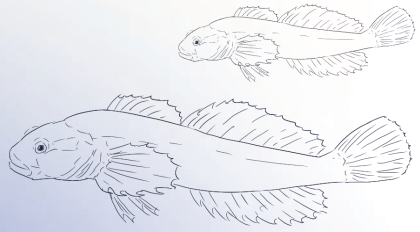
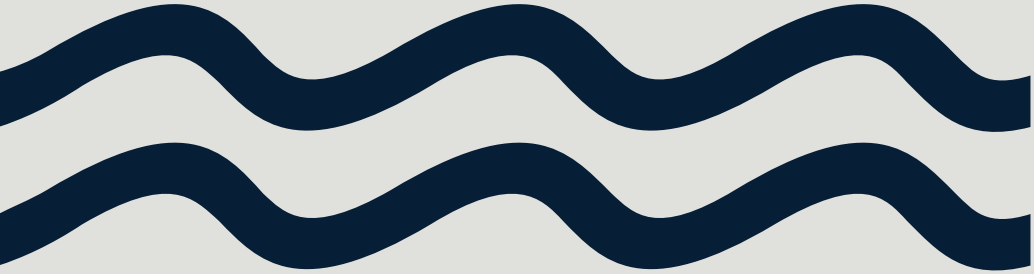


The Fresh Rhine

A STRATEGY FOR A CLEAN AND CONSISTENT WATER FLOW IN A RESILIENT RHINE RIVER BASIN



The Fresh Rhine

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R and D Studio: Spatial Strategies for the Global Metropolis (AR2U086)
Research and Design Methodology for Urbanism (AR2U088)

Abstract

The global water crisis could 'spiral out of control' due to overconsumption, pollution, and climate change. Building resilient freshwater systems is one of the most significant challenges in the face of climate change.

The Rhine River basin is home to over 60 million people. It's a center for trade, industry, and food production. However, the region's complex ecosystem is currently under threat from direct and indirect consequences of human activity. The ecosystems and habitats are disappearing, and pollution is still present in the water due to untreated sewage, industrial waste, and agricultural runoff. The growing population and increasing industrial demand for water use are putting a significant strain on the freshwater flow and supply, while droughts and floods further exacerbate the issue. This has resulted in the depletion of the quality of freshwater, creating further environmental risks..

The goal is to create an integrative and resilient Rhine River basin, with a special focus on the South Holland delta, which enhances the well-being of citizens, improves biodiversity, and ensures climate justice through the preservation of freshwater.

To achieve this, our vision for the Fresh Rhine employs a range of theories and methods such as resilience, sustainability, and nature-based solutions. They are applied in four critical locations: Lake Constance as the main water reservoir of the system; the area around the city of Kaub, a "blocked artery" of the river, especially sensitive to droughts; the Ruhr area, the main industrial center and pollutor of the region; and finally - the South Holland delta, where all these different conditions come together and meet the sea, another big threat to freshwater. The strategy focuses on renaturing the shorelines, reintroducing wetlands, and creating networks of wetland biotopes, as well as employing innovative ways of water reuse in agriculture, industries, and cities.

This will require collaboration between stakeholders, including government, private companies, civil society groups, and local communities. Ultimately, the project envisions a future where the Rhine River basin and the delta are leaders in sustainable water management, and a model for other regions facing similar challenges.

The implications of our strategy can extend beyond just the Rhine River basin. We aim to provide a more integrative approach to regional strategies for freshwater management in rivers that span across borders. The outcome of this project can be built upon for other regions facing similar challenges and provide a roadmap for creating resilient freshwater systems.

Keywords: freshwater, Rhine river, water cycle, wet landscape, water pollution, water scarcity, spatial planning, Delta

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01

The World Needs Freshwater


ECOLOGY
INDUSTRY
SOCIAL
AGRICULTURE

The World Needs Freshwater

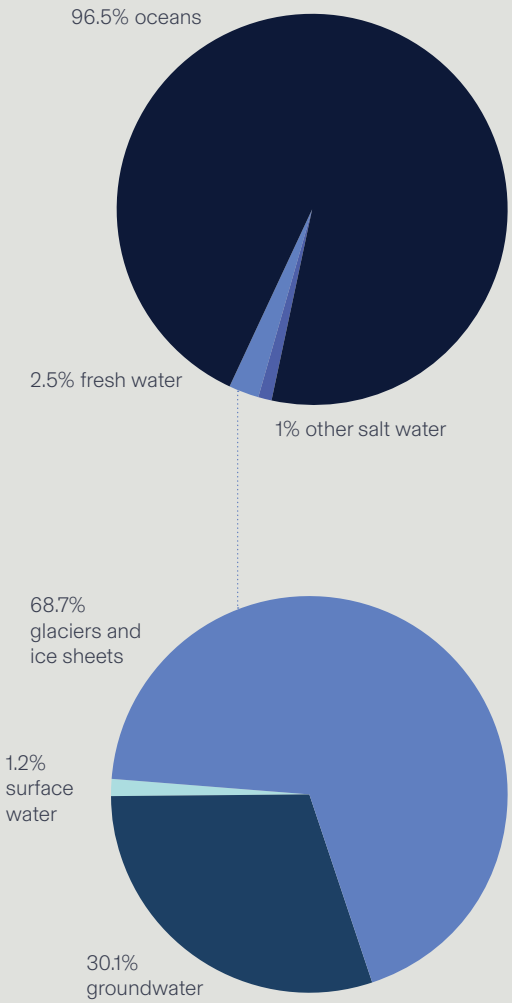
We live on a Blue planet.

The nickname comes from the fact that 71% of Earth's surface is covered by water. When looking for other planets that can sustain life, water is one of the main criteria. Human lives, and the ecosystems we thrive in, are dependent on our relationship with water. But before we go looking for water elsewhere, what about the water on our home planet?

Water can be generally separated into salt water and fresh water. Salt water is 97% of all water and is found mostly in our oceans and seas. Fresh water is found in glaciers, lakes, reservoirs, ponds, rivers, streams, wetlands, and groundwater. These freshwater habitats are less than 1% of the world's total surface area yet home to 10% of all known animals and up to 40% of all known fish species. Except for habitat, fresh water is important for sustenance. Humans, like most mammals, cannot consume salt water, due to its high density and concentration of salt and other minerals. Also, most of our food, both plants and animals, are sustained with fresh water.

Although all water on Earth partakes in a continuous hydrological cycle, fresh water is a finite source, since the amount of fresh water available at any given time is limited by various factors, such as the amount and timing of precipitation, the rate of evaporation, and the capacity of natural water storage systems like rivers, lakes, and groundwater aquifers.

Moreover, human activities, such as water consumption, pollution, and climate change, can also have a significant impact on the availability and quality of freshwater resources, further exacerbating the finite nature of this critical resource. Recently this has become more and more evident, and soon, clean fresh water simply flowing from our tap may not be the normal occurrence it is now.



Source:
Based on https://water.usgs.gov/edu/gallery/watercyclekids/earth-water-distribution.html

Main uses of fresh water

Fresh water also supports various human activities and has played a significant part in developing our civilizations and society. It has always been a primary resource, and it plays a critical role in the global economy. In this chapter, we will take a closer look at the different ways we are dependent on fresh water.

Agriculture is one of the most significant users of freshwater globally. According to the Food and Agriculture Organization (FAO), agriculture accounts for 70% of the world's fresh water withdrawals. Fresh water is used for irrigation to cultivate crops, which are a vital source of food and income for many. Without freshwater, food production would be severely limited, and many people would go hungry.

Industry is another significant user of fresh water, accounting for approximately 22% of global freshwater withdrawals. Freshwater is used in various industrial processes, including manufacturing, mining, and energy production. The energy sector is particularly reliant on freshwater, with power plants using freshwater for cooling purposes.

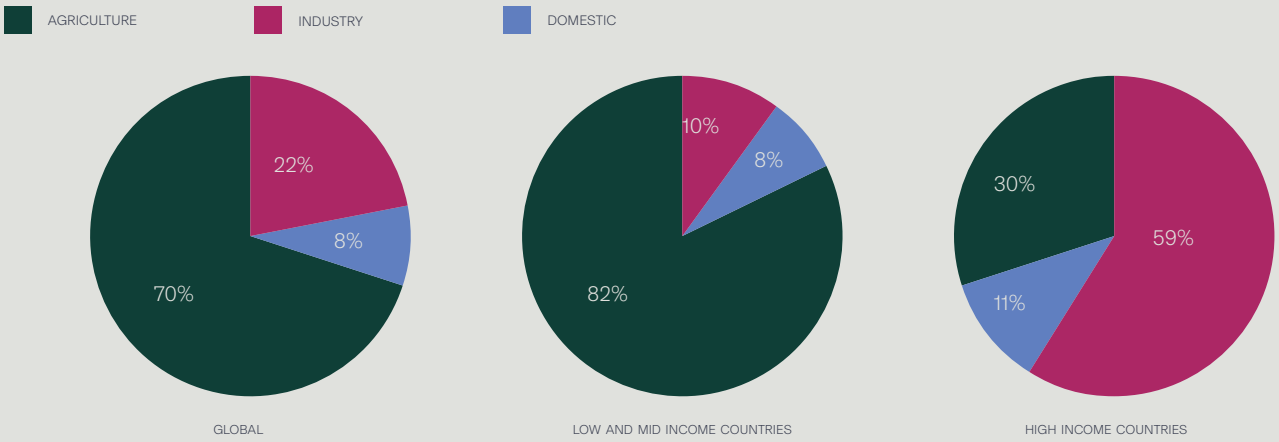
Shipping is also reliant on fresh water for navigation purposes. Ships carrying essential materials and other cargo use the fresh water waterways in order to reach inland ports, warehouses and factories. Changes to the fresh water supply severely impacts the shipping, hindering global trade and economic growth.

Naturally, fresh water is critical for ecological sustainability. Many ecosystems are relying on freshwater areas such as wetlands, lakes, streams and river to maintain biodiversity and support life. Freshwater ecosystems provide various ecosystem services, including water purification, flood control, and carbon sequestration.

Finally, freshwater is essential for human well-being and happiness. Access to freshwater is critical for hygiene, health, and sanitation. Domestic fresh water us accounts for about 8% of water withdrawal.

Also, freshwater resources provide many recreational opportunities, such as swimming, fishing, and boating. once again contributing to social well-being and happiness. Finally, having a healthy and resilient natural blue-green environment, such as rivers, lakes or wetlands has been found to impact physical and psychological health, therefore contributing to happiness and general well-being (Jimenez et al. 2021).

WATER USE BY SECTOR



Source: https://www.unesco.org/water/wwap/facts_figures/water_industry.shtml

Water use trends in northwestern Europe

North West Europe, as a wealthy region with high living standard and a diverse economy, has a significant reliance on water resources. Most water in Europe is abstracted from rivers and groundwater, with some water captured through artificial reservoirs.

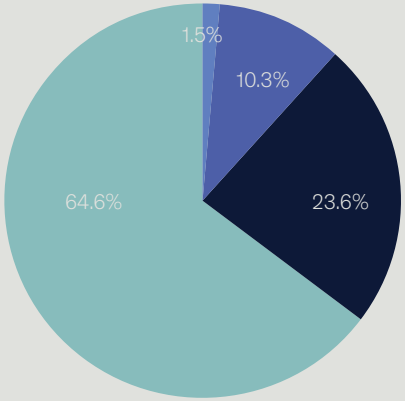
Agriculturally, the region is known for high-value crops, such as vegetables, fruits, and flowers, which require significant amounts of water for growth and production. For example, the Netherlands is the world's second largest exporter of agricultural products, with greenhouse-grown produce, such as tomatoes, cucumbers, and peppers, being one of the country's main agricultural exports. The production of these crops relies heavily on irrigation and hydroponic systems, which require a reliable supply of freshwater.

The region has several industrial centers, with major industries being the production of chemicals, paper and textiles. All of them require significant amounts of water for production processes and cooling systems. For instance, the chemical industry in the region is one of the largest in the world, and its production processes require large amounts of water for cooling and cleaning purposes.

Since part of the region lies in the delta, it is also home to several major ports, including Rotterdam, Antwerp, and Hamburg, which are important hubs for international trade and commerce. Thus, the river shipping industry, with the region's extensive river network, provides a critical transportation infrastructure for goods and commodities. The Rhine, which is the largest river in the region, is a vital transport route for goods such as coal, oil, and chemical products. However, the river is also subject to frequent droughts and low-water conditions, which can disrupt shipping traffic and cause economic losses.

Since the region is very prosperous, the domestic water use is also above average. However, the countries in the region have some of the best water treatment procedures, policies and technologies in the world.

Water protection is therefore a critical issue in northwestern Europe. Luckily, the region has a long tradition of environmental protection and cooperating to preserve valuable natural resources. The EU has implemented various regulations and policies to protect water quality and ensure sustainable water management in the region.



FRESHWATER ABSTRACTION BY SOURCE (EU)

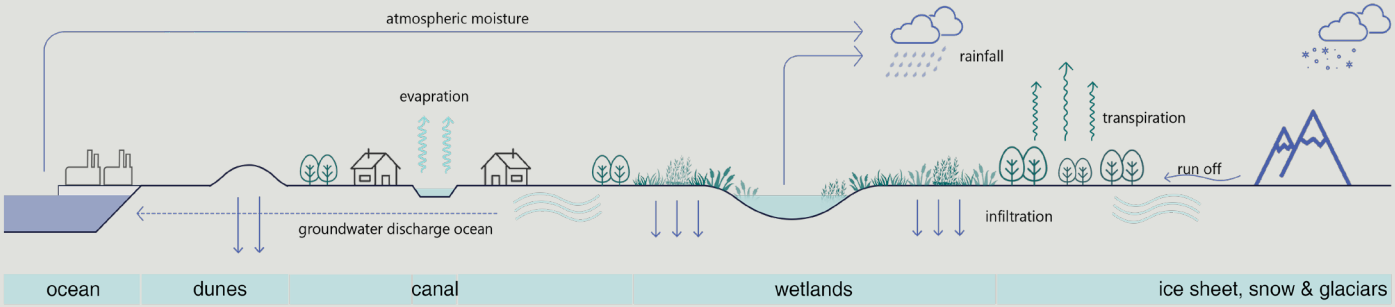
LEGEND

- RIVERS
- GROUNDWATER
- ARTIFICIAL RESERVOIRS
- LAKES

Source: EEA Indicator on freshwater resources

The hydrological cycle

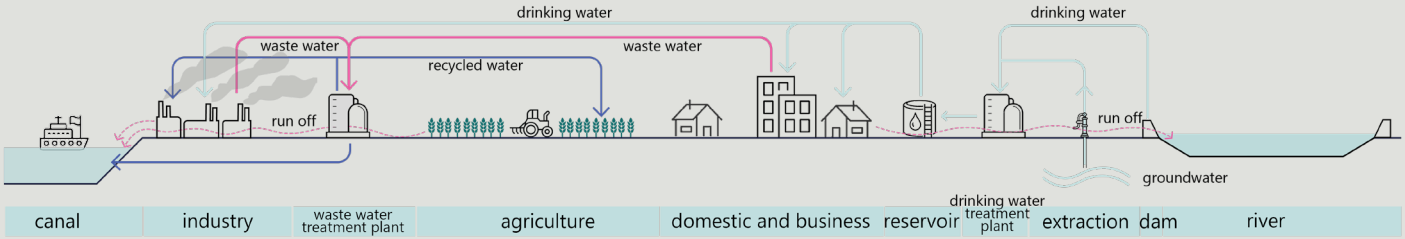
NATURAL CYCLE



The natural hydrological cycle is the continuous movement of water through the environment. It starts with evaporation from the sea, dunes, rivers, wetlands, and other water bodies, as well as from atmospheric moisture. This water vapor then condenses into clouds and falls as precipitation, including rainfall, snow, and ice. Some of this precipitation is stored in ice sheets, glaciers, and snowfields, while some infiltrates into the ground as groundwater.

Plants also absorb water through their roots and release it through transpiration. The remaining water runs off into rivers and wetlands, which eventually discharge into the sea, restarting the cycle. This process is crucial for maintaining the Earth's water balance and supporting life on the planet.and ensure sustainable water management.

HUMAN CYCLE

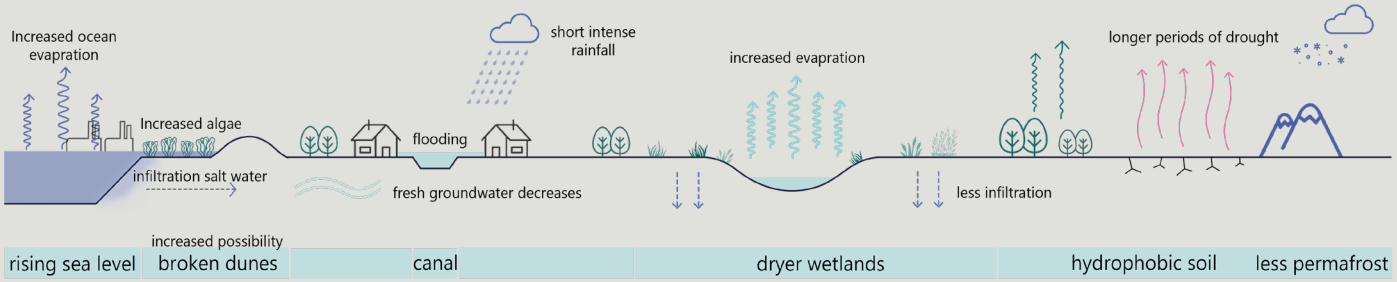


In the human hydrological cycle, we extract water from various sources like reservoirs, rivers, and groundwater for domestic, agricultural, and industrial uses. Once used, the water is treated at waste water treatment plants to remove impurities and pollutants before being released back into the environment. To ensure that the water is safe for human consumption, drinking water treatment plants are employed.

Agriculture affects the cycle through irrigation and run-off, while industries also treat water for their specific needs. We store some of the water in dams and reservoirs for future use, and recycled water is also used to combat water scarcity. However, the excess water and chemicals from farming can pollute waterways.

Effects of climate change on the hydrological cycle

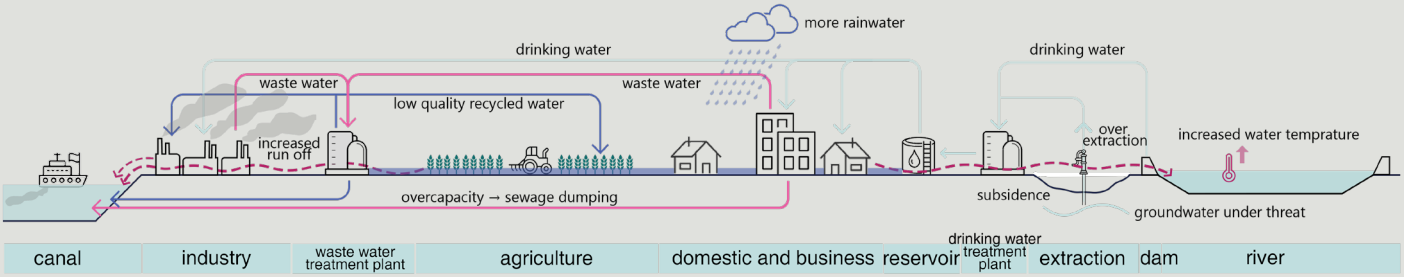
NATURAL CYCLE



Climate change is disrupting the natural hydrological cycle in various ways. The rising sea level due to global warming is causing the infiltration of salt water into the freshwater sources, leading to a decrease in the availability of groundwater. The increased ocean evaporation and algae growth are also affecting the natural hydrological cycle, resulting in wetlands dying and a decrease in infiltration. Additionally, climate change is causing shorter, more intense rainfall, which is causing flooding in some areas and droughts in others.

This longer period of drought is leading to hydrophobic soil and less permafrost, further affecting the natural hydrological cycle. The increased possibility of broken dunes is also causing water to move more quickly and unpredictably, making it difficult for water managers to properly allocate resources.

HUMAN CYCLE



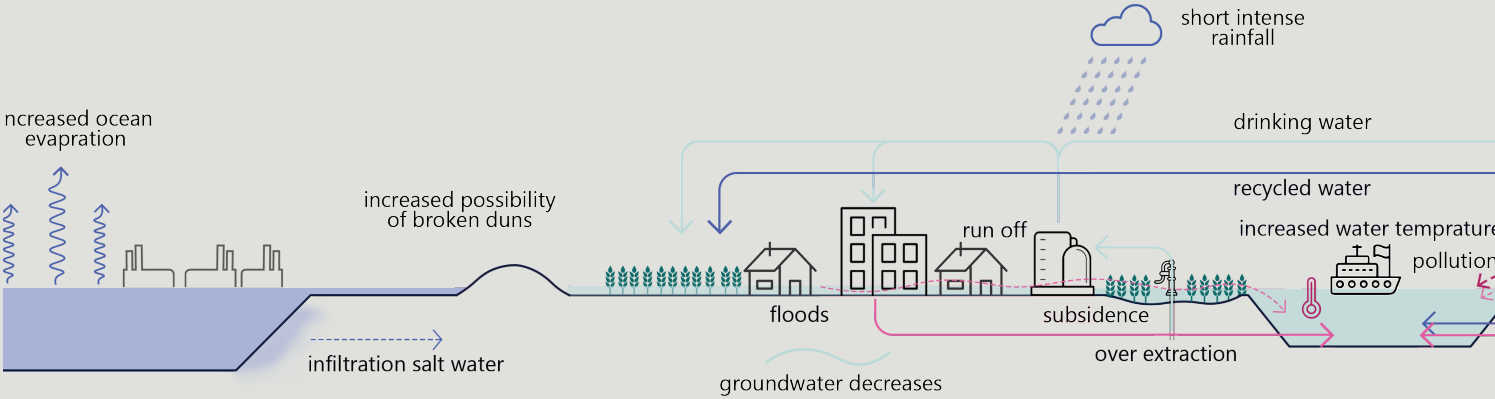
The increasing demand for water due to the expanding industries and population has led to overcapacity, over-extraction of groundwater, and sewage dumping. This, in turn, is leading to subsidence and threats to groundwater resources. Additionally, climate change is causing increased water temperature and more intense rainwater, leading to flooding, erosion, and contamination of rivers.

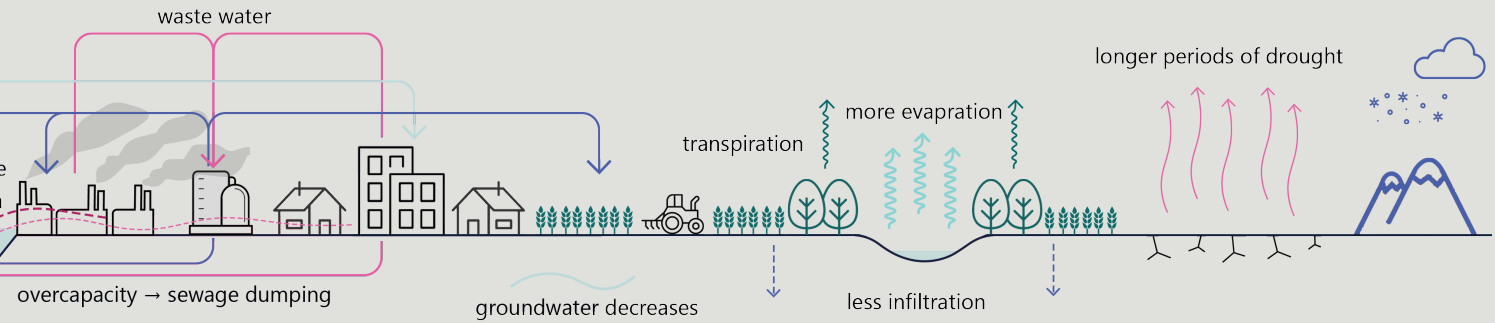
The wastewater treatment plant is also struggling to cope with the increasing demand for water and the production of low-quality recycled water. The domino effect of the different consequences of human caused pollution, overuse and climate change gets even worse when we take the cumulative effects of the deterriorated natural and human cycles together.

Cumulative effects of climate change on the hydrological cycle

INTERACTION BETWEEN THE NATURAL AND HUMAN HYDROLOGICAL CYCLES UNDER CLIMATE CHANGE

Climate change is disrupting both the natural and human hydrological cycles, with a range of interconnected effects. The rising temperature caused by global warming is increasing the sea's evaporation rate, leading to more intense rainfall and an increased risk of floods. The resulting run-off of this water is causing subsidence and threatening groundwater resources, with saltwater infiltration affecting both the Rhine river and agricultural land. The increased possibility of broken dunes is further exacerbating these issues. In addition, industrial overcapacity and sewage dumping are polluting water sources and making it more difficult to manage water sustainably.
Climate change is also causing hydrophobic soil and dryer wetlands, leading to less infiltration and transpiration. Most tragically, the melting permafrost is causing a decline in water availability, resulting in long periods of drought.




waste water
longer periods of drought
more evapration
transpiration
overcapacity → sewage dumping
groundwater decreases
less infiltration
drinking water treatment plant
industry
domestic & business
agriculture
dryer wetlands
hydrophobic soil
permafrost

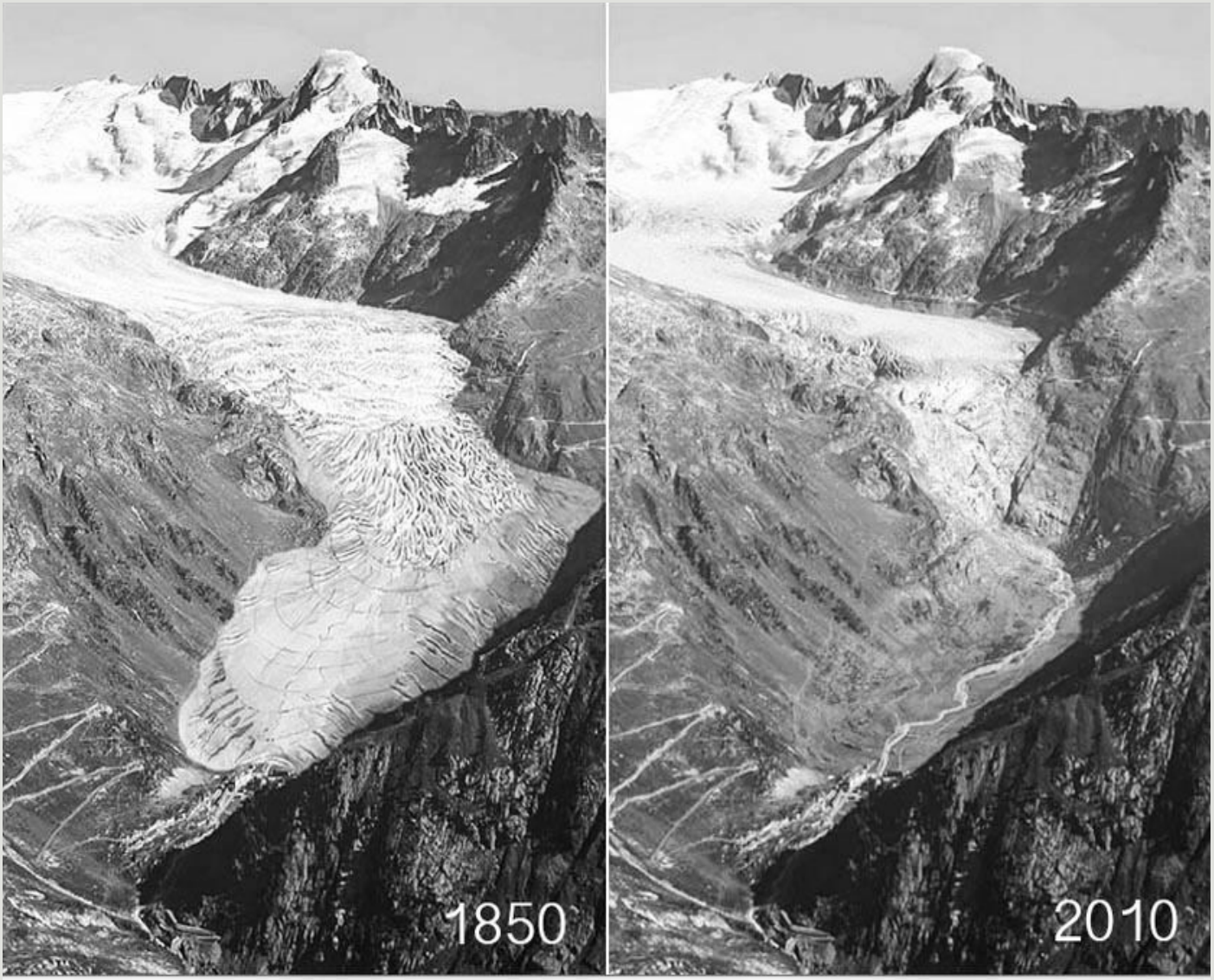


FIGURE 1: RHONE GLACIER IN 1850 AND 2010

Effects of climate change and human activity in northwestern Europe

The past couple of summers have made the effects of climate change more obvious than ever before.

In the summers of 2018 and 2022, the region was hit with severe droughts. EU Commissioner for innovation, research, culture, education and youth, Mariya Gabriel, said: "The combination of a severe drought and heatwaves has created an unprecedented stress on water levels in the entire EU. We are currently noticing a wildfires season sensibly above the average and an important impact on crops production."

The prolonged heat and drought also decimated the shipping industry, as the Rhine waterway was closed for goods of transport for a total of 132 days in 2022. Industries and shipping companies are already seeking alternatives as this is becoming more and more common.

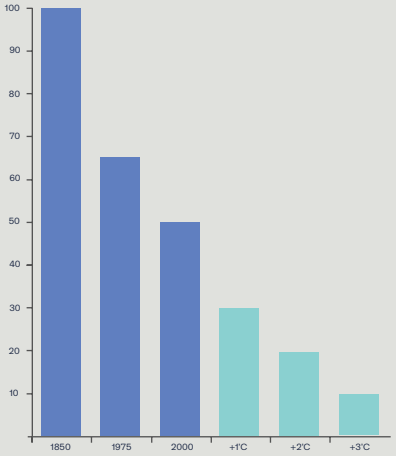
On the other hand, there are floods. Torrential rain in combination with scorched dry soil resulted in massive flooding along the Rhine in 2021. Several towns and villages were significantly damaged, and over 200 people lost their lives.

There is also a silent disaster, becoming obvious only once you reach the tops of the Alps. The glaciers which supply our rivers with fresh water are disappearing at an alarming rate, further bringing about drought conditions and water scarcity. The countries of northwestern Europe have started to ring the alarm on the very real possibility that drinking water shortages might occur as soon as 2030 if drastic measures are not taken.

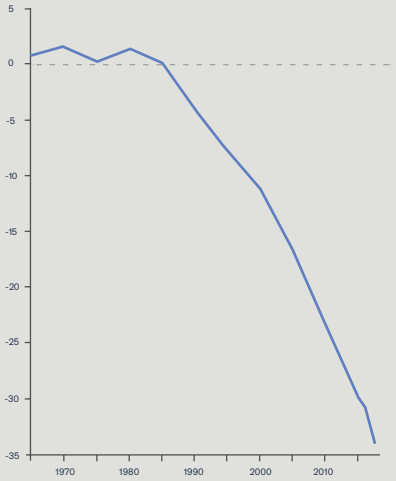
For the Netherlands specifically, an added danger in the Delta are subsidence, sea level rise and salinization. As there is less fresh water in the ground and in the river bank, the salt water seeps through more easily. Pumping out the water will only cause the land to further subside, making it more vulnerable to floods.

Responding to this challenge is difficult, but not impossible. We believe that the most important step is to look towards the original natural structures of the area, and find sustainable and nature based solutions. Therefore, we must first examine the natural and human structures of the Rhine River basin, Europe's second largest river and a true life-line of the region.

REMAINING GLACIER SURFACE IN THE ALPS



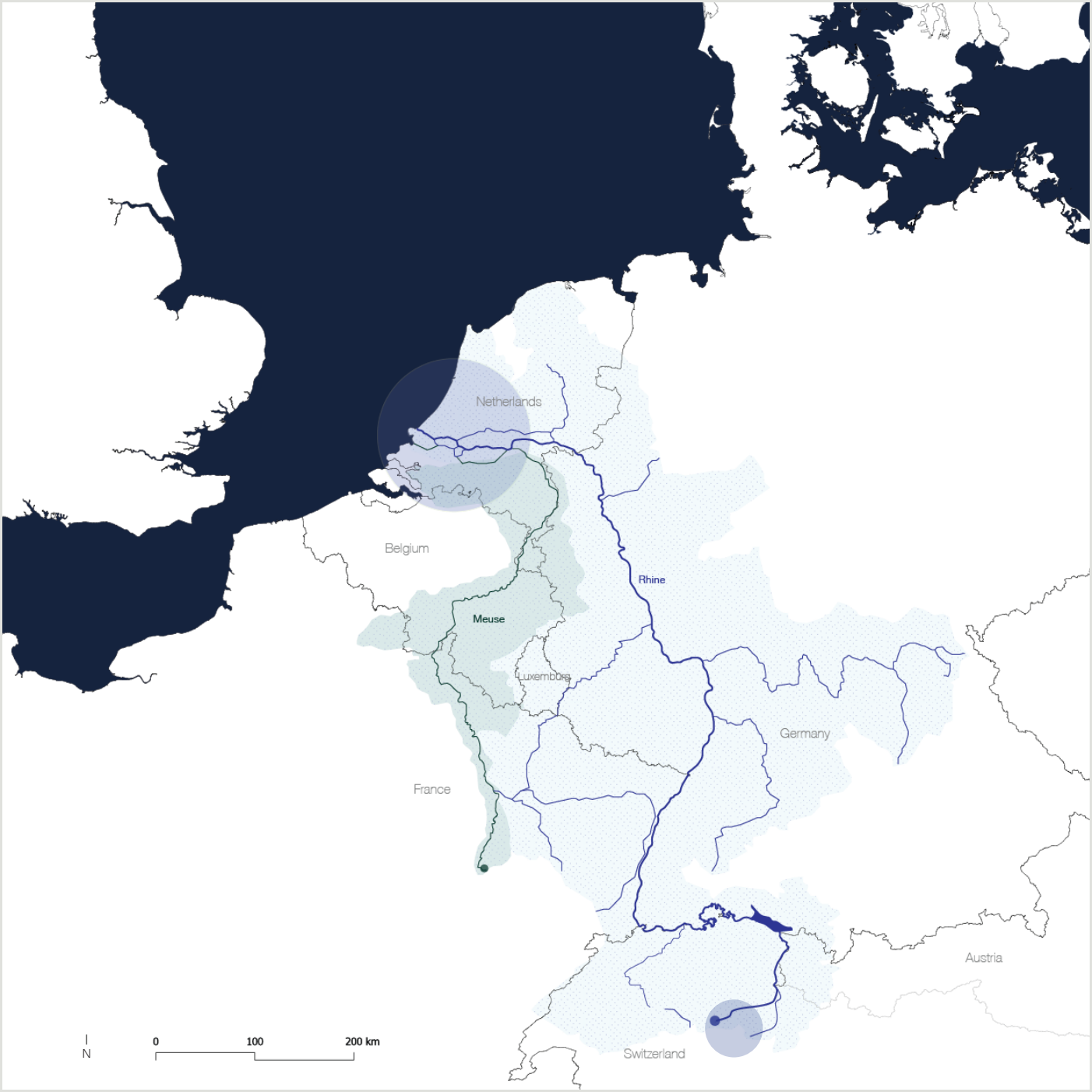
ANNUAL CUMULATIVE GLACIER MASS BALANCE



Source: Permanent Secretariat of the Alpine Convention (2017), based on the underlying data from Zemp, M., Haeberli, W., Hoelze, M. and Paul, F., (2006), Alpine glaciers to disappear within decades?,

02

Exploring the Rhine River basin


Netherlands
Belgium
Rhine
Meuse
Luxembourg
Germany
France
Austria
Switzerland
N
0
100
200 km

The Rhine River basin

CONTEXT

The Rhine River got its name from the Celts, and it stands for "great running water". Seeing as the length of the river is approximately 1,233 kilometers, and the river basin covers an area of approximately 185,000 square kilometers, spanning across nine different countries in Western and Central Europe, that name seems quite fitting.

The Rhine is a significant ecological, cultural and economic axis in Middle Europe, connecting the Alps to the North Sea. Its use is more intensive and varied than that of all other European rivers, serving as a major transportation route for goods and a hub for industry and agriculture. Its watershed is home to over 60 mililon people whose lives are tied to and dependent on it. It passes through thousands of smaller villages and towns but also larger important cities such as Basel, Strasbourg, Frankfurt, Cologne, Dusseldorf, Maastricht and Rotterdam.

The river, along with its tributaries, brooks, lakes, wetlands, and groundwater, creates an extensive network of water bodies that flow towards the North Sea. They can be observed as smaller sub-basins depending on their characteristics and geographical location, just as the river itself is divided into sections - Alpine Rhine, High Rhine, Upper Rhine, Middle Rhine, Lower Rhine and Delta. The delta is shared primarily with the Meuse, with some influence from the Scheldt delta in the westernmost areas of the mouth.

The water in the Rhine catchment is an integral part of the global water cycle. Sooner or later all precipitation in the Rhine area reaches the Rhine and eventually the North Sea. In the North Sea, part of the water evaporates to form clouds and re-precipitates. The speed at which water completes its cycle is determined by the duration of its retention before reaching the North Sea. Water from precipitation or melting snow infiltrates the soil and travels to the sea as groundwater. Plants and glaciers are also able to retain substantial amounts of water.

Therefore, the rate of the runoff in the Rhine can vary across seasons, depending on precipitation levels, the rate of glaciers melting and the water uptake. But even though low water levels and droughts are a part of the natural cycle of the Rhine, climate change and human activity have further exacerbated this effect. Natural river shores, meanders, floodplains and wetlands, as well as the river itself, were engineered for easier passage of ships and access to shore. This had a grave effect not only on biodiversity, put also the capacity of nearby areas to mitigate floods and droughts.

source: Tomasee, Switzerland; elevation 2,345m
2nd source: Paradies Glacier, Switzerland
mouth: North Sea, Nieuwe Waterweg, Netherlands; elevation 0m
length: 1,233km
basin: 185,000 km2
discharge: average 2,900 m3/s; minimum 800 m3/s; maximum 13,000 m3/s
countries: Switzerland, Liechtenstein, Austria, France, Germany, Netherlands (basin also reaches Luxembourg and Italy)
managed by: ICPR - International Committee for the Protection of the Rhine

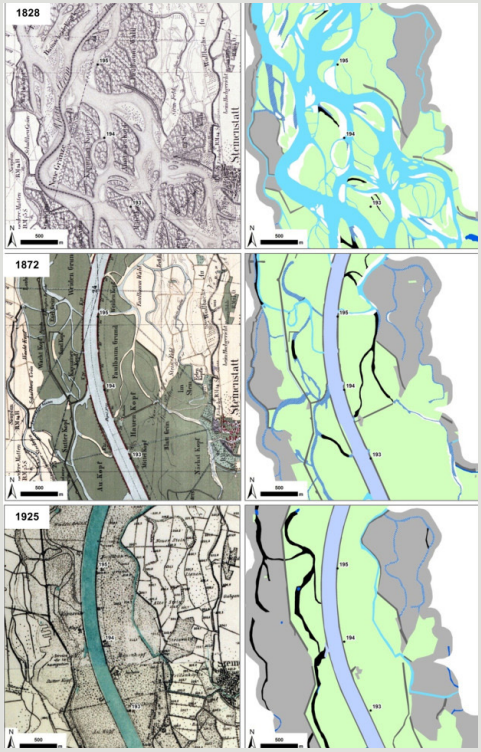


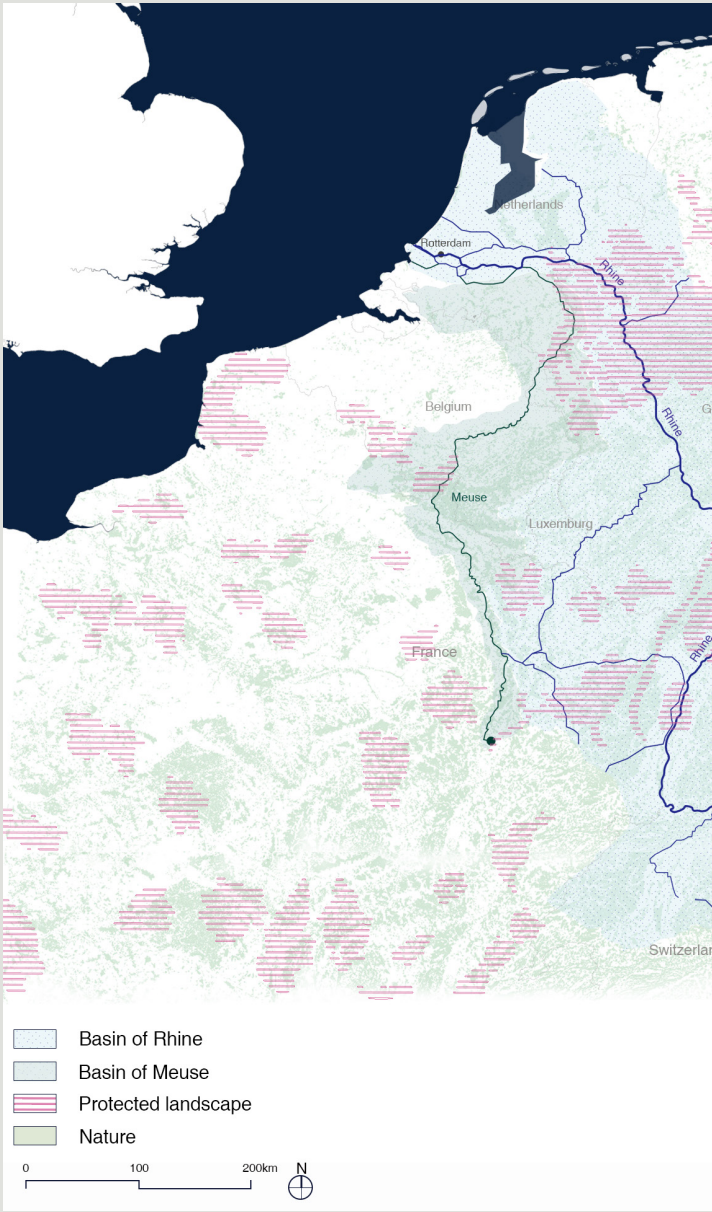
FIGURE 1: ENGINEERING OF THE UPPER RHINE FROM 1828 TO 1925

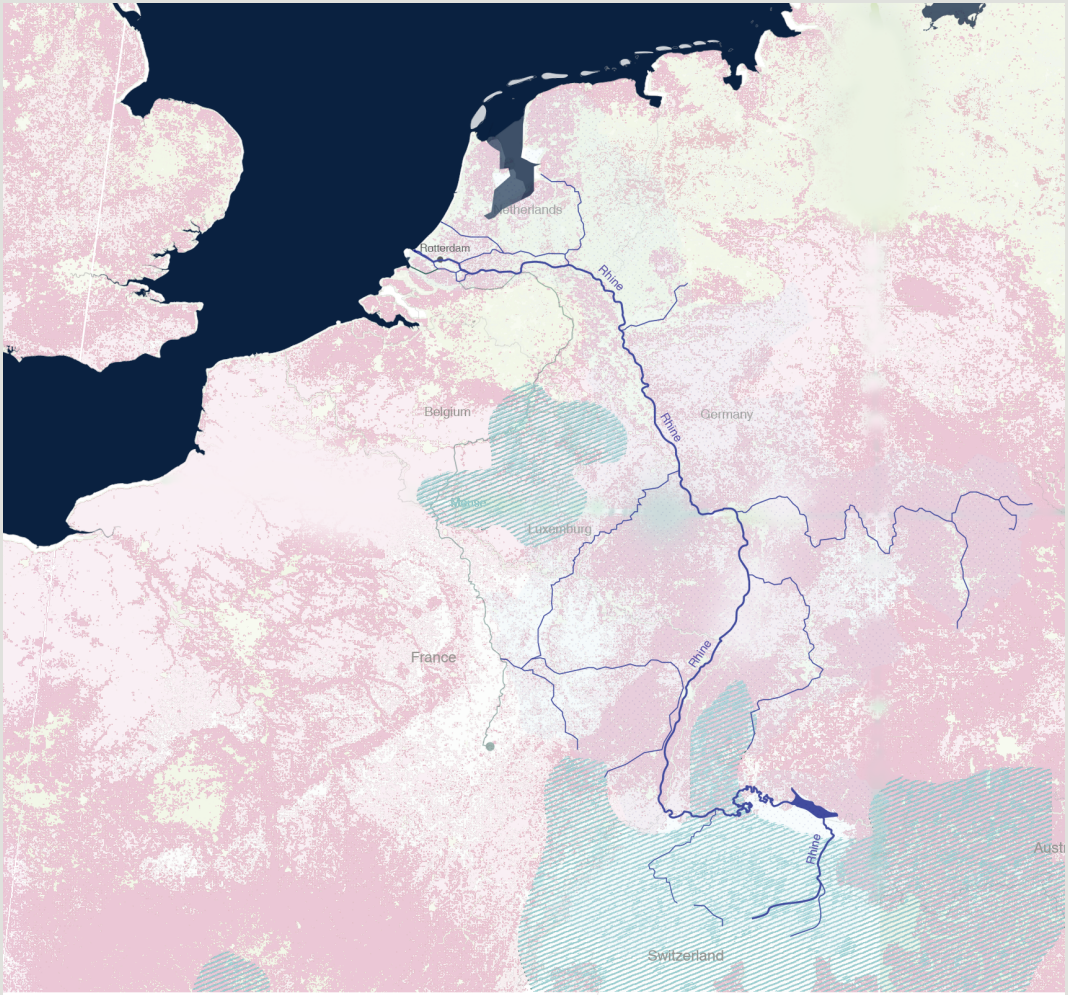
Natural structures in the Rhine River basin

The basin is characterized by a diverse range of natural structures, including forests, meadows, wetlands and other nature-protected areas, varying soil types, and different precipitation rates across the basin. There are several important nature reserves and protected areas, such as the Upper Rhine Valley, the Rhine Gorge or the Biesbosch.

The region's soil types range from sand and peat in the delta, through fertile loam in the Lower Rhine agricultural areas to rocky terrain in the mountainous regions.

Precipitation rates are highest in the mountainous regions, particularly in the Alps and the Black Forest, where both snow and rain are frequent. There are also precipitation hot spots in the lower areas, specifically in the delta.




Netherlands
Rotterdam
Rhine
Belgium
Germany
Rhine
Meuse
Luxemburg
France
Rhine
Rhine
Switzerland
sand loam
loam
silt loam
average annual precipitation >1000mm, 1940-1995
0
100
200km
N

Human structures in the Rhine River basin

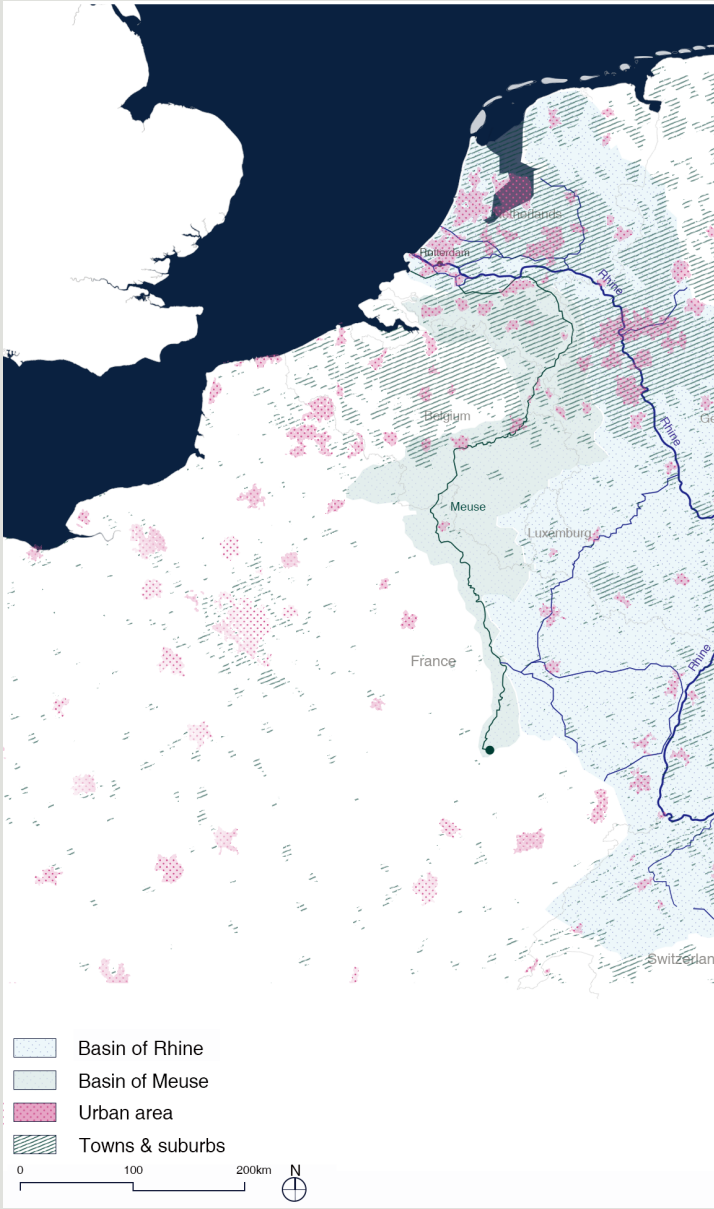
A diverse range of human structures are situated along the Rhine, including urban areas, agricultural land, and industrial sites connected by shipping routes. Several major cities, such as Basel, Strasbourg, Frankfurt, Cologne and Rotterdam, are located along the river, serving as hubs of industry commerce, culture, and tourism.

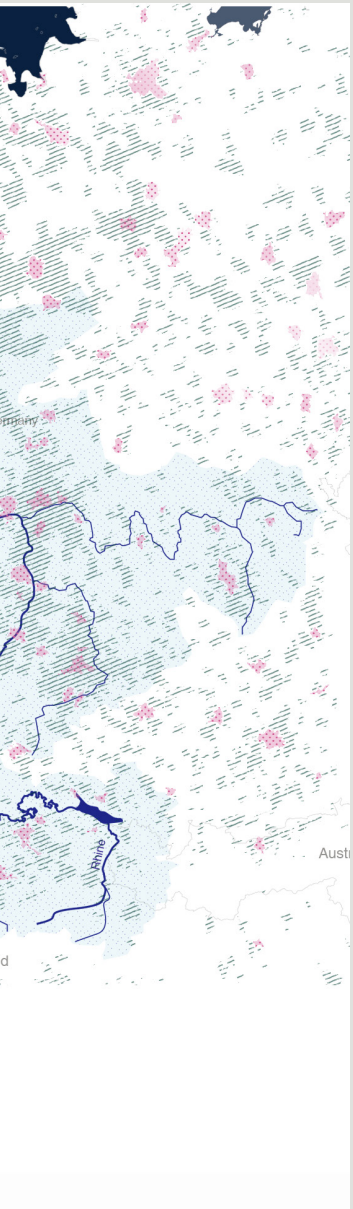
Agriculture is also a significant economic activity in the region, with fertile soils in many areas supporting a variety of crops, with the most commonly grown crops in the basin being cereals such as barley, wheat and maize. They further propel the food industry, as they are used for food production, animal feed and biofuel. Other important crops in the basin are fruits and vegetables

Industry is another major player in the Rhine river basin, with several industrial sites located along the river. There are six main industrial centers: Basel-Mulhouse-Freiburg, Strasbourg, Rhine-Neckar, Frankfurt-Rhine-Main, Ruhrgebeit and Rotterdam Europoort. They produce a wide range of goods, including petrochemicals, pharmaceuticals, chemicals, machinery, and textiles. The production of chemicals along the Rhine is very important on a global level with BASF industrial site in Ludwigshafen being the largest chemical producer in the world.

The Rhine river also serves as a major transportation route for goods, with shipping routes connecting several major ports along the river, such as Rotterdam and Antwerp.

While human structures have brought economic benefits to the region, they have also had a significant impact on the environment. Pollution from industry and agriculture has led to water quality issues in some areas, and urbanization has led to habitat destruction and fragmentation.




Rhine
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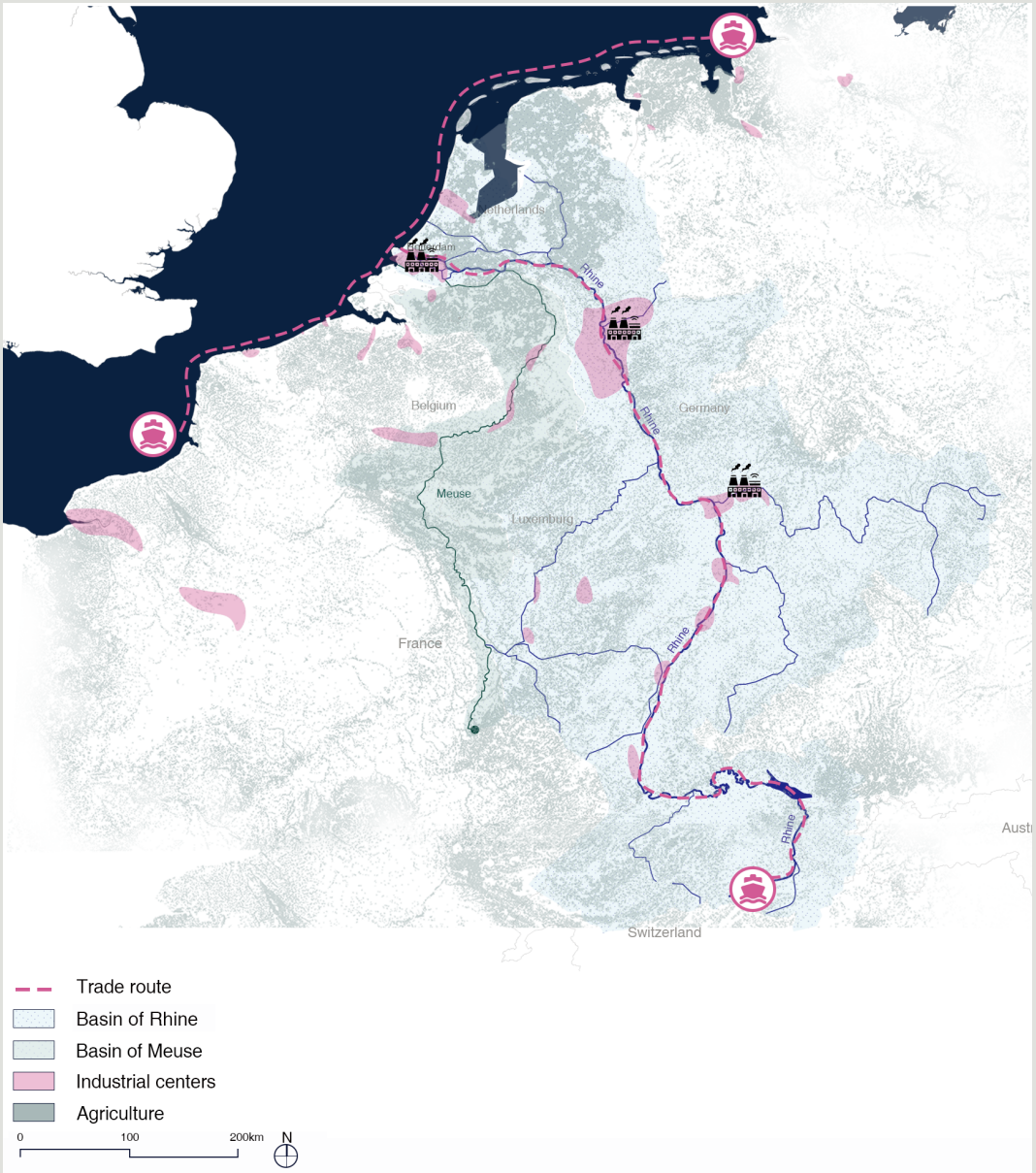

Netherlands
Amsterdam
Rhine
Belgium
Germany
Rhine
Meuse
Luxemburg
France
Rhine
Rhine
Austr
Switzerland
Trade route
Basin of Rhine
Basin of Meuse
Industrial centers
Agriculture
0
100
200km
N

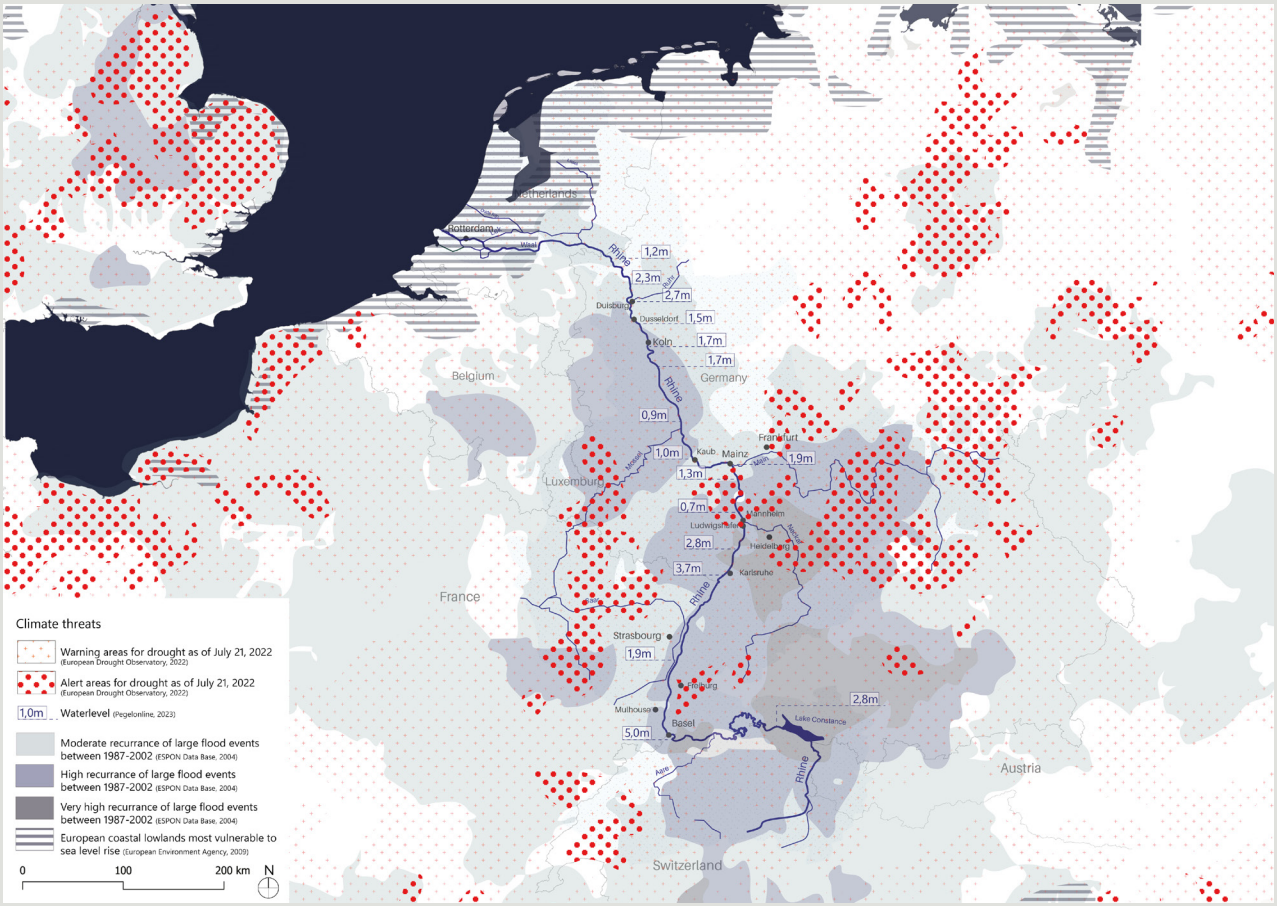
Effects of climate change in the Rhine River basin

Climate change is having a significant impact, particularly on the discharge patterns of the Rhine and its tributaries, with more frequent and severe periods of floods and low flow. As previously mentioned, the floods and droughts that happened along the Rhine and its tributaries in the past five years have shown how deadly and destructive the combination of climate change effects and the Rhine's natural water flow cycles can truly be.

These changes can lead to increased damage from floods and limitations on navigation and water supply during periods of low flow. Also, low flow can impact the quality and recharge of groundwater. Rising air temperatures are also leading to higher water temperatures, which, when combined with low flow, can cause ecological and chemical changes in water bodies.

It is important to note the role of over-designing the river banks and the removal of natural floodplains, meanders and oxbow lakes which mitigate short term flood discharge, and hold in moisture during dry periods.

Efforts have been made in recent years to better understand and assess the degree of impact on the discharge patterns of the Rhine due to climate change. A 2011 report on the Rhine discharge regime by The International Commission for the Protection of the Rhine found that winter discharges in the Rhine catchment could increase by up to 20% by the middle of the century, while summer discharges could decrease by up to 10%, with possible regional variations. In the delta, the salinization and subsidence also come into play, as they are made worse by any disbalance in the discharge levels.



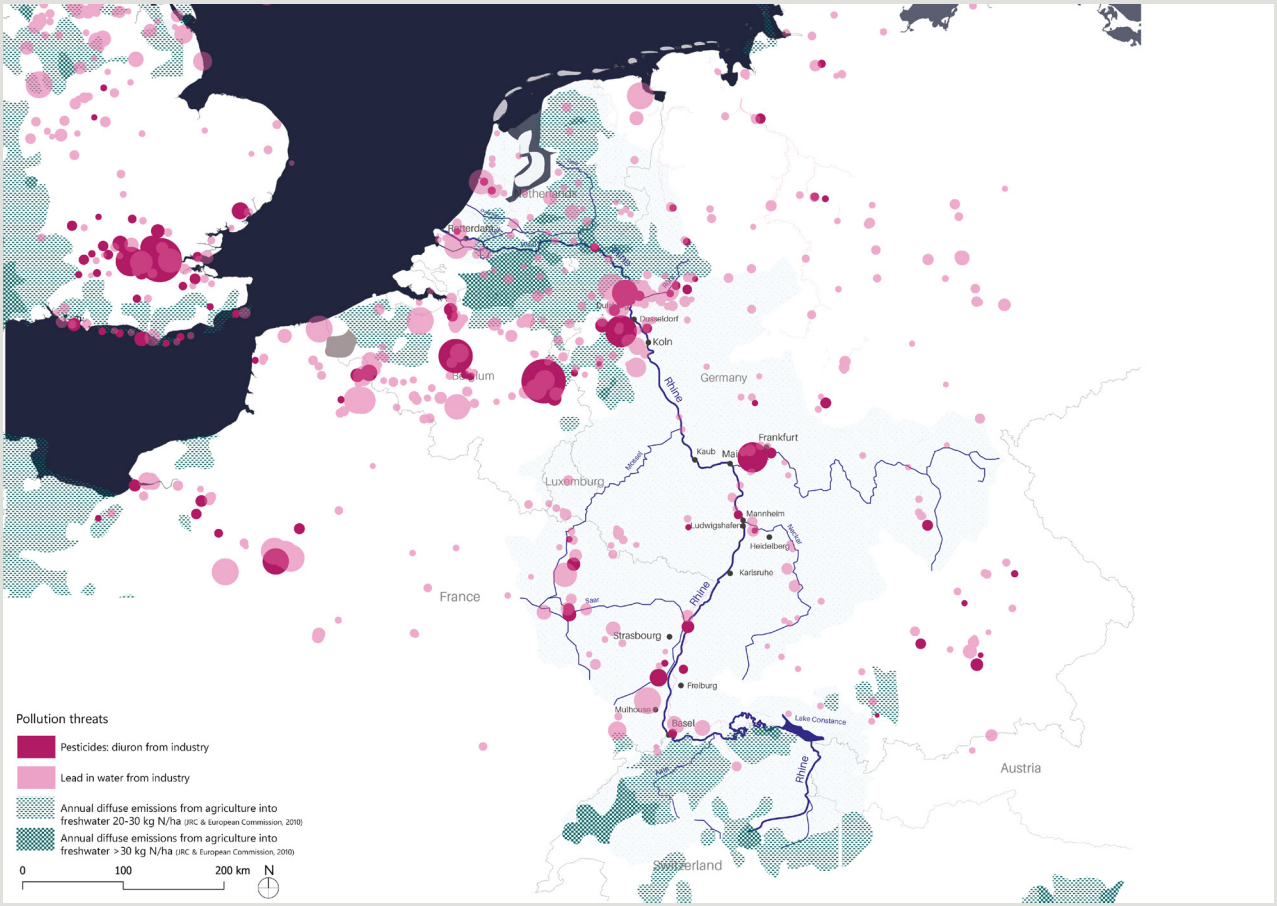
Effects of pollution in the Rhine River basin

Pollution in the Rhine River basin mostly originates from the surface, (diffuse) inputs of nitrogen and pollutants from agriculture, pollution due to historically polluted river sediments and substances measured in very low concentrations in water bodies (micro-pollutants). Nutrient pollution also takes part in warming of the waterbodies, causing eutrophication.

Industrial sites are also common sources of pollution, even though they are closely monitored. Industries present a threat mainly in case of accidents, such as the one which happened on Lake Constance in 2022, when almost three tons of toxic extinguishing foam got into the lake, which is normally used for drinking water. Shipping and navigation also continue to

Domestic pollution also needs to be closely monitored, as increasing amounts of microplastics and residual chemicals from antibiotics and other pharmaceuticals are found, not only in waste water, but also in the river itself.

In recent years, the Rhine and its tributaries have experienced significant pollution reduction, thanks to the collaboration of all ICPR member states and the implementation of the Rhine 2020 Programme. Notably, the reduction of point source pollutants from industrial and municipal sources contributed to this improvement.



03

Building our approach

Developing integrative resilience in the Rhine River basin

PROBLEM STATEMENT

Due to the accumulated consequences of climate change, pollution and extensive human intervention in the natural discharge, design, use and ecosystems of the Rhine River basin, the refion is left extremely vulnerable to flooding, drought, pollution, eutrophication, salinization and subsidence. This might result in overall loss of fresh water as we know it, both from the surface water of the rivers and lakes, as well as the groundwater. Thiswould have a destructive effect on the ecological systems, human health, well-being and happiness, and it would decimate our economies. Furthermore, effects of freshwater system collapse in the Rhine basin would have overarching consequences for millions of people around the world, since the region hosts some of the world's biggest production and distribution structures in terms of industry and agriculture.

However, the region is also one of the best-equipped for dealing with this type of challenge. Aside from being a wealthy and prosperous region, the countries in the Rhine basin have a history of collaboration and innovative solutions, as well as nature conservation.

Natural systems themselves hold strenght for transformation and resilience, and going back to applying nature based principles in order to deal with these challenges might allow for the system to regenerate, adapt and mitigate negative effects.

CONCEPTUAL FRAMEWORK

The Fresh Rhine is a project that seeks to create a resilient Rhine river basin by ensuring a clean and consistent water supply. Our goal is to achieve integrative resilience, which means that the system is regenerative, adaptable, and able to mitigate negative effects. Our approach involves looking at the topic through three hierarchic layers: Ecology, Society, and Economy.

The Ecology perspective is the most critical in our project, as without a functional ecosystem, other categories cannot work. We believe that a functioning ecosystem in the Rhine has biodiversity and regenerative wetland areas, but also needs to be thought through the lens of climate action. By using nature-based principles, we can restore the natural balance of the Rhine and ensure the sustainability of the entire system.

To achieve a functioning society in the region, we need to prioritize climate justice and ensure public access to water for everyone, so general well-being and happiness can be achieved. We also believe that having collaborative governments is a critical factor without which an integrative approach would not be possible.

Lastly, to ensure a functioning economy, all the previous categories should be satisfied, along with providing a functional water supply and compatible reuse cycles for agriculture and industries. We believe that by applying nature-based solutions, we can achieve a sustainable and thriving economy that benefits everyone.

The Fresh Rhine project highlights the importance of restoring the natural balance of the Rhine river basin and acknowledging the interconnectedness of the ecosystems, society, and economy.

ECONOMY

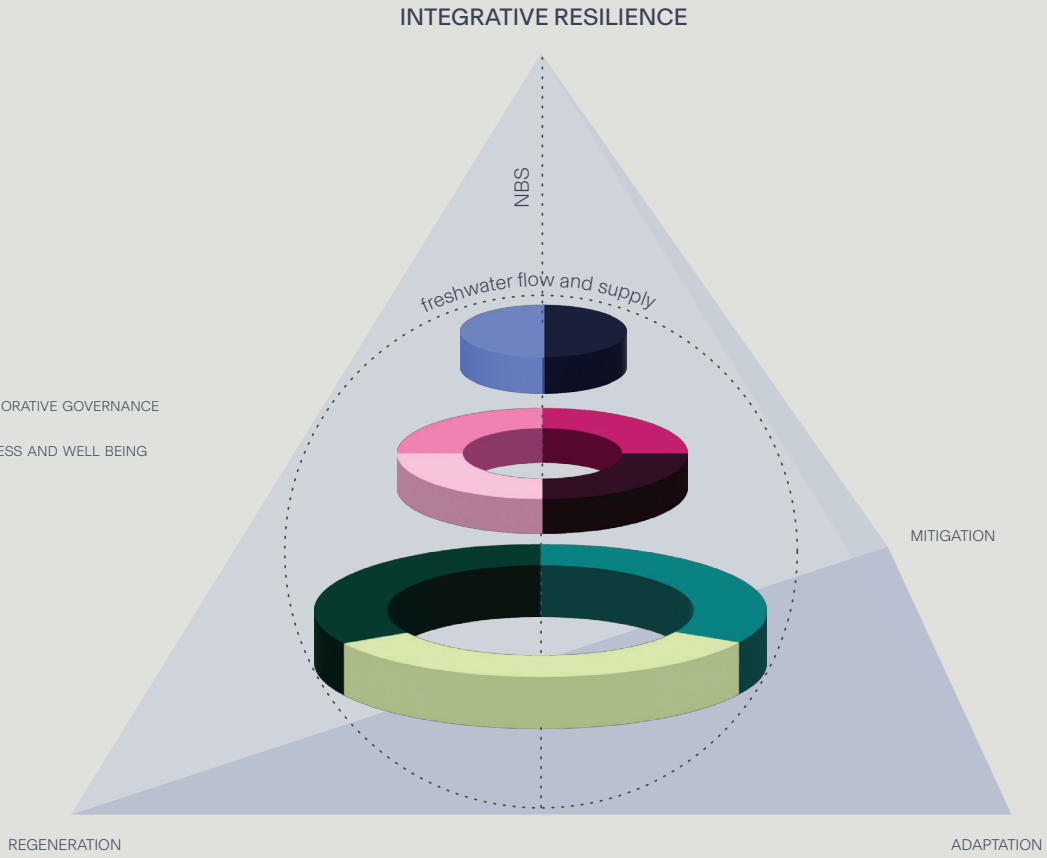
- COLLABORATIVE WATER CYCLES
- FUNCTIONAL WATER SUPPLY

SOCIETY

- CLIMATE JUSTICE
- WATER AS COMMON GOOD
- COLLABORATIVE GOVERNANCE
- HAPPINESS AND WELL BEING

ECOLOGY

- CLIMATE ACTION
- BIODIVERSITY
- REGENERATIVE WETSCAPES



Goals and objectives

The goal of achieving a resilient and integrated Rhine River basin, across the three main perspectives covered in our conceptual framework, is a big one. Our goal is to participate in achieving it by ensuring a clean and consistent freshwater flow and supply, which is the main goal for our project.

We plan on achieving this goal by reaching three objectives:
Creating a network of wetscapes (meaning blue network, with an accent of wetland landscape in particular), creating compatible cycles of water use (across sectors), and the integration of cross-border procedures (among the states sharing the basin).

broader goal
(A WIDER GOAL WE ARE CONTRIBUTING TO)

A RESILIENT AND INTEGRATED RHINE RIVER BASIN

goal
(ACHIEVABLE BY THIS PROJECT)

CLEAN AND CONSISTENT FRESHWATER FLOW AND SUPPLY

objective 1.

ESTABLISHING A NETWORK OF WETSCAPES

objective 2

CREATING COMPATIBLE CYCLES OF WATER USE

objective 3

CROSS-BORDER PROCEDURE INTEGRATION

Research question

How can **establishing a network of wetscapes** and **creating compatible cycles of water use**, while **integrating cross-border procedures** bring us towards achieving the goal of having **clean and consistent freshwater flow and supply** in a resilient Rhine river basin?

Principles introduction

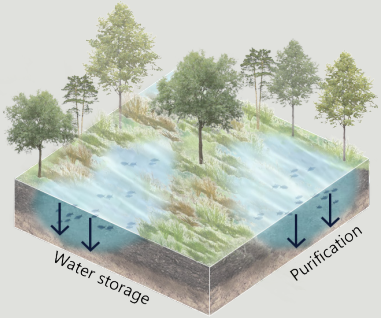
HOW DO WE ACHIEVE OUR OBJECTIVES?

principles	objective 1. ESTABLISH A NETWORK OF WETSCAPES	objective 2. CREATING COMPATIBLE CYCLES OF WATER USE	objective 3. CROSS-BORDER PROCEDURE INTEGRATION
SPATIAL PRINCIPLES	WETLANDS FLOODPLAINS RE-MEANDERING NATURAL SHORELINES	SUSTAINABLE AGRICULTURE WATER ADAPTIVE CITIES SUSTAINABLE INDUSTRIAL SITES	–
POLICY PRINCIPLES	CONSERVATION AND PROTECTION WETLAND RESTORATION AND RIVER RE-NATURING	MEASURES AGAINST POLLUTION RESPONSIBLE WATER USE	MONITORING AND EVALUATION COMMON LAWS ON BUILDING RESTRICTION, POLLUTION REDUCTION MEASURES AND WATER USE

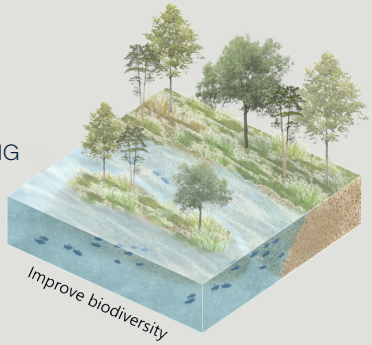
Spatial principles

ESTABLISHING A NETWORK OF WETSCAPES

WETLANDS



NATURAL ISLANDS AND RE-MEANDERING



Wetlands are areas of land that are saturated with water, either seasonally or permanently. They create unique ecosystems that support a diverse range of plant and animal species. Wetlands act as natural filters, purifying water and reducing pollutants that can cause harm to both wildlife and human health, while also playing an important role in mitigating the effects of climate change through carbon and nitrogen storage.

There are four main types of wetlands: marshes, swamps, bogs, and fens. Marshes are characterized by grasses and other non-woody plants, while swamps are dominated by trees and shrubs. Bogs and fens are both peat-forming wetlands, bogs are acidic and fed only by precipitation, while fens are fed by groundwater and are less acidic.

Wetlands act as carbon sinks, storing carbon from the atmosphere in soil and vegetation. Wetlands also play an important role in nitrogen storage, with the ability to convert nitrogen from the atmosphere into a form that can be used by plants. In order to sink the average carbon and nitrogen produced in the Netherlands, we would need an area of Amsterdam and Rotterdam combined to be covered in wetlands.

Wetlands help mitigate floods by acting as natural sponges, absorbing and slowly releasing excess water, reducing the risk of downstream flooding. During droughts, wetlands can help maintain streamflows and groundwater recharge. Wetlands also help prevent subsidence, the sinking of land due to groundwater withdrawal, by maintaining a high water table that supports soil stability.

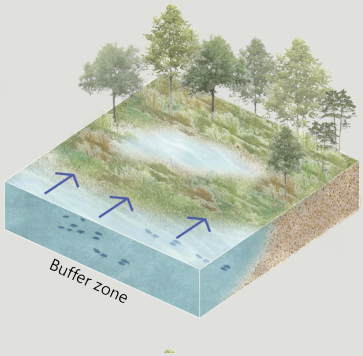
However, if they are not restored correctly and start drying out, they can become quite a danger to the environment, as they are known to be the most potent releasers of methane gases.

Re-meandering is the process of restoring a river to its natural, meandering channel after it has been altered or straightened by human activities such as channelization, dredging, or damming. Re-meandering provides several benefits, such as improving water quality, increasing biodiversity, and reducing the impacts of floods and droughts. Natural meanders help to slow down water flow, allowing sediment to settle and providing space for aquatic vegetation to grow. This, as well as increased absorption, can help reducing the speed and volume of water discharge during floods

Re-meandering can also help to mitigate droughts by increasing the amount of water stored in the riverbed and surrounding soils, which can be released during dry periods to maintain streamflow and support plant growth.

During re-meandering, oftentimes a small river island will be created where the bank used to be. These are very valuable as stepping stones in the creation of blue-green corridors and larger networks, since many species cannot get across the river if it is too wide. They also provide extra shallows, necessary for the development of rich riverine habitats, as well as for cleaning the water, mitigating high water discharge during floods and storing the moisture to be released during droughts.

FLOODPLAINS



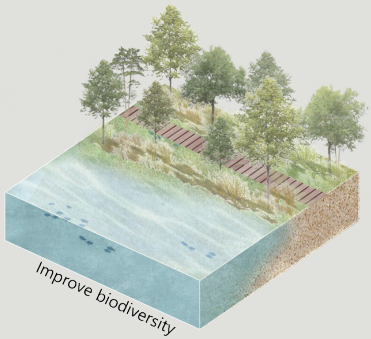
Floodplains are low areas adjacent to rivers that can be flodded periodically. These areas are among the most productive and diverse ecosystems on the planet, supporting a wide range of plant and animal species, and providing a host of valuable ecosystem services. Floodplains also provide opportunities for farming and other forms of land use, but their management requires a careful balance between preserving ecological health and providing economic benefits.

Floodplains play an important role in mitigating the impacts of floods by acting as natural sponges that absorb and slowly release excess water, reducing the risk of downstream flooding. Floodplains also help to filter and purify water, reduce erosion, and provide habitat for fish and wildlife. They are also important for recreation and cultural values, providing opportunities for fishing, hunting, and other outdoor activities.

In addition to their ecological benefits, floodplains can also provide opportunities for farming and other forms of land use. Floodplains are typically rich in nutrients and can support a wide range of crops, including rice, vegetables, and fruits. However, farming on floodplains requires careful management to minimize the risk of erosion and soil degradation, as well as the potential for crop loss due to floods.

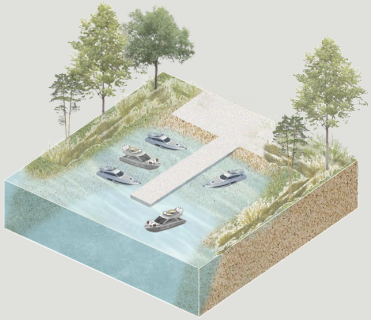
One approach to managing floodplains for both ecological and economic benefits is through the implementation of integrated floodplain management plans. These plans seek to balance the needs of different stakeholders, including farmers, landowners, and conservationists, and to promote sustainable land use practices that support both ecological health and economic development.

NATURAL SHORELINES



Natural shorelines are important for lakes and rivers because they provide habitats for aquatic and terrestrial species, protect against erosion, and filter pollutants. They also connect wetlands to the main water body, creating an interconnected ecosystem that supports biodiversity and provides important ecosystem services.

NATURAL PORTS

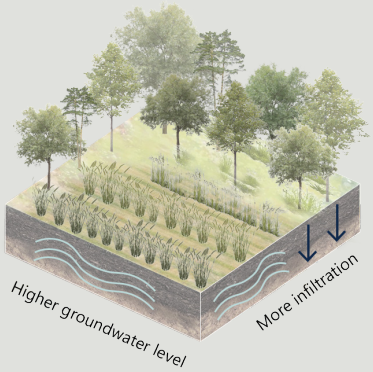


Ports can be designed in such a way that they have a dike with a natural shoreline around them, providing better natural connectivity for the shallow habitat, as well as a natural protection barrier for the port.

Spatial principles

CREATING COMPATIBLE CYCLES OF WATER REUSE - SUSTAINABLE LAND AGRICULTURE

AGROFORESTRY

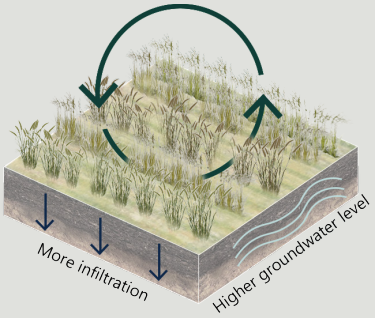


Agroforestry is a sustainable land management practice that combines agricultural crops with trees and/or livestock in the same area. It is considered a resilient approach that promotes natural resource conservation, biodiversity, and soil health. One of the main benefits of agroforestry is its ability to reduce water use.

It is particularly effective at reducing water use because the trees provide shade, which helps keep the soil cooler and reduces water loss through evaporation. Also, they can capture and lock in moisture for lower levels. Trees also stabilize the soil, reducing erosion and increasing the soil's water-holding capacity. Agroforestry can also be practiced in floodplains, which is another one of our principles. There it can provide additional benefits such as reducing erosion, stabilizing riverbanks, and improving water quality.

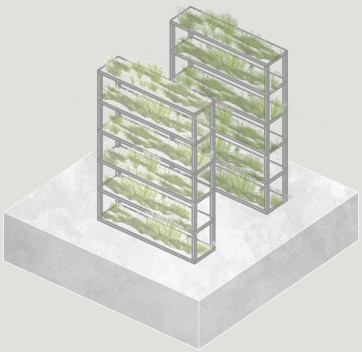
In our areas, there are several crop combinations that are commonly used in agroforestry systems. One popular combination is apple trees with pasture for grazing livestock, which is known as silvopastoral agroforestry. Another popular combination is cereal crops such as wheat or barley with rows of trees, which is known as alley cropping. Another combination that can be grown in North West Europe is hazelnut trees with berry bushes or vegetables, which is known as multi-strata agroforestry. This system can be particularly effective at reducing water use because the trees provide shade and the berry bushes or vegetables help retain moisture in the soil.

CROP ROTATION



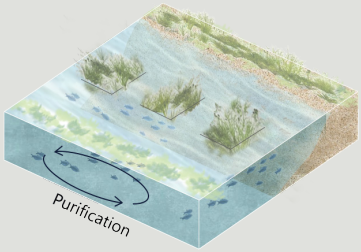
Crop rotation is a technique that involves planting different crops in a specific sequence on the same area of land over several years. This method of farming saves water by preventing the depletion of soil nutrients, which in turn reduces the need for more irrigation. For example, legumes like peas or beans can be planted in the first year, which add nitrogen to the soil, followed by cereals like wheat or barley in the second year, which take up the nitrogen from the soil. A third year may be left fallow, allowing the soil to recover, before re-starting the crop rotation cycle.

VERTICAL FARMING



Vertical farming is an innovative agricultural practice, which allows farmers to save space by stacking plants on top of each other. This frees up a lot of space currently dedicated to fields, but also presents an opportunity to combine with other sustainable practice. Hydroponics and aquaponics are popular soilless choices for vertical farming.

FLOATING FARMS

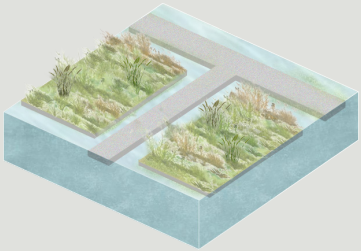


Floating farms are a new and integrative concept of farming that involves growing crops and/or raising livestock on floating platforms. They are used in urban areas, at the coast, or in flood-prone areas, where space is very limited or the land is prone to subsidence. Floating farms can be an alternative to agricultural practices which are currently causing subsidence since they do not rely on the ground for support, making them immune to soil subsidence or ground instability.

If the flood is not too strong or sudden, floating farms can also be used in floodplains as a flood mitigation measure by diverting floodwaters onto the farms, which can reduce the impact of floods on nearby communities. They can also provide additional benefits, such as reducing soil erosion, improving water quality, and creating new habitats for wildlife.

The integration of floating farms with floodplains can be achieved by designing them to withstand floodwaters and incorporating flood-resistant crops and livestock. This can help reduce the risk of crop loss and animal casualties during flooding, and also increase the resilience of the farm. Additionally, floating farms can serve as a means of food production during and after flooding events, providing a source of food security for local communities.

AQUACULTURE



Aquaculture is the cultivation of aquatic organisms, such as fish, shellfish, and aquatic plants, in controlled environments such as tanks, ponds, or raceways. Recently, it has become a rapidly growing sector of food production and plays a significant role in meeting the increasing demand for seafood while reducing the pressure on wild marine habitats and fish populations.

Aquaculture is also beneficial for water use, because it requires significantly less water when compared to traditional land-based agriculture. This is because the water used in aquaculture gets recycled, and the waste products produced by the fish or shellfish are then reused as a nutrient source for aquatic plants or as fertilizer for crops.

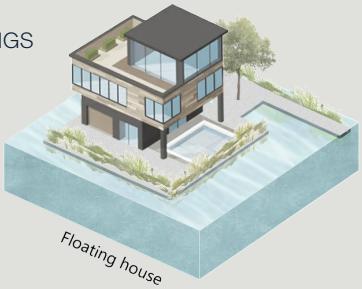
There are several examples of successful aquaculture operations. In Scotland, salmon farming is a significant industry, with an estimated production value of over £1 billion. Norway is also a major producer of Atlantic salmon, and the Netherlands is a leader in European eel farming. In the Netherlands, this is also a popular method for farming mussels and oysters.

In addition to fish and shellfish, seaweed cultivation is also gaining popularity in northwest Europe. Seaweed is a sustainable crop that can be used in a variety of products, such as food, cosmetics, and fertilizers. One such example is Ireland, which has growing seaweed industry that produces a range of products, from health supplements to skincare products.

Spatial principles

CREATING COMPATIBLE CYCLES OF WATER REUSE - WATER ADAPTIVE CITIES

WATER RESISTANT BUILDINGS



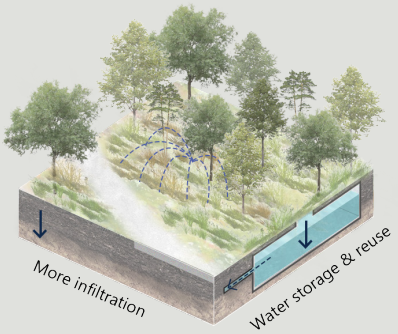
One way to mitigate the impact of both regularly occuring, and climate change fueled flooding is through the construction of water-resistant buildings, which are designed to withstand water intrusion and remain habitable during and after flood events.

Water-resistant buildings can take many forms, but two popular strategies are building on stilts and constructing floating housing. Building on stilts involves elevating the living space above ground level, creating a buffer zone between the building and potential floodwaters. This method is commonly used in coastal areas and flood-prone regions, where storm surges and rising sea levels pose a threat to traditional construction. In case of placement in a sensitive area such as near the river or lake shore, or in the dunes, the houses must be made low-impact on the environment in other regards as well.

Floating housing, on the other hand, is designed to float on top of water, allowing it to rise and fall with changing water levels. This approach is particularly useful in riverine or delta regions, where floods can occur quickly and without warning. Floating homes can be built on pontoons, which provide stability and support, and can be anchored in place to prevent drifting.

Water-resistant buildings can be helpful in reducing subsidence and water stress because they reduce the need for unsustainable flood mitigation measures, such as dams, dikes and levees. By constructing buildings that are designed to withstand flooding, communities can reduce the risk of property damage, loss of life, and economic disruption.

URBAN SPONGES

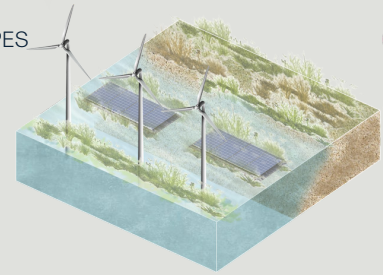


Urban sponge parks mimic natural hydrological processes in order to absorb and manage rainwater runoff. They are designed to collect and retain water in soil and vegetation, and then allow it to slowly infiltrate and recharge groundwater systems, rather than overwhelming drainage systems and causing flooding, which happens with traditional impermeable city infrastructure. By retaining and filtering water, sponge parks can also help mitigate drought conditions by increasing soil moisture and reducing the need for irrigation.

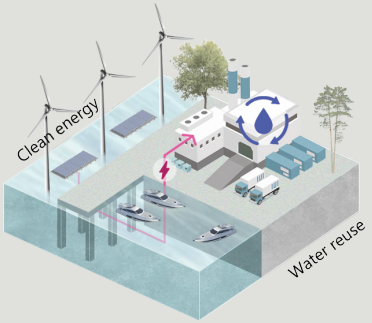
The parks are typically designed with features such as rain gardens, bioswales, and with permeable pavement to facilitate water infiltration and retention. They can also include elements such as green roofs, trees, and other vegetation that help absorb and transpire water. Urban sponge parks can also improve air quality, provide habitat for wildlife, and enhance urban aesthetics and recreation opportunities, contributing to overall happiness and well-being of citizens and urban flora and fauna.

CREATING COMPATIBLE CYCLES OF WATER REUSE – SUSTAINABLE INDUSTRIAL SITES

NEW ENERGY LANDSCAPES



SUSTAINABLE PORTS



As we move toward a low-carbon future, the demand for clean energy sources such as hydrogen is also increasing, which requires significant amounts of power. This means that the transition to sustainable energy sources is bringing us to the emergence of new energy landscapes, where areas are will have to be transformed to accommodate large-scale wind and solar energy generation infrastructure.

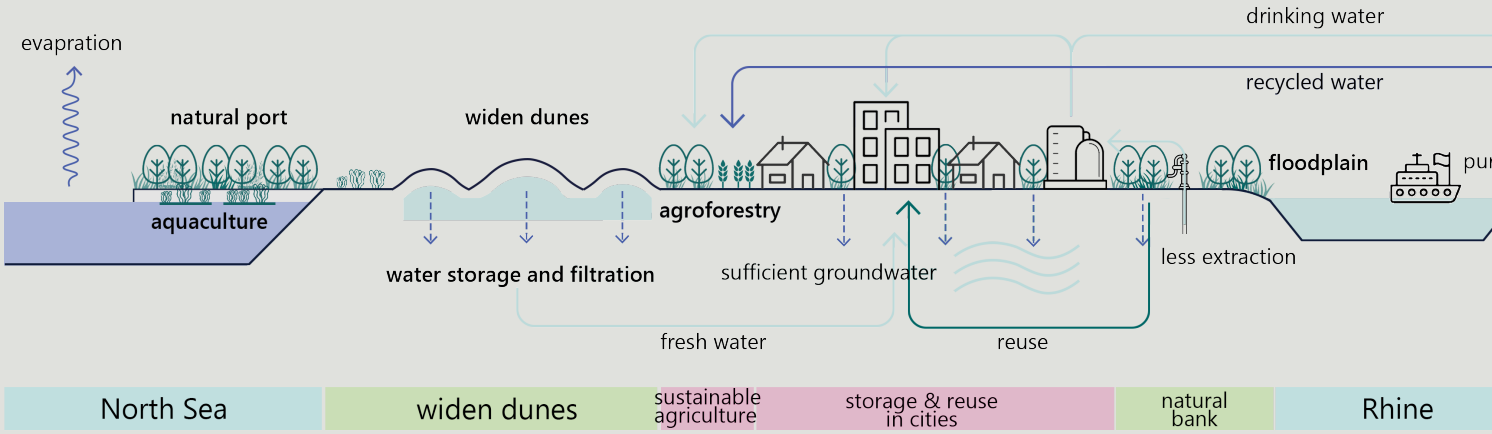
To meet this demand, hybrid systems that combine renewable energy generation with water storage should be applied. Also, the construction of these new energy landscapes presents an opportunity to integrate water conservation measures into their design. By including features such as rainwater harvesting, greywater recycling, and green infrastructure, these landscapes can help to reduce water demand.

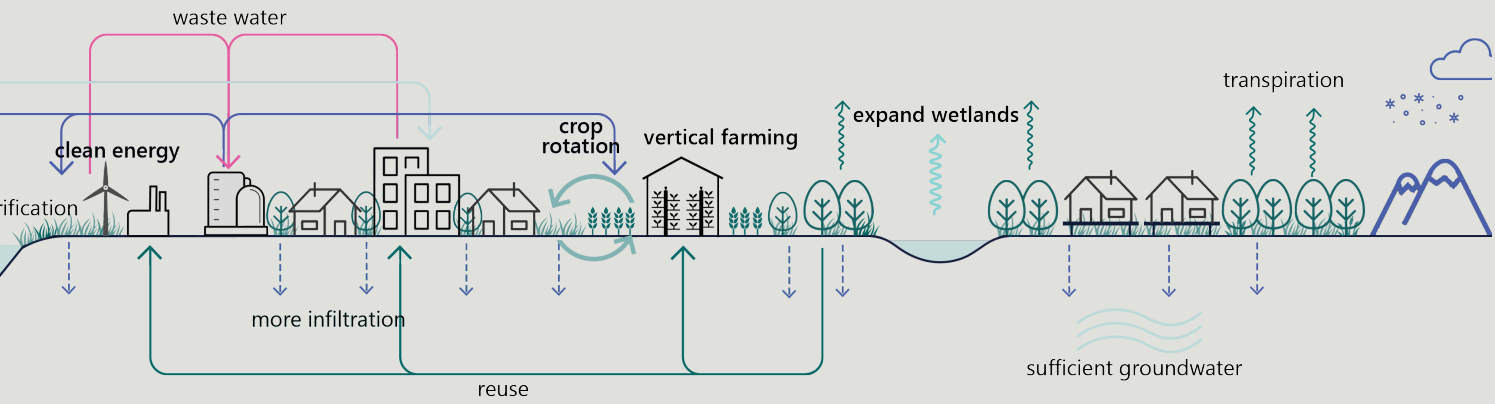
We plan on achieving this goal by reaching three objectives:
Creating a network of wetscapes (meaning blue network, with an accent of wetland landscape in particular), creating compatible cycles of water use (across sectors), and the integration of cross-border procedures (among the states sharing the basin).

Cumulative effects of the application of all spatial principles on the hydrological cycle

In this section we show the full application of our spatial principes on the hydrological cycle. If observed in combination with the section describing the effects of climate change (pages 16 and 17) it becomes clear how exactly our interventions have an impact not only for the location and specific issue they relate to, but also on the entire cycle.

However, in order to achieve this we need to have policies which makes the implementation of these principles possible.




waste water
clean energy
rification
crop rotation
vertical farming
expand wetlands
transpiration
more infiltration
reuse
sufficient groundwater
natural bank
green industry
storage & reuse in cities
sustainable agriculture
wetlands network
water resistant buildings
wetlands
permafros

Policy principles

Policy principles are applied in order to support the spatial interventions, and create the opportunities for reaching the objectives, and finally, the goal of the project. They are also a continuation or in some cases, intensification of already present policy efforts put forth by the ICPR, EU, Ramsar and UN (more on this in chapter 5). An added objective specifically for the policy principles is the topic of cross-border procedure integration, a key topic and takeaway from our project, which can only be done effectively through policy.

ESTABLISHING A NETWORK OF WETSCAPES

POLICY PRINCIPLE 1.1: CONSERVATION AND PROTECTION

Even though the region already has some of the best conservation and protection practices, this direction needs to continue and accelarate in order to provide significant protection to wetlands, floodplains, rivers, lakes and other natural structures. Our policy principle forsees the spreading of the network of conservated and protected wet areas, providing protections even for small scale wetlands, such as oxbow lakes and small urban wetlands in order to create and strenghten networks and corridors.

POLICY PRINCIPLE 1.2: WETLAND RESTORATION AND RIVER RE-NATURING

In order to be able to transform the areas back into natural structures such as wetlands or natural shores, legislation and financial incentives will be required in order to solve issues of land ownership, existing and future infrastructure that needs to pass through the area, etc.

CREATING COMPATIBLE CYCLES OF WATER REUSE

POLICY PRINCIPLE 2.1: MEASURES AGAINST POLLUTION

Going towards a goal of zero environmental impact by 2100, meaning zero chemical, micropollutant, nutrient, oxygen or thermal pollution caused by humans measured in the waters.

POLICY PRINCIPLE 2.2: RESPONSIBLE WATER USE

Incentives, and later policy, promoting water reuse within the household or business, as well as across different sectors. The goal is to reduce the amount of water extracted from natural sources by 15%

CROSS-BORDER PROCEDURE INTEGRATION

POLICY PRINCIPLE 3.1: MONITORING AND EVALUATION

Completely comon system for glacier melting, rainfall, flood, drought, pollution, and salinization monitoring for all countries in the basin. A similar thing already exists but the integration needs to continue towards internal government agencies, research institutes etc.
More regular to real-time monitoring accross more areas, available to all members. Incentivising the development of new technologies for more specific monitoring and reporting. Stricter evaluation procedures.

POLICY PRINCIPLE 3.2: COMMON LAWS ON BUILDING CODES, POLLUTION AND WATER USE

Equalizing the existing distances in policy and legislation accross the different countries in the basin, such as set back distances for river shores. Creating new common laws, such as new laws for the restoration of wetlands etc.

04

Vision for a Fresh Rhine


Delta
Netherlands
Rotterdam
Waal
Ruhr area
Rhine
Ruhr
Duisburg
Dusseldorf
Koln
Belgium
Germany
Rhine
Upper-middle Rhine
Kaub
Mainz
Frankfurt
Main
Mosel
Luxemburg
Mannheim
Ludwigshafen
Neckar
Heidelberg
Karlsruhe
France
Saar
Rhine
Strasbourg
Freiburg
Lake Constance
Mulhouse
Basel
Lake Constance
Aare
Rhine
Austria
Switzerland
100
200 km
N

Defining the subregions

FINDING RHINE'S CRITICAL SPOTS

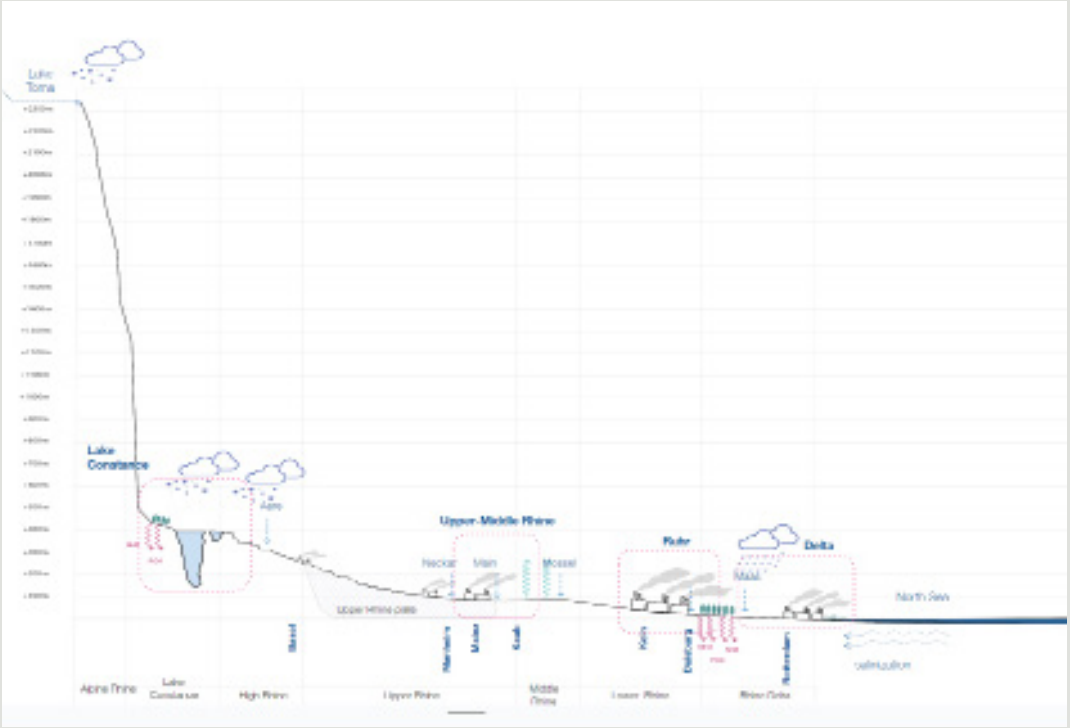
After researching the area, we noticed several interesting areas. We wanted our areas to be located across different sections of the Rhine, to show the realities of some of the most urgent issues. However, that still left us with a lot of choices. So we examined the river even further, trying to under stand its specific hydrological cycle and how are problems created and solved within the Rhine basin.

When looking at the section, the altitude difference which occurs in the first 100 km is astonishing. This is one of the reasons we found the location of Lake Constance to be of particular interest to us. It is a deep basin into which glacial water is stored. But what happens when there is no more glacier? And how can we preserve this natural water reservoir from pollution and warm temperatures?

The second location was not hard to find. Kaub, a small town in the Rhine mountains is famous for being the chokehold of the Rhine, with the lowest water levels usually being measured there. Observing the map and section explained why this happens. Kaub is situated in a gorge, after the river went through a flood plain. The discharge speed before Kaub is too slow, while at Kaub it gets very fast due to the shape of its embankment.

Third location we decided on is Ruhr. The famous German industrial area, once known for its coal related industries, now going through a green transition. How can we use this example to show the future of a co-existence of rivers and carbon neutral industries?

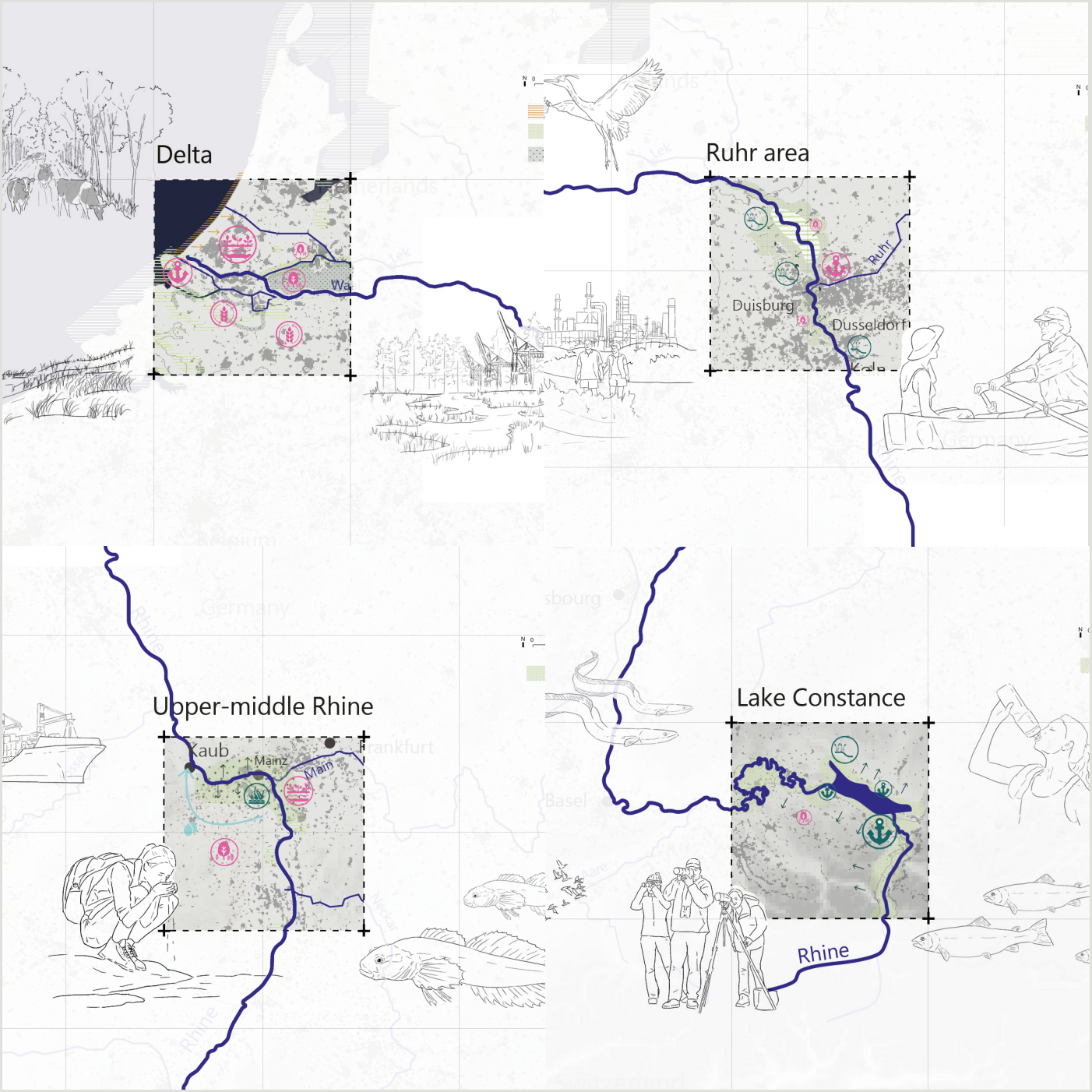
The final location is the South Holland delta, where Rhine meets the North Sea. A lot of issues flow downstream to the delta, only to be met with new ones, in particular salinization, subsidence and sea level rise.



IN 2100..

the Rhine will be an integrative and resilient river basin that c
utes to the happiness and well-being of the region's citizens,
biodiversity within a wetscape network, ensuring climate just
by preserving the freshwater system.

contrib-
improves
tice for all


Delta
Ruhr area
Ruhr
Duisburg
Dusseldorf
Upper-middle Rhine
Kaub
Mainz
Main
Lake Constance
Rhine

Vision statement and visions for the subregions

ELABORATION

Our vision is a resilient Rhine river basin that contributes to the happiness and well-being of the region's citizens, improves biodiversity, and restores vital landscapes while ensuring climate justice for all by preserving the freshwater system. By the 22nd century, we aim to develop an adaptable, integrative, and regenerative human system that operates in harmony with the natural water cycle.

The Rhine River basin's condition is defined by its dependence on freshwater systems, spanning across North Western Europe. Freshwater pollution and scarcity are significant challenges that require innovative solutions. Therefore, we believe that introducing new compatible water use cycles within cities, agriculture and industries, as well as creating adaptable wetscapes can help ensure the protection, conservation, and sustainable use of freshwater resources in the region.

Focusing on four crucial areas along the river, we will create a system that prioritizes a clean, adaptable, and regenerative water cycle that caters to the varying functional and spatial aspects of the different locations along the Rhine. To achieve this, we will implement targeted spatial solutions and general principles tailored to the specific needs of each area, collaborating with stakeholders, including government, private companies, civil society groups, and local communities.

We envision a future where the Rhine River basin and the selected subregions are leaders in sustainable water management and a model for other regions facing similar challenges. We believe that by creating a more integrative resilience system, we can build a better future for generations to come, where we leave room for nature, prioritize sustainability, and ensure the protection, conservation, and sustainable use of freshwater resources in the entire Rhine River basin. We are committed to making this vision a reality and inspiring others to do the same.

In Lake Constance, we want to preserve the health of the lakes which are storing clean glacial waters to travel further downstream along the Rhine. In the future, this large water basin might become critical infrastructure, and we have to treat it as such even now. Creating buffer zones of wetlands, and renaturing the shores will be a priority, in order to restore the self-cleaning mechanisms of the lake.

In Upper-middle Rhine we need to tackle the issue of the water discharge, especially in periods of drought. Therefore, we want to create floodplains which can capture the water before it reaches the bottleneck in the mountains. Water storing will also be done in higher areas on the hills, as well as urban areas like Mainz, where extraction rates need to be fully minimized.

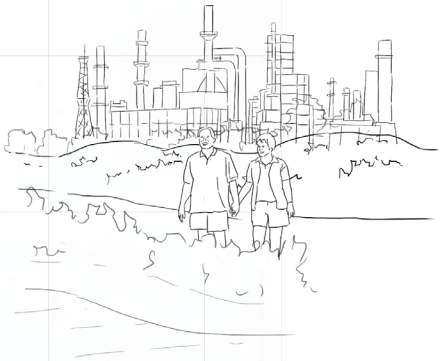
In the Ruhr area, we are saying goodbye to the industrial pollution dripping into the waterstream. As the energy and industry sectors transition towards a carbon neutral future, we need to secure a more natural shoreline, which needs to connect into a bigger wetland network. Allowing access to the river bank will also positively impact the many citizens of the Ruhr metropolitan area.

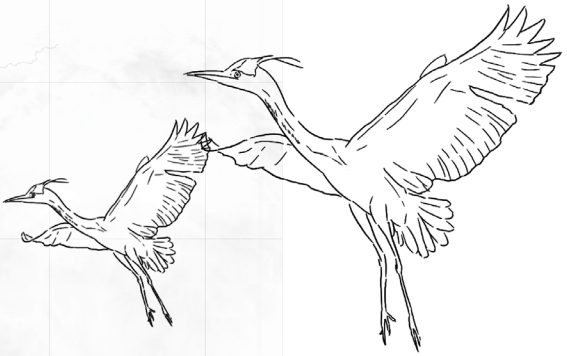
In the Delta, a variety of problems can be resolved by applying principles that are elaborated in a multifunctional way. For instance, recreation and dunes, or wetlands and agroforestry. The important factors to consider are that the dunes need to be widened, the port needs to become sustainable, reuse is needed in cities, and agriculture should transform into sustainable forms of agriculture.

For the entire Rhine river system, all the principles can be connected and summarized into two main spatial objectives for the entire Rhine river basin, as well as one that is non-spatial: the creation of adaptive wetscapes and the establishment of compatible cycles of human water use, as well as a cross-border collaboration on policy and legislation.

The wetscapes are visible in the overall vision map, are important in each area, and will be connected with green structures along the Rhine. These wetscapes can serve as an essential green-blue network. The establishment of compatible cycles of human water use is mainly connected in a non-spatial way, and their influences and connections become apparent in the systemic sections. These cycles work as a system, and the countries in the basin need to work together too, in order to bring about this vision.


Delta
Ruhr
Belgium
Luxemburg
France
Saar
Widening dunes
Expanded wetlands
Wetscape network
Agroforestry
0
100
200 km
N





area

Ruhr

burg

Düsseldorf

Cologne

Germany

Upper-middle Rhine

Koblenz

Mainz

Main

Frankfurt

Mosel

Neckar

Rhine

Strasbourg

Lake Constance

Basel

Aare

Rhine

Switzerland

05

Strategy for a Fresh Rhine

Stakeholder analysis

STAKEHOLDERS TOTAL OVERVIEW

As an overview of the relevant stakeholders in our intervention areas, we look at which belong to the public, private and civil sectors. Generally speaking, key topics for the public sector are interrelations and policy change, for private sector the topics of space, practices and profit, and for the civic participation and responsibility.

UN

international organization dedicated to ensuring peace, dignity and equality on a healthy planet

NATIONAL GOVERNMENTS

Swiss, Austrian, German and Dutch government and their ministries

INDUSTRIES

chemical factories, petrochemical, textile and materials, steel industry, manufacturing

CITIZENS

citizens in the area, but also those affected by any changes in the processes in the Rhine, specifically industries, shipping and food production

EU

supranational political and economic union of 27 member states on the European continent.

*Liechtenstein and Switzerland are not in the EU.

STATES/CANTONS/PROVINCES

Vorarlberg
St. Gallen
Thurgau
Schaffhausen
Badem - Wurttemberg
Rheiland - Pfaltz
Nordrhein - Westfalen
Zuid Holland

PORTS

Port of Konstanz
Dusseldorf port
Duisburg port
Port of Rotterdam

* also other ports sharing shipping routes with the ports along the Rhine

ACTIVIST ORGANIZATIONS

Greenpeace, Xtinction Rebellion (international);
Klimavolksbegehren (Austria);
Pro Natura (Switzerland);
BUND, Germanwatch (Germany);
Milieudefensie URGENDA (Netherlands)

ENVIRONMENTAL AGENCIES

intergovernmental
UN-Water, European Environment Agency
NGO
WWF, Deltares, Wetlands international, Bodensee Stiftung, Living Lakes

GOVERNMENT AGENCIES

UBA, BAW, BMLRT, Austrian provincial water directories; FOEN, EAWAG, SAEFL, Swiss canton water agencies; BfN, BfG, UBA, WSV, German state water agencies; Rijkswaterstaat, Waterschappen, PBL

FARMERS ASSOCIATIONS

Osterreichischer Bauernbund (Austria); Schweizerischer Bauernverband (Switzerland); Deutscher Bauernverband (Germany); LTO Nederland (Netherlands); COPA and Cogeca (EU)

NATURE

silent, everpresent stakeholder

International Commission for the Protection of the Rhine (ICPR)

9 states and regions in the Rhine watershed co-operating to harmonize the many interests of use and protection in the basin.
Focal points are sustainable development and the good state of all waters in the watershed.

MUNICIPALITIES

Bregenz; Kreuzlingen; Konstanz, Friedrichshafen, Mainz, Kaub, Dusseldorf, Duisburg; Krimpenerwaard, Molenlanden Hoek van Holland, Westland, Voorne aan Zee, Voorne Putten, Goeree-Overflakkee

EMPLOYEES

workers in different sectors in the Rhine basin, who will be affected by the strategy, as well as current climate change trends.

FUTURE GENERATIONS

silent, not yet present stakeholder

Central Commission for Navigation on the Rhine (CCNR)

responsible for the safety and environmental impact of shipping on the Rhine (ship design and construction, training of crew members, and transport of dangerous goods).

ASSOCIATIONS OF WATER TREATMENT AND SUPPLY COMPANIES

OWAV (Austrian);
Aqua suisse (Swiss);
BDEW (German);
Vewin (Netherlands)

TOURISTS

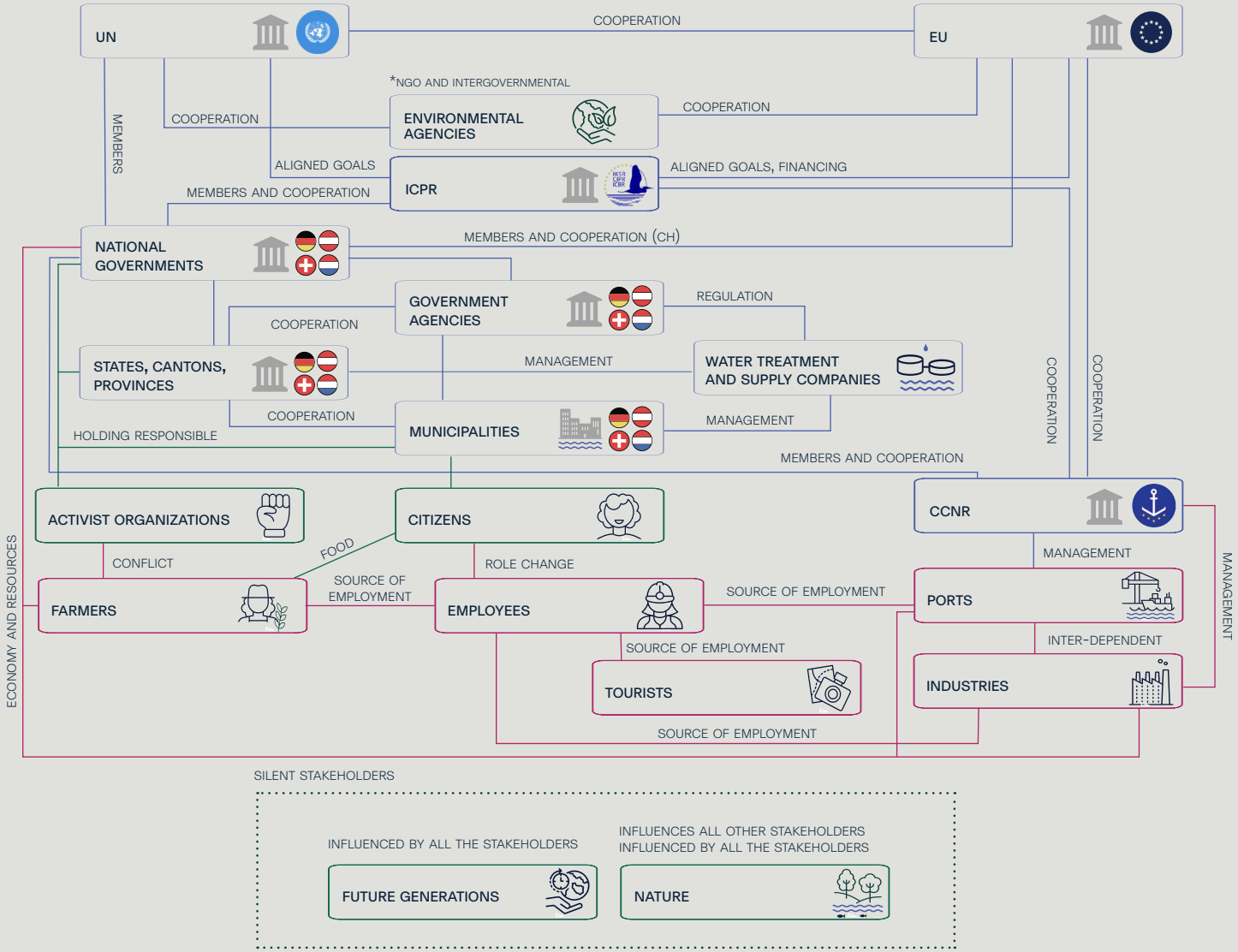
visitors to the Rhine basin cultural, natural and urban areas, that bring economic growth to the region, but can also put a strain on water use as well as create additional pollution and disturb the habitat.

LEGEND

PUBLIC
PRIVATE
CIVIL

Stakeholder analysis

STAKEHOLDER RELATIONS



Stakeholder analysis

CONCLUSION

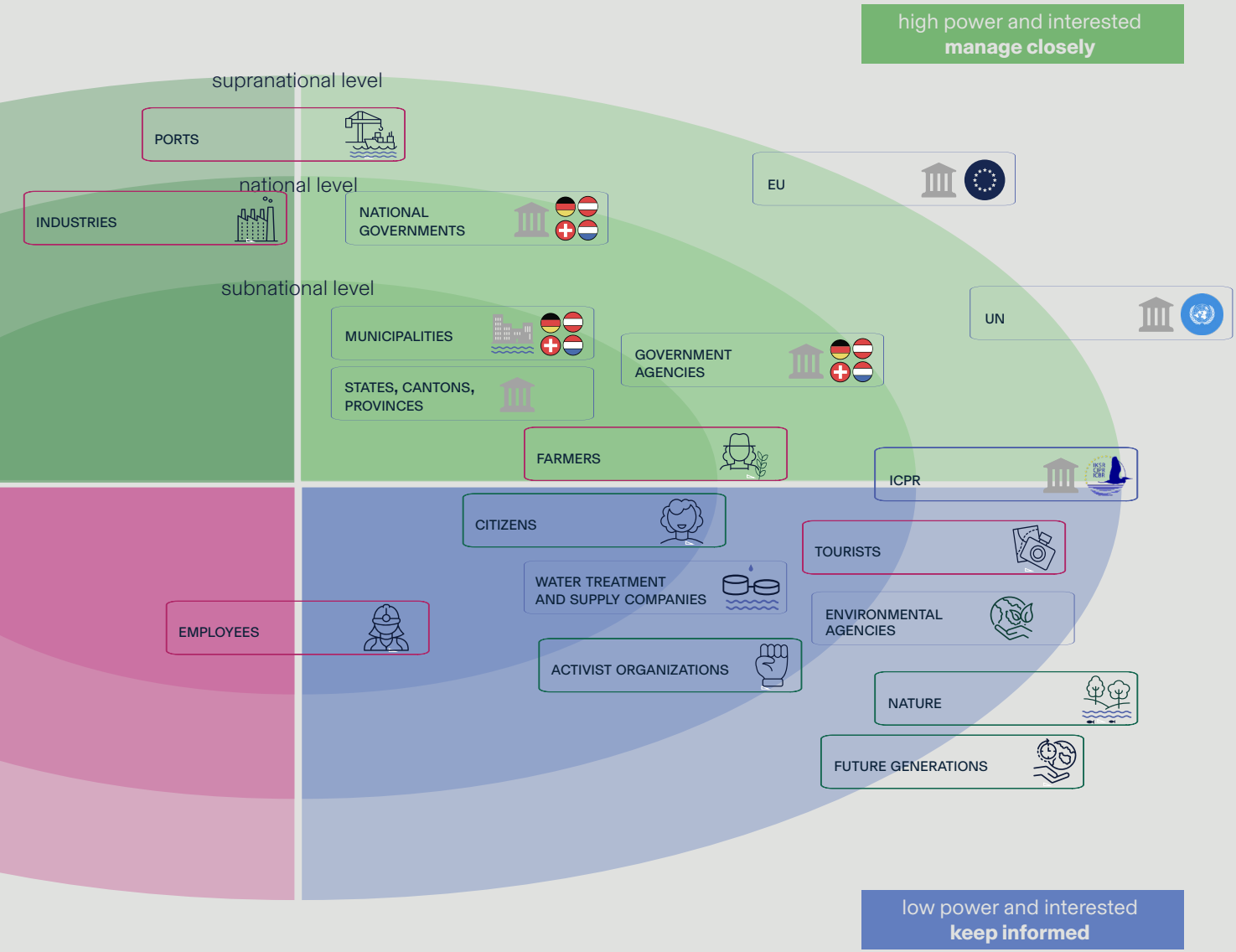
Understanding the scope, relations, and positioning of stakeholders within this project is crucial for developing an implementation strategy.

Since we are looking at the entire Rhine River basin, and projects range over 600 km of distance, listing everyone impacted by any changes in the river system and adjacent areas would be impossible, therefore we have selected the stakeholders it is necessary to communicate and engage with throughout the strategy's implementation.

In the total overview, we have looked at not only the general groups of stakeholders but have tried to provide as much precision as possible in terms of specific associations, agencies, organizations, municipalities, subnational administrational units, and companies, identifying them as public, private and civic stakeholders (or sometimes a combination!). Furthermore, looking at their interrelations allowed us to understand what type of influence different stakeholders hold over one another. It also helped to see which stakeholders wield a wider net of influence and can serve as connectors between those stakeholders that might have conflicting needs. To finish the analysis, we mapped the stakeholders depending on their level of power and interest across three scales: subnational, national, and supranational. This provided input on how we can approach different stakeholders, and further helped to identify key players.

As a result of our stakeholder analysis, we can conclude that the national governments and their ministries, due to their legislative power, are the key to achieving the goals and objectives of this strategy. However, the EU and international organizations, specifically the ICPR, need to be highly involved in order to strengthen the integration and cooperation between the different governments, as well as other stakeholders from the civic and private sectors. Special attention needs to be given to future generations and nature, as silent stakeholders, towards whom we carry a duty of care.

STAKEHOLDER MAP


high power and interested
manage closely
supranational level
PORTS
national level
INDUSTRIES
NATIONAL GOVERNMENTS
EU
subnational level
MUNICIPALITIES
STATES, CANTONS, PROVINCES
GOVERNMENT AGENCIES
UN
FARMERS
ICPR
CITIZENS
TOURISTS
WATER TREATMENT AND SUPPLY COMPANIES
EMPLOYEES
ENVIRONMENTAL AGENCIES
ACTIVIST ORGANIZATIONS
NATURE
FUTURE GENERATIONS
low power and interested
keep informed
interest

Policy analysis

OVERVIEW OF KEY EXISTING POLICY

ICPR

RHINE 2040

It is a collaborative strategy aimed at improving the ecological and chemical quality of the Rhine river and ensure its resilience and sustainability, **especially promoting working together.**
Main objectives are:
1. Networked habitats - passability of migratory fish, Rhine biotope network, reducing thermal discharges and pollutants
2. Good water quality - reducing nutrients going into ground water, micropollutants to be reduced by 30% in regards to 2016-2018 period, joint water evaluation system, reduced entry of waste
3. Mitigation of flood risks - 15% reduction in flood risks by 2040, by 2030 additional measures and floodplains
4. Managing low water - joint monitoring and measures

RAMSAR CONVETNITON

STRATEGIC PLAN 2016-2024

The Ramsar Convention is an international treaty which promotes the conservation, restoration and sustainable use of wetlands and their resources.
The strategic plan for 2016-2024 period includes:

1. Addressing the drivers of wetland loss and degradation
2. Effectively conserving and managing the Ramsar site network
3. Wisely using all wetlands
4. Enhancing implementation

UN

2030 AGENDA FOR SUSTAINABLE DEVELOPMENT

2030 SDA aims to globally end poverty, protect the planet, and ensure peace and prosperity for all by 2030 through 17 Sustainable Development Goals, that cover a range of interconnected social, economic, and environmental issues. SDG 6, dealing with clean water and sanitation, has the following targets:

1. Universal access to drinking water
2. Access to adequate sanitation
3. Reducing water pollution
4. Increase water-use efficiency
5. Implement integrated water resources management
6. Protect and restore water-related ecosystems - forests, wetlands, rivers, aquifers and lakes

EU

WATER FRAMEWORK DIRECTIVE

WFD sets the fundamental framework for water policy in Europe, influencing both EU and national water laws. The WFD has led to significant improvement in the state of waters across Europe. Main objectives are:

1. To protect, enhance and restore the quality of surface waters and groundwater
2. To ensure the sustainable use of water resources
3. To contribute to mitigating the effects of floods and droughts
4. To promote the progressive reduction of the pollution of water.
5. Encouraging the use of nature-based solutions
6. Enhancing public participation
7. Addressing emerging pollutants

EU

HABITATS DIRECTIVE

HD aims to protect and conserve Europe's natural habitats and species.

It requires Member States to establish a network of protected areas called **Natura 2000** sites. These sites must include habitats and species listed in the Annexes, which are considered to be of European importance. The level of protection given to Natura 2000 sites is high, and these sites are afforded a range of legal protections.

The Directive also requires Member States to designate Special Areas of Conservation.

EU

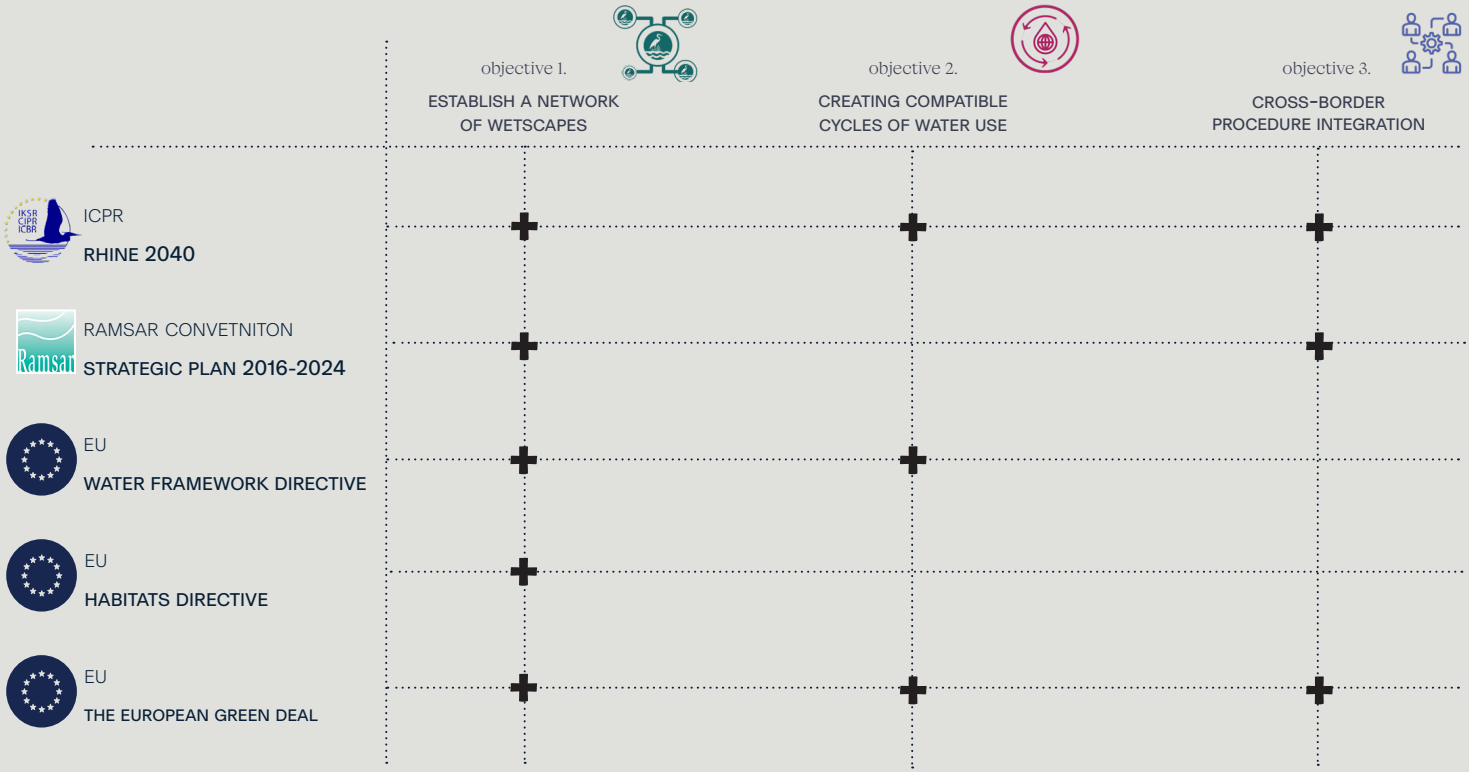
THE EUROPEAN GREEN DEAL

The Green Deal aims to transform the EU economy to be more sustainable and CO_2-neutral. Its main objectives include:

1. Climate neutrality - net 0 by 2050;
2. Clean energy;
3. Sustainable mobility;
4. Biodiversity - to protect and restore biodiversity, including the restoration of degraded ecosystems;
5. Sustainable food systems;
6. Circular economy;
7. Pollution reduction - including water;
8. Just transition - no one left behind.

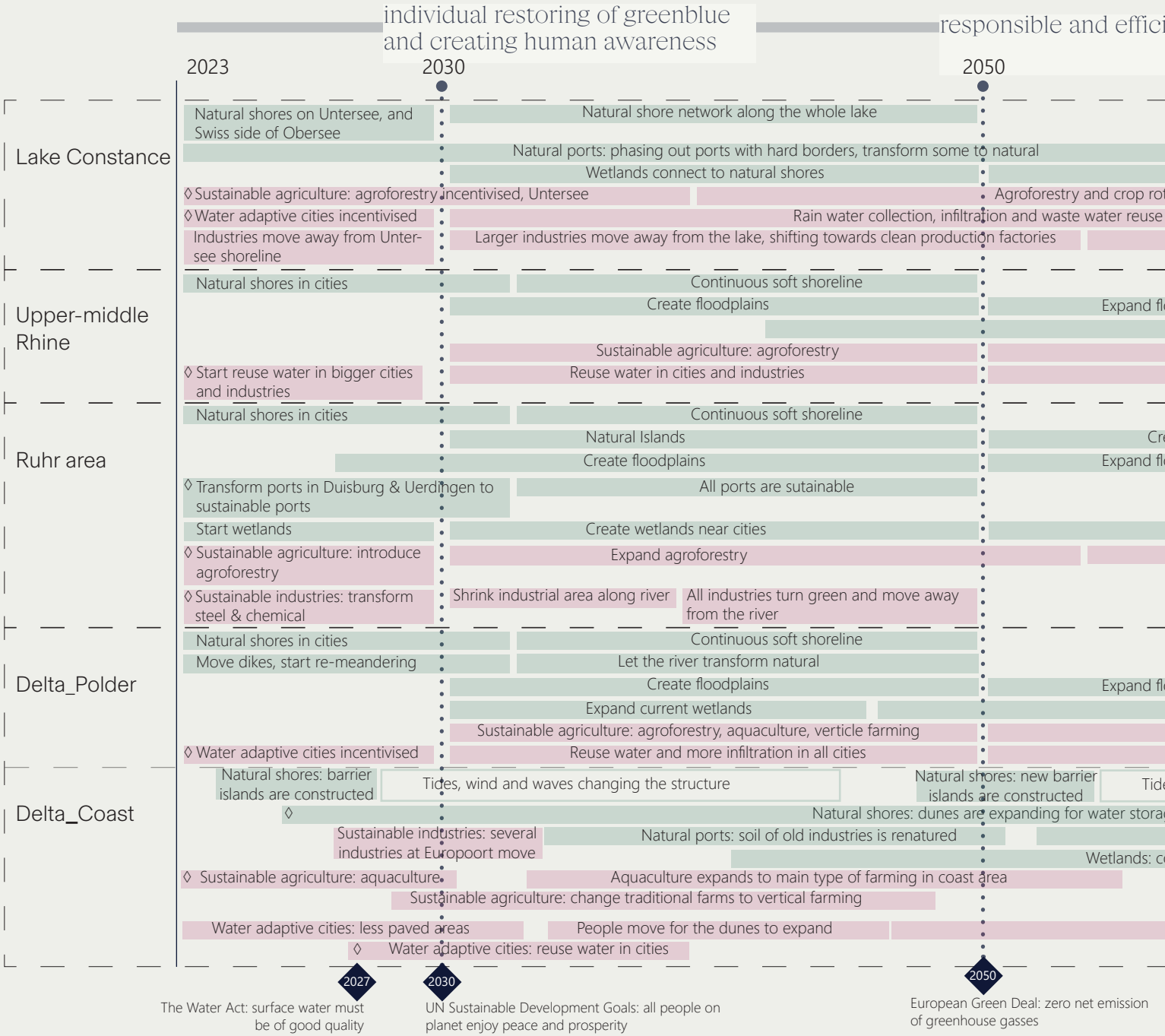
Policy analysis

ALIGNMENT OF OUR GOALS AND OBJECTIVES WITH EXISTING POLICY



SDG'S THIS PROJECT ADDRESSES*

*THIS PROJECT MOSTLY RELATES THE AFOREMENTIONED SDG'S TO SDG 6


individual restoring of greenblue and creating human awareness
responsible and effici
2023
2030
2050
Lake Constance
Natural shores on Untersee, and Swiss side of Obersee
Natural shore network along the whole lake
Natural ports: phasing out ports with hard borders, transform some to natural
Wetlands connect to natural shores
◊ Sustainable agriculture: agroforestry incentivised, Untersee
Agroforestry and crop rot
◊ Water adaptive cities incentivised
Rain water collection, infiltration and waste water reuse
Industries move away from Unter-see shoreline
Larger industries move away from the lake, shifting towards clean production factories
Upper-middle Rhine
Natural shores in cities
Continuous soft shoreline
Create floodplains
Expand fl
Sustainable agriculture: agroforestry
◊ Start reuse water in bigger cities and industries
Reuse water in cities and industries
Ruhr area
Natural shores in cities
Continuous soft shoreline
Natural Islands
Cr
Create floodplains
Expand fl
◊ Transform ports in Duisburg & Uerdingen to sustainable ports
All ports are sutainable
Start wetlands
Create wetlands near cities
◊ Sustainable agriculture: introduce agroforestry
Expand agroforestry
◊ Sustainable industries: transform steel & chemical
Shrink industrial area along river
All industries turn green and move away from the river
Delta_Polder
Natural shores in cities
Continuous soft shoreline
Move dikes, start re-meandering
Let the river transform natural
Create floodplains
Expand fl
Expand current wetlands
Sustainable agriculture: agroforestry, aquaculture, verticle farming
◊ Water adaptive cities incentivised
Reuse water and more infiltration in all cities
Delta_Coast
Natural shores: barrier islands are constructed
Tides, wind and waves changing the structure
Natural shores: new barrier islands are constructed
Tide
◊
Natural shores: dunes are expanding for water storag
Sustainable industries: several industries at Europoort move
Natural ports: soil of old industries is renatured
Wetlands: c
◊ Sustainable agriculture: aquaculture
Aquaculture expands to main type of farming in coast area
Sustainable agriculture: change traditional farms to vertical farming
Water adaptive cities: less paved areas
People move for the dunes to expand
◊ Water adaptive cities: reuse water in cities
2027
2030
2050
The Water Act: surface water must be of good quality
UN Sustainable Development Goals: all people on planet enjoy peace and prosperity
European Green Deal: zero net emission of greenhouse gasses
Initiated policies
Cross-border collaboration on policy and legislation
Network of wetlands
Compatible cycles

The following diagram underwrites how the goal of a clean freshwater supply will be reached, and what different steps need to be taken.

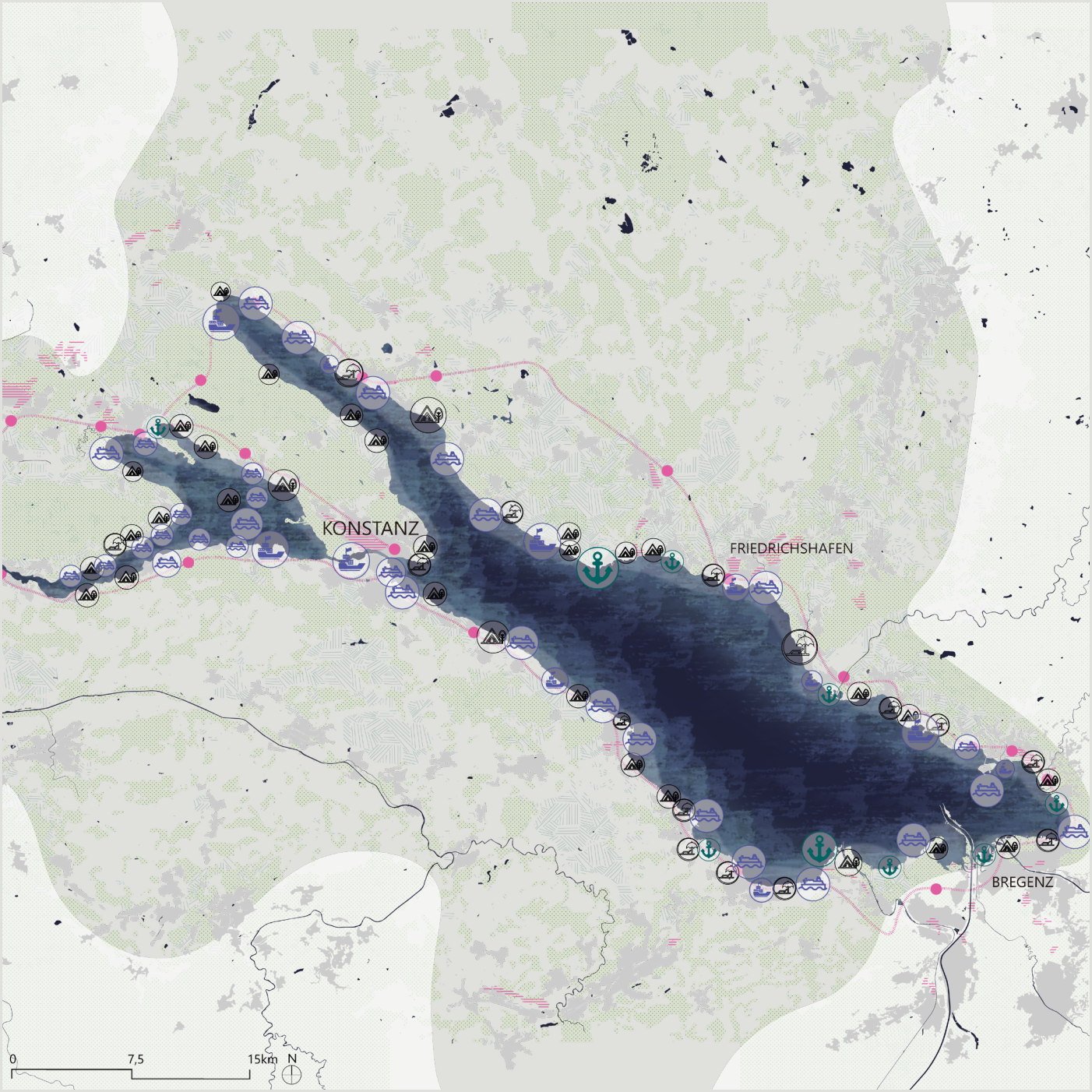
The phasing starts with implementing individual measurements and creating awareness for the citizens. In the next phase, it connects the individual measurements to a network, which will result in responsible and efficient water use. The last steps are expanding this network and letting new natural structures grow when the clean freshwater supply is achieved.

There are a lot of big transitions to be made, which will happen with the help of the different activation strategies.

The initiated policies are shown at the bottom. Which policies will be specifically used per category is explained in the chapter about policy principles and framework.

◊ Start with activation strategies
Compatible cycle interventions
Network of wetlands interventions

Lake Constance


KONSTANZ
FRIEDRICHSHAFEN
BREGENZ
0
7,5
15km
N

Lake Constance

STRUCTURE AND PRESENT DAY SITUATION

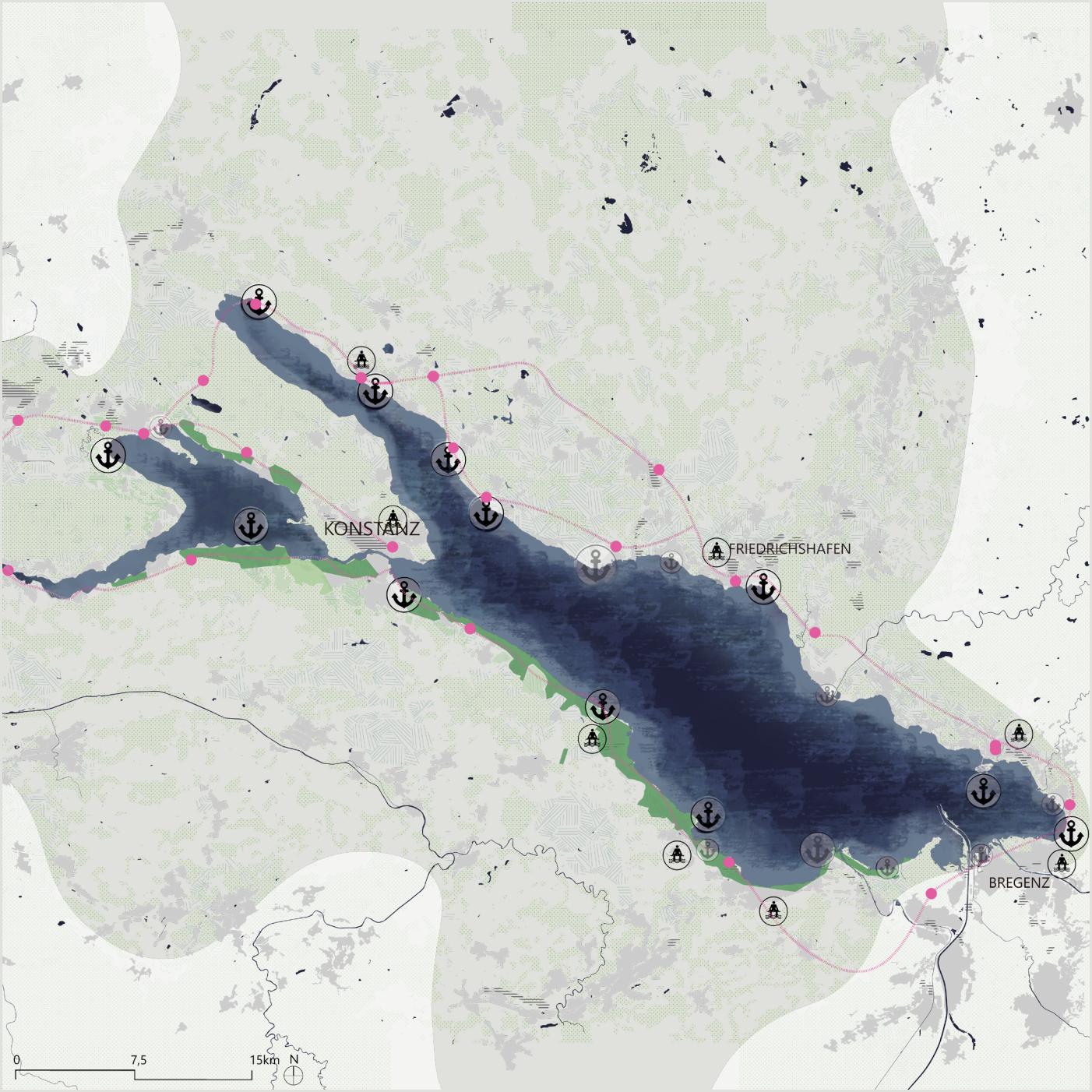
River
Inland water
Industries
Cities
Agriculture
Nature
Train

Port
Ferry port
Camp site
Beach resort

Lake Constance, located in Central Europe, is a vital drinking water reservoir for the region. It is filled by Alpine rivers and rainwater and consists of two parts, the Upper Lake with an area of 500km2 and a maximum depth of 253m, and the Lower Lake with an area of 71.5km2 and a maximum depth of 46m. About 125 million cubic meters of water are extracted from the lake annually for drinking purposes, making up one-third of global water consumption. The economic value of drinking water from Lake Constance amounts to 269 million EUR per year, and it serves as the primary water source for over 5 million people.

Lake Constance is located on the border of Switzerland, Germany, and Austria, and international collaboration has been present in policies for a long time. However, strategies, projects, and infrastructure are still often planned and implemented separately. The main economic sectors in the region are tourism, agriculture, and high-tech industries, which are also the largest polluters of the lake.

Even though Lake Constance is generally a good example of conservation and cross-border collaboration, in times of freshwater water crisis, the lake becomes critical infrastructure, and present measures and collaboration need to be advanced to protect the drinking water source.


KONSTANZ
FRIEDRICHSHAFEN
BREGENZ
0
7,5
15km
N

Lake Constance

STRATEGY 2030

River
Inland water
Industries
Cities
Agriculture
Nature
Train
Wetlands
Agroforestry
Green port
Green ferry port
Beach resorts transform into inland thermal baths

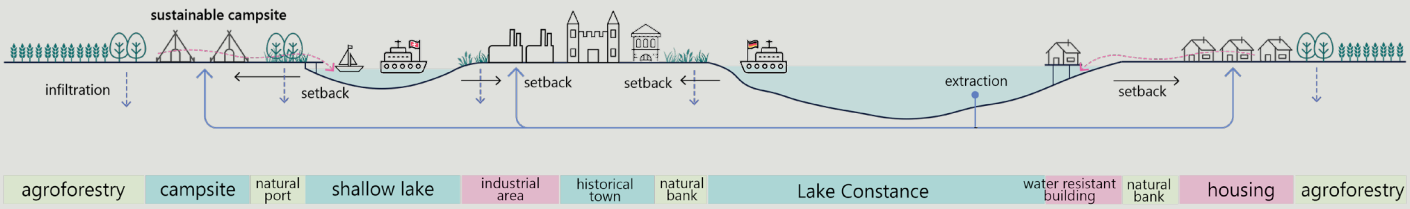
Phase 1 of the strategy focuses on introducing a common building code for all three countries, which includes a setback distance of 25 meters to protect the wetland habitat and ensure safety during flood periods. Building owners and camping sites are incentivized to move further inland or adapt their buildings to be low impact on the wetland habitat, with building on stilts promoted as a traditional local building type.

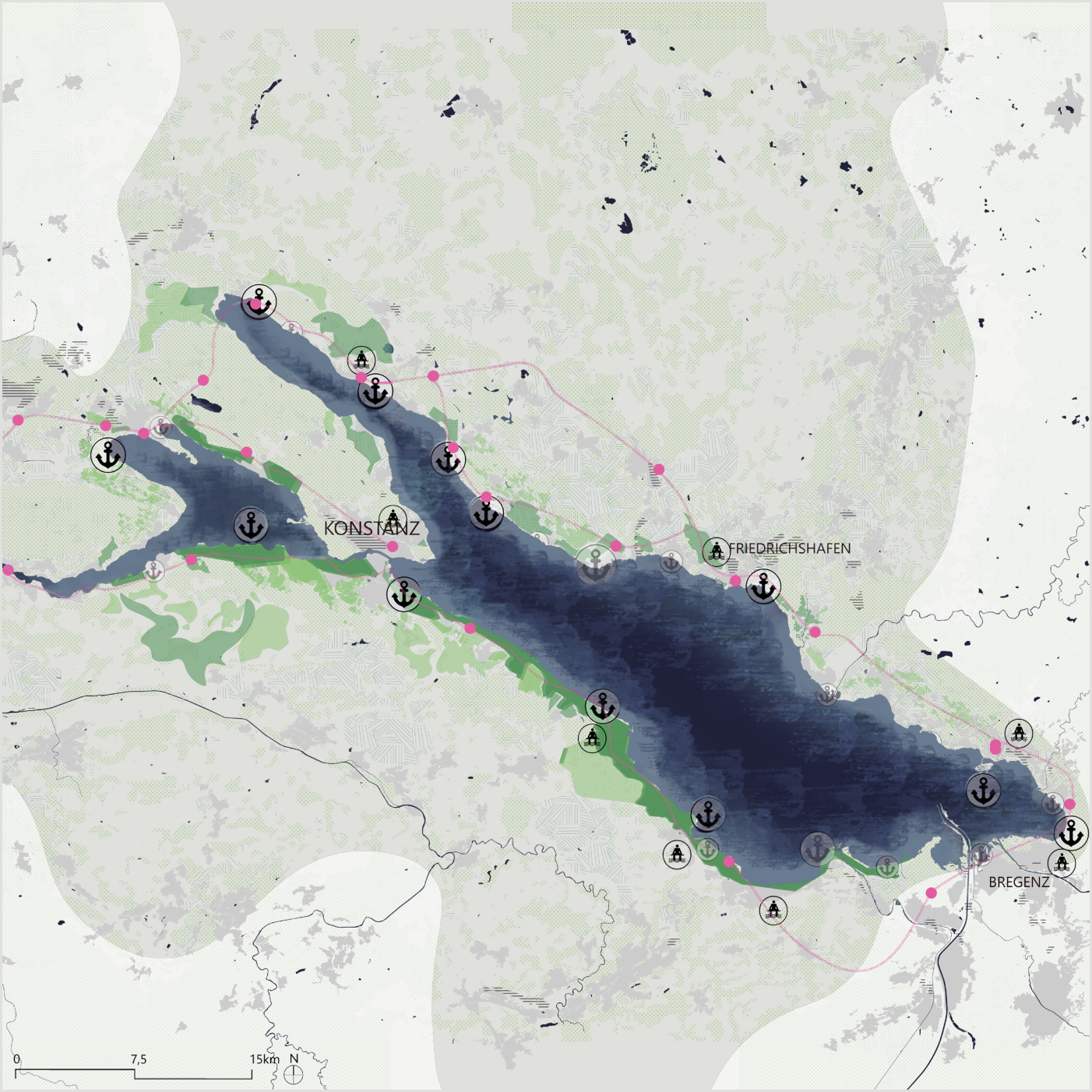
Another crucial aspect of Phase 1 is the renaturation of the shore and the first buffer layer of wetlands around the very shallow Untersee (Lower lake) and shallow south-east areas of the Obersee (Upper lake). Agroforestry pilot projects are being introduced as a second buffer layer, mainly in the Untersee area.

To reduce the impact of tourism, the number of ports for tourist ships is being reduced, and construction of natural ports, especially for residents boats and ferries, is incentivized. A pilot project for a common hydrogen-powered ferry line, with nature ports, between the three countries (10 stops) is also being introduced.

In addition, a train track is being added towards towns on the shore on the northern side, moving the southern track more inland away from the protected delta wetland. Hotels that switch to geothermal tourism are also incentivized, along with smaller industrial complexes on the shore being moved inland.

Finally, water reuse and rain collection by residents and municipalities are incentivized as part of a broader effort to reduce the overall water consumption and promote sustainability.




KONSTANZ
FRIEDRICHSHAFEN
BREGENZ
0
7,5
15km
N

Lake Constance

STRATEGY 2050

River
Inland water
Industries
Cities
Agriculture
Nature
Train
Wetlands
Agroforestry
Green port
Green ferry port
Beach resorts transform into inland thermal baths

In phase 2 of the spatial strategy for Lake Constance, the wetlands continue to expand towards forested areas, and a second layer of agroforestry is also introduced to further protect the wetlands. The tracks for public transport are moved even further away from the shoreline to ensure the safety of the protected delta wetland. The train and ferry lines are now fully commonly operated, with a reduction in the number of ports, especially in the Untersee area.

Additionally, beach resorts with pools near the shore are now required to pay extra taxes if they use chlorine or heavy water treatment within 100 meters of the lake. Geothermal tourism is still incentivized, and large industrial complexes close to the shore are moved to prevent further pollution.

In terms of water conservation, water reuse and rain collection by municipalities is now obligatory.

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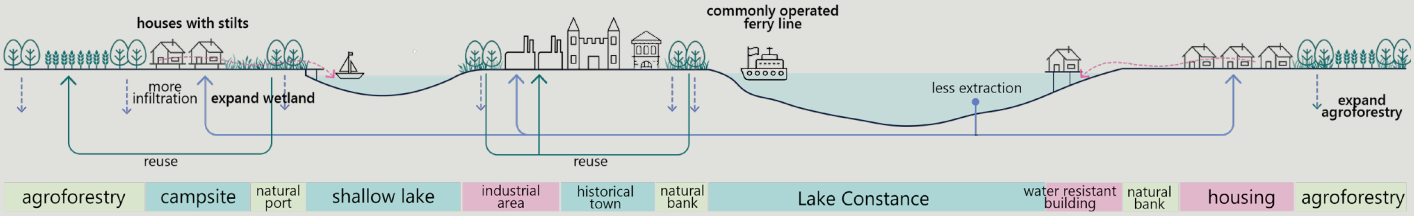
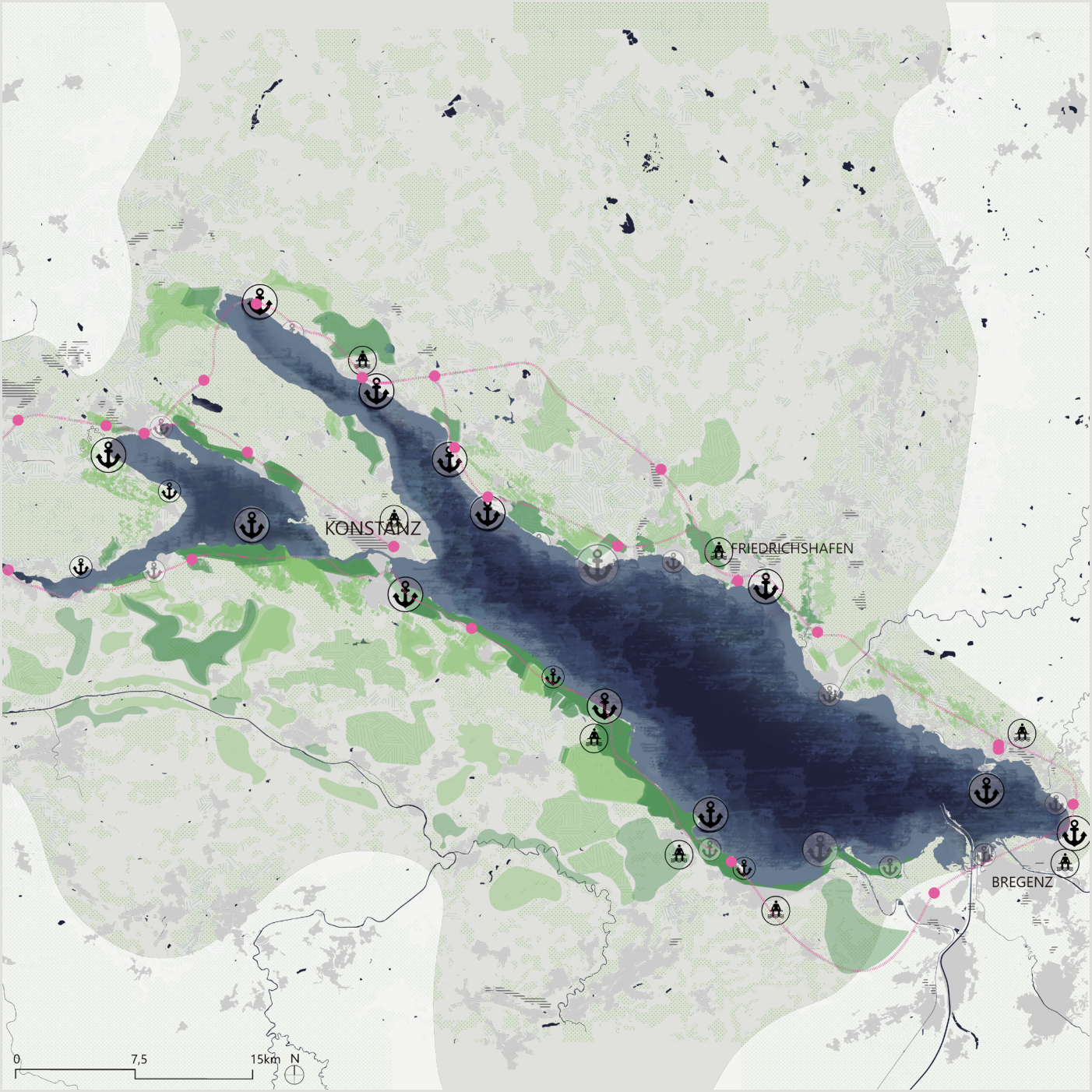



KONSTANZ
FRIEDRICHSHAFEN
BREGENZ
0
7,5
15km
N

Lake Constance

STRATEGY 2100

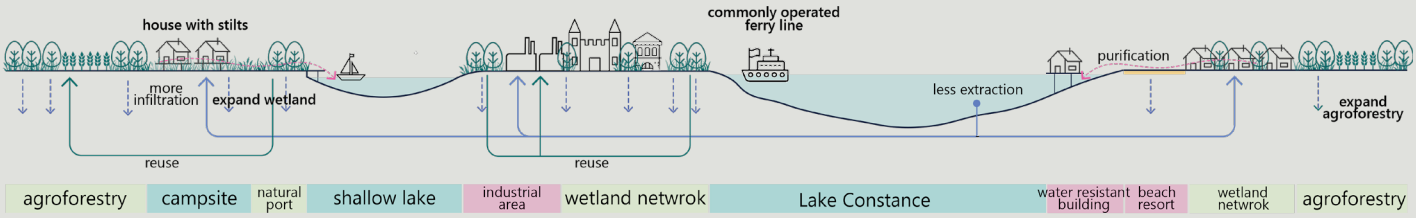
River
Inland water
Industries
Cities
Agriculture
Nature
Train
Wetlands
Agroforestry
Green port
Green ferry port
Beach resorts transform into inland thermal baths

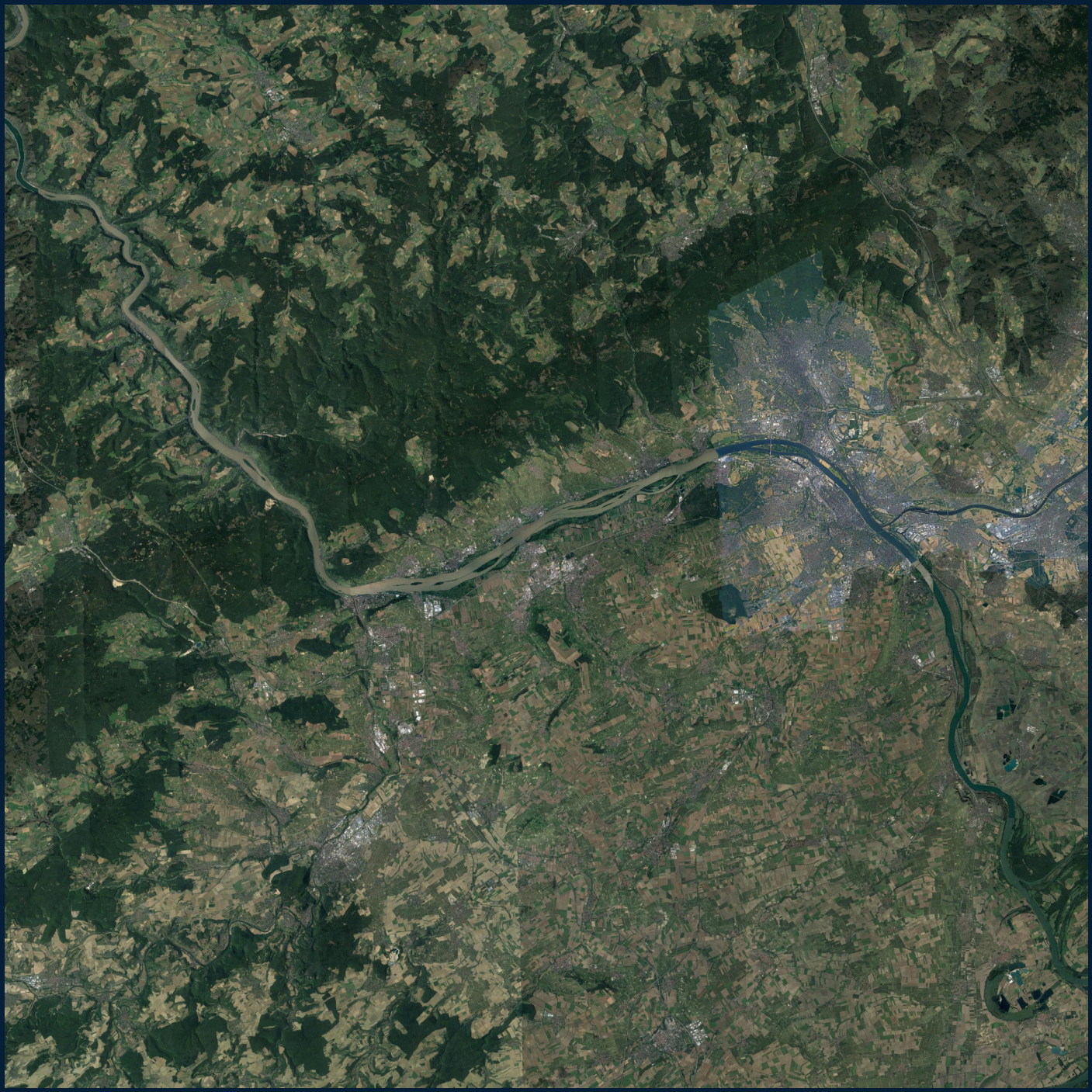
By 2100 shorelines and wetlands of tributary streams and rivers are connected to the wetland network of the lake, with the agroforestry buffer layer also expanding between them.

The number of ports is significantly reduced, and all the existing ones have natural shores. Only hydrogen or solar operated boats with water based paint are allowed in the lake.

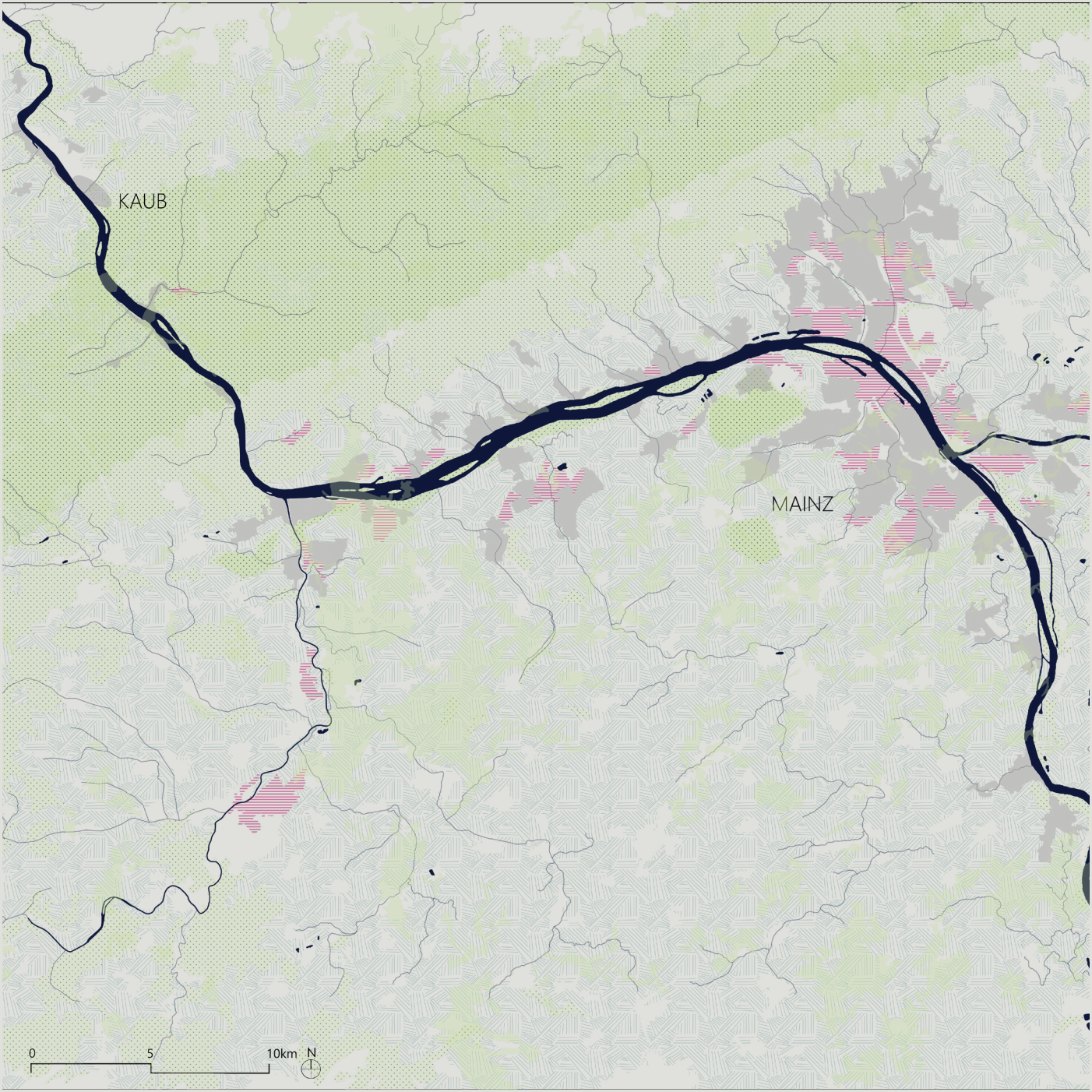
Beach resorts with pools are not allowed witin 200 meters of the shoreline, while geothermal tourism still incetivised.

Towns fully reuse their wastewater and collect rainwater.





Upper Middle Rhine


KAUB
MAINZ
0
5
10km
N

Midddle-Upper Rhine

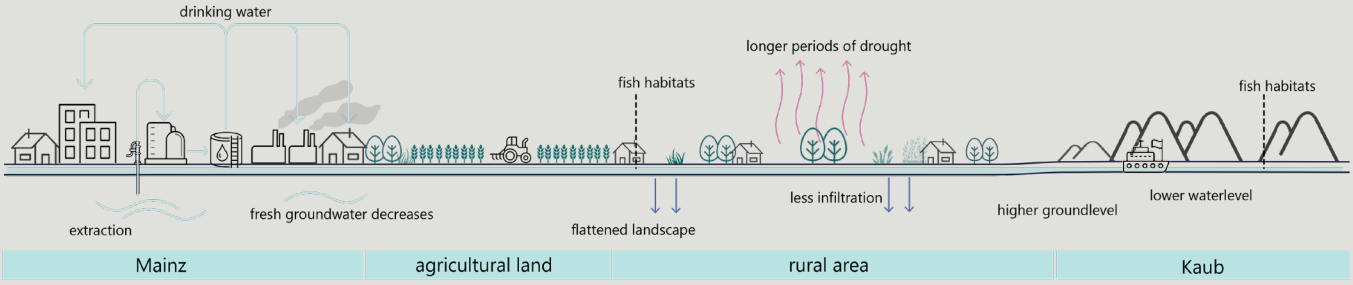
STRUCTURE AND PRESENT DAY SITUATION

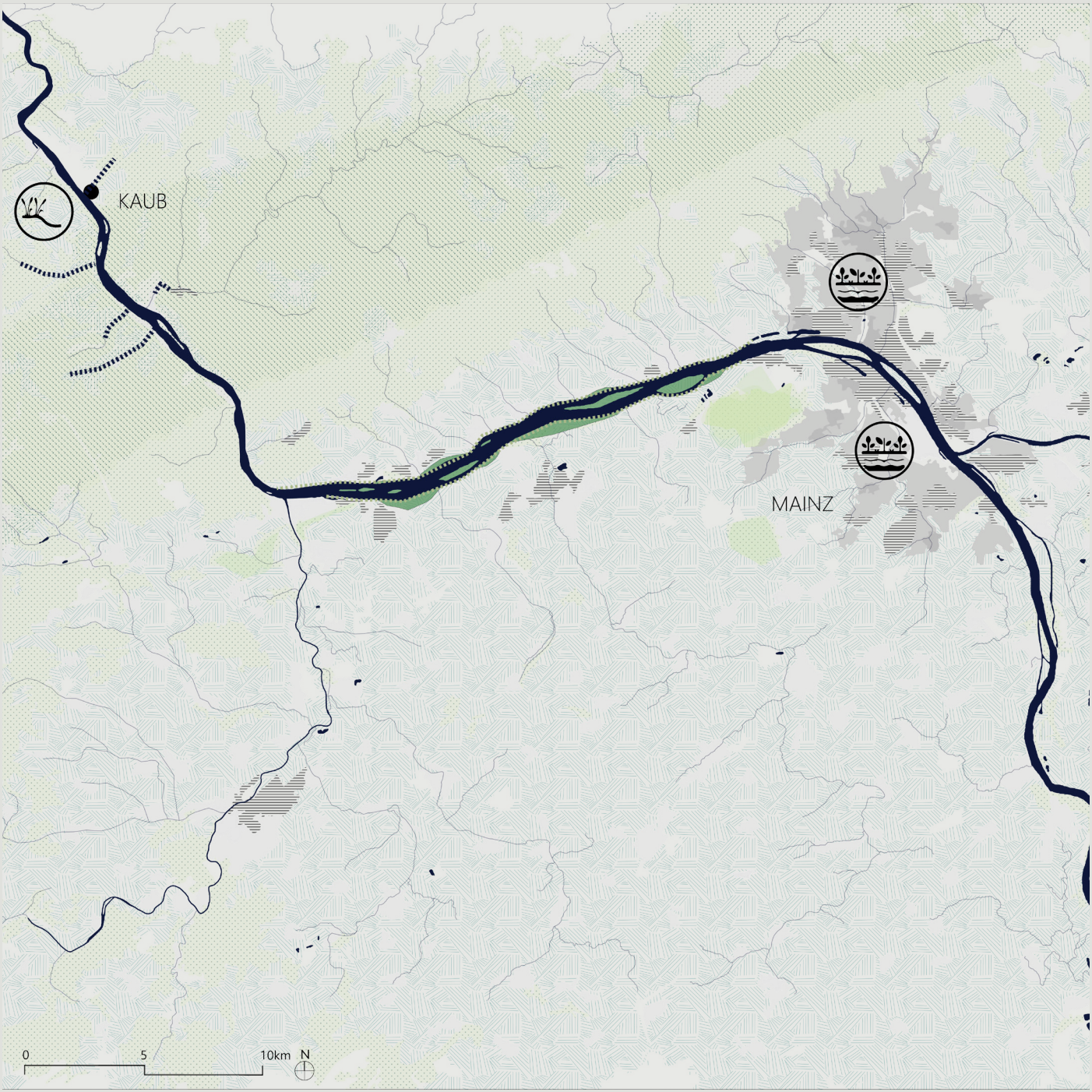
River
Inland water
Industries
Cities
Agriculture
Nature

The most important bottleneck for the Upper Middle Rhine is the water level, which occurs because the water flow slows down due to the mainly flat landscape around Mainz. As a result, around Kaub, where there are more mountains, the water slows down even more, leading to a lower water level.

Deepening the river is an option that different parties are discussing. However, this intervention has consequences. For example, it will decrease the habitats of species such as Salmon, Allis shad, and mussel that live there now. Furthermore, it will move the bottleneck and create problems again in the future, resulting in an ongoing process of deepening the river.

Therefore, other sustainable interventions are necessary. Since the low water level causes problems near Kaub, the first intervention should focus on that area.




KAUB
MAINZ
0
5
10km
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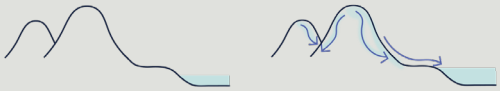
Midddle-Upper Rhine

STRATEGY 2030

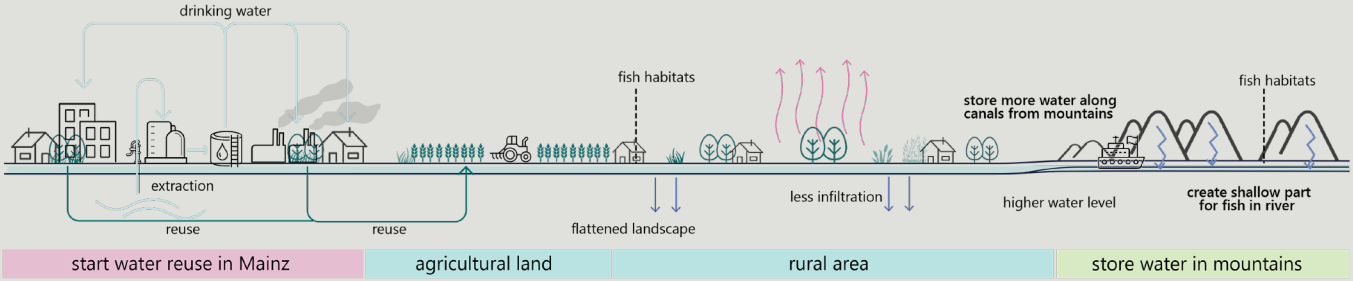
River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands
Maximal water reuse
Reservoirs along canals

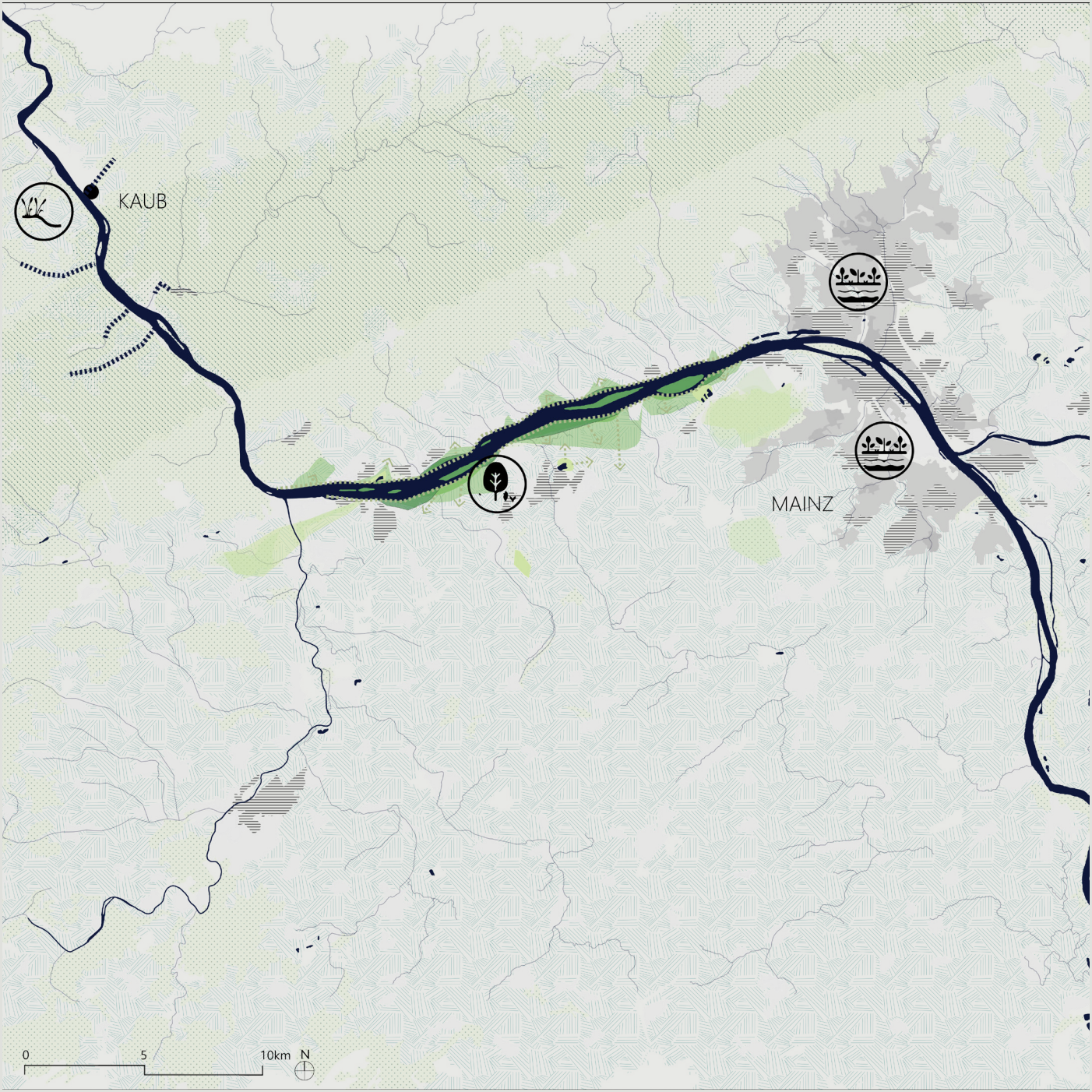
In phase 1, reservoirs along the canals, from the mountains flowing in the river, will be created. These reservoirs will catch and hold more rainwater and will slow down the water flow towards the Rhine. This will help to store and save more water for when it is needed near Kaub in periods of drought.



This intervention on its own is not enough to resolve the problems near Kaub. Due to the landscape and the height characteristics changes are needed before Kaub to in the end achieve a higher water level in Kaub. Therefore the bigger cities and industries (around Mainz) need to start reusing their rainwater and wastewater. So less water will be extracted from the groundwater and in the end from the Rhine itself.

At this moment there live different fish habitats near Kaub which lay their eggs in exactly this area, because of the shallow water. (Muller & King, 2022) It is important to preserve shallower part for these habitats. That is why an intervention is needed near Kaub to create natural shores with enough space for the fish to lay their eggs in those shallow areas. The middle part of the river will be wide enough to let the ships pass in this deeper area. This intervention is shown in the section.




KAUB
MAINZ
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Midddle-Upper Rhine

STRATEGY 2050

River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands
Maximal water reuse
Reservoirs along canals

In phase 2, floodplains will be realized. Because of the structure of the landscape, this intervention is suitable between Mainz and the mountains, as visible on the map. Floodplains are needed in this area to prevent floods when the water level is increasing. Furthermore, floodplains will also catch and store more rainwater for periods of drought. The agriculture which is situated at this time in the floodplain areas will transform in this phase into sustainable agriculture which can be combined with those floodplains. This agriculture will mainly transform into agroforestry, to be specific: Agrosilviculture, which is well suitable in floodplain areas. In agrosilviculture, there is a combination of crops and trees which are suitable in wetlands. (indiaagronet, n.d.)

With extremer weather and more droughts in the future, new techniques should be used to adapt the ships for these circumstances. There are already some tests for innovative ships which can pass easier through low water. (BASF, 2022) In this phase more research on the ships is already done and the new innovative ships can be used.

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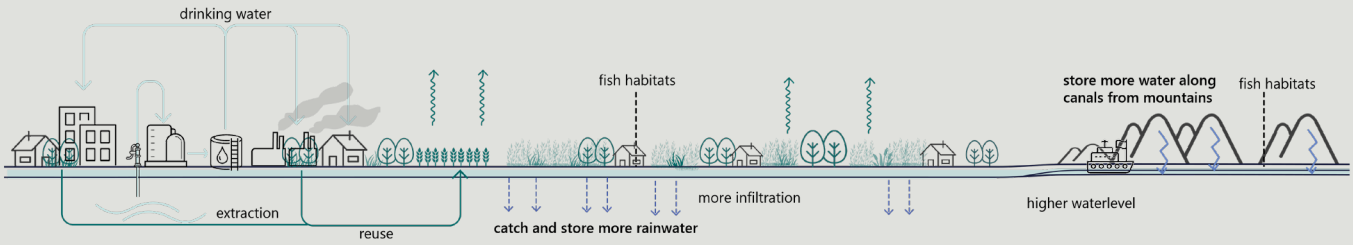
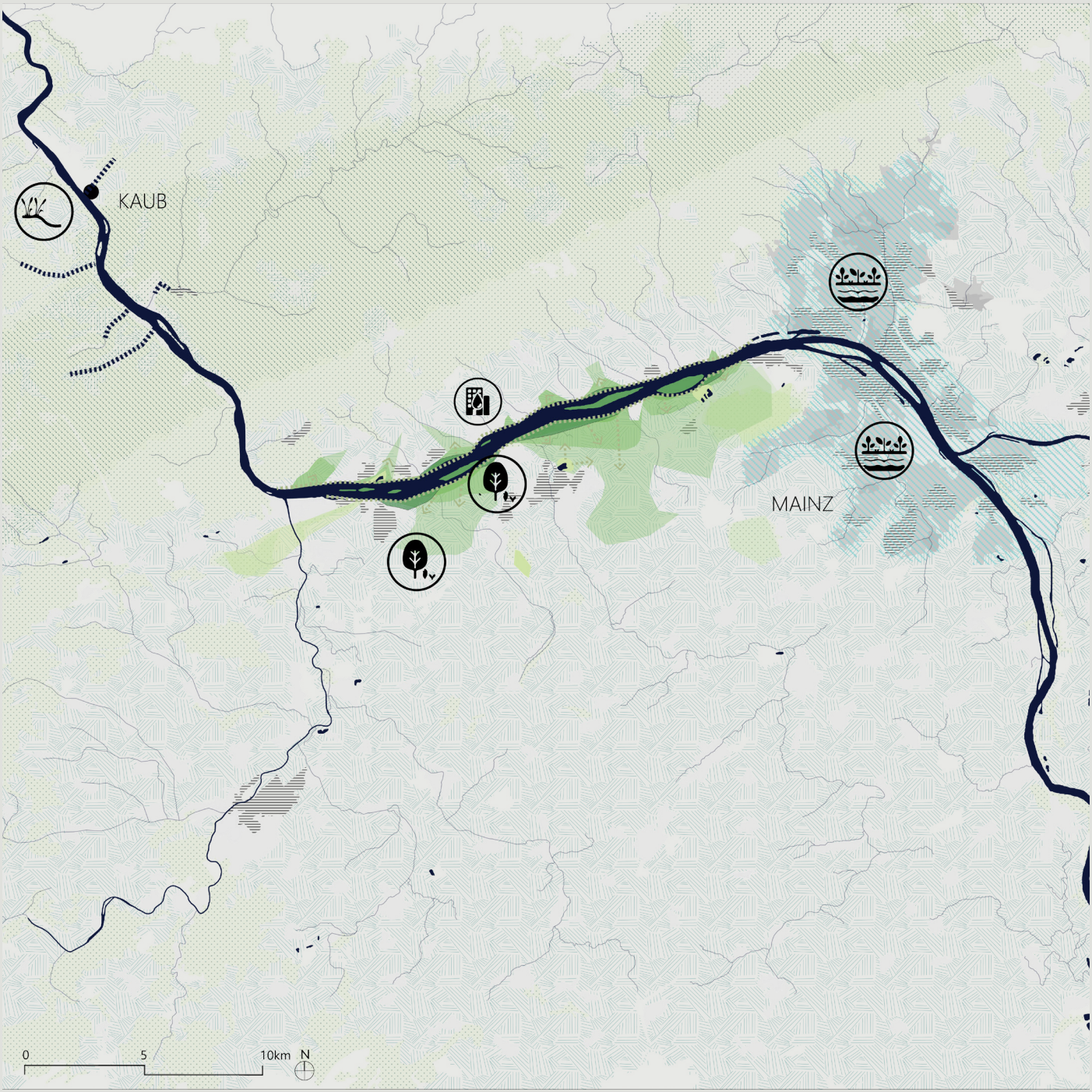



KAUB
MAINZ
0
5
10km
N

Midddle-Upper Rhine

STRATEGY 2100

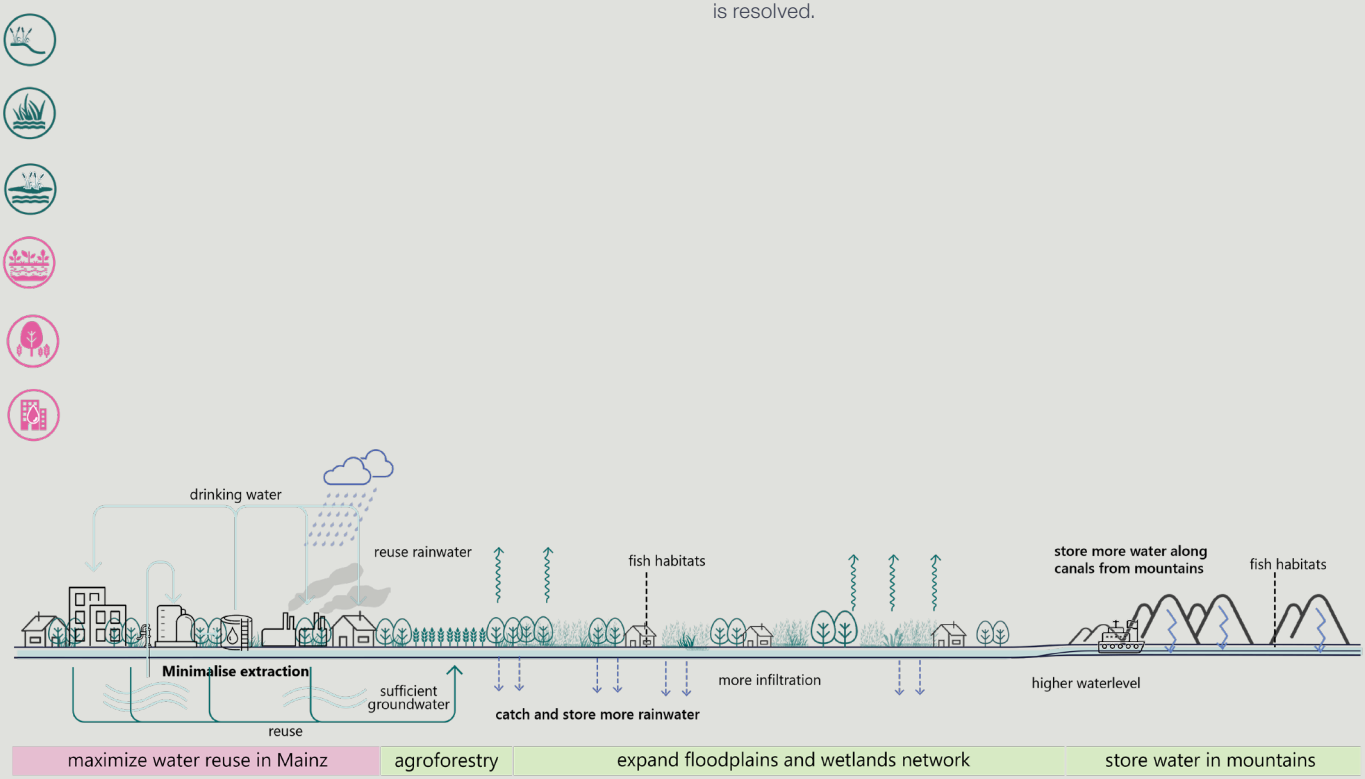
River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands
Maximal water reuse
Reservoirs along canals

In phase 3, the floodplains will expand into a natural system. They are connecting to current green structures and grow into a wetland network. This wetland network will be very appropriate for the different habitats in this area. Since the shallow water in this region, there live a lot of habitats, which also live in wetland areas.

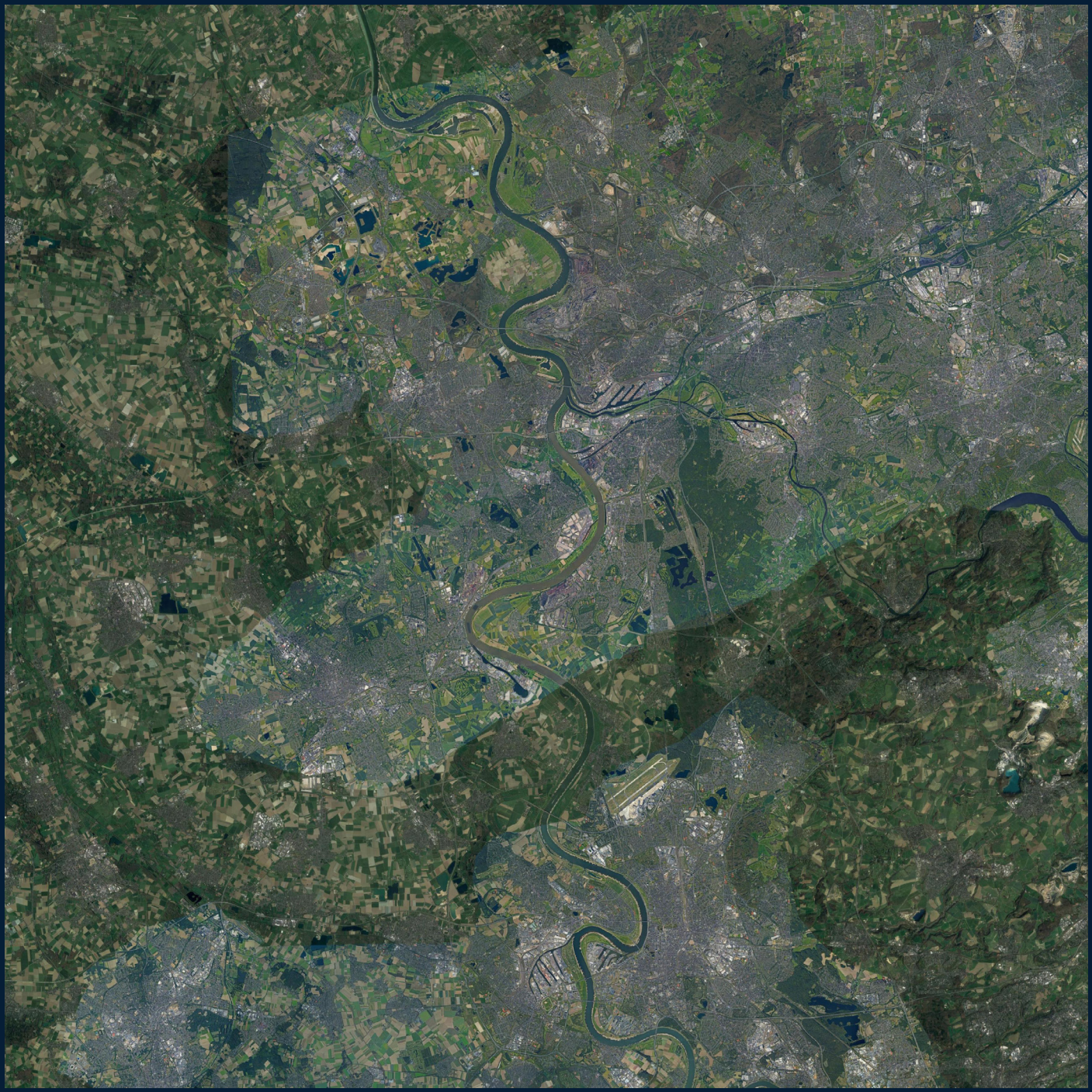
In the meantime, sustainable agriculture will be extended more. Because of the high amount of wetlands between Mainz and the mountains, smaller cities in this area need to transform their building typologies into water-resistant buildings when expanding of the cities is needed.

Furthermore, the bigger cities and industries around Mainz need to reuse water at maximal rates in this phase.

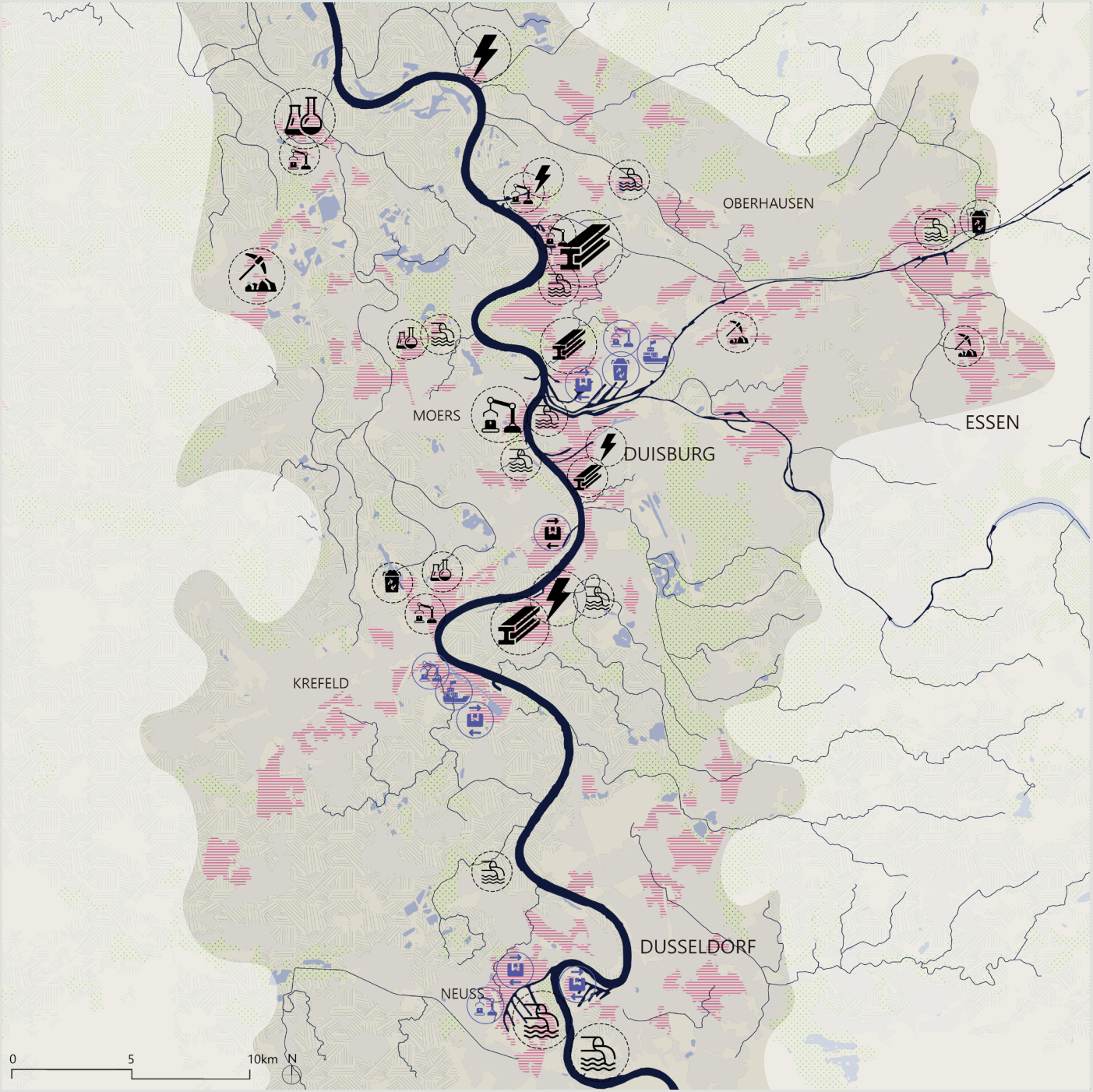
With all these interventions scarcity of the water in this area will be prevented. Looking at the water flow, the system will now stay connected. Furthermore, sustainable land use and biodiversity will be improved. Middle upper Rhine will serve as a natural system for the rhine where the height difference will no longer result in a lower water level in 2100. The bottleneck is resolved.




COSCO SHIPPING



Ruhr


OBERHAUSEN
MOERS
DUISBURG
ESSEN
KREFELD
DUSSELDORF
NEUSS
0
5
10km
N

Ruhr

STRUCTURE AND PRESENT DAY SITUATION

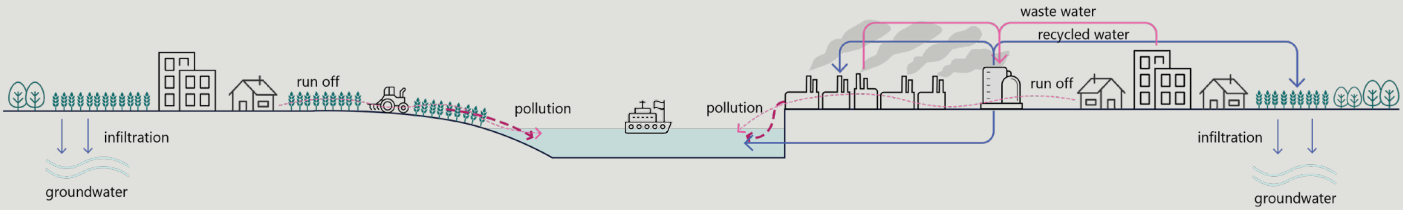
River
Inland water
Industries
Cities
Agriculture
Nature

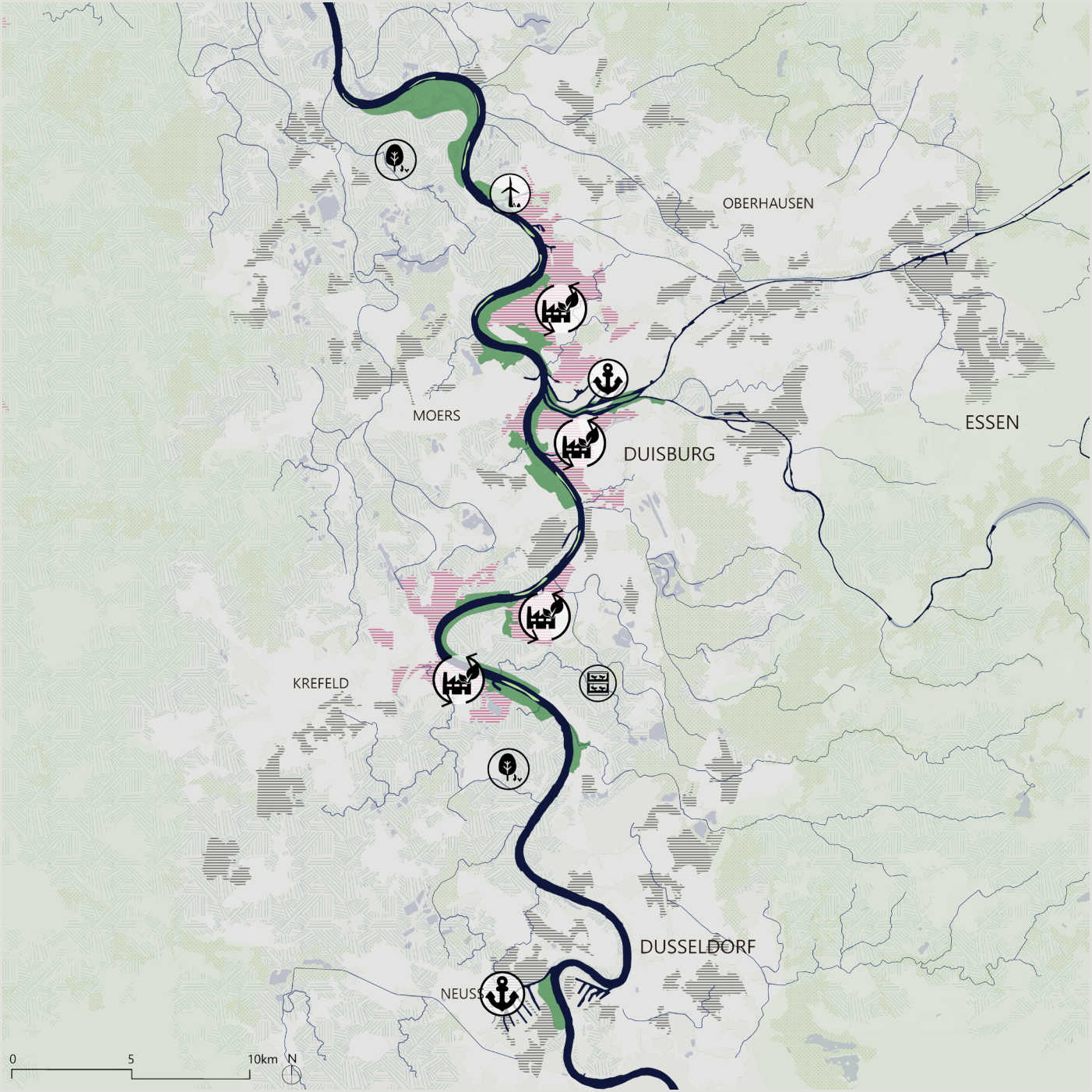
The bigger the icon, the more pollution

Steel
Waste
Electricity
Manufacture
Sewerage
Coal
Chemical
Logistic Port industry
Manufacture Port industry
Waste Port industry
Shipping Port industry

There are several important German industrial cities such as Duisburg and Dusseldorf in this region. The most polluting industries in this region are steel, chemical and electricity production, which need to be transformed. In addition, there are several ports in the region, where logistics, shipping and production industries are mainly located. The urban areas in this region are concentrated along the rivers and behind the cities are mostly natural areas and agricultural land. There is a lack of natural areas in the cities.

The main problem in this area is water pollution, as these industries are mainly located along the rivers and the factories directly pollute the rivers. In addition, since most of these factories do not allow outsiders to enter, the public does not have a high accessibility to the river, which is a spatial inequity. At the same time, most of the river banks in this area are hard banks, which expose the city to flood risks and also do not provide habitat for animals, which is harmful to biodiversity. What's more, some agricultural land is adjacent to the Rhine, which makes surface runoff from agricultural land an important source of river pollution as well.




OBERHAUSEN
MOERS
DUISBURG
ESSEN
KREFELD
DUSSELDORF
NEUSS
0
5
10km
N

Ruhr

STRATEGY 2030

River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands

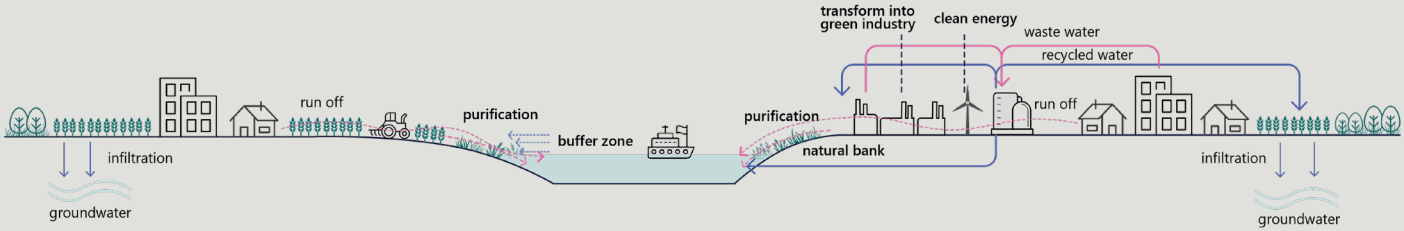
Green industry

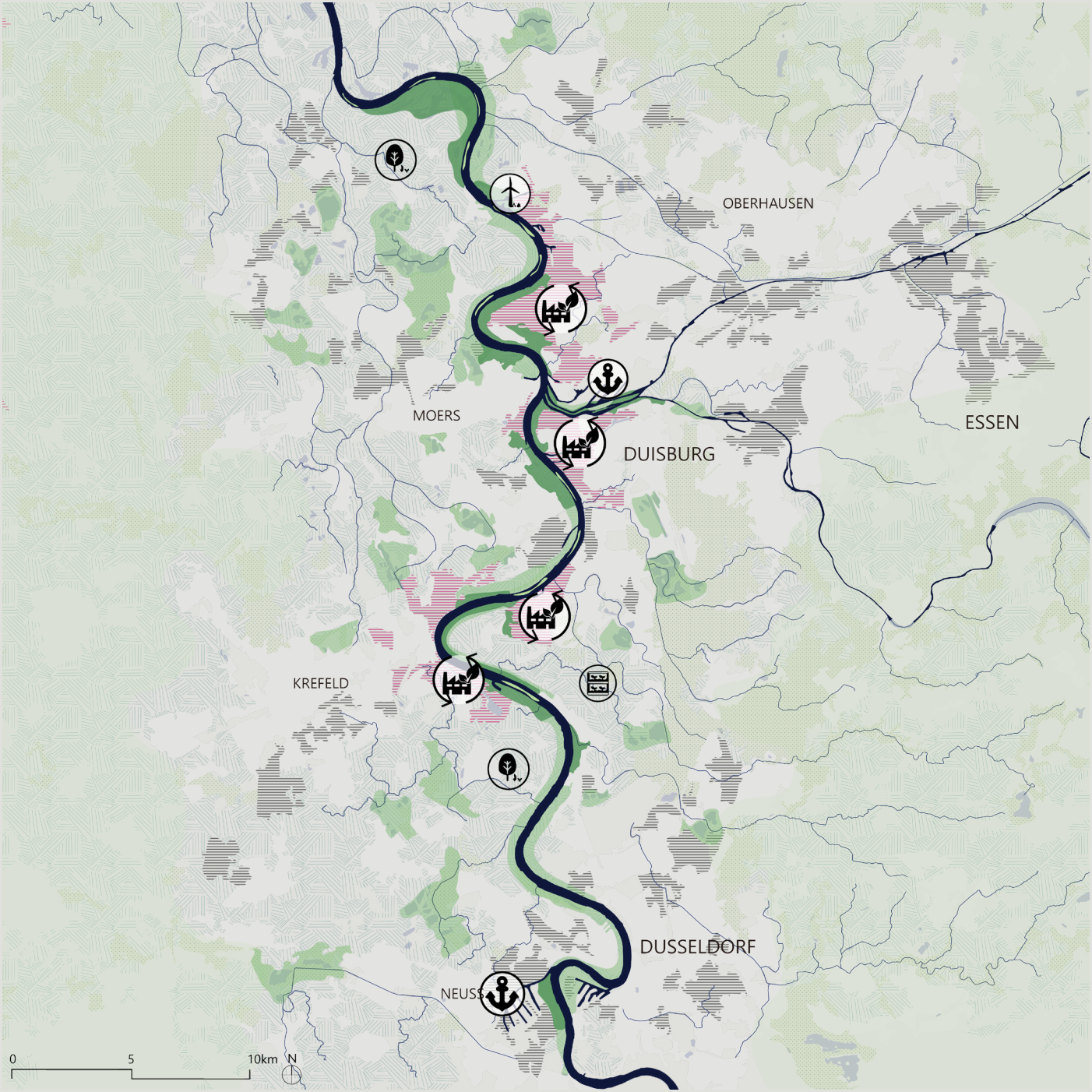
In phase 1, the transformation of the existing industries in the region to green industries will be achieved by using clean energy and maximizing the recycling of water in order to reduce the water consumption of industries and reduce water pollution. The steel industry, a key industry in the region, produces the most water pollution and will be fully transformed to green steel in this phase. The green transformation of the existing industries on the site allows for a reduction in the size of the industrial area, which also provides space for natural solutions.

In addition, the existing ports will be transformed into natural ports. The use of renewable energy will be achieved by setting up windmills, floating solar panels, etc., while reducing waste and implementing recycling programs, as well as reducing the use of hazardous chemicals. Spatially, industries that generate a lot of pollution will be removed, the industrial area of the port will be reduced, and wetlands will be created to clean up surface runoff.

Besides, in this phase, spot wetlands will also be created near the industrial areas. These wetlands will not only act as purifiers to clean the river from surface runoff, but also achieve the transformation of hard riverbanks to soft riverbanks and enhance the accessibility of the river to citizens, which will also be beneficial for enhancing the happiness and well-being of citizens.

Linear wetlands will also be created at the edges of agricultural land along the river to reduce agricultural pollution of the river. In areas of high flood risk, portions of existing agricultural land will also be converted to floodplains to protect the city from flooding. Vertical farming will be introduced in this phase to save land to create wetlands. Agroforestry construction will also be introduced within existing agricultural land to ensure soil health, enhance soil infiltration rates, and recharge the groundwater.




OBERHAUSEN
MOERS
DUISBURG
ESSEN
KREFELD
DUSSELDORF
NEUSS
0
5
10km
N

Ruhr

STRATEGY 2050

River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands

Green industry

In phase 2, existing hard riverbanks will be modified to create continuous natural shoreline. These natural areas will purify surface runoff and reduce pollution to the river. It also improves citizen accessibility to the river to enhance the happiness and well-being of citizens. In addition, natural riverbanks can provide habitat for fish and birds to enhance biodiversity.

In addition, floodplains will be expanded in natural areas that serve as buffer zones to protect the city from flooding, but also to purify surface runoff and reduce river pollution. These floodplains also serve as habitats for animals, and the diversity of species in the area is increased.

Also, in this phase, spot wetlands will be created inland, which are selected based on existing inland water bodies and natural areas that are easier to establish. The creation of these wetlands will increase soil percolation rates, raise groundwater levels, and enhance species diversity.

In addition, the construction of natural islands along the river in non-urban areas will also begin. These islands can provide habitat for animals and enhance biodiversity which can also be used as buffer zones against flooding.

Finally, during this phase, the green transformation of all industries will be completed.

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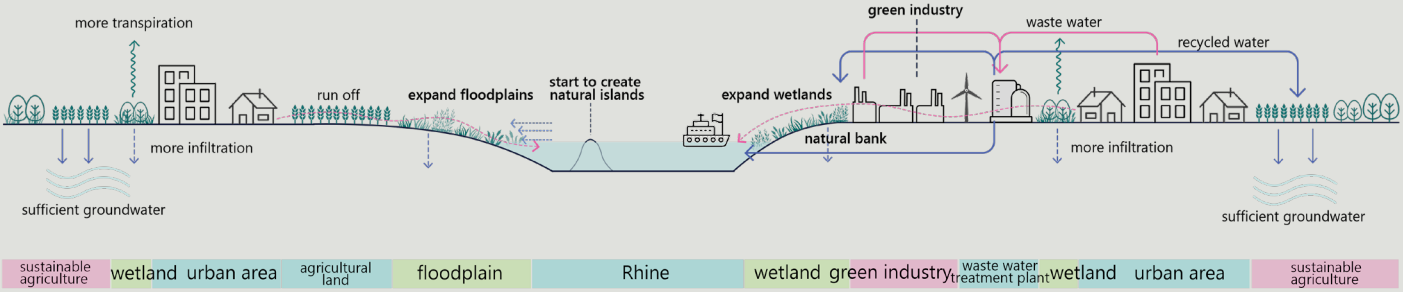
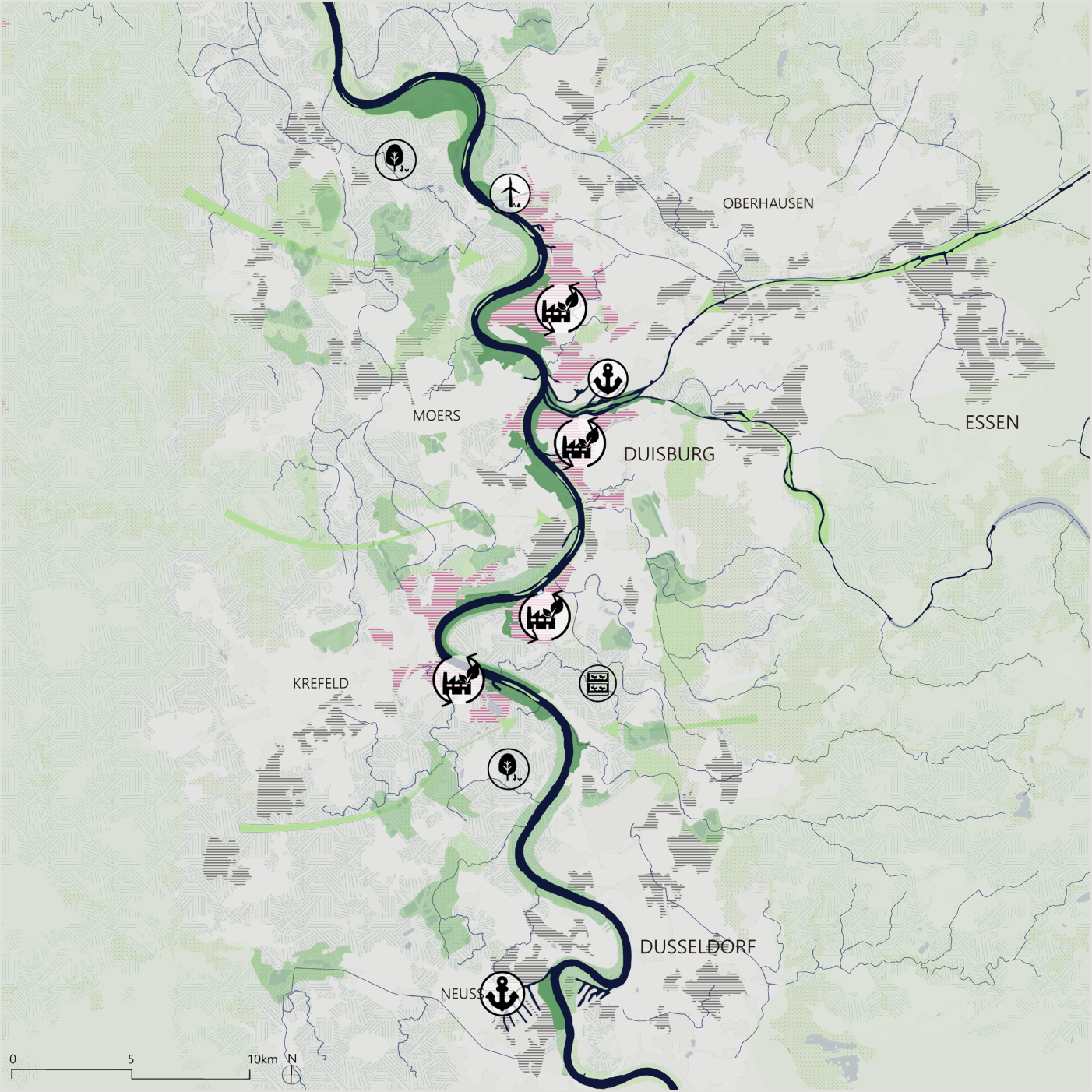



OBERHAUSEN
MOERS
DUISBURG
ESSEN
KREFELD
DUSSELDORF
NEUSS
0
5
10km
N

Ruhr

STRATEGY 2100

River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands

Green industry

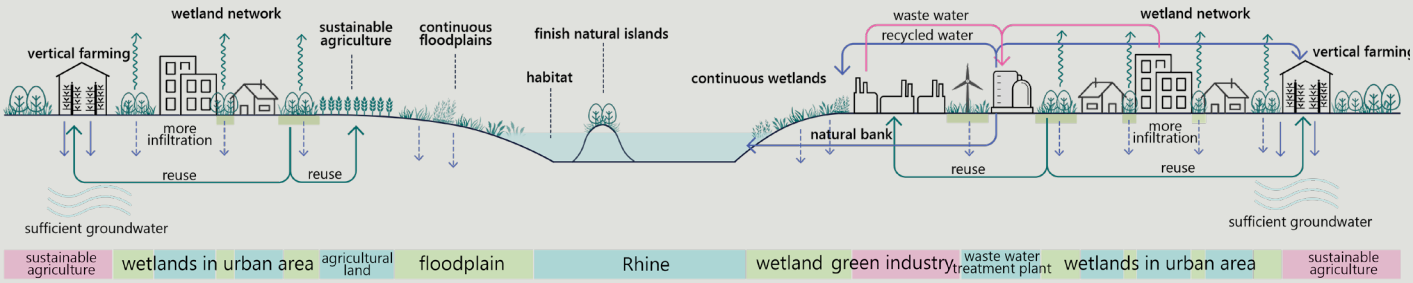
In phase 3, the construction of continuous natural riverbanks along the river will be completed. These soft riverbanks are important places for citizens to access the river, and citizen happiness and well-being will be greatly enhanced. These areas will also be of great benefit in helping the city resist flooding. The species diversity of the riverbanks will also be greatly enhanced.

In addition, floodplains will continue to expand to address more extreme flood risks. At the same time, inland wetland areas are expanding, based on the gradual expansion and extension of the previous phase's spot wetlands to form networks of wetland landscapes. These wetland networks can store sufficient water in the soil and also purify surface runoff, which also enhances species diversity in inland areas.

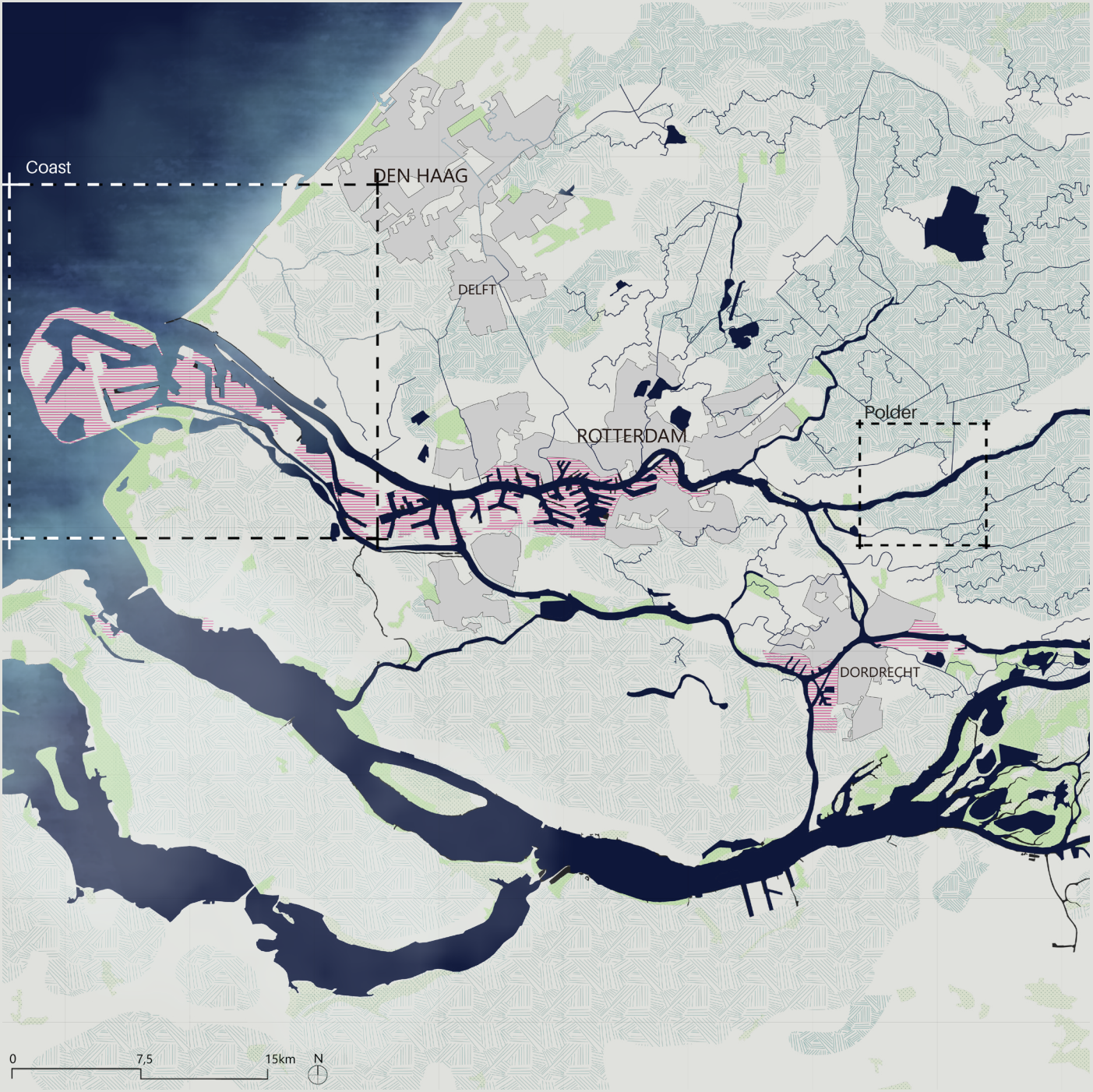
At this stage, the green backbone will extend into the city and connect to the natural riverbanks, forming a complete green network. This network will be useful in combating climate change, reducing pollution and storing rainwater.

The introduction of more vertical agriculture will also be encouraged to save agricultural land and create space for more wetlands.

At the same time, the construction of natural islands will be completed, which are mainly located on the riverbanks near non-urban areas, providing rich habitats for animals and greatly enhancing biodiversity.



Delta


Coast
DEN HAAG
DELFT
ROTTERDAM
Polder
DORDRECHT
0
7,5
15km
N

The Delta

STRUCTURE AND PRESENT DAY SITUATION

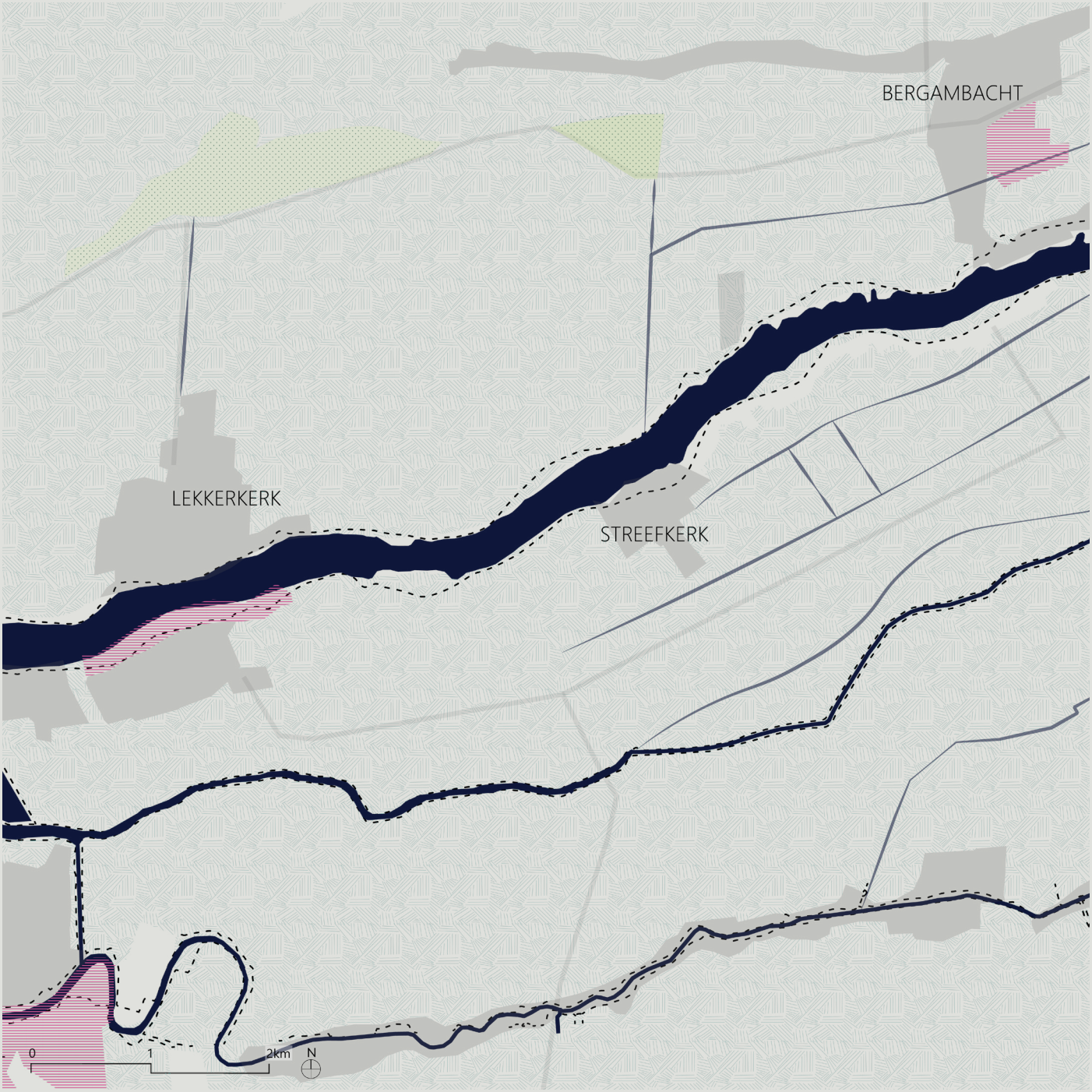
In the Delta area, there are different typologies of the coast, urban areas, fields, and ports. The strategy for this region is shown on a map, which displays the relation between these areas and the phasing. The Delta region combines various weaknesses and threats, such as the rising sea level, salinization in the coastal area, urbanization in big cities, and subsidence in peat fields. In addition to subsidence, the fields also contribute to pollution through the leaching of pesticides into the water and nitrogen emissions from cows.

With big urbanized areas located behind the dikes, the issue of sea level rise and flood risk is a major threat that can have significant financial consequences and should be addressed (PBL, n.d.). On the other hand, the mouth of multiple rivers ends up in the North Sea in this region. In the future, there will be times with more discharge than average, but also times with less discharge (Khoi et al., 2022). The dynamic of the sea and the river under the influence of climate change makes this region particularly vulnerable to its effects.

The areas selected for intervention in the Delta region are the coast bordering the North Sea and the fields located more inland. These areas are chosen because they contain all different types of threats and weaknesses found within the region and combine the different typologies of the area.

Delta

Fields


BERGAMBACHT
LEKKERKERK
STREEFKERK
0
1
2km
N

Fields in the Delta

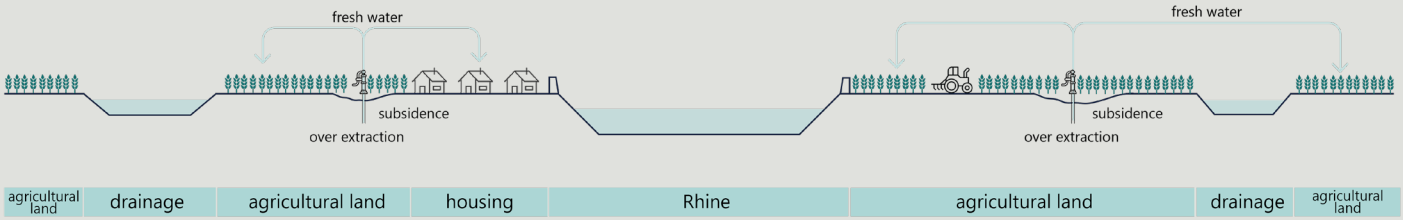
STRUCTURE AND PRESENT DAY SITUATION

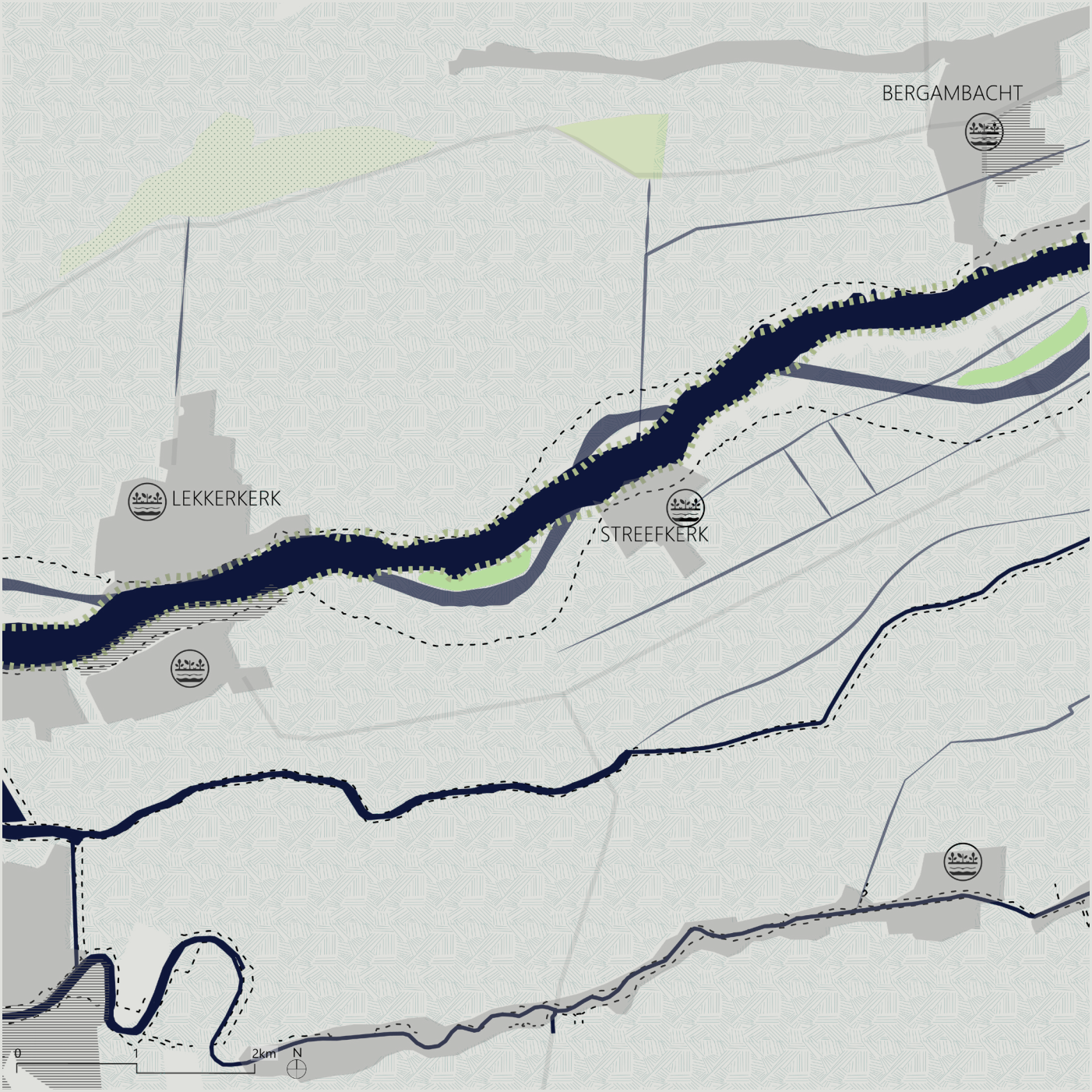
River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands
Infrastructure
Dikes

In this polder area, the problem of subsidence is increasing.

The ground level is getting lower and the flood risk is getting higher. With all the agriculture in this location, water will even get more extracted by the farmers from the groundwater which will increase the subsidence even more. The groundwater level needs to be stopped from becoming lower. That is why new sustainable agriculture interventions are needed.

Furthermore, more room for the river is necessary because of the flood risk. In some parts of the Netherlands, the Rijkswaterstaat already worked on this concept by giving the river more space to flow naturally and with that decrease the flood risk. (Ministerie van Infrastructuur en Waterstaat, 2022)




BERGAMBACHT
LEKKERKERK
STREEFKERK
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2km
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Fields in the Delta

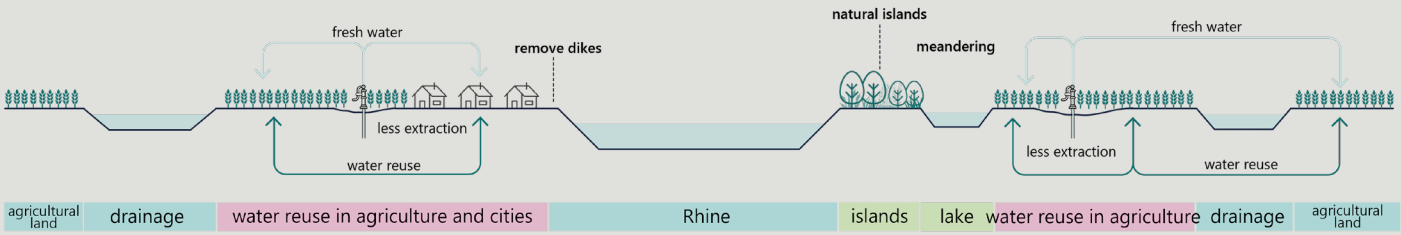
STRATEGY 2030

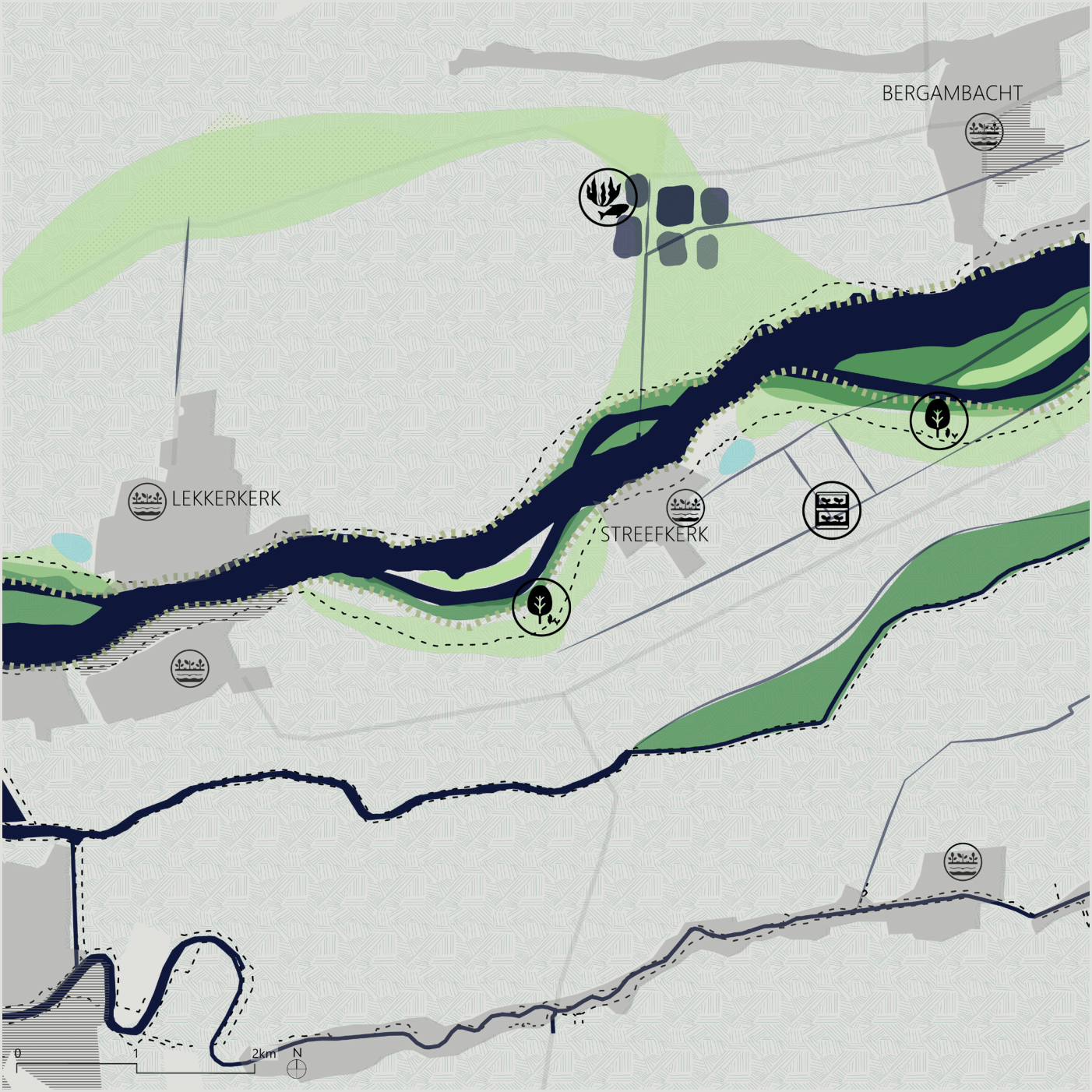
River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands
Infrastructure
Dikes

In phase 1, the dikes will be relocated. This is the first step needed to create room for the river. This was also an important principle in the 'room for the river' project: "Relocating a dike land inwards increases the width of the floodplains and provides more room for the river." (roomfortheriver, 2015)

When the dikes have moved a start can be made to re-meander the Rhine. This intervention is important to create more room for the river and to let it flow more naturally. It will decrease the flood risks. With this re-meandering, natural islands will be created. These islands will for example improve the biodiversity and give opportunities for sustainable agriculture in the next phases. Natural shores are also created along the cities.

The groundwater heightening will be initiated by introducing permits for groundwater pumping. This will have an effect on farmers, which pump up groundwater on their own property. More water reuse in agriculture is needed to use the water more efficiently. At the same time, more water reuse and infiltration is necessary in cities. This will be done by for instance educating people on the importance and making them enthusiastic. Furthermore, the pavement in the cities will be reduced to achieve more infiltration of rainwater.




BERGAMBACHT
LEKKERKERK
STREEFKERK
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2km
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Fields in the Delta

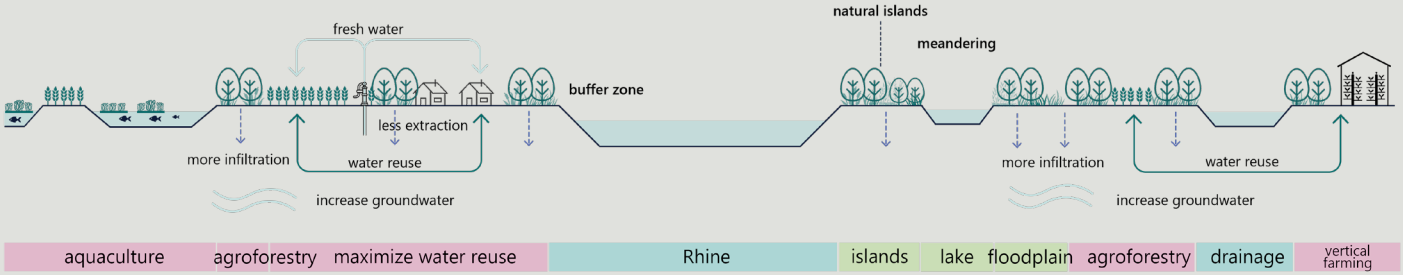
STRATEGY 2050

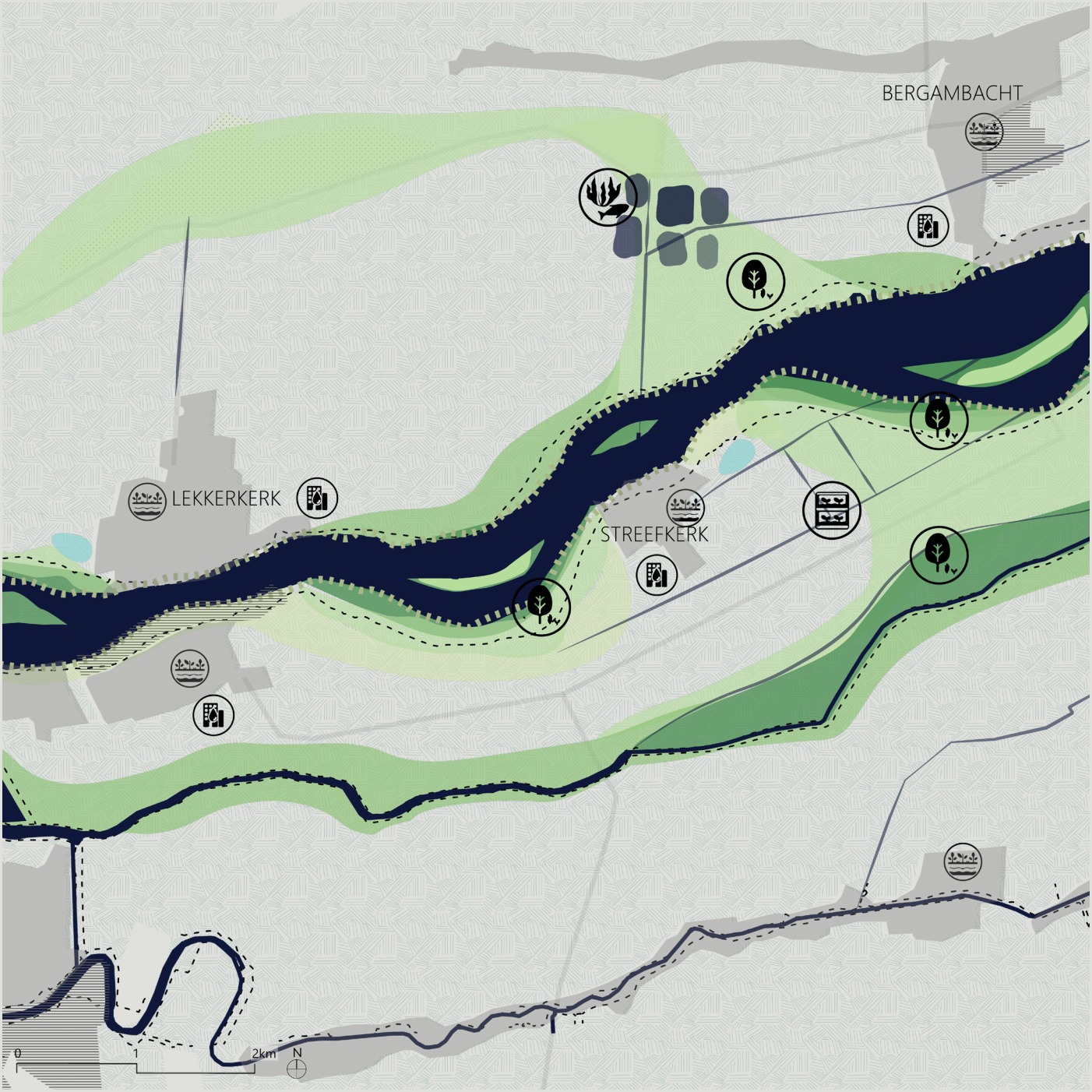
River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands
Infrastructure
Dikes

In phase 2, floodplains are forming along the river. Additionally, current wetlands will expand. The agriculture which is situated at this time in the floodplain and wetland areas will transform in this phase into sustainable agriculture which can be combined with those wetlands. Sustainable forms of agriculture that will be introduced in this area are: agroforestry, aquaculture and vertical farming. Vertical farming will situate outside the wetland areas, but are interesting because it works more efficiently for land surface use and water reuse. Then aquaculture is interesting in this area, because it can be combined with wetlands. An example is fish farming in the wetlands.

Besides, different types of agroforestry will be realized in combination with the wetlands. To be specific: Agrosilviculture, which is a combination of crops and trees that are suitable in wetlands. Agrosilvipastoral, which is a combination of crops and trees that are suitable in wetlands together with animal husbandry. And arosilviaquapastrol, which can form a gradient between aquaculture and the other agroforestry types. This is a combination of crops, trees, animal husbandry and fishery. (indiaagronet, n.d.)

Furthermore, some artificial aquifers will be created.




BERGAMBACHT
LEKKERKERK
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2km
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Fields in the Delta

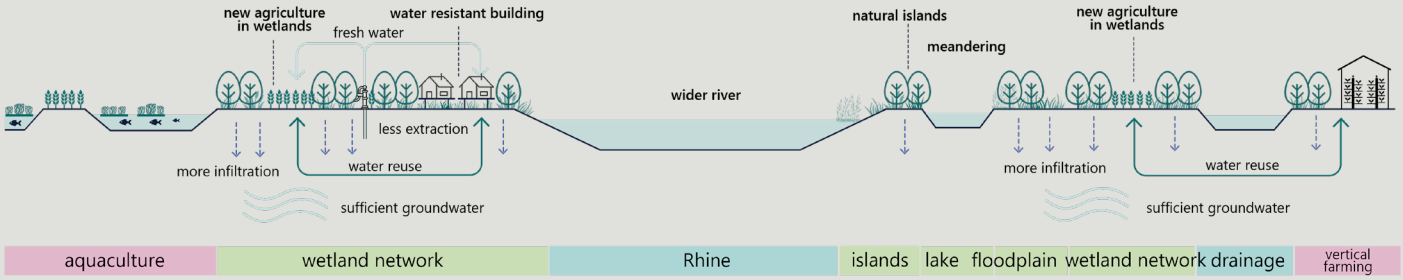
STRATEGY 2050

River
Inland water
Industries
Cities
Agriculture
Nature
Floodplains
Wetlands
Infrastructure
Dikes

In phase 3, the floodplains will expand into a natural system. They are connecting to current green and wetland structures and grow into a wetland network.

In the meantime, sustainable agriculture will be extended more. Cities need to transform their building typologies into water-resistant buildings when expansion of the cities is needed.

In 2100 the structure of the area is drastically changed, which is necessary to achieve the goals for a resilient freshwater basin. There is much more room for the river and sustainable agriculture is implemented everywhere. The wetlands help cleaning the water. The subsidence is in control and there is a good and natural flood risk area. The polder changed into a natural sustainable agriculture location.



Delta Coast


0
2,5
5km
N

Coast in the Delta

STRUCTURE AND PRESENT DAY SITUATION

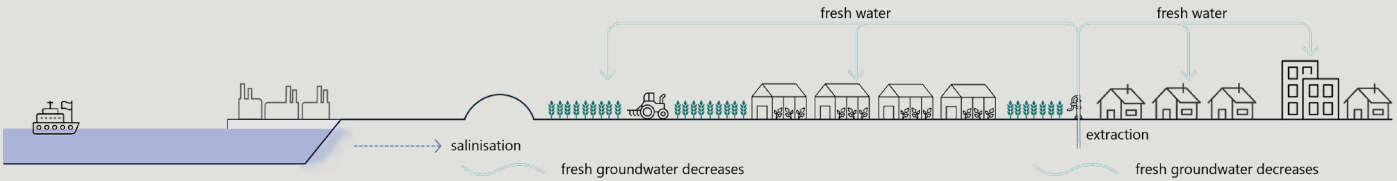
River
Inland water
Industries
Cities
Agriculture with mostly glass house
Agriculture
Nature
Floodplains
Wetlands

In the coastal area, there is the problem of urbanization and salinization which are the main treats. The urban areas will become more populated, with more water consumption as a result (Harbers, 2021).

This then leads to salinization as a result of the extraction of groundwater and surface water in coastal areas (U.S. Department of Agriculture, n.d.). Heightening the groundwater is a good solution in this area specifically to keep the salinization out, and keep the land from subsiding. Furthermore, the ecology and its biodiversity will by positively influenced by this (Griebler, n.d.). This will have implications on farming and housing. Houses cannot be built in with high groundwater, and the traditional agriculture machines will not be able to drive on soggy soil.

Next to that, also the biggest port of Europe, the Port of Rotterdam, is situated in this area (Donnelly, 2022). The port will move to a sustainable port, the port aims to be a green hydrogen hub in the year 2050 (Port of Rotterdam, n.d.). To be able to produce this green hydrogen, the port has several plans to build wind engine farms offshore to provide the energy.

The last function in this region is the horticulture in the Randstad area. In the coastal part of Westland particularly, glass houses dominate the landscape. This type of agriculture has a bad effect on the soil health: it causes soil compaction, salinization and affects the quality with pollutants of toxic chemicals (Wainwright et al., 2014). This asks for a change in farming in this region.




0
2,5
5km
N

Coast in the Delta

STRATEGY 2030

- River
- Inland water
- Industries
- Cities
- Agriculture with mostly glass house
- Agriculture
- Nature
- Floodplains
- Wetlands
- Water storage

In phase 1, the introduction of aquaculture will start right away.

In the sea, the seaweed farms will be started and at the shore a test site for the oyster farms will be placed. Here, the traditional farmers in this area can look at how things are done and it will make them more enthusiastic. Next to that, the original farming will already be done in a different way.

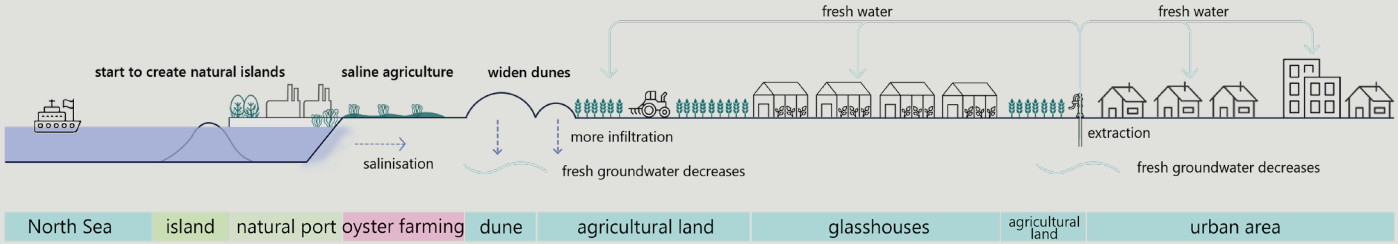
Policies stating that pesticides will be injected instead of sprayed are introduced to prevent over usage.

The groundwater heightening will be initiated with introducing permits for groundwater pumping. This will have an effect on farmers, which pump up groundwater on their own property. The water board will adjust weir heights to keep more water from land going into the river.Pavement will be reduced to let the rainwater infiltrate in the ground and higher the groundwater table.

The dunes are starting to expand in the regions where there are no people living. Inhabitants will be educated on the importance of freshwater, and the negative effect of the excessive usage right now. They will be shown in expositions how the water storage in dunes work and how drinking water is generated.

Next to that, after some subsidies and policies, the barrier/natural islands will be started. The sand will be won from the north sea soil and will be put in this place via pipes, as was done with the Sand Motor.

The port area in the line of the dunes is being cleared from industries. This will happen together with the transition to green hydrogen of the port, which also requires spatial changes.




0
2,5
5km
N

Coast in the Delta

STRATEGY 2050

River
Inland water
Industries
Cities
Agriculture with mostly glass house
Agriculture
Nature
Floodplains
Wetlands
Water storage

In phase 2, people will have to move out of their homes in the area where the dunes will be expanded.

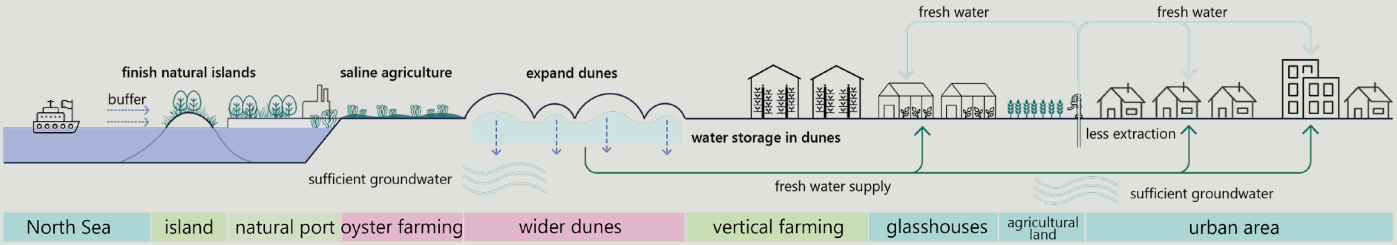
After the education inhabitants will be aware of the urgent freshwater scarcity problem and they will be more likely to move. The inhabitants will also be offered monetary compensation for their move, and a few can move into new housing typologies built in the dunes.

After the drinking water infrastructure in the dunes, both pipes and an extra water treatment plant, is built actual water can be won from the dunes. Pilots are being run to turn brackish groundwater from the dunes into drinking water. It is still in the testing process (Dunea, n.d.).

In the port, in the area where the industries are removed the soil will be naturalized from pollutants from the former industries. This will take at least a decade.

The barrier islands are fully done and are ready to start protecting the shore. Animals are already making use of these islands. Due to wind, tides and waves, the form of the islands will change quickly.

For the agriculture, a lot of the traditional farmers have moved to aqua-culture: oyster farming and seaweed farming. In the places where the traditional farming used to be, there is now vertical farming, which is less freshwater dependent. There are only a few traditional farms left, which are all organic.




0
2,5
5km
N

Coast in the Delta

STRATEGY 2100

River
Inland water
Industries
Cities
Agriculture with mostly glass house
Agriculture
Nature
Floodplains
Wetlands
Water storage

In the last phase, new habitats have formed in the dunes and on natural barrier islands.

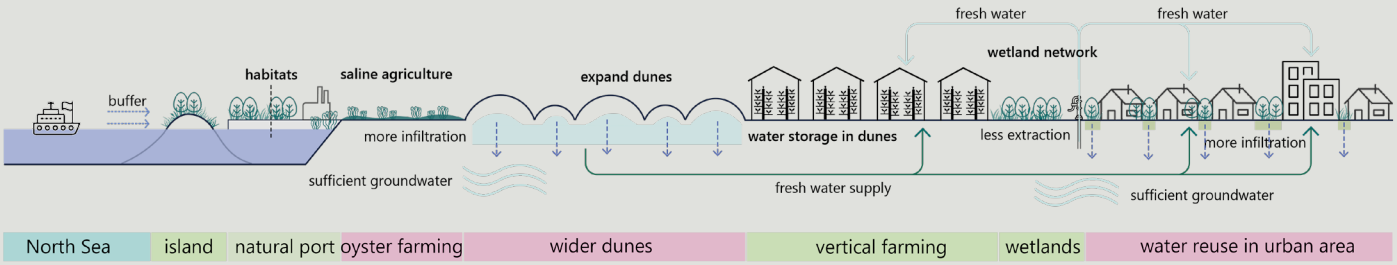
The previous barrier islands have vanished due to natural weather events. Therefore new islands have been resurrected.
The agricultural scenery is completely changed. The main agricultural type in the coast area is now aquaculture.

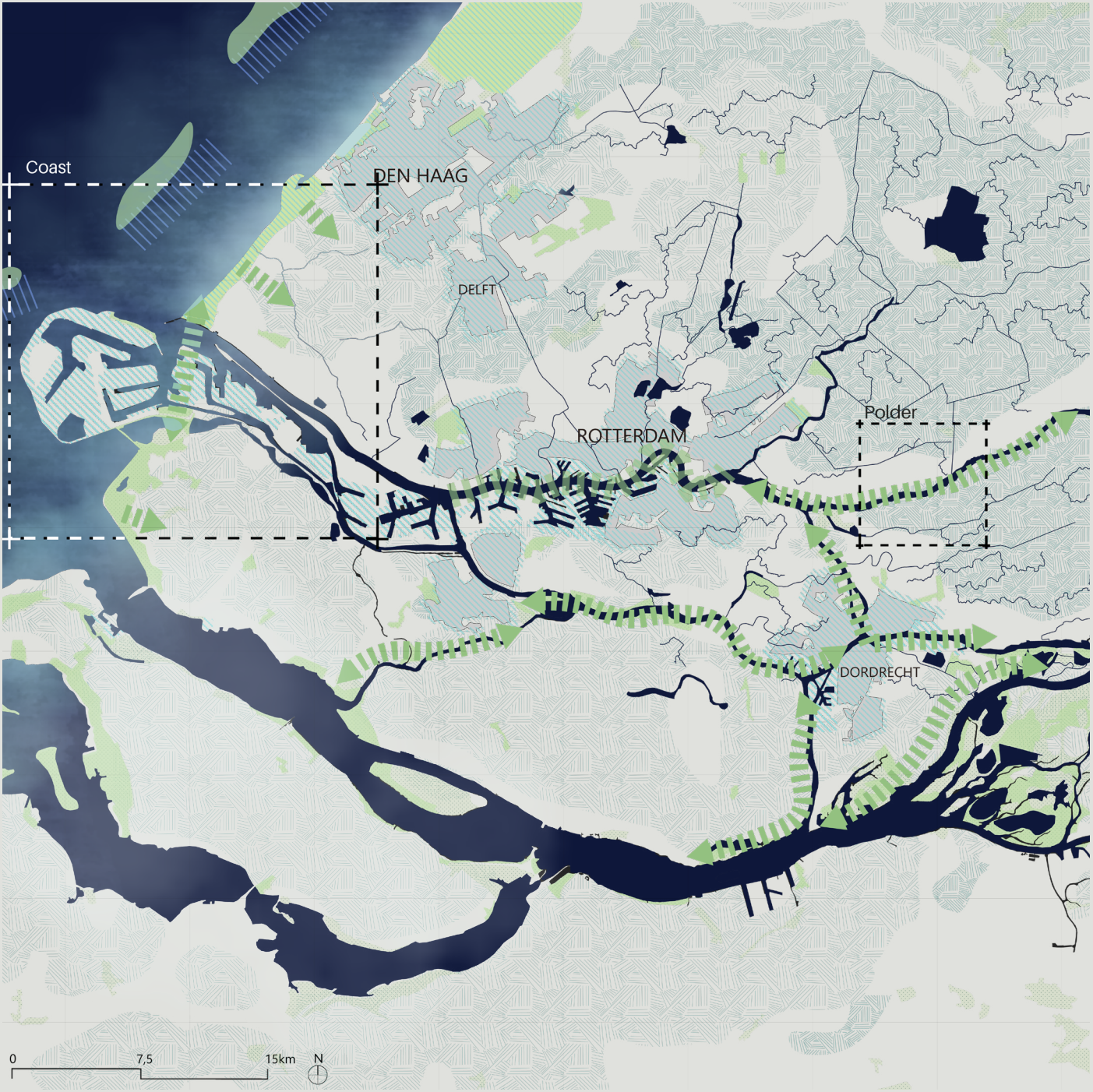
On land, the main farming is vertical farming as well as crops which can be grown with the high groundwater table.
The houses will also be adjusted to high (ground)water. There will be neighborhoods of amphibious housing and floating houses.

The corridor in the port area is green and habitats are starting to use this corridor to get from dune to dune. The dunes itself are most expanded and people are living in new housing in these dunes.

Around the urbanized areas marshes are created which reach to the dunes and connect the green blue structures in the region.

The freshwater supply for the area is now from practically renewable sources, because the pilot to make freshwater from brackish water succeeded. Furthermore, the freshwater storage in the dunes has become very big. It can provide all inhabitants of South-Holland with drinking water.




Coast
DEN HAAG
DELFT
ROTTERDAM
Polder
DORDRECHT
0
7,5
15km
N

The Delta

STRATEGY 2100

The Netherlands is a pioneer in the field of water management. This begun out of urgence with the flood in 1953, but nowadays it is an incentive to be innovative and find new ways to deal with future challenges. For the strategy of 2100 the innovative ways of water management are the core of the development strategy.

This will be done by connecting wet landscapes following the existing water structures together with the responsible use of water by both society and industries.

The dunes will form a big new water storage structure and for the agricultural land the water is taken into the land. In other places the agriculture is taken into the water.

Almost all agriculture is turned into aquaculture, vertical farming, agroforestry or crop rotated fields by 2100. The coast is protected against big floods with barrier islands and the oyster farms on the beach protect the shore as well.

With the Delta being small and having so many different things going on, the goal for this area is to have multifunctional land use.

With a lot of different topics going on, there are a lot of different opinions. At this moment, the themes of nitrogen and groundwater height, which we address in the development strategy, are very polarizing. This is something that especially in the process of transforming the area need to be taken into account.

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Activation strategy

HOW TO ACTIVATE THE STAKEHOLDERS?

With the spatial and non-spatial principles proposed, there are several parties that need to be convinced. This will be done with different activation strategies. To create awareness for citizens as to why certain measurements are necessary a few different approaches are possible.

EDUCATION

The first step is to tell the parties involved why these measurements are needed. People will cooperate sooner when they have more knowledge of a problem. Educating can be done with campaigns, on posters throughout a city, or via social media, for instance. For bigger interventions, expositions are an approach which can help people understand how an intervention works and why it is needed.

ENGAGE IN CONVERSATIONS

With our project, we touch on a few controversial topics. With these topics, it is of great importance to talk with the people, instead of to them. Politicians should engage with people affected by transitions from a very early stage on. This will take more time but will create more support base for a transition, and trust in future transitions.

MONETARY COMPENSATION AND INCENTIVES

There are different situations in which monetary compensation helps with implementing measurements. Subsidies are an incentive for people to move towards more sustainable (freshwater) use (Garrone et al., 2019). This can be a subsidy for either water-saving water taps/shower heads or in some other cases a subsidy for moving away from an area where an intervention might take place.

06

Reflections

General reflection

CONCLUSIONS, LIMITATIONS AND FUTURE RECOMMENDATIONS

To conclude, we proposed a series of interventions along the Rhine River, guided by spatial and policy principles in order to achieve three main objectives: a creation of a network of wetscapes and compatible cycles of water use, as well as cross-border cooperation on legal and policy procedures. We looked at a total of five areas, some of them over 600 km apart (areal distance!).

We believe the value of this project is its integrative nature, as well as our consistency in the objectives, principles and how they are applied spatially. The distance between our interventions once again echoes the underlying message of this project - all of the waters around us belong to systems, and fixing an issue only in one spot does not solve the problem which lies in the disfunctional systems. The same goes for the stakeholders within the project, especially the national governments that wield a lot of legislative power.

Focusing on the selected five areas is supposed to illustrate a domino effect approach, within which certain dominoes do have the ability to take down more than just one, and have far reaching consequences. This has also turned out to be one of the limitations of our strategy, as it was very difficult to provide adequate attention to the areas and their transformations and at the same time clearly illustrate how their change influences all the other area, and in fact creates this network of wetscapes.

Another limitation is the lack of attention we were able to give to the analysis and incorporaation of shipping industry, energy production on the river, and different implications of our project on the soils (other than simply storing moisture). This omission was made purposefully in order to prioritize capacities, however, we believe it could make for an interesting continuation of the project.

Therefore, if there were any next steps, we would recommend exploring how does a network on such a large scale work, and how can the topics of shipping, energy and soil also be integrated into solving the freshwater crisis in the Rhine River basin.

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Personal reflections

MAAIKE JANSEN VENNEBOER

What is the role of a vision in the planning and design proposal of your group project and how has it influenced your development strategy?

The role of the vision is crucial, it is the first step towards a strategy and later on, a detailed design for each small area within this vision. Visions are useful for each scale, it is the key to conveying the goal/message of your project and its relation towards other areas, also the ones that might not be in the frame of the area of intervention.

The vision takes quite some time to be formed, usually because a lot of background research is needed to come to this goal. This was also in our group project the case, we first got to know the area and performed problem analysis to start seeing what problems might be used for our vision. In the phase of forming the vision, there are still a lot of different topics open which might, or might not, come into the vision. This was a hard part in the group project: deciding which subjects to elaborate on, and which subjects not. Especially in the visioning phase, where we were still exploring what the problem was and what possible solutions might fit it.

The vision has, especially in such an overwhelmingly big project as this one, a major role in the phase after the visioning: coming up with the development strategy. With the project being on the scale of Northwestern Europe, it was very easy to get off track. Having the vision to remind yourself of the goals you initially wanted to reach, and how, helps with staying focused on the right information.

On the other hand, there is also the pitfall of hanging on too tight to the vision. The vision is meant to be a guiding line and the structure and main theme should remain somewhat the same, but it is not all set in stone. This was not something that occurred in our group project, someone always thought of it and we reminded each other. With getting towards the development strategy, more and more context and information were researched, which also gave us more options for our vision.
I think that the vision especially helps in the structure of the process of getting towards a development strategy with a group project. When doing a project together with other people, the vision is not only there to keep you on track, but also the other group members, and to keep looking in the same direction. It is a (visual) tool to keep everyone aligned in the project.
All in all, doing a group project like this was a very useful and fun experience. I have learned a lot from everyone in the group, everyone had their own strengths which combined perfectly and made it a real team effort. I want to thank both Marcin and Alex for their knowledge and the good and fun studios!

YUQIAN JIANG

I see research as the basis for design in our group project, but also research and design as an interactive process where research can influence the way design is done and design determines the content and direction of research.

Our project aims to create a resilient Rhine basin and provide a sustainable supply of fresh water. First we identified the problem we wanted to solve by studying the freshwater situation in Northwest Europe and the context about water. Based on this problem, we identified the planning area in the Rhine basin and through our research we identified stakeholders at different scales, which influenced the subsequent design. Secondly, we conducted research on how to solve the problem of freshwater shortage and water pollution, browsed some relevant case studies and papers, and proposed two systems of natural and human water cycle, for which we proposed natural and human solution strategies. These specific strategies are based on research and largely determine the direction of the design. This was followed by a study and SWOT analysis of the Rhine basin, based on which the different sub-regions were identified. Based on the study of the policies and problems of different sub-regions, the key problem of each region was identified, and the stakeholders of the different regions were studied, based on which the strategies to be used were decided and the design and vision of each region was finally developed. Thus, in our project, the dynamic process in which research and design influence each other is carried out throughout the whole project and through different scales.

I think the vision guides the direction of the strategy development and provide common goals for all stakeholders involved in the process. Our vision is to create resilient Rhine river basins that can enhance the happiness and well-being of citizens and improve biodiversity while securing freshwater supplies. This vision has guided the direction of our project development, and in proposing our strategy, we deconstructed the vision to propose strategies related to storing, purifying, and recycling water through natural and human-made methods, creating resilient river basins, addressing water pollution, improving water accessibility and availability, ensuring a functioning economy, and enhancing biodiversity, using the three pillars of ecology, society, and economy.

Governance aspect is embedded in our design in several ways: starting with research into relevant laws and regulations to ensure that our design proposals are consistent with them. In addition, stakeholder involvement is important to keep stakeholders informed about the plan and to ensure that their interests are considered. It is also important to educate citizens through festivals, events, etc. to raise public awareness of water scarcity and to encourage and persuade multiple stakeholders to cooperate. For example, in Lake Constance, which is a cross-border region, we propose strategies such as set back along the lake and unifying ship routes, which are strategies that require the cooperation of several countries, and in this case, governance is particularly important. In addition, governance in our project also includes monitoring and evaluation. For each sub-region, we propose different strategies and objectives to be achieved at different time points, and monitoring and evaluation ensures that the planning process is on track and that adjustments can be made in time if problems occur. Therefore, the reason why governance is embedded in our projects is to ensure that the proposed solutions are in line with policies, regulations and the interests of the stakeholders.

VERA VINCE

What is the role of a vision in the planning and design proposal of your group project and how has it influenced your development strategy?

The vision had several roles in the planning and design of our strategy.
Firstly, the vision was a way for us to bridge the gap between somewhat abstract goals and values, and the specific strategy we had been tasked to develop. It made it easy to operationalize this process, and for us to be more explicit with our intentions and guiding principles. Working together on the vision specifically, made it easier to understand what desireable future we wish to achieve. Therefore, I see visioning first and foremost as a communication tool which is useful both within the planning process, and when it is time to communicate your project to different stakeholders.

Furthermore, creating a vision really focused my research, not only topic and location wise, but also in terms of my intentions which were made more clear to me as well. In a project as wide and far-reaching as this one, it is almost impossible not to get lost. This is why we would sometimes refer to our vision as "our north". When we started exploring the issue of freshwater two months ago, it was a very steep learning curve. From learning about the hydrological cycle, to the carbon sinking abilities of the wetlands, sometimes it was hard to understand what the project was. This is where the vision came in.

Except for making the project more understandable and intentional, the vision gave us a positive way forward. After reading about the total degradation of our environment and researching the domino effects of pollution and climate change for several weeks, building our vision gave us an optimistic direction towards building our strategy. It also allowed us to express ourselves a bit more creatively than we might be used to when dealing with research and strategy building.

All in all, after the experience of this studio, I believe that creating a vision as a step in any wide-scale project gives you the ability to be more intentional and explicit with your design, makes it easier to communicate those intentions to others, and gives you an opportunity to give your strategy some more feeling and character which might furter better illustrate your ideas to relevant stakeholders or colleagues.

Reflecting back on this quarter, I learned a lot about how to more seamlessly, and yet transparently integrate different parts of tworking on a strategic project of this scale. Taking into consideration different stakeholders, their relations to each other and to our project, as well as incorporating policy research into our strategy was a new approach for me, and I appreciated it greatly.

SANDRA WOLFERT

What is the role of a vision in the planning and design proposal of your group project and how has it influenced your development strategy?

Within our project, the vision had an important role in achieving the proposed strategy. With my bachelor in Urban Design, I was used to work on design projects on the scale of a street/ neighborhood or city. For our strategies in this project, we choose to focus on the Rhine. To achieve a well-researched strategy it was important to look at the whole Rhine River basin. With developing our vision we started working on the scale of North West Europe. Which was a massive scale I have never worked with before.

Our starting point was to research the whole Rhine river basin to conclude with a vision for the whole region which we could use to work out a strategy for the delta. Nevertheless, an important outcome of our vision was that we determine a lot of problems, related to the river, which we can not fix all in the delta by itself. The whole Rhine River is a connected system, certain bottlenecks occur earlier along the river before it reaches the Delta. Therefore, our vision proposes three subregions before the delta, each subregion with a focus on the problem it causes for the Rhine River. This approach has influenced the locations for our development strategy. While a lot of groups focus on a strategy for the province of South Holland, we propose strategies also for different regions along the Rhine in North West Europe.

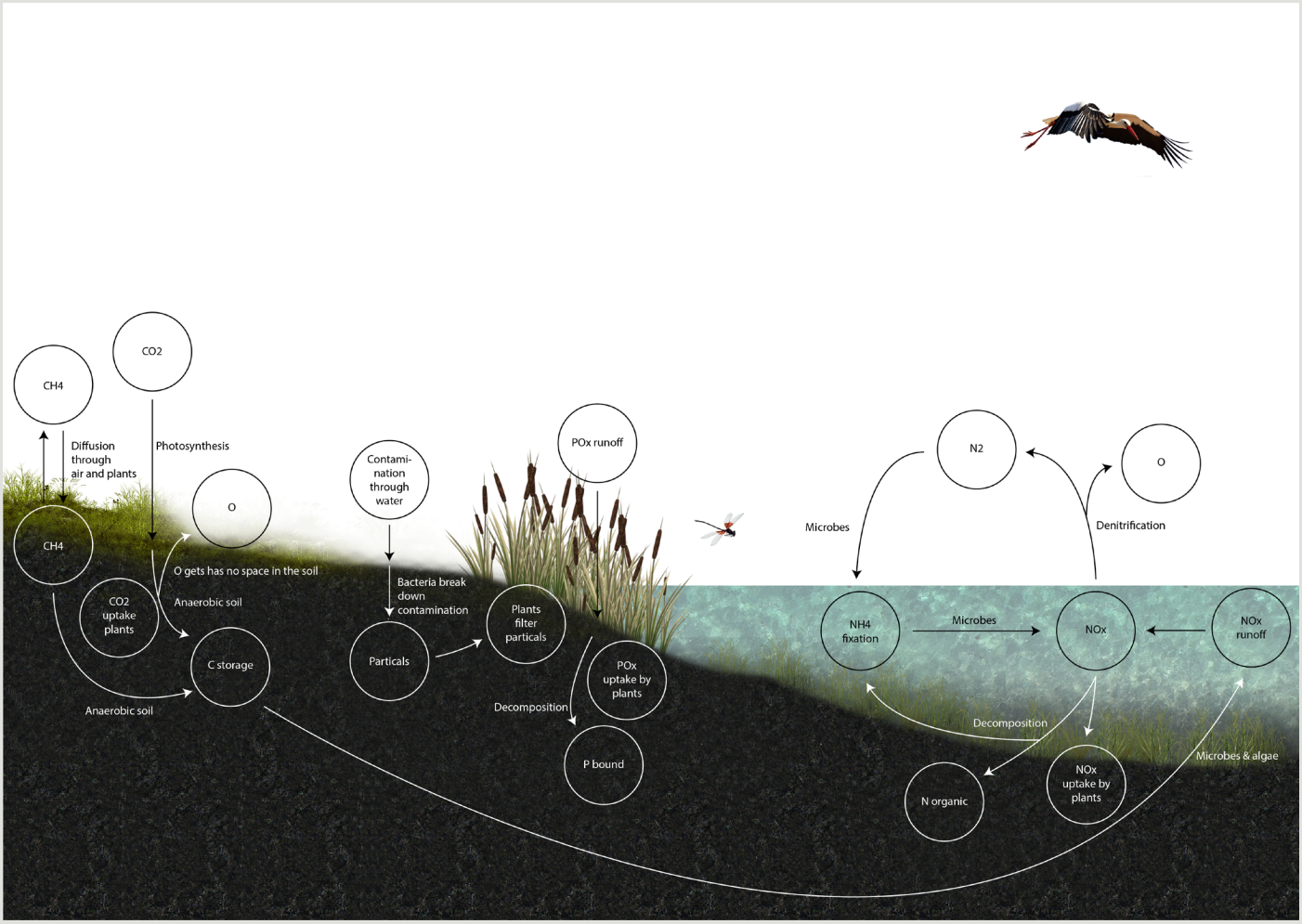
Furthermore, our vision gave us guidelines for developing our strategy. As discussed in the lecture given by dr. Verena Balz about Strategy-Making, the development strategy will identify concrete action which has to be taken in the light of a vision. For our strategy, this is formed with the use of principles from our vision. With our vision, we concluded for example that we wanted to create a network of wetlands that could have a multifunctional use and decrease multiple problems. This network of wetlands: the wetscape network, was a guideline for our further developed strategy as an important principle.

Reflecting on this quarter, I learned a lot about working on a larger scale. Which was in the beginning difficult for me, because I was used to zoom in on specific locations from the start of a project. This project required a broader perspective and gave me insights into the importance of systems and how they are connected and influence each other. This is not only happening with the Rhine, but also for example with the landuse and circularity. I want to thank my tutors for the accompaniment during this course.

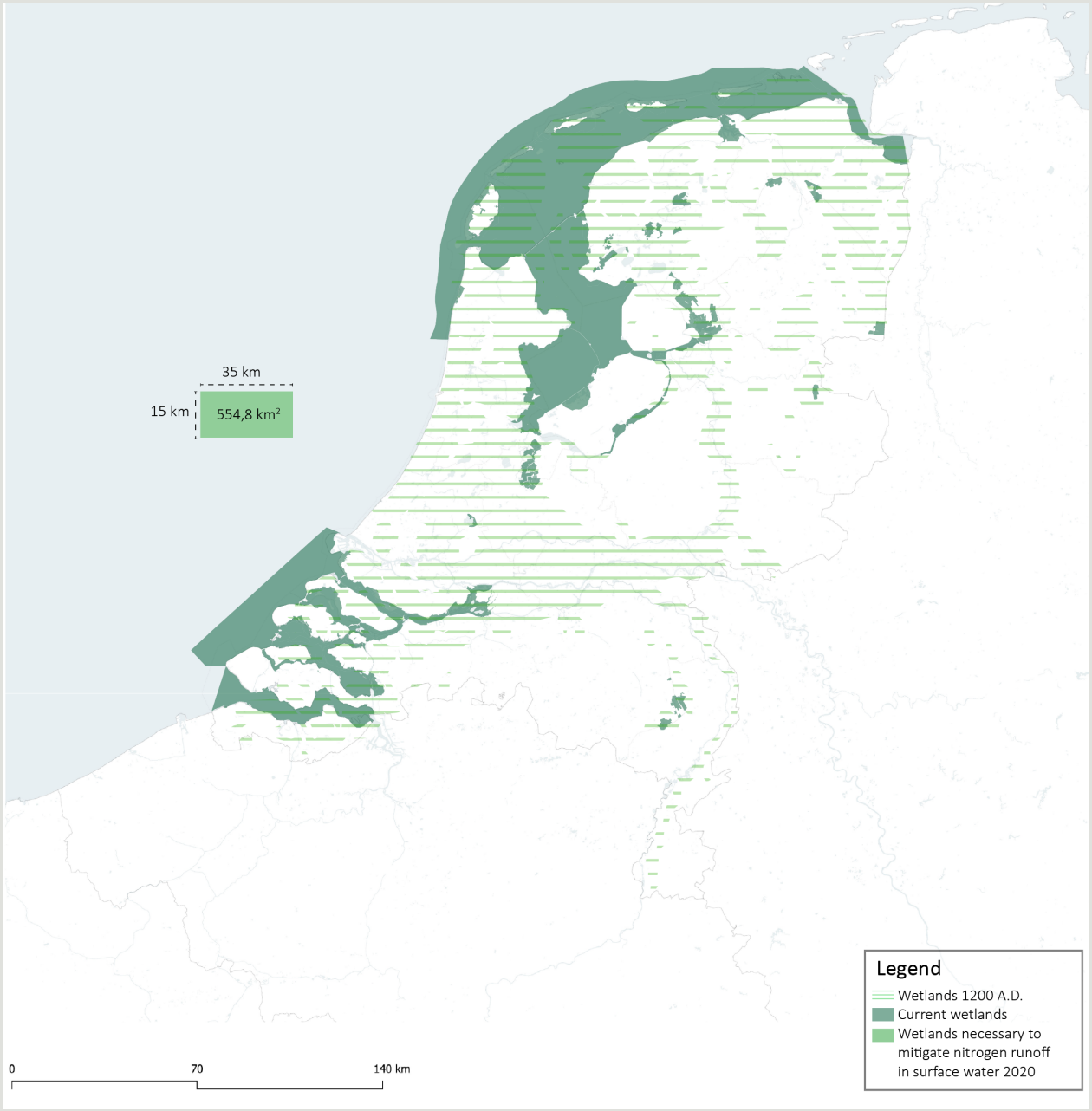
07

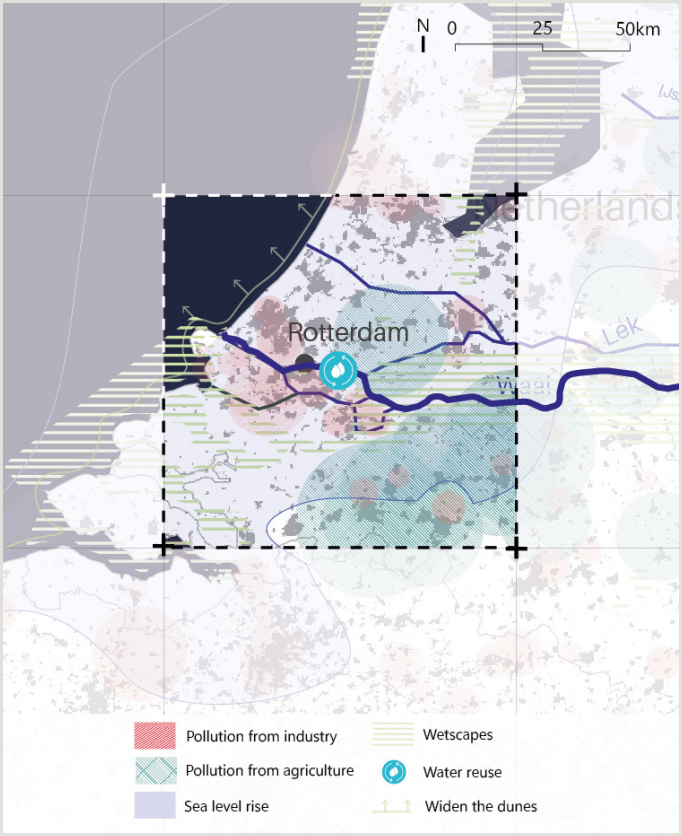
Appendix

WETLAND SINKING, ILLUSTRATION BY CHRISTEL VONCKEN

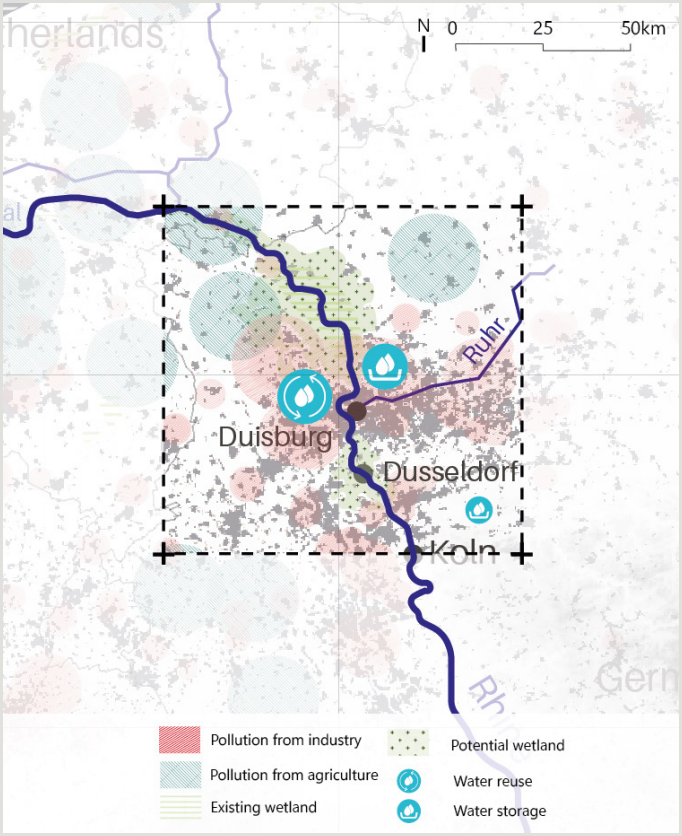


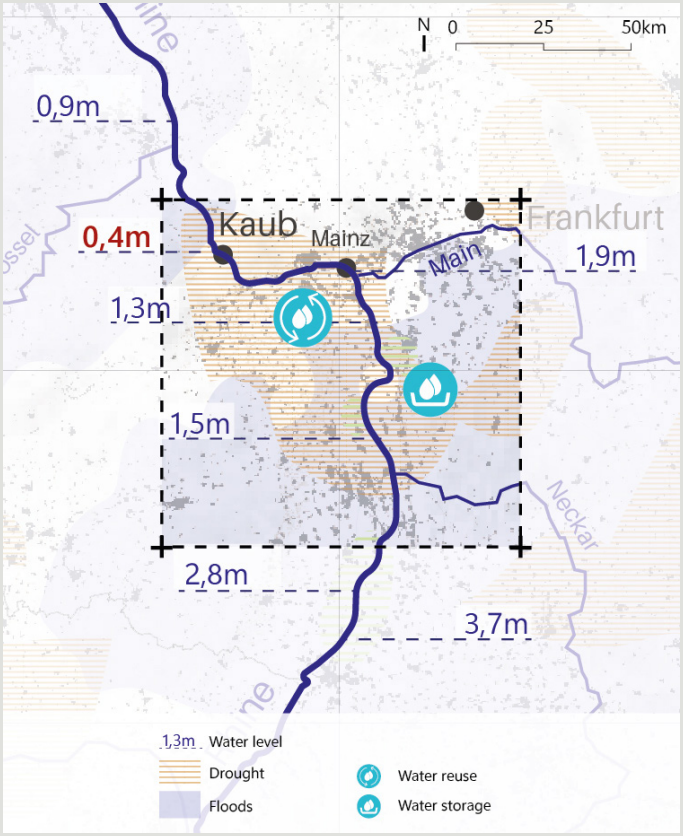
AMOUNT OF WETLANTS NECCESSARY TO CLEAN THE NETHERLANDS, MAP AND CALCULATION BY CHRISTEL VONCKEN

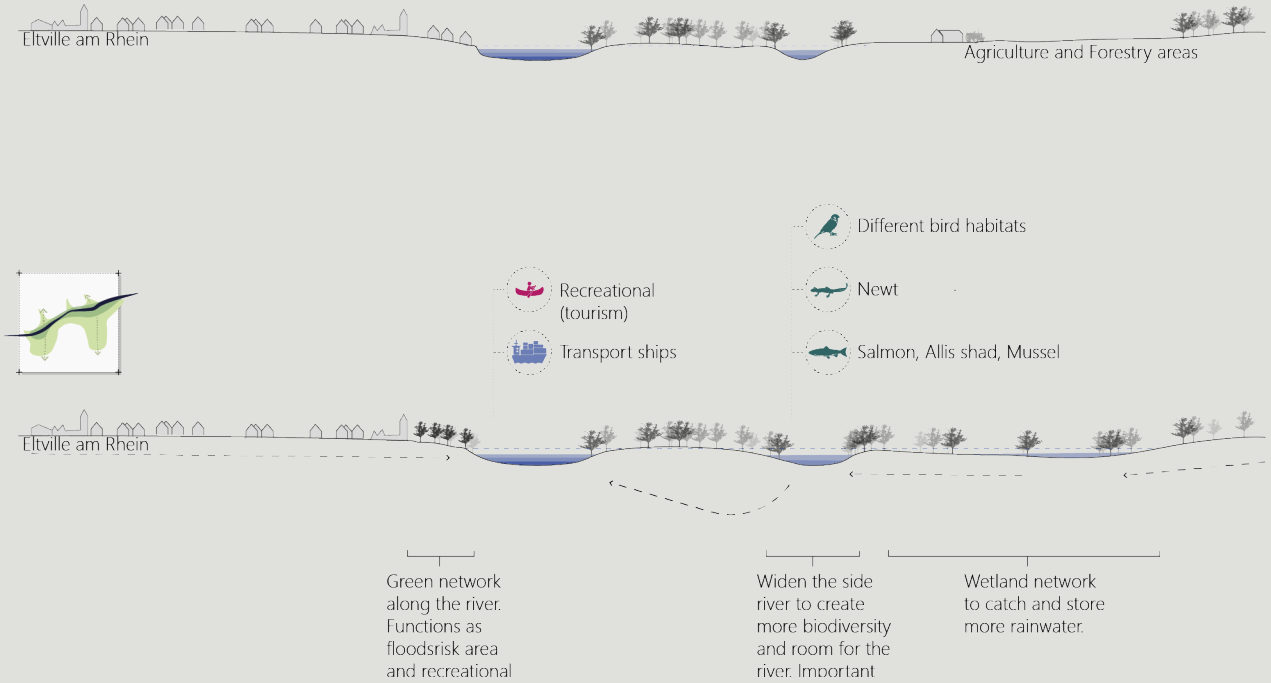


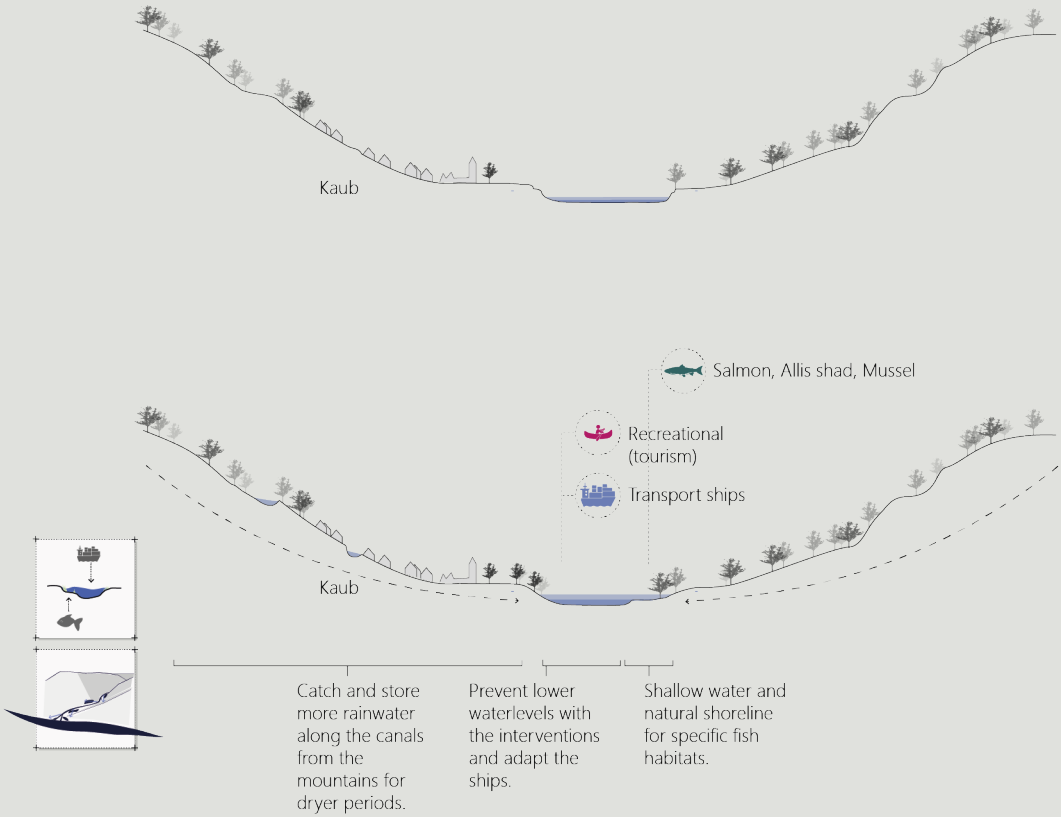

N 0 25 50km
Rotterdam
Lek
Pollution from industry
Pollution from agriculture
Sea level rise
Wetscapes
Water reuse
Widen the dunes


N 0 25 50km
Lake Constance
Rhine
Pollution from agriculture
Drought
Floods
Renaturalized shoreline
Water storage


herlands
N 0 25 50km
Ruhr
Duisburg
Dusseldorf
Köln
Pollution from industry
Pollution from agriculture
Existing wetland
Potential wetland
Water reuse
Water storage


N 0 25 50km
0,9m
0,4m
Kaub
Mainz
Main
Frankfurt
1,9m
1,3m
1,5m
2,8m
3,7m
Neckar
1,3m Water level
Drought
Floods
Water reuse
Water storage


Eltville am Rhein
Agriculture and Forestry areas
Different bird habitats
Recreational (tourism)
Newt
Transport ships
Salmon, Allis shad, Mussel
Eltville am Rhein
Green network along the river. Functions as floodsrisk area and recreational
Widen the side river to create more biodiversity and room for the river. Important
Wetland network to catch and store more rainwater.


Kaub
Salmon, Allis shad, Mussel
Recreational
(tourism)
Transport ships
Kaub
Catch and store more rainwater along the canals from the mountains for dryer periods.
Prevent lower waterlevels with the interventions and adapt the ships.
Shallow water and natural shoreline for specific fish habitats.

Reference table

ALL WEBSITES, DATASETS AND OTHER RESOURCES WERE ACCESSED BETWEEN 13TH OF FEBRUARY AND 12TH OF APRIL 2023

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