FACING THE TIDE

Challenging the prevailing perspectives on flood risk management by re-imagining the existing flood management in the Scheldt Estuary as a tool to harmonise human and non-human processes.

Christel Diana Voncken | Metropolitan Ecologies of Places Graduation Report

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Cover image 'Excited Wave' taken by Platteeuw (2015) and modified by the author.

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I would like to thank my mentors, Luca Iuorio and Laura Cipriani, for their invaluable support throughout this thesis. Their guidance helped me think critically and boldly—beyond the conventional. Our sessions were both inspiring and enjoyable. I always left with new perspectives, topics and approaches to explore.

I am also deeply grateful to the participants of the workshop: researchers, government officials, urban designers and planners. They shared with me the local values and socio-political perspectives of the Scheldt Estuary. Their insights not only challenged me to become more critical of my own work and design approach, but also gave me hope for the future of my home region. The workshop was a source of joy and inspiration, and it greatly enriched this thesis.

Lastly, I want to thank my family and friends for their continuous support throughout this process. A special thanks to my partner, who stood by me through difficult moments and supported me emotionally. He, along with our dog Pochi, brought much-needed balance and relief during times of stress.

Thank you all.

MOTIVATION

Growing up in the Dutch delta, I developed a connection with the deltaic landscape and the systems that manage it. This bond was not just geographical. It was personal, emotional and slowly, intellectual. Over the years, what began as fascination turned into a driving curiosity. How do we live with water, and how could we live differently?

One of the most fond memories from my childhood was visiting the Drowned Land of Saeftinghe. Standing in that vast, tidal marshland, I imagined what it would mean to live in such a place. Not by resisting the tide, but by living with it. This idea stayed with me. What if, instead of removing or controlling the delta, we shaped our lives around it? What if we became as dynamic and adaptive as the landscape itself?

As climate change accelerates and sea levels rise, I believe the Netherlands faces one of its greatest existential challenges. Our current way of life is under threat. If we continue along the same path, I fear disaster. Not necessarily for my generation, but for the ones that follow. They too deserve safety and well-being. But achieving that might require a new relationship with the land and water.

This thesis is my attempt to contribute to that shift. I wanted to explore and present an alternative vision for flood and coastal management. One that goes beyond tradition, beyond convenience and dares to imagine a more adaptive and symbiotic way of living with water. My hope is to inspire others to think critically and creatively. And, to see that resilience does not lie in more control, but in learning how to let go.

ABSTRACT

This thesis challenges the dominant paradigm of flood risk management in the Netherlands, which has led to rigid and technocratic landscape practices. The research reimagines flood management as a driver of socio-ecological transformation rather than a threat to be controlled. The thesis tests this approach in The Scheldt Estuary. The study investigates how deactivating existing flood defences might enable new relationships between human and non-human systems. And, how it would reshape the delta as a living and adaptive landscape. It does this through spatial analysis, design exploration and critical reflection.

Four research questions guide this exploration, addressing:

- The historical and social narratives underpinning Dutch coastal management;
- The projected ecological and spatial consequences of returning to Deltaic Conditions;
- The potential of design to reframe flooding from a threat into a generative force;
- And, the strategic pathways to foster symbiosis between human and non-human ecosystems.

Three design scenarios illustrate how different levels of engagement with tidal processes (retreat, adaptation, and cohabitation) could inform a new form of "Tidal Urbanism." An approach that is responsive to changing conditions while remaining sensitive to deltaic contexts. This approach serves as the base for the vision .

The thesis concludes with a vision for the Scheldt Estuary in 2130. It imagines a landscape that has shed human boundaries and embraced its identity as a marshland. Flood management evolves into an adaptive system of flow regulation. Coastal design becomes an act of radical co-creation, where humans and non-humans shape space together. Rather than resisting change, this vision welcomes the tide. It offers a future built not on control, but on coexistence. Transformations that would arise from this vision are explored, such as tidal reintegration, modular and delta-sensitive urbanism. The realisation of this vision demands radical changes in space as well as in governance and organisation.

Ultimately, this project reframes resilience not as the elimination of risk, but as the capacity to live with uncertainty; ethically, iteratively and collectively.

Drowned Land of Saeftinghe (Eskonpeupejer, 2019)

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[Fig.1] Storm Eunice Vlissingen (Witte, 2017)

CHAPTER 1 INTRODUCTION

1.1 PROBLEM FIELD: CLIMATE CHANGE AND THE DUTCH DELTA

The Delta Paradox

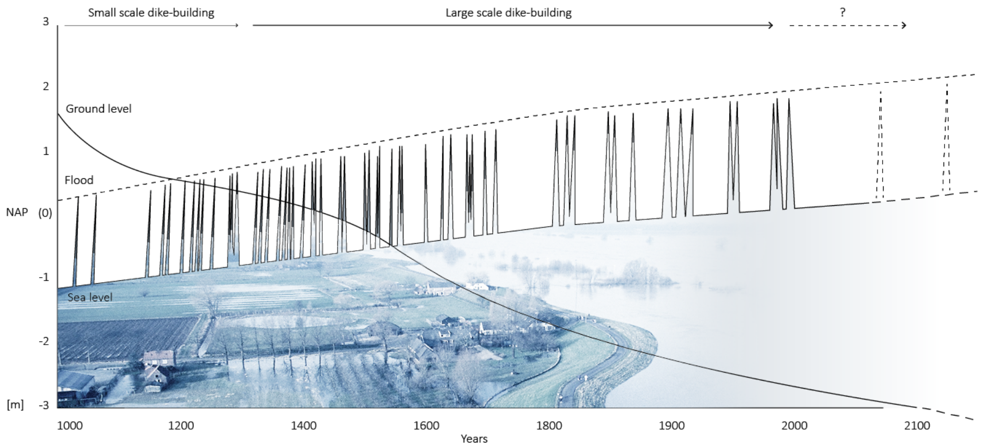
A delta is the meeting point of two systems: the river and the sea. The interplay of these systems shapes the morphology of the landscape and creates a system of connected processes. This environment generates dynamics which result in a wealth of ecosystem services (Meyer, 2022). The fertility and strategic location of deltas have historically attracted human habitation. This began on a small scale but expanded significantly during the Industrial Revolution. A growing belief formed that these dynamic systems could be controlled. Consequently, humans began suppressing the nature of rivers and deltas to maximise socio-economic benefits (Meyer, 2022).

This brings us to the delta paradox. While the deltaic landscape is inherently at risk of flooding, this risk is exacerbated by increasing vulnerabilities coming from long-term exploitation. There remains a strong desire to inhabit these areas due to the quality of life that has been established (Kok et al., 2017). Today a third of the Dutch population (6 mln citizens) lives underneath sea level and two-third in flood prone areas (12 mln citizens) [Fig.2].

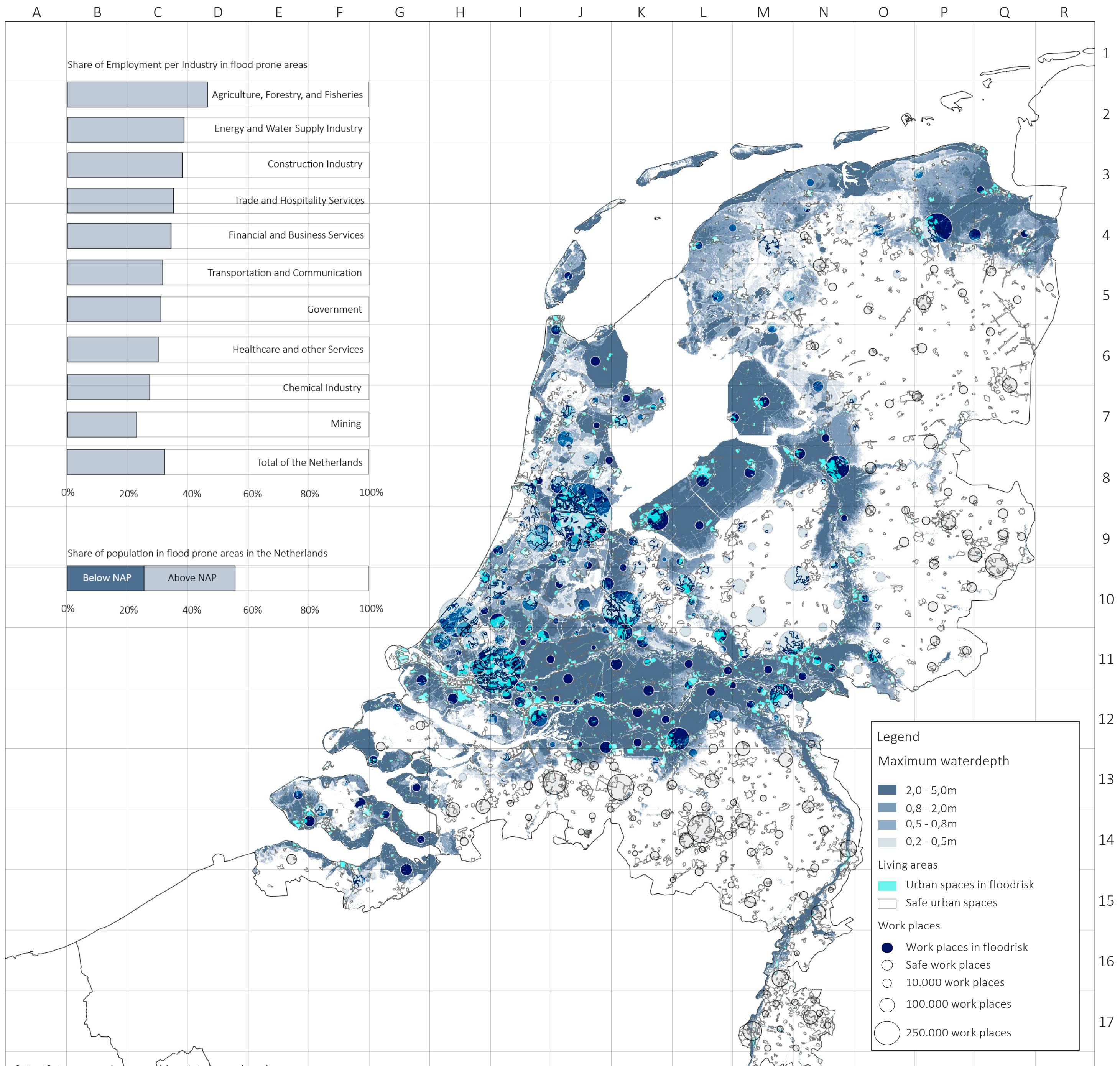
Climate Change and Sea Level Rise

The Dutch Delta illustrates this process. It became a driver of economic growth and prosperity. The natural system has been significantly altered to suit human needs. It functions increasingly like a mechanical system. This has created the illusion that rivers and deltas can be controlled and streamlined like industrial machines. This illusion is now falling apart in the face of climate change and the adverse consequences of mechanisation (Meyer et al., 2022).

While sea levels are rising, the human-altered landscape is sinking [Fig.1]. This increases both the likelihood and the severity of flooding. It represents a turning point where a decision must be made. Either to continue further constraining the delta or to adopt a new direction.



[Fig.1] Changing conditions: Sea level rise and soil subsidence.
Source: (Van Eyck, 1993; Pleijster & Van Der Veeken, 2014)



[Fig.2] Areas endangered by rising sea level.
Source: (CBS, 2009; Keessen et al., 2013; LIWO, 2022; CLO, 2024; TU Delft, 2024)

1.2 PROBLEM FIELD: REACHING THE LIMIT OF MECHANISATION

Dutch Flood Risk Management

Dutch flood management aims to minimise the risk of flooding as much as possible. To achieve this, they use the formula: Flood Probability × Flood Impact = Flood Risk. Flood probability refers to the likelihood of a flood occurring. Flood impact concerns the socio-economic damage that would result if a flood were to occur (Kok et al., 2017). This formula is the base of the three-layered flood management approach. The first step is reducing flood probability through coastal dikes. The second involves reducing damage by compartmentalising the landscape and elevating vital infrastructure. The final step is organising evacuation strategies. However, due to the Netherlands' low-lying geography, reducing flood probability through dikes remains the most effective method of mitigating flood risk (Kok et al., 2017).

Mechanisation of the Landscape

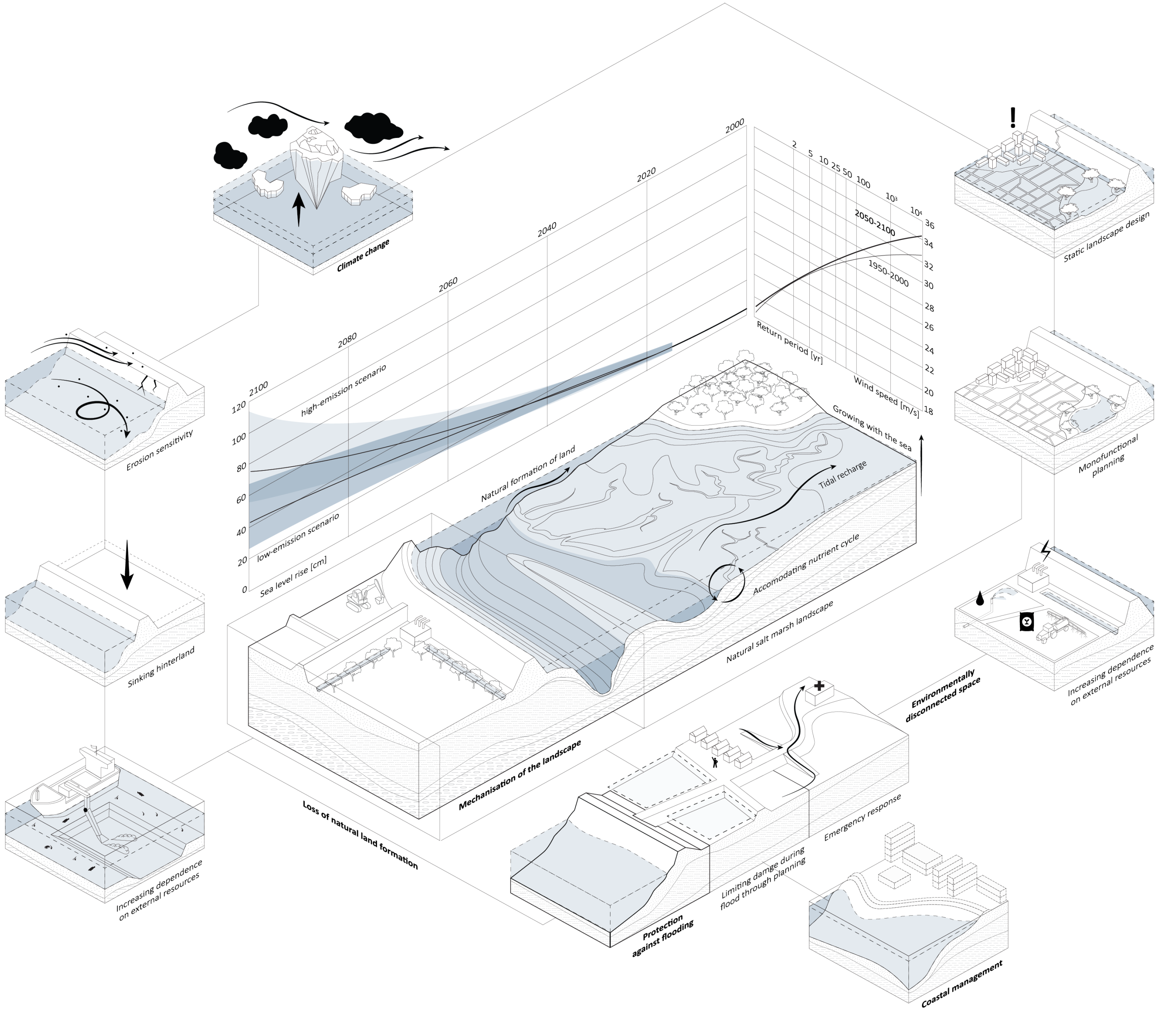
Flood risk management in the Dutch Delta focuses on reducing the probability of flooding using hard coastal dikes (Kok et al., 2017). These structures protect reclaimed land from the sea, but they also remove the delta's natural capacity to adapt and grow with rising sea levels through sedimentation. The transformation of the delta into a production landscape has disrupted natural systems. It prevents nutrient cycles by reducing habitat diversity and restricts tidal movements (Meyer et al., 2022). As a result, the delta's natural resilience to rising sea levels has been severely reduced.

Coastal Squeeze

The core elements of the Dutch flood management approach—coastal dikes—are increasingly threatened by "coastal squeeze,". A phenomenon exacerbated by rising sea levels and erosion (Doody, 2004; Berendse et al., 2015). Erosion increases due to the declining biodiversity. The soil integrity weakens as fewer plant roots stabilise the soil (Berendse et al., 2015; Sharma & Birman, 2024). Additionally, more frequent droughts weaken dikes and heighten salinisation risks (Ritzema & Van Loon-Steensma, 2017). Rising sea levels are expected to increase demand for sand, gravel and clay to reinforce dikes. However, these resources are becoming scarce and their extraction damages marine ecosystems (De Groot, 1979; Phua et al., 2002). Furthermore, water drainage from the hinterland and the hindering of natural sedimentation, contributes to subsidence. Destabilising the dikes even further (Temmerman et al., 2013).

Context-Blind Development

The flood management strategies employed in recent decades have been largely successful, but have introduced significant challenges. The stabilisation of the landscape enabled the growth of settlements and industries. Simultaneously, it rendered spatial design blind to its environmental context. The emphasis on production growth and efficiency has resulted in static, mono-functional land uses, which are dependent on external resources to function (White, 2010). Today, climate change challenges these traditional settlements and their water defences. Adaptive and context-sensitive approaches are needed (Veerbeek et al., 2012).



[Fig.3] Illustration mechanisation of the the coast and the consequences and stressors.
Source: (KNMI, 2023)

1.3 MY POSITIONING: STAYING WITH THE TROUBLE

My positioning within this project and these challenges is deeply influenced by Donna Haraway's book Staying with the Trouble: Making Kin in the Chthulucene (2016). Her work is a call to reflect on and reimagine the era beyond the Anthropocene. She terms it as the Chthulucene. Haraway argues that "staying with the trouble" enables us to engage more seriously and vibrantly with the present. This stands in contrast to the sombre futurism that often rises as a response to the fears of the Anthropocene and the Capitalocene. Her concept of learning to be truly present by "staying with the trouble" resonated with me and became central to my project's approach.

Haraway critiques the reliance on technofixes, whether secular or religious. Also, the fatalistic perspective that "the game is over" or that "we are too late." Confronted with a relentless history in which non-humans have suffered greatly, she is uninterested in reconciliation or restoration. Instead, she advocates for modest, partial recuperation. What she calls "staying with the trouble", as a means to become truly present.

"Chthulucene is a simple word. It is a compound of two Greek roots (khthon and kainos) that together name a kind of time-place for learning to stay with the trouble of living and dying in response-ability on a damaged earth" (Haraway, 2016, p. 2).

In the Chthulucene, humanity confronts its arrogance and short-sighted sense of superiority. This era invites humility and encourages making kin with other Earth-bound beings. The Anthropocene and Capitalocene centred humans as the primary actors. In the Chthulucene this hierarchy is reorganised. Biotic and abiotic forces of Earth take the lead and humans return to being part of the Earth. This shift diminishes the dualism between nature and culture. Recognising the interdependence of life forces on the planet. Haraway touches on posthumanism but describes herself being a "compostist,". Someone that looks beyond current entities (human and non-human) to view them as forces that compose and decompose. This forms the basis for ecological and evolutionary growth in both worldly and unworldly systems.

"Staying with the trouble requires making oddkin; that is, we require each other in unexpected collaborations and combinations, in hot compost piles" (Haraway, 2016, p. 4).

The assembly of organic species and abiotic actors forms history. No species acts alone, not even humans. This collective responsibility calls for shaping conditions that enable multispecies flourishing. Even if we contend with painful and sometimes joyful histories. However, not all beings are response-able in the same ways and these differences matter across ecologies, economies, species and ways of life. Haraway argues that flourishing can be cultivated through multispecies response-ability. A collective free from the arrogance of secular or religious gods. By regaining their capacity to absorb stresses through complex adaptive systems, planetary forces can sustain sympoiesis. A collective of production systems that transcend spatial and temporal boundaries. Governance and information within these systems are distributed among networks, forming dynamic, evolutionary processes.

"The Children of Compost would not cease the layered, curious practice of becoming-with others for a habitable, flourishing world" (Haraway, 2016, p. 168).

Haraway's ideas of "staying with the trouble" and making kin with other beings prompted me to question the Dutch approach to flood management. I began to wonder whether alternative strategies could create conditions for flourishing that confine both human and non-human entities. This inquiry forms the basis of a multispecies design approach. One that acknowledges and supports the complex and adaptive dynamics of natural forces. Instead of 'making' a safe delta, we are 'making with' the delta a safe living environment.

The current flood management paradigm in the Netherlands is rooted in a combative relationship with natural forces. A battle against the sea and floods. Decades of development have produced a world-renowned flood management system. Yet, it relies heavily on technocratic designs and practices. This mechanisation of the coastal front has created an imbalance. Human prosperity has come at the expense of non-human processes. This imbalance led me to explore the concept of flood management in greater depth. Contemporary flood management often frames flooding as a disaster. Even though it is a natural and necessary phenomenon in deltaic landscapes. In my research, I sought to reframe flooding as a fundamental element of estuarine systems. Introducing designs that foster thriving conditions for both human and non-human forces within collective landscapes.

While Staying with the Trouble advocates for being truly present. It also emphasises the processes of composing and decomposing entities. This involves not only engaging with the current world but also being mindful of what we leave for future generations. In my work, I have sought to understand the dynamics of the Scheldt Estuary through various disciplinary lenses. These lenses include engineering, ecology, history, biochemistry and economics. However, it is crucial to acknowledge that these perspectives alone do not fully capture the complexity of the Estuary and the greater Scheldt basin. I deliberately focused on specific concepts with direct spatial implications and the potential to challenge the dominant flood management paradigm. Nevertheless, the limitations of my study stem from the perspectives I was unable to incorporate.

Lastly, my project seeks to explore what it could mean to create conditions for sympoiesis between human and non-human entities in coastal design. This involves addressing the legacy of the Anthropocene. Not only by tackling its physical remnants but also by challenging the entrenched power dynamics it has left behind. It also means extending agency to non-human and neglected elements. They need to be integrated in the reframing of flood management paradigm. This creates a space for deltaic-centred egalitarianism while incorporating inhuman, nonhuman and posthuman perspectives in its metabolism. The base for composing and decomposing future conditions.

"A common livable world must be composed, bit by bit or not at all. What used to be called nature has erupted into ordinary human affairs and vice versa, in such a way and with such permanence as to change fundamentally means and prospects for going on, including going on at all." (Haraway, 2016, p. 40)


Waterfront Terneuzen.

CHAPTER 2 CONTEXT

2.1 THE SCHELDT ESTUARY

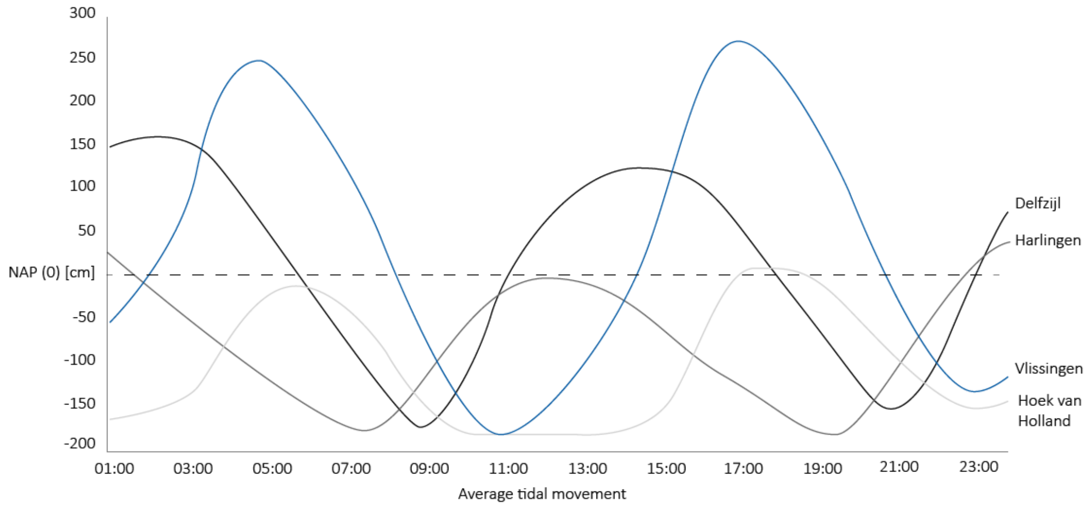
To explore alternative directions in flood management, it is necessary to look for a place where mechanisation is hitting it limites as well as greatly influenced by deltaic processes.

Where the Sea and the River meet

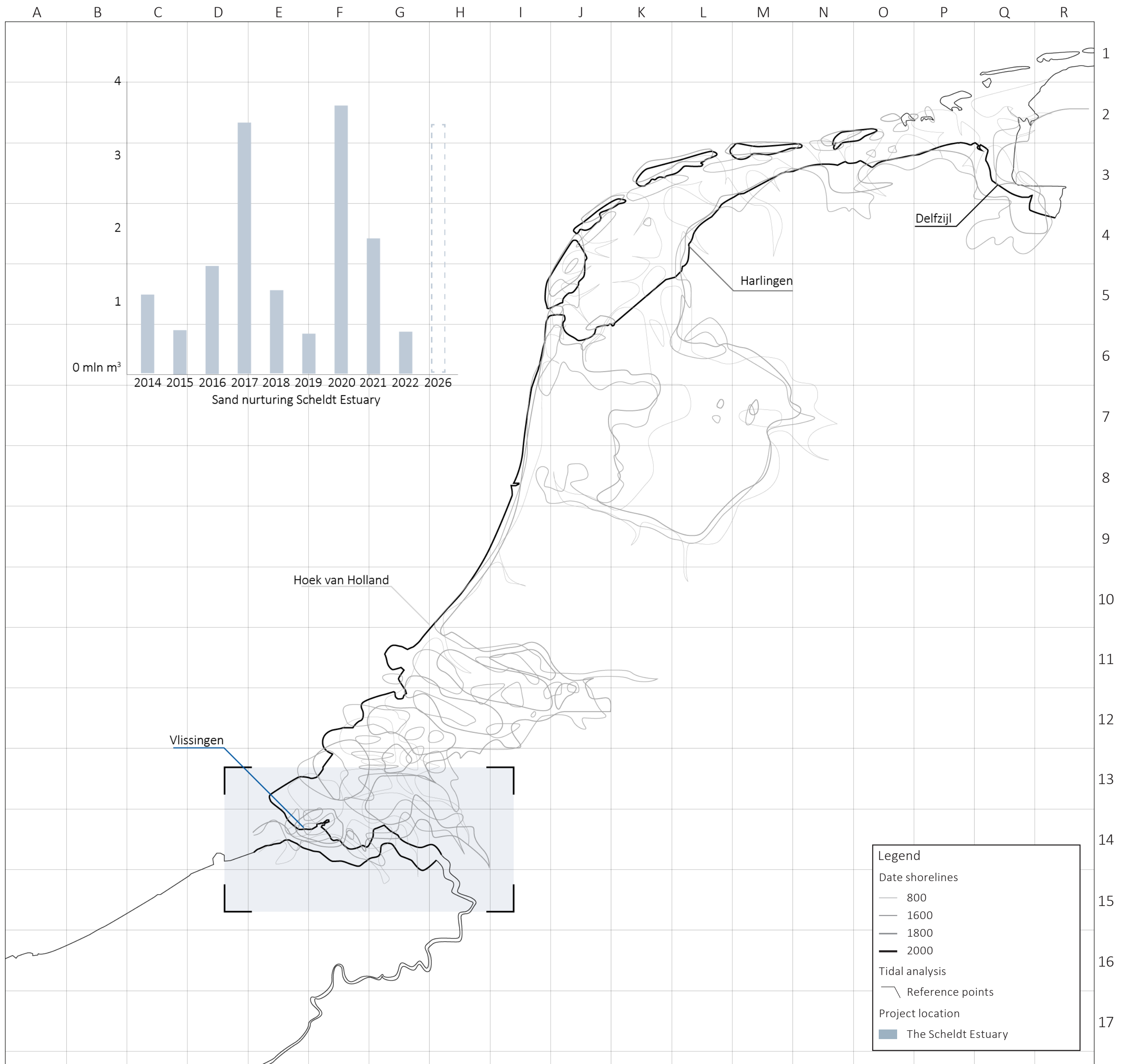
The coastal dikes represent the greatest leverage in the mechanisation of the landscape. The placement of dikes along the shores of reclaimed land has led to a significant shortening of the shorelines of the Netherlands. The last remaining direct and uncontrolled connection between the sea and river is the Scheldt Estuary. The rivermouth in the Southwest Delta region [Fig. 5]. This is the shipping route to the port of Antwerp. Thus, the coastal dikes position along the river mouth rather than closing it off. However, this results in an extensive dike line. The great length realises a high demand on sand and clay. This will only increase with rising sea levels (Rijkswaterstaat, 2024).

Tidal Dynamics

The open connection between the sea and the Scheldt River preserves the natural dynamics of the water. On average, the river's tidal range reaches 5 metres [Fig. 4], making it the greatest in the Netherlands (Dutch Ministry of Defence, 2022). The continuous tidal movements heighten the need for maintenance of the estuary to meet safety demands. The high maintenance requirements and strong Deltaic Conditions create a conflicting landscape. Therefore, shaping an opportunity to explore alternative futures.



[Fig.4] Variations in average tidal range in the Netherlands.
Source: (Dutch Ministry of Defence, 2022)



[Fig.5] Shortening of the shoreline, last direct connection between sea and river.
Source: (Kok et al., 2008; Taal et al., 2023; Rijkswaterstaat, 2024)

2.2 DUTCH FLOOD MANAGEMENT: FROM TOOL TO IDENTITY

The socio-economic, spatial and cultural development of the Scheldt Estuary shows the strongly influenced by the flood management.

(Re-)Claiming the Scheldt Estuary

Although the Scheldt Estuary's mouth remained open. Its shoreline was significantly shortened and reshaped. The earliest settlements were established on elevated plains (Weisscher et al., 2022). As peat from the land and coasts was extracted, natural buffers were lost. This led to more frequent flooding. Even after dikes were built, peat mining continued both inside and outside the protected areas. The removal of peat exposed fertile clay soil, ideal for agriculture, which increased the economic incentive for land reclamation. This reinforced peat extraction and diking (Henderikx & Brusse, 2012).

Each newly reclaimed polder was situated higher than the previous one. This was due to prolonged sediment accumulation. Today, this process is most evident in the 'Drowned Land of Saeftinghe' (Fig. 6), a polder returned to the sea after war damage and renaturation efforts (Weisscher et al., 2022).

Dynamic Growth of the Region

<u>0–1000</u>
The first settlements in the estuary were on creek backs. These were elevated areas less prone to flooding. Basic drainage systems helped manage water, though flooding remained a challenge (Redactie Zeeuwse Ankers, 2020).

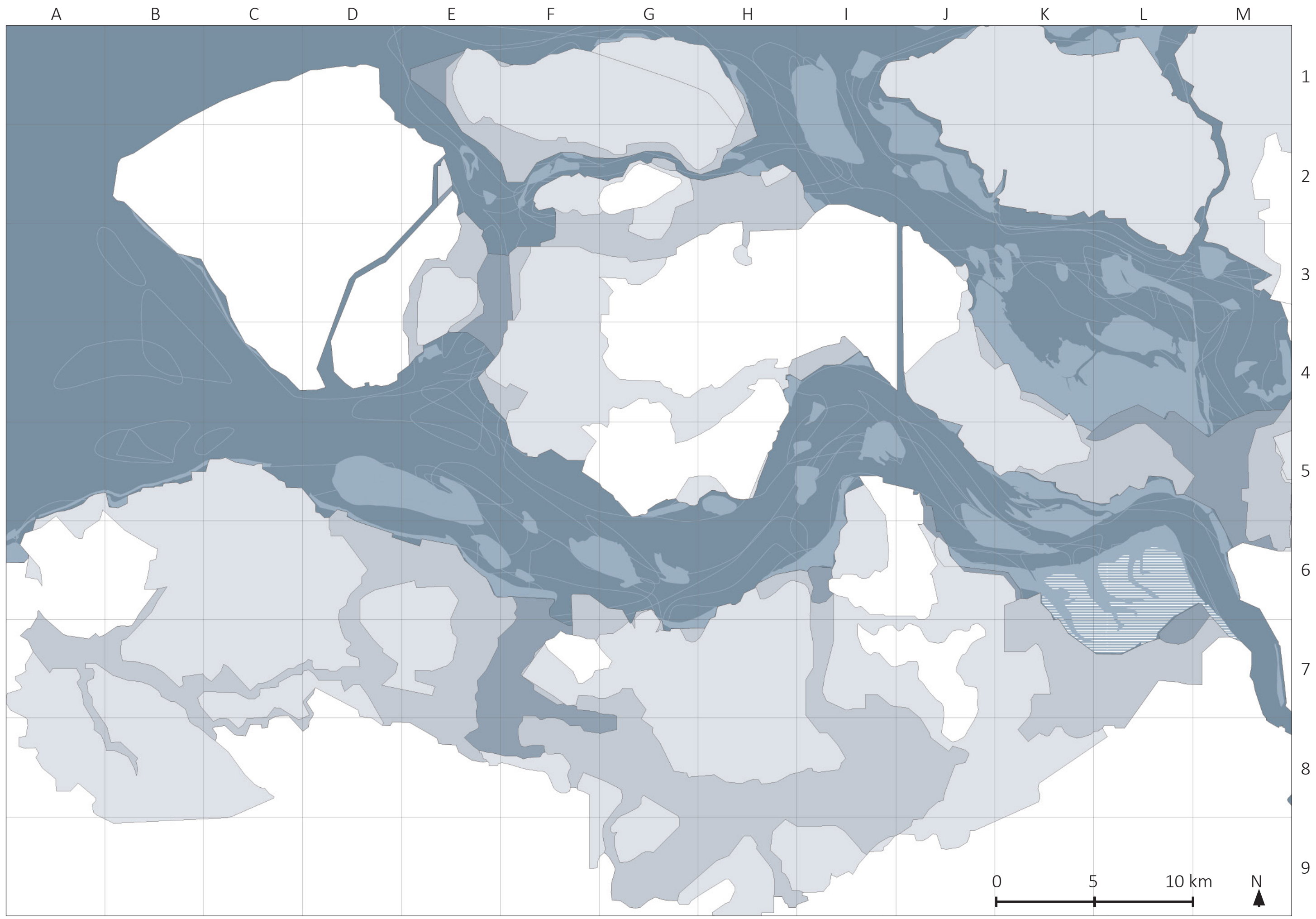
<u>1000–1500</u>
With salt mining and reclaimed agricultural land, settlements grew and became fortified. As peat extraction increased, flooding worsened. This prompted collective dike construction. Storm surges in the 15th and 16th centuries caused dike breaches, inundating the land with fertile clay, spurring further reclamation efforts (Meyer et al., 2017; Redactie Zeeuwse Ankers, 2020).

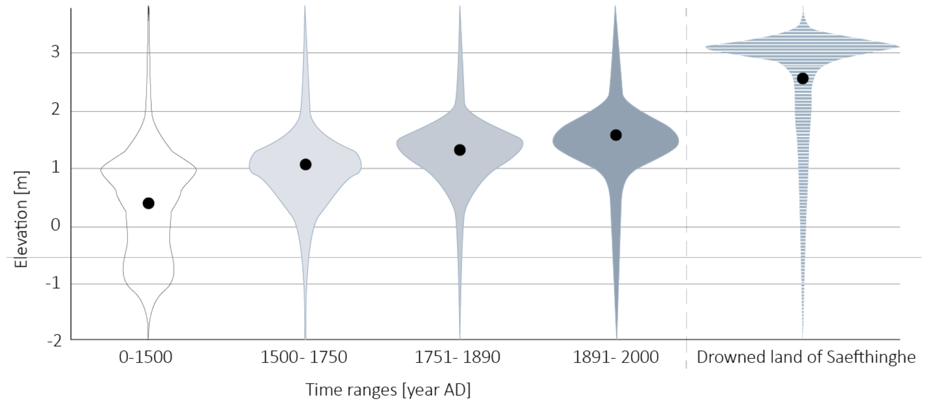
<u>1500–1800</u>
Stronger dikes supported land cultivation. The 16th century saw trade and prosperity flourish, with Antwerp becoming Europe's key port. However, storm surges and dike failures led to economic decline. Shifting the region's focus back to agriculture. In the Dutch Golden Age the ports trade rose again (Meyer et al., 2017; Redactie Zeeuwse Ankers, 2019).

<u>1800–1890</u>
The establishment of Rijkswaterstaat in 1798 centralised water management. This enabled the design of regional flood defences. Improved polders and drainage systems supported agriculture and industrialisation of the landscape (Meyer et al., 2017).

<u>1890–1990</u>
Despite modernisation, dikes remained vulnerable to Dutch standards. Strengthening the dikes was delayed because of prioritisation of repairs from the world wars. Then in 1953 a heavy storm surge devastated the region. It broke hundreds of dikes. This disaster, North Sea Flood, spurred the construction of the Delta Works and solidified flood defence as a cornerstone of national identity (Meyer et al., 2017).

<u>1990–Present</u>
The region now enjoys stability, with expanding cities and a landscape that reflects Dutch pride. However, a desire to reconnect with nature has emerged. Polders are reopened for ecological purposes and water-themed designs incorporated into new developments (Meyer et al., 2017).

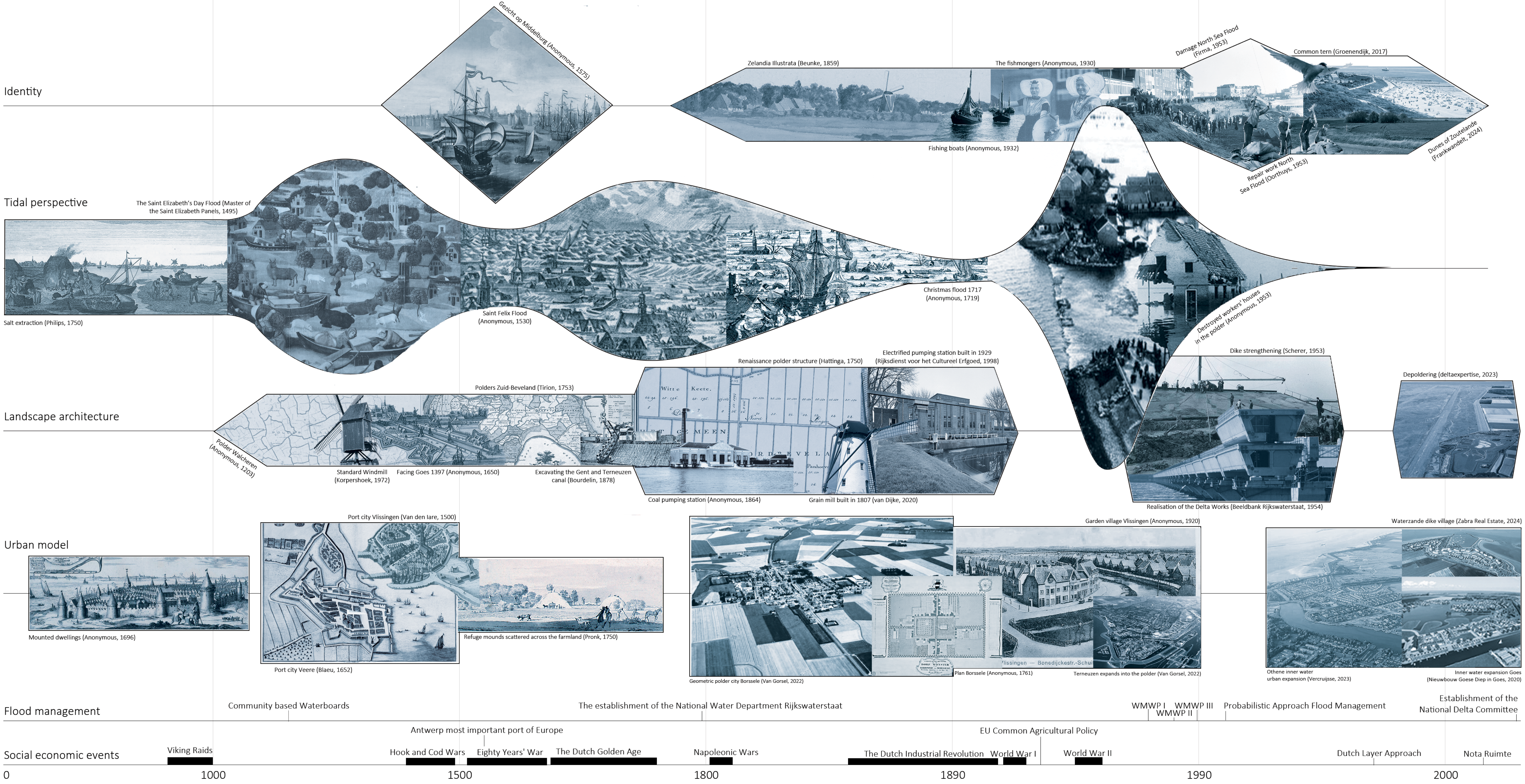




Legend
Land reclamation
0 - 1500
1500 - 1750
1751 - 1890
1891 - 2000
Tidal landscape
Drowned land of Saefthinghe
Salt marshes
Lost tidal shorelines

[Fig.6] Western Scheldt reclamation. Source: (Meyer et al., 2015; Weisscher et al., 2022)

Next page: [Fig.7] Historical development of Scheldt Estuary. Source: (Wesselink et al., 2007; Hooimeijer, 2011; Meyer et al., 2017; Redactie Zeeuwse Ankers, 2020



Identity
Gezicht op Middelburg (Anonymous, 1575)
Zelandia Illustrata (Beunke, 1859)
The fishmongers (Anonymous, 1930)
Fishing boats (Anonymous, 1932)
Damage North Sea Flood (Firma, 1953)
Common tern (Groenendijk, 2017)
Repair work North Sea Flood (Oorthuys, 1953)
Dunes of Zoutelande (Frankwandelt, 2024)
Tidal perspective
The Saint Elizabeth's Day Flood (Master of the Saint Elizabeth Panels, 1495)
Salt extraction (Philips, 1750)
Saint Felix Flood (Anonymous, 1530)
Christmas flood 1717 (Anonymous, 1719)
Destroyed workers' houses in the polder (Anonymous, 1953)
Landscape architecture
Polders Zuid-Beveland (Tirion, 1753)
Polder Walcheren (Anonymous, 1203)
Standard Windmill (Korpershoek, 1972)
Facing Goes 1397 (Anonymous, 1650)
Excavating the Gent and Terneuzen canal (Bourdelin, 1878)
Renaissance polder structure (Hattinga, 1750)
Electrified pumping station built in 1929 (Rijksdienst voor het Cultureel Erfgoed, 1998)
Coal pumping station (Anonymous, 1864)
Grain mill built in 1807 (van Dijke, 2020)
Dike strengthening (Scherer, 1953)
Realisation of the Delta Works (Beeldbank Rijkswaterstaat, 1954)
Depoldering (deltaexpertise, 2023)
Urban model
Mounted dwellings (Anonymous, 1696)
Port city Vlissingen (Van den Iare, 1500)
Port city Veere (Blaeu, 1652)
Refuge mounds scattered across the farmland (Pronk, 1750)
Geometric polder city Borssele (Van Gorsel, 2022)
Plan Borssele (Anonymous, 1761)
Garden village Vlissingen (Anonymous, 1920)
Terneuzen expands into the polder (Van Gorsel, 2022)
Waterzande dike village (Zabra Real Estate, 2024)
Othene inner water urban expansion (Vercruijsse, 2023)
Inner water expansion Goes (Nieuwbouw Goese Diep in Goes, 2020)
Flood management
Community based Waterboards
The establishment of the National Water Department Rijkswaterstaat
WMWP I
WMWP II
WMWP III
Probabilistic Approach Flood Management
Establishment of the National Delta Committee
Social economic events
Viking Raids
Antwerp most important port of Europe
Hook and Cod Wars
Eighty Years' War
The Dutch Golden Age
Napoleonic Wars
The Dutch Industrial Revolution
World War I
EU Common Agricultural Policy
World War II
Dutch Layer Approach
Nota Ruimte
0
1000
1500
1800
1890
1990
2000


Strengthened Dikes Rilland.

CHAPTER 3 PROBLEM DEFINITION

3.1 THE FLOOD MANAGEMENT PARADIGM

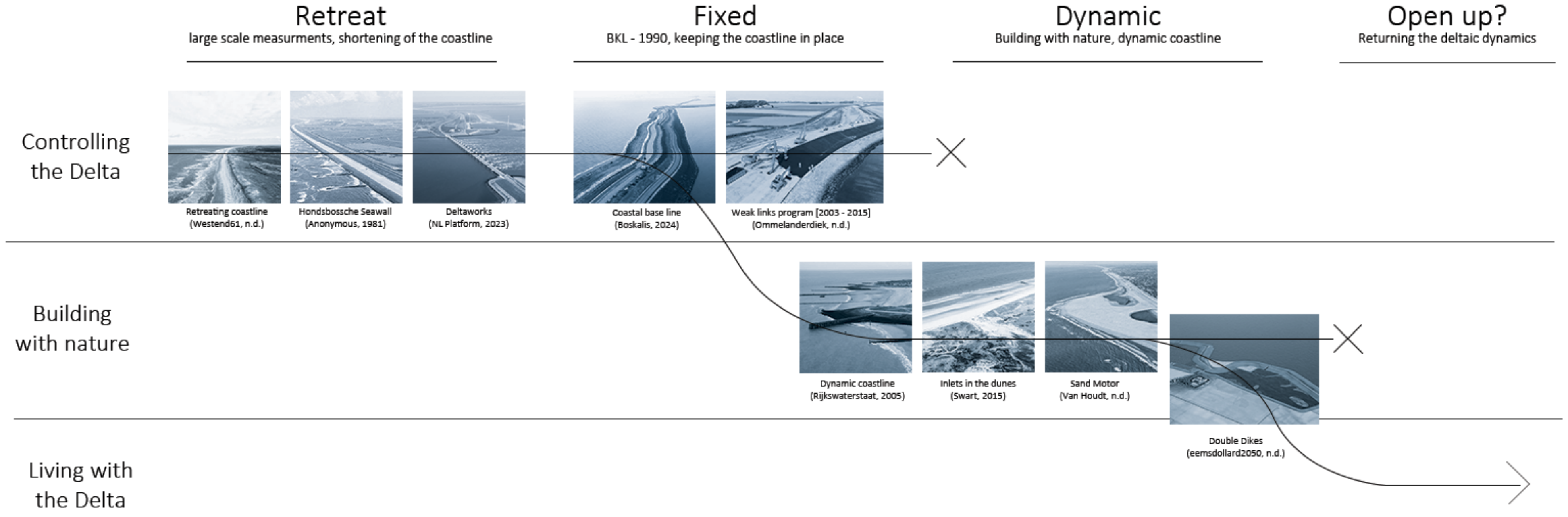
Flood Management as Landscaping Instrument

The design of our waterfronts has evolved into more than a mere extension of urban territory. It is an essential element shaping the functional and spatial structures of cities and landscapes (Meyer, 2014).

In the Netherlands, the flood management system was shaped by the powerful and centralised state-owned institution, Rijkswaterstaat. Flood policies were closely intertwined with national governmental policies on the industrialisation and urbanisation of the Deltas (Meyer, 2009). Today, the delta regions face various developments that render this approach ill-suited. Especially, to realities of local and regional communities and other stakeholders. Port-related industries, which dominate economic and spatial development in delta areas, must address globalisation and technological transitions. Meanwhile, the fertile soils, which have historically attracted extensive agricultural and fishing practices, now conflict with urban, industrial and natural conservation interests. These stirrings highlight the need to recognise the roles and responsibilities in flood management. In the public and private sectors, as well as individual citizens (Meyer, 2014).

New concepts such as the 'multi-layer safety' approach have been introduced to accommodate these development (in Fig. 3 in chapter 1.2). This approach incorporates not only the assignment of appropriate levels of flood defences. It also places greater emphasis on the probability of flooding and evacuation strategies. By introducing this perspective, responsibility shifts from central governmental institutions. It now also involves local and regional governments, private organisations and citizens (Ministerie van Infrastructuur en Milieu, 2009).

There is a growing awareness of the complexity and (climate) vulnerability of urbanised deltas. This have driven a paradigm shift in flood management. In particular, in the spatial planning and the governance of these regions. The focus has moved beyond merely solving 'problems' like developing strategies to protect deltas from subsidence, erosion and flooding (Meyer, 2014). It is also seen as tool that influences new land uses and allows more dynamic landscape and coastal compositions.



[Fig.8] Diagram with images of changing flood management forms.
Source: (Brand et al., 2014)

Path Dependency: Flood Prevention

Despite a growing shift from static to dynamic coastal management (Brand et al., 2014). Flood risk management remains heavily focused on flood prevention (Wesselink et al., 2007; Kok et al., 2017). The reliance on scarce resources avoids addressing the greater challenge posed by climate change. This 'lock-in' not only limits the forms of flood defences but also constrains the spatial design of landscapes. Reducing their capacity to respond to potential flooding and its consequences.

The emerging field of Delta Urbanism seeks to challenge this approach. It advocates for a more 'Darwinistic' strategy that emphasises the evolutionary nature of delta regions. It promotes adaptability, rather than prevention, as the primary survival strategy (Meyer, 2020). This perspective calls for a shift from flood prevention to living with water. It represents the next step in coastal management. From building with nature to fully coexisting with it. This thesis explores the possible spatial developments that could result from this approach.

3.2 OBJECTIVE OF THIS PROJECT

The aim of this research is to challenge the prevailing perspectives on flood risk management that have "locked in" landscape design and management practices in the Netherlands. This management has resulted in the diminishing of natural processes through mechanisation. A process that leaves the coast vulnerable to coastal squeeze. Disconnects landscape design from Deltaic Conditions. And, allows settlements to grow ill-equipped to handle potential flooding.

By reimagining existing flood management in the Scheldt Estuary, this study seeks to offer insights into alternative approaches to flood management and urban forms inspired by Delta Urbanism. The exploration of these alternative directions enables the testing of landscape designs that reintroduce natural cycles, reconnect to deltaic systems and promote climate- and tidal-responsive urbanisation.

This approach paves the way for 'Stay With The Trouble'. It enables us to be truly present to our environment. It enhances our responsiveness to the dynamics of the delta. And, recognises our influence in composing and decomposing it. Instead of making the delta, this vision accommodates room to making with the delta.

The project aims to advocate for a symbiosis between human and non-human processes. Emphasising, the potential of reconnecting with our environment to enhance urban flood resilience and regenerate socio-ecological systems.

3.3 RESEARCH QUESTION

How can the [1] re-imagining of existing flood management in the Scheldt Estuary [2] inform landscape design enhancing [3] deltaic and climate adaptivity and [4] promotes symbiosis between human and non-human ecosystems?

1. What are the historical and social precedents that need to be redefined in rewriting the Dutch coastal management paradigm?

2. What Deltaic Conditions will arise in the Scheldt Estuary when the flood defences are deactivated?

3. What are the landscape designs in which different forms of flooding events in the delta can be reframed from a risk to an opportunity?

4. Which strategies will accommodate Deltaic Conditions in the Scheldt Estuary while realising a symbiosis between human and non-human systems?

Drowned Land of Saeftinghe (Reisroutes, n.d.)

CHAPTER 4 THEORY AND CONCEPTS

4.1 THEORETICAL FRAMEWORK

The theoretical framework gives insight into the bodies of literature which have informed the argumentation of this project. Selected pieces of literature are arranged in overarching topics and how the topics addressed my various authors.

Making with – Living with Deltaic Conditions

Traditional flood protection methods are being questioned by academics, governments and communities (Abdulkareem & Elkadi, 2018). Authors such as White (2008), Yu et al. (2008), Berke et al. (2009) and Lennon et al. (2014) advocate for a holistic approach that integrates urban design with flood risk management. Han Meyer (2020), the original head of the research program Delta Urbanism, takes this idea further. He suggests that flood management should actively steer urban development and encourage more radical engagement with water.

Delta Urbanism adopts a 'Darwinistic' perspective. It views delta regions as dynamic, evolving systems that must continuously adapt to environmental and social changes. Within this framework, Meyer (2014; 2020) identifies water being a key driver of transformation. He proposes a paradigm shift: from "water follows function" to "function follows water." This philosophy also aligns with the Dutch contemporary place-based approach to spatial development. "Water en Bodem Sturend" in which water and soil are seen as guiding principles. This approach highlights the influence of water and soil systems and advocates for viewing them as an integrated whole. Instead of focusing on their individual components (Ministerie van Infrastructuur en Waterstaat, 2022).

In the context of my hypothesis, this concept will be expressed through a design proposal guided by Deltaic Conditions. Estuaries carry the characteristic of allowing the sea to "come in," producing unique hydrological, ecological and geomorphological qualities. These landscapes are influenced by both tidal and riverine forces. The presence of both enables the mixing of saline and freshwater and, accommodating high rates of seasonal flux (Lopez & Martin, 2023). By adopting a fluid and evolving guiding principle, the design will challenge traditional approaches. While, encouraging adaptability and responsiveness to changes in Deltaic Conditions. It will serve like a catalyst for broader urban and environmental transformation. Redefining flood management in the process and allowing the co-creation with deltaic processes.

Response-ability – Urban Flood Resilience

Conventional spatial planning focuses on creating the desired development based on existing conditions. In contrast, the adaptive approaches treat these conditions as the object of intervention (Rauws, 2017). The main idea behind this approach is to allow planners and designers to work in a world that is 'becoming'. A reality which is ever-changing and evolving (Tsoukas & Chia 2002; Byrne 2005). Rauws (2017) argues that the key feature of complex adaptive systems is their capacity to continuously evolve. They do this in response to their dynamic environment, aiming for the most optimised 'fit'. This aligns with the perspective of evolutionary resilience. The ability or capacity of ecosystems to respond to stress and change by adapting or transforming (Holling, 1973; Davoudi et al., 2013).

This concept of capacity building is important for designing with the uncertainties, such as climate change (Liao et al., 2016). This evolutionary approach can also be seen in the definition of flood resilience of Liao (2012). She sees it as the capacity to tolerate flooding to evade catastrophe when experiencing flooding. Or, when damage and socioeconomics does occur that there is the capacity to quickly reorganise. In this regard, flood resilience doesn't imply preventing the flood. Liao et al., (2016) translated urban flood resilience into three principles for urban design: (1) Urban design must anticipate and accommodate flooding, (2) urban design needs to attune to the ecological process of flooding and (3) urban design has to exhibit the flood dynamics to the public.

Flood resilience requires learning from floods (Liao, 2012). Socio-ecological resilience to a disturbance increases when learning from that particular disturbance (Berkes et al., 2003). Thus, urban flood resilience is characterised by three essential features: the ability to respond effectively to floods at a local level, the capacity for prompt adaptation following each flooding event and the presence of redundant subsystems to ensure functionality (Liao 2012).

Compostist – Ecological Engineering

The subsystems that build capacity to absorb flooding span both human and non-human systems. Healthy soil-water systems are key to creating a resilient, climate-adaptive environment (WUR, 2023). Ecological engineering is defined as "the design of sustainable ecosystems that integrate human society with the natural environment for the benefit of both" (Mitsch & Jørgensen, 2003). It focuses on restoring ecosystems disrupted by human activities, such as pollution or land degradation. And, creating new sustainable ecosystems that benefit both people and the environment (Mitsch & Jørgensen, 2003). Belanger (2017) sees ecological engineering as an alternative to linear, static and monofunctional engineering approaches. It emphasises adaptability, circular processes, system relations and multidimensional potential.

Mitsch & Jørgensen (2003) outline five principles of ecological engineering: (1) It leverages ecosystems' self-designing capacity; (2) It tests ecological theories; (3) It uses systems approaches; (4) It conserves non-renewable energy sources; and (5) It supports biological conservation. Ecological engineering mitigates pollution, preserves ecosystems and conserves non-renewable resources by harnessing nature's self-designing abilities. This takes place with ecosystems serving as prototypes for such design.

Nature-based Solutions (NbS) are interventions that work with natural systems to address environmental challenges while benefiting both human and non-human ecosystems (Cohen-Shacham et al., 2016). NbS have proven effective in reducing flood risks (Willemsen et al., 2020; Zhu et al., 2020). They also restore natural landscapes and cycles in estuarine environments (Dunlop et al., 2023). In my design, ecological engineering will harmonise human and non-human flows. NbS will be used as interventions to compose new ecological cycles.

Chthulucene – Symbiocene

"Staying with the trouble" means confronting challenges directly. By reintroducing the Deltaic Conditions as the driving force in the estuary, urban and landscape design must become adaptive. They will learn through experimentation and grow a capacity for continuous improvement. This approach reconnects communities to the landscape, in space and experience. Restoring natural cycles will enhance ecosystem health. While, linking of production and ecological cycles to public safety and livability. The harmonisation allows the symbiosis of human and non-human processes.

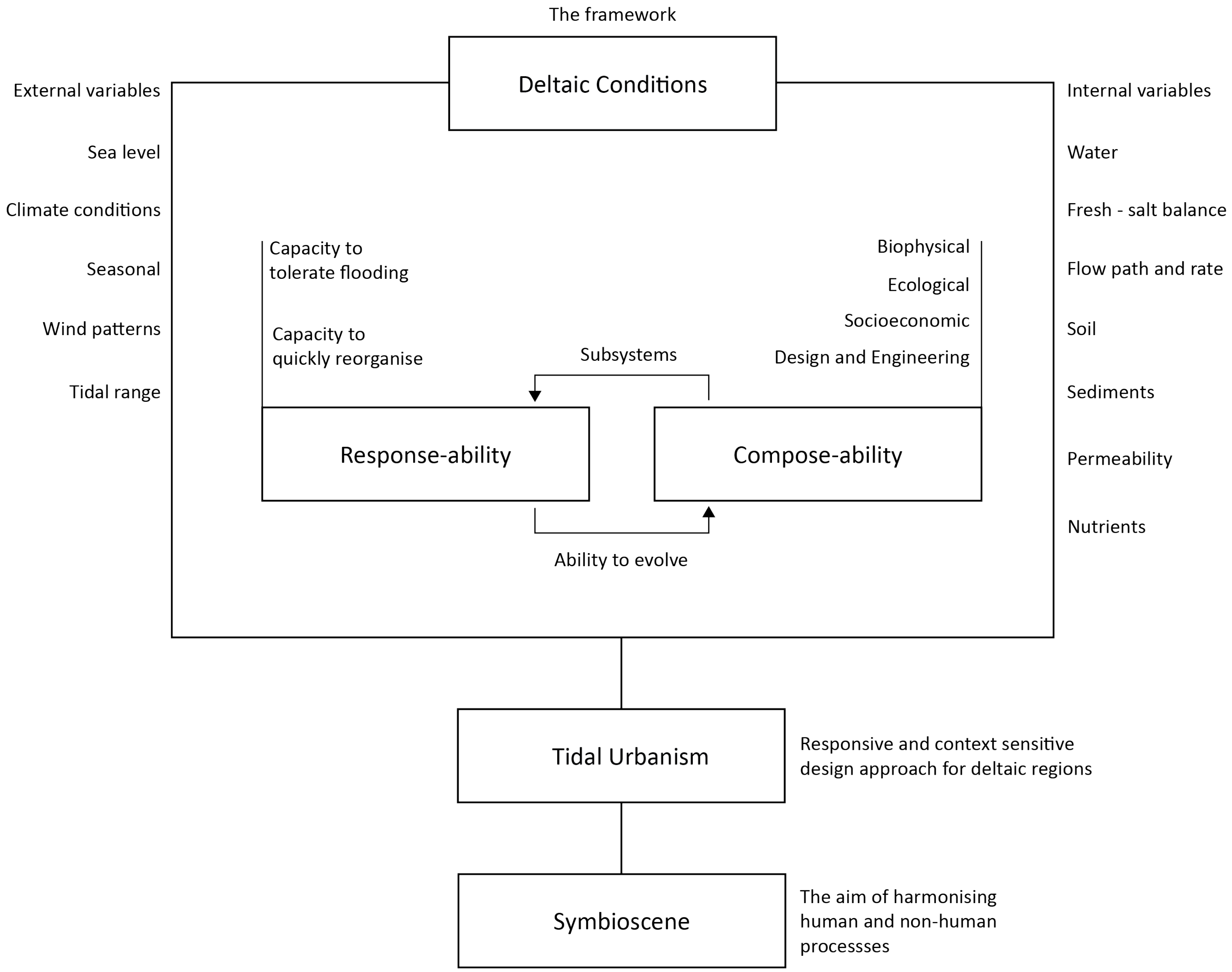
4.2 CONCEPTUAL FRAMEWORK

The theoretical framework positions the project. It provides the foundation on which the conceptual framework can structure the research and design [Fig.9].

By framing the project within the context of Deltaic Conditions, human processes must recognise both their dependence on and their influence over these dynamic and ever-changing natural processes.

The perspective of flood management through flood tolerance creates opportunities for land uses. Capacity to respond to these stirrings and changes can be developed. Subsequently, enhancing their ability to evolve with shifting climates and conditions. To build this response capacity in coastal management, subsystems must be composed and decomposed. In the mean time, addressing the need to evaluate the impact of every intervention on the broader deltaic system.

Designing within this framework enables exploration towards a form of Tidal Urbanism. An approach that is responsive to changing conditions while remaining sensitive to deltaic contexts. This approach could serve as a stepping stone towards a future where human and non-human forces coexist in symbiosis. A vision aligned with the concept of the Symbiocene.



[Fig.9] Conceptual framework.


Bird's view Terneuzen (Hollandse Hoogte, 2017)

CHAPTER 5 METHODOLOGY

5.1 Research Framework

5.1 RESEARCH FRAMEWORK

Subreseach questions	Area of study	Methods		Scale	Products	Outcome
1. What are the historical and social precedents that need to be redefined in rewriting the Dutch flood risk management paradigm?	**Understanding the history and culture of water politics** to redefine the role of flood management and defences.	HR	SPA	BASIN ESTUARY	1. Time line and map reclamation of the Scheldt landscape. 2. Map relating the estuary to the basin and its influences.	A geosynthesis as the **critical justification to shift away from the current flood management system**, through showcasing the limits and risks of the conflicting landscape dynamics.
	Documenting the current flood response-ability and relating it to the flood management and landscape design.	LR	AC	ESTUARY	3. Maps indicating the current flood response of the region.	
	Mapping the different degrees of mechanisation and current composition of the Scheldt Estuary.	FW	AC	ESTUARY POLDER	4. Maps and section of flood management influence on urbanity. 5. Maps different subsystems and their conflicting processes.	
2. What Deltaic Conditions arise in the Scheldt Estuary when the flood defences are deactivated?	Gathered local insights through **interviews and literature on how landscape identity and values relate to its composition**.	FW	LR	ESTUARY SITE	6. Narrative of the Scheldt Estuary through the lens of the inhabitants and literature through text and pictures.	**A strategic framework at a macro scale to coexist with the Deltaic Conditions** in the Estuary.
	Creating a projection of the **risks when returning to Deltaic Conditions** as means to formulate design principles.	LR	AC	ESTUARY	7. Geomorphological and hydrological layers for the base map. 8. Deltaic condition base map for scenarios and strategy.	
3. What are the landscape designs in which different forms of flooding events in the delta can be reframed from a risk to an opportunity?	**Abstraction of the deltaic dynamics** based on projected meteorological data.	LR	AC	BASIN ESTUARY	9. Meteorological and climate data projected in space for the base map.	**Site interventions at macro and meso scales enhance the response-ability** of the estuary by composing and decomposing subsystems.
	Creating **scenarios in which flooding is accommodated in the compositon** of the Scheldt Estuary, thus forming a symbiosis.	MMR	RD	ESTUARY POLDER	10. Scenarios Tidal Urbanism in section, collage and maps. 11. Design principles of tidal urbanism through tiles.	
4. Which strategies will accommodate deltiac conditions in the Scheldt Estuary while realising a symbiosis between human and non-human systems?	**Synergising the scenarios** with experts and enable visioning and reflection.	WO	RD	ESTUARY POLDER SITE	12. Vision and guidelines for 2130 in maps and sections. 13.Exploration until 2080 with time line and transformations.	**Exploration of a form of landscape design that re-imagines flood management** transform flooding to a potential, to harmonises human and non-human processes.
	Strategies are explored on compositional logic, responsiveness and capacity to enable Deltaic Conditions, followed by reflection on feasibility and shifts in power.	SPA	RD	ESTUARY	14. Evaluation and reflection of transformations.	**Evaluation and reflection** of the exploration.

Historical Text Review	HR	Mixed Media Review	MMR	Stakeholder Power Analysis	SPA
Literature Review	LR	Field Work	FW	Research through Design	RD
Analytic Cartography	AC	Workshop	WO		

[Fig.10] Research framework thesis.

Bird's view Terneuzen (Hollandse Hoogte, 2017)

CHAPTER 6 DIAGNOSIS

6.1 RESPONSE-ABILITY

Primairy Dike Ring

To analyse the response-ability of the estuary to flooding, it is necessary to understand how it handles these events. The 'multi-layered' flood management system has shaped the landscape and, consequently, its response. The first layer of flood management mitigates the presence of flooding in the region. It does this through a primary flood defence ring, comprising dikes, dunes, dams and sluices. This system preserves the reclaimed lands of the estuary and enables habitation in these low-lying areas.

Zeeuws-Vlaanderen is land-bound due to its connection to Belgium. The northern side of the River consists of two islands: Walcheren in the west, the oldest island and Zuid-Beveland in the centre, the largest island.

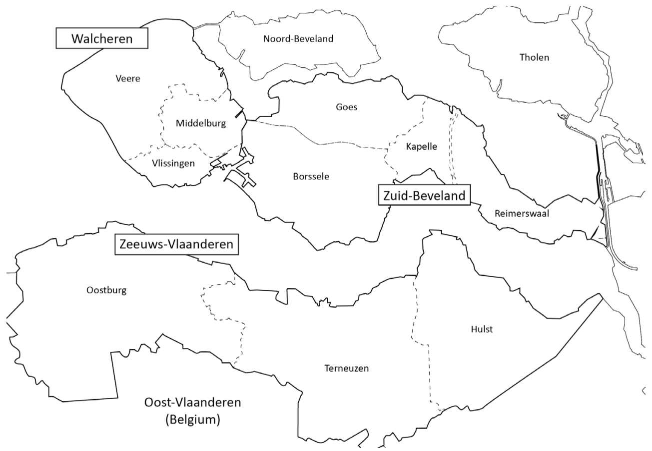
Despite being separated by channels, these islands are connected by a dike ring established with dams and sluices, enclosing the region as a whole. Dams were used to connect Walcheren to Zuid-Beveland. It integrates the two islands and creating an artificial lake within the dike system.

Strength of the Dike

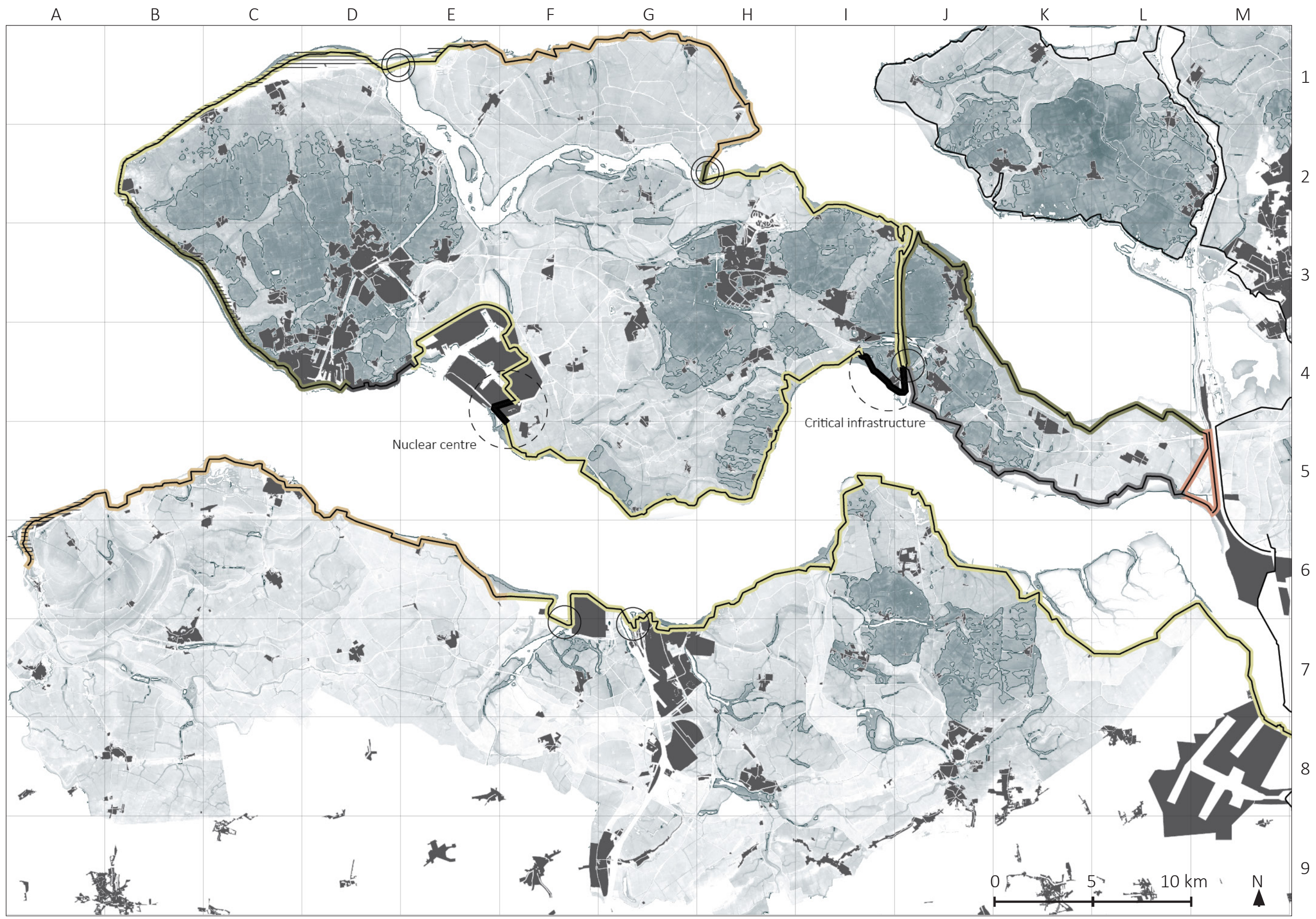
As mentioned in subchapter 1.2, flood risk management is organised based on the calculation: Flood Probability × Flood Impact = Flood Risk.

The required strength of a dike is determined by this formula. The necessary strength, which reduces flood probability, links to the socio-economic damage it would cause if it were to fail, i.e. the flood impact. Consequently, areas with higher socio-economic value demand a lower flood probability than areas with lesser value.

In Fig. 9, it is evident that the strongest dikes are located near the most densely populated areas and the lowest-lying landscapes. Especially Hansweert, which is 1 to 2 metres below NAP (1:1.000.000) and Vlissingen, one of the largest cities in the region (1:300.000). The nuclear centre in Borssele also has a high safety threshold (1:1.000.000) to prevent the risk of a major nuclear disaster. In contrast, the weakest dike range is on the west side of Zeeuws-Vlaanderen, with a flood probability of 1:300.



[Fig.11] Spatial organisation Scheldt Estuary. Island region are the thick lines, these are seperated by dotted lines into municipalities.



[Fig.12] Dike seperating low-lying settlement Bath from the sea.

Legend

Safety threshold primary dikes

- Dike ring
- 1:100
- 1:300
- 1:1.000
- 1:3.000
- 1:10.000
- 1:30.000
- 1:1.000.000

Elements dike ring

- Sluice
- Dam
- Critical area
- Dike
- Dune

Elevation and urbanisation

- Urbanisation
- Elevation to NAP
- -2 m
- -1 m
- 0 m
- 1 m

[Fig.13] Flood prevention Scheldt Estuary.
Source: (Elias & Van Der Spek, 2015; Jongejan et al., 2016; CartoNext, 2024; TU Delft, 2024)

6.1 RESPONSE-ABILITY

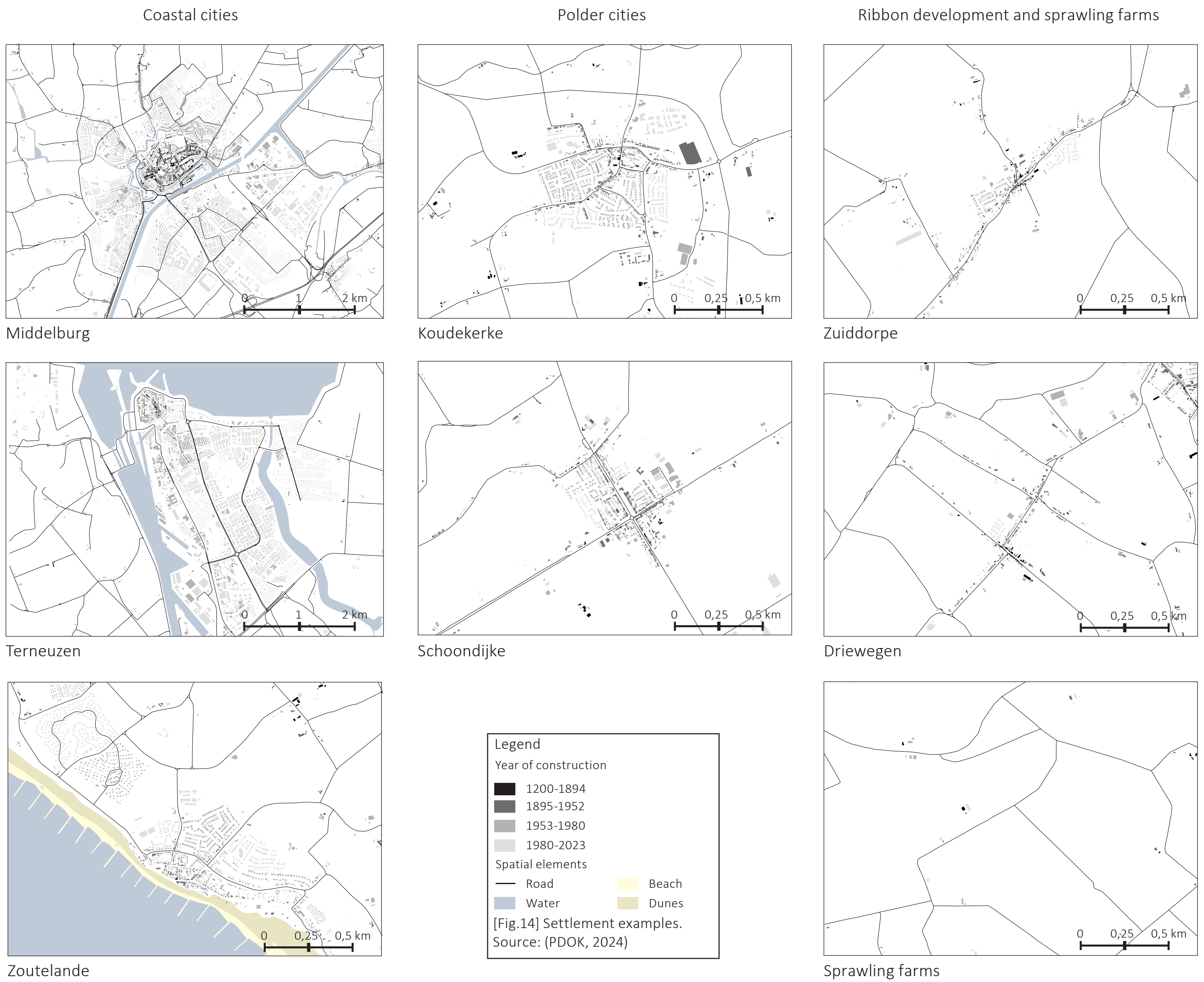
The flood management approach influenced the development of settlements and their ability to tolerate flooding.

Dry Feet

Most settlements in the region share a common origin: they were established on elevated land. This was a response to the frequent occurrence of flooding. After the North Sea Flood of 1953, the Delta Works were implemented. Also, the flood defences were rebuilt and strengthened. This ushered in a period with almost no flooding. Without the threat of flooding, the spatial limits on expansion were removed. It allowed cities to expand or be built in the lower polders [Fig. 14].

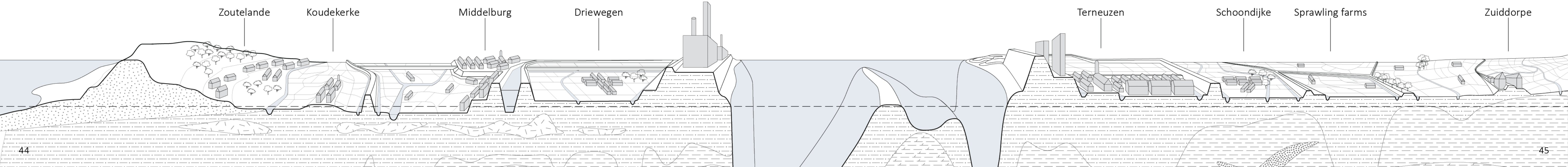
Bathtub Landscape

To prevent floods from overtopping the dikes, the dikes typically reach about 10 metres above sea level. The dunes can rise up to 40 metres. Combined with their width, these features form massive elements within the landscape. The imposing coastal front separates the inland polder areas from the sea. Most housing in the region is no higher than 2–3 storeys. The exception is the waterfront towers, which further emphasise the separation between sea and land [Fig. 15].



[Fig.14] Settlement examples.
Source: (PDOK, 2024)

[Fig.15] Relation between flood defences and settlement (TNO, 2024)



6.1 RESPONSE-ABILITY

If the primairy dikes fail, the second layer of flood defence comes in to play: the secondary dikes.

Secundary Dikes: Absorbing the Damage

Reducing flood probability is possible to a certain extent. However, there will always be factors of uncertainty that may cause a coastal dike to fail. In anticipation to this the landscape has been compartmentalised using secundary dikes. It accommodates the flooding in areas and preventing further harm to the inland.

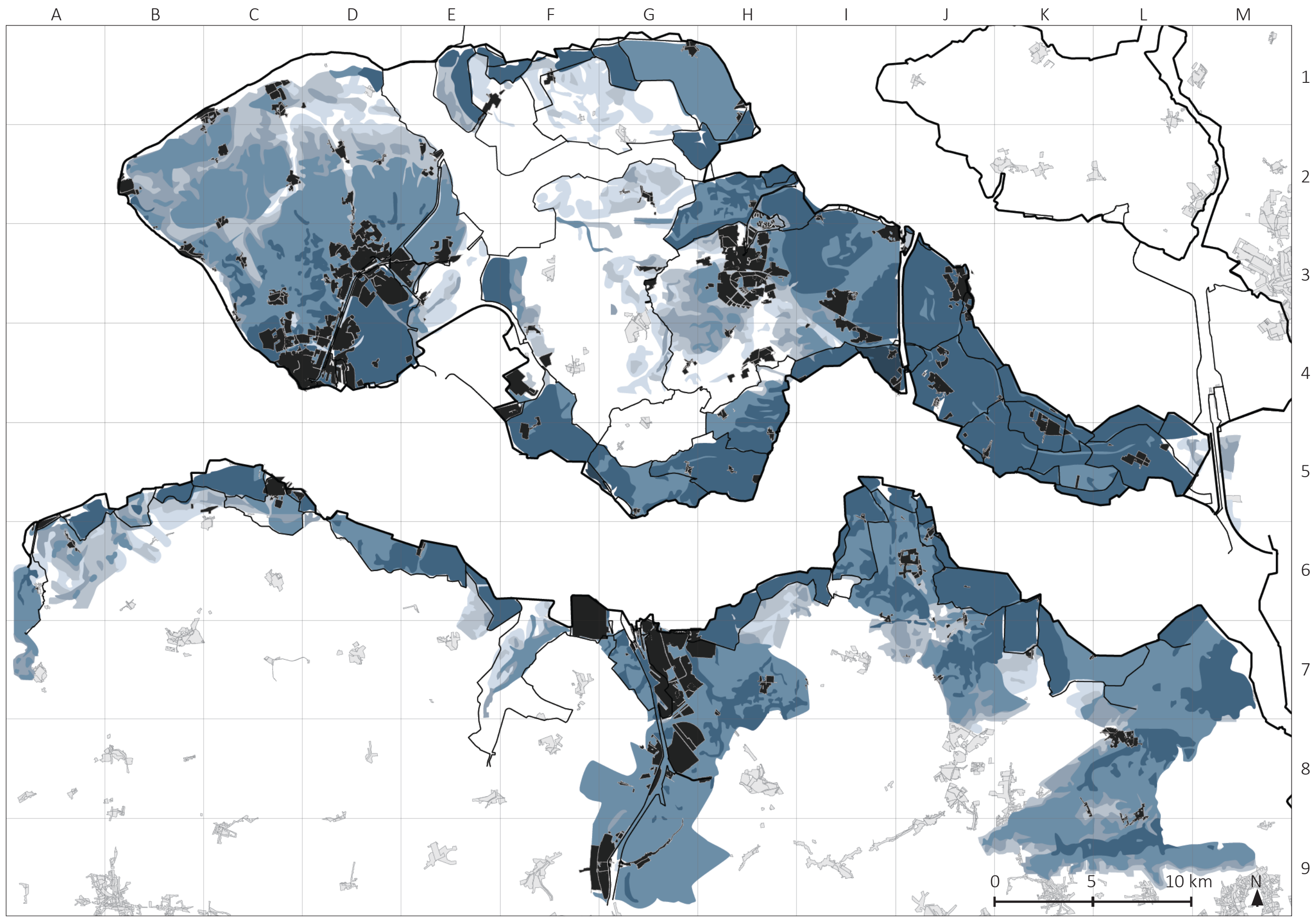
In Zeeuws-Vlaanderen and Zuid-Beveland, secundary dikes form a buffer for the hinterland. Walcheren has fewer secundary dikes due to the greater protection provided by the dunes and the dam connecting it to Noord-Beveland. Vlissingen which is a critical area has a higher dike safety threshold. Reimerswaal has no space for a buffer zone of secundary dikes. The dikes are fragmented on the narrow island. These dikes support the elevated infrastructural network above the polders.

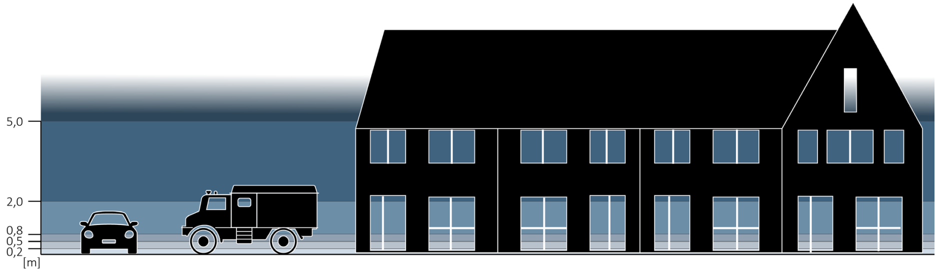
Water Levels

Most of the largest cities in the estuary are located at the edges of the islands. They are partially or completely within the second line of flood defence. Fig. 15 illustrates the water levels that would occur if the primary dike were to breach (Keessen et al., 2013).

If flooding reaches 0.2 metres, cars can still drive. At 0.5 to 0.8 metres, only army vehicles can transport people in the area. At 0.8 to 2.0 metres, the first floor of buildings remains accessible, but beyond 2.0 metres, only the attic is reachable. If flooding exceeds 5.0 metres, houses will be completely submerged [Fig. 16].

Most of the houses in the Netherlands are constructed from concrete and brick. This makes them relatively heavy and resilient to water hitting the sides. However, the danger to individuals and the potential damage could increase due to debris in the floodwaters. This could cause further harm in the streams.





[Fig. 16] Waterlevels of flooding compared to modes of transport and vertical evacuation.

Legend

Waterdepth after primary dike breaks

- > 5,0m
- 2,0 - 5,0m
- 0,8 - 2,0m
- 0,5 - 0,8m
- 0,2 - 0,5m
- 0,2m
- Primairy dike
- Secundairy dikes

Flood damage

- Urban spaces in flood range
- Safe urban spaces

[Fig.17] Secundary flood defence Scheldt Estuary. Source: (Ministerie van Infrastructuur en Milieu,2015; TU Delft, 2024)

6.1 RESPONSE-ABILITY

The ability to tolerate and reorganise after a flooding is also dependent on the aftermath of a flood.

Economic Corridor

The Scheldt Estuary has a long history in shipping and transport. It's a gateway where the sea meets the river, making it a strategic position for trade and logistics. The estuary accommodates two Dutch ports, Terneuzen and Vlissingen and two Belgian ports, Antwerp and Ghent. Antwerp ranks as the second most important port in Europe.

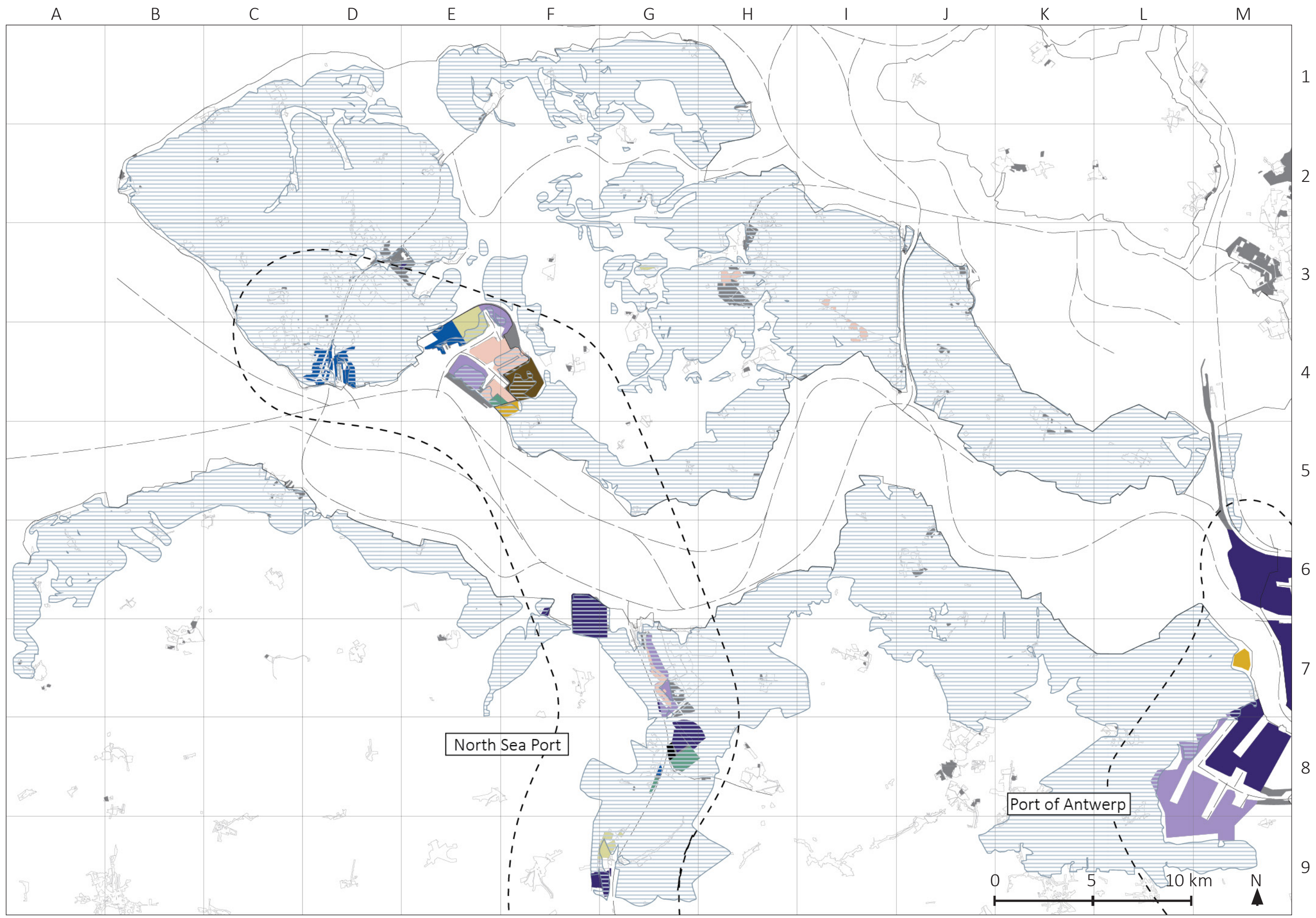
The ports serve as a crucial economic and industrial corridor for the region, particularly for chemical industries, maritime trade, logistics and related sectors. They are also among the largest employers in the area. The North Sea Port (Vlissingen, Terneuzen and Ghent) provides approximately 100,000 jobs (Zeeland.com, 2023), while the Port of Antwerp accounts for around 164,000 jobs (Port of Antwerp-Bruges, 2024).

Pollution Hazard

While the economic benefits of these spaces are significant, the industries present can cause severe harm if affected by a flood. Although, the container and cargo ports themselves are often situated at higher elevations than the seabed. The hinterland where materials and industrial installations are located, lies in lower areas [Fig. 19]. Even if machinery is resistant to water, the materials, bulk goods and chemicals will seep into its surrounding. It could contaminat the surface, air and soil can spread further into the land and water.

Flooding can also hinder economic and port activities by disrupting the bulk of goods, contaminating critical infrastructure or affecting the accessibility of port spaces. This would result in delays, financial losses and logistical challenges.

Such events would cause a biochemical hazard, endangering human and non-human life and damaging agricultural production landscapes. The same risks apply to the nuclear centres at Vlissingen (Borssele) and Antwerp (Doel).



Legend
Industries
- Nuclear powerplant
- Chemical industries
- Petrochemical Production
- Recycling/waste processing
- Maritime Industry
- Logistics and transport
- Food Processing
- Light industries
- Heavy industries

Infrastructure
- Dike
- Navigation channnel
- Port zone
- Flooded area when primairy dike fail

[Fig.19] Flood-zone ports and industries.
Source: (Port of Antwerp-Bruges, 2023;North Sea Port, 2025)

[Fig. 18] Yara industrial site in Sluiskil, southern part of the North Sea Port (Gundlach, 2025)

6.1 RESPONSE-ABILITY

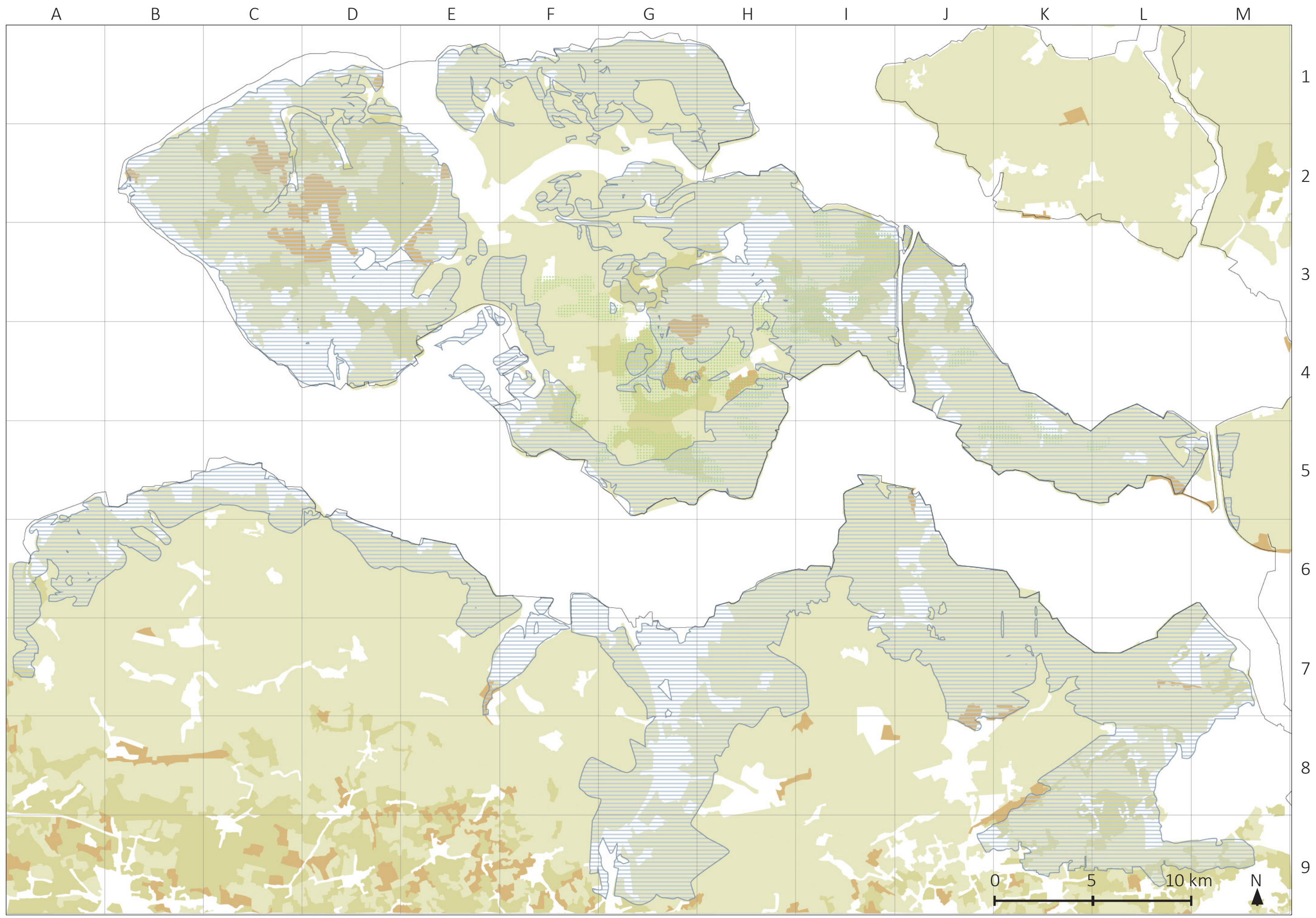
Agricultural Powerhouse

Most of the land that gets flooded is agricultural land. From a risk perspective, this area has less socio-economic value. But for this region, it is their second-largest export product after (petro-)chemicals. The region produces 25% of the Dutch fruit, is the leading exporter of onions and also produces other products such as potatoes, legumes, sugar beet, wheat, grain and flax (Zeeland.com, 2023).

Soil and Water Contamination

Agricultural production predominantly consists of the cultivation of crops on arable land. This land is constantly worked to ensure it remains as fertile as possible. The potential contamination from industries, as mentioned in the previous chapter, could cause significant harm to the soils and their microbes. This leads to land that is unusable for both human and non-human consumption.

Aside from the man-made pollution, the salt from seawater would also challenge current agricultural practices. The produce from this region is mainly based on freshwater crops. It varies from crop to crop how they will handle saltwater. Of the current produce, sugar beet can handle salt the best, but grains and onions are less resistant. Potatoes, apples and maize are highly sensitive to salt (STOWA, 2021). The introduction of saltwater into the landscape would have long-term implications for agricultural practices.



[Fig. 20] Polders of Zeeuws-Vlaanderen (Swart, 2013)

Legend

Agricultural land and produce

- Crop cultivation
- Complex cultivation mix
- Pastures
- Fruit cultivation

Flood effected areas

- Dike
- Flooded area when primairy dike fail

[Fig.21] Flood in agricultural landscape.
Source: (Meyer et al., 2015; European Union's Copernicus Land Monitoring Service information, 2018)

6.1 RESPONSE-ABILITY

The last layer of flood defence is the ability to flee the area or get to higher ground.

Evacuation

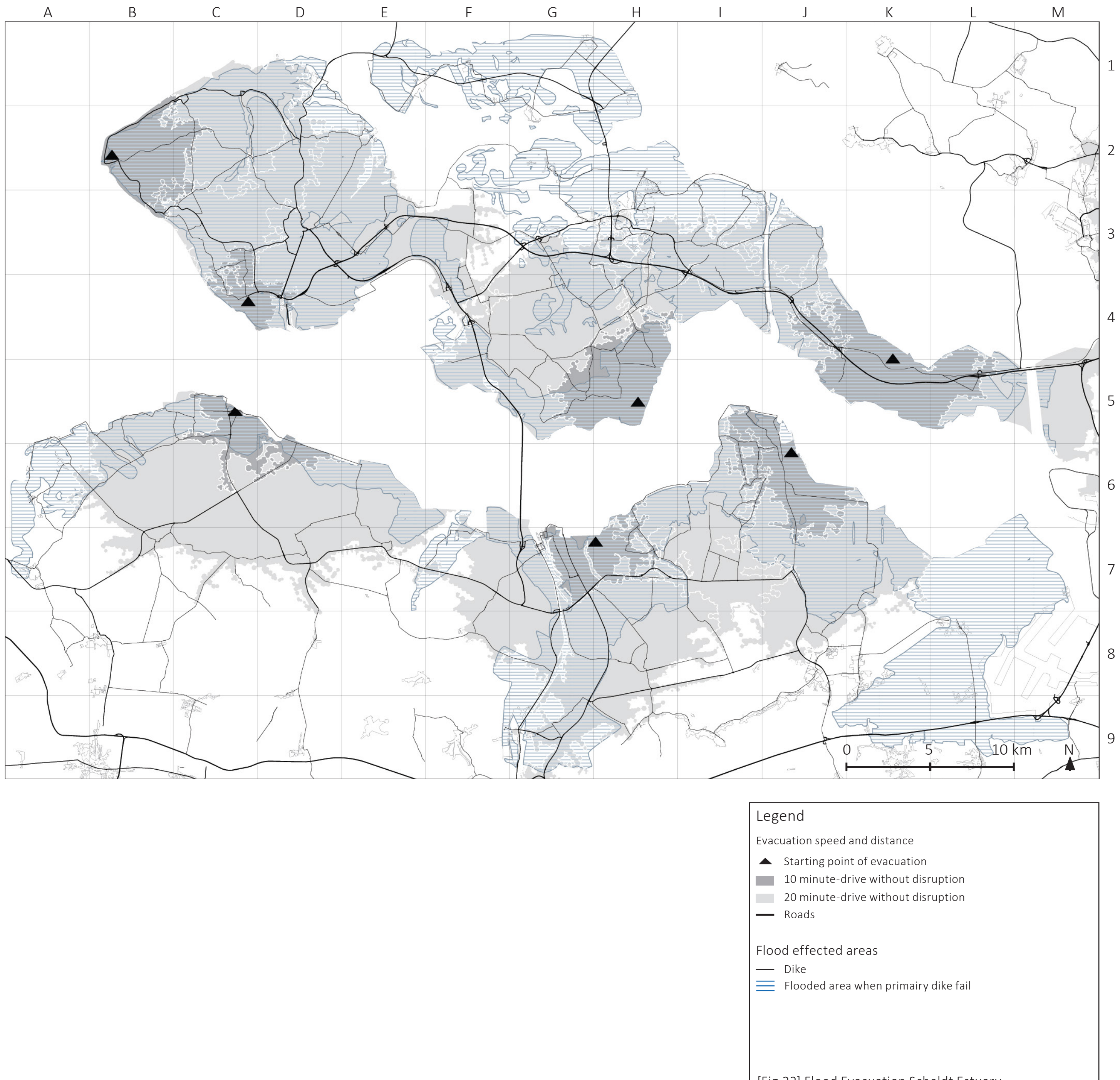
The response is evacuation. People need to have the opportunity to flee to dry land. Due to the extensive layout of the flood zone and the sprawling urban clusters, this will require most of the road infrastructure to accommodate travel by car.

Following the framework of flood risk management, regional roads are supposed to be situated on elevated ground and, in rural areas, on dikes. This ensures an uncompromised escape route. However, many of the provincial roads sporadically dip to or even below, sea level. Moreover, the two-lane roads are not suited to accommodate large numbers of vehicles. This could result in traffic congestion and limited mobility.

To Higher Grounds

Zeeuws-Vlaanderen is in the best position for evacuation, due to the many directions one can take to reach Belgium. However, Walcheren has limited evacuation options but has the dunes as elevated spaces for evacuation. Zuid-Beveland has space in its centre, while Reimerswaal has to flee either to Zuid-Beveland or Brabant.

The congestion of the roads and there potential flooding can cause more harm than good. As response, the regional crisis plan suggests two methods of evacuation: preventative and vertical evacuation. Preventative evacuation occurs when people are notified by the government before the flood, when there is time to flee, to leave the area. Vertical evacuation is when people flee to higher levels in a building or their home. However, the research by Terpstra & Buijs (2020) shows that even if inhabitants are urged by the government to stay in their homes and vertically evacuate, 32% of the participants will still attempt to leave the area. This would be about 150.000 people if reflected on the population of the region.



[Fig.22] Flood Evacuation Scheldt Estuary.
Source: (TravelTime, 2024; TU Delft, 2024)

Zeeland's clay (van Riet, 2014)

6.2 COMPOSE-ABILITY

To construct the subsystems that enabled the response to flooding, the Dutch have altered the landscape and soil. The shortening of the coastline and the remodelling of the coastal area have turned the region into an industrial mechanism for anthropogenic processes.

Landscape of clay

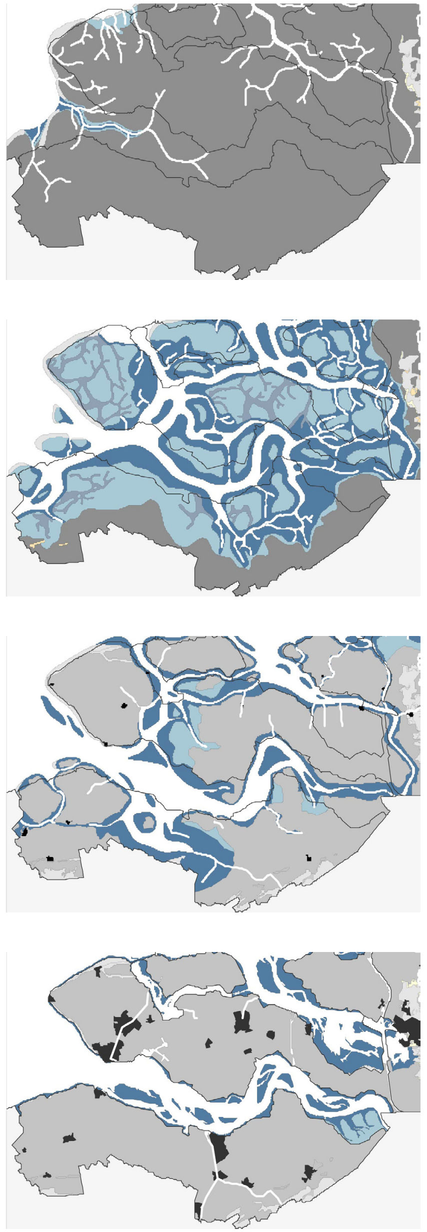
The landscape is characterised by fertile clay, shaped by both human and natural processes. Continuous salt extraction from peat soils has removed the topsoil, exposing the fertile clay beneath. This process was repeated for every reclaimed parcel of land [Fig. 23].

Mosaic of Polders and Plots

The reclaimed land was converted into clay polders.As the islands gradually expanded, the polders progressively reshaped the landscape. Further reducing the length of the coastline [Fig. 24]. This transformation not only shortened the coastline but also diminished the areas where tidal processes took place. It thins the transition from land and water.

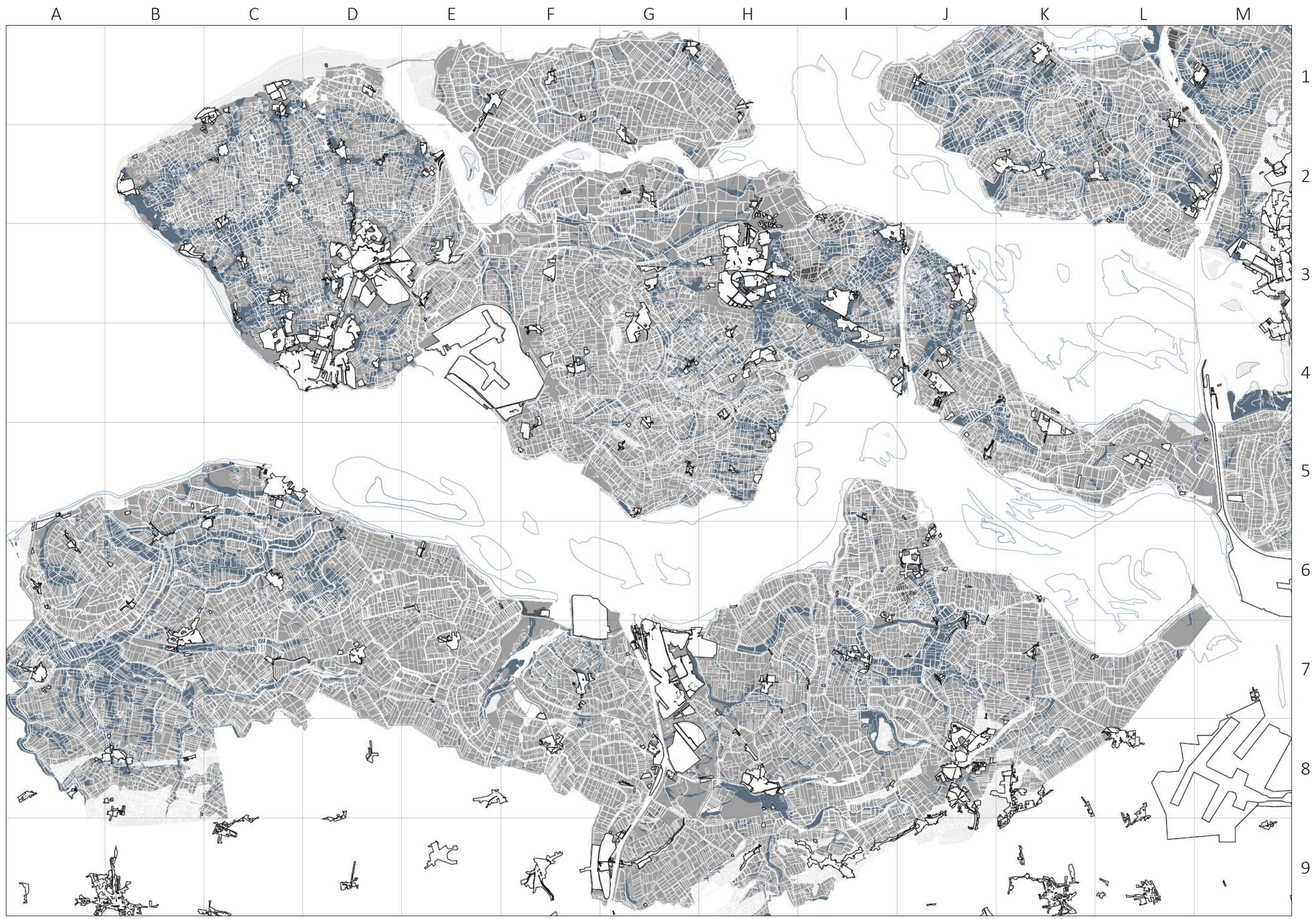
The polders compartmentalised the drainage system of the land. In the mean time, the agricultural plots created a mosaic pattern. The design prioritised maximum efficiency the polder system, while also demonstrating a nuanced recognition of soil types, particularly the creek ridges [Fig. 25].

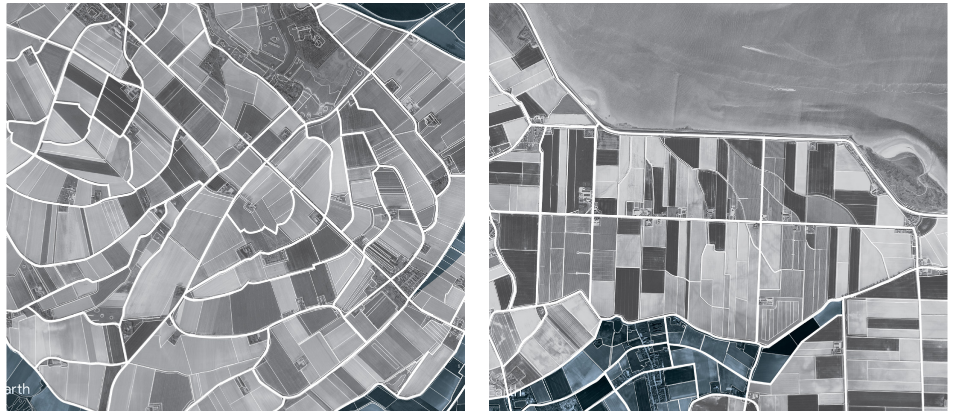
This mosaic reflects the extensive anthropogenic influence on soil composition. It also illustrates the dependency on specific soil types to optimise the system's functionality for mechanisation [Fig. 24].



Legend
Geomorphology
Sand
Peat
Clay
Creek ridge
Sand
Urbanisation

[Fig.23] Land alteration. Top to bottom: 100, 800, 1500, 2000 AD. Sources: (Vos et al., 2020)





[Fig.25] Mosaic of polders and plots. Left: B6 area. Right: J6 & K6. Sources: (Google Earth, 2025)

Legend
Geomorphology
Sand
Peat
Clay
Creek ridge
Compositional elements
Dike
Urbanisation and industrial ports
Polder edge
Agricultural Plot edge
Tidal landscape ede

[Fig.24] Polder mosaic, composing the top soil. Source: (Waterschap Zeeuwse Eilanden, 2005; WUR, 2023; NASA, 2024; TU Delft, 2024)

6.2 COMPOSE-ABILITY

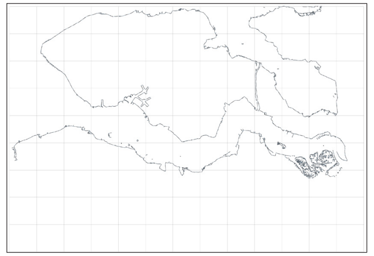
The Dutch government has established a reference line along the coastal front, known as the BKL ('BasisKustLijn'). This reference enables the organisation of sand nourishment along the coast. It enables detecting coastal retreat due to erosion (Rijkswaterstaat, 2025). By imposing this line, the composition of the landscape renders the transitional zone between land and water static. Meanwhile, the water dynamics of the delta continue to shift both horizontally [Fig. 26 & 27] and vertically [Fig. 28].

Each Time a Different Coast

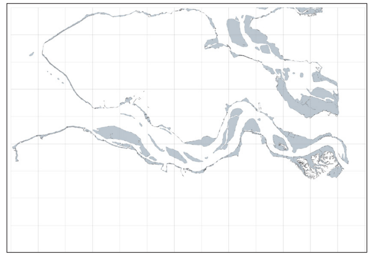
The dikes have restricted the movement of the waterfront by creating a boundary. By removing water movement from the landscape, it became possible to stabilise the region for habitation and preserve freshwater resources for agricultural purposes. While outside the dike, the coast stretches and contracts with each wave, tide and storm, the inland area remains fixed in size.

Hidden Transitional Zone

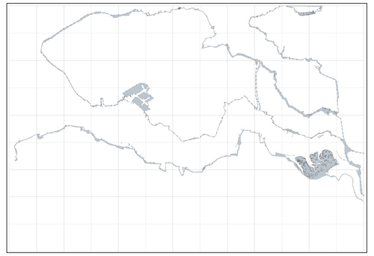
The coast is often viewed as the transition zone between land and water. However, this is only at the surface level. The clay that forms the landscape, including the dikes, is 'marine' clay, essentially a part of the seascape. Furthermore, the intrusion of salt water through the soil demonstrates that disconnecting the sea from the land with dikes is not entirely impermeable. Flood management efforts may attempt to control Deltaic Conditions to some extent. Although, they require constant maintenance and remodelling to sustain this arrangement.



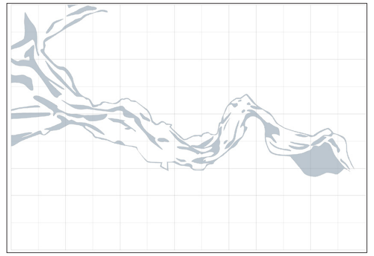
Minutes to hours - Waves & Swell



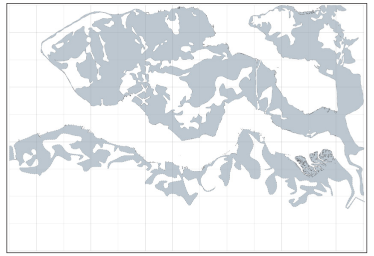
Hours to day - Low tide & High tide



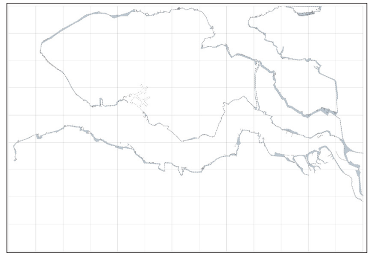
Days to weeks - Storm surge



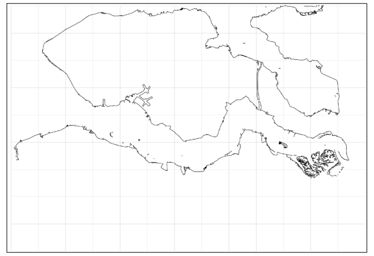
Weeks to months - Erosion & Sediment



Years to decades - Salinisation



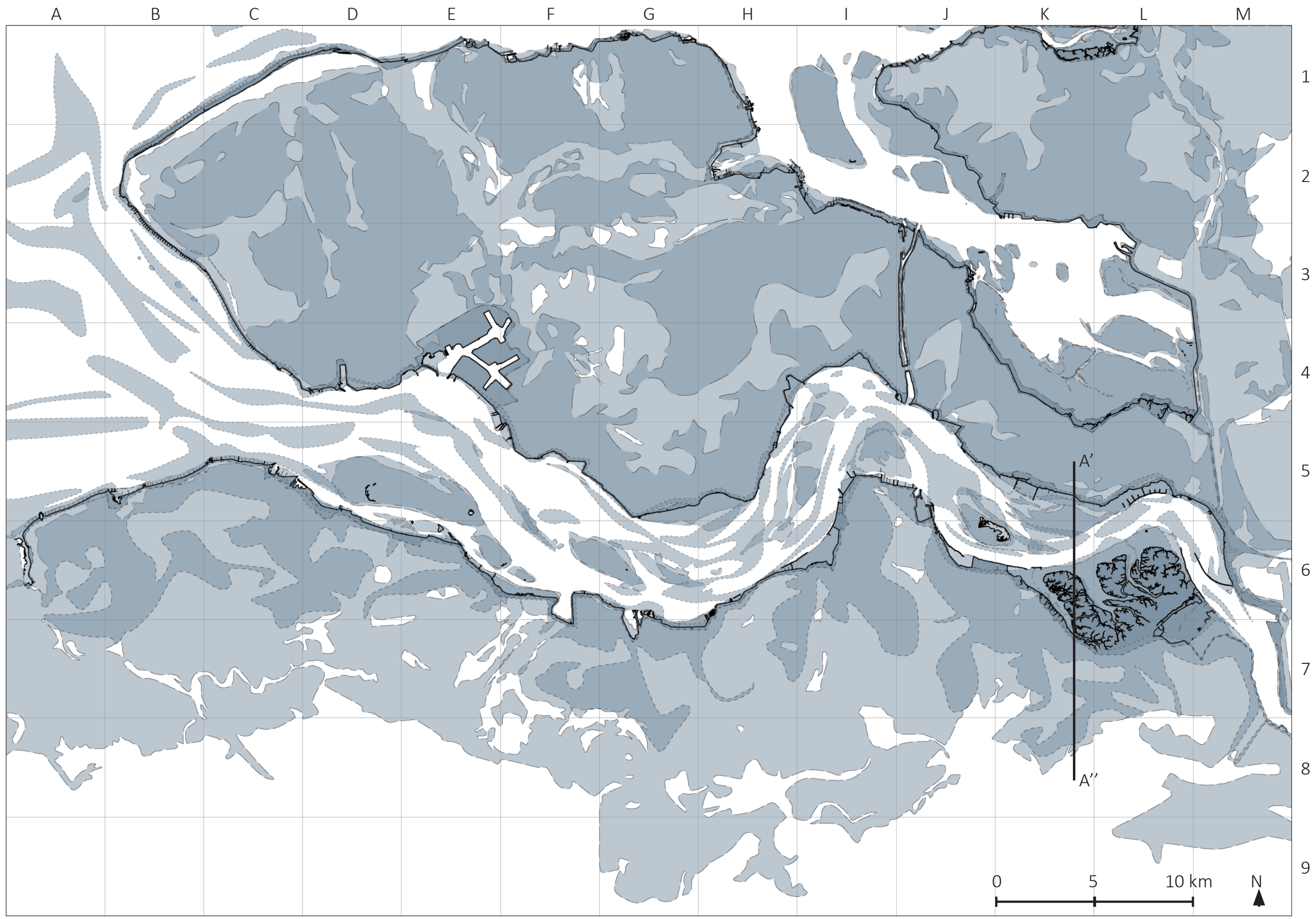
Years to decades - Standarised coastline



Decades to centuries - Mean Sea Level

Decades to centuries - Geological form

[Fig.26] Dynamic coastlines.
Sources: (Groenedaal, 2005; Elias & Van Der Spek, 2015; Kanj, 2023)



Legend

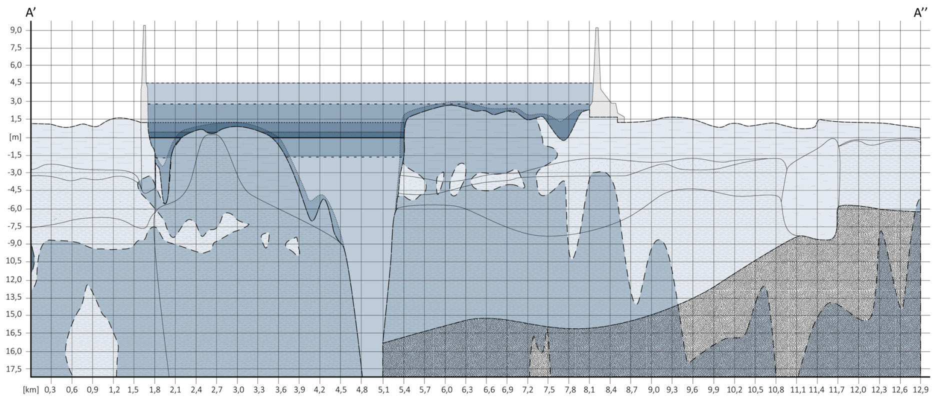
Coastlines

- Official Coastline
- Waves & Swell
- Low & High Tide
- Stormsurge
- Erosion & Sediment
- Salinisation
- Mean Sea Level
- Geological form
- Dynamics in the coast

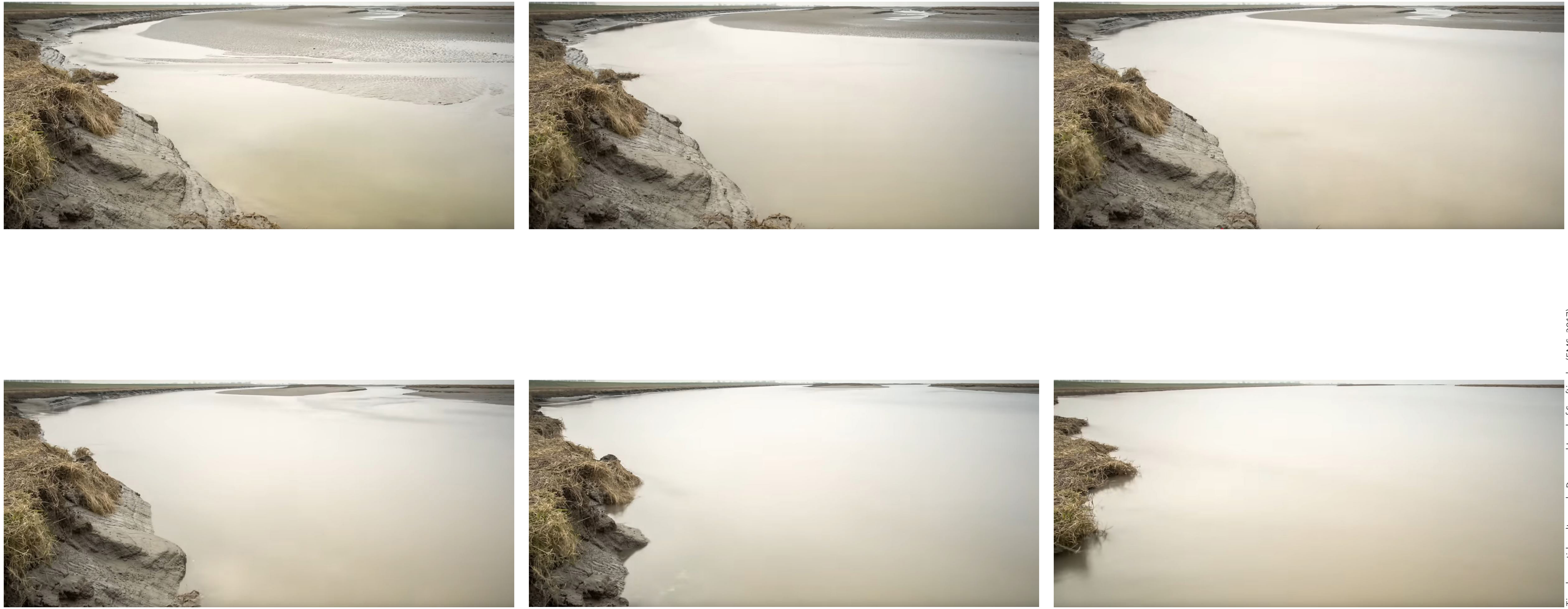
Geomorphology

- Anthropogenic deposits
- Coastal sand and gravel
- Sand and humic clay
- Coarse sand, partly clay
- Tidal sand and clay
- Fluvial sand with clay layers
- Clay, humus, with shells
- Moss peat

[Fig.27] Dynamic coastlines. Sources: (Groenedaal, 2005; Elias & Van Der Spek, 2015; Kanj, 2023)



[Fig.28] Dynamic coastline section.
Sources: (Dutch Ministry of Defence, 2022; TNO, 2024; Deltares, 2024)



Timelapse tide salt marsh, Drowned Land of Saeftinghe (EMS, 2017)

6.2 COMPOSE-ABILITY

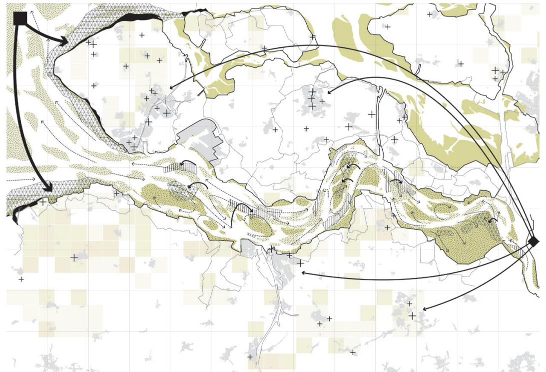
To sustain the mosaic and industrialised landscape, significant maintenance is required. This involves the continual relocation of soil.

Human vs Non-Human Processes

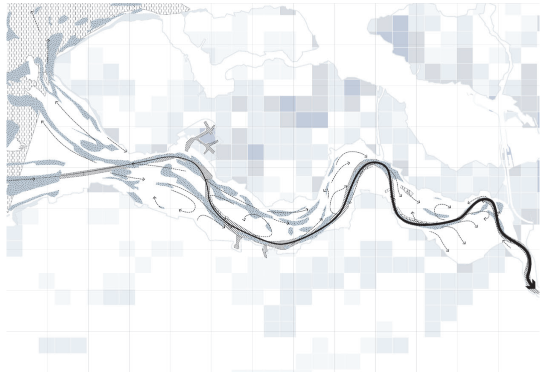
The Scheldt Basin and North Sea supply the delta with sediments, while anthropogenic activities redistribute sand and clay. Maintaining dikes and dunes necessitates regular nourishment with sand, often sourced from the North Sea [Fig. 29]. Sediments that accumulate in the estuary are frequently dredged to clear shipping channels and are subsequently relocated to sandflats, eroding riverbeds, dumping sites or transported to Antwerp for processing [Fig. 30]. Refined sand and clay are then utilised to maintain existing settlement infrastructure or to create foundations for new construction. As long as the current flood management approach and its spatial impacts persist, these energy-intensive activities will remain essential [Fig. 31].

Imbalance in Soil Accumulation

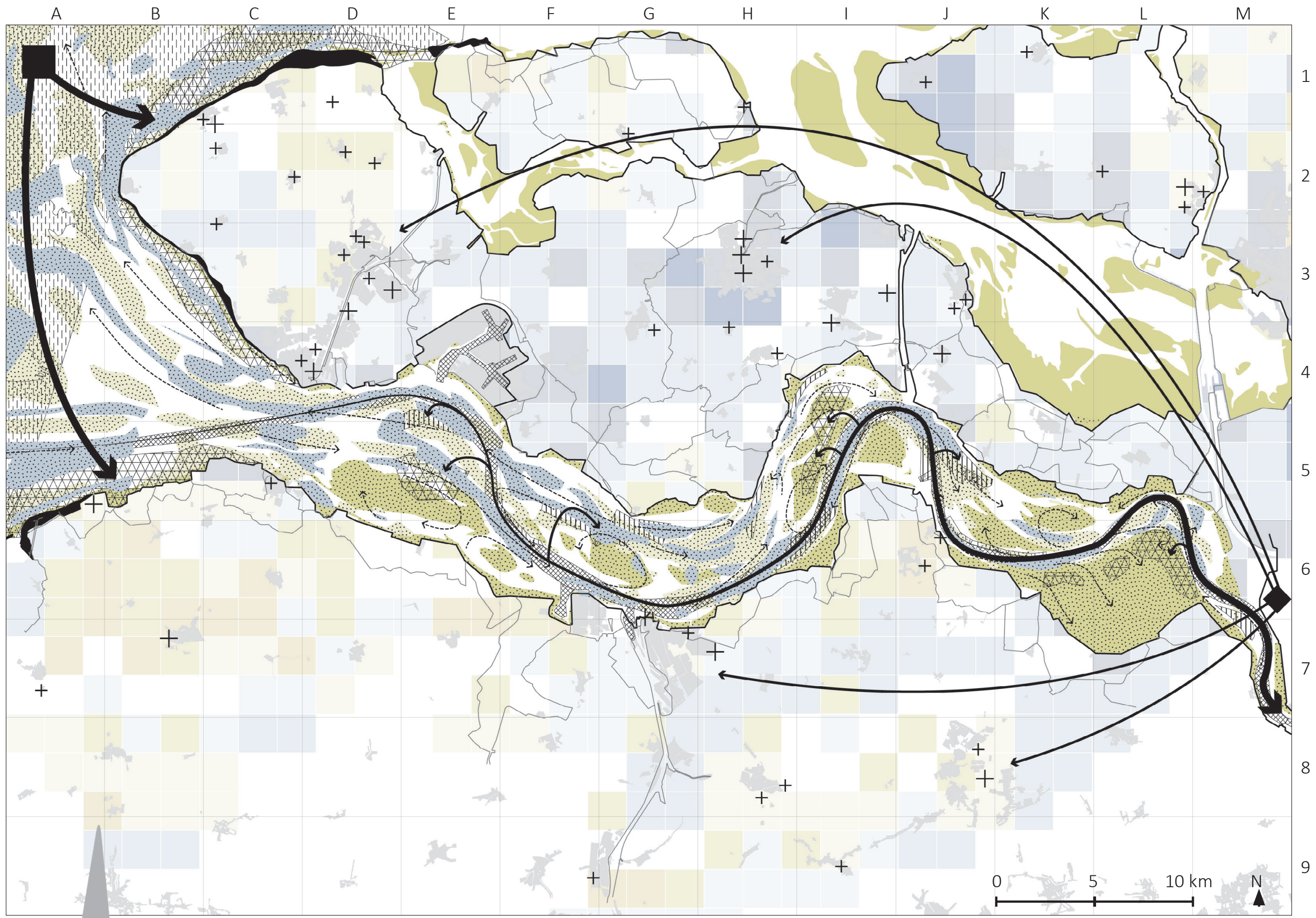
While the estuary is continuously replenished with sediments from the sea and river, the dikes obstruct the natural flow of sediments into the hinterland. This creates an imbalance in soil accumulation. Although the water remains rich in newly deposited sediments, the land is deprived of nourishment. Additionally, drainage exacerbates land subsidence, as stabilised clay contributes to soil sinking. The current configuration of subsystems prevents the land from being replenished, while over-enriching the water with sediment [Fig. 32].

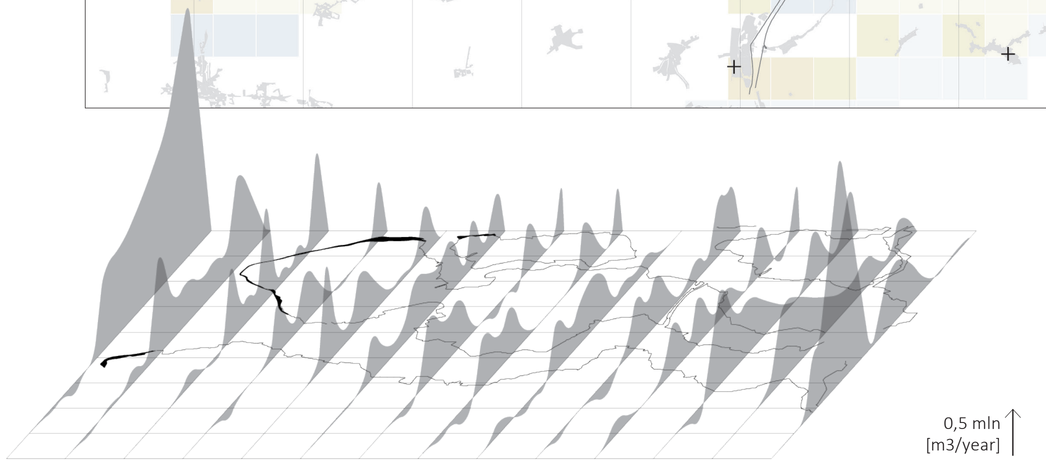


[Fig.29] Composing the soil.
Source: Extraction of the Composing and Decomposing map.



[Fig.30] Decomposing the soil.
Source: Extraction of the Composing and Decomposing map.





[Fig.32] Sand accumulation in the water, while slightly decreasing behind the dike.
Sources: (Storm, 1996; Deltares, 2019; Arcadis, 2022; NCG & SkyGEO, 2022)

[Fig.31] Composing and decomposing of soil.
Source: (Storm, 1996; Kornman et al., 2003; Deltares, 2019; Arcadis, 2022; NCG & SkyGEO, 2022; Zeeuwse Woondeal Zeeland, 2023)

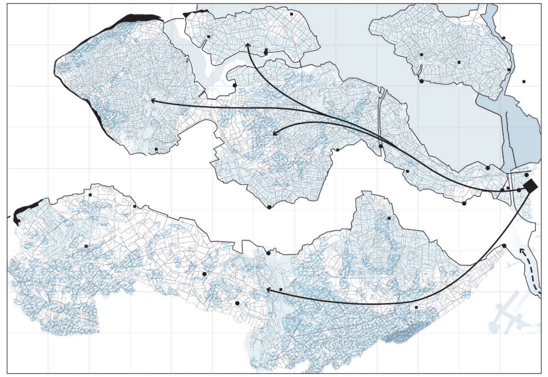
6.2 COMPOSE-ABILITY

The preservation of freshwater for agricultural practices requires the constant management of salt and freshwater distribution. This is achieved through the use of dikes and drainage systems that compose the landscape.

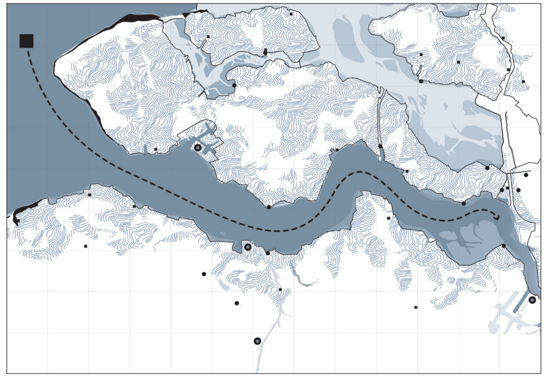
Freshwater Machine in a Saltwater Environment

To sustain the current mode of habitation in the landscape, freshwater is continually imported from the Biesbosch and West-Brabant [Fig. 33]. This supply is used primarily for drinking water but also for agricultural lands, where the capacity for local groundwater is limited. However, the extraction of groundwater exacerbates the process of salinisation [Fig. 34].

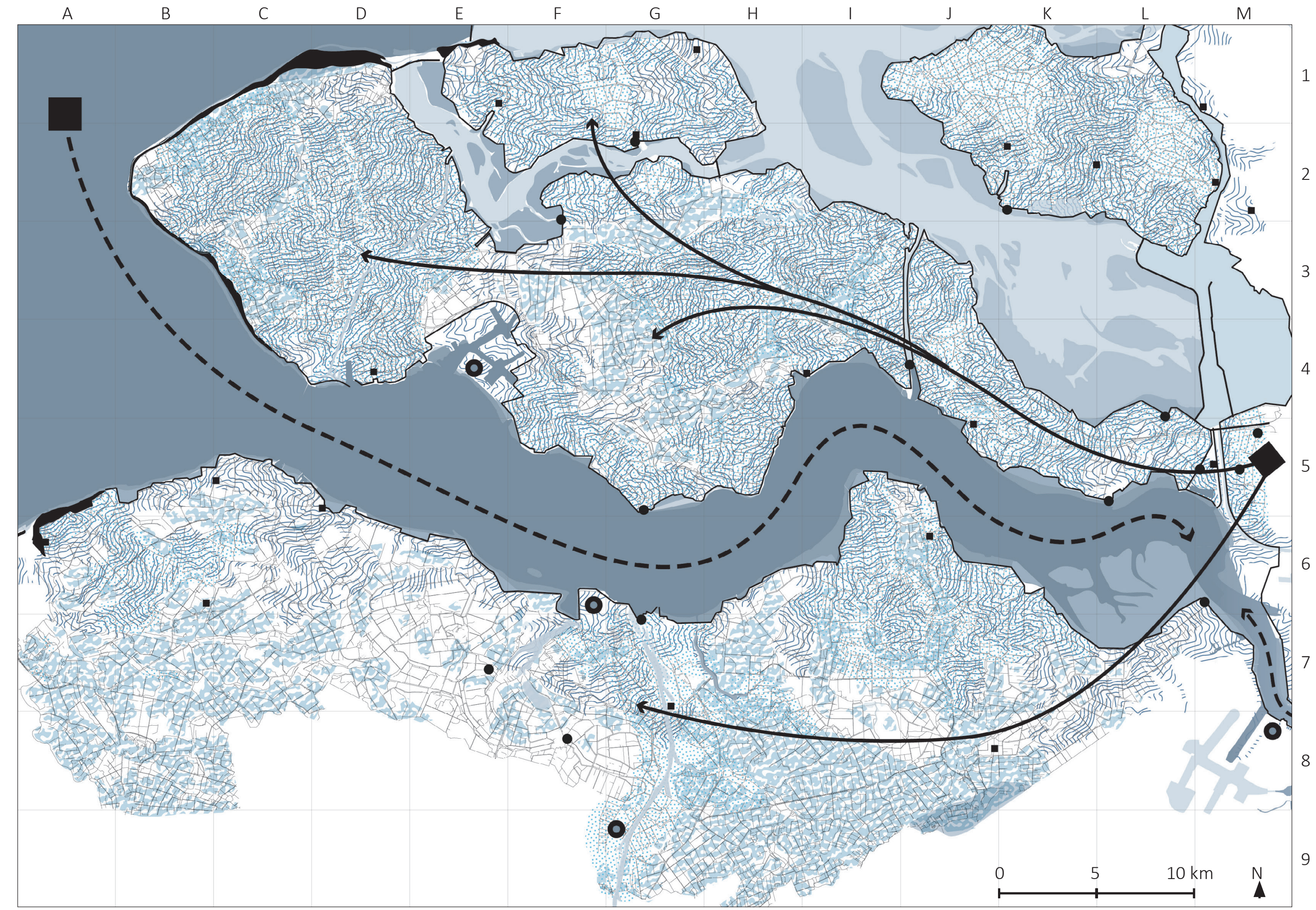
To mitigate this, a practice known as flushing is employed. Freshwater is pumped into the polders and their channels to 'flush out' the salt (Rijkswaterstaat, 2019). This represents yet another anthropogenic intervention against the natural conditions of the deltaic system by forcing the salt water back into the river [Fig. 36]. The current mechanisation of the landscape necessitates the constant introduction of external freshwater supplies [Fig. 35].

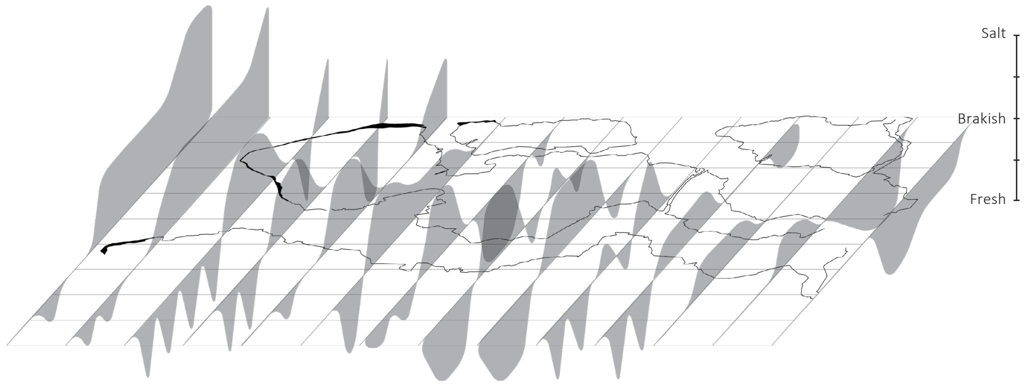


[Fig.33] Composing the fresh water system.
Source: Extraction of the Composing and Decomposing map.



[Fig.34] Composing the salt water system.
Source: Extraction of the Composing and Decomposing map.





[Fig.36] Distribution of salt and fresh water.
Sources: Based on the Compose and Decompose map.

[Fig.35] Composing and decomposing of water.
Source: (Provincie Zeeland, 2015; Evides, 2023; Provincie Zeeland, 2023; Deltares, 2024; Provincie Zeeland, 2024)

6.3 THE SCHELDT BASIN

The composition of the estuary is greatly influenced by its international connections. On one end, the North Sea; on the other, the wider Scheldt Basin which extends into Belgium and France.

Sea-fed River Basin

Saltwater travels deep into the river due to the low discharge of freshwater coming from upstream. The inflow of freshwater from the Scheldt River, its tributaries and local drainage accounts for only 1% of the tidal prism. The tidal prism refers to the volume of water that flows into and out of an estuary with the ebb and flood of the tide. The average inflow of freshwater from the river is around 110 m³/s (Van Maldegem et al., 1993; Ysebaert et al., 1993), compared to the North Sea's inflow of 254,629 m³/s (Gerritsen & de Jong, 1983; Claessens, 1988; Baeyens et al., 1998). This causes the estuary to be naturally saline. To reach a salinity of one on the Practical Salinity Unit (PSU) scale (equivalent to one gram of salt per litre), one must travel upstream just beyond Antwerp (Vandenbruwaene et al., 2013).

Looking ahead, climate change and sea level rise introduce uncertainty regarding future balances. However, the combination of rising sea levels and longer periods of drought is expected to result in higher levels of salinisation, extending even beyond the estuary (Zhu et al., 2024).

North Sea Sediment

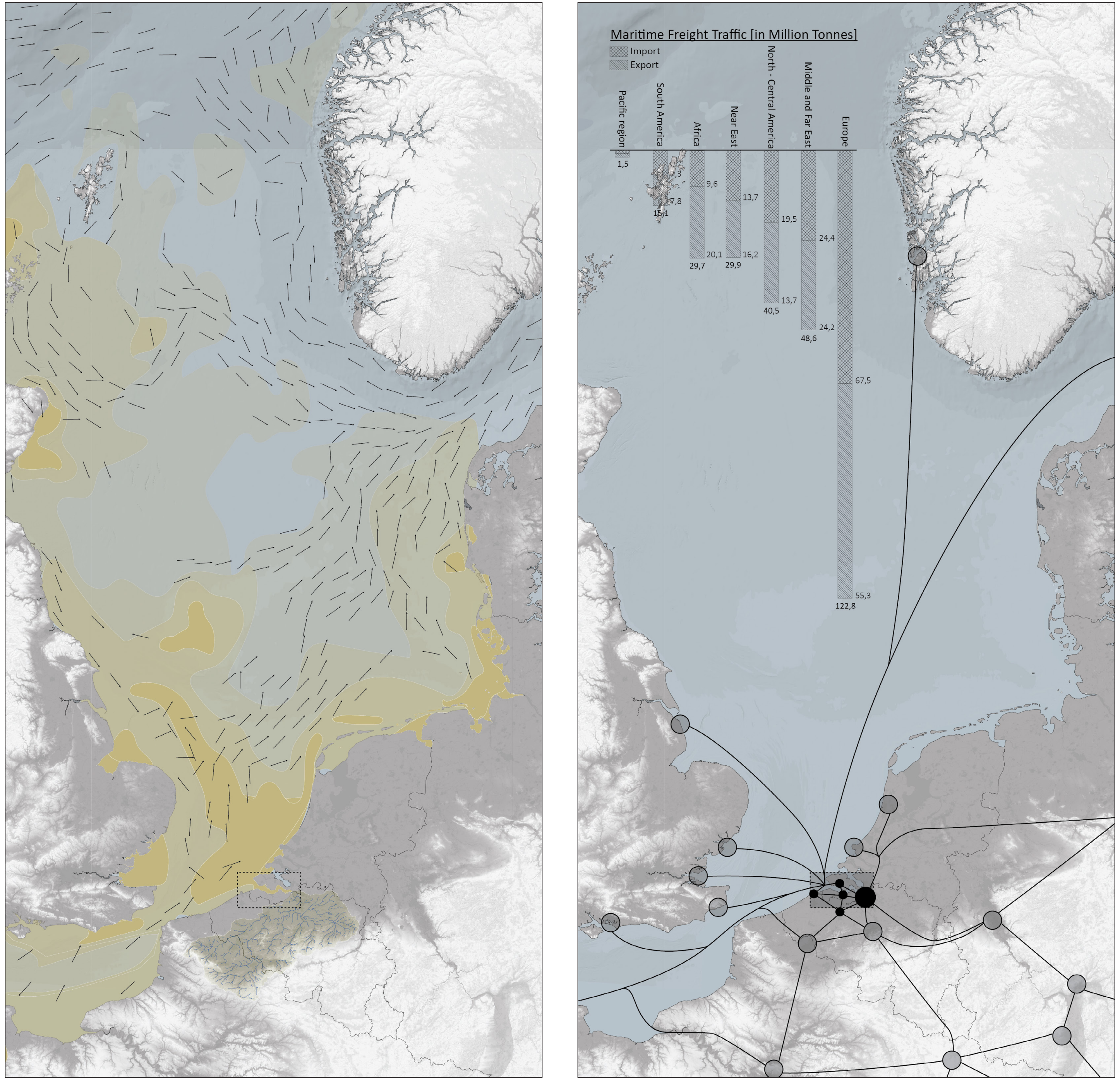
The influence of the sea is also evident in the sediment deposited in the Scheldt. Most of the sediment in the region originates from the seabed [Fig. 37], with an average deposition of 1.6–2.6 million m³ per year. While the river does carry sand and clay downstream, the volume is comparatively small (around 0.16 million m³ per year) relative to the North Sea's tidal input (Elias et al., 2023).

International Gateway

The Scheldt supports multiple ports, including the Port of Antwerp-Bruges, the second largest port in Europe and a close partner of the largest, the Port of Rotterdam. Antwerp trades globally in bulk, container and chemical cargo (One Ocean Maritime Media, 2022).

Dredging the river is essential to maintain these trade routes, but it also disrupts natural river processes such as nutrient cycling and ecological functioning. It increases the tidal range due to riverbed deepening. Closing the trade route would have major repercussions for the region. Including job losses and reduced capacity for local businesses to trade internationally.

The estuary is shaped by international flows converging in the region. It reflects local complexity and a high degree of dependence on global interconnectedness [Fig. 37].



[Fig.37] Scheldt Estuary external influences. Left: Movement of sediment from North Sea and Basin. Right: International port crossroad of Europe and the world.
Sources: (European Environment Agency, 2016; Wilson et al., 2017; Henry et al., 2018; Safety4Sea, 2023; de Vriend et al., 2024; TU Delft, 2024; ArcGIS, 2025)

6.4 IDENTITY AND VALUES

Now that the international relations have been outlined. It is necessary to understand the local values and identity connected to the composition of the landscape. To this end, the work of Van Keken (2011) has been consulted, alongside insights drawn from my own fieldwork and conversations with local inhabitants.

Born from Water and Clay

I travelled along the coastal edge of the estuary, from dikes to dunes. Each time I asked a local resident to describe the landscape of Zeeland, the first elements they mentioned were clay and water. These are the foundational components of the local communities, sustaining livelihoods from farming to seafaring. This relationship dates back to early times and remains evident today. The methods may have become mechanised, but the underlying principles remain the same.

The relationship with water is also the most frequently cited aspect of Zeeland's identity in Van Keken's (2011) research. It reflects not only the importance of the coastal landscape, but also the enduring struggle against water. A theme deeply rooted in both historical and contemporary community life. Zeeland's motto is "Luctor et Emergo!". This roughly means "I struggle and rise up!" (translated from Latin). It captures the spirit of resilience in the face of flooding, war and other adversities. It reflects the enduring strength and adaptability of the people of Zeeland.

A Landscape of Never-Ending Views

Space and tranquillity are core values associated with the landscape. Van Keken (2011) links this to the spatial experience of the endless polder views and expansive water surfaces. The openness, stability and gentle sound of waves contribute to a sense of calm. During my fieldwork, this sentiment was echoed by residents. One local remarked, "No better place to watch the sky!" (translated from Dutch). The statement highlights the broad horizons and lack of vertical obstructions in the landscape.

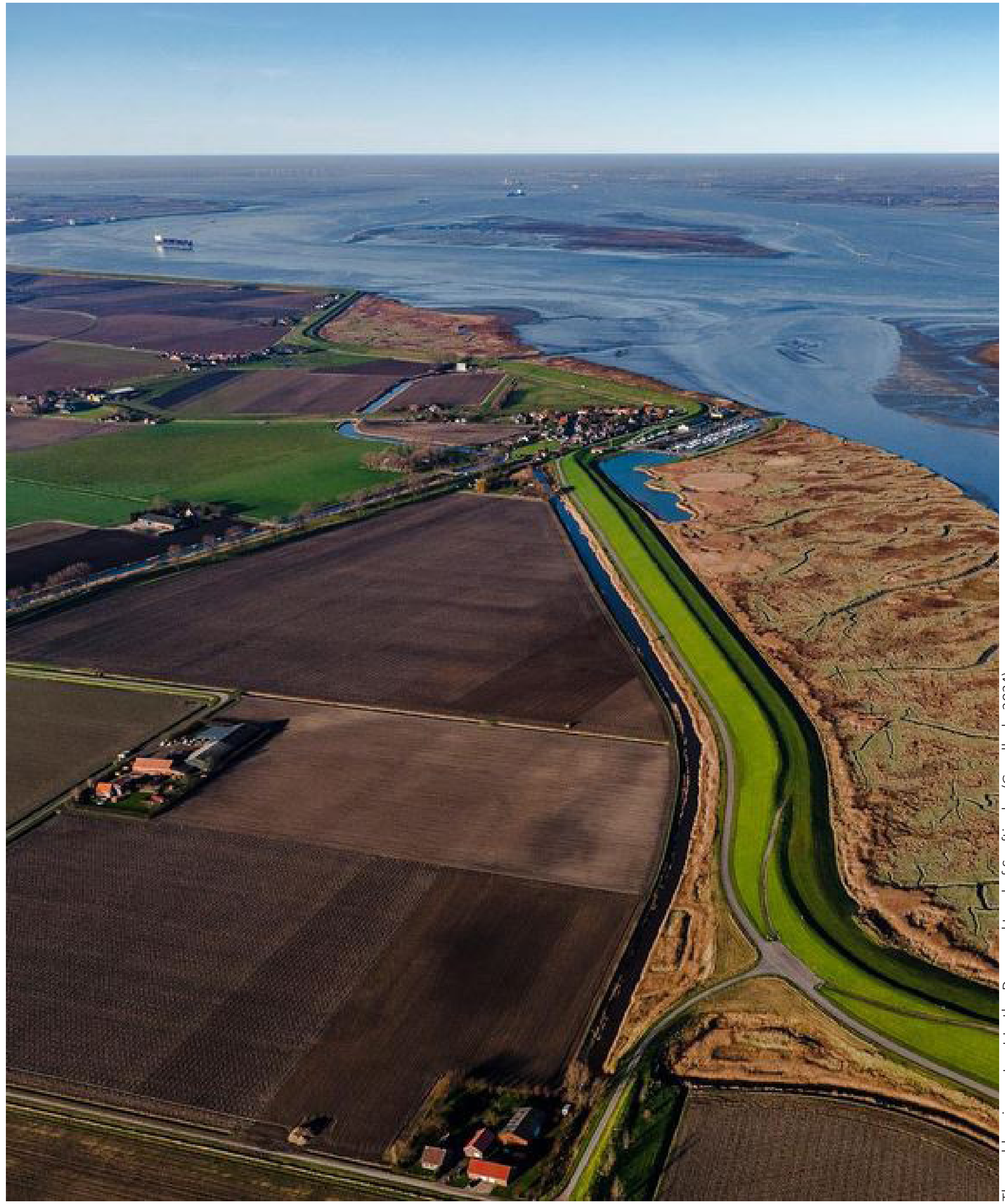
Pride in Nature and Heritage

Residents take pride in both their natural surroundings and cultural heritage. Many spoke of the wildness of Zeeland's nature. The incoming waves along the shores, the richness of the dunes and beaches. At the same time, landmarks such as churches and water towers serve as visual anchors in the landscape, valued for both navigation and historical significance.

The polders and dikes are more than infrastructure. They are part of the cultural heritage and a source of collective pride. Residents express a deep attachment to their environment and the defining features of the Delta, shaped by both human and non-human forces. Water and clay have formed not only the landscape but also the character of the communities. While adaptable to change, these communities remain strongly rooted in the region.

These local values and identities must be integrated into future scenarios and visions for the area.

[Fig.38] Images used in Van Eken's research, sourced from local photographers and the archive of Zeeland.
Sources: (Van Eken, 2011).



The polders in contrast to the Drowned Land of Saeftinghe (Gundlach, 2024)

CHAPTER 7 PROJECTING THE DELTAIC CONDITIONS

7.1 RETURN OF DELTAIC CONDITIONS

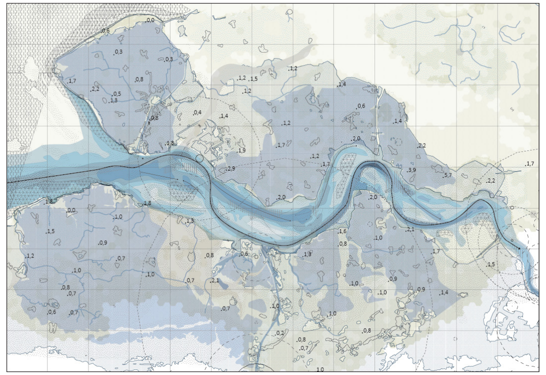
This chapter analyses the uncontrolled return of Deltaic Conditions by deactivating flood defences and drainage systems. The reintroduction of these conditions will reveal conflicting dynamics as well as potential synergies between ecosystems

Conflict: Human Systems & Dynamics

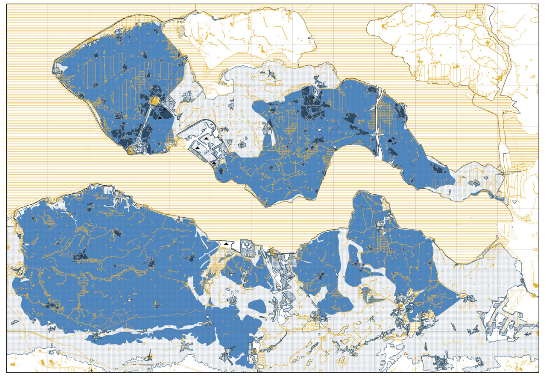
The opening of the dikes reintroduces dynamics that have been absent from the landscape for hundreds of years, such as tides and sediments [fig. 39]. The interaction between elevation levels and water flows creates new conditions in the region [fig. 42]. However, these conditions and flows conflict with human infrastructure. Living spaces are flooded, landscape and architectural heritage are affected, agricultural practices are disrupted. Most critically, chemical pollution spreads into both rural and urban areas. The current configuration of human infrastructure and industry is not adapted to accommodate the reintroduction of tidal flows, leading to serious conflict.

Potential: Non-Human Systems & Dynamics

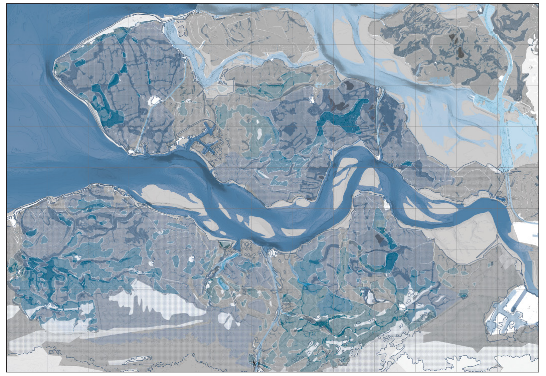
In contrast, apart from the chemical pollution, the non-human composition is welcoming the return of the deltaic flows [fig. 41]. The tide allows nutrients cycles to be returned, land growth to take place and the salt marsh habitat is being revived. While the human systems are not designed for these tides, the non-human system gets nourished by it.



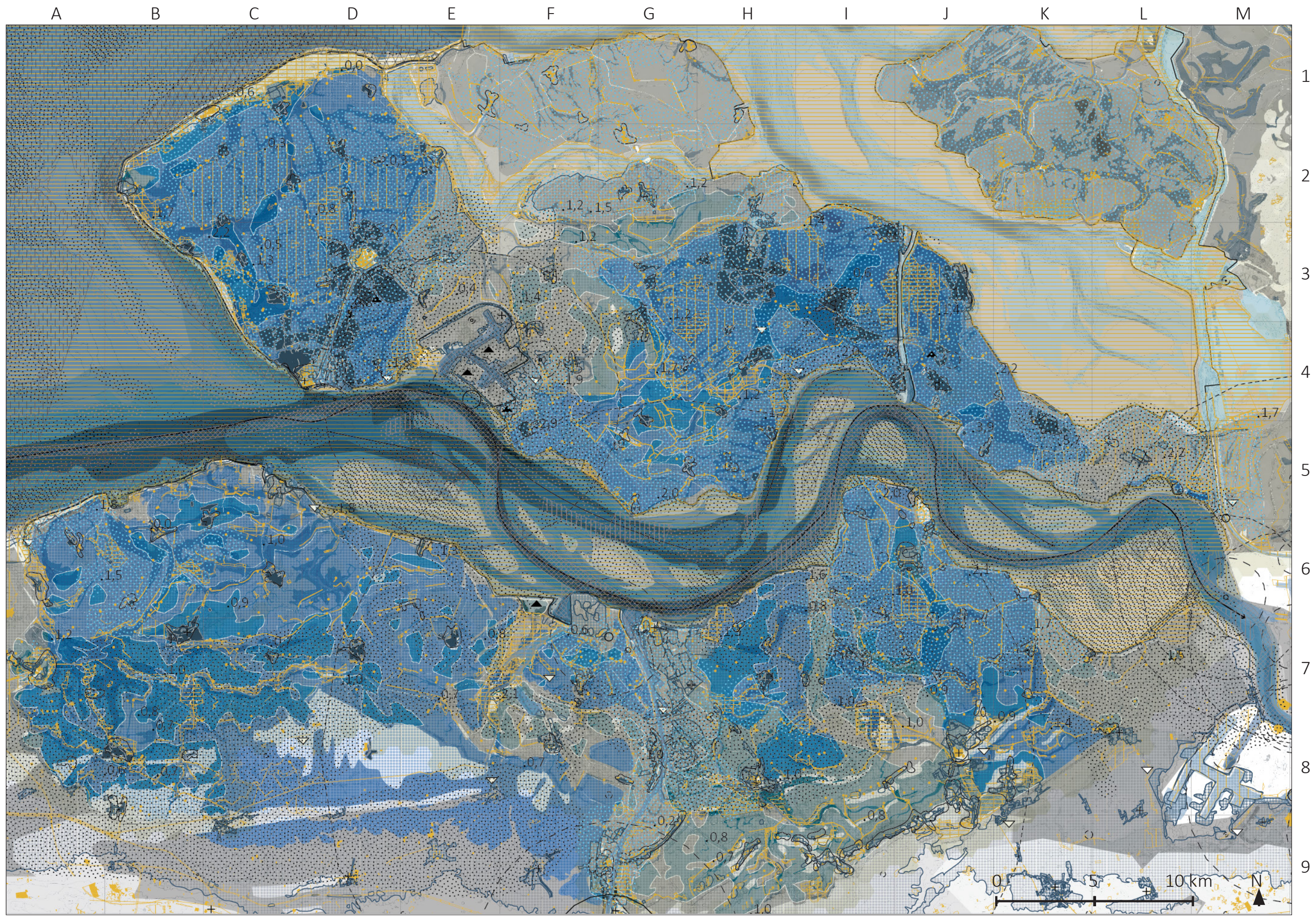
[Fig.39] Deltaic Conditions: Flows.
Source: Extract from the Deltaic Condition map

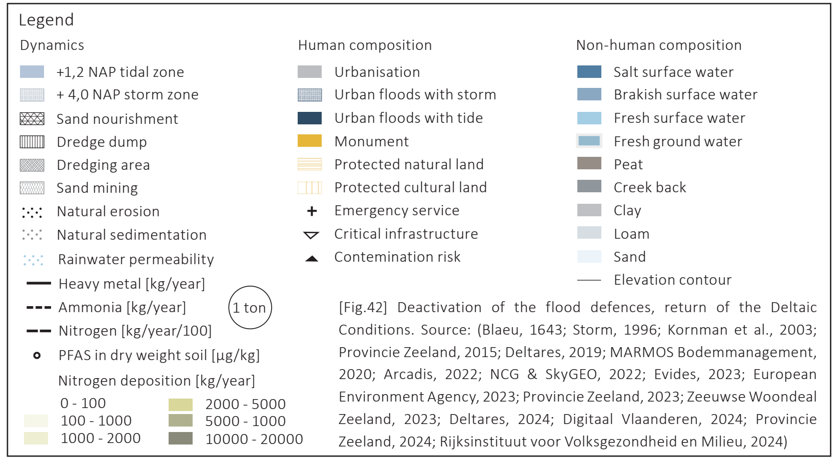


[Fig.40] Deltaic Conditions: Human composition.
Source: Extract from the Deltaic Condition map

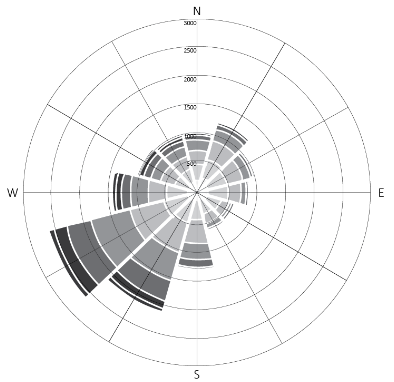


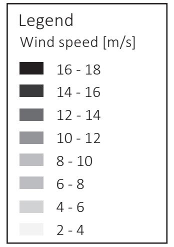
[Fig.41] Deltaic Conditions: Non-human composition.
Source: Extract from the Deltaic Condition map





[Fig.42] Deactivation of the flood defences, return of the Deltaic Conditions. Source: (Blaeu, 1643; Storm, 1996; Kornman et al., 2003; Provincie Zeeland, 2015; Deltares, 2019; MARMOS Bodemmanagement, 2020; Arcadis, 2022; NCG & SkyGEO, 2022; Evides, 2023; European Environment Agency, 2023; Provincie Zeeland, 2023; Zeeuwse Woondeal Zeeland, 2023; Deltares, 2024; Digitaal Vlaanderen, 2024; Provincie Zeeland, 2024; Rijksinstituut voor Volksgezondheid en Milieu, 2024)





[Fig.43] Wind patterns 1998 - 2018 in days.
Source: (Delta Expertise, 2019)

7.2 CRITICAL FLOWS

The returning tide carries three primary flows: nutrients, water and sand. If managed effectively, they could transform flooding into a beneficial process. While non-human ecosystems flourish with its return. The human environment remains ill-equipped to accommodate these shifting conditions [Fig.45].

Natural and Industrial Nutrient Cycles

The delta naturally regulates nutrient cycles. Although, the closure of the coast has disrupted this balance. With the reintroduction of Deltaic Conditions, the remediation potential of the landscape is restored. However, alongside natural nutrients, chemical pollutants from industrial ports and agriculture now enter the system. This influx revives natural cycles but also overloads the landscape. It would lead to an ecological imbalances.

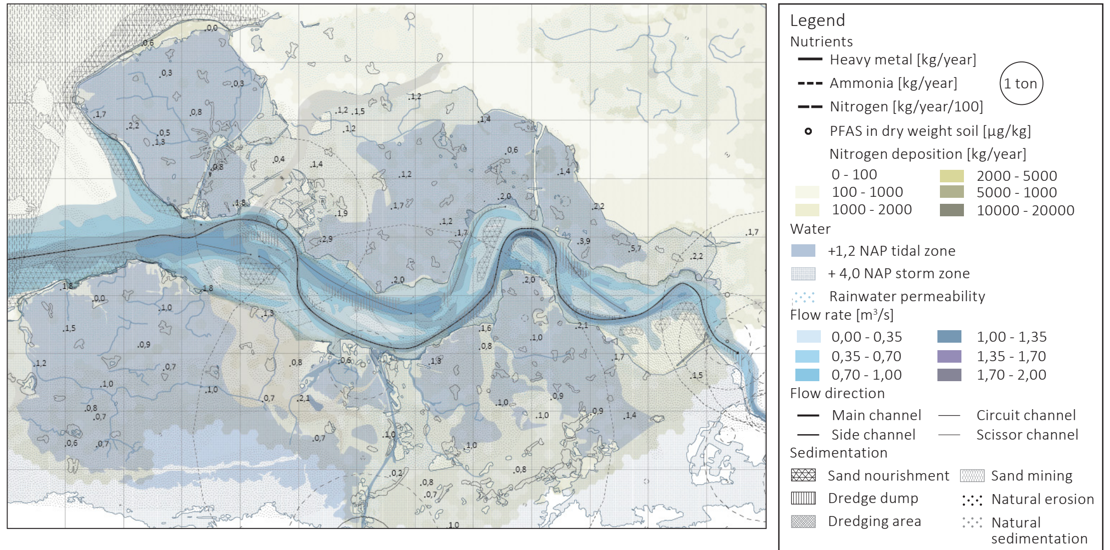
Waterscapes

The return of tidal flows reactivates ecological processes. However, settlements remain vulnerable to flooding. Rising water levels, particularly during storms, could extend as far as Belgium. The higher estuarine sea levels amplify the tidal range further upriver (Weisscher et al., 2022). While saltwater intrusion damages freshwater agriculture, it also enables the return of native brackish wetland habitats.

Land Growth

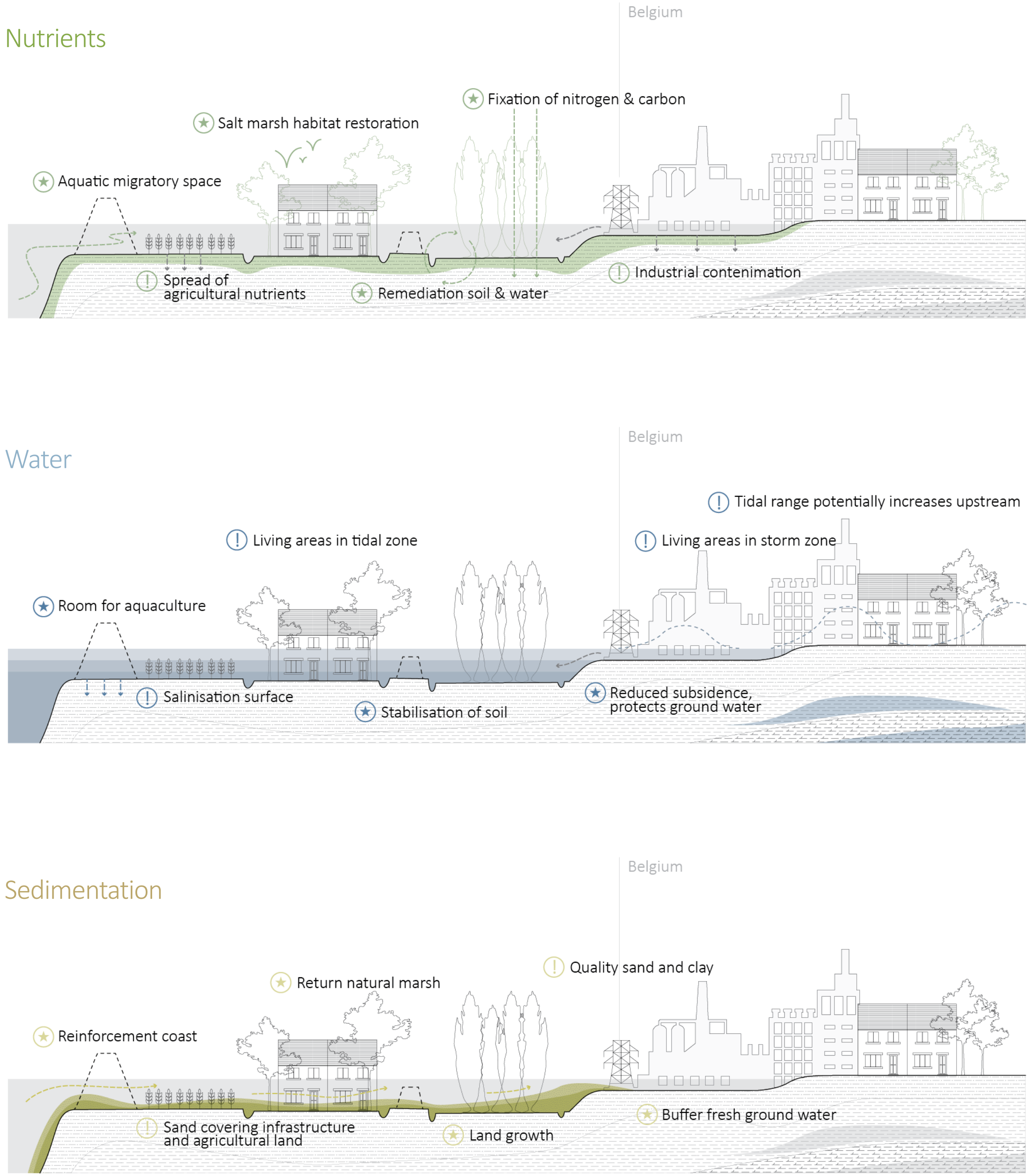
The natural accumulation of sand supports marshland expansion and land growth. But, sand deposits on agricultural land disrupt farming activities. The influx of sediments from both the North Sea and the river poses risks to soil quality.

To enable flooding to become positive force, these three flows are explored. In terms of how they can shape a beneficial response for human and non-humans.



[Fig.28] Deltaic Conditions: Flows. Source: Extract from the Deltaic Condition map

[Fig.44] Deltaic Conditions: Flows.
Source: Extract from the Deltaic Condition map



[Fig.45] The three critical flows: Nutrients, water & sedimentation.

The Beach of the Nuclear Centre in Borssele (Steketee, 2016)

CHAPTER 8 SCENARIOS

8.1 MAXIMISATION OF TIDAL FLOWS

Critical flows can serve as leverage points to transform flooding from a threat into an opportunity for the region. A method of maximisation was applied to develop three scenarios [Fig.46]. In each scenario, one of the three flows was optimised to generate the greatest possible value. These scenarios are then evaluated and the outcomes inform the development of design principles for Tidal Urbanism.

Sketching the Optimisation

Using free-form sketching methods, optimisation strategies were explored in both sectional and systemic forms. The results of these explorations shaped the design principles that guided the scenario development.

Working Through Scales

The design principles were translated into spatial strategies across multiple scales and mapped accordingly. This multi-scalar mapping enabled analysis and evaluation of spatial impacts at international, regional and local levels. It also revealed the consequences and potential of refining each flow.

Implementation and Timeframe

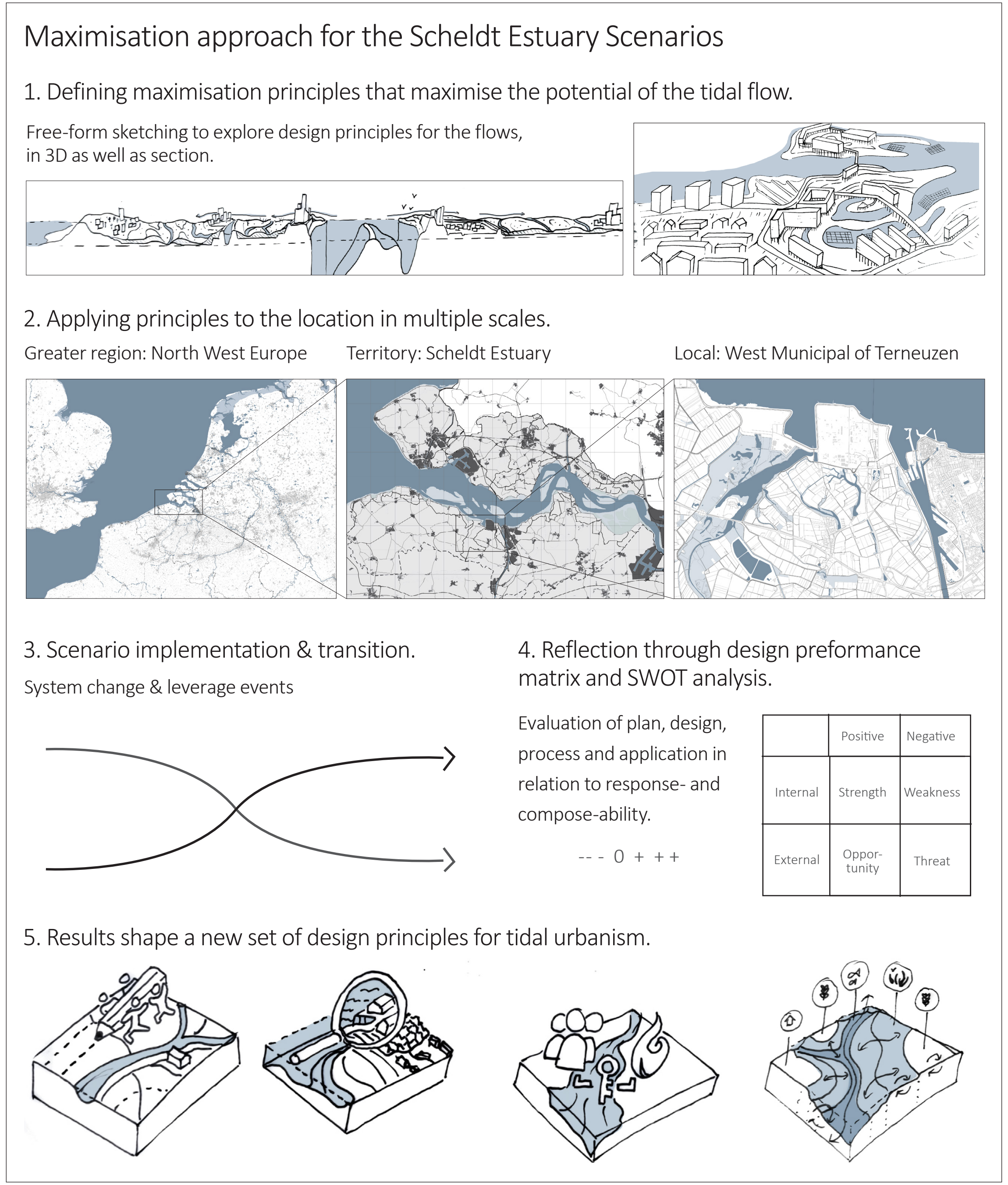
A transition timeline based on the X-curve model was developed to examine key leverage points and necessary activities that support the transition process. These events are not only spatial but also affect everyday life, financial structures and shifts in collective mentality. The timeline integrates social and economic dimensions into the environmental transition, acknowledging that these elements are inherently interconnected. The X-curve provides a comprehensive overview of where these dimensions converge.

Evaluation and Reflection

The performance of each scenario was evaluated in terms of its contribution to response-ability. During the workshop, the SWOT method (Strengths, Weaknesses, Opportunities, Threats) was used to critically assess each scenario on compose-ability. This structured approach provided valuable insights into the feasibility and resilience of the designs. Additionally, the workshop offered input and diverse perspectives that supported a broader reflection on the socio-ecological impact of the designs and on the social, ecological, economic and technical transformations needed to realise a viable future.

Input for Tidal Urbanism

The three flows are derived from tidal movement, which defines much of the dynamism of the delta landscape. The outcomes of this scenario-based exercise will inform a set of design principles that are both responsive and adaptive to Deltaic Conditions and climate challenges. These principles lay the groundwork for the development of Tidal Urbanism.



[Fig.46] Maximisation appoach explained.

8.2 SCENARIO 1: OPEN COAST

The Open Coast scenario maximises the potential of nutrient flows within the tides. It does this by reimagining flood management to accommodate flooding where it naturally belongs within the original ecosystem. Therefore, coastal management, which shapes the composition of the coast, prioritises ecological restoration. This chapter first describes how the composition of the region is altered, reflecting these changes across different scales and time periods.

Space for Remediation

The current landscape of the Scheldt Estuary is heavily polluted and contaminated by various chemicals from agriculture and industrial activities. To remediate the water and soil, large areas of open land within the floodplain are required. In this scenario, all flood-prone areas are returned to the tide, while humans retreat to higher, dry elevations.

Removal of Sources of Contamination

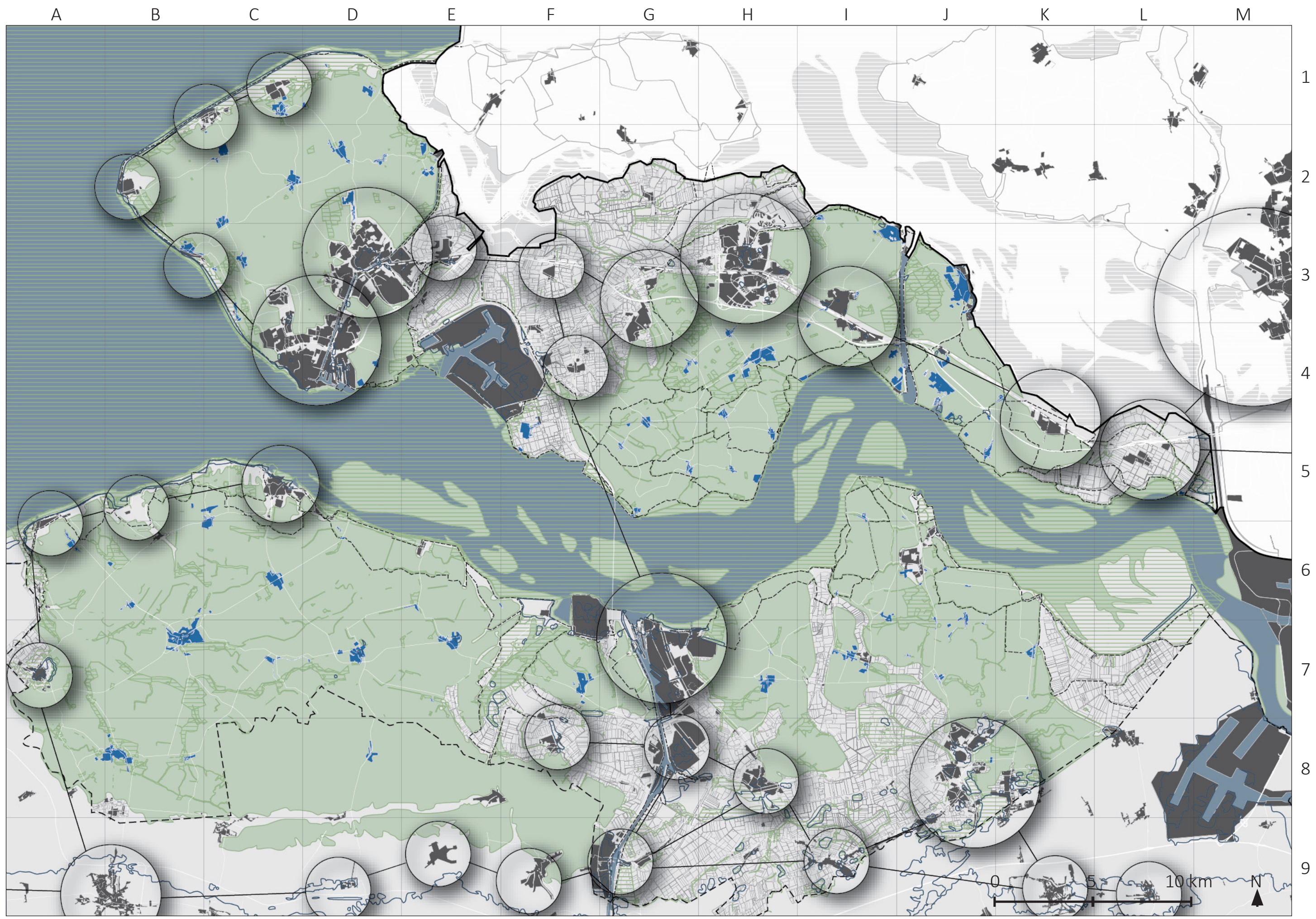
To further support remediation, upstream polluters are pressured to change their activities through sanctions and incentives, encouraging them to adapt their facilities and production methods. Within the estuary itself, polluting materials and harmful practices are also removed. Abandoned homes and infrastructure are cleansed of hazardous materials and intensive agricultural practices are discontinued.

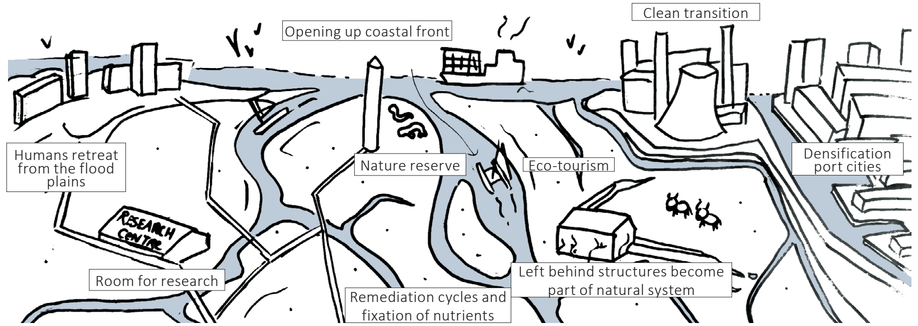
Strategic Retreat and Letting Go

Humans relocate to elevated plains near the Belgian border. The deconstruction of human infrastructure in the tidal landscape allows biodiversity to return, from migratory birds to mammals and fish. As flora and fauna re-establish themselves, nutrient cycles are naturally restored.

Eco-livelihood

To preserve this natural enclave, it is essential to link human livelihoods to ecosystem health. This can be achieved through eco-tourism, pollution credits and research programmes. The communities surrounding the estuary must take on the role of stewards, actively participating in the regeneration of ecosystem services.



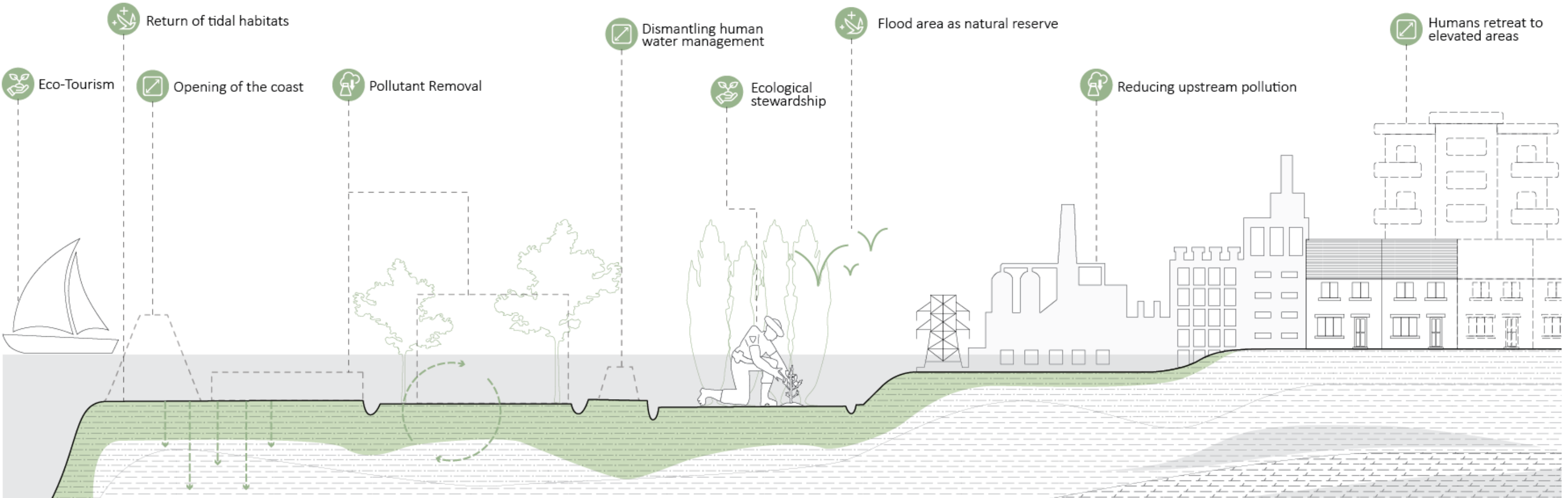


[Fig.47] Sketch Open Coast main elements.

Legend

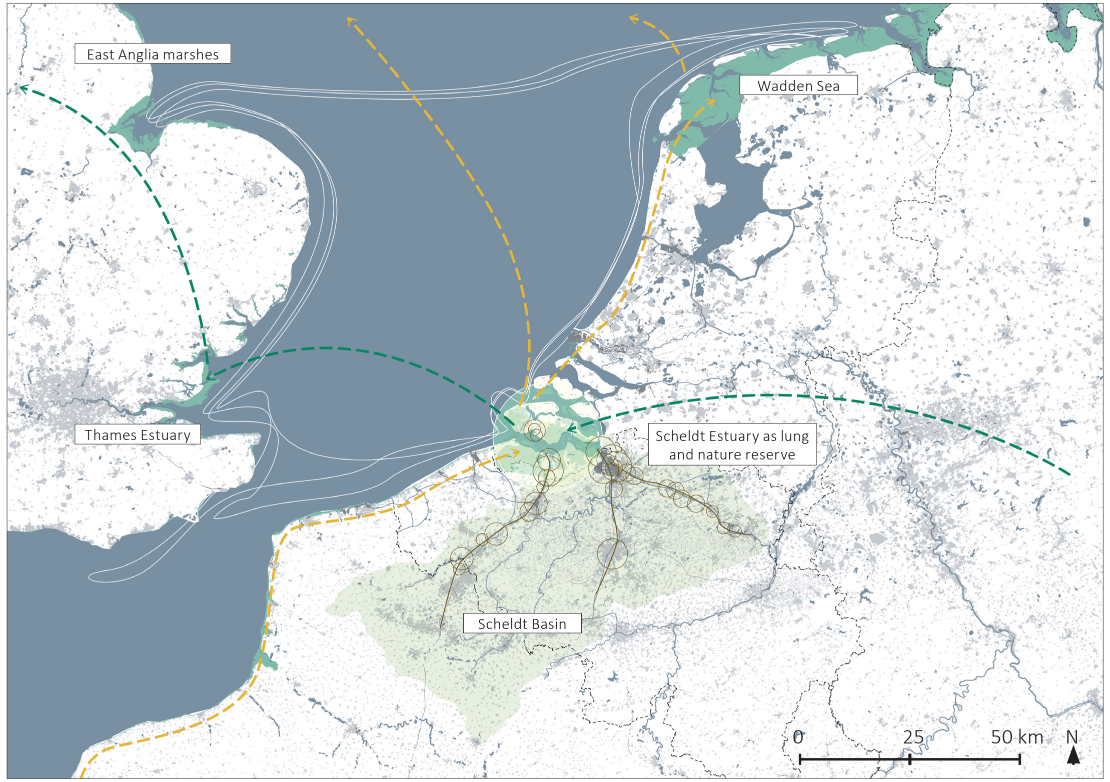
- Land
- Water
- Border Belgium
- Dike
- Removed dike
- Urbanisation
- Ports and industries
- Agricultural plots
- Protected nature
- New tidal landscape
- Left-behind urbanisation
- Train tracks
- Roads
- Densification areas

[Fig.49] Scenario Open Coast Estuary.
Source: Based on the deltaic condition map data.



[Fig.48] Maximisation nutrient flow through Open Coast design principles.

8.2 SCENARIO 1: OPEN COAST



Ecological Bridge

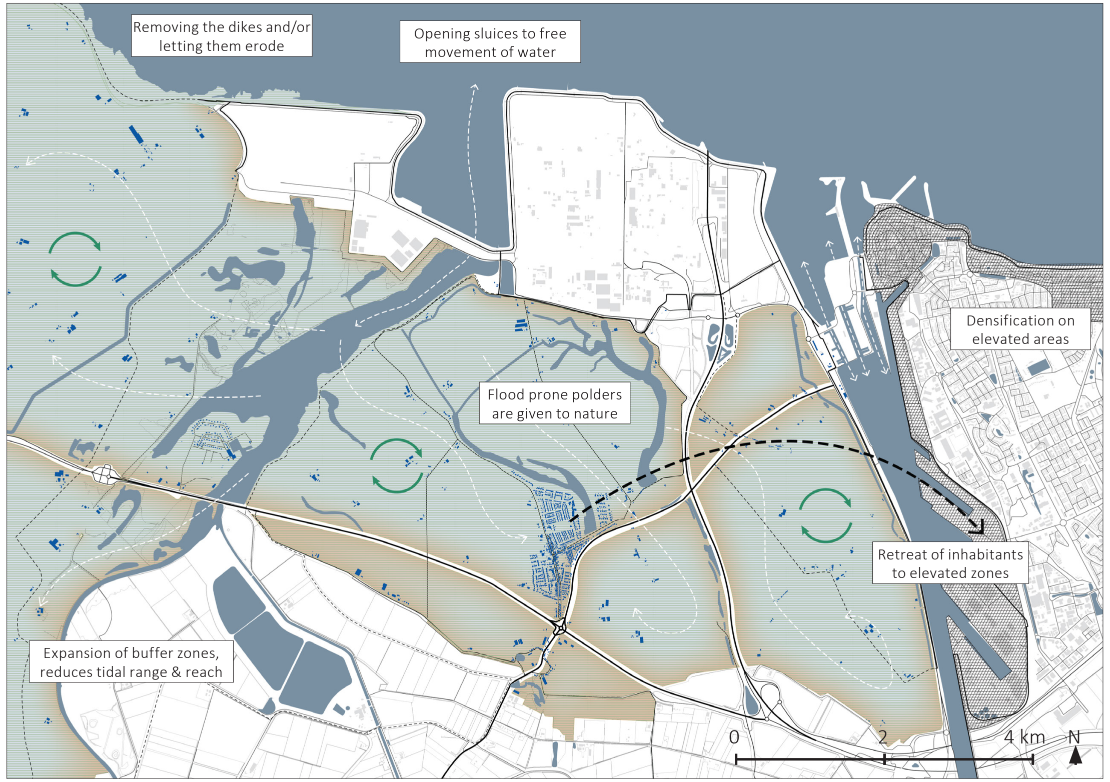
Legend

	Land		Ecological bridge
	Water		Coastal bird mirgation
	Border		Land bird mirgation
	Urbanisation		Seal migration
	Ports and industries		Pollution flows
	Wetlands		Pollution sources
	New flood lands		Clean basin transition

[Fig.50] Scenario Open North West Europe.
Source: (IMARES, 2013; Bonvicini, 2018; TU Delft, 2024)

The Scheldt Estuary, today, is resting spot for migratory birds and seals. While it also captures pollution from the Port of Antwerp. In the Open Coast scenario, these roles will expand.

The estuary will act as an ecological bridge, supporting wildlife and filtering seawater by absorbing pollution and fixing nutrients within the landscape. When the area would become a nature reserve, it would potentially extend the Natura 2000 zone. This will drive a clean basin transition into Belgium and France.



Giving Control Back to Nature

Legend

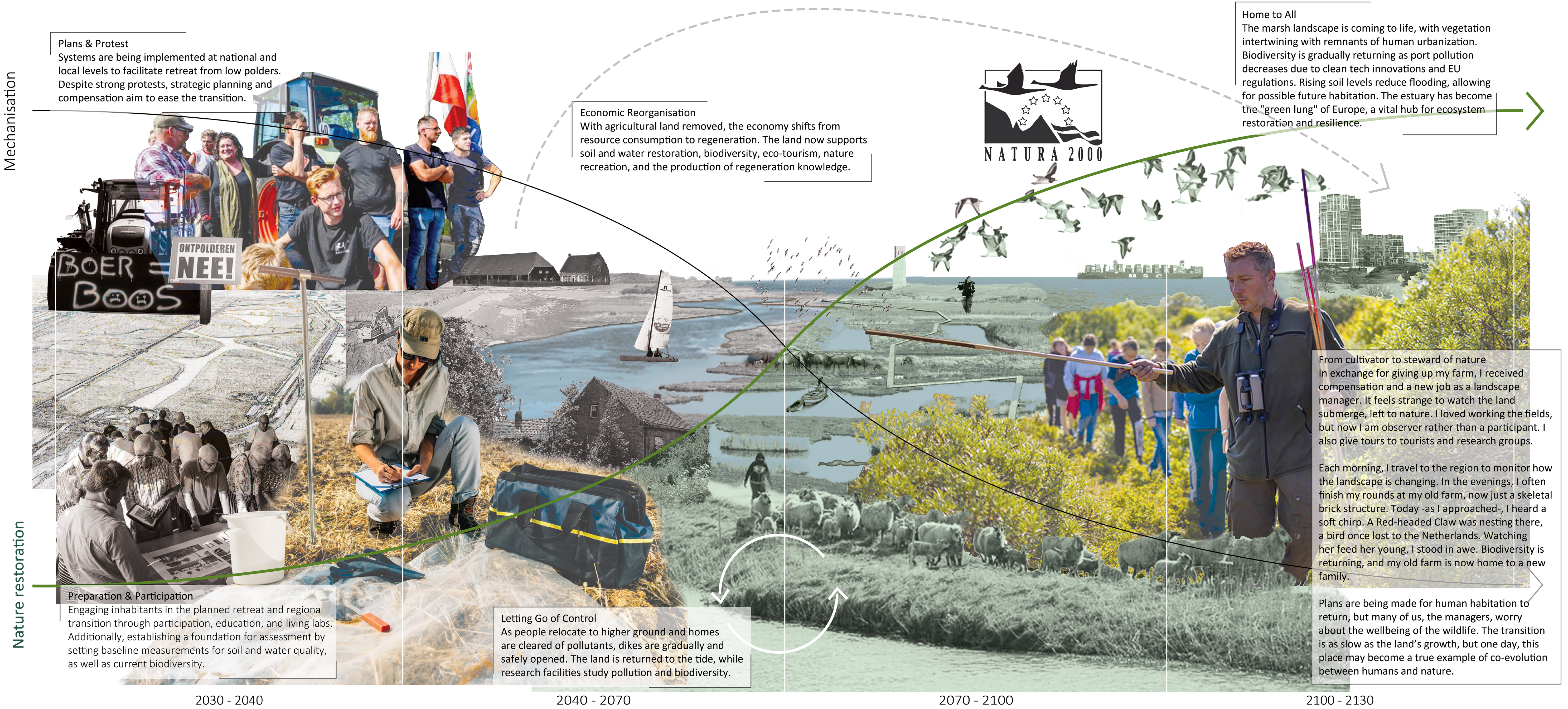
	Land		Roads
	Water		New tidal landscape
	Preserved dike		Water flow
	Removed dike		Sedimentation
	Preserved urbanisation		Ecological restoration
	Preserved industries		Left-behind urbanisation
	Agricultural plots		Densification areas

[Fig.51] Scenario Open Coast polder scale.
Source: (PDOK, 2025)

At the local level, communities will relocate to elevated plains, leaving their homes behind as the landscape is fully returned to nature.

The nature reserve will act as a buffer, reducing the power and volume of floodwaters. Even in the event of extreme flooding and high sea levels, this buffer zone will mitigate the impact, ensuring the elevated areas remain safe.

8.2 SCENARIO 1: OPEN COAST



Plans & Protest
Systems are being implemented at national and local levels to facilitate retreat from low polders. Despite strong protests, strategic planning and compensation aim to ease the transition.

Preparation & Participation
Engaging inhabitants in the planned retreat and regional transition through participation, education, and living labs. Additionally, establishing a foundation for assessment by setting baseline measurements for soil and water quality, as well as current biodiversity.

Economic Reorganisation
With agricultural land removed, the economy shifts from resource consumption to regeneration. The land now supports soil and water restoration, biodiversity, eco-tourism, nature recreation, and the production of regeneration knowledge.

Letting Go of Control
As people relocate to higher ground and homes are cleared of pollutants, dikes are gradually and safely opened. The land is returned to the tide, while research facilities study pollution and biodiversity.

Home to All
The marsh landscape is coming to life, with vegetation intertwining with remnants of human urbanization. Biodiversity is gradually returning as port pollution decreases due to clean tech innovations and EU regulations. Rising soil levels reduce flooding, allowing for possible future habitation. The estuary has become the "green lung" of Europe, a vital hub for ecosystem restoration and resilience.

From cultivator to steward of nature
In exchange for giving up my farm, I received compensation and a new job as a landscape manager. It feels strange to watch the land submerge, left to nature. I loved working the fields, but now I am observer rather than a participant. I also give tours to tourists and research groups.

Each morning, I travel to the region to monitor how the landscape is changing. In the evenings, I often finish my rounds at my old farm, now just a skeletal brick structure. Today -as I approached-, I heard a soft chirp. A Red-headed Claw was nesting there, a bird once lost to the Netherlands. Watching her feed her young, I stood in awe. Biodiversity is returning, and my old farm is now home to a new family.

Plans are being made for human habitation to return, but many of us, the managers, worry about the wellbeing of the wildlife. The transition is as slow as the land's growth, but one day, this place may become a true example of co-evolution between humans and nature.

[Fig.52] Scenario Open Coast implementation timeline and collage.

8.3 SCENARIO 2: POLDER INVERSION

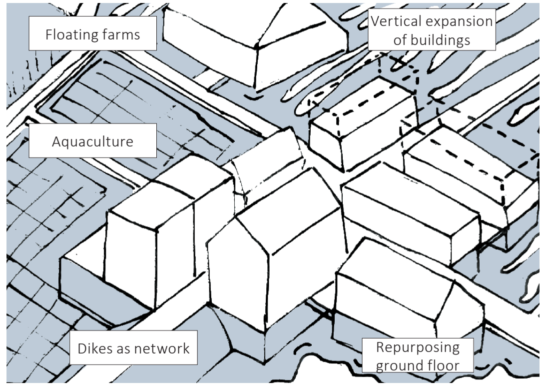
In the Polder Inversion scenario, flood management embraces flooding movement as intrinsic elements of the urban water system. Coastal management no longer focuses solely on protection, but instead integrates the presence of water into both the landscape and life.

Inverted Water Management

Where flood defences once served to keep water out, they now regulated and managed submersion. The system of primary, secondary and historic dikes is transformed to create a network of ponds in areas where deep polders once dominated. By reshaping coastal dikes, tidal water is permitted to flow into the land, intentionally flooding designated zones. Periodic overtopping of dikes becomes part of a broader system, contributing to natural water and nutrient cycles.

Preservation Through Adaptation

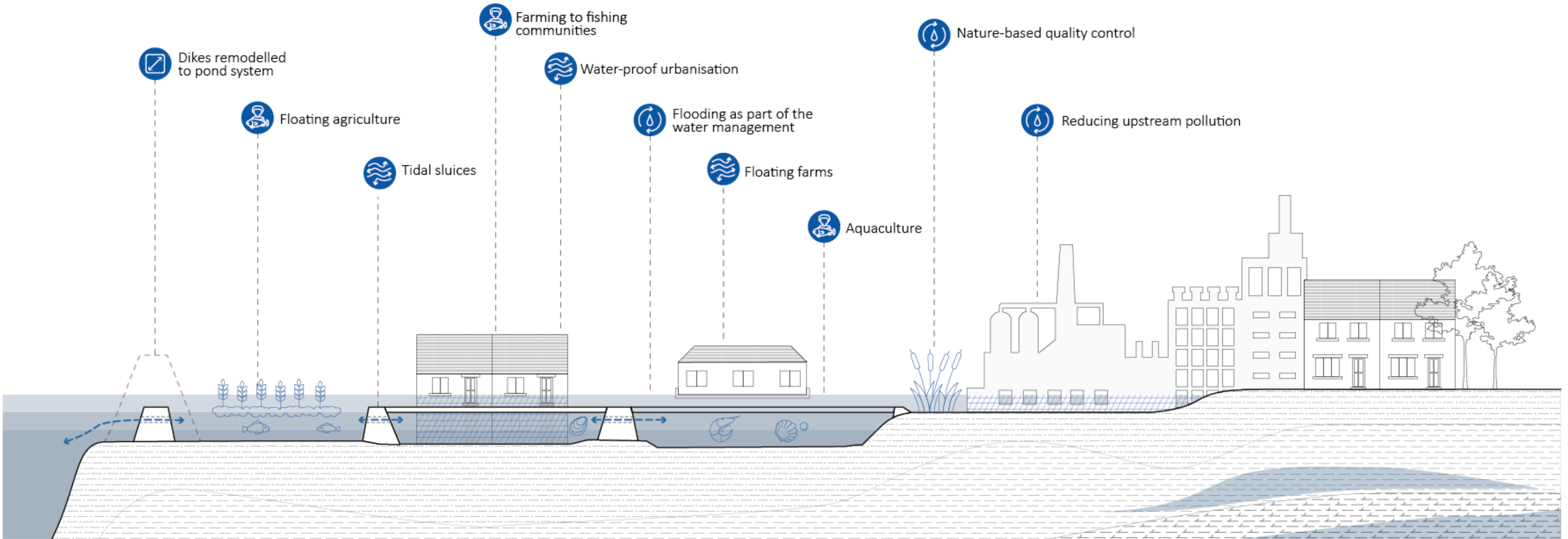
In this scenario, human life does not retreat from water flows, but adapts to them. Urban infrastructure is retrofitted to accommodate water. In this way, water becomes a visible and accepted element of daily life, rather than a threat to be resisted.

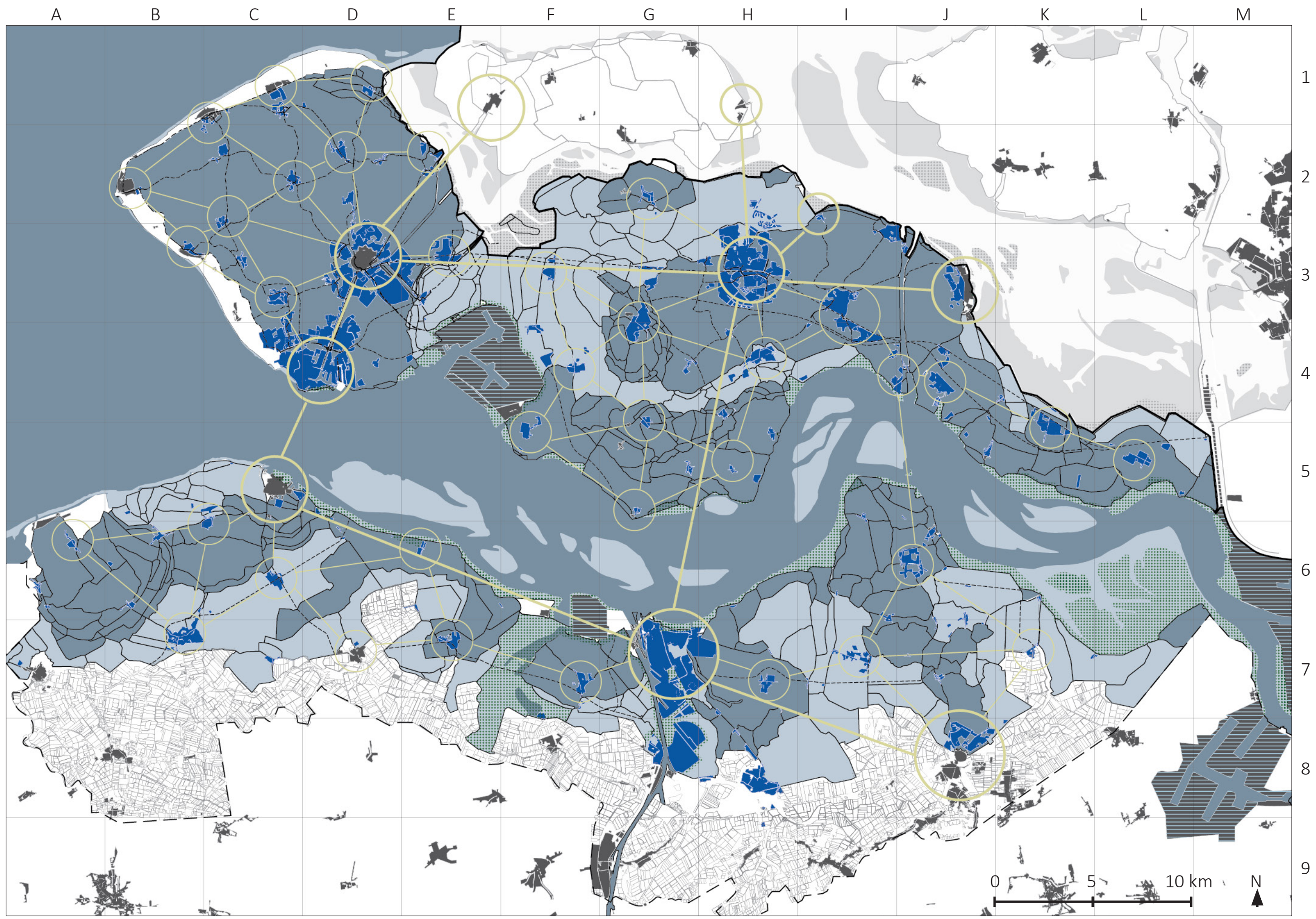


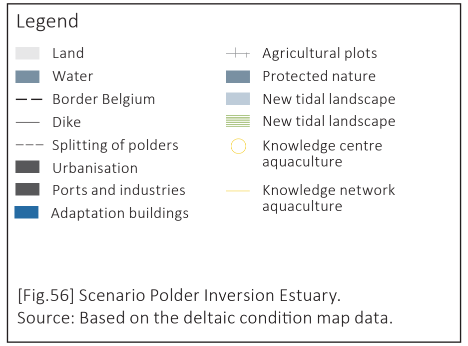
[Fig.53] Zoom in elements scenario Polder Inversion.

Watercultivators

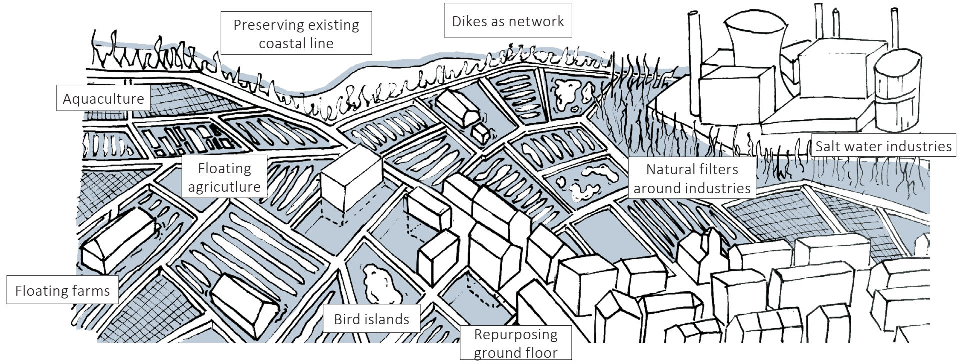
Water already underpins the region's economy, but its use shifts from dryland farming to saline and aquatic cultivation. Traditional farmers become water cultivators, producing salt-tolerant and aquatic crops that support a resilient local economy.







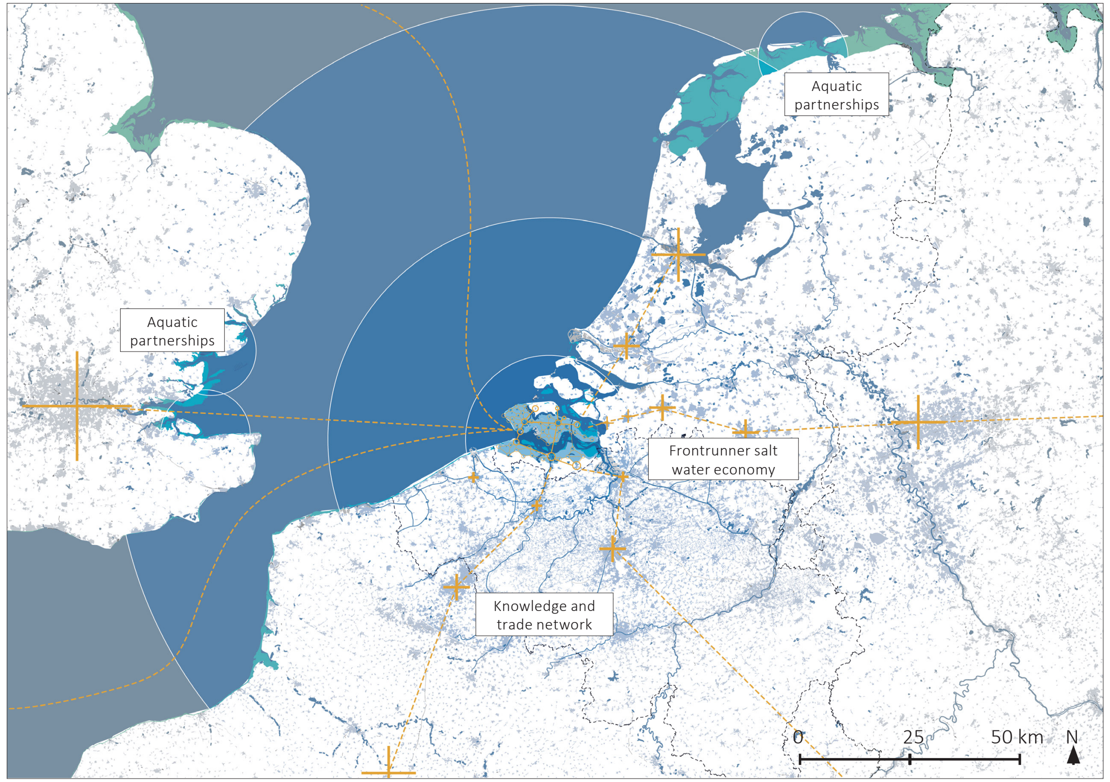
[Fig.56] Scenario Polder Inversion Estuary.
Source: Based on the deltaic condition map data.



[Fig.54] Sketch scenario Polder Inversion main elements.

[Fig.55] Maximisation nutrient flow through Polder Inversion design principles.

8.3 SCENARIO 2: POLDER INVERSION



European Aquacultural Centre

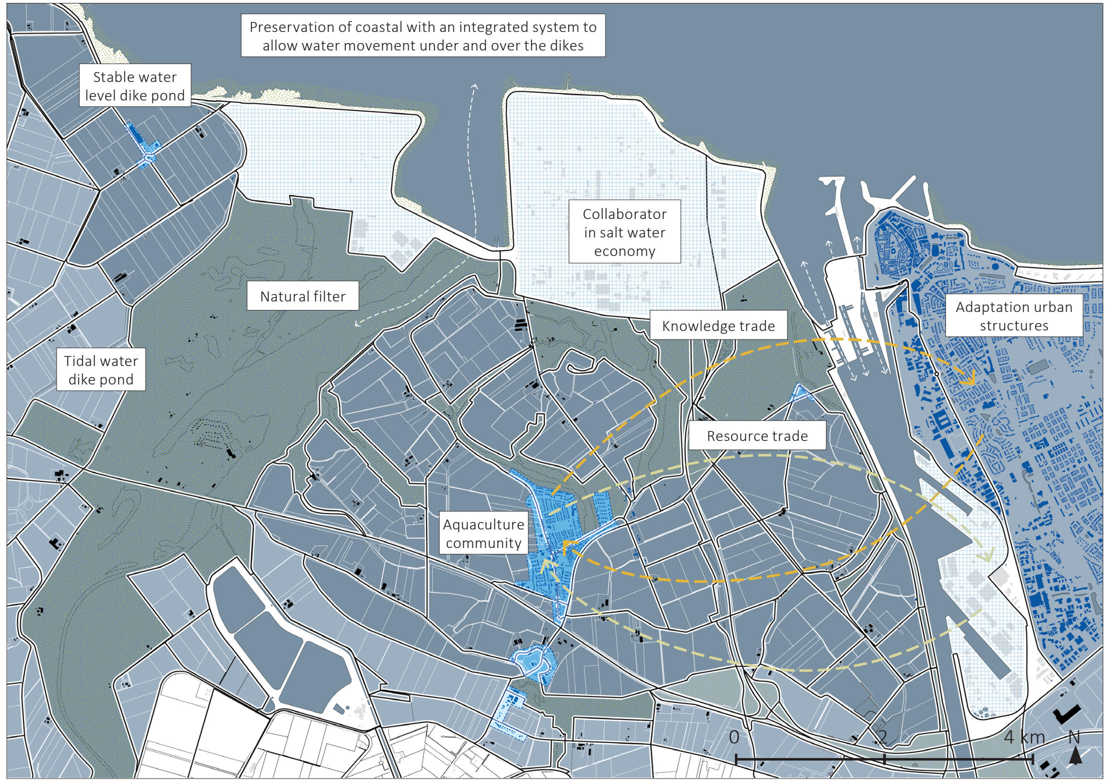
Legend

- Land
- Water
- Border
- Urbanisation
- Ports and industries
- Wetlands
- New flood lands
- Aquaculture hub
- Trade network
- Collaboration
- Production centre
- Distribution centre

[Fig.57] Scenario Polder Inversion North West Europe. Source: (TU Delft, 2024)

Today, the estuary already supports several private and public organisations focused on aquaculture and salt-tolerant agriculture (Provincie Zeeland, 2010). This scenario would encourage these organisations to expand and strengthen their networks.

The Scheldt could position itself as a leading aquacultural centre. It would serve as both a model for similar estuarine regions and an economic hub in response to the growing demand for aquaculture (Ministerie van Landbouw, Natuur en Voedselkwaliteit, 2020).



Inverted Polder Community

Legend

- Land
- Water
- Preserved dike
- Removed dike
- Preserved urbanisation
- Preserved industries
- Agricultural plots
- Roads
- Deep water dike pond
- Tidal water dike pond
- Dike village collective
- Transform to floating farms
- Water adapted urbanisation
- Transition to clean industry
- Knowledge
- Resource
- Biofilter
- Water flow

[Fig.58] Scenario Polder Inversion polder scale. Source: (PDOK, 2025).

At the local scale, the inversion of the polder landscape would enable residents to remain in their communities. It could even revive the historic role of villages as trade centres for regional produce.

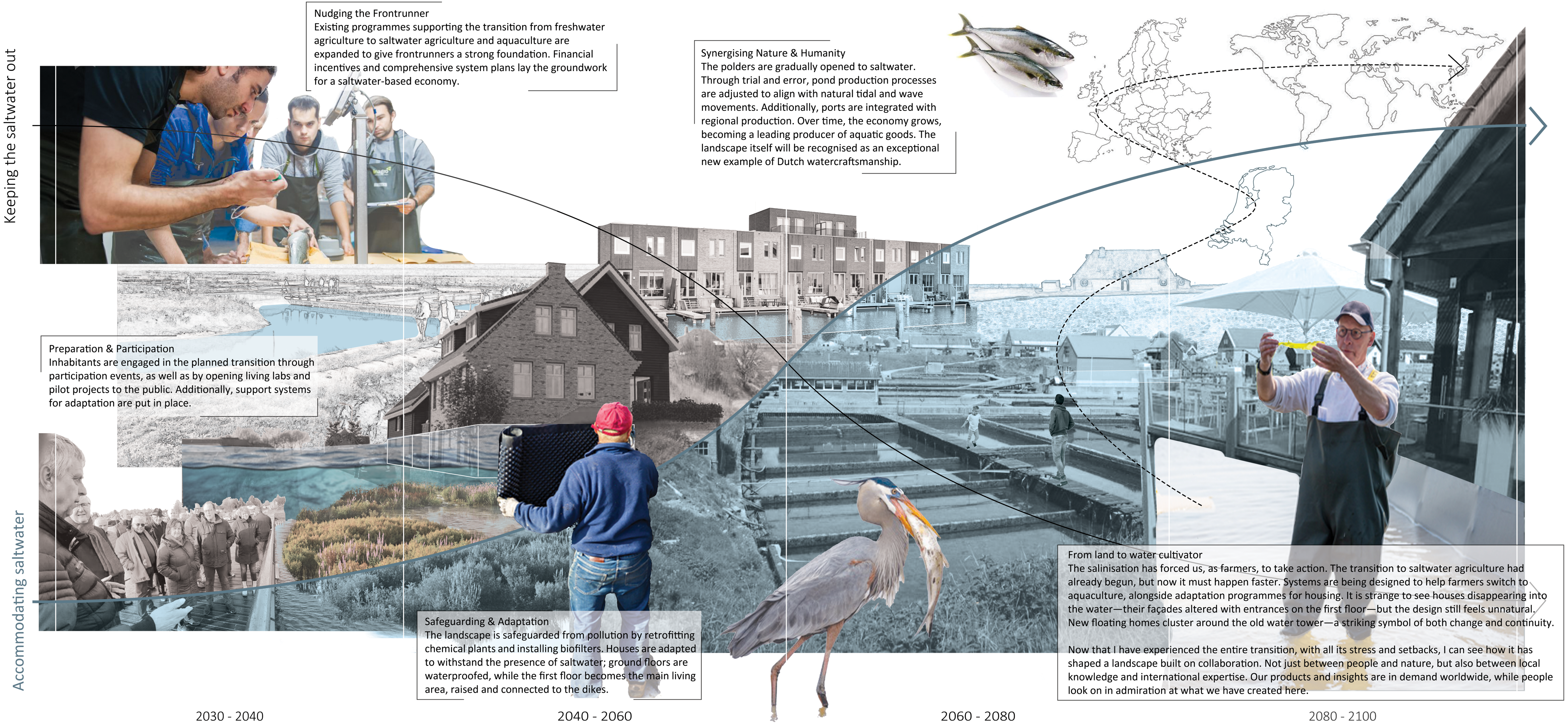
Urban infrastructure would need to be retrofitted to accommodate water at ground level. Living spaces would shift to the first floor. This transition requires local investment, collective effort and acceptance of a reduced amount of usable space.

8.3 SCENARIO 2: POLDER INVERSION

Nudging the Frontrunner
Existing programmes supporting the transition from freshwater agriculture to saltwater agriculture and aquaculture are expanded to give frontrunners a strong foundation. Financial incentives and comprehensive system plans lay the groundwork for a saltwater-based economy.

Synergising Nature & Humanity
The polders are gradually opened to saltwater. Through trial and error, pond production processes are adjusted to align with natural tidal and wave movements. Additionally, ports are integrated with regional production. Over time, the economy grows, becoming a leading producer of aquatic goods. The landscape itself will be recognised as an exceptional new example of Dutch watercraftsmanship.

Preparation & Participation
Inhabitants are engaged in the planned transition through participation events, as well as by opening living labs and pilot projects to the public. Additionally, support systems for adaptation are put in place.



Safeguarding & Adaptation
The landscape is safeguarded from pollution by retrofitting chemical plants and installing biofilters. Houses are adapted to withstand the presence of saltwater; ground floors are waterproofed, while the first floor becomes the main living area, raised and connected to the dikes.

From land to water cultivator
The salinisation has forced us, as farmers, to take action. The transition to saltwater agriculture had already begun, but now it must happen faster. Systems are being designed to help farmers switch to aquaculture, alongside adaptation programmes for housing. It is strange to see houses disappearing into the water—their façades altered with entrances on the first floor—but the design still feels unnatural. New floating homes cluster around the old water tower—a striking symbol of both change and continuity.

Now that I have experienced the entire transition, with all its stress and setbacks, I can see how it has shaped a landscape built on collaboration. Not just between people and nature, but also between local knowledge and international expertise. Our products and insights are in demand worldwide, while people look on in admiration at what we have created here.

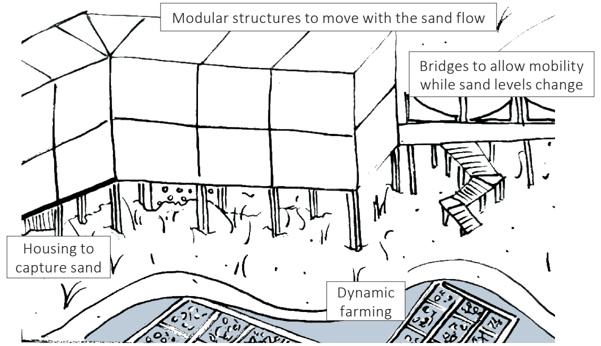
[Fig.59] Scenario Polder Inversion implementation timeline and collage.

8.4 SCENARIO 3: ROOM FOR MARSHES

This scenario views flood management being a tool to guide water movements in ways that enhance natural sedimentation processes. Coastal management provides the necessary infrastructure to support sediment capture.

Building Sandcastles with Nature

The Dutch already use sand groynes and breakwaters to limit coastal erosion. In this scenario, such interventions are scaled up and designed to work with natural dynamics. By reconfiguring the coastline and allowing deep and frontal polders to flood, sediment is deposited in these areas. These zones then grow naturally with the sea, offering protection to the hinterland and potentially becoming new areas for future habitation.



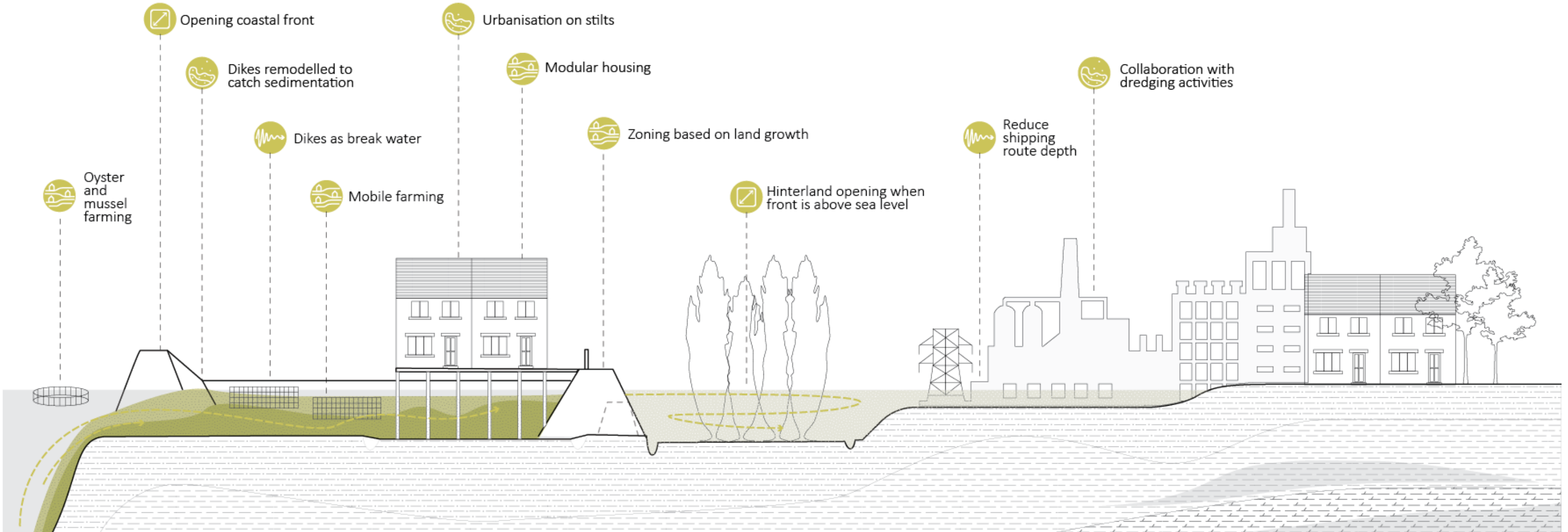
[Fig.60] Scenario elements Room for Marshes.

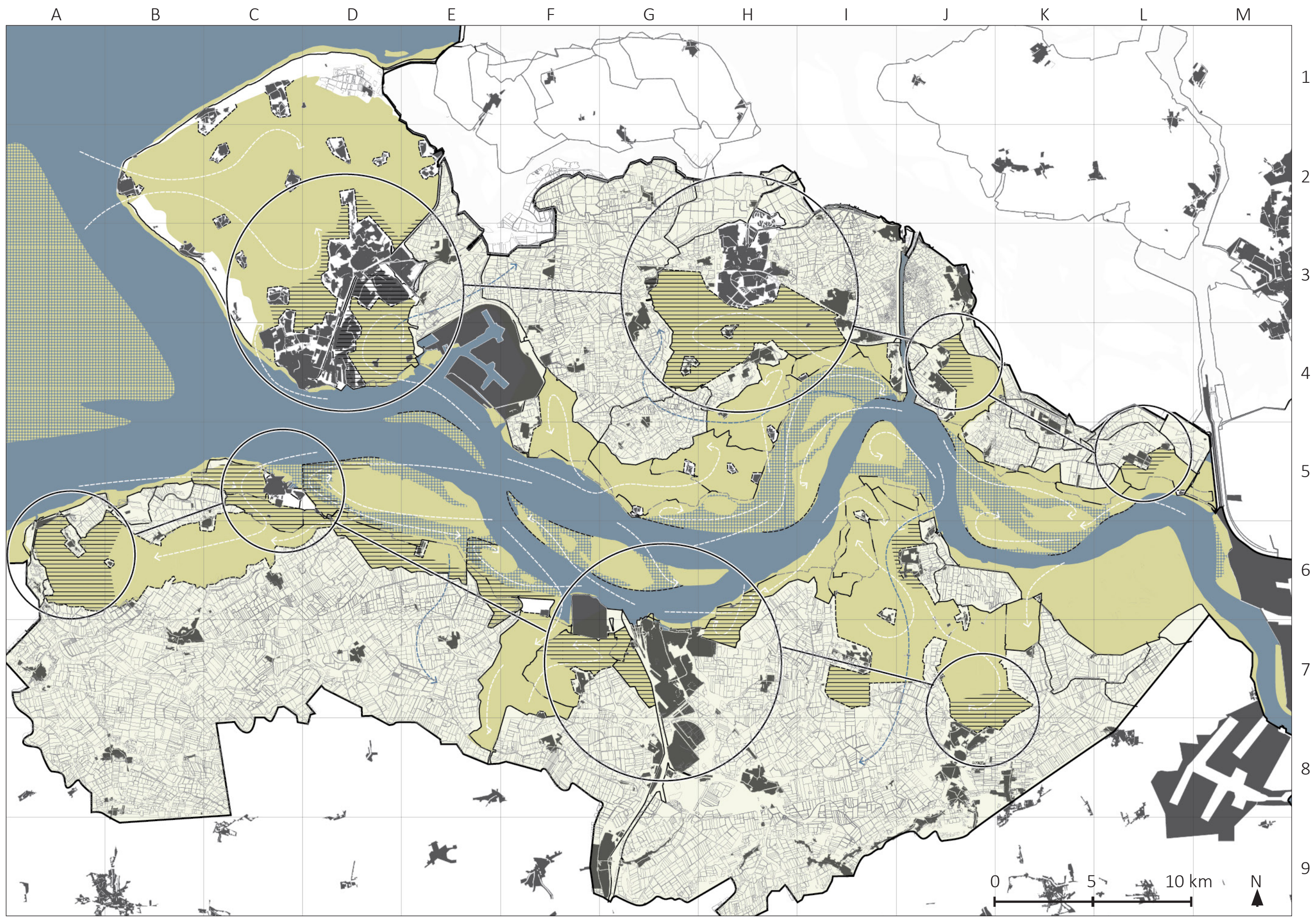
Marsh Living

To make space for marsh restoration, living areas must either retreat or adapt to changing conditions. Existing buildings and dikes can be repurposed, while new developments may include housing on stilts. This kind of infrastructure can help slow water movement, encouraging greater sediment accumulation and supporting marsh development.

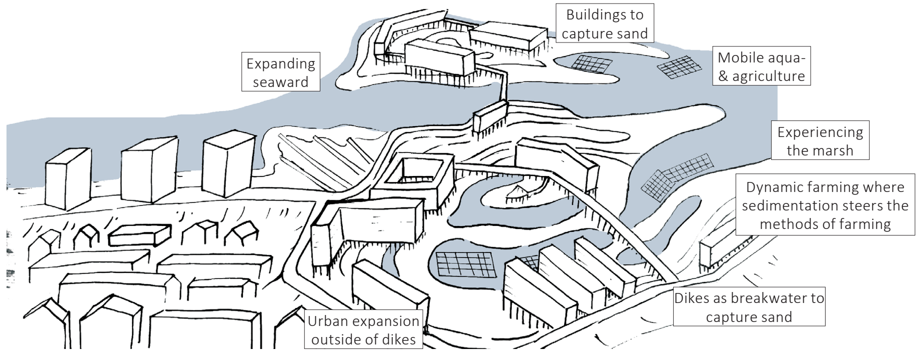
Dynamic Farming

Land use practices can also support sedimentation. The restoration of oyster reefs and tidal vegetation is already being trialled globally. These efforts can be integrated with productive activities such as mussel farming and seaweed cultivation. These forms of aquaculture help trap sediment while contributing to the local economy.





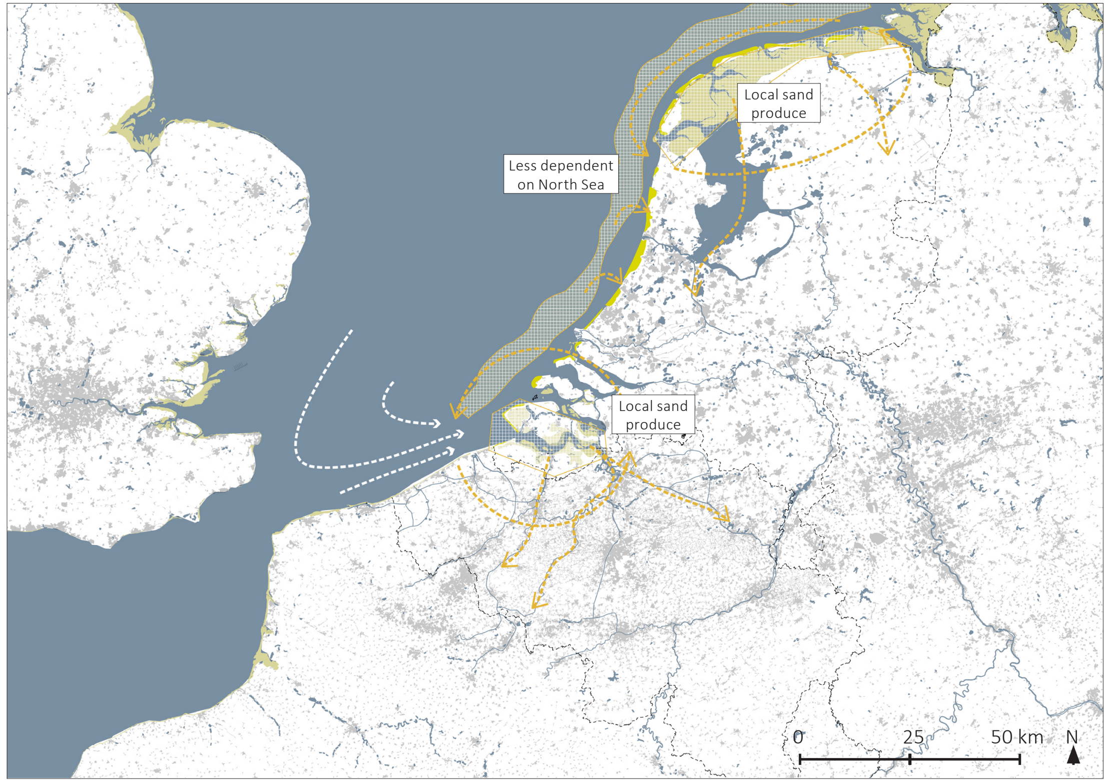
[Fig.63] Scenario Room for Marshes Estuary.
Source: Based on the deltaic condition map data.



[Fig.61] Sketch scenario Room for Marshes main elements.

[Fig.62] Maximisation sediment flow through Room for Marshes design principles.

8.4 SCENARIO 3: ROOM FOR THE MARSHES



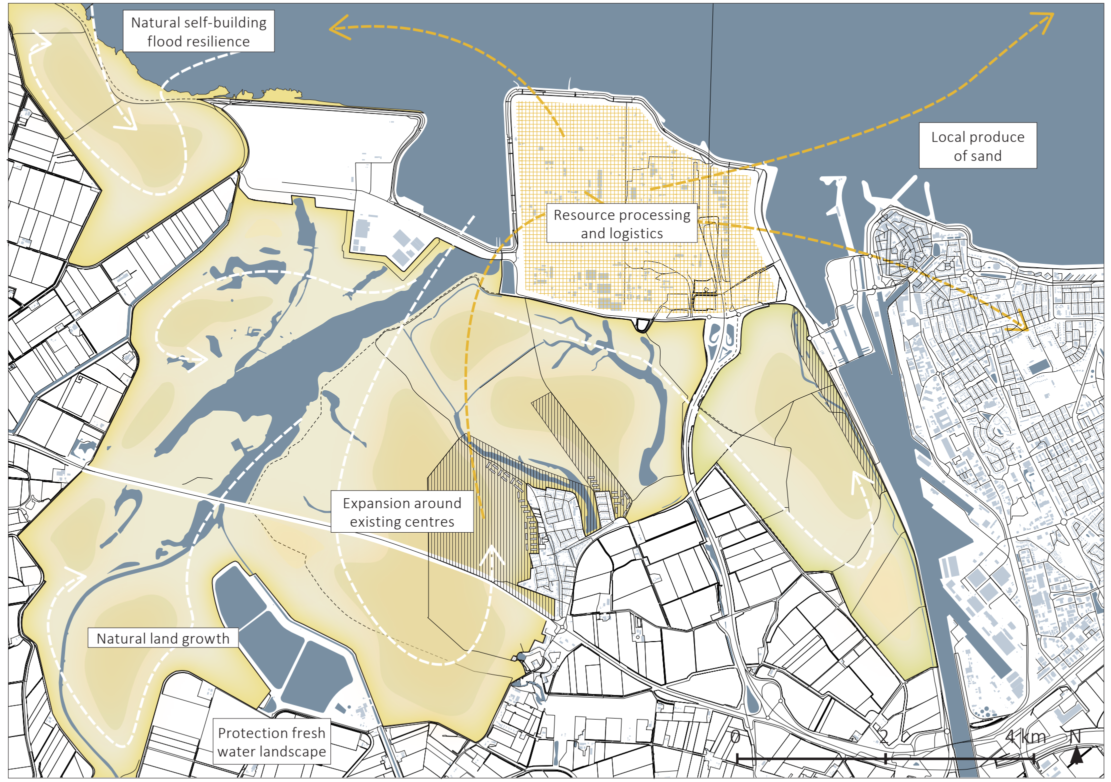
Natural and Local Sand Trade

Legend

- Land
- Water
- Border
- Urbanisation
- Ports and industries
- Dunes
- Existing tidal landscape
- New tidal landscape
- Sand extraction
- Sand flows
- Natural sedimentation flow

[Fig.64] Scenario Room for Marshes North West Europe.
Source: (Rijkswaterstaat, 2016; TU Delft, 2024)

The current coastline of the Estuary relies heavily on sand extraction from the North Sea seabed, alongside dredging of the Scheldt's shipping routes. These practices demand resources and disrupt the ecological balance. By creating space for natural sedimentation and reducing water speed (e.g., by limiting dredging activities), the Scheldt could become a sand-producing system. Similar processes occur in the Wadden Sea. This way, the estuary could become self-sufficient in sand supply and even export sand, helping to meet national demand and reduce dependence on the North Sea.



Moving to the Marsh

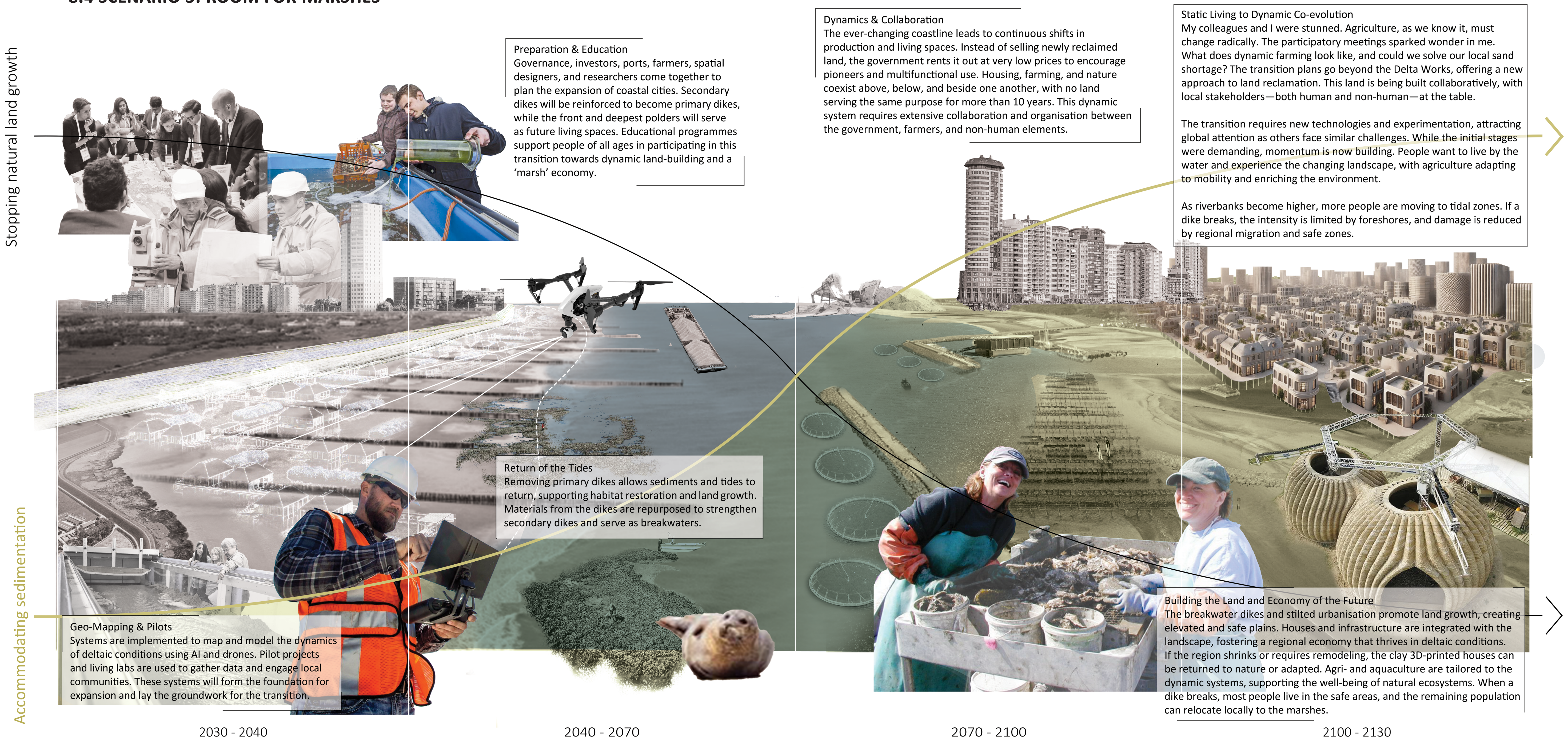
Legend

- Land
- Water
- Preserved dike
- Removed dike
- Urbanisation that gets hit by flood in time of storm
- Agricultural plots
- Roads
- Salt marshes
- Water flow
- Sedimentation flow
- Resource processing
- Urban expansion

[Fig.65] Scenario Room for Marshes polder scale.
Source: (PDOK, 2025)

Unlike the abrupt retreat seen in Open Coast scenario, this approach allows for a gradual adaptation. By giving up the frontal polders, there is no need for a full and immediate evacuation of the hinterland. These areas can instead become sites for future living and urban expansion adapted to Deltaic Conditions. When sea levels eventually reach the limits of the existing dikes, communities can relocate to these higher, sediment-enriched zones. Sediment thus becomes not only a natural resource but also a driver of urban development and regional trade.

8.4 SCENARIO 3: ROOM FOR MARSHES



[Fig.66] Scenario Room for Marshes implementation timeline and collage.

8.5 SCENARIO REFLECTION

The scenarios developed for the Scheldt Estuary are each assessed based on their contribution to response-ability, a core concept drawn from the theory of Urban Flood Resilience (see Chapter 4.1). Response-ability refers to the capacity of socio-ecological systems not only to endure disturbances such as flooding, but also to adapt, reorganise and evolve in response to them. The evaluation focuses on two core components: the ability to tolerate flooding and the ability to quickly reorganise.

The Ability to Tolerate Flooding

In terms of physical and spatial strategies for flood tolerance, the Open Coast scenario performs particularly well. By avoiding flood prone areas and relocating development to higher ground, it minimises exposure and reduces vulnerability to flood events. This proactive spatial retreat creates a buffer that enhances long-term safety and reduces reliance on engineered protections.

Room for the Marshes also demonstrates flood tolerance through a more adaptive strategy which also accepts wet feet occasionally. It supports phased retreat, retrofitted infrastructure and the creation of elevated urban expansions, enabling human habitation to remain integrated with a dynamic and shifting delta landscape. This approach allows water to shape the land, while still maintaining liveability and safety.

The Polder Inversion scenario, by contrast, retains much of the existing spatial configuration and infrastructure. It allows for continued settlement within the current footprint, but this requires intensive reliance on human-managed systems for water control. While it incorporates flooding into daily life through heavily retrofitted infrastructure, it provides less tolerance to uncontrolled flood events and its dependence on ongoing maintenance presents risks in the context of climate uncertainty.

The Ability to Quickly Reorganise

By withdrawing from dynamic landscapes, Open Coast preserves functionality but does not actively build adaptive capacity in response to change.

In contrast, Room for the Marshes excels in fostering reorganisation. It encourages co-adaptation between human and non-human systems. By incorporating flexible infrastructure and embracing environmental transformation, this scenario supports reorganisation both locally and regionally. It enables communities to remain rooted in place while adapting to new conditions.

The Polder Inversion scenario offers some continuity of place by conserving built structures, but it is more rigid in its configuration. Its heavy reliance on controlled water systems limits the potential for spontaneous or organic reorganisation. Additionally, it contributes little to sedimentation or ecological regeneration, making it less effective as a long-term adaptive strategy.

Response-Ability Through Co-Adaptation

Among the three, Room for the Marshes provides the most balanced and future-oriented form of response-ability. It supports flood tolerance through phased retreat and adaptive strategies, while also enabling quick reorganisation and in place learning. By fostering human–nature collaboration and embracing modular design, this scenario lays the foundation for responsive urban development in the Scheldt Estuary.

Response-ability		Scenario 1: Open Coast	Scenario 2: Polder Inversion	Scenario 3: Room for Marshes
The ability to tolerate flooding	Ability to infiltrate water	++ Removal of infra and dikes allows 80% of the landscape to infiltrate water.	0 Dike ponds cause water saturation at the coast. Limited infiltration during floods.	+ Removal of infra and dikes allows 40% of the landscape to infiltrate water and in the future almost 70%.
	Ability to store water	++ Retreat of humans have made room for buffer capacity in the low polders.	+ The amount of water delivered by a flood can be spread over the ponds.	+ Floods can be stored in the frontal marshes & later on also in the hinterland.
	Ability to convey water	++ Water roams free in tidal landscape, even beyond Belgiums border.	+ Water flow is coordinated & monitored by drainage systems.	+ Water flows freely in the frontal marshes & later on also in the hinterland.
	Ability to absorb flood impacts	++ Floods stay in the low polder, humans are safe on the elevated plains.	+ Ponds absorb the access flood waters and preserve functionality.	0 The marshes can absorb the flood like a sponge, although the existing cities can't absorb much.
	Ability to anticipate flooding	- By leaving the flood-prone areas, the need to anticipate is removed.	++ Tidal and flood movements are monitored to support water quality and quantity for aquaculture.	++ Tidal and flood movements are monitored and steered by the breakwater structures.
	Ability to accommodate flooding	++ Accommodating flooding by letting it go free gives room to all tidal flows.	+ Mostly water is accomodated. Sediment and remediation flows are hindered.	++ By accommodating sedimentation, other flows from the tide are also reintroduced into the system.
The ability to quickly reorganise	The ability to ensure functionality	++ Ensuring continous functionality by avoiding interaction with floods.	+ Dryproofing & water produce, however floods can hinder daily life.	+ Waterproofing existing urbanisation and elevating urban expansion. Mobile installations have risks.
	The capacity for prompt adaptation following each flooding event	- Flooding events don't reach the urbanisation, thus no adaptation.	+ Systems are based on the regular presence of flooding but little on sedimentation.	++ Systems continously adapt to new water and sedimentation levels.
	The ability to respond effectively to floods	- Flooding events don't reach the urbanisation, thus no respons.	++ Design makes flooding give a positive affect on aquaculture, while limiting urban hinderance.	++ By collaborating with the tidal flows, each of the three flows is maximised.

Effect on response-ability: Significant Decline - - Decline - Neutral 0 Increase + Significant Increase + +

[Fig.67] Evaluation table Response-Ability.

8.5 SCENARIO REFLECTION

In a workshop with local officials and researchers, the compose-ability of each scenario was assessed through SWOT analysis and open dialogue. Compose-ability refers to the capacity of socio-ecological systems to evolve through change, integrating environmental and socio-economic dimensions (chapter 4.1). Experts from diverse backgrounds contributed insights grounded in local knowledge. Their reflections revealed key strengths and limitations across scenarios:

Scenario Reflections

Open Coast was perceived as requiring the least investment and ongoing energy input due to its withdrawal-based strategy. However, it was also identified as the most controversial. It implies the large-scale abandonment of fertile land and cultural heritage, alongside the evacuation of the region. Within the political landscape, even minor proposals, such as returning a polder for experimental use, are already highly contested, suggesting limited social acceptance.

Polder Inversion demands substantial investment and technical adaptation. Nonetheless, it was seen as more socially acceptable, as it conserves existing communities, infrastructure and employment. Concerns were raised about the lock in of current systems, potentially hindering parallel transitions such as energy transition.

Room for the Marshes also requires significant investment but was regarded as more aligned with prevailing economic paradigms of growth. It supports land expansion through natural processes and reduces reliance on external energy by using locally sourced materials. Relocation is phased and limited, which increases public acceptability and mitigates the social costs of displacement.

Operational and Systemic Considerations

Maintenance demands vary across scenarios. Open Coast entails the lowest long-term maintenance burden. Polder Inversion, by contrast, requires ongoing management of complex technocratic systems. Room for the Marshes involves fewer mechanical interventions but places greater emphasis on community participation, returning agency to local actors. Reminiscent of the traditional Dutch polder model. Here, flood resilience becomes a shared responsibility, balancing top-down strategies with bottom-up engagement.

In terms of adaptability, Room for the Marshes and Open Coast were seen as best able to respond to future uncertainties. Both scenarios involve dynamic landscapes that evolve with sedimentation and sea-level rise. Polder Inversion, in contrast, seeks to stabilise current land use, offering less flexibility in the face of long-term environmental change.

A shared concern across all scenarios was the persistent pollution in the Scheldt River. Experts emphasised that without great changes in the industrial and chemical sectors, the feasibility of the scenarios remains low.

Among the three scenarios, Room for the Marshes was considered the most feasible from a compose-ability perspective. It builds upon the historical Dutch tradition of land reclamation, but transforms it into a dynamic, collaborative model that works with natural processes. The scenario allows for gradual and inclusive transitions, empowering communities to participate in the reshaping of their environment.

Scenario 1: Open Coast		
	Positive	Negative
Internal	- Low energy and maintaince demand. - Natural growing water defence. - Return of natural balancing of nutrients through remediation. - Densification can increase access and availability of urban services. - Land growth and protection of deep fresh water sources. Strength	- Pressure on existing cities with densification. - Spreading of pollution from contaminated soil and water. - Loss of fertile land. - Loss of heritage and relocating communities. Weakness
External	- Filter for the greater Scheldt basin. - Investments from carbon credits and 'pollution credits'. - Enhancing its position as resting place for migratory animals. - Potential for eco-tourism. - Research opportunities. Opportunity	- Annexation of Zeeuws-Vlaanderen by Belgium. - Potential tidal increase in upper sections of the river. - Increasing pollution from upper river industries. - Belgium is in tidal risk area. Threat

Scenario 2: Polder Inversion		
	Positive	Negative
Internal	- Preservation of production landscape, more acceptable transition. - Communities can stay in their living environment. - Stabilisation of soil and protection of deep fresh water sources. - Local organisation and farmers already work with salt transition. - Through adaptation preservation of heritage. Strength	- Necessity of strong and technical water management system to support water quality and quantity. Need for maintenance. - Enormous costs of the adaptation of infrastructure and buildings. - Contaminated soil and water can limited produce options. - Waterproofing the ground floor, reduces living space. Weakness
External	- Potential to position as European aquaculture frontrunner. - Aquatic tourism and sports, like fishing & sailing. - Collaboration with the ports for processing and logistics produce. Opportunity	- Challenged mobility and accesibility due to adaptation and tides. - Other transitions can be hindered due to complex composition. - Sea level could also decrease which would empthy the ponds. - Increasing pollution from upper river industries. Threat

Scenario 3: Room for Marshes		
	Positive	Negative
Internal	- Marshes as sponge for water, natural water buffer. - Land growth and protection of deep fresh water sources. - Increase natural worth while allowing extensive farming. - Slower transition allows people to move on their own pace. - Internal natural collection of sand and clay resources. Strength	- Heavy mentality and work change, from static to dynamic. - Reorganising land-ownership system: complex system and very dependent on community involvement. - Unregularity in sedimentation flows limites predictability. - Need for a very flexible landscape design. Weakness
External	- Growth in land or urbanisation attracts investment. - Synergies between living, farming and natural values. - Collaboration with the experiments in the Wadden Sea. - Investments from carbon credits and 'pollution credits'. - Unique marsh tourism. Opportunity	- Less sedimentation than expected. - Increasing pollution in the North Sea and upper river contaminating sedimentation and water flows. - Sea level increases way quicker, transition can be too slow. - Shipping route of Antwerp. Threat

[Fig.68] SWOT table Compose-Ability.

8.5 SCENARIO REFLECTION

The final element of reflection focuses on the relationship between flood and coastal management and the broader collaboration between human and non-human systems. These aspects, when considered alongside the concepts of response-ability and compose-ability, offer a comprehensive framework for selecting a scenario to develop into a vision for Tidal Urbanism in the Scheldt Estuary [Fig.69].

Flood and Coastal Management

In terms of flood management, each scenario presents a different approach. Open Coast returns flooding it into the ecosystem. Polder Inversion shifts the paradigm by making flooding a functional part of human-managed water systems. Room for the Marshes, on the other hand, uses flood management as a tool to guide sedimentation processes.

Coastal management similarly varies across the scenarios. In Open Coast, the focus is on ecological restoration combined with human retreat, allowing nature to reclaim space. Polder Inversion integrates water directly into the urban fabric, embedding it into daily infrastructure and systems. Room for the Marshes captures sedimentation in tandem with urban development, enabling coastal landscapes to grow and evolve over time with minimal disruption.

Response- and Compose-Ability

Open Coast avoids flooding completely. In contrast, Polder Inversion treats flooding as an operational tool, especially for aquaculture. Room for the Marshes stands out for its adaptability; its systems are designed to evolve in response to changing water levels and sediment dynamics, fostering resilience through continual adjustment.

When considering compose-ability, the degree to which humans and natural systems co-create the landscape becomes clear. Open Coast prioritises a hands-off approach, allowing nature to reshape the land with minimal human intervention. Polder Inversion represents a controlled form of adaptation. Room for the Marshes, however, suggests a model where human and ecological processes collaborate in shaping the landscape.

Optimisation and Symbiosis

The optimisation of flood potential also reveals different priorities. Open Coast frames flooding as valuable primarily for non-human systems, treating inundated areas as ecologically rich but disconnected from human use. Polder Inversion focuses on human benefits, using floods to support aquaculture and controlled water regimes. Room for the Marshes balances both, recognising the mutual potential of floods for ecological regeneration and sustainable economic activity.

In terms of human–non-human symbiosis, each scenario offers distinct visions. Open Coast largely separates the two systems, encouraging retreat and minimal interaction. Polder Inversion relies on technological means to manage nature, maintaining a level of control over natural processes. In contrast, Room for the Marshes encourages a cooperative relationship, where human systems adapt in response to ecological changes, promoting a genuinely collaborative dynamic.

Scenario for Tidal Urbanism

Room for the Marshes is identified as the most promising scenario for further development into a vision for the Scheldt Estuary. It supports a dynamic, collaborative relationship between human and non-human systems and demonstrates the greatest potential for response and adaptation in light of evolving Deltaic Conditions.

The scenario builds on the Dutch tradition of land reclamation while reintroducing bottom-up approaches to landscape organisation and flood management. It allows for phased adaptation and limited relocation, offering new, habitable areas as sea levels rise. Ultimately, Room for the Marshes represents a forward-looking model of Tidal Urbanism that is grounded in resilience, local identity and ecological cooperation.

CONCEPTS	Scenario 1: Open Coast	Scenario 2: Polder Inversion	Scenario 3: Room for Marshes
FLOOD MANAGEMENT	Returning the flood where it is part of the ecosystem	Making flooding part of the human water management	Steering sedimentation flows to motivate land growth
COASTAL MANAGEMENT	Organisation of ecological restoration and human retreat	Integration of water in the urban fabric and systems	Capturing sedimentation while growing along with it
RESPONSE-ABILITY	None, retreat from flood prone areas	Flooding as tool for aquaculture, limiting hinderance by waterproofing	Systems continuously adapt to new water and sedimentation levels
COMPOSE-ABILITY	Human retreat from the landscape, letting nature compose the landscape	Adapting to the presence of water, while managing its flows to benefit life and economy	Composing the future landscape together with nature, while adapting the urban farbic to grow with it
OPTIMISE FLOODING	Flooding bring mostly non-human potential	Flooding bring mostly human potential	Flooding brings human and non-human potential
SYMBIOSIS BETWEEN HUMAN AND NON-HUMAN	The systems avoid each other	Heavy technological human systems enable the maximisation of the flow	Human systems adapt to changes in non-human processes, collaborative

[Fig.69] General Reflection scenarios in relation to Tidal Urbanism.

8.6 TIDAL URBANISM PRINCIPLES

The evaluation of the scenarios has provided insights into how a transition towards Tidal Urbanism can be enabled. This transition is rooted in the delta dynamics and guided by both human and non-human systems. The following principles form the conceptual foundation for the vision.

Making with the Delta

A fundamental step is to recognise the Scheldt Delta, along with its human and non-human actors, as co-constructors of the region's future. Their flows shape the landscape and thus must be nurtured and enabled to actively contribute to its evolution. Localising spatial development allows zoning processes to respond more rapidly to environmental conditions and adapt based on local needs and capacities.

To enhance the performance of Tidal Urbanism, a strategy of continuous experimentation and learning is required. The ever-changing delta demands a community that is equally dynamic. An ever-learning society capable of adjusting to its shifting environment.

In support of this flexibility, land ownership must be reimagined as collective and regionally organised. This approach strengthens communal responsibility for the environment and livelihoods. Including non-human actors (such as water, soil and vegetation) as stakeholders in land governance ensures the recognition of the rights of nature.

Delta-Sensitive City

To align with deltaic flows, urban systems must adopt a mentality of accommodation and adaptation. Water, as the most transformative flow, must be given spatial freedom. Adapting to its presence requires the flood-proofing of new structures and waterproofing of existing infrastructure, allowing human habitation to co-exist with tidal fluctuations. Creating space for water also inherently makes space for other flows, such as sediments, nutrients, species and energy.

While natural systems are inherently adaptive, human infrastructure tends to be static. To function within a dynamic environment, our built environment must become modular and adaptable, enabling transitions not only related to flooding but also future changes such as energy transition or technological shifts.

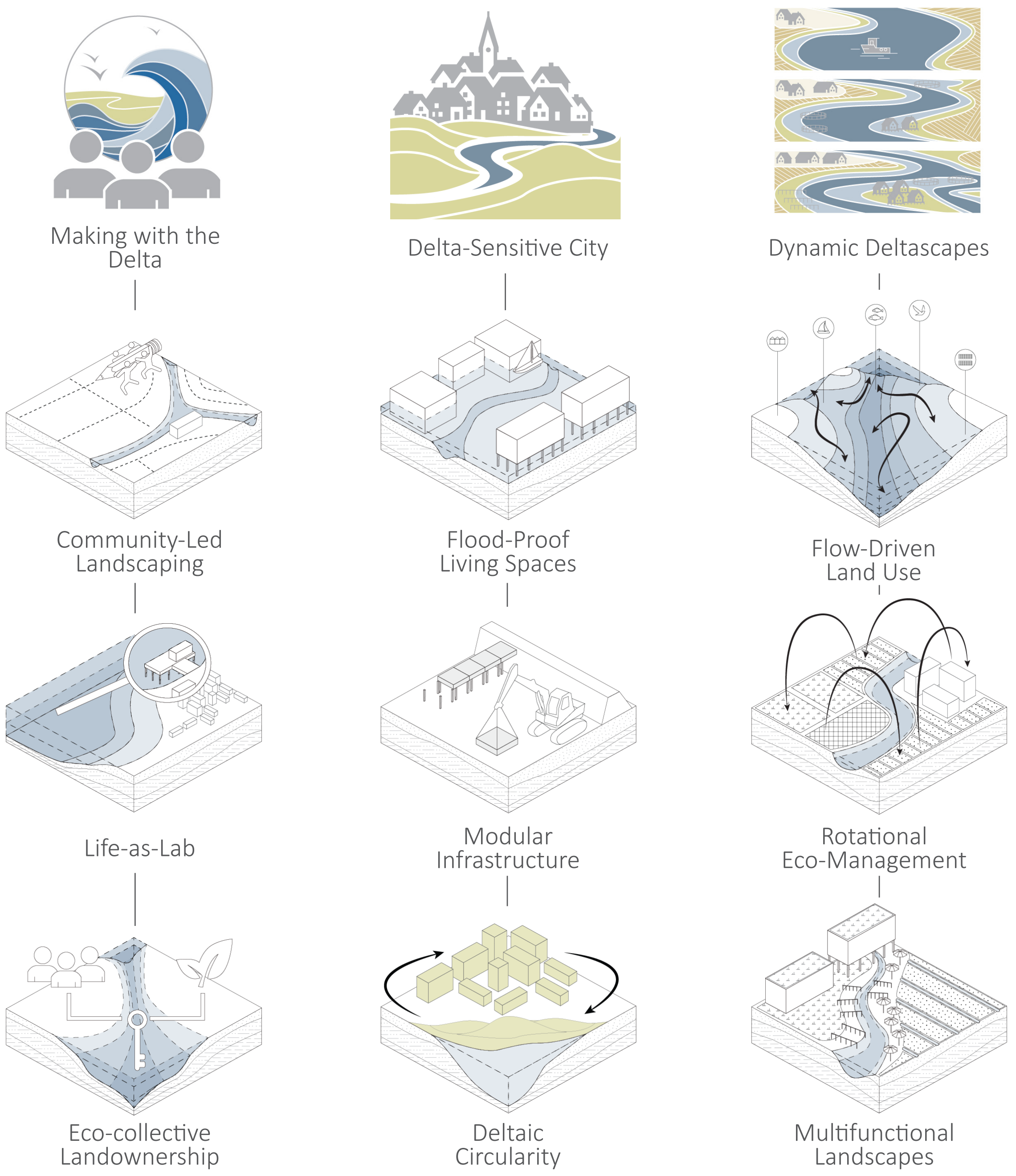
Urban design must also reflect the material logic of the delta. As the landscape continuously composes and decomposes through the action of flows, building with locally and naturally sourced materials ensures compatibility with natural cycles.

Dynamic Deltascapes

The traditional Dutch polder landscape, while engineered for stability, has led to ecological degradation through static land-use patterns and continuous pressure on limited resources. In contrast, fluctuations are the core strength of delta systems, enabling them to remain fertile, biodiverse and resilient.

Land use must mirror the fluidity of the landscape, responding to changing soil, water, sediment and nutrient conditions. As these variables shift over time, so too should agricultural and urban practices. To support this responsiveness, rotational and tenure-based land management systems should be implemented.

Monofunctional landscapes limit the value and resilience of land. By integrating multiple functions (such as combining agriculture with biodiversity conservation, tourism or education) interventions can deliver cultural, ecological and social value simultaneously.



[Fig.70] Design Principles Tidal Urbanism.

Vision Image Rise of the Marshians.

CHAPTER 9 EXPLORATION

9.1 VISION

This chapter outlines a vision for the Scheldt Estuary. It evolved from the Room for the Marshes scenario and grounded in the principles of Tidal Urbanism. While the original scenario emphasises the maximisation of a single flow, this vision embraces the full complexity of Deltaic Conditions. It acknowledges the interwoven forces that shape the estuarine landscape.

Rise of the Marshians

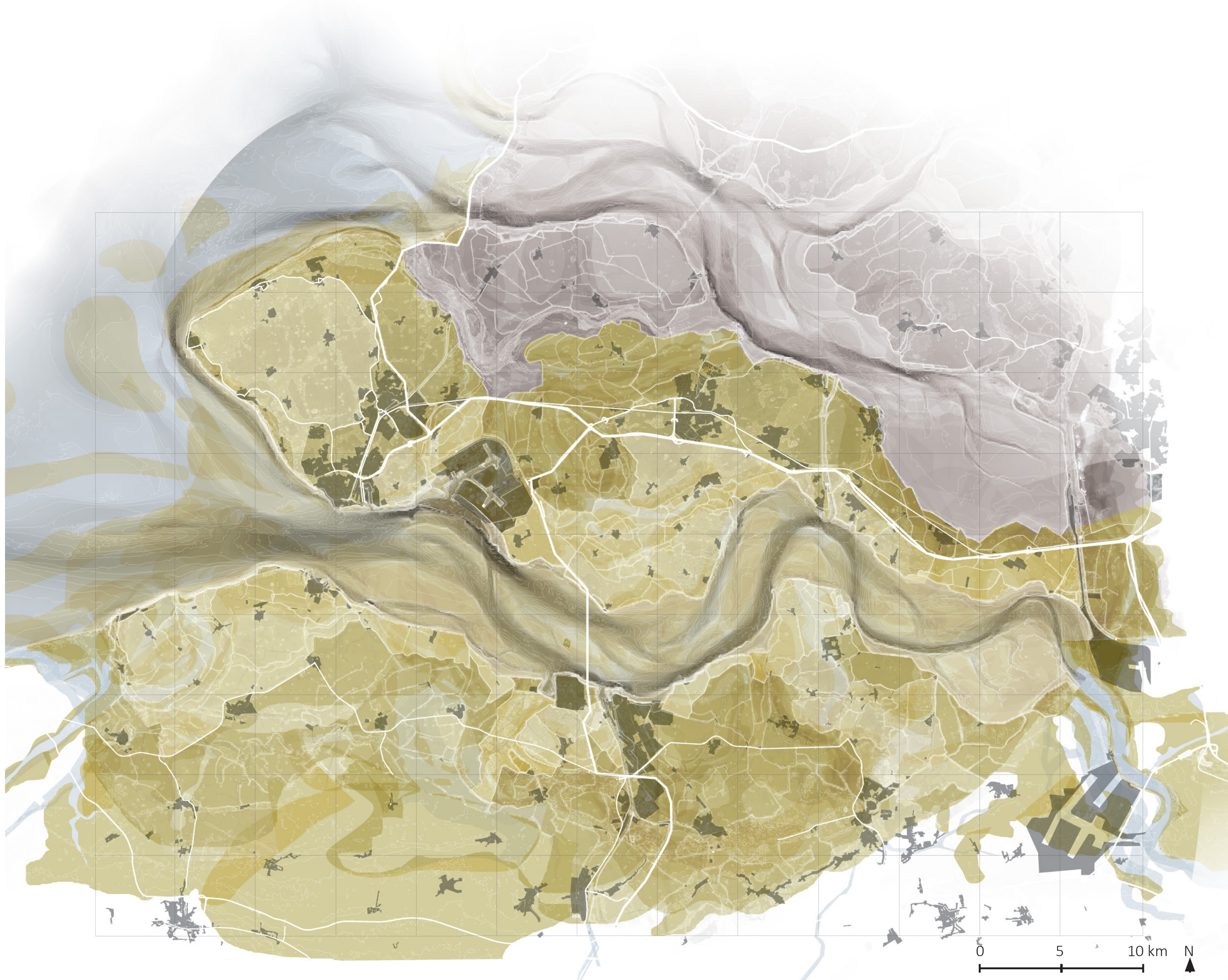
The Scheldt Estuary will have shed its rigid, human-imposed boundaries. And, it will return to a natural marshland identity by 2130. Flood management will no longer be defined by resistance or containment, but by adaptive systems of flow regulation. Infrastructures will evolve with the landscape rather than working against it.

Coastal management will be redefined as a radical collaboration. Humans and non-humans co-creating an environment of continuous adaptation. This is not a future of control, but of coexistence. A shared agency between species, systems and cycles.

The landscape will not merely react to the unpredictable forces of climate change and deltaic transformation; it will thrive within uncertainty. Tidal changes, sediment flows and biological processes are partners in shaping space and time.

In this envisioned future, humans will no longer dominate nature. Instead, they will participate in the web of life that sustains the Estuary. Creating a legacy of resilience and co-existence for generations to come.

[Fig.71] Birds eye impression vision: Rise of the Marshians.



[Fig.72] Vision map: Rise of the Marshians.
Sources: (vision layers combined with bing qgis map)..

9.1 VISION

This chapter explores how the marsh might return. It builds upon the structures and flows that shape the Scheldt Estuary today.

2030 – Preparation for Opening the Coast

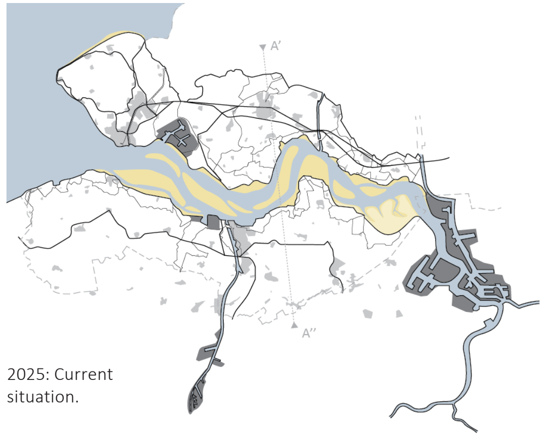
Through public participation, communities will be prepared for the transition. Frontal and deep polders will be the first to open. This establishes a marshland frontline and demands the relocation of populations from the high-risk areas. Provincial roads and secondary dikes are redesigned as primary dikes to preserve the hinterland. Allowing the original coastal dikes to be gradually removed. The newly designated primary dikes will carry utility and energy infrastructure. They form a backbone for the region.

Meanwhile, Belgium must prepare for an increase in tidal range due to the widening of the river mouth. Designated nature zones and agricultural land will be repurposed as floodplains. Industries and port linked to the river basin will be required to cease pollution. Failure to comply will result in heavy 'pollution fines', which will fund the transition or lead to the facility's closure.

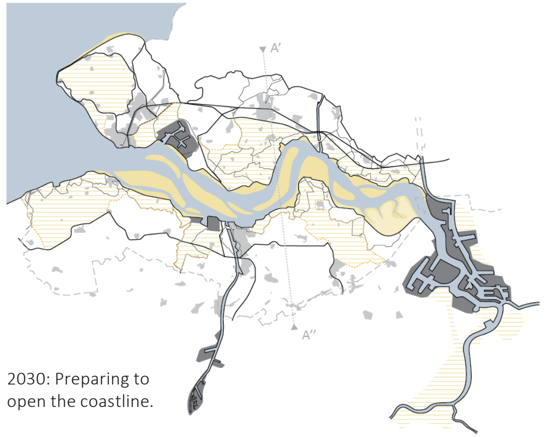
2050– Cleaning and Mapping

The phased removal of frontal dikes will allow one-third of the landscape to re-engage with delta processes. This reintroduces natural systems but also mobilises existing soil and water pollution. At this stage, ecological remediation, supported by research and environmental organisations, is essential.

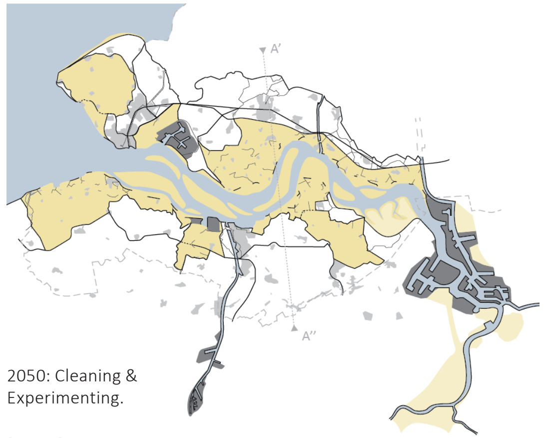
To enable adaptive spatial planning, flow patterns must be mapped and integrated into planning frameworks. Pilot projects in marsh cultivation will start.



2025: Current situation.



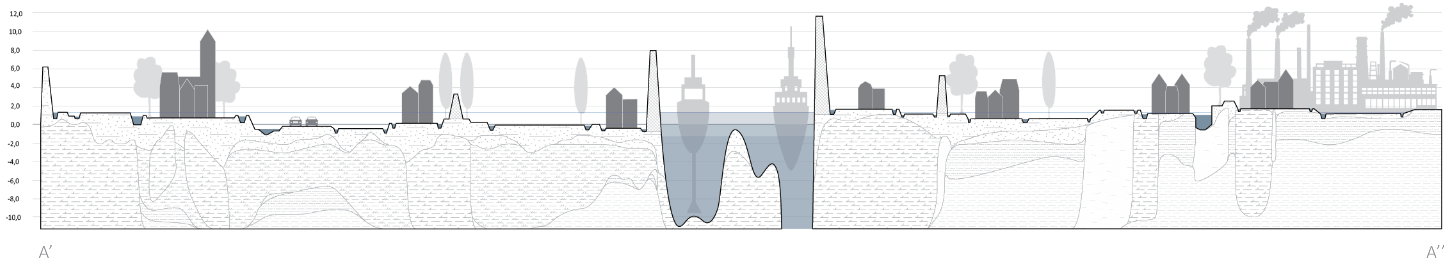
2030: Preparing to open the coastline.



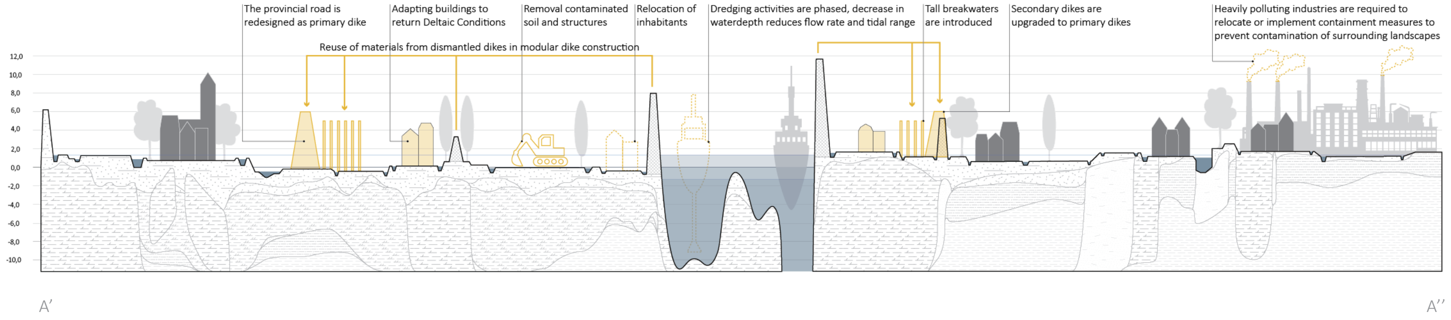
2050: Cleaning & Experimenting.

[Fig.73] Vision transition maps.

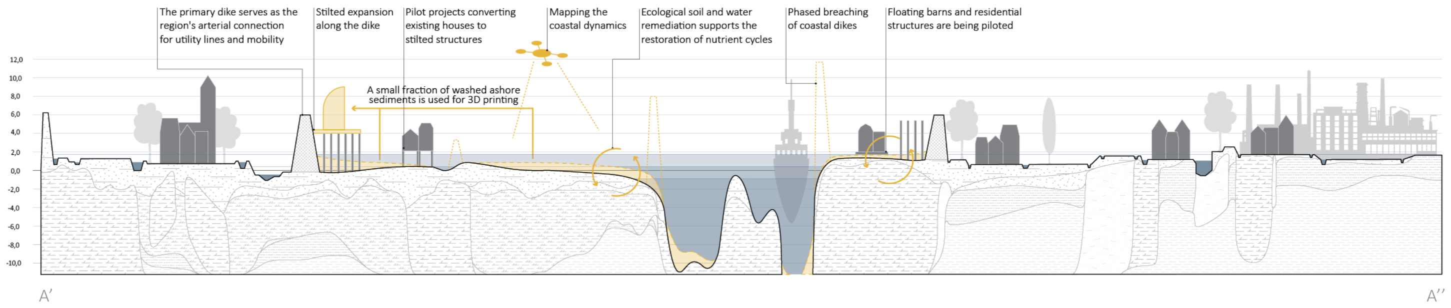
2025 Current situation



2030 Preperation for opening coastline



2050 Cleaning & Experimenting

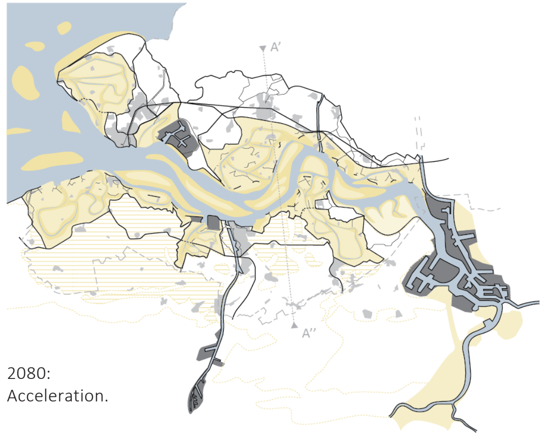


[Fig.74] Vision transition sections.

9.1 VISION

2080 – Acceleration

Heavily polluted soils are repurposed for infrastructure. In the meantime, the majority of the landscape will be sufficiently remediated. Agricultural production in the buffer zones is re-imagined, utilising practices that reflect the dynamism of the landscape. Communities have become more accustomed to flexible, nature-oriented land use strategies. Educational programmes extend into the dry hinterlands. Preparing these regions for the eventual return of tidal flows. Housing slowly adapts to accommodate Deltaic Conditions.

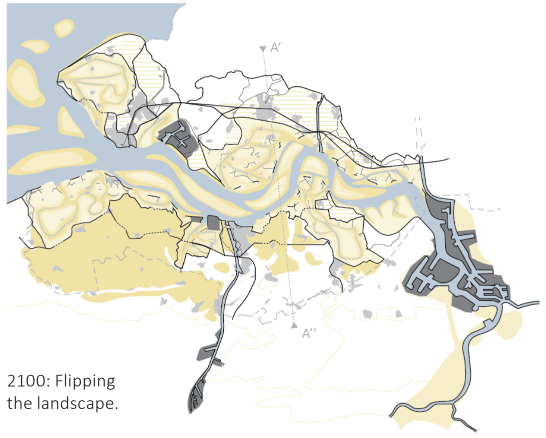


2080: Acceleration.

2100 – Flipping the Landscape

Historical river routes reopen to let the tide into the hinterland. Former dry hinterlands become the new coastal zones, while areas once on the coast now serve as elevated islands. Techniques previously applied to the frontal marshes are now replicated in the hinterland.

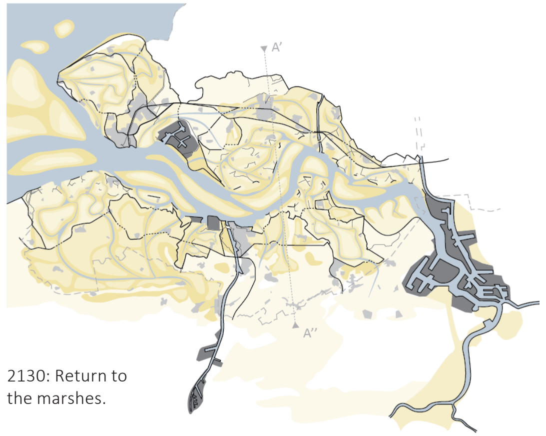
The housing market consists of adapted legacy structures and new dwellings constructed from locally sourced materials. The buildings decompose and recompose using harvested materials such as clay, reeds and sand. This gives them the ability to adapt and take part in a symbiotic relationship with the ecosystem.



2100: Flipping the landscape.

2130 – Return of the Marsh

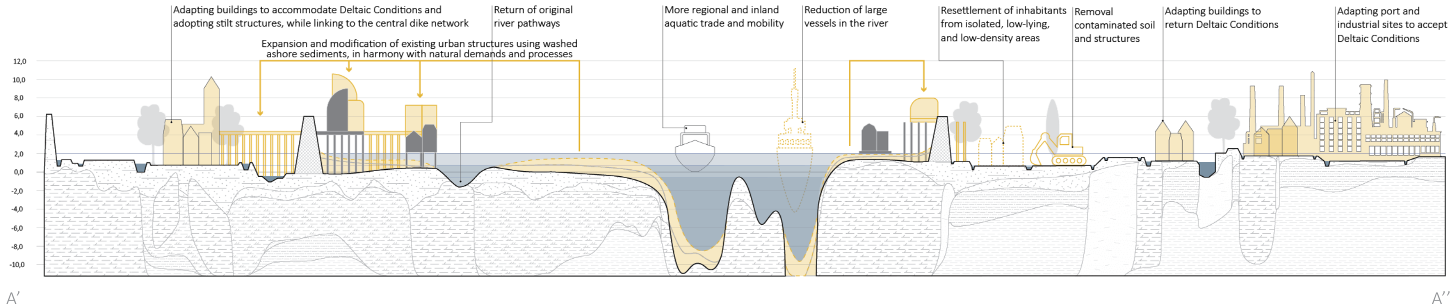
The Scheldt Estuary returned to its original dynamic marshland form. In this landscape humans live in synergy with the ecosystem. Whether confronted with rising sea levels or further deltaic shifts driven by climate change, the inhabitants possess the adaptive capacity to transform with the environment, ensuring their survival.



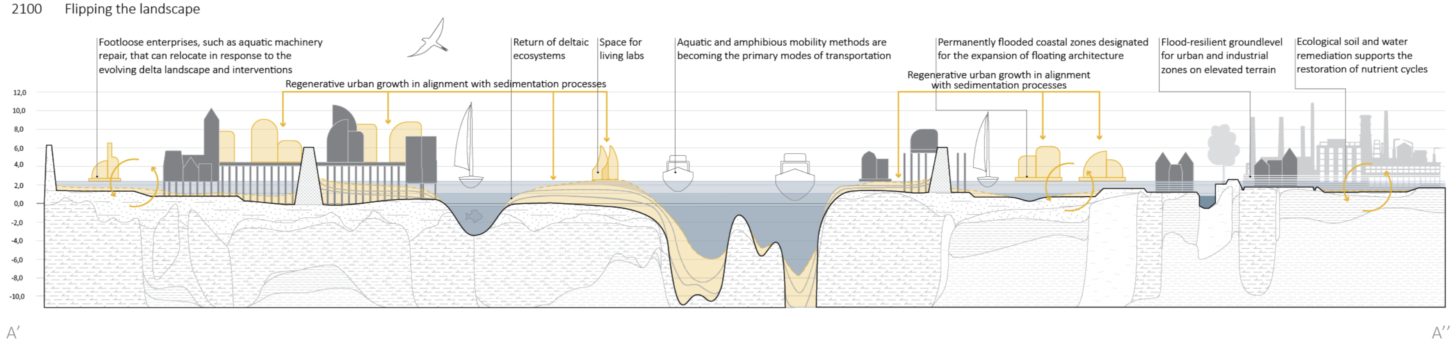
2130: Return to the marshes.

[Fig.73] Vision transition maps.

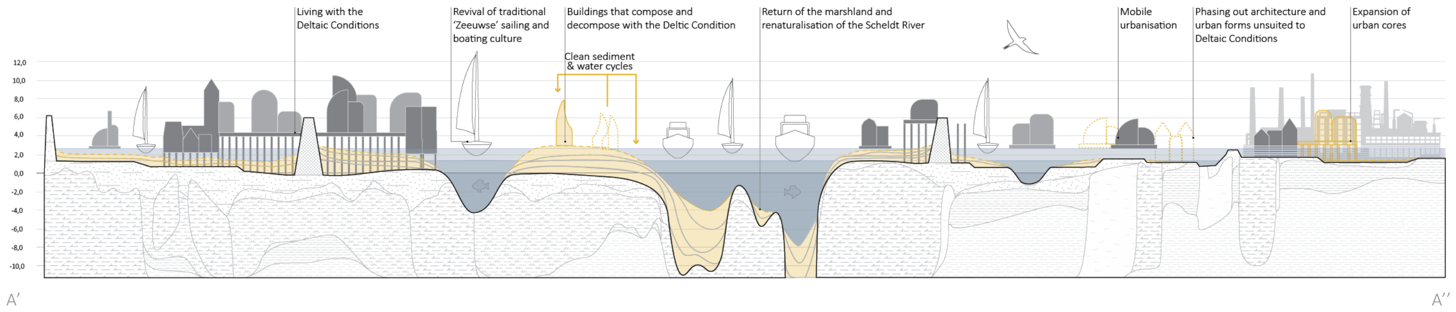
2080 Acceleration



2100 Flipping the landscape



2130 Return to the marsh



[Fig.74] Vision transition sections.

9.2 EXPLORATIONS

The following explorations delve into key areas where the vision can begin to take form. These experiments explore how principles of Tidal Urbanism manifest across diverse urban and Deltaic Conditions. Each location offers a unique lens. General transformations link all three explorations. However, each one reveals distinct challenges, opportunities and spatial logic. These are not solutions, but test grounds for co-evolving with the delta.

Deltaic Spine Vlissingen

Located on Walcheren, this exploration encompasses the urban fabric of Vlissingen and Middelburg. The Estuary's most densely populated zone. Home to many of Zeeland's cultural, economic and political institutions. Despite its elevated role, the area lies behind a primary dike and much of its terrain sits below sea level.

Here, the question is not whether to invest in safety, but how to reformulate safety within a shifting estuarine future. The reintroduction of marshes becomes more than ecological repair. It becomes a framework for re-imagining urban expansion. Water-resilient infrastructure and elevated systems shape a new urban condition. Dikes and roads become dual-purpose lifelines, integrating evacuation routes, energy corridors and flood-adapted housing into a spine.

This exploration investigates how high-density environments can evolve into wetproof habitats. That align with the flows and uncertainties of the Delta.

Marsh Cultivation Kloosterzande

In East Zeeuws-Vlaanderen, the rural landscape surrounding Kloosterzande presents a contrasting condition. Predominantly agricultural, the area follows an ancient riverbed, with farmland lying at or below sea level. The village itself is elevated at +1.5 metres NAP.

The area's high flood risk and low population density provide ground for spatial reorganisation. It offers an opportunity to experiment with dynamic agricultural practices. While lacking resources for major flood infrastructure, the village's slight elevation allows for tolerable shallow flooding and household-level adaptations.

This exploration envisions a shift from traditional, static farming toward dynamic cultivation. And, small-scale flood resilience in rural settings.

Living Lab Hoofdplaat

In the western frontal polders, the village of Hoofdplaat sits elevated but compromised: its soils are contaminated with lead. This creates serious risks in a flood scenario. Hoofdplaat was once a farming village, it now serves primarily recreational purposes.

This exploration imagines Hoofdplaat as a "living lab" for remediation. Its dual character (exposed yet accessible, toxic yet teachable) makes it an ideal site for testing ecological healing as participatory process. The decommissioned dike nearby could form a framework for regeneration. It can guide sediment flows, filter water and host marshland species.

Hoofdplaat may become a site to engage with the delta transformation, pollution legacies and multi-species futures. The aim is not to restore what was, but to cultivate a space for awareness and experimentation.

[Fig.75] Exploration locations.
Sources: (Vision layers combined with ArchGIS (2025)..

9.2.1 DELTAIC SPINE VLISSINGEN

Each exploration begins by setting out the context and how it would respond to restoring Deltaic Conditions in the current state.

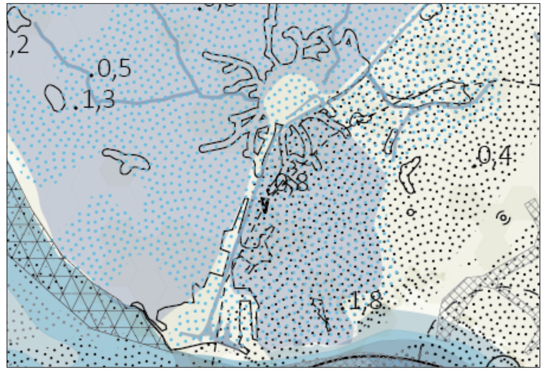
Context

This area on Walcheren includes the urban zones of Vlissingen and Middelburg. It hosts the highest population density within the estuary. It is home to many of Zeeland's governmental, cultural and economic institutions. The region lies directly behind a primary dike ring, placing it within the direct flood range should that line fail. Much of the land sits below sea level, as this was among the first islands reclaimed from the sea. Even the provincial roads (crucial for evacuation) rise only slightly above sea level, making them vulnerable and likely to become unusable during flood events.

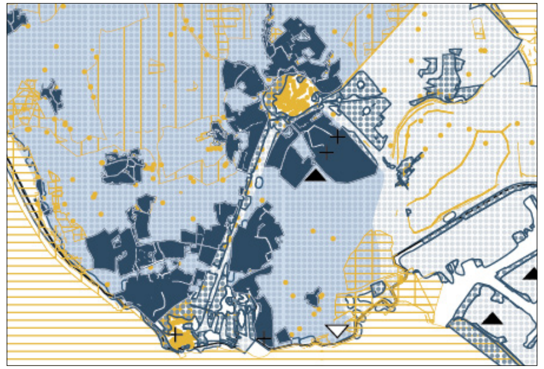
Response to Deltaic Conditions

In its current state, restoring deltaic flows by reopening the dikes would lead to significant disruption. Settlements would flood with up to two metres of tidal water during high tide. Historic buildings and cultural landscapes would be at risk [Fig.77]. The urban centres contain lead contamination and agricultural fields also hold various pollutants. The tidal inundation could disperse these toxins into surrounding ecosystems [Fig.76].

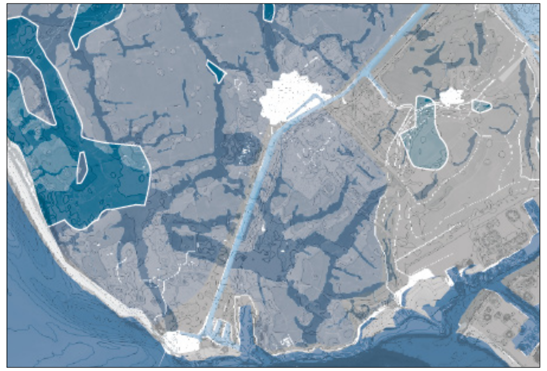
Yet, these same tidal flows could offer regenerative potential. Rehydration of soils would halt ongoing subsidence, stabilising urban foundations and protecting freshwater reserves beneath the dunes [Fig.78]. Sediments carried inland could also help reinforce the dunes from behind. Softening the current coastal erosion [Fig.76].



[Fig.76] Flows Vlissingen.
Source: (Layers from the Deltaic Condition map).



[Fig.77] Human system Vlissingen.
Source: (Layers from the Deltaic Condition map).



[Fig.78] Non-human system Vlissingen.
Source: (Layers from the Deltaic Condition map).

[Fig.79] Exploration Location Vlissingen.
Source: (ESRI, 2025)

9.2.1 DELTAIC SPINE VLISSINGEN

Challenge & Exploration

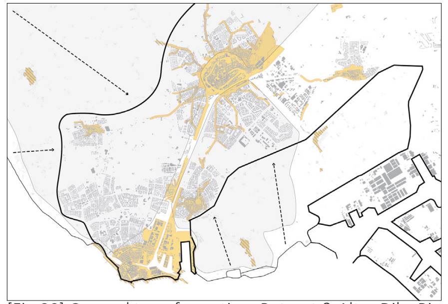
Given the concentration of critical infrastructure and population, rethinking safety is not optional. It's fundamental. The current urban form is deeply incompatible with tidal reintroduction. This exploration asks: what if the dike didn't only defend, but also enabled?

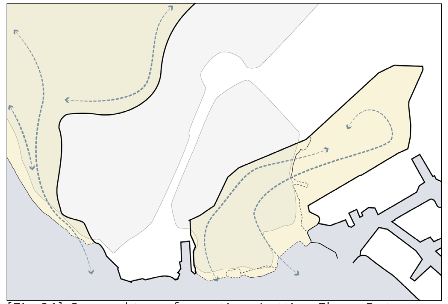
By strategically retreating and reconfiguring the dikes, they could become dual-purpose structures. They can serve as evacuation corridors, utility conduits and structural backbones. Their redesign would protect the hinterland and support functionality even during flood events.

Opening historic dikes would invite foreshores to return, facilitating natural sedimentation and soil remediation. Vegetated buffers placed around creeks and erosion-prone soils would slow water flow. Stilted structures might allow for new modes of life within marsh conditions. These adaptive zones would not only defend, but also expand into productive, living marshlands. These transformations would enable urban communities time to evolve alongside sea-level rise.

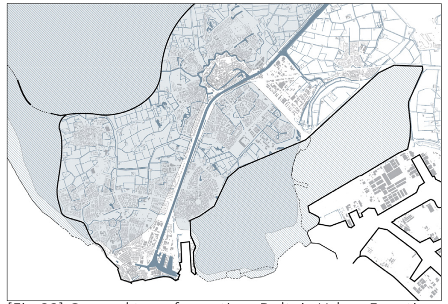
Aim

This exploration seeks to imagine how dense urban environments could transition into wet-proof living systems. Settlements that don't resist the delta, but engage it. The goal is a future where built form and tidal rhythm co-exist. Ensuring adaptability, resilience and long-term survival in a dynamic estuarine context.


[Fig.80] General transformation: Retreat & Alter Dike Ring.

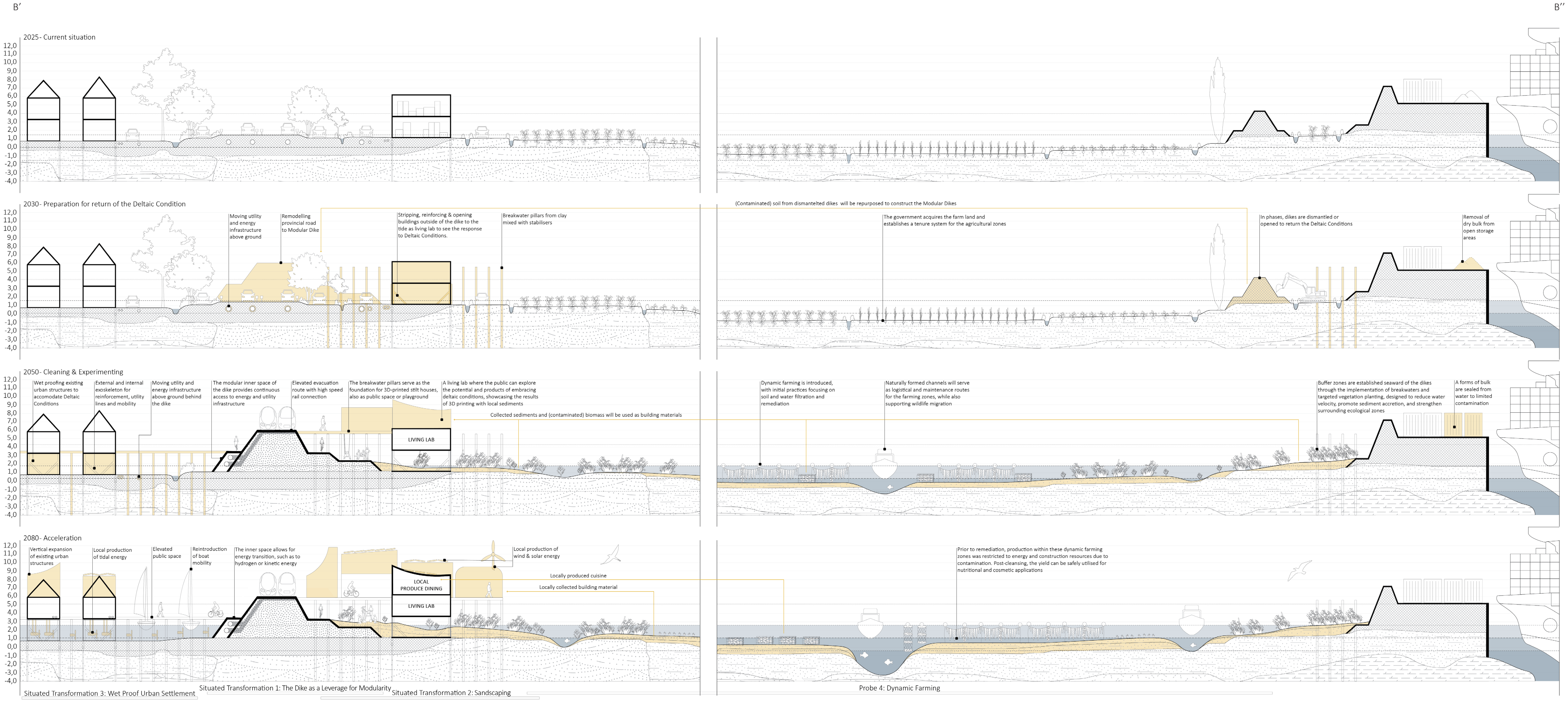

[Fig.81] General transformation: Letting Flows Return.


[Fig.82] General transformation: Building Marsh Lanscape.


[Fig.83] General transformation: Deltaic Urban Functions.

[Fig.84] Exploration Deltaic Spine Vlissingen. Source: (WUR, 2023; PDOK, 2025).

9.2.1 DELTAIC SPINE VLISSINGEN



[Fig.85] Timeline and section exploration: Deltaic Spine Vlissingen.

9.2.1 DELTAIC SPINE VLISSINGEN

Criteria Implementation of Vision into the Exploration Location				Exploration		Impact of Transformations on the Scheldt Estuary			
Composition of Landscape			Response to retun Deltaic Conditions	Vision Alterations	Situated Transformation	Interscalarity of Transformations		Exploration Goal	Relation to Design Principles
Systems	Subsystems	Type				Transformation	Effects		
Non-Human	Soil	Clay	Erosion of creek ridges causes return of original river path	Letting the flows compose the landscape	2. Sandscaping	Harvest locally sourced (polluted) sand to build artificial landforms and constructions, that enhance the land growth.	Reintroduces dynamic land-making processes into the delta. Strengthens local circular use of resources, repurposes polluted soil.	Harnesses natural sediment dynamics and human waste streams to co-create new landforms, aligning with a future where water shapes the landscape.	Deltaic Circularity, Flow-Driven Land-Use, Multifunctional Landscape, Life-as-Lab
		Creek Ridges	Return of sedimentation & tidal flows	Enhance land growth by slowing down water flow					
	Hydrology	Permeability	Salinisation	Reduce salinisation of ground water by reintroducing land growth					
	Elevation	-1 to 0 m NAP	Continous flooding of the whole landscape	Adapting existing urban settlements to the presence of water	3. Wetproof Urban Settlement	Retrofit existing buildings to be waterproof and sealed at ground level. Redesign access: the current first floor becomes the new ground floor, with platform-based entries above flood level.	Preserves the identity and investment of existing urban fabric. Enables layered transformation rather than abrupt replacement.	Allows urban life to persist through adaptation, embracing water as a structuring presence rather than a threat.	Flood-Proof Living Spaces, Deltaic Circularity, Community-Led Landscaping, Life-as-Lab
Human	Land use	Urban Settlement							
		Agricultural Land							
		Retail and Logistics							
		Community Farms							
	Engineered Hydrology	Channels							
		Ditches							
	Transportation Infrastructure	Provincial Road	Hindered of mobility due to inundation	Elevating primairy infrastructure	1. Dike as Leverage for Modularity	Transform low-lying main roads into linear dikes, allowing a phased opening of the coast. Integrate energy lines and utilities within these dikes to protect critical functions and keep them accessible.	Ensures maintainability and flexibility of utilities in shifting ground and water conditions. Creates a flexible backbone for future urban expansion and alterations.	Transforms rigid infrastructure into adaptive frameworks, to enable humans to be as dynamic as its environment.	Modular Infrastructure, Multifunctional Landscape
		Local Road							
	Water Safety Infrastructure	Primairy Dike	The decomposition of the dike and landscape due to erosion allows contamined soil to spread	Repurposing polluted soil for infrastructure and building material					
	Energy & Utilities Infrastructure	Regional Gas Pipeline	Reduction in accessibility and increase in risk on damage on utility infrastructure	Concentrating energy infrastructure in a space which accesible and adaptable to new changes					
		Regional Energy Line							

[Fig.86] Overview Situated Transformations Deltaic Spine Vlissingen.

9.2.1 DELTAIC SPINE VLISSINGEN

Situated Transformation 1: The Dike as a Leverage for Modularity

Among the many possible pathways toward a Marshian future, one of the most critical lies not in resisting water. But, it lies in rethinking the structures we've long used to contain it.

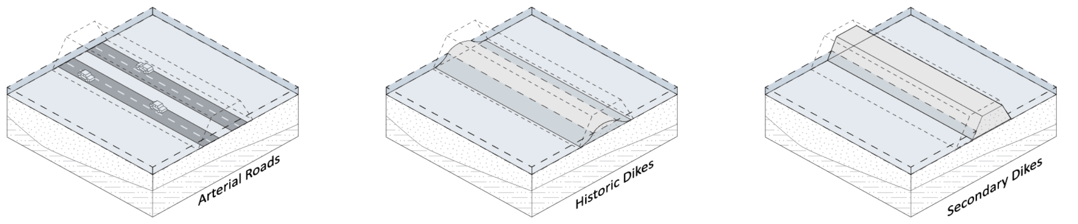
This exploration re-imagines the dike not as a barrier, but as a infrastructural spine. A structure that enables the landscape to shift toward marshland while preserving the vital flows of urban life. In this vision, the dike becomes more than infrastructure: it becomes a framework for modular adaptation.

Existing arterial roads, old dikes and secondary embankments are reconsidered as components of a new kind of modular dike system. These elevated routes, woven through city edges and open landscapes, form a connective tissue. It upholds mobility, evacuation capacity and utility continuity. Rather than resisting change, they facilitate it. Offering above-sea-level access even in scenarios of rising tides or managed retreat.

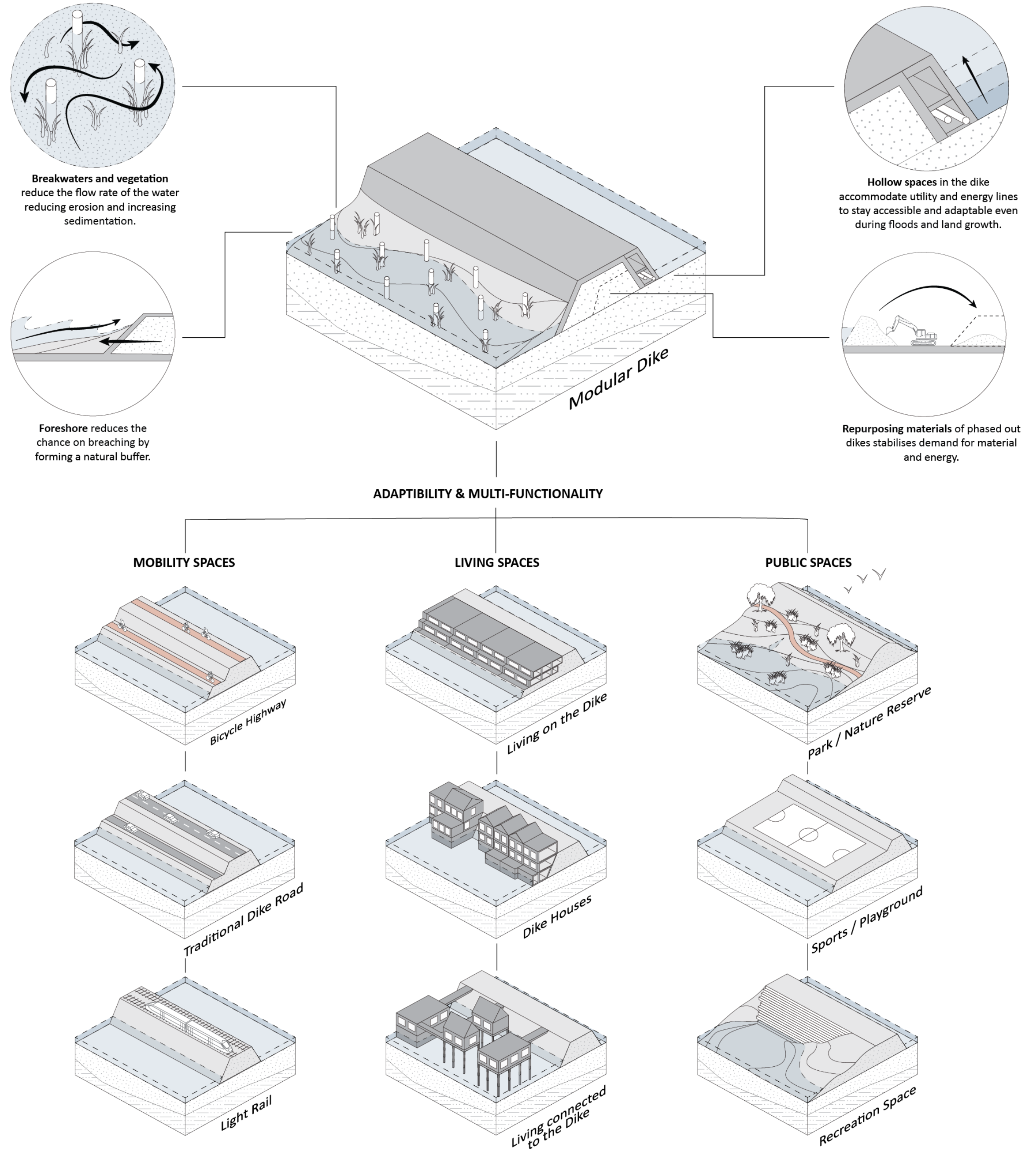
In this transformation, flood defences are no longer fixed lines of resistance. Instead, they become the core of the transformation. A multi-functional platform for adaptation, connectivity and layering. They host water, people, energy and movement; all in one evolving structure.

As climate pressures intensify and landscapes reconfigure, these modular dikes arise as non-regret interventions. They are robust yet flexible structures that ensure continuity. Creating a foundation for ecological processes and urban transformation. They are lines of defence as well as lines of possibility.

As each segment of the dike is designed based on the local demands, the role of the dike becomes vague. It always has been a part of the urban fabric, but now its role becomes more centralised, more present in daily life. As it was a static element that always gave room to live, it now can grow and alter with it. It is a reflection of the urban community while also its foundation for its development.



[Fig.87] Foundation for the Modular Dike transformation.



[Fig.88] Situated Transformation: Modular Dike.

9.2.1 DELTAIC SPINE VLISSINGEN

Situated Transformation 2: Sandscaping

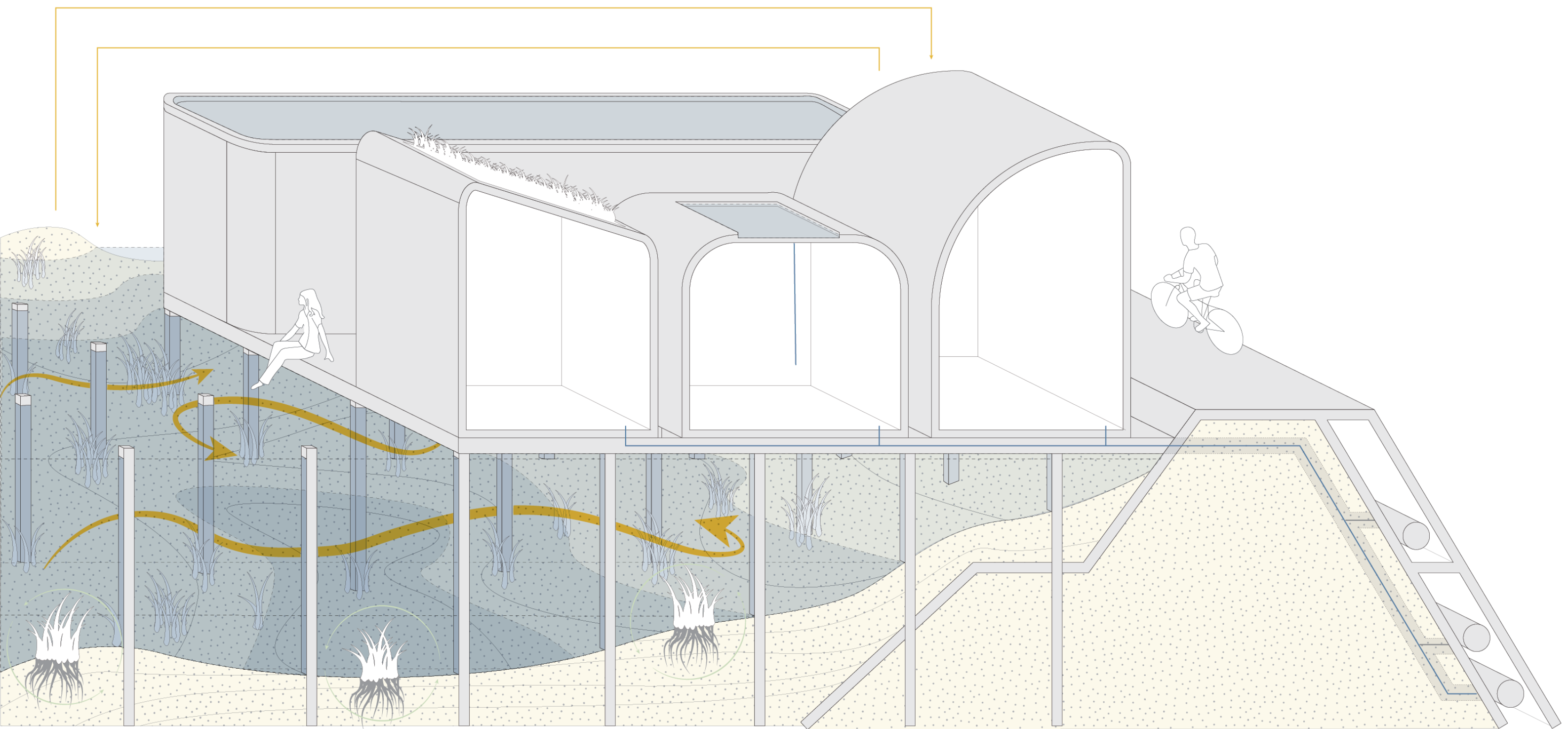
While infrastructure can guide the transition, materials themselves hold the potential to shape a deltaic way of living. This transformation explores sandscaping as a method of working with, rather than against, the natural conditions of the estuary. By repurposing locally sourced materials new forms of adaptive infrastructure emerge. Think about materials such as the surplus sand and clay in the landscape to excavated dike matter. These materials not only support human habitation, but also reinforces the deltaic metabolism.

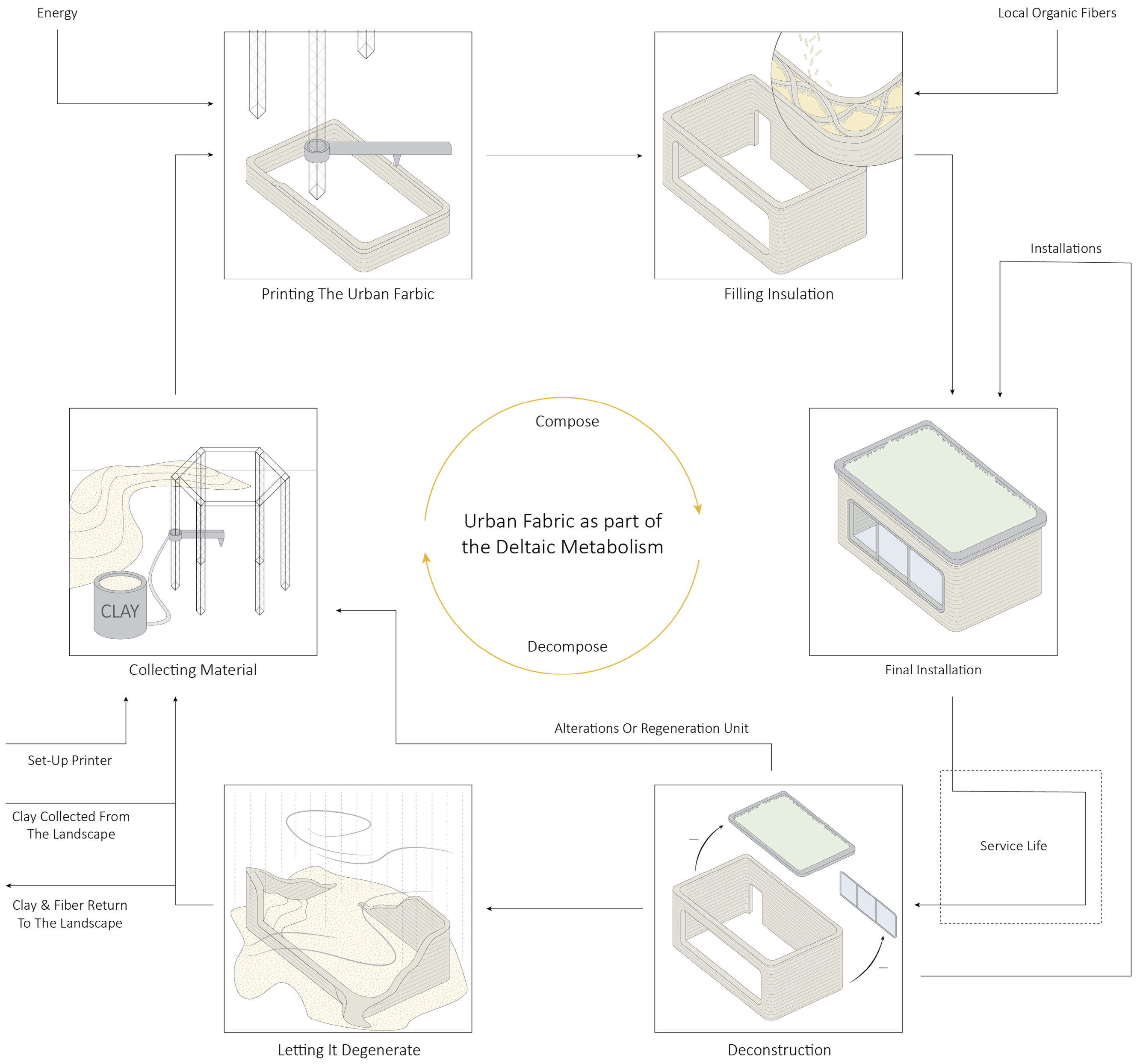
At the heart of this approach is the creation of 3D-printed breakwater stilts. These would be crafted from local sediments. These porous, biodegradable structures slow water movement. Thus, reducing erosion and encouraging the slow accumulation of sediment.

This results in land to grow. Over time, these constructions participate in a cycle of composition and decomposition. Synergising with the deltaic metabolism and evolving with the estuary.

Beyond infrastructure, these same materials and techniques extend to stilt-based housing. These are flood-proof dwellings take part in the tidal logic of the marsh. These homes are more than shelters. They become agents of regeneration, protecting dikes and enhancing biodiversity. There presence enables coexisting with rising and falling waters.

Sandscaping is not simply about erosion control. It is a design language grounded in the materials of place. It supports life, buffers risk and builds a future where human presence is not imposed, but adapts to land and its dynamics.





[Fig.90] Sandscaping, connecting to the Deltaic Metabolism.

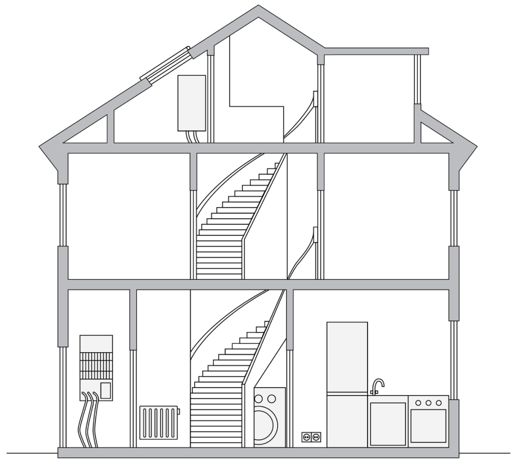
[Fig.89] Sandscaping through urban expansion on silts.

9.2.1 DELTAIC SPINE VLISSINGEN

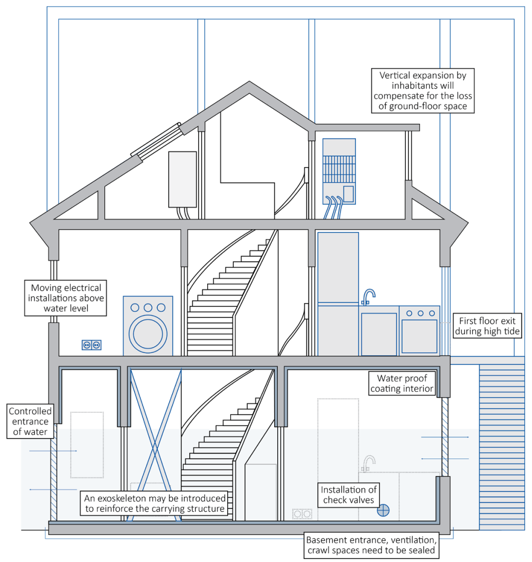
Situated Transformation 3: Wet Proof Urban Settlement

This transformation explores how existing urban settlements evolve into wet proof habitats, as flooding becomes a regular part of life. The transformation starts with the retrofitting of individual homes. The use of wetproofing and water-sealing techniques limits damage from occasional inundation. Over time, these interventions scale up to address the urban fabric as a whole. Individually and collectively, people start reshaping streets and public spaces. Enabling them to operate within wet conditions.

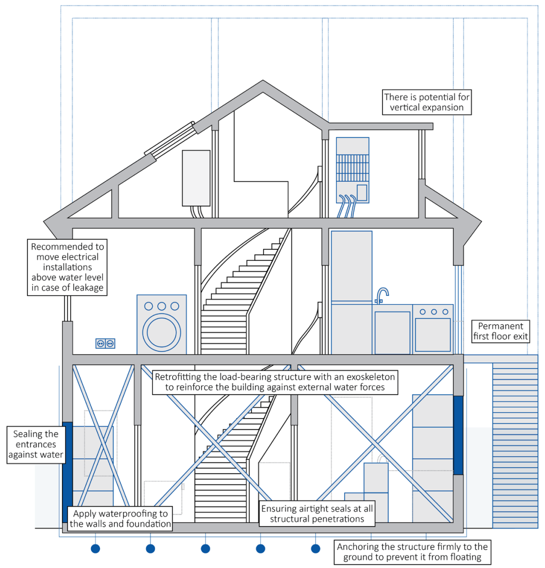
In a context of accelerating flood risk, wetproofing is a non-regret investment. What starts as damage control becomes the basis for a new kind of urbanism, one that coexists with water.



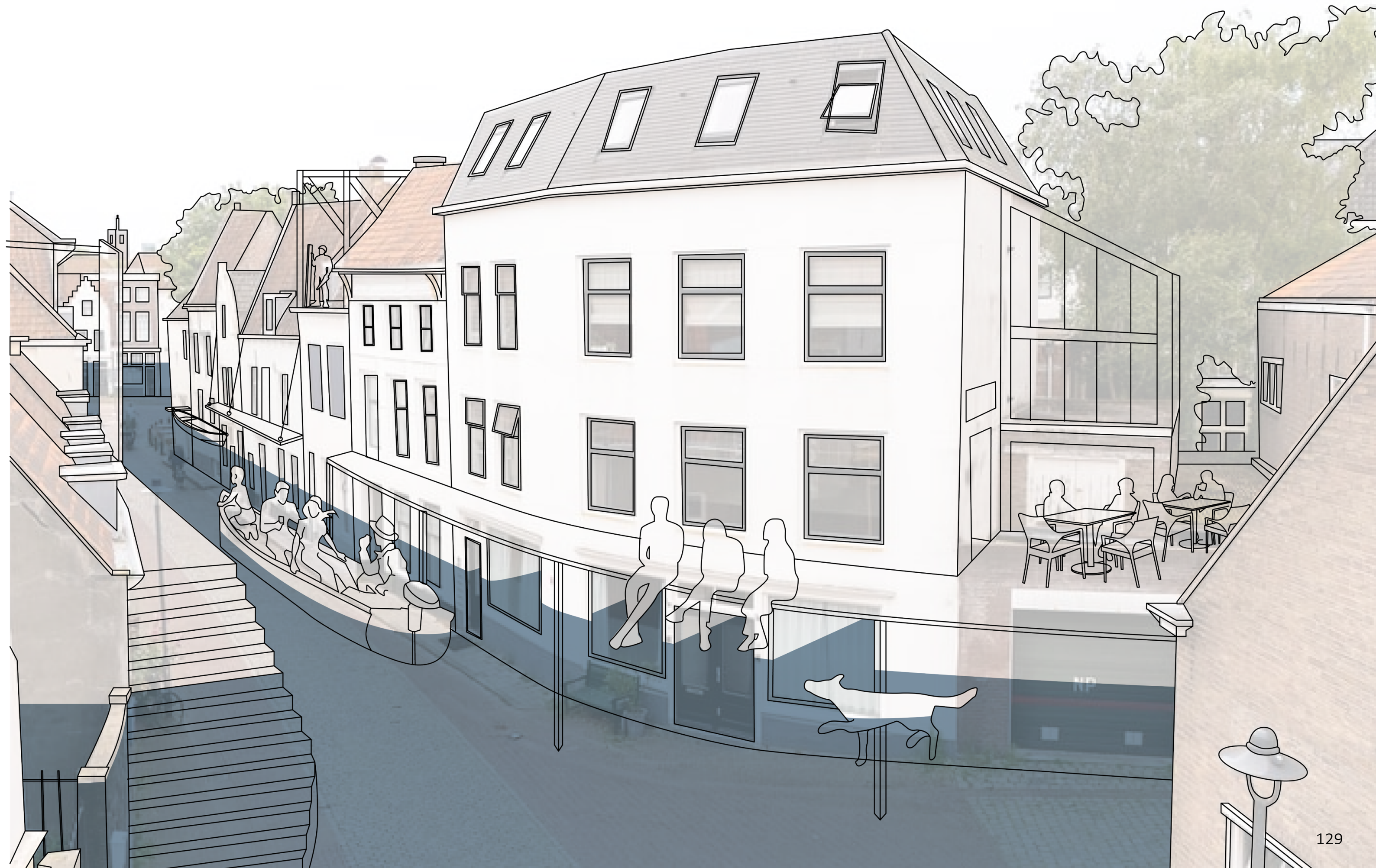
[Fig.91] Standard Dutch Rowhouse Section.



[Fig.92] Wetproofing Dutch Rowhouse.



[Fig.93] Water-sealing Dutch Rowhouse.



[Fig.94] Situated Transformation: Wet Proof Urban Settlement.
Source background image: (Krijger & Dieleman Makelaars en Taxateurs, 2024)

9.2.1 DELTAIC SPINE VLISSINGEN

Tidal Urbanism through Transformations

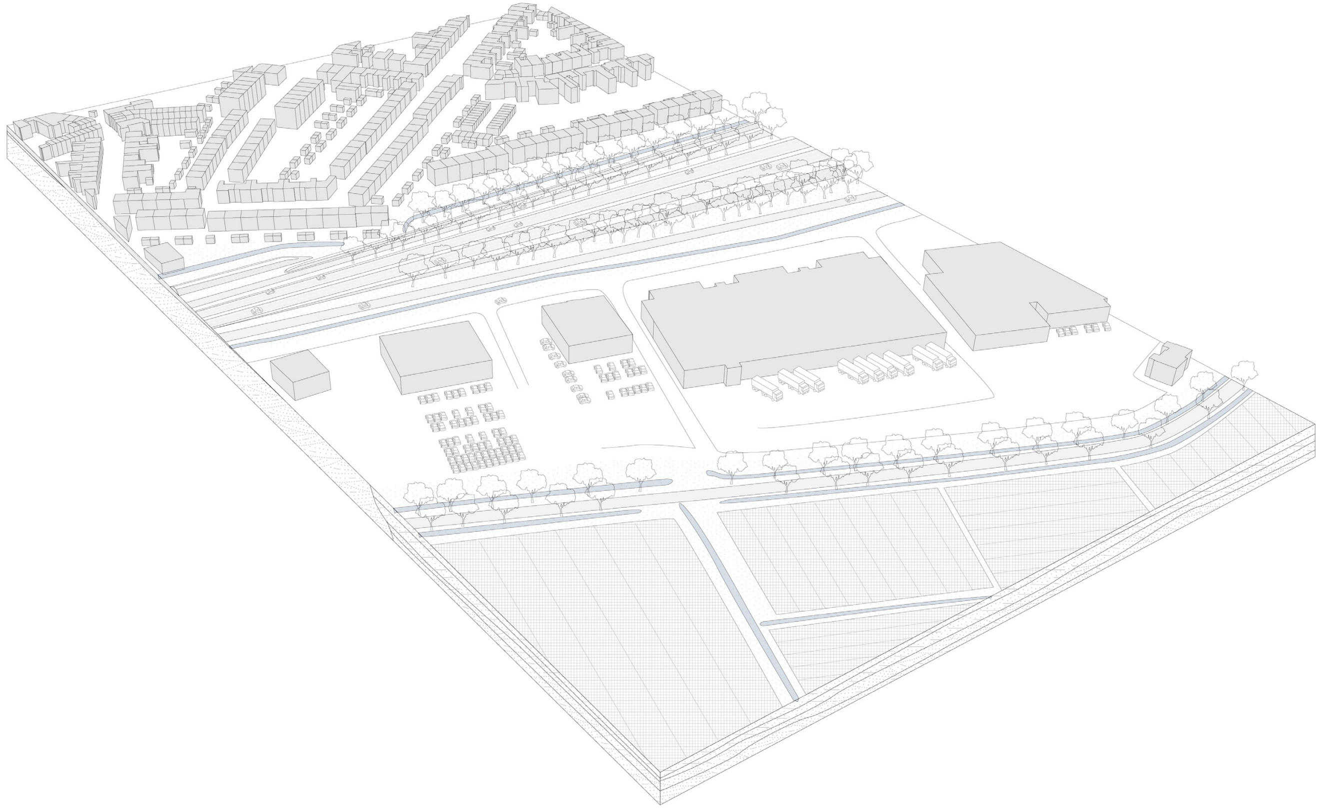
This chapter illustrates how the General and Situated Transformations collectively introduce Tidal Urbanism into the urban fabric. They shape a phased adaptation from vulnerability to resilience. While envisioning a long-term shift toward deltaic cohabitation. A future where human and environmental systems live in interdependence.

But this transition is not without tension. It demands new forms of trust, investment and cultural reorientation as water returns to places long defined by its absence.

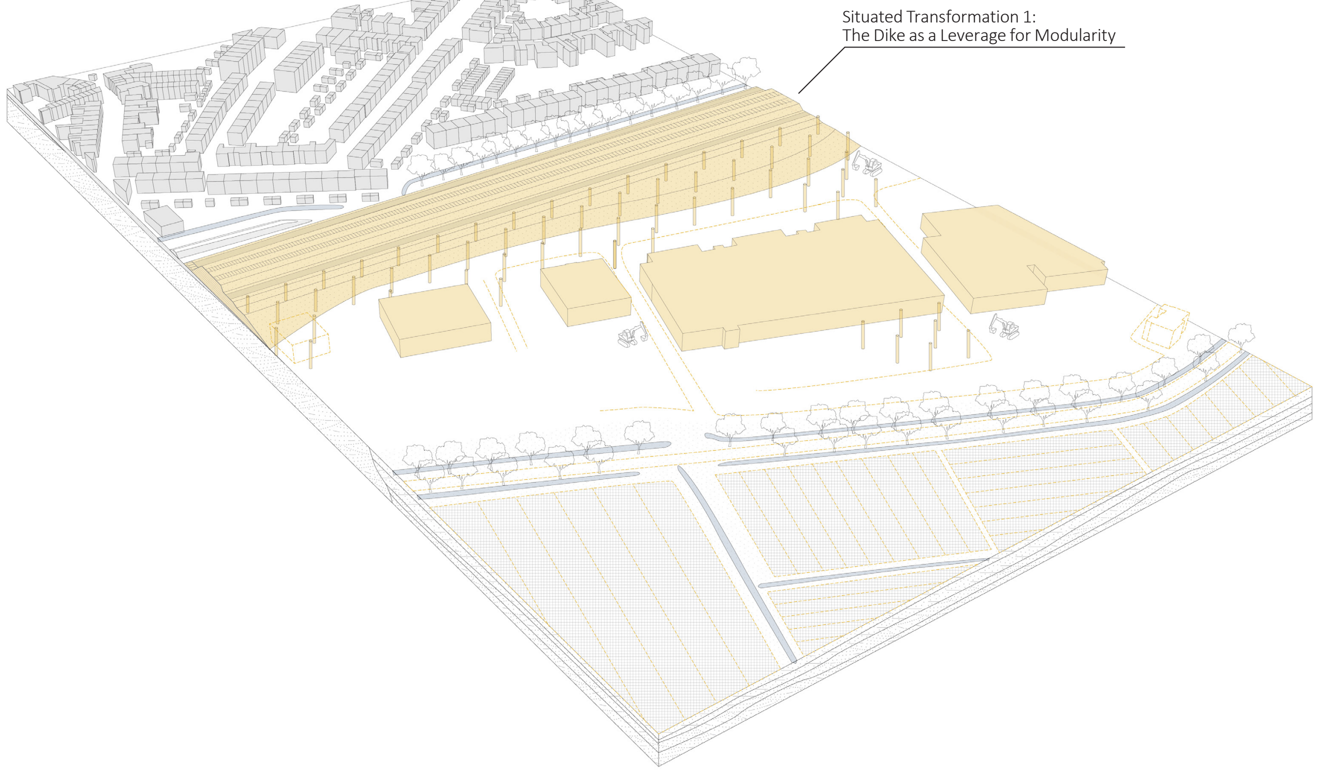
In the initial stage, the region is ill-equipped to handle flooding. Infrastructure is outdated and the urban fabric is rigid. Human habitation remains isolated from the natural forces of the delta. While the risk is growing, adaptation is hindered by a persistent desire for control. People fear disruption, loss and the unknown.

The introduction of a new primary dike in 2030 marks the first major structural shift. Serving as the spine of the region, this dike ensures safety and supports critical functions. Although, it also demands significant financial and spatial investment. It introduces a reframed relationship with water. And, enables the cleansing and preparation of land and buildings in its foreground. Socially, this may raise anxieties: relocating residents, reshaping land value and reconfiguring long-held perceptions of where it is safe to live.

[Fig. 95] Location Vlissingen Exploration Tile.



[Fig.96] Deltaic Spine Vlissingen 2025 - Current Situation.

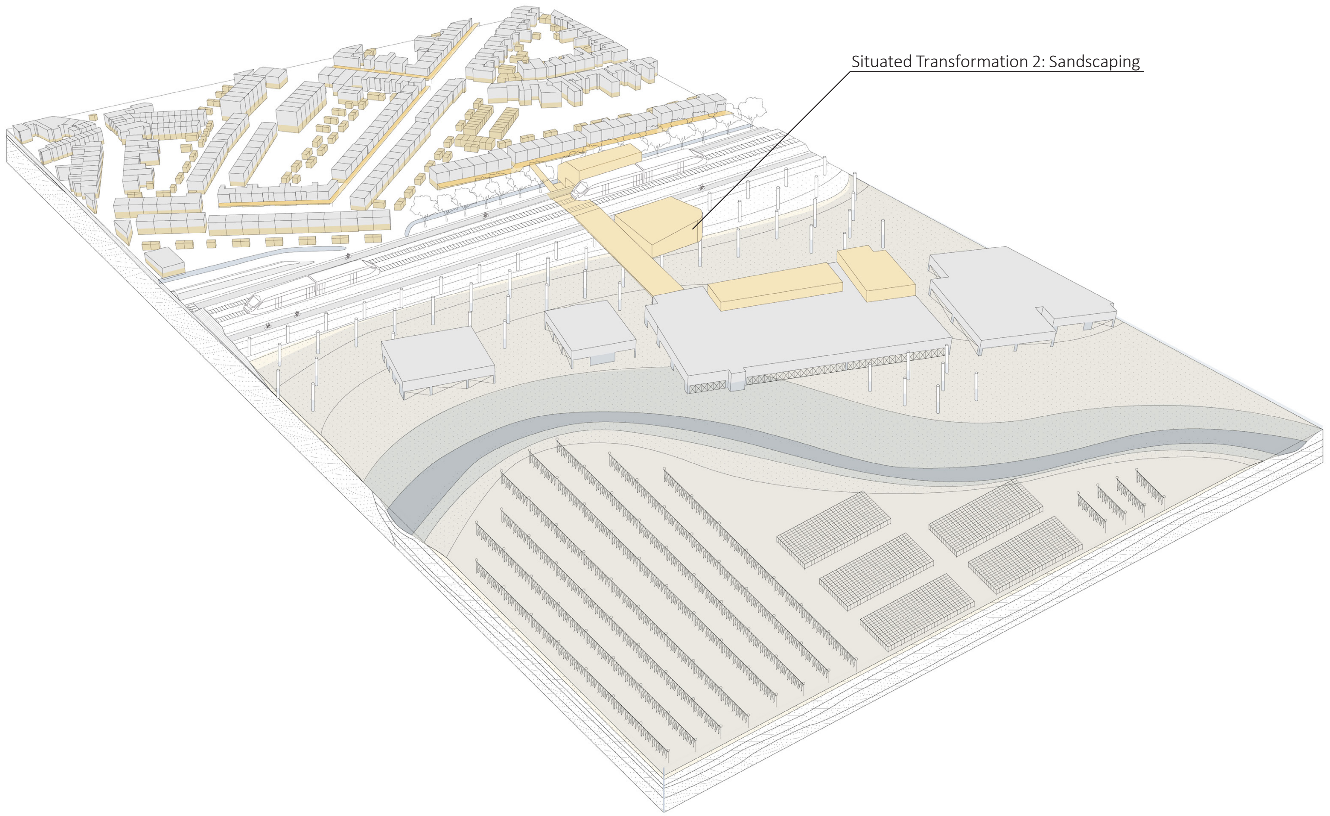


[Fig.97] Deltaic Spine Vlissingen 2030 - Preparation for Opening the Coast.

9.2.1 DELTAIC SPINE VLISSINGEN

By 2050, Deltaic Conditions return to the frontal polders. Tidal flows utilised through adaptive agriculture and the use of stilts and elevated systems. The dike evolves into a bridge connecting hinterlands to the foreshore and urban cores. Pilot projects in ecological farming and amphibious living arise. It signals the creation of new spatial identities.

The reintroduction of water into inhabited landscapes still carries risks.Public health concerns need to be accounted for as well as the population adapting to uncertainty.

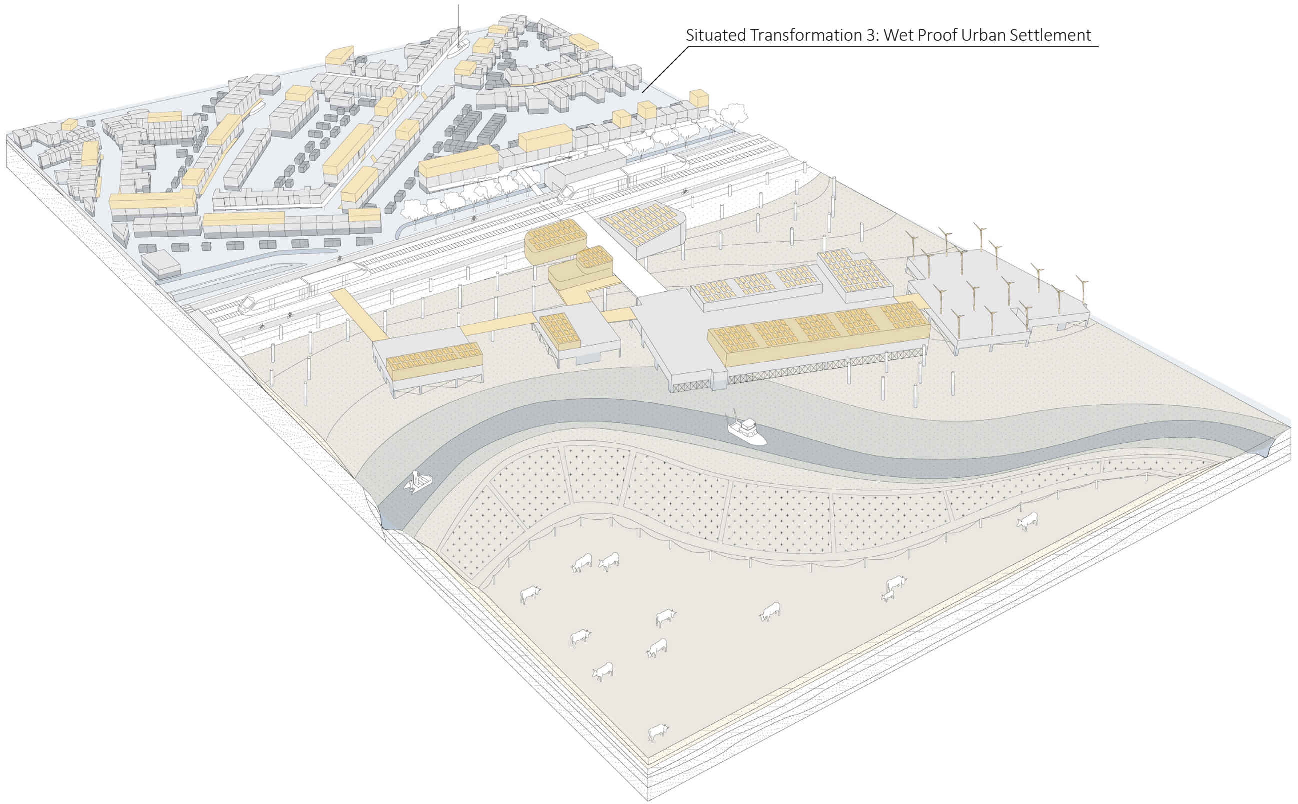


[Fig.98] Deltaic Spine Vlissingen 2050 - Cleaning & Experimenting.

Around 2080, the dike fully transforms from a boundary into a social and spatial connector. It links communities, supports mobility and frames a more flexible landscape logic. Its role becomes not only infrastructural but cultural. It mediates between old and new ways of inhabiting the delta. If sea levels continue to rise, the system is prepared. The Deltaic Conditions can expand into the hinterland without sacrificing continuity or functionality.

Yet for such a shift to take place. It will need collective negotiation and emotional resilience. There needs to be a willingness to accept water taking on the role of co-creator of space and place.

Through this sequence, the Transformations offer more than technical solutions. They form a relational framework for living with water. It embraces its unpredictability, redistributing risks and designing not just for survival, but for coexistence.



[Fig.99] Deltaic Spine Vlissingen 2080 - Acceleration.

9.2.2 MARSH CULTIVATION KLOOSTERZANDE

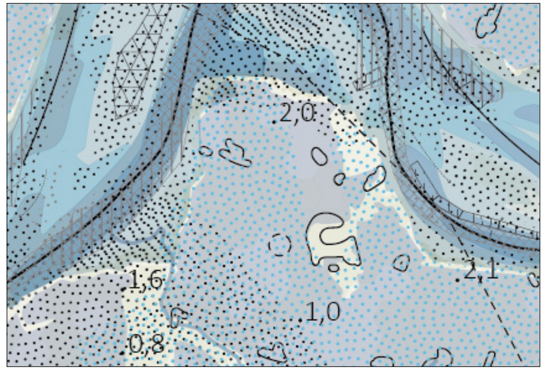
Context

This exploration is set in East Zeeuws-Vlaanderen. The area is a patchwork of traditional agricultural polders with few low-density villages. The largest among them is Kloosterzande, located at +1.5 metres NAP. While the village sits slightly elevated, the surrounding farmland lies at sea level. The plots tracing the path of an old riverbed. For centuries, coastal dikes have kept Deltaic Conditions at bay. This has enabled a static landscape of controlled cultivation and fixed settlement.

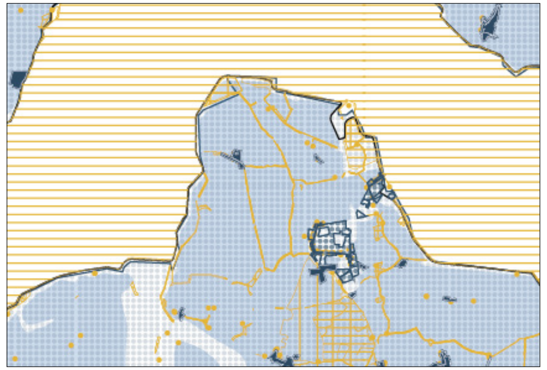
Response to Deltaic Conditions

Reintroducing tidal flows disrupts this long-standing stability. Once the dikes open, the flat terrain gives way to a dynamic riverbed. Erosion strips away vegetation, sediment buries existing crops and saline water infiltrates the soil. Traditional farming methods will become obsolete. While low-lying fields inundate, villages experience only shallow flooding due to their elevation. This contrast creates a spatial gradient of disruption and adaptation.

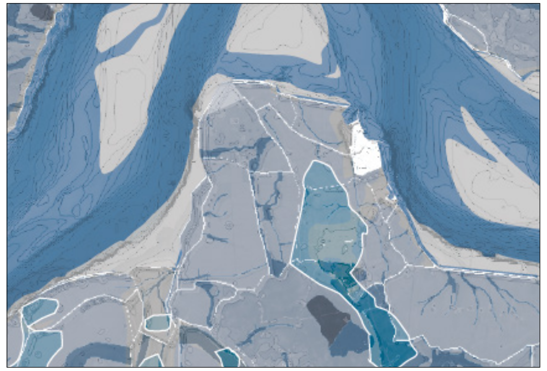
Yet, as human systems are unsettled, natural processes are revived. The returning tide rehydrates the soil. This stops further subsidence, protecting deep freshwater reserves from salinisation. Nutrient cycles are reactivated and sedimentation begins to regenerate degraded land. Legacy pollution remains a critical obstacle to full ecological recovery. Especially, lead deposits beneath old dikes.



[Fig.100] Flows Kloosterzande.
Source: (Layers from the Deltaic Condition map).



[Fig.101] Human system Kloosterzande.
Source: (Layers from the Deltaic Condition map).



[Fig.102] Non-human system Kloosterzande.
Source: (Layers from the Deltaic Condition map).

[Fig.103] Exploration Location Kloosterzande.
Source: (ESRI, 2025).

9.2.2 MARSH CULTIVATION KLOOSTERZANDE

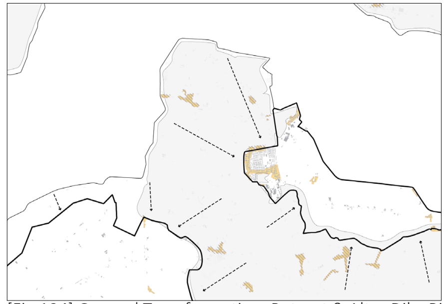
Challenge & Exploration

The region's sparse population and high flood risk present an opportunity for spatial reorganisation. By retreating the dike ring to encircle the elevated settlements, the frontal polders are opened to deltaic influence. This establishes a test bed for new flexible and delta-sensitiveness agricultural models. By constructing a modular dike with a bulkhead system atop the old dikes, allows containment of contaminated soils. This prevents their dispersal into the marsh land and water.

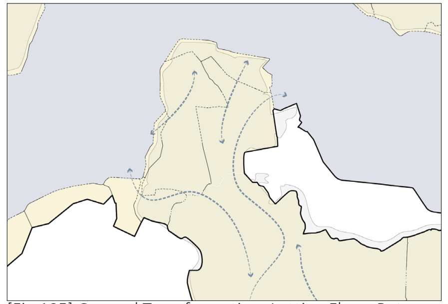
By downscaling the Modular Dike transformation, infrastructure costs can be reduced to the limited budget of a rural area. It is a shift in management: less a rigid line of defence, more a responsive threshold allowing controlled inundation. The urban fabric, which is elevated just enough to permit shallow flooding, becomes a space of tolerable disruption. Here, flood resilience would be realised at the scale of households. For example, water-sealed ground floors, elevated systems and adaptive living routines.

Aim

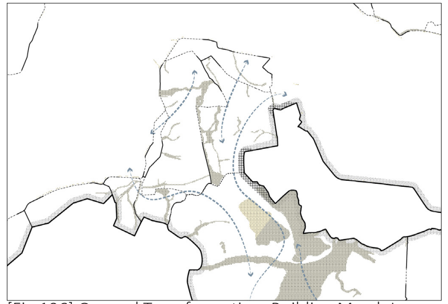
This exploration investigates the transition from static, land-dependent agriculture to dynamic cultivation embedded within an evolving delta landscape. It also demonstrates how rural settlements can cultivate small-scale flood resilience. It does this by adapting to shallow, frequent flooding through decentralised and flexible means.



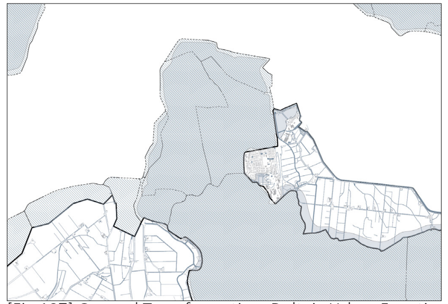
[Fig.104] General Transformation: Retreat & Alter Dike Ring.



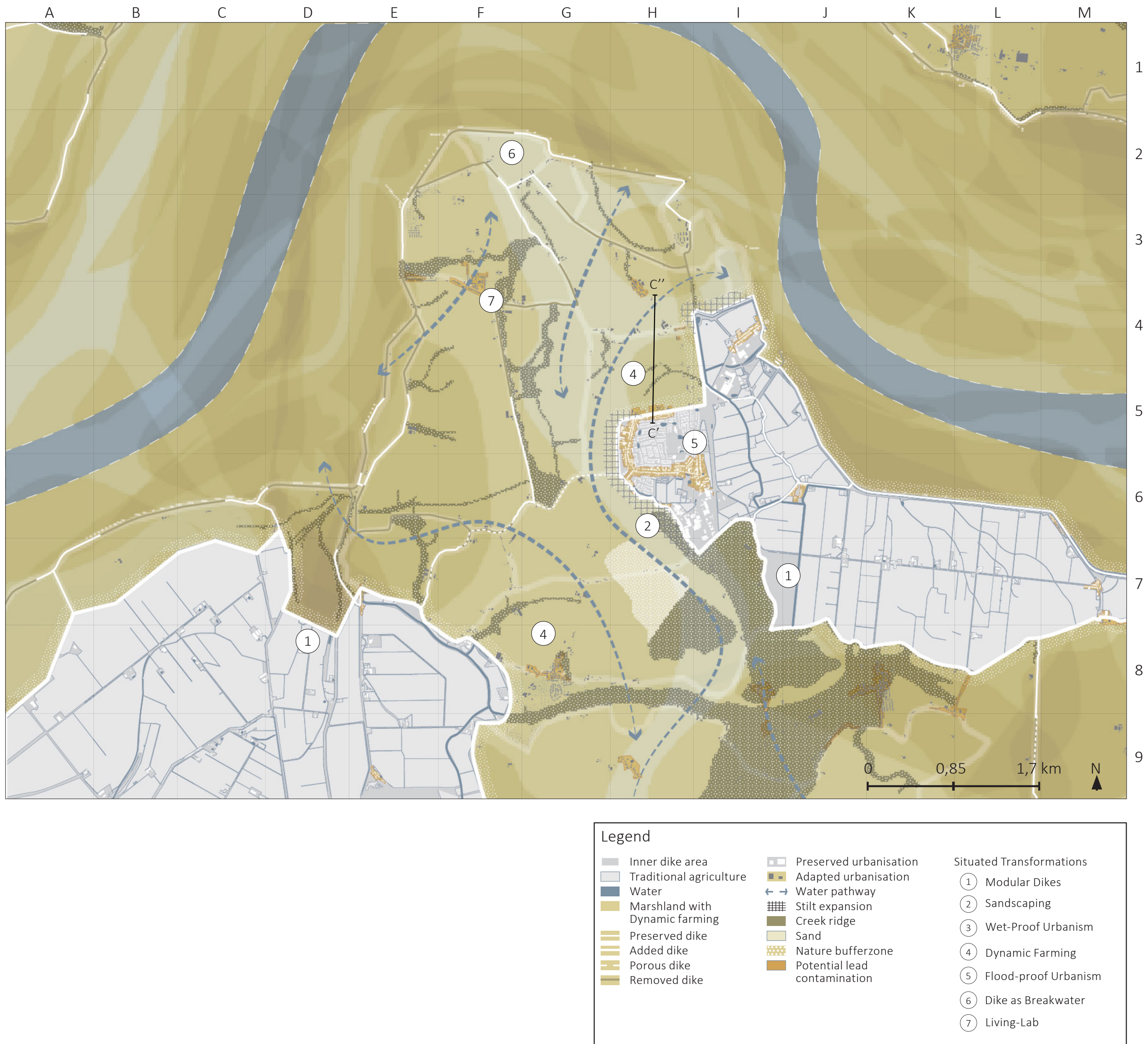
[Fig.105] General Transformation: Letting Flows Return.



[Fig.106] General Transformation: Building Marsh Lanscape.

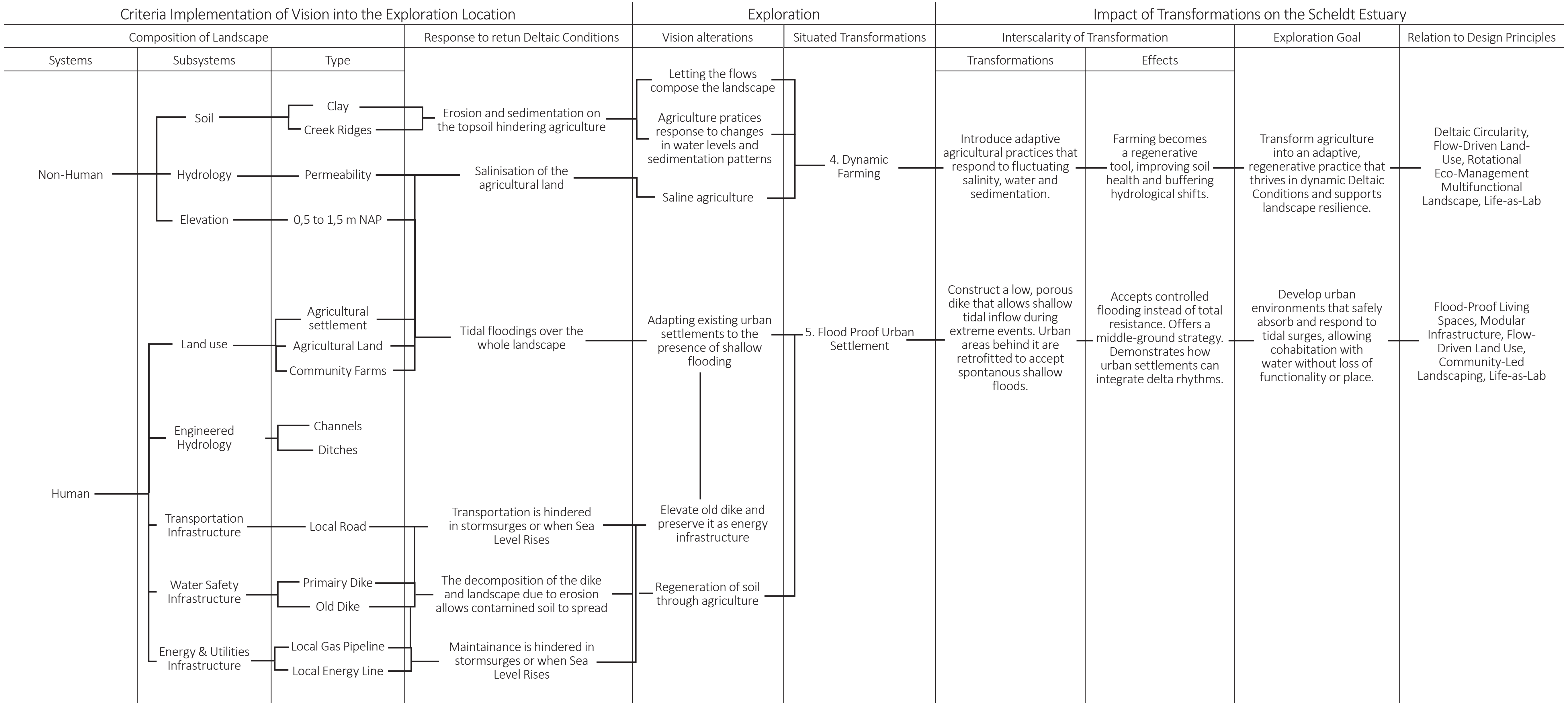


[Fig.107] General Transformation: Deltaic Urban Functions.



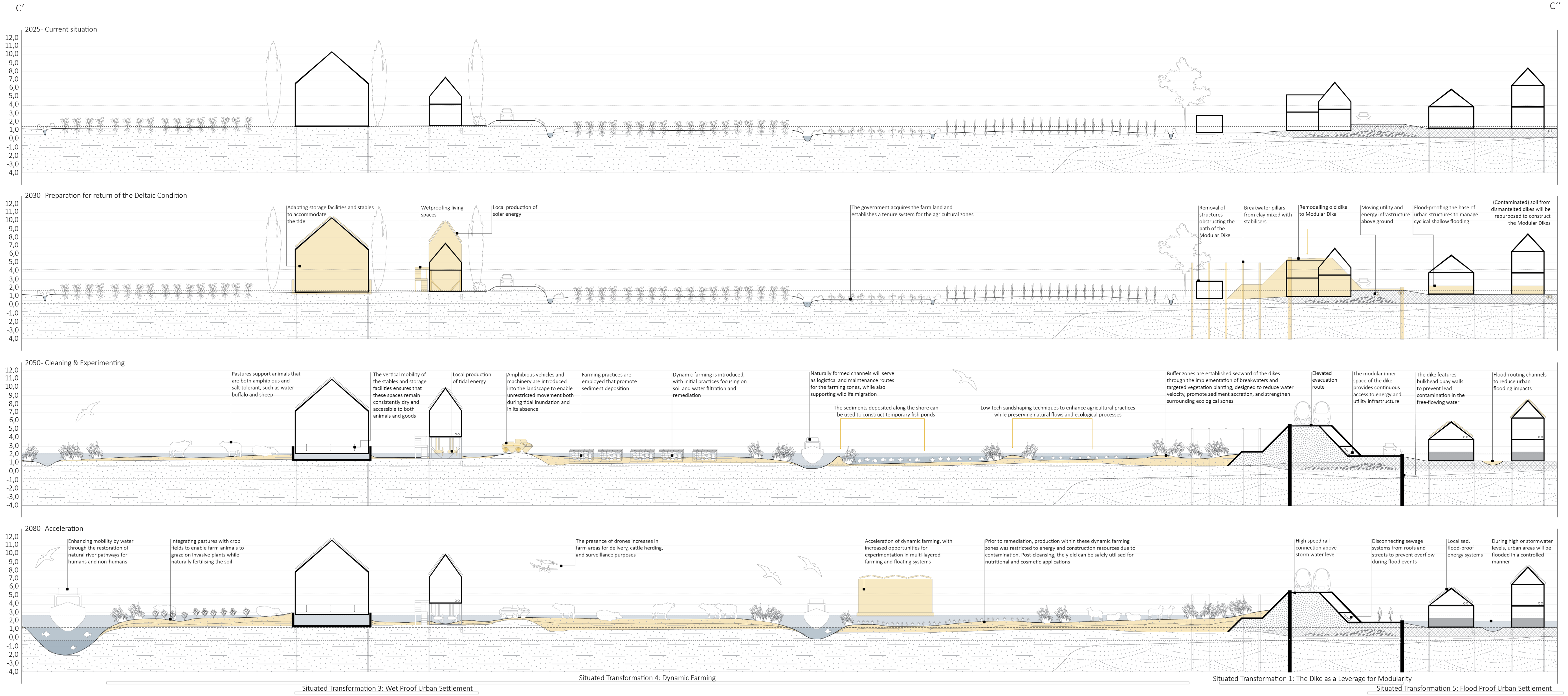
[Fig.108] Exploration Marsh Cultivation Kloosterzande.
Source: (WUR, 2023; PDOK, 2025).

9.2.2 MARSH CULTIVATION KLOOSTERZANDE



[Fig.109] Overview Situated Transformations Marsh Cultivation Kloosterzande.

9.2.2 MARSH CULTIVATION KLOOSTERZANDE



[Fig.110] Timeline and section Exploration: Marsh Cultivation Kloosterzande.

9.2.2 MARSH CULTIVATION KLOOSTERZANDE

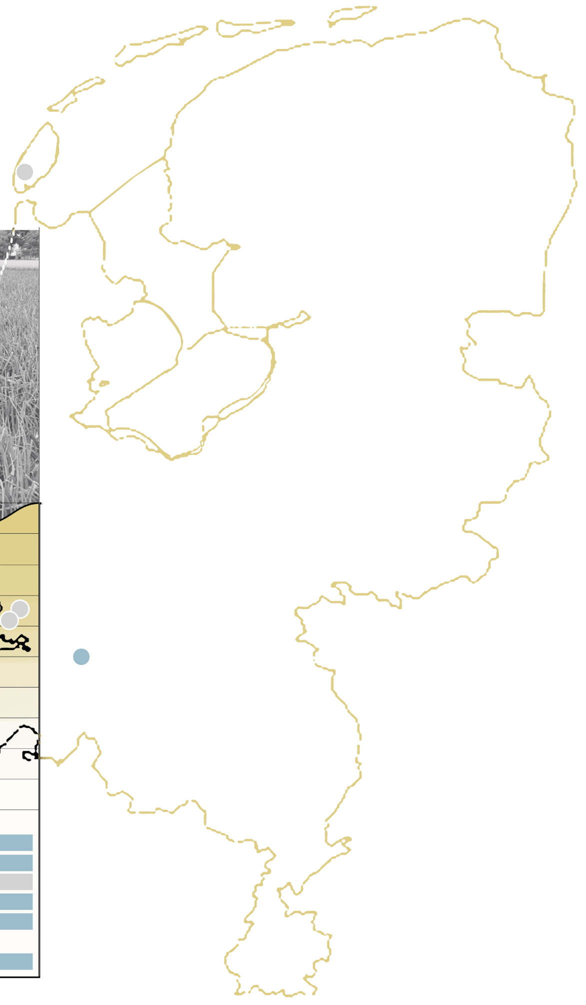
Situated Transformation 4: Dynamic Farming

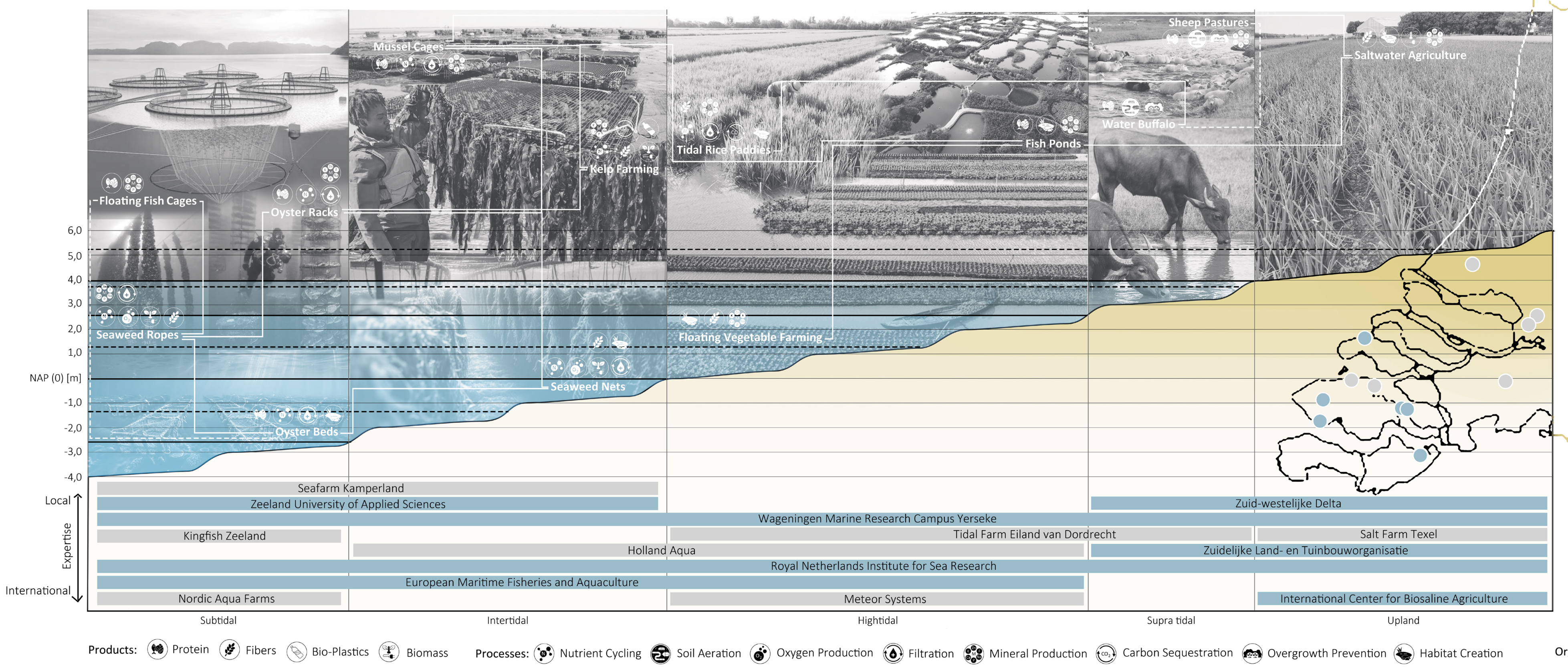
Dynamic farming redefines the relationship between agriculture and the deltaic landscape. Instead of controlling or resisting natural forces, this approach embraces the ever-shifting conditions of the delta. It constantly adapts to water levels, salinity, sedimentation and ecological rhythms (Subtidal, Intertidal, Hightidal, Supratidal and Upland) [Fig.111].

Unlike static farming, which alters the environment to maintain predictability, dynamic farming evolves with it. Fields and tenures shift in time, following the logic of the landscape. The organisation of land becomes temporal and adaptive. Thus, responding to the health and behaviour of the system. In this sense, farming becomes not just a productive practice, but a regenerative one. It supports land stability and ecosystem recovery.

This approach also relies on strong regional collaboration. Local knowledge is essential [Fig. 111]. In the mean time, farmers also become part of a wider network sharing data, techniques and observations. The transition will begin slowly, with trial plots and controlled experimentation. Over time, as confidence and expertise grow, so too will the productivity and resilience of these adaptive systems.

Dynamic farming is not merely an agricultural method. It is a way of reinhabiting the delta in cooperation with its cycles. When you need to stop controlling it, you need to start working with it.





[Fig.111] Situated Transformation: Dynamic Farming, Guidelines System, Produce and Knowledge Network.

9.2.2 MARSH CULTIVATION KLOOSTERZANDE

To illustrate the spatial and temporal evolution of dynamic farming, four maps have been developed. These trace the transformation of the polder landscape at the edge of Kloosterzande. These visualisations capture the shift from static agriculture to an adaptive, co-evolving system in dialogue with the delta.

The map of 2025 depicts the current state of the landscape. Agriculture is organised in a fixed grid, disregarding land elevation or hydrological logic. Straight lines dominate. Parcels are owned, static and managed individually. The system is intensive and high-maintenance, requiring regular dredging of drainage channels, external fertilisation and constant human intervention to maintain productivity. The landscape is isolated from its deltaic nature.

Following the reopening of the dikes, the polder is inundated. Deltaic Conditions return, initially as Intertidal dynamics (regular tidal flooding with minimal sedimentation). During this early phase, the focus is on ecological remediation. Pollutants are filtered through the introduction of pioneer vegetation and marsh development. Experimental dynamic farming begins with kelp and shellfish aquaculture. Both of which thrive in these inundated conditions while also contributing to water filtration and habitat creation.

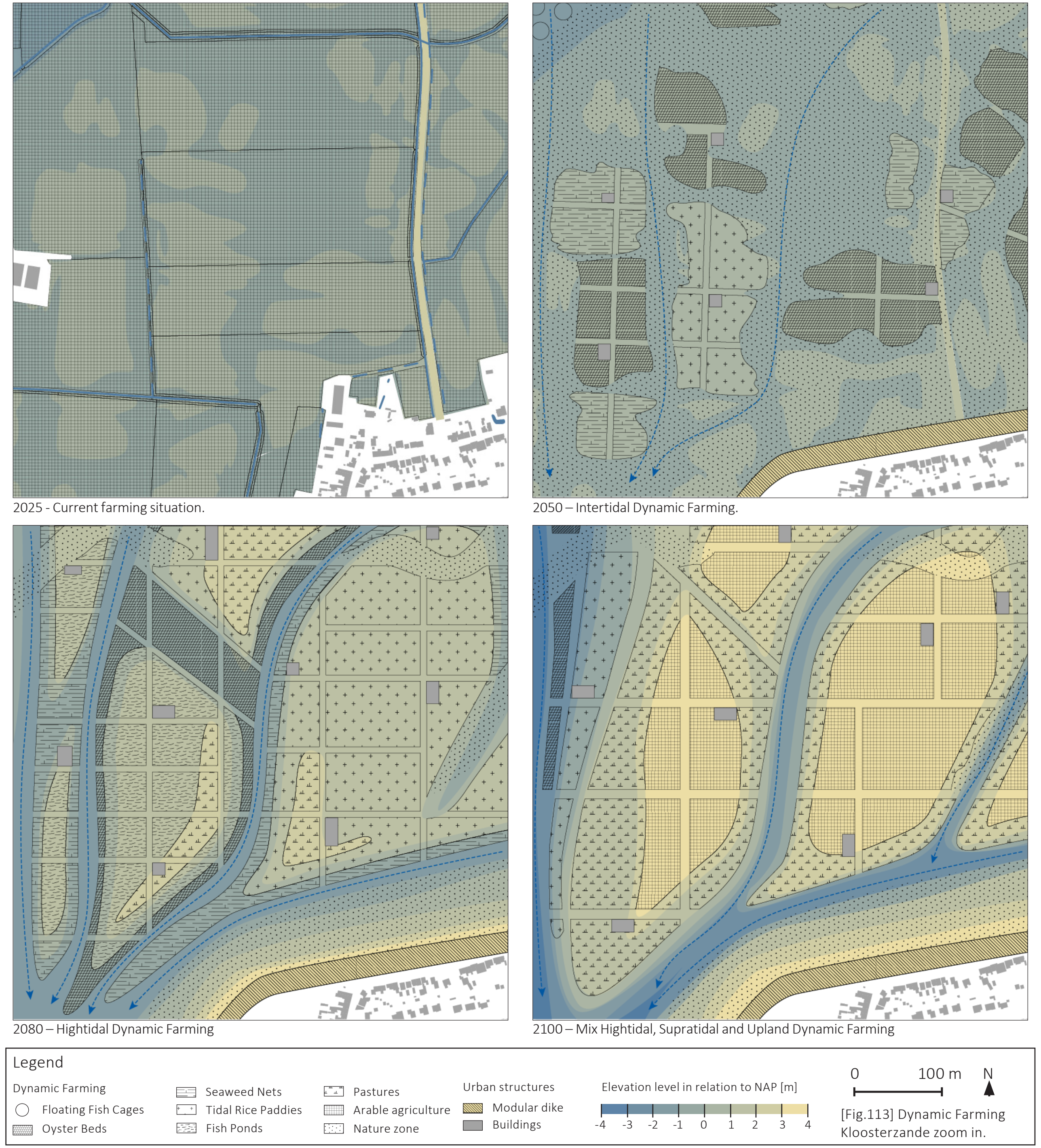
By 2080, sediment accumulation has reshaped the landscape. It creates shallow ridges and new Hightidal gradients. With the growing familiarity in the community, more diverse and extensive farming practices are introduced. Floating infrastructure, such as mobile storage units and maintenance routes, support a flexible system.
It enables adaptation to the constantly evolving land.

Farming now responds directly to seasonal patterns, tidal ranges and sediment shifts. Static boundaries dissolve and land tenure becomes collective and adaptive.

By 2100, the re-emergence of an ancient river course has shaped a layered deltaic landscape. Farming follows ecological gradients, from Hightidal to Supratidal zones. Practices are chosen not only for productivity, but for their ecological function and compatibility with one another. Water buffalo support rice cultivation by consuming invasive weeds. Oysters filter water polluted by fish farming. And in turn, fish find habitat and food in the oyster reefs. Farming becomes a co-creative process. It nests itself in a living system that balances food production with ecological health.

This mapping exercise reveals that dynamic farming is not a fixed model. It is a continuous exploration of how agriculture and ecology can evolve together. It offers a vision for a productive landscape that grows not in spite of change, but through it.

[Fig.112] Location Kloosterzande zoom in Dynamic Farming.



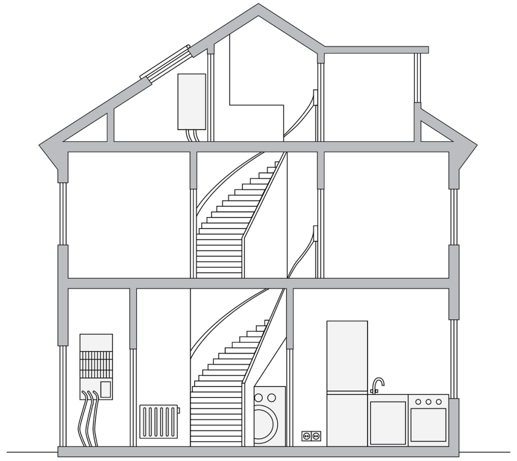
[Fig.113] Dynamic Farming Kloosterzande zoom in.

9.2.2 MARSH CULTIVATION KLOOSTERZANDE

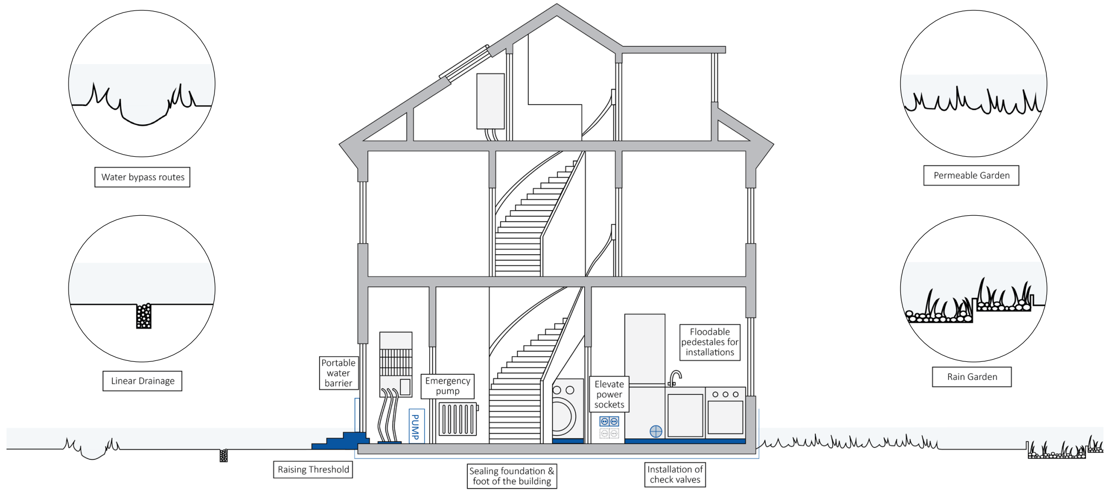
Situated Transformation 5:
Flood Proof Urban Settlement

This transformation explores how urban settlements can be retrofitted to coexist with shallow, periodic flooding. Rather than resisting water entirely, the built environment is adapted to accommodate it. The transformation begins at the scale of the house: waterproofing basements, thresholds and elevating electrical systems. These interventions reduce the impact of minor inundations. It makes them manageable, even mundane.

Beyond the individual dwelling, the urban fabric itself evolves. Streets and public spaces are reimagined to steer, store and infiltrate water through (soft) infrastructure. This can be water gardens, bioswales, infiltration channels and wadis. These features reduce the pressure on the drainage system while adding to the ecological and aesthetic value to the city. This transformation makes living with water becomes part of daily life. A cultural and spatial shift toward a tidal-accepting urbanism.



[Fig.114] Standard Dutch Rowhouse Section.



[Fig.115] Standard Dutch Rowhouse Section.

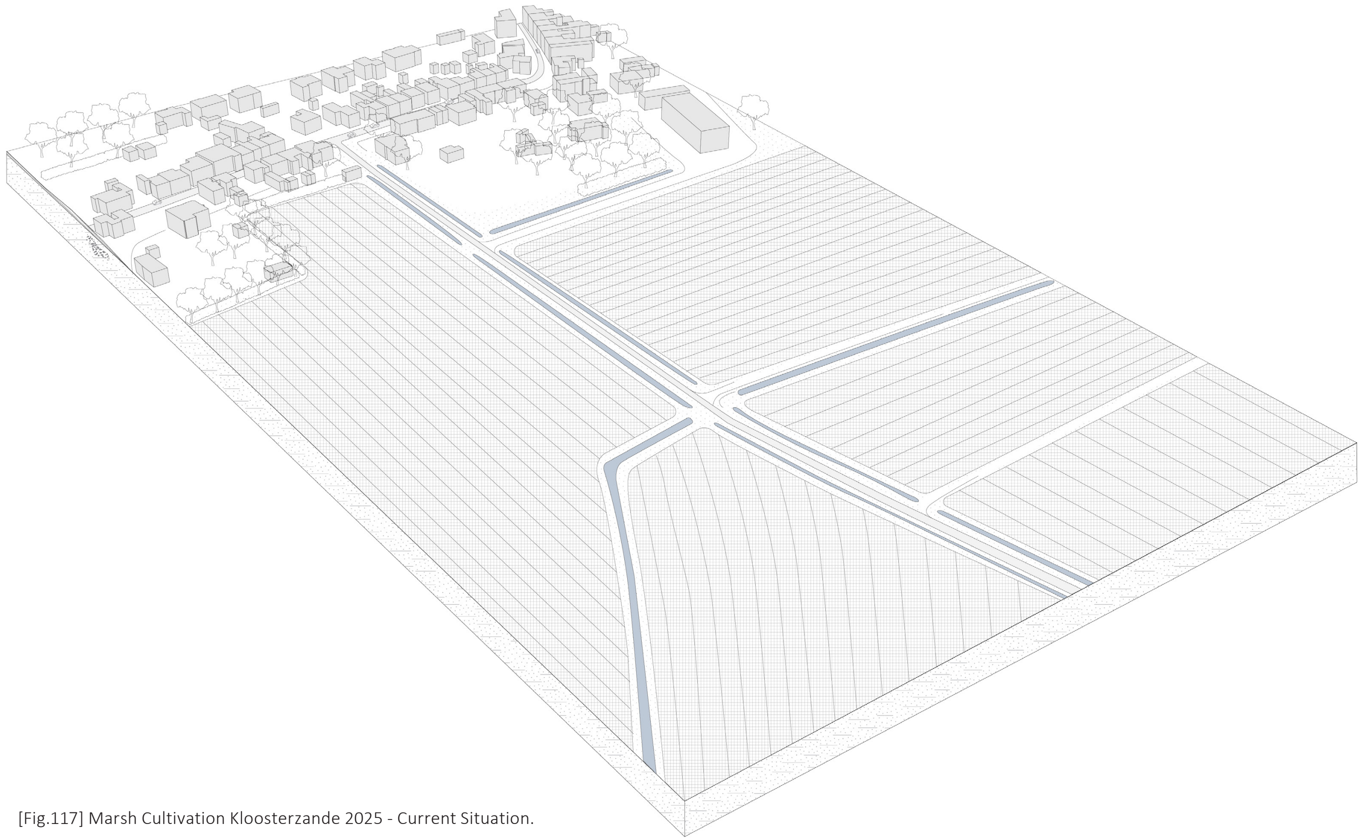
[Fig.116] Situated Transformation: Flood Proof Urban Settlement.
Source background image: (Brandax Makelaardij BV, 2025)

9.2.2 MARSH CULTIVATION KLOOSTERZANDE

Tidal Urbanism through Transformations

This chapter illustrates how the General and Situated Transformations introduce Tidal Urbanism into the rural fabric of East Zeeuws-Vlaanderen. The sequence of spatial interventions reflects a gradual adaptation towards cohabitation with Deltaic Conditions. This chapter also reflects on the social, ecological and economic consequences of these changes.

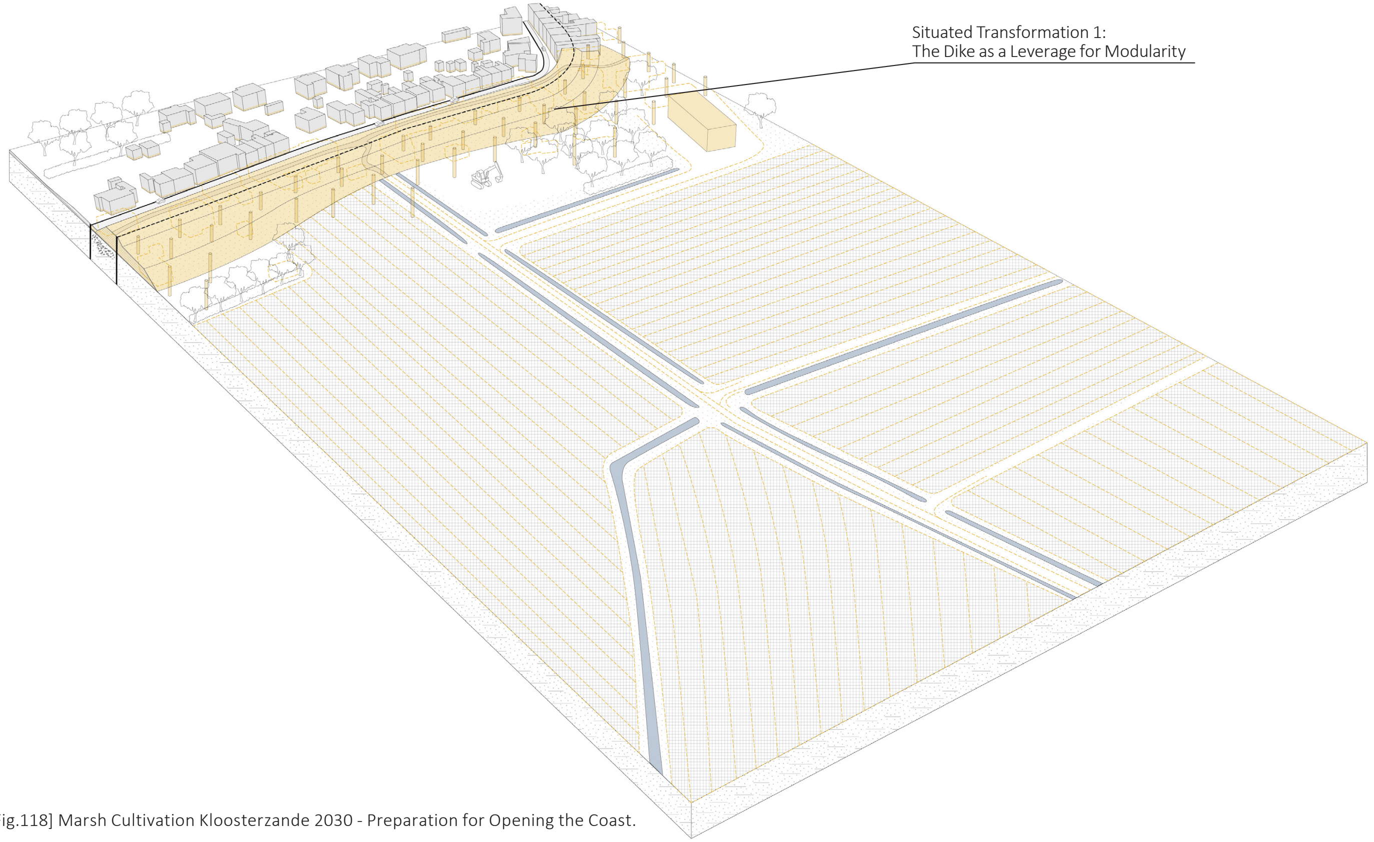
Today, the settlement is encircled by farmhouses that outline the old dike road. They overlook the static, intensively cultivated agricultural landscape. Monoculture plots stretch across the polder, maintained through constant intervention. Farming activities operating independently from the Deltaic Conditions. The village is also isolated from tidal processes.



[Fig.117] Marsh Cultivation Kloosterzande 2025 - Current Situation.

2030 marks a turning point. The edge of the village is cleared to make way for the new modular dike, reshaping the relationship between settlement and landscape. Bulkhead dam walls are integrated into the dike to contain the lead contamination. Land designated for future tidal exposure is prepared to allow for a safe reintroduction of water. Buildings are removed and soils are cleaned. This moment represents not only a physical but also a psychological rupture. Residents must confront the loss of homes and farmland and the uncertainties of a changing environment.

[Fig.116] Location Kloosterzande Exploration Tile.



[Fig.118] Marsh Cultivation Kloosterzande 2030 - Preparation for Opening the Coast.

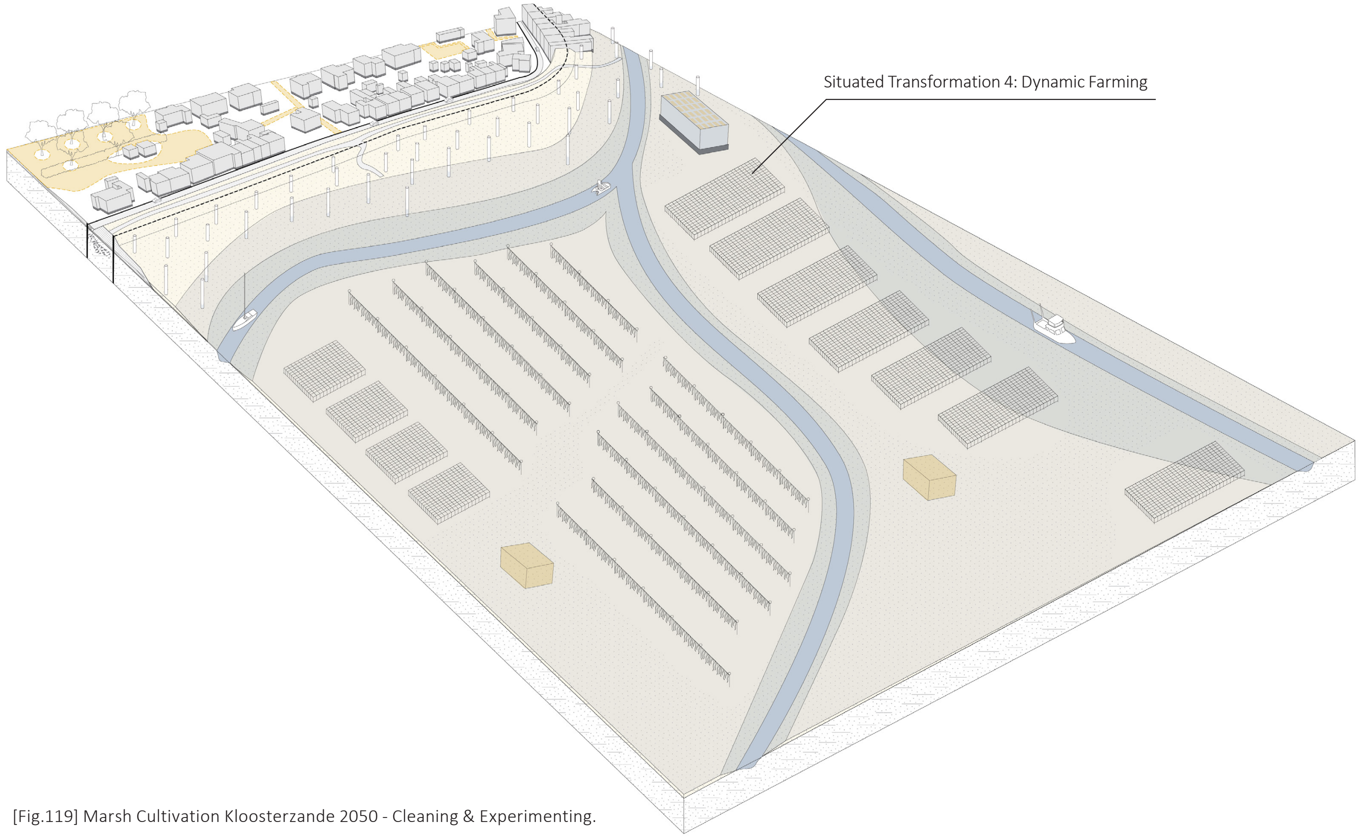
9.2.2 MARSH CULTIVATION KLOOSTERZANDE

In 2050, the tide return to the land. The opening of the frontal dikes allows the tides to re-enter the landscape. It transforms agricultural plots into an intertidal zone. The tidal flows carry nutrients, initiate marsh formation and begin to rehydrate the land. Ecological remediation begins. Through natural processes and small-scale interventions such as oyster and kelp farming.

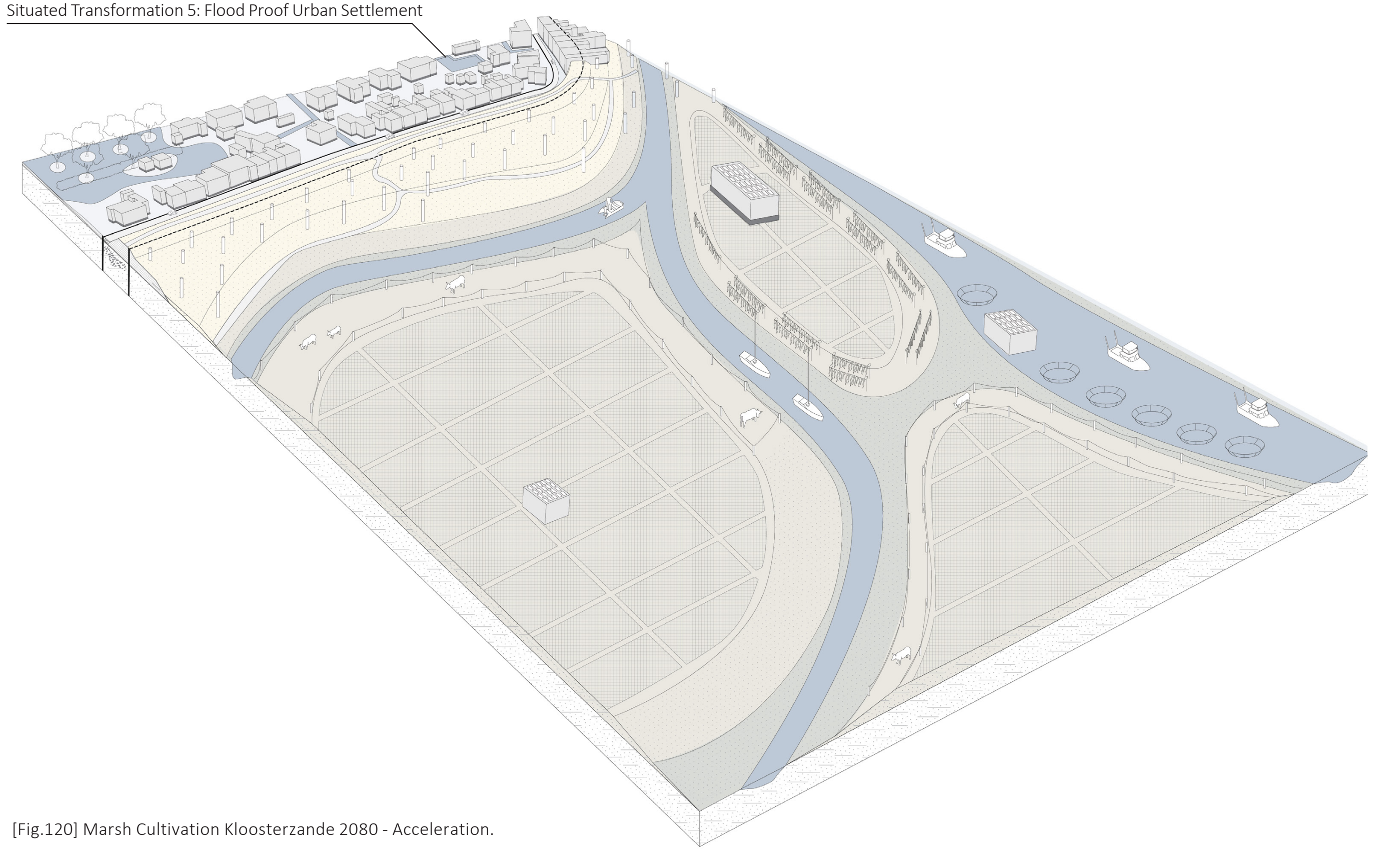
Within the village, shallow flood adaptation takes shape. Homes are modified, thresholds are raised and water-resilient public spaces begin to take shape. These early adaptations mark a cultural shift in how water is understood and experienced.

The landscape has fully transformed into a living riverbed by 2080. Sedimentation and erosion have reshaped the terrain, steering both agricultural and urban development. Dynamic farming becomes the norm; adaptive, responsive and ecologically grounded. Farmers work with the rhythms of the delta. And, the village no longer merely tolerates water but incorporates it into daily life.

This culmination of interventions reflects not a return to nature, but a new hybrid. Where human and deltaic systems negotiate their coexistence through design, resilience and adaptation.



[Fig.119] Marsh Cultivation Kloosterzande 2050 - Cleaning & Experimenting.

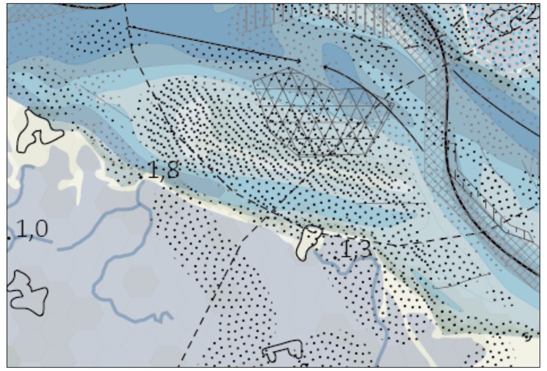


[Fig.120] Marsh Cultivation Kloosterzande 2080 - Acceleration.

9.2.3 LIVING LAB HOOFDPLAAT

Context

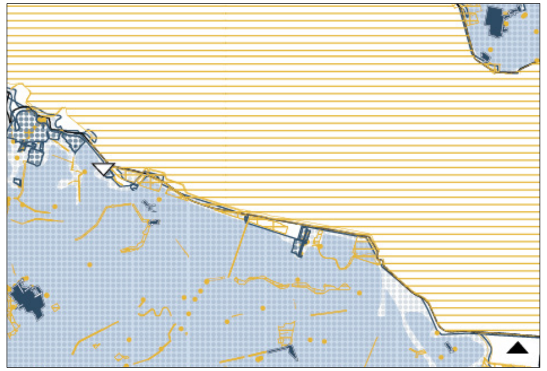
This exploration takes place in the western frontal polders of Zeeuws-Vlaanderen. The polders are located around +1.5 metres above sea level. The area is home to the former farming village of Hoofdplaat, which today mostly serves recreational and seasonal purposes. Positioned along the edge of a dike lined up for decommissioning in the vision. Hoofdplaat faces a landscape of open farmland, sparsely populated with farmhouses. Beyond the coastal dikes, sand flats stretch into the estuary. They form crucial habitats for birds and other wildlife.



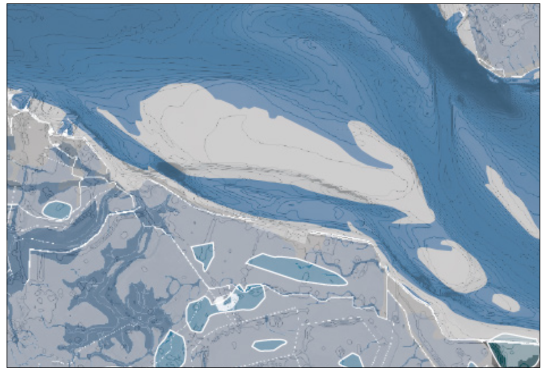
[Fig.121] Flows Hoofdplaat.
Source: (Layers from the Deltaic Condition map).

Response to Deltaic Conditions

The region's elevation limits flooding to shallow levels, similar to Kloosterzande. Hoofdplaat faces a unique and severe risk: its surface is contaminated with legacy lead. Unlike lead contained within dike structures, here the contamination spreads across the village itself. If the dikes were to open and tidal conditions return, this lead would leach into the surrounding landscape. It would reach agricultural soils, aquatic systems and wildlife habitats. The contamination wouldn't be confined to the polder but would circulate. The tide magnifying its impact across the broader estuarine system.


[Fig.122] Human system Hoofdplaat.
Source: (Layers from the Deltaic Condition map).

Despite the ecological advantages of restored deltaic processes (such as nutrient cycling, sedimentation, marsh restoration and soil rehydration) the presence of lead turns these same dynamics into pathways for pollution dispersal. The risk to both human and non-human health is substantial and long-lasting.


[Fig.123] Non-human system Hoofdplaat.
Source: (Layers from the Deltaic Condition map).

[Fig.124] Exploration location: Hoofdplaat.
Source: (ESRI, 2025)

9.2.3 LIVING LAB HOOFDPLAAT

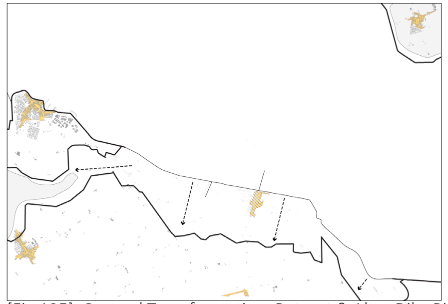
Challenge & Exploration

The contamination demands a retreat from Hoofdplaat, even in the absence of an immediate dike breach. Its continued habitation presents an unacceptable health hazard. The necessary evacuation and isolation of the village also offer an unexpected opportunity. By sealing the contaminated area with bulkhead dam walls, Hoofdplaat can transform into a living lab for environmental remediation.

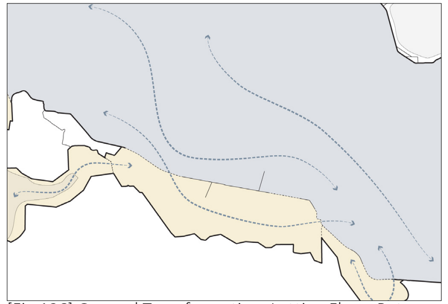
The village could evolve into a public site of awareness and experimentation. By utilising its existing recreational function and visibility. It becomes a space where citizens, scientists and visitors engage with questions of environmental pollution, land restoration and adaptive futures. Its proximity to a decommissioned primary dike ring makes it a valuable testbed. By demonstrating how infrastructural transformation can support ecological recovery.

Aim

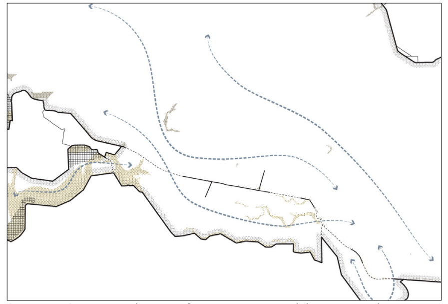
This exploration aims to convert a site of risk into a platform for learning and adaptation. Hoofdplaat becomes not just a place of retreat, but a catalyst for wider understanding and action. Where the challenges of contamination, relocation and landscape transition are met with transparency, innovation and shared responsibility.



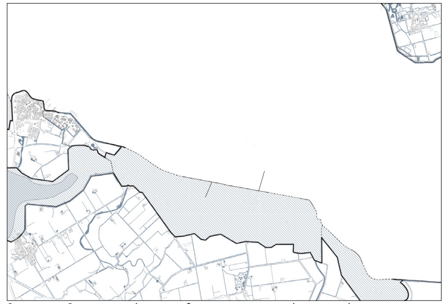
[Fig.125] General Transformation: Retreat & Alter Dike Ring.



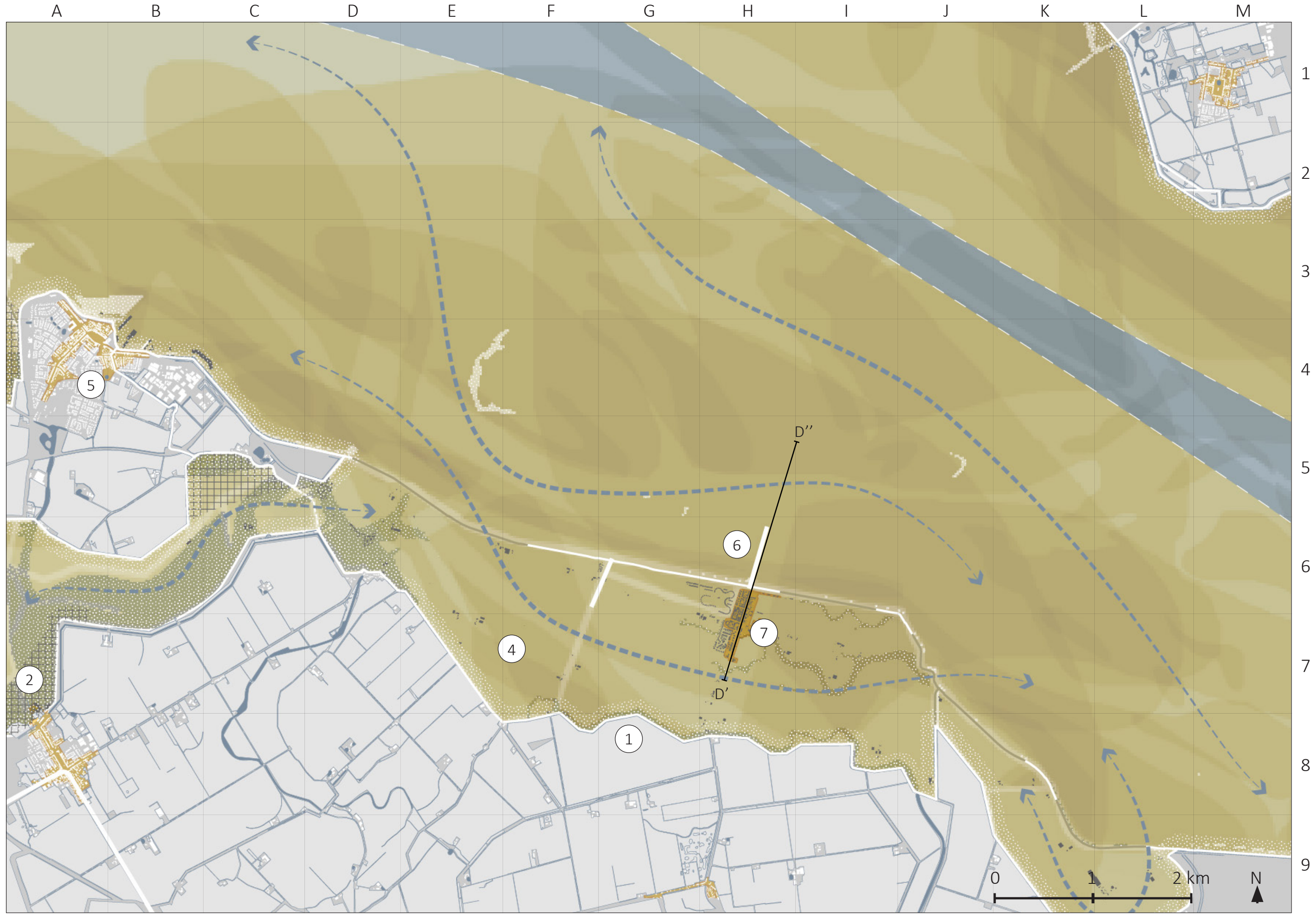
[Fig.126] General Transformation: Letting Flows Return.



[Fig.127] General Transformation: Building Marsh Lanscape.



[Fig.128] General Transformation: Deltaic Urban Functions.



Legend

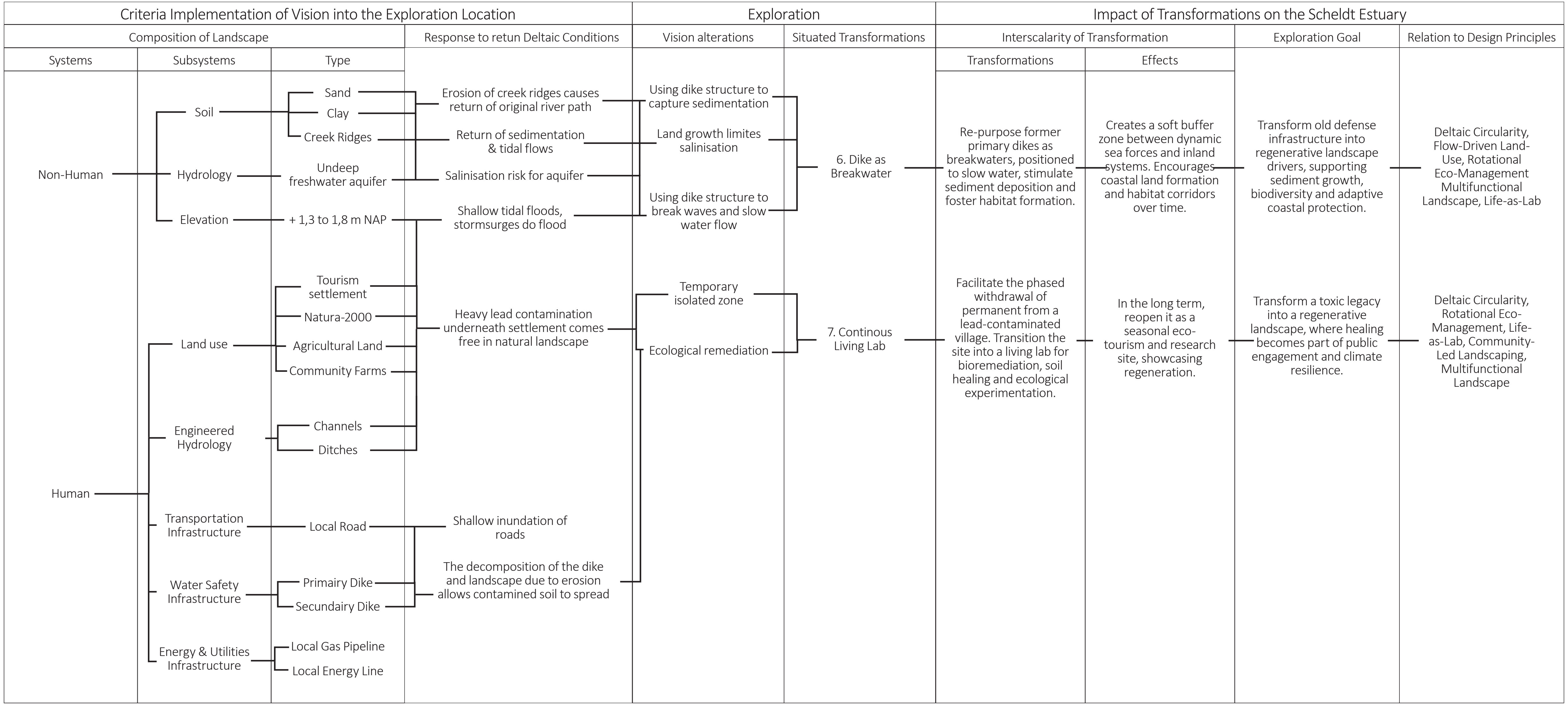
- Inner dike area
- Traditional agriculture
- Water
- Marshland with Dynamic farming
- Preserved dike
- Added dike
- Porous dike
- Removed dike
- Preserved urbanisation
- Adapted urbanisation
- Water pathway
- Stilt expansion
- Creek ridge
- Sand
- Nature bufferzone
- Potential lead contamination

Situated Transformations

1. Modular Dikes
2. Sandscaping
3. Wet-Proof Urbanism
4. Dynamic Farming
5. Flood-proof Urbanism
6. Dike as Breakwater
7. Living-Lab

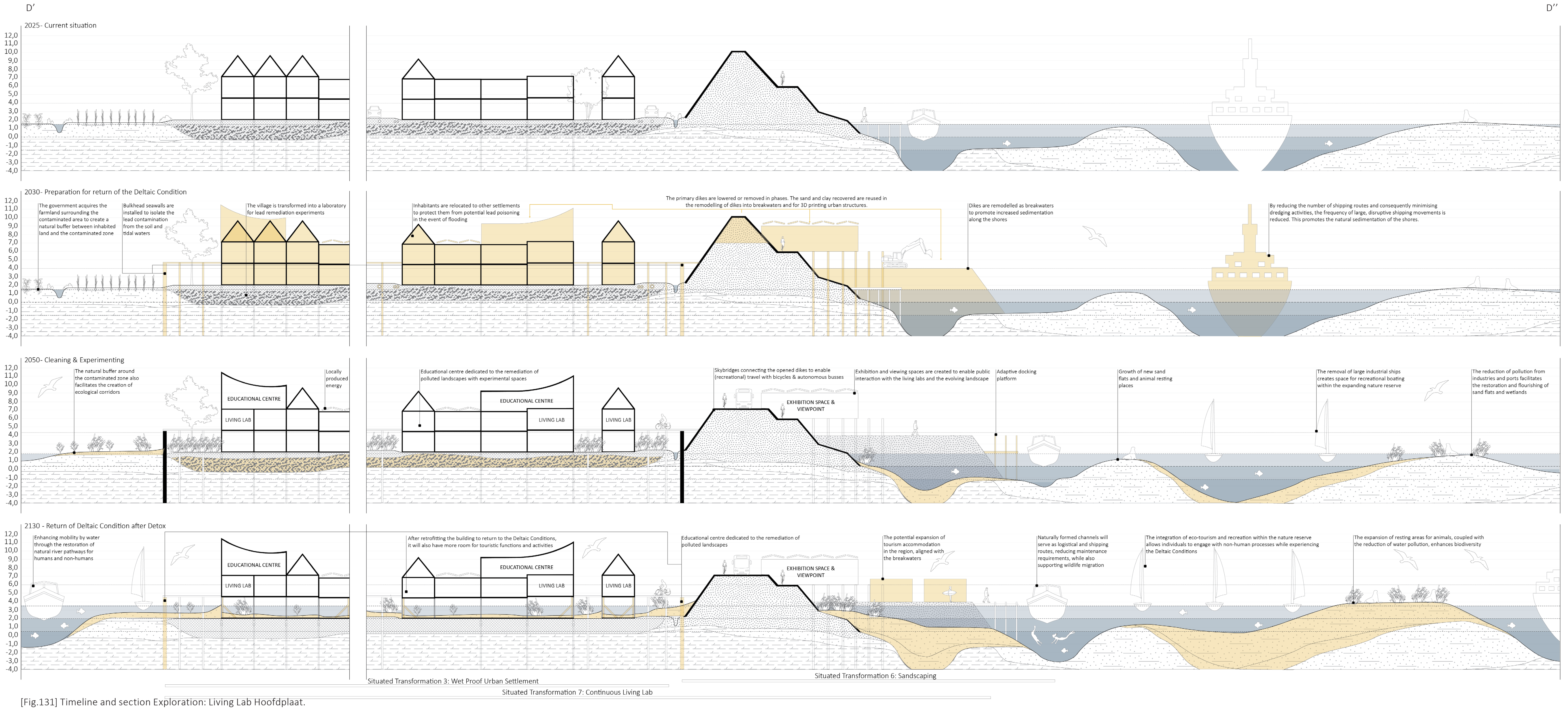
[Fig.129] Exploration Living Lab Hoofdplaat.
Source: (WUR, 2023; PDOK, 2025).

9.2.3 LIVING LAB HOOFDPLAAT



[Fig.130] Overview Situated Transformations Living Lab Hoofdplaat.

9.2.3 LIVING LAB HOOFDPLAAT



[Fig.131] Timeline and section Exploration: Living Lab Hoofdplaat.

9.2.3 LIVING LAB HOOFDPLAAT

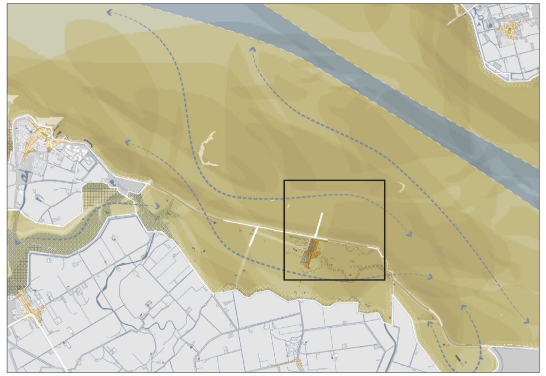
Situated Transformation 6: Dike as Breakwater

In a the marsh landscape shaped by erosion and sedimentation, the dike no longer functions solely as a barrier. It becomes an active instrument of landscape formation. Through selective openings, extensions and fragmentation, the dike can disrupt water flow. This reduces wave energy and stimulates sediment deposition.

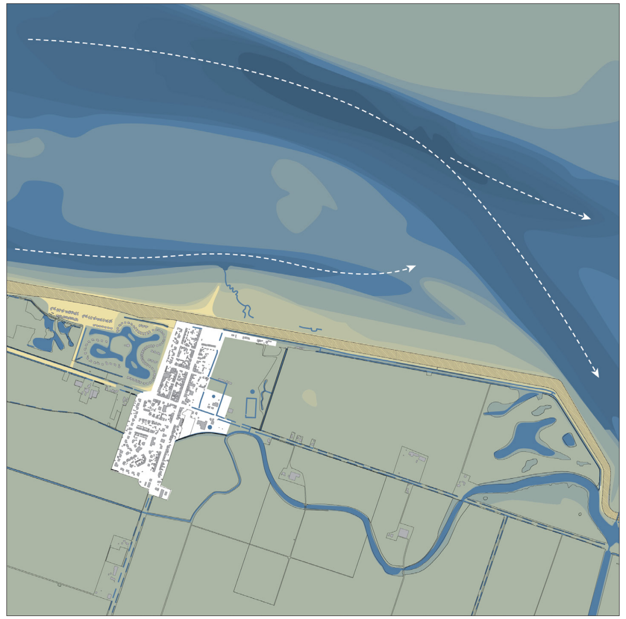
This transformation explores how repurposing materials from decommissioned dikes enables new breakwater structures to result from existing infrastructure. These modified dike segments act as sediment traps. They encourage the growth of sandbanks and elevating new land masses both inside and outside the old ring.

Maps illustrate this transformation around Hoofdplaat [Fig. 132 & 133]. Currently, the coastal dike acts as a hard edge, preventing sediment from entering the polder landscape. By 2050, through calculated interventions, it becomes porous and performative. It will be actively drawing in sediment and reshaping the estuarine edge. This process enables the formation of tidal islands in later years. This transformation supports habitat creation and facilitates the re-opening of historic river paths. These river carry sediment deeper into the newly formed marshlands.

In this way, the dike no longer defends the land from water. It mediates between them, fostering a dynamic landscape that is both protective and generative.

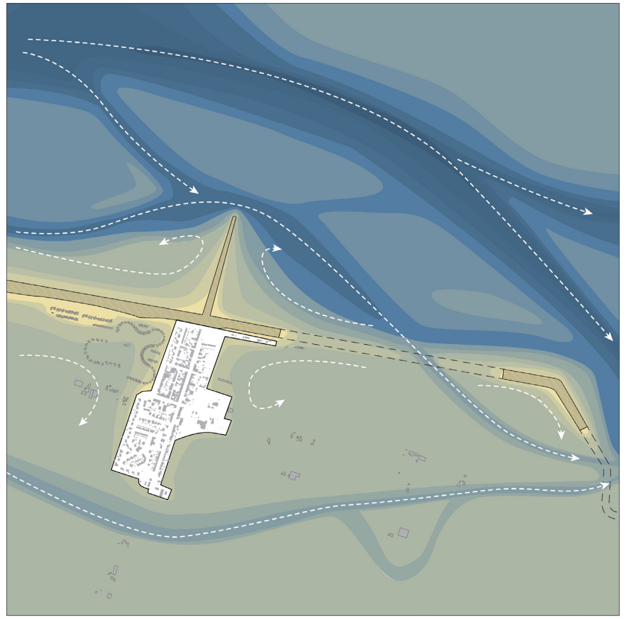


[Fig.132] Location Hoofdplaat zoom in Dynamic Farming.

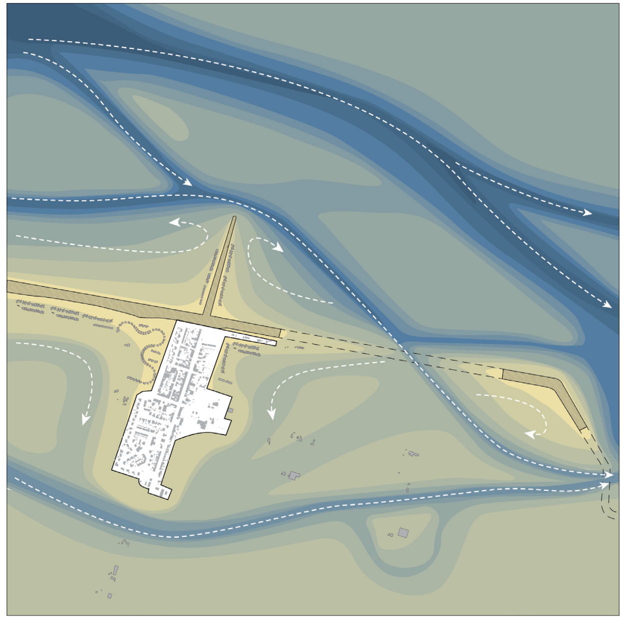


20525 – Current situation dikes prevent sedimentation.

2050 – Retrofitting Dikes.



2080 – New land formations and return of river path.



2100 – Land rises and moves into the river.

Legend

Urban structures

Modular dike
Buildings
Isolated lead zone by bulkhead barriers
Water flow

Elevation level in relation to NAP [m]

<-7 -6 -5 -4 -3 -2 -1 0 1 2 3 >4

0 300 m N

[Fig.133] Dike as break water Hoofdplaat zoom in.

9.2.3 LIVING LAB HOOFDPLAAT

Situated Transformation 7:
Continuous Living Lab

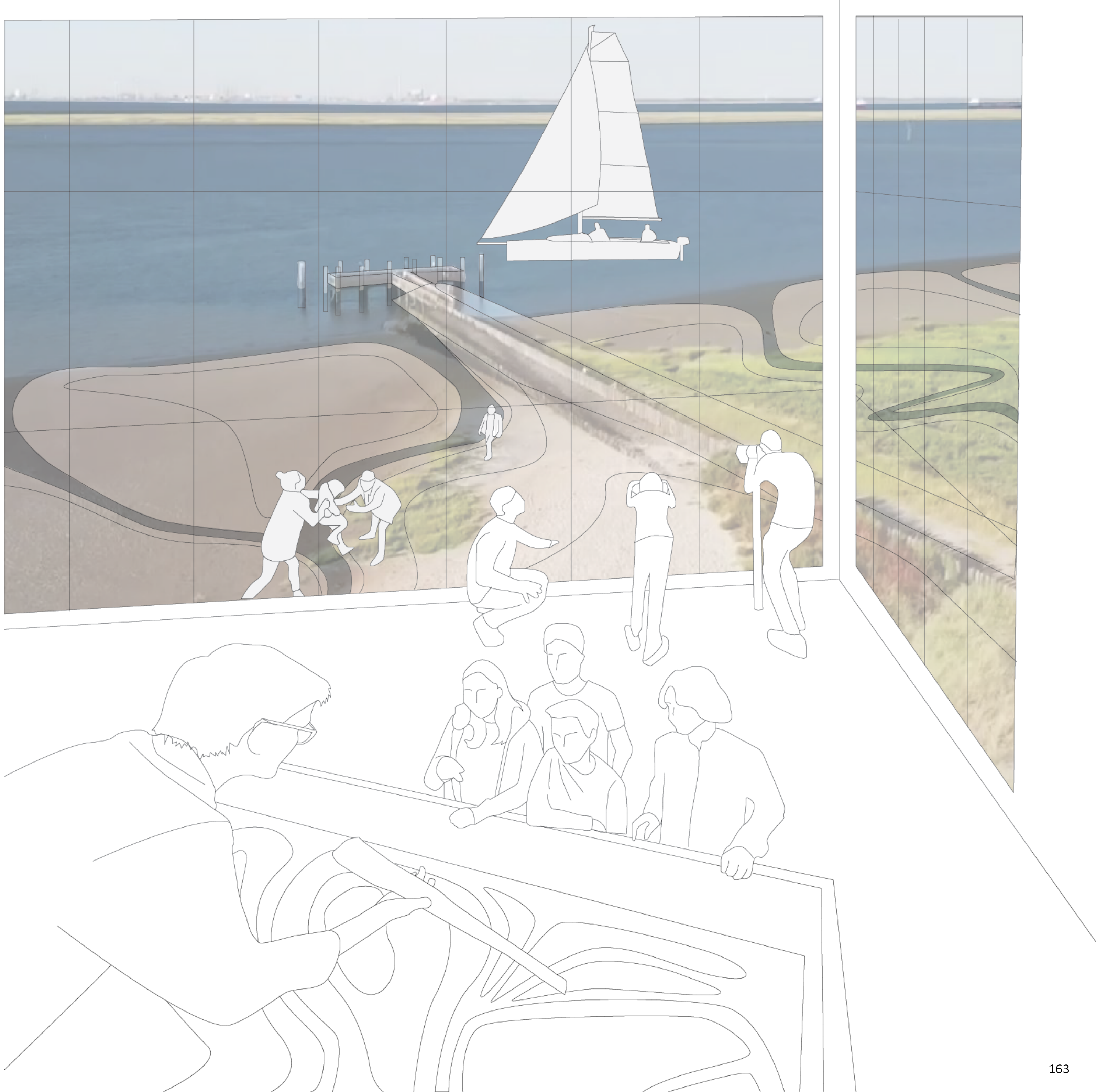
These bold shifts, opening dikes, shifting farming practices, retrofitting settlements, do not happen in isolation. They unfold within real communities, embedded in daily lives. Their success depends on how people perceive, respond to and participate in the transformation.

By converting Hoofdplaat into a Continuous Living Lab, the village becomes a frontline site of experimentation, observation and education. As dikes are redesigned into breakwaters and tidal flows return to reshape the land. Hoofdplaat acts as both a testing ground and a public platform. Phased remediation experiments (such as lead encapsulation, sediment filtering and marsh bioaccumulation) can be trialed here. Farming with new methods, testing local sediment dynamics and water management strategies become visible. They become adaptable processes rather than closed technical exercises.

The Living Lab includes tidal viewpoints and educational pavilions. Restored public spaces that frame the transition as something shared, open and visible. Tour routes enabling residents and visitors to observe sediment growth, new marsh ecologies and gradual remediation. Former streets may transform into water monitoring corridors or seasonal wet gardens. It would turn the urban fabric itself into a learning tool.

At the heart of the Lab are knowledge and participation. Through partnerships with schools, environmental groups and local residents, Hoofdplaat can serve as a hub for collaborative learning and adaptive design. Public education centres and workshops support not only understanding but also engagement. It will enable citizens to influence, adapt to and co-shape the transition.

In doing so, Hoofdplaat moves beyond its role as a passive landscape at risk. It becomes an active node in a wider network of change. The Continuous Living Lab thus ensures that the transformation toward deltaic living remains socially just, spatially grounded and ecologically aware. It makes Tidal Urbanism a lived and shared experience rather than an abstract ambition.



[Fig.134] Situated Transformation: Living Lab Hoofdplaat.
Source background image: (Verdonck, 2019)

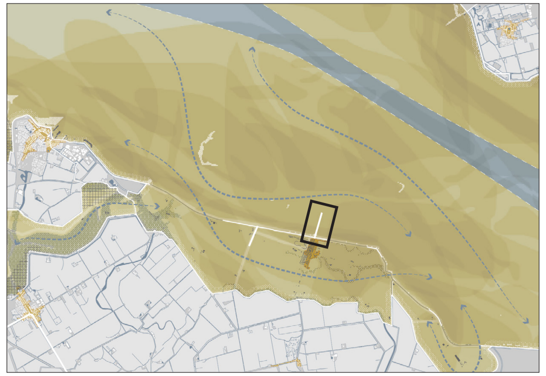
9.2.3 LIVING LAB HOOFDPLAAT

Tidal Urbanism through Transformations

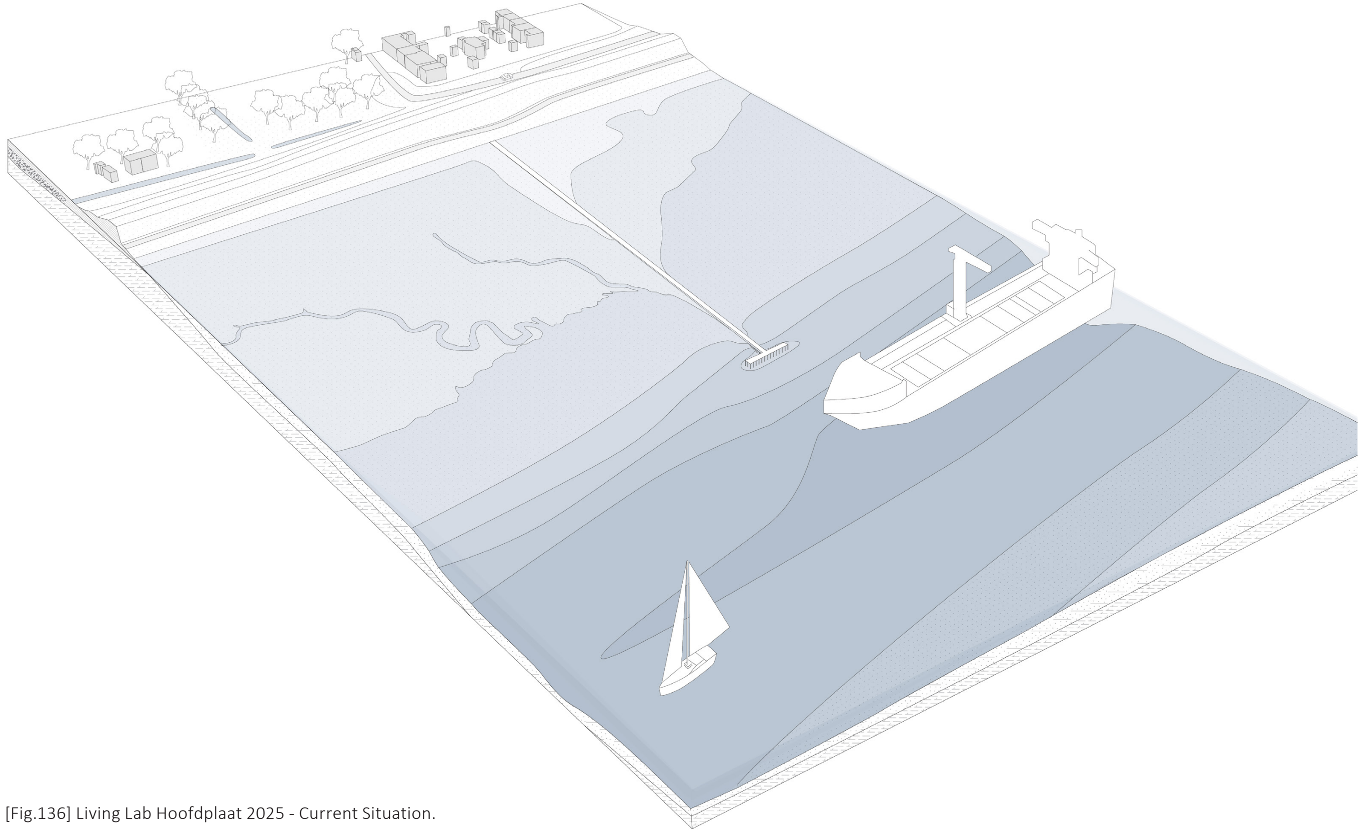
This chapter illustrates how the General and Situated Transformations collectively introduce Tidal Urbanism into the design of Hoofdplaat. It shifts from a static polder village to a centre of engagement.

Today, Hoofdplaat is protected from the Deltaic Conditions by a coastal dike. Once a thriving agricultural village, it now functions primarily as a recreational destination. A long dock stands perpendicular from the dike and reaches into the Scheldt River. It accommodates leisure boats and offering views over the estuary's sand flats. Despite the coastal location, the village remains disconnected from the Deltaic Conditions.

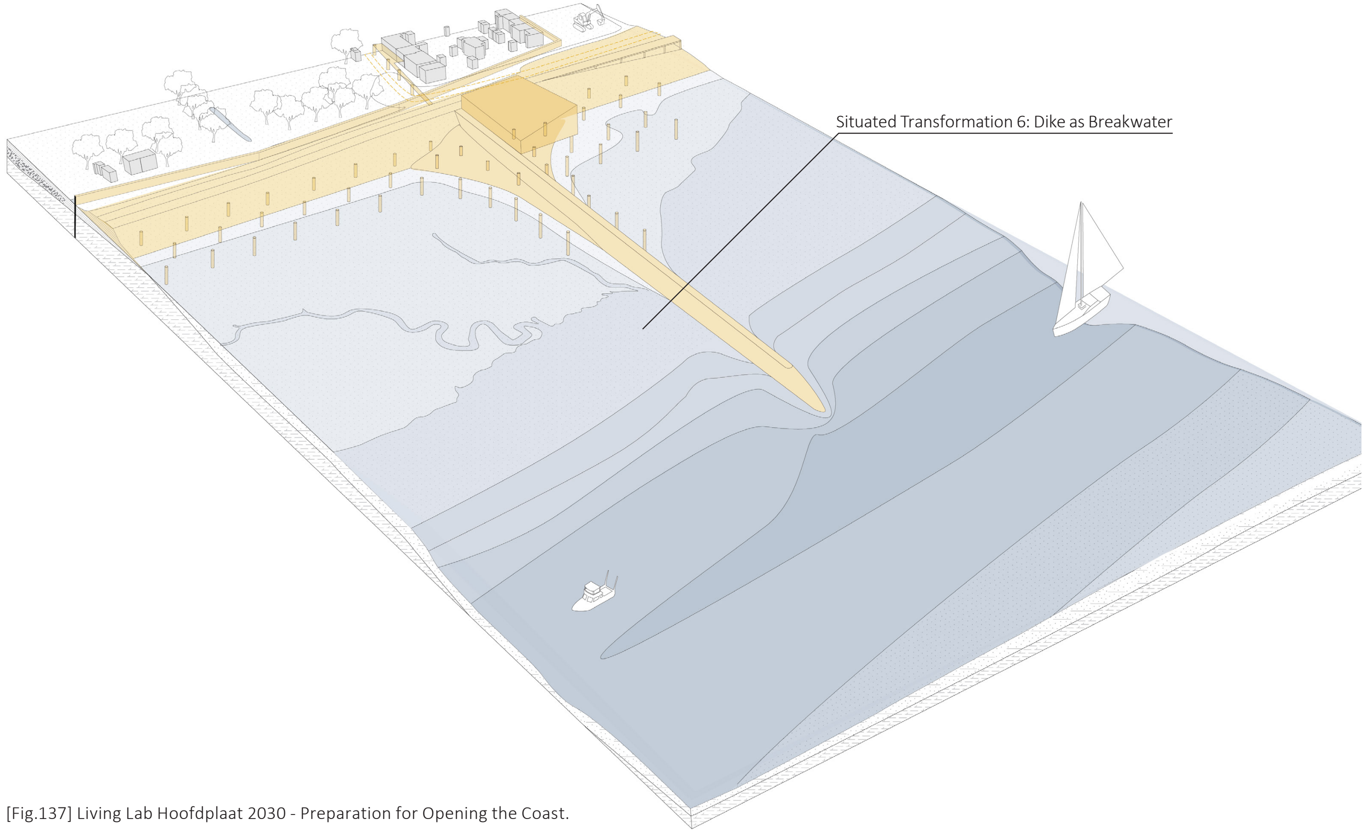
By 2030, preparations begin for a profound transformation. The dike is selectively modified. Some segments remain while others are opened to allow sediment and water flows to re-enter the polder. The existing dock is repurposed as a sediment-catching breakwater. It will intercept tidal forces to promote land growth. Around the village, a bulkhead wall system is installed to prevent the spread of subsurface lead contamination. As safety measures are implemented, residents are gradually relocated. Acknowledging the long-term risks while initiating a new use for the site.



[Fig.135] Location Hoofdplaat Exploration Tile.



[Fig.136] Living Lab Hoofdplaat 2025 - Current Situation.



[Fig.137] Living Lab Hoofdplaat 2030 - Preparation for Opening the Coast.

9.2.3 LIVING LAB HOOFDPLAAT

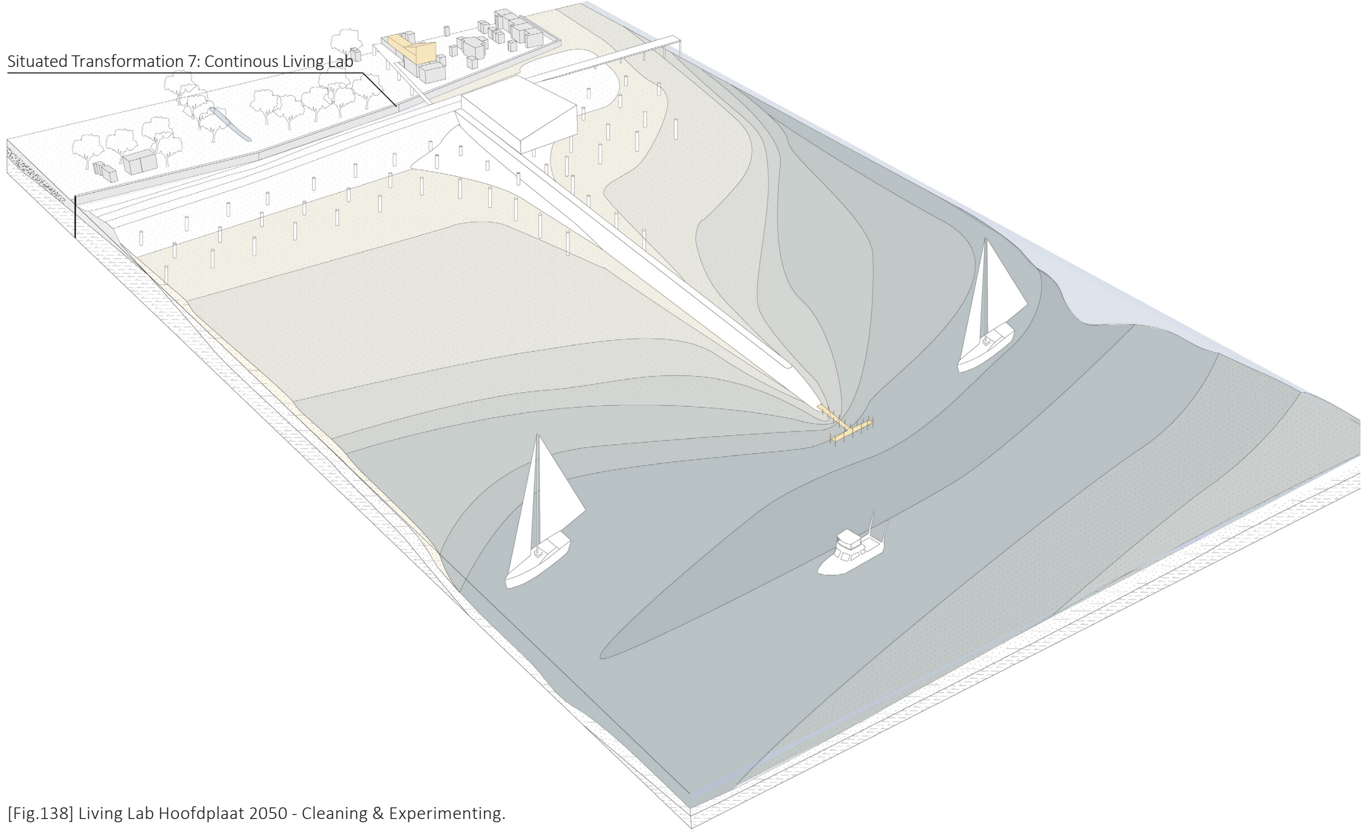
Around 2050, the coastal dikes are breached. What remains of the dike structure now functions as a series of elevated walkways and ecological corridors. It links Hoofdplaat to other settlements and reinforces its regional role. Sediment deposition accelerates around the breakwater. Beginnings of marshlands are forming to the east and sandy shoals are forming to the west, near the estuary mouth. Within the now-isolated village, the Living Lab is fully operational.

Scientists, ecologists, hydrologists and designers from across the country visit Hoofdplaat to test and showcase innovations in soil remediation, adaptive architecture and sediment management.

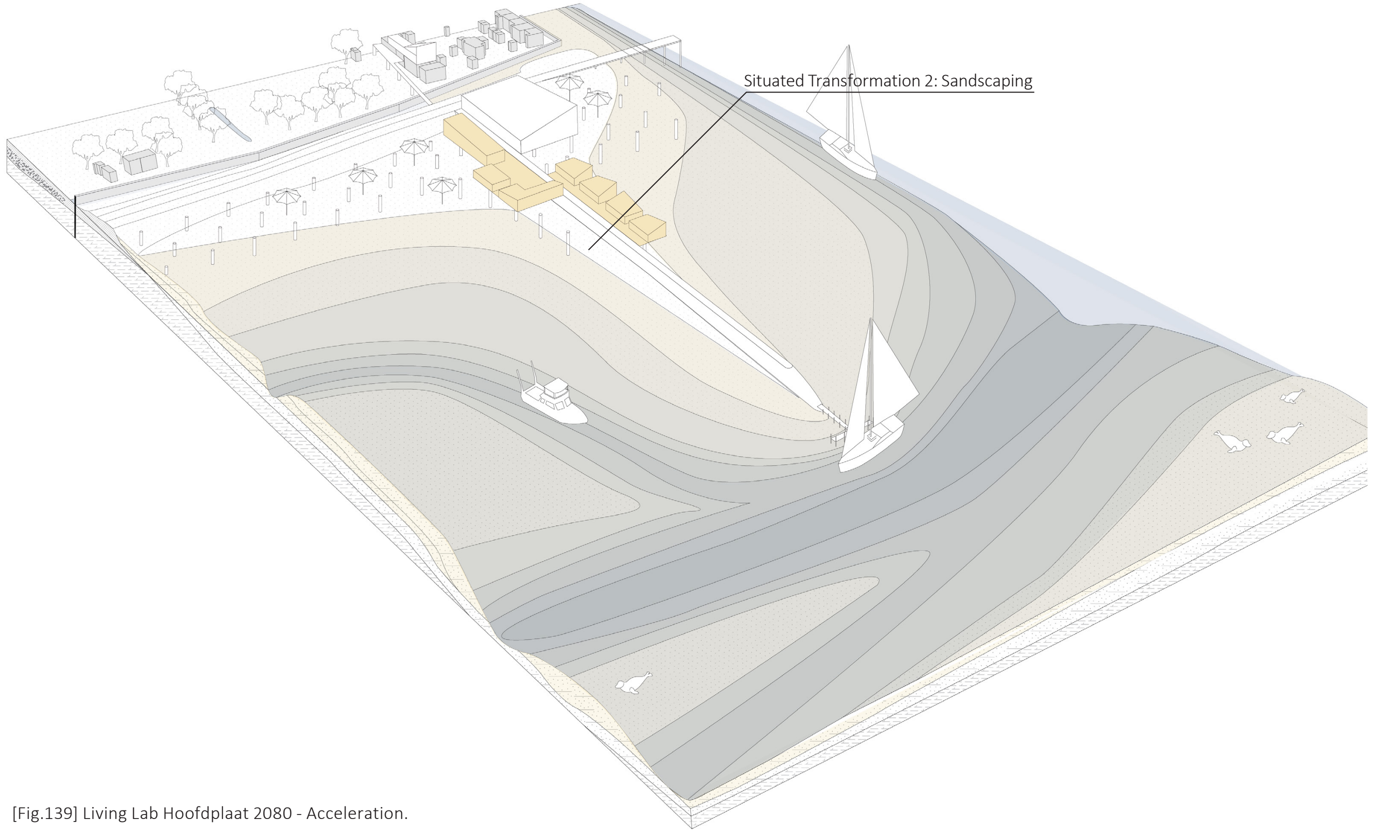
Crucially, local residents and citizens from the wider region begin to engage. Community workshops, guided tours and educational programs draw visitors into the transformation process. A public educational centre, made with Sandscaping, becomes a landmark of learning and observation. It offers views across the emerging marshland and tidal flats.

By 2080, sediment growth has created stable terrain. The once-polluted and inert landscape now supports many uses. Children explore the soft marshlands, while families sunbathe on newly formed beaches. The breakwater got a new dock. It hosts sailing vessels from both the sea and the newly navigable inland rivers, reconnecting Hoofdplaat to a broader deltaic network. The excess sediment and clay have been used to shape new tidal-adaptive structures. These can be modular dwellings, seasonal labs and recreational homes. They grow organically along the new shoreline and the breakwater.

The transformation of Hoofdplaat is no longer experimental alone. It is intergenerational and participatory. Ecological research and public recreation intertwine. Farmers, scientists, tourists and residents share space and knowledge. Where new cultivation methods are trialled, locals learn how to adapt, contribute and co-design their living environment. Hoofdplaat's transformation embodies the spirit of Tidal Urbanism. It is resilient, collaborative and deeply integrated in place.



[Fig.138] Living Lab Hoofdplaat 2050 - Cleaning & Experimenting.



[Fig.139] Living Lab Hoofdplaat 2080 - Acceleration.

9.3 POLICY & GOVERNANCE

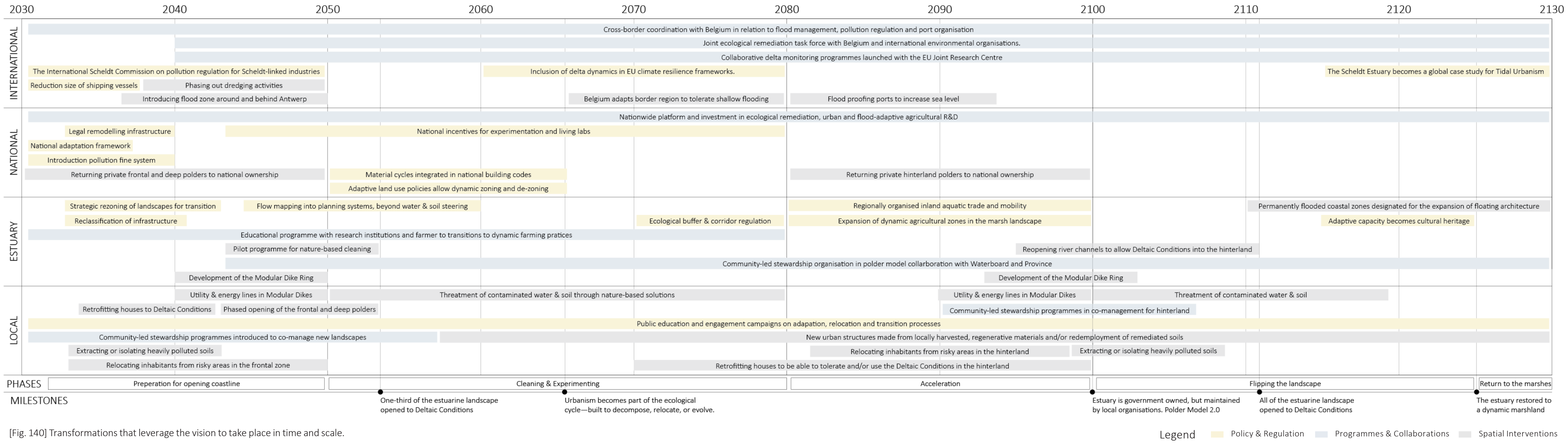
Timeline with policies

Shifting away from static coastal defense requires a fundamental change in thinking. Moving toward a dynamic and flow-based management model demands early and decisive regulatory changes. These changes are not distant or abstract. They must begin now. This will help secure space, support experimentation and build the institutional capacity needed for long-term resilience.

One of the most urgent steps is the transformation of zoning regulations to enable flexible land use. Regulations must support a landscape that evolves with water, sedimentation and ecological processes. To make this possible, land must be acquired from private owners and returned to collective control. This could take the form of state ownership or community stewardship. Doing so will unlock the freedom to experiment, to adapt and to accommodate changing conditions. It also limits hinder from fragmented ownership.

This transition also calls for great upfront investments. Adaptive infrastructure and pilot projects need upfront investment before they deliver results. But these early investments are critical. Over time, they reduce the escalating costs of coastal maintenance. Also, they help prevent the catastrophic losses that will result from future disasters. Early investment in public education and participation makes policy change more than just technical. It becomes cultural. The shift to a flow-based mentality is as important as the shift in law.

This reorientation must happen across multiple scales. Cross-scalar cooperation is vital. It links local municipalities and water boards to national governments, neighbouring countries and the European Union. At the same time, local groups and knowledge institutions bring invaluable, place-specific expertise. Only through this bridging of legal, spatial and institutional scales can a vision be developed and sustained.



[Fig. 140] Transformations that leverage the vision to take place in time and scale.

9.3 POLICY & GOVERNANCE

Reorganisation of Power and Interests

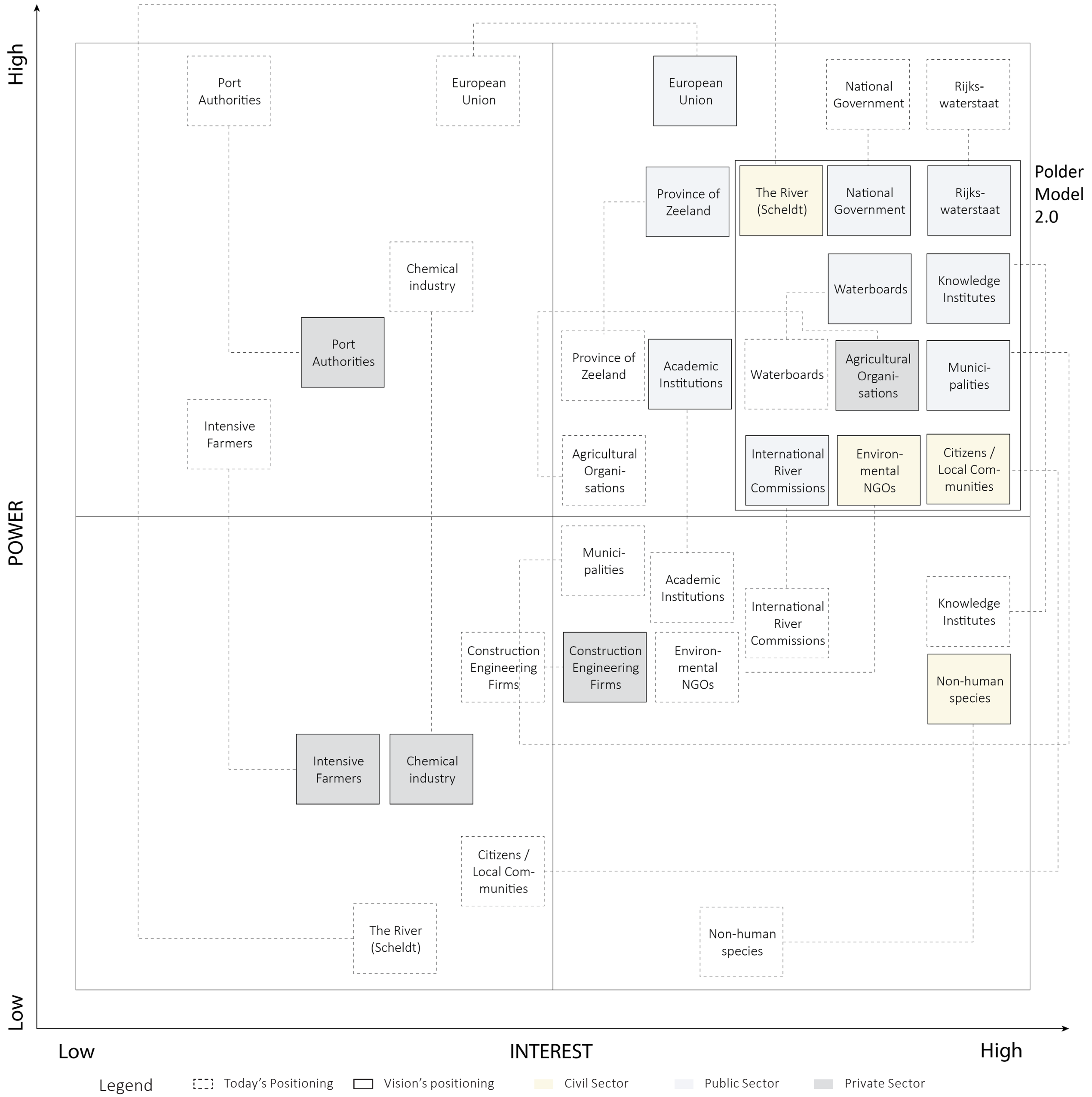
Beyond legal frameworks and policy updates lies a deeper transformation: the reorganisation of power and responsibility across the governance landscape. As the physical environment is reshaped by water and sediment, the systems of decision-making must evolve alongside it.

National and local governments must operate in more horizontal, cooperative ways. Governance becomes a distributed network of responsibilities and capabilities, instead of top-down. Research institutions, environmental organisations and universities become more than advisors. They become central actors, facilitating collaboration between society and landscape.

This evolving arrangement forms a new "polder model". Not one that seeks to hold back water, but one that understands water as an co-actor in shaping the land. Shared responsibility replaces harsh control. The governance system becomes an interface between human systems and ecological dynamics.

Crucially, this model gives voice to the river itself. Its conditions are acknowledged as active forces in decision-making. Local stakeholders, including water managers, ecologists and farmers, act as representatives of these processes. They don't just advocate for local interests, but for the health and integrity of the larger delta system. Through this stewardship, the river becomes a participant in governance rather than a passive backdrop.

Such a shift also increases the legitimacy and resilience of the transition. The local communities gain meaningful roles in shaping their environments. This enables the process to become more inclusive and socially just. Education, collaboration and transparent organisation empower residents to participate as co-creators. The result is a governance framework that is adaptive, fair and grounded in ecological literacy. A system capable of responding to current climate risks and to the uncertainties of the future.



[Fig. 141] Exploring shifts in organisation of the Estuary through a power-relation matrix. Reflected on the Flood Management and Coastal Management.


Nieuwvliet Visit West Zeeuws-Vlaanderen (Anonymous, 2021)

CHAPTER 10 CONCLUSION & REFLECTION

10.1 CONCLUSION

This chapter concludes the research by answering the central question and reflecting on the results.

Challenge and Aim

The aim of this thesis is to challenge the prevailing perspectives on flood risk management. They have "locked in" landscape design and management practices in the Netherlands. By reimagining existing flood management in the Scheldt Estuary, this study seeks to offer alternative approaches to coastal management. The project advocates for a symbiosis between human and non-human ecosystems. It underlines the potential of reconnecting with our environment to amplify urban flood resilience and regenerate socio-ecological systems. The main question is: *"How can the re-imagining of existing flood management in the Scheldt Estuary inform landscape design enhancing deltaic and climate adaptivity and promotes symbiosis between human and non-human ecosystems?"*

Main Result

The findings show that a reimagined flood management approach, as support system to the dynamics of the delta itself, can fundamentally reshape how we design and live with the estuarine landscape. Rather than framing flooding as a hazard to be suppressed. Flooding can be repositioned as an agent of spatial, ecological and cultural transformation. This requires a departure from the current engineering-dominated paradigm and rigid land design. Toward adaptive and cooperative systems of flood and coastal management.

Sub Result

Re-evaluating Historical and Social Precedents
Historically, flood management in the Netherlands has not only protected but defined the land. This legacy, however, is increasingly unsustainable. A control-based relationship with the delta has produced landscapes cut off from their estuarine context. These become ecologically isolated and structurally vulnerable to failure. Social perceptions have mirrored this mindset, treating the delta as a tool to be tamed rather than a system to be lived with. As sea levels rise and land subsides, this illusion of stability becomes increasingly fragile.

Analysing the Deactivation of the Flood Defences
Mapping and spatial analysis revealed that reintroducing Deltaic Conditions through deactivating flood defences, would allow the return of tides, saltwater, sediment and nutrients. This poses significant risks to current human systems. Simultaneously, it supports non-human ecosystems through land growth, ecological regeneration and restored hydrological cycles. These findings emphases the potential of flooding not as a threat, but as a powerful design and ecological force.

Design Scenarios and the Reframing of Risk
Three design scenarios (Open Coast, Polder Inversion and Room for the Marshes) illustrated diverse pathways for transforming flood events into beneficial spatial conditions. Each scenario explored different degrees of human engagement and ecological responsiveness. From retreat and restoration to controlled inundation, to sediment-driven growth. The evaluation through the lenses of response-ability and compose-ability revealed that only when human and non-human systems co-adapt does a resilient deltaic future become possible.

Room for the Marshes came out as the most promising model. It balances ecological function and human habitation through phased land return. It also implies adaptive infrastructure and collaborative stewardship. In this model, flooding is no longer framed as threat but as a catalyst for evolution. A concept that forms the basis for a new form of Tidal Urbanism.

Strategies for Symbiosis
The vision developed in this thesis imagines the Scheldt Estuary in 2130. As a region that has shed its fixed boundaries and returned to its marshland. Flood management becomes a living system of flow regulation. Coastal management becomes an act of radical co-creation between humans and nature. The strategies proposed support this future through tidal reintegration, ecological remediation, modular infrastructure and adaptive agriculture. Each of the strategies responsive to the conditions of the delta.

- Making with the delta, where planning is shaped by the flows of water, sediment and life.
- Delta-sensitive urbanism, where infrastructure accommodates natural cycles rather than resisting them.
- Deltascapes, where land use is multifunctional, adaptive and ecologically embedded.

Governance and Institutional Change
For these strategies to take root, they must be supported by a corresponding transformation in governance. The current regime of static land zoning and top-down control must give way. Making room for flexible, decentralised and locally responsive systems. Empowering communities and integrating the rights of nature into planning frameworks are crucial. It is necessary for a delta that is both liveable and healthy.

Reimagining flood management in the Scheldt Estuary reveals not only new ways of designing with water. It showed a fundamentally different relationship with the land. The strategies embrace Deltaic Conditions and fostering symbiosis between human and non-human actors. Landscape design can become a tool for resilience, regeneration and shared futures in the face of climate uncertainty.

10.2 DISCUSSION

This chapter critically reflects on the implications, feasibility, and limitations of the proposed vision and exploratory outcomes.

Limitations of Dynamic Planning

Planning inherently involves navigating uncertainty. Even with extensive data, the future remains unpredictable. In the context of this thesis, identifying reliable trends to guide long-term flood management is especially challenging. Modelling the implications of opening dikes requires highly complex and time-intensive simulations. For this research, historical maps were used to trace original sedimentation patterns. However, centuries of human intervention and climate change may have altered the Scheldt's flow dynamics so greatly that past models only offer limited guidance.

Given the speculative nature of this research, such approximations were enough to explore. Nonetheless, future implementation would require extensive environmental modelling. This together with extensive testing before any large-scale intervention is considered.

The transformations envisioned in this thesis emphasise responsive planning and modularity. It favours flexibility over fixed design templates. Knowledge exchange, continuous mapping and on-the-ground experimentation are positioned as essential tools for engaging with a continuously evolving landscape. A "spine" of adaptable infrastructure is explored to support this approach. It enables iterative development in response to shifting conditions. While such adaptability demands technical capability, the increasing availability of AI, drone-based mapping and modelling software renders it more feasible. Arguably even necessary, for future planning.

Yet, this vision carries an inherent paradox. In seeking to de-mechanise the estuary and restore tidal dynamics, we inevitably impose new layers of technological and infrastructural control. The ambition to "let the Deltaic Conditions return" is still framed through our own terms. It is calibrated for human safety, comfort, and permanence. This contradiction reveals a fundamental limit. The more we attempt to choreograph nature's processes through design, the less we truly relinquish control. The presence of human settlement—its needs, fears, and infrastructures—defines the boundary of how far we are willing to let the tide roam. In this sense, true freedom for the estuary may only be possible in our absence.

Another underlying assumption in this vision is that people will choose to remain in the region. However, faced with rising costs, risks or perceived loss of control, some may choose to leave. This would drastically alter the vision's foundation. Possibly, it would result in managed retreat or abandonment of entire zones. Vulnerable populations with fewer resources or mobility could be left behind in degraded or unsafe areas. A shift from adaptive inhabitation to depopulation would redefine the spatial strategy. And, it raise serious questions of equity and responsibility.

Feasibility of Transforming the Status Quo

From a socio-political perspective, the vision proposed in this thesis is unlikely to gain social acceptance. So, the willingness to invest in such a transformation is also limited. In recent years, research institutions have explored the potential of reintroducing tidal landscapes through polder de-poldering. But, these initiatives have encountered significant resistance. During one workshop, a governmental official stated that the region of Zeeuws-Vlaanderen has formally halted de-poldering projects. This follows the contentious and costly de-poldering of the Hedwige Polder. Despite its relatively small agricultural community. The compensation and legal proceedings required millions of euros. It also undermined trust in governmental bodies (Giele, 2022; Schreuder, 2022).

Public sentiment remains sensitive. During the research I was invited to a delta-focused workshop hosted by the local University of Applied Sciences (HZ). This workshop was joined by researchers, policymakers and agricultural representatives. There, the mere suggestion of converting another polder into a living lab sparked intense debate. Concerns were raised over safety, the loss of fertile land and the contamination risks posed by river waters.

While the social complexity of this issue can't be resolved within this thesis, the proposed vision attempts to explore a softer transition. This is done by examining a phased approach. It first focuses on front and deep polders where the cost-benefit ratio is most favourable. These areas are currently the most expensive to maintain and pump. They are also most vulnerable to salinisation and flooding. This makes them less suitable for traditional agriculture and habitation. Restoring these zones as buffers allows the hinterland to remain dry for a longer period. In the event of future dike breaches, newly accreted land at the front can offer alternative. They can be an elevated settlement zone.

Moreover, the spatial interventions suggested are designed as "no-regret" transformations. Even though, they are leverages for the vision, they align with the traditional flood management too. Modular dikes offer both adaptive infrastructure and emergency routes. Wet-proofing homes helps mitigate damage from pluvial and fluvial flooding. Living labs generate valuable empirical insights, while adaptive agricultural techniques enhance soil resilience. Capturing sediments through dike reconfiguration reduces the need for costly material imports. Although initial investments (both financial and organisational) are substantial, these costs are likely to diminish over time. Eventually, may even yield returns. This is mostly in terms of reduced maintenance and disaster response expenses.

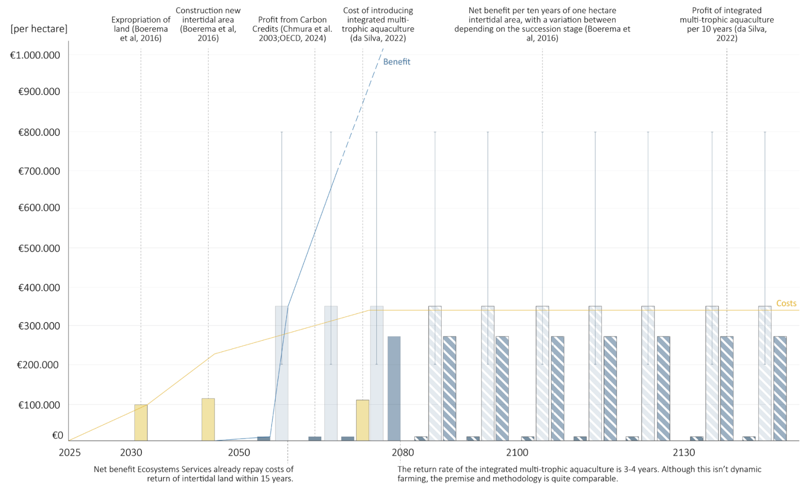
10.2 DISCUSSION

Literature (Boerema et al, 2016) suggests that polders returned to nature deliver more long-term benefits than those maintained for agriculture. When nature restoration is paired with nature-sensitive agriculture or aquaculture, it could result in direct economic gains (da Silva, 2022). However, whether these gains scale positively across larger regions remains unclear and if the benefits sustain over time. There's also a risk that one use (such as aquaculture) may dominate. Potentially forming a new monoculture, which the vision seeks to avoid.

By spacing out implementation, the vision allows time for the community to reflect and experience the change. This gradual phasing may help build trust. It also enables alternative livelihoods to emerge within the region. Furthermore, through living labs and knowledge exchange, citizens and farmers can be engaged in the transition process. This would foster a sense of agency and shared ownership in shaping the delta landscape.

A further challenge relates to the collective organisation of returned lands. The proposal to transfer land ownership back to the state or collective entities introduces the risk of a "blank space" in responsibility. While the collective is tasked with stewardship, it may lack the authority or resources to maintain these areas. This ambiguity could result in neglected spaces. These could turn in unauthorised claims or use as informal dumpsites. On the other hand, these areas might evolve into informal developments or experimentation grounds. An outcome with both potential and risk.

Safety governance adds another layer of uncertainty. Under the current system, the government is responsible for flood protection. In a decentralised model of adaptive flood zones and collective ownership, it becomes unclear who ensures safety. Is it a shared responsibility among collectives, individual households or the state? Without clear frameworks, this ambiguity risks undermining public confidence and legal accountability in high-risk scenarios.



[Fig.142] Conceptual Cost-Benefit diagram. Transformation of one hectare of polder land, giving it back to the tide and enabling marsh cultivation.

Unintended Consequences of the Transformation

Potential unintended consequences must also be considered. Opening dikes to reintroduce tidal dynamics can lead to both short- and long-term ecological and public health challenges. Contaminants carried by the Scheldt, including agricultural runoff and industrial pollutants. They may accumulate in newly flooded areas, threatening biodiversity and agricultural viability. The reduction of upstream industrial pollutants and the isolation of heavily contaminated soils may limit this spread. Ecological filtration could help remediate the land, but the timeframe over which this occurs is uncertain.

Tidal flooding could also increase the spread of waterborne diseases. Historically, channelling and pumping dry landscapes were seen as part of creating healthy environments (Boelee et al., 2002; Naik, 2023). The return of water could reintroduce diseases such as malaria. This topic must therefore be handled with great sensitivity and awareness. It may call into question the liveability of the marshlands.

Alongside these environmental concerns, social and behavioural adaptation remains a significant challenge. While some community members may embrace the vision's values of resilience and ecological stewardship, others may perceive it as threats to personal autonomy. Challenging their property rights and regional identity. Such transitions could further accelerate depopulation in rural areas. The remaining inhabitants may be those least equipped to take part in or benefit from the transition process. Expecting vulnerable populations to navigate such a challenging transition risks creating more problems.

Finally, this thesis pays limited attention to how such changes intersect with Zeeuwse cultural identity. The vision builds on certain local drives (land expansion and flood resistance) and the motto Luctor et Emergo ("I struggle and rise above"). But, it does so in a highly technical and spatial manner. The cultural transition is not fully explored. Especially how emotional attachment, regional pride, and lived memory align with flood infrastructures. This gap points to a direction for future research. One which integrates narratives of identity into the physical transformation of space.

10.2 DISCUSSION

Viability of Human–Non-Human Symbiosis

At the start of this thesis, Donna Haraway's 'Staying with the Trouble' (2016) was introduced as guiding framework. Her work challenges human-centred thinking and urges people to stay present with the processes around them. She invites us to see all life forms as "oddkin" in the shared experience of living and dying on Earth. This calls for a kind of humility that blurs the boundary between nature and culture.

The vision in this thesis aims to support a more collaborative relationship between humans and non-humans. Yet, the possibility of real symbiosis remains uncertain. While the work promotes engagement with natural processes, non-human forces like tides and ecosystems are still mostly treated as conditions to manage. They are acknowledged and respected, but not approached as equal participants in shaping the landscape.

This raises a difficult question. Has the approach moved far enough from the current paradigm? Traditional flood management sees water as a threat. This thesis offers an alternative by recognising ecological flows and working with them. But even here, the non-human is often positioned as something to optimise. The human system is still central, and the ecological system becomes a context to adapt to, not a collaborator.

The focus on deltaic processes does shift attention to the role of non-human systems. However, placing them in governance does not mean they are recognised as partners. Tools like adaptive zoning or rotational land use encourage compatibility with nature. Still, they rarely give the non-human a seat at the table. For that to happen, stronger advocacy is needed. This could come through environmental NGOs, research institutions or governance models that better reflect ecological values.

In summary, the vision points toward a more-than-human way of thinking. But it still operates within human-led structures. True collaboration would mean more than accommodating nature. It would require changing who makes decisions and how space is shaped. Without those shifts, the non-human risks remaining a background condition, rather than a co-creator of place.

[Fig.143] Groot Gat West Zeeuws-Vlaanderen (Kaim, 2023).

10.3 REFLECTION

In this chapter, I reflect on my thesis process by addressing the questions outlined in the Graduation Model, along with two additional questions I formulated based on my personal interests and evolving perspective.

What is the relation between your graduation project topic, your master track (A, U, BT, LA, MBE) and your master programme (MSc AUBS)?

This graduation project is part of the Urbanism track of the MSc Architecture, Urbanism and Building Sciences (AUBS) programme. It examines the relationship between flood management and spatial development in the Netherlands. The project addresses the limitations of traditional, technocratic flood management strategies. Instead, it advocates for a more adaptive and spatially integrated approach. One that aligns with the Urbanism emphasis on resilience, systems thinking, and multiscalar design.

By engaging with regional planning challenges in deltaic landscapes, the project reflects the programme's broader ambition to respond to climate change through interdisciplinary and research-based design. It investigates how systemic shifts (ecological, political, and cultural) can be translated into spatial transformations that reframe the role of flooding. Not as a threat to be controlled, but as a dynamic agent shaping urban and rural development.

In doing so, the project contributes to ongoing discourse within Urbanism on the integration of natural systems into urban design. And, it supports the MSc AUBS's mission to equip designers with the tools to navigate complexity and uncertainty in spatial practice.

How did your research influence your design/ recommendations and how did the design/ recommendations influence your research?

The reciprocal relationship between research and design has been central to the development of this thesis. Early in the research phase, it became evident that reimagining flood management in the Dutch estuarine context is a wicked problem. Rittel and Weber (1973) defined a wicked problem as a problem that is complex, interdependent, and resistant to clear solutions. The spatial, ecological, cultural, and political layers involved in this topic underscore the challenges of defining the problem itself. Let alone, resolving it through linear planning processes.

Recognising this wickedness shifted the project's trajectory from a focus on concrete, physical interventions (such as a pattern language or toolbox) toward the shaping of systemic design principles. These principles aim to guide adaptive and context-sensitive spatial principles rather than prescribe fixed outcomes. The wickedness of the problem called for a methodological response capable of engaging with uncertainty, multiplicity, and transformation over time.

Here, the iterative process of research-by-design proved essential. This approach allowed for the design to be informed by research. And, enabled research to evolve through design experimentation. The act of testing design principles through site-specific interventions helped surface new insights. It showed spatial and systemic consequences of reintroducing dynamic marsh landscapes.

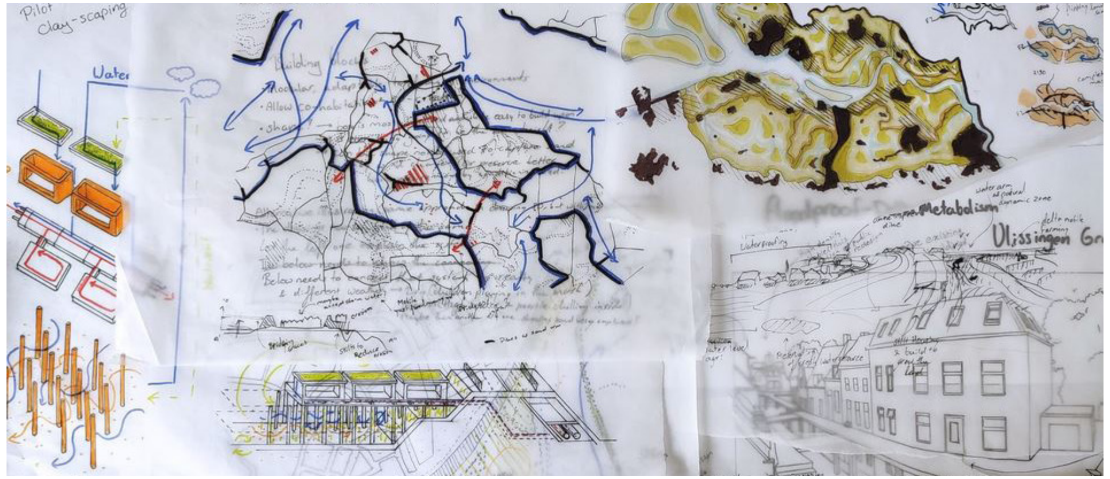
This is in line with the work of Pietrzyk (2022). He recognises research-by-design as a mode of inquiry particularly suited to wicked problems in urbanism. In my work, it allowed me to engage with future conditions that are uncertain and consequences that are difficult to predict. Also, it reduces epistemic uncertainty through iterative feedback loops.

Moreover, design choices implemented at the conceptual level often redefined the problem itself. This highlights the intertwined nature of working with wicked problems. These extra loops in the design process, where systemic feedback that gave new perspectives on the problem. It reinforced the need for an open-ended, reflective approach. It became clear that the value of the work lies not in resolving every complexity. It was in making critical spatial arguments that engage with the sensitivities of the estuarine landscape.

This interplay also revealed personal tendencies influencing the project's development. I frequently struggled with an urge to explore too many involved topics, leading to a scope that became difficult to manage.

Consistent feedback during mentor sessions helped me reorient the project. After reflection, research and design questions be came more focussed: What are the conditions required for reintroducing marsh landscapes? What forms of flood and coastal management align with this? And what are the long-term spatial consequences?

Finally, this process made me aware of the limitations of my own design vocabulary [Fig.144]. I am grounded in a more technical and zoned approach to planning. During the thesis, I had to learn to embrace ambiguity and experiment with representing spatial flows. Communicating through more expressive and evocative forms of drawing. Letting go of the intend to "solve" everything enabled a shift from a engineering mindset toward a more exploratory design stance. One better suited to the wicked nature of the problem. Although, I still need to practice this a ton, before becoming comfortable and commendable in it.



[Fig.144] Some of my sketches made during the research, balancing between dynamics and constants.

10.3 REFLECTION

How do you assess the value of your way of working (your approach, your used methods, used methodology)?

The value of my approach lies in its adaptive and iterative nature. It follows a research-by-design methodology, which suits the complexity of deltaic landscapes. My regional analysis provided a strong basis for understanding the spatial and systemic impacts of flood management. However, I now see that the analysis would benefit from more attention to international and geopolitical dynamics. These broader forces influence both the landscape and planning decisions but were underexplored in my work.

The methodology evolved greatly during the process. I initially planned a scenario-based exploration. Over time, this shifted toward a maximisation approach, focusing on amplifying deltaic flows. This change was not planned from the start but materialised from earlier research insights. It confirmed that the process was following a logical trajectory. However, since the original scenarios did not fully align with this new focus, I had to revise parts of the work after P3 to reflect the shift more clearly.

Working with scenarios also deepened my understanding of response-ability and compose-ability. These concepts guided the formulation of design principles. They go beyond spatial form, touching on governance and management levels as well. While I would have liked to include quantitative evaluation, the complexity of the systems involved made this unfeasible. Especially within the scope of the thesis.

The stakeholder workshop added further value. It introduced diverse perspectives and surfaced insights I had not previously considered. Feedback from professionals and researchers, alongside the SWOT analysis, enhanced the reflection process.

In summary, the strength of my methodology lies in its flexibility and ability to engage with complexity. Iteration allowed the work to evolve in response to new findings. However, this process also showed where improvements are needed. Especially in scope management and where possible, measurable validation.

How do you assess the academic and societal value, scope and implication of your graduation project, including ethical aspects?

This thesis presents an alternative approach to flood management, reframing it as a spatial, systemic, and ethical challenge. The research aligns with several key Sustainable Development Goals, including SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land). Through design, the project seeks to support long-term environmental resilience. At the same time, it promotes more just and inclusive futures.

Academically, the thesis contributes by expanding flood management discourse. It does this through the lens of systemic landscape change, spatial justice, and research-by-design. It explores how future-oriented scenarios can be developed. Not only as technical solutions, but as spatial imaginaries that help societies engage with complexity, uncertainty and long-term transitions.

From a societal perspective, the work addresses the urgent need to shift from reactive to proactive transformations. In the current Dutch context, action is often postponed until crisis conditions arise. This approach leads to higher economic and social costs. The thesis argues that early, managed adaptation offers greater benefits. And, that transition should be embraced as an opportunity for regeneration.

Ethically, the project seeks to balance two key rights: the rights of nature and the human rights of communities. Restoring natural flows acknowledges the ecological agency of landscapes. While reinforcing the principle that safe, and resilient environments are a human right. This includes the right to protection from environmental hazards. But also, the right to take part in decisions that shape one's living environment. This principle is closely related to SDG 16 (Peace, Justice, and Strong Institutions).

At the same time, the reintroduction of dynamic natural systems reveals environmental risks. Polluted rivers and coastal waters pose serious health concerns. Without addressing systemic pollution, restoration efforts may result in new vulnerabilities. The thesis argues that supporting nature's self-remediation requires both spatial interventions and political commitment.

This work is therefore both critical and speculative. It calls for a shift in landscape governance that prioritises environmental and social justice. The decentralisation of flood and coastal management is one such approach. Strengthening local adaptive capacities while addressing current inequities. Such as the disproportionate flood protection between urban centres like Rotterdam and rural areas in Zeeland. All communities have rights to safety, protection, and a say in their future living environment.

Finally, the project's reception must be carefully considered. In a political climate where land-use interventions (such as nitrogen regulation) have provoked strong public reactions. It is likely that proposals involving controlled flooding or landscape transformation meet resistance. It is therefore essential to communicate the exploratory nature of this research. The thesis does not prescribe solutions, but opens a discursive space. The work uses design as a medium to question existing systems. It also gives a imagine of inclusive, resilient and ethical pathways forward.

10.3 REFLECTION

How do you assess the value of the transferability of your project results?

The design principles developed in this project are transferable to other estuarine regions. Many of which face similar challenges related to climate change and the increasing mechanisation. These principles are intentionally broad. This enables them to adapt to diverse biophysical and socio-cultural contexts. This flexibility enhances their relevance across different geographies.

However, their abstract nature can make practical application less straightforward. To address this, the thesis includes a spatial vision and shifts. They serve as examples of how such principles can be grounded in a specific context. These examples aim to bridge the gap between conceptual thinking and implementation. It increases the project's value as a transferable model.

How has my personal connection to the region influenced my research and design choices?

My connection to the region provided valuable tacit knowledge. I have a deep understanding of its spatial logic, history and environmental dynamics. This helped shape my design choices and made the work feel grounded. However, it also created blind spots. I skipped over certain research steps (like zooming out to the delta's wider basin and economic role) because they felt obvious to me. For others, this missing context could weaken the storyline.

Xiong et al. (2020) describe this as the "curse of knowledge": assuming others know what you know. This made me more aware of how I communicate my work. I now see the need to better structure content for different audiences to avoid gaps in understanding.

Still, I kept enough distance to stay open to major changes in the landscape, even near heritage sites or my hometown. One personal interest did shape the project: my childhood connection to the Drowned Land of Saeftinghe. From the start, I was drawn to exploring habitation in a marsh landscape.

Feedback from tutors, peers, and workshop participants influenced my scenario development. But the concept that stayed with me throughout Room for the Marshes evolved into Return of the Marshians. This vision reflects both my personal ties and my critical design intent.

How did the thesis process influence my positioning on flood risk management in the Netherlands?

Growing up in a Dutch coastal city, I was raised in a cultural narrative of mastery over water. This takes form in engineering excellence and a belief in total control. I began this thesis with an interest in exploring alternative approaches for flood risk management. As the research unfolded, my perspective evolved significantly.

While I still acknowledge the resourcefulness and historical necessity of the Dutch flood defence system, I have come to question its long-term viability. The dominant paradigm treats flooding primarily as a technical threat to be managed. It focuses on prevention and control. It relies heavily on metrics such as Flood Probability × Flood Impact = Flood Risk. A approach which offers clarity but also obscure broader ecological and social consequences. This framework sidelines slow degradation, systemic vulnerability, and inequitable risk distribution. These issues surfaced repeatedly in my research.

The thesis process compelled me to confront these blind spots. It challenged me to move beyond conventional assessments of risk. Motivating me to explore the entanglements between water, territory, governance and life. The work of Donna Haraway helped me reframe uncertainty. Something to not eliminate, but to engage with. Instead of seeking definitive solutions, I began to see value in iterative, situated and often uncomfortable processes of co-existence with the delta.

However, this shift also revealed internal contradictions. I advocate for more adaptive, ecologically embedded approaches (dynamic planning, modular interventions, and the reintroduction of natural processes). Yet these strategies still rely on design and control. We invite the tide back in, but only on negotiated terms. Even as we attempt to de-mechanise the estuary, we introduce new layers of infrastructure. And, governance is designed to manage its rewilding. This raises critical questions about whether these explorations are genuinely transitioning toward coexistence. Or, they simply redesigning control under a different name.

My thesis also interrogated the role of non-human actors in flood risk management. While ecological processes are acknowledged, their agency remains secondary to human priorities. Nature is often treated as a set of constraints or resources rather than as a partner in decision-making. This results in the envisioned 'collaboration' remaining one-directional. An ecological tuning calibrated to human goals.

This realisation has significantly altered my position on adaptation. It is no longer a matter of improving technical systems or developing smarter tools. It involves questioning our foundational assumptions: our need for stability, our desire for control and our tendency to exclude non-human perspectives from governance. The Dutch delta is safe but it is also rigid, ecologically exhausted, and socially uneven. If we continue on this path, retreat may become inevitable. And, those with the fewest resources will bear the greatest cost.

10.3 REFLECTION

Though the vision in this thesis may appear radical or impractical. Its intention is not to provide a fixed solution. Rather, it functions as a critical lens and an invitation: to rethink how we relate to water, territory and uncertainty. The political, cultural, and financial barriers are substantial. But by engaging now, through experimentation, inclusion and reflexivity, we create the possibility of a more just and adaptive future.

Ultimately, this process has influenced not only my academic positioning, but also how I approach design itself. I became more aware of how flood management principles (control, safety, prediction) have shaped my own design instincts. Even when advocating for adaptive strategies, I found myself returning to frameworks of order and clarity. Letting go of that mindset, even partially. has been one of the most difficult aspects of this work.

In conclusion, the thesis has repositioned my understanding of flood risk management. It went from a problem of technical optimisation to one of relational negotiation, between humans and water, between institutions and ecologies, between control and adaptation. True resilience, I have come to believe, is not the absence of risk but the capacity to engage with it ethically, iteratively, and collectively.

[Fig.145] RO&AD architecten | Veldstation Groot Saeftinghe - Nieuw Namen (RO&AD architecten, 2023)

Westkappelle.

CHAPTER 11 REFERENCES

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