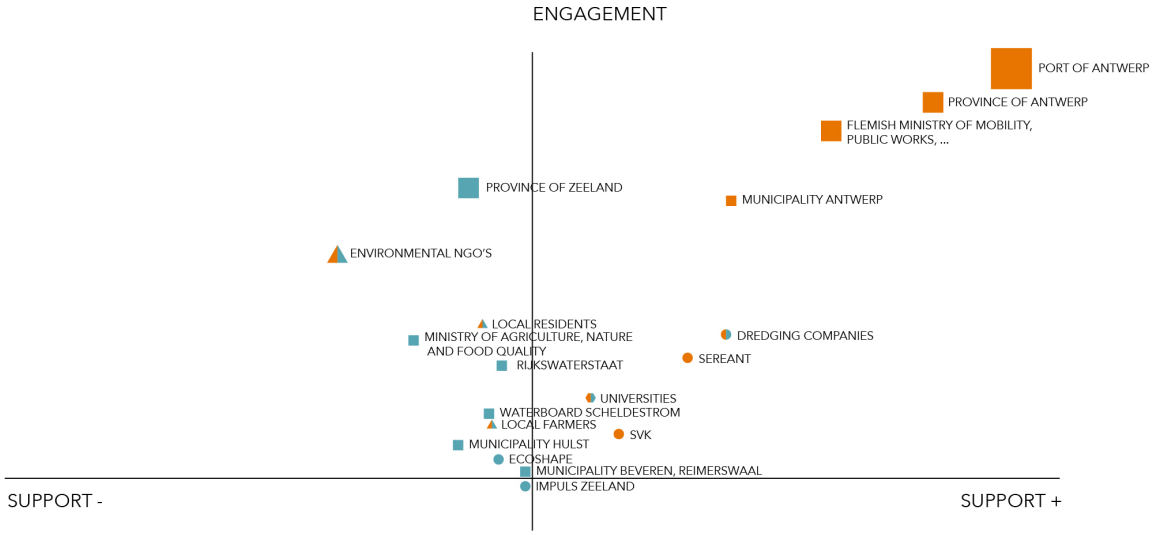


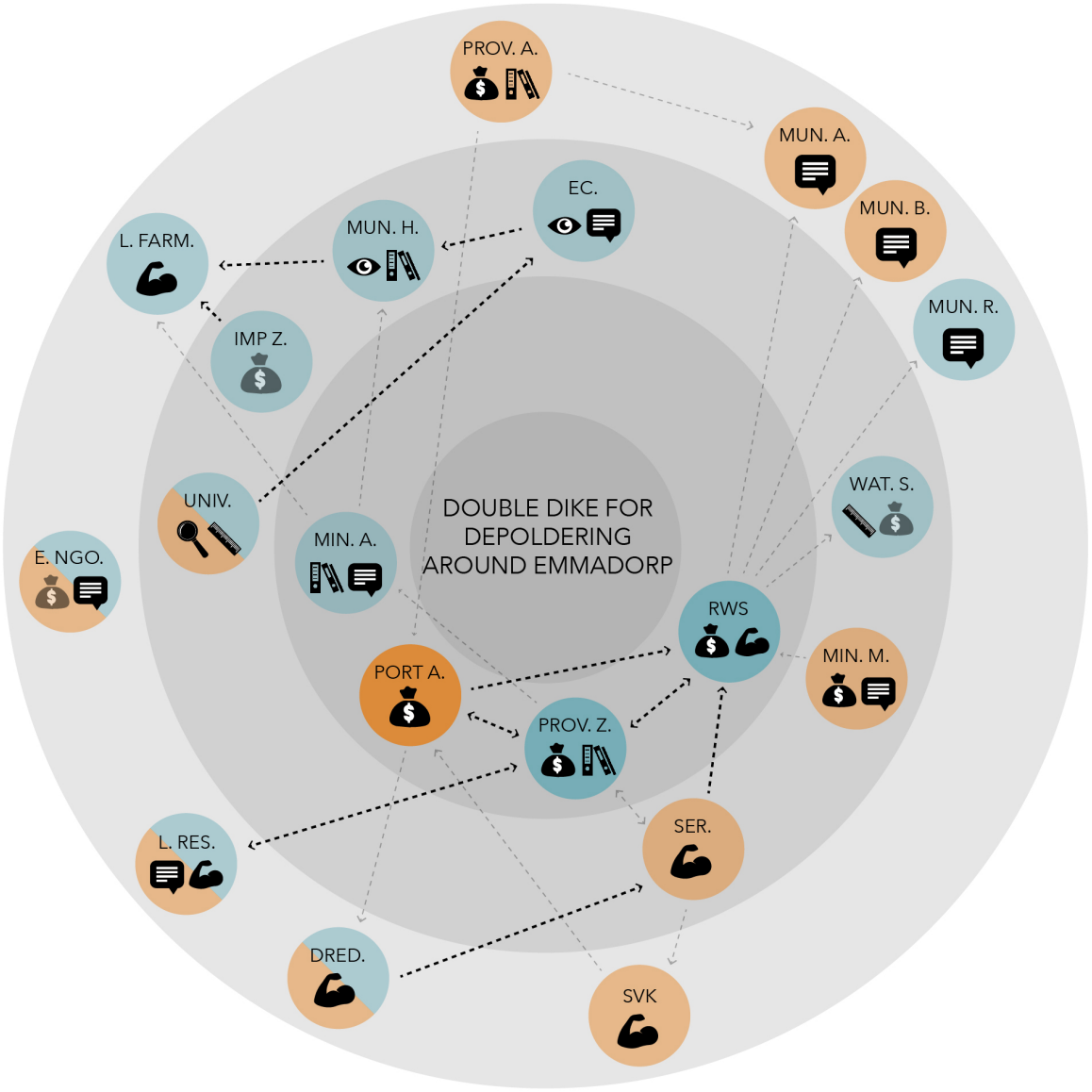
Figure 86: Stakeholder matrix "business as usual" scenario Zone 3 (Elaborated by author)

The expansion of Port of Antwerp in mostly an autonomous project. The Flemish government will support it based on the economic benefits, but at the same time trying to minimize the impacts.

Environmental groups, as well as local farmers and residents will create resistance to be displaced without proper compensation. In the case of the environmental groups, the Natura 2000 policy will be a tool to demand the bird and habitat compensation.

In this case, the isolated port expansion project has minimal involvement of the Dutch stakeholders. The province of Zeeland may be concerned with the negative environmental impacts that more port activity may bring to the area.

ONION DIAGRAM ZONE 3



PORT A.	Port of Antwerp	Labor force
PROV. Z	Province Of Zeeland	Economic support
RWS	Rijswaterstaat Zee and Delta	Regulation (Policies)
MIN. A.	Ministry of Agriculture, Nature and Food Q.	Supervision
WAT. S.	Waterboard Scheldestromen	Consultation
SER.	SEREANT	Monitoring
MIN. M.	Ministry Mobility, Public Works, ...	Research
UNIV.	Universities	
EC.	Ecoshape	
MUN. H.	Municipality Hulst	
IMP. Z.	Impuls Zeeland	
L. FARM.	Local Farmers	
L. RES.	Local Residents	
DRED.	Dredging Companies	
E. NGO.	Environmental Ngo's	
SVK	SVK (Materials company)	
PROV. A.	Province of Antwerp	
MUN. A.	Municipality Antwerp	
MUN. B.	Municipality Beveren	
MUN. R.	Municipality Reimerswaal	

Figure 87: Onion diagram for governance proposal Zone 3
(Elaborated by author. Based on D. Czischke 2018)

MAIN STAKEHOLDER ARRANGEMENTS ZONE 3

1- In the higher part of the Western Scheldt, some sediments can be removed and use for other purposes.
Both dredged material and sediments which can be vacuumed from the higher marshes can be transported to the SEREANT station located in the Port of Antwerp.
SEREANT will then purify sediments and provide them as materials to build the new double dikes or new construction materials.

2- This local and processed material will reduce costs for flood defences in the new depoldered area. This way, Rijkwaterstaat will increase its willingness to intervene this low-priority area.

3- The Ministry of Agriculture, Nature and Food Quality, ECOSHAPE and the associated research centres will guide the development of more agricultural activities on salty soils in the new area between dikes. They will also develop research on environmentally friendly ways to extract marsh sediments and monitor the local balance over time.

4- The local farms will be relocated on higher grounds adjacent to the second dike, allowing them to remain in the area and be involved in these new forms of agriculture. The new Emmadorp is also an opportunity to relocate residents from Doel that were displaced after the port expansion
The research groups will be financed by both countries and will teach the farmers to work with salty crops and also share knowledge with local communities as part of a branding strategy.

5- With good cross-border collaboration, the depoledered areas in the Netherlands may be part of the compensation proposal for port of Antwerp and as a possible trade with the sand nourishment on the coast of the municipality of Sluis

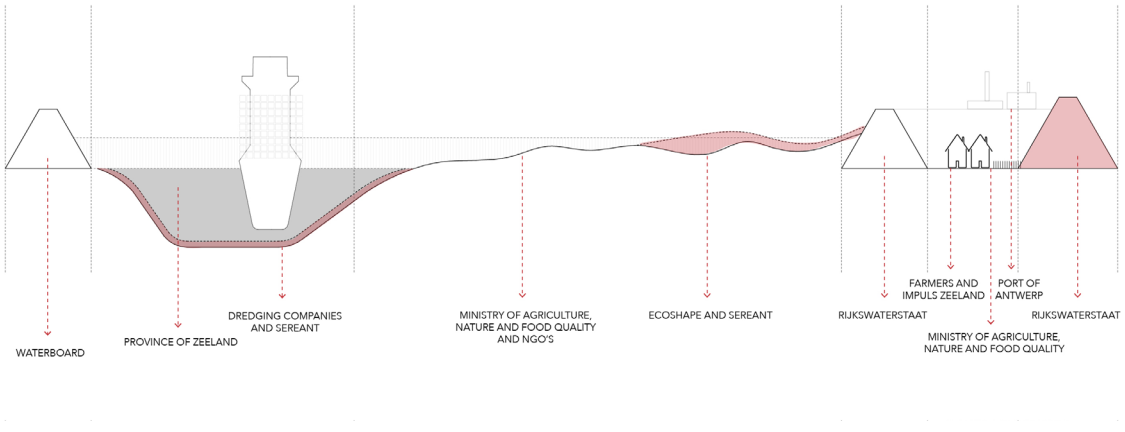


Figure 88: Governance in space Zone 3
(Elaborated by author)

SHIFTS IN STAKEHOLDER'S POSITION ZONE 3

LOW COLLABORATION PROJECT AREA 3

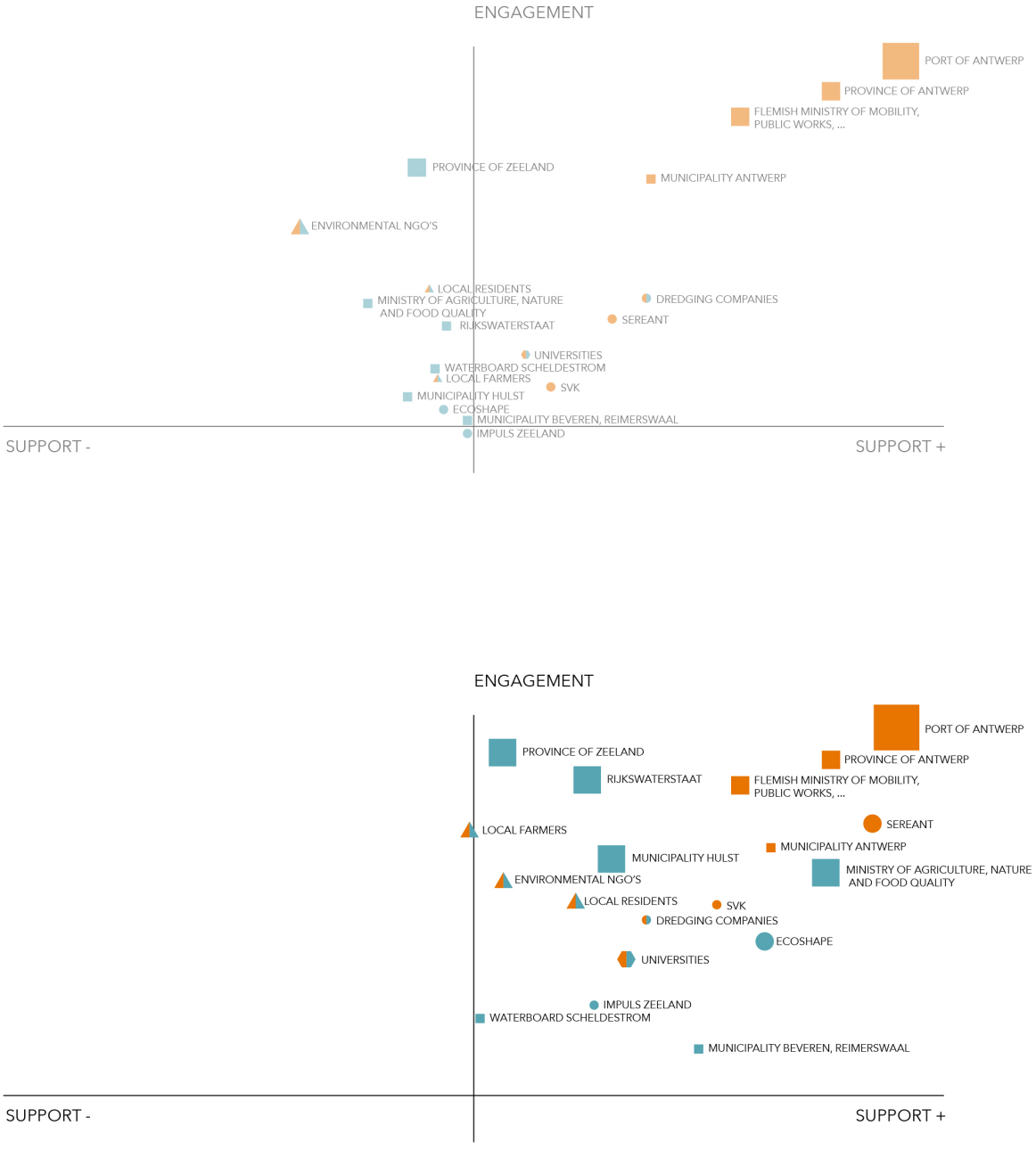


Figure 89: Stakeholder matrix and shift in positions for high collaboration scenario Zone 3 (Elaborated by author)

9.4. OVERVIEW

Each paired port development - BwN project expands the network of stakeholders, creating multiple opportunities. This can result in an increased support for the proposal and in some cases the division of costs and labour.

Changing the position of Port authorities from independent drivers to network drivers, ecosystem management and the subsequent EbA are more likely to happen.

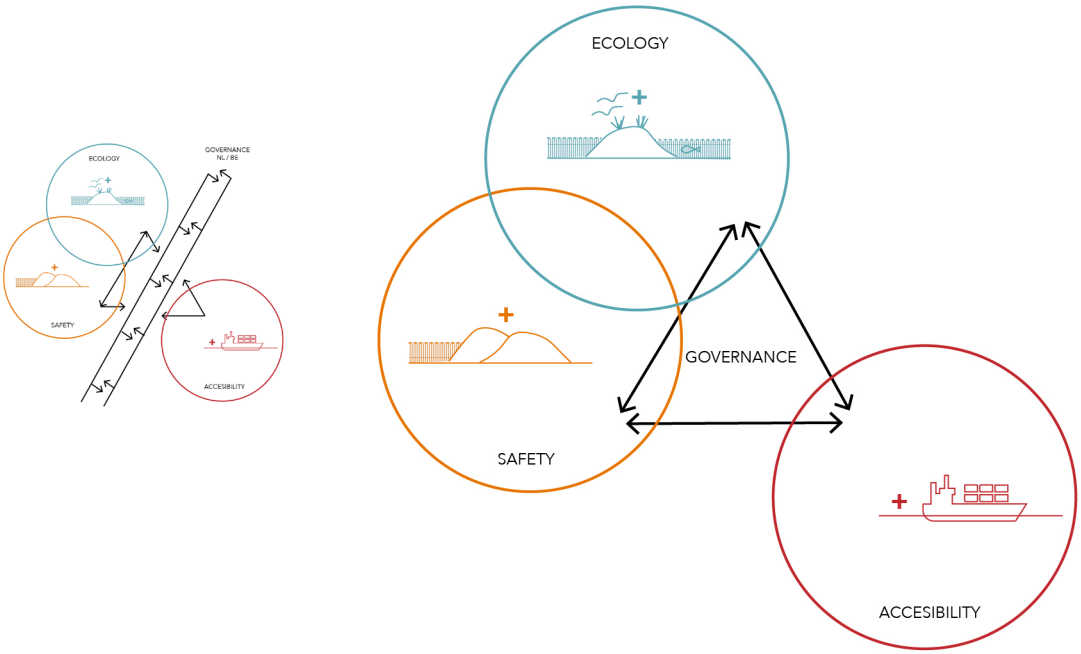


Figure 90. Approach for governance in proposal
(Elaborated by author.)

10. SPATIAL TRANSFORMATIONS OF THE PROPOSAL

As a result of the proposed governance arrangements, more collaborative and integral stakeholder networks will be involved in the development of the Western Scheldt.

This will facilitate the implementation of BwN strategies, with a proper management plan for each intervention. By revealing the added values of the managed ecosystems, they can be used to engage with the stakeholders' interests and trigger actions for change. The spatial transformations will contribute to the functions of safety, ecology and accessibility and increase the overall EbA capacity of the region.

The chapter will explain the main actions and processes that will take place in this combined port development - BwN projects and the transformation of the Western Scheldt by 2100.

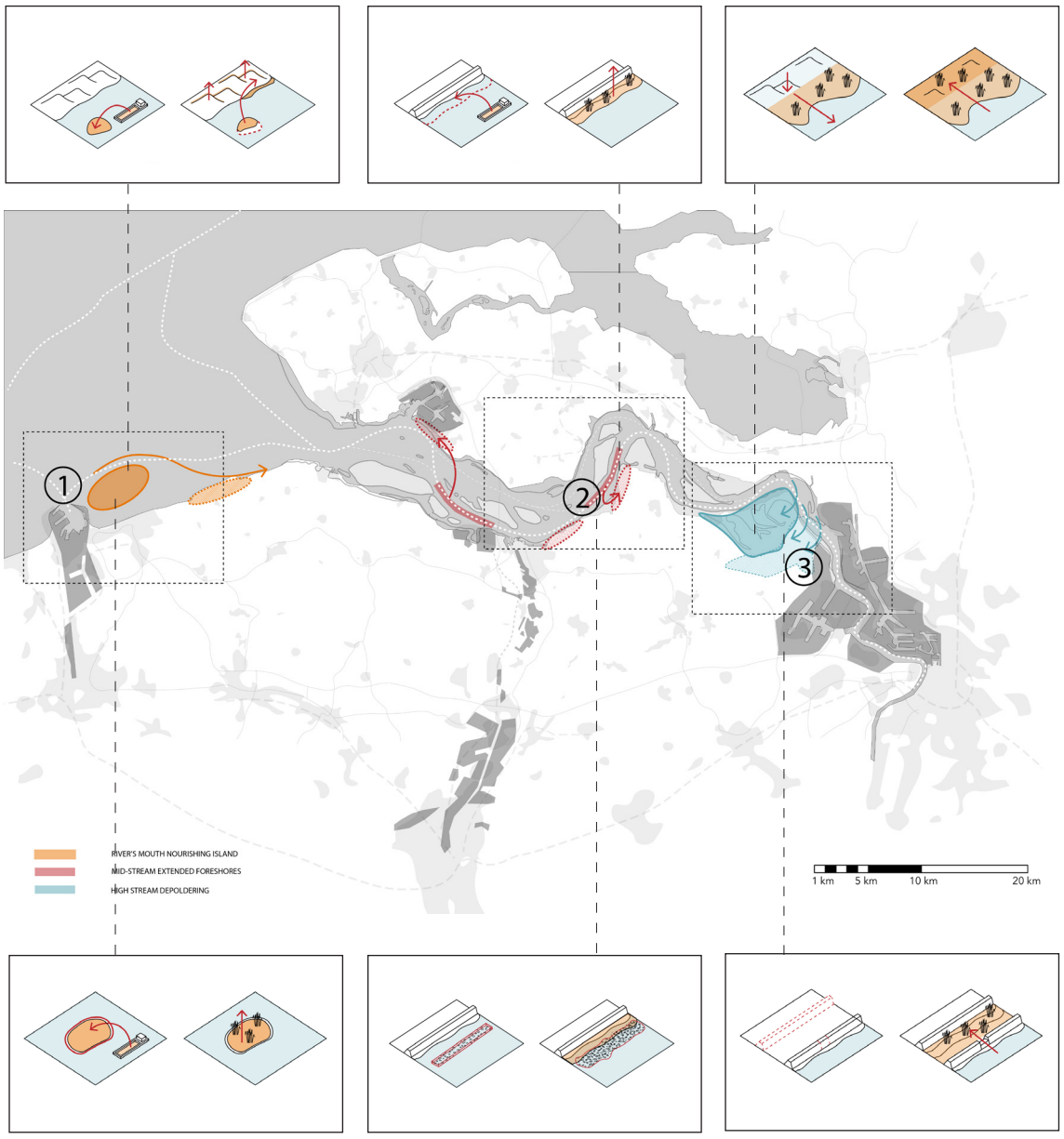


Figure 91: Applicable BwN projects in Western Scheldt (Elaborated by author)

10.1. DESIGN PROJECT ZONE 1: ZEEBRUGGE (RIVER MOUTH)

The possibility to expand the port of Zeebrugge seaward and adjacent energy island will alter current sediment flows. For this reason, the artificial island will be strategically placed next to the port. If part of this island is made of loose sand, the sediments will be transferred by the currents to the coasts of the municipalities of Knokke-Heist and Sluis.

This transformative part of the island would work with the same principle as the sand engine nourish beaches and make dunes higher to protect the coastal areas. In comparison to the sand motor near The Hague, the flexible part of the island will be twice as big and needs to nourish 3 times the amount of coastline. This means if 43 mm3 of sand are placed there for the pilot (Double amount of sand than the first sand motor) it should last about 15 years.
Sediments that land on the way to the coast will continue to cover the area where war waste was dropped and reduce the risk of it diluting in water.

On the lines with the long-term program of "Flemish bays 2100". The program aims to make the Flemish coasts safe, while contributing to the sustainability, attractiveness, natural conditions and evolution of the coasts over time.
The proposal of the nourishing island on the Port of Zeebrugge addresses all these objectives.

-Safety: The position of the island in proximity to the coastline will serve as a wave-breaker and reduce the intensity of the waves that hit the coast. The nourishment from the island will make beaches and dunes more resilient to sea impacts.
-Sustainability: The island can incorporate energy supply functions based on tidal energy. It can also be source of production for food and biomass.
-Attractiveness: The island will alter the sediment flows, creating an extending beach area in the town of Heist aan Zee. This beach already concentrates recreational activities and a larger surface can contribute to the beach activities' growth. This can reinforce water sports, gastronomy, wellness, night life, etc. The Zwin polder will increase the richness and attractiveness of its habitats when tides start to reach the current silted areas.
-Natural conditions: The new island, the Zwin polder and some port areas can increase the availability of natural areas. Some of them will be developed on the intertidal shores of the island and some can be developed on the elevated grounds.
-Evolution: As ecosystems increase their capacities to provide services, some economies will be strengthened as well, including forms of aquaculture, sediment provision, beachfront activities, etc.

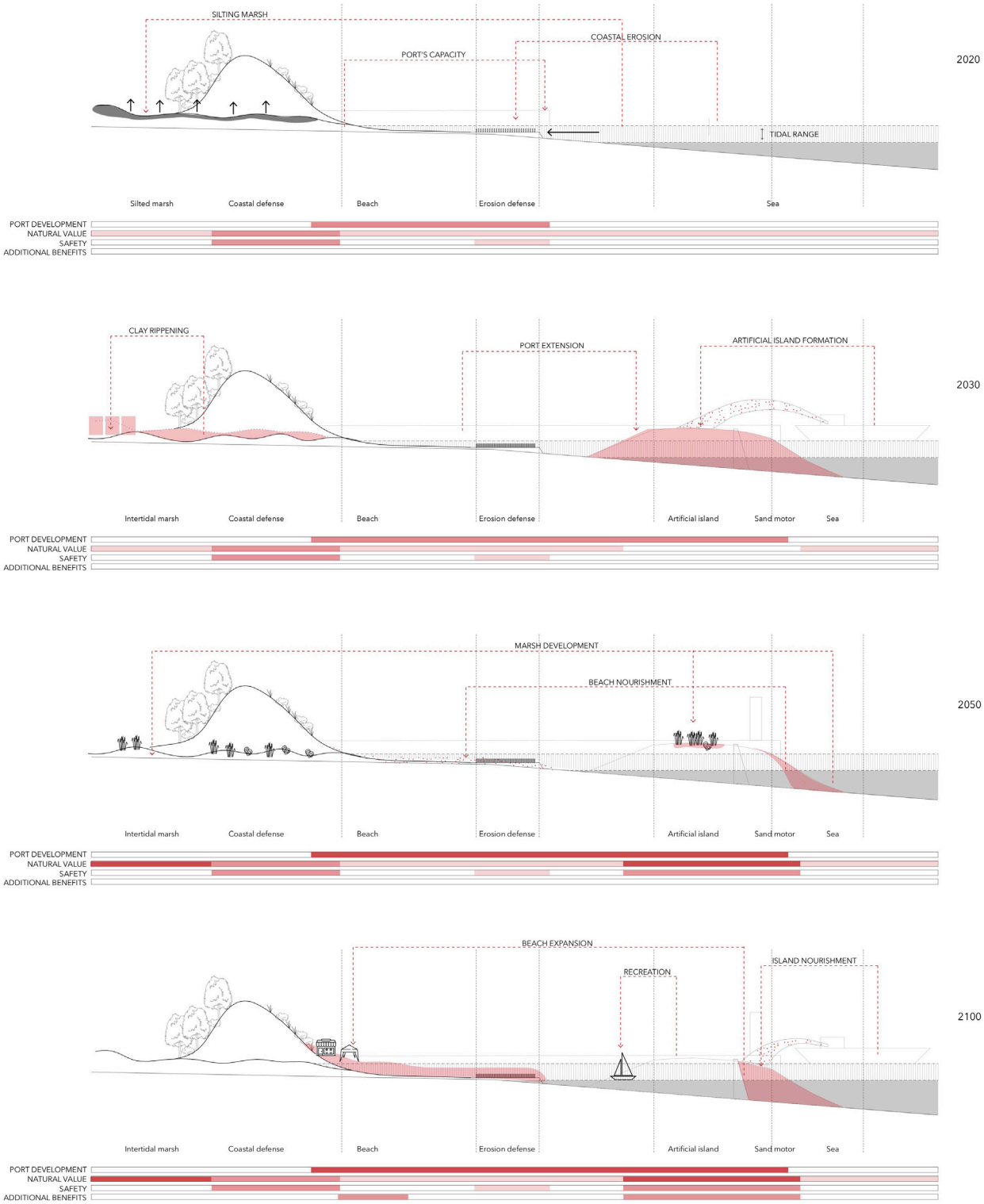
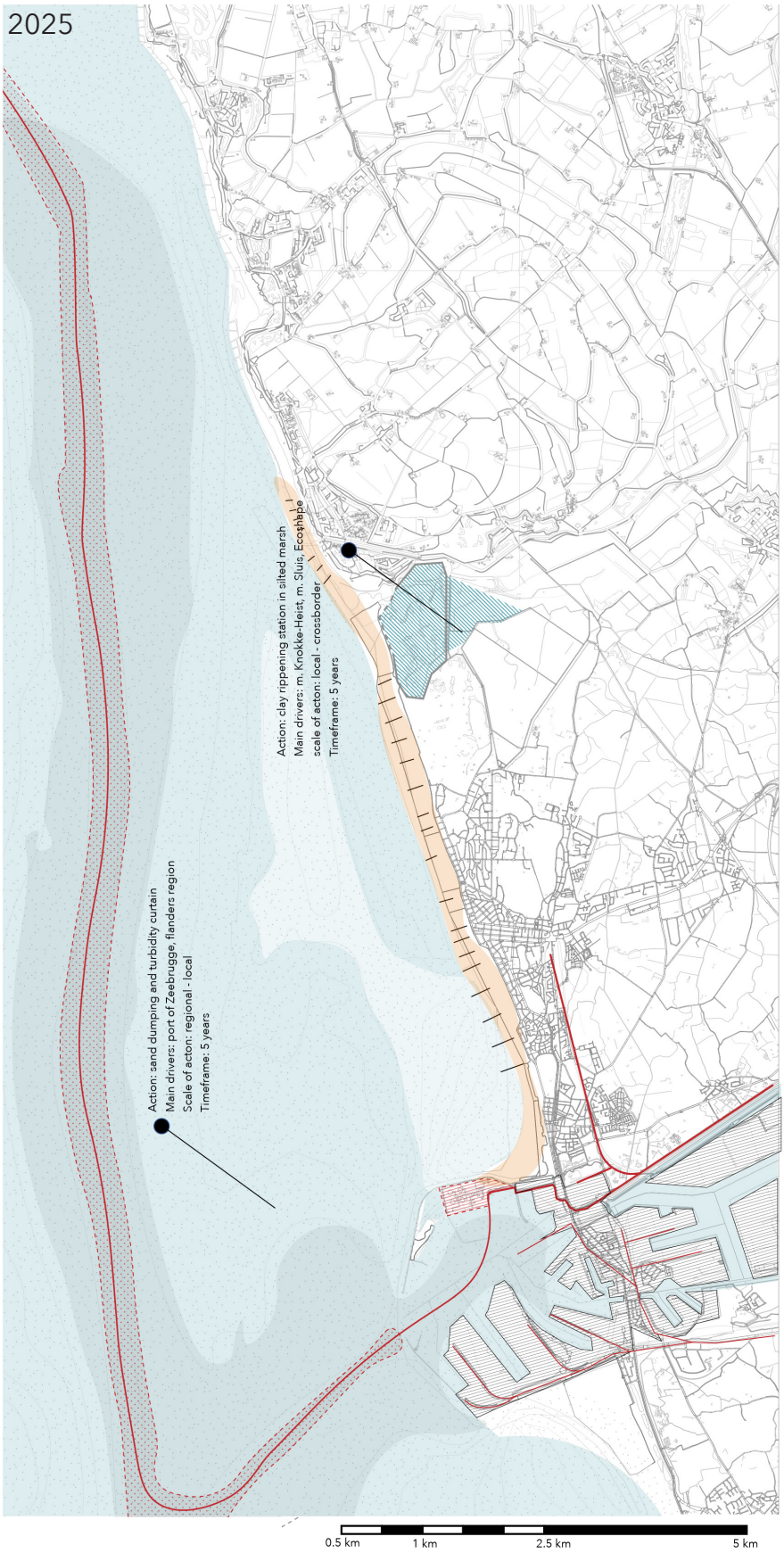
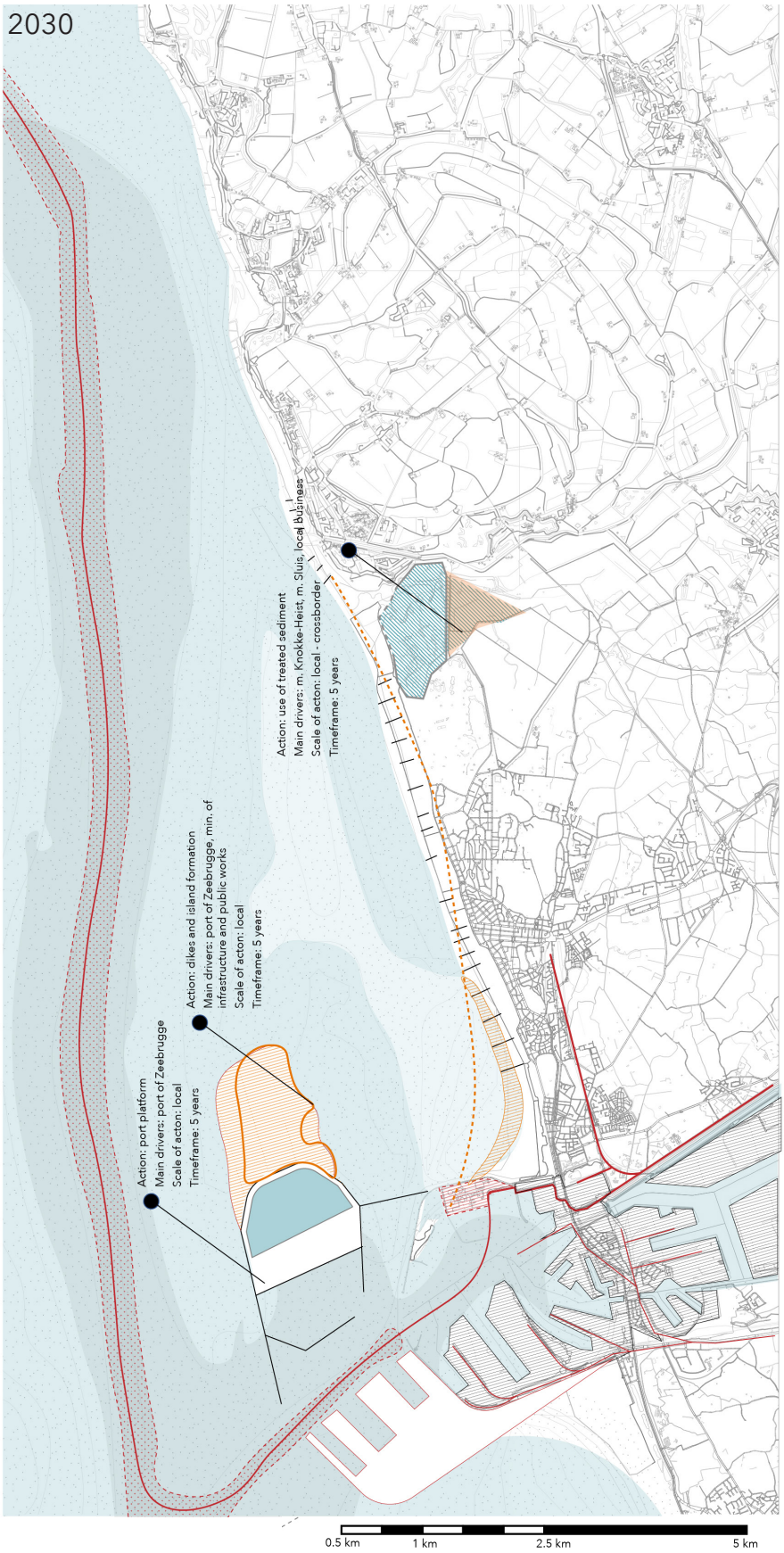
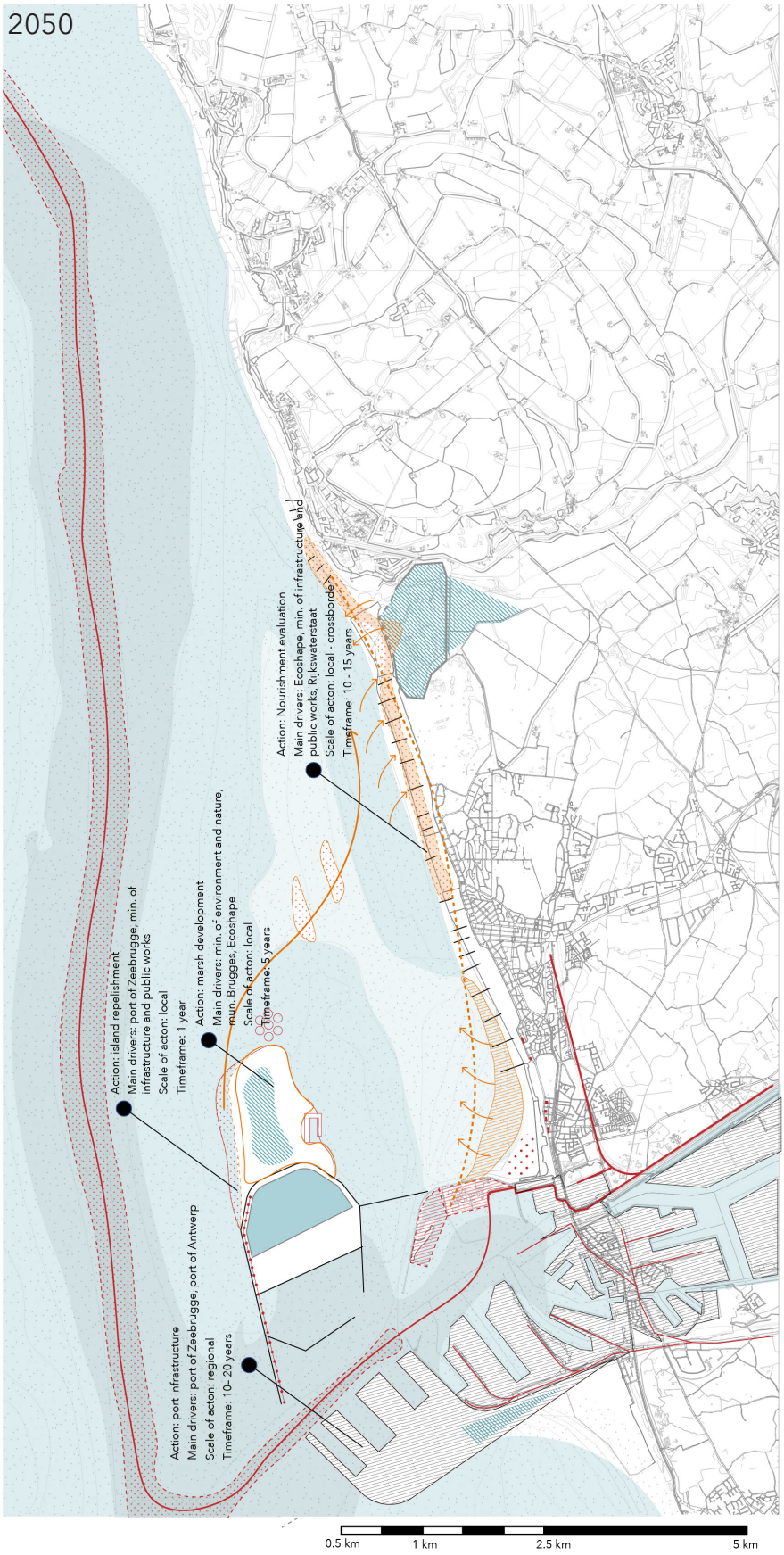


Figure 92: Evolution of processes in time and increased values Zone 1
(Elaborated by author)


2025
Action: clay rippening station in silted marsh
Main drivers: m. Knokke-Heist, m. Sluis, Ecoshape
scale of acton: local - crossborder
Timeframe: 5 years
Action: sand dumping and turbidity curtain
Main drivers: port of Zeebrugge, flanders region
Scale of acton: regional - local
Timeframe: 5 years
0.5 km
1 km
2.5 km
5 km


2030
Action: use of treated sediment
Main drivers: m. Knokke-Heist, m. Sluis, local business
Scale of acton: local - crossborder
Timeframe: 5 years
Action: dikes and island formation
Main drivers: port of Zeebrugge, min. of infrastructure and public works
Scale of acton: local
Timeframe: 5 years
Action: port platform
Main drivers: port of Zeebrugge
Scale of acton: local
Timeframe: 5 years
0.5 km
1 km
2.5 km
5 km


2050
Action: island repelishment
Main drivers: port of Zeebrugge, min. of infrastructure and public works
Scale of acton: local
Timeframe: 1 year
Action: marsh development
Main drivers: min. of environment and nature, mun. Brugges, Ecoshape
Scale of acton: local
Timeframe: 5 years
Action: Nourishment evaluation
Main drivers: Ecoshape, min. of infrastructure and public works, Rijkswaterstaat
Scale of acton: local - crossborder
Timeframe: 10 - 15 years
Action: port infrastructure
Main drivers: port of Zeebrugge, port of Antwerp
Scale of acton: regional
Timeframe: 10- 20 years
0.5 km
1 km
2.5 km
5 km

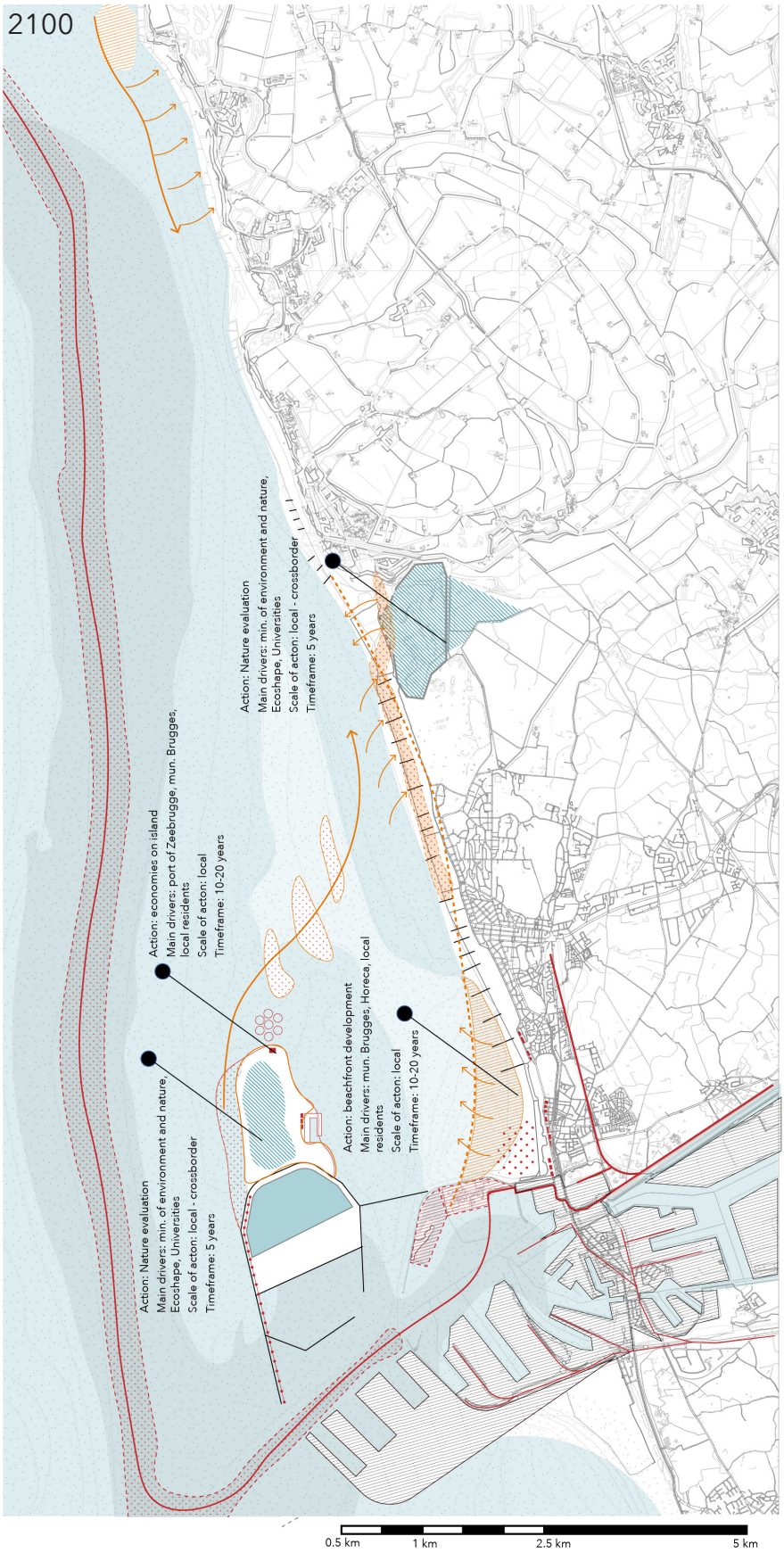


Figure 93-96: Evolution of space in time Zone 1
(Elaborated by author)

10.2. DESIGN PROJECT ZONE 2: ZEEDORP (MID STREAM)

Along the Western Scheldt, significant amount of sediments need to be dredged constantly. After the last enlargement of the navigation channel, the maintenance dredging volumes exceed the 10 mm3. This volume is more than enough to maintain all the mudflats of the river if they don't raise at the same paste than the sea level. The dredged material from the navigation channel will be dumped in the mudflats to maintain their optimal height of 0 to 1 m above water level and optimize wave dissipation

In addition to this, when the navigation channel is too close to the river's border, the angles of the river bank become too steep and put the stability of the dikes at risk.

In the project, the morphological dumping is taken one step further. Part of the extracted material will be dumped in the river banks, while the navigation channel is narrowed or displaced inward when possible. This will reduce the steepness of the collapse vulnerable areas.

This dumped material will be used to develop the extended foreshores along the river, ideally with a minimum of 200 m width. To deal with the 28 km that are steeper than the 1/10 inclination, about 70 mm3 of sediments will be required. If 1/3 of the annual dredged material is used to gradually develop the extended foreshores between 2025 and 2050.

The extended foreshores will be protected with oyster reef barriers. Research made by Rodriguez et al. (2014) shows that oyster can grow between 40 and 50 cm in the 10 years after they have been placed. Also, intertidal oysters grow 34% faster than subtidal oysters (Rodriguez et al., 2014). This means that eventually, sea level will rise faster than the oyster barrier and they will have to be replaced. The presence of oysters attracts crabs, and some fishes. This biodiversity can become a form of local food production once the water quality improves

As the foreshores stabilize and vegetation starts to grow, these areas will collect sediments, reducing the maintenance work of the navigation channel, improving the resistance of the dikes, purifying the water and increasing the biodiversity in those areas.

The river banks near Zeedorp were chosen for the pilot project. The area is in the middle of the Western Scheldt, which means the salinity levels and tidal fluctuation are medium. It is also a medium risk area in terms of navigation channel, border distance. The pilot will reveal information that can be used to improve the later extended foreshore areas.

For later stages, if sea level rises at a fast paste, the proposal can extend from the river banks to the shoal banks (borders of the mudflats). Depending on the space availability they can use the oyster barrier strategy or a simpler stabilization method based on rush mattresses.

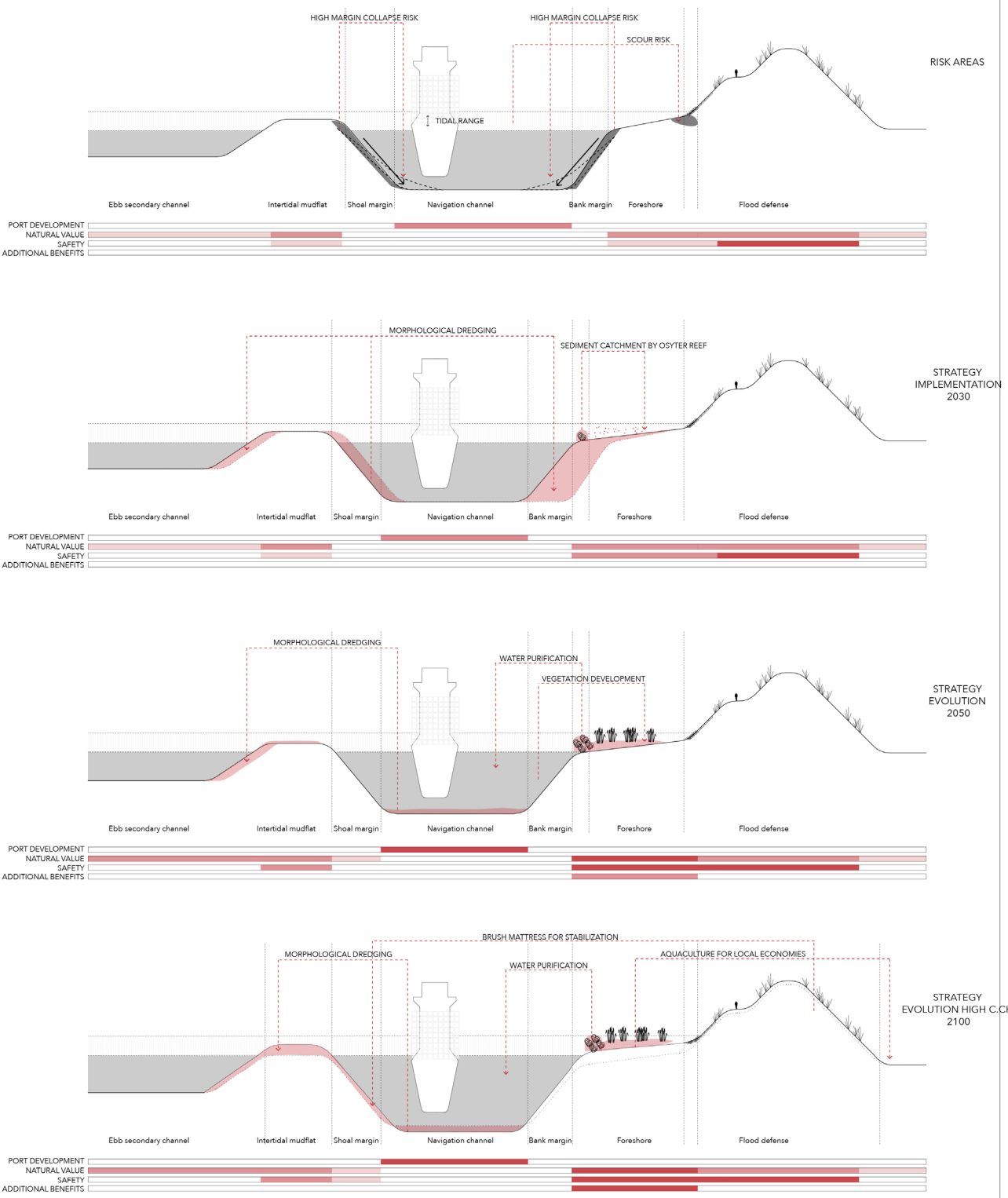
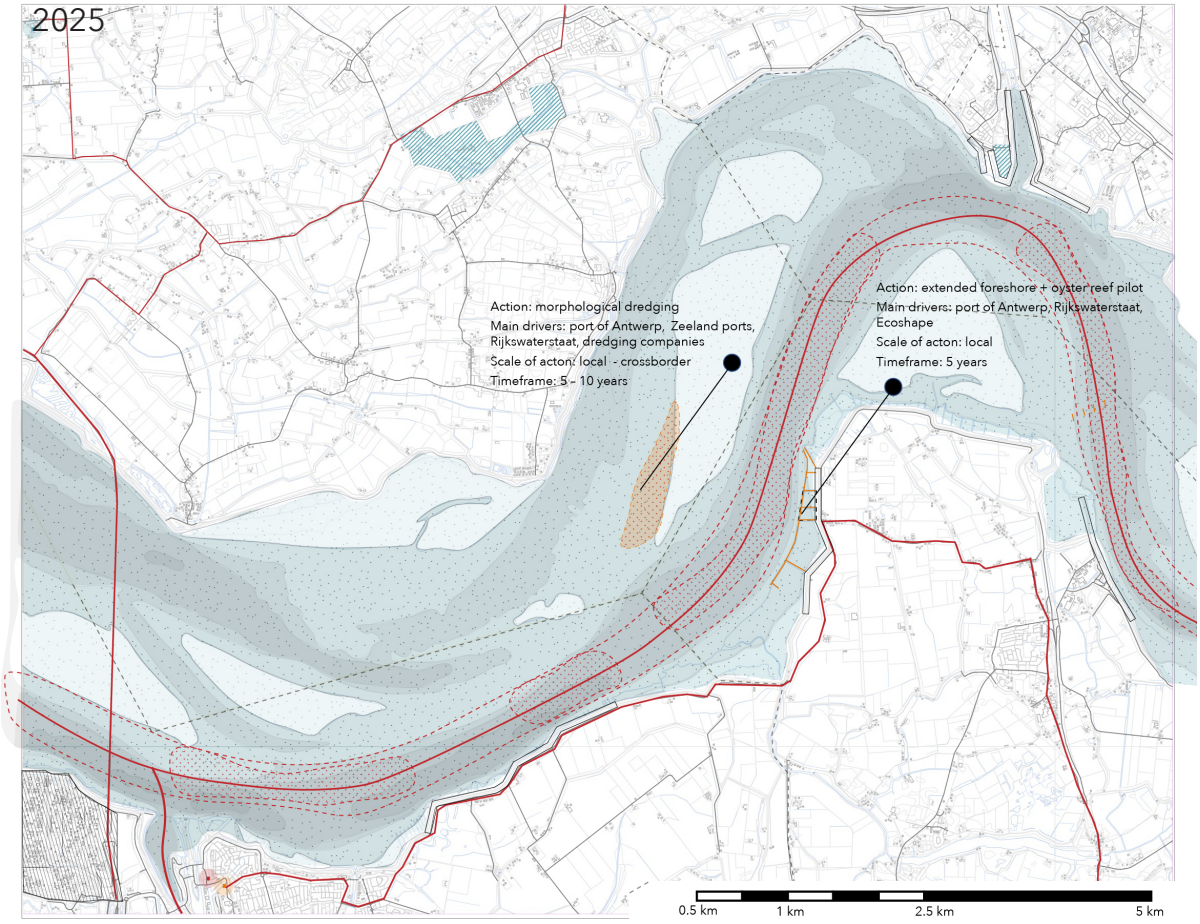
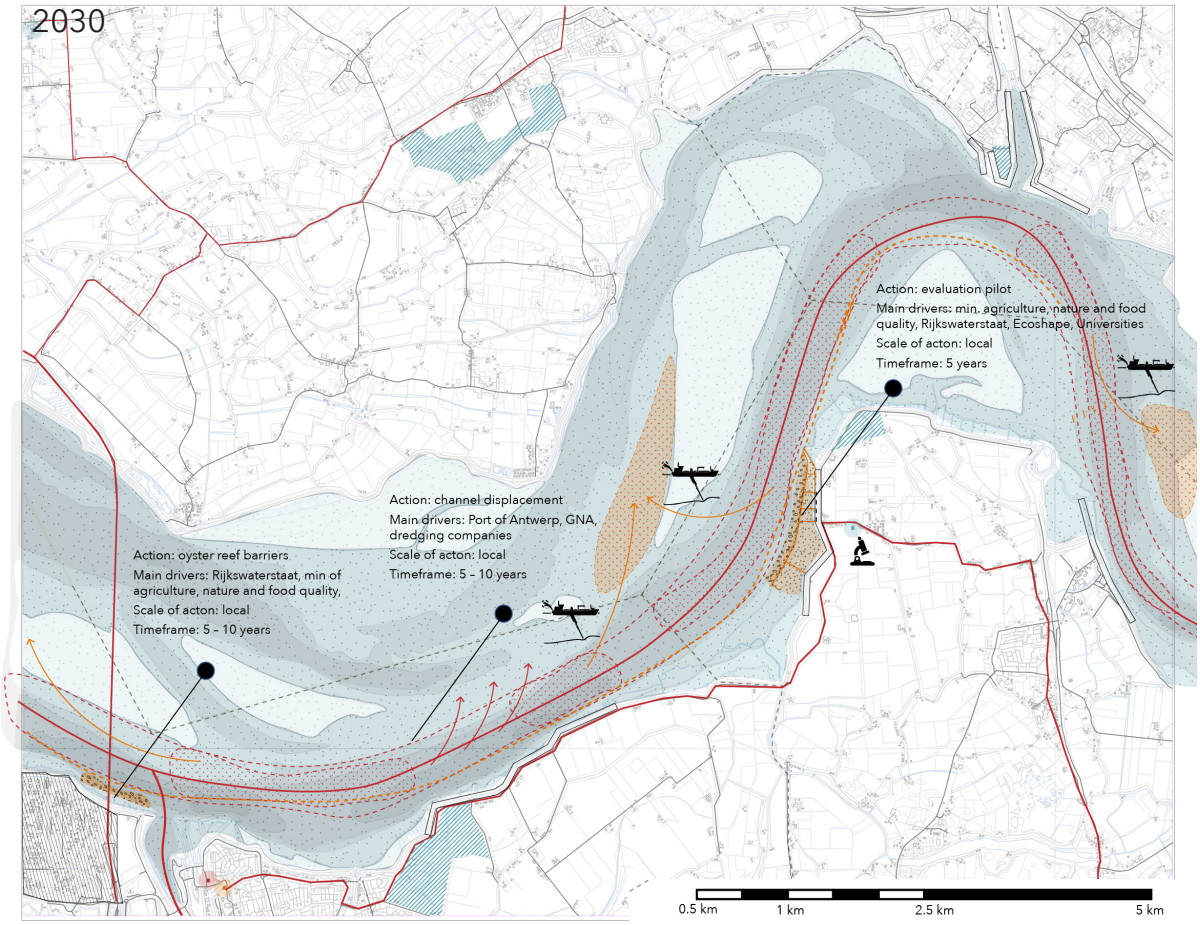
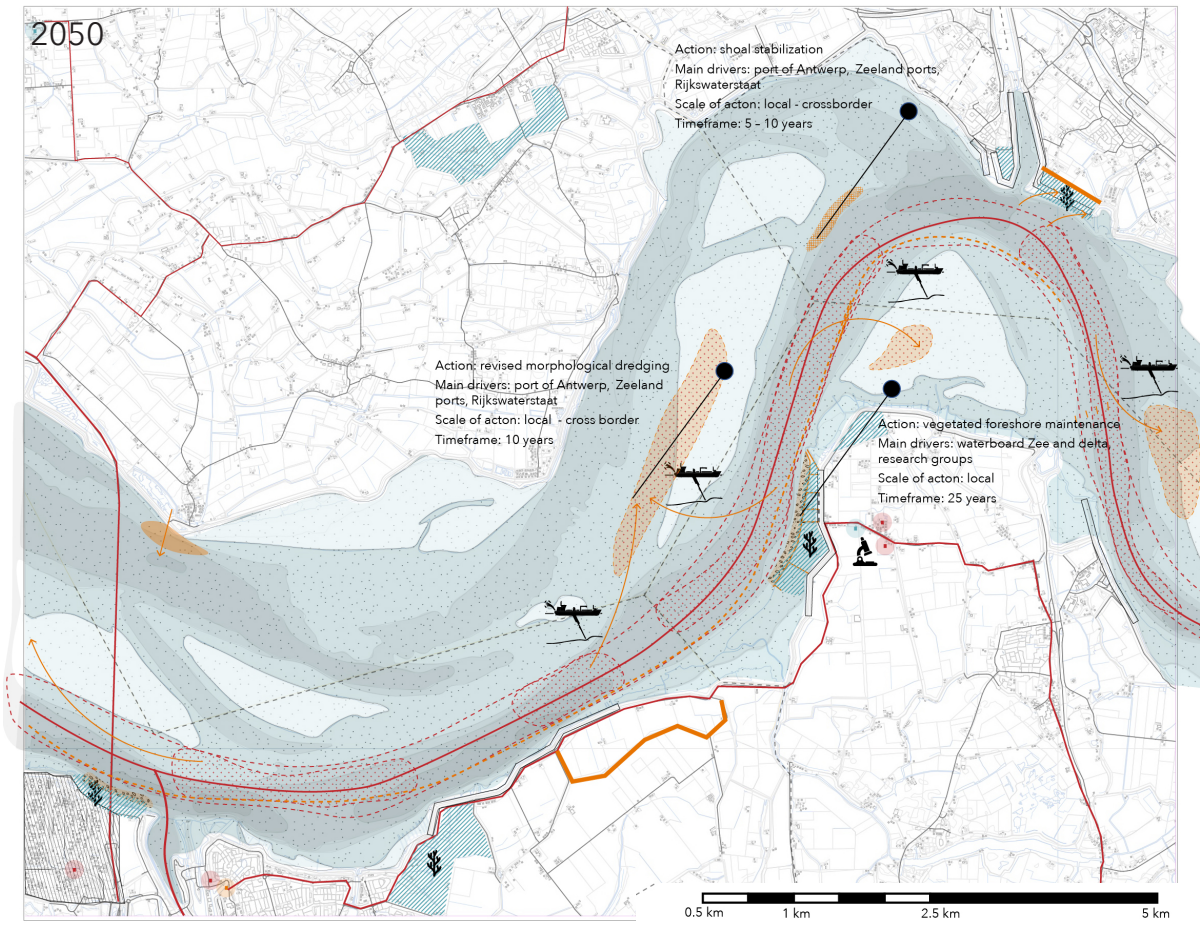


Figure 97: Evolution of processes in time and increased values Zone 2 (Elaborated by author)


2025
Action: morphological dredging
Main drivers: port of Antwerp, Zeeland ports, Rijkswaterstaat, dredging companies
Scale of acton: local - crossborder
Timeframe: 5 – 10 years
Action: extended foreshore + oyster reef pilot
Main drivers: port of Antwerp, Rijkswaterstaat, Ecoshape
Scale of acton: local
Timeframe: 5 years
0.5 km
1 km
2.5 km
5 km


2030
Action: evaluation pilot
Main drivers: min. agriculture, nature and food quality, Rijkswaterstaat, Ecoshape, Universities
Scale of acton: local
Timeframe: 5 years
Action: channel displacement
Main drivers: Port of Antwerp, GNA, dredging companies
Scale of acton: local
Timeframe: 5 – 10 years
Action: oyster reef barriers
Main drivers: Rijkswaterstaat, min of agriculture, nature and food quality,
Scale of acton: local
Timeframe: 5 – 10 years
0.5 km
1 km
2.5 km
5 km



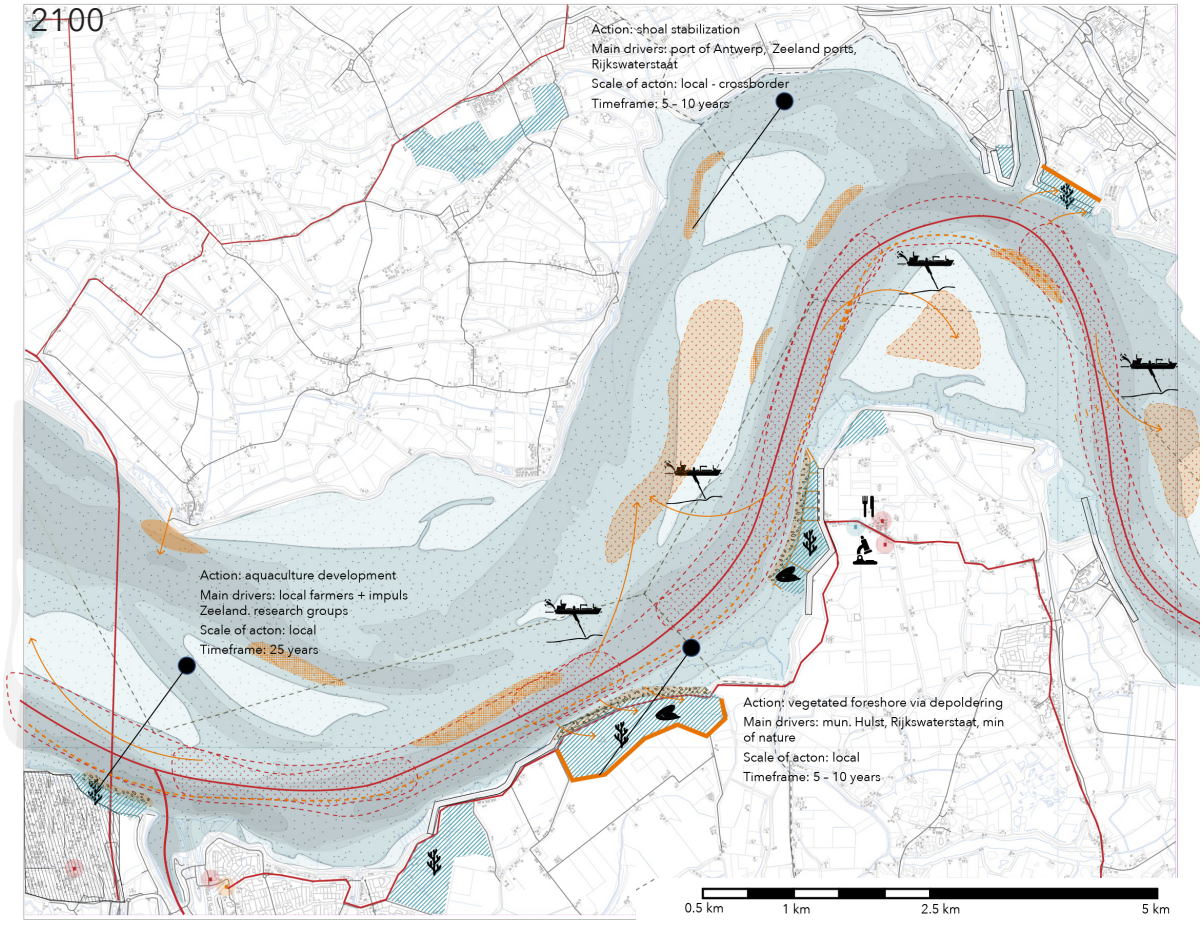


Figure 98-101: Evolution of space in time Zone 2 (Elaborated by author)

10.3 DESIGN PROJECT AREA 3: EMMADORP (HIGH STREAM)

The expansion of Port of Antwerp will require compensation for the habitat and bird site loss. If the port demands for more dredging in the future, the wave intensity will increase further, especially in this narrow part.

To mitigate the wave impacts, and provide new natural areas for compensation, depoldering can be used. It has been studied (Stark, 2017) that expanding the river space with flooding areas will have higher impact on wave dissipation on higher parts of the river. For this reason, the intervention site will be located on the high part of the Western Scheldt (Previous depoldering projects like the Hedwige/Prosper polder are also located in this area).

Initial arrangement will consider the Rijkswaterstaat and the Port of Antwerp as the main drivers of the depoldering strategy. Rijkswaterstaat will increase the willingness to depolder an extensive area that mostly benefits Belgian territory if this action is rewarded by the Flemish government. The dredged material as well as the excess of sediments that can be collected in the Verdronken land van Saeftinghe will be transported to the *Amoras* station of the Port of Antwerp, where it will be purified and stored until is needed. This can be used as the main material to build the new dikes of the area to be depoldered and other infrastructural projects.

This will then lead to two potential developments:

-The research and experimentation of sand silt and clay as material for construction purposes (Including fabrication of brick and aggregates for concrete) will help to develop sustainable construction industries in the area. Since raw material is collected in both countries, the knowledge and technical applications can be shared and distributed. This action will also lead to managing the height increase of the marsh in a way that it can maximize its capacity to decelerate waves and maintain its intertidal condition. This is particularly important if sea level rises slowly. Siltation of the marshes will continue and can eventually lose their intertidal condition.

-To further develop salty crops. The new delpoldered areas can be used for these purposes. Considering that the levels of salinity on the higher parts of the Wester Scheldt are relatively low, the shock on the soil and plantation should be low and allow this new form of agriculture. If sea level rise is more extreme, the area will be exposed to more frequent cycles of water intrusion and storm events. The crops will then receive constant natural irrigation and grow successfully. Plants will also contribute to dissipate waves.

The new areas for nature-friendly salty agriculture can be a compensation to local farmers that are no longer able to do traditional agriculture in those plots. The new relocated Emmadorp will develop this as part of their local brand and combine their marsh visitors centre with a research and learning centre for this kind of activities.

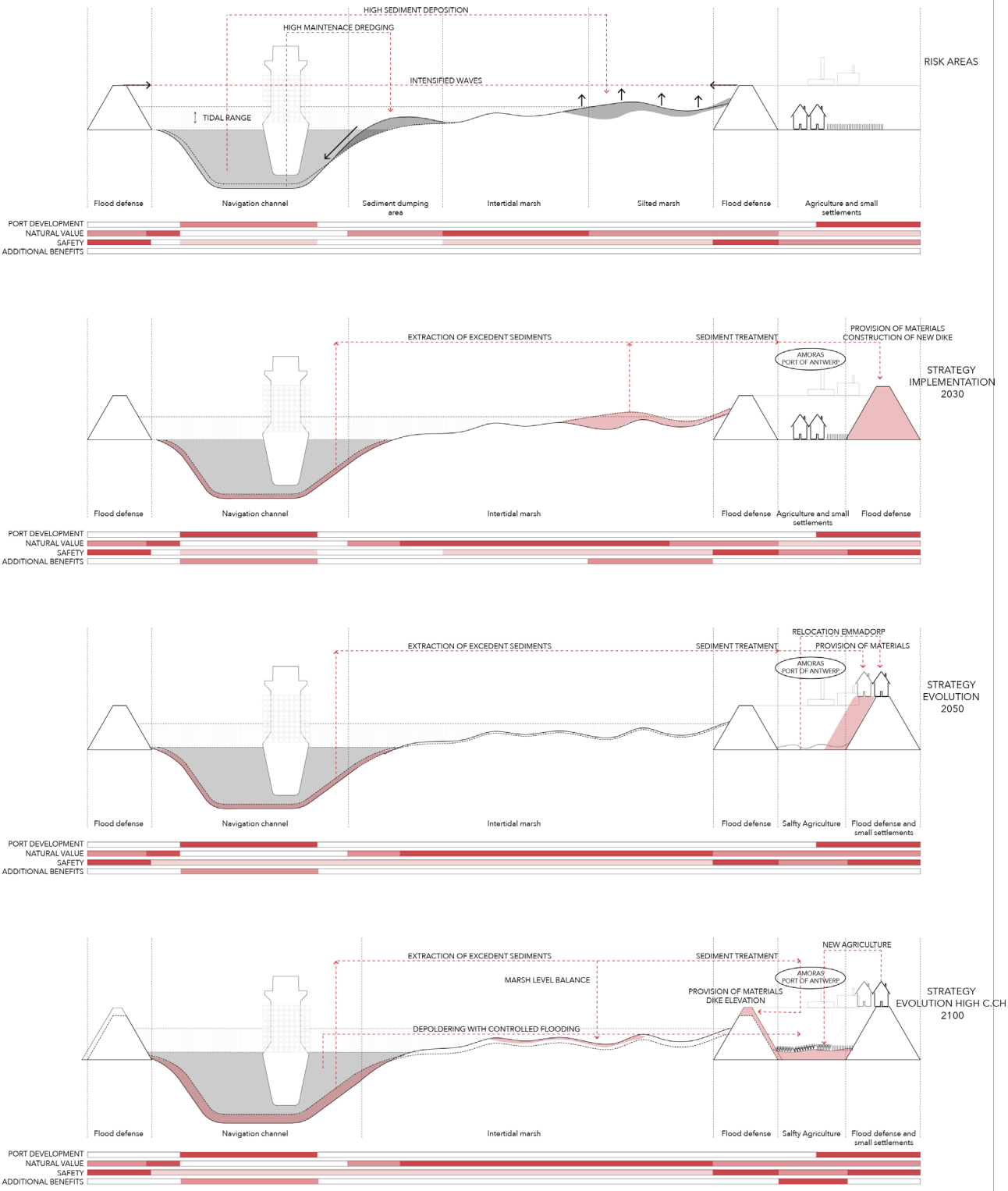
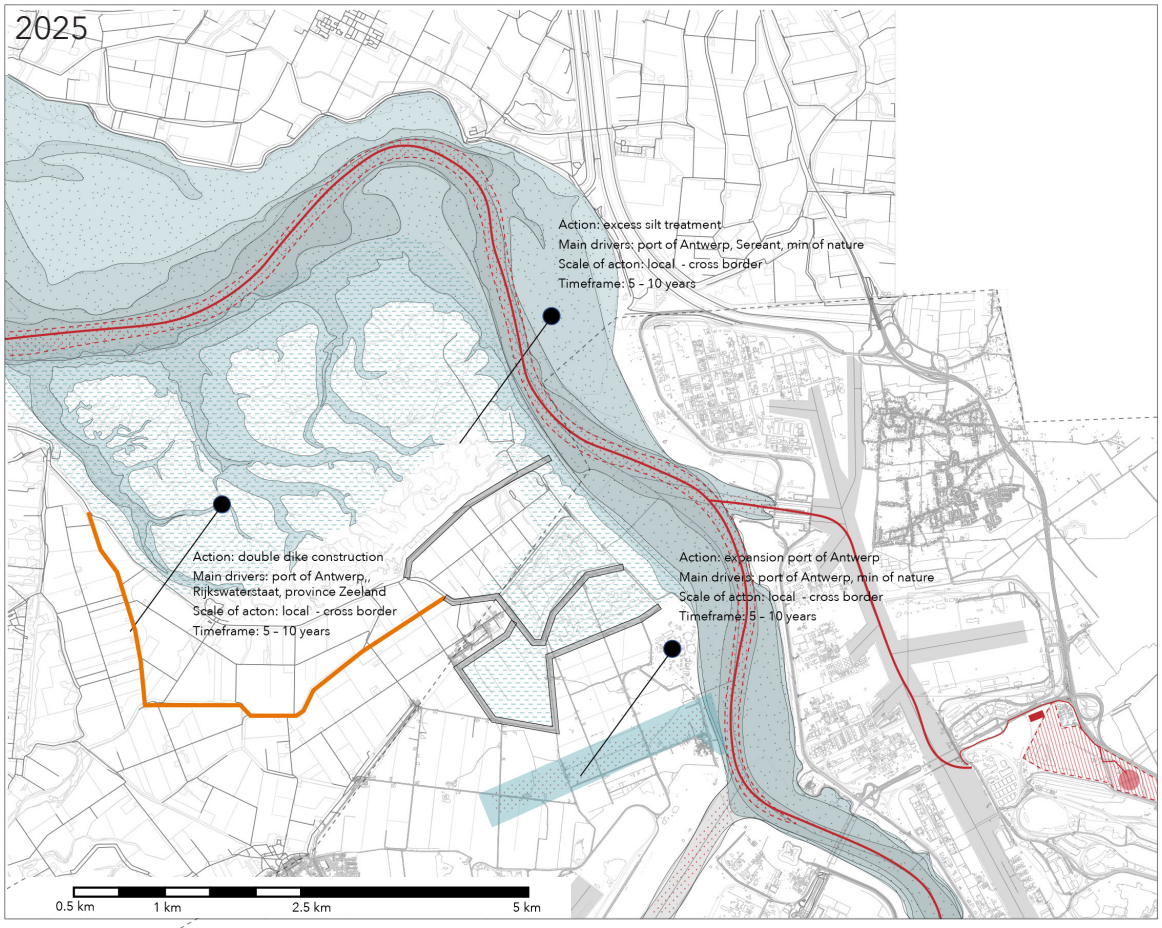
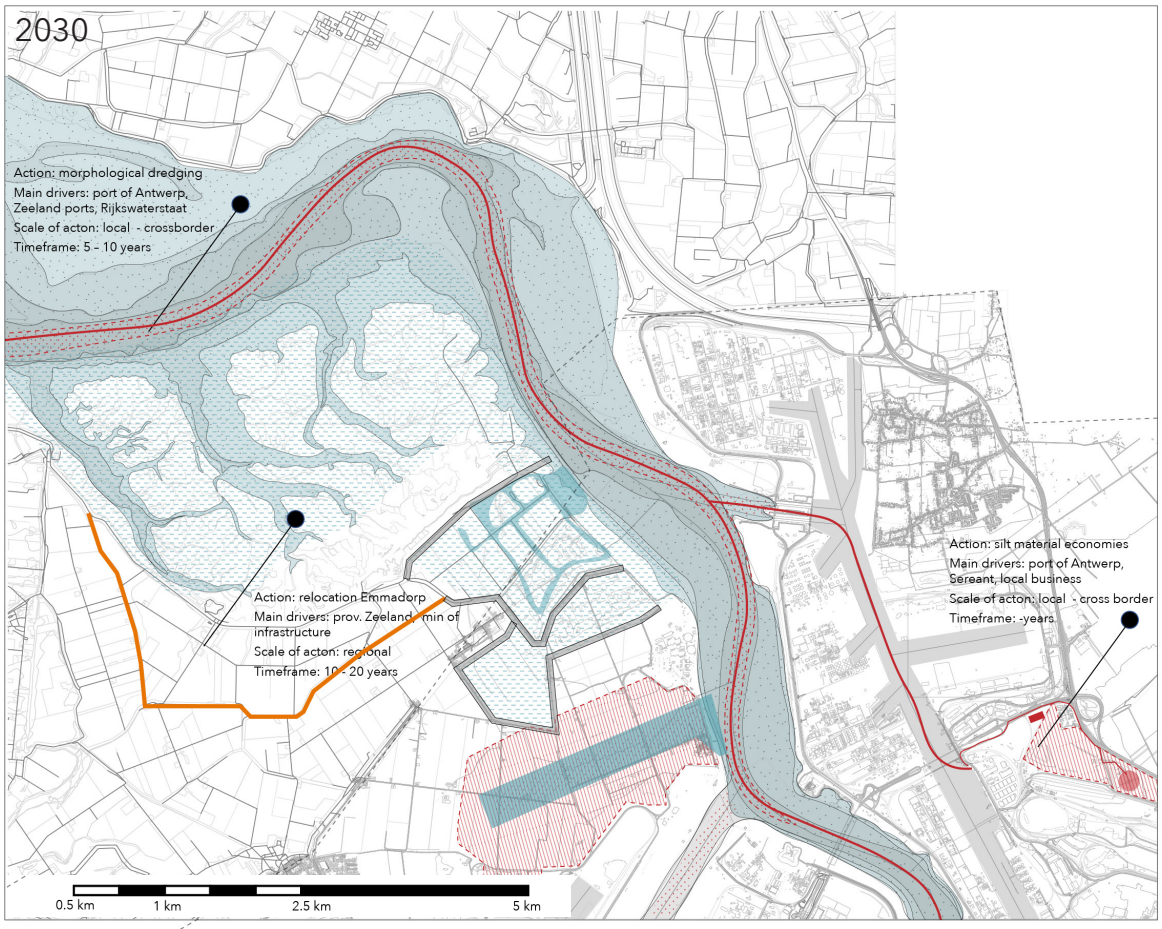
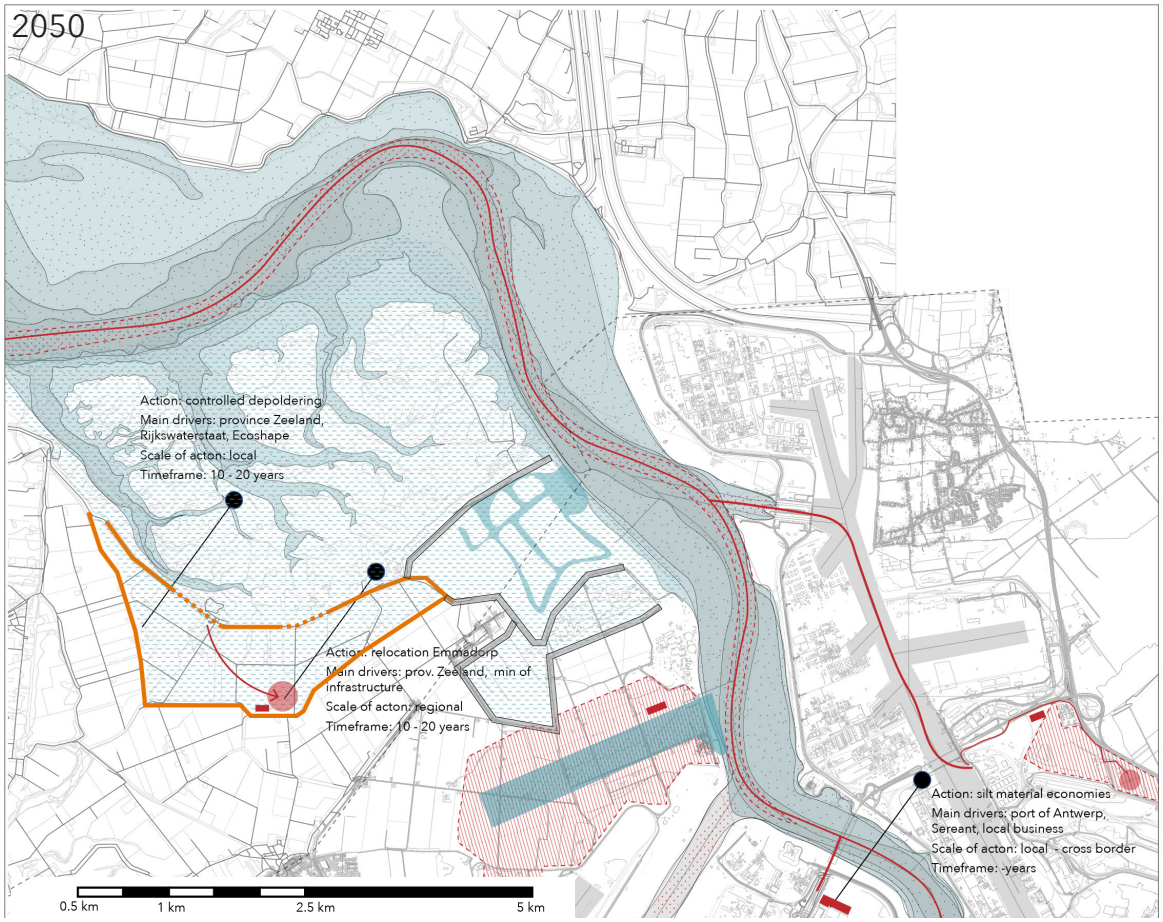


Figure 102: Evolution of processes in time and increased values Zone 3 (Elaborated by author)


2025
Action: excess silt treatment
Main drivers: port of Antwerp, Sereant, min of nature
Scale of acton: local - cross border
Timeframe: 5 - 10 years
Action: double dike construction
Main drivers: port of Antwerp,, Rijkswaterstaat, province Zeeland
Scale of acton: local - cross border
Timeframe: 5 - 10 years
Action: expansion port of Antwerp
Main drivers: port of Antwerp, min of nature
Scale of acton: local - cross border
Timeframe: 5 - 10 years
0.5 km
1 km
2.5 km
5 km


2030
Action: morphological dredging
Main drivers: port of Antwerp, Zeeland ports, Rijkswaterstaat
Scale of acton: local - crossborder
Timeframe: 5 - 10 years
Action: relocation Emmadorp
Main drivers: prov. Zeeland, min of infrastructure
Scale of acton: regional
Timeframe: 10 - 20 years
Action: silt material economies
Main drivers: port of Antwerp, Sereant, local business
Scale of acton: local - cross border
Timeframe: -years
0.5 km
1 km
2.5 km
5 km



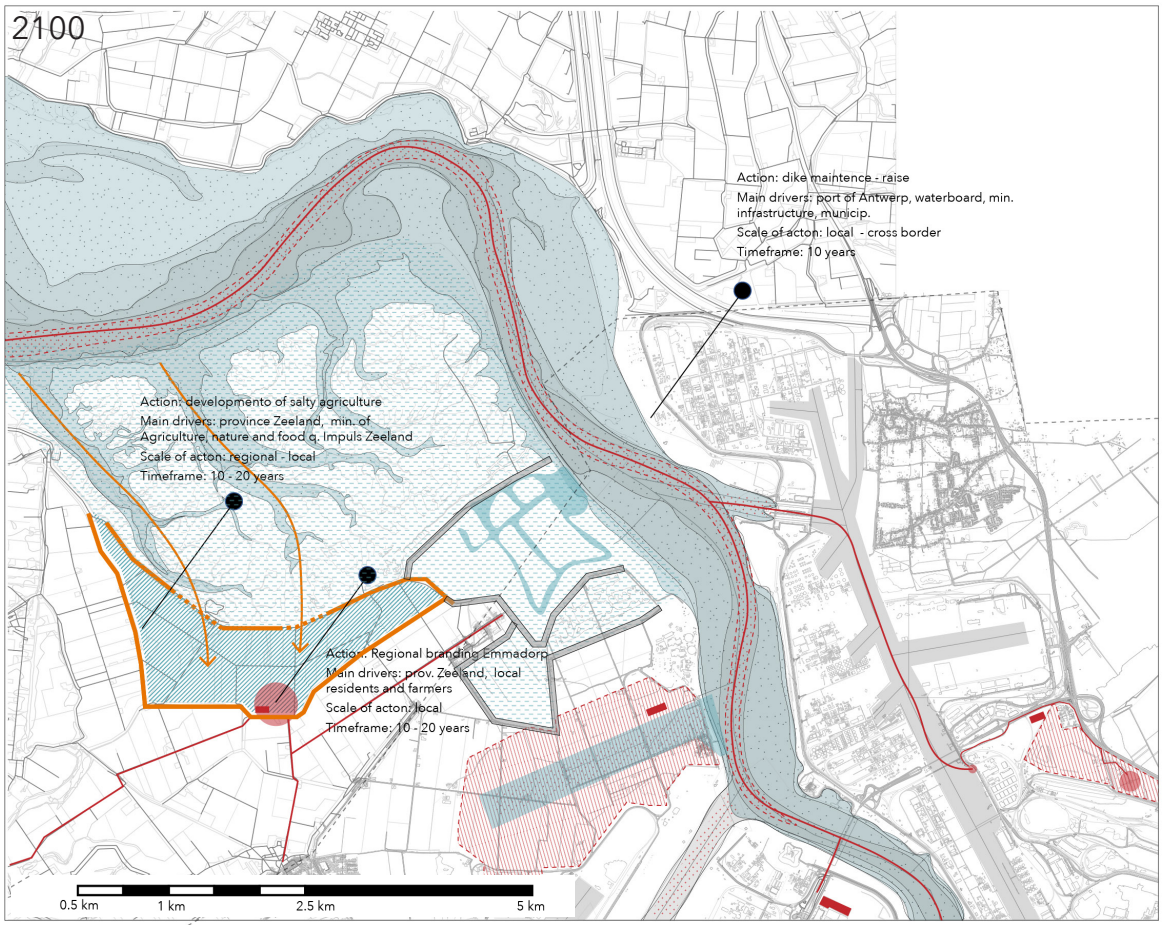


Figure 103-106: Evolution of space in time Zone 2
(Elaborated by author)

10.4. PROJECT'S. TIMELINE

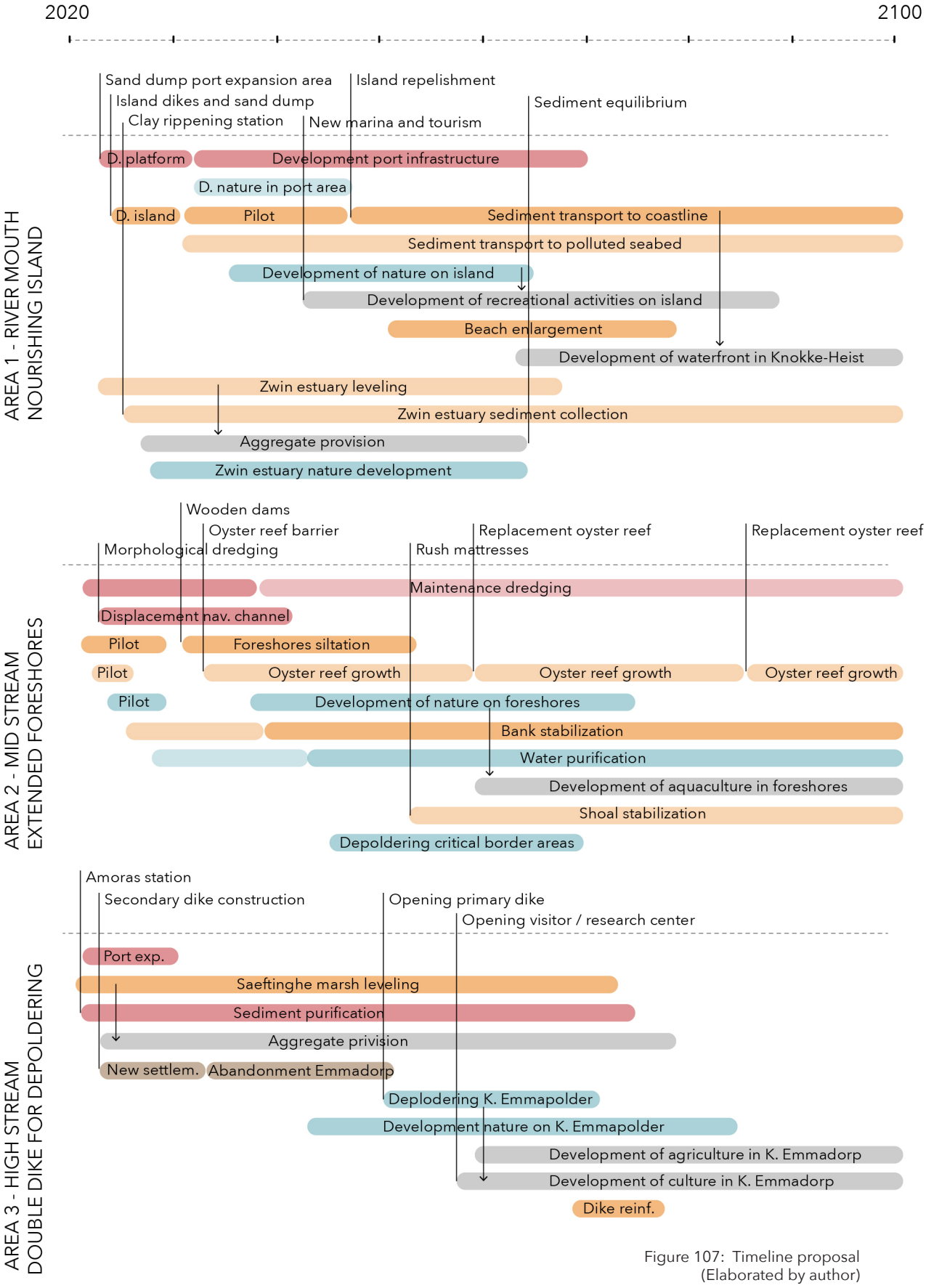


Figure 107: Timeline proposal
(Elaborated by author)

11. EVALUATION

This chapter will explain the contribution of the collaborative strategies for the 3 main functions defined for the sustainable development of the Western Scheldt.

First, it will reveal what is the contribution of each project zone for EbA by using ecosystems to increase the values for Safety, Ecology and Accessibility. Also, what added values they can create for other functions in the area and how can this future (by 2100) look like.

Then, their performance will be compared to the "business as usual" - low port collaboration scenario. This will emphasize the importance of increasing collaboration to operationalize EbA strategies.

Finally. an overview of the whole Western Scheldt system will summarize the impacts of the proposal and inform about the amount of new habitat areas created. (marshes and mudflats)

11.1. PROJECT'S PERFORMANCE ZONE 1

GOVERNANCE

ADDED VALUE

Waterfront development
(Horeca, beach sports, bathing)
Island's inner coast development
(Eco-tourism, marina)

ECOLOGY

Compensation with high quality habitats
Coastal marsh expansion
Additional coverage of war pollution site

SAFETY

Wave breaker in front of coastline
Reduced coastal erosion
Low impact beach nourishment

ACCESIBILITY

Shared infrastructure development
Increased seaport capacity
Decongestion on Western Scheldt

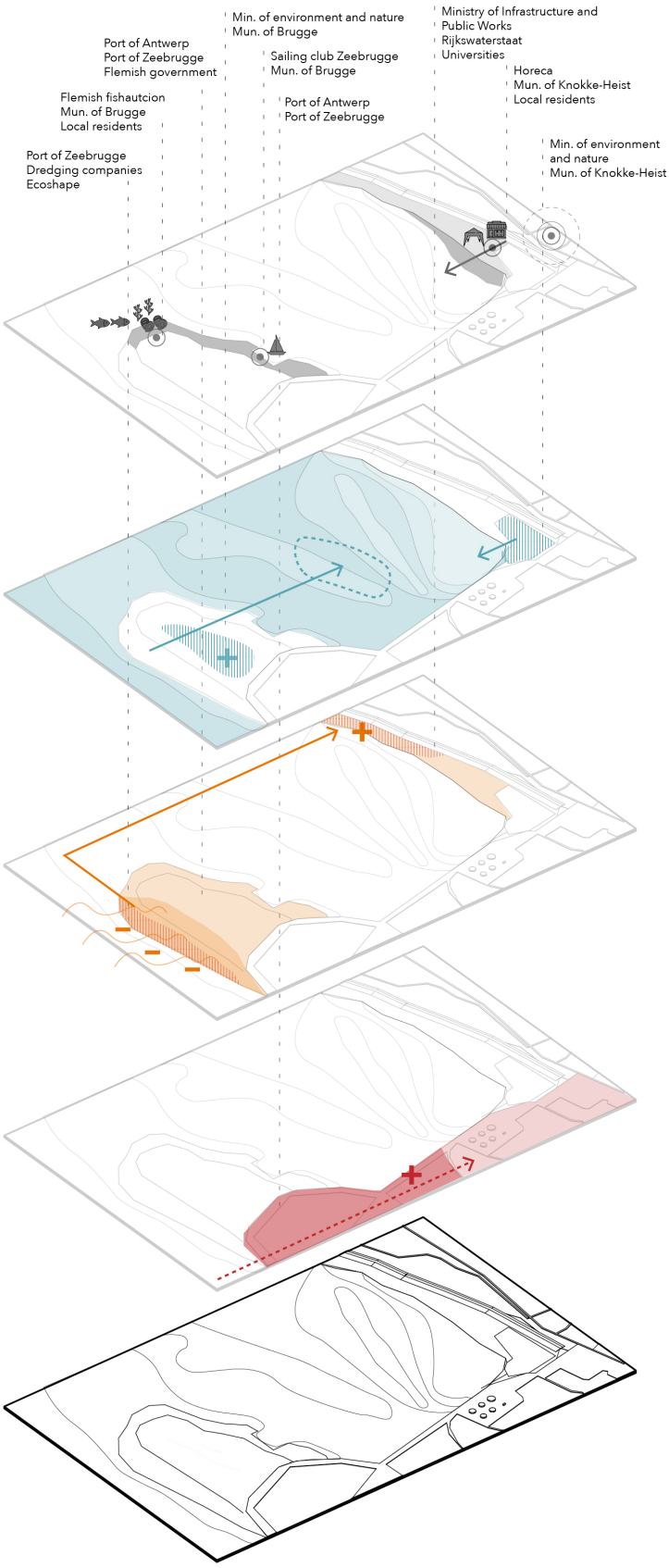
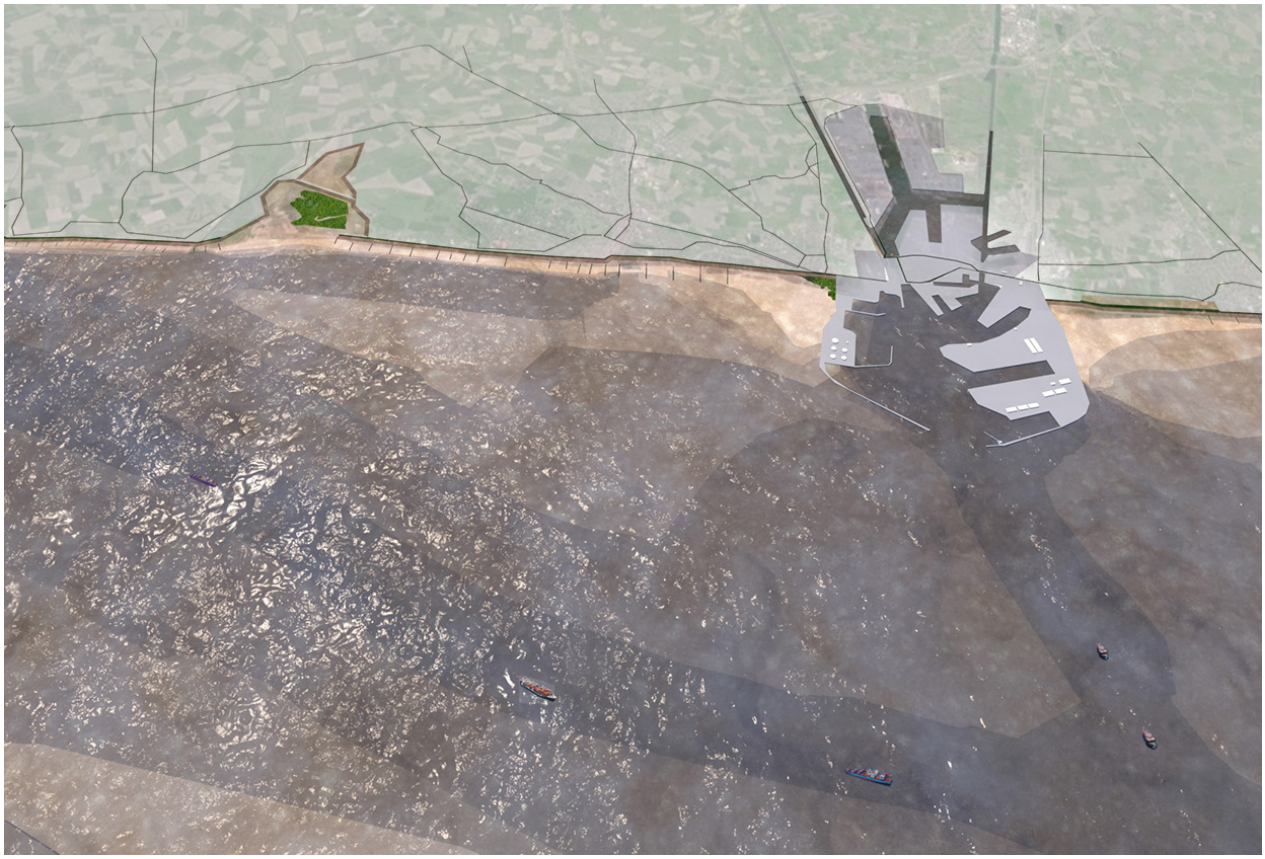


Figure 108: Exploded axonometric with added values for each system Zone 1 (Elaborated by author)

ZONE 1 TODAY



ZONE 1 IN 2100 WITH COLLABORATIVE STRATEGY FOR EBA

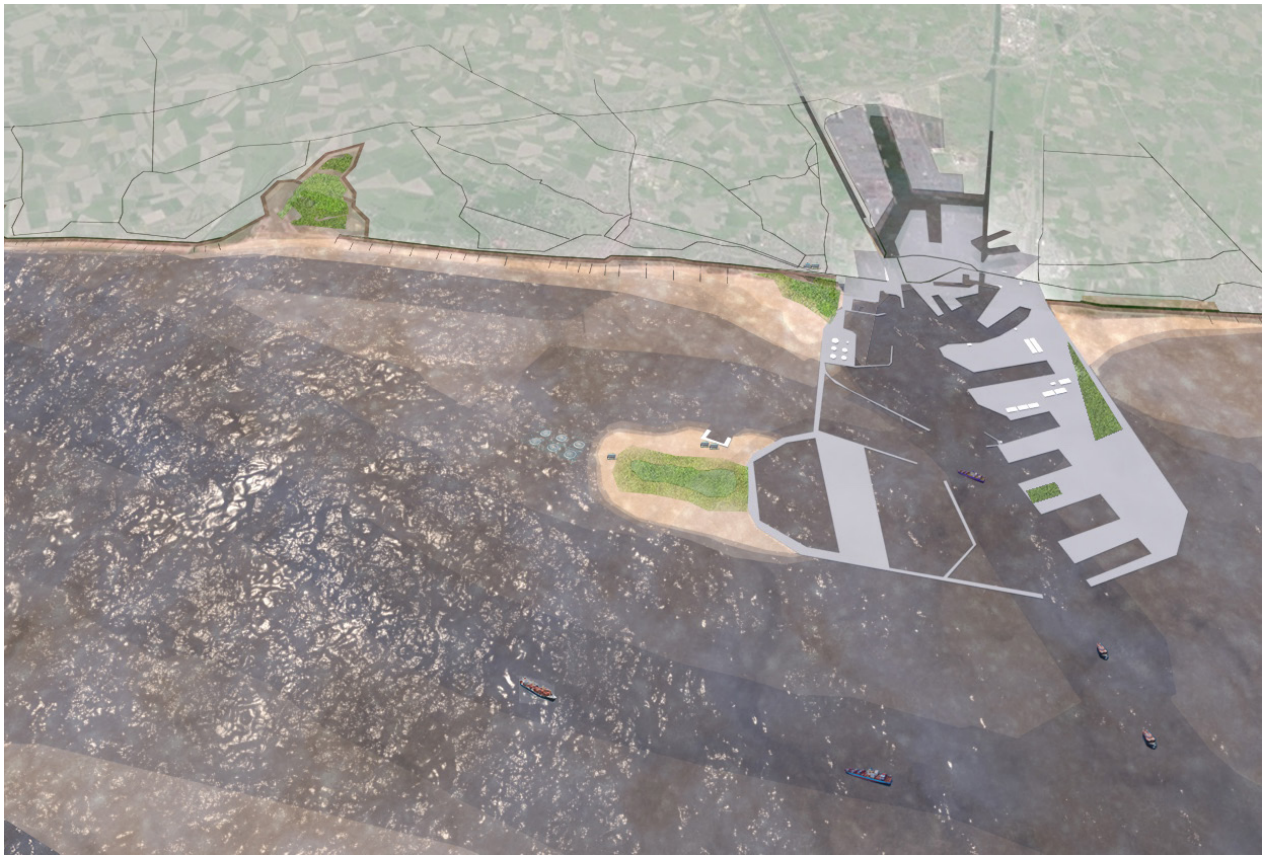


Figure 109-110: Current and Spatial transformation after strategy Zone 1 (Elaborated by author)

11.2. PROJECT'S PERFORMANCE ZONE 2

GOVERNANCE

ADDED VALUE

Biomass and biofuel products in foreshores
Oyster harvesting in mid-term stage
Food production in foreshores in long term stage

ECOLOGY

Ecosystems in vegetated foreshores
Increased water,soil and air quality
Integration nature-agriculture

SAFETY

River banks stability and reduced scouring
Optimized mudflats elevation
Wave dissipation

ACCESIBILITY

Optimized navigation space
Reduced nav. channel obstruction with loose sediments

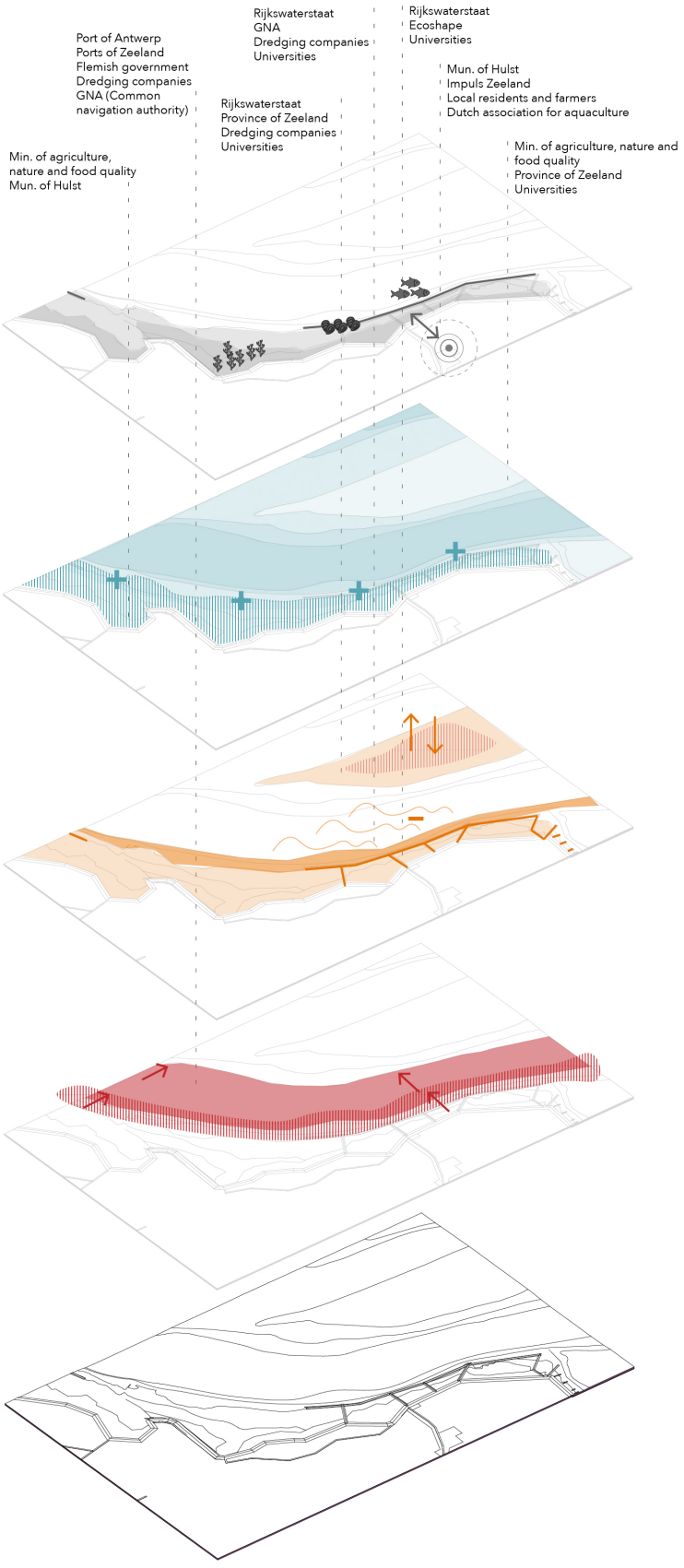


Figure 111: Exploded axonometric with added values for each system Zone 2 (Elaborated by author)

ZONE 2 TODAY

ZONE 2 IN 2100 WITH COLLABORATIVE STRATEGY FOR EBA

Figure 112-113: Current and Spatial transformation after strategy Zone 2 (Elaborated by author)

11.3. PROJECT'S PERFORMANCE ZONE 3

GOVERNANCE

ADDED VALUE

Salty agriculture in local identity
Knowledge development
Diversified ,low-maintenance agriculture
Silt based economies

ECOLOGY

Increased tidal influence on marsh
Extendend river and marsh space
Integration nature-agriculture

SAFETY

Additional controlled flooding area
More surface resistance for waves
Relocation in higher and safer grounds

ACCESIBILITY

Marsh collects more sediments
Reduced dredging maintenance
Sediment excess transfered for other uses

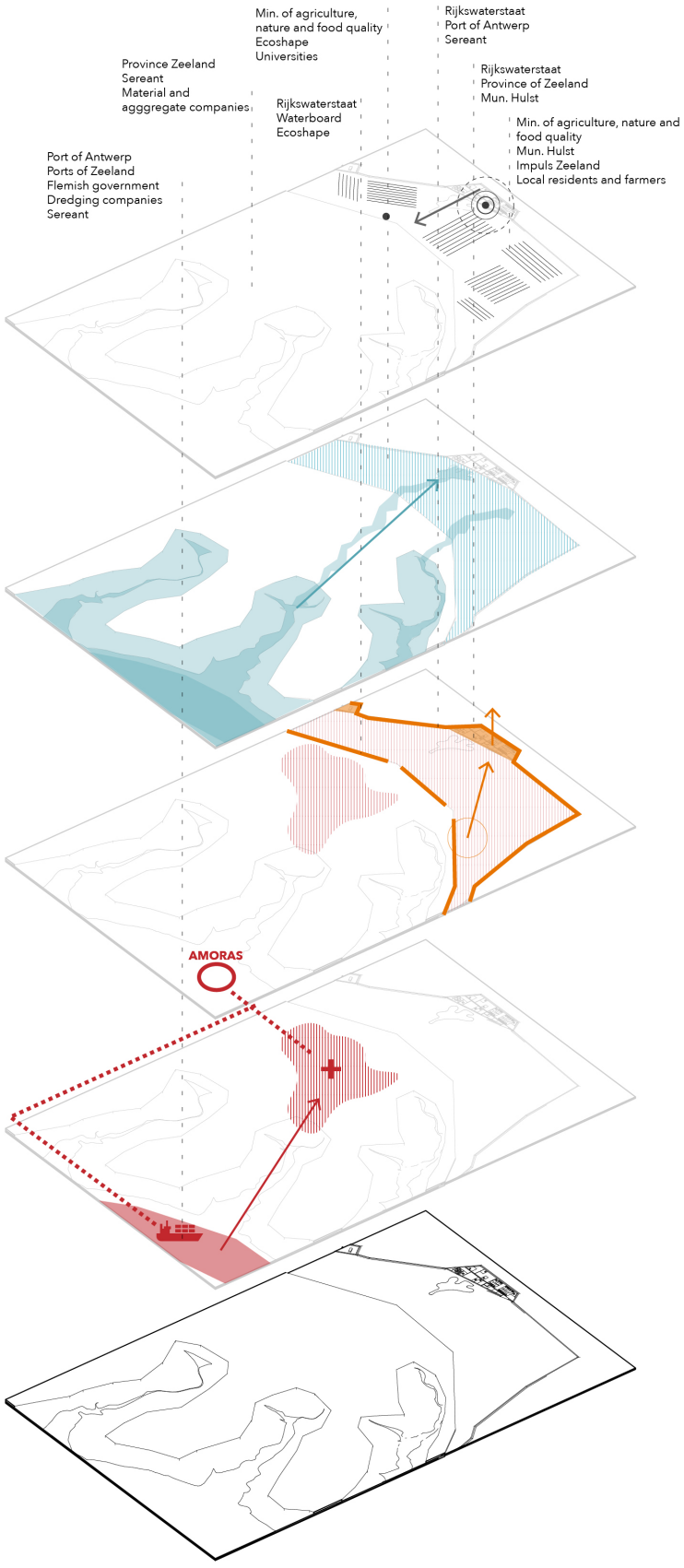
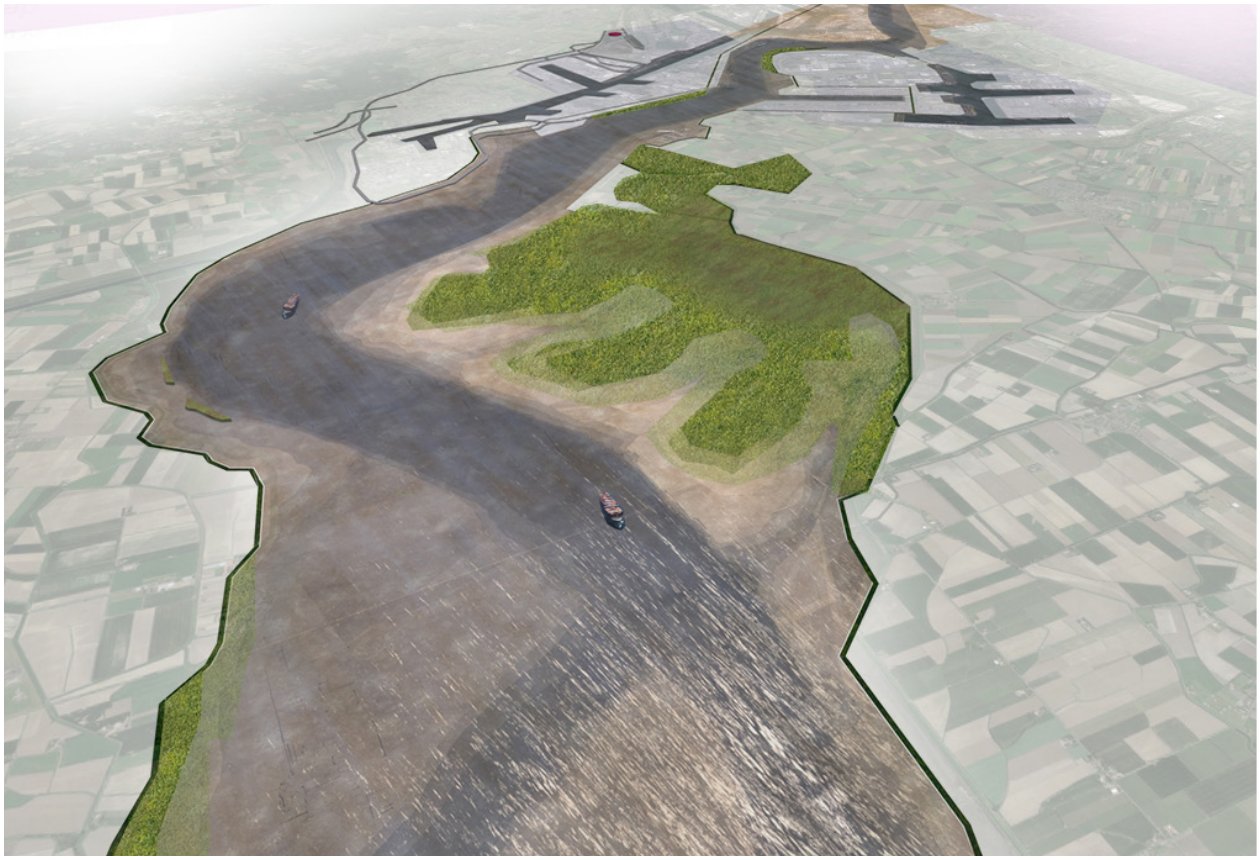


Figure 114: Exploded axonometric with added values for each system Zone 3 (Elaborated by author)

ZONE 3 TODAY



ZONE 3 IN 2100 WITH COLLABORATIVE STRATEGY FOR EBA

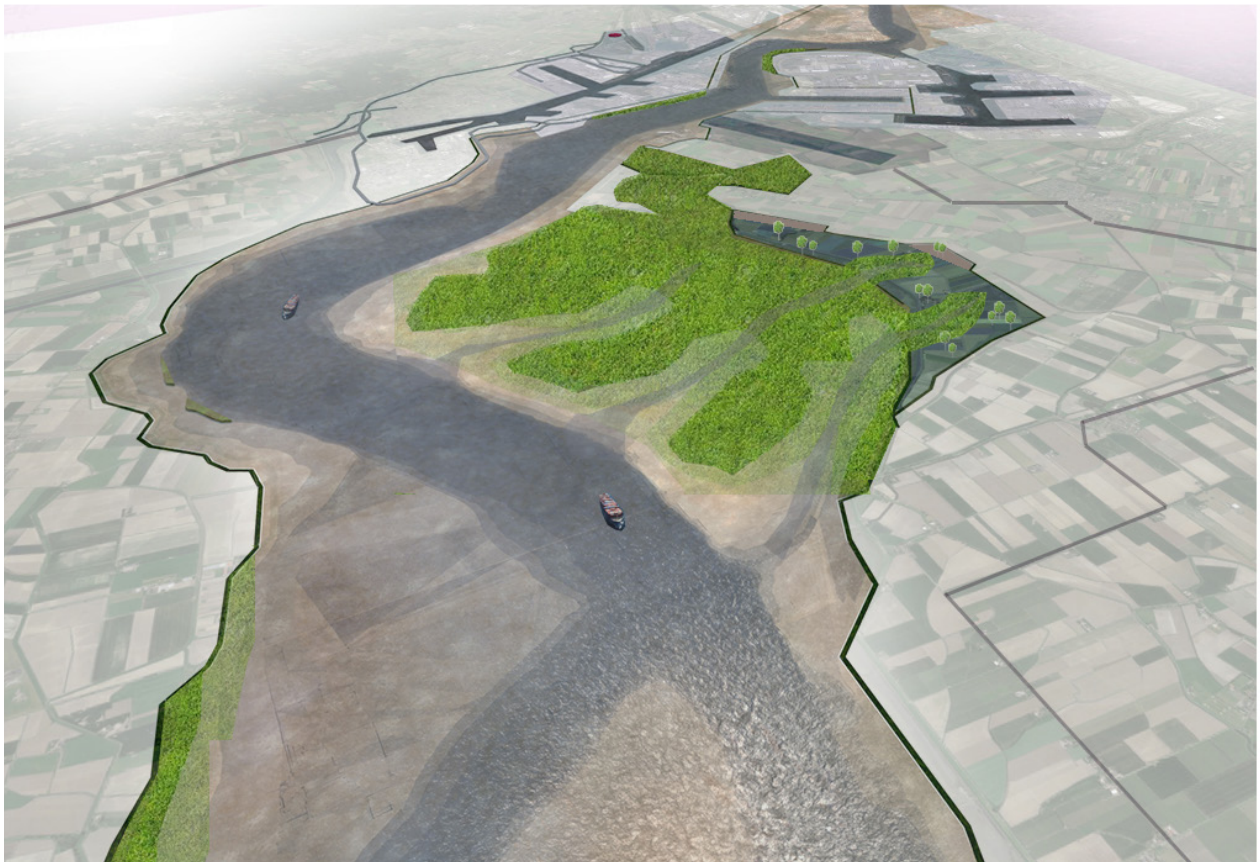


Figure 115-116: Current and Spatial transformation after strategy Zone 3 (Elaborated by author)

11.4. PROJECT'S COMPARATIVE PERFORMANCE LOW/HIGH COLLAB.

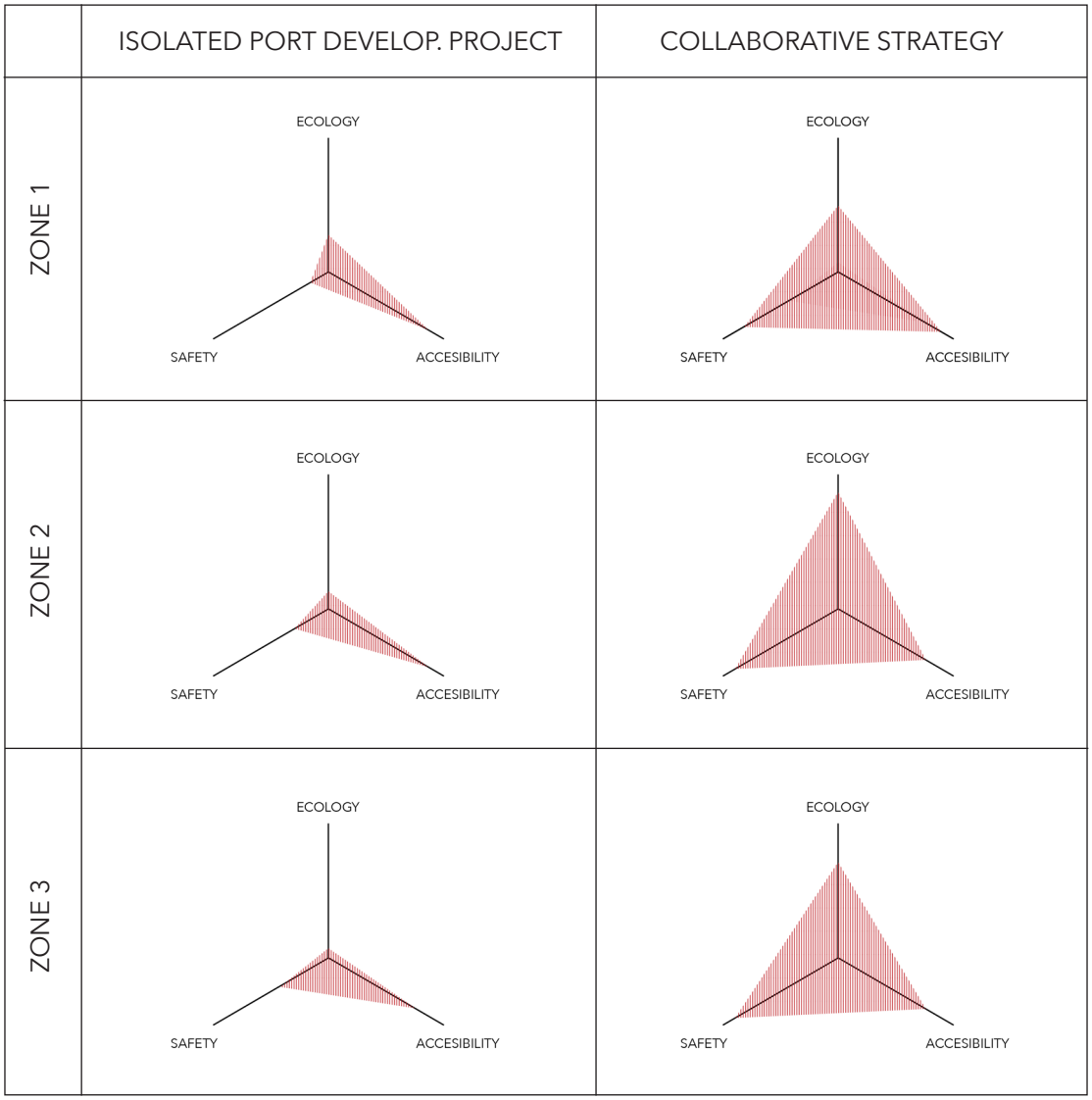


Figure 117: Comparative performance between isolated port project and proposal (Elaborated by author)

The comparative projects' performance clearly shows that is possible to simultaneously combine port development and ecosystem management. Using the Natura 2000 policy to demand for nature compensation and trigger EbA has been used as a common strategy in the three zones.

In the proposal, the responsibility of the ports is used as the starting point and by developing the collaboration networks, the potentialities are maximized.

11.5. PROJECT'S ADAPTABLE GOVERNANCE

The scenario considers the optimal conditions for collaboration, but the proposed governance arrangements can also operate in less desirable conditions.

The governance arrangement includes clusters at both regional and local scale. If port authorities were not interested in dealing with their compensation requirements through a slow process of agreements of the collaborative networks, the proposed BwN strategies can still be implemented.

The clusters of local stakeholders are created as a result of the potentialities that the ecosystem management can create for the development of the built environment. (For example the recreation and production in the new island, the green network along the river for leisure or the new forms of environmentally-friendly agriculture behind the Saeftinghe marsh) This can be used as a tool to engage with investors and initiate local projects for EbA in the Western Scheldt.

When the BwN projects achieve the improvement of the safety, ecologic and accessibility conditions, the port authorities will still benefit (for example the reduced maintenance dredging) and can later contribute back to the network.

This shows the robustness and adaptability of the both governance network and the proposed spatial transformations.

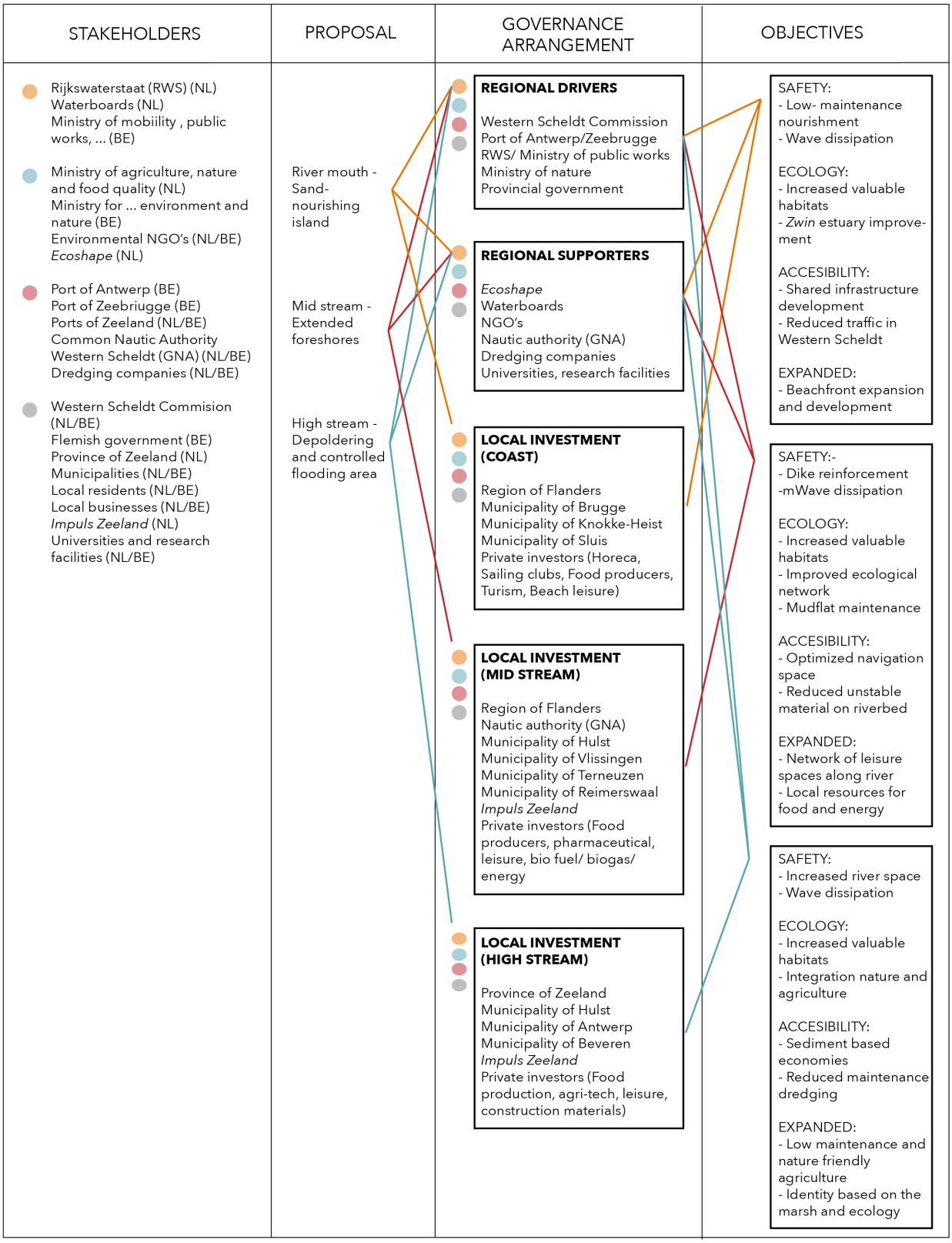


Figure 118: Proposed network and adaptabilty for different levels of collaboration (Elaborated by author)

11.5. URBAN DEVELOPMENT POTENTIALITIES OF THE PROPOSAL - ZONE 1

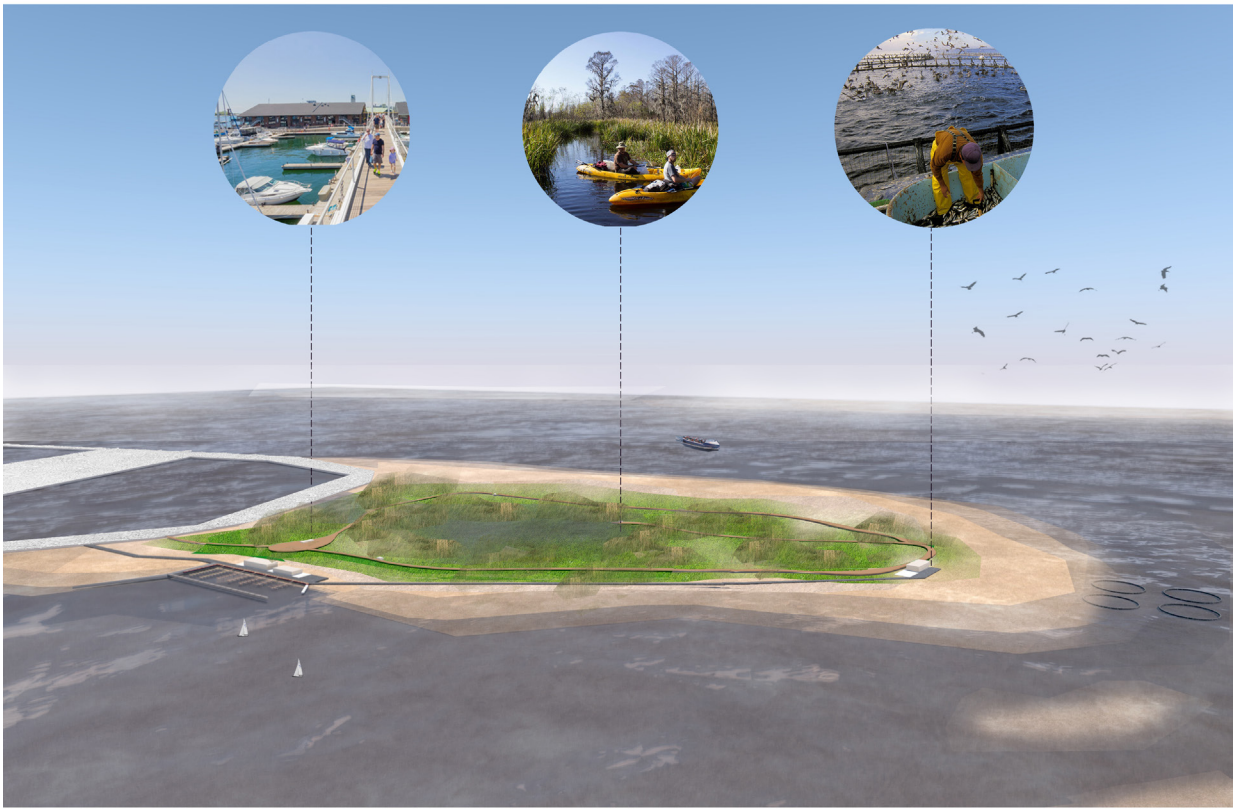


Figure 119: Urban development potentialities of the proposal - Zone 1
(Elaborated by author. Sources:
Marina: http://www.harbourfrontcentre.com/marine/ourmarinas/m4/index.cfm
Ecoturism: https://neworleanskayakswamptours.com/benefits-of-kayaking/
Aquaculture: https://www.seafoodwatch.org/ocean-issues/aquaculture)

11.5. URBAN DEVELOPMENT POTENTIALITIES OF THE PROPOSAL - ZONE 2

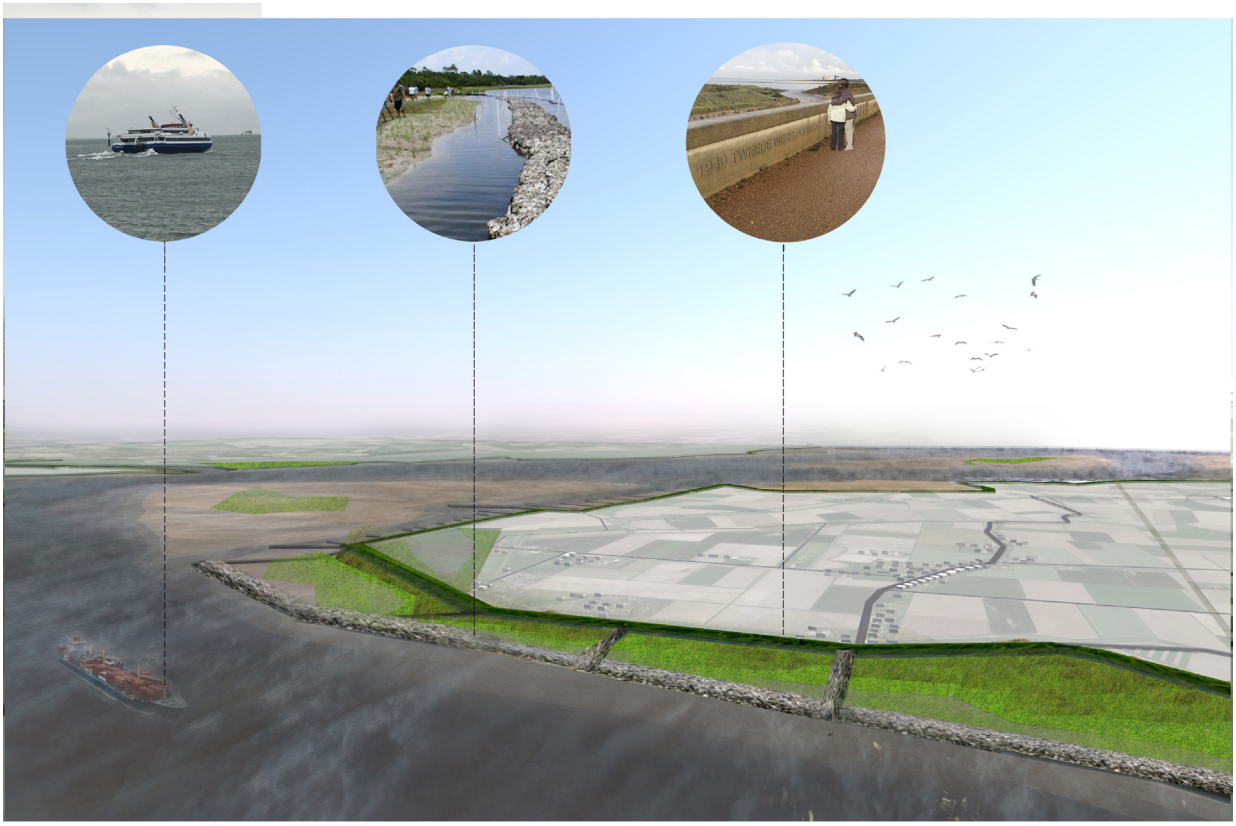


Figure 120: Urban development potentialities of the proposal - Zone 2
(Elaborated by author. Sources:
Ferry: Picture taken by author
Oyster reef: http://www.whatsonwilmington.com/event.php?id=30254
Leisure aling the marshes: Picture taken by author

11.5. URBAN DEVELOPMENT POTENTIALITIES OF THE PROPOSAL - ZONE 3

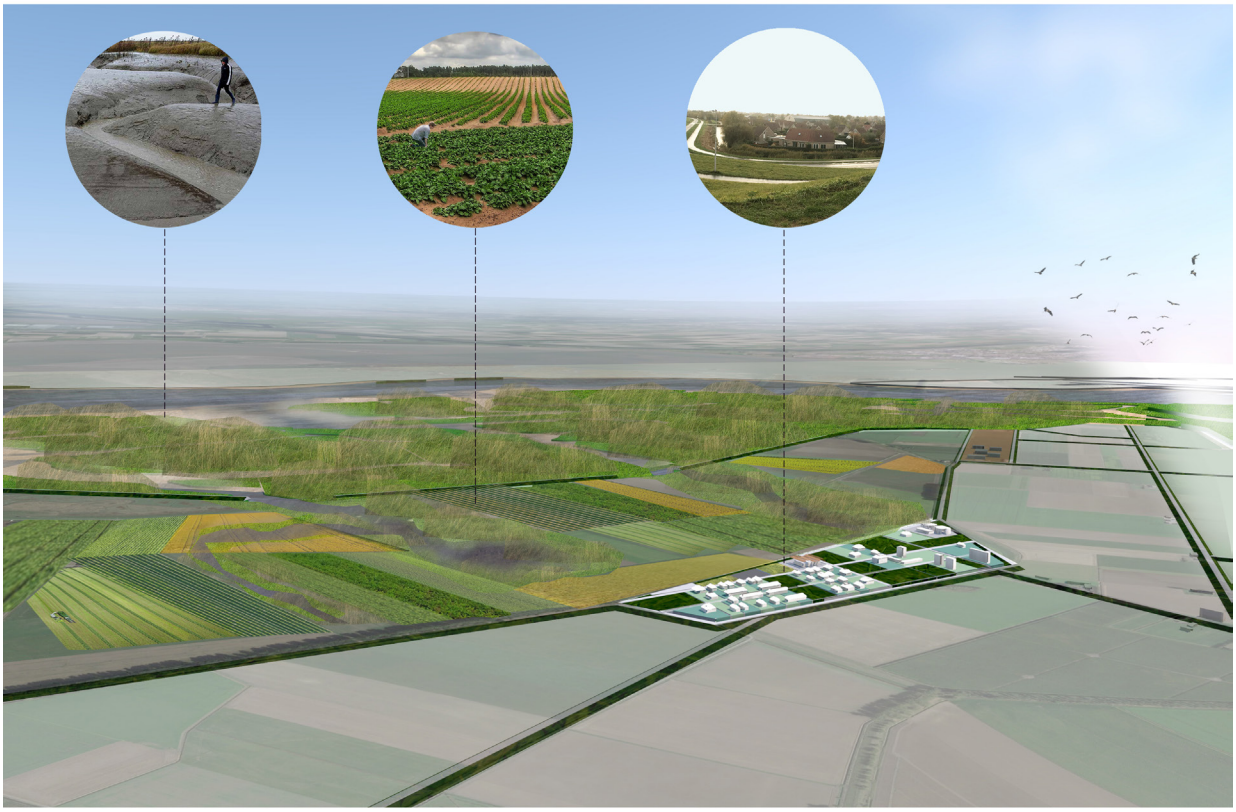


Figure 121: Urban development potentialities of the proposal - Zone 3
(Elaborated by author. Sources:
Saeftinghe marsh: https://www.natuurfotografie.nl/gebieden/het-verdronken-land-van-saeftinghe/#
Salty crops: https://www.seren.bangor.ac.uk/other/environment/2014/10/28/dutch-farmer-invents-salt-resistant-potato/
Settlements near the estuary: Picture taken by author)

11.6. OVERVIEW TRANSFORMED WESTERN SCHELDT

As a result of the wave dissipation, the current dikes are estimated to last between 5 and 8 more years in the Antwerp area in an accelerated climate change scenario (between 15-25 in low climate change scenario) and around more 10 years in the areas of Hulst and Reimerswaal. Reduced scouring should also reduce the maintenance of the dikes.

The different strategies are expected to create around 1.400 hectares of valuable ecosystems along the Western Scheldt. This includes the new island marsh, the Zwin polder extension, the extended foreshores and the depoldering of the Konigin Emmapolder.

The regional ports will have a more efficient distribution of the transported goods. Larger vessels will dock in port of Zeebrugge and the connection by train, roads and pipelines will be improved. Infrastructure required for these larger vessels was developed in collaboration with port of Antwerp and the earnings will be divided.

Added values create opportunities to expand in diverse local economies.

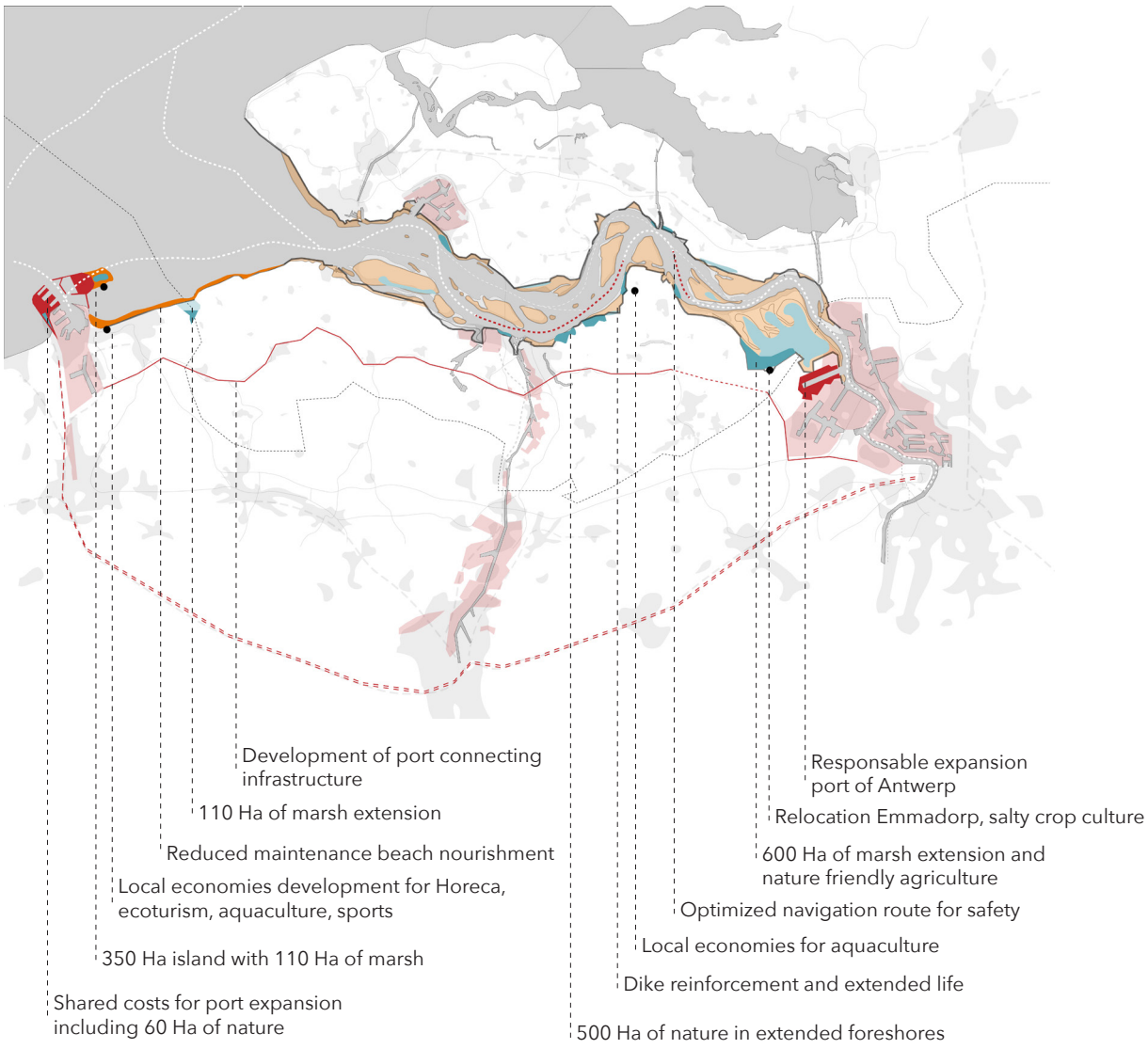


Figure 122: General performance of proposal (Elaborated by author)

12. CONCLUSION

The purpose of this research was to test the potential use of EbA to plan the future of the Western Scheldt, taking into consideration that is an area with high exposure to the effects of climate change.

In addition to this, the area has to meet the needs of 2 countries: the Netherlands and Belgium. Dealing with flood related risks and nature conservation are very important issues for the Netherlands, but the peripheral positon of the Western Scheldt for the country makes it a low priority area to intervene. For Belgium, the river connects the North Sea and the country's economic centre and is used for exchanging goods through the port system.

Both countries have increased the collaboration to plan the future of the Western Scheldt. Through the Western Scheldt Commission, a long-term vision has been developed and the main functions of flood safely, ecology and accessibility have been defined as priority for the sustainable development of the Western Scheldt.

Previous experiences have shown that addressing these functions separately can improve a function's performance, but hinder the others. Ecosystems are complex and their sub-systems are interdependent. For this reason, interventions are increasingly aiming to approach these multiple-systems simultaneously.

Using ecosystems and biodiversity to help us maintain these values for the future and deal with the climate change effects (the definition of EbA) would be then a desirable alternative. In the Western Scheldt, research has revealed that intertidal marshes and mudflats in the area provide ecosystem services that can contribute to the functions of safety, ecology and accessibility.

EbA is cost-effective, because it deals with multiple systems simultaneously. If one intervention can provide benefits for issues of different sources, then the resources needed to implement these interventions can be shared. This is particularly important in the Western Scheldt, where resources from the Dutch government may be limited for this low priority area.

EbA is primarily about "soft" infrastructure, which can complement and support the existing "hard" infrastructural solutions like dikes and barriers. For example, island formations and vegetated foreshores are very effective to dissipate wave energy. This will slow down the deterioration of the dikes and extend the period before raising them is required.

EbA (ecosystem-based adaptation) is adaptive. This should not only mean that nature reacts to changes and evolves. In our capacity to manage and intervene nature, we should be capable to change the course of our plans if nature is not providing the expected benefits.

This is an important aspect taken into consideration in my proposal. The proposed interventions come from previous experiences using the ecosystems capacities and scientific research (Evidence-based urbanism).

The first intervention uses the ideas of artificial islands to protect the coastline and lower maintenance nourishment by using the natural currents. The island nourishment is a pilot project and the process requires to be monitored and evaluated. If the transported sediment is not sufficient, then alternatives can be considered, like modifying the shape of the island, creating a second island or increase the traditional nourishment.

The second intervention zone uses the pilot experiences of Building with nature for extended foreshores, oyster reefs and morphological dredging. A total of 28 km of river banks have been identified as "steeper than desirable" (1/10 slope). The pilot project is developed on a 1 km stretch with intermediate conditions of tide, salt intrusion and space limitations. The information collected on this pilot project, which is expected to take 10 years until is functioning to the 100%, can be used for the remaining steep bank areas.

The third project zone also is part of learning about depoldering and controlled flooding areas. This has already been done in other areas along the Western Scheldt, including the Hedwige/Prosper polder a couple of km away. At the same time, the research on crops that grow on salty soils is being developed in the area. By the time the area has been cleared and ready for depoldering, the knowledge of the salty agriculture will be more developed and applicable as a competitive economy, which could lead to more controlled flooding areas in the future of the region.

As it was explained for the three project zones, the proposed interventions are reactions to the understanding of the ecosystems capacities to deliver certain services, but with potential to adapt as these processes evolve over time. This results in gradual low investments that can be accumulated to reach long-term goals or be small losses when a different pathway has to be taken.

For example, the current annual extraction volume of sediments is 2.6 mm3 in the Western Scheldt. As sea level rises and the sediment balance is monitored, it may result in the eventual prohibition to extract sediments from the river. For such change, the clay ripening strategy does not rely in big infrastructural development and can be stopped with very low economic repercussions.

The cost-efficiency, complementarity and adaptability are values that make EbA a desirable way to deal with the sustainable development of the Western Scheldt. The implementations of EbA strategies are challenged by the administrative divisions of the territory and the Western Scheldt represents the extreme of this governance/ territory conflict.

This means that not only the interdependency of the systems and their changes over an uncertain future need to be taken into account for EbA. To properly manage these ecosystems, the different stakeholder groups that benefit from them need to join efforts and share responsibilities. In this case, collaboration is required even between groups from different countries.

Luckily in Western Scheldt, there is already a good level of collaboration between the Netherlands and Flanders (Belgium) and it has improved over the years. However, ports in this area have mostly developed autonomously and independently from the other functions. They are very influential on the river and their development projects have further increased the flood risks and deteriorated the local ecosystems.

The project proposal takes the regional collaboration one step further and brings ports to the middle of the network to manage the EbA strategies. The 3 aspects mentioned in the research paper explain the governance proposal for this new network.

First, it identifies the site-specific group of stakeholders that would have an important role in the implementation of the proposed EbA strategies.
Second, the regional drivers are established and connected to local-scale groups that benefit from the provision of ecosystem services. This contributes to initiate and maintain the conditions of these ecosystems.
Third, the network highlights synergies between different sectors, facilitates the exchange of interests, knowledge and perspectives and distributes responsibilities to ensure the networks robustness.

These aspects of collaboration will contribute to the implementation of EbA by increasing the overall support, minimizing trade-offs, revealing additional potentialities and channelling resources efficiently.

This new form of governance also needs to be flexible and adapt to the changes in the ecosystems performance. For this reason, constant monitoring and evaluation should guide the steps for the ecosystem management and which stakeholders can be engaged.

It is important to take into considerations the disadvantages of EbA strategies. They require long periods to reach accord and even longer periods to reach the desired performance levels. This can potentially be the reason for some stakeholder groups to not engage into these governance networks. For example, port authorities may choose to plan their own compensation strategy and propose an inferior alternative that is cheaper, easier and yet considered “sufficient”.

For this reason, the proposed governance network can still push for the development of these EbA strategies without support of the ports as drivers. The robust network considers stakeholders that operate at different scales. If regional stakeholders do not engage with the strategies, the local groups can take a bigger role in the implementation and maintenance of ecosystems. The potentialities that these EbA strategies can create for the local built environments can be used to stimulate investment of different sectors and projects can be implemented without one specific linear pathway.

When the ecosystems eventually deliver the improved services that benefit port related functions (such as reduced maintenance dredging), this can be used to convince them to join the network for future projects.

This shows that the use of ecosystem management for the sustainable development of the Western Scheldt can be achieved not only in an optimal scenario for cross-border collaboration, but also with more limited levels of collaboration. The timeline of the projects will however be altered to some extent if the big drivers (especially economic) do not engage.

But in any case, this kind of proposal demands for a shift in the way we plan spatial development. Using natural processes for adaptation needs to start a long time before the conditions of a region are critical. That way, ecosystem management strategies can be optimized and the natural processes can stabilize in their enhanced conditions.

In order to encourage collaboration for EbA strategies and contribute to the sustainable development of the Western Scheldt, I would make the following recommendations to the Outline 2010:

First, to have the Western Scheldt Commission expand on their engagement with the different stakeholder groups. The cross-border Commission should be working on making the benefits of an empowered ecosystem apparent for the stakeholders. That way, they can be aware of their responsibilities to maintain and improve the ecological conditions and be more supportive for proposals that have that purpose. Also, to establish an agenda for different stakeholder groups to meet and share their perspective and issues related with the future of the Western Scheldt.

Second, to exploit the compensation requirements of the Natura 2000 regulations. These requirements can be used to trigger ecosystem management strategies. This report and proposal shows how this can apply in the case of port development projects on the Western Scheldt, but the policy regulations extend to other fields such as urbanization, roads, industries, etc. The Western Scheldt Commission can be involved in the process and help the responsible groups for the compensation to make the most out of these projects. Also, to connect the responsible groups with other supporting stakeholders that can benefit from it.

Third, to understand the importance of integrating knowledge producers in the evaluation and monitoring of the modified natural processes. Following their evolution and their reaction to natural and human induced interventions should lead the adaptive condition of the ecosystem management.

The research explored the potentialities for EbA in scenarios where climate change is accelerated and the urgency to deal with these impacts is higher. That is one big uncertainty for the future and further research could be done to explore what other strategies are possible if climate change is little or moderate.

The research was also focused on the main 3 functions defined for the sustainable development of the Western Scheldt, but the research can be taken further by integrating other functions and their systems as well. Another possibility for future research involves taking the same collaboration principles to help implement EbA strategies in other regions, but the EbA strategies and governance structures are site-specific.

CROSSING THE LINE FOR NATURE:
CROSS BORDER PLANNING COLLABORATION FOR EFFECTIVE ECOSYSTEM-BASED ADAPTATION

REFLECTION CHAPTER

13. REFLECTION

13.1. RESULTS AND EFFECTIVENESS OF THE APPROACH:

The conducted research for this thesis led me to the question "How can EbA play a role in the sustainable development of the Western Scheldt, and how can cross-border collaboration in planning be adjusted to facilitate the implementation of EbA strategies?"

I believe that throughout the project I was able to come up with an answer to this question.

For the first part of this question I had to reveal what are the potentialities of using ecosystems to maintain and improve the functions of flood safety, ecology and port accessibility in this region. Also, in which ways they can be cost-effective, an addition to existing infrastructure and adaptable to changing conditions.

To do so, the systems approach was used in the assessment part of the research. It was sometimes difficult to make this division, especially because the systems are interdependent and many of their components are shared. For example, dredging is an activity directly related to port accessibility. But dredging also creates turbidity, affecting the biodiversity and influences the wave intensity and dike stability. Despite this "categorization" challenge, the systems approach helped me to show what how ecosystems are capable to help to these main functions and the overall sustainable development of the Western Scheldt. It also showed some key aspect that guided the design strategies.

The field trip just provided perspective on the current state of things in the area. It appears to be an acceptable level of coexistence between human activity and nature and the willingness to plan for more environmentally friendly interventions. It doesn't really tell about the loss of nature over the past centuries or decades or what are the future risks for the Western Scheldt as a system. It provided some insight on the governance of the area. For example, learning that planning in Antwerp is divided between city and port planning department, which shows the importance of port authorities as stakeholders in the spatial development. Also, I could see that no spatial differences were apparent while crossing borders in several areas, not in nature or even on the built environment.

In order to define what kind of planning and governance arrangements could facilitate the implementation of EbA strategies in this cross-border context I used scenario planning. This helped me to limit the big uncertainties of climate change and politics in the future of the Western Scheldt. Scenarios allowed me to identify the potential risks of current practices with limited collaboration between the 3 main functions and how they will not be sustainable with accelerated climate change. These include for example mudflats being permanently flooded, more invasive dredging, siltation of marshes in the higher part of the Western Scheldt, etc. On the other hand, a high collaboration scenario revealed how can the driving influence of ports be used at the same time to develop ecosystem management strategies for a EbA. In this case, the scenario makes the assumption that stakeholders are very willing to collaborate in these governance networks, but highlighting the benefits for each stakeholder sector should increase their support.

The design proposal was heavily informed by research on the biophysical conditions and behaviour, related projects that intervene the ecosystems' capacities and the understanding of the position and interests of different stakeholders in the region. Sand modelling could have helped me to get a general estimation of changes in sediment transport in the coastline with the port expansion and island development, but existing computer models (Vries, 2016) of these dynamics were available and more precise to inform the design.

13.2. MENTOR'S FEEDBACK:

The research involved many complex topics, uncertainties, overlapping concepts and interrelated systems. This challenged me to structure the report and explain the relation between all of these variables clearly. My mentors were extremely helpful in this part and have constantly pushed me to redefine the structure so it can be well understood. They have also helped me in the editing process to separate the core aspects and complementary information.

My mentors have indicated the importance of assigning measures to my proposals, for example how much sand will be dumped in the island, how many people and functions will be displaced with depoldering. This help me to define timelines for both the natural cycles (and their proper management) and some milestones to reach implementation or adaptation pathway. The definition of roles, rights and responsibilities of key stakeholders was also mentioned to then explain governance arrangements in a clearer way and to establish the correspondent policies and recommendations related to the project.

13.3. WHAT I HAVE LEARNED FROM MY WORK:

While working on the research and design of the project, I have learned about the relevance of the research question on this moment in time. The very recent merging of port of Ghent and ports of Zeeland in 2017, the research on collaboration between port of Antwerp and Port of Zeebrugge developed between 2017 and 2019, the "Flanders port area" branding, the morphological dredging studies after the last channel enlargement and the recent pilot Building with Nature projects in the last decade show that the Western Scheldt is at a defining moment to take collaboration pathways that can influence implementation of EbA. This means that willingness to collaborate is already there and could soon influence decision-making and the intervention on natural processes. This also made me more aware that nature depends heavily on politics.

While I was developing the project, I realized how much knowledge has already been produced on the area about the biophysical conditions and how they react to impacts. I also found a lot of information about the governance structures that are involved in the Western Scheldt. Because of the amount of information available, it was challenging leave things out and identify how can I contribute to the knowledge in such an advanced case study. This also helped with my information filtering skills.

Other skills that I developed through the research process included the extraction of layers of information from maps with digital image tracing tools and the improvement of my Dutch while revising policy documents, papers, reports, etc.

13.4. FUTURE STEPS OF THE RESEARCH:

As it was mentioned in the conclusion, there are 3 main directions for future research related to this report:

- The research and project was focused on the main 3 functions defined in the Long-Term vision for the sustainable development of the Western Scheldt, however other functions may also have an important influence on the biophysical conditions and could be considered in these collaborative networks for governance.

- The research developed 2 "extreme" scenarios to compare the impacts of collaboration, however there could be different outcomes in a medium collaboration scenario. Both scenarios considered accelerated climate change projections to emphasize the urgency to develop plans in the region, but other timeframes and opportunities may appear if climate change was considered to be moderate or limited.

- The ideas related to an "adaptive and flexible governance" that reacts to ecosystems performance could be studied in other regions. As it was mentioned before, ecosystems and the products and services they provide are specific to the context. This means, that the strategy I propose for the case study will probably not be applicable in other areas. In fact, it will be nearly impossible to find a universal answer to operationalize EbA in spatial planning. The research approach can however be applicable in other contexts, because the analysis of the specific ecosystem dynamics, urban dynamics and governance structures is a required step to propose a custom planning coordination strategy.

13.5. RELATION BETWEEN THE PROJECT'S TOPIC, THE STUDIO TOPIC AND THE MASTER TRACK:

The project explores the evolution of a territory, the mutual influence of natural and urban dynamics and how can we create better synergies between them. These are very relevant topics for the transitional territories studio, specially this year that the theme is centred on the North Sea and the idea of coexistence. The project will be developed around the Western Scheldt, which is part of the Rhine-Meuse-Scheldt delta that is directly connected and influenced by the North Sea. With the project, I will test alternatives of regional strategies and the capacity of small scale projects to contribute to large scale dynamics. It will also deal with the issue of governance and policy that could facilitate the implementation of these EbA strategies. More importantly, the project studies the relation between site-specific, project-specific and adaptable governance and the capacity to properly manage the territorial scale at which ecosystems operate.

I learned a lot while developing the project, but also realized how much knowledge already exists and how advanced the discussion for planning is in the North Sea region. I would like for the studio to encourage more the research on other parts of the world, and use the knowledge of this area as an example for development. At some point, North Sea study becomes background information for the individual project so it does not necessarily need to be developed there.

13.6. SOCIETAL RELEVANCE:

The projects highlight the value of working with and not against nature to become more resilient towards the effects of climate change. It increases environmental consciousness of society so they can be more involved in the process of support and maintain the conditions of their local ecosystems. Well preserved ecosystems can then operate and provide the wide range of products and services needed by society. This societal engagement with Ecosystem-based adaptation is also part of the local level management strategies.

In the case of the Western Scheldt, the quality of the ecosystems plays a vital role in the intensity of risks related to climate change. If human intervention continues to deteriorate them, flood risks will increase faster in the area. Part of the value of the project is coordinating the need to maintain ecological quality with the need to keep land safe and aligned with the ambitions of port economic development. This aims to optimize resources and increase stakeholder's engagement with nature conservation goals.

As the project proposes a more site-based, project-based, inclusive and coordinated governance, it is possible that some groups of society may be important to consider in the process of decision-making. That way, society is better informed about what is at stake for them and for everyone, how are they influencing natural dynamics and how can they contribute to the sustainable development of the region.

13.7. SCIENTIFIC RELEVANCE:

Planning coordination is fundamental to develop effective plans to manage ecosystems, including Ecosystem-based adaptation strategies. The main reason is that the extension of ecosystems frequently does not align with the traditional administrative divisions of governance.

Large scales and time frames of natural processes require new arrangements of governance that recognize the site-specific conditions, defines the optimal scales to operate and includes the corresponding stakeholders in the process of decision-making. This flexibility should also facilitate the exchange of perspectives, knowledge and resources within the scope of each project in order to make well-informed decisions and reduce trade-offs.

Planning coordination can then facilitate operatizing ecosystem management via small-scale projects and interventions that can also contribute to a long-term vision and the improvement of the natural systems at their territorial dimension.

Natural dynamics change at a slow paste, but can provide many benefits and be cost-effective. For this reason, we have to find ways to incorporate them in planning not only as a goal, but how to make it possible. When properly managed, Ecosystem-based adaptation can increase the resiliency of the built environment against climate change, which is major threat that will become more problematic in the future.

Transferability of the project to "reality" appears to be high, mostly because there is already discussion on how to balance port development and the safety and nature conservation. The Rhine-Meuse-Scheldt delta (Including the Western Scheldt) is a worldwide leading area in research and exploration on how to develop human activities, reduce risks and consider the value of nature. The applicability goes beyond the Western Scheldt, as it proves such approach to be feasible and other parts of the world can learn about how can planning and governance allow it to happen.

13.8. ETHICAL CONSIDERATIONS:

In terms of the research and design of the project, a very important aspect is the high amount of information available on the Western Scheldt. Some components of the strategies that are being proposed in the project already come from other discussed and modelled projects, which prove their effectiveness. Authorship of that knowledge needs to be recognized during the design stage of the project.

It's important to emphasize that the contribution of this projects relies on finding ways to facilitate the implementation of such strategies. What kind of collaborations, synergies and arrangements can be introduced to increase resources, understanding and support for such complex and multipurpose strategies.

On the report, there is a tendency to present the ports of the region as "the bad guy" of the Western Scheldt. It is important to acknowledge that they also contribute positively to nature and safety in some cases and their involvement in collaboration has improved over time. The point of using port development as a key element of the strategy is based on the influence of these stakeholders in the region and what it could mean if they took their responsibility for ecosystem management further.

The main consideration of this project in practice relies on equity. One of the aims it to reduce the distance between the ones who know, the ones who decide and the ones that win/lose from changes in ecosystem management. It is difficult to provide a win/win response when land and water space is limited and interests are conflictive. However, the projects aim to consider a wide range of stakeholders and what can they get from ecosystems in order to increase their willingness to collaborate.

For example, proposing to relocate the small settlement of Emmadorp may be considered a sensitive issue. The proposal also includes to relocate them only 2 km away, but on higher, safer grounds with a 25-year time of implementation and empowered with innovative economies based on salty crops. In relation to this subject, it also worth mentioning that the port expansion in Antwerp involves demolishing of the village of Doel, a bigger and older settlement. In this case the compensation is only economic.

Figure 123. Coexistence in the Western Scheldt.
(Picture taken and edited by author.)

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15. APPENDIX

15.1. NORTH SEA RESEARCH

15.1.1. INCREASING FLOOD RISKS

In the context of the North Sea, the vulnerability of coastal areas is also present. It is possible to identify that multiple areas in the coast are under increasing flood risk as a result of sea level rise. A large concentration of vulnerable areas is located in the Belgian, Dutch and German coasts, where land elevations are low and can even be lower than the current normal sea level. In the Netherlands for example, about 50% percent of the population in lives under the sea level and the most populated cities are located there. These large extensions of land were reclaimed from the sea by human intervention and would be completely flooded today if coastal defence solutions have not been implemented in the past and present. However, these defences need to be improved in order to respond to future sea level rise and keep these low lands safe.

In addition to this, inland processes of subsidence are causing some areas to sink lower. For example, Hoogland, van den Akker and Brus (2010) modelled the subsidence of the Polder Groot-Mijdrecht near Amsterdam. The results showed that soils with a peat layer are experiencing subsidence of around 8mm per year mostly due to peat oxidation. Some of these sinking lands that in the past were safe could now be exposed to flooding as well.

Another relevant aspect to consider are storm surges. The following map shows the concentration of strong winds and storm surges which is primarily present in the southern part of the North Sea. As currents push the sea water in a north-eastern direction, they hit mostly the coasts of Belgium, The Netherlands, Germany and Denmark.

During a storm surge event, sea water can raise several meters above its normal level. Climate change is increasing the intensity and frequency of these events and when the base sea level raises in the future, storm surges will have a higher impact on the coasts.

Sea level rise has also an impact on rivers flows. A higher sea level will result in a reduced capacity of the rivers to discharge water into the sea. In cases of high precipitations, additional rainwater will be discharged from urban areas into the rivers. If water can't find its way to the sea, this will cause additional flooding mostly in areas near the river mouths.

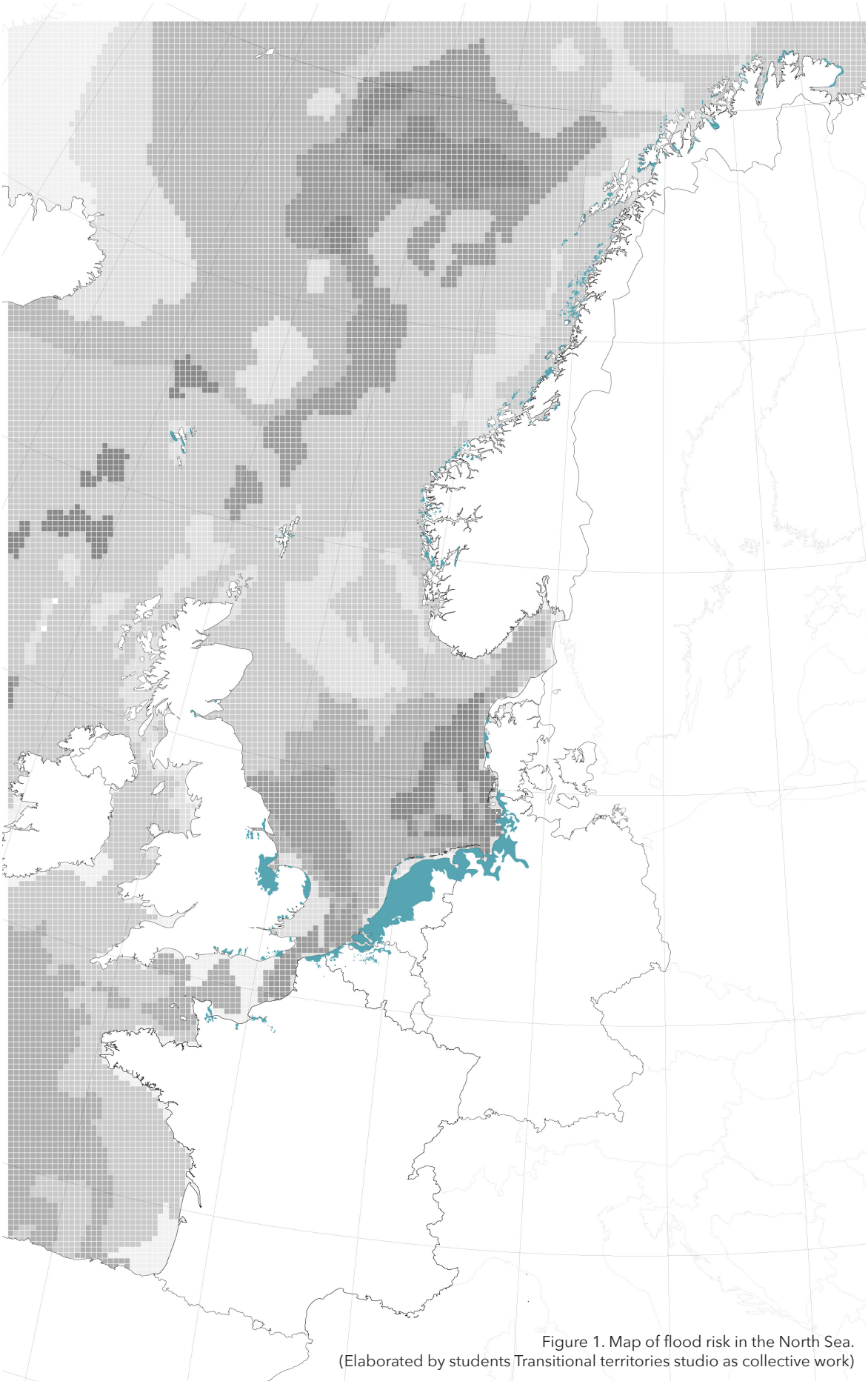

Figure 1. Map of flood risk in the North Sea.
(Elaborated by students Transitional territories studio as collective work)

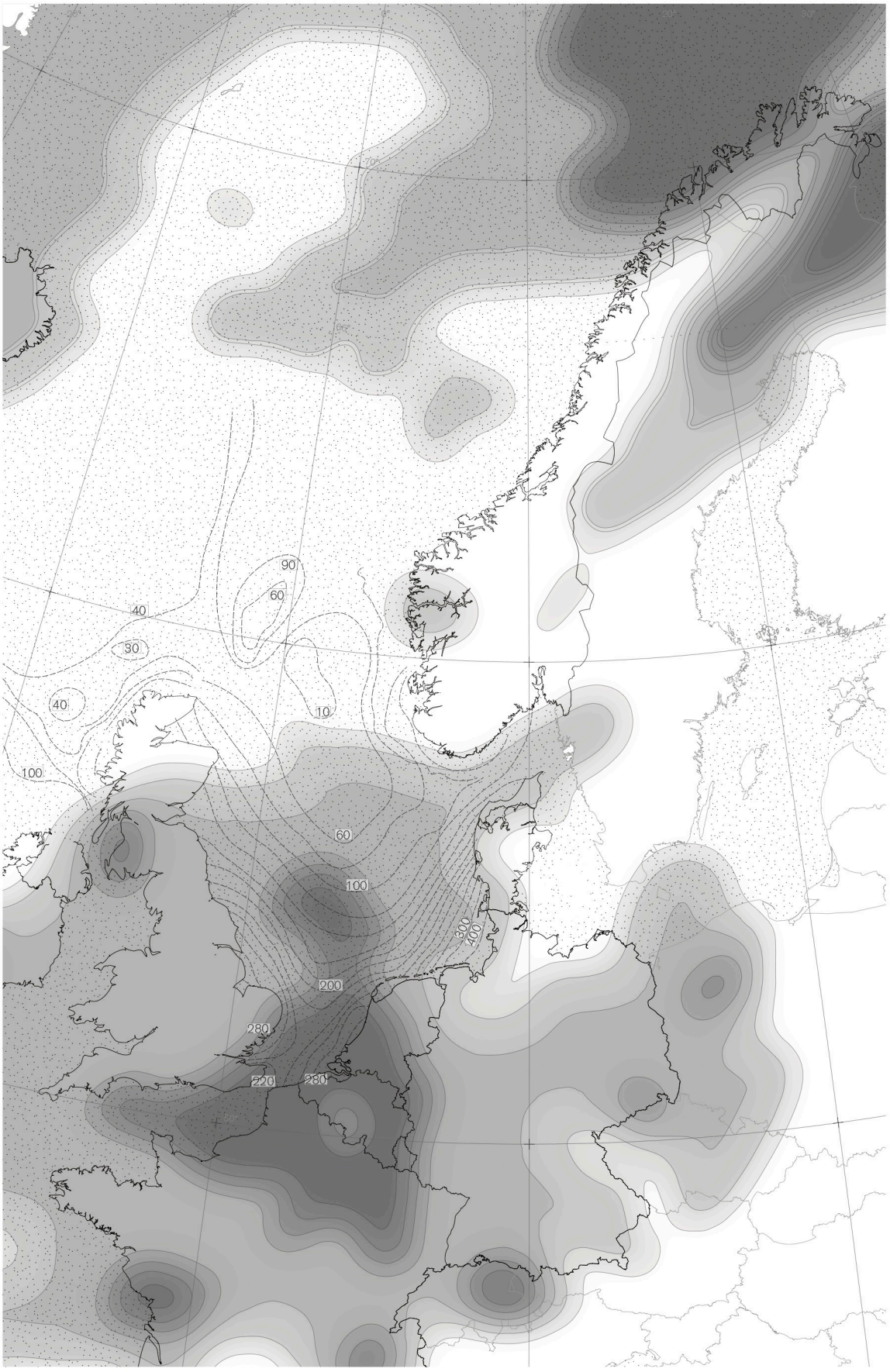

Figure 2. Map of strong winds and storm surges in the North Sea.
(Elaborated by students Transitional territories studio as collective work)

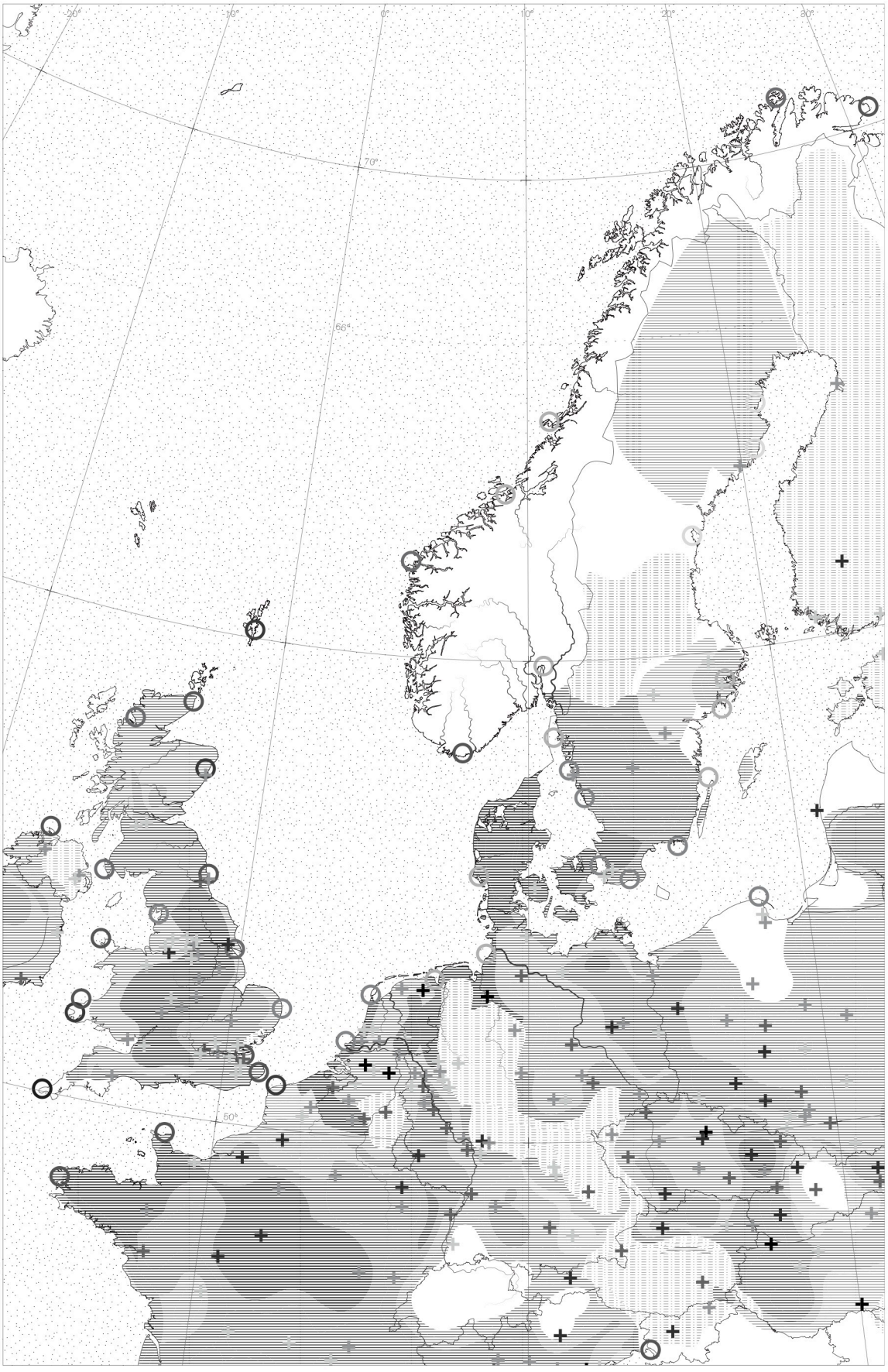

Figure 3. Map including river flooding in the North Sea.
(Elaborated by students Transitional territories studio as collective work)

From the North Sea perspective, other sediment flows influence the change in the morphology of the coastline. The main superficial currents coming from the English Channel transport sediments in a south-north direction. The movement of these currents near the coast favor the sediment supply in the Dutch and Belgian coastlines, while wind transports them from the shore to the dunes. [123]

Map of currents and projected coastal change under sea level rise.

Figure 4. Map of sea currents.
(Elaborated by students Transitional territories studio as collective work)

15.1.2. THE SEA AS A PLACE FOR EXCHANGE

To deal with these risks, which will become even more extreme in the future, create just barriers between land and sea in not an option.

The North Sea is a place of high economic relevance as it provides a wide range of resources such as fish, sand, oil, and even wind. This has attracted the development of economic activities to extract, harvest and process these resources on sea and the coastal areas. The strategic location on the coast of the North Sea also facilitates the exchange of goods and services and where some of the largest ports are located.

For example, the ports of Rotterdam, Antwerp and Hamburg had the biggest volumes of freight transport in Europe in 2017 (Port of Antwerp, 2018). The port of Rotterdam imports and stores the largest amounts of crude oil and the port of Antwerp has the largest integrated oil and chemical cluster in the continent. The high economic value of the North

Sea area has pushed countries to develop marine spatial plans to combine many different functions optimize the use of their space.

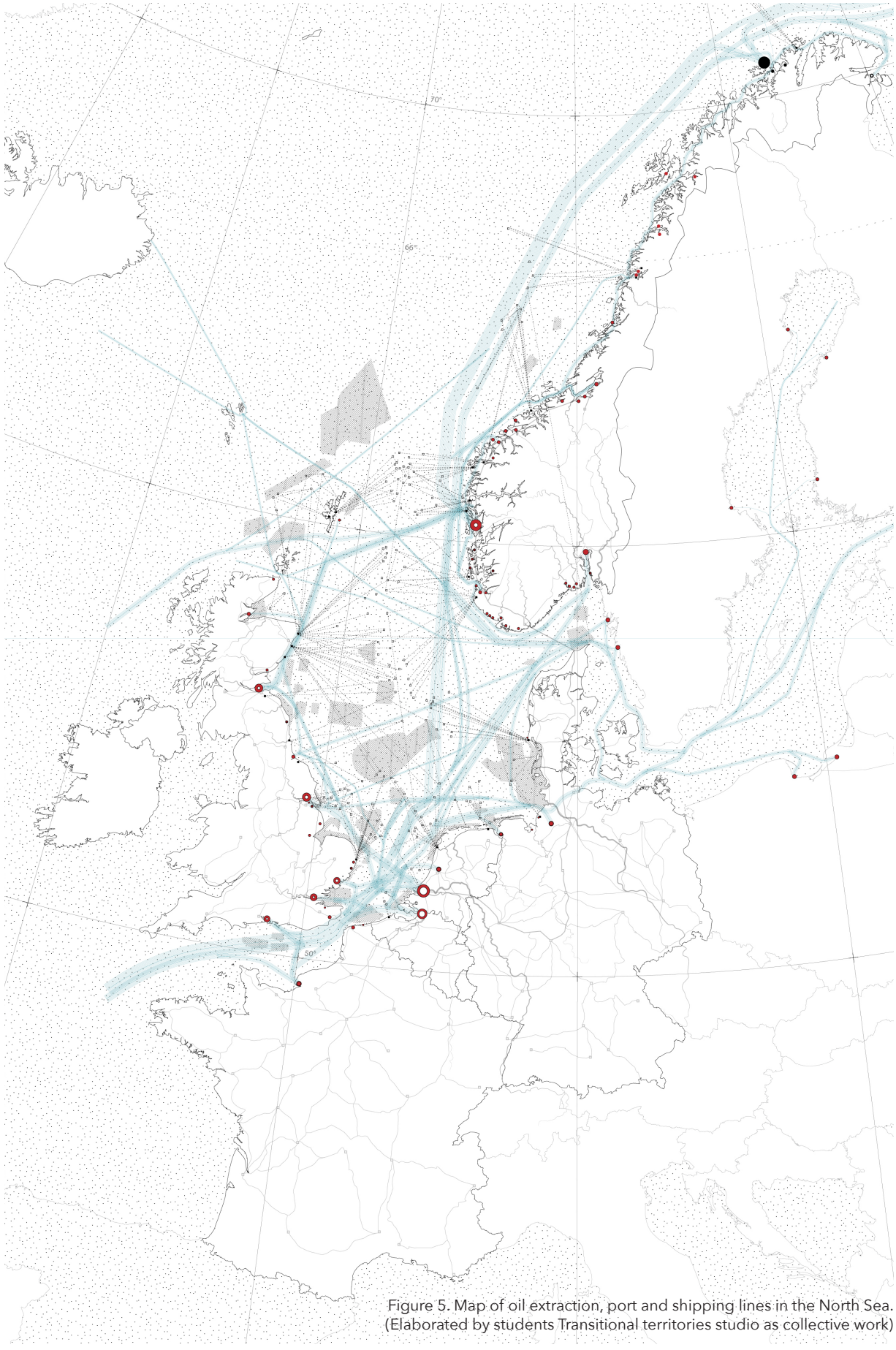

Figure 5. Map of oil extraction, port and shipping lines in the North Sea.
(Elaborated by students Transitional territories studio as collective work)

15.1.3. ECOSYSTEMS FACING DEGRADATION

Between the North Sea and the coastal areas, we can find diverse and very valuable ecosystems. But the conditions of these ecosystems are being altered as a result of climate change. Increasing temperatures, changes in salinity and even oxygen concentrations are causing migration of species and the extinction of others.

Human presence in coastal areas has also influenced the degradation of these ecosystems. Urban settlements are an important source of multiple types of pollutants that are released into the water and alter the chemical balance of the ecosystems. For example, fertilizers used in agriculture increase the amount of nutrients in the water. This causes eutrophication, (excessive amounts of nutrients in the water) which can facilitate the growth of seaweed while creating a hostile living environment for most sea species due to the low levels of oxygen.

Other activities like land occupation, use of extensive concrete surfaces in cities, excessive resource extraction and even building infrastructure for coastal defence affect natural dynamics and damage the local environment. The capacity of deteriorated ecosystems to provide ecosystem services is reduced and vulnerability towards sea climate change of the built environment increases as a result.

To prevent further degradation of the ecosystems, some environmental policies and laws assign to these areas labels to protect them from human's negative impacts. Natura 2000 is the largest coordinated network of protected areas in the world that includes 18% of the EU land area and 6% of the EU marine surface (European commission) The following map illustrates the protected areas around the North Sea.

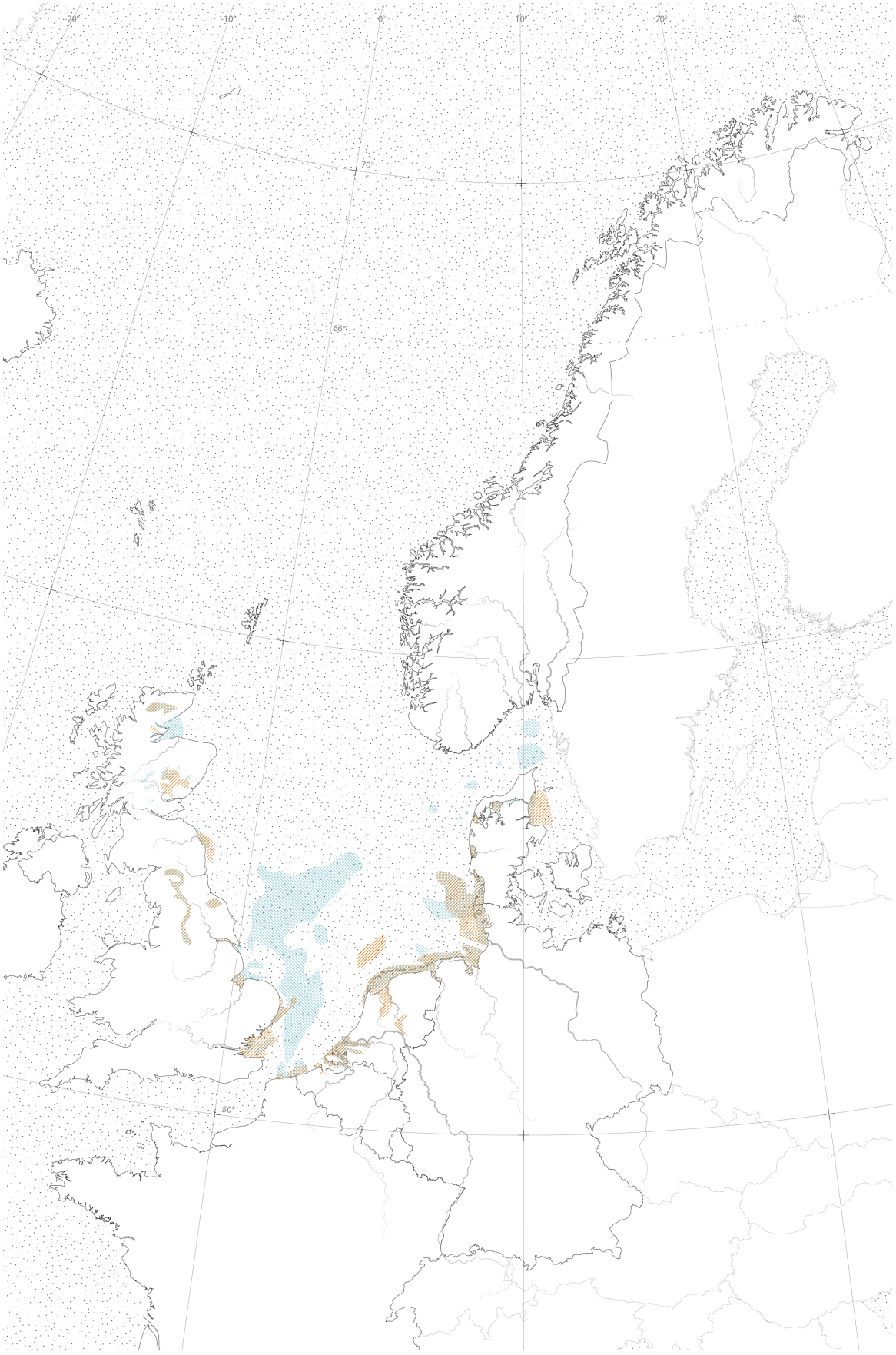

Figure 6. Map of Natura 2000 conservation areas around the North Sea.
(Elaborated by author. Source European Environmental Agency EEA.)

15.1.4. BOUNDARIES AND GOVERNANCE LIMITATIONS

Countries "draw" lines to define the boundaries of their power and authority on the territory. These lines are in most cases invisible, specially between some of the European countries that attempt to be a united region.

The political boundaries normally do not respond to territorial divisions in space and do not define the limits of ecosystems or natural dynamics. Water, sediments, fish, birds as some examples are constantly moving across these lines.

As these natural resources have intrinsic value, countries try to influence the natural conditions to retain and increase the resources in their territory. The political divisions limit the capacity of an isolated nation to properly manage natural dynamics and increase their potential and may even trigger conflicts with neighbouring countries.

In the North Sea area, these division lines are just as important on the water as on land, because all of the economic value that was mentioned before.

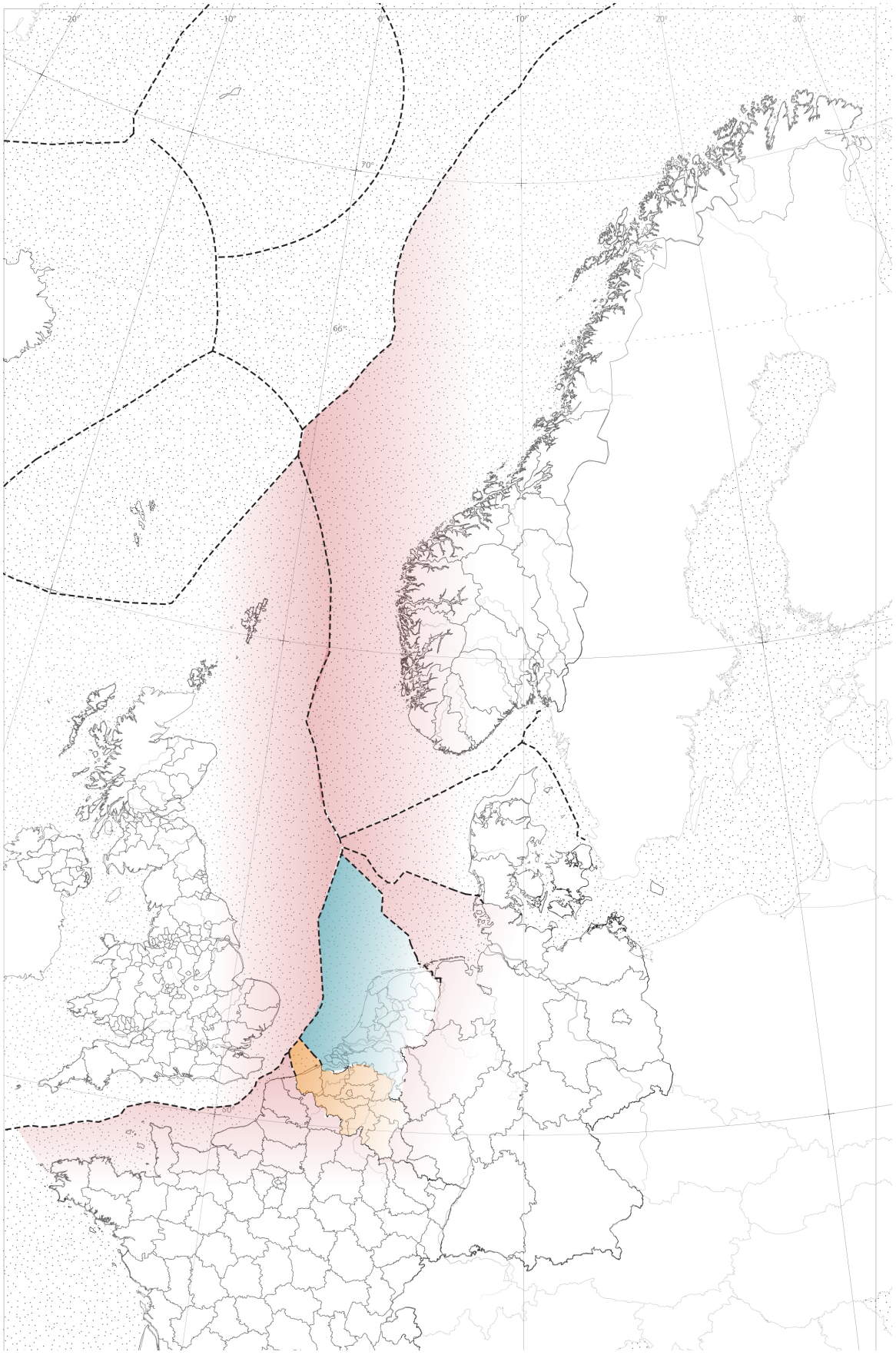

Figure 7. Administrative division of the North Sea.
(Elaborated by author)

15.2. RESEARCH PAPER:

The potential of Planning Coordination to operationalize cross-border Ecosystem-based Adaptation (EbA). The case of the Western Scheldt

The potential of Planning Coordination to operationalize cross-border Ecosystem-based Adaptation (EbA). The case of the Western Scheldt

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05 December 2018

Abstract

Sea-level rise, coastal erosion and destruction of natural habitats are some of the effects of climate change that are now affecting many parts of the world, particularly near coastal areas, where about 23% of the population is currently living. In the past, we have generally relied on hard engineered solutions to deal with the risks, but they have high costs and a limited adaptive capacity. Ecosystem-based adaptation (EbA) Is a concept that has recently been introduced in planning to respond to the effects of climate change. Wide range of studies show that EbA solutions are more sustainable, cost-effective and can provide many additional co-benefits. However, not much has been said about how to incorporate EbA in urban conditions where more land use conflicts are present. In most cases, EbA is presented as a goal, but frequently is not translated into practical actions.
This paper will first reexamine the roles of coordinated planning in relation to the concept of EbA to explain why this is a key factor to properly manage the territorial dimension of ecosystems and why planning structures need to adapt to site-specific conditions and normally cross their administrative borders. The discussion will then be developed in the case study of the Western Scheldt, which deals with the extreme of cross border planning coordination. The Western Scheldt is influenced by two different planning systems (Dutch and Belgian) and is an example of how planning coordination is used in the development of cross border EbA solutions.

Keywords: Ecosystem-based adaptation, adaptation strategies, planning coordination, cross border coordination,

INTRODUCTION:

Since the second half of the 20th century, we have been experiencing accelerated processes related to climate change. "Climate change presents the single biggest threat to sustainable development everywhere" (UNFCCC).
In coastal areas, some effects of climate change such as sea level rise and more extreme weather conditions make them particularly vulnerable. Dealing with this vulnerability requires special attention, considering that coastal areas are highly populated areas and about 23% of the total world's population lives within 100 km of the coast (Adger et al. 2005, p.1036). Establishing urban settlements in proximity to the coast has been driven by the diversity of resources and trading opportunities these areas provide (McGranahan et al. 2007, p.18). These areas concentrate diverse development opportunities including trade, food and mineral extraction, energy production, recreation, etc., creating high pressure to continue the urbanization processes. Therefore, "increase coastal resilience to these threats is a priority for many countries and a global need" (Barbier, 2014).

Even if actions are taken globally to mitigate the effects of climate change (Like reducing Co2 emissions and by that reducing temperature rise), cities still need to adapt to climate change. Most solutions that we have implemented until now will most likely not be effective in the future. For this reason, we have to aim for plans and implementations that can be more adaptable to the changing conditions. In the past, we have strongly relied on hard engineered solutions to deal with risks, which have a very limited adaptive capacity and result in high costs and constant interventions. Approaches like seawalls, building dams, levees and channels to control flooding and even relocating infrastructure and settlements may help to some extent, but do not address integrally the climate change impacts. Moreover, they can contribute to the destruction of fragile ecosystems and even reduce their adaptive capacity. (Hale et al., 2009, p.2). Hard structures can be used in more severe cases like highly urbanized areas, but should be in sync with natural dynamics. (Hale et al., 2009, p.4).

Both urban development and natural processes are operating in a context that is in need of constant adaptation to the uncertain context of climate change. In this process, each component reacts to the change, creates new interactions and modifies the overall system. Without an understanding of the system dynamics it is very difficult to predict these large-scale behaviours (Mitchell and Newman, 2001, p.1). In addition to that, both systems influence each other and understanding this interrelation between the human-induced urban development and natural processes is an issue of high complexity (Zagare, 2018, p.19,44). As cited by Zagare (2018), Richard Peet (1998, p.2) indicates that "the relation between society and nature is thus an entire system, a complex of interrelations", where each of these open systems affects the other and together shape the space where we live.

Recently we have rediscovered the potentialities that the natural systems offer in relation to risk reduction, with water retention, soil stabilization and Co2 absorption as some examples. There has been a shift of perspective related to adaptation to climate change from working against nature to work with nature and using it to increase the resiliency of the built environment. Ecosystem based adaptation has been introduced as an approach to build with nature and face climate change. However, the challenge is to take EbA from a goal to practice.

In this paper, I will argue that this challenge is mainly caused by the limited capacities of traditional planning systems to make decisions over territorial issues like ecosystem management. Ecosystems extend beyond administrative and political borders, which will require customized and comprehensive planning coordination. The relevant aspects that planning coordination should consider to implement EbA strategies will then be discussed on the case study of the Western Scheldt. This represents an extreme case where cross-border planning coordination is needed and used to develop the area, which needs to deal with increasing coast-related risks of climate change.

EBA AS A RESPONSE TO CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

For the purpose of this paper, the definition given by the Convention of Biological Diversity (CBD) will be used: "The use of biodiversity and ecosystem services (BES) as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change (CBD, 2009).

EbA is an anthropocentric concept, it is centred on meeting people's needs (WWF,2011). The concept also implies that by "using" the ecosystem services, humans are capable to alter to some extent their performative capacities. EbA is considered a multiscale and multisectorial approach to manage ecosystems so they can help reduce the vulnerability that people is facing with climate change (Sierra-Correa and Cantera, 2014). This means that we are responsible to take good care of the ecosystems we rely on if we want them to be more productive.

But in the context of climate change, not only human action has an impact on the environment. Natural cycles on the planet create temperature variations over time and have effects on the habitat of species, the melting of ice and weather conditions. Society also needs to find ways to make their built environment more resilient to these changes and working with nature can be provide many opportunities. The extent to which ecosystems, food supplies and sustainable development are in danger is related to their exposure to climate change and the ability of these systems to adapt. (Smit et al.,2001, p.879)

EbA can be a key instrument to drive the transition towards a sustainable development (Scarano, 2017, p.66) because it can adapt to this evolving target as we learn and understand better our socio-environmental system (Bagheri et al., 2007, p.84). As Holling (2004) describes, "sustainable" aims to create, test and maintain adaptive capacities and "development" simultaneously aims to create opportunities. EbA can be a link between the socio-economic and environmental issues that sustainable development attempts to combine (Hopwood et al. 2005, p.39). If ecosystems are preserved and properly managed, they can contribute to a sustainable development by the provision of food, risk reduction, water management and livelihood diversification (Munang et al. 2013). EbA can offer a policy mix to guide this sustainability transition by preserving biodiversity, but also reducing social vulnerability and shaping economic and infrastructural development. (Scarano, 2017, p.67). It can work as a long-term investment to ensure future environmental, social and financial benefits (Munang et al. 2013). This means that long term vision and planning is required, especially considering the speed of change of natural processes.

PLANNING COORDINATION FOR EBA – A CROSS-BORDER ISSUE

Most of the definitions for EbA describe diverse potential benefits that these solutions may provide, how they can be more cost-effective, provide many other co-benefits and even be integrated with other functions (Munang et al. 2013). For all the reasons mentioned above, EbA is currently being mainstreamed into planning systems (Wamsler, 2014). The EbA concept is relatively new in planning (Wamsler, 2014) and still needs to be further developed in the field, particularly for urban contexts. Where in Geneletti and Zardo's (2015) review on European climate adaptation plans shows that EbA appears more frequently as a goal to achieve, but more limited presence of measurements to achieve such adaptation. In fact, their study resulted in 52% of the cases introducing measures to implement EbA.
Some authors acknowledge the concepts of multi-sectoral, multi-scale among the guiding principles for EbA (Fedele et al., 2015) (Sierra-Correa and Cantera, 2014), but state that the challenge in planning is to operationalize EbA. For example, the Assessment of the potential of ecosystem-based approaches to climate change adaptation and mitigation in Europe by Naumann et al. (2011) indicates that despite the concept being more recognized in policy and research, there is still insufficient practical implementation. Munang et al. (2013) support the idea that governments have not yet exploited the potential of EbA, despite the increasing evidence of its benefits.
The United Nations Environment Programme (UNEP) offers a programme to help mainstreaming EbA strategies in countries. This includes: Knowledge support, capacity building and help to integrate them in national plans. (Munang et al. 2013)

The main limitation in operationalizing EbA is related with the differences between the scale at which ecological dynamics occur and the scales of governance that can potentially manage these ecosystems. Traditional planning structures do not align with the territorial dimensions of ecosystems and cannot manage them properly. (Andrade et al. 2011, p.8). Ecosystems can cross cities, regions and even countries and therefore be subject to many different and conflictive planning structures. For example, highly urbanized areas have limited available land and high pressure to be developed in comparison to rural areas. One ecological body can extend though 2 or more countries, which may have drastically different governance structures. From the beginning of the 21st century, this discussion even involves the differences between land and sea with the introduction of marine spatial planning.

As it was mentioned before, the complexity of the natural systems is high and needs to be understood on a territorial scale. However, in most cases, this scale will not be confined in the traditional administrative boundaries and one isolated planning system will not have sufficient knowledge or power to manage these ecosystems. Any intervention in one place could potentially have effects in other.
Planning coordination is then necessary to deal with these cross-border issues. Territorial transformations, including EbA strategies, can then be realized faster, the use of resources can be optimized and all the stakeholders have a better understanding about what will be their loss and gains.

PLANNING COORDINATION FOR EBA – CONTEXT-SPECIFIC

According to Douvere (2008, p.764-765), the concept of ecosystem-based management departs from traditional management approaches by focusing on a specific ecosystem and its related activities instead of a single species, sector activity or concern. It aims to look at the system from a spatial and temporal perspective and direct policies and strategies to influence how human use ecosystems and its resources.
Similar recognition of this biophysical context appears in the cohesion policy under the name of place-based. The place-based definition aims to reduce the inefficiency of resources and the increase of social inclusion by defining and producing tailored public goods and services according to the area (Barca, 2009).
By recognizing the geographical dimension of ecosystems, we should define then governance structures that respond accordingly. As one of the dimensions of territorial governance indicated in the European cohesion policy document (2015), policy making has to be place-based, consider the territorial specificities and adapt to the changing context (Böhme et al.2015, p.18).
Allmendinger and Haughton's (2009) concept of "fuzzy boundaries" is based on the idea that planning systems need to be more fluid and not be completely restricted by the statutory scale of governance. "Fuzzy boundaries" allows for more tactical associations that can respond to the real geographies and better explore the potential problems and opportunities. That way, governance structures may extend their involvement beyond their administrative boundaries and establish some level of participation when they may be affected by decision making in that territory. Such dynamics would blur the preexisting administrative boundaries of planning to respond to "spatial" planning.

PLANNING COORDINATION FOR EBA – MULTIPLE SCALES OF PLANNING

Consideration of multiple geographical scales and linkages between them is frequently mentioned as one of the principles for EbA. As it was stated before, functional scales of ecosystems are generally broad and not necessarily match the administrative structures or the scales at which project developers operate. (Andrade et al. 2011, p.8).
"With the existence of multiple scales of governance that consider the global change problems, gaps and mismatches can occur in these regulatory frameworks, affecting the overall coherence". (McDaniels et al.,2005)
Planning scales have different roles, and these roles vary according to the context of each country. Taking into consideration that the case study area focuses on the Dutch and Belgian territories, we can indicate that both planning systems share some of these scale-related trades. National plans of both are currently aiming towards decentralizing power and ensure that local scales of governance can develop and implement their own plans (Alpkokin, 2012).
According to Adger (2005), there are two main categories for taking action in order to adapt to change, one involves making policies or regulations and the other involves operational actions. While larger scales (national, regional) focus on creating a framework to regulate the interventions (including policies), local scales have a bigger responsibility in developing strategies to implement and manage projects.
But there is still a need to ensure that local projects work in an associative way and not a solution creating problems somewhere else. A high scale plan cannot be just based on the combination of many low-scale plans when frequently these local plans and projects are conflictive with each other (Rivolin, 2005, p.101)

Adger (2005) elaborates on this idea of achieving successful adaptation. For adaptation to be successful it needs to be evaluated in terms of meeting its own goals, but also if it affects the ability of other strategies to reach their goals. In other words, an isolated project may increase the local adaptive capacity, yet reduce the large-scale adaptive capacity.
Policies are also present in this multiplicity of scales, ranging from global to a local. As the areas regulated by these scales of policies overlap, there is a challenge in meeting the multiple criteria for a successful adaptation as defined by each scale. There are limitations regarding to translating global-scale agreements to small scale policies and also small scale EbA solutions cannot always scale up to influence large scale goals (Scarano, 2017, p.68).
As an example, an urban project that deals with river renaturalization can't be managed by a city alone. However, these strategies can well be coordinated with other planning scales (Geneletti and Zardo, 2015).
In a cross-border context, the complexity increases. Different countries have different planning systems, but they will need to find common ground to define policies, strategies and projects that involve shared ecosystems. The concept of vertical subsidiarity as explained by Rivolin (2005) is related to the relations between the scales involved in territorial governance. Under this vertical governance, the addition of an EU scale and the territorial cohesion policy in 2005 as an overall framework can help with development of spatial plans that include cross-border, transnational and supra-national dynamics. But the cross-border cooperation of this policy prioritizes economic growth and creation of jobs to increase competitively of border regions (Miosga, 2008, p.27) over ecological issues.

PLANNING COORDINATION FOR EBA – MULTIPLE SECTORS AND ACTORS

Implementing EbA strategies has spatial implications by preserving areas for ecological processes. It requires to be coordinated with the needs of other sectors to resolve potential land use conflicts. In urban areas, where land is scarce, competing against economic drivers is one of the main limitations for EbA. In order to gain relevance, EbA research takes a problem-focus approach and relates multiple academic fields such as ecology, nature conservation, risk management and development (Brink, 2016 p.112)
This requires a better coordination between plans of different sectors to make EbA feasible and desirable (Geneletti and Zardo, 2015).
In Rivolin's (2005) horizontal dimensions of subsidiarity promotes sharing of governance perspectives among the different actors (private and public) as a way to contribute to overall cohesion of plans and strategies.
Adger (2005) state that the value of equity is relevant in this discussion, because of the duality between the groups that are responsible in the decision-making and the groups that benefit or suffer from these decisions. For example, using land for natural conservation may reduce the land available for agriculture and therefore affect the farmers source of income.
Based on the cascade model of EbA elaborated by Brinks et al. (2009), the consideration of equity is particularly relevant in three aspects: (i) Equal distribution of the adaptation benefits as well as other co-benefits like recreation and beautification, (ii) equal consideration in the valuation of things by understanding what is a desirable state for the different groups, and (iii) equal consideration in the managing processes, where different stakeholders can be involved in the decisions that will affect them.

Not only multi-disciplinarity is necessary for an equal participation, but also including social participation is necessary to integrate social, economic and environmental demands into policy-making (Scarano 2017). Societal participation is relevant for their engagement with ecosystem conservation and being informed about the relevance of being more adaptable to change and be more resilient.
This involvement however, is not only limited to groups physically present on the areas of discussion. For an effective and successful EbA strategy, the knowledge coming from the researchers is fundamental. Disciplines such as biology, geology, chemistry, sociology, economy, etc. may provide very useful information to make proper decisions. Bridging this knowledge from other disciplines constitutes frequently a challenge, where there are spatial and administrative separations between the groups that demand the ecosystem services, the groups that can influence the ecosystem service provision and the groups that generate and analyse the information for a proper management of these ecosystems (Vignola et al. 2013). To illustrate an example, there could be accelerated erosion on the lower part of a river, but the problem needs to be managed on the high part on a different administrative unit. The effective integration of scientific knowledge can inform for a proper definition of scales of governance that can deal with ecological problems (Boesch, 2006, p.9)
There is a role for planning not only at the phase of management of ecosystems as stated in Brink's cascade model for EbA. In addition to these formal roles of defining laws and policies to manage the problem of environmental degradation, there are informal roles in facilitating interactions between groups that are part of this complex network related to ecosystems and the planning of adaptive responses. (Vignola 2013)

To deal with the differences that planning systems may pose and find common ground to define EbA strategies, the following aspects need to be considered for an effective planning coordination:
-Flexible governance structures, where existing structures don't limit their area of concern exclusively to the administrative boundaries and new forms of governance that are context-specific can emerge.
-Vertical coordination among scales, where common goals are defined and higher levels of administration not only supervise but ensure that local level projects also contribute to the overall improvement of the ecological systems.
-Horizontal inclusion of stakeholders, to facilitate the flow of knowledge and perspectives even if they are spatially separated.

As a way to contribute to the challenge of taking EbA from a goal to operationalization, these aspects will be discussed from a practical perspective. The case of the Western Scheldt will be used as an example of working with coordination in planning to address EbA strategies.

CASE STUDY DISCUSSION: THE WESTERN SCHELDT

The case study of the Western Scheldt deals with the challenge of implementing Ecosystem-based Adaptation (EbA) by reinforcing planning coordination of the involved governance structures. It represents an extreme case where the territorial dimension of the ecosystem is not confined by the administrative boundaries and the traditional planning scales. We are talking about a river delta that is present in 2 countries, Belgium and the Netherlands. The cross-border delta also plays a significant role for both countries, but driven by different goals and different planning systems (Eker and Houtum, 2013).

From the Belgium side, the presence of the ports of Antwerp and Ghent influence significantly the management of the Western Scheldt. Belgium and the Netherlands signed in 1863 an agreement that allows unconditional freedom of navigation to the port of Antwerp. This economic activity is the main catalyst for altering the river and facilitate ship accessibility from the North Sea to the ports. As a result, pollution, water diversion to new canals, edge straightening and increasing dredging have changed significantly the natural dynamics of the river. (EEA, 2016, p.3). On the other hand, the Dutch government is responsible of the last portion of the river including the river mouth. For the Netherlands, it is important to maintain the natural dynamics of the estuary. This includes conservation of bird-breeding sites, allowing the transition from salt to fresh water, preserving the intertidal marshes and the sediment quality (Maillefert, 2013, p.1).
Maintaining a good connectivity between the sea and the ports required the delta arm to remain open. Unlike the Western Scheldt, other arms of this delta were closed by dams as part of the Delta Plan. This decision was taken after the disaster of 1953, where flood defenses could not withstand the storm and significant damage was caused inland (de Vlieger, 2017, p.25-26). The closed deltas have had an impact on the ecological systems of the area and deteriorated their conditions, which adds extra pressure on the Western Scheldt to maintain ecological values.

The cross-border condition of the Western Scheldt requires coordination between the two countries to fulfill the different goals in an optimal way. However, both countries have different planning cultures, which may pose an obstacle to reach coordination.
The Dutch planning culture has a long history which dates back even to the creation of polders and is well embedded in the development of the country. In Belgium, spatial planning has become more important for the development of the country since the decree of 1997. As another example, the Dutch society has high expectations the government capacities to solve problems, while the Belgians emphasize the stakeholder agreement in their decision-making (Eker and Houtum, 2013). There is even a difference in the position that planners take when they propose strategies. Flemish planners tend to have a recognizable political inclination while the Dutch planners tend to stay neutral (Eker and Houtum, 2013). It is also important to mention some similarities between the countries' planning systems, including the language (to some extent), the transition of the Flemish planning system from regulative to development oriented (similar to the Dutch) and the increasing decentralization of responsibilities in the development of plans and strategies (Eker and Houtum, 2013)

In the specific context of this cross-border delta area, several governance structures have emerged trying to develop a coordinated plan. Some examples are the Border Commission (VlaNed), the Euroregions, the Rhine-Scheldt Delta cooperation and Project Team Development Perspective Scheldt Estuary (PROSES). Most of these governance structures have had limited influence of the development of the delta. Their broad scope of initiatives and the bottom-up approach has led "to a fragmented use of already limited resources" (Vries, 2008).
The most successful cross-border structure in this area has been PROSES. Both countries signed to this project in 2005 and worked on an outline for the future of the estuary by 2030. They established 3 main objectives that need to be simultaneously developed: Maintain good accessibility to the ports, increase safety by reducing flood risks and increasing the ecological quality of the delta. This outline has created a framework to guide the development of an updated "Deltaplan" for the Netherlands and the "Sigmaplan" for Belgium. Both plans work by coordinating several local-scale projects along the Western Scheldt.

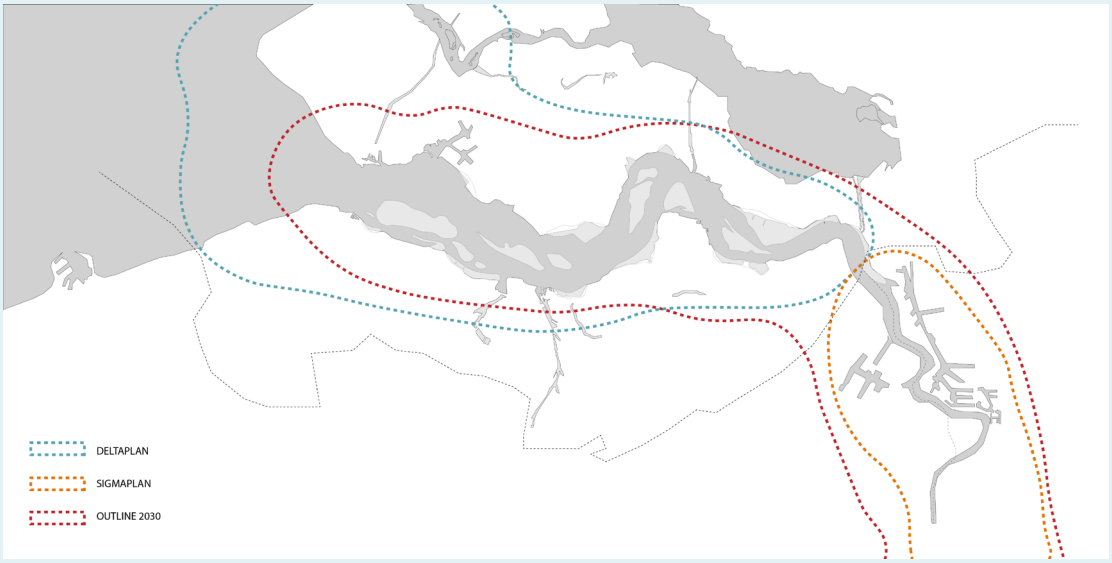

Figure 1: Diagram of plans area of application on the Western Scheldt (Elaborated by author)

The international EU scale also influences the decision-making process in relation to these 3 goals. For example, under the EU nature legislation, port expansions require to compensate for the loss of natural areas with new flooding areas and by 2030 is expected around 2458 ha of these areas to be created. (EEA, 2016, P.4)

From the Belgian side, the Sigma plan considered collaboration between the Flemish and the Dutch government to tackle this compensation for the expansion of the port of Antwerp. This consisted in "depoldering" two adjacent zones of the Scheldt riverbank in order to make room for the river in case of increase of the water level and providing protection. At the same time, such areas will be exposed to the natural tidal processes of the Scheldt, which would help restore some of the intertidal marshes of the river. In this case, the Sigma plan studied and evaluated optimal spaces to intervene with a cost-benefit analysis and several discussions between environmental conservation groups and port authorities. These studies were elaborated with a larger perspective that was not limited to the countries limits, but to the tidal processes along the river. As their results proved that depoldering some areas in both Belgium and the Netherlands would contribute to the optimal solutions, coordination between the 2 countries became necessary. The Belgian government would be responsible for part of the costs related to this project.

Figure 2: Diagram of cross-border depoldering project on the Western Scheldt (Elaborated by author)

Even though both countries initially agreed to this plan, the Dutch government and the citizens presented opposition. Depoldering those areas would result in the loss of agricultural land and the Dutch parliament was not willing to affect the farmers of Zeeland to benefit the development of Flemish ports (Warner and van Buuren, 2009)
The project was supposed to start no later than by 2007, but these reevaluations of the solutions delayed the project, which started in 2017 on the Dutch side. This collaborative process was successful to some extent, but not including the group that was going to be mostly affected by the deal resulted in a major setback to the implementation of the plan (Warner and van Buuren, 2009)

Planning coordination in this case will result in an extensive area of ecological value, which if it was managed separately would have had an inferior spatial structure. Both depoldered area will now be connected to the adjacent natural estuary. Coordination could have been optimal if both timelines were integrated. It would have resulted in efficient use of resources to transform the areas, a more concentrated impact related to noise and pollution. From an economic perspective, this EbA strategy based on the restauration of marsh areas will have recovered the investments in a period of 20 years (Broekx et al, 2011, .57)

The discussion about planning coordination still has a lot of potential to improve the conditions in the Western Scheldt. Until recently, the development of the ports along this river have followed autonomous development patterns. This means that there is high competition between all the ports in the area and results in misuse of resources, unnecessary environmental impacts and even wasted economic opportunities. Recent models, including the Ghent-Terneuzen port association and the branding of the combined Flemish ports as "Flemish port area" are changing this pattern and will require further development of these context-specific governance structures, the coordination between scales (including cross-border regions) and the involvement of all the relevant stakeholders to implement future infrastructure that can reduce the pressure over the local ecosystems.

CONCLUSION:

Planning coordination may contribute to any large-scale strategy, but it is fundamental for the development of plans involving ecosystem management, including ecosystem-based adaptation (EbA). The scale and time frames of EbA are large and complex to incorporate in planning, but in a long-term perspective can offer a very positive cost-benefit balance.
Governance requires to understand the territorial dimension of ecosystems and elaborate custom planning systems that respond to them. This may demand for flexibility in the areas of concern of traditional planning scales and have "fuzzy boundaries" between different local, regional and even national divisions to define possible EbA strategies. Coordination between the multiple scales involved in these ecological dynamics will facilitate recognizing the value of local adaptation strategies and how they can contribute towards the overall systems' adaptive capacity and mitigation of impacts. The involvement of the multiple sectors and stakeholders will facilitate the flow of knowledge and perspectives, increase the benefits and distribute them more equally.
As it can be seen on the case study, the Netherlands and Belgium cannot be restricting their concerns to the borders when natural dynamics take place in both countries. Trying to balance economic development of the ports, safety in relation to flood risk and environmental concerns became the pillars to align the different priorities of both countries. This reduces the potential of one country's solution to become and incremental issue for the other. The plan considered international, national, regional and local scales and developed strategic plans associated with the river ecosystems. This allows to implement local measures that can adapt according to long-term objectives and benefit the whole system' equilibrium. The omission of the most affected group (Zeeland farmers) in the decision-making process proved to affect the level of efficiency to implement the project by delaying part of it for 10 years. Luckily the plans remained as they were planned in the beginning and can still result in a highly successful adaptation strategy.
This example of cross-border coordination can provide lessons for future collaboration between Belgium and the Netherlands. There are multiple opportunities to operationalize EbA strategies and contribute to the outline's 2010 goal of an accessible, safe and natural Wester Scheldt in 2030 if the regional port infrastructures develop as a network instead of as autonomous entities.

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15.3. BUILDING WITH NATURE (BWN) IN THE REGION

12 Typologies of BwN projects have been identified, which can contribute to the Port Accessibility / Nature Conservation conflicts and are applicable on the Western Scheldt.

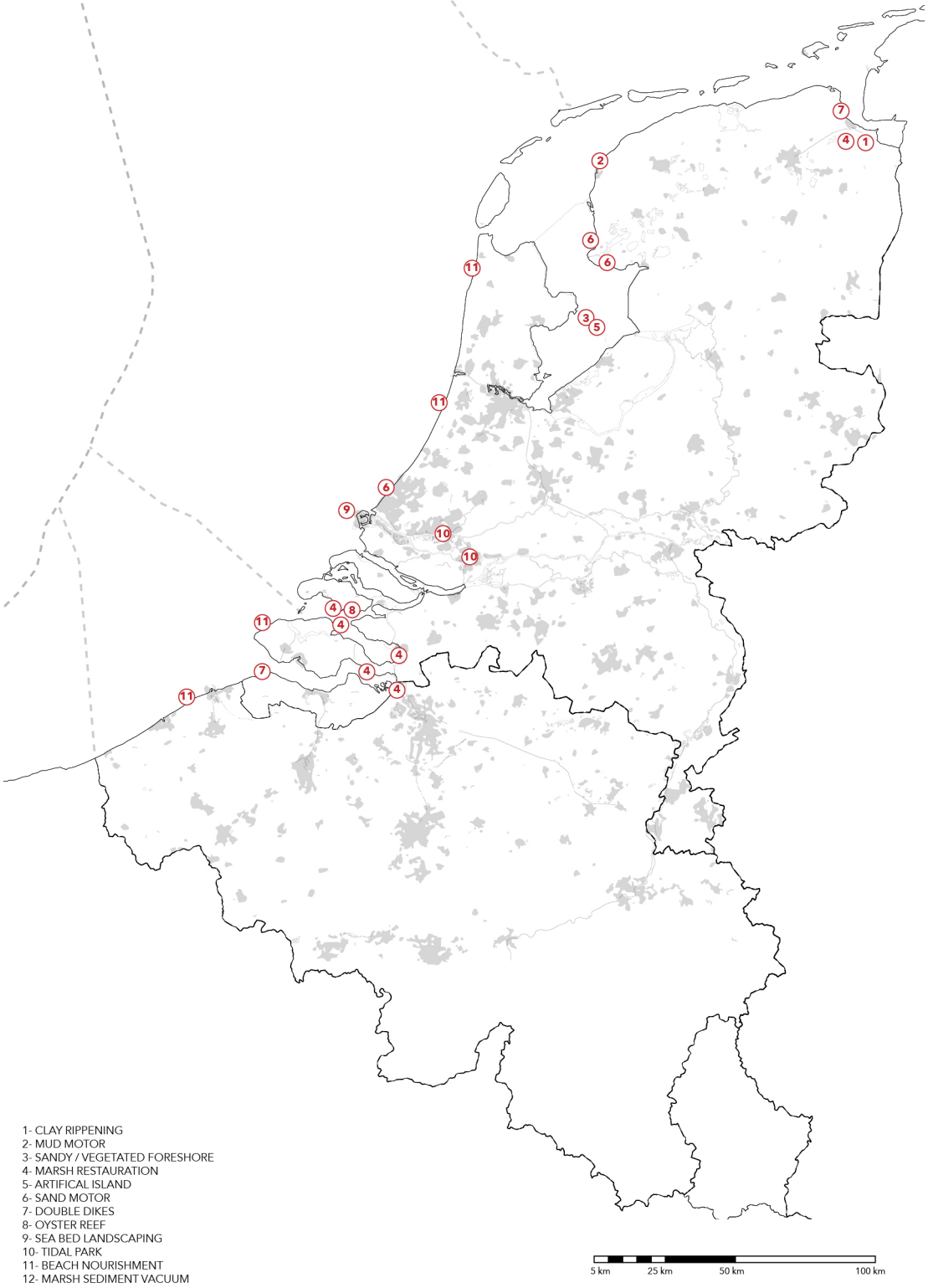
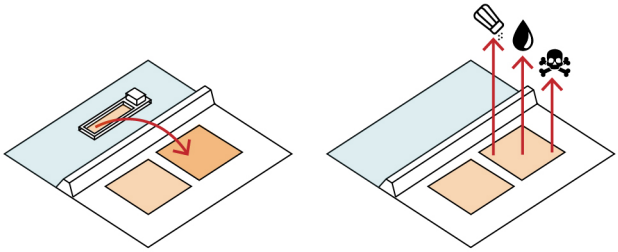


Figure. Location of BwN projects in the Netherlands and Belgium.
(Elaborated by author. Sourcec: ECOSHAPE)

BUILDING WITH NATURE STRATEGIES

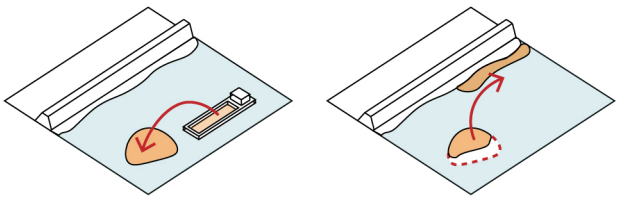
1- CLAY RIPENING



On the higher parts of the Western Scheldt, the sediment balance results in a total accretion. The exceeding material can be extracted, processed and used in land.
Clay ripening extracts water, pollutants and salinity from the clay to make it suitable for landfills and construction material.

- Efficient use of exceeding dredged material
- Clean polluted sediments, maintain intertidal conditions
- Source material

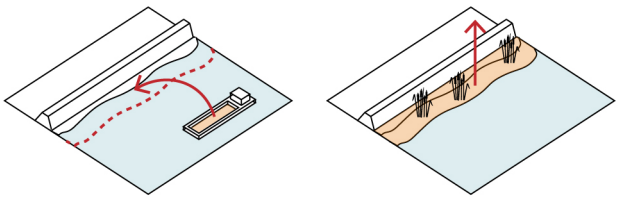
2- MUD MOTOR



The Western Scheldt is exposed to both sea currents and fluvial processes. As a result, sediments are constantly being moved from one place to another.
By understanding such movements, dumping of dredged material can be optimized and used to deal with erosion.

- Efficient use of exceeding dredged material
- Dike reinforcement
  Wave dissipation
- Habitat development
- Space for recreation and learning

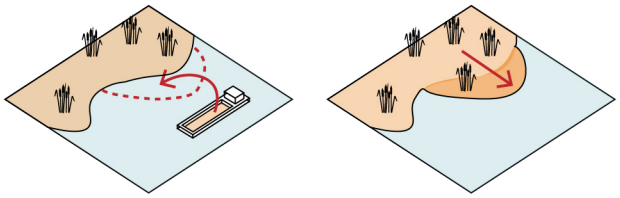
3- SANDY / VEGETATED FORESHORE



Some shoal and river banks experience erosion, which eventually compromises the stability of the soil.
By extending the foreshore and using barriers and vegetation, sediments can be captured.

- Avoid shoal and bank collapse that obstruct navigation channels
- Reduced scouring, dike stability
- Vegetated foreshores have high potential for habitats
- Local economies for fishing, aquaculture and algae

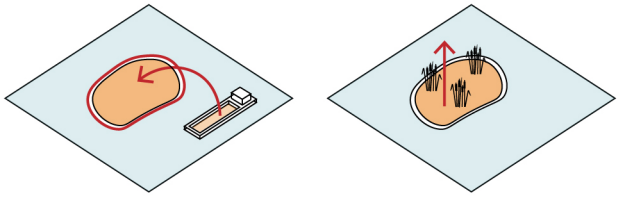
4- MARSH RESTAURATION



The most valuable ecosystems of the Western Scheldt are created by the tidal influence on natural areas. Both increasing the space of the river and the elevation of water areas can increase the habitats.

- Efficient use of exceeding dredged material
- Tide and wave dissipation
- More biodiversity, water purification
- +

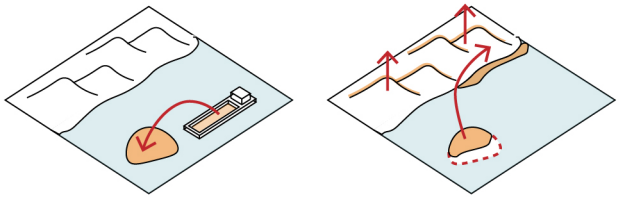
5- ARTIFICAL ISLAND



Coastlines are exposed to the sea and its waves. Shallow areas and island formations receive these wave impacts first. The waves lose intensity when they reach the shores.

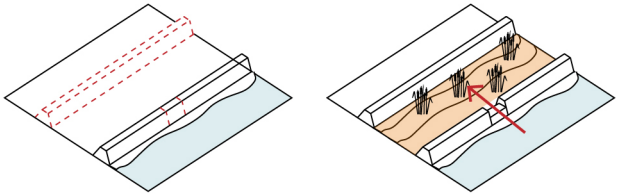
- Efficient use of exceeding dredged material
- Wave dissipation
- Habitat development
- Land to be used for different activities

6- SAND MOTOR



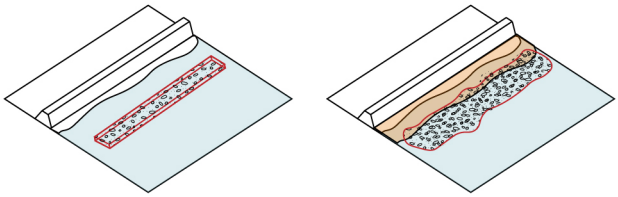
The Dutch and Belgian coasts are experiencing an overall sediment loss. Nourishment is used to maintain the coastlines. The sand motor principle uses the currents to distribute the additional sand deposited.

- Efficient use of exceeding dredged material
- Dune and coastline preservation
  Wave dissipation
- Habitat development
- Space for recreation and learning



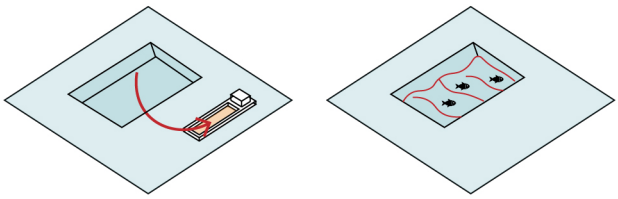
The low density and rural dominance in Zeeland favors the alternative to transform back agricultural land into marshes. These in between areas can have controlled flooding and still be productive.

- Sediment catchment
- Tide and wave dissipation
- More biodiversity, water purification
- Recreation, learning, local food production



Some banks of the Western Scheldt need additional protection to maintain stability. Some Oysters can create very resistant reef structures, which can be used as an alternative to build barriers and wave breakers.

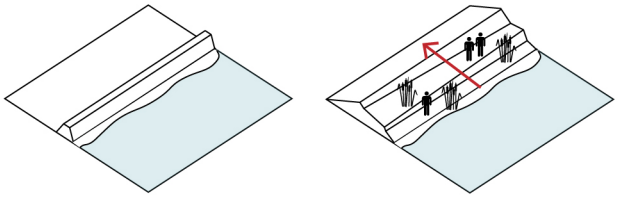
- Sediment catchment
- Wave dissipation
- More biodiversity, water purification
- Food source



The need to extract sand from the sea will continue to increase for both beach replenishment and construction purposes, specially under intense sea level rise. This method of sand extraction creates patterns, which favor habitat creation.

- Deeper navigation channels
- Biodiversity increase, habitat restauration
- Food sources

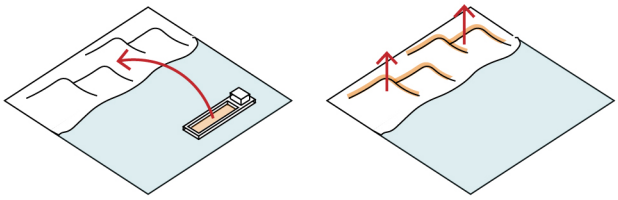
10- TIDAL PARK



Another way to deal with the wave intensity is to push back the flood defences and make room for the river. Those areas can be used for nature development as well as recreation.

- Wave dissipation
- More intertidal habitats
- Recreation, learning, local production

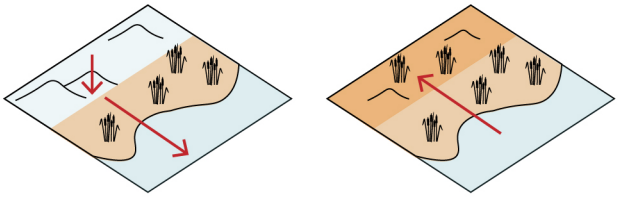
11- BEACH NOURISHMENT



The coastline of Zeeland and Flanders is exposed to erosion and sea level rise. To maintain the sediment balance sand can be extracted from lower areas and dumped on the beaches.

- Strategic dumping of dredged material
- Higher dunes
- Coastal nature preservation

12- MARSH SEDIMENT VACUUM *



Some marshes accumulate sediments at a fast rate. As a result of this, their elevation changes and eventually tides don't reach those areas. To extract exceeding sedimentation can help to maintain the tidal influence and habitat quality.

- Reduced sedimentation on navigation channels
- Wave dissipation
- Habitat quality maintenance
- Local economies for fishing, aquaculture, algae and sediments

15.4 STAKEHOLDER LIST ON THE WESTERN SCHELDT IN RELATION TO PORT DEVELOPMENT, NATURE, SAFETY

PUBLIC

EUROPEAN SCALE

DUTCH GOVERNMENT
MINISTRY OF INFRASTRUCTURE AND WATER MANAGEMENT
MINISTRY OF AGRICULTURE, NATURE AND FOOD QUALITY
MINISTRY OF ECONOMIC AFFAIRS AND CLIMATE POLICY
Rijksdienst voor Ondernemend Nederland (RVO)
MINISTRY OF FOREIGN AFFAIRS

BELGIAN GOVERNMENT
MINISTRY OF FOREIGN AND EUROPEAN AFFAIRS

FLEMISH GOVERNMENT
Flemish Ministry for Mobility and Public Works, the Brussels Periphery, Tourism and Animal Welfare
Flemish Ministry for Town and Country Planning, Environment and Nature
Flemish Ministry for Finance, Budget and Energy
Flemish Ministry for Work, Economy, Innovation, Scientific Policy and Sport
EQUIVALENT TO RIJKSWATERSTAAT IN FLANDERS

RIJKSWATERSTAAT ZEELAND
PROVINCE OF ZEELAND
PROVINCE OF ANTWERP
PROVINCE OF EAST FLANDERS

PORT OF ANTWERP
PORT OF ZEEBRUGGE
PORT OF ZEELAND / PORT OF GHENT

MUNICIPALITY OF SLUIS
MUNICIPALITY OF VLISSINGEN
MUNICIPALITY OF HULST
MUNICIPALITY OF ANTWERP
MUNICIPALITY OF BRUGGES
MUNICIPALITY OF KNOKKE-HEIST

WATERBOARD ZEE AND DELTA

PRIVATE

WORLD ORGANIZATION OF DREDGING ASSOCIATIONS (WODA)
INTERNATIONAL ASSOCIATION OF DREDGING COMPANIES (IADC)
Dredging companies
Van oord
Boskalis
Royal hoskoning dhv
DEME
Envisan (Dredging and silt tratment)
SEREANT (DEME + Envisan)

TRANSPORTATION COMPANIES

NAVIGATION
GEMEENSCHAPPELIJKE NAUTISCHE AUTORITEIT (GNA)

WATER SAFETY
HKV CONSULTANCY

ENERGY

CONSTRUCTION
SVK
AGREX

OTHERS:

ECOSHAPE - NATURE BASED SOLUTIONS
IMPULS ZEELAND - INNOVATION AND BUSSINESS

RESEARCH

TU DELFT
UNIVERSITY OF WAGENINGEN
VRIJJE UNIVERSITETI AMSTERDAM
UNIVERSITY OF TWEENTE
UNIVERSITY OF UTRECHT

UNIVERSITY OF ANTWERP
UNIVERSITY OF GHENT

DELTARES
IMARES

STOWA

CIVIL / NGO

LOCAL RESIDENTS NL
LOCAL RESIDENTS BE

ROYAL DUTCH ANGLING ASSOCIATION (recreational fishing)

LOCAL FISHERS / COLLECTORS -
Nederlands Genootschap voor Aquacultuur (NGvA)
Nederlandse Vereniging van Viskwekers (NEVEVI)

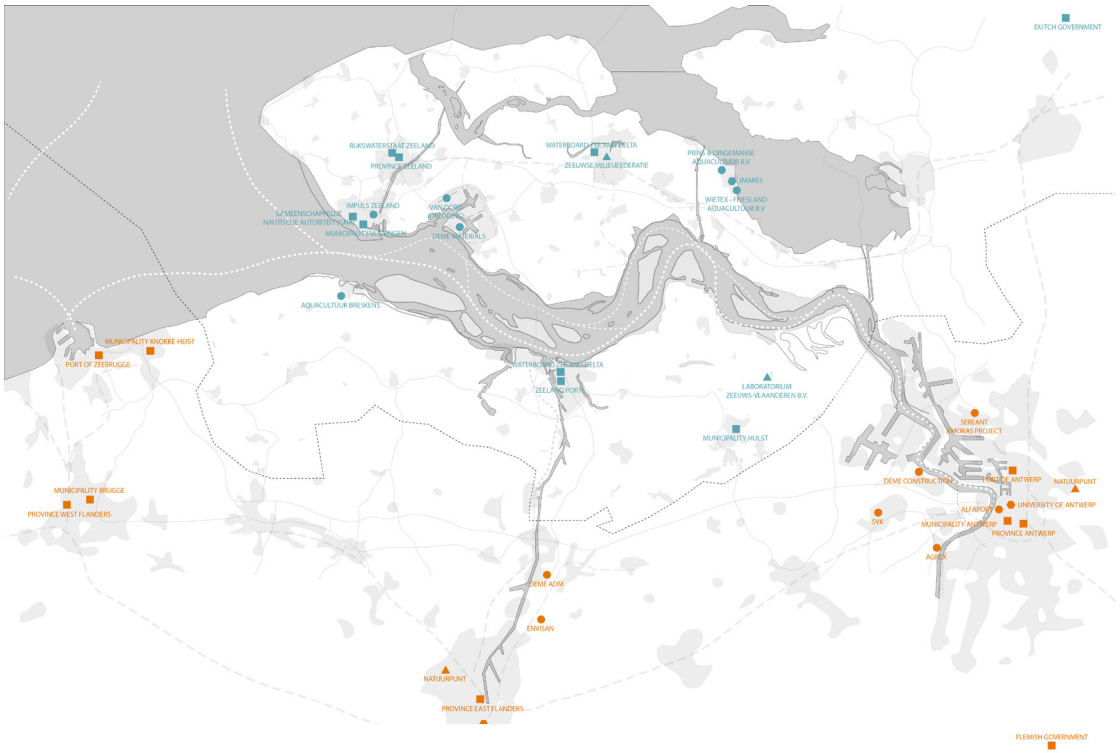
LOCAL FARMERS

NATUURMONUMENTEN
NATUURPUNT
WETLANDS INTERNATIONAL

ZEEUWSE MILIEUFEDERATIE (ZMF)

STICHTING DE NOORDZEE

15.4 1.STAKEHOLDER LIOCATION ON THE WESTERN SCHELDT IN RELATION TO PORT DEVELOPMENT, NATURE, SAFETY



BELGIAN / DUTCH PUBLIC STAKEHOLDER

BELGIAN / DUTCH PRIVATE STAKEHOLDER

BELGIAN / DUTCH RESEARCH STAKEHOLDER

BELGIAN / DUTCH CIVIL STAKEHOLDER

15.4.2. STAKEHOLDERS' INTEREST, RESPONSABILITIES AND BENEFITS

PROJECT 1: SAND NOURISHING ISLAND

STAKEHOLDER	MAIN INTEREST	SCALE OF OPERATION
PORT OF ZEEBRUGGE	Economic growth Increase competitiveness Balance profit, people and planet	International - Regional
REGIONAL GOVERNMENT FLANDERS	Sustainable and optimal use of the scarce and therefore valuable areas	Regional
MINISTRY FOR MOBILITY, PUBLIC WORKS, ..	Provide and efficient newtork for different modes of mobility Effective water management to protect from flooding and provide an improved water and air quality	Regional
MINISTRY FOR ... ENVIRONMENT AND NATURE	Limiting and reversing harmful impacts on water systems and pollution of the atmosphere, Control noise and odour nuisance and other environmental disturbances that affects people's health	Regional
RIJSWATERSTAAT ZEE AND DELTA	Have a safe, sustainable and prepared country, particularly against flood risks	Regional
PORT OF ANTWERP	Economic growth Increase competitiveness Develop as an European logistics, maritime and industrial center	International - Regional
HANSON AGGREGATES	Provide responsible, reliable, safe and good quality service in producing and distributing agreggates	International - Regional
ECOSHAPE	Through interdisciplinary collaboration find effective solutions for engeneering that boost nature, recreation and economy Develop and spread knowledge about BWN	National
UNIVERSITIES	Transfer expert knowledge to be used in and for society	National
MUNICIPALITY BRUGGES	Economic, social and environmental development of their territory, with the appropiate management of the resources and promoting participation of the community	Local
MUNICIPALITY KNOKKE-HEIST	Economic, social and environmental development of their territory, with the appropiate management of the resources and promoting participation of the community	Local
MUNICIPALITY SLUIS	Economic, social and environmental development of their territory, with the appropiate management of the resources and promoting participation of the community	Local
PROVINCE OF ZEELAND	Economic development, growth, innovation in Zeeland Be strong in the sectors of biobased economy, ports and logistics, recreation, tourism, energy, agriculture and fishing and aqualulture Rural development and nature restauration	Regional
DREDGING COMPANIES	Provide innovative and competitive solutions, while maintaining high standards of safety and sustainability	National - National
ENVIRONMENTAL NGO's	The long-term protection of important habitats, species and landscapes	International - National
SAILING CLUB ZEEBRUGGE (RBSC)	Promote water sports and pleasure boating Ensure optimal conditions of the infrastructure for this use	Local
FLEMISH FISHAUCTION AQUACULTURE (VLL)	Bring together the supply and demand of fresh wild fish	Local
LOCAL RESIDENTS	Good health, education, job opportunities, safety life quality, healty environment, access to services	Local
HOTELS, RESTAURANTS, CATERING FLANDERS	Advocacy, support and networking in the hospitality industry	Local

PROJECT 1: SAND NOURISHING ISLAND

STAKEHOLDER	RESPONSABILITIES	BENEFITS
PORT OF ZEEBRUGGE	Main investor as compensation for habitat and erosion	Improved environmental qualities Shared costs of port expansion
REGIONAL GOVERNMENT FLANDERS	Economic support Sand nourishing island project Regulations new island space	Increased flood safety in coasts Economic growth
MINISTRY FOR MOBILITY, PUBLIC WORKS, ..	Support Flemish ports accesibility Infrastructure development	Increased efficiency Improved traffic in navigation channel
MINISTRY FOR ... ENVIRONMENT AND NATURE	Regulate new nature and forms of interventions Monitor the evolution of the nourishing island, coast expansions and Zwin polder	Shared costs of nature development Resources and labor force to maintain new nature in foreshores
RIJSWATERSTAAT ZEE AND DELTA	Monitor of the coastal sediment balance Consultation about sand motor principles	"Free" coaastal nourishment in Sluis coasts
PORT OF ANTWERP	Economic support	Shared costs of infrastructure development
HANSON AGGREGATES	Regulate siltation in Zwin Polder Control clay rippening station	Increased volume of raw material for comercialization
ECOSHAPE	Supervision of the evolution of the nourishing island and clay rippening site	Improvement of their BwN understanding for future projects
UNIVERSITIES	Research and modelling of possible effects and changes Monitor biophysical changes	Jobs
MUNICIPALITY BRUGGES	Supervision of the port expansion and island project Regulate activities in new island space	More protected areas of ecological value Economic gorwth
MUNICIPALITY KNOKKE-HEIST	Regulation of activities in new beach areas	Increased flood safety in coasts Beach expansion area for new activities
MUNICIPALITY SLUIS		Increased flood safety in coasts
PROVINCE OF ZEELAND	Regulate on coastal nourishment Consultation about sand motor principles	Increased flood safety
DREDGING COMPANIES	Nourishment of the sand island + repelishment	
ENVIRONMENTAL NGO's	Financial support maintenace of new nature	More protected areas of ecological value
SAILING CLUB ZEEBRUGGE		Expanded activity
FLEMISH FISHAUCTION AQUACULTURE	Support new aquaculture	Expanded activity
LOCAL RESIDENTS		New recreation areas Improved environmental qualities
HOTELS, RESTAURANTS, CATERING FLANDERS	Spread local values and identity	Local business opportunities / jobs

PROJECT 2: EXTENDED STABLE FORESHORES

STAKEHOLDER	MAIN INTEREST	SCALE OF OPERATION
PORT OF ANTWERP	Economic growth Increase competitiveness Develop as an European logistics, maritime and industrial center	International - Regional
RIJKSWATERSTAAT ZEE AND DELTA	Have a safe, sustainable and prepared country, particularly against flood risks	Regional
PROVINCE ZEELAND	Economic development, growth, innovation in Zeeland Be strong in the sectors of biobased economy, ports and logistics, recreation, tourism, energy, agriculture and fishing and aqualulture Rural development and nature restauration	Regional
MINISTRY OF AGRICULTURE, NATURE AND FOOD QUALITY	Restore and maintain natural areas Consolidate the agriculture sector's leading position Strengthen the link between nature and agriculture Improve farmers' economic situation	Regional
WATERBOARD ZEE AND DELTA	Maintenace of dikes and dunes for safe living conditions work, recreation, and trnasportation	Local
DREDGING COMPANIES	Provide innovative and competitive solutions, while maintaining high standards of safety and sustainability	National - National
PORT OF GHENT	Economic growth through the diversification of sectors Achieve a sustainable increase in added value employment and transhipment volumes	International - Regional
PORTS OF ZEELAND	Economic growth through the diversification of sectors Achieve a sustainable increase in added value employment and transhipment volumes	International - Regional
COMMON NAUTIC AUTHORITY WESTERN SCHELDT (GNA)	Responsible use of the waterway by shipping and for the management of traffic	Regional
MINISTRY FOR MOBILITY, PUBLIC WORKS, ..	Policy making, for mobility and road safety Investment, management and operation of the transport and port infrastructure:	Regional
MUNICIPALITY HULST	Economic, social and environmental development of their territory, with the appropiate management of the resources and promoting participation of the community	Local
UNIVERSITIES	Transfer expert knowledge to be used in and for society	National
ECOSHAPE	Through interdisciplinary collaboration find effective solutions for engeneering that boost nature, recreation and economy Develop and spread knowledge about BWN	National
IMPULS ZEELAND	Develop opportunities in Zeeland for innovative and sustainable business ventures Connecting entrepreneurs with institutes of higher education, governmental organizations, economic actors	Regional
ENVIRONMENTAL NGO'S	The long-term protection of important habitats, species and landscapes	International - National
REGIONAL GOVERNMENT FLANDERS	Sustainable and optimal use of the scarce and therefore valuable areas	Regional
LOCAL FARMERS	Good working conditions, fairly profitable work	Local
DUTCH ASSOCIATION FOR AQUACULTURE (NGVA)	Exchange knowledge and experience of the field of aquaculture Create networks of contacts	National
LOCAL RESIDENTS	Good health, education, job opportunities, safety life quality, healty environment, access to services	Local
MUNICIPALITY REIMERSWAAL MUNICIPALITY VLISSINGEN MUNICIPALITY TERNEUZEN	Economic, social and environmental development of their territory, with the appropiate management of the resources and promoting participation of the community	Local

PROJECT 2: EXTENDED STABLE FORESHORES

STAKEHOLDER	RESPONSABILITIES	BENEFITS
PORT OF ANTWERP	Main investor foreshore extension project	Reduced dredging maintenance Reduced obstruction risks
RIJKSWATERSTAAT ZEE AND DELTA	Main investor foreshore extension project	Shared costs of flood safety project Extended life of dikes
PROVINCE ZEELAND	Economic support Regulation on the new habitats and conditions for intervention	More areas of ecological value Reduced flood risks Improved environmental qualities
MINISTRY OF AGRICULTURE, NATURE AND FOOD QUALITY	Regulate new nature and new forms of aquaculture Support development of new nature and new forms of aquaculture	Shared costs of nature development Resources and labor force to maintain new nature in foreshores
WATERBOARD ZEE AND DELTA	Maintenace of dikes	Dikes need less maintenance and last longer if waves are dissipated
DREDGING COMPANIES	Sustainable dredging and dumping Maintenance eroding banks	Work on flood safety issues
PORT OF GHENT	Economic support	Reduced dredging maintenance Reduced obstruction risks
PORTS OF ZEELAND	Economic support	Reduced dredging maintenance Reduced obstruction risks
COMMON NAUTIC AUTHORITY WESTERN SCHELDT (GNA)	Monitor the navegability conditions Consultation in relation to changes in navigation routes	Maintain safe, efficient and informed navigation
MINISTRY FOR MOBILITY, PUBLIC WORKS, ..	Supervision of the changes in navegability	
MUNICIPALITY HULST	Economic support Land use regulations Supervision of the evolution of the foreshores and oyster reefs	Reduced costs of safety infrastructure Improved environmental qualities
UNIVERSITIES	Research and modelling of possible effects and changes Monitor biophysical changes	Jobs
ECOSHAPE	Supervision of the evolution of the foreshores and oyster reefs Consultation regarding maintenance	Improvement of their BwN understanding for future projects
IMPULS ZEELAND	Support innovation in aquaculture	Development of regional branding
ENVIRONMENTAL NGO'S	Financial support maintenace of new nature	More protected areas of ecological value
REGIONAL GOVERNMENT FLANDERS	Economic support for maintenance of the navigation channel	Economic gorwth
LOCAL FARMERS	Maintain foreshores clean and healthy	Development on aquaculture Jobs
DUTCH ASSOCIATION FOR AQUACULTURE (NGVA)	Support new aquaculture	
LOCAL RESIDENTS	Collaborate in maintenance Inform problems	Improved environmental qualities Local business opportunities / jobs Recreation areas
MUNICIPALITY REIMERSWAAL	Economic support Land use regulations Supervision of the evolution of the foreshores and oyster reefs	Reduced costs of safety infrastructure Improved environmental qualities
MUNICIPALITY VLISSINGEN	Economic support Land use regulations Supervision of the evolution of the foreshores and oyster reefs	Reduced costs of safety infrastructure Improved environmental qualities
MUNICIPALITY TERNEUZEN	Economic support Land use regulations Supervision of the evolution of the foreshores and oyster reefs	Reduced costs of safety infrastructure Improved environmental qualities

PROJECT 1: SAND NOURISHING ISLAND

STAKEHOLDER	MAIN INTEREST	SCALE OF OPERATION
PORT OF ANTWERP	Economic growth Increase competitiveness Develop as an European logistics, maritime and industrial center	International - Regional
RIJKSWATERSTAAT ZEELAND	Have a safe, sustainable and prepared country, particularly against flood risks	Regional
PROVINCE ZEELAND	Economic development, growth, innovation in Zeeland Be strong in the sectors of biobased economy, ports and logistics, recreation, tourism, energy, agriculture and fishing and aqualulture Rural development and nature restauration	Regional
MINISTRY OF AGRICULTURE, NATURE AND FOOD QUALITY	Restore and maintain natural areas Consolidate the agriculture sector's leading position Strengthen the link between nature and agriculture Improve farmers' economic situation	Regional
ECOSHAPE	Through interdisciplinary collaboration find effective solutions for engeneering that boost nature, recreation and economy Develop and spread knowledge about BWN	National
MINISTRY FOR MOBILITY, PUBLIC WORKS, ..	Policy making, for mobility and road safety Investment, management and operation of the transport and port infrastructure:	Regional
WATERBOARD ZEE AND DELTA	Maintenace of dikes and dunes for safe living conditions work, recreation, and trnasportation	Local
MUNICIPALITY OF HULST	Economic, social and environmental development of their territory, with the appropiate management of the resources and promoting participation of the community	Local
SEREANT	Separate the sand extracted in the maintenance dredging material and treat it.	Local
UNIVERSITIES AND RESEARCH	Transfer expert knowledge to be used in and for society	National
PROVINCE OF ANTWERP	Economic growth Increase competitiveness Develop as an European logistics, maritime and industrial center	International - Regional
MUNICIPALITY OF REIMERSWAAL	Economic, social and environmental development of their territory, with the appropiate management of the resources and promoting participation of the community	Local
MUNICIPALITY OF ANTWERP AND BEVEREN	Economic, social and environmental development of their territory, with the appropiate management of the resources and promoting participation of the community	Local
IMPULS ZEELAND	Develop opportunities in Zeeland for innovative and sustainable business ventures Connecting entrepreneurs with institutes of higher education, governmental organizations, economic actors	Regional
LOCAL FARMERS	Good working conditions, fairly profitable work	Local
RESIDENTS EMMADORP	Good health, education, job opportunities, safety life quality, healty environment, access to services	Local
DREDGING COMPANIES	Provide innovative and competitive solutions, while maintaining high standards of safety and sustainability	National - National
ENVIRONMENTAL NGO's	The long-term protection of important habitats, species and landscapes	International - National
SVK	Manufacture sustainable construction materials	International - Regional

PROJECT 3: DOUBLE DIKE FOR DEPOLDERING

STAKEHOLDER	RESPONSABILITIES	BENEFITS
PORT OF ANTWERP	Main investor as compensation	Shared profit for sediment treatment Reduced dredging maintenance
RIJKSWATERSTAAT ZEELAND	Economic support Double dike infrastructure project	Shared costs of flood safety project
PROVINCE ZEELAND	Economic support Regulation on the expanded network of natural spaces	More areas of ecological value
MINISTRY OF AGRICULTURE, NATURE AND FOOD QUALITY	Regulate new nature and new forms of agriculture Support development of new nature and new forms of agriculture	Shared costs of nature development
ECOSHAPE	Supervision the land transformation of the depoldered area Consultation regarding maintenance	Improvement of their BwN understanding for future projects
MINISTRY FOR MOBILITY, PUBLIC WORKS, ..	Economic support Consultation regarding safety	Increased flood safety
WATERBOARD ZEE AND DELTA	Maintenace of dikes	Dikes need less maintenance and last longer if waves are dissipated
MUNICIPALITY OF HULST	Regulation on the land use changes Development agenda to transfer knowledge to locals Supervision and management of transformed space	Improved air, water and soil quality Increased flood safety Jobs
SEREANT	Treat and purify sediments	Shared profit for sediment treatment
UNIVERSITIES AND RESEARCH	Research and modelling of possible effects and changes Monitor biophysical changes	Jobs
PROVINCE OF ANTWERP	Economic support Regulation of Natura 2000 compensation and management	Reduced costs of safety infrastructure
MUNICIPALITY OF REIMERSWAAL		Increased flood safety
MUNICIPALITY OF ANTWERP AND BEVEREN		Increased flood safety
IMPULS ZEELAND	Support innovation in agriculture	Development of regional branding
LOCAL FARMERS	Develop nature friendly and salinity resistant agriculture	Diversification of agriculture Lower maintenace in production
RESIDENTS EMMADORP	Provide imput for relocation project Spread local values	Safer community in relation to flood risks
DREDGING COMPANIES	Transport dredged material to be treated and purified	
ENVIRONMENTAL NGO's	Financial support maintenace of new nature	More protected areas of ecological value
SVK	Transform sediments into construction materials	Increased volume of raw material

15.5. DETAILED RESEARCH FRAMEWORK

MOTIVATION

Climate change is threatening humans and the built environment.
Coastal areas are particularly vulnerable and about 23% of the population live near the coast.
Cities need to become more resilient to these threats
Ecosystem-based adaptation (EBA) strategies have emerged recently in planning as a good alternative to respond to climate change.

PROBLEM FIELD

The challenge is to take EbA from a desired goal to practical solutions
The territorial dimension of ecosystems are not aligned with traditional administrative boundaries.
Coordination in planning is key to implement such complex and long-term strategies, and maximize potential benefits

PROBLEM STATEMENT

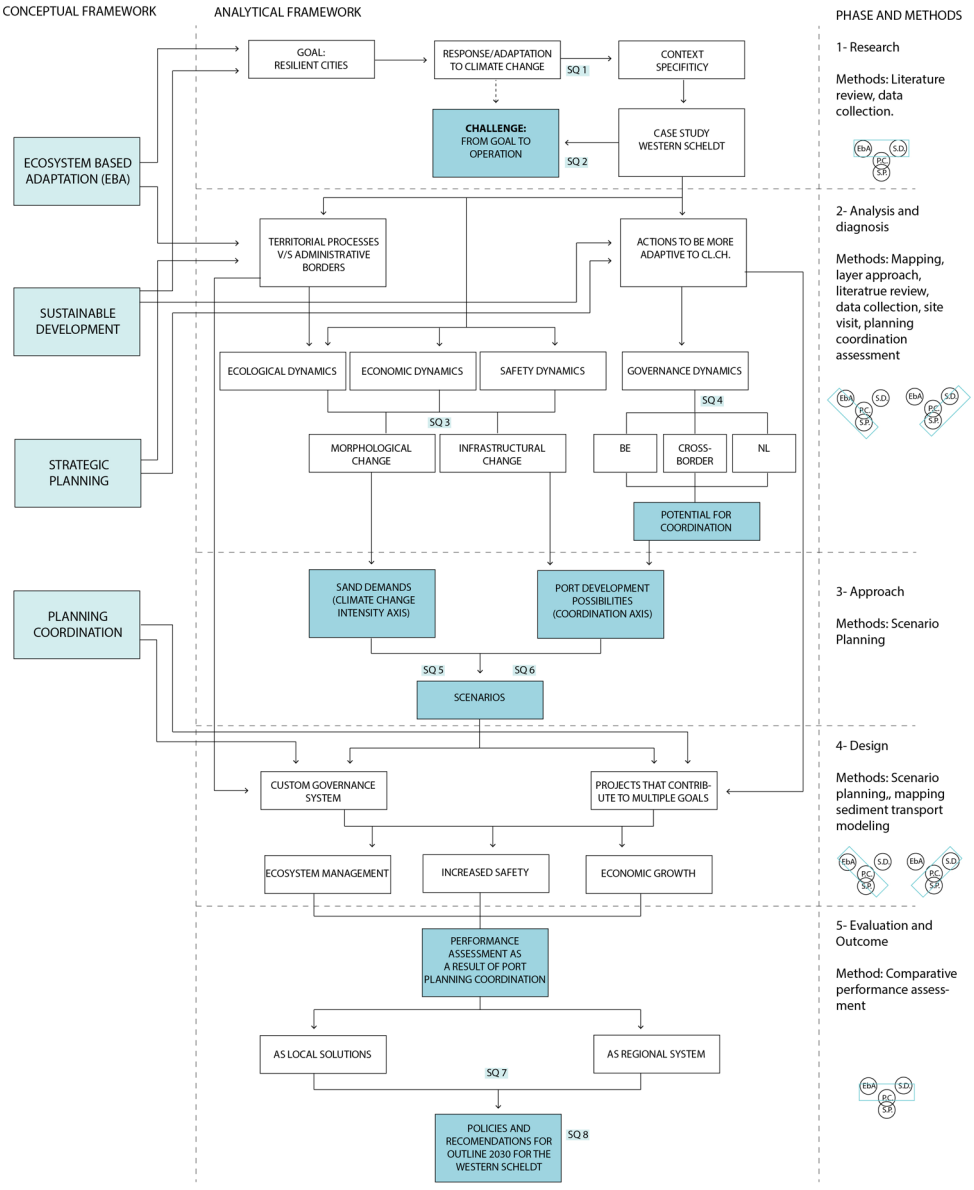
In the cross-border context of the Western Scheldt, where Dutch and Belgian local administrations have a bigger responsibility to develop plans and strategies, finding a way to coordinate efforts can result in a effective and efficient implementation of Ecosystem-based adaptation (EBA) strategies and increase adaptive capactiy to climate change.

RESEARCH QUESTION

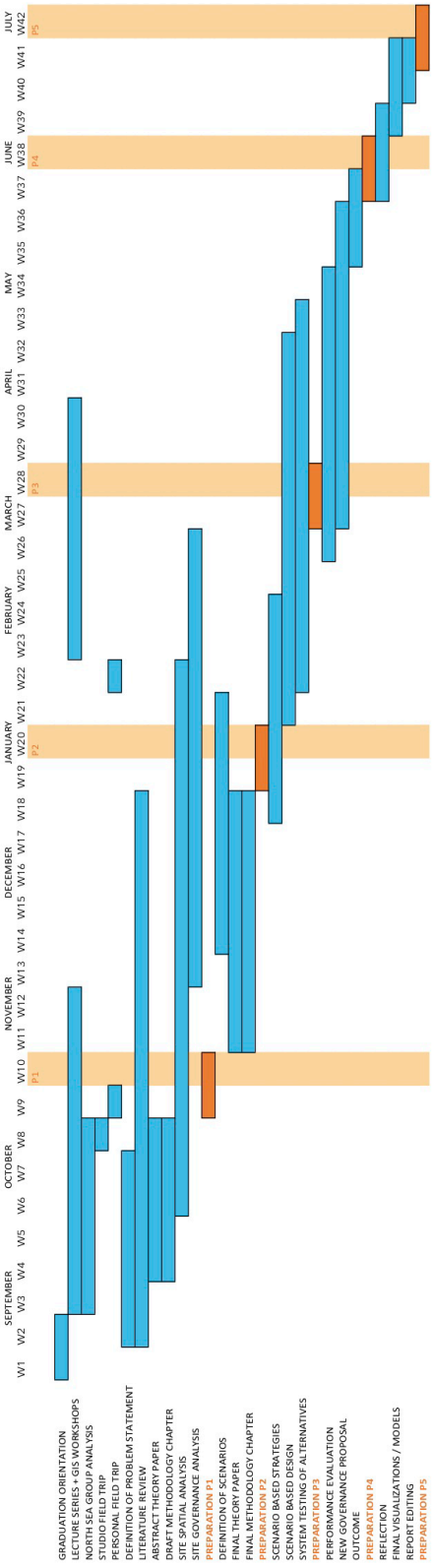
RQ: "How can EbA play a role in the sustainable development of the Western Scheldt, and how can cross-border collaboration in planning be adjusted to facilitate the implementation of EbA strategies?"

SUB- QUESTIONS

SQ1: How can an increasing sand demand influence the development of the Western Scheldt area?
SQ2: What are the values, potentialities and limitations of ecosystems in the Western Scheldt area to facilitate adaptation to climate change?
SQ3: What is the relevance of the port function in the Western Scheldt?
SQ4: How do the safety, ecologic and economic systems relate to each other in the Western Scheldt?
SQ5: What is the influence of the 2 planning systems (Dutch and Belgian) in the Western Scheldt?
SQ6: What are the main alignments and conflicts in policies related to the functions of safety, ecology and accessibility in the Western Scheldt area?
SQ7: What are the main opportunities and limitations from a planning perspective to operationalize EbA in the Western Scheldt area?
SQ8: How can the degree of collaboration of the ports in the Western Scheldt influence the possibilities to implement EbA strategies?
SQ9: How does a high degree of planning collaboration create opportunities for local projects that can help manage the ecosystems of the Western Scheldt?
SQ10: How can the Long-term Vision 2030 for the Western Scheldt facilitate cross-border implementations of adaptive strategies like EbA?



15.5.1 RESEARCH'S TIMELINE



15.6. HISTORICAL GROWTH PORT OF ANTWERP