River Recovery

Eem valley as a pilot for a healthy Eurodelta

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2024

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Delft University of Technology
April 2024

Master of Architecture, Urbanism and Building Sciences

Track Urbanism
Year 2023/2024, Quarter 3

AR2U086 R and D studio: Spatial Strategies for the Global Metropolis

AR2U088 Research and Design Methodolgy for Urbanism

Foreword

We proudly present you with the report we have worked on in the past ten weeks. We are Nathan van Beem, Maaike Dijkstra, Eva Egelmeers, Tejon Kraan, and Yillin Yang. As students of the TU Delft master program Urbanism, we were asked to write and present the research and design we conducted for quarter three. Compared to previous quarters, the design assignment of quarter three is focused on designing within a regional planning context. The subject region is a self-chosen Dutch area within the Eurodelta. This delta consists of the catchment areas of the rivers Schelde, Meuse, and Rhine. The area we chose is the Eem Valley.

The design objective had to be either nitrogen, carbon dioxide, or water. Although crossovers were likely to happen, and, above all, encouraged. The main objective of our design is water. More specifically: water pollution.

In this report, you will find the design and research we did. Under the supervision of Irene Luque Martin and Caroline Newton, we underwent a process that eventually led to two main products: firstly, a spatial vision, and secondly, a development strategy. Although distinctive products, these are inseparably intertwined.

A spatial vision is about imagining a plausible and desirable long-term spatial future based on distinct values. It functions as a normative agenda, aiming to convince, enable, and engage stakeholders. A development strategy, on the other hand, focuses on the implementation of this vision. The transition towards the vision is realised through carefully planning spatial interventions, with stakeholder engagement management, and policy-making.

We shortly want to thank Irene Luque Martin and Caroline Newton for their time and effort put into guiding us critically yet enthusiastically.

We wish you, the reader, an enjoyable reading experience. We hope you learn just as much as we did during this quarter!

Nathan, Maaike, Eva, Tejon and Yilin

Abstract

Only 1% of the surface water in the Netherlands has been classified as 'good', making it the EU member state with the worst quality of surface water (Didde, 2022). Polluted rivers cause problems such as worsened human health, reduced biodiversity, and poor soil fertility. To comply with the Water Framework Directive, there is an urgent need to transform water management in the Netherlands. This report adopts a research-by-design approach to address the issue of water pollution on a pilot project scale, specifically the river Eem in the Netherlands. The policies and interventions implemented in the river Eem area are categorised according to their transferability to different programming areas, namely urban, industry, or agriculture, creating a toolbox that can be used to upscale the same approach in various parts of the Eurodelta. The report answers the following research question: How can the transformation of the Eem Valley turn the river Eem into the healthiest river in Europe as a pilot for the Eurodelta? It catalyses rethinking pollution flows from human activities, industries, and agricultural practices. The goal is to come up with sustainable practices for the land surrounding the river and to create a synergy between the improved soil and water quality. Finally, the report concludes with a toolbox of interventions and policies that contribute to the improvement of river water quality. The toolbox forms the basis for implementing this small-scale approach on a larger scale.

Keywords: water quality, soil quality, water pollution, sustainable land use, research-by-design

▼ *Figure 0.1: panorama taken at the end of the Eem (source: own work)*

▼ *Figure 0.2: panorama taken at the entrance of Amersfoort (source: own work)*

1 Introduction

Panorama taken at the brooks

Contents

In this chapter, the main objective of our project, water pollution, will be introduced. The complexity of this multi-faceted issue will be depicted in the flow analysis after which the problem is spatially analysed on the European scale. This will lead to the problem statement, followed by policy document analyses. To round up this introductory chapter, we will look at the United Nation's Sustainable Development Goals and how they relate to the problem statement.

1.1 Water pollution

Our rivers are deteriorating. Only 1% of our waters meet the criteria for being labelled as "good", making the Netherlands the lowest-scoring country in terms of water quality in the European Union (Didde, 2022). But what are the polluters of our waters? To answer this question, we researched nutrient, chemical, (heavy) metal, and plastic waste.

Nutrient pollution

The main reactive nitrogen compounds that humans introduce into the atmosphere through emissions are ammonia (NH3) and nitrogen oxides (NOx) (the sum of nitrogen monoxide (NO) and nitrogen dioxide (NO2)). These emissions deteriorate air quality before they deposit elsewhere (TNO, 2022).

Nitrogen deposition, also known as eutrophication deposition, refers to the number of nitrogen-containing compounds removed from the atmosphere through direct uptake by vegetation and soil (dry deposition) or through precipitation (wet deposition).

In the Netherlands, the critical deposition value for nitrogen is exceeded on 72% of the terrestrial nature. The critical deposition value is the threshold above which there is a risk that the quality of the habitat will be significantly affected by the acidifying and/or eutrophying influence of atmospheric nitrogen deposition.

In addition to its impact on air quality, nitrogen compounds play an important role in themes such as water quality, drinking water quality (nitrates), and greenhouse gas emissions (nitrous oxide).

Figure 1.1, shows that Ammonia mainly originates from livestock farming, with cattle (49%) and pigs (15%) making the largest contributions. For the total emissions of reactive nitrogen (Nr), agriculture is responsible for 61% of the total emissions (TNO, 2022).

The Nutrient Monitoring Network for Agricultural Specific Surface Waters (MNLSO) report reflects that the water quality in agriculture-specific waters is improving. However, between 2014 and 2017, about 40% to 60% of the measuring locations did not meet the water authority standard for total N or total P (OECD, 2023).

To maintain the water quality, it is essential to keep ammonia (NH3) emissions below the level that would result in N deposition above critical thresholds. The overall target is to reduce the emissions by 50% by 2030. Similarly, nitrate (NO3-) emissions should remain below the level that would degrade surface and groundwater quality. The Water Framework Directive (WFD) has set the target at 50 mg/l.

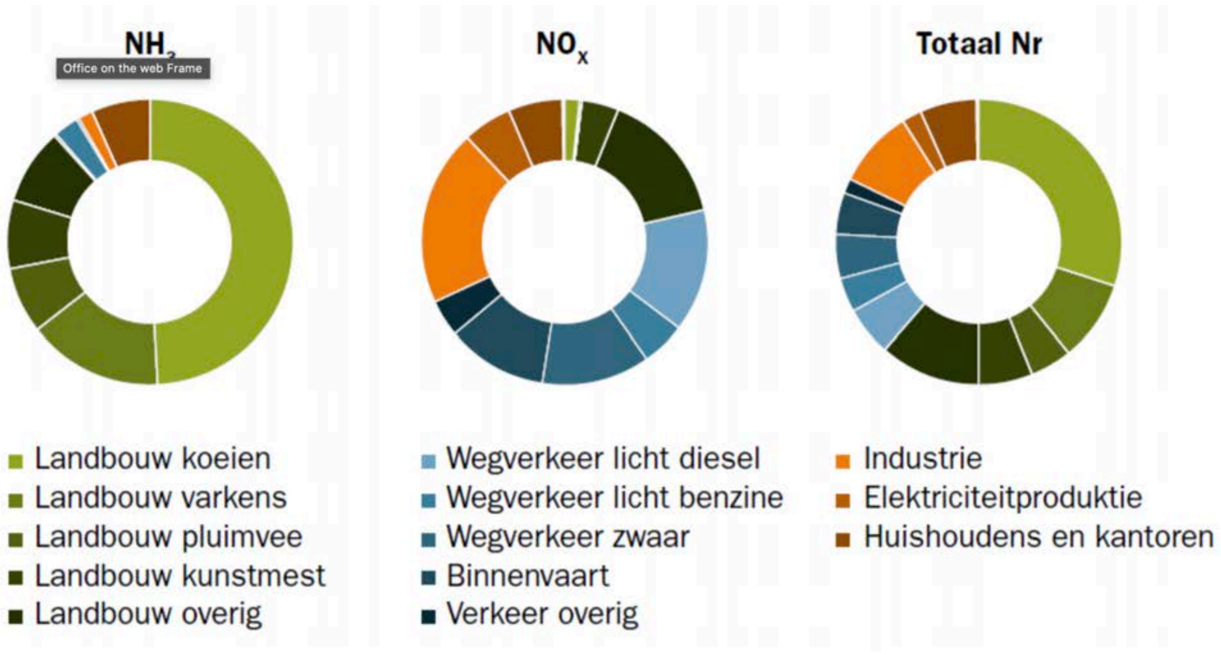
To adhere to the Nitrates Directive, N and P application within the Good Agricultural Practice, and N from livestock manure should not exceed a limit of 170, 230 or 250 kg N/ha, total N and P manure-production below 2002 quantities. Moreover, methane (CH4) emissions should be below greenhouse gas targets to reduce the total emission of greenhouse gases in the sector by 49% by 2030 (OECD, 2023).

It is worth noting that all these thresholds are closely related to livestock production, specific animal husbandry, or other farming practices. The measures in the action plan will also help to achieve the objectives of the WFD as agricultural practice is responsible for emissions of nitrogen and phosphorus to ground and surface waters (including coastal and transitional waters) that affect WFD targets (OECD, 2023).

Chemical pollution

Different types of chemical pollution are pesticides, household waste, oil spills and ammonia. Each of these pollutants forms a problem for the water quality.

Pesticides, for instance, are a major source of pollution. They create health problems for people and the environment. Nowadays, European agriculture relies heavily on the use of pesticides. "In 2020, one or more pesticides were detected above thresholds of concern at 22% of all monitoring sites in rivers and lakes across Europe. 83% of agricultural soils tested in a 2019 study contained pesticides residues." (European Environment Agency, 2023)



▲ *Figure 1.1: for the total emissions of reactive nitrogen (Nr), agriculture is responsible for 61% of the total emissions. (source: TNO, 2022)*

The reduction of the use of pesticides is distinctly present in The European Green Deal (European Environment Agency, 2023):

- A 50% reduction in the use and risk of chemical pesticides.
- A 50% reduction in the use of the more hazardous ones.
- At least 25% of the EU's agricultural land to be under organic farming.

Oil spillages can destroy marine and riverine habitats and kill many animals. Yet, for every litre of oil consumed, one litre ends up in our waters: "Half of all purchased lubricant oil will become waste oil. The rest is lost during use or leakage." (European Commission, 2008)

Ammonia, an inorganic chemical compound of hydrogen and nitrogen, can have negative impacts on aquatic ecosystems and can cause damage to vegetation. Increased acid depositions and excessive levels of nutrients cause this problem in our soil and/or water. "Eutrophication can lead to severe reductions in water quality with subsequent impacts including decreased biodiversity, and toxicity effects." (European Environment Agency, 2019)

Heavy metals

Globally, less than one percent of our land area is used for mineral extraction, which is a very small portion when compared to agriculture. However, mining is a major factor in environmental pollution. To top that, John Ruggie, a UN Special Representative for Business and Human Rights, says that the number of complaints received about the mining and oil industry is higher in comparison with any other branch of the economy. Mostly by locals in connection to major unwanted changes to their environments or even forced evictions (Heinrich Böll Foundation, and Institute for Advanced Sustainability Studies, 2015)

Nonetheless, the demand for minerals, fossil fuels, and metals is still rising. Iron ore, cobalt, and coal output went up by 180%, 165%, and 44%, respectively in the last 10 years. "In the United States, one person consumes 17 tonnes of metal, minerals, and fossil fuels per year – that makes 1343 tonnes in a lifetime." (Heinrich Böll Foundation, and Institute for Advanced Sustainability Studies, 2015, p.32). This is problematic since for every tonne of ore being excavated, 3 tonnes of soil and rock have to be removed. Besides, toxic waste is being produced during the process of refining the ore.

This is quite challenging for the environment and the surrounding landscape. Especially if the waste ends up in open water bodies and contaminates areas far beyond the mine's home region. Legally, the mining companies are expected to deal with the waste. However, often when the mining period is over, the mines close or go into bankruptcy, and the mess is left to the government and taxpayers to clean up.

Plastic waste

About 80% of the plastics found in our oceans are derived from land and flow into our oceans through rivers, with the most commonly detected items being plastic bags, bottles, and food containers. The solution to this problem is to prevent plastic from entering rivers or the sea in the first place (the Great Bubble Barrier, n.d.).

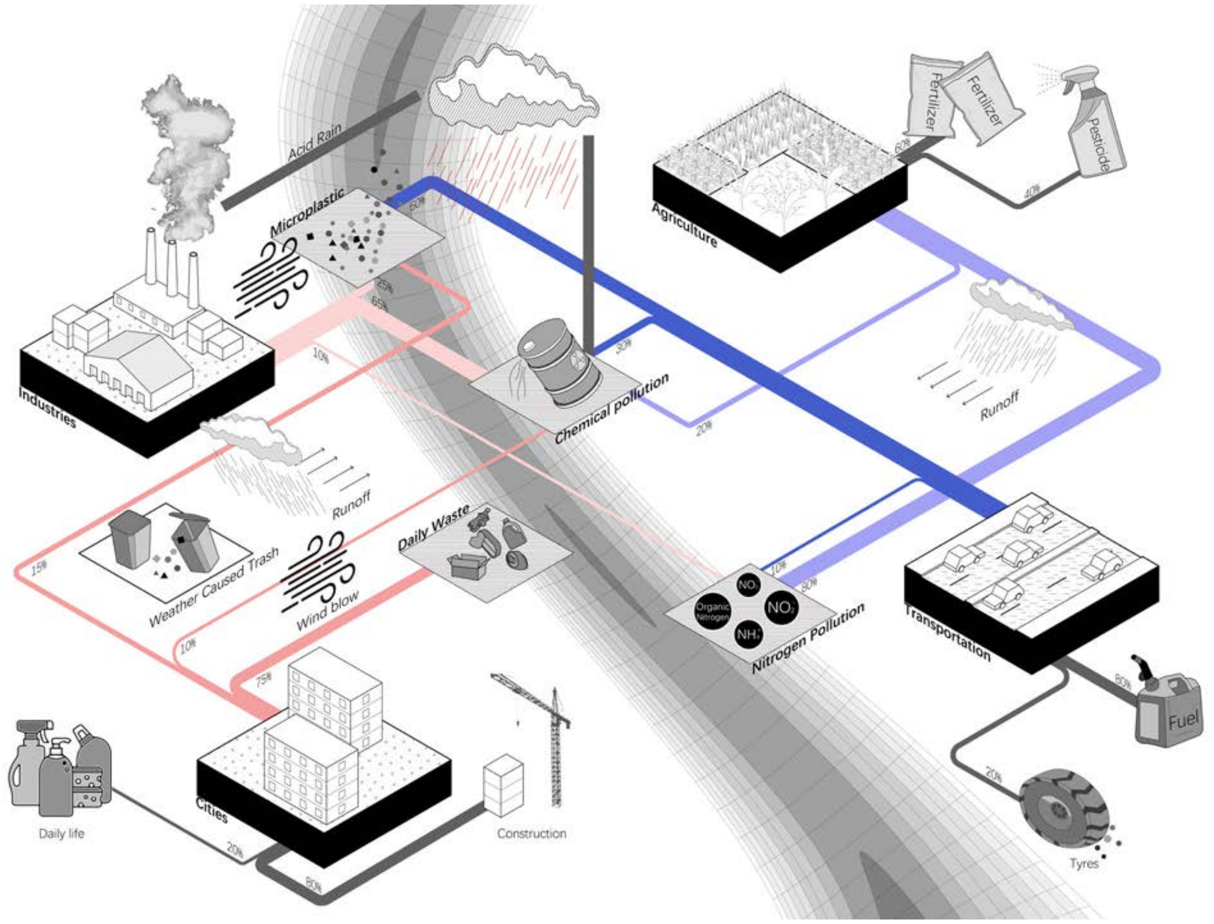
Littering is one of the significant factors here – from less careful disposal on roads to random large-scale illegal dumping. At times, littering is done accidentally, and some individuals may want to dispose of their waste properly when there is a lack of appropriate waste management facilities. Plastic's light weight makes it a victim of wind dispersion, commonly escaping from open bins or transport vehicles only to be eventually swept into the rivers through the runoff. Regardless of the collection of plastic waste, recycling rates are still very low, and only about less than 10% of all plastic ever produced has been recycled (the Great Bubble Barrier, n.d.).

Originating from man-made plastics, microplastics are largely persistent, increasingly found globally in the environment, and have even been detected within the human body. In the Netherlands, the primary sources of microplastics are packaging, car tyres, and agricultural foils (Urbanus et al., 2023). This issue is projected to worsen by 2050. The lack of comprehensive data on human exposure to microplastics and their effects hinders proper risk evaluation. Consequently, the Dutch government has adopted the precautionary principle to minimise the use, generation, and dissemination of microplastics, aligning with EU strategies.

Driving is also creating a growing source of microplastics, particularly from tyre wear. By the end of the next decade, it is expected that one-third of microplastics recovered from UK waters will be from tire abrasion. Through the friction process with road surfaces, tyre particles are gradually lost, causing a decreased weight of the tyre eventually. Many of these minuscule particles linger in rivers, accumulating in stagnant pools or settling along riverbanks for extended periods. Only about 2% of plastic entering rivers eventually makes its way to the oceans (the Great Bubble Barrier, n.d.).

Formerly, it was considered that a few major rivers contributed to funnelling the plastic into oceans, meaning that managing the plastic waste of these rivers could substantially eliminate the issue. Nevertheless, the latest studies also show the picture is more complicated, with more than 1000 smaller rivers now being involved in the process of delivering plastic waste to our oceans and rivers (the Great Bubble Barrier, n.d.). To conclude this chapter we have combined all different waste flows into a diagram shown in figure 1.2.

▶ *Figure 1.2: analysis of flows that are polluting rivers (source: own work)*



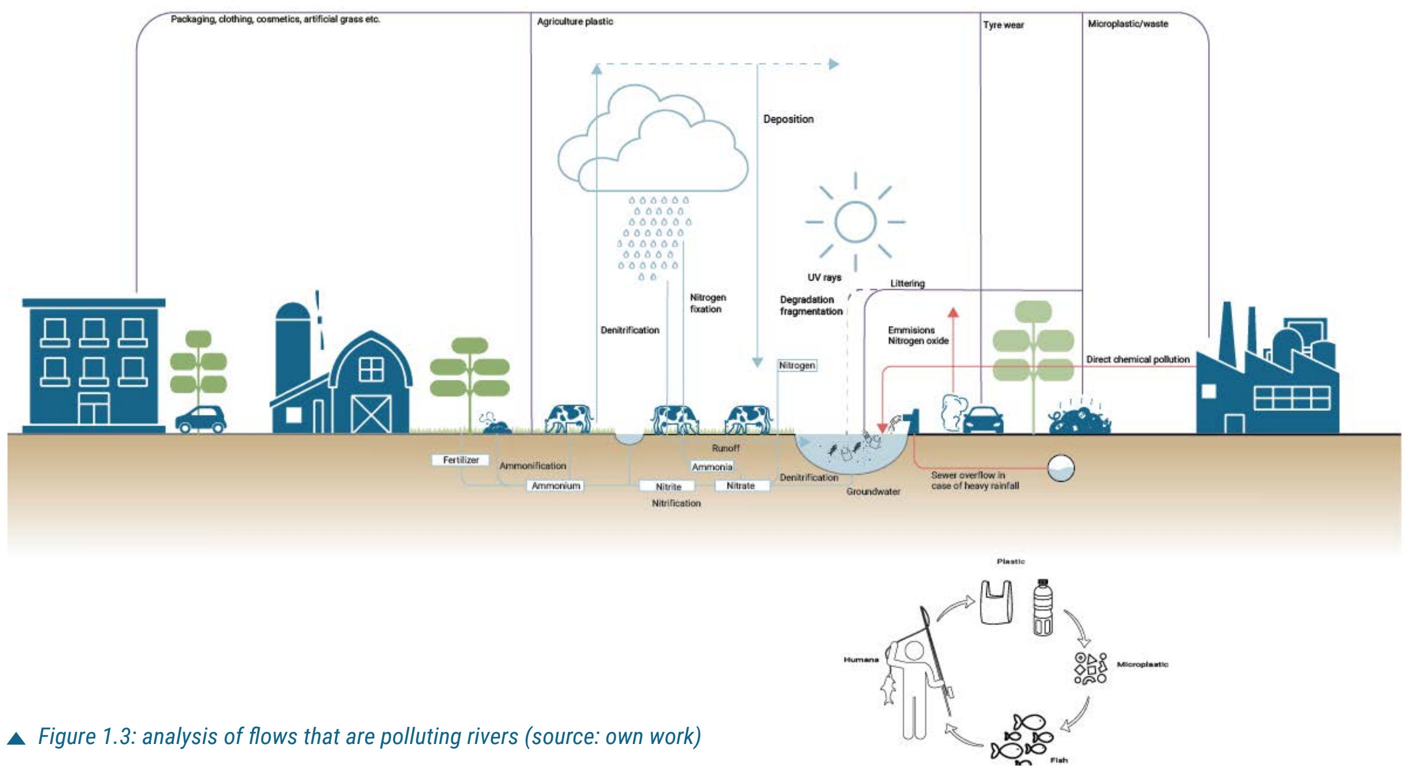
▲ *Figure 1.2: analysis of flows that are polluting rivers (source: own work)*

1.2 Flow analysis

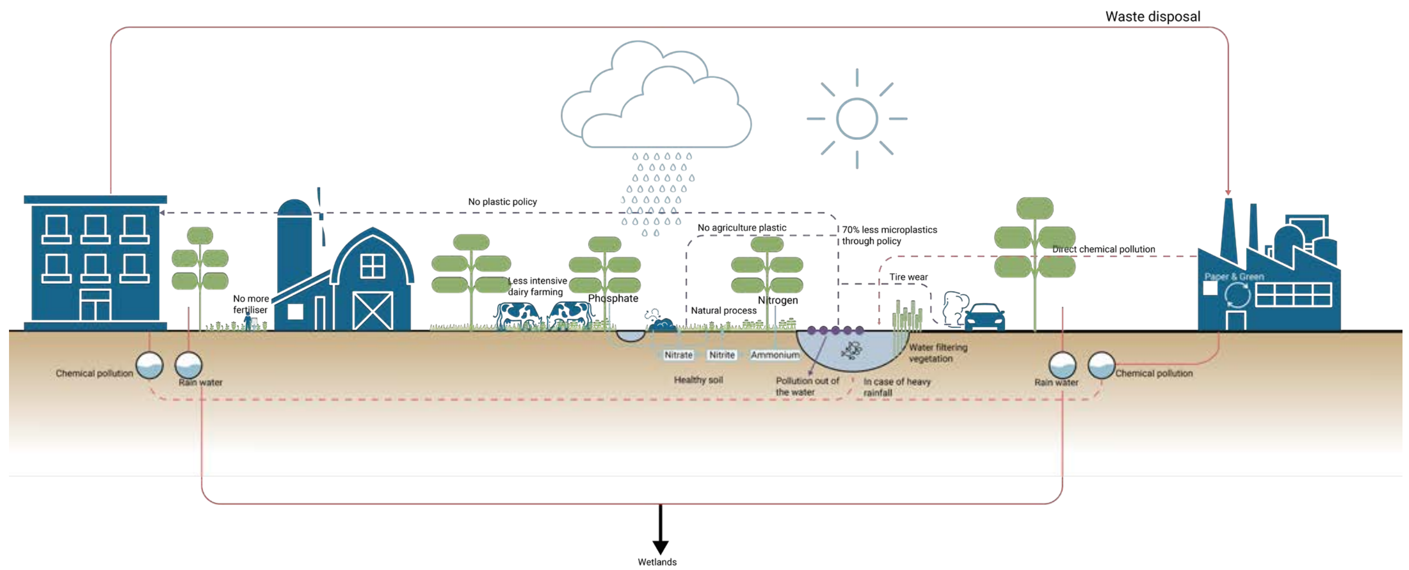
To get a grip on the complexity of all these pollution sources and flows, we conducted a flow analysis. In the Netherlands, the most common agricultural practice is degenerative agriculture (figure 1.3). Degenerative agriculture refers to a nitrogen cycle that is disrupted or imbalanced, mostly because of human activities such as deforestation, pollution, waste and immoderate fertiliser usage. This imbalance in the nitrogen cycle causes problems such as soil degradation, biodiversity loss, excessive greenhouse gas emissions, and water pollution (Oudman, 2023).

The nitrogen cycle is the process of conversion of nitrogen into its various chemical forms in the environment. The nitrogen cycle involves several crucial steps as nitrogen fixation, ammonification, nitrification, assimilation, and denitrification (Aczel, 2019). First, biological nitrogen fixation converts nitrogen gas into ammonia or nitrate. Secondly, organic nitrogen from dead plants and animals is, during decay, transformed into ammonia by bacteria. Thirdly, nitrifying bacteria convert ammonia into nitrite and then into nitrate. Plants then take up nitrate or ammonia from the soil and use it to construct organic compounds like proteins and nucleic acids in a process called assimilation. Fourthly, the process of denitrification transforms nitrogen back into nitrogen gas, which releases it back into the atmosphere and completes the cycle. This process enables nitrogen to move between the atmosphere, soil, water, and living organisms, playing a crucial role in ecosystem functioning and supporting life (Aczel, 2019).

Several approaches can be undertaken to convert a degenerative cycle into a regenerative cycle. For instance, sustainable agricultural practices can be implemented, such as agroforestry, crop rotation, and seasonal agriculture (Oudman, 2023). These sustainable ways of agriculture, as shown in figure 1.4, benefit a balanced nitrogen cycle because they don't need synthetic fertilisers and reduce nutrient runoff. Using organic fertilisers that are released slowly also reduces nutrient drainage and runoff. The implementation of biological filters as well as upgraded water treatment methods can also reduce water pollution by filtering before discharge. The government has to take strict regulatory measures to limit the polluted discharge as well. Next to this improving the ecological health is also beneficial for the water quality. Restored hydrological processes boost the resilience of water ecosystems.



▲ *Figure 1.3: analysis of flows that are polluting rivers (source: own work)*

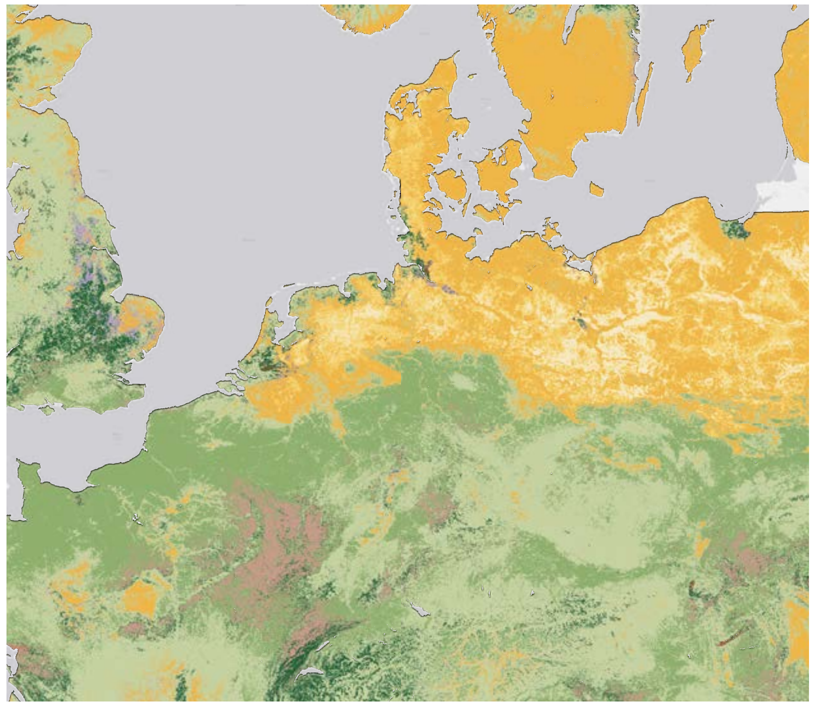


▲ *Figure 1.4: possible sollutions to decrease the flows that are polluting rivers (source: own work)*

1.3 Europe analysis

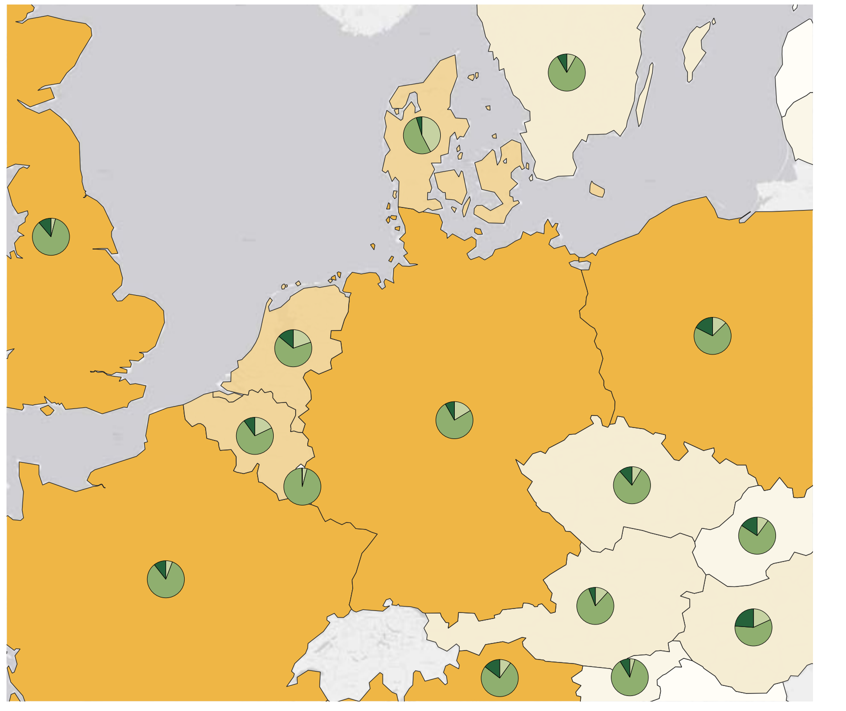
To create a proposal for the European scale, some analysis had to be done. Specifically, certain general information needed to be researched, such as land cover, soil type, and Natura 2000 areas. This general information is for instance necessary to propose sustainable ways of agriculture that are specific to a certain soil type. Additionally, it's important to identify which areas are assigned as Natura 2000 areas, which are protected sites. The landcover map provides an overview of the clustering and distribution of programming.

Some analysis maps are specifically related to water pollution. One map shows the percentage of water bodies classified as 'good' by the Water Framework Directive per country. It indicates that the Netherlands, Belgium, and Germany have the worst rating in Europe. Another map displays problem areas in the sea, highlighting priority areas when it comes to littering. A third map shows the amount of plastic litter in water bodies, pointing out areas of urgency. In addition to these water-related maps, some analysis is also conducted on soil health. For example, rural and forest areas maps provide information on the land cover of rural areas and forest density. The pH value of soil is also mapped, providing information on the status of soil health. The search for overly alkaline or acidic soil gives insight into which soil is at risk. A separate map shows the concentration of heavy metals in agricultural soils, which impacts the water quality of water bodies (Bartz et al, 2019). This research is crucial for the project's mission of improving water quality.



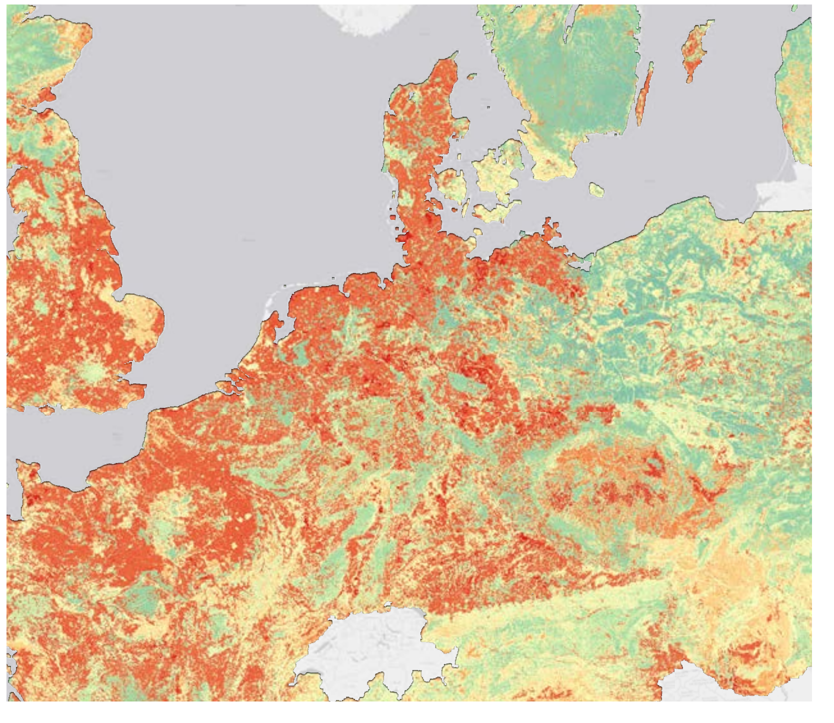
▲ *Figure 1.5: soil type (source: Ballabio et al., 2016)*

Clay
Silty Clay
Silty Clay-Loam
Sandy Clay
Sandy Clay-Loam
Clay-Loam
Silt
Silt-Loam
Loam
Sand
Loamy Sand
Sandy Loam



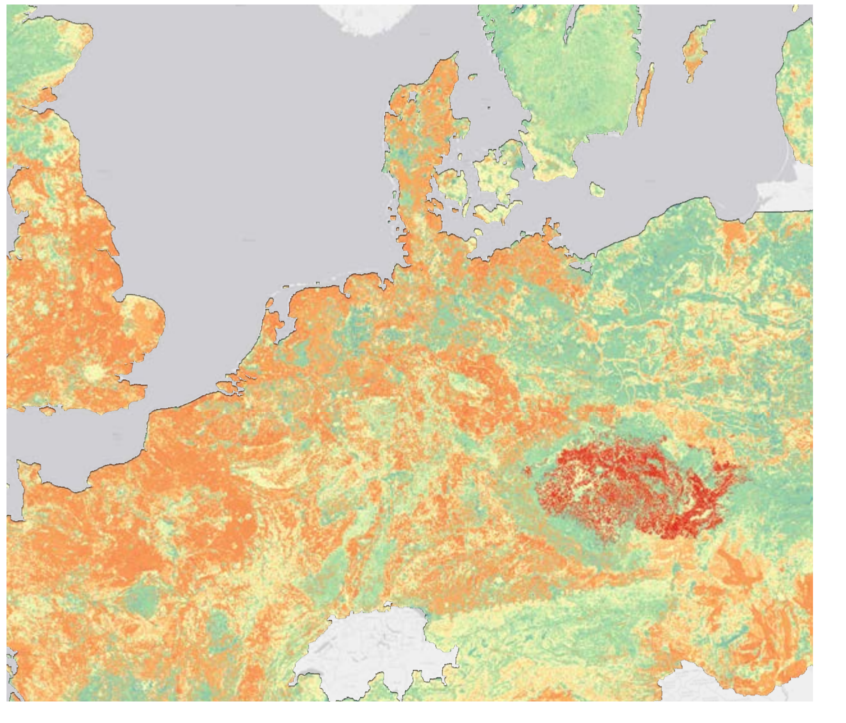
▲ *Figure 1.6: manure (source: Köninger et al., 2021)*

0.3-6.7
6.7-12.8
12.8-30.1
30.1-95.6
95.6-276.2
Source of Manure
Pigs total
Cattle total
Chickens total



▲ *Figure 1.7: soil fauna threat (source: Orgiazzi et al., 2016)*

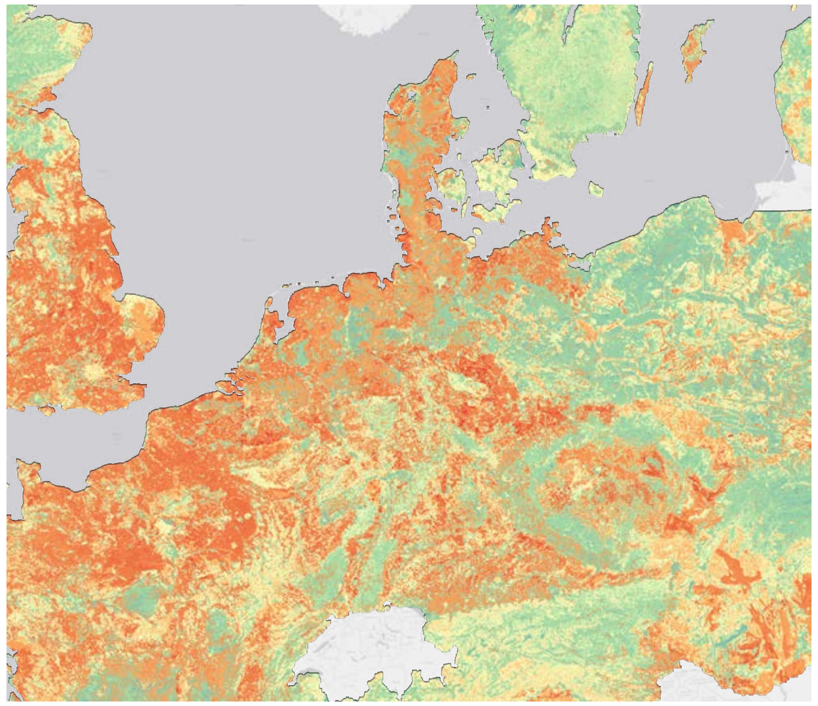
High
Moderate
Low



▲ *Figure 1.8: soil biological factor threat (source: Orgiazzi et al., 2016)*

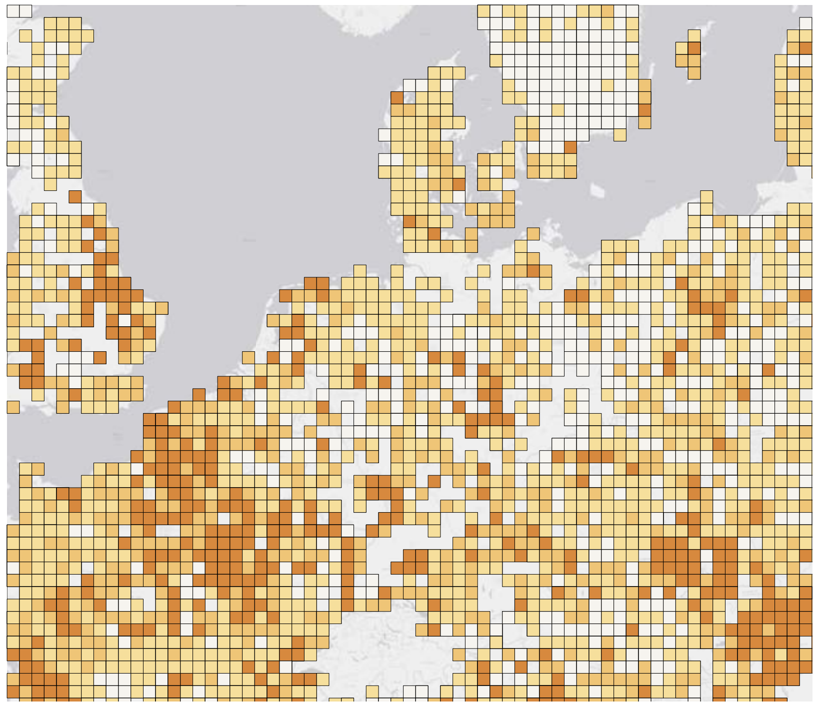
High
Moderate
Low

0 100 200 km
N



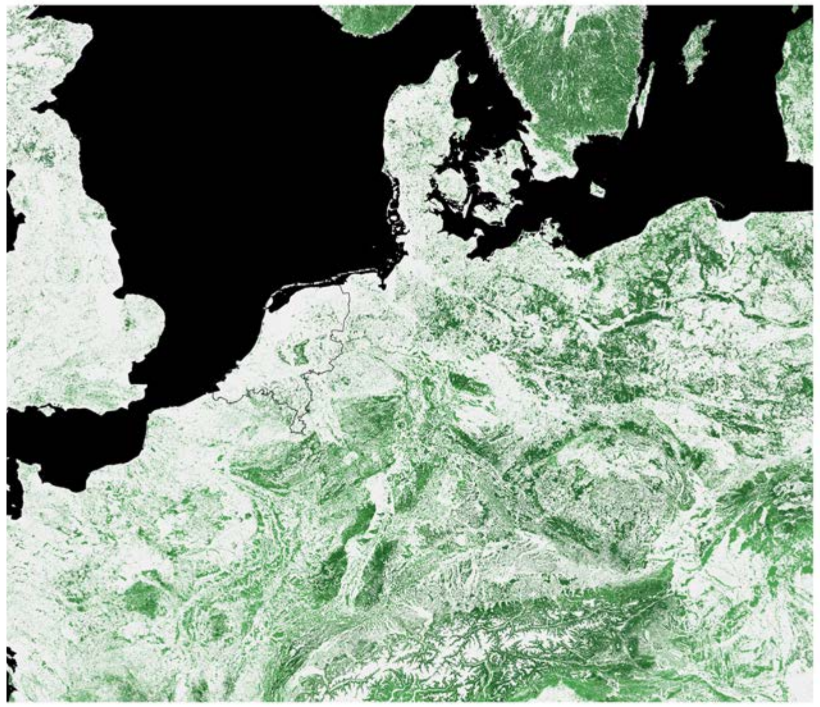
▲ *Figure 1.9: soil micro organism threat (source: Orgiazzi et al., 2016)*

High
Moderate
Low



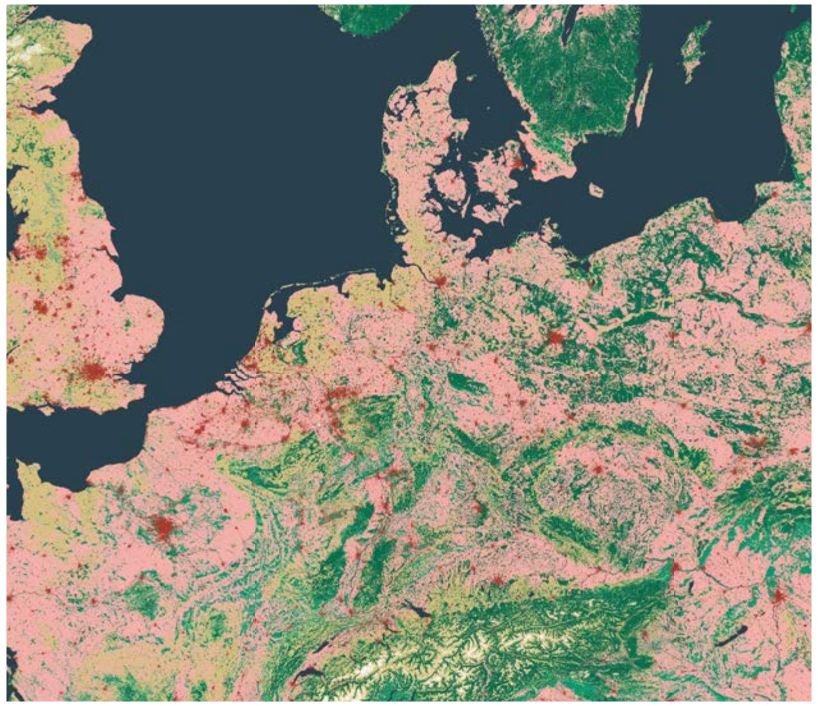
▲ *Figure 1.10: pH CaCl2 (source: European Environment Agency, 2023)*

Far too acid
Too acid
Good
Alkaline



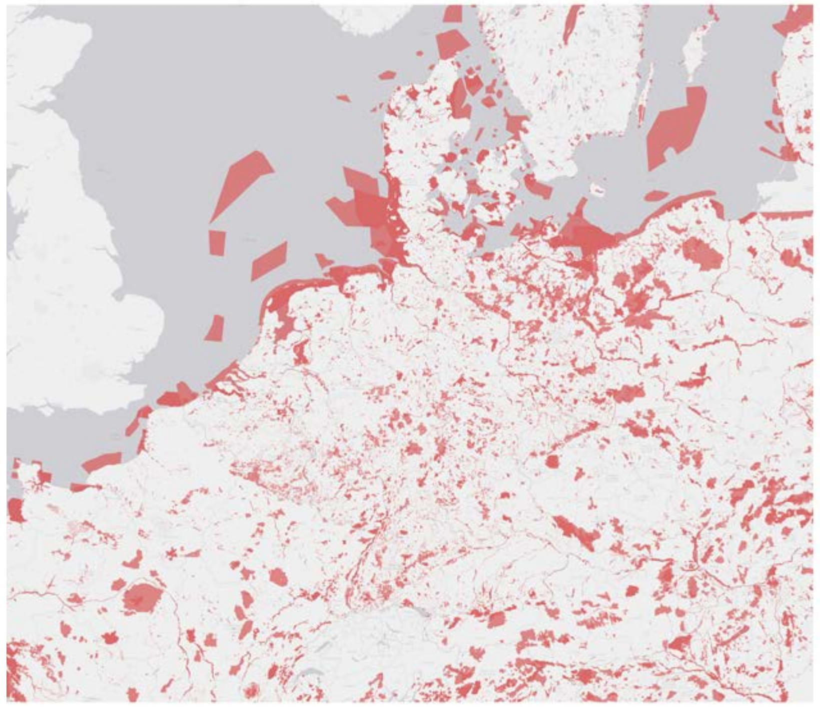
▲ *Figure 1.11: forest density (source: Copernicus, 2018)*

High
Low



▲ *Figure 1.12: land cover (source: Copernicus, 2021)*

Mostly Cropland
Grassland, Scrub, or Shrub
Mostly Deciduous Forest
Mostly Needleleaf/Evergreen Forest
Sparse Vegetation
Bare area
Swampy or Often Flooded Vegetation
Artificial Surface or Urban Area
Surface Water
Permanent snow and ice



▲ *Figure 1.13: Natura2000 areas (source: European Environment Agency, 2021)*

Natura2000 areas

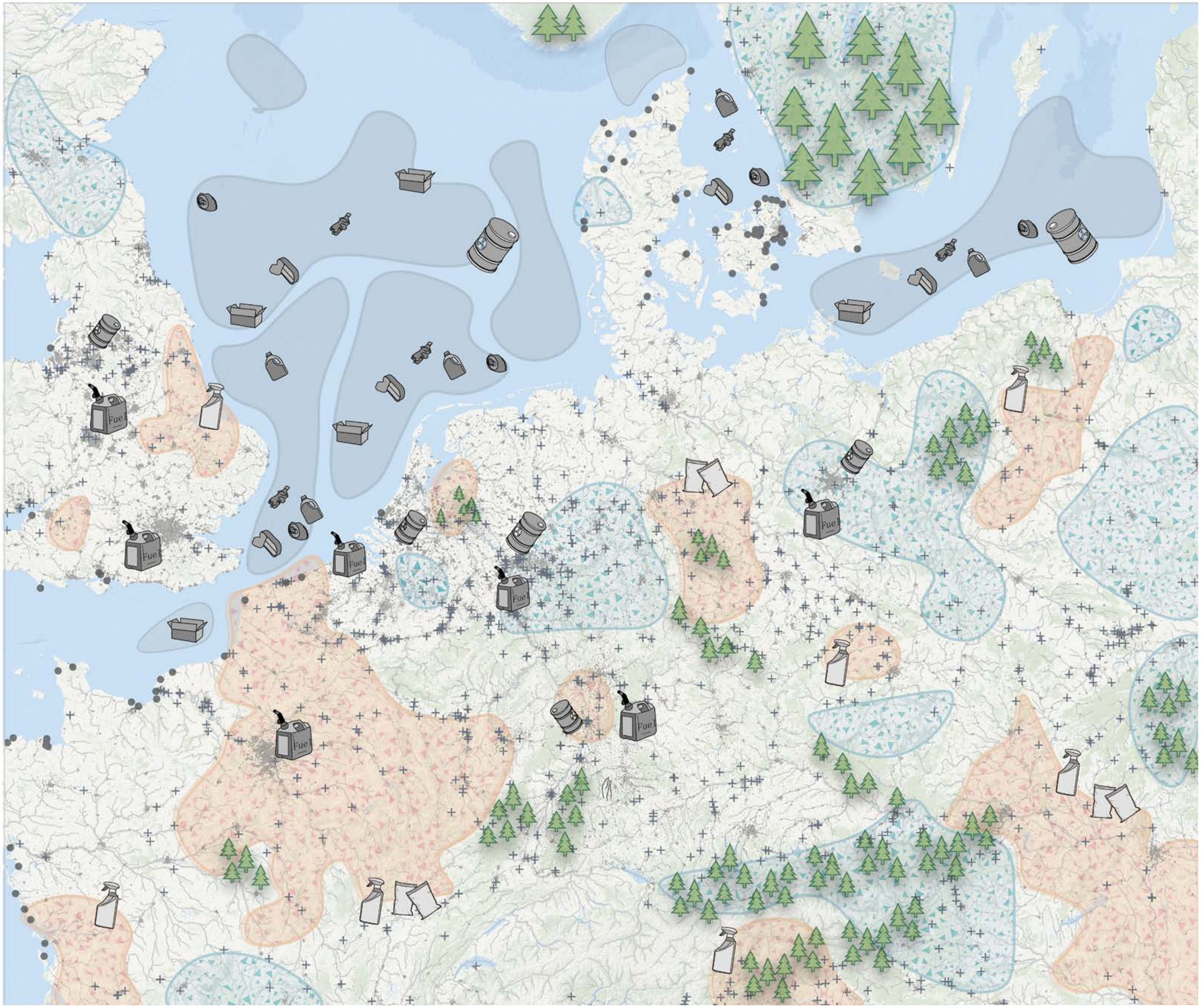
▲ *Figure 1.14: rural area landuse (source: Copernicus, 2018)*

Forestry
Mining and quarrying
Semi-natural and natural areas not in use
Agriculture

0 100 200 km
N

1.4 Problem statement

To conclude our research into water pollution in the Eurodelta, this is our problem statement: the Netherlands, a nation marked by its prosperity and significant population density, owes much of its development to the robust sectors of industry, agriculture, and urban areas. The presence of a well-established infrastructure plays a central role in facilitating success across these areas, thereby promoting economic expansion and enhancing the country's overall wealth. However, these typologies—industry, agriculture, and urban areas, along with the infrastructure supporting them—come with substantial environmental costs. They are considerable sources of pollution, leading to a progressive deterioration of the soil, water, and air quality within the country. Over time, this has culminated in a notable environmental issue: the Netherlands now exhibits the poorest surface water quality in Europe, with merely 1% of its surface water classified as 'good' (Didde, 2022). This project takes up the challenge of improving the surface water quality of rivers, starting with the river Eem. By doing so, it not only enhances the country's wealth but also protects the very foundation of life - water. The river Eem functions as a pilot for the Eurodelta since the river Eem is entirely located in the Netherlands, and thus the pollution flows as well as the effect of what is envisioned, are best traceable.



▲ *Figure 1.15: european synthesis map (source: own work)*

1.5 Policy analysis

Now the problem has been stated, it would be useful to read into policy documents. What do they state about this issue? And how can it influence our vision and strategy? To answer these questions, we looked into the Program MOOI Nederland of the Dutch Ministry of Internal Affairs, Nationaal Programma Landelijk Gebied by the Dutch Ministry of Agriculture, Nature, & Food Quality, the report Water Bodem Sturend by the Dutch Ministry of Infrastructure and Waterstaat, the NOVEX program, and finally the regional vision of Amersfoort.

MOOI Nederland

Program MOOI Netherlands positions the experiential, utility, and future values at the heart of spatial planning, aiming to maintain the Netherlands' beauty, functionality, robustness, and sustainability. This endeavour unfolds along two principal lines of action (Ministry of Internal Affairs and Kingdom Relations, 2022).

Action line 2 of the program focuses on crafting tangible design solutions for complex, regionally prevalent themes, such as enhancing biodiversity alongside agricultural transition, recreation, and the integration of small-scale residential and economic activities.

Through design research, the program illustrates how to synergise tasks without compromising spatial quality, even adding to it. This process involves close cooperation with stakeholders possessing relevant expertise.

The framework is grounded in three perspectives outlined in the Spatial Planning Letter of May 17th: agriculture and nature; energy and (circular) economy networks; and liveable cities and regions. For each perspective, three themes have been chosen. By October 2023, nine sets of design and layout principles are expected to be available for broader application.

Related to our research is perspective 1: Agriculture and Nature:

- Green-blue veining of the rural area: We seek solutions to strengthen the spatial structure in the rural area, combined with increasing biodiversity, improving water quality and sequestering more CO2.
- New cultural landscapes in the transition areas near vulnerable natural areas: We focus on concrete solutions that combine the strengthening of biodiversity with the transition of agriculture, recreation and small-scale housing and economic activity.
- Biobased production landscapes: we develop new perspectives for agriculture by making cultivation of biobased building materials, clean energy, clean water, biodiversity and recreation attractive to farmers, other landowners and rural society. We connect these practices with the "buyers" of these products in the city.

The perspective in this program could function as an inspiration to our vision. Specifically through focusing on green-blue structures. The fact that the Ministry of Internal Affairs and Kingdom Relations is stimulating design solutions for complex, regional transitions such as the agricultural transition, could make them an important agent of change in the strategy.

NPLG

The Nationaal Programma Landelijk Gebied (NPLG) is a comprehensive initiative that aims to manage the rural areas in the Netherlands through a collaborative approach. The goals include nature conservation, water management, climate control, and the relationship with agriculture. It is an important step towards achieving a sustainable and thriving rural area in the country. At its core, the NPLG contains (Ministry of Agriculture, Nature and Food Quality, 2022):

1. The framework targets for, for instance, nitrogen emission reduction, greenhouse gases and water quality.
2. The structuring choices, such as making the soil and water systems guide spatial planning.

The NPLG focuses on three core objectives: to realise the European international obligations in the field of (1) nature, (2) water, and (3) climate in a coherent approach. These goals are strongly interrelated and normative. As an EU-member state, the Netherlands is legally obliged to meet them. But meeting the targets is ultimately mainly about realising a supported perspective for people, businesses, and nature (Ministry of Agriculture, Nature and Food Quality, 2022)..
The starting nota, which outlines the NPLG, provides the first spatial consequences and emphasises connecting the spatial vision to other (national) programs in rural areas. To make sure the NPLG is not working in isolation, but rather in collaboration with other initiatives that are aimed at managing the rural area.

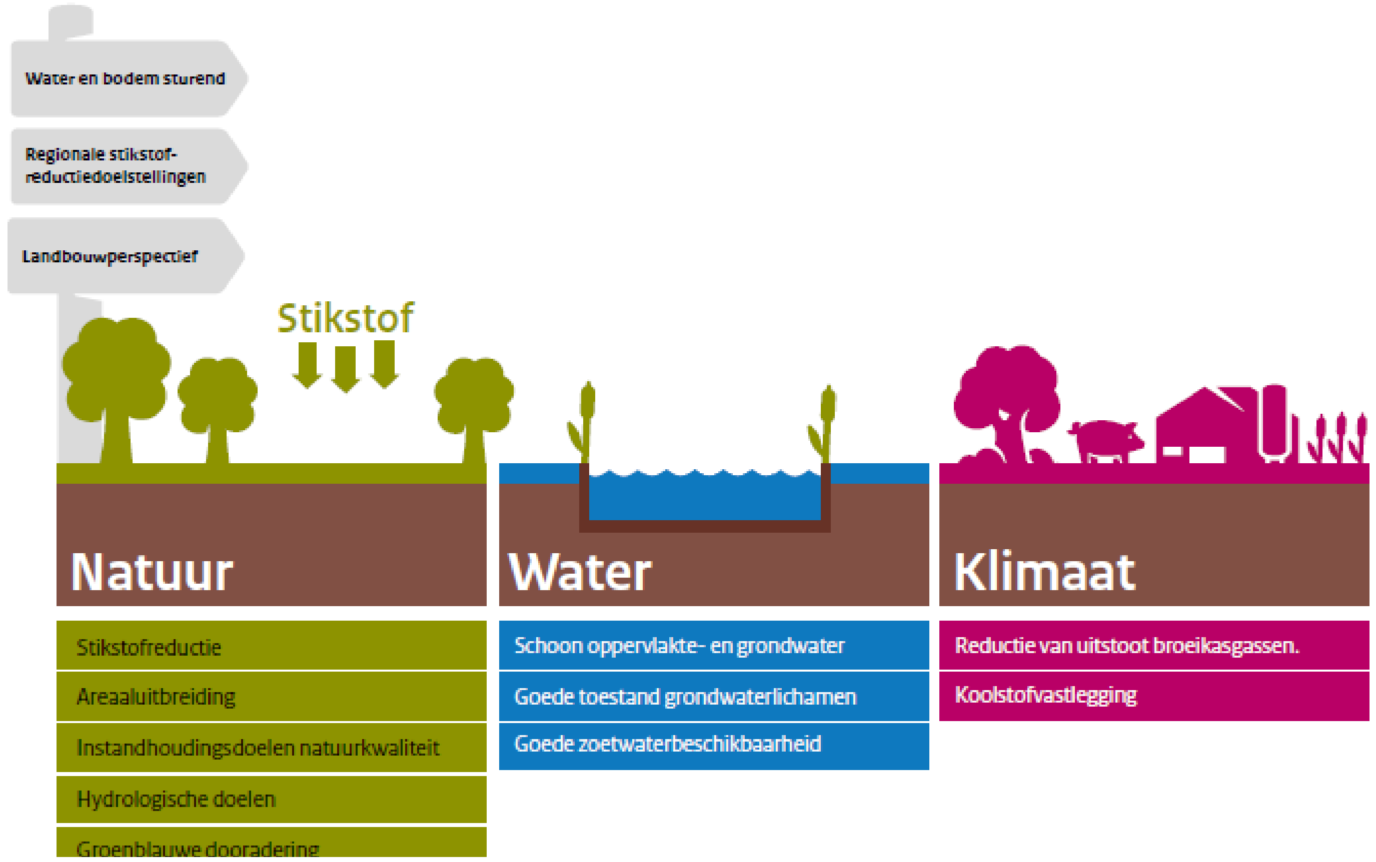
Additionally, it highlights how this collaboration is linked to the Transition Fund Rural Area and Nature, an initiative to manage the rural area in the Netherlands (Ministry of Agriculture, Nature and Food Quality, 2022).

This program stimulates us to use a collaborative approach, meaning the stakeholder engagement should be carefully managed. Moreover, the Ministry of Agriculture, Nature and Food Quality could help provide continuous financial support through funds.

Water en bodem sturend

Water en Bodem sturend is a letter from two ministers of the Ministry of Infrastructure & Waterstaat. In the Netherlands, drinking water is collected from the groundwater. Nonetheless, persistent access to sufficient drinking water is no longer self-evident.

Figure 1.16: goals NPGL (source: Rijksoverheid, 2022)



Flora and fauna are under pressure, and land subsidence and low water levels cause problems with the foundations of buildings. In addition to this, roads and railways will require extra maintenance (Harbers & Heijnen, 2022).

Climate change is impacting the functional waterways too. Causing problems in shipping, agriculture, energy, and nature. In 2022 the water levels in rivers were so low that ships could not go through the rivers anymore. Because of these drought effects, harvests declined, and there was an algae and botulism issue, deteriorating the water quality even more.

The authors emphasise it is necessary to think about the worst-case scenarios since it is expected these kinds of events will happen more frequently than in the past decades. We need to design a resilient ecosystem again; an ecosystem that is better at withstanding disruptions caused by climate change. It is therefore also important to have more room for the river (retain, store, and drain).

In healthy conditions, the soil can store nitrogen, and carbon, and it can buffer water. If we don't change how we treat the soil, it will lose these abilities. This contributes to water quality and biodiversity. For low-lying peat areas, it is important to focus on reducing CO_2 emissions and minimising soil subsidence and aim for the highest possible groundwater level (20-40 cm below ground level). High sandy soils cause major water quality, soil, and biodiversity problems. This is due to the intensive use of fertilisers, crop protection products, and local discharges from sewage treatment plants. Due to poor soil structures, the number of contaminated (ground)water sources is increasing (Harbers & Heijnen, 2022).

This letter should be the basis for understanding and solving some of the issues at hand. In the vision, these solutions should be visible.

NOVEX

The NOVEX program in the Netherlands proposes a comprehensive approach towards spatial planning, emphasising collaboration and cooperation among governments and stakeholders. The program focuses on accelerating, strengthening and innovating spatial planning and implementation in the Netherlands. It addresses major challenges like affordable and sustainable housing, climate-proof landscapes, biodiversity and nature restoration, and the transition to circular agriculture and clean energy (Ministry of Internal Affairs and Kingdom relations, 2022).

When it comes to water pollution, the program underscores the importance of creating landscapes that are resilient to climate change and emphasises the need for nature restoration. It recognises the crucial role of water management and pollution control in achieving these objectives.

Besides, the program aims to take a data-driven approach to enhance spatial information, which could potentially include water and pollution data. This information can then be used to inform decision-making and policy implementation.

Certain areas under the NOVEX-program, such as the North Sea Port District and the Peel, have specific tasks that may involve water pollution issues. For instance, the North Sea Port District aims to make the port-industrial complex more sustainable, which may include addressing industrial water pollution. Similarly, The Peel's focus on tackling drought, improving water quality, and agricultural and energy transition may involve strategies to migrate water pollution. Emphasising collaboration and cooperation among stakeholders, this document too stimulates us to carefully manage the relevant stakeholders. It also encourages us to use spatial data to include qualitative research on water pollution issues to create a vision with resilient landscapes.

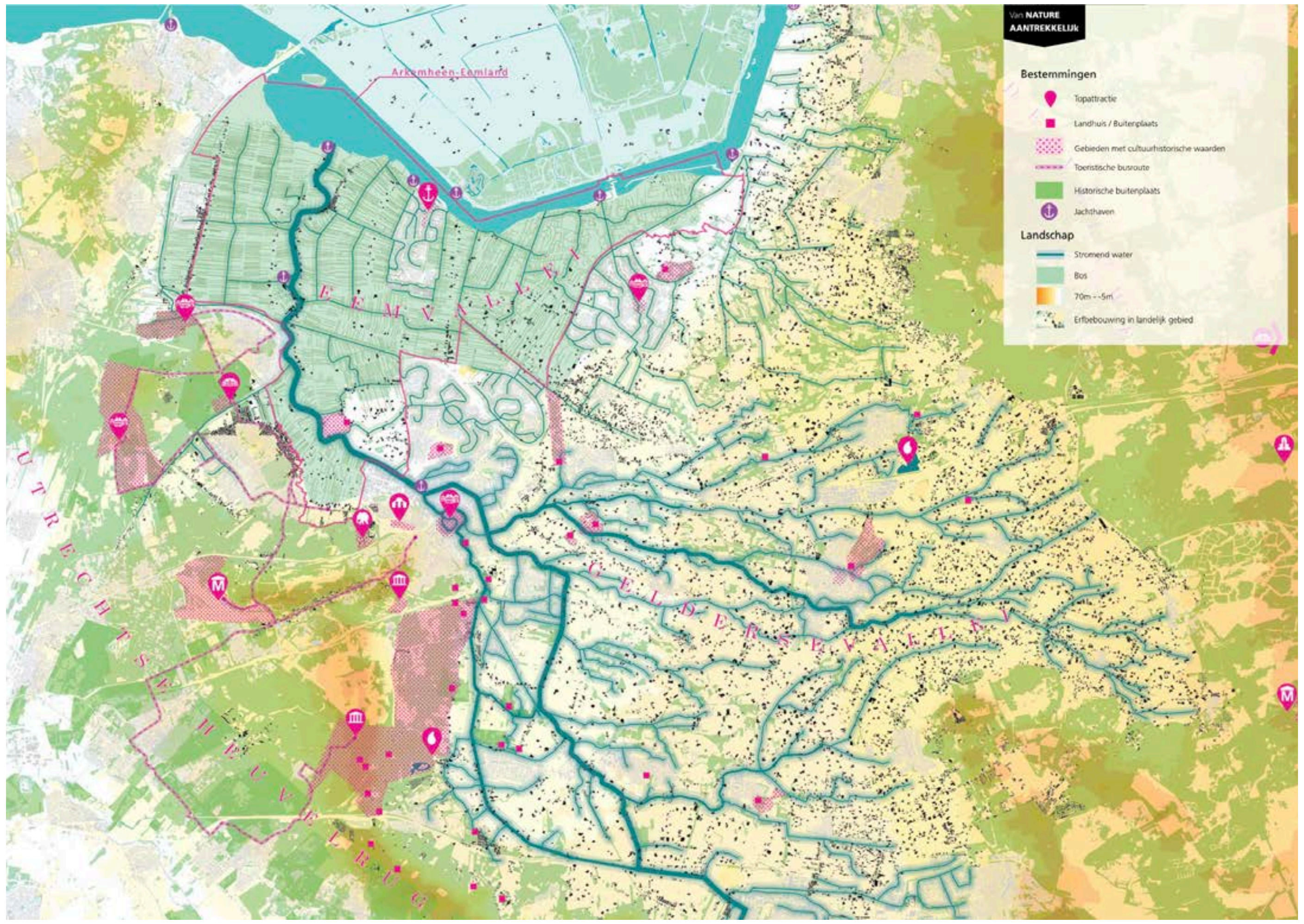
Vision region Amersfoort

The landscape and its water networks in Amersfoort are essential to the regional spatial vision. They underline the fundamental role of these features in the region. The area is surrounded by higher-lying ridges in the east, south, and west, which direct the water through a comprehensive system of brooks into the river Eem that disposes its water into the lakes north of the region. Therefor this policy document uses the water system as one of its main focuses for creating a vision (Regio Amersfoort, 2017).

The regional vision, with its focus on water quality, heat stress, waterlogging, and shortage has an impact on both urban and agricultural environments that often wreaks havoc on nature. The complex water system is considered not only as a means of climate adaptation but also as a basis for regional identity, and architectural innovations.

Changes in agriculture are essential to make the water system resilient for the future and to ensure water safety, quality, and control of excess water. Not only does the transformation of the water system offer opportunities for spatial development but also for enhancing the quality of life within urban areas and along the waterfront.

Linking relevant, existing regional visions, like this on is for the Eem Valley, to your vision can help gain credibility for your vision.



▲ *Figure 1.17: sub vision region Amersfoort (source: Regio Amersfoort, 2017)*

1.6 Sustainable Development Goals

The United Nations has introduced the Sustainable Development Goals (SDGs) to help guide the transition towards a sustainable future around the world. It is therefore relevant to see how the SDGs can inform us on the topic of water pollution. We listed all the relevant SDGs and elaborated on what these could mean to our project:

SDG 6 Clean water and sanitation: the surface water in the Netherlands and Eurodelta should improve. By improving the surface water, the groundwater will also improve and therefore the drinking water will become cleaner. We aim for no more water pollution in the drinking water.

SDG 9 Industry, innovation, and infrastructure: industry is an important sector in the realisation of clean surface water. Therefore, convincing and engaging the industry to focus on sustainable development and reduction of water pollution is key.

SDG 11.6 Sustainable cities and communities: more than half of the world's population lives in urban areas today and they produce a lot of waste. If we want to improve waste processing, it is important that we change the waste flows in cities.

SDG 12.2 and 12.5 Responsible consumption and production: overconsumption and a lack of awareness or moral responsibility make for irresponsible consumption and production in today's society. The focus should be on using our resources more efficiently. We should focus on reusing, reducing, and other R-strategies to protect our rivers from waste.

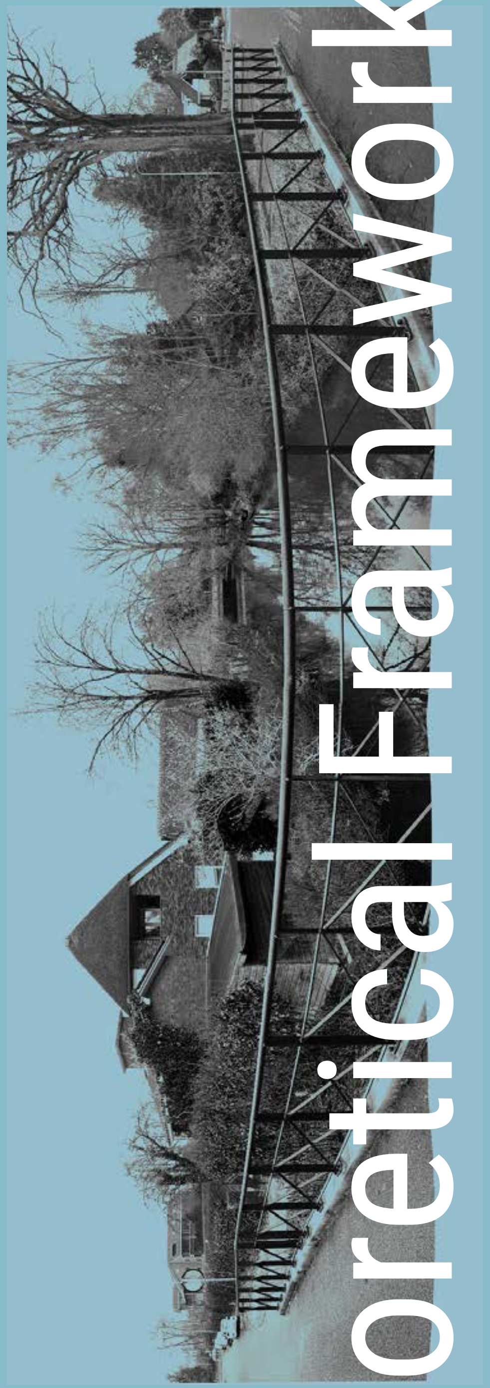
SDG 14.1 Life below water: when there is less pollution in rivers, the biodiversity and life below water will improve. To reach this goal, water pollution should be brought back to zero.

SDG 15 Life on land: a healthy river provides for healthy habitats; within its water, as well as on the surrounding land. The river can support life on land with increasing biodiversity and eco-connectivity between protected natural areas like the natura2000.

Figure 1.18: relevant SDGs (source: GLEC Global, 2015)

2

Theoretical Framework



Panorama taken at the village

Contents

In this chapter, we will introduce the research approach that will be used for the pilot project. Firstly, we will briefly explain the location of the project, which is the river Eem in the Netherlands. Then, we will introduce the approach for this project and state the research question: how can the transformation of the Eem Valley turn the river Eem into the healthiest river in Europe, as a pilot project for the Euro Delta? The next step is to establish some definitions in the theoretical framework. After this, we will explain the research-by-design approach and the pilot approach. Finally, we will clarify our conceptual framework.

2.1 Introducing the Eem

As mentioned before, the Eurodelta encompasses the catchment areas of the rivers Schelde, Meuse, and Rhine rivers. All of these rivers originate outside of the Netherlands. Since the Netherlands is downstream, polluters from upstream also contaminate the Dutch part of these rivers. To address water pollution, it's essential to intervene at the source and work your way downstream.

For this project, we had to select a region within the Netherlands, focussing specifically on a river with its origin in the Netherlands. As it turns out, there is only one river that originates in the Netherlands, and that's the river Eem which is located in the Eem Valley. The valley emerged during the Ice Age when ice caps pushed up the Utrechtse Heuvelrug and Veluwe, creating a valley that was entirely isolated from the Rhine and Meuse. The river Eem has several smaller brooks that originate in the Gelderse valley in the east of the valley and discharge in the Eemmeer in the North. The catchment area of the river Eem is the natural boundary of our region. Amersfoort (name meaning "fort on the Eem") is the regional centre with over 150.000 inhabitants. Additionally, there are many villages and smaller towns within the region. The region spans two provinces (Utrecht and Gelderland) and two waterboards (Vallei & Veluwe and Amstel, Gooi & Vecht).

Figure 2.1: location of the Eem (source: own work)

Fieldtrip

During the second week of our project, we had a field trip to the Eem where we conducted tests to analyse the water quality and identify various locations along the river. The purpose of the water quality tests was to highlight the issues faced by the Eem, such as pollution caused by chlorine, iron, lead, and nitrate. The test results indicate the levels of substances that are permitted in drinking water to still classify its quality as good. We conducted tests at six different locations along the river to determine if there was any difference in water quality, but we found that the quality was relatively consistent throughout the river. This helped us gain a better understanding of the challenges faced in ensuring healthy water. The detailed analysis of the water tests can be found in the appendix of this report.

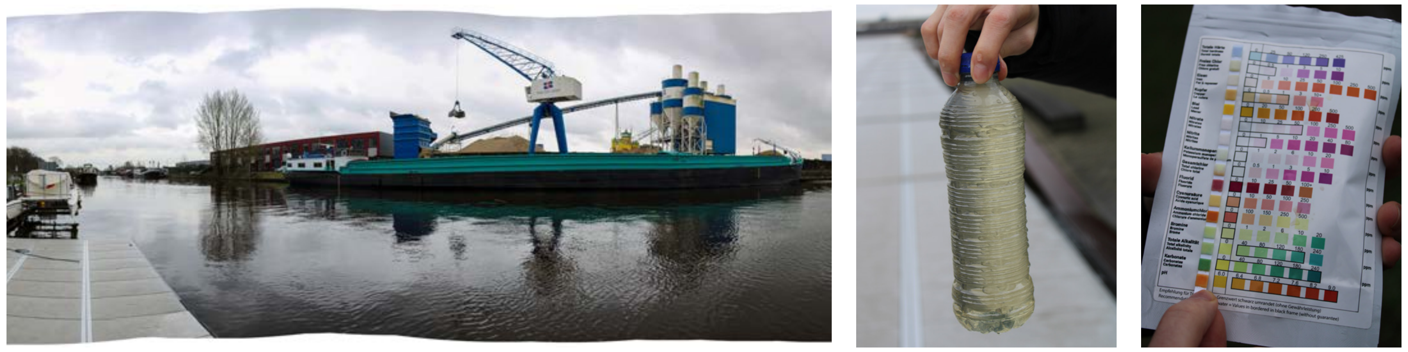
▲ *Figure 2.2: the brook (pictures: own work)*

▲ *Figure 2.3: rural area (pictures: own work)*

▲ *Figure 2.4: old city centre (pictures: own work)*

▲ *Figure 2.5: Eemplein (pictures: own work)*

▲ *Figure 2.6: urban redevelopment (pictures: own work)*



▲ *Figure 2.7: industry (pictures: own work)*

▲ *Figure 2.8: agriculture (pictures: own work)*

2.2 Research question

In this project, we focus on the river Eem to tackle the multifaceted issue of water pollution. The Eem is a river that both originates and discharges in the Netherlands, which makes it a manageable size for our research. By studying the various flows that pollute the river, we can map them and consider the possible solutions. Based on the solutions that are researched at the scale of the Eem, we can then look at implementing these at the scale of the Eurodelta. In this way, the Eem serves as a pilot project to address the larger problem of polluted European rivers. This led to the formulation of the following research question: how can the transformation of the Eem Valley transform the river Eem into the healthiest river in Europe, as a pilot for the Eurodelta? Water pollution is a complex system with many contributing factors, which is why our research must look beyond just the water. The landscape surrounding the water is also essential, which is why we include the Eem Valley in our research question.

2.3 Theoretical framework

To address the research question, we need to establish some definitions. For instance, to identify a 'healthy' river, it's not enough to just consider the water quality of the river itself. We need to look at the broader ecosystem to ensure the river is healthy. Therefore, we introduce three pillars to ensure that rivers regain their health: healthy water, healthy landscape and healthy habitat. These pillars are based on how the Water Framework Directive defines water. The Water Framework Directive defines good-quality water as water with both a good chemical and good ecological status (European Parliament & Council of the European Union, 2000). For us, the pillar 'Healthy water' is about having water with a good chemical status. The pillar 'Healthy landscape' is about creating waterbodies and landscapes with a good ecological status. The pillar 'Healthy habitat' is about creating good living conditions. The combination of these three pillars results in a healthy river ecosystem.

2.4 Methodology

As the research question states, the ultimate goal for the entire Eurodelta is to consist of healthy river ecosystems. However, to research the entire Eurodelta within the given project timeline is not feasible. Therefore we selected a Dutch river within the delta that serves as a pilot for the Eurodelta. By using a research-by-design approach we will study how to address water pollution in rivers, starting with the river Eem.

The policies and interventions implemented in the river Eem Valley are categorised according to their transferability to different programming areas, namely urban, industry, or agriculture, resulting in a toolbox that can be used by urban planners and decision-makers to implement a similar approach in various parts of the Eurodelta.

2.5 Conceptual framework

The three pillars, as mentioned before in the theoretical framework, form the core (the inner ring) of our conceptual framework. These pillars are essential to our research and their combination leads to a healthy river ecosystem. The first ring of the framework includes the different topics that fall under each pillar and that need to be analysed before we can envision a future scenario for the Eem Valley. The second ring shows the possible solutions that can be implemented at the scale of the Eem. The third ring shows those solutions from the Eem scale that can also be scaled up to the Eurodelta scale. At the Eurodelta scale, contextualisation of certain interventions will be necessary as each context of a river is unique. For this project, we contextualised the interventions based on the Eem Valley, but this context will change when implemented somewhere else. Therefore, additional research about the context of the river is always needed when using the general toolbox.

Figure 2.9: theoretical framework (source: own work)

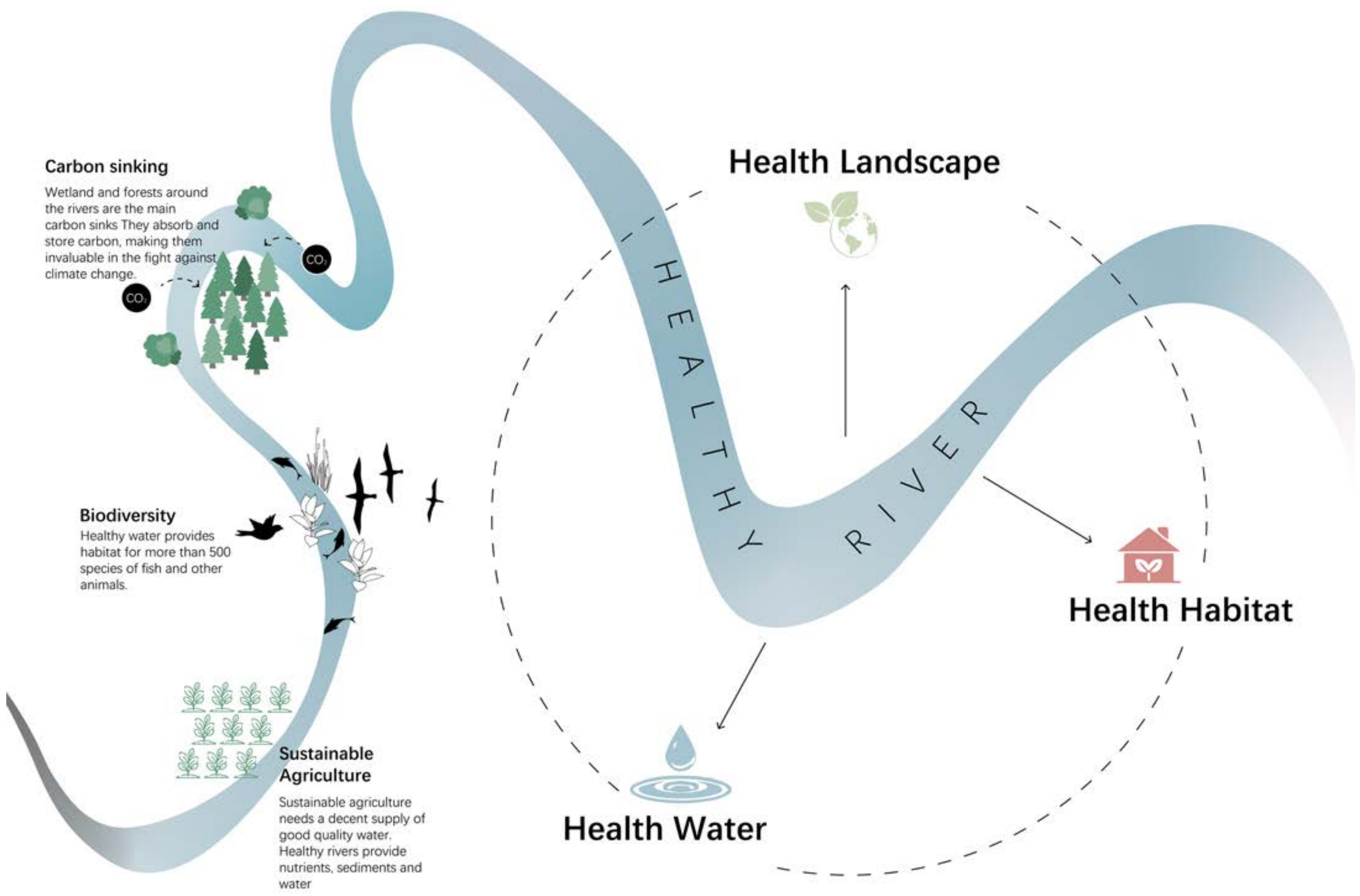
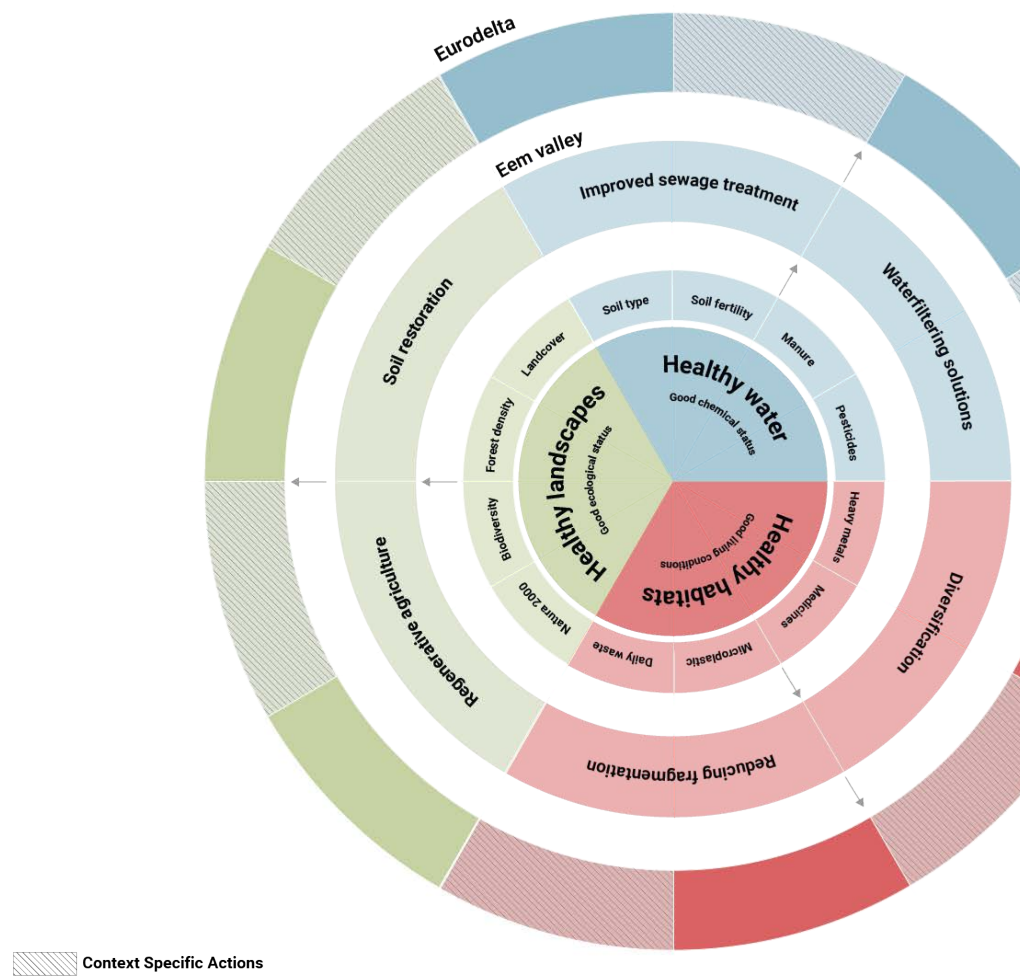
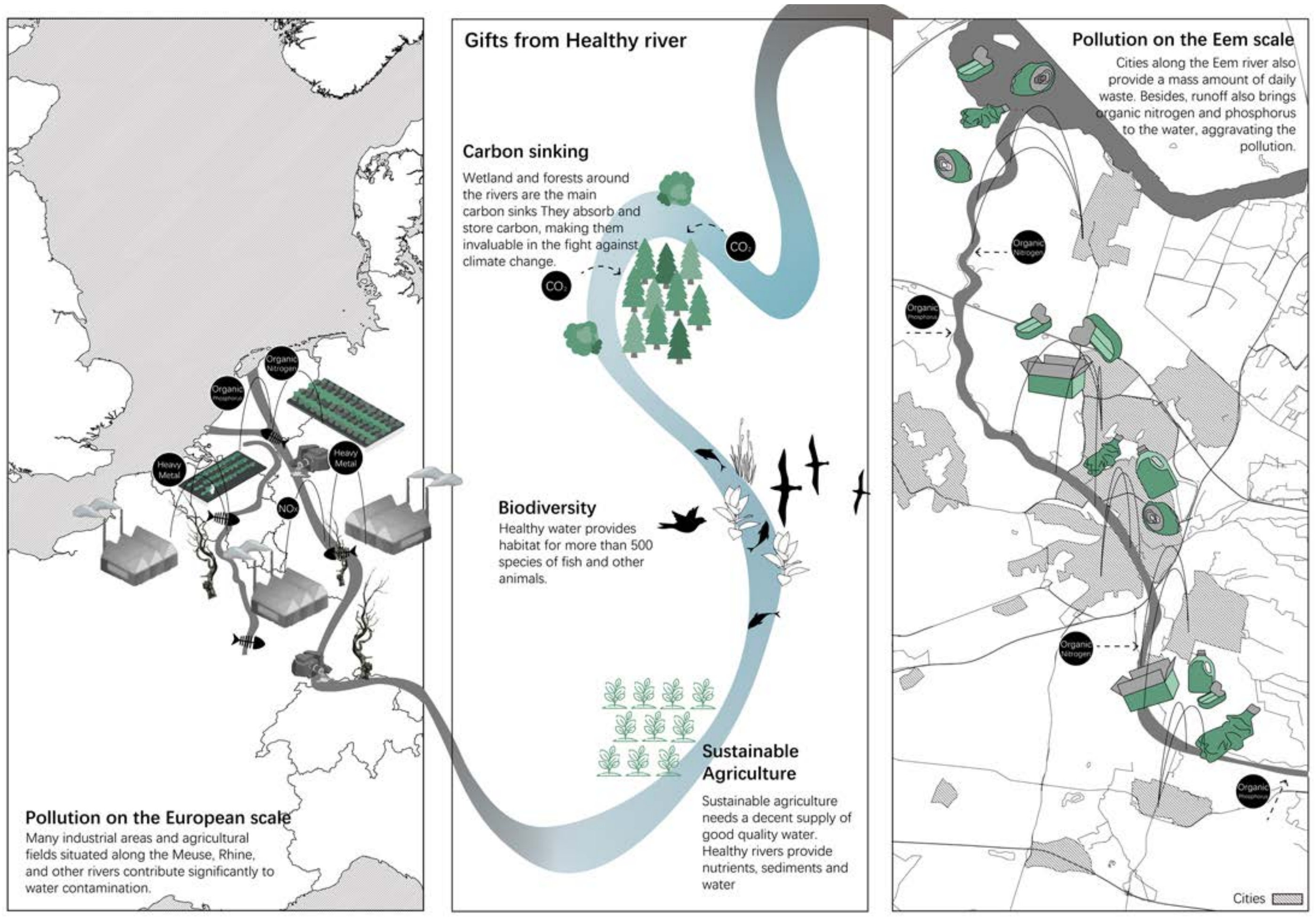


Figure 2.10: conceptual framework (source: own work)



▼ *Figure 2.10: research approach (source: own work)*



3

Analysis

Panorama taken at the Eemplein, Amersfoort ◀

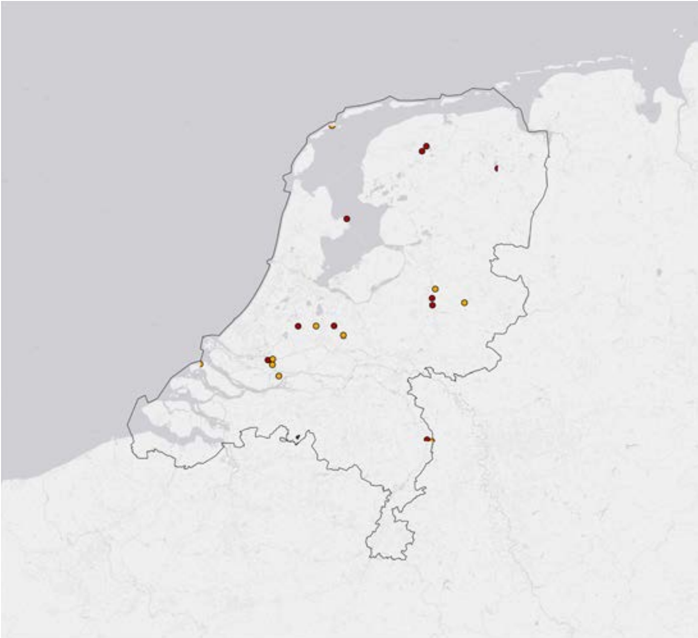
Contents

In this chapter, the three pillars, healthy water, healthy landscape, and healthy habitat will be analysed. This will be done on the scale of the Netherlands. To conclude the analysis of each pillar, a synthesis map will be displayed. Together, these maps will be the foundation for the vision.

3.1 Analysis NL: Healthy Water

The analysis maps, figure 3.1 - 3.6, illustrate how most European lakes and rivers are currently underperforming in ecological status, or are prone to deteriorate in the near future. This has to do with the high concentration of heavy metals in surface water in combination with nitrogen pollution and other chemicals. Furthermore, the map exposes the amount of littering in the North Sea: 122 items of litter per 100 meter beach.

When zooming in on the Netherlands, it illustrates there are almost as many red dots as green dots. The red dots mean that there is one or more problem substances in the drink water extraction points.

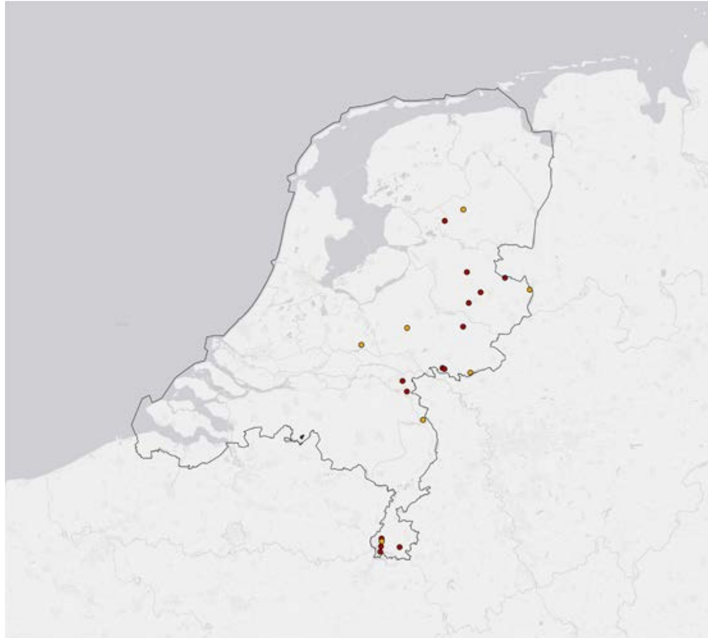


▲ *Figure 3.1: chloride in drinking water (source: RIVM, 2015)*

- Current problem substance
- Potential problem substance

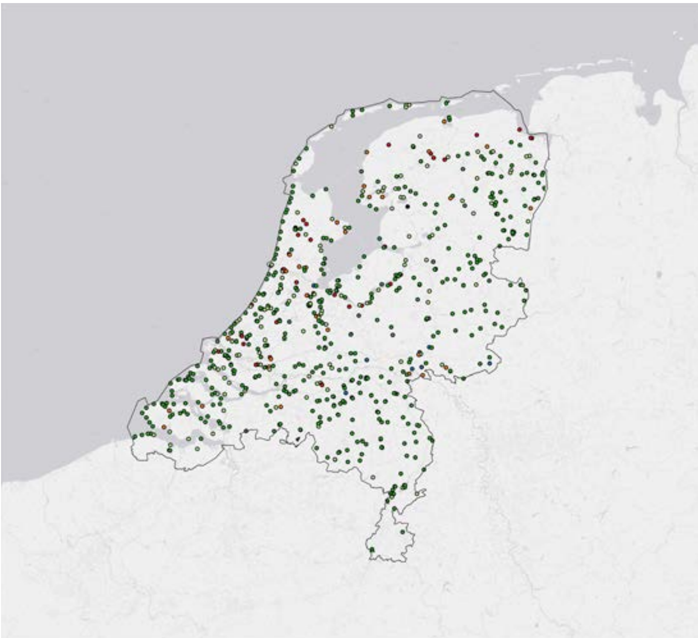
▲ *Figure 3.2: emissions industry (source: RIVM, 2015)*

- Emission industry



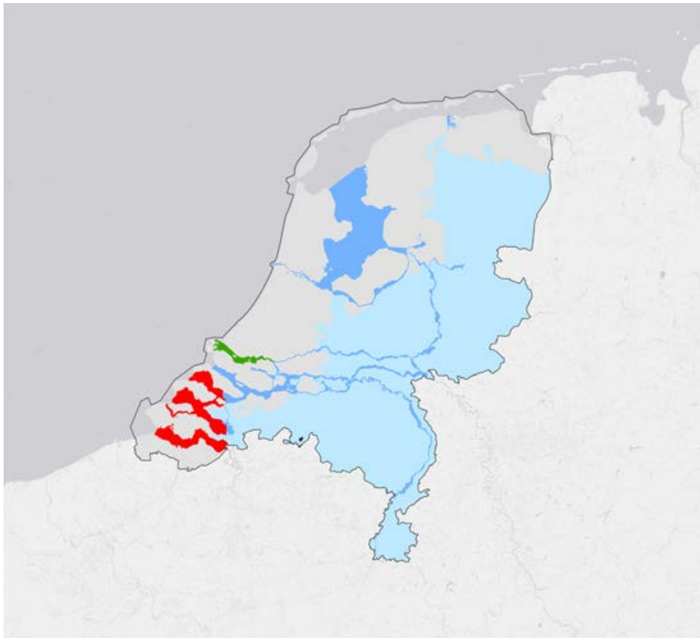
▲ *Figure 3.3: nitrate in drinking water (source: RIVM, 2022)*

- Current problem substance
- Potential problem substance



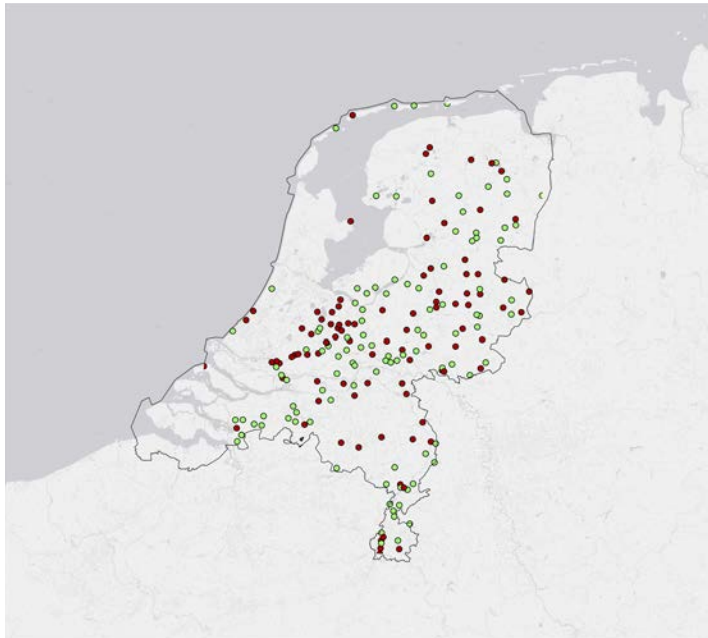
▲ *Figure 3.4: swimming water (source: RIVM, 2015)*

- excellent
- good
- sufficient
- poor
- new
- closed



▲ *Figure 3.5: salination of surface water (source: RIVM, 2015)*

- Local and regional surface water salt
- Local and regional surface water sweet
- Sweet
- Salt
- Salt intrusion

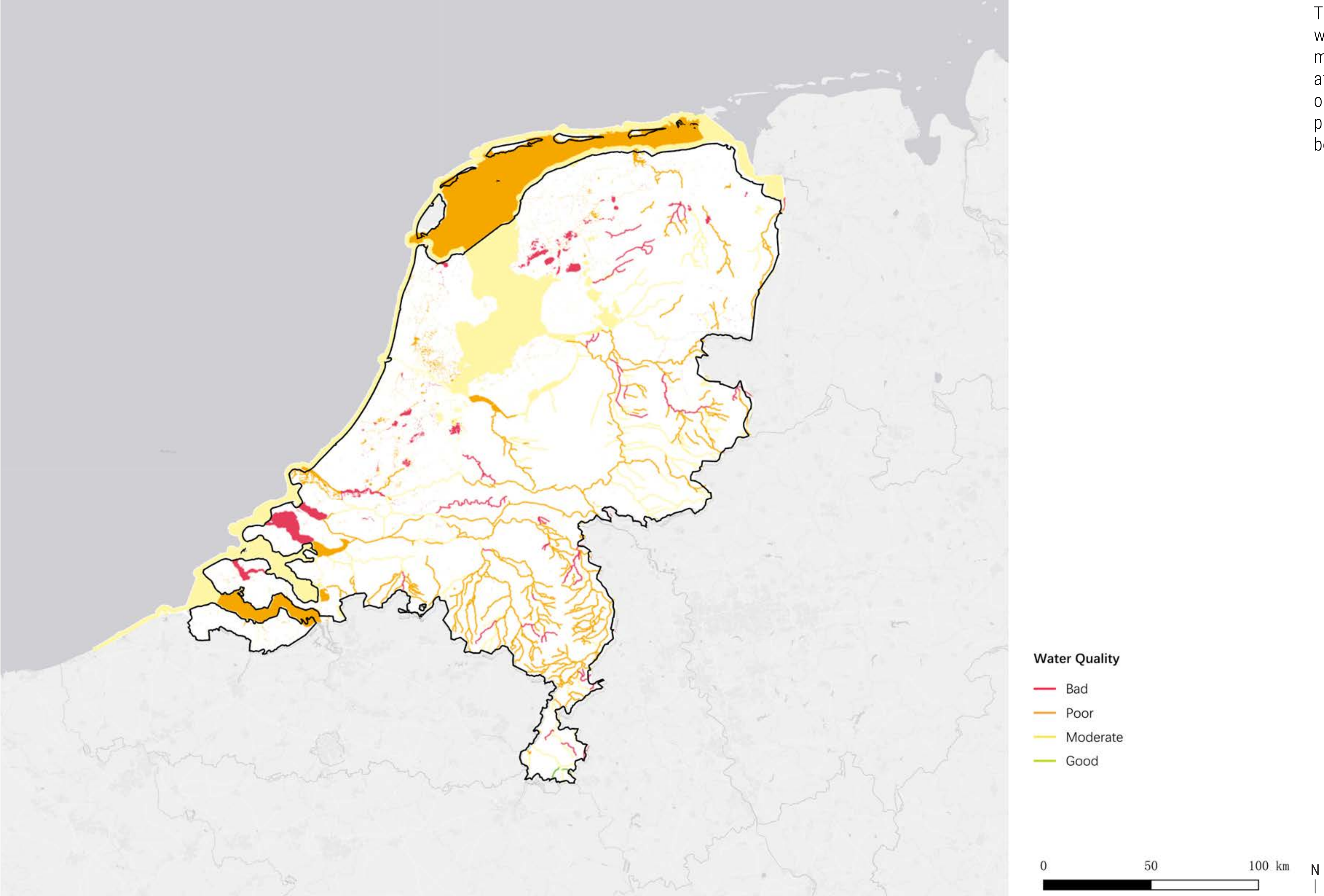


▲ *Figure 3.6: potential problems substances (source: RIVM, 2015)*

- 1 or more problem substances
- No current problem substances

0 50 100 km

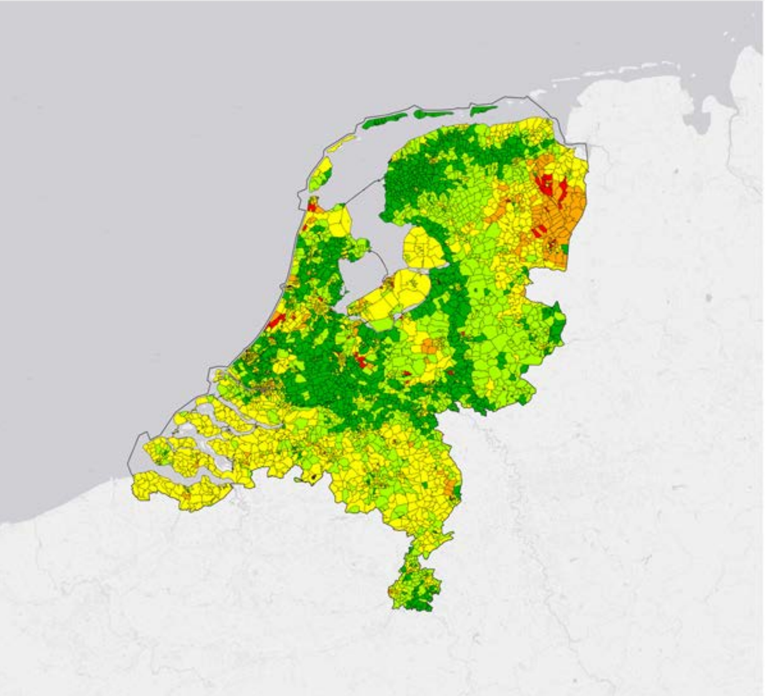
N



▲ *Figure 3.7: conclusion map Healthy Water (source: own work)*

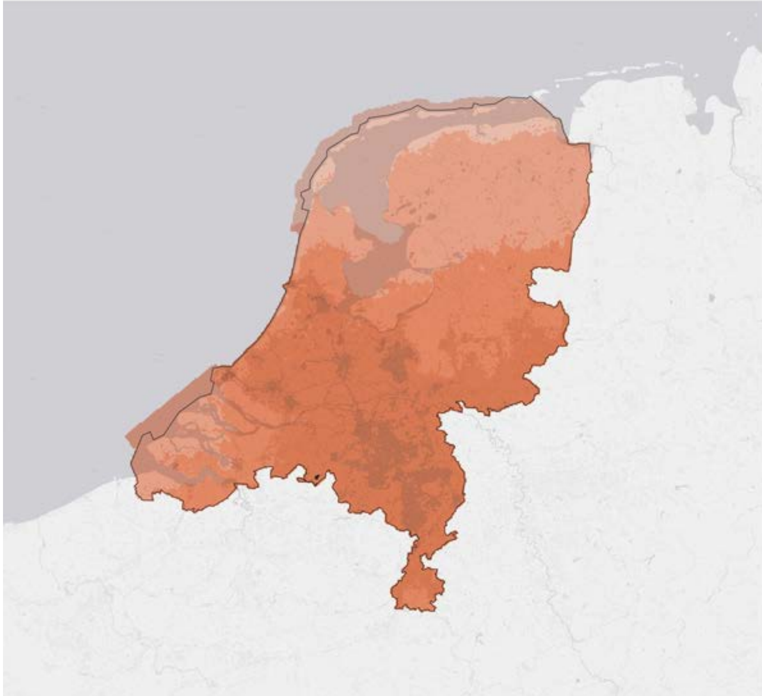
3.2 Synthesis map

The synthesis map, in figure 3.7, shows the current water quality of the Netherlands. As is evident in the map, the water quality is noticeably affected by the aforementioned waste flows. A lot of this pollution originates abroad. What we should focus on is preventing water pollution from increasing within the borders of the Netherlands.



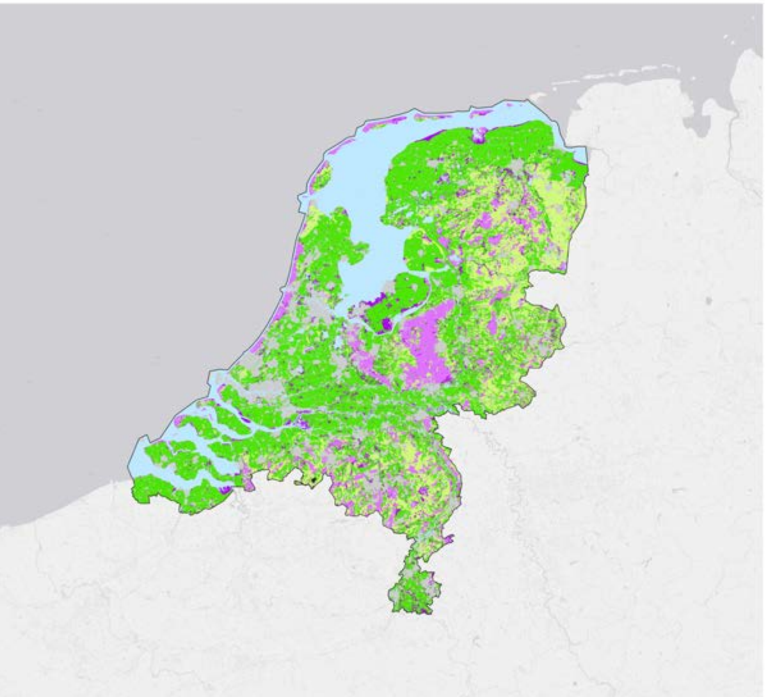
▲ *Figure 3.8: soil carbon balance (source: RIVM, 2015)*

- < -0,5 tons C/ha/year
- -0,5 - -0,2 tons C/ha/year
- -0,2 -0,2 tons C/ha/year
- 0,2 -0,5 tons C/ha/year
- > 0,5 tons C/ha/year



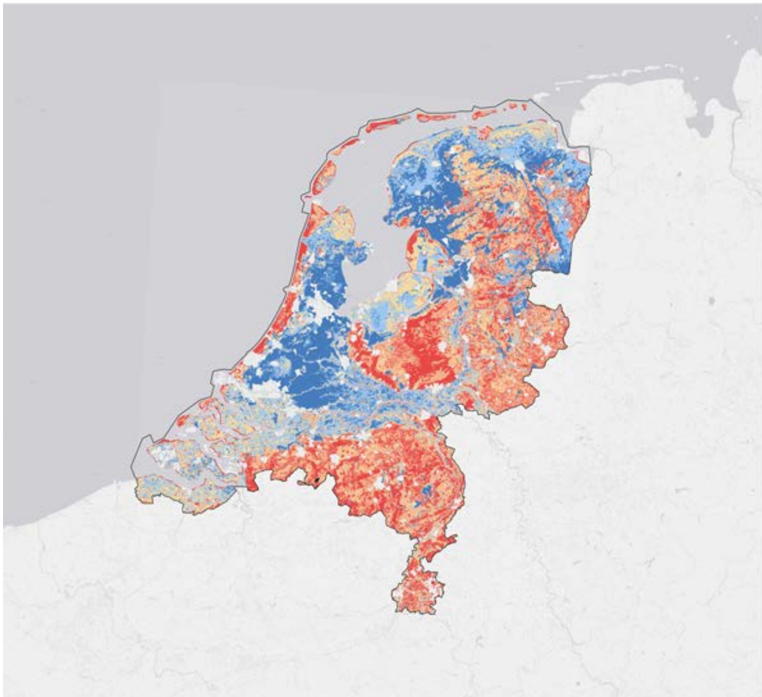
▲ *Figure 3.9: particulates (source: RIVM, 2015)*

Particulates (pm10)
- Moderate
- Intermediate
- Severe



▲ *Figure 3.10: soil fertility (source: RIVM, 2015)*

- Agricultural areas fertile soil
- Agricultural areas less fertile soil
- Nature areas fertile soil
- Nature areas less fertile soil
- Water
- Buildings and other areas



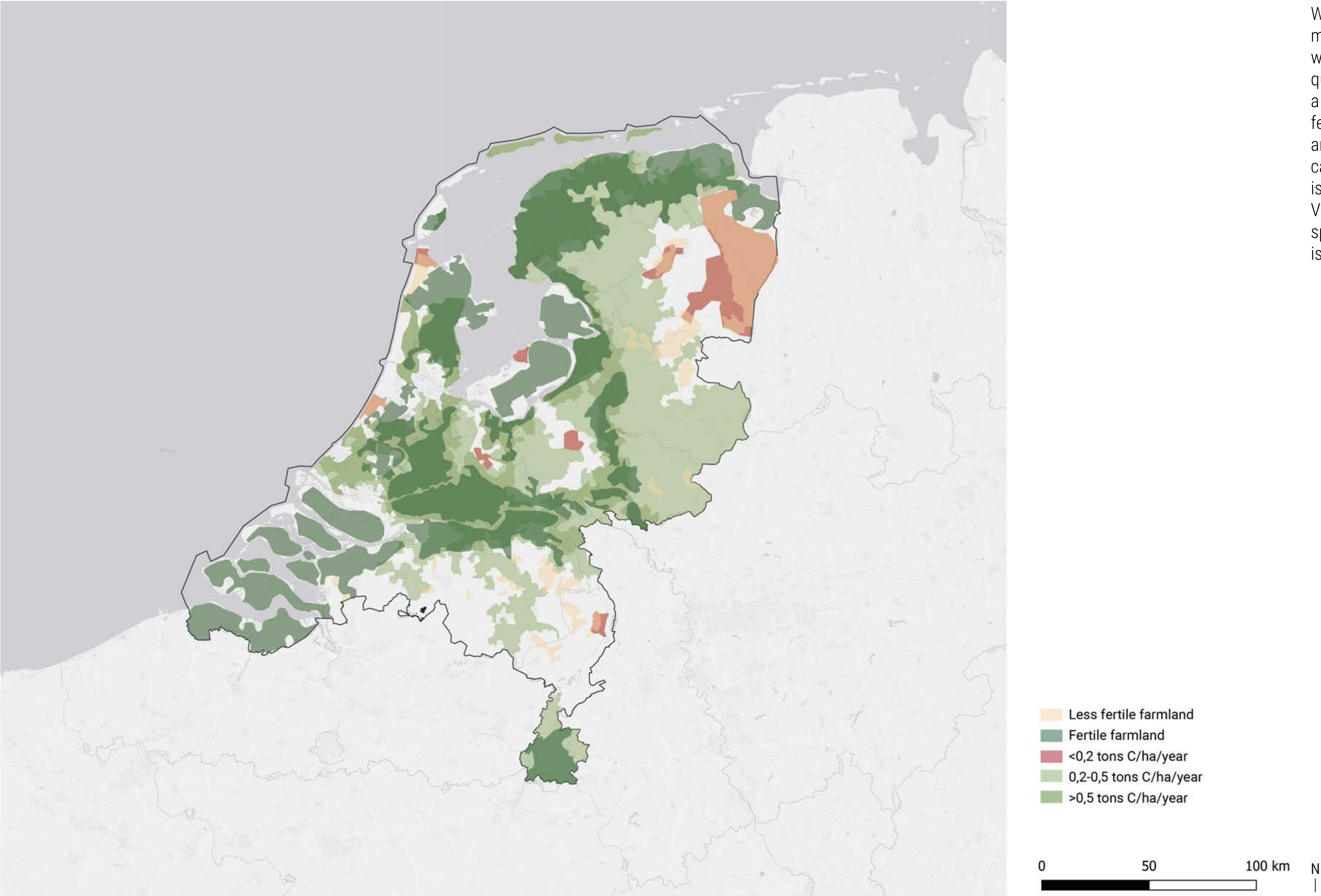
▲ *Figure 3.11: water regulation topsoil (source: RIVM, 2015)*

- Lower than average
- Average
- Higher than average

0 50 100 km N

3.3 Analysis NL: Healthy Landscape

The analysis maps, in figure 3.8 - 3.11, show that there are a few different problems related to soil quality and biodiversity. Large parts of the Netherlands are having soil problems; there is a microorganism, fauna, and biological function threat. This problem does not exclude the natural areas in the Netherlands. For instance, the dunes, the Utrechtse Heuvelrug, and the Veluwe have low soil fertility. This creates problems for flora and fauna. Furthermore, there is a low carbon balance in the locations where there is a lot of crop farming.



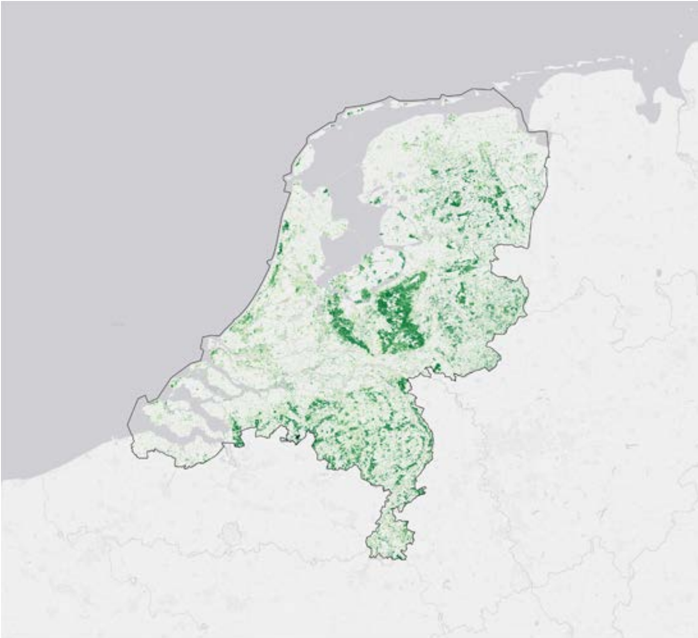
▲ *Figure 3.12: conclusion map healthy landscape (source: own work)*

3.4 Synthesis map

When combining the analysis maps in a synthesis map (figure 3.12), it illustrates the problematic areas with bad soil quality and the areas with higher soil quality. For instance, the east of Groningen has a bad carbon balance in the ground and has less fertile farmland. The Veluwe, northwest Friesian, and Utrecht have more fertile farmland and a better carbon balance. This means that the ground there is better than average in the Netherlands. The Eem Valley is a region that stands out because there is one spot with a really bad carbon balance. This location is Barneveld.

3.5 Analysis NL: Healthy Habitat

The inventory maps of the Netherlands demonstrate there is a high grass density in most parts of the Netherlands. The protected areas are generally not very large except for the Waddenzee and the Veluwe. This means there is a lot of fragmentation which limits animal migration and thus causes problems for the biodiversity. Because animals are bound to the habitat that they live in, fauna will struggle to spread as well. By overregulating forests and natural areas, this problem will be kept in place; this unhealthy balance will be maintained, putting pressure on flora and fauna.



▲ *Figure 3.13: tree density (source: RIVM, 2024)*

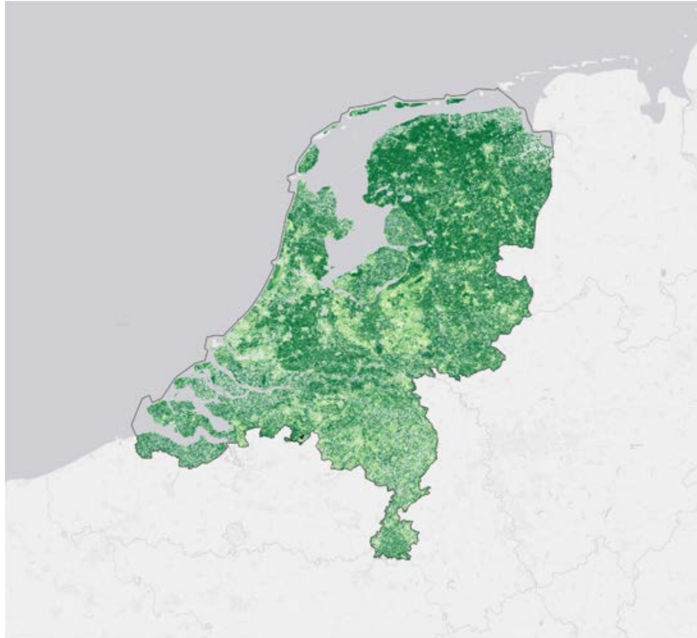
Trees (%) higher than 2,5 (m)

- < 10
- 10 - 30
- 30 - 50
- 50 - 70
- 70 - 100

▲ *Figure 3.14: shrub density (source: RIVM, 2022)*

Shrubs (%) lower than 2,5 (m)

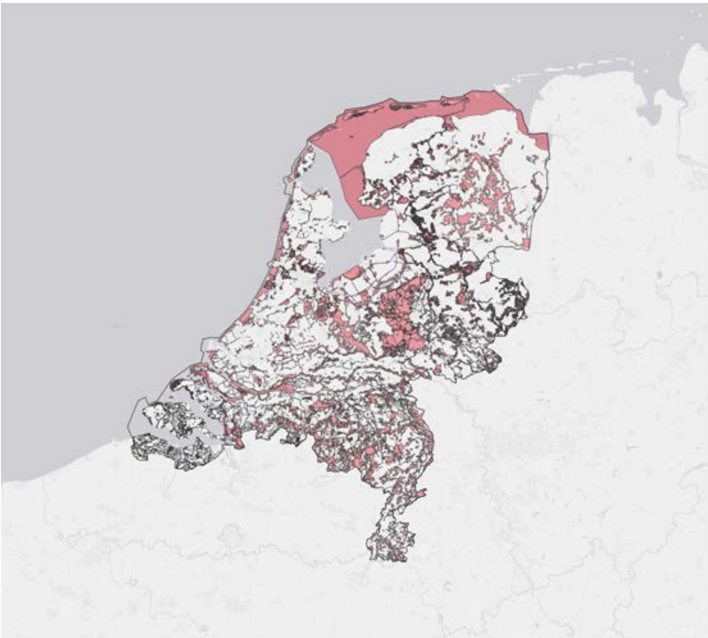
- < 5
- 5 - 10
- 10 - 20
- 20 - 40
- 40 - 100



▲ *Figure 3.15: grass density (source: RIVM, 2020)*

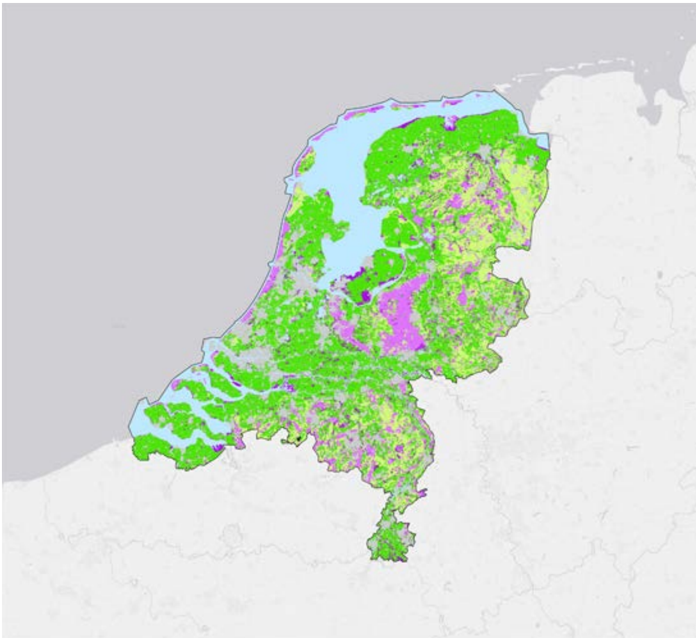
Low vegetation (%) up to 1 (m) high

- < 10
- 10 - 25
- 25 - 50
- 50 - 75
- 75 - 100



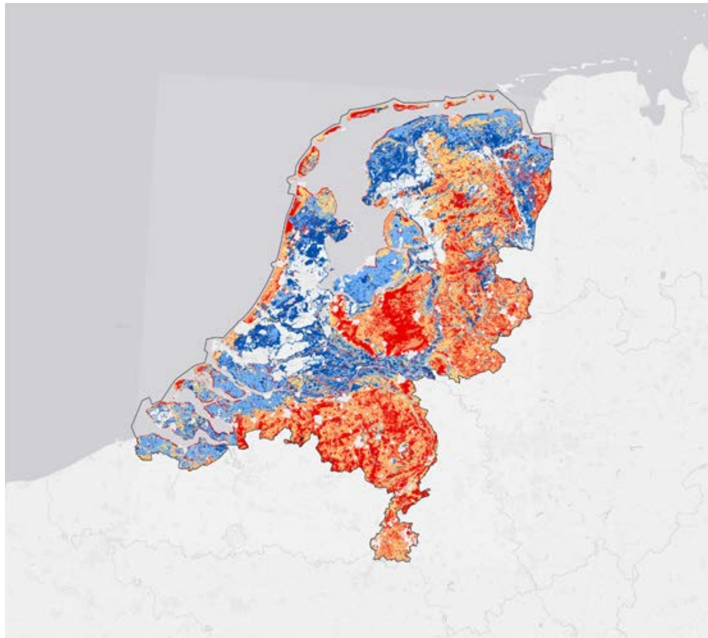
▲ *Figure 3.16: protected sites (source: PDOK, 2023)*

- Protected sites



▲ *Figure 3.17: soil fertility (source: RIVM, 2015)*

- Agricultural areas fertile soil
- Agricultural areas less fertile soil
- Nature areas fertile soil
- Nature areas less fertile soil
- Water
- Buildings and other areas



▲ *Figure 3.18: water regulation topsoil (source: RIVM, 2015)*

- Lower than average
- Average
- Higher than average

0 50 100 km

N

3.6 Synthesis Netherlands

After combining the grass density and the tree density it shows that these areas are not in the same place. Besides, high tree density does not mean that there is also a high biodiversity and soil fertility. Instead, places with more trees are the places with lower soil fertility. Also, it shows that the Natura2000 areas do not have a good biodiversity. The Veluwe is, after the Waddenzee, the largest area of Natura2000 area with different types of nature; it has a forest but also heaths. Nonetheless, the Veluwe has a low biodiversity and a low soil fertility.

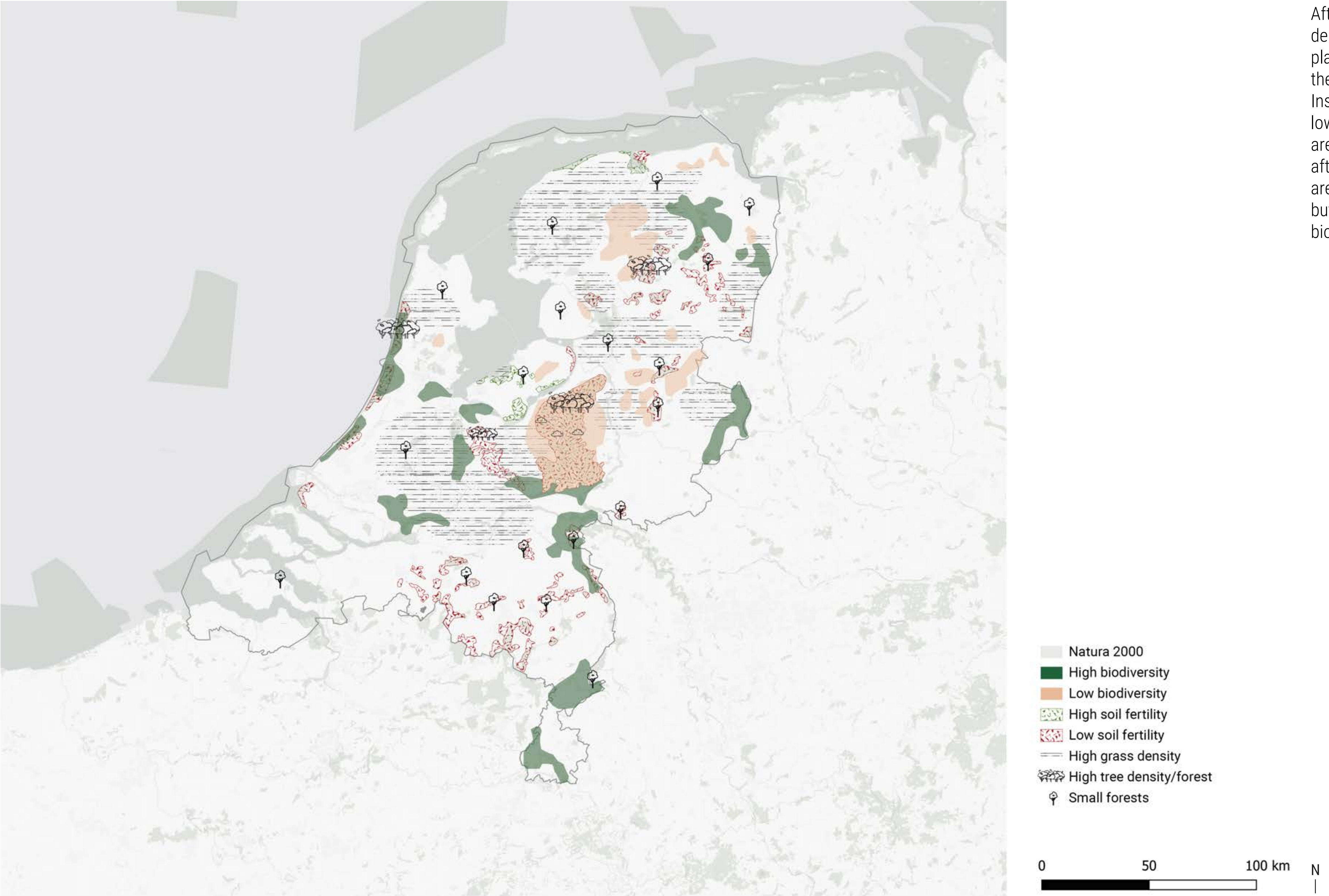


Figure 3.19: synthesis map healthy habitat (source: own work)

Panorama taken at an industrial zone along the Eem

4

Contents

In this chapter, we will introduce our vision for the River Eem. Firstly, we will briefly explain the vision statement. Then, we will introduce a sub-vision for each pillar: Healthy Water, Healthy Landscape, and Healthy Habitat. Finally, we will combine these sub-visions into one overall vision, to make the River Eem the healthiest river in Europe.

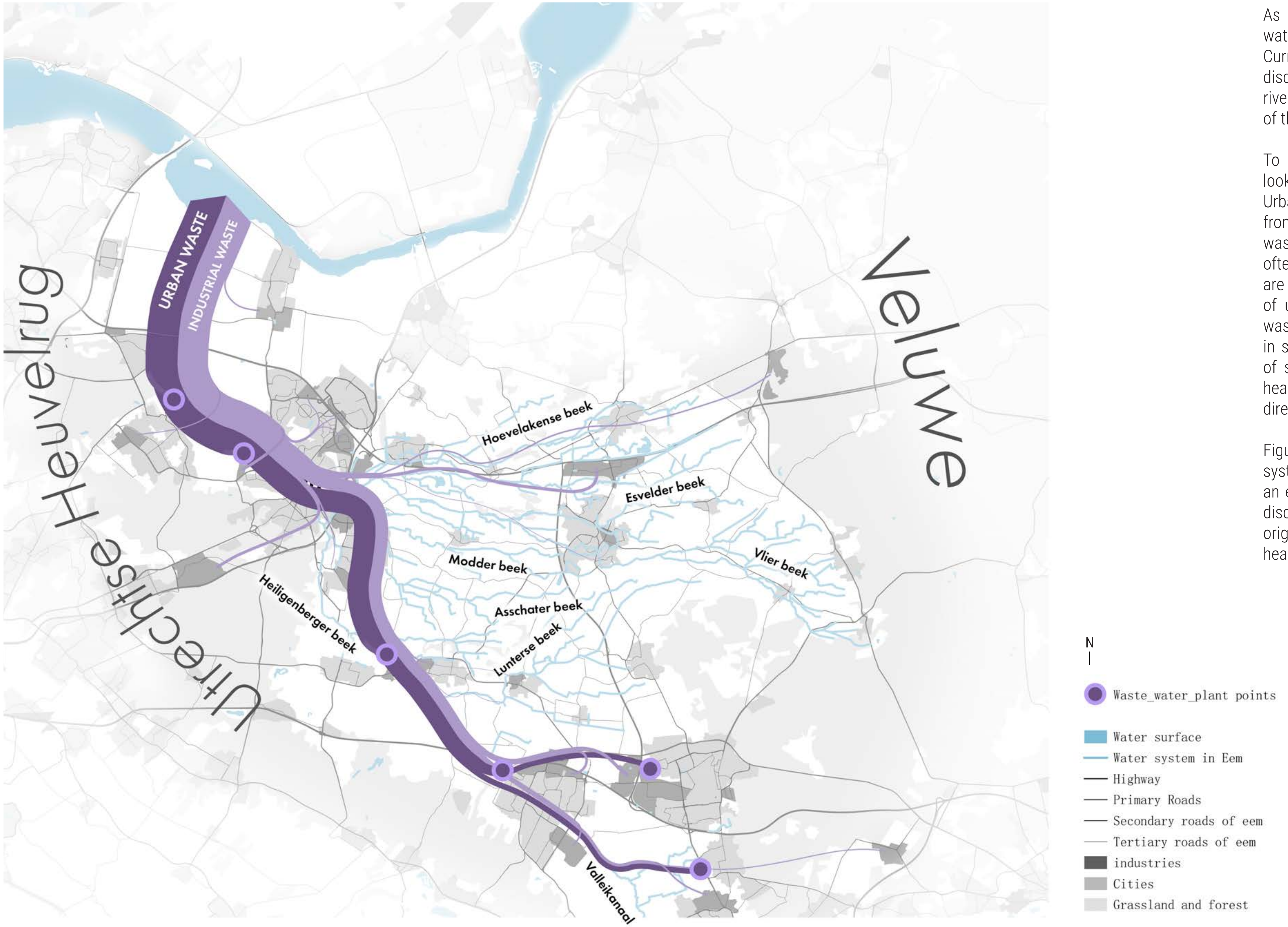
So far, we explored the issues at hand and their sources. We analysed these spatially on the Eurodelta scale as well as on the scale of the Netherlands. Next up is to envision the future for the Eem Valley. This will be done by making a sub-vision map for each pillar, before combining these three sub-vision maps into a final vision map for the Eem valley. Every sub-vision map will be made on a quick analysis of the Eem valley. The vision map will be made according to the vision statement.

4.1 Vision statement

In 2075, the river Eem is the healthiest in Europe and functions as a pilot for the Eurodelta.

Imagine that by 2075 the river Eem flows as the healthiest river in Europe, setting an example for the rest of the continent. To achieve this, we have to identify the flows that pollute the river at different scales. The vision focuses on three essential pillars: healthy landscape, healthy water, and healthy habitat. This will result in a river that has a good ecological and chemical status and provides excellent living conditions. The river can become healthy by introducing sustainable agriculture and industrial practices, as well as adapting waste flows. The relationship between the river and the valley will be emphasised: a healthy river provides healthy water, healthy habitats, and healthy landscapes. In the Eem Valley, a healthy river is a crucial element for improving living conditions. And so, the vision in 2075, for the Eem to be the healthiest river in Europe that functions as a pilot for the Eurodelta will ensure the improvement of the river, its valley, and all forms of life within it.

Figure 4.1: impression vision (source: own work)



▲ *Figure 4.2: build up map healthy water (source: own work)*

4.2 Healthy water

As mentioned before, the objective of the healthy water pillar is to achieve good chemical status. Currently, municipalities along the river Eem discourage their inhabitants from swimming in the river. This is a clear indicator that the chemical status of the river is out of balance.

To map the problem and sources of pollution, we looked into urban and industrial waste in the river. Urban waste includes litter and (micro)plastics from urban areas, as well as effluent from urban wastewater facilities. Although filtered, the effluent often still contains medicine residues and PFAS which are harmful to the river ecosystem. Another source of urban waste is the direct discharge of excess wastewater during heavy rainfall. These can be found in spots where the sewer system is mixed instead of separated. Industrial waste includes chemicals, heavy metals, and toxins that are being discharged directly into the water system from industrial sites.

Figure 4.2 shows the waste flows in the water system of the Eem. Even though the river Eem has an extensive water system of brooks upstream, we discovered that industrial and urban waste mostly originates in one of the brooks. The sub vision for the healthy water pillar is therefore focused on this axis.

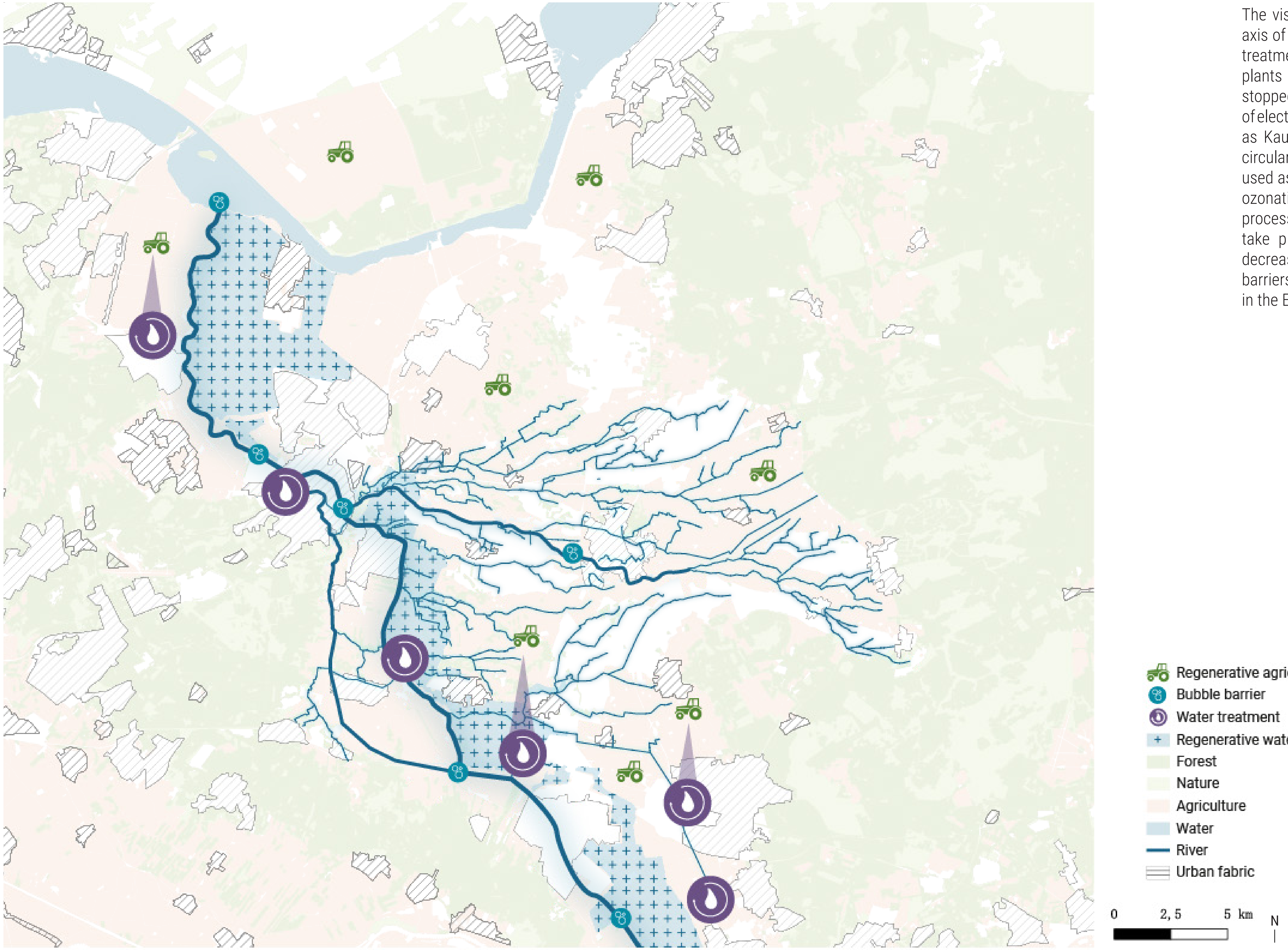
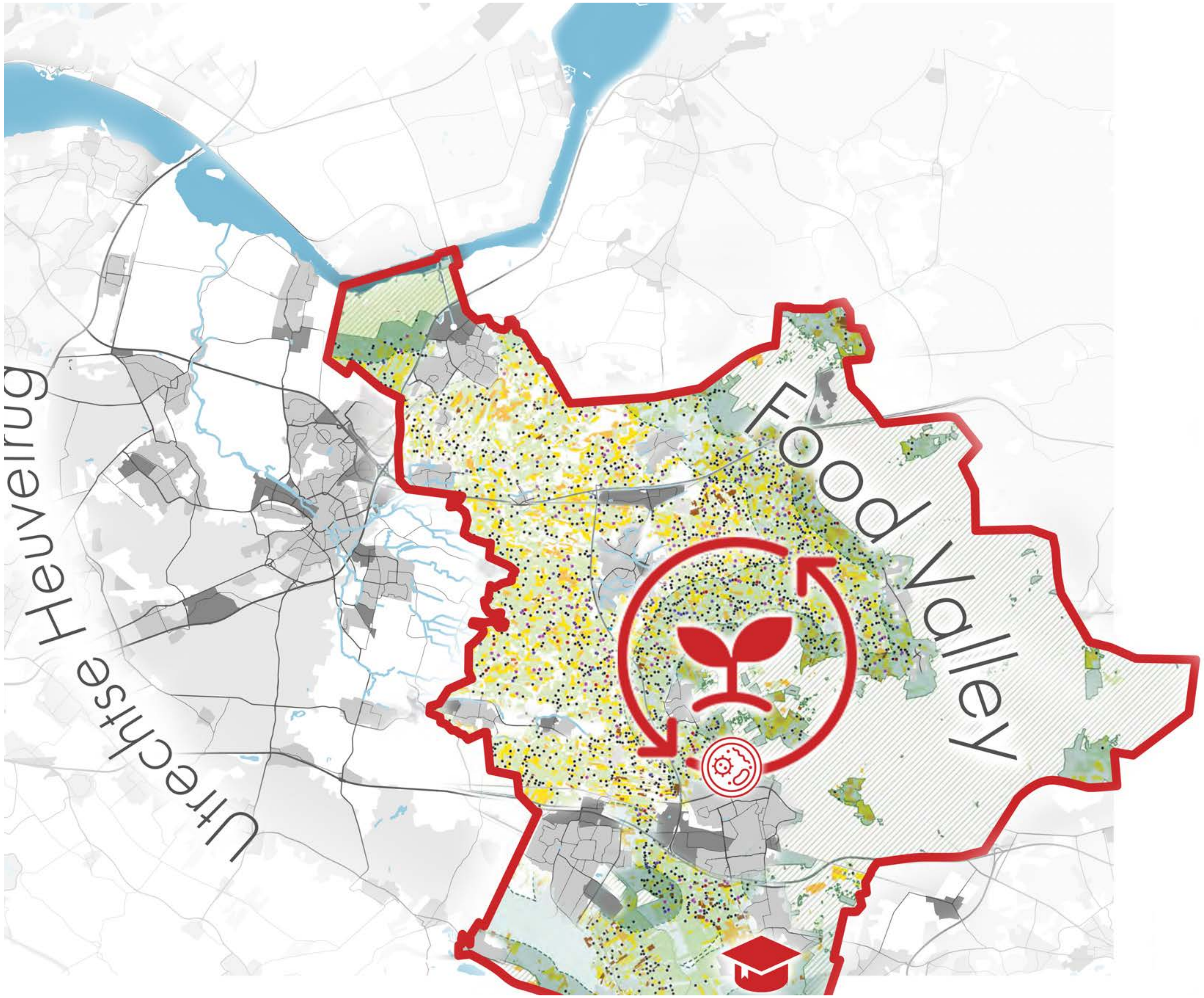


Figure 4.3: vision map healthy water (source: Brightspace, 2020)

The vision, as shown in figure 4.3, shows how this axis of waste is fought by upgrading the wastewater treatment facilities. By making the sewage treatment plants more sustainable, water pollution can be stopped: by using urban wastewater for the production of electricity, biogas and innovative raw materials such as Kaumera, the sewage treatment plants become circular. In addition, the remaining effluent can be used as process water in the agricultural sector if an ozonation + BIO process is added to the purification process. Additionally, natural water purification can take place by implementing helophyte plants. To decrease the plastic waste in the Eem River, Bubble barriers are strategically placed in multiple locations in the Eem.

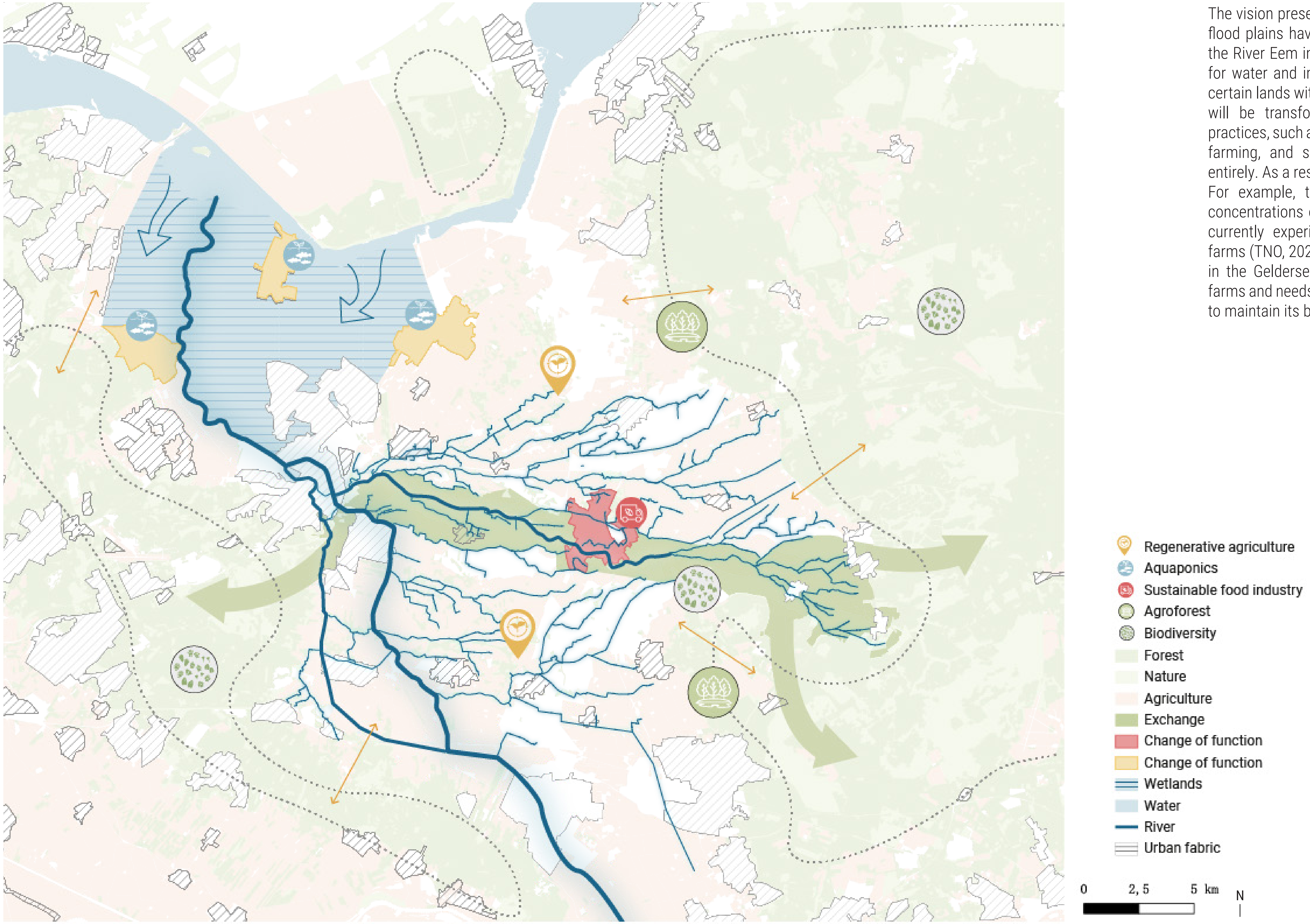


▲ *Figure 4.4: build up map healthy landscape (source: own work)*

4.3 Healthy landscape

The objective of the healthy landscape pillars is to create good ecological status. As mentioned in the problem statement the world's remaining topsoil will be completely gone by 2080 (Tickle & Harrell, 2020) if we don't change our agricultural practices. This also applies to the Eem Valley. To save our topsoil, we have to envision a future with a healthy landscape rather than a degenerative one.

Figure 4.4 shows a unique strength the Eem Valley possesses. Which is that the Eem Valley is part of the Food Valley region, which is a partnership of eight municipalities in the Gelderse part of the valley. An important component of this partnership is its connection to Wageningen University and Research (WUR). This university tests and implements innovative regenerative agricultural practices in this region. This offers an opportunity to expand this partnership towards the rest of the Eem Valley.



▲ *Figure 4.5: vision map healthy landscape (source: own work)*

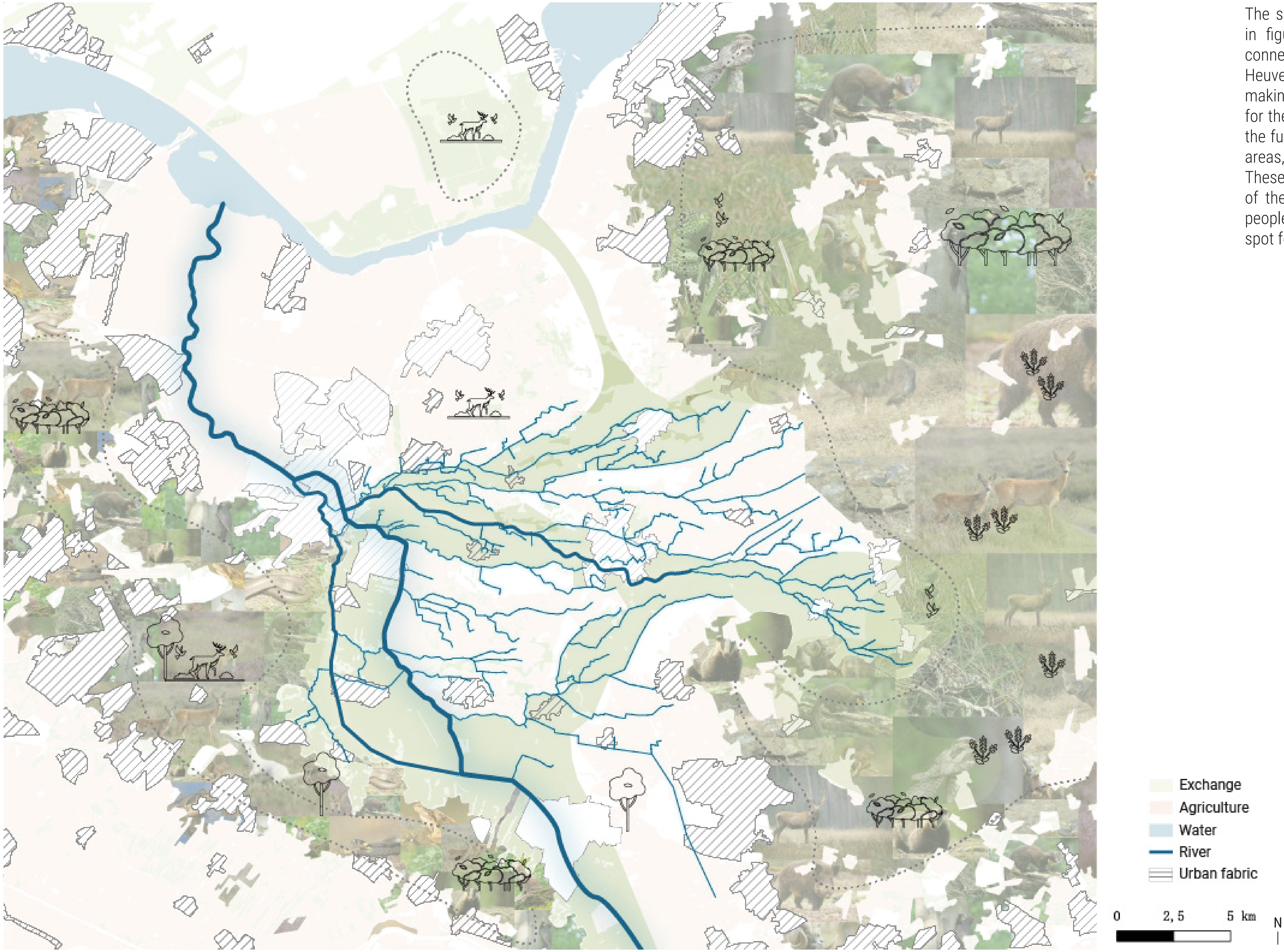
The vision presented in figure 4.5 demonstrates that flood plains have been allocated near the mouth of the River Eem in the North, serving as natural filters for water and improving water quality. Additionally, certain lands with degenerative agricultural practices will be transformed into sustainable agricultural practices, such as agroforestry, aquafarming, organic farming, and seasonal agriculture, or repurposed entirely. As a result, certain areas will shift character. For example, the Gelderse Valley now has high concentrations of pig and poultry farms and hereby currently experiences high emissions from these farms (TNO, 2022). The village of Barneveld, situated in the Gelderse Valley, is renowned for its poultry farms and needs to adopt more sustainable activities to maintain its business.

▲ *Figure 4.6: build up map healthy habitat (source: own work)*

4.4 Healthy habitat

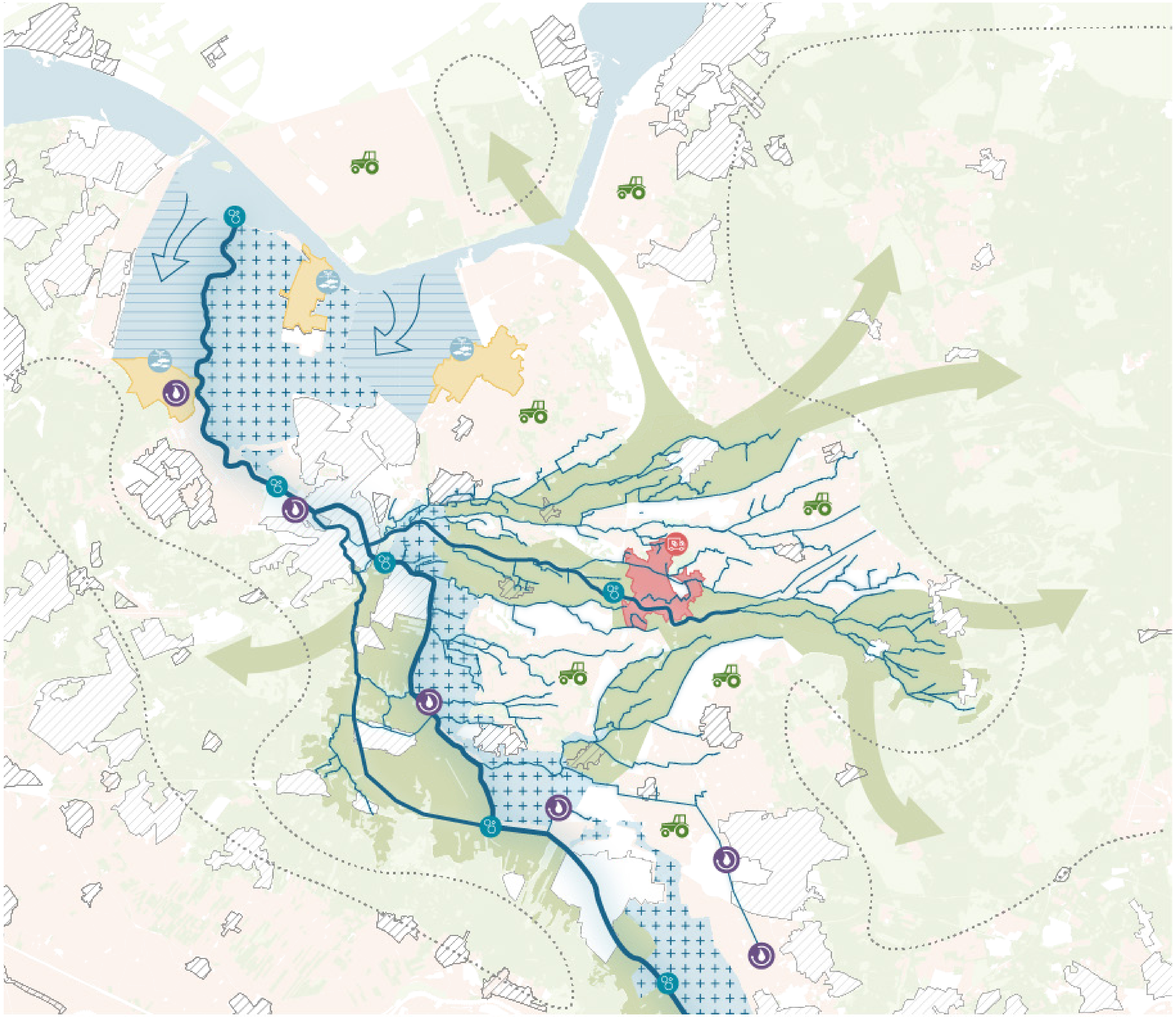
The objective of a healthy habitat is to create good living conditions. This applies to animals as well as humans. Again, the example of the Eem not being swimmable shows how the living conditions for humans are badly affected without healthy rivers.

The Eem Valley is surrounded by protected Natura 2000 areas. To the east you can find the Veluwe, in the south and west the region is limited by the Utrechtse Heuvelrug, and located in the north, there are multiple lakes. But, as shown in figure 4.6, the rivers and brooks do not support or connect the nature reserves at all. This is a missed opportunity.



▲ *Figure 4.7: vision map healthy habitat (source: own work)*

The sub-vision for the healthy habitat pillar, shown in figure 4.7, is focused on increasing the eco-connectivity between the Veluwe, the Utrechtse Heuvelrug, and the lakes. This will be done, by making use of the river and brooks as a backbone for the natural infrastructure. Hereby animals will, in the future, be able to migrate between these natural areas, stimulating biodiversity throughout the region. These green corridors can be seen as an expansion of the natural areas, bringing nature closer to the people, and making the river a vital, green, and diverse spot for people to visit.



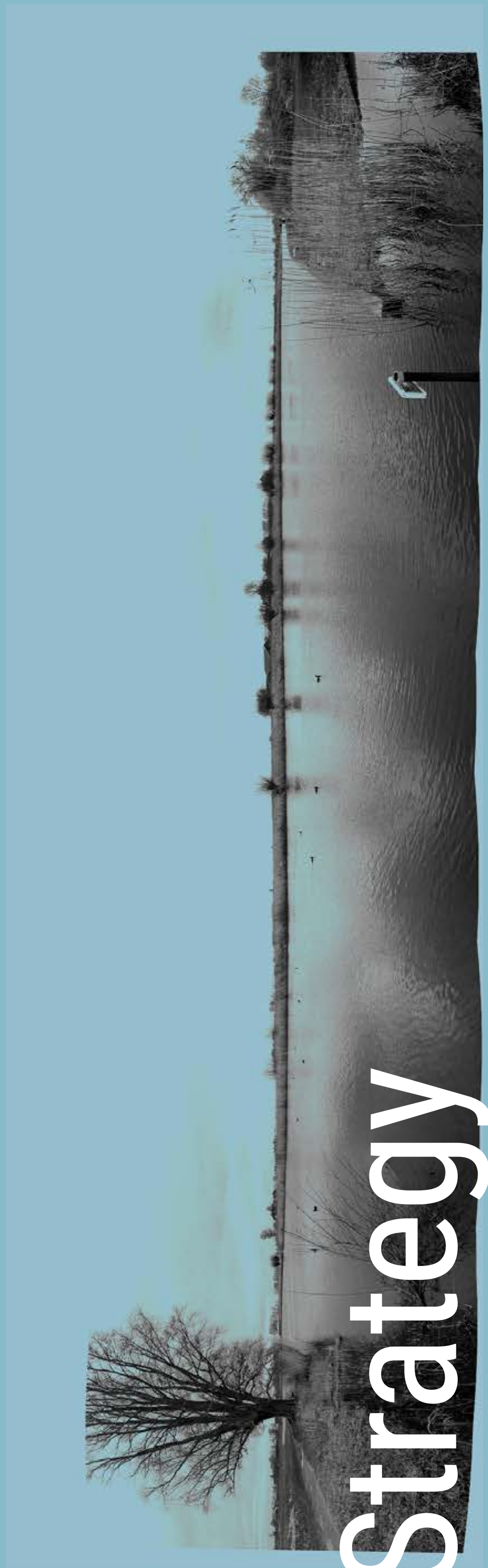
▲ *Figure 4.8: vision map Eem (source: own work)*

4.3 Vision Eem

Combining the three sub-vision maps, as shown in figure 4.8, the final spatial vision for a healthy river Eem emerges. In this vision, the river Eem provides healthy water with a good chemical status, a healthy landscape with a good ecological status, and healthy habitats with good living conditions for all forms of life. Through the reduction of urban and industrial waste in the river, the water will be suitable for swimming again. By transforming agricultural land into flood plains, aquafarming, agroforestry, and regenerative farms, the soil and water quality will improve. The Eem will become an essential factor in improving biodiversity and diversification by becoming a green-blue connection between the Utrechtse Heuvelrug and the Veluwe. To conclude, the Eem becomes a shining example of what can be achieved when we prioritize healthy ecosystems.

5

Strategy



Panorama taken at an agricultural zone along the Eem

Contents

In this chapter, we will present our strategy for the River Eem and provide a toolbox that can serve as a guide for decision-makers and planners. Firstly, we will explain who the stakeholders are. Then, we will describe certain policies that aim to discourage or stimulate certain habits. Next, we will introduce the interventions that are being implemented on the River Eem. Additionally, we will provide a timeline and phasing plan. Finally, we will focus on three locations in the Eem Valley that have different programming.

5.1 Stakeholders

To explain the strategy, we start by looking into the stakeholders. Doing a stakeholder analysis clarifies what role or position each relevant actor occupies in the process. By looking into their attitude towards the spatial vision, what power or interest they might have, and how they relate, we will gain an understanding of the conflicts and synergies in place. Besides, it will allow us to understand how to, later, include stakeholder engagement management into the timeline.

Our stakeholder analysis consists of two parts. Part one is meant to differentiate the stakeholders from different sectors: public, private and civil society.

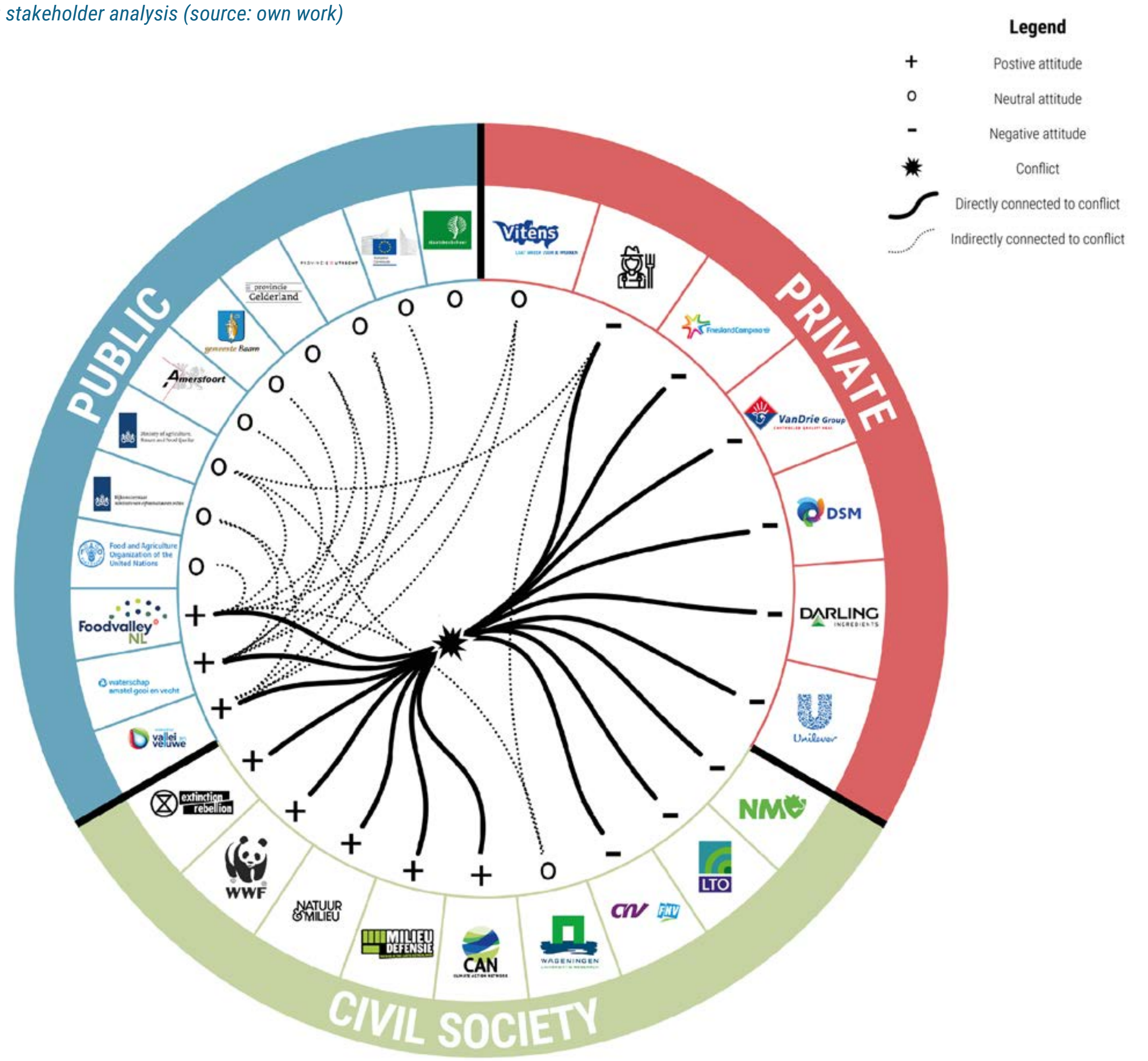
In figure 5.1, we categorised the stakeholders within these sectors. To expand the stakeholder analysis, we looked into their attitude toward the spatial vision.

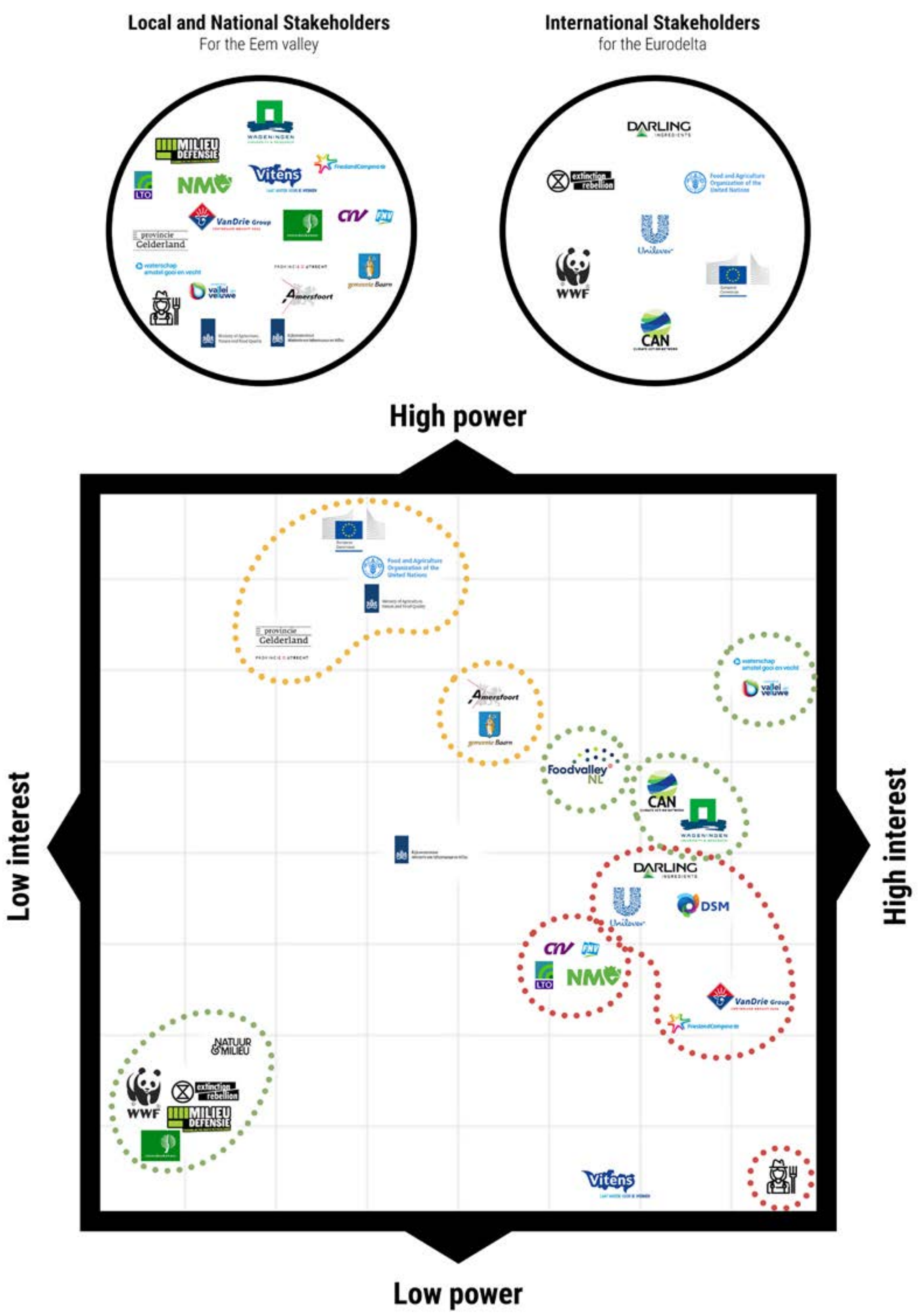
It is noticeable that a conflict arises between most of the private sector actors and the Waterboards and Food Valley alliance.

The civil society seems to be divided: the climate action organisations have a positive attitude, whereas the labour unions support and represent the farmers and industrial companies. The University of Wageningen occupies a unique position as a neutral stakeholder in civil society. They offer an opportunity to use innovation and knowledge to find a compromise in the conflict.

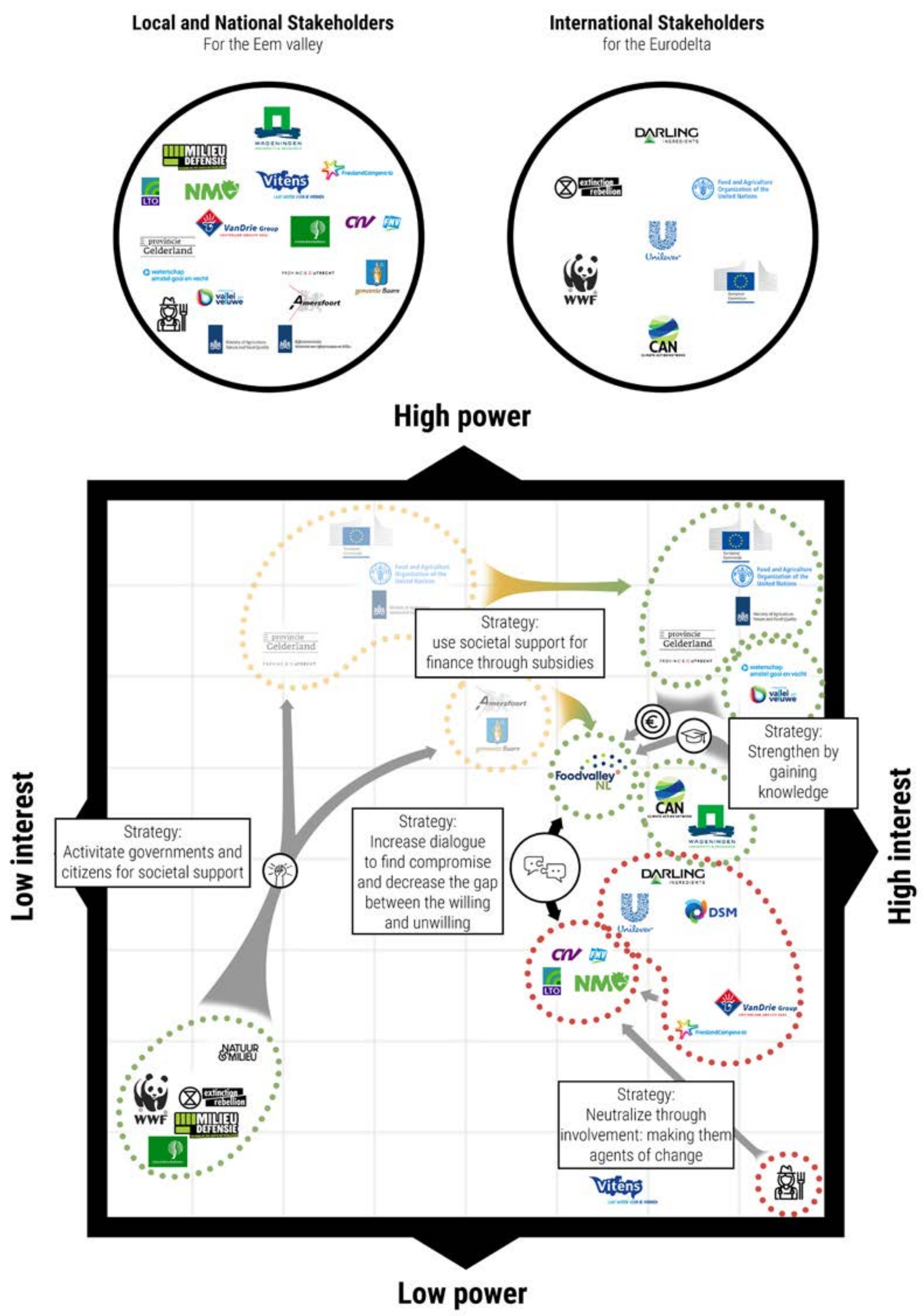
Although the actors with a negative attitude towards the vision outnumber the ones with a positive attitude, neutral actors from the public sector are mostly connected indirectly to other public stakeholders with a positive attitude.

Figure 5.1: stakeholder analysis (source: own work)





▲ *Figure 5.2a: power interest matrix (source: own work)*



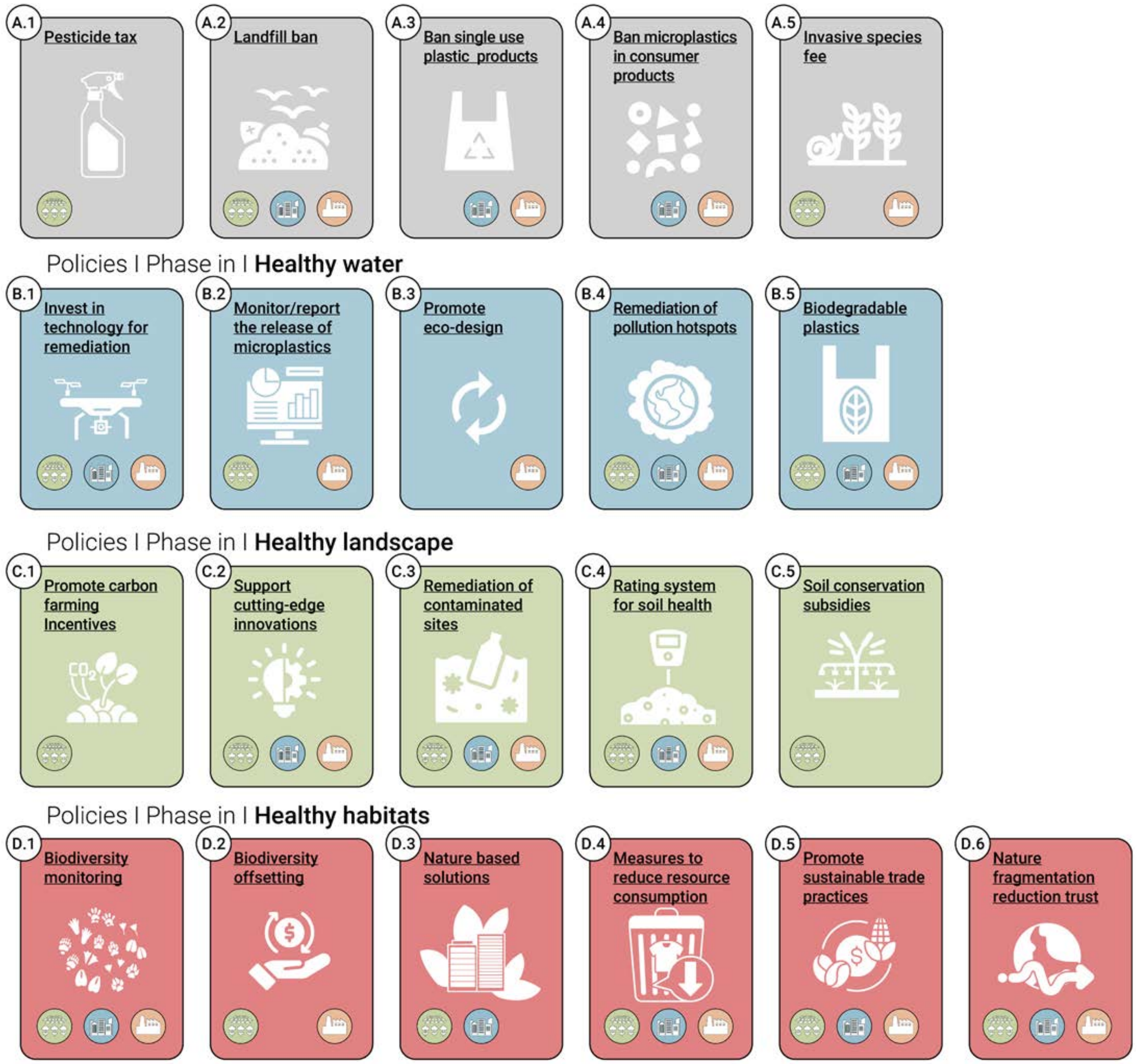
▲ *Figure 5.2b: power interest matrix strategic actions (source: own work)*

The second part of the stakeholder analysis is meant to gain an understanding of the interest and power that the actors hold within the transition towards the spatial vision. In Figure 5.2a, the stakeholders are placed in a power-interest matrix. Similar actors are clustered in groups to get a better overview of the current situation.

In Figure 5.2b, the strategic actions that are needed to make the transition happen are shown. To finance the transition, there has to be continuous support from governments and governmental organisations. Since these are governed by democratically elected people, broad societal support is needed. Here, climate action organisations come in to create awareness and lead society in the right direction.

One of the most important things that needs to be done to achieve this, is to neutralise the stakeholder clusters with a negative attitude. This can only be done by making them agents of change. The dialogue with these stakeholders and decision-makers is thus essential.

Investing time and money in innovation, mutual knowledge exchange, and sharing experiences from practices are vital for making these sustainable ways of land use feasible and profitable to private companies. CAP, a powerful multi-national NGO spread over 95 countries, and the University of Wageningen and Research can help guide this process.



▲ *Figure 5.3: policy cards (source: own work)*

5.2 Policies

Besides information about the stakeholders, we have to get an idea of which policies will be needed to achieve these healthy river ecosystems. The following policies have been formulated to ensure these healthy rivers, and they are divided into three pillars: Healthy Water, Healthy Landscape, and Healthy Habitats.

The first category of policies aims to eliminate certain practices that have been negatively impacting the water quality. As part of this effort, for instance, a pesticide tax will be imposed on the use of chemical herbicides and pesticides in agriculture. This will encourage farmers to explore alternative methods that are more environmentally friendly. A landfill ban will also be implemented, which will prohibit the disposal of recyclable materials such as cardboard, metal, glass, plastic, and paper in landfills. Single-use plastic products will also be banned to reduce plastic use and promote the use of alternative, eco-friendly materials. Additionally, microplastics will be banned in consumer products such as fertilisers, cosmetics, detergents, and paints to reduce their impact on the environment. Finally, an invasive species fee will be imposed to fine those who possess, import or sell invasive plant and animal species.

The second category of policies is related to the three pillars of Healthy Water, Healthy Landscape, and Healthy Habitats. The policies within the Healthy Water pillar aim to improve the chemical status of surface water. To achieve this, the government will invest in technologies for remediation, such as nanotechnology, which can selectively remove microplastic from both soil and water. Additionally, creating methods to monitor and report microplastic pollution can promote eco-design, towards a circular economy. The government will also support remediation in heavily polluted areas, such as cleanup initiatives, research, and community engagement, to remediate pollution hotspots. Lastly, the use of biodegradable plastic reduces the accumulation of plastic and can break down more easily in the environment.

The third category of policies is focused on the Healthy Landscape pillar. The policies are beneficial for achieving a good ecological status in the surface water and surrounding areas. The policies include promoting carbon farming, which can sequester and store carbon via farming practices such as crop rotation, agroforestry, and year-round roots. The government will also remediate contaminated sites, prevent soil degradation, and promote sustainable land use. Furthermore, a rating system for soil health that incorporates multiple indicators, such as chemical, ecological, and physical properties, can be developed. Lastly, subsidies for farmers and landowners for implementing soil conservation practices can be provided.

The fourth and final category of policies falls under the Healthy Habitats pillar, which aims to achieve good living conditions inside and surrounding waterbodies. The policies include biodiversity monitoring, which can improve data collection, decision-making, and community engagement. Biodiversity offsetting will also be implemented to compensate for biodiversity loss caused by human activities. Additionally, a strategy that includes guidelines to support the implementation of nature-based solutions can be adopted. Furthermore, promoting circular practices and minimising waste can reduce resource consumption. Besides, supporting conservation projects and advocating stronger international agreements can tackle global biodiversity challenges. A fragmentation reduction trust can also be established to mitigate the impact of nature fragmentation. The fund can be used for the restoration and reconnection of fragmented nature areas.

5.3 Interventions

Bubble barrier: the Bubble Barrier is an innovative solution to combat plastic pollution in waterways. It uses a bubble curtain to block and direct plastic waste to the surface, where it can be collected. It operates continuously to prevent plastic from reaching the oceans without hindering regular river activities (The Great Bubble Barrier - A Smart Solution To Plastic Pollution, 2024).

Aquaponics: aquaponics combines aquaculture and hydroponics to create a symbiotic environment where fish waste feeds plants and plants purify the water for fish (Vergeer, 2023).

Wastewater treatment: wastewater treatment removes contaminants from water before it is released back into the environment or reused. The process includes primary, secondary, and tertiary stages to remove pollutants. Primary treatment separates solid waste. Secondary treatment degrades dissolved organic matter. Tertiary treatment purifies water through filtration, disinfection, and removal of nutrients. This ensures clean water for discharge or reuse, protecting water bodies and public health (Wastewater Treatment | Process, History, Importance, Systems, & Technologies, 2010).

Separated sewage system: a separate sewer system handles sewage and rainwater separately. This reduces wastewater volume, minimises sewage overflows, and is more effective for managing water resources (Soapbox, 2023).

Underground water storage: underground water storage is a sustainable strategy that uses natural or artificial tanks to store water for future use. It helps to manage floods, recharge groundwater, and store surplus water for shortage periods. It can also improve water quality and is used in various contexts, such as irrigation, urban water supply, and environmental restoration.

Sustainable drainage systems: SuDS are eco-friendly alternatives to traditional drainage systems. They imitate natural processes to minimise the impact of urbanisation on water quality and flood risk. These systems manage rainfall on-site, either by using it, letting it soak into the ground, or slowing down its flow into watercourses. SuDS are vital to urban planning as they address water quantity and quality while supporting biodiversity and providing community amenities (Sustainable Drainage, z.d.).

Compost city waste: composting city waste is the process of breaking down organic waste materials into a nutrient-rich fertiliser through controlled aerobic decomposition. This can significantly reduce waste and reliance on chemical fertilisers (Solid-waste Management | Definition, Methods, Importance, & Facts, 2024).

Floodplains: floodplains are flat lands near rivers that flood periodically. They absorb and distribute floodwaters, reduce the impact on surrounding areas, and support wildlife. They also help in filtering pollutants and sediments from floodwaters, thus improving water quality.

Grazing: grazing can improve water infiltration, reduce surface runoff, enhance groundwater recharge, and minimise erosion.

Covered soil: covered soil is the practice of keeping soil covered with organic materials, which helps with water protection by enhancing water infiltration, reducing evaporation, and preventing soil erosion. It also leads to cooler soil temperatures and better moisture retention, which benefits both crop production and water conservation (Delgado et al., 2021).

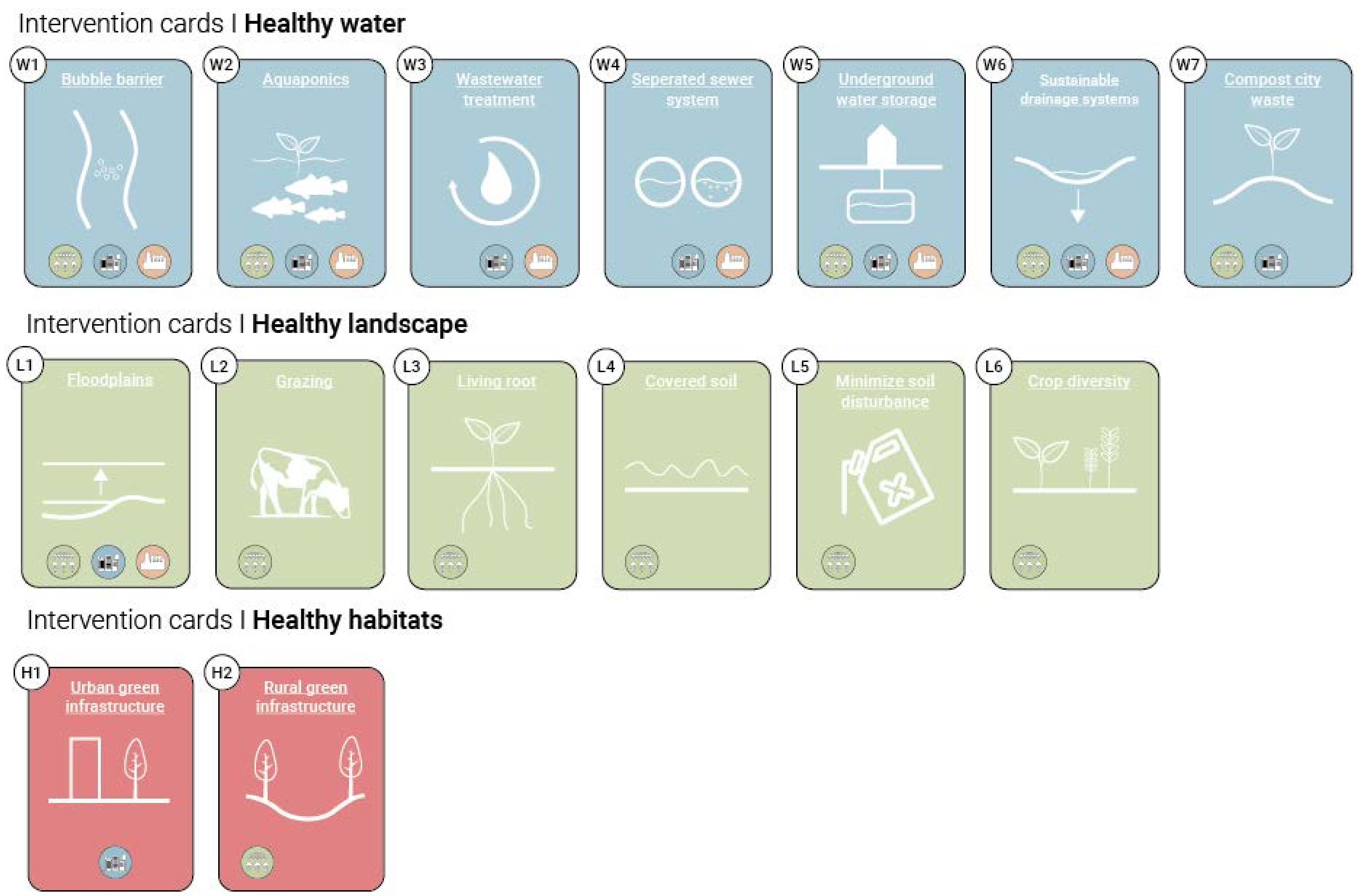
Minimise soil disturbance: this practice improves soil structure, enhances water retention, prevents pollution, and protects water quality and aquatic habitats. It also increases organic matter and supports soil health (Walia & Kay, 2022).

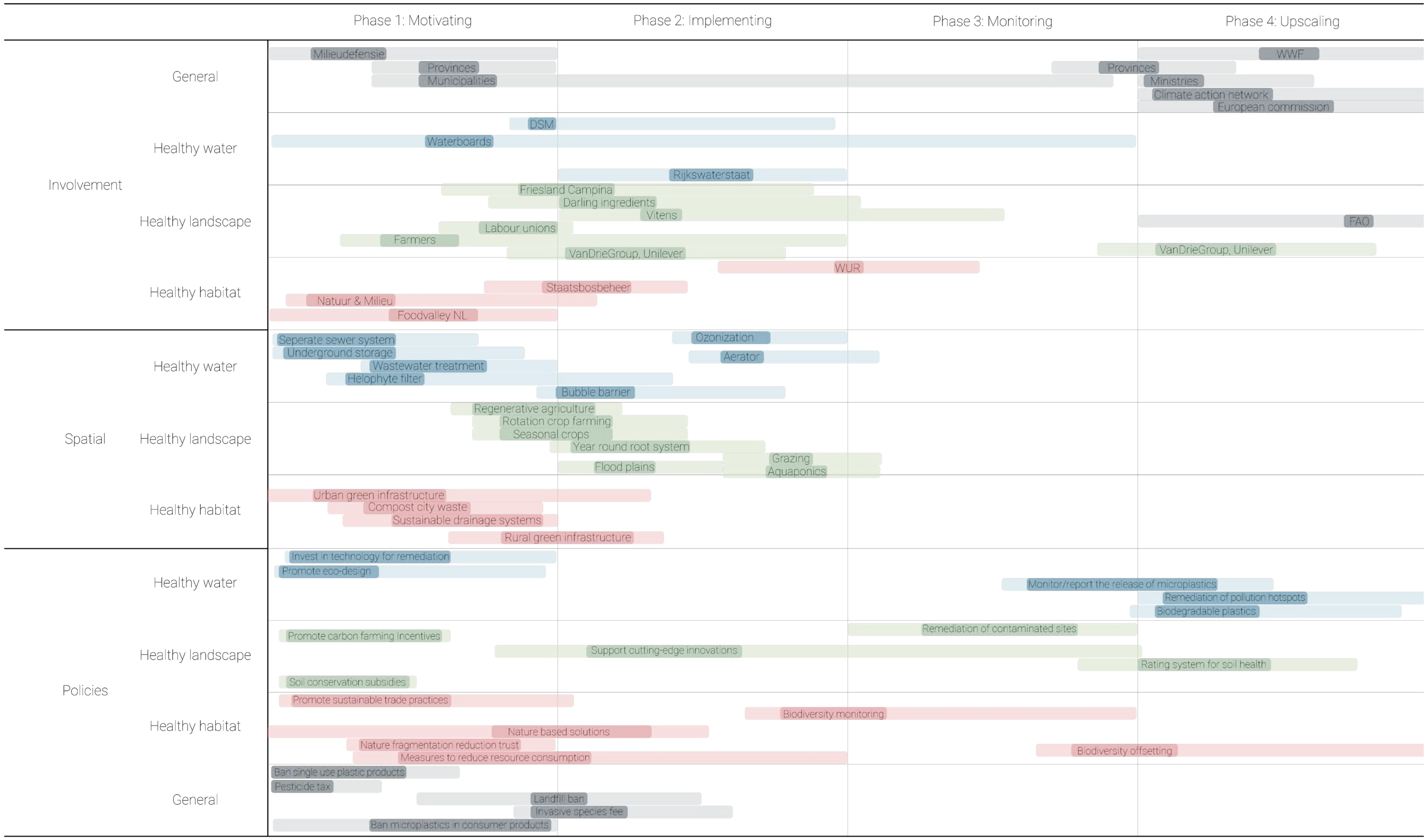
Crop diversity: diverse crops improve soil quality, benefit farmers economically, and promote resilience against climate change, benefiting the environment and communities (Crop Diversity Improves The Health Of Our Water – And Our Climate, 2021).

Urban green infrastructure: green systems like parks, green roofs, and rain gardens can reduce stormwater runoff, filter pollutants, and improve water quality. Integrating green spaces into urban planning is essential for sustainable water management and protecting urban water resources.

Rural green infrastructure: green infrastructure in rural areas uses natural landscapes like wetlands, forests, and riparian buffers to protect water resources. Preserving and restoring these natural systems can enhance water quality and availability, reduce erosion, filter pollutants, and support biodiversity. This improves the health of river ecosystems and resilience against climate change impacts.

Figure 5.4: intervention cards (source: own work)





▲ *Figure 5.5: phasing (source: own work)*

5.4 Phasing

To develop a strategy, we must consider the different phases involved. The timeline outlines our vision for the next fifty years and covers all the topics we have previously discussed. It outlines which stakeholders are important in different phases, which policies should be implemented during specific time frames, and illustrates the various spatial interventions. All the elements are grouped into the three pillars of our vision: healthy water, healthy landscape, and healthy habitat.

The stakeholders play an important role in our vision since the most significant changes involve rethinking the way we approach the problems of the river. For example, to shift from degenerative agriculture to regenerative agriculture, farmers must be willing to change and should be motivated as soon as possible. Therefore, they are in the first phase of the timeline. The subchapter with the stakeholder analysis further explained the actions of each stakeholder.

The spatial category of the timeline shows the different interventions and their scale levels. Most of the interventions are implemented in the shorter term because the Eem Valley serves as a pilot. Therefore, it should be clear what the interventions are and how they work before they can be scaled up to the Euro Delta.

The policies are mostly in the motivating and upscaling phase. Some policies provide room for the interventions, while others cannot be implemented at present due to a research gap. Therefore, they will be implemented during the upscaling phase. For instance, the monitoring of microplastics is not yet feasible. We lack information about the quantification of microplastics in the ground or surface water. Therefore, it is necessary to do additional research on technology that can measure microplastics, before implementing the policies.

5.5 X-curve

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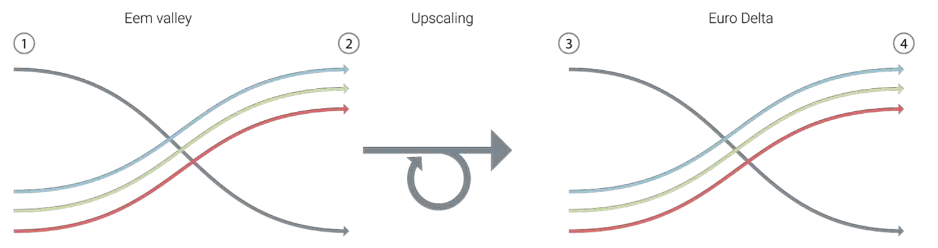
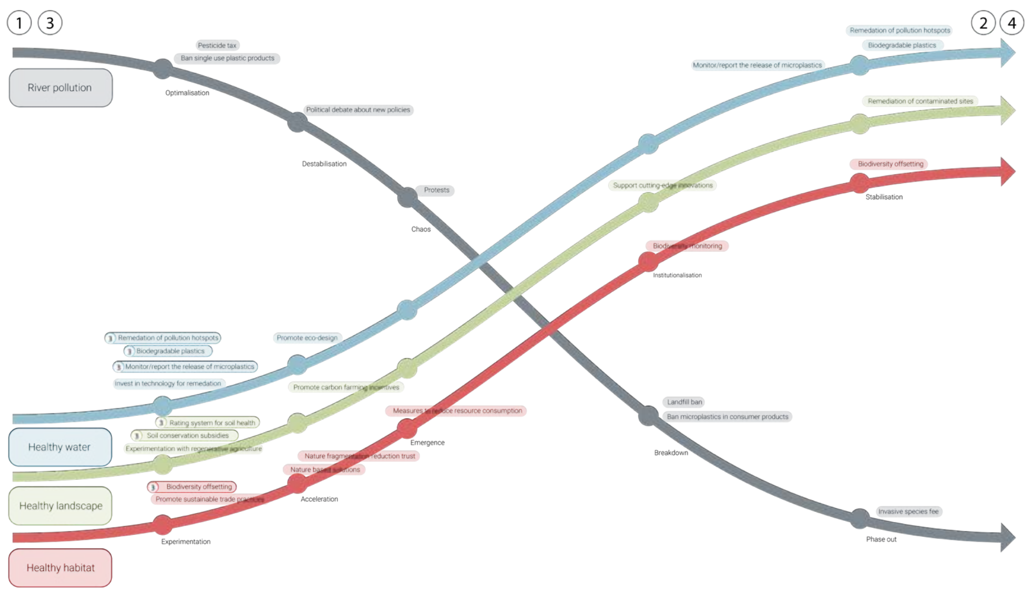


▲ *Figure 5.6: x-curve (source: own work)*



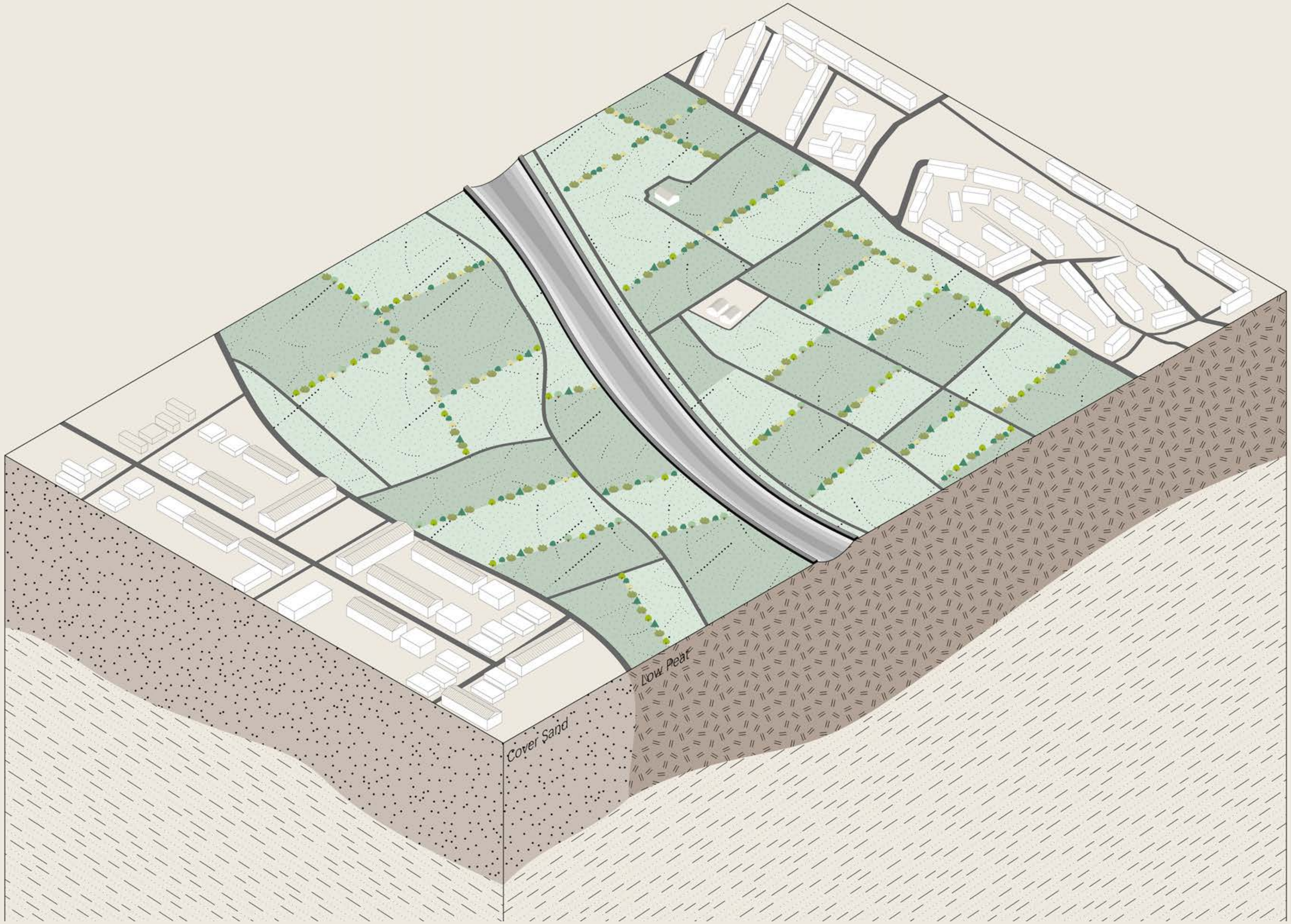
▲ *Figure 5.7: policies phase in and phase out (source: own work)*

5.6 Sections

We identified three areas in the Eem Valley that have different combinations of programming, namely urban with agriculture, industry with agriculture, and urban with natural areas. For these areas, we developed a strategy based on a research-by-design approach. Each intervention was contextualised based on the specific location.

▲ *Figure 5.8: location of the sections (source: own work)*

Current situation



▲ *Figure 5.9: current situation (source: own work)*

Section 1A

The first area is located near the mouth of the Eem River. Currently, the river is surrounded by many agricultural fields, which results in a large amount of nitrogen pollution in the river. Moreover, there are few green spaces in the nearby cities, which means that runoff is likely to carry pollution from the city into the water system.

Wet scenario

▼ *Figure 5.10: implemented interventions (source: own work)*

▲ *Figure 5.10: wet scenario (source: own work)*

Section 1B

In the future, we plan to convert the current agricultural areas into wetlands to protect the river. We have considered the wetlands' purpose in both dry and wet seasons. During the rainy season, the wetlands will serve as a means of reducing the runoff and storing rainwater. The wetland will also act as a green buffer for the Eem river, absorbing pollutants from nearby cities or agricultural land. As a result, the water system will have a greater chance of remaining healthy. For the cities nearby, certain technological innovations can be implemented. Firstly, the helophyte filter uses plants that thrive in wet environments to naturally remove contaminants from both the rainwater and daily sewage as it passes through the root zone. This process mimics natural wetland functions, which are excellent at filtering and purifying water. Secondly, a separate sewer system handles sewage and rainwater separately. This reduces wastewater volume, minimises sewage overflows, and is more effective for managing water resources (Soapbox, 2023). Thirdly, Aquaponics combines aquaculture and hydroponics to create a symbiotic environment where fish waste feeds plants and plants purify the water for fish (Vergeer, 2023).

	P.1	P.2	P.3	P.4	P.5	P.6
Phase out	A.1 ●	A.2 ●	A.3 ●	A.4 ●	A.5 ●	
Healthy water	B.1 ●	B.2 ●	B.3 ○	B.4 ●	B.5 ●	
Healthy landscape	C.1 ●	C.2 ●	C.3 ●	C.4 ○	C.5 ●	
Healthy habitats	D.1 ●	D.2 ●	D.3 ●	D.4 ●	D.5 ●	D.6 ○

▲ *Figuur 5.17: implemented policies (source: own work)*

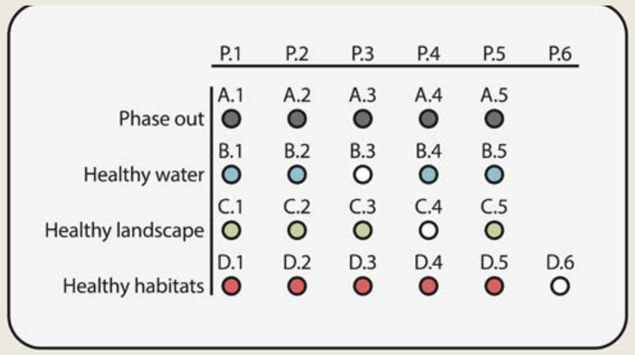
Dry scenario

▼ *Figure 5.10: implemented interventions (source: own work)*

▲ *Figure 5.11: dry scenario (source: own work)*

Section 1C

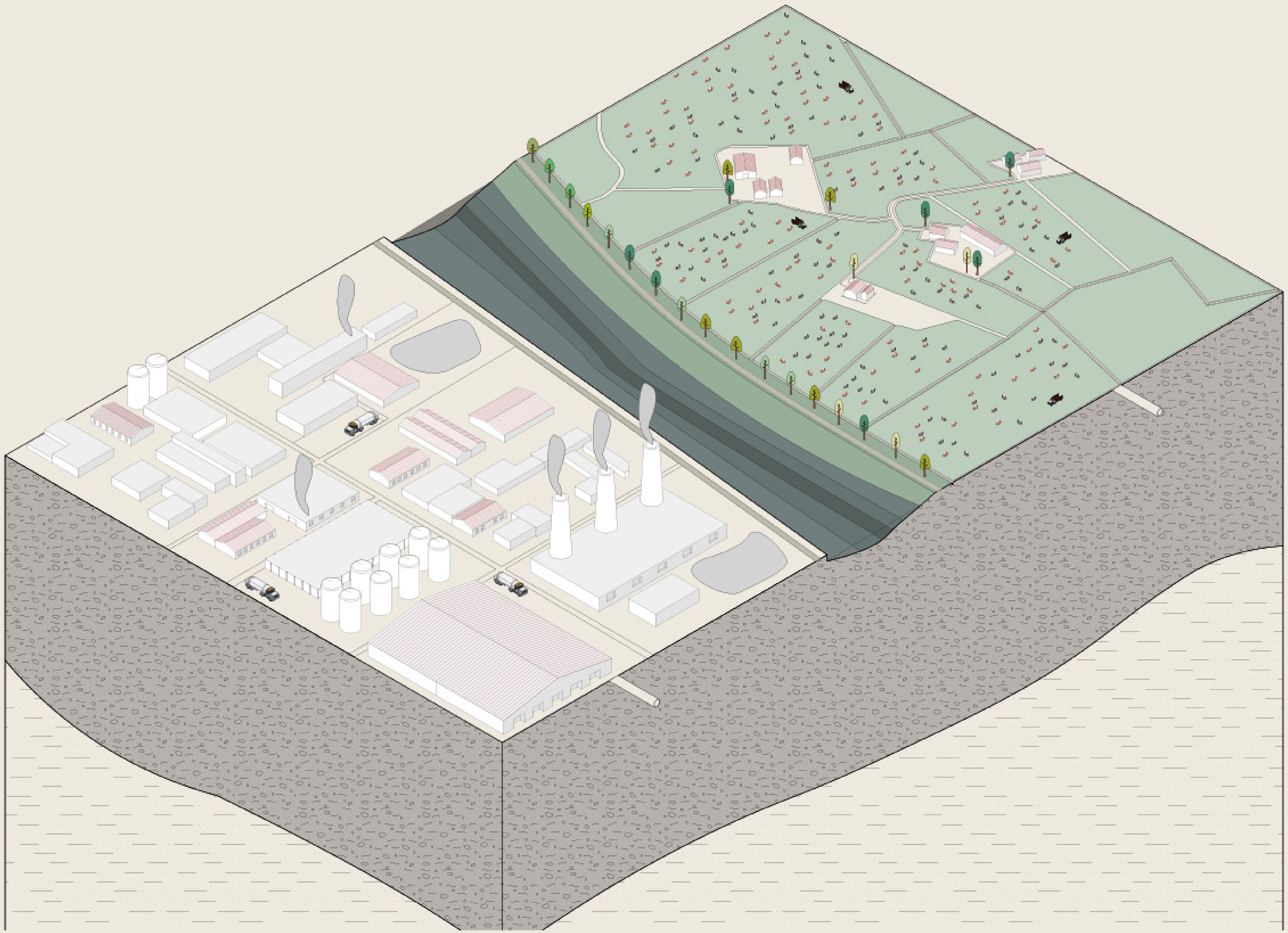
During the dry season, the wetland area will be used for grazing livestock. This controlled grazing will help to regulate the growth of vegetation, prevent overgrowth and reduce the water demand. This will make the land more permeable and reduce the chance of soil erosion. Additionally, grazing will help to maintain biodiversity and ecological functions along the Eem river. The excreta from the livestock can be used as a resource for compost, which can replace chemical fertilisers used in agricultural fields. To benefit the surrounding cities, green roofs will be implemented. These roofs will not only reduce runoff and store water but also help to mitigate the urban heat island effect.



▲ *Figuur 5.17: implemented policies (source: own work)*

▲ *Figure 5.12: impression wet and dry scenario (source: own work)*

Current situation



▲ *Figure 5.13: current situation (own work)*

Section 2A

In the second section, we will discuss an industrial and agricultural area that is located near the river Eem. Unfortunately, the proximity of industrial areas to rivers results in water contamination from various sources, including microplastics and chemical pollutants. On the north side of the river, there is an area of pastureland with low crop diversity.

Transforming industries

Figure 5.10: implemented interventions (source: own work)

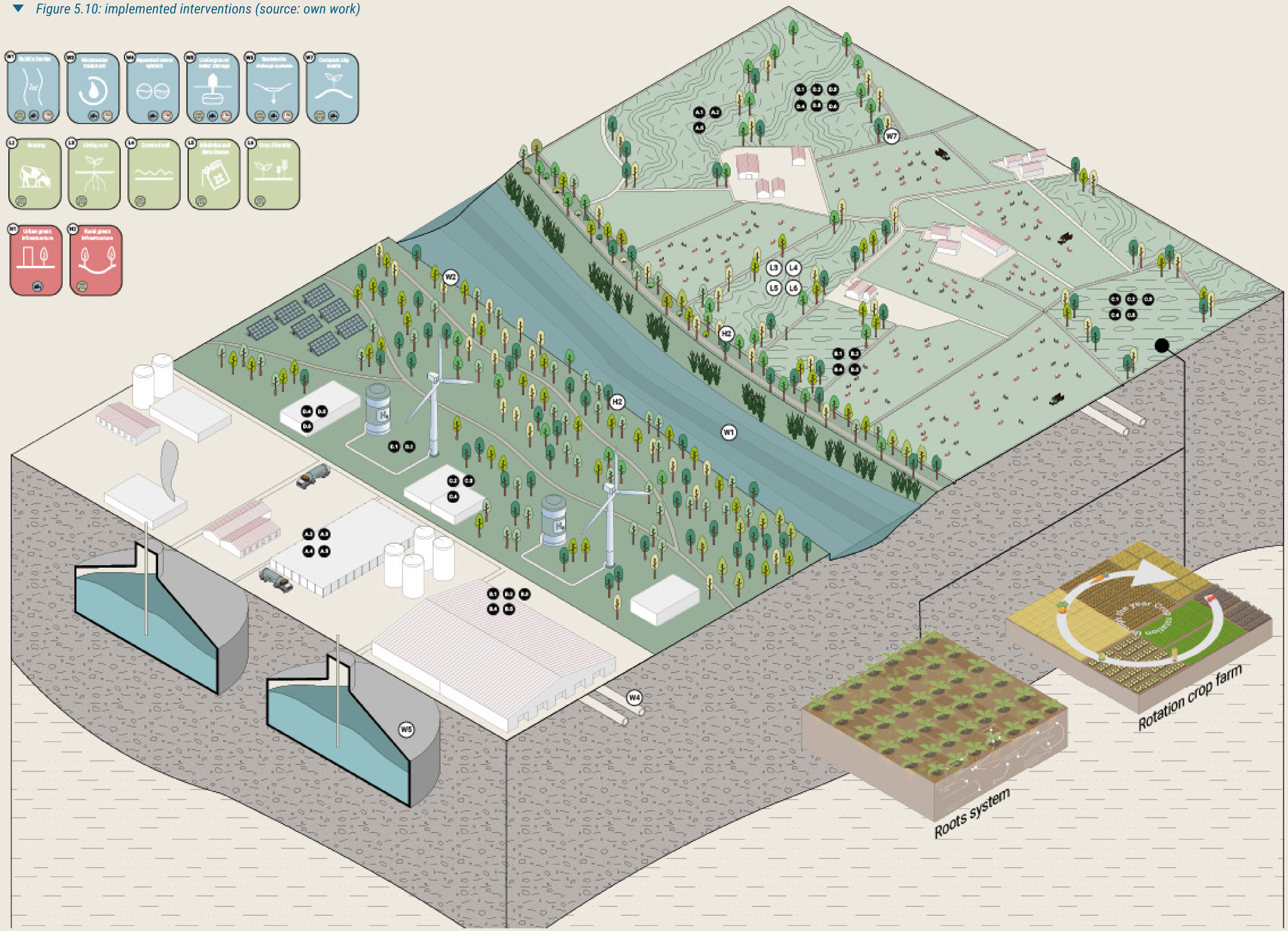


Figure 5.14: transforming industries (source: own work)

Section 2B

We have considered two future scenarios for this area: one where stakeholders are willing to change and another where they are not. In the scenario where stakeholders are not willing to change, we will focus on nature-based solutions rather than transforming industries into sustainable green industries. We plan to demolish a certain number of industries to create space for green buffers that can effectively absorb pollutants. The goal is to strike a balance between industrial activity and a healthy soil and water system.

Crop rotation will also play a significant role in preserving soil fertility and crop vitality. By rotating crops in a certain period, we can improve soil health, optimise the nutrients in the soil, and combat weed pressure. It also requires less use of pesticides because pests become less of a problem when there are different types of crops in a sequence. Pests are usually a significant problem when the same crop is grown every single year. By implementing crop rotation farming, the chance of settling pests is lower, creating a better environment for the soil, as there will be no more pesticides in the ground.

	P.1	P.2	P.3	P.4	P.5	P.6
Phase out	A.1	A.2	A.3	A.4	A.5	
Healthy water	B.1	B.2	B.3	B.4	B.5	
Healthy landscape	C.1	C.2	C.3	C.4	C.5	
Healthy habitats	D.1	D.2	D.3	D.4	D.5	D.6

Figuur 5.17: implemented policies (source: own work)

Sustainable industries

▼ *Figure 5.10: implemented interventions (source: own work)*

▲ *Figure 5.15: sustainable industries (source: own work)*

Section 2C

In the scenario where stakeholders are willing to change, we will transform the industries into environmentally sustainable green industries that harness renewable energy sources, such as wind power and emit significantly less pollution. We will establish green buffer zones along riverbanks to effectively absorb pollutants and diversify agricultural practices to enhance biodiversity and maintain a living root system.

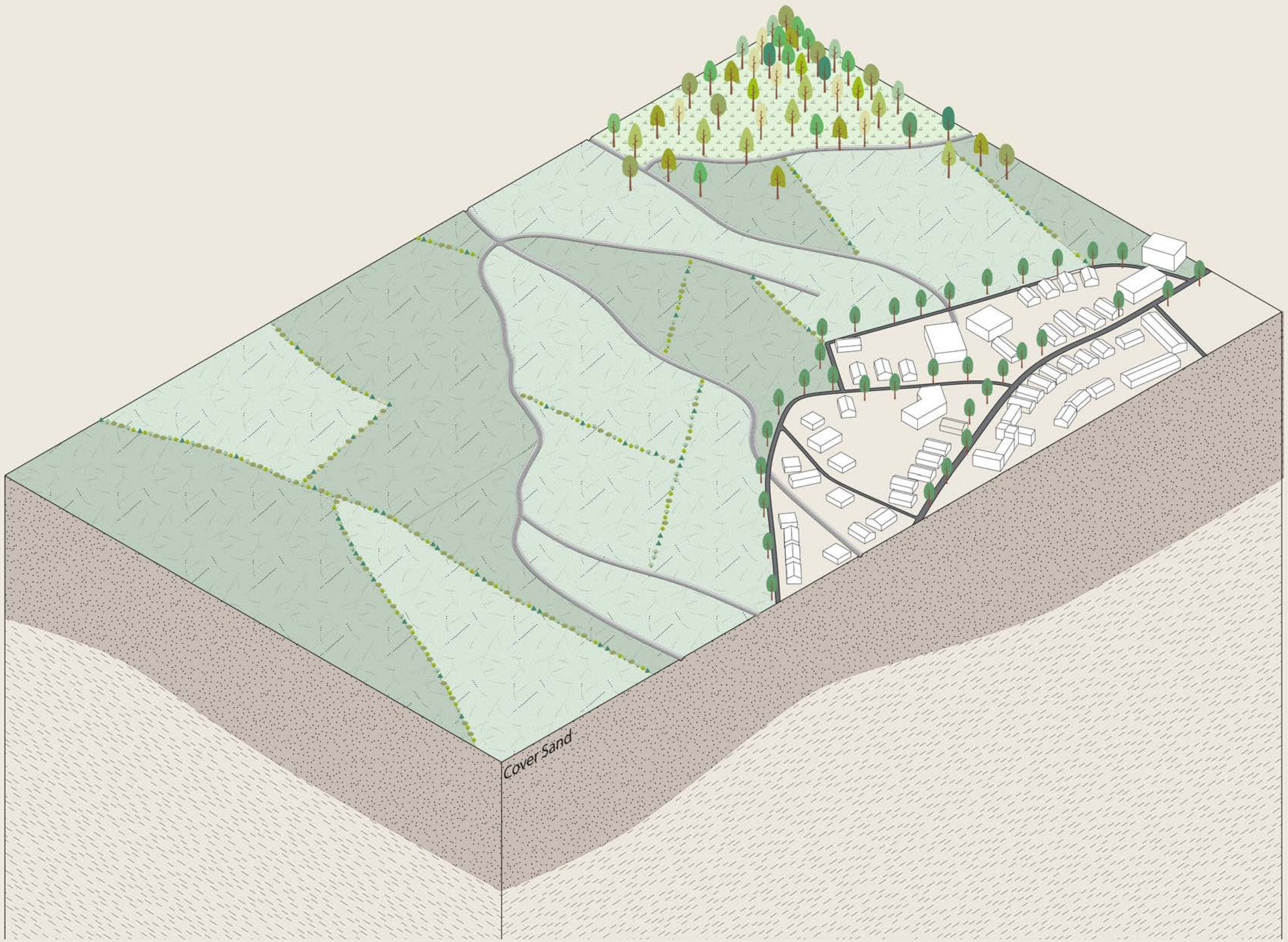
To achieve these goals, we will implement certain agricultural practices, such as a riparian buffer, which has benefits for the ecosystem, including filtering pesticides, nutrients, and chemicals from agriculture, industry, and urban areas. It also stabilises riverbanks and provides for wildlife. We will also maintain a living root system year-round, which focuses on improving soil quality. The living roots within the soil create an environment where it can retain nutrients and improve plant growth and microbe biodiversity.

	P.1	P.2	P.3	P.4	P.5	P.6
Phase out	A.1 ●	A.2 ●	A.3 ●	A.4 ●	A.5 ●	
Healthy water	B.1 ●	B.2 ●	B.3 ●	B.4 ●	B.5 ●	
Healthy landscape	C.1 ●	C.2 ●	C.3 ●	C.4 ○	C.5 ●	
Healthy habitats	D.1 ●	D.2 ●	D.3 ●	D.4 ●	D.5 ●	D.6 ○

▲ *Figuur 5.17: implemented policies (source: own work)*

▲ *Figure 5.16: impression sustainable industries (source: own work)*

Current situation



▲ *Figuur 5.17: current situation (source: own work)*

Section 3A

In the third section, we will discuss two areas - a nature area and an urban area - that are located near the river Eem. Unfortunately, the forest in this part of the Eem river is segmented by agricultural fields, which destroys the bio-connection and migration of animals. Additionally, there are small ditches in the area that carry runoff from agricultural practices and human activities from nearby villages into the river Eem.

The green connection

Figure 5.10: implemented interventions (source: own work)

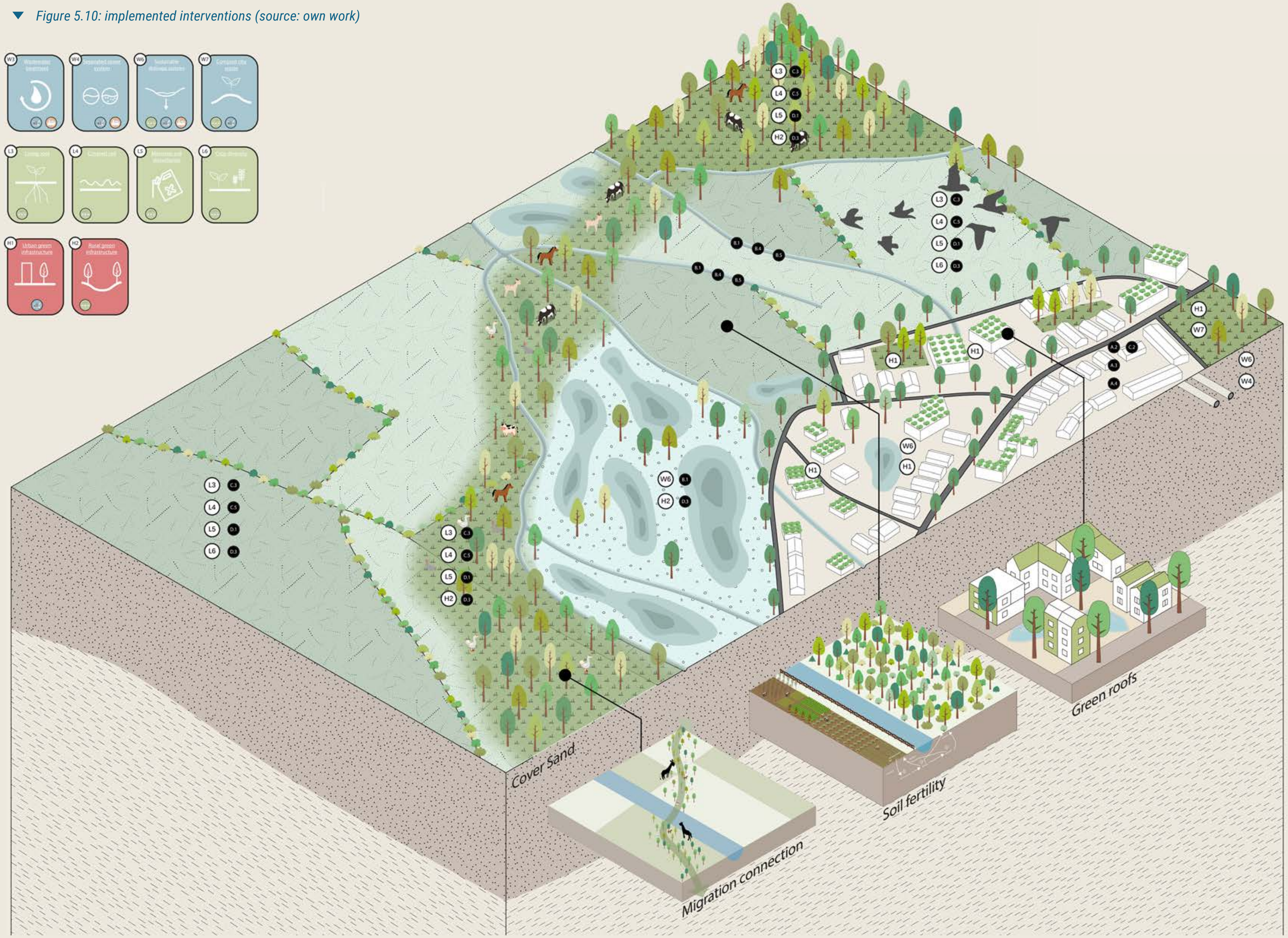


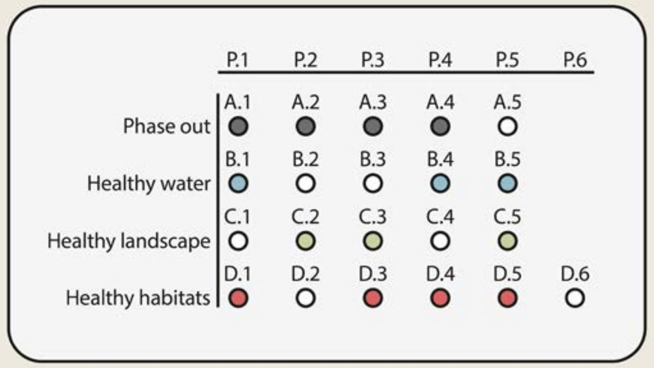
Figure 5.18: the green connection (source: own work)

Section 3B

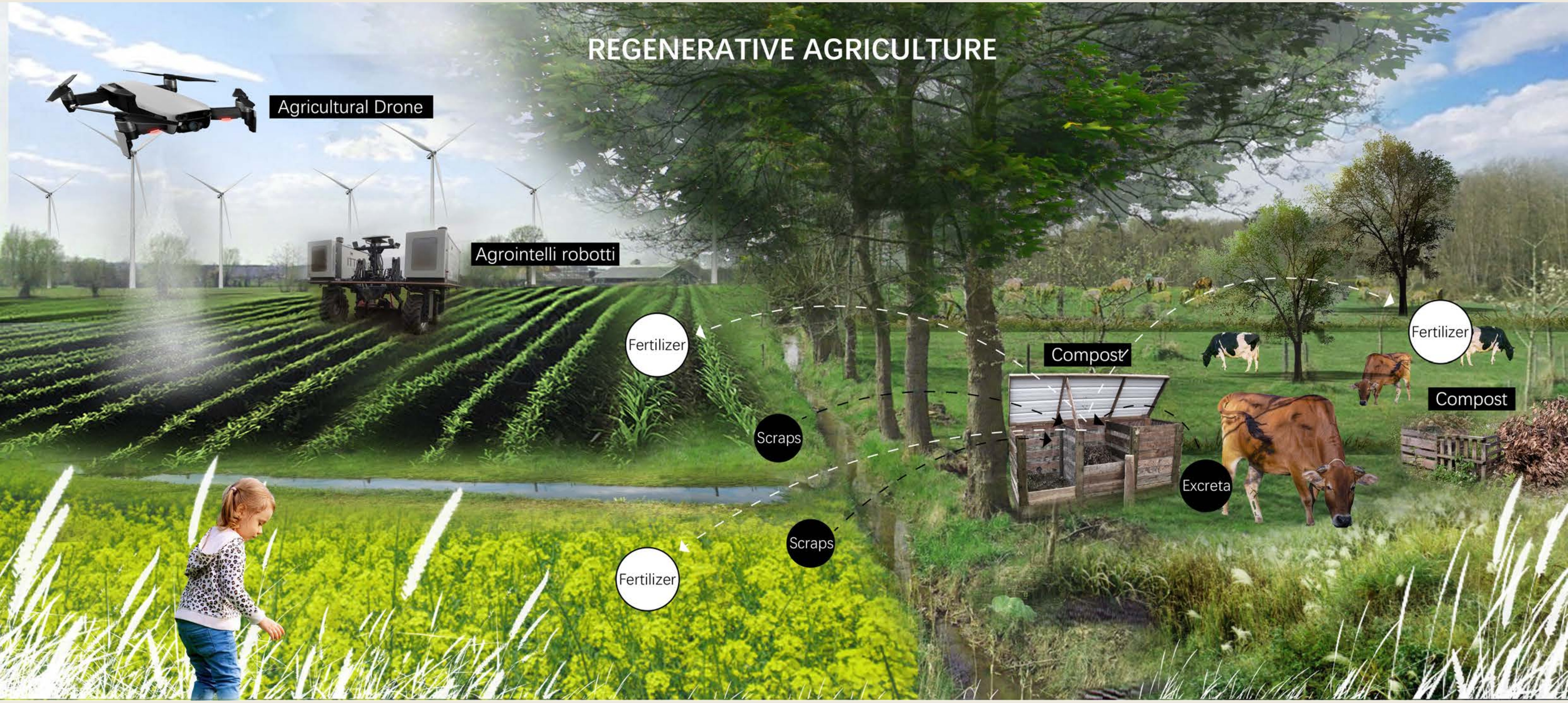
For this section, we have considered one future scenario to improve environmental health. We have established an ecological corridor linking fragmented forests which provides wildlife with an uninterrupted migratory path and diversifies agricultural practices. Furthermore, we have constructed a series of small wetlands around drainage areas that serve as a natural filtration system to prevent pollution.

In urban areas, green infrastructure such as green roofs and pocket parks are the main strategy to cut runoff and store water in the urban area. This absorption can filter pollutants that would otherwise enter water systems and helps manage stormwater. By mitigating runoff, green roofs play a role in protecting the quality of water in the surrounding environment.

In the agricultural and nature areas, we focus on improving soil fertility. Banning the use of fertilisers on agricultural land will restore the soil and create a new nutrient balance. Different bacteria in combination with plant growth are important for the balance of nitrogen. A balanced and fertile soil will keep nitrogen in the ground, instead of letting it escape via runoff or to the air. The soil will keep the nitrogen in the ground because of the different bacteria. When fertilisers are used, the soil cannot keep up with the nitrogen that is added to the ground, creating an unhealthy soil balance that causes problems for plant growth and quality.



Figuur 5.17: implemented policies (source: own work)



▲ *Figure 5.19: impression of the green connection (source: own work)*

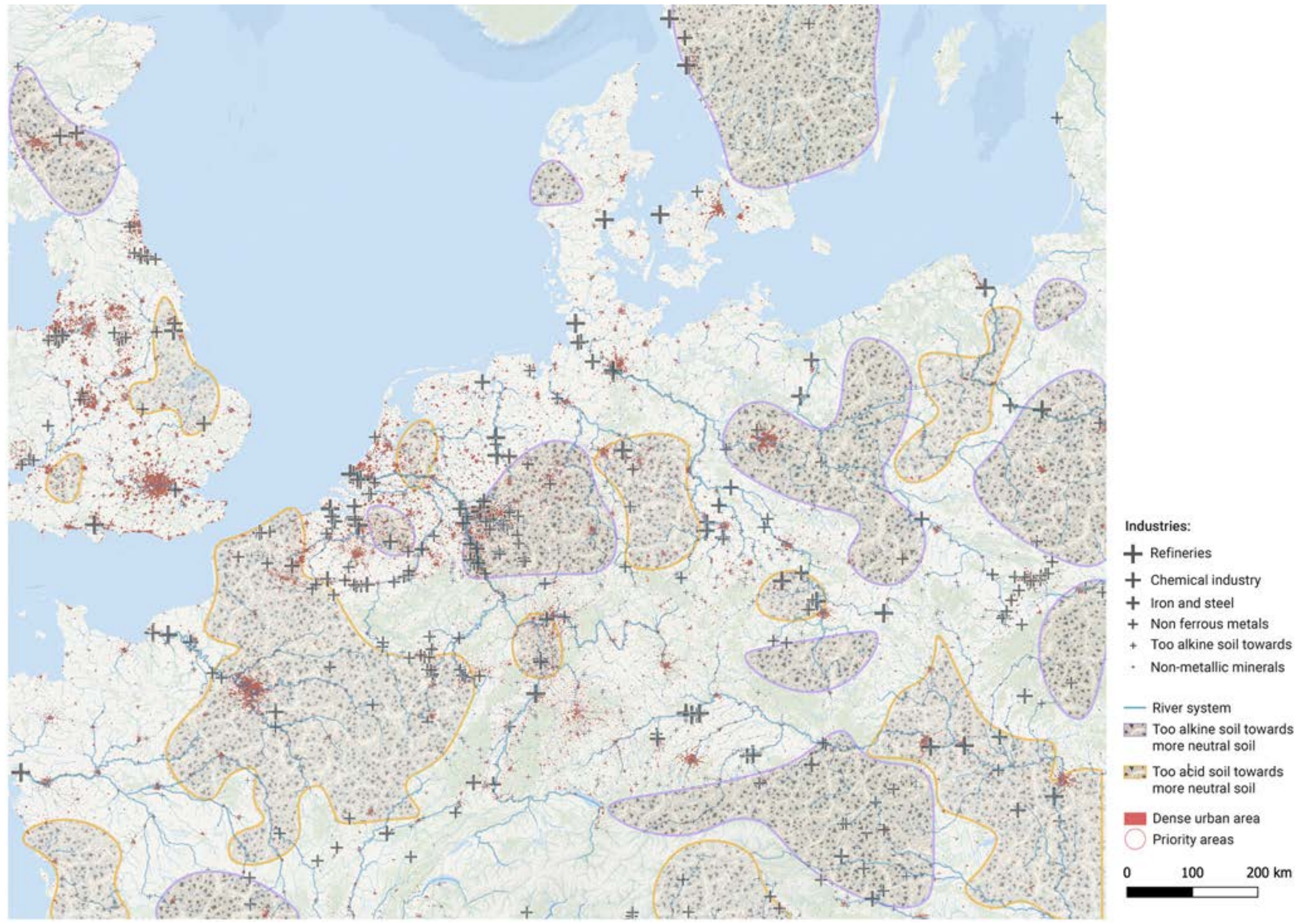
5.6 Europe urgencies maps

To create a toolbox that can be used to upscale policies and interventions implemented in the River Eem to other parts of the Euro Delta, we need to categorise the transferability of these interventions to certain programming areas. We use the categories of urban, industrial, and agricultural areas for this approach. For each policy and intervention, we clarify in which category it can be implemented. To understand the scope of the toolbox, we need to explain and analyse these categories. Each category is first analysed individually to determine where the urgency level for transforming water management is the highest.

To identify the most problematic areas regarding water pollution due to human activities, we mark dense urban areas in Europe. This gives an idea of where urban areas are clustered and where human activities are a significant source of water pollution. To identify priority areas regarding agriculture, we analyse the pH level of the soil. The map shows where the soil is too acidic or too alkaline. These areas should shift towards a more neutral soil. Too-acidic soil is mostly caused by excessive use of fertilisers, while too-alkaline soil is caused by a surplus of sodium carbonate, which can be caused by the weathering of soil minerals and by industrial and domestic applications that consist of sodium salts.

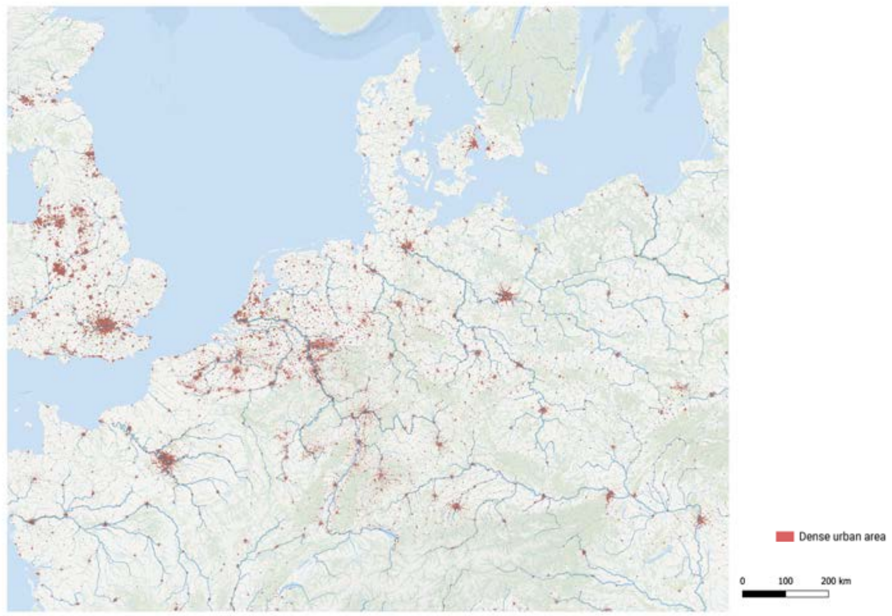
The last category is the industrial area. We differentiate between different industrial facilities, ranking them from the biggest polluter to the least polluter. Refineries and chemical industries are more polluting than paper and printing industries and industries with non-metallic minerals, for example. The map shows where industrial areas are clustered and the distribution of the most and least polluting industries. For instance, the Ruhr area in Germany, the Lotharingen region in France, and the Silesia region in Poland, as shown in figure 5.23, are areas where the iron and steel industry is prominent.

The combination of these three categories shows where polluting programming is clustered in Europe. This map serves as a framework for addressing future transformation areas, similar to the River Eem.

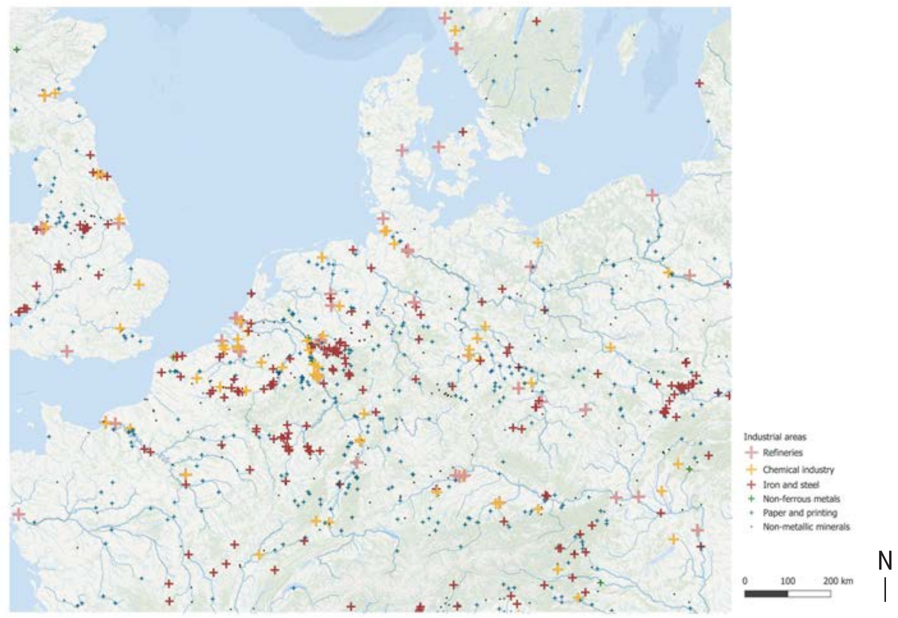


▲ *Figure 5.20: urgencies map (source: own work)*

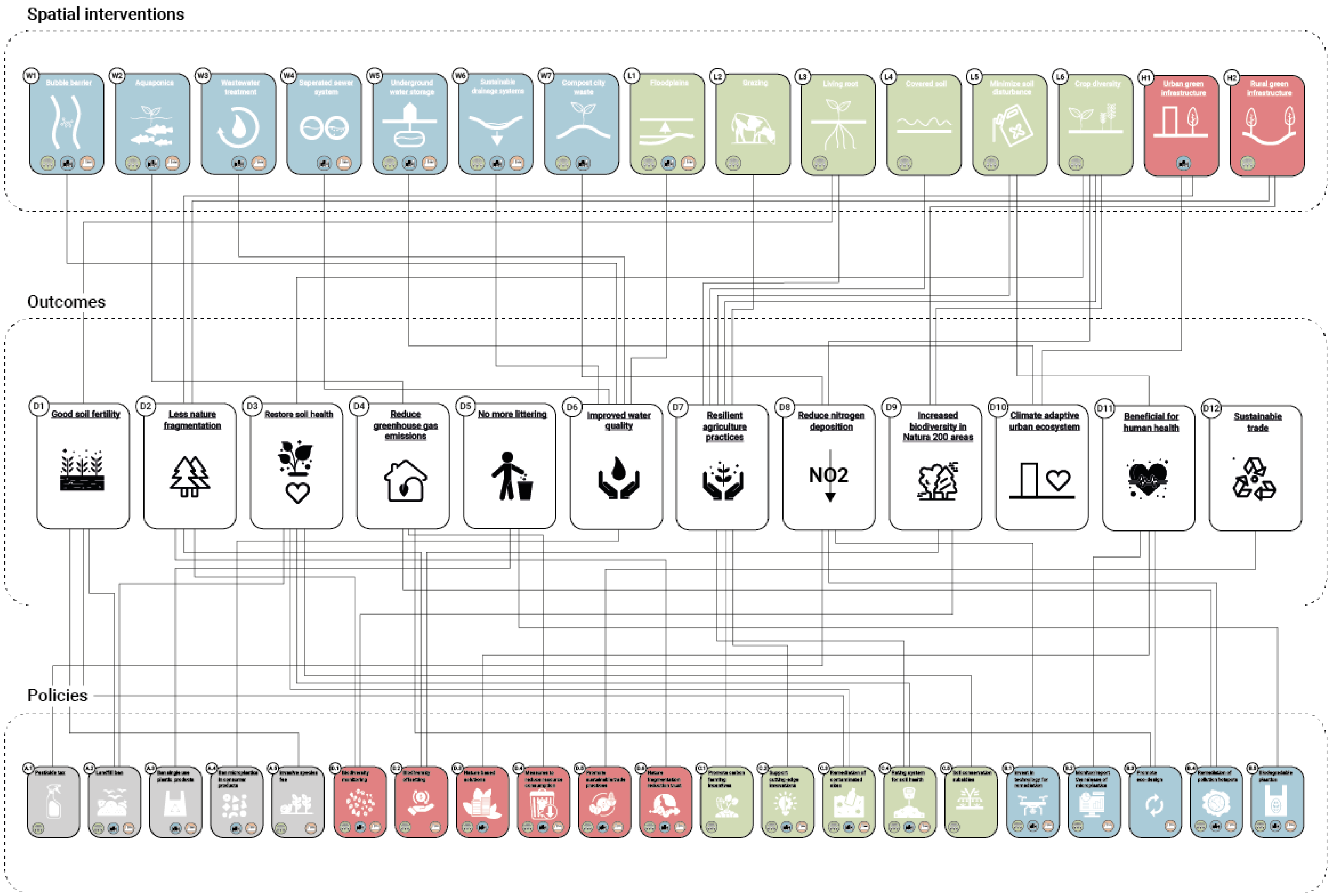
▲ *Figure 5.21: endangered soil (source: European Environment Agency, 2023)*



▲ *Figure 5.22: urban fabric (source: own work)*



▲ *Figure 5.23: industrial areas (source: European Environment Agency, 2018)*



▲ *Figure 5.24: toolbox (source: own work)*

5.7 Toolbox

After exploring all the policies and interventions in the Eurodelta, we have identified the priority areas by mapping the urgencies. Using the policies and interventions implemented on the river Eem, we have created a toolbox to guide decision-makers and urban planners in other regions of the Eurodelta. The toolbox contains both spatial interventions and policies with a direct link to specific outcomes of the project, such as social, environmental, economic, and health outcomes. This categorisation of outcomes serves as a framework for decision-makers to determine which interventions and policies to apply based on the outcomes they want to achieve. The model in the toolbox illustrates how certain policies and interventions can lead to specific environmental outcomes, highlighting the importance of a multifaceted approach to tackling complex challenges. The model provides professionals with a clear understanding of the outcome of each intervention and policy, which can be referred back to the problem statement. Ideally, the outcomes should serve as solutions to the stated problems.

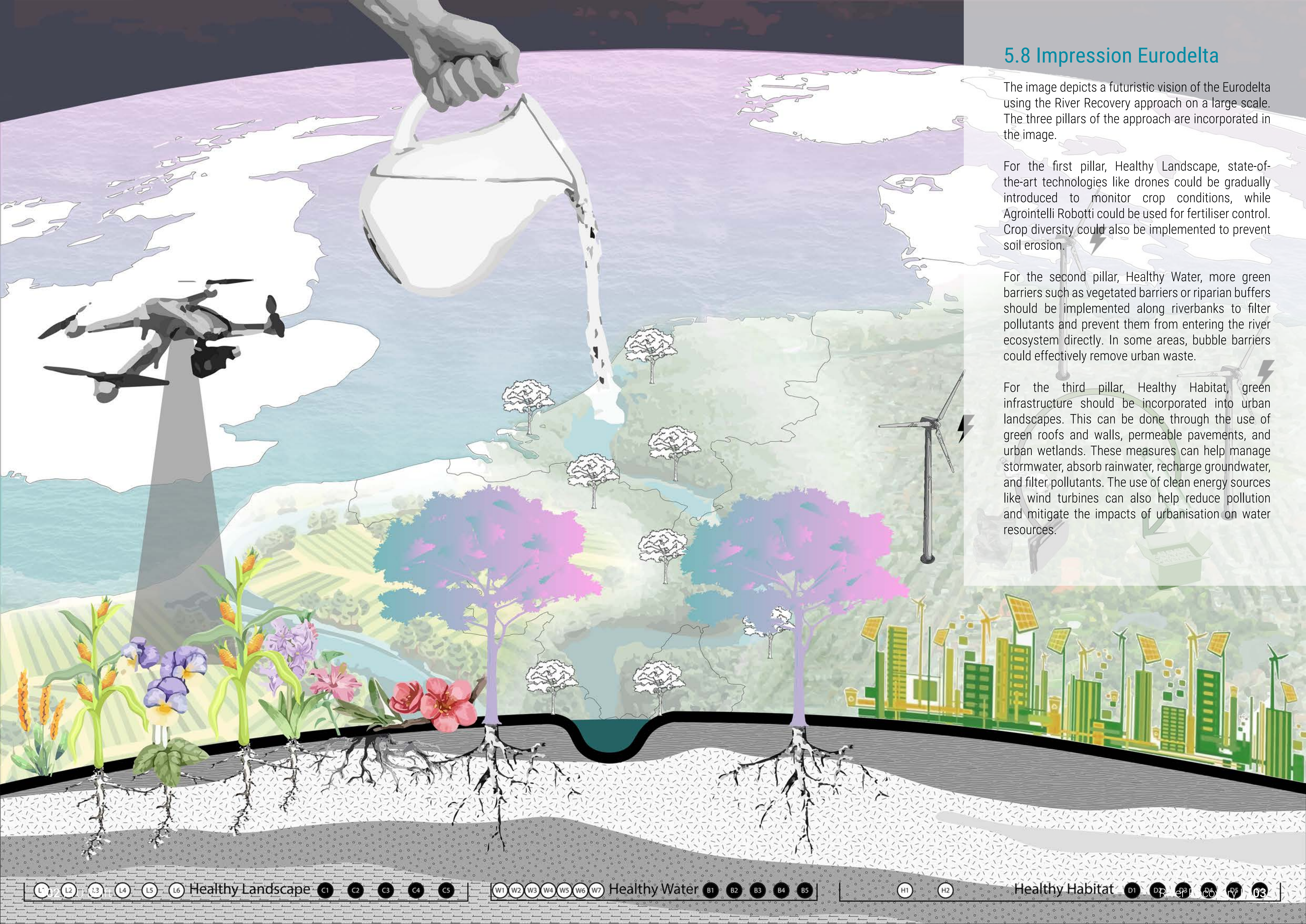
5.8 Impression Eurodelta

The image depicts a futuristic vision of the Eurodelta using the River Recovery approach on a large scale. The three pillars of the approach are incorporated in the image.

For the first pillar, Healthy Landscape, state-of-the-art technologies like drones could be gradually introduced to monitor crop conditions, while Agrointelli Robotti could be used for fertiliser control. Crop diversity could also be implemented to prevent soil erosion.

For the second pillar, Healthy Water, more green barriers such as vegetated barriers or riparian buffers should be implemented along riverbanks to filter pollutants and prevent them from entering the river ecosystem directly. In some areas, bubble barriers could effectively remove urban waste.

For the third pillar, Healthy Habitat, green infrastructure should be incorporated into urban landscapes. This can be done through the use of green roofs and walls, permeable pavements, and urban wetlands. These measures can help manage stormwater, absorb rainwater, recharge groundwater, and filter pollutants. The use of clean energy sources like wind turbines can also help reduce pollution and mitigate the impacts of urbanisation on water resources.



Conclusion & reflection

Panorama taken at mouth of the river Eem

6

Contents

Now that the research and vision are explained, and the strategy has been completed, it's time to answer the research question. This chapter will start with a short recap of the work we executed in the past weeks. Next is the conclusion, which answers the research question. To finalise this chapter we will look into the scientific and societal relevance of our research and design, followed by the ethical reflection.

6.1 Recap

At the start of the report, we introduced the main theme of our project: Water pollution. We explored the complexity of this multi-faceted issue by doing research into the sources, flows, and effects of water pollution. Besides, we analysed policy documents, including the UN's Sustainable Development Goals.

With the use of the theoretical framework, introduced in chapter two, we stated the research question: How can the transformation of the Eem Valley turn the river Eem into the healthiest river in Europe, serving as a pilot for the Eurodelta? Applying a research-by-design approach, the Eem Valley functions as a pilot.

In the analysis chapter, the three pillars, healthy water, healthy landscape, and healthy habitat were analysed on multiple scales. In chapter four, these analyses were used in the making of the spatial sub-vision maps. Combined, these sub-vision maps shaped the spatial vision for the Eem Valley in 2075.

To support the spatial vision, a strategy chapter followed. In this chapter, we worked towards a stakeholder analysis, a timeline and phasing plan, and a toolbox that can be used by designers, planners, and decision-makers for upscaling it in the Eurodelta.

6.2 Conclusion

Throughout this project, we aimed to answer the following research question: "How can the transformation of the Eem Valley turn the river Eem into the healthiest river in Europe, serving as a pilot for the Eurodelta?"

In order to transform the Eem Valley into a healthy river area, it is necessary to change the waste and pollution flows directed towards the river. To achieve this, it is essential to rethink both the practices and behaviour on industrial sites, farmland, and urban areas towards pollution and waste. Since multiple stakeholders are involved in this process, each with a different interest, attitude, and power, it is crucial to consider all these factors. These factors determine the policy application to either discourage old habits or stimulate stakeholders to invest in a more sustainable environment. To answer the research question, we will first look at each program individually.

For agricultural land, there should be a tax on pesticides and a fee on invasive species to discourage their use and promote biodiversity. Regenerative practices such as soil conservation subsidies, crop rotation farms, aquafarms, organic farms, and carbon farms must be encouraged. Certain cutting-edge technology including drones can also help to monitor the condition of crops and control the usage of fertiliser. In this case, the pollution coming from the agricultural sector will witness a great drop. Besides, interventions related to farmland transformation aim to improve soil health. This is crucial since topsoil depletion will occur by 2080 without intervention (Tickle & Harrell, 2020). Good soil health is also essential for farmers to continue their agricultural practices. This problem must be used as an incentive towards farmers.

For urban areas, interventions are focused on adding green infrastructure and changing human activities and habits. The use of chemical and microplastic-containing products, such as domestic or cleaning products, must be banned, and the use of biodegradable plastics and ecological products should be encouraged. Decision-makers have to count on eco-design and nature-based solutions.

Industries must reassess their waste and pollution management to minimise chemical and plastic waste and resource consumption. It is their responsibility to monitor the release of microplastics and implement interventions such as bubble barriers and wastewater treatment plants near industrial areas to improve water quality. By taking these measures, the chemical status of the water will benefit significantly.

Through the implementation of the interventions and policies outlined above in each program, the river Eem can gradually be transformed into the healthiest river in Europe. By targeting the biggest polluters, such as urban areas, industrial areas, and farmland, the project can have the greatest impact. By addressing each pollution source individually, a concise approach can be created that is beneficial to both stakeholders and the environment. Additionally, dividing the project into different programs makes it

easier to explore potential areas for implementing certain tools from the toolbox.
However, the challenge of pollution dynamics is quite complex because the sources of pollution are different in different locations. Additionally, the current interventions focus solely on the river Eem and need to be scaled up to the entire Eurodelta region. To achieve this, it is crucial to conduct area-specific research and explore the possibilities of contextualising these interventions. The Eem Valley serves as an excellent pilot for a healthy river ecosystem, as it allows for a comprehensive analysis of an entire river system, from its source to its mouth. Ideally, this approach should be implemented throughout the entire Euro Delta River system, leading to a significant improvement in the soil and water quality throughout Europe.

6.3 Scientific relevance

Our project focuses on water pollution, and we aim to contribute to this research field by adding our findings to the existing canon of projects related to this subject. However, our research had some limitations.

Although we tried to cover as many sources of pollution as possible, we received feedback during the midterm presentation that there were many other sources we could have included. For instance, drug-related waste due to illegal dumping has a significant impact on nature and biodiversity in some parts of the Netherlands, but we did not consider it in our research. Therefore, it would be useful to map more types of pollution sources to obtain a more comprehensive and overarching vision. Regarding heavy metal pollution, we have limited our implementation of solutions because the Netherlands has fewer mines compared to other countries in the Eurodelta. However, heavy metal pollution significantly damages water quality.

The confined knowledge of microplastics makes for limited interventions in our vision. Once more is known about the subject, we recommend an upgrade of the vision.

Another limitation in our research is related to our research-by-design approach. By using the river Eem as a pilot for the Eurodelta, we unintentionally assume that this river is comparable to all the rivers in the Eurodelta. Although we differentiated between contextualised and general solutions, we have not conducted enough research to prove that these solutions will indisputably work in another context. Therefore, preliminary research will be necessary before implementation in another river.

In addition to this, the research-by-design approach has resulted in us focusing on interventions applicable to the river Eem. This means that general solutions that didn't make sense for the river Eem, were not included in the toolbox, even if they could be great solutions in other rivers. We recommend future designers look beyond our toolbox and conduct further research on other rivers in the Eurodelta.

6.4 Societal relevance

Water pollution is a pressing theme on the regional, and national scale. The abundance of presence in multiple policy documents proves the urgency of the theme in today's society. Access to water is a fundamental human right and it concerns everyone. Climate change causes problems related to both the quality and quantity of water. The water shortages and surpluses that are caused by climate change, have a big impact on human activities. This strategy also includes adaptations in the land use so it retains more water.

Although, the challenges of water are even more complex than we mostly elaborated on in this report. For instance, this project didn't take into account the accessibility to water and what the social impacts of this aspect are. We think that the water system can serve as a spatial backbone for vision making. In our opinion, water is connecting people and creates communities, which could inspire the strategy and serves as an incentive for convincing stakeholders.
Looking back on the SDGs, we included all the relevant SDGs in our vision from the start. Our vision, therefore, is a stepping stone towards a sustainable future.

However, this requires major societal and behavioural changes to accomplish these sustainable development goals. SDG 12.2 and 12.5 acknowledge the importance of responsible consumption and production. Although responsible production can be directed through a spatial vision and policy-making, these cannot bring about inner behavioural change towards responsible consumption.

6.5 Ethical reflection

The combination of research and design is meant to convince and engage relevant stakeholders. Through the stakeholder analysis, we looked into the engagement management of stakeholders leading to a comprehensive timeline.

However, in retrospect, we could have focused more on the people aspect. Our project now focused a lot on the ecological and environmental aspects, and less on the social aspect. In the end, the people and smaller communities within the region are the pioneers who kickstart the transition towards a sustainable future. Somewhere you have to find people who dare to take a leap and test out innovative, experimental, and regenerative agricultural practices. Supporting these initiators of change financially as well as with knowledge is essential to a successful outcome.

In our stakeholder analysis, we tended to emphasise large-scale organisations and institutions. They have the most power and are needed to anchor the vision in the face of creating a robust sustainable future and long-term perseverance. These organisations are also vital to upscale the vision towards the Eurodelta. Therefore, we would recommend future designers and planners who will use our toolbox to look for local agents of change who are willing to kickstart the transition in their region.

7

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Panorama taken at the brooks

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8

Appendix

Panorama taken at the brooks

Contents

8.1 Individual reflections

Yilin Yang

In quarter 3, we focus on a large-scale environmental planning which I seldom engaged in China. This group project provides me a lot of knowledge of water, and it also brings me a new experience on collaboration which is totally different from the group work in my bachelor.

In our project, we specifically investigate water pollution in the Emm River. During our excursion, what impressed me the most was the water testing experiment. To visually demonstrate the issue of river water pollution, we purchased some test strips before conducting our research. We tested different locations along the Eem river, and although the water appeared the same in each part, the chemical composition varied greatly across different sections of the river. Those conclusions can never be reached if we had relied solely on visual observations.

The research on water pollution is very complex, because various types of factors may affect the water quality including policies, human activities and ecological situations. In order to make our project become more structural, we classified the pollution into four types; in this way, we were able to know the source of pollution clearly. Mapping is also an indispensable method to show how rivers are polluted. For example, when we put the nitrogen pollution map, biodiversity map and land use map in GIS, we reached the conclusion that agriculture and transport is one of the main sources of nitrogen pollution and nitrogen pollution also cause damage to the biodiversity.

The role of a vision in our planning and design proposal was also essential. We developed three pillars to describe our future vision. This gives us a clear direction to create strategies for the Eem River. The strategy part is also quite interesting for me in that I also learn some new methods to reduce the pollution like the bubble barriers which are rare to see in China.

Collaborating as a team this quarter presented both obstacles and opportunities. We found that by leveraging each other's strengths, we were able to seamlessly blend our skills together. Take, for instance, my personal challenges with analysis on policies and writing report. I compensated for this by contributing illustrations to enhance our report layouts, thus ensuring the completion of everyone's tasks.

Some of the workshops are also very attractive for me. In this semester, the "R" studio taught me a way to grasp information from websites and articles. Compared with manual retrieval, programming saves a large amount of time for more important work. However, I believe that this workshop should take place before the mid-term presentation, so we can use this method to do the previous research practically.

Tejon Kraan

The main topic of our research and design is water pollution. I was personally very impressed by the amount of research we have accomplished on this topic during the course. I learned quickly that, in comparison to the research done during the analysis phase of urban and public space design, regional design relies more heavily on facts and figures; objective research and analyses through geodata, for example, have been a big part of the research we conducted.

Research into policy documents has also been of great help; long-term societal trends, which are expressed in policy documents of governmental institutions on regional, national, and international levels, are at the core of regional design. In a way this is not surprising to me; these institutions are tasked with ensuring a desirable future for us and generations to come by laying the foundations for the essential long-term transitions ahead of us. To do extensive policy document analyses helped us set our goals for the spatial vision.

By evaluating the policy documents, we started to understand where the probable future will lead us. Furthermore, by challenging these goals we could push the boundaries of what was plausible and possible to look beyond the probable future. This was especially handy when the research pointed to a disastrous probable future. To give an example related to our project: By 2080, the world's remaining topsoil will be completely gone if we do not change our agricultural practices (Tickle & Harrell, 2020). With less than 60 harvests left without a spatial vision to guide the transition, this illustrates the immense urgency of redirecting the probable future towards a new, more sustainable, possible future that is more desirable.

The vision is a spatial expression reacting to observed development trends and commonly shared norms derived from the research we did. Making the Eem valley in the Netherlands a pilot for the Eurodelta, allowed us to use a research-by-design approach. This enabled the creation of a spatial vision that could be more detailed about specific interventions and the local implementation requirements thereof. By evaluating the transferability of each intervention, we were able to put together our toolbox that can be used in other river regions all over the Eurodelta, which is an indispensable part of the development strategy.

For the first time, through this project, I got to think about what is needed to actually realise a vision. The transition needed to accomplish the vision impacts many groups of people turning spatial planning into a collaborative effort: governance over government. Initially, we had some clusters of stakeholders with a negative attitude towards the vision. By engaging these stakeholders in our strategy, we were able to let them be agents of change and bring about the transition towards a desirable sustainable future for everyone. In an iterative process, the vision shaped the stakeholders, and the stakeholders shaped the vision.

Eva Egelmeers

As urban planners and designers, how can we encourage a shift towards a more sustainable society? This is what the course was all about for me. Regional design is about changing complex systems, which often involves political, behavioural, and systematic change. Despite the complexity, I found the course inspiring. It was great to have the freedom to choose the topic of research and discuss it with my teammates. Although it was overwhelming at times to have to know a little bit of everything, I was mostly inspired by it.

Initially, I focused heavily on researching water pollution, but I soon realized that our practice is about spatializing complex solutions and processes. By addressing issues in a specific location, they become more understandable. As a group, we utilized a research-by-design approach, which worked well with the topic of research. During the strategy phase, we focused on how to graphically visualize the "how are we going to intervene" to make the complex and broad topic more simplified. By assigning a pilot project, we were able to dive into depth within a specific area. Then, we had to generalize the specific interventions and zoom out again to focus on the "what are the outcomes". This approach allowed for circular reasoning, as we started by stating the problems and ended by stating the outcomes that would fix them.

Access to water is a fundamental human right. In the Netherlands, water has been a secure resource for a long time. However, due to climate change, the situation has changed. Water quality is being affected by pollution, and climate change is also making it harder to access water. Recent news reports indicate that there is not enough drinking water for new housing developments in Amersfoort and the surrounding areas, as well as new construction sites around Enschede and Hengelo (Van Der Boon & Gras, 2024). This makes the already complex challenge of water management even more difficult. Both the quality and quantity of water are becoming bigger problems day by day. As a result, we need to focus on the combination of these two challenges. There are still countless research opportunities to use surface water as drinking water. Additionally, greater efforts are required to achieve self-sufficiency, especially in the field of drinking water supply.

Our project started with the book "Drinkable Rivers" by Li An Phoa. This book made us dream big in the beginning, but then we narrowed it down to focus on specific areas and became more concise. Now I have a better understanding of the possibilities and the vast research field that still needs to be explored, I understand that the issues of water pollution and scarcity are exacerbating each other. In the end, it might not be so outrageous to dream of drinkable rivers. To end with a thought-provoking question: would people become more mindful of water if it became a luxury?

Nathan van Beem

Research has been a constant source of design considerations within the project. This can be seen from the solid foundation laid with the research into the various streams (nutrient, chemical, heavy metals and plastic) that pollute a river. The research into these streams of pollution was done in the first few weeks and guided the drafting of the vision and strategy, among other things, throughout the project. I also noticed that the intensity of research in regional design is many times higher than in public space design.

Drawing up the vision helped me to look in broad lines at possible solutions for the problems on the scale of the Eem Valley. It also helped to orientate the strategy on three locations, where we were able to make the solutions concrete. These solutions can only be validated by placing them in the larger perspective of the vision. Thus, the vision is not only an important source for the strategy, but also a framework within which the strategy can be placed. Moreover, the vision helped us identify stakeholders, who are then heard in a tactical way in the strategy.

Inside our project, we strongly weighed a research-by-design approach against a systematic approach. During the process, we found out that a research-by-design approach fits our research better. This is partly because scaling up the strategy to the Eurodelta requires too much additional research for a systematic approach. Unfortunately, there was not enough time for such an approach within the available time frame of this quarter. Now that it has received my attention, I would like to experiment more with a systematic approach during my graduation project next year.

The conceptual framework helped us a lot to map out the approach to our research and guide us throughout the project. I have never applied this before, which highlighted the importance of a conceptual framework. Without such a framework, you can get lost in the methodology and approach to research.

Finally, the project deepened my appreciation for the diversity of skills and perspectives within a team; I learned that each member can make a unique contribution. Within our group, we tried to empower everyone. In the beginning, this brought complications, while later in the group process, it happened very naturally. In addition, I realised how important it is not to avoid conflicts, but rather to address them in a constructive way to improve group dynamics.

Maaike Dijkstra

During the first few weeks of the project, I learned that there was a lot of knowledge missing before we could start designing. This has to do with the difficulty of our subject, pollution in the river. By doing research and trying to understand the meaning of the different polluters you slowly begin to understand the different processes and it gave the chance to make arguments and changes to these processes. By discussing the problems and the research, we began to understand the subject and started to form a vision. If we missed information or thought that we needed more maps to make the vision stronger, we started to gather more information and maps. When I look back at the information we gathered, I think we found a lot but there is still a knowledge gap because the subject is so broad. There is still a lot I don't know about what makes a good phasing or how you can solve the problems with microplastics and nitrogen.

The SDS course was helpful during the design course. At the beginning of the course, we already needed to make a flow section of the different flows connected to our subject. These flow sections were very useful in understanding nitrogen, plastic and chemical pollution. For me, this made the subject much more comprehensive and understandable. In addition, the research for instance on the x-curve and figuring out what should happen when, gives you a better grip on telling the story in a logical order. Some interventions can only happen after the policies are made or can only happen when the stakeholders approve of these interventions.

Starting the design process (making the vision and sections), gave us new ideas and input on information we needed to gather. There is a balance between research and design. Designing gave me more clarity on the gathered information and explains how to implement different outcomes in a specific location. This project made me realise that research can be a really important factor for the design and can make the design better.

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Water test results

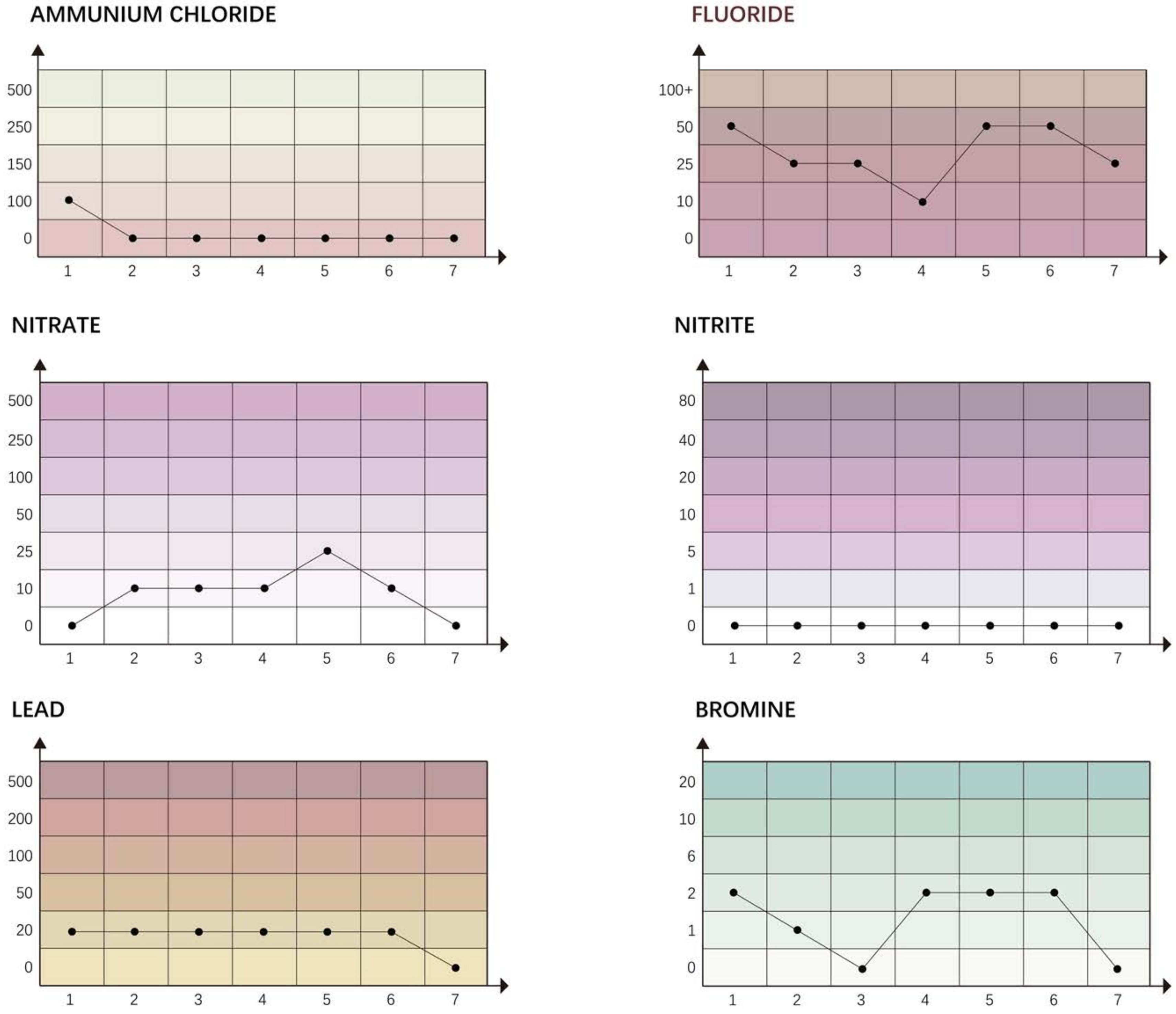


Figure 8.1: water test results (own work)

CHASE contamination

▲ *Figure 8.2: CHASE contamination of seas (source: European Environment Agency, 2018)*

Items of litter

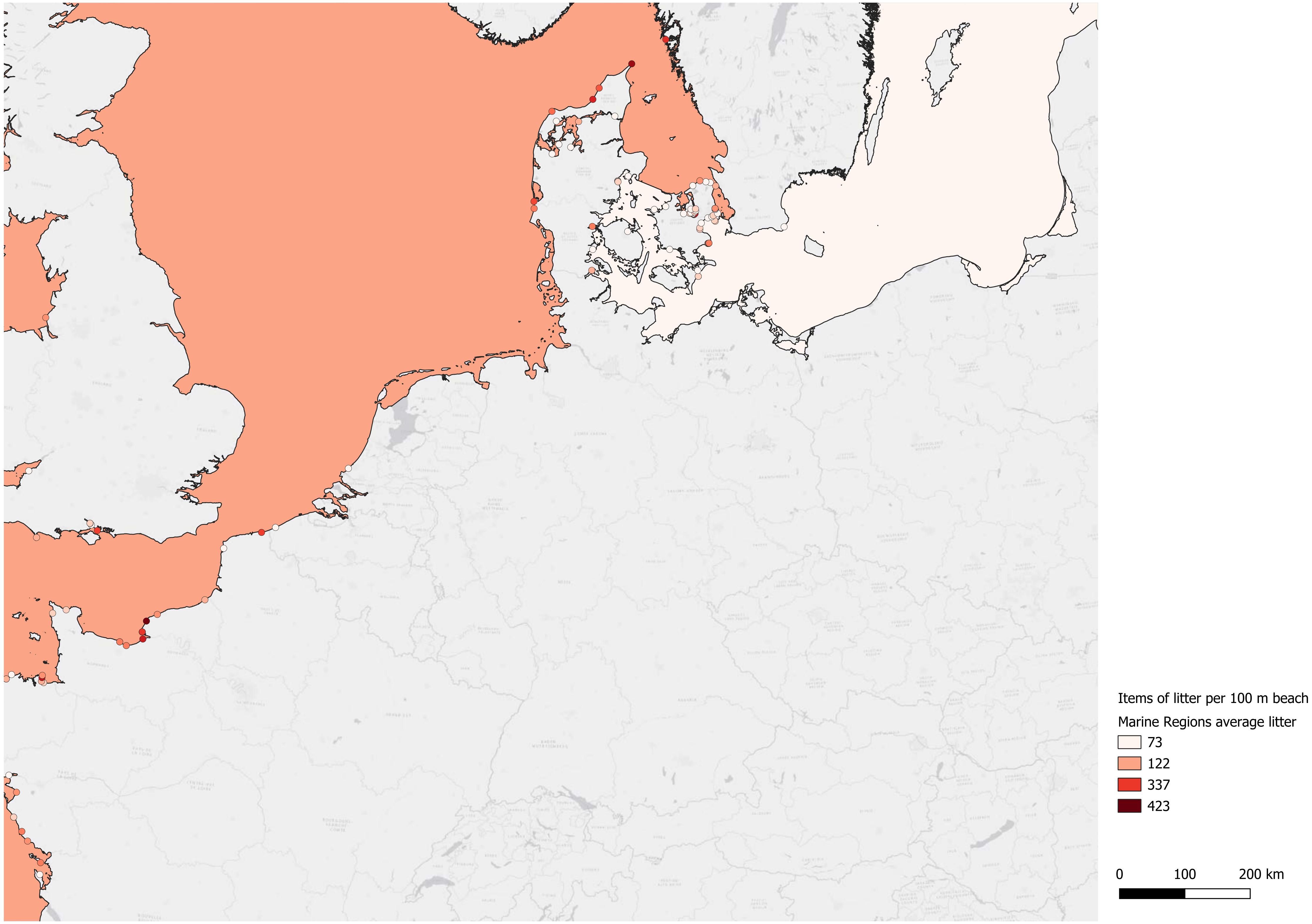


Figure 8.3: litter per 100m beach (source: European Environmental Agency, 2022)

SWOT healthy water	**Strength:** Grebbelinie= natural geography allows for water plains	**Weakness:** "Garbagelinie" of industrial and urban waste
Opportunity: Innovative technological and natural water purification methods	Further develop a natural water purification system on the Grebbelinie plains using waterplants	Neutralize the "garbagelinie" by improving the RWZI's so that the effluent is less polluted
Threat: Increase in (direct) waste dumps in river due to population growth	Implement anti-waste dump policies: make the grebbelinie into a protected natural reserve	Eliminate direct river dumps by implementing seperated sewer systems

Figure 8.4: SWOT analysis healthy water (source: own work)

SWOT healthy landscape	**Strength:** Region is part of the food valley = top region in agrifood	**Weakness:** Monocultural agriculture disrupts and negatively effects the ecology of the Eem valley
Opportunity: New forms of regenerative agriculture	Strengthening the agricultural landscape by implementing regenerative agricultural practices	Implement regenerative agriculture to reverse negative effects of monoculture
Threat: Desertification = soil turns to dust (deadline 2080)	Protect food security in the future by recharacterising local food hubs	Eliminate desertification by making the agriculture part of the ecological back bone of the region

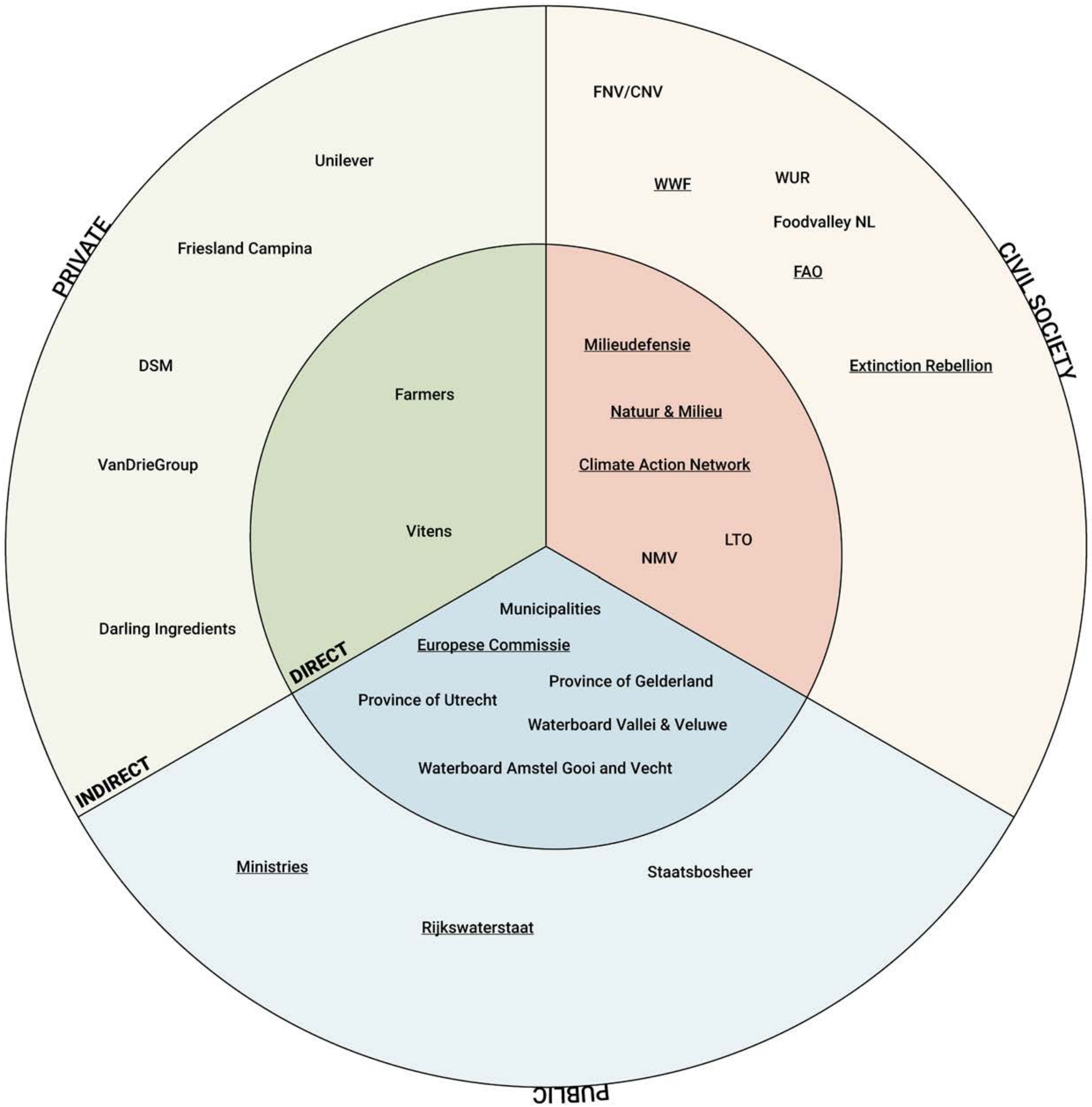
Figure 8.5: SWOT analysis healthy landscape (source: own work)

SWOT pillars

These SWOT analysis were made as a starting point for the vision map for each pillar.

SWOT healthy habitat	**Strength:** Surrounded by valuable protected nature reserves	**Weakness:** The rivers and brooks do not support or connect the nature reserves well
Opportunity: Trend towards increase of eco-connectivity in europe	Expand the nature reserves by using the brooks and river within the Eem valley	Strengthen the ecological value along the river and brooks
Threat: Overregulation of the nature reserve wil reduce the biodiversity	Protect the nature reserves by rewilding these reserves: stopping overregulations	Eliminate biodiversity loss in the Eemvalley by reconnecting biospheres

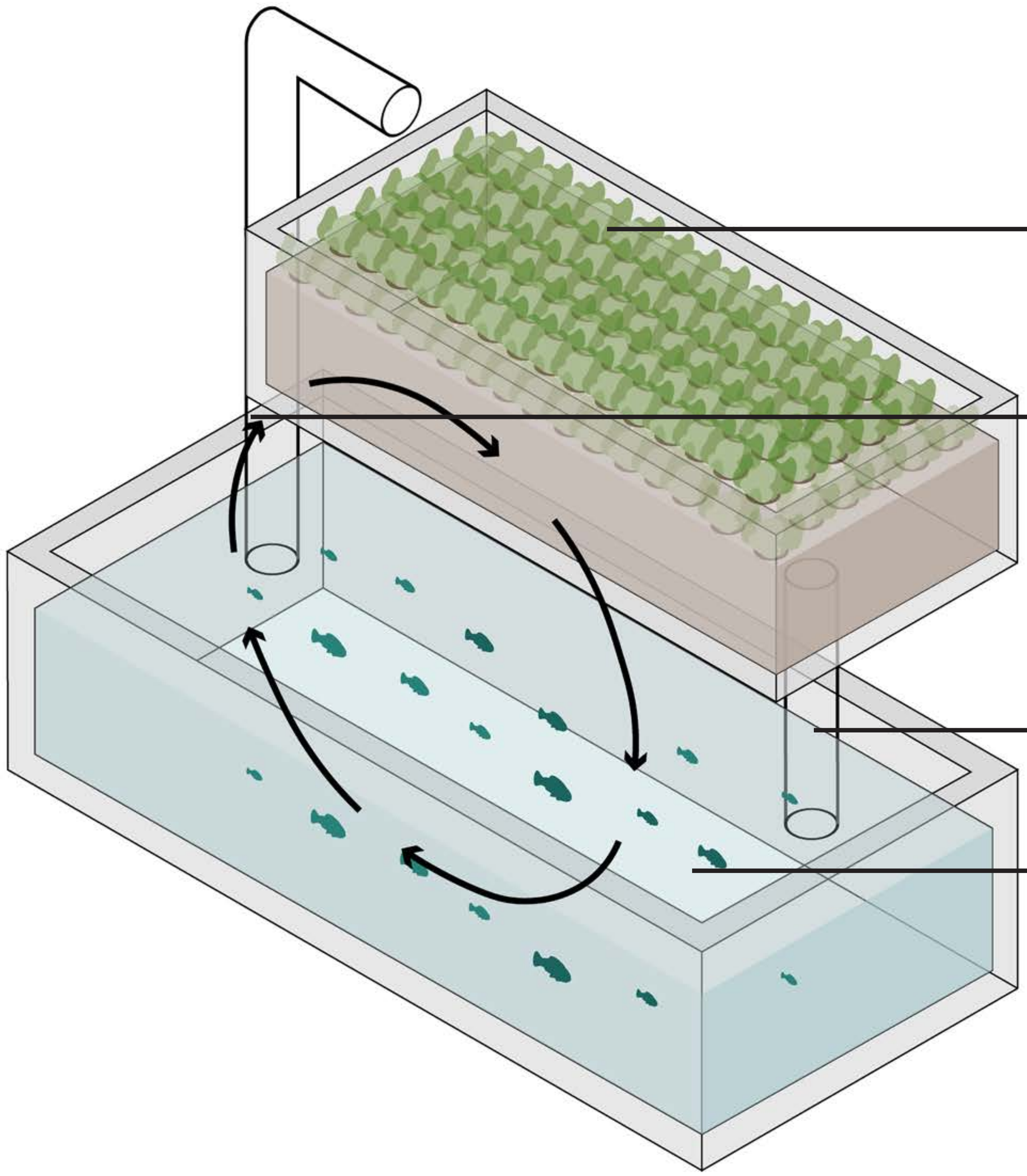
Figure 8.6: SWOT analysis healthy habitat (source: own work)



▲ *Figure 8.7: stakeholder analysis direct and indirect relation (source: own work)*

Stakeholders

This diagram shows the indirect and the direct relation between the Eem Valley and the stakeholders. For instance, the Dutch ministries are a stakeholder in the process of river recovery but are not directly involved in the Eem.



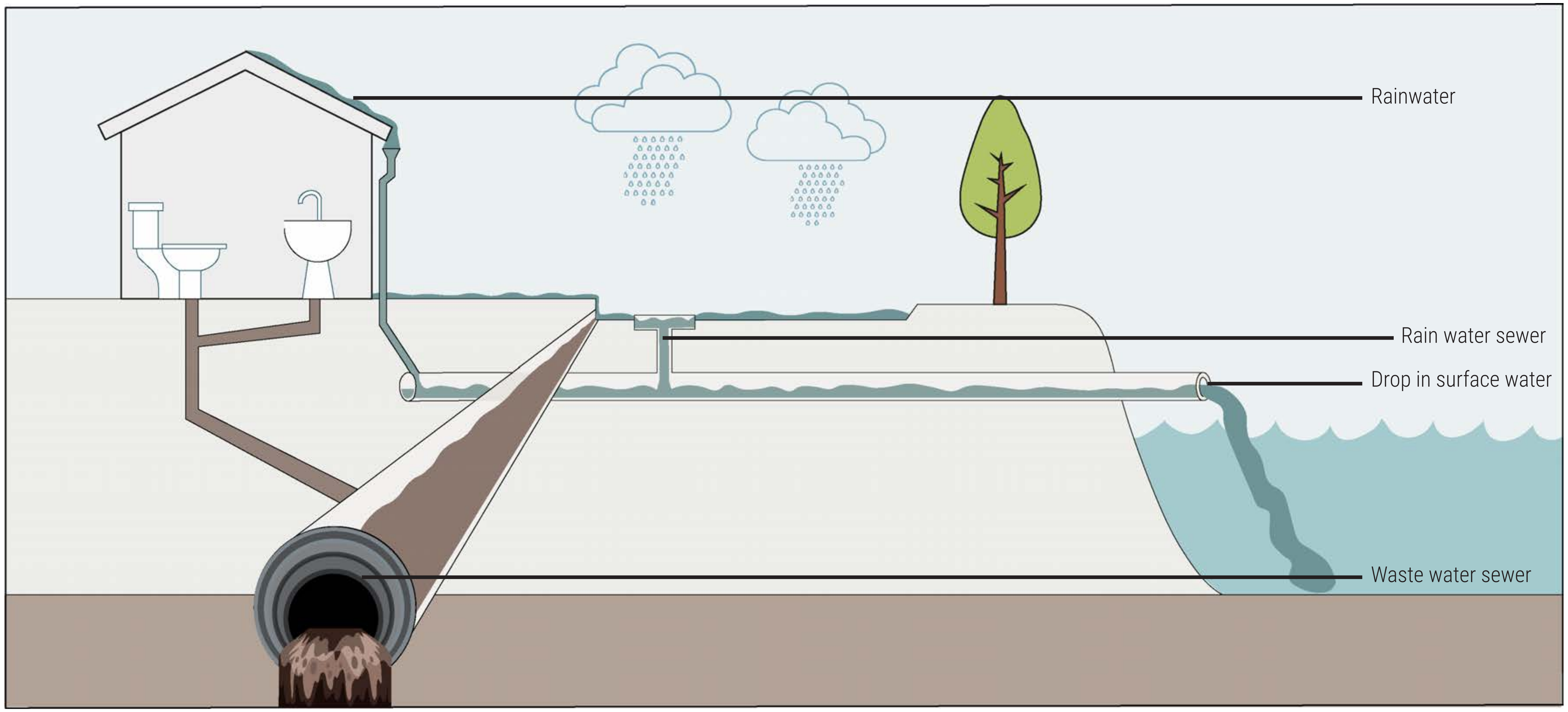
▲ *Figure 8.8: zoom in aquaponics (source: own work)*

Aquaponics

Aquaponics combine aquaculture and hydroponics to create a symbiotic environment where fish waste feeds plants and plants purify the water for fish.

Seperate sewer system

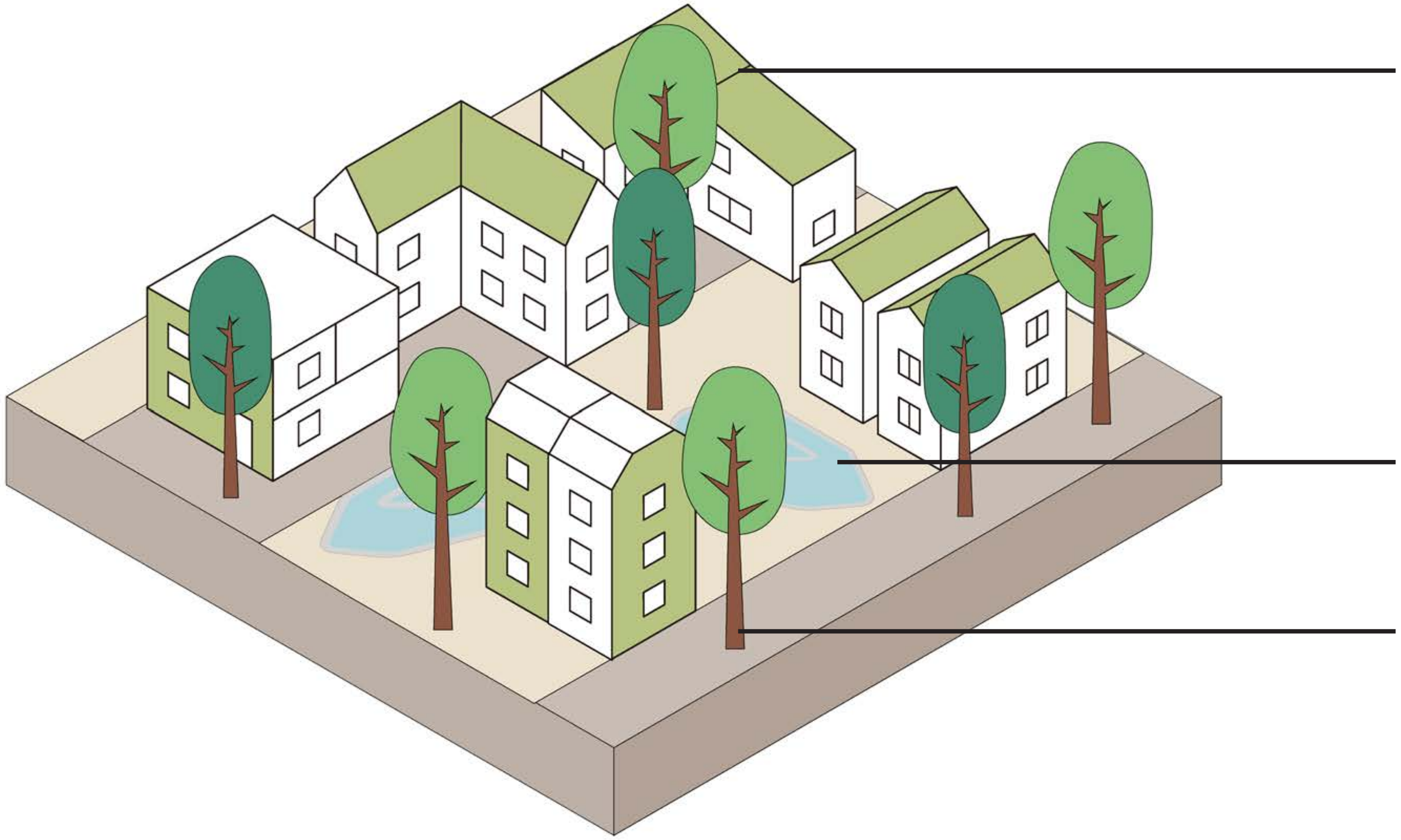
A separate sewer system handles sewage and rainwater separately. This reduces wastewater volume, minimizes sewage overflows, and is more effective for managing water resources.



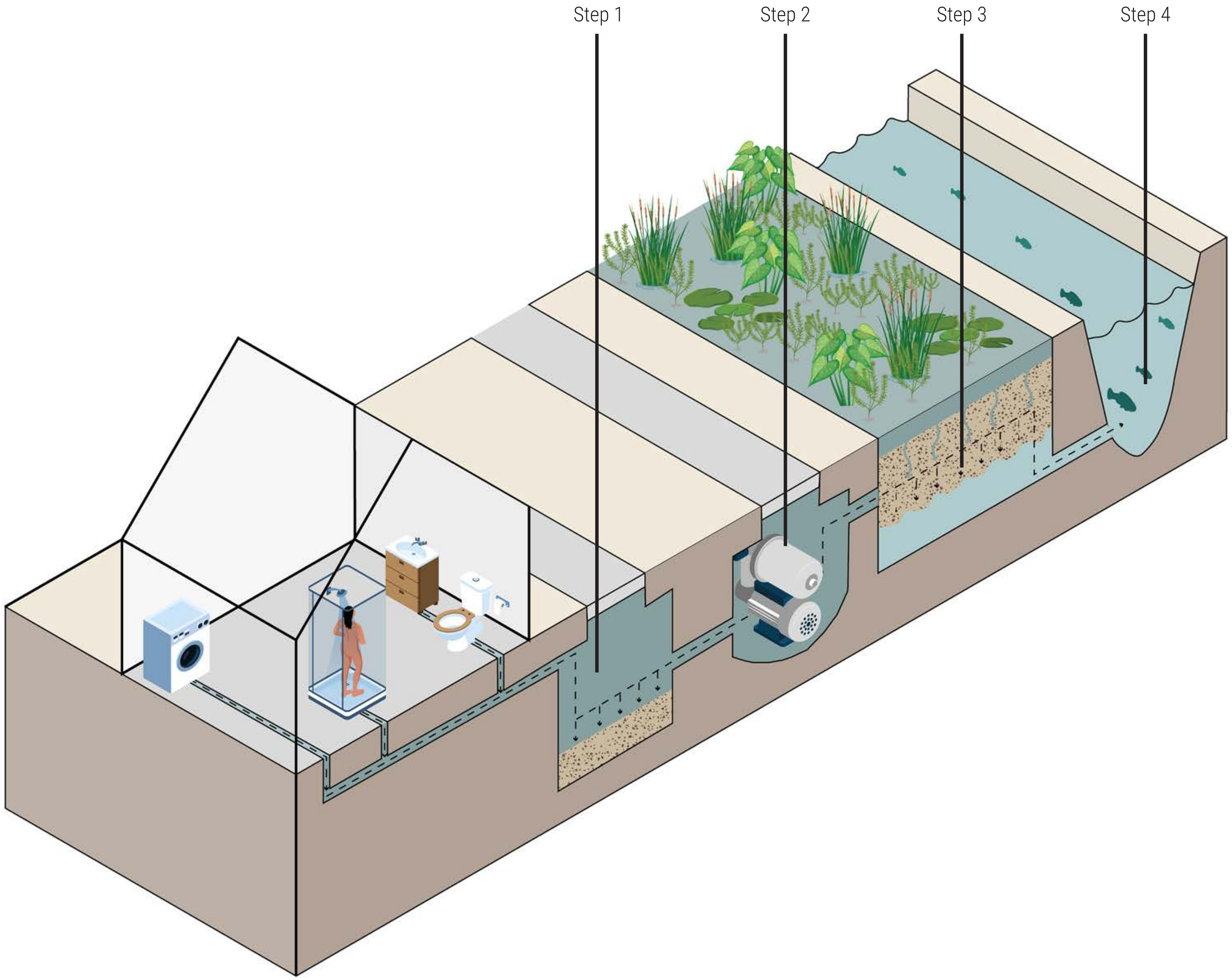
▲ *Figure 8.9: zoom in seperated sewer system (source: own work)*

Urban green

Green roofs will be implemented to reduce runoff and store water. In addition it will help mitigate the urban heat island effect. There are also more trees/ greenery to reduce runoff.
Furthermore there will biosphales to store water.



▲ *Figure 8.10: zoom in urban green (source: own work)*



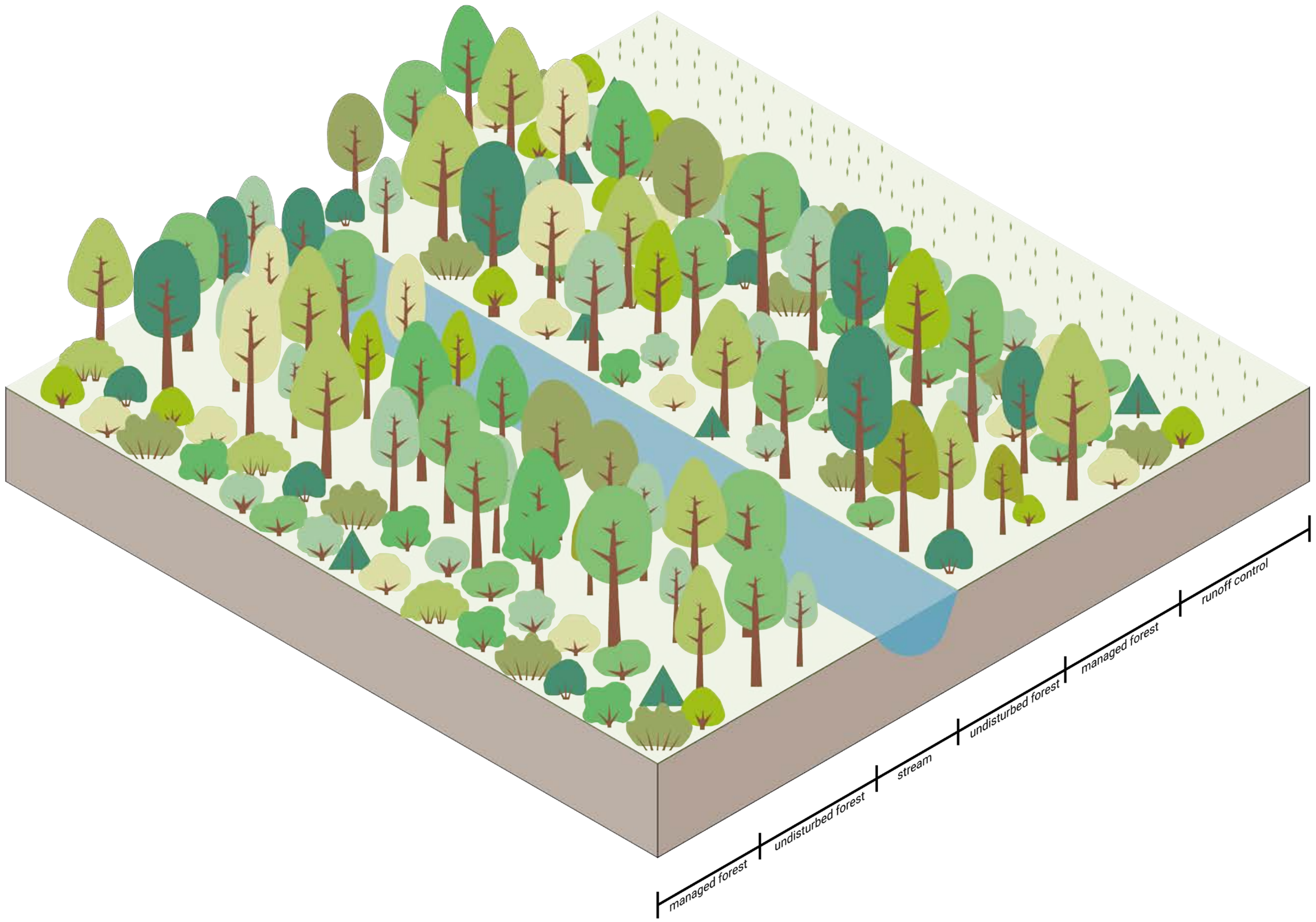
Zoom-in helophyte filter

The helophyte filter uses plants that thrive in wet environments to naturally remove contaminants from both the rainwater and daily sewage as it passes through the root zone. This process mimics natural wetland functions, which are excellent at filtering and purifying water.

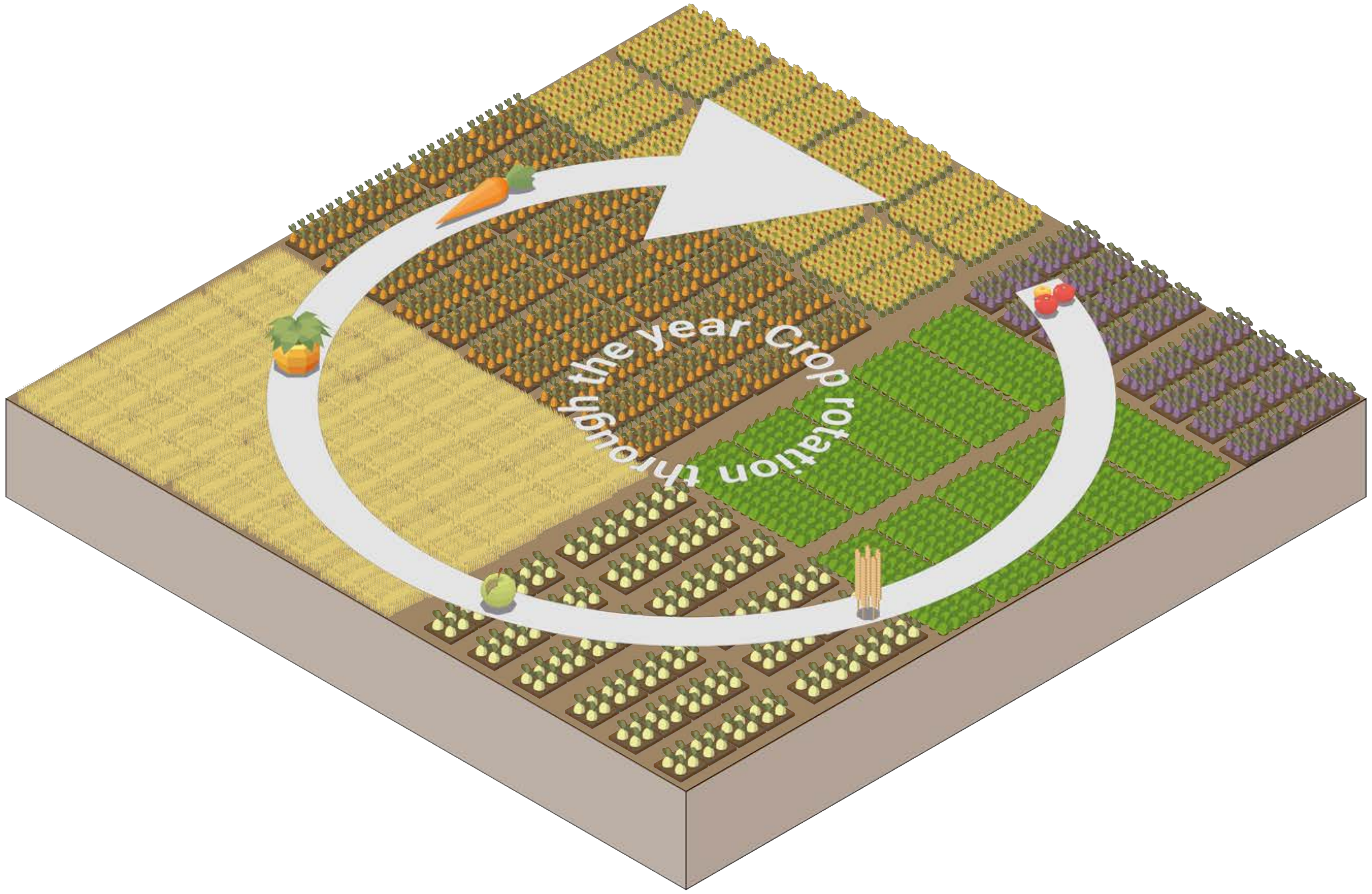
▲ *Figure 8.11: zoom in helophyte filter (source: own work)*

Riparian buffer

The riparian buffer has benefits for the ecosystem, including filtering pesticides, nutrients, and chemicals from agriculture, industry, and urban areas. It also stabilises riverbanks and provides for wildlife.



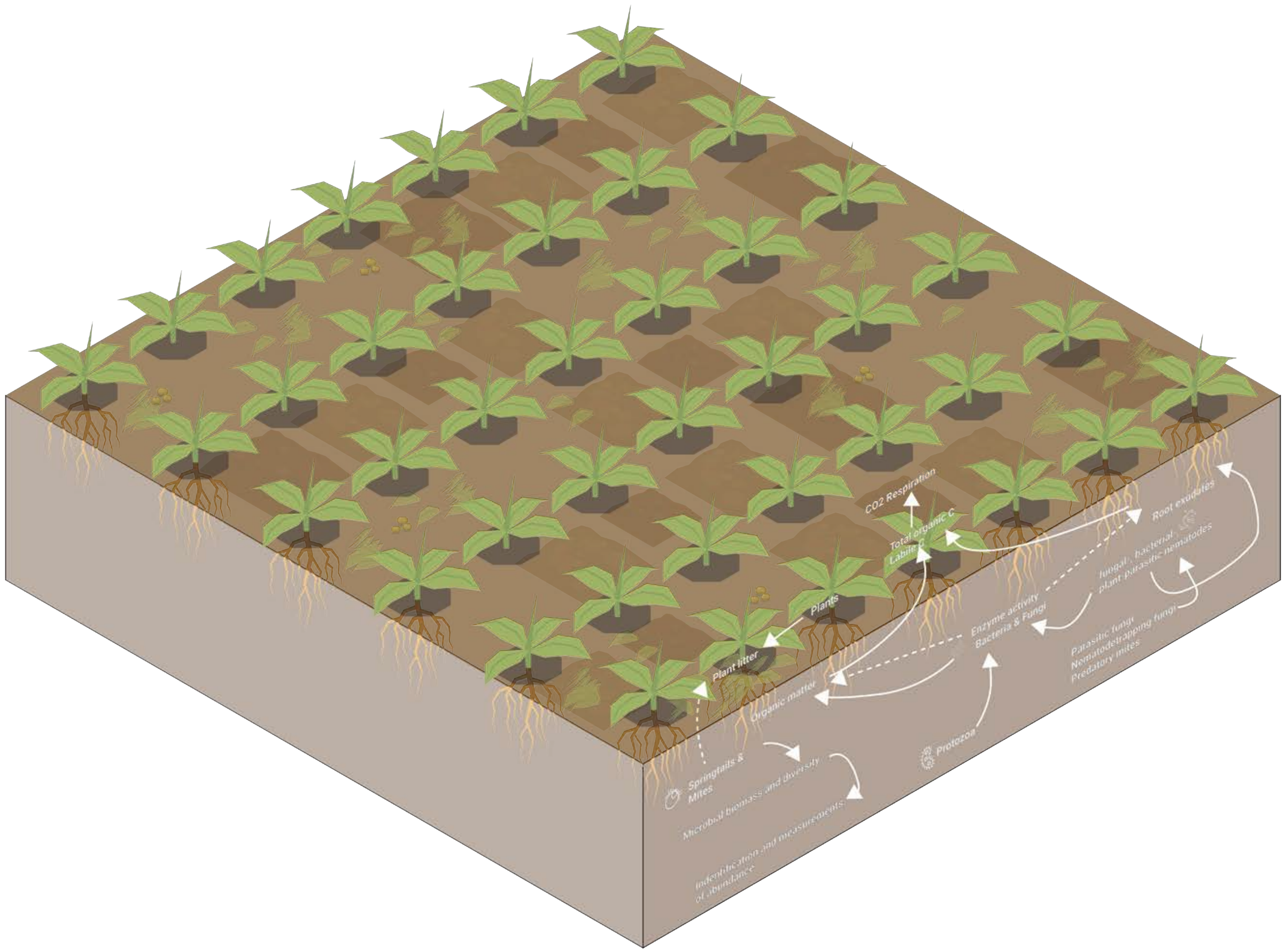
▲ *Figure 8.12: zoom in riparian buffer (source: own work)*



▲ *Figure 8.13: zoom in crop rotation farm (source: own work)*

Rotation crop farming

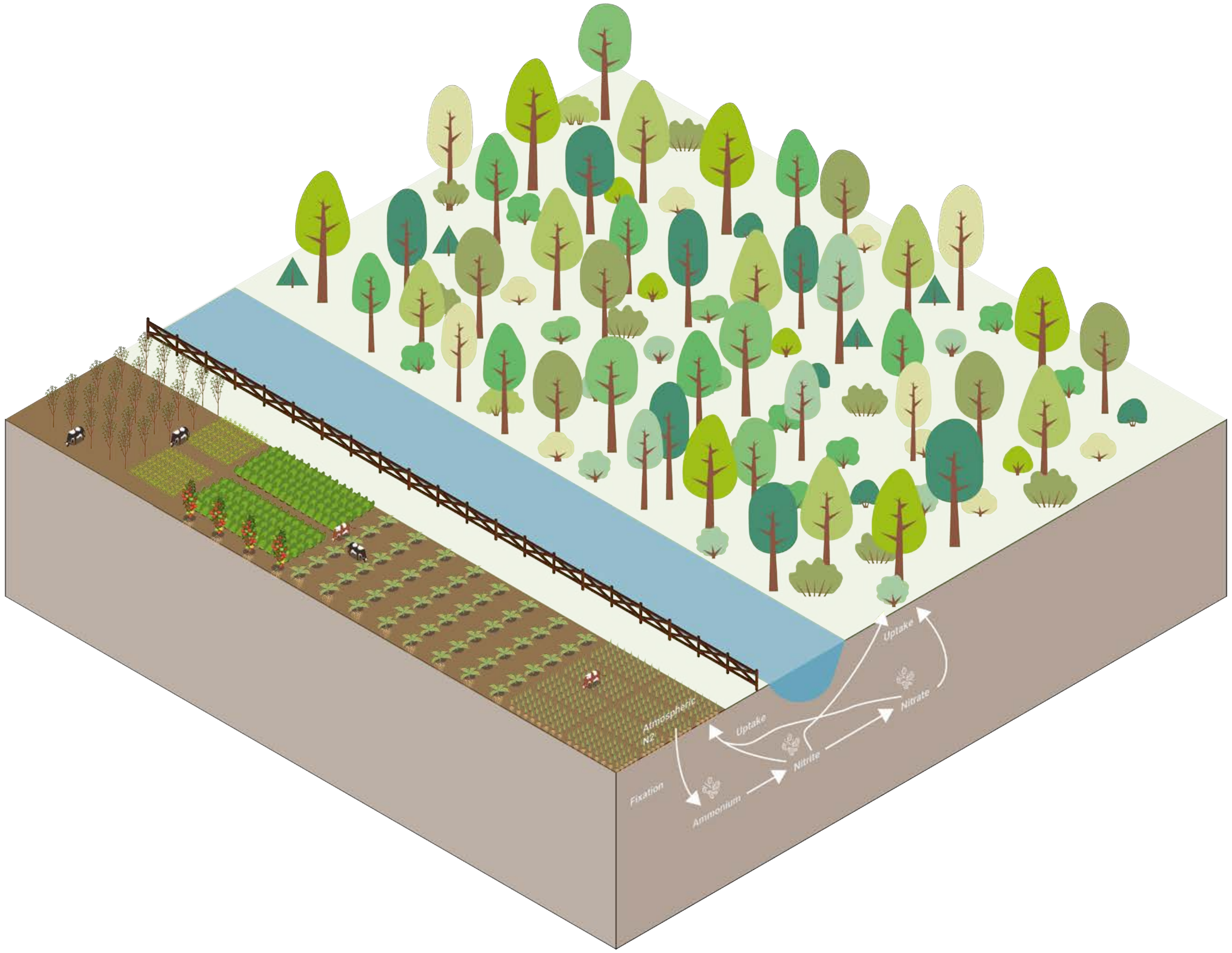
Crop rotation will also play a significant role in preserving soil fertility and crop vitality. By rotating crops in a certain period, we can improve soil health, optimize the nutrients in the soil, and combat weed pressure. It also requires less use of pesticides because pests become less of a problem when there are different types of crops in a sequence. Pests are usually a significant problem when the same crop is grown every single year. By implementing crop rotation farming, the chance of settling pests is lower, creating a better environment for the soil, as there will be no more pesticides in the ground.



▲ *Figure 8.14: zoom in root system (source: own work)*

Root system

The living roots within the soil create an environment where it can retain nutrients and improve plant growth and microbe biodiversity.



▲ *Figure 8.15: zoom in soil fertility (source: own work)*

Soil fertility

Banning the use of fertilisers on agricultural land will restore the soil and create a new nutrient balance. Different bacteria in combination with plant growth are important for the balance of nitrogen. A balanced and fertile soil will keep nitrogen in the ground, instead of letting it escape via runoff or to the air. The soil will keep the nitrogen in the ground because of the different bacteria. When fertilisers are used, the soil cannot keep up with the nitrogen that is added to the ground, creating an unhealthy soil balance that causes problems for plant growth and quality.