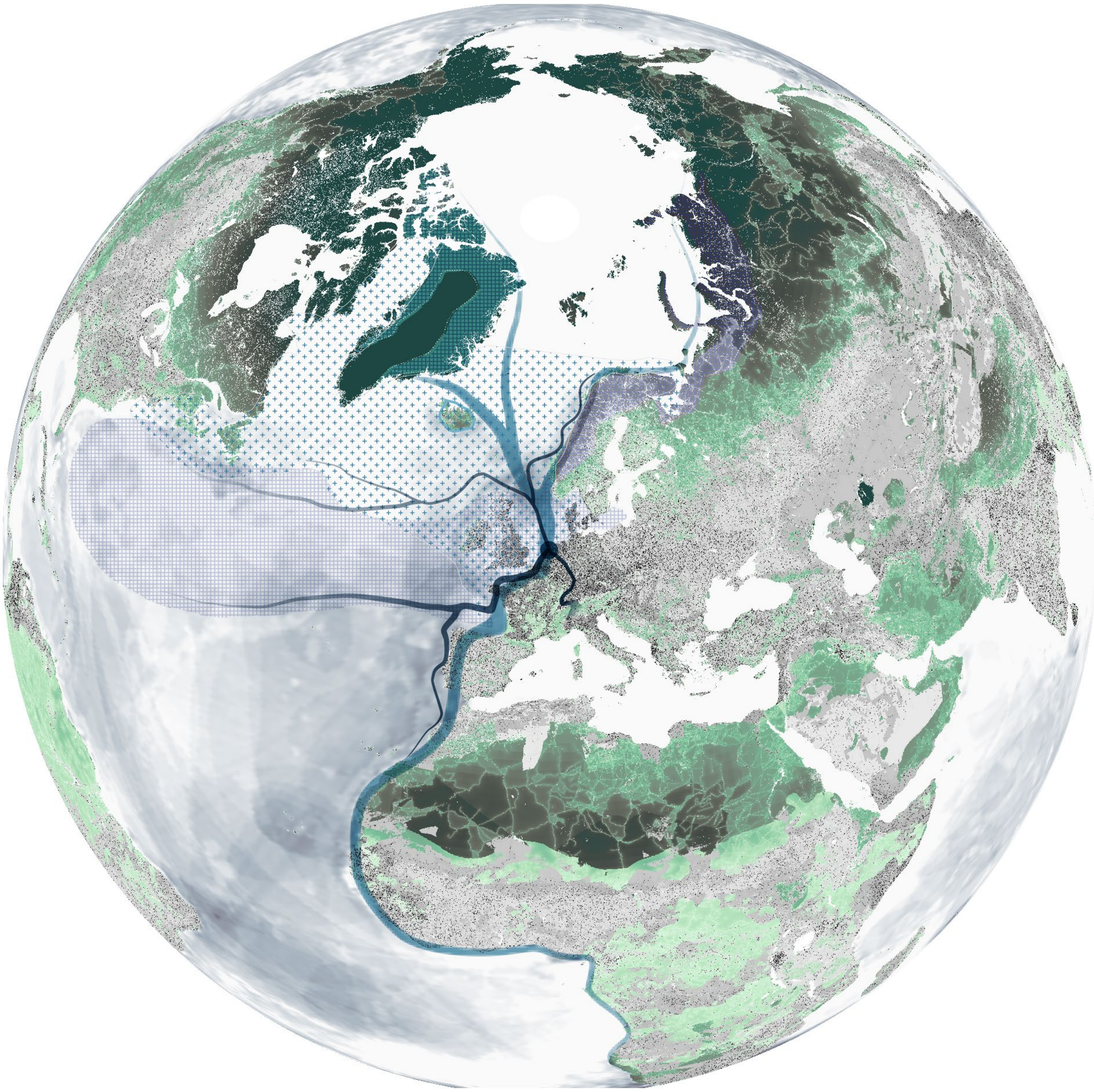

The Blue Heart

A territorial envisioning of evolutionary agro-urban ecologies

Fabio Alberto Alzate Martinez / P5 Report / TU Delft Urbanism

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agro-urban ecologies

P5 Report

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ABSTRACT

The Blue Heart is the deltaic territory composed of the IJssel Estuary, IJsselmeer-Markermeer, Wadden Sea, and the reclaimed polders of Flevoland and Wieringermeer. The Blue Heart is a globally important node of migration of aquatic species and birds due to its delta estuary geomorphology. However, the same deltaic conditions that allowed intense biodiversity were dangerous for local human settlements, constantly facing disasters due to storm surges from the North Sea. As an adaptation measure to minimize the probability of flooding, the Zuiderzeewerken implemented new linear flooding defenses in the Blue Heart Delta, such as the Afsluitdijk and new dikes that surrounded the newly reclaimed polders. However, this adaptation measure had severe ecological trade-offs. It interrupted the migratory routes and completely changed the endogenous brackish water ecosystem of the Zuiderzee into a freshwater reservoir for the demand for agriculture and housing. In the process, the water infrastructure morphology eliminated most of the vital local species of the brackish water habitat, degrading the ecological succession processes in the lakes. Currently, the lakes Markermeer and IJsselmeer have severe ecological challenges related to the lack of biodiversity, which not only impacts the global web-of-life of the Blue Heart but also the original local fishing activities. Furthermore, the Province of Flevoland was developed as an intensive agricultural land towards exportation, facilitated by favorable marine clay fertility conditions and advanced farming technologies. As new climate conditions appear in uncertain future horizons, the limits of the paradigms that maintain the current territorial conditions and functions of the Blue Heart are increasingly urgent. The project starts by shifting the harmful conditional and functional paradigms by adopting a nexus of ecology, water infrastructure, food, and housing. Then it proposed a planned adaptation model that guides the territorial recomposition and regional deconstruction of the Blue Heart to achieve endogenous agro-urban ecological interfaces. In that sense, proposing a socioeconomic system that can synergize with the web of life. The new spatial possibilities allow a regional envisioning for Flevoland that is rooted in ecological reintegration and water infrastructure change considering the future socio-climate scenarios of Deltares.

Keywords: delta, agro-urban, climate adaptation, regional envisioning, research-by-design

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Composition (Figura Só). Tarsila do Amaral, 1930
Source: www.enciclopedia.itaucultural.org.br

MOTIVATION

My education process was always guided by a personal broad interest in the several elements that compose and sustain life. Since my childhood I had a strong family academic influence in the fields of biology and agronomy, being part of the younger generation from a traditional Colombian rural family of coffee farmers. In this context, I developed a continuous sensibility and curiosity regarding ecology and agriculture, and also awareness about the struggles, complexity, and beauty of growing life to nourish our bodies and soul. An interest that I have been weaving with architecture and urbanism since my bachelor's in Brazil. During my bachelor thesis, I proposed the concept of an hyperterritory: an agro-urban interface in the region I grew up that links smallholder food production farmers with urban infrastructures. A project that showed me the importance of bridging agriculture into spatial planning to avoid land use pressures and food security issues. Especially important now that our food system is collapsing, and technocratic unsustainable industrial solutions are emerging as saviors for an environmentally decaying world, such as transgenics and lab-produced meat, while local smallholder farmers are increasingly losing space.

And with that, we are losing our connection with agriculture, our perception of food as life, and the critical dimension of our responsibility regarding our choices, fundamental elements of human identity since the Neolithic agricultural revolution. A sort of sedentary civilization identity that was constantly challenged by environmental transitions and crises. Until we reach the present, the climax of the weight of our responsibility upon the Earth amidst an anthropogenic climate crisis that will force a review of our place among the web of life. To explore alternatives for this cloudy future, I decided to study in the Netherlands, a country that has a secular history of natural control to maintain the status of an effervescent agro-urban socio-economic order. A tight system that when facing the multi-layered climate-ecological crisis, has the opportunity to navigate through a new set of worldviews of non-exploitative coexistence, towards a better future for all.

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1. INTRODUCTION

1.1 The biodiversity crisis

In December of 2022, world leaders gathered in Montreal at the United Nations Biodiversity Conference (COP15) to discuss accords to reverse global nature loss. Earth's web-of-life is fraying while one million species of plants and animals are getting closer to extinction.

According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services report for policy makers (IPBES, 2019), the current global rate of species extinction is tens to hundreds of times higher than the average for the past 10 million years, and it is accelerating. As also endorsed in the report, this reinforces our responsibility upon the planetary web of life, as we are currently the dominant global influence on the planet.

Furthermore, most of the drivers of biodiversity loss are based on our capacity of managing landscapes in alignment with non-exploitative values and behaviors. In that regard, the five main anthropogenic biodiversity loss drivers (Figure 1) are land/sea use changes, direct exploitation of living organisms, climate change effects on ecosystems, pollution, and invasive alien species. Problems inherited by exploitative development models that actively involve sociocultural, economic, technological, and governance spheres of influence.

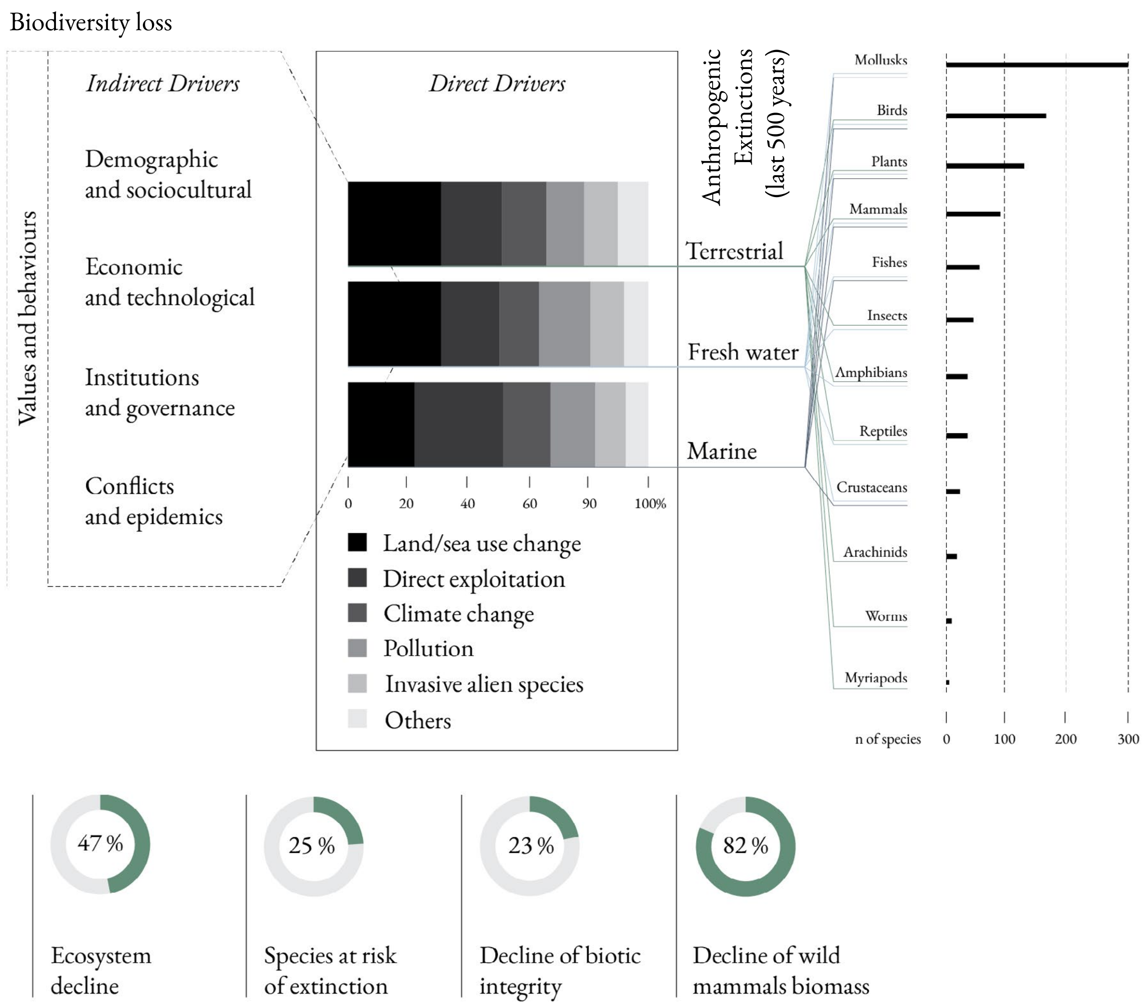


Figure 1. Biodiversity loss and anthropogenic extinction distribution of 900 species
(By author based on: *IPBES, 2019, p. 27; and Rull, 2022*)

Figure 2. Wadden Sea landscape
(Author: *Klaus Dieter Meinen* / Source: *www.whc.unesco.org/en/documents/114787*)

1.2 A future of complex climate-driven uncertainties

The shifting from exploitative models of development towards regenerative land-water use becomes increasingly fundamental when understanding the degrees of impact and uncertainty of climate change. As discussed by Leclère et al. (2020), climate change effects on biodiversity are primarily locally detrimental, and their synergistic relations with land-use change will increase in global importance in the near future. This implies that a transformative and coordinated leadership is essential to align the interdependent sustainability goals, aiming to increase the spatial allocation of biodiversity restoration efforts and climate change response.

Moreover, the understanding of the interdependent spatial and systemic aspects of land use, natural systems, and climate change is crucial to address the multi-domain challenges that humanity must face in this century. The ongoing ocean and atmospheric changes caused by human activities, such as the sea level-rising (SLR) and temperature alterations, have accelerated severe bio-geochemical and biophysical effects on crucial elements of the biosphere, with observed biological and ecological alterations that indicate that natural ecosystems are changing fast (Peñuelas et al., 2013). Hence, the climate-driven disruption of the complex layered system of interactions between the organisms is reducing Earth's capacity to maintain the balance of life, consequently affecting the stability of sociocultural systems that have an increased dependency on ecosystem services in the context of economical growth (Guo et al., 2010).

In that sense, human and natural systems under climate pressure face increased vulnerability when also affected by land pressure (Ostberg et al., 2015), especially in landscapes with contextualized physical, chemical, and biological anthropogenic degradation, such as soil erosion, industrial pollution of water systems, and deforestation. Then, these degradations can potentially reduce the possibility of the adoption of natural systems as a base for climate response strategies, commonly framed as nature-based solutions (NBS). The socioeconomic and environmental intersectionality trend indicates that a holistic ecosystem-sensitive understanding is essential to plan possible climate response strategies (Malhi et al., 2020). Thus, allowing an integrated sustainability assessment that analyses and envisions synergies and trade-offs between ecological interactions, geochemical cycles, land use, and human activities.

To face this high degree of complexity, the IPCC Summary for Policy Makers 2022, indicates a climate-resilient development approach that links future climate change, human systems transition, and ecosystems transition (Portner et al., 2022), dealing with the multiple trade-offs, and possible effects of adaptation, restoration, and provision. This also implies that more than integrative frameworks, integrative understandings of intersectionalities are extremely necessary for climate response. In the context of climate adaptation, the notion of an Adaptation Frontier bridges the understanding of a transitional adaptive operative space with socio-ecological activities that interfaces safe and unsafe domains (Preston et al., 2013). This understanding allows the identification of driving forces, outcomes, challenges, trade-offs, and the effects of conflicting socio-environmental values on desired adaptation outcomes that deals with a complex network of actors and ecosystems. This indicates a demand for new paradigms on climate risk governance that can potentially reflect upon societal values that will determine sustainability.

However, even the robust frameworks that deal with complex system interactions will be challenged by degrees of regional uncertainty in climate change effects, especially regarding SLR (Hu & Deser, 2013). When considering scenarios that have a high level of uncertainty in their interdependencies, such as the ice sheet melting in Antarctica, the effectiveness of decision-making will be severely affected. In that sense, water defense infrastructural planning has to face an uncertain rate and magnitude of SLR, and thus deal with diverse impact possibilities, summarized by different contextualized scenarios, on national and regional scales (Haasnoot et al., 2020).

Hence, the future of SLR-sensitive water infrastructure development, and renewal, will face the challenge of quickly deciding scenarios based on strategic frameworks that deal with uncertainty, considering the large time span to execute projects, necessary investment, and environmental volatility.

Furthermore, this is an important moment of paradigmatic transition, where infrastructure planning have the opportunity to transform the widespread notion of development that is reduced to economic growth and measured by narrow financial metrics and indices. With a fundamental reminder that this same development paradigm of economical reductionism was one of the main responsible for the failure of climate mitigation, since it is blind to the importance of holistic socio-ecological interdependencies, allowing the current power structures to survive uncontested where the difficulties are "acknowledged" and "internalized". And furthermore, "solved" through promised technological futures that are meticulously costed in complex models (Stoddard et al., 2021). In that sense, new sustainable paths of development must be guided and assessed by a set of values that aim for socio-ecological responsibility and planetary care. Which allows the re-envisioning and contesting of technocratic solutions that have a narrowly optimized economical reductionism.

1.3 Industrial Agriculture and the global food system failure

In the context of climate uncertainty, a generalized reform in the food system into a socio-environmental sustainable activity is one of the most crucial challenges to ensure our coexistence with Earth. Human activity has stressed and pushed the limits of the natural environment during the past century, especially after the Green Revolution, which introduced intensive chemical and physical alterations in agricultural lands. Under the paradigm of maximizing production to optimize prices, large monocultural areas received intense use of pesticides and herbicides, leading to the loss of 70% of the world's agrobiodiversity, which was held by smallholder agroecosystems (Holt-Giménez & Altieri, 2012), and disrupted by changes on the agriculture land structure. Way beyond the effects on contextual agricultural ecologies, the global food system is the primary driver of biodiversity loss, and in the past 50 years the transformation of natural ecosystems for crop production or feedstock was the main cause of ecological habitat loss (IPBES, 2019). According to the 'Red List' from the International Union for Conservation of Nature (IUCN), agriculture is identified as a threat to 24,000 of the 28,000 species so far documented by IUCN as at risk of extinction (Ritchie & Roser, 2022).

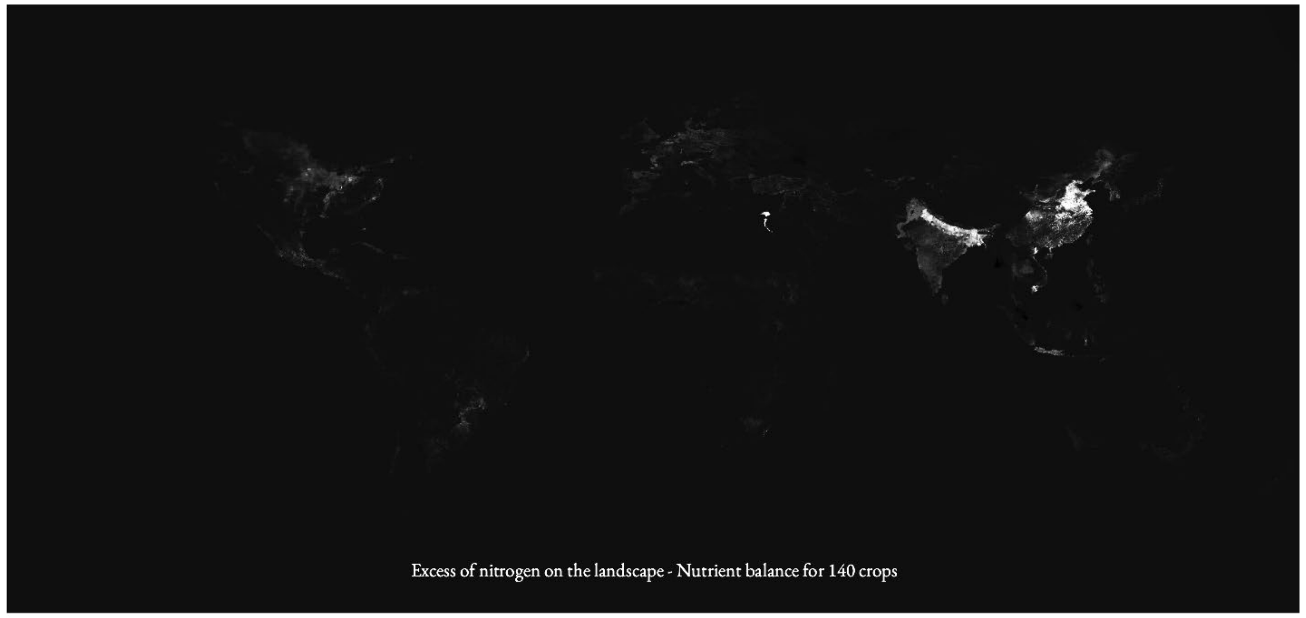
The biodiversity loss due to industrial agriculture methods is intrinsically related to the intensive degradation of the soil-water ecosystems, which has severe effects on the provision of ecosystem services and the balance of ecological interdependencies. The common practice of intensive use of agrochemicals, to optimize crop yield and profit margins, is highly nocive to the soil biota, capable of destabilizing the balance of geochemical cycles. For example, the intensive use of nitrogen-based fertilizers can disrupt the nitrogen cycle due to the nitrogen exceedance, which can lead to the acidification of the soil and high rates of nitrogen deposition due to acid rains, triggering the eutrophication process that can lead to hypoxia and harmful algae bloom, also contaminating water systems. The combined harmful trade-offs of this example, along with the nitrogen emissions from cattle farming, are observed in the current Dutch nitrogen emission crisis, where nitrogen exceedance is compromising the plans to protect nitrogen-sensitive Natura 2000 areas.

Furthermore, agriculture's harmful environmental degradation also has critical implications for climate response. The soil is one of the most fundamental biophysical structures that act directly on climate mitigation, being a carbon sink and regulator of atmospherical gases, also essentially contributing to climate adaptation because of its ecological and ecosystemic function that allows life permanence (Álvarez de Toledo, 2017). Hence, intense soil management, such as intensive tilling, can potentially fracture the soil, disrupting its structure and accelerating soil erosion and emission of GHG gases. Agriculture is currently responsible for 10-12% of total global anthropogenic emissions and almost a quarter of the continuing increase of greenhouse gas (GHG) emissions, a problem that can be significantly reduced by shifting from industrial agriculture to ecological-sensitive activities with reduced scale, embracing frameworks of agro-ecological management (Lin et al., 2011).

Alongside the biodiversity and natural resources depletion failure, the current industrialized food system also fails to deliver a healthy diet, in a way that dietary preferences, and the supplying chain of those preferences, have become significant factors in environmental and human health deterioration, regardless of whether they are made consciously or as a result of policies or food environments (Holt-Giménez & Altieri, 2012). In that sense, the industrialized food system was responsible for the increment of diet-related chronic diseases such as obesity, type 2 diabetes, cardiovascular diseases, and cancer (Hawkins, 2019), and also diseases that come from the use of agrochemicals, such as pesticides. Therefore, improving human health through sustainable nutrition and environmental restoration is a crucial condition to ensure Food and Nutritional Security, having an essential role in policies and strategies that aim for a shift towards a sustainable agri-food system, that promotes positive feedback on ecological interdependencies within a nexus of climate change, biodiversity, and nutrition (FAO, 2021).

Furthermore, the global dimension of the food system also had its failures revealed since the conflicts of the Russia-Ukraine war in 2022. Food security has been one of the biggest challenges as food, fertilizer, and energy prices had increased significantly after the supply chain disruptions from Russia and Ukraine, as both countries are major exporters of grains, agricultural products, and natural gas. Higher food prices are especially a challenge for the segment of the population with low income that spends a significant portion of their food budget on cereals. Hence, food supplies will also be under pressure in some nations that rely heavily on Ukrainian and Russian cereal imports, such as Egypt, Turkey, and the Middle East, with minor consequences for the EU (van Meijl et al., 2022). Despite the crisis, there is recent international optimism about the potential role of other international suppliers to attend to the global demand, with India already increasing wheat exports. However, diverse climate change effects, such as drought, and record spikes in fertilizer prices, are raising doubts about the ability of wheat-producing countries being able to provide global supplies (IPES-Food, 2022).

According to a recent report from the International Panel of Experts on Sustainable Food Systems, the rapidly unfolding food security crisis showed that the major structural challenges and weaknesses of the global food system are the "food import dependencies; path dependencies in production systems; opaque, dysfunctional, and speculation-prone grain markets; and the vicious cycles of conflict, climate change, poverty, and food insecurity" (IPES-Food 2022). To tackle these challenges, the panel argues that is urgent to take action on "providing financial assistance and debt relief to vulnerable countries; crackdown on commodity speculation; build regional grain reserves and a global food aid apparatus fit for the protracted crises societies face; diversify food production and trade systems; and rebuild resilience and cut harmful dependencies through diversity and agroecology".



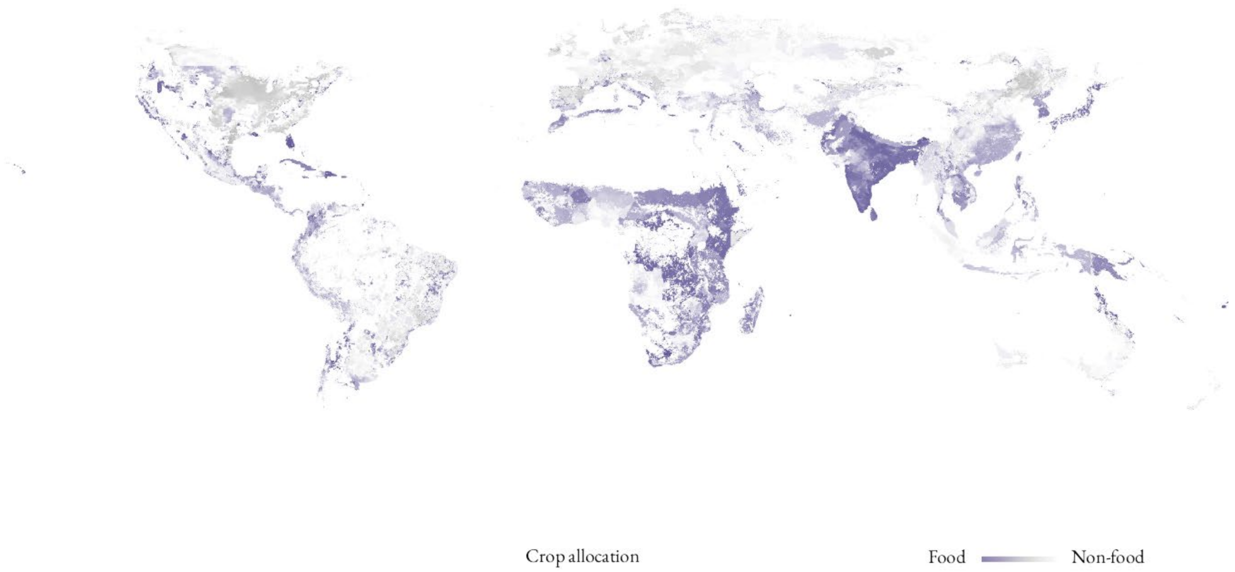


Figure 3. Nitrogen nutrient excess on soils and crop allocation
(By author, data source: *Eurostat database*)

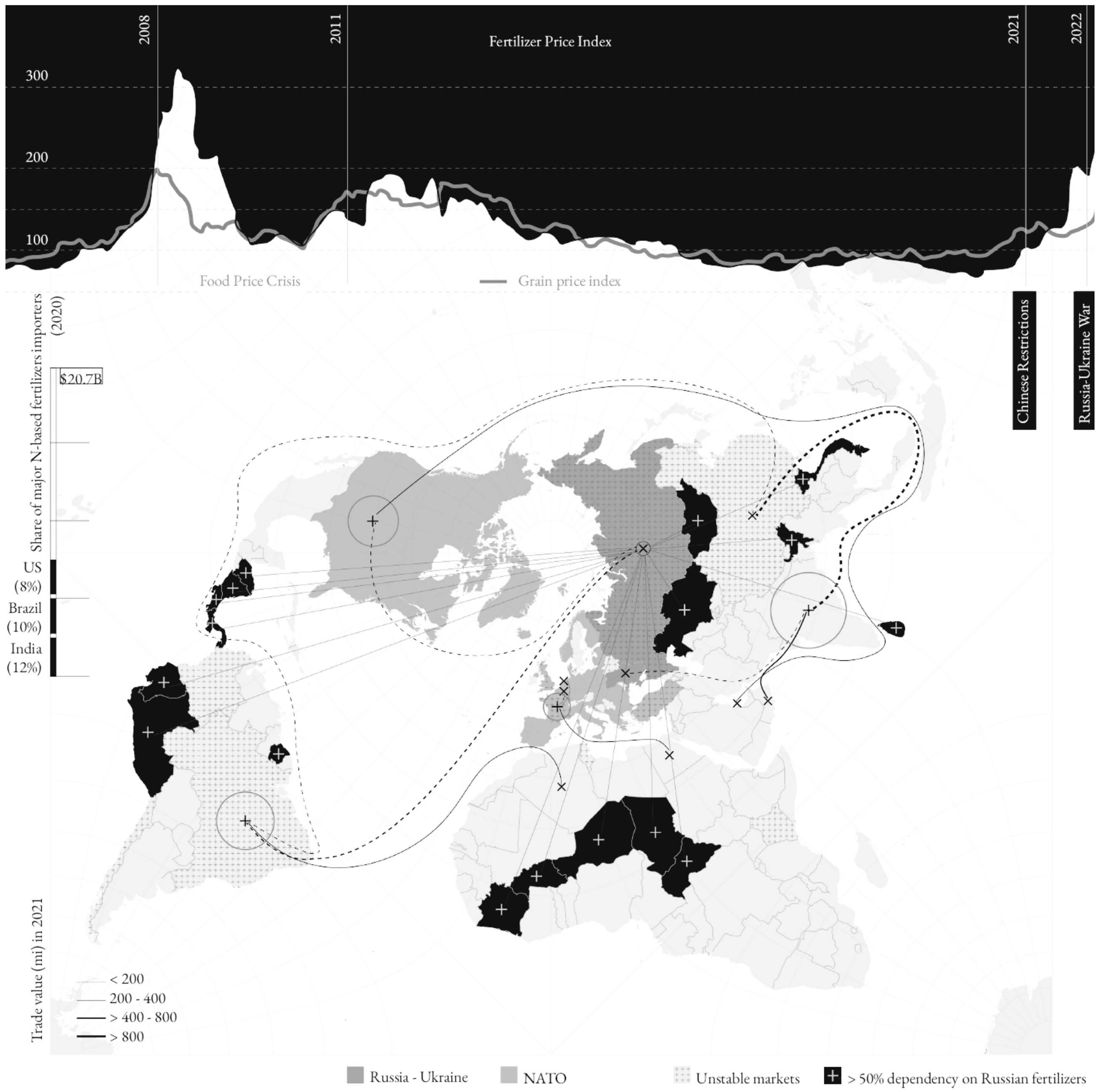


Figure 4. Nitrogen-based fertilizer disruptions and the food crisis.
(By author, data source: *Atlas for Economic Complexity, World Bank, US Bureal of Labor Statistics*).

"Climate change involves the convergence of a set of global, intergenerational, and theoretical problems. This convergence justifies calling it a 'perfect moral storm'. One consequence of this storm is that, even if the other difficult ethical questions surrounding climate change could be answered, we might still find it difficult to act. For the storm makes us extremely vulnerable to moral corruption"

(Gardiner, 2006)

1.4 The framing of holistic notions and paradigms to face the perfect storm

The acknowledgment of these complex multi-domain interactions sets a new demand for reframing understandings about our responsibility of care and the socioecological possibilities to coexist with natural dynamics. In the last decades, new ways of reframing those understandings are emerging as integrative notions that challenge established paradigms. For example, the integrative notion of a Critical Zone (CZ) in earth sciences, defines a near-surface terrestrial environment that sustains life by interfacing with the complex interactions of rock, soil, water, air, and living organisms (Richardson, 2017). According to Bruno Latour, an understanding of CZ not only collapses a two-dimensional cartographic view of planet Earth but also reframes the legal and political unity of global views (Latour & Weibel, 2020), reformulating our notion of space and interrupting the idea that we are dealing with a unified Earth system, leading to the realization that we need to compose a common world (Latour, 2014).

In that sense, the CZ is a worldview capable of understanding the codependency of the aforementioned human challenges of providing infrastructural solutions to thrive during uncertain climate futures, and the necessary actions that need to be taken to restore biodiversity and ecological balance by rethinking the impact of our activities on the landscape. This understanding is based on the intersections of dynamic interactions in the different time frames of geochemical processes, living organism cycles, and environmental conditions, indicating that possible synergies can be unveiled to reduce trade-offs between systems when a specific landscape presents these complexities simultaneously.

Finally, in order to properly face the climate-environment-driven challenges, the foremost important domain and value that needs to be taken as a fundamental intersection of those complexities is health. To go beyond the climate change effects on bodies and biodiversity loss and ecological destruction, the anthropologist Arturo Escobar (2019) proposes a broader understanding of health that is related to the disruption of human sociality, collapse of social bonds, multiplication of conflicts and brutality, heinous injustice, and the difficulty that young people experience in creating meaningful lives. As a consequence of that understanding, health, such as ecology, becomes a fundamental element to pursue the desire for a better and different coexistence with the Earth. Health takes place as an emergent property of the dynamic interaction of self-organizing networks embedded in biophysical, economic, political, cultural, environmental, and spiritual systems (Escobar, 2019). This ontological perspective of health clashes with current ontologies predominant in the West, that separate body, mind, communities, and environment. Hereby lies the opportunity to bridge health with the ontology of the pluriverse, defined as a worldview that proposed new forms of creating meaning, experience, and knowledge that challenges and goes beyond the normative, Western, or Eurocentric ethical and ontological epistemologies (Perry, 2021).

Moreover, pluriversal health becomes a fundamental ontology to navigate through the ongoing climate-driven storms defined by Gardiner (2006). The notion of pluriversal health acts directly on the global and intergenerational storms addressed by Gardiner, since health as a value can be a unifying value and assessment for the future of humanity. Hence, helping the navigation through the dispersion of causes and effects, fragmentation of agencies, and institutional inadequacy, that characterizes these two storms, observed by the increasing complexity of problems, power structures, and actors involved - which led to the selective attention strategies that dissolved the possibility of a strong global mitigation responsibility. Also, it can help humanity to navigate through the theoretical storm, characterized by the severe difficulties of addressing interdependencies between scientific uncertainty, intergenerational equity, human contingencies, natural systems, and living organisms, fundamental to tackling the multidomained and uncertain nature of climate effects. And finally, also essential to overcome the moral storm, avoiding the generational mistakes of environmental exploitation that took advantage of the future, which is now our present, without any charges for the responsibility of setting a world of uncertainties and disasters.

2. THE CHALLENGES FOR THE NETHERLANDS

2.1 The formation and paradigms of a controlled nature

"There's a saying – 'God created the earth, but the Dutch created the Netherlands'. The idea behind this is that the Netherlands are artificial – we took our land literally from the sea; there is now land where there used to be just water. Over a thousand-year period, cities have been built on the water, and the Dutch have created the landscape with their own hands."
(Neutelings, 2015)

SLR, more than a global concern, is an especially critical transition that reveals the formation, current concerns, and potential futures for the Netherlands. Across history, the formation of the Netherlands faced several challenges in water management, especially in the construction of the polders that characterize the Dutch lowlands (Figure 5). The initial occupations of the western half of the country were made upon a low-lying delta landscape, originally covered by highly compressed layers of peat and clay soils. Over many centuries, land use practices resulted in the loss and decay of these soils, causing an intense process of subsidence. Concomitantly, a period of post-glacial sea-level rise, high tides, and storms resulted in the flooding of large areas, inflicting several socio-economical losses.

However, the process of reclaiming these lost lands started in the sixteenth century, and "resulted in a country where one-third of the land lies below mean sea level and without dunes, dikes, and pumps, 65% would be under water at high tide" (Hoeksema, 2007). According to Hoeksema (2007), the historical development of land drainage and reclamation happened in three main stages:

The first stage was in the 16th and 17th centuries, when lakes in the north of Amsterdam were drained, with the use of windmills, and reclaimed for agricultural purposes;

The second stage in the 19th century, marked by the largest lake drainage, by using exclusively steam-powered pumps to drain the Lake Haarleem to form the polder Haarlemmermeer;

The final stage in the 20th century, the draining and reclamation of the Zuiderzee tidal estuary, forming the Flevopolders, and the Border lakes, resulting in an additional 1650 km2 of land for agriculture, recreation, and urban expansion.

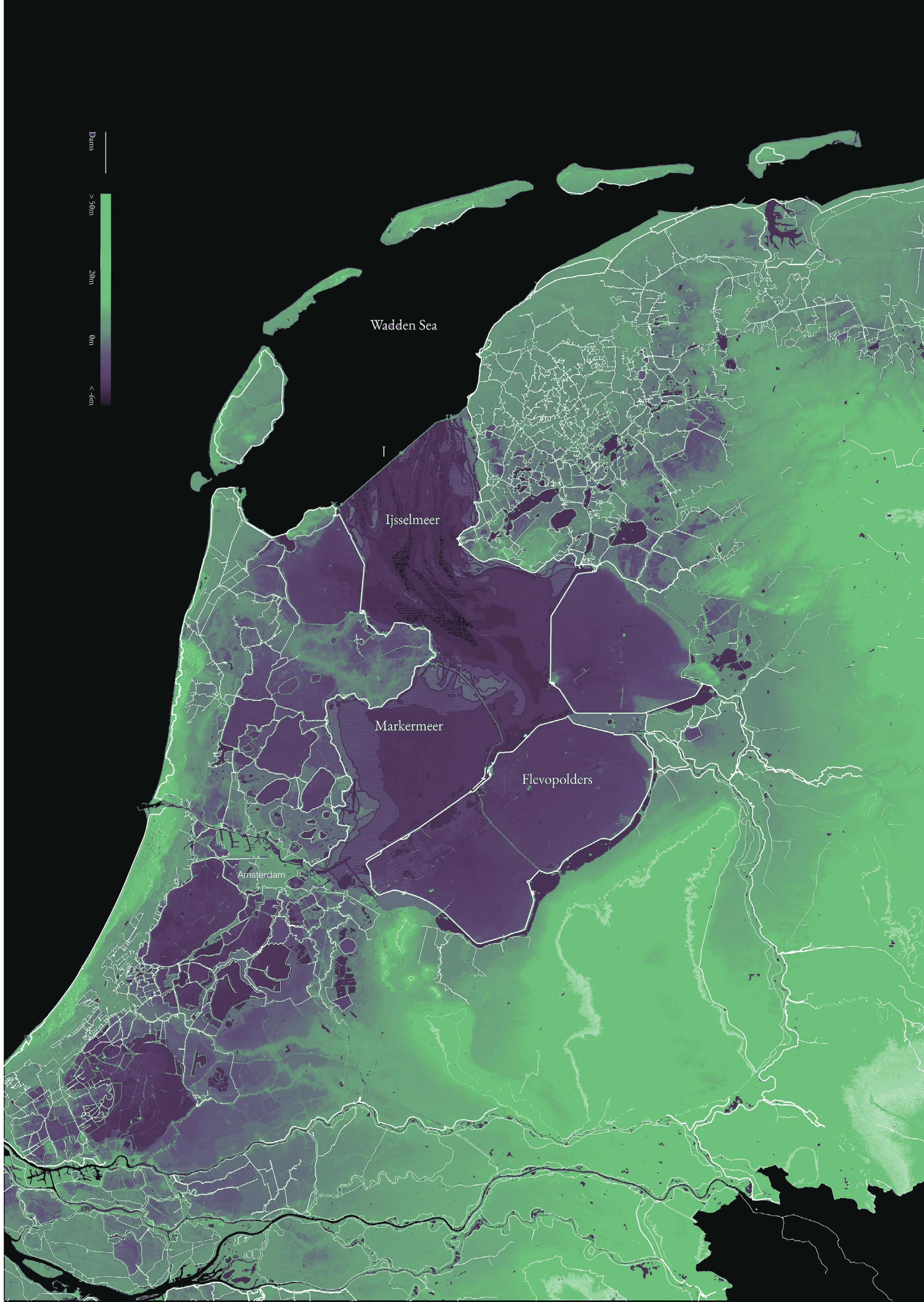


Figure 5. Map Controlled nature based on digital terrain model and bathymetry of the IJsselmeer and Markermeer.
(By author, data sources: *Rijkswaterstaat, Actueel Hoogtebestand Nederland AHN*)

As a result, Dutch socioeconomic dynamics were able to develop in a highly controlled lowland landscape, characterized by the control of the Rhine Delta flows along a static body in between dikes and water management systems, the intense management of polders which are constantly being operated by an intricate water infrastructure, and the extensive network of coastal water defense infrastructures that protect the country against storms and sea level rising fluctuations. However, during the process of formation of this landscape, the paradigms of physical safety that guided development plans changed. During the 19th century, the paradigm for physical safety was "responsibility"; in the 20th century, it became "solidarity" with the nation-state as the guardian reflecting a uniform risk level for the Netherlands and all its citizens, grounded in the understanding that risk is the product of probability and consequence; and according to the Netherlands Scientific Council for Government Policy, the new paradigm for the 21st century should be "precaution" (Meyer, 2017).

According to Meyer (2017), such paradigmatic change brings controversies and implications for flood-protection policy since it changes the state monopoly of responsibilities over flooding protection that aim to minimize the probability of flooding, towards a new paradigm that aims for a shared responsibility of government and society, where joint actions of the government and private sector must reduce risks, uncertainty, and vulnerability. This new approach also sets the idea of reducing the consequences of flooding, and it was already reflected in several "Room for the River" projects. For example, since 2015 some areas of Noordwaard have been depoldered at Werkendam, creating a high-water flood area, and for the first time demonstrating that is possible to successfully plan a flooding system in habitable areas while keeping roads and houses dry through design (RWS, n.d.). This example also was a threshold for new relationships between the government, which actually took measures to increase flooding probability, and private individuals that took actions to limit the consequence of it.

2.2 Adaptive pathways and the Delta Scenarios

Despite the historical efforts to protect the lowlands from the sea, the current uncertainty on SLR scenarios, and socioenvironmental interdependencies, are pushing the government to adopt dynamic adaptive management frameworks that operate around different scenarios and pathways. An example of a framework is the Dynamic Adaptive Policy Pathways adopted by Deltares, in which planners should develop a long-term strategic goal, commit to short-term actions, and establish a framework to guide future actions. A strategy that incorporates these concepts enables dynamic adaptation over time to meet changing conditions (Haasnoot et al., 2013). As an essential component of this strategy, Deltares also formulated four different socio-environmental scenarios (Steam, Busy, Warm, and Rest) based on climate change and socioeconomic development, to predict where and when alternative (water) measures will be necessary for the future. It is important to highlight that the Delta Scenarios are not predictions or target scenarios. Rather, they are context scenarios that work around uncertainty to indicate how the climatic and socioeconomic may influence water management in 2050 and 2100. Since they describe a limited, reasonable range of autonomous developments, it is likely that advances in the next century will occur outside of this spectrum. Hence, the Delta Scenarios can be used to detect future water-related concerns, evaluate measures, and spark ideas for new infrastructure and urban development (van de Brugge & Bruggeman, 2017).

2.3 The geopolitical and ecological pressures on Dutch Agriculture

> "At its best, the Netherlands is a place of fascinating ideas, dynamic people, and innovative energy policies. But the wheels of its green agenda are in desperate need of oil. Rather than chasing the headlines, ambitious politicians need to win broader local support for uncomfortable changes, sort out their regulatory system, and ditch their sentimentality for pretty buildings that only let out hot air. There's a cold winter coming." (Boztas, 2022a)

In a country with the EU's highest density of livestock, the nitrogen-based emissions from manure and the excessive use of fertilizers became a critical problem that is compromising European environmental goals. Since the 1980s, initiatives have been implemented to limit agricultural fertilizer emissions, leading to a much lower nitrogen and phosphorus surpluses at the farm level, and lower nitrate concentrations in groundwater and surface waterways (Bos et al., 2013). Nevertheless, in 2019 a court decision determined that nitrogen-based pollution could not be 'traded' as it was previously (Boztas, 2022a). Ever since, the Netherlands has been facing the challenge of reducing emissions from farming, which correspond to 40% of the nitrogen emissions in the country. To achieve this goal, the government proposed a new nitrogen reduction law with a focus on protecting Natura 2000 nitrogen-sensitive areas, and the acquisition of 3000 farms that are top polluters (Boztas, 2022b), to reduce the harmful trade-offs on the EU-protected nature reserves.

In the Dutch context, the efforts to reduce the environmental impact of agriculture on regional or lower scales will be still problematic since Dutch agriculture is embedded in an unsustainable global food system. Current efforts of governmental, research, and agricultural organization point towards strengthening the position as a second agricultural exporter in a supposedly growing world market, and that implies that the global role of the Dutch food system is also related to the country's position to feed a world's growing population. (Bos et al., 2013). Still, considering that Germany, France, and Belgium are the main importers of Dutch food (OEC, n.a.), it is important to remark that these countries are not having significant population increase to justify the need for further intensification of Dutch agriculture, especially considering the European trend of demographic decline.

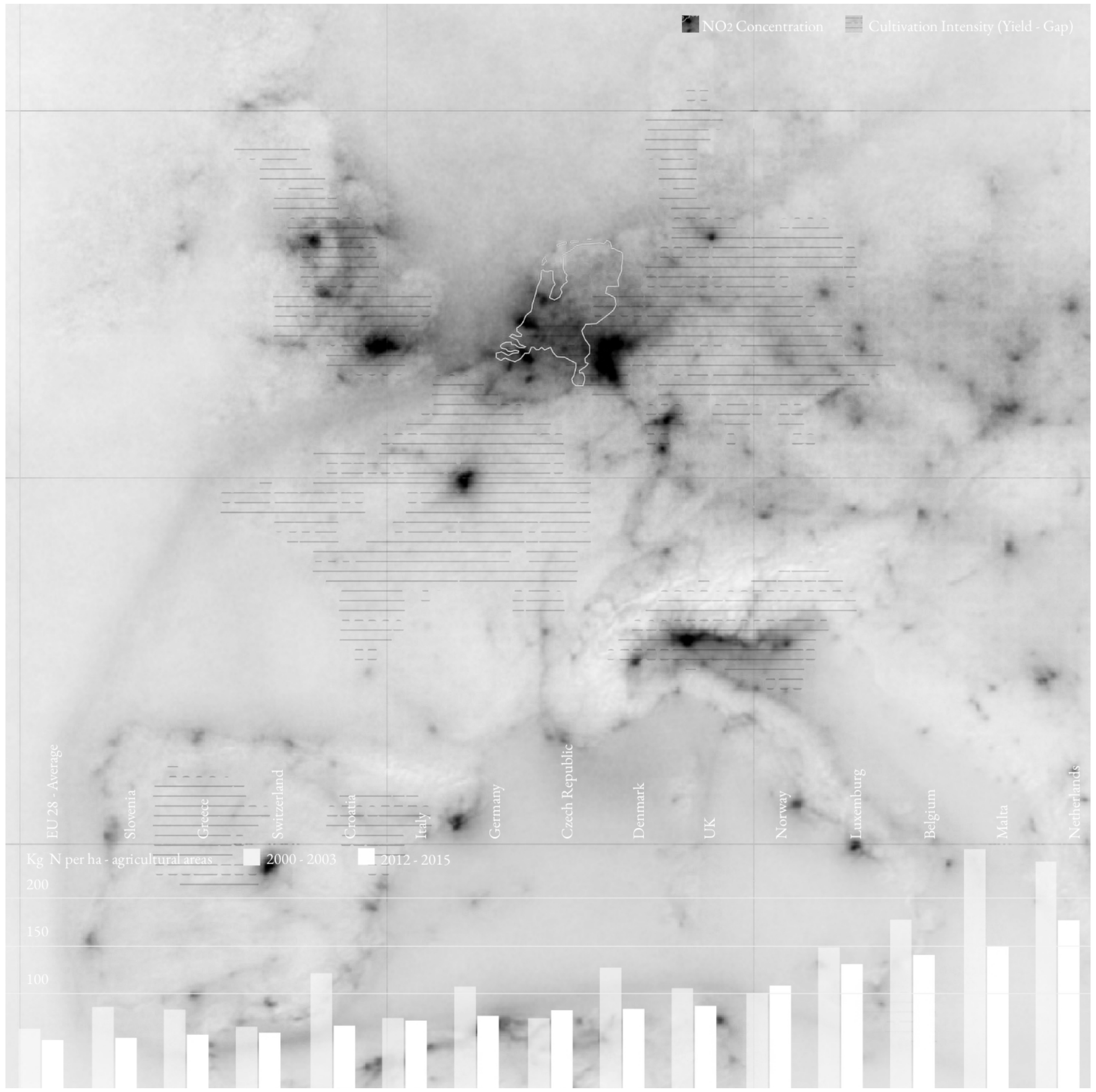


Figure 6. Nitrogen concentration in the atmosphere.
(By author, data source: *Copernicus S5P, International Food Policy Research Institute, WUR, Eurostat*).

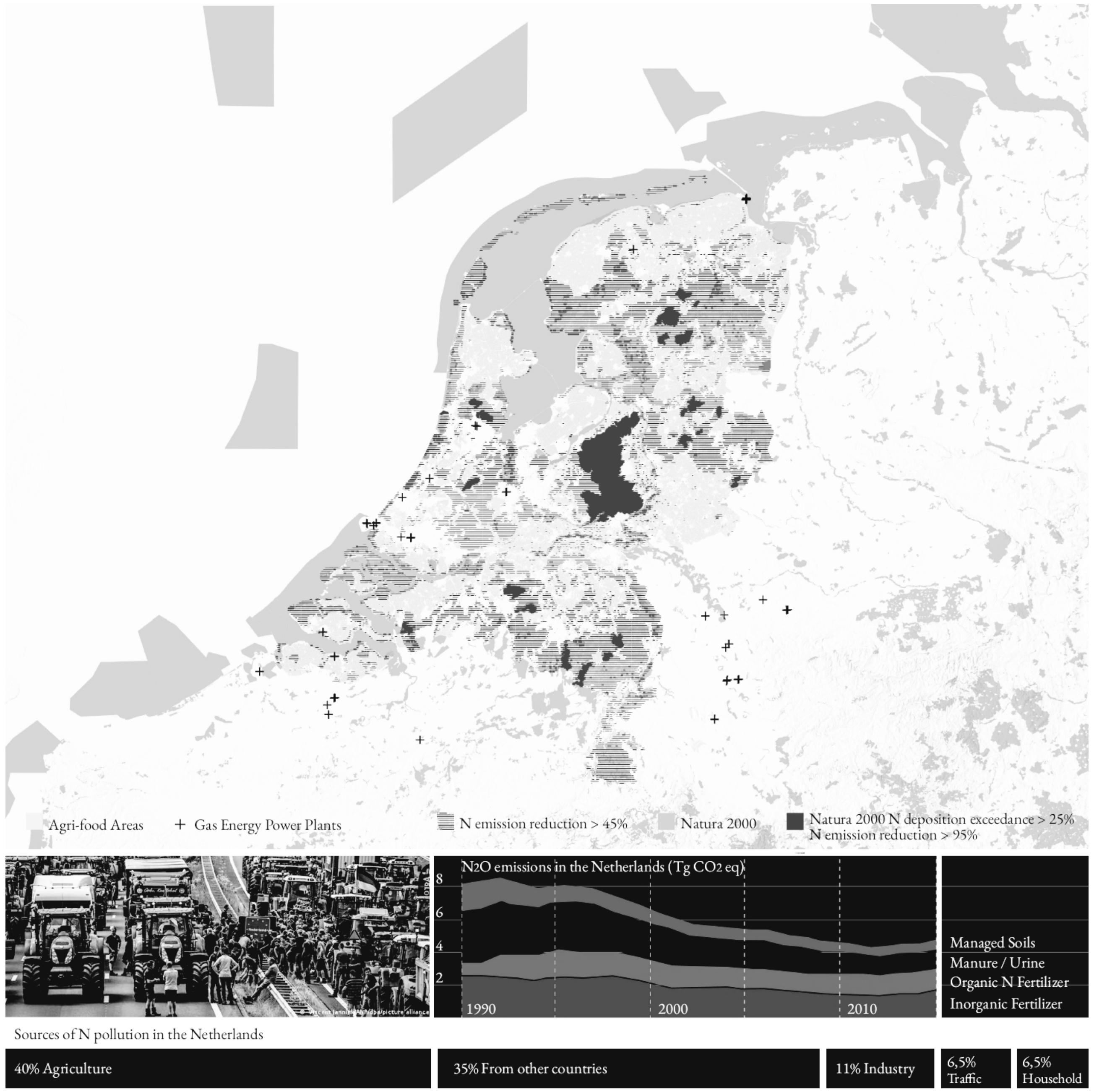


Figure 7. Nitrogen reduction and Natura 2000.
(By author, data source: *RIVM, Natura 2000, WUR*).

3. THE BLUE HEART

3.1 A critical node for the web-of-life

The Blue Heart is a deltaic territory that share a common ecological, geomorphological and sociocultural history, composed by the Wadden Sea, IJsselmeer-Markermeer, IJssel estuary, and the reclaimed polders of the Zuiderzeewerken. It is a global node of migration routes of species that are tightly intertwined in the web of life. The Blue Heart connects the Alps with the North Sea through the Rhine basin, being an important route for several species such as the European eel and Atlantic salmon. The fish migration routes cross the estuarine basin of the Blue Heart (IJsselmeer) and the intertidal/dune areas of the Wadden Sea, attracting birds of the East Atlantic Flyway that search for feeding areas and shelter during winter. Hence, being an important stop of the migration route of several coastal waterbirds that move from arctic breeding grounds that stretch from Canada east to central Siberia to wintering grounds in Western Europe and West Africa.

As a globally important biodiversity node and World Heritage by UNESCO, it is estimated that the Wadden Sea is a transitional habitat for almost one million ground-breeding birds as ducks, geese and swans, essential for the existence of 52 populations of 41 migratory waterbirds species that use the East Atlantic Flyway *. The water bird species mostly frequent the Wadden Sea for several months to absorb enough nutrients and energy for further migration, which is why the annual number of bird inhabitants can reach 12 millions.

Furthermore, the historical abundance of fish, animals, and fertile lands in Blue Heart delta's also was one of the reasons of the flourishing of human settlements since its formation, with historical records of Swifterbant culture inhabitants during the Sub Neolithic (c5300 BC and 3400 BC). According to Gardiner & Atkin (1993), the settlements in the water-land transitional areas, such as wetlands, were a deliberate choice by prehistoric communities seeking for attractive ecological conditions and high natural productivity. The prehistoric economy was based on a strategy of diversify food sources instead of increasing volume. In that sense, prehistoric wetland areas as found where the Flevopolders are currently located, offered good fishing, hunting, small-scale cattle farming and cultivation of different local crops. Still according to the authors, the decreased occupation of wetlands and fresh tidal zones at the end of the Neolithic was perhaps due to a growing interest in self-sufficient crop cultivation linked to the development of a initial mixed-farming system. A system that required arable lands, not practicable in peat and tidal zones.

A transition from hunter-gatherer sociocultural organization to domesticated animals farming, mostly cows and pigs, occurred around 4800–4500 BC, with expressive populations during the Roman Empire, which named the Blue Heart's fresh water/slightly brackish water estuary as Lake Flevo, known during the Middle Ages as Lake Almere. Etymologically revealing the migratory intensity of the area as Almere likely comes from the Dutch aal or ael, ael mere = "eel lake". Memories of this distant past are still present in regional nomenclatures, such as the city Almere, and the Province of Flevoland.

* According to the official Wadden Sea page: www.waddensea-worldheritage.org/breeding-and-migratory-birds

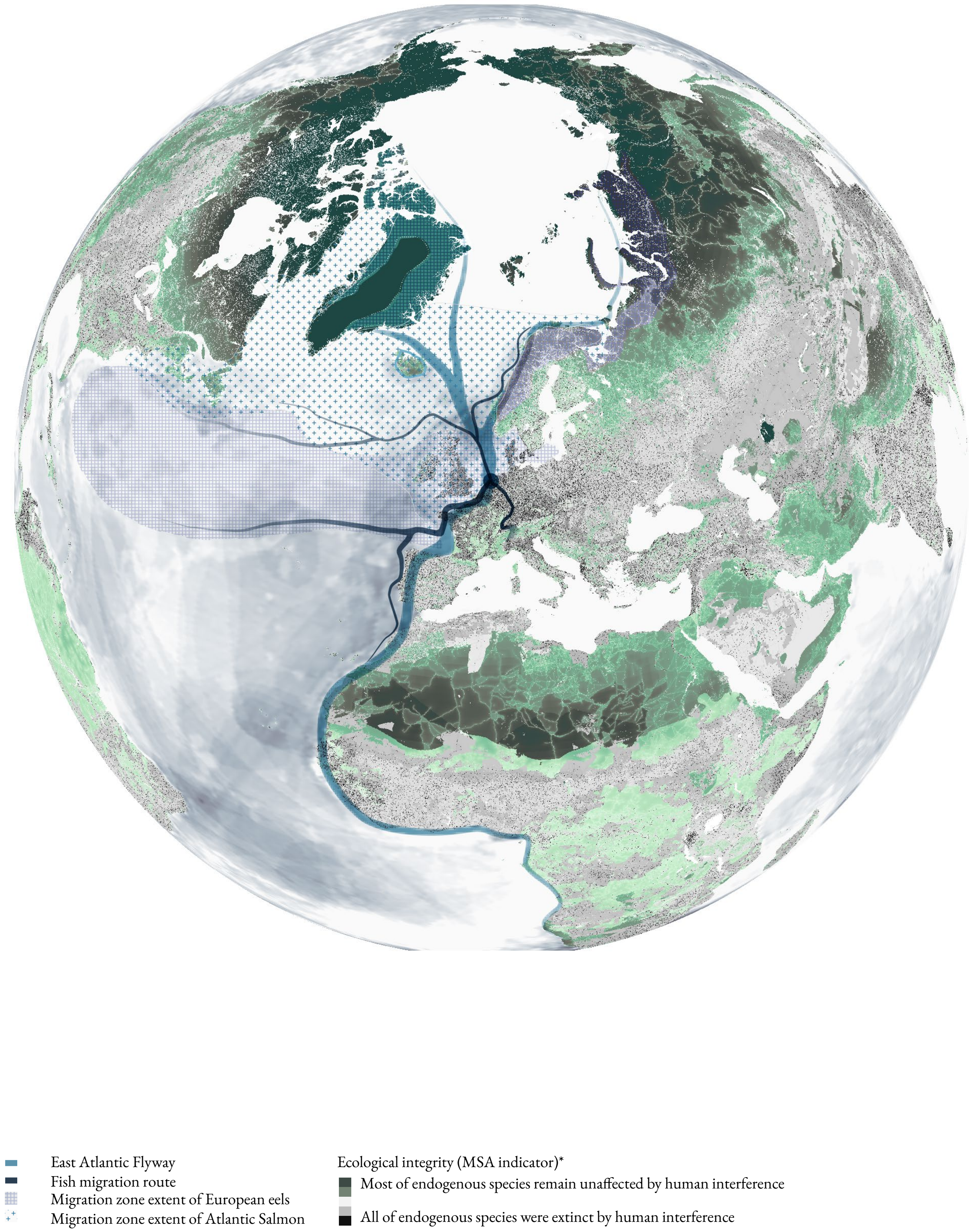
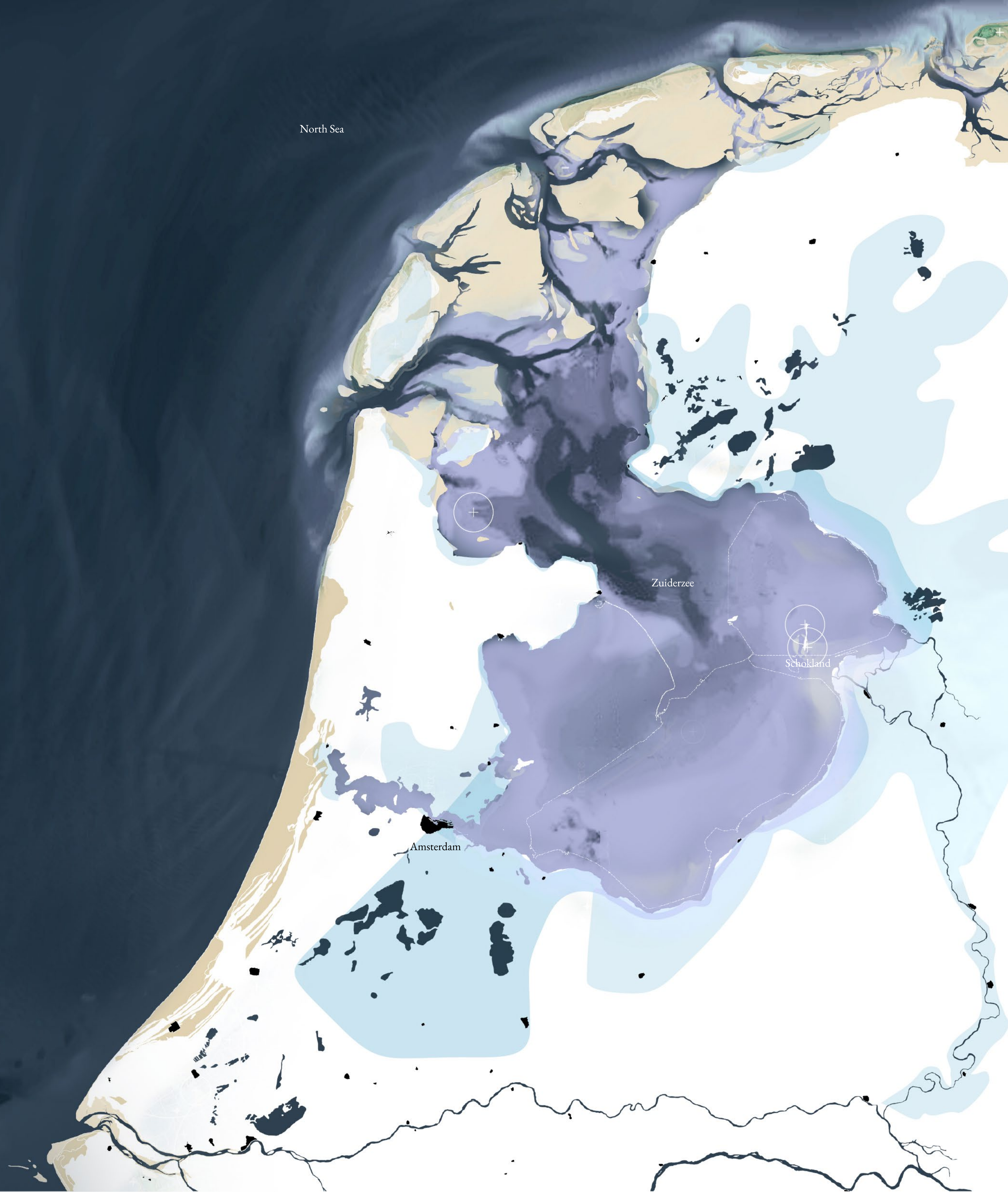


Figure 8. The Blue Heart, a node of planetary biodiversity.
(By author, data source: *Globio [MSA indicator*], www.waddensea-worldheritage.org [migration routes], Pimm et al., 2014, Jenkins et al., 2013 [sea birds richness]*).



"We have lived for centuries on our small island Schokland in the Zuiderzee (...). But terrible floods are threatening us always, and now, in 1859, our government wants us to leave. Only a few people are allowed to stay behind to work at the lighthouse. We have lost our fight against the water."

(Source: *www.worldwateratlas.org/narratives/flevoland-a-world-water-wonder/the-zuiderzee-floods/#we-must-leave*).

- 1825 Zuiderzee flood
- 1675 Allerheiligenvloed
- Intertidal zones
- Dunes
- \+ Settlements lost during flooding events

Figure 9. The Blue Heart before the Zuiderzee Works reclamation.
(By author, data source: *EMODnet Bathymetry, Paleogeografische kaart van Nederland*).

The Blue Heart Delta estuarine morphology was formed around 1500 BC. After a series of tidal variations and storm surge events, the lakes in formation and some peat/marshland areas merged into Lake Almere (also known as Flevo). The storm surge caused by St. Lucia Flood opened an outlet to the sea, changing the freshwater peatland lake into the brackish water Zuiderzee. As the sea flooded the area and tides defined the shores, the peatland was gradually eroded. Between 600 and 950 AD the River IJssel was formed, in a flooding event from the Rhine basin, creating a major open link between the Zuiderzee and the Rhine Delta (Figure 10). This allowed the development of several trading centers such as Kanpen, Doesburg, Zutphen, and Deventer. Also, with the north sea opening, Amsterdam gained an northward access through the Zuiderzee, which was used for centuries.

By 1500 AD the Zuiderzee has reached its maximum size, and especially in the North, the peatland areas were at their peak of porosity. The increased number of lakes and wet areas in the peatlands threatened human settlements from the rising sea levels and the riverine erosion. The only adaptation option was the creation of dikes and mounds, and the first communal water management plans were made which later evolved into the water boards (heemraadschappen and waterschappen). Following this adaptation plan, from the year 1000 AD onwards most of the rivers were diked, which initiated an accelerated sedimentation deposition in the river mouths and floodplains outside dikes. This new territorial condition also increased the river beds, which demanded the raise of dikes to maintain their safety. This happened while the dried peatlands received ditches to drain the excess of water, allowing the growth of agriculture and housing land use. And transportation through the branching waters from the delta allowed the socioeconomic growth of the emerging society. However, this new occupation caused the peatland sponge to contract, and the soil quickly suffered from subsidence. From this moment on, the reclaimed areas were below sea level, increasingly depending on the constantly renewed linear flooding defenses.

The Netherlands evolved under the paradigm of nature control, with incrementally sophisticated water infrastructure techniques to maintain the reclaimed lands. In this context, the Zuiderzee still functioned as an important port area, however constantly suffering from sedimentation and flooding events during storms. With the development of land transportation such as railways and roads, the Zuiderzee gradually lost its key transportation function, and it was eventually reclaimed during the Zuiderzeewerken. This had many ecological and socioeconomic impacts. This circumstance is defined by Palmboom (2018) as an example of the impact of the 'Delta Paradox'.

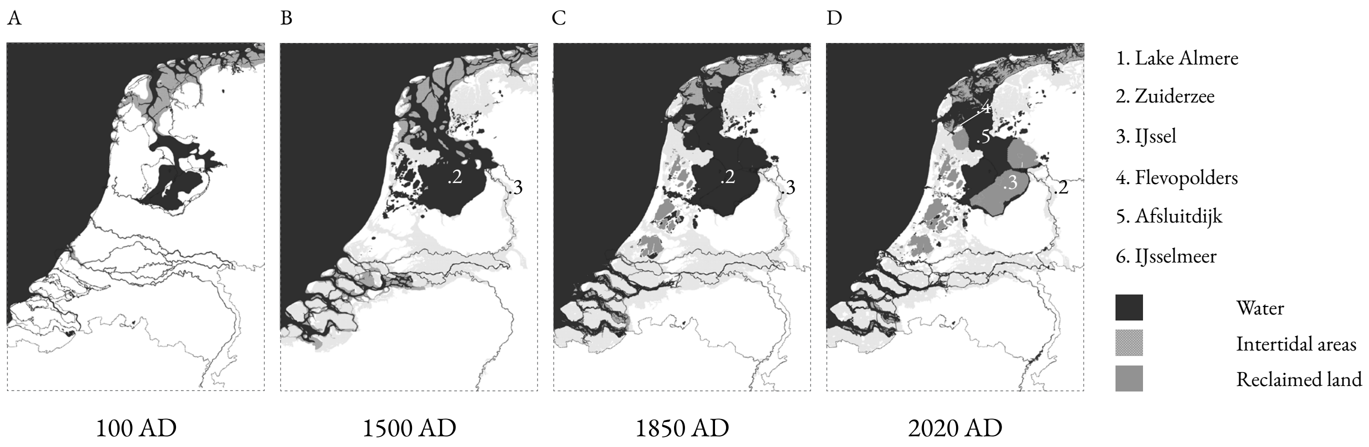


Figure 10. Maps of the Blue Heart's geomorphological formation.
(Adapted from Alzate-Martinez, 2023)

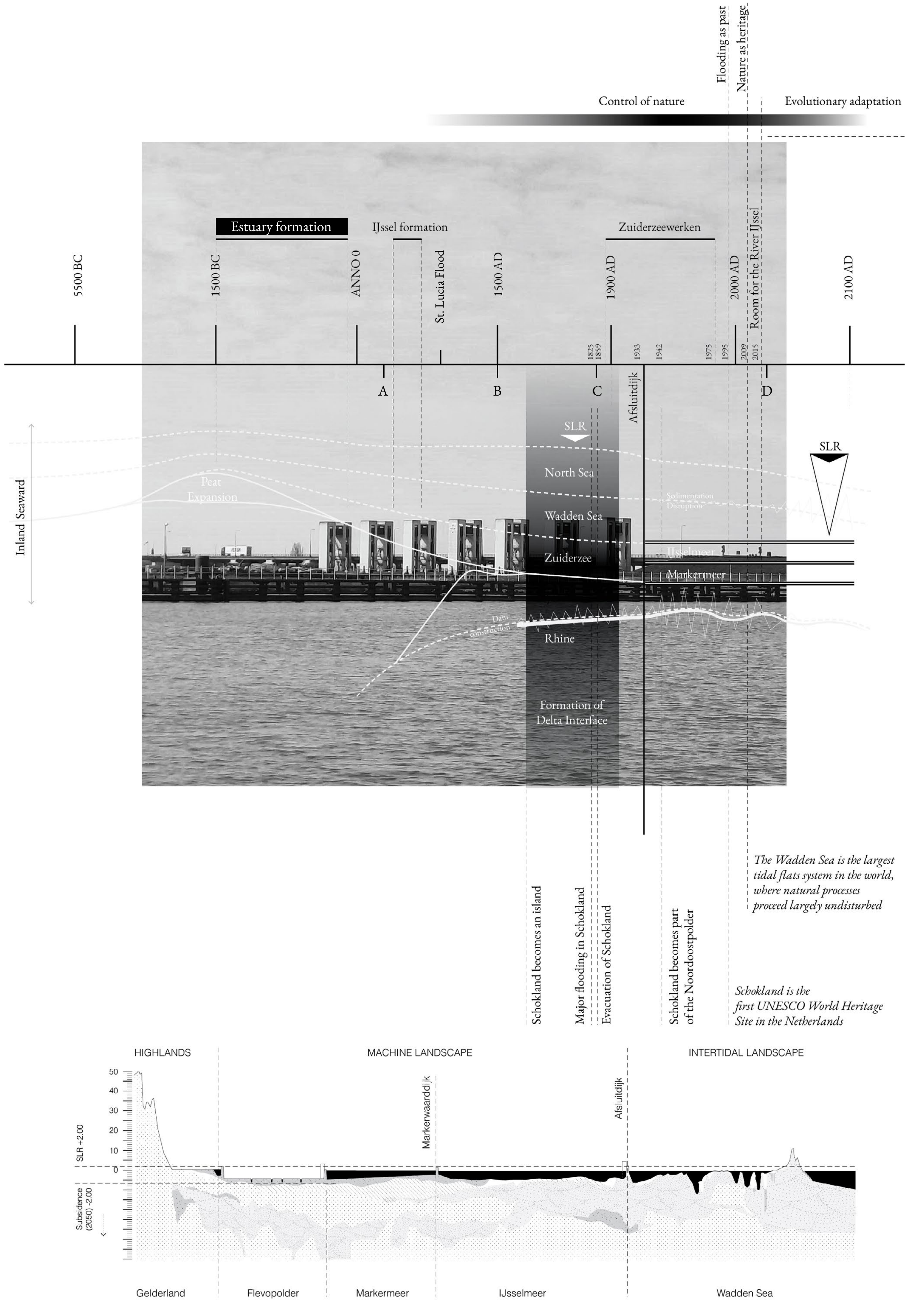


Figure 11. Formation of the Blue Heart Delta and geomorphological section of present conditions.
(By author. Section adapted from Alzate-Martinez, 2023)

3.3 A manufactured palimpsest: The Zuiderzeeweken

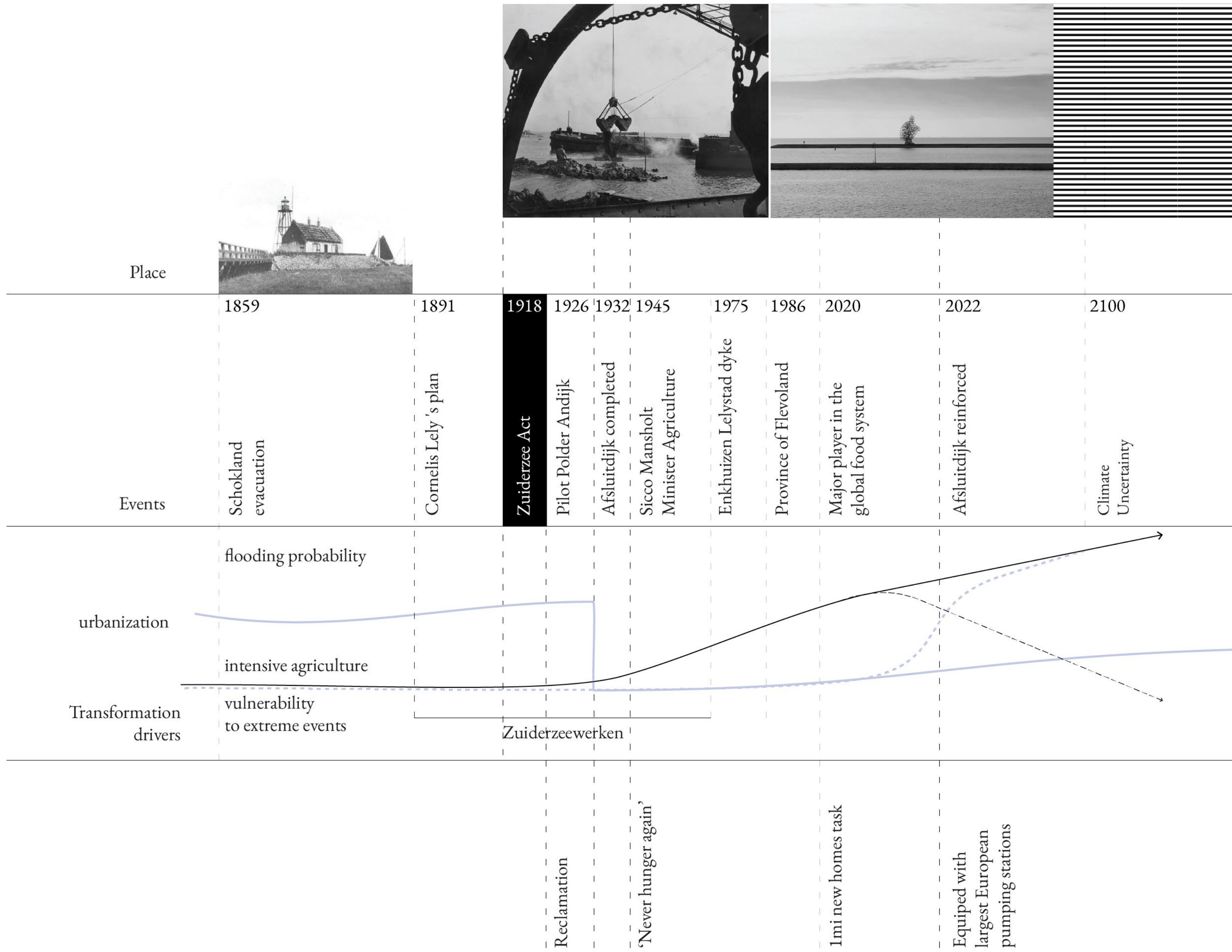
The reclamation process started with the need for protection against storms, high tides, and sedimentation (Figure 12). The evacuation of Schokland in 1859 was a final flooding-event driver for the implementation of the infrastructure works. With an increased support towards the idea, several projects were made by different engineers, and Cornelis Lely was selected to carry out his plan. The plan consisted in the enclosure the Zuiderzee from the North Sea, through the construction of the Afsluitdijk. Also, it proposes the construction of polders in shallow areas around the coast of the Zuiderzee mostly composed by marine clay, a highly fertile type of soil that was formed by river sediments.

After years of debate, the Zuidezeewerken officially started in 1918, when the Dutch parliament decided to start the reclamation project with the Zuiderzee Act. Heavy steam powered machinery was used for the reclamation work, and during decades the polders were built. The first one to be built was the Noordoostpolder, reclaimed in continuity with inland areas. Later, due to the water management problems that were originated by the polder-inland continuity, the next polders were isolated from the coastal area, surrounded by water boundaries denominated Border Lakes. After the World War II, and the subsequent food security crisis across Europe, the minister Sicco Mansholt carried out the motif of "never hunger again", designating value towards the development of the highly intensive economically-oriented agricultural development in the Flevopolders.

The Zuiderzeewerken ended in 1975, after the construction of the last dike in Lelystad. To prepare the land for further agro-urban development, innovative agricultural technologies were employed to prepare the soil for occupation. During several years, special types of grass were cultivated to improve the biophysical qualities of the marine clay. And, after massive intentional fires, more crops were cultivated to fixate nitrogen and nutrients in the soil. Despite the success of the ongoing reclamation, the final polder, located where now is the Markeermer was never reclaimed, which remained as a fresh water lake.

Figure 12. Mud mills keeping the Zuiderzee navigable for merchant ships
(Source: *www.hydro-international.com/content/article/the-hydrography-of-the-former-zuiderzee*)

Figure 13. The Zuiderzeewerken timeline
(By author)



3.4 Compartmentalization, fragmentation, and climate vulnerability

The Blue Heart's reclamation interrupted the geomorphological unity of the delta, disrupting the deltaic "equilibrium" state (Figure 14), changing the sediment transport regime of the basins from exporting to importing (Dastgheib, 2012). And more fundamentally, separating the human and natural habitats (Figure 15) that were intertwined by a complex set of ecosystems. The Zuiderzee originally had a salinity range from 30% closer to where is the Wadden Sea now, 8% in the middle portion, and freshwater conditions next to the IJssel. These different conditions present in the same body of water led to the formation of a diverse arrangement of species that interacted in a very unique ecosystem. And with the fragmentation of the Zuiderzee into the Markermeer and the IJsselmeer, all of this biodiversity disappeared in a period of 15 years (Havinga, 1954). That led to the regional disappearance of several fish species as the anchovy, the Zuiderzee-herring, and the Brentgoose which foraged on the eelgrass fields in shallow waters along the original coastline. It destroyed the nursery ground for shrimps, having serious cascade effects on the Wadden Sea and the IJssel.

The ecological impact of the linear flooding defense infrastructure is still present. The hard land-water edges of the dikes form a critical issue to recover the biodiversity in the lakes. The infrastructure morphology that replaced the original deltaic gradual transitions of land-water erased important areas of ecological succession that once allowed a vibrant range of species to have a habitat (Figure 15, 16, 17, 18). To reverse some of these challenges, restoration projects are being built. One example is the Marker Wadden, a landfill partially made with the sludge that suffocates the lake. Essentially, the project shapes the Blue Heart's geomorphology to host restorative habitats for the Markermeer. Despite the positive effects, this action still is a land reclamation that aims the improvement of human water use.

The compartmentalization of nature and the human habitat of the Blue Heart is the reflex of a development model that aimed to provide flooding defense while promoting optimal land-water use for a intense industrial agriculture, protected by a robust highly technological water defense system. In this process, the fragmented delta acquired a conflictive relationship between its land use and its hydrogeomorphology. The freshwater from the lakes is a critical resource for industrial agriculture and the growing urban centers originated after the reclamation process. However, its maintenance depends on a linear flooding defense infrastructure, which interrupts the deltaic hydro geomorphology that is the host for the Blue Heart's original habitats. And this fragmentation is an example of the severity of the biodiversity and ecological trade-offs from water-land use. And it unveils the missed change of a transition towards a sustainable regional economy in synergy with the natural deltaic abundance.

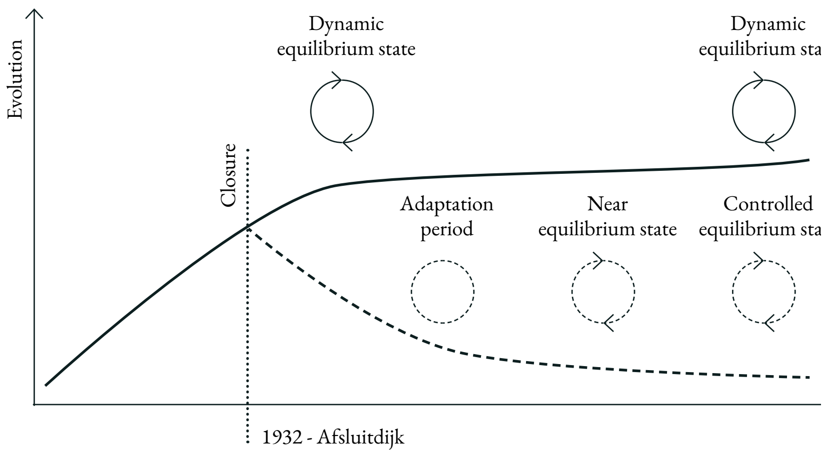


Figure 14. The Blue Heart dynamic equilibrium disturbance.
(By author, adapted from Dastgheib, 2012).

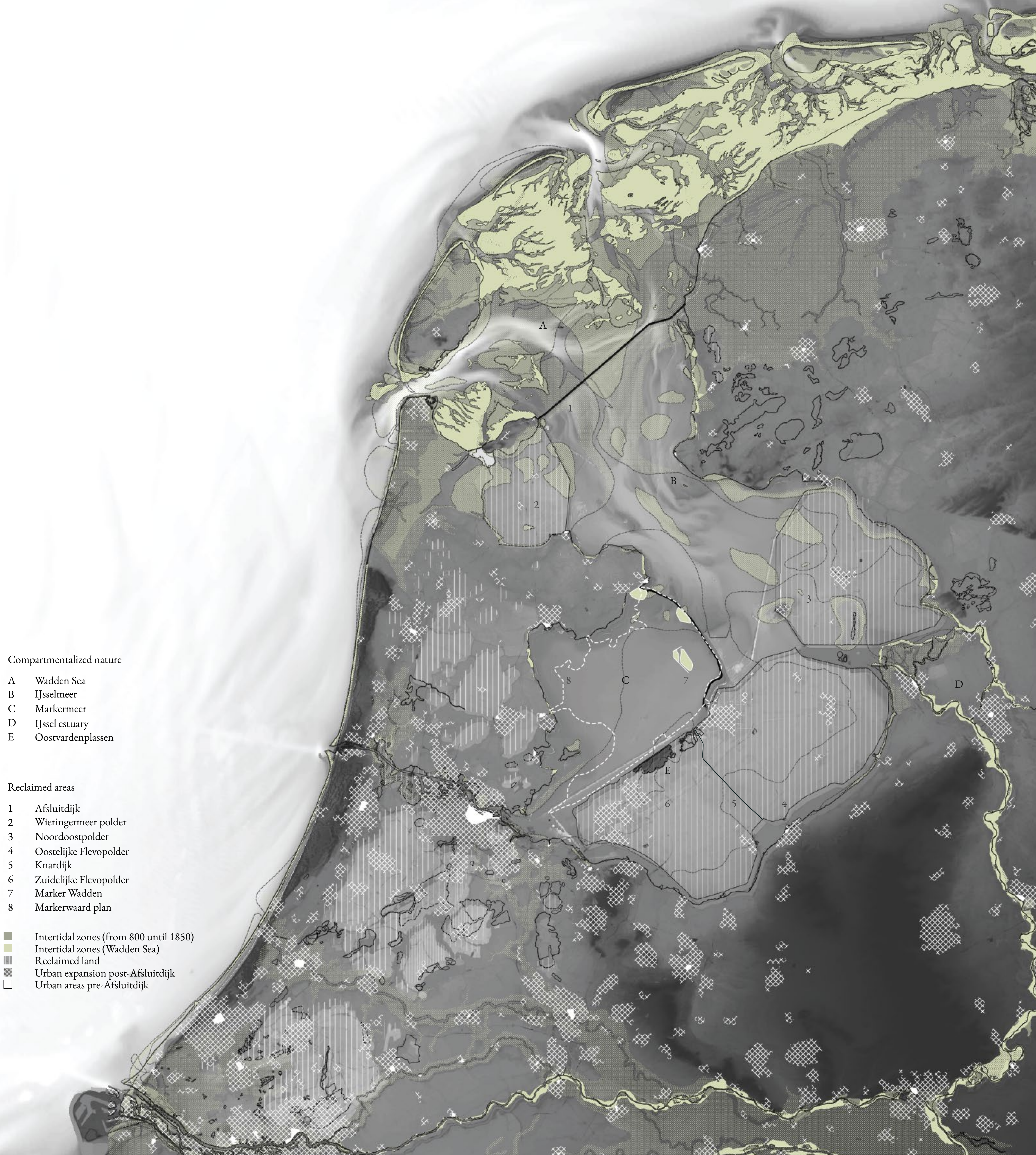


Figure 15. Map of the geomorphological reconfiguration, reclamation, and habitat compartmentalization.
(By author, data source: *EMODnet Bathymetry, Paleogeografische kaart van Nederland*).

Figure 16. Land-water transition in Lelystad-Markermeer
(By author).

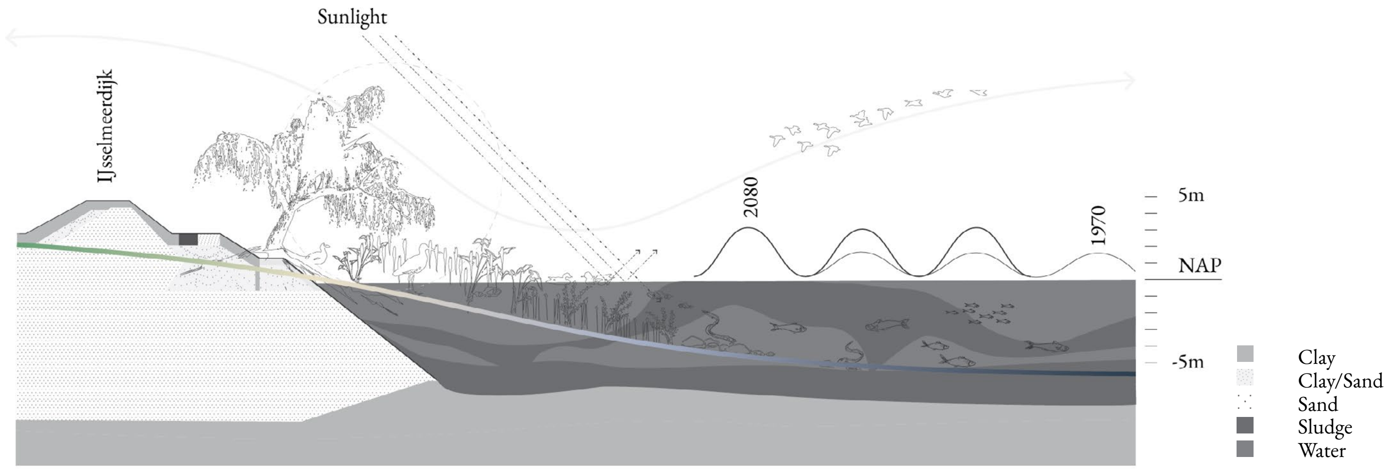


Figure 17. Lack of ecological succession due to hard edges of water infrastructure and the problems with sludge in the Markermeer (By author).

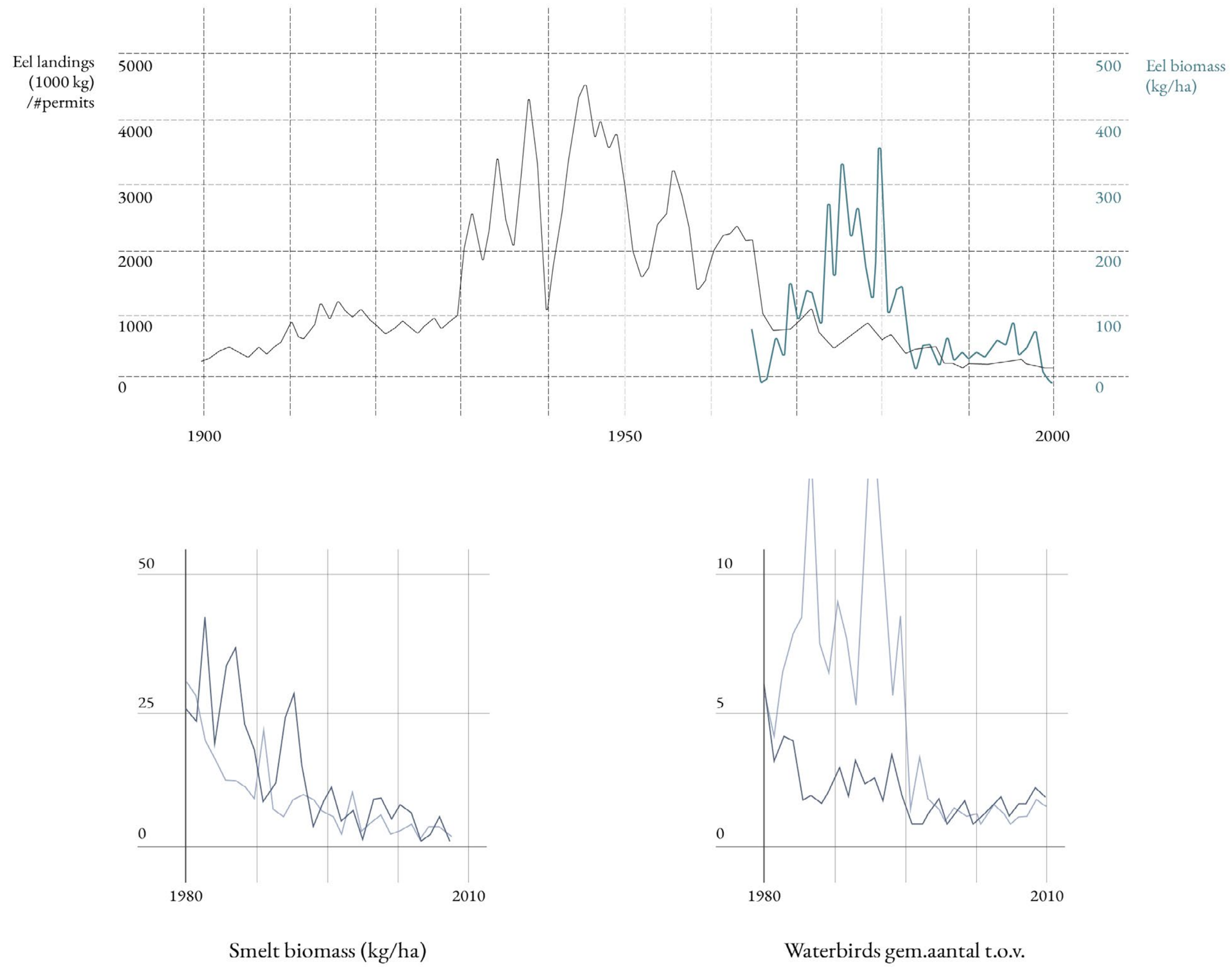
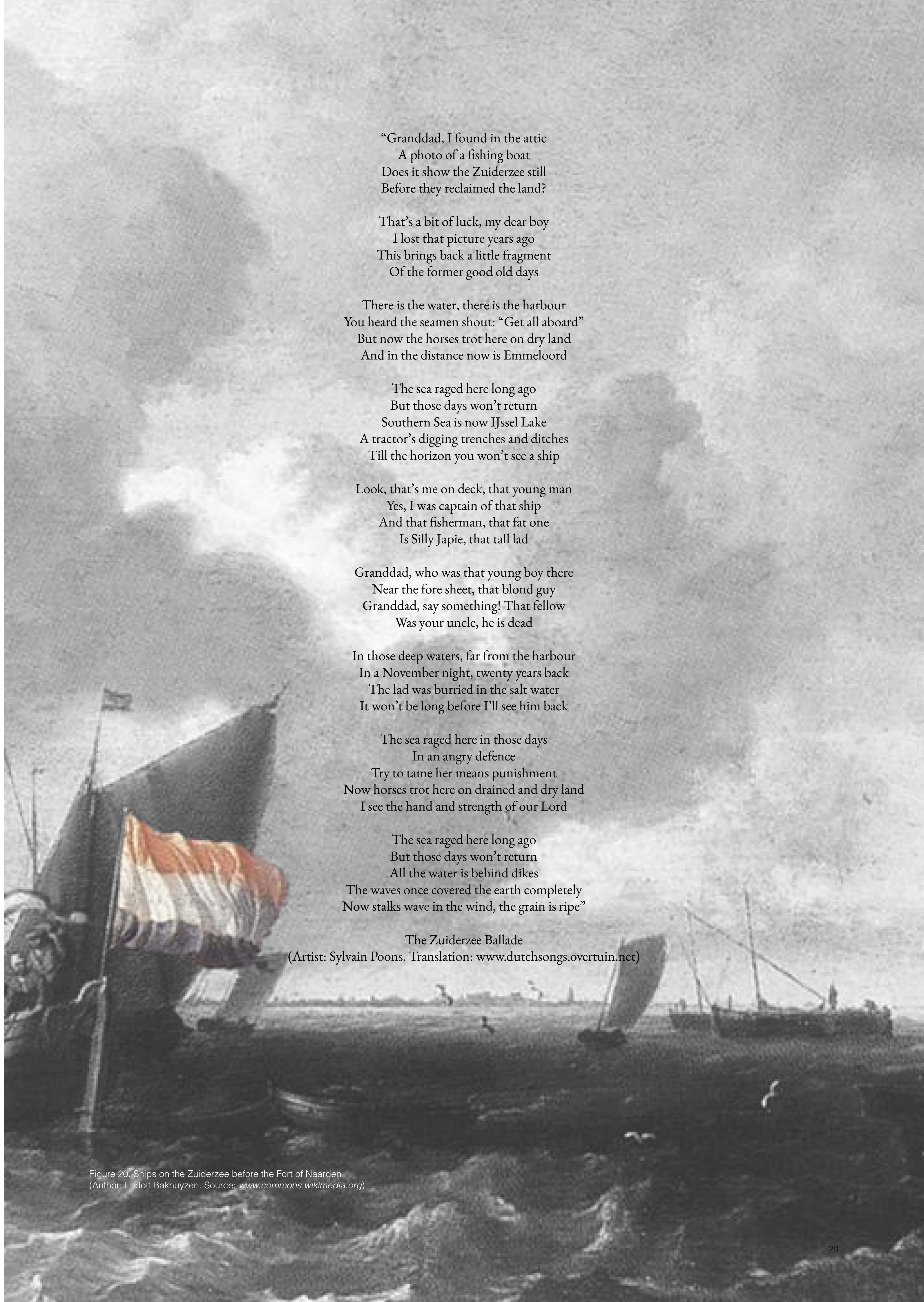


Figure 18. Populational decrease of Eels, Smelt, and Waterbirds.
(By author, adapted from *de Leeuw et al., 2021*).

Figure 19. Eibert den Herder, fisherman and critic of the reclamation project.
(Source: *www.historiek.net/de-don-quichot-van-de-zuiderzeewerken-eibert-den-herder/58797/*)



"Granddad, I found in the attic
A photo of a fishing boat
Does it show the Zuiderzee still
Before they reclaimed the land?

That's a bit of luck, my dear boy
I lost that picture years ago
This brings back a little fragment
Of the former good old days

There is the water, there is the harbour
You heard the seamen shout: "Get all aboard"
But now the horses trot here on dry land
And in the distance now is Emmeloord

The sea raged here long ago
But those days won't return
Southern Sea is now IJssel Lake
A tractor's digging trenches and ditches
Till the horizon you won't see a ship

Look, that's me on deck, that young man
Yes, I was captain of that ship
And that fisherman, that fat one
Is Silly Japie, that tall lad

Granddad, who was that young boy there
Near the fore sheet, that blond guy
Granddad, say something! That fellow
Was your uncle, he is dead

In those deep waters, far from the harbour
In a November night, twenty years back
The lad was burried in the salt water
It won't be long before I'll see him back

The sea raged here in those days
In an angry defence
Try to tame her means punishment
Now horses trot here on drained and dry land
I see the hand and strength of our Lord

The sea raged here long ago
But those days won't return
All the water is behind dikes
The waves once covered the earth completely
Now stalks wave in the wind, the grain is ripe"

The Zuiderzee Ballade
(Artist: Sylvain Poons. Translation: www.dutchsongs.overtuin.net)

Figure 20. Ships on the Zuiderzee before the Fort of Naarden
(Author: Ludolf Bakhuyzen. Source: *www.commons.wikimedia.org*)

Figure 21. Noordoostpolder before draining.
(Source: *reproduction from the Batavialand Museum exhibition*)

Figure 22. Polder workers.
(Source: *reproduction from the Batavialand Museum exhibition*)

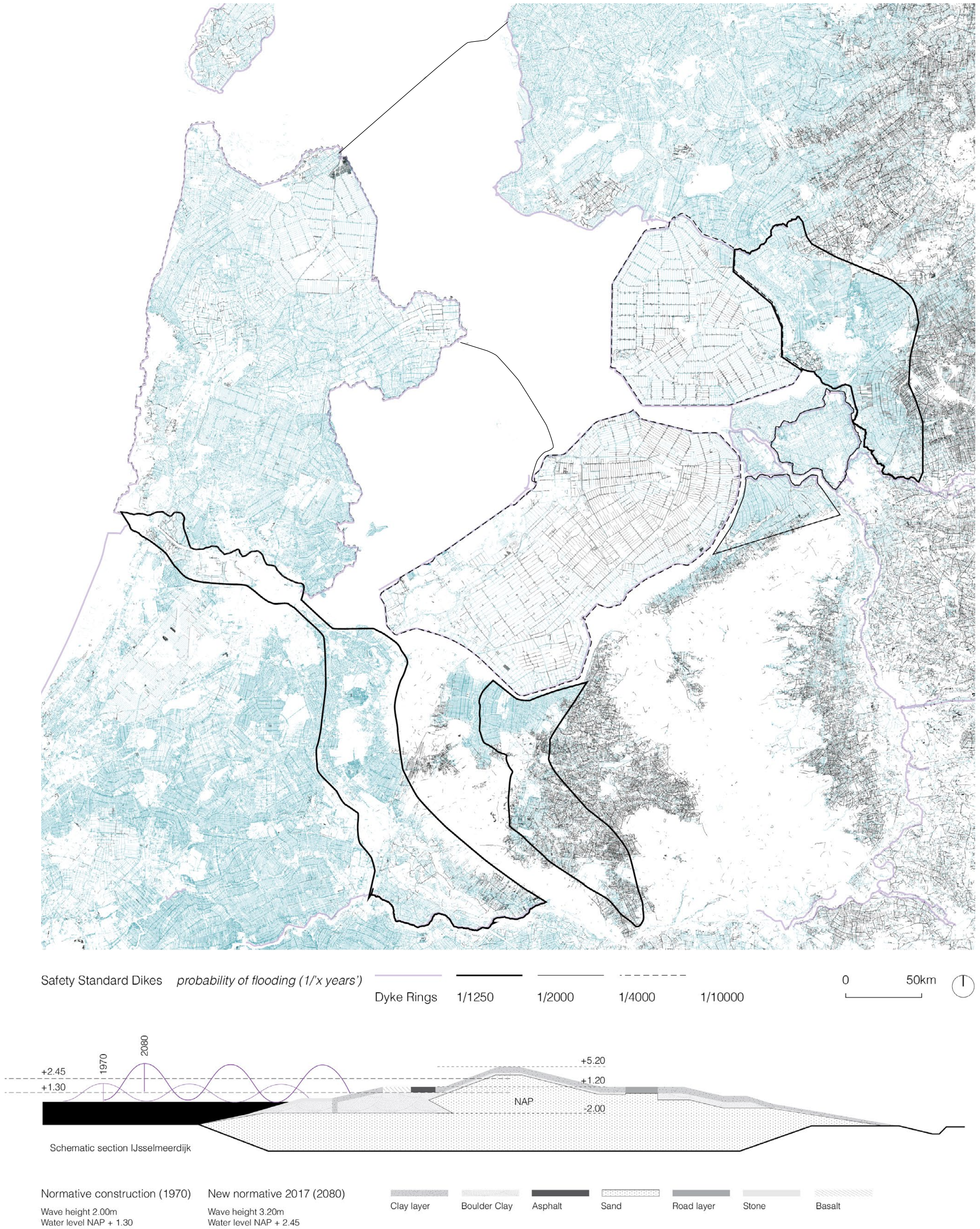


Figure 23. Map (Water defense rings), Section (IJsselmeerdijk renewal proposal).
(By author based on *Rijkswaterstaat Basisregistratie Topografie - BRT)*

3.5 Climate uncertainty

The historical development of the water infrastructure to defend against flooding, by controlling water dynamics with a sophisticated systems of dams and dikes. This type of flooding defense infrastructure is focused on reducing the probability of flooding, to avoid the disruption of the agro-urban land use, and their related human activities.

Due to the ongoing SLR, a renew of the dike infrastructure is being carried in Flevoland, both in the Flevopolder dikes, and the Alfsludijk. New safety standards, expressed as flooding event probability in a certain time span, must be increased. However, the predicted effects of the future discharge and pressures in the Wadden Sea-Border Lakes-IJssel are becoming less reliable due to the high degree of uncertainty on the SLR dynamics and the melting of the Alps. A problem that tend to continue while land and water keeps its transitional relationship. Every 50-80 cm of SLR increase the probability of flood with a factor of 10 (Figure 22). Which means that discrepancies of the several SLR scenarios with the unfolding reality will severely increase the pressure on infrastructure planning of linear defense systems.

A shift to incrementally adopt infrastructure strategies of reducing flooding consequence, instead of fighting the probabilities, may allow continuous cycles of adaptation with the natural dynamics of the natural dynamic of the Blue Heart. Which can relieve the social-economic-environmental pressure on flooding prevention infrastructure, increase possibilities of ecological integrations, guarantee the safety of the human and ecological systems, minimizing the historical biodiversity trade-offs.

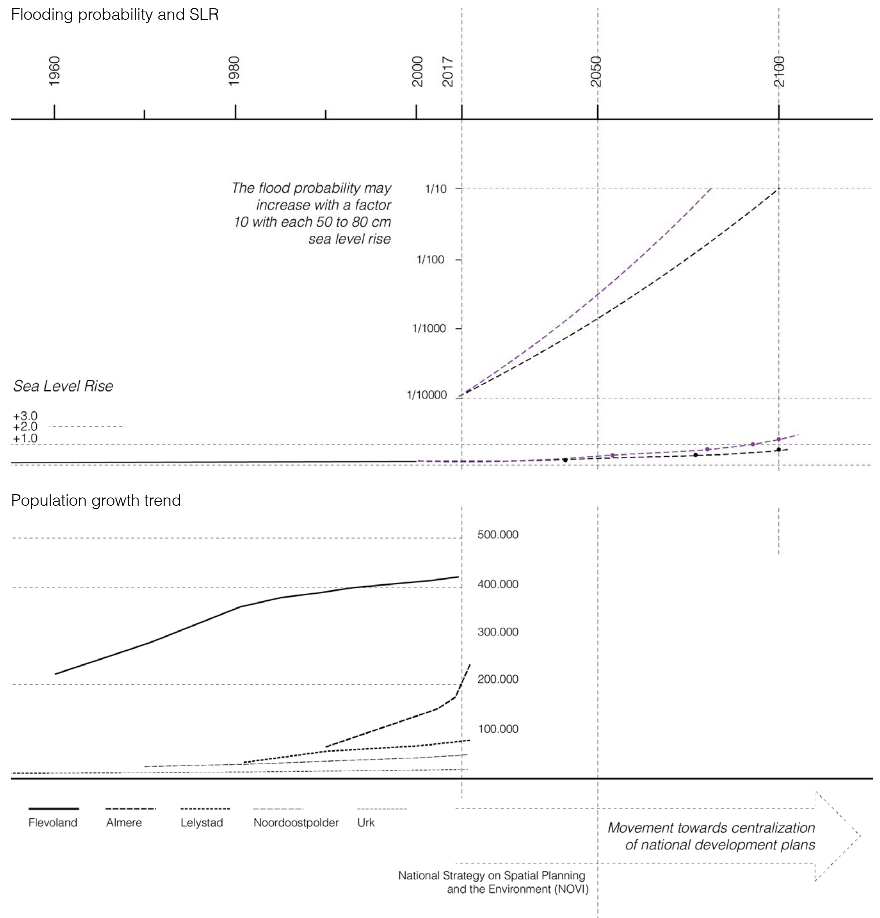


Figure 24. Diagram of linear flooding defense limits.
(By author based on: *CBS, Aerts et al.,2008*)

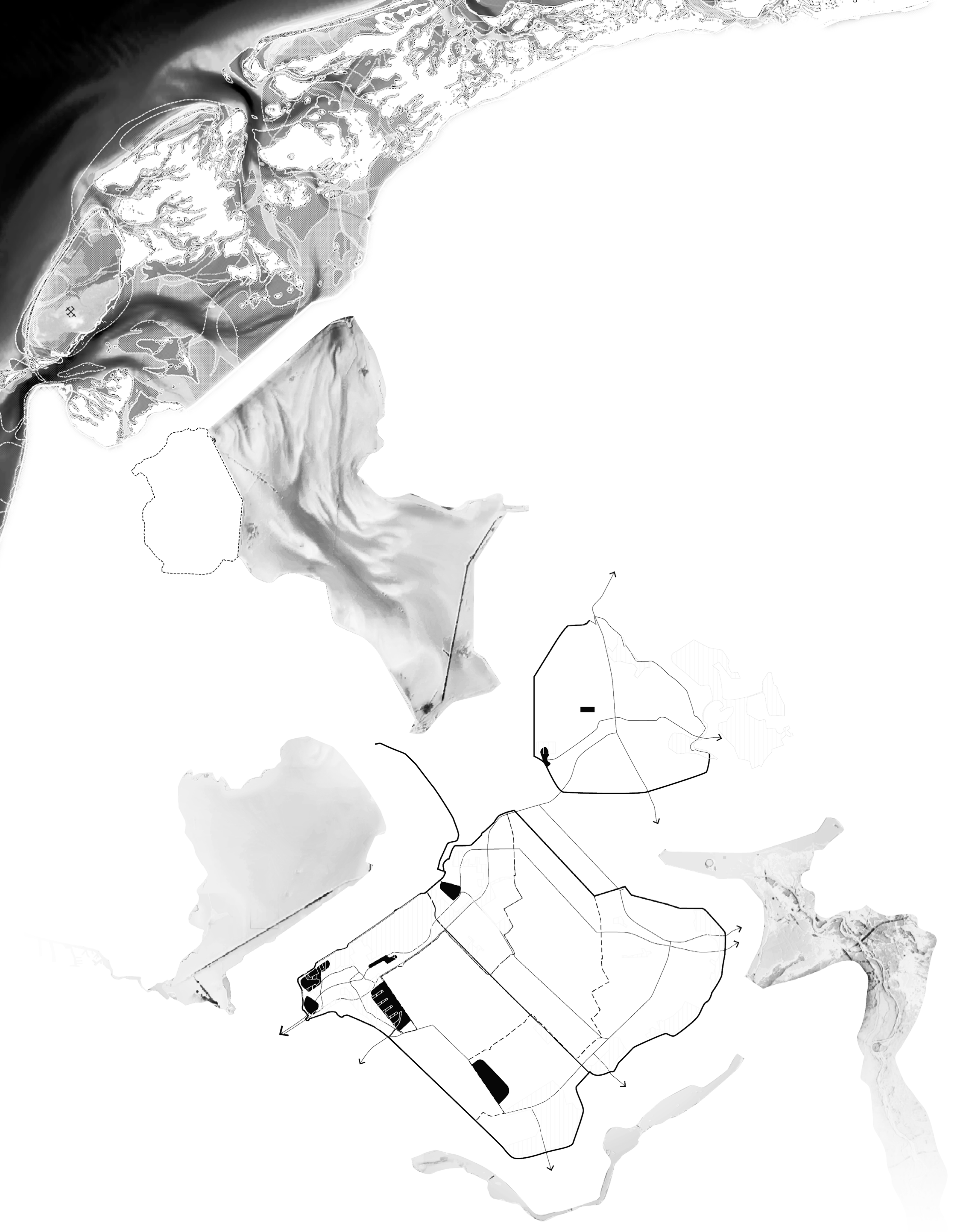


Figure 25. The fragments of the Blue Heart. (By author)

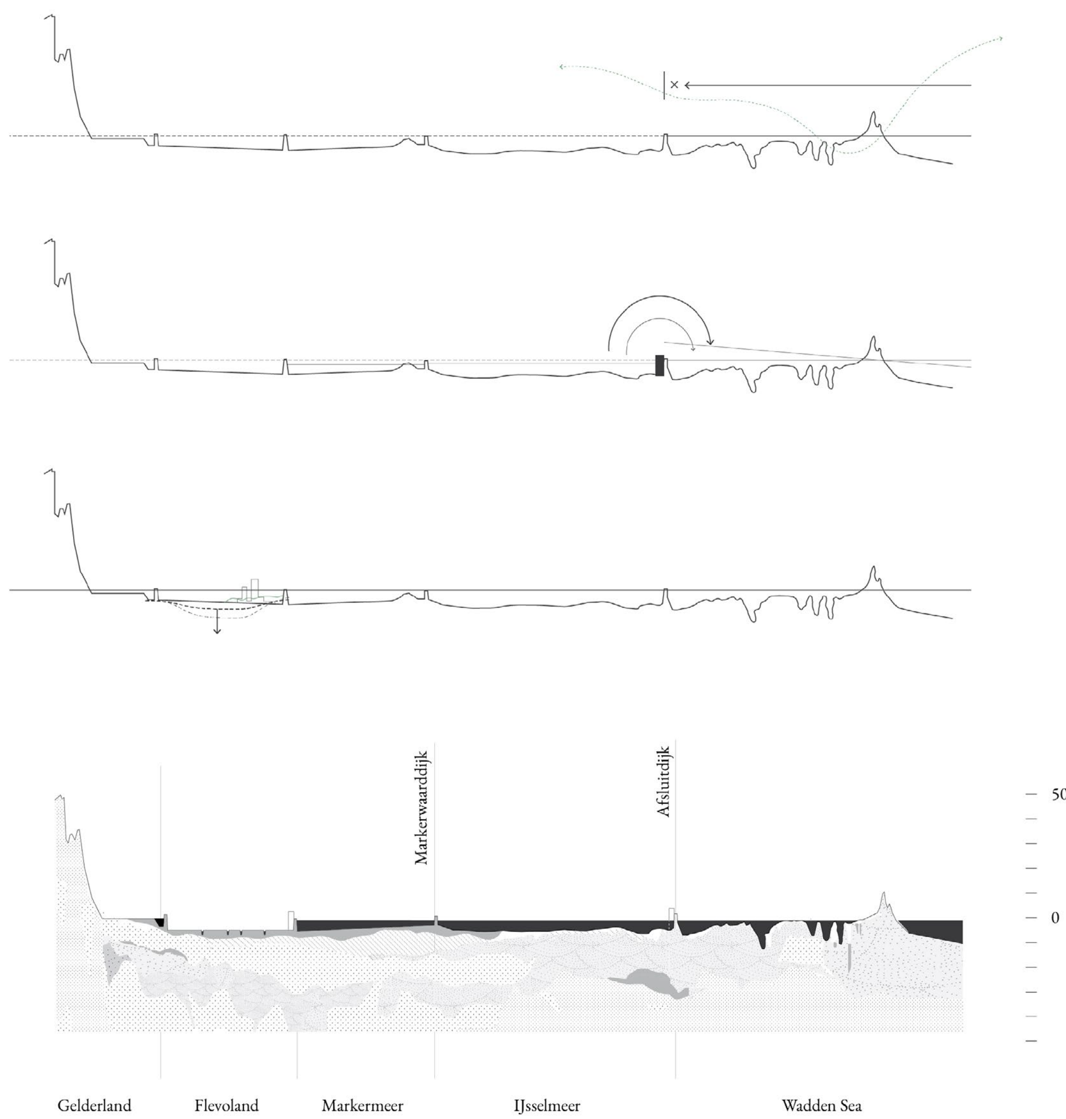


Figure 26. Fragmented climate vulnerability in the compartmentalized habitats. (By author).

The effects of climate uncertainty in the linear flooding defense system planning become materialized by the fragmentation of climate vulnerability in the Blue Heart's compartmentalized habitats (Figure 25 and 26). With the Afsluitdijk enclosure, the Wadden Sea loses an important zone to naturally retreat (Wang et al., 2018) by growing and moving with the sedimentation process. Hence, being the most climate vulnerable of all of the fragments, which is the last habitat that still retains the Blue Heart's endogenous ecology. In the case of the IJsselmeer-Markermeer system, the increase discharges from the Rhine due to the alps melting, and the increase on extreme rainwater events will create a triple challenge on maintaining the safe water levels - done by pumping water from the IJsselmeer to the North Sea that is also rising. This demands a immense increase on the pumping capacity, and currently the largest European pumping stations are being built in the Afsluitdijk. A complexity that also affects the Province of Flevoland, that provides a globally important agriculture land use on the subsiding bottom of the Blue Heart, completely dependent on its linear flooding defense systems.

4. FLEVOLAND IN TRANSITION

4.1 A critical land-use infrastructure

As one of the most productive agricultural-intensive areas in the world, Flevoland has critical landscapes for the operation of the global Dutch Food System. The province of Flevoland is composed by the Flevopolders: Noordoostpolder, Oostelijke, and Zuidelijke, surrounding by the IJsselmeer and Markermeer.

Through advanced land management techniques, the reclaimed marine clay was prepared for large-scale agricultural and intensive farming practices with an emphasis on export. Flevoland is today one of the most productive agricultural areas in the world, thanks to excellent agricultural conditions, sophisticated farming technologies, and intensive soil management. It is a key actor in the global food chain, with a highly productive, export-oriented agricultural industry that has strong connections to the port of Rotterdam. Flevoland is known for having some of the best yields per acre in the world for onion, potato, and carrot, and the majority of the output is destined for export.

Flevoland in numbers
Souce: CBS

Area 2.412,31 km^2
Land 1.411,63 km^2
Water 1.000,68 km^2

Figure 27. Agriculture landscape in Flevoland.
(Source: *www.visitflevoland.nl/en/now/highlights-in-flevoland*)

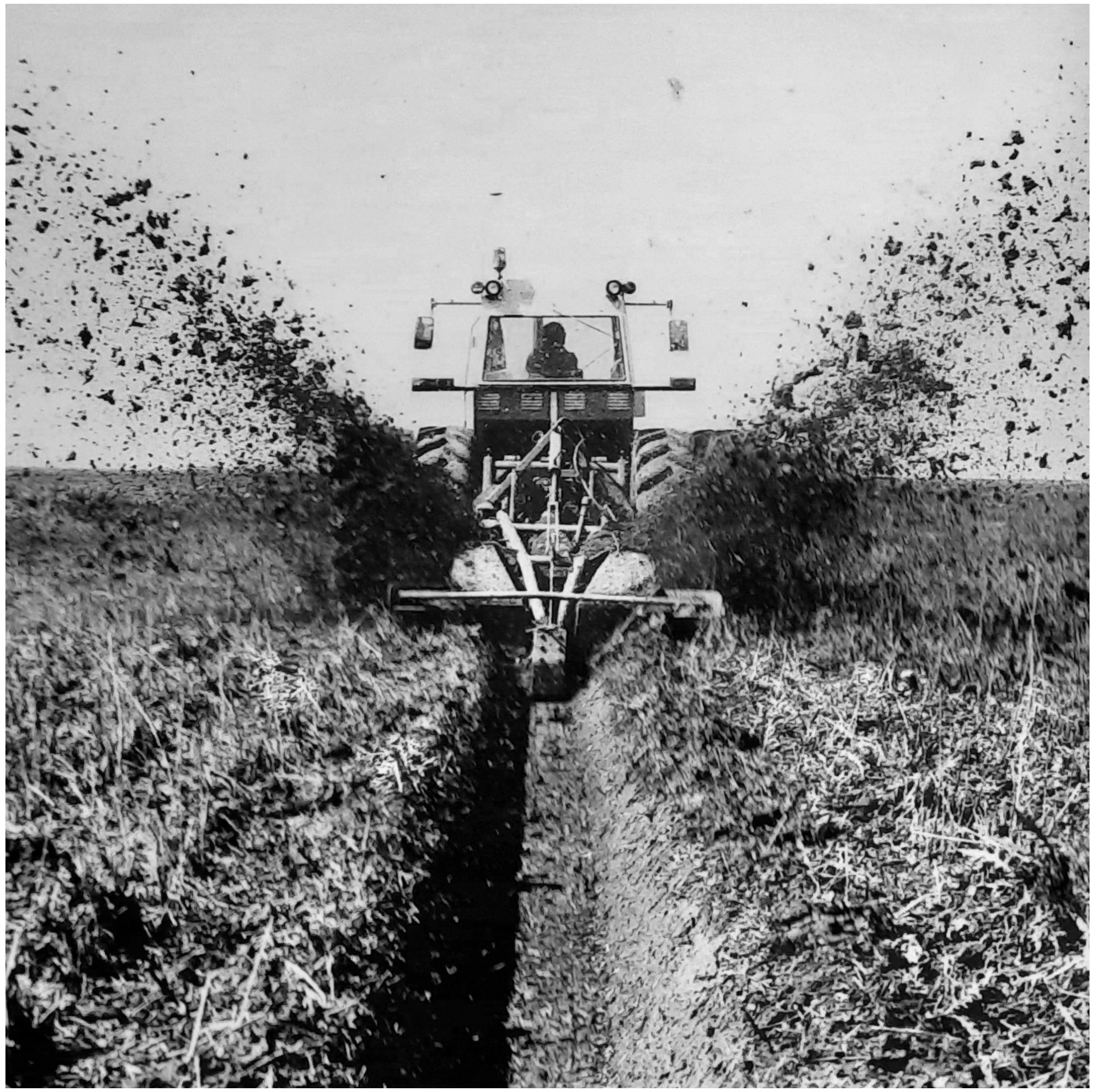


Figure 28. Tilling process.
(Source: reproduction from the Batavialand Museum exhibition)

4.2 A history of agro-urban development

During the Zuiderzeewerken, diverse plans for the occupation of the polders were carried out by several built environment professionals and engineers. The task of providing efficient land use planning to attend to the demand of urbanization and productive agricultural areas led to the adoption of revisions from several branches of the Garden City planning theory by Ebenezer Howard.

An example is the plan for the Noordoostpolder made by L. Brandts Buys, which is based on an arrangement of polynuclear villages that surrounds a central city, embedded in an extremely efficient set of small-medium sized agriculture plots. A strategy capable of annexing the former island Urk into an agro-urban spatial network. Due to the spatial strategies adopted, there are some indications that the project revised Christaller's 1930 planning principles of the "Central Place Theory" (van der Wal, 1997). In this theory, settlements functioned as central nodes that provide economic services to surrounding areas. Smaller settlements that are designed to work in synergy are placed close to each other to reduce travel distances, while larger settlements with more specialized goods and services were placed in more distant areas. That concept was formulated during the military expansion of the Third Reich, in which principles of rural colonization of empty(ied) spaces were intended to be adopted to occupy the newly conquered territories (Barnes & Minca, 2013). The central place theory is criticized for being static and ignoring the temporal aspect in the development of central places and the inclusion of industrial or postindustrial areas.

In a more innovative context, the Zuidelijke polder was a place of several agro-urban experiments. A recent example is the Almere-Oosterwold master plan made by MVRDV. Almere-Oosterwold is Almere's newly planned area and integrates agri-food production into its urbanization proposal. The Oosterwold Master Plan dedicates 50% of Oosterwold as an urban agriculture area and responds to the city expansion of 60,000 new houses in a time span of 30 years approved in 2006, as part of a national program to improve the international competitiveness of Amsterdam Metropolitan Area (Ministerie van VROM et al., 2006). The urban planning proposal for Almere-Oosterwold reflected the ambitions of the Almere 2.0 program, launched in 2009, which identified the emergent urban agriculture as a way of achieving broader planning goals, promoting a city of hybrid functions, based on the principles of self-organization and multifunctional landscape.

The concept of self-organization in Oosterwold implies that in addition to designing and building their own homes, the new residents must also self-organize (individually or cooperatively) all types of infrastructure. In that sense, self-organizing facilities, from roads, electricity, waste, and sewage systems, to shops and schools, are elements typically planned and funded by the municipality in the Netherlands. This principle found some challenges in its implementation, due to the lack of consistency in the built outcome and inefficiency.

Figure 29. L. Brandts Buys plans for the Noordoostpolder and the Christaller planning theory, 1942 (Source: *van der Wal, 1997*)

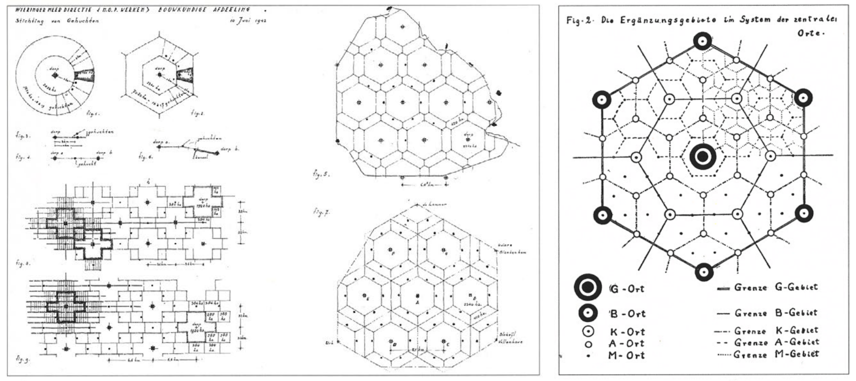


Figure 30. Noordoostpolder agro-urban plan. (Source: *Steenbergen et al., 2009*)

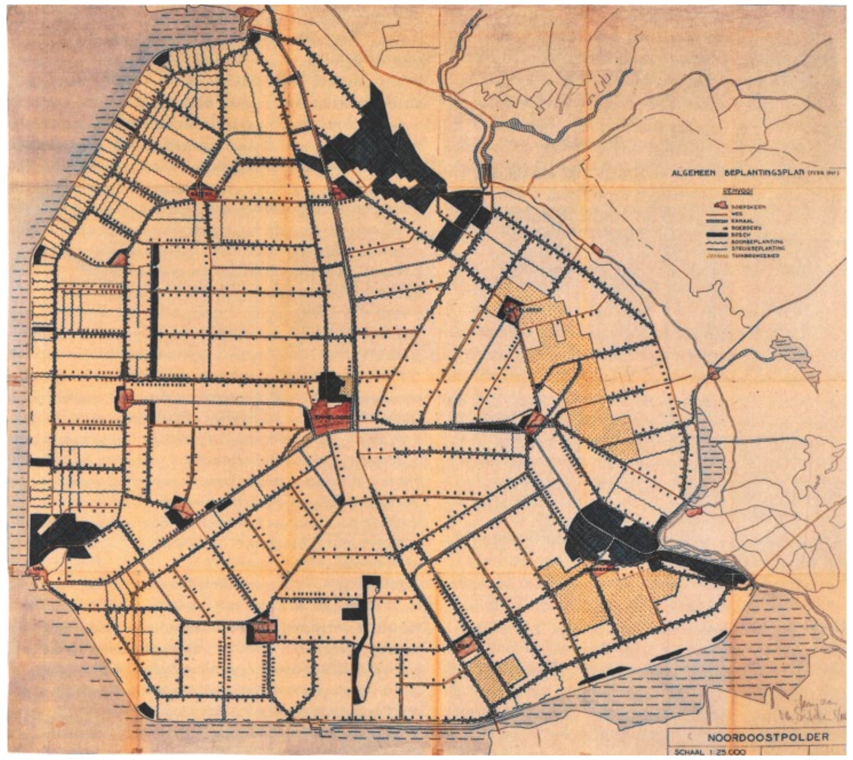


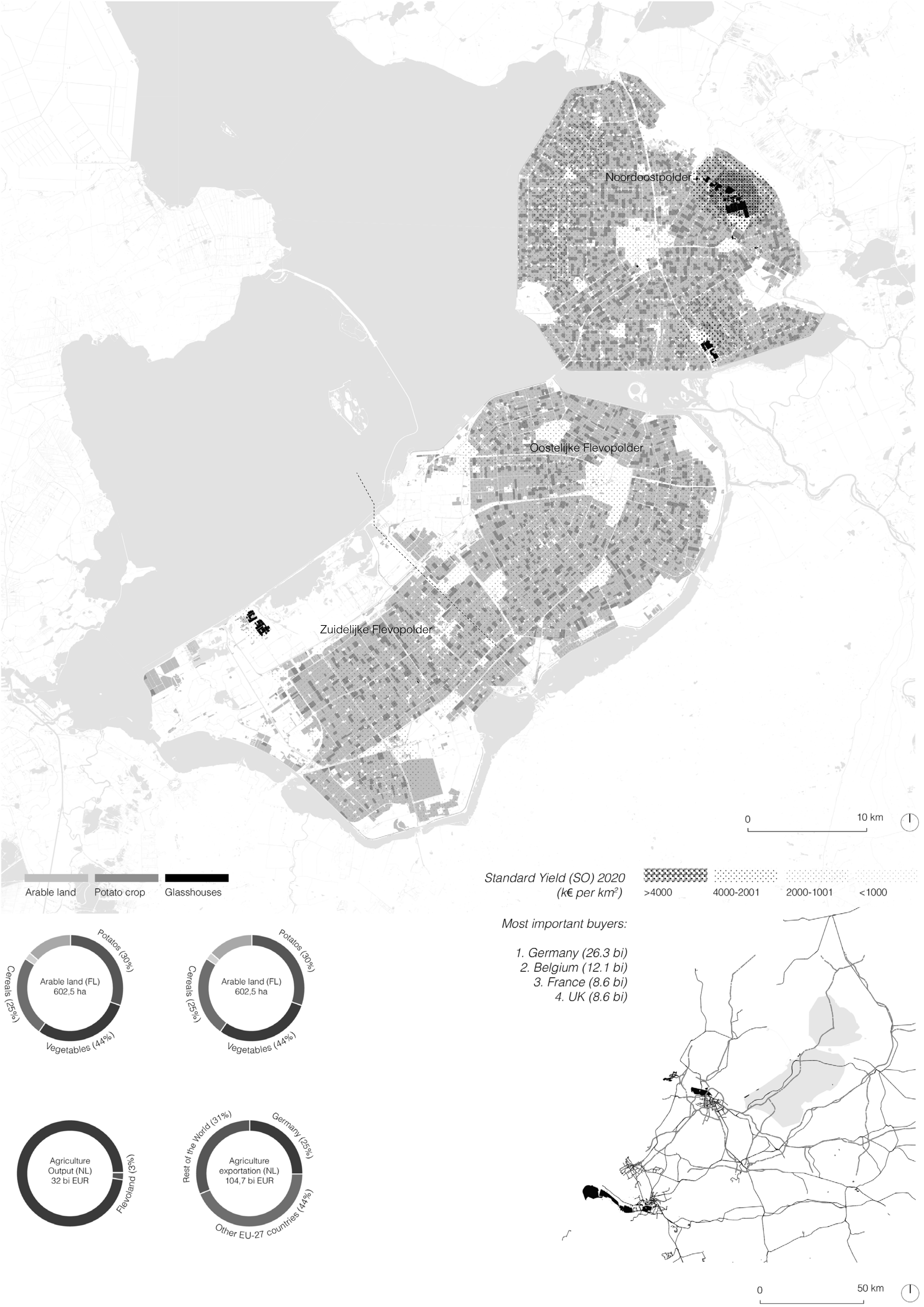
Figure 31. Conceptual drawing of Almere-Oosterwold (Source: *www.mvrdv.nl*)

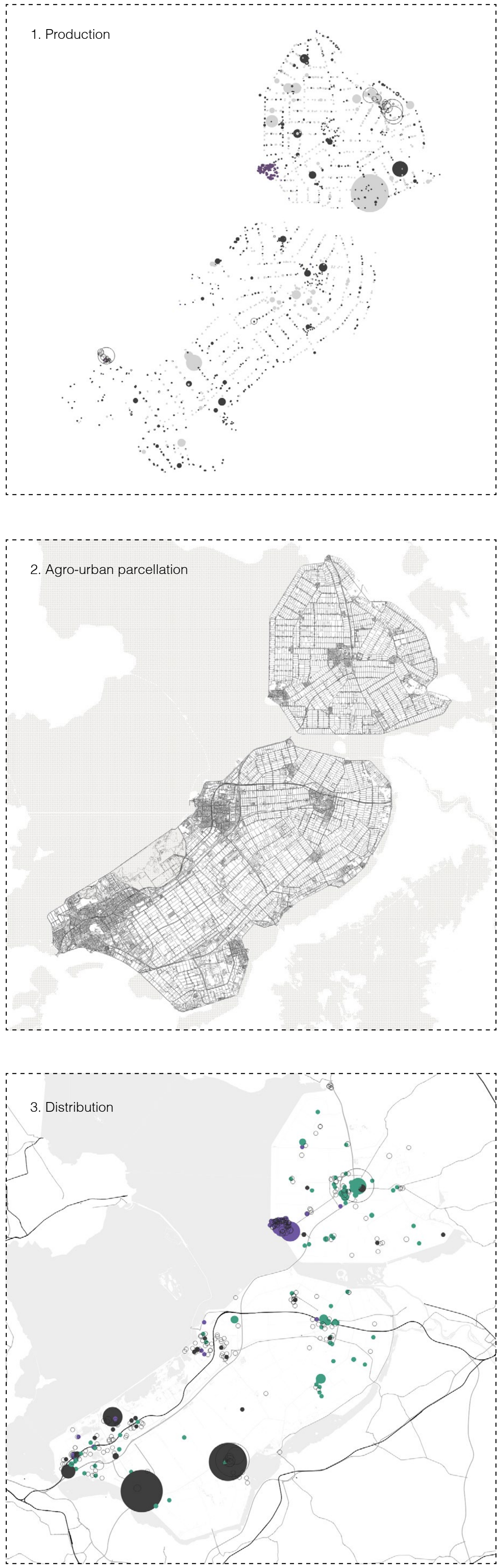
Figure 32. “Polder boys” preparing the land.
(Source: reproduction from the Batavialand Museum exhibition)

Figure 33. First families in Lelystad.
(Source: reproduction from the Batavialand Museum exhibition)

Figure 34. Noordoospolder from above.
(Author: Paul Paris)

Figure 35. Aerial view of Almere-Oosterwold.
(Source: *www.siebeswart.nl/image/I0000burKSQey4Rc*)





4.3 The limits of land use in Flevoland

Intensive arable agriculture

The majority of Province of Flevoland is dedicated to agricultural production. However there are some structural differences in the agricultural land use in the different polders that can be observed by analysing the production destination, intensity, parcellation, and distribution centers.

The Noordoostpolder has a vast diversity of production outcomes, with food products coming from arable land, cattle, glasshouses, and fishing activities - traditional activity from the former island Urk, now part of the inland province. The agricultural plot sizes in the Noordoostpolder are the smaller ones, which reveals that the determined land areas changed due to new technologies that were adopted in the subsequent reclaimed Oostelijke and Zuidelijke Flevopolders. Proportionally, the Noordoostpolder has the highest standard yield of all the remaining polders.

The Oostelijke and the Zuidelijke are the only ones with railway access, also being completely surrounded by water, a difference from the previous polder. In that sense, the transportation of agricultural goods by motorized vehicles plays a essential role in the Noordoostpolder.

The Zuiderlijk was set to have innovative and experimental agro-urban development, also concentrating the majority of population of Flevoland. The agriculture parcels are notabily bigger, with a high concentration of distribution centers and food wholesale centers, with recent development of glasshouse infrastructure.

1. glasshouses
fishing
animal creation
arable agriculture

2. Natura 2000 areas

3. food transportation companies
wholesale of fish, crustaceans, molluscs
wholesale of meat and live animals
wholesale of non-animal agricultural products
motorways and primary roads
railway

Employed workers (permanent + temporary contracts)

>300 … >5

Figure 36. Flevoland's agriculture overview.
(By author based on: *Agrarisch Areaal Nederland (AAN), CBS, Open Street Map, Basisregistratie Topografie (BRT) TOPNL*)

Figure 37. Agriculture trends in Flevoland.
(By author based on: *Agrarisch Areaal Nederland (AAN), CBS*)

The number of arable agriculture farms is decreasing in Flevoland, with aproximadely 500 farms decrease since 2000. A trend that is observed at regional and municipal level. However, the agriculture surface area is not decreasing in the same pace. The interpretation of this data is supported by information from the official webpage from the Province of Flevoland, which indicates that smallholder farms are becoming vancat due to the lack of farmer succession (meaning that younger generations of family farmers are not staying in Flevoland). In that sense, larger agriculture operations are buying land and expanding the size of their properties, which gradually is changing the ownership structure, especially in the Noordoostpolder. A process that is likely accelerated by the new nitrogen reduction measures.

This situation is even more dramatic regarding the horticulture glasshouse land-use and ownership dynamics. Despite the trend of the reduction of glasshouse companies since 2000, in that same period, the surface area of glasshouse horticulture is increasing dramatically in the Noordoospolder. That may indicate that few companies are expanding operations and concentrating ownership in the glasshouse land use structure. Also, that Flevoland, and is under a moment of horticultural production intensification, which also means higher consumption of energy, and visual changes in the landscape, especially in the Noordoostpolder.

Figure 38. Farm in Almere.
(By author)

0 10 20 km

Flevoland is not only being intensified in agriculture, but also in population. The Netherlands is currently facing a housing crisis, and set an objective of providing 1 million homes until 2030. The areas within and closer to the Randstad are priorities to receive new investments in housing. One of these target areas is Almere, which since its foundations is perceived as an extension of the urbanization coming from the Metropolitan Area of Amsterdam. Almere has the goal to provide 60,000 new houses and 100,000 jobs by 2030.
Several projects are currently aiming to provide this demand, both on the Markermeer area (A - Almere 2030), and inland (B - Eemvallei Stad). Beyond the immediate provision of housing and related services infrastructure, these expansion areas are intertwined with biophysical challenges. Especially regarding the ecological restoration of the Markermeer area, which suffers from the lack of biodiversity due to high levels of turbidity; the severe soil subsidence that affects both urban and agricultural areas; and ecological agendas such as the Natura 2000, that aims to propose a large scale ecological network.

- Water turbidity (Markermeer)
- Agriculture land use
- Urban land use in Flevoland
- Urban areas
- Natura 2000
- Moderate subsidence
- Severe subsidence

Municipalities

1. Almere
2. Zeewolde
3. Lelystad
4. Dronten
5. Urk
6. Noordoostpolder

Figure 39. Flevoland agro-urban land use and challenges overview.
(By author. Data sources: *Agrarisch Areaal Nederland (AAN), Open Street Map, Basisregistratie Topografie (BRT), RIVM, WUR(BRT) TOPNL*)

0 5 10 km

Figure 40. Urban expansions in Almere. (By author. Data sources: *Agrarisch Areaal Nederland (AAN), Open Street Map, Basisregistratie Topografie (BRT), RIVM, WUR*)

A

Figure 41. Almere 2030 - MVRDV
(Source: *www.mvrdv.nl/projects/357/almere-2030*)

B

Figure 42. Eemvallei Stad - IMOSS
(Source: *www.eemvalleistad.nl*)

Figure 43. Land use and water: functionality versus territorial conditions.
(By author. Data sources: *Agrarisch Areaal Nederland (AAN), Basisregistratie Topografie*)

0 10 20 km N

4.4 Multi-level demands for a functional transition

Policy objectives towards a sustainable territory indicate an incoming transition in Flevoland`s landscape. Proposals such as the increase of liveability of countryside areas in Flevoland, and the decrease of agro-chemicals use, by the Agenda Vital Countryside (2015), can potentialy be synergized towards a landscape reconfiguration to achieve an evolutionary adaptive territory. Other examples of potential converging policies and agendas are: the OECD Guidance for Responsible Business Conduct (2018), that puts pressure on reducing agrobusiness environmental impact; the EU's Common Agricultural Policy CAP (2019), which led to the loss of economical benefits of intensive agricultural farms; and the Nitrogen Action Program and Reduction pact (2020), responsible for imposing a technology and management transition to reduce nitrogen emissions. Also, Flevoland is recently developing a Rural Area Program (2023), to have access to the National Transition Fund for Rural Areas, representing an important moment of possible transformations.

Currently, the IJsselmeer Agenda, and Flevoland Agenda are being discussed and formulating, with initial stages indicating an special attention for sustainability, circularity, recreation, and natural restoration. An important aspect considering that the Blue Heart is mostly determined as a Natura 2000 area, due to its ecological importance. Other drivers for the regional transition are: the increasing farm vacancy, and the demographic aging of Western Europe, since a significant amount of workers come as temporary work-force from that region. Also, the ongoing agro-urban experiments to provide housing in Almere can be synergized with agro-urban design strategies incubators. In that sense, exploring local experiments of different solutions that can be integrated into feedback loops, allowing a medium and long term design evaluation of possible adaptation pathways.

4.5 An opportunity for higher-value bioeconomy

To implement a socioeconomically sustainable transition, concepts of the bioeconomy model emerge as possible pathways of a futures with reduced arable land, and a less intensive agricultural system. Considering the biomass volume equivalence in economic value, Flevoland has the opportunity to catalyze a transition towards a high-value and low volume agricultural related products, coupled with the increasing important seeding exportation. Also, it has the potential of implementing a circular bioeconomy system that operates concomitantly with the strengthen of a regional agroecosystem - with shorter and more controllable flows and less dependency on external market dynamics.

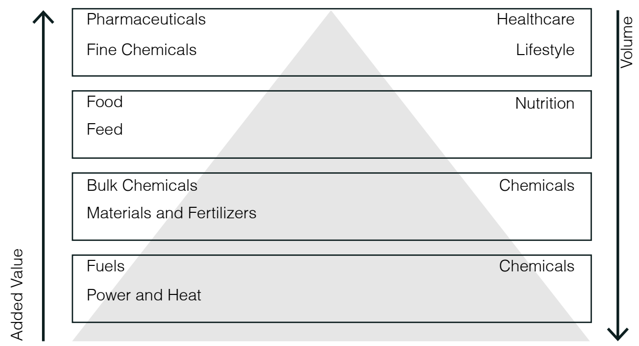


Figure 44. Biomass value pyramid diagram. (By author based on *Bosman & Rotmans, 2016*)

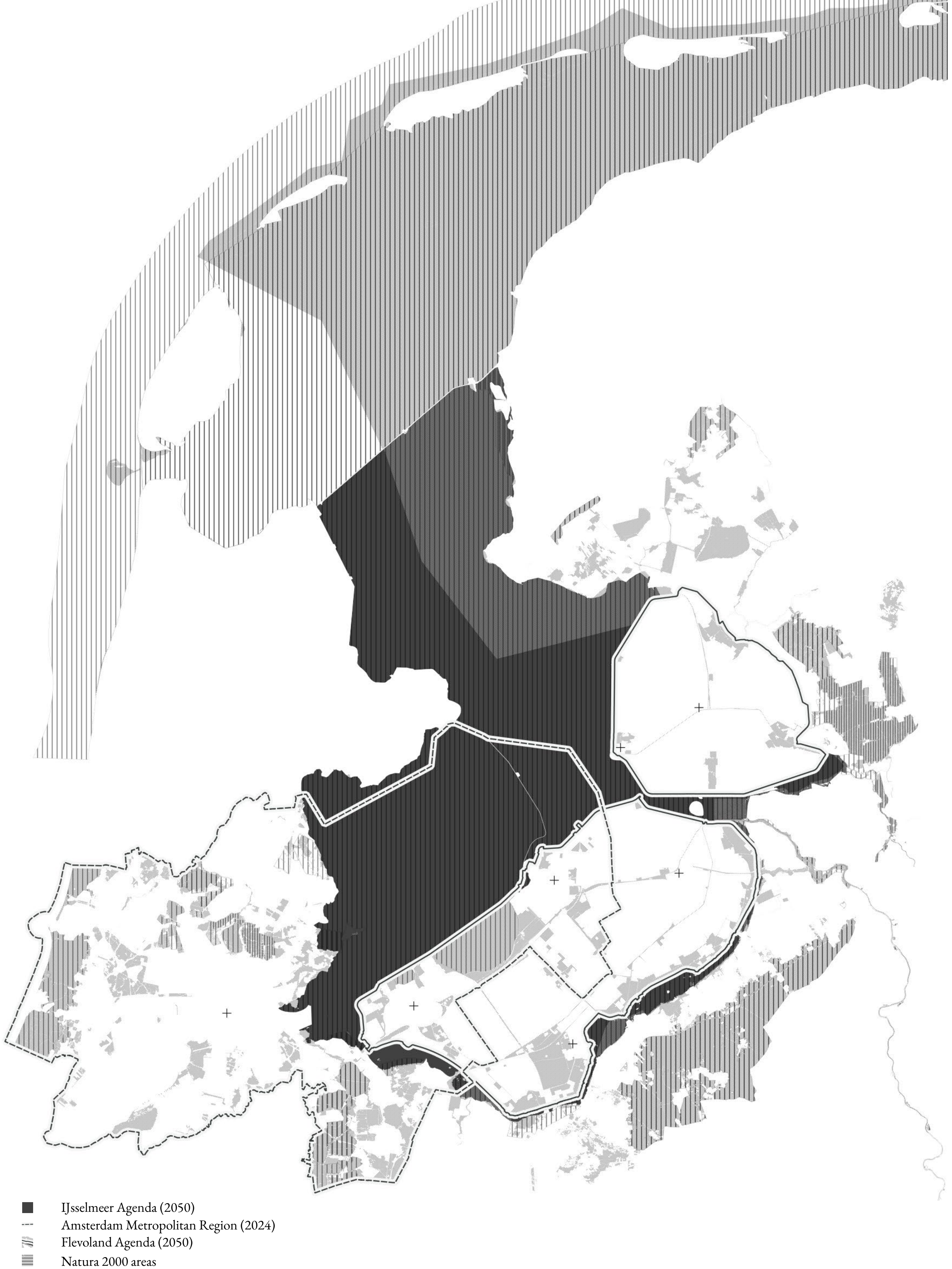


Figure 45. Agendas in the Blue Heart.
(By author)

4.6 A puzzle of agendas and socioeconomic development intentions

The diverse set of European and National transformative and sustainable policies in the Blue Heart, with especial emphasis on Flevoland, is reflected on the current discussions present in the formulation of the new agendas for 2050 for Flevoland and the IJsselmeer (Figure 45) . The regional objectives for the IJsselmeer and Flevoland have sustainability, ecological restoration, climate adaptation, and recreation as importnt elements. Which are also in synergy with the objectives and interests of the Amsterdam Metropolitan Region, which include the municipalities of Almere and Lelystad, with special attention for the development of a regional green economy. Which can be implemented also to improve the sustainability of the degrading industrial agriculture sector.

In that sense, by seeking for the alignments between agendas, it is possible to propose a convergent regional development for climate change adaptation and ecological restoration (Figure 46). Avoiding the cross-level trade-offs experienced during the Zuiderzeewerken, such as the economical impact on fishing activities in Urk and surrounding villages/cities. This strategy can also facilitate the fulfillment of the a different set of agendas by setting a territorial transformative goal that incorporate important cross-agenda alignments on its conceptualization.

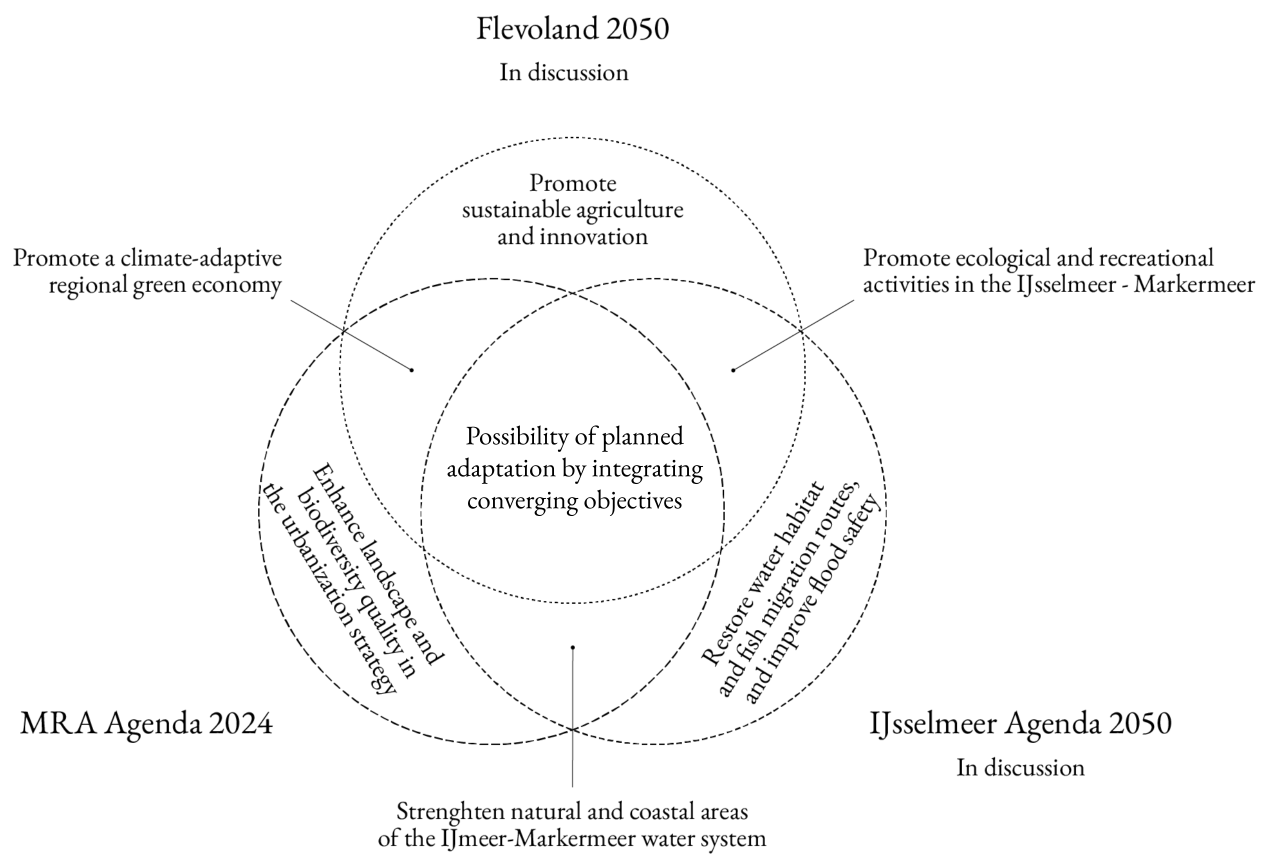


Figure 46. Opportunity of objective convergence.
(By author)

5. METHODOLOGY

5.1 Problem statement and research questions

A) Water infrastructure and socio-ecological interdependency (territorial composition)
The implementation of the extensive water defense infrastructure system, built during the enclosure and land reclamation in the Zuiderzee, fractured the Blue Heart's geomorphology and ecosystems, by erasing the water-land transitions. Currently, the lack of ecological habitats in the water-land boundaries of the water infrastructure in the Province of Flevoland affects the national and European ambitions to achieve environmental restoration goals.

B) Land-use (territorial functions)
Furthermore, the agriculture activities and housing expansion in Flevoland also have crucial environmental trade-offs in the reclaimed land and surounding ecosystems. The Province of Flevoland operates an intense industrialized agriculture system towards global food exportation, which causes intense environmental deterioration and soil subsidence. Concomitantly, the current housing expansion ambitions of the Amsterdam Metropolitan Area in Almere and Lelystad, can potentially increase the soil degradation, the land-use pressures in ecological and agricultural areas, and the demand for food that is not currently supplied within the province.

C) Climate adaptation (future scenarios)
Sea-level rising uncertainty poses critical challenges to ensure the long-term operability and reliance of linear flooding defense infrastucture, which is responsible to reduce the probability of flooding events. In that sense, the socio-economical safety dependence in the current water defence infrastructure can potentialy reduce the climate adaptation capacity of the Province of Flevoland and compartmentalized habitats of the Blue Heart in face of future climate uncertainty. To achieve long-term sustainable agriculture and housing activities in the region, new types of water infrastructure and landscape approaches must be explored to minimize the possibility of climate-driven disruption events.

Main research question:
What are the fundamental spatial and systemic synergies (A) between ecology, agriculture, and housing (B) to achieve an evolutionary nature-based climate adaptation (C) in Flevoland?

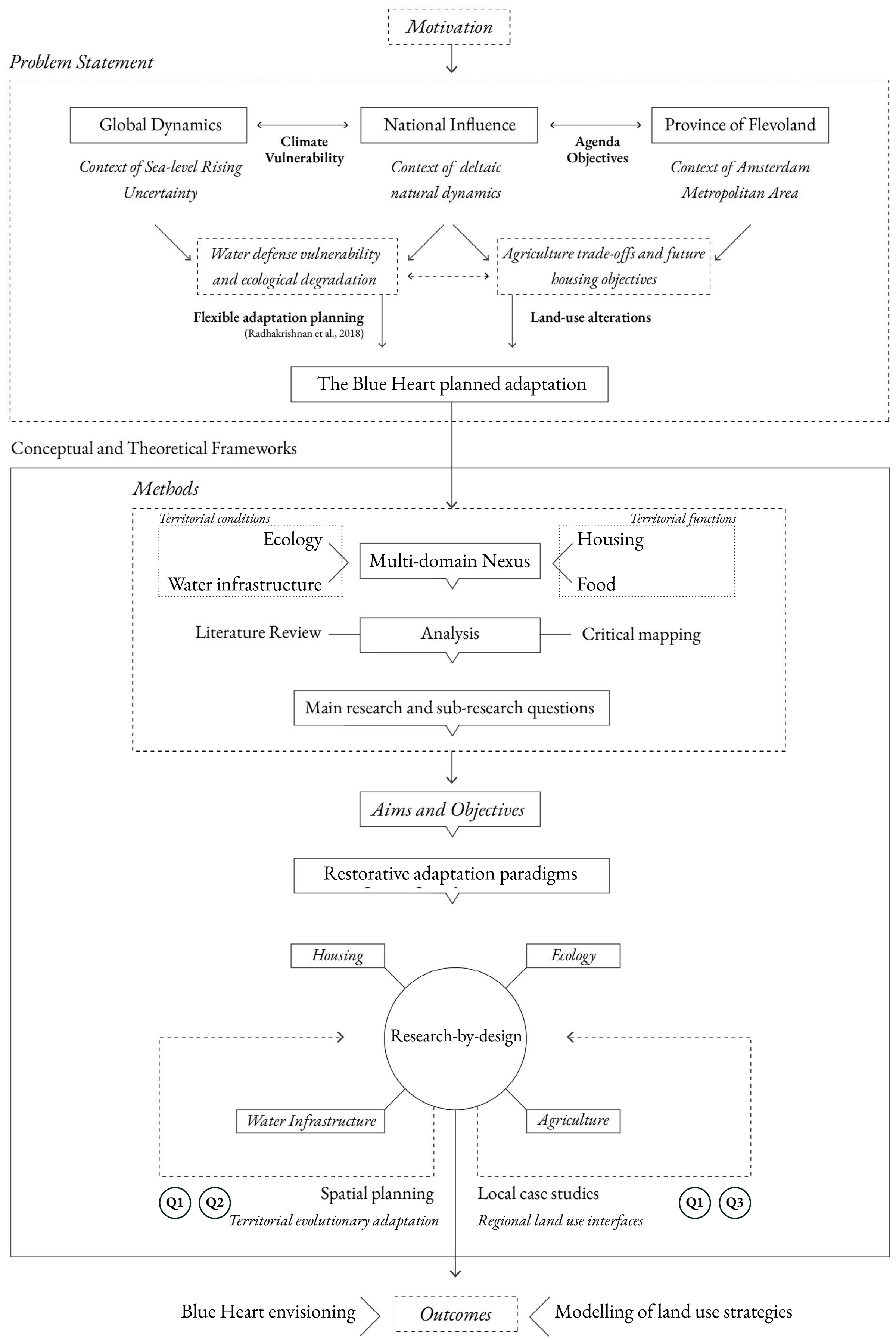
Sub research questions:

(Q1) A + B = How can a long-term water infrastructure integration with natural systems (A) be coupled with land use transformations (B) ?

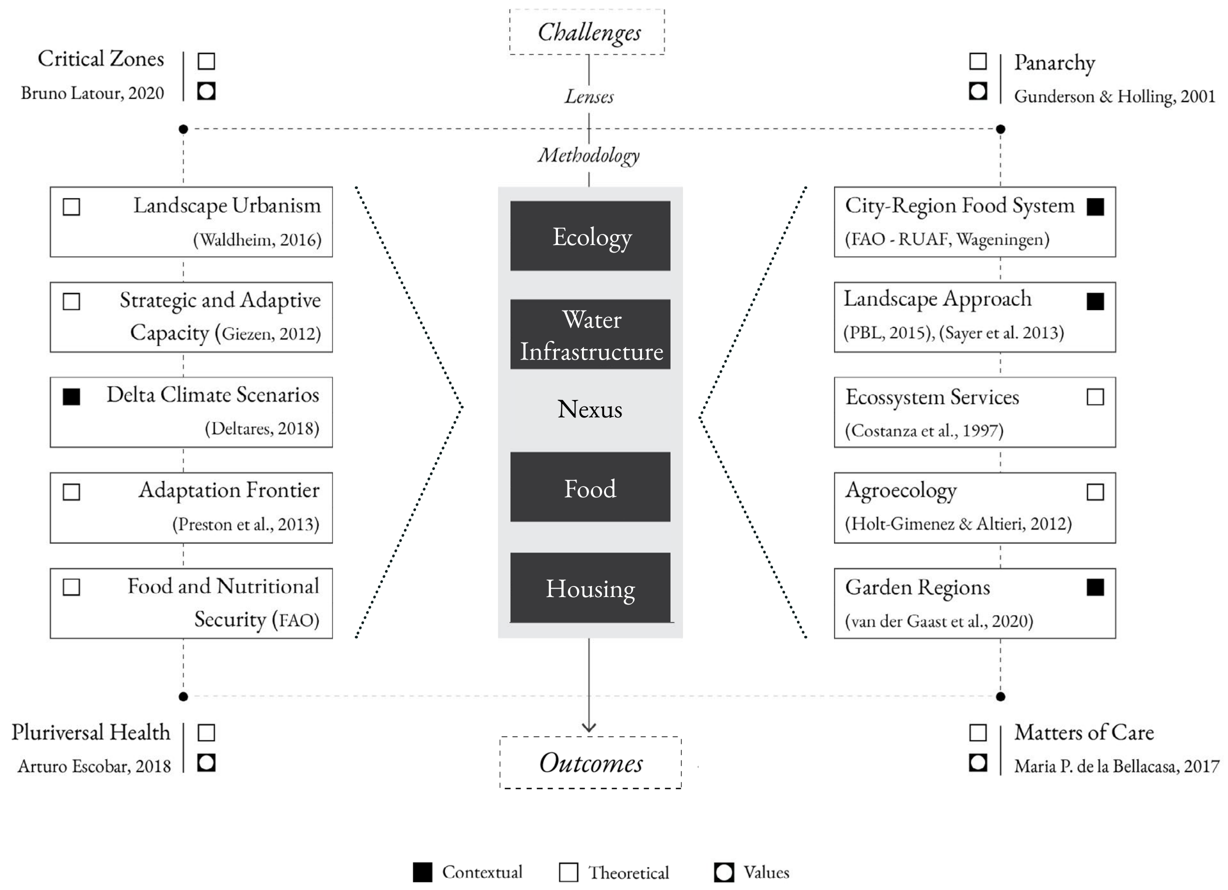
(Q2) A + C = How can the integration of natural systems into water infrastructure (A) promote a long-term dynamic climate adaptation of the province of Flevoland (C) ?

(Q3) B + C = What potential land use spatial qualities that converge governance alignments (B) can be achieved with a restorative climate adaptation strategy (C) ?

5.2 Methodological Framework



5.3 Theoretical Framework



The design process on the scales of the territorial envisioning and local interventions is carried out through an nexus of territorial conditions (Ecology and Water Infrastructure) and functions (Food and Housing) design principles able to unveil the contextual spatial critical interdependencies and opportunities in the Blue Heart. The nexus is based on the identified domains that intersect the spatial challenges of the Blue Heart discussed in the problem statement. The operationalization of the nexus then is guided by a multi-domain theoretical body of knowledge guided by territorial values to start a process of adaptative planning.

After an initial survey and interpretation of the worldviews exposed by the Critical Zones, Pluriversal Health, Panarchy, and Matters of Care, it is possible to set ecology as the foremost crucial element of the nexus. In that sense, the project will seek to seek for ways of decompartmentalizing the once vibrant habitats to achieve an evolutionary healthy relationship with the Blue Heart territory.

In that sense, the Blue Heart territorial design will seek to achieve the healing the web of life on its fragments (Pluriversal Health) towards an evolutionary, sustainable, and sensitive coexistence with nature. To plan it in a adaptation perspective, the design adopts the principles of adaptive cycles which can increase the systems' redundancies to face unpredictable futures, allowing a safe transition towards the future. Finally, to guide this process, the Matters of Care is adopted as a core ethical and political positioning, pushing the long-term vision based on humanity's responsibility of expanding the web of care by balancing the human subject position among natural webs of care to reorganize human-nonhuman relations towards non-exploitive forms of co-existence.

5.4 Theoretical application

Theoretical Lenses:

Critical Zones (Latour & Weibel, 2020): the definition adopted for this thesis is based on the revision of Bruno Latour about the Earth Sciences concept of Critical Zones. Hence, adding the decision-making, political, and socioeconomic dimensions of the multilayered interactions that sustain life through geochemical cycles and living organisms' interdependencies.

Panarchy (Gunderson & Holling, 2002): is a framework of nature's transitions across time, recognizing the function of systems at multiple scales of space, social order, and natural dynamics. It aims to connect adaptive cycles in nested hierarchies, in which the adaptive cycle's phases have different levels that are intertwined by revolt and remember moments, in a way that slower and larger levels set conditions for the functioning of smaller and faster levels.

Pluriversal Heath (Escobar, 2019): this definition is a holistic framing of health as a qualitative characteristic of the interaction between systems, fundamental to weaving and healing the web of life. It is conceived within a broader pluriversal cosmology that incorporates the diverse knowledge of different worldviews that share the planet, especially the ones that are aligned with social justice and the systemic character of life. Health then becomes a provider of life's necessities, in the physical, emotional, and spiritual dimensions.

Matters of Care (de la Bellacasa, 2017): the 'matters of care' is an ethical and political positioning that acknowledges humanity's responsibility of expanding the web of care by balancing the human subject position among natural webs of care to reorganize human-nonhuman relations towards the envisioning of non-exploitive forms of co-existence.

Nexus propositions:

Territorial conditions

Ecology: propose the environmental restoration of the Blue Heart. The design must comprise the ecological interdependencies in the natural ecosystems intertwined with human activities. It is based on one hand in a interpretation of a Landscape Approach (van der Horn & Meijer 2015; Sayer et al., 2013), which is a framework largely adopted in the Netherlands, that acts in the relation between the landscape hybrid functions with stakeholders. In that sense, it aims to achieve landscape transformations by the identification of entry points, leverages, and value convergence guided by a territorial restoration process. The hybrid functions of the landscape, on the other hand, can be synergized with Ecosystem Services (Costanza et al., 1997), which allows the maintenance of natural ecosystems, and the soil-water capacity for human activities of the landscape.

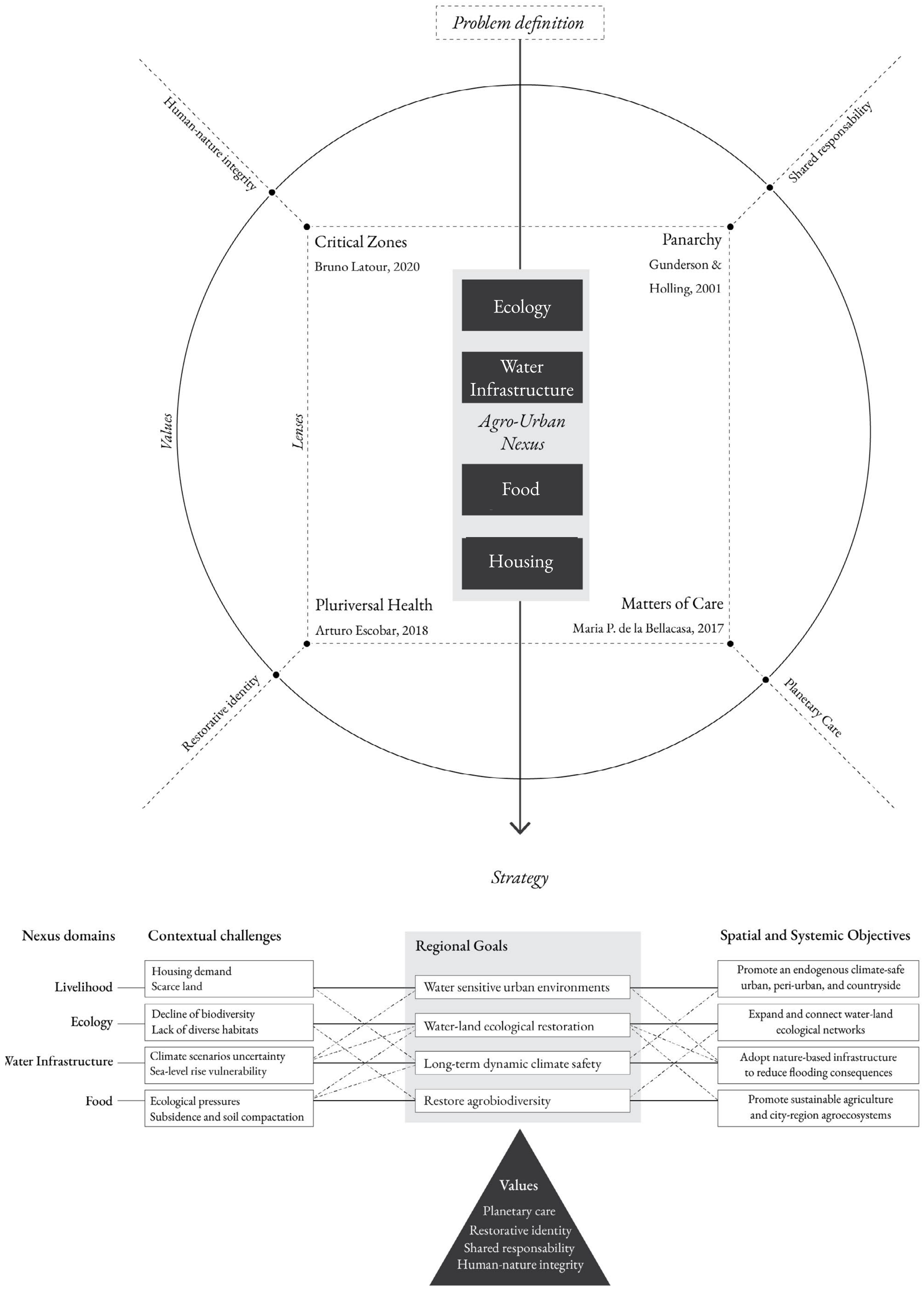
Water infrastructure: propose an evolutionary adaptation of the Blue Heart. It is established within the correlation between the socioeconomic climate scenarios from Deltares (Appendix C), and the desirable safety operability of systems during climate adaptation (Preston et al., 2013). Hence, placing environmental uncertainty is a pivotal element in planning. In that sense, spatial planning must navigate adaptive strategies through climate uncertainty and complexity, by providing adaptive capacity and strategic capacity (Giezen, 2013) to achieve desired outcomes.

Territorial functions

Food: propose a regional food system for Flevoland. This concept is defined by the operation of a food system within the regional scale of a landscape (van der Horn, S., & Meijer, J, 2015; Sayer et al., 2013) that provides Food and Nutritional Security by supporting food availability, accessibility, utilization, and stability (FAO). It is the core of Flevoland's future, using the robust food infrastructure and extensive patches of small and medium farms as leverage to promote an agroecological system (Holt-Gimenez & Altieri, 2012) capable of regenerating ecosystems (Constanza et al., 1997), while creating an identity within a garden region composed by second-tier cities (van der Gaast et al., 2020), such as Almere. Therefore, this approach integrates food as a core for the landscape urbanism approach (Waldheim, 2016), aiming for a safe adaptation (Preston et al., 2013) to climate uncertain futures for the Netherlands towards an evolutionary non-exploitive human-nature coexistence.

Housing: propose an adaptive livelihood for Flevoland. Which implies in align socio-economic activities, local identities, and converging objectives to thrive in climate change uncertainty. It is established through the theoretical framework of Landscape Urbanism (Waldheim, 2016), in which the landscape transformations and conditions are intrinsically related to the formation and functioning of the urbanized landscape.

5.5 Conceptual Framework



The reclamation of the Blue Heart created a tight system of interdependencies that intertwine national and regional crises. When interpreted through the holistic lens of Pluriversal Health, Critical Zones, Matters of Care, and Panarchy, it is concluded that maintaining the current territorial linear flood protection system and land use model in Flevoland is unsustainable for ecological, infrastructural, and biophysical reasons. In that sense, the project proposes a territorial re-organization to kickstart a new adaptive cycle that is guided by restorative values. That being the first step of reconnecting the Blue Heart's fragments.

5.6 Vision and Hypothesis

Embrace uncertainty towards an evolutionary future. (By author)

The Blue Heart:
A territorial envisioning of an evolutionary agro-urban ecology

Territorial conditions:
Release compartmentalized nature towards a new restorative water infrastructure.

Territorial functions:
Cultivate healthy and regenerative regional agroecological landscapes
and guarantee evolutionary livelihood and agro-urban coexistence in the natural habitats.

Hypothesis: the adoption of the holistic ethics and values to guide a planned adaptation design will allow an integral and sustainable envisioning of the Blue Heart, able to indicate future adaptation pathways towards a non-harmful and restorative land use and flooding safety.

5.7 Aims, Outcomes, and Limitations

This thesis aims to provide an adaptation perspective, guided by restorative values, for the Blue Heart until 2085 with indications on how to achieve long-term stability. It has the purpose to propose a new social construction of human-nature non-exploitative coexistence, allowing the implementation of deltaic land use. Gradually transforming the region into an ever-evolving sustainable agro-urban ecology, indicating a future to reduce agricultural intensification, highlighting the regenerative potential and synergies of an multi domain agro-urban development.

Relevance: The project deals with the intersection of major global and regional crisis. Expressed in Flevoland through the degradation of the water-soil biophysical structures, the demand for housing expansion, the socioenvironmental limits of intense agriculture, and the vulnerability towards sea level rise uncertainty. The proposed outcomes of this project, envisioning and design strategies, can contribute to the necessary and vibrant discussion of how to deal with those crisis through design. Presenting possible and feasible narratives of future coexistence. In this process, also it adds to the theoretical discussion of the holistic integrations of food into urban planning, largely explored in the last years. Hence, provided a different approach that is based on interdependencies with other systems, in both regional and local scales. Finally, the project is also inserted in a paradigmatical shift in the Netherlands regarding flooding prevention and defense, due to future climate uncertainty. Therefore, it also can be a test ground for contextualized possibilities of new measures, such as reducing flooding consequence. Exploring possible futures of agro-urban development within cycles of adaptation towards a natural continuum.

The expected outcomes are:

1 - Territorial envisioning of the Blue Heart, expressed through drawings and schemes;

2 - A modeling of land use strategies that will guide the proposition of new territorial functions, expressed through drawings and schemes;

3 - A report containing the supporting methodologies, literature review, the project's narrative, and conclusions.

Limitations

- Due to the complex nature of territorial projects, it will be defined that the territorial envisioning the Blue Heart will be concentrated in the relationship of Flevoland, as the currently functional part of its geomorphology and the water fragments. In that sense, excluding the other areas that had other administrative regional units, which will increase the complexity of the exercise beyond its experimental purpose.

- Also it will not consider the energy transition topic to focus on the relationship of housing and food that is historically essential for the Blue Heart sociocultural context.

6. PROPOSITION

Speculative perspective of the Blue Heart's endogenous habitats

The project starts with a speculative projection on how the Dutch landscape could look like if all the endogenous deltaic habitats evolve without considering the current land use. This first experimental exercise aims to unveil de degrees of ecological and geomorphological interference of water infrastructure. Hence, opening the critical question if there is a way forward to achieve through a reformed land use adapted to local conditions.

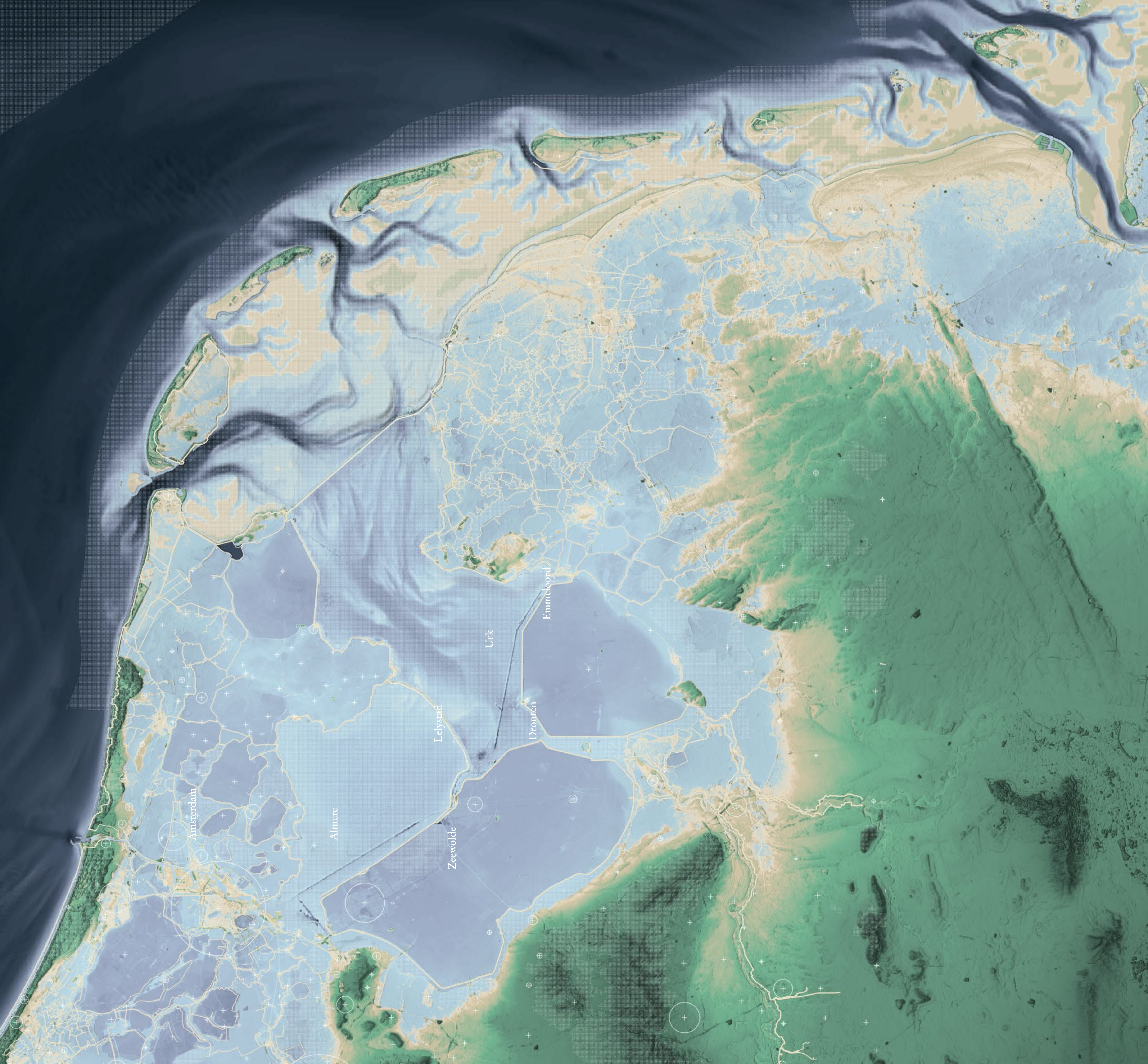


Figure 47. Visualization of potential endogenous habitats in SLR scenarios +0.4m (STOOM and WARM 2050), +0.8 (STOOM and WARM 2085), +1.2m (By author)

7. HONOURS MASTER PROGRAMME (HPM)

Alzate-Martinez, F. A. (2023). Agro-Urban Ecologies: Design of a climate-adaptive agroecosystem and urban expansion in Almere-Pampus. [HPM Honours Programme report, Delft University of Technology]. http://resolver.tudelft.nl/uuid:efa399b2-bdef-4e81-a469-390757a60f45

7.1 Research laboratory and collaboration with graduation studio

The research carried during the HPM "Elements of productive urban greening" started 6 months before the graduation studio as an independent research experience. It was supervised by Victor Muñoz Sanz and with the collaboration from Paola Huijding *(Projectdirecteur, Senior stedenbouwkundige Gemeente Almere)*. It started with the proposed site of Pampus-Almere, focused on a real case of a planning challenge, on which I decided to explore food production landscapes. Along the programme, the research was made in synergy with the graduation thesis, by adopting the same nexus approach to become a research laboratory to test an experimental approach.

The work Agro-Urban Ecologies revealed possible ways of expanding nature-base infrastructure projects executed in the Netherlands as basis to propose a regenerative agroecosystem. In the process, also unveiling which were the relevant regional backbones and limitations to elaborate the design exercise of agroecological typologies.

7.2 Results

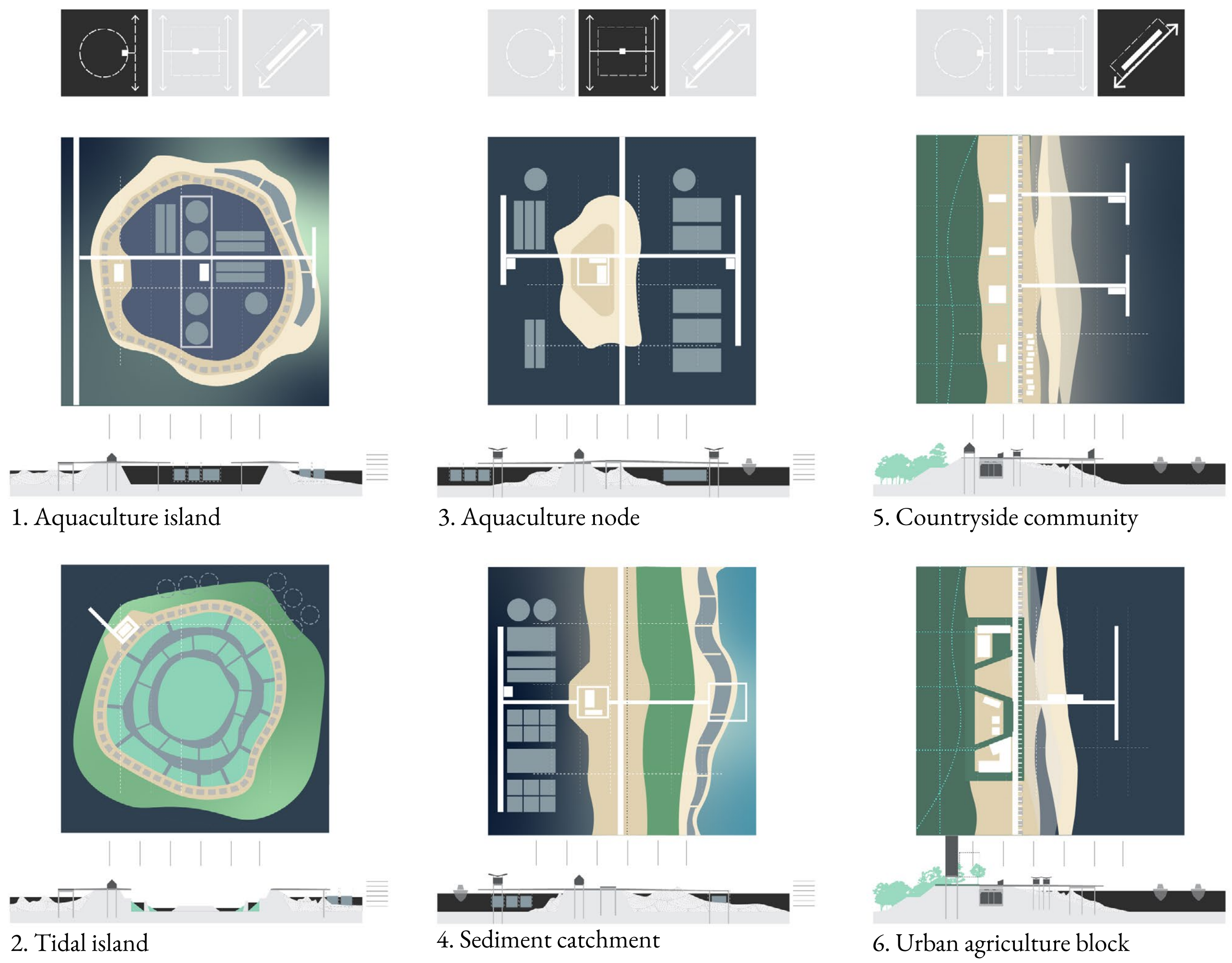
The research by design method explored in the HPM tested the integration of urban design as an mediator of ecological transformations, climate adaptation, and agroecology production through a renaturalization proposal. The case study exercise on Almere-Pampus found six agroecology typologies (Figure 48): aquaculture island, tidal island, aquaculture node, sediment catchment, countryside community, and urban agriculture block. Moreover, the evaluation of these typologies indicates that their implementation can promote gradients of urban and countryside land use. And by operating within a nexus, it envisions the recovery of endogenous habitats, offer food that is in synergy with a local agroecosystem all year round, and integrate its habitats with transport infrastructure.

7.3 Lessons from the design of Pampus-Almere

A) From local nature-base initiatives to a projective depoldering
In an initial process to gather design references, the Marker Wadden project and the Noordwaard depoldering were selected as case studies (Figure 49).

- The Marker Wadden is a geomorphological alteration in the Markermeer, by using silt that is trapped and deposited in the bottom of the Markermeer. It comprises a wide range of habitats, such as wetlands, dunes, marshlands, and different gradients of water depth. Morphologically it can be read as a small scale and condensed set of the endogenous habitats present in the Blue Heart. Therefore, it was analyzed in terms of its potential agrobiodiversity to identify the possible ecosystemic relations of a new type of agroecology endogenous from the Blue Heart.

- The depoldering of the Noordwaard is the largest project from the Room for River programme by the Rijkswaterstaat. It was flooded in 2020, proven to allow a safe indeterminant flooding by implementing mounds that elevate farmhouses and guarantee that the main transportation lines remain dry. The strategy caused resistance on the farmers due to farmland size reduction, and in close consultation the project was refined. Hence, being an example of land use planning that integrate multi-actor engagement towards a new planned adaptation system that reduces flooding consequences on land use.



Local Access

1. Aquaculture island

Production: centric ecological aquaculture production, with seasonal availability of crustaceans, oysters, and shrimps.
Access: waterway, streets.
Habitat: tidal and aquatic habitats.

2. Tidal island

Production: partially wet arable agriculture with tidal irrigation systems. Offers water plants, cereals, and rice in synergy with fish creation.
Access: waterway, streets.
Habitat: gradients of wetlands and marshlands.

Secondary Access

3. Aquaculture node

Production: shallow and deep water aquaculture farming.
Access: waterway, roads.
Habitat: accretion motor in synergy with tidal habitats.

4. Sediment catchment

Production: fishing, arable land, aquaponics.
Access: main roads, train/metro, boats.
Habitat: accretion motor dunes, wetlands, and tidal areas.

Primary Access

5. Countryside community

Production: fishing.
Access: main roads, train/metro, boats.
Habitat: gradients of wetlands and tidal habitats, coupled with forests and other types of land use.

6. Urban agriculture block

Production: local food parks and productive rooftops.
Access: main roads, train/metro, boats.
Habitat: gradients of wetlands and intertidal ecosystems, and allows the protection of forests and other types of land use beyond the secondary dike.

Figure 48. Typologies of restorative agro-urban practices extracted from the depoldering exercise in Pampus-Almere. (Source: *Alzate-Martinez, 2023*)

1

2

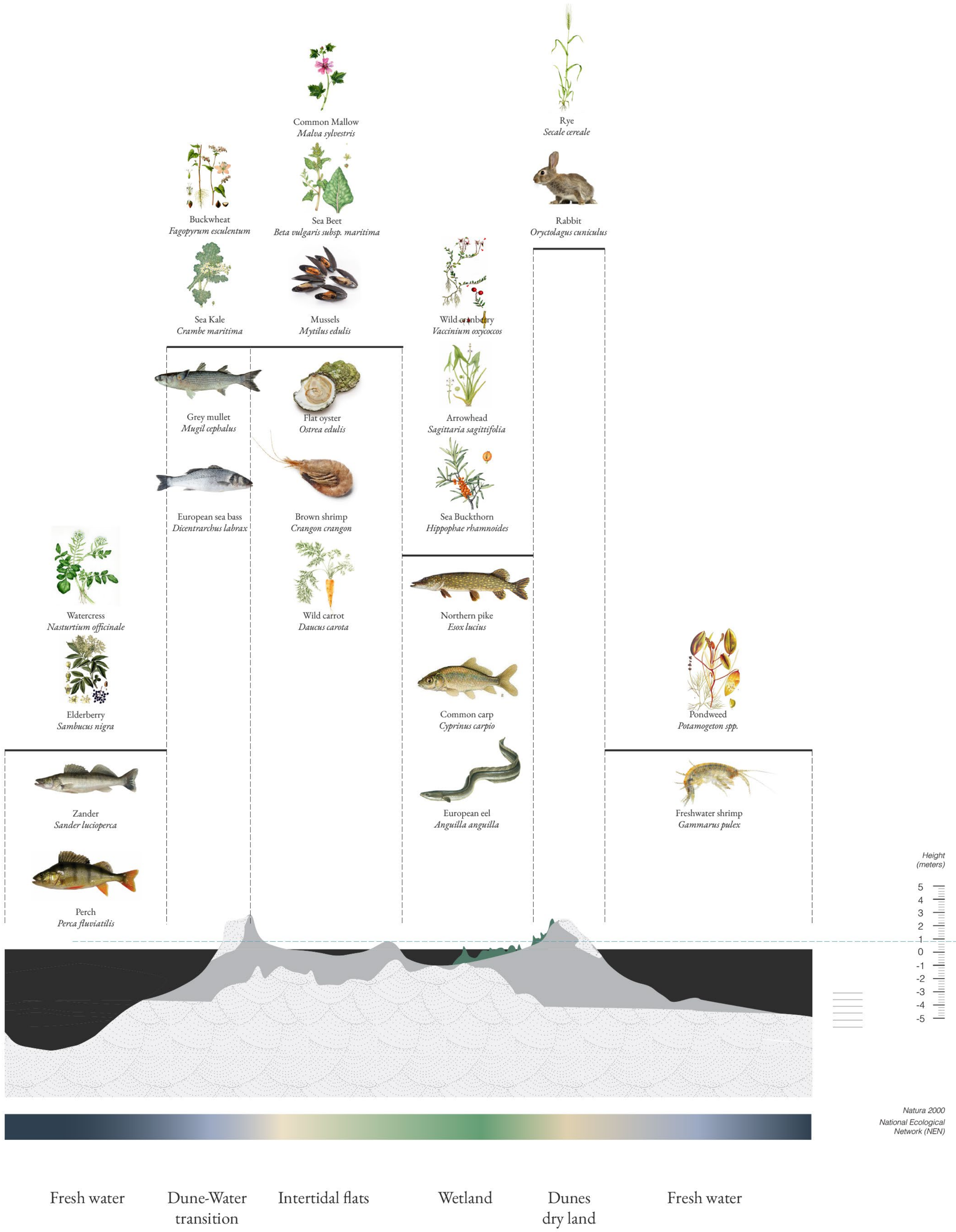
Figure 49. Marker Wadden (1) and Noordwaard (2) case studies.
(Source: *Alzate-Martinez, 2023*)

B) The critical role of transportation infrastructure
During the design phase, the accessibility of the depoldered agroecological typologies was perceived as fundamental. Especially because it could indicate the role of existing transportation infrastructure to guide the depoldering process. In that sense, the project adopted the logic of organizing the strategies based on its connectivity, based on Pampus-Almere site. In that regard, this reasoning allows the transferability of the proposal to other places with similar accessibility conditions.

C) Setting an endogenous agroecology system
Finally, the project allowed the visualization of the agroecological potential of the Blue Heart in terms of agrobiodiversity (Figure 50) and how to structure the productive typologies in the regional structures such as transportation, ecological areas, and dikes.

7.4 Limitations and applications

The design typologies do not indicate how they could perform in evolutionary process. Also, do not indicate the necessary stakeholder alignments and further cross-level governance systems. In that sense, the following steps for the Blue Heart territorial project of this thesis will address this questions by advancing on the lessons from the HPM in terms of the depoldering morphology and its relation with land use, the critical role of transportation lines, a regional backbone that intertwine housing and food, and the agrobiodiversity from the Blue Heart that allows the ecological feasibility of the project.



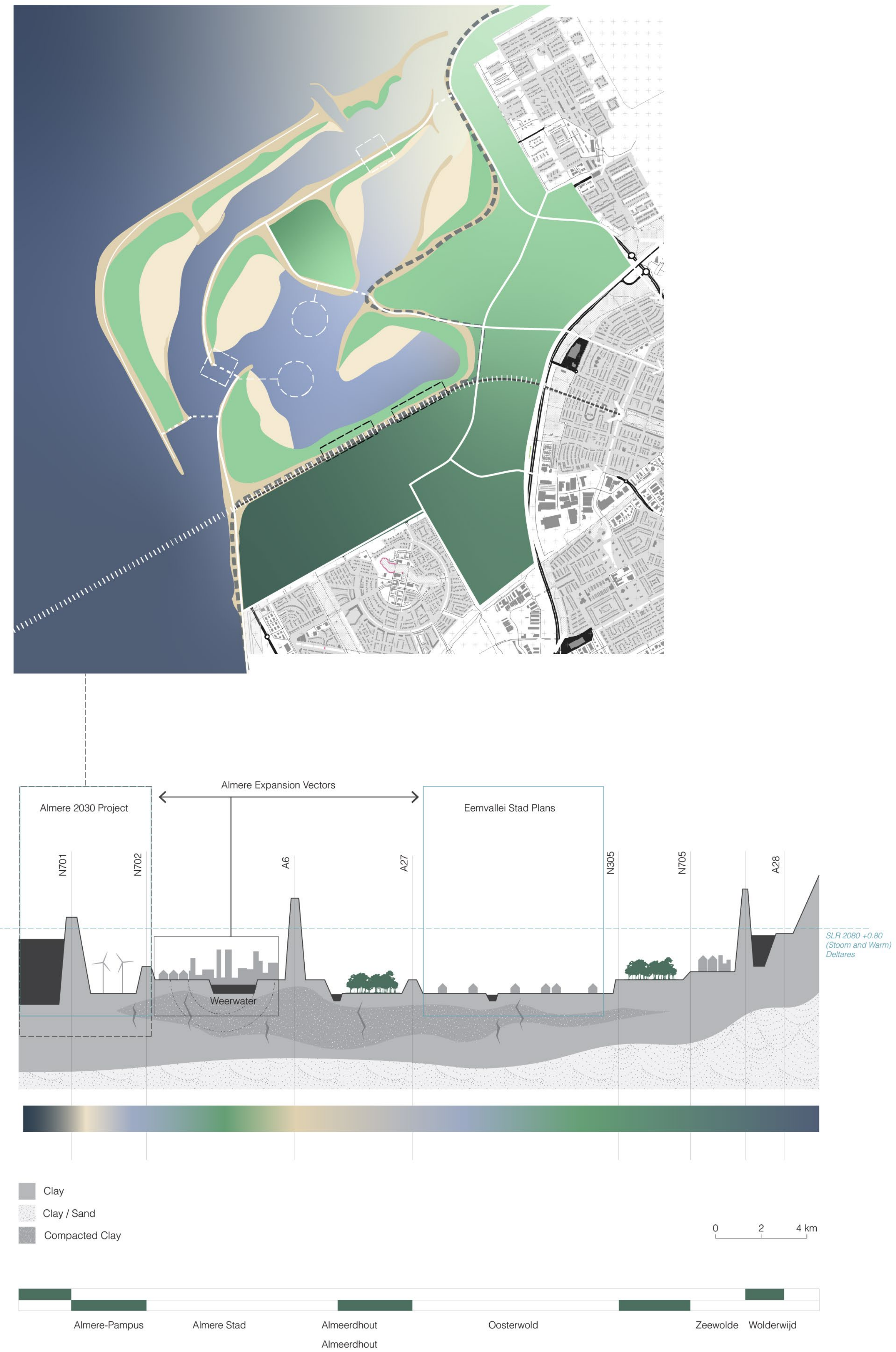


Figure 50. Agrobiodiversity and the depoldering of Almere-Pampus. The color scheme of habitats and their corresponded agrobiodiversity. **The color scheme corresponds to the projective map (Figure 47) and it will be adopted by the rest of the thesis to address ecological habitats.**
(Source: *Alzate-Martinez, 2023*)

4. PLANNED ADAPTATION CYCLE

The design starts with the exploratory design task of proposing a new adaptive cycle (Figure 51) for the Blue Heart delta. The objective is to use design as a method to inquiry, read (Figure 53) and synthesize a climate adaptation process for the future uncertain SLR possibilities considering actors, agendas, and guided by restorative values (Figure 52).

This adaptation process will seek to open a possibility for a new balance on land use (Figure 54) that can be synergized with biodiversity restoration. In that sense, unveiling the agency of the different scales in design o achieve a cohese ecosystem based adaptation, which can allow the Delta to evolve, while promoting new types of regional functions and infrastructure.

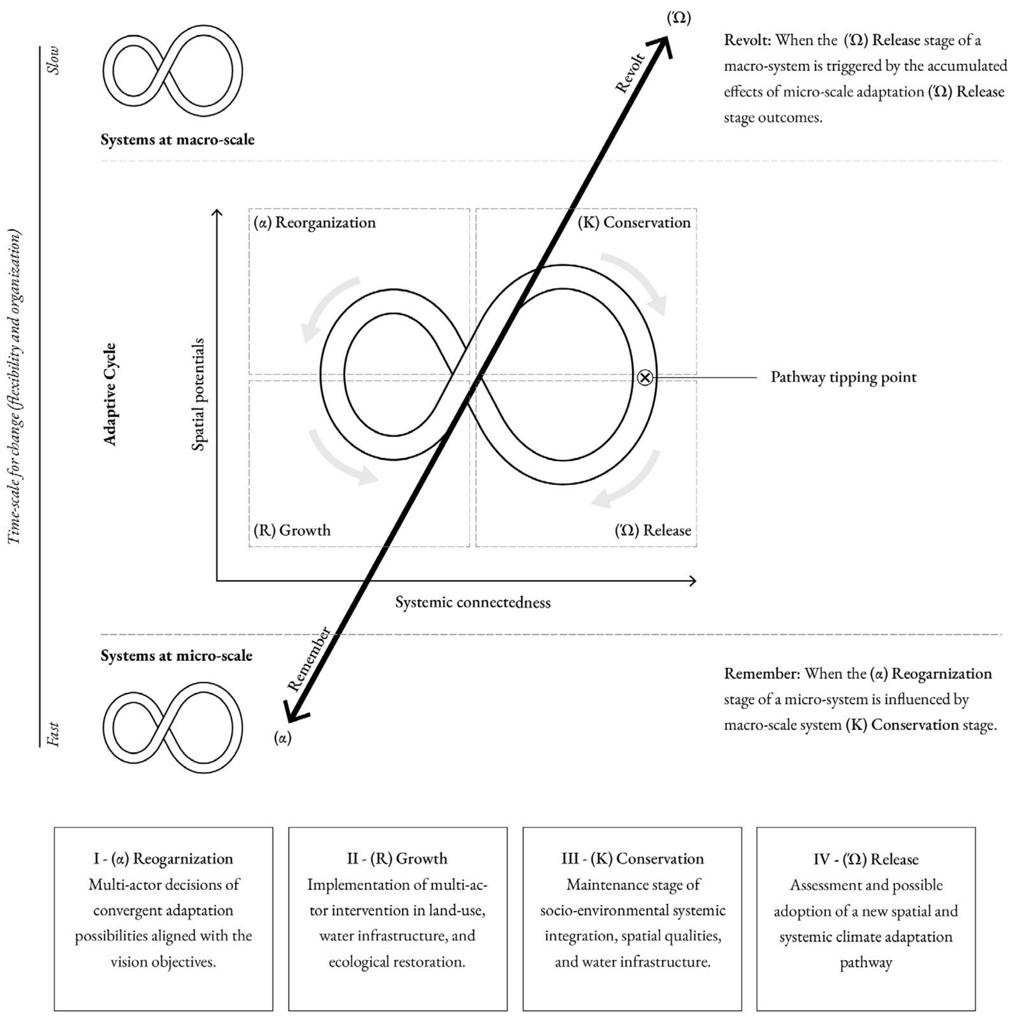


Figure 51. Adaptation cycle diagram.
(By author based on: *Gunderson & Holling, 2002*)

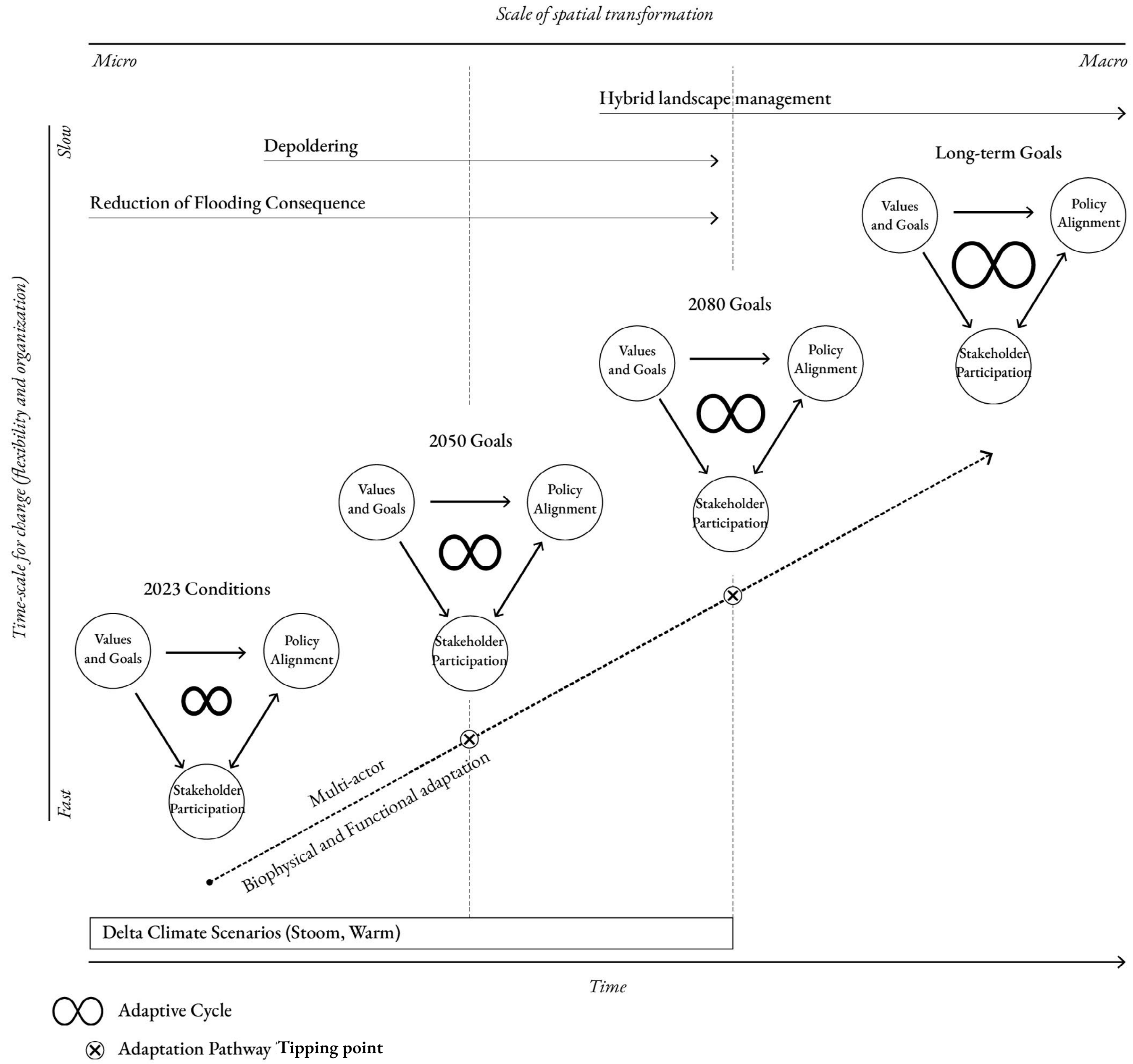
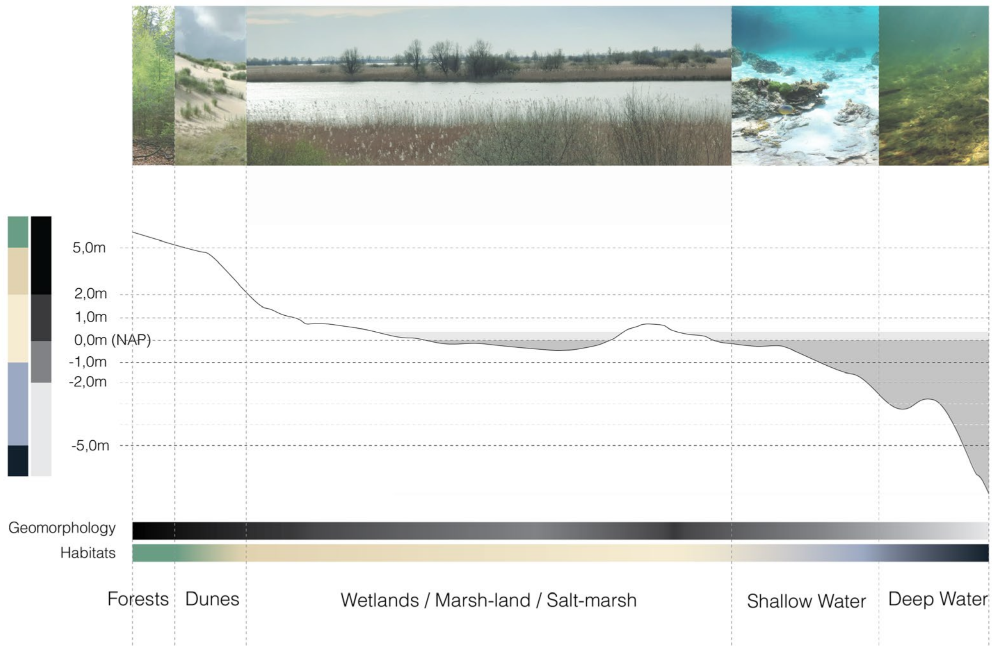


Figure 52. Adaptive regional governance principle diagram
(By author interpreted from adaptive cycle: *Gunderson & Holling, 2002; strategic adaptive management: McLoughlin & Thoms, 2015; dynamic adaptive pathways: Haasnoot et al., 2013*)



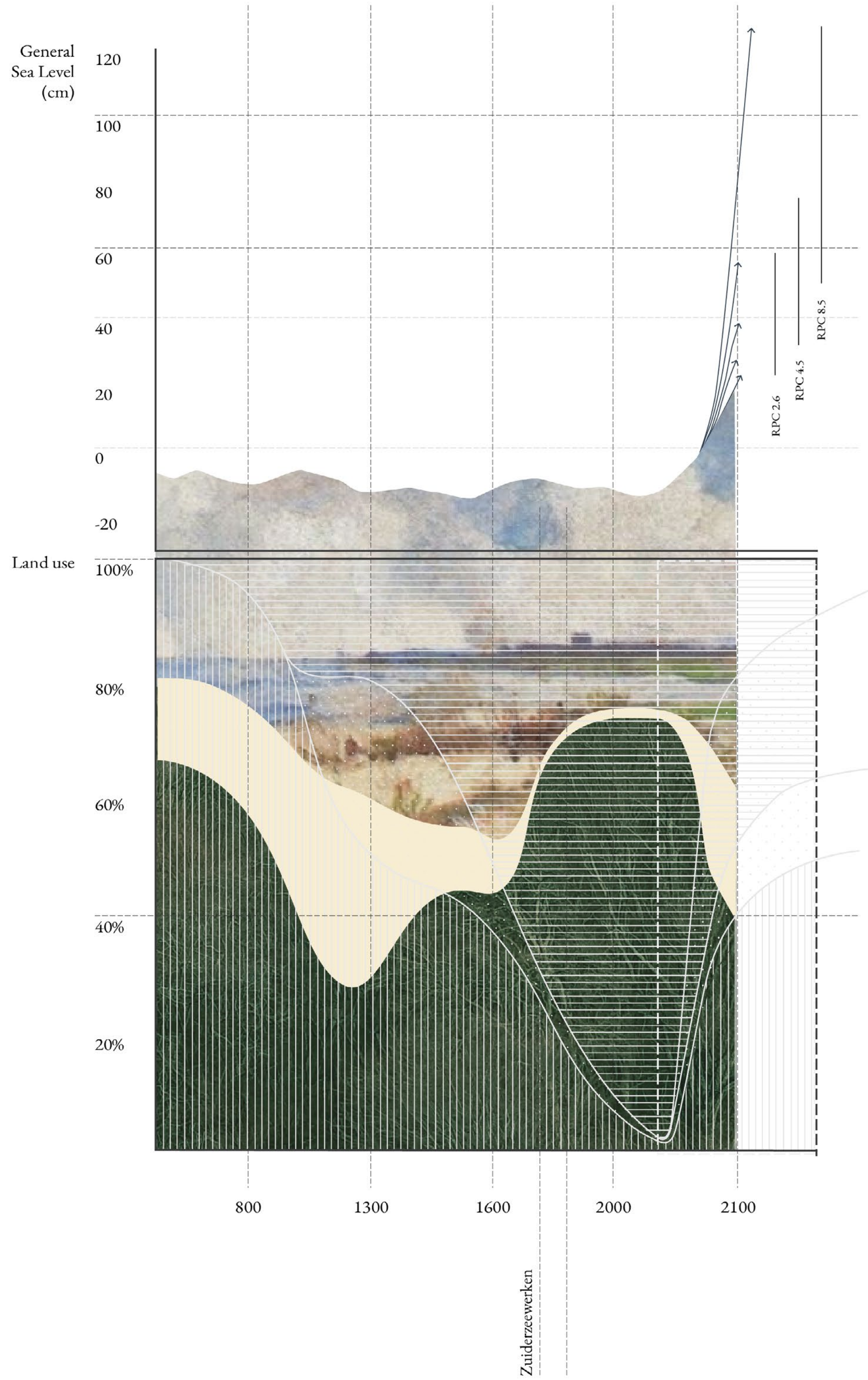


Figure 53. Reading method of the gradients of endogenous habitats related to geomorphology used in the design.
(By author)

Figure 54. The new Blue Heart's land use balance.
(By author adapted from land use interference in the IJsselmeer region: *Lotze et al., 2005*)

Habitats	Land-use
dry land	nature
intertidal	semi-natural
water	cultivated

8.1 Design framework

The design process starts by shifting critical paradigms that were consolidated in the Zuiderzeewerken adaptive cycle that are the cause of current challenges, in order to start a new cycle of planned adaptation. To do it, the design exploration follows the methodological nexus defined in the problem statement as a form of guiding a multi-domain response to current challenges in the Blue Heart's territorial conditions and functions. This shift allows a project in 2 stages:

I - Macro: The Blue Heart territorial recomposition. This step is an experimental test ground for new types of ecological and water infrastructure paradigms that aim to restore the geomorphological and ecological integrity of the Delta through a new adaptive cycle.

II - Micro - Meso : The regional indeterminant deconstruction. This step aims to unveil the functional alterations necessary for food and housing to achieve the desired territorial composition framed on the Macro scale.

Scales of intervention:

Micro: As an operationalization method, three city-scale interventions site were chosen: Lelystad, Almere, and Urk-Noordoostpolder. By adopting a shared new type of water infrastructure based on nature-based flooding protection, the design of those locations explore design possibilities of the shifting of the ecology, housing, and food paradigm. This modeling exercise then allows an overview of spatial and systemic interfaces of land-use, related to accessibility conditions.

Meso: It is expected that the projection of those strategies in the Province of Flevoland will provide possible pathways of transformation during different climate scenarios. As a modeling exercise, two socio-climate delta scenarios (see Appendix) will be considered with a reduced degree of complexity:

STOOM: intense climate change with SLR of 40cm by 2050, and 80cm by 2085. Increased population (+1,5 million inhabitants in NL) and high socioeconomic development and internationalization.

WARM: intense climate change with SLR of 40cm by 2050, and 80cm by 2085. creased population (-1,5 million inhabitants in NL) and low socioeconomic development focus on regional and local development.

The projection and management of the spatial strategies toward a planned adaptation of the region are expected to indicate different functional gradients. And how they still can attend to a territorial project of recomposition.

The paradigmatic shift is powered by transformative values, defined after an interpretation of theoretical worldviews aimed towards the restoration of life and healing our systemic relationship with Earth's web of life. And regarding its practical implementation, the paradigmatic shift has as a driver the current challenges related to the methodological nexus, designating ecology and water infrastructure as territorial conditions. And food and housing as territorial functions.

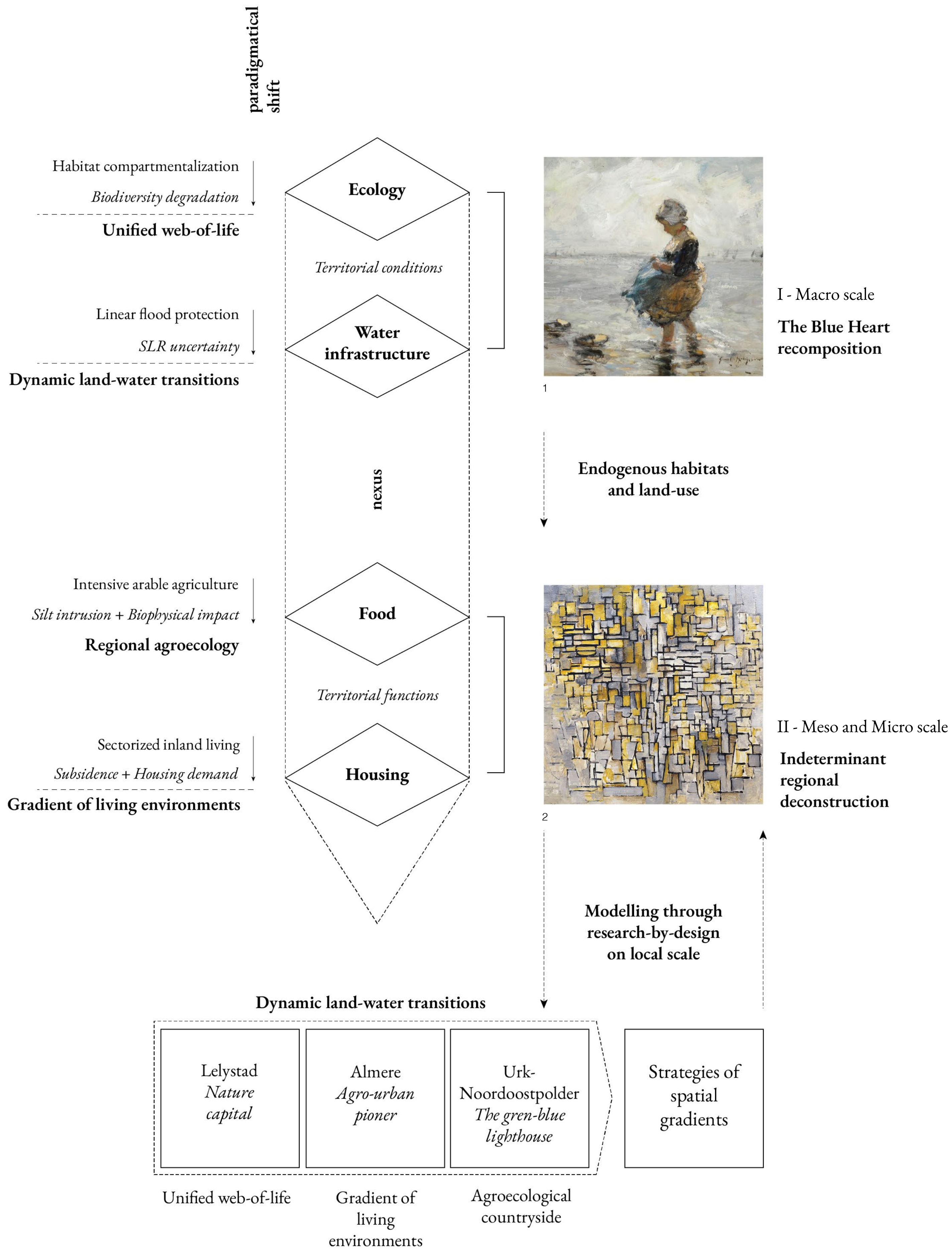


Figure 55. Design framework.
(By author. Paintings: 1 - *Robert Gemmell Hutchison | By the Side of the Zuiderzee; 2 - Piet Mondrian | Composition N.7*)

The Blue Heart Recomposition
Paradigmatic change in territorial conditions (I - Macro Scale):

Ecology: shift the paradigm of habitat compartmentalization, which is a trade-off from linear flooding defense infrastructure, towards a unified web of life as a response to the challenge of biodiversity loss. An implementation of this concept can allow multiple new paths of development, placing the Netherlands as a promoter of global biodiversity.

Water infrastructure: shift the paradigm of linear flooding defense, which has limitations during times of uncertainty, towards the adoption of a buffered landscape infrastructure for flooding defense. Using the Blue Heart's deltaic geomorphological capacity of sedimentary accretion, local suitability for wetlands, and tidal habitats as strategies to reduce the impact of storm surges. The implementation of this new paradigm can allow a development model that promotes restorative forms of infrastructure, preventing possible ecological trade-offs.

Indeterminant Regional Deconstruction
Paradigmatic change in territorial functions (II - Meso and Micro Scale):

Food: shift the paradigm of intensive arable agriculture towards regional agroecology as a response to the loss of agrobiodiversity which was a trade-off of the industrial agriculture model that responds to a global food system. Intensive agriculture land use also became increasingly problematic also due to local challenges of climate uncertainty, subsidence, and nitrogen pollution. An implementation of a regional agroecology can allow the development of a strong local economy, powered by the restoration of the endogenous agrobiodiversity abundance of the Blue Heart. The new regional agroecology paradigm must be based on knowledge-intensive aquaponics, fishing, and permaculture practices that are environmentally restorative and connected through a city-region food system. Furthermore, being part of the reformed territorial climate response strategy that aims to provide local food.

Housing: shift the paradigm of sectorized inland living towards a gradient of living environments as a response to the urgent national housing land use pressure next to urban centers, which face the problems of subsidence and climate vulnerability. Gradients of living environments aim to promote an endogenous type of habitable land use, spreading the densification efforts across the territory in gradients of the countryside and urban zones. Moreover, it aims to minimize the demand for building new heavy transportation infrastructure by enhancing the already robust territorial transport infrastructure fabric. In the long term, this shift promotes a stronger city-region food system that can offer gradients of restorative urban and countryside housing that are planned from the beginning to be adapted to the deltaic conditions.

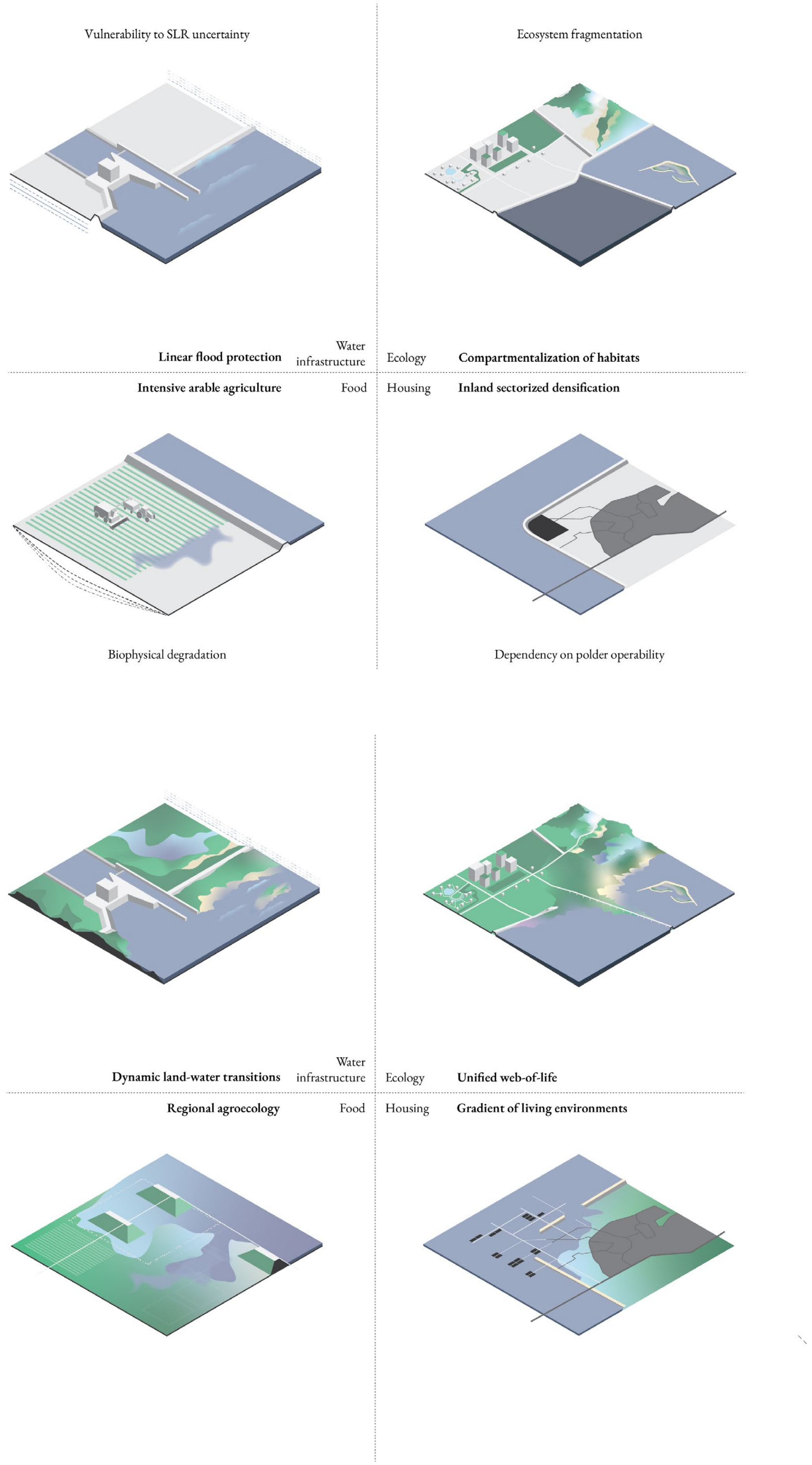


Figure 56. Paradigm shift in Territorial conditions and functions.
(By author)

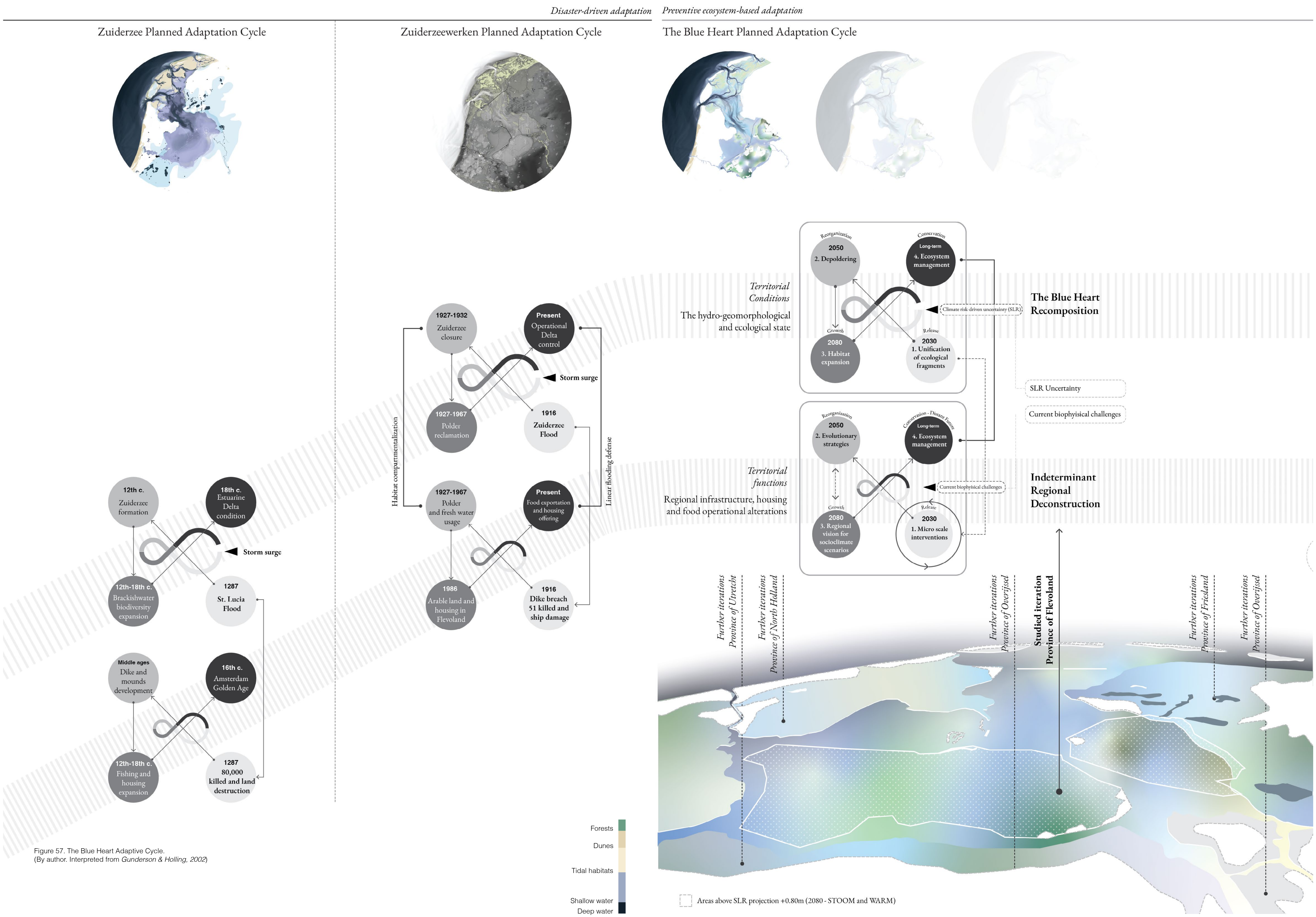


Figure 57. The Blue Heart Adaptive Cycle.
(By author. Interpreted from *Gunderson & Holling, 2002*)

8.3 Territorial Recomposition

I - Macro Territorial Design: Blue Heart's recomposition

Following the paradigmatic shift, the project starts by setting an experimental approach to territorial recomposition. The framed area is limited to the relationship between the Wadden Sea, the IJsselmeer-Markermeer, the IJssel Estuary, and the Province of Flevoland, which are fundamental parts of the territorial geomorphological and ecological compositions. An area that is expressively being affected by the problematic outcomes of the paradigms to be shifted.

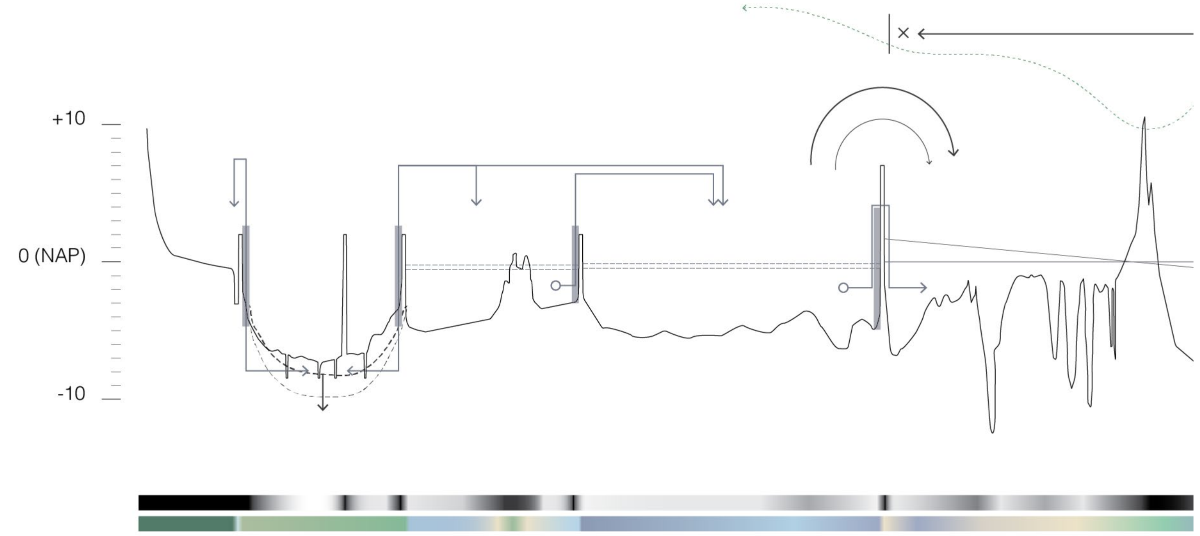
The paradigmatic shift in ecology and water infrastructure allows the adoption of the extended restored natural habitats as a release of water infrastructure linearity. Hence, it aims to promote land use management as part of an SLR-adapted habitable landscape infrastructure that works with natural buffers that absorb climate stresses. A system that can increase the safety of all its endogenous habitants intertwined by the territorial web of life as it grows.

In practical matters, the shift can be managed by frameworks on nature-based solutions coupled with biodiversity restoration related to the Blue Heart's territorial conditions, such as the storm surges part of this delta's past and future. In the matters of feasibility, it will adopt the studied examples of the Dutch nature-based experience such as the Marker Wadden and the depoldering of the Noordoostpolder as technological possibilities.

Present - Conservation / Operational Delta Control (Figure 57)

Design challenges: The area presents urgent challenges in infrastructure related to biodiversity and climate uncertainty. On one hand, the global role of the Blue Heart as a biodiversity keeper is increasingly affected by the geomorphological obstacles imposed by the dike system. The current dike system blocks the access of fish (from the IJssel - North Sea connection) to its endogenous habitat. Allowing the fish crossing is essential to maintain the population of fishes in the IJsselmeer to allow extended periods of fishing and increase the biodiversity in the Markermeer. Also, the dike morphology doesn't allow the ecological succession on water-land transitions, severely affecting the effectiveness of ecological restoration efforts.

On the other hand, future SLR uncertainty makes the plan for flooding protection infrastructure increasingly challenging. Due to the uncertainty on SLR projections and future discharges from the IJssel that depends on the Alps melting, there is a demand for technological-intensive solutions to maintain a safe water level in the IJsselmeer. As a response to that, new pumps are being built in the Afsluitdijk to guarantee the safety of the region until 2050, and flexible water management is being implemented . However, these strategies come from the same lock-in that sustains the harmful water infrastructure and ecological paradigms. Hence, this is the last stage of the implementation of spatial and systemic strategies that promote the active continuation of linear flooding defense strategies that fragment ecological habitats.



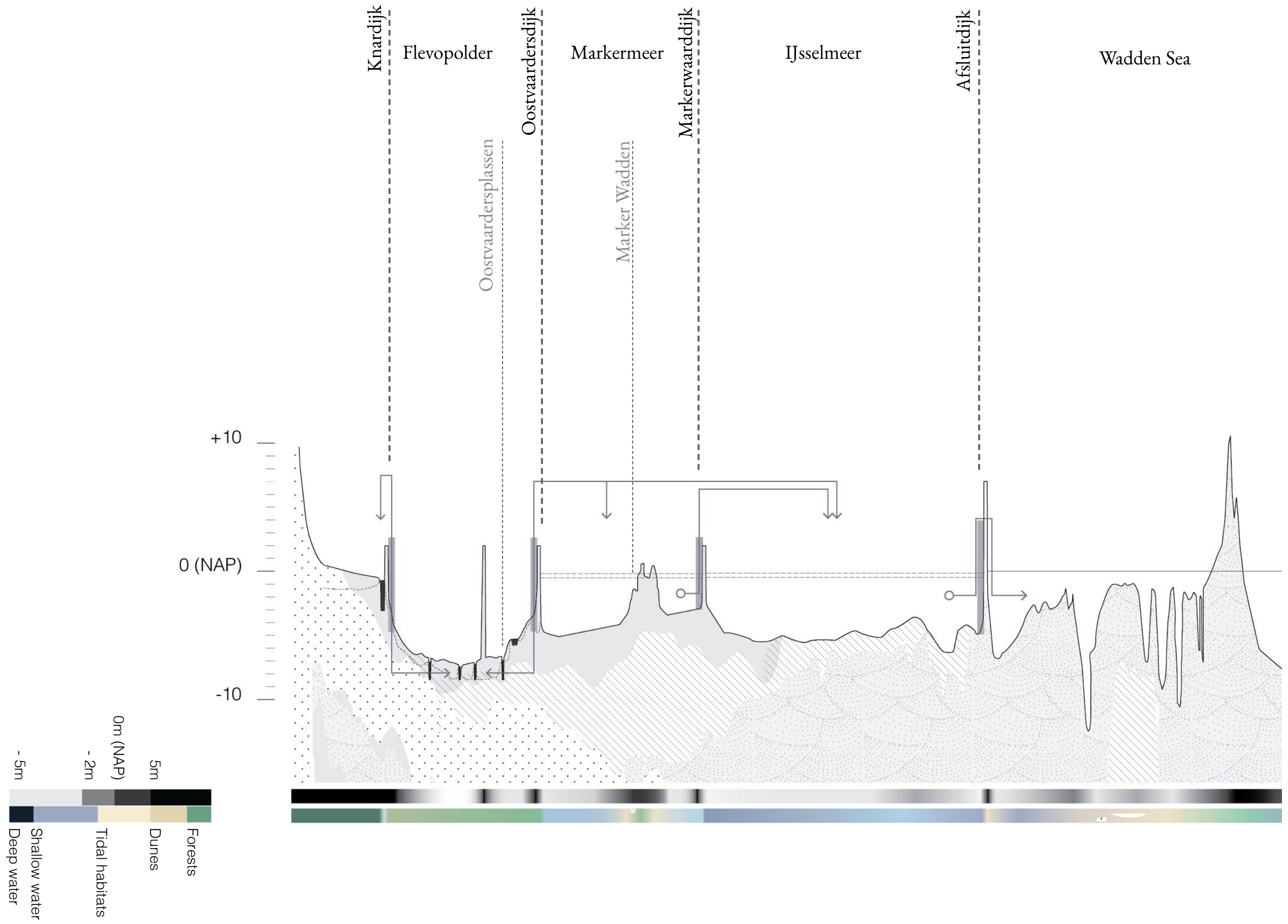


Figure 57. Territorial section - present.
(By author. Interpreted from *Gunderson & Holling, 2002*)

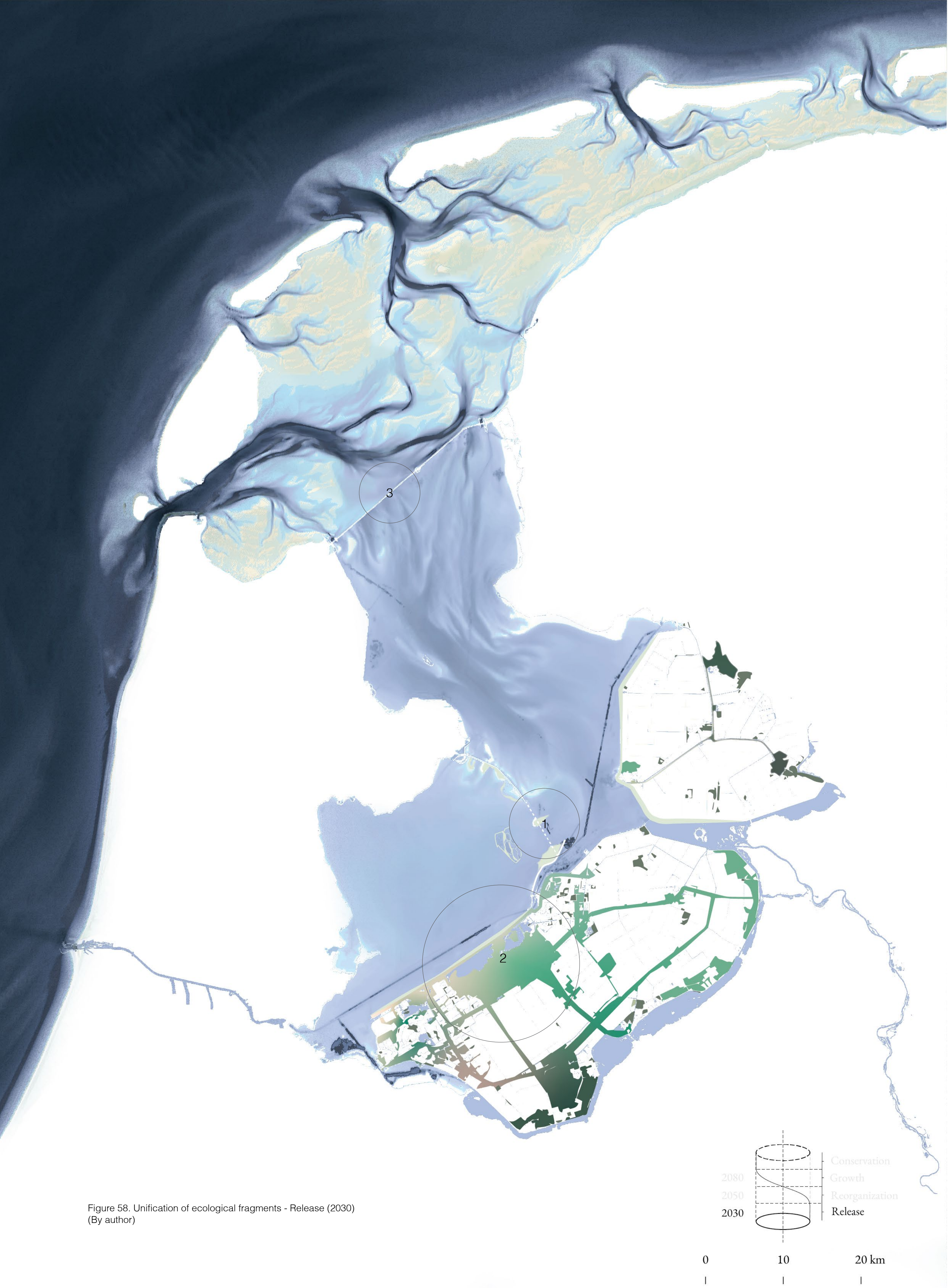


Figure 58. Unification of ecological fragments - Release (2030)
(By author)

2030 - Release:

Design aim: Unification of ecological fragments
Kickstart the ecological unification of the compartmentalized natural deltaic habitats of the Blue Heart. This step aims to be a seed of an evolving water-land landscape infrastructure that reduces water infrastructure linear operational intensity. This strategic step allows the testing of a natural-based water infrastructure that can become more extensive and adaptable to the endogenous uncertainty of deltaic habitats.

1. Re-integrate the Markermeer with IJsselmeer

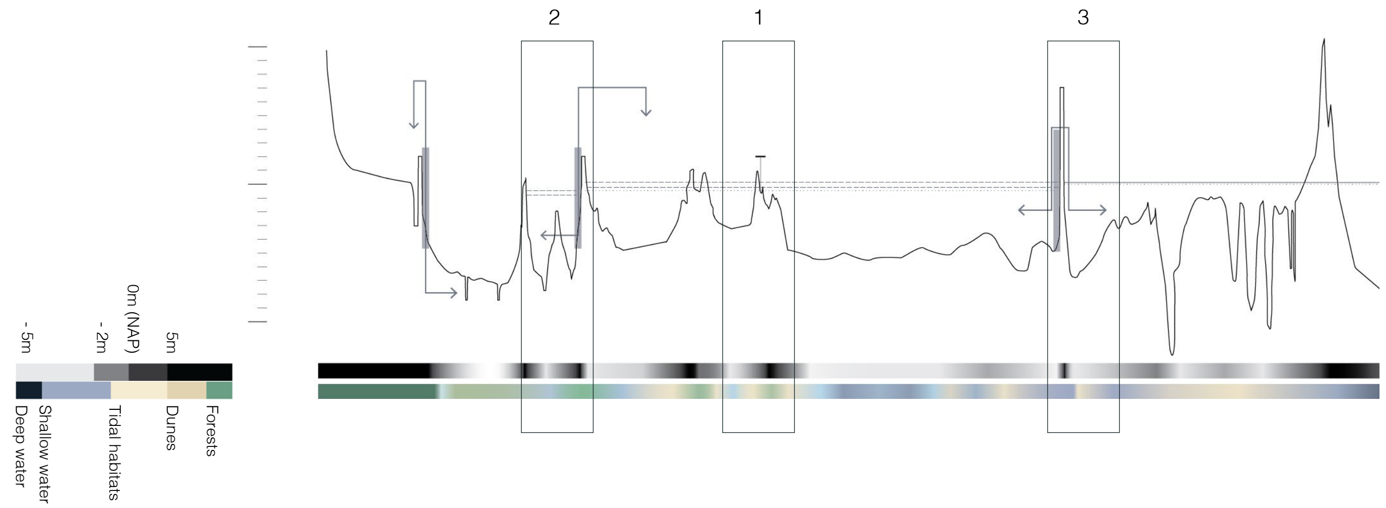
Create openings in the Houtribdijk maintaining existing road as an elevated highway, allowing an expansion of the Marker Wadden to promote the increase of biodiversity on a unified Markermeer-IJsselmeer estuary. This action will increment natural water flow to gradually reduce the sludge challenges in the Markermeer. The Houtribdijk is reminiscent of the original intention to reclaim the Markerwaard. This stage aims to recompose it into a buffered system of nature-based infrastructure that mitigates the effect of storm surges in Flevoland and Amsterdam. From a management perspective, the integration of the Markermeer and the IJsselmeer will be an important step to set a flexible water management system. It aims to adopt a bandwidth of 40cm in Summer-Winter on the water level, as already set in current plans, to gradually follow the SLR increment. From a feasibility perspective, this strategy adopts the new pumping station in the Afsluitdijk as a water level regulator and coordinates a process of land use adaptation.

2. Expand the Oostvaardersplassen

Promote the expansion of the wetland, placing infrastructural adaptations and depoldered incubators to allow the wetland migration to higher areas and gradual growth into a robust buffer that naturally absorbs climate stresses. Currently, the Oostvaardersplassenhas has ecological problems due to its isolation, being contained by fences with no direct contact with the estuarine water and ecosystems. The action of release will recover the natural role of the wetland to be part of an evolutionary land-water transition, also being an essential extended component that allows the study and testing of new forms of land use related to food and housing in tidal/partially wet environments.

3. Build fish crossings in the Afsluitdijk

The transformations in the Afsluitdijk start with the completion of the Fish Migration River (www.theafsluitdijk.com/projects/fishmigrationriver/), which aims to increase the connectivity of the IJssel and the Wadden Sea. Also, gradually promoting a reintroduction of brackish water composition.



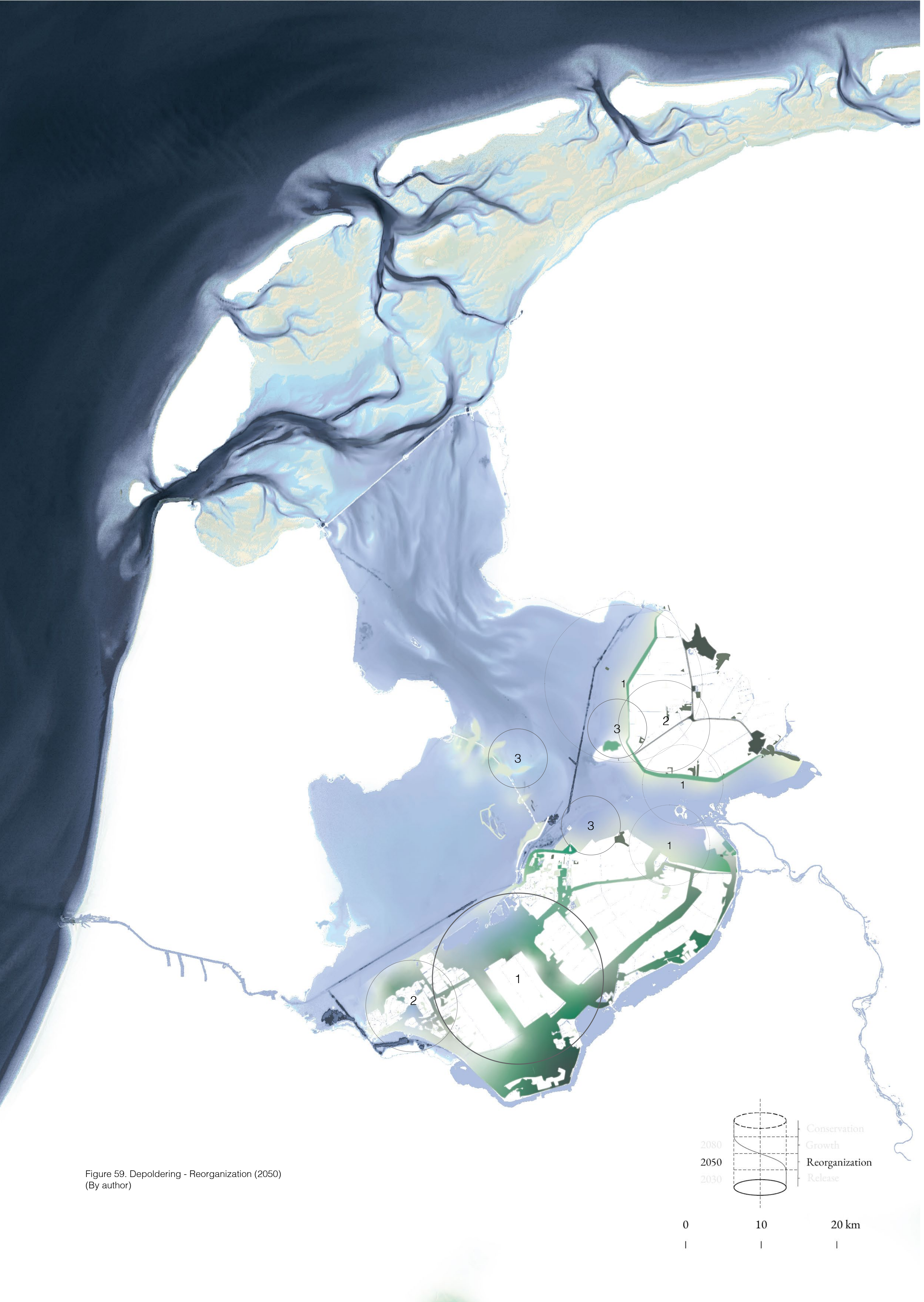


Figure 59. Depoldering - Reorganization (2050)
(By author)

2050 - Reorganization (STOOM and WARM, SLR +0.5m):

Design aim: Depoldering. Expand the extent of nature-based flooding protection by depoldering segments of Flevoland. This step aims to promote and test new forms of land use and strategies to capture fresh water.

1. Match SLR with water level in depoldered areas

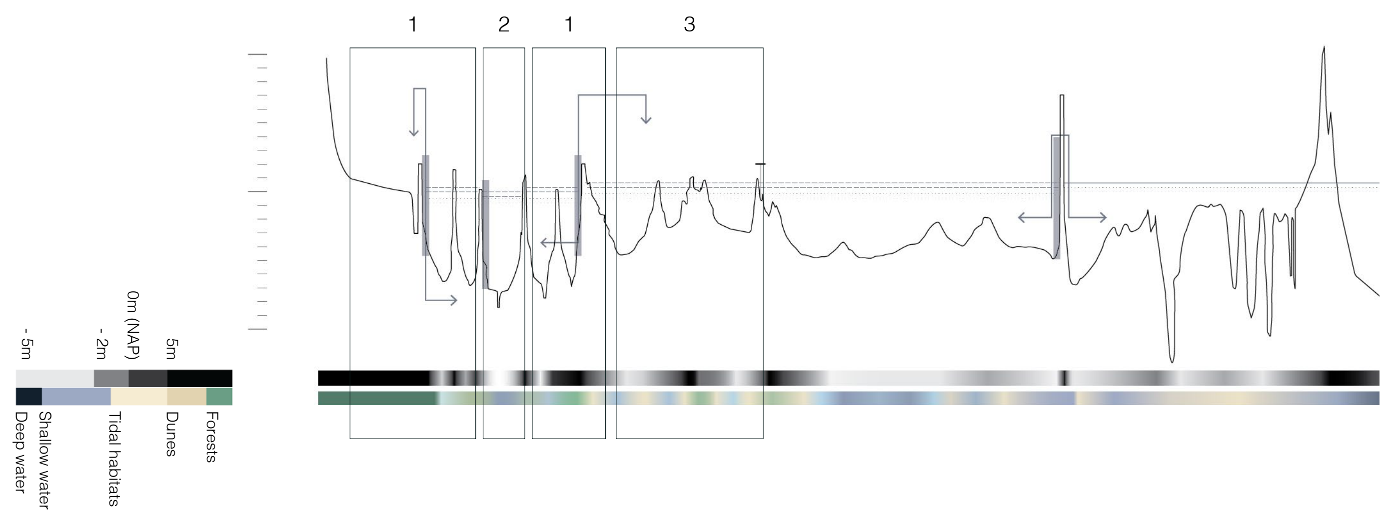
Implement secondary dikes that aim to protect urban centers and protected forests. This step aims to set a new variety of restorative dikes integrated with nature-based infrastructure, able to expand wetlands, allow the migration of forests to higher areas, and determine areas that will absorb tidal variations of a dynamic water system, growing with sedimentation. References of dikes: Wide green dike and tidal dikes (Marijnissen et al., 2020). Gradually, thorugh a reflective process, the water level is set to follow the on going SLR, still maintaining the Afsluitdijk as adaptation redundancy.

2. Implement storm-water basins

As the recovery of the brackish water habitat takes place, this step envisions the construction of storm-water basins, capable of retaining and purifying water from rain events and tidal variations for agricultural and housing consumption.

3. Seed tidal wave breakers

Place wave breakers that grow with the acceleration of sedimentation processes, creating geomorphological barriers for storm surges.



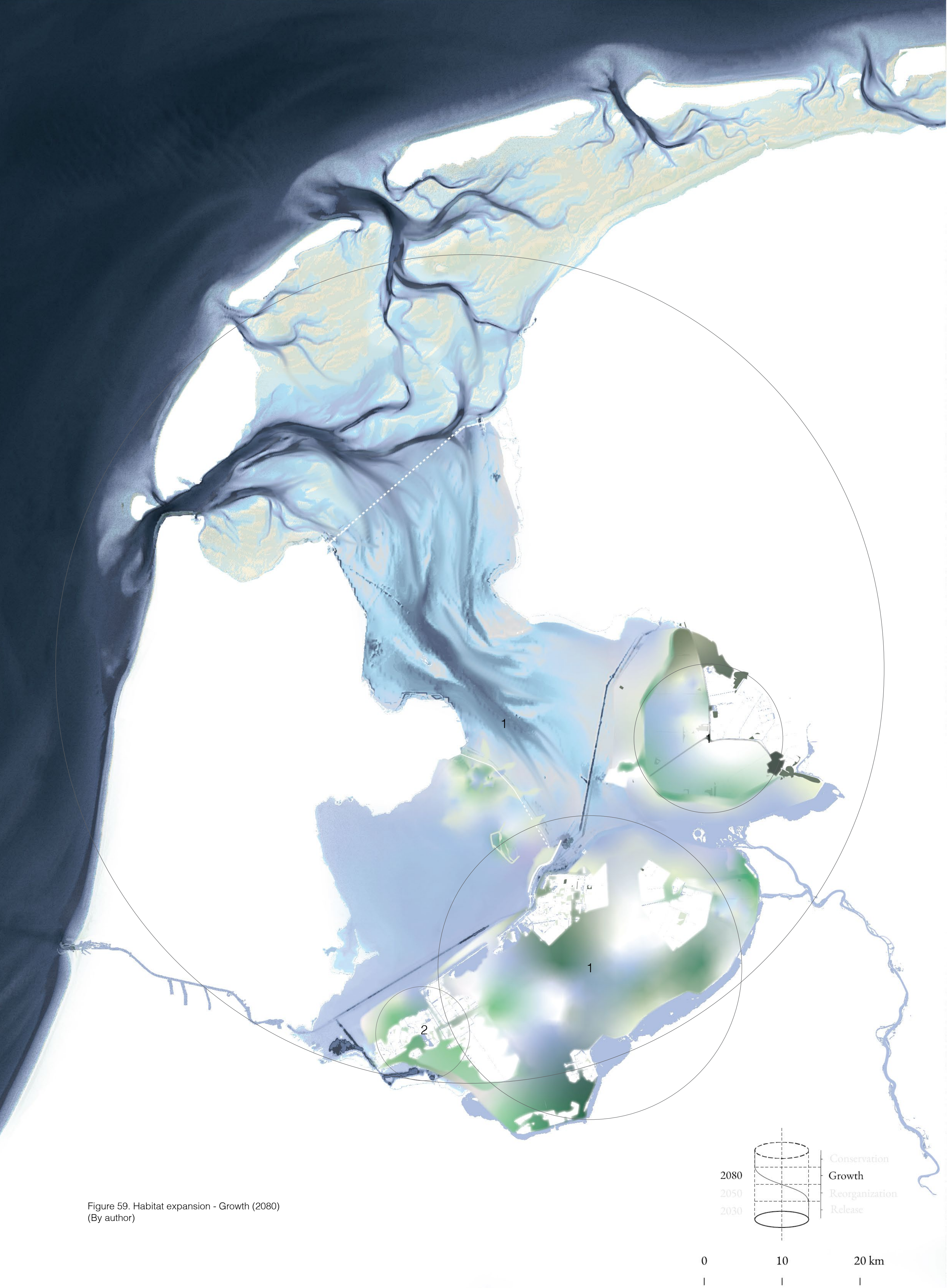


Figure 59. Habitat expansion - Growth (2080)
(By author)

2080 - Growth STOOM and WARM, SLR +0.8m):

Design aim: Habitat expansion. Grow the integrated water system towards a renaturalized deltaic condition. At this stage, the implemented nature-based infrastructure reaches its stable form, allowing the geomorphological integration of the Blue Heart. The tidal accretion process takes place and accelerates as the Wadden Sea starts growing towards the estuary, incrementally providing new storm surge protection buffers and full integration of migration routes.

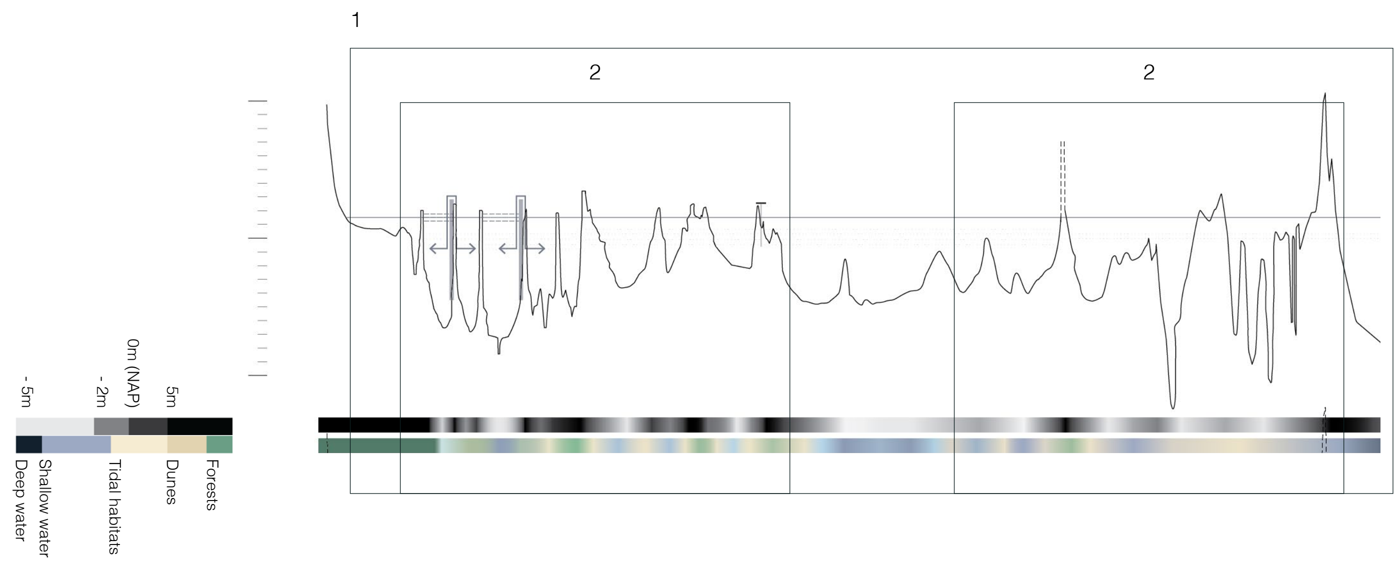
1. Strenghten ecological synergies

Implement previously tested and pioneer deltaic landscape infrastructure, with gradual use of the Afsluitdijk morphology to expand the accretion process, allowing the Wadden Sea to cross the dam. This step aims to return the biodiversity abundance natural to the area, with the return of endogenous fishes, mammals, and birds. Allowing the growth of local agroecology that is coupled with this new condition. In case of successful integrated regional infrastructure development, this design step highlights the importance of other iterations with the relationship of regions with the studies ecological fragments.

2. Diversify water management nature-base infrastructure

As the ecological habitats grow stronger, storm surge defense nature-based infrastructure buffers get stronger. This stage aims to reach Deltaic stability that allows the flourishing of human and non-human populations. This state is based on scientific evidence that the Zuiderzee Delta estuary was close to achieving long-term stability before the reclamation, also considering that evolutionary nature-based infrastructure has the potential to reach this stage through modeling, simulations, and precise implementation.

With the shifting from linear Lake-Polder management towards buffers of dry and wet areas, the non-linearity of the flooding defense infrastructure allows the development of a diverse set of solutions. This forms a combined matrix of depoldered and tidal areas become testgrounds to analyse the performance of different solutions in the long-term for possible regional adaptation pathways.



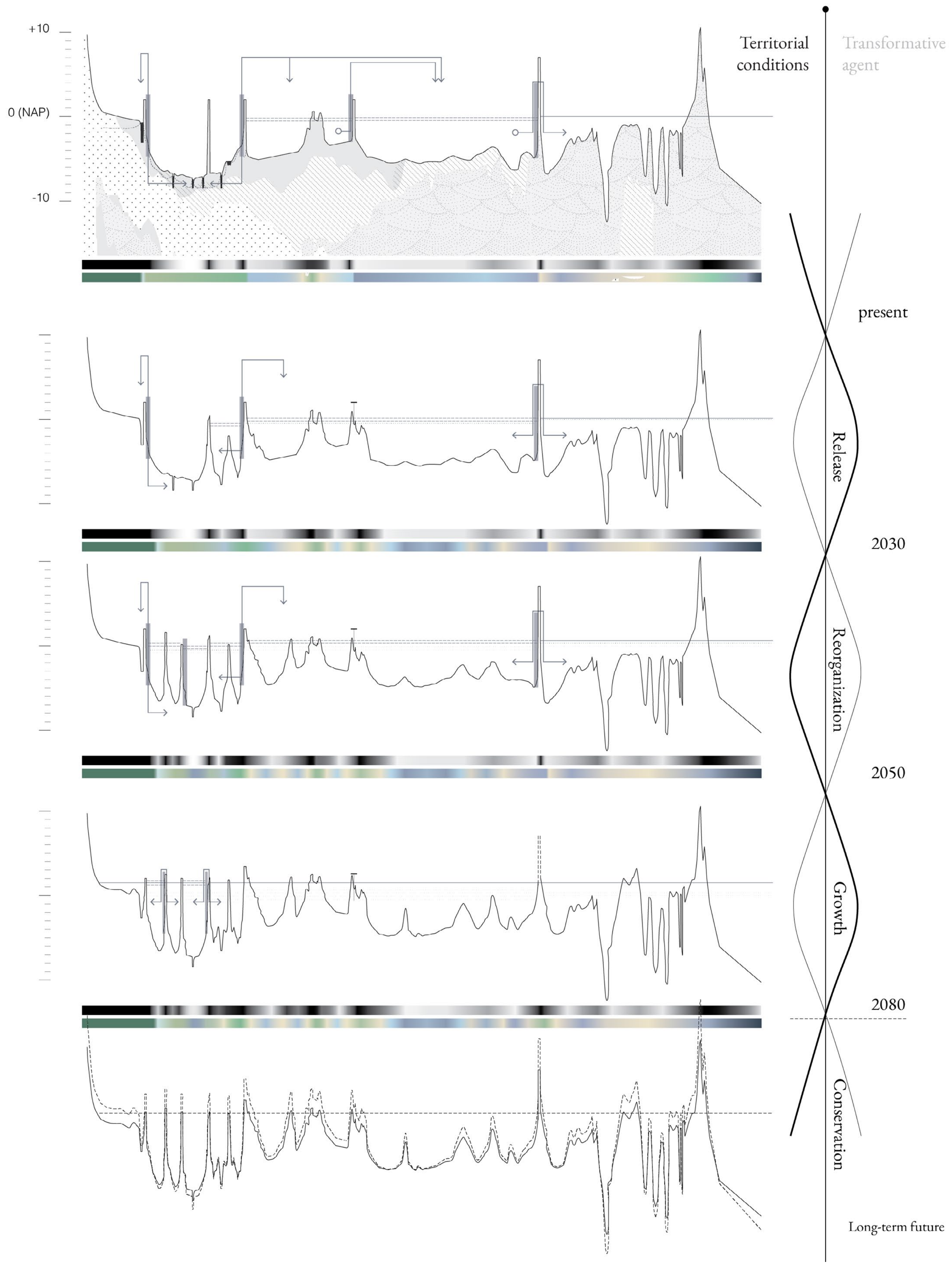
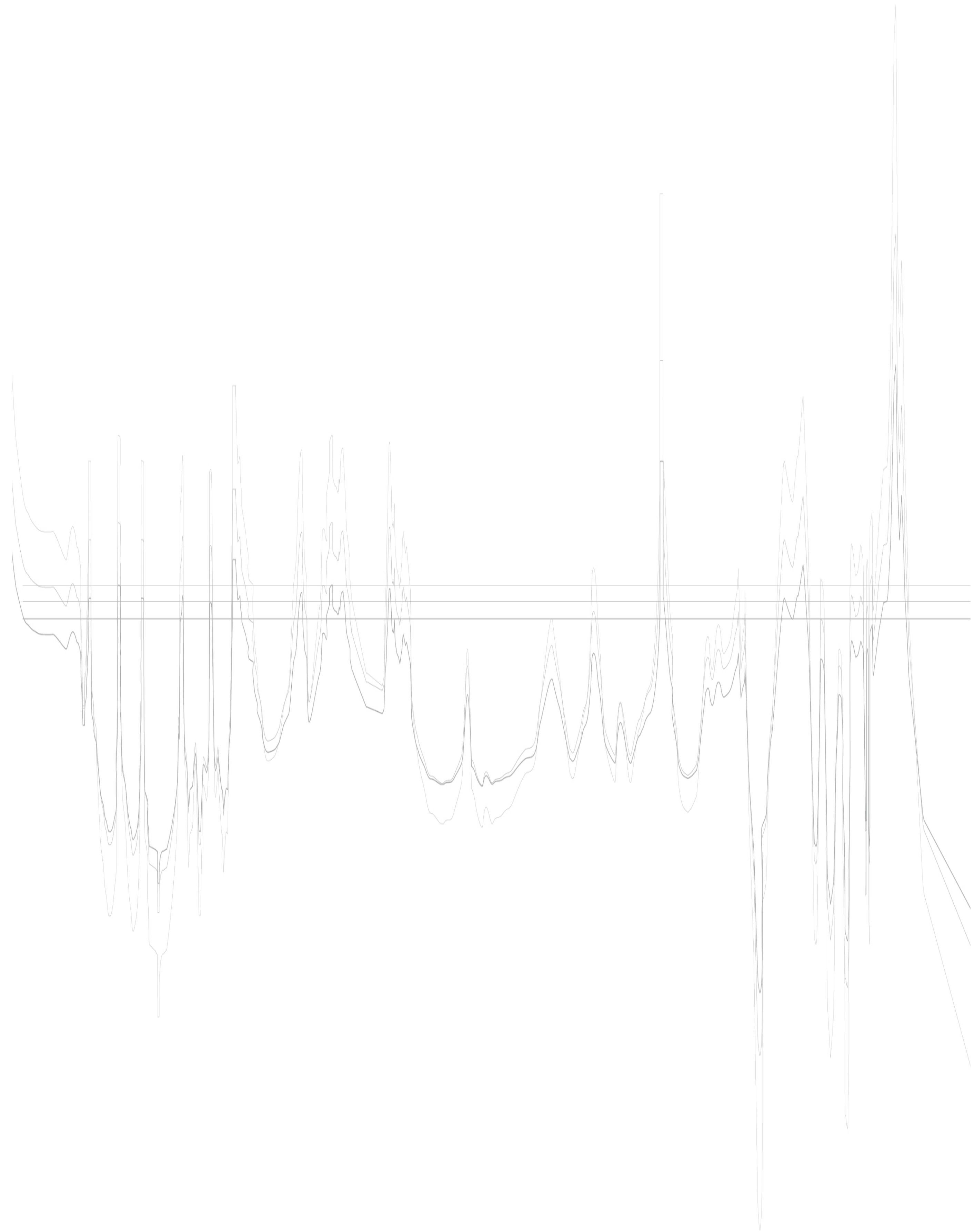
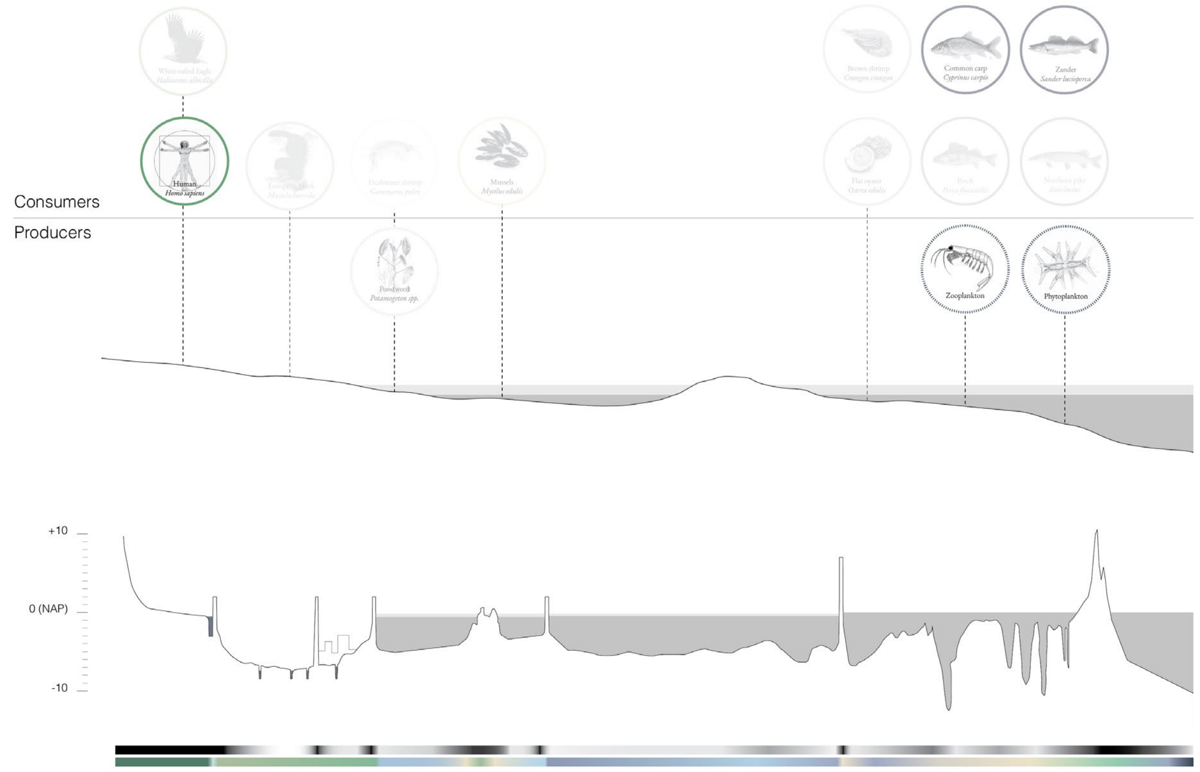


Figure 60. Long term future human and non-human habitat maintenance through ecosystem-based adaptation - Conservation (Dynamic deltaic equilibrium). (By author)





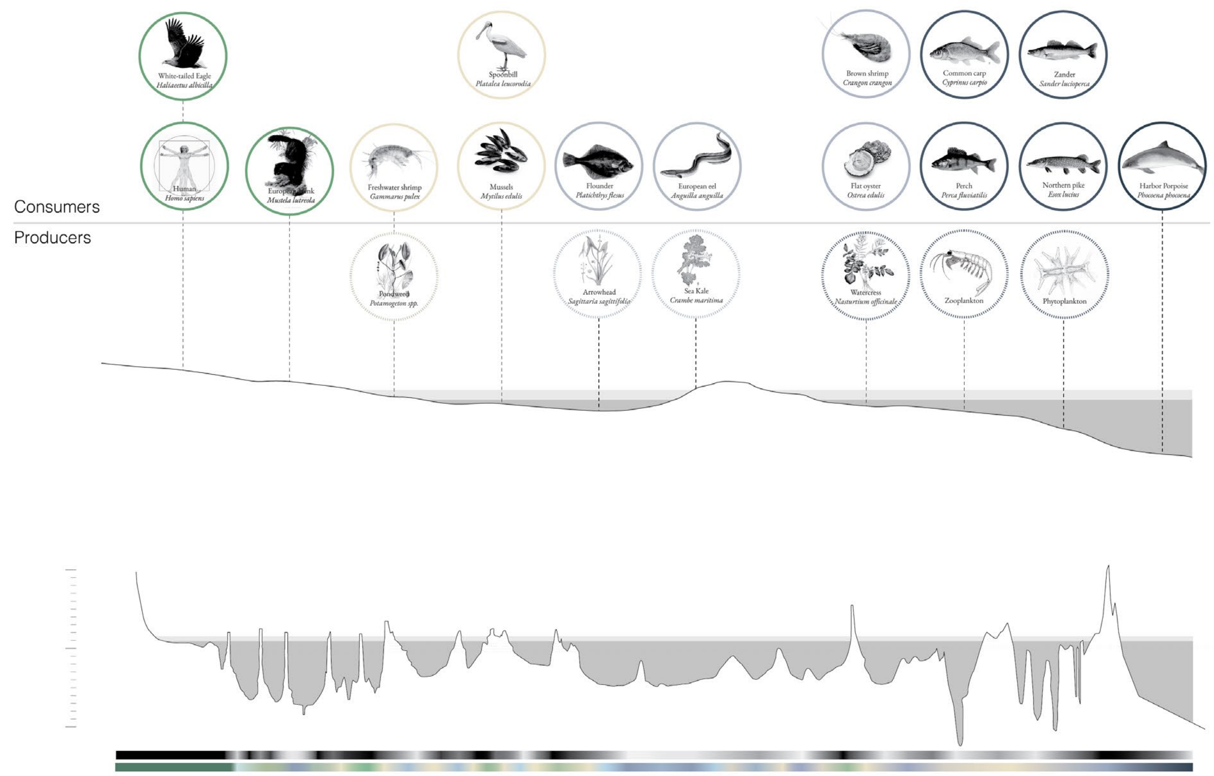


Figure 61. Recovery of main endogenous species of consumers and producers, allowing the reconnection of the web of life.
(By author)

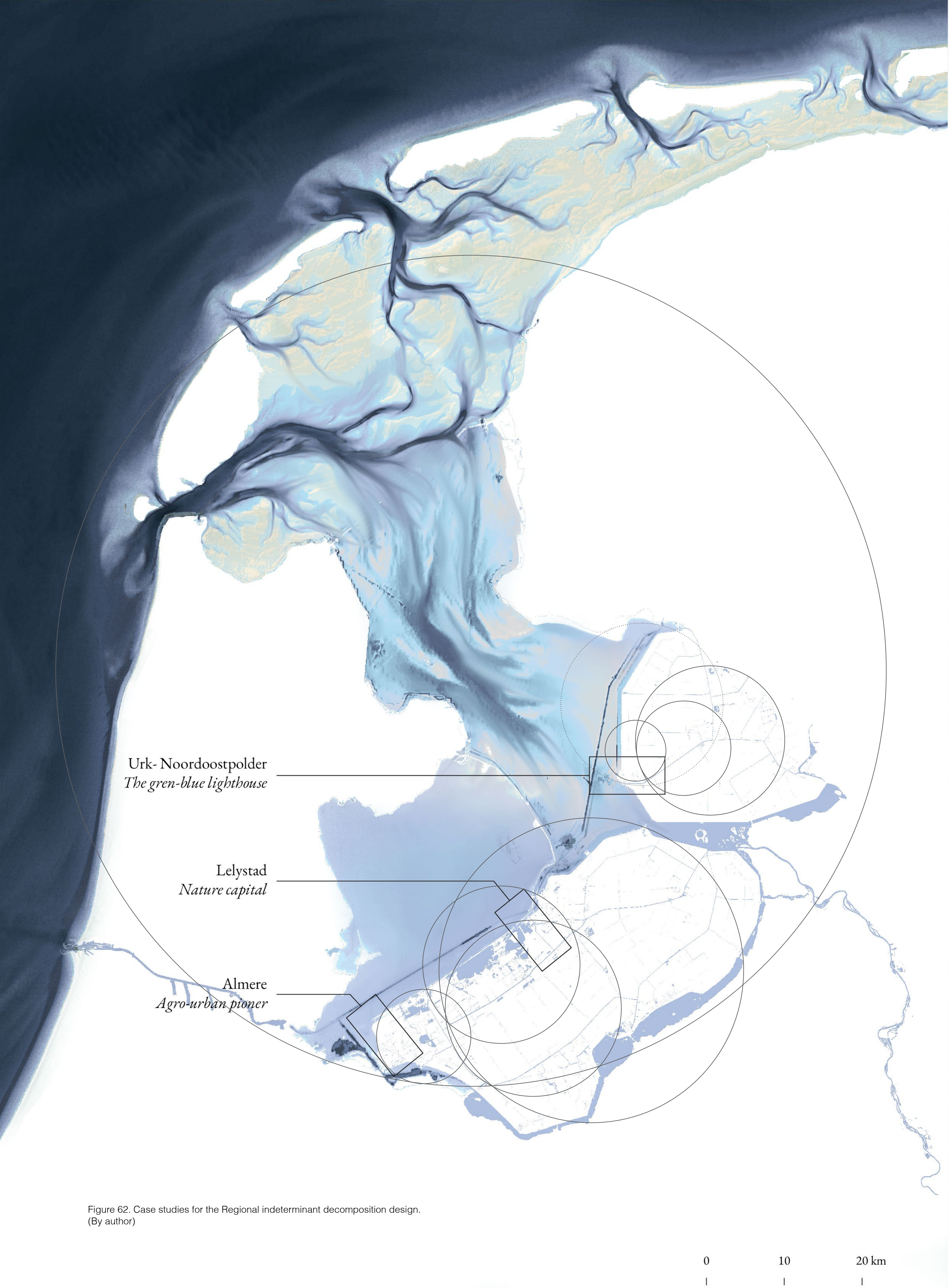


Figure 62. Case studies for the Regional indeterminant decomposition design.
(By author)

II - Micro-Meso Territorial Design: The regional indeterminant decomposition

Micro-scale modeling: These explorations aim to model a set of evolutionary strategies that respond to local challenges in places in on-going transformation, that can be part of a broader ecosystem-based landscape infrastructure. The strategies will guide the functional adaptation of the region to attend to the territorial conditions set for the Blue Heart recomposition planned adaptation. Hence, the selection of case studies represent the several overlappings of the planned macro design objectives, allowing the exploration of benefits and limits of infrastructure transformability.

Overview of case studies for modeling through design:

I - Almere - The agro-urban pioneer
Brief on local characteristics: Almere is a city with a historical role of innovation and pioneers in new forms of living, such as the decentralized infrastructure/habitation development of Oosterwold that integrates food into its core conceptualization.
Current challenges (housing): The city is set to be part of the efforts to implement solutions for the housing crisis. However, current development models of sectorized urban expansion, set the area of Pampus-Almere for the creation of a new neighborhood, which implies in the construction of a dense housing infrastructure in a land compromised by accelerating subsidence. Which also increases the pressure on the flooding protection infrastructure.

II - Lelystad - The nature capital
Brief on local characteristics: Lelystad is the capital of the Province of Flevoland with the development ambitions of setting a climate adaptive strategy to become a green city. It is home to the Oostvardersplassen, a wetland that emerged spontaneously during the reclamation process.
Current challenges (ecology): Despite its ambitions to become nature's capital, Lelystad is in the intersection of fragmented habitats (Local forests - Oosvarderplassen - Markermeer - IJsselmeer), that are separated by dikes and transportation lines. A problem that imposes limitations on the promotion of biodiversity and a cohesive green infrastructure.

III - Urk-Noordoostpolder - The blue-green lighthouse
Brief on local characteristics: Urk was originally an island of the Blue Heart. For centuries it holds a central role in fishing activities, an activity that drastically changed with the Zuiderzee Works. Currently, it is attached to the Noordoostpolder, the first reclaimed polder and currently an area of intense arable agriculture.
Current challenges (food): After the reclamation process, the fishing activities in the IJsselmeer could never be continued due to the lake's incapacity of recover its fish populations. The Noordoostpolder currently is actively involved in the production of food, however with severe environmental trade-offs, such as nitrogen emissions and subsidence. Undermining the attempts of ecological restoration on the lakes.

I - Almere - The agro-urban pioneer

2030 - Release:

Functional aim: Set a new habitable condition in expansion areas to test housing land-use adapted to the Delta condition
Strategy: Release dependency on border dikes for urban growth: start a process of depoldering in Pampus-Almere as a stage for planning a new neighborhood prepared for flooded environments. This stage starts the construction of a secondary dike ring around the urban core of Almere and protected forests and designates Pampus-Almere as a depoldered area. In that sense, it stops the necessity of renewal of the border dikes by creating a buffer for storm-surge protection.

2050 - Reorganization:

Functional aim: Create a gradient of living environments from the urban
Strategy: Implement a stormwater basin that works in synergy with the Weerwater to ensure the availability of fresh water for Almere and the new neighborhood.

Agro-Urban Ecological interfaces

Primary accessibility: **Urban buffer (Wetlands x Urban core)**
Brief description: A buffered transition from urban to wet areas. A secondary dike ring covers a tunneled primary access transportation line adjacent to flooding landscapes of linear parks that minimize the impact of storm surges.

Secondary accessibility: **Tidal neighborhood (Tidal flats + Wetlands)**
Brief description: A floating neighborhood that thrives in tidal fluctuations basin, able to adapt to different water levels, anchored to a secondary dike ring.

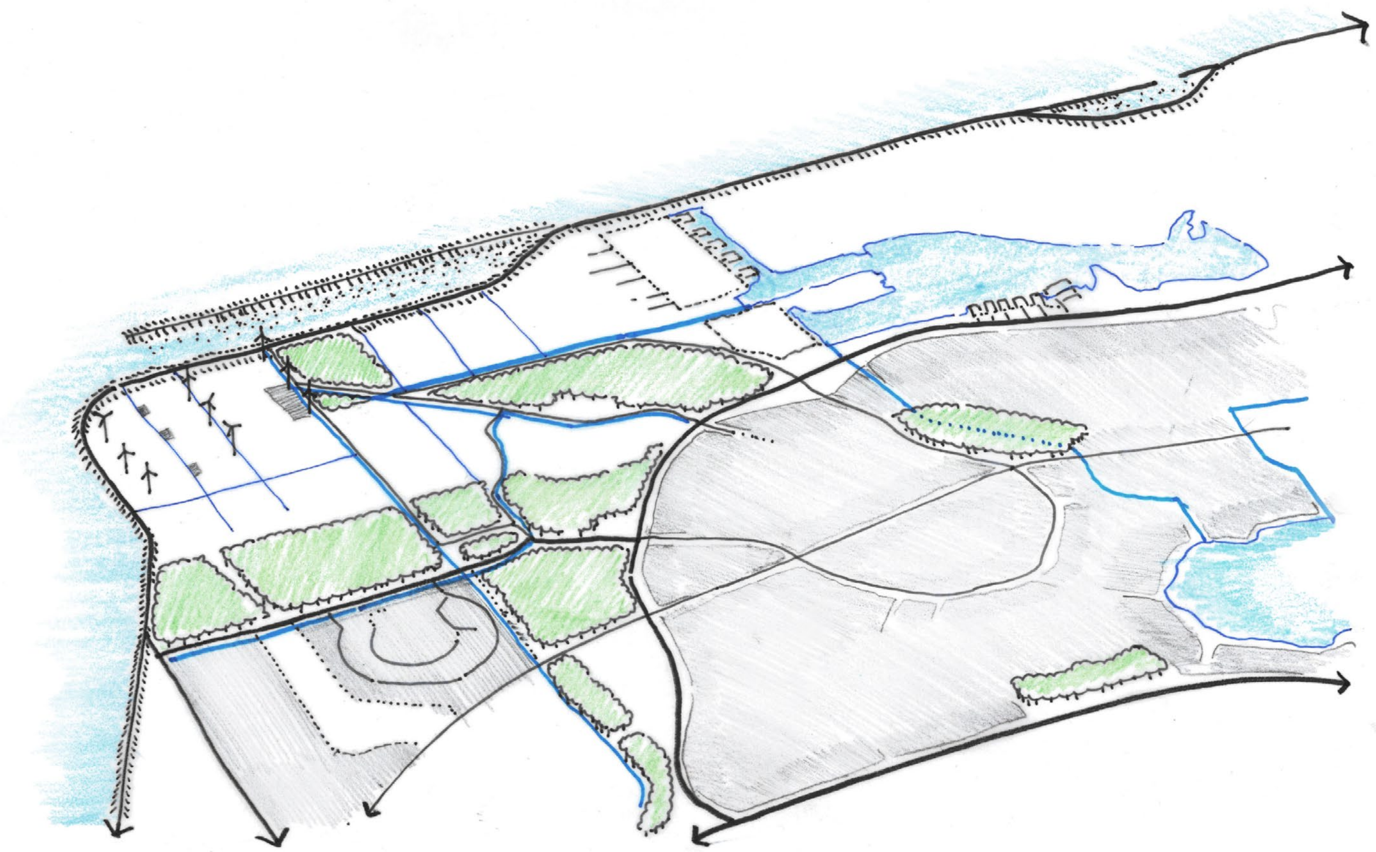
Local accessibility: **Habitable frontier (Deep water + Tidal flats)**
Brief description: Elevated mounds that allow the sprawl of tidal zones and wetlands and eventual flooding events that occur below. In advanced stages, it can guide the accretion process through careful planning that considers sedimentary capture.

Figure 63. Drawing base Almere.
(By author)

Geomorphology

Urban area, Agriculture, and Forests

Access (local, secondary, primary)



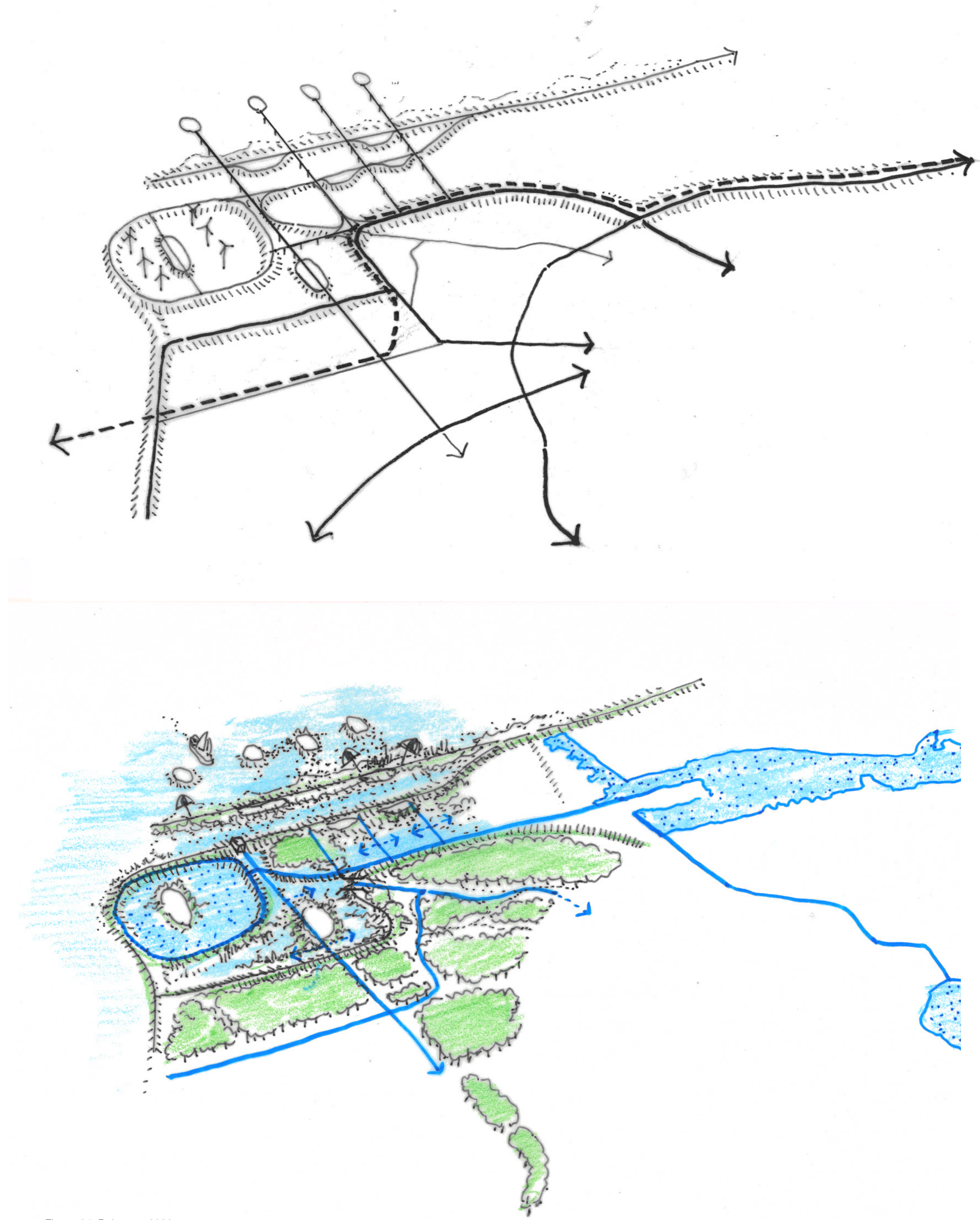


Figure 64. Release - 2030.
(By author)

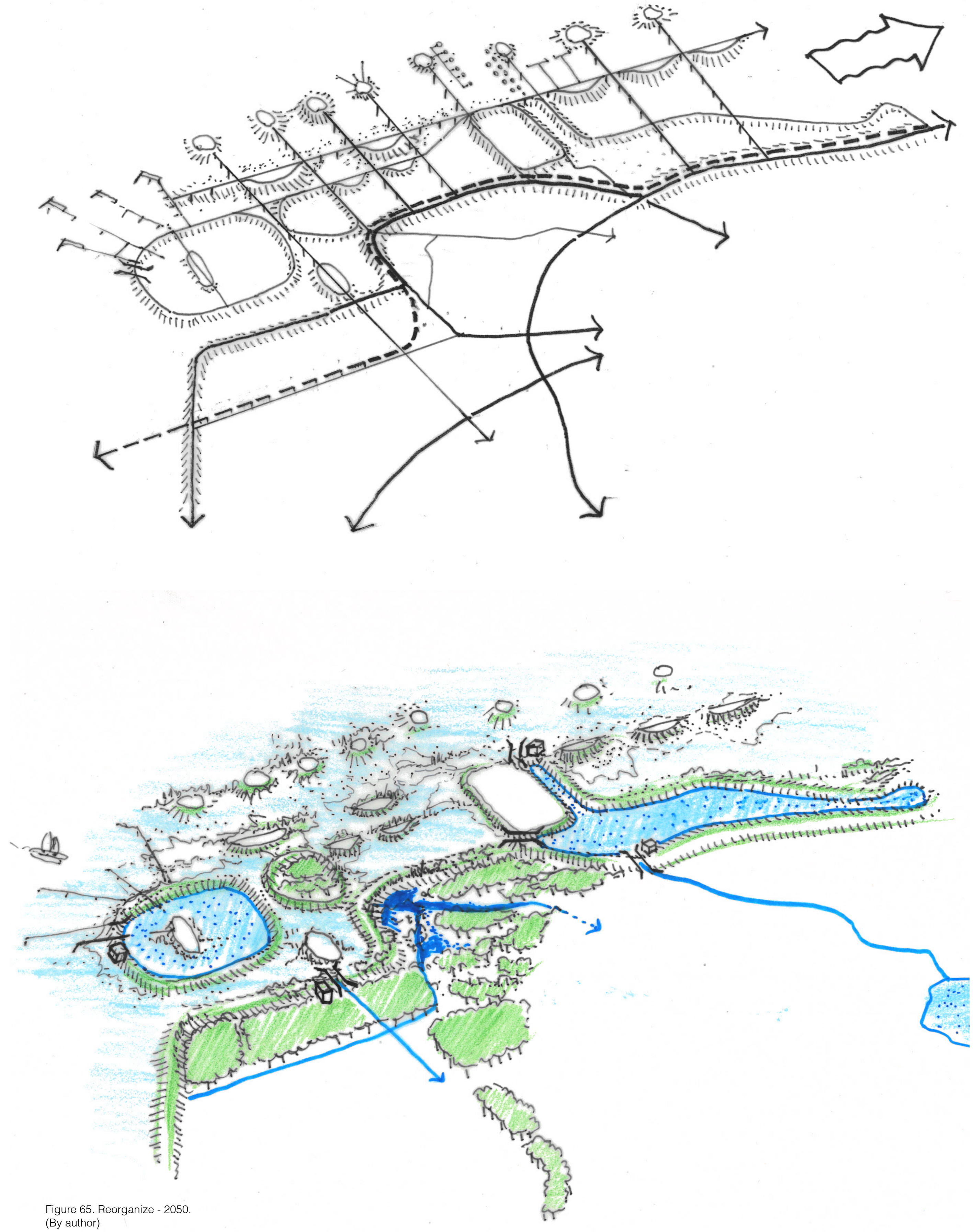
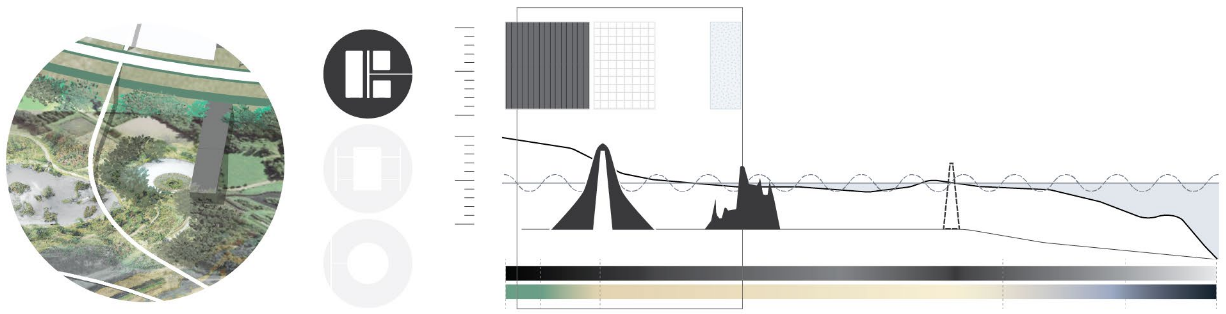
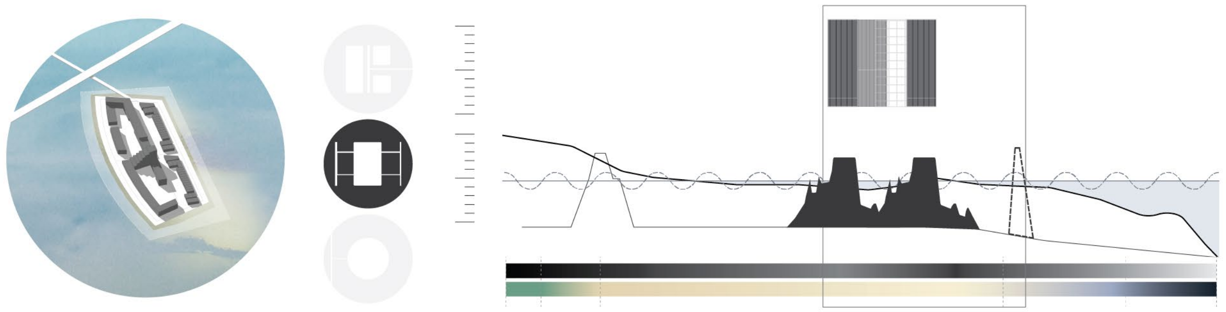


Figure 65. Reorganize - 2050.
(By author)

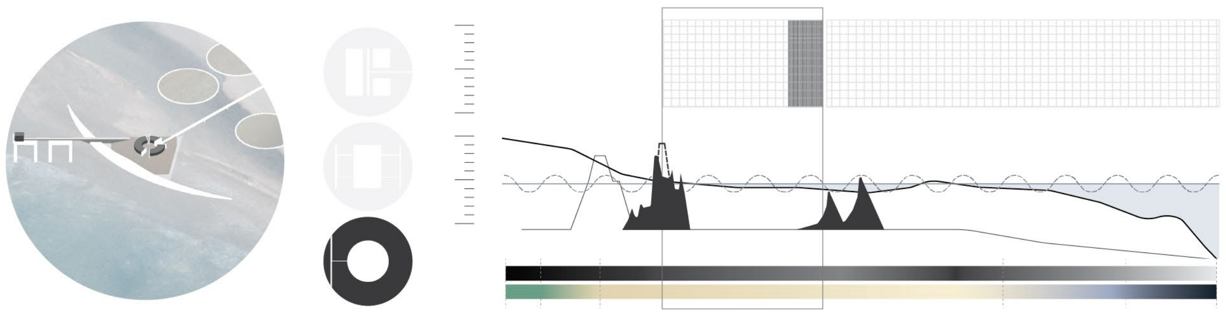
Urban buffer (Wetlands x Urban Core)
Primary access

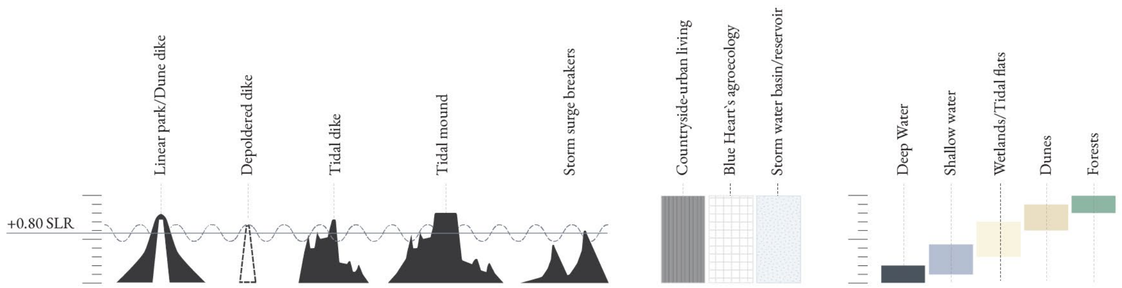


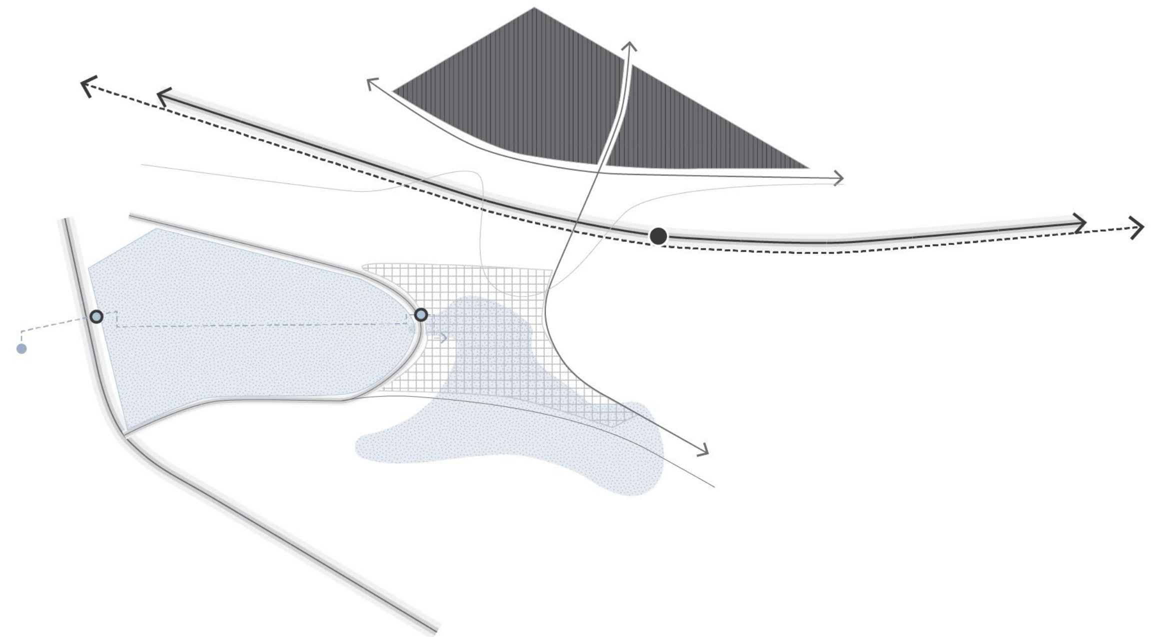
Tidal neighborhood (Tidal flats x wetlands)
Secondary access



Habitable frontier (Water x Tidal flats)
Local access







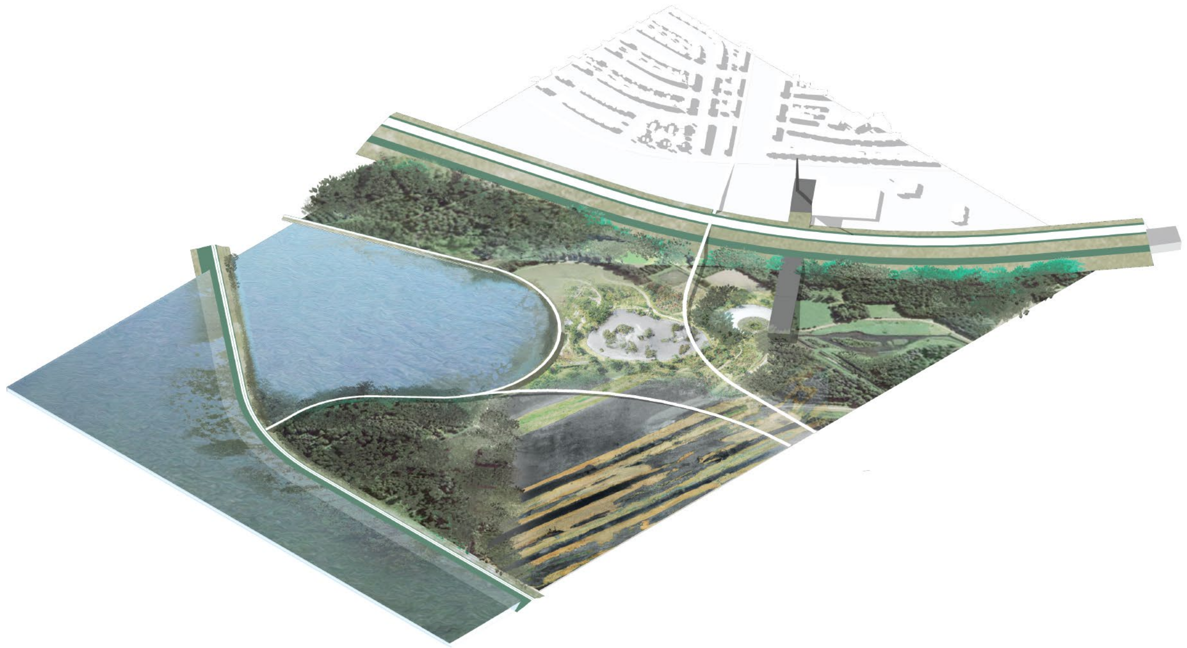


Figure 66. Urban Buffer (By author).

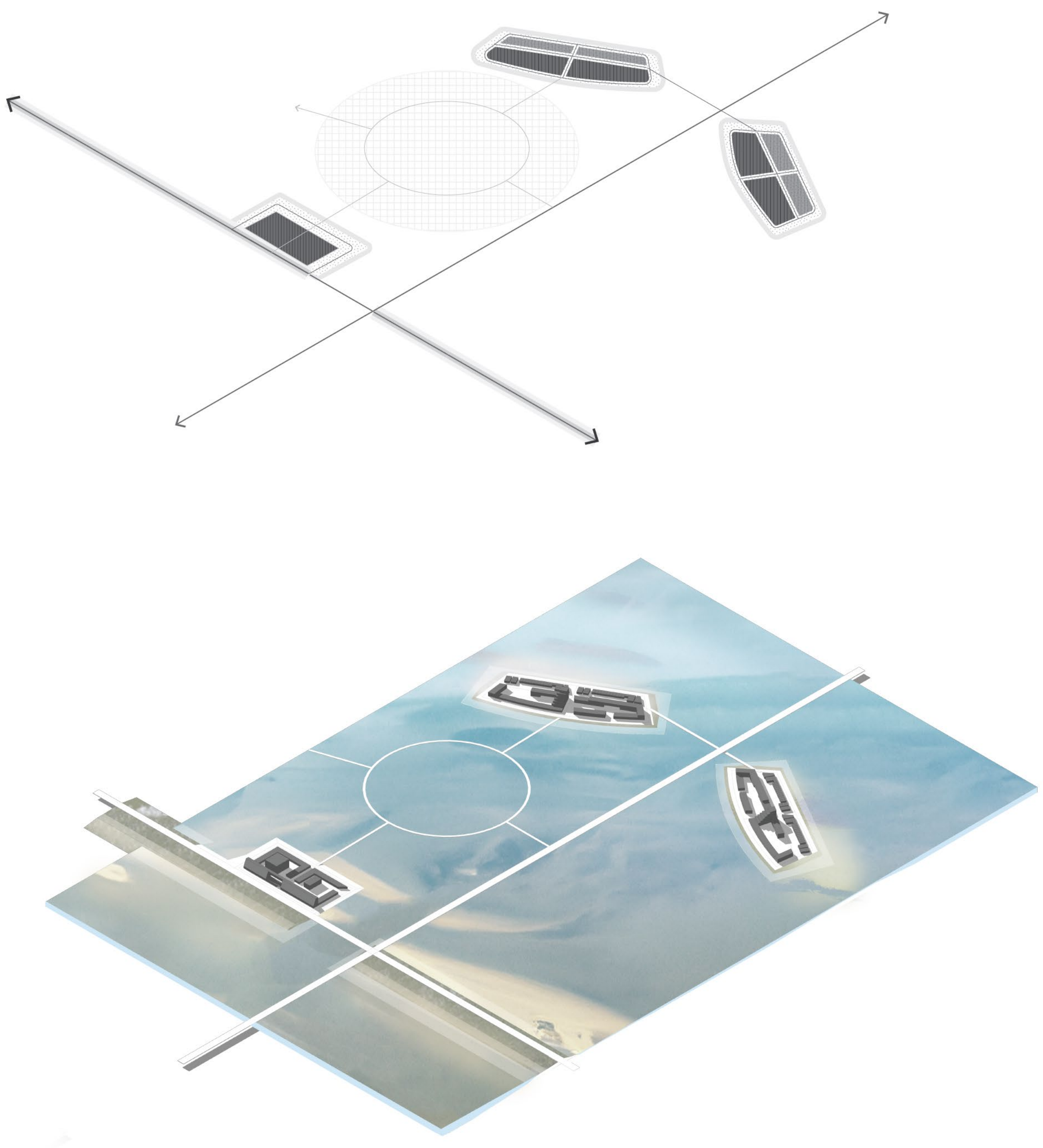


Figure 67. Tidal neighborhood (By author).

Fresh water storm basins
Housing
Food
Dikes
Waterway routes
Railway
Primary access
Secondary access

0 100 m

Figure 68. Habitable frontier (By author).

Fresh water storm basins
Housing
Food
Dikes
Waterway routes
Railway
Primary access
Secondary access

0 100 m

II - Lelystad - The nature capital

2030 - Release:

Functional aim: Release the compartmentalized Oostvaardersplassen.
Strategy: Create a crossing through the Knardijk to integrate the Oostvaardersplassen with surrounding water bodies. Concomitantly, also implement natural supporting dikes that are able to allow habitat transition to higher areas, starting the elevation road N701 to allow the connection of the wetland with the Markermeer.

2050 - Reorganization:

Functional aim: Reorganize agricultural areas and living environments to embrace the wetland habitat.
Strategy: Set a secondary dike ring surrounding the urban core of Lelystad to allow the gradual depoldering of evolving natural areas. In the process setting new guidelines for local neighborhoods to adapt to tidal conditions and high biodiversity, creating attractive living environments. Also, building mounds to ensure the permanence of countryside living in flooding conditions, transforming agricultural areas into regenerative wetland nurseries

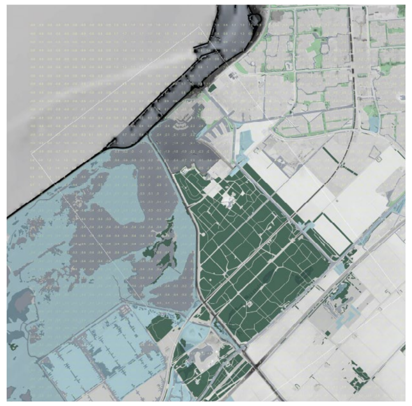
Agro-Urban Ecological interfaces

Primary accessibility: **Restorative landscape infrastructure (Wetland x Water)**
Brief description: Tunneled infrastructure line integrated with a dike to support natural growth and habitat transition and expansion.

Secondary accessibility: **Wetland community (Wetland x Urban Core)**
Brief description: Local neighborhoods adapted to coexist with the wetland conditions, offering plenty of recreational areas and natural landscapes.

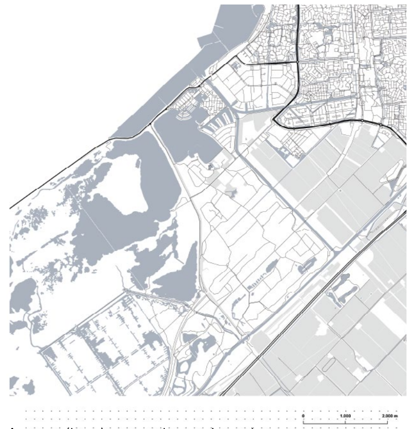
Local accessibility: **Wetland nursery (Wetland x Forest)**
Brief description: Agricultural areas that were converted into spaces for the propagation and study of local wetlands while securing a countryside environment based on mounds. These areas are responsible for carefully understanding wetland dynamics and how they can be incorporated into landscape infrastructure.

Figure 69. Drawing base Lelystad.
(By author)

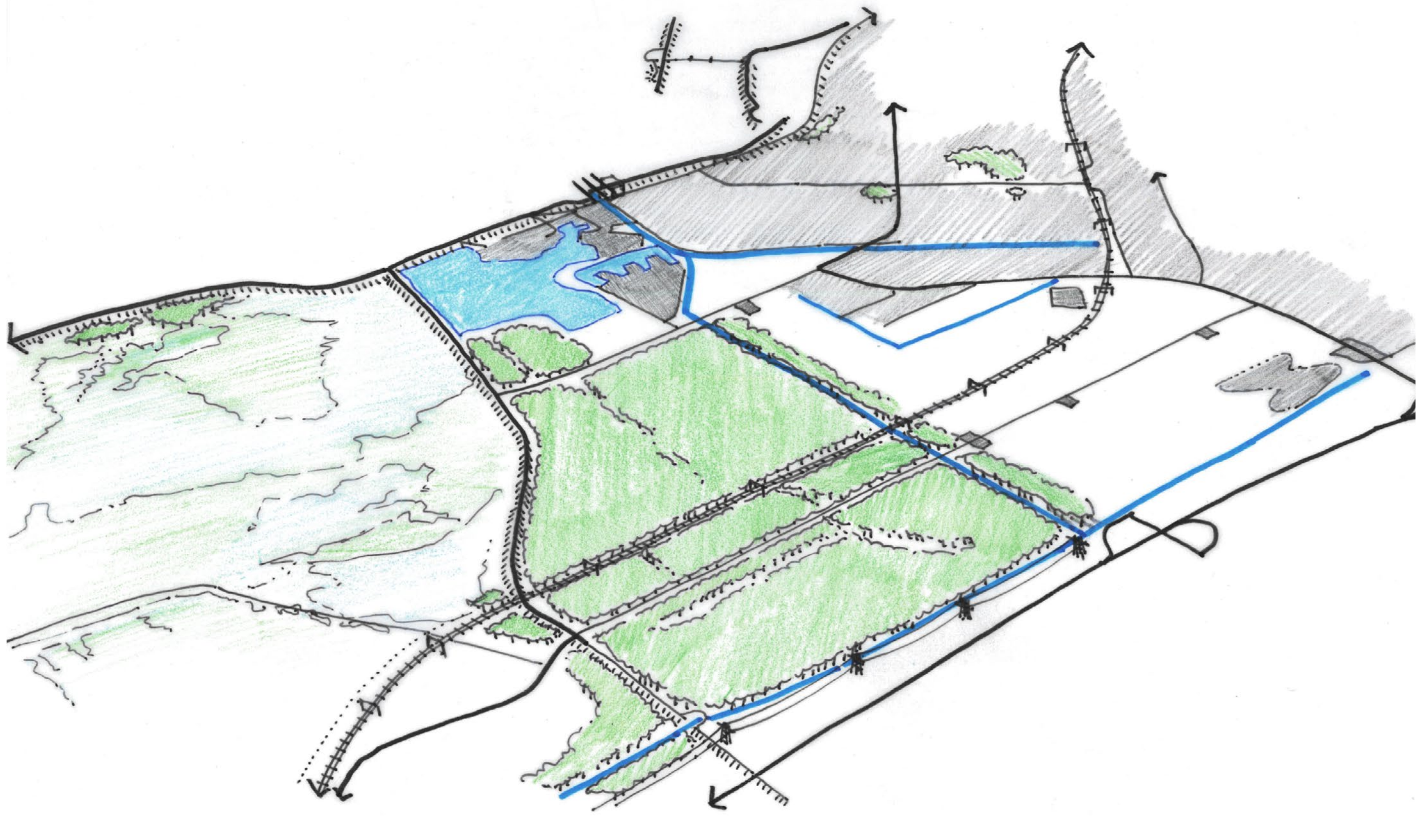


Geomorphology

Urban area, Agriculture, and Forests



Access (local, secondary, primary)



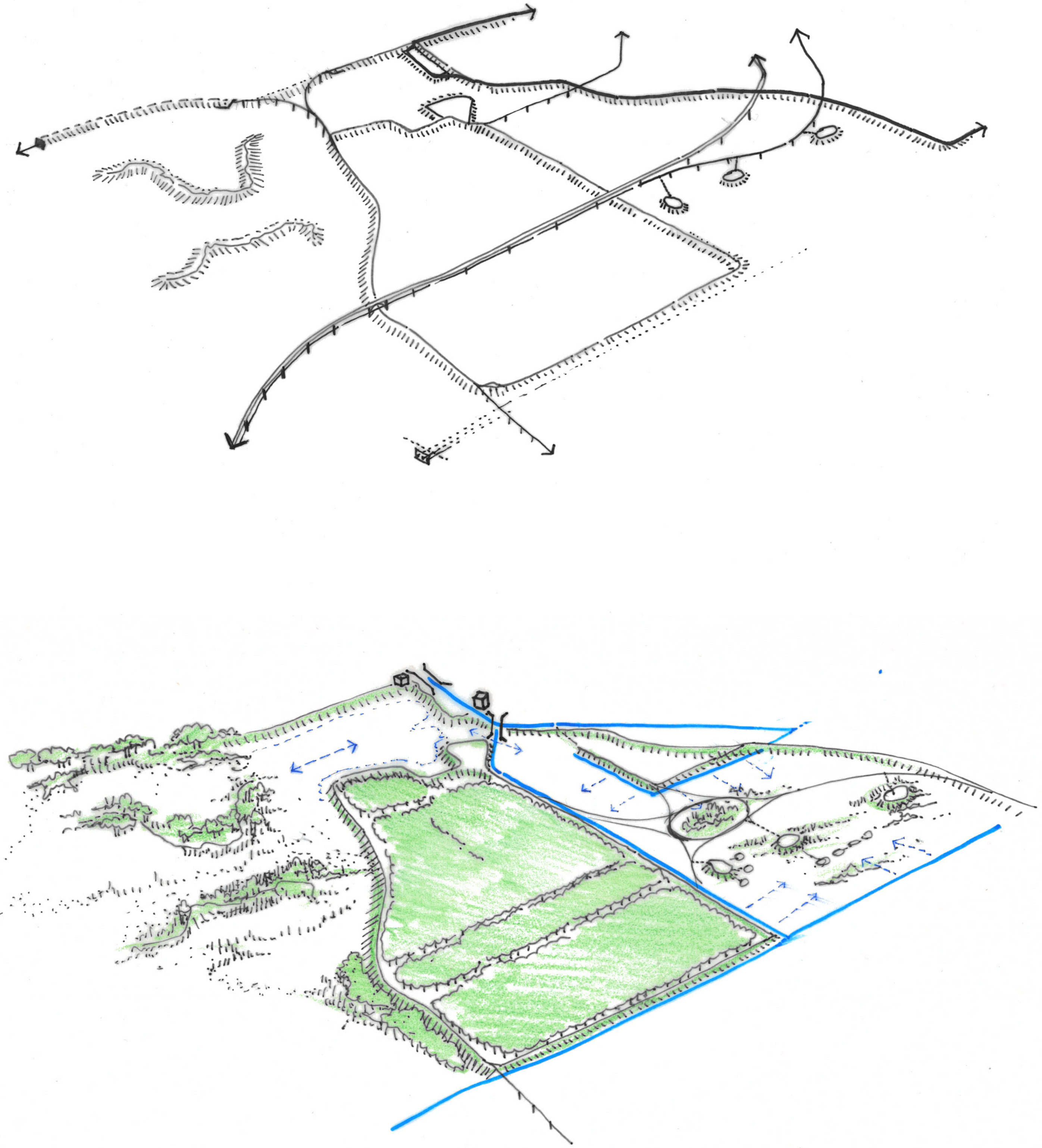


Figure 70. Release - 2030.
(By author)

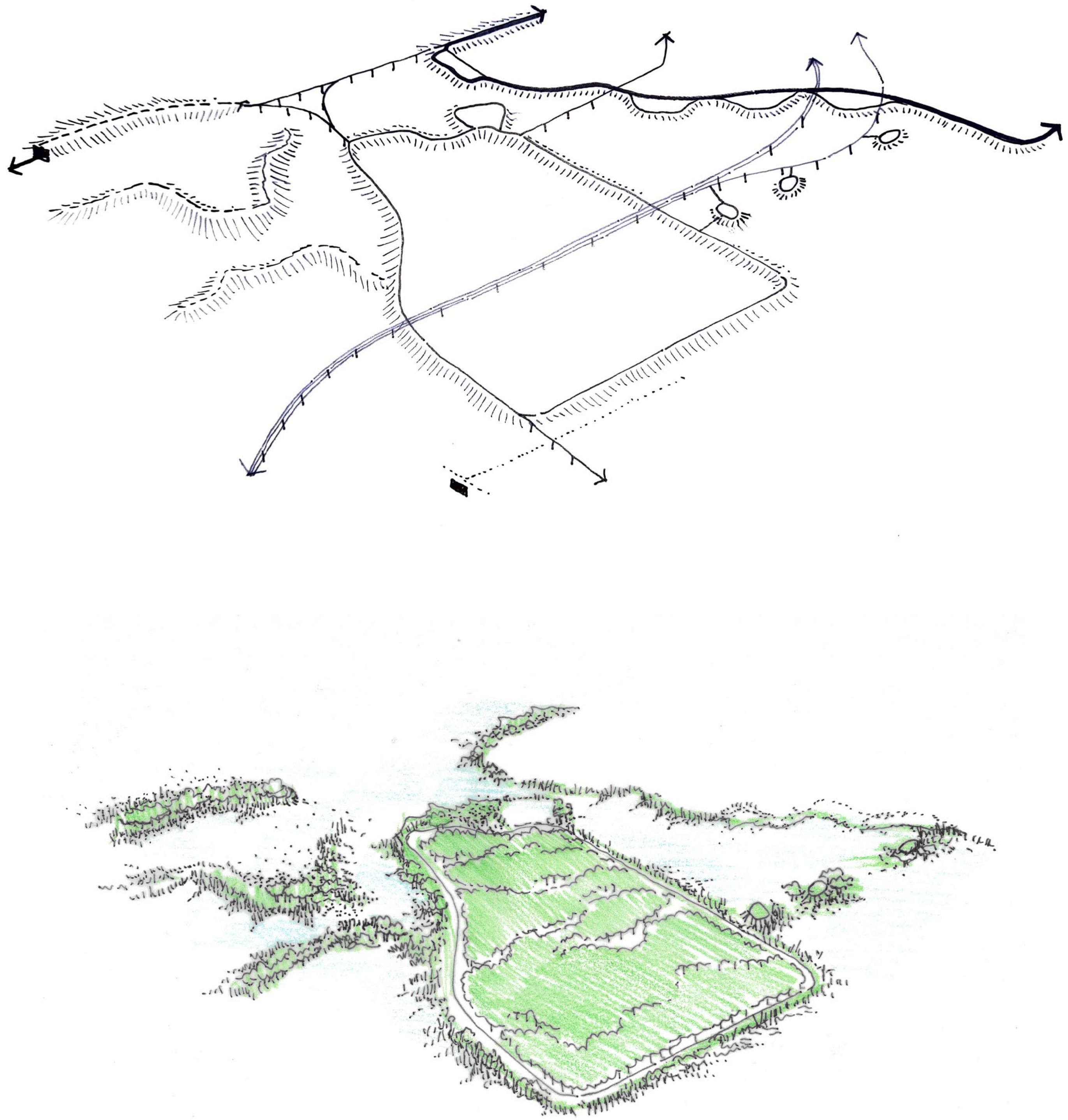
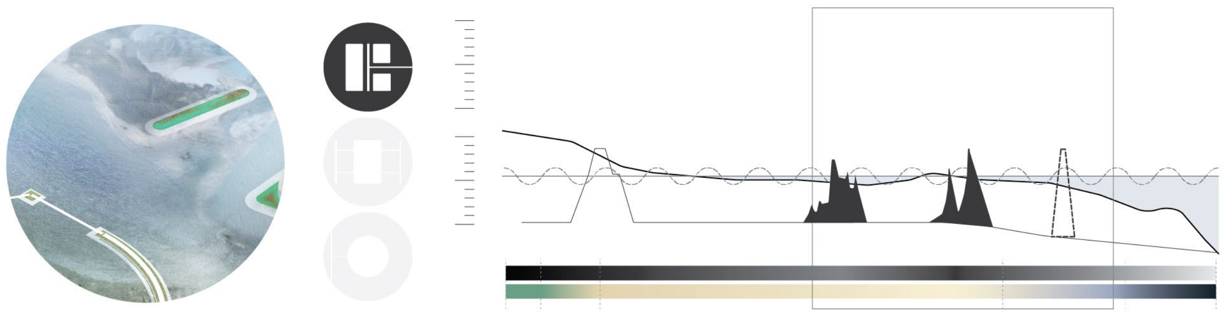
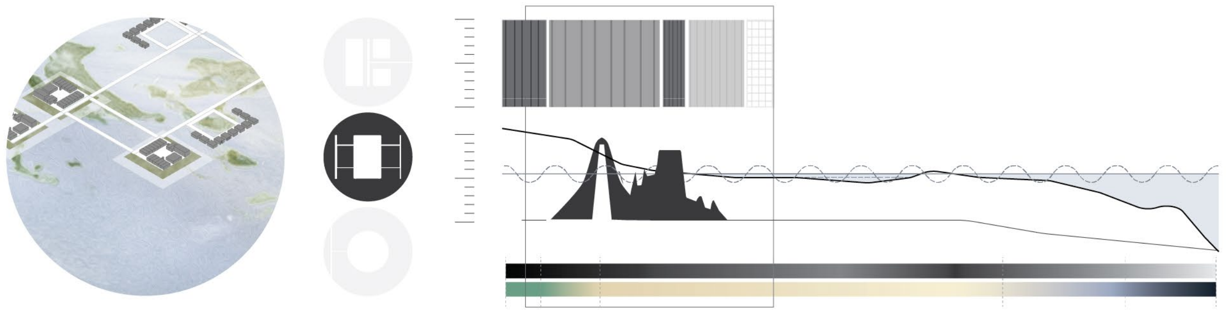


Figure 71. Reorganize - 2050.
(By author)

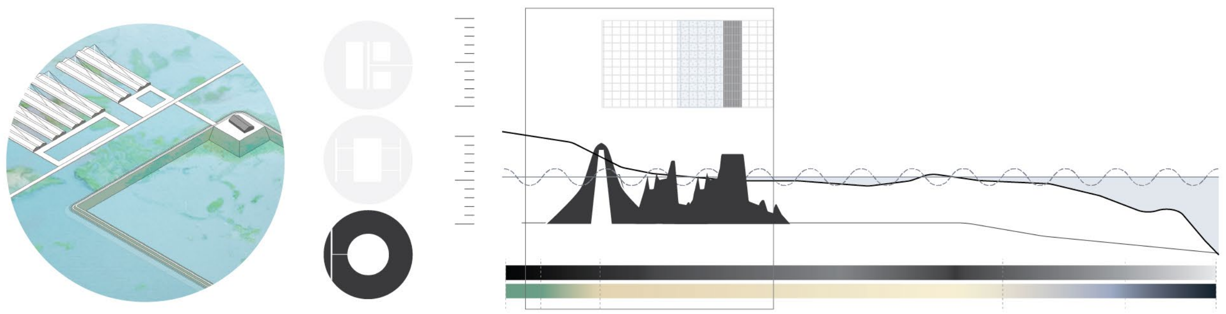
Restorative landscape infrastructure (Wetland x Water)
Primary access



Wetland community (Wetlands x Urban core)
Secondary access



Wetland nursery (Wetlands x Forests)
Local access



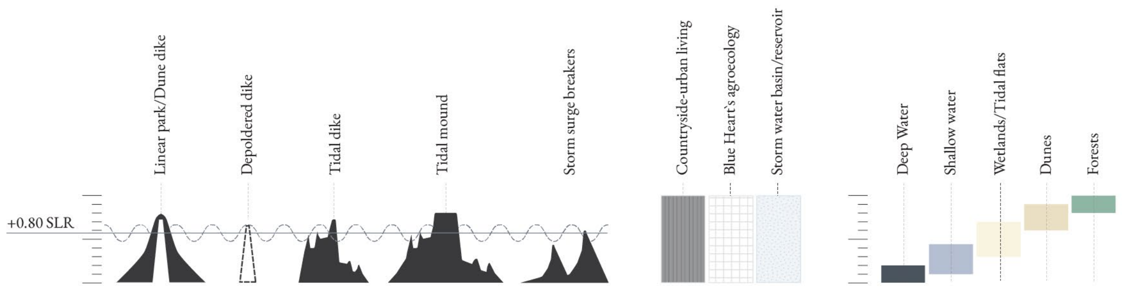


Figure 72. Restorative landscape infrastructure (By author).

- Fresh water storm basins
- Housing
- Food
- Dikes
- Waterway routes
- Railway
- Primary access
- Secondary access

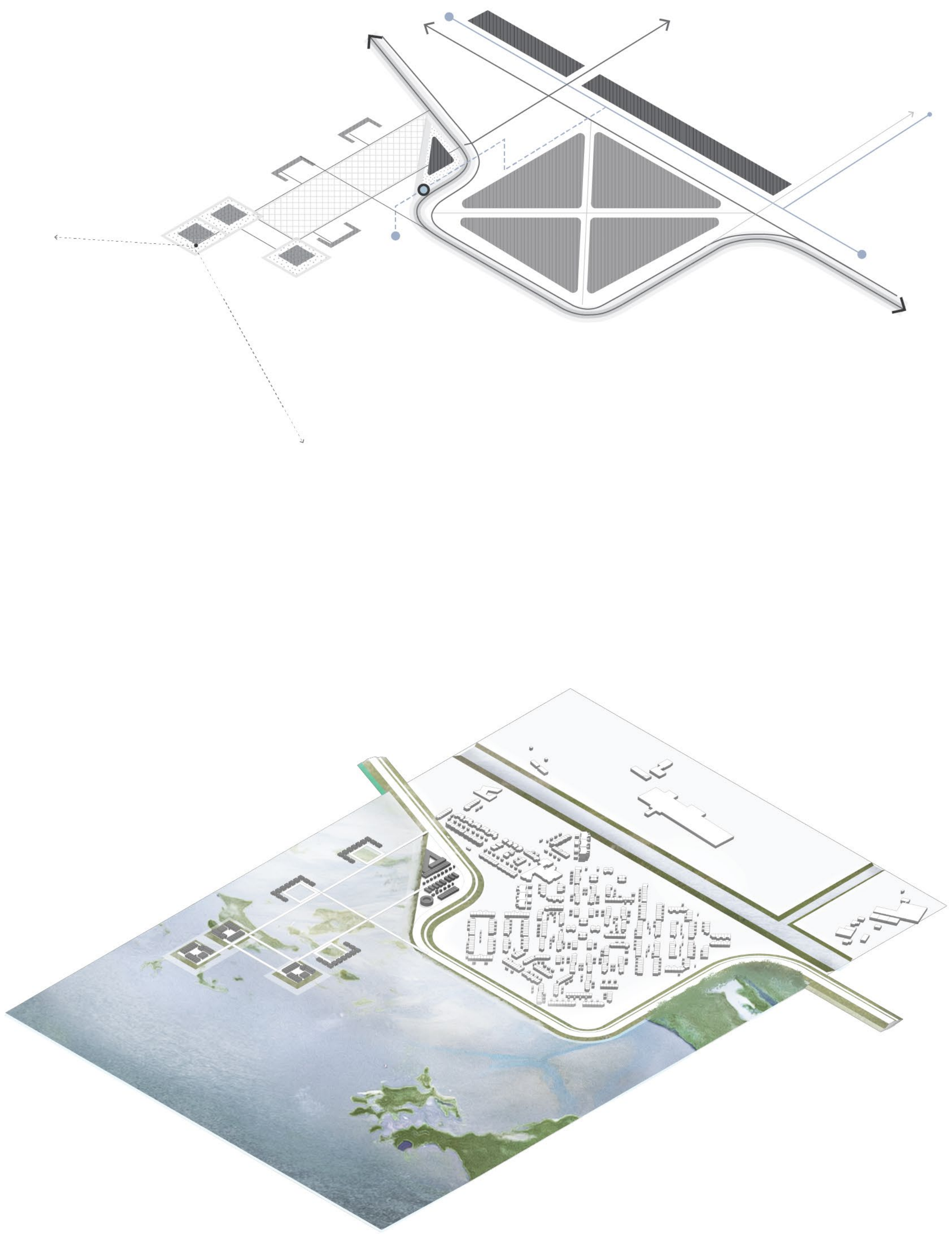


Figure 73. Wetland community (By author).

Fresh water storm basins
Housing
Food
Dikes
Waterway routes
Railway
Primary access
Secondary access

0 100 m

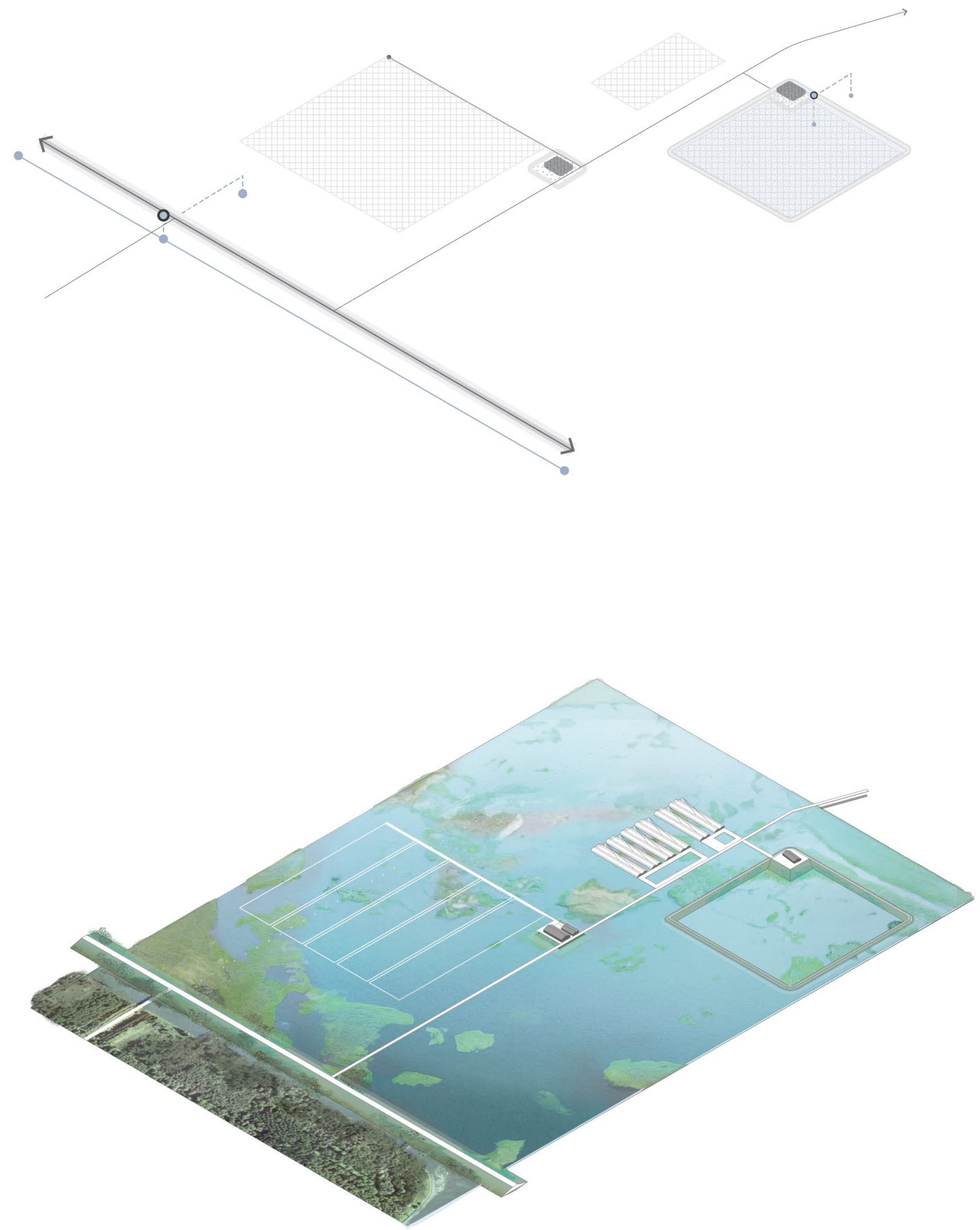


Figure 74. Wetland nursery (By author).

Fresh water storm basins
Housing
Food
Dikes
Waterway routes
Railway
Primary access
Secondary access

0 100 m

III - Urk-Noordoostpolder - The blue-green lighthouse

2030 - Release:

Functional aim: Start the depoldering of subsiding areas from the Noordoostpolder. This action will allow the gradual growth of a tidal habitat that grow with the sedimentation in the IJssel.
Strategy: Create a secondary dike ring around Urk and inner arable land in the Noordoostpolder.

2050 - Reorganization:

Functional aim: Consolidate a coastal buffer that protects higher lands from following while promoting extensive recreational areas. In the process, depoldering inner agricultural areas to allow discharge variations.
Strategy: Extend the coastline of Urk with storm breakers to protect the island. Concomitantly, establishing fishing and agroecological communities distributed in mounds across the previous agricultural area, with gradients of agglomeration and connectivity.

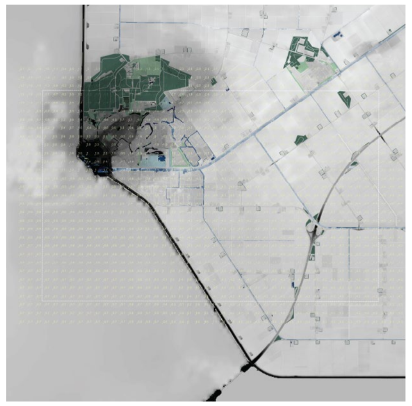
Agro-Urban Ecological interfaces

Primary accessibility: **Maritime coastline (Tidal flats x Urbanized areas)**
Brief description: Extensive beach areas that host fishing spots and recreational zones.

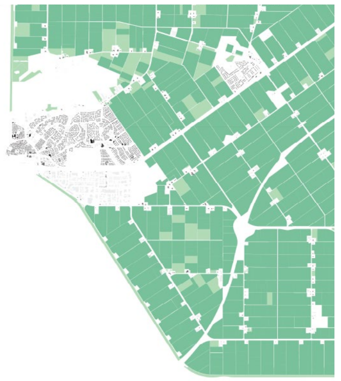
Secondary accessibility: **Agroecological community (Wetlands x Tidal flats)**
Brief description: Countryside communities based on mounds which different degrees of agglomeration and accretion suitability, allowing farming in tidal areas, wetlands, and dry lands on mounds.

Local accessibility: **Restorative aquaponics (Wetlands x Arable land)**
Brief description: Isolated food production water use based on fishing and aquaponics systems, with the possibility of being accretion promoters, growing as small archipelagic islands over time.

Figure 75. Drawing base Urk (By author).

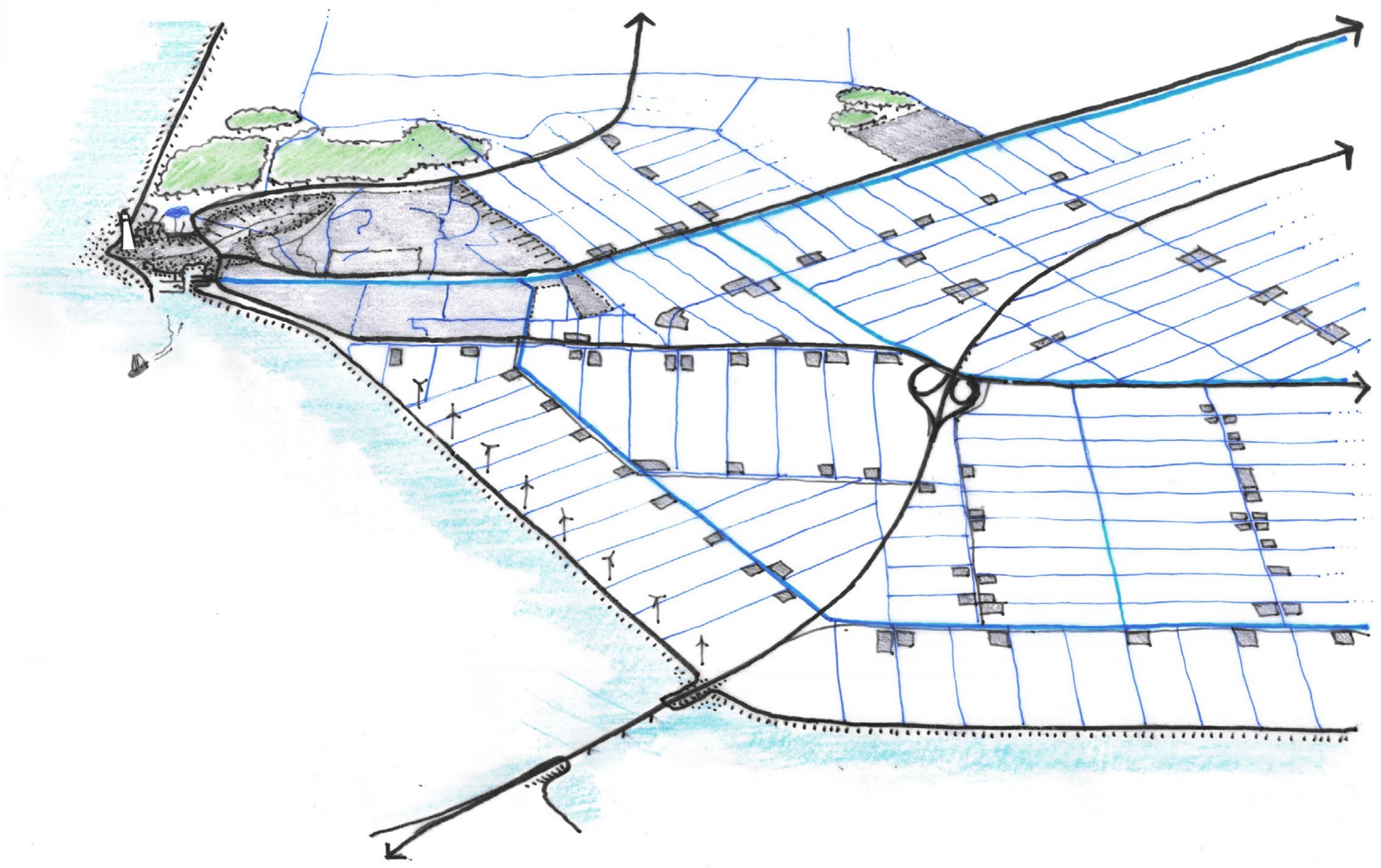


Geomorphology



Urban area, Agriculture, and Forests

Access (local, secondary, primary)



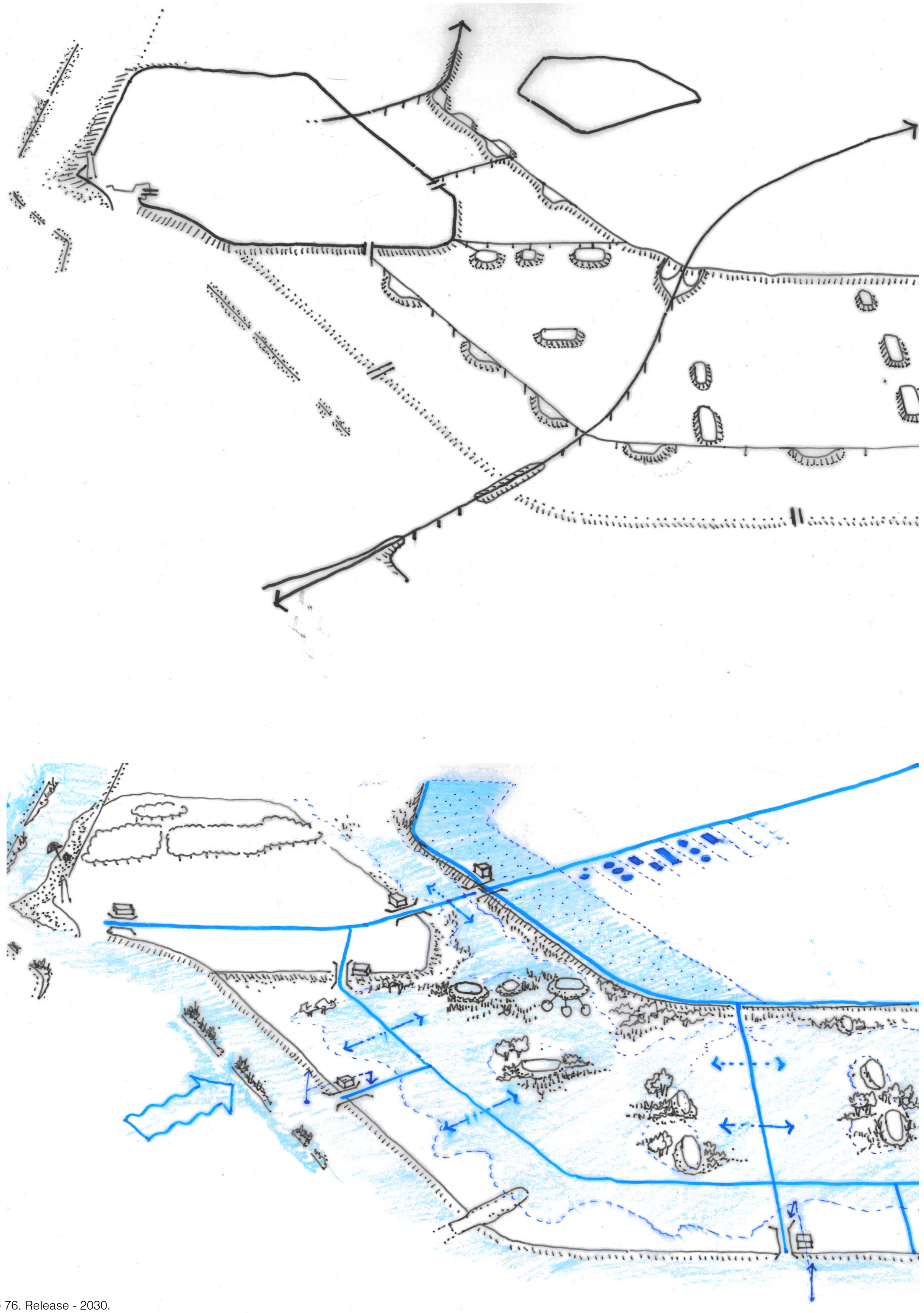


Figure 76. Release - 2030.
(By author)

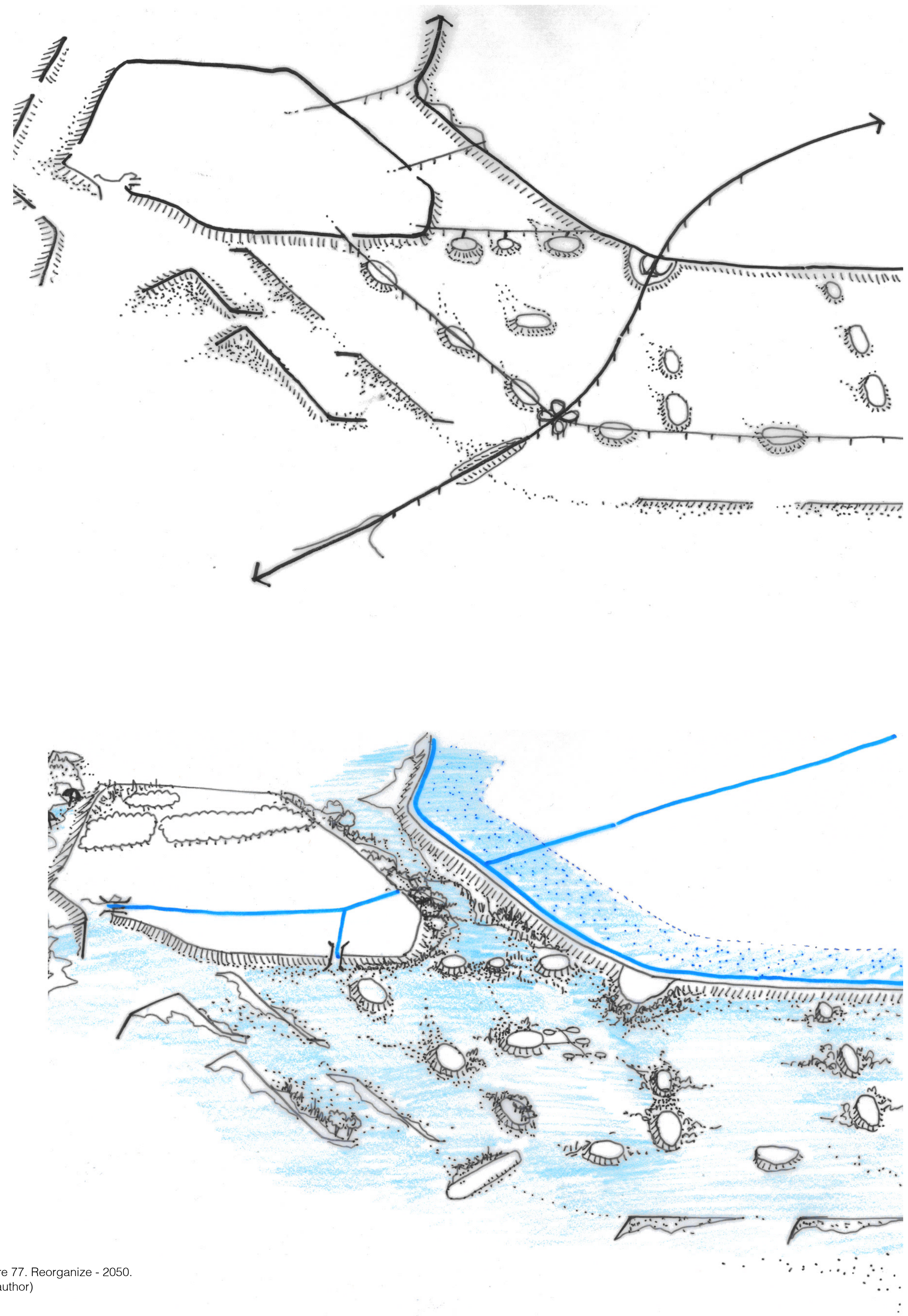
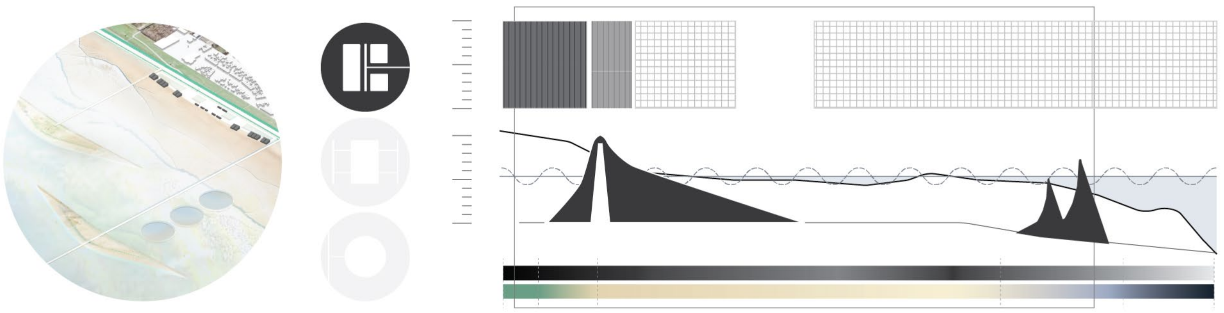


Figure 77. Reorganize - 2050.
(By author)

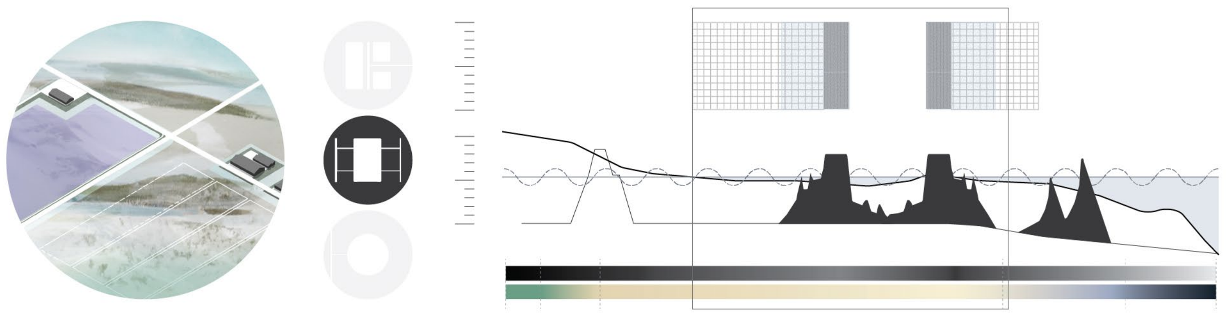
Maritime coastlines (Tidal flats x Urbanized areas)

Primary access



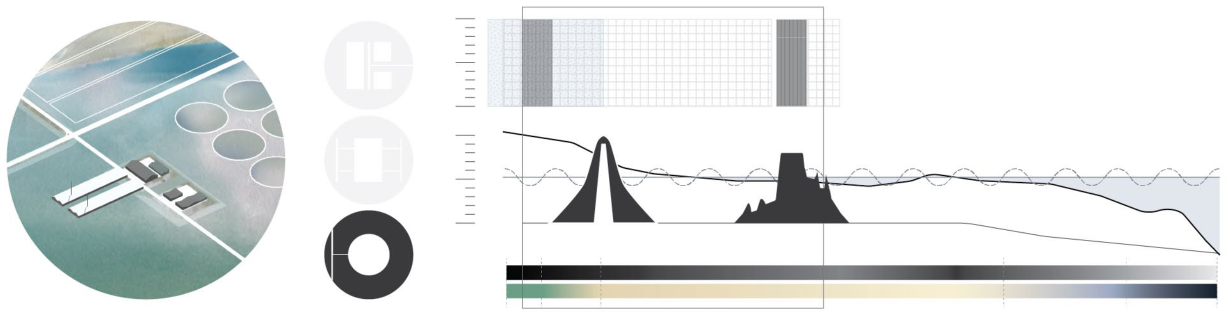
Agroecological community (Wetlands x Tidal flats)

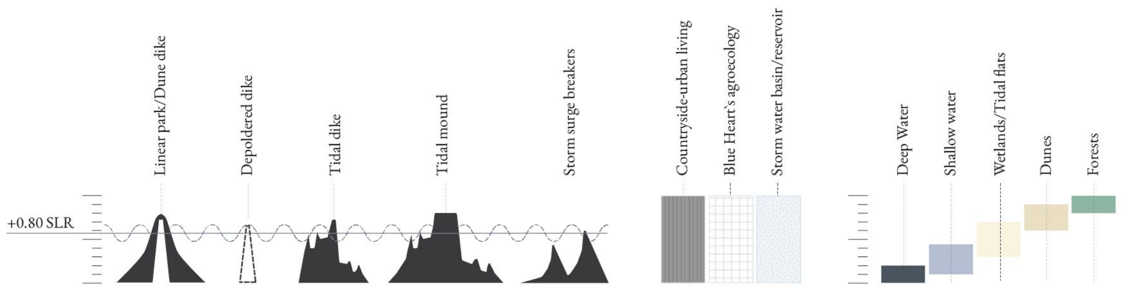
Secondary access

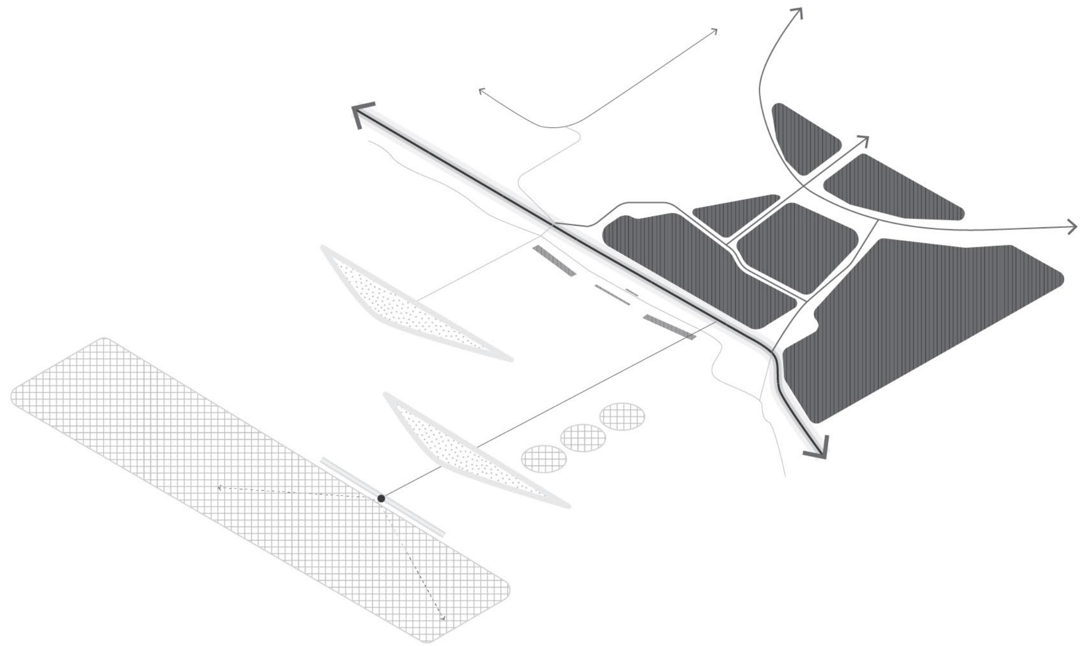


Restorative aquaponics (Wetlands x Arable land)

Local access







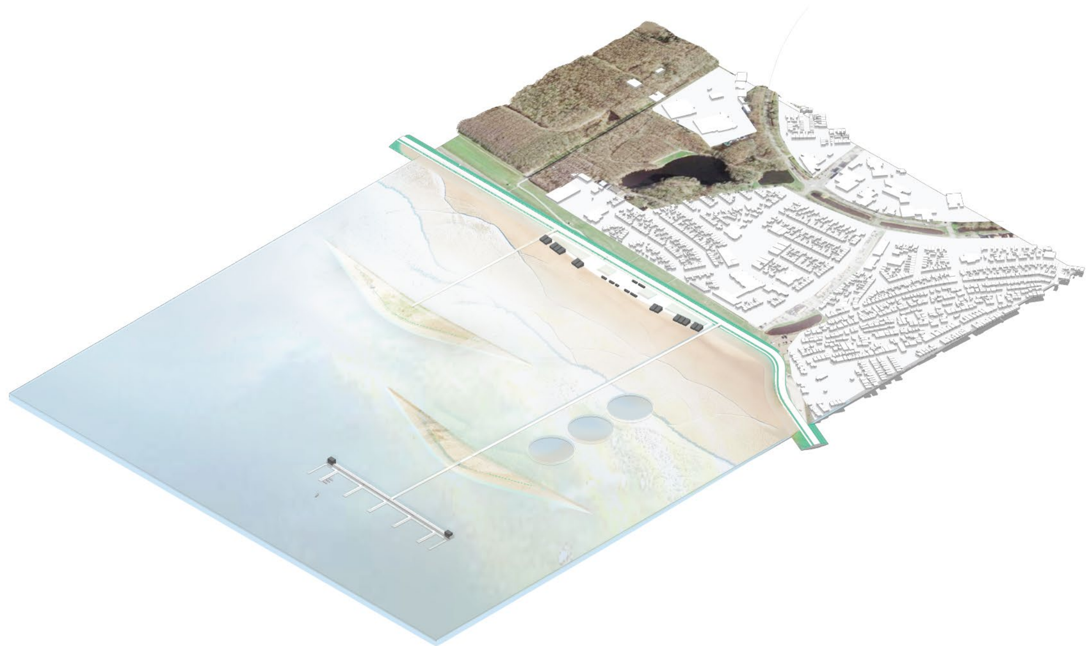


Figure 78. Maritime coastlines (By author).

- Fresh water storm basins
- Housing
- Food
- Dikes
- Waterway routes
- Railway
- Primary access
- Secondary access

0 100 m

Figure 79. Agroecological community (By author).

Fresh water storm basins
Housing
Food
Dikes
Waterway routes
Railway
Primary access
Secondary access

0 100 m

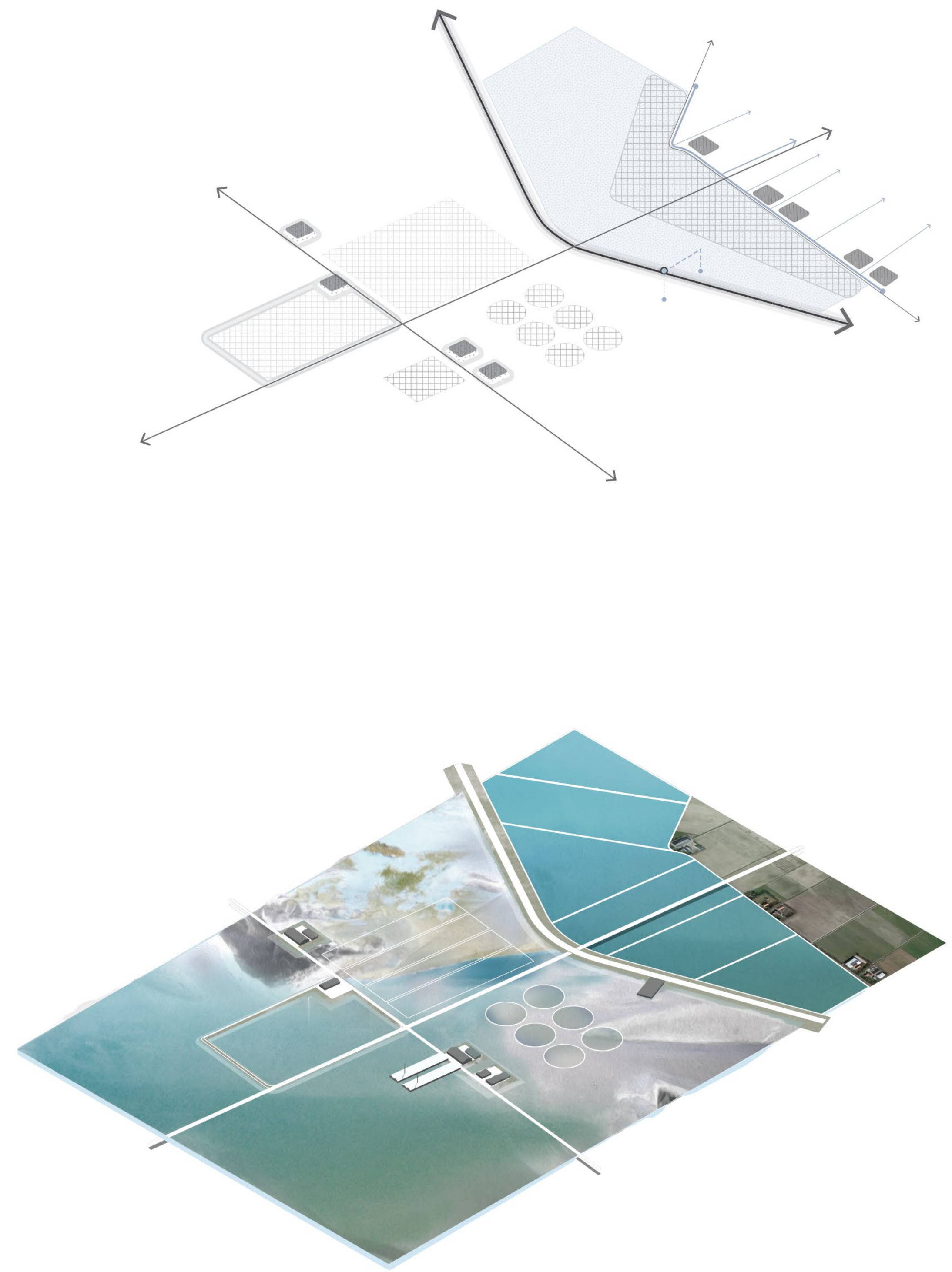


Figure 80. Restorative aquaponics (By author).

Fresh water storm basins
Housing
Food
Dikes
Waterway routes
Railway
Primary access
Secondary access

0 100 m

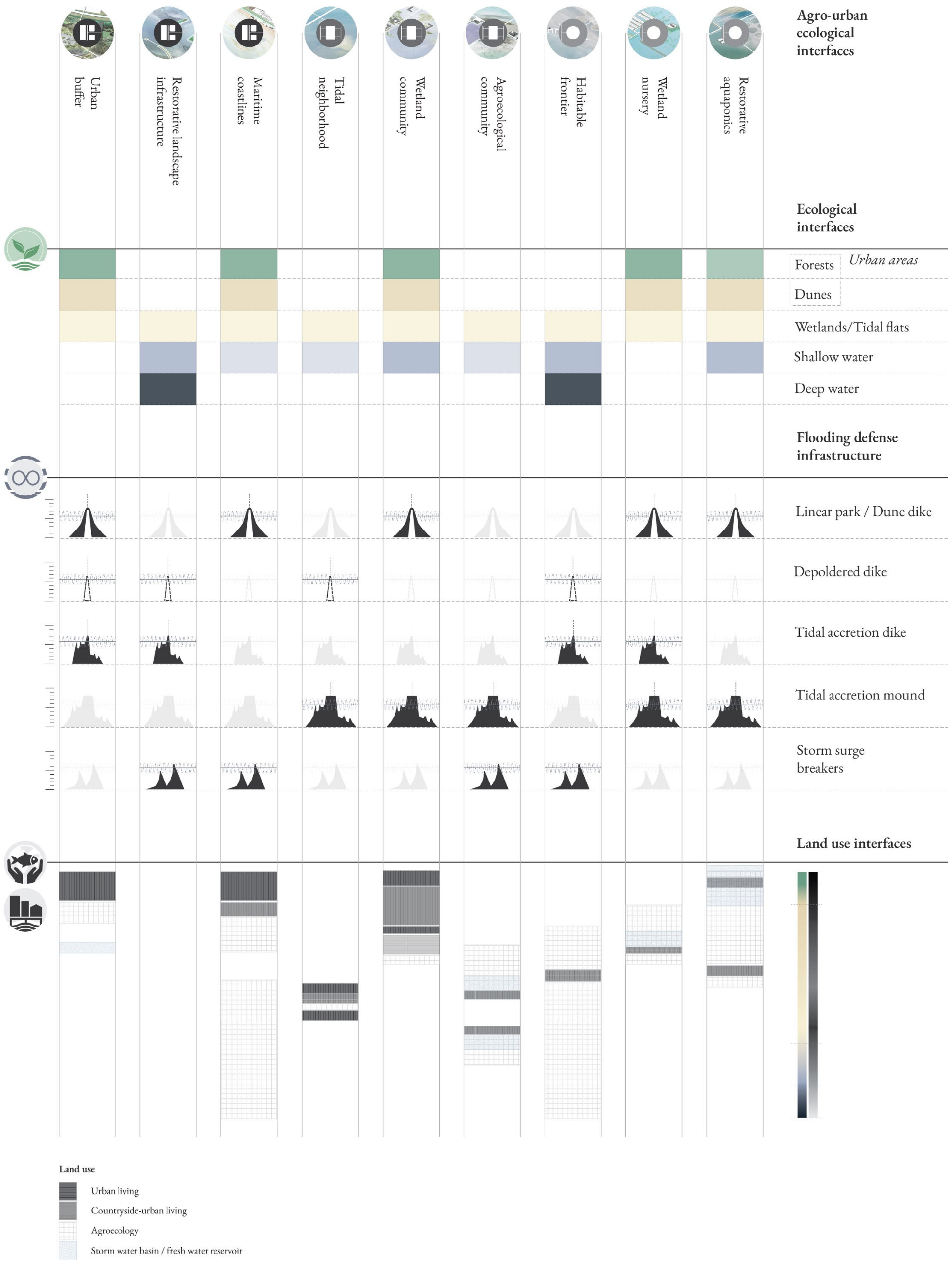


Figure 81. Agro-urban ecologies: Overview of ecological and land use interfaces, and flooding infrastructure conditions.
(By author)

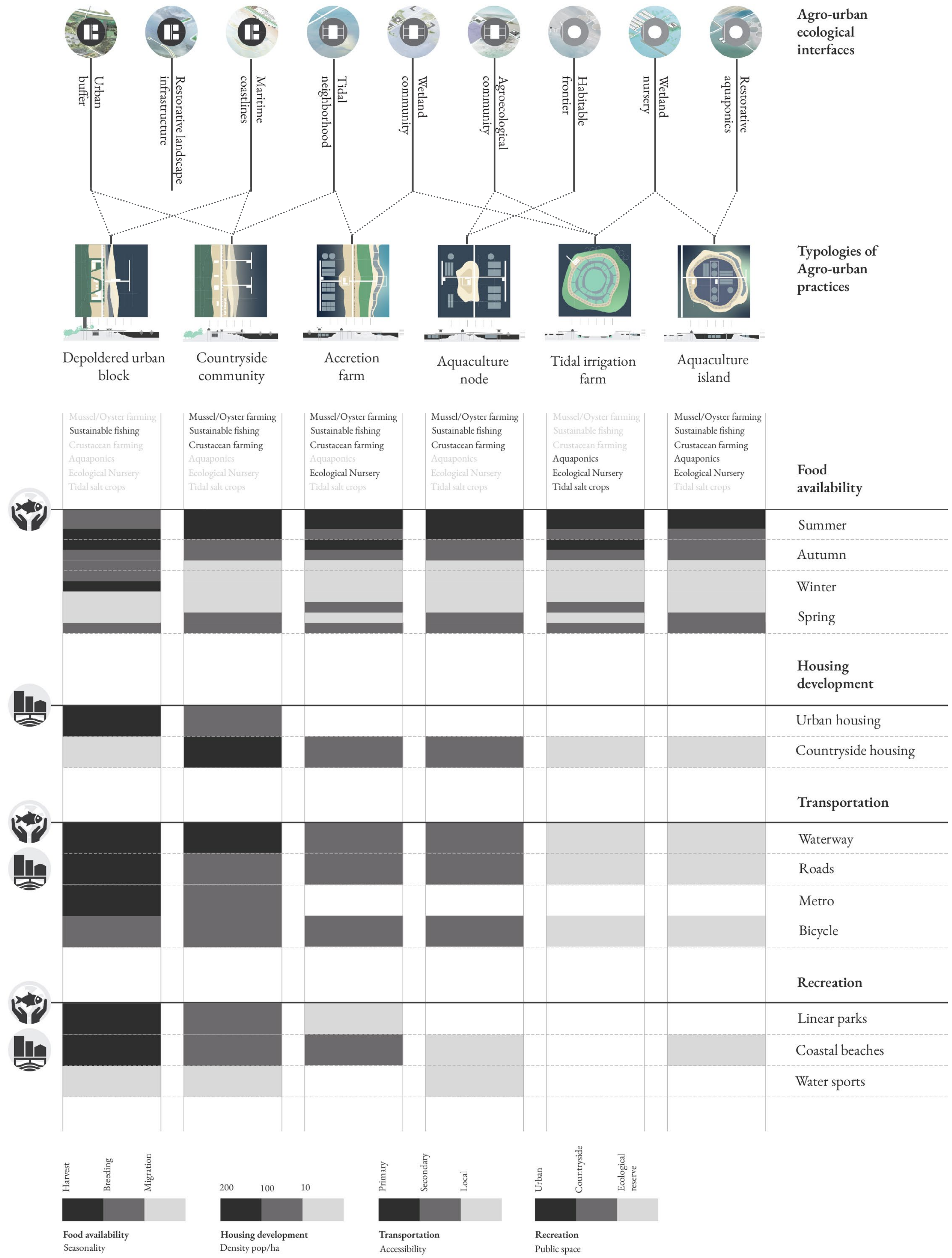


Figure 82. Agro-urban ecologies: Functional intensity adapted from the assessment of agro-urban ecologies (Alzate-Martinez, 2023).
(By Author)

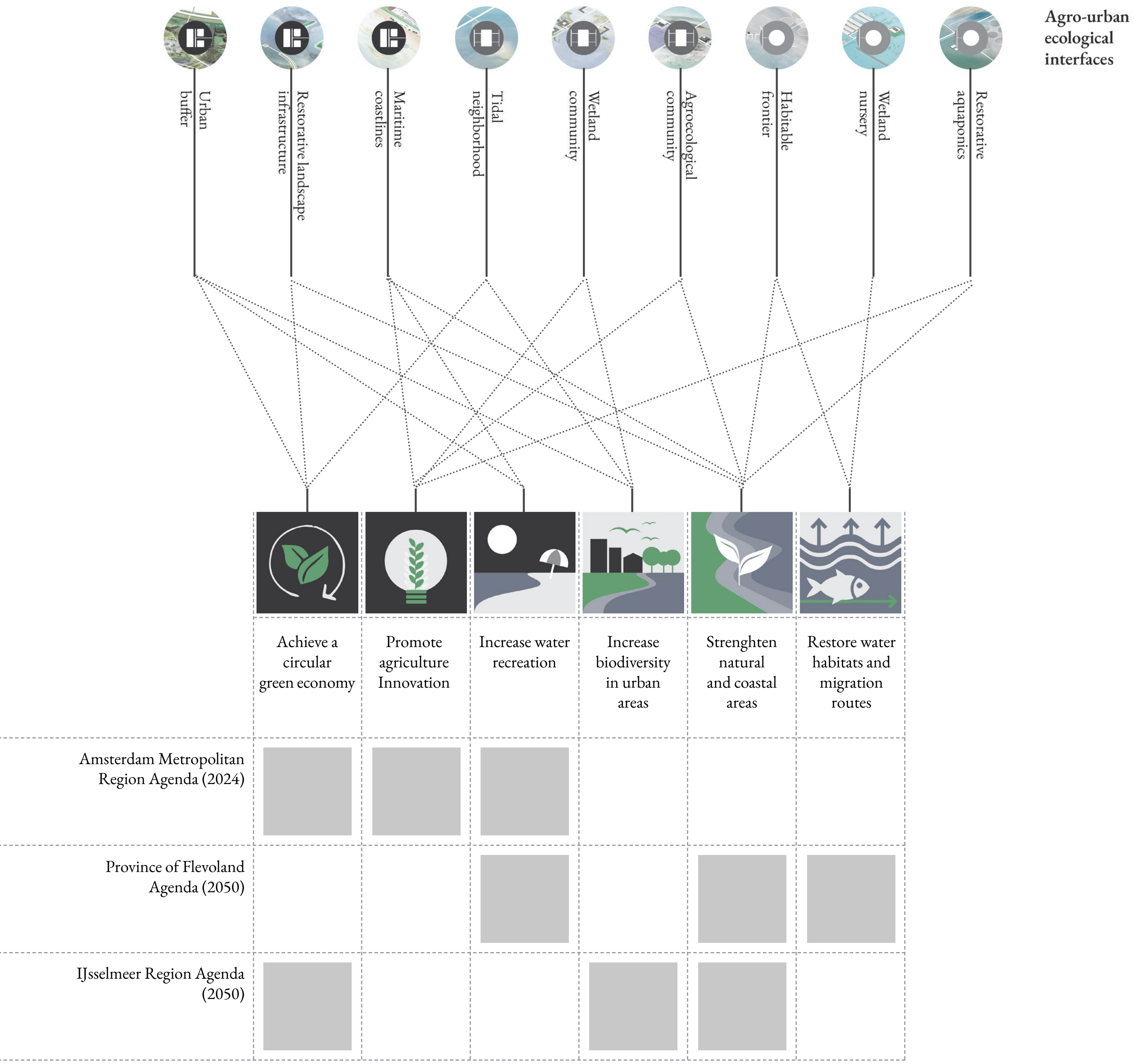
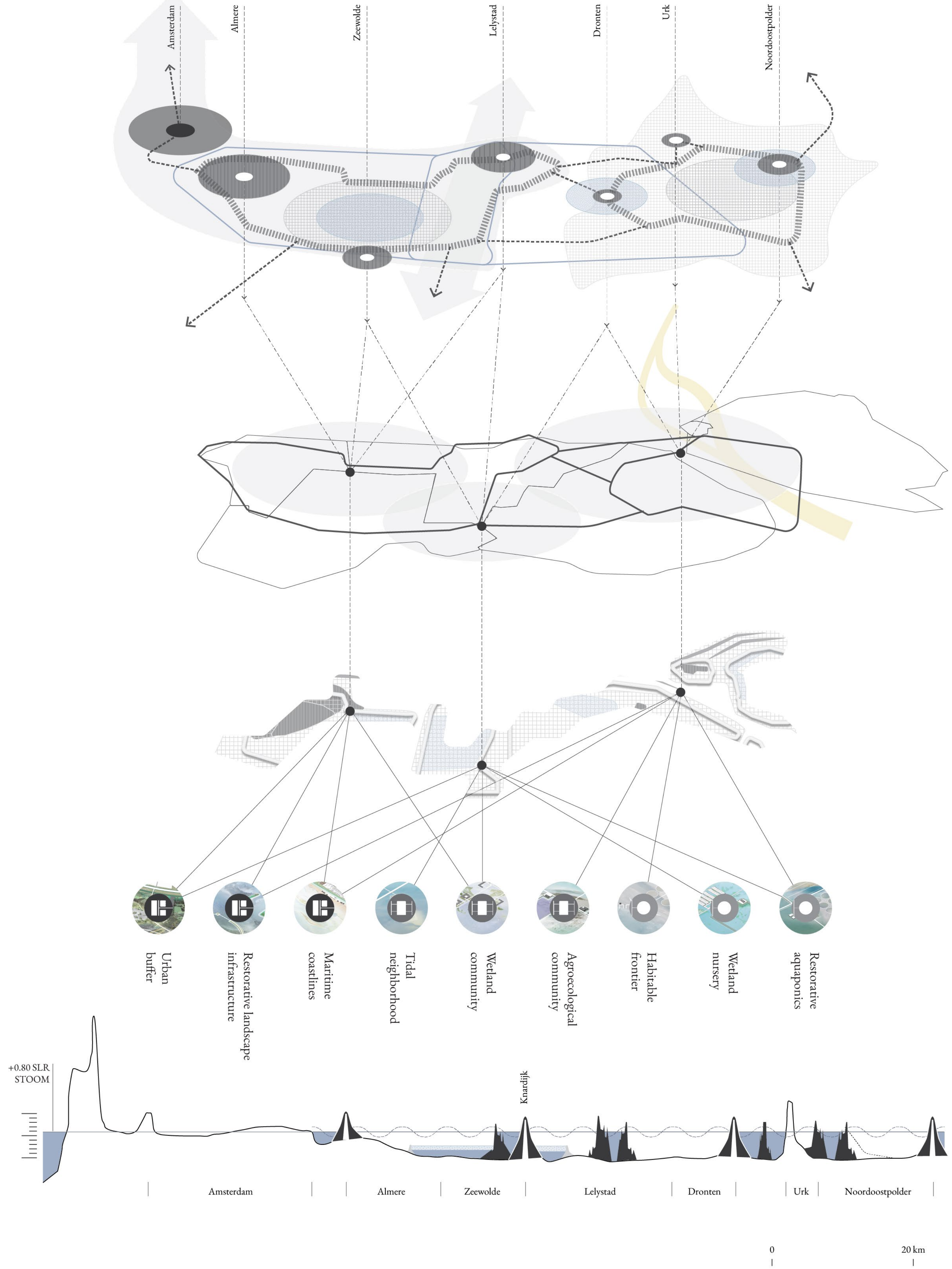


Figure 83. Agro-urban ecologies: Agenda Alignment.
(By author)

The Agro-Urban Ecologies

This study of micro-scale modeling revealed a set of evolutionary strategies that respond ed to local challenges and territorial opportunities in places in on-going transformation. In that sense, the agro-urban ecologies came from an endogenous exploration, both in ecological, functional, and infrastructure perspective. The habitats achieved correspond to geomorphological alterations to restore the Blue Heart's biodiversity, these alterations became part of a broader ecosystem-based landscape infrastructure. The strategies can incrementally guide the functional adaptation of the region to attend to the territorial conditions set for the Blue Heart recomposition planned adaptation with more iterations of the method.



Circular agro-urban mosaic

2080 - Growth (Regional envisioning - Urban intense - STOOM Scenario)

Climate scenario conditions: STOOM: intense climate change with SLR of 40cm by 2050, and 80cm by 2085. Increased population (+1,5 million inhabitants in NL) and high socioeconomic development and internationalization.
Total inhabitants in Flevoland: 800.000 (increment of around +400.000)

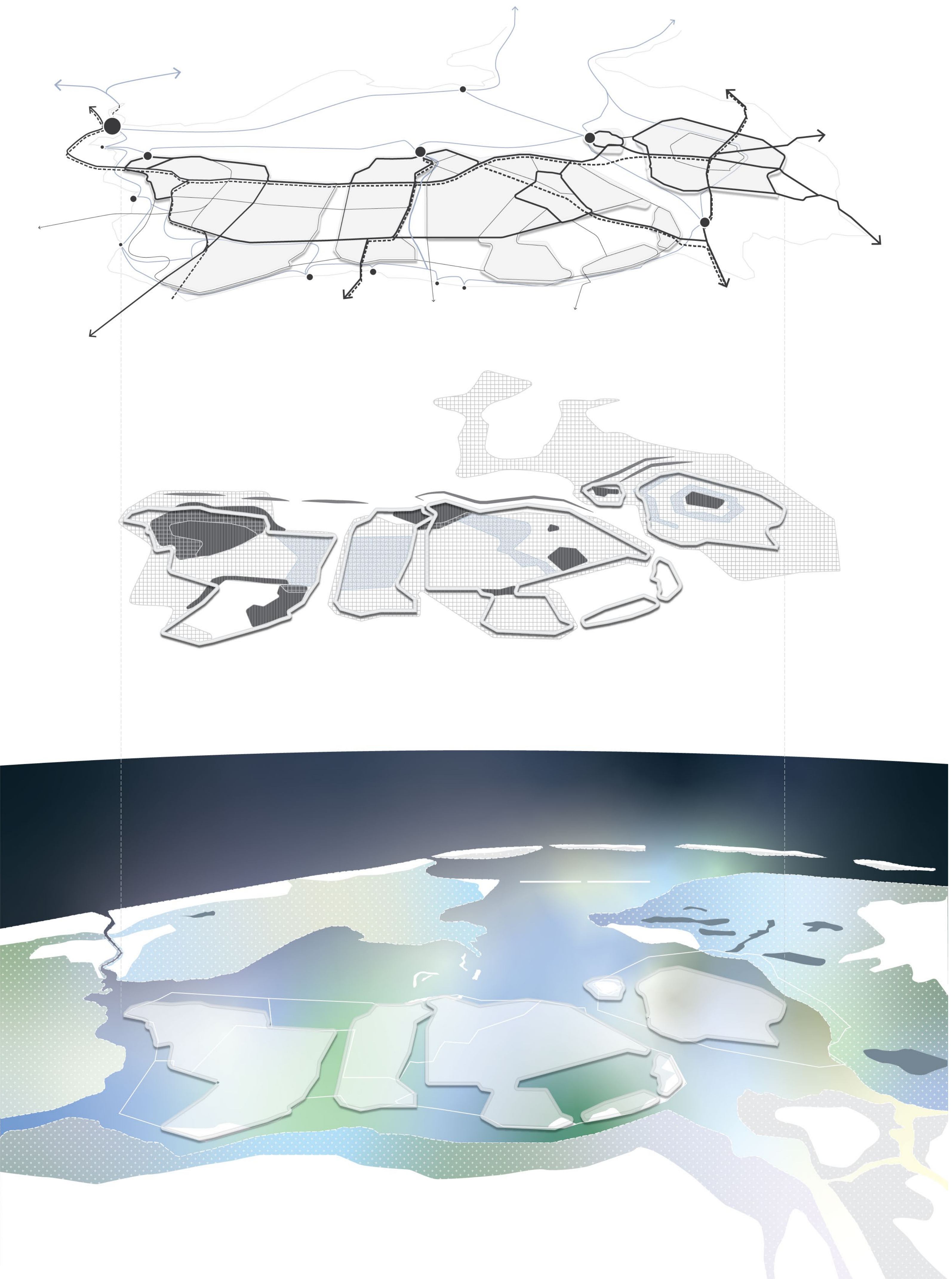
Figure 84. Circular agro-urban mosaic. Flevoland 2080 vision.
(By author)

Envisioning an urban intense Flevoland 2080:

Territorial conditions/Ecology and water infrastructure: The Province of Flevoland adopts extensive nature-based infrastructure to protect its growing urban centers, with the adoption of buffered dikes surrounded by wetlands and tidal areas. A regional restorative dike rings protect the cities of Almere and Lelystad, allowing a gradient of urban and countryside conurbation in synergy with the wetland conditions. In this new configuration, the unity of Almere and Lelystad forms three islands with strong mobility connections through water, trains, and subterranean motorways. Large stormwater basins capture the exceedance of rainfall and water discharge during storm surgers and provide areas for recreation and freshwater supply.

Territorial functions/Food and housing: The region operates in synergy with the Amsterdam Metropolitan Region towards a high-value bioeconomy, fuelling the growing bio-industrial centers of the Port of Amsterdam with bioproducts, subproducts, and biowaste from its extensive agroecological food system. An extensive cascade flow route is established across the Zuiderzee shores by boat, with collection and processing centers close to major infrastructural lines. Vibrant and ecologically dense urban and agro communities are the base for mixed land-use patterns, spreading and reacting to new demands in density reaching approximately 800.000 inhabitants that work and live in the province. Abandoning the project of the airport extension, Lelystad is consolidated as a European transportation hub, by integrating an expanded train station with a port. This allows the transportation of regional products that promotes the unique Flevoland cultural food identity abroad while receiving European tourists seeking warm beaches and ecological tourism during summer. The increased demand for food is regulated by the glasshouse actors in Flevoland, that in cooperation with research centers develop studies on the nature-based infrastructure species, allowing the exportation of knowledge and seeds.

Trade-off on planned territorial conditions: habitat expansion of wetlands and tidal zones to reinforce extensive storm surge barriers. The barriers and redeveloped dikes extend linear parks with beaches and tidal areas, intensively used as recreation which can potentially undermine the integrity of the delicate ecosystems. In this scenario, a rigorous set of policies and management guidelines must ensure the balanced equilibrium in human recreational usage, biowaste maetrial usage, and cautious sand extraction for urban development.



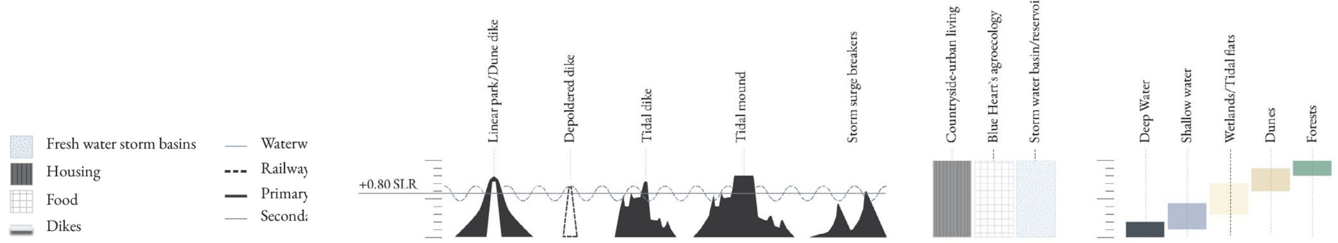
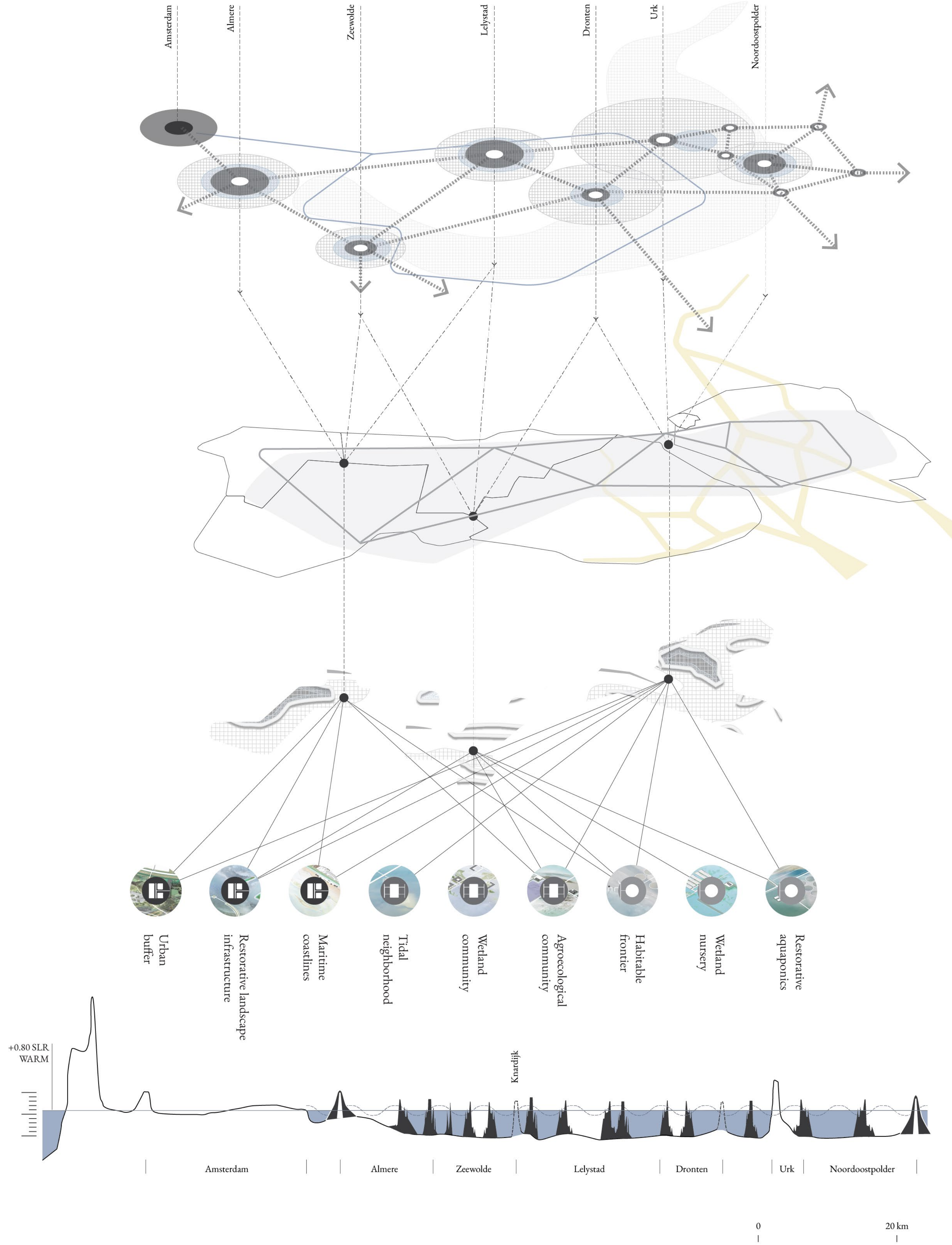


Figure 85. Agro-urban ecologies: Functional intensity.
(By author)

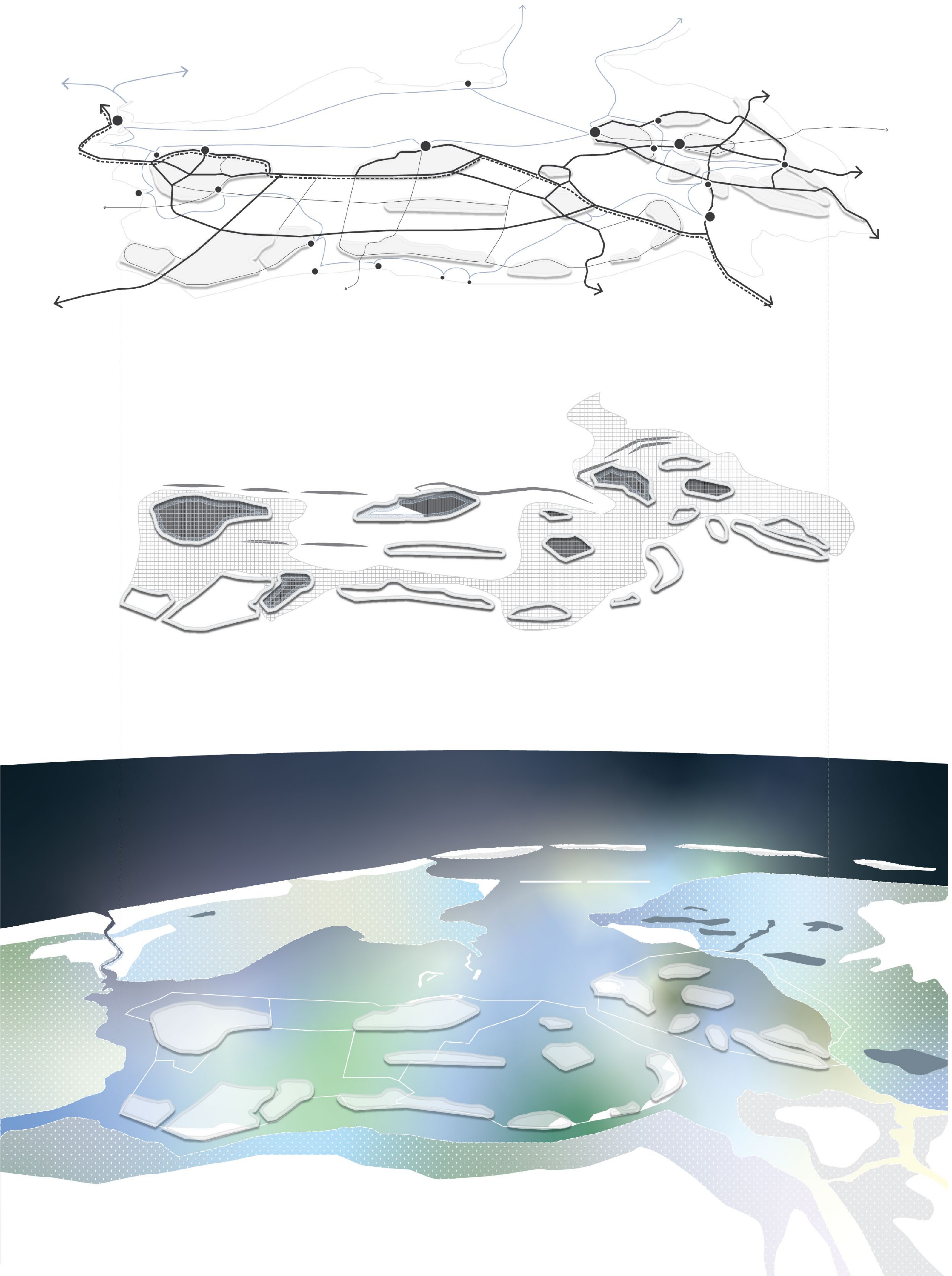


Recombinant archipelago

2080 - Growth (Regional envisioning - Agro intense - WARM Scenario)

Climate scenario conditions: WARM: intense climate change with SLR of 40cm by 2050, and 80cm by 2085. Decreased population (-1,5 million inhabitants in NL) and low socioeconomic development focus on regional and local development. Total inhabitants in Flevoland: 300.000 (decrease of around -100.000)

Figure 86. Recombinant archipelago: Flevoland 2080 vision.
(By author)



Envisioning an agro intense Flevoland 2080:

Territorial conditions/Ecology and water infrastructure: The Province of Flevoland adopts extensive nature-based infrastructure that intertwines pulverized spots of polycentric city-region food system development. The costly maintenance of urban centers due to accelerated subsidence led to a transition towards a housing system based on extensive agro-urban communities, with a strong local identity and tailored combinations of land-use interfaces. Local stormwater basins capture the exceedance of rainfall and provide a fresh water supply for local cities and villages, spread across different arrangements of mounds, dikes, and natural buffers with plenty of recreational areas. Flevoland becomes the meeting area of an extended Wadden Sea and IJssel estuary, forming large intertidal areas with several kilometers of beaches and wetlands.

Territorial functions/Food and housing: The Province of Flevoland is known as a center of biodiversity, with its communities fulfilling the role of keepers of Delta. Flourishing agroecological and sustainable fishing practices allow the provision of local products to nearby Dutch regions and cities, with a strong identity based on land, water, and local biodiversity. Due to the reduced demand for terrestrial and maritime transportation infrastructure, the region becomes nature intensive and a buffer for climate adaptation to surrounding regions of the Blue Heart.

Trade-off on planned territorial conditions: habitat expansion of wetlands and tidal zones to can potentially generate conflicts with ecological growth. The agro intensive development must be followed by clear natural and resources management.

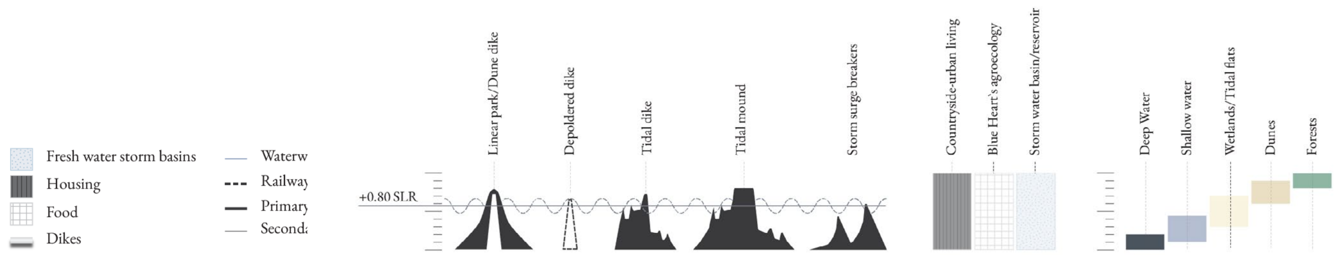
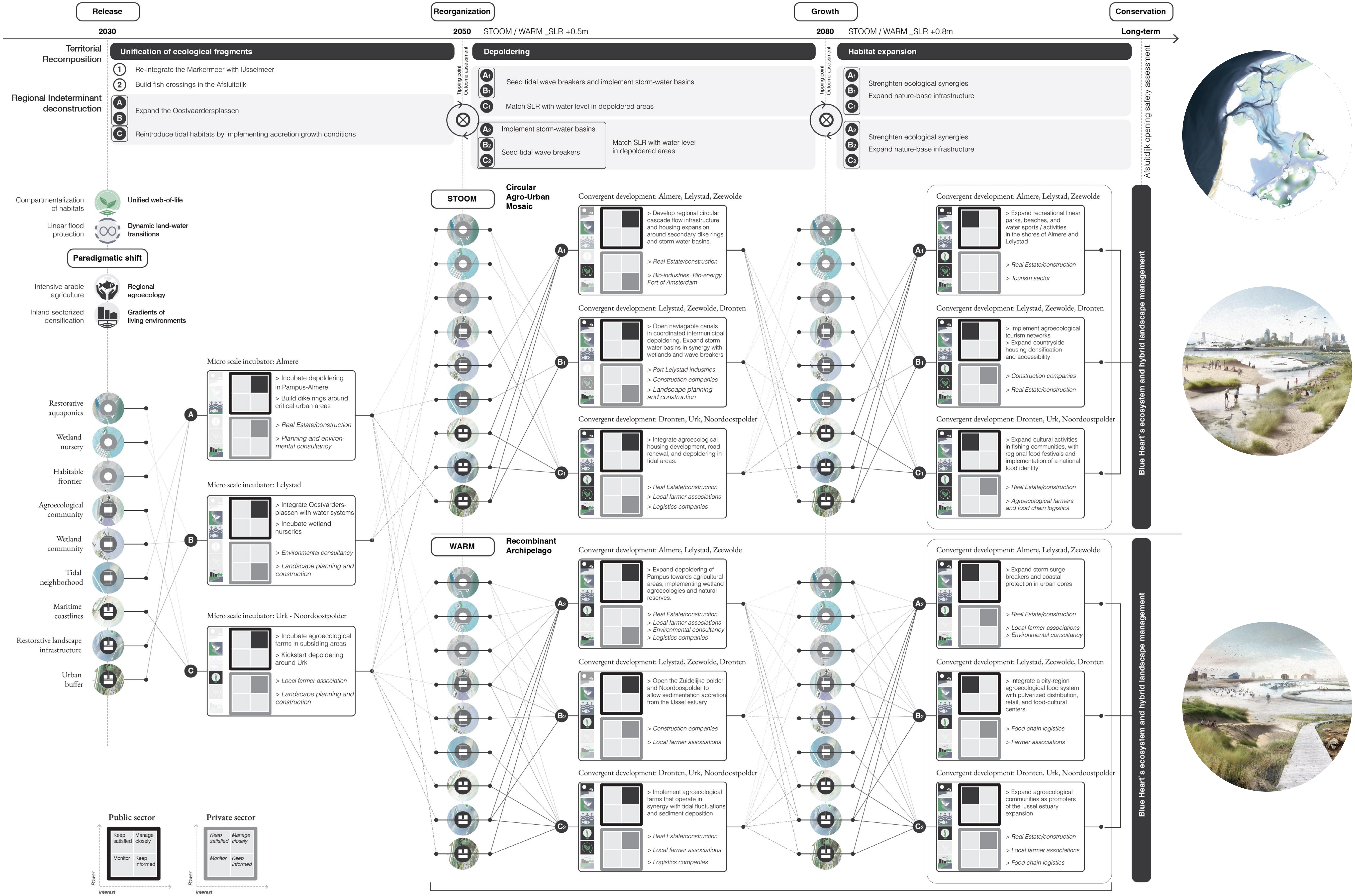


Figure 87. Agro-urban ecologies: Functional intensity.
(By author)



Regional transformation study: Province of Flevoland

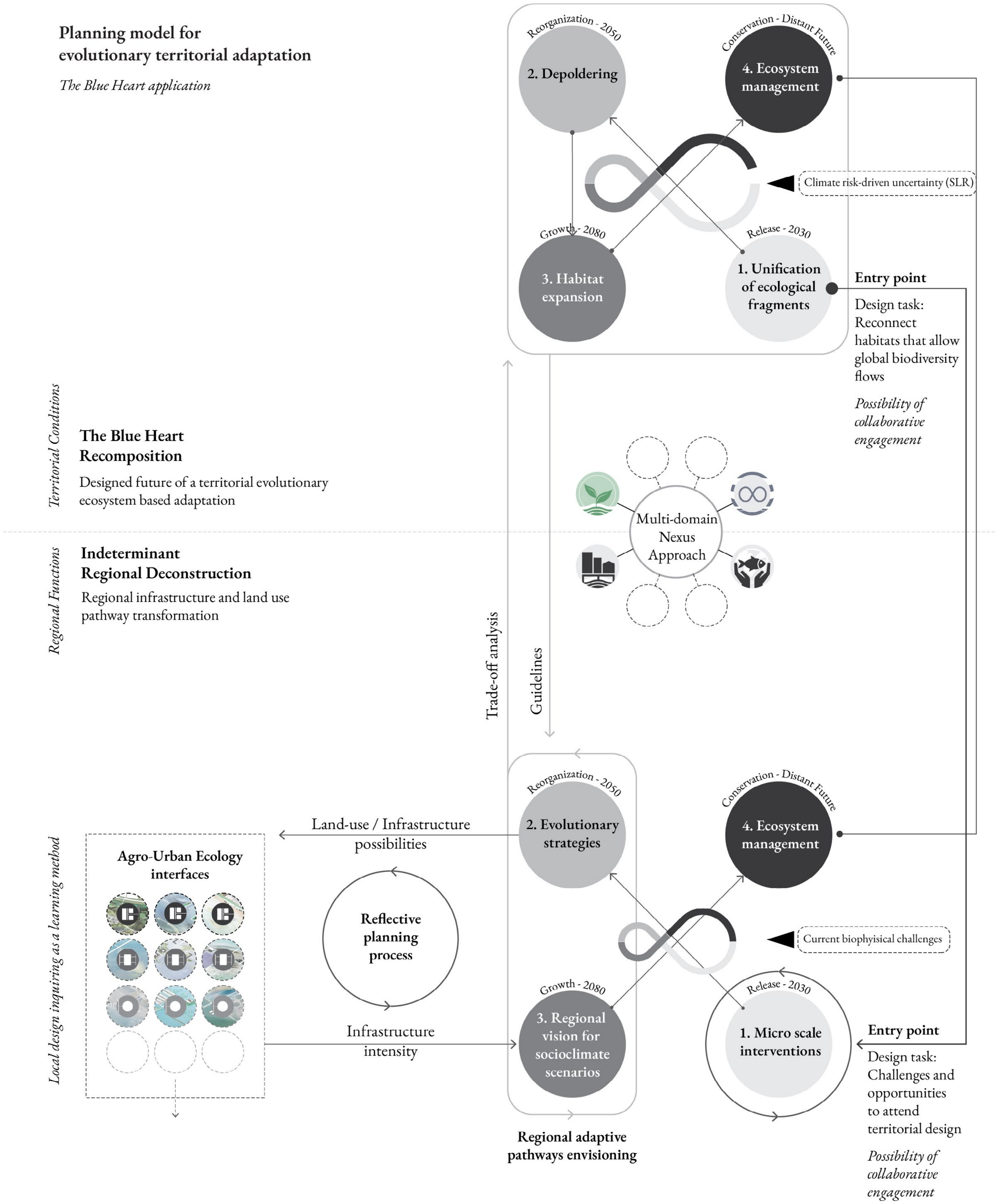


Figure 88. Adaptive governance of territorial recomposition and regional indeterminant deconstruction through agro-urban ecologies.
(By author, based on the design study and interpreted from Adaptive Cycles, Gunderson and Holling, 2002).

Figure 89. Territorial planning model to achieve ecosystem-based adaptation.
(By author based on Adaptive Cycles, Gunderson and Holling, 2002).

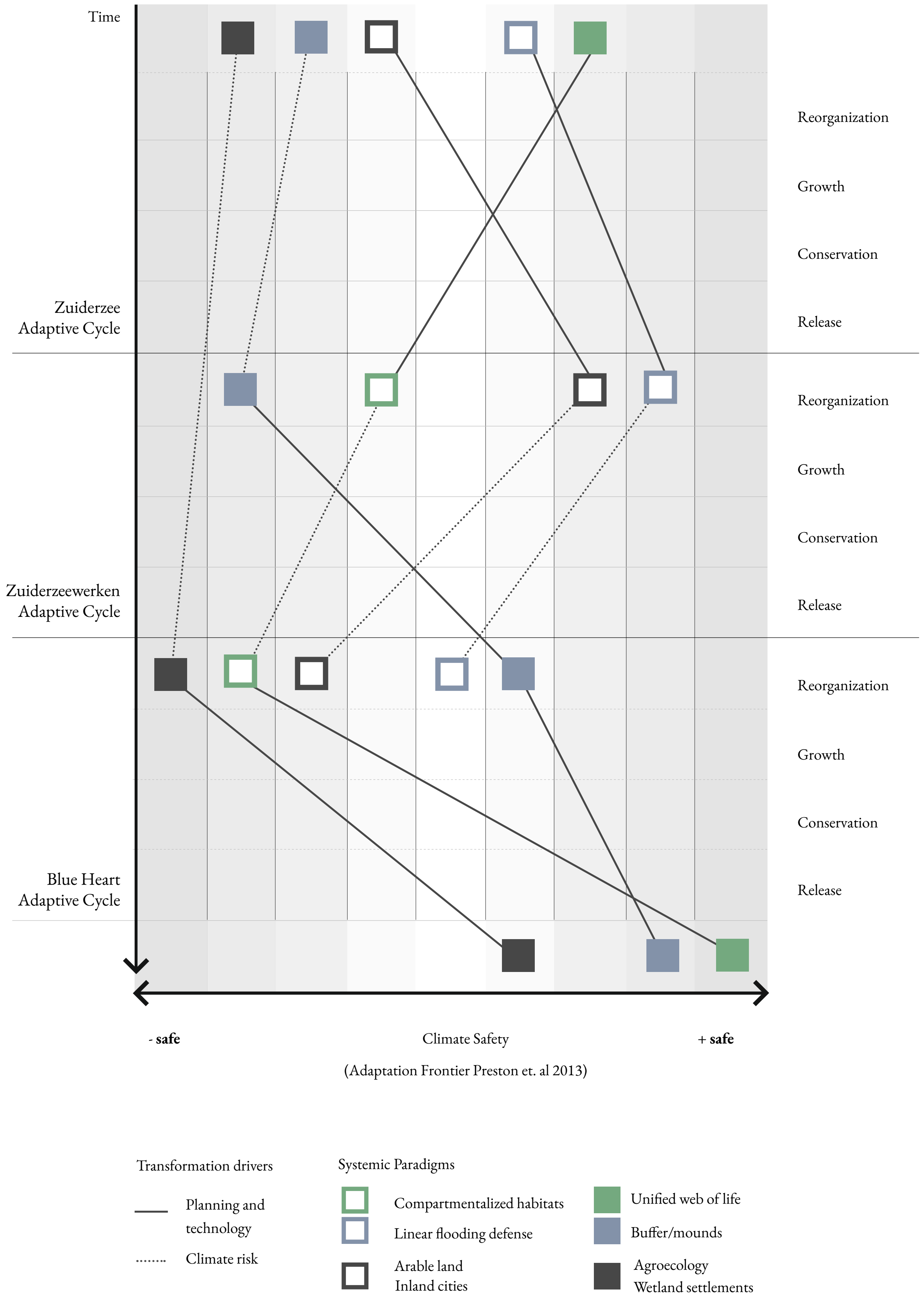


Figure 90. Reflection on development.
(By author, based on Adaptive Cycles, Gunderson and Holling, 2002, and Climate adaptation frontier, Preston et. al 2013).

9. RESULTS

This research found that the transition in the Blue Heart is deeply embedded into larger socioenvironmental and economic dynamics that are pushing the territory towards an uncertain future. These dynamics are the intersection of important fish and birds migratory routes, the national supply of fresh water, a global food system operation, and a national linear flooding defense system that guarantees the safety of surrounding land use but has severe biodiversity trade-offs.

In that sense, the Blue Heart Delta territory presents the characteristics of biodiversity degradation moved by land use and climate change, as indicated in the introduction for being the main direct causes of this phenomenon. More than that, it is also an example of how values (climate safety, socioeconomic growth) shaped climate-response development progression through an adaptation cycle in the last century. And also, how this development was embedded in a set of paradigms fundamentally on water infrastructure (linear flooding defense), ecology (compartmentalization), food (industrial agriculture), and housing (inland sectorized densification).

As an extension of its history, these development paradigms are revealed to be related to current challenges, mostly related to environmental degradation and climate vulnerability. The current linear flooding defense system is vulnerable to SLR uncertainty, while the ecological compartmentalization imposes challenges to restoring biodiversity being conditioned by the maintenance of water infrastructure. Furthermore, the current territorial functions of housing land use depend on the maintenance of both ecological and water infrastructure paradigms. Increasing the pressure on infrastructure that must provide a safe operation of a global food system and a housing-demanding future. Both operate in a low land water management condition, embedded with subsidence, ecological problems, and salt intrusion. A circumstance creates challenges to successfully attend cross-boundary ecological agendas such as the Natura 2000 that overlap with the regional agendas of the IJsselmeer and Flevoland, and the Amsterdam Metropolian Agenda. A mixed set of development orientations that can be synergetic when aligned towards convergent values to propose spatial/systemic interventions.

The research also revealed the interdependence of ecology and geomorphology - as the host physical environment for habitats to thrive. This important relation led to the understanding of water infrastructure as a terraforming force, that shapes and controls the highly dynamic deltaic condition. Also, this interdependency allows the understanding of what is truly nature, and what is closer to the garden, regarding the degree of human interference and management. In that sense, is possible to say that Flevoland, Markermeer and the IJsselmeer are currently a system of land-water uses related to food and housing. In an ecological perspective, being part of a large reclaimed almost exclusively human habitat.

Finally, the design brings to the discussion a future planned adaptation for the Blue Heart that adopts current initiatives as transformation leverages. The first step is the recognition of the Delta as a unified estuarine system, that is fragmented by water infrastructure. Then the release from the previous adaptation cycles starts with the adoption of local initiatives: the Marker Wadden, the fish migration project in the Afsluitdijk, and the objective to improve nature (applied to the Oostvarderplassen), also as a release from the current development paradigms. Then, gradually implementing a paradigm shift on water infrastructure and ecology in the territorial level, proposing buffered flooding defense systems that operate in synergy with a unified web of life. A mutual relationship that benefits from the natural capacity of land-water transitional habitats to naturally provide storm surge flooding safety to its inhabitants. After all, these ecological habitats that thrive under land-water transition are evolving for millions of years not only offering adaptation capacity but also an extensive set of agrobiodiversity. A node of life where humanity can be set in harmony.

Main research question:
What are the fundamental spatial and systemic synergies (A) between ecology, agriculture, and housing (B) to achieve an evolutionary nature-based climate adaptation (C) in Flevoland?

This research found that transportation infrastructure development and agrobiodiversity are key elements to create spatial and systemic synergies in between ecology, agriculture, and housing. Through the experimental design exploration of a new adaptive cycle based on the project of territorial composition and regional indeterminant deconstruction, the territory was analyzed in two perspectives: functional (food and housing) and conditional (ecology and water infrastructure). In that sense, territorial conditions guide the functions that are the vectors of development and transformation. To achieve an entry point towards the restoration of the Blue Heart, Flevoland became a case study on how to set a territorial goal that guide regional transformations. Furthermore, by setting the hierarchy of macro systems as ecology and flooding defense infrastructure, the trade-offs of both became evident as a fundamental spatial and systemic infrastructure x nature conflict perpetuates.

In that sense, the design step understood the endogenous agrobiodiversity of the Blue Heart as a pillar to start decomposing the paradigm of intensive arable agriculture while promoting a restorative action towards the global web-of-life.

Sub research questions:

(Q1) A + B = How can a long-term water infrastructure integration with natural systems (A) be coupled with land use transformations (B) ?

The coupling was achieved through a territorial planning towards an evolutionary system of ecosystem based adaptation process interpreted from the concept of Adaptive Cycles (Gunderson and Holling, 2002). The land use transformations were guided by a territorial intention, in a reflective planning system that was operationalized into a planning model as a synthesis of the design exploration.

(Q2) A + C = How can the integration of natural systems into water infrastructure (A) promote a long-term dynamic climate adaptation of the province of Flevoland (C) ?

The integration of natural systems into water infrastructure was achieved through the promotion of geomorphological alterations that can simultaneously create storm surge defenses, and recover the endogenous habitats adapted to these local conditions. The long-term and dynamic adaptation highlighted the importance of an incremental and reflective planning model, that can streghten natural and human safety across climate change.

(Q3) B + C = What potential land use spatial qualities that converge governance alignments (B) can be achieved with a restorative climate adaptation strategy (C) ?

It was possible to achieve a combination of gradients of agro-urban ecologies, interfaces that can guide intermunicipal and regional restorative development. The spatial qualities that emerge from these study, reveals that the spatial qualities of land use are based on a gradient of intensities. Regarding agroecological food production, population density, and infrastructure renew. The regional vision of STOOM and WARM has as indicators a set of agro-urban ecologies that create land use interfaces, recreational areas, and a gradient of urban-countryside identity

10. DISCUSSION

What is nature and where is humanity in it
In contemporary landscape and urban planning in the Netherlands the concept of building with nature is gradually implemented as a form of sustainable development. However, in the Dutch territory, especially in the Blue Heart, land use and water management set a clear boundary of natural dynamics - which are essentially borderless. In that sense, it is possible to read the Marker Wadden as a regional garden, that relies on constant water level management. A critical perspective that unveils the extent of our appropriation and harmful interference with ecology. Perhaps the problem is placing ourselves out of nature's domain - a set of complex interactions that may include as well climate change. In that sense, a more holistic building with a nature project will essentially mean working with territorial and global uncertainty, and dynamic change. In our sedentary society is no surprise that nature, which once provided us with food and shelter, became an enemy when the first cities and agriculture systems thrived. These are land use forms that cannot absorb change in nature's pace, leading to destruction and loss during climate fluctuations.

As discussed by Rossano, (2021) in the book Floodscapes, our relationship with nature is what defines our own narrative of flooding, which can be gradual, oscillatory, or disruptive. If flooding is the enemy kept under control through a robust infrastructure, the disruptive capacity of flooding becomes a reality solely due to a human failure (in planning, execution, or management of defense infrastructure). In the last 5000 years the SLR was around 120m, which implies that if we still plan for our presence on this planet for the next thousands of years, we must identify which paradigms will make sense in the long term. Not only regarding infrastructure adaptation capacity but also our role in which type of species we want to be. Currently, humanity is the dominant species on Earth, and the legacy of our rule in the global web of life is bringing immense harm.

In between wizards and prophets
In the introduction chapter of the book Taking the Country's Side by Sebastien Marot (2019), he introduced two contrasting perspectives on planning: the wizards and the prophets. On one hand, the wizards see hard facts as statistical tendencies and the role of science and technology to be the manipulation of reality to overcome history, postponing our limits of development. The prophets, on the other hand, focus on the limits that the wizards try to push and overcome, stressing that the carrying planetary capacity has boundaries. And for the prophets, pushing these boundaries can lead to a violent end. Hereby are two different perspectives on science and technology, which led to divergent paradigms of planning and development. While the purpose of science and technology for the wizards is to overcome nature, for the prophets is to live in intelligence with natural dynamics.

More than exploring and dissecting the dichotomy aspects of development paradigms, it is important to understand that we are often in a gray area of the wizard-prophet gradient. The climate-change urgency and new discoveries on natural and ecosystemic functioning, shed light on our capacity for adaptation, and on which side the gradient we want to be. Urgent adaptation measures are needed, which are costly, demand several years to execute, and have a vast socio-environmental impact. From a paleogeographical perspective related to the wizard-prophet metaphors, the Blue Heart Delta was always a place of dispute where science and technology overcame the transitional territorial condition of the delta. Guaranteeing human habitat safety for a period of almost 100 years to achieve the flourishing of a technologically and economically advanced society. However, at the cost of the thriving life ecosystem that can enable a more stable ecosystem-based adaptation capacity for the future. Here a paradigmatic change in development can open the opportunity to coexist with the deltaic geomorphology, its endogenous habitats and forms of life.

Toward multi-domain planned adaptation cycles

The planning of an evolutionary system of socioecological adaptation may indicate a path to re-orient development-driven vulnerabilities and harms that came from a long-term infrastructure lock-ins. At the same time that infrastructure renewal may be a development concern, it is also an opportunity to navigate through the wizard-prophet gradient. Making small steps towards a paradigmatic area that allows us to provide safety and wellness not only to ourselves but to the other organisms that coexist with us - such as natural and domesticated plants and animals.

The idea of a planned adaptation, which can take the form of a different range of frameworks as the adaptive cycles by Gunderson & Holling, (2002) may indicate a path of introducing small cyclical and planned changes on our position towards the planetary health. Being that a form of guiding the implementation of new forms of infrastructure that essentially respond to transformative values. The design step of this reveals that this can be an opportunity to guide development in socio-climate uncertainty, by allowing the constant reflection on past and planned cycles. In that sense, setting a step for the proposition of a planning system that is incrementally informed by how territorial conditions and functions relate to a set of relevant multi domain indicators.

11. REFLECTION

My choice for the Transitional Territories Graduation Studio was motivated by the studio's openness to explore spatial and systemic aspects of a diverse set of domains, allowing new ways of designing. In that way, I could fit my initial objective to work with food production landscapes, an interest that I carry since my bachelor's. Gladly, the studio's approach also made me realize that production landscapes is a topic of several interdependencies and that my initial interest in working with agriculture in Flevoland could evolve to ask more fundamental questions. This moment of expansion between P1 and P2 involved the elaboration of a nexus methodology between food, ecology, water infrastructure, and housing, which I considered the essential critical domains of Flevoland.

The elaboration of the nexus methodology and multiscalar research-by-design approach from the study plan opened a diverse range of domains and challenges to be tacked in the final design. Despite helping to understand complexity and uncertainty, to some extent, the approach opened so many possibilities for building a coherent single narrative that compromised the research focus over a few months. The problems with finding a clear narrative were related to the amount of complexity that could be managed and the experimental nature of the adopted research and design process. With the mentoring process, I gradually realized which topics and challenges were more fundamental than others. This allowed the setting of hierarchies, keeping the fundamental theoretical and personal values as subjective and qualitative guidelines. In an overall assessment, the nexus methodology and research-by-design approach worked, and perhaps it should have been more simplified in the beginning. I think that if the proposed frameworks were more based on fundamental questions with less theoretical density, they could have guided a more stable process of experimental research.

In that sense, the research was fundamental to the design proposal. Only after an extensive process of diverse types of analysis, I could gather enough information to finally define the territory as a unit of design. In the beginning, such an approach would rather seem too out of my scope, since I proposed to work with a regional scale limited to the province as an administrative unit. With research on the interdependency of geomorphology and ecology, I realized that the fundamental issue in the Blue Heart was the disruptions in that intersection of domains promoted by the pinned relationship between water infrastructure and land use. A relationship that unveiled the hidden deltaic narrative of this area, currently maintained as a freshwater reserve, intensive agriculture, and housing expansion. A territory that so critical that is even hard to see it as a single territory. Each one of its fragments has such a high degree of compartmentalization and socioeconomically relevance that they seems unrelated to its original deltaic transitionality and biodiversity. Especially considering the Blue Heart's extent on the national scale and amount of areas that depend on its maintenance.

The first steps of the design were carried out during the Honours Programme (HPM), where I shared the same topic and methodology as a form of the synergetic research laboratory in smaller scale (Pampus-Almere). The results showed possibilities of design that I did not consider initially, with allowed me to refine the research's direction, and assess the feasibility of new transformative actions in the territory. This intermediate step of the research unveiled the importance of this topic and area. Initial results were presented in the municipality chamber of Almere for an inter-university activity, and carried an extensive discussion about the relation of different domains and the new possibilities in design, governance, and infrastructure with an engaged group of students and professors from the University of Utrecht, Wageningen, and Leiden. Moreover, the collaboration of Paola Huijding, senior urban planner of Almere, in the research and design process of the HPM, brought valuable inputs of the current plans, discussions, and the importance of transformative forward-thinking.

As I move forward with the design, the essential values that aimed for a better planetary future for all set the boundaries of what could be considered more ethical ways of planning climate-response infrastructure. In times of environmental crisis, societies committed to a sustainable future started to impose actions towards animal wellness. In that sense, the apparent invisibility of the harm caused by the Zuiderzeewerken is a very relevant topic to set the extent of the role of values, narratives, and paradigms to achieve a sustainable future. The preliminary results indicate the possibility of the transferability of the research and design process to other contexts to unveil how a territory definition can guide regional development. Especially, if understanding that the nexus methodology and research-by-design approach are based on the local context. A new iteration of this process on the Blue Heart could implement a different set of nexus since the framing of operative domains also sets the limitations of the design. As an example, new questions that could emerge can be related to how the energy transition can be integrated into this territorial vision. And also in which moments a more collaborative way of designing can change the project, the perception of the extent of the territorial unit, and definition of the problems.

Due to the level of complexity, this graduation project expanded my horizons previously learned during the first year of the Master in Urbanism. The shared framework from the Transitional Territories Studio allowed the understanding of the diverse landscape and environmental systems that affect the urbanism practice. And the limits of design to achieve a project that deals with uncertain futures. Which I believe to be essential considering the time spans of urban projects, and the long-lasting impact of their outcomes. For the final stage of the thesis, the design step will focus on the finalization of the meso-micro scale interventions and the further elaboration of 2 regional visions based on gradients of the land-use interfaces. In that sense, providing a more comprehensive strategy and visualization of the ecological and food systemic relations, and the role of a reformed agricultural and housing land-use as mediators of this relationship.

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13. APPENDIX

A) Agro-Urban Ecologies: HPM Report

Alzate-Martinez, F. A. (2023). Agro-Urban Ecologies: Design of a climate-adaptive agroecosystem and urban expansion in Almere-Pampus. [HPM Honours Programme report, Delft University of Technology]. http://resolver.tudelft.nl/uuid:efa399b2-bdef-4e81-a469-390757a60f45

Agro-Urban Ecologies:
Design for a climate-adaptive agroecosystem
and urban expansion in Almere-Pampus

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Honours Programme Report
HPM Elements of productive urban greening

Supervisor: Victor Muñoz Sanz

Collaborator: Paola Huijding
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Faculty of Architecture
Master of Science Architecture,
Urbanism and Building Sciences

Track: Urbanism

March 2023

Abstract

This research explores the potential of urban design to fulfill the role of integrating the domains of ecology, food, and climate change to achieve long-term restorative goals. Also, the potential of urban design to be the operator of a dynamic coexistence with nature by acting upon the diverse layers of landscape infrastructure and embedded socioenvironmental systems. After establishing the theoretical foundations on the domain intersections, this research adopts a research-by-design methodology that aims to answer the question of how can urban design simultaneously operationalize the intersection of ecological restoration, climate adaptation, and food production through spatial possibilities in an exploratory case study. Divided in three steps, the case study exercise starts by a pre-design step, that aims to achieve a contextual problem definition; subsequently, the design step focuses on developing a program, proposals, and evaluation of the proposals; and finally, the post-design step establishes a synthesis of the projections and discusses the wider knowledge acquired during the process. Through a contextual analysis of the case study of urban expansion in the Netherlands (Almere-Pampus), it is revealed that territorial dynamics, the trade-offs between current land use, and also the political context of the site are intertwined with its landscape infrastructure, that is vulnerable to sea-level rise. Furthermore, by adopting local references of "building with nature" approaches, it establishes a projective design exercise to investigate the potential of answering the research question through the proposition of a renaturalization process grounded on an agroecosystem that functions on base of local habitats. The results of the research indicate the potential of endogenous forms of production and land use to coexist with natural dynamics and guide the spatial design of multifunctional backbones. Also, it reveals the possible agency of a reformed countryside to be part of a decentralized water infrastructure that guides renaturalization efforts, integrating local actors and agenda demands.

Keywords: urban design, research-by-design, agroecosystem, ecology, landscape infrastructure, Almere

B) Water Level Management overview IJsselmeer - Markermeer

Goossens, Lisa (2022). Effects of flexible water level management on flood risk in areas outside primary levees around the IJsselmeer and Markermeer. [Master's thesis, TU Delft Civil Engineering and Geosciences]. http://resolver.tudelft.nl/uuid:fbc068d5-6625-4939-ba5a-b1c88e67b22c

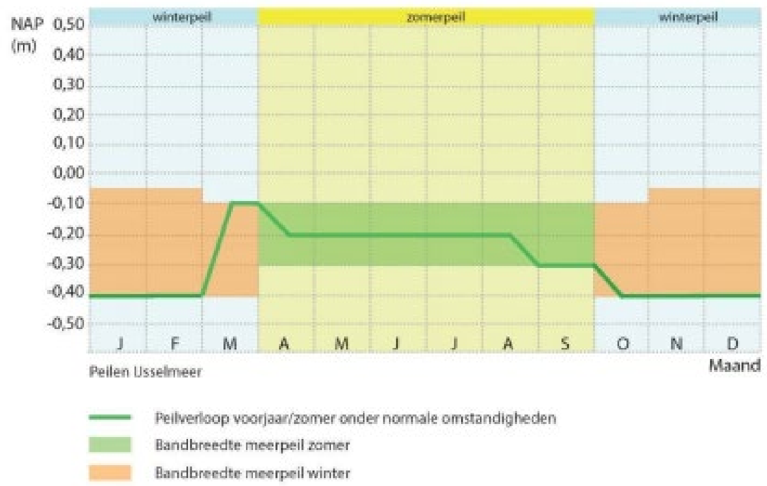

Figure 2.9: Target water levels and bandwidths for the IJsselmeer by applying flexible water level management (Rijkswaterstaat, 2018).

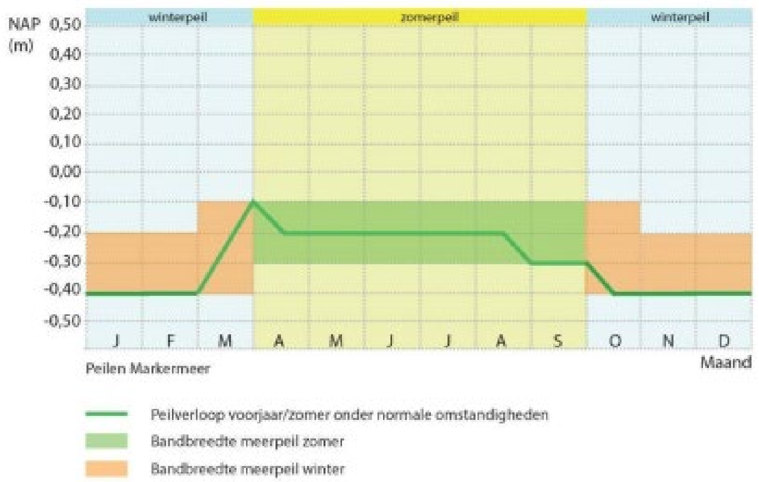

Figure 2.10: Target water levels and bandwidths in the Markermeer by applying flexible water level management (Rijkswaterstaat, 2018).

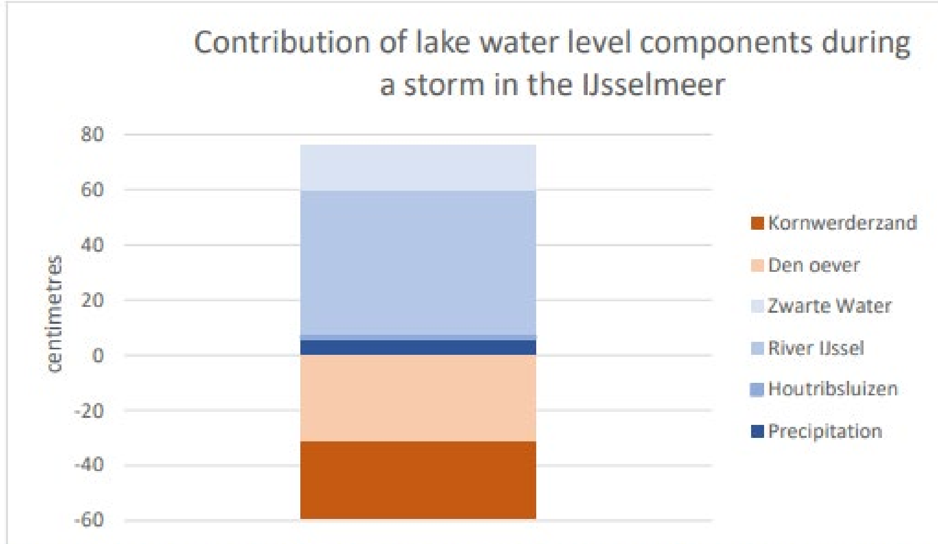

Figure 3.3: Contribution of lake water level components during an extreme weather event in the IJsselmeer.

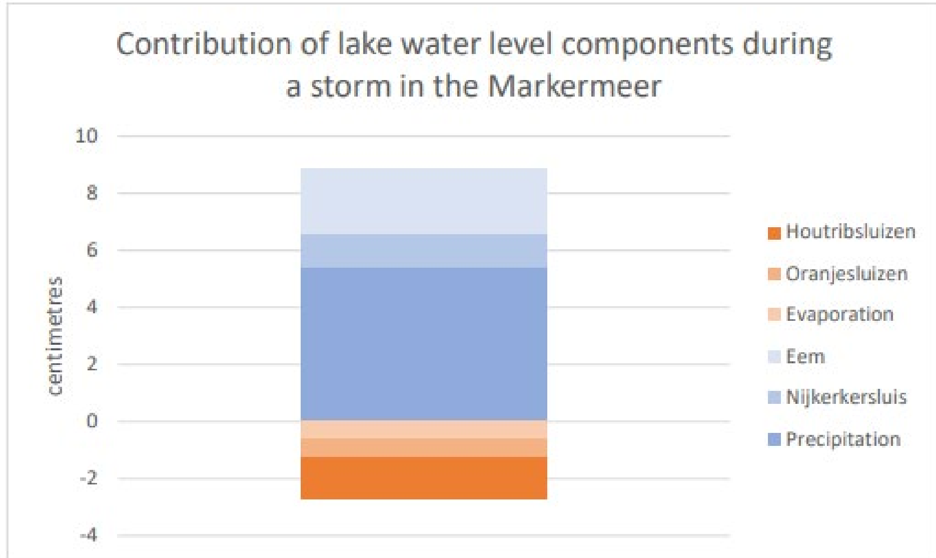

Figure 3.4: Contribution of lake water level components during an extreme weather event in the Markermeer.

C) Socioclimate Scenarios

H.A. Wolters, J. Hunink, J. Delsman, G. de Lange, G.J. van den Born, S. Reinhard, 2018, Deltascenario's voor de 21e eeuw, actualisering 2017,Achtergrondinformatie over gebruiksfuncties en sectoren, Deltares, Utrecht

KLIMAAT			Zichtjaar 2050 Deltascenario's 2017 (KNMI14)					Zichtjaar 2085 Deltascenario's 2017 (KNMI14)				*Ter vergelijking:* Zichtjaar 2050 Deltascenario's 2013 (KNMI06)			
scenario		REF'17	**DRUK**	**STOOM**	**RUST**	**WARM**	**DRUK-Parijs**	**DRUK**	**STOOM**	**RUST**	**WARM**	**DRUK**	**STOOM**	**RUST**	**WARM**
onderliggend KNMI-scenario			GL	WH	GL	WH	GL	GL	WH	GL	WH	G	W+	G	W+
temperatuurstijging	°C	0	1	2	1	2	1	1,5	3,5	1,5	3,5	1	2	1	2
zeespiegelstijging	cm	0	15	40	15	40	15	25	80	25	80	15	35	15	35
jaarneerslagsom	mm	851	+4%	+5%	+4%	+5%	+4%	+5%	+7%	+5%	+7%				
gem. neerslag winter	mm	211	+3%	+17%	+3%	+17%	+3%	+5%	+30%	+5%	+30%	+4%	+14%	+4%	+14%
gem. neerslag lente	mm	173	+5%	+9%	+5%	+9%	+5%	+8%	+12%	+8%	+12%				
gem. neerslag zomer	mm	224	+1%	-13%	+1%	-13%	+1%	+1%	-23%	+1%	-23%	+3%	-19%	+3%	-19%
gem. neerslag herfst	mm	245	+7%	+8%	+7%	+8%	+7%	+8%	+12%	+8%	+12%				
jaarsom pot. verdamping	mm	559	+3%	+7%	+3%	+7%	+3%	+3%	+10%	+3%	+10%				
pot.verdamping zomer	mm	266	+4%	+11%	+4%	+11%	+4%	+4%	+15%	+4%	+15%	+3%	+15%	+3%	+15%
herhalingstijd van een Rijnafvoer van 14400 m3/s *	jaar	1250	200	200	200	200	200	200	100	200	100	ca 1000	ca 400	ca 1000	ca 400
verandering gemiddelde jaarlijkse laagste 7-daagse Rijnafvoer *	%	0	+5%	-20%	+5%	-20%	+5%	+5%	-30%	+5%	-30%	+5%	-20%	+5%	-20%
herhalingstijd van een Maasafvoer van 3900 m3/s **	jaar	1250	300	300	300	300	300	300	100	300	100	ca 1000	ca 400	ca 1000	ca 400
verandering gemiddelde jaarlijkse laagste 7-daagse Maasafvoer **	%	0	+5%	-45%	+5%	-45%	+5%	+3%	-60%	+3%	-60%	+3%	-30%	+3%	-30%

SOCIAAL-ECONOMIE												
scenario		REF'17	**DRUK**	**STOOM**	**RUST**	**WARM**	**Parijs**		**DRUK**	**STOOM**	**RUST**	**WARM**
onderliggend WLO-scenario			WLO-H	WLO-H	WLO-L	WLO-L	WLO-H					
aantal inwoners	miljoen	17	19	19	16	16	19	voor 2085/2100 geen WLO-scenario's beschikbaar	20	20	15	15
omvang BBP	miljard €	600	1320	1320	940	940	1320		1600	1600	900	900
economische groei	%/j		2	2	1	1	2		2,5	2,5	1	1
stedelijk gebied	% opp	18	20	21	18	18	20		23	25	21	21
natuur en recreatie	% opp	23	26	25	24	24	27		22	20	20	19
landbouw	% opp	60	54	54	58	57	53		51	51	56	56

D) Space Syntax (QGIS) analysis of connectivity of potential accesses classified into primary, secondary, and local streets.

(By Author)

This study aims to access the road hierarchy vocation of current infrastructure network. The difference on achieved connectivity and existing road hierarchy may indicate pathways for a dynamic infrastructure redevelopment. It also may reveal the extend of the impact of the not finishing the original plans for the Markerwaard. For example, Lelystad was supposed to be in the center of an extended urban fabric towards the Markermeer (in the Markerwaard's urban fabric), got enclosed in a land-water edge, with poor connection with Almere.

E) Stakeholder participation in regional envisioning goals

Stakeholder participation in regional envisioning goals diagram. (By author interpreted from: cross-scale, cross-level and multi-actor governance *Allen et al., 2023*)