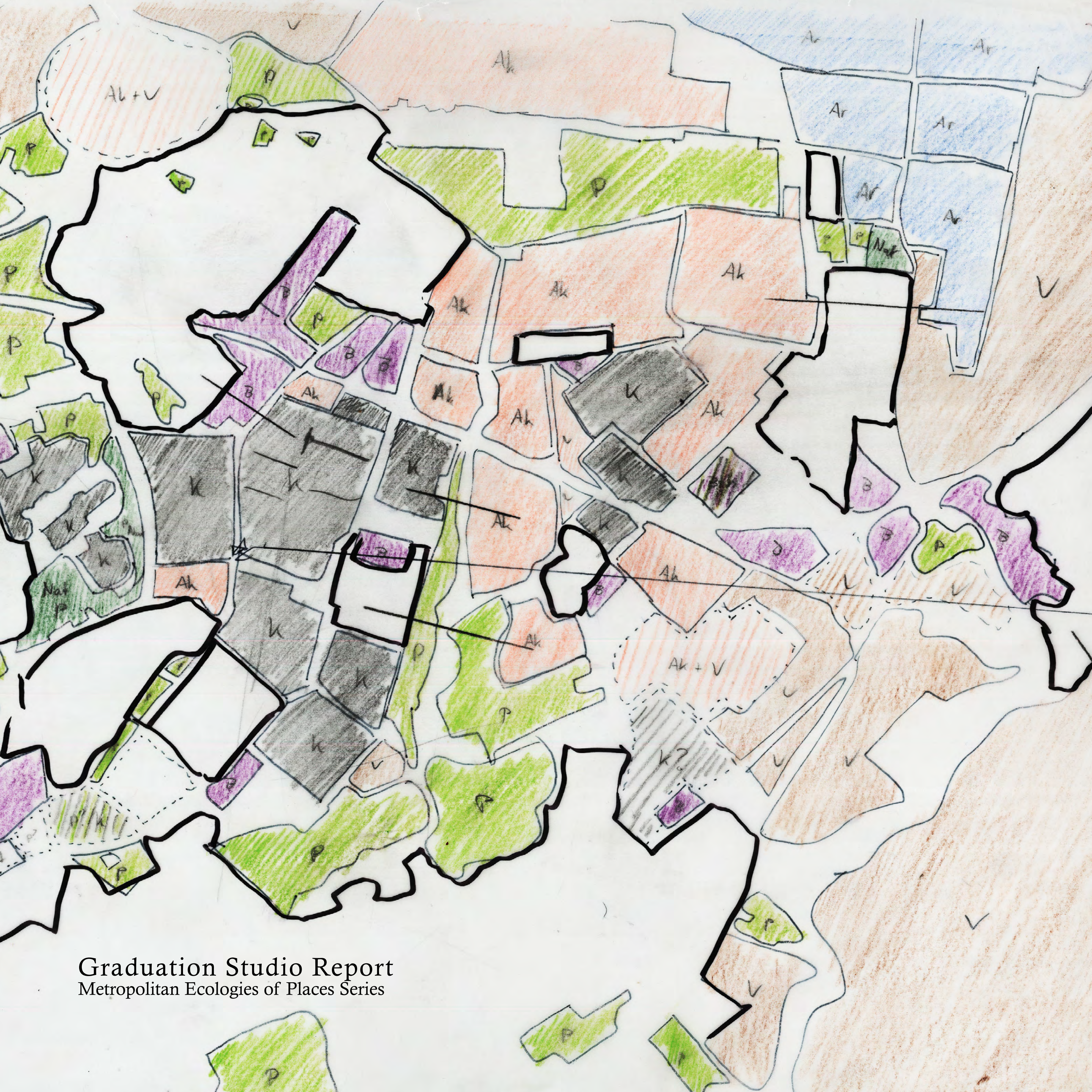


Graduation Studio Report

Metropolitan Ecologies of Places Series

Master Thesis - P5 Report

MSc Architecture, Urbanism and Building Sciences - Track Urbanism

Faculty of Architecture and the Built Environment
Delft University of Technology

Patching up the Lowlands:
Towards sustainable metropolitan development and enhanced spatial qualities in the peri-urban interface of the Deltametropolis

Graduation Lab:
Metropolitan Ecology of Places

Pieter van Os
4644816

Supervisors:

Dr. Alexander Wandl
Environmental Technology and Design

Prof.ir. Eric A.J. Luiten
Regional Planning and Design

Patching up the Lowlands

Metropolitan Ecologies of Places Series

Contents

Abstract

The Netherlands is a place where the interplay between mankind and Nature[1] resonates deeply within the roots of its omnipresent cultural landscape. Proactively shaping this landscape, which is widely considered as the most eminent aspect of place identity of the Lowlands, stands at the cradle of the by now long and rich tradition of planning urban development. The unintentional production of this key facet of Dutch culture traces back to the Middle Ages when the peatlands of the western delta were cultivated and colonized, gradually forming over millennia through natural processes. Inhabiting this inhospitable environment led early settlers to adopt a technophilic[2] approach, perceiving nature as something that needed to be controlled. This organized endeavour resulted in rapid polycentric urbanization, where manmade inland waterways interconnected medieval cities and rural villages spatially, socially and economically, on the territorial scale of what is referred to in this thesis as the Deltametropolis[3]. However, the transition to modernity disrupted this equilibrium, creating a divide between the increasingly separate spheres of 'urban' and 'rural' driven by the pursuit of global economic competitiveness. A metropolitan region was starting to take shape based on the already centuries-old urbanized configuration – complete with mutually competitive and independent cities in a discontinuous countryside, connected by an extensive infrastructural network, and where each individual citizen could compose their own polycentric city. While urban and rural typologies have long been dissolved into a continuum, today public policy still prioritizes compact city models and sectoral economic development, overlooking strategic interdependencies within the metropolitan region and worsening socio-economic inequalities. With the increasing pressure from Natural forces – once the core catalyst of the production of Dutch culture – the Anthropocene is experiencing a second deep transition that will once more inevitably alter our relation towards our natural environment. In anticipation of an uncertain future, this design exploration aims to express an authentic articulation of the spatial configuration of the Deltametropolis, drawing lessons from the past to shape the future, in which urban and rural spatial qualities are symbiotically reintegrated and our relation with Nature is critically reassessed.

(de Geyter et al., 2002; Geuze et al., 2016; Koolhaas et al., 1993; Palmboom, n.d.; Van der Woud, n.d.)

1. "Nature" is written with the capital "N" to indicate the biosphere and the abiotic matrices (soil, air, and water) where it flourishes (Barbiero et al., 2021).

2. Biophilia' was conceptualized by Erich Fromm and later Edward O. Wilson, among other things , as an 'the inherent human inclination to affiliate with Nature' (O. Wilson, E & R. Kellert, S. (1995) in Amat et al., (2020)). Hence, 'technophilia' in this context interpreted as dissociating oneself from Nature, and seeing it as something separate. The technophilia-biophilia dichotomy employed serves as a simplification of the intricate and multifaceted historical developments. Nevertheless, it should be approached with nuance and an understanding that it represents a spectrum rather than a binary division. Instead of introducing a new dichotomy, the adoption of a balanced and integrated perspective is essential in sustainable spatial developments, one that acknowledges the significance of both technological advancements and ecological harmony.

3. In this thesis, the Deltametropolis largely refers to the Dutch Deltametropolis - the metropolitan region consisting of the so-called Randstad and Green Heart. The collaboration of the four alderman for Spatial Planning of Amsterdam, Rotterdam, The Hague and Utrecht resulted in a joint 'Verklaring Deltametropool' – Declaration Deltametropolis (1998), which aimed at a shared vision and strategy of the urban agglomeration of these four largest Dutch cities within the larger international delta region of the Rhine, Meuse and Scheldt rivers, competing with other global regions.

Figure 1 - View of Delft from the Northwest, by Hendrick Cornelisz Vroom, 1634

Context Setting

Deep Transitions

It is hypothesized that we are collectively living at a pivotal moment in history which calls for a fundamental restructuring of our socio-technical systems. As of today, our global socio-technical systems and the economic processes associated with them have exacerbated disparities in industrial consumption and production worldwide. Furthermore, the resulting disruption of global ecosystems has led to unprecedented consequences of climate change.

As these processes cannot be sustained, we face a critical choice: either prolong and extend current development pathways or collectively invest in transforming our world, as envisioned in the United Nations' Agenda 2030 and its 17 Sustainable Development Goals (United Nations, 2015). This transformation will inevitably ask significant changes to our living environment.

Researchers from Utrecht, Eindhoven and Wageningen Universities have been analysing the sociotechnical development of the Netherlands from a long-term perspective based on the underlying concept known as the 'deep transition'. This encompasses a series of interconnected transitions in various socio-technical systems that are fundamental to society, including energy, mobility, food, healthcare, and communication (Schot, 2016). A deep transition meets three criteria:

1. The transitions involve significant changes to established socio-technical systems.

2. These changes mark a new phase in the history of industrialization, modernity, or industrial consumption.

3. The transitions unfold gradually over a period longer than a century.

The first deep transition emerged through technological advancements, spanning from the 19th-century Industrial Revolution to the widespread adoption of information systems and telecommunications in the 1970s. These developments marked the beginning of industrial modernity and shaped the socio-technical systems that accelerated environmental and societal developments, as seen in the context of the Netherlands in figure 2.

Kanger & Schot (2019) theorize that we are currently in the midst of a second deep transition. Central to their research is the fundamental question of what measures can be taken to pave the way towards a sustainable future in the second deep transition. While we cannot determine the outcome due to the inherent uncertainty of the future, we still have the choice to select desired spatial outcomes for our living environment that align with our values. In doing so, we can actively shape the future we aspire to achieve, while acknowledging the uncertainty that surrounds it.

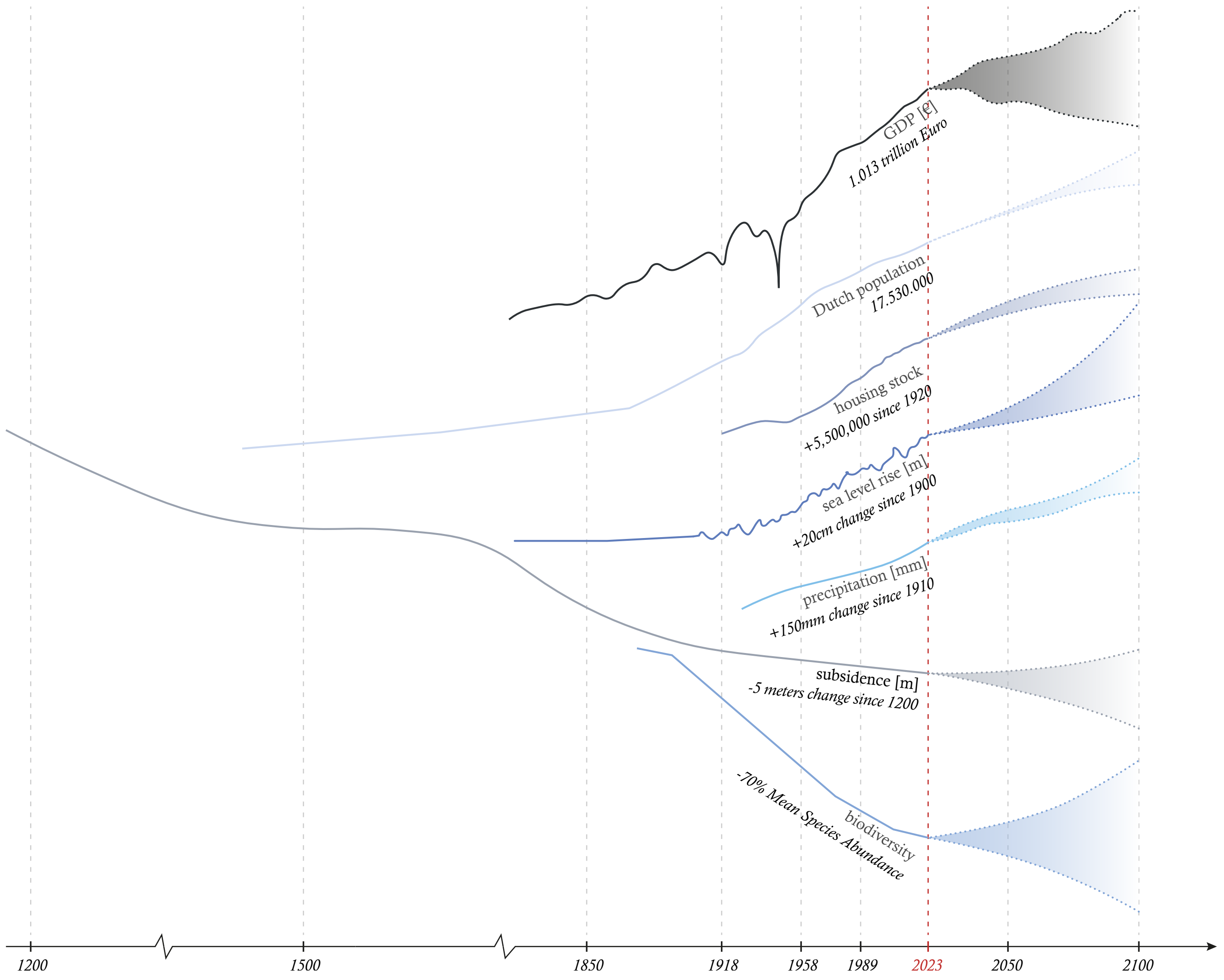


Figure 2 - Environmental and societal developments in the Netherlands towards an uncertain future

Biophilia and Technophilia

The Deep Transitions Futures team (2023) aims to accelerate the shift towards alternative systems that align with the SDGs in order to address global challenges by fundamentally restructuring the social-technical systems established during the process of modernization. Consequently, the project envisions different plausible future scenarios that offer potential alternatives for the food, energy, and mobility systems.

Earthshot

The first scenario, called “Earthshot”, draws inspiration from the ambitious moon missions of the 20th century. It revolves around addressing the major challenges of our time through human ingenuity and entrepreneurial spirit. This imagined world is guided by principles such as eco-modernism, circular economies, and the adoption of mission-oriented development at all levels of governance, from local to global. A deep commitment to these strategies drives a surge in radical and disruptive innovation. Achieving inclusive Green Growth through technological advancements becomes a reality through the consolidation and democratization of global innovation systems. Each country contributes its unique capabilities while sharing in the overall outcomes. This system exemplifies the triumph of human beings, or “homo faber,” as they exercise control over their destiny and environment through inventive solutions.

Do No Harm

In the second scenario, the fundamental principle is “Do No Harm.” The severe loss of biodiversity and destruction of ecosystems force us to recognize our dependence on the natural world. By abandoning our neglect and disregard for the living world around us, we commit to transforming our systems by working harmoniously with nature. We acknowledge that humans are just one part of an intricate interconnected web of life. In this vision, farmers are no longer regarded solely as food producers but also as ecological stewards, responsible for managing ecosystem health, including biodiversity and soil quality, above all else. Concurrently, supply chains shift away from a focus on global trade of large quantities of standardized products. Previous agricultural research priorities, which centred around industrial farming techniques, are redirected to support regenerative agriculture and nature-based solutions.

Earthshot

Figure 3 - Forms of food production ‘detached’ from nature such as urban farming and lab-grown meat become the norm. ‘Nature’ becomes a wild space largely devoid of agricultural activities, concentrating activities in urban and industrial centres, but also opening up new spaces for production.

Figure 5 - Global coordination of energy production and consumption is facilitated by cross-regional transmission networks and innovation surges in green energy technologies

Figure 7 - Personal mobility opportunities evolve around new modes, technologies and ownership concepts – ACES: Autonomous, Connected, Electric and Shared

Do No Harm

Figure 4 - Regenerative agriculture and nature-based solutions have become mainstream. Vegan and vegetarian are widespread and aligned with geographical and cultural contexts but meat, fish and dairy production continue on smaller scales and in line with the natural productivity of the earth.

Figure 6 - The energy system undergoes a decentralisation process in which prosumers (consumer/producer) drive more localised markets. Self-sufficiency is the key value.

Figure 8 - Mobility becomes a public right and good. Equitable access to service-based mobility with enhanced networks of transport modes. New technologies rely solely on renewable energies and transform existing mobility types

The two scenarios can be interpreted on a spectrum between 'biophilia' and 'technophilia', which reflects our general attitude of where we place ourselves respective to Nature: whether we perceive ourselves as an integral part of it or create a sense of separation. In the specific context of the Netherlands, where nearly every square meter is part of a cultural landscape that has been extensively modified through drainage, planning, infrastructure development, and cultivation, this question takes on particular significance.

Following the 'Grote Ontginning' in the early Middle Ages, urbanization has been primarily driven by factors related to occupation and network development, while the subsurface became subordinate (College van Rijksadviseurs et al., 2022). A system of dykes and locks needed to be constructed in order to keep dry feet in an increasingly wet, subsiding landscape. Today, the most urbanized and densely populated area of the Netherlands is located several meters below sea level, safeguarded by intrinsically unstable technical solutions that require ongoing maintenance and management to ensure their effectiveness.

While proactively shaping the landscape is an eminent aspect of place identity in the Netherlands, it has become rooted in a technophilic mindset, leaving the delta landscape vulnerable and unprepared for the impending challenges of climate change. The resulting imbalances in society, economy, and ecology are becoming increasingly apparent, as illustrated in figures 9 and 16. While there have been strong efforts and initiatives to promote sustainability and environmental development on a national scale, this thesis proposes that a more profound biophilic approach may be necessary to achieve a sustainable resolution. Indeed, Nature is fundamental to our existence, and the inclusive development of Nature should be considered as a foundational choice. In the context of spatial planning for the cultural landscape of the Netherlands, the primary challenge lies in integrating biophilic and technophilic spatial characteristics, achieved through strategic decisions that are linked to the soil and water system. However, to delve deeper into the future of spatial planning in the Netherlands, it is crucial to understand the evolution of spatial planning practices in recent decades that have lead to the challenges we face today.

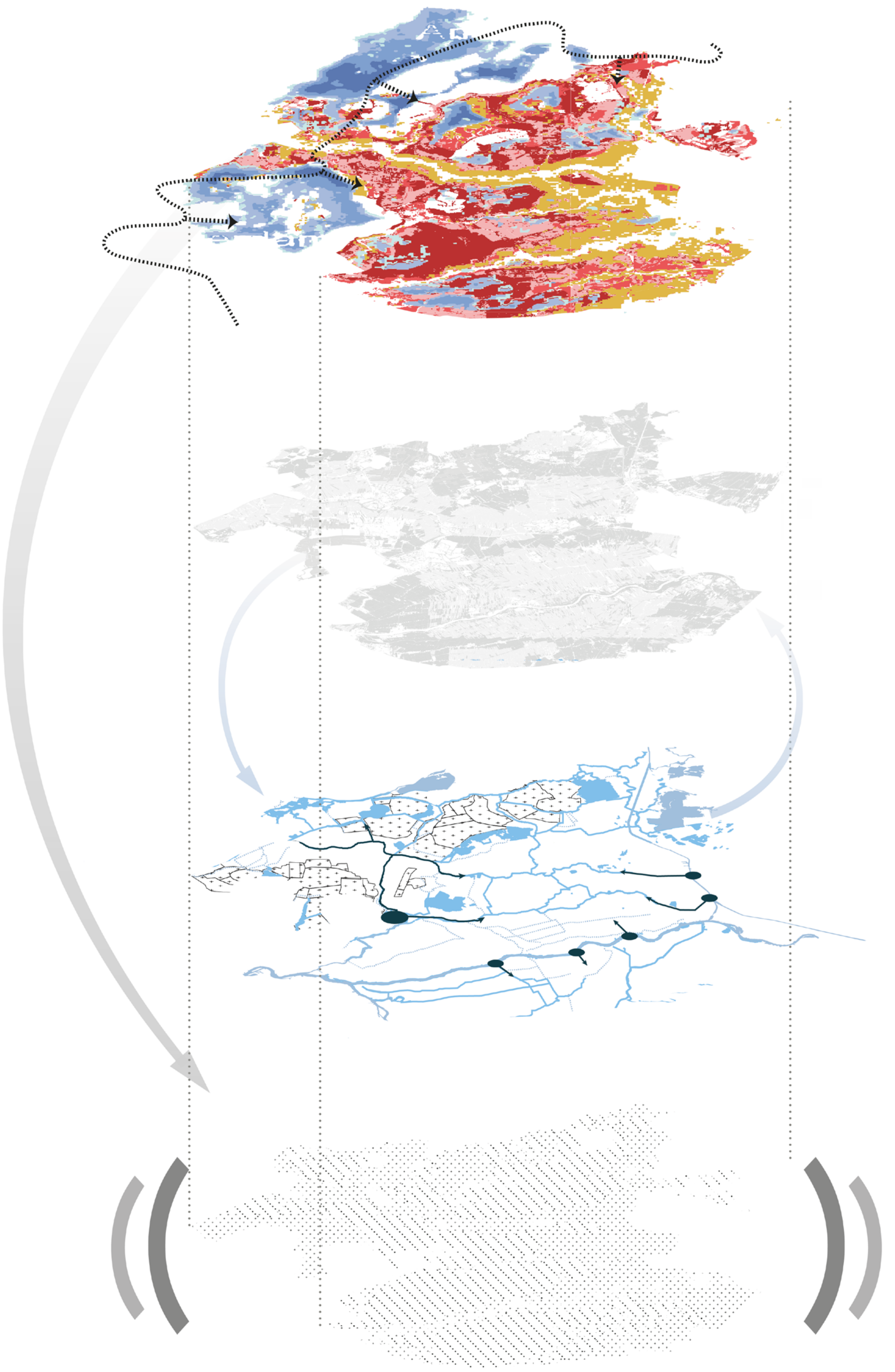


Figure 9 - Highlighted is the challenge associated with the market-driven development of recent decades, which has rendered the substratum layer subordinate due to the intensification of the agricultural sector in the Green Heart. Further elaboration can be found on page 26.

Problem Field

Nota's Inzake de Ruimtelijke Ordening

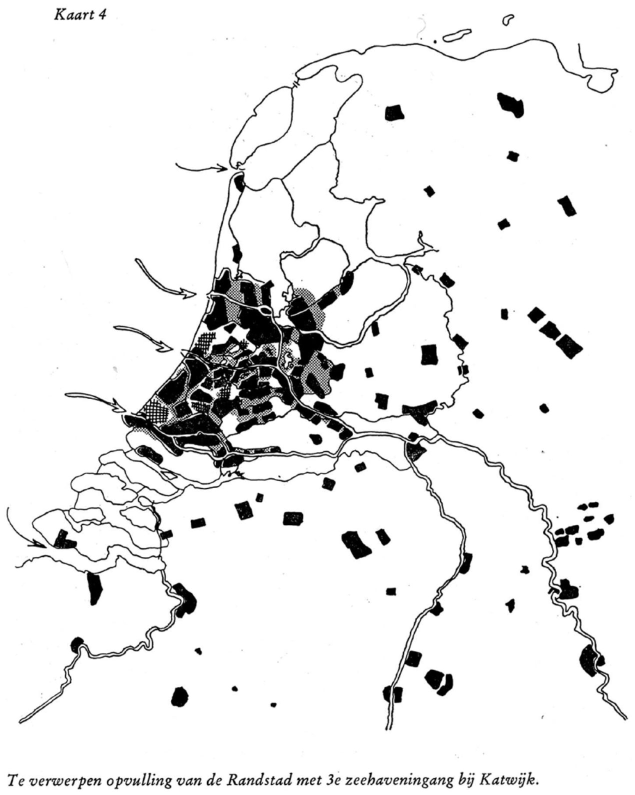
The prevailing planning paradigm in the Netherlands is deeply rooted in the urban-rural dichotomy embodied by the Randstad and the Green Heart. This approach has prioritized efficiency-driven development in both urban and rural areas. In the market-driven climate of recent decades, it has resulted in the emergence of a technologically advanced and highly productive agricultural landscape, alongside a pursuit of polycentric urbanization for global competitiveness.

As the country transitioned towards contemporary modernity, national planning policies established industrial production patterns that contribute to the societal, economic and ecological imbalances that are negatively impacting the metropolitan region's landscape today. First, this thesis will elaborate on the influence of national spatial planning instruments since the 1950s on the spatial configuration of the Deltametropolis. Furthermore, it will examine the spatial and cultural outcomes from these planning decisions. In conclusion, this review will provide a concise overview of the recently published Draft National Strategy for Spatial Planning and the Environment (NOVI), along with the Ruimtelijke Verkenning 2023 (Spatial Exploration), as these documents represent the most recent official publications on spatial planning.

In their book 'The Randstad: A polycentric metropolis', Zonneveld and Nadin (2020) distinguish five key episodes in addressing the Randstad-Green Heart region in Dutch spatial planning policy. These episodes are related to waves of urbanization, socio-economic change and political priorities, gradually showing the transition to modernization.

Figure 10 - A spatial image that provided to be highly effective for accepting the concept of the Green Heart.

Ranitz, 1964, in Zonneveld, 2007



A Sea of Houses

The first episode of the post-war period was marked by reconstruction and the recovery of industrial production. Cities grew rapidly, and the general population was predicted to nearly double by 2020. Subsequently, an advisory report entitled 'De Ontwikkeling van het Westen Des Lands' – the Development of the West of the Country – warned of a massive increase in urbanization that would eventually lead to uncontrolled suburbanization, as illustrated in figure 10. As this 'sprawl' did not fit within the ideals of a densely populated city and an open, green countryside, the central government built the necessary capacity in the form of administrative and research organizations. According to Lörzing (2004) it was during this period that the Dutch planning system acquired the characteristics it has today. In this policy statement, the government assumed the concept of a single functional urban region, the Randstad.

This belt of cities surrounded an open Green Heart, which would act as an area for food-production and recreation for city-dwellers. With a still vivid memory of the so-called hunger winter of 1944/45, the agricultural sector gained significant influence on keeping this agricultural landscape open under the notion of 'Nooit meer honger'. Naturally, this neatly fell within the ambition to keep the historical cores of the cities legible. This was accompanied by restructuring policies aimed at making the agricultural sector more modern and efficient through re-allotment, supporting the interests of this highly influential sector (Zonneveld, 2007). As shown in figure 11, this 'ruilverkaveling' aimed to consolidate fragmented agricultural plots into larger, contiguous parcels to enhance efficiency, accessibility, and mechanization. However, it faced criticisms concerning its impact on small farms, biodiversity, and cultural heritage.

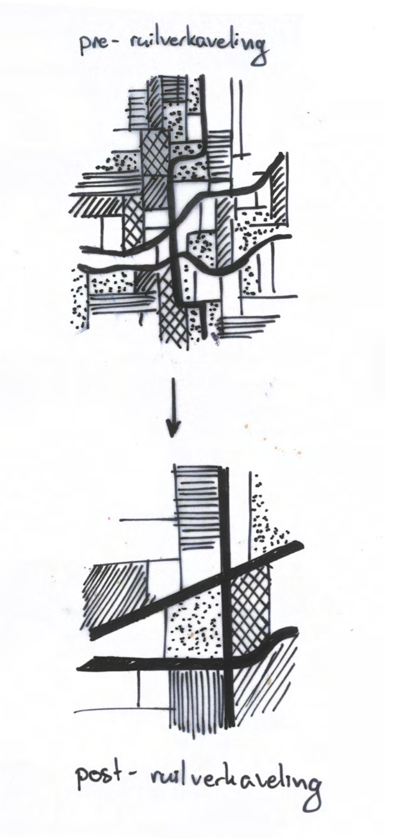


Figure 11 - The so-called 'ruilverkaveling', a large-scale reorganization of agricultural areas, was implemented as a response to the need for more efficient agricultural production, enlargement of plot sizes, and improvement of infrastructure.

To further the goal of controlling the process of suburbanisation, the 'Tweede Nota over de Ruimtelijke Ordening', or Second Report of Spatial Planning (1966), established the principle of concentrated deconcentration. This resulted in the establishment of urban growth centres which were mostly located in and around the Randstad region. However, some were located within or adjacent to the Green Heart, contradicting the initial goal of keeping the Green Heart open. This was further contradicted by a rapidly expanding motorway network, needed for accessibility (Ritsema van Eck & Van der Wouden, 2020).

1970s and 1980s: Urban Revitalization

In the 1970s, post-war expectations for rapid and sustained economic growth were dashed by the oil crises of 1973 and 1979, leading to a recession. To some extend, this slowed urban development and suburbanization, although the growing demand for space remained uninterrupted. This slower growth highlighted the cities' vulnerability to economic recession, after which public attention shifted to focussing on the economic competitiveness of its territory and market-oriented thinking. Correspondingly, the late 1980s could be interpreted as a transitional period in which the social-democratic Dutch welfare state gave way to the first neo-liberal policies (Pisano, 2018). The Third Report (1973) focused on urban renewal and the revitalisation of the cities replacing the concept of 'concentrated deconcentration' with the 'compact city' model. In service of the original aim of urban containment from a rural countryside, the compact city model ideally facilitates relatively high residential density as well as efficient public transport, with newly constructed urban districts being less dependent on the car. From a planning perspective, this model fits seamlessly into the strongly entrenched conceptualizations of Randstad and Green Heart, as it reinforces the urban-rural dichotomy. However, even before implementation in the Fourth Report its legitimacy proved to be questionable, as observed by a young architect who had just left the Office for Metropolitan Architecture.

A Patchwork Metropolis

When drawing up plans for Ypenburg on behalf of the municipality of The Hague, Willem Jan Neutelings needed to have a clear view of the possible development on the extremely complex area between The Hague and Rotterdam. From what he observed in his urban study in 1989, he denounced the "notion of a romantic opposition between an arcadian paradise and a megalomaniac metropolis". Instead, he understood this urban morphology as a patchwork of spatial, programmatic fragments, each with their own specific programme and spatial pattern. Extending this observation to the equally complex Randstad territory, a new way of understanding this conurbation was devised, in which the opposition between city and countryside was abolished. In this 'patchwork metropolis', this polarity makes place for one continuous landscape of patterns. How Neutelings represented this territory turned out to be a striking anachronism, as this conceptual framework revealed principles that would govern the territorial developments in the decades that followed (Neutelings et al., 1989; Pisano, 2018).

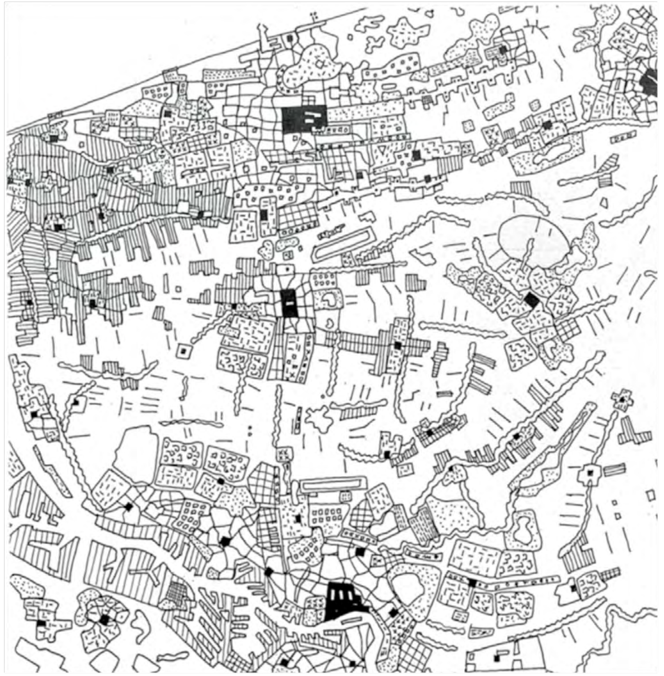


Figure 12 - The Hague and Rotterdam region as 'Tapijtmetropool'; a Patchwork Metropolis, opposing the urban-rural dichotomy paradigm.

Source: Neutelings et al., 1989

1990s: A Compact City?

As urban growth recovered, the idea of an internationally economically competitive Randstad became a major topic within neo-liberal political spheres in the run-up to the Fourth Report (1988). For the first time, the well-organized polycentric structure of major urban centres around an open Green Heart was seen as an opportunity. Subsequently, spatial planning policy was redirected from public housing towards economic development and infrastructure in order to meet the demands of new companies and face future globalization (Ritsema van Eck & Van der Wouden, 2020). Accordingly, greater attention was given to the two designated 'Mainports' of Schiphol and the Port of Rotterdam, and the numerous intensive agricultural clusters, or 'Greenports'.

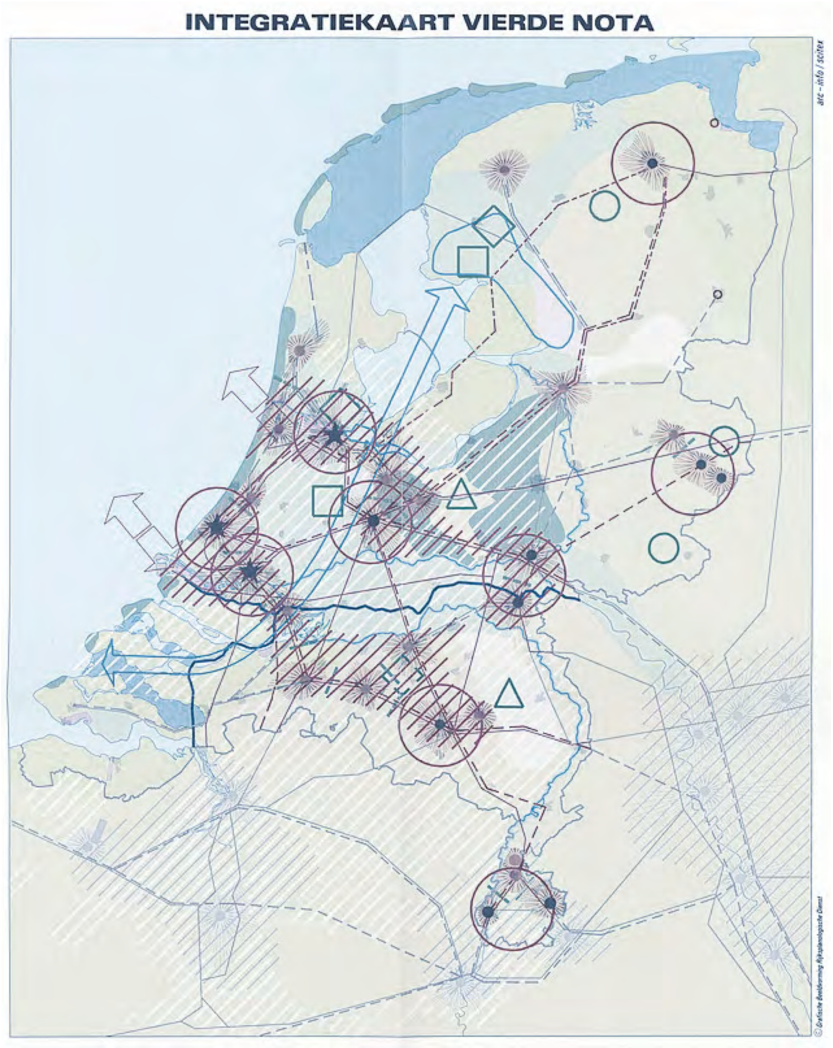


Figure 13 - Structural plan, Fourth Spatial Planning Report

Source: Tweede Kamer der Staten-Generaal, 1988

Vinex

The 'Vierde Nota over de Ruimtelijke Ordening Extra', or Vinex in short, was an added policy document aimed at delivering more than 750,000 homes, of which a third were to be constructed within the Randstad conurbation. This major territorial urban expansion manifested the previously coined compact city concept: Future housing construction would take place either as inner-city projects or greenfield developments close to the city, with the latter making up the majority of established dwellings. Furthermore, growth of car mobility was to be limited as much as possible, as to reduce the already alarming environmental impacts.

On paper, the Vinex policy turned effective: the extensive housing task was realized in or in the immediate vicinity of the existing cities, under the direction of the local authorities and with an important role for market parties (Boeijenga et al., 2008). However, Vinex districts were often separated from parent cities due to infrastructure such as canals, motorways and railways acting as a significant barrier. Moreover, a (much) lower density of dwellings was realized than the original target at most locations, which was largely the result of negotiations with market parties.

This attracted a heterogeneous demographic make-up that commutes daily to their work, shopping centres or children's schools which were located in other urban centres within the Randstad region. As residents could now compose their own polycentric city, this ultimately resulted in more car mobility and congestions, and further reduced the functional and morphological relation with the parent city. Vinex had become a legitimized form of suburbanization and encourages, rather than discourages, mobility and segregation (Boeijenga et al., 2008). The same indifference for the compact city policy can be observed in the distribution of new business parks, shopping malls and other commercial facilities. Notably within the Green Heart and below Zoetermeer, the amount of land used by business parks increased rapidly (Van der Wouden, 2020). Together, these juxtaposed patches are locally functionally isolated, yet generate great regional dynamics between socio-economically related patches where infrastructure serves both isolation and connectivity.

Therefore, the territorial spatial manifestations of the compact city policy was completely inconsistent with its original intentions. While it seemed effective for the re-urbanisation of large cities, it did not contain sprawl, ultimately questioning the legitimacy of the conceptualizations of the Randstad and the Green Heart (Van der Wouden, 2020).

Policy Outcomes

Figure 14 - (below)
The formation of a network metropolis as a result of spatial planning policy

Territories-in-Between

At its conception in the 1950s, the Randstad consisted of a belt of densely populated cities surrounding an open countryside. Today, it aligns more with the characteristics of a multi-centred metropolitan region that no longer corresponds to this traditional dichotomy, as defined by Castells (2010) in Wandl et al., (2014). In fact, most of its territory today can be classified as neither urban nor rural, as Wandl et al. call 'territories-in-between'. Although the Randstad-Green Heart conceptualization arose out of fear of uncontainable sprawl, its ensuing anti-sprawl policies indirectly led to a new phase of urbanisation which is characterized exactly by suburbanization, labelled as the 'after-sprawl condition' by De Geyter et al. (2002). While sprawl often has a negative connotation, its processes and principles are simply not yet sufficiently researched and designed for, as a result of its neglect in planning policy (Wandl et al., (2014); De Geyter et al., (2002)). The Deltametropolis at large can be regarded as an embodiment of the Horizontal Metropolis concept, as presented by Corte and Viganò (2022) and illustrated in figure 14. It encompasses urban centres, suburban areas, and rural landscapes, integrated with waterfronts and infrastructure. This amalgamation forms a polycentric network of interconnected spaces, effectively dissolving the traditional urban-rural dichotomy.

To promote sustainable metropolitan development, it may be necessary to abandon the dichotomy of the numerous anti-metropolitan city regions surrounding a Green Heart in spatial planning policy. Instead, a more holistic approach that integrates urban and rural spatial characteristics should be adopted. In order to investigate this evolving peri-urban context, this thesis proposes a design exploration focused on an area where the conceptual boundary of the Green Heart has shifted the most. Taking a critical perspective on the long-term sustainability of this cultural landscape, the exploration will delve into strategies that address the ecological, social, and economic implications of future development.

Figure 15 - Urbanisation patterns rendering the framework of the cultural landscape underneath invisible, necessitating a shift of the conceptual border of the Green Heart.

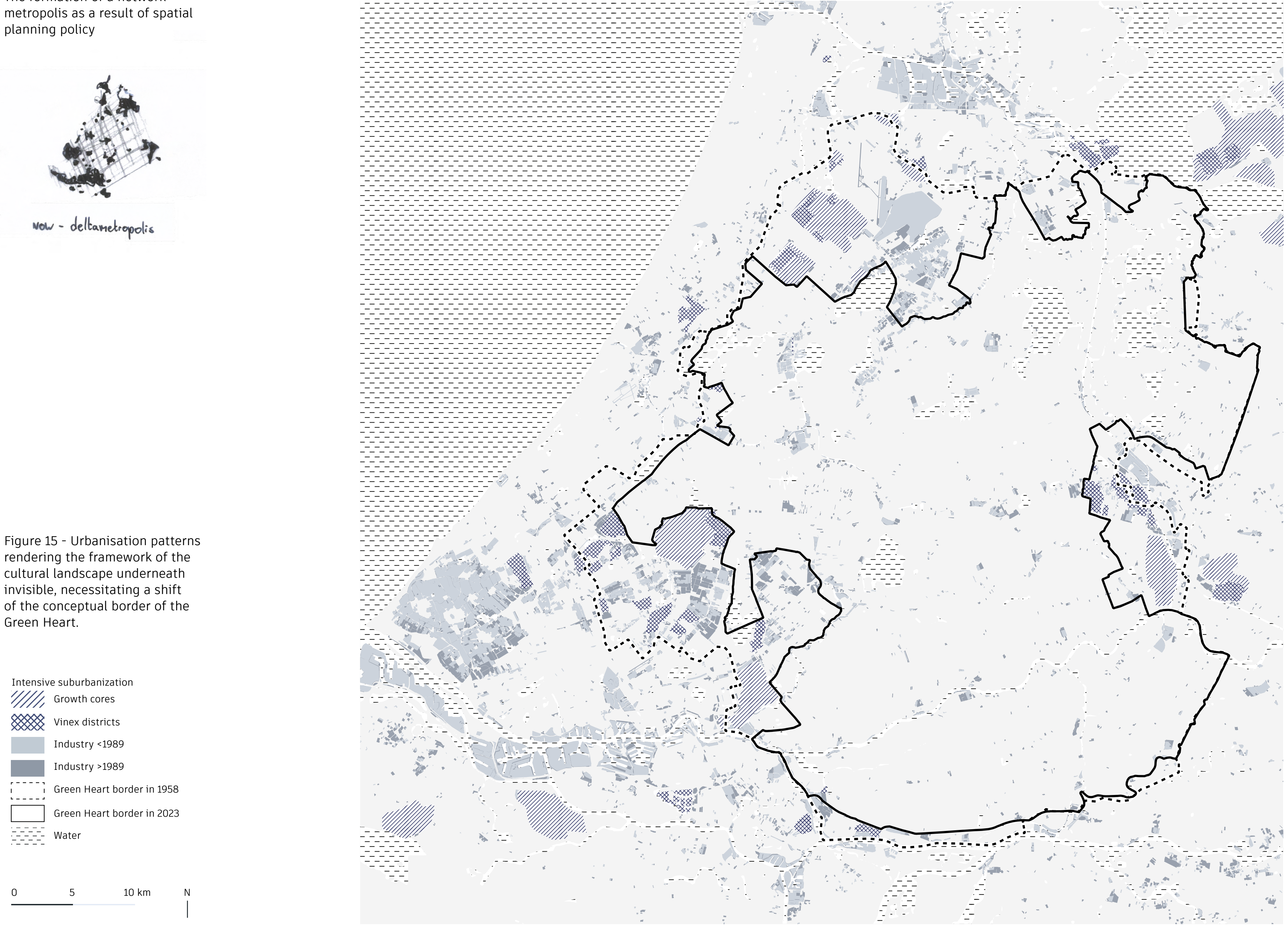


Figure 16 - Issues per soil type as a result of a landscape kept in lock-in in service of intensive agricultural production

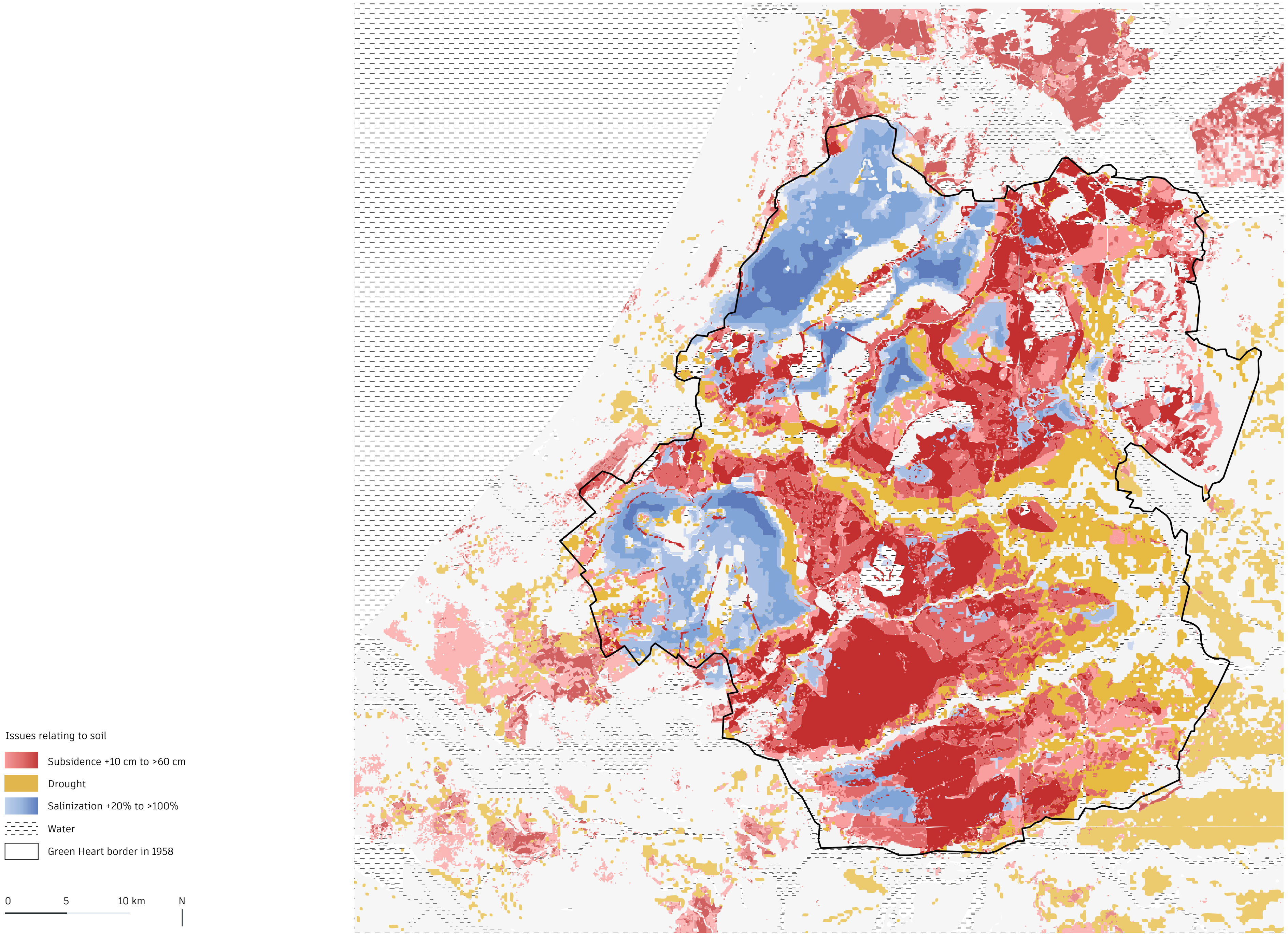
A Landscape in Lock-In

Namely the Fourth Report of Spatial Planning allowed for market-driven spatial development that established industrial production patterns that rendered the subsurface of the soil and water system subordinate. Figure 16 illustrates how this is represented most notably in the region of the Green Heart as demarcated in 1958.

The conceptualization of this dichotomous archetype allowed for a more efficient utilization of its centuries-old polders, with the central aim to increase its industrial productivity to ensure sufficient and affordable food for the Dutch population. The intensification of the agro-food sector, in line with global trends and driven by economic development objectives outlined in the Fourth Report, further intensified and accelerated this process. Consequently, conventional farmers have become increasingly reliant on globalized cooperations that handle the processing and marketing of their agricultural products, on an expanding global market. While the contemporary Dutch agricultural system has gained international recognition and admiration for its efficiency, the local consequences have been the emergence of an intensive production landscape characterized by the pursuit of maximization through scaling, intensification, monoculture, and the increased use of chemical inputs (College van Rijksadviseurs et al., 2022). In turn, this has lead to significant loss of biodiversity and soil deterioration.

The current water management system in the Dutch delta is closely tied to the intensive agricultural practices. The focus has historically been on supplying and draining water to optimize agricultural productivity on peat soils, river clay areas and droogmakerijen (reclaimed land). However, this system is expected to face significant challenges due to climate change, rising sea levels, increased precipitation, river overflows, drought periods, subsidence, and saltwater intrusion.

To sustain the productivity of peat soils, the dairy industry relies on maintaining a low groundwater level that supports heavy machinery and promotes high grass yield (Raad voor de Leefomgeving en Infrastructuur, 2020). Traditionally, these low-lying peat areas have served as natural buffers for fresh water. However, the once diverse meadows, abundant with herbs, have now been homogenized, drained, and prepared for early spring ryegrass harvest using large machinery. In addition to biodiversity loss, the variety of landscape types have also diminished, resulting in a loss of recognizability and experiential value. The low water level in service of the dairy



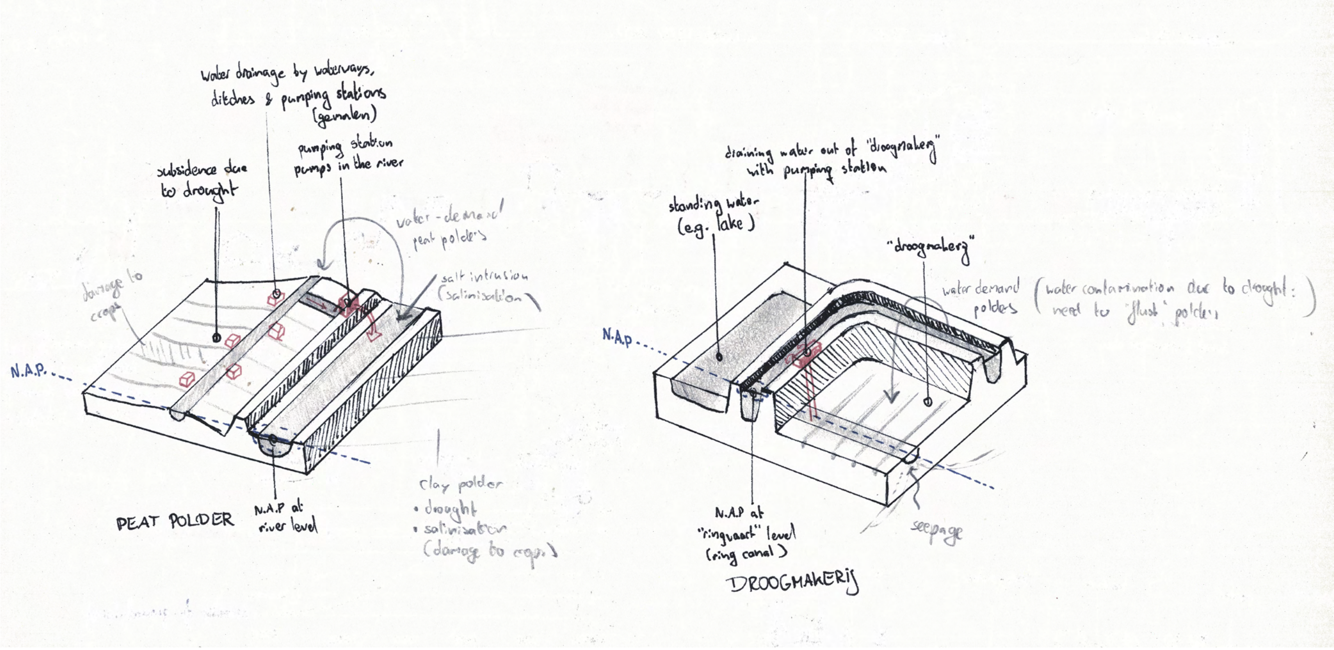


Figure 17 - Sketch of the environmental issues for peat polders and droogmakerijen. Inspired from Buro Sant en Co & Fabrications, 2019

industry leads to subsidence of peat, primarily due to oxidation, at a rate of 8 millimeters per year. Consequently, this process not only emits 1.4 Megatons of CO_2 in the Green Heart region per year, but also causes harm to infrastructure and buildings, both of which would potentially result in billions of euros in damages over the coming decades (RLI, 2019; Buro Sant en Co & Fabrications, 2019).

River clay areas and droogmakerijen are less affected by subsidence but face crop yield losses due to drought. Droogmakerijen are particularly vulnerable to drought as well as salinization. Here, the competition for space is intensified by the juxtaposition of agriculture, intensive horticulture, urban areas, and industrial zones, which leaves minimal room for water retention during periods of excess precipitation. Moreover, the rising sea levels increasingly add pressure to the fresh groundwater, while insufficient rainfall and reduced water supply from the Rhine, Meuse, and Scheldt rivers provide insufficient counterpressure, leading to increased salinization through seepage that infiltrates these relatively low polders. To mitigate the consequences of this salinization, the polder water system is flushed, which requires significant amounts of freshwater. (De Louw et al., 2010; De Louw et al., 2011; Buro Sant en Co & Fabrications, 2019)

A Perceived Cultural Divide

The implementation of policies targeting nitrogen and phosphorus pollution in May 2019 further strained the already tense relationship between conventional farmers and the coalition government. This has contributed to a perceived cultural divide between urban and rural areas, which is supported by survey findings indicating that nearly 60 percent of citizens and more than 85 percent of farmers acknowledge a gap between urban and rural regions. Similar percentages are also achieved in the perceived gap between the Randstad and the rest of the country (AD, 2023). Farmers argue that these measures have disproportionately impacted rural communities, threaten their livelihoods and view them as neglecting their agricultural traditions and rural way of life. In contrast, urban dwellers prioritize sustainability and environmental concerns, seeing the measures as necessary for protecting natural habitats and reducing pollution. However, some scholars argue against oversimplifying the differences between urban and rural areas.

Salemink (2023) highlights the increased convergence between these areas, facilitated by enhanced connectivity and shared experiences and resources. Huijsmans (2020) also indicates that the perceived cultural divide between urban and rural areas is not as pronounced as often portrayed. He states it is crucial to avoid oversimplifying and stereotyping areas and their residents, recognizing the significance of individual identities regardless of residential location. In the context of spatial planning, this introduces a cultural issue alongside the metabolic concerns within the metropolitan landscape. Oversimplifying the urban-rural dichotomy can perpetuate division and hinder effective policy development. Where there is little distinction between city and countryside, policies based on this generalization may not adequately address the specific challenges of these territories-in-between.

Figure 18 - The juxtaposition and interconnectedness of urban and rural landscapes, showcasing agricultural land against the backdrop of the skyline of Rotterdam
Source: AD, 2023

Nationale Omgevingsvisie

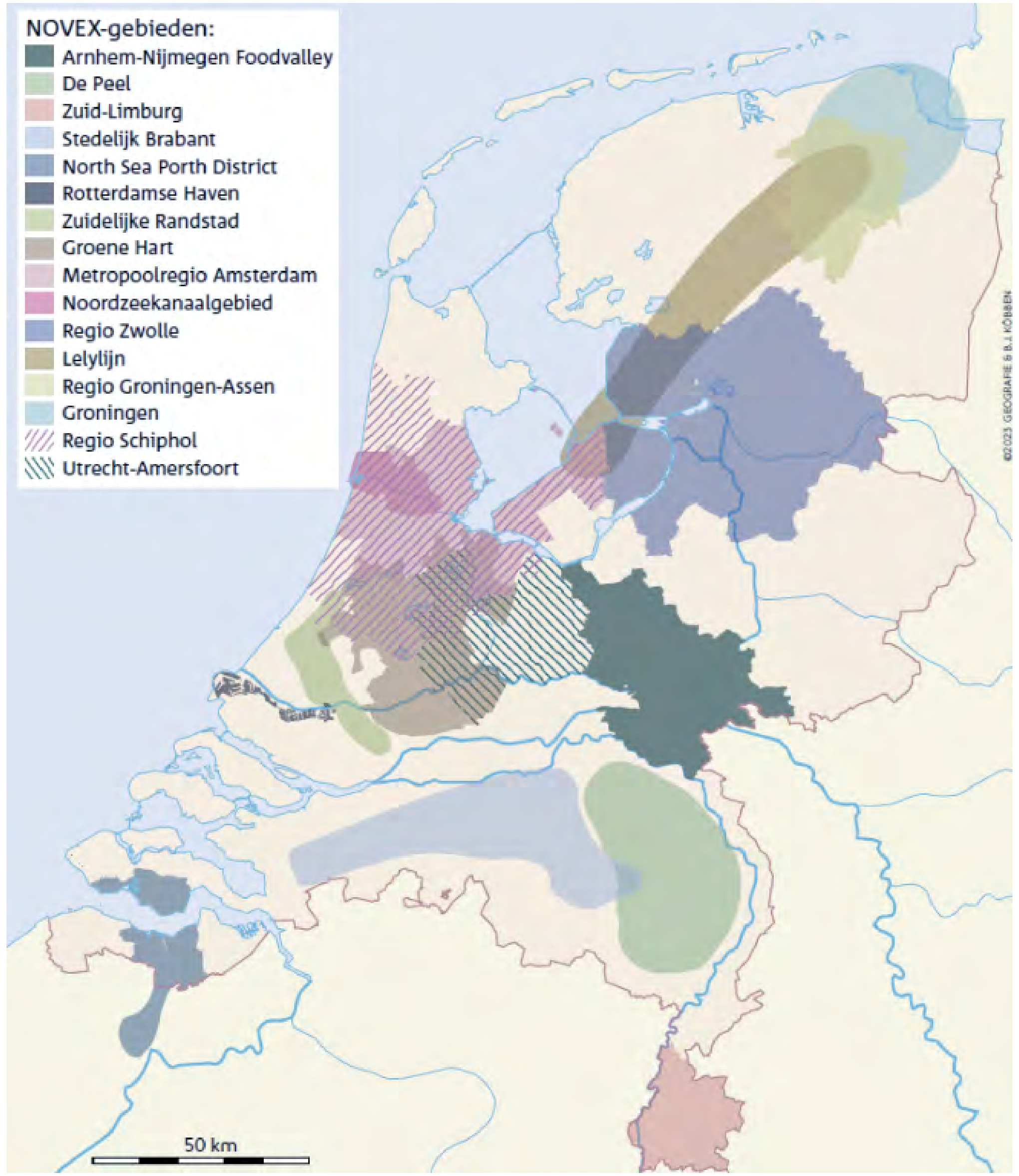
Similar to previous reports, the foundations of the Nationale Omgevingsvisie (NOVI) are rational and sectoral. National programs will converge in economically significant regions and Mainports, with little divergence in underlying social or ecological values at present, as depicted in the NOVEX-areas in figure 19. Strategic interrelations between these regions receive little attention. The Randstad, for example, is only mentioned once as an urban counterpoint to the Green Heart, whose "open character is essential for the quality of life and a necessary contrast with the large cities that surround it." (BZK, 2020: 134).

The National Housing Agenda aims to construct 900,000 homes by 2030, with nearly 60% of them planned for Utrecht and the Holland provinces (BZK, 2022: 8). However, there is no adaptive strategy to account for fluctuating levels of growth, creating uncertainty, especially considering previous plans like Randstad 2040 and the recent COVID-19 crisis. Additionally, little is mentioned about the quality of these houses, as it would require negotiations with provinces and private parties. Insufficient transparency regarding the necessary funding for achieving the proposed goals can raise questions on the plan's feasibility and the availability of resources. Moreover, implementation challenges may arise due to unclear responsibilities and coordination among various stakeholders, which can impede the progress of the proposed measures. Once again, as with many growth centres and Vinex policies, quantity seems to overshadow quality. The question of how we want to live should be at the core of planning sustainable urban development, but it appears to be of lesser priority.

Lastly, the NOVI incorporates conflicting objectives, such as promoting economic growth while also striving to protect the environment. This ambiguity can lead to conflicting policy decisions and a lack of clarity regarding the intended direction. Overall, the NOVI suffers from vagueness and lacks specificity in its formulation, making it challenging to derive concrete actions and measures. The absence of well-defined objectives and timelines could hinder effective policy implementation.

However, the Environmental Assessment Agency (Planbureau voor de Leefomgeving, or PBL) has taken a positive step by conducting a value-driven scenario study specifically tailored for the Netherlands, as shown in figures 20 to 23. This marks the first time that Dutch officials have undertaken such a study, acknowledging the importance of considering varying political preferences and addressing short-term political deadlines (PBL, 2023). Scenario studies in the field of spatial planning offer valuable insights into uncertainties, preconditions, and key considerations for addressing the most significant national objectives. As a result, there is a shift in focus from a sector-specific approach to implementing a cohesive spatial structure aligned with these value patterns. This shift allows policymakers to embrace a coordinated strategy that transcends the current fragmented policies, leading to enhanced sustainability in spatial planning throughout the Netherlands.

Figure 19 - NOVEX areas in the Nationale Omgevingsvisie



Policymakers face numerous moral decisions, where one choice impact others. However, given the self-imposed climate transition deadlines, it is crucial for the government to adopt stricter decision-making than the current approach. To guide policymaking, the government has already established three thematic perspectives: 1) agriculture and nature, 2) energy and circular economy network organization, and 3) liveable cities and regions. The PBL introduced a fourth element: implementing a primary spatial structure. By linking long-term investments to a spatial structure, synergies can be found between i.e. agriculture and nature. To support policymakers in their short-term investment planning, the PBL (2023) has developed four value-driven scenarios that offer insights into different future visions, shown in figures 20 to 23.

The central question was: How might a spatially high-quality, future-proof Netherlands look like by 2050, and what pathways can lead to these futures? Consequently, the question arises: What are the key spatial structuring choices that must be prioritized, and what other choices can follow from them?

The purpose of these scenarios is not to dictate a single course of action, but rather to develop a more informed assessment of the spatial consequences related to distinct short-term and value-based planning policy. This would shed light on the conflicts that may arise along various future pathways, although it is important to recognize that pathways within one scenario does not necessarily exclude pathways within another scenario. Nevertheless, concerning the European targets for nature development, it is important to note that only in the Green Land scenario and the Regionally Rooted scenario the envisioned developments offer a pathway to achieve these targets.

Within all four scenarios, the overarching goals for the Netherlands revolve around achieving circularity and climate neutrality. However, the main differences are based on distinct value patterns. Within the context of this thesis and along the spectrum between biophilia and technophilia, the value patterns of 'Regionally Rooted' and 'Green Land' can be considered as leaning more towards biophilia, while 'Global Entrepreneurship' and 'Fast World' tend to lean more towards technophilia.

However, it is important to acknowledge that this bio-techno dichotomy simplifies the multitude of value patterns and related governance structures found within future pathways. While this thesis primarily focuses on the spatial alterations of ecological systems in productive landscapes, it recognizes their interconnectedness with urban, social, and economic systems at a supra-regional scale. This encompasses considering opting for either centralized or decentralized spatial planning and development, which entails different roles for the market, central government, or local stakeholder networks. Consequently, these interrelated dynamics influence the patterns of compact or dispersed urbanization and the overall dynamics between urban and rural areas. These aspects will be further elaborated upon in greater detail in the following chapters, and in the conclusion.

Figure 20 - Global Entrepreneurship: Society prioritizes competition, individualism, hedonism, and profit, while aiming for "green growth" driven by technology and dominated by large international companies. However, urban-rural disparities increase, and humanity distances itself from nature. Metropolitanization in the urbanized west and centre of the country results in a pronounced contrast with the remainder of the country.

Figure 21 - Regionally Rooted: Regional communities prioritize the well-being of citizens, nature, and landscape, fostering trust, cooperation, and regional self-sufficiency. Agriculture faces limitations in scaling, leading to many agricultural companies operating as cooperatives. The Netherlands will exhibit a mosaic of landscapes with significant regional variations.

Figure 22 - Green Land: People view themselves as part of nature and identify with the collective society, emphasizing natural solutions over technological ones. However, this entails restricted consumer freedom, reduced material usage, and income redistribution. The government plays a major role, focusing on public transport, energy, and slow infrastructure networks, leading to urbanization centred around infrastructure nodes.

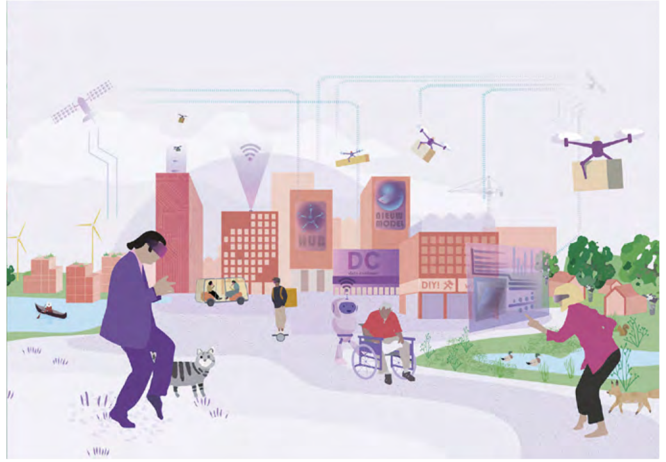


Figure 23 - Fast World: Technology enjoys significant interest, shaping society into digital lifestyle groups. The digital realm surpasses the physical space, leading to scattered urbanization and a fragmented physical landscape. Thriving sectors of i.e. the experience economy and delivery services are led by small high-tech companies.

Problem Statement

Driven by an urge to inhabit an inhospitable landscape, early settlers in the delta of the Netherlands were forced to adopt a technophilic relation towards their natural environment. As the country transitioned towards contemporary modernity, national planning policies established industrial production patterns that contribute to the societal, economic and ecological imbalances that are negatively impacting the metropolitan region's landscape today. The intensive production landscapes of the Netherlands subsequently aimed at maximization by scaling, intensification and an increased use of chemicals, disregarding the soil and water system on which they thrived. In turn, this resulted in the disruption of ecosystems and significant loss of biodiversity, and an inherently instable landscape that can not respond to the contemporary negative environmental externalities as a result of climate change. (RLI, 2019). Indeed, this system is expected to face significant challenges due to rising sea levels, increased precipitation, eutrophication, river overflows, drought periods, subsidence, and saltwater intrusion.

While spatial planning should aim for sustainable metropolitan development to mitigate this, the existing sectoral approach and the perceived cultural urban-rural divide maintain this original dichotomy, thus disregarding the strategic interconnections within the larger metropolitan region. Nevertheless, a polycentric metropolitan region has taken shape that no longer corresponded to this traditional dichotomy, on the territorial scale of what is referred to in this thesis as the Deltametropolis. In fact, most of this territory can be classified as neither urban nor rural, as Wandl et al. (2014) call 'territories-in-between'. While urban and rural typologies have been dissolved in a continuum, they are functionally and morphologically isolated as juxtaposed patches.

To promote sustainable metropolitan development, a more holistic approach that spatially, socially, ecologically and economically connects urban and rural land uses might need to be adopted. As the landscape of the Deltametropolis was culturally formed through a technophilic attitude which has led to the societal, economical and ecological imbalances it is currently facing, the hypothesis is that biophilic spatial structuring choices must be prioritized in order to sustainability resolve these imbalances.

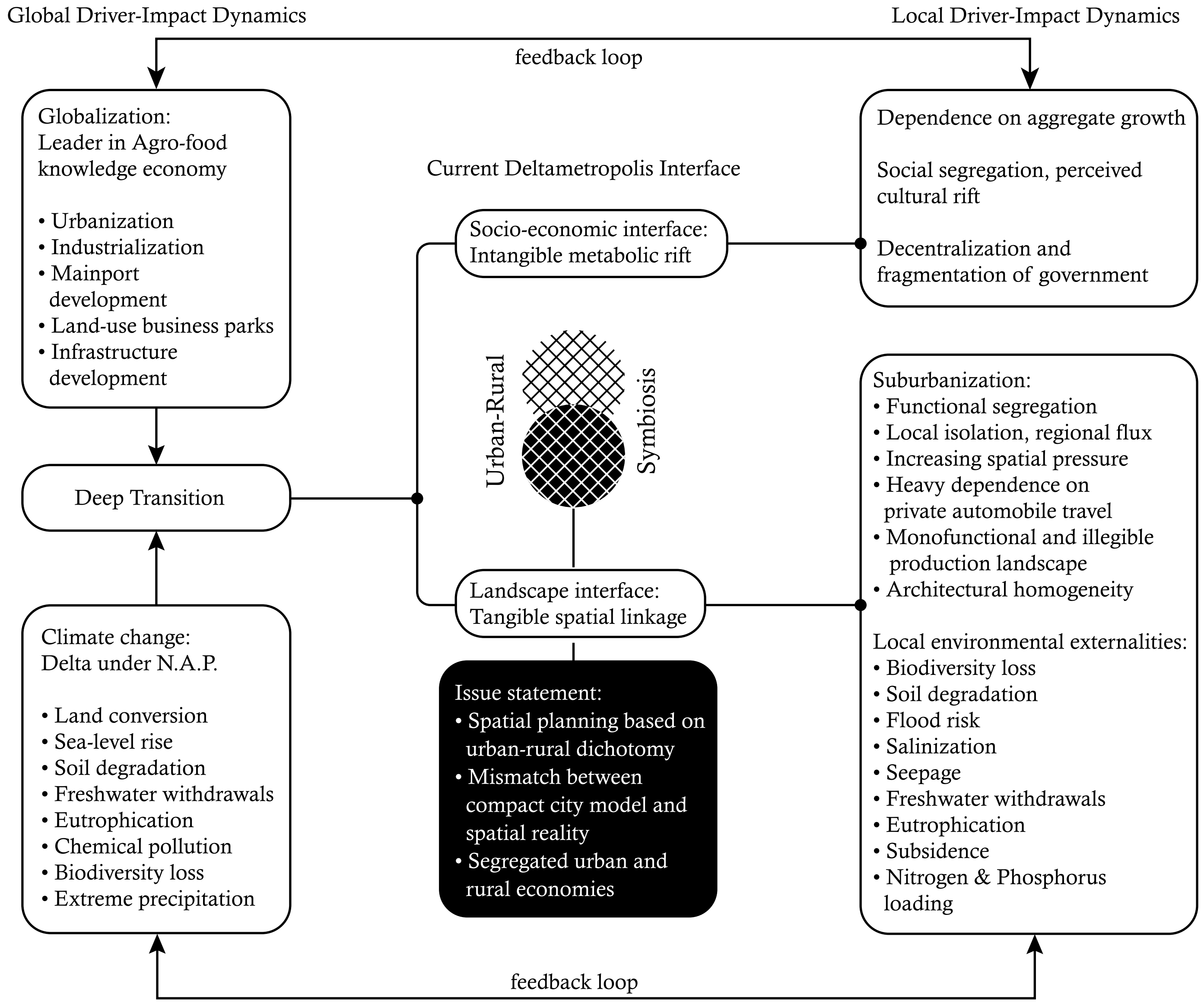


Figure 24 - Schematic overview of the problem field

Methodology

Research Aim

The aim of this thesis is to promote sustainable socio-economic and ecological metropolitan development in the peri-urban interface of the Deltametropolis by connecting urban and rural land uses and enhancing their respective spatial qualities.

The Dutch delta landscape has undergone cultural formation and intensification, driven by a technophilic mindset. However, this approach has indirectly contributed to the societal, economic, and ecological imbalances that characterize the current locked-in landscape today in 2023. To address these challenges in a sustainable manner, it is hypothesized that embracing biophilic-led planning and designing spatial development may be necessary.

The primary objective is to provide structural choices that allow the development of the agricultural sector to once more align with what the soil and water system can offer. In light of an uncertain future, it is essential to explore how this landscape can regain its adaptability to changing circumstances. By posing “what-if” questions, research by design could generate valuable insights and arguments. This approach involves testing potential spatial alterations and examining how they interact within the existing context. This will put forward a morphological framework in which natural and artificial spatial qualities are merged and functional programmes and uses can flourish.

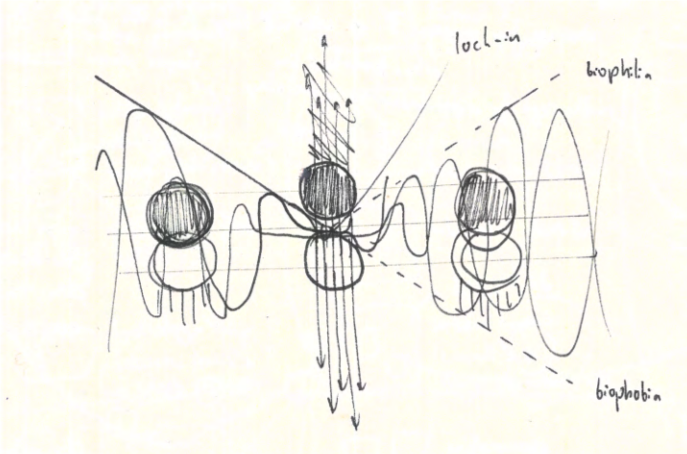


Figure 25 - Preliminary sketch when developing the research aim, which depicts the urban-rural divide and their reintegration through balancing ‘technophilic’ and ‘biophilic’ developments. Through transitioning towards sustainable and nature-inclusive production methods, there lies an opportunity in reintegrating urban and rural economies and communities.

Research Questions and Methods

The methodology is organized by outlining the research questions together with their respective related aim, and methods of research and design. This manifests in a set of primary and secondary methods, that build up the required knowledge through implementation. This either feeds directly into a sub-question or into a different method, as shown in the methodological framework.

Research Question

In the transition towards a sustainable Deltametropolis, how can an adaptive design enhance spatial qualities in the peri-urban interface through biophilic and technophilic developments?

Sub-question 1

How did the spatial, socio-economic and ecological dimensions of the Deltametropolis form over time, what were the main driving forces, and what could this mean for the future?

Aim

To understand the context-specific preconditions and dimensions of the metropolitan region as a basis for future development

Method: Diachronic Analysis

A more thorough understanding of the spatial development of the Deltametropolis must be achieved. This can be accomplished by looking at the spatial, socio-economic and ecological dimensions to show how urban-rural relations evolved over time. With the benefit of hindsight, patterns, drivers, or striking changes within the landscape can be traced. In turn, this might give insight into potential future trajectories, by noting qualities that might have been obtained or lost, whether it be spatial, ecological or economical.

Sub-question 2

How can the deep transition be understood and what are the risks, values and resultant spatial qualities associated with a technophilic or biophilic future for the agricultural sector in 2100?

Aim

To explore and define adaptive pathways into plausible futures for the agricultural sector based on risks, values and resultant spatial qualities

Method: Adaptive Pathways

Behind any development is a set of values that guide or steer transitions, entrenched in paradigms from that time. To be able to think of sustainable future developments that enhance the liveability of the landscape, these values have to be proactively (re)defined in order to consciously prompt for change and development. In the context of this thesis, adaptive pathways are used to identify spatial pathways that over time allow for a multitude of values to manifest in spatial development, accounting for unforeseen circumstances.

Sub-question 3

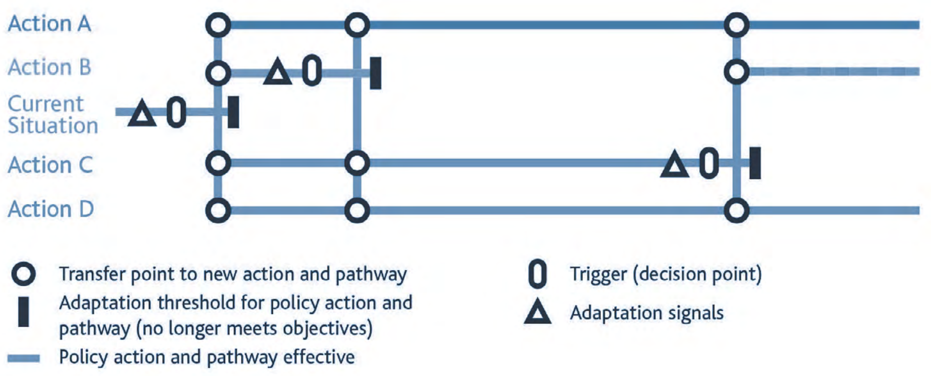
How can urban and rural spatial qualities in the peri-urban interface of the Deltametropolisbe strengthened by merging biophilic and technophilic values?

Aim

To give an expression to the articulation of peri-urbanism in the Deltametropolis, by testing sustainable land use configurations

Method: Research by Design

Research by design contributes to new knowledge by posing well-defined “what-if”-questions to guide the design for a specific location. This method generates design-based insights or argumentation by testing potential spatial alterations and how they interact within an existing context. It could visualise a desired outcome which could be implemented in an overall strategy, or produce insights to be fed back into the iterative design process, i.e. a new “what-if”-question.



Adaptive Pathways

The Adaptive Pathways framework, developed by Deltares (2016), involves defining a specific desired end-state, and then working backwards to identify multiple possible development pathways to achieve that goal. The pathways are measured against changing conditions, such as levels of subsidence or drought, of which the exact years are unknown. Considering the objective, it may be necessary over time to switch between pathways in order to prevent a lock-in: the consequences would be severe, or it would become very expensive to move to a different pathway later in time.

The future is deeply uncertain and transitions between actions may be needed sooner or later, depending on how the future unfolds. Acknowledging the deep uncertainties of the future, this framework recognizes that political, socio-cultural, and economic factors are subject to change and cannot be precisely predicted. But the pathways remain unchanged, making this a robust framework that works with deep uncertainty.

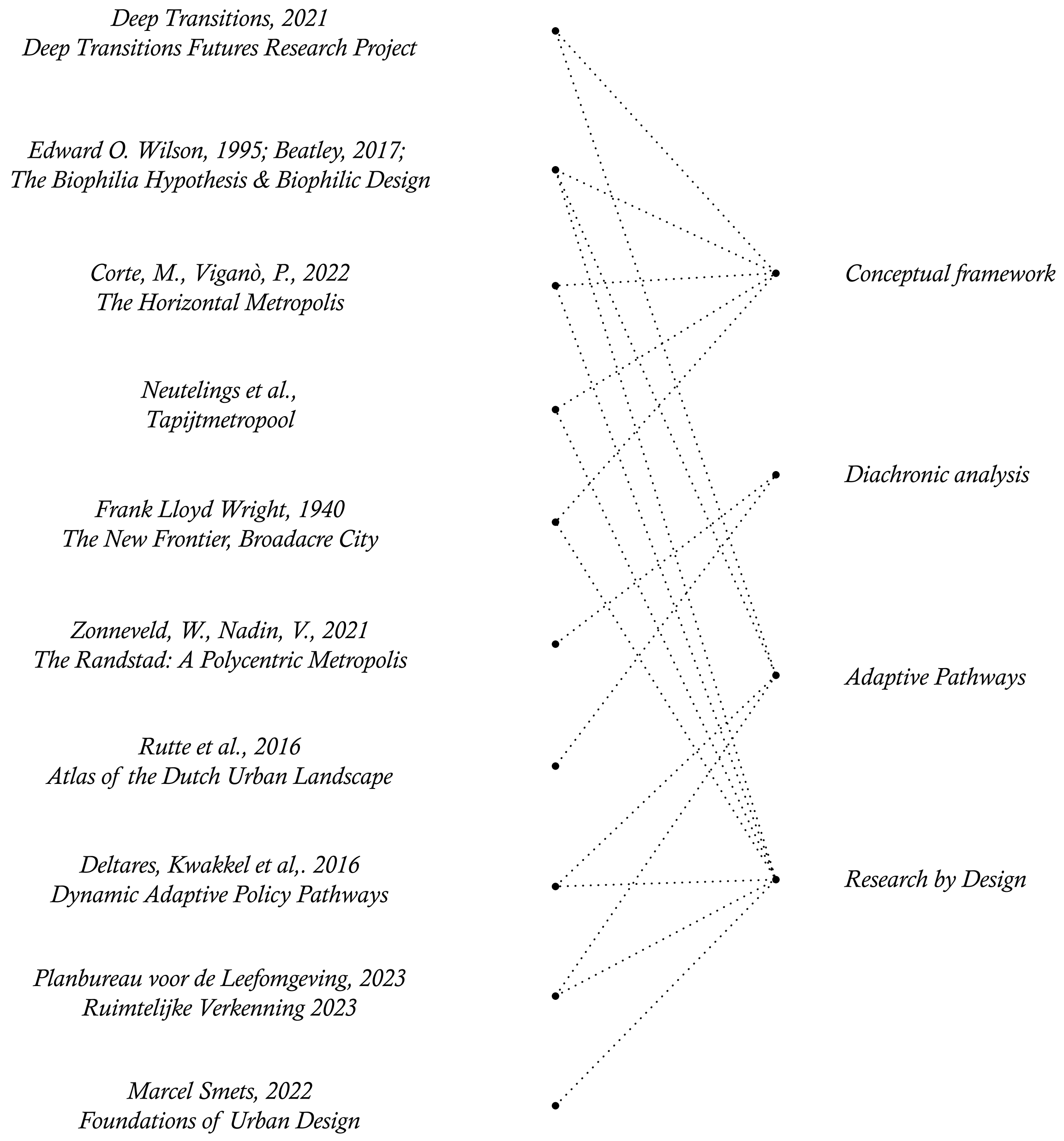
In this thesis, adaptive pathways are used to examine how and when the currently unsustainable agricultural production methods might transition towards sustainable production methods, and what spatial infrastructure is necessary before that transition can happen. By formulating land uses that can stay within planetary boundaries, it then seeks to establish structural spatial choices that can guide policy-making. This will be further elaborated upon while discussing the strategy, and the framework developed in this project is seen in the appendix.

This thesis employs adaptive pathways to analyze the transition from current unsustainable agricultural production methods to more sustainable forms of land use, to ultimately examine the necessary spatial infrastructure necessary for this transition. These aspects will be further discussed in the strategy section, and the project's framework can be found in the appendix.

Figure 26 - (top)
Adaptive Pathways Framework

Source: Deltares, 2016

Theoretical Framework



Submethods

Thick Mapping

The method of thick mapping aims to spatially, informatively and artistically render the thickness of the abstract urban palimpsest. It is routed in a multidimensional notion of space, and thus intents to encompass both this space and the people inhabiting it in the through the anatomy of a map. In his Dictionary of Sociology, Scott (2014) illustrates: “Intensive, small-scale, dense descriptions of social life from observation, through which broader cultural interpretations and generalizations can be made”. The superimposition of several layers of information reveals interrelations and allows for synergies between these layers to be disclosed. Scoring can moreover be used as a supporting approach to aid the thick mapping process.

Field work, Observing, Scoring

Key to observation is realizing space is constantly changing by movements through time. It can therefor increase the understanding of interactions and patterns throughout a given time and spatial environment.

Scoring can be used to notate perceived sensory conditions that belong to the landscape and serve as stimuli. This can also be used to represent non-visual qualities of space, such as sound, smell, horizontal and vertical locomotion, or the feeling of a certain material. An interesting feature of scoring is that the observer consciously or subconsciously discriminates and extracts, making notation a balance between an objective and subjective experience. As there are many different qualities linked to the environment, the same route needs to be walked multiple times.

Literature Review

Research is the process of generating new knowledge, partly by using existing knowledge in a new way as to generate new concepts, methodologies and understandings. Existing, thematically adhering knowledge is to be found in (academic) papers, books, and reports. This moreover informs, implicitly or explicitly, a gap in knowledge, still to be researched and discovered.

GIS-supported Spatial Analysis

Spatial analysis is used across multiple sections, layers and scales to investigate relations between seemingly separate things, categories, and silos. It serves as a tool for understanding complex systems and visual thinking.

A geographic information system (GIS) further aids this process by creating, managing, analyzing and mapping numerous types of data. It connects data to a framed space, and integrates location data with descriptive information. This helps to understand patters, relationships, and geographic context.

Network Analysis

Through network analysis, relationships and relational properties within or between datasets are examined. It differentiates between nodes (individual entities within a network) and their connective links (interactions between these entities). For example, it could aid the understanding of the movement of people within and between patches of the Deltametropolis.

Data Visualisation

Data visualization is widely used to give a graphic representation of information. It moreover allows for translating numerical information into a visual representation. In visualizing data, it is imperative that otherwise complex or abstract information can be comprehensively understood through visualization. An example of the appliance of this method in this thesis if for mapping information throughout time in the diachronic analysis.

Method:
Projecting Theoretical Models

As there is a gap between the urban theoretical model that the government imposes on the territory of the Deltametropolis, alternative theoretical urban models could provide further insight into territorial development which is more spatially coherent and sustainable, given the current spatial conditions. Certain values, leitmotifs or ordering principles could be derived from these theoretical models, and through research by design, implemented onto the contemporary spatial layout to explore their interaction within the contemporary context.

One of the earliest and most influential decentralized urban planning concepts is Broadacre City. In 1935, architect Frank Lloyd Wright showcased his visionary project at an exhibition in Rockefeller Center, New York. Broadacre City proposed a decentralized model of communities based on small-scale farming, local government, and individual property ownership. Developed during the Great Depression, this project addressed pressing social, economic, and environmental concerns that remain relevant today. The centerpiece was a 12-foot by 12-foot model representing 4 square miles of “typical countryside” accommodating 1,400 families. It incorporated all essential elements of modern society, including farms, factories, schools, parks, places of worship, and individual houses. Wright emphasized the importance of local scale and property ownership, with each citizen owning at least one acre of land and a car for transportation. Broadacre City aimed to break down artificial divisions between urban and rural life, promoting natural freedom and decentralization.
As Wright noted, “So Broadacre city is no mere ‘Back-to-the-Land’ idea but is, rather, a breaking down of the artificial divisions set up between urban and rural life. In Broadacres you will find not only a pattern for natural freedom for the individual as individual. You will find there structure based upon decentralization of nearly everything big business has built up to be ‘Big’” (Wright, 1940, 36). As Watson (2018) notes, “Broadacre City was not a utopian master plan but rather a hermeneutical framework for managing socio-spatial change.” His vision and methods serve as inspiration in this thesis, as it invites to reflect about the issues of our time within a similar morphological context.

Figure 27 - Broadacre City

Source: Frank Lloyd Wright (1940) & Watson (2018).

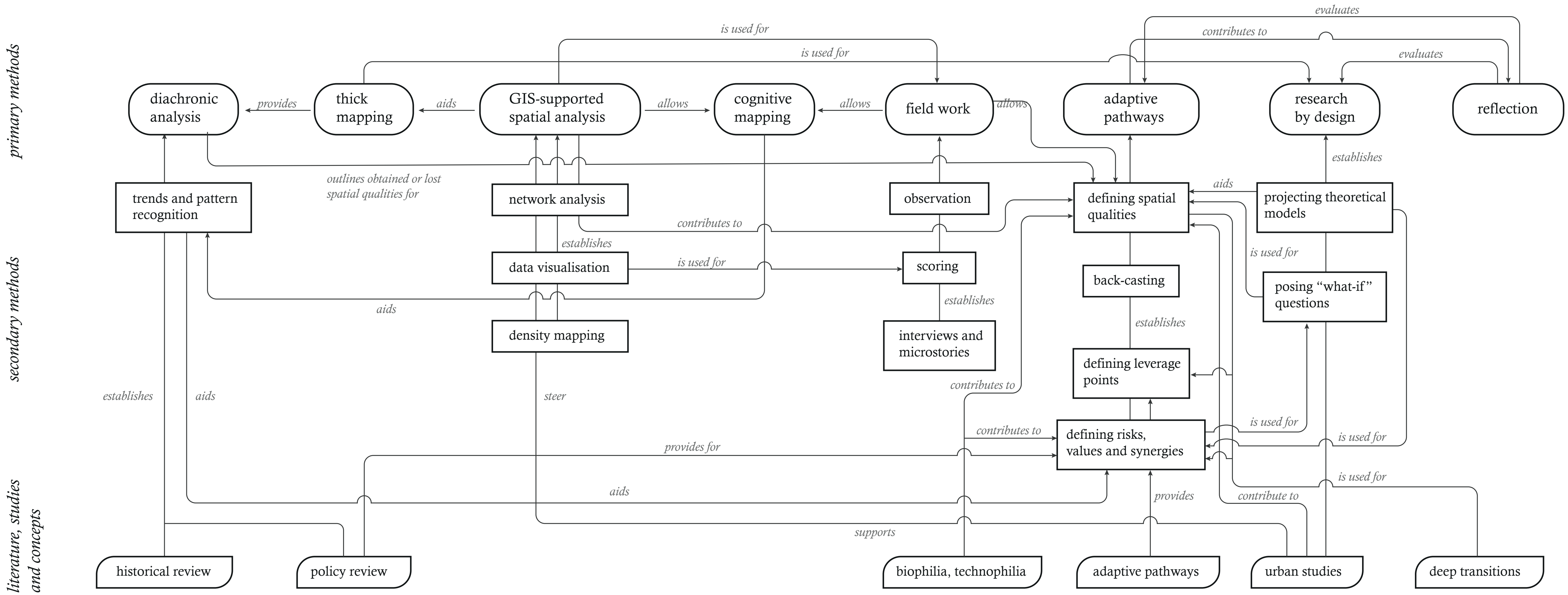
research questions

Research question: In the transition towards a sustainable Deltametropolis, how can an adaptive design enhance spatial qualities in the peri-urban interface through biophilic and technophilic developments?

Subquestion I: How did the spatial, socio-economic and ecological dimensions of the Deltametropolis form over time, what were the main driving forces, and what could this mean for the future?

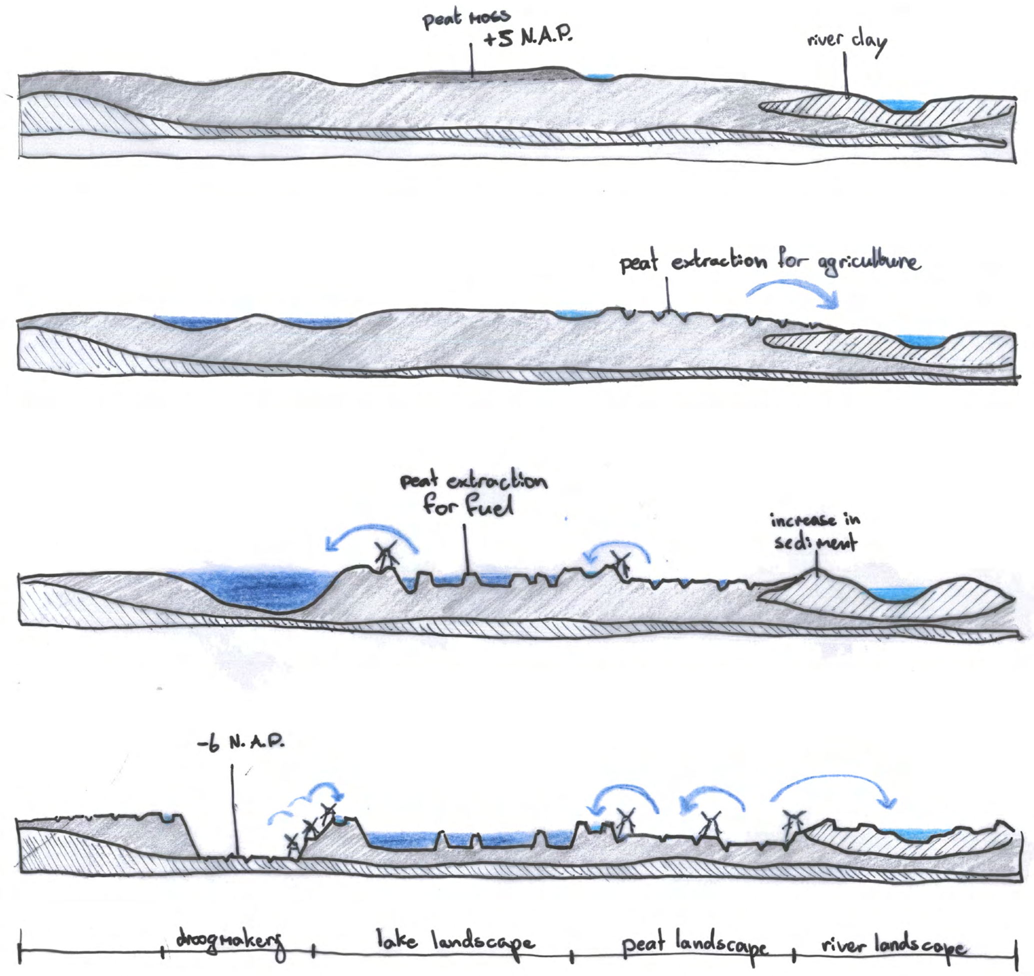
Subquestion II: How can the deep transition be understood and what are the risks, values and resultant spatial qualities associated with a technophilic or biophilic future for the agricultural sector in 2100?

Subquestion III: How can urban and rural spatial qualities in the peri-urban interface of the Deltametropolisbe strengthened by merging biophilic and technophilic values?



Analysis

Diachronic Analysis



The aim of conducting a diachronic analysis is to comprehend the historical evolution of the spatial, socio-economic, and ecological aspects of the Deltametropolis region, in order to provide a foundation for future development. To understand the dynamics between city and countryside, it will examine the alterations in- and the interactions between settlement patterns and the agricultural sector, along with their impact on the wider landscape. Given the extensive and intricate history of the Deltametropolis, this analysis will only focus on the key factors that have influenced the region's development in each section. Ultimately, the proposed design will be grounded in, or oppose the distinguished drivers, trends, patterns, values or spatial qualities, naturally building upon the diachronic analysis.

Figure 28 - Section of the evolving landscape formation of droogmakerijen, lakes, peat meadows, and rivers, highlighting the extraction of peat and the subsequent drainage of lakes to establish the droogmakerijen we see today, as well as the ongoing requirement for continuous drainage in the lowlands

Throughout its history, the urbanized landscape of the Netherlands has been heavily influenced by its geographical location by the Rhine, Meuse, and Scheldt rivers intertwining to form a Delta. The resultant alluvial plans have been among the most bountiful agricultural areas in the world, resulting in the most densely urbanized regions on earth today. Early settlements mainly developed around fertile soils and waterways, with inhabitants living on dunes and higher deposits in the Maas and Rhine estuary before 1000 A.D.. Beyond these areas lay swampy peat bogs, rising one to three meters above sea level. From 1000 pioneer communities began to cultivate these peat bogs. The reclamation of marshes and wetlands was obtained through the systematic drainage by means of ditches and catchment basins, leading to the formation of soils suitable for agriculture and development. To protect themselves from floods while expanding their territory, settlers began building dikes, dams, and canals, which extended an already rich natural network of waterways (Rutte et al., 2016).

As reclaiming the peatlands enabled agriculture to be practiced on a regional scale, this led to the first agricultural revolution: a surplus of food that could be traded in medieval towns, ultimately resulting in a relatively late but rapid period of urbanization and the development of a modern market economy in which labour and the exploitation of agricultural land became highly commodified. The extensive transportation network of inland waterways facilitated a spatial, social and economic symbiosis between city and countryside, forming the foundation of a polynuclear urban region. As agriculture on peat soils deteriorated due to subsidence, this resulted in an economic shift towards cattle breeding and various industries between competing cities, such as textile production or brewing, coupled with shipping and shipbuilding. After all, the strategic position of the Netherlands on the intersection of England, France, Southern Germany and Scandinavia meant that the surplus of produce could be traded on the international market (Engel et al., 2013).

In conclusion, during this time period, reclamation, hydraulic alterations, and urbanization were inextricably linked. As drainage and supply canals also functioned as steering instruments for urban development, the dimensions of open and built-up space became closely correlated, ultimately turning the geographical disadvantage of inhabiting a deltaic swamp into an advantage. The growth of Holland was mainly due to export, a strong infrastructural basis and economic and administrative foundations.

1000 – 1500

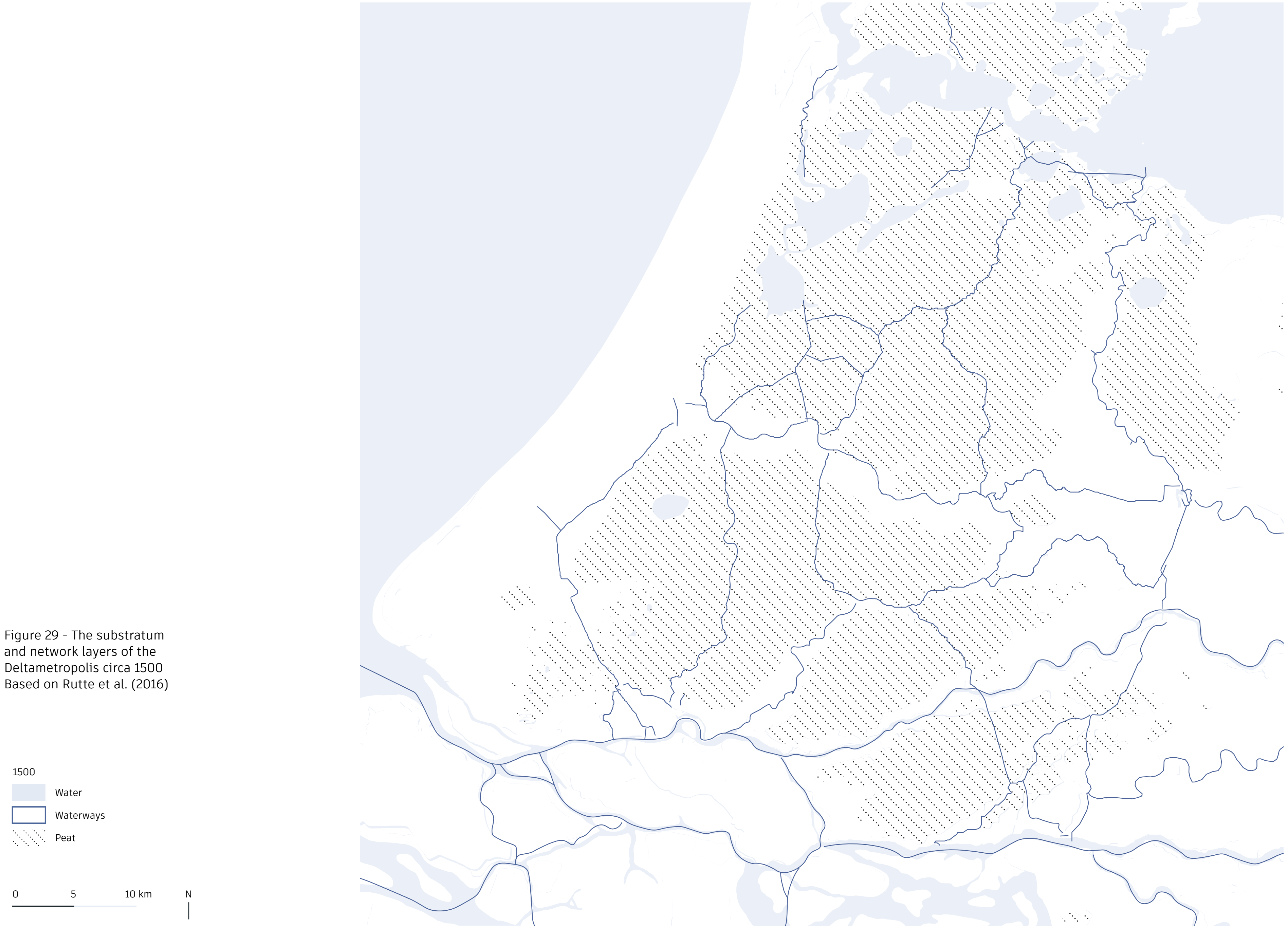


Figure 29 - The substratum and network layers of the Deltametropolis circa 1500 Based on Rutte et al. (2016)

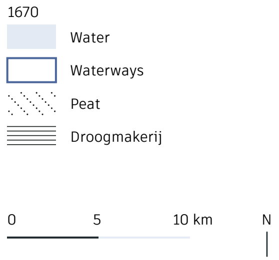
Around 1530, dredging equipment was introduced in peat extraction, which allowed for the harvesting of deeper layers of peat. This resulted in the creation of deep pools that grew into lakes as their shores eroded, eventually posing a threat to roads, villages, and dikes. The introduction of drainage windmills made it possible to build dikes around these lakes and then pump them dry, resulting in the so-called 'droogmakerijen'. Land reclamation, facilitated by the collaboration between farmers, nobles, and townspeople, regardless of heritage or class, led to the emergence of the waterboard, one of the first forms of civil society (Rutte et al., 2016).

This public-private partnership was also seen in the extension of inland waterways. These were initiated by the two cities that connected them, which subsequently quickly developed around water engineering works (dams or locks) and where goods were traded and markets were held. The resultant dense water network was intensively used by reliable, regular departures of horse-drawn inland ships, and these excellent connections made a variety of economic activities possible and led to competition between cities. As previously inaccessible inland areas became more closely interconnected with various urban economies located near the sea, this further enhanced the international trade of inland produce.

After the 80-year war, Amsterdam increased its grip on the international market due to its specialization in Baltic grain trade, which became in high demand due to war between Spain and its rebellious provinces. Together with the excellent inland infrastructural basis for trade, this resulted in the so-called Golden Age of the 17th century, where Holland specialized in herring, shipping and shipbuilding, livestock, fuel in the form of peat, grain trade, and the bulk goods of wool and linen (Zonneveld, & Nadin, 2021). However, this also meant that the urban centre of gravity would eventually become located below sea-level.

1500 - 1670

Figure 30 - The substratum and network layers of the Deltametropolis circa 1670
Based on Rutte et al. (2016)



In the 18th century, London took over Amsterdam's role, and as competition between international markets rose, many cities in Holland stagnated or shrunk. At the same time, the national government increasingly assessed more control over especially infrastructural projects. As around 1800 many roads were still largely unpaved, a number of paved roads were built, doubling the total length of paved roads in the country. This had the benefits of faster and cheaper transport, but also using this infrastructure all the year round, becoming economically and militarily worthwhile.

Within a few decades, the success of new paved roads was undermined by the advent of the steam train. Both paved roads and railway lines were intended to link up the main population centers. Many of the railway lines in the Randstad area therefore largely followed the water and land routes that had existed since the Middle Ages. Construction of the railway system had to compete with the unique system of public transport via barge canals and goods transport by water.

Competition between water transport and the railways dominated the debate of the development of new infrastructure during the 19th century. The answer was found in a merger between the two, for around 1900 the shift in emphasis from water to land transport had not yet reduced the importance of shipping. During the 19th century, a great deal was also done to improve the wet infrastructure by building new canals and increasing the size of existing locks, as domestic goods transport was still dominated by shipping. The Noordzeekanaal and de Nieuwe Waterweg improved Amsterdam and Rotterdam's links to the sea, respectively, and Rotterdam manifested itself more and more as a direct competitor in international trade (Rutte et al., 2016).

Concludingly, in this period, the polycentric spatial configuration of the contemporary Randstad-region were further entrenched, where once more, not one city was dominant in hierarchy. The modernisation of overland passenger and goods transport during the 19th century greatly increased its extent and importance.

1670 - 1850

Figure 31 - The substratum and network layers of the Deltametropolis circa 1850 Based on Rutte et al. (2016)

1850
Water
Waterways
Peat
Droogmakerij
Rail

0 5 10 km N

The creation of a large-scale infrastructure network was an important condition for growth. Modern large-scale industry appeared wherever canal and railway met. This extensive modernisation had a major impact not only on cities, but also on the countryside, which became even more accessible. Urban and rural areas were brought closer as travel times were reduced and transport becoming more reliable.

Steam powered drainage helped improve water management, allowing for many of the inland seas and lakes to be drained. The large-scale drainage of for example the Zuidplaspolder (1839) and Haarlemmermeerpolder (1852) subsequently allowed for more intensive agricultural production (Engel et al., 2013).

Factory production furthermore led to standardization and hence more constant quality. The produce became more readily marketable and increased farmers' earnings. Hence a flourishing rural culture developed.

However, the agricultural crisis in Western Europe between 1878 and 1895 caused the prices of agricultural products to plummet. This was a serious blow to rural areas, but also speeded up the modernization of agriculture. In order to save on labor costs, the more wealthy farmers purchased agricultural machinery. As a result of this mechanization, employment declined, and a large part of the rural population moved away, mostly to the cities. Due to the urbanization that was the result of this, industrialization increased tremendously, and particularly in cities, industry boosted employment.

1850 - 1918

Figure 32 - The substratum and network layers of the Deltametropolis circa 1918 Based on Rutte et al. (2016)

Stimulating measures taken earlier finally started to have effect. In the second half of the 19th century, all towns underwent unprecedented growth due to the combined effects of industrialization, improved sanitation practices, based on the functional characteristics previously established (Zonneveld, & Nadin, 2021). For a long time afterwards, this growth was primarily seen from an economic perspective, with the belief that expanding industry and commerce would benefit society as a whole and lead to progress. Consequently, growth became the primary condition for progress.

After the First World War, two new modes of private transport were on the rise due to the technological advancements. Schiphol near Amsterdam became the leading airport, functioning as an international passenger and goods hub, which was an important impulse to compensate for Amsterdam's decline as a seaport. As mass production of the car after WO1 increased road traffic, the first National Road Plan was launched in 1927, mainly improving existing roads, but also adding new road links between major cities (Engel et al., 2013).

The emergence of an autonomous network of motorways marked a significant shift in the national accessibility system, introducing a new hierarchy that did not merely follow the traditional urbanization pattern. The aim was to establish a system that offered universal accessibility and ensured that all destinations within the network were equally accessible from any point of origin within that same network. In subsequent decades, areas close to highways and former port zones became focal points for new developments, leading to the creation of a territorial isotropy that facilitated the spread of cities across the countryside without any restrictions. Even before the Randstad and Green Heart were conceptualized in 1960, the literal and metaphorical infrastructure was already in place to render the ideal image of the city impossible. As a result, the Deltametropolis transformed from a collection of compact cities surrounded by an expansive agricultural landscape to an almost continuous urban field interwoven with patches of agricultural land and green spaces.

The new motorway system and the airports were of crucial importance to agricultural exports. Nevertheless, upscaling through consolidation of agricultural holdings was considered essential if arable areas were to remain profitable. From the late 1950's onwards large areas of farming land were changed drastically within the framework of land consolidation projects. Small-scale farms, which previously relied on manual labor across many dispersed parcels, became mechanized, while efficient road infrastructure facilitated the access of tractors and trucks. The traditional small-scale landscape, which was less productive but highly effective in closing material cycles, was replaced by a large-scale landscape that was highly productive but resulting in a metabolic rift. However, what is striking is that the aforementioned development was mainly confined to the clay polders, leaving the reclaimed peatlands largely untouched (Zonneveld, & Nadin, 2021).

1918 - 1989

Figure 33 - The substratum and network layers of the Deltametropolis circa 1989 Based on Rutte et al. (2016)

1989

- Water
- Waterways
- Peat
- Droogmakerij
- Rail
- Tram
- Road
- Industry

0 5 10 km N

Spatial Analysis

As outlined in Nota's Inzake de Ruimtelijke Ordening, the market-driven climate of spatial planning of the decades that followed have resulted in the emergence of a highly productive yet unsustainable agricultural landscape, alongside unprecedented suburbanization in especially the South Wing of the Randstad.

To conduct research by design, the region that shows the highest tension between urban and rural dynamics has been selected: the cluster of droogmakerijen in de South Wing of the Randstad, which has experienced a significant shift in the conceptual boundary of the Green Heart, as well as the neighboring peat polders that remain part of the Green Heart.

The droogmakerijen are primarily utilized for intensive horticulture and agriculture, while the peat meadows are predominantly dedicated to intensive dairy farming. The arboriculture of Boskoop is also part of this region, although it is not the main focus and in stead serves as a reference for agroforestry systems. Exploring the merger of technophilic and biophilic qualities through design could offer valuable insights when comparing these distinct cultural landscapes. Additionally, striving for the closure of regional metabolic flows makes it worthwhile to identify synergies within and between these landscapes, with the ultimate goal of enhancing regional metabolism and urban-rural relationships.

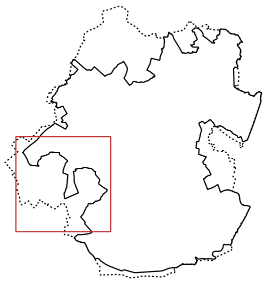
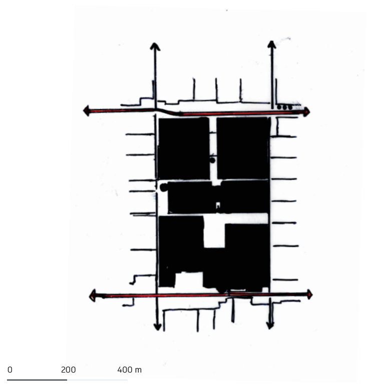
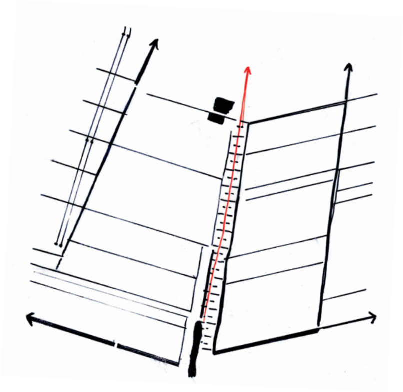


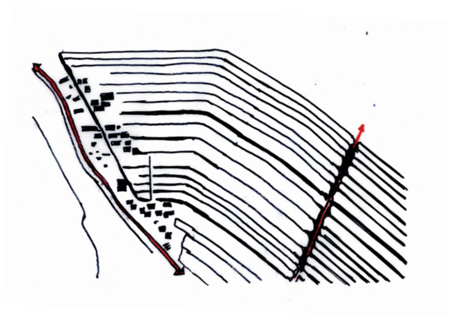
Figure 34 - (right)
The selected region for research by design, enclosed by the cities of Delft, Zoetermeer, Gouda and Rotterdam.

Source: PDOK, 2022

Figure 35 - (below)
A sketch of the form of the cultural landscape and the relation between built-unbuilt of horticulture, agriculture and dairy farming, respectively.







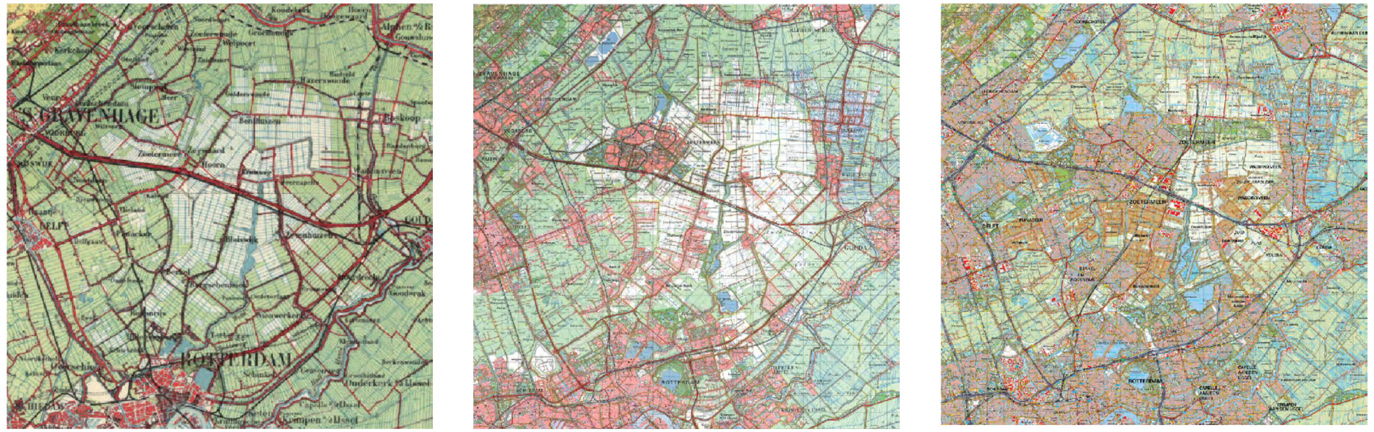


Figure 36 - The gradual urbanization patterns shown in 1958, 1989 and 2019, respectively

Source: TopoTijdreis, 2019

In the droogmakerijen, the rational design of the drainage allotments that came into existence after draining the large water-bodies made these regions well-suited locations to accommodate land-uses that were more challenging to realize elsewhere such as large-scale infrastructure, growth cores such as Zoetermeer and Vinex districts in Lansingerland.

What has been less affected by national spatial policy than by the development of the global economy is the establishment of large greenhouses and agro-logistic complexes in distribution centers located nearby business parks, all occupying a large grain and thus rendering the cultural landscape underneath largely invisible. This is a type of settlement pattern that has been planned from above and is designed on the basis of a specific, intrinsic functionalism. It constitutes an enclave within the fabric, which Smets (2022) calls a ‘void’ in the landscape. Their design is dictated by internal efficiency, and have taken the upper hand over landscaping conditions. It neither takes into consideration their location, the composition of the soil or their relation to the surrounding constructions, resulting in the emptiness of the void.

Figure 37 - The archipelago of business parks and greenhouses

Agro-citadels

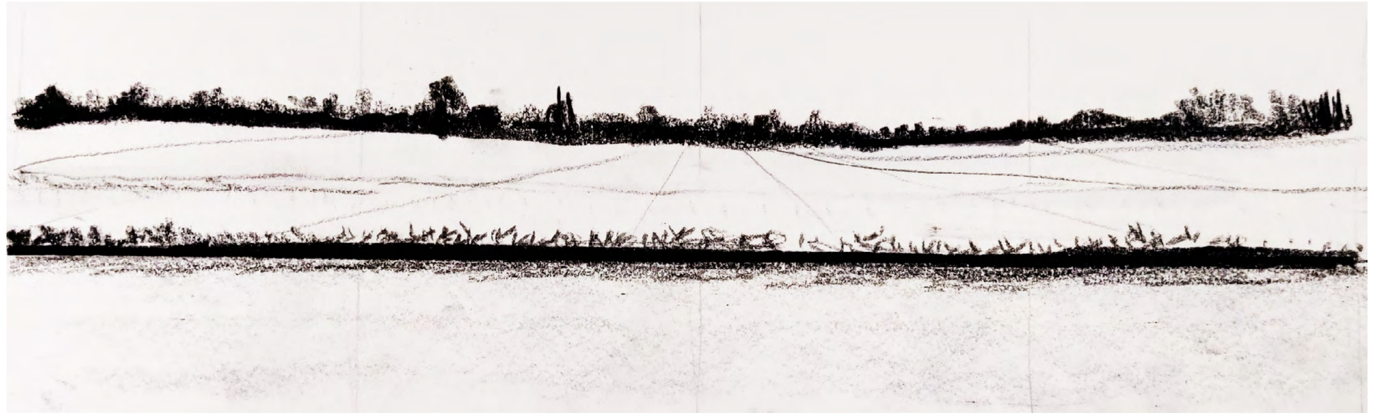
- Business parks and greenhouses
- Secondary roads
- Primary roads
- Motorways

0 2 4 km N

As the original landscape structure was most neglected here during the gradual suburbanization including the construction of large-scale infrastructure, the framework of natural elements no longer offered a hold and have disappeared. As we often collectively move along these infrastructures, we systematically travel through a void. The void thus becomes the dominant perception of the current urban space (Smets, 2023).

Figure 38 - Spatial characteristics of the droogmakerijen

The centuries-old peat meadows are characterized by their openness, water features, and cows grazing along extensive strips of land. However, the once diverse meadows, abundant with herbs, have now been homogenized, drained, and prepared for early spring ryegrass harvest using large machinery. In addition to biodiversity loss, the variety of landscape types have also diminished, resulting in a loss of recognizability and experiential value.



Figures 39 to 41 - Panorama sketches made during field work showing spatial characteristics of peat meadows

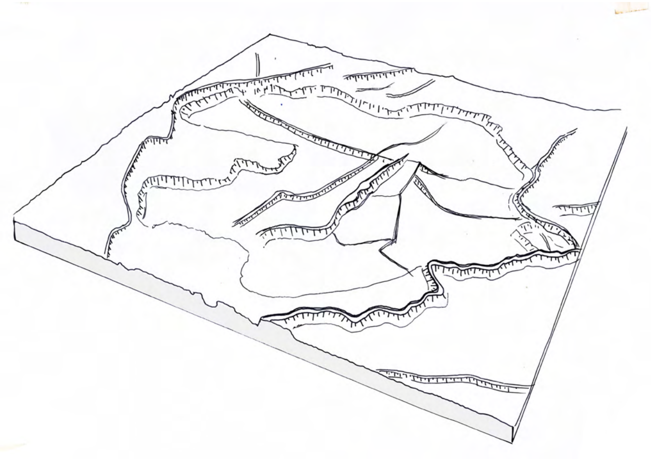


Figure 42 - (left)
3D sketch of elevation. The terrain of the droogmakerijen visually appear as a void as a result of peat reclamation in the past

Figure 43 - (right)
Elevation of droogmakerijen and peat polders, kept dry by the boezem system.
Based on Bobbink (2016)

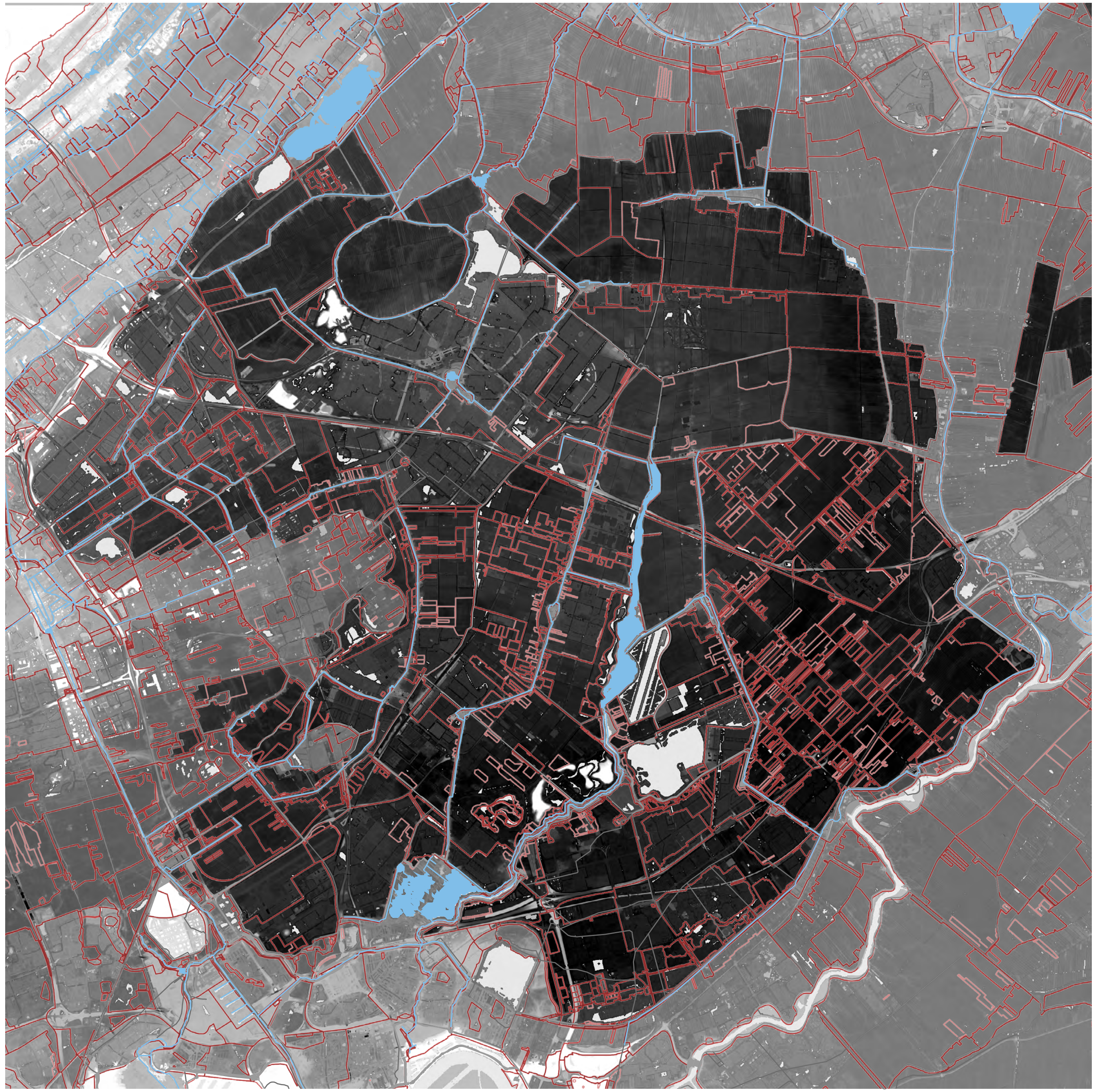
Polder-Boezem System

In the Lowlands, the effective drainage of water is of utmost importance. The peat polders and droogmakerijen are always surrounded by embankments, and consist of one or more 'peilvakken', or water level compartments. Within one peilvak, the aim is to achieve a certain water level that is suitable for agriculture, nature or other functions within that area. Polders discharge their excess rain or seepage water through a pumping station, directly to the open water, to a reservoir, or through another polder to the open water (Bobbink, 2016).

Due to the conversion of land use within a polder, such as urbanization, agriculture, or nature management, the need for different water levels has arisen. This has resulted in a highly fragmented water management system, which has increased by more than tenfold in recent decades, as illustrated in figure 43. (Kwakernaak & Rienks, 2005).

On average, the peat polders, due to subsidence and/or peat extraction, lie at approximately NAP -2.50 meters and are mainly used as grasslands. The water flows through natural drainage or through the operation of a mill or pumping station, from the ditch to the larger waterways where it is collected. By using weirs, ditches and waterways can be separated into individual peilvakken. As the land gets wetter, the ditches are closer together and/or wider. This network of ditches forms the 'circulatory system' of the landscape.

Droogmakerijen are situated between NAP -2.00 and -6.00 meters deep, on average significantly deeper than the peat polders. The soil of the droogmakerijen, usually clay, is highly suitable as agricultural land. This clay soil is typically rich in organic matter and has a good structure, which makes it an ideal growing medium for crops. The water flows through natural decline, or through the operation of the mill or pumping station via a ditch to the canal and/or waterway, and from there to the pumping station.



The task of drainage is overseen by governmental organizations known as waterschappen, or water boards, within the boundaries of boezemgebieden, or storage basins, which acts as watersheds. The waterschappen have several primary responsibilities, including managing the water system within their designated areas to prevent water shortages and drain excess water. They also take charge of wastewater treatment generated by households, industries, and agricultural activities, while implementing measures to protect and enhance water quality. In addition, water boards work closely with other water management authorities such as provinces and Rijkswaterstaat, as well as stakeholders like farmers and nature organizations. They actively encourage public participation in water management and ensure stakeholders are involved in decision-making processes (AZ, 2022).

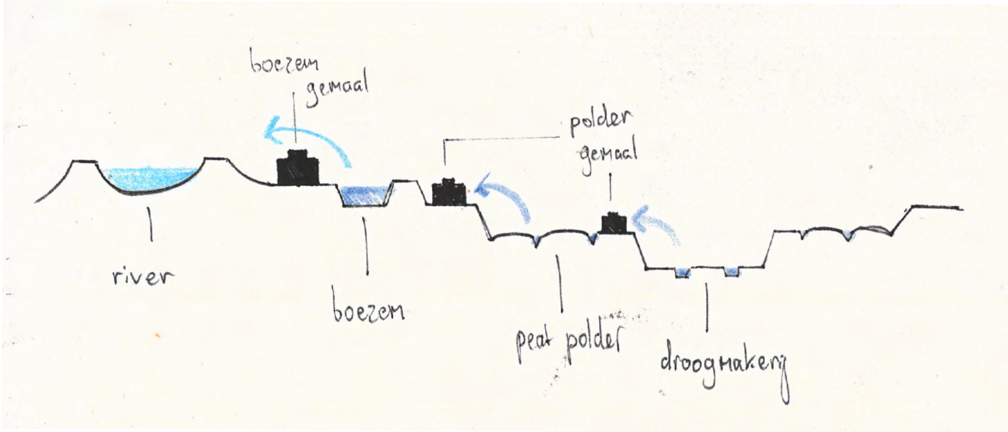
Given the increasing responsibilities and significance of waterschappen in the future management of the water system in the Netherlands, a holistic approach is proposed in this thesis for the redesign of the water system at the scale of each waterschap, as opposed to incremental adaptations on, for example, a polder level. This is particularly crucial in the Lowlands due to the complexity of the polder-boezem system.

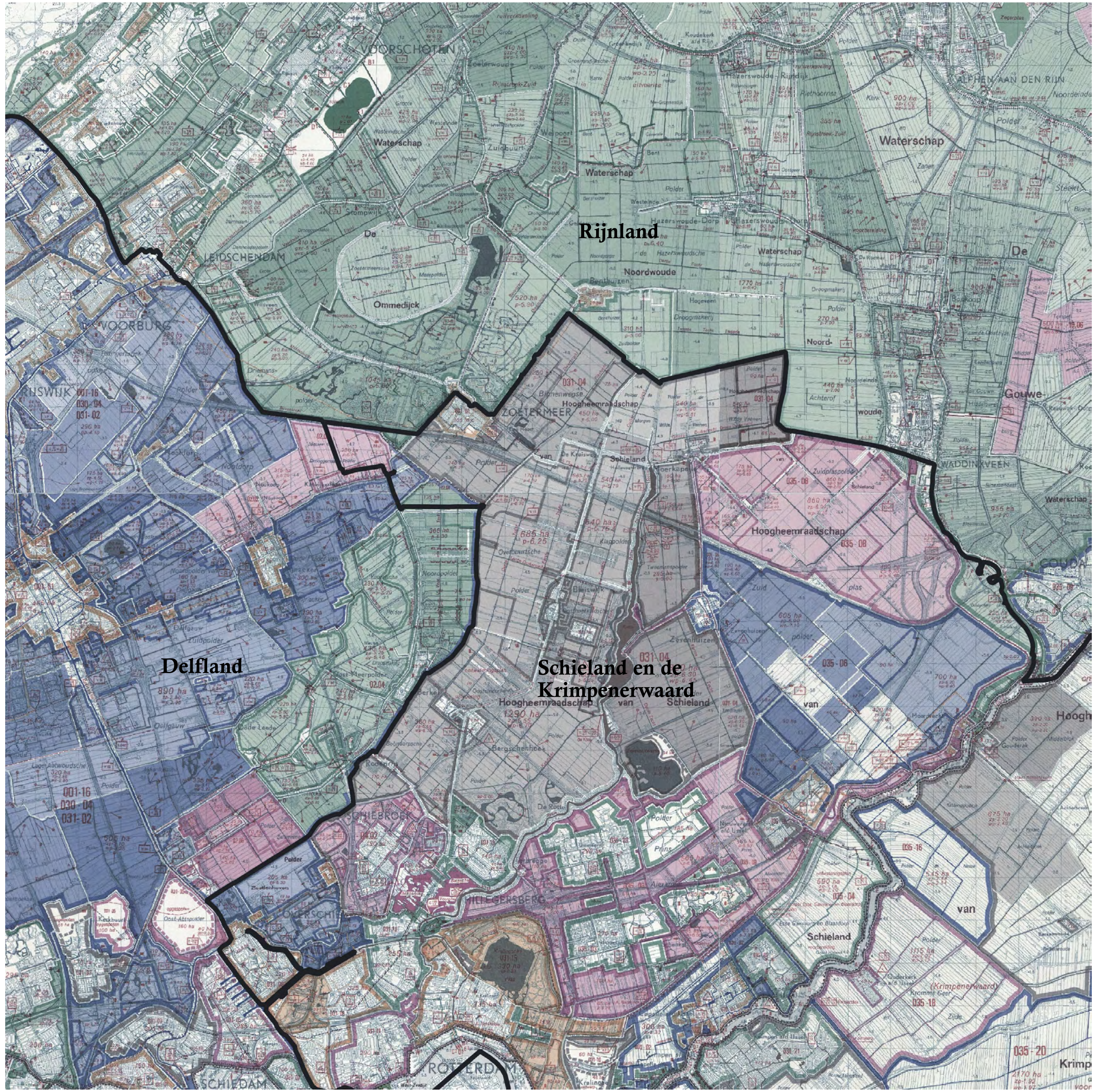
Firstly, interconnectedness plays a vital role in this complex water system. As the different elements within the system are interconnected, changes in one area can have cascading effects on other parts of the system. Secondly, a holistic approach enables the necessary integration of water management. Multiple stakeholders, such as water boards, government agencies, farmers, communities, and environmental organizations, have distinct goals and responsibilities, that contributed to the increasing complexity of the system in the first place, and asks for fostering cooperation and comprehensive strategies on a regional scale. Thirdly, a holistic approach emphasizes the development of a systemic understanding. By viewing the system as a whole, relevant stakeholders can identify underlying patterns, drivers, and vulnerabilities that might not be evident when focusing on individual components. This systemic understanding aids in making informed decisions and developing effective long-term water management strategies.

Figure 44 - (right)
The study area contains numerous boezemgebieden that differ greatly in size and function as independent units, but its waterways are nevertheless connected to each other and the open waters via locks, pumping stations and inlets to allow the water to flow in and out.

The design region is for a large part governed by the Hoogheemraadschap Schieland en de Krimpenerwaard (HHSK). In order to facilitate effective coordination and cooperation between local stakeholders and authorities, three design locations will be chosen that fall within the administrative boundaries of the HHSK.

Figure 45 - (below)
The system of drainage can be divided into three main groups based on the water level: the polder water, the boezem water, and the open water (Bobbink, 2016).





Strategy

The Water Trinity

To ensure the long-term sustainability of water management, a transition is needed from a historical focus on rapid drainage to a more balanced approach that emphasizes water retention. The Commission "Water Management in the 21st century" has introduced a three-step strategy, known as the "water trinity," which involves retaining water, storing water, and, if necessary, discharging water, as illustrated in figure 45 (Commissie Waterbeheer, 2000).

Within the polder-boezem system, specific measures should be implemented to retain more rainwater in the polders and boezems. This can be achieved through wider ditches, canals, and seasonal water reservoirs. The goal is to create a flexible and resilient water system that can adapt to changing circumstances and extreme events, utilizing the natural water-absorbing properties of the subsurface. In order to achieve a sustainable transformation, the water management should guide land use decisions, rather than the other way around, as Deltares et al. (2021) illustrates in figure 46.

In line with this, the strategy framework in this thesis encompasses two essential components: the necessary spatial developments related to the substratum layer and network layer, and the potential land uses that may subsequently emerge as a result.

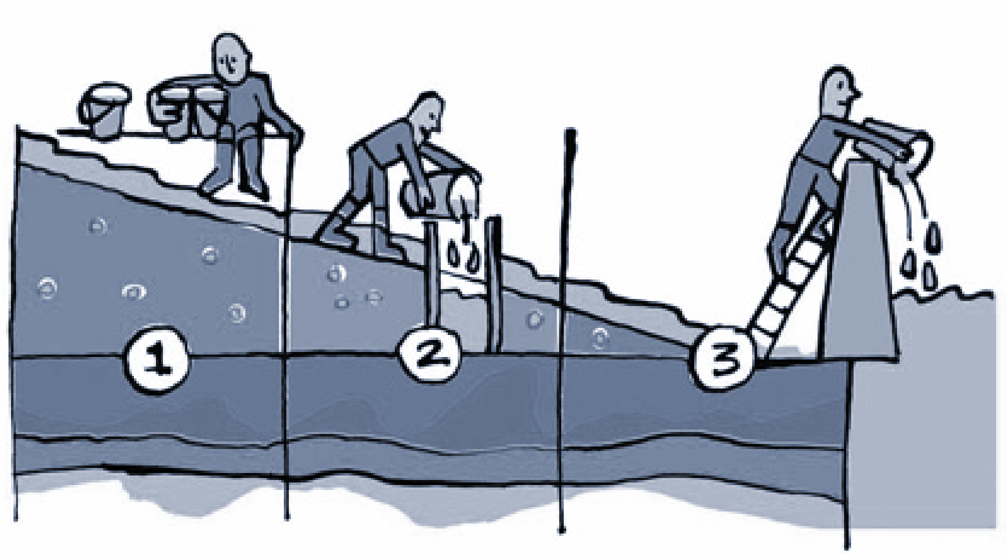


Figure 46 - In 1999, the 'Waterbeheer in de 21e eeuw' Committee conducted research into the water management structure of the Netherlands. The 'water trits' was one of the recommendations that was introduced.

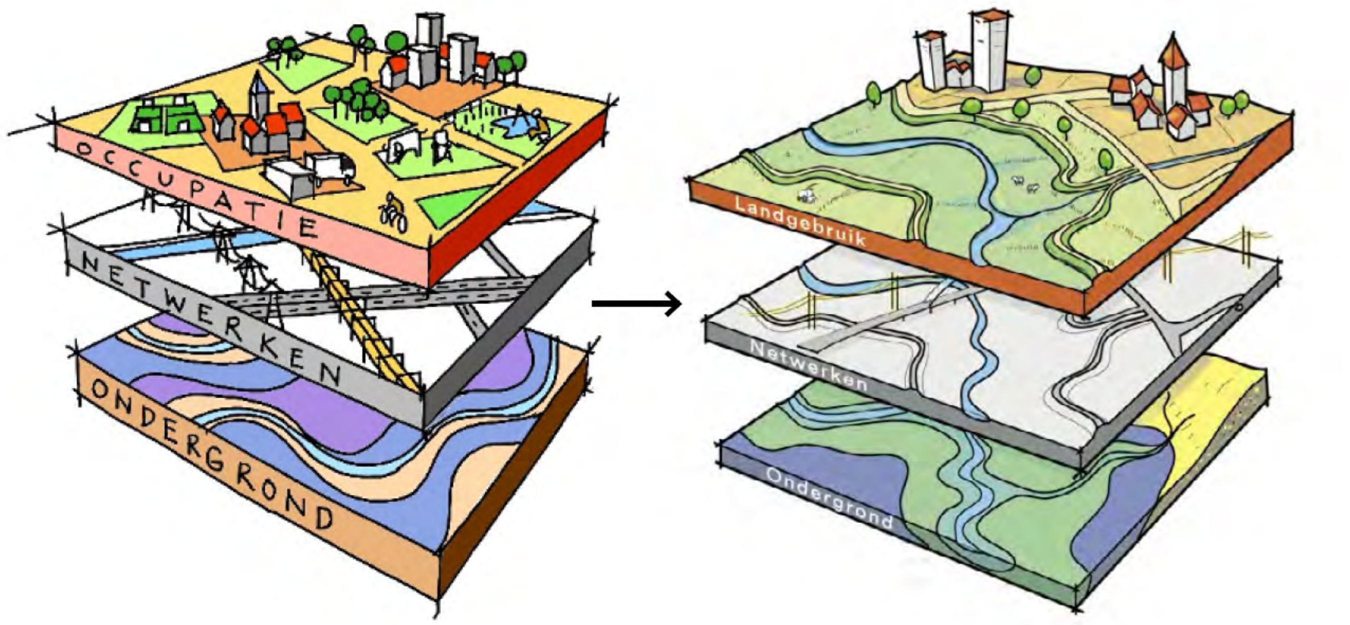
In the context of this thesis, the first component namely focuses on the redevelopment of the water system for the patches of horticulture, agriculture and dairy farming practices in the polders of the Lowlands. This entails identifying necessary interventions for water retention and storage to address challenges such as drought, salinization, and subsidence. Simultaneously, this provides the opportunity to expand the recreational network.

The water system will be redeveloped in a way that respects and preserves the current character and context of a place, following the existing network of waterways or access roads. Besides a practical viewpoint, it can create a sense of continuity and familiarity. This continuity can help people feel more connected to the place and can make it easier for them to accept and embrace the changes that have been made. By revitalizing the underlying landscape structure, the design gives new meaning to the stepping stones and references from the past by assigning them a concrete role in the overall spatial framework that exemplifies the intended social improvement.

In other words, the rational way in with the cultural Dutch landscape was developed could become handles to allow the landscape to go back to a more 'natural' state. In effect, by redeveloping the water system and let that guide land use decisions, local communities can embrace a sustainable future perspective while simultaneously allowing for diverse and attractive landscapes, robust nature, and a high-quality living environment.

Figure 47 - A 'water-based' spatial planning approach.

Source: Deltares et al. (2017)



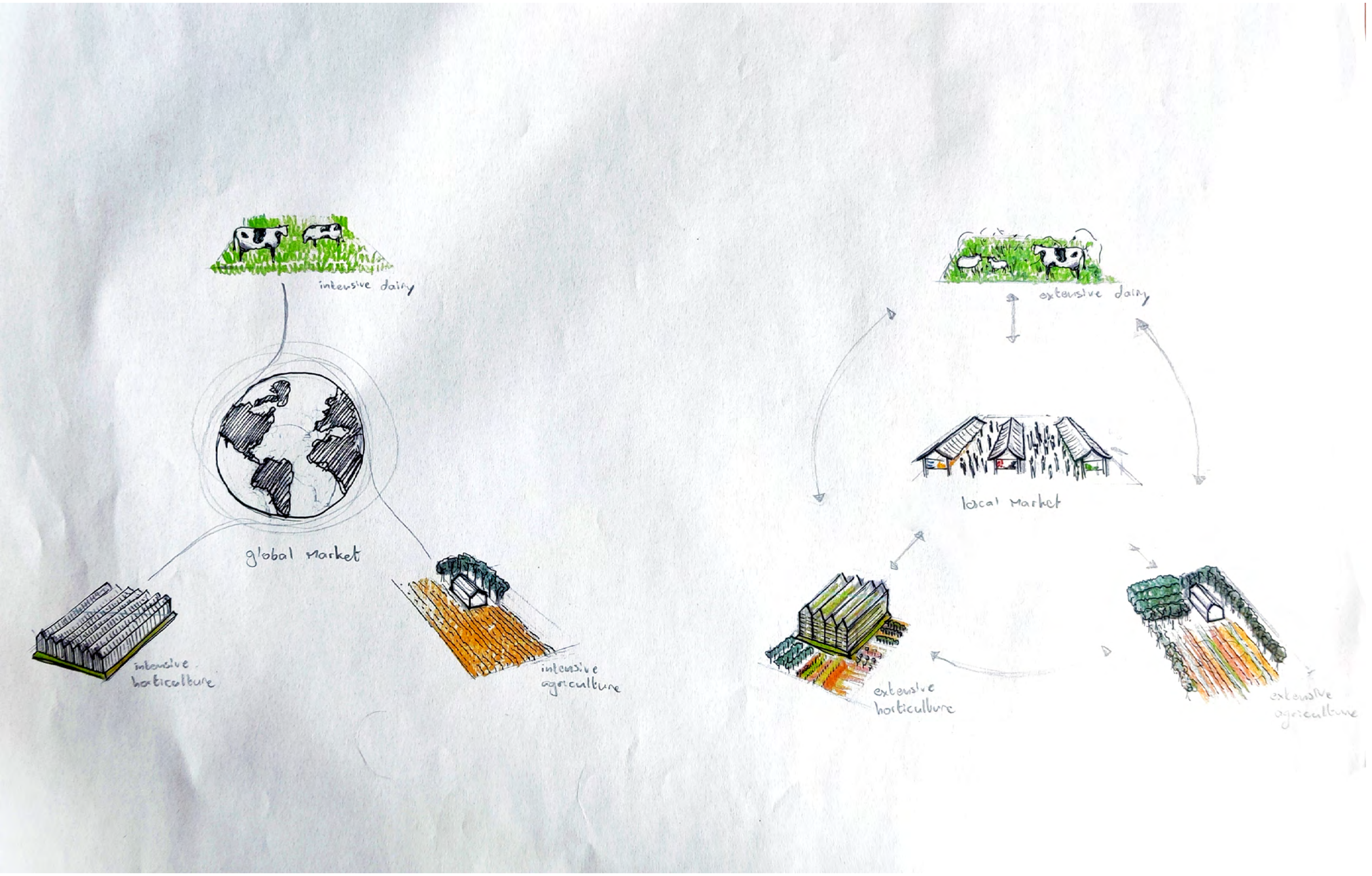
In the second component, the appearance of the landscape stems from the type of construction or plantation that develops on the new parcellation it delimits. The new network of waterways and slow infrastructure allows for equal development conditions along its outlines, but it does not prescribe what that development should look like. In other words, it allows for flexibility of new land use and creates the freedom to determine this land use from the bottom up, and by doing so, allows for local autonomy of development within the limits of what the soil- and water system can allow.

This assumes a future productive cultural landscape with a decentralized form of governance that closely aligns with the Regionally Rooted scenario proposed by the PBL (2023) and discussed on page 33. Indeed, this thesis argues that close collaboration, joint development, and management among stakeholders, including farmers, citizens, water boards, and municipalities, are necessary to address the complexity of the local context and enhance the spatial qualities and urban-rural relations of this peri-urban landscape.

Ultimately, this may foster the development of environmental stewardship and cooperation among local residents, instilling a sense of shared responsibility towards the environment and future generations. What could emerge is a heightened sense of connection and community among residents, fostering a stronger bond with their immediate surroundings and each other. Local amenities and services would be easily accessible within close proximity, leading to a region-focused lifestyle where individuals primarily travel within their own area.

Figure 48 - Sketch showing an envisioned shift in the food industry from the global market to the local market as the quintessential component for sustainable metropolitan development.

Citizen participation in food production as proposed by the Regionally Rooted scenario provide solutions for the deadlock that exist within the power dynamics of today's food chain in the Netherlands. The dependence of farmers to this centralized food chains poses a challenge to the transition towards more sustainable agricultural practices. While farmers often face blame for their unsustainable production methods, it is society that possesses the capacity to catalyse transformative change by placing greater value on sustainable food production.



The Horizontal Metropolis

The two strategy components will be researched through design in the South Wing of the Deltametropolis, which is characterized by its polycentric urbanization, experiencing fragmentation and growing spatial pressure. In their proposal for a landscape park for the South Wing, Provincie Zuid-Holland et al. (2017) have the aim to integrate this landscape park with upcoming large-scale investment programs such as urbanization, energy transition, and climate adaptation. This park would establish a blue-green main structure, serving as the backbone for the metropolitan landscape park. By integrating these various transitions, the park would enhance urban-rural connections within the larger metropolitan region.

These developments would follow the model of the horizontal metropolis, with a focus on preserving and integrating natural and agricultural landscapes. This approach promotes self-contained communities where residents can live, work, and access essential services locally (Viganò et al., 2018). In the horizontal metropolis, green areas, including parks, forests, and agricultural lands, are integral components of the urban fabric, offering recreational spaces, ecological benefits, and opportunities for sustainable food production. Connectivity is a crucial part for the horizontal metropolis, and the South Wing can capitalize on its existing dense network. Fully implementing recreational slow and high-speed cycling networks, including e-bike infrastructure, would leverage the potential of the blue-green main structure, connecting different scale levels within the metropolitan region through cross connections and linking green sequences. This approach contributes to the establishment of a sustainable and coherent mobility system, reducing dependence on cars. Energy- and water systems could be co-implemented and co-managed by stakeholder-networks, including municipalities, environmental organizations, water boards, farmers and other inhabitants.

By embracing a decentralized and interconnected model, the horizontal metropolis aims to establish vibrant, interconnected, and liveable communities that provides symbiosis for urban and rural patches. It promotes environmental stewardship and ensures equitable access to opportunities and resources for all residents. Ultimately, this approach seeks to foster a harmonious relationship between humans and the natural environment, thereby enhancing overall quality of life.

Figure 49 - A sketch to 'capture' the patchwork metropolis in the design region. This continuous fabric of patches derives its form from the infrastructure of dykes, roads and railways, resulting in a fragmentation of the landscape.

An Allegory of Good Governance

Figure 50 - The painting shown is the fresco of Ambrogio Lorenzetti (1338) titled 'allegory of the effects of good government' - Palazzo Pubblico, Siena

It represents a symbiotic partnership of city and countryside where mutual prosperity is based on cooperation and trade. He posed that 'good government' should be maintaining a balance between the urban and rural sides of the state.

In the context of the Horizontal Metropolis, what would Ambriogio Lorenzetti paint today? What would an allegory of the effects of good government look like?

Research by Design

Design Locations

For the research by design, three locations will be chosen within the administrative boundaries of The Hoogheemraadschap Schieland en de Krimpenerwaard in order to explore the transition of water management for the different productive patches of intensive horticulture, agriculture and intensive dairy farming.

In the application of the strategy for the droogmakerijen, both the Tweemanspolder and the northern part of the Bleiswijkse polder have been chosen. They are situated on adjacent sides of the Rotte. The Tweemanspolder could serve as an exemplary droogmakerij polder that is currently used for agriculture, while the Bleiswijkse polder form an important link in the blue-green structure as described on page 78. For the peat meadows, the northern part of the Krimpenerwaard has been chosen due to its proximity to Gouda, which includes the polders of Middelblok, Veerstalblok, and parts of het Beijersche and Kattendijkseblok.

These polders are incorporated in both the Natuurnetwerk Nederland (Ecological Network of the Netherlands) and the Krimpenerwaard Program. The Natuurnetwerk Nederland aims to enhance biodiversity and establish connectivity between various ecological zones. Additionally, the Krimpenerwaard Program, developed by the province of South-Holland, focuses on preserving and developing the valuable agricultural cultural landscape and its associated natural values in alignment with the objectives of the Natuurnetwerk Nederland. (Zuid-Holland, 2022)

For each location, the spatial conditions will be discussed that have been relevant for the design decisions that have been made. Subsequently, methods of nature-inclusive production will be examined that are necessary to restore a more natural state for the soil and water system in the region. These interventions will serve as a foundation for the transformation towards a diverse range of land uses that seamlessly integrate natural and artificial qualities in the peri-urban interface.

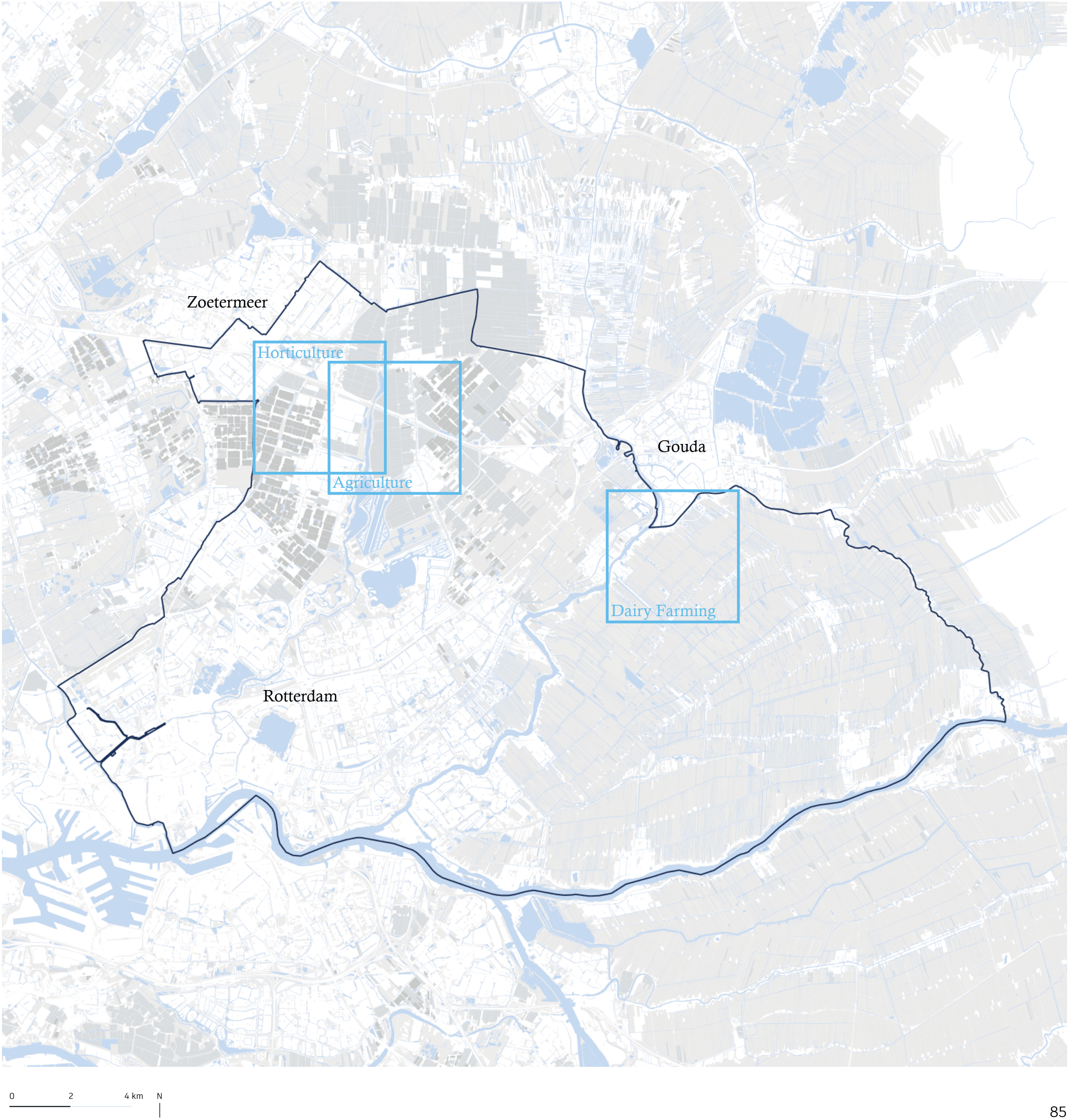


Figure 51 - The HHSK was formed through a merger of two water boards with similar responsibilities in water management, safety, and quality. The decision to merge was made in order to operate more efficiently and effectively as a single water board. The integration resulted in a larger water board capable of addressing water management challenges more effectively. The HHSK now allocates resources efficiently, shares expertise, and implements a consistent policy to ensure water safety and quality in the region (HHSK, 2014).

Horticulture

The Bleiswijkse polder includes the area of the former peat polders: the Klappolder, the Overbuurtsche Polder, Hoekeind, Oosteind, and the Boterdorpsche Polder. During the reclamation, the polder water pattern consisted of a number of canal strips more or less parallel to the Rotte, with numerous perpendicular ditches at regular intervals. Today, three pumping stations can keep the polder dry with regard to the twenty-seven mills that were used to drain these polders.

Due to changes in land use from traditional agriculture to horticulture, housing, and recreation, each of which places different demands on the water management, the polder water pattern has continuously changed on a large scale. The large-scale greenhouse complexes have been integrated into the original structure of the polder water but have made the water pattern much coarser. The greenhouses, along with their water storage basins and raised earthen walls, occupy more than 50% of the polder surface area. At the edges of the greenhouse area, land has been excavated to buffer extra water in the polder water system. Parts of the canals, but especially the ditches of the original polder water system, have disappeared. Only a few canals run the full length of the polder today (Bobbink, 2016).

Figure 53 - Sketch showing the main waterways used for drainage towards the Rotte

Figure 52 - Areal view of the nothern part of the Bleiswijkse polder

Source: PDOK, 2022

0 250 500 m N

While the Bleiswijkse polder forms an important link in the blue-green structures of the South Wing, the large grain of greenhouses prevent open soil for water retention and biodiversity. There is less natural infiltration of rainwater, which can lead to extra salinization of the subsoil or desiccation in surrounding areas. Furthermore, the intensive horticulture practices has lead to a decline in biodiversity, which is further exacerbated by issues such as light pollution and the urban heat island effect. Therefore, it might be necessary to downscale the surface area occupied by greenhouses, and switch to vertical farming. Part of the original structure of polder water system could then be reintroduced to revitalize the water management and function as the artery of the area. Overall this transformation to vertical farming results in a new parcellation for a more diverse program to take place.

However, the requirement of a large surface area for sunlight to function as an efficient energy source presents a disincentive for horticulturists to open up soil. While alternative light sources such as LED are being explored, they are still in a pilot phase and their feasibility remains uncertain. (WUR, 2022). Moreover, the large roof surfaces of the existing greenhouses can collect significant amounts of rainwater, which can be stored in individual water basins for irrigation purposes.

Therefore, in order to incentivize horticulturists to downscale the surface area of their greenhouses on a large scale, it would firstly be necessary to prioritize investment in research on vertical farming methods. This would include researching systems that allow for controlled environmental factors such as temperature, humidity and light in vertical greenhouses. This research and development could be conducted by a collaboration between horticulturists and Wageningen University and Research, who already has a business unit in the location (WUR, n.d.). This might further incentivize the switch to the highly profitable breeding of high-quality seeds, as a more precisely controlled environment of greenhouses can be tailored to meet the specific needs of the seed varieties being grown (Van de Ven, 2022).

Phasing

To encourage horticulturists to transition towards vertical farming and downscale their greenhouse surface area, a land use plan could be implemented that imposes a regulation limiting them to utilize only 50 percent of their current surface area. This gradual shift would involve transitioning from traditional greenhouses to vertical greenhouses. Considering that the economic lifespan of a greenhouse is typically between fifteen and twenty years, horticulturists who are scheduled for maintenance within the next five years could be incentivized to consider the switch to vertical farming. By engaging in participatory planning with all stakeholders, including horticulturists and local communities, the process can ensure their involvement and prevent any disadvantage to current horticulturists. It is crucial to promote long-term economic viability that benefits the local community, and alternative incentives such as transforming the greenhouses into residential neighborhoods could be explored. Additionally, this transformation provides an opportunity to improve the collective water and energy systems in the region.

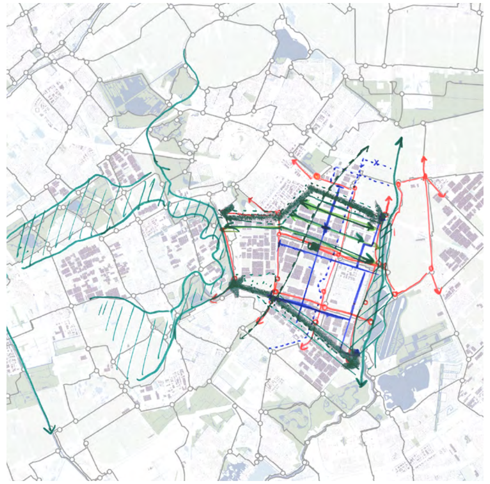
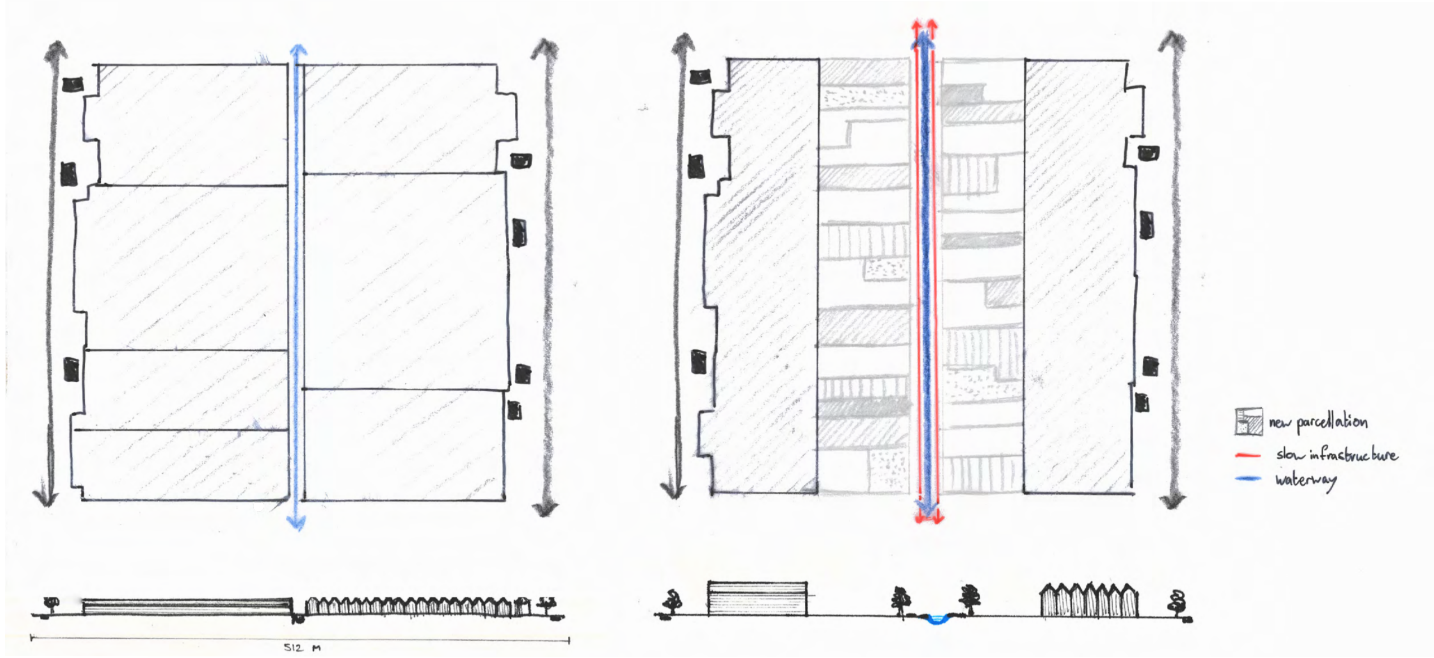


Figure 54 - (left)
Exploration of potential ecological corridors within the larger blue-green network, based on Landschapspark Zuidvleugel (Provincie Zuid-Holland et al., 2017)

Figure 55 - (below)
Sketch of a new parcellation that could be used for diversified land use. To further incentivise the opening of soil, these could be consist of parcels for the residential development as well as forms of agriculture on open soil.



Collective Water Management

As horticulture businesses are now obligated to treat their wastewater flows, farmers could jointly invest in treating wastewater as opting for a collective solution for water treatment will yield organizational and financial benefits when compared to an individual approach (World Horti Center, 2018).

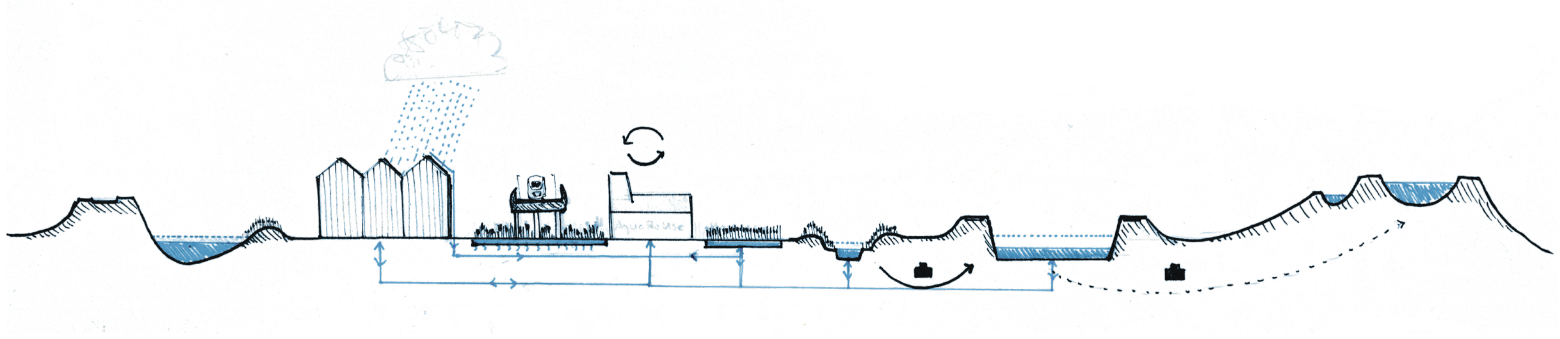
Although many horticulturists currently use individual water basin, constructing one or a few larger reservoirs is more efficient as it will allow for more precise control over water use. Furthermore, the large water basin could act as peak storage that is more effective in preventing flooding during periods of heavy rainfall. It is worth noting that water basins in horticulture are typically covered to prevent the growth of algae that results from sunlight exposure.

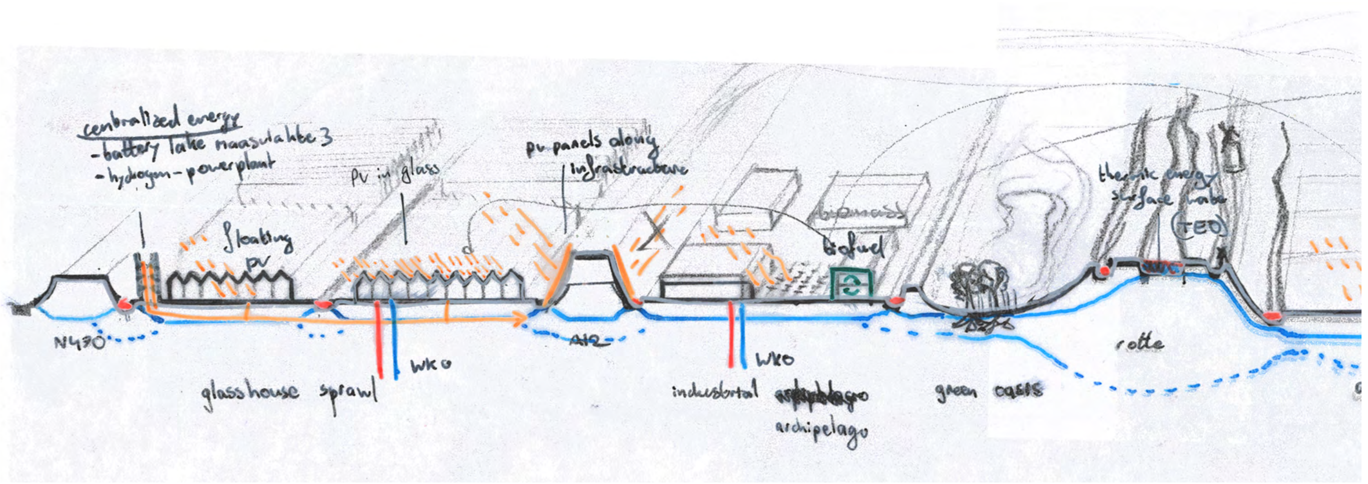
This also incentivises installing solar panels as a means of covering the surface, thereby eliminating light penetration (Van der Elst, 2020).

Widening the system of ditches further increases the overall water storage and buffering capacity, and additionally, restore part of the original polder structure. Ecological banks will be incorporated into these expanded ditches to enhance biodiversity and improve the collective water treatment by filtering nutrient-rich water. However, to prevent potential pests and diseases that may arise, it will be necessary to (re)construct the converted greenhouses further away from the ditches than their current proximity. Furthermore, research is currently being conducted on micro-drones measuring 4x4 cm that can detect and eliminate harmful insects inside greenhouses (World Horti Center, 2018).

Figure 56 - (below)
Section showing a circular water system for the horticulture area

Figure 57 - (right)
Section showing a decentralized energy system for the horticulture area





Energy

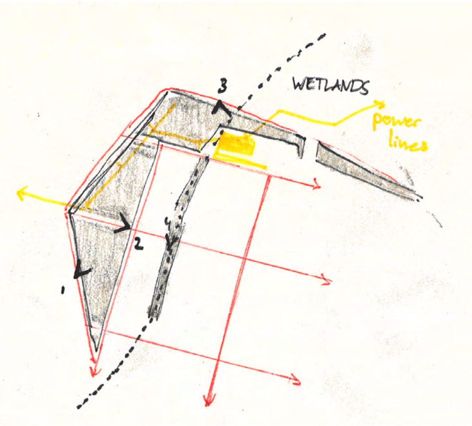
The demand for energy will be collectively solved through the implementation of a heat grid, which will transport energy from a local geothermal energy source to horticulture businesses, offices or houses. This geothermal energy source will require drilling into water-carrying packages at depths ranging from approximately 1.5 km to 4 km, to recover heat between 60°C and 90°C. By storing excess heat during the summer, peak demand in winter can be levelled. During summer, cold water is pumped up and transferred to an office building or horticulture business via a heat exchanger, which heats the water before transferring it into the heat source. During winter, warm water is pumped up and used for heating houses, or greenhouse horticulture businesses. This technology allows for the exchange of hot and cold energy between houses and buildings on the one hand, and greenhouses on the other, optimizing energy use (World Horti Center, 2018).

The Bleiswijkse polder already houses existing geothermal energy infrastructure, with the first geothermal energy installation in the Netherlands being constructed by tomato grower A+G Van den Bosch in 2007. However, deficiencies were found in both the lower and upper parts of the well, and the company is currently allowed to utilize only the upper part for geothermal energy production upon meeting safety requirements (EZK, 2022; Geothermie Nederland, 2022). This situation presents an opportunity for further research and development in expanding this energy infrastructure.

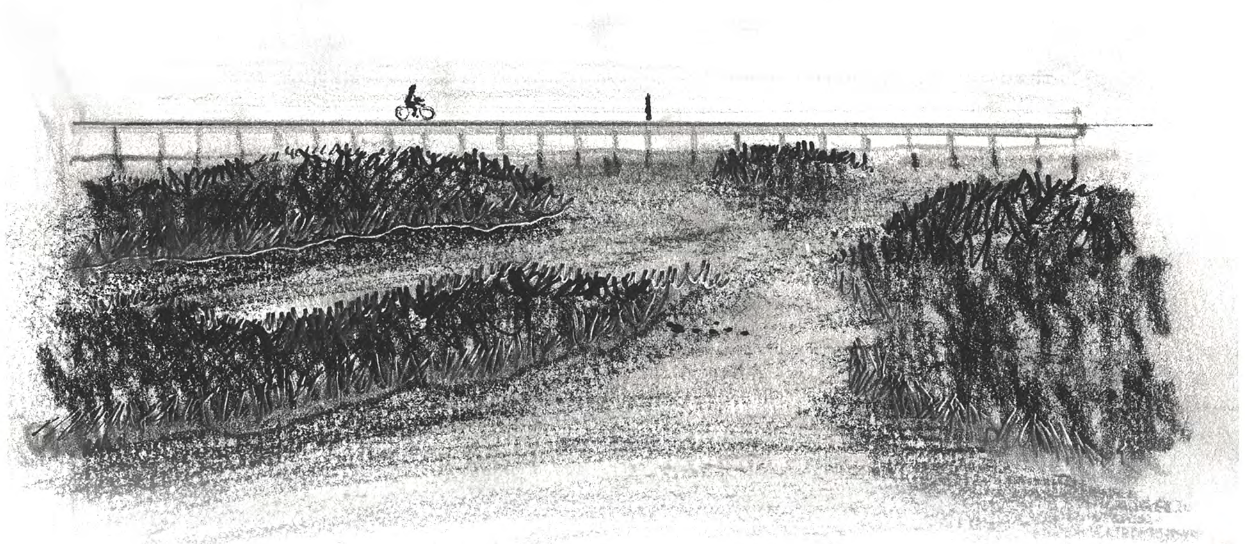
In addition, the utilization of biomass derived from willow, elephant grass and duckweed cultivated in peat meadows and droogmakerijen used for agriculture will be processed in factories situated in nearby business parks.

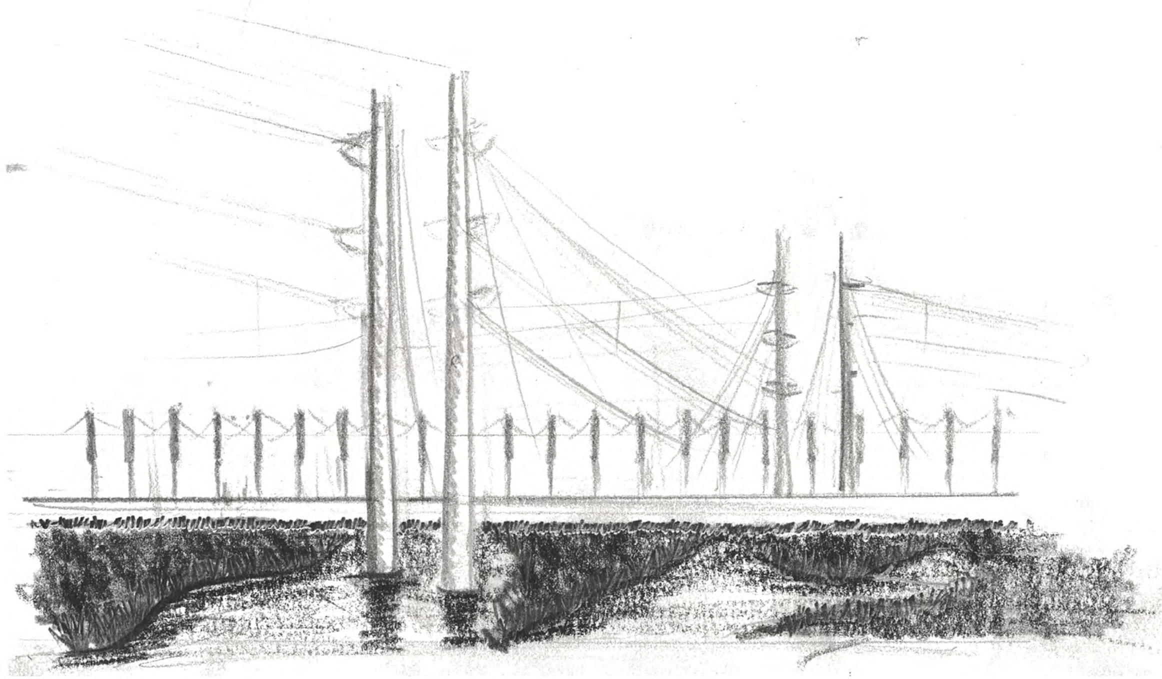
Wetlands

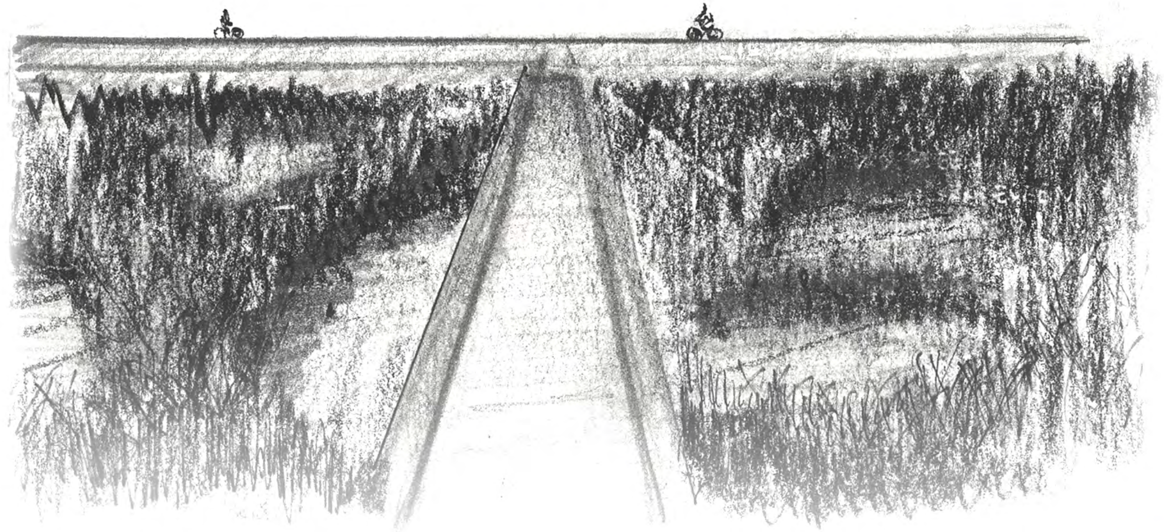
Greenhouses located in regionally strategic locations, such as directly south of Zoetermeer, would have to be removed in an earlier phase to implement an eco-corridor (see: figure 54). This will consist of wetlands with reeds and cattail that will be placed at the edges of the polder and on the vacant space along the railway. These can effectively treat process water or improve the quality of ditch-water to make it suitable for crop irrigation.



Figures 57 to 60 - Impressions of a new type of landscape for the greenhouse districts



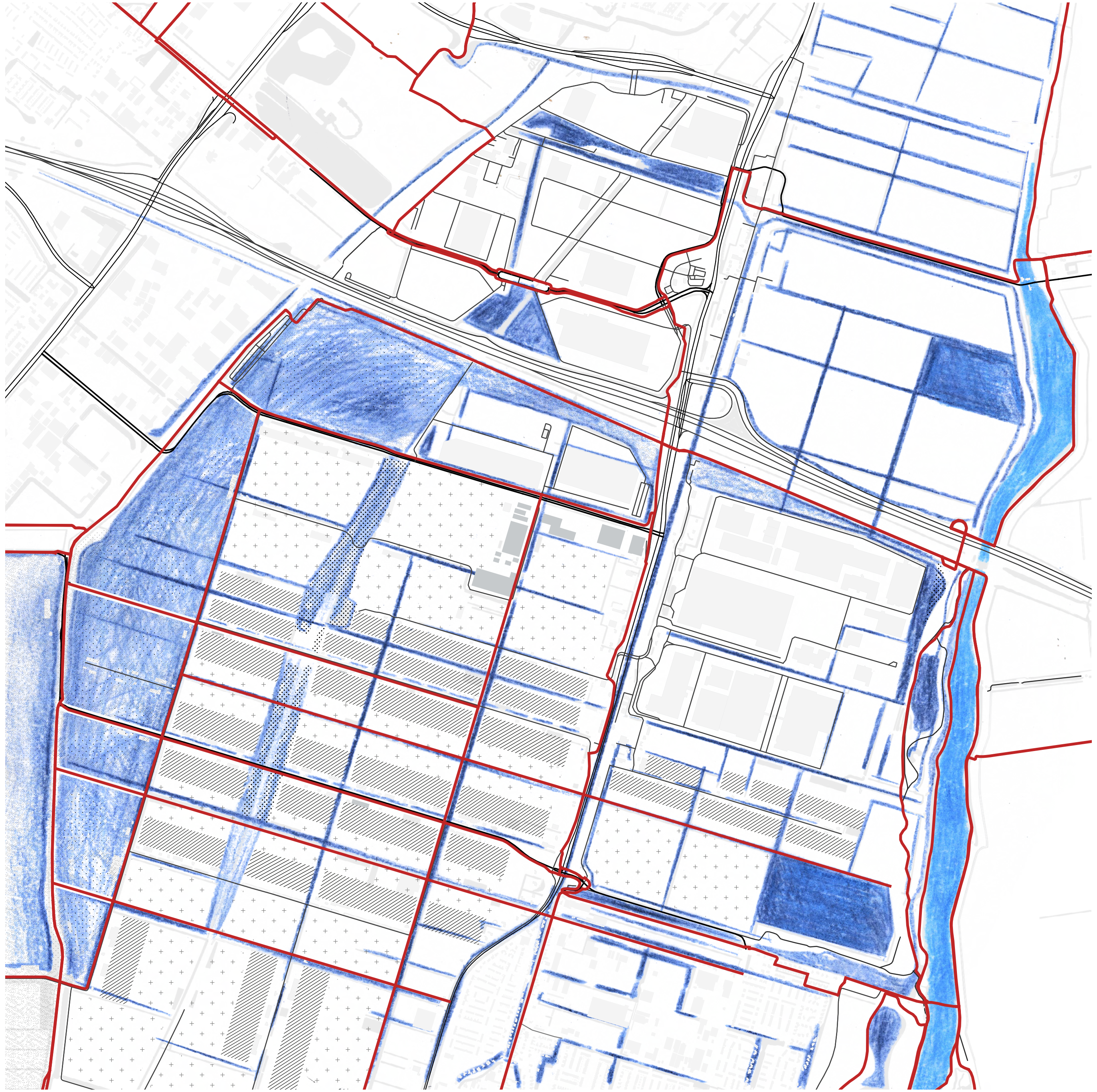




Design

Overall, the gradually opening up of soil together with the revitalized network of waterways will allow for collective land uses for water and energy that will serve both the horticulture business as well as the collective liveability of the area. It will furthermore provide the opportunity for several recreational routes that run from the west bank of the Rotte to the edge of the Bleiswijkse polder, which is accentuated by avenue planting of trees. The area becomes more permeable, and attractive to walk through.

Figure 62 - Adapted water- and recreation network for horticulture



Horticulture

- Rotte
- Wetlands
- Slow infrastructure network
- Water reservoir
- Diverse parcellation
- Vertical greenhouses

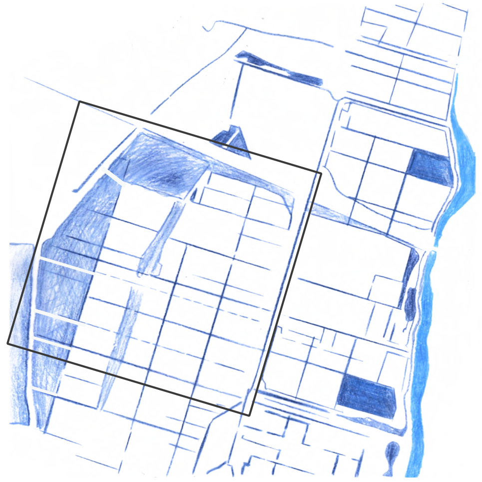
0 250 500 m N

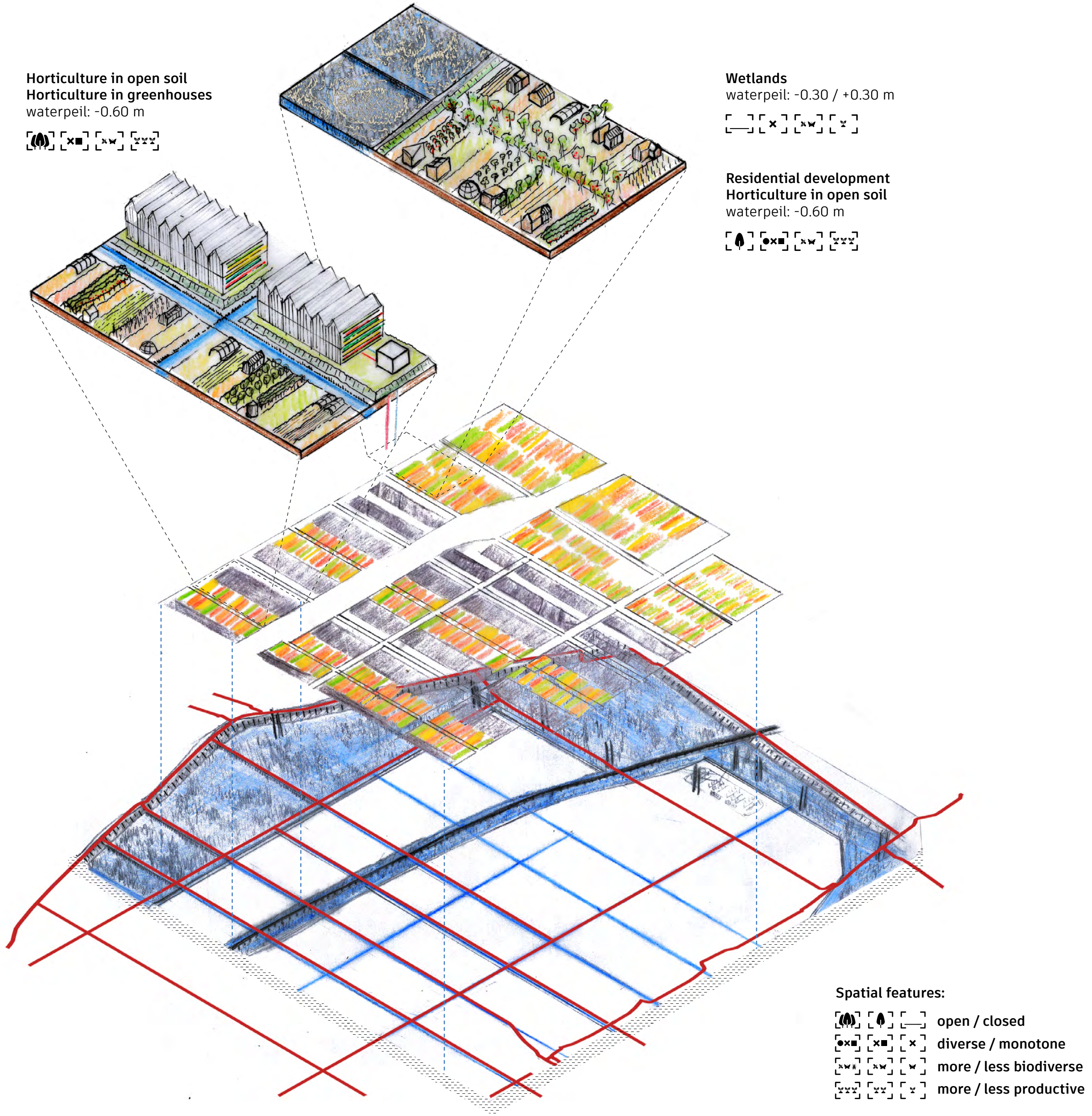
Spatial exploration of possible emergent land uses

In the droogmakerijen used for horticulture, the nature-inclusive land uses that may emerge following the redevelopment of the water system, as explored in this thesis, include wetlands, vertical greenhouses, open soil horticulture and residential development.

As discussed, wetlands in droogmakerijen used for horticulture provide the ecosystem services of increased water buffering and purification, as well as CO_2 sequestration. The wetlands would be located in the lower parts of the area for a natural inflow of water. A sufficient land area would be needed to adequately counter drought, salinization, and provide fresh water for the surrounding horticulture and housing. Spatially this would result in a larger-scale and more open landscape compared to horticulture on open soil and residential development. The latter would have a small grain that complements the new parcellation, delimited by the redeveloped water system and slow infrastructure network, which further enhances the variety and porosity of the landscape. Compared to the current large grain of greenhouses, these developments would significantly enhance the possibilities for water buffering, biodiversity, diversity, permeability, and overall liveability of the area.

Figure 63 - De design of the water system and slow infrastructure network allows for a combination of land uses that have distinct spatial features and ecosystem services, resulting in a regenerative and diverse landscape.
Based on Studio Marco Vermeulen (2021).





Residential Development

As mentioned, there is also an opportunity to create a new type of neighbourhood in the area. The houses in this neighborhood would be constructed using materials grown in the agroforestry systems of agricultural plots, as well as paludiculture on peat soils. Additionally, being close to a fine-meshed public transport network, including station Lansingerland, the neighborhood is to be largely car-free, with innovations such as drone deliveries being used to transport goods.

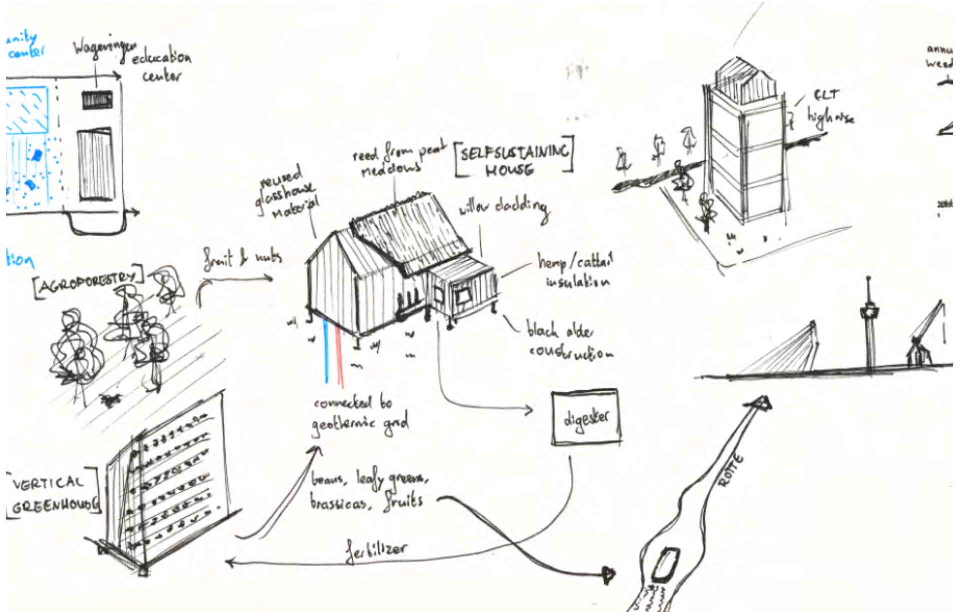
This new development has a nearly closed urban metabolism, meaning that it would be nearly self-sufficient in terms of energy, water, food production, and waste management. It could feature community and educational horticultural centers that will provide space for residents to work, socialize, and learn about sustainable agriculture. They could also serve as venues for organizing events and community gatherings.

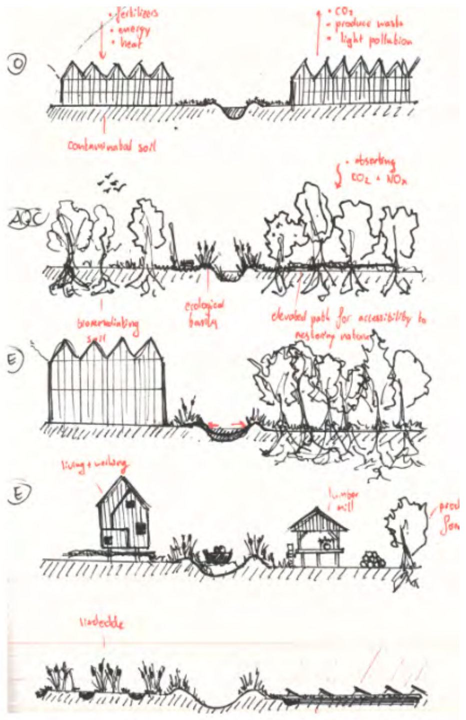
Horticulture in open soil

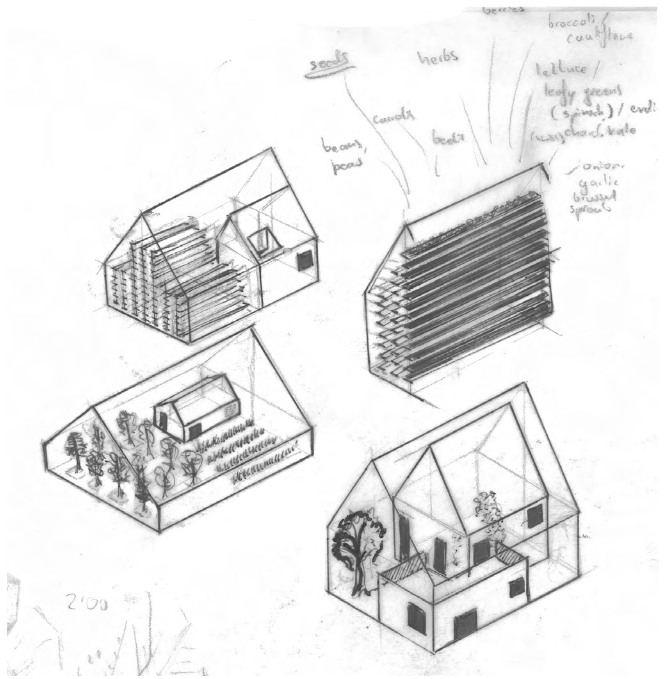
The produce of both vertical greenhouses as well as horticulture on open soil could meet the growing demand of locally grown produce while also reducing the carbon footprint associated with long-distance transportation of food. This expanded range of crops will include various protein-rich foods such as beans or peas, leafy greens such as lettuce, spinach, or endive, brassicas such as broccoli, cauliflower, and kale, alliaceae such as onion, leeks, or garlic, as well as an array of fruits such as berries.

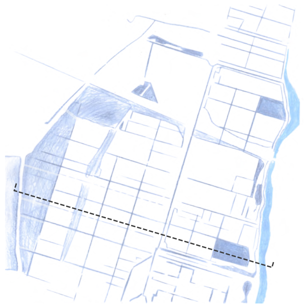
This diverse range of locally grown agricultural products will become better accessible to inhabitants in the vicinity, and will also be transported via the Rotte to supply the markets of Rotterdam. The transformation of agricultural landscapes aims to both maximize overall well-being as well as utility: A hybrid in land-use would be formed with state-of-the-art technology and flourishing biodiversity. The proposed diversification of land use, with a mix of residential development, open soil agriculture, and vertical farming, can contribute to local food production, reduce carbon footprint, improve access to fresh produce, and enhance liveability.

Design exploration potentials for residential development in terms of spatial qualities and metabolism









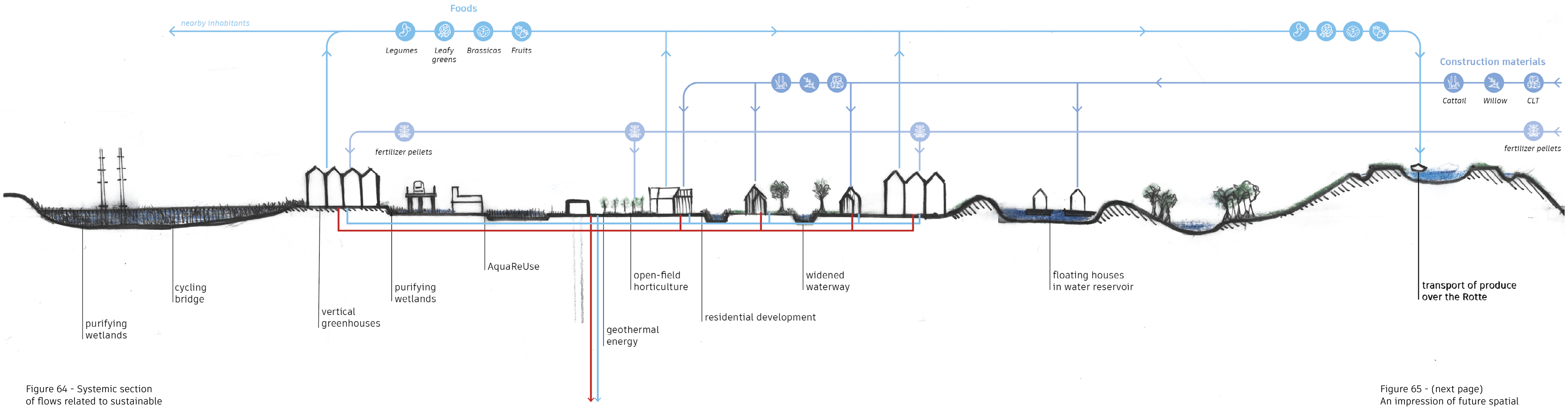


Figure 64 - Systemic section of flows related to sustainable productive horticulture landscapes

Figure 65 - (next page) An impression of future spatial qualities resulting from biophilic and technophilic developments


PAPER BOX

Agriculture

The Tweemanspolder was reclaimed between 1727 and 1734 and consists of a single, flexible waterpeil between NAP -5.95 and -6.05 meters within the larger waterboard. The water system features two canals or "tochten" that run longitudinally through the polder. Perpendicular ditches extending at even intervals provide additional drainage and are parallel to the polder's eastern dike. The stepped mill complex, situated about halfway through the polder and perpendicular to the first ditch and the Rotte, comprises three mills standing in a row that discharge water onto the binnenboezem (inner reservoir), which is located in the Rotte dike. The fourth mill on the Rotte dike drains temporarily stored water onto the Rotte (Bobbink).Today, the ditches are primarily used for agricultural purposes in the polder. Only the ditches between the eastern ditch and the polder edge remain, while all other ditches have been replaced by drainage. The railway line and A12 motorway diagonally interrupt the ditches. However, the ditches are connected to one another via watercourses that run parallel to the motorway and an electric pumping station that pumps water through a pressure pipeline beneath the motorway. The pumping station is situated at the end of the southern watercourse along the motorway and is located at the base of the Rotte dike.

Although the entire mill complex is still present in the polder, its function has been taken over by the pumping station. The binnenboezem has partially lost its function and has been excavated. However, the mill complex and the segment of the binnenboezem situated midway along the northern dike of the polder are still extant. The waterline here is located between the boezem water level and the polder water level and drains into the polder water via weirs.

Figure 66 - (below)
Sketch showing the main waterways used for drainage towards the Rotte

Figure 67 - Areal view of the Tweemanspolder

Source: PDOK, 2022

Water reservoirs

In order to address challenges related to drought, salinization, and nutrient-rich water, the water system of the Tweemanspolder has to undergo modifications. Three water reservoirs are constructed near the Rotte to collect and store water during the winter, which can then be utilized for irrigation during dry periods. This serves the purpose of ensuring a consistent and dependable water supply for agricultural activities. These reservoirs can be connected to the polder's drainage system through canals or pipelines, facilitating the distribution of water for irrigation purposes. The water reservoir also offers potential for energy production from floating PV panels and the construction of small windmills that would provide a modern contrast to the traditional windmills already present. Additionally, the reservoirs provide a habitat for aquatic plants and animals, thus contributing to increased biodiversity. Finally, the construction of embankments for the reservoirs presents an opportunity to extend the existing recreational route from the Rotte, utilizing the embankments to access the other side of the polder.

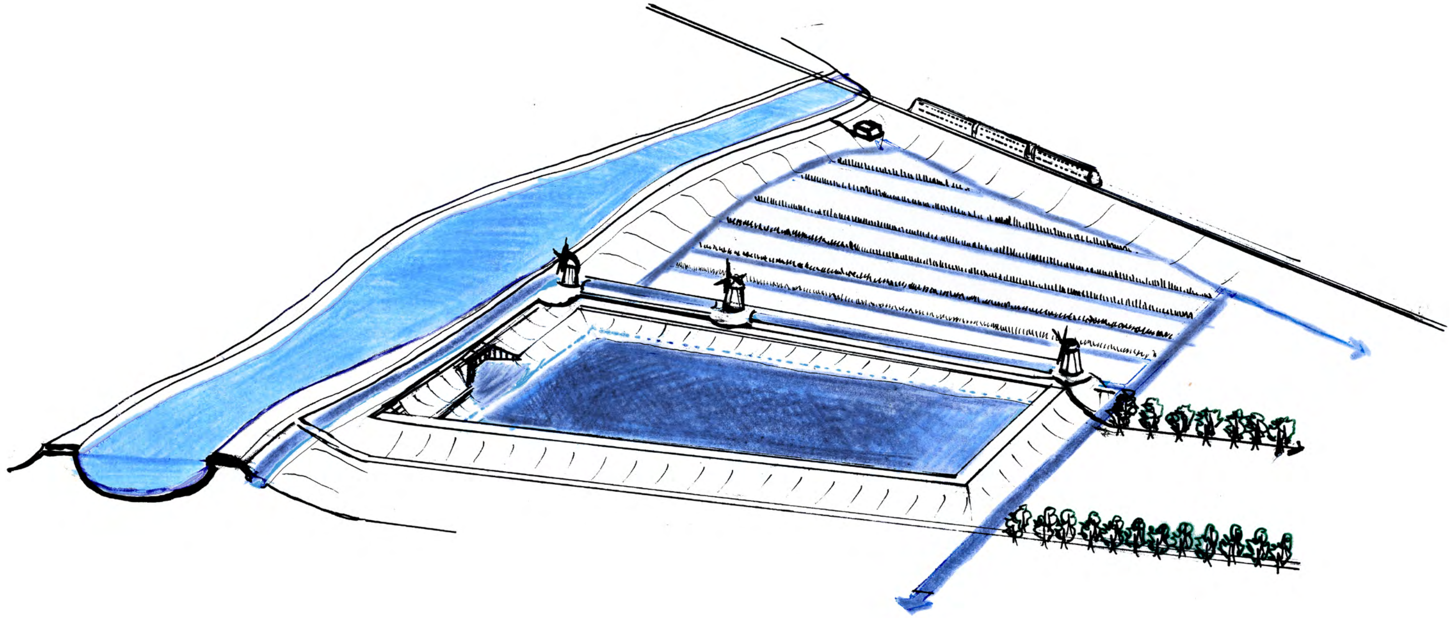
To enhance water management and counteract salinization, the existing drainage ditches, including the 'tochten', will be widened to serve as water buffers. Furthermore, additional ditches aligned with the water reservoirs are introduced to improve water quality in the Tweemanspolder. Similar to the helophyte filters employed in the Bleiswijkse polder, these added ditches incorporate helophyte filters on the northern bank, employing reed and cattail vegetation to remove excess nutrients from the water. This purification process not only benefits the polderwater and the Rotte, but also contributes to the restoration of the historical landscape pattern.

Energy

For energy production, five small windmills will be installed adjacent to each water reservoir, as illustrated in figure 72. These windmills have a total height of 21 meters and a peak performance capacity of 10 kilowatts. Considering an average wind speed of 5 meters per second, this generates a yearly power output of 35,000 kilowatt-hours (kWh). These modern windmills would serve as a contemporary alternative to the existing four mills, which were originally utilized for drainage purposes. As a result, they would provide the polder with a consistent supply of 525 megawatt-hours of sustainable energy throughout the year. (Zep, 2021; EAZ wind, 2023)

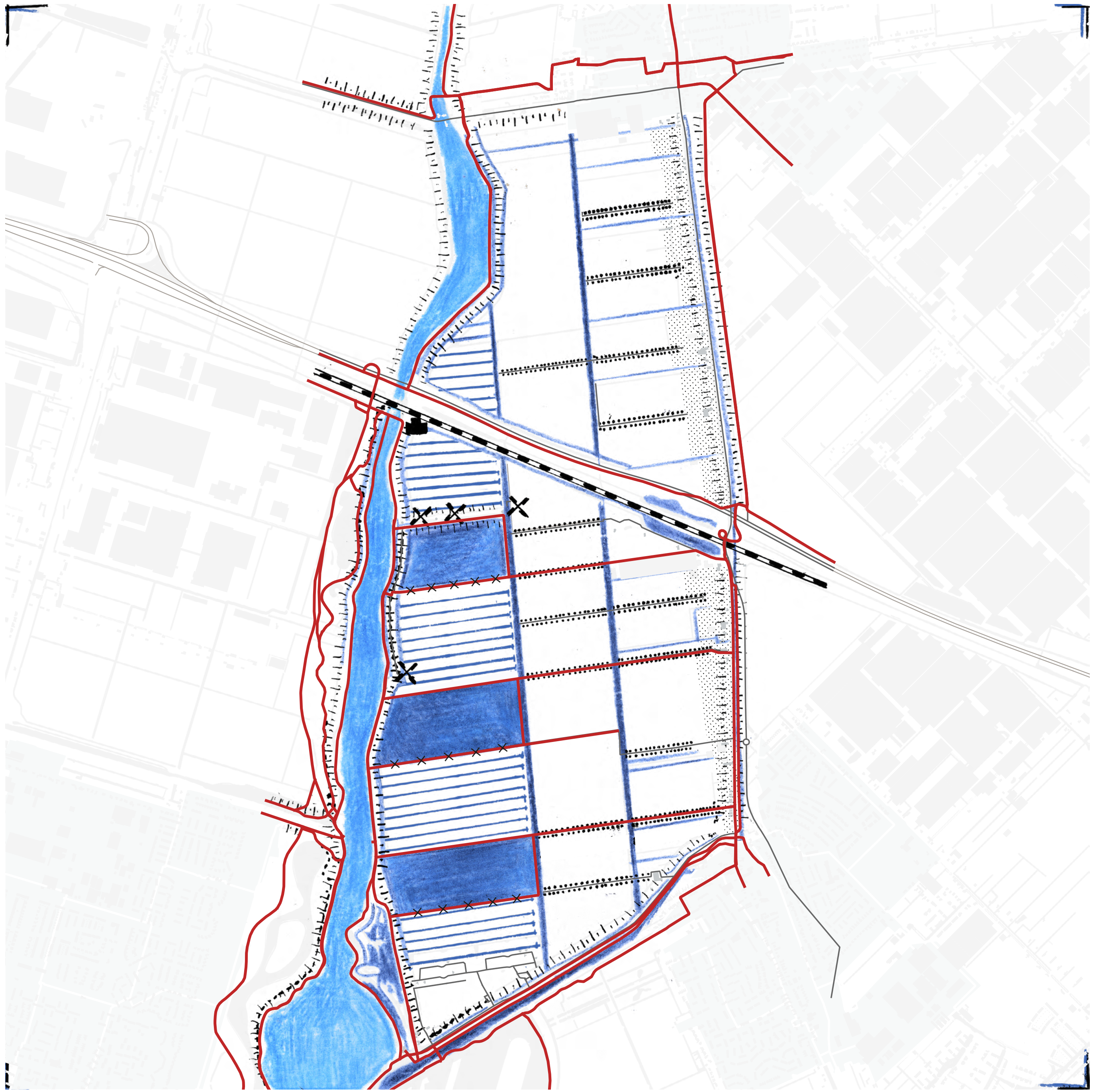
Figure 68 - (left)
Impression of the reflection of historic windmills on the new waterbody

Figure 69 - Isometric drawing of all water management components functioning in tandem



The interventions for water management in the Tweemanspolder are integral to the slow infrastructural network, as the interventions become seamlessly integrated into the fabric of the polder. This ensures that water management becomes an integral part of the everyday experience The integration of helophyte filters and landscape restoration further enhances the aesthetic and ecological qualities of this network.

Figure 70 - Adapted water- and recreation network for horticulture



Agriculture

- Rotte
- Slow infrastructure network
- Water reservoir
- Windmills
- Ditches with helophyte filters

0 250 500 m N

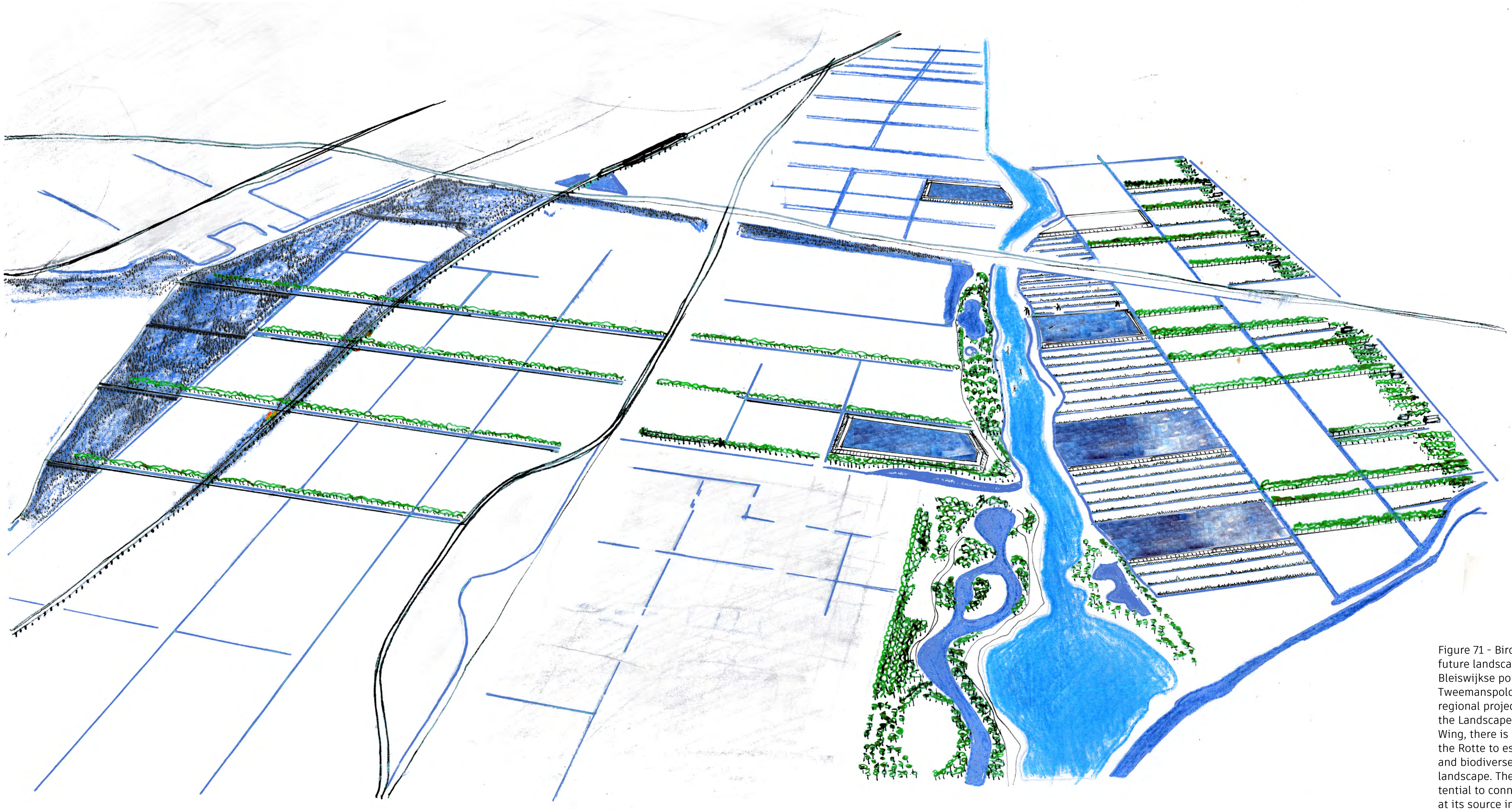


Figure 71 - Bird's eye view of the future landscape structure of the Bleiswijkse polder adjacent to the Tweemanspolder. As one of the regional projects in the vision for the Landscape Park of the South Wing, there is an opportunity for the Rotte to establish a coherent and biodiverse metropolitan landscape. The Rotte has the potential to connect the countryside at its source into the capillaries of the inner city of Rotterdam.

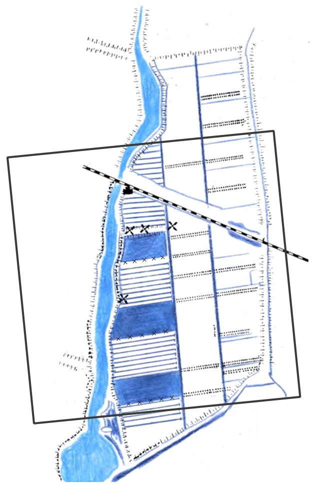
Spatial exploration of possible emergent land uses

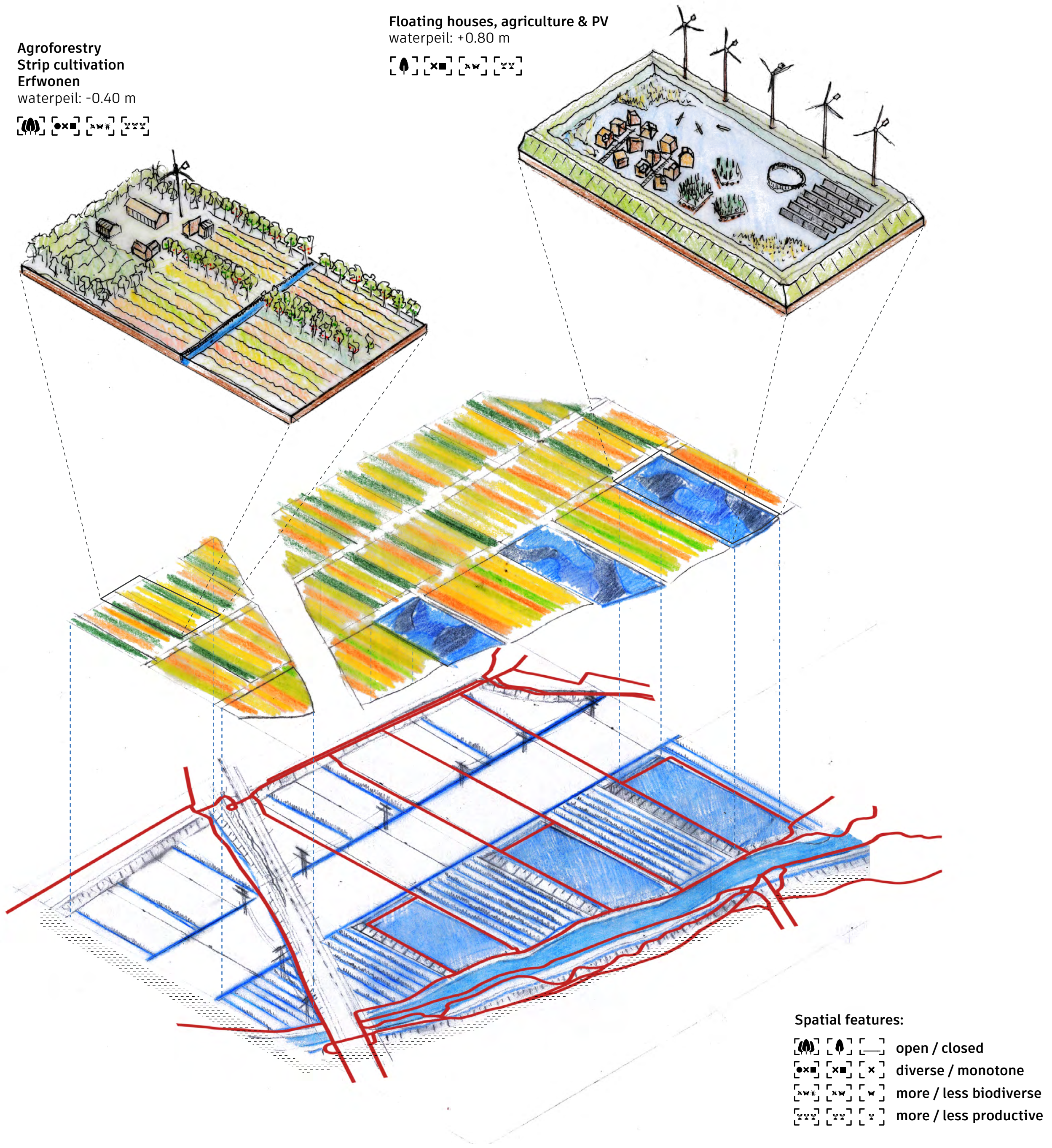
In the droogmakerijen used for agriculture, the nature-inclusive land uses that may emerge following the redevelopment of the water system, as explored in this thesis, include aquatic land uses on water reservoirs, agroforestry, and strip cultivation.

This transition would involve a shift from large-scale arable plots to a mosaic of large-scale water reservoirs and small-scale strip cultivation and agroforestry systems. The water reservoirs would facilitate diverse uses and would therefore result in a highly diverse aquatic landscape that is also productive in terms of energy, aquaculture, and aquatic agriculture. Strip cultivation and agroforestry systems would contribute to the biodiversity and spatial diversity of the area, with various crops intermixed with flower strips.

Among the three explored areas, this particular area currently has the fewest conflicting land uses, as evidenced by the unfragmented peilvak throughout the entire polder. This creates a landscape that may more easily adapt to diverse land uses, particularly the establishment of additional water reservoirs in the future, should there be an increased regional demand for fresh water or a need for enhanced water retention.

Figure 72 - De design of the water system and slow infrastructure network allows for a combination of land uses that have distinct spatial features and ecosystem services, resulting in a regenerative and diverse landscape.
Based on Studio Marco Vermeulen (2021).





Aquatic Agriculture

The implementation of water reservoirs in droogmakerijen such as the Tweemans-polder opens up opportunities for diverse and versatile usage. The introduction of floating platforms made of willows grown on peat soils enables a transition from conventional dry arable crops to wet cultivations like rice paddies, cranberry fields, or the cultivation of elephant grass and duckweed for biomass production. Additionally, the reservoirs could serve as potential sites for constructing floating houses using locally sourced materials. However, the feasibility of this requires further research and design.

Strip Cultivation

The current large-scale and homogeneous agricultural plots may undergo a transformation to strip cultivation, which involves a diverse range of arable crops alternated with permanent nature strips. This strategy aims to mitigate soil erosion and nutrient runoff, enhance biodiversity, and promote natural pest control, while reducing the susceptibility of crops to diseases. The traditional use of slurry will be replaced by composted products, straw-rich manure, and digestate from extensive dairy farms, while artificial fertilizers will be substituted with the wet fraction from manure separation in farms situated in peat soils and urban areas. In addition, the implementation of strip cultivation presents an opportunity to experiment with silt-resistant cultivation, including quinoa and various types of potatoes.

Agroforestry

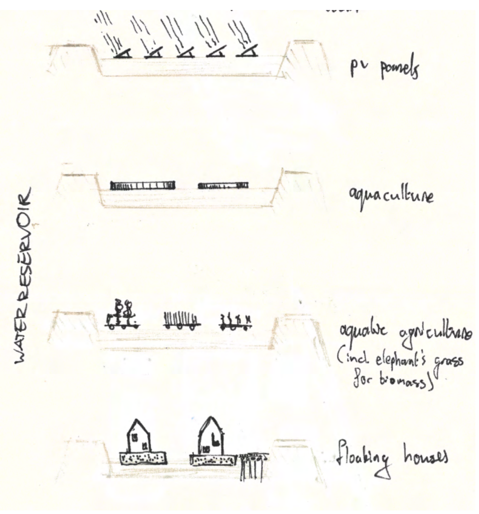
Other regenerative agricultural practices like agroforestry promotes biodiversity, enhances soil quality, sequesters CO_2, and reduces soil erosion. It offers farmers the opportunity to generate additional income through fruits, nuts and timber. Fast-growing trees such as poplar and ash could be utilized for constructing wooden buildings like CLT for tiny houses or public facilities. Additionally locally-sourced materials like cattail, reed, and willow grown in the peat meadows could also serve as construction materials.

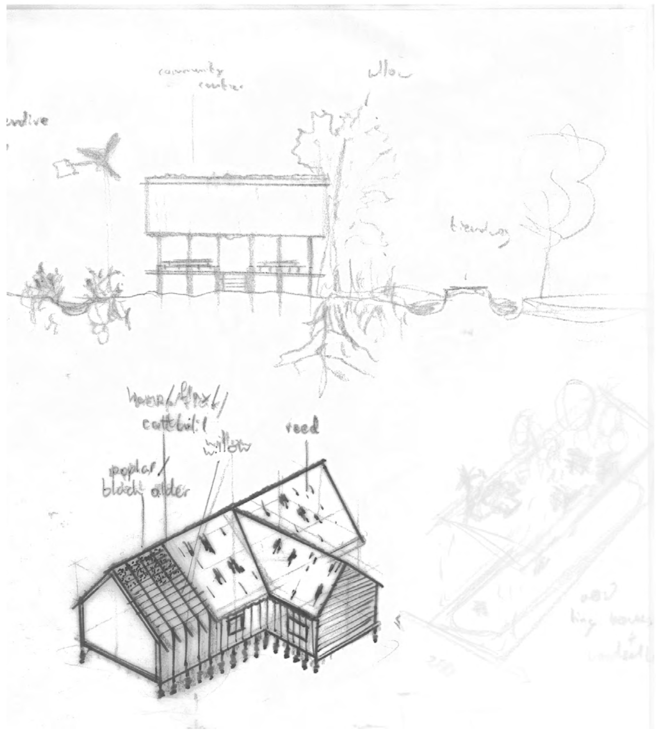
Furthermore, trees will be planted along the access roads of the farms, emphasizing the polder pattern and marking a transition towards agroforestry systems in the adjacent agricultural plots.

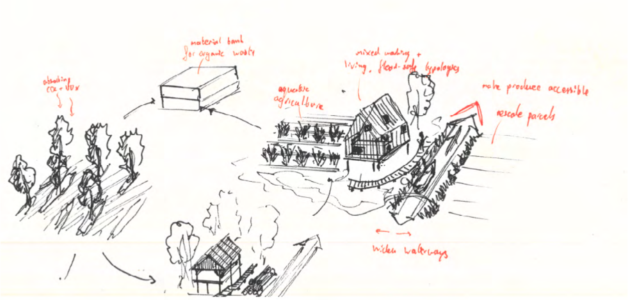
Erfwonen

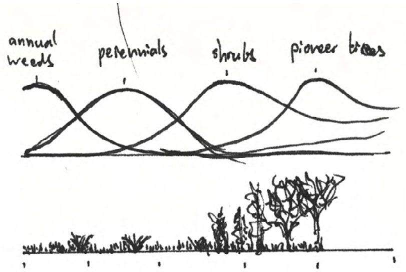
Finally, there is also the potential for “erfwonen” on the farmyards, which involves creating a collective living arrangement in rural areas where houses can be constructed using locally sourced materials. This concept provides for urban residents to reconnect with agriculture and the natural environment, fostering activities such as agro-tourism. This interaction between urban and rural communities can cultivate a deeper understanding and appreciation for rural livelihoods and the significance of agriculture in rural areas.

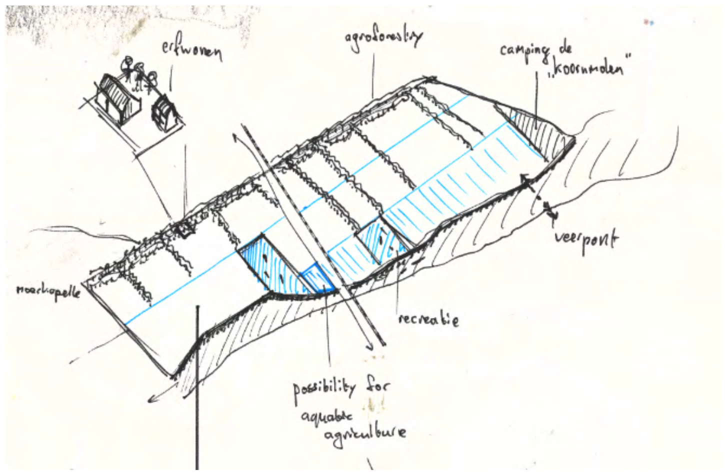
Design exploration potentials for agricultural and residential developments in the Tweemans-polder











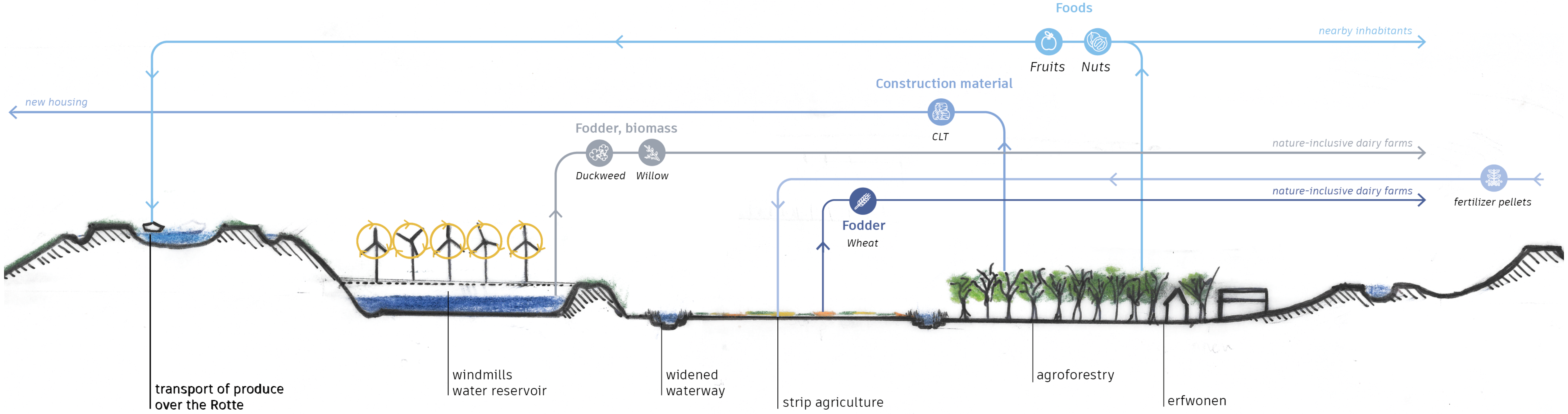


Figure 73 - Systemic section
of flows related to sustainable
productive agriculture landscapes

Figure 74 - (next page)
An impression of future spatial
qualities resulting from biophilic
and technophilic developments

Dairy Farming

The spatial development for the peat meadows aimed at water retention present an opportunity to create an adaptive, resilient, and diverse landscape, based on the principles of nurturing a healthy soil and implementing a sustainable water system. Feeding the peat soil and the clay on peat soils with local groundwater increases the sponge effect and moisture retention capacity. This means that more differentiated water level management and land use is necessary in the Krimpenerwaard. This would provide the opportunity to connect larger residual flows to regional cycles, utilizing renewable energy sources, and ultimately shortening the distance between farmers and local residents. Moreover, the overall landscape image will become more legible and diverse, while the existing structures and character of the landscape will be largely preserved.

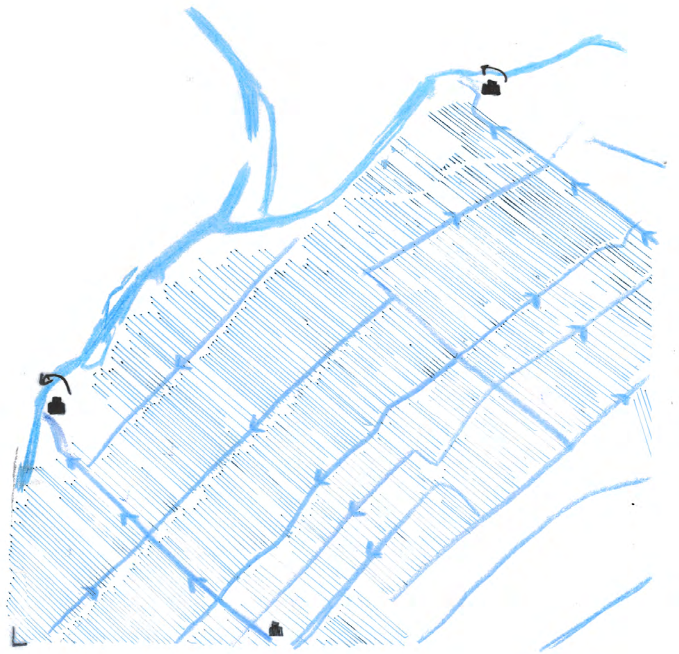


Figure 75 - Sketch showing the drainage of the peat polders

Areal view of the peat meadows below Gouda

Source: PDOK, 2022

Soil

Within this particular area, there is a gradient of roughly three distinct soil types: Liedeerd, Weideveen, and Koopveen.

Weideveen soils are a product of peat moss growth and typically have a high water level, which makes them more suitable for intensive dairy farming. Liedeerd soils, in contrast, have been formed from the deposition of clay sediments from the Ijssel and generally have a greater load-bearing capacity than Weideveen. This makes Liedeerd more suitable for construction and agriculture.

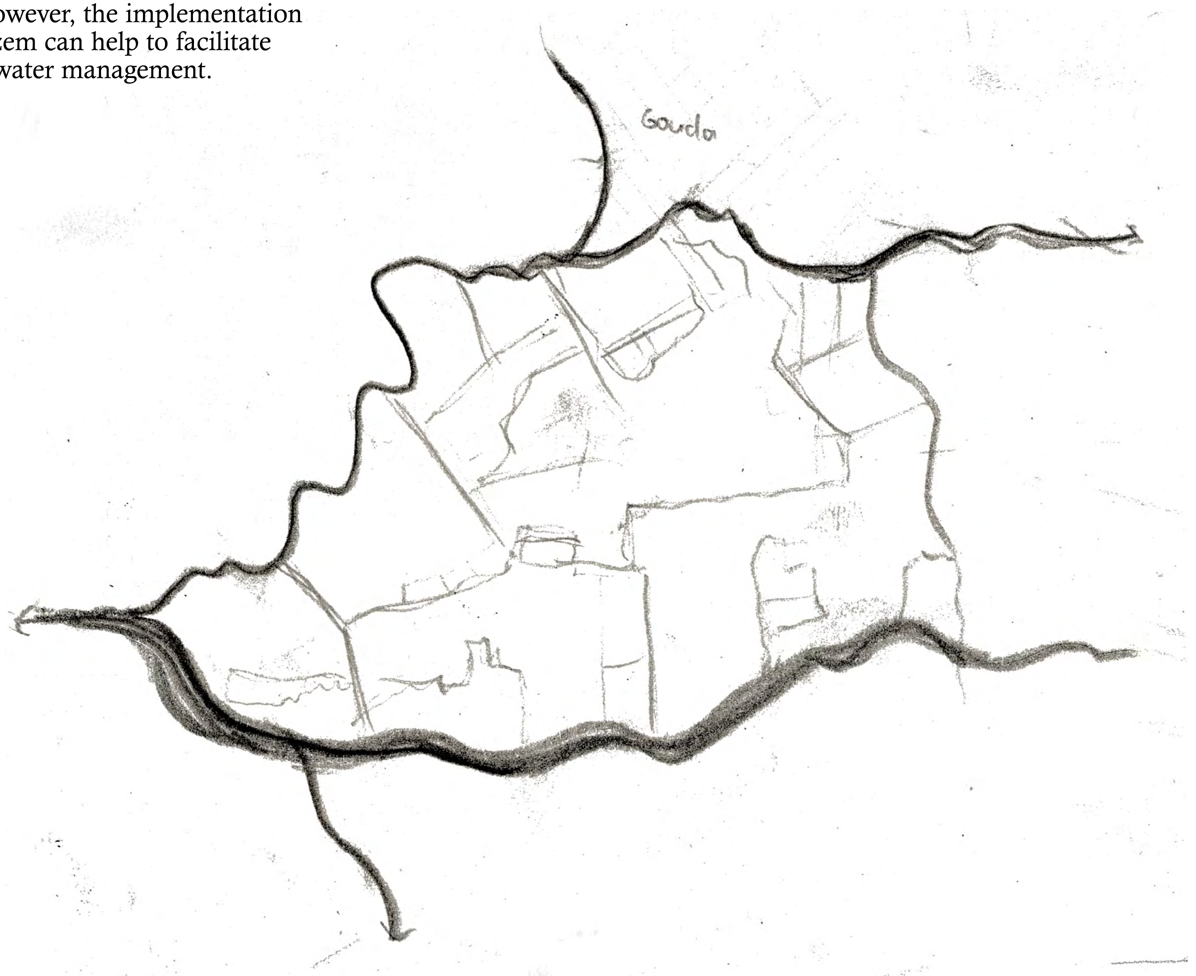
Koopveen soils have a more dense layer of peat and can have a substratum layer of either Bosveen or Zeggeveen. Koopveengronden on Bosveen are typically more nutrient-rich than those on Zeggeveen because the plants that used to grow in this environment resulted in more organic material in the soil. Conversely, Koopveengronden on Zeggeveen tend to be more acidic and lower in nutrients, which means they cannot support much plant growth. However, these soils may be suitable for specific plant species adapted to these conditions, such as reeds or peat moss (sphagnum) (WUR, n.d.).

Figure 76 - Soil map. Subsidence is more evident in the denser Koopveen soils and becomes less pronounced in the Liedeerd soils near the river. Therefore, a cascade of peilvakken that corresponds with different types of cultivation could be implemented to systematically mitigate subsidence. This approach allows for a differentiation between drier zones and wetter zones of cultivation on Liedeerd soils and Weide- and Koopveen soils, respectively.

Peilvakken

The conversion of land use in the polders has led to a fragmented water management system, characterized by the presence of numerous peilvakken in the area. When restoring the water retention capacity of peat lands, this fragmentation can pose challenges to water management, necessitating enhanced coordination between the water board and landowners. Aligning strategies and ensuring consistent practices across these fragmented compartments becomes more challenging. However, the implementation of a tussenboezem can help to facilitate more effective water management.

Figure 77 - Sketch showing the different waterpeilen in the Krimpenerwaard



Tussenboezem

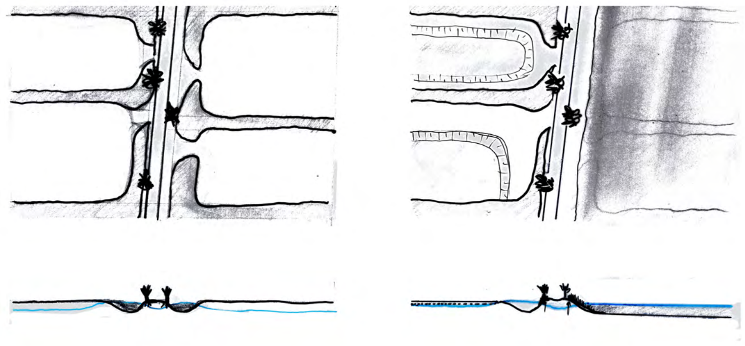
In the transformation process towards regenerating peat soils, the implementation of an intermediary water storage area, known as the ‘tussenboezem’, will play a crucial role. This tussenboezem will offer increased flexibility in managing water levels, particularly during periods of heavy rainfall, by providing a means to store excess water for use during dry periods. Moreover, the tussenboezem will feature a gently sloping embankment, creating favourable conditions for the development of wet grasslands and reed zones. It will also serve as a habitat for freshwater fish and meadow birds, thereby promoting biodiversity in the region.

To facilitate water infiltration into the peat ribbons, the waterways along Tiendewegen and Achterweteringen will be extended to approximately 50 meters, with the assumption that this would provide sufficient storage capacity. These waterways were originally constructed for drainage purposes during the reclamation of the peat meadows, and will be revitalized for enhanced accessibility in a wetter landscape. The various embankments and paths will need to be raised to accommodate the higher water table resulting from the tussenboezem. Through natural gravity, the elevated water level will effectively moisten the peat ribbons without the need for external pumps. The extension of the waterways and embankments will also extend the recreational network and provide new recreational opportunities, including paddling and fishing sports.

This project will significantly expand the surface area of the current boezem system, leading to a more resilient and climate-adaptive water management system. The increased capacity for water buffering and controlled release of freshwater will improve water storage and management in the area. The establishment of new peilvakken between the network of tussenboezems and embankments will enable the creation of independently managed water compartments, as depicted on pages 126 and 136. Currently, there is limited differentiation between the water levels of the ditches and the boezem within the landscape, which contributes to a lack of diversity and legibility. The implementation of the tussenboezem, along with the emerging new parcel divisions, will enhance the legibility and diversity of the landscape, as well as provide landowners and stakeholders with greater autonomy for various purposes.

Figure 78 - (right)
Impression of the spatial and recreational qualities of the tussenboezem

Figure 79 - (below)
Peat ribbons along a Tiendweg before and after the implementation of the tussenboezem



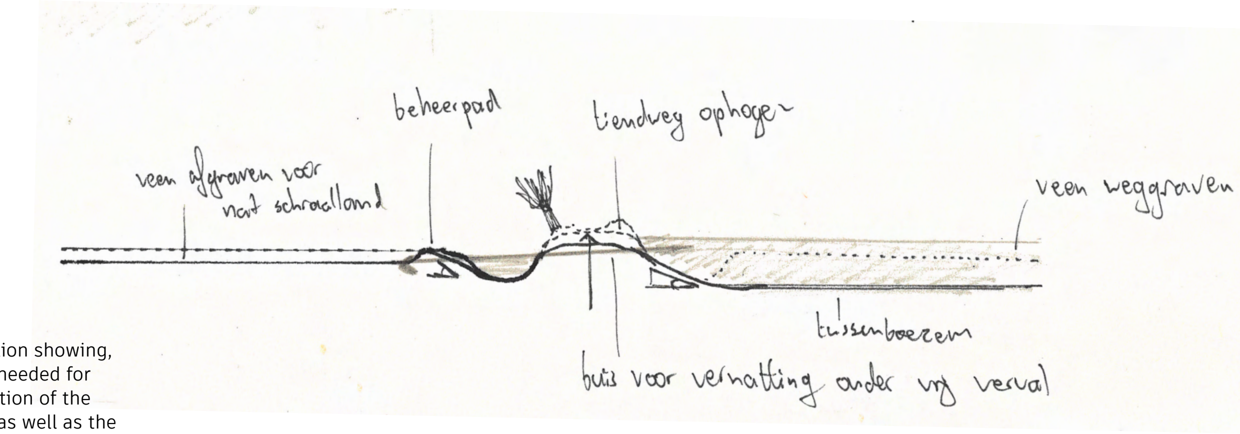


Figure 80 - Section showing, in Dutch, steps needed for the implementation of the tussenboezem: as well as the water being supplied from the tussenboezem to the adjacent peat parcels

It should be noted that this intervention assumes a holistic approach that encompasses the entire Krimpenerwaard region, as opposed to, for example, implementing it as a pilot project confined to a single polder, such as Middelblok.

While the latter option may allow for a more gradual transition, enabling farmers to adapt at the polder level, it would require the construction of infrastructure such as gemalen (water pumps) that would become unnecessary once the entire boezem system is inevitably interconnected. In terms of scale and technical implementation, such a reconstruction of this agricultural land is comparable with the larger land consolidations from the mid-twentieth century.

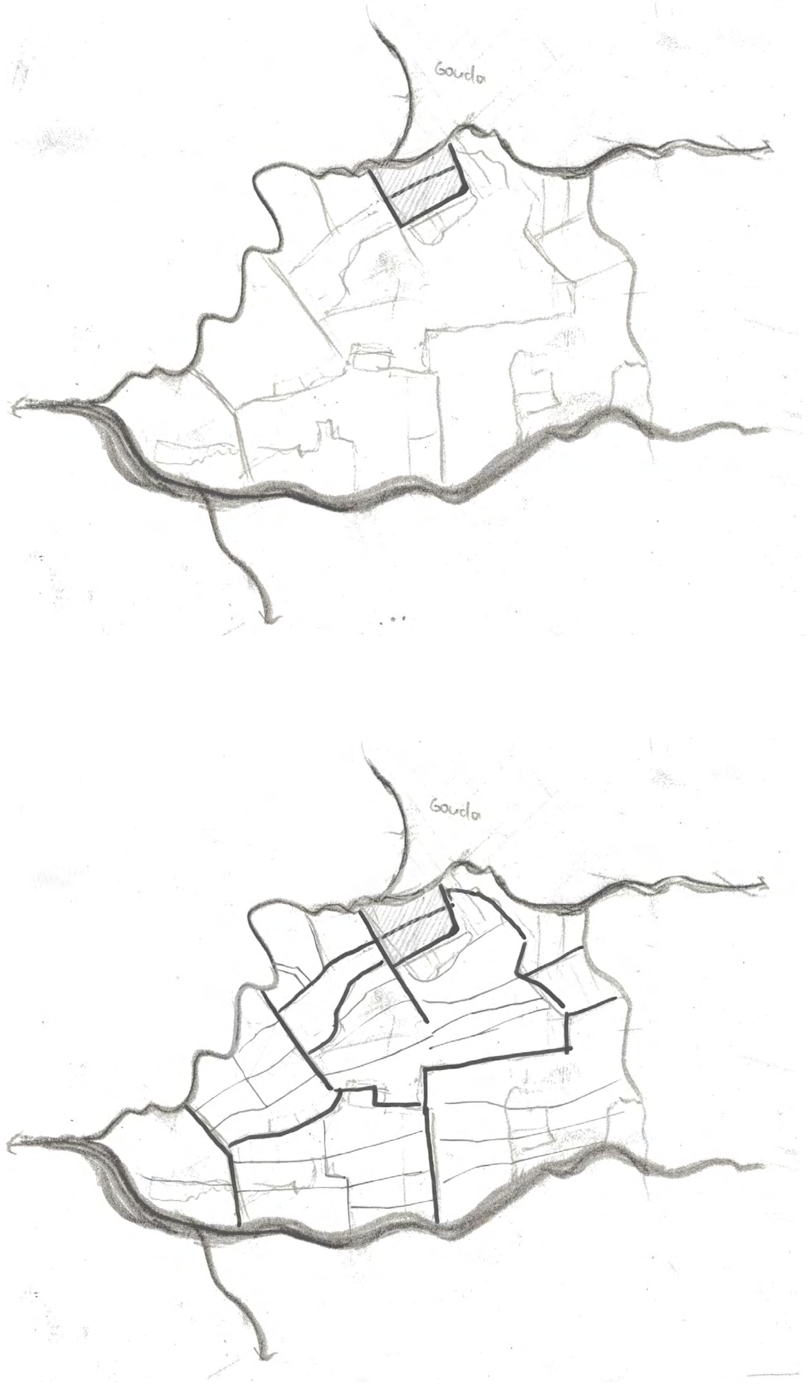


Figure 81 - A choice for the scale of transformation of the Krimpenerwaard

Furthermore, within the new peilvakken, it could be possible to allow for additional parcel divisions and assign individual water levels to each farmer, provided they fall within the allowed fluctuations for that specific compartment. This approach would enhance the autonomy of farmers, allowing them to adjust the water level according to their specific production needs. However, implementing this system would require the construction of numerous embankments and pumps. Additionally, if it becomes evident that climate change is progressing faster than anticipated and further reductions in emissions are necessary, it may be crucial to prioritize CO_2-absorbing plantations like peat moss over agricultural productivity at large. In such a scenario, maintaining an unfragmented peilvak will be more effective, making the implementation of embankments potentially costly in the long term.

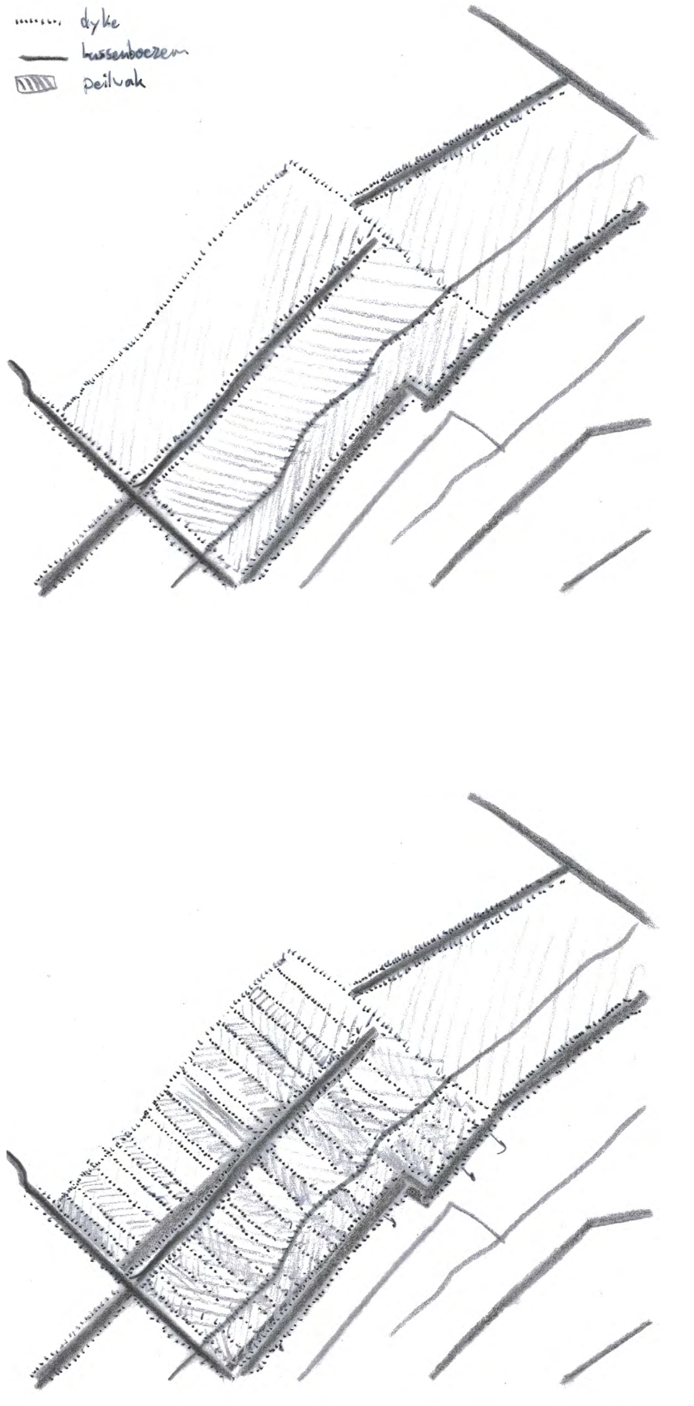
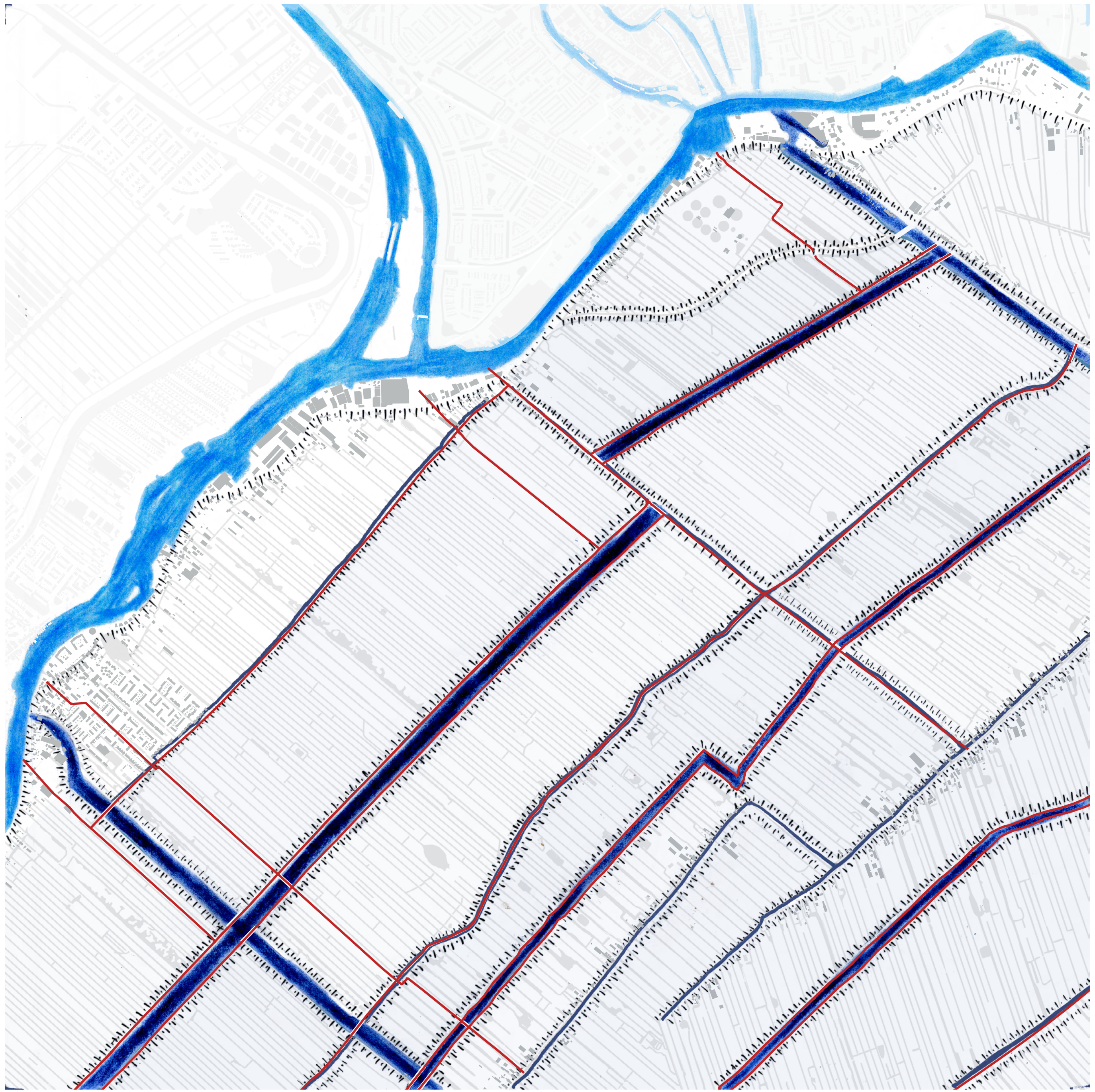


Figure 82 - A choice for the scale of production within one collective peilvak

Design

The implementation of a tussenboezem will play a crucial role in managing water levels and promoting biodiversity. Extending waterways and embankments, along with raised paths, will facilitate water infiltration and create a wetter landscape with wet grasslands, paludiculture, and serve as a habitat for freshwater fish and meadow birds. Overall, this expansion of the boezem system will enhance water storage and resilience, while extending the recreational network, offering activities like paddling and fishing. Independently managed water compartments will improve diversity and legibility, benefiting landowners and stakeholders. This holistic approach ensures a comprehensive transformation that will contribute to the resilience and enjoyment of the landscape.

Figure 83 - Adapted water- and recreation network for dairy farming



Dairy Farming

Ijssel

Slow infrastructure network

Tussenboezem - Tiendweg

Tussenboezem - Achterwetering

0 250 500 m

N

Figure 84 - Bird's eye view of the future landscape structure of the peat meadows in the northern part of the Krimpenerwaard

Spatial exploration of possible emergent land uses

In the peat meadows, the nature-inclusive land uses that may emerge following the redevelopment of the water system, as explored in this thesis, include extensive dairy farming and hay lands, paludiculture and peat moss. As discussed on page 132, marshland woods (broekbossen) are beyond the scope of this study, and further research is needed to investigate their spatial qualities and ecosystem services.

In terms of addressing subsidence and promoting the regeneration of peat soils, peat moss proves to be the most beneficial land use. It not only stops subsidence but also allows for the growth of peat and sequesters CO_2. However, as this would prove more effective on a larger scale, this would result in a landscape with a larger grain and a more monotonous character. Nonetheless, when combined with broekbossen, it can restore the traditional peat landscape before the Grote Ontginning.

On the other hand, paludiculture, which involves the cultivation of wet crops and raw materials, offers a relatively higher landscape variety compared to peat moss. Wet food crops such as duckweed result in a more open but less diverse landscape, while wet raw material cultivation with plants like willow, cattail, and elephant grass creates a more sheltered and diverse landscape.

Extensive dairy farming, combined with hay lands and herb-rich grasslands, introduces new spatial dimensions of openness and seclusion compared to intensive dairy farming. Both paludiculture and extensive dairy farming provide more development space for economic activities with less restrictive regulations compared to peat moss growth.

Each new land use significantly enhances biodiversity but with different implications. Paludiculture, especially of willow, can serve as shelter, forage, or resting places for various fauna. Cattail, on the other hand, creates important habitats for dragonflies and aquatic fauna. Meadows used for extensive dairy farming can become habitats for meadow birds. Peat moss growth may reintroduce currently rare flora and fauna found in more natural high and low peat conditions.

For the peat soils that subside with a faster rate and emit more CO_2, it might be necessary to give more space there for land uses that promote the halt of subsidence. Simultaneously, land uses in the vicinity of cities, such as Gouda in this specific area, may be more suitable for productive land uses that require active citizen involvement and contribute to a larger flow of regional activities.

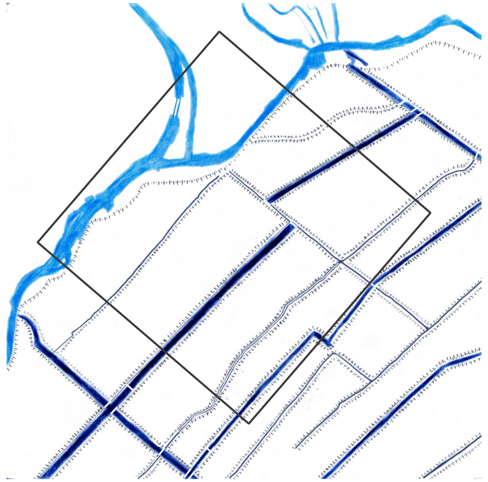
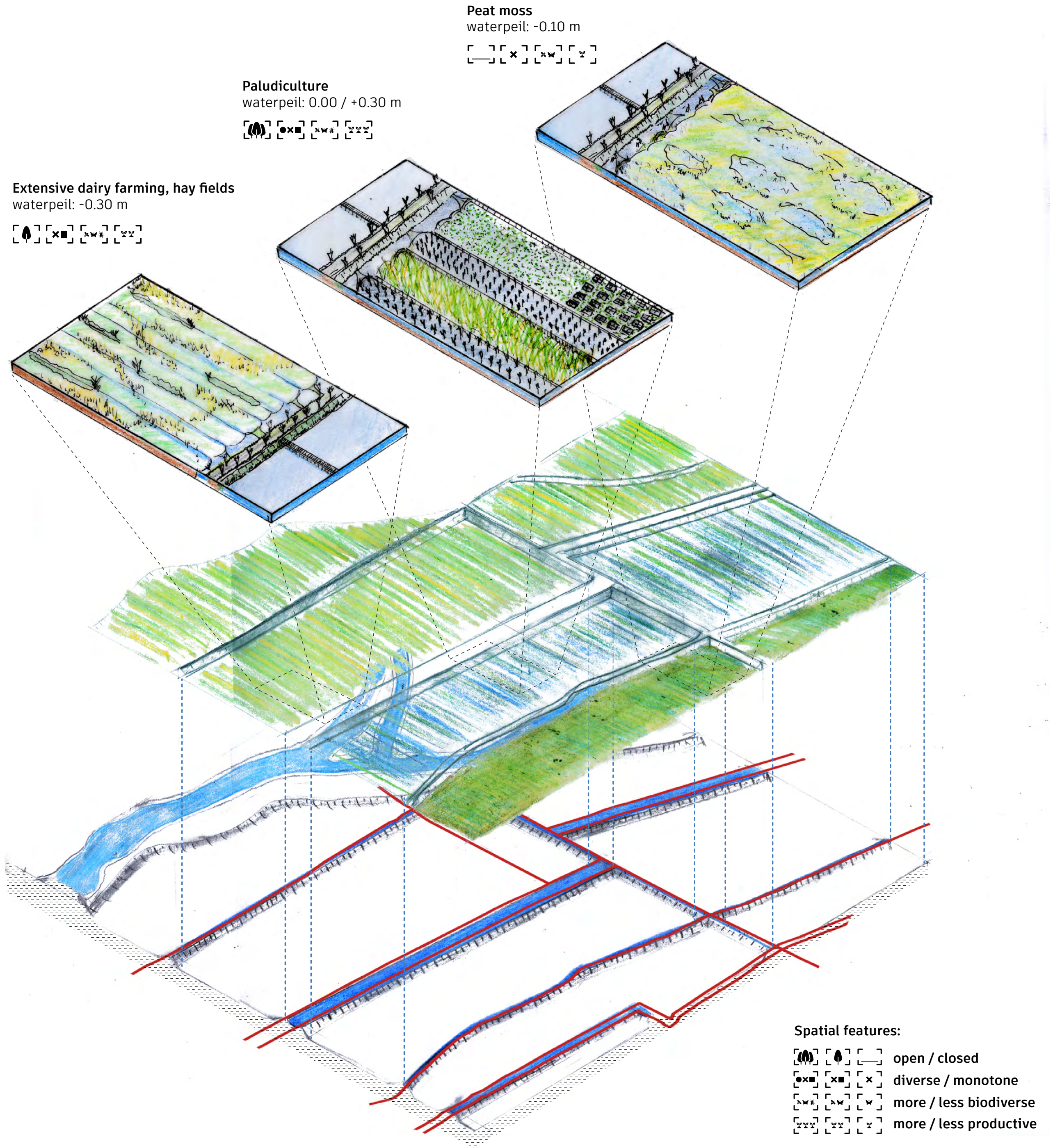


Figure 85 - De design of the tussenboezem- and slow infrastructure network allows for a combination of land uses that have distinct spatial features and ecosystem services, resulting in a regenerative and diverse landscape.
Based on Studio Marco Vermeulen (2021).



Nature-inclusive Dairy Farming

Intensive dairy farming is being replaced with extensive, nature-inclusive dairy farming that allows for the cultivation of produce that requires a higher water level, such as hayfields and herb-rich grasslands. The higher groundwater helps limit soil subsidence and reduces CO_2 emissions, while the herbaceous grasslands, including clover and other plants, help fix nitrogen. Furthermore, hay can be used to purify water for agricultural- or residential purposes and can also serve as a roofing material for new housing. Finally, these extensive hay meadows and wetlands would serve as the foundation for a robust meadow bird population in the Krimpenerwaard (Veenweiden Krimpenerwaard, 2021).

Old Dutch cattle breeds and other farm animals like those painted by Paulus Potter will be reintroduced as the diversity of farm animals is crucial for multiple reasons. It ensures a genetic resource bank for future needs, including developing new resistant varieties and restoring genetic diversity. Diverse farm animals contribute to the resilience and adaptability of the agricultural sector. Furthermore, a diverse herd promotes sustainable farming practices, with certain breeds displaying better disease resistance, efficient resource utilization, and reduced environmental impact. Embracing diversity in farm animals is a sustainable investment in the future of agriculture, enabling adaptation to evolving challenges. (Groen Kennisnet, 2021).

In nature-inclusive dairy farming, livestock is fed as much as possible on the basis of residual flows and produces valuable manure. The cow will graze outdoors as much as possible and will go to a 'bedding barn' in winter, which score more positively on animal welfare, facilitate carbon sequestration in the soil, increase water retention capacity and drainage and a richer soil life (Pijlman et al., 2018).

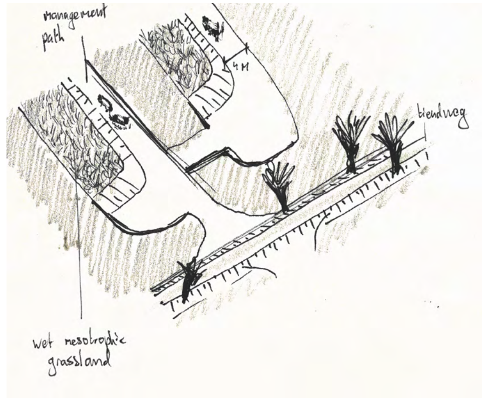
To supplement the bedding, reed, willow, and cattail are gathered from the areas meant for wet cultivation. Additionally, the cow's diet has been modified to include duckweed fern, which is supplemented with crushed wheat and straw from agriculture in the droogmakerijen.

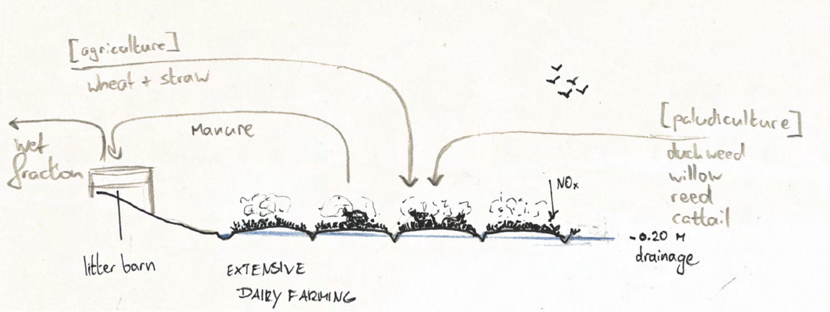
The use of an extensive grazing system in combination with a modern litter barn allows for the fermentation of manure into a wet fraction, which can be used for the production of wet crops. The remaining digestate is then used as fertilizer pellets for agriculture or horticulture. This process significantly reduces the formation of ammonia and decreases the need for artificial fertilizers. (Buro Sant en Co & Fabrications, 2019).

Figure 86 - 'De Stier', by Paulus Potter (1647).
The tradition of painting cows in the meadow reflects the strong connection between cows and the Dutch landscape. The paintings often depict old Dutch cattle breeds such as Blaarkop, Witrik, Lakenvelder, Brandrode, Fries zwart- en roodbont and the Maas-Rijn-Ijsselvee. These dual-purpose cows were capable of producing both milk and meat solely from grass or hay.

However, the introduction of artificial fertilizers and richer feed led to a demand for high-yielding cows focused on milk or meat production. As a result, the once prominent old Dutch cow breeds have been marginalized and are now classified as endangered.

Design explorations for systemic and spatial qualities of nature-inclusive dairy farming.





Paludiculture

In the wetter zones near the center of the Krimpenerwaard, the tussenboezem will be the key in allowing diversified wet cultivations. With various water levels comes various possibilities for produce, each with their own vulnerability to water fluctuation, market outlets and flows within the overall metabolic system. In the wetter areas adjacent to the tussenboezem, livestock farming has been replaced by wet crop cultivation, which includes duckweed, cattail, elephant grass, and willow.

Duckweed presents an opportunity for highly efficient protein production, being six times more efficient than soy due to its rapid reproduction and high protein content, and is being explored as a potential source of human consumption. This plant species is also considered one of the most efficient in the world in terms of biomass production per hectare. Additionally, it can contribute to water purification by removing nutrients from the water. It can also be combined with floating solar panels for energy production (VIC, 2017).

Cattail is capable of storing large amounts of carbon in the soil and can be used as a raw material for paper, textiles, and insulation materials for buildings.

Elephant grass is a fast-growing grass that produces a significant amount of biomass and can be used as an energy crop. It can be converted into bioenergy such as pellets, briquettes, or biogas, making it a sustainable replacement for fossil fuels.

Willow can be grown as biomass for the production of sustainable energy or as fodder for livestock. The young shoots of willows are rich in protein, making them suitable as animal feed. Moreover, willow wood can be used as a building material for fences, furniture, façade cladding, and roof slats (Köbben, 2021).

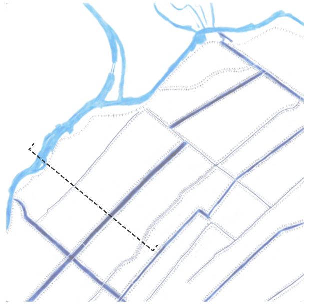
Peat Moss

One potential approach under consideration is the cultivation of peat moss on Koopveen soils. This cultivation method promotes the growth of peat, effectively halting subsidence and even sequestering CO_2. Furthermore, this method would largely depend on farmers receiving payment for providing social services such as the halting of subsidence, sequestering CO_2, improving water quality and nature conservation (Buro Sant en Co & Fabrications, 2019). To make carbon sequestration profitable and penalize the emission of CO_2, a CO_2 tax may be introduced that reflects the actual cost of emissions. While this approach could lead to a regenerative and CO_2-positive landscape, it could also significantly reduce the productivity of the land and result in a less diverse landscape.

Marshland woods (Broekbossen)

With an even higher water level, broekbossen could develop, resulting in a permanently wet landscape that effectively deals with flooding and fluctuating water levels. However, it is important to note that although such a high water level would lead to a reduction in CO_2 emissions, it would also cause an increase in methane emissions from anaerobic processes due to the production of marsh gas. Further research is necessary to determine an optimal balance of emissions considering the water level for the development of marshland (Buro Sant en Co & Fabrications, 2019). Although the development of broekbossen may prove to be an attractive landscape on peat soils, its spatial qualities are not assessed in this thesis.

Figure 87 - Spatial explorations for different forms of paludiculture and peat moss (sphagnum) development, respectively. Sphagnum may face challenges when combined with other wet cultivations within the same water level zone, particularly in relation to managing high fluctuations in water levels. Therefore, it might be more effective for sphagnum development to occur in collective peilvakken in stead of individual parcels, as described on page 127. This would result in a landscape that is perhaps more similar to the current peat meadows. In contrast, ascending crops seen in paludiculture would result in new spatial dimensions of openness and seclusion.



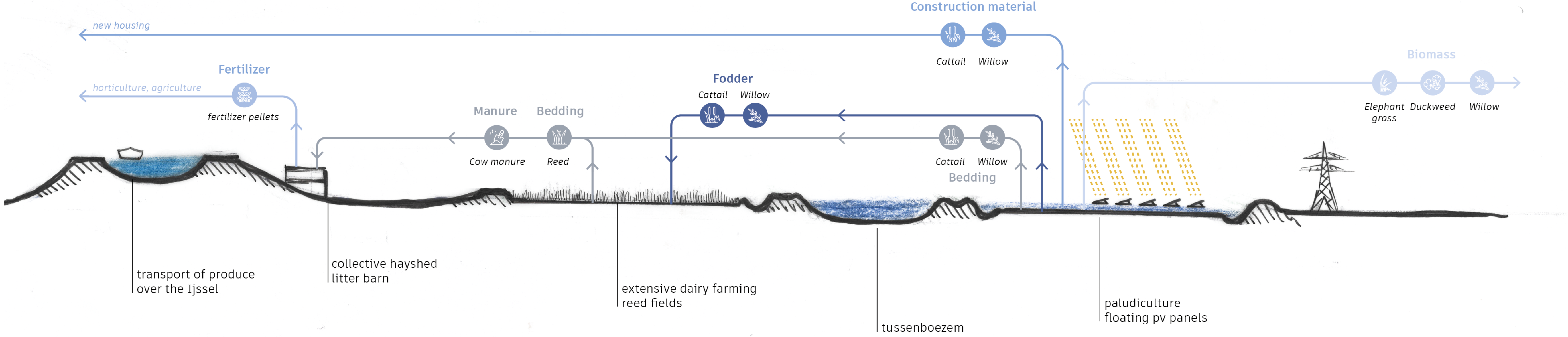


Figure 88 - Systemic section of flows related to different productive landscapes on peat soils

Figure 89 - (next page) An impression of future spatial qualities resulting from biophilic and technophilic developments

Figure 90 - Redevelopment of the water system on the scale of Hoogheemraadschap Schieland en de Krimpenerwaard, which is key for adaptive and sustainable spatial development

Figure 91 - Perspective of a (bio) diverse and productive peri-urban landscape, based on the Regionally Rooted scenario by PBL (2023)

Conclusion

Introduction

As the Netherlands transitioned towards contemporary modernity, national planning policies based on the urban-rural dichotomy established industrial production patterns that contribute to the societal, economic and ecological imbalances that are negatively impacting the metropolitan region's landscape of the Deltametropolis today. The efficiency-driven climate of spatial development of recent decades have resulted in the emergence of a highly productive yet unsustainable agricultural landscape that has pushed the soil and water systems to their limits. Additionally, unprecedented suburbanization, particularly in the South Wing of the Deltametropolis, have dissolved urban and rural areas into a continuous patchwork landscape. The globalization of the agricultural sector has further resulted in little direct social or economic affiliation between urbanites and farmers, which enhances a perceived cultural rift between the two groups and perpetuates the urban-rural dichotomy in spatial planning.

In the context of transitioning productive landscapes in the Deltametropolis, the two planning paradigms of the urban-rural dichotomy and market-driven development call for a different approach in spatial planning. Instead of draining the vulnerable droogmakerijen and peat meadows in service of intensive and monofunctional agricultural production, the hypothesis of this thesis proposes that a more biophilic spatial structure based on the soil and water system is essential for achieving sustainable and liveable urban and rural land uses. This biophilic spatial structure may enable the emergence of extensive and multifunctional land use in this predominantly peri-urban landscape.

An adaptive design approach can provide insights into the necessary structural spatial choices that policymakers need to make in the short term, so that the spatial qualities of living, production, and natural environments may mutually reinforce each other in the long term.

It therefore poses the Research Question: *In the transition towards a sustainable Deltametropolis, how can an adaptive design enhance spatial qualities in the peri-urban interface through biophilic and technophilic developments?*

Strategy

The adaptive design modifies the water system to enhance its capacity for retaining rainwater, ensuring an adequate supply of fresh water to mitigate local externalities. This expansion of green and blue corridors is accompanied by a connected slow infrastructure network, serving as a link between rural landscapes and urban cores. This thesis argues that the implementation of this new water infrastructure should be conducted simultaneously on a regional scale, encompassing the entire water board. Adopting a regional approach is expected to enhance management effectiveness, feasibility, and cost-efficiency, especially in the more complex polder-boezem system of the Lowlands.

The modified water management system in turn enables a spectrum of land uses, ranging from more biophilic to more technophilic, roughly associated with higher and lower water levels, respectively. These diverse land uses integrate resource productivity and nature development, with biophilic land uses prioritizing nature development and technophilic land uses emphasizing resource productivity.

or both, it is conceivable to envision a sustainable future for the cultural productive landscape with new revenue models to support this (Buro Sant en Co, Fabrications & WUR, 2019). However, the goal of creating a balanced living environment necessitates a combination where nature development and resource productivity mutually enhance each other.

Horticulture

The adaptive design for the horticulture of the Bleiswijkse polder includes a wetland system that serves as a water buffer and purifier, capturing CO_2, preventing salinization, and supplying fresh water for both open soil and greenhouse horticulture as well as for residents. Additionally, the implementation of a geothermal heat grid is planned to provide sustainable heating for horticultural businesses, offices, and houses in the surrounding area.

The transformation to vertical greenhouses would significantly increase the permeability and accessibility of the area. This transformation would be implemented in the short term through a phased approach, considering the economic lifespan of individual greenhouses and the type of produce they cultivate. The older greenhouses, as well as those cultivating unsustainable produce like flowers, would be prioritized for replacement.
Both vertical greenhouses and open-soil horticulture would cater to the growing demand for locally grown produce. This would result in a wider range of locally grown agricultural products being readily available to nearby residents. Additionally, these products would be transported to urban markets in nearby cities and villages, including the markets of Rotterdam via water transport over the Rotte.
Residential development could be constructed with materials grown within the agroforestry systems of agricultural plots, along with materials from paludiculture. The district's energy, water, food production, and waste management systems could be designed to achieve near self-sufficiency, due to the utilization of geothermal heat grids and local food production.

Agriculture

The adaptive design for the agriculture of the Tweemanspolder entails the construction of water reservoirs that, together with ditches with helophyte filters, serve as water storage and purification, ensuring a reliable water supply for irrigation during dry periods. Along the water reservoirs, small windmills will be installed that would provide sustainable energy.

The water reservoirs offer possibilities for various uses such as floating PV panels, floating housing, aquaculture, and aquatic agriculture, which can be utilized for wet cultivation of cattle fodder, biomass, and construction material.
Strip cultivation promotes biodiversity by creating diverse habitats and corridors within agricultural landscapes, while agroforestry systems contribute to the production of raw materials for circular building materials, supporting sustainable housing and local food production with fruits and nuts. These integrated approaches enable collective living arrangements for farmers and citizens, fostering a sense of community.

Dairy Farming

The adaptive design for the dairy farming on peat polders below Gouda involves implementing a network of tussenboezems on the scale of the Krimpenerwaard. These tussenboezems will enable water infiltration into the peat ribbons, addressing subsidence and CO_2 emissions. This design will significantly increase the surface area of the boezem system and improve the slow infrastructure network, which will allow for the creation of independently managed peilvakken within the waterway network.

Peat moss promotes the growth of peat, completely halting subsidence, and also sequestering CO_2. However, it would significantly reduce the productivity of the landscape and, due to its larger scale, also reduce landscape diversity.
Paludiculture can be subdivided into wet food crops and wet raw material cultivation that can be used for construction materials or biomass. Wet food crops result in a more open but less diverse landscape spatially, while wet raw material cultivation leads to a more sheltered but also more diverse landscape.
Extensive dairy farming includes hayfields and herb-rich grasslands that fix nitrogen and serve as the foundation for a robust meadow bird population. Reintroducing old Dutch cattle breeds and other farm animals would ensure a genetic resource bank, contribute to the resilience and adaptability of the farm, and provide multiple sources of income. By implementing a bedding farm, cattle manure can be effectively separated into a wet fraction and a dry fraction, providing natural fertilizers suitable for wet and dry forms of agriculture, respectively.

Biophilia and Technophilia

The Biophilia-Technophilica dichotomy employed in this thesis has served as a simplification of the historical and future spatial developments of cultural landscapes in the Netherlands. However, it is important to approach these multifaceted developments with nuance and an understanding that Biophilia and Technophilia, representing the relationship between Nature and Culture in both cultural and spatial senses, exist along a nonlinear spectrum.

This thesis argues that achieving a sustainable future for productive landscapes necessitates a balance between natural and cultural spatial developments, wherein resource productivity is coupled with the enhancement of natural systems. Indeed, all the developments explored in this thesis exhibit a combination of biophilic and technophilic elements. Consequently, the following section delves into the spatial qualities of these productive landscape developments, employing the terms '*more-biophilic*' and '*more-technophilic*'.

Spatial Qualities

The main differences in terms of spatial quality between more-biophilic and more-technophilic landscapes lie in their variety, size and accessibility.

More-biophilic landscapes (wetlands, water reservoirs and peat moss fields) require a larger size and lower accessibility to facilitate biodiversity regeneration, water buffering and purification, as well as to better address challenges such as subsidence, salinization, drought, and CO_2 absorption.
On the other hand, *more-technophilic* landscapes explored in this thesis (agroforestry systems, strip cultivation, horticulture on open soil, paludiculture and extensive dairy farming) resemble traditional, small-scale productive and more easily accessible landscapes.

Both contribute to biodiversity, with the distinction generally being quantity (*more-biophilic*) versus diversity (*more-technophilic*). They also offer different nature experiences, with *more-technophilic* landscapes providing daily interactions and *more-biophilic* landscapes offering a more natural or 'untamed' experience. In combination, biophilic and technophilic developments enhance landscape variety and legibility, with each land use visibly related to its respective water level. Indeed, only a combined approach may provide holistic solutions for the current unsustainable, monofunctional, and impermeable productive landscapes.

In determining the appropriate quantities of *more-technophilic* and *more-biophilic* land uses within the landscape, further exploration is needed. However, with the overarching goal of fostering balanced socio-economic and ecological development, it may be necessary to maximize regional productivity to stimulate the circular economy. Accordingly, a greater area for technophilic landscapes as opposed to biophilic landscapes would foster increased local circulation of resources, including construction materials, natural fertilizers, and locally produced food, thereby enhancing urban-rural relationships through enhanced economic and social interaction. By closing cycles on a small scale, reminiscent of pre-Ruilverkaveling practices, an agricultural economy can be established that is less reliant on exports and thus more self-sustaining.

If needed on the long term, the adaptive design allows for more water retention and nature development to take place within the landscape. In particular, in the peat meadows and agricultural areas, there is potential for converting land use into *more-biophilic* landscapes without necessitating substantial modifications to the water system infrastructure and access roads. This is due to the relatively lower level of construction in these areas compared to the productive landscapes dedicated to horticulture. This could become necessary if there is a greater need for CO_2 sequestration or if the demand for freshwater exceed initial expectations.

Policy Recommendations

In terms of governance, the adaptations of the water system facilitates collaboration among stakeholders, including farmers, citizens, water boards, and municipalities, in the joint development and management of the region. This assumes a productive landscape with a decentralized form of governance that closely aligns with the Regionally Rooted scenario proposed by the PBL (2023). Therefore, further policy recommendations will build upon the future pathways outlined in this scenario.

The Regionally Rooted scenario is based on the assumption that the Netherlands will shift away from its position as the world's second-largest exporter of agricultural products. This shift is driven by a growing demand for local food production, which is partly motivated by concerns about food quality and health. Additionally, the scenario envisions a significant reduction in overall livestock production as part of a transition towards alternative protein sources.

The emergence of "regional provinces" is anticipated, which would be smaller than the current provinces but would have decentralized responsibilities for food, energy, water, and waste systems. To effectively carry out their tasks, these regional provinces must be allowed sufficient capacity and power, including the ability to collect taxes and generate the necessary resources and workforce.

This approach promotes self-contained communities that align with Elinor Ostrom's eight principles for managing common-pool resources (1990) to achieve effective decentralized governance. In terms of urbanization, the scenario assumes concentrated growth in smaller cities and villages, reflecting a dispersed form of urbanization. Following the urban model of the Horizontal Metropolis proposed by Viganò et al. (2018), the Deltametropolis would become a sustainable metropolitan region where residents can live, work, and access essential services locally. This vision would facilitate interconnected and sustainable urban environments through biophilic and technophilic developments.

Reflection

Introduction

The interdisciplinary studio Metropolitan Ecologies of Place forms a crystallization point between the different disciplines of urbanism and landscape architecture, which sparked my initial interest. Central to both this studio and this thesis is the socio-economical and ecological transition towards regenerative and biophilic design. It looks at urbanism through the lens of the territorial landscape, examines how cultures have urbanized previously natural landscapes throughout history, and explores how new hybrid commons of Cultural and Natural typologies can be researched and designed.

At the heart of my graduation project is a research by design that examines the urban developments of the late twentieth-century of the Randstad region, where the gradual urbanization dissolved urban and rural on a continuous patchwork landscape. Through national spatial planning policy that is embedded in the urban-rural dichotomy, market-driven developments established industrial and technocratic productive landscapes that have pushed the soil and water system to its limits. The climate- and energy adaptation transition provides the necessity and opportunity to opt for structural spatial developments that strengthen sustainability and spatial qualities in the peri-urban interface.

Societal Relevance

The globalization of the agricultural sector has resulted in little direct social or economic affiliation between urbanites and farmers, which enhances a perceived cultural rift between the two groups and has perpetuated the urban-rural dichotomy in spatial planning. The implementation of policies targeting nitrogen and phosphorus pollution in May 2019 further strained the already tense relationship between conventional farmers and the coalition government. The implementation the landbouwakkoord of 2023, which has showed to be unsuccesful at the time of writing, highlights the lack of trust of farmers towards the central governments.

While transitioning to nature-inclusive agriculture is crucial for achieving long-term ecological balance and promoting the well-being of regional ecosystems, it is important to acknowledge that these transitions have disproportionate impacts on local communities. A successful harmonious transition relies on ensuring that farmers have the means to recover their investments through new agricultural practices. After all, the transformation of these productive landscape should prioritize the overall well-being for people living and working in the region.

With the goal of combining nature development and resource productivity, Buro Sant en Co, Fabrications, and WUR (2019) envisioned new revenue models on the scale of the Green Heart to support a sustainable future for the culturally productive landscape and provide farmers with diverse opportunities to adapt their agricultural methods while safeguarding their livelihoods. However, further research by design is needed on the local scale to ensure the viability of these models, as they currently only serve as generic guidelines for addressing the complexities of the local context. It should also be noted that these models depend on the adaptations to the water system as proposed in this thesis, which might need to be enforced through central policy.

Central Policy

In the transition proposed by this thesis, the national government bears primary responsibility for policy development, while executive government services, provinces, water boards and municipalities are mainly responsible for policy implementation. In the current planning system, spatial planning policy throughout the scales is not integrated and do not sufficiently complement each other. Therefore on the short term, the national government should empower themselves as a stronger coordinator in spatial planning in order to give clear guidance for all stakeholders involved. A national policy framework and strategy is necessary which integrates policies regarding i.e. nitrogen as well as subsidence. This would set an objective (e.g. a target of 50% subsidence reduction by 2030) to indicate direction and increase transparency. This requires sufficient substantive knowledge of the limits of natural systems, which makes it essential to collaborate with knowledge institutions to develop capacity in terms of expertise in this matter.

In order to increase transparency for all stakeholders, the costs and benefits of transitioning towards nature inclusive agriculture must be mapped out. A realistic national estimate must be made of what this transition will cost, compared to the costs of unchanged policy. Furthermore, a fund should be made available for farmers willing to transition to a new business model, and they should be compensated for the environmental and societal services they will achieve by doing so, as they will gain are more vital role in linking food production with nature preservation. Capital can further be sourced through crowdfunding or loans from banks like the Rabobank. While nature-inclusive agricultural business models have already demonstrated profitability, further research is needed to assess the financial risks associated with unchanged policies for the bank's risk assessment.

Ultimately, this necessitates a central knowledge base that finds these synergies between the numerous local pilot projects on this matter today. Once the synergies between challenges and solutions have been mapped out at a national scale, they can again be more specifically elaborated and communicated at a decentralized level in regional and local plans (BZK, 2020). Local policymakers should then effectively communicate and address the challenges and opportunities associated with transitioning from existing systems to alternative ones. This decentralized elaboration and collaboration is vital since generic national policies may inadequately address the complexities of local challenges. Indeed, the lack of trust among farmers, stemming from the government's consistent enforcement on models, standards, and selective measurements (Nieuwe Oogst, 2023), underscores the need for decentralized approaches.

Decentral Elaboration

This thesis argues that a forceful and generic national policy, like a maximum amount of cattle per hectare, does not adequately address the complexity of local challenges and may compromise individually desired spatial qualities and freedoms in the living environment. In stead, simplified laws and regulations in spatial planning on the national level may be needed. Furthermore, it is crucial to not only focus on spatial policy but also prioritize social participation processes. Neglecting these processes can result in resistance and the potential failure of spatial plans (PBL, 2023). Adopting the governance model of Regionally Rooted enables decentralized authorities to customize transformations according to specific local challenges and solutions.

This may entail provincial governments and water boards dividing their transitioning territories into a number of sub-areas based on the redeveloped water-, food-, and energy systems. In areas dedicated to horticulture and agriculture, this could involve different companies and residents sharing water retention, purification, or energy facilities. In the peat meadows, this approach could be based on the new peilvakken enclosed by the numerous tussenboezems. These sub-areas would be jointly managed and implemented by relevant stakeholder networks, including municipalities, environmental organizations, water boards, farmers, and other citizens. This may foster the development of environmental stewardship and cooperation among local residents, instilling a sense of shared responsibility towards the environment and future generations. What could emerge is a heightened sense of connection and community among residents, fostering a stronger bond with their immediate surroundings and each other.

It is important to note that this vision aligns with reduced globalization (PBL, 2023). In this scenario, rising fuel costs would diminish global trade and travel, resulting in overall reduced individual freedom of consumption. While this shift may contribute to shrinking income disparities and bridging the perceived divide between farmers and citizens, it may also heighten tensions within and between decentralized communities. The potential exclusion of outsiders or newcomers with divergent interests and perspectives could pose a challenge to community dynamics.

Participation Strategies

Citizen participation in food production as proposed by the Regionally Rooted scenario may provide solutions for the deadlock that exist within the power dynamics of today's food chain in the Netherlands. The dependence of farmers to this centralized food chains poses a challenge to the transition towards more sustainable agricultural practices. Unbridled consumerism of recent decades has made the general population used to having all products available at all times for the lowest possible price, seeming to have forgotten the value of food and its origin. Moreover, with various expenses on the rise, such as high energy bills, consumers feel pressured to cut down on their food costs, often opting for the cheapest options, which are typically more unsustainable (Mersbergen, 2022). Powerful cooperates in the agricultural industry determine these cheap product prices, incentivizing farmers to intensify production and rely on bank loans and government subsidies. While farmers often face blame for their unsustainable production methods, it is society that possesses the capacity to catalyze transformative change by placing greater value on sustainable food production.

In the short term, raising awareness among citizens about the ecological and health benefits of locally grown food can help them make more conscious consumption decisions. Initially, this can be achieved by introducing locally grown food to the city and later by actively involving interested citizens in food production. Furthermore, empowering local and independent citizen collectives that support nature-inclusive farming initiatives can ensure fair pricing for nature-inclusive farming. In a collaborative effort, these collectives would join hands with farmers to navigate the transition towards nature-inclusive farming practices. By providing financial support, the collectives would assist farmers in making the necessary changes. As part of this cooperative endeavor, farmers would have the opportunity to become members and share in the benefits. The farmer cooperatives would handle their own financial affairs, significantly reducing the influence of large retailers. Conventional farmers would increasingly sell their products directly to consumers or local supermarkets, allowing them to demand a fairer price. However, it should be noted that this would result in significantly higher food prices for society at large (PBL, 2023).

Scientific Relevance

This thesis contributes to the body of knowledge of transitioning productive landscapes in peri-urban delta regions through adaptive design, specifically the Deltametropolis of the Netherlands. Most of the Deltametropolis' territory today can be classified as neither urban nor rural, as Wandl et al. (2014) call 'territories-in-between'. Today, the Deltametropolis can be viewed as an embodiment of the Horizontal Metropolis concept, as presented by Corte and Viganò (2022). However, there is still a lack of research by design regarding peri-urban development in the context of the current climate adaptation challenge for productive landscapes. Hence, the objective of this thesis is to demonstrate how an adaptive design can strengthen peri-urban spatial qualities in the Deltametropolis.

Research by design shows that the redevelopment of the water system is best approached on the regional scale of the water boards, particularly in the Lowlands due to its complexity of the polder-boezem system. As elaborated on page 70, this is attributed to the interconnectedness of the system and the imperative for integrating water management with a systemic understanding among relevant stakeholders. This thesis argues that there is a lack of sufficient research and design focused on the regional elaboration of the spatial redevelopment of the water system. Therefore, it emphasizes the need to prioritize such an approach when formulating a holistic strategy for transitioning productive landscapes.

Ruimtelijke Verkenning 2023

The spatial exploration of possible emergent land-uses builds upon aspects from numerous scenarios from de Ruimtelijke Verkenning by PBL (2023), which will outlined in the following section.

The adaptive design of the modified water management system enables a spectrum of land uses, ranging from *more-biophilic* to *more-technophilic*, roughly correlated with higher and lower water levels, respectively. These diverse land uses integrate resource productivity and nature development, with *more-biophilic* land uses prioritizing nature development and *more-technophilic* land uses prioritizing resource productivity.

Spatially, this correlation aligns with the distinction between the *Green Land* scenario and the *Regionally Rooted* scenario. In the Green Land scenario, there is a greater emphasis on *more-biophilic* landscapes, while the Regionally Rooted scenario places a greater emphasis on *more-technophilic* landscapes. Additionally, this distinction assumes different roles for centralized and decentralized governments. In the Green Land scenario, the central government asserts more capacity to implement more large-scale, regionally transcending biophilic landscapes through national policy. Conversely, in the Regionally Rooted scenario, decentralized governments collaborate with local stakeholders to implement more small-scale technophilic solutions. Nevertheless, both the Green Land and the Regionally Rooted scenarios offer a pathway to attain the European targets for nature development. Therefore, the adaptive design seeks to find a middle ground between the spatial and governance aspects of Green Land and Regionally Rooted. Governments would solely bare responsibility for altering the water infrastructure, while the resulting land use would be co-designed and co-developed by local citizen collectives together with decentralized governments. If the central government were to solely implement large-scale landscapes for the purpose of nature development and recreation, there would be a potential risk of creating a 'biophilic lock-in' in contrast to the current 'technophilic lock-in.' This could result in a natural landscape that would be challenging, costly, and subject to controversy when attempting to transform it back into more productive landscapes.

Although the resulting landscape may spatially resemble the traditional small-scale Dutch cultural landscape, this does not mean going back to the past. Indeed, technological elements from the scenario of Snelle Wereld (*Fast World*) is also considered and is best visible in the collages on pages 102, 119 and 140. Computerised sensors combined with precision drone mapping offer assistance to farmers by continuously monitoring soil moisture and mineral content. This data enables farmers to identify specific fields and plants that require attention (Steel, 2021). By embracing this *technophilic* development, humans and technology are not seen as mutually exclusive but instead strive for symbiosis, similar to how *biophilic* developments view humans and nature as non-mutually exclusive.

Recommendations for Further Research

The dimensions of the redeveloped water infrastructure in this thesis are based on assumptions regarding the requirement for fresh water to address environmental challenges. However, further calculations are necessary to adequately and realistically determine the dimensions of components such as tussenboezems, water reservoirs, and wetlands. These calculations should consider local and regional water demands, both presently and in the future, taking into account the uncertainties surrounding increasing drought severity, salinization, and subsidence.

Furthermore, it should be noted that the timescales of these environmental challenges are correlated but lack a causal relationship, and the urgency of climate change is escalating with uncertain magnitude. Consequently, determining the dimensions of this water infrastructure may prove challenging, requiring certain assumptions to be made. Naturally, this should take into account that more space for the water infrastructure means less space for local land use development and autonomy of citizens in developing their living environment.

Furthermore, for a planning strategy between decentralized governments and farmers, further research and design would be necessary. This might entail analyzing the spatial distribution of individual farms on a regional scale, looking at their size, their amount of export, or their (spatial) links to cities. This can help determine the initial level of involvement and collaboration with regional stakeholders. Furthermore, certain revenue models might be more suitable for farms with similar spatial conditions.

Finally, this thesis does not include research and design of revenue models incorporating highly technophilic solutions like underwater drainage and desalination methods, which support intensive production methods. This thesis argues that these approaches are not sustainable in the long term and hinder the necessary transition to extensive production methods. However, they may provide temporary benefits, allowing governments to build knowledge capacity and develop a comprehensive strategy while fostering trust with farmers and farmer cooperatives for harmonious implementation. Therefore, it would be interesting from a sociopolitical perspective to study the potential of these highly technophilic solutions.

Advantages and Limitations of the Methodology

The methodology is subdivided into primary and secondary methods, where the primary methods together seek to answer the research question. These primary methods are conducting a diachronic analysis, developing adaptive pathways and researching by design. The advantages and limitations of these methods as well as the overall methodology will be discussed.

Diachronic Analysis

To add to the comprehension of the Green Heart as a planning concept, it was necessary to conduct a diachronic analysis on the morphology of the region. This analysis led to a better understanding of the school of thought on the Horizontal Metropolis. This contemporary urban condition is most evident in the locations where the conceptual border between the Green Heart has been most shifted, resulting in an opaque imaginary border between urban and rural. In line with this, the Droogmakerij-cluster situated in the South Sing of the Randstad region was chosen as the primary research and design location. This region was subdivided into 'patches' (greenhouses, business parks, urban fabric, peat meadows, etc.), referencing to the Patchwork Metropolis (Neutelings et al., 1989). Through an examination of the discussions and interpretations surrounding the establishment of the Randstad and the Green Heart, a comprehensive understanding of the key drivers and core principles guiding their development was achieved. The proposed design is built upon various trends, drivers, and spatial configurations that have evolved over time. For example, in its pursuit of biophilic development, the design proposal distances itself from values that prioritize aggregate growth, as advocated in the Fourth Report of Spatial Planning. Furthermore, it promotes the concept of a Ruilverkaveling 2.0, which refers to the first ruilverkaveling prior to the conceptualization of the Green Heart. As a final example, it recognizes the well-established infrastructural network, and aims to enhance this by providing an additional slow-infrastructure expansions.

However, it is important to acknowledge the limitations encountered during the diachronic analysis. Given the extensive time period and geographic scope, there was a personal temptation to engage in extensive research. This reflects my inherent desire to acquire more insights, leading to a personal challenge in prioritizing the research within the context of the overall design project. Furthermore, the abundance of accumulated knowledge created difficulties in identifying the key drivers and relevant spatial transformations with regard to the thesis topic.

Additionally, it is important to recognize that the historical analysis resulted in a one-sided perspective, as it is impossible to capture every nuance. This limitation influenced the initial adoption of a dichotomous concept, namely the division between '*biophilic*' and '*biophobic*', which was later revised to '*technophilic*'. Just as the dichotomy of purely urban and rural spaces does not fully align with the urban configuration of the Deltametropolis, the dichotomy of biophilic and technophilic perspectives does not encompass the attitude of the Dutch population towards their living environment, in the past, today and in the future.

Adaptive Pathways

The Adaptive Pathways framework, developed by Deltares (2016), involves defining a specific desired end-state, and then working backwards to identify multiple possible development pathways to achieve that goal. The pathways are measured against changing conditions, such as levels of subsidence or drought, of which the exact years are unknown. Considering the objective, it may be necessary over time to switch between pathways in order to prevent a lock-in: the consequences would be severe, or it would become very expensive to move to a different pathway later in time.

However, in the problem statement addressed in this thesis, the complexity and multitude of external drivers are amplified due to the objective of identifying synergies between land uses that are associated with correlated but not causally linked environmental issues. Consequently, the timing of critical tipping points may vary depending on the specific soil types and their respective land uses.

For instance, intensive dairy farming practiced on peat soils is connected to issues of subsidence and rising sea levels, while conventional arable farming in reclaimed land areas (droogmakerijen) is related to concerns such as seepage or the availability of freshwater. To address these diverse scenarios of external drivers, one approach could involve developing adaptive pathway frameworks that account for each possible combination of these scenarios.
For example, examining the interplay between a high subsidence scenario, low sea level rise, and seepage, or a low subsidence scenario, moderate sea level rise, and seepage. Furthermore, the resulting pathway framework would still be anchored in an initially specified end-state, which is determined by the chosen values during the framework's development process. Within the context of this thesis, the overarching aim is to prioritize spatial development guided by the soil and water system. This aligns with the objective of integrating urban and rural spatial qualities by harmonizing biophilic and technophilic values.
Despite these limitations, the adoption of the Adaptive Pathway approach has facilitated the prioritization of design implementations that are crucial for the emergence of distinct land uses.

Research by Design

Research by design has been conducted for the productive patches with monofunctional uses to provide a morphological framework for new uses and urban activities to develop. This involved studying historical maps, analysing multifaceted data, and conducting thorough design-oriented investigations to understand the unique character of the location. Posing "what-if" questions generated design-based insights or arguments by examining potential spatial alterations and how they interplay with the existing context. This has been an iterative process of both research and design, which ultimately lead to insights for both components.

The designs in this thesis look at one patch of approximately 5x5 km for the different productive landscapes. In practice, it would be more precise to look at the larger region in which this patch is embedded. Adopting an integrated and holistic research and design approach is imperative when implementing landscape interventions at such a large scale.

As stated before, further research should facilitate a more accurate quantification of factors like the buffer capacity of the added surface water, or the production of energy and food. This would allow for the development of a phased plan that strategically establishes linkages between metabolic flows within and between patches at the appropriate moments, resulting in a more realistic and efficient planning strategy.

Transferability of Project Results

The recommendations for the transferability of the project results depend on the geographical, ecological, economic and sociocultural specificities of the region of research and design, both historically and in the present day. The case-study locations consist of three peri-urban productive 'patches' within the water board of Schieland en de Krimpenerwaard located in the Deltametropolis region.

These areas have undergone significant suburbanization in recent decades, leading to the emergence of monofunctional land use patches and extensive infrastructure.
The geographical context of these locations includes droogmakerijen- and peat polders, which are situated, on average, at depths of -6.00 and -2.50 meters below sea level, respectively.
The drainage of these polders has served urbanization and the globalized intensive agricultural industries, exacerbating local environmental externalities. These externalities are further amplified by the global trends of globalization and climate change. The conflicting top-down spatial planning policies, primarily based on the urban-rural dichotomy, aimed to address these environmental externalities. In spatial terms, this conflict is evident in the trade-off between agricultural productivity and nature development.

In light of this context, this thesis explores a strategy employing the Water Trinity (Commissie Waterbeheer, 2000) that aims to improve water management and soil health through structural choices. This strategy primarily focuses on enhancing water retention capacity and management, with the ultimate goal of establishing a flexible and resilient water system capable of adapting to changing circumstances and extreme events.

While the redevelopment of the water system should be approached on a national scale, it is important to consider transferability by distinguishing between 'Laag Nederland' and 'Hoog Nederland,' which respectively refer to land in the Netherlands below or above water level.

Regarding the redesign of the water system within the design region of this thesis, the main conclusion suggests a holistic approach at the scale of the waterboard of Schieland en de Krimpenerwaard, as opposed to incremental modifications at the polder level (as discussed on page 70). This recommendation arises from the complexity of the water system, which is further influenced by the diverse goals of various stakeholders. Addressing challenges which particularly affect the droogmakerijen and peat polders in the Lowlands, necessitates an integrative and holistic approach, distinct from the Highlands. As discussed in the *Scientific Relevance* section, additional calculations are required to accurately and realistically determine the dimensions of water system components. These calculations should be conducted comprehensively, not only at the scale of individual water boards but potentially on a national level. Subsequently, each water board can implement the appropriate water retention and storage measures based on their specific local requirements.

In terms of spatial planning and policy, spatial development in the Lowlands necessitates a closer and more holistic collaboration between the aforementioned stakeholders on the short term, which might accelerate the agricultural transition as opposed to the Highlands.

This thesis argues that a combination of *more-biophilic* and *more-technophilic* landscapes is essential for achieving holistic and sustainable metropolitan development. However, it suggests that in peri-urban areas in the Deltametropolis, *more-technophilic* landscapes (productive, small-scale) would better foster urban-rural relations compared to *more-biophilic* landscapes (unproductive, large-scale). This is attributed to the increased local circulation of resources, catering to higher population density, and enhanced accessibility for slow infrastructure.

Nevertheless, considering the current state of urbanization within the Deltametropolis, where urban and rural patches are in close proximity, particularly in the design region of the South Wing, an alternative conclusion may be drawn where peri-urban areas are less concentrated. In regions where the mosaic of urban and rural patches is less dense, such as outside the Deltametropolis, a greater spatial variety in the landscape and a larger grain of urban or rural patches may be observed. This may provide more opportunities for productive landscapes to continue serving the international market, while productive landscapes within the Deltametropolis may primarily cater to the local or regional market. Ultimately, this emphasizes the significance of decentralizing spatial planning to consider the varying conditions of urbanization, energy-, water- and food-systems across different parts of the country.

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