# AGRO-URBAN ECOLOGIES

## Design of a climate-adaptive agroecosystem and urban expansion in Almere-Pampus

Fabio Alberto Alzate Martinez

TU Delft Urbanism, HPM Report

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

Fábio Alberto Alzate Martinez 5510406

Honours Programme Report
*HPM Elements of productive urban greening*

Supervisor: Victor Muñoz Sanz

Collaborator: Paola Huijding
*(Projectdirecteur, Senior stedenbouwkundige*
*Gemeente Almere)*

*Technische Universiteit Delft*

*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*

Gemeente Almere

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# 1. INTRODUCTION

Urban design is becoming increasingly interdisciplinary, especially when dealing with the anthropogenic degradation of natural systems. The role of humanity as a harmful geological force that alters the environment and living systems is vastly acknowledged (Monastersky, 2015). Anthropogenic biophysical and ecological degradation is systemic, cultural (Gardiner, 2008), and present in diverse scales of natural and urbanized landscapes. And to promote non-exploitative forms of coexistence with nature, the coupling of ecology with the new models of economy, social relations, and culture is fundamental to achieving long-term goals and restorative transformations in landscapes.

As a coupling agent, urban design can be a fundamental discipline to achieve restorative goals, fulfilling its potential as an intersection of the design disciplines that act in the transformation of the built environment (Waldheim, 2009). This role has been explored under the theory of landscape urbanism, moving forward from a previously idyllic ecological narrative toward the understanding that the landscape is a type of infrastructure. And furthermore, the landscape and its embedded socio-environmental systems become the ordering mechanisms of urban design by integrating spatial and ecological relationships (Waldheim, 2016).

Following the reading of the landscape as infrastructure, urban design discipline emerges as a field with the potential to integrate climate adaptation and ecological restoration. The failure of climate change mitigation, mostly related to the impediments in changing carbon and energy-intensive models of development (Stoddard et al., 2021), sets an urgent demand to explore spatial and organizational alternatives for climate adaptation. Recently, strategies to couple climate adaptation with the restoration of natural systems are being broadly explored under the principle of nature-based solutions (NbS).

The core of NbS is the understanding that natural ecosystems are active systems in climate response, especially when synergized with development objectives (Malhi et al., 2020). Therefore, implementing green-blue ecosystems into a multipurpose landscape infrastructure can improve the climate resilience of cities, liveability, and quality of public spaces, setting an opportunity for new types of social relations with the landscape. In this intersection, urban design can provide new perspectives on governance and socio-environmental cohesion, those being common challenges of the implementation and success of NbS (Kabisch et al., 2016).

Additionally, the designing of a landscape infrastructure that provides climate adaptation and the expansion of ecological networks also has the potential to explore new forms of sustainable food production landscapes. Agricultural activity, especially since the Green Revolution in the 20th century, has stressed and pushed the limits of the natural environment by introducing intensive chemical and physical alterations on soils and water systems. 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 held by agroecosystems (Holt-Giménez & Altieri, 2012).

Therefore, the integration of food production into the design of landscape infrastructures can create spaces for regenerative forms of food production. Then, reducing the biodiversity trade-offs of food production by promoting farming practices that enhance soil health, biodiversity, and ecosystem services (Power, 2010). These regenerative practices can be integrated into larger ecological strategies for climate adaptation, creating opportunities for community engagement and regional sustainable economic development, by for example being part of the objectives of a sustainable city-region food system (Foster et al., 2015).

The aim of this paper is to set paths on *how urban design can be integrated with ecological restorative and climate-adaptive food production*. To answer this question, a contextual design framework is synthesized from the theoretical foundations of food landscapes and the territorial particularities of an exploratory case study in the Netherlands. Furthermore, the design framework guides a research-by-design method to unveil spatial and systemic typologies. Finally, the assessment of the typologies provides a discussion about the potential of an integrative approach through urban design able to operate within ecological, food production, and climate adaptation domains.

# 2. THEORETICAL FOUNDATIONS ON FOOD AND URBANISM

## 2.1 Literature review

While the challenges of ecology and climate change are well known and recognized, current spatial development and policies do not integrate simultaneously food and nutrition with ecology as a fundamental interdependency (FAO, 2021). The intersection between food, biodiversity, and climate change is essential to guarantee the capacity of food systems to provide Food and Nutritional Security (FNS) across climate change futures and uncertain natural dynamics. FNS is achieved when physical, social, and economic access to food is guaranteed by providing safe, sufficient, and good quality food to meet dietary needs and food preferences, supported by adequate sanitation and health services (USCN, 2013). The systemic and spatial aspects of FNS become evident as the fulfilment of its objectives is intrinsically related to the capacity of landscapes to maintain the safety of the production of food, the reliability of logistics and consumption networks, and other livelihood elements such as the provision of housing and public spaces.

The intrinsic spatial relation between food and landscape also reveals the fragility of our food systems. Humanity's main calorie intake relies on the most produced types of staple food, which increases the pressure on productive landscapes. The staple food is the main source of energy and nutrients in a population's diet (National Geographic, n.d.), and often is characterised by having high caloric density. Although there are over 50,000 edible plants on the planet, only 15 of them generate 90% of the world's calorie intake according to estimates by the Food and Agriculture Organization (FAO) of the United Nations. Two-thirds of the world's caloric intake is mostly provided by rice, corn, and wheat, also with significant consumption of millet, sorghum, potato, cassava, yams, taro, beef, and fish.

The susceptibility of staple food crops to climate change conditions and pests (Oerke, 2006) reveals a systemic fragility of global food systems. The maintenance of the large-scale production of common staple foods demands an increasing utilisation of pesticides, fertilizers, soil management, and genetic technology to increase productivity to attend to global demand, far beyond endogenous boundaries of production. That often leads to ecological and soil degradation, and therefore climate vulnerability. Moreover, the global operation of food systems is also related to the decline of the nutritional quality of produced staple food, which combined with the climate change threat, poses severe complexities to achieving a sustainable and long-term FNS.

And to achieve a sustainable FNS, biodiversity can become a powerful ally by reducing the climate and nutritional fragilities of our food system. Millions of years of adaptation to several types of extreme natural environments created a rich genetic diversity of wild relatives of modern cultivated staples (Gruber, 2017). The rich biodiversity of staple food species is expressed in an immense collection of valuable traits with the potential to improve the nutritional quality, ecological integration, and climate adaptability of modern crops. Furthermore, biodiverse-rich food production can be integrated with structural ecological restorative projects and climate adaptation solutions. However, a sustainable relationship between the production of staple food with its endogenous productive landscape is maintained by the capacity of local and regional species to synergize with the surrounding ecosystem, which often faces degradation promoted by agriculture.

Over the last three decades, several publications have explored the integration of food systems with their landscapes with the term "foodscapes." However, there is no consensus on these approaches, which are commonly divided into spatial, social and cultural, behavioral, and systemic (Vonthron et al., 2020). To include the domains of these approaches into a more integrative reading of food landscapes, there is a need for a multi-domain and operational understanding of the integration of food and landscapes, particularly in light of uncertain climate conditions such as sea-level rising (SLR) and the role of different stakeholders to plan cohesive regional strategies.

As a result, there is an increasing interest in research about approaches that integrate climate change, landscape, food, and multi-actor and cross-scale governance. Recent publications in landscape approaches aim to set strategies for climate response and sustainable development by integrating policies, multiple stakeholders, and land use towards achieving sustainable development, potentially including the attendance of SDG objectives (Mbow et al., 2015), the reconciliation of biodiversity conservation with agriculture (Sayer et al., 2013), and the potential synergies with productivity and market access (van der Horn & Meijer, 2015). Also, several studies indicate that the operability of a food system on a regional scale can minimize the environmental trade-offs and guide landscape governance (CDI advisory et al., 2020; FAO & RUAF, n.d.; Foster et al., 2015).

Therefore, the intersections of climate, food, and ecology within landscapes can become operable in the field of urbanism. Especially when considering that land use planning in different scales (Campanhola & Pandey, 2019; Sayer et al., 2013) and stakeholder engagement are central to achieving a sustainable landscape, and meeting long-term climate adaptation goals (Field et al., 2014). Despite the intersections of climate and ecology in the landscape urbanism theory and practice, the incorporation of food into a multi-scale and multi-domain urbanism framework that guides the design of the landscape infrastructure is still missing.

According to Cabannes & Marocchino (2018), the incorporation of food into urban planning can allow urban planners to address the food and nutritional security challenges; the new definitions and understandings of "urban" in an urbanizing world; the environmental and climate transitions; and the accessibility of food-related land. Still, according to the authors, the literature on the integration of urban planning and food is very limited, and the few examples of best practices in urban planning lack visibility and reflections on their limits and success. And while the integration of food into the design of the urban fabric has been explored typologically in urban agriculture frameworks (Goldstein et al., 2014; Verzone et al., 2021), urban planning and design approaches do not address the transformative potential of the intersection of food, urbanism, and governance with climate and natural dynamics.

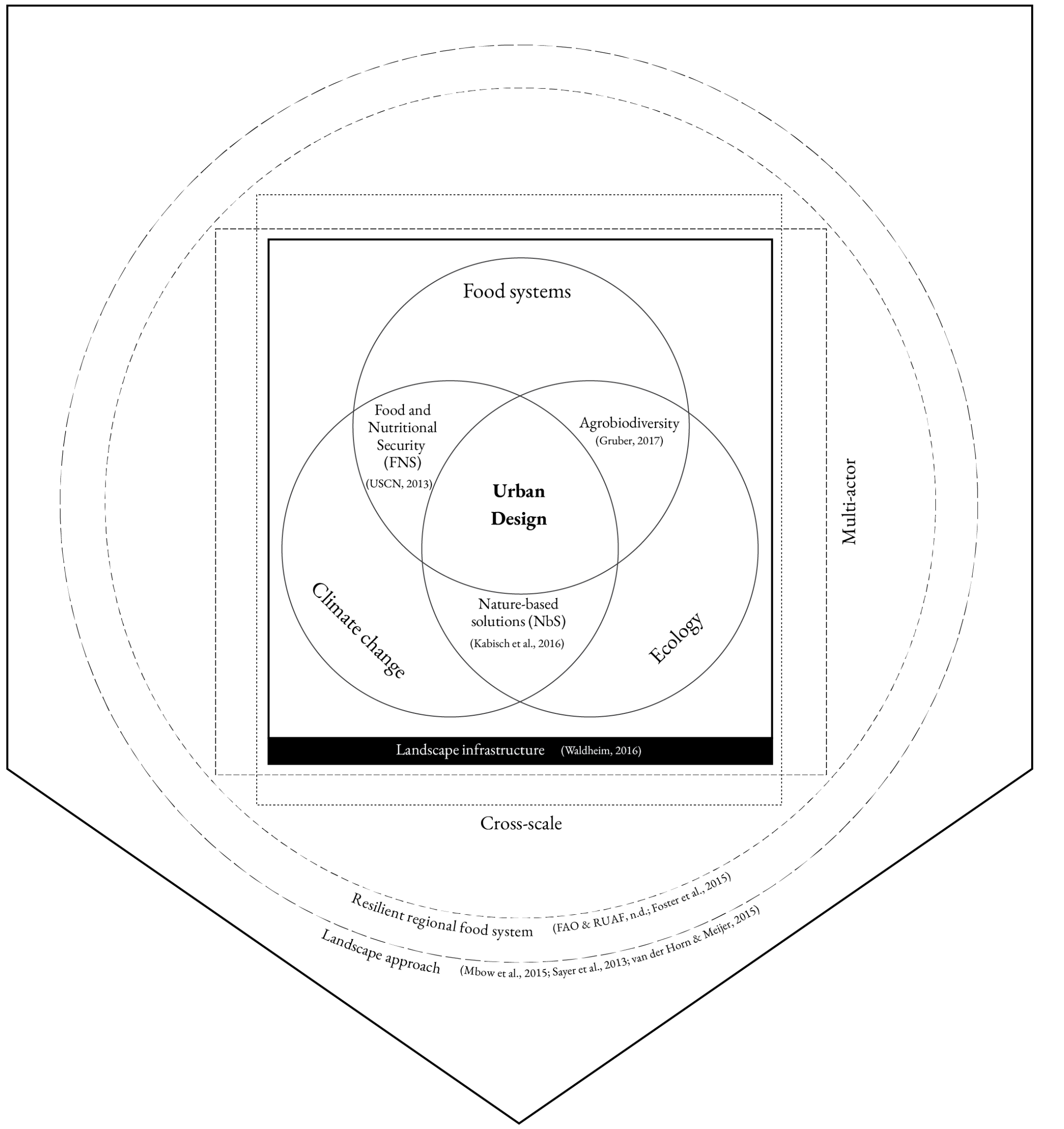
In urban theory history, the perception of urban form through the spatial structure of agriculture has been the core of the theory of agrarian urbanism since the beginning of the last century. According to Waldheim (2010), those urbanists assumed that cities would remain decentralized and that the landscape would become the primary medium of urban form. Frank Lloyd Wright's "Broadacre City" (1934–35), Ludwig Hilberseimer's "New Regional Pattern" (1945–49), and Andrea Branzi's "Agronica" (1993–94), and its further development, "Territory for the New Economy" (1999) incorporated agriculture into the development of a suburban landscape that connected urban infrastructure, agricultural and industrial landscapes.

As Waldheim indicates, the legacy of agrarian urbanism can reveal the cultural and paradigmatical dimensions of the agricultural influence in urbanism (Waldheim, 2010). Furthermore, by engaging in those dimensions through design, urbanism can act in the promotion of cultural and paradigmatical transformations around food. And these transformations can become operational by designing in the overlapping behavioral, economic, and infrastructural influences that shape productive landscapes. And by designing through this overlapping is possible to achieve an integrated territory that responds to cross-scale climate and environmental agendas within a city-region food system (Foster et al., 2015).

In the literature review presented, it is revealed a missing gap in an integrative approach in the field of urban design that acts upon ecology, climate response, and food production. Furthermore, it is indicated that this is a relevant intersection due to its potential to operationalize diverse cross-scale and multi-actor spatial transformations, addressing ecological restoration, FNS, and climate adaptation measures through the hybridization of multi-purpose landscape infrastructure.

In that sense, to face the aforementioned complexity, this research paper aims to answer the research question: how can urban design simultaneously operationalize the intersection of ecological restoration, climate adaptation, and food production?

## 2.2 Theoretical framework



Research Question

How can urban design simultaneously operationalize the intersection of ecological restoration, climate adaptation, and food production?

**Figure 1.** Theoretical framework

*Note:* Synthesis of literature review regarding the intersection of urban design with food systems, climate change, and ecology, as basis for the Research Question, by author.

# 3. METHODOLOGY

## 3.1 Approach and methods

The future complex challenges and interactions in ecology, climate change, and food production, design are "wicked problems" (Rittel & Webber, 1973), which means that they have no final solution and requires continuous projective directions towards a desirable future. In that sense, to answer the research question, a methodological approach of research-by-design was selected due to its capacity to explore complex intersections of domains by inquiring and projecting.

Through a combination of analytical, projective, and synthesis steps, the research-by-design method adapted from Roggema (2016) aims to explore desirable spatial possibilities in an exploratory case study location (Yin, 1984). The research-by-design process is divided into three explorative steps that are embedded in the local, cultural, and political context of the case study (Figure 2):

1 - Pre-design step: focuses on the development of theoretical foundations, contextual analysis of the case study, and problem definition;
2 - Design step: aims to develop a program, proposals, and evaluation of the proposals;
3 - Post-design step: establishes a synthesis of the projections and discusses the wider knowledge acquired during the process and its social impact.

These steps guide the research project towards the elaboration of operational frameworks for the case study area, to achieve evaluated proposals which will be the basis of the final discussion.

## 3.2 Methodological framework

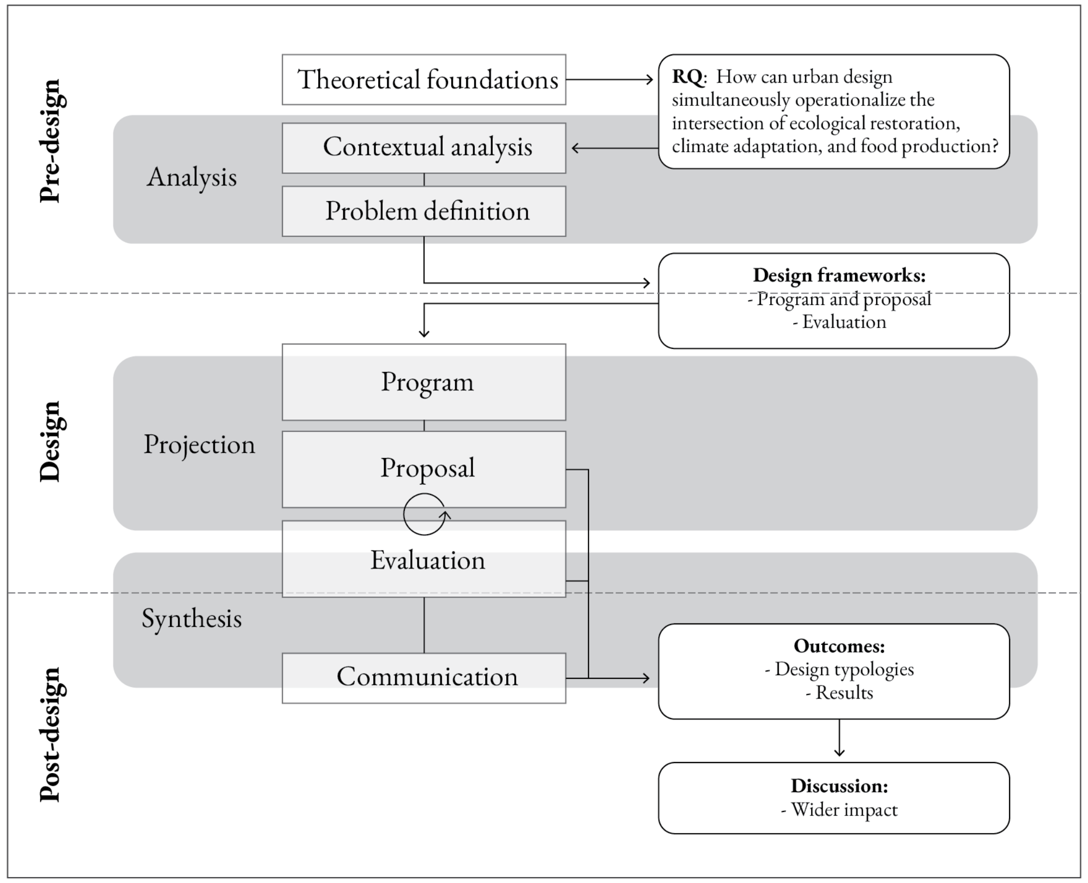


**Figure 2.** Methodological framework

*Note:* Adapted from Roggema, R. (2016). Research by Design: Proposition for a Methodological Approach. 1(1), p. 8 (https://doi.org/10.3390/urbansci1010002).

# 4. CASE STUDY ANALYSIS: ALMERE-PAMPUS, THE NETHERLANDS

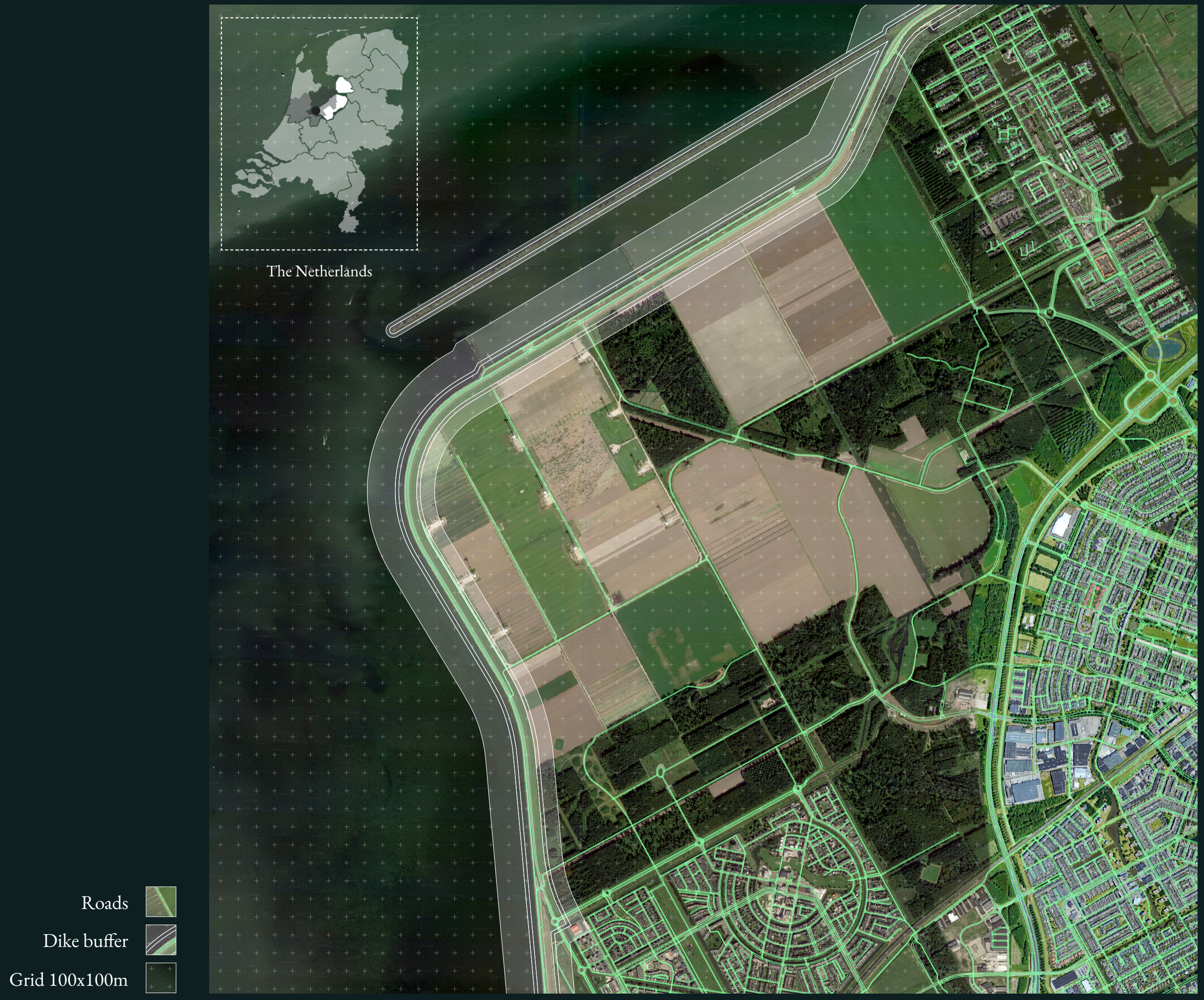


**Figure 3.** Almere-Pampus location map

*Note:* Location map showing access roads and buffer area of dike infrastructure. By author, using the software QGIS 3.16. Datasets: Keringen waterschappen IMWA, Nationaal Wegen Bestand (NWB), Google Earth

Almere-Pampus is an area located in the municipality of Almere, part of the Province of Flevoland, and included in the Amsterdam Metropolitan Area (Figure 3). Currently, Almere-Pampus is mostly used as a productive landscape (agriculture and wind energy) with ecological areas that are protected under the National Ecological Network. However, the area is in imminent transformation, since it is a strategic area for the expansion of Almere and Amsterdam, especially in order to answer to the Dutch housing crisis. Almere-Pampus also is a crucial area for ecological restoration agendas, since it borders the Markermeer, which faces severe ecological problems that are related to the water infrastructure boundaries. The infrastructural-drivel ecological degradation is one of the causes of the lack of biodiversity in the Markermeer, since the hard edges of the dikes that surround the lake hinder the ecological succession in the water-land transitions, a problem observed in the Zuiderlijk Polder where Almere-Pampus is located.

Beyond the ecological challenges of the water infrastructure in Almere-Pampus, sea-level rising (SLR) poses an increasing threat to the operability of the landscape infrastructure of the area, which was reclaimed from the former Zuiderzee at the beginning of the 20th century. Therefore, this case study was selected due to its intersection of cross-scale governance demands, ecological restoration objectives, productive landscape characteristics, and housing objectives that overlap with Almere-Pampus's climate-vulnerable landscape infrastructure.

## 4.1 Agriculture, urbanism, and pressures in the Dutch context

In the last decades, a growing number of publications attempted to integrate food production with policy-making and urban planning in the Netherlands. For example, by exploring the role of nutrition on spatial planning set on studies on the protein production impact made by the independent agency Netherlands Environmental Assessment Agency (PBL), in which land-use and carbon footprints of animal food products were assessed (Nijdam et al., 2012). And furthermore, in the context of the housing demands of Almere, the development of Almere-Oosterwold is an example of the integration of agriculture into urbanism by placing urban designers and planners as coordinators of interdisciplinary operations (Jansma & Wertheim-Heck, 2021).

The Oosterwold Master Plan dedicates 50% of Oosterwold as an urban agriculture area and responds to the city's demand for 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 urban agriculture as one of the means to achieve its planning goals, promoting more functions to the city than just food production, which is made explicit in the Almere 2.0 Master Plan statement that city and agriculture form a contemporary combination that mutually reinforce each other, by making the city greener and more sustainable (Almere, 2009).

The new experiments of urbanism and food in Almere are part of a long-lasting tradition of development models that have agriculture as an essential component. The effervescent research and practice interest in food systems is a core element of the spatial development in the Netherlands, known worldwide for its food economy, exporting 9.6 billion euros worth of horticultural products in 2020, and 104.7 billion euros in agricultural goods in 2021 (CBS, 2022). In this context, to achieve cost and land efficiency to operate in the global food system, there is a fast-paced adoption of automation and high-end data-driven production technologies, which are increasingly becoming a core element of the Dutch agri-food systems. As indicated by Sanz et al. (2018) farmers have gradually become entrepreneurs and off-site managers, with fewer and more specialized employees, in a process that has efficiency, corporate interest, finance, and government policies as main drivers. Still, according to the author, the outcome of it is an ever-changing and problematic automated landscape, and its patterns of intense capital-oriented production reflected in the spreading megafarms and greenhouses across the Netherlands. In that sense, posing a challenge to achieve a sustainable countryside identity, in light of the challenges of animal wellbeing, the lack of cultural integration, and the high demand for energy from the automated landscapes. Therefore, this type of agro development also poses challenges to achieving sustainable food production that is endorsed by European and International agendas.

A transition towards a sustainable local and regional food system is strongly supported by international organizations and agencies, such as the FAO (FAO & RUAF, n.d.), and the IPES-FOOD (IPES-Food, 2022). Also, it is one of the main strategies of the European Green Deal, known as Food to Fork. This strategy aims to transform the European food systems towards a sustainable activity by ensuring sufficient, affordable, and nutritious food within planetary limits, reducing by half the use of fertilizers and pesticides, increasing organic farming, promoting sustainable and healthy diets, improving animal welfare, and reducing food loss and waste. It also aims to minimize import dependence and promote sustainable, climate-resilient food systems (Farm to Fork Strategy, n.d.).

Recently, the Dutch nitrogen reduction measures revealed this supranational pressure on achieving sustainability goals, especially due to the nitrogen deposition sensitivity of the Natura 2000 areas. The exceedance of nitrogen can cause chemical degradation of the soil and eutrophication of water, imposing barriers to achieving biodiversity and ecological restoration. And as one of the main causes of nitrogen emissions, the Dutch agricultural sector is being constrained by national legislation (Kros et al., 2015). In that sense, the recent farmer's protest (Figure 4) and changes in the agricultural land-use structure are an example of the effects of this constraint and may be an indicator of the sociocultural role of the achievement of these agendas, which must ideally be integrated into a landscape cross-scale and multi-actor transformation. In Almere-Pampus, this is especially relevant considering that the environmental policy pressures overlap with subsidence and compactation of clay (Figure 5), a combination that limits traditional urban expansion, and agricultural innovation.

**Figure 4.** Farmers' protest against nitrogen reduction policy (2019)

*Note:* The farmers' protests against the nitrogen reduction policy sparked in 2019, 2020, and 2022 by a government proposal to reduce agriculture's nitrogen emissions and deposition on Natura 2000 areas. Dutch news media have reported that the new policy can lead to the closure of about 30 percent of livestock farms in the Netherlands. Source: www.anp.nl

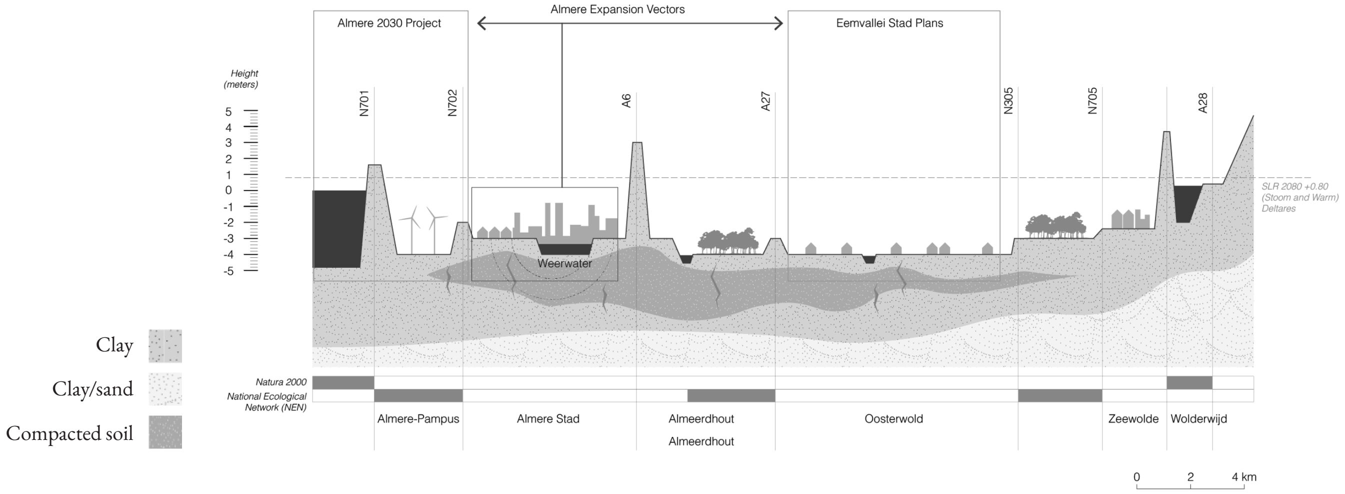


**Figure 5.** Section of Almere's expansion areas.

*Note:* Overlapping of agendas and biophysical pressures. By author.

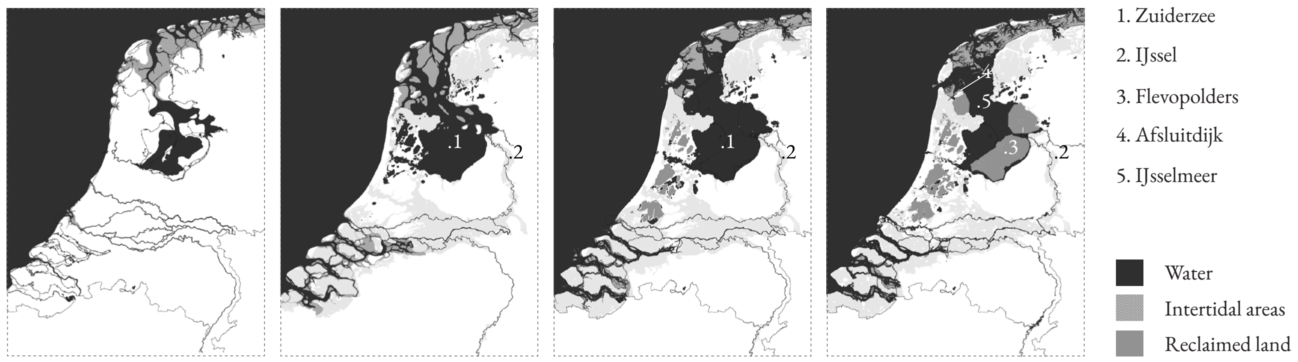
## 4.2 A reclaimed landscape infrastructure territory

Moreover, the sociocultural role of the landscape transformations is embedded with the historical process that formed the territory of the Province of Flevoland. Almere-Pampus, and the whole Flevoland, is located on the bottom of the former Zuiderzee, a brackish water tidal estuary that connected the IJssel River with the North Sea (Figure 6). Due to its deltaic condition, the Zuiderzee was a dynamic natural system prone to high tide variation, strong sedimentation, and storms (Havinga, 1954), that severely affected Dutch settlements on its borders. A series of flooding events culminated in the evacuation of Schokland in 1859, which accelerated the plans for reclaiming the area in order to provide a water defense strategy against disruptive water dynamics. With increased support, several projects were made, and finally, the project from the engineer Cornelis Lely was chosen to be executed. Lely's plan consisted of the enclosure of the Zuiderzee from the North Sea, through the construction of the Afsluitdijk. Moreover, it proposed the construction of five polders in shallow areas around the coast of the Zuiderzee mostly composed of marine clay, a highly fertile type of soil.

In 1886 a group of prominent citizens formed the Zuiderzee Association with the objective to fund the research and design of the Zuiderzee reclamation, and after years of debate, the Zuidezeewerken officially started in 1918 when Zuiderzee Act initiated execution of Lely's plan. Heavy steam-powered machinery was used for the reclamation work, and for decades the dams and polders were built, marking the last stage of the long-term Dutch tradition of land reclamation (Hoeksema, 2007). The enclosure of the Zuiderzee from the North Sea converted the sea into the freshwater lake IJsselmeer which currently is an important freshwater reserve. Hence continuing its original designation, that according to Hofstee (1954, p. 292) was to serve as a reservoir for the IJssel discharges and to safeguard freshwater for agriculture irrigation and drinking water.

The intensity of land use of the reclaimed polders was influenced by the food security crisis across Europe after WWII. In this context the minister Sicco Mansholt carried out the motif of "never hunger again", designating a highly intensive economically-oriented agricultural development in the reclaimed polders. The fundamental role of agriculture is present in all the polders, that along the reclamation process were improving their agricultural efficiency and management technologies. The first polder to be reclaimed was the Noordoostpolder, structured in continuity with inland areas. Later, due to the water management problems that originated from the polder's inland continuity, the next polders were isolated from the coastal area, surrounded by water bodies denominated border lakes.

To prepare the land for further agro-urban development, innovative agronomic technologies were employed to prepare the soil for agricultural production. For several years, special varieties of plants were cultivated to drain the marine clay. Innovative agronomic techniques were used to fixate nitrogen and nutrients in the soil, and together with intensive soil management, the reclaimed land flourished in an export-oriented global agriculture system that characterizes the Province of Flevoland. However, the final stage of the reclamation, the construction of the Markerwaard, was never completed. The final polder was destined to provide new agricultural, urban, and recreational lands, and the location for a new national airport. The area remained as a freshwater lake known as Markermeer, and in 1991 the government decided to not reclaim the Markerwaard, putting an end to the dike and drain approach to land reclamation in the Netherlands (Hoeksema, 2007).



100 AD 1500 AD 1850 AD 2020 AD

**Figure 6.** The formation and control of the Zuiderzee

*Note:* By author, using the software QGIS 3.16. Dataset: Paleogeografische kaarten

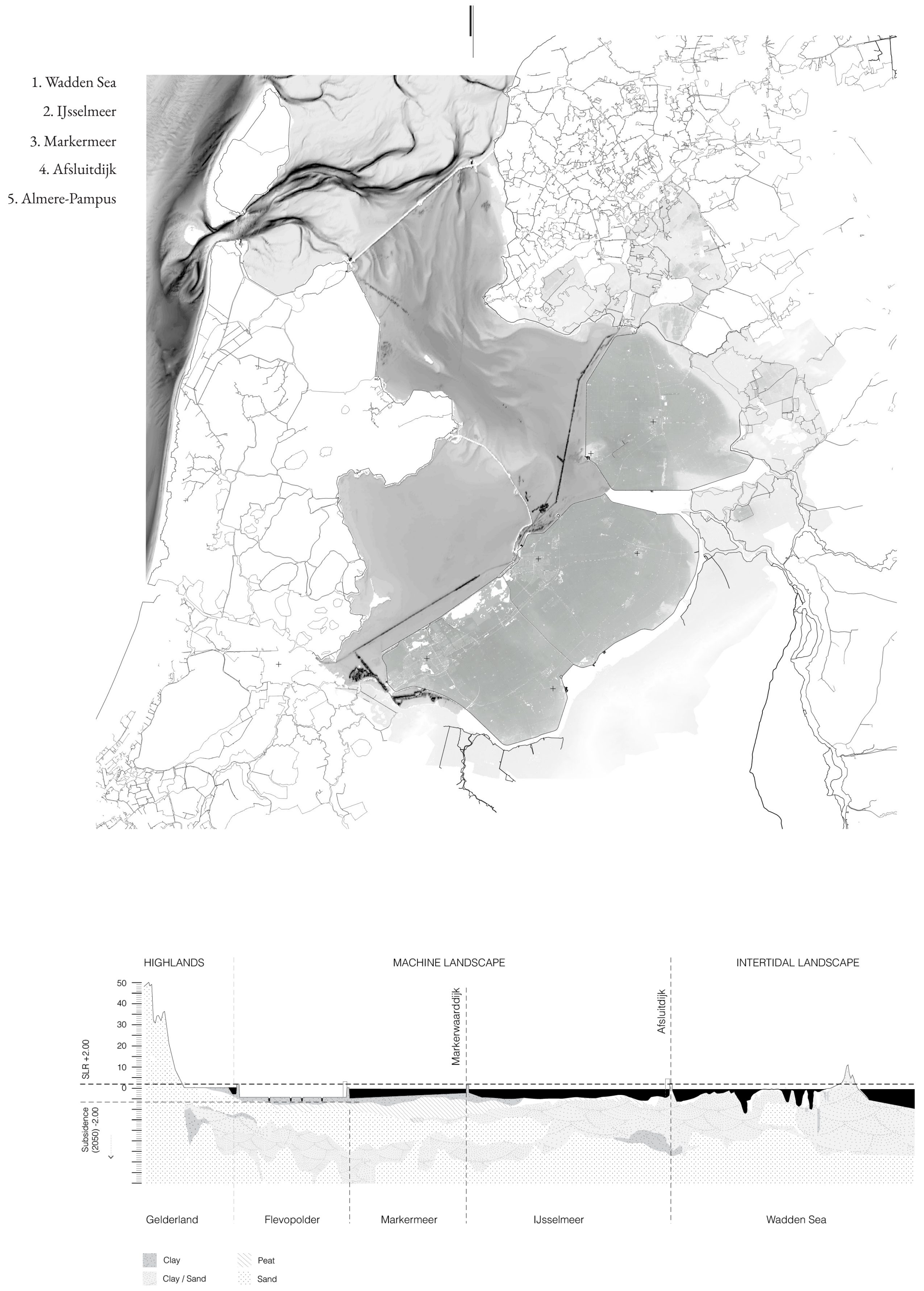


**Figure 7.** Map and section of the IJsselmeer-Markermeer-Flevopolders territory

*Note:* By author, software QGIS 3.16. Dataset: EMODnet Bathymetry, AHN-3, Esri Topobathy, Keringen watershappen IMWA.

## 4.3 Pressures and limits of ecological restoration

The reclamation process led to disruptive and long-lasting ecological degradation starting with the destruction of the rich Zuiderzee brackishwater ecosystem (van Vierssen & Breukelaar, 1994). As multiple ecological reports indicate, the perpetuation of the lack of biodiversity in the lakes is a general consequence of the absence of ecological succession and habitats in the water infrastructure borders between the reclaimed land and water. Moreover, the land-water transition in the context of Almere-Pampus also faces the specific ecological challenges of the IJmeer and Markermeer, which have suffered from sludge accumulation, leading to ecosystem problems and a decrease in water quality. These issues have been exacerbated by the pressures of the European environmental agendas, considering that the border lakes are important protected areas of the Natura 2000 and the National Ecological Network. Therefore, the ecological restoration of those lakes became a crucial topic of regional spatial agendas, such as the IJsselmeer 2050 Agenda, the Flevoland 2050 vision, and the Amsterdam Metropolitan Area agenda.

Besides the ecological degradation of its context, Almere-Pampus also faces the problem of soil subsidence, which was a problem as soon as soil was reclaimed. The intense management practices of agricultural activities and increasing urban expansion led to the further compaction of the marine clay, which affects the landscape's infrastructural stability. Therefore, compromising water infrastructure systems, ecological habitats, housing areas, and agricultural lands.

## 4.4 A paradigmatical climate vulnerability

The Zuiderzee reclamation is part of the long history of Dutch water defense, which is based on the traditional approach of controlling nature to reduce the flooding probability of important socio-environmental areas. The historical development of a sophisticated water infrastructure composed of dams, dikes, and reclaimed land was, and still is, the main technological answer to the continuous disruptive flooding events that severely affected settlements and social stability. Nevertheless, considering the unpredictability of SLR, and facing the deltaic geography of the Netherlands, defending against water seems to be a Sisyphean task. And more critically, the fragility of this paradigm is revealed by the role of water defense infrastructure as the main responsible for the assurance of the stability of agro-urban systems and their embedded sociocultural dynamics. In light of a climate adaptation framework (Preston et al., 2013), this condition pushed the operability of those systems towards an unsafe boundary when facing extreme climate events and natural dynamics.

Due to the SLR, a renewal of the water infrastructure is being carried out in Flevoland, including the Zuidelijkde Flevopolder, where Almere-Pampus is located. The polder dikes and the Afsluitdijk are being updated with new safety standards for future SLR scenarios. 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. Hence, a paradigmatical shift to increasingly adopt planning strategies for reducing flooding consequences may allow continuous cycles of adaptation to the natural dynamics of natural water systems. The designing of these new systems may relieve the social-economic-environmental pressure on flooding prevention infrastructure, increase possibilities of ecological integrations, guarantee the safety of the human and ecological systems, and heal the negative value of water and natural dynamics.

In that sense, while the flooding defense infrastructure is focused on reducing the probability of events, the disruption of the agro-urban systems and their related human activities by a flooding event will be conditioned to be an infrastructure maintenance failure or an underestimation during planning stages. As Rossano (2021) indicates, the narratives of flooding were present since the early stages of humanity, and their concrete outcomes on one hand produced the catastrophic myths, and on the other hand brought the question of how humans adapted to the 120m in SLR between 15000 and 5000 BP. From a historical perspective, due to a technological lock-in, the narrative of the dutch flooding is conditioned to be catastrophic, while gradual and oscillatory narratives may allow different forms of climate adaptation to SLR for the next centuries to achieve coexistence with nature through a reformed culture and values towards the water.

## 4.5 Towards a new Dutch tradition of designing with natural dynamics

In alignment with the promotion of new relationships between man and water through a landscape ecology approach, the Dutch practice in landscape architecture and urban planning is exploring innovative forms of water management and land use. In the small but socioeconomically intense territory of the Netherlands, the understanding of the different layers that compose the built environment is fundamental in the design process. Spatial interventions often affect several systems that share the same landscape, such as water infrastructure, energy, urban areas, networks of transportation, and nature. Traditionally, the Dutch layers approach identifies the importance to analyse the relationships of the substratum layer (ondergrond), composed of the abiotic, biotic, and water system; the network layer (netwerklaag), composed of the traffic, energy, and green networks; and the occupation layer (occupatielaag), composed by the urbanization patterns. Regarding the organization of these layers, some authors argue about the limitations of this tool due to its operational ambiguity and inconsistency (Hagens, 2006), and inefficient integration with spatial planning (van Schaick & Klaasen, 2011).

In the contemporary landscape-based urbanism practice and research, new forms of the layering method provide a valuable tool to unpack complex systems and subsystems. Not as a static or hierarchical arrangement, but as a method to reveal the possible interdependencies of layers that influence one another in different intensities over time, Nijhuis (2022), synthesizes the landscape complexity in three layers:

The natural context layer relates to human modifications, interventions, culture, organization, and politics, including geological processes, relief, water, soil, and climate conditions. This layer determines the landscape's basic condition and is subject to slow, imperceptible changes;

The human modifications and interventions layer encompasses the areas of living, working, and recreation, including land reclamation, diking, and canalization, which can lead to drastic changes in the landscape;

The culture, organization, and politics layer, deals with the cultural, spiritual, and political dimensions of the landscape, including design concepts and aesthetic ideals. The dynamics of this layer are short-term and linked to people and politics.

For example, following the aforementioned layers, it is possible to conclude that the land reclamation in the IJsselmeer area was motivated by economic, geopolitical, and environmental concerns. And because of that, in Almere-Pampus the landscape is the central and inextricable component of the several systems that will guide human and natural transformations. Hence, projecting these transformations with design explorations in this area can promote futures to heal the natural scars left by the reclamation process by promoting new types of restorative sociocultural organizations through an adaptive and engaging landscape transformation.

Furthermore, an example of the applied understanding of the landscape as a complex system is the Room for the River program. The Stork Plan, the first prize of a competition organized by the Eo Wijers Foundation in 1986, set a design and theoretical precedent to include dynamic visions that integrated alluvial nature as an important and malleable component of the river landscape. Between 1995 and 2000, the Room for the River concept was under fast development and incorporated into governmental reports and policy documents, and oriented the achievement of flooding safety by a landscape ecological approach, involving several parties in the process (Rossano, 2021b). 30 projects were developed to create more space for rivers to safely flood by using a multi-layered approach based on landscape ecology and water management.

For instance, measures such as removing dykes, excavating new river channels, and creating floodplains are designed to reduce the risk of flooding consequences, while also improving the ecological quality of the landscape. The project takes into account the long-term dynamics of the landscape, including natural cycles and human history, as well as short-term factors such as political, social, and economic considerations. The approach of the Room for the River project reflects a shift in water management towards a more holistic, interdisciplinary perspective that acknowledges the complex, interconnected nature of landscape systems.

## 4.6 Lessons from local initiatives

### Marker Wadden

The Marker Wadden project (Figure 8) is part of the ongoing efforts to restore the Markermeer ecosystem, and carried out by Natuurmonumenten (Dutch Society for Nature Conservation) and Rijkswaterstaat (the executive agency of the Ministry of Infrastructure and Water Management). As explained in the official website of Natuurmonumenten, the Marker Wadden proposes the solution of the water turbidity that affects the lake by a "building with nature" approach that uses the natural sediment transport process to reduce turbidity and build islands with lake sediments. The thick layer of silt in the bottom of the Markermeer that causes the turbidity problem is used to create a landfill that fulfils a role as ecological habitat and natural water defence.

Due to a new type of landfill system that is responsive to tidal fluctuation, the Marker Wadden has soft gradients on its water-land borders, becoming an important biodiversity node with areas of wetlands and intertidal habitats. In that sense, this project indicates possible dimensionings of the extent and spatial features of new renaturalized areas, since it shares the same lake ecological habitat, and problems, of Almere-Pampus borders. Also, it provides a precedent of the beneficial use of silt from the Markermeer to attend the design ambition on ecological restoration.

### Noordwaard

The depoldering of the Noordwaard (Figure 8) is the largest measure of the Room for the River project carried out by the Rijkswaterstaar. The Noordwaard was flooded for the first time in 2020, proven to allow safe flooding through the design of a layout that places farmhouses on built moulds, and guarantees that the main mobility infrastructure remains dry (Waterstaat, n.d.). It is anticipated that the polder will flood once every 1000 years, with only the essential infrastructure and the rising farms remaining dry. Initially, the farmers presented resistance to the project, especially because of the farmland size reduction from 2000 to 700 ha. A step of close consultations with residents allowed the discussion of the plan to elaborate a more precise strategy. In that sense, more than a land-use planning, the Noordwaard depoldering was able to promote space for flooding through a multi-actor engagement, which reduced the pressure on the traditional dike-polder water infrastructure that aims to reduce flooding probability.

## 4.7 Problem definition

To achieve the coupling of ecology, climate change, and food production through urban design, the transformation of the landscape infrastructure condition of Almere-Pampus is essential. Due to the polder landscape's intrinsic vulnerability to sea level rising, especially in the Almere-Pampus deltaic condition, this paper takes a position towards a non-defensive relationship that aims for the adaptation of the historically highly volatile natural dynamics. This means that climate adaptation in this context will be spatially determined by strategies that promote a non-disruptive relationship with flooding. This position becomes more relevant due to the possibility of embedding this new relationship with ecological values. And in this alignment, the research-by-design process will test the hypothesis that urban design can orient ecological restoration while promoting long-term FNS. And achieving it by placing agroecological farming as the central part of a hybrid ecological and water climate-adaptive infrastructure landscape.

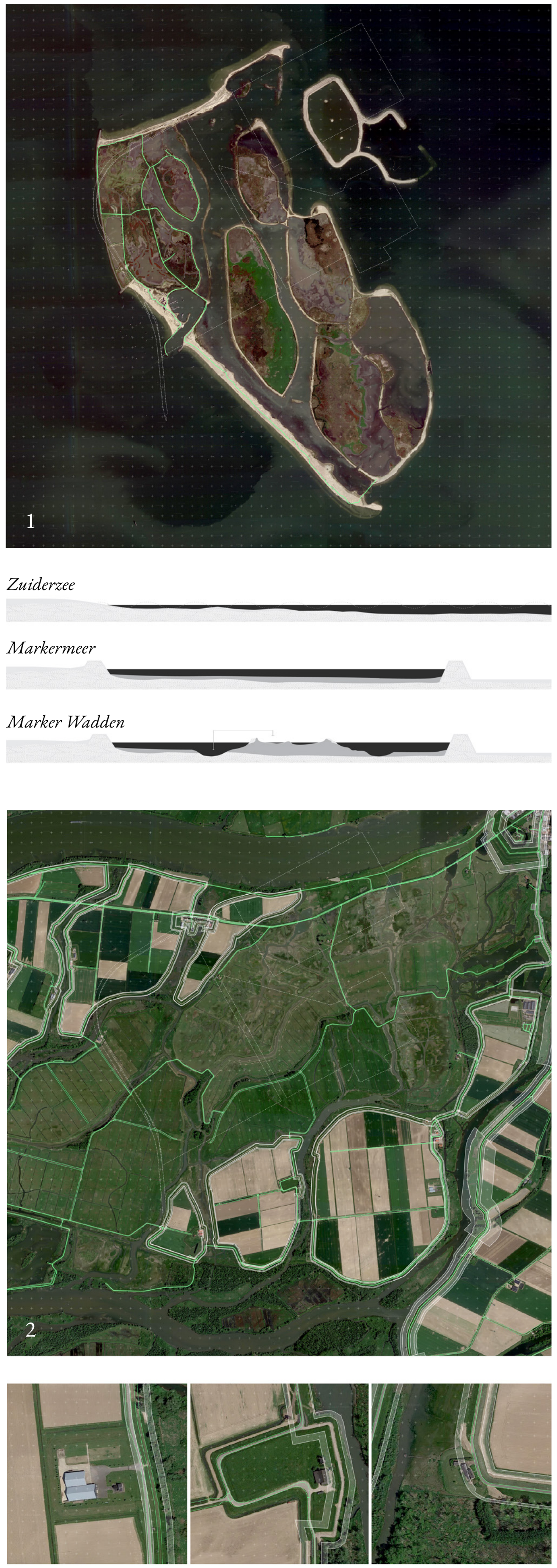


**Figure 8.** Marker Wadden (1) and Noordwaard (2).

*Note:* By author, software QGIS 3.16. Dataset: Google Satelite, Open Street Maps.

# 5. DESIGN FRAMEWORKS

## 5.1 Program and proposal

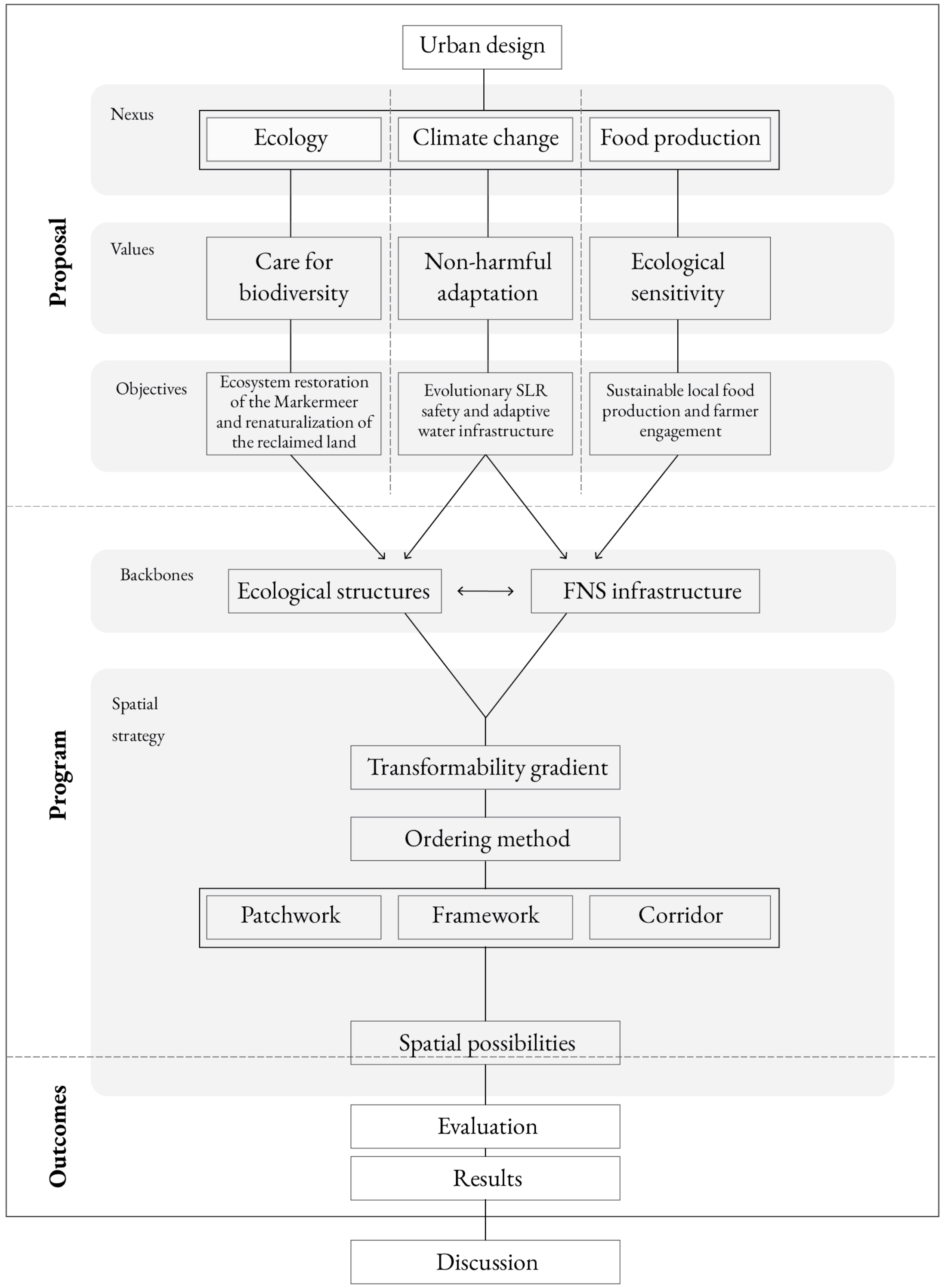


**Figure 9.** Design framework

*Note:* By author, interpreted from Roggema, R. (2016). Research by Design: Proposition for a Methodological Approach. 1(1), p. 8 (https://doi.org/10.3390/urbansci1010002).

The design framework (Figure 9) starts from the understanding that urban design operates by an ordering landscape that is a multi-purpose infrastructure (Waldheim, 2016). As a projective exercise, the design envisions a better future that allows a synergetic and long-lasting relationship with nature. And it that way, it guides the propositions on the initially identified nexus of ecology, climate change, and food production with the guiding design values: care for biodiversity (to heal the web-of-life of the border lakes); non-harmful adaptation (to allow a human-nature restorative relationship), and ecological sensitivity (to streghten a diverse agroecosystem). And based on these projective values, the contextual objectives that answer to the problem definition (p. 21) are the ecosystem restoration of the Markermeer and renaturalization of the reclaimed land without losing land-use, evolutionary SLR safety through an adaptive water infrastructure. These changes in the landscape infrastructure then are set to synergize with an regional agroecosystem, that ensures local FNS and ecological restoration, based on a city-region food system (Foster et al., 2015).

The design of the proposal adopts ecological structures and the infrastructure as backbones to guide the space explorations. by integrating productive areas (sustainability), networks of transportation (safe transport), housing (consumption), and public spaces (health). The design exercise starts by setting boundaries of high dynamic capacity (agricultural and water areas), and low dynamic capacity (housing, major transport lines, and existing ecological areas that are not adapted to flooding). These boundaries guide a speculative depoldering renaturalization proposal, grounded on the references exposed in chapter 4.6 Lessons from local initiatives. In the next step, the depoldering proposal is overlapped with three ordering spatial strategies interpreted from Nijhuis (2022): patches, framework, and corridor applied to the infrastructure indentified infrastructure backbones. The meeting of the ordering spatial strategies with the depoldering proposal guides the design of agroecological and urban typologies.

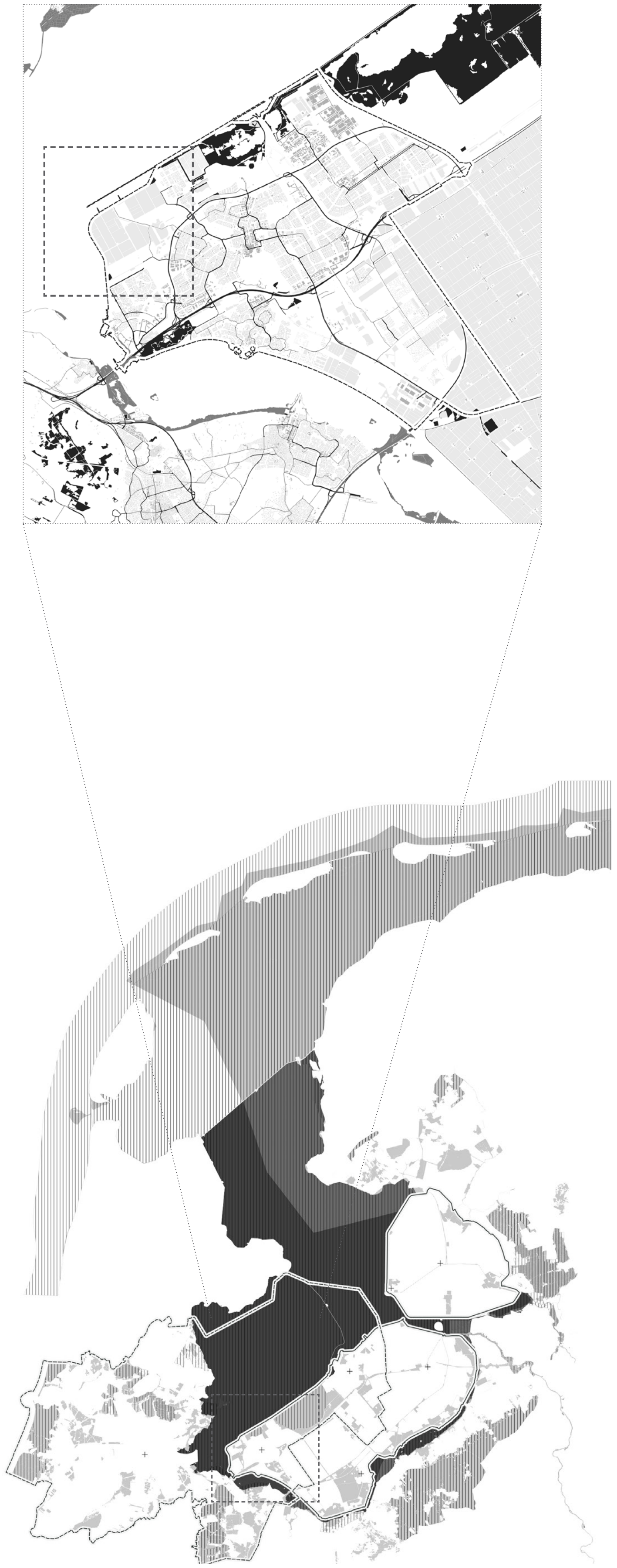
## 5.2 Evaluation

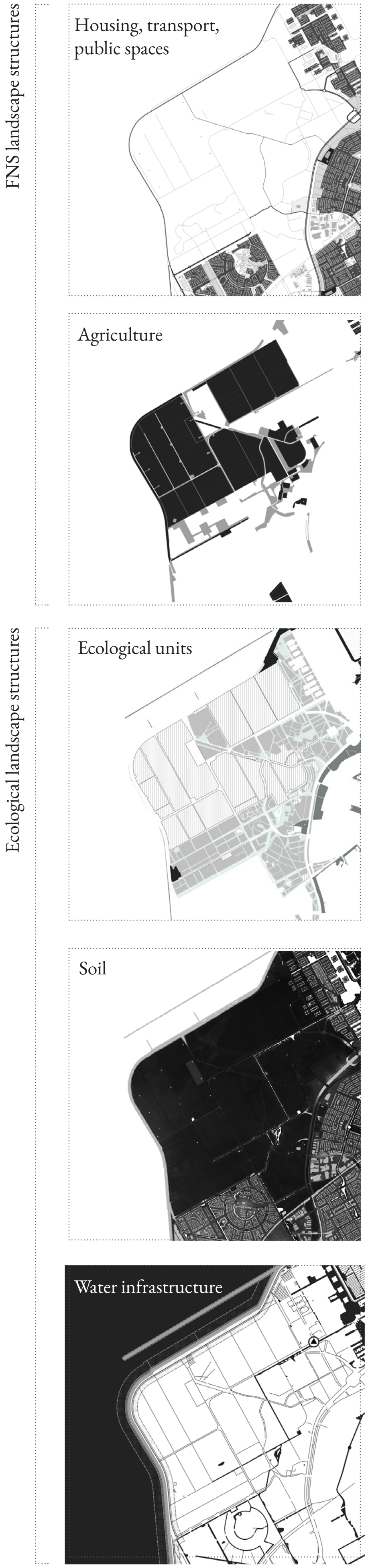
The evaluation (Figure 10) of the spatial possibilities of the case study are based on the gradients of achieved populational density; fresh water offering, presence of ecological habitats (intertidal flat, wetland, dune, forests); food availability on summer, autumn, winter, spring (considering the presence and the reproduction cycles of endogenous agrobiodiversity); the intended transportation intensity on different transport modals related to the infrastructure backbones; and the intended intensity of recreational use, countryside housing, and urban housing.

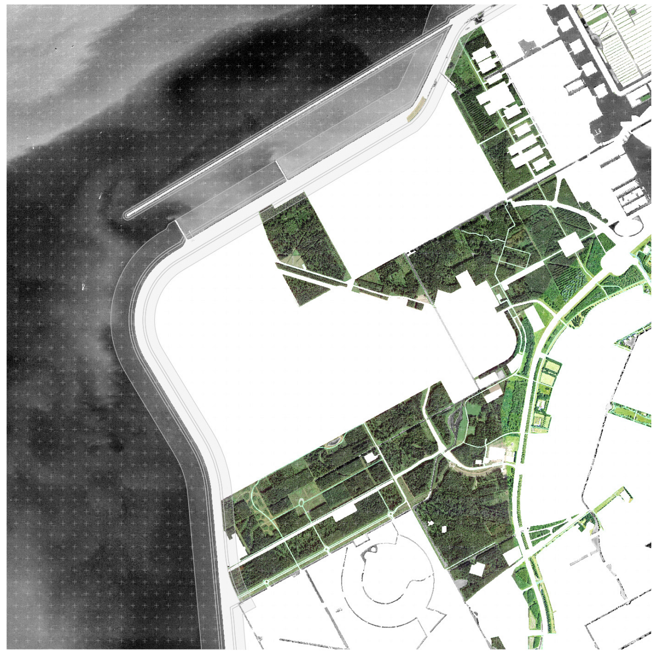
**Figure 10.** Evaluation

*Note:* By author

# 6. DESIGN PROPOSAL







Ecological Structures

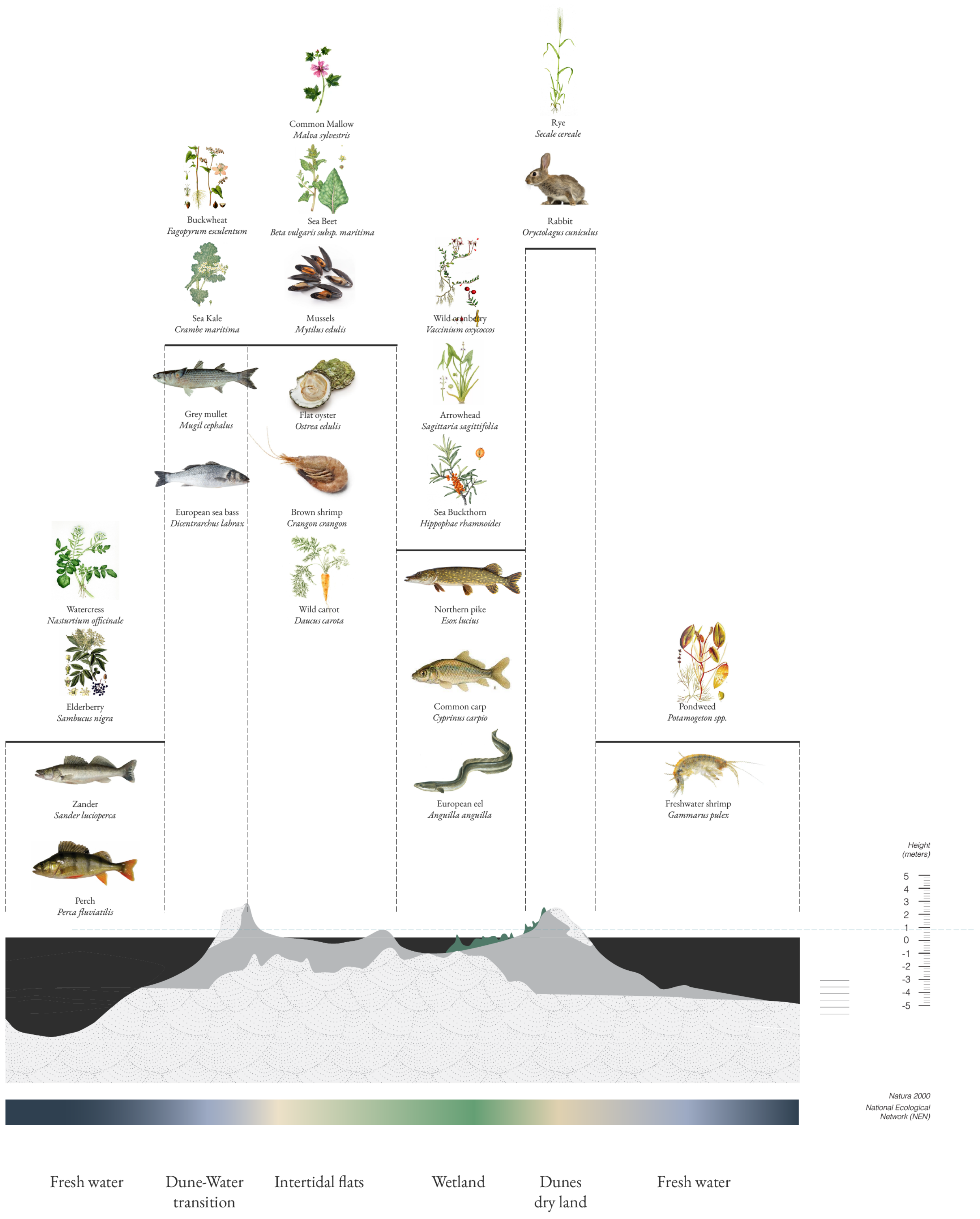
Elements:
Protected deciduos forests/public parks; Markermeer; and water-land borders.

FNS Infrastructure

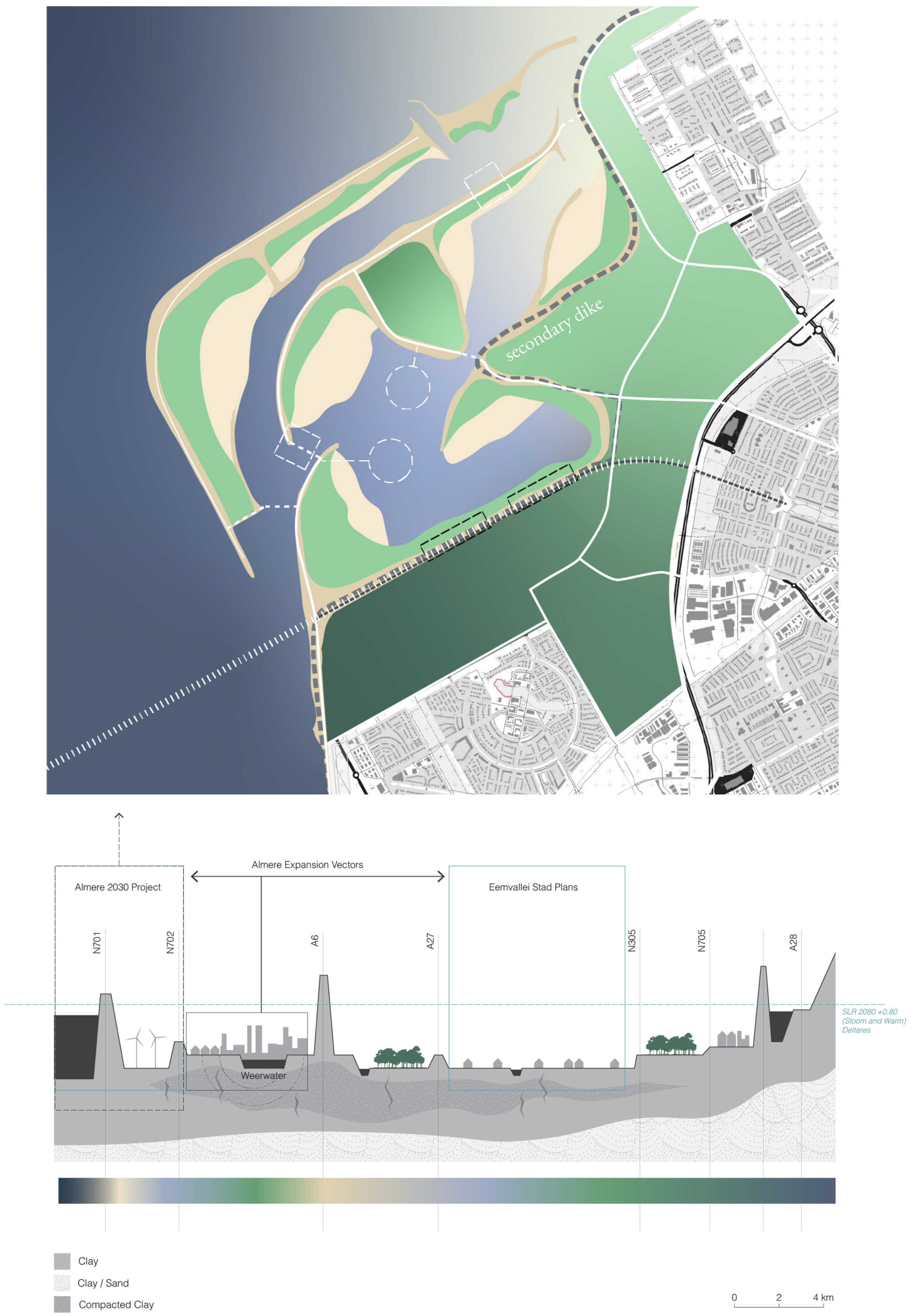
Elements: Arable farms, roads, housing areas, retailing infrastructure.

Transformability gradient

To implement the renaturalization through an local agroecosystem, the water areas and arable land were set for immediate transformation. The protected forests that are interwined by parks are set to be preserved in a first stage of adaptation, giving time for a gradual ecosystem transition. And finally, the housing/retailing infrastructure will be preserved in the landscape transformations, and integrated with the proposal by transportation backbones (primary and secondary roads).

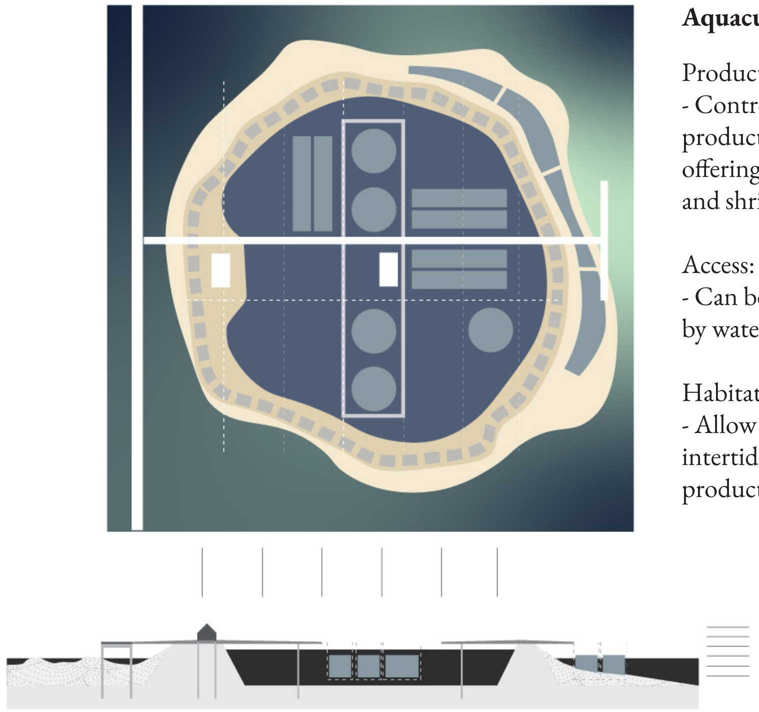


Agrobiodiversity of endogenous restorative habitats



Projection on Almere-Pampus landscape

## PATCHWORK

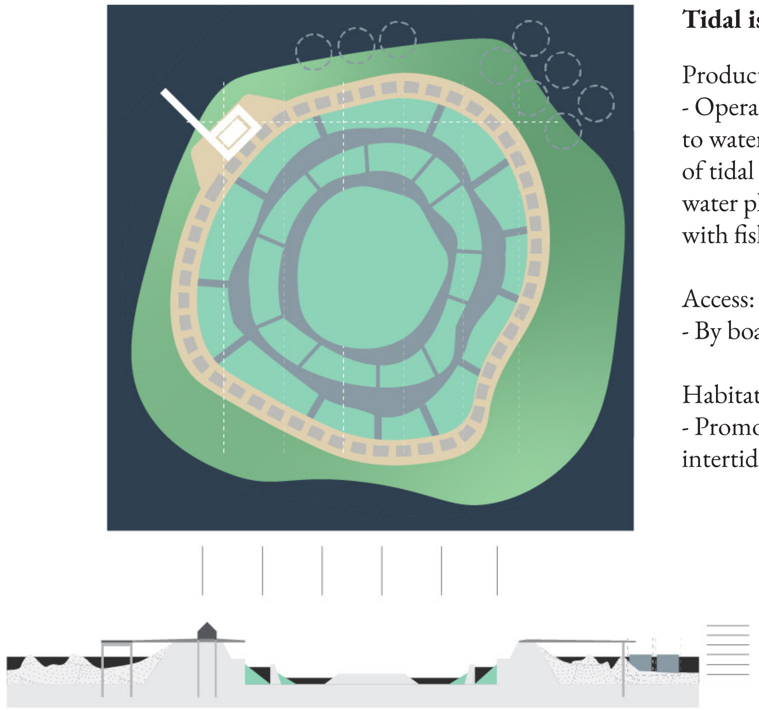


### Aquaculture island

Production:
- Controlled ecological aquaculture production on its center, and seazonal offering of intertidal crustaceans, oysters, and shrimps.

Access:
- Can be placed on remote areas, accesed by water, and support sustainable fishing.

Habitat:
- Allow the extension and retreat of intertidal zones without compromising production capacity.



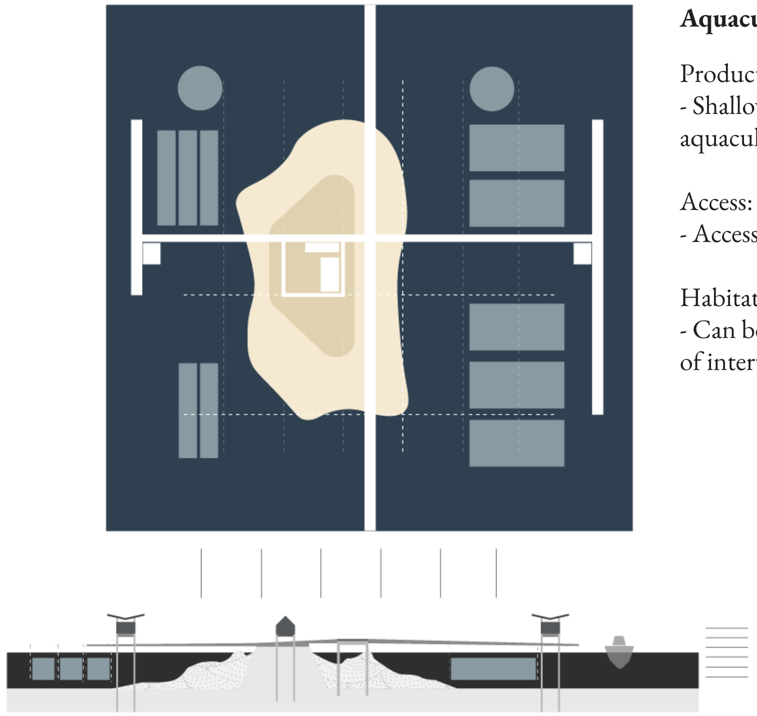
### Tidal island

Production:
- Operates arable land agriculture adapted to water fluctuations through the use of tidal irrigation systems. Can produce water plants, cereals, and rice in synergy with fish creation.

Access:
- By boat or road when suitable.

Habitat:
- Promote gradients of wetlands and intertidal ecosystems.

## FRAMEWORK

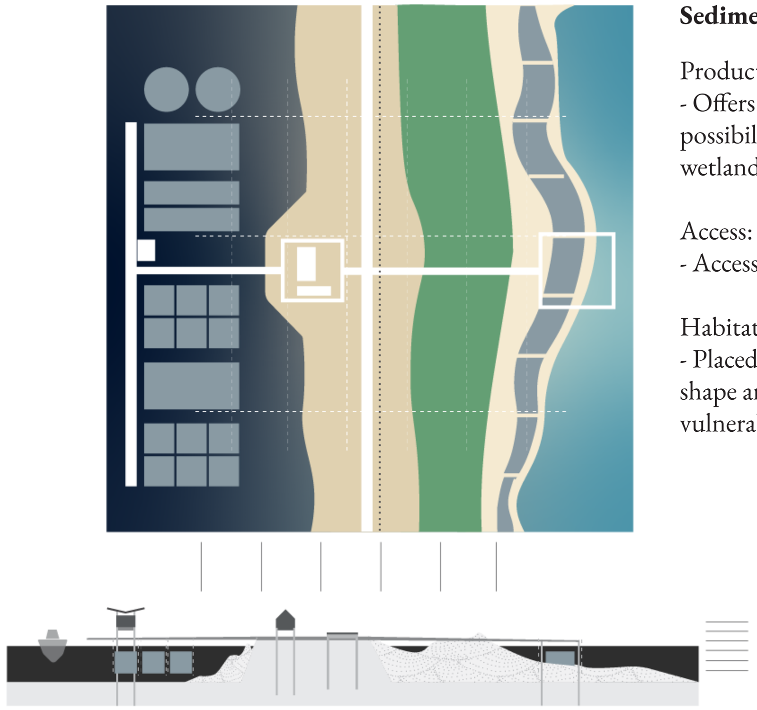


### Aquaculture node

Production:
- Shallow and deep water ecological aquaculture farming.

Access:
- Access by roads and boats.

Habitat:
- Can be placed to stimulate the creation of intertidal zones through sedimentation.

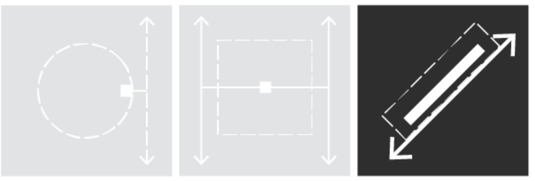


### Sediment catchment

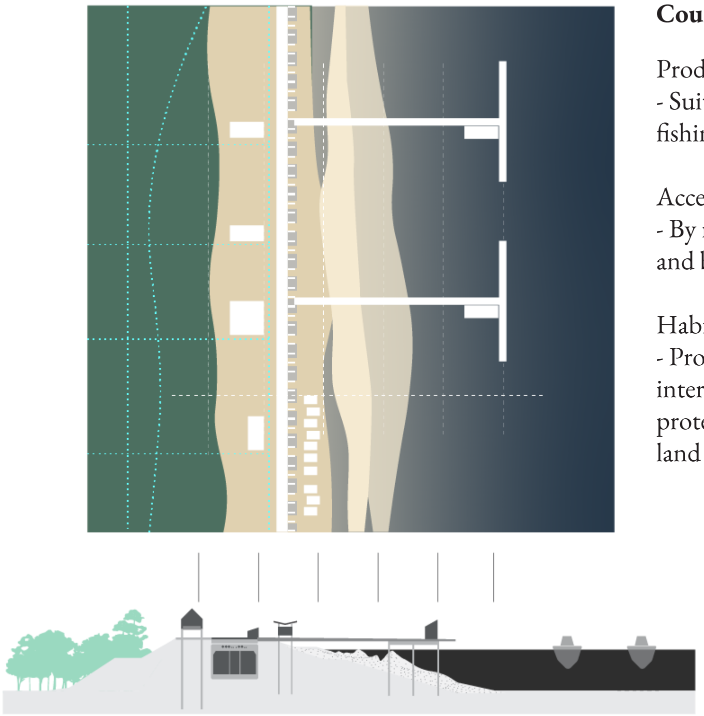
Production:
- Offers a diverse range of production possibilities in deep/shallow water, dunes, wetlands, and intertidal zones.

Access:
- Access by roads and boats.

Habitat:
- Placed on dune edges that can guide the shape and protection of wetlands and vulnerable areas.



# Countryside community

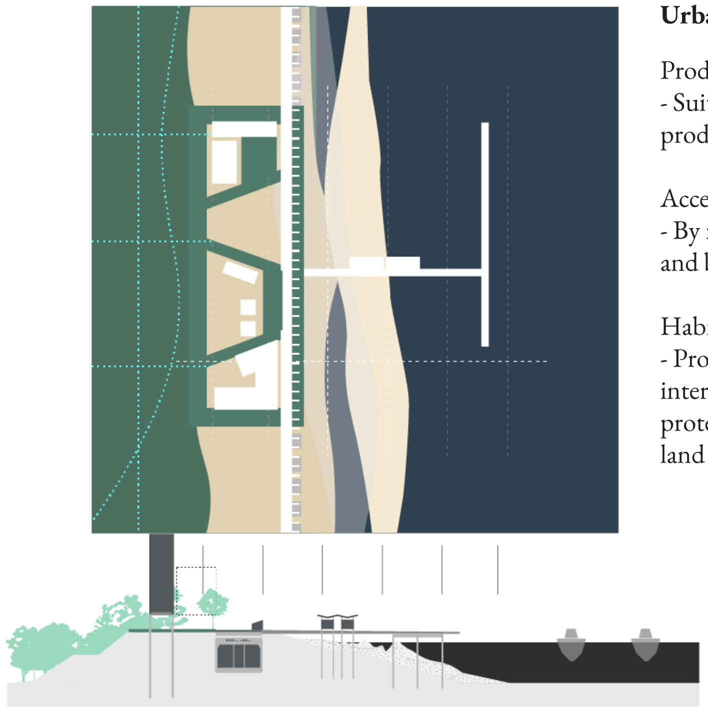


**Countryside community**

Production:
- Suitable for the promotion of vibrant fishing communities.

Access:
- By roads, public transport infrastructure, and boats.

Habitat:
- Promote gradients of wetlands and intertidal ecosystems, and allows the protection of forests and other types of land use beyond the secondary dike.

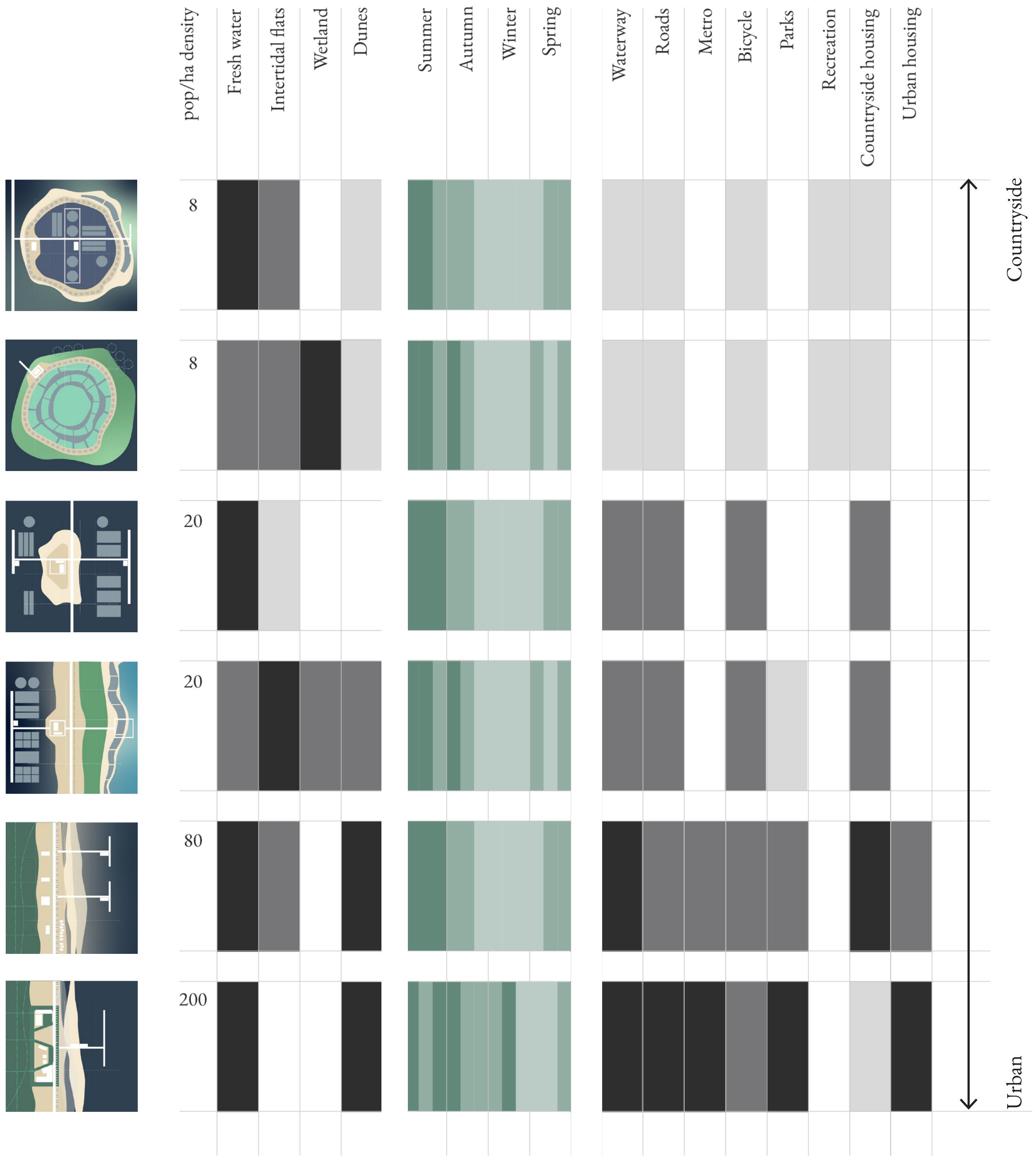


**Urban agriculture block**

Production:
- Suitable for local food parks and productive rooftops.

Access:
- By roads, public transport infrastructure, and boats.

Habitat:
- Promote gradients of wetlands and intertidal ecosystems, and allows the protection of forests and other types of land use beyond the secondary dike.



## 7. RESULTS

The research by design method explored the integration of urban design as an operator of ecological transformations, climate change adaptation, and sustainable food production through a renaturalization proposal. The applied exercise on Almere-Pampus unveiled six typologies aquaculture island, tidal island, aquaculture node, sediment catchment, countryside community, and urban agriculture block. The evaluation of these typologies indicates that their implementation can promote gradients of urban and countryside land use. Also, it can promote 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.

## 8. DISCUSSION

The outcomes from the research-by-design exercise demonstrate the transformative potential of the nexus in urban design, ecology, climate change, and food. Furthermore, it also opens the possibility of understanding the elements of the landscape infrastructure as promoters of FNS, while coping with environmental restoration cross-scale demands. That is highly valuable in the regional context of the intervention area, due to its intrinsic agricultural characteristic that can only operate with the constant management of the polder's water infrastructure. Hence, through a multi-domain urban design, the water infrastructure system could be decentralized by adopting a model of shared responsibility, similar to the Noordwaard project. Furthermore, for not presenting a fragmented set of nature x production, it also expands the "building with nature" approach towards an integrated system that is culturally relevant, safe, and capable to evolve together with the natural change of habitats and ecosystems.

In that sense, it also shows how a local agroecosystem can be designed through its intrinsic connection with endogenous habitats. And by presenting a gradient of the countryside and urban characteristics, the extracted typologies also became endogenous types of land-use, that are highly contextualized. Then, setting a different path from the traditional approach to agriculture, which demands land transformation to adapt to the intended staple food production outcomes. Also, it indicates that a reformed countryside can be the key to living with tidal fluctuations and sea-level-rising futures. Especially because of the immense diversity of edible species that inhabit Earth, and then also pointing a direction towards an end where agriculture has the role of ecological management and water infrastructure, which is decentralized and works as a dynamic hybrid landscape.

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# 10. APPENDIX

EDIBLE SPECIES ENDOGENOUS FROM THE MARKER WADDEN ECOLOGICAL HABITATS

| **Ecological Habitat** | **Animals** | **Plants** |
|---|---|---|
| **Wetland** | Northern pike (Esox lucius) | Wild cranberry (Vaccinium oxycoccos) |
| | Common carp (Cyprinus carpio) | Arrowhead (Sagittaria sagittifolia) |
| | European eel (Anguilla anguilla) | Sea Buckthorn (Hippophae rhamnoides) |
| **Intertidal flats** | Mussels (Mytilus edulis) | Sea Beet (Beta vulgaris subsp. maritima) |
| | Flat oyster (Ostrea edulis) | Common Mallow (Malva sylvestris) |
| | Brown shrimp (Crangon crangon) | Wild carrot (Daucus carota) |
| **Sand dunes** | Rabbit (Oryctolagus cuniculus) | Sea Kale (Crambe maritima) |
| | Grey mullet (Mugil cephalus) | Rye (Secale cereale) |
| | European sea bass (Dicentrarchus labrax) | Buckwheat (Fagopyrum esculentum) |
| **Underwater** | Zander (Sander lucioperca) | Elderberry (Sambucus nigra) |
| | Perch (Perca fluviatilis) | Watercress (Nasturtium officinale) |
| | Freshwater shrimp (Gammarus pulex) | Pondweed (Potamogeton spp.) |