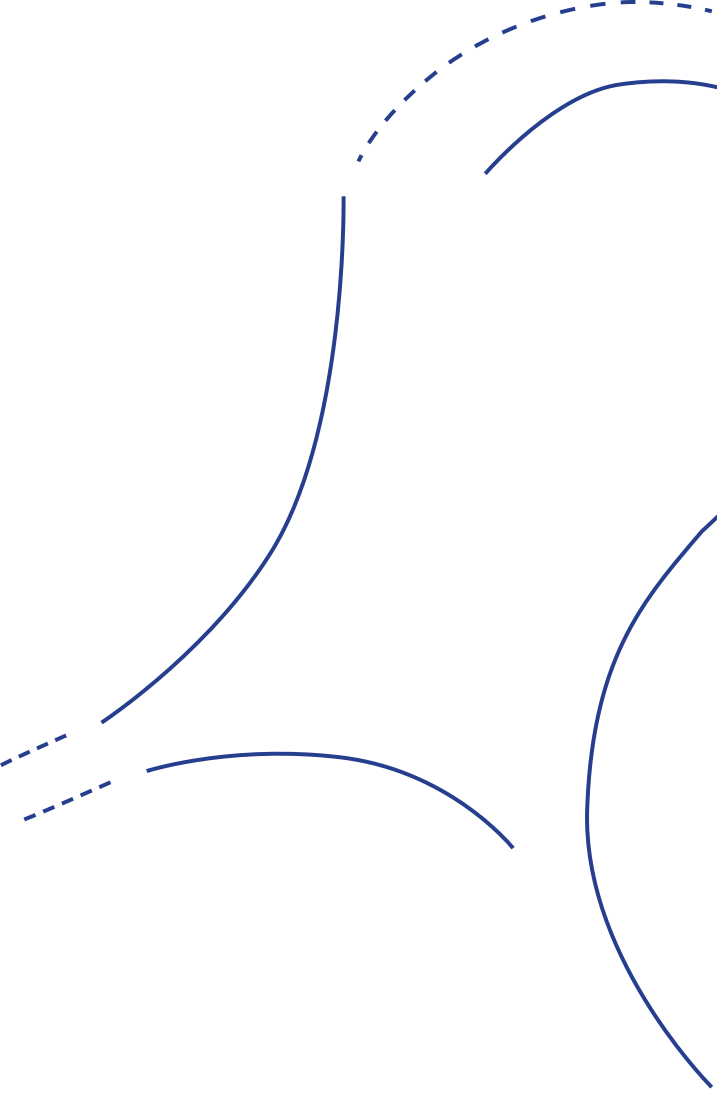


WATER TRANSITION TO WATERSCAPES

Strategic spatial planning for the synergy of living landscape in the IJsselmeer Region

Graduation studio Transitional Territories

Yiyan Zhou | 5976286
All the photographs and drawings in this thesis are made by the
author unless stated otherwise.

First Mentor | Fransje Hooimeijer
Second Mentor | Verena Balz

P5 Report
May, 2025
Delft University of Technology
Faculty of Architecture and the Building Environment
Department of Urbanism
MSc Architecture, Urbanism & the Building Sciences

Abstract

Freshwater scarcity in the IJsselmeer Region is intensifying due to the dual pressures of climate change and socio-economic development. Rising temperatures, salinisation, and increased water demand have exposed the limitations of the current water system. This research addresses the urgent need for adaptive spatial planning by developing a Dynamic Spatial Adaptive Pathway (DSAP) methodology to expand freshwater buffer capacity through water circularity. The approach combines regional planning frameworks with design-based spatial strategies and consists of six steps, grouped under four phases: system framing, vision learning, decision supporting, and strategy implementing. The methodology is applied to the Northwest Overijssel region, a key transitional area facing both ecological sensitivity and human water demands. By integrating scenarios based on Delta planning and water policy, the study identifies spatial typologies and sectoral tipping points, enabling phased design responses across different future trajectories. This adaptive approach bridges policy and design, allowing for the monitoring of system changes and timely responses through spatial interventions. The methodology not only responds to uncertainties in water supply but also enables co-benefits for ecological quality and long-term resilience. Through a combination of scenario planning, stakeholder engagement, and adaptive design, this research offers a replicable planning framework for other regions within the Dutch Delta context and provides strategic insight for linking high-level water policy with grounded spatial implementation.

Keywords: Adaptive spatial planning, water circularity, freshwater resilience, climate uncertainty, Adaptive design

Acknowledgement

I would like to express my sincere gratitude to the Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, for offering me the platform to explore complex spatial challenges through research and design. This graduation project was shaped within an environment that fosters interdisciplinary thinking and critical reflection, for which I am deeply thankful.

My deepest appreciation goes to my first mentor, Dr. Fransje Hooimeijer. Her sharp insights, patient guidance, and unwavering encouragement have been essential throughout this process. She consistently helped me navigate through moments of uncertainty, guiding me back to clarity and purpose. Her ability to reveal the joy of academic thinking has profoundly influenced the way I approach research. I am truly grateful for the inspiration and support she has given me, which made this journey not only productive but also enjoyable.

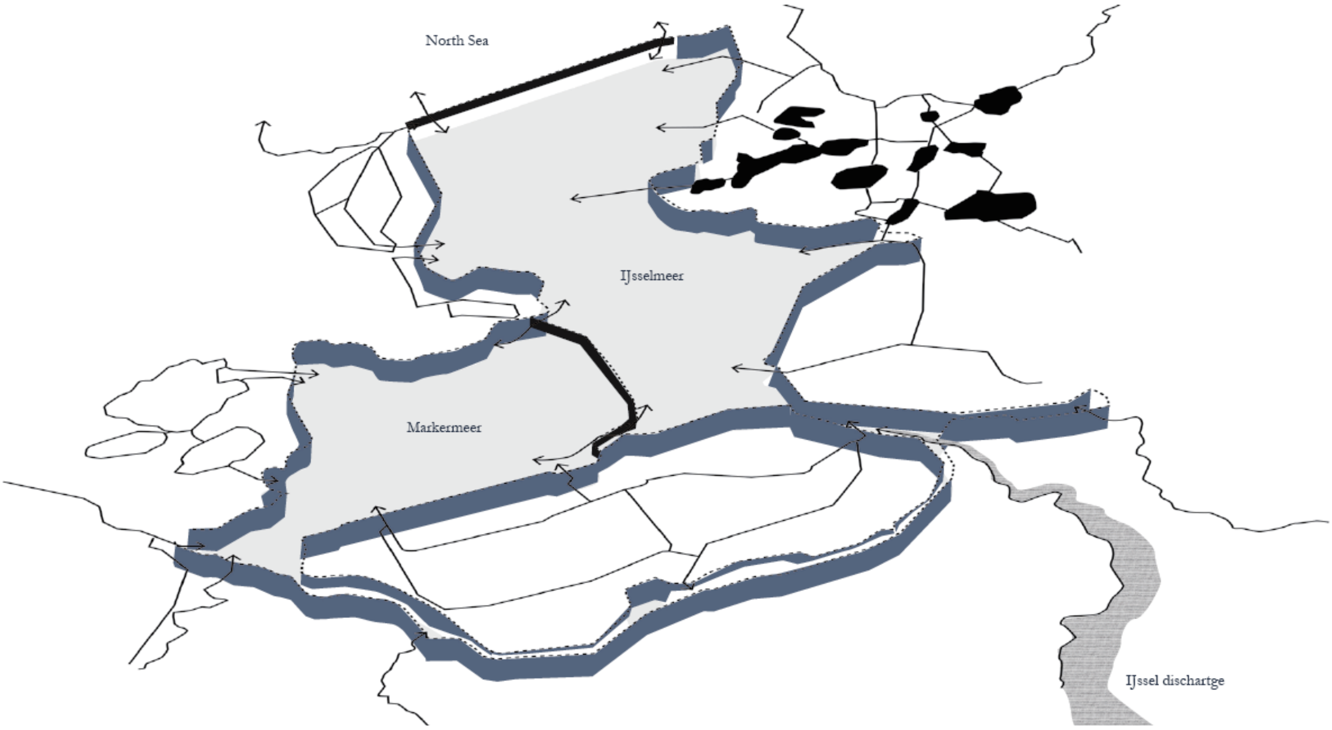
I would also like to thank my second mentor, Dr. Verena Balz, whose clear analytical approach helped me further develop and solidify the methodological framework of this thesis. Her constructive feedback played a vital role in shaping the coherence and robustness of the research.

My sincere thanks go to my fellow students and colleagues for their generous exchange of ideas and critical conversations throughout the process. Their input has helped me to continuously question and improve my work. I am equally thankful to my family, whose constant support and encouragement gave me the strength and motivation to complete this project.

Finally, I would like to acknowledge the OKRA Academy internship program. This experience not only gave me the opportunity to engage with real-world design tasks, but also deepened my understanding of the Dutch spatial and hydrological context. It provided a solid grounding for my graduation topic and taught me how to balance research, practice, and personal growth. The internship was both enriching and transformative, and I am grateful to have been part of it.

Thank you.


BOOT MARKER WADDEN
BARTJES



"Water is the connecting element. "
-Agenda IJsselmeer Area 2050-

Motivation

My motivation to pursue this thesis stems from both my personal experiences in the Netherlands and my professional interests in water management. Having spent significant time in this country, I have witnessed firsthand the remarkable way in which water management is ingrained in both the landscape and the daily lives of the people. The Netherlands stands as an exemplary model for water management, offering invaluable lessons on how communities adapt to the dynamic challenges posed by water scarcity, flooding, and changing climates.

What particularly excites me about this opportunity is the chance to explore the evolving relationship between human and non-human elements within these systems. The interplay between ecosystems, human development, and the forces of nature offers a unique perspective on how societies can be both resilient and sustainable. The Netherlands provides a rich context for observing these interconnections, and I see it as a perfect case study to reflect on how we might reconsider our approach to water and space in an increasingly uncertain future.

Through this research, I aim to bring a deeper understanding of how we can shape our environments to foster cohabitation between human and natural systems. I hope to offer insights on how adaptive water management strategies, when integrated thoughtfully into the landscape, can both address immediate needs and contribute to a more harmonious and resilient society in the long term. This is more than just a professional interest—it's a personal passion to uncover how we can reimagine the balance between our built environment and the natural world, especially as we face the mounting pressures of climate change.

Table of content

CHAPTER
1.

INTRODUCTION

Problem field

"Too much and too little water"

The impacts of climate change have become increasingly evident and appear to be accelerating in recent years (IPCC, 2023). The Paris Climate Agreement aims to limit global warming to well below 2°C above pre-industrial levels (1850–1900), with a target of 1.5°C. Based on climate models, the IPCC projects that the 1.5°C threshold could be reached around 2033, necessitating sharp reductions in emissions and large-scale removal of CO2 from the atmosphere to stabilize warming at 1.5°C by 2100 (KNMI'23, 2023) (see figure 1).

The KNMI'23 climate scenarios outline four possible trajectories (see figure 2) for climate change in the Netherlands (including the Caribbean Netherlands) through 2050 and 2100, serving as a foundation for long-term planning. Estabulished in 2011, the Dutch Delta Act is critical in ensuring the Netherlands remains protected against flooding and well adapted to extreme climate effects, and that freshwater supplies are sustained, with its sustainable strategies based on the KNMI scenarios (Delta Programme Commissioner, 2023; KNMI, 2023).

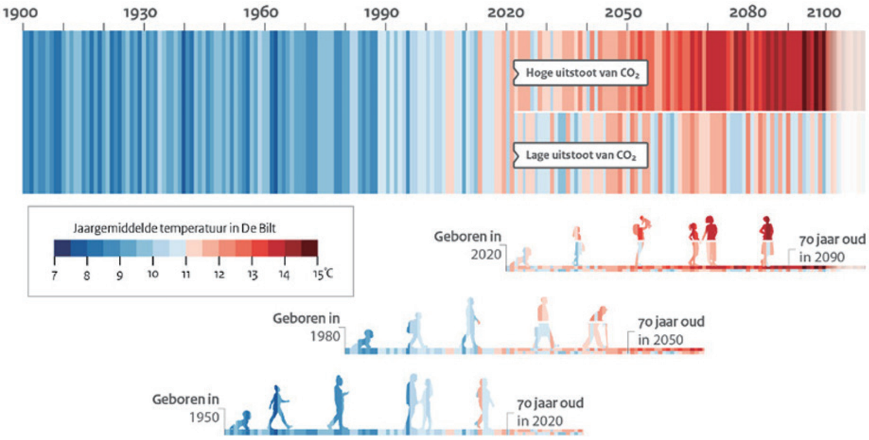
As the "Blue Heart of the Netherlands," the IJsselmeer region holds vital social and economic significance for the northern Netherlands. However, climate change intensifies water scarcity and water surplus in this region. Rising temperatures, increased evaporation, reduced river inflows during summer, and changing precipitation patterns contribute to more frequent and severe droughts. At the same time, intensified rainfall events raise the risk of local and regional flooing. This increasingly variability stresses the region's capacity to balance competing water demands from urban, agriculture, and ecological sectors, and calls for more adaptive and resilient water management strategies.

Resource:

IPCC (2023). Climate Change 2023: The Physical Science Basis. Intergovernmental Panel on Climate Change.

Delta Programme Commissioner. (2023). Delta Programme 2024: Continuing the work on the delta – Increasing the pace of implementation. Ministry of Infrastructure and Water Management. Retrieved from https://english.deltaprogramma.nl

KNMI. (2023). KNMI'23 Climate Scenarios for the Netherlands: A guide for climate adaptation. De Bilt: Royal Netherlands Meteorological Institute. Retrieved from https://www.knmi.nl/kennis-en-datacentrum/uitleg/knmi23-klimaatscenario-s



>Figure 1, Climate change in the Netherlands: What will you experience from this? (KNMI, 2023)

>Figure 2, Four scenarios for climate change in the Netherlands. The number of small blocks represents the extent of climate change around 2100 compared to 1991-2020.(KNMI, 2023)

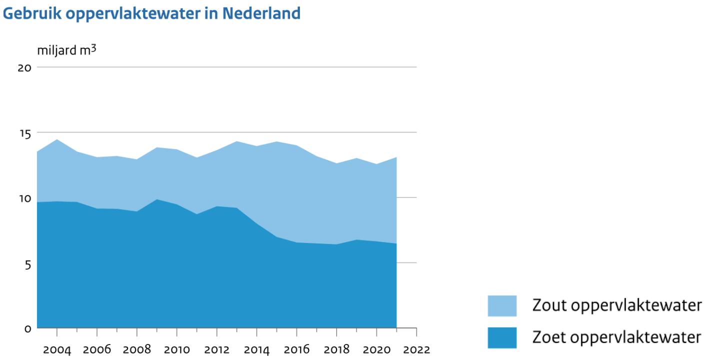
Water demand and socio-economic prosperity

Water is a natural resource of tremendous importance to all life and to the economy (CBS, 2022). The economy depends on water in many ways. Water is used as drinking water,irrigation of land for agricultural land for agricultural production, cooling purpose, as input for production in manufacturing for transportation and more. To ensure the availability of water for these different purposes, water resource need to be managed (see figure 4, figure 5).

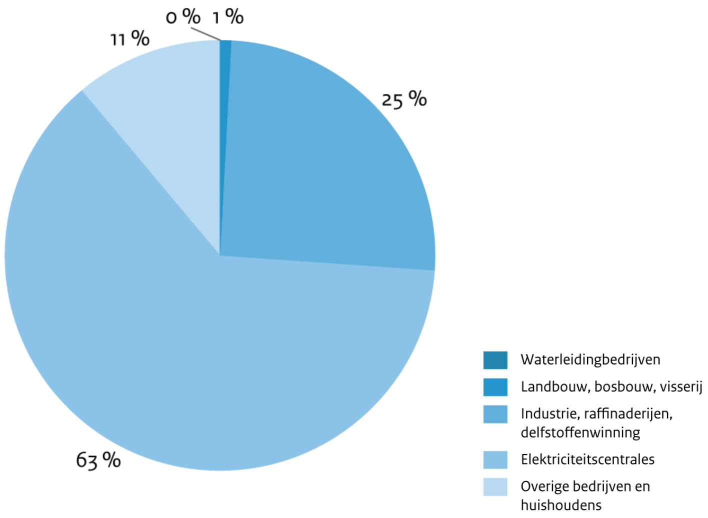
In the Netherlands, surface water is the most important source of water for industry and energy companies. Drinking water companies extract most of the water from groundwater (see figure 3).

Over the past several decades, considerable media attention has been given to the relationship between water and conflict (with peace generally understood as the absence of conflict), specifically, water disputes (Michela and Richard, 2024). Water nurtures prosperity by meeting basic human needs, supporting healthy livelihoods, and economic development, underpinning food and energy security, and defending environmental integrity (Water for Peace and Prosperity, 2024).

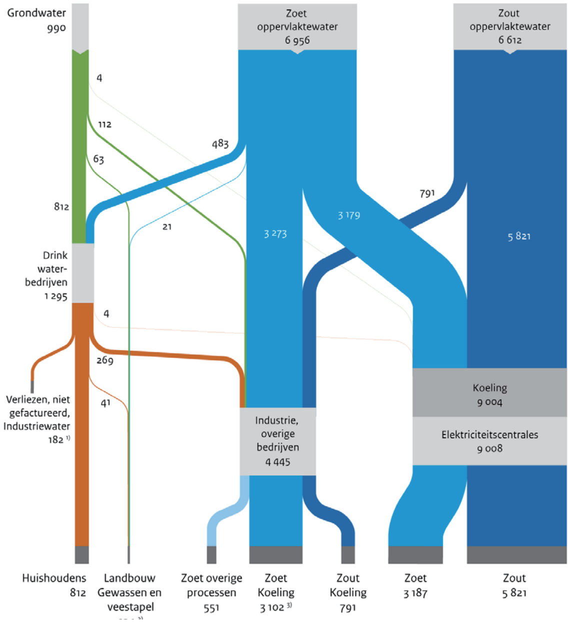
The conflict between water use and urban development, with a rising demand for urbanization. While water use has levelled off in countries across North America and Europe since the early 1980s (USGS Water Science School, 2018; Kuzma et al., 2023), the global demand for freshwater has been increasing by just under 1% per year during this period (AQUASTAT, n.d.). Rising demand is primarily driven by a combination of socio-economic development and related changes in consumption patterns, including diet (Zucchinelli et al., 2021), such that the bulk of this increase is located in cities, countries and regions that experience rapid economic development, most notably in emerging economies (Ritchie and Roser, 2017). Recent and future trends in water demand are notoriously difficult to measure and estimate (United Nations, 2023a). However, the available evidence suggests that water demand from the municipal (or domestic) sector has experienced a considerable increase relative to the other sectors and is likely to continue growing as populations urbanize and the water supply and sanitation systems servicing these cities expand.



>Figure 3, Surface water use in the Netherlands (CBS, 2023)



>Figure 4, Extraction and use of water in the Nethelrands, 2021 (CBS, 2023)



>Figure 5, Water use per sector, 2021 (CBS, 2023)

Hydrological disruption and ecosystem services

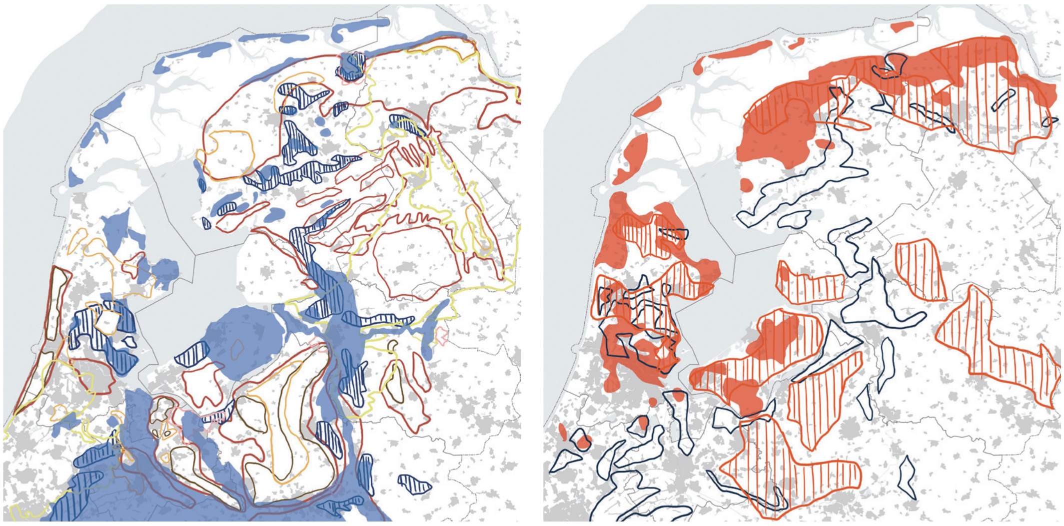
The hydrological cycle is a critical process that governs the movement, distribution, and availability of water across ecosystems, shaping biodiversity and enabling essential ecosystem services (Pittock et al., 2015). These services—including water purification, flood regulation, carbon sequestration, and habitat maintenance—are vital for maintaining environmental balance and human well-being (TEEB, 2010). However, hydrological disruptions, driven by climate change and unsustainable human practices, are increasingly jeopardizing the capacity of ecosystems to provide these services (Rockström et al., 2009). These risks are intensified not only by changes in the hydrological cycle—such as altered flows and precipitation patterns—but also by the rigidity of existing water infrastructure, which was originally designed under stable climatic assumptions and is now increasingly inadequate (IPCC, 2023).

Ecosystem services depend on a healthy, functioning hydrological cycle. Disruptions to water availability, such as droughts, flooding, and saltwater intrusion, impair the natural systems that regulate water quality and quantity, thereby diminishing their ability to support biodiversity and human activities (Batker et al., 2010). For example, the degradation of wetlands due to water table fluctuations can lead to the loss of flood regulation services, while changes in river discharge impact water purification and fish migration (Pittock et al., 2015). Moreover, the interactions between hydrological processes and natural capital—such as freshwater systems supporting agricultural productivity and biodiversity—generate co-benefits that are often overlooked in traditional economic models (Daily et al., 1997). These co-benefits are critical for the long-term resilience of both ecosystems and human communities, and their loss could undermine food security, water access, and climate stability (Figure 6).

The lack of circularity measures in managing water resources exacerbates the problem. Circularity refers to the continuous reuse and regeneration of natural resources, ensuring that water, nutrients, and ecosystem services are sustained and restored through integrated management approaches (Ghisellini et al., 2016). In many regions, however, water management still operates in a linear fashion—exploiting water resources without accounting for the interdependencies between hydrological cycles, ecosystem health, and resource recovery (EEA, 2015). This results in inefficient use of water, poor land management, and a decline in ecosystem services, which further disrupts the hydrological balance (Rockström et al., 2009).

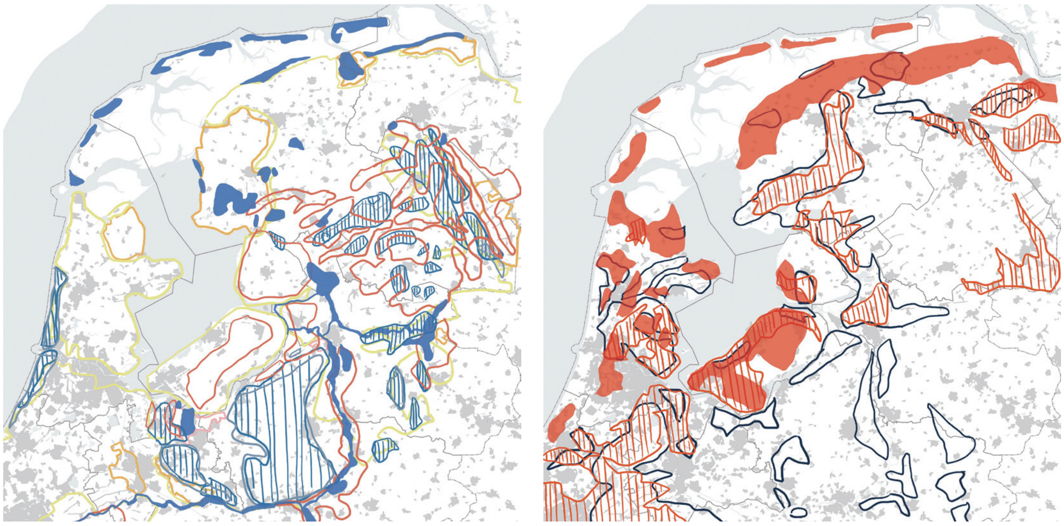
The urgency of addressing these issues grows as climate change accelerates. The IPCC (2023) projects that the future of water availability will become increasingly uncertain, with more frequent and severe droughts, floods, and shifts in seasonal rainfall. In turn, these changes will exacerbate the disruption of ecosystems and the services they provide. Effective adaptation to these changes requires integrating ecosystem services into hydrological management frameworks, ensuring that water is not only used efficiently but that it also supports the restoration and maintenance of ecosystems (TEEB, 2010).

To prevent further degradation and build resilience, it is essential to reframe water management in terms of ecosystem service preservation, ecosystem-based adaptation, and circular economy principles. This involves recognizing the interdependence of human and natural systems and developing strategies that prioritize both water and ecosystem health (Batker et al., 2010). By fostering greater circularity and integrating ecosystem services into decision-making, we can enhance the resilience of both ecosystems and human societies to future hydrological disruptions.



Water condition current

Soil condition current



Water condition 2050

Soil condition 2050

>Figure 6, Water and soil conditions in current and 2050 (By Yiyan Zhou)

Legend

- ▭ Water
- ▭ Urban area

Water condition

- ▬ Flood risk
- ▥ Average highest groundwater level
- ▭ Lowest groundwater level
- ▭ Surface water deficit extremely dry year

Soil condition

- ▥ Soil subsidence
- ▬ Location of the interface between fresh and salt water
- ▭ Risk of oxygen stress

Positioning IJsselmeer

IJsselmer region means of Netherlands

Positioned within the Dutch delta system, the IJsselmeer Area is a central component of national water management, functioning as a key freshwater buffer and regulatory basin at the downstream of the Rhine River. (see figure 7) The region is also embedded in broader EU water governance frameworks, such as the Water Framework Directive and the Delta programme (European Commission, 2000; Delta Programme Commissioner, 2023).

Water management in the Netherlands

The Netherlands has faced the challenge of managing water for centuries, a persistent issue shaping both human and non-human systems. The IJsselmeer Area exemplifies the Dutch relationship with water, where the interplay between water, old land, and reclaimed new land creates a globally unique landscape (Agenda IJsselmeer Region 2050, 2018).

"Blue Heart" in the Netherlands

The basic functions of the IJsselmeer delta are now under serious pressure: water storage during high water, the fresh water supply during droughts and the ecosystem as the basis for the food chain. The water and ecosystem are reaching a tipping point. This also puts economic, landscape and cultural-historical values at risk.

The pressure from climate change makes the IJsselmeer region more important on the map as the Blue Heart of the Netherlands (Agenda IJsselmeergebied 2050, 2018). The aim is to take the IJsselmeer region as a freshwater buffer to meet the uncertain future. The IJsselmeer region plays an important role in the freshwater supply for the Northern Netherlands. Water from the IJsselmeer region is used in normal and extremely dry situations (Rijkswaterstaat & Deltares, 2022).

A systemic approach to regional planning

Adopting a system-thinking approach for water distribution and spatial organization demands collaborative efforts and effective communication about the area. Regional and systematic guidance is necessary to integrate individual ambitions, tasks, and projects across the IJsselmeer Area, fostering cohesion and addressing challenges comprehensively. The Agenda IJsselmeer Region emphasizes tasks that extend beyond individual subareas, focusing on large-scale, interconnected goals.

Defining the research area

The IJsselmeer Area does not have strict boundaries (see figure 7). The areas that drain into it differ from those that rely on its water supply. Furthermore, exploring the region's urbanization patterns and ecological

Resource:

Delta Programme Commissioner. (2023). Delta Programme 2024: Continuing the work on the delta – Increasing the pace of implementation. Ministry of Infrastructure and Water Management. https://english.deltaprogramma.nl

European Commission. (2000). Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (Water Framework Directive). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060

Agenda IJsselmeergebied 2050. (2018). Agenda IJsselmeergebied 2050: Joining forces for the Blue Heart. Ministry of Infrastructure and Water Management. https://platformijsselmeergebied.nl/kennisartikel/agenda-ijsselmeergebied-2050-krachten-bundelen-voor-het-blauwe-hart/

Rijkswaterstaat, & Deltares. (2022). Verkennende systeemanalyse IJsselmeergebied: Bouwstenen voor integrale keuzes in het ruimtelijk-fysiek systeem [Exploratory system analysis of the IJsselmeer area: Building blocks for integrated choices in the spatial-physical system]. Ministry of Infrastructure and Water Management. https://platformijsselmeergebied.nl/kennisartikel/verkennende-systeemanalyse-ijsselmeergebied/

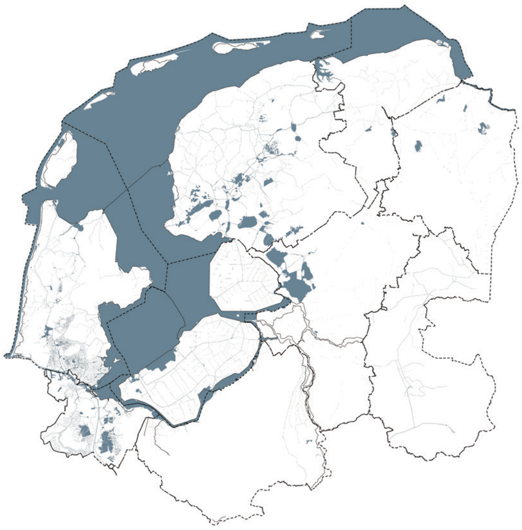
>Figure 7, Study area (By Yiyan Zhou)

values does not necessarily align with water-related perimeters. Therefore, this thesis focuses on the IJsselmeer water body and its broader sphere of influence, encompassing areas impacted by or reliant on its waters.

Knowledge sharing and spatial exploration

The IJsselmeer Area offers an experimental landscape through a series of pilot projects aligned with the Agenda IJsselmeer Region. These projects provide opportunities to guide national strategies; however, they often lack sufficient knowledge to effectively translate concepts into practice. Addressing this gap can enhance spatial exploration and foster innovative solutions for sustainable water management.

a) Rhine river basin



b) IJsselmeer Lake region

c) IJsselmeer Lake

Water pressure in the IJsselmeer Area

The water pressure is caused by two main factors (see figure 8):

1. Climate change and sea level rise

The Sea Level Rise Knowledge Programme (Delta Programme Comissioner, 2023; Deltares, 2021) has highlighted the significant impacts of accelerated sea level rise on the IJsselmeer area. Rising sea levels, combined with climate change, are placing unprecedented pressures on flood control systems along the Dutch coast.

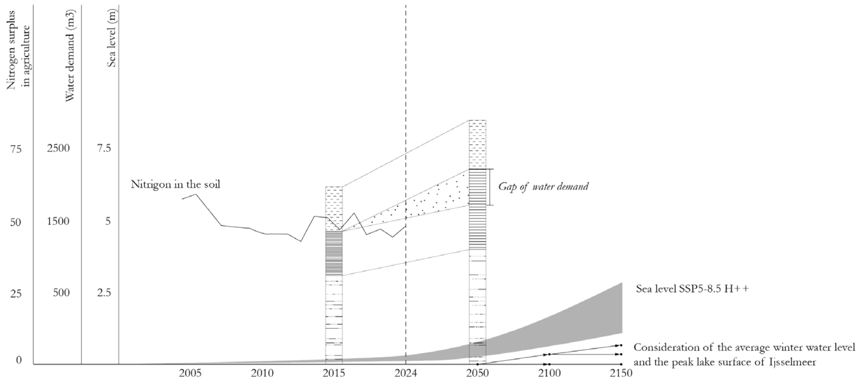
For the IJsselmeer area, these changes will likely lead to an increased inflow of surplus water from the Rhine catchment and smaller drainage basins feeding into the lake. This is due to higher winter discharges from the Rhine and more extreme precipitation events in surrounding basins caused by climate change. At the same time, sea level rise reduces the window of opportunity for gravity-based drainage through the Afsluitdijk, limiting outflow capacity. As a result, surplus water accumulates more easily in the lake, increasing hydrological pressure (Deltares, 2021; Rijkswaterstaat & Deltares, 2022).

To address these challenges, measures such as increasing the capacity of discharge locks in the Afsluitdijk and installing pumps have been proposed (Deltares, 2021). However, sea level rise exacerbates existing problems, including salt intrusion, flood risks, and the region's overall hydrological balance.

2. Rising water demand

The increasing demand for water within the IJsselmeer region adds further stress to its freshwater system. This demand comes from multiple sectors, including agriculture, industry, and urban development, creating a significant gap between supply and demand. The dual pressures of rising water needs and insufficient storage capacity make it difficult to maintain the region's role as a reliable freshwater buffer.

Together, these challenges underscore the need for a strategic and adaptive approach to water management in the IJsselmeer area, ensuring its functions as a resilient "Blue Heart" for the Netherlands in the face of climate uncertainties.



▪▬▪ Country border

— Rhine River catchment

▩ Water body within Rhine River catchment

▢ Urban area

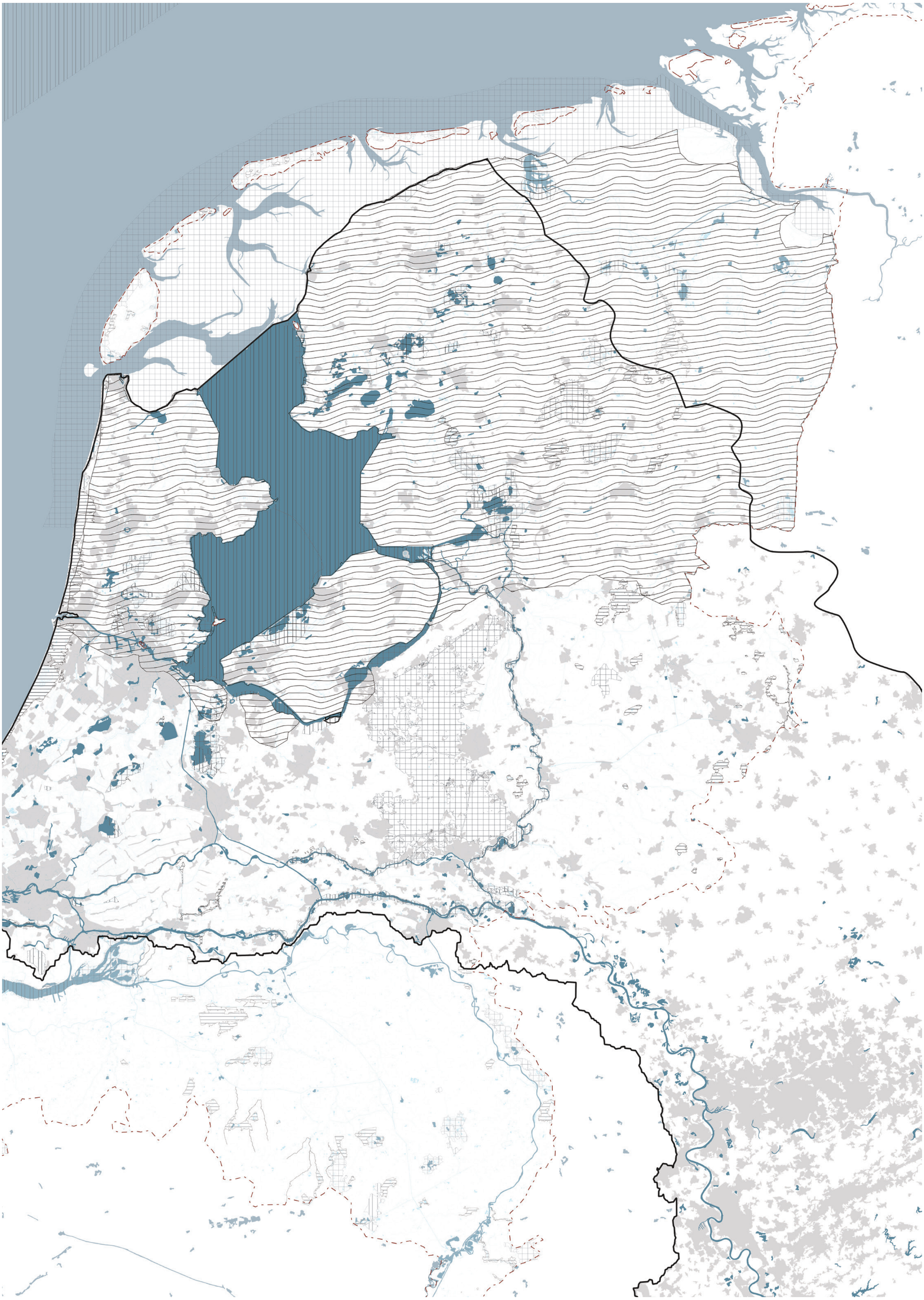
Natura 2000

◫ VR

⊟ HR

⊞ VR+HR

<Figure 8, Limitation (By Yiyan Zhou)



Regulation and goals

Water Framework Directive (WFD)

The WFD establishes a framework for the sustainable management of water resources across Europe, with specific goals for the IJsselmeer area:

1. Achieving Good Ecological and Chemical Status: The WFD aims to restore and maintain the ecological and chemical quality of surface and groundwater in the IJsselmeer region. This includes reducing pollutants and managing nutrient levels to prevent eutrophication in the lake and connected water bodies.

2. Integrated Water Management: Promotes a holistic approach to water resource management by integrating water quality, water quantity, and ecosystem health, particularly in the IJsselmeer catchment.

3. Measures for Hydromorphological Alterations: The IJsselmeer area, with its dike systems, locks, and reclaimed polders, requires specific measures to mitigate hydromorphological impacts on ecosystems, including improving fish migration routes and restoring natural water flow.

Natura 2000 Regulations

The Natura 2000 network focuses on protecting biodiversity and key habitats in the IJsselmeer area. It includes:

1. Habitat Protection: The IJsselmeer area is designated as a Natura 2000 site, hosting vital habitats for migratory birds, including 8 significant bird habitats, many of which are located in areas outside the dike. Regulations mandate preserving these habitats to support biodiversity and ecological balance.

2. Species Protection: The area serves as a critical corridor for fish migration. Measures are required to reduce the impact of flood defense and freshwater infrastructure on fish populations, ensuring safe migration routes and maintaining healthy aquatic ecosystems.

3. Water Level Management: Regulations under Natura 2000 emphasize maintaining water levels and hydrological conditions that support the specific ecological needs of protected habitats and species.

4. Balancing Conservation with Human Activities: Encourages harmonizing conservation efforts with ongoing economic activities, such as shipping, fishing, and recreation, while minimizing adverse effects on protected ecosystems.

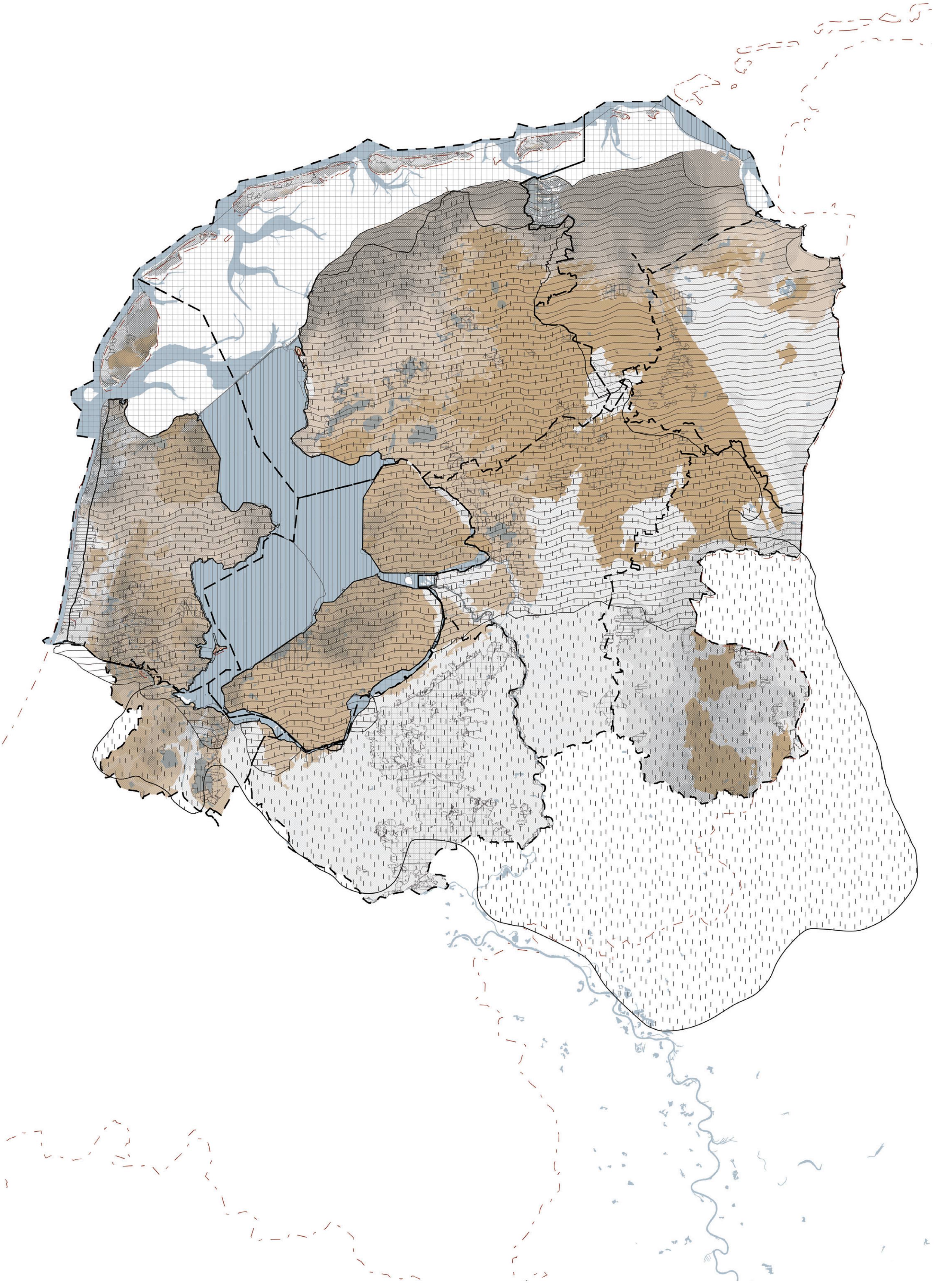
Key Goals for the IJsselmeer Area Under WFD and Natura 2000

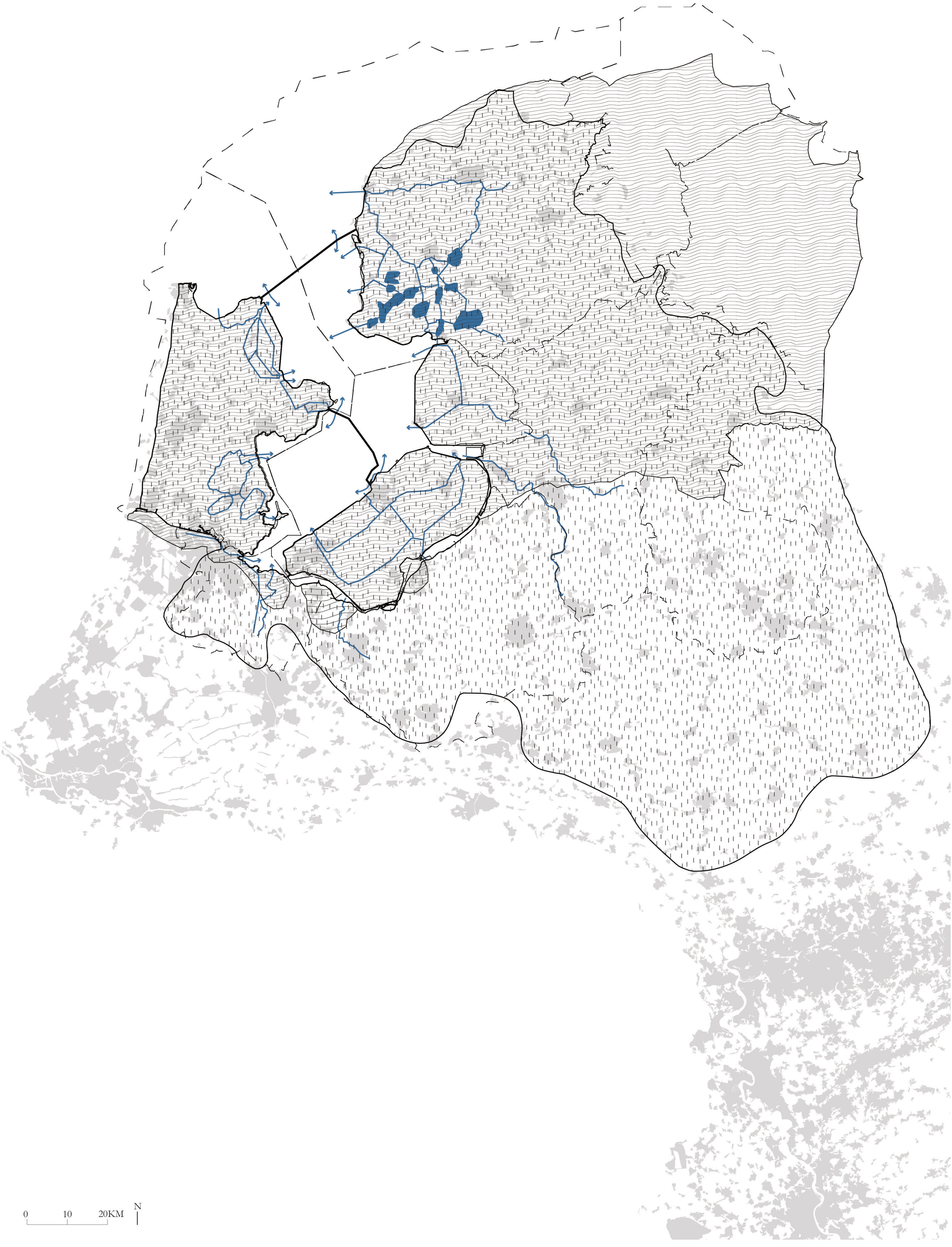
The primary goals include balancing water management, ecological protection, and socio-economic needs, improving ecological connectivity between land and water systems, and addressing climate change challenges such as sea level rise and increasing water demand. Emphasis is placed on adaptive strategies and collaborative efforts to achieve water quality, biodiversity targets, and sustainable development in the IJsselmeer region.

— Country border
▬ Dutch Water Institution
■ Water body within IJsselmeer catchment
☐ IJsselmeer Discharge area (winter)
☐ IJsselmeer Supplyment area (summer)

Basic natura system Netherlands
■ Clay loam area
■ Reclaimed area
■ Lowland peat
■ Sea clay polders

Salinization_groundwater
▦ 0-5m
▦ 5-10m
▦ 10-25m
▦ 25-50m
▦ 50-100m
▦ >100m




0
10
20KM
N

Problem statement

Problematization

As the largest freshwater buffer in the northern Netherlands, the IJsselmeer Lake Region holds a critical responsibility for freshwater supply in the coming dry years. However, with the rising demand for water from various sectors and the increasing pressures of climate change, the capacity of the freshwater buffer is facing both active and passive threats. The ecosystem services that include human aspects, such as water supply for agriculture and urban areas, are interwoven with more-than-human aspects, like biodiversity and ecosystem health. Modern human activities cause interactions between both social and natural systems, which are often linked by water (Liang, J., Xie, J., Wang, X., Wang, S., & Yu, M. 2022). These interconnected systems have a symbiotic relationship, where the well-being of one affects the other. This makes it increasingly important to rethink the relationship between water and land in the IJsselmeer Lake Region.

Resource:
Liang, J., Xie, J., Wang, X., Wang, S., & Yu, M. (2022). Visualization of Multi Scenario Water Resources Regulation Based on a Dualistic Water Cycle Framework. Water, 14(7), 1128. https://doi.org/10.3390/w14071128

Under the pressures of climate change, it becomes crucial to organize hydrological space in a way that accommodates both development needs and climate adaptation. This includes addressing rising sea levels, which pose significant risks to the region, and incorporating spatial quality as one of the most important values in managing the area's spatial performance. Spatial quality here refers not only to ecological and economic factors but also to social and cultural dimensions that support sustainable development and resilience.

Research aim

To propose a new spatial adaptation approach to water management within the hydrological area, serving as a knowledge advisory to foster co-benefits between human and non-human entities. This involves organizing synergies among diverse ecosystem services and finding a balance to bridge the gap between economic-centric and nature-centric development.

What distinguishes this approach is its spatial foundation and integration of design thinking into decision-making processes. It links top-down systemic understanding of environmental and socio-political contexts with bottom-up design-based local adaptations. Through this iterative interaction, spatial planning becomes not only a tool for implementation, but also a framework for negotiation, experimentation, and transformation in adaptive water governance.

Different water boundary

▬ Dutch Water Institution
— Water supply and drainage basins around IJsselmeer
☐ IJsselmeer Discharge area (winter)
☐ IJsselmeer Supplyment area (summer)
■ Urban area within Rhine river catchment

CHAPTER 2.

RESEARCH APPROACH

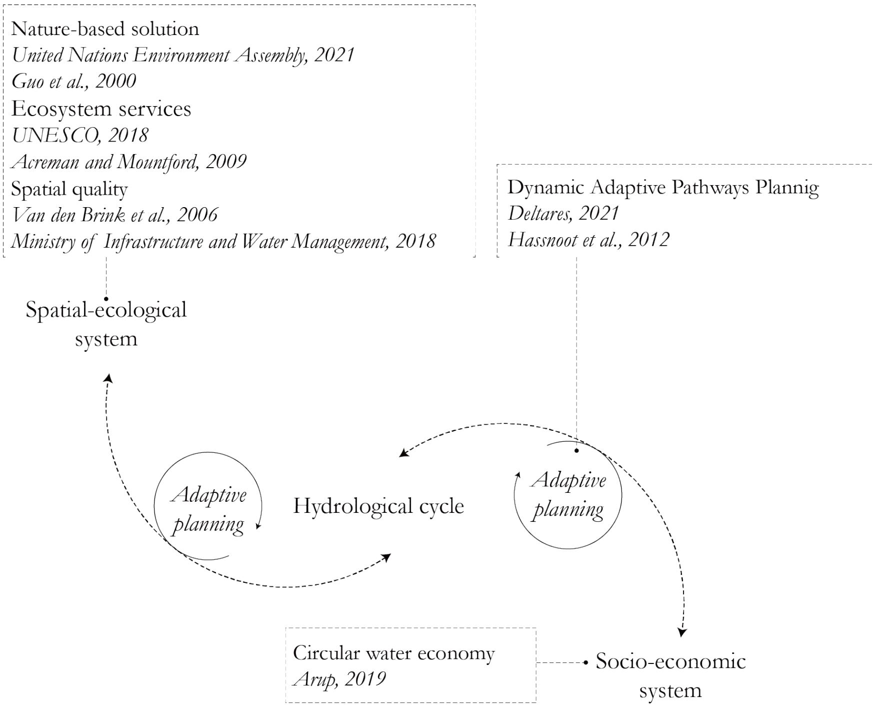
Theoretical notions

Introduction

This research draws upon an integrated set of theoretical perspectives to understand and reimagine the relationship between hydrological systems, spatial envrionments, and socio-economic dynamics in the IJsselmeer region. At the center of this conceptual approach is the hydrological cycle, which acts as both a biophysical process and a spatial connector between the spatial-ecological system and the socio-economic system.

The spatial–ecological dimension is informed by theories of nature-based solutions (United Nations Environment Assembly, 2021; Guo et al., 2000), ecosystem services (UNESCO, 2018; Acreman & Mountford, 2009), and spatial quality (Van den Brink et al., 2006; Ministry of Infrastructure and Water Management, 2018), while the socio–economic side is shaped by ideas of the circular water economy (Arup, 2019).

To bridge these interconnected layers, the concept of adaptive planning—particularly as articulated through Dynamic Adaptive Pathways Planning (DAPP) (Haasnoot et al., 2012; Deltares, 2021)—is used to guide flexible and iterative decision-making. By linking top-down contextual insights with bottom-up local design interventions, this approach supports spatially grounded adaptation strategies that respond to the increasing complexity and uncertainty of water governance.



<Figure 9, Conceptual framework (Own illustration)

Nature-based solutions (NBS)

Nature-based solutions (NBS) refer to strategies that work with natural systems to address environmental and societal challenges. In water management, NBS have gained attention for their ability to reduce flood risk, support water purification, and enhance resilience to climate change. Rather than replacing natural systems with engineered ones, NBS aim to use and strengthen natural processes to achieve desired outcomes (UN WWDR, 2018).

The concept has its roots in early ecological applications. In the 2000s, wetlands began to be recognized not only as habitats but also as valuable tools for wastewater treatment and watershed regulation. Research by Guo et al. (2000) and Kayser and Kunst (2002) demonstrated how wetlands could be used to filter nutrients, regulate water flows, and support hydropower systems. These early examples illustrated the practical benefits of integrating ecosystems into water infrastructure.

Beyond these technical functions, NBS are now closely linked to the concept of ecosystem services, which highlights the benefits nature provides to both people and the environment (Acreman & Mountford, 2009). In spatial planning, this perspective opens new ways of thinking about land use—not just in terms of zoning or development, but in terms of how landscapes can simultaneously support ecological health, economic productivity, and social well-being. The integration of NBS into spatial strategies allows planners to embed adaptive capacity and co-benefits across scales, from local interventions to regional water systems (UNESCO, 2018; Van den Brink et al., 2006).

> *"actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems that effectively and adaptively address social, economic and environmental challenges, while providing benefits for human well-being, ecosystem services, resilience and biodiversity"*
>
> *-United Nations Environment Assembly, 2021-*

Ecosystem services

The water-related processes and functions of ecosystems can be managed to deliver benefits to people as 'ecosystem services' (UNESCO, 2018).The UNESCO (2018) defines ecosystem services composed with water-related services and water-dependent services.

Water-related ecosystem services can be grouped into those that relate to the movement of water (e.g. evaporation, overland flow and infiltratio into the ground), the storage of water (principally in soils, groundwater and wetlands) or the transformation of water, including its quality (Acreman and Mountford, 2009). Meanwhile there are three dimensions of water resources challenges that underpin most, which are water availability (supply or quantity), water quality and moderating risk and extremes.

Resource:

Acreman, M. C., & Mountford, J. O. (2009). Wetlands. In H. van der Ploeg & P. Jeffrey (Eds.), The ecological and hydrological functions of wetlands (pp. 14–24). IWMI/ UNESCO.

Guo, Z., Xiao, X., & Li, D. (2000). An assessment of ecosystem services: Water flow regulation and hydroelectric power production. Ecological Applications, 10(3), 925–936. https://doi.org/10.1890/1051-0761(2000)010[0925:AAOESW]2.0.CO;2

Kayser, K., & Kunst, S. (2002). Constructed wetlands for wastewater treatment in Europe. Water Science and Technology, 45(9), 321–327.

UNESCO. (2018). Nature-based solutions for water. United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000266462

UN World Water Assessment Programme. (2018). The United Nations World Water Development Report 2018: Nature-based solutions for water. UNESCO. https://www.unesco.org/en/wwap/wwdr/2018

Van den Brink, A., van der Valk, A., & van Dijk, T. (2006). Planning and the challenges of the metropole: Dealing with spatial quality. In A. van der Valk & A. van den Brink (Eds.), Dutch Planning in Transition (pp. 197–215). Sdu Uitgevers.

Water-dependent ecosystem services include products directly obtained from ecosystems (e.g. food, fibre and energy), benefits derived from ecosystem processes (e.g. air quality and cimate regulation), supporting services (e.g. nutrient cycling and soil formation) and cultural services (e.g. recreation (UNESCO, 2018).

Spatial quality

Spatial quality in Dutch planning is understood as a value-driven, integrative concept, combining functional utility, aesthetic experience, and long-term resilience (Busscher et al., 2019). Often referred to as the "Vitruvian triplet" of user value, experiential value, and future value, it has become central in spatial policy and design evaluation. Nelissen and ten Cate (2009) emphasize the importance of ruimtelijke kwaliteitszorg (spatial quality care), where design review bodies like welstandscommissies protect spatial and cultural values. Their comparative study Mooi Europa shows how countries institutionalize spatial quality to preserve valued landscapes and prevent disorder.

In adaptive spatial and water management, spatial quality serves as a strategic design criterion. The Room for the River program made spatial quality and flood safety equal objectives (Busscher et al., 2019). A Q-team of experts reviewed plans, guided designs, and monitored that each intervention improved both landscape and ecological values (Van Assen & Van Campen, 2014). Research shows that projects with strong Q-team involvement achieved better spatial outcomes and stronger landscape integration (Busscher et al., 2019; Restemeyer et al., 2024). Van den Brink and colleagues note that spatial quality here links engineering with broader planning goals, guiding interventions toward multi-benefit outcomes.

This logic extends to the IJsselmeer region, where spatial quality informs adaptive planning by focusing on openness, natural character, and cultural continuity (Van Campen & Mulder, 2020). Rather than an aesthetic add-on, it supports place identity and resilience in the face of climate change.

Internationally, this approach aligns with the UN-Habitat New Urban Agenda, which promotes safe, resilient, and high-quality public space as part of sustainable urbanism (UN-Habitat, 2016). Similar principles in EU and UNESCO guidance advocate spatial quality as a foundation for integrated, adaptive development.

Resource:

Arup, Antea Group, & Ellen MacArthur Foundation. (2019). Water and circular economy: A white paper. Arup. https://www.arup.com/perspectives/publications/research/section/water-and-circular-economy

Brears, R. C. (2023). The circular water economy: Opportunities and challenges. Mark and Focus. https://medium.com/mark-and-focus/the-circular-water-economy-opportunities-and-challenges-ab03040ea807

Busscher, T., van den Brink, M., & Verweij, S. (2019). Strategies for integrating water management and spatial planning: Organising for spatial quality in the Dutch "Room for the River" program. Journal of Flood Risk Management, 12(S1), e12448. https://doi.org/10.1111/jfr3.12448

Nelissen, N., & ten Cate, F. (2009). Mooi Europa: Ruimtelijke kwaliteitszorg in Europa. Amsterdam: SUN.

Restemeyer, B., van den Brink, M., & Arts, J. (2024). A policy instruments palette for spatial quality: Lessons from Dutch flood risk management. Journal of Environmental Policy & Planning, 26(3), 249–263. https://doi.org/10.1080/1523908X.2024.2282540

UNESCO. (2018). Nature-based solutions for water: The United Nations World Water Development Report 2018. United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000266462

UN-Habitat. (2016). New Urban Agenda. United Nations Human Settlements Programme. https://habitat3.org/the-new-urban-agenda/

Van Assen, S., & van Campen, J. (2014). Q-factor: Ruimtelijke kwaliteitsteams in Nederland. Wageningen: Blauwdruk.

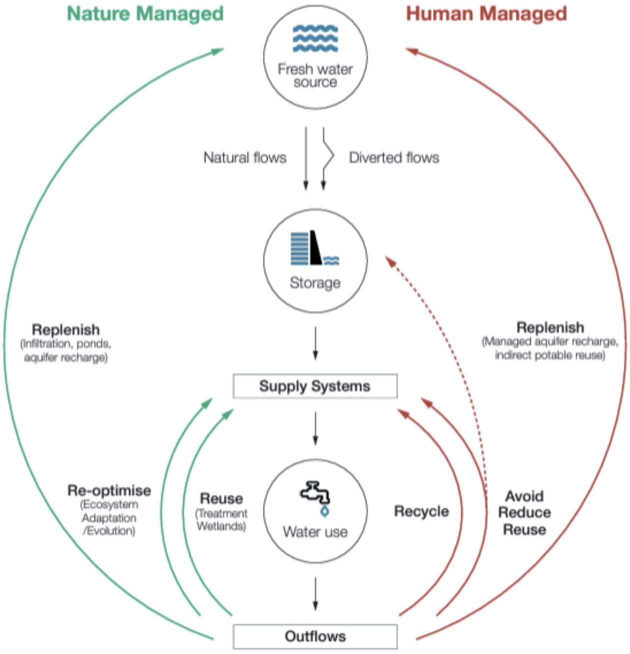
Van Campen, J., & Mulder, W. (2020). Handreiking adviesstelsel voor omgevingskwaliteit (Deel 1). Den Haag/Amersfoort/Amsterdam: VNG, RCE, & Federatie Ruimtelijke Kwaliteit.

Water circularity

Integrating circular economy principles into water management offers a sustainable path to address the global water crisis. This approach challenges the traditional linear "take-use-discharge" model of water use, advocating instead for strategies that minimize waste, optimize reuse, and regenerate natural systems (Arup, Antea Group, & Ellen MacArthur Foundation, 2019). Circular thinking aims to align water use with natural cycles while maximizing resource efficiency and ecosystem health.

In a circular system, water plays multiple roles—as a service, a carrier, and a source of energy (Brears, 2023). As a service, water supports sanitation, industrial processing, and cooling, where innovations such as waterless dyeing reduce dependency. As a carrier, water can transport nutrients and pollutants, enabling recovery of resources like phosphorus and nitrogen from wastewater. As an energy source, water's flow and thermal capacity are harnessed in energy-positive treatment plants such as Denmark's Ejby Mølle facility, which generates more energy than it consumes.

A systems-thinking perspective is essential, linking water systems with agriculture, industry, and urban infrastructure. For instance, Renault's Tangier facility recycles nearly all its wastewater, reducing water use by 70% (Arup et al., 2019). Similarly, the Upper Tana-Nairobi Water Fund demonstrates how watershed conservation upstream benefits both urban water users and rural farming systems downstream (UNESCO, 2018). These case studies show how circular water strategies create cross-sectoral benefits, contributing to sustainability and resilience in the face of climate and resource pressures.

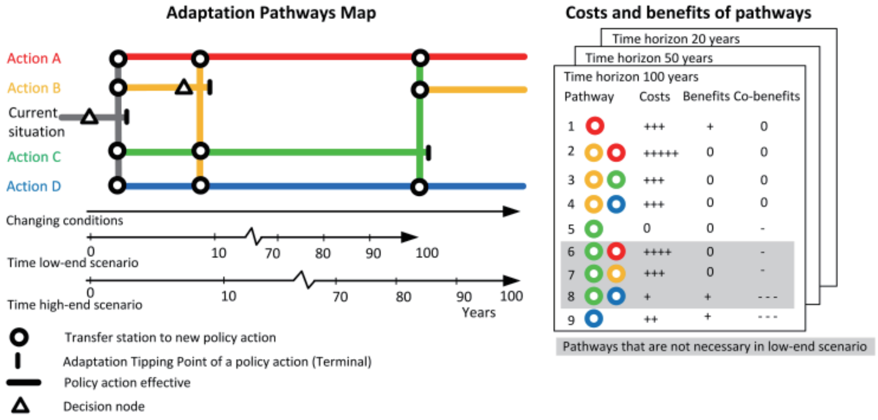


>Figure 10, Scheme of water for circular economy (Arup, Antea Group, & Ellen MacArthur Foundation, 2019)

Dynamic Adaptive Pathways Planning Approach (DAPP)

The Dynamic Adaptive Pathways Planning (DAPP) approach is a method for planning under uncertain future climatic or socioeconomic conditions that falls under the broader umbrella of decision making under deep uncertainty (Deltares, 2021). Hassnoot et al. (2012) developed and tested this new approach to explore different pathways for sustainable water management in tiver deltas under uncertainty. Pathways, as a decision-oriented approach to map sequences of policy actions, shift policy-making away from the ambition of attempting to chieve static, predefined outcomes (Zandvoort et al., 2019). An adaptive plan specifies actions to be taken immediately to be prepared for near futures as well as actions to be taken to keep options to adapt open in more distant futures if needed (see figure 10).

DAPP allows planners to identify short-term no-regret actions and be prepared for actions needed in the mid- to long-term as the future unfolds (Deltares, 2021). The adaptation pathways are senario-netural, which means they are not tied to any specific secnario. DAPP works with adaptation tipping points, with using scenarios to estimate the timing of that. Adaptation pathways have been used in many adaptive flood risk planning projects, including the Bangladesh Delta Plan, the Dutch Delta Programme in the Netherlands, the Hutt River City Center Upgrade Project in New Zeland, and for palnning and strategic analysis for the Calcasieu Parish-wide watershed in Louisiana (Deltares, 2021).



Time horizon 100 years

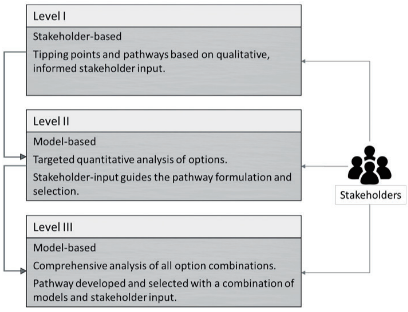
Pathway	Costs	Benefits	Co-benefits
1 🔴	+++	+	0
2 🟠 🔴	+++++	0	0
3 🟠 🟢	+++	0	0
4 🟠 🔵	+++	0	0
5 🟢	0	0	-
6 🟢 🔴	++++	0	-
7 🟢 🟠	+++	0	-
8 🟢 🔵	+	+	- - -
9 🔵	++	+	- - -

Pathways that are not necessary in low-end scenario

<Figure 11, example of adaptation pathways map and a scorecard for each of the pathways (Deltares, 2021)

Levels of analysis refer to a tiered approach to DAPP planning, starting with the most qualitative problem scoping assements and progressively moving towards more quantitative and sophisticated analyses (Deltares, 2021) see figure 11). Firstly, the Level I analysis is a qualitative, stakeholder-driven approach to the steps of DAPP and is highly recommended even when ultimately carrying outh Level II or Level III-type analysis, which requaire multiple stakeholder engagement sessions. This step provides opportunities to identify the mesures that resonable to be considered in the tipping points, which keeps the modeling efficient and targeted. Secondly, the Level II analysis refers to quantitative, model-based approach, to determine adaptation tipping points and develop action plans by culculating the possible divers that cause the future vulnerability. Then the Level III analysis is bulit upon the outputs of the Level II analysis, which is a further intersction with other approaches to decision making under deep uncertainty. Specifically, figure 12 shows an example of a computataional framework for a level II analysis, by using hazard and damage model to evaluate flood risk for different adaptation options under different climate and socio-economic projections.

The DAPP approach is a policy-oriented adaptive planning method. Its analytical process helps the thesis examine how policies at different scales and in various domains address specific research issues and propose corresponding strategies. By balancing the needs of different stakeholders, it supports the development of short- to long-term adaptation interventions. However, this method lacks a focus on spatially adaptive policies.



>Figure 12, Three levels of analysis, to meet different needs, budgets, and data/modeling resources (Deltares, 2021)

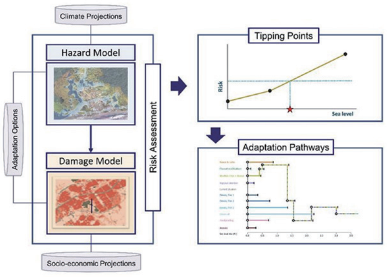


Figure 15: Schematization of a Level II quantitative approach to developing a pathways map

>Figure 13, Schematization of a Level II quantitative approach to developing a pathway map (Deltares, 2021)

Conceptual framework

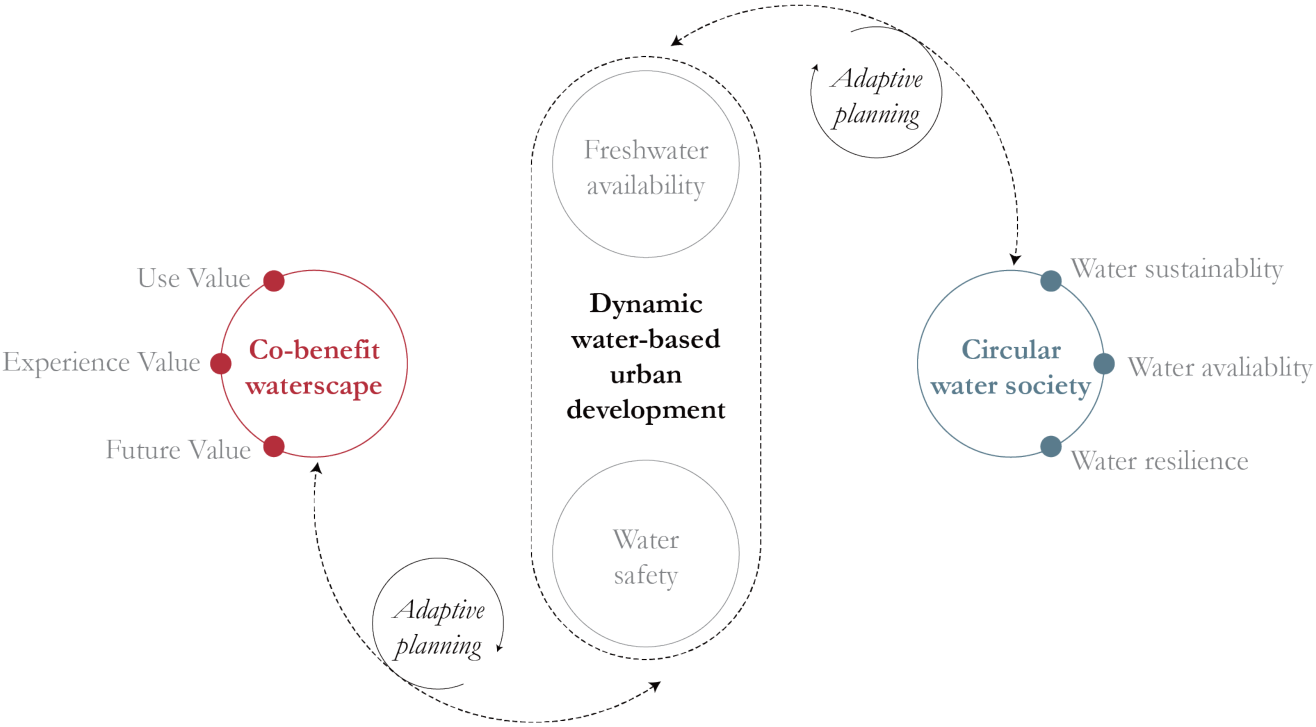
Based on the systematic diagram of the theoretical notions, the scheme (see figure 14) illustrates the main concept proposed in this thesis of dynamic water-based urban development as an adaptive and systemic solution. This development is centered around two main water aspects: freshwater availability and water safety.

The Co-benefit Waterscape refers to the integration of cultural and ecological systems that align with spatial quality, aiming to improve the quality of both human and non-human living environments. This approach seeks to create synergies between ecological preservation and the enhancement of human spaces, ensuring the resilience of ecosystems and the livability of urban environments.

The Circular Water Society concept emphasizes water-oriented development within the socio-economic system. It aims to close the water loop, moving away from the traditional linear use of water. This approach enhances efficiency in spatial use while considering the social, economic, and ecological perspectives of water management. It promotes sustainable water cycles and aims to minimize waste and overuse.

The principles, guidelines, and spatial design measures derived from these two concepts will be implemented through adaptive planning processes at both the governance and spatial adaptation levels. This approach offers a new way to understand and manage the hydrological system in relation to urban development. The adaptive planning approach, based on the DAPP methodology, is extended further to propose spatial adaptation strategies that are flexible to time and context. It operates within a horizontal time scale, considering extreme conditions and focusing on the balance of different services' co-development. This includes balancing the needs of various sectors while implementing spatial adaptation strategies that accommodate technical, ecological, and social requirements.

>Figure 14, Conceptual framework (By Yiyan Zhou)


Use Value
Experience Value
Future Value
Co-benefit waterscape
Adaptive planning
Freshwater availability
Dynamic water-based urban development
Water safety
Adaptive planning
Water sustainablity
Circular water society
Water avaliablity
Water resilience

Research question

Main research question

How can the water-based services (A) of IJsselmeer region organise system synergies and adapt to a future-proof (B) and circular waterscape (C)?

The main research question contains with following keywords:
A: water-based services
B: Future-proof
C: Circular waterscape

Sub-research question

Phase 1 Problematization

SQ1: What are the current and ongoing challenges in the Netherlands that are affecting the water crisis in the IJsselmeer Lake Region?

Phase 2 Evaluation

SQ2: What is the existing position of the IJsselmeer region in the context of national water governance?

SQ3: How is spatial performance developed by different services in the IJsselmeer Region?

Phase 3.1 Envision

SQ4: How can design framework and principles can be designed to expand the capacity of freshwater buffer in the IJsselmeer Region?

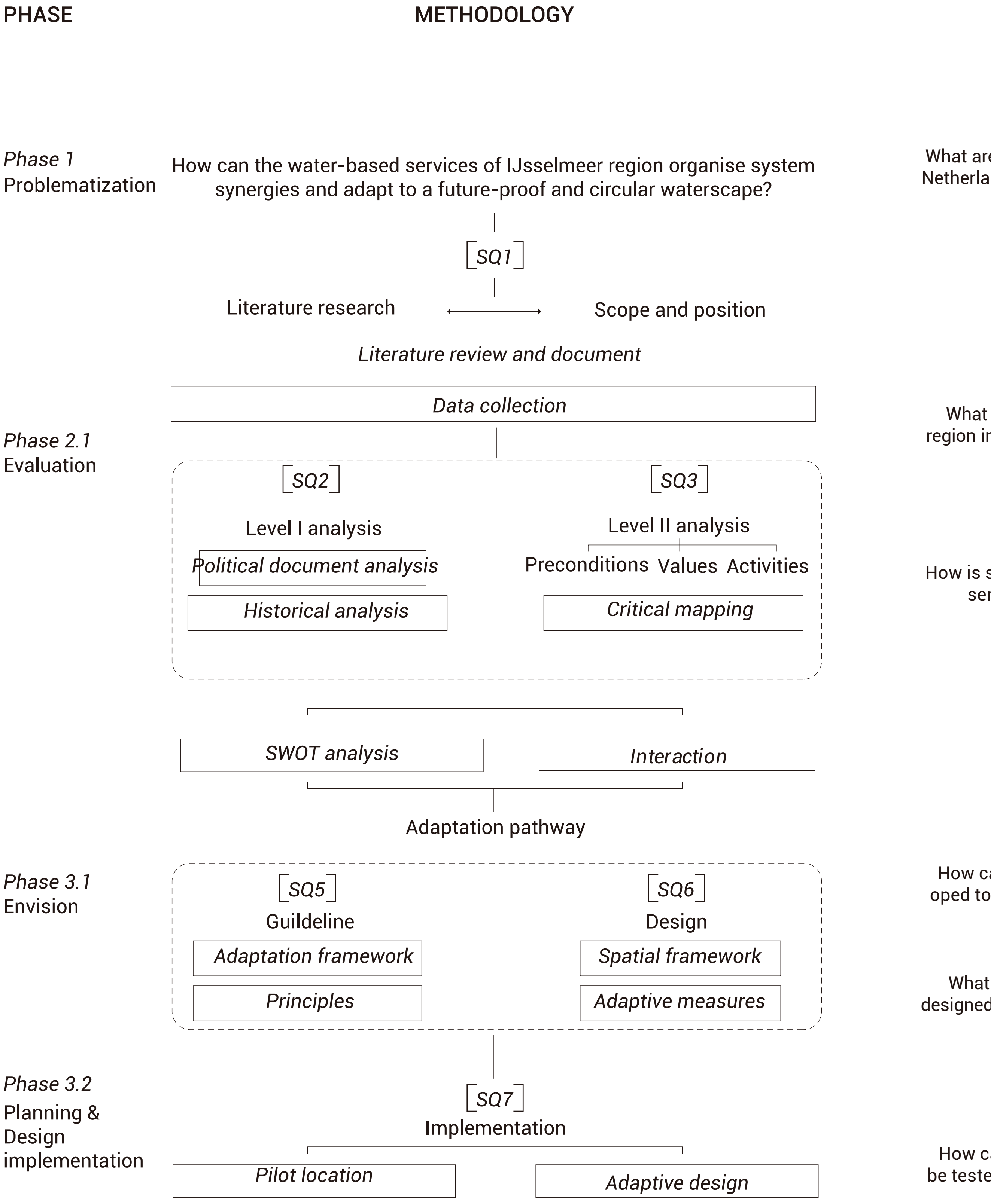
Phase 3.2 Identification

SQ5: How can Spatial Adaptive Pathway be developed to meet the future-proofing targets between the water and land?

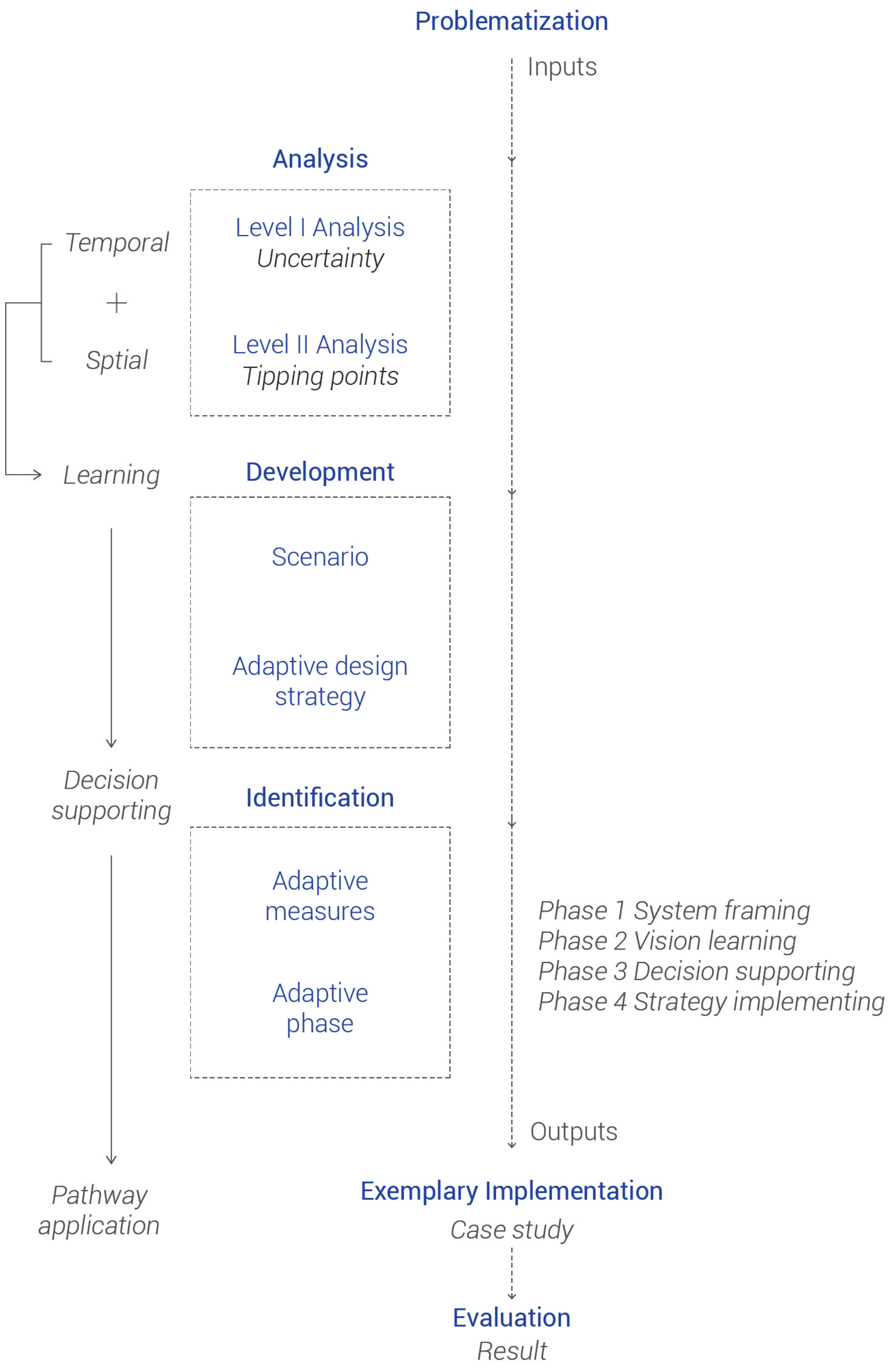
Phase 4 Implementation

SQ6: How can the guidelines and different scenarios be tested in a case study area to form an Spatial Adaptive Pathway?

Methodology framework



RESEARCH QUESTION	Literature review	Policy document review	Critical mapping	Pattern language	Site visits
SQ1 e the current and ongoing challenges in the nds that are affecting the water crisis in the IJsselmeer Lake Region?	☐				
SQ2 is the existing position of the IJsselmeer n the context of national water governance?	☐	☐			
SQ3 spatial performance developed by different rvices in the IJsselmeer Lake Region?			☐		☐
		☐	☐		
SQ4 an spatial adaptation pathways be devel- meet the future-proofing targets between the water and land?	☐	☐	☐	☐	
SQ5 kind of framework and principles can be l to expand the capacity of freshwater buffer in the IJsselmeer Lake Region?	☐			☐	
SQ6 an the guidelines and different scenarios d in a zoomed-in area to form an adaptive design pathway?			☐	☐	☐



** The analysis steps Level I and II is an adapted version from the analytical framework of Dynamic Adaptation Pathway Planning approach (Deltares, 2021b).*

Research road map

The thesis is defined as a knowledge document within the context of the political framework governing the IJsselmeer region, with a focus on the tipping point leading up to 2050. Its goal is to address the knowledge gap and provide a new methodology to support the implementation of policy measures in spatial adaptation. The document aims to guide spatial planning decisions that can effectively integrate the region's water management, ecological, and socio-economic goals.

The analysis phase of the thesis adopts the DAPP (Decision Analysis for Policy Planning) approach. In Level I analysis, the focus is on reviewing existing policy documents to identify the current needs of stakeholders. These needs will serve as the tipping point for determining the adaptation pathways moving forward. In Level II analysis, which combines insights from the original methods of Levels II and III, the study integrates data from hazard and damage models with spatial factors such as ecological systems, hydrology, energy distribution, and urbanization. This comprehensive approach enables the development of adaptive strategies that are firmly grounded in spatial design, providing actionable recommendations for the region's future development.

Introduction

This chapter analyzes the current policy landscape of the IJsselmeer Region in relation to future ambitions and its disconnection from climate uncertainty. By examining policies through a temporal lens, it traces how the IJsselmeer Region has evolved into a central component of Dutch water management. At the same time, the analysis identifies the region's emerging challenges under two major sources of uncertainty: climate change and socio-economic transitions.

Dynamic Spatial Adaptive Pathway approach - Step 1 (Regional level)

CHAPTER

3.

LEVEL I ANALYSIS

Building a body for knowledgy

System services

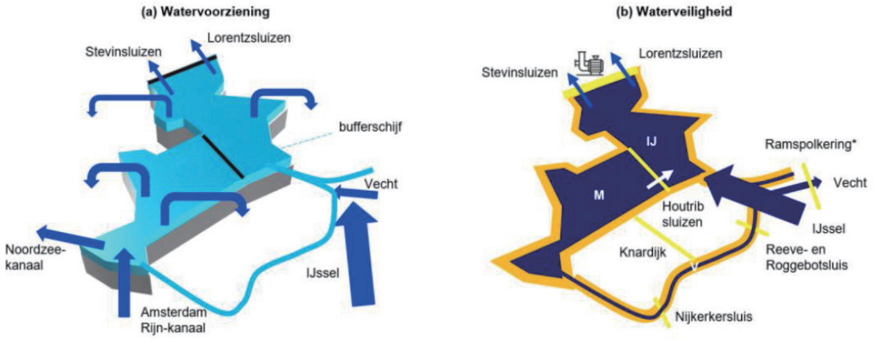
The organization of the water system serves as a critical entry point for understanding the spatial and hydrological dynamics of the IJsselmeer area, acting as a key tipping point. The IJsselmeer area is considered an integral part of the primary water system, encompassing the large water bodies—the IJsselmeer, Markermeer, and Randmeren—as well as the IJssel-Vechtdelta and the terrestrial areas outside the dike (Verkennende Systeemanalyse IJsselmeergebied, 2022). Additionally, the IJsselmeer area includes all structural components that regulate this system and its subsystems, such as the Afsluitdijk, the Houtribdijk, the compartmentalizing barriers in the peripheral lakes, and the connecting locks. In a broader context, the IJsselmeer region functions as both a supplied system (e.g., connected to the Rhine basin) and a drained system (e.g., linked to the Wadden Sea and North Sea).

Water system of IJsselmeer area (2022) clarified the IJsselmeer area can be seen as a large and diverse geo-ecosystem: an ecosystem of geographical dimensions that distinguishes itself from the land around it by characteristic properties of soil and water. If this geo-ecosystem functions well, it can provide crucial services for a huge part of the Northern Netherlands: geo-ecosystem services. These services are of national importance and that is precisely why the central government has the system responsibility for this area, which are:

Flood defense as part of flood control, if 1) it cannot be discharged due to storm surge or high sea level, 2) the river supply through the Ijssel and/or from the region is very high, or 3) a combination of both;

Stock storage about the freshwater supply, if there is a meteorological drought and supply through the Ijssel is temporarily insufficient to meet the anticipated demand;

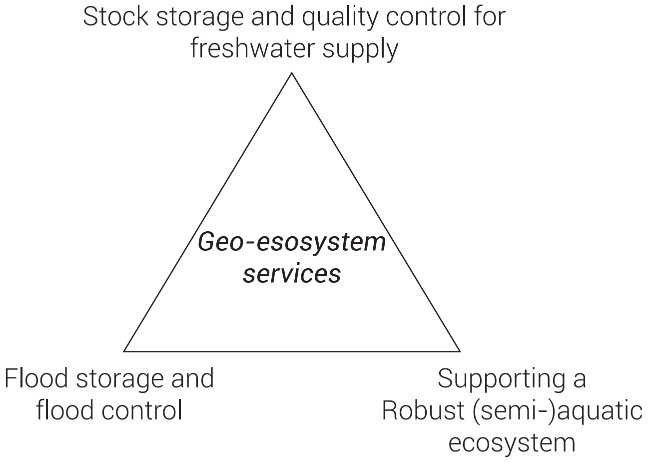
A robust (semi-) aquatic ecosystem as part of the Nature Network The Netherlands (NNN), Natura 2000 (European nature network and protected by the Birds and Habitats Directive), the Water Framework Directive (WFD), and as a habitat for flora and fauna and as a functional area for foraging (including cormorant) or molting sedentary birds and as a winter habitat for migratory birds.


(a) Watervoorziening

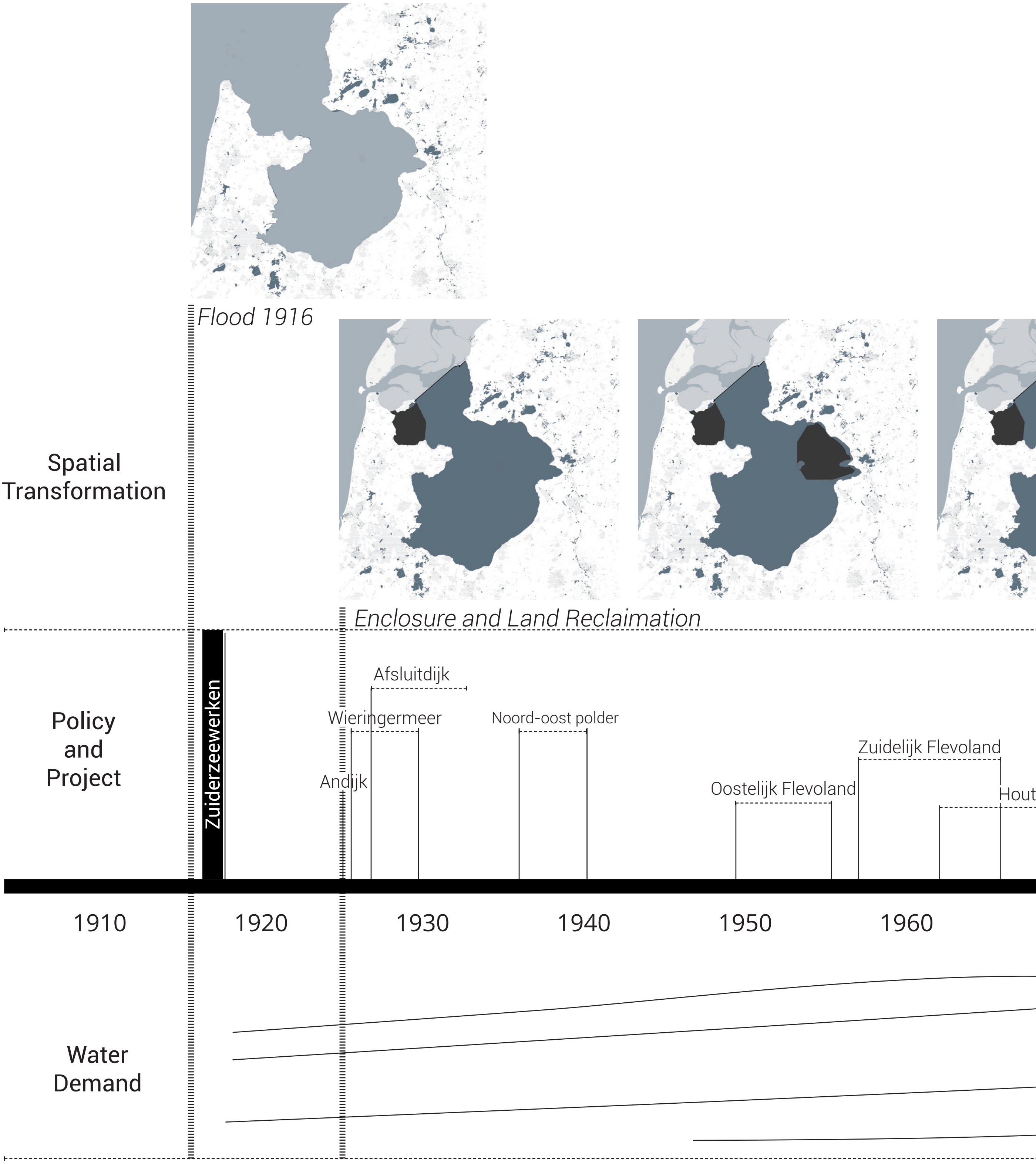
(b) Waterveiligheid

(c) Waterkwaliteit en ecologie

>Figure 15, Schematic overview of the three main functions fulfilled by the IJsselmeer area (Verkennende systeemanalyse IJsselmeergebied, 2022)
M=Markermeer
IJ=IJsselmeer
V=Veluwerandmeren.



>Figure 16, System operation in outline (Verkennende systeemanalyse IJsselmeergebied, 2022)


Spatial Transformation
Flood 1916
Enclosure and Land Reclaimation
Policy and Project
Zuiderzeewerken
Afsluitdijk
Wieringermeer
Noord-oost polder
Andijk
Zuidelijk Flevoland
Oostelijk Flevoland
Hout
1910
1920
1930
1940
1950
1960
Water Demand

Water governance

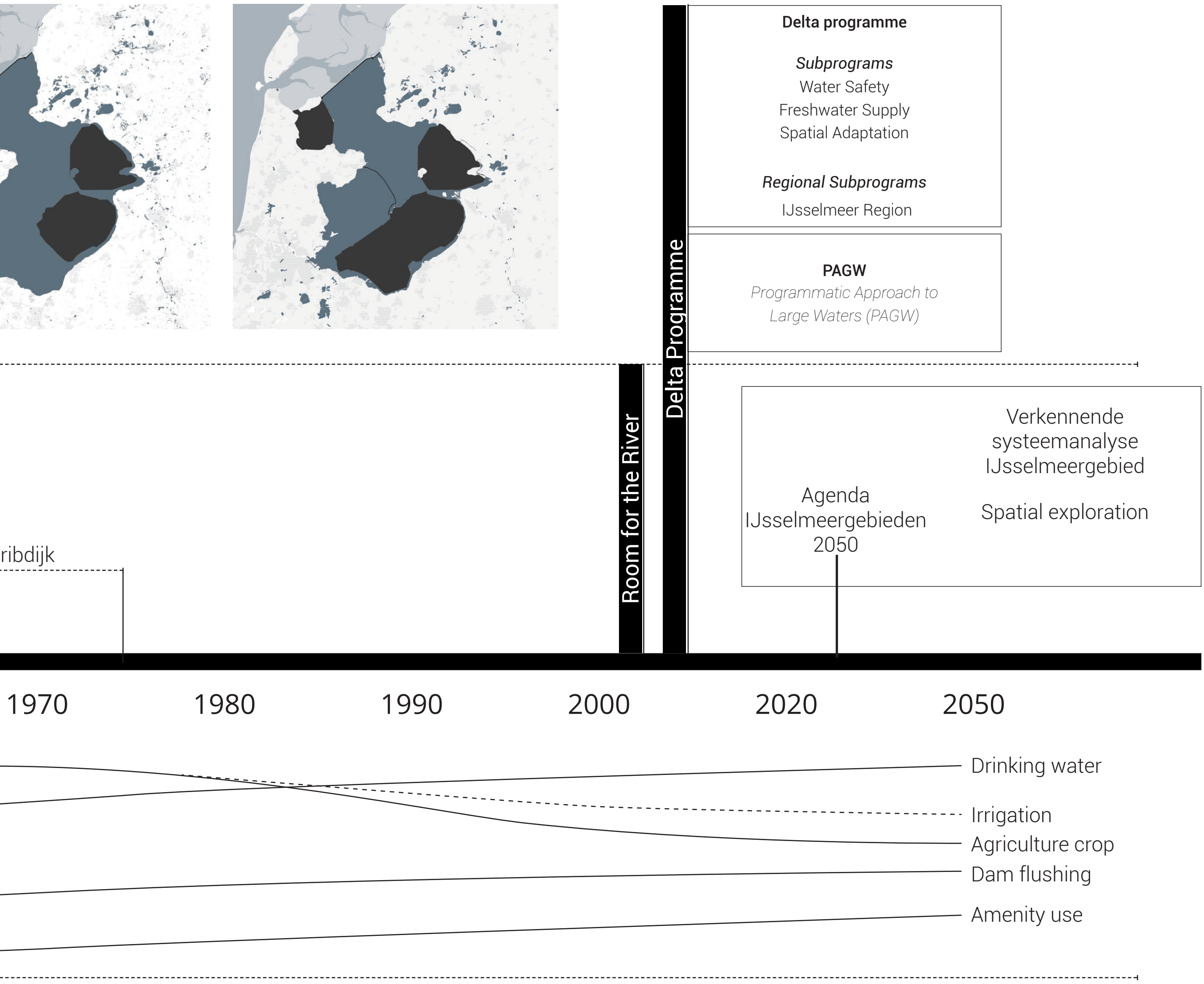
As early as the seventeenth century, Hendrik Stevin proposed damming the Zuiderzee to prevent flooding in Amsterdam, marking one of the earliest recorded plans for enclosing the inlet (Britannica, 2024). In the late 1800s, Cornelis Lely further advanced this vision by developing detailed plans for land reclamation and water control, based on contemporary hydrological studies. However, it was the catastrophic flood of 1916 that served as the turning point. This event directly led to the adoption of the Zuiderzee Act in 1918 and the construction of the Afsluitdijk, completed in 1932, which transformed the saltwater Zuiderzee into the freshwater IJsselmeer Lake (Britannica, 2024; Delta Commissioner, 2023).

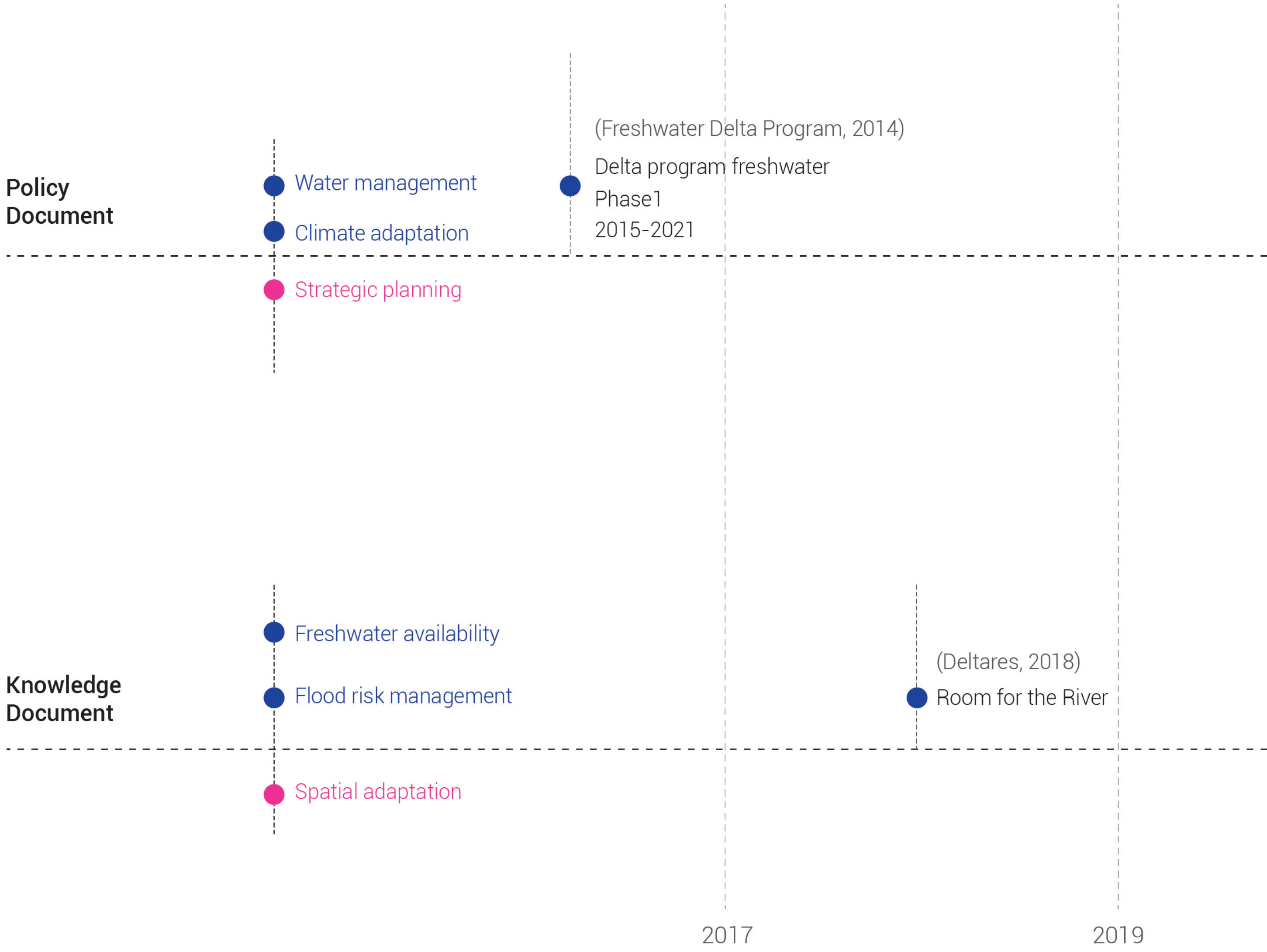
Since then, the region's water governance priorities have continued to evolve. What began as a system focused on flood protection and land reclamation now also faces rising pressure from climate change and increasing freshwater demand. Today, the IJsselmeer region must carefully balance its dual functions of water safety and freshwater provisioning. These goals must be met in a way that accommodates both ecological needs and human activities, reflecting the transition from traditional hydraulic engineering toward more integrated, adaptive water management (Delta Commissioner, 2023).

Source:

Britannica. (2024). Zuiderzee. In Encyclopaedia Britannica. Retrieved from https://www.britannica.com/place/Zuiderzee

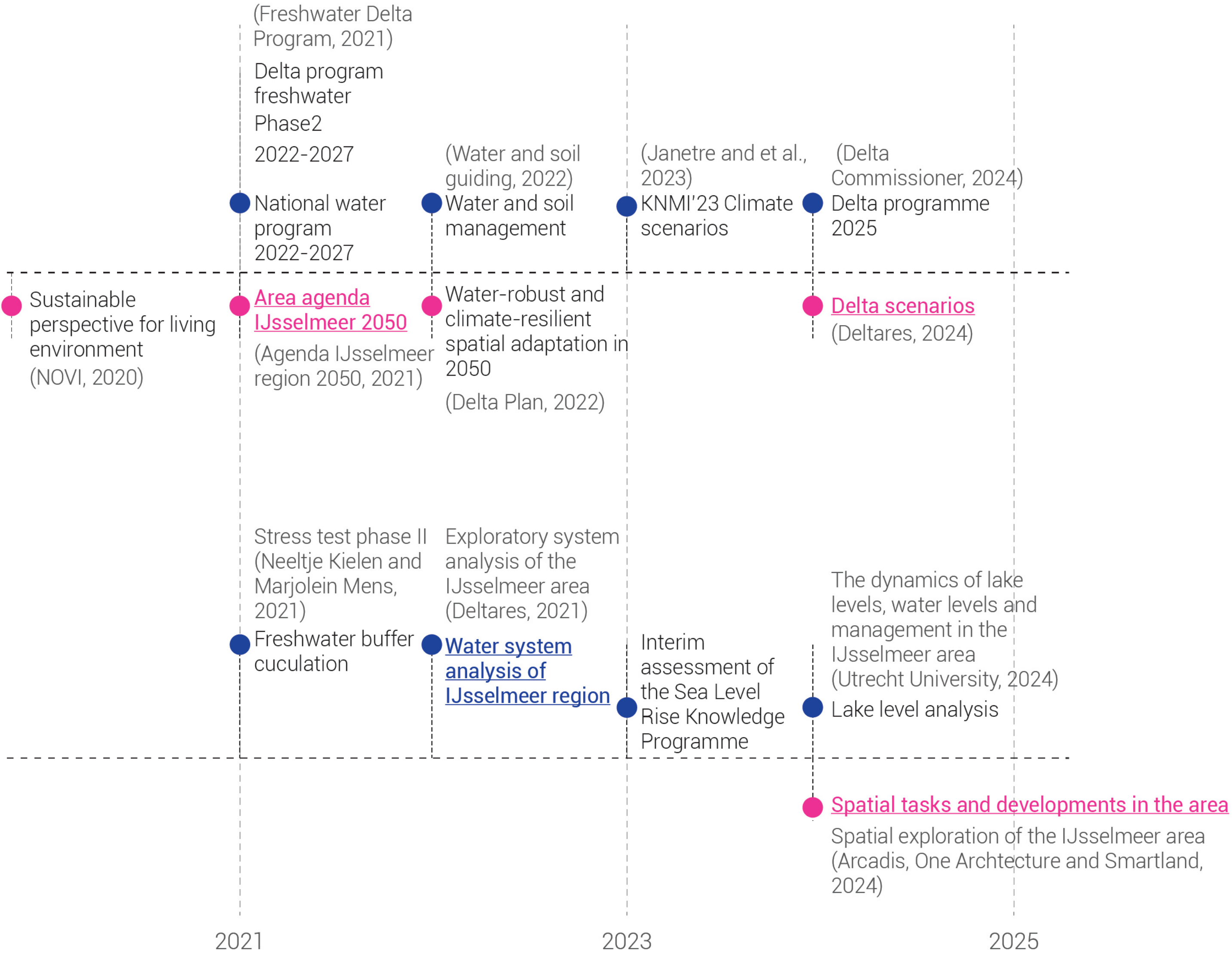
Delta Commissioner. (2023). Delta Programme 2024: Now for the future. Ministry of Infrastructure and Water Management. Retrieved from https://english.deltaprogramma.nl/delta-programme




Policy Document
Water management
Climate adaptation
Strategic planning
(Freshwater Delta Program, 2014)
Delta program freshwater
Phase1
2015-2021
Knowledge Document
Freshwater availability
Flood risk management
Spatial adaptation
(Deltares, 2018)
Room for the River
2017
2019

Political framework

For the policy document, they are mainly relevant with topic of water management, climate adaptation, and strategic planning. The Delta Program and National Water Plan as two main leading national policy guide the IJsselmeer region to reach the goals, which give a point to step into the project.



Future trends and uncertainties

Projected ranges of key global and regional indicators illustrate the deep uncertainty surrounding future climate and socio-economic conditions. For instance, global temperature rise by 2100 could be relatively moderate or extremely high depending on emissions pathways (IPCC,2023). Likewise, sea level rise in the Nethelrands (according to KNMI'23 scenarios) spans a wide band and exceed one meter by 2100 (KNMI, 2023). Socio-economic factors such as population growth, water demand, and land use (e.g. agriculture area and nature area) also show divergent trajectories under different scenarios. These broad ranges make it clear that planning cannot rely on a single predicted future, necessitating a scenario-based approach to strategy development.

By 2050-2100, projections indicate a wide range of possible pressure on the water system:

Global climate: Depending on greenhouse gas emissions, average global warming by 2100 may range from ~1.4–1.8 °C (if strong mitigation) up to ~4–4.5 °C under a high-emission pathway (IPCC, 2023). This drives more extreme weather and long-term sea level rise.

Sea level rise: The sea level in the Netherlands is projected to rise anywhere from a few tens of centimeters to well over 1 m by 2100 (KNMI,2023), Threatening coastal and delta regions with higher flood and salinisation risks.

Polulation and demand: The national population could grow from ~17 million today to around 20–22 million by mid-century in high-growth scenarios, or stabilize in low-growth scenarios (CBS,2021). More people mean greater freshwater demand.

Overall, the future climate and socio-economic context presents high uncertainty. Hotter, drier summers and population growth are expected to exacerbate freshwater shortages, while wetter winters and sea-level rise intensify flood and salinity challenges. As one of the most important freshwater buffer in the Netherlands, these trends imply that pressures will vary widely over time, which needs for a flexible planning approach.

Data source:

CBS. (2021). Population forecast 2020–2070. Statistics Netherlands. https://www.cbs.nl

Deltares & PBL. (2024). Delta Scenarios 2024: Exploring plausible futures for climate and socio-economic development. Deltares & Netherlands Environmental Assessment Agency (PBL).

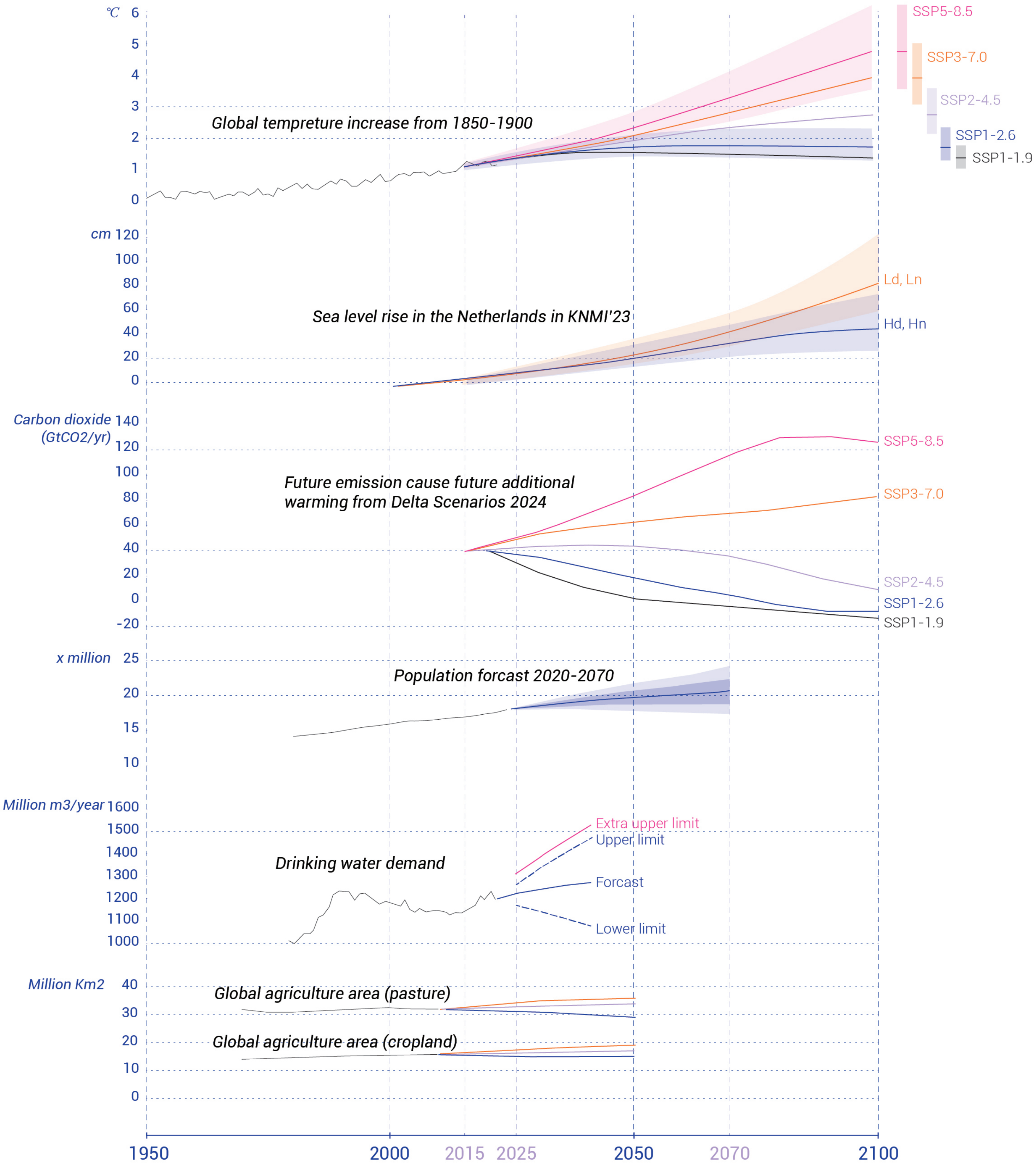
Deltares. (2022). Drinking water supply in the Netherlands under climate stress: Forecast 2022–2050. https://www.deltares.nl

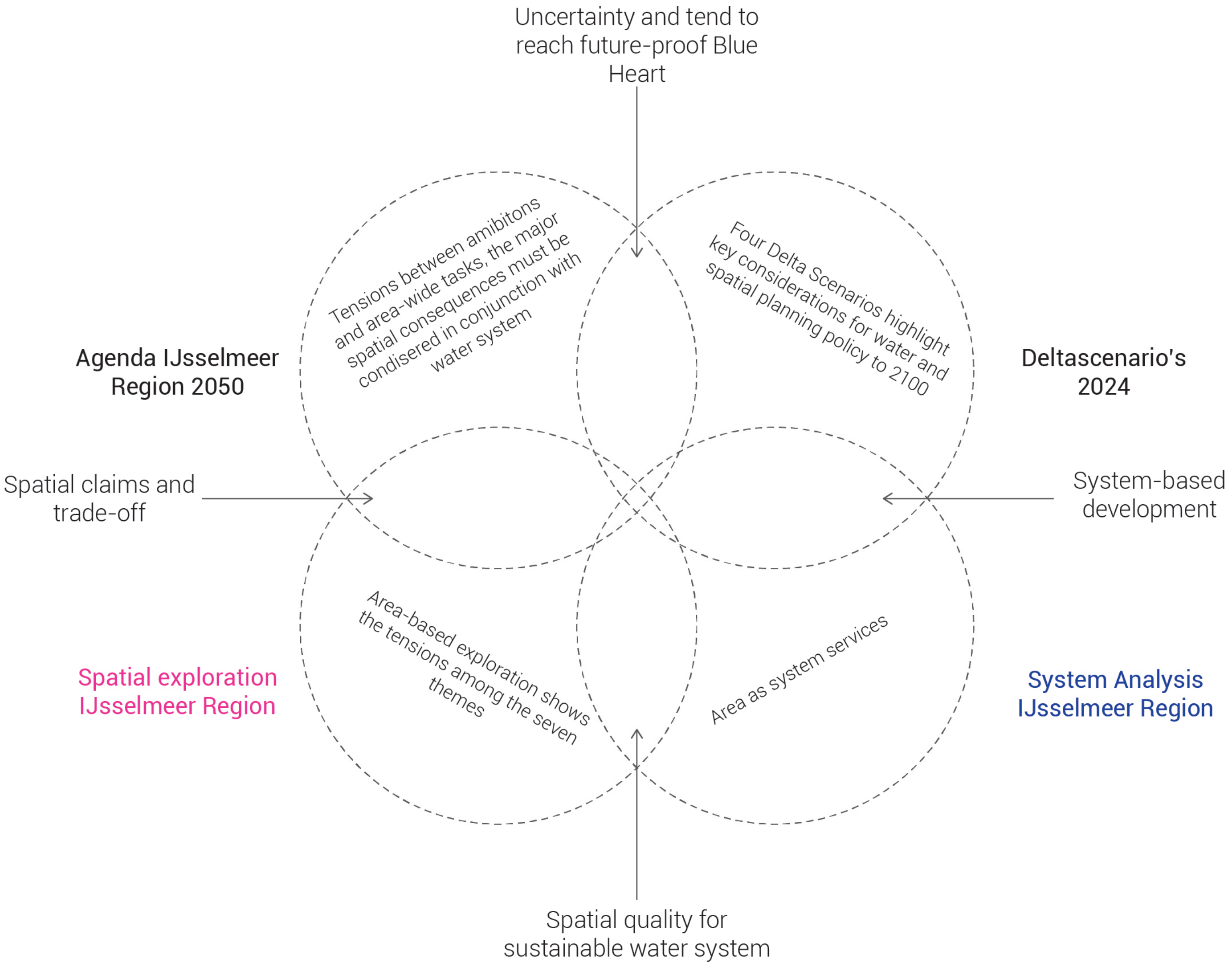
FAO. (2023). FAOSTAT: Global land use and agricultural trends. Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat

IPCC. (2023). Sixth Assessment Report: Climate Change 2023 – Synthesis Report. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/syr

KNMI. (2023). KNMI'23 climate scenarios for the Netherlands. Royal Netherlands Meteorological Institute. https://www.knmi.nl

>Figure 17, Future trends from climate change and soico-economic aespects (By Yiyan Zhou)


℃
6
5
4
3
2
1
0
Global tempreture increase from 1850-1900
SSP5-8.5
SSP3-7.0
SSP2-4.5
SSP1-2.6
SSP1-1.9
cm
120
100
80
60
40
20
0
Sea level rise in the Netherlands in KNMI'23
Ld, Ln
Hd, Hn
Carbon dioxide (GtCO2/yr)
140
120
100
80
60
40
20
0
-20
Future emission cause future additional warming from Delta Scenarios 2024
SSP5-8.5
SSP3-7.0
SSP2-4.5
SSP1-2.6
SSP1-1.9
x million
25
20
15
10
Population forcast 2020-2070
Million m3/year
1600
1500
1400
1300
1200
1100
1000
Drinking water demand
Extra upper limit
Upper limit
Forcast
Lower limit
Million Km2
40
30
20
10
0
Global agriculture area (pasture)
Global agriculture area (cropland)
1950
2000
2015
2025
2050
2070
2100


Uncertainty and tend to reach future-proof Blue Heart
Agenda IJsselmeer Region 2050
Tensions between amibitons and area-wide tasks, the major spatial consequences must be condisered in conjunction with water system
Deltascenario's 2024
Four Delta Scenarios highlight key considerations for water and spatial planning policy to 2100
Spatial claims and trade-off
System-based development
Spatial exploration IJsselmeer Region
Area-based exploration shows the tensions among the seven themes
Area as system services
System Analysis IJsselmeer Region
Spatial quality for sustainable water system

Levle I analysis conclusion

The regional system analysis shows that the IJsselmeer Region lies at the intersection of multiple long-term policy ambitions, spatial pressures, and growing uncertainty. This conclusion is drawn from a comparative review of major policy documents such as the Agenda IJsselmeergebied 2050 (Rijksoverheid, 2018) and the Delta Programme 2024 (Delta Commissioner, 2023), together with supporting knowledge frameworks including the Delta Scenarios 2024, the Spatial Exploration of the IJsselmeer Region (Ministerie van IenW & BZK, 2024), and recent system-based environmental assessments (PBL, 2023).

The Agenda IJsselmeergebied 2050 provides a shared vision for the future of the region, promoting its role as a freshwater buffer and a multifunctional landscape. However, the translation of this vision into spatial form brings overlapping demands for agriculture, urban growth, ecological restoration, and infrastructure. These demands create spatial tensions that must be addressed in conjunction with the water system. The Delta Scenarios 2024 introduce a forward-looking framework that highlights uncertainty in climate and socio-economic trends. These uncertainties could lead to tipping points where existing policies or spatial systems fail to meet their intended objectives. In this research, such tipping points are recognised across four domains: water infrastructure and management, agriculture and land use, urban and economic development, and ecosystem health (Kwadijk et al., 2010).

The spatial exploration further supports a transition from theme-based planning to a system-oriented approach. It identifies the region not as a fixed territory but as a spatial system composed of interlinked services and functions. This Level I analysis confirms the need for a planning method that can integrate policy objectives while remaining responsive to sectoral bottlenecks and long-term uncertainty. It provides the foundation for an adaptive design framework that aligns future visions with spatial strategies and decision moments.

Source:
Delta Commissioner. (2023). Delta Programme 2024: Now for the future. Ministry of Infrastructure and Water Management.
Kwadijk, J. C. J., Haasnoot, M., Mulder, J. P. M., Hoogvliet, M., Jeuken, A., van der Krogt, R., ... & van Waveren, H. (2010). Using adaptation tipping points to prepare for climate change and sea level rise: A case study in the Netherlands. Wiley Interdisciplinary Reviews: Climate Change, 1(5), 729–740. https://doi.org/10.1002/wcc.64
Ministerie van Infrastructuur en Waterstaat & Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2024). Ruimtelijke Verkenning IJsselmeergebied 2024. Den Haag: Rijksoverheid.
PBL Netherlands Environmental Assessment Agency. (2023). Ruimtelijke Verkenning 2023: Naar een duurzame inrichting van Nederland. The Hague: PBL.
Rijksoverheid. (2018). Agenda IJsselmeergebied 2050: Samen werken aan een vitaal meer. Retrieved from https://www.rijksoverheid.nl/documenten/publicaties/2018/06/29/agenda-ijsselmeergebied-2050

<Figure 18, Political condition conclusion (By Yiyan Zhou)

Introduction

This chapter investigates the spatial implications of the policy ambitions outlined in Level I by identifying current system vulnerabilities, spatial pressures, and sectoral claims within the IJsselmeer Region. Through a thematic analysis of three categories: Preconditions, Value, and Activities, it reveals the spatial manifestations of water-related challenges, particularly under climate stress. Seven themes are used to structure the assessment—each representing a distinct set of spatial demands and interactions affecting freshwater availability. By translating sectoral ambitions into spatial claims, the analysis exposes the critical bottlenecks where competing land functions and hydrological demands intersect. This spatial diagnosis provides a foundation for understanding the conditions that shape regional and local tipping points, and forms the basis for the visioning and scenario-building process in the following chapters.

Dynamic Spatial Adaptive Pathway approach - Step 2 (Regional level)

CHAPTER
4.

LEVEL II ANALYSIS

04. Level II Analysis

Capacity - Introduction

The philosophical basis for the Spatial Exploration follows the definition of the IJsselmeer Region as outlined by the Bestuurlijk Platform IJsselmeergebied (BPIJ) in their Spatial Exploration of the IJsselmeer. The definition suggests considering the IJsselmeer Region as a "system with a capacity to provide systems." This concept of capacity and services is broad, including tangible services like freshwater buffers and foraging areas for migratory birds but also more intangible aspects such as the open landscape and the region's livable identity (Figure 19).

This research focuses mainly on the dynamics of freshwater buffer capacity in the IJsselmeer Region. The system (water system, ecosystem, and socio-economic system) is under pressure, requiring ever-increasing capacity. This pressure comes from two main factors: climate change, which leads to sea level rise and more extremes, and an increasing population, which leads to urbanization and more infrastructure, manifesting itself as increasingly intensive use of space. Issues concerning the quality, quantity, and safety of water systems are frequently influenced by dynamic changes in the ecosystem and socio-economic services, which directly reflect future demands for the sustainable allocation of water resources.

This chapter aims to build upon the existing spatial exploration conducted by BPIJ to further identify the uncertainties affecting the future development of the freshwater buffer capacity in the IJsselmeer Region, as presented in the services related to these seven themes.

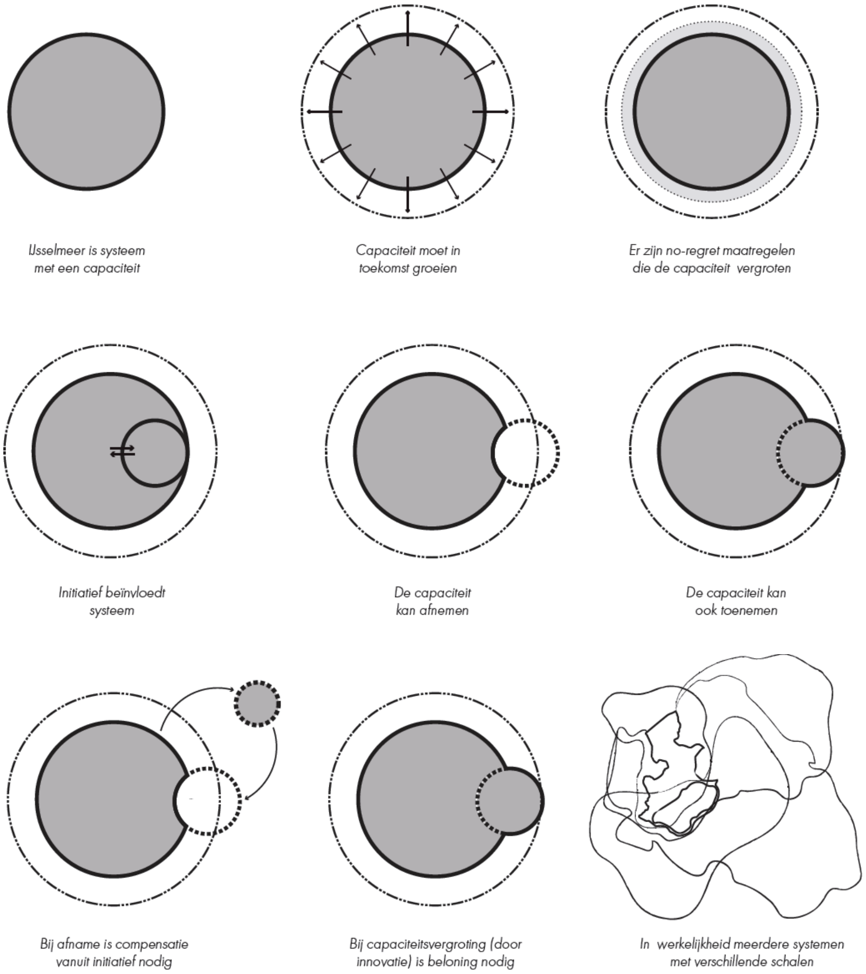


Figure 19, Philosophical line of reasoning (Source: Ministerie van Infrastructuur en Waterstaat & Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2024)

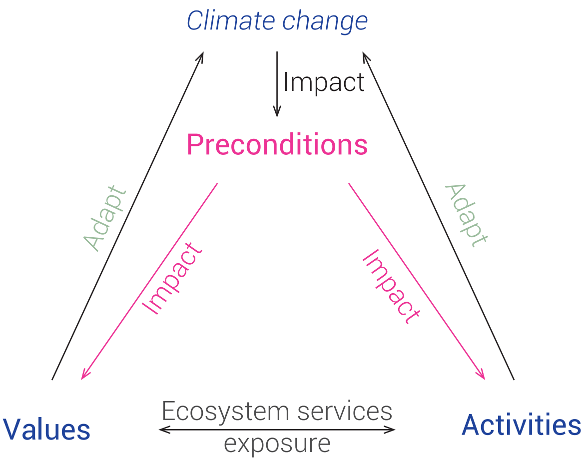
Seven themes

To develop the main factor that

The seven themes are divided into thress categories:
A. Preconditions for the people living in the area and surroundings:
-Freshwater availability
-Water safety

B. Values that are generally held in high worth and are partly protected by legislation. However, these values are also to a large extent "outlawed":
- Future-proof ecosystem
-Spatial quality

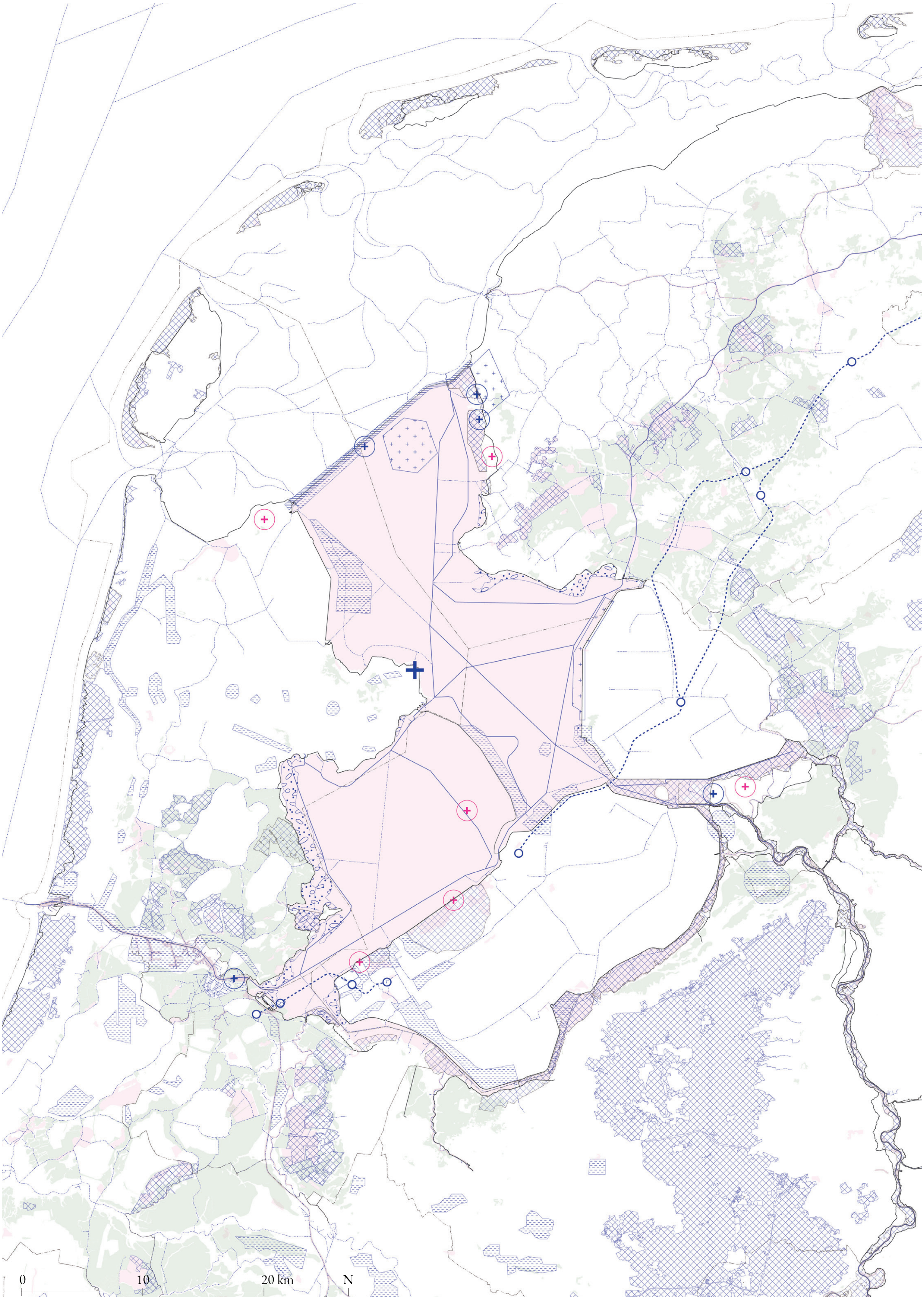
C. Activities of people:
-Economic functions
- Living envrionment and housing
-Energy transition



<Figure 20, The pyramid relationship between three factors

>Legend

🟩 Peat area with higher water demand
▨ Natura 2000
+ Threatened water intake
⁘ Energy potential area
⊕ Protected birds habitats
⊕ Protected fish migration point


0
10
20 km
N

Critical Situation

Conlusion of analysis

The IJsselmeer Region provides several ecosystem services that are of significance to the Netherlands. The present study explores seven themes associated with these services, which are directly related to the objectives established for the IJsselmeer Region.

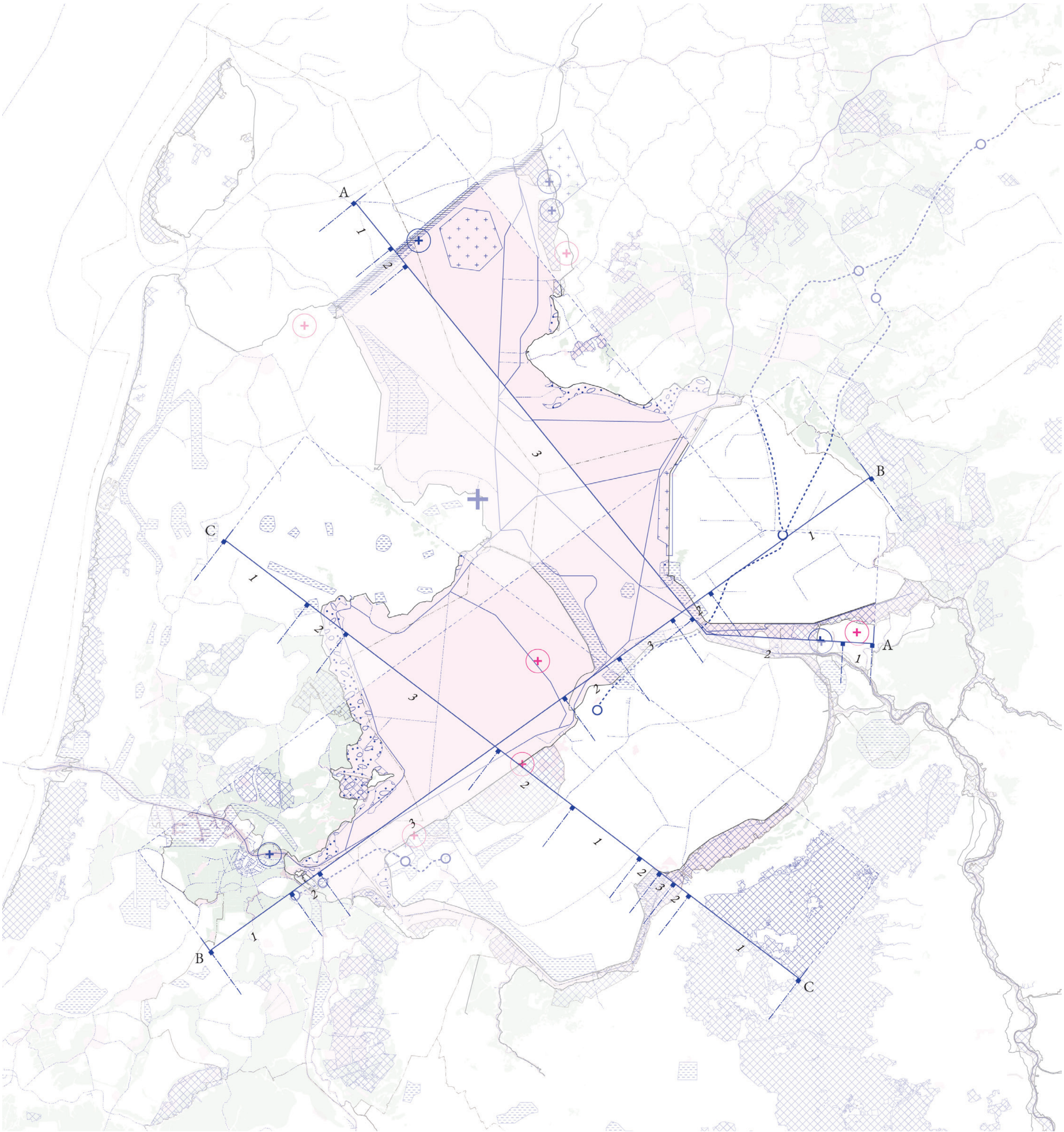
The state of the water system can directly reflect spatial complexity. The spatial complexities are resulting from the various demands of multiple themes on a given space indicate the scarcity of resources and the limited nature of space. The IJsselmeer Region, distinguished by its unique geographical location, functions as a nexus between the sea and inland freshwater bodies, thereby playing a pivotal role in hydrological processes. Furthermore, historical land reclamation has led to alterations in water quality, resulting in dynamic hydrological conditions that reflect the region's diverse activities throughout history. This underscores the pivotal role the IJsselmeer Region plays in shaping the Netherlands' future development trajectory.

In the IJsselmeer Region, the existing spatial structure and service functions have profoundly influenced water resource management, primarily manifested in conflicts between human activities and ecosystems, as well as conflicts over space and resource allocation among different activities. These issues have a particularly significant impact on freshwater buffer capacity, necessitating urgent measures to optimize resource use and allocation to ensure that the region's water resources can sustainably and effectively support future ecological and social needs.

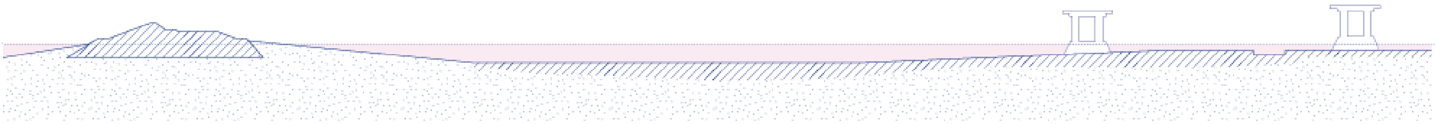
The study employs a systematic categorization of the space based on the relevance of different water bodies and activities. This categorization divides the space into three distinct regions: large open water, transition zones, and hinterland. As delineated on page 86, a thorough exposition of the definitions and associated activities is provided.

0 10 20 km N

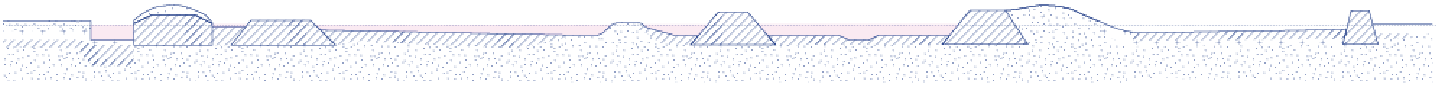
>Legend
1 Hinterland
2 Transition zones
3 Large open water



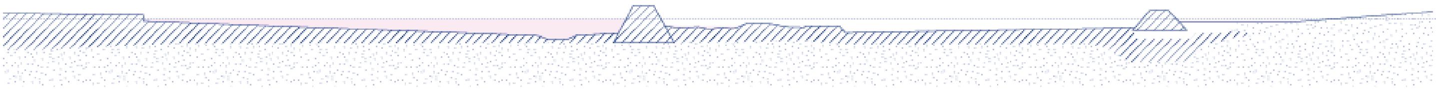
Section A-A



Section B-B



Section C-C



Hinterland

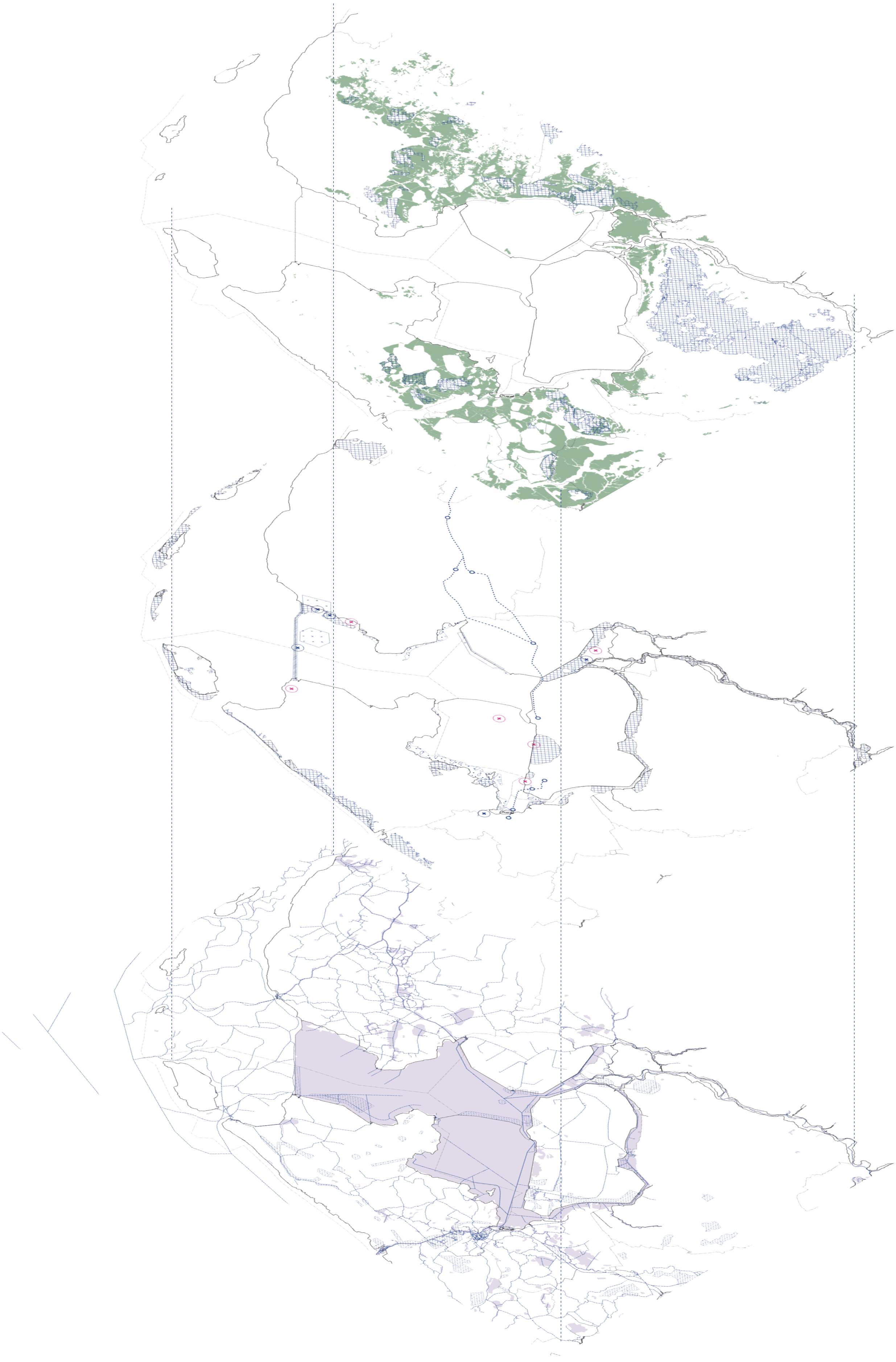
The hinterland is defined as the hydrological space associated with inland small water bodies, where water management and spatial distribution are closely intertwined with socio-economic activities. In this region, agricultural practices, predominantly livestock farming, have been identified as a major source of conflict with water management in peat soil areas. These conflicts arise from the disparate water level demands of agricultural activities, which clash with the high water level needs for soil moisture retention. Moreover, the increasing urban population has been shown to exacerbate existing tensions in space usage and water demand, driven by the growing need for housing. Consequently, the hinterland is confronted with the challenge of achieving an equilibrium between water requirements for agriculture, urban development, and the preservation of natural soil functions.

Transition zones

The transition zones are dynamic areas situated between open water surfaces and the inland regions. These environments are distinguished by frequent and varied hydrological activities, resulting in highly dynamic water management and spatial distribution. In such areas, a multitude of environmental concerns have been identified, including but not limited to flooding, water contamination, fragmentation of habitats, and obstruction of fish migration. The varied and variable hydrological conditions characteristic of these regions require the implementation of adaptive management strategies to ensure the fulfillment of ecological and human necessities. These zones play a critical role in regulating water quality and facilitating biodiversity, making them essential for maintaining the resilience of the surrounding water systems.

Large open water

Large open water areas, primarily composed of surface water bodies, play a crucial role in maintaining freshwater buffer capacity. These areas are generally more susceptible to alterations in water quality and serve as the foundation for sustaining freshwater systems. In the Netherlands, the government has established large water bodies, including those in the IJsselmeer Region, with the aim of improving ecological water quality and enhancing the natural environment. This approach is intended to ensure the long-term sustainability of these ecosystems, thereby contributing to the broader environmental goals of the region. The substantial expanses of open water are pivotal to preserving the overall integrity of the freshwater buffer capacity, thereby assuming a critical function in the regulation and quality control of water.



Identify factors that affect capacity

For what expands the capacity of freshwater buffer in the IJsselmeer region, for what makes potential decrease the capacity of freshwater buffer in the IJsselmeer region

Strengths

Have strong water-related history and culture
People have identity with water
Good base of water infrastructure

Weakness

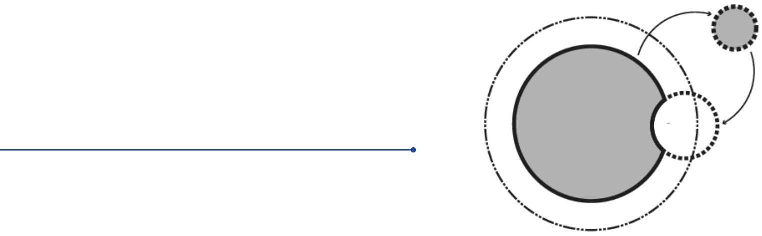
Water circularity
Space conflict between flood storage and freshwater storage
Lack of accessibility between land and water

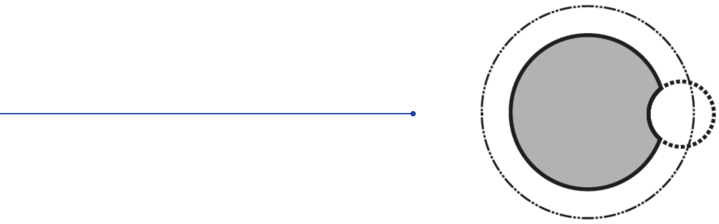
Opportunities

More space for housing and energy use
Educational use from water
Co-benefit development with both ecology and socio-economic use

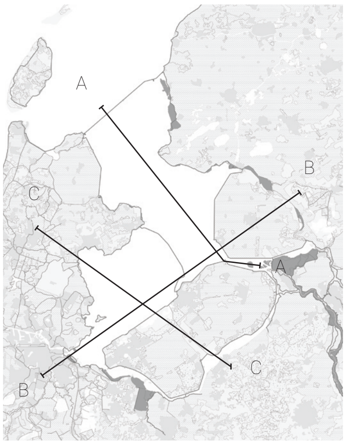
Threats

Climate change and increasing flooding events
Habitats fragementation due to water system change
Rising demand of water
Salinisation threaten the intake of freshwater

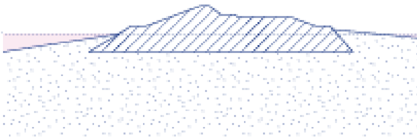




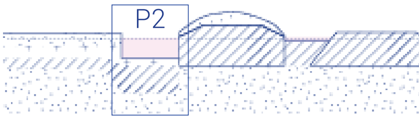
		Open water
PRECONDITIONS	Freshwater availability	**P1** Water demand for new energy generation
		P2 Inadequate depth for transportation
	Water safety	
VALUES	Nature and biodiversity	**V1** Disruption of bird migration
	Spatial quality	
ACTIVITIES	Livability and housing	**A1** Recreational pressure
	Economic functions	**A2** Less space for commercial fishing and related business
	Energy transition	**A3** Tensions between energy generation and other function



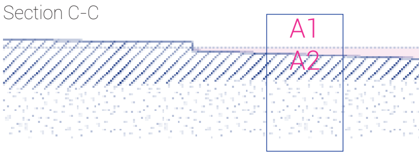
Section A-A



Section B-B



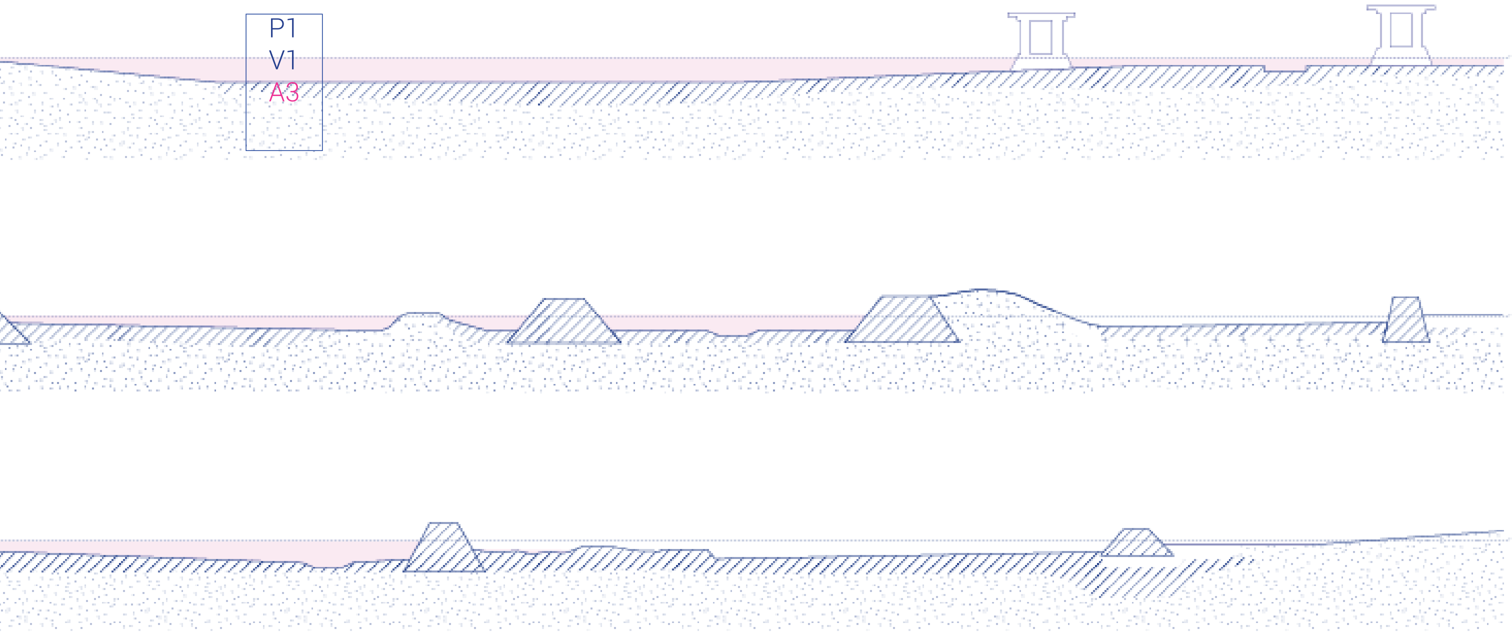
Section C-C



Large open water

By catagorizing three main spatial zones in open water, transition zones, and hinterland, overlapping with the demands and conditions of 7 themes, we then found the possible challenges related to thoes condisions.

Figure 21, Opportunities and problem of open water
Base map adapted from Spatial Exploration IJsselmeer Region (2023), with modifications and additional content created by Yiyan Zhou.



Transition zones

PRECONDITIONS

Freshwater availability

- P4 Flushing requirement of dam
- P5 Water intake availability due to salinisation
- P6 Outside dike building/ nature reduce water quality

Water safety

- P7 Unsafety infrastructure

VALUES

Nature and biodiversity

- V3 Fragemented migration routes
- V4 Habitat fragementation

Spatial quality

- V5 Dike reinforcement
- V6 Tension between urbanization and space for river

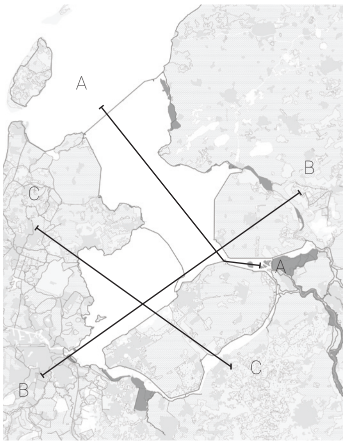
ACTIVITIES

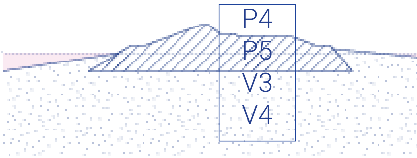
Livability and housing

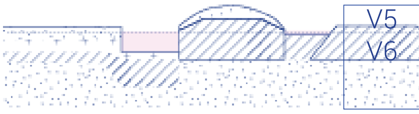
- A4 Unsafety water recreation outside dike

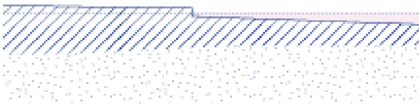
Economic functions

Energy transition




Section A-A


Section B-B


Section C-C

Transition zones

By catagorizing three main spatial zones in open water, transition zones, and hinterland, overlapping with the demands and conditions of 7 themes, we then found the possible challenges related to thoes condisions.

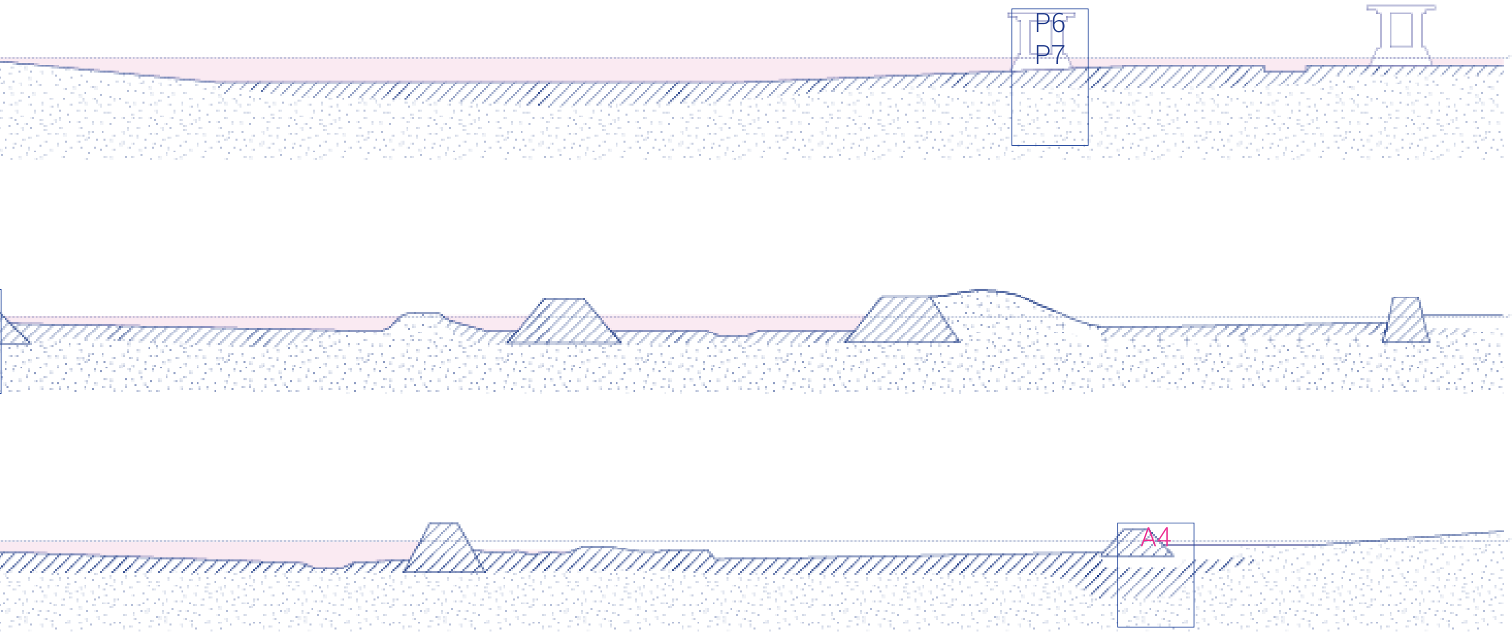
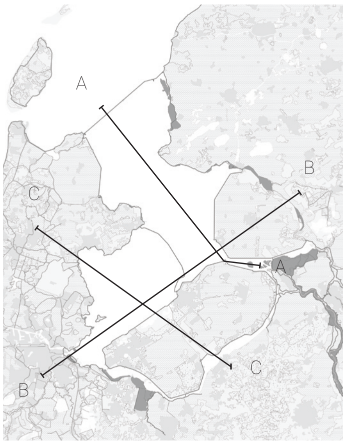
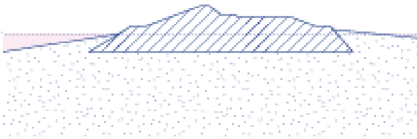


Figure 22, Opportunities and problem of open water
Base map adapted from Spatial Exploration IJsselmeer Region (2023), with modifications and additional content created by Yiyan Zhou

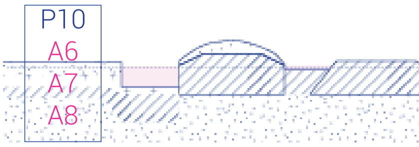
		Hinterland
PRECONDITIONS	Freshwater availability	P8 Less freshwater storage capacity P9 Decreasing groundwater level P10 Uncontrolled nutrients
	Water safety	P11 Limited water detention
VALUES	Nature and biodiversity	
	Spatial quality	
ACTIVITIES	Livability and housing	A5 Limited water infiltration
	Economic functions	A6 Flushing and irrigation needs of agriculture A7 Land subsidence
	Energy transition	A8 Greenhouse effect due to CO2 emission from peat soil



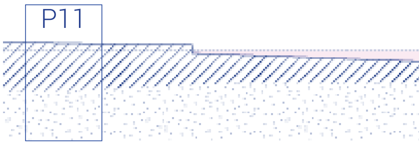
Section A-A



Section B-B



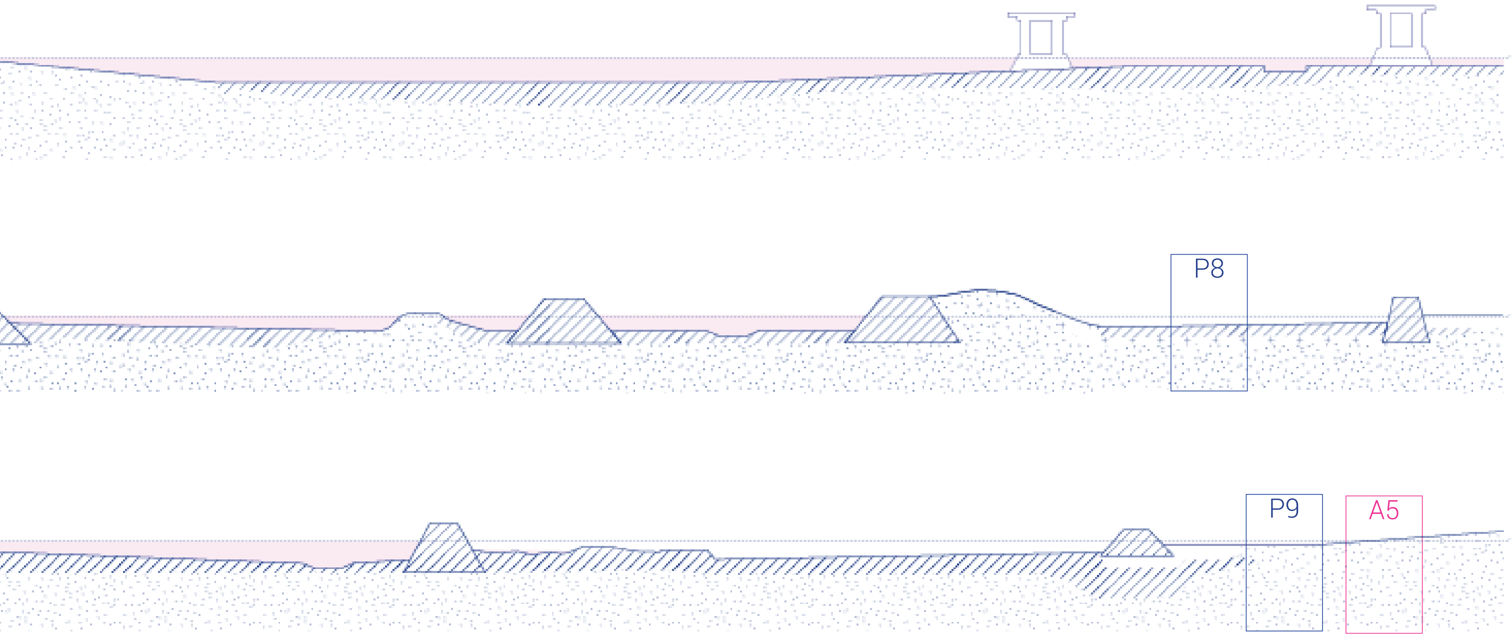
Section C-C

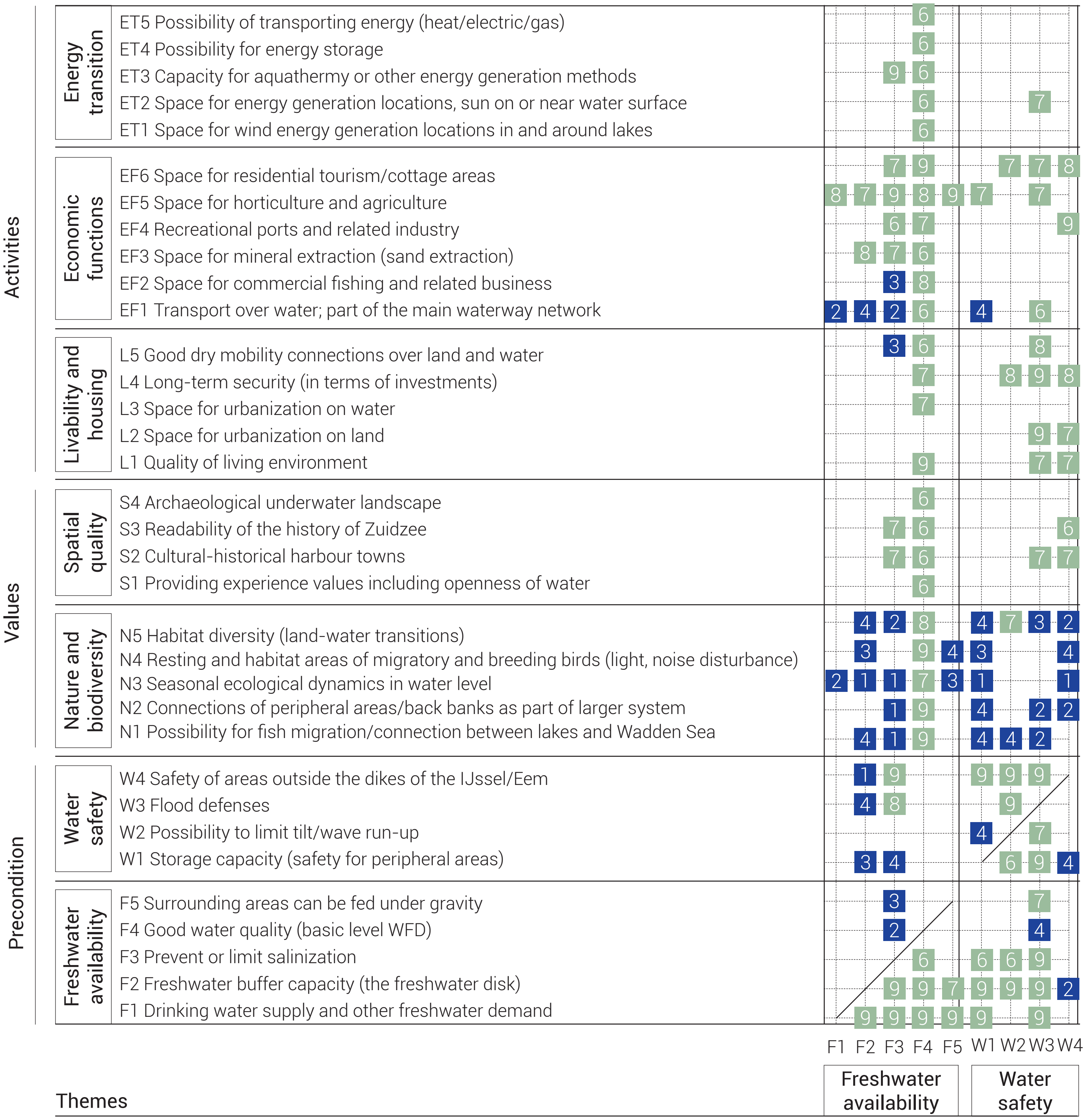


Hinterland

By catagorizing three main spatial zones in open water, transition zones, and hinterland, overlapping with the demands and conditions of 7 themes, we then found the possible challenges related to thoes condisions.

Figure 23, Opportunities and problem of open water
Base map adapted from Spatial Exploration IJsselmeer Region (2023), with modifications and additional content created by Yiyan Zhou





			Freshwater availability					Water safety			
		Themes	F1	F2	F3	F4	F5	W1	W2	W3	W4
Activities	Energy transition	ET5 Possibility of transporting energy (heat/electric/gas)				6					
		ET4 Possibility for energy storage				6					
		ET3 Capacity for aquathermy or other energy generation methods			9	6					
		ET2 Space for energy generation locations, sun on or near water surface				6				7	
		ET1 Space for wind energy generation locations in and around lakes				6					
	Economic functions	EF6 Space for residential tourism/cottage areas			7	9			7	7	8
		EF5 Space for horticulture and agriculture	8	7	9	8	9	7		7	
		EF4 Recreational ports and related industry			6	7					9
		EF3 Space for mineral extraction (sand extraction)		8	7	6					
		EF2 Space for commercial fishing and related business			3	8					
		EF1 Transport over water; part of the main waterway network	2	4	2	6		4		6	
	Livability and housing	L5 Good dry mobility connections over land and water			3	6				8	
		L4 Long-term security (in terms of investments)				7			8	9	8
		L3 Space for urbanization on water				7					
		L2 Space for urbanization on land								9	7
		L1 Quality of living environment				9				7	7
Values	Spatial quality	S4 Archaeological underwater landscape				6					
		S3 Readability of the history of Zuidzee			7	6					6
		S2 Cultural-historical harbour towns			7	6				7	7
		S1 Providing experience values including openness of water				6					
	Nature and biodiversity	N5 Habitat diversity (land-water transitions)		4	2	8		4	7	3	2
		N4 Resting and habitat areas of migratory and breeding birds (light, noise disturbance)		3		9	4	3			4
		N3 Seasonal ecological dynamics in water level	2	1	1	7	3	1			1
		N2 Connections of peripheral areas/back banks as part of larger system			1	9		4		2	2
		N1 Possibility for fish migration/connection between lakes and Wadden Sea		4	1	9		4	4	2	
Precondition	Water safety	W4 Safety of areas outside the dikes of the IJssel/Eem		1	9			9	9	9	
		W3 Flood defenses		4	8				9		
		W2 Possibility to limit tilt/wave run-up						4		7	
		W1 Storage capacity (safety for peripheral areas)		3	4				6	9	4
	Freshwater availability	F5 Surrounding areas can be fed under gravity			3					7	
		F4 Good water quality (basic level WFD)			2					4	
		F3 Prevent or limit salinization				6		6	6	9	
		F2 Freshwater buffer capacity (the freshwater disk)			9	9	7	9	9	9	2
		F1 Drinking water supply and other freshwater demand		9	9	9	9	9		9	

Level II analysis conclusion

Services with service quantitive analysis

The freshwater availability and water safety are considered as two main indicator that impact the capacity of freshwater buffer in the IJsselmeer lake region, namely preconditions, which interact with the other five themes and also themselves, causing impact from negative to positive at the same time. The sub indicators under the themes and the impact scores are taken from the Spatial Exploration IJsselmeer Region (2023), see figure x. All indicators are selected by Spatial Exploration IJsselmeer Region (2023).

>Negative impact:
Salinisation> Water quality(nutrients)> Freshwater demand(water quantity)

A) Freshwater Availability
Salinization is a key challenge that reduces the capacity of the freshwater buffer, threatening the ecological values of nature and biodiversity. Furthermore, reduced freshwater availability and lower water levels limit the spatial capacity for water transportation, constraining economic activities and connectivity within the region.

>Negative impact:
Storage capacity> Safety ouside dike> Flood defences> Possibility to limit tilt run-up

B) Water Safety
Most interventions to improve water safety pose significant risks to ecological diversity, with flood storage measures and safety strategies outside the dike being particularly detrimental to ecosystems. Additionally, the conflict between flood storage and freshwater storage highlights the need for trade-offs and integrated strategies to balance these competing demands. Higher water levels further exacerbate spatial limitations for water transportation, creating additional challenges for regional mobility and economic functions.

<Score:
1 Very bad 2 Bad 3 Negative 4 Bit negative
5 Neutral
6 Bit positive 7 Positive 8 Affordable 9 Very favorable

Introduction

This chapter outlines a long-term spatial vision for the IJsselmeer Region in 2050, grounded in the ambition to enhance water circularity as a core strategy for expanding freshwater buffer capacity. Building on the spatial and sectoral challenges identified in the previous analysis, the vision responds to the dual uncertainties of climate change and socio-economic development by proposing a future-oriented yet flexible direction for regional water-based planning. Central to this vision is the integration of ecological, agricultural, and urban systems into a circular freshwater structure that promotes adaptive land use and resilient water management.

To operationalize this vision, the chapter introduces a set of guiding principles that translate the abstract ambition of circularity into spatial strategies. These principles are structured around key themes: water quality, water quantity, and water safety, and serve as a foundation for cross-sectoral coordination and design decision-making. The vision and strategies presented here inform the following scenario and design framework development, offering a shared reference for both policy and spatial intervention.

Dynamic Spatial Adaptive Pathway approach - Step 3 & 4 (Regional level)

CHAPTER
6.

VISION AND STRATEGY

Envisioning IJsselmeer Region 2050

Four Narrow Down Scenarios in the IJsselmeer Region

Spatial Structure and Strategy

Envisioning IJsselmeer Region 2050

Aims

This research aims to develop a spatial planning framework that supports dynamic water cycle management in response to climate change and socio-economic challenges in the IJsselmeer Region. Together, these aims provide the foundation for a resilient and multifunctional landscape.

The approach is guided by three interconnected ambitions:

Future-proof construction
Climate adaptation, and mitigate climate change

Co-benefit waterscape
Space for urbanization, balance the demand of food related agriculture and nature, extra value to both human and non-human aspects

Circular water loop
Sustainable economy development, sustainable water chain and water distribution

>Figure 24. Vision collage of adaptive water system in the IJsselmeer region. (Base image generated using AI (DALL·E), subsequently edited and adapted by Yiyan Zhou)

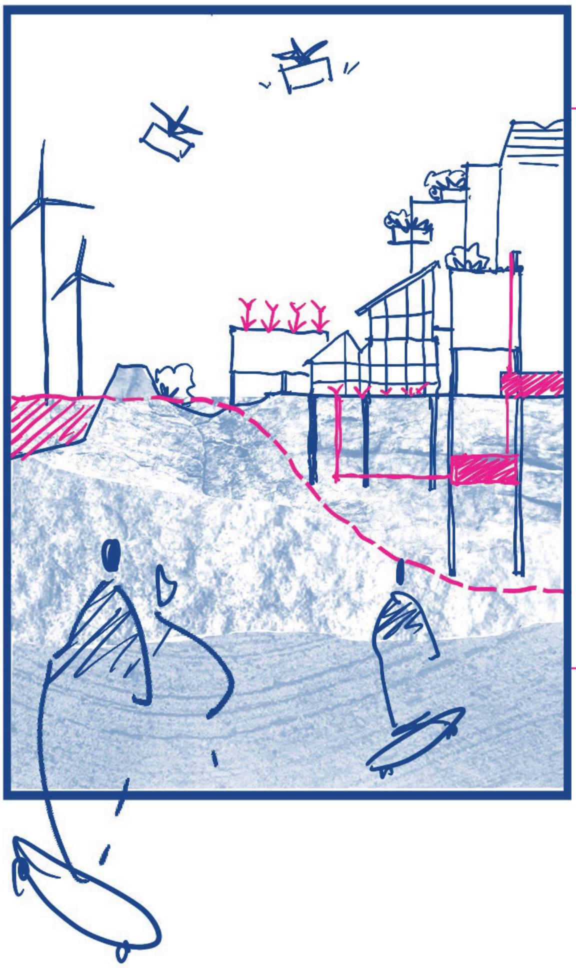
By 2050, we envision the IJsselmeer Region as an area with a circular water system and a higher freshwater self-sufficiency rate, enabling the region to address the dual challenges of "too much water" and "too little water."

CLIMATE IMPACE & EMISSION

MODERATE

WATER CIRCULAR SOCIETY

High socio-economic pressure



SELF EFFICIENT SOCIETY

Low socio-economic pressure

Climate impact

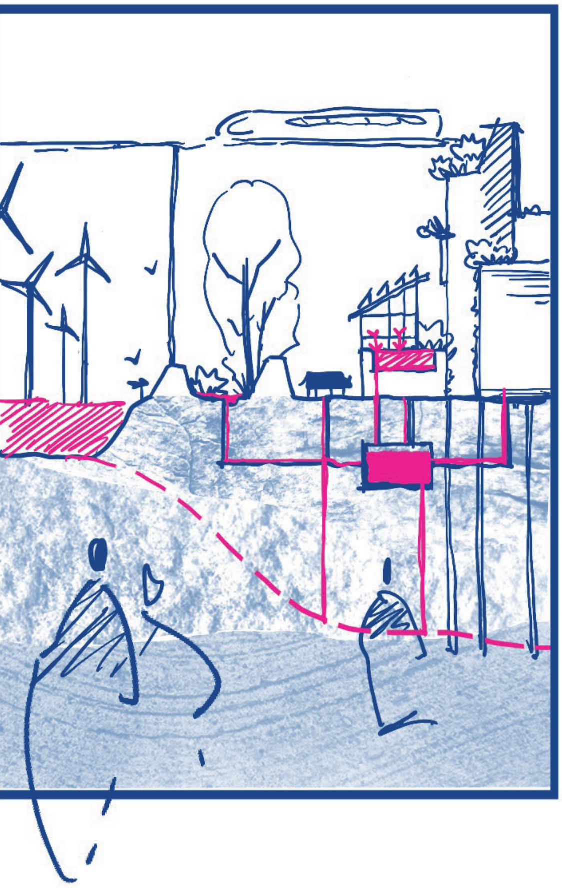
Socio-economic development

	High	Moderate
Tight	STOOM	WARM
Resilient	DURK	RUST

<Figure 25, Four scenarios developed in two dimensions (Redraw from [Deltraes & PBL, 2024])

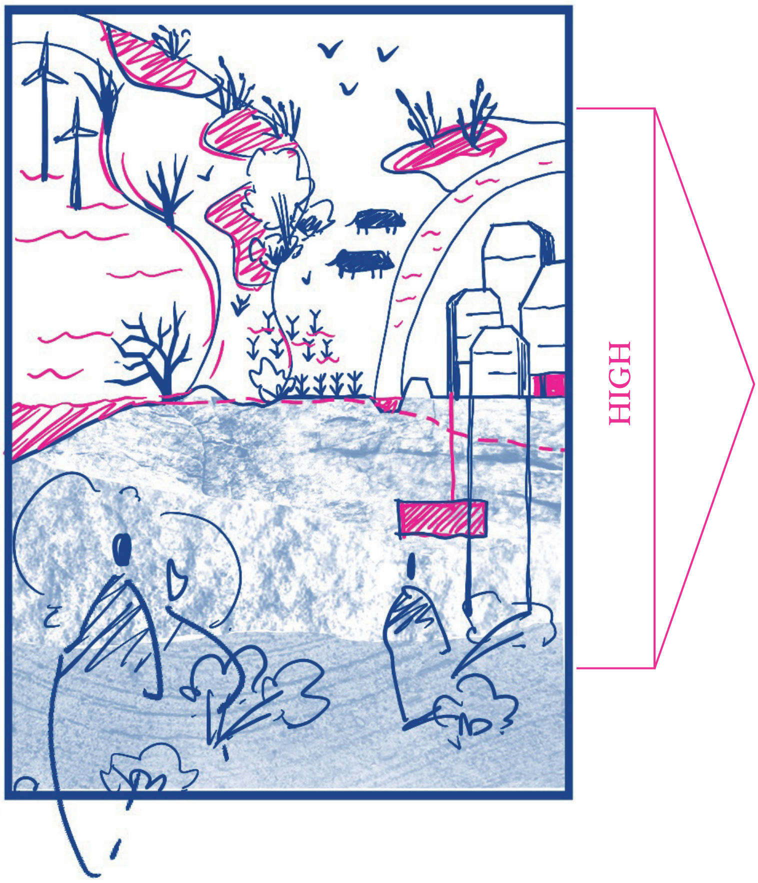
INNOVATIVE WATER SOCIETY

High socio-economic pressure



GREEN IJSSELMEER

Low socio-economic pressure



Four Narrow Down Scenarios in the IJsselmeer Region

Based on the ambitions and goals proposed for 2050, and driven by the dual uncertainties of climate change and socio-economic development, four possible future scenarios emphasizing water circularity have been envisioned. The evaluation criteria for the scenario envisions are based on the delta scenario for the Netherlands in 2050 (Deltares & PBL., 2024).

In all four IJsselmeer Region scenarios under the base purpose from Delta scenario (Deltares & PBL., 2024), tasking for freshwater availability, flooding and flood safety increase substantially in 2050 and 2100. This affects all areas and water users. Freshwater availability and flooding tasking are already urgent in the short term. In areas where there are already bottlenecks today, problems will increase in the future.The scenario space is spanned along an climate change axis and a socio-economic axis. Each scenario describes a different combination of climatic changes, efforts to reduce emissions, and socioeconomic developments. Each scenario therefore faces different water and spatial challenges.

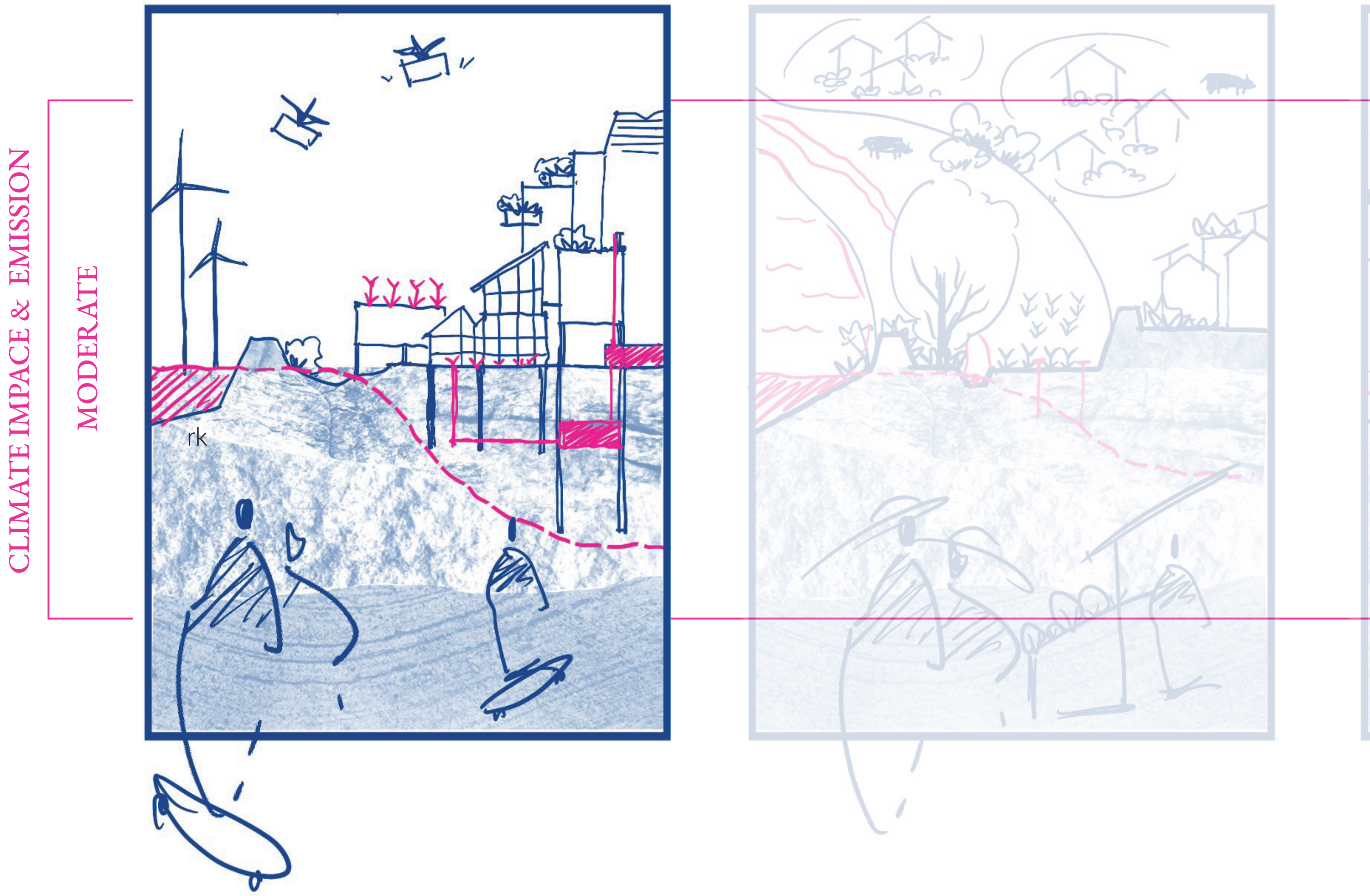
In the high-emission scenarios, water challenges continue to increase. In the low-emission scenarios, climate change stabilizes after 2050, with only limited sea level rise continuing thereafter.

WATER CIRCULAR SOCIETY

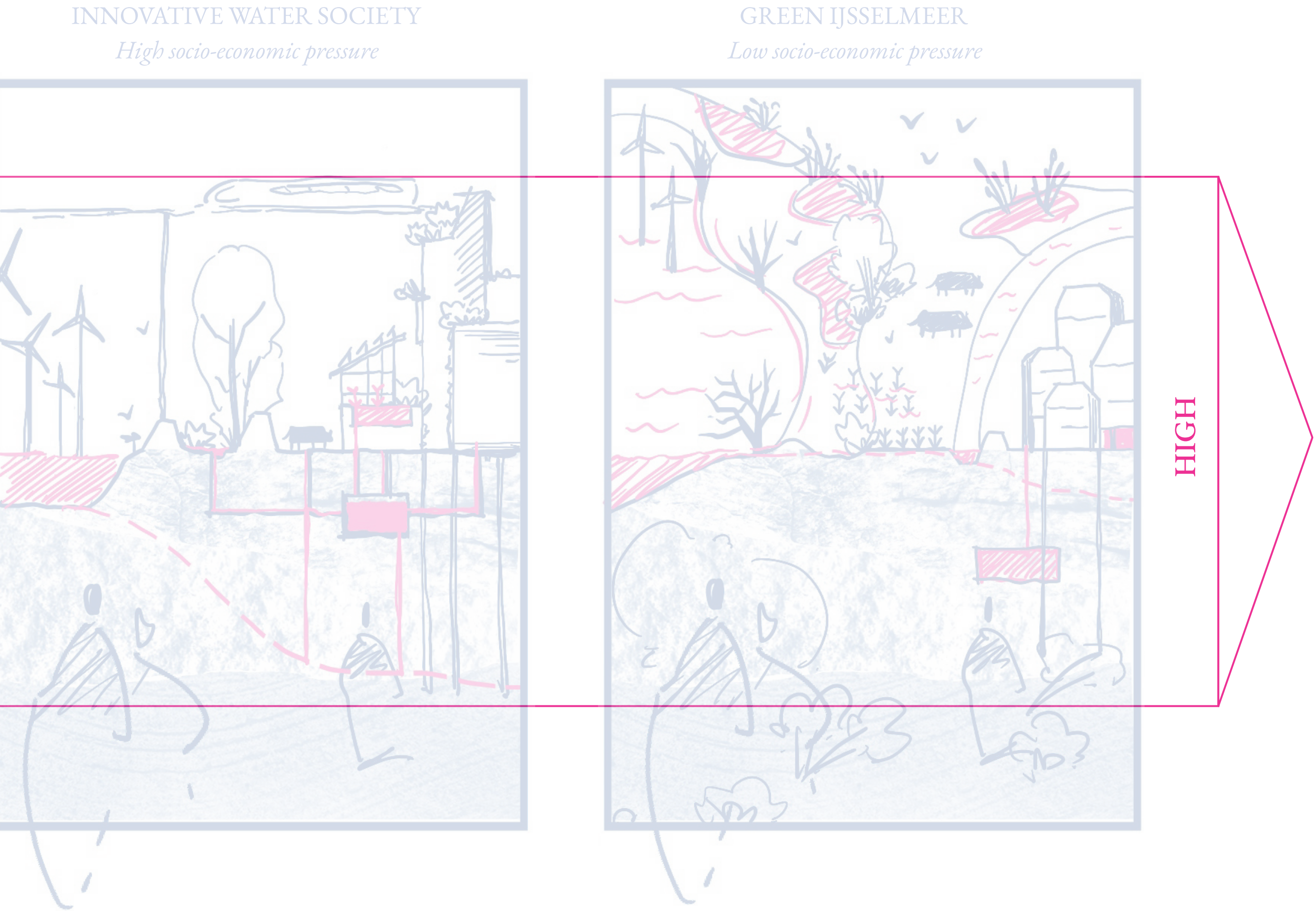
High socio-economic pressure

SELF EFFICIENT SOCIETY

Low socio-economic pressure



Climate impact	Tempreture increase	▬▬▬
	Drought, precipitation deficit, low river discharges	▬▬▬
	Sea level rise	▬▬▬
Emission	Rewetting the peat land	▬▬▬▬▬
	Reduction through energy mobility, agriculture	▬▬▬▬▬
Socio-economic pressure on water availability	Drinking water demand	▬▬▬▬▬
	Economic growth (industry, shipping)	▬▬▬▬▬
	Increase in nature area	▬▬▬



Scenario I: DRUK

Under the DRUK scenario, climate change will increase all water tasks through 2050. The task for freshwater availability will increase because of the larger precipitation shortage in the summer, and lower river discharges will reduce the water supply. The level of the peatland will rise to bring additional fresh water. Water demand increases due to economic growth and population growth.

We envision a water circular society in this scenario. The rising freshwater demand is mainly attributable to population growth and economic production such as agriculture and the energy sector. Water demand in this area requires more efficient water utilization within and between sectors, resulting in a high standard of water recycling.

<Degree of change in 2050

Limited ▬

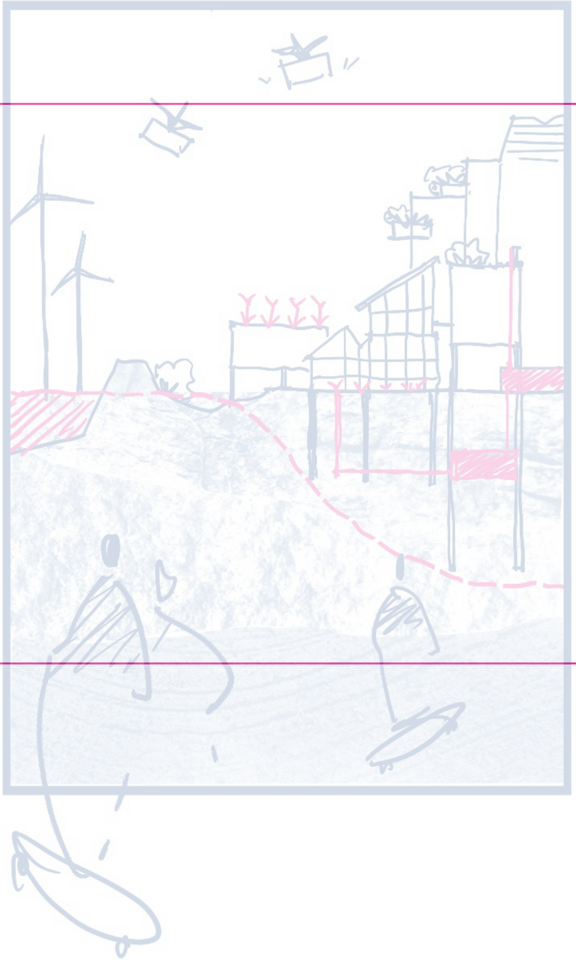
Many ▬

CLIMATE IMPACE & EMISSION

MODERATE

WATER CIRCULAR SOCIETY

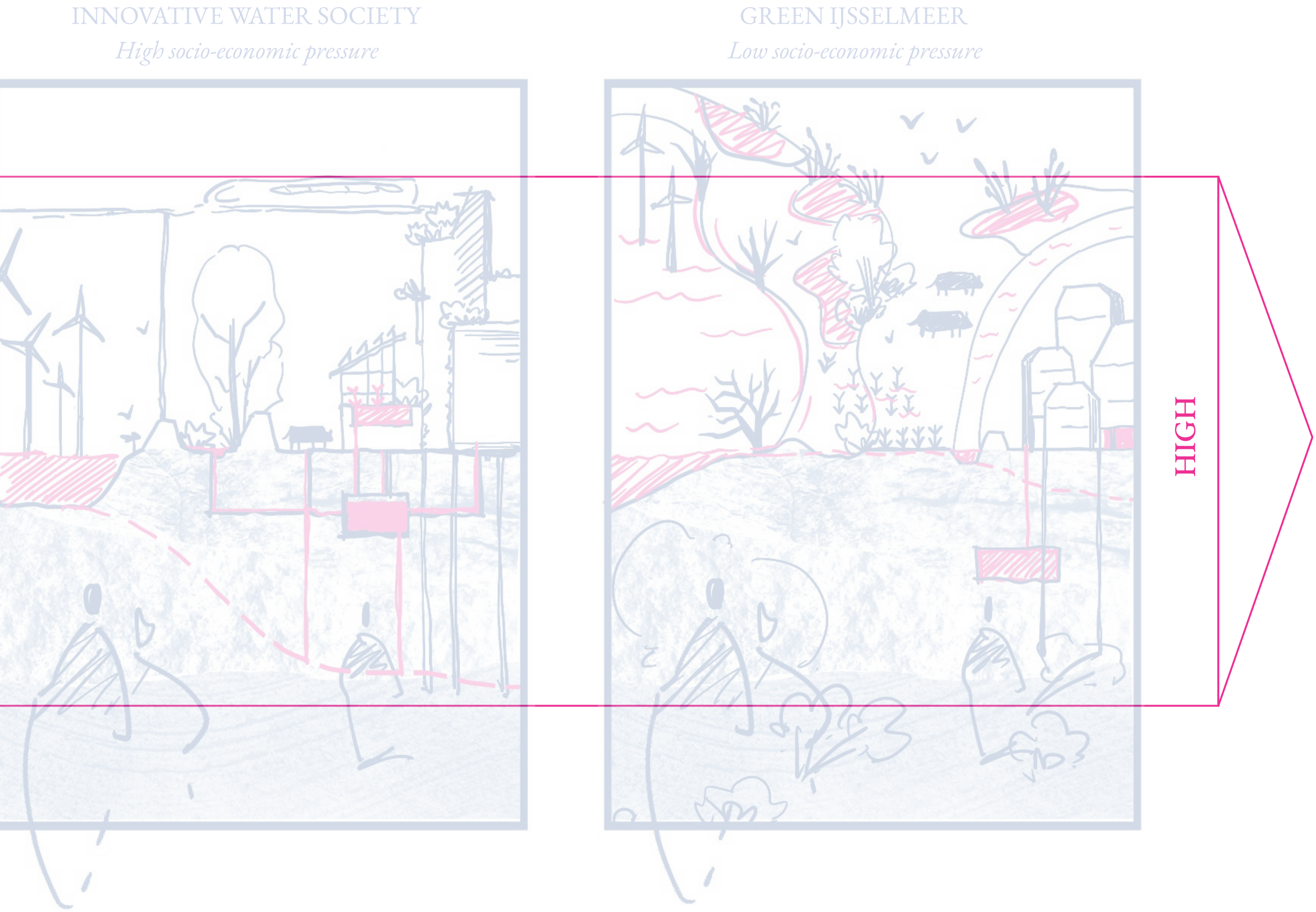
High socio-economic pressure



SELF EFFICIENT SOCIETY

Low socio-economic pressure

Climate impact	Tempreture increase	▬▬
	Drought, precipitation deficit, low river discharges	▬▬
	Sea level rise	▬▬
Emission	Rewetting the peat land	▬▬▬▬
	Reduction through energy mobility, agriculture	▬▬▬▬
Socio-economic pressure on water availability	Drinking water demand	▬▬
	Economic growth (industry, shipping)	▬▬
	Increase in nature area	▬▬▬▬



INNOVATIVE WATER SOCIETY

High socio-economic pressure

GREEN IJSSELMEER

Low socio-economic pressure

Scenario II: RUST

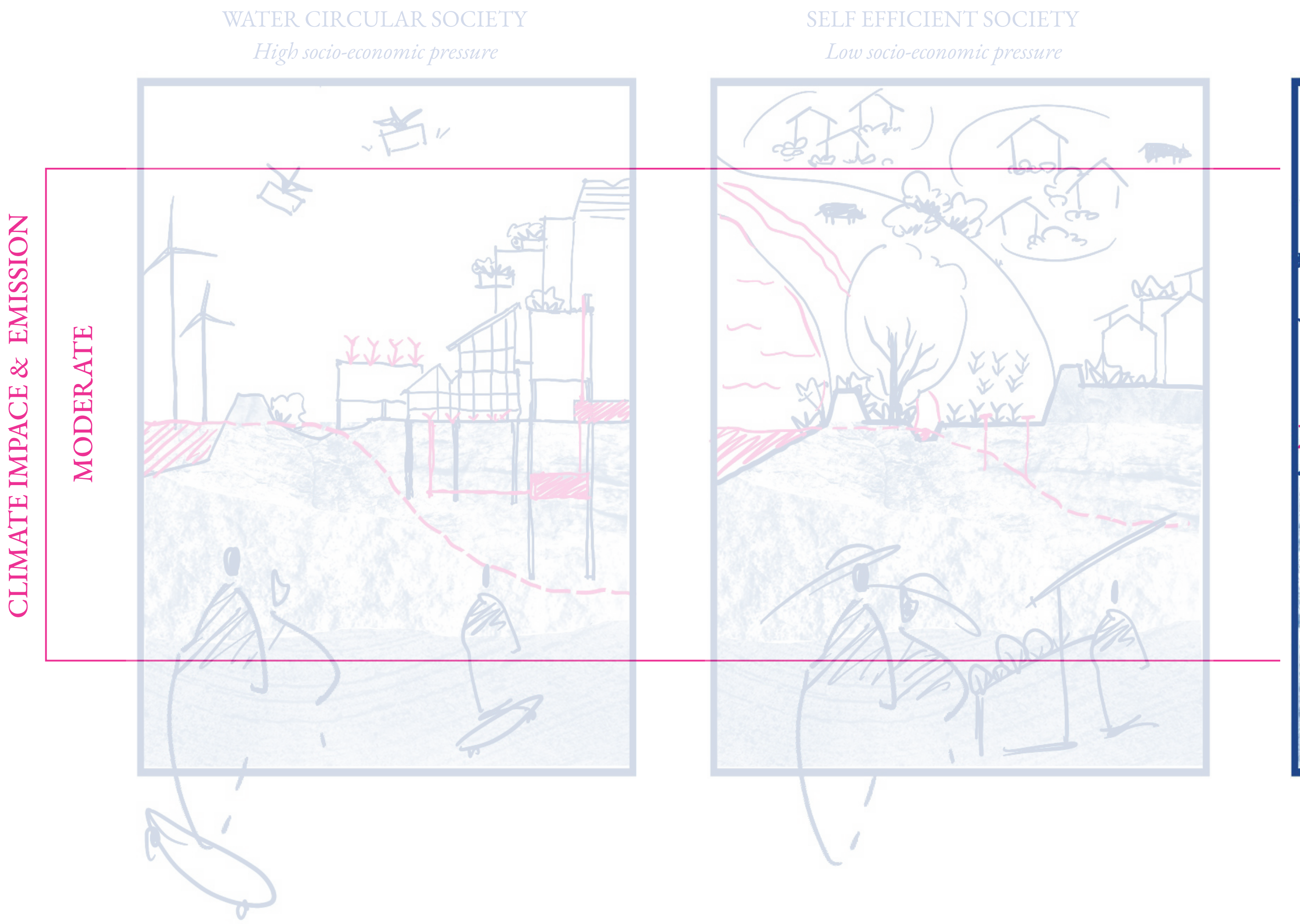
Under the scenario RUST, climate change will cause all water tasks to increase through 2050. The task for freshwater availability will increase because of the larger precipitation shortage in the summer, and lower river discharges will reduce the water supply. Compared to scenario DRUK, the drinking water demand will hardly increase, so that no more withdrawals from ground and surface water will be needed either. Cooling water demand from industry and power plants is also lower.

In doing so, a self-sufficient society can be imagined to meet the demand locally, and keep the capacity of freshwater within region in order to facilitate the water circularity. Human society will coexist with water as part of nature.

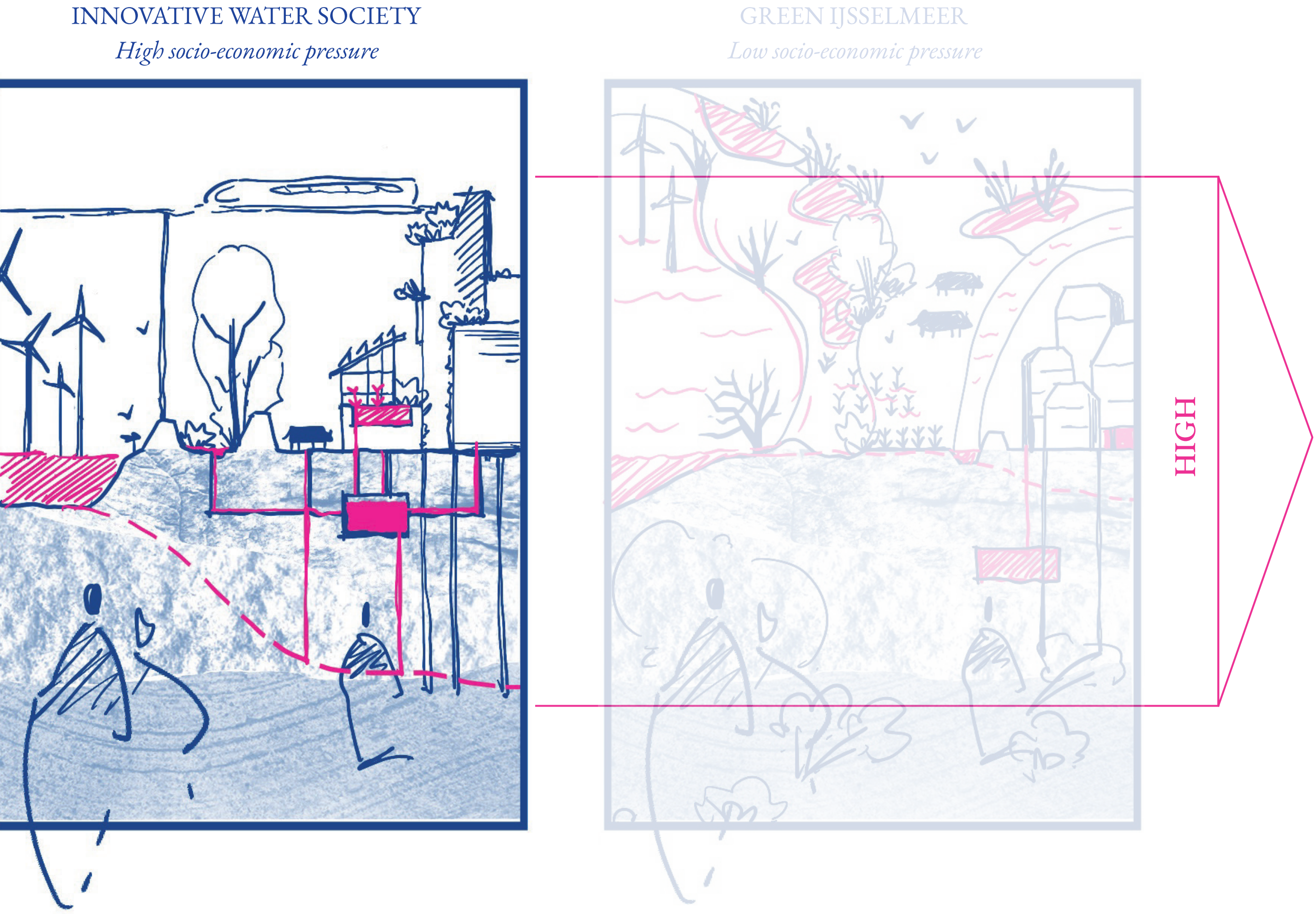
<Degree of change in 2050

Limited ▬

Many ▬



Climate impact	Tempreture increase	██████
	Drought, precipitation deficit, low river discharges	██████
	Sea level rise	██████
Emission	Rewetting the peat land	░░░░
	Reduction through energy mobility, agriculture	░░░░
Socio-economic pressure on water availability	Drinking water demand	██████
	Economic growth (industry, shipping)	██████
	Increase in nature area	░░░░



INNOVATIVE WATER SOCIETY

High socio-economic pressure

GREEN IJSSELMEER

Low socio-economic pressure

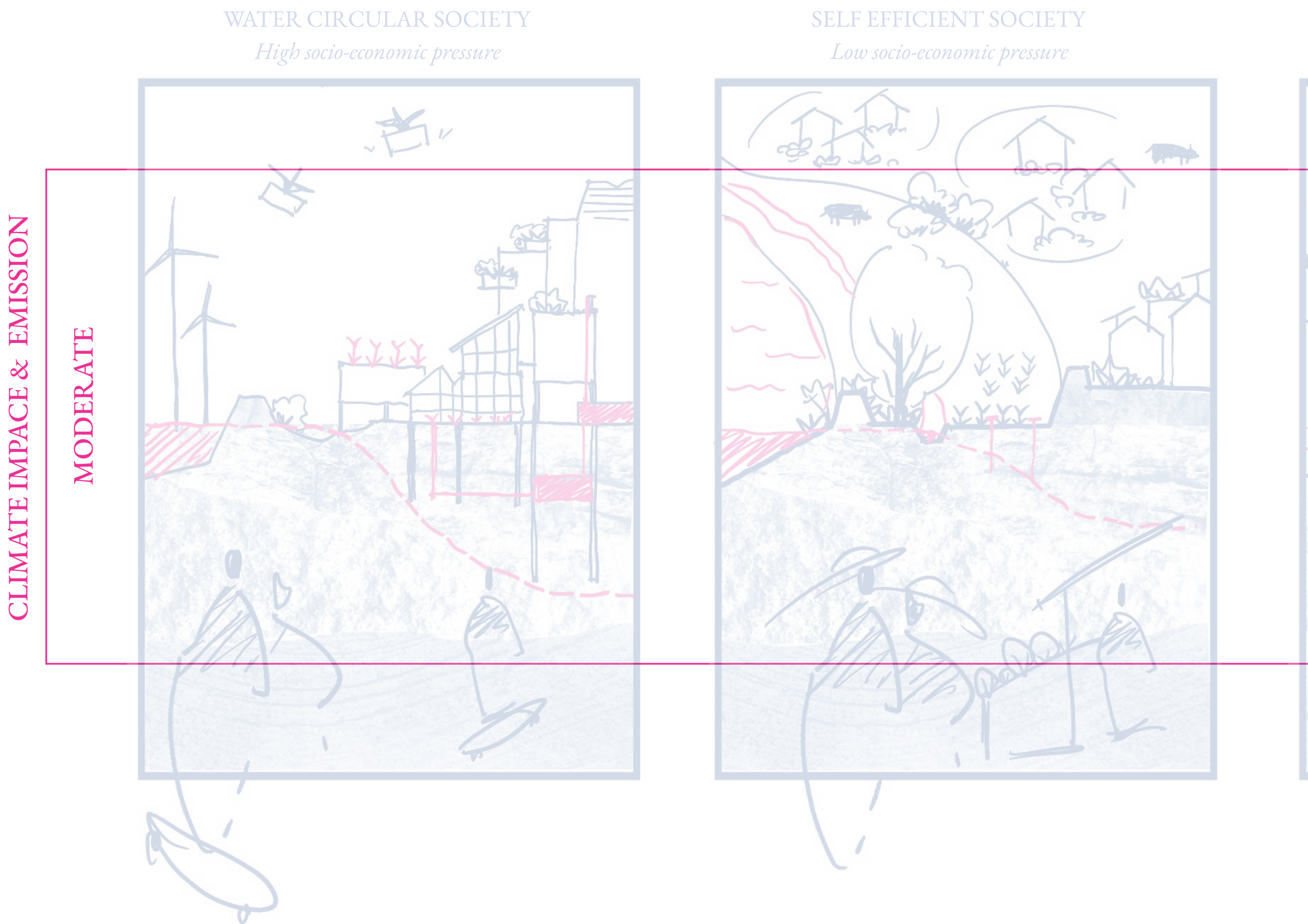
Scenario III: STOOM

Under the STOOM scenario, climate change ensures that all water tasks will continue to increase until 2050 and beyond. The increased shortage of precipitation and lower river discharges, which means less water can be brought in, are tasking for freshwater availability. Salinisation is growing strongly along the coast due to faster sea level rise and periodic low river discharges. More flushing of the regional water system is needed, and freshwater is required due to the level increase in the peat meadow.

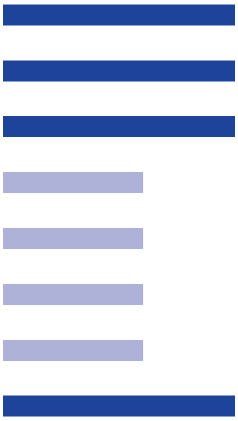
In this scenario, it is possible that a mismatch between supply and demand will occur, so we envision the Innovative Water Society with a developing innovative transition of economic sectors to mitigate the influence of the shortage of water supply.

<Degree of change in 2050

Limited	▬
Many	▬

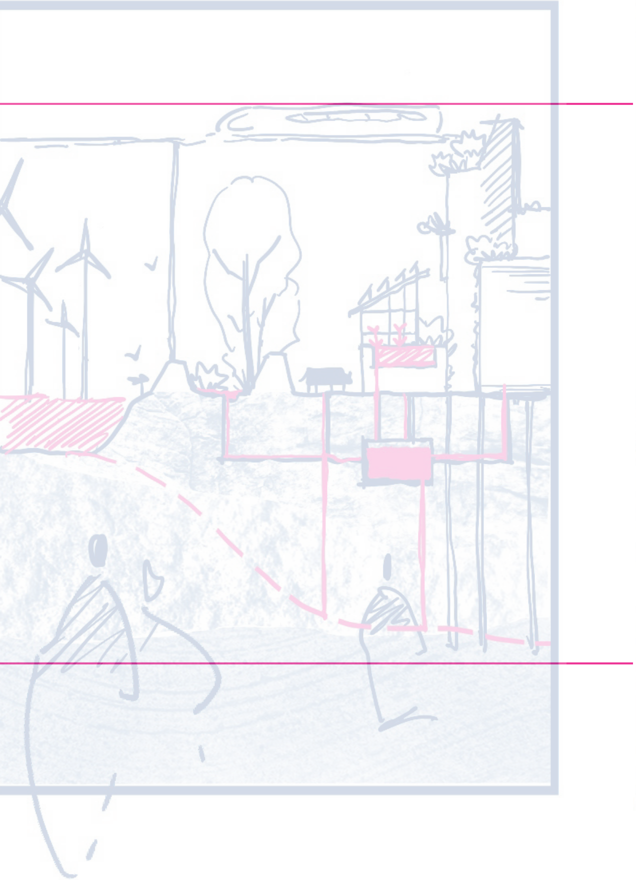


Climate impact	Tempreture increase
	Drought, precipitation deficit, low river discharges
	Sea level rise
Emission	Rewetting the peat land
	Reduction through energy mobility, agriculture
Socio-economic pressure on water availability	Drinking water demand
	Economic growth (industry, shipping)
	Increase in nature area



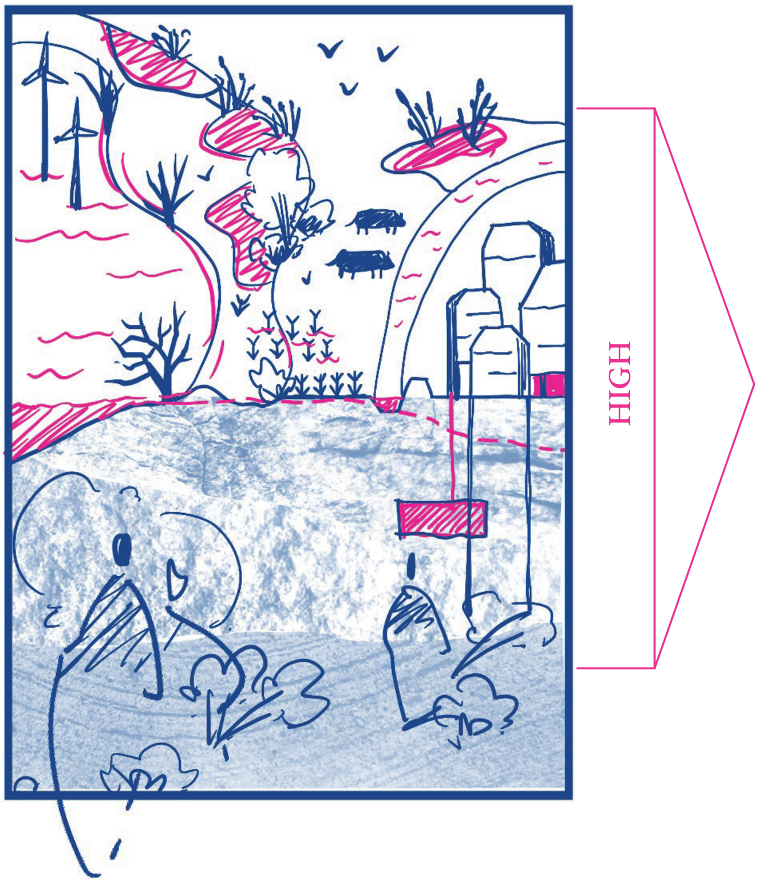
INNOVATIVE WATER SOCIETY

High socio-economic pressure



GREEN IJSSELMEER

Low socio-economic pressure



Scenario IV: WARM

Under the scenario WARM, climate change ensures that all water tasks will continue to increase until 2050 and beyond. Salinisation is growing strongly along the coast due to faster sea level rises and periodically low river discharges, which require more flushing of the regional water system. Unlike in STOOM, drinking water demand does not increase, and no additional ground or surface water withdrawals result. The economic sectors also have smaller water demand.

As water demand is mainly from climate change, which influences the natural environment, we envision Green IJsselmeer responding to the nature-based transition.

<Degree of change in 2050

Limited	▬
Many	▬

Spatial structure

Spatial synergy

Derived from the vision are the following three major water cycle objectives:

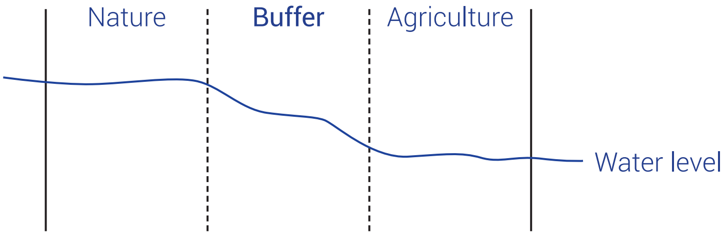
Water quantity
Enhance the resilience of freshwater resource regulation, storage, and supply (e.g., increase the water storage capacity of lakes and surrounding areas to ensure water supply during droughts);

Water quality and ecology
Improve water environment quality and promote ecosystem health (e.g., reduce nutrient loss and protect wetland biodiversity);

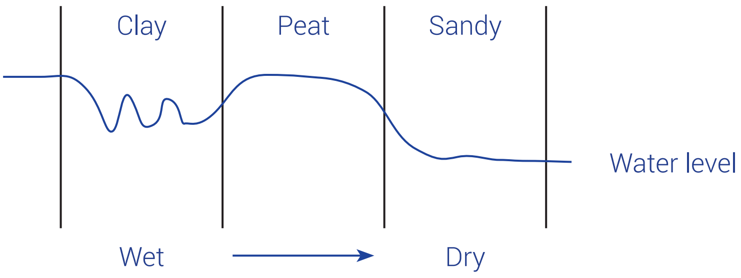
Climate robust (Water safety)
Enhance the region's flood control and drought resistance capabilities and adaptability to climate extremes. These three objectives are mutually reinforcing and collectively serve the long-term vision of sustainable water cycle management.

Two different gradient for water circularity(water quality, water quantity, water safety), to adress the guding principle is that following the nature-based rules, and adapt to the water circularity: (1) Land use as main focus; (2) Soil type as main focus

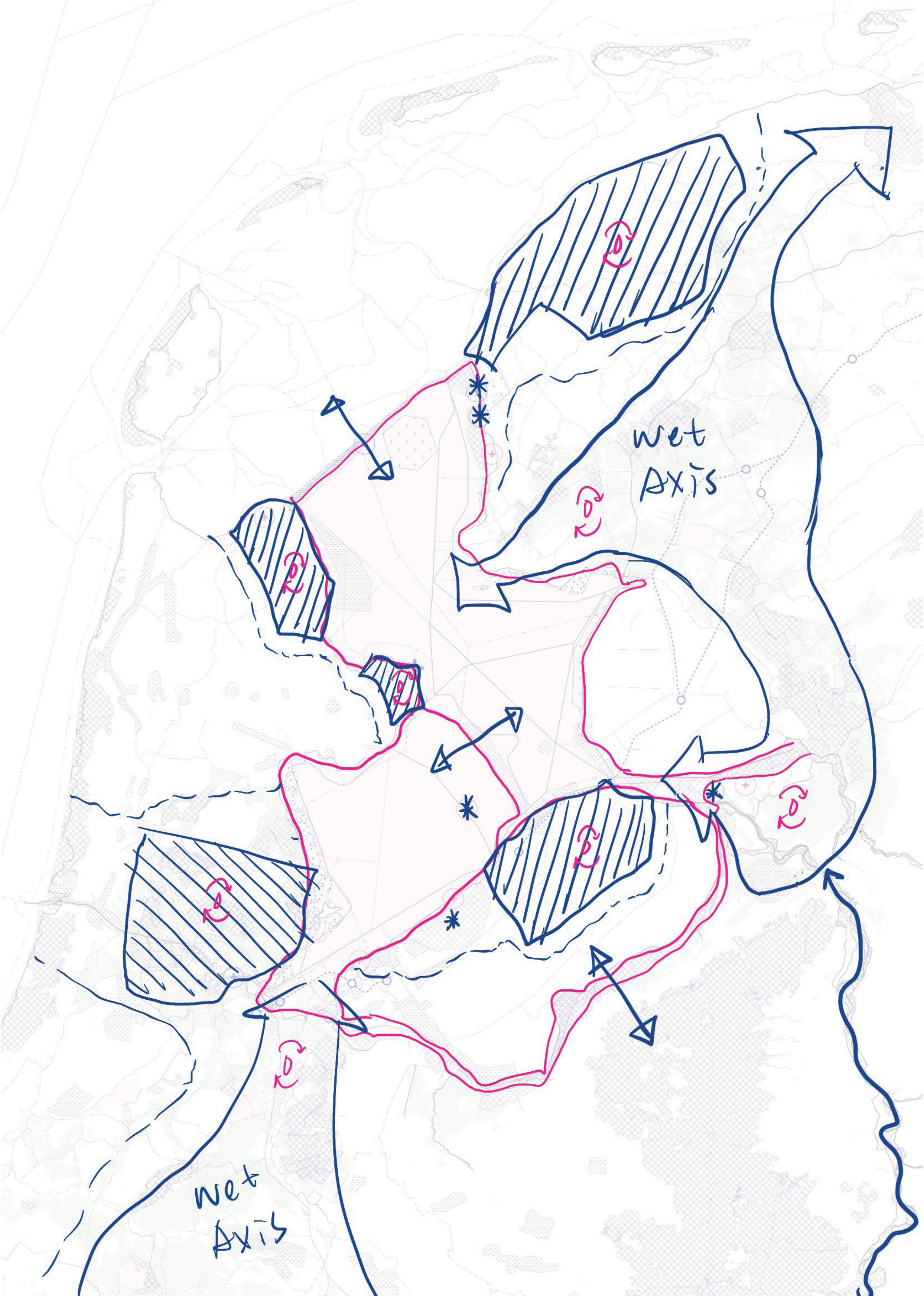
Landuse adaptive water level



Soil type-based water level transition



<Figure 25, Two different gradient for water circularity (By Yiyan Zhou)
>Figure 26, Vision map with spatial structure (By Yiyan Zhou)


wet Axis
wet Axis

System, actor and environmental actions

WATER MANAGEMENT
& INFRASTRUCTURE

W1 Climate adaptive water level

Strategies that enable dynamic control of water levels to respond to droughts, floods, and seasonal variability, balancing ecological needs and water storage capacity.

W2 Climate adaptive infrastructure

Infrastructure that integrates flexibility and multifunctionality—such as controlled flooding areas, multifunctional dikes, or adaptive drainage—to cope with climate extremes while supporting spatial quality.

AGRICULTURE
& LAND USE

A1 Nature-inclusive agriculture

Farming practices that work with natural systems—such as agroforestry, buffer strips, or rotational grazing—to maintain soil health, reduce runoff, and enhance biodiversity.

A2 Balancing sustainable land use

Spatial strategies that align agricultural productivity with ecological and hydrological constraints, avoiding land overuse and guiding development toward areas with lower environmental pressure.

WATER-BASED
ECONOMY

E1 Close the water loop

Systems that prioritize water reuse, cascading use between sectors, and decentralized treatment, reducing reliance on freshwater and extending water's utility across the economy.

E2 Efficient economic structure

Strategic spatial-economic planning that concentrates high water-use sectors in appropriate zones, promotes sectoral synergy, and supports industry transition toward low water dependency.

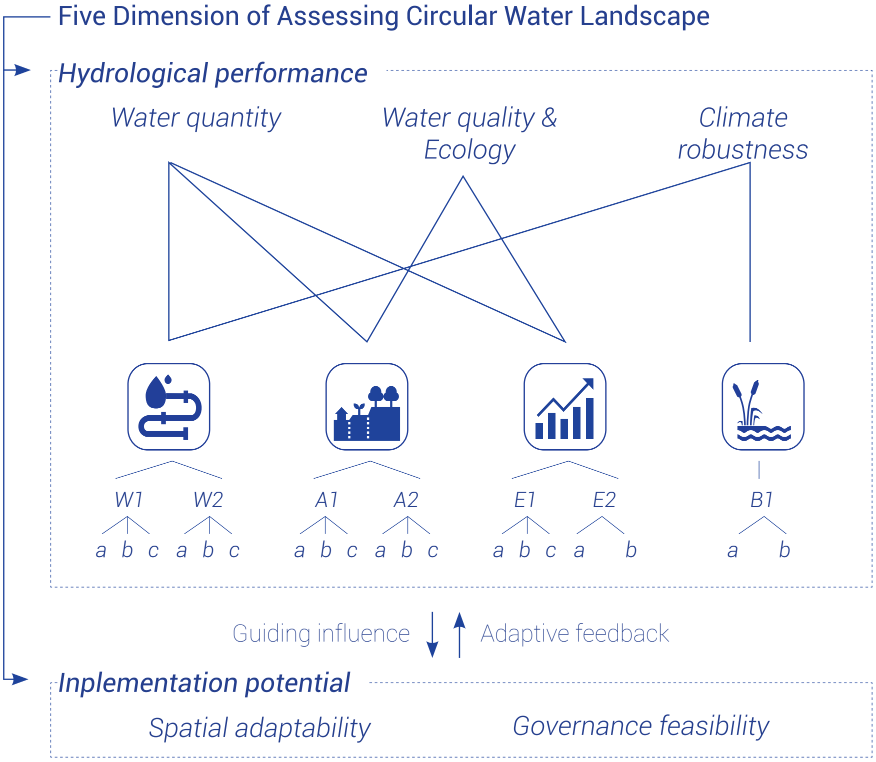
BIODIVERSITY
& ECOLOGY

B1 Systemic ecological landscape

A connected ecological network—such as riparian corridors, sponge landscapes, and buffer strips—that filters water, absorbs excess flows, and links fragmented habitats across the catchment.

Focusing goals Guiding principles	Water quality & Ecology	Water quantity	Climate robustness
W1 Climate adaptive water level		■	■
W2 Climate adaptive infrastructure			■
A1 Nature-inclusive agriculture	■	■	
A2 Balancing sustainable land use	■		
E1 Close the water loop	■	■	
E2 Efficient economic structure	■	■	
B1 Systemic ecological landscape	■	■	■

>Figure 27, Focuses of different guiding principles (By Yiyan)

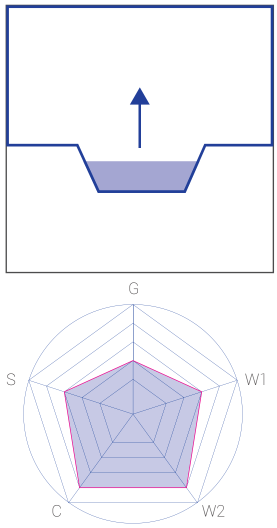


>Figure 28, Five dimensions of assessing circular water landscape in the IJsselmeer Region (By Yiyan)

Adaptive measures

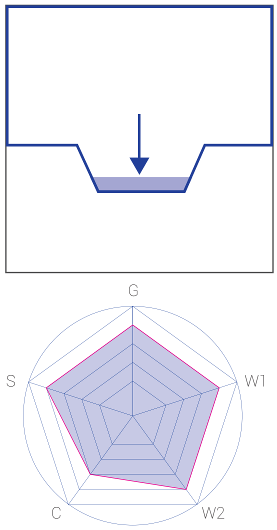
W1 Water infrastructure

Climate adaptive water level



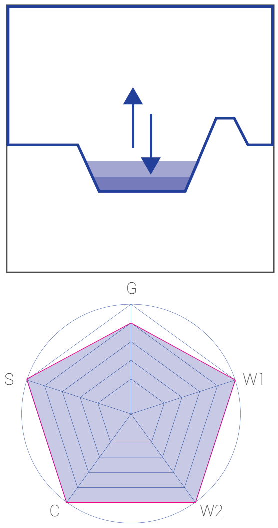
W1a High water level

A strategy focused on maintaining elevated water levels that can offer water storage but may limit spatial flexibility.



W1b Low water level

Helps to conserve water resources but may be limited by infrastructure or environmental constraints in different regions.

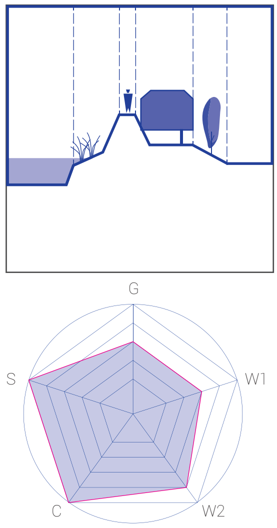


W1c Flexible water level

Highly adaptable to various conditions, supporting both water storage and quality while mitigating climate risks.

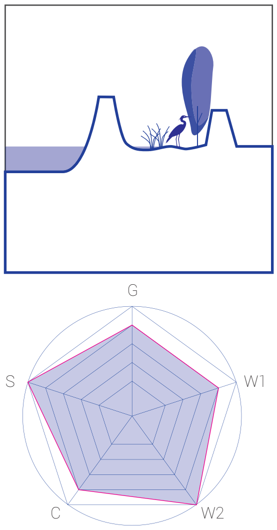
W2 Water infrastructure

Climate adaptive water infrastructure



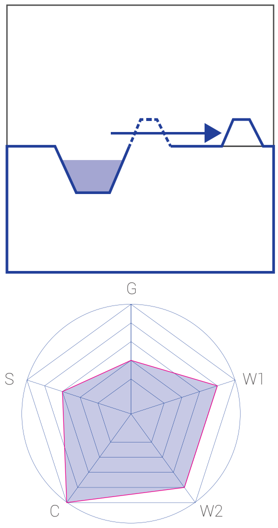
W2a Multifunctional dike

A dike system that serves multiple purposes, including flood control and agriculture, making it both resilient and versatile.



W2b Double dike system

A layered dike structure creating multifunctional zones between inner and outer dikes, allowing space for controlled water retention, landscape transformation, and risk buffering.

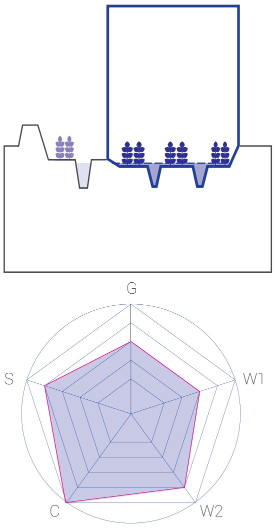


W2c Transboundary depoldered area

A shared, lowered landscape between regions or sectors that allows temporary inundation, offering spatial flexibility for flood management and ecological restoration.

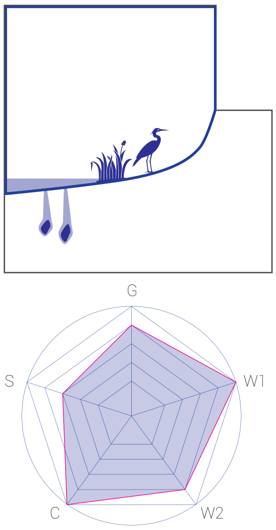
A1 Agriculture & Land use

Nature inclusive agriculture



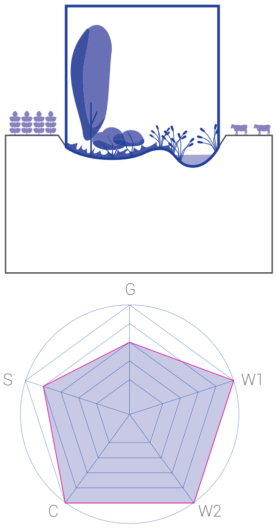
A1a Paludiculture

Agroforestry designed to integrate climate resilience and sustainable land use practices.



A1b Salt marsh

Agriculture that can thrive in saline conditions, offering a potential solution for changing water quality, but implementation is region-specific.

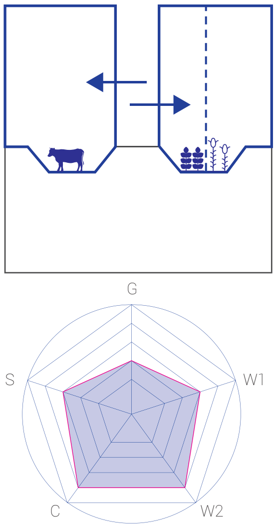


A1c Agro-ecological buffer zone

Supports biodiversity, water quality, and soil health while enhancing landscape adaptability.

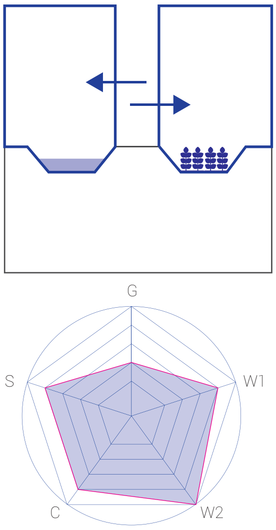
A2 Agriculture & Land use

Balancing sustainable land use



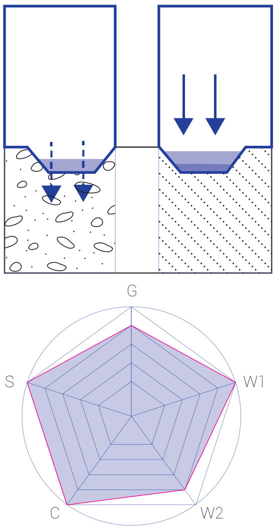
A2a Agro-pasture rotation

A land-use framework that allocates space based on water, soil, and ecological capacity, optimizing synergies between agriculture, urbanization, and nature.



A2b Rotation water buffer farming

Alternating between pasture and cropping on the same land to enhance soil resilience, water retention, and nutrient cycling, especially under shifting hydrological conditions.



A2c Soil-based water retention

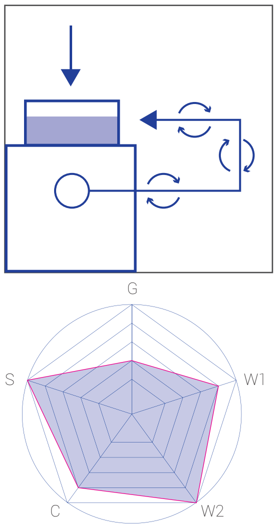
This solution offers high water retention and can be adapted to different soil types, though practical implementation may be challenging.

Radar chart
W1: Water quality and ecology
W2: Water quantity
C: Climate robust
S: Spatial adaptation
G: Governance feasibility

Each guiding principle will be scored on a 5-point scale (1 = low, 5 = high) for each dimension:
Water Quality: How well the solution contributes to maintaining or improving water quality.
Water Quantity: How well the solution addresses water availability and sustainable management.
Climate Robustness: How adaptable the solution is to climate change impacts (e.g., droughts, floods).
Spatial Adaptability: How flexible the solution is for different regions or scales.
Governance Feasibility: How realistic it is to implement, considering political, social, and economic factors.

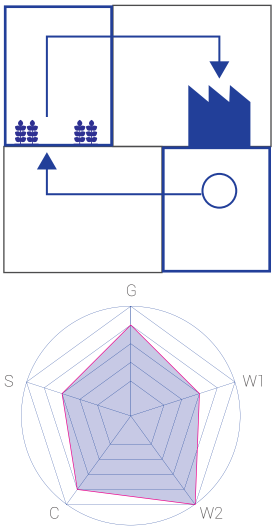
E1 Water chain

Close the water loop



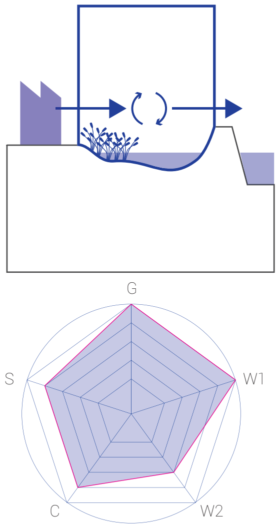
E1a Decentralized water reuse

Small-scale, localized systems that treat and recycle water on-site, reducing pressure on centralized infrastructure and increasing system resilience.



E1b Cross-sector water cycle system

A spatial-industrial system where water flows are reused between different sectors (e.g., agriculture - industry), creating closed-loop economies across landscapes.

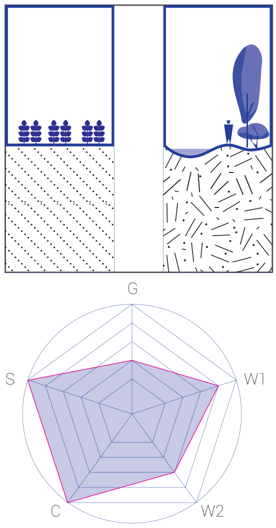


E1c Eco-integrated water purification system

Nature-based infrastructure that treats wastewater through ecological processes, providing both purification and biodiversity benefits.

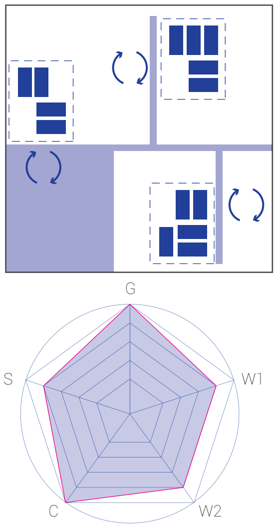
E2 Water chain

Efficient economic structure



E2a Water sensitive economic zoning

Promotes efficient water use in urban and industrial sectors, ensuring resilience to climate changes while promoting economic growth.

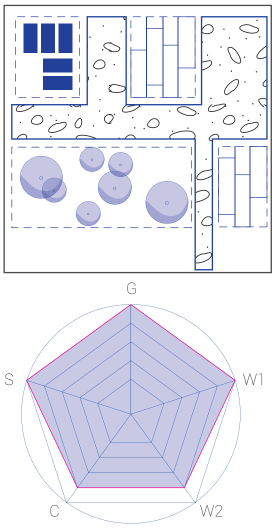


E2b Crossing boundary water-economy systems

Integrated spatial-economic planning where water use and reuse are optimized across administrative and functional boundaries, aligning production, treatment, and reuse flows for greater regional efficiency.

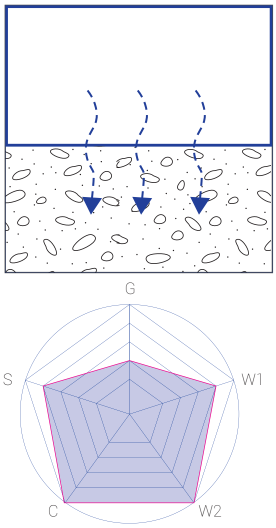
B1 Biodiversity & Ecology

Systemic ecological landscape



B1a Ecological water quality buffer strip

A vegetated edge between contrasting land uses or water bodies that filters pollutants, protects sensitive ecosystems, and maintains water quality thresholds.



B1b Adaptive sponge landscape

A mosaic of natural and semi-natural features that absorb, store, and gradually release water, helping to mitigate flood and drought while enhancing ecological value.

Radar chart
W1: Water quality
W2: Water quantity
C: Climate robust
S: Spatial adaptation
G: Governance feasibility

Each guiding principle will be scored on a 5-point scale (1 = low, 5 = high) for each dimension:

Water Quality: How well the solution contributes to maintaining or improving water quality.
Water Quantity: How well the solution addresses water availability and sustainable management.
Climate Robustness: How adaptable the solution is to climate change impacts (e.g., droughts, floods).
Spatial Adaptability: How flexible the solution is for different regions or scales.
Governance Feasibility: How realistic it is to implement, considering political, social, and economic factors.

CHAPTER

5.

DYNAMIC SPATIAL ADAPTIVE PATHWAY FRAMEWORK

Development of adaptive measures

Adaptive pathway

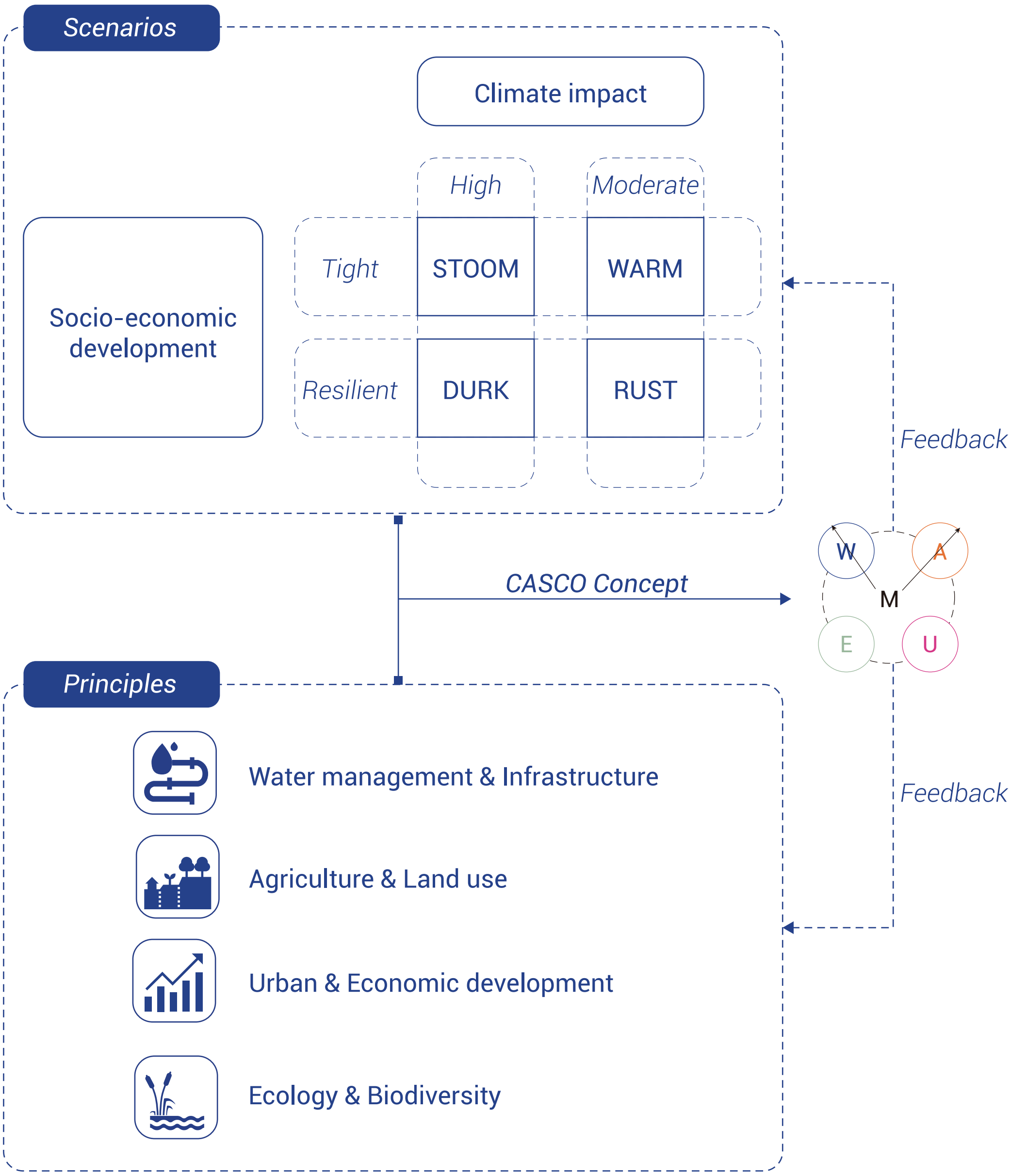
Adaptive phase

Development of adaptive measures

Adaptive measures are formed through the combined action of scenarios and adaptive principles (Figure 29).

Adaptive approaches are formed through the combined effects of scenarios and adaptive principles. First, the development priorities of the IJsselmeer region under different water demand conditions are clarified by identifying possible scenarios, and critical areas are superimposed to distinguish the development priorities, regional importance, and complexity of challenges of sub-regions. These are also identified spatially as different typologies. Then, four types of adaptive principles formed based on problem analysis provide corresponding spatial design solutions for different spatial typologies.

In order to respond to the uncertainty resulting from different scenarios and to achieve the vision in 2050 in the IJsselmeer Region, the research uses the CASCO concept as a spatial medium to implement guiding principles in critical areas from overlapping scenarios. The result would be multidisciplinary spatial measures that can adapt to sectoral challenges to avoid the extreme situation with tipping points.



>Figure 29, Illustration of developing adaptive measures (By Yiyan Zhou)

Adaptive pathway

In order to address the increasing uncertainty caused by climate change and socio-economic development, this thesis establishes an adaptive pathway framework to guide the strategic implementation of spatial and policy measures over time. The adaptive pathway is designed to respond to changing conditions by identifying key moments, or tipping points, at which existing strategies no longer meet their objectives and alternative measures must be adopted (Figure 30).

Starting point

The adaptive pathway begins from the current condition, which may reflect the existing spatial configuration or prevailing policy direction. This starting point provides the contextual baseline from which future decisions are made. It reflects the initial assumptions and determines the space of possible adaptive actions. Existing strategies and constraints are not discarded but re-evaluated as part of a dynamic planning process.

Climate trends & Socio-economic developments

Tipping points emerge when changes in external conditions compromise the ability of existing strategies to meet their objectives. As defined by Kwadijk et al. (2010), "An adaptation tipping point is reached when the magnitude of the external change is such that a policy can no longer meet its objectives, and new actions are needed to achieve the objectives." In this research, tipping points are categorized into four sectoral bottlenecks: (1) water management and infrastructure, (2) agriculture and land use, (3) urban and economic development, and (4) ecology and biodiversity. Each tipping point reflects a mismatch between policy effectiveness and changing environmental or socio-economic conditions.

Transition phases (x-axis)

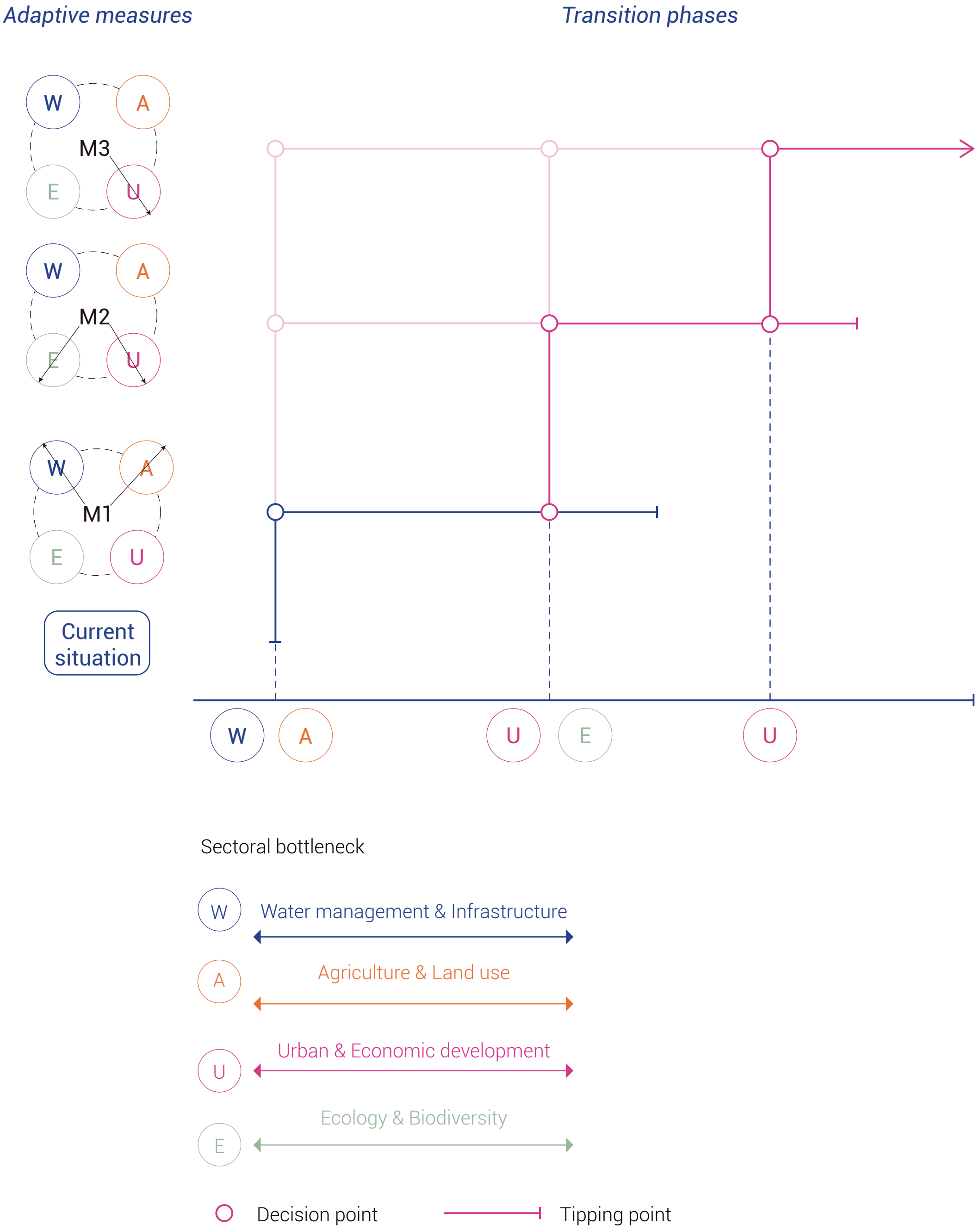
The pathway includes temporal transition phases along the x-axis, which represent potential moments of change. These are not fixed chronological milestones but rather decision points that arise in relation to observed or anticipated system bottlenecks. While these phases acknowledge uncertainty in the rate and nature of change, they serve as practical intervals for policy evaluation. They are assessed based on climate projections, socio-economic trajectories, and spatial system behaviour.

Adaptive measures (y-axis)

Along the y-axis, adaptive measures are proposed as a response to one or more sectoral challenges. These are not single-solution interventions, but rather integrated and multi-functional strategies derived from both regional planning priorities and local spatial characteristics. Measures can be implemented at different moments depending on emerging needs and include interventions such as decentralized water retention, land-use diversification, ecological corridor restoration, or flexible infrastructure systems. The adaptive measures are inherently cross-sectoral, intended to build spatial resilience and delay or avoid the crossing of critical tipping points.

Source:

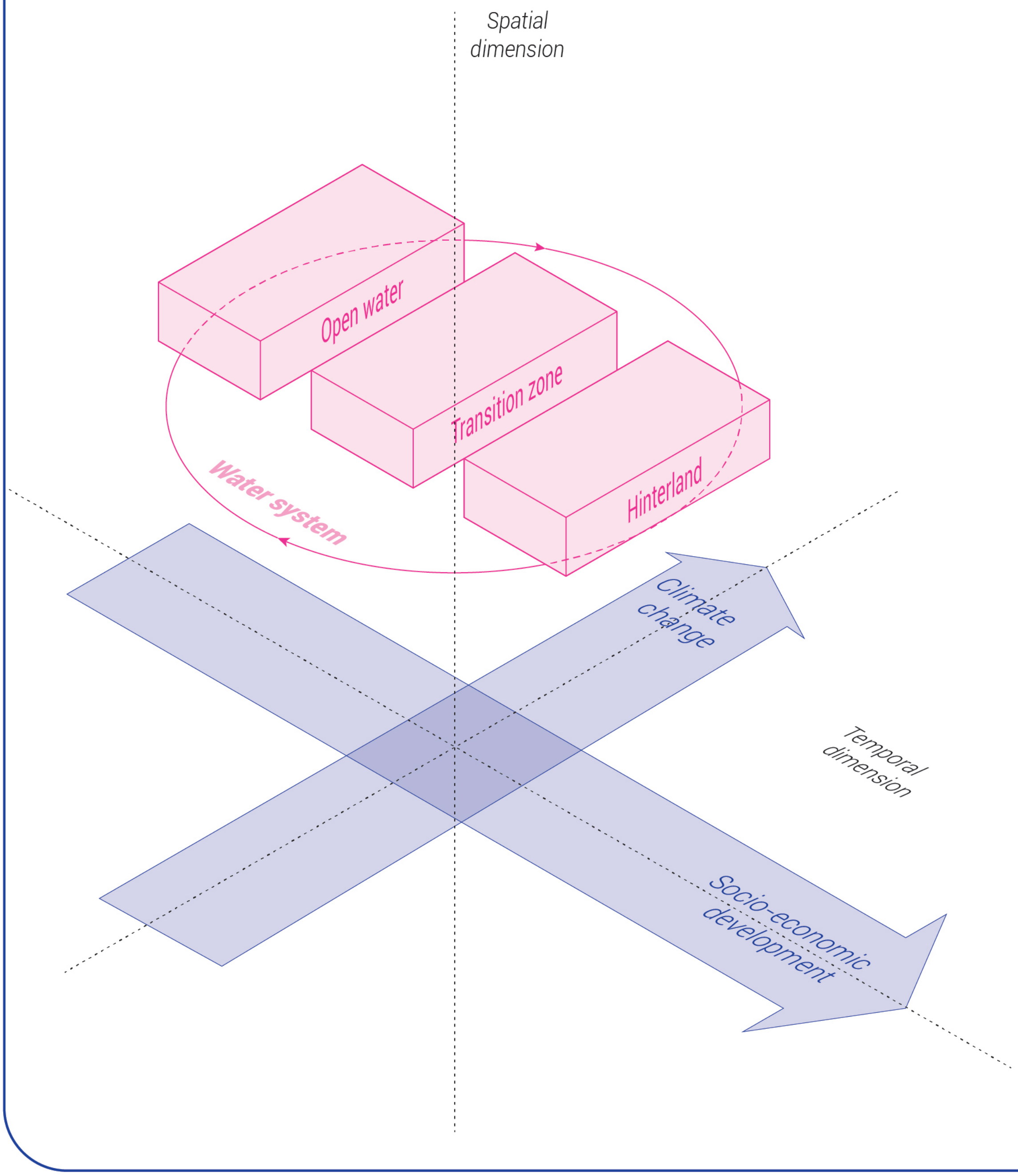
Kwadijk, J. C., Haasnoot, M., Mulder, J. P., Hoogvliet, M. M., Jeuken, A. B., van der Krogt, R. A., ... & de Wit, M. J. (2010). Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands. Wiley interdisciplinary reviews: climate change, 1(5), 729-740.



>Figure 30, Adaptive framework (By Yiyan Zhou)

Adaptive phase

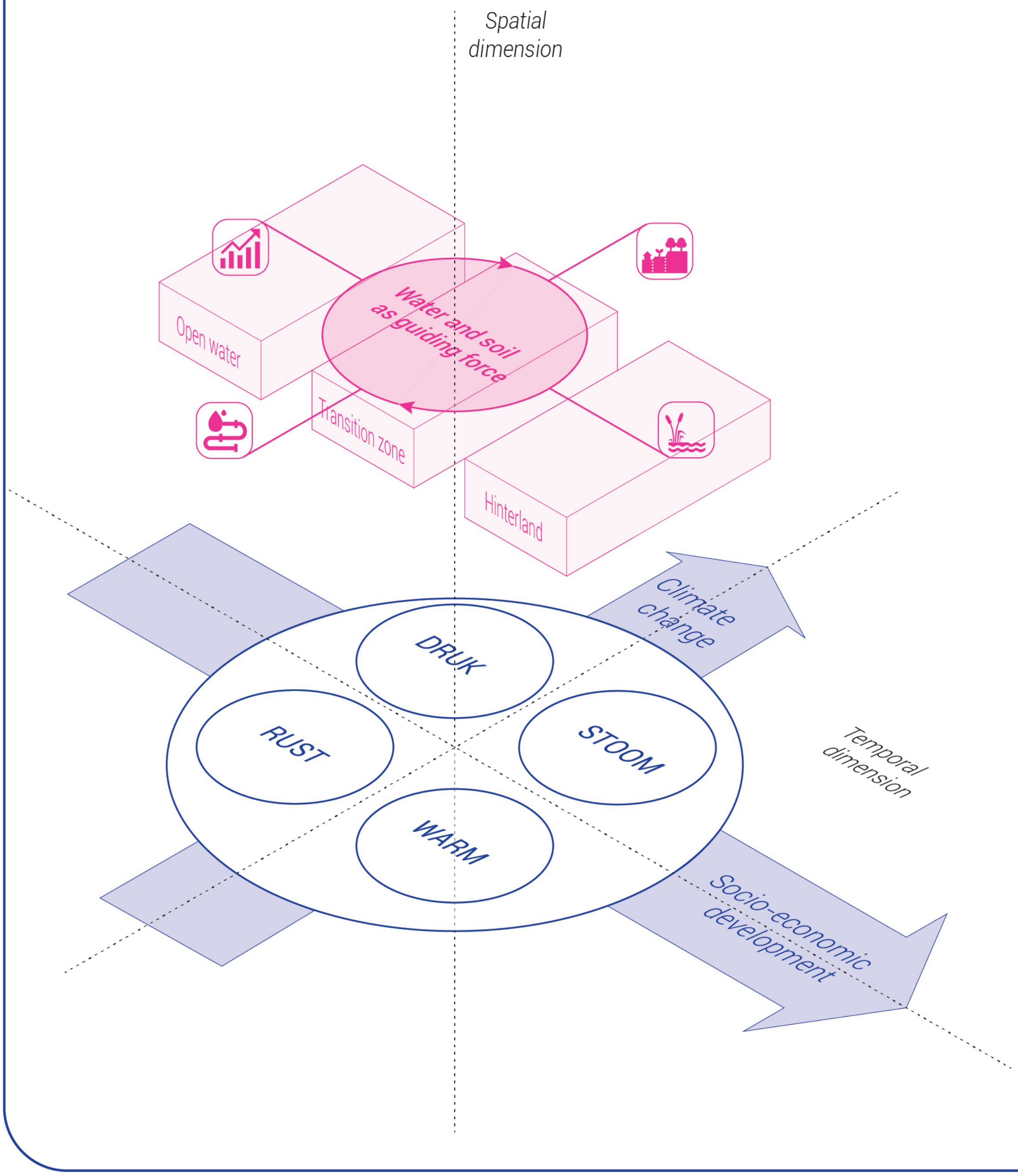
Phase 1: System framing



Step 2
Assess the system vulnerabilities, challenges, and opportunities

Step 1
Describe the system, specific objectives, and identify the uncertainty

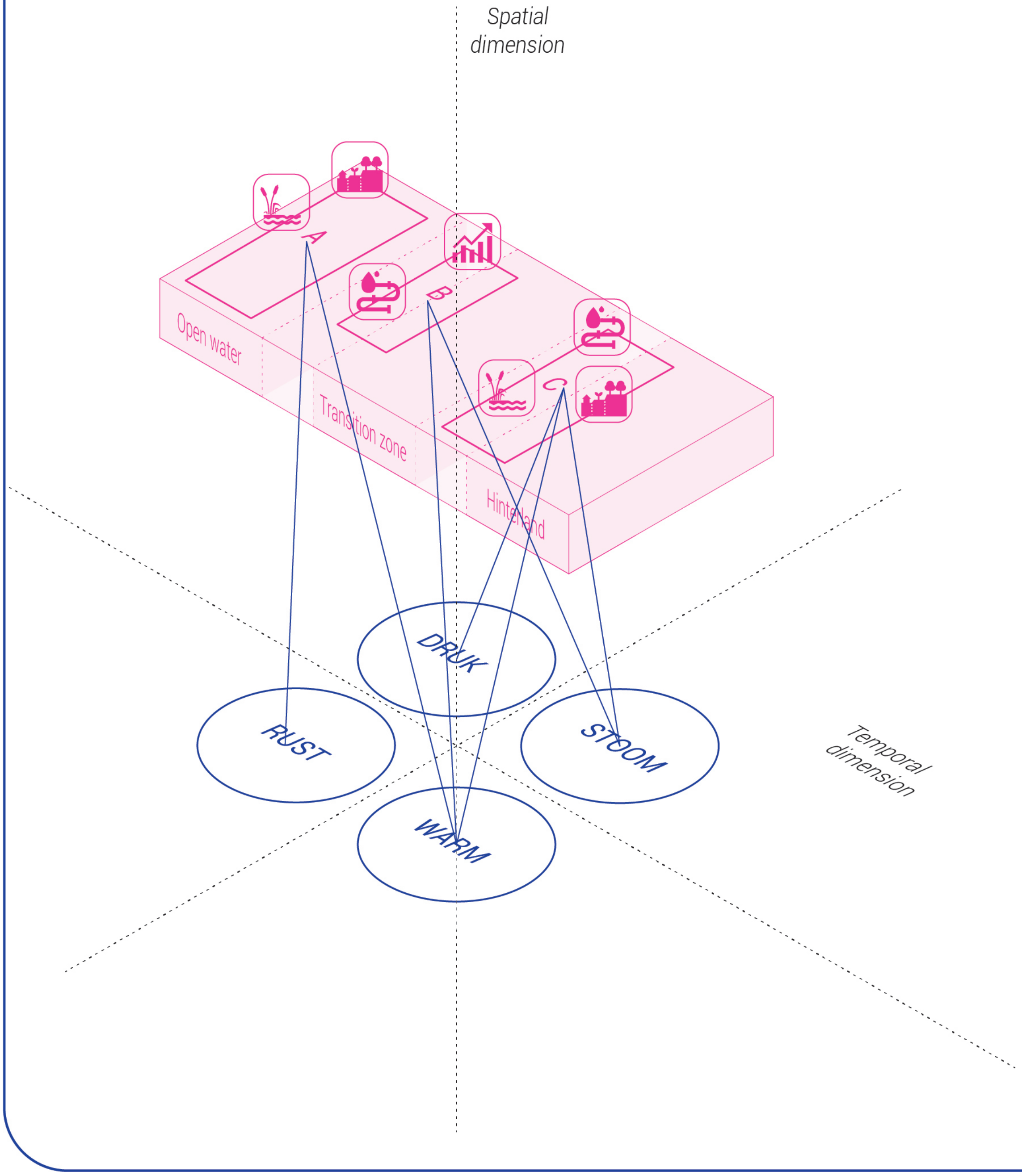
Phase 2: Vision learning



Step 4
Integral set of guiding principles

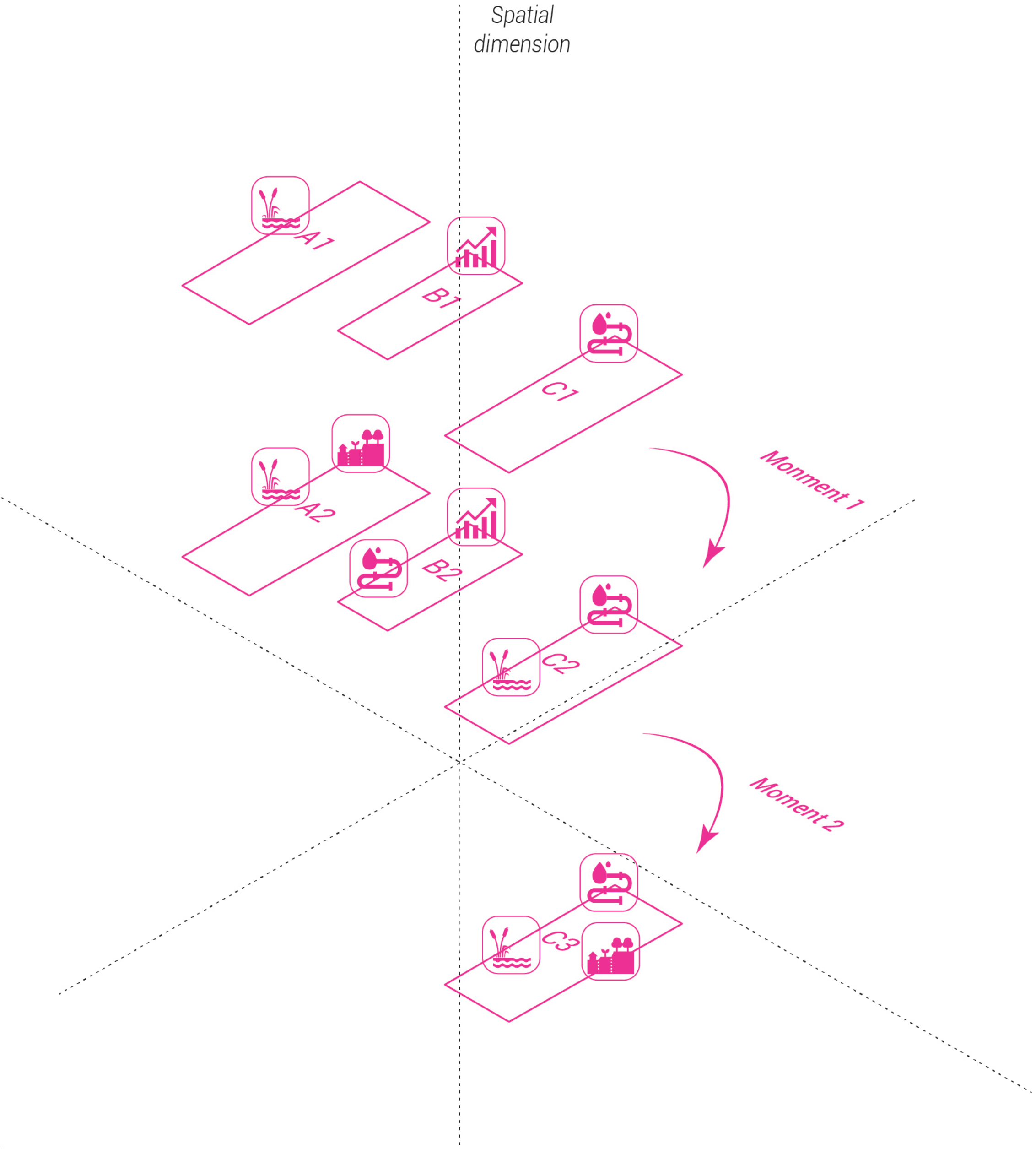
Step 3
Establishing guiding vision and possible scenarios

Phase 3: Decision supporting



Step 5
Supporting decision making from design strategy set up

Phase 4: Strategy implementing



Step 6
Implement adaptive design strategies at the local level

In this chapter, we selected Northwest Overijssel as pilot region to test the adaptation pathway from regional decisions to local design.

CHAPTER

7.

PATHWAYS IMPLEMENTATION

Phase I: System Framing

Phase II: Vision Learning

Phase III: Decision Supporting

Phase IV: Strategy Implementing

Phase I: System Framing

Step 1: Describe the policy system, specific objectives, and identify the uncertainty

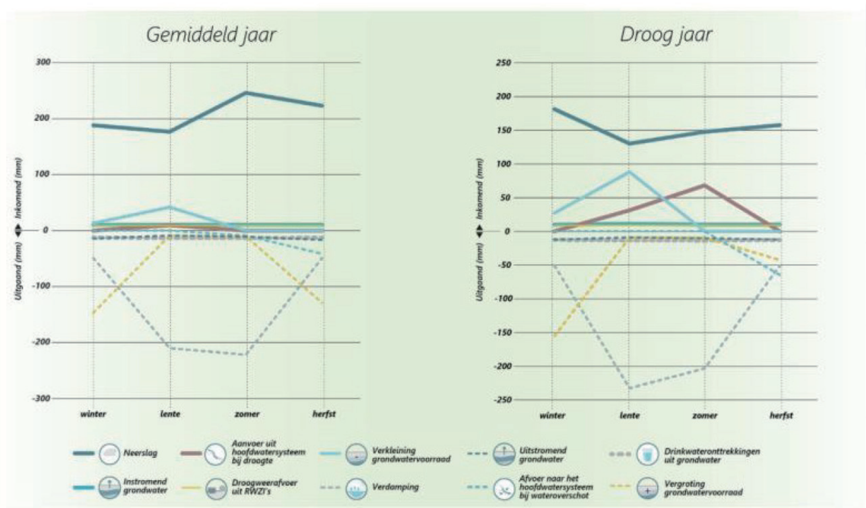
Pilot region Northwest Overijssel: Hydrological position in the IJsselmeer

Northwest Overijssel occupies a strategic position within the IJsselmeer water system, serving as a hydrological transition zone where major rivers meet the lake. The IJssel and Vecht rivers converge in this IJssel-Vecht delta area, delivering flows into Lake IJsselmeer (Ven & Van Tiel, 2021). This unique location means Northwest Overijssel functions as an interface between upstream river catchments and the IJsselmeer, which is "at the heart of Dutch water management" as a controlled freshwater lake (Delta programme, 2023). Due to the importance of IJsselmeer as a freshwater buffer supplying the surrounding provinces, Northwest Overijssel's situational context, in the IJssel-Vecht delta, makes it a critical node for managing water levels and flows in the IJsselmeer Region.

Political positon: priority "hotspot"

Northwest Overijssel plays a vital political and institutional role in Dutch climate-adaptive water planning. The national "Programmatic Approach to Large Waters" (Ministry of Infra-structure and Water Management [I&W], 2022) identifies the IJssel-Vecht delta (in North-west Overijssel) as a priority "hotspot" for ecological and hydrological system restoration. Reflecting its strategic importance, the region features prominently in national policy frameworks such as the Delta Programme which highlights the IJssel-Vecht Delta as a fo-cus area for climate resilience (Delta programme, 2023), as well as in the National Environmental Vision (NOVI). Fur-thermore, Northwest Overijssel serves as a multi-level governance interface, collaborating on integrated adaptation initiatives (Wageningen University & Research [WUR], 2021).

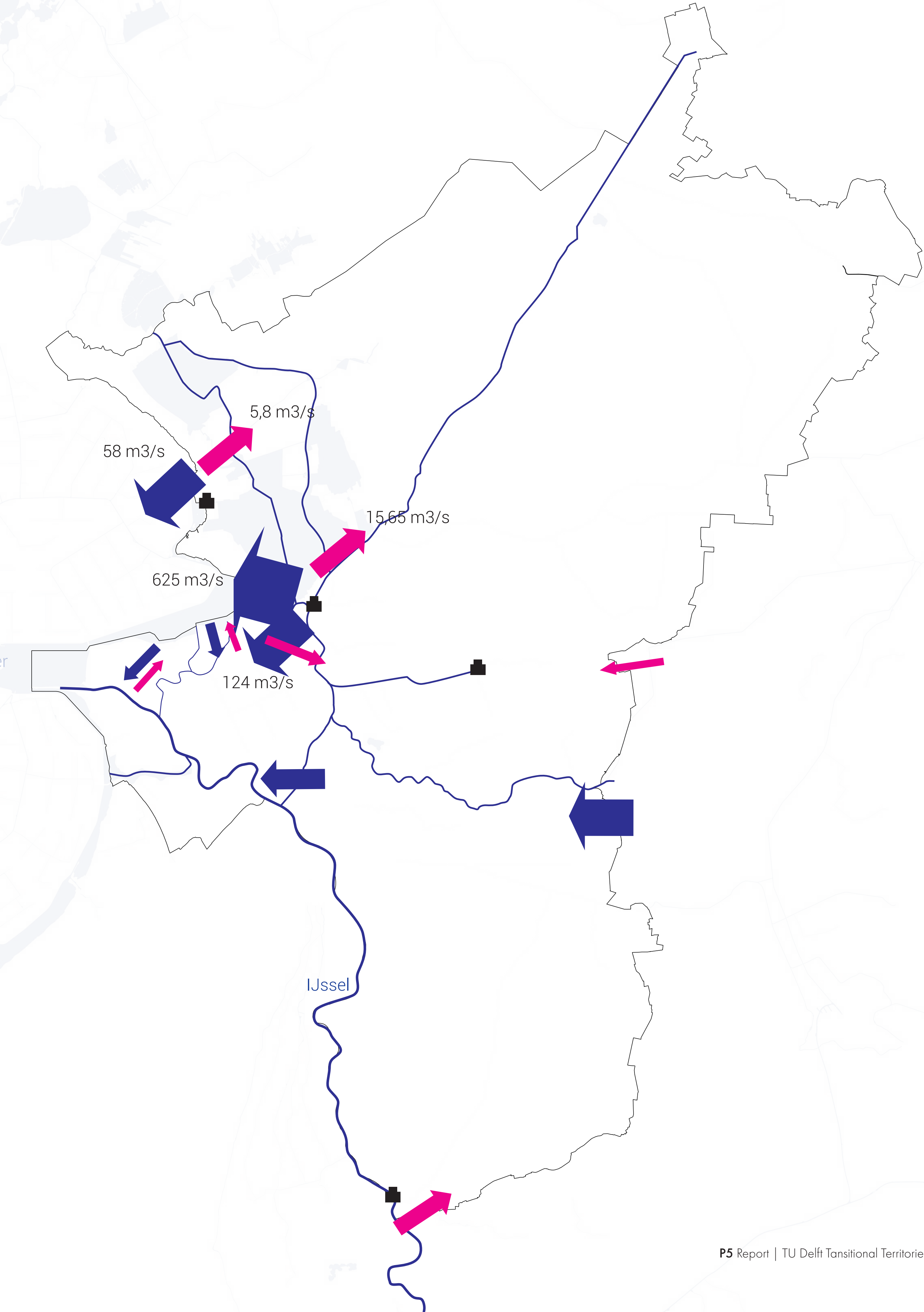
<Source:
Ministry of Infrastructure and Water Management. (2022). Programmatic Approach to Large Waters (Grote Wateren). https://www.grotewateren.nl
Delta Programme. (2023). Delta Programme 2023: Working towards a climate-proof Netherlands in 2050. Ministry of Infrastructure and Water Management. https://www.deltaprogramma.nl
Wageningen University & Research. (2021). Gebiedsgerichte aanpak voor klimaatadaptatie in de IJssel-Vechtdelta. Wageningen UR. https://www.wur.nl



<Figure 31, Seasonal graph of water balance Overijssel in an average and dry year (Redrawn from [Building block water and soil guiding in Overijssel, 2023])

>Legend

—	waterway
➡	Water discharge
➡	Water supply
■	Pumping station


5,8 m3/s
58 m3/s
15,65 m3/s
625 m3/s
124 m3/s
IJssel

Step 2: Assess the spatial system vulnerabilities, challenges and opportunities

Preconditions

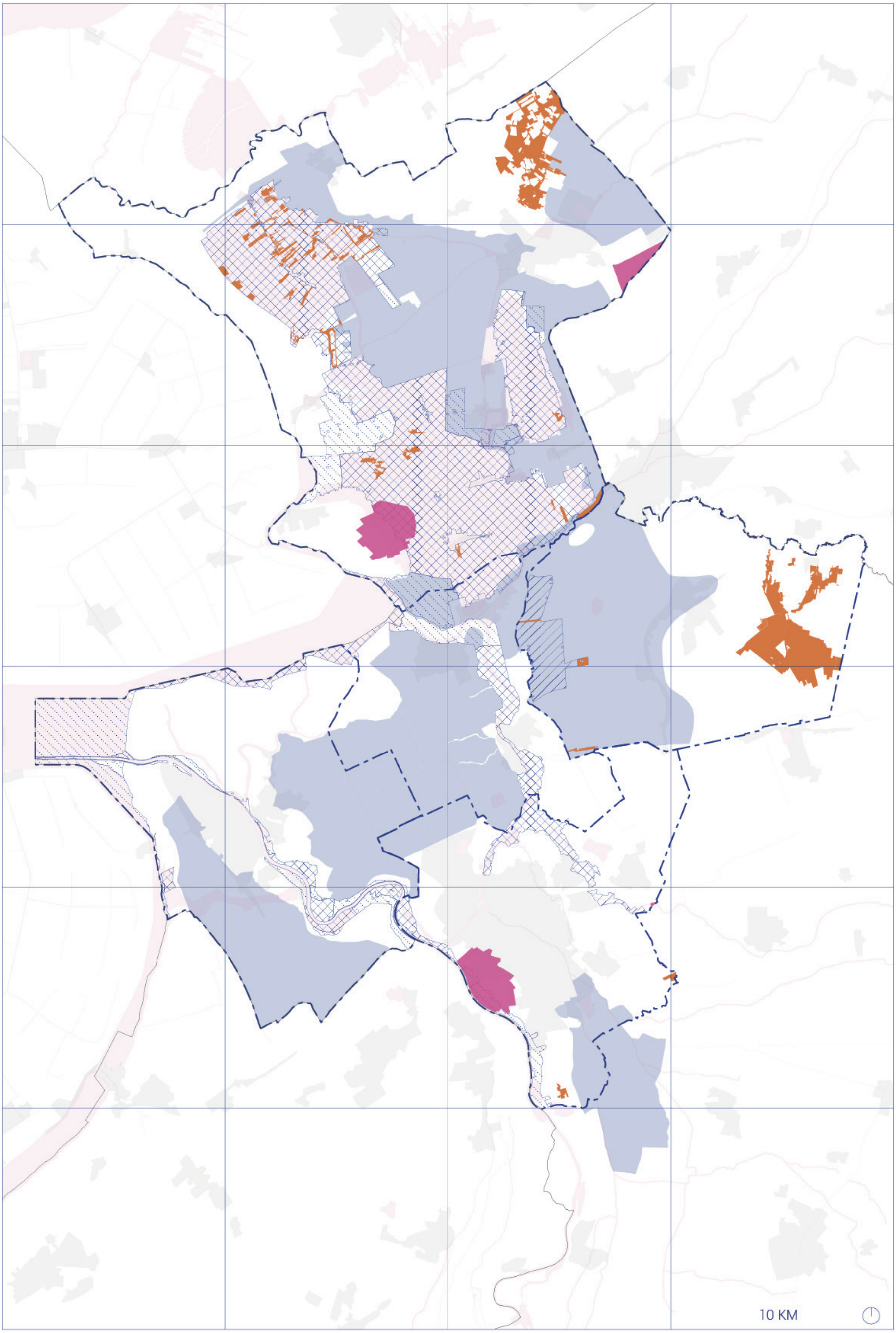
Freshwater availability

The Northwest Overijssel is now facing the vulnerabilities to freshwater scarcity under changing climate conditions. Northwest Overijssel is increasingly exposed to periods of summer drought and water deficits as climate change leads to more erratic precipitation and higher evaporation (Figure X). Moreover, Northwest Overijssel faces competing demands for the limited freshwater available. The area encompasses extensive agricultural polders and peat meadows, ecologically valuable wetlands, and growing urban centres, all of which require water. To be noticed, the Northwest Overijssel has the largest peat soil landscape in the Netherlands, which meet the highest challenge about more water irrigation to mitigate the effect of CO2 emissions.

Water safety

Northwest Overijssel's low-lying peat polder landscape faces twin water challenges: high flood risk and periodic freshwater shortages. The region's spatial configuration – a complex, vulnerable water system of peat wetlands and pumped polders – exacerbates these issues.

>Legend
□ Water
□ Province boundary
⌐ Municiple boundary
■ Low peat landscape
■ Groundwater protection area
■ Very vulnerable areas
Natura 2000 area
▨ HR
░ VR
▩ HR+VR


10 KM

Values

Northwest Overijssel is distinguished for its rich spatial qualities, merging extensive recreational options with a historic water landscape. Tourism is a significant catalyst: Giethoorn attracts thousands of visitors annually, prompting efforts to distribute them into the neighboring Weerribben-Wieden natural reserve. The region's infrastructure includes an extensive network of cycling routes and waterways.

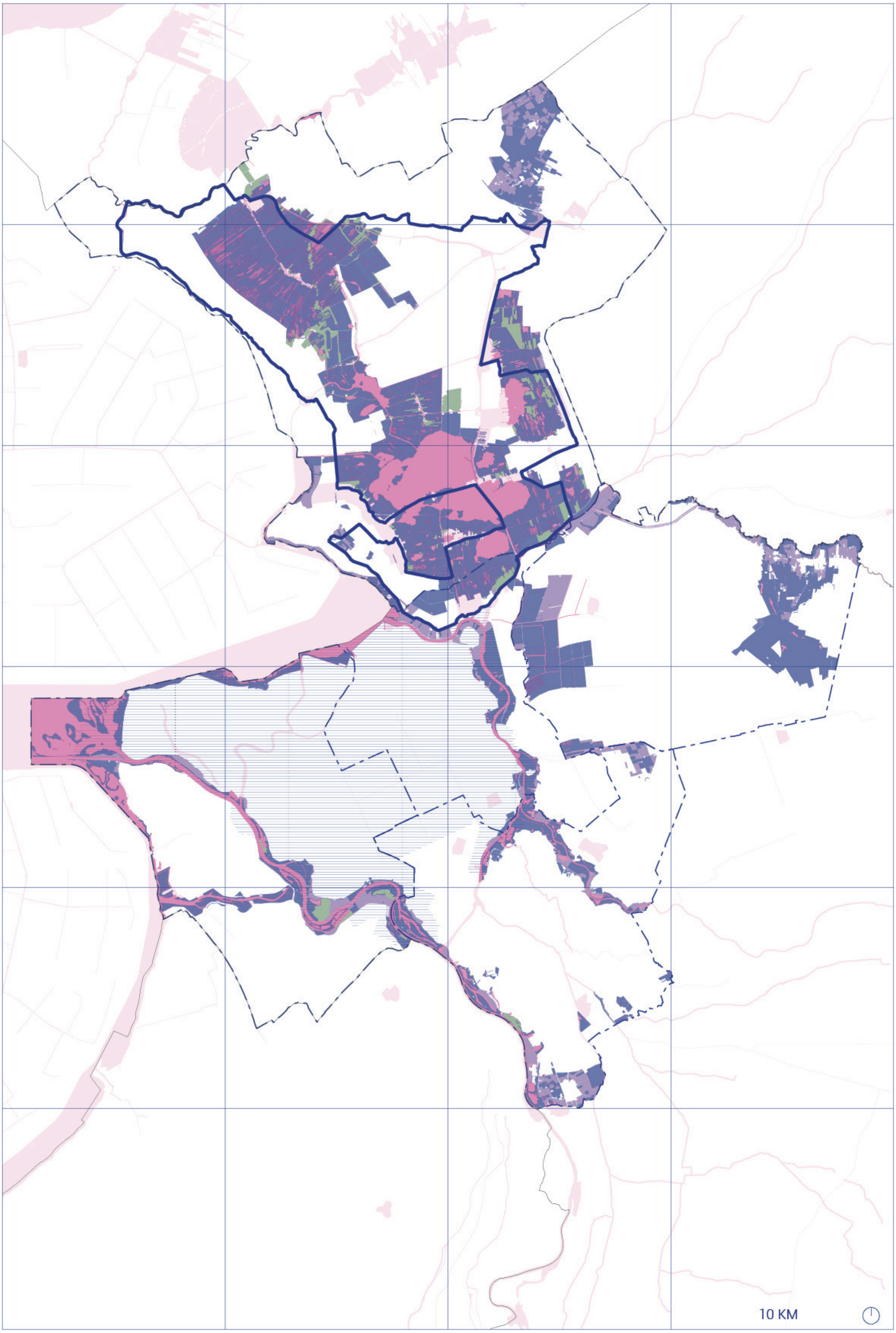
Together, De Weerribben and De Wieden form the most extensive and varied peat bog landscape in the Netherlands, encompassing a full succession of habitats from open water and reed marshes to swamp forest and wet meadows. As a National Park it is a core part of Natuurnetwerk Nederland (the national ecological network), serving as an important ecological corridor in the country's conservation framework.

>Legend

▭ Water
▭ Province boundary
┄ Municiple boundary

■ NNN Water
■ NNN Nature
■ NNN Dvelopment area natura 2000

▭ Bike routes
☰ National landscape IJssel-Vecht delta


10 KM

Activities

Livability and housing

As one of the most important NOVEX regions, it is crucial for Zwolle how to integrate living and working tasks with climate tasks and the water system. It is noted that the demand for water will increase due to the plan to increase the urbanization area to accommodate more people to live. From the NOVEX report (2024), by 2040, the Zwolle area will need 49000 houses and provide 20000 jobs, which pushes to a challenge for "climate adaptive urbanization".

Energy transition

Northwest Overijssel is expected to use more wind energy instead of coal and gas to produce electricity in order to meet the cleaner energy use, with a plan of 90 new wind turbines to be installed by 2030 at the latest (Province of Overijssel, n/i). This plan helps to improve the circularity in the economic and water system, creating the co-benefit for the living environment.

Economic function

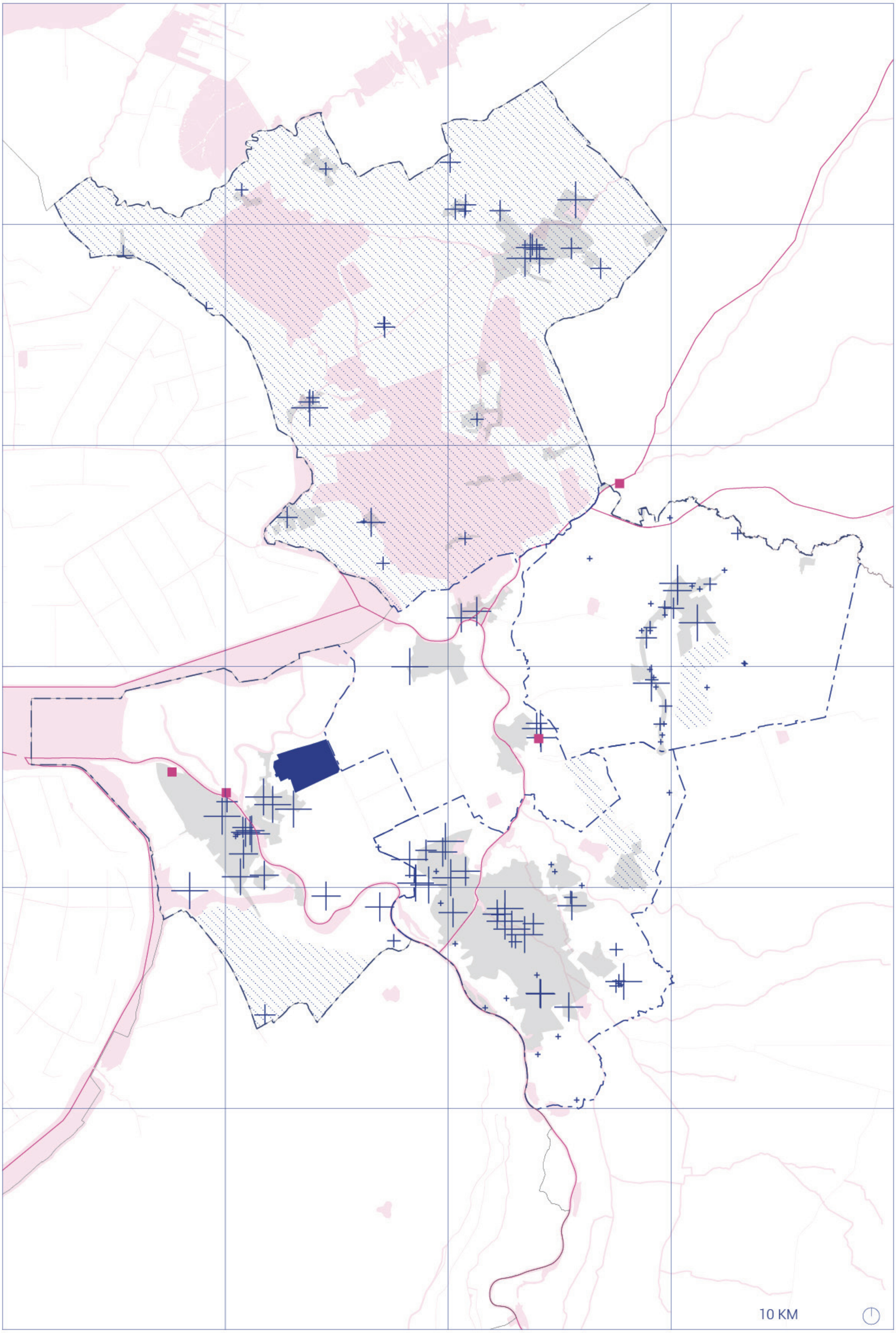
Port of Zwolle, the joint port authority of Zwolle, Kampen and Meppel, plays an important role in the logistics ecosystem. The ports act as hinterland for the main ports of Rotterdam and Amsterdam and are of great added value for the many SME manufacturing companies in the . In addition, the ports are an important link in the chain for the energy transition and the future circular economy.

<Source

Ministerie van Volkshuisvesting en Ruimtelijke Ordening. (2022, juli 1). Programma NOVEX [Rapport]. Rijksoverheid.nl. https://www.rijksoverheid.nl/documenten/rapporten/2022/07/01/programma-novex

>Legend

▭ Water
▭ Province boundary
⬚ Municiple boundary
■ Greenhouse horticulture
■ Port
▨ Potential wind enegy area
+ Planned new housing area


10 KM

Phase II: Vision Learning

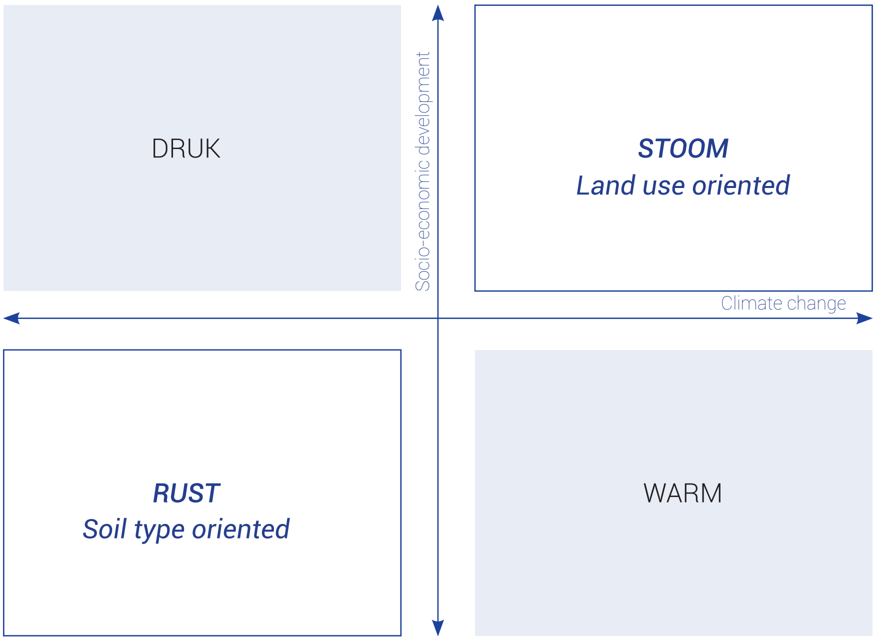
Step 3: Establish guiding vision and possible scenarios

Northwest Overijssel faces growing pressure from dual uncertainties: climate change intensifies droughts, floods, and salinization, while socio-economic development increases competition for land and freshwater. Its low-lying peat landscape depends on the IJsselmeer system but struggles to balance water safety and availability. Despite national attention, the region lacks a spatially adaptive framework to address freshwater buffering under future extremes, requiring integrated strategies across scales and scenarios.

To respond to uncertainty, in 2050, two scenarios are constructed on the basis of possible future developments and transition towards water circularity future. The secnarios explore developments of national and regional trends and how they influence the freshwater buffer capacity. The scenarios are based on the decision of Delta scenario on the following developments:

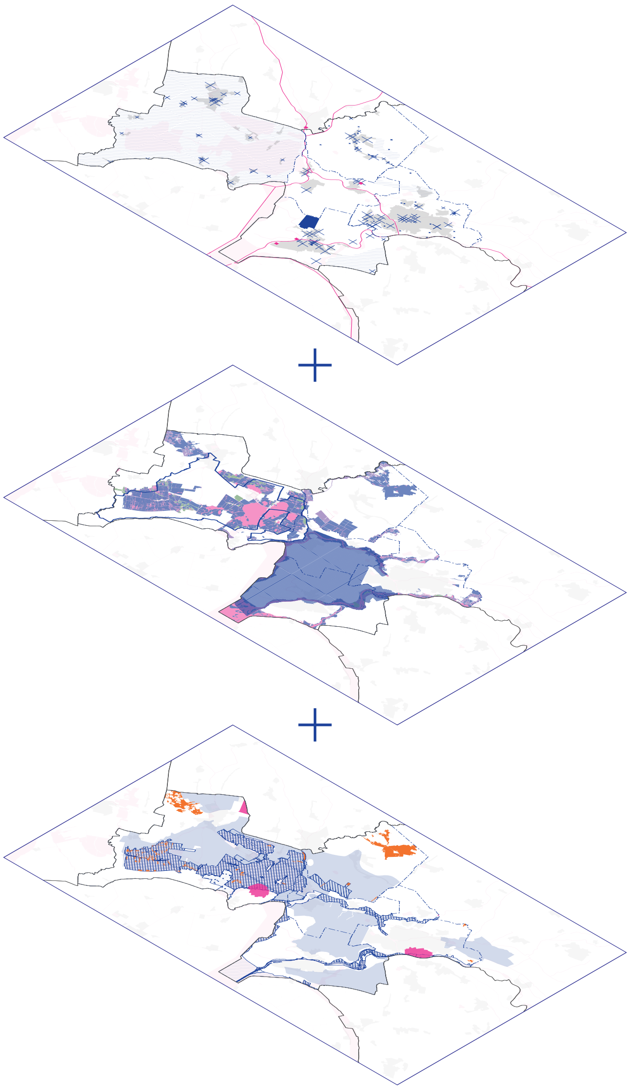
- *STOOM* is a scenario which develop with the priority of *land use* set up for the more water-efficient circular future to support more economic activities.

- *REST* is a scenario which develop with the priority of *soil type* set up for the more nature-inclusive circular future.



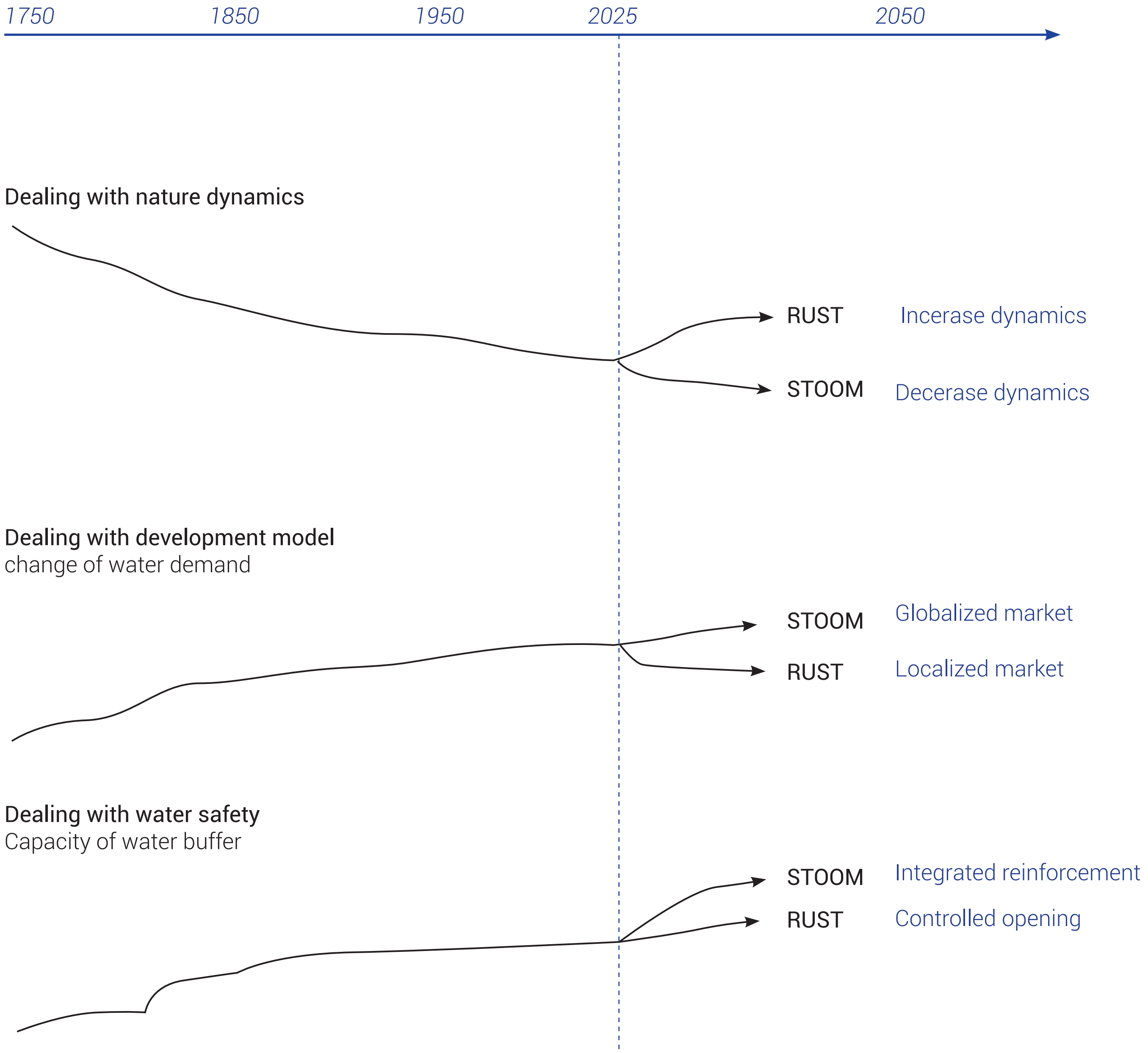
Current

2050



STOOM

RUST


1750
1850
1950
2025
2050
Dealing with nature dynamics
RUST
Incerase dynamics
STOOM
Decerase dynamics
Dealing with development model
change of water demand
STOOM
Globalized market
RUST
Localized market
Dealing with water safety
Capacity of water buffer
STOOM
Integrated reinforcement
RUST
Controlled opening

<Figure 32, Three timelines of the principle system mechanisms

Scenarios set up

Three timelines of the principle system mechanisms were developed (Figure 32). These timelines take their basis in historical progress and examine future possibilities based on projections and hypothesis. They may continue into the future along the same lines as they have in the past, or there may be a transition.These timelines are extended to the two future scenarios. These are utilized in the development and analysis of the regional map and evaluation of the scenarios.

Step 4: Define an integral set of guiding principles

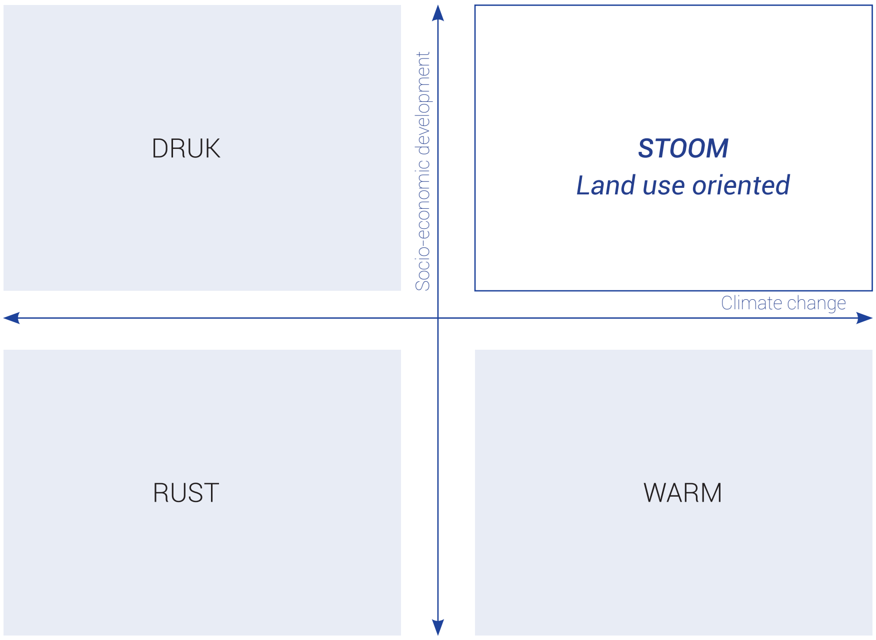
Elaboration of STEAM scenario model

Systemic position in the IJsselmeer Region

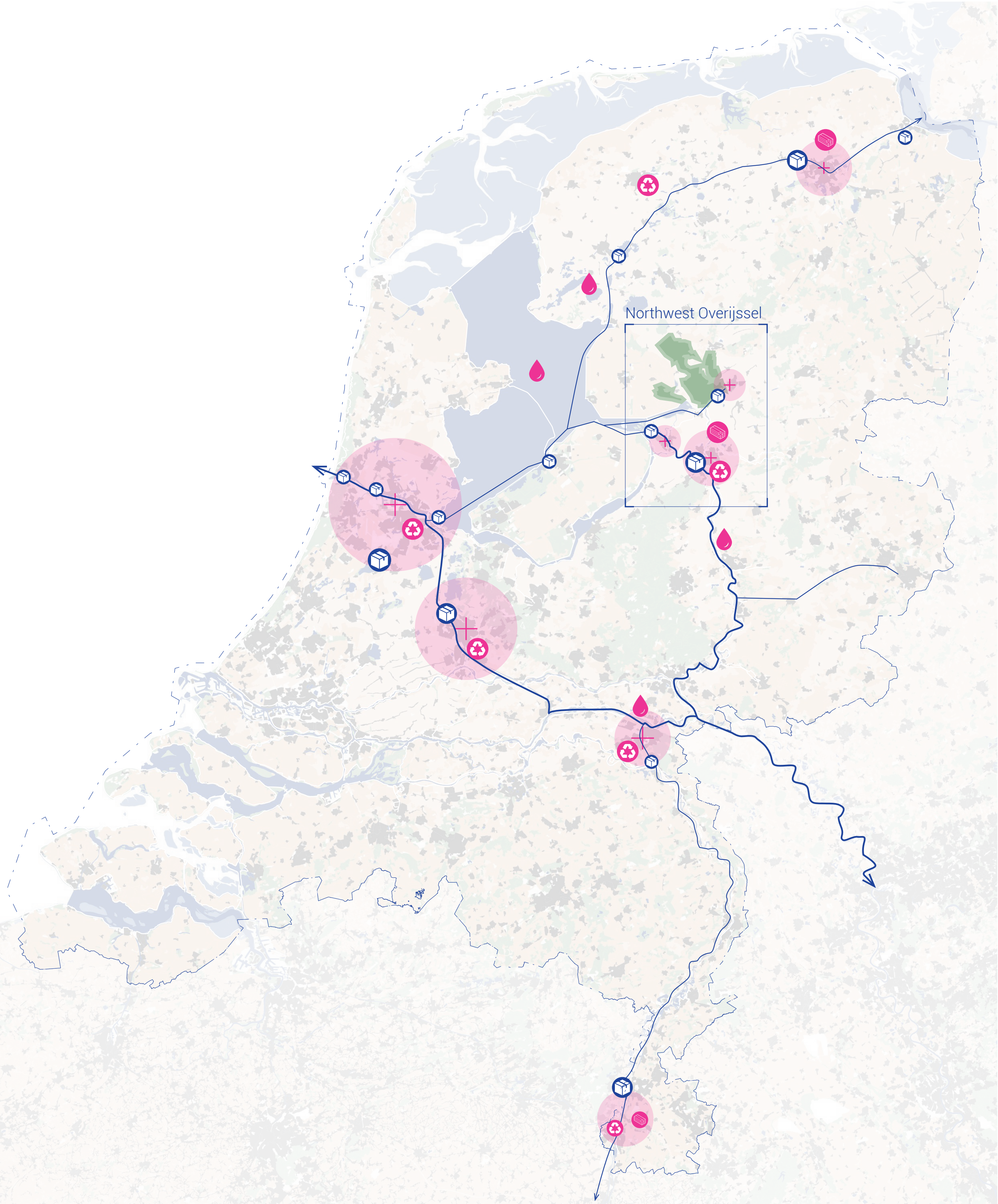
1. Water loop: Reuse water through cross-boundary corporation to improve water circularity, reaching Energy-Food-Water Nexus. City can be considered as circular center to recycle water, taking water as a resource

2. Co-benefit: Independent function for rural and urban area, to develop various function of water infrastructure such as multifunctional dikes to expand the extra value of space

3. Future-proof: Focus on climate adpative construction including housing and infrastructure, such as "floating housing"



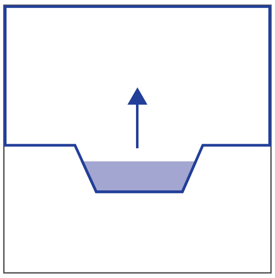
> Figure 33, Regional STEAM scenario model (By Yiyan Zhou)


Northwest Overijssel

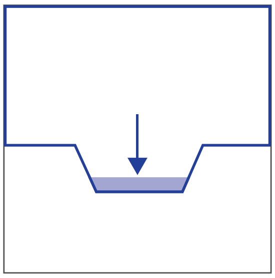
Adaptive principle

WATER MANAGEMENT
& INFRASTRUCTURE

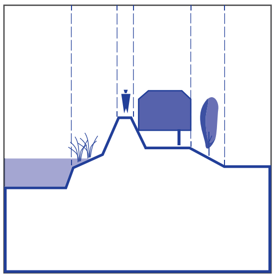
G1 Climate adaptive water level
G2 Climate adaptive infrastructure



High water level



Low water level

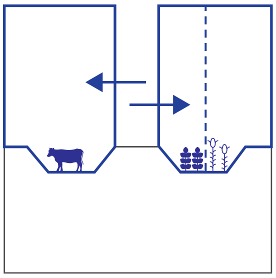


Multifunctional dike

In the category of water management and infrastructure, due to economic growth, more types of land use would be considered as productive landscape, which requires different height of water level. Meanwhile, with increasing spatial tension, water infrastructure should be applied in various spatial uses such as housing, recreational areas and also nature habitat.

AGRICULTURE
& LAND USE

G3 Nature-inclusive agriculture
G4 Balancing sustainable land use

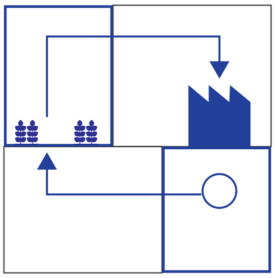


Agro-pasture rotation

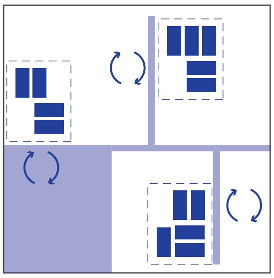
To ensure soil fertility and sustainable agricultural production, an economic model for crop rotation should be selected under a high economic development model.

WATER-BASED
ECONOMY

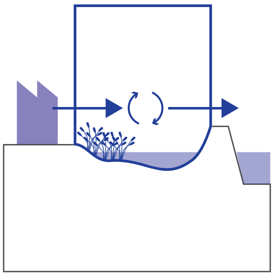
G5 Close the water loop
G6 Efficient economic structure



Cross-sector water cycle system



Crossing boundary water-economy systems



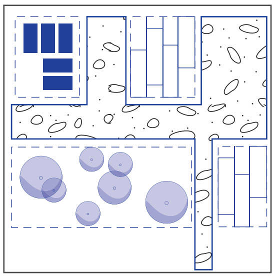
E1c Eco-integrated water purification system

- Establish transition zones in polluted water bodies to achieve decentralized treatment, recycle gray water, and prevent secondary pollution at the final discharge point.

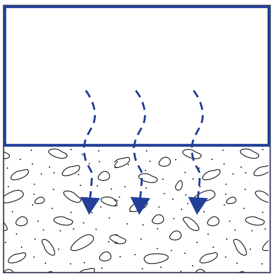
-Higher efficiency water use within and between sectors

ECOLOGU &
BIODIVERSITY

G7 Systemic ecological landscape



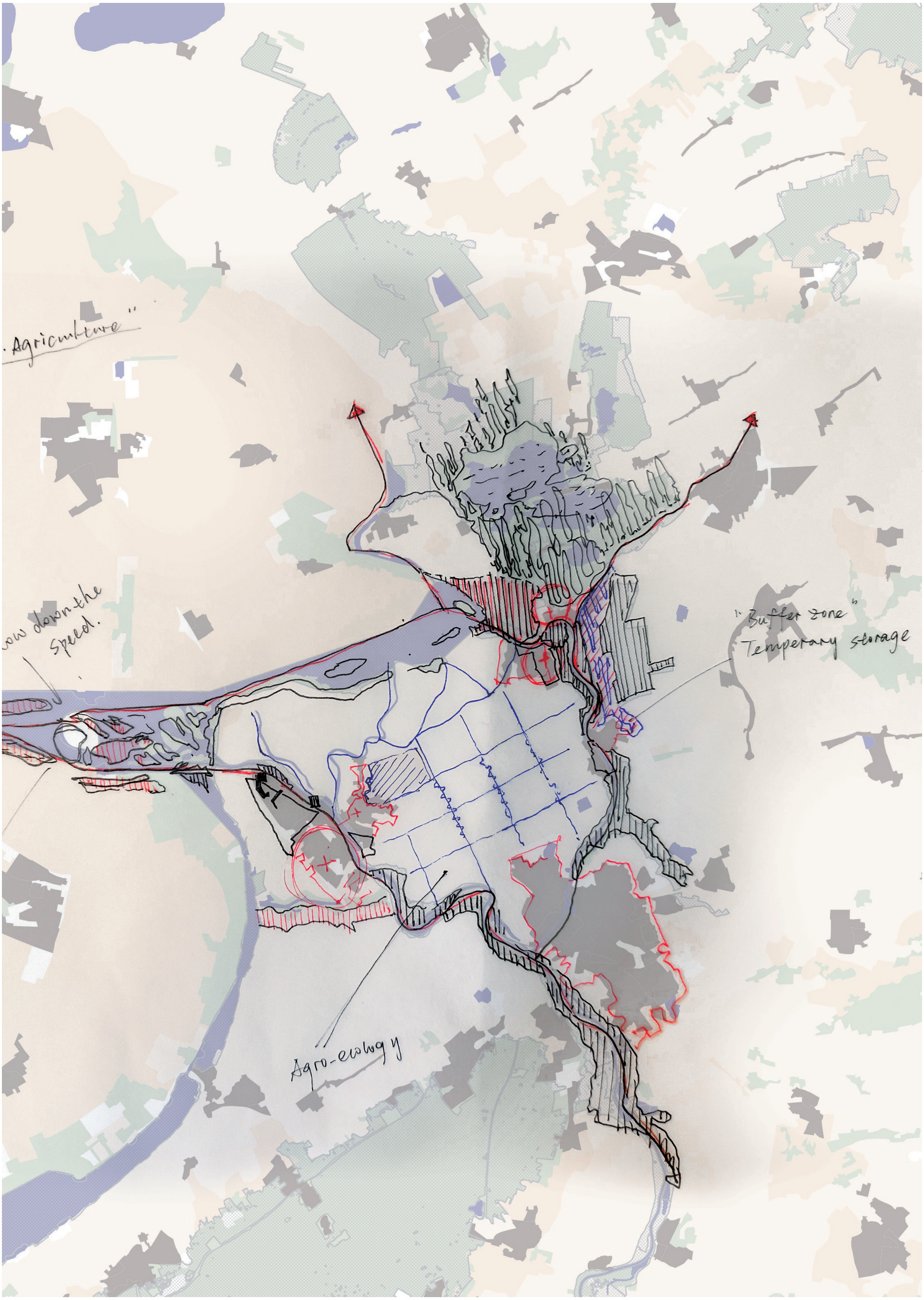
Ecological water quality buffer strip



B1b Adaptive sponge landscape

-Improve the filtration of water, to recharge the aquifier better, keeping ecosystem heathier

-Applying buffer zones to separate areas with different water quality

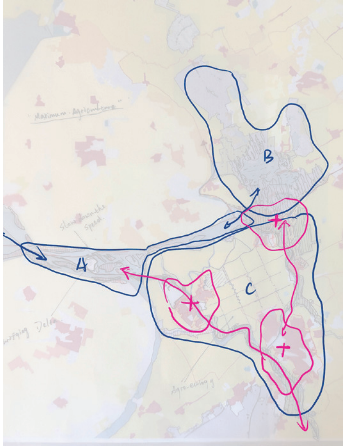

. Agriculture "
ow down the speed.
" Buffer zone "
Temperary storage
Agro-ecology

STEAM | High efficient Northwest Overijssel

1.Socio-economic development: In this scenario, the emission are only partially reduced due to increasing economic activities such as waterway transportation from IJsselmeer to Zwolle and then to more aborad. More economic activities mean the water quality would be a bottleneck that prevent to reach the circularity, which require to facilitate the ketel delta and river riparian zones as purifying landscape to clean up the polluted water and help to reuse cross the sectors. Meanwhile, we propose buffer area to seperate areas with different water qualities to ensure the resilience of freshwater buffer capacity.

2. Climate change: As a result, climate change continues beyond 2050, which means more extreme weather and temperature increases (by 1.6°C in 2050). During the dry period, the water discharge from the river IJssel will be less and the flood discharge are increasing by 7-10%. To decrease the emission of peatland, the area is considered to rise the water level so that more freshwater distribution would be considered for agriculture.

3. Water task: With rising demand of water that mainly from the growth of population and economic activities due to the globalization and urbanization, the water distribution would be considered more.



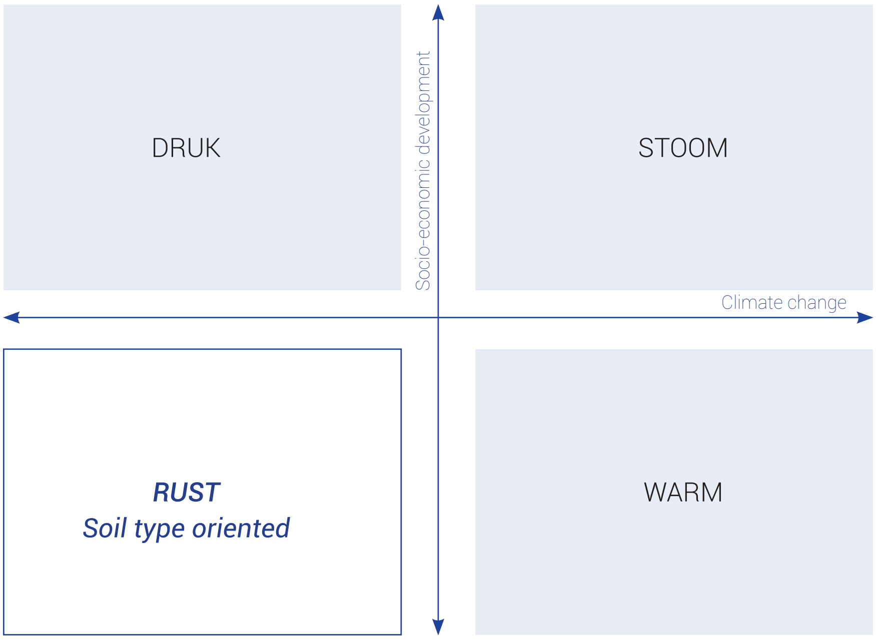
Elaboration of RUST scnario model

Systemic position in the IJsselmeer Region

1. Water loop: Emphasizing the dynamic exchange between natural and constructed hydrological systems, this objective promotes decentralized water retention, reuse, and circulation across spatial scales.

2. Co-benefit: Recognizing human society as an integral component of nature, allowing for in restoring constructed spaces to aquatic or ecological habitats, consequently enhancing the value of nature in reviving the living environment.

3. Future-proof: Focus on nature-inclusive living environment, encouraging to integrate nature-based solution with constructions



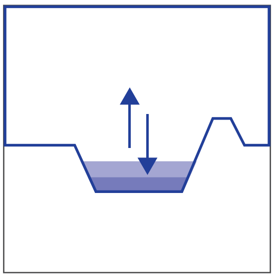
> Figure 34, Regional RUST scenario model (By Yiyan Zhou)

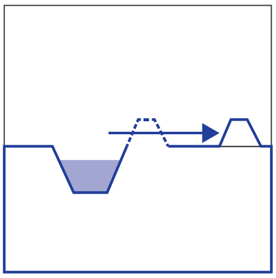

Northwest Overijssel

Adaptive principle

WATER MANAGEMENT
& INFRASTRUCTURE

W1Climate adaptive water level
W2 Climate adaptive infrastructure

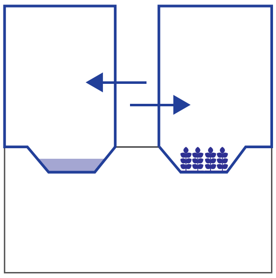

W1c Flexible water level

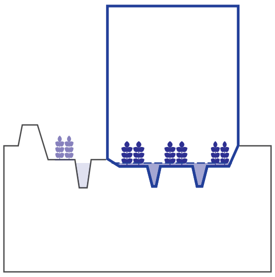

W2c Transboundary depoldered area

-More robust ecosystem with a combination of water level

AGRICULTURE
& LAND USE

A1 Nature-inclusive agriculture
A2 Balancing sustainable land use


A2b Rotation water buffer farming

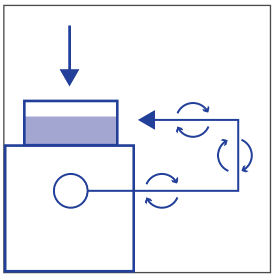

A1a Paludiculture

-Give more space for water

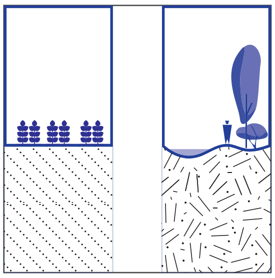
-Encourage water-inclusive agriculture form to adapt to cilmate uncertainty

WATER-BASED
ECONOMY

E1 Close the water loop
E2 Efficient economic structure



E1a Decentralized water reuse

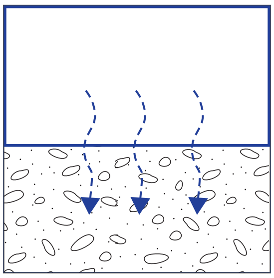


E2a Water sensitive economic zoning

-Separating economic zones to keep the basic value of freshwater buffer

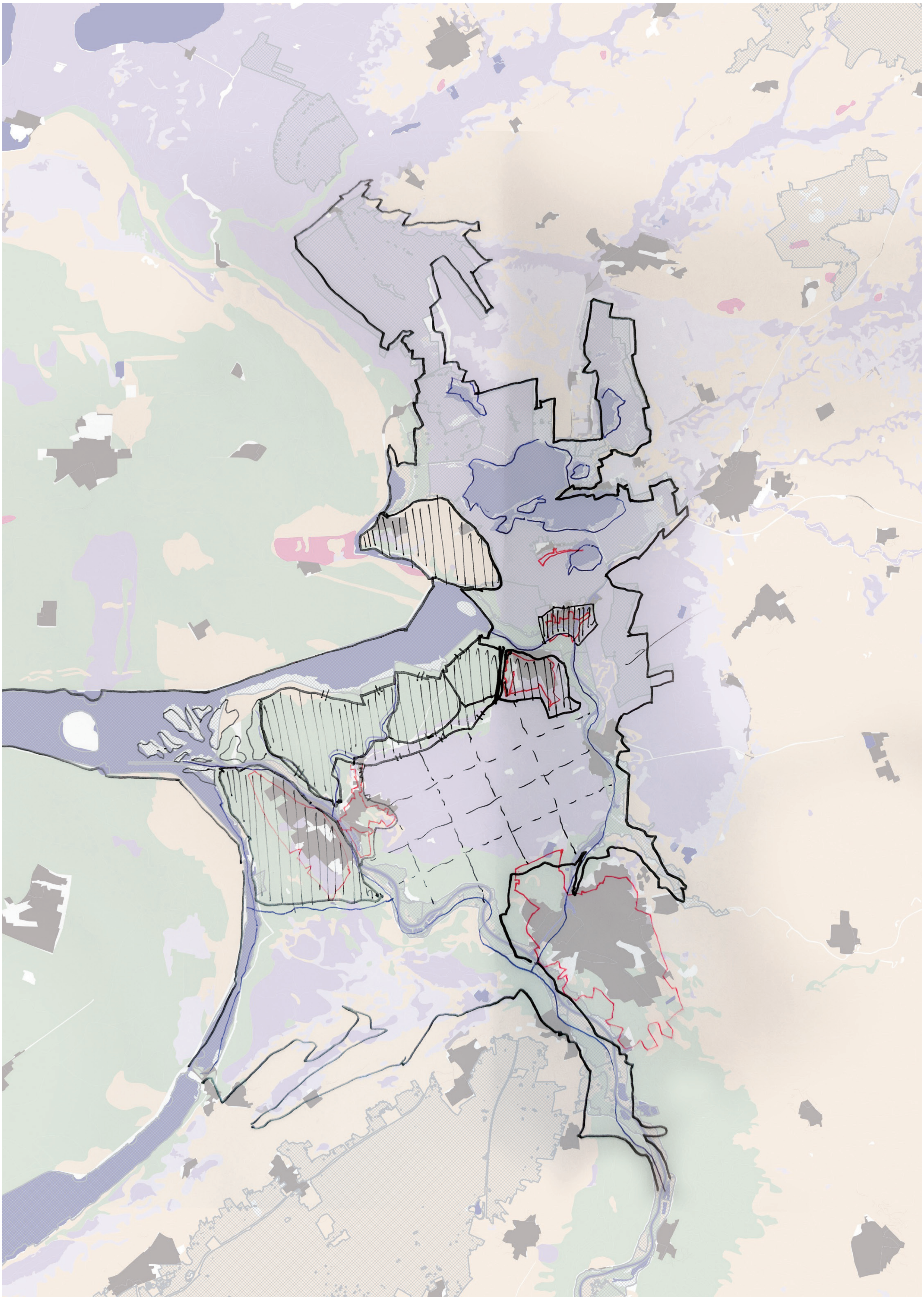
BIODIVERSITY
& ECOLOGY

B1 Systemic ecological landscape



B1b Adaptive sponge landscape

-Improve the filtration of water, to recharge the aquifier better, keeping ecosystem heathier

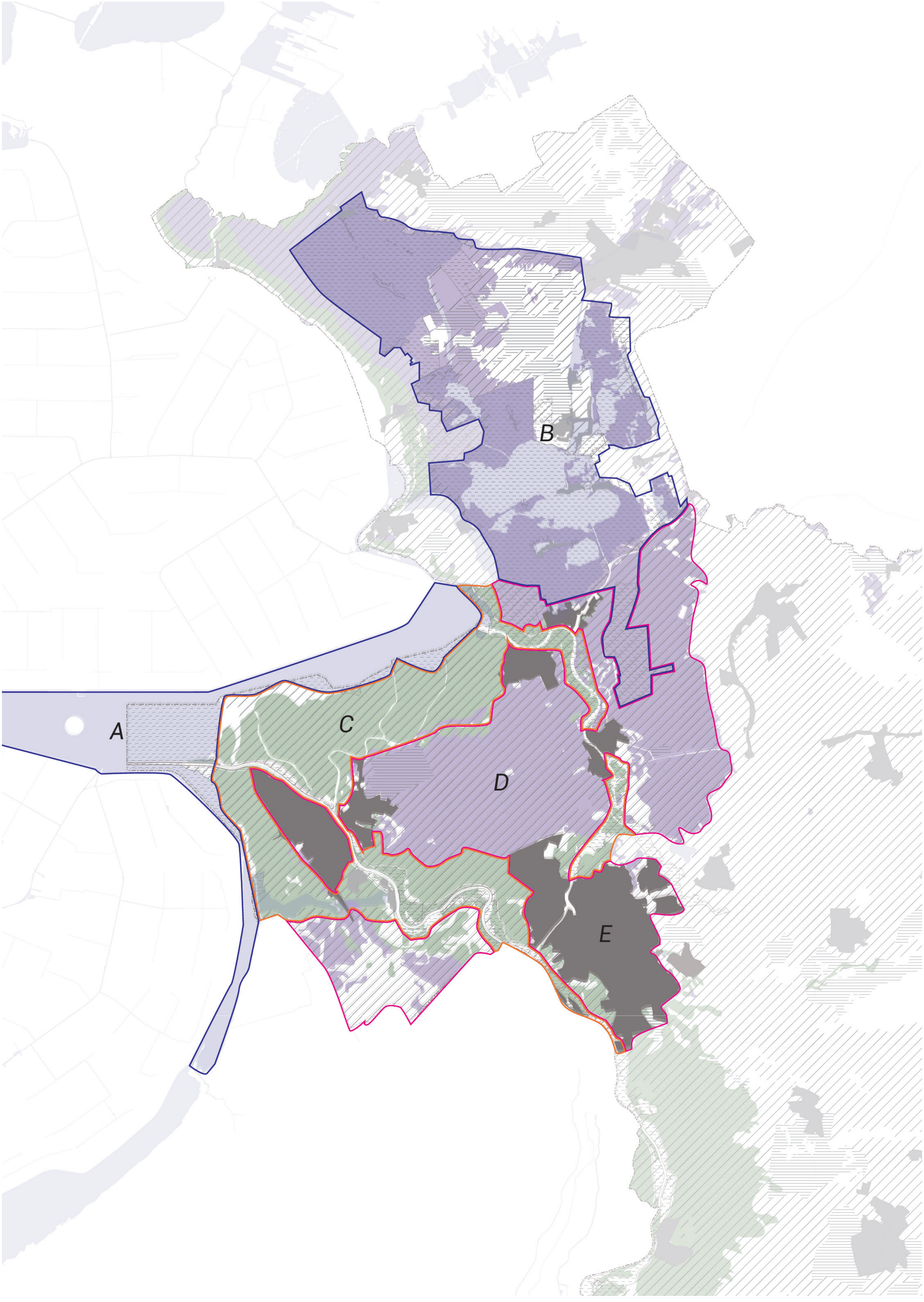


RUST | Self-sufficient Northwest Overijssel

1.Socio-economic development: In this scenario, the population size decrease initially slightly, but will start to decrease after 2040 to 17.9 million in 2050. The nature network is realized and further expanded, increasing the area of nature. Economic growth is moderate and less transportation would make more localized market.

2. Climate change: In this scenario, global greenhouse gas emissions are significantly reduced, limiting the global temperature increase to 1.7°C above pre-industrial levels, well below 2 degrees. It also allows for a higher water level within the peatlands, suggesting that water-inclusive and nature-inclusive forms of agriculture should be promoted through agricultural practices. The urban and rual areas are considered as a part of nature to adapt the climate change, which allowing the depoldering construction works happen and requires more nature-based living environment.With the aim of nature-inclusive future, and the projection with rising precipitation in the wet winter, the scenario proposes to create more nature space for water.

3. Water task: Even in this scenario, the task becomes to distribute freshwater to all functions increasingly difficult, while the task of combating flooding is also increasing.


A
B
C
D
E

Phase III: Decision Supporting

Step 5: Support decision-making from design strategy setup

Identifying critical areas

"Trying to predict the future is pointless, anticipating possible development is crucial." By overlapping multiple scenarios, it is possible to capture the diversity of challenges that sub-areas may face under different circumstances. This approach reveals the complexity and variation of challenges across regions in response to different scenarios.

Three distinct types of areas emerge from the overlapping of scenarios: 1) Areas where the challenges remain the same across different scenarios, indicating stability and consistency in the region's future; 2) Areas where change occurs in one scenario but not in another, highlighting vulnerability that only manifests under certain conditions; and 3) Areas where the challenges differ in each scenario, demonstrating the potential for multiple pressures and the need for adaptive strategies. This method of scenario overlapping allows for a more nuanced understanding of regional challenges, providing a foundation for more effective planning and adaptation.

<Legend

Category A & B

Areas that do not change in either scenario

▨ Peat land

■ Water system

▨ Natura 2000 area

Category C

Areas that change in one scenario and not in the other

▨ River clay land

▤ Intensive agriculture

■ River clay land

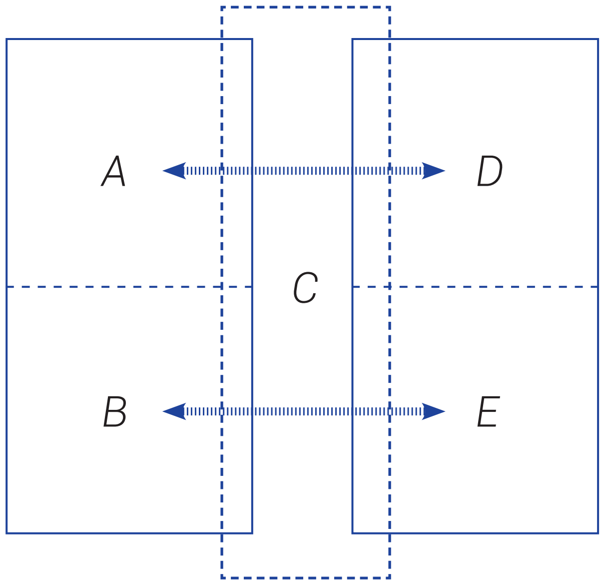
Category D& E

Areas that change in both scenarios, but in different ways and under the influence of different drivers

■ Built area

■ Peat land

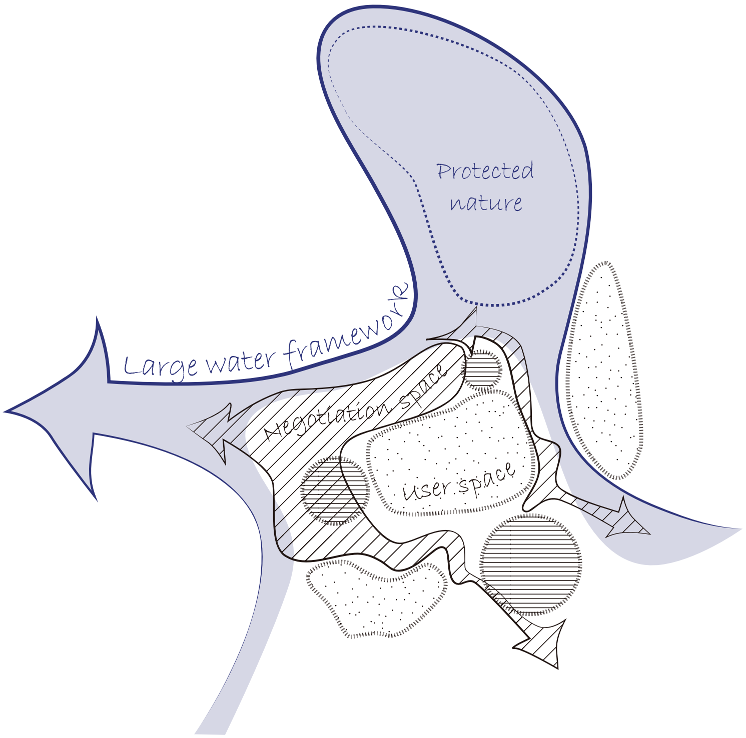
▨ Pasture

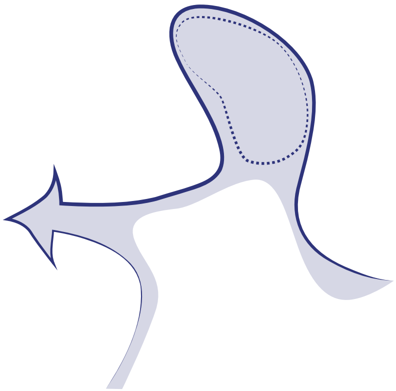


A: 1=2
B: 1≠2
C=D: 1or2

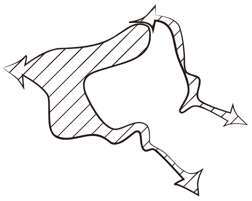
Sub-area typologies

To ensure the path of the field, the research then divides five sub-areas specifically, based on critical challenges into three kinds of catagory of sub-area the structure of the sub-area are represented by the CASCO concept.

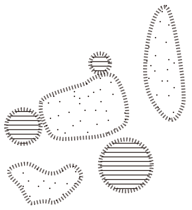




Large water framework



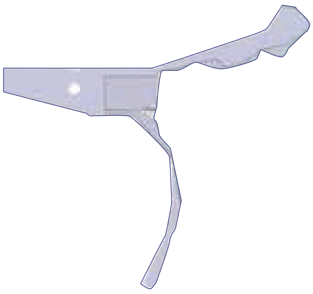
Negotiation space



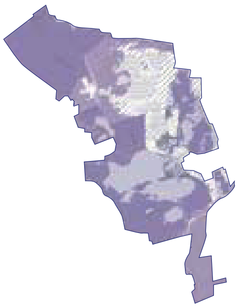
User space

Structure of design

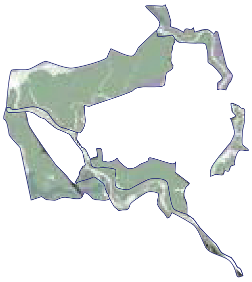
In order to achieve the ambition of water circularity, the research set up a spatial structure with three different spaces. These spaces were based on different roles of space in relation to water quality, quantity, and safety. The areas in consideration are dynamic in synergy, with the large water framework serving as the base water buffer. Expansion of capacity is achieved through the adjustment of local functions in specific areas.



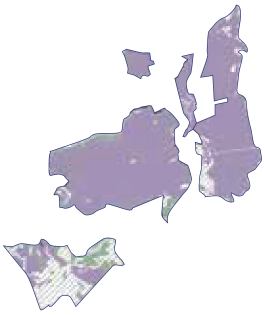
Inner delta
acts as an exchange interface with the lake at the downstream end of the river



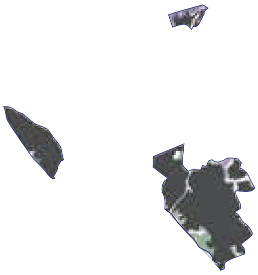
Protected nature
acts as the largest hydrological stablization area that ensure the basic freshwater buffer capacity



Clay river landscape
acts as an exchange interface with the other two types of areas, conditions changeing frequently due to different tasks of surrounding areas



Peat landscape
acts as a functionality area with mainly agriculture use, transition depends on the condition of negotiation space



Built area
acts as a functionality area with mainly urban area, transition depends on the condition of negotiation space

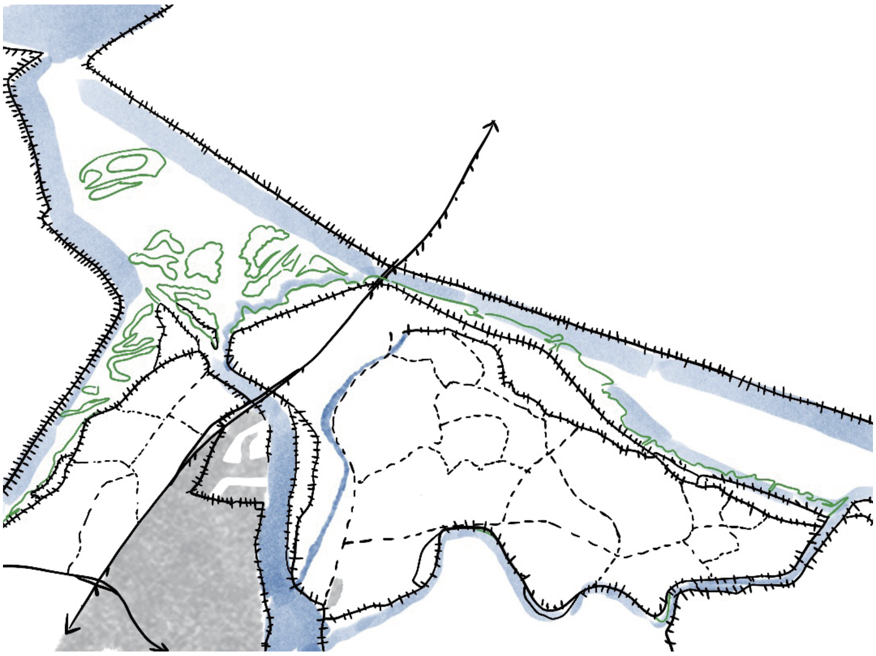
Phase IV: Strategy Implementing

Step 6: Implement adaptive design strategies at the local level

<u>Adaptive design</u>

The adaptive design phase marks the final step in the adaptation process, where the principles and challenges identified in earlier stages are synthesized to develop effective spatial measures. This stage bridges theoretical insights with practical solutions by integrating the challenges posed by various scenarios with the underlying principles of adaptation. The goal is to identify and implement spatial strategies that not only address the identified challenges but also enhance resilience and sustainability. By considering the specific characteristics of each area, adaptive design allows for the development of context-specific solutions that can evolve over time, ensuring the long-term viability of the space in the face of dynamic environmental and social pressures.

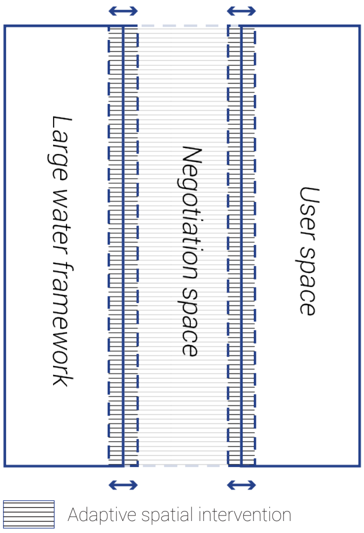
The keteldelta and surrounding area are chosen to be a case study area to apply the possible steps of measures (Figure 35).

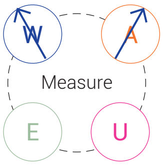


<Figure 35, current condition of zoom area
(By Yiyan Zhou)

Measure 1: Focus on dike reinforcement and pumping capacity

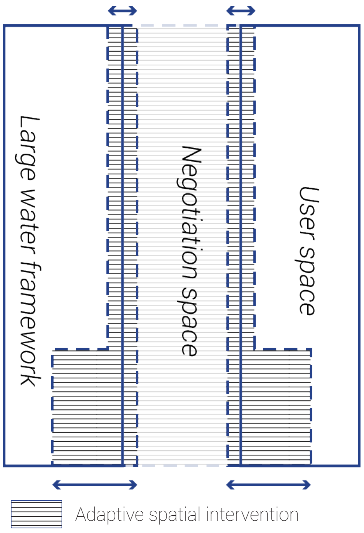
To save productive landscape as much as possible, keeping intensive agriculture partially and start to refuse high polluted form of economic production, meanwhile to develop the diverse function of dike.

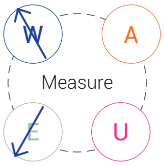




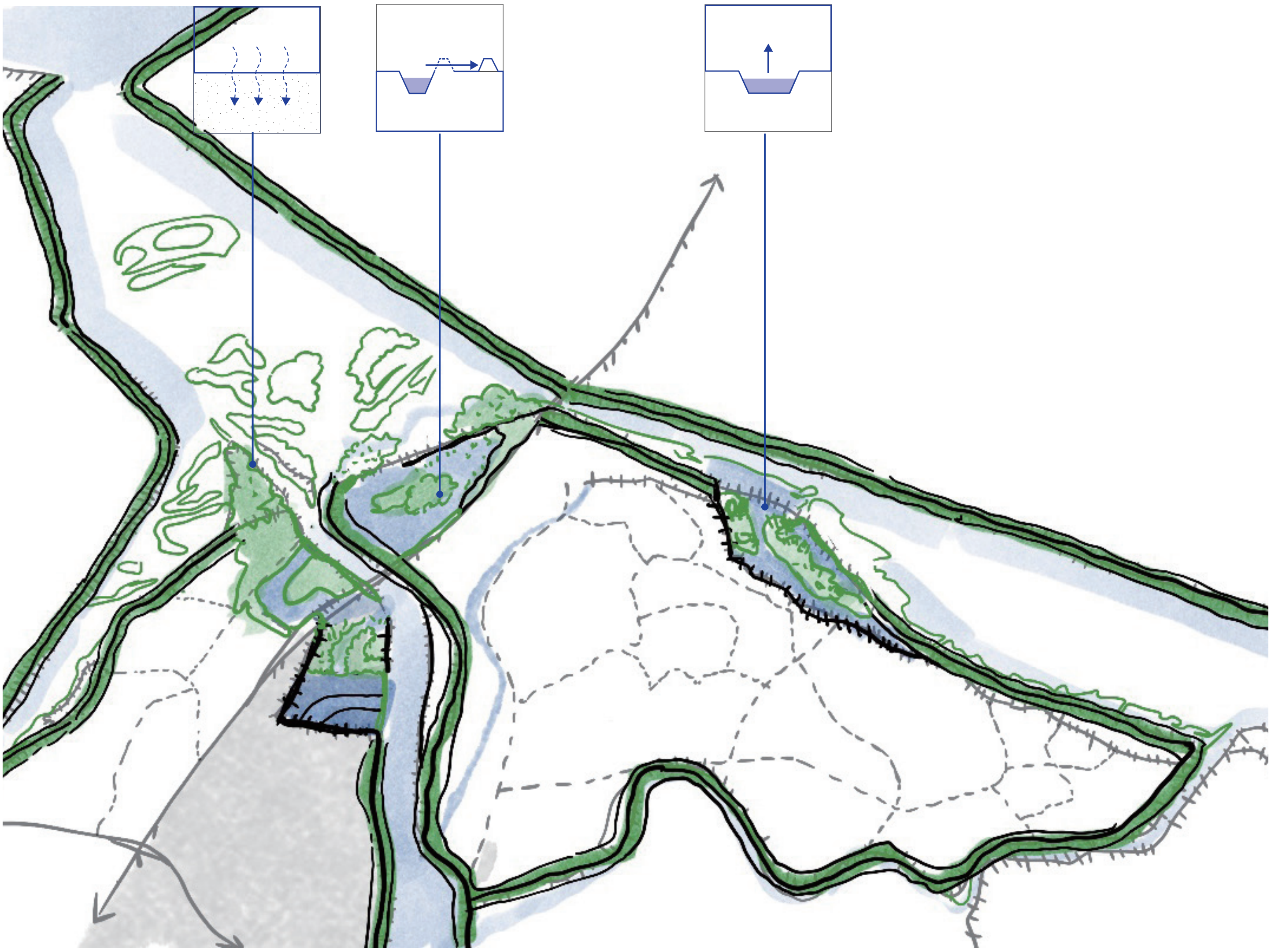
Legend
Main challenges to tackle with
W: water management & Infrastructure
A: Agriculture & Land use
E: Ecology & Biodiversity
U: Urban & Economic development

Measure 2: Polder delta

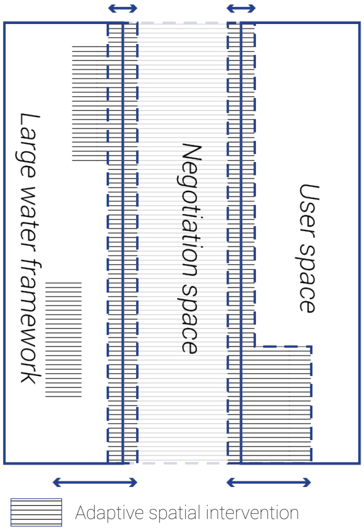


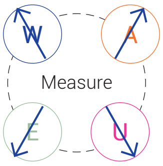


Legend
Main challenges to tackle with
W: water management & Infrastructure
A: Agriculture & Land use
E: Ecology & Biodiversity
U: Urban & Economic development

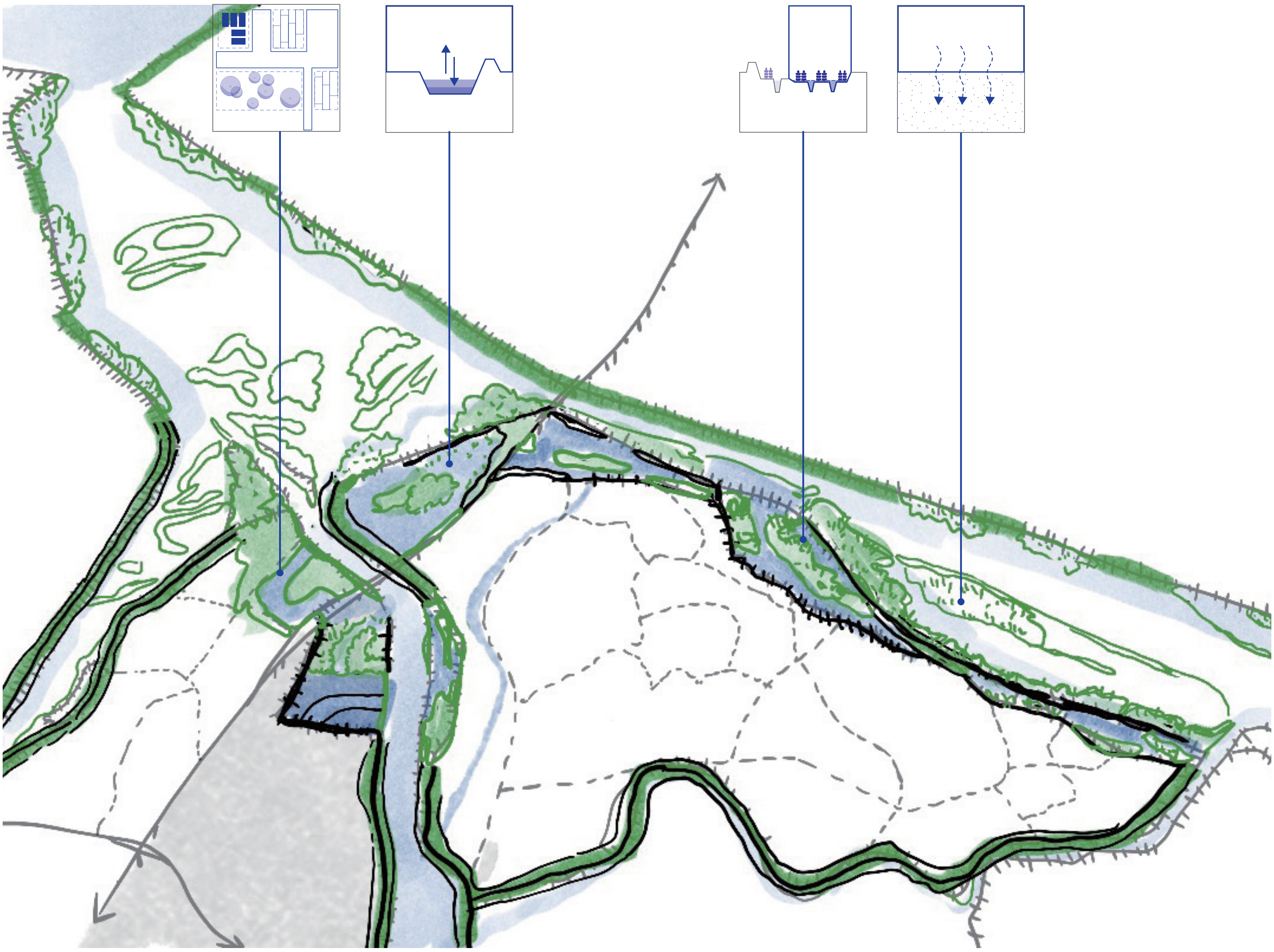


Measure 2: Buffer delta

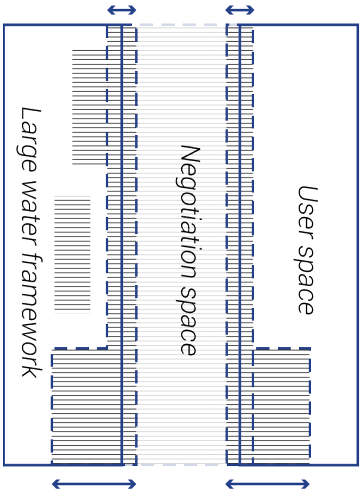




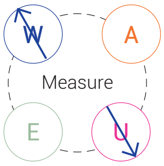
Legend
Main challenges to tackle with
W: water management & Infrastructure
A: Agriculture & Land use
E: Ecology & Biodiversity
U: Urban & Economic development



Measure 4: New energy delta



▤ Adaptive spatial intervention



Legend

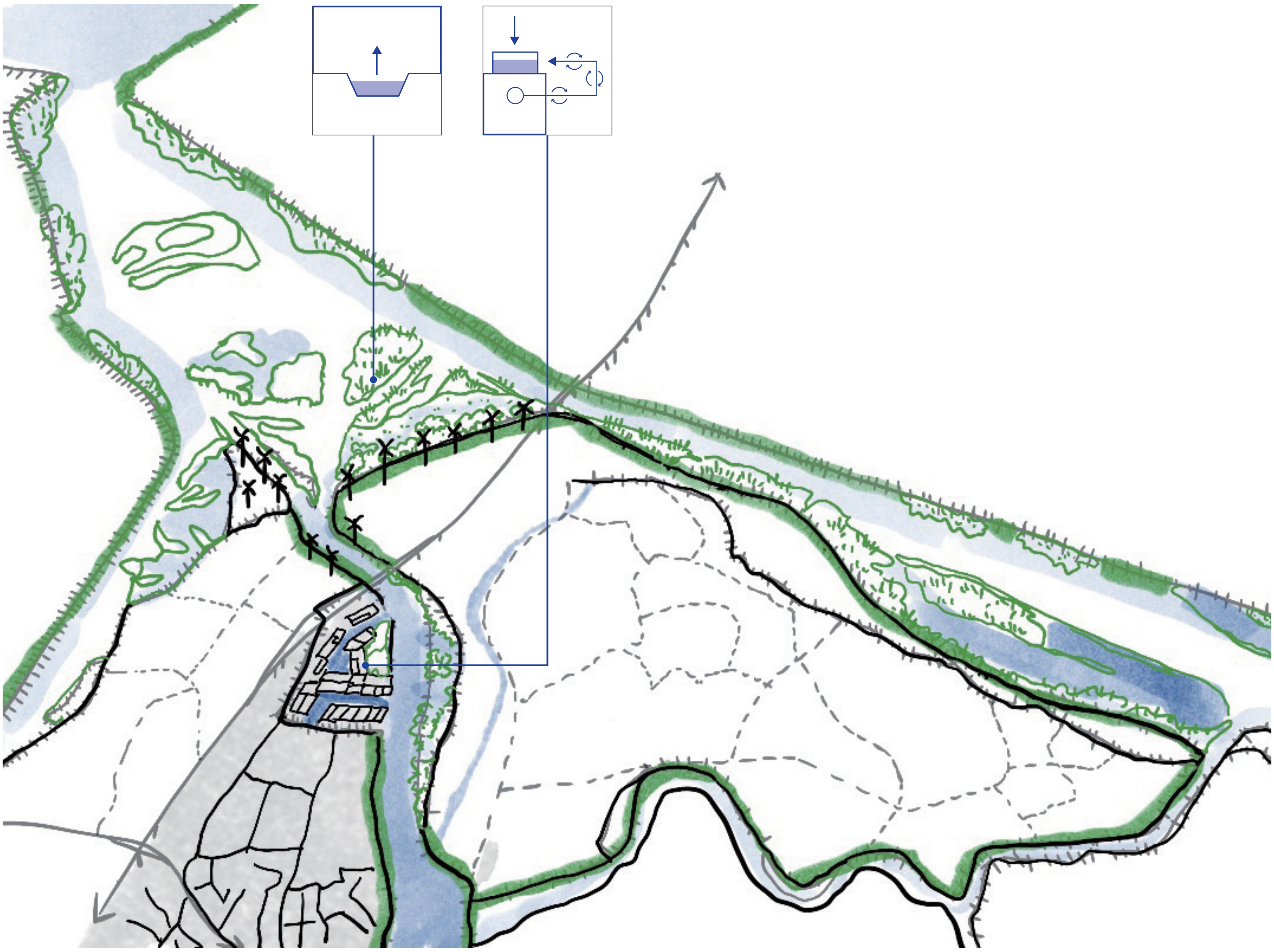
Main challenges to tackle with

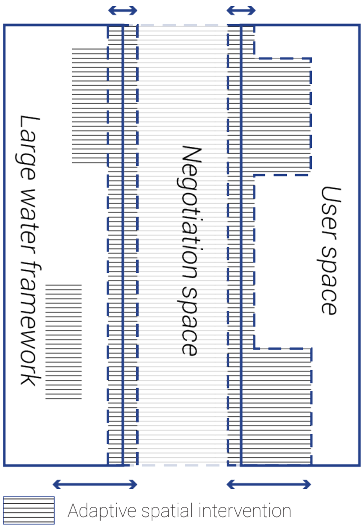
W: water management & Infrastructure

A: Agriculture & Land use

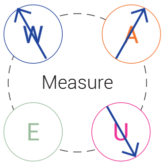
E: Ecology & Biodiversity

U: Urban & Economic development

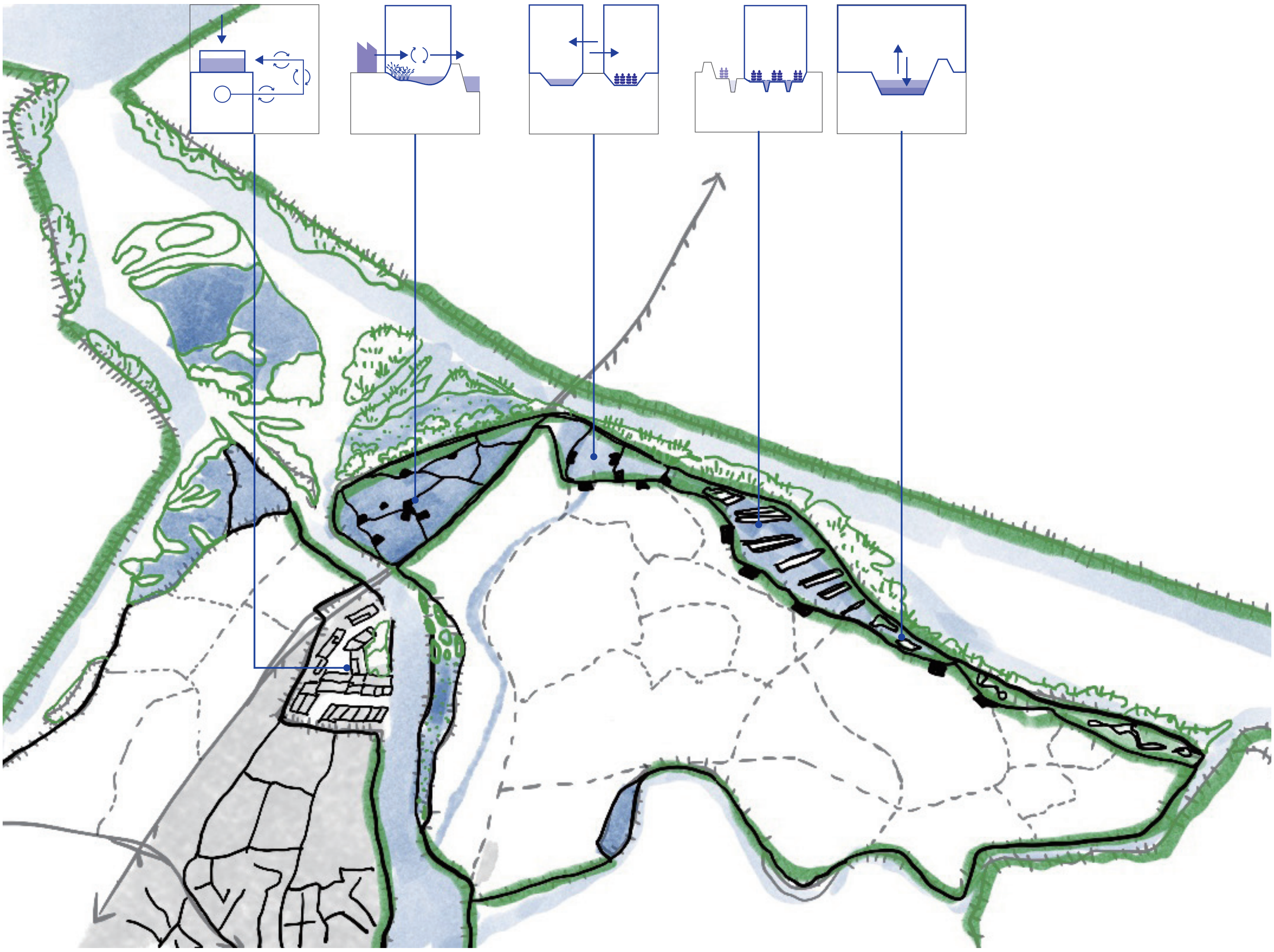




Measure 5: Purfying delta

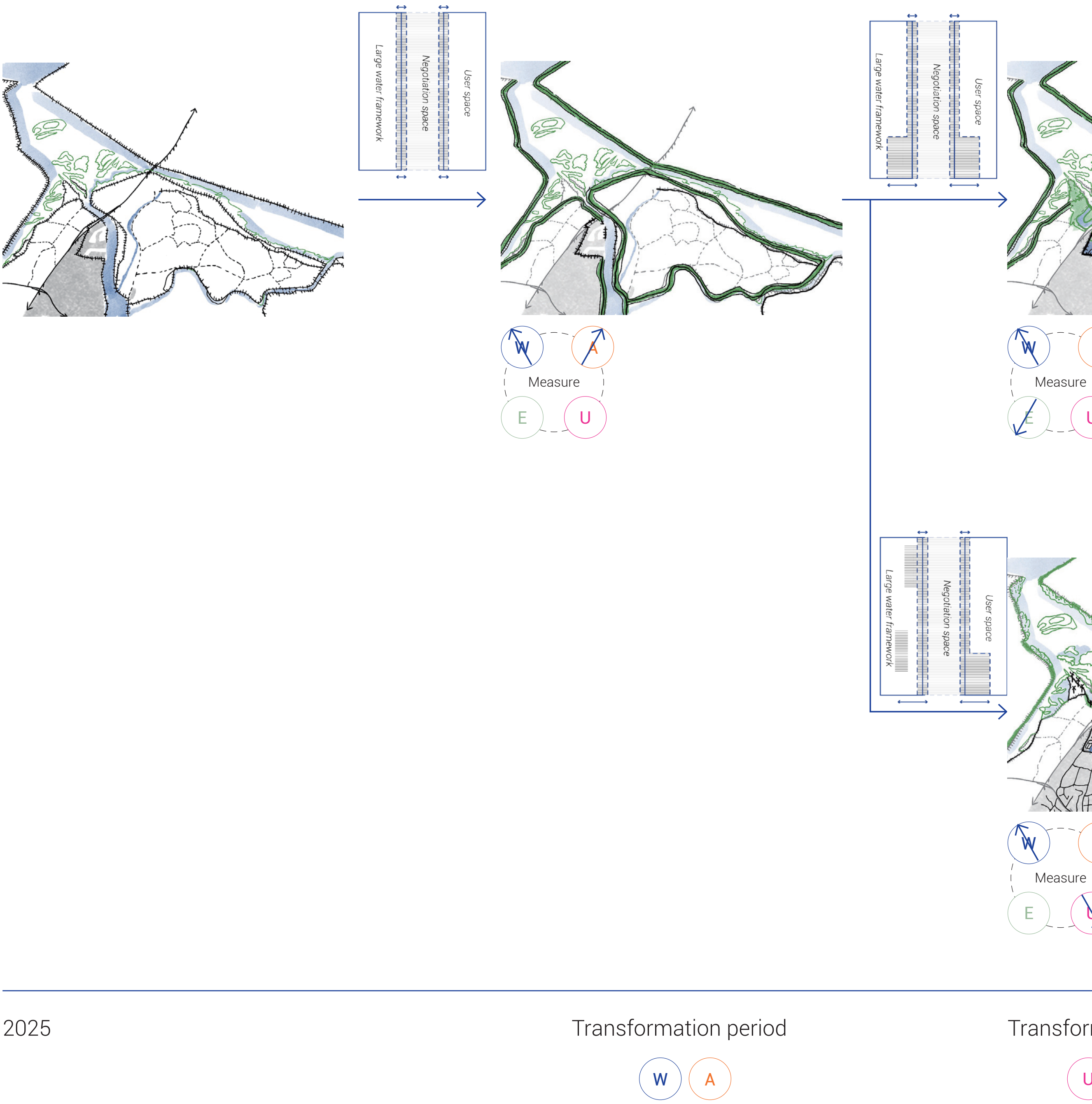


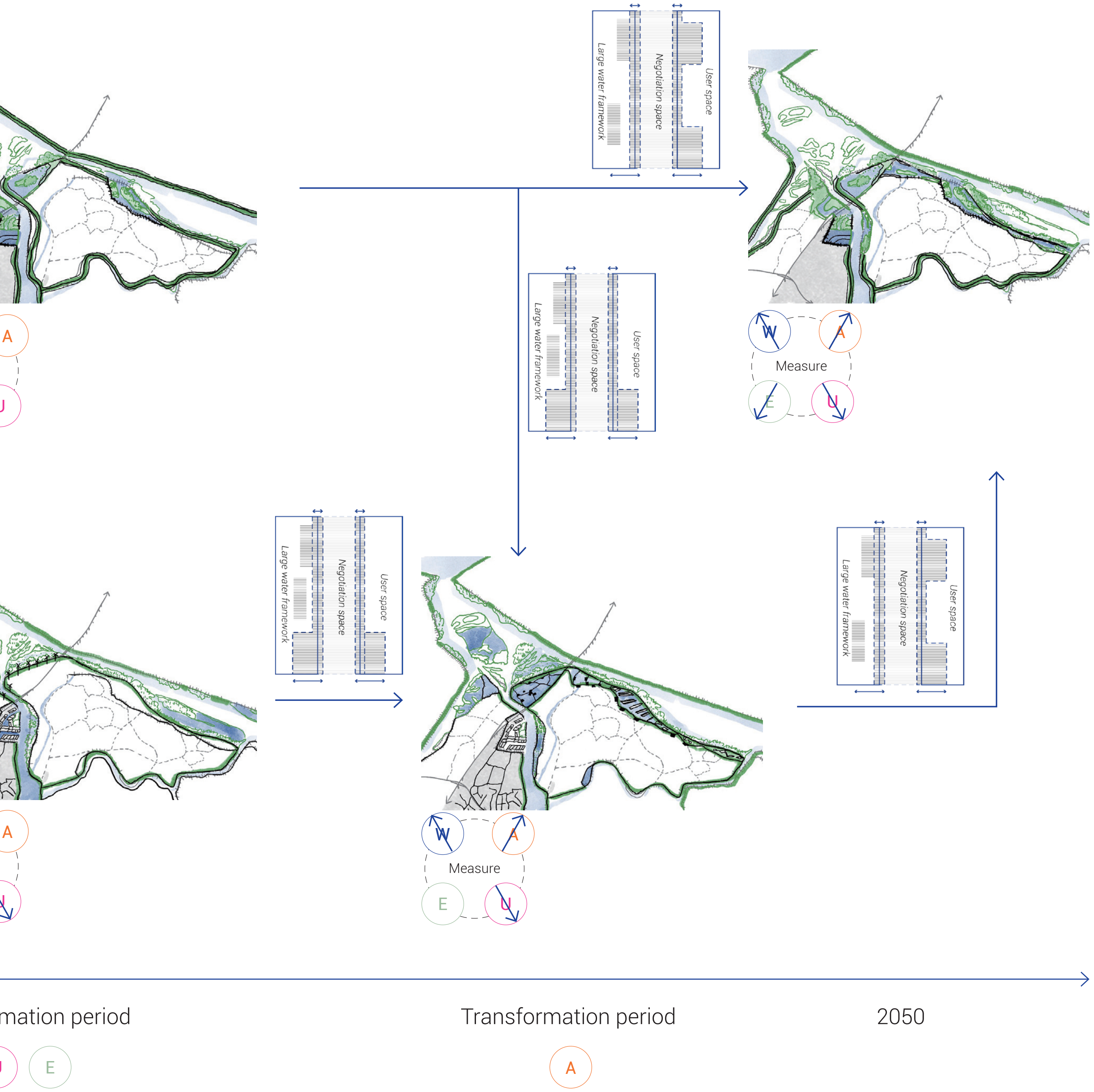
Legend
Main challenges to tackle with
W: water management & Infrastructure
A: Agriculture & Land use
E: Ecology & Biodiversity
U: Urban & Economic development



Conceptual adaptive design pathways

Finally, to propose adaptation pathway in spatial design from current situation to possible future, by adapting different measures to tackle with sectoral bottlenecks, to delay the situation meeting the tipping points.




Large water framework
Negotiation space
User space
Large water framework
Negotiation space
User space
W
A
Measure
E
U
A
U
Large water framework
Negotiation space
User space
Large water framework
Negotiation space
User space
A
W
A
Measure
E
U
mation period
Transformation period
2050
U
E
A

CHAPTER
8.

RESULTS

Dynamic Spatial Adaptive Pathway approach

Evaluation

Dynamic Adaptive Pathway approach

Scope of DSAP Approach

The Dynamic Spatial Adaptive Pathway (DSAP) approach consists of four interconnected phases: Phase 1 – System Framing (Step 1 & 2), Phase 2 – Vision Learning (Step 3 & 4), Phase 3 – Decision Supporting (Step 5), and Phase 4 – Strategy Implementing (Step 6) (Figure X). Each phase addresses a specific aspect of adaptive planning, yet they are interdependent in ensuring both robustness and responsiveness in spatial strategy-making. Importantly, the DSAP approach operates as a cross-level methodology, connecting regional ambitions with local design responses. Phase 1 and 2 are predominantly conducted at the regional level, focusing on policy framing, scenario-building, and spatial analysis of systemic challenges. However, they also recognize the presence of local spatial tensions and vulnerabilities embedded within broader strategic goals. Phase 3 bridges the gap between regional visions and local strategy formation, offering spatial structuring and typological zoning to prepare for design translation. Phase 4 is fully situated at the local level, delivering adaptive spatial design measures, yet it loops back to address regional system bottlenecks identified in Phase 1. This iterative structure enables the DSAP method to function not only across multiple temporal scales, but also across governance levels, supporting alignment between long-term policy trajectories and short-term spatial action.

System Framing (Step 1 & Step 2)

Step 1: Describe the policy system, specific objectives, and identify the uncertainty

The first step estabilishes a clear problem frame by analyzing the governance context in the temproal lens, defining specific policy objectives, and explicity identifying sources of uncertainty. This involves outlining the policy system's scope (institutional arrangements, legal frameworks) and the goals it seeks to achieve. At the same time, it catalogs the deep uncertainties, such as climate change scenarios, economic shifts, or demographic trends, that could affect those objectives. Embracing uncertainty at the outset reflects the recognition that complexity and unpredictability are defining features of contemporary planning (Davoudi. S, 2018). By clarifying what needs to be achieved and what might change, step 1 ensures that subsequent steps are grounded in a well-defined purpose and an awareness of the challenges ahead.

Step 2: Assess the spatial system vulnerabilities, challenges and opportunities

Building on the policy context, the second step shifts focus to the spatial domain: it analyzes the physical environment and spatial dynamics to uncover vulnerabilities, challenges, and potential opportunities. This assessment builds on the spatial system exploration outlined in the Ruimtelijke Verkenning IJsselmeergebied (Spatial Exploration IJsselmeer

Source:

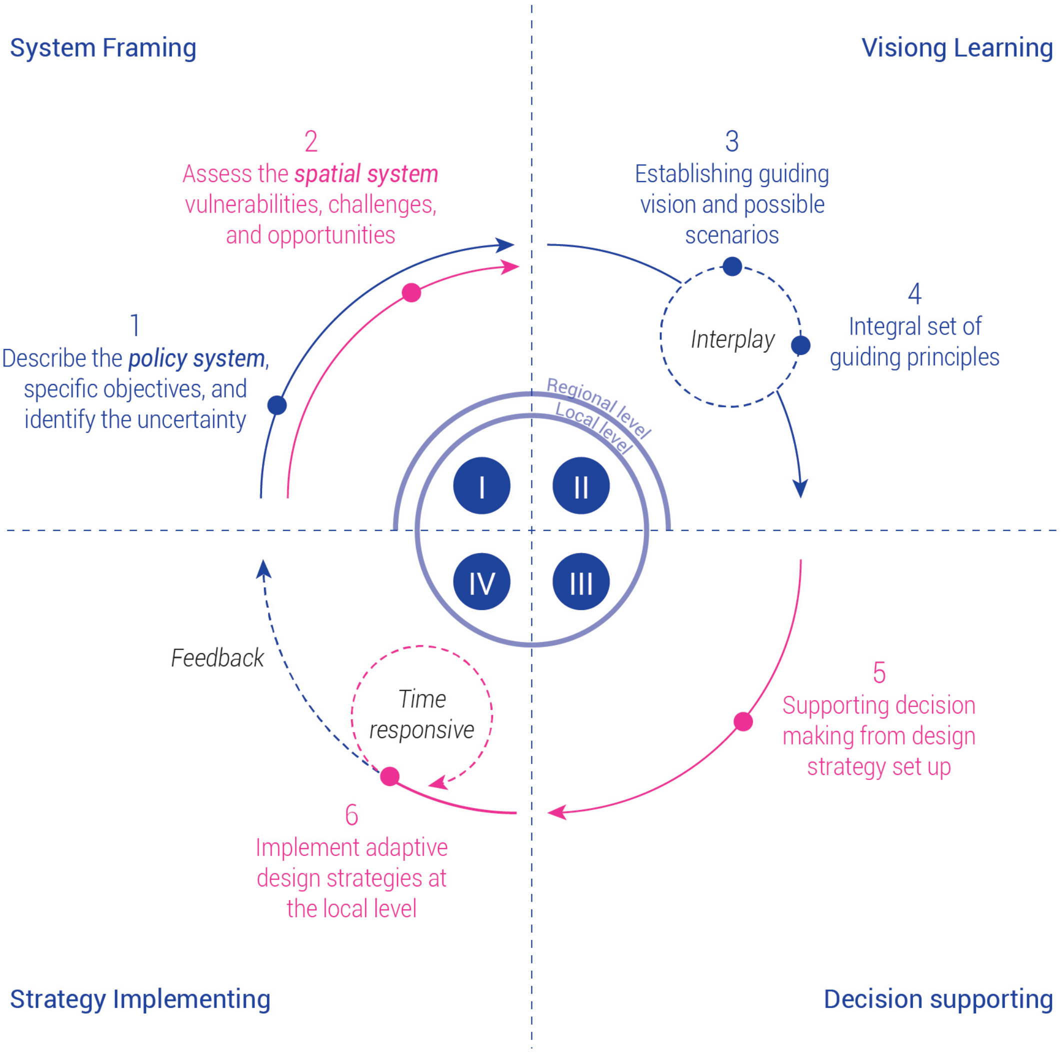
Agenda IJsselmeergebied 2050. (2018). Krachten bundelen voor het Blauwe Hart: Uitvoerings-, kennis- en innovatieagenda 2021–2026. Bestuurlijk Platform IJsselmeergebied.

Davoudi, S. (2018, July). Resilience, uncertainty, and adaptive planning [AESOP Annual Congress keynote lecture]. Association of European Schools of Planning (AESOP) Annual Congress, Gothenburg, Sweden.

Delta Commissioner. (2023). Delta Programme 2024 – Now for the future. Ministry of Infrastructure and Water Management, The Hague.

Ministerie van Infrastructuur en Waterstaat & Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2024). Ruimtelijke Verkenning IJsselmeergebied 2024. Den Haag: Rijksoverheid.

Region) which highlights seven thematic layers of pressure: water safety, freshwater supply, biodiversity and ecology, spatial quality, housing, livability, and energy trantision. Thes themes are treated not as sectoral silos but as overlapping spatial claims that interact over limited space (Ministerie van IenW & Ministerie van BZK, 2024). Through spatial mapping and cross-theme analysis, this step reveals how each theme's needs place pressure on the existing water and land system. Importantly, this stage does not only map problems but actively searches for opportunities: multifunctional zones, flexible land uses, or transition areas that could accommodate adaptive measures. This spatial intelligence grounds the adaptive pathway in the actual territorial dynamics of the IJsselmeer region and ensures that long-term strategic ambitions are sensitive to the practical constraints and possibilities of the land and water system.



> Figure 36, Dynamic Spatial Adaptive Pathway approach Framework (By Yiyan Zhou)

—— *Governance-based decision*
—— *Spatial-based decision*

Vision Learning (Step 3 & Step 4)

Step 3: Establish guiding vision and possible scenarios

Step 3 initiates the strategic stage by formulating a long-term guiding vision and developing exploratory scenarios to address future uncertainty. The vision serves as a normative direction, aligning spatial and policy ambitions for adaptive water system transformation. Rather than prescribing a fixed end-state, it provides a reference point against which multiple spatial futures can be tested. Scenario development in this step draws upon the national Delta Scenarios framework, which combines climate change severity and socio-economic development into four plausible future worlds (Delta Commissioner, 2023). These national narratives are refined and spatialized to fit the IJsselmeer region, particularly in relation to its ambition for enhanced circular water systems. By downscaling the Delta Scenarios and integrating them into regional design thinking, this step enables planners to explore how different futures could affect spatial claims, water-related pressures, and land-use priorities. The method promotes a scenario-informed visioning process, which allows for robust exploration of spatial strategies under conditions of deep uncertainty (Haasnoot et al., 2013). It also supports iterative planning: as the scenarios evolve, the vision remains a flexible compass rather than a rigid goal, encouraging ongoing adjustment and adaptive capacity.

Step 4: Define an integral set of guiding principles

Building on the long-term vision and exploratory scenarios, Step 4 defines a structured set of guiding principles that translate conceptual ambitions into sector-specific directions for design and planning. Central to this step is the operationalization of water circularity as a systemic strategy to expand freshwater buffer capacity and improve spatial resilience. These principles serve as an intermediary layer between vision and design—they are broad enough to guide strategy across scenarios, yet specific enough to support local spatial interventions. Inspired by adaptive and transition-oriented planning frameworks (Davoudi, 2018; PBL, 2023), the principles promote robust yet flexible design decisions, avoiding sectoral lock-ins by encouraging multifunctionality and phasing. As such, Step 4 is a critical methodological hinge that ensures continuity across scales, sectors, and temporal pathways.

Decision Supporting (Step 5)

Step 5: Support decision-making from design strategy setup

In Step 5, the pathway approach transitions from strategic framing to the structuring of spatially grounded design strategies. The primary objective is to transform long-term visions and scenario-based directions into

Source:

Davoudi, S. (2018, July). Resilience, uncertainty, and adaptive planning [AESOP Annual Congress keynote lecture]. Association of European Schools of Planning (AESOP) Annual Congress, Gothenburg, Sweden.

PBL Netherlands Environmental Assessment Agency. (2023). Spatial outlook 2023: Spatial scenarios for the Netherlands in 2050. The Hague: PBL.

Hartmeyer, L., Kaletkina, A., Iuorio, L., & Hooimeijer, F. (2024). The Casco concept as an enabler for interdisciplinary design: Designing with flood risk in Venice, Italy. Journal of Urbanism, Article 2424531. https://doi.org/10.1080/17549175.2024.2424531

Van Buuren, A., Ellen, G. J., & Warner, J. (2010). Path-dependency and policy learning in the Dutch delta: Towards adaptive water management. International Review of Administrative Sciences, 76(3), 403–424. https://doi.

Kwadijk, J. C. J., Haasnoot, M., Mulder, J. P. M., Hoogvliet, M., Jeuken, A., van der Krogt, R., ... & van den Hout, H. (2010). Using adaptation tipping points to prepare for climate change and sea level rise: A case study in the Netherlands. Wiley Interdisciplinary Reviews: Climate Change, 1(5), 729–740. https://doi.org/10.1002/wcc.64

Raso, L., Kwakkel, J. H., & Timmermans, J. (2019). Assessing the capacity of adaptive policy pathways to adapt on time by mapping trigger values to their outcomes. Sustainability, 11(6), 1716. https://doi.org/10.3390/su11061716org/10.1177/0020852310372452

coherent, actionable spatial frameworks. This translation is operationalized through the CASCO concept—a Dutch spatial planning framework that distinguishes between three functional zones: Core (CA) for critical water infrastructure and natural buffers, Adaptive (SC) zones where functions must negotiate with changing water conditions, and Opportunistic (CO) areas oriented toward flexible human uses. Originally developed in Dutch flood risk management and spatial design contexts, CASCO concept provides a way to incorporate climate robustness and spatial resilience with dynamic landscapes (Hartmeyer et al., 2023; Van Buuren et al., 2010).

By applying this structure to the scenarios developed in Step 3, the method enables a typological mapping of different regional futures. It highlights not only which areas are vulnerable or strategic, but also how their functions may shift depending on socio-economic and climatic trajectories. Each zone is thus assigned specific design goals and spatial performance criteria, aligned with the guiding principles from Step 4.

In doing so, Step 5 creates a bridge between abstract scenario thinking and concrete design proposals. Rather than prescribing fixed solutions, it offers a structured set of design pathways embedded in spatial conditions and tied to potential future system changes. This approach empowers stakeholders to visualize how spatial planning can anticipate change and selectively commit to robust options while maintaining flexibility under uncertainty.

Strategy Implementing (Step 6)

Step 6: Implement adaptive design strategies at the local level

The final step translates strategy into localized design interventions that respond to sectoral bottlenecks identified in Step 5. Based on CASCO zoning and scenario logics, a flexible set of design measures—such as dike realignment, infiltration zones, or water-level adaptive land use—is developed. These measures are not implemented all at once; instead, they are activated adaptively based on dynamic environmental and spatial conditions. Crucially, tipping points are not defined by static thresholds but emerge from the interplay of biophysical stress and socio-spatial demand (Kwadijk et al., 2010). Once a tipping point is approached—such as increasing salinization or reduced buffer capacity—the appropriate design option is selected from the pre-developed portfolio. This diverges from linear, technical applications of DAPP by integrating spatial responsiveness and decision phasing. The approach allows local adaptation to occur more timely and incrementally, delaying critical failure and enhancing long-term resilience (Raso et al., 2019).

Evaluation

Adaptive planning under serious uncertainty and adaptive governance

Spatial planning in the IJsselmeer Region faces deep uncertainty due to climate change and socio-economic conditions. Such uncertainty and complexity in spatial planning is a key argument for more "adaptive" planning tools and processes (Nadin et al., 2020). The planning approach in this thesis is designed to continuously incorporate new knowledge and adjust decisions, reflecting the literature's call for iterative, learning-based governance. Adaptive governance, as described by Folke et al. (2005), refers to "flexible and learning-based collaborations and decision-making processes involving both state and nonstate actors, often at multiple levels". By engaging various actors (government agencies, municipalities, water boards, communities) in iterative decision cycles, the methodology situates itself within this adaptive governance framework. It consciously avoids top-down prediction and control, moving toward a more collaborative and experimental approach to spatial planning.

A key contribution is how the methodology addresses uncertainty. Conventional planning often assumes that future conditions can be predicted and controlled through technical expertise, which has been critiqued as insufficient under complex, changing conditions (Nadin et al., 2020). Authors like Zandvoort et al. (2018) and Skrimizea et al. (2019) note the weakness of planning tools that assume uncertainty can be tamed by rational prediction. In contrast, the thesis employs tools from the adaptive planning literature, notably Dynamic Adaptive Policy Pathways (DAPP) and scenario planning, to handle deep uncertainty. These tools provide a structured way to make decisions that remain robust under a range of future scenarios instead of eliminating uncertainty. In doing so, the adaptive plan includes a monitoring system for early warning signals of change. It specifies contingency actions if conditions deviate from expectations, embodying "learning-by-doing" in governance. This approach echoes the notion that working adaptively means not waiting to be overtaken by new insights or developments, but being constantly alert and ready to take action at the right time (Delta Programme, 2024). By planning for adaptation tipping points and alternative pathways, the strategy ensures that short-term actions are linked to long-term goals while remaining flexible

The role of spatial design in participatory feedback loops

Spatial design plays a pivotal role as a catalyst for participatory feedback loops and institutional learning in this project. The spatial design implementation and different scenarios can be organized as a participatory workshop to actively involve stakeholders and experts in co-creating the plan. In these contexts, urbanists do not merely serve as advisors. Their position is to act as facilitators who can translate the evidence and urgency behind urban transformations into strategies that can influence

<Reference

Nadin, V., Stead, D., Dąbrowski, M., & Fernandez-Maldonado, A. M. (2020). Integrated, adaptive and participatory spatial planning: trends across Europe. Regional Studies, 55 (2021)(5), 791-803. https://doi.org/10.1080/00343404.2020.1817363

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. Annual Review of Environment and Resources, 30, 441–473. https://doi.org/10.1146/annurev.energy.30.050504.144511

Zandvoort, M., van Delden, H., Martí, R., & Kok, K. (2018). Mapping complexity: Place-based scenario mapping as a tool for discussion support. Futures, 97, 39–49. https://doi.org/10.1016/j.futures.2017.06.002

Skrimizea, E., Haniotou, H., & Parra, C. (2019). On the 'complexity turn' in planning: An adaptive rationale to navigate spaces and times of uncertainty. Planning Theory, 18(2), 223–242. https://doi.org/10.1177/1473095218763225

policy decisions. By translating abstract data and future uncertainties into concrete spatial images and designs, stakeholders from multiple disciplines can more tangibly engage with possible futures. Afterwards, this participatory design process creates a feedback loop: Stakeholders provide local knowledge and preferences that inform the design, and the evolving design spurs further feedback and dialogue. By participating through co-design, stakeholders and institutions can learn together about the problem and related ambitions, and possible solutions for an uncertain future.

Additionally, spatial design in this context is about producing a plan and facilitating institutional learning. Institutions such as municipalities, regional authorities, and water boards learn to collaborate in new ways when engaged in a joint design exercise.

Transferbility of the Approach

An important consideration is the transferability of this adaptive planning approach beyond the IJsselmeer region. The core principles, embracing uncertainty, scenario-based planning, iterative monitoring, and stakeholder co-design, are not site-specific and can be applied to other regions facing similar complex challenges. In the Netherlands' broader Delta context, such adaptive planning has already gained traction. The national Delta Programme, for example, adopts Adaptive Delta Management, which explicitly links near-term decisions with long-term agendas and keeps multiple strategies open so that a quick switch is possible if circumstances change (Delta Programme, 2024). This mirrors the research's use of adaptation pathways, signaling that the approach aligns with best practices in Dutch climate adaptation efforts.

However, transferability also comes with caveats. Each region has unique socio-ecological contexts and institutional arrangements, which means the tools must be tailored accordingly. The IJsselmeer approach benefits from a relatively well-organized network of Dutch water authorities, municipalities, and knowledge institutions willing to collaborate. Regions lacking such governance capacity or tradition of consensus-building might find it challenging to implement an intensive adaptive planning process. Moreover, maintaining an iterative monitoring system and frequent stakeholder engagements requires resources and long-term commitment. These conditions are not guaranteed everywhere. Thus, while the approach is conceptually generalizable, its successful application hinges on ensuring the necessary governance conditions, such as political buy-in, cross-sector partnerships, and continuous funding for adaptation, are in place. Encouragingly, the growing adoption of adaptive pathway planning in Dutch policy arenas (and interest in similar methods internationally) indicates a trend towards these supportive conditions (Delta Programme, 2024). In essence, the methodology is applicable and relevant well beyond the IJsselmeer case, but it must be sensitively adapted to local realities and accompanied by capacity-building for true transferability.

Reflection on Policy Context

The DSAP methodology provides a structured way to connect the long-term goals outlined in major Dutch policy documents, including the Agenda IJsselmeergebied 2050 and the Delta Programme 2024, with spatial strategies and design implementation. These regional frameworks define strategic ambitions for freshwater availability, ecological quality, and integrated land use. However, they often leave open how these ambitions can be spatially translated and adapted to local conditions. The DSAP framework helps operationalise such goals by aligning them with region-specific objectives and uncertainties. By doing so, it enables adaptive responses within the broader governance context defined by these policies.

The method also plays a role in bridging communication between planning authorities and spatial designers. Rather than positioning spatial design as a representational tool, this approach treats design as a way of structuring complex decisions. Through scenario building, spatial typologies, and adaptation tipping points, the method clarifies how long-term visions can guide short-term choices. This supports a more dynamic and interactive relationship between design processes and policy development. In this context, design becomes a tool for decision-making and not merely for policy implementation.

Documents such as the Agenda IJsselmeergebied 2050 provide an integrated vision for the region but may lack mechanisms to adjust strategies under changing conditions. The DSAP methodology adds value by offering a process for monitoring system change and responding to it with design-based interventions. While this is not a critique of the policy objectives themselves, it highlights the need for more flexible and iterative tools to implement them effectively. The approach complements existing strategies by creating feedback loops that inform both planning and design, contributing to more adaptive and responsive regional development.

Source:

Delta Programme. (2023). Delta Programme 2023: Now for the future. Ministry of Infrastructure and Water Management.

Davoudi, S. (2018). Resilience, uncertainty, and adaptive planning. AESOP Lecture Series.

Rijksoverheid. (2018). Agenda IJsselmeergebied 2050: Samen werken aan een vitaal meer. Retrieved from https://www.rijksoverheid.nl/documenten/publicaties/2018/06/29/agenda-ijsselmeergebied-2050

CHAPTER
9.

CONCLUSION

Research outline

Climate change and socio-economic development have created substantial uncertainty regarding freshwater availability in the IJsselmeer Region. Rising temperatures, variable precipitation, and sea-level rise alter the catchment hydrological cycle, while changing demands from agriculture, industry, and municipalities increase pressure on water resources. Recent droughts (2018–2022) and associated salinization highlighted the region's limited buffer capacity (Delta Programme, 2023). At the same time, long-term trends indicate continued growth in population and economic activity, which will further increase freshwater demand (OECD, 2014). These dual trends underscore the need for resilient, adaptive spatial planning to secure freshwater functions.

This research addresses this challenge by developing an adaptive spatial-planning methodology for water circularity, aiming to enhance freshwater buffer capacity in the IJsselmeer Region, with a focus on the Northwest Overijssel case. Specifically, the methodology emphasizes expanding the region's storage and conveyance through dynamic circular-water planning, supported by four sectoral categories: safety, quality, supply, and ecological services. This goal aligns with national strategies—such as the Freshwater Delta Programme and Delta Programme 2023—emphasizing increased freshwater buffers and integrated land–water planning to strengthen spatial resilience (Deltares, 2022; KNMI, 2023).

Answers to main research question

How can the water-based services (A) of IJsselmeer region organise system synergies and adapt to a future-proof (B) and circular waterscape (C)?

This research demonstrates that integrating water-based services into a Dynamic Spatial Adaptive Pathway (DSAP) enables synergies between ecological and societal functions. By aligning regional spatial planning with adaptive water circularity strategies, the IJsselmeer region can transition toward a future-proof and resilient waterscape. The methodology promotes a system-thinking approach that links water safety, supply, and land-use flexibility—anchored in adaptive tipping-point mechanisms, spatial design tools, and multi-level governance logic

Answers to the sub-research quetions

SQ1: What are the current and ongoing challenges in the Netherlands that are affecting the water crisis in the IJsselmeer Region?

The region is under pressure from climate-induced droughts, salinization, and land subsidence. Droughts between 2018–2022 severely impacted the freshwater supply, while socio-economic demands continue to grow.

Source

Deltares. (2022). Exploratory system analysis of the IJsselmeer area (Fresh Water research 2022–2027). Ministry of Infrastructure and Water Management.

Delta Programme. (2023). Delta Programme 2023: Now for the future. Ministry of Infrastructure and Water Management.

KNMI. (2023). KNMI'23 Climate scenarios for the Netherlands. Royal Netherlands Meteorological Institute.

OECD. (2014). Water Governance in The Netherlands: Fit for the future? OECD Publishing.

These stressors reveal the need for systemic adaptation and highlight the spatial-functional mismatches in land and water systems .

SQ2: What is the existing position of the IJsselmeer region in the context of national water governance?

The IJsselmeer Region is a keystone in the Netherlands' national freshwater strategy. Policy documents like the Delta Programme 2024 and Agenda IJsselmeergebied 2050 recognize it as a major buffer and emphasize its multifunctional potential in climate adaptation and long-term resilience.

SQ3: How is spatial performance developed by different services in the IJsselmeer Region?

Spatial performance is shaped by overlapping functions such as ecological protection (e.g., Natura 2000 areas), agriculture, heritage, and water infrastructure. These are grouped into three service layers—preconditions, values, and activities—each of which contributes to water demand or supply in complex, sometimes conflicting, ways.

SQ4: How can design framework and principles can be designed to expand the capacity of freshwater buffer in the IJsselmeer Region?

A principle-based framework was established, aligning water quantity, quality, and safety with spatial design goals. Based on circularity, the principles promote decentralized water reuse, nature-based retention, and flexible infrastructure. These concepts are aligned with planning philosophies in Dutch water governance.

SQ5: How can Spatial Adaptive Pathway be developed to meet the future-proofing targets between the water and land?

The DSAP method translates long-term policy and regional goals into an implementable spatial strategy via four phases. This multiscale pathway allows for visioning, scenario testing, decision support, and local implementation to evolve over time and respond to tipping points in the land-water system.

SQ6: How can the guidelines and different scenarios be tested in a case study area to form an Spatial Adaptive Pathway?

In Northwest Overijssel, two contrasting future scenarios—high and low socio-economic development—were applied to test spatial flexibility. Overlapping results informed the development of three functional zones (core, negotiation, user), forming a foundation for spatial strategy packages that are robust yet adaptable

CHAPTER
10.

REFLECTION

Relation to Urbanism

The thesis builds on the Dutch tradition of integrated water and spatial planning, which is highly relevant to contemporary Urbanism. Water management under climate uncertainty is a pressing topic in Dutch spatial planning, and the thesis contributes a case-based study and methodology that future urban planners can learn from. By expanding the freshwater buffer, the thesis demonstrates the value of urbanism in sustainable and resilient spatial development.

The research draws attention to the multidisciplinary nature of the work, which intertwines spatial planning, water management, and climate adaptation. At the core of urbanism lies the integration of environmental and spatial design considerations. To illustrate, the project integrated urban design principles (e.g., visions, spatial strategies) with planning tools (e.g., scenarios, adaptation pathways) to address a tangible, multiscale challenge in a real-world context. This approach enables the efficient identification of problems at various levels and in diverse areas within complex urban environments, facilitating the development of systematic strategies.

“Research by design”: Mutual benefit

The research findings demonstrate a mutually beneficial relationship between design and research, wherein both disciplines complement each other.

Firstly, the research informs the design process by providing evidence-based guiding principles for design on different scales during the initial research phase. Preliminary research established the overall thesis's values and research path. Specifically, the study identified dynamic system changes and uncertainty risk analysis as the primary research methods. These findings subsequently provided supporting evidence for the later design framework. Those principles directly shaped the spatial interventions proposed later on. For instance, an understanding of hydrological dynamics and uncertainty has informed the design of adaptive water buffers and flexible land-use typologies. The research objective was to translate each scenario into a design response that would ensure the proposals' robustness under different future conditions.

Conversely, reflect on how the design process fed back into the research. Design is a process of repeatedly validating and researching the rationality of the adaptation pathway. This study proposes adaptive strategies for complex and changing water systems under spatial planning in the face of future uncertainties. The design steps have been shown to offer a more pragmatic approach to addressing spatial issues while providing practical strategies that are directly applicable to real-world projects. Drawing scenarios has been demonstrated to expose knowledge gaps, including unforeseen socio-economic implications and technical constraints. This exposure has led to two potential outcomes: additional research and adjustment of theoretical frameworks. This iterative loop is a distinguishing feature of the Urbanism approach, which utilizes design as a method of inquiry. It is imperative to emphasize specific instances of this dynamic interplay in the reflection. To illustrate, a proposed layout for water storage might have prompted inquiries regarding its ecological implications, prompting the student to delve into research on ecosystem-based adaptation, a field of study that refined the design.

The integration process was instrumental in ensuring that the recommendations were conceptually sound, empirically substantiated, and aesthetically evaluated through comprehensive visual testing.

Value and limitations of the approach and methodology

The thesis provided a participatory methodology combining spatial visioning and strategy, scenario planning, and adaptation pathways. One of the values is the ability to handle complexity and uncertainty in a structured manner. The methodology supports a robust strategy rather than a single rapid plan by breaking long-term challenges into achievable steps while driving policy decisions upwards through local practice. The adaptive pathways approach has enabled stakeholders and planners to understand risks and potential solutions better. This approach has provided stakeholders and planners with a comprehensive view of various options and the possible outcomes of decisions over time. Additionally, the integrative nature of the methodology, which bridges environmental, social, and spatial aspects, ensured that the advisories were not one-dimensional. For instance, spatial interventions like creating a newly constructed wetland serve ecological purposes such as water storage and habitat, spatial quality such as recreational space, and risk management, reflecting a robust value that would systematically enhance human and non-human living environments.

However, the approach also has limitations and challenges that have become evident. One limitation is the complexity of the process itself. Managing a workshop that applies this methodology is resource- and time-intensive. The project has to simplify certain elements, such as choosing a limited number of scenarios or focusing on specific pathways, which might overlook some uncertainties. The literature notes that the complexity of adaptive pathways, involving many actors and scales, is challenging (Haasnoot, Di Fant, Kwakkel, & Lawrence, 2024). Furthermore, this method is highly dependent on stakeholder participation and consensus. Its limitations lie in its inability to resolve conflicts fully; some disagreements may only be postponed. In this thesis, stakeholders were generally positive, but scaling this up to a real planning process requires sustained commitment and clear decision rights. Methodologically, another limitation is the transferability of detailed results. While the overall approach can transfer, the specific design and pathway outcomes are

>Reference:
Haasnoot, M., Di Fant, V., Kwakkel, J., & Lawrence, J. (2024). Lessons from a decade of adaptive pathways studies for climate adaptation. Global Environmental Change, 88, 102907. https://doi.org/10.1016/j.gloenvcha.2024.102907

based on the local context and might not be directly valid elsewhere.

Academic contribution and Societal relevance

The thesis added to knowledge and methodologies. Academically, it is substantiated by empirical evidence from the IJsselmeer Region, enhancing the development of a more comprehensive body of knowledge on climate adaptation in spatial contexts. The proposed methodology involves creating a dynamic planning framework (Haasnoot et al., 2013; Walker et al., 2013) that may serve as a model for pertinent research, thus enhancing the academic discussion on adaptive spatial planning. In particular, the thesis demonstrates a novel application of adaptation pathways in designing spatial interventions (e.g., land use changes and infrastructure adaptations) for the IJsselmeer Region, bridging a gap between technical water management literature and design-oriented urban planning research. Furthermore, the project's interdisciplinary methodology, combining hydrology, policy analysis, and urban design, exemplifies the integrated research the Urbanism field calls for. It then serves as a reference for conducting research-through-design to tackle climate adaptation challenges at multiple scales.

The societal relevance of the study is equally significant. The IJsselmeer Region is a critical water system in the Netherlands, serving as a freshwater reservoir, a flood safety buffer, and a living environment for communities and ecosystems. By proposing dynamic and adaptive spatial strategies, this project addresses real-world challenges such as climate change-induced sea level rise, changing precipitation patterns, and land subsidence that affect the water cycle. The findings offer a strategic outlook that can inform policymakers and regional planners in the Netherlands. Moreover, by visualizing future pathways, the project can facilitate dialogue among stakeholders about long-term trade-offs (such as balancing agricultural water use with ecological needs or urban expansion with flood risk management).

Ethical considerations were integrated into the study process and proposals. One ethical consideration is intergenerational responsibility: climate adaptation planning fundamentally addresses effects on future generations. The thesis asserts that contemporary planning shouldn't compromise the safety and well-being of future individuals in the area. This is evident in the careful focus on long-term sustainability and preventing solutions that merely push risks to the future. Another ethical consideration is ensuring that adaptation plans are just and inclusive. The thesis did not perform original social research. Still, it recognized many stakeholder groups, including farmers, urban dwellers, and nature conservationists, with an interest in the water management of the IJsselmeer.

>Reference:

Haasnoot, M., Kwakkel, J. H., Walker, W. E., & ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. Global Environmental Change, 23(2), 485–498. https://doi.org/10.1016/j.gloenvcha.2012.12.006

Walker, W. E., Haasnoot, M., & Kwakkel, J. H. (2013). Adapt or perish: A review of planning approaches for adaptation under deep uncertainty. Sustainability, 5(3), 955–979. https://doi.org/10.3390/su5030955

CHAPTER
11.

BIBLIOGRAPHY

Literature and policy document

Acreman, M. C., & Mountford, J. O. (2009). Wetlands. In H. van der Ploeg & P. Jeffrey (Eds.), The ecological and hydrological functions of wetlands (pp. 14–24). IWMI/UNESCO.

Arup, Antea Group, & Ellen MacArthur Foundation. (2019). Water and circular economy: A white paper. Arup. https://www.arup.com/perspectives/publications/research/section/water-and-circular-economy

Batker, D., et al. (2010). The role of ecosystem services in sustainable development. Earth Economics.

Brears, R. C. (2023). The circular water economy: Opportunities and challenges. Mark and Focus. https://medium.com/mark-and-focus/the-circular-water-economy-opportunities-and-challenges-ab03040ea807

Brink, A., van der Valk, A., & van Dijk, T. (2006). Planning and the challenges of the metropole: Dealing with spatial quality. In A. van der Valk & A. van den Brink (Eds.), Dutch Planning in Transition (pp. 197–215). Sdu Uitgevers.

Busscher, T., van den Brink, M., & Verweij, S. (2019). Strategies for integrating water management and spatial planning: Organising for spatial quality in the Dutch "Room for the River" program. Journal of Flood Risk Management, 12(S1), e12448. https://doi.org/10.1111/jfr3.12448

CBS. (2021). Population forecast 2020–2070. Statistics Netherlands.

Davoudi, S. (2018). Resilience, uncertainty, and adaptive planning. AESOP Lecture Series.

Delta Programme Commissioner. (2023). Delta Programme 2024: Continuing the work on the delta – Increasing the pace of implementation. Ministry of Infrastructure and Water Management. https://english.deltaprogramma.nl

Delta Programme Commissioner. (2023). Delta Programme 2024: Now for the future. Ministry of Infrastructure and Water Management. https://english.deltaprogramma.nl/delta-programme

Deltares. (2022). Exploratory system analysis of the IJsselmeer area (Fresh Water research 2022–2027). Ministry of Infrastructure and Water Management.

Deltares & PBL. (2024). Delta Scenarios 2024: Exploring plausible futures for climate and socio-economic development. Deltares & Netherlands Environmental Assessment Agency (PBL).

European Commission. (2000). Directive 2000/60/EC of the European

Parliament and of the Council establishing a framework for the Community action in the field of water policy (Water Framework Directive). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060

FAO. (2023). FAOSTAT: Global land use and agricultural trends. Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. Annual Review of Environment and Resources, 30, 441–473. https://doi.org/10.1146/annurev.energy.30.050504.144511

Ghisellini, P., et al. (2016). A review on circular economy: The expected transition to a balanced system. Journal of Cleaner Production.

Guo, Z., Xiao, X., & Li, D. (2000). An assessment of ecosystem services: Water flow regulation and hydroelectric power production. Ecological Applications, 10(3), 925–936. https://doi.org/10.1890/1051-0761(2000)010[0925:AAOESW]2.0.CO;2

Haasnoot, M., Di Fant, V., Kwakkel, J., & Lawrence, J. (2024). Lessons from a decade of adaptive pathways studies for climate adaptation. Global Environmental Change, 88, 102907. https://doi.org/10.1016/j.gloenvcha.2024.102907

Haasnoot, M., Kwakkel, J. H., Walker, W. E., & ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. Global Environmental Change, 23(2), 485–498. https://doi.org/10.1016/j.gloenvcha.2012.12.006

Hartmeyer, L., Kaletkina, A., Iuorio, L., & Hooimeijer, F. L. (2024). The Casco concept as an enabler for interdisciplinary design: Designing with flood risk in Venice, Italy. Journal of Urbanism: International Research on Placemaking and Urban Sustainability, 1–20.

IPCC. (2023). Climate Change 2023: The Physical Science Basis. Intergovernmental Panel on Climate Change.

KNMI. (2023). KNMI'23 Climate scenarios for the Netherlands. Royal Netherlands Meteorological Institute. https://www.knmi.nl

Kwadijk, J. C. J., Haasnoot, M., Mulder, J. P., Hoogvliet, M., Jeuken, A., van der Krogt, R., ... & van den Hout, H. (2010). Using adaptation tipping points to prepare for climate change and sea level rise: A case study in the Netherlands. Wiley Interdisciplinary Reviews: Climate Change, 1(5), 729–740. https://doi.org/10.1002/wcc.64

Liang, J., Xie, J., Wang, X., Wang, S., & Yu, M. (2022). Visualization of multi-scenario water resources regulation based on a dualistic water cycle framework. Water, 14(7), 1128. https://doi.org/10.3390/w14071128

Ministry of Infrastructure and Water Management. (2018). Mooi Nederland: Naar een mooie, duurzame en functionele inrichting van ons land. The Hague: Ministry of Infrastructure and Water Management.

Ministry of Infrastructure and Water Management. (2022). Programmatic approach to large waters (Grote Wateren). https://www.grotewateren.nl

OECD. (2014). Water Governance in The Netherlands: Fit for the future? OECD Publishing.

PBL Netherlands Environmental Assessment Agency. (2023). Spatial outlook 2023: Spatial scenarios for the Netherlands in 2050. The Hague: PBL.

Rijkswaterstaat, & Deltares. (2022). Verkennende systeemanalyse IJsselmeergebied: Bouwstenen voor integrale keuzes in het ruimtelijk-fysiek systeem [Exploratory system analysis of the IJsselmeer area: Building blocks for integrated choices in the spatial-physical system]. Ministry of Infrastructure and Water Management. https://platformijsselmeergebied.nl/kennisartikel/verkennende-systeemanalyse-ijsselmeergebied/

Rijksoverheid. (2018). Agenda IJsselmeergebied 2050: Samen werken aan een vitaal meer. Retrieved from https://www.rijksoverheid.nl/documenten/publicaties/2018/06/29/agenda-ijsselmeergebied-2050

UNESCO. (2018). Nature-based solutions for water: The United Nations World Water Development Report 2018. United Nations. https://unesdoc.unesco.org/ark:/48223/pf0000266462

Walker, W. E., Haasnoot, M., & Kwakkel, J. H. (2013). Adapt or perish: A review of planning approaches for adaptation under deep uncertainty. Sustainability, 5(3), 955–979. https://doi.org/10.3390/su5030955

World Bank. (2021). Water in circular economy and resilience (WICER). World Bank. https://www.worldbank.org/en/topic/water/publication/wicer

Data source

European Environment Agency (EEA). (n.d.). EEA analysis and interactive charts, dashboards, and maps. https://www.eea.europa.eu/en/analysis?size=n_10_n&filters%5B0%5D%5Bfield%5D=objectProvides&filters%5B0%5D%5Btype%5D=any&filters%5B0%5D%5Bvalues%5D%5B0%5D=Chart%20%28interactive%29&filters%5B0%5D%5Bvalues%5D%5B1%5D=Dashboard&filters%5B0%5D%5Bvalues%5D%5B2%5D=Figure%20%28chart%2Fmap%29&filters%5B0%5D%5Bvalues%5D%5B3%5D=Infographic&filters%5B0%5D%5Bvalues%5D%5B4%5D=Map%20%28interactive%29&filters%5B1%5D%5Bfield%5D=readingTime&filters%5B1%5D%5Btype%5D=any&filters%5B1%5D%5Bvalues%5D%5B0%5D=All&filters%5B1%5D%5Bvalues%5D%5B0%5D%5BrangeType%5D=fixed&filters%5B2%5D%5Bfield%5D=issued.date&filters%5B2%5D%5Btype%5D=any&filters%5B2%5D%5Bvalues%5D%5B0%5D=Last%205%20years&filters%5B3%5D%5Bfield%5D=language&filters%5B3%5D%5Btype%5D=any&filters%5B3%5D%5Bvalues%5D%5B0%5D=en

KNMI. (n.d.). Climate effects atlas. https://www.klimaateffectatlas.nl/en/viewer

National Spatial Data Infrastructure (NSDI). (n.d.). Geonetwork. https://www.nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/home

OpenStreetMap. (n.d.). OpenStreetMap. https://www.openstreetmap.org/

Rijkswaterstaat. (n.d.). Leven met water - Map viewer. https://rce.webgis.nl/nl/map/leven-met-water

Water Management Network. (n.d.). Broloket. https://www.broloket.nl/ondergrondmodellen/kaart

Wageningen University & Research. (n.d.). PAGW (Planning and Environmental Assessment). https://www.pagw.nl/

CHAPTER
12.

APPENDIX

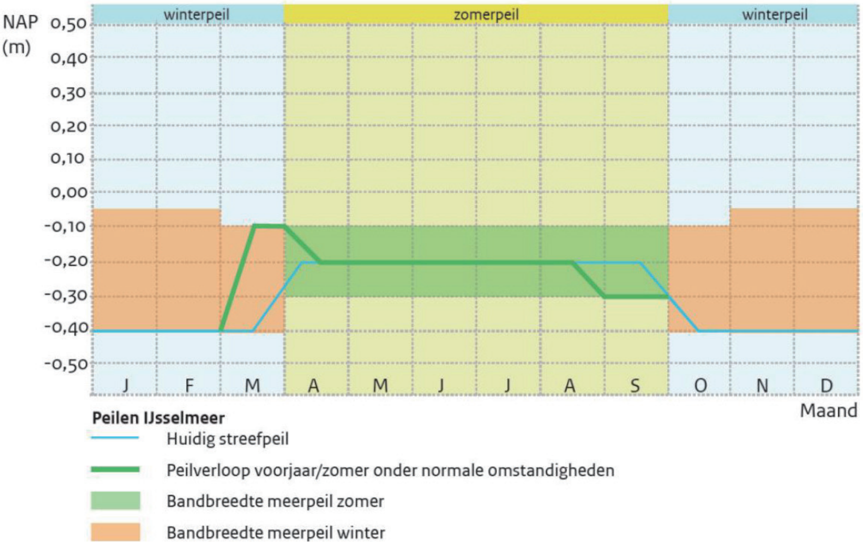
Water level management

The current water level decision in the IJsselmeer lake region (Rijkswaterstaat, 2018) is going to be against the background of flooding, as the main reason for the creation of the IJsselmeer lake region in its current form (Water system analysis, 2022). This decision has been made by Rijkswaterstaat in 2018, which is shown in figure x.

The Water System Analysis in IJsselmeer Area (2022) has stated the water level decisions in different situations in detail. Decided by different season primarily, in winter the tidal storage function is most important, the IJsselmeer level must not become too high, in order to mitigate the dikes' threats from the tilt and waves during a storm. At this moment, the aim for the Ijssel- and Markermeer is a winter level of -0.40 m NAP, see figure x, with IJsselmeer lake receives much more water from the IJssel. In the summer, the storage function is most important. The IJsselmeer lake region then functions as a kind of reservoir at sea level, into which water continuously flows (mainly form IJssel) and water is extracted, in order to meet the greater demand for water from the region for maintaining the polder levels, flushing to combat salinization and providing water for agriculture. The aim is for a level between -0.10m and -0.30m (Figure x), in anticipation of the water demands for the supply area.

The water level is threatened by the climate uncertainty at the same time. After 2050, the average winter level in the IJsselmeer and Markermeer may rise by a maximum of 30 centimeters in line with the sea level rise in order to make it possible to respond to new developments if necessary. The option remains open of increasing the bandwidth of the flexible water level in the IJsselmeer and Markermeer to a maximum of 50 centimetres – from NAP -0.40 m to NAP +0.10 m – after 2050.

For the water level decision, the water level in the summer need to be higher than the one in the winter, which is against the nature water level dynamic. In addition to water levels and fluctuations, changes in the water level regime also affect salinity gradients and fish migration possibilities, and have effects on the course of water depth through the season and further have effects on aquatic plants and the availability of food for (non-diving) water birds. The above indicators for the water level management is meeting a balanced solution fulfilling for dynamic IJsselmeer lake region.



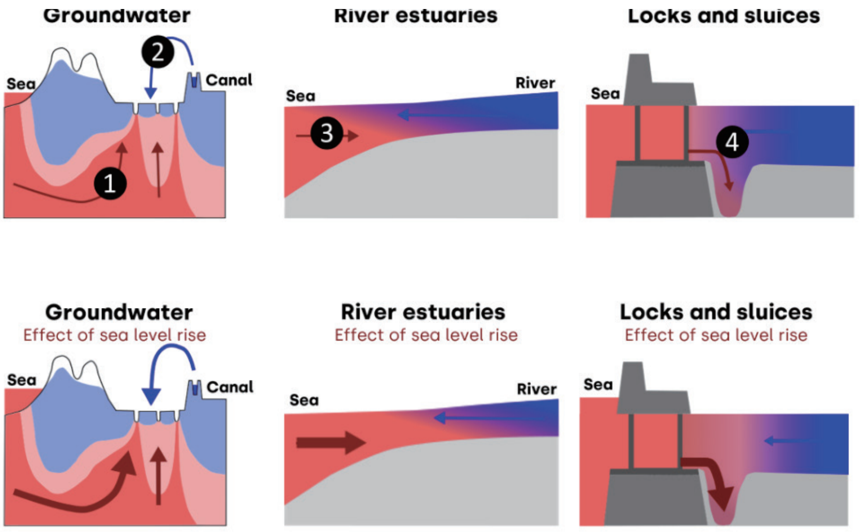
>Figure 17, Water level decisions in the IJsselmeer area (Deltares, 2021)

Freshwater capacity optimization

According to the KNMI'23 climate scenarios (2023), the three main functions of the IJsselmeer lake region—water storage, freshwater supply, and ecosystem services—will come under significant pressure. In all scenarios, a precipitation deficit is expected to increase in spring and summer, leading to reduced water inflow into the region. Meanwhile, the demand for water, driven by both ecological needs and economic activities, will continue to rise. To ensure the IJsselmeer lake region can sustain its role as a freshwater buffer, significant changes will be required to optimize its buffering functions.

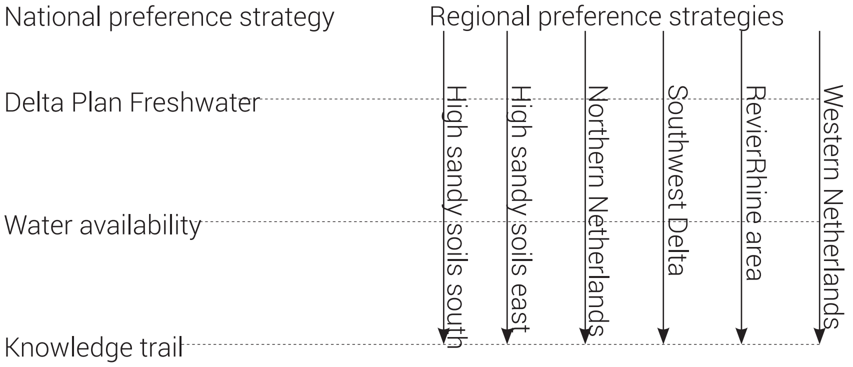
The findings suggest that sea-level rise and autonomous processes will result in severe salinization, particularly in low-lying polder areas near the coast. Additionally, enhanced land subsidence, driven by salt extraction activities, will further exacerbate the salinization process. Autonomous salinization refers to the increase in groundwater salinity resulting from past alterations in hydrological boundary conditions, such as the reclamation of inland lakes (Oude Essink et al., 2010). These developments underline the urgent need for adaptive measures to mitigate the effects of these changes and maintain the freshwater function of the IJsselmeer lake region in the face of climate change.

Ever since the Afsluitdijk transformed the open Zuiderzee into a closed lake, the IJsselmeer has acted as a massive freshwater reservoir buffering the surrounding provinces' water supply needs (Delta programme, 2023).



<Source
Delta Programme. (2023). Delta Programme 2023: Working towards a climate-proof Netherlands in 2050. Ministry of Infrastructure and Water Management. https://www.deltaprogramma.nl

Delta Decision on Freshwater



Source: Deltaplan freshwater 2022-2027

Northern Netherlands

Climate change, agricultural growth and economic developlment increase regional demand for freshwater. Efforts to curb subsidence, prevent pile rot and reduce heat stress also contribute to this. Partly because of this, water systems are reaching the limits of their resilience at an accelerated pace.

Issues and Bottlenecks

Salinization of storage basin systems due to shipping movements

Salinization due to
- Sea level rise
- subsidence
- drought

Salinization in the event of intake restrictions in storage basins, areas with high-value crops and reclamation areas

Long-term intake restrictions

Declining groundwater levels

Water quality problems

Source: Deltaplan freshwater 2022-2027

Regional goals and values

The National Water Plan states that there must be good balance between the mesures to make the water system more robust and the various utilization functions.

As the "Blue Heart" of the Netherlands, the IJsselmeer area carries significant regional development responsibilities, serving diverse thematic and systemic goals. It faces a range of complex challenges, including urbanization, energy transition and economic development, all of which have profound spatial implications. These challenges must be addressed in an integrated manner within the broader water system. (Agenda IJsselmeergebied 2050, 2018). To make the water system more robust and to expand the capacity of freshwater buffer, the area agenda (2018) focuses primarily on area-wide tasks that transcend the scale level of individual subareas, meanwhile looking for the synergy opportunities between water management, nature, culture heritage, urbanization and economy (including agriculture, fishing, recreation, nautical sector, drinking water extraction, energy extraction) of the national, provincial and municipal governments (Area IJsselmeer Area 2050, 2018).

>Figure 18, Ambitions of IJsselmeer area in 2050 (Agenda IJsselmeergebied 2050, 2018)

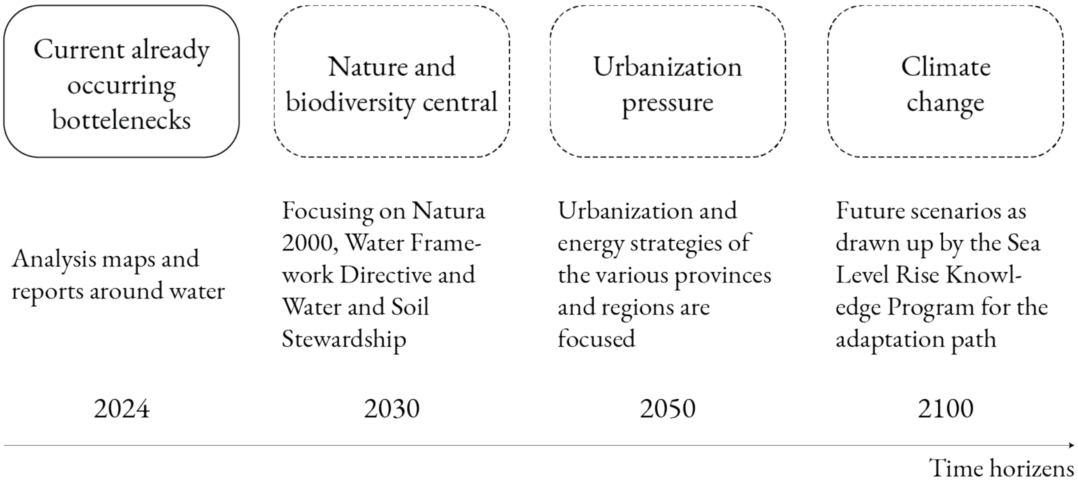
At the "system level" of IJsselmeer area, there are seven sectoral tasks been made to develop the opportunities, exploratory and dilemmas (Figure 18). The area agenda (2018) discussed about the interrelationships between these tasks, and gave three ambitions (Figure 19) to guide the spatial tasks, which built up a big picture in 2050 for the IJsselmeer area. The main idea is that, in the uncertain future under the rising sea level, it is more than important to consider the water in the most priority and to think about a new position between the water and land. This also makes people actually have to learn to live with water, and try to mitigate the impact from water. The three ambitions also align with the dimensions of spatial quality—amenity value, future value, and use value—defining potential benefits for both human and non-human actors. These dimensions are translated into guiding principles for spatial tasks under each ambition.

>Figure 19, Different time horizons and their main perspectives (Ruimtelijk Verkenning IJsselmeergebied, 2023)

Additionally, different time horizons provide distinct perspectives on priorities and interconnections among tasks (Spatial Exploration IJsselmeer Area, 2023). For the current perspective, the focus centers on water, laying the groundwater for integrated management. In 2030, priorities include compliance with Natura 2000, the Water Framework Directive, and Water and Soil Stewardship, leveraging ecological research in and around the IJsselmeer area. For 2050 the urbanization plans and regional strategies of provinces and municipalities take precedence, shaping mid-term developments. While for the 2100, the focus shifts to addressing sea-level rise, particularly under the KNMI climate scenario "Protect Closed," with a key emphasis on safeguarding the Afsluitdijk in alignment with the Sea Level Rise Programme.

These time horizons not only clarify task priorities but also provide a roadmap for organizing space and water as part of an adaptive pathway for future transitions. The next step will focus on developing strategies to spatially integrate water and land management, ensuring long-term resilience and sustainability in the IJsselmeer area.

Ambitions	Spatial quality	Principles
World-class Landscape	Amenity value	Cultural-historical qualities Spatial identity
Future-proof water and ecosystem	Future value	Water safety Water quality Energy transition
Vital Economic interests	Use value	Recreational use Area quality Socio-eonomic vitality



Current already occurring bottelenecks	Nature and biodiversity central	Urbanization pressure	Climate change
Analysis maps and reports around water	Focusing on Natura 2000, Water Framework Directive and Water and Soil Stewardship	Urbanization and energy strategies of the various provinces and regions are focused	Future scenarios as drawn up by the Sea Level Rise Knowledge Program for the adaptation path
2024	2030	2050	2100

A: Preconditions

Freshwater availability

A) Freshwater supply
Salt intrusion is a critical issue that significantly reduces the capacity of the freshwater buffer in the IJsselmeer Lake Region. This challenge stems from both natural processes and human-induced factors, such as climate change and altered hydrological cycles. The main freshwater intake points in the region face increasing threats from salinization, particularly due to the intrusion of saline groundwater into previously freshwater-dominated areas. These changes compromise the availability of freshwater for various uses, including drinking water, industrial processes, and agricultural irrigation.

B) Rising demand of water
The growing demand for freshwater further exacerbates the pressure on the IJsselmeer Lake Region's water resources. One significant driver is the increased flushing demand for dams, which is necessary to maintain water quality and prevent saltwater intrusion. Additionally, agricultural activities, especially in low-lying polder areas, require substantial volumes of water for both irrigation and flushing purposes. These competing demands highlight the urgent need for an adaptive and sustainable water management strategy that can balance freshwater availability with the growing needs of various sectors while safeguarding the region's ecological and socio-economic resilience.

🟪 Dunes

⬜ Urban area

— Dike (water defense)

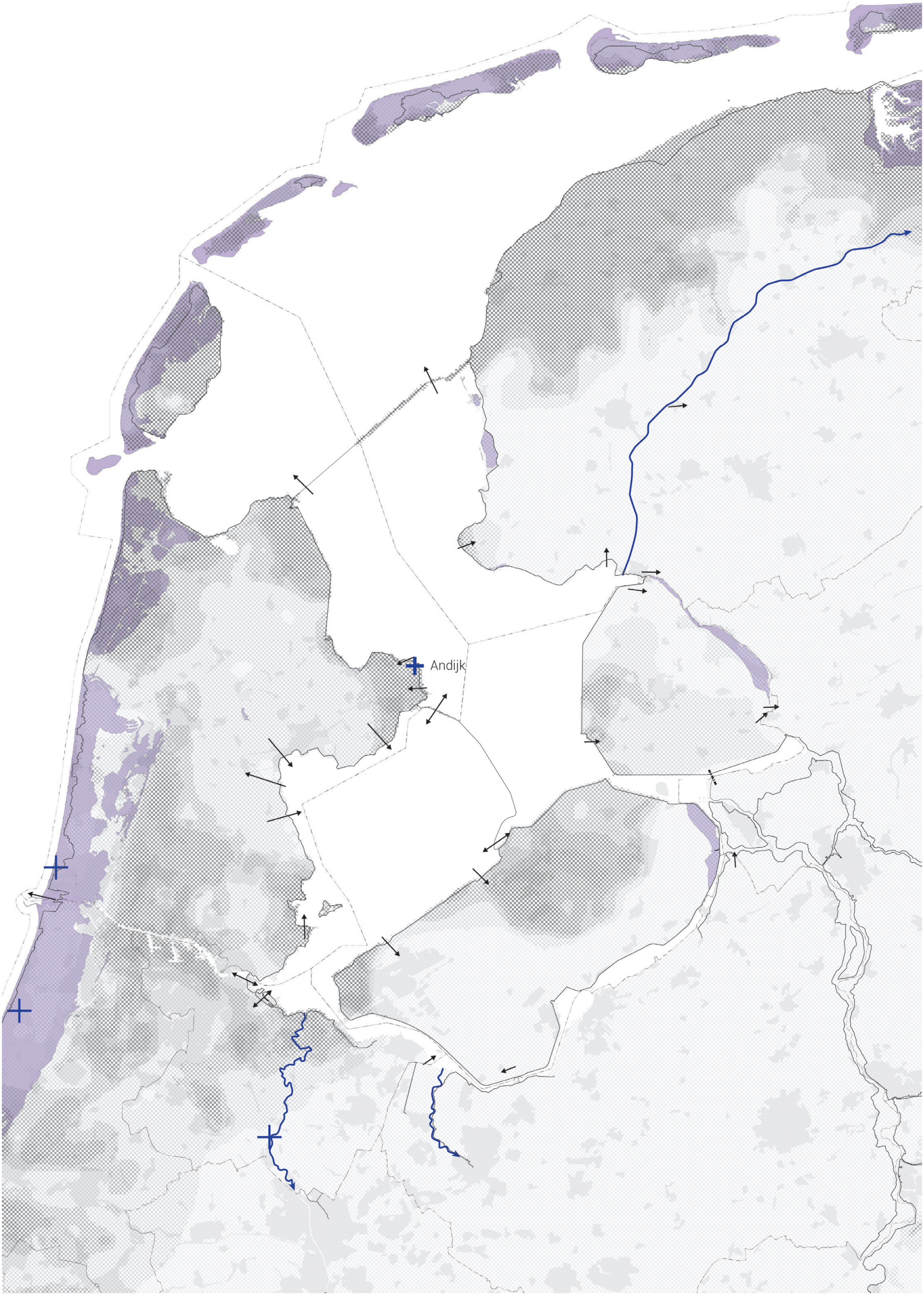
◄► water inlet/water discharge

+ Freshwater intake point

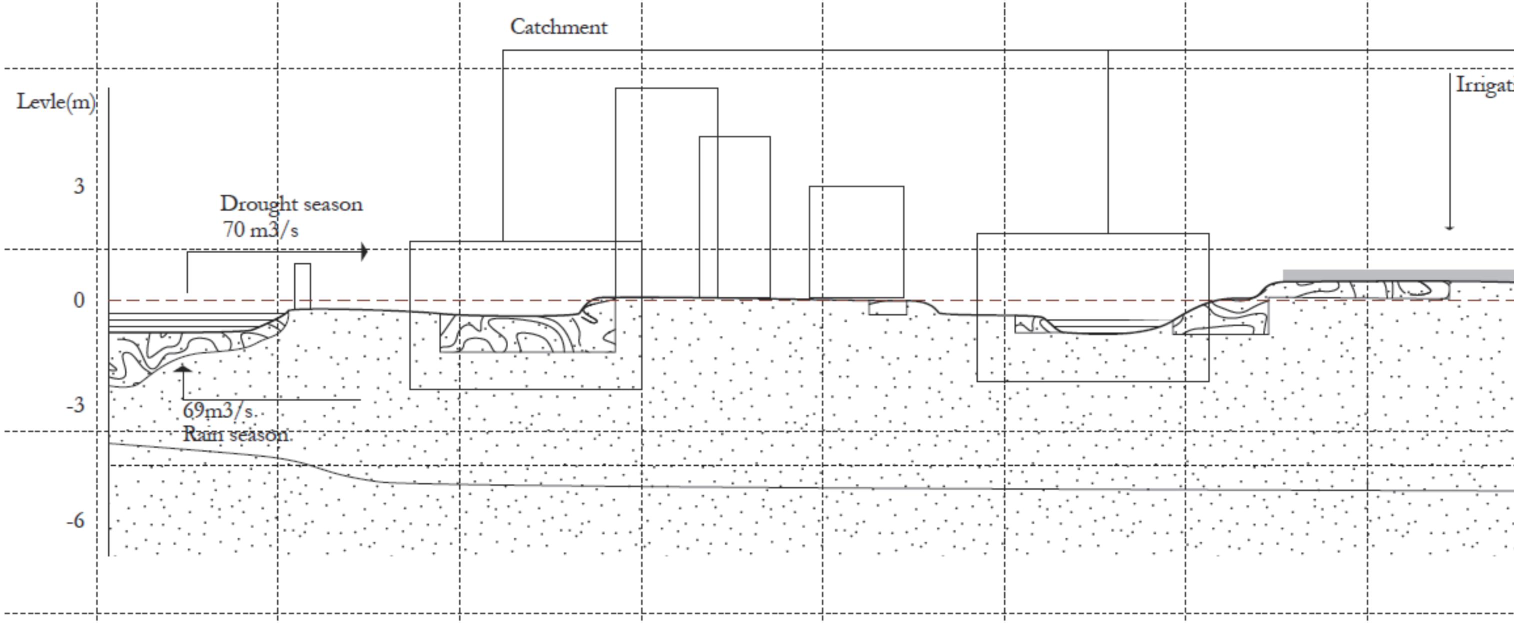
Salinization_groundwater

-5m

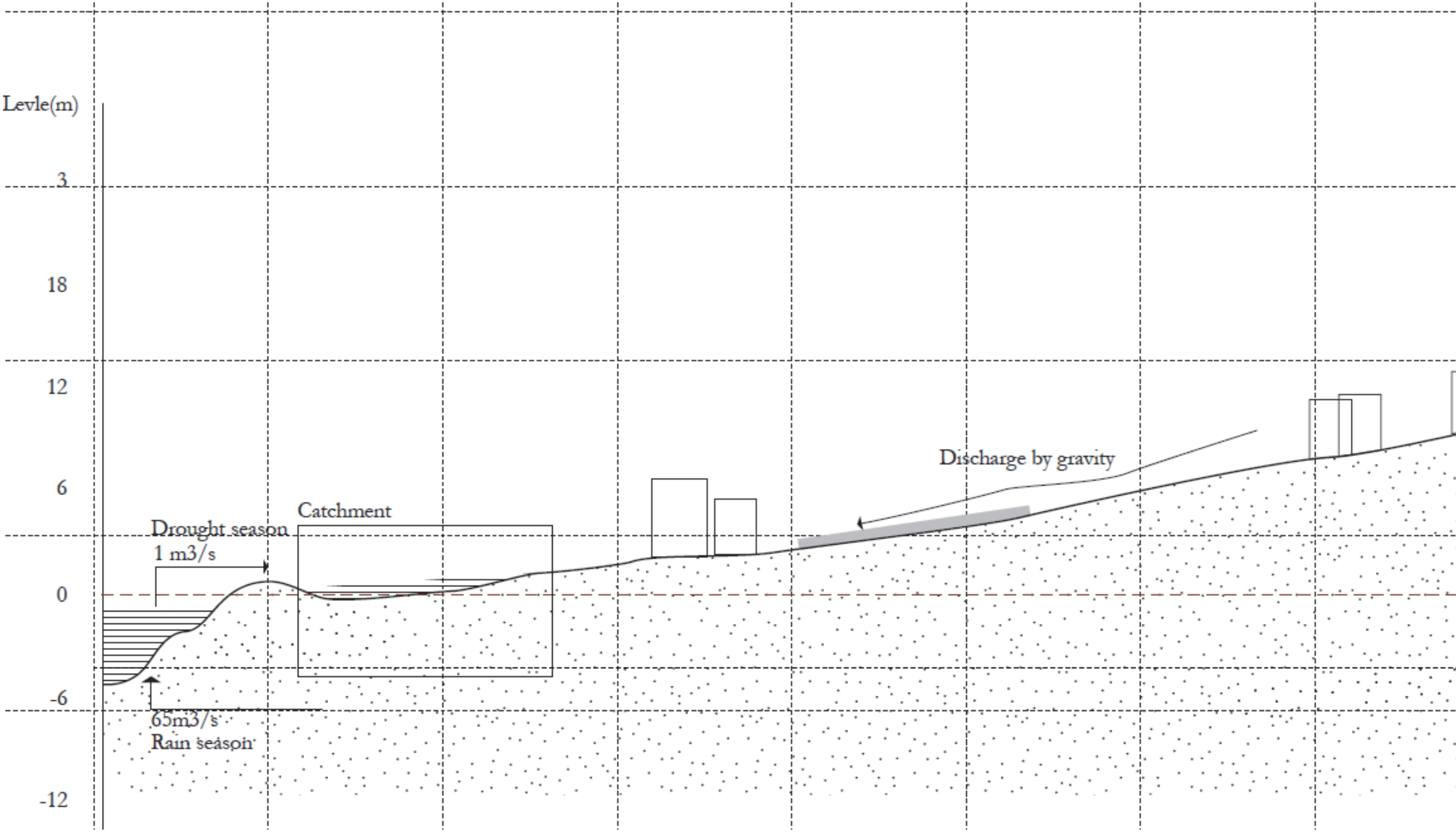
>100m

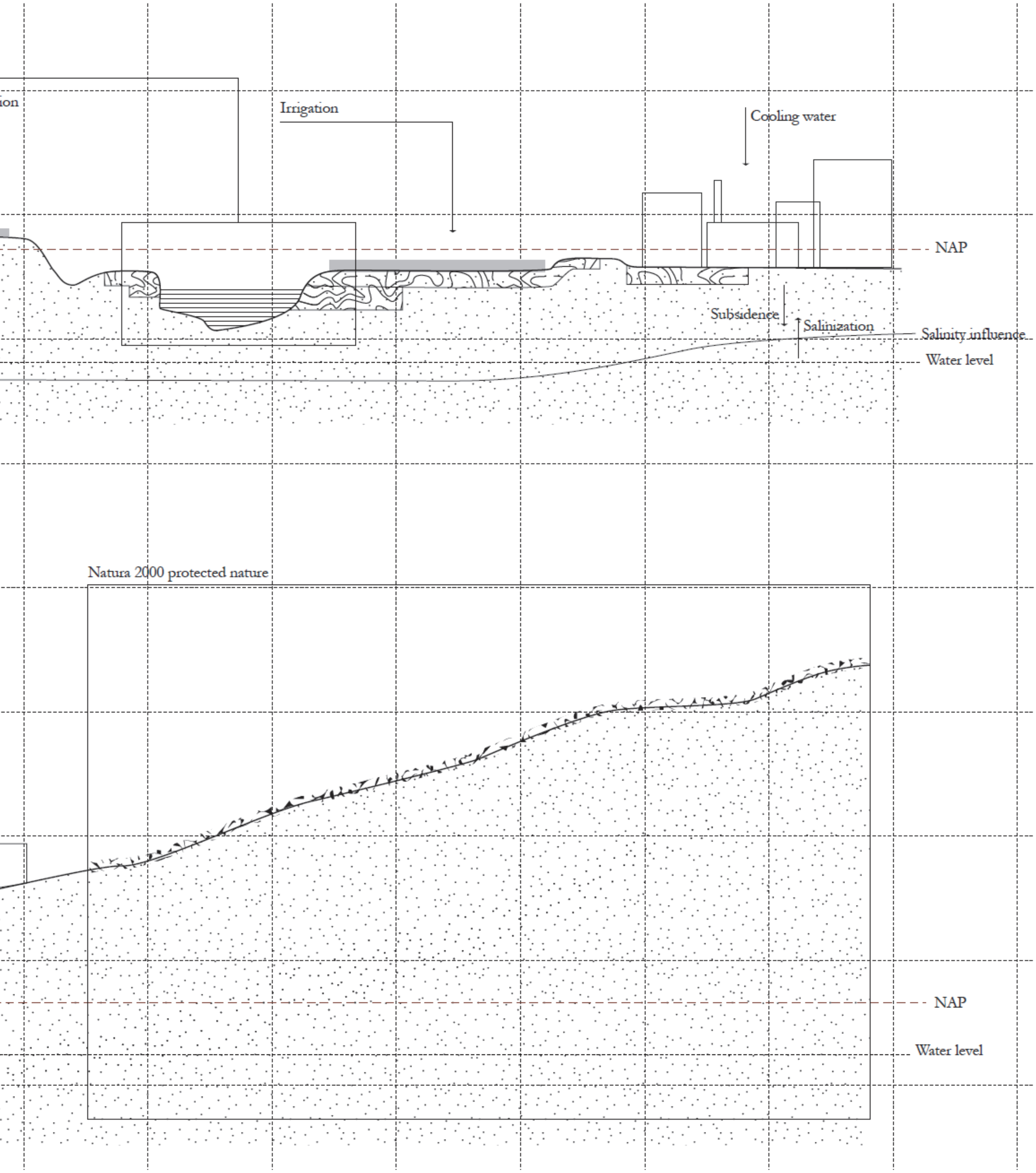

Andijk

Water flow in between living environment and IJsselmeer



Water flow in between nature and IJsselmeer




ion
Irrigation
Cooling water
NAP
Subsidence
Salinization
Salinity influence
Water level
Natura 2000 protected nature
NAP
Water level

Water safety

The reclaimed polders in the IJsselmeer Lake Region are highly susceptible to flooding, as they lie below sea level and depend on robust water management infrastructure to remain dry. These areas represent some of the highest flood risk zones due to their reliance on continuous pumping and dike systems, which are increasingly strained under the pressures of climate change and rising sea levels.

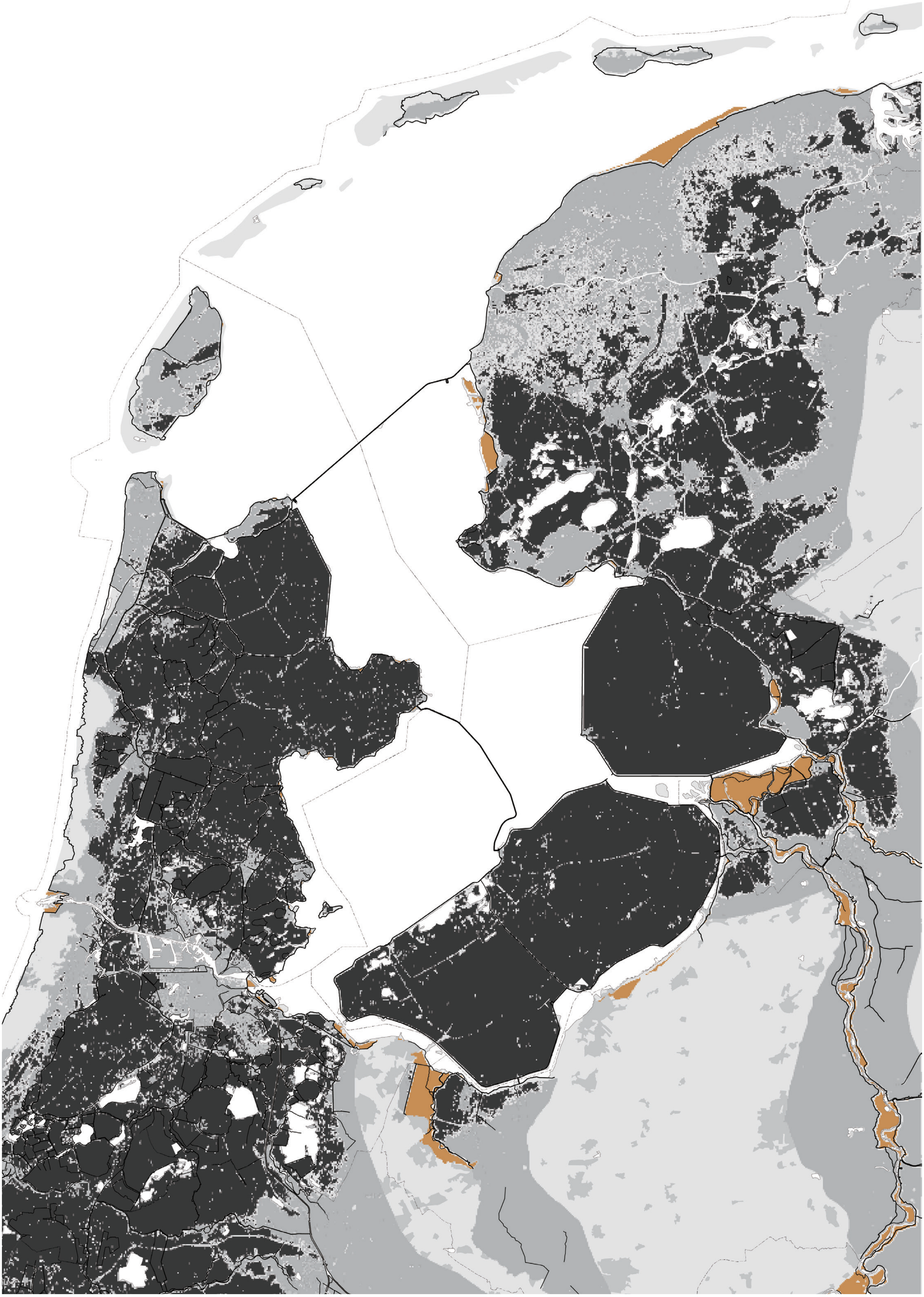
In addition, areas located outside the dikes face heightened vulnerability to flooding, with landscapes being significantly altered as a result. Flooding in these zones not only threatens existing ecosystems but also disrupts land use patterns, affecting agricultural productivity, human settlements, and natural habitats. These challenges underscore the critical need for integrated flood risk management approaches that combine land-use planning, ecosystem restoration, and resilient water infrastructure to adapt to changing hydrological conditions.

⬛ Below NAP

⬜ Above NAP

🟧 Area outside dike

— Dike (water defense)



B: Values

Nature & Biodiversity

A) Freshwater supply
Salt intrusion is a critical issue that significantly reduces the capacity of the freshwater buffer in the IJsselmeer Lake Region. This challenge stems from both natural processes and human-induced factors, such as climate change and altered hydrological cycles. The main freshwater intake points in the region face increasing threats from salinization, particularly due to the intrusion of saline groundwater into previously freshwater-dominated areas. These changes compromise the availability of freshwater for various uses, including drinking water, industrial processes, and agricultural irrigation.

B) Rising demand of water
The growing demand for freshwater further exacerbates the pressure on the IJsselmeer Lake Region's water resources. One significant driver is the increased flushing demand for dams, which is necessary to maintain water quality and prevent saltwater intrusion. Additionally, agricultural activities, especially in low-lying polder areas, require substantial volumes of water for both irrigation and flushing purposes. These competing demands highlight the urgent need for an adaptive and sustainable water management strategy that can balance freshwater availability with the growing needs of various sectors while safeguarding the region's ecological and socio-economic resilience.

Spatial quality

The reclaimed polders in the IJsselmeer Lake Region are highly susceptible to flooding, as they lie below sea level and depend on robust water management infrastructure to remain dry. These areas represent some of the highest flood risk zones due to their reliance on continuous pumping and dike systems, which are increasingly strained under the pressures of climate change and rising sea levels.

In addition, areas located outside the dikes face heightened vulnerability to flooding, with landscapes being significantly altered as a result. Flooding in these zones not only threatens existing ecosystems but also disrupts land use patterns, affecting agricultural productivity, human settlements, and natural habitats. These challenges underscore the critical need for integrated flood risk management approaches that combine land-use planning, ecosystem restoration, and resilient water infrastructure to adapt to changing hydrological conditions.

Figure 27, Ecology
By Yiyan

🟩 Peat soil

⬜ Urban area

Natura 2000 area

▨ Habitat directive area

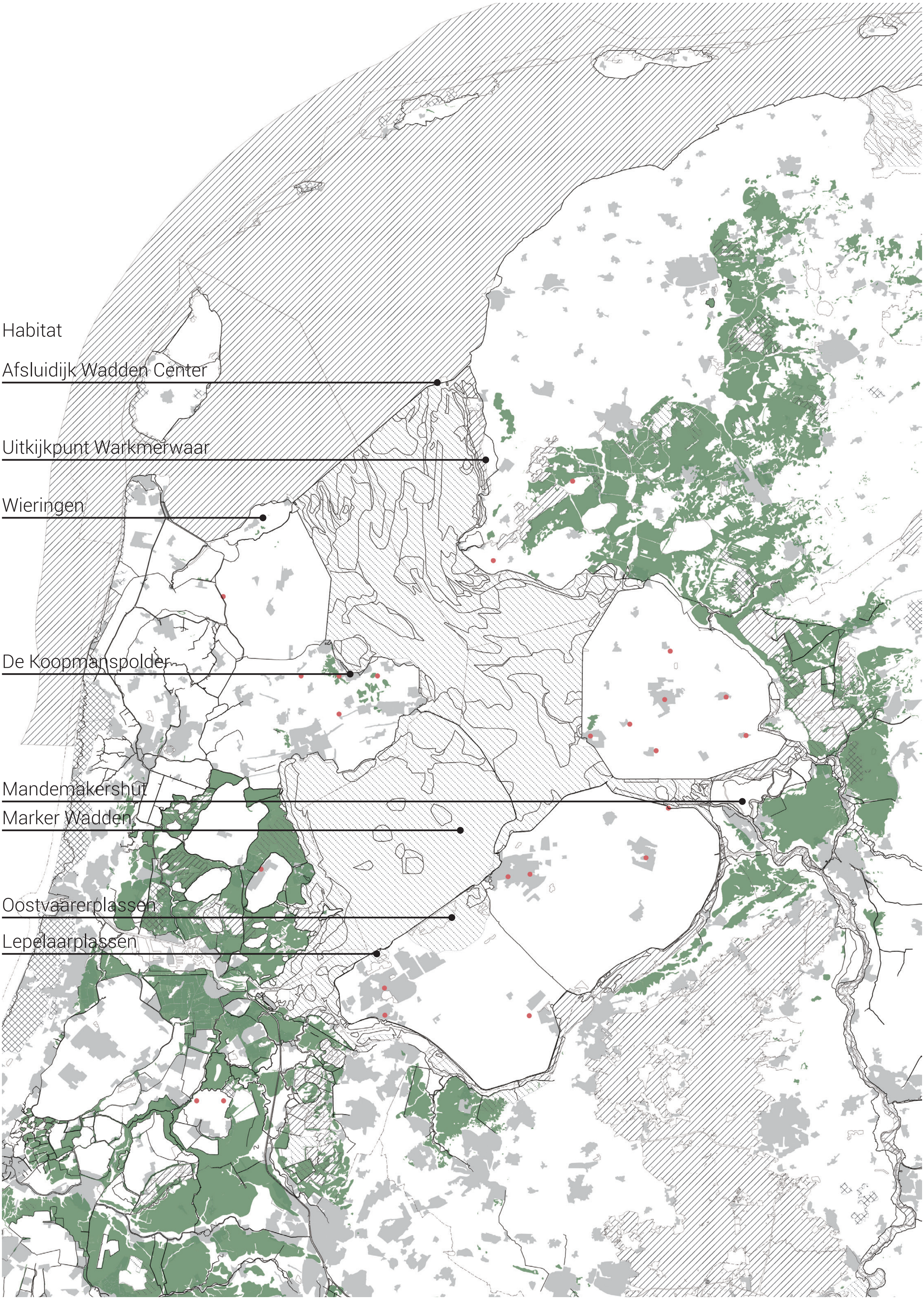
▨ Birds directive area

Birds + Habitat directive area

☐ Area outside dike

● Bird colony location

— Fish routes


Habitat
Afsluidijk Wadden Center
Uitkijkpunt Warkmerwaar
Wieringen
De Koopmanspolder
Mandemakershut
Marker Wadden
Oostvaarerplassen
Lepelaarplassen

C: Activities

Livability and housing

In the Amsterdam Metropolitan Region and its surrounding areas, increasing population and economic activities have intensified spatial demands. The inland spaces are under significant pressure, with rising demands for residential, industrial, and agricultural development, coupled with escalating water needs. These challenges highlight the necessity for integrated spatial planning to balance urbanization with sustainable water resource management.

Energy transition

The energy transition introduces the need to optimize the use of open water for energy production, such as wind and solar farms. Clustering these facilities on open water not only maximizes efficiency but also frees up land-based areas for other critical uses. This approach ensures that space is utilized effectively while supporting the transition to renewable energy and maintaining spatial quality for other economic and environmental purposes.


Friesland
Noord-Holland Noord
Flevoland
West-Overrijssel
Noord-Holland Zuid
Noord Velurwe
Amersfoort
Stedendriehoek/cleantechregio
U10/U16
FoodValley

Economic function

A) Space on Open Water
The IJsselmeer Lake Region faces spatial conflicts on open water due to competing demands from different economic activities. Shipping routes, critical for regional and international trade, often overlap with areas used for recreational water activities such as sailing and tourism. Balancing these uses requires strategic spatial planning to minimize conflicts and ensure the efficient and sustainable use of water surfaces.

B) Space in Transitional Zones
Ports and transitional zones between land and water offer opportunities to enhance freshwater storage capacity. These areas could integrate multi-functional uses, such as serving as water buffers while supporting economic activities like logistics and trade. Such adaptive designs can strengthen the region's resilience to climate change while maintaining its economic vitality.

Figure 28, Economy
By Yiyan

☐ Commercial port

☐ Recreational port

■ Urban area

— Main waterway

------ Waterway

∠ Movable bridge