Go with the Flow

Dynamize the Delta

R and D Studio: Spatial Strategies for the Global Metropolis (AR2U086)

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Abstract

The Netherlands, renowned for its flat landscape and strategic location at the confluence of major rivers, combined with fertile soil and a mild climate, boasts optimal natural conditions for agricultural production. However, the success of the Dutch agricultural sector and its developments has significant implications for biodiversity, as excessive nitrogen levels contribute to a decline in plant and animal species, ultimately disrupting the ecosystem balance. Currently, functions are separated by human engineered boundaries with little to no interaction with each other. Agriculture is hyper focused on the productive part of the system, lacking equilibrium ripping the balanced system apart. Ideally, water, agriculture and soil live in perfect harmony and so envisioned for the year 2070 is a dynamic river landscape in the Dutch Delta region; a landscape where there is room for the water to flow as it pleases. In this vision, a river's natural flow is embraced; free flowing water with little constraints. Instead of seeing this freedom as a problem that must be controlled, this project values the river's morphological changes and water fluctuations through time. This vision and strategy not only makes room for the river, but creates a new dynamic system in which water, biodiversity and agriculture works together. Adjustments are mainly made to the land-uses to correspond to the shifts of the river, using a catalogue with several interventions, divided into practical, spatial and facilitating tools that support the previous categories. A green network of 'in between' wetlands is situated within the river basin. This network serves as vital ecosystems that enhance the resilience of the region. These green marshes overflow with biodiversity, serving as havens for formerly threatened animal and plant species alike to thrive and flourish. In this project, we apply these strategic tools to three locations with different conditions, such as moderately wet, wet, and extremely wet, acting as pilots to be extended into more parts of the Dutch Delta region in the future. . This forward-thinking approach not only ensures the sustainability of agriculture but also fosters a healthier, more diverse environment for generations to come.

Keywords: dynamic river delta, sustainable land-use, agriculture, nitrogen

CONTENTS

01

INTRODUCTION

02

APPROACH

03

WHAT’S UP WITH THE DELTA?

04

GO WITH THE FLOW

01

INTRODUCTION

01

Diving into the EuroDelta

The Eurodelta, one of the seven remaining European mega regions, encompasses the West-South-Netherlands, Belgium, West-Germany, North-France, and Luxembourg. Situated in one of Europe's most significant deltas formed by the Rhine, Scheldt, and Meuse rivers, the Eurodelta boasts an urban polycentric network of cities, including Amsterdam, Brussels, Cologne, and Lille. Cooperation within the Eurodelta is ingrained in its inhabitants' DNA, enabling them to address common and complex challenges (METREX SURE Expert Group, 2019).

In the context of the urgent transition to sustainability, the Rhine, Scheldt, and Meuse rivers serve as the blue highways of the Eurodelta, playing a crucial role in the region's ecosystem. However, these rivers have undergone significant alterations to accommodate the needs of Delta inhabitants, historically serving as disposal routes for waste. Consequently, surface water quality in the Eurodelta has been severely compromised. While improvements have been made in recent decades, pollution from agriculture, urban, and industrial sources persists, resulting in surface water bodies in northwestern Europe having the lowest quality in the continent (European Environment Agency, 2019).

Like the rest of the world, the Eurodelta region faces climate change implications, including rising sea levels and increased discharges, exacerbating threats from river flooding and droughts. These challenges underscore the vulnerability of water management systems along the rivers, necessitating the integration of climate-induced changes into water management strategies (Middelkoop et al., 2001).

The Netherlands, situated at the mouth of the Eurodelta, is particularly vulnerable to these trends and confronts dual challenges in water management, needing to address both flood protection and water quality concerns. Compounded by its low-lying geography, the country is at a heightened risk of flooding, despite its history of innovative water management. Initiatives such as the "het Kennisprogramma Zeespiegelstijging" are crucial in exploring long-term strategies to safeguard against climate change. These strategies encompass reinforcing coastal defences, exploring innovative approaches like land-use adaptation, and implementing new coastal structures (Ministerie van Infrastructuur en Waterstaat et al., 2023). Furthermore, concerning water quality, because it is known as the "Drain of Europe," the Netherlands contends not only with its own water contamination issues but also with polluted water inflows from neighbouring countries (Didde, 2020).

Map 1: European Delta Region

02

Problem Statement

Currently, the Netherlands ranks lowest among all EU member states in terms of water quality, as assessed by the new Water Framework Directive (WFD) set to take effect in 2027. The WFD aims for waters in all member states to achieve a 'good ecological and chemical state', yet only 1 percent of the total water bodies in the Netherlands meet this standard. Particularly concerning is biodiversity, with 83% of water bodies lacking diversity due to excessive nutrients like nitrate and phosphate, as well as pesticide residues, present in groundwater and surface water such as rivers, canals, streams, and lakes (Didde, 2020). Agriculture, covering 54% of Dutch land (CBS, 2020), contributes significantly to this issue, accounting for about a third of the failure to meet WFD goals through fertiliser and pesticide leaching (Didde, 2020).

The Netherlands boasts a deeply ingrained agricultural tradition, facilitated by its flat landscape, strategic river confluences, fertile soil, and mild climate, providing optimal conditions for agricultural production (Wageningen University, 2020). This has led to the development of a sophisticated and intensive agricultural sector, making the Netherlands the world's second-largest food exporter despite its relatively small surface area of 40,000 square kilometres, ranking 134th globally (Government of the Netherlands, n.d. a). The agricultural sector contributes nearly 7% to the GDP, with a total added value of approximately 57 billion euros in 2021 and employment of 600,000 working years, representing 7.5% of total national employment (Wageningen University, 2023).

However, the success of Dutch agriculture has come at a cost, particularly in terms of nitrogen emissions. Agriculture accounts for 52% of the country's nitrogen deposition, posing environmental challenges (CLO, 2024). Nitrogen from fertilisers and wastewaters, seeps through the ground into the rivers and into the sea, altering the water salinity and nutrition composition (Myserli, 2018)

These challenges have significant implications for biodiversity, as elevated nitrogen levels lead to a decline in plant and animal species, disrupting ecosystem balance. Increase of nitrogen in aquatic ecosystems leads to overgrowth of planktons and algae. Resulting in organic-rich sediments storing excess nutrients and creating anoxic benthic environments (Fuller et al., 2021) . This murky water environment prevents animals from seeing their prey, as well as suffocating the natural vegetation from growing. This change to oxygen depleted aquatic environment proposes a serious threat, in disrupting the whole natural food chain of that fauna, by drastically lowering the diversity of animal and plant species (Aertebjerg et al., 2001), as well as poisoning of animals including humans by algal toxins(Myserli, 2018). In the Netherlands, the situation is particularly dire, where biodiversity has decreased to approximately 15% of its original state, a loss that surpasses that of many other regions (CLO, 2013). Consequently, the Netherlands has relatively little biodiversity left to lose.

In conclusion, the Netherlands' intensive agricultural practices, while highly productive, have significant ramifications for water quality, nitrogen emissions, and biodiversity. Ideally, these principles should coexist in a healthy balanced system, but current agricultural production disrupts any form of equilibrium by mainly focussing on intensive production.

Our observations during the site visit to the Dutch polder landscape further underscored this imbalance. The area appeared highly bio-uniform, dominated by vast expanses of grasslands bordered by dikes and ditches. This landscape design seemed to prioritise function over form, with distinct land use functions segregated without any meaningful ecological interaction between them. The absence of intermediary zones highlighted the disjointed nature of agricultural practices, further emphasising the need for a more holistic approach that considers biodiversity, nitrogen emissions, and water quality in tandem with agricultural production.

Figure 1 Current Situation

03

Vision Statement

In 2100, the Dutch Delta region will undergo a transformation into a dynamic river landscape, where the natural flow of the rivers is embraced without constraints. Rather than considering this freedom as a problem requiring control, this project recognizes and values the river's dynamic morphological changes and water fluctuations over time.

Agricultural practices in this future landscape have shifted away from highly intensive methods towards collaborative approaches that adapt to the changing river levels. New forms of agriculture, suited to wetter and saltier conditions, have been embraced to accommodate this shift in water usage.

Across the countryside, a green network has been established. Wetlands situated along river basins and streams serve as vital ecosystems, enhancing the region's resilience. These green marshes teem with biodiversity, providing havens for formerly threatened animal and plant species to thrive. Additionally, the return of the bocage landscape between farming parcels offers shelter for diverse groups of animals and plants.

Figure 2 Go with the Flow

04

Sustainable Development Goals

The 2030 Agenda for Sustainable Development, adopted by all Member States of the United Nations in 2015, introduced the Sustainable Development Goals (SDGs), a set of 17 strategic objectives aimed at fostering sustainable development and inclusivity by the year 2030 (Rijksoverheid, 2023). These goals serve as a comprehensive action plan to combat poverty, promote prosperity, and address the challenges posed by climate change (United Nations, 2021). The Go with the Flow project aligns with several of these SDGs, as outlined below

Goal 6: Clean water and sanitation
Go with the Flow aims to improve water quality and restore ecosystems in and around water bodies by adopting more sustainable farming practices and allowing water to flow naturally.

Goal 12: Responsible consumption and production
By fostering collaboration among farmers and emphasising sustainable farming methods, the project seeks to promote responsible and sustainable arable production while facilitating knowledge exchange within the agricultural community.

Goal 13: Climate Action
Allowing rivers to flow freely helps address the increased river runoff and droughts associated with climate change, thereby contributing to climate action efforts.

Goal 14: Life below water
Go with the Flow endeavours to regenerate biodiversity along rivers and reduce pesticide runoff into water bodies by promoting sustainable farming practices, ultimately enhancing aquatic ecosystems and supporting diverse river life.

Goal 15: Life on land
Through the creation of a green network around arable fields and rivers, coupled with the adoption of sustainable farming practices, the project aims to restore and conserve ecosystems on land, thus contributing to the preservation of terrestrial biodiversity.

By addressing these SDGs, the Go with the Flow project plays a vital role in advancing sustainable development and fostering a more resilient and inclusive world for future generations.

Figure 3 Applicable SDG's (United Nations, 2021)

02

APPROACH

01

Methodology Framework

To develop a regional vision and strategy, a variety of methods have been employed. Thematic focus, literature research, and background research were necessary to substantiate the problem statement and our resulting vision and strategy. The process consists of four phases: orientation, research, design, and evaluation. The research and design phases were executed through an iterative process, alternating between our vision and strategy. The development of a conceptual framework was used to explain the main concept behind Go with the Flow, formulating a research question and providing a clear overview of the required analysis. Sub-questions were formulated to address the research question, which were deliberated upon our research and design phases.

For the research phase, various methods were applied, including map analysis, historical analysis, data analysis, and policy analysis. QGIS data was used to generate maps on the project's main topics: nitrogen, biodiversity, agriculture, water, soil, and flood risk. For this data, we consulted institutions such as PDOK, the Government of the Netherlands, and Copernicus (Corine). In addition to data analysis, scientific research was important to deepen our understanding on the different themes of our project during the research and design phases. By zooming in on three strategic pilot projects, our vision was further refined. Both iteration between different phases as well as iteration between different scales were used to create a strategy on how to Dynamize the Delta. The vision of the pilot projects was scaled up at both the Dutch Delta scale and the Euro Delta scale.

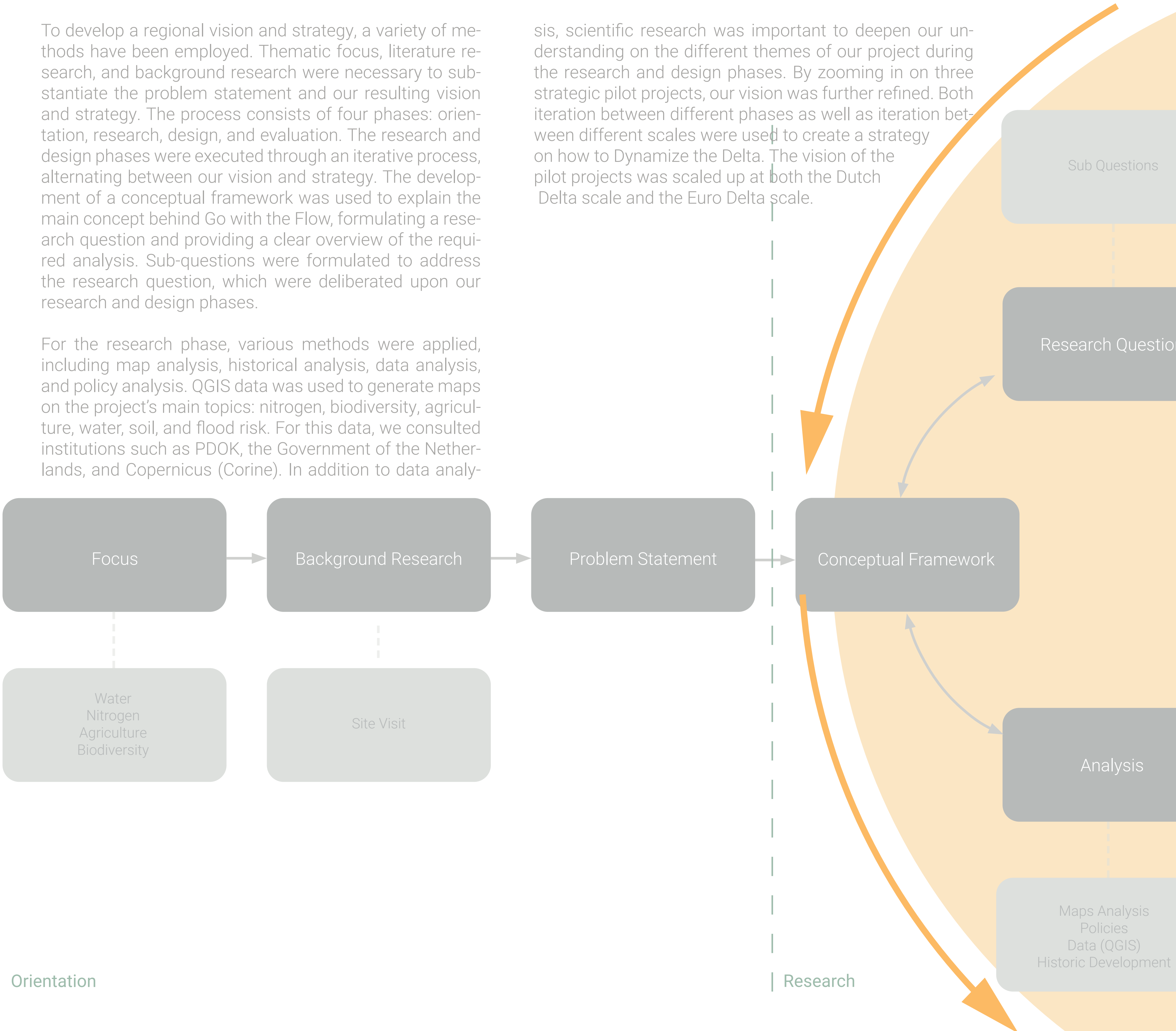
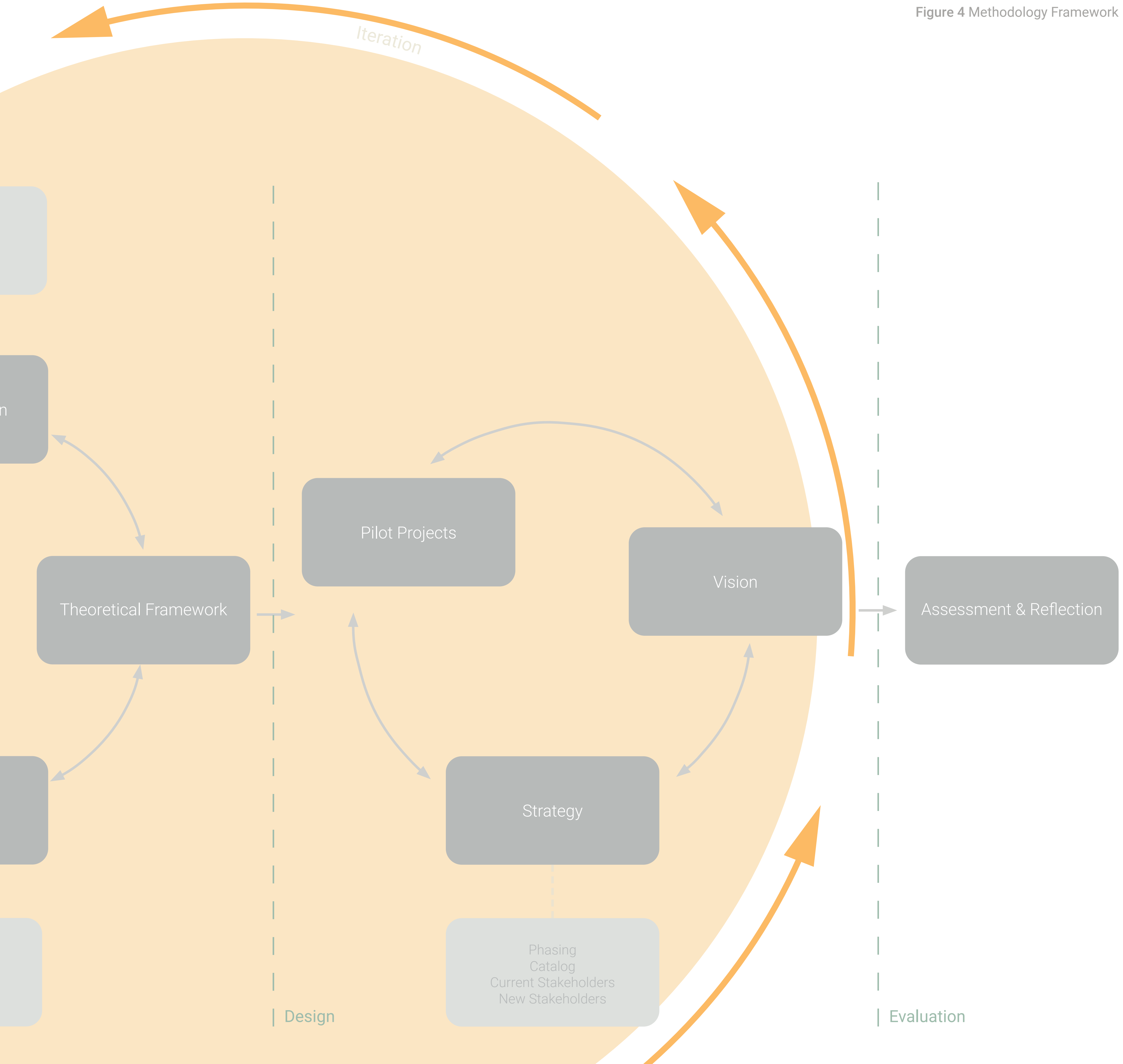


Figure 4 Methodology Framework



02

Research & Sub Questions

The research question, 'How can we design a healthy balanced system by increasing dynamics?', was defined to explore a new dynamic system involving interactions between land use, soil, and water flows. The impact of agricultural practices, in conjunction with soil types and water flows, on a healthy balanced system were analysed to facilitate integration and collaboration among them. The boundary conditions among these factors were spatially examined to determine their presence and how they can be transformed.

To formulate an answer to the research question, the following sub-questions have been developed:

1. What are the dynamics between land use, soil and water flows?
2. Which boundaries are present among these factors, and how can these boundaries be transformed?
3. Which dynamic system is facilitated by transforming boundaries?
4. What is the impact of the dynamic system on People, Planet, and Prosperity?

With this research question and its sub-questions, the main objective of the project is to create a new dynamic system that maintains a healthy balance between agriculture, nitrogen, and biodiversity. To assess this new system and determine if a healthy balance is achieved, the last sub-question needs to be answered. Hypothetically, in this new dynamic system, the implementation of sustainable land use results in high-quality water, healthy soil, reduced nitrogen emissions, and increased biodiversity levels.

We defined a healthy, balanced system as one in which agriculture, nitrogen, and biodiversity exist in perfect harmony. To achieve this, people, planet, and prosperity need to be equally balanced, and one perspective cannot benefit at the expense of another.

How can we design a healthy balanced system by increasing dynamics?

We defined dynamics as the extent of interaction among land use, soil type, and water flows.

03

Theoretical framework

System Change

Go with the Flow employs a new approach to rethink space, land use, and conditions in the Netherlands. This entails a departure from the old layer approach that was previously predominant. The origin of the layer approach in landscape and ecological planning dates back to the publication of 'Design with Nature' by Ian McHarg in 1969. The layering of different functions and conditions in space was introduced using the example of Staten Island. Each condition was delineated with a clear boundary line, and overlap demonstrated increasing complexity in certain areas (McHarg, 1969).

This old layer approach focuses on space as the defining condition. The ground plane is the limiting area, and stacking functional layers on top of it is possible without limits. In terms of designing for the future, this represents an end-of-pipe solution: the future situation is designed from the starting point by zoning future spaces on top of it. In the Dutch governmental policies we analysed, this approach has been recognizable by terms like 'multifunctional use of space', 'beckoning picture of the future', and 'spatial zoning rules'. The focus is on steering toward an end image, instead of steering toward a dynamic process framework.

A well-known project that can be compared with Go with the Flow is 'Room for the River'. Due to very high water levels in the rivers in 1993 and 1995, the Dutch government initiated new flood risk management measures that focused on creating space for rivers to flow more freely and accommodate higher water levels during periods of flooding. The solution was spatial: the driving idea behind the plan was the creation of more space for water in extreme circumstances, such as through the construction of new bypasses and larger floodplains (Rijkswaterstaat, n.d. a). In terms of the layer approach, water emerged as the most important layer requiring an engineered solution.

But with the introduction of water and soil steering policies (Ministerie van Infrastructuur en Waterstaat, 2022), we depart from the idea of space being the defining factor in future spatial planning. A new dynamic model is required, in which space is allocated, but conditions change over time. Through time, conditions become dynamic and reappear within intervals. This dynamic approach aligns with the rhythm of natural processes, such as river and tidal flows. The linearity of time has transformed into a dynamic circular process, a rhythm with many different voices playing the same music. The result can be compared to the famous urban example of 'The Open City': not an engineered spatial condition with rigid boundaries, but a framework supporting dynamic, porous gradients that allow exchanges, fluidity, and mixing (Sennett, 2006). This transforms the Netherlands into an open, dynamic landscape.

Triple bottom line theory

The introduction of this dynamic system can result in a healthy balanced system. The triple bottom line theory of Elkington (1998) can be applied to develop this healthy balanced system. The three perspectives, People, Planet, and Prosperity, need to be equally balanced, and one perspective cannot benefit at the expense of another. In order to create a better balance between the three perspectives, there needs to be a healthy balance within the perspectives themselves. These balances will be researched through land use, discussing the governance of the commons and sustainable land use.

Sustainable land use

Go with the Flow envisions sustainable use of the Dutch landscape in the river Delta region. Sustainable land use is practised through an even balance of land, water, and biodiversity distribution (WUR, n.d. 1), utilising natural resources while ensuring long-term productivity and environmental functions are maintained (FAO, n.d.). Currently, 54% of Dutch land is allocated to agriculture (CBS, 2000), with much of it intensively cultivated (PBL, 2023). However, this intensive cultivation has resulted in negative impacts on biodiversity and ecosystems (WUR, n.d. 2). Natural resources and land sustainability are threatened by poor water quality, soil degradation, and loss of biodiversity (WBGU, 1996). Therefore, it is crucial to adopt new methods of land use and management, such as Sustainable Land Management, integrating ecology and socio-economic factors into agricultural land management. An integral part of sustainable land use and management is the involvement of multiple stakeholders in developing realistic and ecological solutions at the local level (Hurni, 2000).

Governing of the commons

Currently, the cultivation of agricultural land is very individually focused; every farmer owns their own land and decides which crop or cattle is kept there. ‘Go with the Flow’ advocates for a transition in the viewing of the Dutch agricultural landscape. Instead of a high degree of parcelization with continuous production of similar crops, the land should be seen more as a common good, where land is shared among several farmers. The concept of commons presents challenges, as highlighted by Hardin’s (1968) “The Tragedy of the Commons.” Hardin suggests that human nature often leads to overexploitation of shared resources because people are driven by individual self-interest. However, other studies challenge this view. In “The Struggle to Govern the Commons,” Dietz et al. (2003) emphasise the importance of effective institutional arrangements in sustainable management.

A good balance between bottom-up and top-down planning could be the answer. In their book ‘De Spontane Stad’, Urhahn & Urhahn Urban Design (2011) distinguish two approaches to planning: planned spontaneity and spontaneous planning. Different starting points can contribute to the idea of spontaneous urban design, where top-down and bottom-up approaches are integrated. One of these starting points is to create collective values, in which integral developments call for collective investments. Even though collective values are important in spontaneous planning, the main focus should be on the primary stakeholder. Participation structures are not the aim of the project, but the efforts in creativity, investment capacity, and the energy of all stakeholders need to be taken into account in urban design. The end goal is to create top-down policies where bottom-up initiatives can thrive.

03

Conceptual Framework

The conceptual framework illustrates our approach to the process of dynamizing the Delta. Go with the Flow aims to increase dynamics by breaking boundaries. Agriculture, nitrogen, and biodiversity greatly influence each other but are currently perceived as separate systems. By treating these three aspects as one integral system, we can ensure that no trade-offs are made between them, resulting in greater overall value. We are convinced that redefining agriculture, regenerating biodiversity, and rebalancing the nitrogen cycle can be achieved through sustainable land use practices. Soil types, land uses, and water flows are integrated into sustainable land use. Embracing the natural flow of water and adjusting land use accordingly, by breaking boundaries, creates a dynamic system where land use is not defined by space, as in the old layer approach, but rather by time. This represents a new approach to thinking of space, land use, and conditions in the Dutch Delta region.

Redefining agriculture, regenerating biodiversity, and rebalancing the nitrogen cycle are related to the overarching perspectives envisioned in the third ring. This ring completes our conceptual framework and connects our project to the principles of People, Planet, and Prosperity, and the balance between these elements. This context defines where our project is situated, aiming for the outcome of a healthy balanced system.

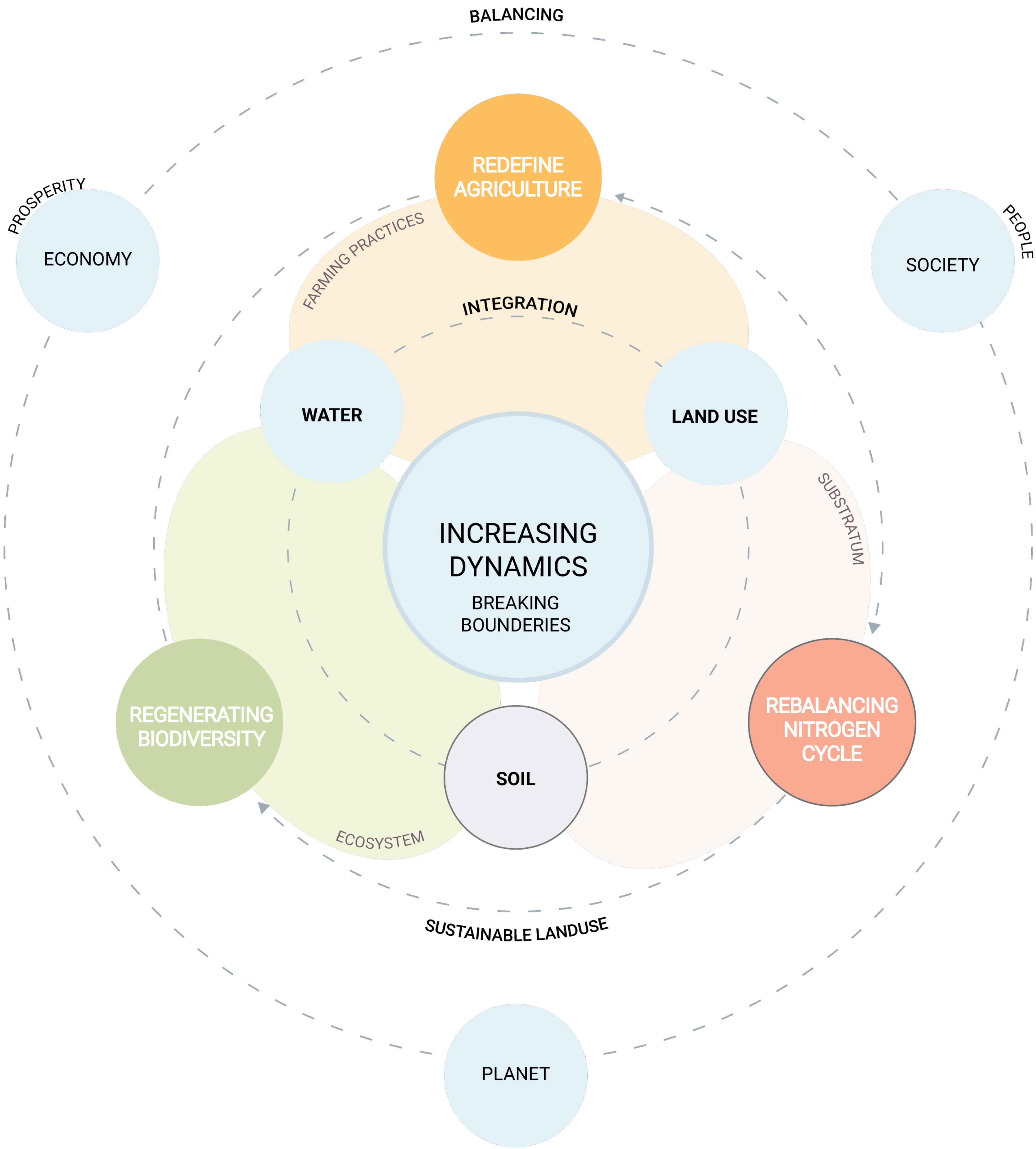


Figure 5 Conceptual Framework

03

WHAT'S UP WITH THE DELTA?

01

Soil & Water

The landscape of the Netherlands has changed significantly over time, particularly in terms of soil types and water bodies. The analysis maps clearly show these changes. Around 2750 BC, the country primarily consisted of peat and sand. However, over the years, there has been an increase in river clay, especially in areas near the rivers and the Wadden Sea. Nowadays, there is a mixture of soil types, with sand and river clay dominating, and a small fraction of peat. Over the years, the development of water features has also been significant. New islands have formed in Zeeland, and there have been substantial changes around the IJsselmeer. The Delta river area has undergone significant transformations, with new rivers appearing, old ones changing course, and some disappearing altogether.

These developments in soil and water have shaped the current landscape of the Netherlands: a flat terrain strategically located at the confluence of major rivers, combined with fertile soil and a mild climate. Three primary soil types—sand, river clay, and peat—are depicted on the map because they are the most significant soil types in the Netherlands and have undergone the most significant historical transformations (Wageningen University, 2016). River clay is conducive to retaining water and is nutrient-rich, but tends to acerbate faster, posing a challenge in agricultural practices. Peat is highly nutritious and does not dry out quickly, but the soil can become overly wet for crop cultivation. Sandy soils offer good drainage and adaptability but are low in nutrients and also tend to acerbate quickly (Landleven, 2021). The Netherlands boasts high-quality fertile soil due to the deposition of fertile river clay and the formation of peat under wet conditions. As a result, Dutch landscapes are intensively utilised for agricultural practices (Wageningen University, 2022).

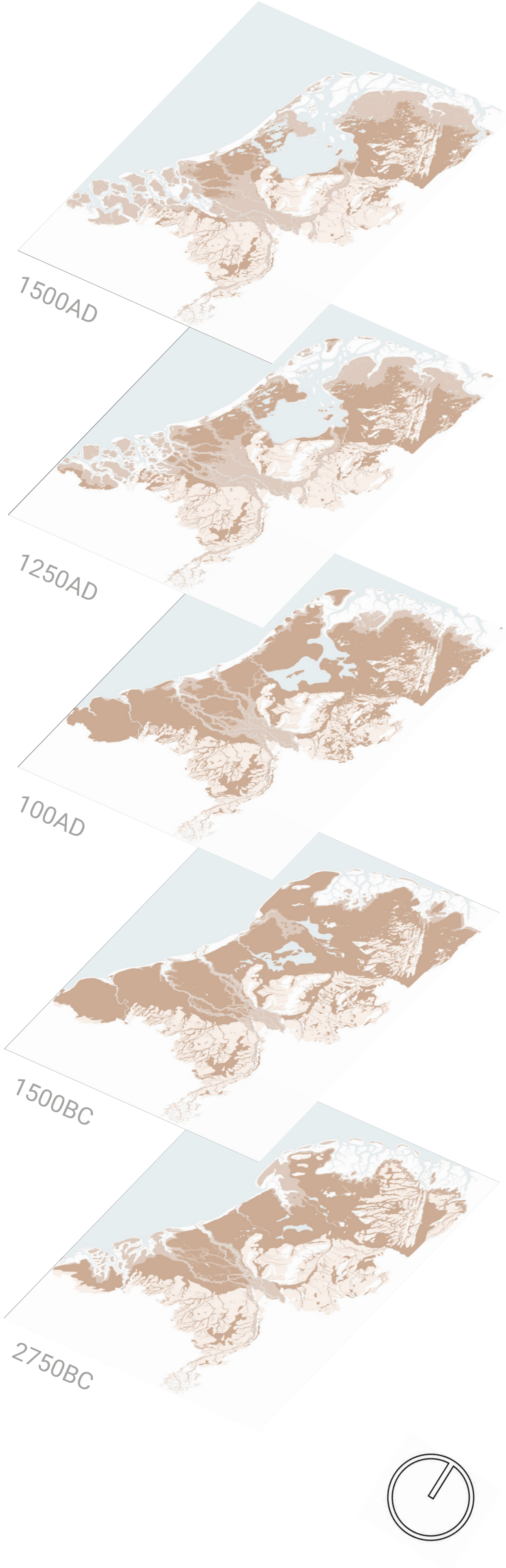
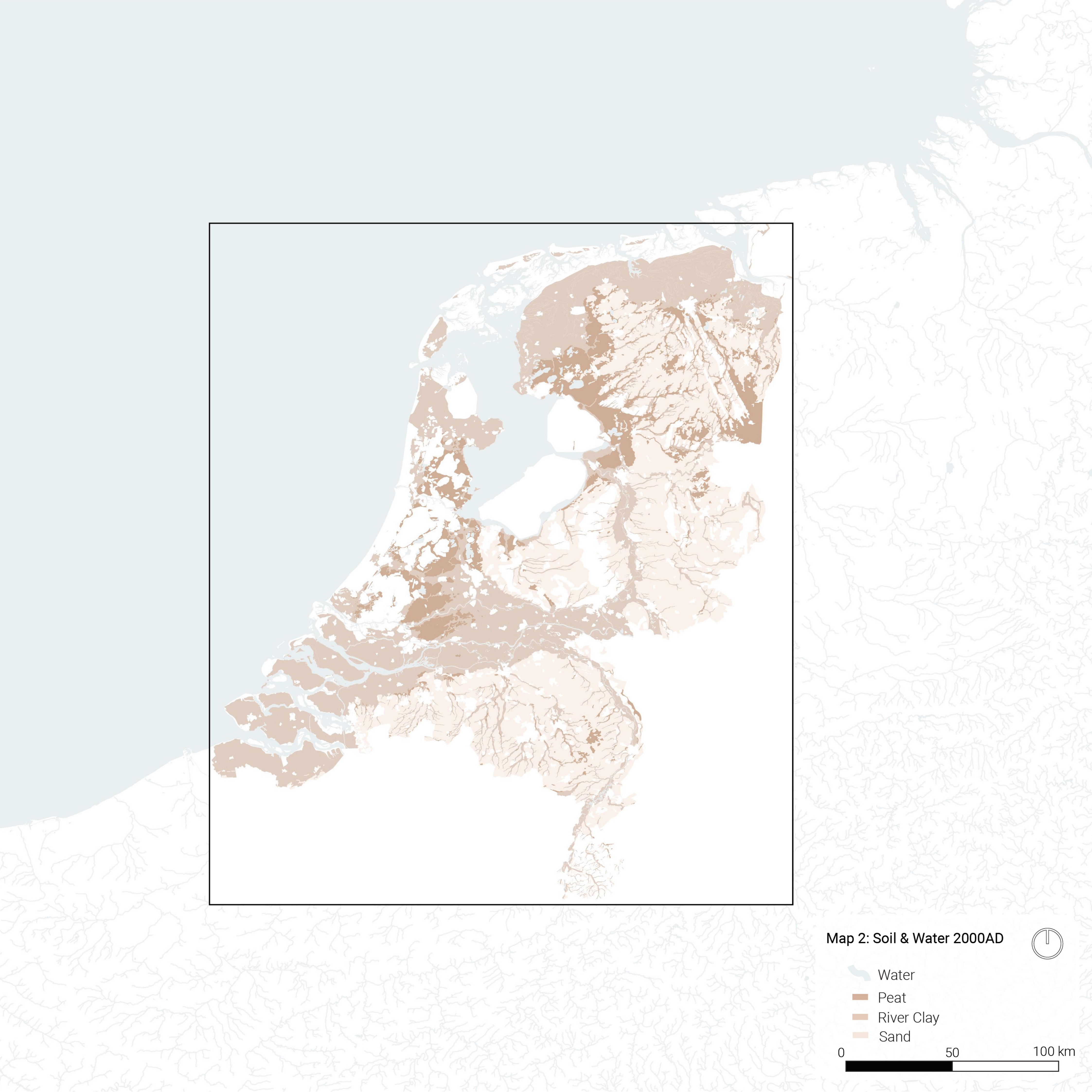


Figure 6 Netherlands' soil type and water flows through the ages (Ministerie van Onderwijs, Cultuur en Wetenschap, 2022)

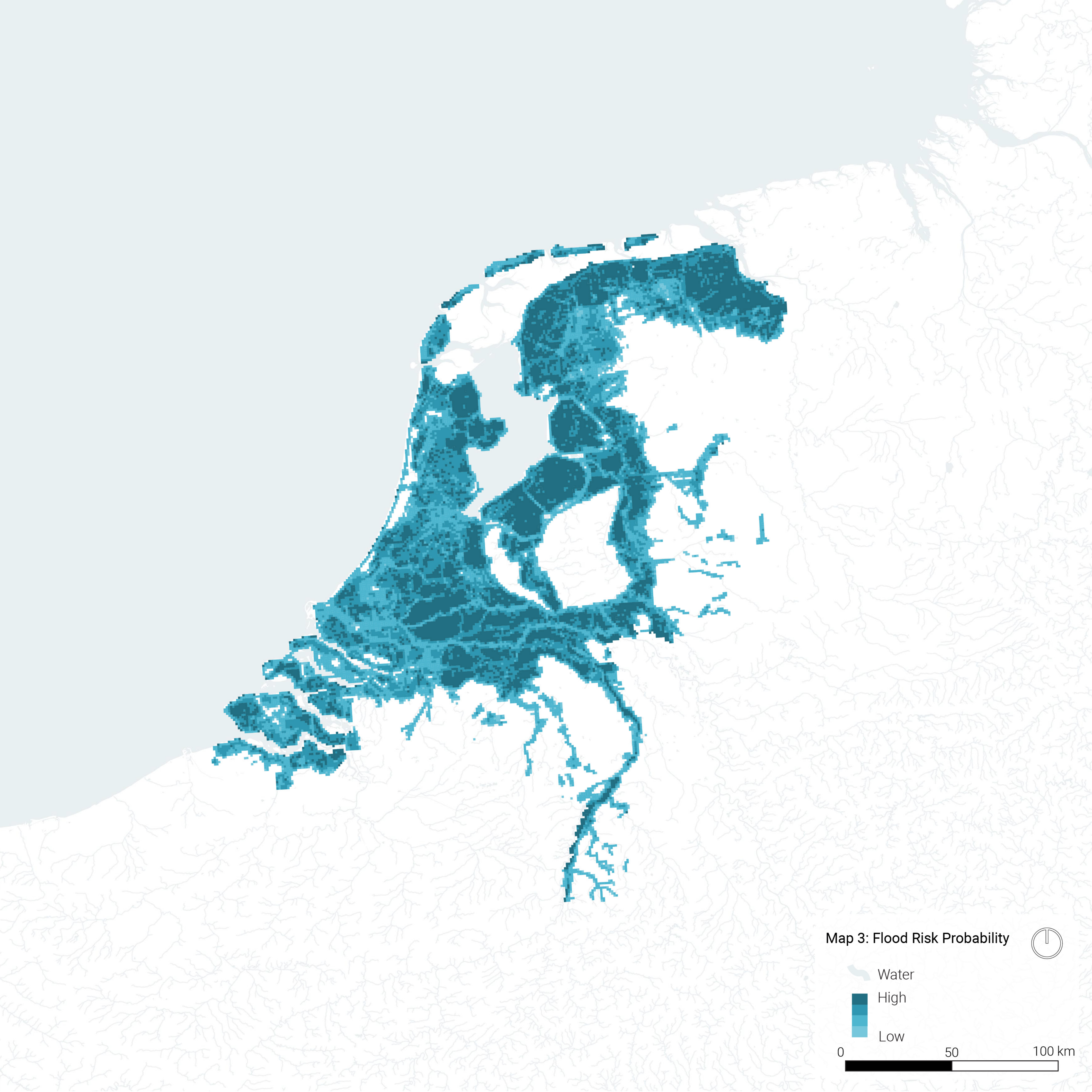


Map 2: Soil & Water 2000AD

02

Flood Risk

The Dutch landscape is well-protected against flooding, thanks to the Delta works and the reinforcement of many dikes (PBL, n.d.). However, the sea level is rising due to global warming caused by humans. Global warming leads to the addition of water from melting ice and glaciers, as well as the expansion of seawater as it warms (NASA, 2023).
Despite the Netherlands' robust flood defences, we cannot indefinitely hold back the rising sea levels. Approximately 59% of the Dutch landscape is at risk of flooding, with 26% lying below sea level (PBL, n.d.). This map illustrates areas with a high probability of flood risk and those with a lower probability, encompassing almost the entire Dutch landscape. This analysis is utilised to determine areas where a significant number of water dynamics can be created.


Map 3: Flood Risk Probability
Water
High
Low
0
50
100 km

03

Policies

In recent years, agricultural policies within the European Union (EU) have been subject to scrutiny and debate as they navigate the delicate balance between agricultural productivity, environmental sustainability, and socio-economic concerns. One such initiative is the collaboration between Staatsbosbeheer and farmers, wherein farmers committing to nature-friendly practices are granted opportunities to expand by leasing additional natural land. This policy aims to promote nature-inclusive farming while addressing concerns over land use and biodiversity. However, conflicts arise over the effectiveness of these measures in meeting policy goals, reflecting varying opinions among stakeholders.

CURRENT POLICIES

Common Agricultural Policy (CAP)

Common Agricultural Policy (CAP) are policies set by the proposed by the European Commision. The policies strive to secure a resilient future for agriculture and forestry, all while achieving the European Green Deal Objectives.*

European Commission. (2024 a)

Agreement between Staatsbosbeheer and Farmers

Farmers who commit to working in nature-friendly manners on their entire farm are granted opportunities to expand by leasing additional natural land from Staatsbosbeheer.

Staatsbosbeheer. (2024)

Nature restoration Act

Members of the European Union take nature restoration measures on 20% of European land and sea areas by 2030.

Haahr, T. (2024)

*The most recent, CAP 2023-27, positions its policies with 10 key specific objectives. The 10 key CAP 2023-27 Objectives are strongly linked to the European Union's goals for social, environmental and economical sustainability in agriculture (European Commission, 2024 a).
The Dutch's CAP Strategic Plan was jointly prepared through collaborations between the Dutch government, different provinces and the water board. The main objectives are strategized to support farmers who contribute to the transition to sustainable agriculture (European Commission, 2024 b).

CONFLICTS

Concerns about the effectiveness of concessions to farmers. Debates about the role of the EU in regulating agriculture.

Van De Wiel, C. (2024 a)

Protests and criticisms arise regarding the preferential treatment of animal-based products over plant-based alternatives, given their higher environmental impact.

Hanegreefs, S. (2024)

Concerns exist about the inequitable distribution of subsidies, with smaller farmers struggling and larger producers benefiting disproportionately.

Hanegreefs, S. (2024)

CAUSE

The Common Agricultural Policy (CAP) within the European Union (EU) allocates significant subsidies primarily based on land use, favoring animal production and crop cultivation for animal feed. Conflicts and disagreements arise due to the substantial proportion of subsidies directed towards high-emission animal products, contradicting EU's climate targets and broader environmental objectives.

Hanegreefs, S. (2024)

Concerns over the effectiveness of measures in meeting policy goals

Schreuder, A. (2018)

Differences in opinion between farmers and environmentalists regarding the feasibility and effectiveness of specific farming practices

Schreuder, A. (2018)

Opposition from the CDA due to concerns about its impact on European agriculture and food supply.

Van De Wiel, C. (2024 b)

Farmers express concerns about stricter obligations for reducing nitrogen emissions potentially affecting agricultural practices.

Van De Wiel, C. (2024 b)

The largest European agricultural organization, Copa-Cogeca, criticized the law for its perceived top-down approach, predicting increased costs and administrative burdens for its members.

Nijenhuis, H. (2024)

Conclusion

The intersection of agricultural policies, environmental conservation, and economic sustainability presents complex challenges for policymakers and stakeholders within the EU. Initiatives such as the Nature Restoration Act and the Common Agricultural Policy (CAP) 2023-27 strive to align agricultural practices with broader environmental objectives, but they are not without controversy. Conflicts persist regarding the balance between supporting agricultural productivity and mitigating environmental impacts, highlighting the need for ongoing dialogue and adaptation in EU agricultural policy to address evolving challenges effectively.

04

Agriculture

As mentioned earlier, the soil and water have been optimal for agricultural production in the Netherlands (De Wolf, 2022) for a long period of time, leading to the Netherlands now being the second-largest food exporter in the world (Government of the Netherlands, n.d. a). Diagram 1 illustrates this development with its key moments. In 1800, at the start of the French era, several administrative and legal reforms were implemented. These reforms resulted in a boom in infrastructure (Van der Woud, 2009).

After the Second World War, there was a remarkable increase in agricultural productivity (Feng, 1998). Because many people in the Netherlands were hit by an acute famine during the war, known as the Hunger Winter (Lumey & Van Poppel, 1994), a large-scale expansion of agriculture began afterward to prevent such an occurrence from happening again. Around 1950, a significant number of agricultural workers were attracted to rebuilding and industrialization, resulting in a shortage in the sector. However, this shortage led to a rapid development of mechanised agriculture, which, coupled with the large-scale expansion, contributed to the upward trend in the diagram (Feng, 1998).

A more recent development in the agricultural sector has been the introduction of genetically modified organisms (GMOs) around 2000 and the rapid increase in this type of agriculture. Since 1996, the global land used for GMOs has increased a hundredfold in size (E.A.S.A. Council, 2013). These developments have led to a rapid increase in the agricultural use of Dutch land. Currently, 54% of the land in the country is used for agriculture (CBS, 2020). In the analysis map of the current state of agriculture in the country, we have divided agriculture into three types: cultivated land parcels, arable land, and pastures. While all three types occur in the agricultural landscape, pastures make up the majority of it, while cultivated land parcels and arable land are mostly clustered in the southeast of the Netherlands.

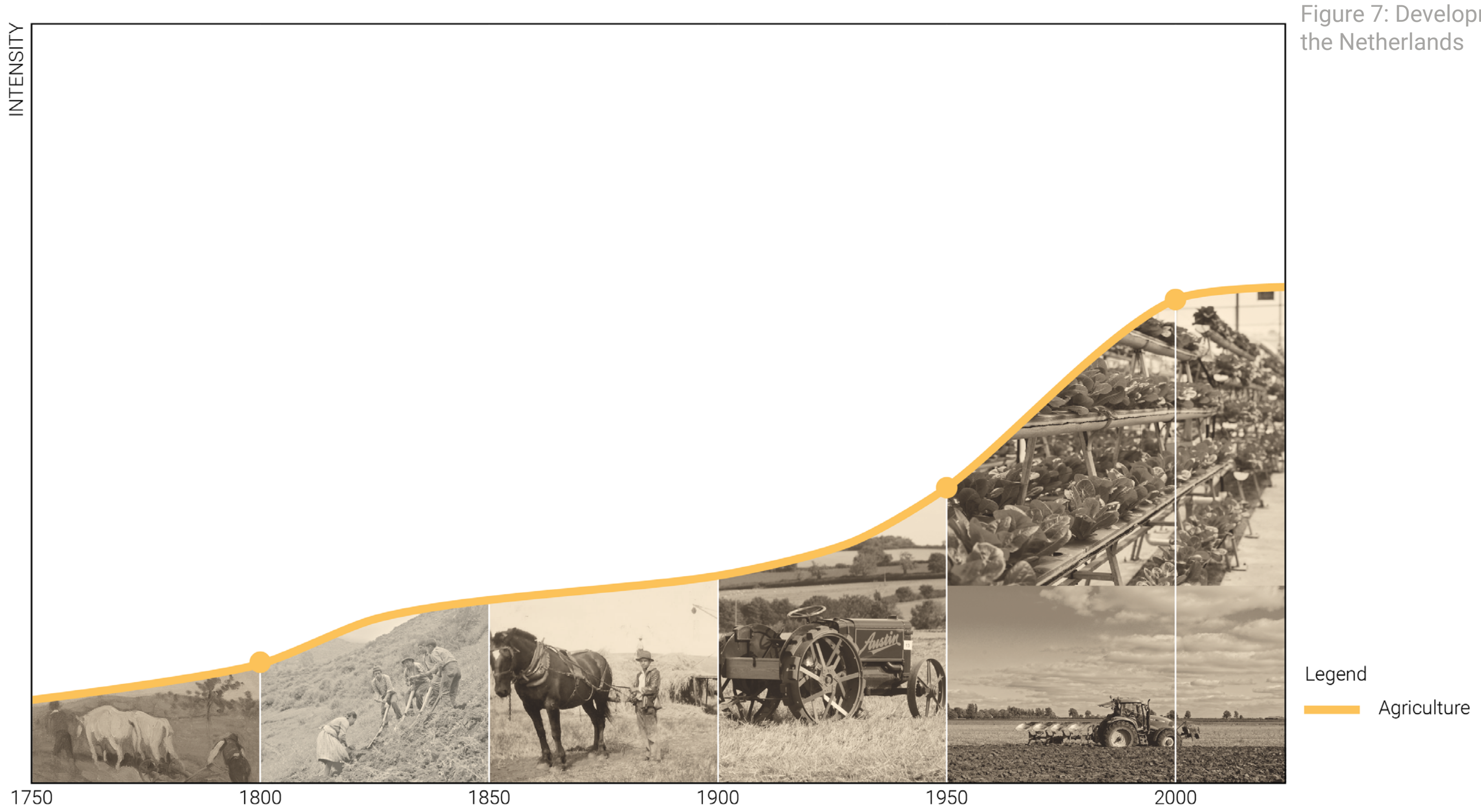
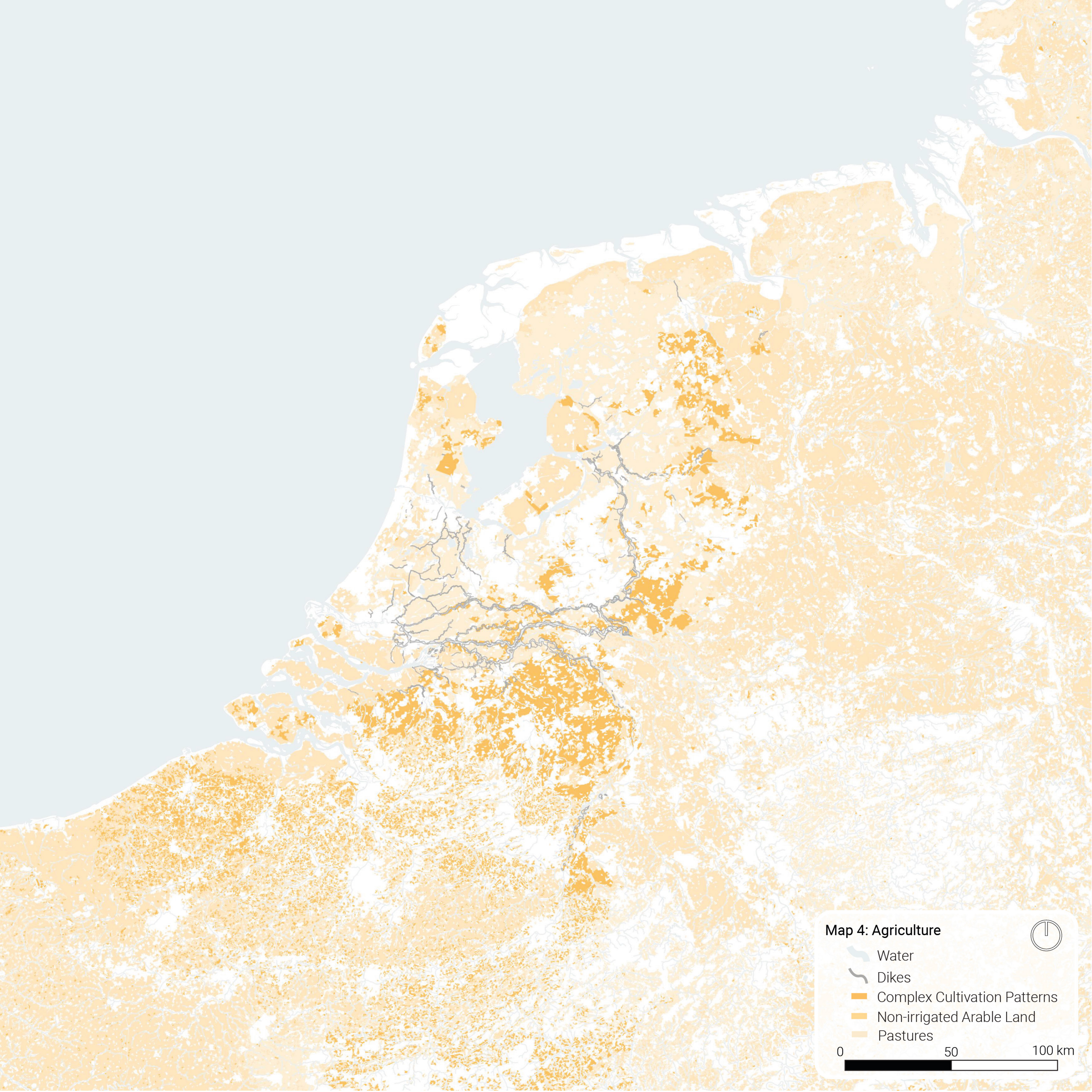


Figure 7: Development of Agriculture in the Netherlands


Map 4: Agriculture
Water
Dikes
Complex Cultivation Patterns
Non-irrigated Arable Land
Pastures
0
50
100 km

05

Nitrogen

Around 1850, industrialization began in the Netherlands. Larger machines were developed, and production became more focused on a mass scale. This development in industrialization had a significant influence on the need for new agricultural products and also created a demand for more infrastructure to support this agricultural development (Feng, 1998), resulting in increased nitrogen emissions.

The expansion of agricultural practices led to a rise in nitrogen emissions. In 1930, with the introduction of large-scale fertilisers, nitrogen levels increased even further. The use of fertilisers and artificial manure containing nitrogen directly enters the soil (Wageningen University, n.d. c). The surplus of nitrogen affects soil conditions and water systems, which brought about the realisation of the nitrogen problem around 2000. People had already become more aware of environmental issues since the 1980s (Feng, 1998). Nitrogen deposition has remained constant since 2010 (CLO, 2022). Currently, agriculture is responsible for 52% of our country's nitrogen emissions (CLO, 2024). In the neighbouring countries of the Netherlands, agriculture is also the primary source of nitrogen deposition. However, the amount of nitrogen emissions in the Netherlands is the highest in Europe and four times the European average. Of the nitrogen deposition in the Netherlands, 46% comes from agriculture, 6% from traffic, and 32% from abroad (Milieucentraal, n.d. b). The analysis map depicts the three highest levels of nitrogen deposition in the Netherlands. The hotspots indicate where the most significant nitrogen problems are, mainly situated in the southern and western parts of the Netherlands.

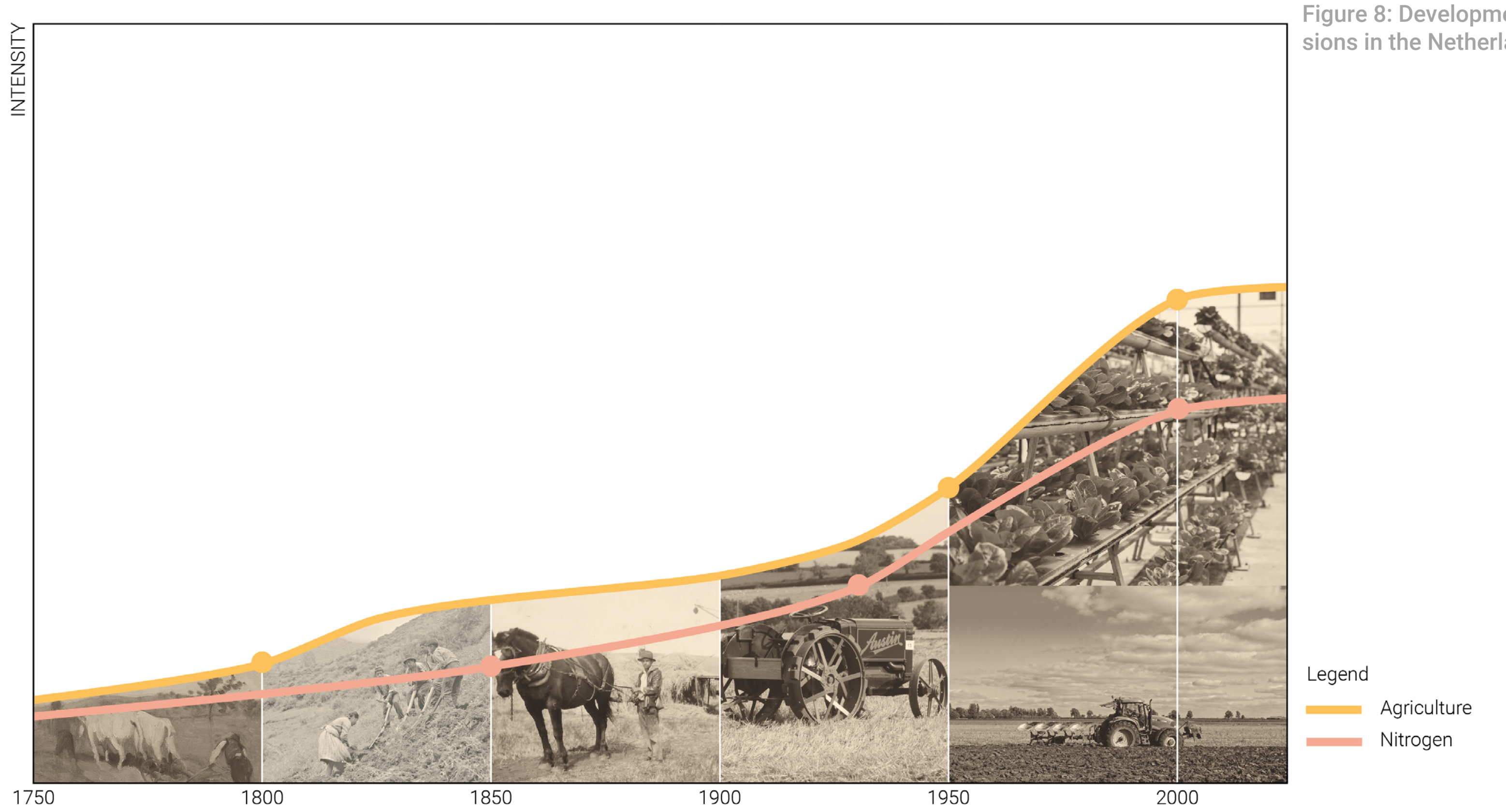
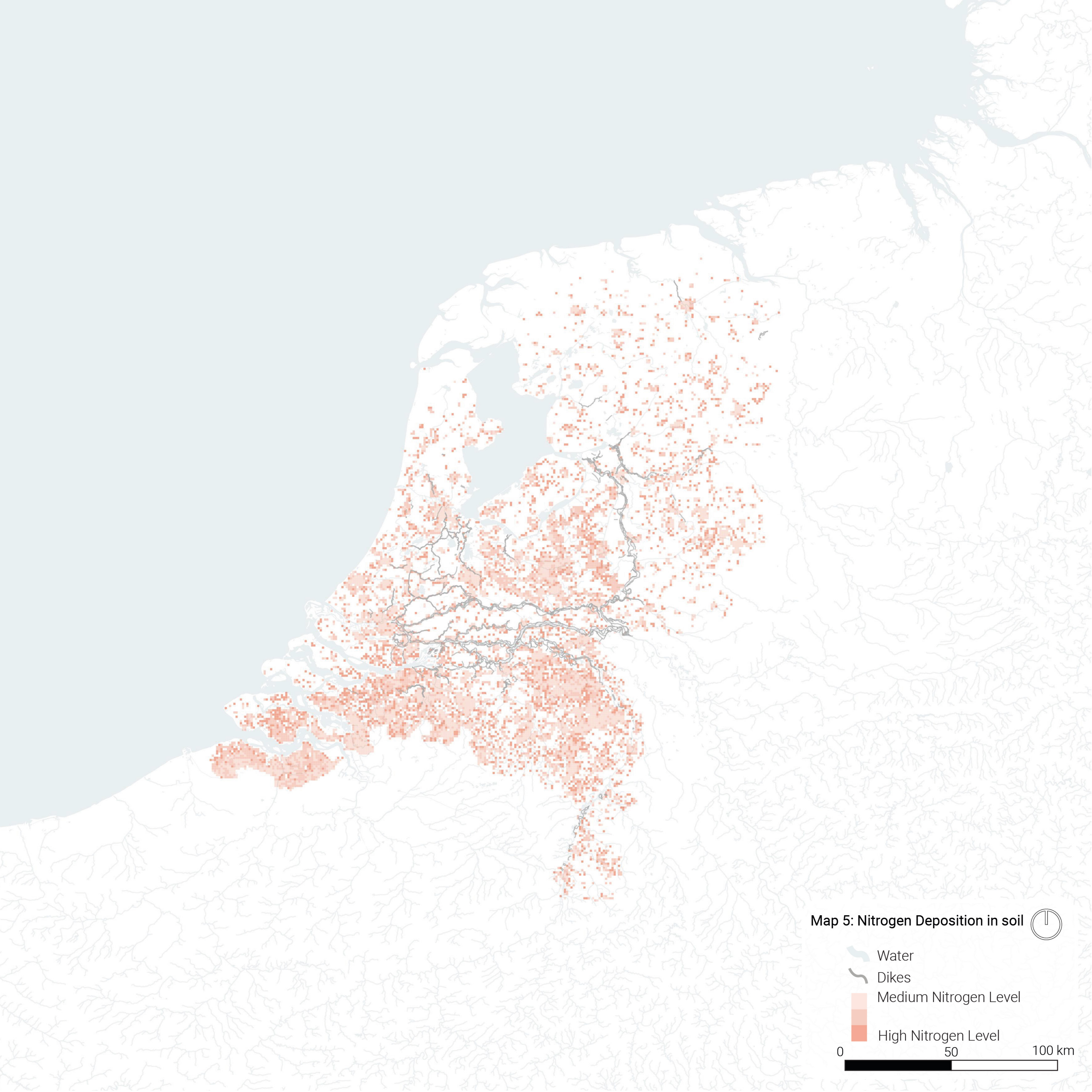


Figure 8: Development of Nitrogen Emissions in the Netherlands


Map 5: Nitrogen Deposition in soil
Water
Dikes
Medium Nitrogen Level
High Nitrogen Level
0
50
100 km

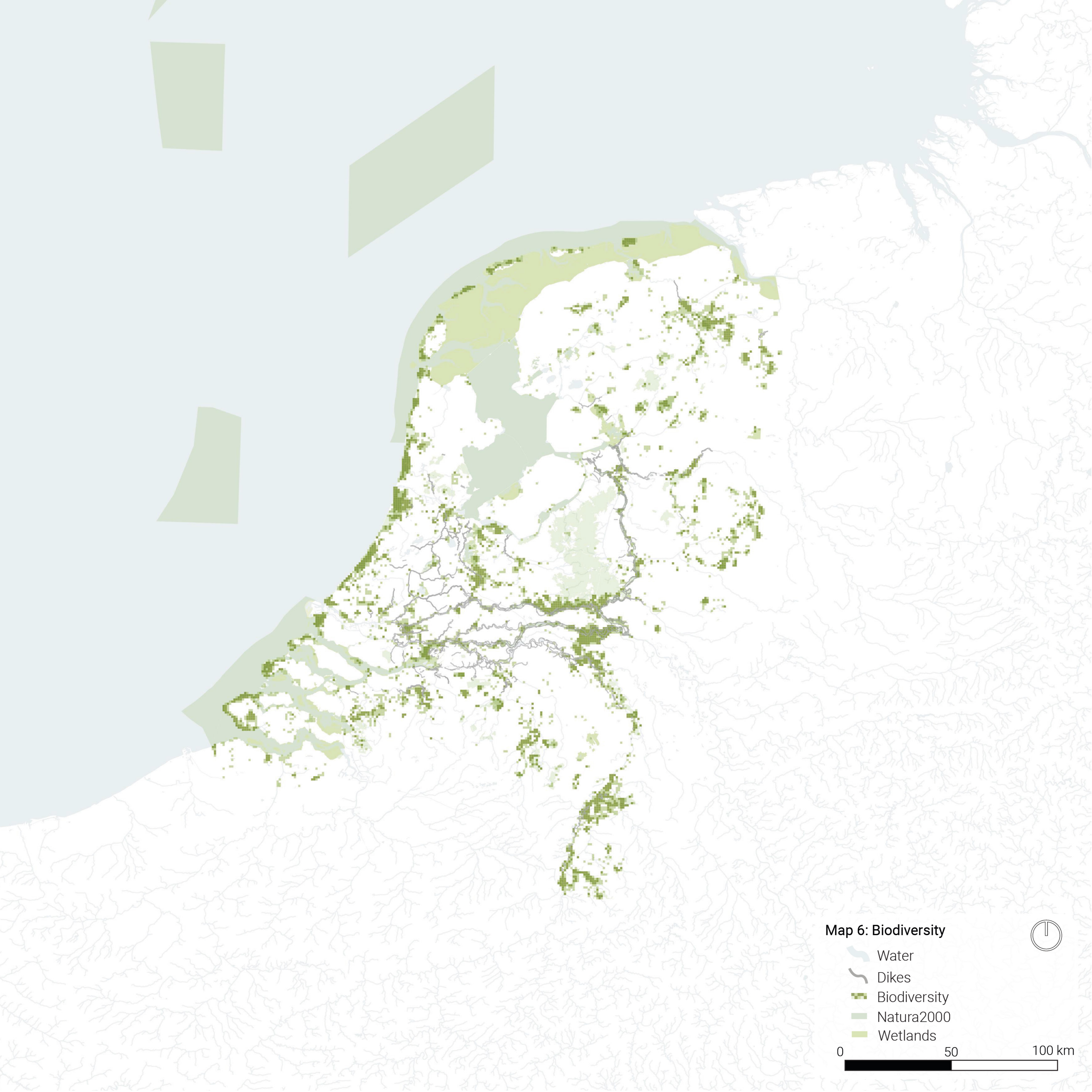
06

Biodiversity

There has been a remarkable and negative development in the amount of biodiversity present in the Netherlands, as evident in the diagram. In 1850, when the Industrialization era began, there was a decrease in space for nature due to the infrastructure needed for agriculture (Feng, 1998). During this era, the traditional bocage landscape, formed by big hedges which acted as green highways for fauna, were replaced by barbed wire to allow cattle to graze without supervision (Hoste, 2002). A century later, there was a large-scale agricultural expansion, coinciding with the widespread use of pesticides (Karel, 2010). Pesticides have a significant impact on biodiversity, as they have toxic effects on organisms in the short term and cause changes in habitat and food chains in the long term. Agricultural pesticides can reduce the abundance of plant species that serve as important food sources for various species (Isenring, 2010). Another major trend in agricultural development was the intensification of agricultural practices, with little attention to environmental issues (Feng, 1998). The excessive nitrogen levels rose rapidly and led to a decline in biodiversity and disruption of the ecosystem balance (De Vries, 2021). Fortunately, legislation for nature protection increased from 1970 onward (Janssen, 2009), which could positively affect the biodiversity curve, although it has not been entirely successful yet (CLO, 2013).

The analysis map depicts the location of wetlands, Natura 2000 areas, and the three highest biodiversity levels. Currently, wetlands are mainly found in the Wadden Sea. Natura 2000 areas are protected nature areas where certain species and their habitats are safeguarded to preserve biodiversity (Government of the Netherlands, n.d. b). The synthesis of the biodiversity map envisions biodiversity hotspots and biodiversity hotspots within Natura 2000 areas, both of which present opportunities for connecting these hotspots.

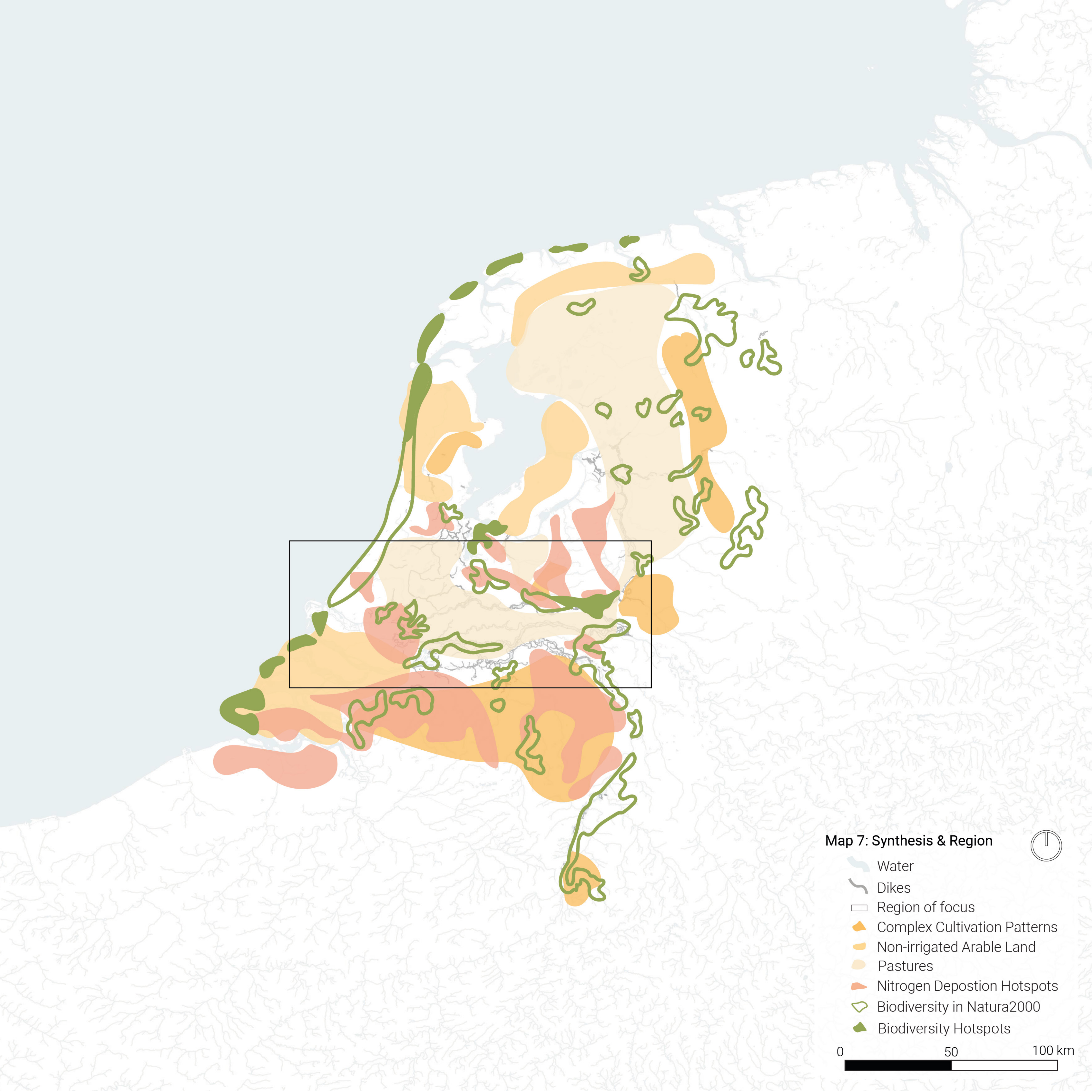
Figure 9: Development of Biodiversity in the Netherlands


Map 6: Biodiversity
Water
Dikes
Biodiversity
Natura2000
Wetlands
0
50
100 km

07

Synthesis

The development of these three themes—agriculture, nitrogen, and biodiversity—is highly interrelated, as shown in the diagram. However, these themes do not currently work together and instead have a negative impact on one another. For example, the increase in nitrogen emissions negatively affects biodiversity levels (CLO, 2013).
They are also closely linked to the quality of soil and water, as healthy soil and high-quality water can increase biodiversity and positively affect agricultural practices. By overlaying the analysis of agriculture, nitrogen, and biodiversity, the focus region emerges. This region encompasses all three types of agriculture, large nitrogen hotspots, biodiversity hotspots (including those within Natura 2000 areas), and is situated near the river delta.

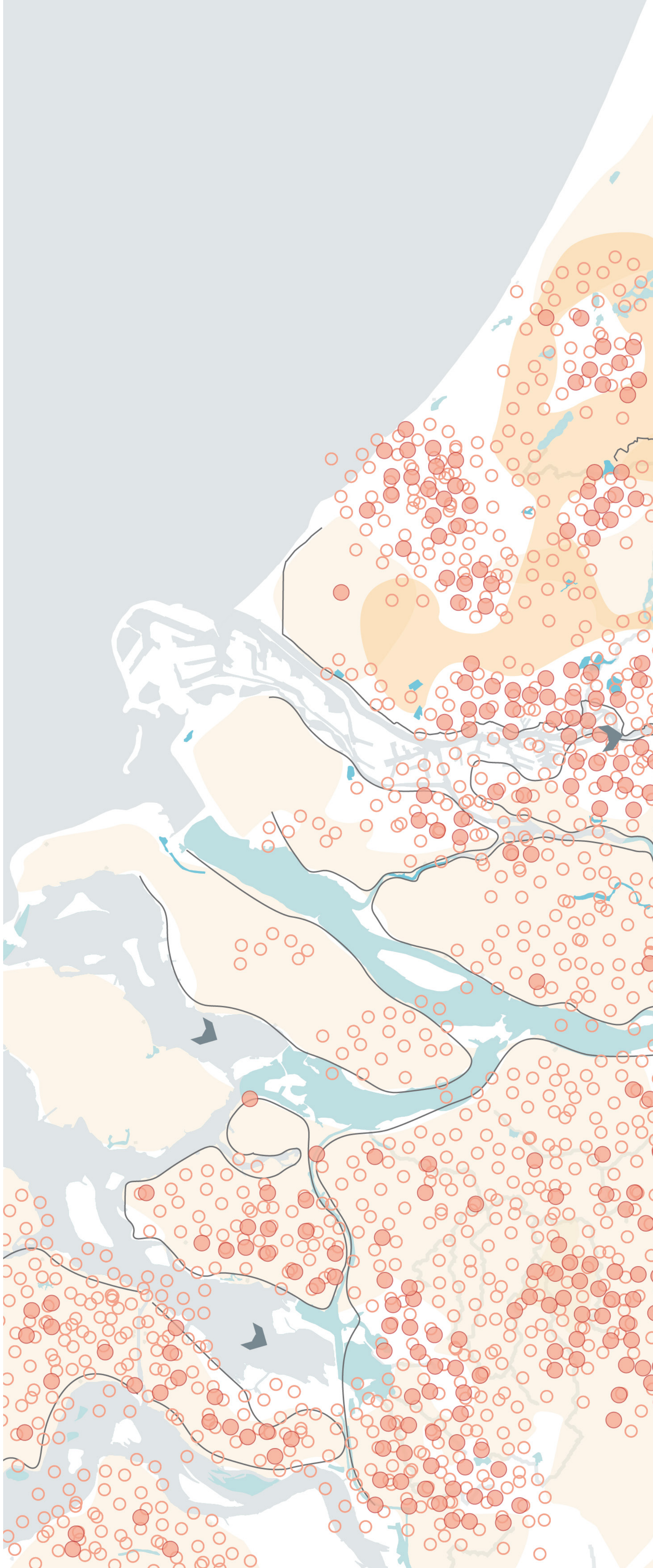


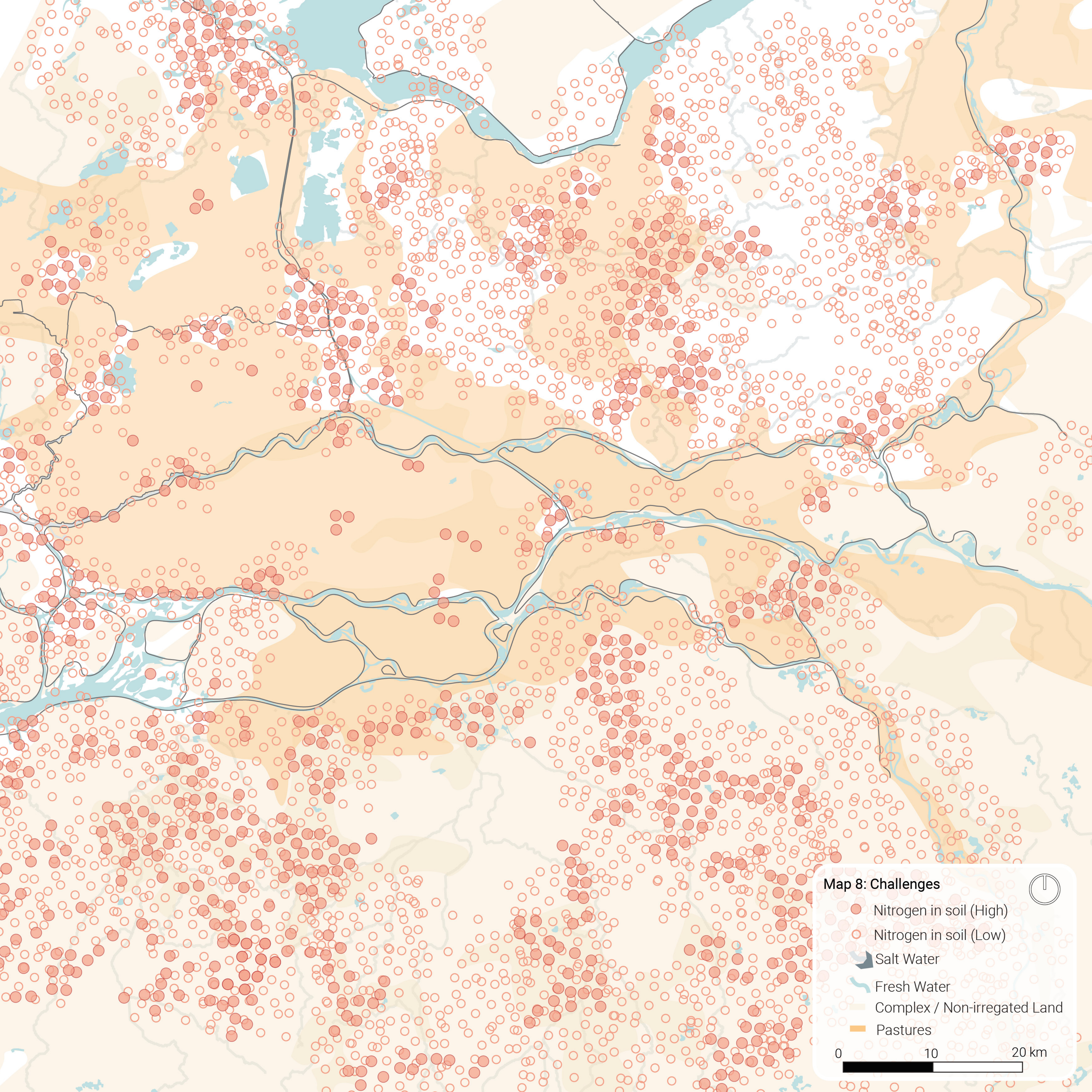
Map 7: Synthesis & Region
Water
Dikes
Region of focus
Complex Cultivation Patterns
Non-irrigated Arable Land
Pastures
Nitrogen Depostion Hotspots
Biodiversity in Natura2000
Biodiversity Hotspots
0
50
100 km

08

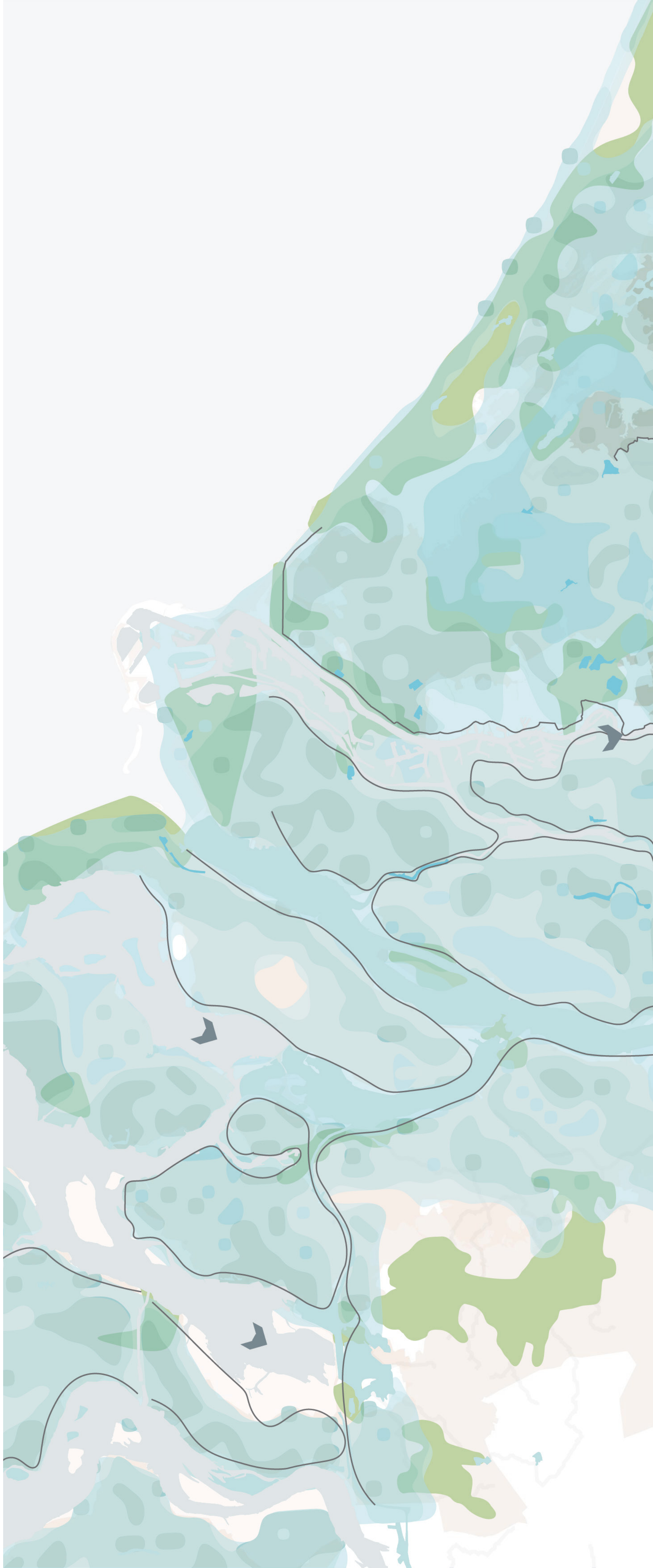
Challenges & Opportunities

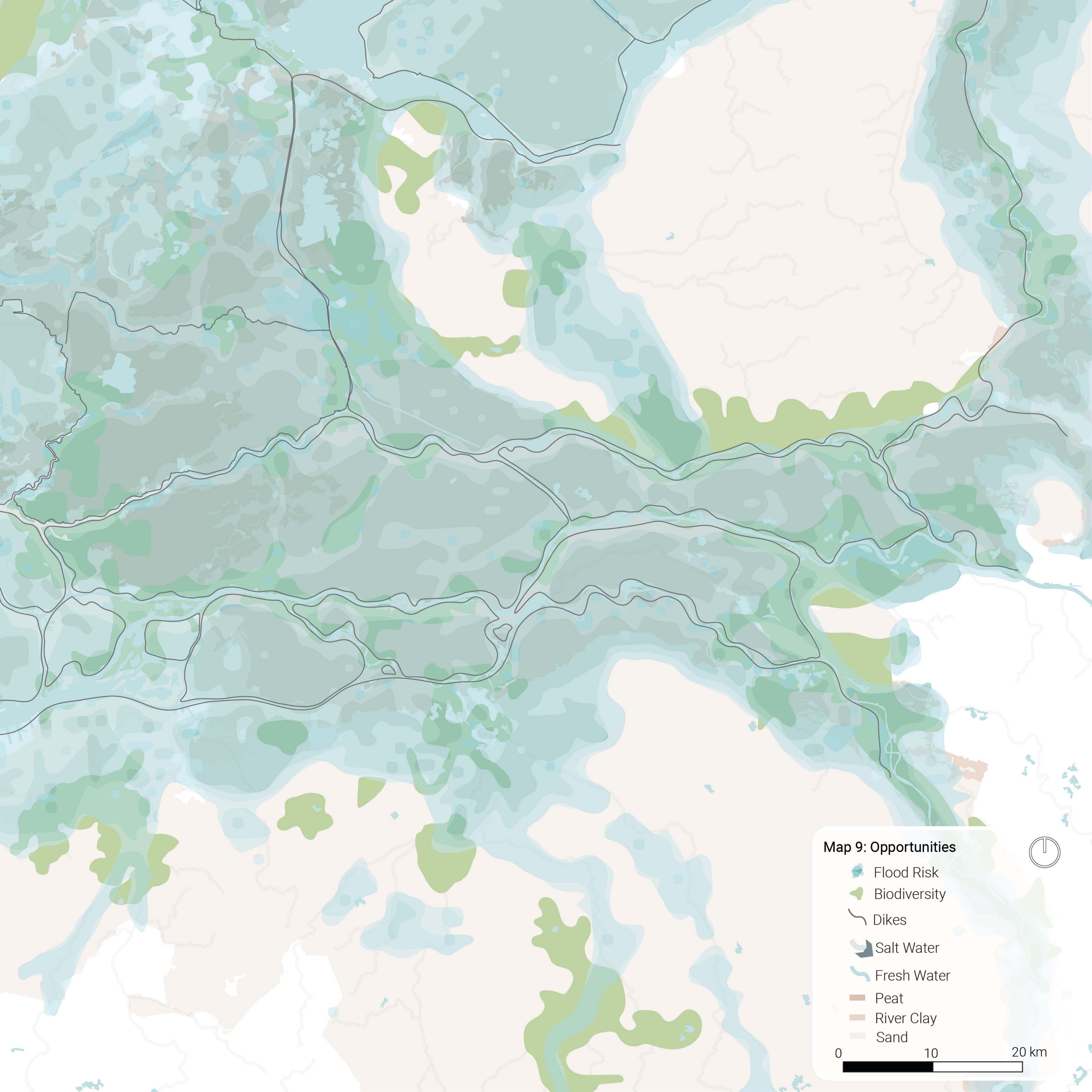
Zooming in on our Dutch Delta region, we encounter several challenges and identify numerous opportunities. One challenge in this region is the high level of nitrogen emissions, which needs to be significantly reduced. The sandy soils in the province of Brabant exhibit a high level of nitrogen, as depicted on the map. As discussed previously, these nitrogen emissions result from agricultural practices in the Netherlands. The map illustrates three types of agriculture, with pastures being the largest agricultural type, primarily used for cattle farming.




Map 8: Challenges
Nitrogen in soil (High)
Nitrogen in soil (Low)
Salt Water
Fresh Water
Complex / Non-irregated Land
Pastures
0
10
20 km

The possibilities map illustrates the flood risk of the region alongside biodiversity hotspots and soil types. While flood risk is often viewed as a challenge, it can be transformed into an opportunity by embracing the natural flow of water. The fluctuation of water levels presents an opportunity for a healthier river landscape with ecological systems along the river basins. This is where the opportunity to connect biodiversity hotspots aligns with utilising the flow of water. By doing so, biodiversity hotspots can become less fragmented, creating a green network. Additionally, the map includes dikes, as transforming them enables the natural flow of water, presenting another opportunity. As demonstrated in the analysis, water and soil are closely interrelated aspects. The presence of three distinct soil types—sand, river clay, and peat—offers the opportunity to align land uses with these soil types under conditions of water fluctuations. Addressing these challenges and seizing these opportunities necessitates a better-balanced system between agriculture, nitrogen, and biodiversity.




Map 9: Opportunities
Flood Risk
Biodiversity
Dikes
Salt Water
Fresh Water
Peat
River Clay
Sand
0
10
20 km

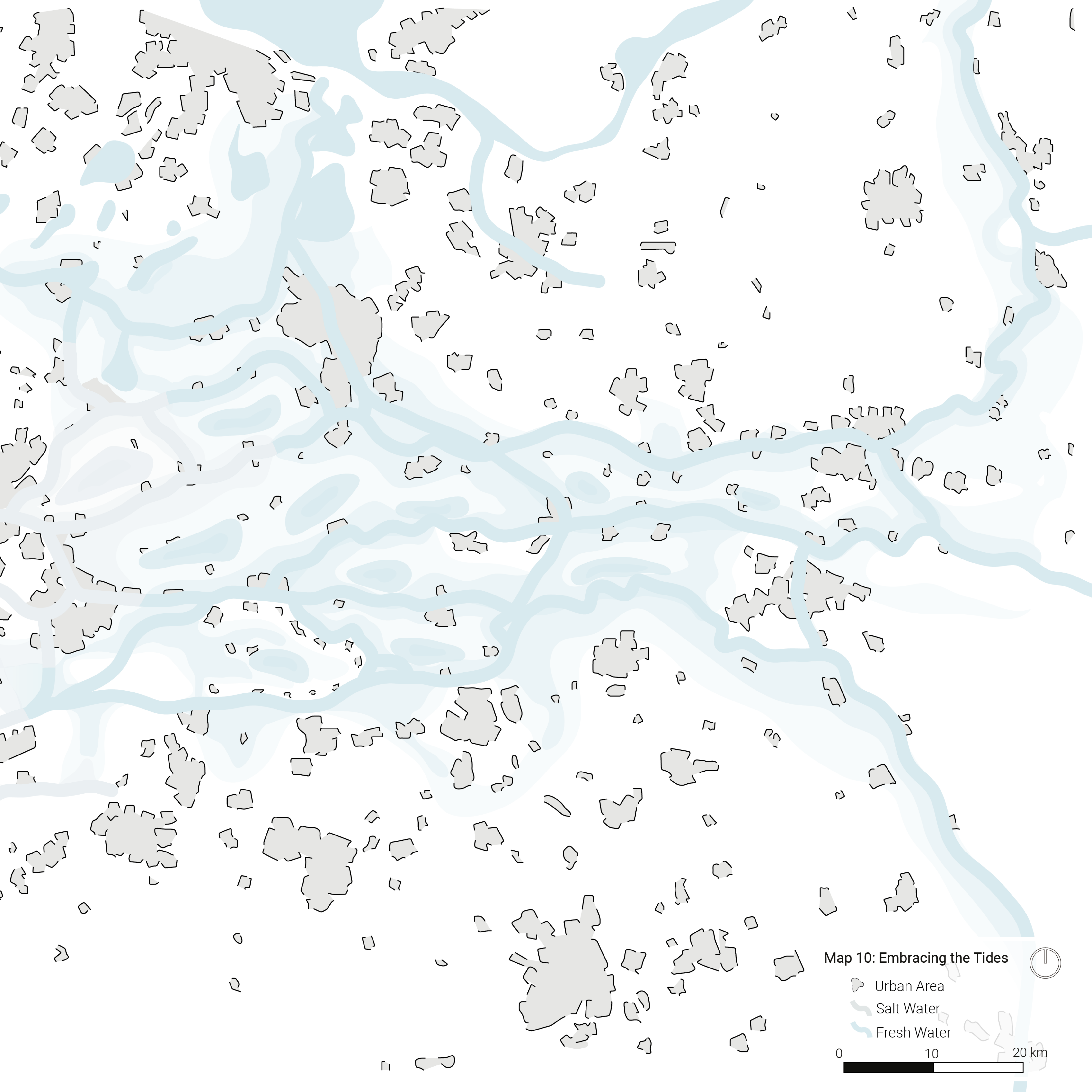
04

Go with the flow

01

Embracing the Tides

The Dutch Delta region will be envisioned as a dynamic river landscape, where the river flows freely, unconstrained by human control. The historical analysis of water features illustrates the morphological changes of the river landscape over the years and depicts the natural flow patterns of water. The vision aims to restore these natural flows, resulting in the river becoming dynamic once again by allowing tidal fluctuations in the river delta. With water levels fluctuating over time, land uses can adapt to these varying conditions, including changes in soil conditions. These new soil conditions present opportunities for introducing sustainable land uses. Water fluctuations result from transforming dikes into softer borders, allowing water to flow into the landscape and naturally rise along the relief. Dikes are relocated to protect main urban areas, while a green network of wetlands is established in river basins to restore biodiversity and enhance the resilience of the river delta region. In addition to wetlands, floodplains are integrated into the dynamic landscape, transitioning into seasonal agricultural polders that are submerged at certain times of the year. This sponge-like area serves as a natural buffer between the river landscape and agricultural and urban areas.


Map 10: Embracing the Tides
Urban Area
Salt Water
Fresh Water
0
10
20 km

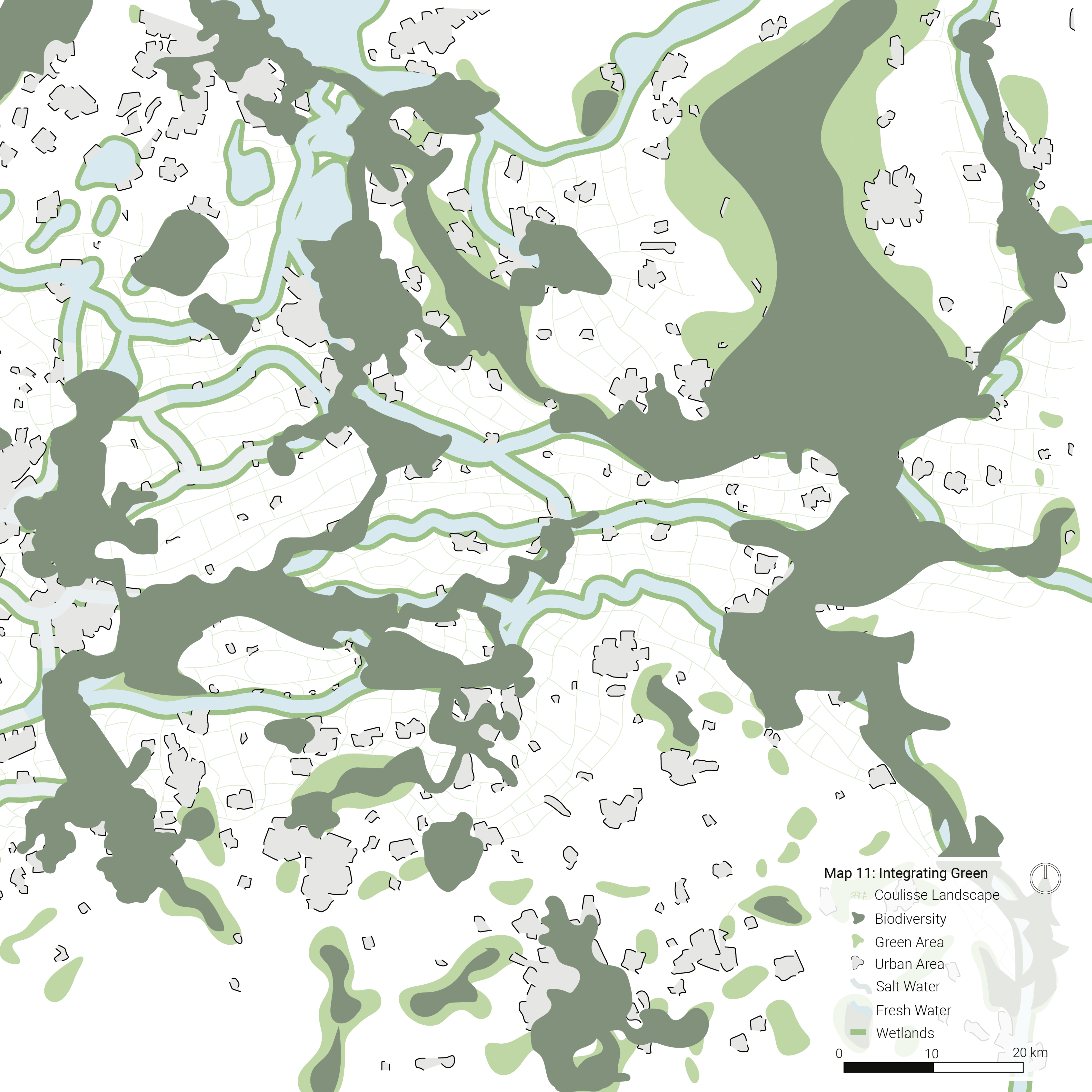
02

Integrating Green

Go with the Flow proposes to achieve balance among nitrogen emissions, agricultural practices, and biodiversity. As indicated by the analysis, biodiversity in the Dutch river Delta currently concentrates in certain areas, but embracing the natural dynamics of the landscape will foster biodiversity and establish a green network.

Arable land will be utilised for sustainable agricultural practices, incorporating herb-rich grasslands. Implementation of crop rotation and rotational grazing will significantly enhance the biodiversity of the land (Bellocchi & Picon-Cochard, 2021; USDA, n.d.; Van Dijk et al., 2012).

With water given more space to flow freely, streams will have the opportunity to meander naturally, aiding in the restoration and preservation of biodiversity. Nature buffer zones along the streams will provide areas to enhance ecosystem resilience against extreme impacts, such as climate change (Eurosite, n.d.). Wetlands will emerge where water meets land, fostering a biodiverse landscape (Wetlands International, n.d.), while the coulisse landscape will be reinstated as a fine-meshed connection between natural zones. By 2075, we envision a landscape abundant with bocage, offering excellent habitats for animals to seek shelter and birds to breed (Koers, 2014).


Map 11: Integrating Green
Coulisse Landscape
Biodiversity
Green Area
Urban Area
Salt Water
Fresh Water
Wetlands
0
10
20 km

03

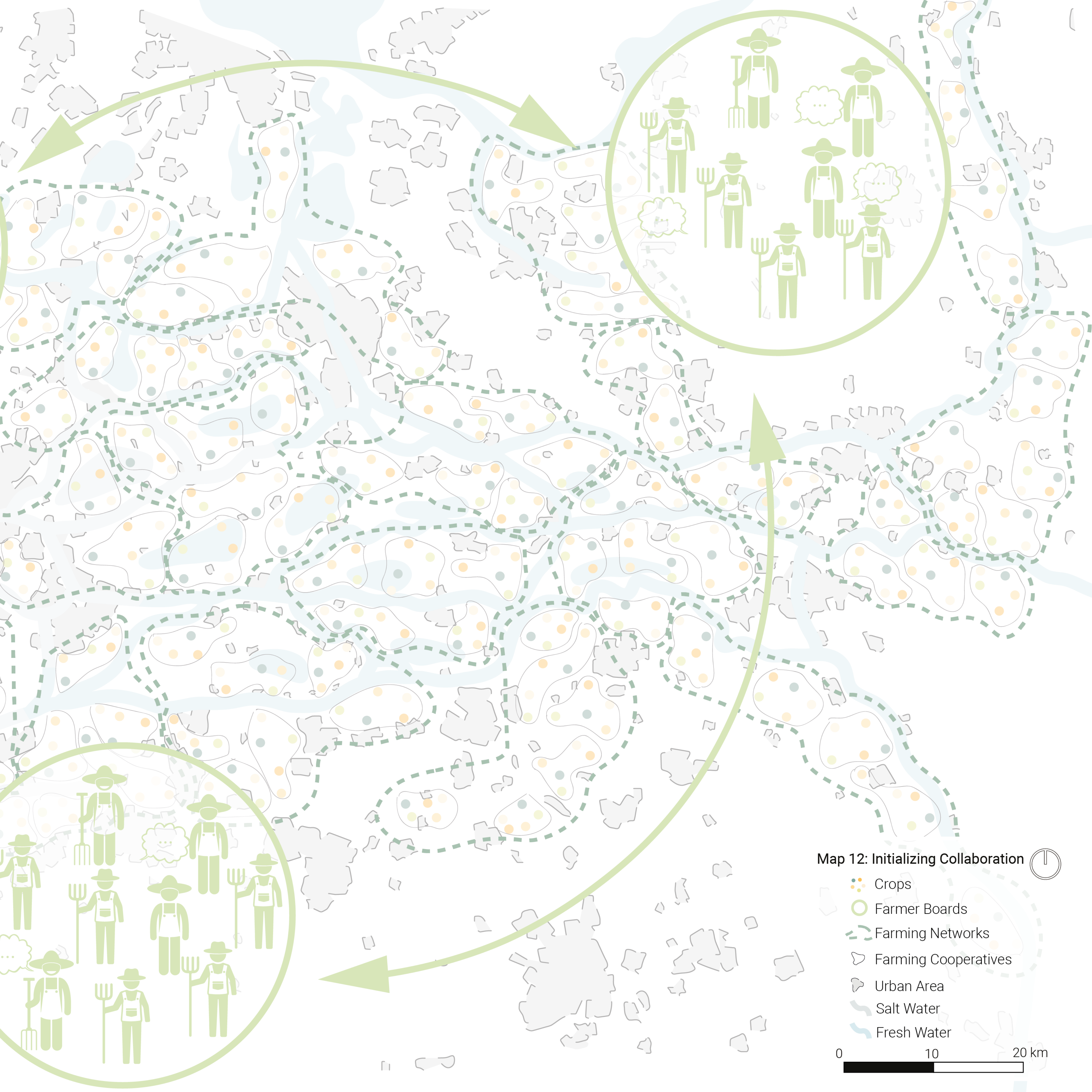
Initializing Collaboration

Go with the Flow proposes a change in how we perceive the Dutch agricultural landscape. Instead of fragmented parcels focused on uniform crop production, we suggest viewing land as a shared resource. Cooperative systems of farmers would oversee sustainable farming practices and the land on which they produce. While Hardin (1968) warns of overexploitation of shared resources due to only looking out for individual good, Diez et al. (2003) argue that cooperatives with effective arrangements can mitigate this risk.

One such successful example of a self-governing institution is a group of farmers in the national park Noardlike Fryske Wâlden (NFW) in the north of the Netherlands (Oudman, 2024). This is a cooperation of farmers who try to develop a form of self-management to strengthen the local economy and ensure its sustainability (Van der Ploeg et al., 2010). In the NFW, the initiative for this collaboration came from the farmers, and currently, nearly 800 farmers manage and preserve the landscape together in this bottom-up cooperative. They believe that biodiversity and sustainable agriculture are necessary for the agricultural sector, as this sector provides food and employment opportunities, among other things (Postma, 2022).

The example of the NFW serves as a valuable model for sustainable management of a common resource, particularly arable land/agriculture. Our goal is to encourage farmers in our region to view their land as a shared resource, and to achieve this, we propose a re-parcellation of agricultural land along with the implementation of new rules governing sustainable agricultural practices through governmental policies. These policies include measures such as a minimum amount of different crops cultivated and a maximum amount of cattle. Re-parcellation will spatially organise farmers into groups, while the policies are implemented to facilitate collaboration among farmers. Farmers who comply with these policies within ten years will be rewarded with benefits, such as tax breaks, while those who fail to comply after ten years will face fines. Through these initiatives, we aim to foster collaboration among farmers and ensure the sustainable management of agricultural practices for the future.

In our vision of the future, agricultural practices are organised across various scales that stimulate cooperation and facilitate optimal coordination. From largest to smallest, these are: Farming cooperatives, Farming networks, Farmer board.


Map 12: Initializing Collaboration
Crops
Farmer Boards
Farming Networks
Farming Cooperatives
Urban Area
Salt Water
Fresh Water
0
10
20 km

Farming Cooperatives

The farming cooperative is the smallest scale at which farmers work together, typically consisting of approximately 30 farmers. At this scale, it is easy to coordinate with the entire group, yet the group is not too small to benefit from economies of scale. The most important aspect of being in the farming cooperative is land sharing; each farmer receives a share of the land based on their land input into the cooperative. Crop rotation, using a 6-year system that does not exhaust the soil, is also designed collectively to provide a larger scale for rotating crops. In this cycle, farmers jointly agree on which crops are grown within the cooperative's territory. Because farmers know their own practices better than anyone else, they are the most capable of monitoring how their colleagues are functioning. This responsibility of checks and balances among cooperatives prevents control from being carried out using public resources.

Farming Networks

The next scale is the farming network, where approximately 5 farming cooperatives are united. Burdens and benefits can be ideally redistributed at this scale, and knowledge can be exchanged more effectively: experts in specific areas within each cooperative can share their knowledge with experts from other cooperatives. Ideally, the municipality maintains contact with farmers at this scale. Representatives from the various cooperatives are appointed to the farming network. These representatives then consult with a municipal representative. This approach limits direct interference from the municipality on a smaller scale and ensures efficient use of public resources without limiting farmers' access to the government, and vice versa.

Farmer Boards

The most large-scale collaboration between farmers is the farmer board. This body, which includes all farming networks on a regional scale, will consist of approximately 20 boards within the Netherlands. In the farming board, farmers themselves determine the rules that are delegated to the networks and cooperatives. Additionally, it serves as a platform for direct consultation with higher levels of government, such as the ministry and the provinces, to formulate policy collaboratively. This arrangement also provides the government with more direct access to the stakeholders for whom it develops policy: the farmer board functions as a sounding board group and is involved in early policy-making phases.

General advantages

Knowledge: The first general benefit of a farming cooperative is knowledge sharing. Since different farmers have different expertise, an expert can be brought in within a collective for each specialised task. Also, considering the new sustainable forms of agriculture and seasonal farming and paludiculture, it is advantageous to be able to benefit from the knowledge present within the community in a knowledge-intensive farming practice. This reduces the investment of time and resources.

Sharing of risk: In addition to sharing knowledge, sharing risk is an important advantage of collaboration among farmers. In the event of unforeseen setbacks, such as drought, crop failure due to pests, or unfavourable market conditions, it is easier to bear the consequences with a larger group. Furthermore, within the cooperative, a certain crop may be less successful, while another crop performs well in a specific year. In this case, advantages and disadvantages can be equalised.

Less administration: A survey conducted by a farmers' platform among hundreds of farmers reveals that 80% of farmers affiliated with this platform spend between 5 and 8 hours a week on administrative tasks. Of these, 7% even spend more than 10 hours a week on administrative duties. Additionally, 88% of farmers believe that their administrative workload will further increase in the next 5 years (Uiennieuws, 2022). This underscores the significant administrative burden on farmers, and looking ahead, it would be highly beneficial if farmers could collectively manage their administrative tasks within a cooperative. The benefit extends beyond saving time to saving money as fewer advisors would be required.

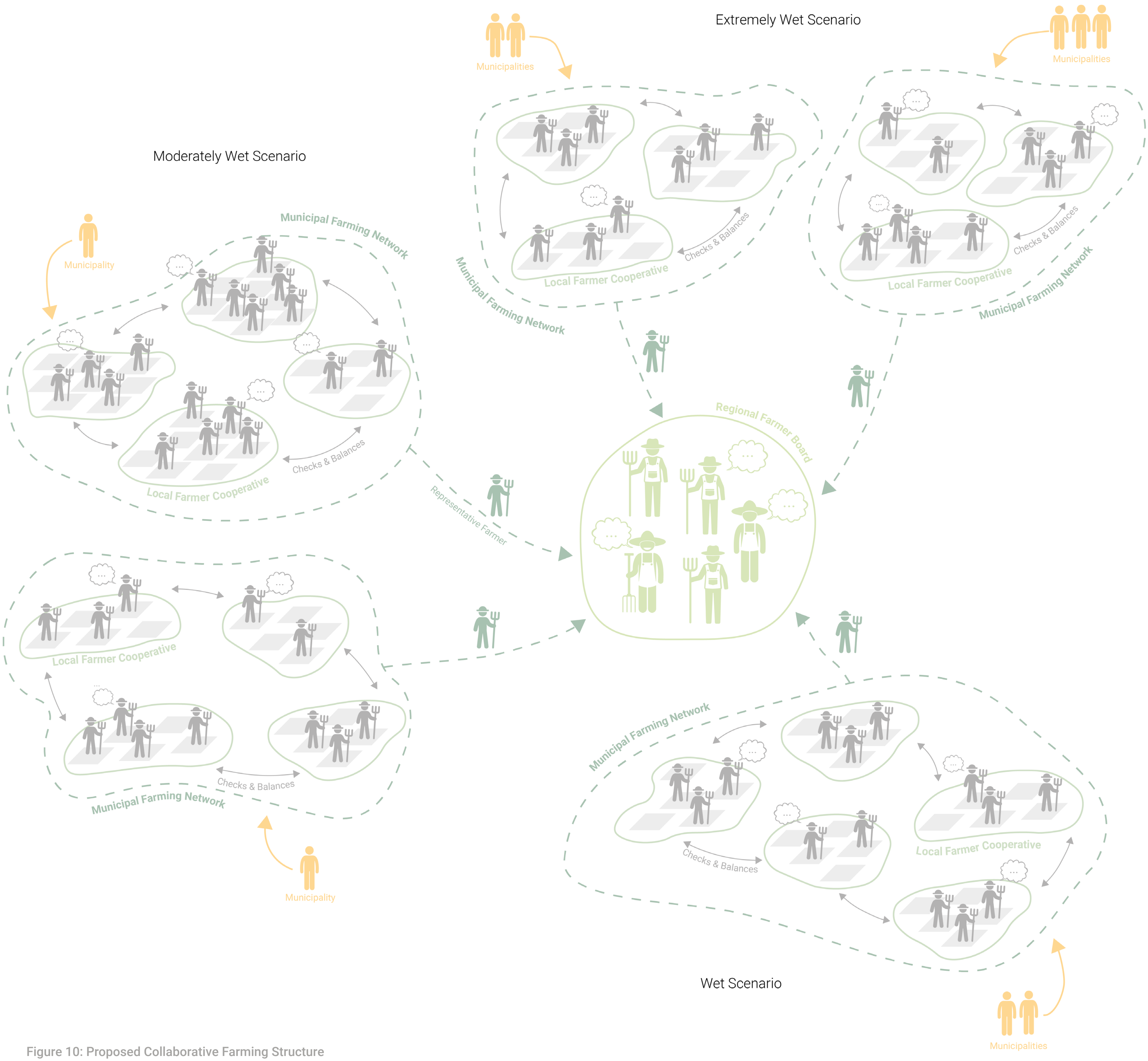


Figure 10: Proposed Collaborative Farming Structure

Financial advantages

Joint financial loan: The most renowned agricultural lending bank in the Netherlands is Rabobank. This bank holds a responsibility to promote sustainability among farms that have loans with them. Banks have frequently been the subject of climate protests in the past, as they are perceived to be partially accountable for the nitrogen crisis. Despite the availability of subsidies to regulate farm expansion, banks still face financial risks due to the escalating requirements imposed on farms (Smit, 2023). Providing loans to a cooperative rather than an individual farmer presents an opportunity to lower the interest rates for the farmer, as the risk for both parties diminishes.

Buying of goods: The advantage of farmers purchasing cooperatively is a lower purchase price. Purchasing on a larger scale allows for a reduction in the unit price. This benefit is passed on to all farmers, leading to lower fixed costs (Candemir, Duvaleix & Latruffe, 2021).

Sharing of equipment: Sharing agricultural equipment, such as tractors and implements, ensures lower purchase costs per farmer. Maintenance costs will also decrease.

Tax cut: Another financial benefit that can be provided to farmers in a cooperative is a tax reduction. This makes it attractive to work together and jointly arrange the cooperative's finances. The government spends less money on monitoring individual farmers, resulting in more financial leeway to reduce taxes.

Joint selling of goods: A financial option for farmers is to sell goods together. If they manage a sales point together and sell their goods directly to the consumer, a smaller investment is required per farmer than if they each had their own sales point. An additional advantage is that there is no longer any mutual competition, resulting in a fair price.

Shared opportunities

Tourism: Developing initiatives related to tourism is easier to tackle collectively than individually. Accommodations and facilities, such as camping grounds, nature trails, and dining locations, can be incorporated on a larger scale. The investment per individual is lower, and the profits can be shared.

Educational and social events: As a follow-up to the opportunity to develop tourism, educational and social events can also be organised because there are sufficient resources available within a cooperative. This allows the farmer's task to shift to informing and offering experiences. This offers rich opportunities to join municipal and social initiatives.

Natural stewardship: Nature stewardship by farmers can be more easily implemented on a collective scale: nature is larger in scale than the property of an individual farmer. It is also easier to assess the results of farmers' efforts to maintain and strengthen nature. The various tasks involved in protecting nature can also be better divided among farmers on a larger scale because there is more insight into who is available at what times for stewardship-related tasks.

05

DYNAMIZING THE DELTA

01

Introduction scenarios

Introduction to the exemplary frames

The new dynamic system can be implemented in various ways, depending on the current conditions of the main components: water, agriculture, soil, and additional determining factors such as flood risk, nitrogen pollution, and the presence of dikes and nature.

Since all these elements work together in a complex way (Lee, Melching, & Wang, 2014), the possible outcome of increasing natural dynamics is very different. To illustrate this, three example locations have been chosen that demonstrate the broadest possible scope of dynamic potential and typologies of potential.

These locations are introduced based on the potential to increase water dynamics, as follows.

Dynamic schemes introduction

The success of implementing dynamics within each location can be measured by their presence throughout the year. The timeframes, displayed with each location, illustrate both the long and short-term processes occurring within this yearly cycle, indicating the coexistence and change of natural, agricultural, and human processes. Certain dynamics, such as river flooding, sustainable agriculture, and tourism, are common across all areas, while aquaculture and moraine groundwater flows are unique to specific locations.

Therefore, each scenario shares some common undertones while also possessing unique elements that define the ‘music’ of the new dynamics. This uniqueness makes the sound recognizable in nature and provides a distinct experience specific to each location.

Figure 11: Collage Pilot Projects

1. Meuse Dunes

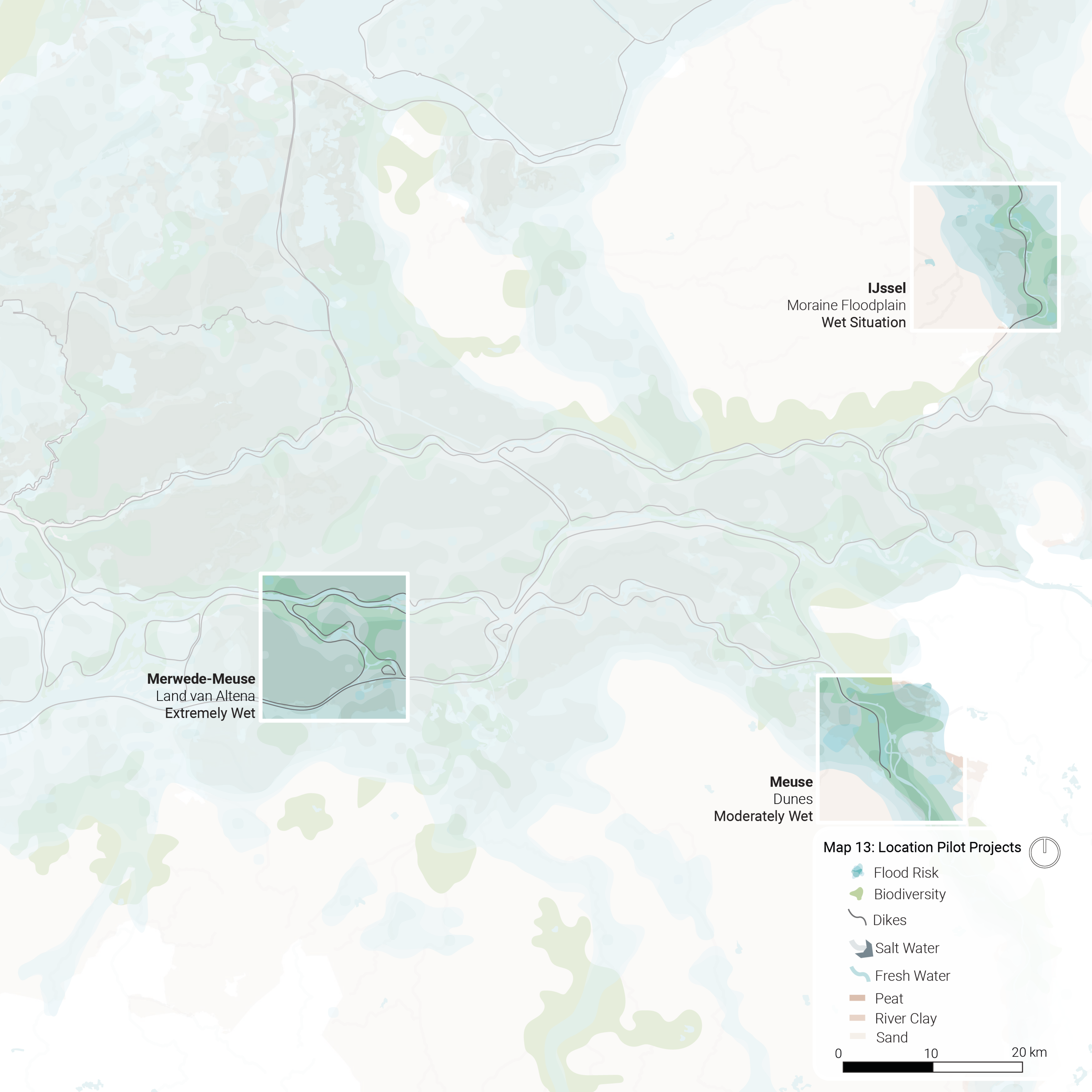
This scenario represents areas with sandy soil and a limited flood risk. In these areas, the flood risk is often limited to the floodplains of the rivers due to the presence of higher sandy soils or river dunes. Additionally, there are scattered forest areas that alternate with agricultural land. Due to these limited options, the measures can be implemented within the shortest time frame, with completion expected by 2035.

2. IJssel Moraine Floodplain

The IJssel Moraine Floodplain is an example of an area with a unique moraine landscape. These areas may exhibit an extreme height difference of approximately 70 metres within a short distance from the rivers, which is unusual by Dutch standards. The dynamics are greater than in scenario 1. Many different soil types are present, including sand on the moraine, peat in the stream areas, and clay in the river zones. The dynamics of the rivers are further influenced by the landscape dynamics of streams and underground seepage flows.

3. Merwede-Meuse River Polder

The Merwede-Meuse River Polder represents river polders with clay soil. Almost all the land in these polders is below the water level of the rivers, with the exception of the dikes. Moreover, tidal dynamics are present in some parts. The predominantly agricultural area within the dikes, recognizable by the rectilinear allotment and waterways, is a man-made landscape. This creates very rigid conditions, despite the potential for various dynamics between water, land use, and soil.


IJssel
Moraine Floodplain
Wet Situation
Merwede-Meuse
Land van Altena
Extremely Wet
Meuse
Dunes
Moderately Wet
Map 13: Location Pilot Projects
Flood Risk
Biodiversity
Dikes
Salt Water
Fresh Water
Peat
River Clay
Sand
0
10
20 km

02

Pilot Project 1: Meuse Dunes - Moderately Wet scenario

Historic situation
Current situation
Section
Proposed situation
Dynamics (observation of success)
Timeline
Actors

Figure 12: Aerial photo Meuse Dunes

Historical perspective

200 years ago, the floodplain of the Meuse was not much different from today. Even then, dikes protected the agricultural land, complemented by the natural relief of the river dunes on the east side of the river. However, the agricultural land was an elongated strip behind the dikes, and not extensive arable land as in modern times. Forests were not as prevalent in the wild area of the river dunes; instead, smaller patches were scattered across the undeveloped areas. Heathlands and sandy areas are easily recognizable in the areas now covered by forest. The towns in the area are almost all located along the Meuse, on the border between clay and sand.

Map 14: Meuse - Dunes
Historic Situation
0
1
2 km

Current situation

The first scenario is located in the Meuse floodplain, and it contains a part of the Natura2000 area Maasduinen. The soil consists of river clay in the riverbed, and sand on both sides of the river. The relief is the result of the formation of sandy river dunes. During high water levels, the coarse sandy soil material carried by the river was deposited close to the river. The repetition of this process, along with river meandering year after year, has resulted in higher areas that are approximately 20 metres above sea level. Forests and heaths are present on these higher sandy grounds, while agricultural fields can be found on the slope of the river dunes. In the central part of this location, we can observe remnants of the river's meandering.

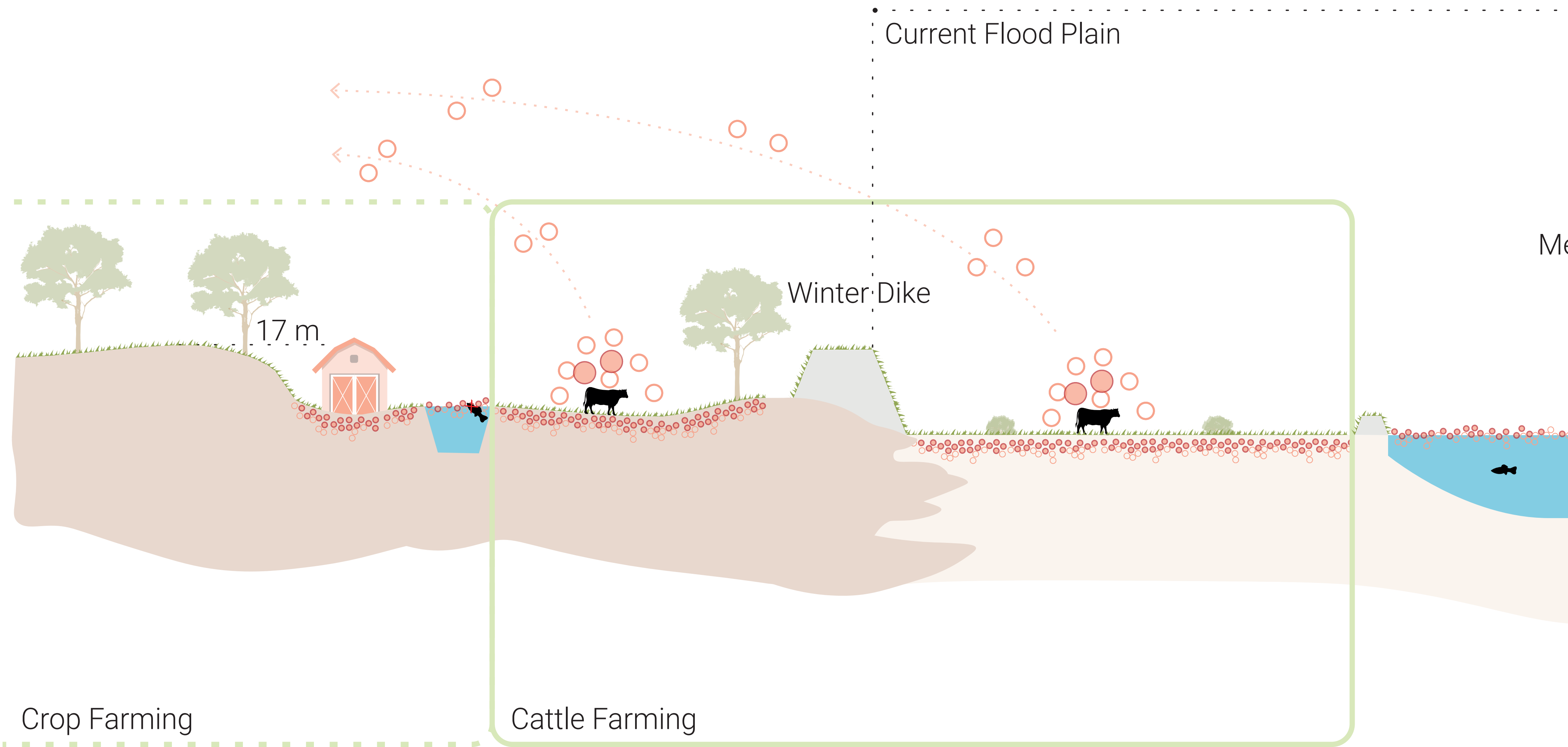
Small streams run through the agricultural area towards the river, following the natural relief. East of the river, an agricultural landscape with smaller forest areas can be found. Most of the forests have disappeared to create space for pastures. Most towns are located directly behind the dike, on the edge of this floodplain, ensuring that water is never far away. This is less threatening than in other locations because the higher sandy soils do not all flood. In the upper right corner, we can see a small part of the German Reichswald, a large forest on the Dutch-German border that is a popular destination for recreation.

Most infrastructure follows the course of the river, running in a north-south direction. A few bridges are located near the larger towns. The railway line runs on the higher sandy ground to the east of the river.

Map 15: Meuse - Dunes
Current Situation
Greenery
Dikes
Roads
Water bodies
Complex / Non-irregated Land
Pastures
0
1
2 km

Section current

The current section shows how intensive livestock farming creates a high nitrogen concentration in the lower areas along the river. The flood-plain between the summer and winter dikes lacks balance: the nitrogen concentration increases year after year. Ammonia (NH3) is transported through the air and also precipitates in the wooded areas and heathlands on the edges of the river dunes. Farms and small towns can be found on the edge of the river dunes, between the higher areas and the river floodplain.



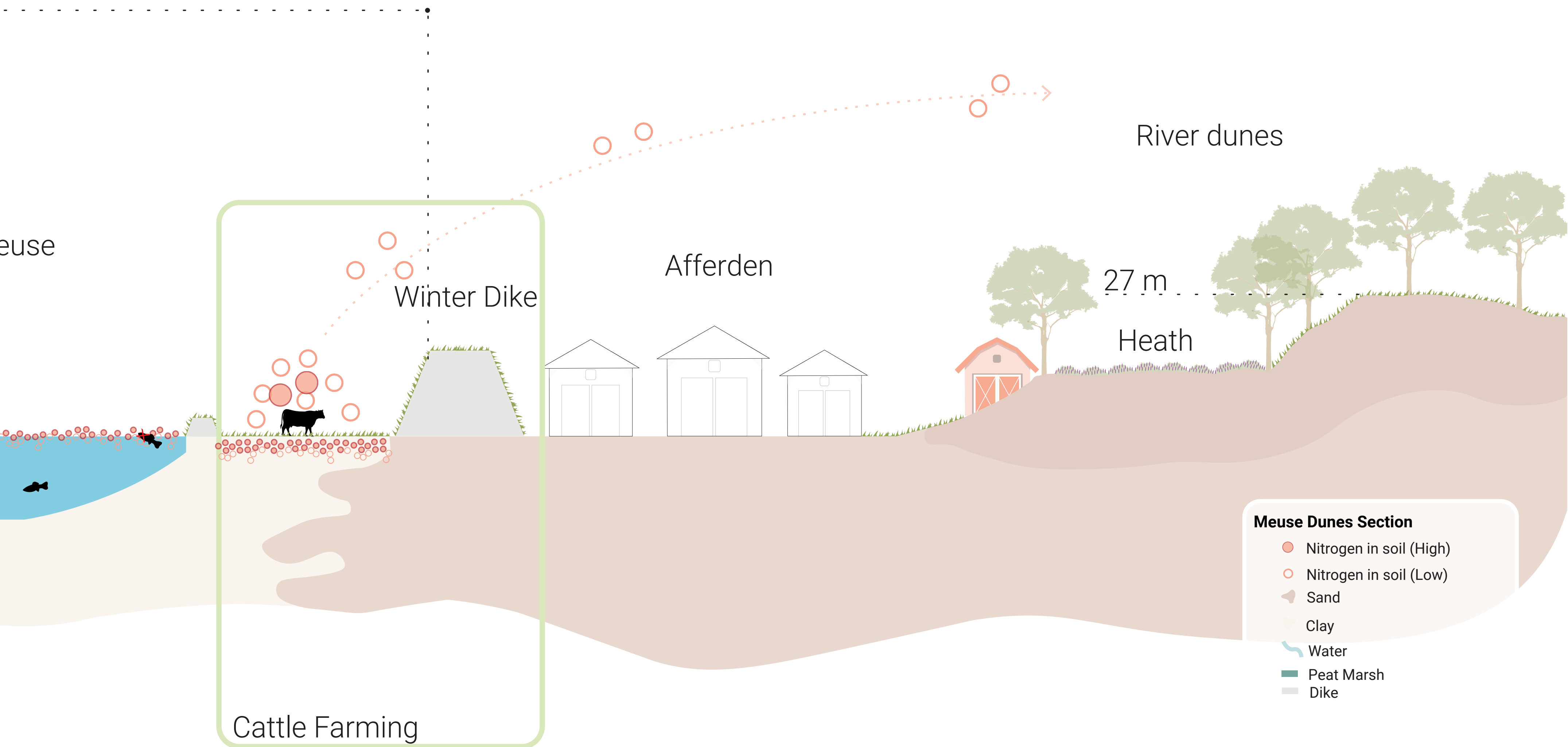


Figure 13: Meuse – Dunes (Section Current)

Proposed situation 2035

In the future, the river floodplain will be given back to nature, and intensive livestock farming in this area will have disappeared. New wetlands will emerge, providing gradient conditions from wet to dry. In combination with water storage, a new habitat for many species will be created. Sustainable farming will characterise the agricultural area, and ecological zones will develop along the meandering streams once again. By breaking the strict guidance towards the river, gradients from dry to wet are created that benefit biodiversity. The bocage landscape is restored by reintroducing the hedgerows, which have different compositions in the higher areas and in the floodplain, making them part of the riparian habitat. The hard boundary between forest and arable land has disappeared and a gradient has taken its place. In the north, the land between the Reichswald and the river will become more wet: here paludiculture gets a place.

Sustainable Farming

Sustainable farming can result in the preservation and restoration of critical habitats, which helps protect watersheds. It also positively affects the soil health and the quality of water (World Wildlife Fund, n.d.). Sustainable farming offers multiple possibilities in agricultural practices. Firstly, a grassland with a wide variety of herbs offers numerous benefits. It allows for better crop production during dry periods. Furthermore, these diverse grasslands help increase biodiversity (Bellocchi & Picon-Cochard, 2021). Additionally, this herbal-rich grass can be used as highly protein-rich roughage for cattle (Altenburg & Wymenga, 2022).

Another sustainable agricultural practice that can be applied is rotational grazing. With rotational grazing, cattle move frequently through different pastures. With this frequent movement, plants can rest and regrow to reach grazing height, while the cattle, at the same time, graze on another pasture. This type of land-use improves soil structure and increases biodiversity (USDA, n.d.).

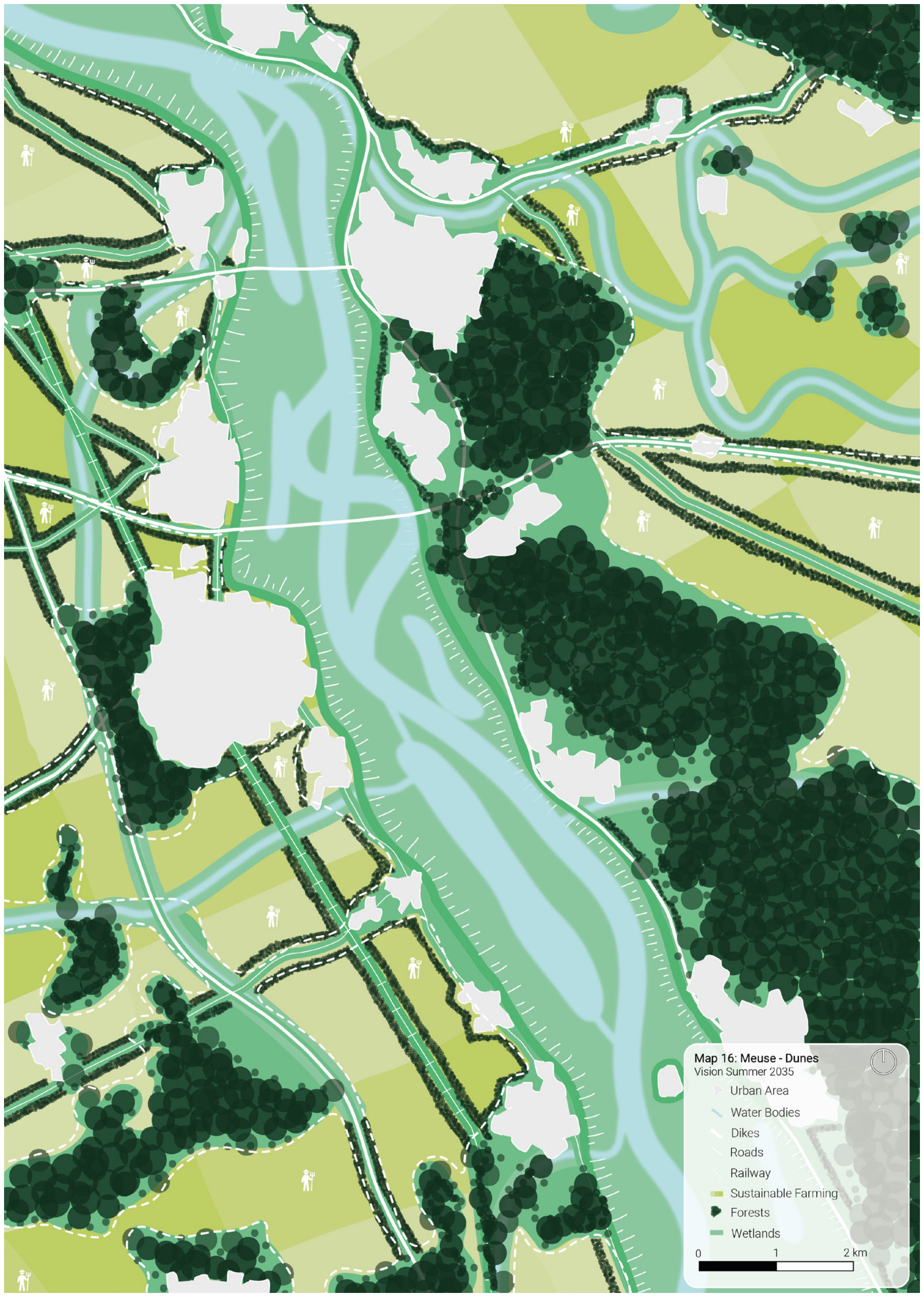
The third implementation is crop rotation and diversification, which is very profitable for farmers because, with a well-designed rotation system, low prices for some crops can be compensated by high prices for others (Wijnands et al., 2002). The practice of crop rotation involves planting different crops sequentially on the same part of the land (Rodale Institute, n.d.) to improve the quality of the soil and to reduce the use of fertilisers and pesticides. The use of crop rotation improves biodiversity and helps return nutrients to the soil without synthetic inputs (Van Dijk et al., 2021). This practice can be applied to dairy farms for the cultivation of cattle feed and to agriculture in general (Rodale Institute, n.d.).

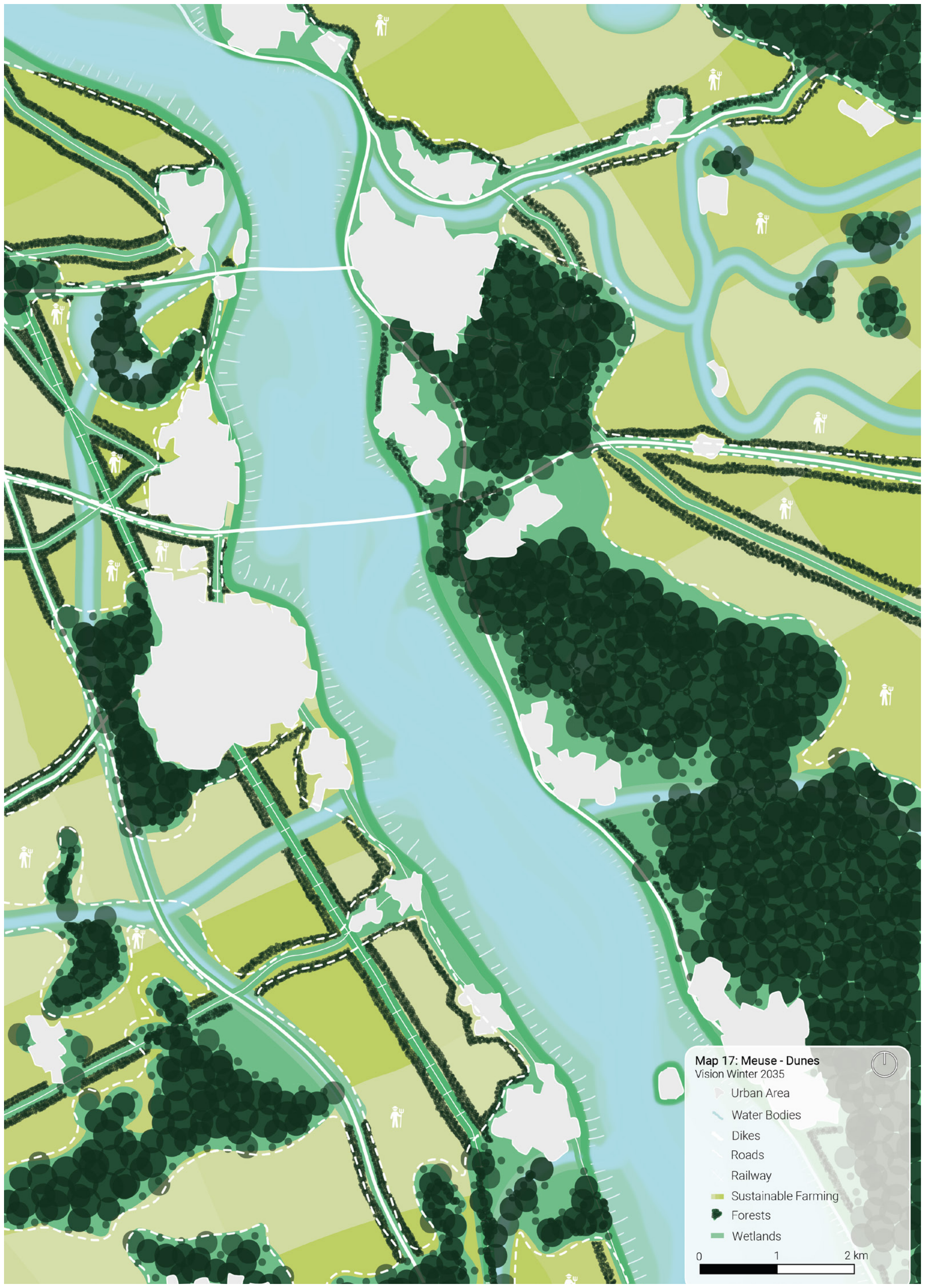
Summer

In the summer of 2035, the Meuse floodplain will be transformed into wetlands in the context of regenerating biodiversity and water storage. In the new situation, the streams that currently flow directly into the river will instead flow via ponds in the riverbed. This ensures that these ponds have sufficient water during dry periods. The agricultural areas will consist of sustainable farming instead of intensive livestock farming. At the edges of the forested areas, a gradient is being created: arable land and forest merge into each other. This process will continue for several decades until its full potential is reached. The stream banks will develop into an ecological zone that facilitates more and more biodiversity over time. In connection with this, the bocage landscape is being reintroduced by restoring the hedgerows that form valuable ecological connections.

Winter

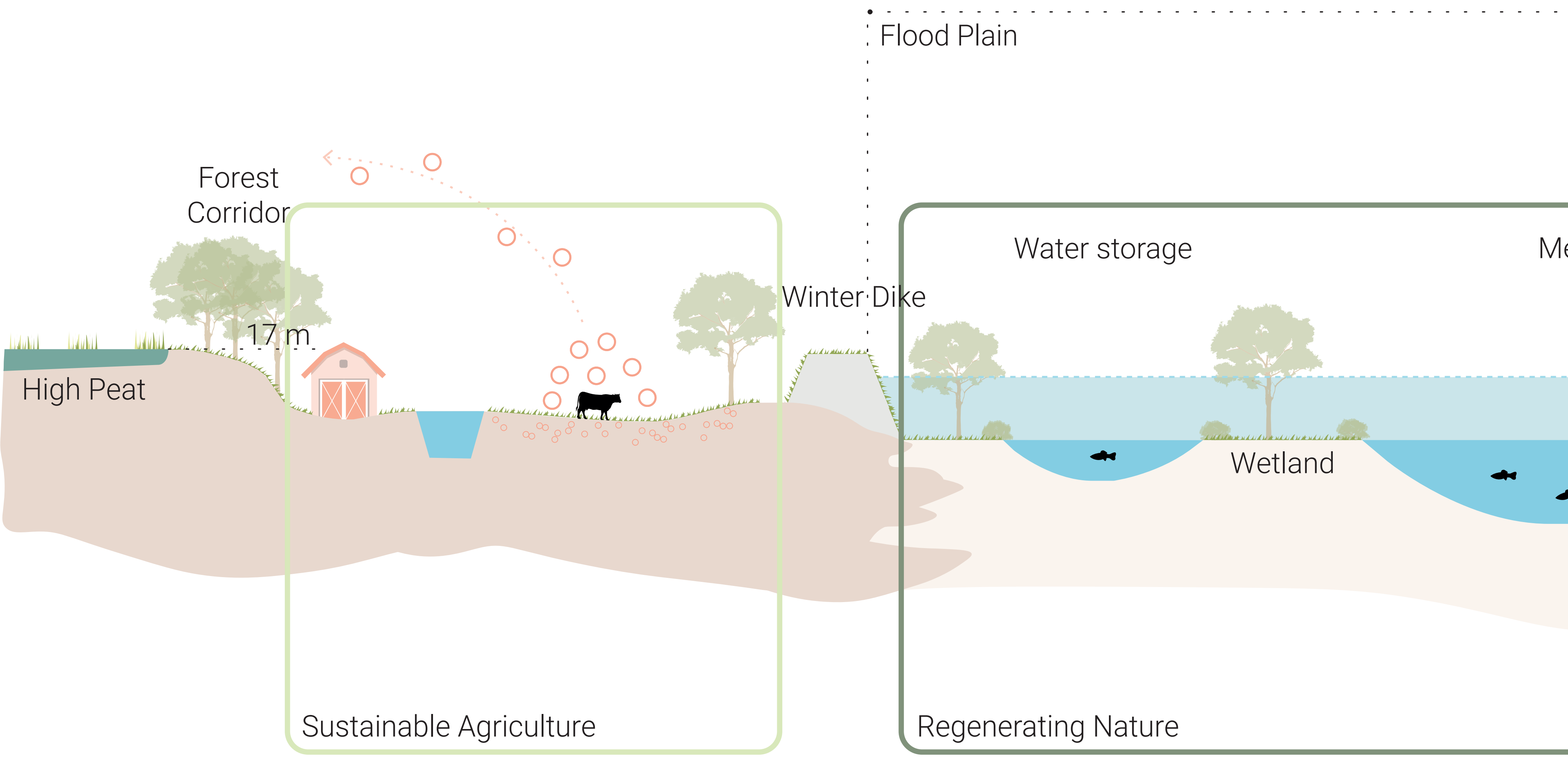
In the winter of 2035, it becomes clear that the current dike structure forms the limit of the peak of the high river levels in the cold months. As a result, water reaches directly into the various towns. The water in the streams is also at a much higher level due to reduced evaporation and less water use by farmers, allowing the retention areas in the floodplain to fill up even after the high water in the river has returned to its summer bed.


Map 16: Meuse - Dunes
Vision Summer 2035
Urban Area
Water Bodies
Dikes
Roads
Railway
Sustainable Farming
Forests
Wetlands
0
1
2 km


Map 17: Meuse - Dunes
Vision Winter 2035
Urban Area
Water Bodies
Dikes
Roads
Railway
Sustainable Farming
Forests
Wetlands
0
1
2 km

Section future

The new section demonstrates that regenerating biodiversity is central to the new riparian habitat: several beds are visible in the floodplain, and the hedgerows of the bocage landscape form ecological connections. The floodplain will not be expanded, but the summer embankments will be removed to create a contiguous wetland. Sustainable agriculture practices take place on the slopes of the river dunes, where the formation of smaller patches of raised bogs also takes place.



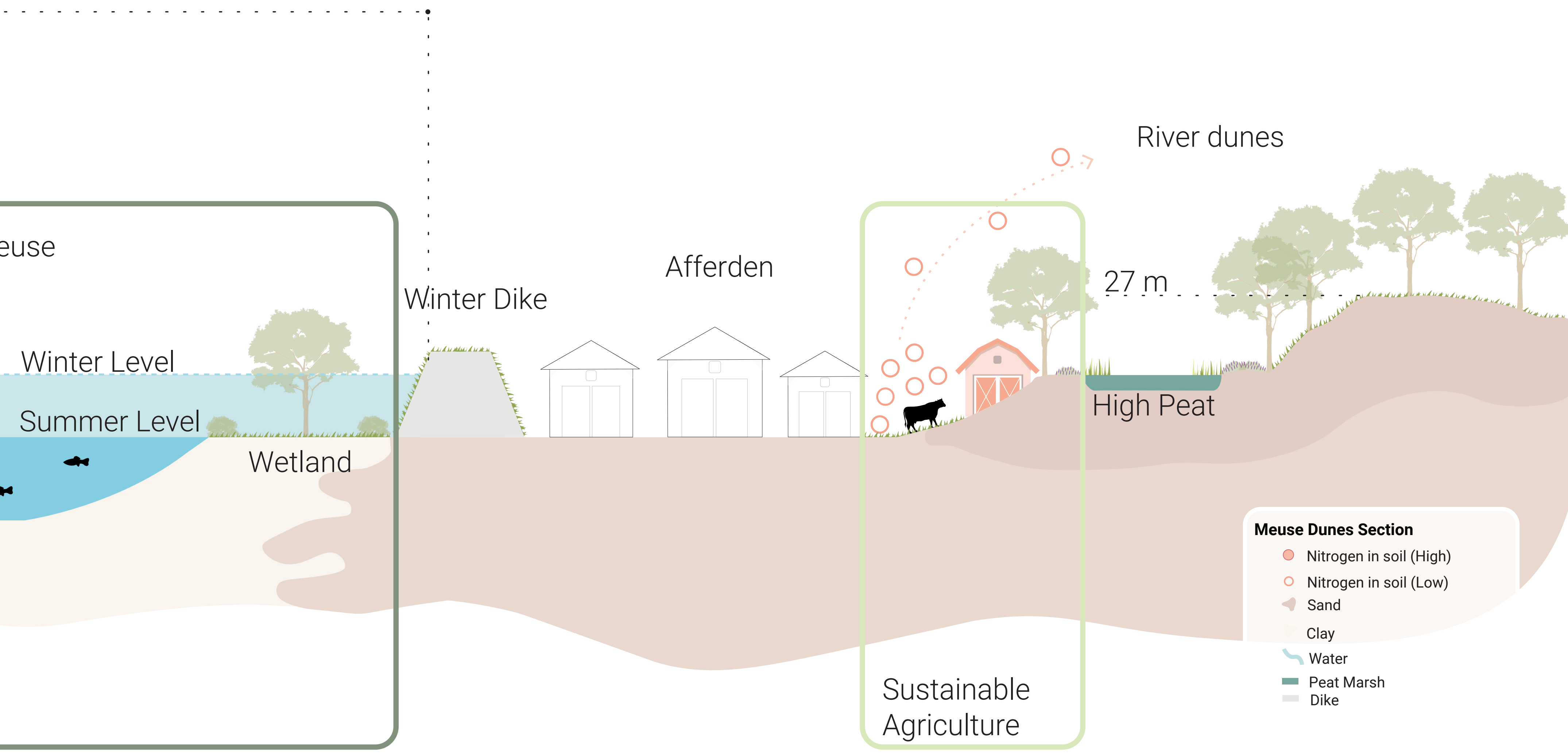


Figure 14: Meuse – Dunes (Section 2035)

Types of Dynamics

The Meuse Dunes scenario focuses on water retention in the floodplain, and apart from the implementation of sustainable agriculture, neither paludiculture nor aquaculture are present. A unique background process is the formation of river dunes. Most Dutch river dunes were created 10,000 years ago at the end of the last ice age. The sand carried by the wind was deposited at high water levels and retained by vegetation along the river, resulting in dunes several metres high (Geologie van Nederland, n.d. a). This process has slowed down and disappeared due to diking, but the formation of levees continues (Geologie van Nederland, n.d. b). Migratory birds arrive in the spring and leave the Netherlands in late summer and fall (Ottens, 2024), providing peaks in the presence of wildlife in the area.

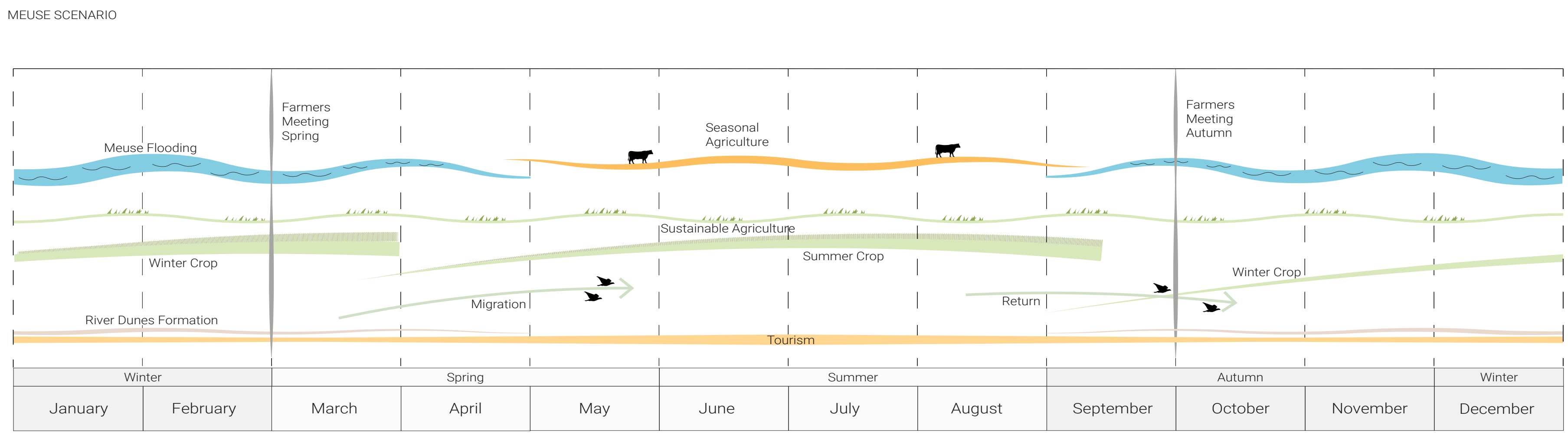


Figure 15: Meuse – Dunes Dynamics

Timeline

The development of the first scenario will completely take place in the first phase of the strategy. Farming cooperatives are formed, and sustainable farming policies are introduced with a hard deadline in 2035. At that moment, farmers should comply with these policies and can expect to be fined when they do not. Prior to this hard deadline, there will be three assessment moments. Farmers who have already implemented the new rules in their agricultural practice will achieve points leading to possible benefits, such as tax breaks. Several interventions will take place in this first phase, such as creating buffer zones and the re-meandering of streams. However, preparations are also being made for later scenarios. Inhabitants will be informed of the upcoming plans, and research for later interventions is started.

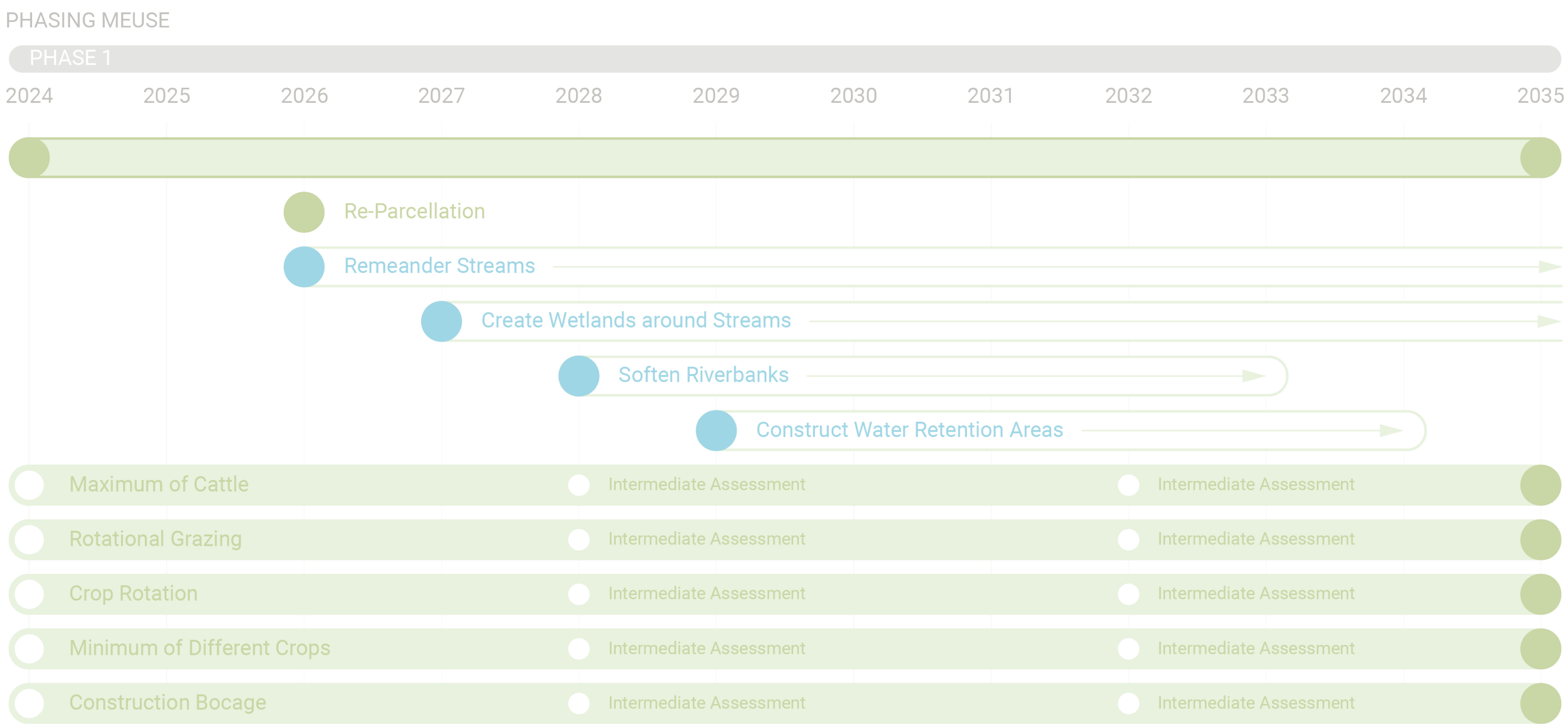


Figure 16: Meuse – Dunes Phasing Timeline

Actors

Farmers (small and big companies)
Role: Pays for the land-tax, user of the land (production purposes)
Goal: Optimise production, highest return from initial in vestment
→ Unite on a local scale in farming cooperatives

Farmer cooperative
Role: Collaboration of farmers in which they work together, share resources and land and carry out checks on each other.
Goal: Good collaboration between farmers within the cooperative, connection with municipality and farming board and assessment of fellow farmers.

Tourists
Role: Indirect tax payers to the land, Visitor of the land (Recreational purposes)
Goal: Self amusement

European Union
Role: Making/setting and enforcing policies and legislations for the greater good/ common roles of the European Union.
Goal: The European Union aims to govern, implement, and enhance the condition of European ecology and biodiversity.

Municipalities
Role: Making/setting and enforcing local policies and legislations for the greater good/ common roles of the region
Goal: Municipalities aspire to enhance citizen satisfaction, economic prosperity and strengthen biodiversity conservation efforts.

Universities
Role: To educate and hold a high concentration of knowledge and skills to be applied in research fields or practical purposes.
Goal: To educate the future population and induce future proof adaptational skills

Inhabitants
Role: Own parts of the land and live there.
Goal: Safe living

Animals
Role: Make use of the nature as their habitat
Goal: Survive, reproduce

Provinces
Role: Governing layer in between national government in the Hague and the municipalities.
Goal: Sustainable spatial development, safe and healthy living area, vital agriculture lands and nature maintaining, maintaining accessibility and economy on a regional scale, supervision of municipalities

Staatsbosbeheer
Role: Protection of nature
Goal: Making sure that current and future generations can enjoy nature in a sustainable way

National Government
- Ministry of Infrastructure and Water Management (I&W)
- Agriculture, Nature and Food Quality (LNV)

Role: Making/setting and enforcing policies and legislations for the greater good/ common roles of the country.
Goal: Municipalities aspire to enhance citizen satisfaction, economic prosperity and strengthen biodiversity conservation efforts.

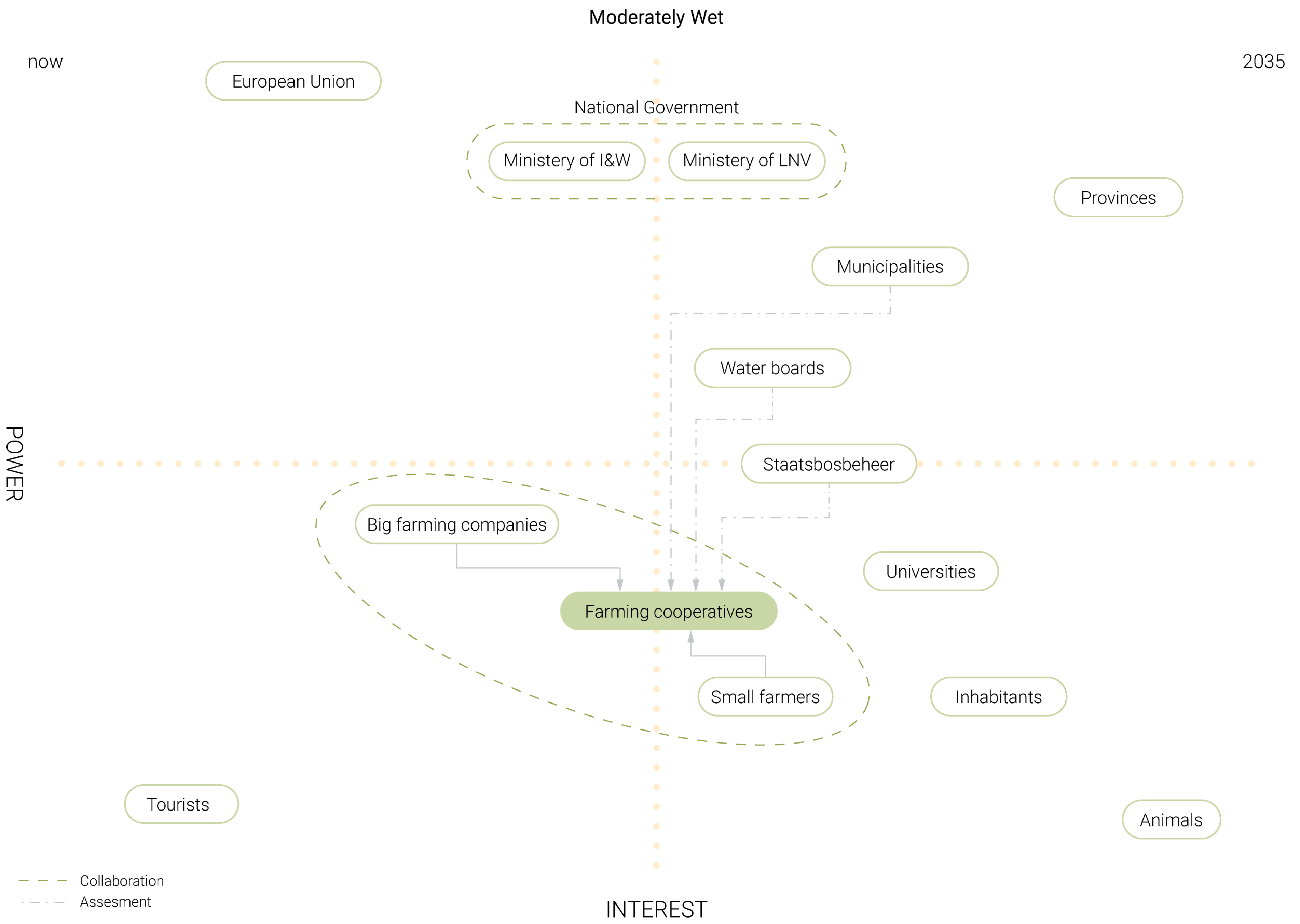


Figure 17: Meuse – Dunes Power/Interest Matrix

02

■ Pilot Project 2: IJssel - Wet scenario

Figure 18: Aerial photo IJssel

Historical perspective

The historical map of the moraine landscape on the IJssel shows a layered landscape structure between the river and the moraine. The moraines are visible in the west of the map, while in the north, there are peat and swampy areas. On the somewhat higher part between the moraine and the flood-prone area along the IJssel, fragmented forests are present. The watercourses in the area, which flow from the moraine towards the IJssel, are fed by underground seepage flows at the edge of the moraine. In contrast, the watercourses in the eastern parts converge near Zutphen, and small forests can also be found in this area. It is not surprising that most towns are located relatively close to the dike, while only a few are in the eastern area.


Map 18: IJssel - Moraine Floodplain
Historic Situation
0
1
2 km

Current situation

The second scenario concerns the moraine floodplain between the IJssel and the Veluwe, an area where a lot of agriculture can be found. The Veluwezoom, in particular, is a large moraine by Dutch standards. Characteristic of this area is that it is relatively wet due to groundwater seepage at the foot of the moraine, but this water is directed to the main rivers by many small streams. The soil consists of many different types: clay, peat, and sand in the higher areas, making the area relatively complex.

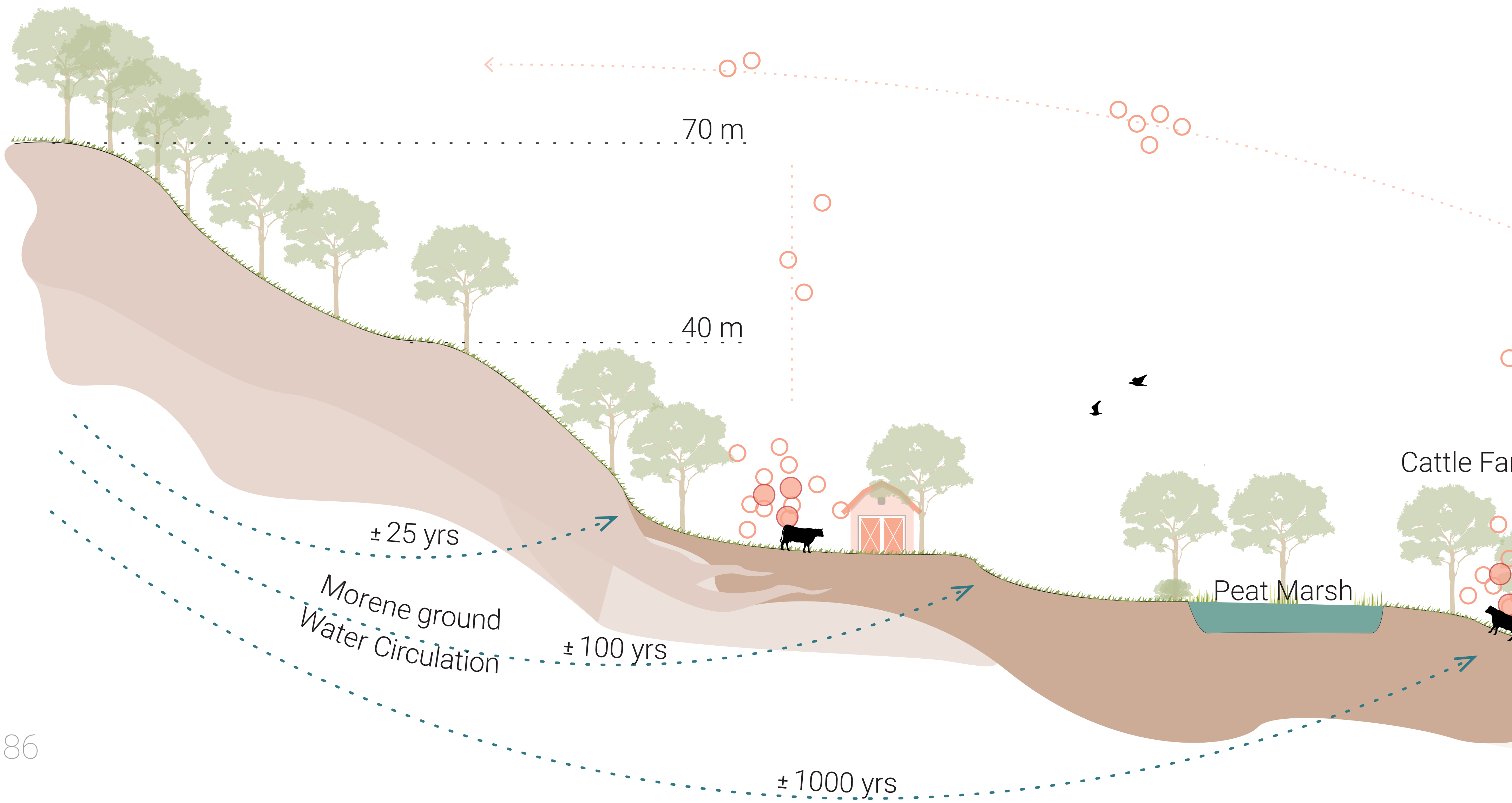
There is a wide, low-lying plain along the river IJssel, which is why strong river dikes can be found everywhere. As a result, the floodplain is narrower than along the Meuse, and much intensive livestock farming is also found here, resulting in nitrogen pollution. In the area between the Veluwe and the IJssel, we find many pastures, and on the higher parts, small-scale wooded areas and a few peat swamps, along with small towns.

The city of Zutphen, which is within the frame, is one of the many old historic towns along the IJssel. Most of the main infrastructure is located near the IJssel and Zutphen. There are few larger roads that run through the agricultural area, but there is a railway line connecting Zutphen and Apeldoorn.


Map 19: IJssel - Moraine Floodplain
Current Situation
Greenery
Dikes
Roads
Water bodies
Complex / Non-irregated Land
Pastures
0
1
2 km

Section current

The extreme relief in this area is immediately visible from the section. The historic city of Zutphen is located directly on the river, and along the river, we find floodplains with intensive livestock farming. This floodplain is strictly limited between the winter dikes. Behind the winter dike, there is agricultural land on the same clay soil, which is quite wide. The precipitation that falls on the moraine is filtered through the coarse sand, and the groundwater supply is replenished, resulting in seepage at the edges of the moraine (Ernst, 1983). Various seepage streams emerge here. The distance to the moraine indicates the age of the water: the further from the moraine, the older the water is. Peat remains can still be found in the area between the river and the moraine as a result of wet periods in the past. On the moraine itself, the peat changes into different types of sand, with the coarsest sand in the higher areas (Whittow, 1984). On the slope of the moraine, we now also find intensive livestock farming.



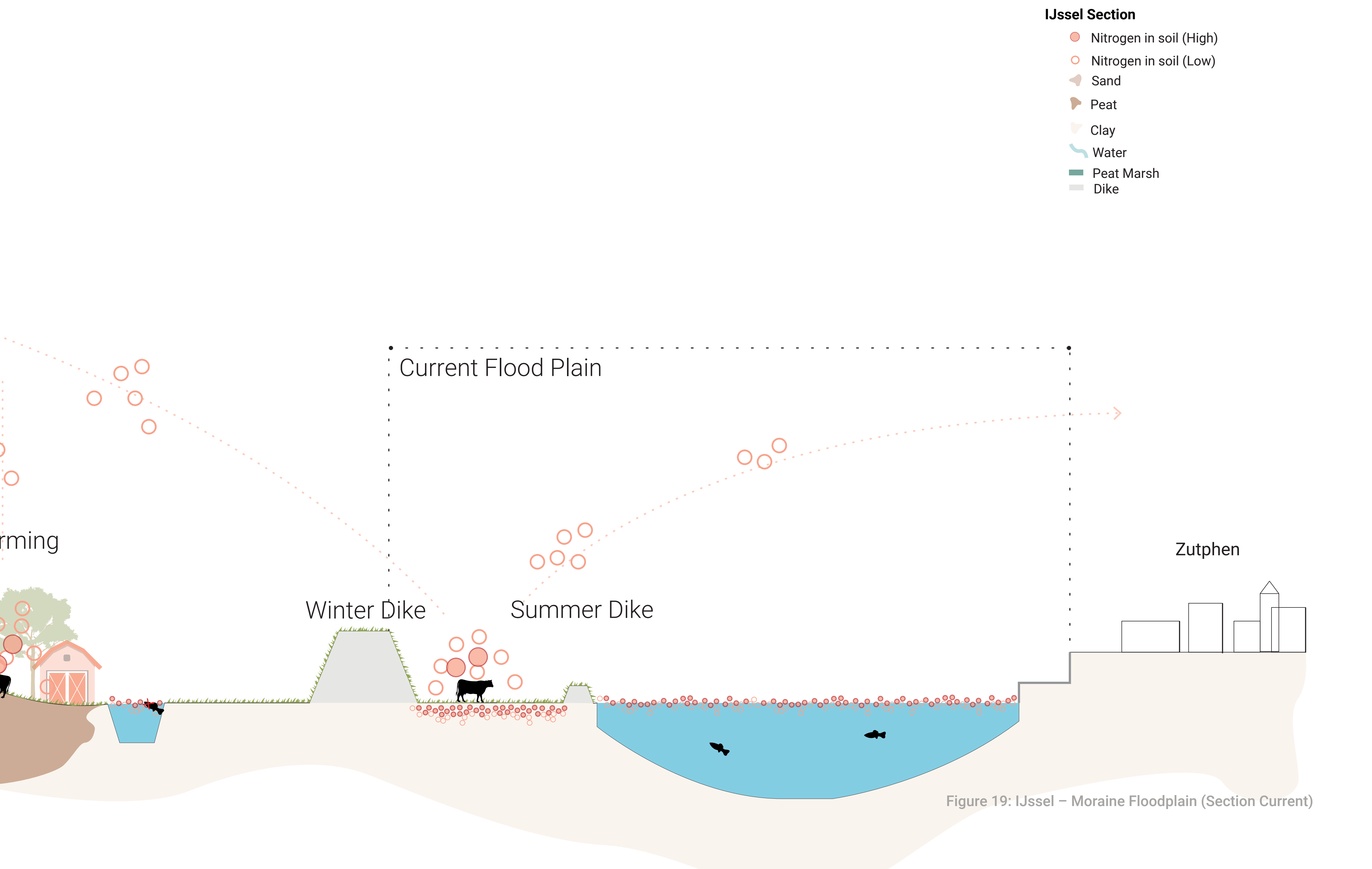


Figure 19: IJssel – Moraine Floodplain (Section Current)

Proposed situation 2035

In the future, the dynamics of the area will be greatly increased by restoring natural processes and breaching the winter dikes. A large part of the area immediately behind the winter dikes will flood every winter, so seasonal agriculture will be found in this area. The water can flow freely until it is stopped by the terrain relief. In this higher area, there is room for sustainable farming, and in the area closer to the moraine, underground seepage will create a much wetter environment. In this wet area, there is space for paludiculture, and peat ponds will form, increasing biodiversity in combination with gradients from wet to drier areas. However, peat formation is a longer-term process (Natuurpunt.be, n.d.). The forested areas also exhibit a clear gradient from forest to open landscape. The bocage landscape connects these areas with the wetlands directly on the river. The many streams are given space to meander and form an ecological network on a smaller scale.

Paludiculture

Paludiculture involves cultivating crops on wet soils, primarily found in peatlands. In conventional agriculture, peatlands are often drained to facilitate activities like cattle grazing. However, this drainage leads to numerous issues such as land subsidence and heightened flood risks. Maintaining a higher water table can help mitigate these problems. Through rewetting, the cultivation of flood-tolerant plant species not only prevents eutrophication but also offers farmers an alternative product (Bestman et al., 2019). Research into paludiculture as a potential alternative to traditional farming in peatlands is ongoing, with the level of productivity and scalability still being studied. There are two types of paludiculture: intensive and extensive paludiculture. In intensive paludiculture, crops like cranberries and wild rice can be grown, although their success heavily depends on maintaining a precise water level, necessitating strict control. In extensive paludiculture, crops such as cattails can flourish despite fluctuating water levels (Deelexpeditie Natte Teelten, n.d.).

Summer

In 2035, the winter dikes along the IJssel have not yet been breached to give actors in the area time to prepare for the impending water. However, the re-meandering of streams and the creation of wetlands along the river are already in full development, as is the restoration of the bocage landscape and the utilisation of gradients between agricultural land and forests. The first results of the new wet ecological zones between the reorganised agricultural lands are visible along the streams. These zones connect to the bocage landscape, the main structure of which has already taken shape, marking the period of facilitating biodiversity before the larger changes occur in the upcoming phases.

Winter

In winter, the water level in the IJssel reaches its peak, rising to the top of the dike slope. The streams overflow, and the ponds along them receive a substantial amount of water, forming a gradient between the agricultural land and the adjacent wet ecological zones.


Map 20: IJssel - Moraine Floodplain
Vision Winter 2035
Urban Area
Water Bodies
Dikes
Roads
Railway
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km


Map 21: IJssel - Moraine Floodplain
Vision Winter 2035
Urban Area
Water Bodies
Dikes
Roads
Railway
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km

Proposed situation 2055

Summer

In 2055, the IJssel dikes have been breached, allowing river water to penetrate inland. However, this does not occur during the summer months when the river water levels are lower. The eastern parts of the area, located at the foot of the moraines, have been further developed into wet, swampy zones where paludiculture takes place. The ecological zones along the streams reflect this new condition in which nature and agriculture coexist harmoniously. The bocages in the agricultural area have evolved into a more intricate network over time, and the gradients between forest and agricultural land have also been enhanced.

Winter

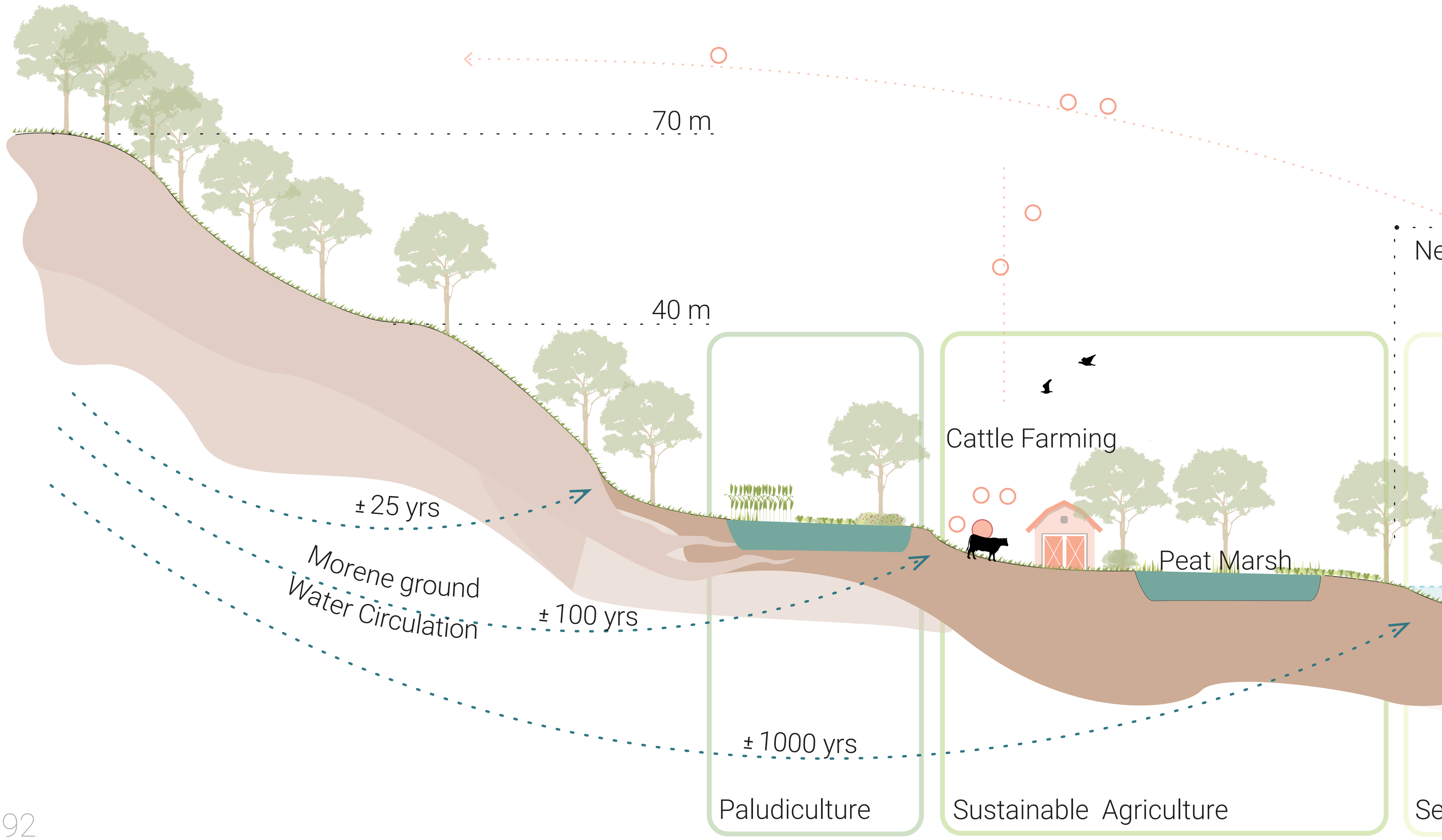
In winter, during periods of high water levels, river water flows inland through gaps in the dikes, resulting in flooding of a large part of the country and erosion of the dikes. Sustainable agriculture continues in the central part of the agricultural land, but farming is temporarily impossible in the areas along the river. In the wet eastern part, the water level is high in the wetlands, and ponds have a higher level than in 2035. Another consequence of the high water levels is the flooding of parts of the infrastructure, rendering some routes temporarily unusable. However, the higher train embankment will remain dry, providing a guaranteed connection.


Map 22: IJssel - Moraine Floodplain
Vision Summer 2055
Urban Area
Water Bodies
Dikes
Roads
Railway
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km


Map 23: IJssel - Moraine Floodplain
Vision Winter 2055
Urban Area
Water Bodies
Dikes
Roads
Railway
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km

Section future

From the section, it becomes clear that a new agricultural threefold division is emerging from the moraine to the river as follows: paludiculture, sustainable agriculture, and seasonal agriculture. The breached winter dike greatly enlarges the floodplain of the IJssel, resulting in semi-annual dynamics of flooding in the winter months. New peat marshes will be created on the higher parts, which will be fed by underground seepage flows. Nitrogen emissions decrease significantly due to these new forms of agriculture, and the soil can recover.



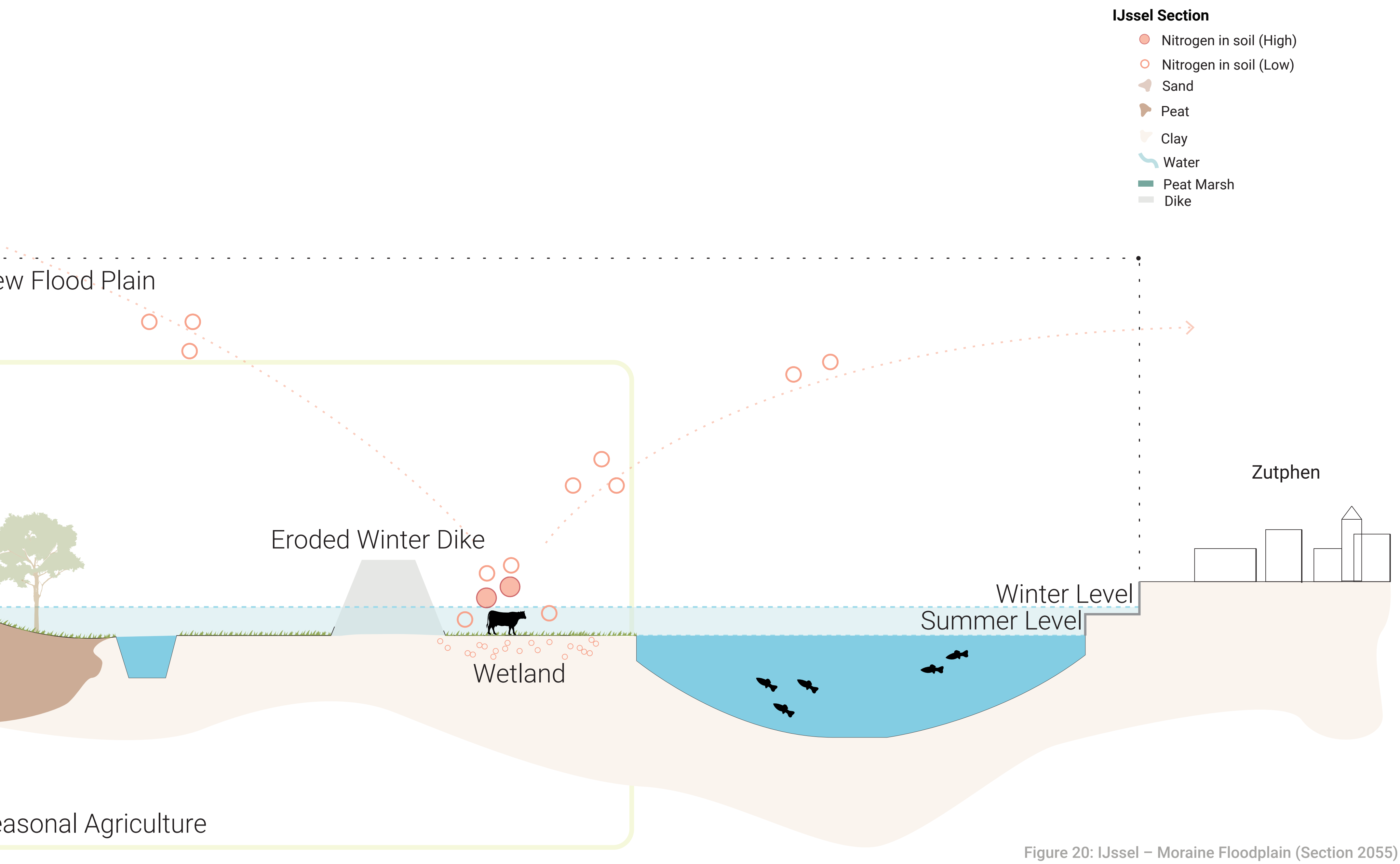


Figure 20: IJssel – Moraine Floodplain (Section 2055)

Types of Dynamics

The IJssel scenario clearly demonstrates the relationship between the flooding of the IJssel river and seasonal agriculture: from May to August, cattle can graze in the flooded areas, but from September to April, during the peak flooding of the large Dutch rivers (Rijkswaterstaat, n.d. b), cattle must be moved to higher ground. Paludiculture and sustainable agriculture are present year-round, with different cycles of harvest and growth (Bestman et al., 2019). The crop rotation schedule alternates between summer and winter crops. It is expected that farmers will collaborate in spring and autumn to assess the impact of these different dynamics on their annual business operations.

Continuous processes include underground seepage flows and peat formation (Waterschap Vallei en Veluwe, n.d.). These underground seepage currents occur at different frequencies, so three representative frequencies have been chosen: short (approximately 25 years), medium (approximately 100 years), and long (approximately 1000 years). The resulting peat formation process operates on an even longer time frame: about 100 years are needed to form 10 centimetres of peat (Natuurpunt.be, n.d.).
The new dynamic landscape also presents opportunities for increased tourism, which may no longer be limited to the summer months. Tourism could also thrive when water levels are high, as the wet area gains new recreational value in winter and provides space for water sports (De Jonge, 2008).

IJSSEL SCENARIO

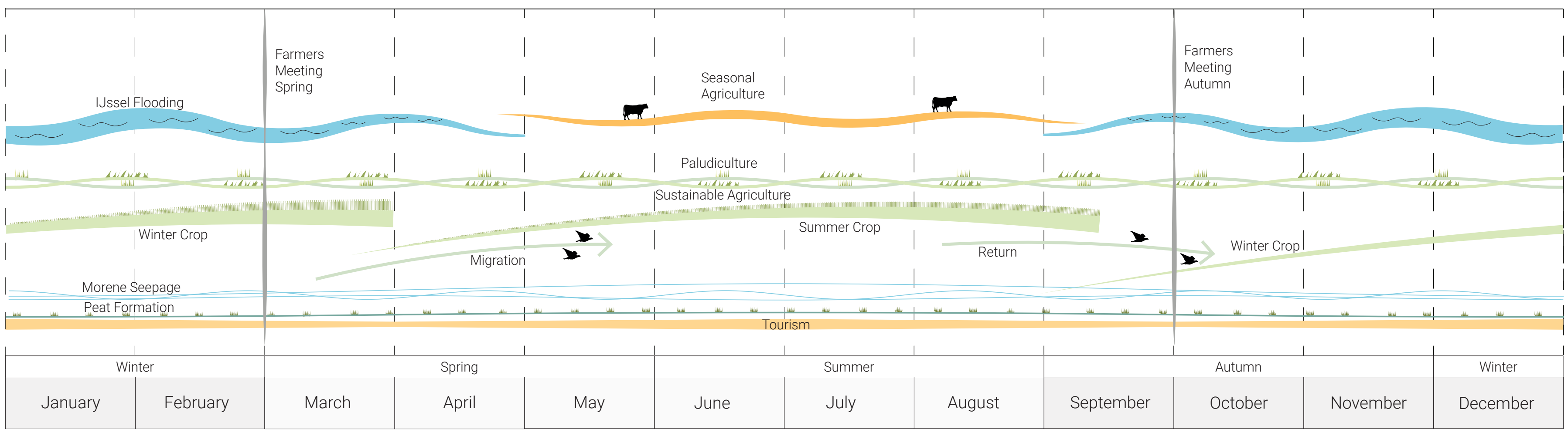


Figure 21: IJssel – Moraine Floodplain Dynamics

Timeline

The second phase spans from 2035 to 2060 and is characteristic of the second scenario. The previously established farming cooperatives collaborate within newly introduced farming networks. During this period, they will discuss the possibilities of implementing new agricultural practices, ultimately leading to the adoption of seasonal farming around 2050. By the end of phase 2, representatives of the farming networks convene in farmer boards, working together on a regional level. Nature zones are expanded through re-parcellation, some parts of the land will be depoldered, and homes will be relocated.

Simultaneously, inhabitants and farmers will be prepared for the changes that will take place in the third phase, particularly in the extremely wet locations where the third phase applies.

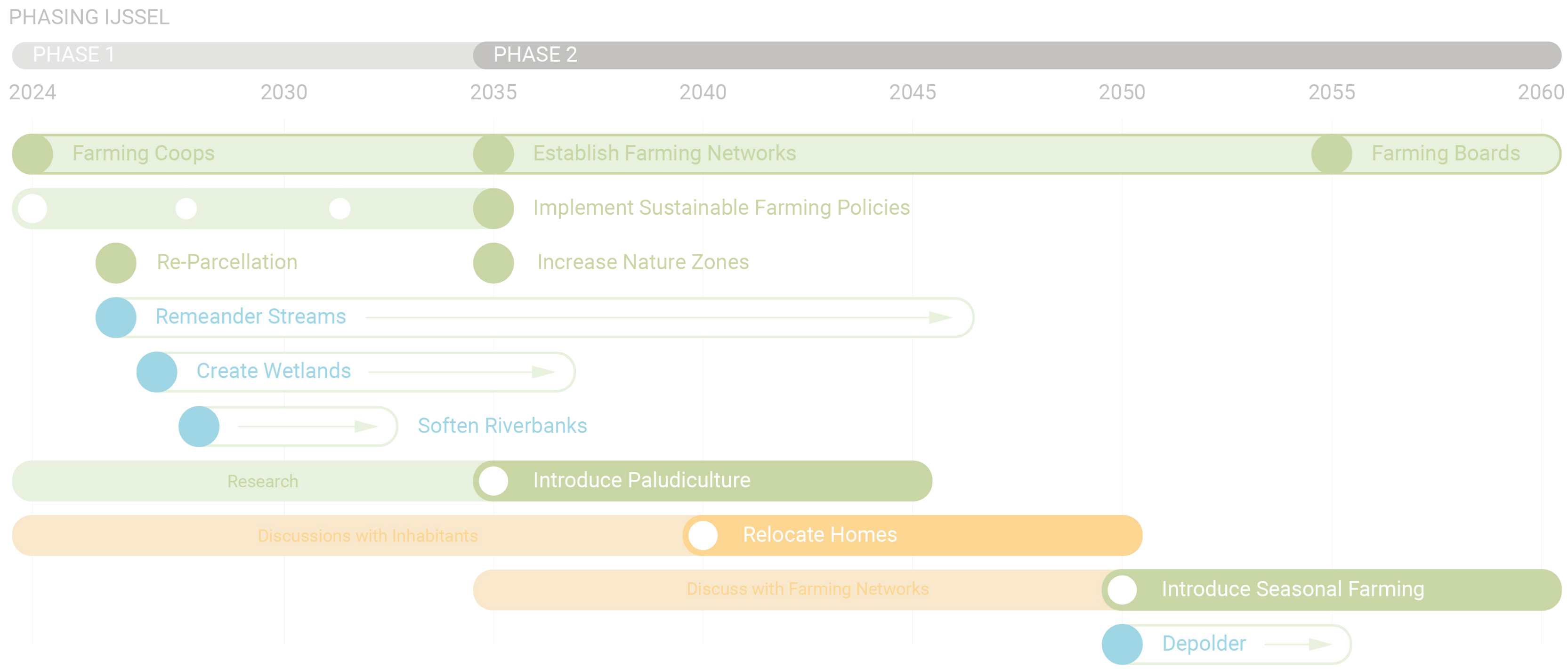


Figure 22: IJssel – Moraine Floodplain Phasing Timeline

Actors

The actors are the same for every phase, but in this phase we introduce a new actor, the Farming Networks. They work together with municipalities.

Farming networks

Role: Distribution of benefits and burdens, sharing knowledge agricultural practices, contact with municipality, choose representative farmer for Farmer Board.

Goal: Fostering collaboration between farming cooperatives.

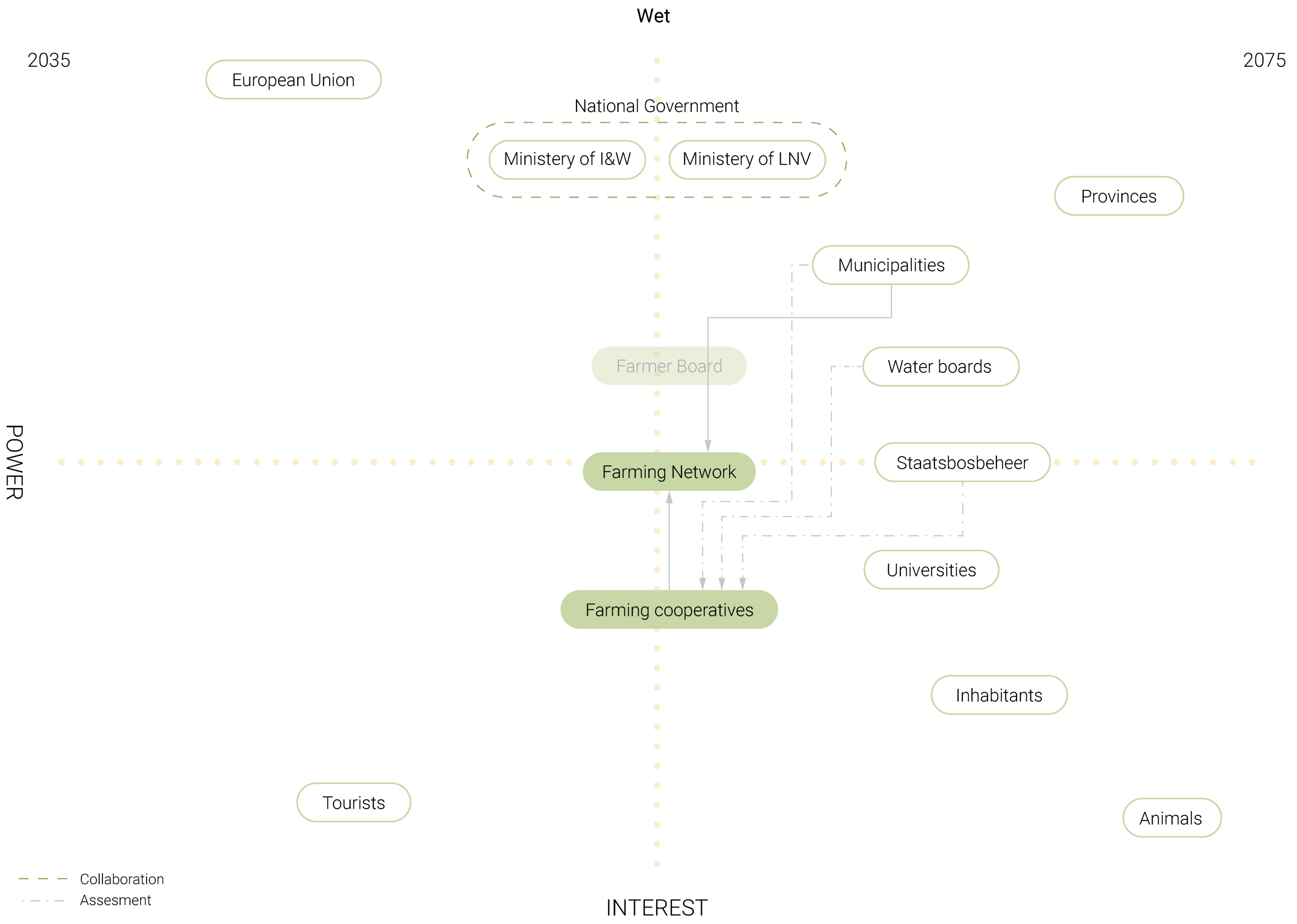


Figure 23: IJssel – Moraine Floodplain Power/Interest Matrix

03

Pilot Project 3: Merwede-Meuse

Figure 24: Aerial photo Merwede – Meuse

■ Historical perspective

In the historic situation of the Merwede-Meuse area, the Merwede is clearly recognizable as the largest river. Remarkably, the Meuse is not nearly as large as it is today. The Dammed Meuse diverts most of the water from the Maas towards the Merwede. The polder structure and the numerous dikes in the area are clearly identifiable, as are the old fortified towns situated directly on the river. The many streams and weirs that drain the polder water towards the rivers also significantly influence the landscape's structure. The towns in the polder landscape are primarily located near the dikes, while some are nestled deeper in the polder, resembling smaller farming villages.


Map 24: Merwede - Meuse
Historic Situation
0
1
2 km

Current situation

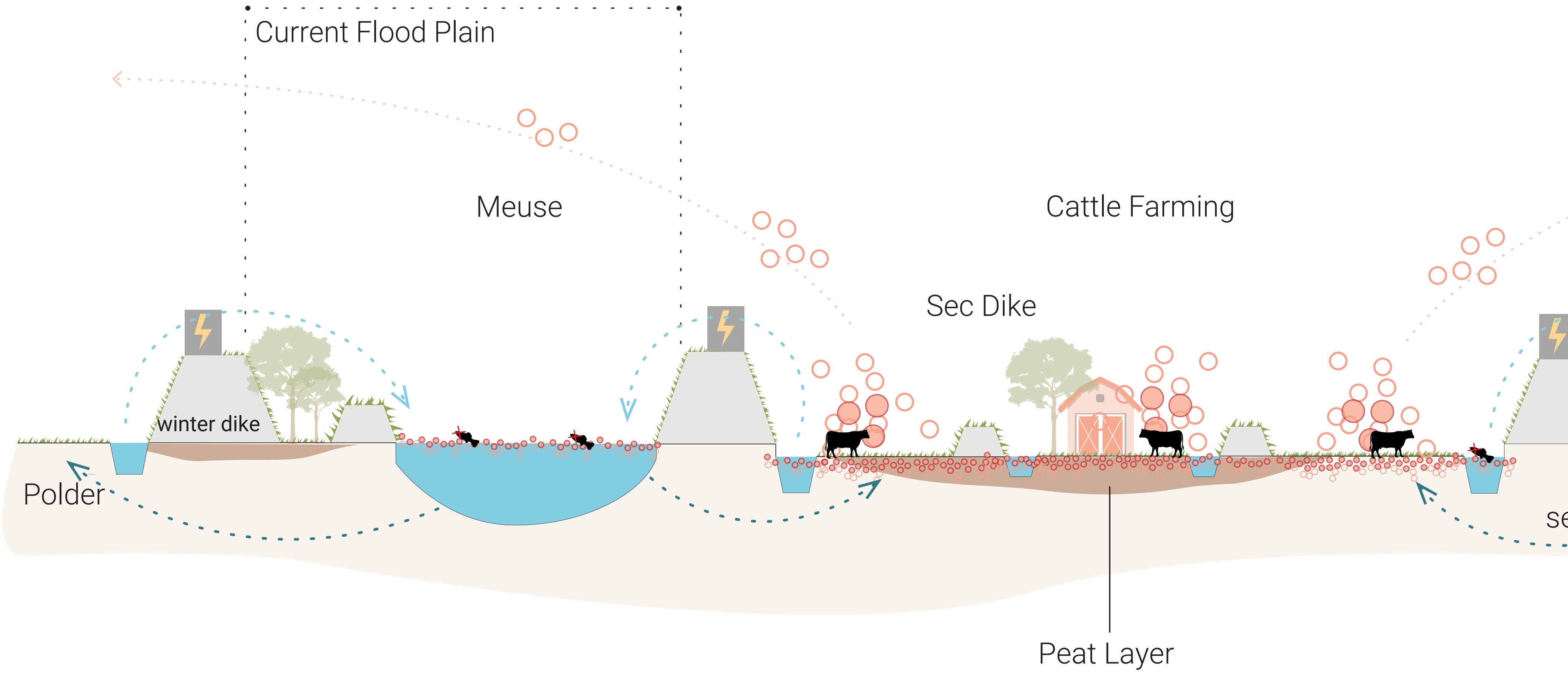
The last location differs greatly from the previous ones in that all the land is below the water level of the rivers, resulting in a high flood potential. Consequently, the Merwede-Meuse area is situated in a zone that epitomises the river polder landscape, where diked agricultural land is omnipresent. This river polder landscape encompasses the largest part of the Dutch river delta compared to the previous typologies. Pockets of nature and associated biodiversity can be found along the rivers, but these are often less well-connected than desired. The soil type in the polder areas primarily consists of clay soils, with peat remains in some locations. Nitrogen pollution is medium to high compared to sandy soils in other locations, but the pollution is transported through water flows. Additionally, this location is influenced by tidal water fluctuation, adding unique dynamics (Tangelder, Winter, & Ysebaert, 2017).

The water system is also distinct: water is kept out of the lower polder by pumping stations and weirs, creating a highly engineered landscape where water dynamics are limited in favour of agriculture and the continuation of the current protective dike structure.


Map 25: Merwede - Meuse
Current Situation
Greenery
Dikes
Roads
Water bodies
Complex / Non-irregated Land
Pastures
0
1
2 km

Section current

It is immediately evident from the section that the land is below the water level, and the polders are kept dry by pumping water into the rivers. The floodplains of the existing rivers are rigidly enclosed by dikes. The low-lying polders, with extensive intensive livestock farming, are heavily polluted by nitrogen, as are the floodplains between the summer quay and the winter dike. Behind the main dikes lies a structure of secondary dikes that zone the polder. In some places, the clay soil still contains a top layer with peat remains, and seepage water rises behind the river dikes, which must be drained through the ditch system.



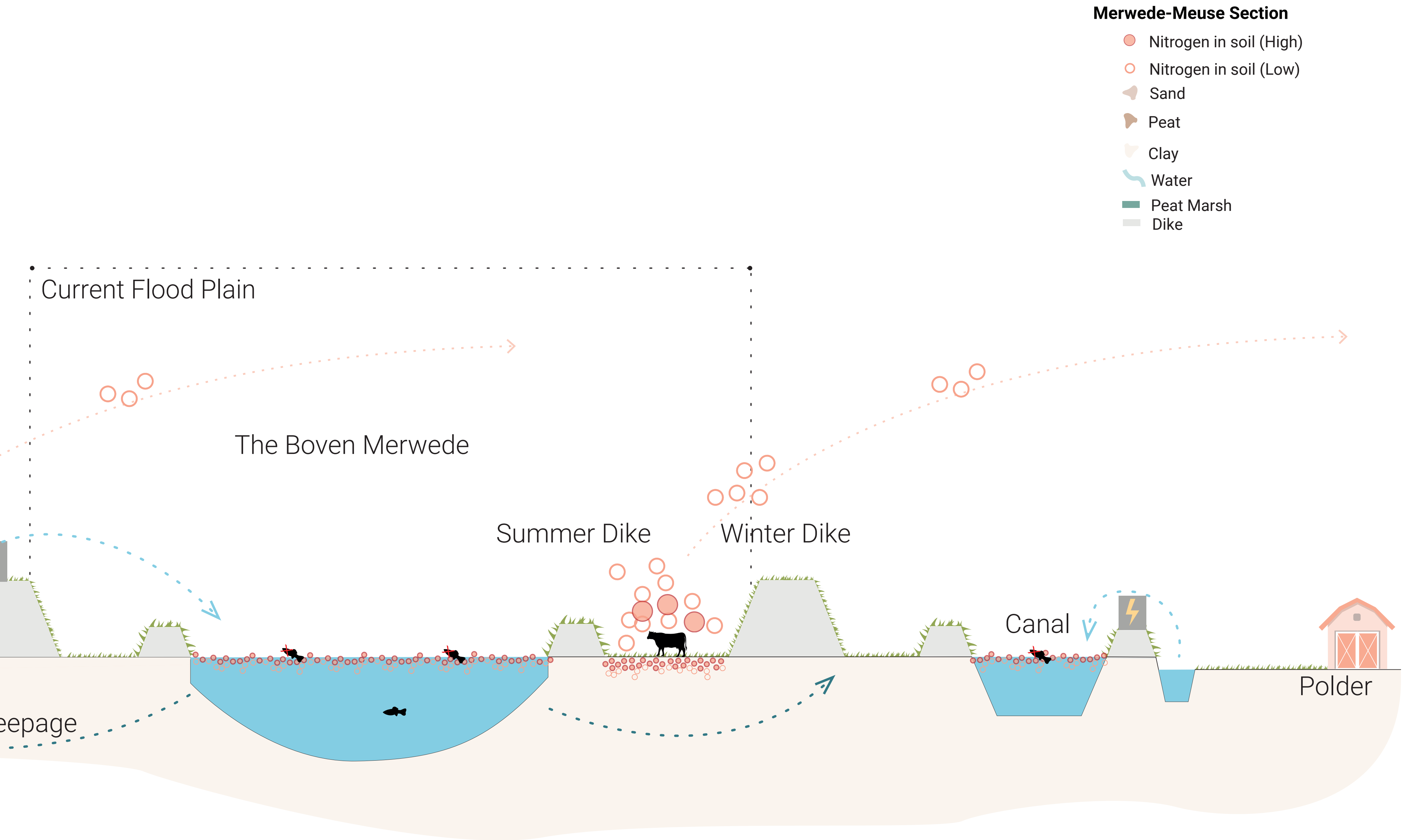


Figure 25: Merwede – Meuse (Section Current)

■ Proposed situation 2035

In the future situation of the Merwede-Meuse scenario, the polder landscape has evolved into a dynamic environment that no longer presents a static contrast with the water; instead, it adapts to the water's movements. By breaching the dikes, areas are created that can be flooded in winter when water levels are high, resulting in large areas suitable for seasonal agriculture. The rigid and tightly organised polder landscape transforms into an area with ecological connections in the form of hedgerows that promote biodiversity. Where water enters the depoldered land, dikes with long slopes have been developed to create gradients between dry and wet areas, further enhancing biodiversity. The towns in the area remain protected behind these dikes. A new form of agriculture specific to this area is aquaculture, as the large ponds provide an ideal environment for cultivating algae, seaweeds, and aquatic organisms. Additionally, the ingress of salt water can be utilised through this practice.

Summer

In the year 2035, no major changes compared to the current situation will be visible, although a start has been made with re-meandering streams, creating wetlands, and softening river banks. The first phase of the bocage has also been realised around the newly classified agricultural plots. This mainly involves the phase of nature restoration and preparation for breaching the dikes.

Winter

During winter, the elevated water levels remain largely unchanged from the current situation. The water reaches up to the top of the dike, and the streams within the polders carry a greater volume of water.

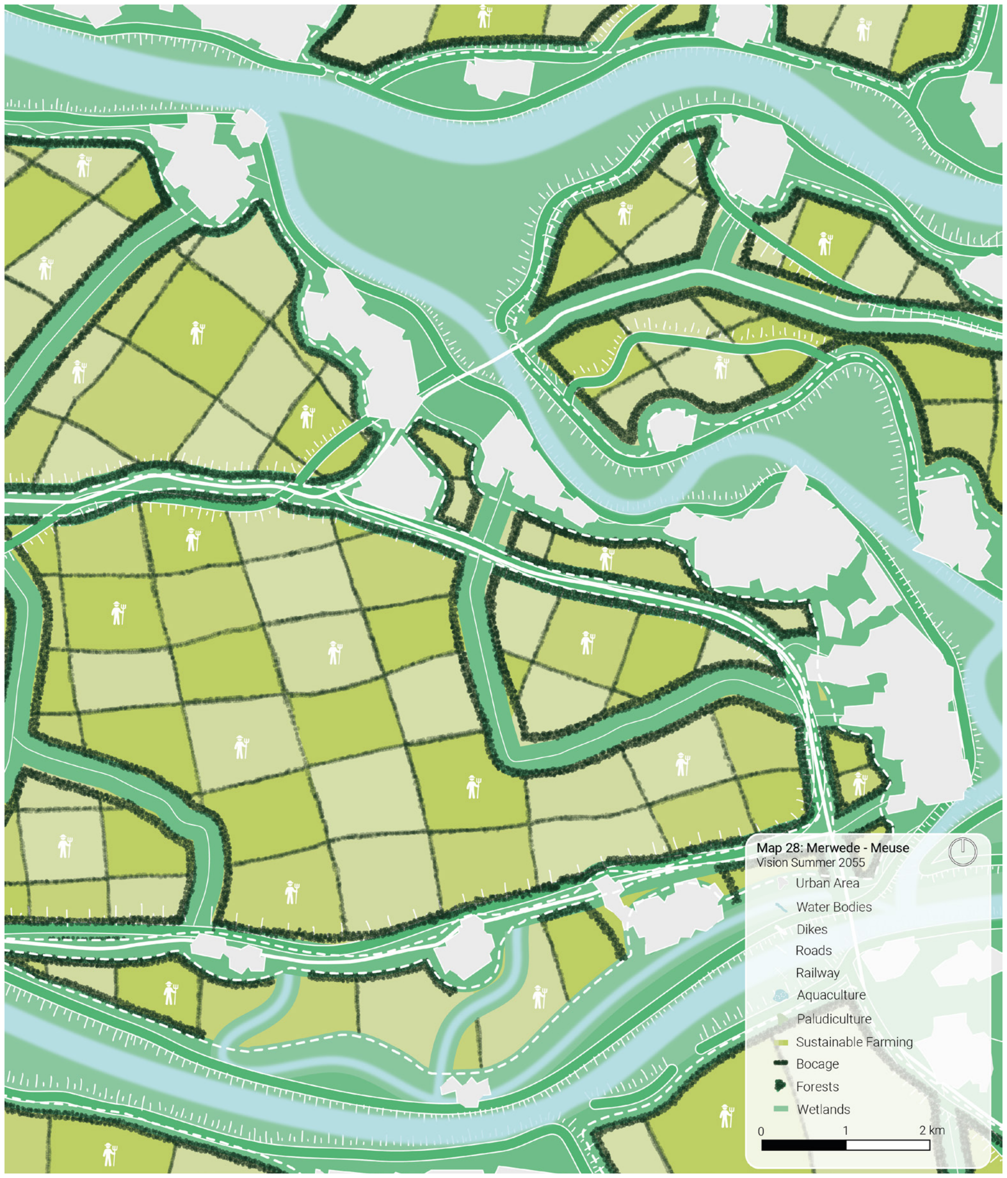

Map 26: Merwede - Meuse
Vision Summer 2035
Urban Area
Water Bodies
Dikes
Roads
Railway
Aquaculture
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km

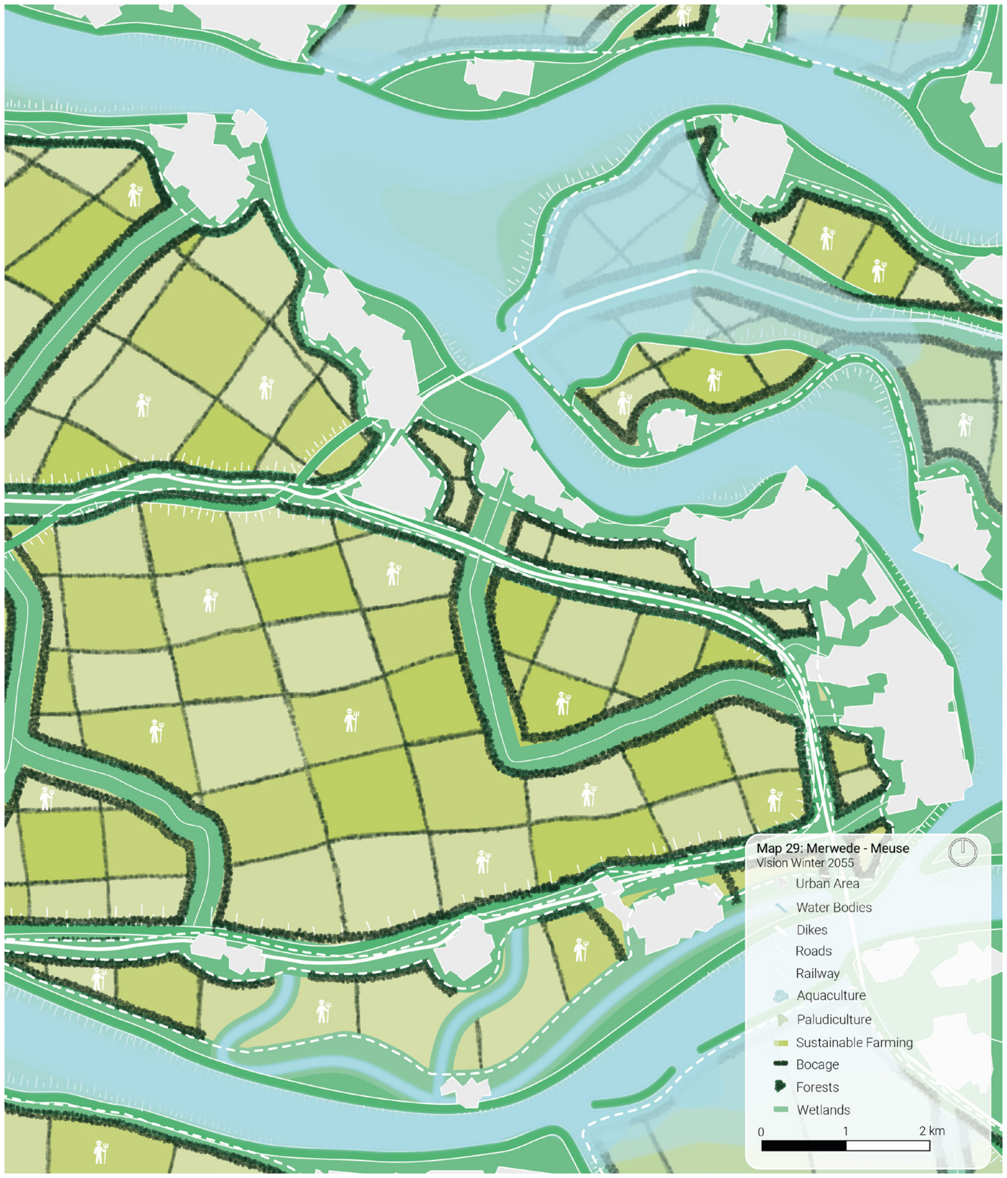

Map 27: Merwede - Meuse
Vision Winter 2035
Urban Area
Water Bodies
Dikes
Roads
Railway
Aquaculture
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km

Proposed situation 2055

Summer
Twenty years later, most dikes have been breached, marking a dynamic shift from controlling water statically to embracing its flow. This depoldering of the area has introduced seasonal agriculture. The development of the bocage landscape has continued, even in areas where semi-annual dry and wet cycles alternate, leading to an increase in ecological values. The larger central part, where aquaculture is planned in the more distant future, is still protected by dikes to accommodate these new forms of agriculture.

Winter
In the winter of 2055, river water will enter the depoldered areas where seasonal agriculture is practised. This primarily affects the smaller polders along the Merwede and Meuse rivers, while the larger central polder area remains protected from flooding, with water still being pumped into the river from these polders. However, this task will become more challenging due to the high water levels in the polder canals and in the river itself. Additionally, infrastructure built on water, such as the main road from east to west, will face increased risks and challenges.


Map 28: Merwede - Meuse
Vision Summer 2055
Urban Area
Water Bodies
Dikes
Roads
Railway
Aquaculture
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km


Map 29: Merwede - Meuse
Vision Winter 2055
Urban Area
Water Bodies
Dikes
Roads
Railway
Aquaculture
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km

Proposed situation 2075

Aquaculture

Aquaculture encompasses various forms of water-based agricultural production, including aquafarming and algae farming. Increasingly, companies are recognizing aquaculture as a viable source of income, with sustainability being essential for its development (Wageningen University, n.d. d).

In aquafarming, there are two primary approaches: the cultivation of animals and crops. This includes the cultivation of aquatic organisms such as fish, crustaceans, and shellfish, as well as the cultivation of crops like aquatic plants. These activities can be carried out in both inland and coastal areas (Wageningen University, n.d. d).

The second type of water-based agricultural production is algae farming. The European Commission's support for large-scale algae farms aims to increase production for food use (Wageningen University, n.d. c). Algae, often referred to as "green gold," can be processed into powders for use as supplements in food (Wageningen University, n.d. c). Unlike traditional crops, algae require less space and can grow in closed systems, which can be located on non-arable land utilising non-potable water, such as brackish or seawater. This enables them to complement rather than compete with conventional agriculture (Diaz et al., 2023).

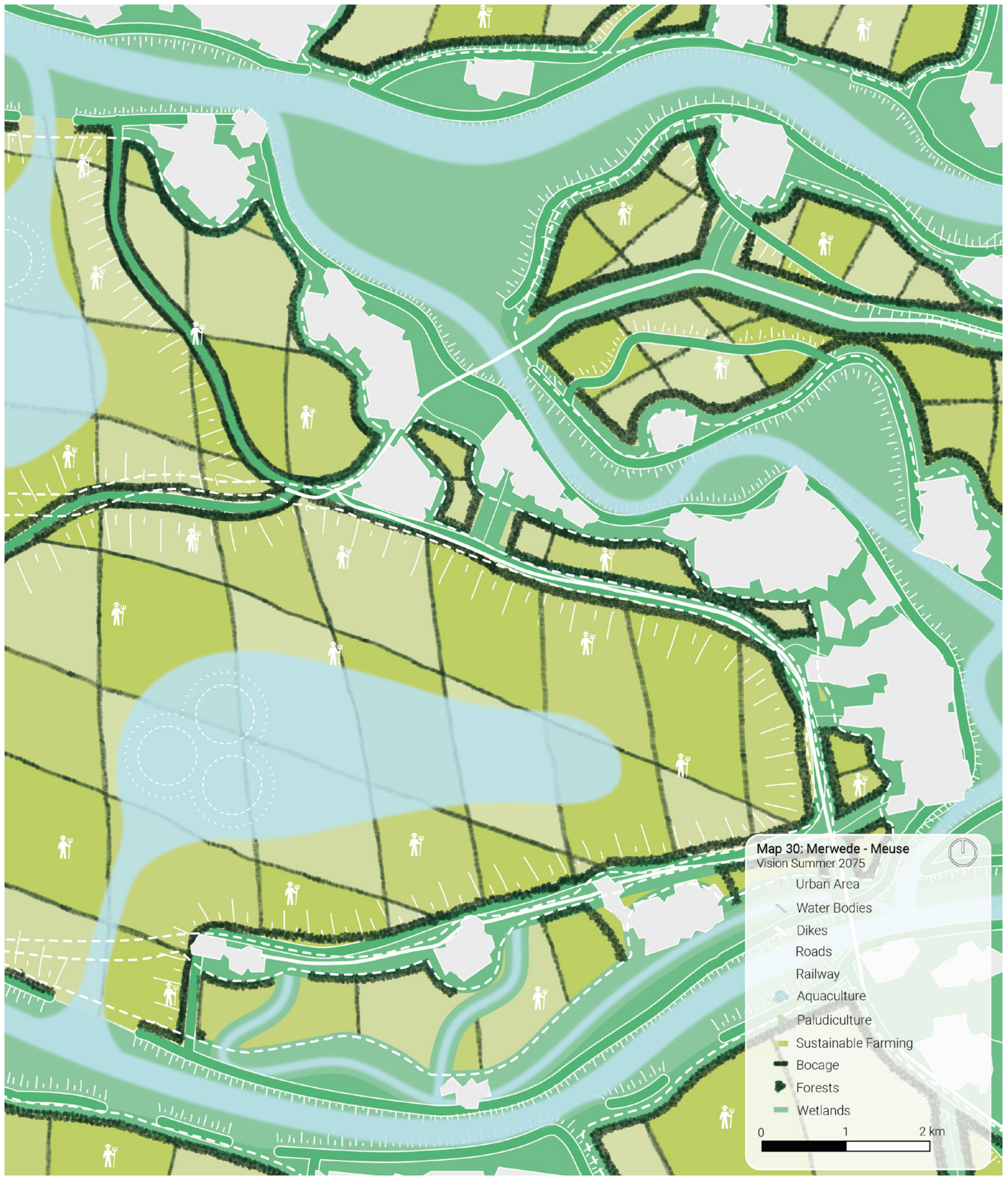
While algae-based products have begun appearing in supermarkets, large-scale adoption is hindered by taste preferences and processing complexities. However, technological advancements and environmental awareness are driving interest in algae as a sustainable food source (Wageningen University, n.d. d).

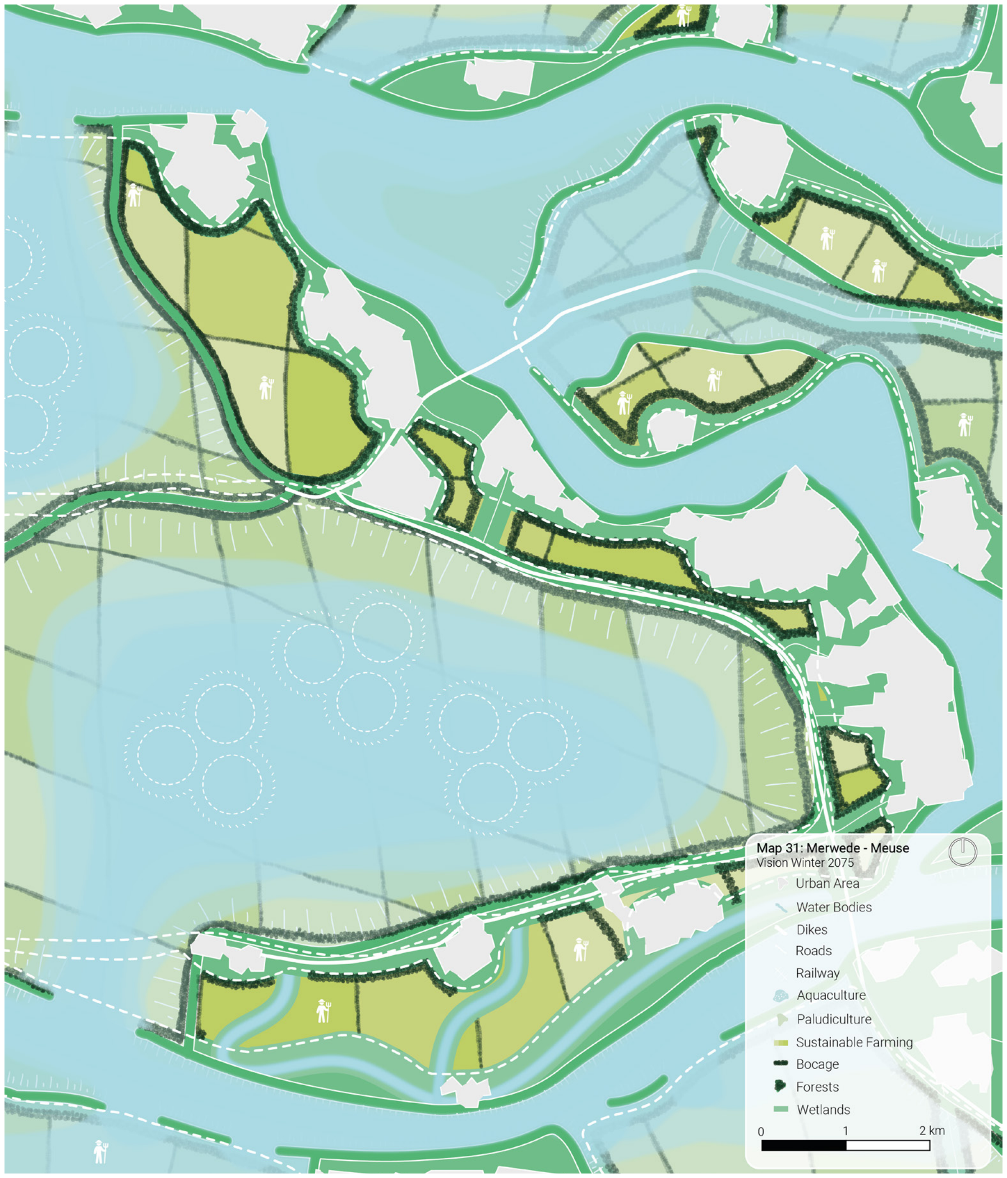
Summer

From 2075 onwards, the full potential of the Merwede-Meuse scenario will be realised: aquaculture will be integrated into the existing agricultural practices in the area, and the remaining dikes will be breached. A new waterway has been created to supply the ponds used for aquaculture with water during the summer months. This is necessary to ensure an adequate water supply and maintain continuity in aquaculture practices.
The zone where many towns are located is protected by a landscape dike with a gentle slope, which now serves as the gradient between dry and wet areas. Sustainable agriculture is practised within this dike ring, while seasonal farming becomes prominent on the slope side. The gradient between seasonal agriculture and aquaculture shifts with the water level.

Winter

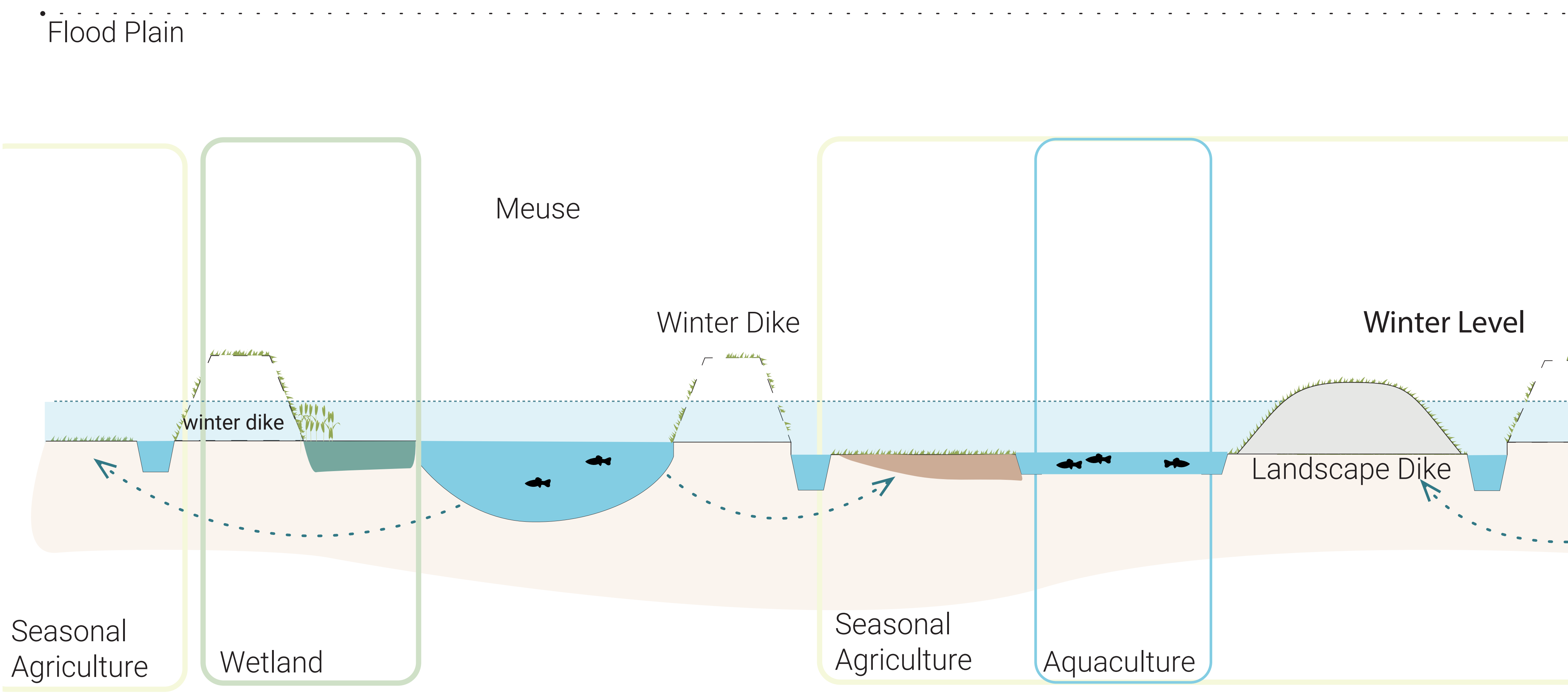
In winter, it becomes evident that the landscape has undergone significant changes: vast new water surfaces have emerged due to the flooding of the larger central polder. Along both the Merwede and Meuse rivers, aquaculture is practised in the now enormous ponds, which rise high against the landscape dike, providing optimal conditions for this practice. The floodplains of the rivers are completely submerged, and large parts of the bocage structures are also flooded. The result is a dynamic depoldered landscape in which land and water cover almost equal areas.


Map 30: Merwede - Meuse
Vision Summer 2075
Urban Area
Water Bodies
Dikes
Roads
Railway
Aquaculture
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km


Map 31: Merwede - Meuse
Vision Winter 2075
Urban Area
Water Bodies
Dikes
Roads
Railway
Aquaculture
Paludiculture
Sustainable Farming
Bocage
Forests
Wetlands
0
1
2 km

Section future

In the new section, the impact of breaching the winter dikes is evident: the floodplain has expanded significantly, aquaculture has found its place in the former polder, and wetlands have been created along the rivers. Agricultural activities relocate to drier areas, and incoming water during winter is redirected by landscape dikes. The extensive use of pumping systems to artificially maintain low water levels in the polders is no longer necessary.



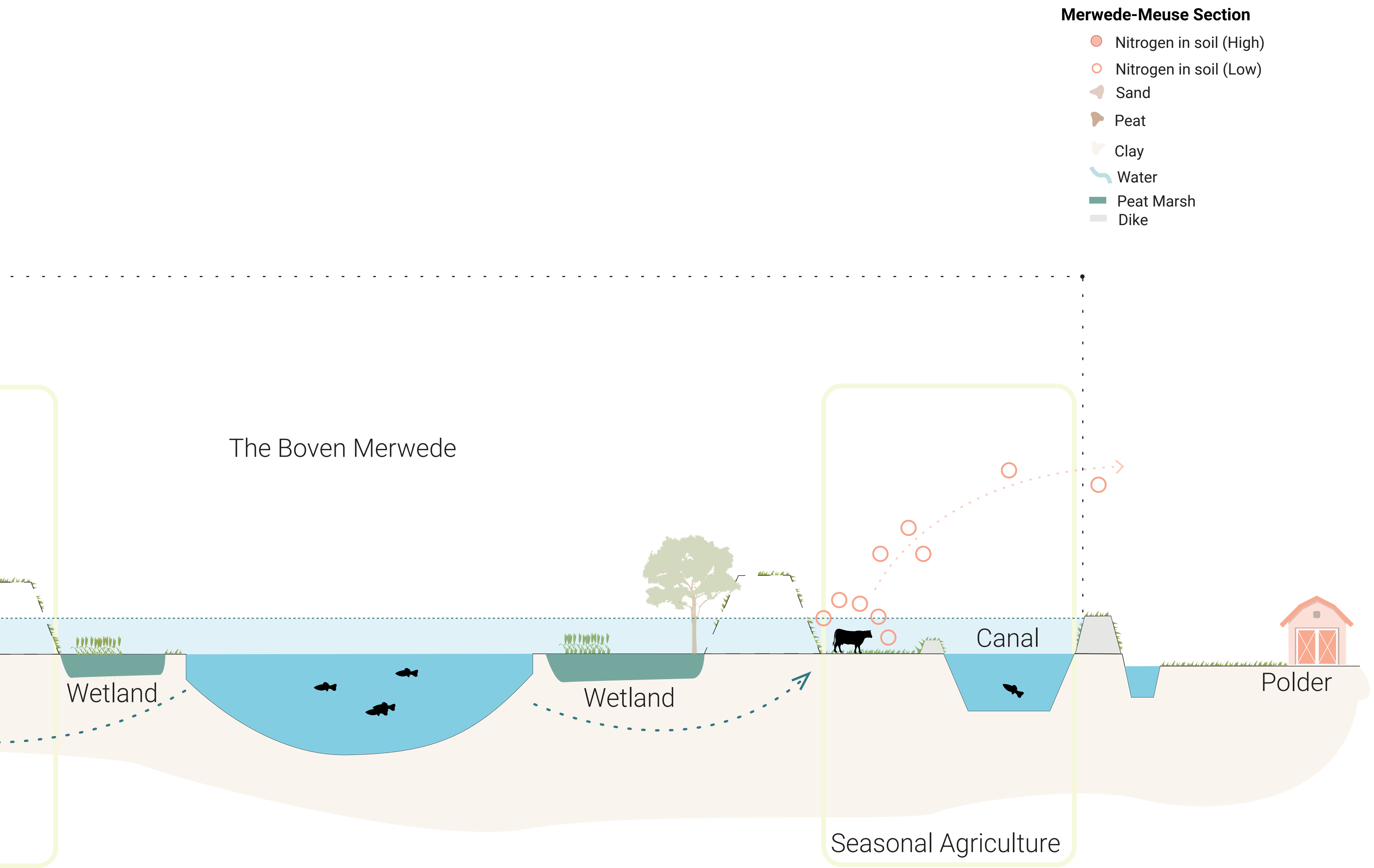


Figure 26: Merwede – Meuse (Section 2075)

Types of Dynamics

In the Merwede-Meuse scenario, similar dynamics are observed as in the previous scenario, except for paludiculture and active peat formation in water features resulting from underground seepage flows. A new aspect is the cycle of aquaculture: depending on the organism being cultivated, it may have a cycle lasting several weeks or months (Wageningen University, n.d. c).

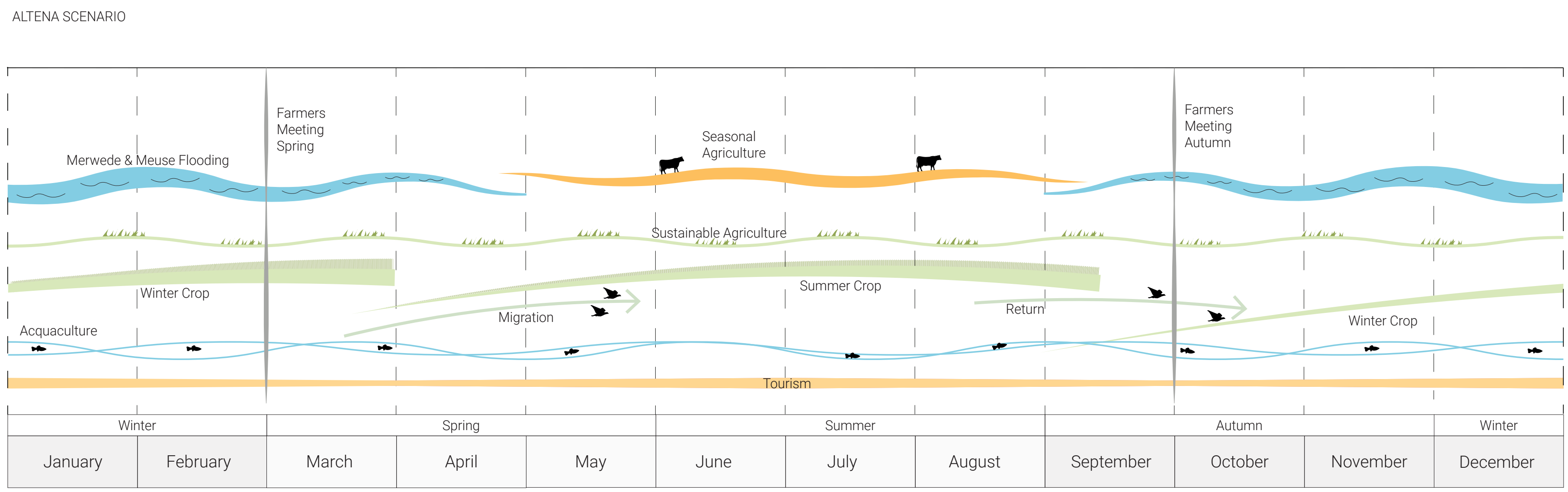


Figure 27: Merwede – Meuse Dynamics

Timeline

The third and final phase encompasses changes until 2090, applicable only to the extremely wet scenario. The farmer boards have been operational for a few years, and after deliberating on this new form of agriculture, aquaculture is introduced. During the preceding phase, homeowners and farmers were informed about the forthcoming changes, such as the relocation of dikes. Now, it is time for additional homes to be relocated and for farmers to be bought out.

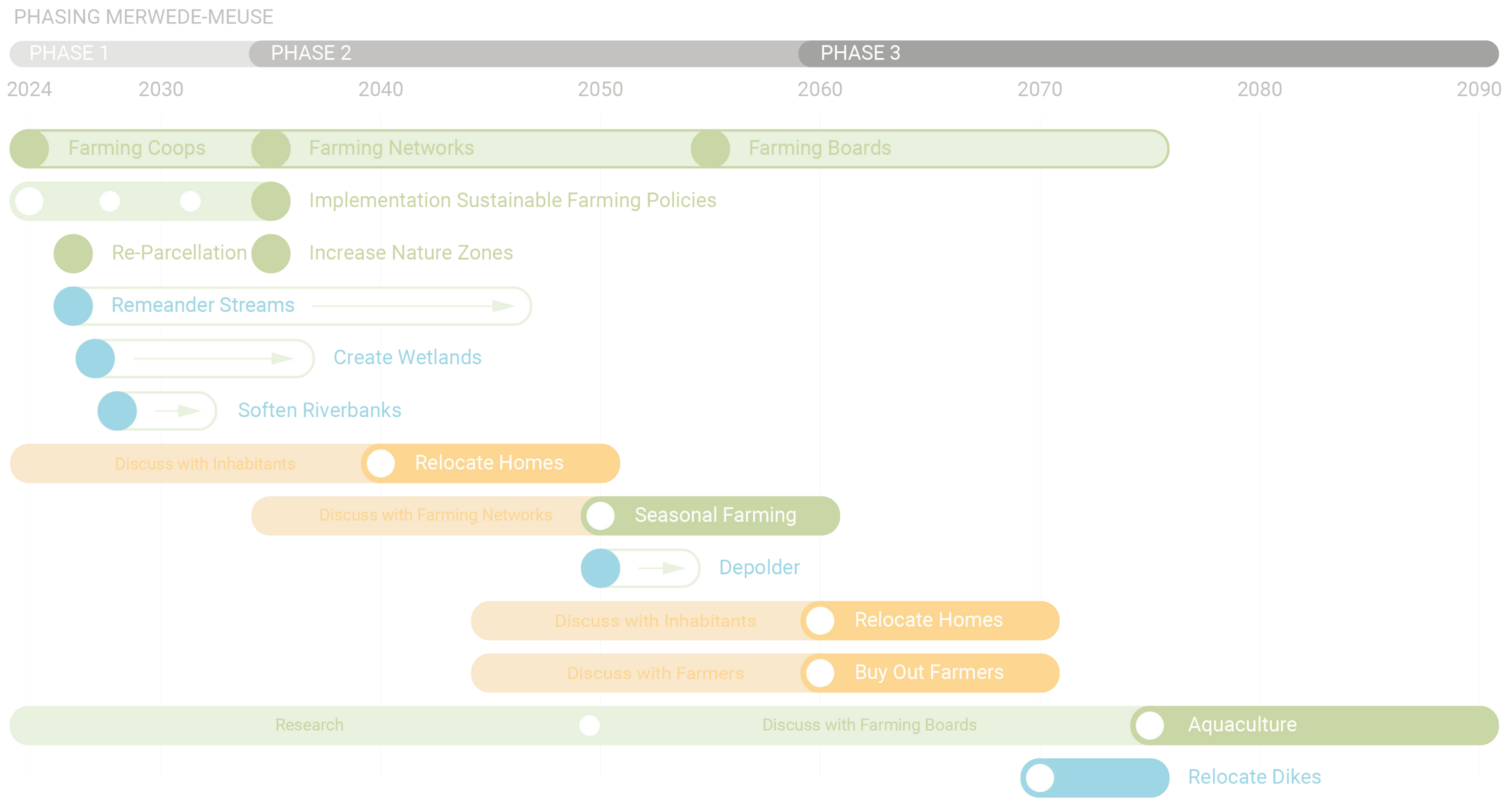


Figure 28: Merwede – Meuse Phasing Timeline

■ Actors

In the last phase we introduce the Farmer Boards. Working together and at the same level as water boards.

Farmer board

Role: Board consisting of representatives of farming networks with farmer coops.

Goal: Good collaboration between networks of farmers, collaboration with waterboards and representation of farmers.

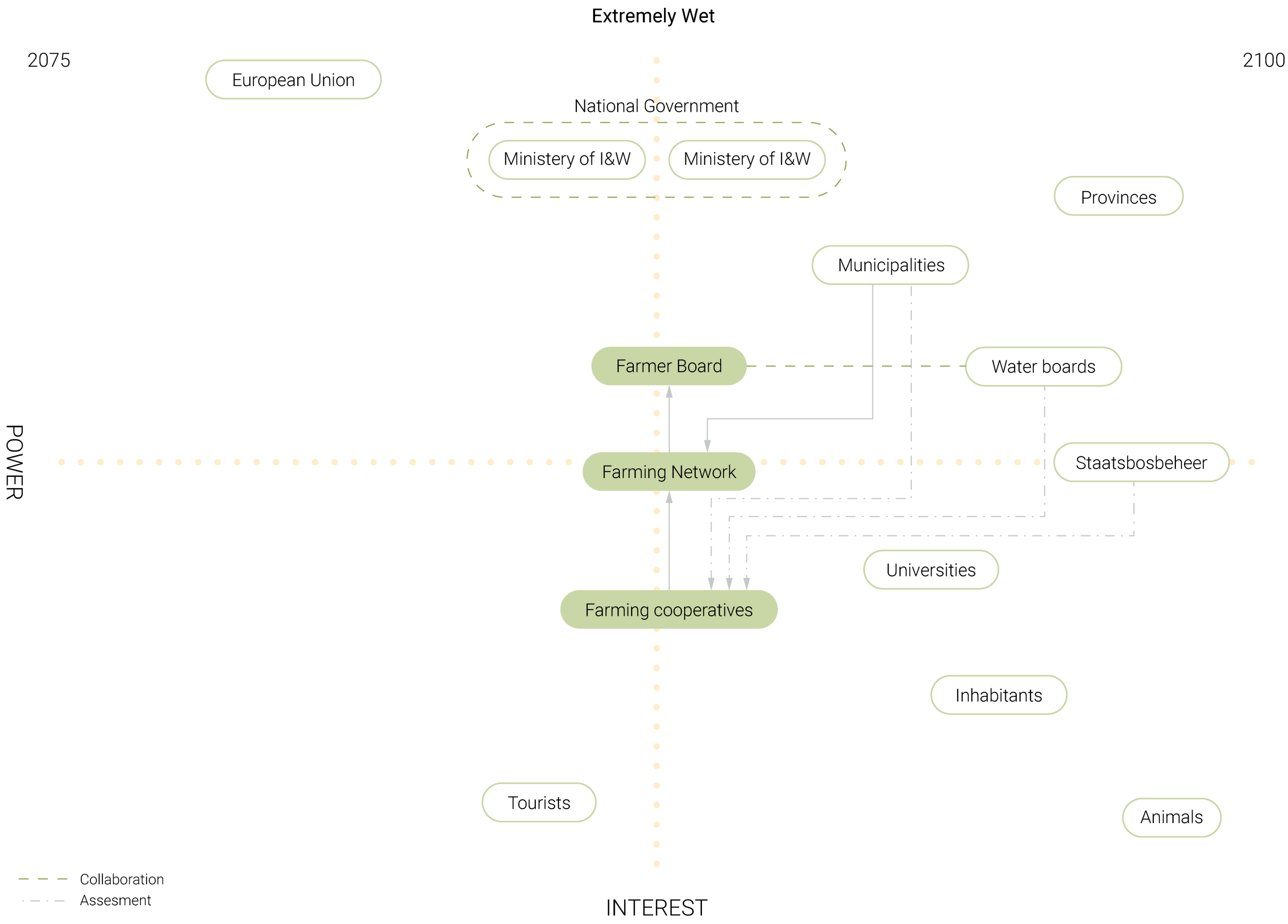


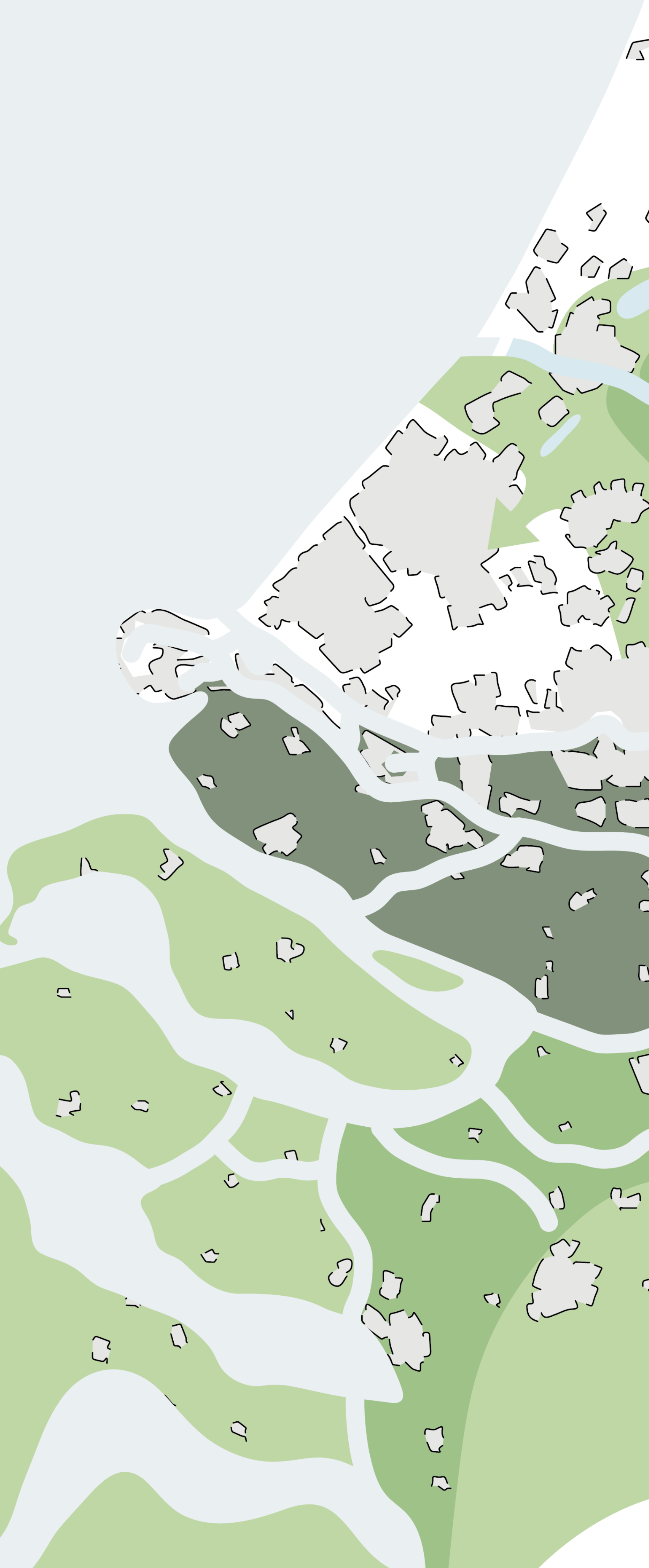
Figure 29: Merwede – Meuse Power/Interest Matrix

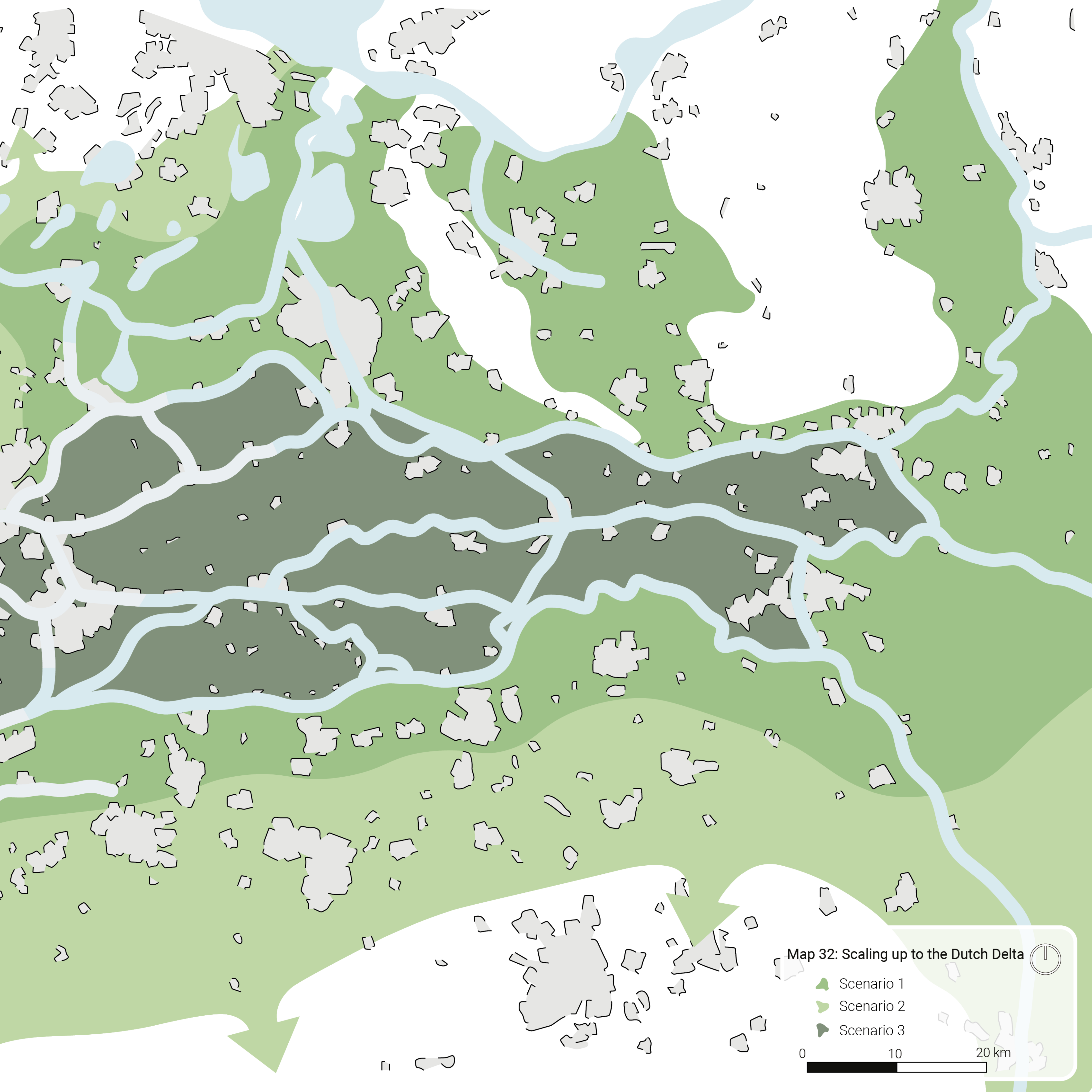
03

Synthesis 'Go with the Flow'

Regional map scenarios

In this map, the different scenarios are depicted across the entire Dutch Delta region. It illustrates how the three pilot projects can be implemented in various parts of the region and how the entire area can transform in accordance with the vision of Go with the Flow.




Map 32: Scaling up to the Dutch Delta
Scenario 1
Scenario 2
Scenario 3
0
10
20 km

Full timeline and interventions

On the right is the complete timeline of our strategy: 'Dynamizing the Delta.' This timeline combines the phases of the three pilot projects, starting from the present. It envisions all implementations that will contribute to the vision of the project: 'Go with the Flow.'

These bird's-eye views below depict the three locations with varying conditions, each with corresponding interventions.

Figure 30: Birdseye Meuse – Dunes

Figure 31: Birdseye IJssel – Moraine Floodplain

Figure 32: Birdseye Merwede – Meuse

Meuse Dunes

- Farming cooperatives
- Sustainable farming
- Reparcellation
- Nature buffers
- Wetlands
- Remeandering streams

IJssel Moraine Floodplain
Interventions Meuse Dunes

- Paludiculture
- Farming Networks
- Depoldering
- Paludiculture

Merwede-Meuse
Interventions Meuse Dunes, and
IJssel Moraine Floodplain +

- Aquaculture
- Relocating dikes

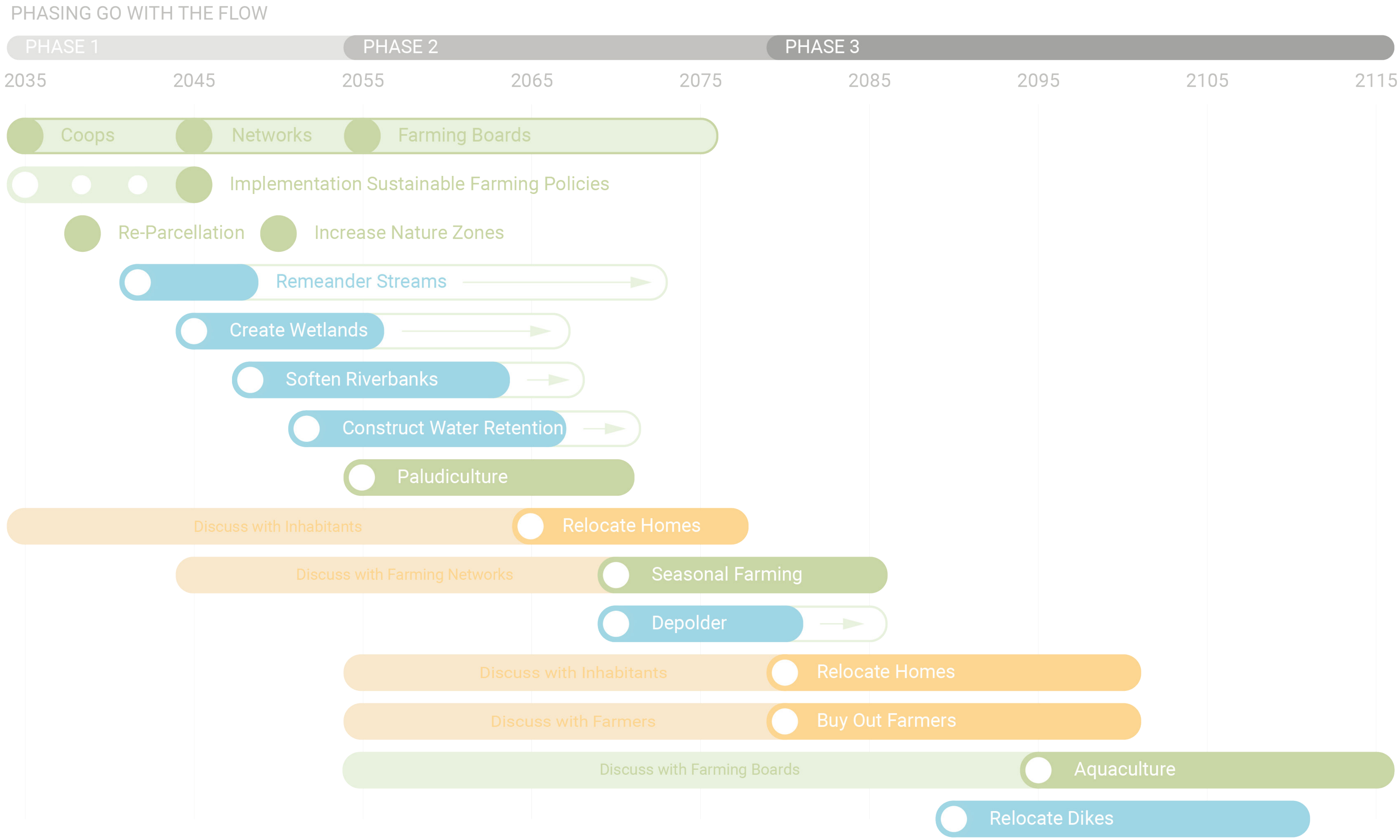


Figure 33: Full timeline 'Go with the Flow'

04

How to scale up to the Eurodelta?

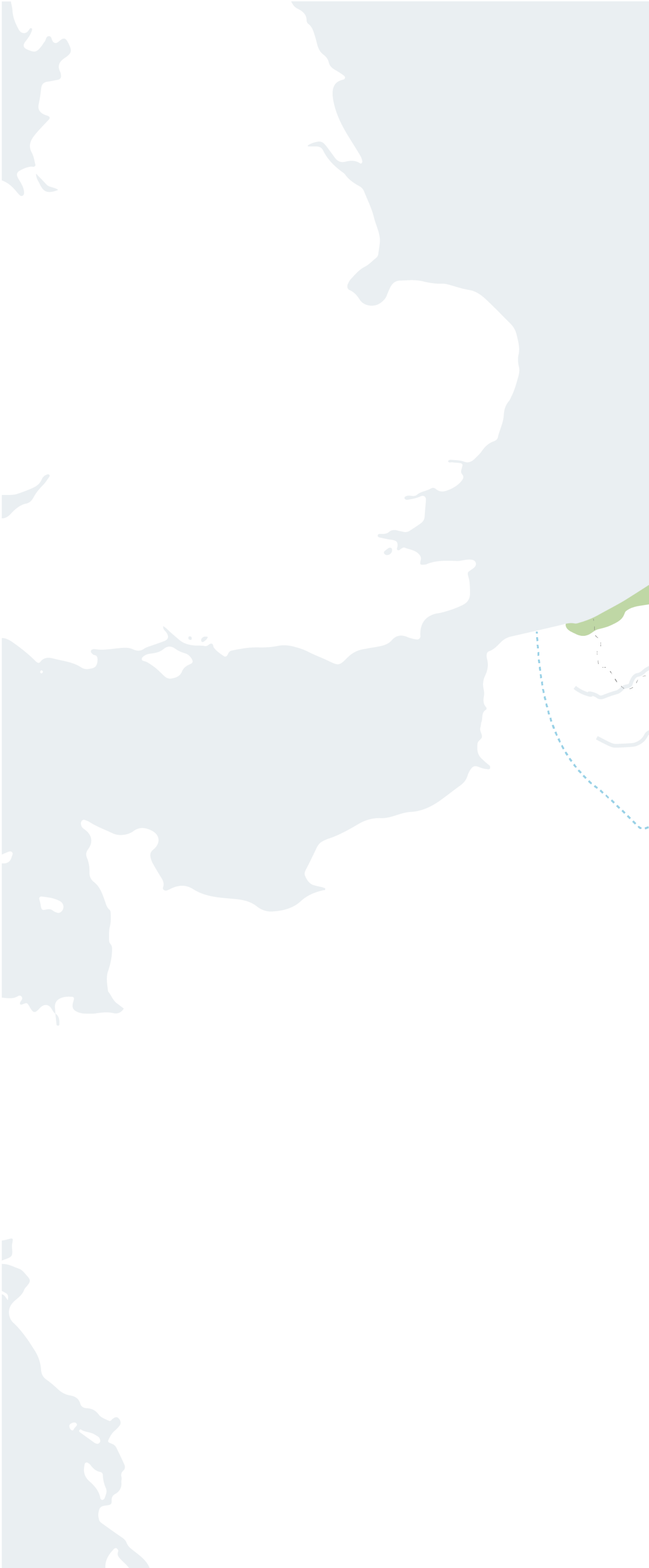
Strategy for the Eurodelta

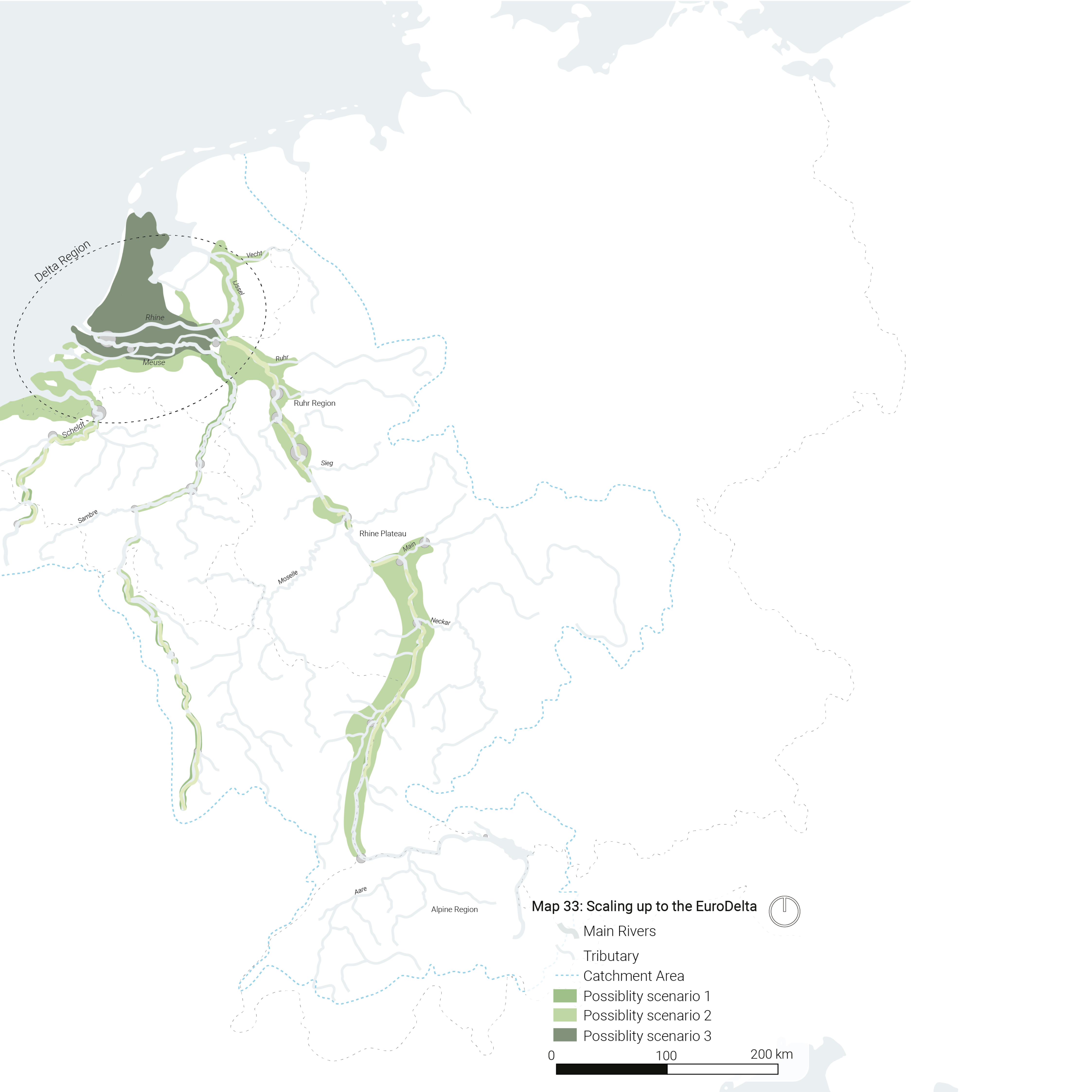
This map illustrates how the best practices from the Dutch delta can be applied to the scale of the Eurodelta. Although the Dutch delta is ideally suited for the new dynamic system due to the concentration of rivers and land below sea level, there are certainly possibilities upstream along the Rhine, Meuse, and Scheldt rivers. The division into the three outlined scenarios has been chosen. While these are not completely identical, the landscape features at the designated locations are comparable, and therefore, so are the dynamic possibilities.

Scenario 1 focuses on strengthening nature and biodiversity in the floodplain, characterised by natural relief that acts as a gradient between dry and wet areas, and the absence of clay soil. Additionally, much of the land along the river lies below the water level. In this context, the possibilities are relatively limited, but parts of the Meuse and Rhine, in particular, can be designated as potential intervention areas. These areas exhibit a significant difference in height between the fields along the river and the relief at a minimum distance.

The possibilities in scenario 2 are more extensive: compared to scenario 1, there is more land that can be flooded before the water is turned back by relief. Additionally, there is more land here that is immediately flooded when the dikes are breached. This creates more opportunities to realise zones of seasonal agriculture, regenerative agriculture, and possibly paludiculture in wetter parts. The areas where it is possible to apply scenario 2 are mainly located along the Rhine, such as the Ruhr Valley and the Upper Rhine Valley between Basel and Mainz. There are also possibilities in the Scheldt delta.

Scenario 3, characterised by polder land lying below the water level of the rivers, is an almost Dutch phenomenon on the scale of the Eurodelta. Here it becomes clear once again that the Delta Region is the most ideal testing area to put new dynamic systems into practice, redefining water, agriculture, and land use. The map clearly depicts the Netherlands as the 'drain' of Europe, providing a significant advantage in terms of opportunities compared to countries such as Belgium, France, and Germany, where opportunities are less abundant.





Map 33: Scaling up to the EuroDelta

06

CONCLUSION & DISCUSSION

01

Conclusion

Through an analysis of the current state of the Dutch river delta, the research indicates that the dynamics between land use, soil, and water flows in the landscape of the region are minimal due to rigid boundaries. The conditions of soil type and water significantly impact land use. For the Netherlands, this means high-quality fertile soil, resulting in intensive agricultural practices. The high concentrations of intense agricultural production in such a small land area, whether in cattle farming or monoculture farming, often lead to high levels of nitrogen emissions. Consequently, nitrogen is stored in large quantities in the ground and water bodies, leading to significant disruptions to the ecosystem.

A well-known aspect of the Netherlands is its large-scale anthropogenic environmental interventions. From national water management to regional parcellation, the Dutch have divided themselves into manageable pieces. These separate but neighbouring entities become inequitable in terms of distribution. Ideally, water, soil, and land use are in a state of equilibrium.

By opening up the boundaries between these entities, the project promotes dynamic changes in conditions over time, thereby dynamizing the delta. The project envisions an integrated approach in which the natural flow of the river is connected to new agricultural practices and land use that keep the soil healthy. This vision not only redefines how the Dutch have historically dealt with flood safety but also creates a new dynamic system in which biodiversity and agriculture work together to create a larger overall value. A dynamic river landscape in the Dutch Delta region does not only favour agricultural land use but treats the system as a whole.

The desired synergy between water, agriculture, and biodiversity is defined in the vision with three spatial referential strategic interventions, or scenarios, located in the Meuse dunes, IJssel, and Merwede-Meuse. In each of the scenarios, adjustments are made to the uses of arable lands, often corresponding to the level of the water at a specific time, or the rebalancing of soil nutrients.
The vision redefines the whole river landscape in the Dutch Delta Region. However, this strongly impacts the social equity of farmers negatively by putting some farmers at a disadvantage. The project addresses this by embedding an aspect of governance in its vision proposal. The proposal particularly emphasises the decentralisation of power and the inclusion of local farmers in decision-making processes. Go with the Flow aims to use a bottom-up strategy where possible and only employs top-down strategies where necessary. This bottom-up approach seeks to empower local communities and ensure that their voices are heard in shaping the region's future. Collaborations are created, and knowledge is shared. This emphasis on social justice and community involvement reflects our commitment to inclusive and participatory planning practices.

In conclusion, the research underscores the pressing need to address the intricate dynamics of land use, soil quality, and water management in the Dutch river delta. Highlighting the adverse impacts of intensive agricultural practices on nitrogen emissions and ecosystem disruption, it advocates for a paradigm shift towards a more integrated and sustainable approach. By embracing the natural flow of rivers and promoting dynamic interactions between water, agriculture, and biodiversity, the envisioned scenarios offer transformative local visions that provide typological tools for larger regions. However, the project recognizes the potential social inequities it may generate, particularly for farmers, and thus embeds bottom-up governance mechanisms aimed at rewarding from a positive attitude. Making decentralisation and community inclusion key points. Through collaborative efforts and participatory decision-making, the project strives to reconcile environmental imperatives with social justice, ensuring a more resilient and equitable future for all stakeholders in the Dutch Delta region.

Figure 34: Collage 'Go with the Flow'

02

Discussion

This report has been drawn up from a visionary perspective aimed at inspiring all those involved in the Dutch landscape, and particularly the delta. By visualising the spatial implications of the dynamics present in the landscape, a picture is sketched that functions as a framework within which the outcome lies. No hard or specific outcome has been set that will certainly be achieved in an identical manner, apart from the three scenarios being more precise.

This way of designing and working on the Dutch landscape, which also involves thinking long-term into the future for a scenario with high societal impact, is not yet present to the same extent at all Dutch design agencies. Thus, this report functions as a pioneering study in this respect, in which we have not avoided throwing the stone into the pond.

We outline a broad perspective on the integrated developments of the different subjects included in our project, aiming to reach a healthy balanced system. Ideally, this system has a balance between People, Planet, and Prosperity, but Go With the Flow naturally favours Planet as the dictating one in this balance.

Some elements of the plan proposed in this report can benefit from further research. One of these elements is the social justice of some stakeholders. We aimed to take all stakeholders into account, but this was not thoroughly possible in the given time. Consequently, we did not manage to meet and interview the stakeholders who are socially impacted the most by the proposed changes, like the farmers. A proper and detailed evaluation of their needs and wishes could increase their perception of our implementations in a positive manner. Besides the farmers, inhabitants who are affected by our interventions could also be discussed more. Especially in the third pilot project, the Merwede-Meuse, many inhabitants need to relocate their homes due to the flooding of land. We could have been more cautious with these stakeholders who experience quite an impact.

Another element that could benefit from further research is the economic effect of implementations as proposed in Go with the Flow. The interventions we plan for the future come with high costs, but we are convinced the project is worth it in the long run because of the decrease in nitrogen pollution, a healthier soil, and sustainable agricultural practices reducing the burden on future generations. The extent of this combination is not entirely clear, as many of its dimensions are challenging to quantify accurately, necessitating further investigation. The topic of economic success on sustainable farming practices, paludiculture, and aquaculture could also be more elaborated, but research on these new farming practices is also incorporated into the timeline of the project.

Taking these discussions into account, the report is a good starting point for embracing the dynamics of the Dutch river landscape, and it can be used as inspiration for future studies on the river Delta and other projects on the Dutch landscape by putting central the changing conditions through time as the main possibility instead of the defined space and its layering as a limiting situation.

07

REFLECTION

01

Reflection

Scientific contribution

With our project, we propose a new system to rethink space, land use, and conditions in the Netherlands. We analysed the old layer approach in which space is seen as the defining condition and focuses on the final product. We propose a more dynamic approach, guiding towards a dynamic process framework that is fit to support future generations as well.
The report goes further than the already existing vision of Room for the River, not only to view space as the defining factor in future planning but to recognize the changing condition over time and the rhythm of natural processes.

Societal Relevance

From our thematic focus, background research, and analysis, the societal relevance became clear. The climate change crisis is a strongly discussed topic in our project, where we should find ways to reduce global warming. The rising sea level had an impact on choosing our region of focus, in which the river delta is the region where a high number of dynamics can be implemented with our strategy. Next to the climate change crisis, the farmers' protest is also one of the main topics of our project. Currently, farmers are concerned about stricter obligations for reducing nitrogen emissions. We are now facing the challenge of differences in opinion between farmers and environmentalists regarding the feasibility and effectiveness of specific farming practices. Both topics need a solution to be able to meet the needs of current and future generations. In our project, we combine these challenges and turn them into opportunities. We use the flow of nature to introduce new sustainable agricultural practices to keep the farmers, but also reduce global warming.

Ethical Reflection

The ambitious project aimed at revitalising the Dutch river delta brings to light complex ethical considerations, particularly regarding its impact on vulnerable actors, such as farmers and inhabitants. While the envisioned scenarios promise a more sustainable and integrated approach to land use, soil quality, and water management, they also raise significant concerns about social equity and justice.

One of the most pressing ethical dilemmas revolves around the potential displacement and disadvantage faced by farmers who collectively may lose parts of their land to nature and water management. For many of these individuals, farming isn't merely a livelihood but a way of life deeply rooted in tradition and personal history. Disrupting this long-standing connection to the land can have profound emotional and economic repercussions, threatening the cultural fabric of rural communities.
This might appear strict from the individual perspective, but the well-being of society, the larger group, is at risk if nothing changes from the current condition. It is our duty to provide future generations with no less than the opportunities we have today, so this could mean limiting the possibilities of a smaller group in order to provide society and the future successors of this specific group with perspective.
A situation that cannot remain the same due to negative repetitive patterns, such as the nitrogen crisis, demands change, and it is impossible to solve this without having any victims, even while this does not mean that the individual discomfort is not present. No action taken has the result that everyone loses their quality of life, so it is the collective duty to make up for individual losses that benefit society.

Social justice

The proposed paradigm shift towards a more dynamic river landscape may exacerbate existing inequalities, as certain farmers may struggle to adapt to the changes or face financial hardships due to land relocation. It is essential to recognize the inherent power imbalances that exist within such transitions and to mitigate the adverse effects on vulnerable groups through proactive measures.
The project's commitment to inclusivity and participatory planning practices is commendable, as it seeks to empower local communities and ensure their voices are heard in shaping the region's future. By facilitating stakeholder participation and fostering collaboration among diverse stakeholders, the project aims to promote equity and social justice.
However, it is crucial to acknowledge that inclusive decision-making processes alone may not be sufficient to ad-

dress the systemic challenges faced by vulnerable actors. Efforts must also be made to provide adequate support and resources to those adversely affected by the transition, including financial assistance, vocational training, and psychological support to cope with the emotional impact of change.
Moreover, the project's emphasis on a bottom-up governance approach should extend beyond consultation to genuine partnership and co-creation with local communities. This requires building trust, fostering open dialogue, and actively involving vulnerable actors in every stage of the decision-making process.

02

Personal Reflections

Jean Bijlsma
How did we 'Go with the Flow' in the process of our project?

The aim of the course was to create a vision for the Eurodelta on the topics of water and nitrogen. During this year of urban design, I have not worked on this big of a scale before, which made me curious to see how working with these bigger scales work. This vision and strategy can be used as a communication tool to various stakeholders. The strategy provides interventions for current and future developments and are elaborated in a clear way. This vision wants to inspire people for a better future, in which we coexist with nature. In this vision we translated our ideas for the future into spatial plans and visualisations. We focus on the decrease of nitrogen emissions and the increase of biodiversity as a result of a new dynamic system.

From the start, we worked well as a group and had few discussions during our process. Working as a group on this project, brought its challenges and its opportunities. We were able to help each other out and share knowledge on different topics. During the start of the process, we did not divide our work in a clear way, but everyone just picked the things they were good at and felt responsible, which did work for the first weeks. I would describe this as going with the flow. After the midterm presentation everybody noticed our way of working and we discussed that maybe it would be nice to also work on new methods or ways of working to improve our own skills. We could see this as the opposite of going with the flow, but sharing knowledge and learning more skills to improve the products you already made can contribute to the flow of the working process. This led to a better division of work in the second half of the course.

From the SDS and the Capita Selecta lectures, we learned new methods to use for the research of our project, however, we did not use them, because we did not feel like they suited our project's process. A relaxed atmosphere in our group helped us get to our final products and narrative, creating a clear overview of what we want to achieve.

In conclusion, the work flow during our project was translated in the vision and the strategy of our project, Go with the Flow. We tested our ideas for a new dynamic system in the delta region and tried to find new implementations that are currently not well researched.

Martijn Timmerman
What difficulties need to be overcome when creating a design and strategy outside the existing boundaries of design and research practice?

During the Capita Selecta at the start of this project, I knew I looked for a project impact that fell outside existing focused scopes through an innovative holistic approach, because I know from experience that the best projects start with visionary setting of frameworks with a high ambition. This starts with integrating aspects that do not directly seem to be related. Knowing that this entails risks: it is difficult to estimate how feasible an ambitious project is, and if overestimated, the result can be much less than with a 'safe choice'. In this respect, choosing an integrated approach of the aspects from Capita Selecta was also taking a risk, although my background and experimental bachelor thesis gave me confidence that the project would be feasible, but in a group project you need to have trust together in a positive outcome, and this has developed through time, with the first weeks being the most difficult as the direction was not completely clear.

The shift from the layer approach to the dynamic model was my own observation that formed the starting point for working with the dynamics of the landscape in the initial phase. On the one hand, this was a big step outside the existing boundaries, but on the other hand, even in the initial phase I could already see how this could be translated into a spatial design by using this as a philosophy in the back of my mind. But sometimes it was difficult to get it clear as a group that everyone was talking and thinking about the same thing, and at moments I found this quite difficult, because I quickly assumed that everyone was on the same page and understood a new idea to the same extent. In this, I could have pointed out the struggles that come with this choice more to prepare everyone for the critical feedback we would surely receive. In this respect, it was instructive that a regional vision is so large-scale that it cannot be worked on other than as a team. In this coordination, the learning aspect of clear communication, both in text and images, was extra important, just like making uses of the strengths of each individual.
The implementation of the dynamic spatial design was a hard part, because from the perspective of spatial and social justice, force is not the way to go to make actors comply to our strategy. The knowledge that all change is met with resistance helped to keep the belief in what was spatially a strong design, resulting in a strategy of pointing out advantages of the possibilities instead of punishment.
In conclusion, the difficulties in creating a design and strategy outside existing boundaries were mainly in the area of targeted mutual communication, taking the risk to take an unknown path and developing the strategic implementation of a visionary spatial design and strategy.

Milo Marler
How did ‘Go with the Flow’ benefit from an iterative design process?

The aim of the course was to create a vision for the Euro- During my undergraduate design projects, research primarily revolved around site analyses, plan development, and exterior studies. However, this studio course challenged us to combine these approaches to form a comprehensive design for a region within the Eurodelta, which was new to me. Forming our group based on a mutual concern for the nitrogen crisis and waterways within the region, after the Capita Selecta lectures in the first week, provided us with a moderate scope to start our design process. After the introductory sessions on GIS, we selectively applied the theory to our analyses. After delving into available data and map production, we arrived at a conceptual framework we were happy with.

Transitioning from this framework to a coherent vision proved challenging, particularly given our focus on river dynamics. In the end, we opted to concentrate on three specific locations for which we created strategic interventions. This decision immensely clarified our project’s overarching goals and facilitated the creation of a vision not only for our designated region but also for the broader Eurodelta.

Following the midterm presentation, our attention shifted towards strategy development. Having already identified three strategic interventions through our earlier spatial exploration, we were quite far in creating it.

Reflecting on this experience, I recognize the value of interdisciplinary collaboration and the iterative nature of design processes. While we navigated challenges and made strategic choices along the way, each decision contributed to our collective understanding and refinement of the project’s direction.

Tanne Brouwer

How do dynamics take part in our research and design process?

This course in research and design challenged me in many ways, but due to the great collaboration within our group, it did not feel like it at all. The project is on a scale I have never previously worked with, but is therefore personally very eye opening and informative on new subjects. The project reveals the importance of different technical, methodological, social and political perspectives in creating a vision and strategy on this scale. We approached the problem through an iterative process of going back and forth between the vision and the strategy. This way the research and the design process were not linear, but more of a dynamic process. We came up with the pilot scenarios in the very beginning and constantly reflected on these throughout the development of Go with the Flow. Our way of team collaboration worked well with this dynamic process. We divided the work amongst all team members to be efficient, but constantly helped each other out or finished where others left off. This started off in a slightly chaotic manner, but during the weeks we learned to integrate our knowledge and skills and created a relaxed work environment.

The course started with a series of Capita Selecta lectures. These lectures in the beginning of the course consisted of experts sharing their knowledge on different types of Dutch spatial planning. This helped to familiarise us with different approaches to planning and especially in the beginning helped with deciding on a main focus of the project. During the course, we also attended different SDS workshops with our group. The one about systemic sections was very useful, because this really encouraged us to think clearly about the current and desired systems. Other workshops were less beneficial to use in our particular case of the research and design process, but added to the dynamic process of the course.

Ian Lu

What is the interplay between research, vision, and governance in shaping the planning and design development?

The journey through this project has been both challenging, extremely demanding but fascinating. Pushing me to explore new scales and perspectives within the realm of urban planning and design. Initially, I was used to focusing on the range between provincial and street scales. The "Go with the Flow" project enlarged the challenge to the Northwest European scale. The Capita Selecta lectures served as pivotal moments, sparking my curiosity, and expanding my understanding of complex issues such as the global oil crisis and the nitrogen problem in Dutch society.

The lectures illustrated the interconnectedness of various factors, emphasizing the need for a holistic approach to problem-solving. Starting with when Carola Hein introduced her "Oil Space" project with a great passion. She delved into the complexities of the global oil issue, emphasizing the interconnectedness of factors such as politics, money, and material flow of oil itself. It sheds light on the intricate web of relationships between these elements, highlighting how actions and decisions in one area can ripple across others. Similarly, the lecture on "Cowborgs in the Polder" by Victor Munoz Sanz offered insights into the nitrogen problem and its relevance to Dutch society, particularly amidst farmer protests. This made me think about how these issues manifest in landscape-based regional design. I realized that addressing societal challenges requires more than just isolated solutions with separate entities but rather a comprehensive understanding of how different elements interact and influence each other. This insight shaped our project's approach as we sought to address the interplay in the Dutch Delta region.

In preparation to the Noordwaard Bieschbosch excursion, we understood the vital role that water plays in nutrient exchange. We were then intrigued by diverse landscapes and their relation to human activities. We examined how spatial planning and engineered boundaries affect interactions between different land uses.

We analysed the Netherlands based on the synergy between water, agricultural land use and nature and came up with a focus region to define scenarios. These scenarios act as referential strategic interventions to the rest of the euro delta region. They are our SPATIAL VISION, "an imagination of a desirable and plausible regional future" (Balz, 2018). Our project's vision served informed our decisions and priorities throughout the planning and design process. It envisioned a dynamic river landscape, emphasizing harmony between economic activities, environmental preservation, and social equity.

Furthermore, the governance aspect was deeply embedded in our proposal through the decentralization of power and the inclusion of local farmers in decision-making processes. By adopting a combination of top-down and bottom-up approach, this reflected our commitment to inclusive and participatory planning practices.
Yet, despite our best intentions, the project was not without its challenges. Balancing the needs and interests of various stakeholders proved to be a delicate dance, requiring constant negotiation and compromise. The scale of the project also presented logistical hurdles, forcing us to grapple with issues of coordination and resource allocation.

Overall, this project challenged me to think critically about the relationship between research and design, the role of vision in shaping development strategies, and the importance of governance in planning processes. It highlighted the interconnectedness of various factors and the need for collaborative and holistic approaches to address complex societal challenges.

08

REFERENCES

01

Literature

Aertebjerg, G., Carstensen, J., Dahl, K., Hansen, J., Nygaard, K., Rygg, B., Sørensen, K., Severinsen, G., Casartelli, S., Schrimpf, W., Schiller, C., & Druon, J. N. (2001). Eutrophication in Europe's coastal waters. http://www.eea.eu.int

Altenburg & Wymenga, Bureau Peter de Ruyter, Atelier des Hollants (2022). Visie klimaatbestendige veenlandschappen. Coalitie Natuurlijke Klimaatbuffers (CNK).

Bellocchi, G., & Picon-Cochard, C (2021). Effects of Climate Change on Grassland Biodiversity and Productivity. Agronomy. 11(6):1047. https://doi.org/10.3390/agronomy11061047

Bestman, M., Verwer, C., van Niekerk, T., Leenstra, F., Reuvekamp, B., Amsler-Kepalaite, Z., & Maurer, V. (2019). Factors related to free-range use in commercial laying hens. Applied Animal Behaviour Science, 214, 57-63. https://doi.org/10.1016/j.applanim.2019.02.015

Candemir, A., Duvaleix, S., & Latruffe, L. (2021). Agricultural cooperatives and farm sustainability – A literature review. Journal of Economic Surveys, 35(4), 1118-1144.

CBS (2020). Hoe wordt de Nederlandse bodem gebruikt? - Nederland in cijfers 2020. | CBS. Retrieved April 4, 2024, from https://longreads.cbs.nl/nederland-in-cijfers-2020/hoe-wordt-de-nederlandse-bodem-gebruikt

CLO (2013) Biodiversiteitsverlies in Nederland, Europa en de wereld, 1700-2010 Retrieved March 31, 2024, from https://www.clo.nl/indicatoren/nl144002-biodiversiteitsverlies-in-nederland-europa-en-de-wereld-1700-2010

CLO (2022.) Stikstofdepositie. Retrieved March 31, 2024, from https://www.clo.nl/indicatoren/nl018919-stikstofdepositie-1990-2020

CLO (2024). Herkomst stikstofdepositie, 2022. https://www.clo.nl/indicatoren/nl050714-herkomst-stikstofdepositie-2022

De Jonge, C. (2008). De gevolgen van klimaatverandering voor recreatie en toerisme. Den Haag: Stichting Recreatie, Kennis- en Innovatiecentrum.

Deelexpeditie Natte Teelten. (n.d.). Factsheet Natte Teelten. Nationaal Kennisprogramma Bodemdaling. Retrieved March 21, 2024, from https://edepot.wur.nl/524205

De Vries, W. (2021). Impacts of nitrogen emissions on ecosystems and human health: A mini review. Current Opinion in Environmental Science & Health, 21, 100249. https://doi.org/10.1016/j.coesh.2021.100249

De Wolf, P. L. (2022). Is something up with soil? Wageningen University. https://www.wur.nl/en/show-longread/is-something-up-with-soil.htm

Didde, R. (2020). Een dikke onvoldoende voor waterkwaliteit. https://issuu.com/wageningenur/docs/ww2022_03_nl/10

Diaz, C. J., Douglas, K. J., Kang, K., Kolarik, A. L., Malinovski, R., Torres-Tiji, Y., Molino, J. V. D., Badary, A., & Mayfield, S. P. (2023). Developing algae as a sustainable food source. Frontiers in Nutrition, 9. https://doi.org/10.3389/fnut.2022.1029841

Dietz, T., Ostrom, E., & Stern, P. C. (2003). The struggle to govern the commons. science, 302(5652), 1907-1912.

E.A.S.A. Council (2013). Planting the Future: Opportunities and Challenges for Using Crop Genetic Impro vement Technologies for Sustainable Agriculture. Retrieved April 8, 2024, from https://easac.eu/publications/details/planting-the-future-opportunities-and-challenges-for-using-crop-genetic-improvement-technologies-for-sustainable-agriculture

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st-century busi ness. Environmental Quality Management, 8(1), 37-51. Retrieved April 9, 2024, from https://doi.org/10.1002/tqem.3310080106

Ernst, L. (1983). Wegzijging en kwel; de grondwaterstroming van hogere naar lagere gebieden. Wageningen: Instituut voor Cultuurtechniek en Waterhuishouding.

European Commission. (2024 a). Agriculture and rural development; The common agricultural policy: 2023-27. Retrieved April 10, 2024, from https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_en

European Commission. (2024 b). Agriculture and rural development; CAP Strategic Plan. Retrieved April 10, 2024, from https://agriculture.ec.europa.eu/cap-my-country/cap-strategic-plans/netherlands_en

European Environment Agency (2021). Water and Agriculture: towards sustainable solutions. EEA Report. No 17/2020. ISSN 1977-8449. https://doi.org/10.2800/73735

European Environment Agency. (2019). Surface waters. EEA. Retrieved April 4, 2024, from https://www.eea.europa.eu/airs/2018/natural-capital/surface-waters

European Parliament. (2024, February 27). Nature restoration: Parliament adopts law to restore 20% of EU's land and sea. Retrieved April 10, 2024, from https://www.europarl.europa.eu/news/en/press-room/20240223IPR18078/nature-restoration-parliament-adopts-law-to-restore-20-of-eu-s-land-and-sea

Eurosite (n.d.). Defining natural Climate Buffers. Retrieved March 25, 2024, from https://www.klimaatbuffers.nl/uploads/eurosite-ncb-leaflet-v04-a4.4aa3cb.pdf

FAO - Food and Agriculture Organization of the United Nations (n.d). Sustainable Land Management | Land &Water | Food and Agriculture Organization of the United Nations | Land & Water. Retrieved April 9, 2024, from https://www.fao.org/land-water/land/sustainable-land-management/en/

Feng, H. (1998). Agricultural development in The Netherlands; An analysis of the history of Dutch agricultural development and its importance for China. (Interne Nota; No. 491).

Fuller, K. M., Fox, A. L., Jacoby, C. A., & Trefry, J. H. (2021). Biological Abundance and Diversity in Orga nic-Rich Sediments From a Florida Barrier Island Lagoon. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.768083

Geologie van Nederland. (n.d. a). Rivierduin. Retrieved April 9, 2024, from https://www.geologievannederland.nl/landschap/landschapsvormen/rivierduin

Geologie van Nederland. (n.d. b). Rivierlandschap. Retrieved April 9, 2024, from https://www.geologievannederland.nl/landschap/landschappen/rivierlandschap

Government of the Netherlands (n.d. a). Agriculture and horticulture. https://www.government.nl/topics/agri culture/agriculture-and-horticulture

Government of the Netherlands (n.d. b). Natura2000. Retrieved April 9, 2024, from https://www.government.nl/topics/nature-and-biodiversity/natura-2000
Haahr, T. (2024, February 27). Nature Restoration: Parliament adopts law to restore 20% of EU's land and sea. New European Parliament. Retrieved April 10, 2024, from https://www.europarl.europa.eu/news/en/press-room/20240223IPR18078/nature-restoration-parliament-adopts-law-to-restore-20-of-eu-s-land-and-sea
Hanegreefs, S. (2024). How EU farm subsidies favour high-emission animal products. Leiden University. Re trieved April 10, 2024, from https://www.universiteitleiden.nl/en/news/2024/04/how-eu-farm-subsi dies-favour-high-emission-animal-products
Hardin, G. (1968). The tragedy of the Commons. Science, 162(3859), 1243–1248. https://doi.org/10.1126/sci ence.162.3859.1243
Hoste, I. (2002). Prikkeldraad: de doornhaag op haar smalst. De Levende Natuur, 103(5), 175. https://natuur tijdschriften.nl/pub/495380/DLN1031751755.pdf
Hurni, H. (2000). Assessing sustainable land management (SLM). Agriculture, Ecosystems & Environment (Print), 81(2), 83–92. https://doi.org/10.1016/s0167-8809(00)00182-1
Janssen, J. (2009). Sustainable development and protected landscapes: the case of The Netherlands. International Journal of Sustainable Development & World Ecology, 16(1), 37–47. https://doi.org/10.1080/13504500902757981
Landleven (2021). Grondsoorten: Zand, Rivierklei, Veen. Retrieved from April 9, 2024, from https://www.landleven.nl/inspiratie/tuin-erf/2021/oktober/grondsoorten/#:~:text=Grondsoort%3A%20 rivierklei&text=Structuur%3A%20vast%2C%20plakkerig-,Voordelen%3A%20houd%20water%20 goed%20vast%2C%20is%20redelijk%20voedzaam.,erg%20uit%20en%20breekt%20deze.
Isenring, R. (2010). Pesticides and the loss of biodiversity: How intensive pesticide use affects wildlife popula tions and species diversity. In Pesticide Action Network Europa. https://www.pan-europe.info/old/Campaigns/pesticides/documents/bees/Pesticides_and_the_loss_of_biodiversity.pdf
Karel, E. (2010). Modernization of the Dutch agriculture system 1950-2010. In Paper for the International Rural History Conference 2010, University of Sussex, Brighton (UK) 13-16 September 2010 https://pure.rug.nl/ws/portalfiles/portal/10468904/Paper_Brighton_september_2010.pdf
Koers, A. (2014). Het coulisselandschap van Twente.
Lee, J. H., Melching, C. S., & Wang, Z.-Y. (2014). River Dynamics and Integrated River Management. Beijing : Tsinghua University Press and Springer Science & Business Media.
Lumey, L. H., & Van Poppel, F. (1994). The Dutch Famine of 1944-45: Mortality and Morbidity in Past and Pre sent Generations. Social History Of Medicine, 7(2), 229–246. https://doi.org/10.1093/shm/7.2.229
McHarg, I. L. (1969). Design with nature. John Wiley & Sons.
METREX SURE Expert Group. (2019). Strategic Urban Region Eurodelta: Narrative and strategy for strengthe ning the megaregion of Strategic Urban Region Eurodelta. Retrieved April 4, 2024, from https://su re-eurodelta.eurometrex.org/wp-content/uploads/2021/03/NarrativeStrategicUrbanRegionEurodel ta20200323.pdf

Middelkoop, H., Daamen, K., Gellens, D., Grabs, W., Kwadijk, J., Herbert, L., Parmet, B., Schädler, B., Schulla, J., & Wilke, K. (2001). Impact of Climate Change on Hydrological Regimes and Water Resources Manage ment in the Rhine Basin. Climatic Change, 49(1/2), 105–128. https://doi.org/10.1023/a:1010784727448
Milieu Centraal (n.d. a). Bodemvervuiling. https://www.milieucentraal.nl/klimaat-en-aarde/milieuproblemen/bodemverontreiniging/#:~:text= De%20bodem%20in%20Nederland%20is,huis%20laat%20(ver)bouwen.&text=Allerlei%20bedrijven%20 kunnen%20bodemvervuiling%20veroorzaken,benzinestations%2C%20garages%20en%20chemi sche%20wasserijen.
Milieu Centraal (n.d. b). Stikstof. https://www.milieucentraal.nl/klimaat-en-aarde/milieuproblemen/stikstof-in-de-lucht-en-bodem/#te-veel-stikstof-slecht-voor-natuur
Ministerie van Infrastructuur en Waterstaat. (2022) Water en Bodem sturend. Den Haag.
Ministerie van Infrastructuur en Waterstaat, Staf deltacommissaris, & Rijkswaterstaat. (2023). Tussenbalans van het Kennisprogramma Zeespiegelstijging.
Myserli, A. (2018). From pollutants to productive landscapes [Re]Natured Economy.
NASA (2023). Sea Level. https://climate.nasa.gov/vital-signs/sea-level/?intent=121
Natuurpunt.be. (n.d.). Veen: ons meest unieke ecosysteem! Natuurpunt.be. Retrieved April 9, 2024, from https://www.natuurpunt.be/projecten/veen-ons-meest-unieke-ecosysteem
Nijenhuis, H. (2024, February 27). Ondanks boerenprotesten is de Europese wet op natuurherstel toch aangenomen. Retrieved April 10, 2024, from https://www.ad.nl/buitenland/ondanks-boerenpro testen-is-de-europese-wet-op-natuurherstel-toch-aangenomen~a4e062ce/
Oudman, T. (2024). De Nederlandse landbouw is verslaafd aan efficiëntie. Dát is het (stikstof)probleem. De Correspondent. https://decorrespondent.nl/15077/de-nederlandse-landbouw-is-verslaafd-aan-efficien tie-dat-is-het-stikstof-probleem/996ef72e-e488-0b6b-2438-3038a92b9891
Ottens, G. (Red.). (2024). Voorjaar = vogeltrektijd. Retrieved April 9, 2024, from https://www.vogelbescher ming.nl/actueel/bericht/voorjaar-vogeltrektijd
PBL (n.d). Low probabilities - large consequences: Reducing the vulnerability of the Dutch population to floods.https://themasites.pbl.nl/o/flood-risks/#:~:text=Around%2059%25%20of%20the%20Dut ch,that%20can%20hit%20the%20Netherlands.
Planbureau Voor de Leefomgeving (2023). Landbouw en voedsel. Retrieved April 9, 2024, from https://www.pbl.nl/onderwerpen/landbouw-voedsel
Postma, S. (2022). 'Noardlike Fryske Wâlden' als voorbeeld voor Nederland? Onder De Loep. V-Focus, Juli 2022. http://edepot.wur.nl/158830
Rijkswaterstaat. (n.d. a). Ruimte voor de rivieren Retrieved April 9, from https://www.rijkswaterstaat.nl/wa ter/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/ruim te-voor-de-rivieren
Rijkswaterstaat. (n.d. b). Hoogwater. Retrieved April 9, from https://www.rijkswaterstaat.nl/water/waterbe heer/bescherming-tegen-het-water/hoogwater

Rijksoverheid (2023). Sustainable Development Goals (SDG's) en brede welvaart | Kenniscentrum voor beleid en regelgeving. Retrieved April 4, 2024, from https://www.kcbr.nl/beleid-en-regelgeving-ontwikkelen/beleidskompas/2-wat-het-beoogde-doel/sustainable-development-goals-sdgs-en-brede-welvaart
Rodale Institute (n.d.). Crop Rotations. Retrieved March 21, 2024, from https://rodaleinstitute.org/why-organic/organic-farming-practices/crop-rotations/
Schreuder, A. (2018, June 6). Ecologisch boeren in ruil voor grond. NRC. https://www.nrc.nl/nieuws/2018/06/06/ecologisch-boeren-in-ruil-voor-grond-a1605579
Sennett, R. (2006). The Open City. (Newspaper Essay). Berlin.
Smit, P. (2023). Rabobank: beeld van financiering boeren is onjuist. Retrieved April 9, from https://www.nieuweoogst.nl/nieuws/2023/08/10/rabobank-beeld-van-financiering-boeren-is-onjuist
Staatsbosbeheer (2024). Natuurinclusieve landbouw. Retrieved April 10, 2024, from https://www.staatsbosbeheer.nl/wat-we-doen/natuurinclusieve-landbouw#:~:text=Meer%20grond%20nodig&text=In%20ruil%20daarvoor%20maken%20we,biodiversiteit%20in%20onze%20natuurgebieden%20groeit.
Tangelder, M., Winter, E., & Ysebaert, T. (2017). Ecologie van zoet-zout overgangen in deltagebieden. Wageningen: University & Research centre.
Uiennieuws. (2022). "SMAG moet tijd voor administratie landbouwbedrijven halveren". Retrieved April 9, from https://www.uiennieuws.nl/article/9396032/smag-moet-tijd-voor-administratie-landbouwbedrijven-halveren/
United Nations (2021). Duurzame ontwikkelingsdoelen - Verenigde Naties - Nederlands. Retrieved April 4, 2024, from https://unric.org/nl/duurzame-ontwikkelingsdoelstellingen/
Urhahn, G., & Urhahn Urban Design. (2011). De Spontane Stad. BIS Publishers B.V.
USDA (n.d.). Rotational Grazing for Climate Resilience. Climate Hubs. Retrieved March 21, 2024, from https://www.climatehubs.usda.gov/hubs/international/topic/rotational-grazing-climate-resilience
US EPA (2024). Why are Wetlands Important? | US EPA. Retrieved April 9, 2024, from https://www.epa.gov/wetlands/why-are-wetlands-important
Van der Ploeg, J. D., Strijker, D., & Hoofwijk, H. (2010). Noordelijke Friese Wouden: leerervaringen. https://edepot.wur.nl/158830
Van De Wiel, C. (2024 a). Boeren krijgen uitstel, maar Europese landbouwopgave blijft. NRC. Retrieved April 10, 2024, from https://www.nrc.nl/nieuws/2024/02/09/boeren-krijgen-uitstel-maar-europese-landbouwopgave-blijft-a4189711
Van De Wiel, C. (2024b). Europarlement keurt veelbesproken natuurherstelwet goed. NRC. https://www.nrc.nl/nieuws/2024/02/27/europarlement-keurt-veelbesproken-natuurherstelwet-goed-a4191400
Van der Woud, A. (2009). Het lege land: de ruimtelijke orde van Nederland 1798-1848. Atlas Contact, Uitgeverij.
Van Dijk, W., Spruijt, J., Runia, W. T., & Van Geel, W. C. A. (2012). Verruiming vruchtwisseling in relatie tot mineralenbenutting, bodemkwaliteit en bedrijfseconomie op akkerbouwbedrijven. Praktijkonderzoek Plant & Omgeving, Onderdeel van Wageningen UR. Business Unit AGV, PPO nr. 527. http://edepot.wur.nl/256035
Verstand, D. (2022). Herbal-rich grassland as Nature-based Solution for climate resilient and circular food systems. Wageningen University & Research. https://edepot.wur.nl/581776

WBGU (1996). Herausforderung für die deutsche Wissenschaft. Jahresgutachten 1996. Welt im Wandel, volu me 1996. Springer Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-80297-3
Wageningen University (2016). Grondsoort en Grondprijs. Retrieved April 9, 2024, from https://edepot.wur.nl/394962#:~:text=De%20belangrijkste%20grondsoorten%20in%20Nederland,ta bel%201%20en%20kaart%201).
Wageningen University (2020). Nederland handelsland – van koopman tot kopman. https://www.wur.nl/nl/show-longread/nederland-handelsland-van-koopman-tot-kopman.htm#:~:tex t=Door%20zijn%20ligging%20bij%20de,goede%20natuurlijke%20omstandigheden%20voor%20land bouwproductie.
Wageningen University (2022). De bodem, daar is toch iets mee? Het goede nieuws. Retrieved April 9, 2024, from https://www.wur.nl/nl/show-longread/de-bodem-daar-is-toch-iets-mee.htm
Wageningen University (2023). Staat van Landbouw, Natuur en Voedsel: Agrarische bedrijven zorgen steeds vaker voor extra inkomstbronnen https://www.wur.nl/nl/onderzoek-resultaten/onderzoeksinsti tuten/economic-research/show-wecr/staat-van-landbouw-natuur-en-voedsel-agrarische-bedrijven-zor gen-steeds-vaker-voor-extra-inkomstenbronnen.htm#:~:text=Het%20hele%20agrocomplex,van%20 de%20totale%20nationale%20werkgelegenheid
Wageningen University (n.d. a). Sustainable land use. Retrieved April 9, 2024, from https://www.wur.nl/en/rese arch-results/research-institutes/environmental-research/programmes/sustainable-land-use.htm
Wageningen University (n.d. b). Hogere opbrengsten natuurinclusieve landbouw wegen nog niet op tegen kosten. Retrieved April 9, 2024, from https://www.wur.nl/nl/onderzoek-resultaten/onderzoek sinstituten/environmental-research/show-wenr/hogere-opbrengsten-natuurinclusieve-landbouw-we gen-nog-niet-op-tegen-kosten.htm
Wageningen University (n.d. c) Wat moet u weten over stikstof: Vragen en antwoorden. Organische meststof fen en kunstmest. Retrieved April 1, 2024, from https://edepot.wur.nl/171879
Wageningen University (n.d. c). Zijn algen het voedsel van de toekomst? WUR. Retrieved March 20, 2024, from https://www.wur.nl/nl/artikel/zijn-algen-het-voedsel-van-de-toekomst.htm
Wageningen University (n.d. d). Cijfers over aquacultuur. WUR. Retrieved March 20, 2024, from https://www. wur.nl/nl/onderzoek-resultaten/onderzoeksinstituten/economic-research/sectoren-feiten-cijfers/ aquacultuur.htm#:~:text=Aquacultuur%20is%20de%20teelt%20van,hierbij%20voor%20data%20en%20 duiding.&text=Het%20kweken%20van%20weekdieren%20en%20waterplanten%20hoort%20ook%20 bij%20aquacultuur.
Waterschap Vallei en Veluwe. (n.d.). BLAUWE OMGEVINGSVISIE 2050. Apeldoorn: Waterschap Vallei en Velu we. Retrieved April 9, from https://bovi2050.nl/wp-content/uploads/2020/11/BOVI2050.pdf
Wetlands International (n.d.). Wetlands. Wetlands occur wherever water meets land and ensure the sustainabi lity of both. Retrieved March 25, 2024 from https://www.wetlands.org/wetlands/
Wijnands, F., Diaz, A. G., & De Haan, J. (2002). Multifunctional Crop Rotation (MCR). Manual On Prototyping Methodology And Multifunctional Crop Rotation, 42–50. http://edepot.wur.nl/11923
Whittow, J. (1984). Dictionary of Physical Geography. London: Penguin, 1984. P. 438. ISBN 0-14-051094-X.

World Wildlife Fund. (n.d.) Impact of Sustainable Agriculture and Farming Practices. Retrieved April 10, 2024, from https://www.worldwildlife.org/industries/sustainable-agriculture

02

Maps, Collage & Icons Sources

Map 1: Soil & water
Ministerie van Onderwijs, Cultuur en Wetenschap. (2022). Paleogeografische kaarten (GIS (fgdb) | zip) Down load 'Paleogeografische kaarten'. Retrieved March 12, 2024, from https://www.cultureelerfgoed.nl/on derwerpen/bronnen-en-kaarten/documenten/publicaties/2019/01/01/paleogeografische-kaarten-zip

Map 2: Flood risk
RIVM (n.d.). Atlas Leefomgeving: Kans op een overstroming vanuit zee, meer of rivier. Retrieved March 10, 2024, from https://www.atlasleefomgeving.nl/kaarten?config=3ef897de-127f-471a-959b-93b7597de188&gm-z=3&gm-x=150000&gm-y=460000&gm-b=1544180834512,true,1;1702303985585,true,0.8&layerFilter=Standaard%20gebruiker&use=piwiksectorcode

Map 3: Agriculture
CLMS (2018). CORINE Land Cover 2018 (vector/raster 100 m), Europe, 6-yearly https://doi.org/10.2909/960998c1-1870-4e82-8051-6485205ebbac
Retrieved March 10, 2024, from: https://land.copernicus.eu/en/products/corine-land-cover/clc2018

Map 4: Nitrogen
RIVM (2023). GCN concentratiekaartbestanden achterliggende jaren. Download: nh3_2023 Retrieved March 10, 2024, from https://www.rivm.nl/gcn-gdn-kaarten/concentratiekaarten/cijfers-achter-concentratiekaarten/gcn-con centratiekaartbestanden-achterliggende-jaren

Map 5: Biodiversity
Nationale Databank Flora en Fauna (2017) Soortendiversiteit. Retrieved March 10, 2024, from http://www.atlasleefomgeving.nl/soortendiversiteit-in-nederland
NGR (2022.) Natura 2000-gebieden. Retrieved March 10, 2024, from https://www.nationaalgeoregister.nl/geo network/home/api/records/8829e5dd-c861-4639-a6c8-fdbb6e3440d2
NGR (2023). Wetlands WFS. Retrieved March 10, 2024, from https://www.nationaalgeoregister.nl/geonetwork/srv/api/records/68a42961-ed55-436b-a412-cc7424fd2a6e

Maps 14, 18, and 24: Historic Situations
PDOK (2023). Luchtfoto 2023 Ortho 8cm RGB. Retrieved March 10, 2024, from https://www.pdok.nl/-/nu-ho ge-resolutie-luchtfoto-2023-bij-pdok

Maps 15, 19, and 25: Current Situations
PDOK (2023). Luchtfoto 2023 Ortho 8cm RGB. Retrieved March 10, 2024, from https://www.pdok.nl/-/nu-hoge-resolutie-luchtfoto-2023-bij-pdok
Rijksdienst voor Ondernemend Nederland (2023) Basisregistratie Gewaspercelen (BRP). Retrieved March 10, 2024, from https://www.nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metada ta/44e6d4d3-8fc5-47d6-8712-33dd6d244eef?tab=contact

Maps 16, 17, 20, 21, 22, 23, 26, 27, 28, 29, 30, and 31: Visions
The noun project (n.d.). Farmer. Retrieved April 10, 2024, from https://thenounproject.com/icon/farmer-1382661/
The noun project (n.d.). Person. Retrieved April 10, 2024, from , https://thenounproject.com/icon/person-883979/

Figure 7: Development of Agriculture in the Netherlands
Aqua, A. (2022). Vertical farming companies in UAE. Retrieved, March 27, 2024, from https://www.flickr.com/photos/163753410@N02/52202316041/sizes/o/
Art Gallery ErgsArt (2015). Dimitrescu_ploughing_1915. Retrieved, March 27, 2024, from https://www.flickr.com/photos/ergsart/22331522961/sizes/l/
Doubleday, L. (2022). Great casterton vintage working weekend. Retrieved, March 27, 2024, from https://www.flickr.com/photos/114112818@N03/52369912598/sizes/l/
Levitus, E. (2018). Por qué ríe la agricultura del llanto pálido del cielo? – Neruda. Retrieved, March 27, 2024, from https://www.flickr.com/photos/elewitus/43672950861/sizes/l/
Sjiens, H. (2020). Ploughing the Field. Retrieved, March 27, 2024, from https://www.flickr.com/photos/hindrik/50652593988/sizes/l/
Snell. J. (2011). 1930's Horse powered hay bailer 01. Retrieved, March 27, 2024, from https://www.flickr.com/photos/jacksnell707/5553221460/sizes/o/

Figure 9: Development of Biodiversity in the Netherlands
April (2009). Cranberries. Retrieved, March 27, 2024, from https://www.flickr.com/photos/91524358@N00/3441039443/sizes/l/
Axtell, S. (2007). Sturgeon Retrieved, March 27, 2024, from https://www.flickr.com/photos/99158622@N00/1245350152/sizes/o/
Clarey, I. (2021). Common Spadefoot Frog / Neobatrachus sudelli. Retrieved, March 27, 2024, from https://www.flickr.com/photos/190014189@N06/51222280533/sizes/l/
De Redelijkheid, E. (2011). Bever. Retrieved, March 27, 2024, from https://www.flickr.com/photos/ericdere/6032533578/sizes/l/
Iacchini, L. (2024). Water Buffalo 2. Retrieved, March 27, from https://www.flickr.com/photos/lucianoiak/53524972818/sizes/l/

Joanna (2009) Reed. Retrieved March 27, 2024, from https://www.flickr.com/photos/joannarb2009/3713308655/sizes/l/
Mylesm00re (2010). Duckweed. Retrieved, March 27, 2024, from https://www.flickr.com/photos/30170234@N08/5285338519/sizes/l/
Owen, J. (2007). Cattails. Retrieved, March 27, 2024, from https://www.flickr.com/photos/29374594@N00/400518624/sizes/l/
Van Geer, C. (2021). On the run at the road, Ypecolsga. Retrieved, March 27, 2024, from https://www.flickr.com/photos/ciska_van_geer/50910746113/sizes/l/
Van Lisdonk, M. (2020). Sea eagle. Retrieved, March 27, 2024, from https://www.flickr.com/photos/190520896@N02/50432578631/sizes/l/

Figure 11 Proposed Collaborative Farming Structure
The noun project (n.d.). Farmer. Retrieved April 10, 2024, from https://thenounproject.com/icon/farmer-1382661/
The noun project (n.d.). Farmer. Retrieved April 10, 2024, from https://thenounproject.com/icon/farmer-1925725/
The noun project (n.d.). Farmer. Retrieved April 10, 2024, from https://thenounproject.com/icon/farmer-2748450/
The noun project (n.d.). Farmer. Retrieved April 10, 2024, from https://thenounproject.com/icon/farmer-2636079/

The noun project (n.d.). Person. Retrieved April 10, 2024, from , https://thenounproject.com/icon/person-883979/
The noun project (n.d.). Cloud Bubble. Retrieved April 10, 2024, from, https://thenounproject.com/icon/left-cloud-bubble-1111746/

Figure 12 Collage scenarios
Buhmann, S. (2005). Hallig Hooge 2005 Neu.jpg - Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Hallig_Hooge_2005_neu.jpg
Carteret Community College. (February 2, 2015). Aquaculture 228. Flickr. https://www.flickr.com/photos/92309032@N05/26477398059/in/album-72157645618222904/
Cebeci, Z. (August 13, 2011). Lycaena thetis - Fiery copper.jpg - Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Lycaena_thetis_-_Fiery_copper.jpg
Grobe, H. (June 11, 2022). Paludi-Bederkesa-1 hg.jpg - Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Paludi-bederkesa-1_hg.jpg

Harper, D. (December 5, 2008). Crop strips below Tor Hill Plantation - geograph.org.uk - 1074462.jpg - Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Crop_strips_below_Tor_Hill_Plantati

on_-_geograph.org.uk_-_1074462.jpg
Harutyunyan, V. (July 22, 2018). Man Walking On Farm. (edited) https://www.pexels.com/photo/man-walking-on-farm-1733192/
Jin, K. (z.d.). Rodion-Kutsaiev-PEM_SLMJT-w-Unsplash. Flickr. https://www.flickr.com/photos/199299808@N06/53247621075/in/photolist-2o8RU5V-2p8iYCk-2p8ifKr-2onDBw9
Littlewood, T. (April 16, 2016) Meandering stream - geograph.org.uk - 4910237.jpg - Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Meandering_stream_-_geograph.org.uk_-_4910237.jpg
Monster, H. (April 24, 2013). Real Dutch landscape this riverforeland in the spring - panoramio.jpg - Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Real_Dutch_landscape_this_riverforeland_in_the_spring_-_panoramio.jpg
Nijeholt (March 21, 2007). Uiterwaarden nabij deventer TN.jpg - Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Uiterwaarden_nabij_deventer_TN.jpg
Noble, G. (July 3, 2011). Barbel returned. Flickr. (edited) https://www.flickr.com/photos/kordafan/5898318012/in/photolist-9Zdqs9-8osY9v-a32wTw-a32wQo-56ruMY-aqa8w5-V7KA6L-bWNNaL-fuX6tz-d3Qpd9-fuXe5K-EY72S-djd5Zo-neQbsJ-bWNPTj-7PQbPT-aR6y8T-bPnuS6-EKXuEW-gKUHHy-8iQaQd-fz6Q8T-8keZa8-cfNMAU-8osYNX-beHPx2-fvcGuA-fvcZ8y-6ykk4y-9AJwim-dfryNr-87si1h-fz6Rgg-63UvAe-cU9v21-fuX7CR-easNUf-bVYi4F-fuXJZz-5EhG4P-VcNyqm-dfrzbg-aekj1F-pRM4CK-bYc7R5-7LokZJ-cqqYsd-cqqZdN-neQbXb-8qYGv7 vv
PNGwing (n.d.). Birds. Retrieved March 26, 2024, from https://www.pngwing.com/
PNGwing (n.d.). Common spadefoot. Retrieved March 26, 2024, from https://www.pngwing.com/
PNGwing (n.d.). Cow. Retrieved March 26, 2024, from https://www.pngwing.com/
PNGwing (n.d.). Dragonflies. Retrieved March 26, 2024, from https://www.pngwing.com/
PNGwing (n.d.). Godwit. Retrieved March 26, 2024, from https://www.pngwing.com/
PNGwing (n.d.). Other plants. Retrieved March 26, 2024, from https://www.pngwing.com/
PNGwing (n.d.). Paludiculture crop. Retrieved March 26, 2024, from https://www.pngwing.com/
PNGwing (n.d.). Sea eagle. Retrieved March 26, 2024, from https://www.pngwing.com/
PNGwing (n.d.). Water Buffalo. Retrieved March 26, 2024, from https://www.pngwing.com/
Rheins (February 3, 2014). Floating Farm on Lake Inle - 2014.02 - panoramio.jpg - Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Floating_Farm_on_Lake_Inle_-_2014.02_-_panoramio.jpg
Salomon, R. (March 25, 2014). Red Admiral Butterfly (Vanessa atalanta). Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Red_Admiral_Butterfly_(Vanessa_atalanta).JPG#file
Strzelecki, J. (March 6, 2007). Castor fiber 05(js), Narew River, Poland. Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Castor_fiber_05(js),_Narew_River,_Poland.jpg
Tync, A. (June 16, 2020). Lycaena dispar Bytom.jpg - Wikimedia Commons. (edited) https://commons.wikimedia.org/wiki/File:Lycaena_dispar_Bytom.jpg
Unsplash (n.d.) Landscape. Retrieved March 26, 2024, fromhttps://unsplash.com/photos/green-grass-field-near-lake-under-blue-and-white-cloudy-sky-during-daytime-GlnwLnAjQyY
Verbeek, M. (July 15, 2021). Tussen Slijk-Ewijk en Andelst, de Waal vanaf de Waaldijk aan het begin van hoog water IMG 9632 2021-07-15 19.49.jpg - Wikimedia Commons. (edited) https://commons.wikime

dia.org/wiki/File:Tussen_Slijk-Ewijk_en_Andelst,_de_Waal_vanaf_de_Waaldijk_aan_het_begin_van_hoog_water_IMG_9632_2021-07-15_19.49.jpg
Vrieswijk, S. (September 9, 2018). _DSC1726.jpg. Flickr. (edited) https://www.flickr.com/photos/154696116@N03/29840366807/

Front Page & Figure 3

Bornstein, A. (n.d.). A view of the river water surface. Motion Array. Retrieved April 10, 2024, from https://motionarray.com/stock-video/a-view-of-the-river-water-surface-1272288/
Chen, F. (2023, September 5). Coastal wetlands are the most valuable type of ecosystem on Earth. California WaterBlog. Retrieved April 10, 2024, from https://californiawaterblog.com/2023/09/03/wetlands-on-the-edge/
Conewago Creek Initiative. (n.d.). Crop Rotation |. Retrieved April 10, 2024, from https://www.conewagoinitiative.net/practices/farm/1296-2
Hudiemm. (2023, October 10). Cut or torn paper background textured isolated on black. iStock. Retrieved April 10, 2024, from https://www.istockphoto.com/nl/foto/cut-or-torn-paper-background-textured-isolated-gm1725499507-541219907
Lancasterfarming (n.d.) Paludiculture. Retrieved March, 26, 2024, from https://www.lancasterfarming.com/farming-news/news/crunch-time-in-the-cranberry-bogs/article_78e57e71-cff6-53b6-863d-38b50f2dcdec.html
Nationthailand. (2022, November 12). Phatthalung's Thale Noi Wetland Buffaloes get FAO recognition. Nationthailand. Retrieved April 10, 2024, from https://www.nationthailand.com/thailand/general/40022011

Opkhonburi, S. (n.d.). Green trees isolated on white background. are Forest and foliage in summer for both printing and web pages. Dreamstime. https://www.dreamstime.com/green-trees-isolated-white-background-forest-foliage-summer-both-printing-web-pages-image221737748
Pngtree. (n.d.). Torn Paper Effect PNG and PSD. https://pngtree.com/freepng/torn-paper-effect_8921033.html
Richter, S. (2023, February 16). Loss of wetlands smaller than assumed so far. DLG-Verlag GmbH, Eschborner Landstraße 122, 60489 Frankfurt, Germany. Retrieved April 10, 2024, from https://www.rural21.com/english/news/detail/article/loss-of-wetlands-smaller-than-assumed-so-far.html
R-J-Seymour. (2011, August 25). Dairy cattle under a summer sky. iStock. Retrieved April 10, 2024, from https://www.istockphoto.com/nl/foto/dairy-cattle-under-a-summer-sky-gm184344585-17509086?searchscope=image%2Cfilm
Rogerson, J. (2021, April 8). Curious kids: What is the sky? The Conversation. Retrieved April 10, 2024, from https://theconversation.com/curious-kids-what-is-the-sky-157834
See Plymouth. (2024, April 3). Cranberry growing & harvesting. Retrieved April 10, 2024, from https://seeplymouth.com/listing/cranberries-org/
The Nature Conservancy. (2019, October 28). Power of wetlands. Power of Wetlands. Retrieved April 10, 2024, from https://www.nature.org/en-us/about-us/where-we-work/united-states/iowa/stories-in-iowa/po

wer-of-wetlands/
U.S. Fish and Wildlife Service. (2019, February 13). Making way for coastal wetlands: a look at sea level rise and urban development. Yale Environment Review. Retrieved April 10, 2024, from https://environment-review.yale.edu/making-way-coastal-wetlands-look-sea-level-rise-and-urban-development
Wetlandsglobal. (2023, June 28). Bending the curve of freshwater biodiversity loss. Wetlands International. Retrieved April 10, 2024, from https://www.wetlands.org/bending-the-curve-of-freshwater-biodiversity-loss/

03

List of Maps

List of Figures