regenerative productive landscapes

A proposal to deal with climate change in the deltaic territory of South Holland

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Regenerative Productive landscapes:

A proposal to deal with climate change in the deltaic territory of South Holland

Student:
Arianna Finatti

Supervisors:
Prof. Michele CERRUTI BUT (Politecnico di Torino)
Prof. Angelo SAMPIERI (Politecnico di Torino)

Prof. Luca IUORIO (Technical University of Delft)*

* The research and development of the thesis took advantage of a research period as a visiting student at TU Delft Department of Urbanism.

Abstract

The thesis aims to explore how productive landscapes can address the environmental challenges of climate change and, in particular, what role spatial design can play in this process. The case observed by this study is more specifically the Delta area of South Holland, where port, horticultural and agricultural activities make the province one of the most economically prosperous in the European context.
For centuries, the area has been subject to a process of 'anthropisation' of the landscape: a continuous transformation of the land to make it habitable by humans, in a way that was able to accommodate the productive activities necessary for their subsistence, until it evolved today into an entirely productive space. This trend is in stark contrast to the vulnerability of this basin, which has been exposed in particular during catastrophic climatic events and is currently at the centre of the debate on the different ways of dealing with climate change.
The hypothesis of this work is that the policies for adapting European productive landscapes to the current and future effects of climate change must fit a spatial specificity, both in terms of given conditions and expected outcomes. This is based on at least two main assumptions: first, European productive landscapes have developed through an efficiency-based functionalist approach that has made such space a "production machine." Second, the sustainability paradigm is not based on a form of adaptation that halts the productivity of an area, but on the project of a renewed prosperity.
According to such hypothesis, the first part explores the case study on a large scale, using the Inquiry Lines Methodology inherited from the Delft University Department of Urbanism. The reading of the productive landscape highlights a sort of contextual and singular “malleability” of each typology, in which water infrastructure, soil type, climatic risks and type of production are inevitably interrelated.
The second part reflects instead on possible adaptation strategies for these territories and develops specific projects grounded in the current policies and future scenarios that aim at challenging their risks and limits by evolving a peculiar for of adaptation: regenerative design.
The main features of such a proposal for the productive landscapes are at least three: (1) given that it is based on the diverse malleability of the territory, regenerative design should operate differently in different contexts; (2) since those landscapes are a physical place that hosts both human and natural agents, it should improve the quality of the habitat in which they are located through urgent ecosystemic interrelation strategies; (3) while moving from a better integration of currently degraded ecosystem services, it reframes an urgent near-in-time adaptation as a model of spatial transformation that can also be implemented incrementally right away.

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A peculiar research experience between Politecnico di Torino and Technical University of Delft

The thesis field of action places itself in the area of intervention of urbanism, and the work was supported by the great opportunity given by Politecnico di Torino to dive into the research in the chosen topic in the context of the Department of Urbanism at the Faculty of Architecture and Built Environment at the Delft University of Technology.

During the time dedicated to the thesis I had the opportunity to develop my research not only as a 'thesis abroad' nut as a formal Visiting Student in Delft University, under the guidance of prof. Luca Iuorio. During the three months of my permanence in Delft I had the chance to follow collective seminares and courses from the Master in Urbanism, and to confront my research with a number of international professors and students. This chance had a particular value because the objectives, interests and approach which guided the shaping of the design were nicely aligned, as well as fruitfully aided by the so called 'Delft Approach'. [1]
Coming back to Torino gave me the opportunity to reframe such approach and methodology into a critical perspective, and develop a personal work.

The Delft Approach in brief

The Delft Approach to Urbanism lies upon some principles that have consolidated thanks to a strong traditin in this education field.
For instance, urban landscape is seen as a multiscae interdisciplinary research object: as it is a complex open system in constant change, the fruitful way to deal with it foresees the need to move between different interrelated scales in time and space, and most of the time with a step-by-step necessary reframing.
In fact, gaining new theoretical understanding while developing solutions to certain problems, may lead to the reformulation of the same problems thanks to newly gained knowledge, or also because of the need to deal with unpredictability.

In this context, the various relations between research and design are highly valued and explored, as the dynamic nature of urban landscapes calls for understanding and generating design proposals to go side-by-side: there is a co-evolution in the process of research and design, sustained by the deployment of different design means. the display of the interrelation between different scales.
Maps, drawings and sketches are a fundamental support to words and text not only to produce knowledge, but also as a design medium themselves. Such an approach has been developed at TU Delt for addressing the social, cultural, environmental and technological issues affecting the urban landscape from a spatial planning and design perspective, and the focus of its teaching is on specific contextual design tasks where expertise from diverse disciplines is integrated into sound multi-scale proposals.

In the context of the typical Dutch geography, which is characterised by a large amount of man-made land below sea level, the idea of urban landscape has been conceptualised as a multi-scale phenomenon in which buildings, cities and landscapes are intrinsically linked, and has been addressed through an approach in which urban planning, urban design and landscape architecture, as well as civil engineering and landscape ecology, have been strongly intertwined.

The specificity of the Delta Urbanism research program

The area of interest for this thesis work is well located not only in the general TU Urbanism context, but even better in the academic background of the Delta Urbanism, seen the strong motivation to deal with climate change.

Delta Urbanism is an interdisciplinary research programme at the Delft University of Technology that explores the potential of linking flood protection, soil and water management strategies with urban design, landscape design and spatial planning to deliver improved spatial forms and structures
and innovative urban systems in urban and metropolitan delta regions. Based on an interdisciplinary approach in which design and engineering disciplines activate innovation in design, technology and governance, the aim is to have an international impact as a specific interdisciplinary field of work.

The dynamic nature of urban development, especially in delta regions, often leads to complex and fragmented urban patterns, combined with increased risk of flooding, soil depletion, erosion and ecosystem degradation.

1. Nijhuis, S., Stolk, E., Hoekstra, M. (2016), *Teaching urbanism: the Delft approach*

In order to mitigate soil erosion and risks of flooding, while improving spatial coherence and ecological quality, Delta Design deals with a possible way of (re)organising the transitional space between land and water.

This thesis attempt to place itself in this context trying to turn the desolation feelings which may come when dealing with climate change in a proactive design, albeit aware of the limitations which can occur from the context and for the time availability.
Channeled by the fascination of the water element and the will to operate in a coastal area, the choice of working in the deltaic area of South Holland came almost obvious, motivated at the same time by the interest to dig into other phenomena central in our current times, such as urbanisation and the transition to a more sustainable large scale production of goods.

Is Urban Design specific? Research question and methodology

Our Earth climate is irrevocably changing and this alterations in temperature and weather patterns, which have been resulting in high impact environmental challenges and climatic adverse events, are caused by human action, which over the last century and half overexploited the world's resources with the emission of massive quantities of greenhouse gases, resulting in the so called 'greenhouse effect'.

Climate change is more and more evident in our present.
World and punctual or extended events such as drought, sea level rise, fluvial or pluvial flooding, and desertification represent clear and heart-breaking manifestations, both for the degradation of our common Earth and for the damage to human life.

Here our interest lies not only in understanding the dynamics leading to these adverse events, but even more in investigating which are the spatial consequences of climate change and how urban design can tackle them, so that the approach to this action can be developed in a scientific way based on theoretical founding and design interdisciplinary moves.

This work aims at exploring how urban design can address the environmental challenges of climate change through spatial devices, in the specific conditions of the productive landscapes.

Productive landscapes are here seen as spatially defined areas where a certain type of production is predominant, being of energy, food or other commodities. The resources may come from the land itself or from other means, nevertheless their production characterise very well the spatial layout of the territory, which presents other land uses besides the productive ones, but whose infrastructures of transport, built fabric and natural environment have been shaped by the dynamics of these productive activities.
It could be argued that the use of the word *landscape* is improper, because we should instead refer to a broader definitionof territory.[2]
Nevertheless, the intentional use of the word *landscape* refers from one side to the very materiality of soils and froms, from trh other side to the specific Landscape Urbanism approach adopted in TU Delft.

There are countless ways to tackle climate change through design, and they all vary depending on their scale application, effectiveness, time resolution on application and outcomes, but they can generally be placed under the division in mitigation or adaptation actions.

Mitigation involves the reduction of the impact of climate change through the prevention or limitation of greenhouse gas (GHG) emissions into the atmosphere. It is achieved either by reducing the sources of these gases, such as the burning of fossil fuels for electricity, transport or heat, or by increasing their storage thanks to the sinks that store these gases, like CO_2 removal technologies or forests, oceans and soil.

2. Bianchetti, C., Cerruti But, M. (2016), *Territory matters. Production and space in Europe.*

The literature about Productive territories and landscapes incresed globally in the last seven years. Together with this I think it could be useful to also mention:
Bianchetti C. (2019, ed.). Territorio e Produzione. Macerata: Quodlibet;
Rappaport N. (2015). Vertical Urban Factory. New York: Actar Publishers;
Rappaport N (2023). Hybrid factories, hybrid cities. New York: Actar Publishers;
Yim D., Luna R. (2021, eds.), Production Urbanism: The Meta Industrial City. Architectural Design Primer;
Hatuka T., Ben-Joseph E. (2022), New Industrial Urbanism: Designing Places for Production. NY, Taylor & Francis;
Nawratek K (2017, ed.), Urban Re-industrialization. Punctum;
Lane RN, Rappaport N (2019), The Design of Urban Manufacturing, London, Routledge;
Hosoya H, Schaefer M (2021, eds.), The Industrious City. Urban Industry in the Digital Age, Wien, Lars Muller;
Together with this researches and book, production and space has also been at the center of a number of European programs and startegies and local/international initiatives or exhibitions such as IABR, Bruxelles Metrolab and others.

Adaptation, on the other side, foresees the anticipation of the negative impacts of climate change and the implementation of appropriate measures to prevent or minimise the damage that may be caused by climate change, or to take advantage of the related opportunities that may emerge. Examples of adaptation measures include large-scale infrastructure changes, as well as behavioural changes.
The thesis intends to investigate on the role of spatial design for adapting productive landscapes to climate change.
The hypothesis suggests that policies aimed at adapting European productive landcapes to the present and future effects of climat change should be tailored to a spatial specificity, both as regars the given conditions adn the expected outcomes.
Productive landscapes have been developed through an efficiency-based functionalist approach that has turned such space into a 'production machine', affecting the quality of the landscape as a whole. In this context, the sustainability paradigm is not built on a form of adaptation that halts the productivity of an area, but on a project of renewed prosperity.
The case observed by this study is more specifically the Deltaic territory of the Dutch province of South Holland, where port, horticultural and agricultural activities make the area one of the most economically prosperous in the European context.

Going back to the framework of the Dutch approach to climate adaptation, it is important to consider the current state of the art, which influenced the modus operandi chosen for the design phase (and will be further discussed later on).
In fact, given the strong tradition of the country with land reclamation, water infrastructure and flooding barriers, an endless source of literature is available, as not only physical solutions to climate change effects are constantly elaborated and physically updated, but also climate scenarios and adaptation plans applied to the country level are developed by national institutions, such as Deltares.

According to such hypothesis and framework, the first part of the thesis explores the case study on a large scale, using the Methodology of the Lines of Enquiry inherited from the Delft University Department of Urbanism. The reading of the productive landscape highlights a certain contextual and singular "malleability" of each typology, in which water infrastructure, soil type, climatic risks and type of production are inevitably interrelated.
The second part, on the other hand, reflects instead on possible adaptation strategies for these territories and develops specific projects grounded in the current policies and future scenarios that aim at challenging their risks and limits by evolving a peculiar for of adaptation: regenerative design.

Critical cartographies

As a consistent part of the thesis research was conducted at the Urbanism Master track of the Technical University of Delft, the opportunity to join the Graduation Studio Transitional Territories during the investigation process in The Netherlands turned out to be a great stimulus for the whole process.

'Transitional Territories has a strong situated approach to design, sensitive to the site (matter), cultures of inhabitation (topos), environment (habitat) and processes (geopolitics). Our design task addresses urbanisation as mutually founded by and a trigger of risk, criticality and emergence.' [3]

The studio explores acts of de- and re-construction of physical, ecological and political relationships within hydrological basins and marine spaces. The guiding hypothesis is that territory is a collaborative project - regardless of scale - in which the urban builds itself in conversation with nature. The projects focus on designing alternative forms of coexistence and care in highly dynamic geographies characterised by fragility, criticality and risk. The thesis topic therefore dovetails well with the studio cycle 'Inland, Seaward' on de and re-territorialisation of places, structures and cultures between land and sea, meaning the palimpsest of inhabitation, production and infrastructure projected on land, river and ocean grounds, while dealing with the actual urgencies linked to climate change impacts.

During the essential part of the research, the development of critical cartographies turned out to be a key tool for the investigation. This act of mapping and thus organising logically the quest process, together with other graphical information, and helped by a widely gained theoretical knowledge, is not aimed at only reproducing what is already known.

'*As a creative practice, mapping precipitates its most productive effects through a finding that is also a founding*'. [4]
Therefore, the aim of this operation was to reflect on the actual conditions trying to unfold the potentials and lacks that the territorial project may reveal for its future (re)imagining.
In this process, the first questions were what to represent and how to reveal it.

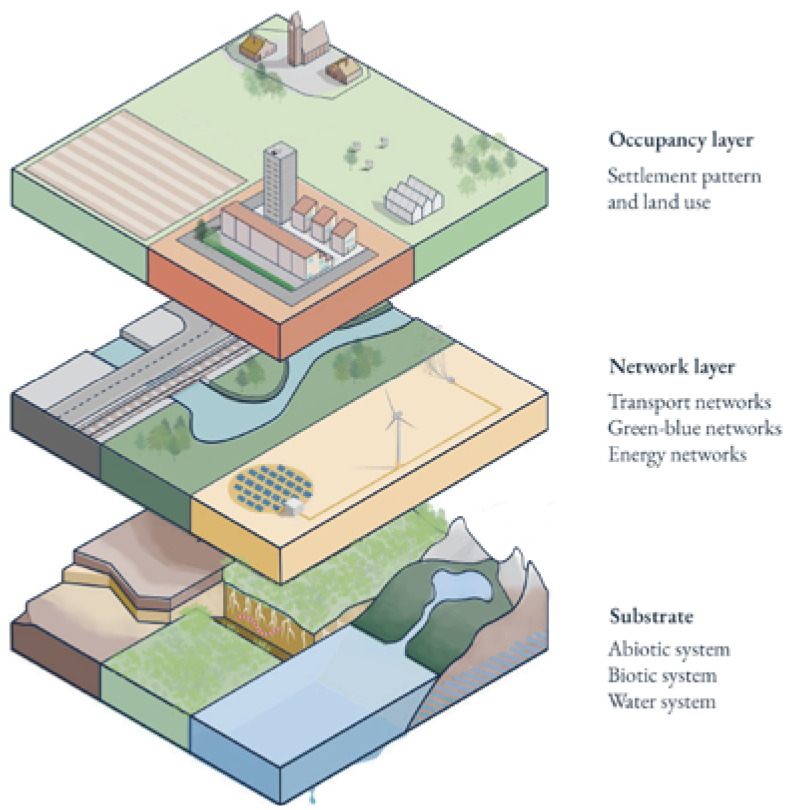
As the purpose of this work is confronting with the reality, some layers of representation and reflexion have been outlined to break down the issue in different 'reading levels'. The Dutch tradition on urban planning provides an endless, sometimes even overwhelming, source of information, and a strong theoretical background, which helped in defining those elements

3. From *Graduation studio transitional Territories,* in *Urban Design TU Delft* website

4.Corner, J,. *The Agency of Mapping: Speculation, Critique and Invention*

functional for the narrative of the research by design. Talking about layers, despite the elected methodology does not follow this approach, we cannot avoid mentioning the Dutch layers approach. This was not integrated as an analysis tool, but its knowledge was fundamental for the geographical context we are located in.
The model was developed between 1996 and 1998 by De Hoog, Sijmons, and Verschuuren, serving as the foundation for the Dutch layers approach environment as part of the research project Het Metropolitane Debat (the metropolitan debate). These planners were asked to establish a foundation for the strategic decisions that would need to be made regarding the future spatial development of the Netherlands in the context of climate change, water management, the economic standing of the country in international networks, urban dynamics in relation to the values and attractiveness of the landscape, and the necessity of comprehensive planning approach.

'... to distinguish three 'layers' in the spatial organisation of the Laagland: the layer of the substratum, the layer of the networks and the layer of the occupation pattern. These layers know different 'times'. ...To these three layers we add the element of coherence. We consider this coherence between the layers as the domain of spatial planning: here we shoot an arrow through the strongly sectorial-coloured problem definition on the distinguished layers.' [5]



5.De Hoog, Sijmons, and Verschuuren, 1998, *Laagland*

Image:
Fig.1 diagram edited by the author from Rijksplanologische Dienst, (2001)

fig2. van Schaick, Jeroen & Klaasen, Ina. (2011) *The Dutch Layers Approach to Spatial Planning and Design: A Fruitful Planning Tool or a Temporary Phenomenon?.* European Planning Studies. 19. 1775-1796.

This model, as some of the authors stated, was elaborated with the purpose of providing a tool for the 'political-administrative management of the 'spatial business'.
The layers approach is an example of how traditional urban and regional planning and design approaches the integration of time aspects into spatial planning practices, i.e. focusing on changes in the physical environment, processes with a large temporal resolution compared to human life span. The link between 'time' and 'space' in this way was one of the foundations of the original 1998 model, which was based on the differences in the rate of transformation of the layers and what this meant for the prioritisation of some planning and design agendas over others (see fig. 2).
In this original model, temporal levels of scale were also related to appropriate spatial levels of scale, and thus to coherent governmental levels. During the years, many adjustments and variations have been elaborated from the original model, as well as some criticism to the ideas and theories behind it. One of the main points against this approach was that, although cartographic and stylistic advantages can be discovered, especially in the planning process, there is no direct correlation between the layer on which the development takes place and its urgency when it comes to the formulation of policies.

All in all, the knowledge of this important moment of the Dutch planning history was not directly functional to the framing of a methodology behind the critical cartographies, but some concepts that carries with it where profitable, such as the 'breaking down' of a complex matter in 'reading levels', and the fact of having the substratum as a starting point for the investigation process, meaning considering the importance of soil and water questions as central.

	Design and planning tasks	Approaches	Time dynamics
Layer 1 Substratum	- Dealing with the physical effects of climate change - Modernising the water management system	- Nature engineering - Civil engineering	100 - 500 years
Layer 2 Networks	- Strengthening the position of the Netherlands in international networks - Control and steer the growth of mobility	- Complexes approach (developing nodes for exchange of information and knowledge) - Corridor approach (developing mainports and hinterland connections)	50 -100 years
Layer 3 Occupation	- Accommodating spatial claims and shrinkage in relation to values and attractivity	- 'Écology'-approach (An ecology defined as a locally characteristic 'life-style-environment') - Mold-Contramold approach (city vs. landscape)	25- 50 years

Lines of Enquiry

Therefore, instead of using those layers for our narrative, the preferred option was to take a step backward and look at the area with alternative peculiar lenses, being inspired by the research developed by the Transitional Territories graduation studio. This section will be organised into three lines of inquiry, Matter, Topos and Habitat.

The considerations under the idea of ***Matter*** refer to its physical meaning of substance, referring to the specific site where the area is located. For centuries, humankind's relationship to the natural world has been one of mastery and control with resources being extracted, processed, transported, distributed, and finally irreversibly consumed. This process has had drastic and far-reaching consequences, with traces left in many ecosystems and landscapes forever altered. From the depths of the subsurface to the heights of the atmosphere, the effects of human actions on matter are undeniable and continue to shape the environment. Water, Soil and Air are the clearest example of elements of matter where these processes have left their profound marks.

Topos, from the Greek place, topological space, a site - a category with finite limits, is the baseline for the establishment of human habitats, the common ground for our existence. Human beings are constantly operating on the landscape to create ways of inhabiting the local natural conditions, in a process that always leaves its own traces behind. As a result, the landscape is continually modified and exploited to meet human needs, and its relationship with anthropocentric needs has shifted towards the accumulation of resources, stripping away the topos layer by layer until nothing 'useful' is left.

What transforms the Topos into a ***Habitat*** is the life that it sustains. Yet what is conceived of as habitat is deeply embedded in the current paradigm of the modern that operationalizes natural systems and commodifies them to serve the global needs of geopolitics. As populations grow fast along with the claims on resources, the coexistence of humans and natural systems is being deeply upset, if not brutally disrupted.
Territories are valued according to what they produce, disregarding the negative externalities they generate. Urban, peri-urban and rural landscapes are equated with industrial zones, economic units and production sites, revealing that they are defined by the way humanity appropriates them. Landscape transformations and territorial claims have a direct impact on everyday human relations, creating conflicts and frictions.

The fouth line on enquiry adoped by Transitional Territories is ***Geopolitics***. Literally meaning- "the politics of earth systems" - these refer to the socio-economic arrangements linked to geographical space, where politics made by humans territorialise and regulate every human and non-human existence. There is an endless series of negotiations and disputes that arrange particular species, patches of forest and geological formations that shape physical territory.
In the Anthropocene, humans have irreversibly become the mediators of such arrangements, dictating the boundaries, limits and territorial dynamics over the landscape, often subjugating non-human entities to their desires, and the exploitation of nature is most often even legitimated by narratives of geopolitics.
Nevertheless, for this thesis we agreed on not to adopt the fourth line of enquiry.

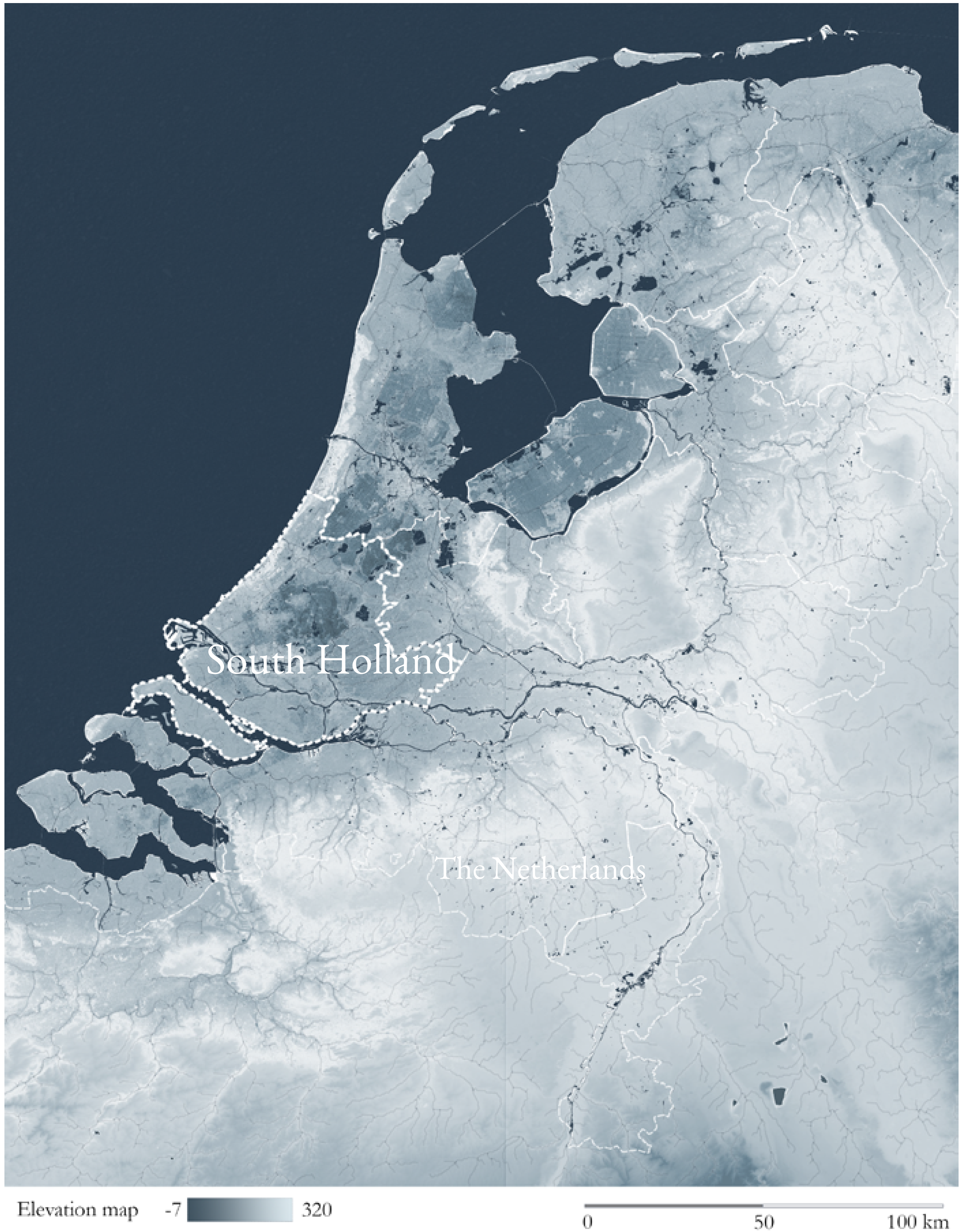
Therefore, these elements have been used as a tool to gain a knowledge of the territory with the 'reading key' of the thesis topic, and the choice of which spatial feature to fall under a certain cathegory was essential to spatialised the recognised issues in a critical territorial framework.

The context: South Holland Productive Landscapes

South Holland is one of the most populous and industrialised provinces in the Netherlands.

It is located largely in the coastal territory of the country, precisely in the marshy areas that hundreds of years ago, being frequently overflowed by the sea water, saw the realisation of a long process of land reclamation, with the aim of being transformed into agricultural land.

In this process, one can see precisely a desire to oppose the geomorphological conditions of the coastal zone, in order to create, driven by human needs, new territories that can sustain their own subsistence, not only in terms of a location for their own livelihood, but precisely in terms of productive activities



land reclamation was possible precisely by reclaiming water from the marshy areas through the construction of barriers to protect them from the sea: a system of hundreds of thousands of kilometres of dykes was built for this purpose.

The map shows the geographical area of the Netherlands and the region of South Holland. In this representation, the water system is displayed together with the topographical levels of the country, and it is evident how much of the coastal areas are at a very low elevation, often below sea level: in fact, between 30 and 60 per cent of the Dutch territory lies under sea level.

Therefore, due to the coastal configuration of the country, the presence of the deltas of three major European rivers (Rhine, Meuse and Scheldt) and the partially subterranean location, the Netherlands has a long tradition of strategies for dealing with extreme climate events, such as flooding due to heavy rainfall, which in recent decades has been compounded by the problem of rising sea levels, which brings with it other environmental challenges.

Therefore, dealing with climate adverse events and working to prevent them led the country to grow a strong expertise, in a way that, the knowledge and means available to face a 'worst-case scenario' are constantly evolved, implemented and well managed. On the other hand, uncertainty is still dominant, as the scenarios that are currently updated by international organisations about temperature changes and sea level rise still have to deal with a certain degree of unpredictability.

South Holland is no exception when considering the vulnerability to climate change scenarios. Its particular delta configuration is very susceptible to flooding, and for this reason, a system of protection had been built, consisting of dunes, levees and dams and protective hydraulic structures, such as locks and storm surge barriers. Furthermore, for its proximity to the coast, it is highly affected by the phenomenon of salinization, and due to its particular spatial territorial system, the polders landscape, the result of the centuries-old process of land reclamation, the course of soil subsidence has a strong impact on the territory.

Map A. Made by the author with GIS data from the AHN3 Actueel Hoogtebestand Nederland) website

Despite all the aforementioned environmental challenges and the threats they can represent, South Holland is still considered as a very desirable area to live in. It is the densest region in Europe, and in the last years it has seen a even increasing number of population (with consequent problems of housing shortage) due to the opportunities it can offers, mostly related to the quality of life and job opportunities.
Being the Netherlands a very economically driven country, production of wealth and goods is central, and looking at the delta area of South Holland, many production sites are located, and it is possible to recognise several large clusters, all well spatially defined, industrialised and developed. Beside agriculture and livestock, the main productive activities are in the area of the Port of Rotterdam and in the Westlands Horticulture Hub.
Nevertheless, this flourishing economy comes with a price. The Netherlands are one of the European countries with the highest rate of emission per capita, with the highest share coming from manufacturing, but having higher impacts also in the sectors of electricity, transport and agriculture.
Following European standards and the aim to develop advanced strategies for a sustainable transition, the country undertook the path to decarbonisation: the Dutch Climate Act of 2019 currently prescribes an 80 to 95% reduction of greenhouses in 2050, compared to 1990.

The strong tradition of economic prosperity led to the development of large areas dedicated to production, to the extent that the territory of the province can be seen as a patchwork of different productive landscapes, with little space left for the quality of the landscape as a whole, perceived more as a habitat than as a productive area, relegating nature to marginal areas.
As the tradition of land reclamation shows, the economic drive led the country towards a anthropisation of the landscape, which saw land primarily as a source of production.
However, while this mindset has been fundamental to the economic prosperity that has characterised the province and the country in general, it has also resulted in an impoverishment of the quality of the territory as perceived by those who inhabit it and, in particular, of the ecosystem services that it can provide, some of which have been degraded by the productive landscapes themselves.
Given the geographical context in which the deltaic territory is located and its vulnerability to climate change, this work therefore aims to address the need for these territories to adapt to climate change as an opportunity to restore these degraded ecosystem services.

Map B. Made by the author with GIS data from the PDOK website

PART 1.1

Lines of enquiry

A Matter of Soil

Types of soils and carbon stocks
Soil subsidence

Topos: the control over water

Spatial layout of water control
Risk and Probability of flooding
Salinisation

Habitat: Landscapes of Production

Petroleumscape
Glasscape
Farmscape

A matter of soil

'Currently, the relationship between humans and matter is one of control and operationalisation. This is reflected in interventions that aim to fixate river dynamics, optimise soil for agriculture by means of fertilisers, and harvest energy by placing hydro-electric dams along rivers. The human occupation of land, sea and air is increasing to enable the extraction of matter on a monumental scale. On land, processes of deforestation have a direct effect on both water and air systems, causing the reduction of water discharge upstream and CO_2 uptake. At sea, increasing air temperatures cause sea ice to regress, allowing the expansion of oil extraction. Traces of the present and historic occupation can be found in the remnants of anthropogenic material, such as particulate matter concentrations in the air or pesticides and debris accumulated in the sediments.

In other areas that enforce less control, the natural dynamics of matter threaten human living, as is the case in some northern coastal areas, where rising air temperatures cause soil frost to decrease, leaving the land exposed to water fluctuation and severe erosion.

In addition to natural and anthropogenic influences, the pressure of climate change works as a catalyst, magnifying existing issues to the point of extreme unbalance. It is the accumulation of these three pressures that now cause matter to change beyond our capacity of control, resulting in a new, hybrid matter, which has different properties, dynamics and states. For example, eutrophication (changing properties), artificial coastlines (change of dynamics) and regressing sea ice (change of state). With anthropogenic matter as a contextual basis, the urban project has to be considered both an appropriation and commodification, that carefully designs its impact on matter – as an interplay between control and release.' [6]

6. from https://tp2021.transitionaterritories.org/text

'There is a lack of awareness of how soil can influence the way we conceive and realise our built environment.' [7]

Starting from this element came almost as a natural choice in a country like The Netherlands, where soil is the matter where centuries of land reclamation took place.
In addition to this, the beginning of this research is moved by the intention of considering our common soil as a driving element in planning decisions.

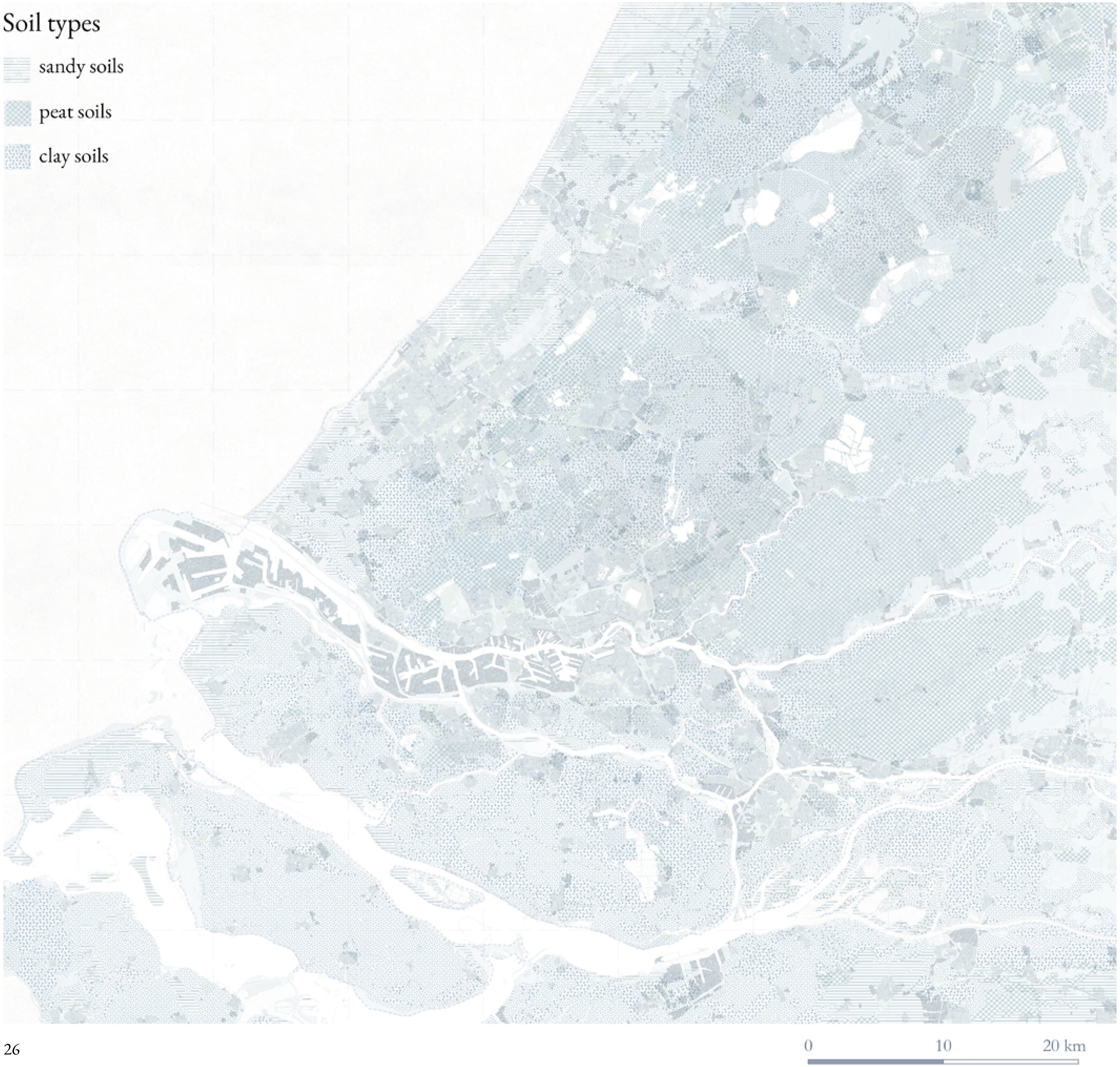
In the specific context of the thesis soil plays a fundamental role, as it will be further explained, but this move of starting the narration of the investigation particularly from this element starts from the recognition of its importance both in general terms in spatial design, and in the discourse about how to deal with climate change.
Therefore, the intention could be summarized by the motivation to consider the soil 'as a space that embraces contingency where (it) interacts and enters into dialogue with a changing climatic environment', but also a place 'for cooperation, where material, ecological and cultural practices intertwine'.[8]

The role of soil goes far beyond its bearing capacity as the material that sustain buildings and infrastructures.
In fact, as integral components of terrestrial ecosystems, serve a multitude of vital functions.[9] These encompass supporting plant growth by acting as reservoirs of nutrients and water while providing structural support for roots. Soils also play a crucial role in maintaining biodiversity by offering habitats for various species and preserving genetic diversity.
Furthermore, soils are involved in the filtration and transformation of substances such as water, which affects drainage and water management , but also carbon, nutrients, and contaminants, in addition to storing these substances, particularly carbon and nutrients. They act as sources of raw materials and provide physical and cultural support for human activities, encompassing habitat creation, transportation, landscape formation, and waste disposal, as well as the conveyance of energy and water.
These soil functions arise from complex interactions between biotic and abiotic components, leading to various products and services that contribute a wide range of factors, from human well-being, including aspects related to health and safety, too environmental conditions: all these refer to the variety of ecosystem services provided by this element of vital importance.

7. Secchi, B., (1980), Progetto di Suolo, in Abitare

8. Kuzniecow Bacchin, T., Recubenis Sanchis, I., (2022) *Soil, Planning and Climatic Crisis in the Dutch Upper Delta*, in *OASE 110 / The project of the Soil*. OASE Foundation & NAi Publishers, Rotterdam, 167-175T

9. Arwyn Jones (European Commission JRC), (2010), *The European Environment, State and outlook 2010,* Luxembourg: Publications Office of the European Union



Types of soil

Soil is a dynamic ecosystem consisting of organic matter, water, gases, minerals, nutrients and living organisms. The most common types of soil in Zuid-Holland are peat, river clay, sea clay and sand, which differ in their composition and the amount of organic and inorganic matter they contain.

Peat soils are the most fertile, as they are made up of plant remains and formed in a bog. Sea clay contains less organic matter than river clay, but is generally suitable for arable farming, whereas the peat soils of South Holland are not used for this purpose because they are too wet.

Starting from the western coastline adjacent to the North Sea, the first part of soil is linked to the presence of coastal dunes. These dunes, comprised of sands with a marine origin, have been deposited by onshore winds. While relatively narrow in width, their role in sea defense is of paramount importance. They not only serve as a safeguard against coastal flooding but also act as a protective barrier demarcating the saltwater domain of the North Sea from the freshwater reserves found inland.

Continuing eastward from the coastal dunes, there is an area characterized by surface marine clays, then, moving further inland, we encounter what was once a coastal swamp region, with peat soil. Over the centuries, extensive excavation of peat deposits has significantly reduced the prevalence of peat in this area.
Consequently, what often remains visible at the surface is the marine clay that originally underlay the peat formations.

Map C. Made by the author with GIS data from the National Georegister

Soil and carbon stocks

Good quality and living soil has positive effects on water management, food production and biodiversity, and for this reason it is important to preserve it reducing erosion risk, improving its capacity to infiltrate the water and ensuring a proper nutrient cycle.

Soil organic matter (SOM) is an essential component of soil, impacting its physical, chemical and biological characteristics and thus playing a major role in the proper functioning of soil . The benefits of soil organic matter include the improvement of soil quality through higher water and nutrient retention, leading to increased plant productivity in both natural and agricultural environments. SOM also contributes to better soil structure and reduced erosion, resulting in improved water quality in both ground and surface water, and hence in greater food security and reduced impacts on ecosystems.

Beside the aforementioned functions, good soil quality is a key factor for carbon sequestration, a process through which CO_2 is removed from the atmosphere and stored, primarily through photosynthesis by plants, which grow better in fertile soil, but also by the soil itself, that acts therefore as a carbon sink pool. The higher the organic matter, the higher will be its capacity to capture CO_2.

This map shows the soil carbon stock in the top 30 cm of the soil for the region of South Holland, in combination with the soil types, and shows how the highest stocks are in areas with peat soils, while the lowest stocks are in areas with sandy soils.
This datum highlights the importance of fertile soil for climate mitigation, and the urgency of preserving peat soil quality amd structurevv

Map D. Made by the author with GIS data from the Environmental Health Atlas

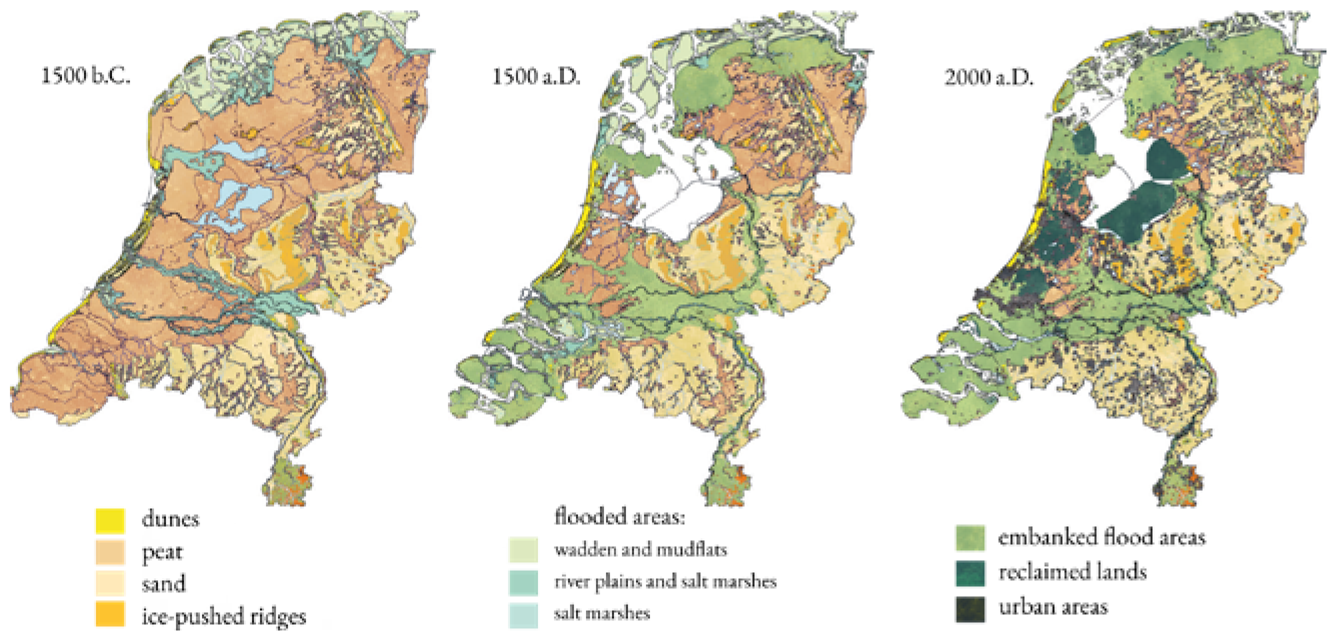
History of reclamation is history of soil

Stepping back at the different types of soilsand their location, it is interesting to consider the the geomorphological history of the formation of The Netherlands, as it shows how the different soil types mutated spatially until the current configuration.

The Netherlands is shaped by the convergence of two major rivers, the Rhine and the Meuse, flowing into the North Sea. Its modern configuration largely emerged during the Holocene, over the past 10,000 years, as the receding ice sheets from the last ice age led to a rise in sea levels, inundating the western part of the country some 5,000 years ago.[10]

Going back in history, the landscape was characterized by free-flowing rivers depositing clay, sand, and gravel during seasonal floods. Swamps formed along the coast, while the higher eastern regions were covered in woodlands and moorlands.

It is during the late Middle Ages (1050 - 1500 A.D.), that the exploitation of peat swamps and moorlands began. Drainage ditches were constructed, and dikes were erected along rivers and the coastline, enabling permanent settlement in the western regions.
The extensive peat resources in the western part of the Netherlands played a pivotal role as an energy source, gaining increasing importance during the 'Little Ice Age' marked by prolonged and harsh winters. This valuable peat fuel allowed for economic and social progress, defying the challenging climatic conditions of the era.



10. **Rijkswaterstaat, Mininitry of Infastructure and the Environment** (2014), *Into Dutch Soils*

11. **Steenbergen, C.M. and Bobbink, I. and van den Heuvel, B. and de Wit, S.**, (2009), *The Polder Atlas of The Netherlands*, THOTH

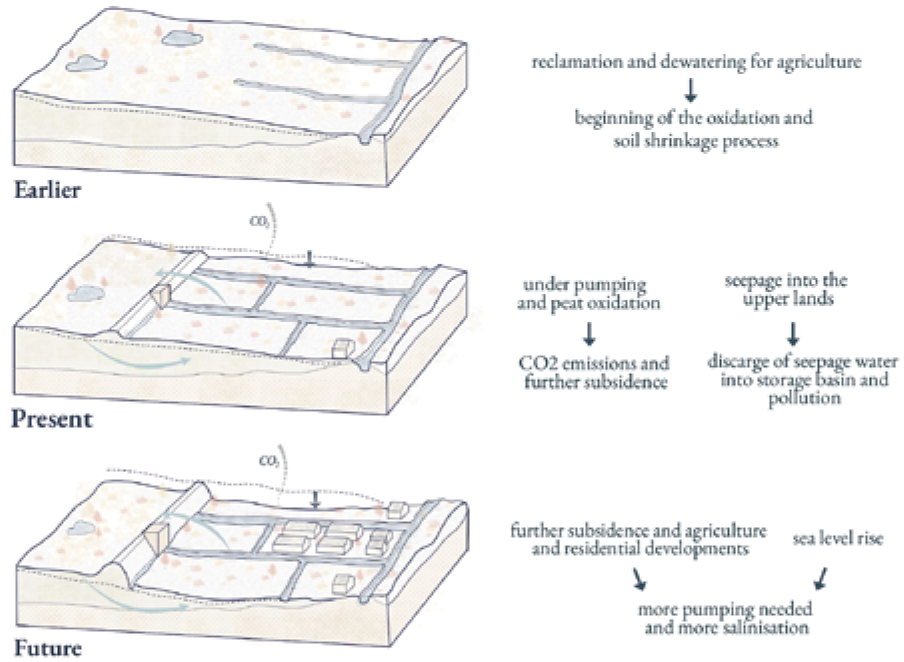
Images:

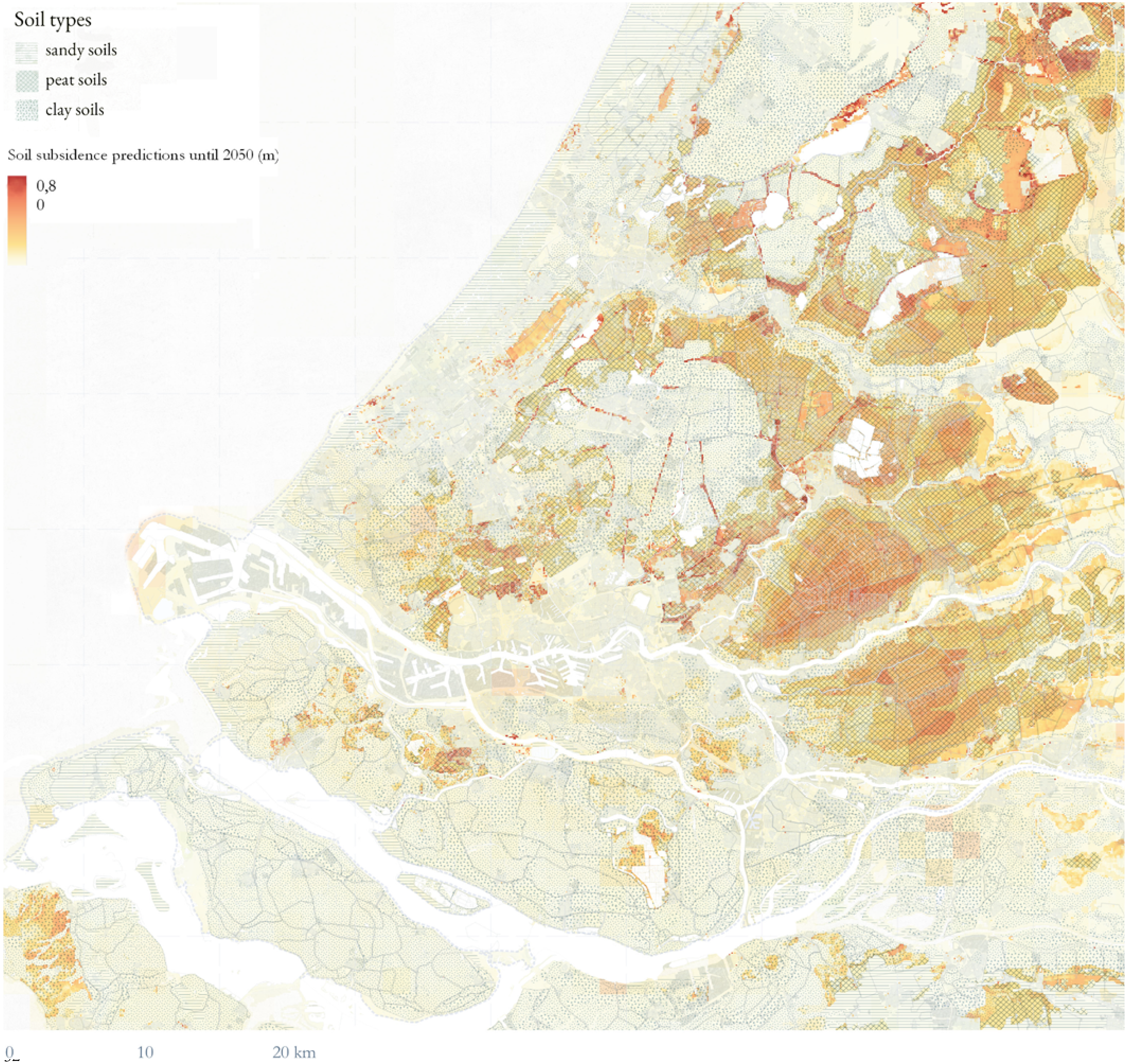
Fig 3. Image from **Deltares, BoschSlabbers & Sweco**, (2021). Copyright © Deltares 2021. *Water-based; limits to the manufacturability of our water and soil system*

Fig 4. Sequence made by the author from **Deltares, BoschSlabbers & Sweco**, (2021). Copyright © Deltares 2021. *Water-based; limits to the manufacturability of our water and soil system*

The 17th century, famously referred to as 'the golden century' in the Netherlands, witnessed a booming economy.
During this period, Dutch maritime power thrived, dominating global trade with a formidable fleet. The rapid population growth fueled increased demands for food and energy, needs that persisted beyond the prosperous 17th century.
In regions with rich peat deposits in the former coastal zone, extensive excavations led to the formation of shallow lakes where peat was abundant. In other areas, natural lakes were encircled by dikes and water was pumped out using windmills, resulting in reclaimed land below sea level, which created more space fro the growing population.
Therefore, the process of land reclamation that started centuries ago ensure that the land could remain livable and productive.

The Dutch polder, the '*most appealing association of the low lands with water*',[11] is a low-lying area reclaimed from a body of water, often the sea, by the construction of dikes, followed by drainage of the area between the dikes and the natural coastline.
It represents at the same time a spatial landscape entity, a cultural element, and an administrative unit of water management, as the drainage of this hypogean territoy unit is controlled for each polder.
In fact, its groundwater level is constantly monitored in order to facilitate the area's users functions, but this process over the centuries led to the lowering of the dried peat soil, in a process called subsidence, meaning a vertical movement of the land, causing precisely slowly falling to a lower level.
The drainage of the polder is not the only responsible for subsidence, but it is one of the main causes.





Soil and subsidence

The critical cartography links the different types of soil with the subsidence levels predictions for 2050, with the aim to reflect about the fact that climate change exacerbates its effect, as higher soil temperatures are conducive to faster conversion of organic matter.

The data are based on the “extensive subsidence” scenario. In this scenario, the climate is warming substantially and the surface water level is lowered further, in response to the subsidence (water level indexation).

The Netherlands has been pursuing water level indexation for centuries: by lowering the water level of ditches and other drainage canals to keep pace with land subsidence, the country prevents water saturation in the soil. However, as already mentioned, water level indexation also fosters continued soil subsidence, and is particularly important in peat areas, where the soil continues to subside as a result of peat degradation. Furthermore, global warming will speed up the rate at which the peat is degrading,

Map E. Made by the author with GIS data from the Klimaat Effect Atlas

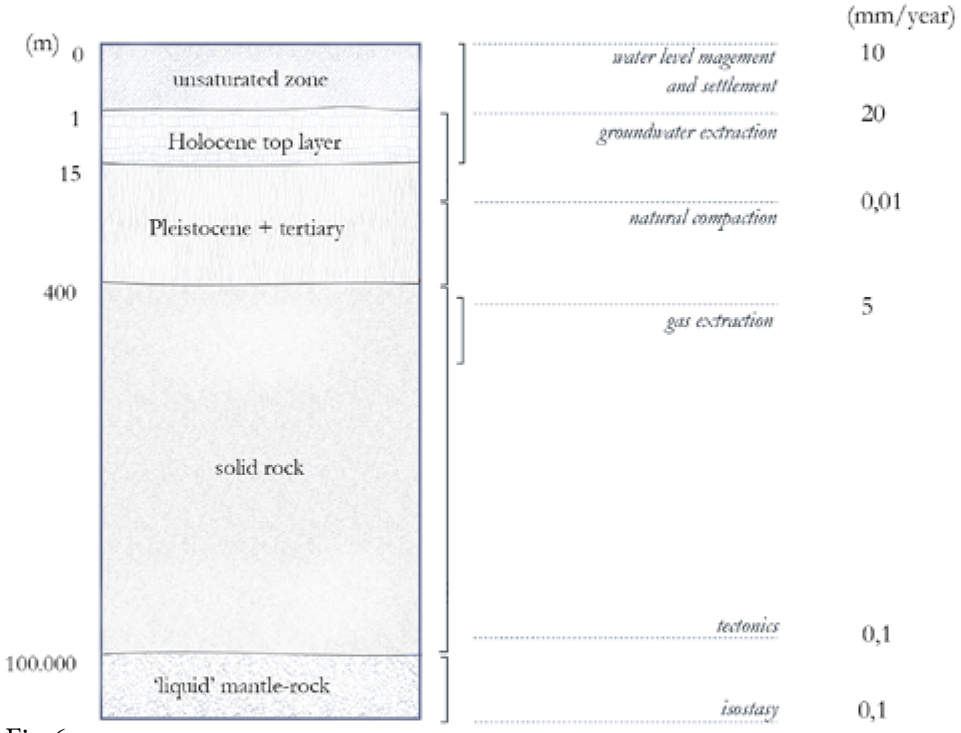
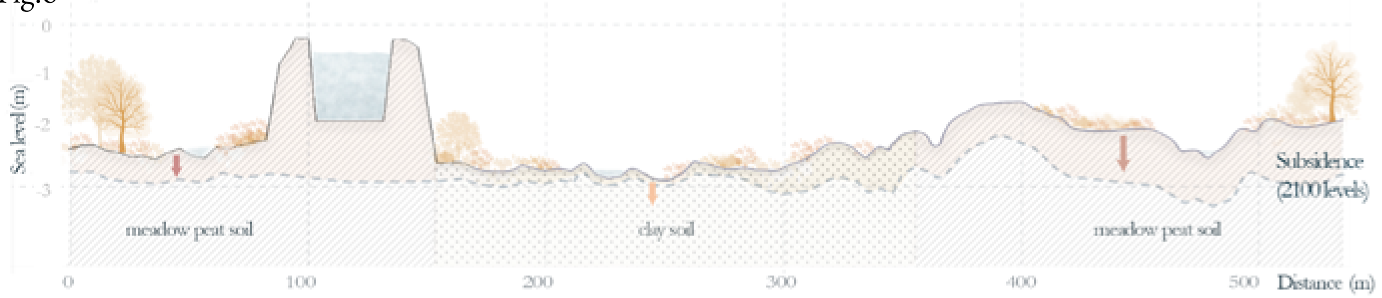


Fig.6

This diagram shows the causes for soil subsidence, broken down by the depth at which it may occurr, therefore linking them with the geological soil layers, but also by the rates of each category. This section is refered to the case study of Midden Delfland, in the Randstad, but can be considered generally true.
Even though the groundwater extraction has a higher impact on the subsidence total trend, this is more a spatially localised cause, while the water management, meaning the drainage, is spread in all the polders area. [12]

In general, the responsible agents are geological processes of moving land, compaction under the weight of different types of charges, shrinkage caused by activities such as gas and oil extraction, and peat oxidation, meaning the breaking down of the organic matter caused by water drainage. While in the clay areas subsidence is induced only by shrinkage and compaction, in peat areas peat oxidation is the main contributor. [13]
Not only this last one determine the highest part of soil subsiding, but also it has the most negative economic impact. The Netherlands Environmental Agency (PBL) has calculated that up to 2050, the social cost of soil subsidence in peat soil will amount to 22 billion euros.

Fig.6



12. **Erkens, G., Kooi, H.** , (2018) *Exploration of soil subsidence in Midden-Delfland*, Deltares

12. PBL (Environmental Assessment Agency) (2016) *Declining soils, rising costs*

Images:

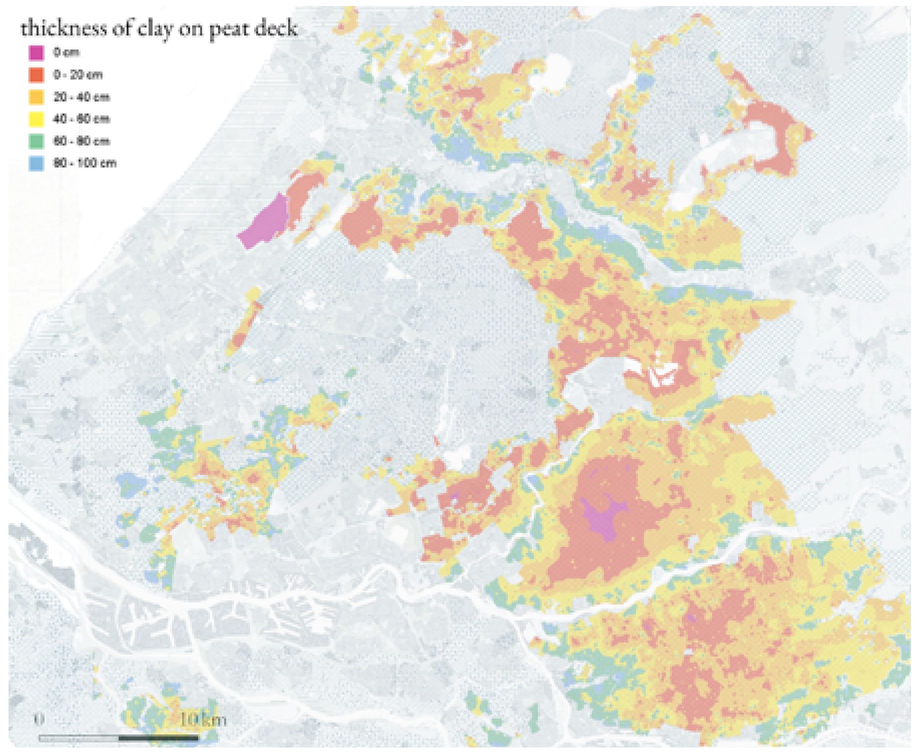
Fig 5. Diagram rielaborated by the author from **Erkens, G., Kooi, H.** , (2018) *Exploration of soil subsidence in Midden-Delfland*, Deltares

Fig 6. Section made by the author using GIS data combining types of soil, current topography and future subsidence levels

Images:

Map F. Made by the author with GIS data from the National Georegister

Fig 7. Section rielaborated by the author from
Vos, G.A., (1984), *Bodemkaart van nederland, Blad 37 West Rotterdam,* Stichting voor Bodemkartering



In peat rich areas, with constant water level management and without restrictive measures, the soil can sink up to approximately 10 cm, and, as already mentioned, the warmer climate will most likely accelerate the subsidence rate, as higher temperatures make the process faster, and the groundwater level sinks deeper.

A factor that determines higher or lower impact of the causes of subsidence is the presence of a clay deck on the peat.
As it can be seen from the map above, where the clay deck is thiner, the rate is higher.

In fact, while having a prevailing soil type, in each location the soil profile is made up of the layering of different soils (as it can be seen by fig.9, showing an example of an area located in South Holland), and on peat soils is common to have a clay cover, which is also symptom of good soil quality. Degraded soils may have little or no cover, and this causes highers rates of peat oxidation, determining higher environmental impacts.

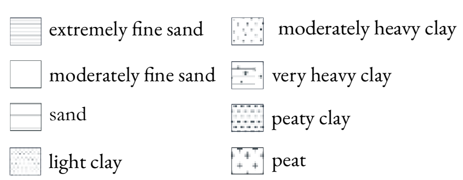
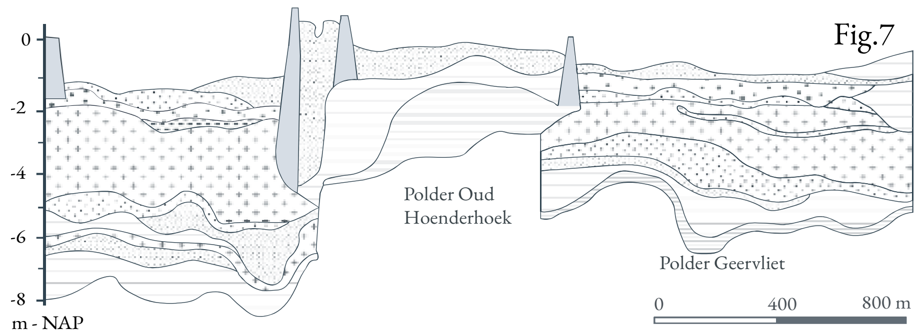


Fig.7



In fact, not only this phenomenon is exacerbated by environmental impacts of climate change, but it also impacts the environment itlsef.
The process of oxidation releases greenhouses gases (mostly CO2, and other too) in the environment, contributing to the 3-4% of the national emissions, therefore Dutch peat areas are partially responsible for global warming at the national scale.
And as long as the polders will be drained, the oxidation of organic material will continue until the organic material will be depleted. This would imply also a loss of the soil quality and fertility, a depletion in all senses, and could be seen as another call for action towards a need to rethink about the relation between soil, land use and environemtal impacts.

Indeed, from this initial study comes a new awareness of the need to consider soil characteristics and the aspects derived from them as one of the leading factors in spatial design choices to be reflected in the discourse on how productive landscapes can meet the environmental challenges of climate change.

Fig 8. Picture taken by the author showing the soil broken down by the action of water in a polder

Topos:
The control over water

"Inquiring the representation of Topos in a territorial project entails both sequences of spatiality and temporality, as it appears through the processes that form-, and erase land. Implicit motions, laterally and longitudinally, shape the multitude of perceptions and sensations of the landscape, observed through the lens of natural processes of sedimentation and erosion versus anthropogenic disturbance events interfering within them. Complex volumes of soil, sole manifestations of past fluidity of marine- and riverine territory through the fixation of sediment, show the ever moving suspension of soil in water. Iterating onto itself through the duality of the formation and degradation processes, creating past, present and future.

Now, within the anthropogenic territory, tension appears through the formation of fields, structures and objects of an infrastructural nature. These rigid remnants of civilization, anchoring human activity onto the territory, unable to achieve the state of fluidity as demanded by the rapidly changing environmental conditions and processes encroaching upon us. Physical barriers are formed to actively destabilize and manipulate natural processes on the long- and short term, in order to create an engineered system of transposition without translation and migration. The mutual engagement of water and sand particles, once the core of terraforming and erasure, diminished to the sheer exchange of anthropogenic pollutants and materials within a rigid field of an ever growing gap between the human and natural territory. Infrastructure will, throughout the climactic zones, across the globe, lead to destabilization of our contemporary representation of Topos on either the short term through shock, or the long term through stressors on the environmental layer. Infrastructure, our vertical alignment with the soil, anchoring humanity, disabling horizontal movement of mankind." [13]

13. from https://tp2021.transitionaterritories.org/text

14. Kuzniecow Bacchin, T., Recubenis Sanchis, I., (2022), *Soil, Planning and Climatic Crisis in the Dutch Upper Delta, in OASE 110*

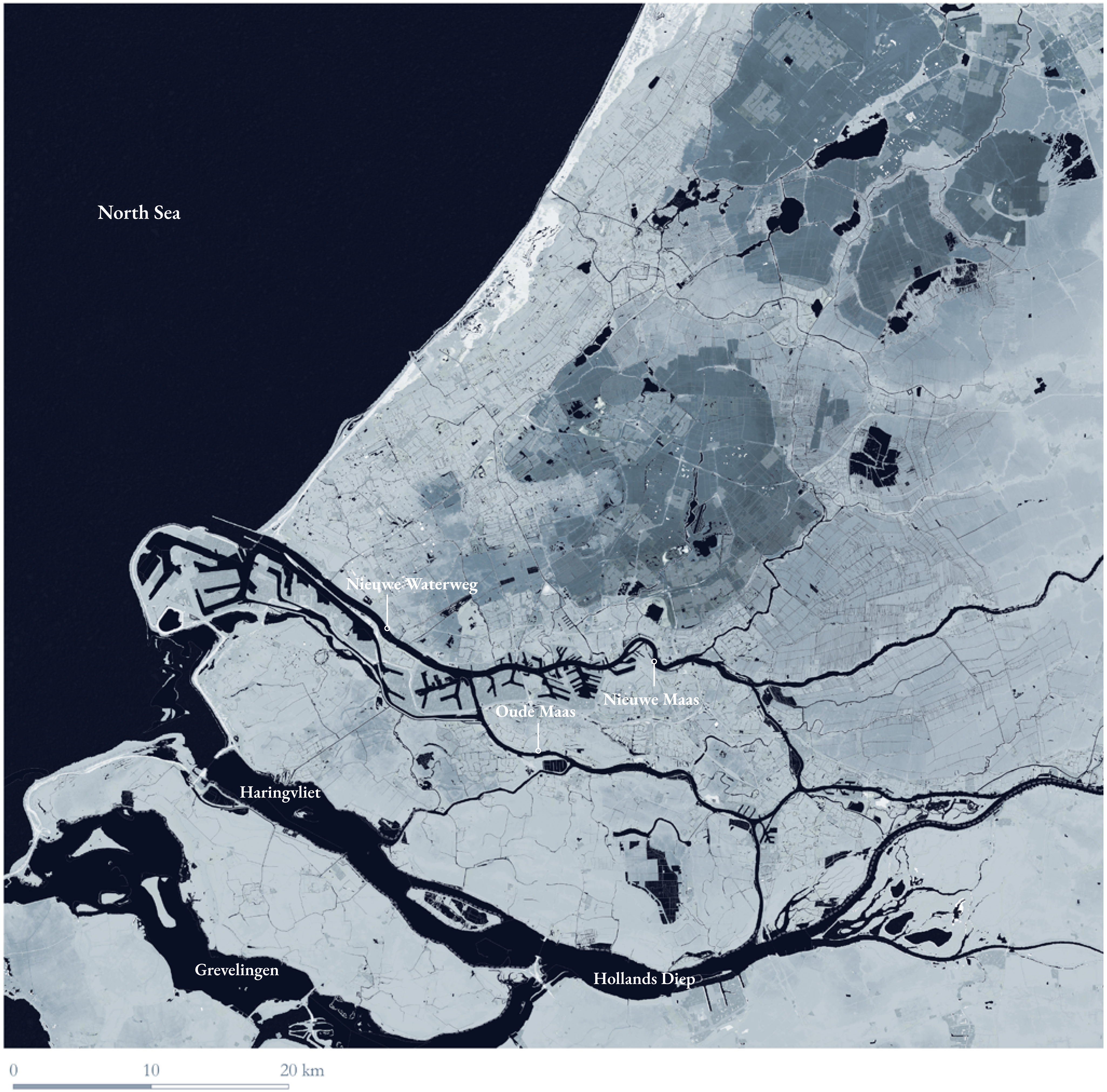
'The Dutch landscape may for a large part be seen as a gigantic highly man made water processing machine. A primary objective for this machine is to limit the probability that the seas and main rivers break through its elevations, the dykes, which protect 65 per cent of the country from flooding.' [14]

The Netherlands is a land of water.

As it forms the low-lying delta of North-Western Europe, it is in a position of particular vulnerability, and while developing a strong expertise in dealing with the possible deriving threats, over the past 1000 years it put many efforts and investments harnessing rivers between higher and stronger dikes, and protecting the lands from the risk of flooding.

As it has been happening in similar contexts around the World, climate change undermines the Dutch delta in a significant way, putting it at stake at three different directions. First from above, seen that for the more unpredictable weather conditions, increasing violent storms or prolonged water showers, and meteorological drought are expected; secondly, from the rising sea, whose rate is still uncertain, but will surely determine higher and higher pressure on the seepage in the lower Netherlands; last, from the hinterlands, from where the rivers in winter discharge higher loads of water due to the melting glaciers, while in summer supply less and less freshwater.

Wherever the 'water threats' may come from, it is clear that safety from flooding is a fundamental national issue, in a country where a considerable part of the land lies below the sea level and has at the same time the highest economic and demographic.



Spatial layout of water control

The map shows the water system present in South Holland, together with the topography of the area: the darker areas represent those that are mostly below sea level, and reach up to a depth of around 8 m below NAP (Amsterdam Ordenance Datum, which is approximately the mean water level of Amsterdam in absence of water motion, and is slightly lower than sea level).

The main elements that can be distinguished are the North Sea, which laps the coasts of the whole country, part of the Rhine Meuse Scheldt Delta, which is located partially in Belgium and partially in the Netherlands, divided between the regions of Zuid Holland and Zeeland. This Delta has enormous geographical and economic importance as it is the gateway from the North Sea to the German Hinteland and Central Europe in general. In its final part it divides into several branches, and among them the Old Meuse flows through the city of Rotterdam, which in the past century, due to economic interests related to the construction of the port, partially altered its course with the construction of the New Waterweg.

In addition to the rivers, both in the coastal area and inland there are a series of lakes, wetlands and canals, a distinctive element of the polder landscape.

Map G. Made by the author using GIS data taken by the National Georegister

Spatial devices of flood protection

To reduce the risks or consequences of flooding, various types of measures can be taken, as a 'multi-layer'[15] safety comprises three lines of action: prevention, namely measures to avoid the occurrence of floods, spatial design (mitigation), which provides solutions to reduce the negative impact of flooding through spatial devices and applications, and crisis management, referring to the contributions aimed at dealing with the consequences of flooding, with the goal of limiting them.

The Netherlands had to deal with extreme flooding occurrences several times in the past millennium, and, often after one of these events, measures were undertaken to reduce the probability of flooding for the coming years, acting therefore with prevention measures. However, protection from flooding is never finished in a Delta, and water infrastructures are constantly updated to keep the land in the safest condition possible.

In order to understand how the country deals with this issue and which the spatial consequences of flooding protection are, it was fundamental to dive into the different typologies mastered by the Dutch expertise.
We could first differentiate these typologies in natural features, artificially made natural landscape devices and man-made artificial structures.

With the first ones, we mostly refer to sea dunes. They are formed by the wind from sand washed ashore, interacting with vegetation that traps and holds the sand. However, this vegetation is not designed or able to prevent sand erosion by wave action during high tides and storm surges. The role of dunes in flood defence relies entirely on the total mass of sand, which must be large enough to guarantee that when a storm erodes part of the dune, enough sand is left to defend the lower-lying land behind the dune belt from the higher sea level.
For this reason, most of the times the natural processes and materials are not effective enough to provide the necessary protections, therefore the Dutch dunes are periodically (over large time spans) replenished with new sand. With this consideration, we look more at the second typology, among whom also levees and dams are to be mentioned, which are artificial earth structures. Compared to dunes, which are eroded by wave overtopping, levees should be able to withstand a certain degree, given their smaller dimensions. Their erosion resistance is a result of the characteristics of the materials they are built of, such as clay covered with grass, stone or asphalt. The shape, often trapezoidal in section, is a distinctive and functional feature of these structures. Indeed, their flood protection capacity is determined by their height, their shape in profile and the ground on which they stand.

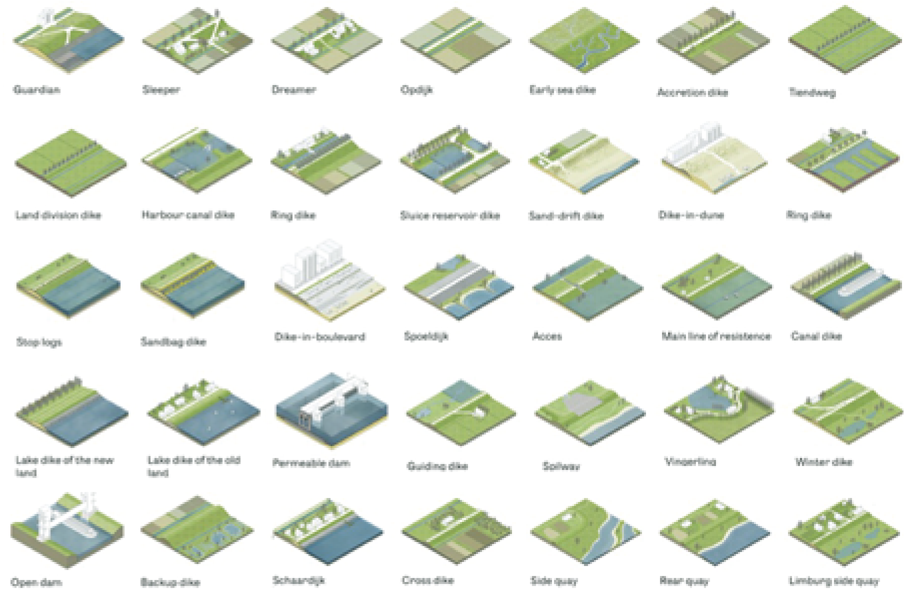
15. Expertise Network Flood Risk Management (ENW), (2016) Fundamentals of flood protection

16. *ibidem*

17. Zhu, H, Xianli M. M., Nicholls, R. J., (2010). *Technologies for Climate Change Adaptation – Coastal Erosion and Flooding.*

Images:

Fig.9 Dyke typologies, from **Pleijster, E.J., van der Veeken, C., (LOLA Landscape Architects)**, (2014), *Dutch Dikes*, nai010 publishers, Amsterdam



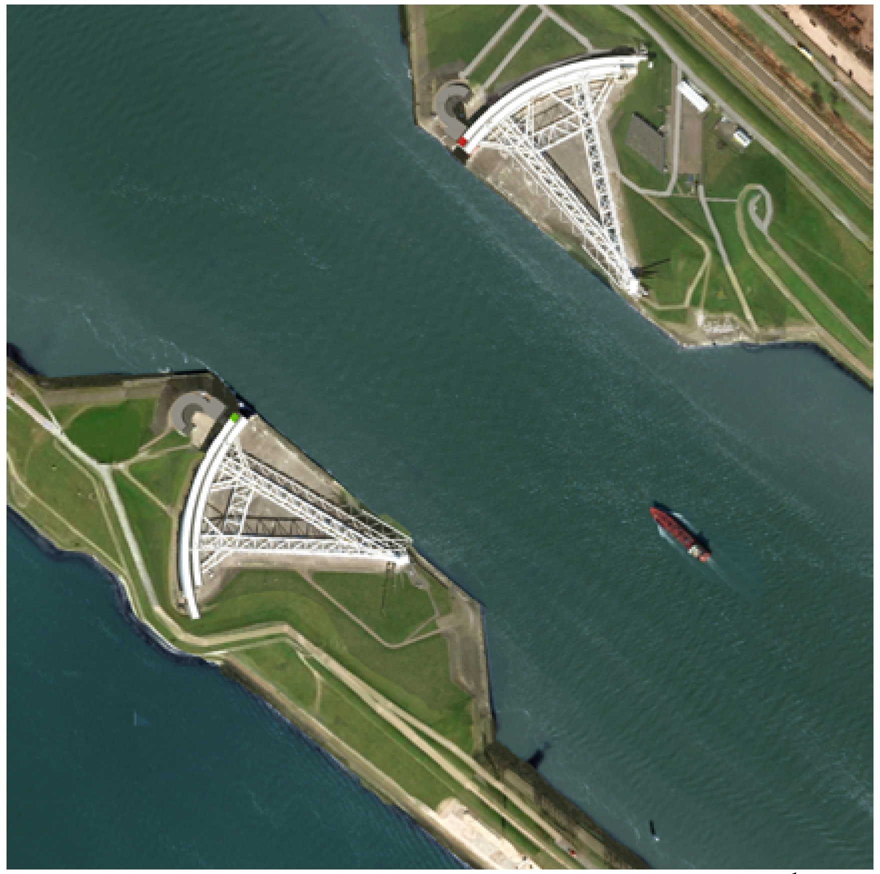
Levees must have sufficient shear strength (stability) and be watertight. Usually they are either located along a river or in a low-lying coastline, with the aim to protect the other landside against flooding, or along canals in low-lying areas.

Finally, hydraulic protection structures are designed to provide a further function that is of overlap with flood protection. '[16] These can comprise structures such as locks and storm surge barriers for shipping, pumping stations, sluices and storm surge barriers for drainage, and cuts for traffic.

Storm surge barriers and closure dams are 'major coastal defence works, designed to provide protection to tidal inlets, rivers and estuaries against incidental storm surges'. (UN Climate Technology Centre and Network).

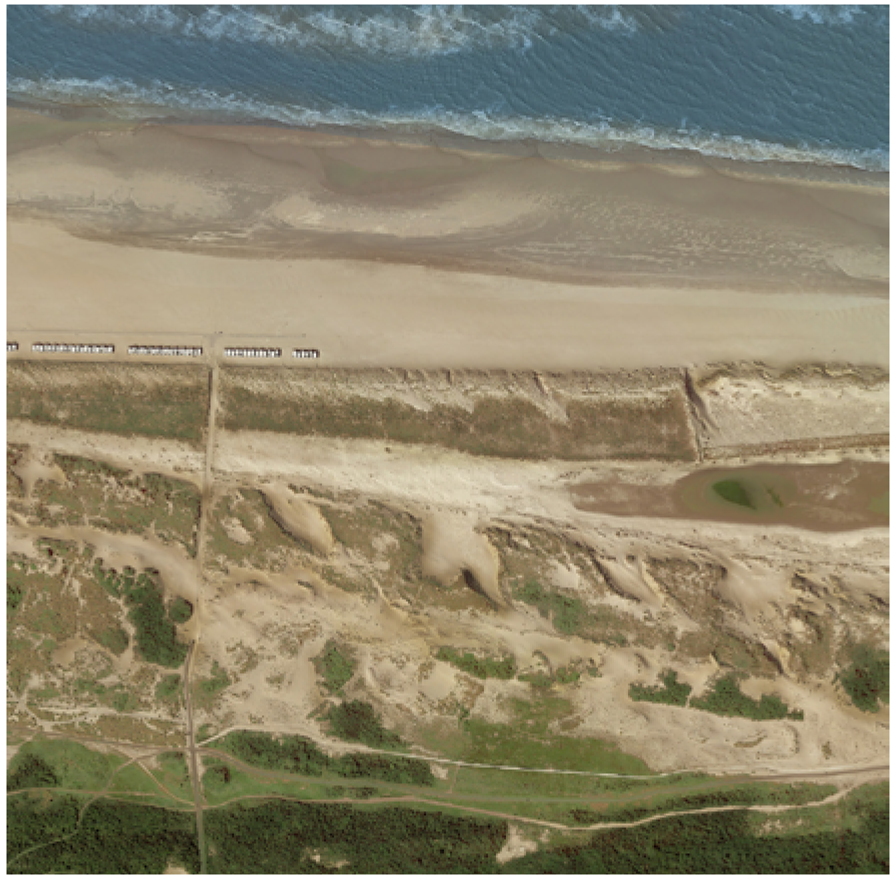
Although there are notable distinctions between the two, the purpose of the structures in terms of coastal defence is the same - to provide a physical barrier that keeps storm surges from moving upstream. These two systems are often used on narrow estuaries, where there are fewer requirements for length of structure, and there are opportunities for reduction of height or length of defences behind them.
Storm surge barriers typically feature a physical, moving barrier across the mouth of a tidal inlet or estuary, while fixed barriers and closure dams are a lower technology option and consist of non-moving barriers. Being moveable, the first ones are usually partially opened under normal conditions: this enables tides and saltwater to flow through the barriers and into the estuary, thus ensuring continued use of waterways for shipping and transport. On the other hand, the presence of closure dams prevents interactions between freshwater and the sea and the other biotic and abiotic beings within them, and also precludes the use of the waterways for shipping and for navigation.

earthen embankment



storm surge barrier

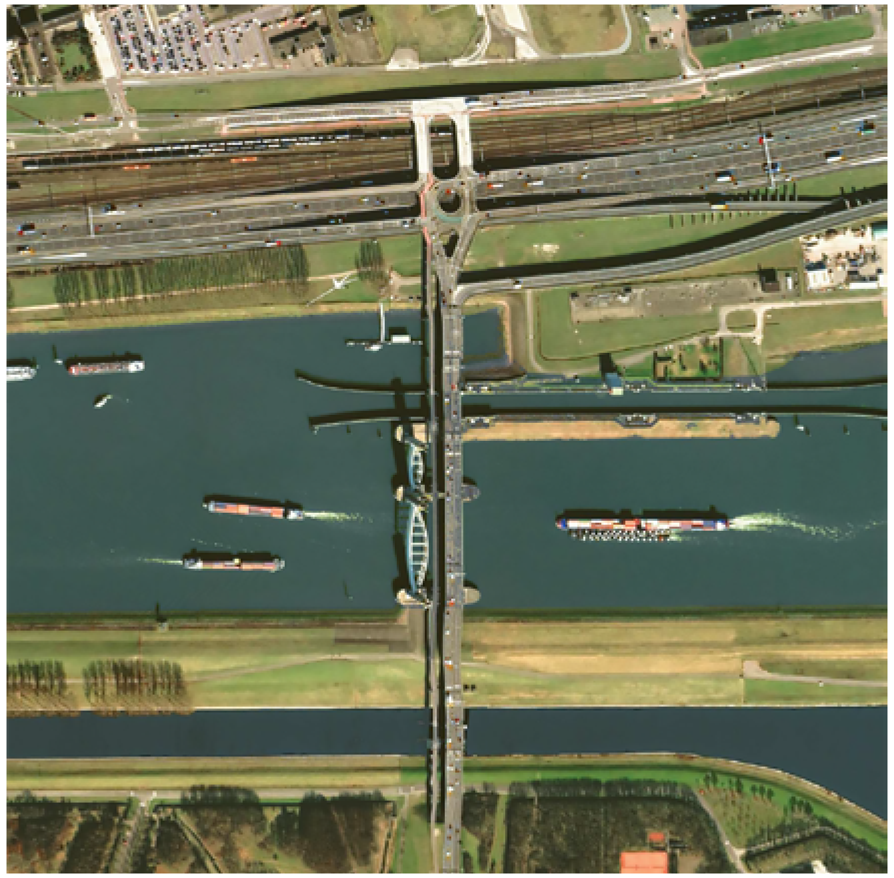
boezem canal way out to the Water Canal in corrispondence to the polder pump and lock



sand dune

fig 10.a,b,c,d,f: images edited byt the author from Google Earth

sluice



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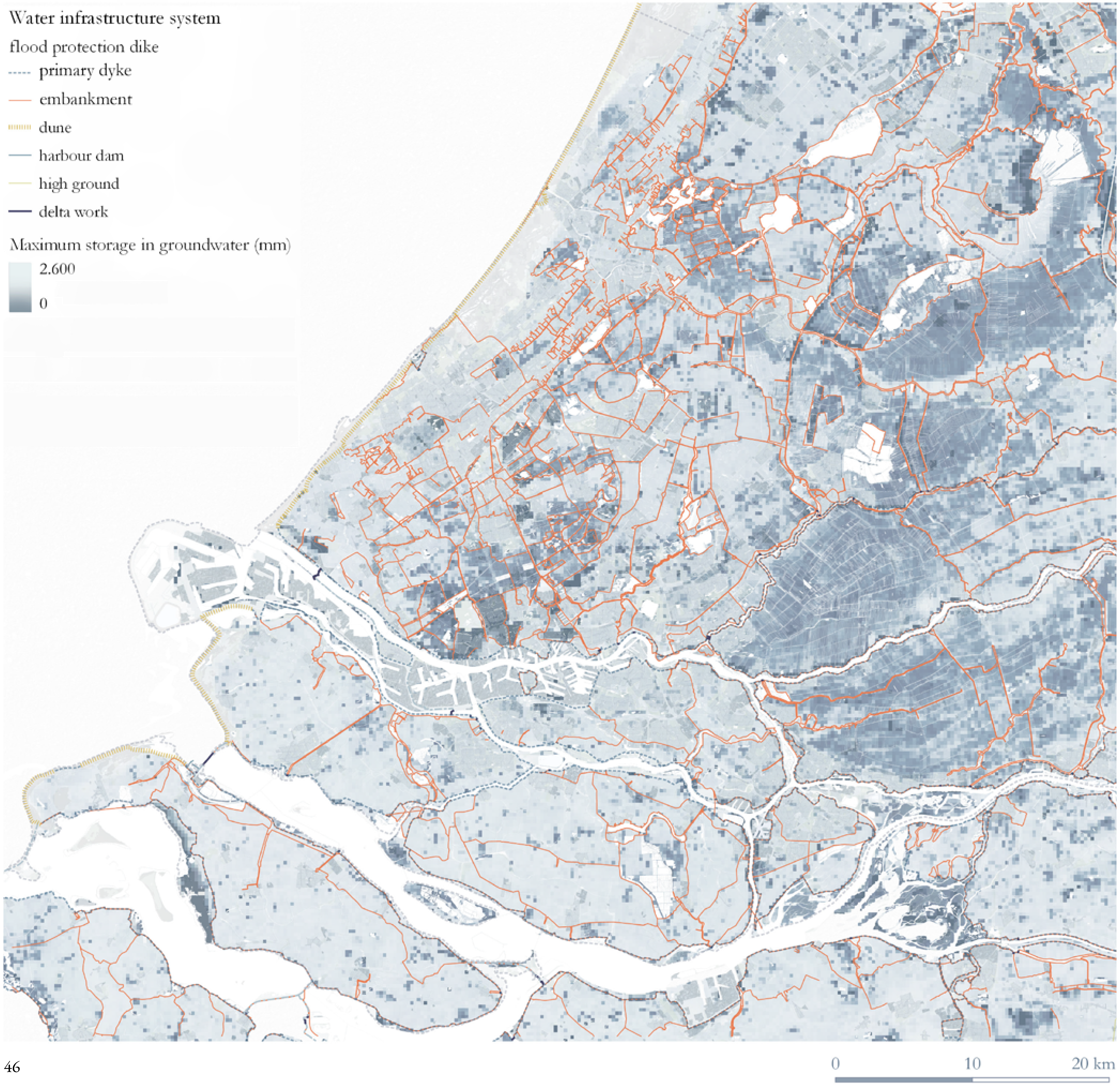


Water infrastructure system and groundwater storage

This critical cartography relates the type of infrastructures for water control with the space for water in the soil.

First, it give a full overview of the larger flood protections, and how they are spatialy located in the province: the dunes along the coast, the primary defence system along the rivers and the earthen embankment mostly in the low-lyin areas.

The data shows also how much water the soil can store until the ground is filled to the surface, highlighting therefore the areas more subjected to waterlogging. The zones where subsoil can store most water are those with the highest topography, such as hills or dunes, as it can be seen on the coast (lighter blue background), while the areas under the sea level are more prone to flooding (and can store less groundwater) ans usually are characterised by a denser system of embankments.

Map H: Made by the author using GIS data taken by the PDOK service and Atlas of Nature Capital

Pumping stations are very typical in the Dutch polders, and essential for their water management and existence. The low-lying areas of the Netherlands are characterised by the polder landscape, and South Holland is no exception, on the contrary, as a consistent part of the region is located below the sea level, the water infrastructure system is strongly related to the polder spatial layout.

As already mentioned, a polder is an area enclosed by flood protection systems where the water level is artificially controlled. The most common type of polder in South Holland consists of land reclaimed from a body of water, which is drained. This is done by building dikes that keep out the water (or part of it), that is pumped away, precisely with pumping stations, from the enclosed land to the upper level, meaning that the polders are always lower than the neighbouring land or the water level.

Whenever a rainfall or seepage occurring in a polder is not essential for use or as a strategic buffer, it can be diverted away and pumped into the storage basin. Polder land is usually formed of separate sections, each with a different channel bed and water level.
Therefore, the full efficiency of this articulated water management regime relies on a system of water pumps, that historically was sustained by the well know Dutch windmills, while now is computer-operated and remotely controlled, in order to contribute to the guarantee of the flooding safetv.

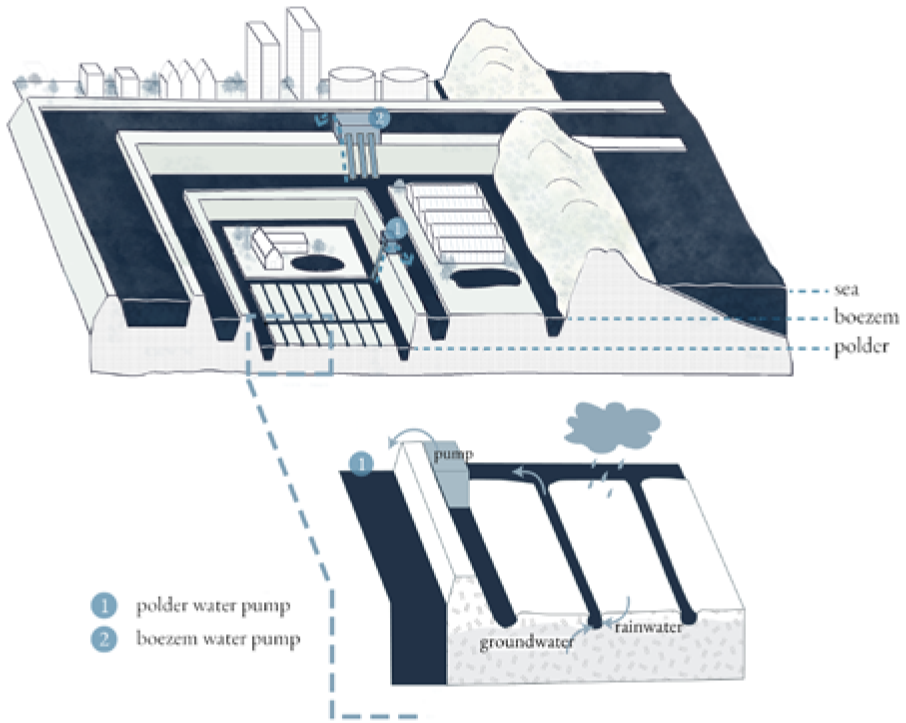


Fig 11. Explanatory diagram made by the author

Water infrastructures and their relation with the space

As mentioned above, the water defence system in a delta can never be considered definitively completed, as the water levels coming from the sea, the upstream rivers and the precipitations are far from stable, indeed, with the climate change alterations are becoming more consistent and fluctuating. In this context, it is interesting to reflect on the spatial implications of a slow yet endless updating of the flood defences.
But first, it goes without saying that this long-running process implies massive funding over time, strong technical expertise, and well organised policies -which will be further explained in this research- but thanks to the valuable Dutch tradition in dealing with water, the country has all the means to keep on being a worldwide reference for water management. However, this has also effects on the space around these water infrastructures, on the way they are perceived and on the activities that rely on their presence or happen in the adjacent areas, whether we refer to hydraulic structures or to dunes and dikes.

The first ones require regular maintenance, in order to provide for the appropriate mechanical operations, and generally their design is made to withstand increasing water quantities thanks to the resistance provided by the materials they are built of and the technology put in place. Nevertheless, rising sea levels may result in a need of mechanical procedures frequency that is not compatible with the maintenance standards they were designed for.
This may be the case of the Maeslantkering: higher sea levels could determine the necessity to close the barriers for a too high numbers of time in a year, and this would be not only financially unsustainable, but also in conflict with the shipping operations of the Rotterdam port, where it is located.
On the other side, the reinforcement of dunes and dikes does not necessarily mean the deployment of very articulated technologies, as it implies replenishment with an extra quantity of the material they are made of, such as sand and earth.
Nevertheless, despite it may seem a simpler measure, actually it is not when considering the effects it might have on the space around them.

First, sometimes they do not only serve the function of spatial devices of flood protection, but they come with other features, as in the case of roads located on top of dikes, therefore their improvement may determine

partial changes also in other fields, such as mobility. But there are even other major factors to take into account when talking about their improvement, alongside the concerns that may come with the huge amount of filling materials needed in case of a national reinforcement plan of dike and dunes.
In fact, this would also require a lot of extra space from a longitudinal point of view, and would increase the spatial segregation between embanked areas. Suffice it to think that rising a dike of one meter for slopes of 1:3 also means making it six meters wider, or even more.

Consequently, this can represent a limit to future spatial development of adjacent activities, as well as be a non-practicable option in case of large economic or urban developments already in loco, and at the same time could increase the visual and physical separation between the already flat Dutch landscape sections, resulting in portions of territory fragmented by 'super dikes'.

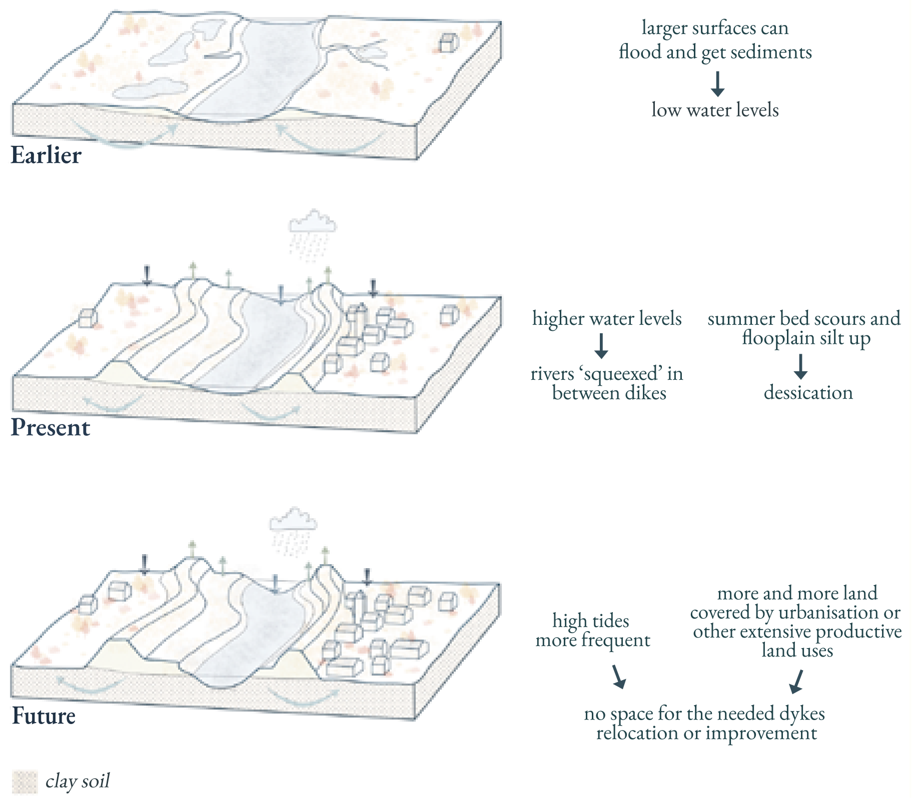


Fig 12. Sequence made by the author from **Deltares, BoschSlabbers & Sweco**, (2021). Copyright © Deltares 2021. *Water-based; limits to the manufacturability of our water and soil system*

Risk and probability of flooding

As mentioned above, the Netherlands has an extensive system of flood defences to protect people and property from floods. Indeed, among the possible approaches of dealing with flooding occurrence and its related risks and consequences, the Dutch expertise in this context has always relied mostly on actions to reduce the probability, rather than dealing with its possible consequences. This is how hydraulic engineering got so much at the forefront of technological innovation. This said, it is also more than evident that many steps have been made in working on policies, practices and designs to foster the ability to lower the negative impacts of flooding and withstand them in a favourable way. Nevertheless, looking at the uncertainties and accelerated rates of climate change trends in the dutch context, this is certainly a path than has high potentials to be further explored with spatial design.

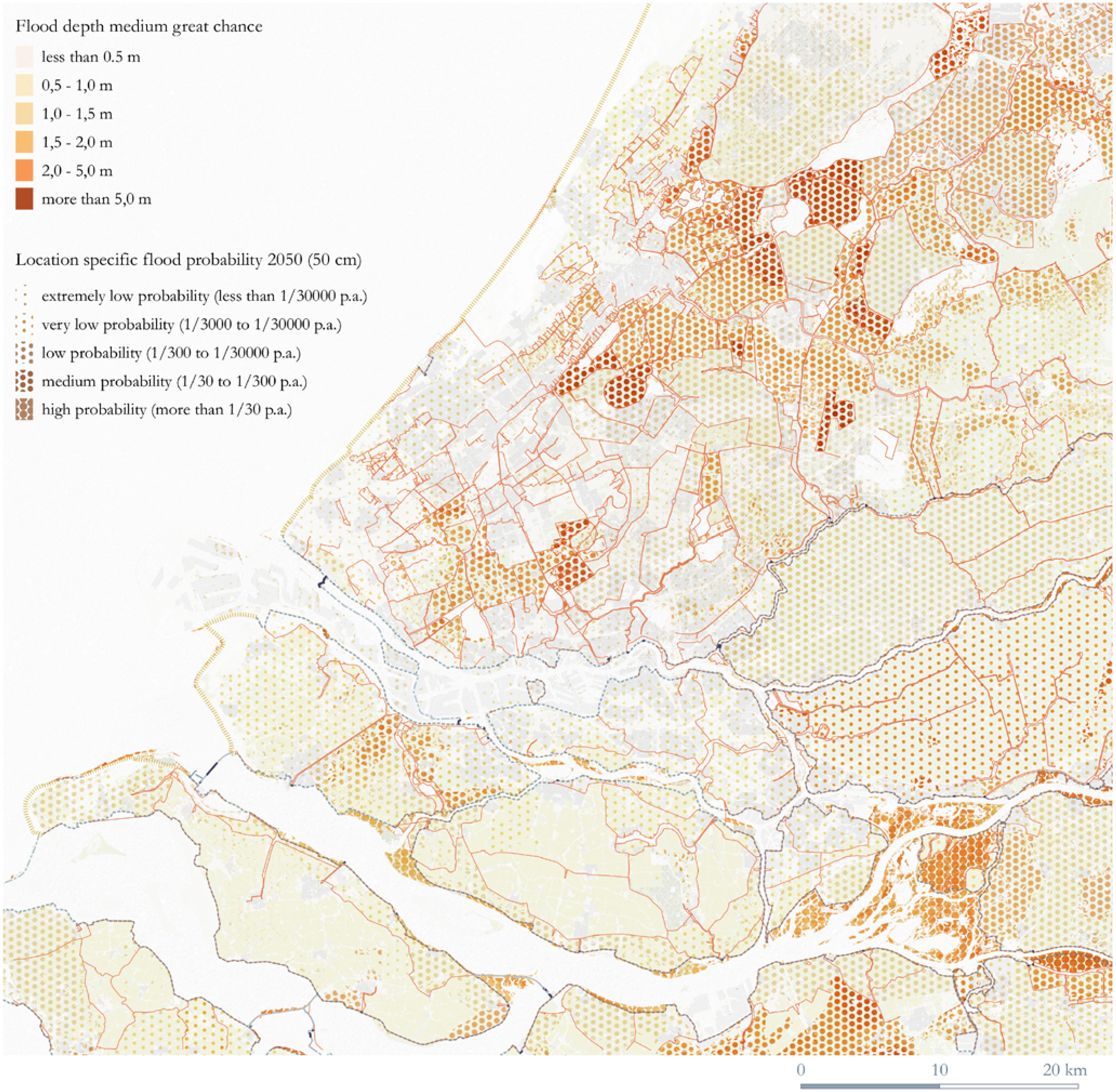
As the standards for flood protection are defined in terms of the probability of flooding, the notion of probability plays a key role in the Dutch flood risk management policy.
This probability is a measure of the likelihood of the occurrence of a flood on the basis of the knowledge available, and is a function of both the hydraulic loading (water levels and wave action) and the strength of the defences (height, width, type of material, etc.), meaning its ability to withstand that load.
A flood can occur in an almost infinite variety of ways, depending on factors such as the conditions under which it occurs, the location of levee breaches and the stability of linear elements in the landscape such as elevated roads and railway lines.

This standard of flood probability is related to flood risk, a concept that covers both the sectorial potential impacts of a flood and the probability of it occurring. [18] It sets out both the consequences and the likelihood of them occurring. Risk is often expressed as probability x economic loss, but it goes beyond that: flood risk can also be defined in terms of other measures, such as societal risk (the probability of large numbers of individuals dying) and individual risk (the probability that a single individual will loose its life). The choice of which measure of risk is preferable will be a function of the factors that determine how serious an impending event is perceived to be.

18. **Expertise Network Flood Risk Management (ENW)**, (2016) *Fundamentals of flood protection*

Images:

Fig 13. diagram edited by the author from *ibidem*

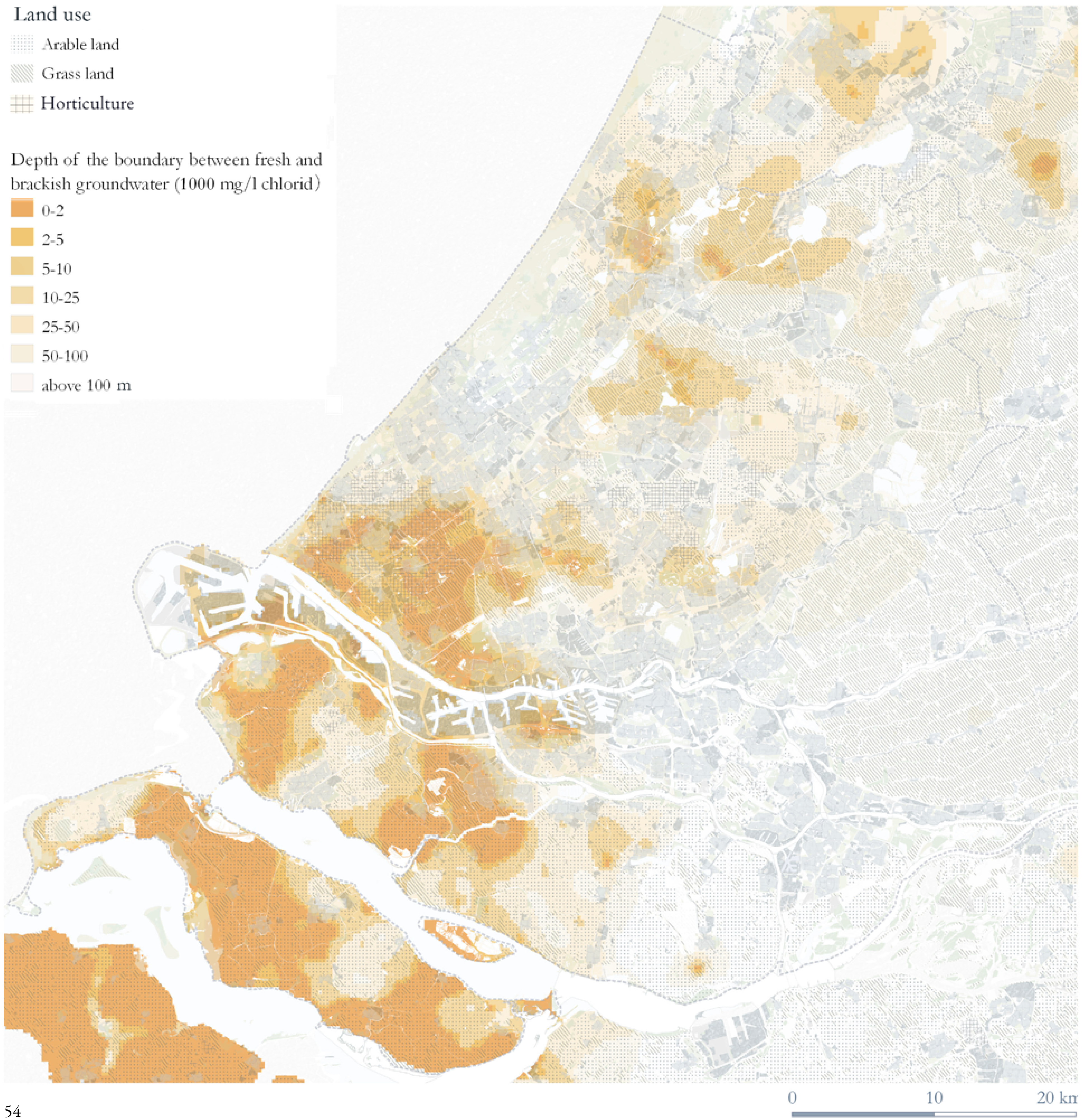


Flooding impact

This map is meant as a spatial graphic representation of the risk of flooding is South Holland. It does not have the ambition to be fully representative, as its aim is not to show all the possible impacts of a flood in a specific area, but more how much it may be affected based on the dimensions of the flooding.

It combines two different series of information, specifically the occurrence of flooding from rivers and the sea inside the protections and the maximum flood depths at medium probability.
Within a single area, the probability of flooding may differ vastly. This means that the need for flood impact reduction measures may differ widely from one location to the next. These location-specific probabilities of flooding are based on the protection standards for flood defences.

Map I: Made by the author using GIS data taken by the Klimaat Effekt Atlas



Salinisation

Another phenomenon of great impact for the South-Holland region that has to do with the water system is the salinisation of groundwater.

In the map, salinization is expressed in terms of chloride concentration.
Chloride is a conservative substance, relatively large compared to other substances, and the dominant representative of water salinity. Water is considered sweet with a chloride concentration under 1000 mg Cl/l, brackish when it is between 1000 and 3000 mg Cl/l, and salty for higher values.

The map shows the salinization together with the land uses. It is visible how this phenomenon is stronger in the areas along the coasts, and at the same time, how this can affect the activities located, in particular agriculture production areas, meaning greenhouses, arable lands and grasslands, because these rely mostly on the extensive use of fresh groundwater, and therefore are more impacted.

Map J: Made by the author using GIS data taken by the Klimaat Effekt Atlas

In the coastal areas of the Netherlands, seawater intrusion through the major rivers and saline seepage, which is the upward flowing of saline groundwater to the surface, lead to the salinization of groundwater and surface water.

This saline groundwater is seawater drawn into the subsoil during the Holocene sea floods, and has flowed back to the surface since the construction of the polders by man. As a result of these processes, there is a great deal of spatial variation in the occurrence of fresh groundwater.

The extent of this phenomenon has increased considerably, and the main drivers of higher rates of salinization are sea-level rise and land subsidence, but there are also other factors that influence its levels, such as reduced river flows and increased water demand, the use of larger ships, which has necessitated the deepening of canals and the construction of large sluices, over-extraction and mismanagement of water, the sealing of the subsoil and the scarcity of fresh water.

Therefore, brackish and saline seepage into the ditches of reclaimed land and polders is becoming more and more prevalent. With predicted climate change and future sea level rise, saline intrusion and saline infiltration from the sea are expected to increase, reducing the availability of fresh groundwater and surface water, which is essential for agriculture, industry, drinking water and nature.

Therefore, the water demand regularly exceeds the water supply. Due to the increasing demands that Dutch people place on the availability of fresh water, the need for a reliable freshwater supply has only increased in the past decade.
This is put at stake not only by long term phenomenon such as sea level rise and subisidence, but also increasingly recurring short-term droughts, that reduce the availability of freshwater and increase the impact of salinisation.

To counteract salinization, the affected areas mostly use fresh water from other sources, as the locally available water cannot be used, at least not to the extent that the land use can withstand salinity, as in the case of salt-tolerant crops.
Much of the water from the Rhine and Meuse is used for this purpose, but to continue to provide fresh water for current agricultural crops, increasing amounts of irrigation water are required, putting great pressure on the water supply system.

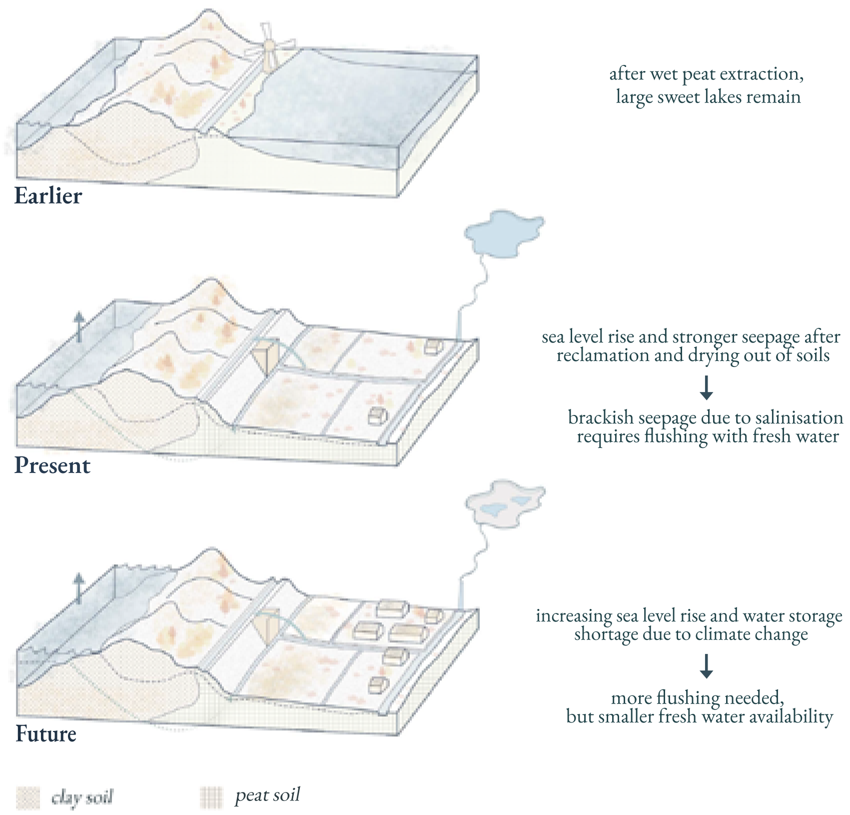


Fig 14. Sequence made by the author from **Deltares, BoschSlabbers & Sweco**, (2021). Copyright © Deltares 2021. *Water-based; limits to the manufacturability of our water and soil system*

Habitat: landscapes of production

"Habitat is recognized as a place or environment to dwell. It hosts life with its diverse forms and drifting anchorages with the site and the climate. Site refers to the flowing topos, including geo political narratives projected upon it. It's not in-situ limited only on land, but extended into the sea and the air. All creatures living in nature are interrelated. As a symphony of systems, habitat is the locus where accumulation of instincts, ideas, and needs of all living creatures is manifested. From within, inhabitation can be experienced either as competition or cooperation, resonance or dissonance. Hence, Habitat is no longer perceived as an origin, it is a second origin. Forged both by natural forces and human activities, including temporal differences, habitat is altered and limited. The flow of habitats is a collection of surviving materials of values, meanings, traditions, and cultures that come from the past and let everything begin anew.

The overlying of fast-paced territorial occupation is reinforced by an acceleration of planetary imagination from humans living in close communication. It creates a vigorous movement to expeditious embodiment beyond land, seaward and even down to the body. Captured within territories, it leads to the untamed desire of rapid response to change — as if everything is in a race. As this evolving Habitat presents us with a transect from purely natural to anthropogenic territories, how can we human, depict the 'real story' of habitat? And how can we understand in which direction it should move towards?." [19]

'*I saw that there was no Nature,*
That Nature does not exist,
That there are mountains, valleys, plains,
That there are trees, flowers, grasses,
That there are streams and stones,
But that there's not a whole to which this belongs,
That a real and true ensemble
Is a disease of our ideas.

Nature is parts without a whole.
This perhaps is that mystery they speak of.' [20]

The conception of nature to be parts without a whole relates to the approach of seeing a landscape as a spatial entity that is not defined a priori, but whose layout of attributes is what makes it so.
This reflection goes beyond the definition of landscape as a sight, the natural elements of which are typically admired, and dwells instead on what a landscape can be when considering the spatial features that characterise it. From this point of view, the territory can be seen as a set of landscapes, of portions that are not necessarily regarded as entities endowed with their own uniqueness according to a universal perception, but instead represent a way of reading the territory in its complexity and wholeness through the spatial features linked to a specific field. The field under consideration in this section is that of production.

This is not to indicate that every territory can be read in the same way through this specific lens, but that the area of South Holland lends itself well to this type of interpretation.

19. from https://tp2021.transitionaterritories.org/text

20. Fernando Pessoa, (1957) *Poemas de Alberto Caeiro*

In-habiting the landscapes

The idea of a habitat is a multi-layered notion and a metaphor for an ideal physical and relational environment.

From the Latin “habitare” meaning “to live” - more precisely “to live in” - it is a word taken from the natural sciences and describes the set of physical and ecological conditions of a ‘topos’ in which a species can optimally find the conditions for its survival.

As a physical spatial entity inside an ecosystem, it is a space colonised by one or more organisms, and a living system in a constant state of flux that evokes concepts such as coexistence, adaptation and protection.
Once anthropised, it becomes a social habitat whose characteristics are shaped by the coexistence of environmental, cultural and relational factors.

In this section, the aim is to reflect on the way in which the area of South Holland is in-habited, starting from the consideration that for centuries the objective of practices that sustained the living have always been aimed at making it a desirable anthropised habitat to live in.
This statement is not intended to claim that in South Holland landscapes there are not valuable environmental features, but more that its landscapes have been mostly shaped by practices of living and producing, which in turn required certain spatial conditions; therefore, the environmental features were shaped more than ever by anthropic needs, and its landscape can be seen as a series of landscapes of production.

‘The landscape is a voluntary geography.
The idyllic vision of landscape as intact nature is denied by experience and memory. Shaped by economic, environmental, and cultural forces, the planet’s panoramas are not the mere result of geology, botanics, and climate: in fact, they are shaped by history, and are themselves documents that record the political, legal, and social mutations taking place over time.’ [21]

Hence, in this section the focus is not on the connotation of landscape as ‘extensive area of land regarded as being visually distinct’, coming from the Greek etymology of skopeo and the ‘visual pleasure’ coming from the act of staring at an open view, but on that of landscape of production, referring to an area where land is the main source through which production is made possible, and around which the condition for human to live are constructed.

'It is through landscape that it is possible to see an often-recurring condition of what we refer to as the social imaginary: the set of “ways in which individuals imagine their social existence, the ways in which their existences are intertwined with those of others”. A repertoire of collective actions made up of practices and knowledge.' [22]

In the Netherlands there is an inherent relationship between culture and landscape. Since the development of the landscapes to their present state is a result of human intervention, the Dutch landscapes can be regarded as cultural landscapes. Human actions such as the creation of polders, land reclamations and urbanisation have had a major impact on the development of the existing landscapes.

‘The landscape resembles the society that built it. It reverberates it, metaphorically.’ [23]

This consideration is more than appropriate when looking at Dutch landscapes, as even the natural features many times appear as the result of an act of ‘domestication’, and the territory seems shaped in a way that it is made capable to host the spatial layout to accommodate anthropic productive activities.
Suffice it to think about areas under the sea level being embanked and turned into polder under draining to host agricultural activities, or the port of Rotterdam being built on artificial land along the channeled Meuse delta.

21. **Fernández-Galiano, L.,** P*roductive Landscapes,* in Aquitectura Viva, https://arquitecturaviva.com/articles/paisajes-productivos-1

22. Sampieri, A., (2008) *Nel paesaggio. Il progetto per la città negli ultimi venti anni*, Donzelli Editore, Roma

23. *ibidem*

Productive landscapes

During the analysis, three main landscapes of production were distinguished in the South Holland region: petroleumscape, glasscape and farmscape, which presents some different characteristic if we consider livestock activities or arable land.

This 'classification' does not portray the totality of the territory, as some areas, such as the largest urban built settlements, do not show the features to falling under it, but it is seen as a way to interpret it.

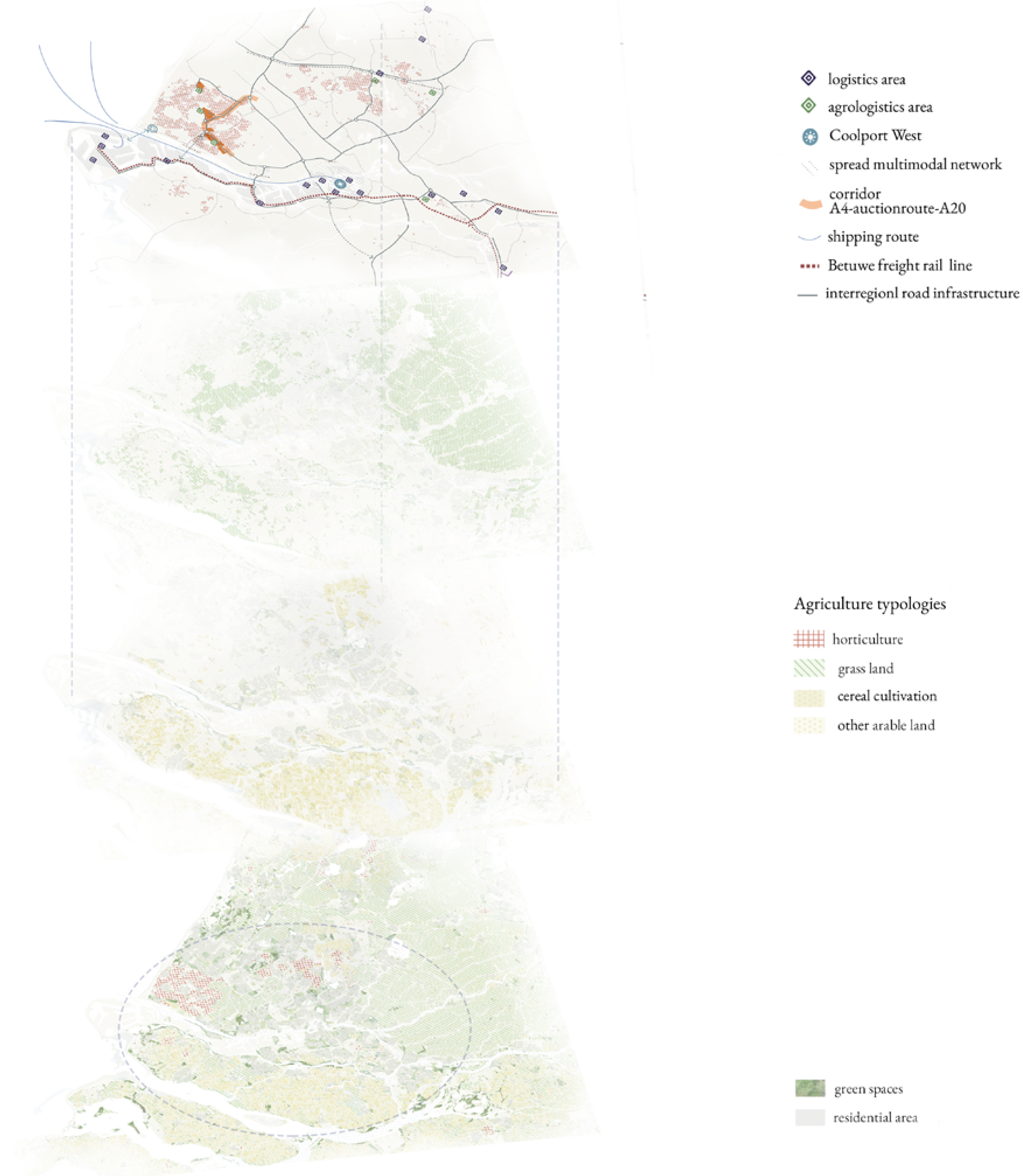
These labels were designated from particular element which define in a certain way the spatial features of the respective landscapes:

Petroleumscape is the landscape where the import, production and export of fossil fuels is made possible, and this production contributed to the creation of a machine landscape, where everything seems to be in a extra-large scale, populated by refineries, huge container storage space and freighter docks;

Glasscape is where horticulture is brought to a territorial scale development, small villages and individual houses seem to have been swallowed up by large glass greenhouses where flowers, plants, fruit and vegetables are grown all year round;

Farmscape refers to the 'production cell' where all the agricultural activities are coordinated, transforming the soil in a source of food production, either in the form of livestock feed of agricultural commodities from arable land.

Map K. Made by the author using GIS data taken by the National Georegister



Food production

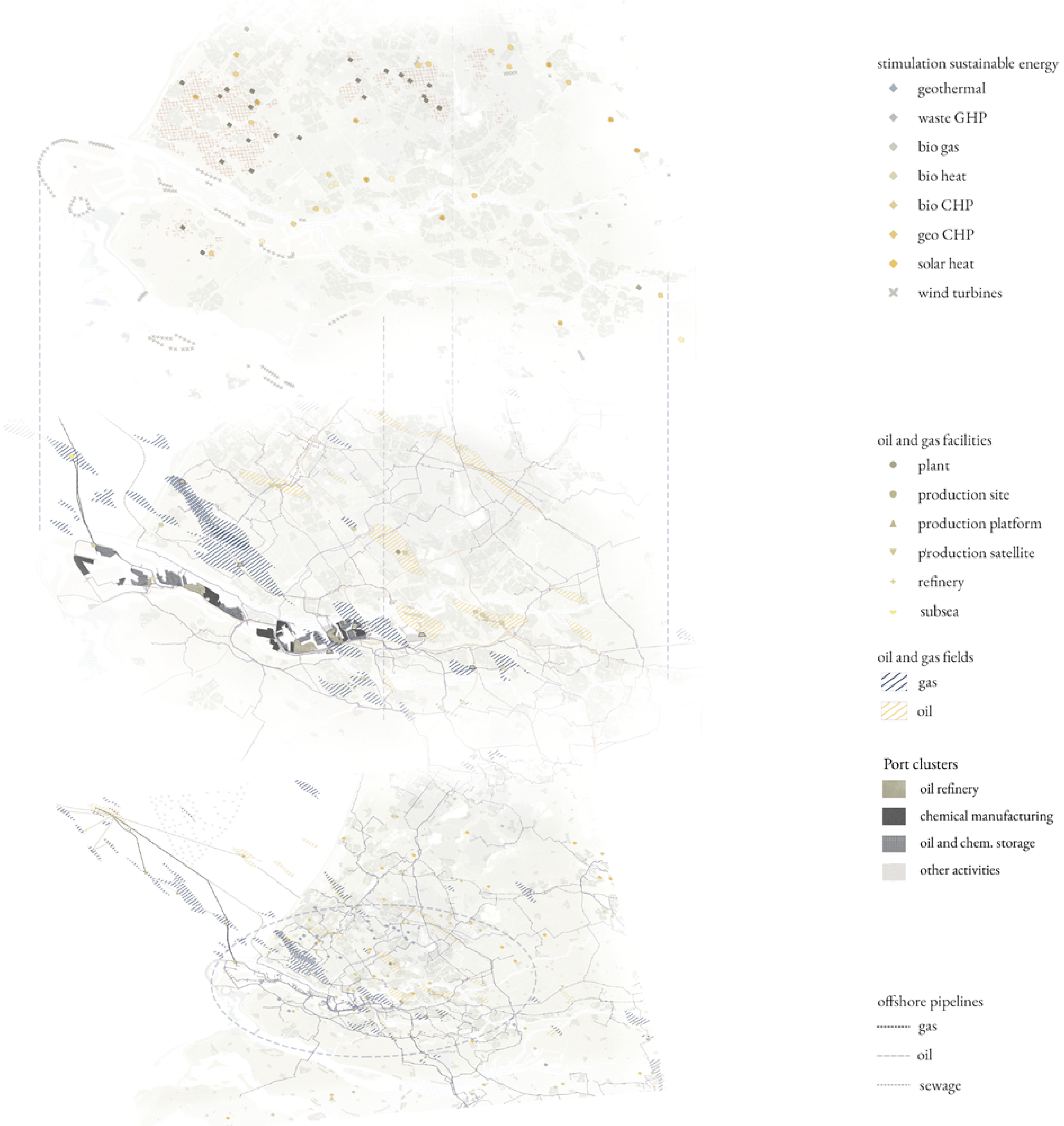
Prior to the analysis of each of the identified landscape types, an initial 'subdivision' was explored on the basis of the type of production. In fact, the productive landscapes of Zuid-Holland relate to the production of food and energy.

As far as the production of raw materials for the food sector is concerned, the areas of grassland for livestock production and arable land are much more extensive and technically more vulnerable, as they are more exposed to the weather and the climatic conditions, since they are located in open fields and need the soil as their primary location for growth, which is also subject to vulnerability and possible changes in its conditions.

The production areas for horticultural production are smaller, have a more recent tradition, and are usually configured as a type of "machine countryside", highly industrialised production areas with a very economic rate of return per area used.

Another interesting element to consider is how the 'glasscape' is intrinsically linked, in a more 'regularised' way, to the infrastructural system of mobility, to ensure that the food and plants grown in this area, once packaged here, can be easily exported, with the support of specially designed links and commercial hubs located outside the production area.

Map M: Diagramatic Cartographies made byt the author with GIS data from PDOK and **Hot - Satelliet Infra-Energie-Ruimte**, *Werkboek Westland, Ruimtelijk Economische Strategie Greenport 3.0*



Energy production

This set of maps shows the complex system of energy production, which goes far beyond the activities within the port.

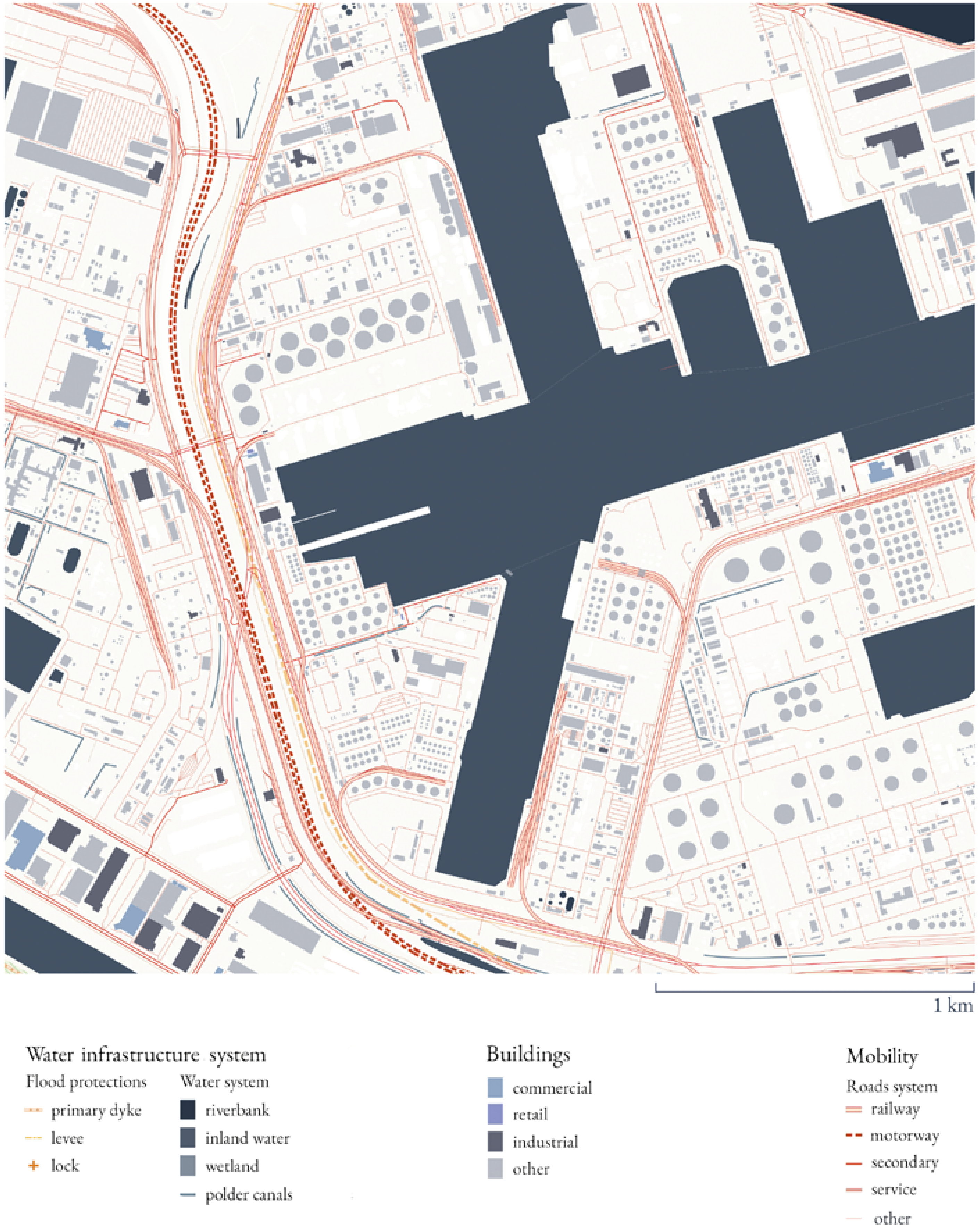
There is no doubt, however, that the so defined 'petroleumscape' represents a central point not only for production but also for distribution, both nationally and internationally, and many of the activities related to the theme analysed in these maps are closely linked to the port itself, as it will bw further discussed.
As a 'machine landscape' par excellence, it presents itself as the site of mega-infrastructures and production facilities of huge dimensions. In this context, the installation of wind turbines over the last two decades fits in well.
In fact, these turbines have been placed in the eastern part of the port because of the greater wind power of the geographical area closer to the sea, combined with the consideration that their installation in the port would have led to a lower perception of 'degradation' of the landscape compared to the alternative of placing them in other areas with a higher quality of landscape, nature and residential use.

However, wind energy is not the only type of sustainable energy production that can be found in the province: among the other types, geothermal sources are the most common, whether traditional geothermal stimulation or CHP, a technology that produces electricity and thermal energy with high efficiency using a range of technologies and fuels. It is particularly striking that these types of energy production and use are mostly located where the greenhouses are located. In fact, given the high heating and energy needs of this sector, they should adhere to a sustainable use of energy to reduce their impact on the environment by emitting less emissions.

Map N:. Diagramatic Cartographies made byt the author with GIS data from PDOK; NLOG and Warmte Atlas

Fig 15. Picture taken by the author

Petroleumscape



Landscape sample

Map O. Made by the author using GIS data from National Georegister and PDOK

Fig. 17. Picture edited by the author from Google Earth

The port of Rotterdam is the biggest port of Europe, and the largest outside Asia, hosting the broadest petro-chemically based industrial complex, and is managed by the port authority, a government corporation jointly owned by the municipality of Rotterdam and the Dutch State.

The main activities of the port are related to import, export, transit, storage and conversion of coal, mineral oil and gas, supporting five oil refineries, along with a massive coal-fire power plant; it is divided into five clusters, and despite the variety of activities, each one is more focused on a certain one. The scale of the port is truly massive, extending for over 40 km and being the production site of many international companies, being therefore a huge player in Rotterdam economy, giving job to around 180 thousand people from the region and outside.

The presence of the port has a huge impact on the region, and being the most polluted in Europe, also in the quality of the air and the soil: also for this reason, during the years, the need to move it away from the city centre of Rotterdam became stronger and stronger, and in this way it could also organise better its clusters in the thousands of square kilometres made available.[24]

Nevertheless, this economic flourishment comes with a price, as the activities in the port account for 17% of the national CO2 emissions, and for this reason, this area plays a key role in the decarbonisation of the country, following the government aims of becoming a carbon neutral country in 2050. Many changes as already in action to achieve the so claimed sustainable transition, despite some argue, seeing the still very high environmental negative impact of the past years, that the pathway to a positive and truly effective decarbonisation is still very long.

24. de Haas J., van Dril T., (2022) *Decarbonisation options for the industry cluster Botlek/Pernis Rotterdam*, PBL Netherlands Environmental Assessment Agency, The Hague

Map P: Map made by the author from GIS data from PDOK and the wesite of the Port of Rotterdam

History of the Port

The story of the port of Rotterdam dates back to the end of the fourteenth century, when the Netherlands started to become a central actor in international trade market and routes, and expanded gradually with the centuries, until when the largest expansions happened, starting from the end of the nineteenth century, when the first refineries were about to be established. The petroleum site in Pernis, which had stored petroleum since 1887, became the central location of the new development.

During the past century, the port has kept expanding to the West, showing a very dynamic transformative characterisation. This transformation did not only imply changes in the port infrastructure itself, as extraction, refining and consumption of petroleum made a huge impact also on sea, regional and national landscapes and cities. With the expansion of the port, many workers residential district were built, as the small villages present in the area were swallowed in the port landscape, and at the same time, many larger transformations were put in place, implying the reclamation of land in the estuary, the construction of new islands and the realisation of the Nieuwe Waterweg.

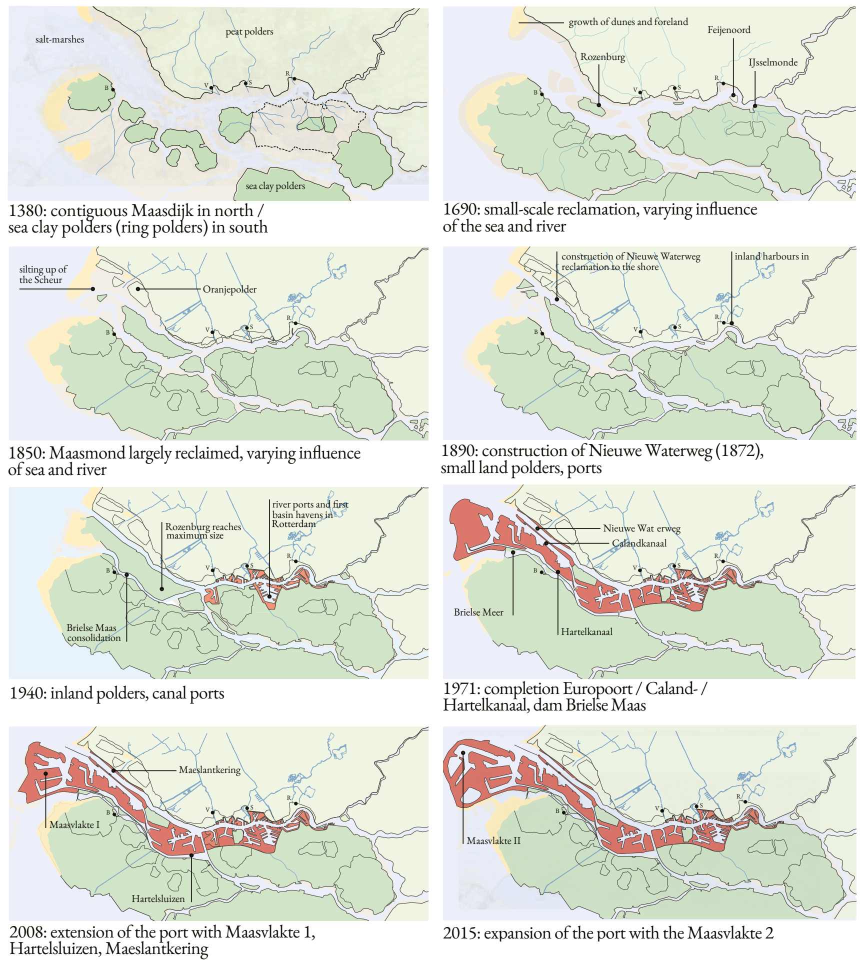


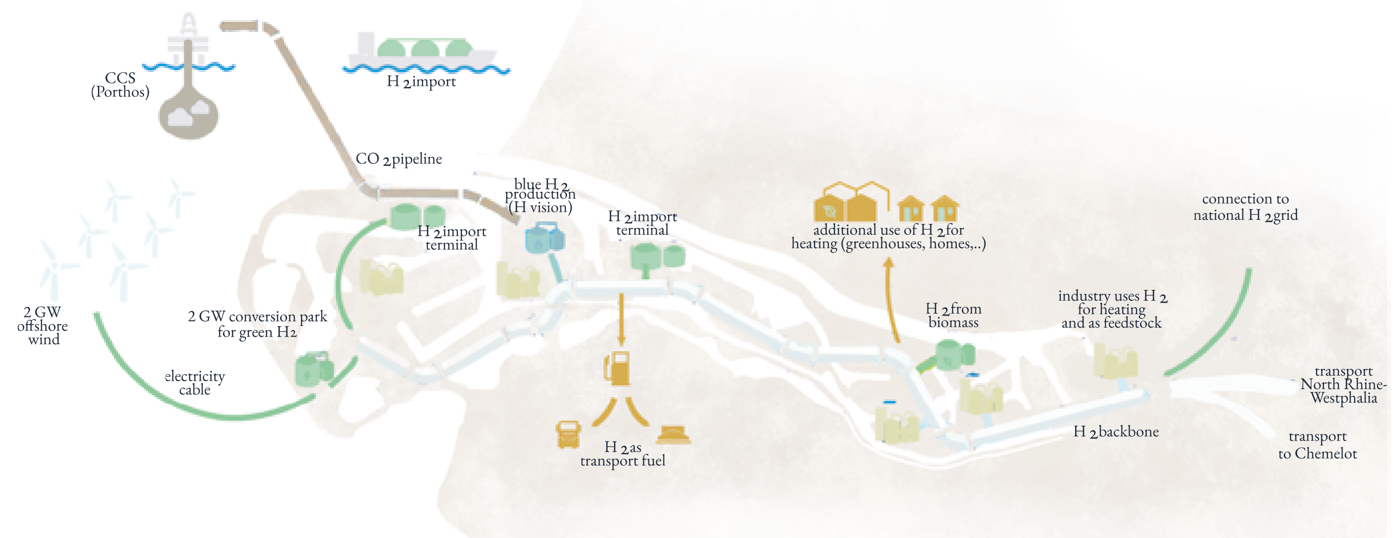
Fig. 18. Historical maps edited from **De Urbanisten, LOLA (LOst LAndscapes), Royal Haskoning DHV** (2022) RDD *Booklet IABR- Team 1: Redesigning Deltas - Rotterdam, from a port city to a port archipelago + sponge watercity. in Five future strategies for the Dutch delta in 2120*

Future of the Port

The port of Rotterdam has the aim to become ‘the smartest and greenest’ port of Europe, becoming a key actor in the transition towards a carbon free society; the scale of the investments needed will be unprecedented, but being so developed, its industrial complex has the technology base to facilitate the emergence of a post fossil energy storage, conversion and distribution hub.
Many transformations are being put in place to reduce the port emissions, and while some of them need to be realised in a shorter time span, others will require more years to adapt the entire port industrial infrastructure to a different type of energy production and its related activities.

The main changes have to do with the reduction of the emissions released in the atmosphere, with the storage of CO2 in underground reserves, or its use for other purposes, such as in the case of the OCAP project, and with the production of non-fossil fuels, such as biofuels and synthetic fuels, and the most important Hydrogen hub creation.
First, in these hard-to-debate sectors, lowering as much as possible the release of CO2 is a first step to the decarbonisation, and despite it could be argued that the easiest way would be to cut the responsible industries of these, we live in a capitalised world, where the economic interests are so high, than most of the times all the efforts are put on finding solutions for the environmental damages, rather than reducing the cause of them. Therefore, the most common path is to start mitigating the negative effects coming from the negative impacts, while developing a new system for being (carbon) neutral. The port of Rotterdam is no exception.

The figure below shows how it may change the port in the upcoming years, taking into account measures which are starting to be implemented and future plans



25. Hein, C. (2018). *Oil Spaces: The Global Petroleumscape in the Rotterdam/The Hague Area*. Journal of Urban History, 44(5), 887–929

Images:

Fig. 19 Map edited by the author using information from the Port of Rotterdam official webpage

Meanwhile the huge hydrogen hub is being developed, other operations are put in place to store the CO2 released in underground exhausted gas reserves with the Porthos project, so that the fossil fuel industry can keep on fully operating, as the economic and geopolitical interests of the companies involved are too strong to cease their activity. Nevertheless, these interests have to meet the European and national standards on decarbonisation, therefore, despite it is not clear if the long path will be fully undertaken in time for the established ‘deadlines’, it is sure that the fossil fuel industry will no longer look the same in Rotterdam.

The main initiatives for the CO2 storage foresee the improvement of its supply to other sectors, as in the case of OCAP, where a part of the CO2 emitted in Pernis plants is sent through a pipeline system to the horticulture companies in the Westlands, and the already mentioned Porthos project.
The OCAP initiative was initiated around 20 years ago, but its scale involves just some of the port companies, and right now is not reliable as the only effective one as a CCUS (carbon capture storage and utilisation) system, as the horticulture CO2 demand is highest in summer, therefore a seasonal CCS (carbon capture and storage) would still be needed.
The Porthos project aims are to acquire a central role in this sense, but the economic investments and technology involved are quite high, nevertheless, finally the companies involved have recently signed a contract, and the system should become operative from 2024 (Porthos project, 2022)

The transition to a non-fossil fuel based port economy see the production of bio based fuels and the aforementioned hydrogen production plants. Regarding the first, Royal Dutch Shell plc is to establish one of Europe’s largest biofuel plants in the port of Rotterdam, which will be able to produce sustainable aviation fuel (SAF) and renewable diesel from waste such as used cooking oil, animal fats and other industrial and agricultural residues.The green hydrogen is produced through a process called electrolysis, being converted from imported H2 thanks to green energy supplied by the offshore wind farm.

The end of ‘oil dominance’[25] is still very far, but it is more than clear that such a shift away from fossil fuels requires tremendous societal changes across a wide range of domains and activities.
Looking at the port itself, the transition to a more sustainable energy production will imply social, geographical and morphological changes its landscape and in the relations and influences it has with the region. At the same time, the port influence is very strong also when considering how securing its ability to keep on fully operate has impact of future scenarios about climate adaptation, as vessels will keep on moving along the direct

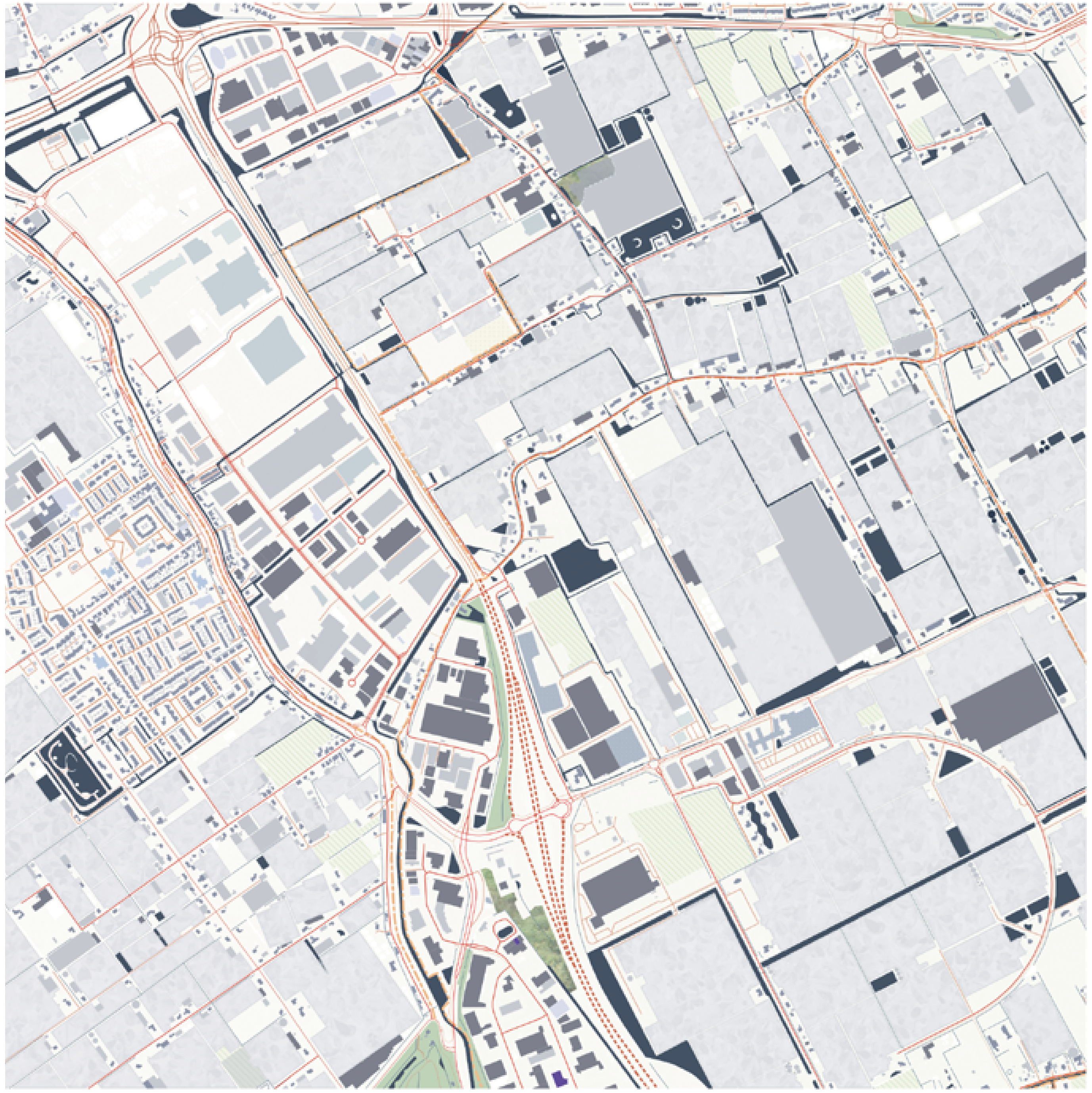
link between the region and the sea, whose level rise considerations are at the centre of the delta scenarios discourse.

Being largely inaccessible to other types of humans and non-humans activities, and at the centre of an unprecedented transformation, it is difficult to foresee how the port will look like in some decades. Indeed, it is a space dedicated to economic interests and, despite its future design will shape great changes in its infrastructures, flows and milieus of production, at the moment it would be too ambitious and partially inappropriate to imagine a reshaping of its landscape in our work, as it would lack a realistic diving in the updated context, that is still uncertain due to the mutations under way. In any case, the understanding of its mechanisms for the thesis purposes was useful to consider the necessity of imagine an area more interconnected to the other landscapes of production, permeable and able to host more biodiversity, human and non-human presence. Hopefully, the transition to a more sustainable energy production will imply a de-pollution of the site, and this could be helped and integrated by ecosystem services provided by nature biotic presence.

Fig 15. Picture taken by the author

Fig 20. Picture taken by the author

Glasscape



1 km

Water infrastructure system

Flood protections
- primary dyke
- levee
- lock

Water system
- riverbank
- inland water
- wetland
- polder canals

Green spaces
- grass land
- allotment
- forest
- park and public gardens
- recreation area
- sports ground

Buildings
- greenhouse
- church
- retail
- commercial
- house
- industrial
- office
- school
- construction
- other

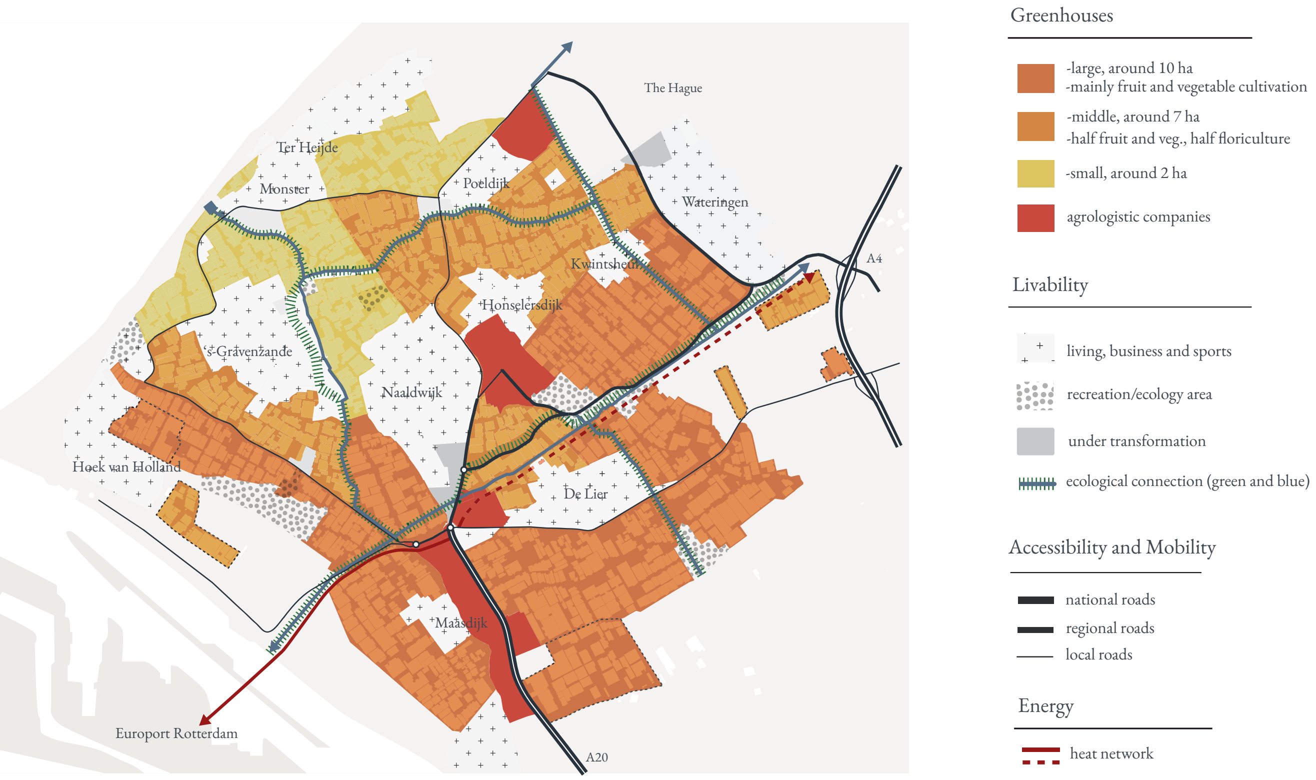
Mobility

Roads system
- railway
- motorway
- secondary
- tertiary
- residential
- pedestrian
- other

Landscape sample

Map P: Made by the author using GIS data from National Georegister and PDOK

Fig. 21. Picture edited by the author from Google Earth



The landscape defined as 'glasscape' is the area where the leading activity is the cultivation of fruit, vegetables and flowers production inside greenhouses.
Greenhouse horticulture is a leading and world-class industry in the Netherlands, which is the second largest exporter of these products in the world, with a huge area dedicated to its production in South Holland, which has grown exponentially in recent decades and will continue to expand, given its economic position, i.e. the ever-increasing demand, income and number of people employed in the industry.
This type of food production is concentrated in a specific area in the western part of the province, most of it in the municipality of Westland, which was formed a few years ago from the merger of several smaller towns. In the Westland area, thousands of hectares are completely covered with glass greenhouses, together with the headquarters of related companies and industrial clusters dedicated to related activities, such as logistics and research and development.

The history of horticulture in the Westland region reveals a continuous reliance on the seventeenth-century landscape as the fundamental basis for various cultivation practices. Over time, there have been expansions of plots, construction of new access roads, and filling of ditches. Nevertheless, the size of these plots has consistently determined the scale of greenhouse horticulture. Presently, Westland can be classified into three types of subdivisions: small irregular subdivisions, rational subdivisions, and block subdivisions, varying between regular and irregular layouts.

Fig. 22 Map edited by the author from **Hot - Satelliet Infra-Energie-Ruimte**, *Werkboek Westland, Ruimtelijk Economische Strategie Greenport 3.0*

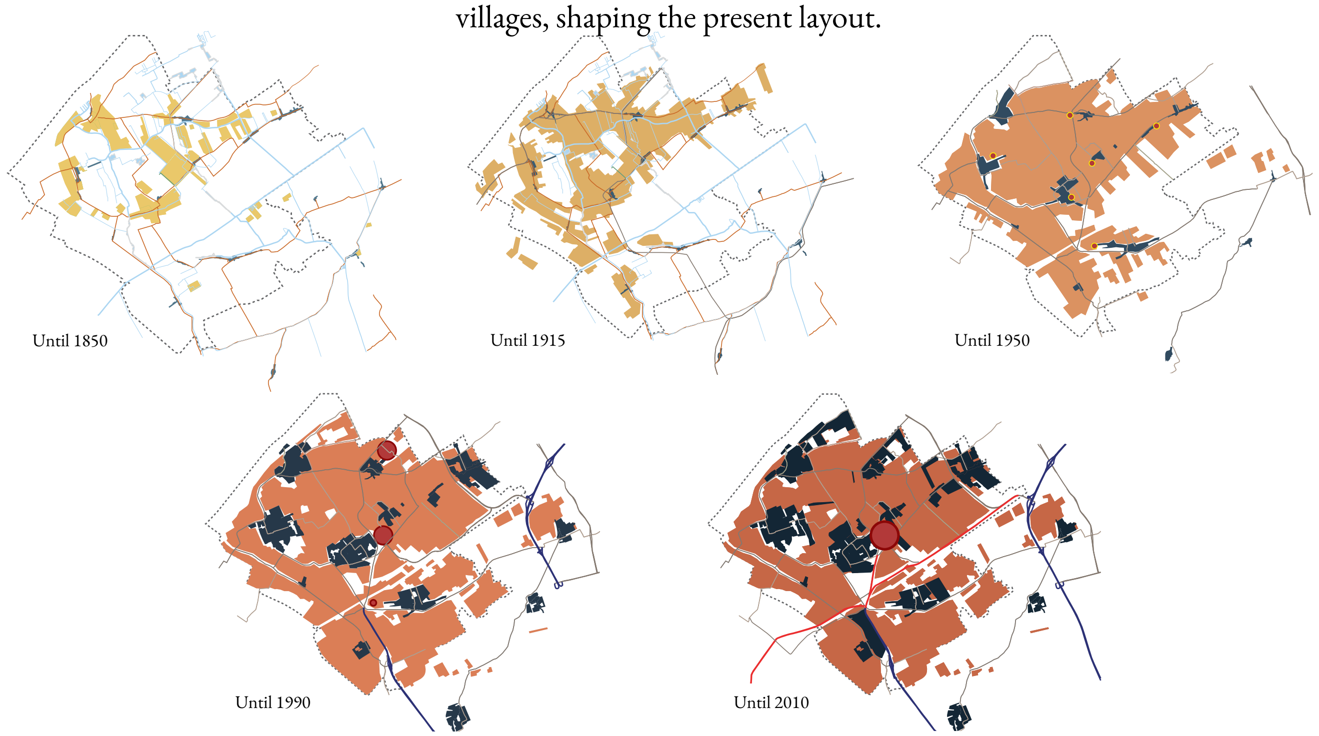
Fig. 23. Ibidem

History

In the past, fruit and vegetable cultivation was limited to a few farmlands situated on the edges of elevated, arid sandbanks, where three small villages were established. This local scale persisted until the late nineteenth century, when the dry sandbanks were excavated, and the wet clay soils were enriched with sand, dredging spoil, and urban waste. Consequently, larger areas of land became suitable for horticulture, and the distinction between high and low lands disappeared.

At the beginning of the twentieth century, market gardeners began organizing themselves into cooperatives and establishing cooperative banks. These developments, combined with the proximity to two large cities, led to a substantial growth of the horticultural sector, resulting in the creation of a large, contiguous horticultural area. However, it was during the 1950s that horticulture truly flourished: original small plots evolved into warehouses or interconnected greenhouses, and growers specialized in single crops. Simultaneously, ditches were filled, and horticultural roads were improved or constructed to link the area to logistical routes, enhancing mobility between greenhouse areas and expanding small towns.

Starting from the 1980s, automation and the adoption of new technologies significantly increased the productivity of horticultural enterprises. The introduction of growing on substrate, an artificial soil, marked a crucial revolution. Meanwhile, urbanization continued to progress, with new residential and commercial areas springing up around the old horticultural villages, shaping the present layout.



Impact on the environment

Despite the substantial workforce employed in the Westland horticultural area, the landscape gives the impression of an automated environment due to its high efficiency and utilization of cutting-edge technologies. To meet the market demand and maintain a high level of quality, fruits, vegetables, and plants are cultivated year-round, even in the challenging climate conditions of the Netherlands. This feat is made possible through the use of artificial heating, lighting, and water and nutrient steam, which, however, result in significant energy consumption.
Indeed, the energy consumption in the Westland greenhouse horticulture sector is substantial, accounting for over 1% of the total energy consumption in the Netherlands. This sector also contributes around 10% of the Dutch gas consumption, which is comparatively high compared to other horticultural regions. Specifically, about two-thirds of the energy used in Westland's greenhouse horticulture is dedicated to heat, with the heat demand varying based on the specific crop being cultivated. Generally, vegetables require high heat, while ornamental plants have a moderate heat requirement.

Horticulturists utilize carbon dioxide in their greenhouses to promote plant growth and reduce water usage. They introduce additional CO2 into the greenhouse using boilers or combined heat and power installations. However, CO2 is a significant contributor to the greenhouse effect, and global efforts to reduce emissions are underway. Ironically, additional natural gas is being burned in combined heat and power plants to generate CO2. Some growers even continue this practice during the summer months when heat is unnecessary. To address this issue, Organic Carbon Dioxide for Assimilation of Plants (OCAP) was established in 2003. OCAP captures CO2 released during industrial processes in the Rotterdam mainport since 2005.[26]

The majority of companies in the Westland area are now connected to the OCAP system, except for those located near the coast. However, the supply security of this system is a concern. If companies in the port cease or temporarily halt their supply for any reason, growers must resort to their traditional methods, such as using their own boilers or combined heat and power installations. Additionally, the supply is dependent on the use of fossil fuels in the Rotterdam port and industrial complex. If this usage declines over time, the CO2 supply will diminish as well.
Many horticulturists generate their own heat through various methods, including heat and cold storage in groundwater or utilizing combined heat and power (CHP) systems. CHP systems simultaneously produce heat and electricity, with the majority of the released CO2 returning to the greenhouse. Most CHP installations are powered by natural gas and have a heat storage tank that converts 92% of the energy content into electricity and heat.
In the eastern region, companies are establishing heat networks where they share CHP systems or collaborate on a common CHP or geothermal energy source. These private networks have the potential to evolve into a sustainable and well-connected energy network for the Westland, based on local investments and tailored to the specific needs of the area.

Water for irrigation is another critical resource for horticultural production. The water requirement varies depending on the crop type, with some crops like tomatoes and peppers requiring substantial amounts of water, while others like spinach and flowering potted plants require less. The distribution of crop species in Westland also contributes to variations in water requirements.

Due to salinization caused by sea level rise and subsidence, groundwater and surface water are not ideal options for irrigation. Horticulturists prefer low sodium content in water, as it allows them to add fertilizers and protection products as needed. A low concentration also enables longer water recirculation, reducing water usage and nutrient loss. Consequently, the only readily available water source that meets the standards of good irrigation water without extensive purification is precipitation. Rainwater that falls on greenhouse roofs is collected in above-ground storage basins.

The estimated total water demand for greenhouse horticulture in the Haaglanden region, including Westland and other greenhouse areas, is approximately 27.4 million m3 per year, with 23 million m3 allocated to substrate companies. In an average precipitation pattern, rainfall seems to be sufficient to meet almost the entire water demand of substrate companies (98%). However, variations in precipitation and the need for supplementation with desalinized brackish groundwater result in a less favorable situation in practice. Nonetheless, sufficient irrigation water is typically available, even in dry years. [27]

Nevertheless, with climate change, rain showers are expected to become more intense, increasing the peak load on the water system. To accommodate this, additional measures and emergency storage facilities are being considered. Currently, a search is underway for an emergency storage facility in the western part of Westland to handle potential system overloads and flood threats. Utilizing space for dual purposes is highly desirable due to the infrequency of such situations, which typically occur once every ten to twenty years. The storage water system is generally functioning well, but there are bottlenecks in flow and discharge during extreme rainfall due to narrow waterways in the storage basin area.

26. Hot - Satelliet Infra-Energie-Ruimte, *Werkboek Westland, Ruimtelijk Economische Strategie Greenport 3.0*

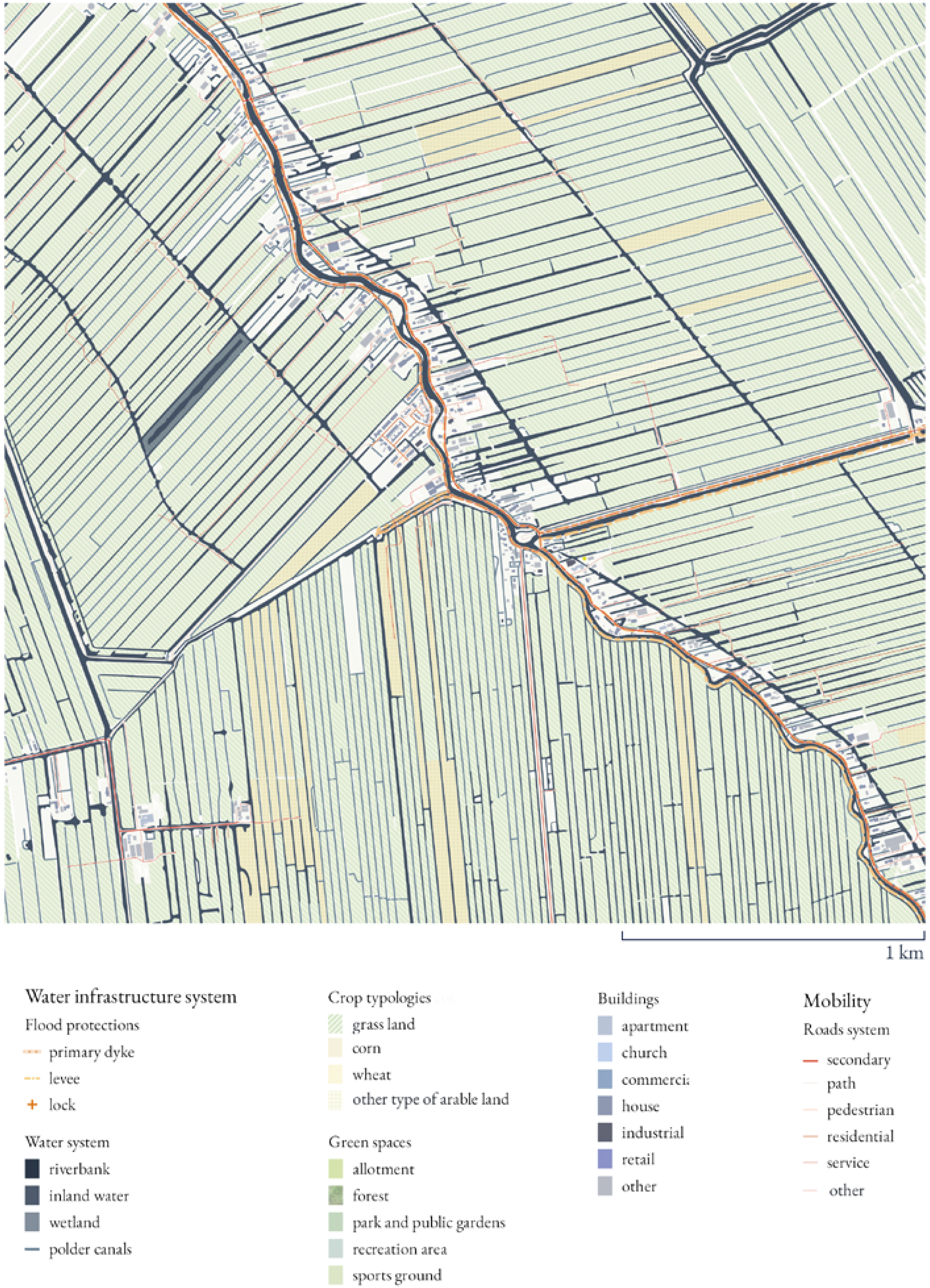
27. *Ibidem*

Last but not least, this productive landscape leave traces in terms of pollution also in the water system. The chemical water quality of the surface water in the Westland still leaves much to be desired, due to the substances added in irrigation water, such as pesticides. Delfland wants to intensify efforts in cooperation with partners (municipality, LTO and market gardeners) to improve the chemical water quality in the greenhouse horticulture area in the coming years. To this end, municipalities have taken measures to further reduce overflows from the sewers or to make them cleaner.

Overall, improving energy efficiency, minimizing CO2 emissions, and adopting sustainable water management practices are essential for the future of greenhouse horticulture in the Westland region.

Farmscape

Fig 24-25. Picture taken by the author



Landscape sample

Map Q: Made by the author using GIS data from National Georegister and PDOK

Fig. 26. Picture edited by the author from Google Earth

Buildings
- apartments
- church
- other
- commercial
- house
- industrial
- retail

Water infrastructure system

Flood protections
- primary dyke
- levee

Water system
- riverbank
- inland water
- wetland
- polder canals

Green spaces
- allotment
- forest
- park and public gardens
- sports ground

Crop typologies cut
- Arable land
- Grass land

Crop typologies cut detailed
- corn
- wheat

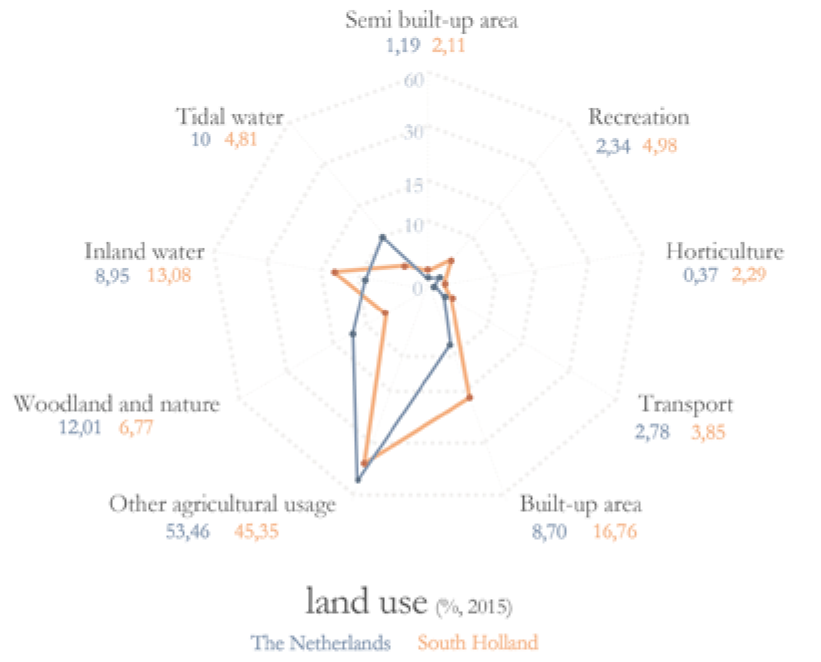
Mobility

Roads system
- cycleway
- path
- residential
- service
- tertiary
- track

Landscape sample

Map R: Made by the author using GIS data from National Georegister and PDOK

Fig. 27. Picture edited by the author from Google Earth



Agricultural production in the Netherlands represents one of the main economic sources of the territory, as well as the most extensive land use nationwide, and the province of South Holland, despite the presence of other much more industrialised economic activities with a more recent tradition, is no exception to this consideration, as can be seen from the figure.

Livestock farming constitutes a pivotal component of South Holland's agricultural sector, encompassing the breeding of animals for diverse purposes such as meat, dairy, and ancillary products. Notably, dairy farming commands a substantial presence in South Holland's livestock production landscape, characterized by Dutch dairy cattle renowned for their exceptional milk productivity and superior milk quality. The province hosts an array of dairy farms, many of which are family-operated establishments.

Furthermore, South Holland plays a significant role in poultry and pig farming, bolstering the supply of these vital components in the daily diets of the Dutch populace and serving as primary export commodities.

However, concerning environmental concerns, it is imperative to highlight that the prevalence of meadows and the eradication of weeds to support intensive livestock farming have exerted adverse ramifications on local biodiversity. This ecosystem modification has compromised the survival and propagation of indigenous wildlife and flora.

Moreover, intensive livestock farming has raised concerns regarding nitrogen emissions. Although nitrogen itself is not inherently deleterious, emissions in the form of nitrogen oxides and ammonia pose substantial environmental risks. Nitrogen oxides originate from fuel combustion, whereas ammonia emanates from animal manure.

Fig. 28. Chart made by the author from PBL data

The excess deposition of these particles can engender adverse effects such as acid rain, soil degradation, groundwater contamination, and biodiversity degradation. Alarmingly, the Netherlands boasts the second-highest nitrogen surplus in Europe, averaging more than double the European average in gross nitrogen balance between 2010 and 2015.

In response to the imperative of mitigating nitrogen emissions, measures have been undertaken, necessitating a meticulous examination of the agricultural sector, which accounts for nearly half of all nitrogen depositions in the country. These endeavors have yielded partial success, with nitrogen deposition nearly halving since 1990. Presently, the Dutch government aims to effect a substantial reduction in livestock numbers by one-third over the next eight years, contemplating strategies such as farmer buyouts, farm relocations away from ecologically sensitive areas, and fostering sustainable farming practices. While voluntariness remains the preferred approach, the potential for compulsory buyouts looms if farmers resist cooperation.

Dutch agricultural production underwent significant intensification post-World War II, guided by policies striving for greater sectoral efficiency. The transformation witnessed a transition from small, diversified farms to large, specialized enterprises. Over this period, the number of agricultural companies plummeted from 410,000 in 1950 to 55,000 in 2016, according to Statistics Netherlands.

In the rural clay landscape that predominates, potato and sugar beet cultivation holds sway. Intensive modern agriculture has translated into substantial financial gains through exports, aligning with burgeoning market demands and affordable prices achieved through mass production. However, monocultural agricultural practices have spawned a slew of environmental issues.

Foremost among these concerns is the injudicious use of artificial fertilizers containing nitrogen, resulting in nutrient leakage. Crops fail to assimilate all nutrients, leaving surplus nutrients and salts to infiltrate groundwater and surface water, instigating water eutrophication. Concurrently, these practices contribute to a substantial loss of biodiversity. The copious use of pesticides in the agricultural sector adversely affects humans, animals, bees, insects, soil, and water, engendering localized accumulation of toxic substances.

Lastly, an estimated 1,028,870 tons of green waste is generated annually throughout South Holland. Addressing this substantial volume of green waste necessitates comprehensive recycling and integration into the circular economy, promising valuable sustainability dividends.

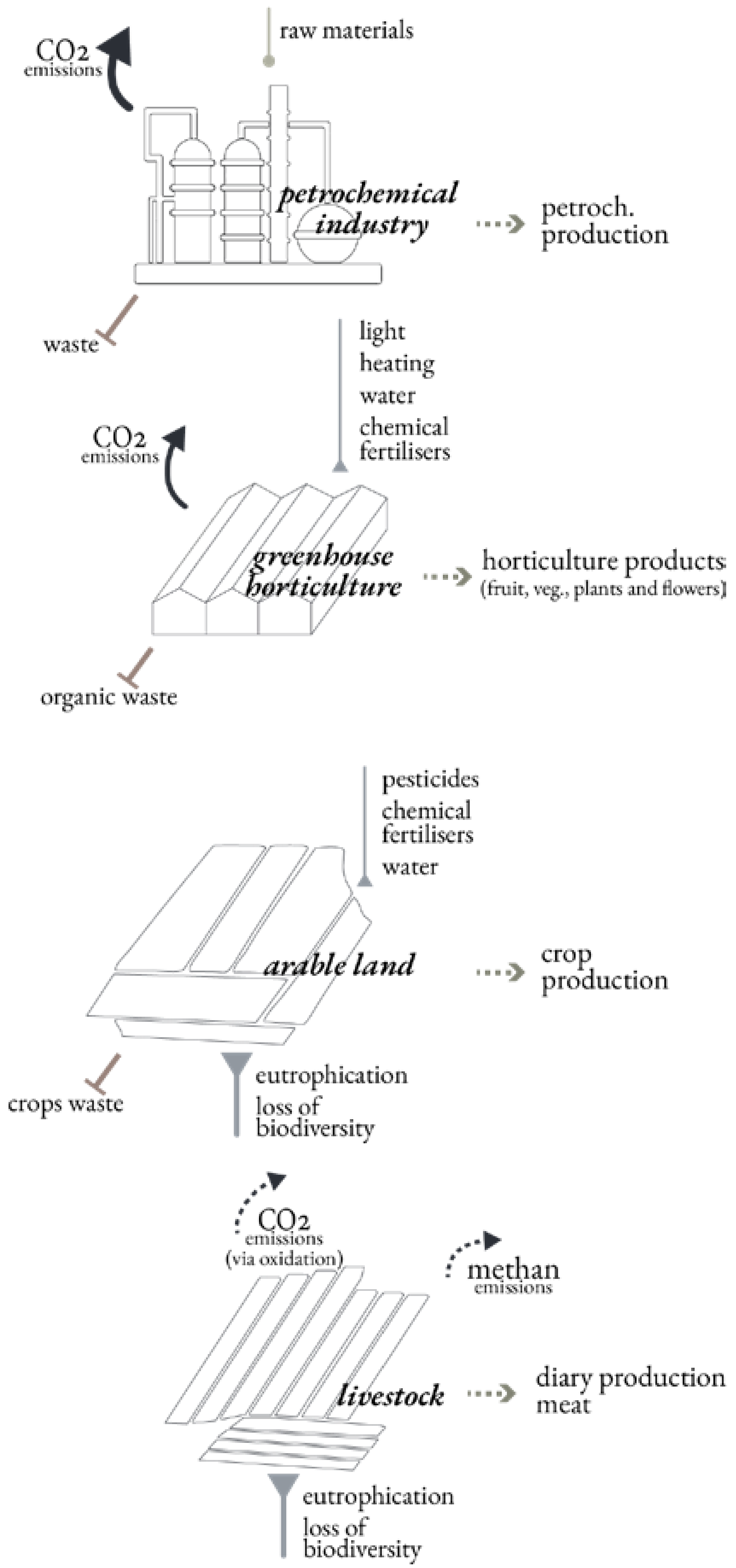


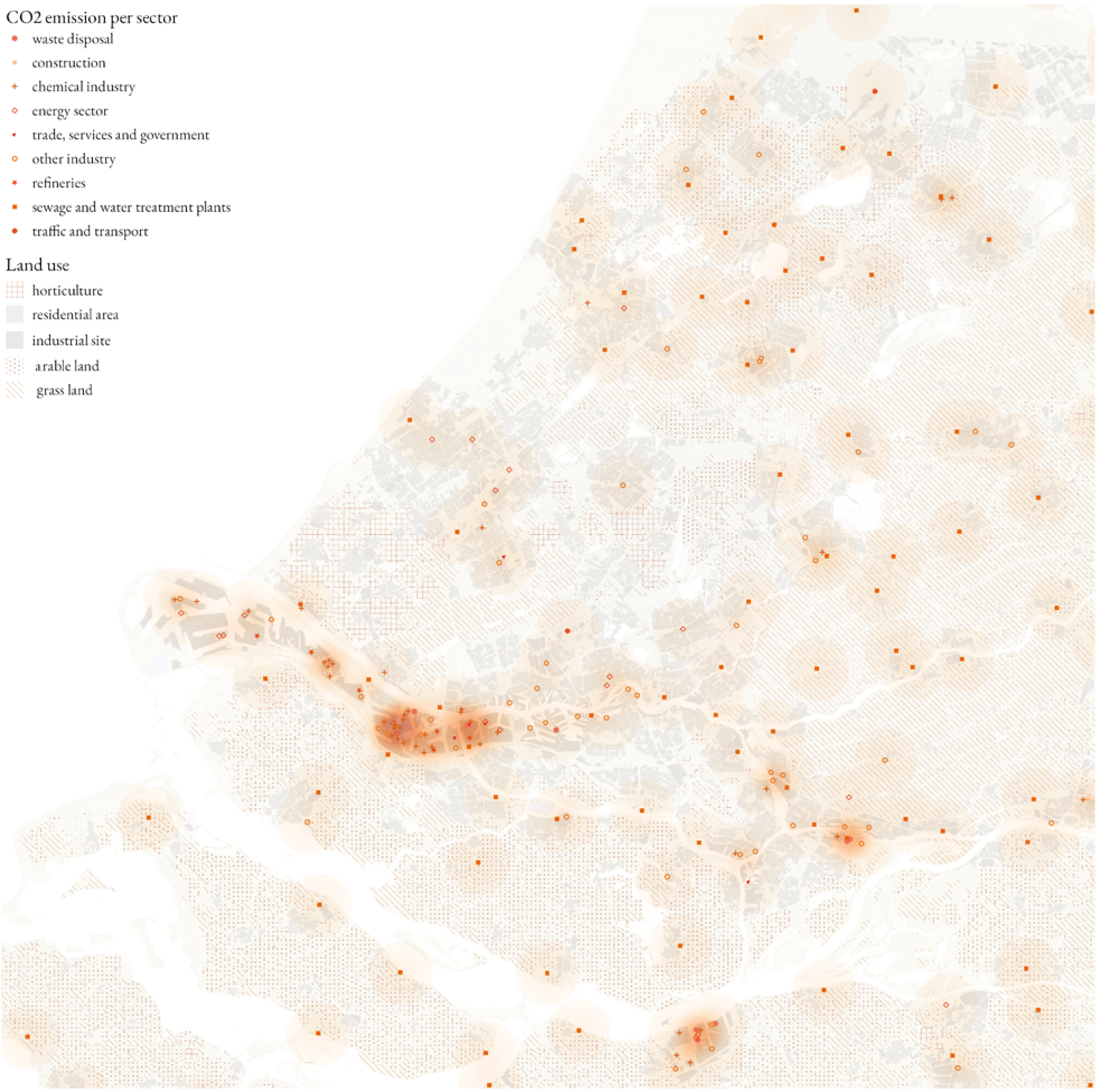
Fig. 29. Diagrams made by the author

Inputs and outputs from and to the environment

These diagrams give an overview of what is discussed in the previous section for each productive landscape, showing the impact they have on the environment, in particular on soil, air and water conditions, as will be shown in the critical cartographies that follow.

This is a starting point for reflecting on what the role of spatial design might be in this context, with the clear understanding that the prerogatives and possibilities of this discipline are not necessarily able to address all of these challenges, but with the idea that by staying within the field of action of the discipline itself, it is possible to include the management of some of these issues in strategies for the adaptation of productive landscapes themselves.

The categories taken into account in these diagrams concern inputs, understood as both raw materials and the means necessary for production, such as energy sources and water, and outputs, taking into account both materials produced, waste and environmental impacts.



Production and air pollution

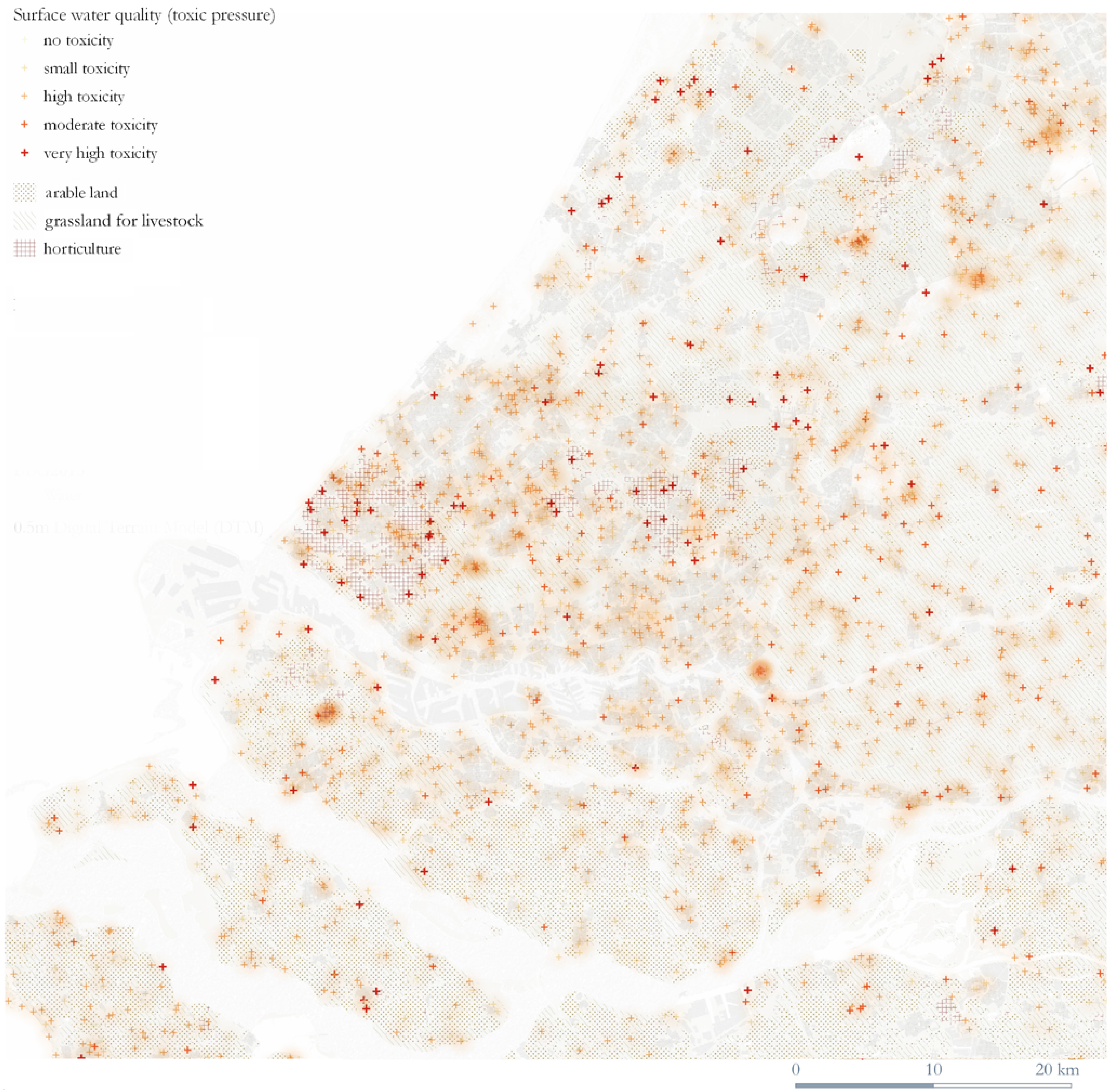
This critical cartography relates pollution levels per sector to the type of land use.

Critical areas of higher intensity (brighter colour) show a higher concentration of emissions in that area.

It is clearly visible that the highest levels in the region are in the zone of the Port of Rotterdam, which, as already discussed, is one of the largest contributors of carbon dioxide and other toxic gases nationwide, mainly due to refinery operations, the presence of which is set to change in the coming years in order to comply with national and international emission guidelines

Horticultural and agricultural production activities are also partly responsible for the generation of emissions, but they have a lower impact at a national level than those of the Port, which are indeed substantial and, moreover, are more diffuse over the territory and not located in more punctual locations, as those shown by the data used to make the map.

Map S: Made by the author using GIS data taken by the National Georegister and the Warmte Atlas



Production and water pollution

This map shows the level of groundwater pollution in relation to the main production activities involved. The use of this term indicates both that these productive landscapes are the most affected by poor water quality and that they are among the main polluters (along with human activities in urban areas and highly polluting industrial activities).

As already mentioned, the chemicals contained in fertilisers and pesticides penetrate the subsoil and reach the groundwater and thus the entire water system.
At the same time, however, this represents a vulnerability factor for the quality of the same water that is a fundamental source for irrigation and the maintenance of production itself.

It should be noted, however, that due to the high salinity of the groundwater in the coastal areas of the region, there is often a tendency to prefer rainwater to groundwater, especially in the case of greenhouses, where groundwater is extracted anyway at times when there is no rainfall.

Therefore, the impact of the production on the environmental conditions is certainly greater than the impact of these conditions on the production, since the degradation of the environment (in this case, water quality) is already caused by the production itself anyway.

Map T: Made by the author using GIS data taken by the National Georegister and the Atlas Natuur Lijk Kapitaal

Climate change policies framework

History of Dutch policies for adaptation to climate change

Sea level rise scenarios

Deltares scenarios

PART 1.2

History of Dutch policies for adaptation to climate change

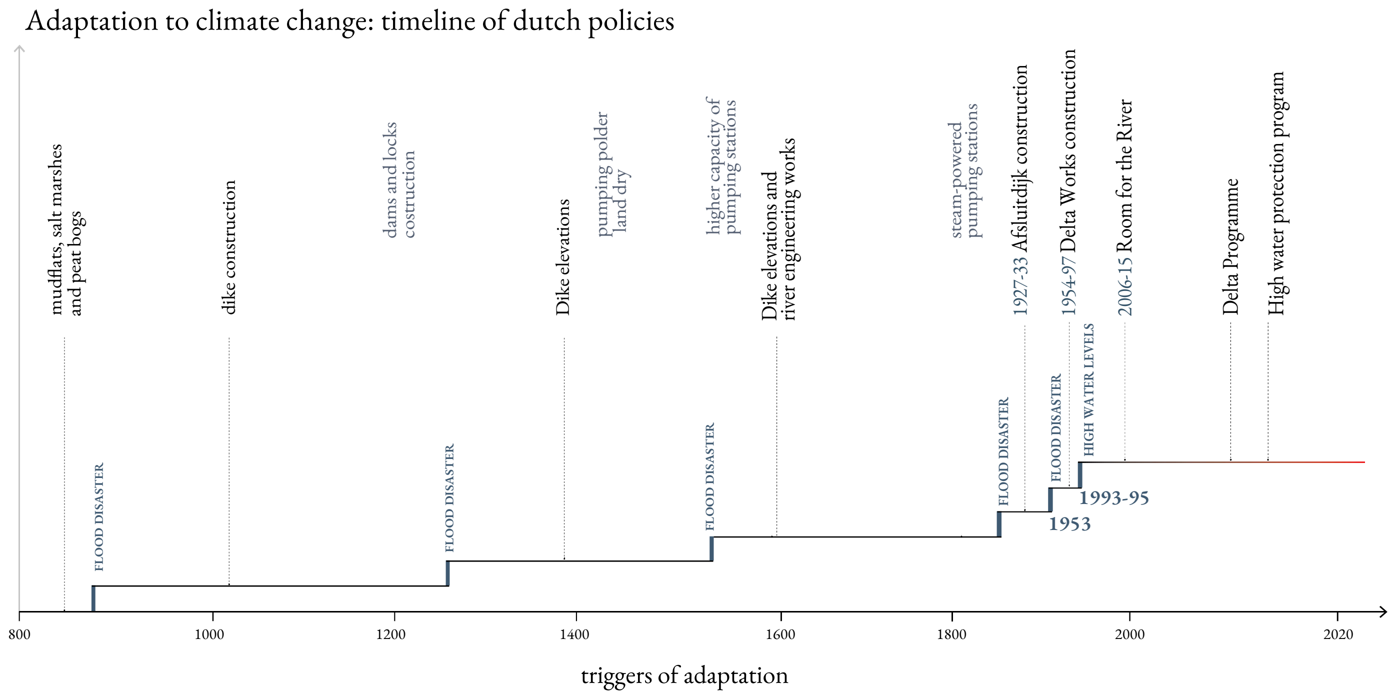
Given the geographical context of the Dutch coastal area and the tradition of land reclamation, the country has a long experience in dealing with the impact that certain adverse climatic events have had on the territory over the past centuries.

Indeed, since the construction of the first dikes, numerous flood risk management measures have been developed, first on a national level and then with specific regional applications. For these purposes, Rijkswaterstraat (Directorate General for Public Works and Water Management) was created at the end of the XVIII century, and Water Boards, which are regional governmental bodies charged exclusively with the management of surface water.

Looking back a few centuries, the measures taken served to increase the level of safety and reduce the risk of flooding.
These measures have been taken partly to define such a system and partly, especially in the last century and a half, to implement it in such a way as to reduce the risks associated with an increase in the probability of their occurrence.

The timeline below show the occurence of climatic adverse events in the past centuries and their relation with measures undertaken at a national level.

Fig. 30. Diagram edited by the author with data from **Deltares, BoschSlabbers & Sweco, (2021). Copyright © Deltares** 2021. *Water-based; limits to the manufacturability of our water and soil system.* and LOLA, Blan B: NL2200- The nation formerly knows as The Netherlands



To take a broader view, the international literature states that "*A diversity of adaptation responses to coastal impacts and risks have been implemented around the world, but mostly as a reaction to current coastal risk or experienced disasters*", meaning that very often measures are taken after the happening of a high-impact adverse climatic event.
This was also the case with The Netherlands. In particultar, some cathastrophic events in the XX century determined the definition of some nation wide policies, that resulted in the consolidation of the defence system, and later on the expansion of the space for the river to host an increased water capacity.

Furthermore, for that same time, it can be stated that there was also an increase in the occurence of these events, due to alterations in weather patterns and associated water levels caused by climate change.

This topic is of particular relevance in a country where around two thirds of the land lies below sea, and, also thanks to the already mentioned expertise, there is a huge debate nation-wide among governmental institutions, and private organisations, from research centres to civil engineering and spatial planning companies. This debate is around risk associated to climate change scenarios, such as expected sea level rise, and the possibile measures to undertake.

The 1953 flood and the Delta Works

This event, remarked as 'the North Sea flood', caused more than 2500 deaths, among which more than 70% occurred in the Netherlands, and marked a deep and lasting impact on the memories of those who survived. This was not the first big flood happening in the country, but it highlighted particularly the importance of flood risk management. In fact, as part of the Delta Plan (1953-1997), extensive measures were taken to reduce the risk of such disasters happening again in the future.

The Delta Plan's primary goal was to protect the low-lying delta region of the Netherlands from future flooding events and to ensure the safety of its inhabitants.
The plan involves a comprehensive network of dikes, dams, sluices, locks, and storm surge barriers strategically placed along the Dutch coastline and major rivers. This intricate system effectively shields the country from both river and coastal flooding.

The Plan was implemented in multiple phases, with the first phase starting in the 1950s and continuing through subsequent decades. One of the most iconic structures of the plan is the Delta Works, which consists of a series of impressive engineering feats, such as the Maeslant Barrier, located close to Rotterdam and the Haringvliet Sluices.
These engineered mega structures have a profound and far-reaching impact on the Dutch, as the project has significantly altered the physical geography of the Netherlands, influencing the relationship between the country and the sea.

One of the most notable consequences of the Delta Works is the transformation of the Dutch coastline. The construction of robust dikes, dams, and storm surge barriers has reshaped the natural contours of the coast-line, creating a fortified coastal defense system.
Furthermore, they have had a significant impact on the country's hydrology and freshwater management. By controlling water levels in major rivers and estuaries, the project has facilitated land reclamation and enabled agricultural expansion. Large areas of polders, once submerged under seawater, have been reclaimed for habitation and cultivation, providing valuable agricultural land to support a growing population.

While the Delta Works have ensured flood protection and land reclamation, they have also had an impact on the natural environment, both positive and negative. While it has protected valuable ecosystems and preserved biodiversity by preventing large-scale flooding, it has also disrupted some natural processes. The construction of barriers and dikes has altered tidal movements and water flow, affecting the habitat of certain species and causing changes in sedimentation patterns.

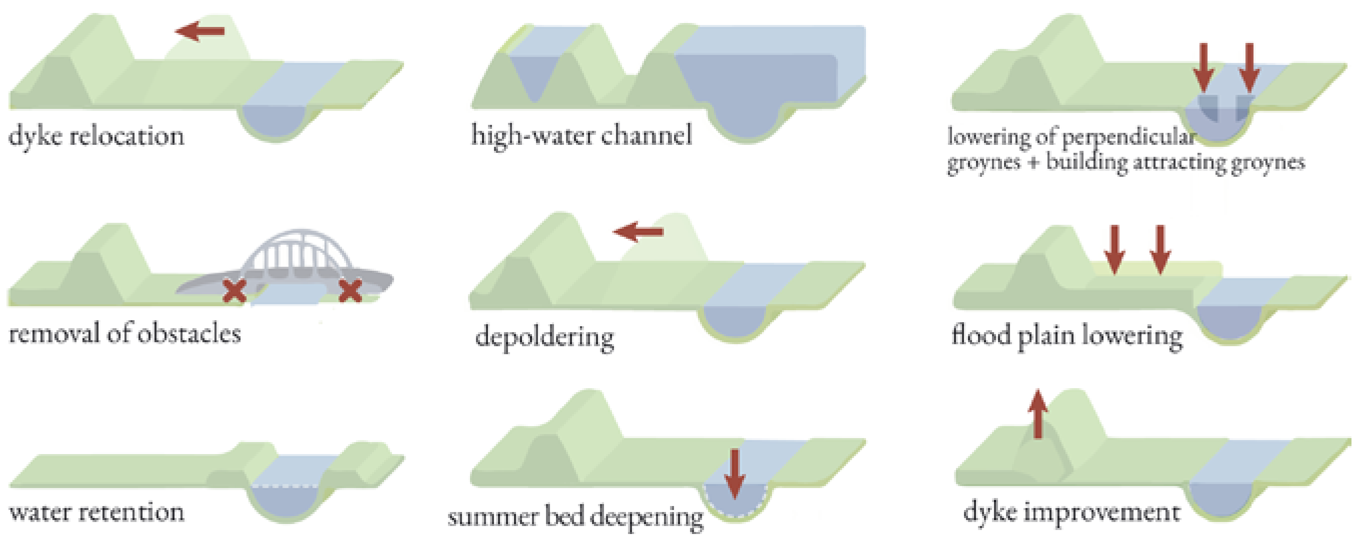
Room for the River

After a few decades, the country had to face another climatic disaster. In 1993 the water of the major rivers rose to threatening levels, and in 1995 the risk of flooding increased to such an extent that the authorities decided to evacuate 250,000 residents and a million animals for safety reasons. [28]

At that point, it became clear that, as climate change and other factors have led to more extreme weather events, conventional flood protection measures became insufficient to cope with potential river overflows.
Therefore, those events gave rise to the Room for the River programme. Its objective was to meet the required level of protection along the Rhine basin and the downstream section of the Meuse, while at the same time further improving the quality of the area, with the idea of a sustainable urban developmenet that integrates haroniously with the natural landscape.
The programme has made the area around the major rivers safer and stronger in economic, ecological and landscape terms, while creating added value for residents, leisure facilities, the economy and nature.

Between 1995 and 2015, around 500 kilometres of rivers were tackled in a programme comprising 34 measures: excavating floodplains, relocating dikes, lowering groynes and embankments, improving dikes, removing obstacles, depoldering and constructing a flood channel. These actions were designed to optimize the rivers' capacity to hold and disperse water, simultaneously offering opportunities for ecological restoration and enhanced recreational activities in the newly created riverine areas.
The project sought to strike a balance between flood protection and environmental considerations. Instead of solely relying on higher and stronger dikes, the Room for the River project aimed to allow controlled flooding in designated areas, which would reduce the pressure on the main river channels and mitigate flood risks downstream.

This approach was based on the understanding that giving the rivers more space to spread out during floods would effectively manage water levels and prevent catastrophic breaches.
Throughout the implementation of the project, collaboration between the government, local communities, environmental organizations, and other stakeholders was crucial to ensure that the chosen solutions would be well-suited to the specific conditions of each river region while minimizing adverse impacts on local ecosystems and communities.



28. Slomp, R, Room for the River, project examples, (2007) lecture at IWASA 37, Aachen

Fig. 31. scheme showinng the measures of the program, edited by the author from the Room for The River website

Sea level rise scenarios

The effectiveness of the country's protection system, its adaptation, and how to pursue it further are crucial topics for the Netherlands and the world in the context of the risks posed by global warming to coastal areas.

Before examining the strategies developed by institution-supporting research organizations such as Deltares and how this thesis fits into this context, it is essential to take a brief step back. In fact, the development of future scenarios for the Netherlands was based on scientific data provided by models developed by international research institutes. Knowledge of these models is essential to fully comprehend their starting points and potential implications.

As stated by the Intergovernmental Panel on Climate Change, '*Based on multiple lines of evidence, there is high confidence that anthropogenic forcing very likely is the dominant cause of observed GMSL (global mean sea level) rise since 1970'.* [29]

Indeed, human activity is largely accountable for discharging a range of harmful pollutants (the main ones being CO_2, CH_4 and NH_4) from diverse sectors which, once emitted into the atmosphere, cause a reduction in the atmosphere's ability to reflect (and partly absorb) ultraviolet radiation, leading to a rise in temperature in the past century, more intensively in thr last decades, which has also led to other extreme climatic events such as periods of drought and heavy rainfall.

One of the most concerning consequences of climate change is precisely the future rise in sea level '*due to thermal expansion, melting of glaciers and ice sheets, and changes in land water storage*'.[30]
A crucial aspect of this issue is its high level of uncertainty. Currently, it is impossible to provide an accurate prediction of the degree of sea level rise for the upcoming century and beyond, as there is a considerable range of variation that depends on the extent of mitigation that can be attained in the coming decades. This greatly hinges on whether the guidelines outlined in the Paris Climate Agreement for the temperature goal can be fulfilled. In fact, emissions released over a given period remain in our atmosphere for many years, so the effect of measures taken over several decades (but in a more structural way with the 2015 agreement) will be better seen in less than thirty years: it is estimated that the resulting levels of sea level rise can be verified from 2050 onwards.

Future rise in GMSL is strongly dependent on which Representative Concentration Pathway (RCP) emission scenario is followed. [31]

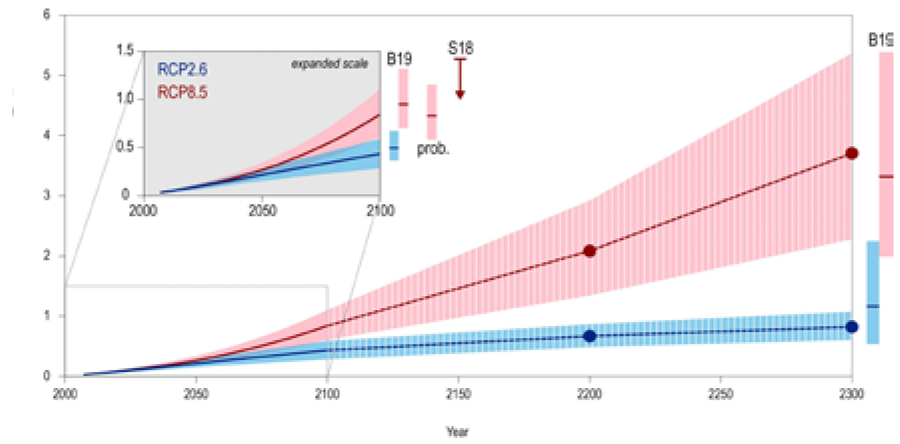
29. Oppenheimer, M., et alii (2019), *Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities.*

30. *Ibidem*

31. *Ibidem*

These are provided by the IPCC and are '*based on scenarios published in the existing literature, developed independently by different modeling groups and, as a set, be 'representative' of the total literature, in terms of emissions and concentrations',* [32] taking into account future possible enrgy uses, carbon emissions, landuses, demographic trends to mention the most important factors.

Taking into account a scenario rather than another has consequences on the corresponding sea level scenario:
As the graph below shows, the range of GMSL varies based on the impact of warming, and it is also visible as the uncertainty rises while going further in time. In fact, the projected sea level rise until 2300 is even more unsure, and the possible range refers to the temperature rising scenario that will occur in the reality.



'*Depending on the greenhouse gas emission scenario, climate change may result in a SLR in 2100 (relative to 1995-2014) of 0.28-0.55 (assuming an extremely loe emission scenario SSP1-1.9) to 0.98-1.88m (assuming an extremely high emission scenario SSP5-8.5). Due to deep uncertainty in ice sheet processes in Greenland and Antarctica, a SLR of 2 m in 2100 cnnot be ruled out.*
These large uncertainties in the projections significantly increase the challenge for investment planning in coastal management strategies in low-lying densely populated coastal zones such as The Netherlands'. [33]

These scenarios have therefore been the basis for the development of possible adaptation strategies to the effects of climate change at international and local levels.
A large part of the recent studies on future impacts has focused on the RCP8.5 warming scenario, which is often referred to as 'business as usual', suggesting that it is a possible outcome if society does not make the necessary efforts to cut harmful gas emissions. [34]

32. IPCC. *Summary for Policymakers. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group 1 to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, (2021) Cambridge University Press: Cambridge, UK,

33. Ibidem

34. Hausfather, Z., (2019) *Explainer: The high-emissions 'RCP8.5' global warming scenario,* in *Carbon Brief*

Deltares scenarios

With the Delta programme, the country continues to prepare for the futu-re. At the same time, people are kept ‘trained’ to deal with adverse events and to remain aware of global warming trends. Together with all stakehol-ders, the country must keep up the pace in implementing the National Delta Programme. Fulfilling the Paris climate agreements is essential if the nation’s water challenges are to be met: reducing global warming and clima-te-proofing the country. Both require simultaneous and dynamic action.

The Programme is a strategic long-term initiative undertaken by the Dutch government to address the challenges posed by climate change and ensure water safety and freshwater supply in the Netherlands. It was launched in 2010 in response to the increasing risks associated with sea-level rise, river flooding, and extreme weather events that could potentially affect the coun-try’s low-lying and vulnerable delta region.
The aim is to to provide a comprehensive and integrated approach to water management, spatial planning, and climate adaptation, and operates on a multi-decadal time frame, typically updated every six years, to account for evolving scientific knowledge and changing circumstances.
Delta Programme has an adaptive approach, trying to find a *’balance between “too little too late’ and ‘too much too early’, to determine the measures that are necessary (or ‘low regret’) for now, maintain open options for future additional measures’.* [35]

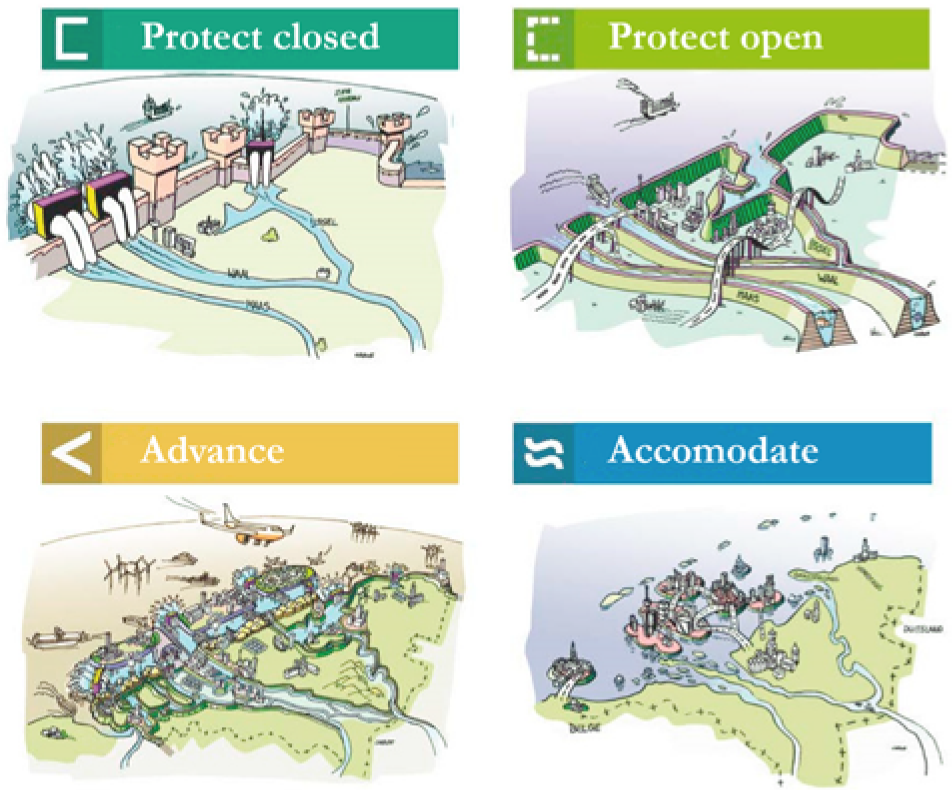
The initiative involves close collaboration between various governmental agencies, research institutes, and the public to develop and implement effective strategies for flood risk management and sustainable water mana-gement.
One crucial partner in the Dutch Delta Programme is Deltares. Deltares plays a pivotal role in providing scientific research, technical expertise, and innovative solutions to support the decision-making process with-in the programme. As an independent research institute specializing in water-re-lated issues, Deltares contributes significantly to the development and assessment of strategies for flood risk management, spatial adaptation, and climate change adaptation.
The research conducted by Deltares helps to identify potential risks and vulnerabilities, develop adaptation strategies, and evaluate the effectiveness of proposed measures.
Additionally, Deltares is involved in the development and improvement of flood risk models, hydrological models, and coastal engineering solutions used in the Delta Programme’s decision-making processes.

35. Bloemen, P.J.T.M.; Hammer, F.; et alii *DMDU into practice: Adaptive Delta Management in the Netherlands*. In *Decision Making under Deep Uncertainty: From Theory to Practice*; Marchau, V.A.W.J., Walker, W.E., et alii.; Springer International Publishing: Cham, Switzerland, 2019; pp. 321–351.

Its contributions ensure that the strategies and measures implemented within the program are based on robust scientific foundations and cut-ting-edge knowledge.

The institution has developed a comprehensive set of scenarios that aim to provide insights into the different possibilities of sea-level rise in the Netherlands. These scenarios take into account various factors, including global climate change projections, local environmental conditions, and potential human responses to chang-ing circumstances.
The scenarios consider a range of sea-level rise projections, which are based on different greenhouse gas emission scenarios and corresponding climate models, precisely those discussed above and elaborated by IPCC.

They are not intended as precise predictions but rather as tools to inform decision-makers and planners about the possible risks and opportunities associated with sea-level rise. By exploring a range of scenarios, stakehol-ders can better understand the uncertainty and make more robust plans and adaptation strategies.
It’s important to emphasize also that they are not mutually exclusive, and various combinations of these strategies may be implemented based on local conditions and the level of acceptable risk.
These scenarios are typically used to assess the potential impacts on coastal infrastructure, urban areas, agriculture, and natural ecosystems. Addi-tionally, they are used to identify vulnerable regions that might require specific attention and investments in adaptation measures.



Four scenarios have been developed:

1. *Protect Close*:
The "Protect Close" scenario centers on strengthening and preserving existing coastal defenses, such as dikes, dunes, and sea walls. This approach is aimed at providing a high level of protection for densely populated areas and critical coastal infrastructure. Within this scenario, the primary focus is on maintaining and enhancing the current defense structures to ensure their resilience against projected sea-level rise and extreme weather events. The strategy's objective is to safeguard immediate coastal regions, enabling society to maintain its existing land use and development patterns with minimal alterations.

As a result of implementing this scenario, there will be an increasing demand for space to accommodate these protective barriers, as well as for temporary storage of river water during periods of high discharge.

2. Protect Open:
The "Protect Open" scenario places a strong emphasis on a more environmentally conscious and dynamic approach to coastal protection. It involves making room for natural coastal processes, such as the formation of sand dunes, the movement of sediment, and the influence of tides. This strategy often entails the restoration and enhancement of coastal ecosystems like salt marshes and sand dunes, which serve as natural defenses against rising sea levels and storm surges. By allowing for more open and natural coastal areas, this scenario aims to preserve ecological resilience, offer recreational and ecological benefits, all while ensuring sufficient protection for inland regions.

It's worth noting that maintaining a closable connection to the sea remains effective up to a certain threshold of sea level rise: most likely this solution is no longer expected to be sustainable froma rise in the sea level of 1 to 1.5 m. To extend this effectiveness, one can consider raising the closing level of barriers that can be sealed and raising the dikes positioned behind them

3. Advance/Seaward:s
In this approach, the current coastline is extended towards the sea to create a more resilient coastal flood defense. This can be viewed as a specialized form of protective strategy, simultaneously yielding 100–500 km2 of new land. A more radical alternative involves constructing a new, closed coastline located 10–20 km offshore. This offshore barrier would protect the existing coastline while also forming a brackish reservoir capable of buffering river discharge during periods of river floods before redirecting it across this new coastline.

Despite with this option the current land use could be mantained, it is noteworthy to consider that for the construction of those islands really a lot of sand would be needed, and despite new land and a coastal lake offer opportunities for economic development and freshwater supply, they would also have major negative consequences for nature, shipping, fishing and recreation

4. Move Along:
The ‘accommodate’ strategy is based on the ‘living with water’ concept. For the Dutch delta, this could be a combination of ‘retreat’ and ‘accommodate’: with the first we refer to the choice of moving people, assets, and activities landward ho higher ground, while with the second, to the idea of vertical retreat, by creating mounds, raising buildings, or creating ring dikes to protects urban areas, or by introducing floating solutions. In this strategy, flood defenses are maintained to the present height, but not raised to rising sea level. As a result, low-lying areas may experience more frequent flooding (e.g., from presently 1:10.000 to 1:10 years in the future).

This strategy may have a large societal impact since large parts of the country must be re-organized or abandoned and millions of inhabitants must adapt or migrate to higher ground

The Netherlands currently has a hybrid open/closed strategy. It is also likely that the combination of different solution strategies will be used in the future. Furthermore, the adaptation path will differ per region due to regional difference in physical conditions and population numbers. All 4 solutions seem possible for the Netherlands, but not all solutions are equally obvious in the various regions.

Position of the project in the described context

Having considered what the international risk situation is for sea-level rise and how the country's position is related to it through research tools and policy, a final consideration must be made prior to moving on to the design stage. In fact, it is important to think about how the intentions of the design stand in relation to the scenarios that have just been described.

The idea is to see spatial design as a tool for adapting the territory to sea-level rise and to the other environmental challenges described above, with an approach that is closer to the idea of "building with nature" than to maintaining absolute reliance on hyper-technocratic systems that, in the long run, in addition to the very high costs of their continuous updating, determine a segregation and fragmentation of the territory even greater than the current conditions. The desire is to understand how productive landscapes can adapt to other future risks, starting from current conditions. With reference to the will to start from the present conditions, this means both the spatial layout of productive landscapes and the maintenance of the protection system in its current state, without further technological developments aimed at their adaptation.
This type of adaptation sees the challenges posed by sea-level rise as a sign of the need to rethink certain dynamics of the economic system with a view to renewed prosperity.
Thus, the option of "living with water" is considered and applied to contexts in which transformation, which is also a choice with few regrets, can be implemented in the near future.

As stated by Deltares, 'it is not yet necessary to choose between the solution directions, there is time to reduce the uncertainty about future sea level rise and to better quantify the possible consequences and to further elaborate possible solutions and strategies. However, in order to keep future options open, further research, experimentation and preparatory actions are needed in the short term.

Therefore, for the design reflection of this work, it was decided to adopt spatial solutions that are not subject to the framework of future scenarios (such as protect close) with long-term application, but rather to reflect on possibilities that can already be investigated in the near future, given the urgency of action, but which can in any case be adapted to a worsening of the same conditions.

A Sample Territory

Choice of the Territory
Sample:
motivation and approach

Site visits

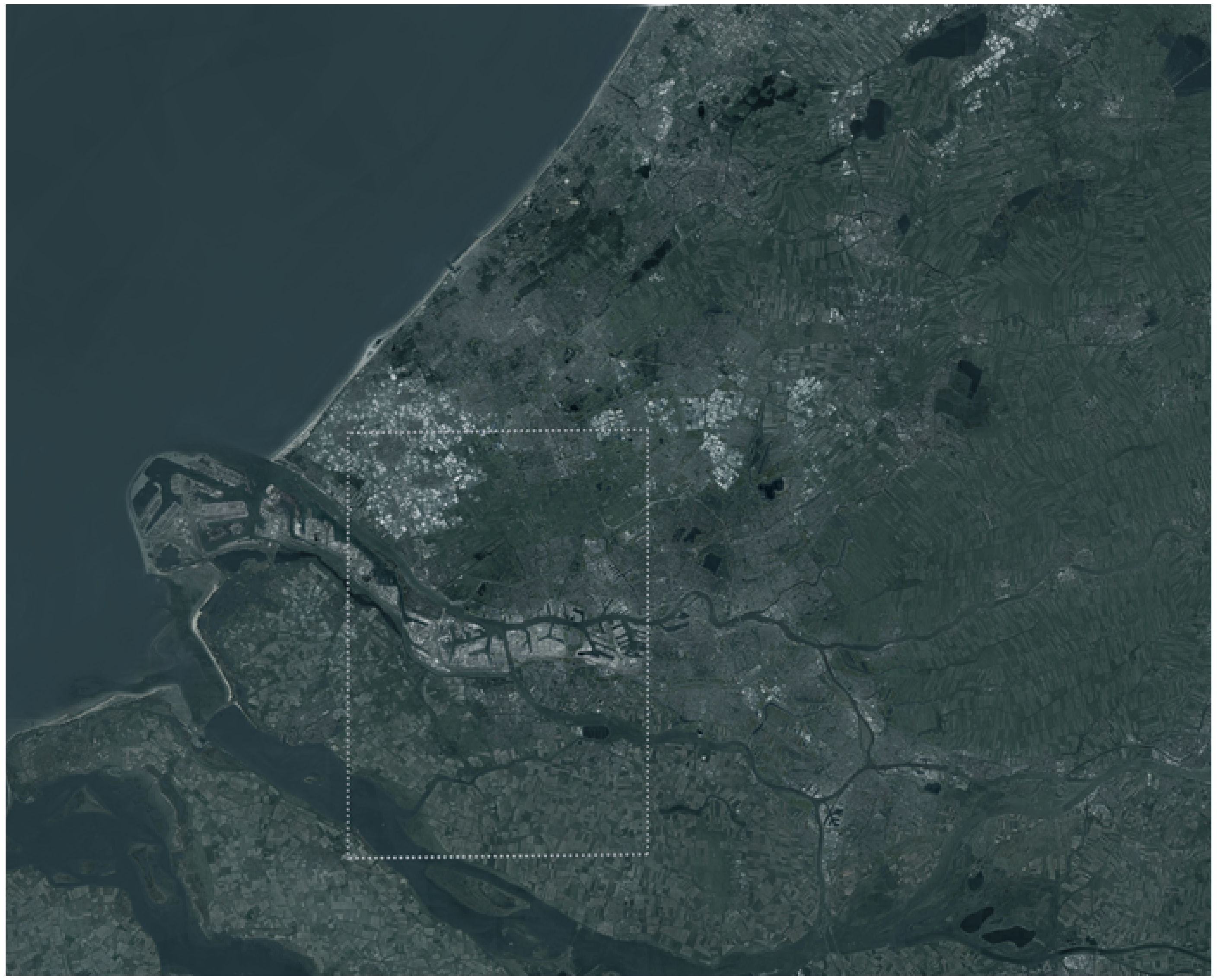
PART 1.3

Choice of the territory sample

Due to the extent of the region examined so far, the next step in the work was to select a smaller area in which to consequently direct the scope for the design phase.

Therefore this section presents the transect that was chosen as the area where to start reimagining some dynamics of the territory at a closer scale.

The choice comes from an operation of overlapping the findings from the topics investigated through the lines of inquiry with the critical cartographies, recognizing that this section is particularly heterogeneous for some features that we consider appropriate starting points for the project sake.



Motivation and approach

The chosen transect displays a heightened degree of sensitivity to the most meaningful environmental challenges linked to climate change in the region, such as salinization, risk of flooding and subsidence. All these factors significantly manifest themselves within a relatively narrow geographical zone, attributable to the intricate interplay of hydrological, morphological, economic, and social attributes unique to this specific territory.
In fact, a consistent part of it lies below the sea level, dominated by the polder landscape, and is located along the Rhine-Meuse-Scheldt delta, protected but vulnerable to future scenarios of sea level rise.
Concurrently, this territory experiences high population density, encountering urban densification pressures, and exists within a context of robust economic prosperity due to its numerous productive activities. Hence, the convergence of these factors renders the region increasingly susceptible to the impacts of climate change.

Moreover, what adds to these considerations and acts as a distinguishing element, elevating the suitability of the area over others within the province in terms of delving into design matters, is the remarkable fact that this particular vertical strip, spanning approximately 30 kilometres, encompasses all the productive landscapes pinpointed in the research.

In addition, looking at the spatial layout of this territory, a consideration about a state of 'liminality' within the productive landscapes could be made. The idea of liminality in this context may refer to the transitional zones or spaces where urban and productive landscapes intersect, overlap, or coexist; it denotes an in-between state, representing a phase of transformation, ambiguity, and potentiality.
Observing more closely these landscapes it seems that the presence of liminal spaces is not perceivable, and that the transition between one and another seems quite sharp: the area almost appears as a patchwork of different tissues juxtaposed but not really interconnected.

Stepping back at the regional scale, it could be argued that this is not the only area in South Holland with adverse environmental conditions and that there are wider zones which could be similarly representative, but this is the specific case where the aforementioned conditions discussed in the Lines of Enquiry section are all present in a relatively limited surface, and the fact that it lies at the hearth of the Delta makes it even more interesting for the thesis purposes.

For this reason, reflecting on certain conditions that may appear to be present to a relatively limited extent in the transect, such as areas of peat soils devoted to livestock farming, provides an insight into a possible approach to be taken in a similar manner in other areas of the province, or the wider geographical context in which they are located.

The decision to make a leap in scale by focusing on a portion of the territory was necessary in order to move closer to practices more proper to the spatial design sphere, with the desire to increase awareness of how the territory is organised and to understand how the issues previously analysed are declined to a local extent. This intermediate shift from the scale of South Holland region to the more local dimension is of crucial importance in order to move consciously from the dynamics more proper to the dynamics of investigation to those of project development, thus having a typical research-by-design approach.

While in the previous phase of the research different levels of territorial representation were interrelated in order to problematize spatial dynamics in line with the objectives of the thesis, the more detailed analysis in this section was done by breaking down the thematisation of the cartographies into more independent levels of interpretation. These are soil type, hydrogeological system, mobility network, built environment, topography, and finally, environmental challenges and land use related to productive landscapes. The latter two have a more 'layered' reading level than the previous ones, but they are fundamental to show cartographically the ethereogeneity that proved to be a decisive factor in the selection of this particular transect.

The "reading" of these cartographies one after the other makes it possible to obtain a more in-depth knowledge of this zone, since they act as a tool for the visualisation of certain spatial characteristics that cannot be identified at the regional level.

In addition, through an operation of 'superimposition' of specific levels for certain areas, the same cartographies proved to be useful for choosing the zones on which the design phase is to be conducted: the choice was guided by the intention to identify zones that are as heterogeneous and representative as possible, and that can represent good practices that can also be adapted to other zones.

Soil types

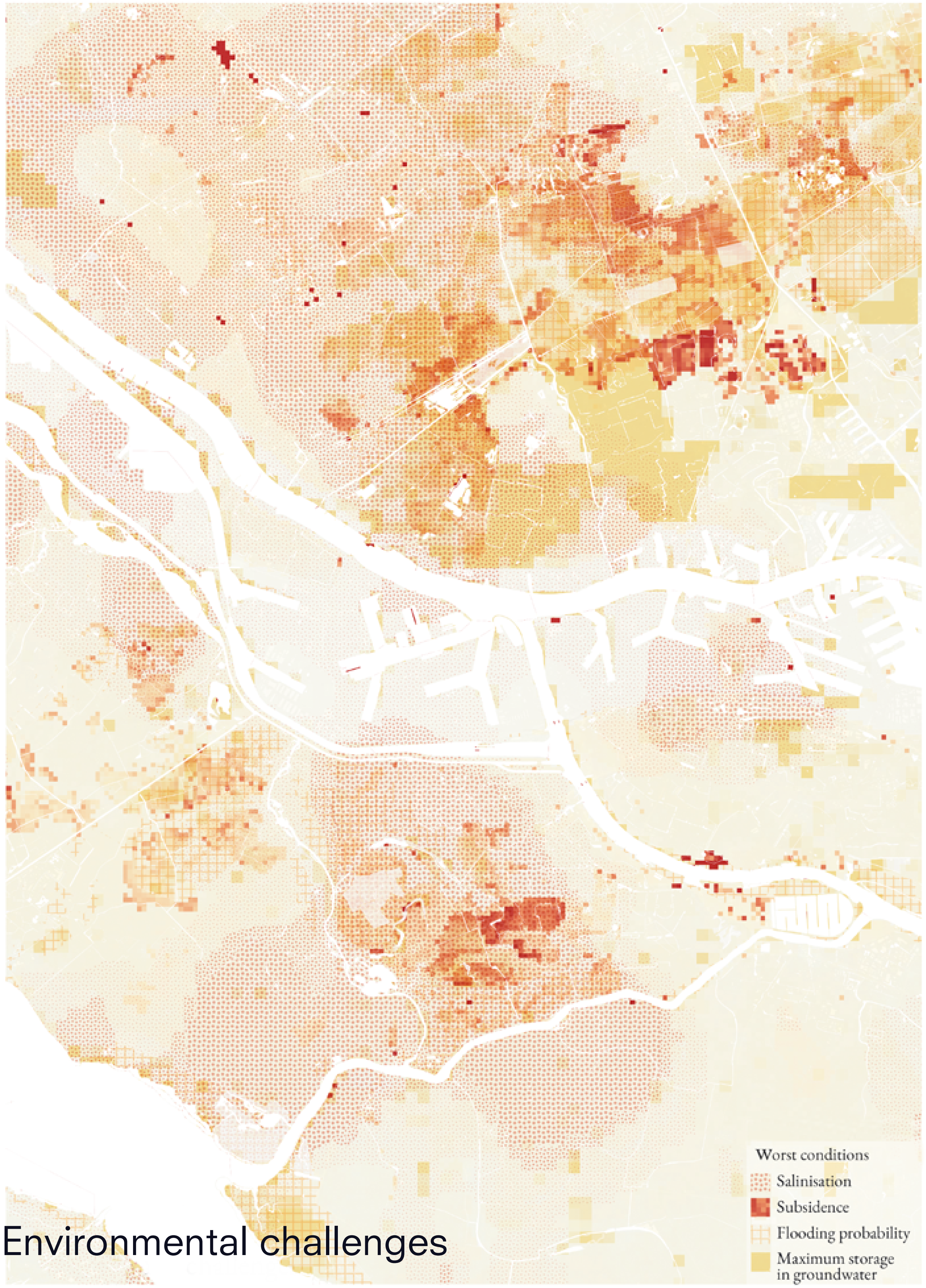
Hydrology

Mobility

Built environment

Topography

Below sea level

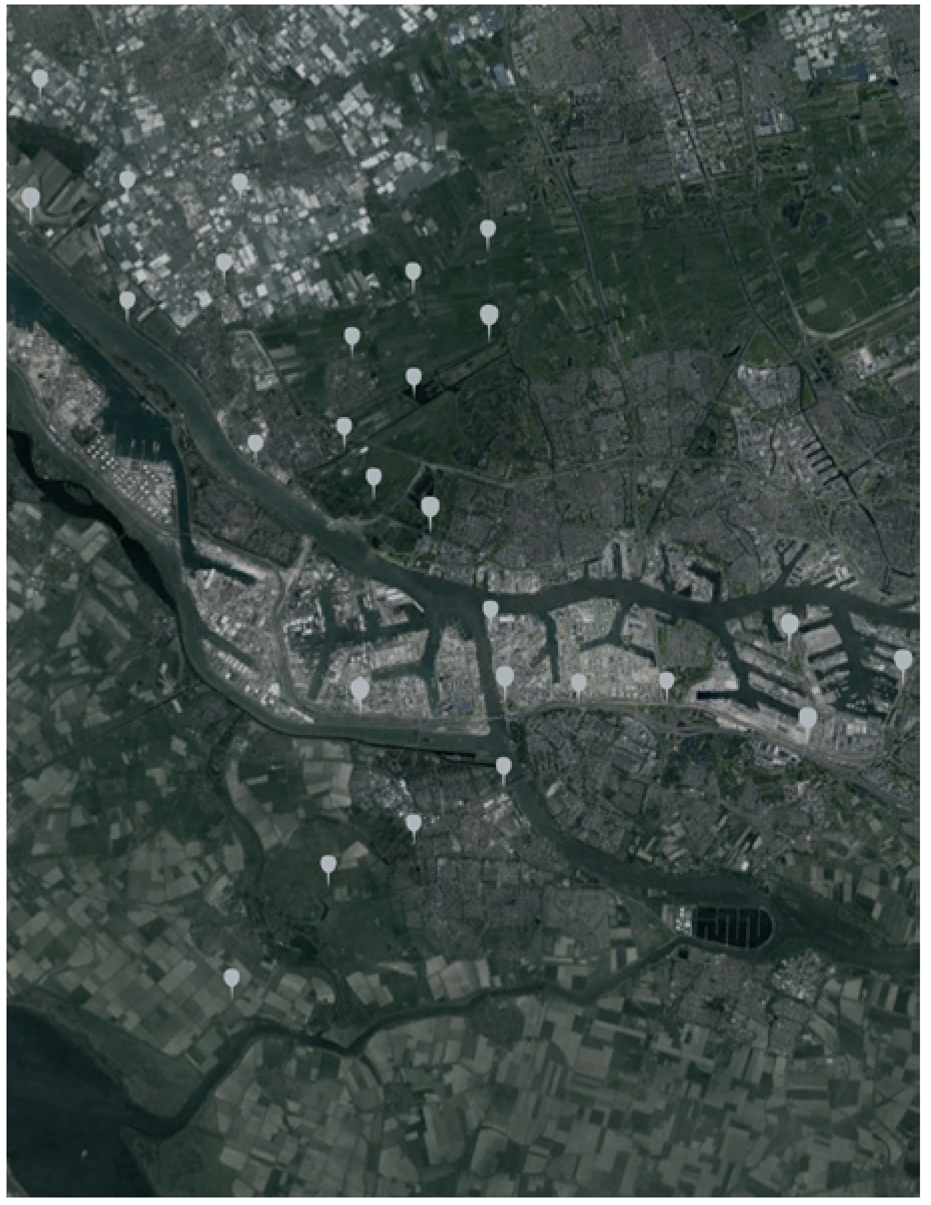


Environmental challenges

Landscapes of production

Site visits

The field visit took place at different times, given the size of the area under study, and was organised with the aim of physically observing the different productive landscapes, their spatial layout, infrastructure and production system.
It can be said that the decision to carry out the field trips in certain places was partly the result of an intuition that the design phase could be developed in some of the places visited, and that the on-site experience was a fundamental part of the choice of certain " areas of focus ".
In other words, the identification of the project sites was not done a priori, but thanks to an in-depth inspection organised over several visits, it was possible to better understand the territory and arrive at the choice of spots.
In this way, the site visit phase did not turn out to be a moment of reportage as an end in itself, but rather a fundamental research tool, indispensable for reflecting on the design interventions.




Educatieboerderij
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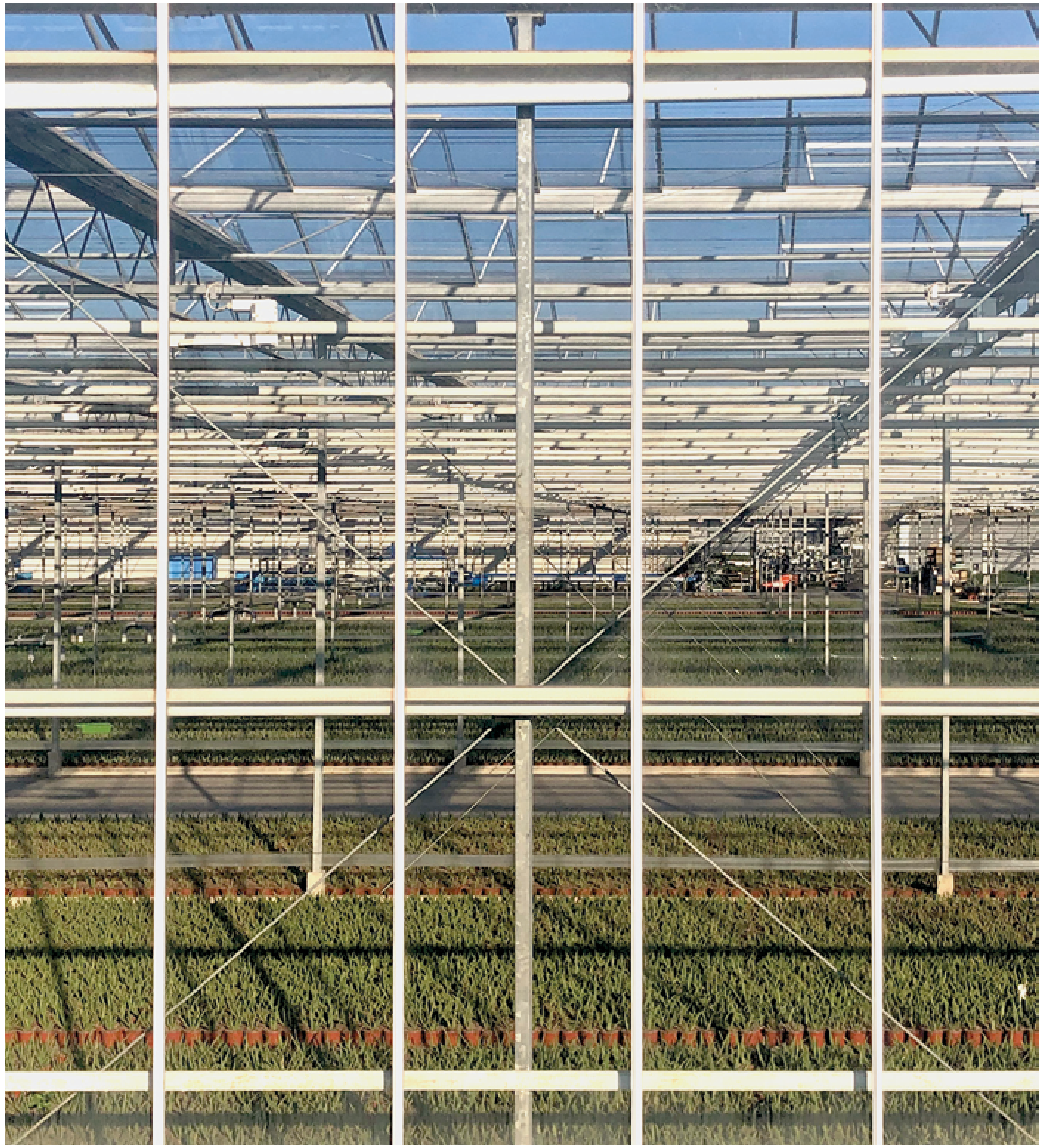
SCHARREL EIEREN 2.50
Stoofpeer 1.00/zak




Botlek


VTG


KABELSTROOK
GEVAARLIJKE LEIDINGEN
VERBODEN TOEGANG
ART. 461 WvS.


Botlek


Loge-info
P
PIER 6
Special cargo
CCIS
NETHERLANDS
Doorgaand
verkeer
UIT / EXIT
LET OP TREIN
PIER 5 6 7

PART 2

Design

A regenerative proposal for adaptation design

The pilot cases

Focus 1: Farmscape- livestock

Focus 2: Mixed farmscape and Glasscape

Focus 3. Petroleumscape

Learning from South Holland

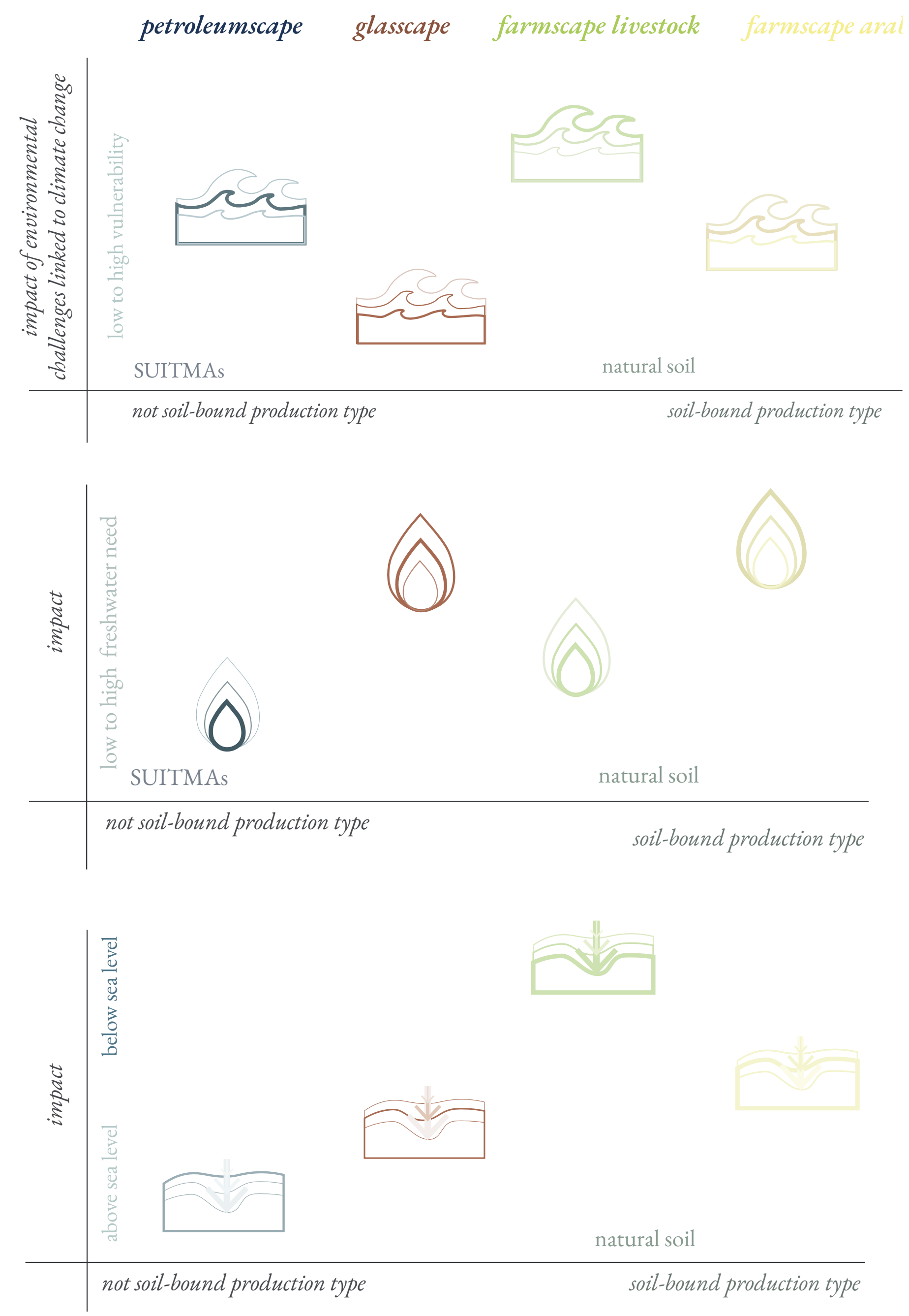
At the end of this critical research phase, the question arises as to what the findings of the research and design process of this work are and how these can be leading elements to somehow identify design principles.

The main outcome of this phase is an awareness of the systemic way in which various environmental challenges affect productive landscapes, and at the same time of the impact that activities located in such landscapes have on the environment. The 'systemic way' refers both to the interrelationship between risk conditions, types of production and their impacts, and to the dynamics between the different typologies in which each of these three emerge. For example, risk conditions related to salinisation in livestock areas may be as severe as in greenhouse areas, but will not necessarily have the same impact. This is due to the way in which the conditions of soil type and water infrastructure network are addressed for each context, resulting in a different approach for each condition.

Thus, with regard to the way in which environmental challenges affect productive landscapes, a differentiation between severity and impact is first distinguished. The condition of specificity of each landscape, given by the interrelation of all the conditions already mentioned, suggests a different intrinsic capacity for adaptation, a kind of malleability in response to risk conditions. This malleability is given by the impact these have and by the characteristics of the landscapes themselves: for example, the capacity of the port area to adapt to the climatic challenges affecting it is different from that of the areas dedicated to livestock farming.
 It should also be emphasised that in some cases this malleability is due not only to the capacity, but also to the readiness/proness to adapt, which is also due, especially in a context such as South Holland, to economic interests.

In fact, the type of adaptation that may be applied in port areas, for example, will most likely be driven by the maintenance of high yield levels and therefore unlikely to result in a substantial transformation of the landscape itself. Conversely, productive landscapes dedicated to agricultural production, although carrying high economic interests, given the importance of the sector in the province, are in a different geopolitical context, and could adapt to the impact of climate challenges while remaining equally productive.

Through this scheme we sought to reflect on the impact of the main environmental challenges in the context of the southern holland, considering not only the extent to which a certain condition occurs, but the effect this condition has on the affected system.
The variations in impact, for each category, has been linked to a determinant factor in its occurrence, while the productive landscapes have been placed along a series of 'interpretative scale'. in fact, it can be seen that they differ in their increasing reliance on soil resources, both as a raw material necessary for the growth of production and for groundwater. In addition, this differentiation is in line with whether they are located on natural or artificial soil (referred to here as SUITMA, soil of urban, Industrial, Traffic, Mining and Military Areas).



On malleability and ecosystem services

Returning to the concept of malleability, this term seems more than appropriate, both for the reference to the materiality that characterises it, coming from the Latin 'malleabilis' and thus referring to the capacity of a material to be deformed, and for the figurative meaning that follows, pointing to the characteristic of an entity capable of adaptive change.
This capacity is precisely linked to the specificity of each context, and it also implies a different type of intervention from a design point of view, in terms of the scale of the intervention, the urgency of its realisation and its impact on the productive landscape as a whole, in its more specific connotations and in its relationship with the surrounding territories.
In fact, in some cases a different malleability may suggest the need for a major change at a structural level, in others a series of small changes to be implemented at a more local level.

Secondly, considering the impact of productive activities on the environment leads to a reflection on the need to preserve it, referring to the state of the habitat as a place that provides the conditions for human and non-human life.
As already mentioned, the Dutch landscape is to a large extent the result of a centuries-old process of anthropisation, in which the presumed subsistence needs of the human species have almost always determined the configuration of the land itself.
However, this consideration is compounded by the realisation that the economic drive that characterises the Dutch 'mindset', which has, among other things, resulted in the regional territory (with the exception of urban areas) being almost entirely dedicated to the development of productive activities, has also led to a degradation of the ecosystem services that the habitat can provide.

This term refers to the wide range of benefits that nature provides to society by maximising biodiversity, i.e. the diversity of all living things, which is essential for ecosystems to function and provide their services. Thus, the consideration of ecosystem services in the context of this research aims to reflect on the capacity of productive landscapes to maintain the conditions necessary for the biotic and abiotic beings that are part of the habitats they contain to find their existence maintained.

In addition to the quality of the habitat, understood from the perspective of promoting biodiversity, the aim is also to reflect on the perceptible quality of the habitat itself, i.e. the capacity of the territory to represent a space in which it is desirable to live, where the quality of natural spaces and, in a broader sense, of open and public spaces is considered an enriching element of the landscapes themselves.
Reflection on the design approach is also based on the assumption that these two conditions are not pursued to a great extent in the productive landscapes of Zuid-Holland, or at least that there is different potential to emphasise them more.

Returning to the concept of ecosystem services, they are traditionally divided into:

- Provisioning services, which are characterised by the ability to obtain products from ecosystems, such as food, water and other resources, such as wood, oil, substances for medicines, etc.
- Regulating services, which are any benefits derived from the natural processes and functioning of ecosystems. Examples include climate regulation, mitigation of floods and other natural hazards, pollination, water purification, biological control of pests and diseases, waste recycling and detoxification, carbon storage and regulation of greenhouse gas emissions.
- Cultural services include non-material benefits that people can derive from ecosystems and are related to spiritual enrichment, intellectual development, sense of place and aesthetics,
- Finally, supporting services are linked to the functioning of the habitat itself and therefore influence survival. For example, photosynthesis, water and nutrient cycles underpin ecosystems, which in turn enable us to sustain ourselves.

Regenerative design

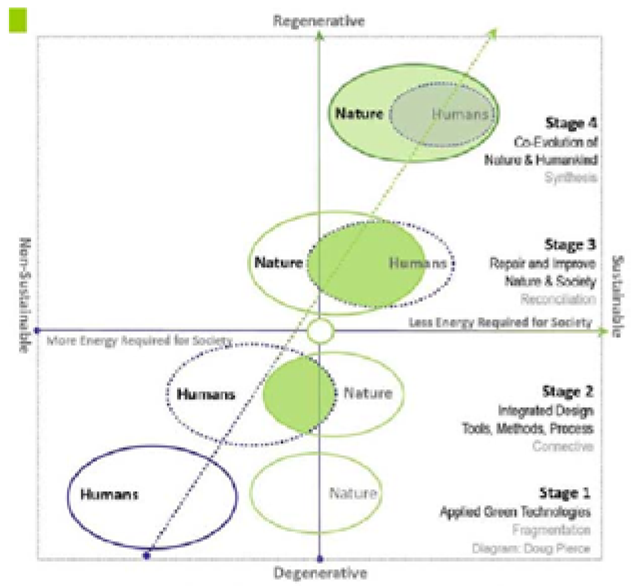
Thus, the idea that guides the design choices is to reflect on possible interventions to improve the capacity of productive landscapes to adapt to the environmental challenges of climate change, and at the same time to see these interventions as a possibility not only to reduce the negative effects of the landscapes on the environment itself - thus having a neutral effect - but rather to have a positive impact, reversing the negative environmental effect through an improvement of the quality of the habitat.

This type of approach can be seen as a regenerative one: the regenerative process is thought of in terms of identifying how to deal with climate change as an opportunity to rethink the landscape.

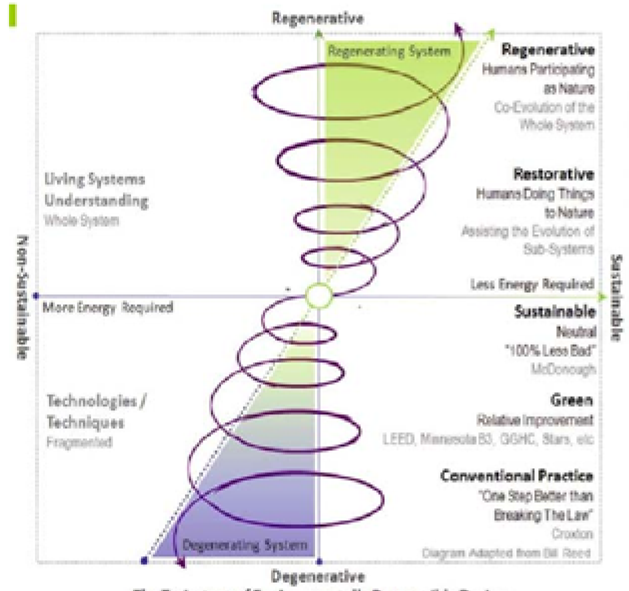
During the reflection that guided the outlining of the design choices starting from the way the research phase was organised, becoming aware of the principles of regenerative design was a sort of validation of the appropriateness of the regenerative adaptation concept that was being outlined. Regenerative design was defined as
'a *design process that engages and focuses on the evolution of the whole of the system of which we are part. Logically, our place -community, watershed and bioregion- os the sphere in which we can participate. By engaging all the key stakeholders and processes of the place - humans, other biotic systems, earth systems, and the consciousness that connect them - the design process builds the capability of people and the 'more than human' participants to engage in continuous and healthy relationships through co-evolution*' . (Reed, B.2007)

From these considerations, it is possible to reflect on what the characteristics of such regenerative design are within the context of the thesis. Firstly, a certain specificity emerges: as already discussed, the adoption of one approach rather than another is the attempt to understand how the system of life works in each specific place. The role of the designer is therefore to understand this functioning in depth and create a system of 'mutually beneficial relationships' from which all beings involved can benefit. Hence the need for the construction of a solid cognitive background, based on scientific data and its transposition to the spatial sphere, and aimed at framing all the actors involved and the systemic interrelationships between them.

Lastly, from this derives the need to have an approach in which 'both planetary scale and place-based approaches are not mutually exclusive': the development of a regenerative process starts from the need to frame the territory on a large scale, but is fuelled by the awareness that in order to verify the appropriateness of a certain project idea, it is necessary to decline its implications to the local scale, as will in fact occur in the design phase of this work.



4 Stages of Transformation to Regenerative Design Thinking
From Fragmentation to Synthesis



The Trajectory of Environmentally Responsible Design
From Fragmentation to Synthesis

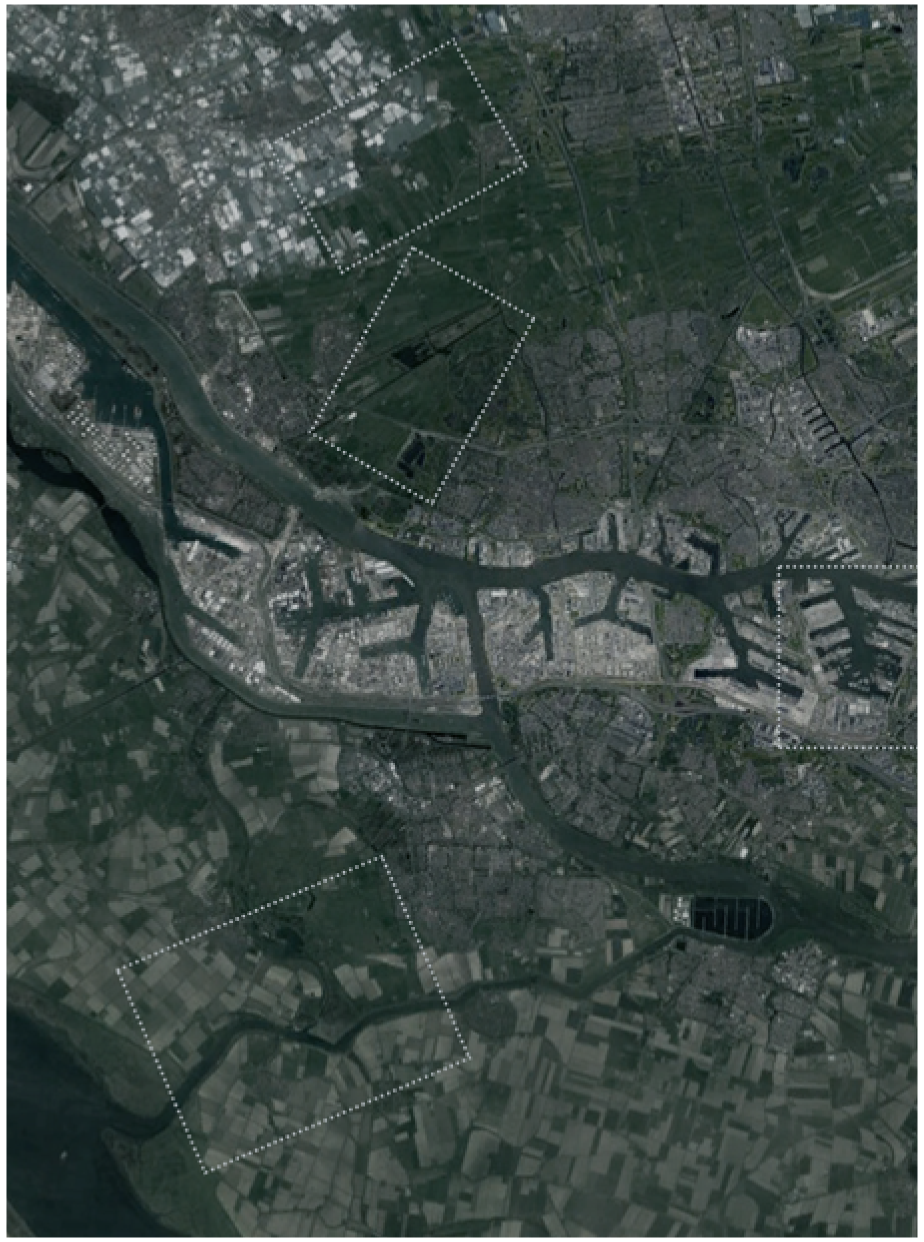
Design approach

As already stated, for the selection of the territory sample, the identification of the area was guided by the intention to deal with the issue under study through a heterogeneity of possible case studies, with the aim of being able to find an application method starting from the consideration of the specificity of each case. Similarly, also for the choice of the four 'zooms' in which to decline design ideas, the choice is due to the variety of conditions considered, both from the point of view of environmental challenges and from that of productive landscapes.
What is assumed is a sort of deductive process, in which the outline of the design approach discussed in the previous section is confronted with the various selected cases and may result in a general reflection that stems precisely from an awareness of the articulated systemic relations between the various parts.
The design phase is treated in a manner that makes a big leap from the initial picture frame referring to the entire region of South Holland, and falls into more local dimensions. The motivation behind this choice is that of wanting to apply design principles guided by a broad analysis in a punctual manner, and that the coherence of project choices on a territorial level can (hopefully) prove to be coherent when the principles can also be grasped on a local scale.
For this reason, a reflection on the territory sample can be thought of as a concluding phase, as a leap backwards in scale in order to return to considerations on the same dynamics at the regional and more general scale, but not only in the outlining of scenarios and strategies at the territorial scale. In fact, the mere identification of strategies would lack a local and specific context, while a more specific type of approach would also make it possible to verify precisely the consistency of the idea conceived for the territorial scale.
This phase of the project therefore, after considering the zooms and re-reading them through the lens of soil types, water networks and infrastructures, productive landscapes and environmental challenges, -a fundamental reading to see the local characterisation of these themes- consists in the selection of further samples in which project developments are outlined. These possible developments are then shown then through the tool of sections.

Introduction to the case studies

Within the sample of territory previously selected, four areas welected for the design development purposes:

· In the first, the dynamics related to livestock farming in a hypogean peatyb landscape are addressed,
· In the second, the consideration of regenerative design is outlined in the context of the glasscape and a mixed (but predominantly livestock) farmscape on clay soils,
· On the other hand, the last area studied is located in the port of Rotterdam.



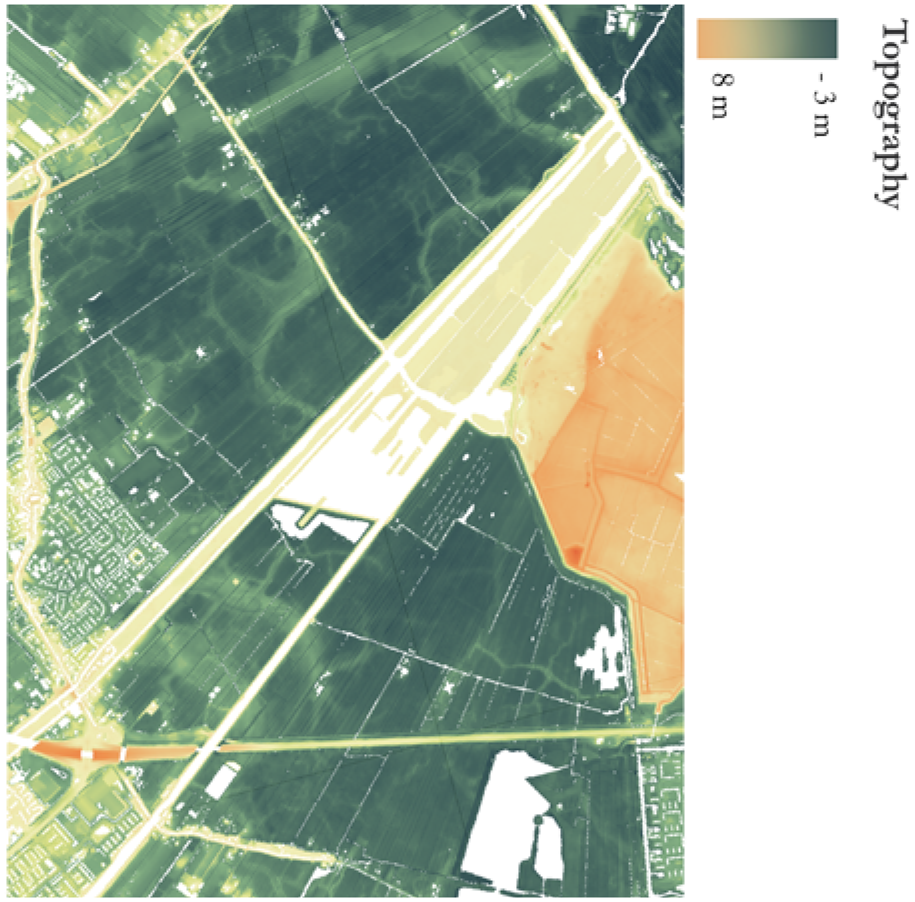
Focus 1: Farmscape livestock

This area was chosen with the aim of exploring new ways of living with water, to increase knowledge of wetlands and their enormous potential, not only as recreational areas, but also for the possibility of exploring new types of agricultural production and, even more importantly, for their role in tackling climate change.

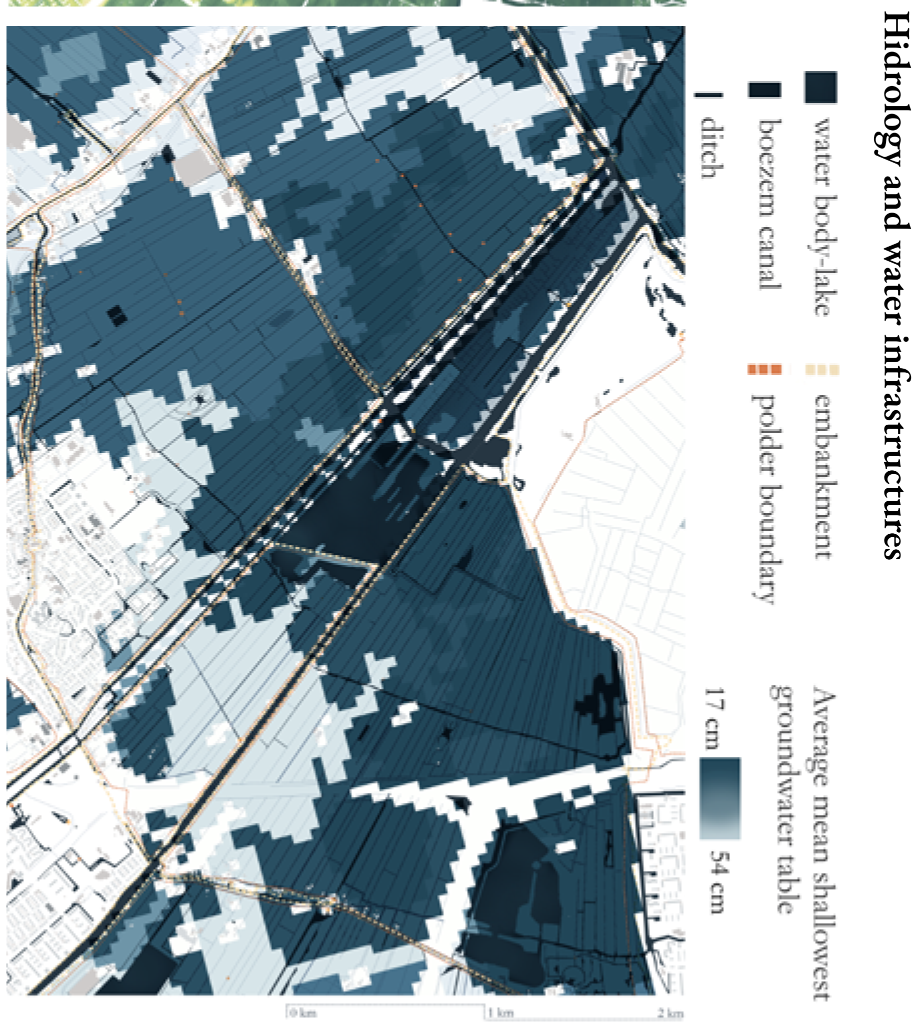
It is located between the municipalities of Vlaardingen, Maasland and Maasluis, and is part of the widespread township of Midden Delfland. The green area in which it is situated was already called by this appellation before the creation of the municipality in 2004, but this action also served in part to create a new spatial institution able to curb the land-take tendencies in this area, linked to the desire to expand the residential areas by the municipalities of Rotterdam and The Hague, and to broaden the horticultural production area of Westland.
Now the area of Midden Delfland is mainly occupied by meadows where grass grows for the breeding of cows and sheep, but it is also an oasis of slower living compared to the rhythms of the neighbouring urban areas, where inhabitants can retreat for recreational activities.

https://www.middendelfland.net/

In the selected strip there are polders within which livestock farming is practised, and a recreational area in the Foppenplas polder (1), which was partly flooded in 1986 to create a lacustrine zone, including a small marina, a restaurant accessible by boat and a partly inaccessible wetland. This area is bordered by the wooded area of the Broekpolder (2), which, after an agricultural past, was temporarily intended as a dredging depot a few decades ago, only to be turned into a wooded area instead.
Sadly, the landscape on the south side of this area is fragmented by the A20 highway presence (3), whose impact will increase with the end of the costruction of the new connection to the Rozemburg port area

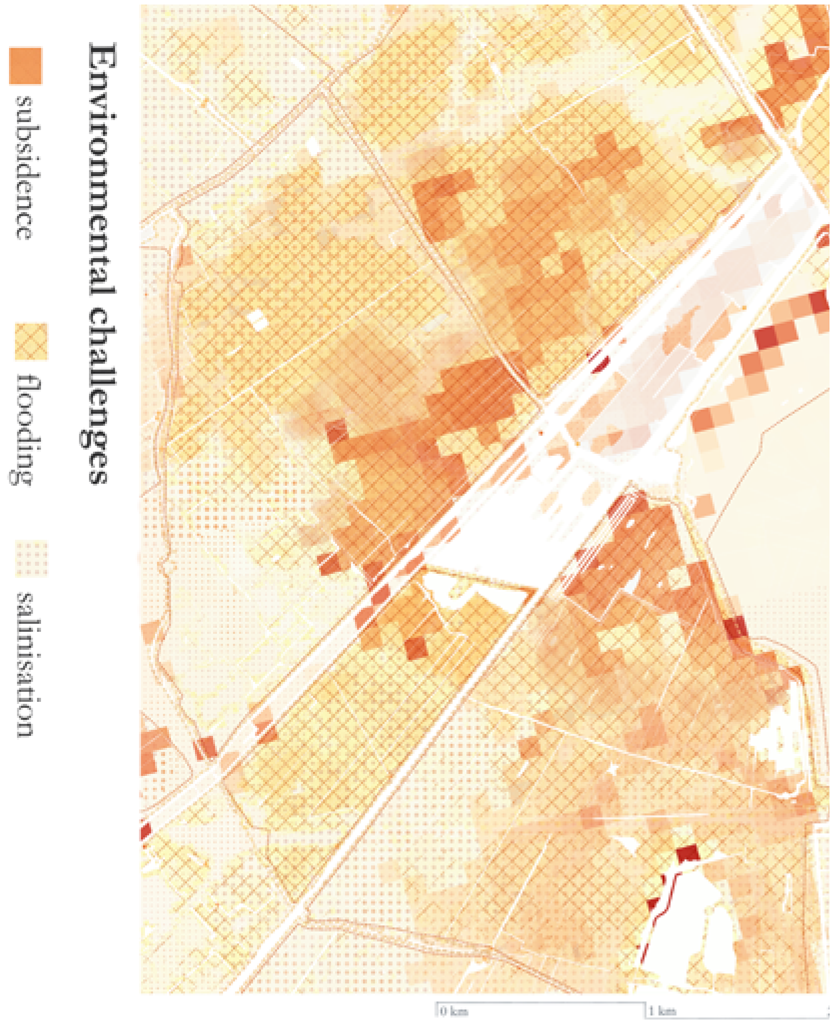


The Midden Delfland area is almost entirely below sea level (green/blue), and this area is no exception.
The only elevated areas (in light yellow/orange) are the residential area on the edge, the highway, the wetland area within the Foppenplas and the wooded area in the Broekpolder, as well as the banks on the edge of the polders.

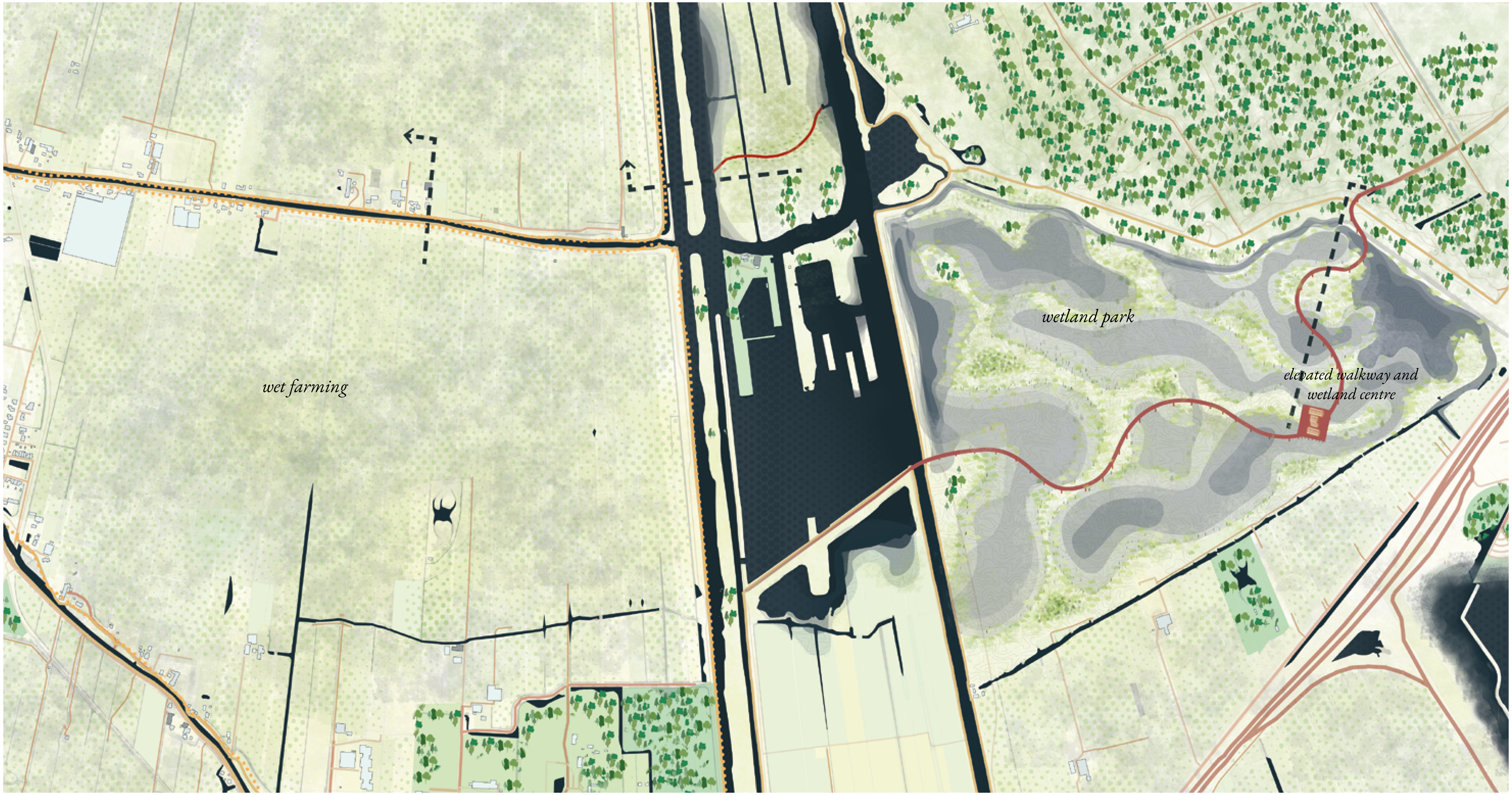


The map shows the water system in the polder area, with the boezems, the polder ditches and the two small lakes, as well as the dikes that generally follow the polder subdivision system.
In addition, another particularly important piece of information in this context comes from the depth model of the groundwater level, and that is the mean minimum depth (MSD), which indicates the lowest average depths of groundwater in centimetres below the ground level. It can be seen that in much of the area these values are rather low: peaty soils below sea level need to be drained more frequently, have a ground level very close to the water table and this results in a greater vulnerability to the subsidence phenomenon.

The livestock farmscape is the only one currently present in the province that peat soil can sustain: the areas covered by this type of soil are too wet for other types of agriculture.
In fact, as can be seen from the map, the soil is predominantly peat soil, with the exception of some clay areas and others with urban soil, as well as the Broekpolder area, which in view of the possible conversion to dredging depot, was at the time covered by contaminated harbour sudge.



This critical cartography is very dense in this area, which may indicate a greater urgency for intervention, and also an opportunity to address the 'malleability' discussed above in a more structural way. Firstly, there is a high level of salinisation of the groundwater, although this is not a major factor in the type of land use, while it is even more remarkable that this area, like other peatlands in the province, is subject to the phenomenon of subsidence and soil oxidation due to the drainage process of the polders. Because the soil is so wet and "under pressure", its capacity to absorb water is not very high, it is easily saturated and does not have a good mitigating capacity in the event of heavy rainfall or flooding from watercourses, a phenomenon to which the area is also particularly vulnerable due to its very hypogeal location.



Strategic plan - scale 1:1000

Design

Applying the idea of regenerative design to this context suggests reflecting on the adverse environmental conditions, in this case the subsidence and the risk of flooding, and on the environmental impacts of the productive landscape, such as the emission of CO_2 through the oxidation process of peat, the reduction of biodiversity and a certain 'homologation' of the agricultural landscape for livestock farming. The purpose of this consideration is to reflect on solutions that attempt to respond to the issues on both fronts.

Raising the water table level is one possible solution to address the problem of subsidence, following national guidelines.
The Council recommends that a 50 per cent reduction in subsidence is mandatory by 2030 and a 70 per cent reduction in subsidence is mandatory by 2050. These targets derive directly from the commitments of the Climate Change Act'.

Raad voor de Leefomgeving en Infrastructuur

Increasing water levels in polders has several benefits. Firstly, it boosts their ability to retain water during heavy rain or flooding, reducing the risk of waterlogging that can harm agriculture, infrastructure, and ecosystems. This enhanced water storage makes polders more resilient to extreme weather events.

Secondly, higher water levels can support the creation or restoration of wetland habitats in polder areas. These wetlands promote biodiversity by providing homes for various plants and animals, including waterfowl, amphibians, and aquatic plants. They also offer opportunities for ecological conservation.

Additionally, this has positive effects on water quality within polders. It improves water circulation, reducing stagnant water and pollutants. This benefits aquatic ecosystems, creating healthier habitats for fish and other aquatic life.

Moreover, it also enhances the aesthetic appeal of polder landscapes and open up recreational opportunities. Water bodies and wetlands become scenic spots, attracting wildlife and offering activities like boating, fishing, birdwatching, and nature exploration. This enhances the overall attractiveness of the landscape for habitation and recreation.

The higher groundwater table could be declined in two different types of solutions here.
Indeed, for this specific area, it is thought that part of the transect in question could be dedicated to the creation of a wetland park, given the favourable location between the wooded area and the lake that are already present. Such a wetland could therefore add value to one of the main uses of this area, along with agriculture, namely recreational use.
The inclusion of a wetland centre could be a useful spatial device to convey in an educational way the importance of preserving these types of landscapes.

In addition to the wetland park, the polders could instead be converted to a type of wet agriculture, which would prove to be an excellent solution against the current need to maintain a constant drainage of the polders through the complex pumps system.

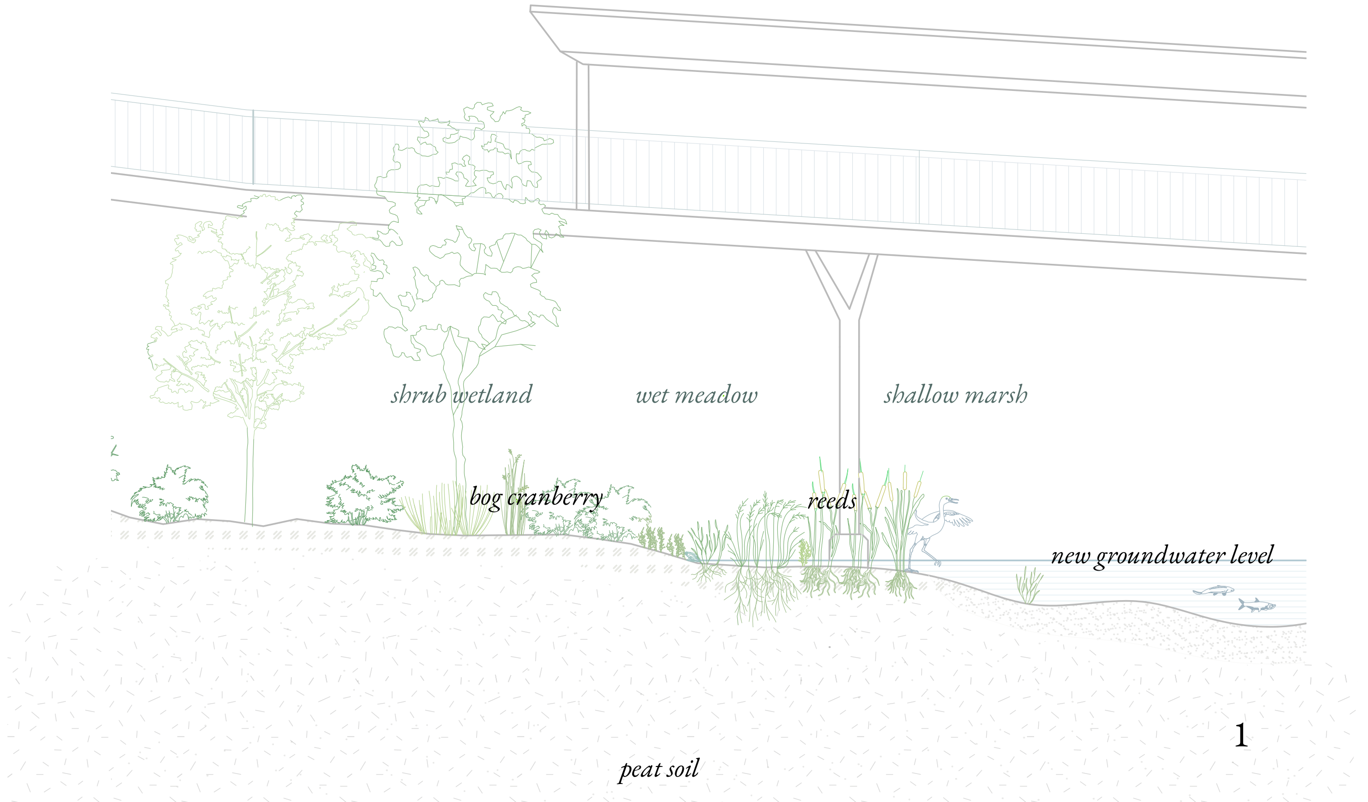
Wetland park

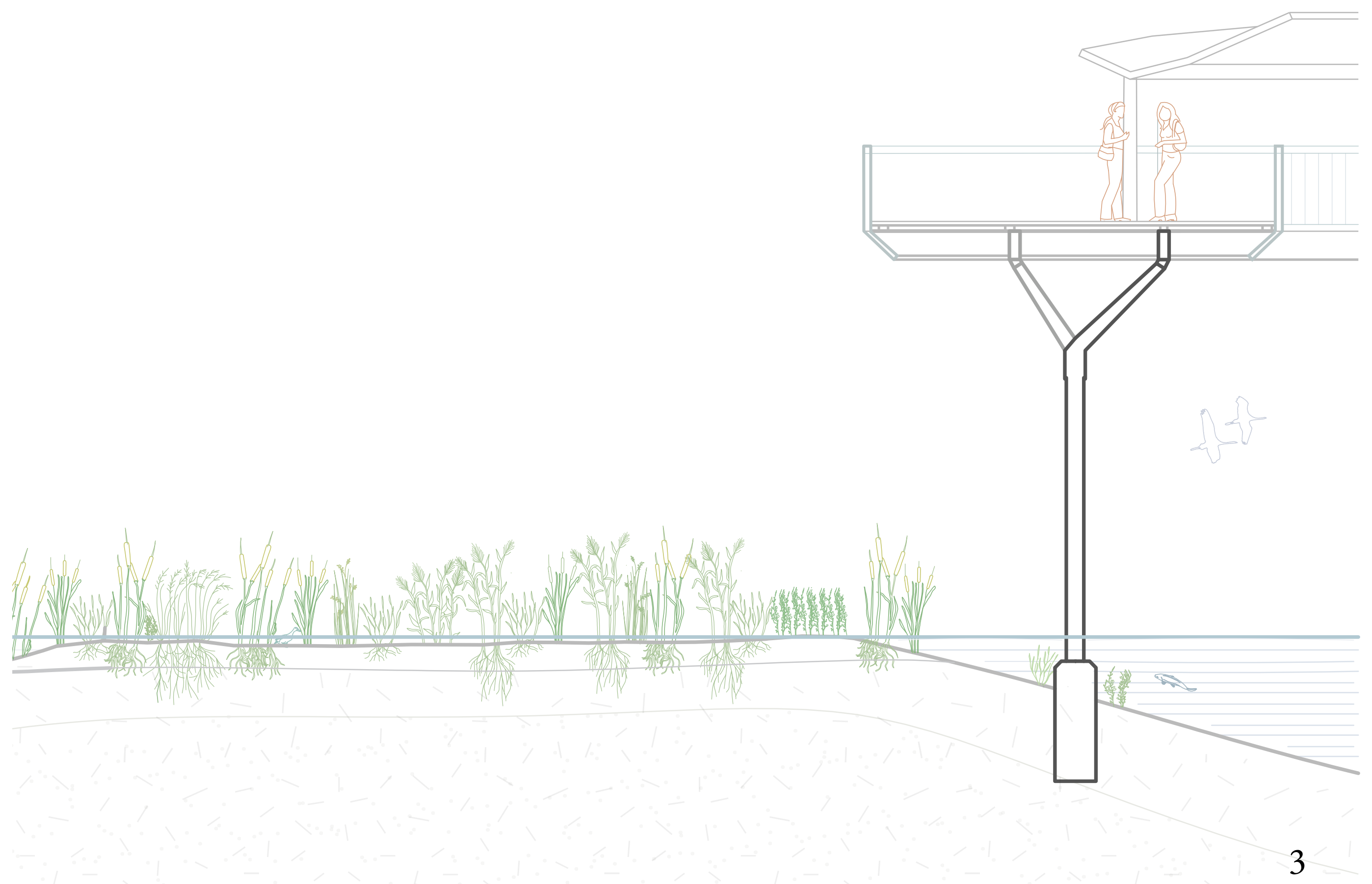
This land is currently partially used for livestock farming, but the high groundwater levels and the very hypogeal location mean that it cannot be fully utilised since it is very humid soil and prone to flooding and waterlogging.
The idea is to expand and improve the small existing damp area in the east, creating a wetland with high landscape, ecosystem and climate regulation qualities.
In fact, the creation of a wetland park in the Aalket-Buitenpolder. would not only connect the wooden area of the Broekpolder with the Vietlanden, increasing the recreational quality of the area, but at the same time it would be of great value for its water storage capacity in case of flooding, which could then be used for the neighbouring urban areas in times of drought. Thus, this intervention could provide a twofold way of addressing environmental challenges related to climate change: reduction of local subsidence and a proactive way to deal with floodings.

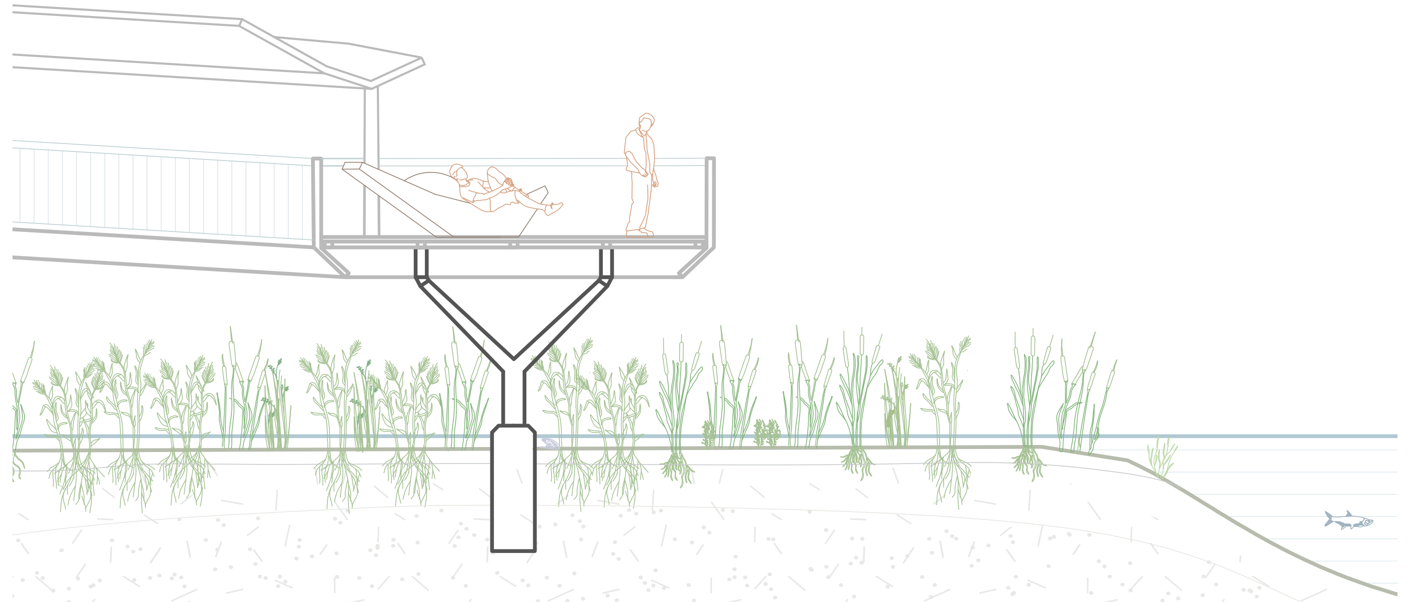
Zoom 1. the beginning of the wetland, where there is a transition from woody vegetation with medium-stemmed plants to that typical of the marshland ecosystem, with shrubs and species such as reeds.

Zooms 2. and 3. the elevated walkway over the park, made of a light steel structure, which connects the wooded area with the Vietlangen.

Zoom 4. the wetland centre that could be built in this area. This structure could take the form of a series of small modular buildings which could house small installations explaining the value of wetlands to raise visitor awareness.



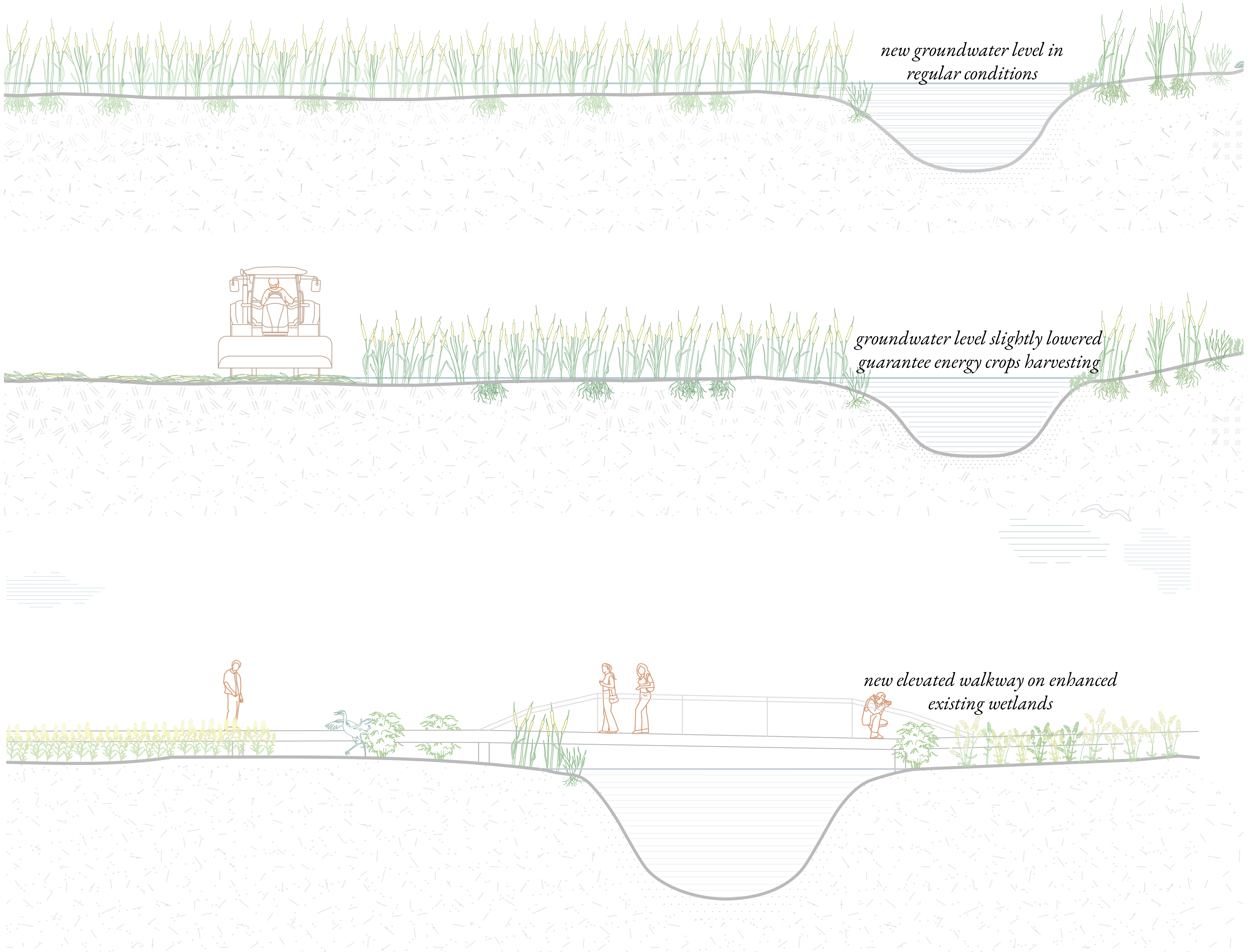


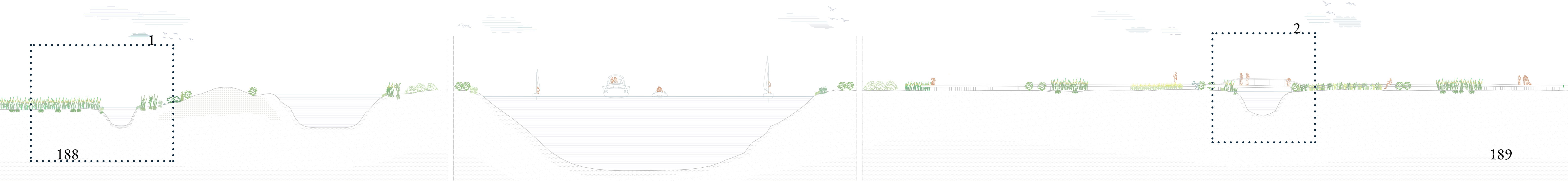


Wet farming

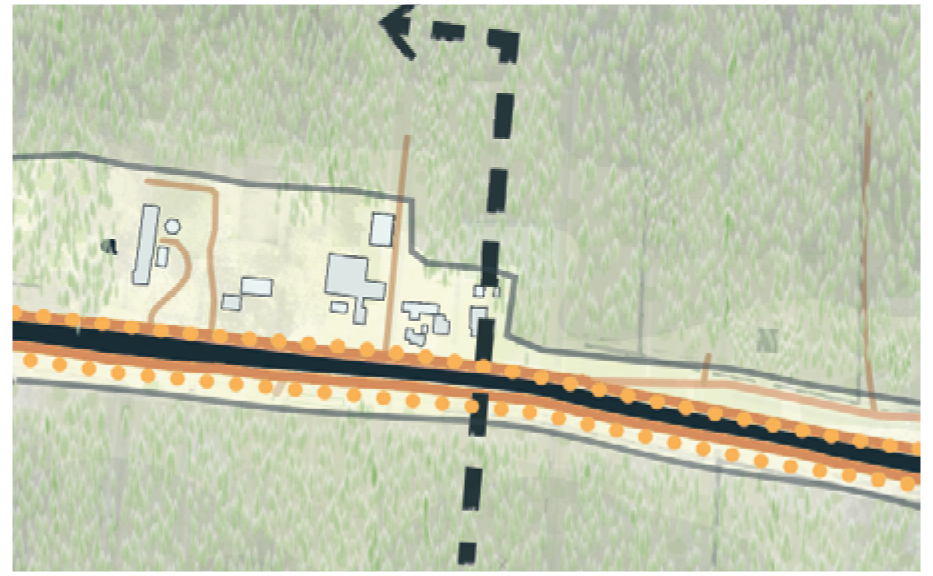
in this area is shown a 'transition zone' between a wetland area that could be improved through conservation initiatives by the local population, and the creation of new elevated paths to enjoy nature without affecting the ecosystem balance of this habitat, and an agricultural area.
In this area, there could be a transition from traditional livestock farming to wetland farming.

Wetland farming practices would reduce the current pressure on the polder control system, as the groundtable level could be left higher in such cases, reducing subsidence, favouring the formation of new peat soils and contributing to the CO2 emissions, reversing the negative carbon footprint through organic matter soil oxidation.

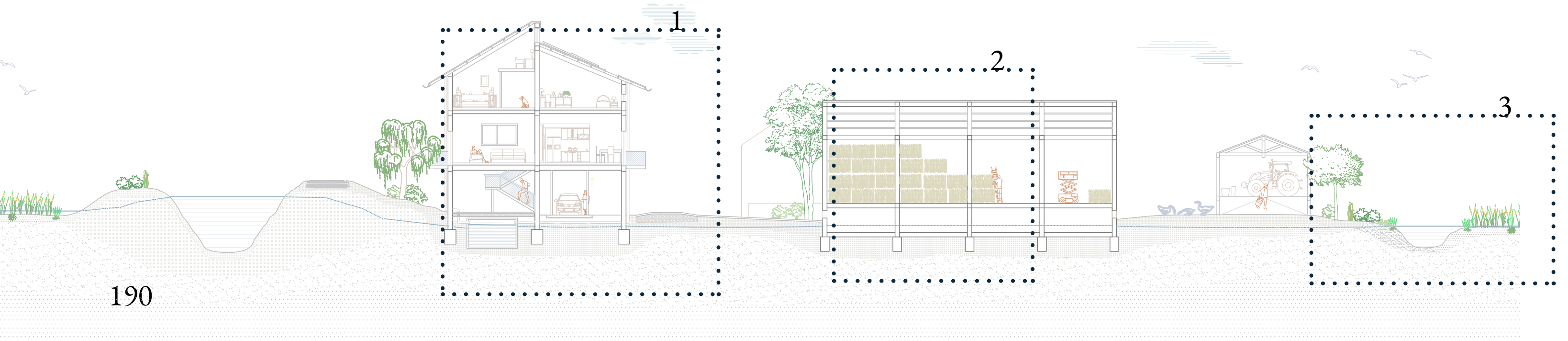


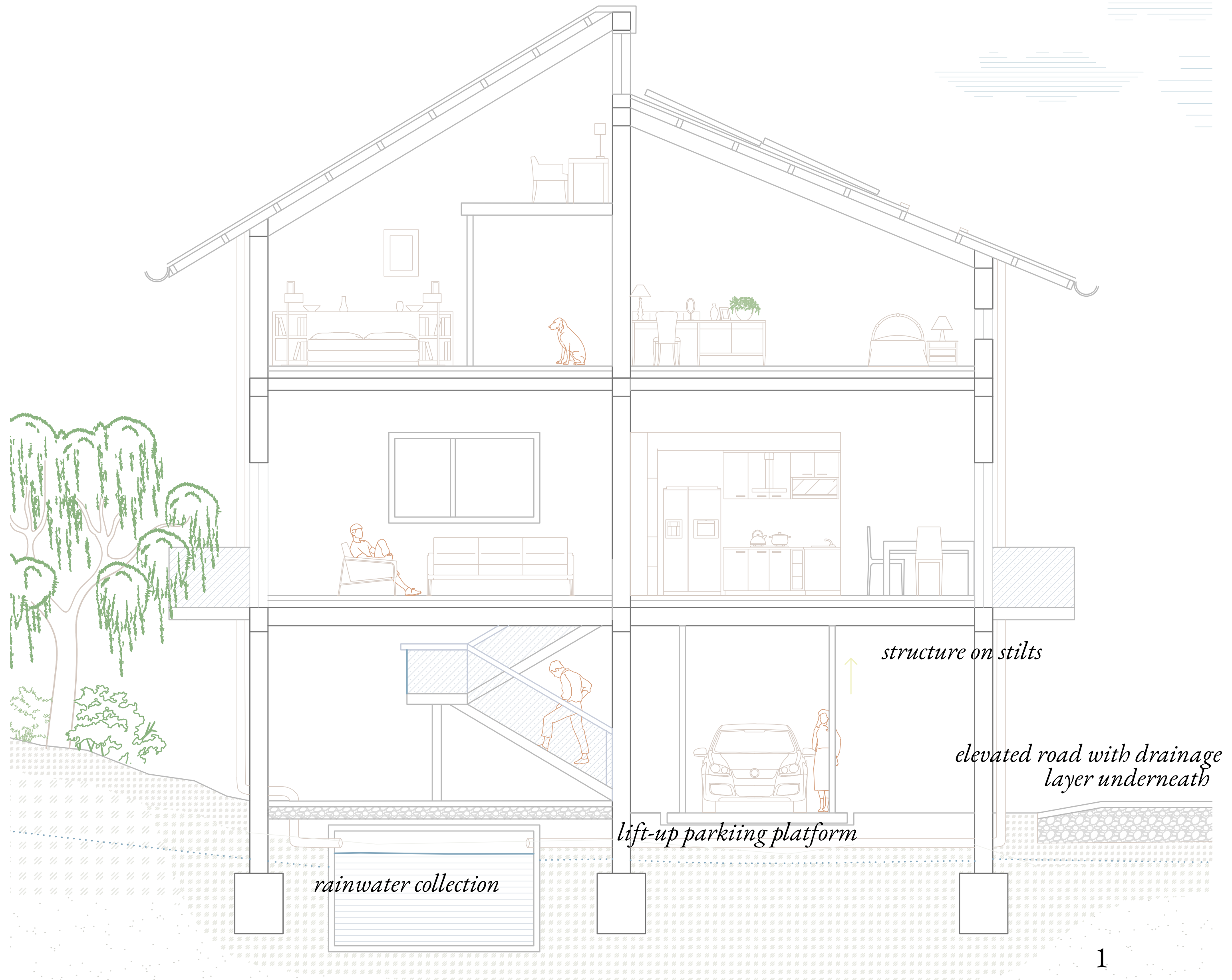


Farmhouse on re-peat



Following the process of partial depoldering and the subsequent transition from livestock farming to wetland farming, the buildings in the polders that could be affected by this process need to be adapted.
Indeed, the rise in water levels would make most of the buildings located at a topographical height close to the new groundwater level susceptible to flooding, both under normal conditions due to the greatly reduced drainage of the polders themselves, and even more so during adverse climatic events such as heavy rainfall.
The possibilities for this adaptation of farmhouses are many, but are limited by the local conditions in which the building may be found (i.e. elevation, proximity to water) and other factors, as the adoption of one choice over another would have economic, cultural and social repercussions.
It should not be hidden that this change could lead to hostility on the part of residents, driven by cultural and emotional factors related to the emotional value of buildings, but a region-wide campaign could help in this regard. Staying with the regional setting, the first step would be to carry out a spatial classification to identify the most vulnerable areas (such as the Green Heart area). Furthermore, the interventions to be carried out could be financed by institutions whose support could also be fundamental in the creation of an informational framework on economic feasibility that should guide the adoption of one choice over another.





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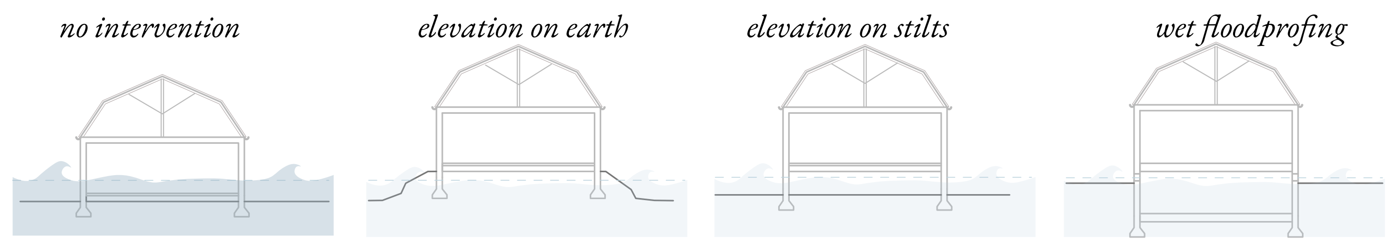
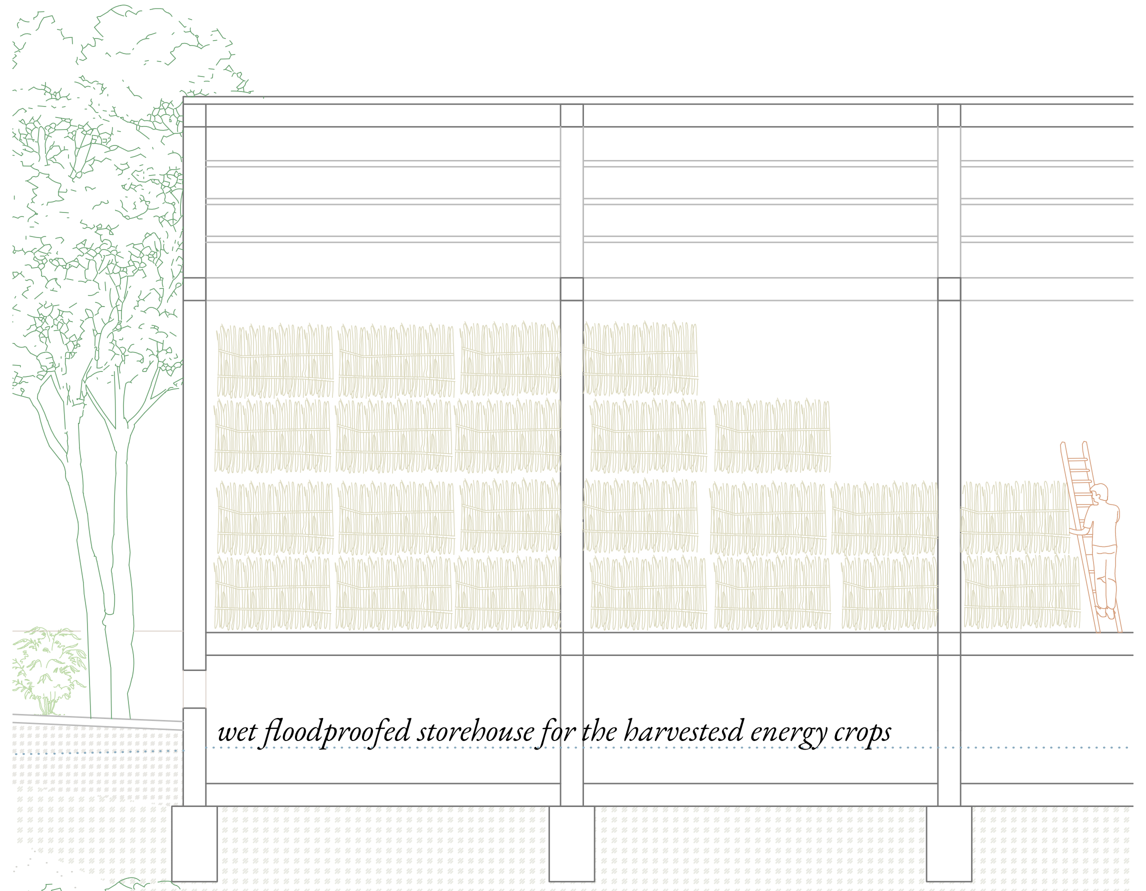


Possible solutions for adaptation of farmhouses on the sides of a polder

Possible solution for adaptation of farmhouses on open field



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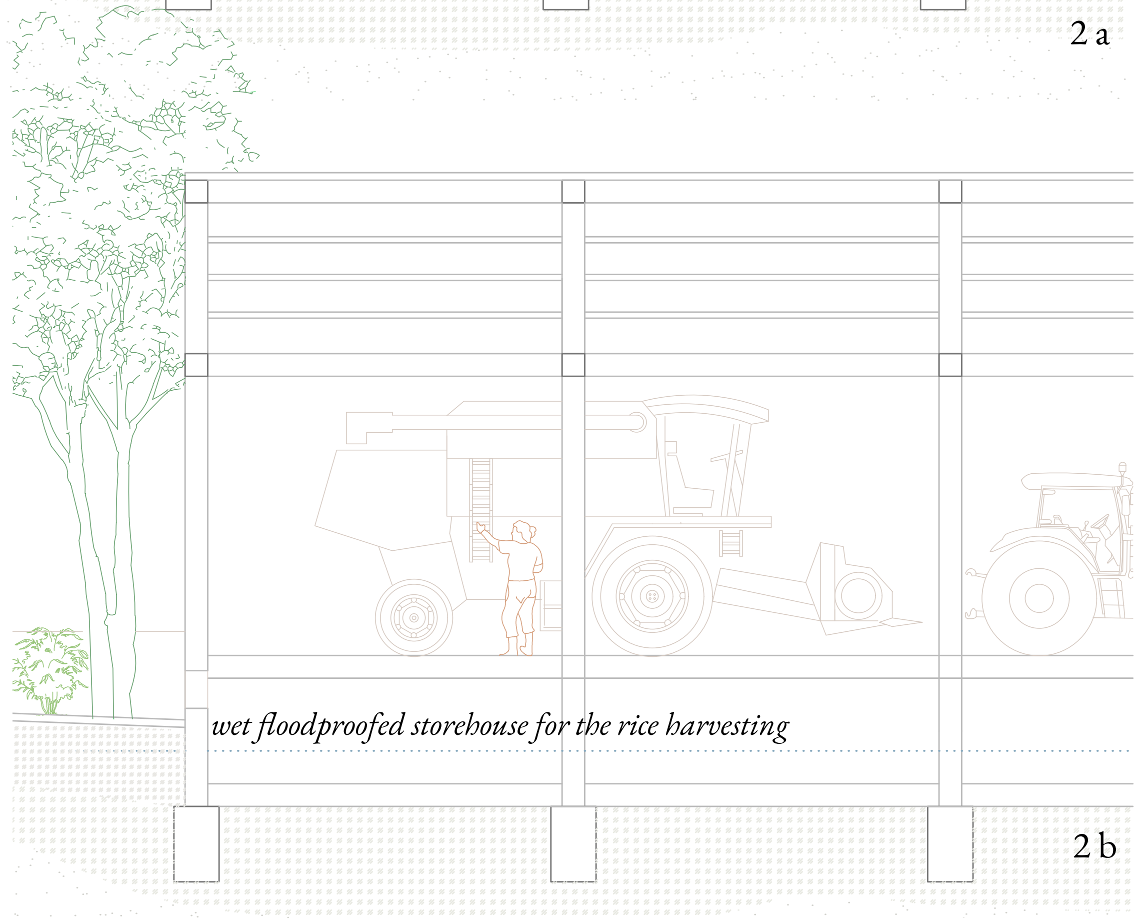
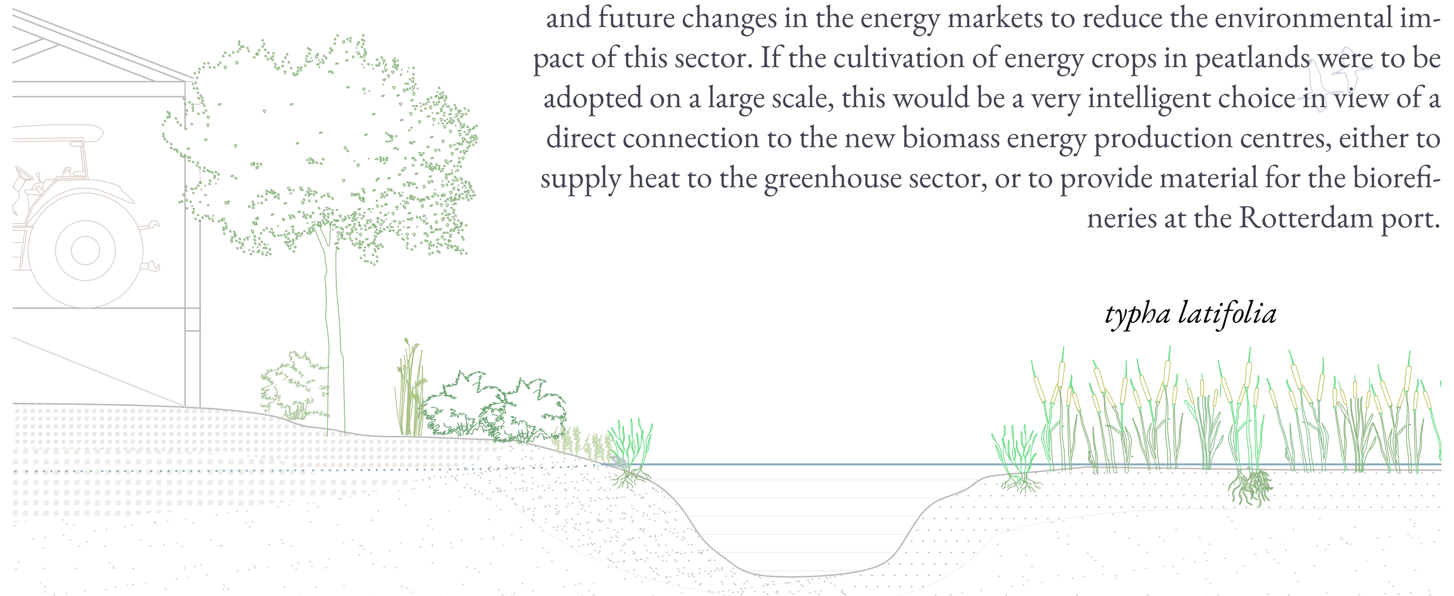


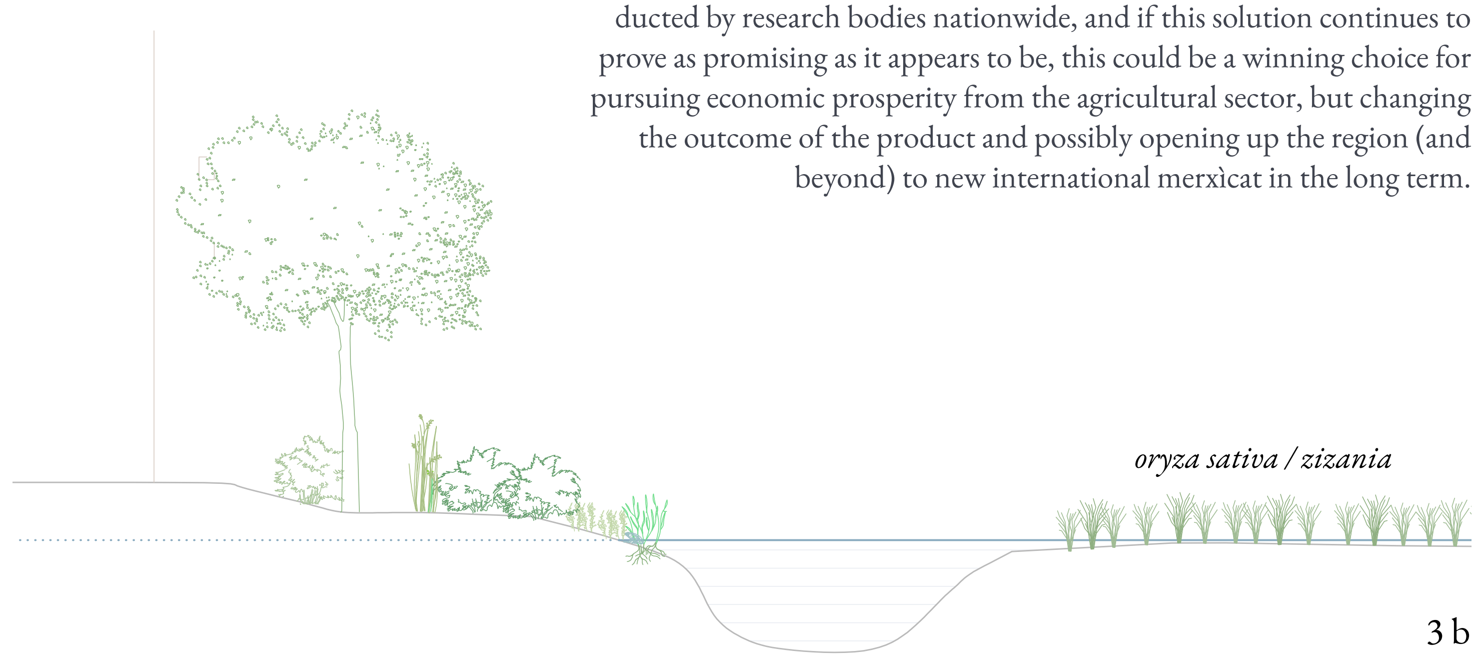
2 b

The use of these new wetland areas for the cultivation of energy crops could be a solution that deviates to some extent from the tradition of the Netherlands in food production through agrarian farming, as shown by the centuries-old tradition in cattle breeding, but could also have a very positive connotation from an economic point of view, given the ongoing and future changes in the energy markets to reduce the environmental impact of this sector. If the cultivation of energy crops in peatlands were to be adopted on a large scale, this would be a very intelligent choice in view of a direct connection to the new biomass energy production centres, either to supply heat to the greenhouse sector, or to provide material for the biorefineries at the Rotterdam port.



3 a

Studies for the cultivation of rice in peat areas are currently being conducted by research bodies nationwide, and if this solution continues to prove as promising as it appears to be, this could be a winning choice for pursuing economic prosperity from the agricultural sector, but changing the outcome of the product and possibly opening up the region (and beyond) to new international merxìcat in the long term.

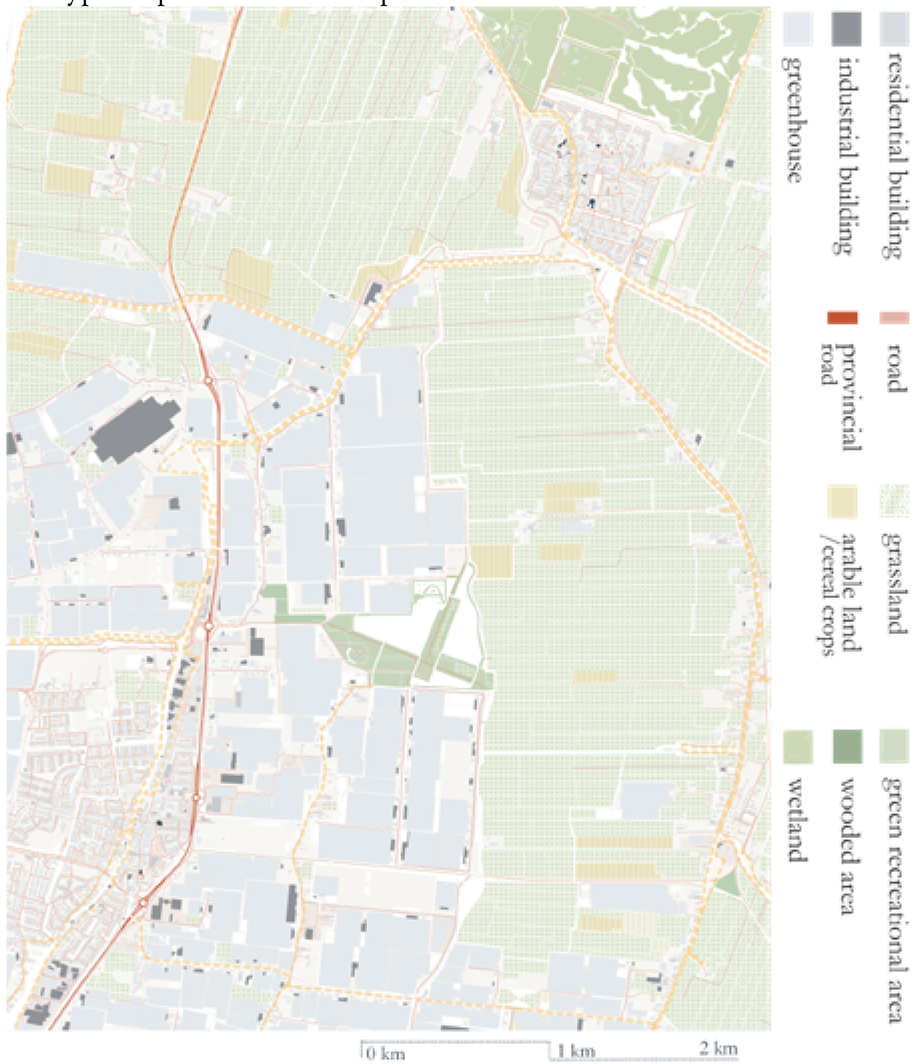


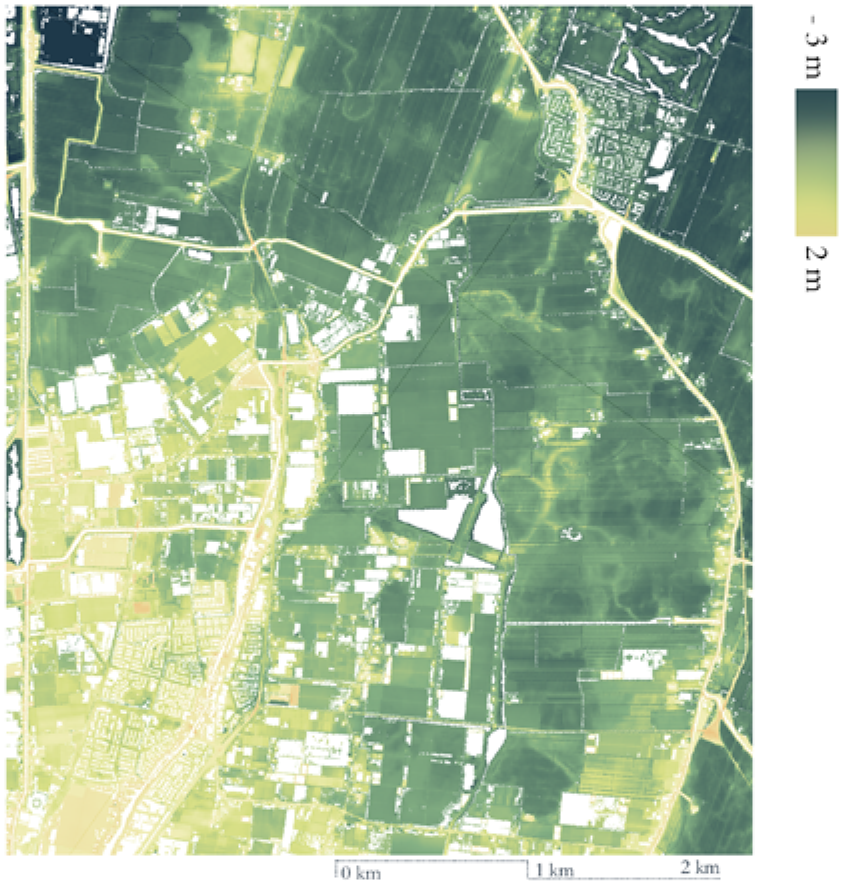
3 b

Focus 2: Farmscape and glasscape

This area is situated between the localities of Maasland, De Lier and Schipluiden, and is also in the widespread municipality of Midden Deltland.

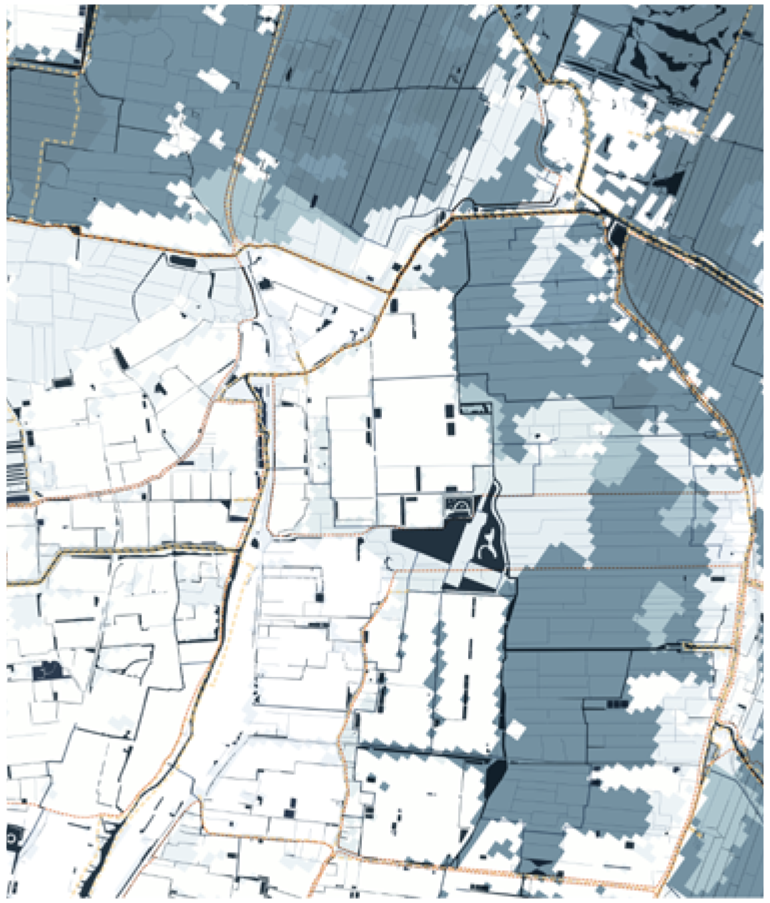
Although this is again an area partly dedicated to agricultural production, it was chosen because certain local conditions suggest that this area can be treated slightly differently than the previous one.
Thus, the approach herecan be a good opportunity to reflect on regenerative farming and its role in addressing climate challenges, as well as an attempt to apply the design approach to glasscape. Although there is no extensive area of greenhouses for fruit and vegetable production in this section, this does not prove to be a limiting factor in thinking about design. In fact, as will be shown and discussed below, the 'malleability' of this type of landscape determines the possibility of adopting strategies to deal with climate change that, although ideally applicable to the entire area, are outlined on the local scale of the individual production cell.
Furthermore, another noteworthy aspect is the willingness to address in some way the condition of 'liminality' between productive landscapes that was discussed earlier, since there is exactly an 'imaginary' boundary between two types of productive landscapes in this area.





Topography

The map shows that this area, which is again partly in the context of the Midden Delfland, is for the most part located in the low-lying landscape of the polders. At the same time, however, it is possible to see how the elevation of the land changes where the greenhouse area begins. Indeed, in the past century, when it was clear that the Westland area was to be transformed into a large centre for the growing of plants, fruit and vegetables, the area was raised by adding soil from other areas in an attempt to limit the possible risks to which the low-lying areas are exposed.



Water infrastructure system

The map shows the water system of the polder area, with the boezems, the polder ditches, a wetland area to the north (east in the geographic rarity, since this map is rotated) and a small recreational pond located in a small border area between the meadows used for livestock farming and the greenhouse landscape

On this critical cartography the different environmental challenges linked to climate change are overlapped.
Apart from the future risk of subsidence, which is higher on the right top side of the map due to the presence of peat soil, there are some other point vulnerable to subsidence, but their location very punctual may be due that it is related to the groundwater extraction by the greenhouses companies.
The risk of flooding is mostly on the clay polder, due to their hypogeal location, while the rate of salinisation is very high all over the area, but surely it affects more the horticulture production.

Environmental challenges
(only the most critical conditions are shown for each category considered)

Strategic plan - scale 1:1000

Design

In order to adopt a design that can be regenerative for the area under consideration, it is necessary to take stock of the environmental challenges facing the area and the environmental impact of production activities, so that the solutions identified can be presented as a possible strategic response on both fronts.

The risk conditions are
a. The salinity of the groundwater, which reduces the availability of freshwater for irrigation in fruit and vegetable production,
b. the difficulty of storing rainwater efficiently in the long term, especially in view of the fact that extreme climatic events such as heavy rainfall and droughts are occurring more frequently and will continue to do so in the future
c. the partial risk of flooding for the clay polder areas used for agricultural production due to their underground location.

Rather, the environmental impacts of the production landscapes in question concern
1. poor water quality due to the use of pesticides and fertilisers
2. low levels of biodiversity due to intensive farming practices and the use of land for very high production activities in order to maximise yields
3. a lack of natural green spaces and, in general, public spaces where landscape quality can be improved.

Once these assumptions were well understood, it was possible to reflect on project ideas that were well rooted in the local context and that could guarantee the continuation of economic interests while reducing the negative impact of productive activities on the environment and improving the ecosystem services that the habitat in question can provide and enjoy at the same time.

1. By creating a natural rainwater harvesting and purification system, the wetland ecosystem is stimulated to increase its capacity to collect water even in emergency situations, minimising the need for saline water extraction in such conditions. By reducing the need to resort to this option, the need to desalinate groundwater is limited and the risk of subsidence due to water extraction is reduced.
In addition, the wetland system itself would create added value in terms of the cultural, social and aesthetic value that could be perceived by the inhabitants through the enjoyment of this space.

The adoption of regenerative farming practices at the local level, but even more so at the regional level, could lead to a renewed capacity for water management, improved soil health, a higher capacity of the soil to absorb water during heavy rainfall, and an increase in biodiversity.
Rather than linear supply chains, regenerative agriculture considers the interconnectedness of all aspects of agriculture, including the production, enhancement, sharing, distribution and consumption of goods and services. The holistic principles behind the dynamic system of regenerative agriculture aim to restore soil and ecological health, address inequity and leave our land, water and climate in better condition for future generations. Regenerative agriculture results in healthy soils capable of producing high quality, nutrient-rich food, while improving rather than degrading the soil, ultimately leading to productive farms and healthy communities and economies.

3. A partial transition to vertical farming would reduce the need to occupy additional land for horticulture in the future, as well as reduce the water quantities needed for irrigation that this practice requires. Although this type of agricultural production is hyper-technological and would further reduce the dimsnion of local production, it is considered as a viable solution given the already highly advanced state of the 'machine landscape' of greenhouse production, both economically and technologically, so it is highly probable that this strong anthropised connotation will not be reduced in the future for greenhouses, but if it is to continue, it would be better to consider solutions with the least possible impact.

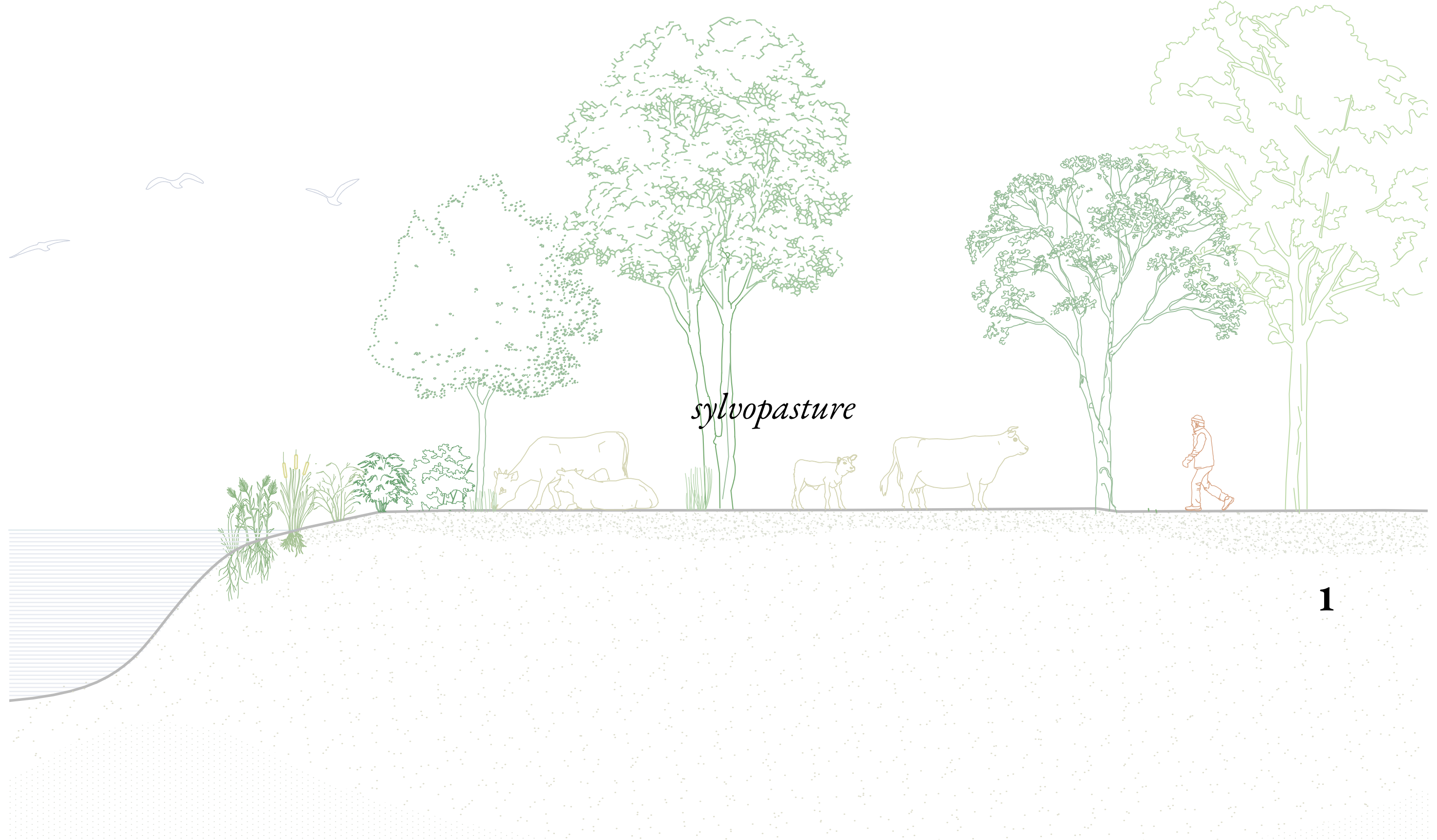
4. The use of currently unused spaces in the greenhouse area could be an opportunity for the insertion of activities on a local scale that could improve the sense of community, create public spaces, and provide a tactical intervention that could also increase the ecosystem services of the area. this could be possible by allocating these empty areas to activities that improve the natural features of the area and increase biodivesity.

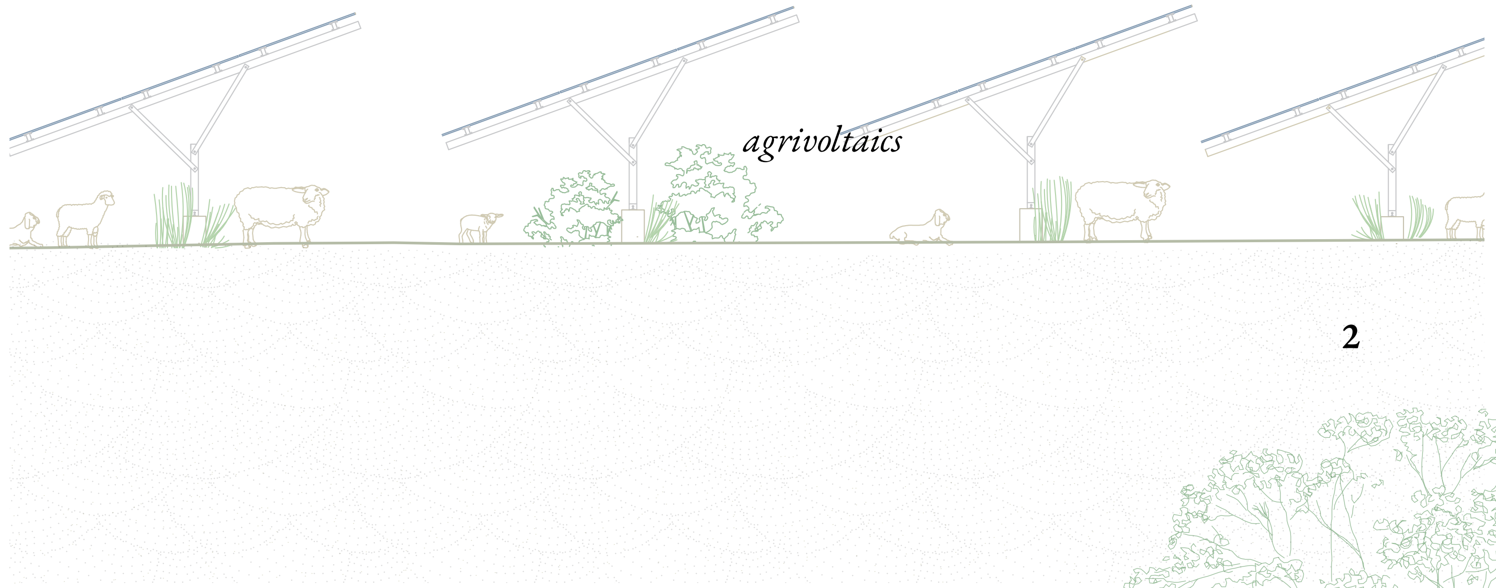
In the following, the spatial strategies conceived are further explored and described.

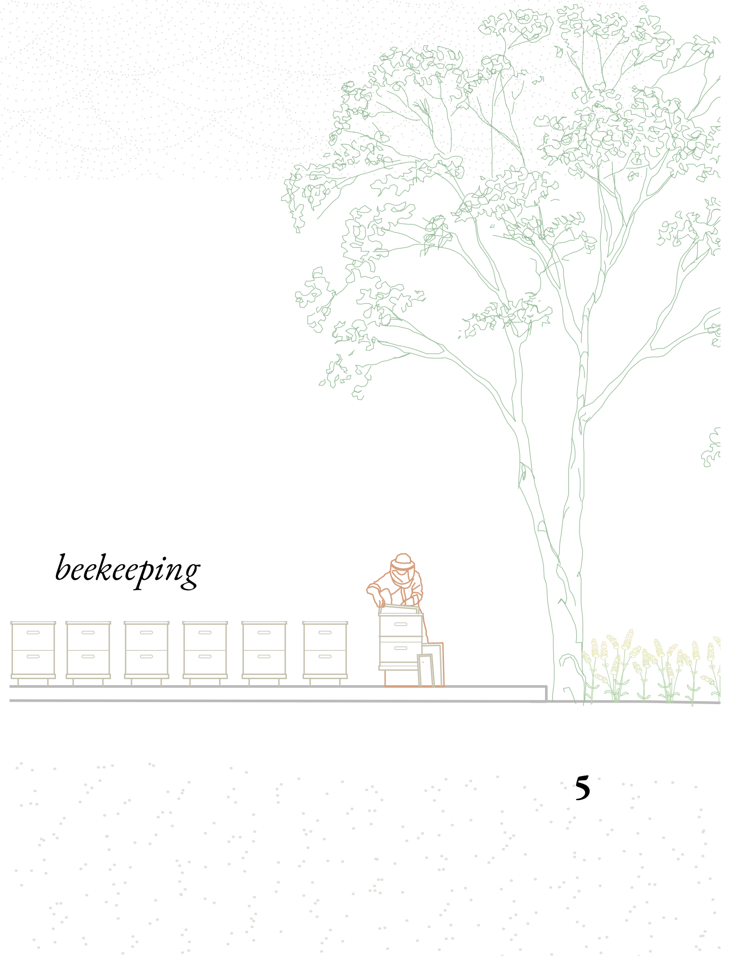
Regenerative farming

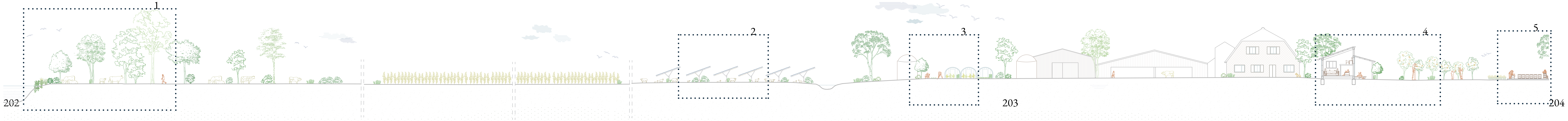
In this area, it is imagined that regenerative farming practices will be encouraged to increase biodiversity and foster an improvement in soil fertility.
Through a systemic network of various mutually supportive farming practices, the farmscape could have a better quality and contribute to ecosystem services.

Sylvopasture would be a regenerative farming practice that at the same time would contribute to the creation of a buffer space from the greenhouses, an ecological corridor where vegetal and animal species can cohexist, such as with beekeping.
If regenerative farming was recognised for its value, it could be created a cooperative of farmers with shared values and which could contribute to make this area also a special tourism destination thanks to the quality of the services provided.

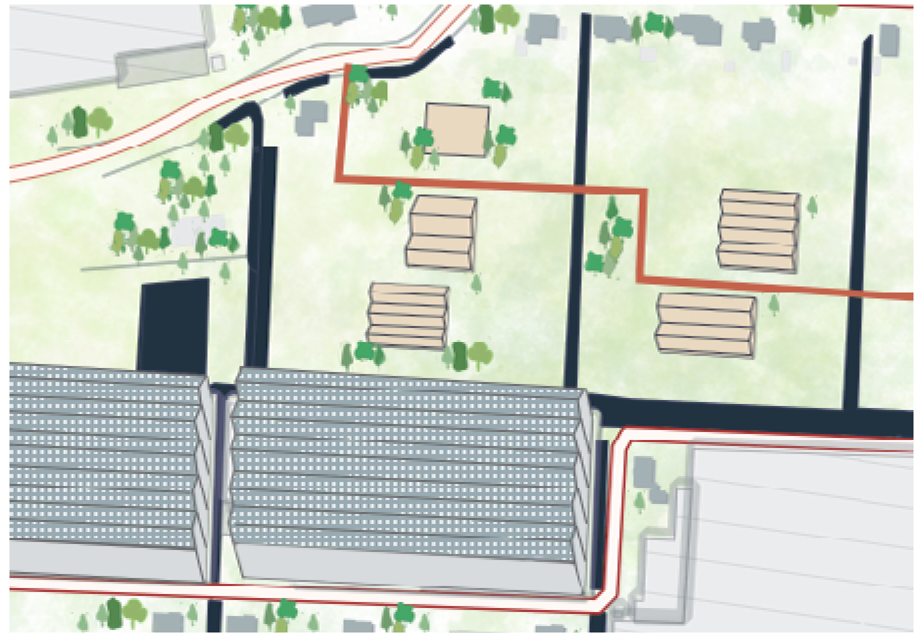




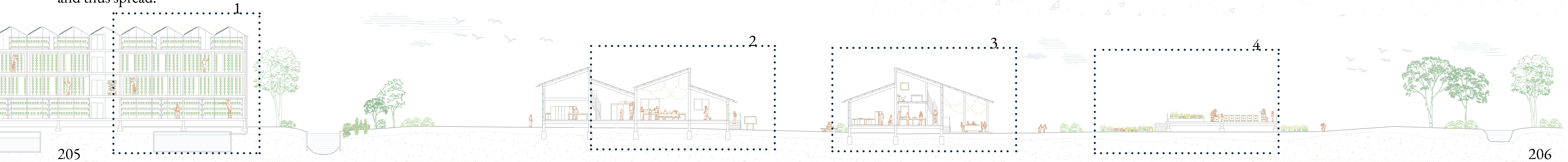


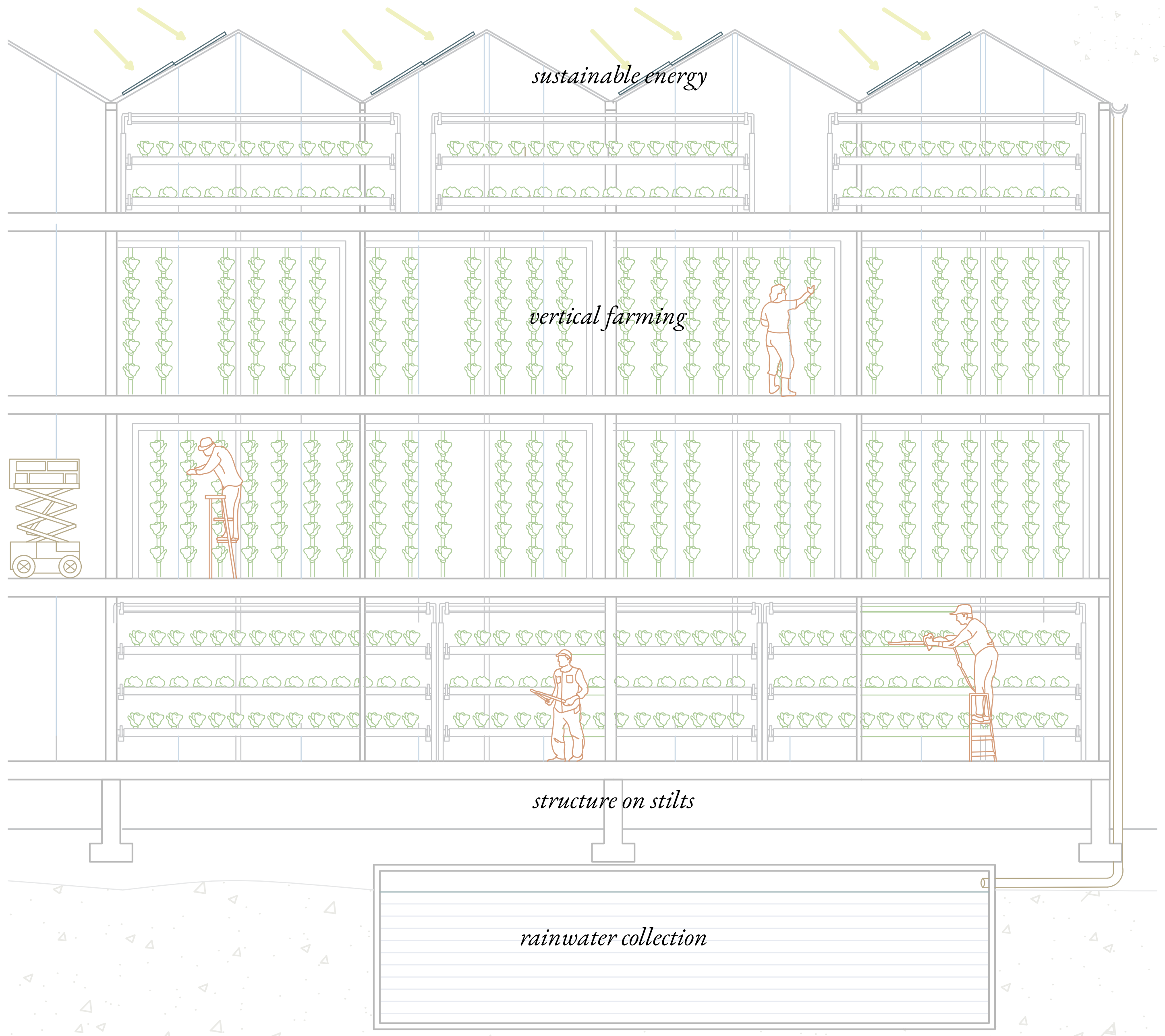


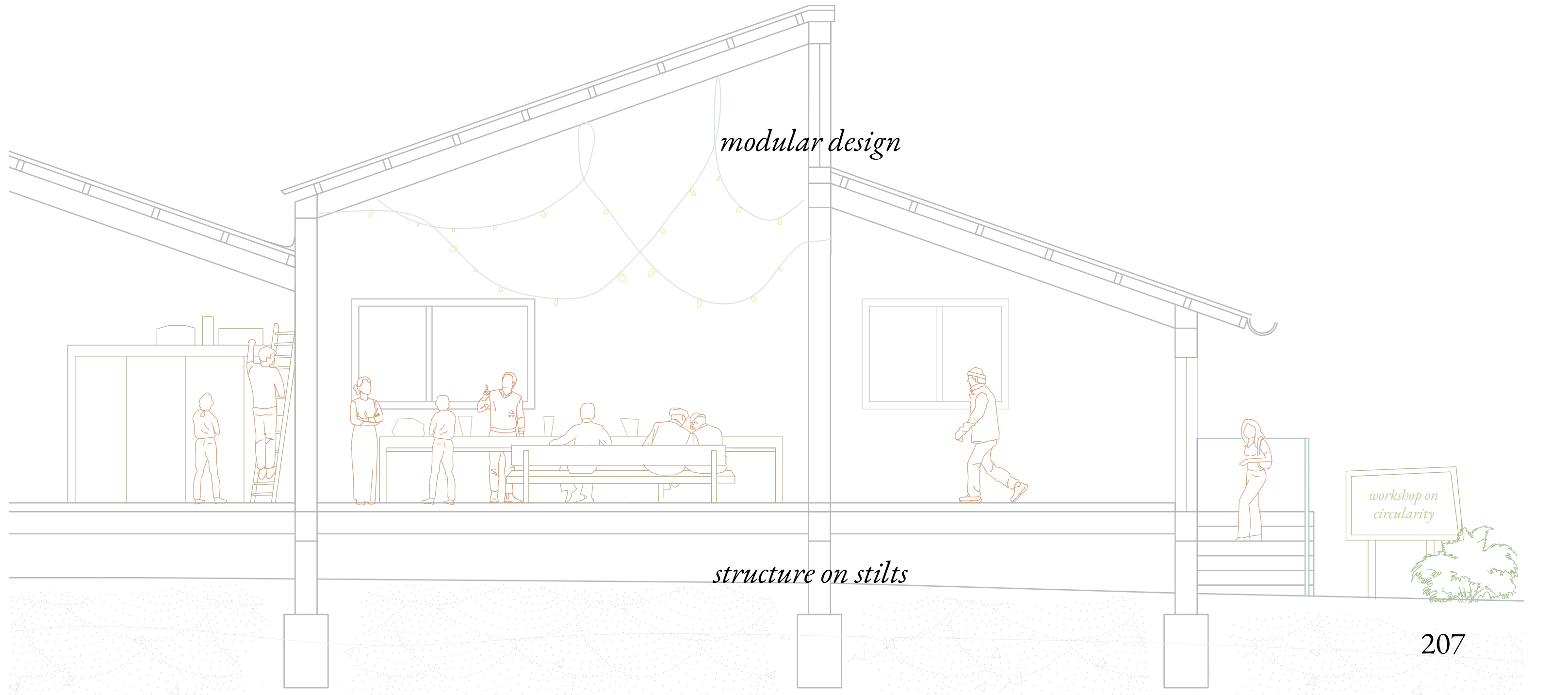
Green-housing



This particular area was chosen due to the current presence of greenhouses in a somewhat backward condition, and some empty plots currently unused. As far as the greenhouse building is concerned, it is expected that a slow transition to vertical farming (for suitable crops) may occur in the future, since with this solution the yield may increase with the same surface area used, and requires less irrigation water. This type of horticulture could therefore be a solution that takes into account the continuous economic expansion of the sector, but without causing the occupation of further open land, which should be avoided at all costs in order to contain the landtake and maintain the few free areas present, which indeed should be preserved.
Based on the latter idea, an initiative could be developed at the level of the Westland region to encourage the occupation of currently vacant areas with pre-fabricated modular buildings for recreational activities.
Such an initiative could increase the supply of quality public spaces in the area and encourage a kind of activities aimed at improving the qualities of the aforementioned 'habitat'. In fact, if these empty spaces were dedicated to activities such as workshops on the circular economy (perhaps linked to the reuse of waste from fruit and vegetable production), cooking classes, or even beekeeping, plant and flower cultivation, the value of local production, which is somewhat lacking in this context, could be passed on and, above all, the biodiversity of animal and plant species at local level could be increased and thus spread.

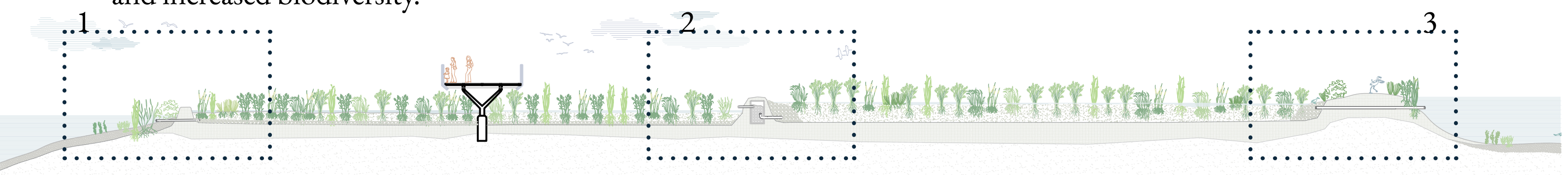




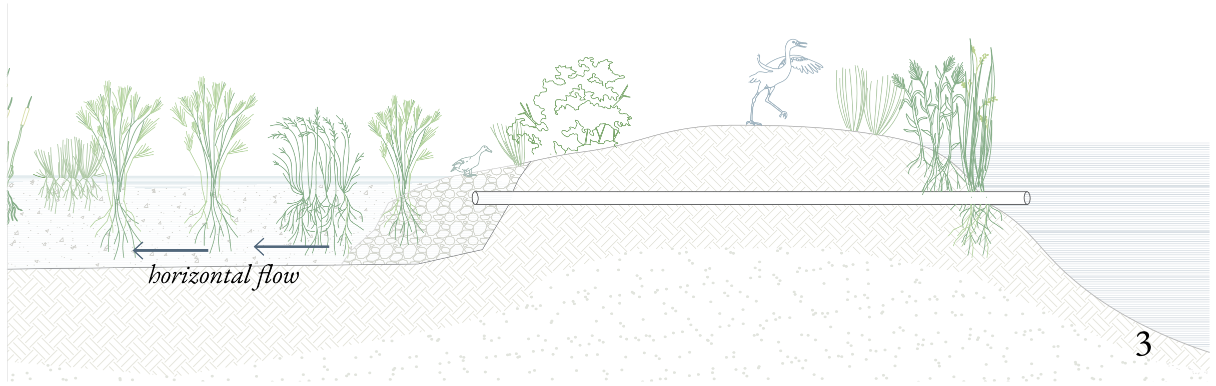


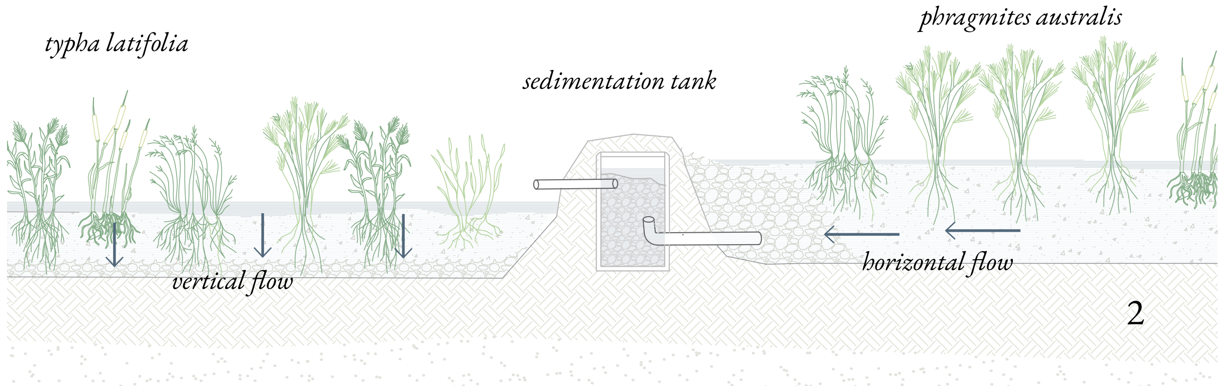
Constructed wetlands

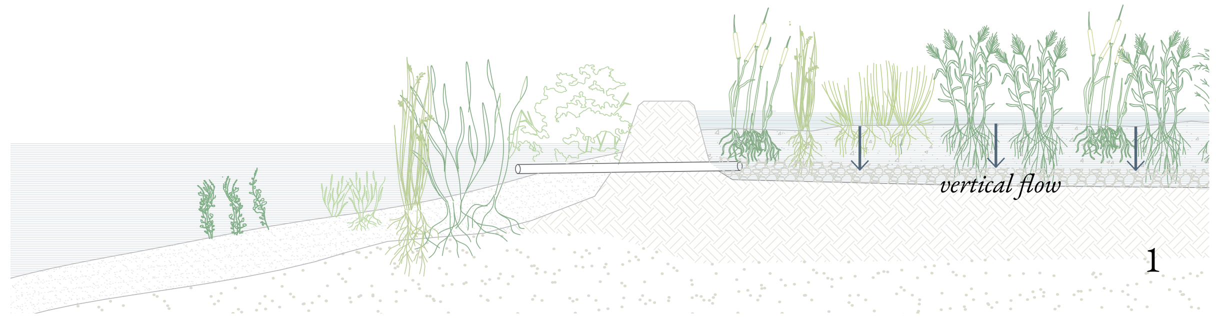
In this area, a system of constructed wetlands, which use plants to remove contaminants and treat residual waters, is envisaged. Due to the neighbouring presence of horticultural activity in greenhouses, groundwater is not characterised by high quality levels here.
Given the current uncertainty of adverse climatic events, such as heavy rainfall and periods of drought, this lake area actually used for recreational purposes could also be provided with a buffer function of water reserve and water purification, at the same time improving the biodiversity features of natural and animal species that characterise wetlands. At present, many greenhouses are equipped with a water collection system, but in times of drought these reserves are depleted and producers extract saline water from underground, contributing locally to the subsidence phenomenon, and this water must be purified before it can be used. At the same time, during periods of heavy rainfall, the potential of rainwater storage basins is related to their size, and potentially, larger quantities could be stored. This constructed wetland system could therefore be used as a reserve of water in times of need, and maintain its filtering role in 'business as usual' situations. Even if a gradual and partial transition to vertical farming, which requires less irrigation water, is decided upon in the future, the need for reserve storage could be reduced, but the presence of this system would remain valuable due to the ecosystem services provided related to water purification and increased biodiversity.



Different from natural wetlands, constructed wetlands have predetermined sizes, locations, types of substrate, hydraulic conditions, and controlled retention times. For the last point, the presence of two already existing pumps and the addition of a new one (x) allows the flows control, so that water from the boezem system doesn't get to the purified water storage basin, and if there is an exceedance in the storage, the cleaned water can be discharged back to the canals instead of being used for irrigation.
Considering instead the C.W. system to adopt, given its ability for water treatment purposes, a combination of constructed wetlands with horizontal sub-surface flow and with vertical sub-surface flow is adopted. As this system uses natural features in a regenerative proactive way, the idea is to make also all the system as natural as possible, avoiding pumps (apart the needed ones for the connection to the boezem system) and other artificial means. Therefore, for the water to flows freely in the wetland, a slight drop in height is needed between zone 3 and zone 1.







Focus 4: Waalhaven

Within the petroleumscape, the Waalhaven was designated as the location where to initiate a reflection about how the port of Rotterdam could answer to the environmental challenges related to the climate change, and at the same time comply to some other issues present in the territory, such as the need to include more nature in anthropized landscapes and the necessity of creating space for a growing population.

In the context of the research carried out in this thesis, it is important to first reflect on the choice of this particular site in relation to the other ones in the port.
The malleability discussed above is related both to the current risk conditions, which was one of the main reasons for this choice, as will be explained below, but also to the current and foreseeable characteristics of the spatial, economic and infrastructural features of the productive landscape. For this reason, the study of how the port of Rotterdam might change in the future in order to try to comply with national and international directives on the reduction of CO2 emissions, despite not referring equally to this zone, was useful both for the choice of the area and for the reflection on the possibilities and necessities of adaptation.
In fact, the areas currently occupied by the system of import, refining and export of fossil fuels escape the dynamics on which the regenerative project reflection of this work falls.
To explain further, this assumption is not intended to deny the need to include ecosystem services in the petroleumscape, on the contrary, this is perhaps the productive landscape where they are most degraded in the current situation. Nevertheless, it is too hard to try reimagining those sections where the spatial, economic and infrastructural features will have to change to reduce the carbon emissions of the petroleumscape, as it is still very uncertain how they will change, as the decision-making processes for their definition are still ongoing.

This area is one of the oldest one to be constructed during the port expansion, which started from the old harbour in the city centre towards the old river estuary to the North Sea.
It offers an interesting subject for study because of the existing land use, which opens up possibilities for smaller, immediate projects as well as larger, more permanent initiatives that involve the entire basin. The selection of this harbour basin was also based on the fact that, following the transformation of other urban harbours such as Oude Haven, Rijnhaven, Maashaven and Keilehaven, this particular basin would be the pioneering one to undergo renovation. Furthermotr, other intesting features are the direct proximity to urban area of the Old Charlois district, and its proximity to an important part of the green-blue infrastructure, the Zuiderpark, that have potential for future enhancement thanks to the connection to the Waalhaven.

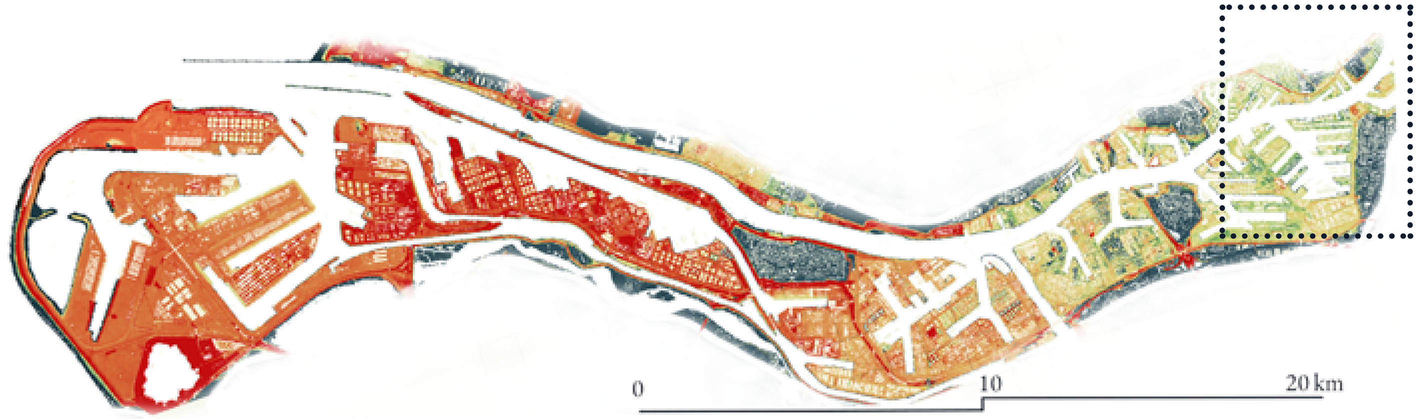
Sea level rise risk conditions

As the port expanded from the old harbour in the city centre towards the old estuary to the North Sea, new clusters were built on higher and higher ground so that the rising sea could have less impact on the activities taking place on the undiked piers.

The Waalhaven, built between 1920 and 1940, has some of the lowest elevations in the entire port area, as can be seen in the figure, and is therefore one of the most vulnerable to flooding. It should also be noted that it is not enough to consider the absolute sea-level rise predicted by climate models, but also the combined effect of tides and possible adverse climatic events, such as strong storm surges caused by heavy rainfall.

This port basin, located along the Nieuwe Waterweg, has direct contact with the North Sea, and this will remain as long as the connection is maintained by the operation of the Maeslantkering. The continuation of the full operation of the storm surge barrier is uncertain for the future, as rising sea levels will require the barrier to be closed more frequently. This may prove unsustainable, both because of the very high costs of closing and opening the barrier, and for the economic interests of the port itself, as a closure of the canal would prevent large ships from reaching the clusters further east along the Waterweg.
It is therefore unclear whether the Waalhaven's connection to the North Sea will remain for centuries to come, as one possible option would be to remove the storm surge barrier and place a barrier in the canal closer to the city of Rotterdam. However, given the context of this thesis, the design thinking for this section does not consider the 'protect close' scenario for the Nieuwe Waterweg, but assumes that the connection to the sea will remain for the future.

In addition, it is interesting to note that even if the influence of the river hydrodynamics were to disappear as a result of stricter water level control (in which case it would be regulated by a new protection infrastructure, which, as already mentioned, is not taken into account), this area would still have to be adapted to new spatial and environmental dynamics, as the functions related to port activities would be lost in any case.



(Leuven, J. R. F. W., Niesten, I., Huismans, Y., et alii, 2023)

Figure .
Map realised by the author showing the topographic height fo the Port clusters

Thus, in all likelihood, port activities will continue in any scenario to expand further and further west, as has been the case in recent decades, and as can be seen by the recent expansion of the Maasvlakte cluster. Following this process, the Waalhaven area would be the first to be redeveloped. The possibilities of transforming this area do not only respond to predictions of future social, economic and spatial conditions, but even more to considerations of risk conditions due to the impact of climate change. These risk conditions are due, as stated above, to the action of sea level rise and the effect of tidal movements, which is part of what has been termed river hydrodynamics.

This tidal influence, caused by the position of the sun relative to the moon, causes (in this region) an average water level difference of 1.65 m between high and low tide. The average daily water level in the Nieuwe Maas is +0.35 m NAP. (Rijkswaterstraat 2005)
During high tide, the water is for 4 hours and 20 minutes higher than this average, and during low tide for about 8 hours and 5 minutes lower,with a total tidal cycle taking 12 hours and 25 minutes. Once every 15 days there is a more extreme tide, the spring- and dead tide, caused by a specific location of the sun in relation to the moon: the spring tide, which is extremely high, causes a water level of +1.70 m NAP, while the dead tide, which is extremely low, causes a water level of -1.00 m NAP. If we also consider the effect of storm waves, which happens with a frequency of 1:10, there is an increase of a further 80 cm.

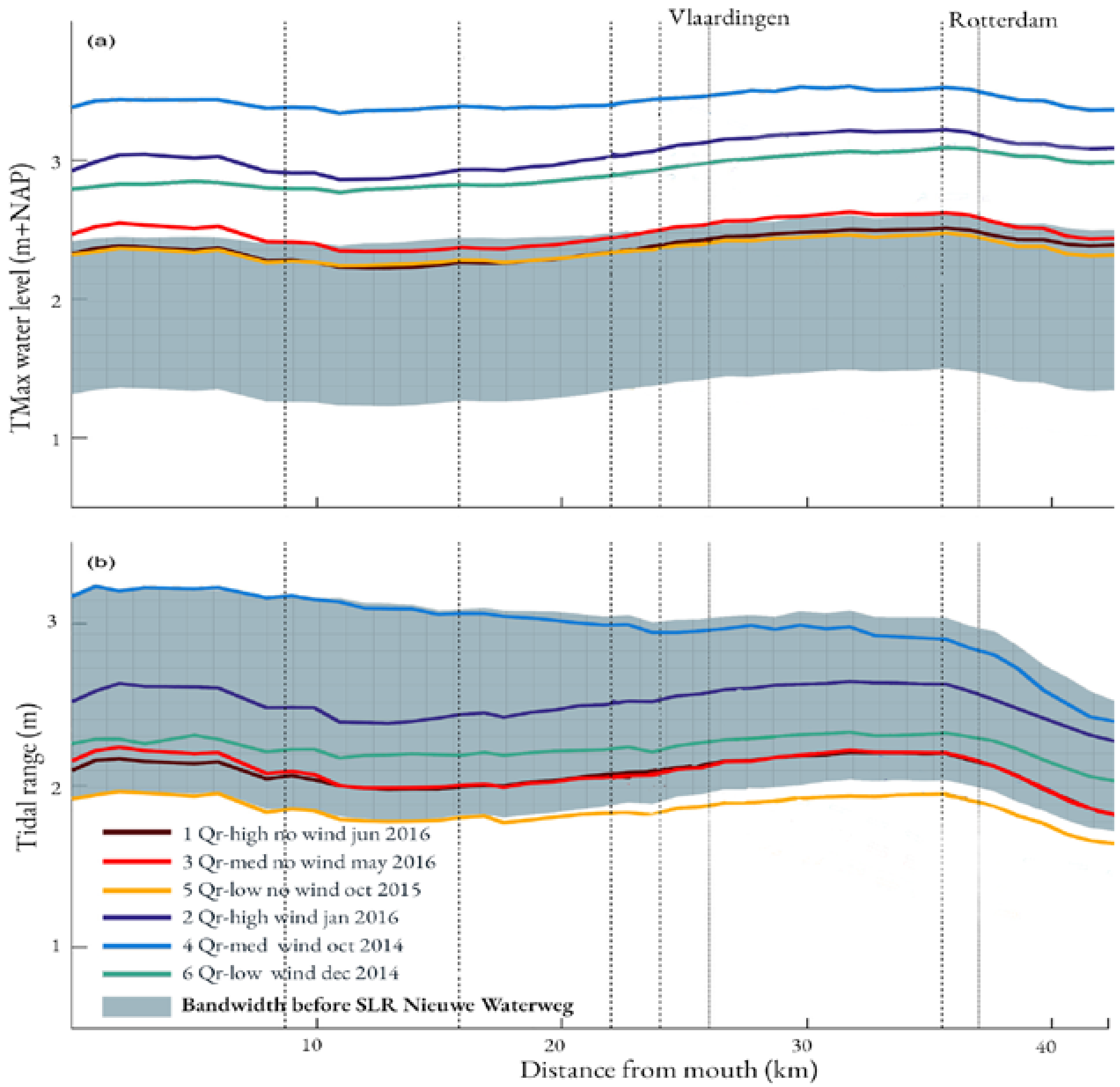
In conclusion, referring to data from a scientific study carried out very recently, '*the tidal range is typically within 2.0-3.5 m, with high water levels at about 2.5 m NAP during storm surges and low water levels of -0.8 m NAP.'*

In the Waalhaven area, which lies at an average elevation of approximately 2.9 to 3.6 metres above sea level, these morphodynamics do not have a noteworthy impact under current conditions, with the exception of the occurrence of particularly adverse events such as strong storm waves.

However, this condition no longer applies if one takes into account the action of sea-level rise, which will result in higher peak water levels. Referring to the present academic contest, *'effects of sea-level rise on future peak water levels in tidal deltas and estuaries are largely unknown, despite these areas being densely populated and at high risk of flooding. Results show that, when the current deepened bed level will be maintained, peak water levels do not rise on par with mean sea-level. . Nevertheless, SLR effects extend far beyond the range of present-day seasonal*

variations, with future low water levels being equal to present-day high water levels, while the tidal range slightly reduces.' (Leuven, J. R. F. Wet alii, 2023).
Thus, despite a residual uncertainty, one can consider the peak waters level for the future as the sum of present-day levels due to tidal movements and storm waves and the sea level rise predicted by the IPCC RCP scenarios.

The graph in Fig., reworked from the same study cited above, considers tidal range and peak water levels in relation to sea level rise and the distance of the areas under consideration from the channel mouth, taking tidal statistics from past years as starting numbers. Thus, assuming a sea level rise of around 100 cm by 2100, according to the RCP 8.5 scenario, the Waalhaven area, which is located between Vlaardingen and Rotterdam, is likely to be affected by the risk of flooding, and that for several periods several parts of its quays will be partially flooded.



From these considerations it follows that it is necessary to reflect on how this harbour basin might be transformed in the future, starting from the assumption that, given also the type of activities currently present in this area, the transhipment and storage function with bulk terminals might be partly abandoned.

At present, only a few piers at Waalhaven are still dedicated to the waterborne transfer of cargo and goods, while the other areas are devoted to logistics, maritime, industrial and business services of companies that have their headquarters at Waalhaven.
Thus, this area does not currently host any residential functions, but is very close to the Charlois neighbourhood, located behind the embankment on the west, and to the Heijplaat neighbourhood, a residential neighbourhood built at the beginning of the last century to accommodate working families at the port itself, which will most likely be subject to the impact of rising sea levels just like the Waalhaven docks, given its similar topographical height.

The conditions of vulnerability already discussed should not be seen as a limiting factor to the possible future development of residential functions in this dock, rather they could be seen as an opportunity to develop new forms of living in the city, and the easily connected location to the centre of Rotterdam is just another favourable condition.

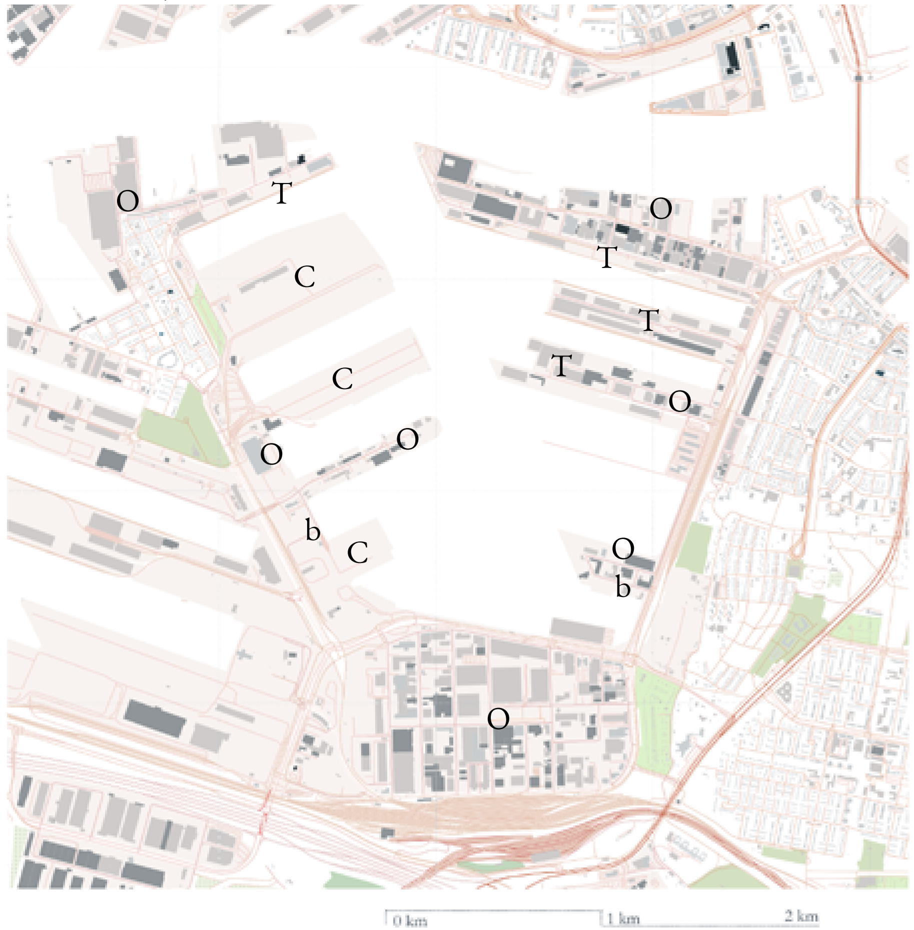
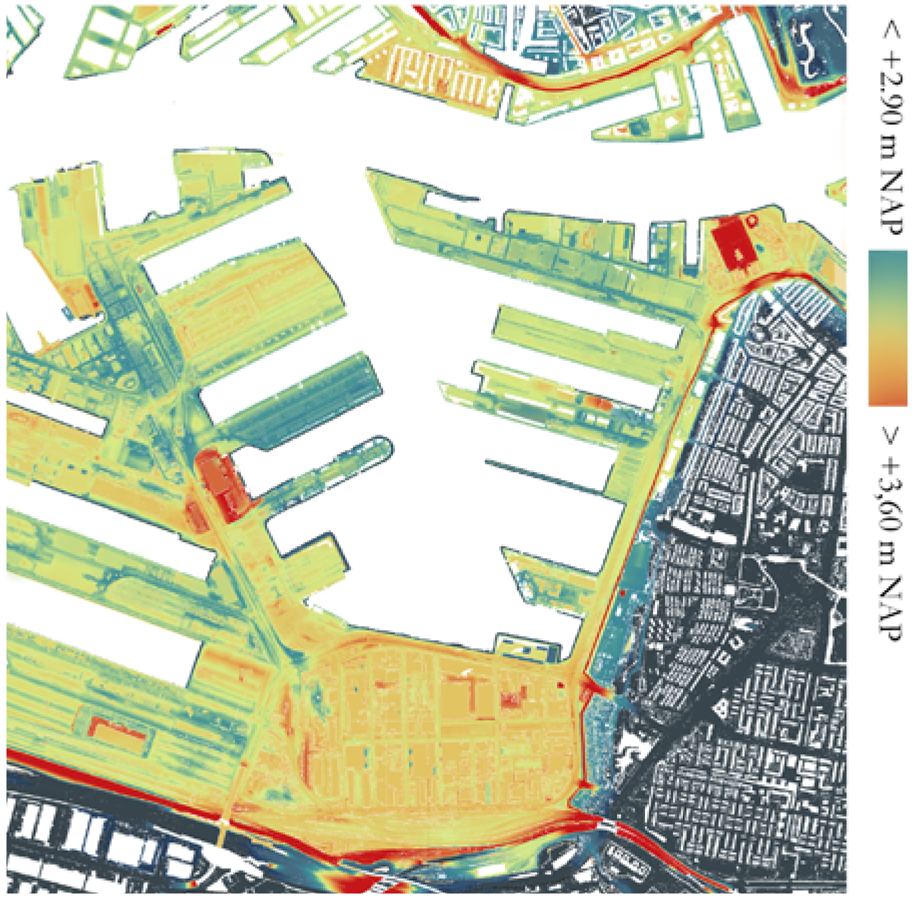


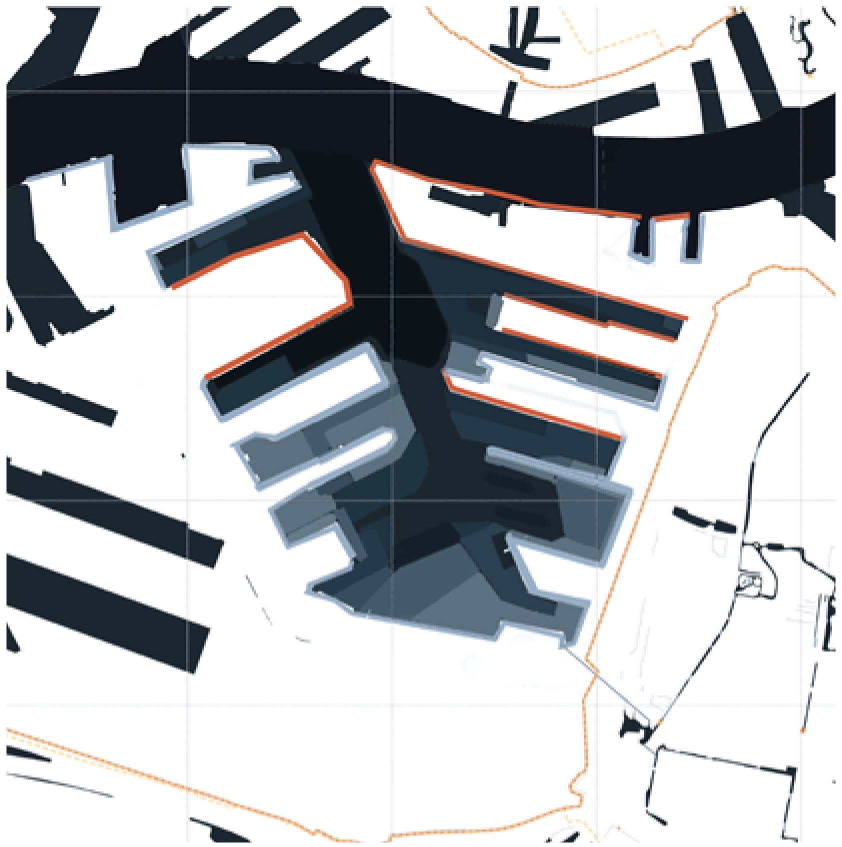
Figure x.
MAp elaboratd byt the author from GIS data and infromations from the Port of Rotterdam webside, showing the different activities present in Waalhavent in current times

B: bulk terminals (transfer via water and land)
C.; containers (transfer via water and land)
T.: transhipment of cargo and goods (transfer via water and land)
O.: other industries/offices



The production of this critical map was very functional for the design phase, as it shows which areas would be at risk from the combined effect of tidal movements and sea-level rise. Considering peak levels of around 3.5 metres due to storm waves, a large part of the Waalhaven would be submerged (in relation to the risk conditions considered and explained above), but nevertheless areas around 3 metres above sea level could be subject to increasingly frequent flooding by the sea even in the next decade with a low SLR.

Like the previous maps, this one is also functional in refining the knowledge of the morphology of Waalhaven in order to understand how the tidal movements will affect the harbour.
The quays are in fact divided into semi-hard and gradual (in light blue), hard and gradual (in orange) and hard and straight (in red). this suggests a different effect of tides morphodynamics on the quays themselves.



This map shows both the bathymetry of the waters at Waalhaven Harbour, indicating rather low levels in the southern area, and whether the harbour's docks are subject to sedimentation or erosion due to tidal movements.
Indeed tidal currents provide the energy needed to move sediments in and out of estuaries, while wave action limits the deposition of sediments on the bottom of estuaries, resulting in the modification and long-term regulation of siltation by erosion or accretion.
Thus, this information is of interest when reflecting on the future configuration of what were once used as quays for mooring vessels.

Dalrymple, R.W., Choi, K. (1978). Sediment transport by tides. In: Sedimentology. Encyclopedia of Earth Science. Springer, Berlin, Heidelberg . https://doi.org/10.1007/3-540-31079-7_181

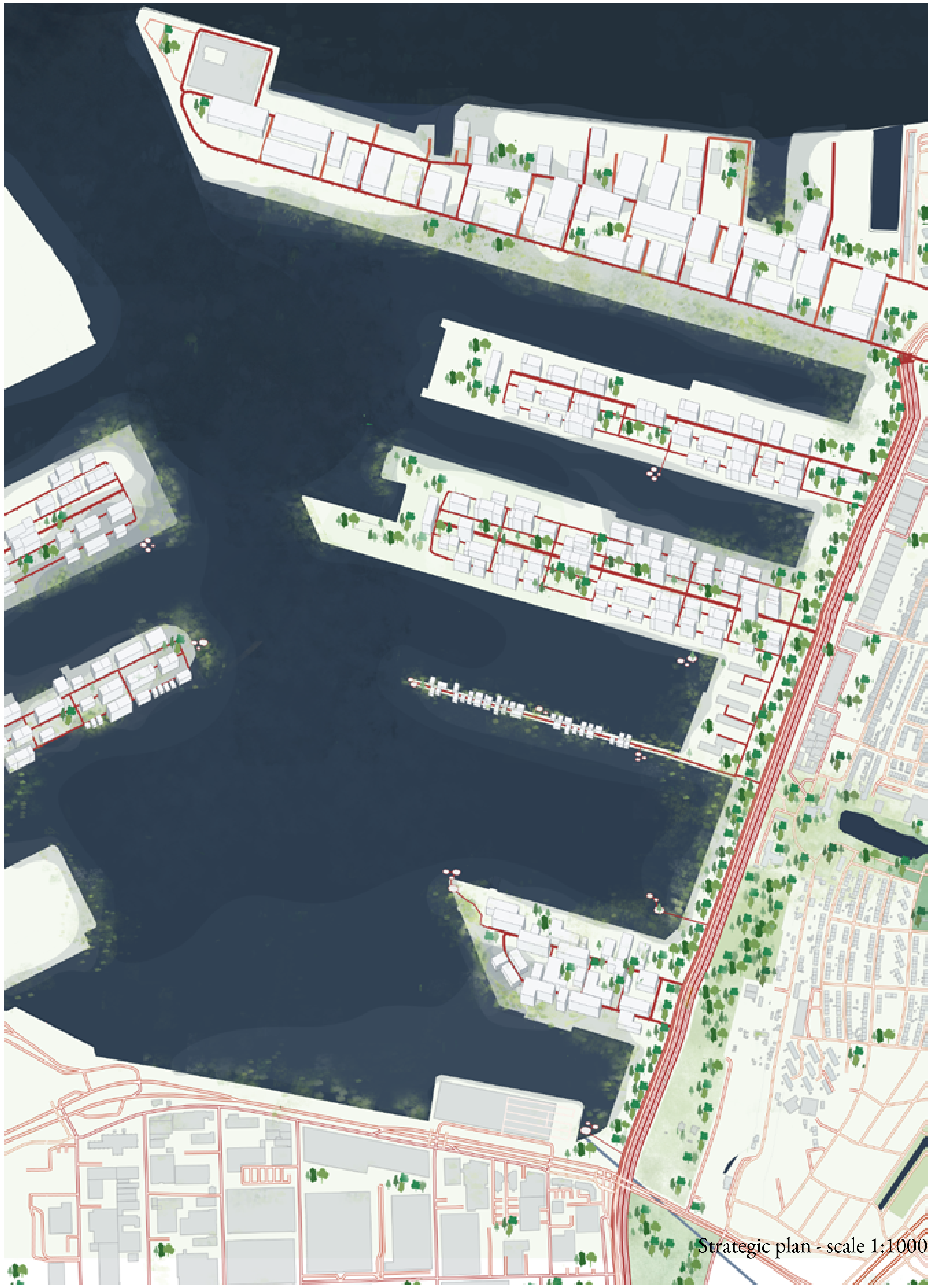
Design

Here again, the elaboration of possible design solutions was guided by the desire to apply a regenerative approach, which would reduce the impact of adverse climatic conditions, and thus favour adaptation, while at the same time reversing the negative effect of productive landscape on the environment.

Although the activities located in Waalhaven do not have the same impact as those located in other port clusters, such as the refineries in Botlek and Pernis for example, there is no doubt that the negative effects that this production area has can be clearly ameliorated.
In fact, due to the high concentration of activities from the past, the area is in part a highly anthropised but not very 'uhmanized' space, as it does not present many favourable conditions for a quality way of life in the port itself. The scarce wualità of the habitat is not only to be adressed considering the human presence, but even more so if one thinks of the natural one, since there is hardly any space for natural features, biodiversity is reduced to a minimum and contact with the water is not seen as a resource but as a negative atract factor due to the conditions of soil and water pollution.

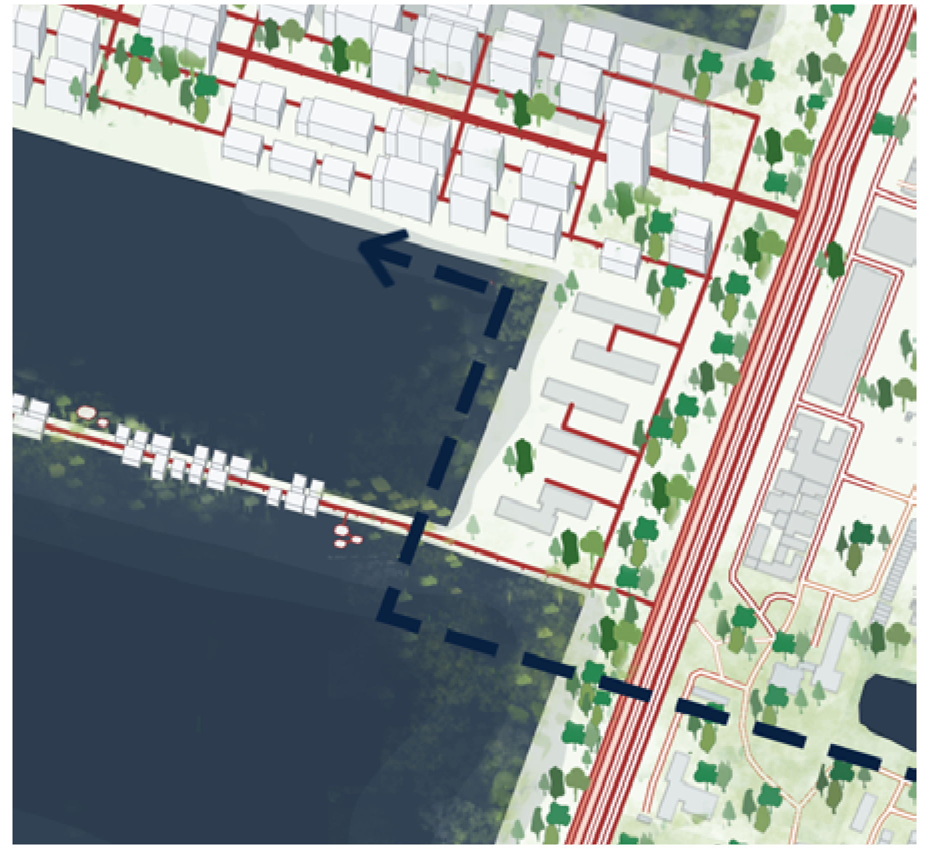
In this context, there is the possibility of creating areas for tidal nature in the Waalhaven quays (thanks to the study of which ones can accommodate such transfromation) and of increasing green areas through the planting of alluvial tree species.
The project 'The river as a Tidal Park' has been initiated by the municipality of Rotterdam for almost 10 years, and consists of several interventions, on a local or larger scale, along the Meuse, and such an intervention in Waalhaven fits well into the context of this initiative.

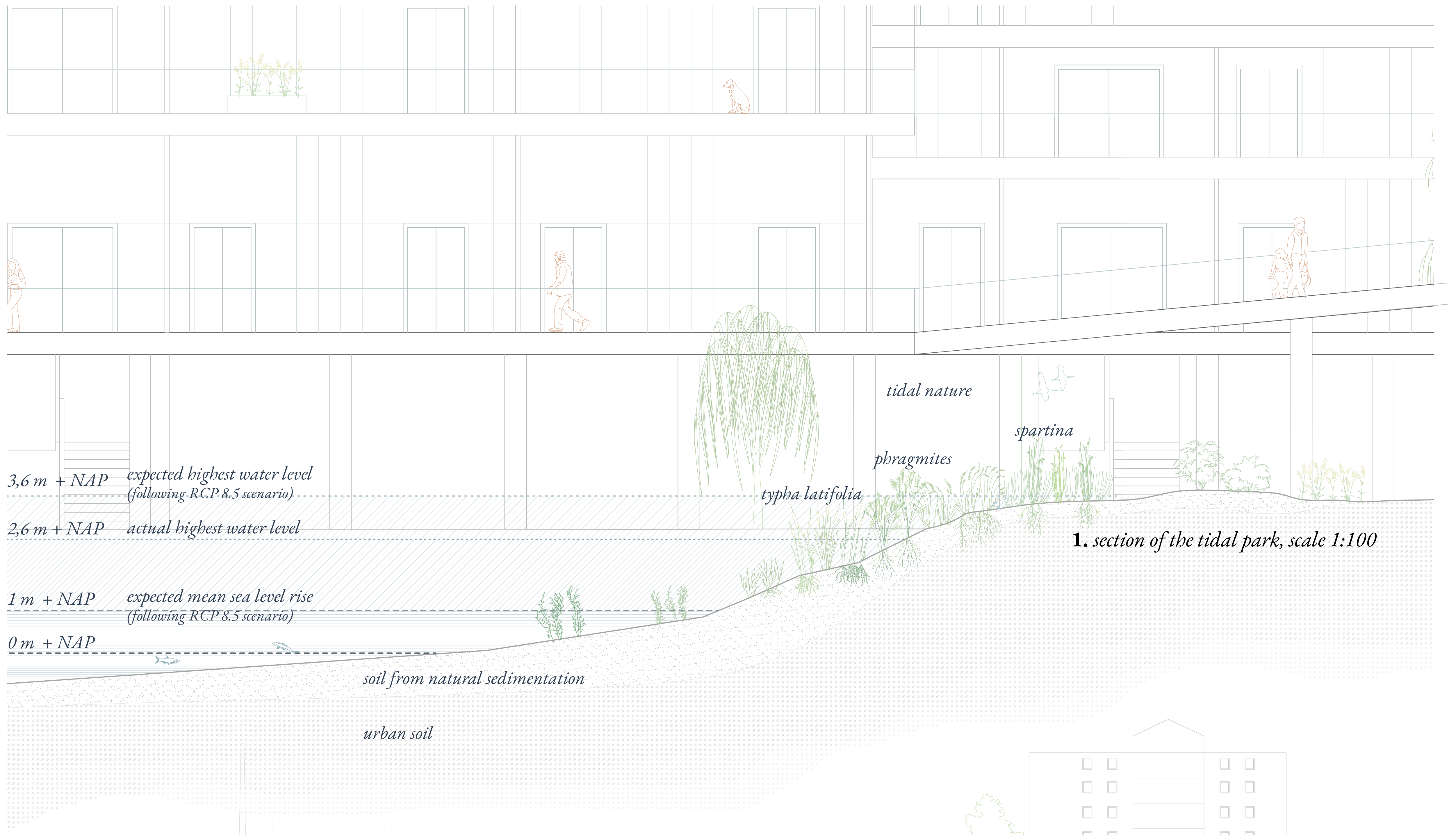
In addition to improving the quality of the natural habitat, another very important idea is considered for this area, namely the concept of 'living with water', based on the hypothesis that, as already stated, this area could accommodate new residential buildings in response to the nation's pressing need to build a large number of new homes by 2030. Therefore, the new residential areas could be built not as a result of an increase in the level of protection as is often the case, but rather with the knowledge that water will be even more of a central and positive element for the continuation of living practices in this area in the future.



Strategic plan - scale 1:1000

Tidal park





1. *section of the tidal park, scale 1:100*

2. *Section of the new mobility connetion, scale 1:100*

This specific area was chosen taking into account the data on erosion and sedimentation phenomena and the type of quay: given the presence of a gradual and sedimentation-prone quay, the long hydrodynamic process of sedimentation could lead to the creation of a tidal nature on this quay. Furthermore, the proximity of the Charlois Park is a good opportunity to link the green and blue infrastructures and to guarantee an easy and pleasant connection, allowing citizens to be more in contact with the water.
Given the risks already discussed, it is argued that residential and mixed-use buildings should be built on stilts or as floating structures, and it is assumed that with rising sea levels, the current mobility systems will have to be abandoned, giving way to a long corridor that could accommodate a linear park populated by alluvial trees. This solution would not only improve the presence of green spaces in the area, but would also have a climate-regulating effect, given the ability of trees such as willows to absorb pollutants (which other parts of the port will probably continue to release to some extent).
The desire to provide the new mobility link on the side of the embankment is not seen as a choice to reinforce the levee, but rather to leave a buffer space towards the new tidal park and residential buildings.
In the event of a further rise in sea level, this buffer space could also be used as a connecting route for light water transport.

Conclusions

This work has been crucial in understanding how spatial design can be a valuable tool in defining an approach to adapting productive landscapes to the risks of climate change.

Although this work has been carried out in South Holland, it is recognised that a similar process can be applied to other contexts where the starting conditions are very different.

In fact, the deltaic territory of South Holland was an excellent case study for gaining a high level of knowledge not only about the initial conditions, but also about contemporary experiences of spatial design. In fact, the accessibility of data and the experience in planning practices provided a very valuable contribution to this work, as did the study of the particular dynamics involved in this context. The strong productive vocation of the region and the heterogeneity of the conditions it presents, the reflection on the economic and demographic pressures and the state of climatic vulnerability were the perfect field in which to elaborate a regenerative design.

The approach developed combines data on the constituent elements of a place (such as soil, water, type of production) with the critical conditions affecting the territory, such as the environmental challenges related to climate change, linking qualitative spatial information (such as soil type) with quantitative information (such as the impact of the occurrence of a certain risk condition) in order to understand the systemic relationships of cause and effect.

An in-depth study of this kind makes it possible both to develop a strategic approach based on a 'scientific' knowledge, and to reflect on more targeted solutions at the local level, thanks to the multidisciplinary knowledge obtained beforehand.

This thesis has led to great personal growth and a renewed awareness of the importance of productive landscapes, because although it is recognised that climate change often affects urban areas the most, due to the significantly higher number of people living there, the presence of these areas is indispensable for human being as a source of economic income, but above all for every living and non-living being, due to their ability to provide essential resources for their sustenance, and ecosystem services for the protection of the habitat.
The recognition of the importance of this last condition is sometimes still not acknowledged as a fundamental element in international debates, and this project moved with the motivation to reflect on these dynamics through regenerative design.

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