A HARD TRANSFORMATION

Transforming Hard Infrastructure to create a sustainable future through the use of green, connected and smart solutions.

Say HI to Sustainability

Delft University of Technology - MSc Urbanism (Architecture, Urbanism and the Building Sciences)
Quarter 3 | AR2U085 R&D Studio - Spatial Strategies for the Global Metropolis
AR2U088 Research and Design Methodology for Urbanism

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Preface

This report will show a proposal on how we can think about Hard Infrastructure when it comes to a sustainable future. We aimed for 2060 because we believe that the next coming 38 years, a lot can change, and that change is absolutely necessary if we are going to attain the relevant climate targets. The proposal is made by Casper van Duuren, Daniel Watchorn, Mayke Giesen, Danyi Xiang and Ke Zhou. We made this report in MSc2, during the courses AR2U086 R&D Studio: Spatial Strategies for the Global Metropolis and during AR2U088 Research and Design Methodology.

A special thanks goes out to our tutors, Alexander Wandl and Caroline Newton, whom helped us through a slow start but also supported us during the whole course, and we appreciate their inputs in our project. Also the tutors of the Research and Design Methodology, Marcin Dabrowski and Roberto Rocco, who helped us throughout the course with their inspiring lectures and exercises.

Abstract

Humans are consuming resources at a rate that the natural world can not sustain. Nations around the world are grappling with large amounts of possible interventions that can stop or at least delay the battle against environmental degradation. While we may not notice it, hard infrastructure (energy, transportation, water management and communications), have a outsized effect on the negative impact that humans have on the natural environment. It is a representation of the backbone of modern society that can both enable, and disable, our ability to transition to a more sustainable future. Directly linked to this our loss of connection with nature. Infrastructure is a critical piece of the puzzle that is the creating of a sustainable future. Thats why this project will focus on using hard infrastructure to enable us to live within the planetary boundaries in the context of South Holland in the Netherlands. An inventory of the existing infrastructure network is completed to understand the scope of the problem. Subsequently, a literature review, analysis of similar case studies and industry research was completed to understand potential solutions. Then, using the existing natural structure as a backbone, a series of green, connected and smart interventions are proposed. These interventions occur on provincial, municipal and local scales and work together to enable the human sphere and the ecosphere to exist in symbiosis.

The following is a proposal on how to achieve a sustainable, innovative, just, accessible and resilient South Holland by the year 2060 through a reimagining of the hard infrastructure system.

1.1 | Context

Climate change is an ever pressing issue that the world is facing. The overconsumption of natural resources, de-forestation, increasing CO2 emissions, among others, have led to a situation where, if a solution is not implemented soon, life on earth as we know it will be significantly negatively affected. The increasing number extreme weather events, sea level rise and the urban heat island are examples of the impacts on the world we are living in now. In the face of a changing climate, a rising sea level and imminent global resource depletion, the maintenance of the status quo is not viable. According to the latest IPCC report on climate change, if a significant reduction in the rate of carbon emissions being expelled into the atmosphere is not achieved quickly (by 2040), the risk to the health of humans, plants and animals is severe. Catastrophic events that are directly caused by climate change will be likely (IPCC, 2022).

As a result, we live well beyond our means. Our consumption habits will have to drastically change, and we will need to be more aware of our planet's resources. There's still a lot of work to be done. We must use our energy more efficiently, eat more plant-based foods, travel in a more sustainable manner, frequent the thrift store for second-hand items, and opt for local alternatives.
In this light, South-Holland is not an exception. South-holland is the most densely populated province of the Netherlands. It is one of the most industrialized areas in the world. South-Holland has a great variety of landscapes, where The Hague, Rotterdam and Leiden are the largest cities, the green heart and the 'bollenstreek' represent the more green areas.

With being the most dense province there is a great opportunity for the transition to a circular economy. Therefore the government has set up some circularity goals for 2050, namely:

1. Existing production processes make more efficient use of raw materials, so that fewer raw materials are needed. Raw materials are used for example for food, electrical appliances and clothing;

2. When new raw materials are needed, sustainably produced, renewable (inexhaustible) and generally available raw materials are used as much as possible. Such as biomass, which is raw material from plants, trees and food waste. This makes the Netherlands less dependent on fossil sources and it is better for the environment.

3. Developing new production methods and circular design of new products.

1.2 | Footprint Netherlands

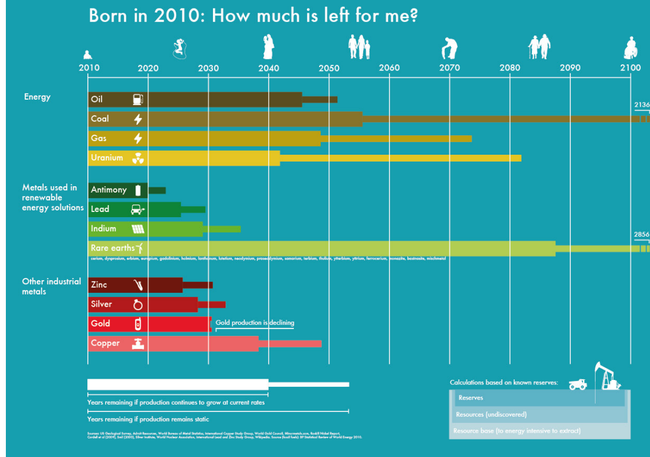
We as humans are rapidly depleting the natural resources of the Earth. At the current rate of production, we are projected to run out of oil by the mid 2040s. Existing copper reserves will be depleted by the mid 2030s (Jerew, 2014).

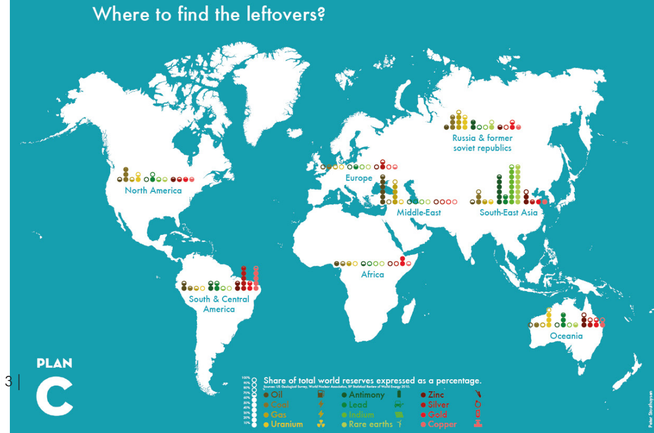
While a transition to a more eco-friendly society has begun, a radical change in Dutch society will be necessary for the Netherlands to adequately do its part to mitigate these issues. The Netherlands today is not a sustainable country. Dutch citizens consume resources at a rate that would require the equivalent of 6.2 Netherlands' to sustain (Earth Overshoot Day, 2022). We should not consume more than the ecosystem can sustain. But that is precisely what we are doing now as Dutch people (and as humanity as a whole).

Natural Capital Day took place on February 19th. This is the day when the Netherlands' annual biocapacity is depleted. That is only 50 days that have passed since the new year began.

There are calculations about how quickly a country's available natural capital is being used by comparing its biocapacity to the ecological footprint of its citizens. The ecological footprint refers to the amount of land required to meet our needs for food, wood, and other materials, for example.

However, there is also the issue of the amount of land required to absorb our CO2 emissions. The Netherlands has a total biocapacity of 13.3 million hectares, or 0.78 hectares of biocapacity per person. The average Dutch person's ecological footprint is 5.7 hectares. This means that the ecological footprint per person is more than 7 times greater than the available biocapacity, and that the natural capital of the Netherlands is depleted after 50 days.





1.3 | Numbers

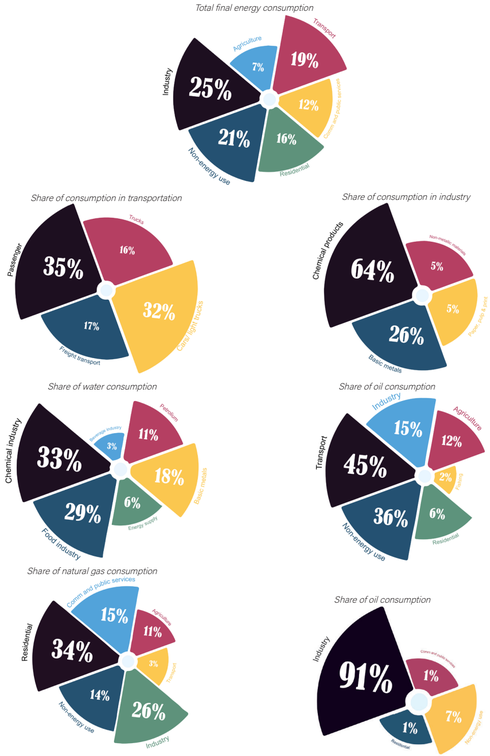
The figures to the right depict the breakdown of the consumption of fossil fuels in the Netherlands in 2019. This consumption accounts for all types of fossil fuel uses, including for electricity generation, use in industrial processes, combustion to power private vehicles, among others.

Energy generation for industrial activity, fuel combustion for transportation and non-energy uses such as feedstock for manufacturing or bitumen for road construction account for 65% of all fossil fuel consumption in the country. Relatedly, electricity production is dominated by fossil fuels. Oil, natural gas and coal accounted for 88% of the electricity production in the Netherlands in 2019 (IEA, 2022). While the share of electricity being generated through renewable sources has been growing over the past decade, the current state of the energy system is still heavily reliant on non-renewable and polluting sources of electricity generation.

Another important consideration for climate change and resilience is waste. Not only can waste physically pollute the environment by finding its way into waterways or other environmentally sensitive areas, but it also represents an over production, or under utilization, of materials. The largest contributor to waste production is the construction industry, which creates 46%of all waste in the Netherlands (Yu. Y et. al. 2021)

The above numbers show the amount of resource consumption in all of the Netherlands. However, since South-Holland is the densest province, a large proportion of these overall resources will be used in the province - and especially by the hard infrastructure. The images on page 5 show the amount of different hard infrastructure in the Netherlands and in South-Holland. This is indicates that hard infrastructure is a huge facilitator of the drainage of fossil fuels.

What is notable by these numbers is the large amount of unused water pipes, electricity lines and communication cables. As we shift towards a gas-free country and a more digital generation, the number of unused lines will only increase. There must be a way for us to reuse these lines for the better.



Communications

1.6 million meters
Telecom related cables

400.000 km
Interlocal cables
16%
Are unused

300.000 km
Interlocal pipes for optic fiber
35%
Is still empty (due stock capacity)

910.000 km
Connections to home
50%
Is inactive

Transportation

550 km
Of provincial roads
290.8 km
Of highways

Almost 700
Bridges, locks, viaducts and tunnels

446 km
Of train tracks

130 km
Of provincial waterways

Water

115.000 km
Of drinking water pipes
10.000
Are inactive

110.000 km
OF wase water pipes
2.000
Are inactive

800 km
Of dykes
364
Alongside rivers

2.000
Are inactive

Energy

225.000 km
Of electricity lines in the Netherlands
30.000 km
Are inactive

7
Main datacenters in use in South-Holland

135.000 km
Of gas pipes

1.4 | Problem statement

‘Humans are consuming resources at a rate that the natural world can not sustain. Hard infrastructure is one of the main facilitators.’

Infrastructure optimization has long been a hot topic in spatial planning and design, but much of the focus has been on optimizing the layout and use of an area. Little attention seems to be paid to how infrastructure can be optimized from a manufacturing standpoint. With many infrastructure manufacturing industries based on a linear economy, this project will focus on how to make these industries circular, with particular attention paid to making the industry greener, more connected and smarter. We can decrease the contribution of infrastructure to climate change and construct a more connected, green, and smart future by intervening in the way physical infrastructure is produced, used, and recycled. Infrastructure must serve everyone equally; improving it is not just a solution to environmental concerns like climate change, but also a symbol of social justice. While South Holland has a high proportion of cycling and public transportation use compared to other industrialized countries, residents nevertheless consume more than a completely sustainable lifestyle would allow.

1.5 | Goals

Identified here are the sustainable development goals published by the United Nations that are most relevant to hard infrastructure. By bringing together civil society, the private sector, and governments, these goals aim to promote prosperity while also protecting the environment. There are 17 goals in total, covering a wide range of social issues such as education, health, social protection, and job opportunities, as well as climate change and environmental protection. With a project this diverse, and the limited amount of time, it is hard to get a direct link to all the goals, but the most important ones for this specific project will be explained.

3 GOOD HEALTH AND WELL-BEING

This goal is to ensure healthy lives and promote well-being for all, at all ages. The interventions being described later on, will improve health and well being in the province because, among other things, people will excercise more and be in a greener environment.

7 AFFORDABLE AND CLEAN ENERGY

This goal is all about access to affordable, reliable, sustainable and modern energy. With the Netherlands going off the gas in 2030 a big step is taken to achieve this goal. However the interventions described in this report will ensure that enough clean energy is produced, which will improve acces to it.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

A resilient infrastructure, promotion of inclusive and sustainable industries and fostering innovation is the aim of this goal. Since this project is focused on hard infrastructure, this goal will be achieved through the innovation of hard infrastructure construction, deployment and practice.

11 SUSTAINABLE CITIES AND COMMUNITIES

This goal is about making cities inclusive, safe, resilitent and sustainable. By changing infrastructure designs in the cities, safety will get a huge boost. Also, the improvement of connectivity between cities will improve resiliency and sustainability.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

This goal is focused on ensuring sustainable consumption and production patterns. Being less dependent on other countries will give a huge boost to our own consumption patterns. The province will be more self-sufficient by introducing an urban mining system and will be able to rely on its own manufacturing.

13 CLIMATE ACTION

This goal is about taking urgent actions to combat climate change. By reconnecting the cities with green corridors and reducing car use, a large step is already being taken to tackle this goal. Sustainable energy production and self-sufficiency will help to achieve this goal.

14 LIFE BELOW WATER

This goal focuses on conservation and a sustainable use of the oceans, seas and marine resources. By being more self-sufficient, fewer ships need to cross the sea, which will improve the quality of the sea.

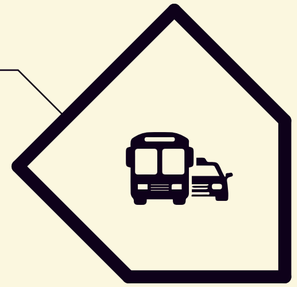
15 LIFE ON LAND

By introducing green connections between cities and creating riparian zones, a huge boost will be given to the biodiversity inside the city as well on the outskirts. By using space more sustainable, more can be dedicated to improving the space for animals on land.

2.1 | Research Question

Transportation

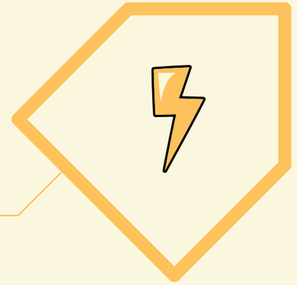
Transportation consists of roads, bridges, rails, paths, waterways, ports and airports



Communications

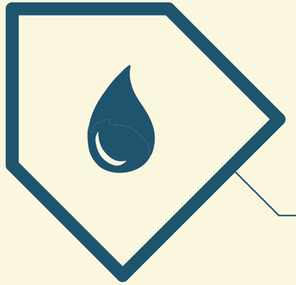
Communications consists of fibre optic cables, cell towers, data centers and sensors

How can the Hard Infrastructure of South-Holland enable us to live within the planetary boundaries?



Energy

Energy consists of pipelines, energy lines, power stations and energy storages



Water

Water consists of damsk dykes, poldes, ports, coastal protection, flood control and drinking water

Sub-reasearch Questions

What is the current hard infrastructure?
What is meant by circularity?
What is meant by climate friendly?
Who are the stakeholders in infrastructure transformation activities? How do they benefit from it?
What are the needs of infrasructure in the future?
How can the transition of the manufacturing of hard infrastructure in South Holland be both circular and climate friendly?
How can a hard infrastructure system in South Holland be created for a circular economy?
What aspects of the existing hard infrastructure can be considered as circular? What aspects are linear?
How is current hard infrastructure contributing to climate change/linear process?

2.2 Maslow scheme

In order to understand what impact hard infrastructure can have on our society it is important to know how this can motivate human beings. Because the hierarchy is concerned with human motivation, it is relevant to organizational theory. Understanding what people need and how those needs differ is an essential component of effective governance. Some people, for example, work primarily for monetary gain, but they also look forward to going to work because they enjoy being respected and appreciated by others for their efforts.

This hierarchy consists of five categories of needs according to Maslow.
- Physiological needs (basic physical needs)
- Safety needs: (A safe environment)
- Love and belonging (feeling loved and accepted, including romantic and social relationships
- Esteem (Feel good about yourself)
- Self-actualization (Feeling fulfilled)

In the scheme, the physiological needs are the most essential needs. They are foundational needs and therefore are the most important to attain.

The self-actualization is different from the other ones, since this is a variable that is different for every individual. According to Maslow, the achievement of this stage is relatively rare, and examples provided by Maslow are people like Abraham Lincoln and Mother Teresa.

In this case the Maslow hierachy of needs is filled in with aspects from hard infrastructure, and are related to the four categories shown the page before: energy, communications, water and transportation. Further provided here is a spatial division of the different elements that define the province. This project will focus on the provincial scale, but some matters can also apply to a national scale. Also the province can be divided into two main landscapes, namely the cities and the rural lands. Because the research question is focused on hard infrastructure, it is also important to take stock of where the current infrastructure will take place in the hierachy.

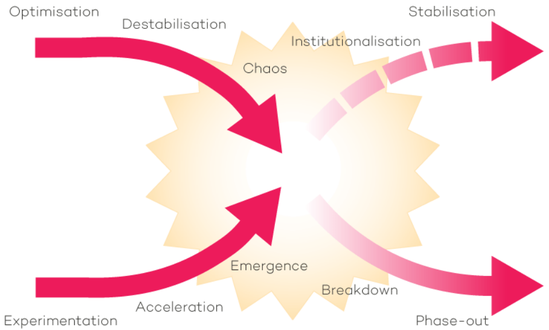
Going into the hierachy, we start at the most essential. This category includes the basic needs for human beings, such as clean drinking water, clean sanitation, agriculture, access to food and enough shelter. These can basically be applied to every scale and are most of the time physical components.

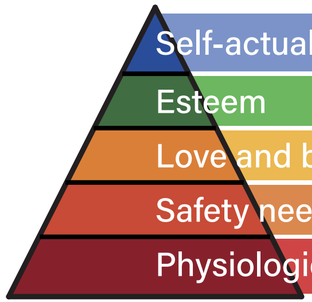
Looking into the safety needs, there is a focus on the human scale such as roads, paths and accesibility, but also on a much larger scale. For example less dependency on other countries can give a safe feeling for people to know that they don't have to rely on others but can take care of themselves.

Hard infrastructure is related to love and belonging in a sense that, for example, integration, railways, bridges and airports are necessary to visit friends and family and therefore can have the feeling of being loved

Esteem is more focused on a personal level and therefore includes quality recreation space, integration and information sharing, since all these things contribute to feelling good about yourself.

The final need consists mostly of non-physical components like, sustainability, classlessness, climate neutrality and room for nature. All of these components will improve the overall health of the world and therefore will be a step towards self-actualization.





	Current infrastructure	Future port	Future cities	Future rural lands	Future country
Self-actualization	Fibre optic cables, Sensors	Innovation hub	Classless, Vibrant, Integrated with nature	Sustainable Room for nature, Resilient to climate change	Sustainable, Climate neutral
Esteem	Data center	Information sharing	Integratied with industries, Enables opportunities	Quality recreation space	
Love and belonging	Bridges, Railway, Airport, Cell-towers, Waterways	Integration with cities/ industry	Encourage socialization, Bikable/ walkable	Share resources with cities	
Safety needs	Roads, Paths, Ports, Coastal management, Energy storage	Less dependent on other countries	Equal, More self sufficient	Accesible, Biodiversity	Productive, Connected, Equal, Less dependent on other countries
Physiological needs	Drinking water, Power stations, Polders, Dykes, Energy lines		Clean sanitation, Green, Less polluted, Helps environment	(Sustainable) agriculture	Acces to food, Clean drinking water, Enough shelter

2.3 | Conceptual Framwork

Humans are consuming resources at a rate that the natural world cannot sustain. Hard infrastructure is one of the main facilitators. Climate change is perhaps the most pressing and existential issue that we are facing as a society, or even species, today. There are many factors that contribute to the enormous environmental impact that humans have. A significant number of these can be boiled down to the way that our societies are designed. Transportation, energy consumption, logistics and shipping, agricultural practices, communication and interaction, etc. are all directly tied to the design of our societies. Likewise, those topics all directly affect our impact on the natural environment. The time to act is now. Our understanding of the impacts that climate change will have on us and the planet has been evolving over the past decades, but it is now abundantly clear that if we stay on our current trajectory, life as we know it will be vastly different. It is with a renewed sense of urgency that we approach this project, and it is why our focus is on a broad and impactful topic.

To begin, an inventory of the existing infrastructure is necessary. Infrastructure has two main components in creating environmental impact: the materials, construction and manufacturing processes; and the way that it is used. This poses a two part challenge: how can infrastructure be reimagined to enable more sustainable use, and how can that new infrastructure be built in the most sustainable manner possible. The sustainable use of infrastructure led to perhaps the most fundamental of questions - what is infrastructure? While there are many ways to define it, most definitions converge on infrastructure as the structures, facilities and systems that societies are built off of (What Is Infrastructure | IGI Global, 2022).

With this in mind, and considering the dynamics of the different types of infrastructure in the province, four main categories were chosen: Communications, Energy, Transportation and Water. While each type of infrastructure is used in a completely different manner, the system is wholly interconnected. The design and function of one type of infrastructure is directly impacted by the design and function of other types.

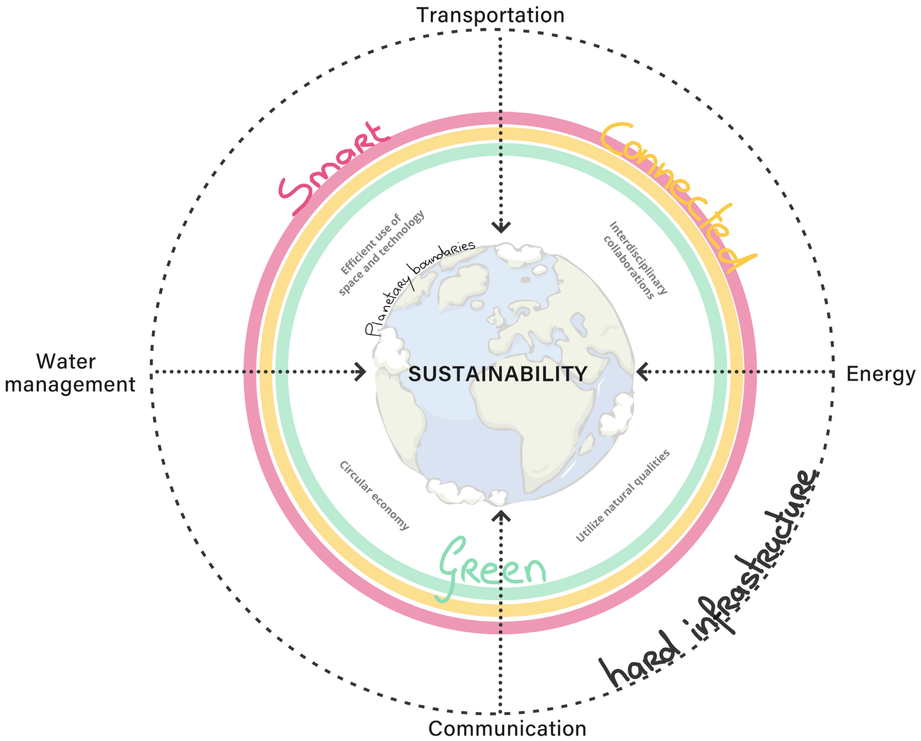
A guiding principle was needed to think about the future of infrastructure use. The concept of doughnut economics is a perfect guiding principle for this topic. In essence, doughnut economics is a new model of economic thinking that considers the negative impacts of both growth and poverty (About Doughnut Economics, 2022). The overshooting of consumption outside of the planetary boundaries is just as important to consider as having shortfalls in the social system. Our future infrastructure must no longer overshoot the planetary boundaries, but cannot reduce the quality of the social foundation.

The manufacturing and construction of the four types of infrastructure needs a somewhat different consideration than the use. With construction, what is most important is simply the reduction of the footprint (carbon and otherwise), while still ensuring that the infrastructure performs as intended. For this, two main theoretical concepts came to the fore: the capitalization on natural qualities and the circular economy.

The capitalization on natural qualities is a field that is growing in terms of its understanding and impact on urbanism. The biophilic city (Beatley, 2011) explains that there are significant benefits in aligning human activities and infrastructure design with natural processes. New infrastructure should be constructed in a manner that maximizes resilience. For too long we have not applied the lessons that the natural world offers us - the construction and design of new infrastructure must capitalize on, and enhance, natural structures. This can be further supported by modern technology and the concept of the smart city (Hall et al, 2012). By taking advantage of the internet of things, digital tools, artificial intelligence, etc. the design and maintenance of infrastructure can become even more efficient. Designing with nature will set the system up in an optimal manner and the smart city will ensure the system runs in an optimal manner.

Materiality and construction techniques lend themselves to the circular economy for a sustainable future (The Key Elements of the Circular Economy, 2022). The circular economy focuses on the effective use and deployment of materials and the responsible design of systems. A truly sustainable infrastructure will not continually deplete natural resources, but rather consume as little as possible. Through this, we must consider how infrastructure can be designed to maximize its circularity.

The above concepts come together to form the basis of our conceptual framework. The new infrastructure must integrate with nature, create excellent societal conditions and be built in the most efficient manner possible. As shown in the conceptual framework diagram, the three categories of 'green, connected and smart' represent these concepts. The three categories will guide the formation of the new infrastructure, and will ultimately enable the province to thrive while respecting the planetary boundaries.



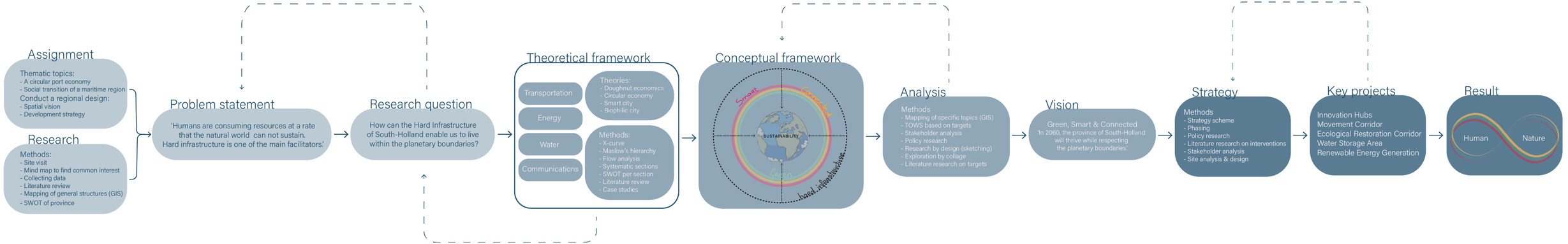
2.4 | Methodology

In the scheme below, our process of the last 9 weeks is visualized. First, an exploration of the assignment, province and common interests within the group was completed. From this, the first version of the problem statement and research question was formulated. During the brainstorming sessions, the group dynamics turned out to be all important in order to get to the final version. Through collaboration and discussion we ultimately were able to form a strategy for creating the vision.

Consequently, the topic of hard infrastructure was divided into transportation, energy, water and communications to be examined using several methods. The systematic sections provided the foundation for this section, where the other methods (flow analysis, SWOT, literature review and case studies) were connected here. After analyzing the outcomes, the basis of the conceptual framework and vision was born: 'green, connected & smart.'

From there on, the extensive analysis on our specific direction started. The translation from collected information towards a spatial vision was made by using GIS mapping, research by design (sketching sessions), and exploration by visuals/collages. In the final phase, new methods were introduced to identify concrete actions to be taken to realize our vision. Before going further into this, a clear strategy scheme was made to align the thoughts within our group. This backbone of our strategy helped to organize the other methods, like phasing, policy research, research on interventions, stakeholder analysis and site analysis.

These methods, and the development of the key projects, shaped each other throughout the process. In the end, the result to be achieved by this project is to create a symbiosis between the human world and nature.



3.1.1 | Transportation

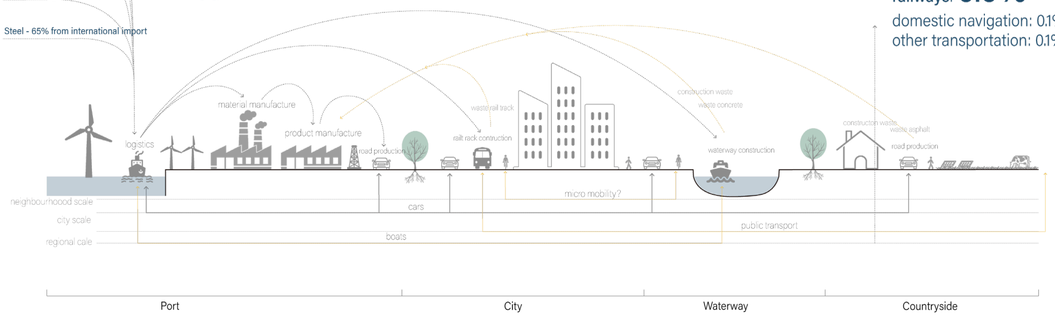
As the most prominent part of the hard infrastructure footprint, the well-developed transport infrastructure in the Netherlands brings accessibility and convenience, but is also tied to the use of large amounts of fossil fuels. In the period of 1990 to 2019, the transport sector contributed more than 32% of greenhouse gas emissions in the Netherlands (PBL, 2021). Within this, road motor vehicles account for up to 29.6% of emissions. The use of automobiles contributes a significant amount of pollution to the transport infrastructure in the province of South Holland. The share of railroads, domestic shipping, and other land transport is only 1%. With a well-developed existing transport system, public transport such as rail and waterways, and micro-mobility, such as shared transport, will become a cleaner and highly viable solution.

A large amount of materials are used to build and maintain carriageways, and according to MaterialenNL (2021), more than 50% of raw materials are used for construction. This includes oil, asphalt, cement, aggregates, sand, steel, etc., and a large portion of these materials are imported internationally. For example, 94% of the oil, 54% of the cement, and 40% of the aggregates are dependent on international imports.

Meanwhile, due to linear construction, transportation infrastructure also generates a large amount of construction waste. It is estimated that about 38% of construction waste is recycled annually (CBS, 2021). This indicates that there is a great potential for recycling and reproduction of transportation infrastructure as technology develops.

Oil- 94% from international Imports
Aggregates - 40% international imports
Cement - 54% from international Imports
Sand - national sources (North Sea and River Dredging)
Steel - 65% from international import

50% of all raw materials is used by building and construction sector (MaterialenNL, 2021)



road vehicles: **29.6%**
railways: **0.9%**
domestic navigation: 0.1%
other transportation: 0.1%

38% of the **construction waste** is recycled (cbs, 2020)

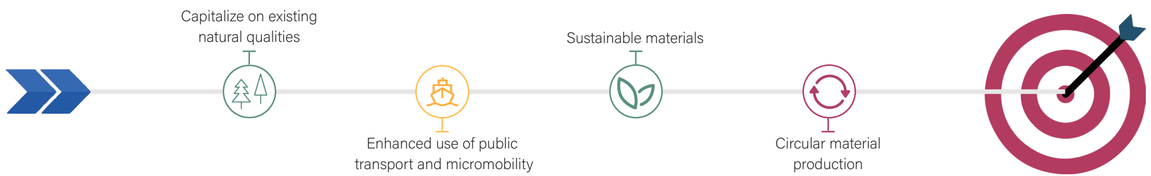
32% of **greenhouse gas** emmision from transportation infrastructure (pbl, 2021)

Strengths
- Developed transport network
- Biking accesibility & walkability
- Low emission of micromobility

Weakness
- Car dependency
- Not efficient enough
- Inconvenient bike renting
- Linear construction
- Unsustainable material

Opportunities
- Large amount of construction waste
- Innovation
- Clustered location of the port
- Development of new technologies

Threats
- Biodiversity loss
- Dependency on other countries



3.1.2 | Energy

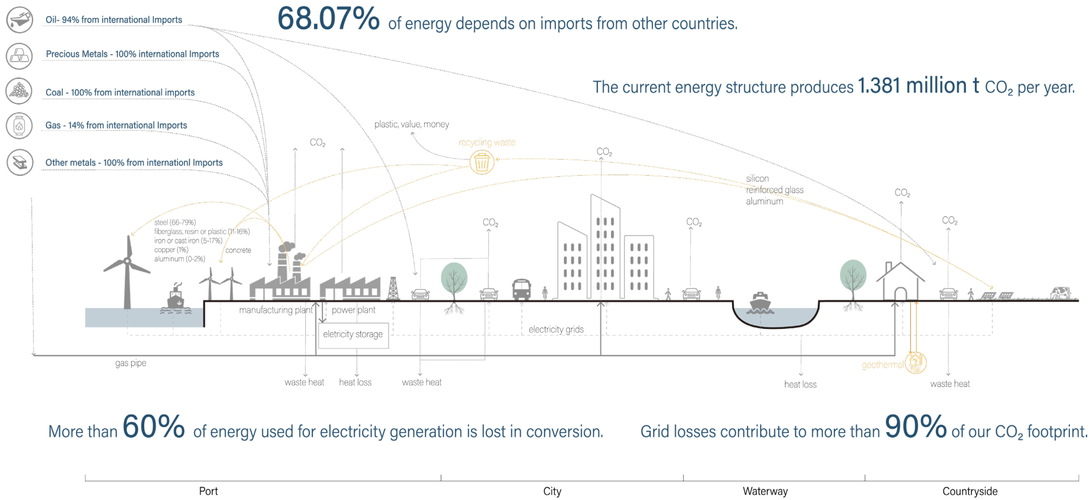
The Netherlands still relies on imports for most of its energy, with only 11% of renewable energy produced locally (including nuclear energy)(statista 2020), which is detrimental to both national security and environmental sustainability.

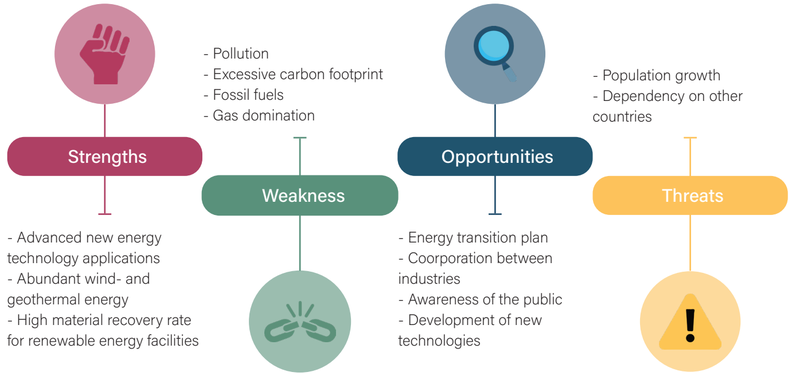
On the other hand, current energy conversion technologies create large energy losses and will continue to create huge waste if fossil fuels continue to be used. More than 60 percent of the energy consumed by U.S. utility-scale power generation facilities was lost in the conversion to electricity in 2019, according to a new report by the U.S. Energy Information Administration. Such low conversion efficiency is only reasonable for renewable energy sources.

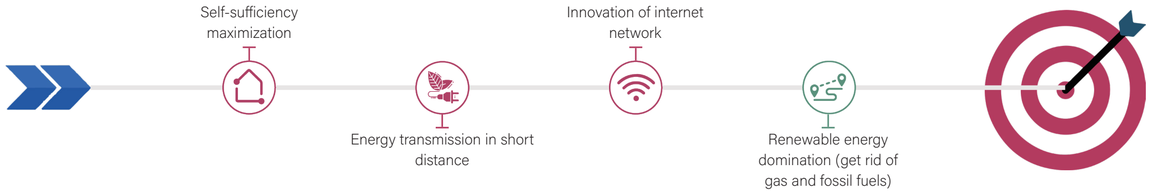
Besides, grid losses contribute to more than 90% of our CO2 footprint, as they inevitably occur during power transmission and result from the difference between energy feed-in, conversion and withdrawal. Transporting electricity a long way can cause larger grid losses compared to smaller quantities of electricity, or when transporting it over a smaller distance (TenneT 2019). As more renewable electricity is fed into the grid, these distances are increasing, as wind and solar electricity is often generated in remote areas, far from where most people consume it. Not only must we reduce our grid losses, we need to also reduce our carbon footprint.

Therefore, in the future, it would be a wise choice to integrate renewable energy into the urban areas to produce electricity locally.

In addition to the energy flow itself, the transition to a renewable electricity system requires more intensive material use, causing shifting problems in environmental impacts (Roelofs, 2020). Currently, wind turbines and solar panels in the Netherlands have recycling measures in place, but sorting is still a major obstacle to recycling materials because it is not easy to disassemble. Technological advances are needed to improve the recycling rate.





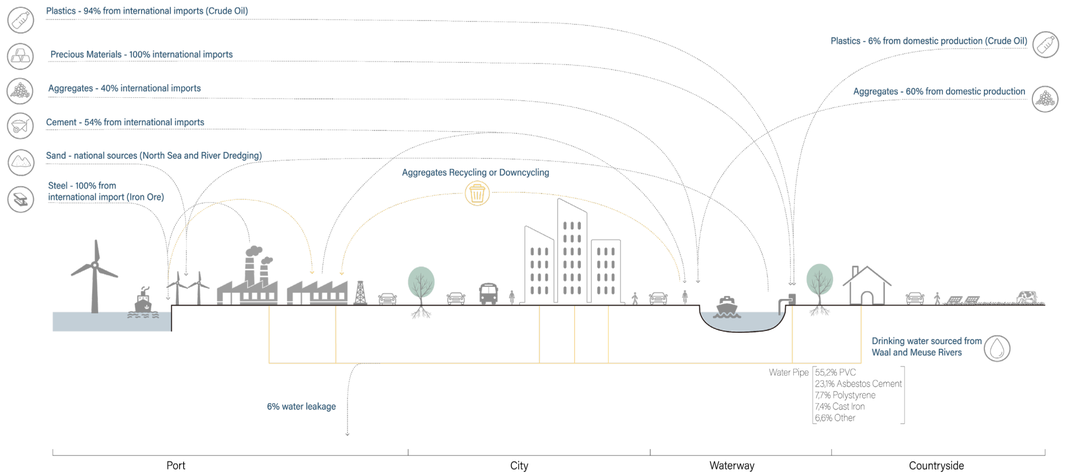


3.1.3 | Water

Water infrastructure is an ever present part of life in the Netherlands. Virtually all of the land that is used in South Holland is directly affected by the water infrastructure, be it poldering, land reclamation, storm surge barriers, etc. The pervasiveness of this infrastructure, however, means that there is a significant material dimension.

Most of the water infrastructure is built from relatively simple construction materials, including concrete, aggregates and sand (van Hijum, 1999). That being said, materials such as steel, precious metals and plastics are all present and important as well (Viewin, 2020). In fact, the construction of the Maeslantkering storm surge barrier took up to 40.000 tons of steel (Watersnood Museum, 2018).

While some of the basic materials can be sourced locally, much of the higher value materials are sourced either partially or wholly from international sources. Precious metals that are critical for the operation of modern pumping stations are sourced 100% from international sources. Even though the Netherlands does have a developed fossil fuels industry, 94% of the crude oil that is necessary for the manufacture of plastics, such as PVC pipes for drinking water, comes from outside of the country (CBS, 2022). This leaves the materiality of the drinking water system in a perilous situation. If international circumstances were to change, and suddenly those materials became unavailable, the security of the water system, and therefore the security of the province in general, would be in jeopardy.



Up to **50%** of the materials in ground, road and water construction is **RECYCLED**.

46% OF ALL WASTE in The Netherlands is generated by the construction sector.

Strengths

- Efficiently moves significant amounts of water
- Low level of drinking water leakage
- Clean and expansive drinking water acces
- Protects cities and lands from major disasters

Weakness

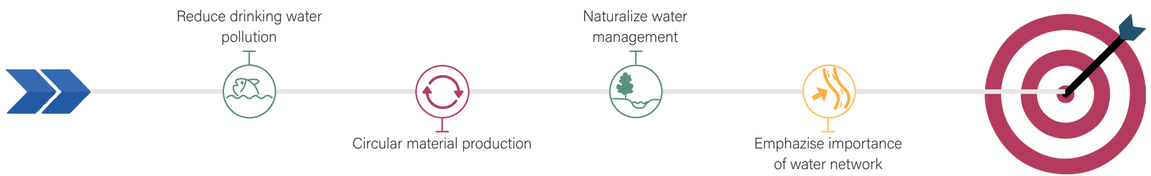
- Resource intensive to maintain status quo
- Creates non-natural land
- Reduces peoples' relation to natural processes
- Creates conditions to locate cities in vulnarable areas

Opportunities

- Expansive and integrated infrastructure system
- Siginificant water management knowledge
- Culture of living with water
- New transportation connection options
- Flexibility for creative solutions

Threats

- Sea level rise
- Intense rainstorms
- Fossil fuel dependence for energy production
- Risk of infrastructure fails
- Soil subsidence



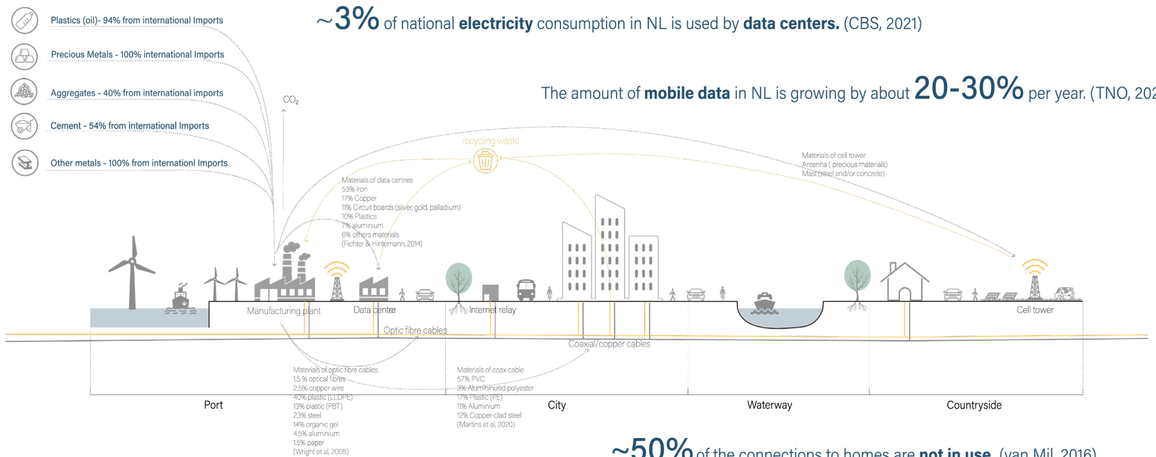
3.1.4 | Communications

Although the infrastructure of communications might be the least visible one, the dependence of modern society on this structure is increasing the most. The elements of this structure can be seen in the section below. The main cables of the widely-spread network consists of older cables like coaxial/copper cables and new optic fibre cables. The latter of which is considered to be the most future-proof communications infrastructure (ACM, 2021b). Almost half of the households in the Netherlands already have this connection, and this number is rapidly growing (ACM, 2021). However, most old cables still remain in the ground. Around 50% of all connections to homes are not in use (van Mil, 2016).

Since those cables are made out of imported precious metals, this means there is a huge amount of materials left untouched. Those materials can be used to expand the communications infrastructure in order to keep up with its growing use, or be repurposed for other uses. The mobile data is currently growing as much as 20-30% per year in the Netherlands

~3% of national **electricity** consumption in NL is used by **data centers.** (CBS, 2021)

The amount of **mobile data** in NL is growing by about 20-30% per year. (TNO, 2021)



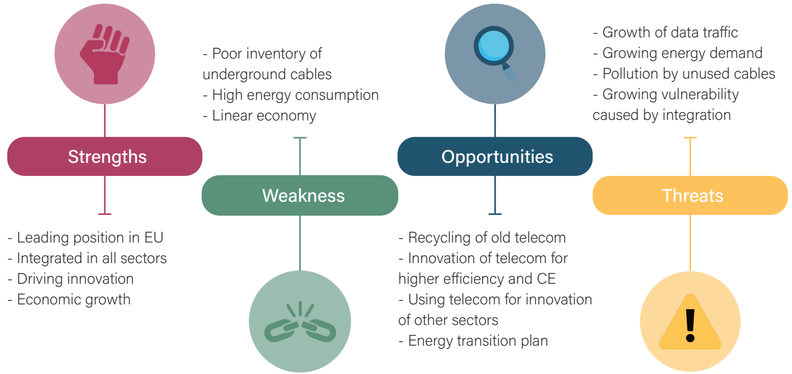
~50% of the connections to homes are **not in use.** (van Mil, 2016)

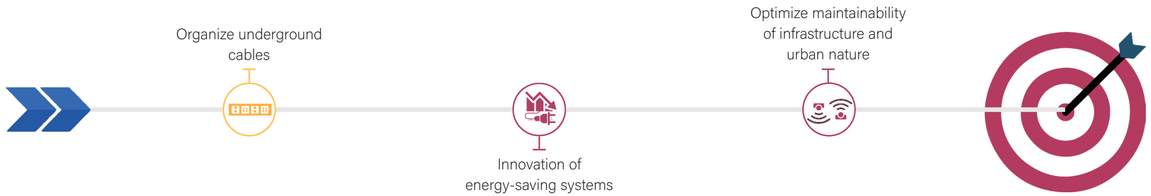
About 46% of households has a **fibre optic connection** in NL. (ACM, 2021)

In 2020, 5.9% of excavations caused **damage to cables and pipelines**, meaning a direct loss of approximately €38 million per year. (Rijksoverheid, 2021)

(TNO, 2021). Since the cables cover almost the whole province, a redesign improving the end-of-life disassembly and recycling of component materials is worth considering. By doing so, the environmental impacts could be reduced by 30-60% and the economic costs by 40% according to Wright et al (2005).

Furthermore, data centers play a major role in the communications network. The data center industry involves a lot of (precious) metals, which have to be imported, meaning that this industry contributes to the dependency on other countries. In order to create an economically stable service and secure supply chain for data centers, the industry needs to be transformed (Andrews et al, 2021). Not only the linear economy, but also the electricity consumption of data centers needs improvement. The amount is increasingly growing, where the current amount is already around 3% of the national consumption (CBS, 2021). That is why innovation of energy-saving systems is a necessity.





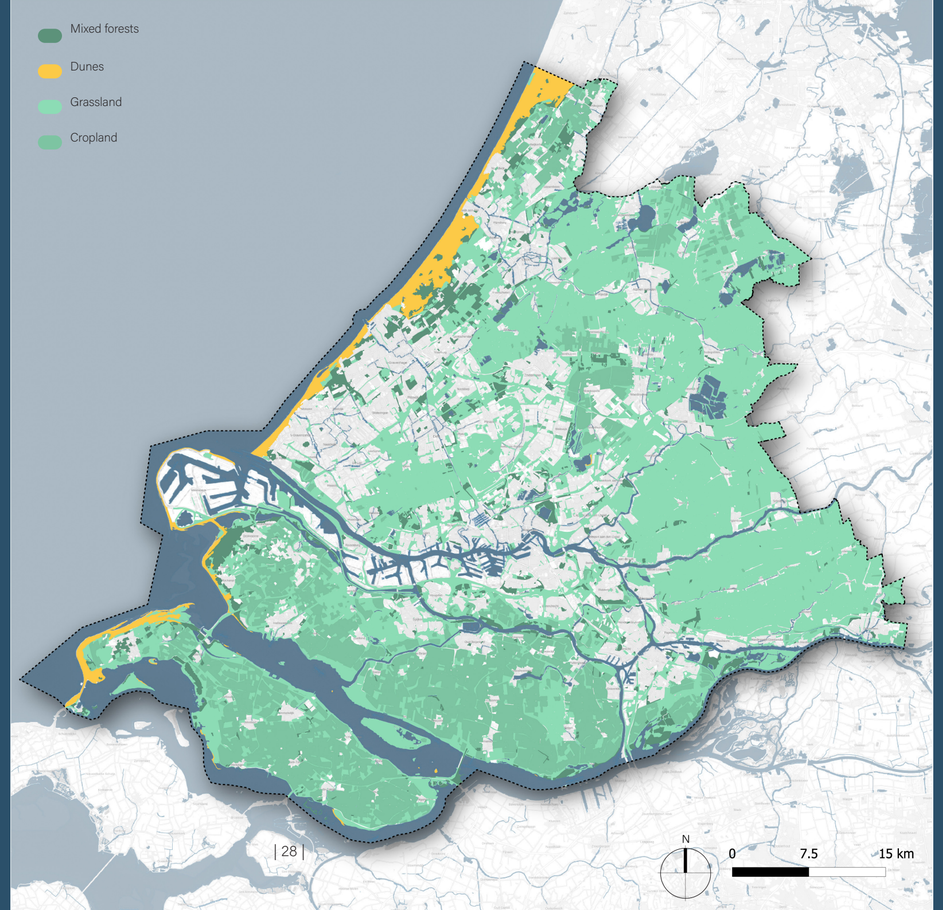
3.2 | Analysis Maps

Greenspace

This map indicates all of the greenspace within the province, with the definition of 'greenspace' being space that is green. This means that agricultural lands are included as being greenspace here.

The greenspace under this definition is quite extensive throughout the province, with notable clusters along the Eastern and Southern borders. Those clusters indicate predominantly agricultural uses.

The blank places on the map are generally filled by urban areas. Connectivity of greenspace in the centre of the map, where most of the urban areas are, is weak. While minor waterways do provide some level of natural connectivity between green areas, there is a lack of robust green connections in the predominantly urban portion of the province.

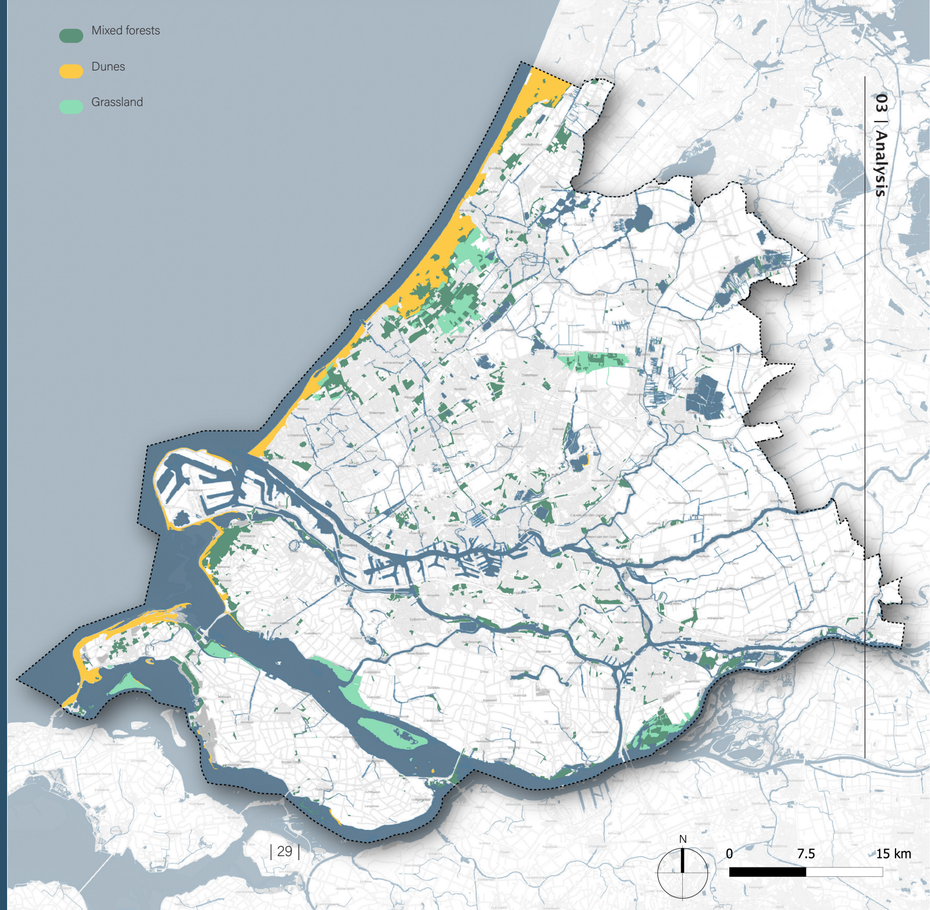


Natural Greenspace

Whereas the previous map indicates all greenspace, including agricultural lands, this map shows only the naturalized greenspace. This is made up of nature reserve areas, dunes, unmanaged fields, and some urban parks (depending on the conditions).

The picture of greenspace in the province according to this more strict definition is much different. The greenspace network is minimal and highly fragmented. There is a complete lack of connectivity of greenspaces and therefore minimal chance for robust habitat formation.

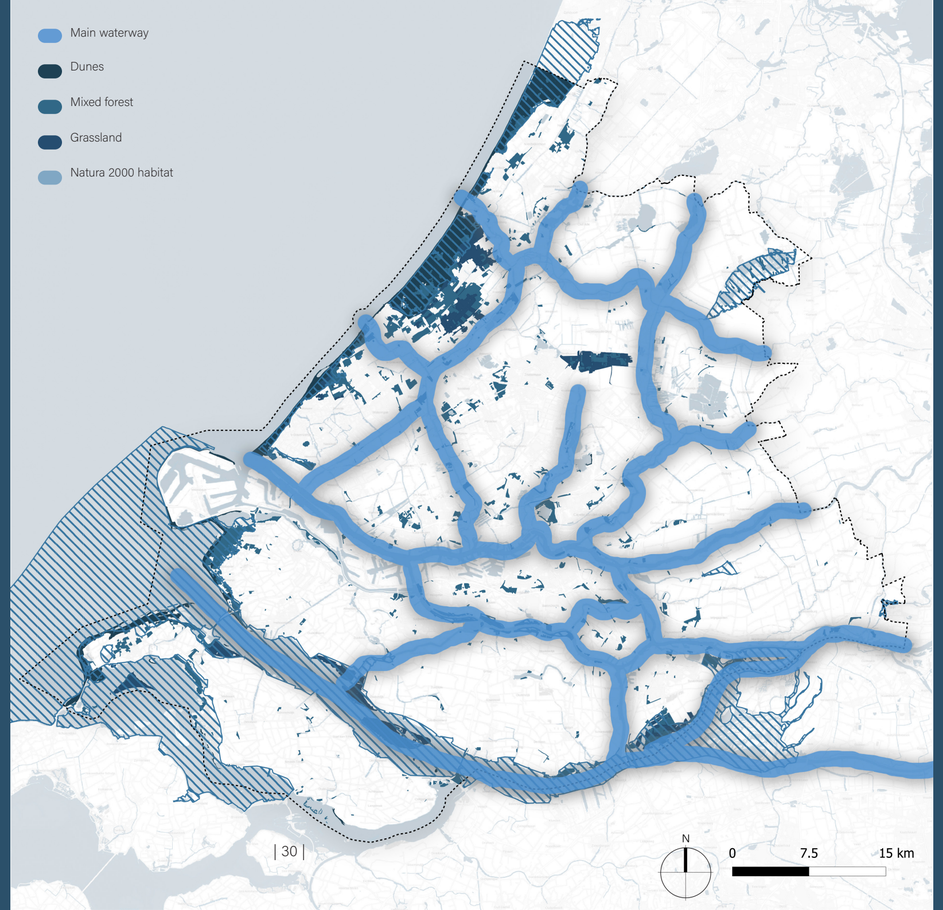
This also indicates the lack of green recreational space. Most nature reserves double as environmental features and as recreational oppotunities for residents. One's ability to connect with nature is limited when there are few convenient location to be able experience it.



Natural Structure

Building off of the previous map, the natural structure of the province begins to form when the Natura 2000 habitats and primary river structure is added to the map. It is clear that the river structure forms the basis of the natural structure, with virtually all of the important green and natural spaces being adjacent to, or close by, the water.

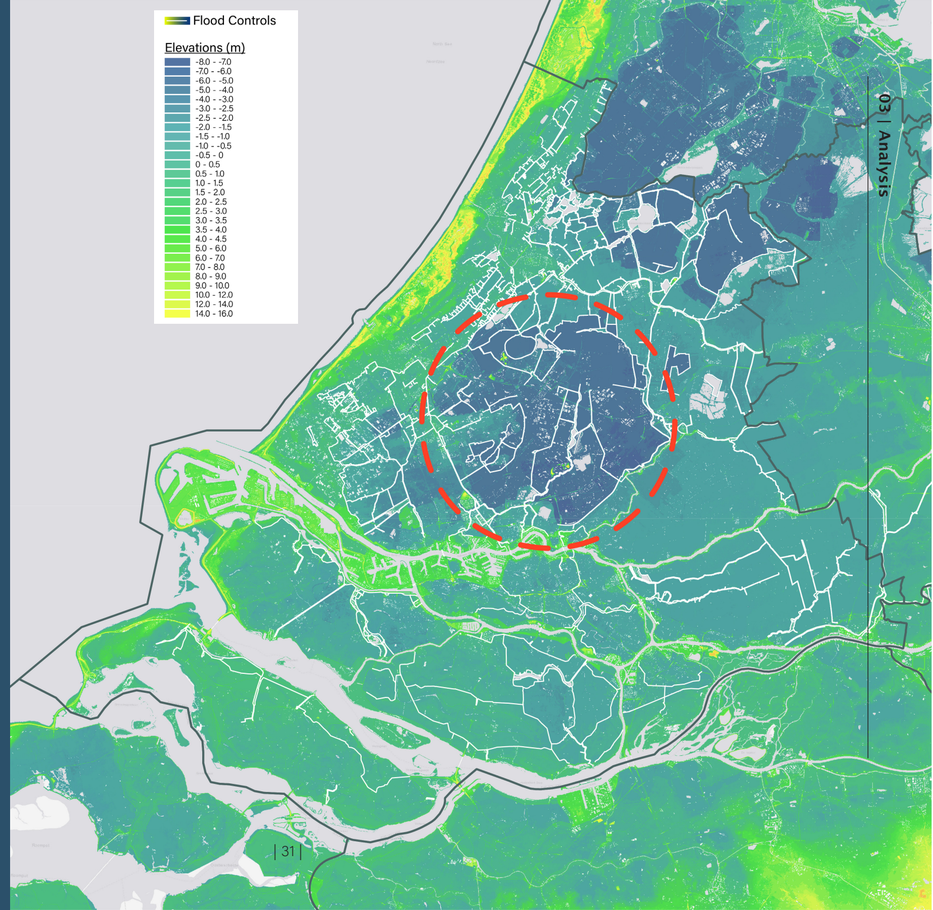
It is also apparent that the important natural habitats are found at the peripheries of the province, and again defined by the waterways (and the sea). However, there is clearly potential to establish new naturalized habitat areas in the centre of the province when considering the river structure itself. The province is well covered by significant rivers which can act as catalysts for the reintroduction of plant and animal species.



Elevations and Flood Defenses

The elevation map helps to illustrate the construction of the province. It is apparent that the portion of the map that is circled in the centre is much lower than the immediately surrounding lands. Of course, this is due to the history of land reclamation and poldering that has been carried out for hundreds of years.

This area in the centre also has a robust flood control system that is almost perfectly surrounding the lower area. These flood controls represent the dyke ring that is responsible for ensure that the area stays dry. It should also be noted that the major cities are located relatively higher than their surrounding countryside lands, again mostly due to the extensive lands engineering projects that have taken place over the history of the country.



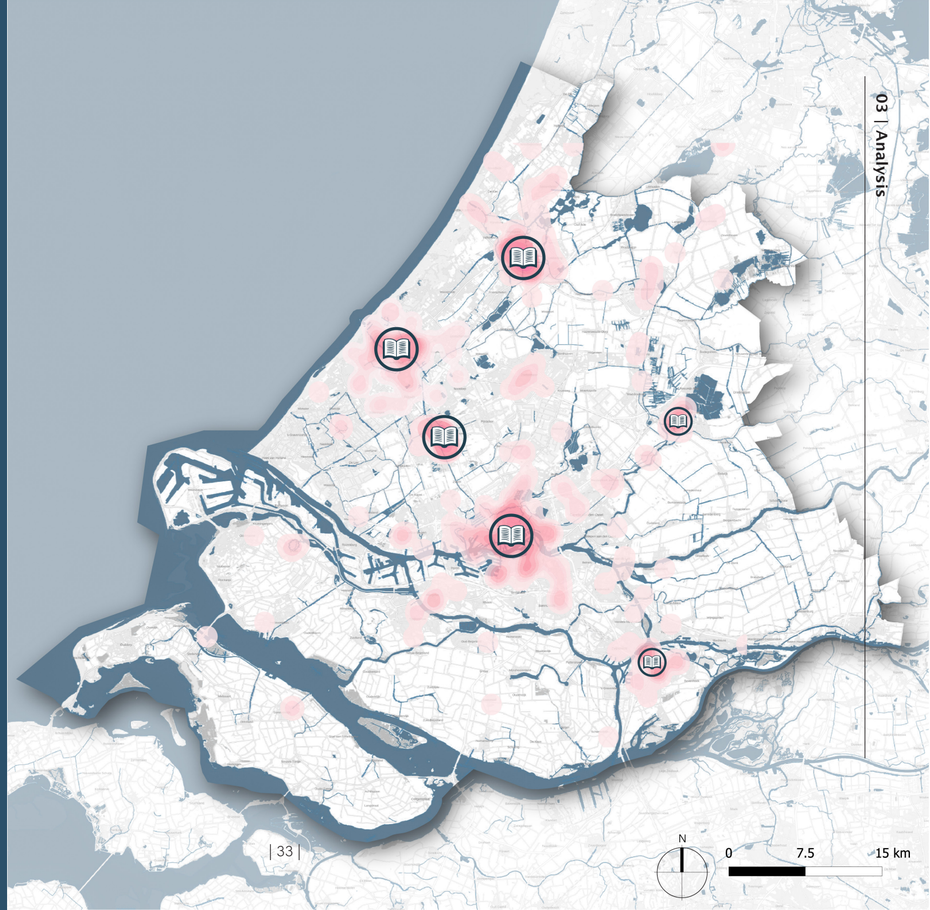
Drinking Water

The majority of the drinking water in the province is predominantly sourced from surface abstraction points (Rijkswaterstaat, 2018). Water is abstracted from the major river system and is then distributed throughout the province. Since most of the drinking water in the province comes from surface sources, it is critical to ensure that runoff water quality is high. If not, even with properly treatment and filtration, the quality of drinking water will degrade.

These locations are predominantly surrounded by agricultural land uses. Agricultural practice can significantly impact the quality of water if not managed appropriately. As such, it is critically important to ensure that the waterways are managed and treated appropriately.

Education Clusters

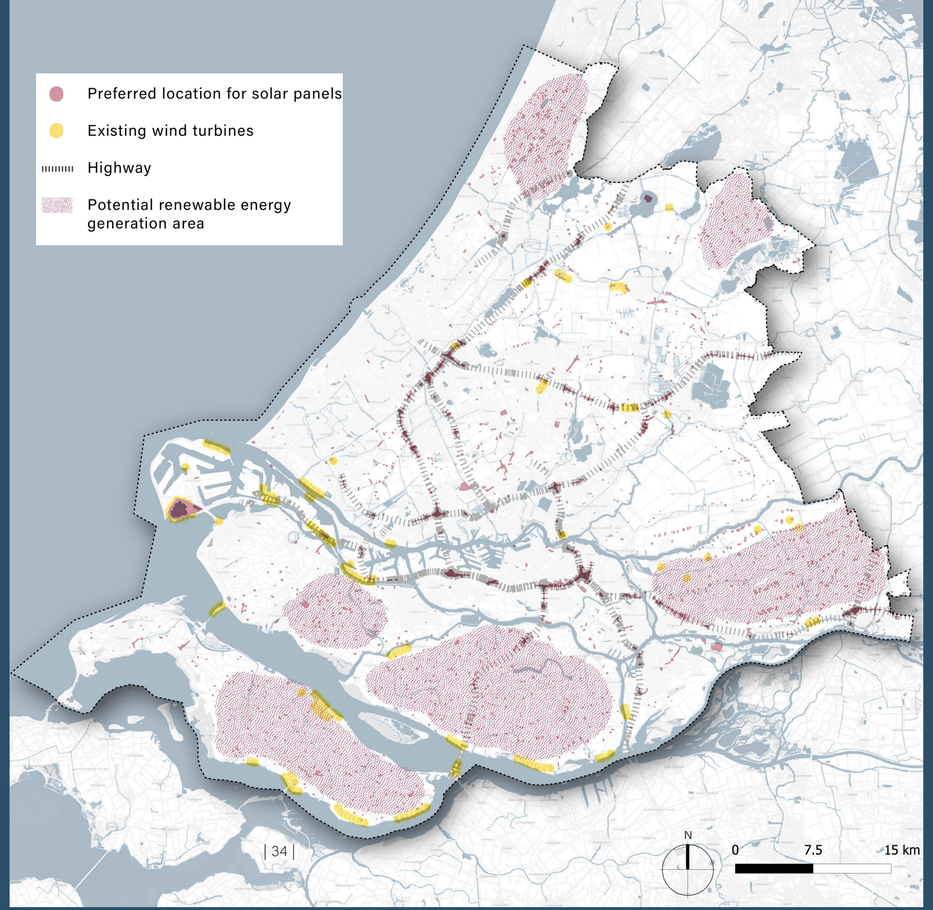
In this map, the educational facilities throughout the province are shown. All facilities of secondary vocational education (MBO), universities of applied sciences and the academic universities are included, and were sourced using the LISA-data. Since knowledge sharing is part of our vision, it is relevant to identify the main knowledge clusters that could form an eventual innovation network. The big cities, Den Haag and Rotterdam, stand out for having the widest spread regions. Leiden and Delft, being university cities, are the most densely covered areas. After that, in Gouda and Dordrecht, smaller clusters can be identified.



Wind and Solar Energy

Renewable energy sources such as wind & solar are the best options to fulfill the world energy demand, but are unpredictable due to natural conditions. The use of the hybrid solar and wind renewable energy systems likely will be the best option for the utilization of these available resources (Wagh & Walke, 2017).

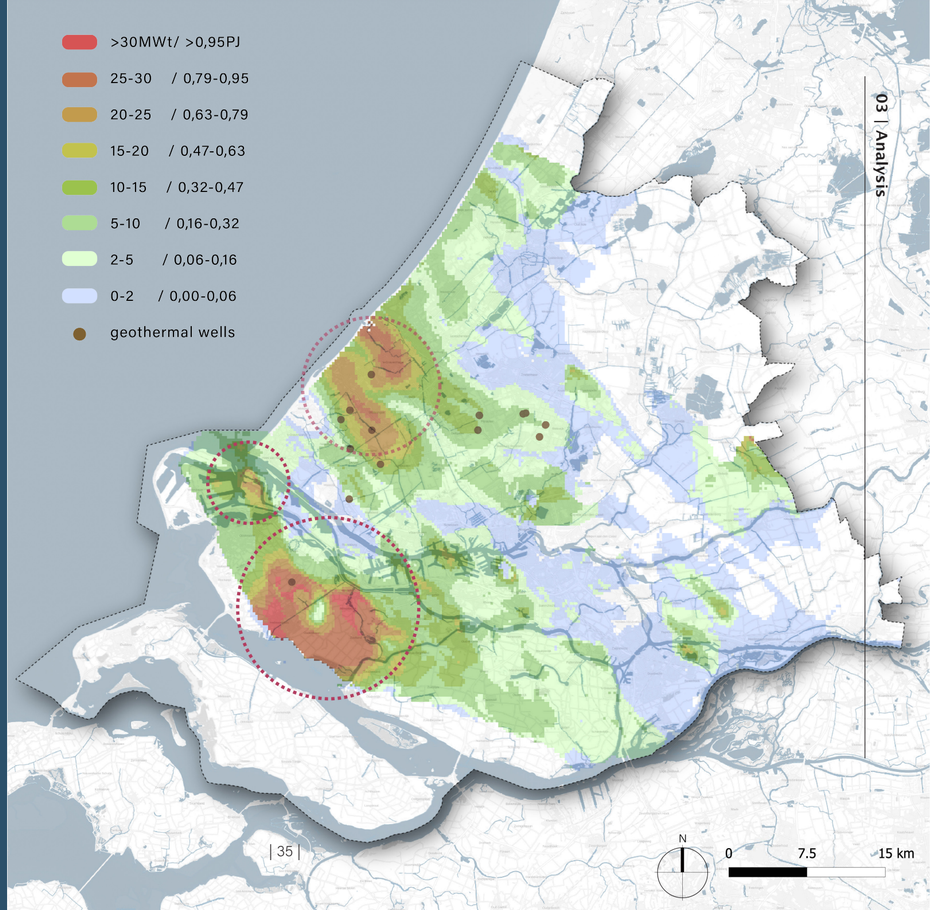
Based on the distribution of existing wind turbines, it can be found that there is a high potential for wind energy near water, while the most suitable places to install solar panels overlap with many highways and farms in the northern part of the South of the province.



Geothermal Energy

Dutch interest and activities in deep geothermal energy – essentially non-existent 10 years ago - has increased dramatically in recent years. The market penetration of shallow geothermal applications has shown very healthy growth numbers (Van & Bakema, 2015) in recent years, and therefore can become a key component of the green energy transition.

Geothermal energy potential in the province of South Holland is mainly distributed in the west and south. The relatively large number of geothermal wells distributed in the west means that geothermal energy in this area has been utilized to some extent, however, geothermal energy in the south has hardly been exploited and has a huge potential for utilization and is a key area for energy transition.



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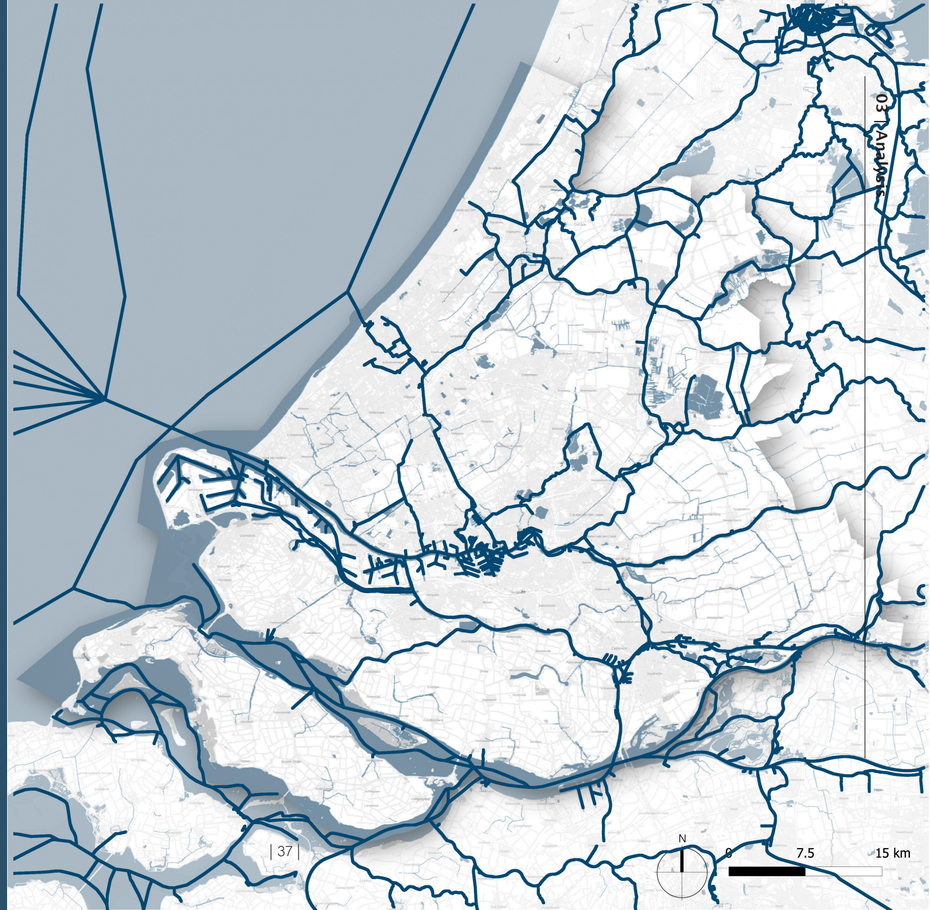
Based on the distribution of existing wind turbines, it can be found that there is a high potential for wind energy near water, while the most suitable places to install solar panels overlap with many highways and farms in the northern part of the South of the province.

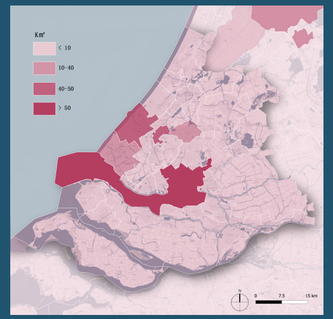
Navigable Waterways

The province of South Holland is covered in a countless number of waterways. However, not all of them function in the same way. It is essential to distinguish the navigable waterways in order to know how the province is connected by boat. The limitations and opportunities of the range of cargo boats can be read from this map. Although Zoetermeer and Westland are not accessible, the older, bigger cities are well connected to each other and main cities outside of the province. Of course, the Port of Rotterdam and the old harbors inside of the city stand out the most.



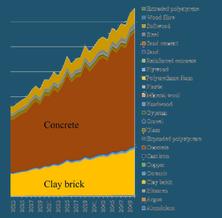
Urban Mining

Urban mining is an important strategy to utilize the stock of anthropogenic materials in the built environment (Akbarieh et al, 2021). The study shows a consistency in the spatial distribution of demolition waste generation and material demand, both concentrated in large cities such as Rotterdam and The Hague. The material outflow increases with time. Concrete (about 60%) and clay bricks (about 24%) account for the largest share of material outflows. Material inflows will decrease in the future and be dominated by concrete, sand and reinforced concrete. There are far more material inflows than outflows, and the structure of material inflows is not consistent with the structure of material outflows. For example, clay bricks have a very large share in outflows, but are almost negligible in material inflows. This means that we can assume that more buildings will be built in large cities in the future, requiring more materials (Xining et al, 2022). Therefore, in the future, innovative research on renewable raw materials may be needed.

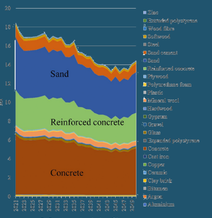


Floor area per city

Material stock per city



Material outflows



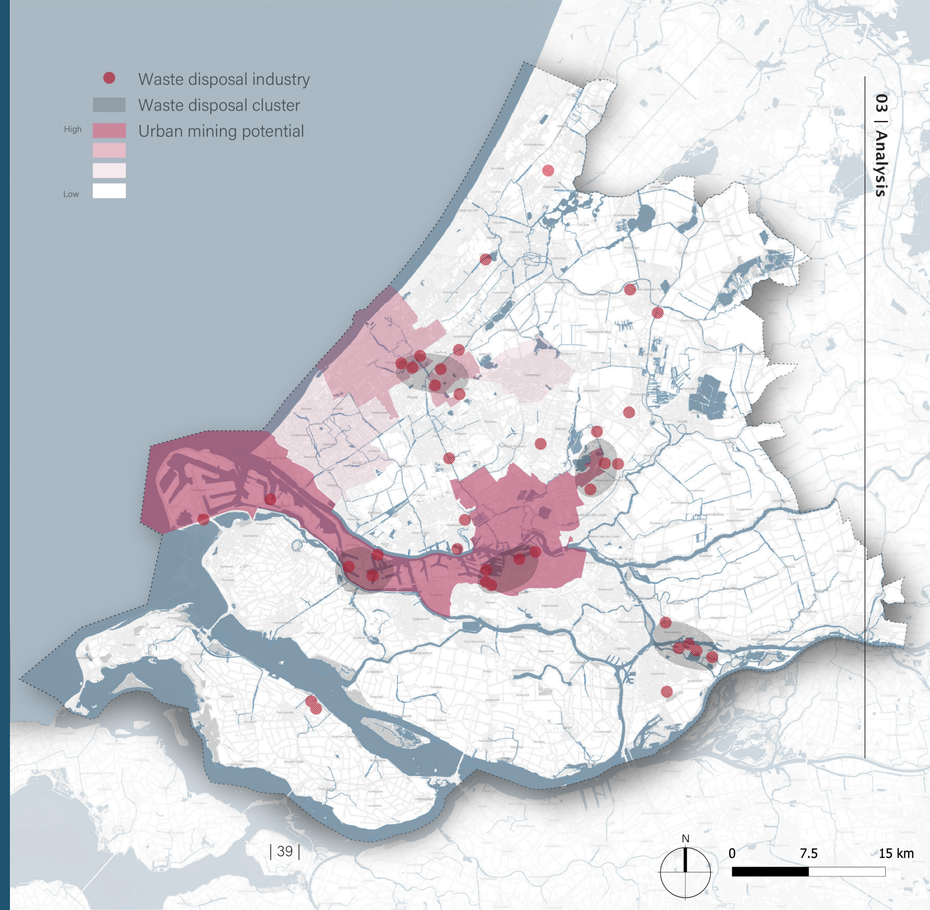
Material inflows

Total material outflows

Total material inflow

Yang, X., Hu, M., Zhang, C., & Steubing, B. (2022). Urban mining potential to reduce primary material use and carbon emissions in the Dutch residential building sector. Resources, Conservation and Recycling, 180, 106215. https://doi.org/10.1016/j.resconrec.2022.106215

A comprehensive look at the construction material stocks, total material outflows and total material inflows in the province of South Holland allows for a summary of its urban mining and construction potential. Among them, Rotterdam and The Hague have the largest urban mining potential. Combined with the distribution of waste disposal industries and their clusters, a large number of them are located in the Rotterdam and The Hague area, therefore there is a certain spatial consistency between waste disposal industries and urban mining potential in the province of South Holland. This would provide a good spatial and facility base for the recycling and manufacturing of urban mining and infrastructure. However, as described in the analysis, the structure of material inflow does not coincide with the structure of material outflow, and urban mining has a limited ability to supply the required types and quantities of materials. This provides the need for the construction of material recycling networks that connect construction waste and construction demand in space and time, and for innovative research on construction materials.

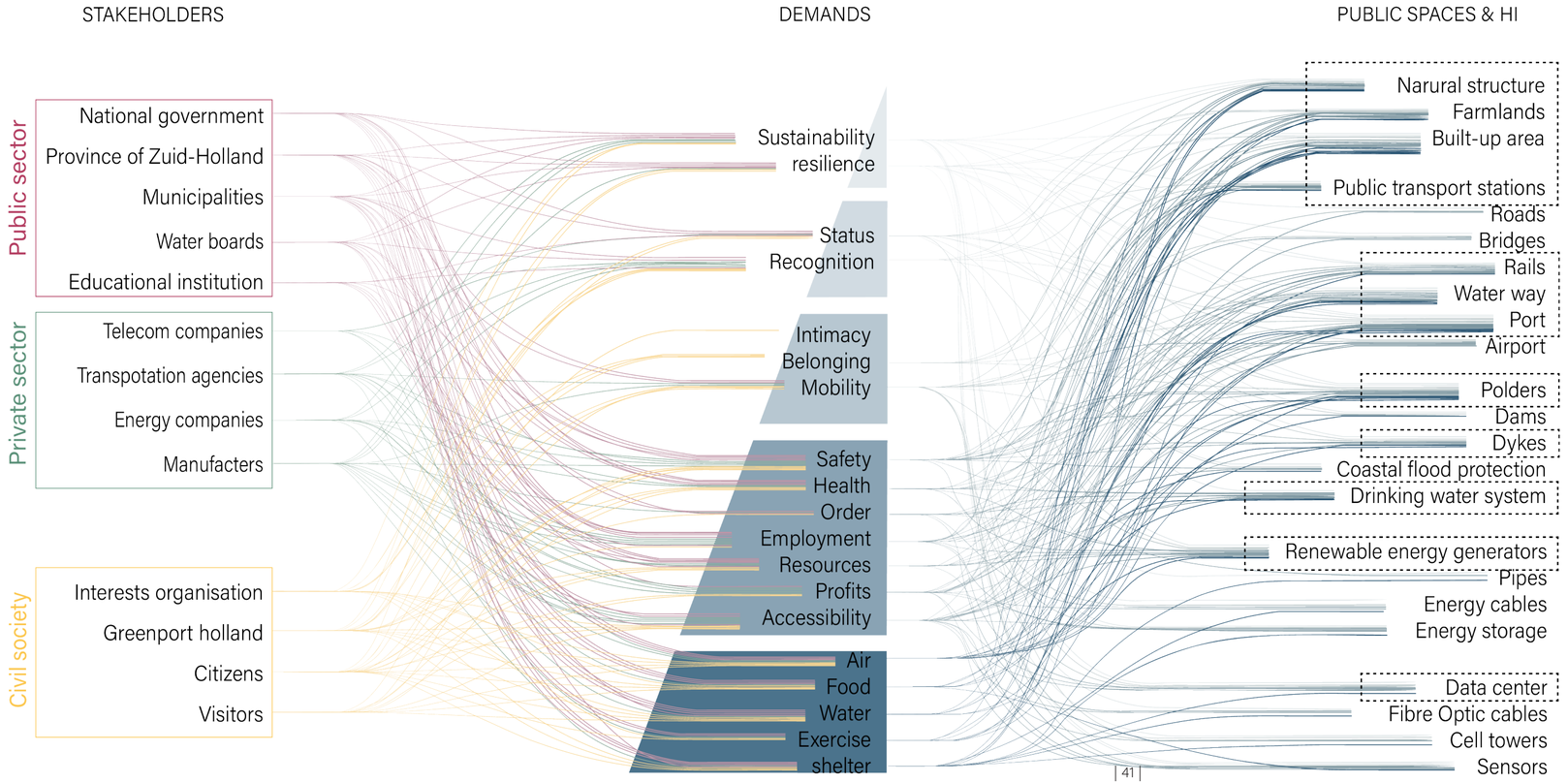


3.3 | Stakeholder Analysis

Under the topic of reconciling the relationship between man and nature, human claims cannot be ignored. While the previous analyses were based on the current situation of the site, this section will focus on how human needs are realized spatially.

The figure divides the interest groups into three categories, namely Public sector, Private sector and Civil society, and sorts out their needs based on Maslow's pyramid, and finds that the common interests of different groups focused on the most basic needs of life and sustainability.

After matching these demands to the typical spatial types of the province of South Holland, and the hard infrastructure we studied, we found that most of the needs can be realized in the natural structure, built-up areas, and agricultural areas. Meanwhile, the public transport facilities is the hard infrastructure with the most potential to provide for these needs, meaning that it should be the driver of the whole transformation.



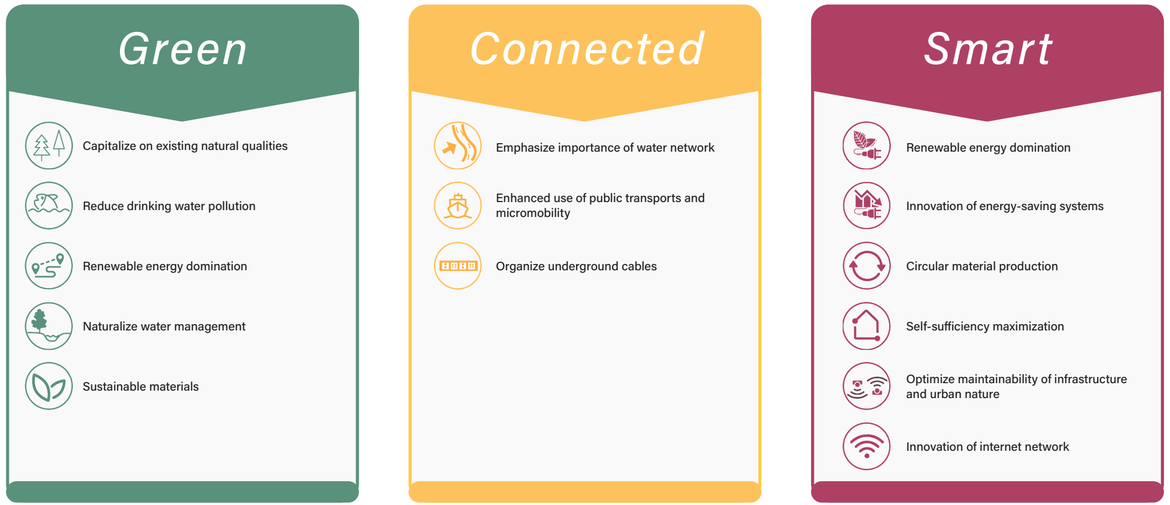
3.4 | Targets

The targets that result from the material flow sections are a big step towards the vision making. Where the sections show the specific targets for that section, it is important to take an overview of all the targets together. This page shows how the targets can be divided into three main categories, that will later come back in our vision.

The first category is 'Green.' This means an utilization of green structures and resources to rethink infrastructure, resulting in a symbiosis of the human sphere and the ecosphere: how can humans and nature co-exist in the world? Most targets are directly linked to natural structures, but also sustainable materials and renewable energy domination are a important target in this category.

The second category is 'Connected.' Here, an interdisciplinary approach to integrate systems, both spatially and digitally is meant. Therefore, the targets in this category will focus specifically on other ways of thinking about how cities are connected to eachother and how these connections are organised, but also on how we can use other forms of transportation.

The final category is 'Smart.' This means problem solving through knowledge sharing, and the implementation of solutions that are appropriate, efficient and resilient. Some targets are energy-related targets, but others will be a more general way of rethinking about not just physical infrastructure but also about non-phyisical infrastructure, such as internet connections and digital monitoring.

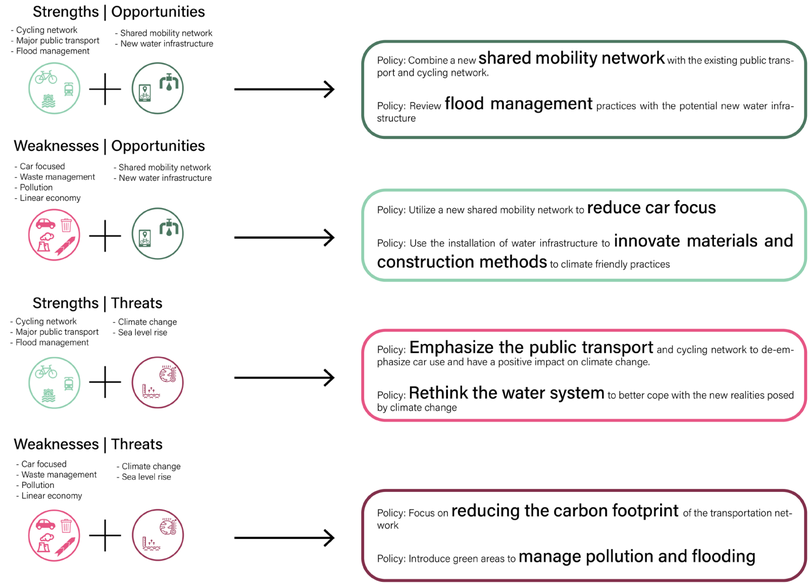


3.5 | TOWS

In order to get a better understanding of the project, a TOWS- analysis was completed. Here, four key areas of strategies are identified, by combining two sections of the SWOT analysis, to create:

SO - How can you leverage the strengths you have to maximise benefit from the opportunities?
ST - How can you sustainably leverage the strengths you have to mitigate the threats?
WT - How can you migitate threats within and reduce the impact of the weakness that you have identified?
WO - How can you utilize the opportunities to overcome the weaknesses that you have identified?

After thorough research of the strengths, opportunities, weaknesses and threats the TOWS are identified by creating the SO, ST, WT and WO combinations. By making these combinations, the most important policies came to light. These key policies will be implemented in the vision and will be a guiding a part of the guiding themes in the strategy. This will ensure that the themes are addressed and can be developed in an integral manner in the vision

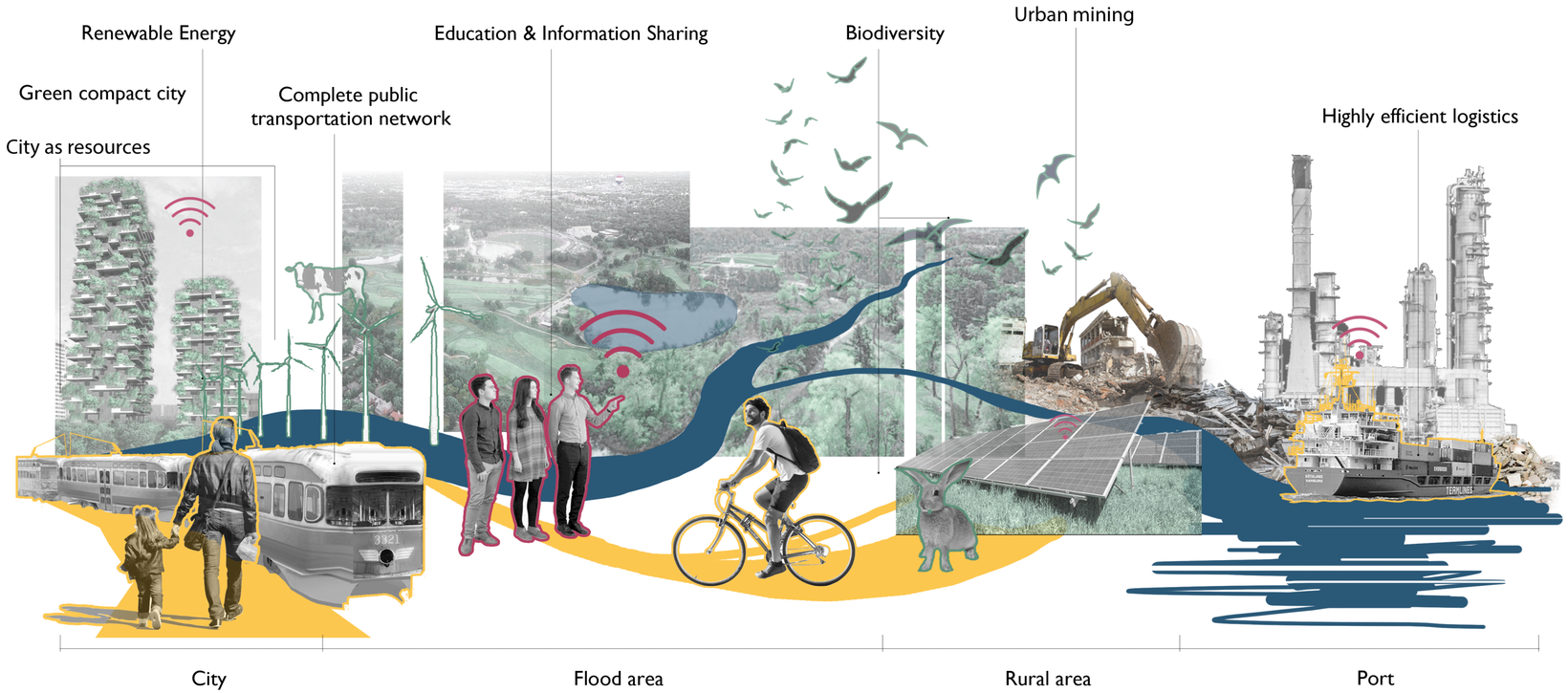


3.6 | Conceptual Collage

Hard infrastructure systems form the backbone of every society, providing essential services, including energy, water, waste management, transport and telecommunications. However, current hard infrastructure can create considerable harmful social and environmental impacts, increase vulnerability to natural disasters and leave an unsustainable burden of debt (Thacker, 2019). In this way, hard infrastructure is a double-edged sword that can destroy the relationship between humans and nature if we are not prudent enough. Therefore, we aimed to build a green, connected and smart hard infrastructure system to re-engage human society in the natural circulation.

Through the analysis of the existing conditions of the province of South Holland, it is clear that the natural green space patches in the province are small and fragmented, but the waterways are well connected and form the natural structure of the entire province. Interestingly, this structure is highly similar to the most convenient major transportation network, and they are located in close proximity to each other. The natural structure is like the backbone of the hard infrastructure network of this province, which offers an excellent opportunity for this regional design. By eliminating the negative impact of hard infrastructure on nature, we can eliminate the contradiction between social development and natural processes, and even take advantage of ecological services to further promote social transformation.

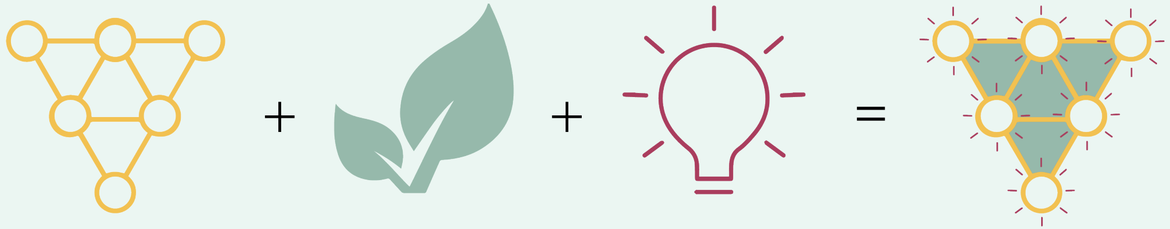
Hence, the core idea of our design is to reinforce the natural structure and the hard infrastructure network to form a framework that runs through the entire province of South Holland and to promote a shift in infrastructure design towards green, connected and smart solutions. This will involve public transport accessibility, urban mining, recycling of materials, renewable energy transition, natural means of water management and advanced and effective information sharing systems.



4.1 | Vision statement

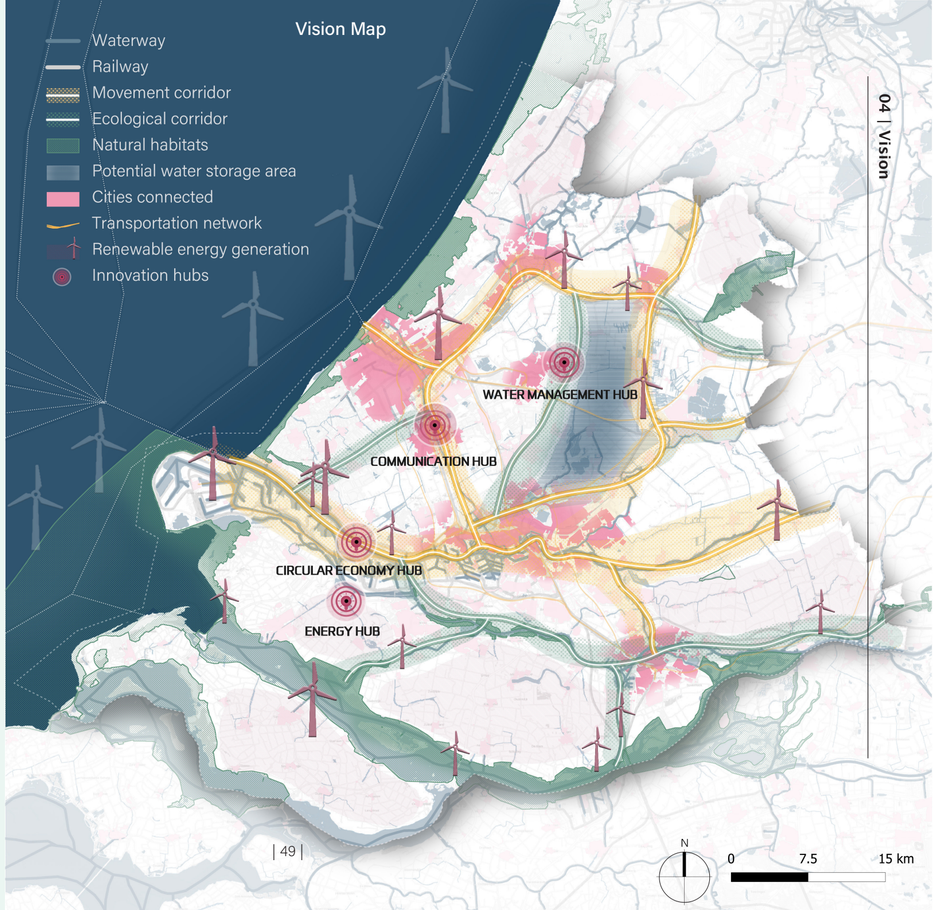
In 2060, the province of South Holland will thrive while respecting the planetary boundaries. The human sphere and the ecosphere exist in symbiosis through an innovative, resilient, accessible, just and sustainable framework. This will be facilitated by the transformation of the hard infrastructure (HI) network, using smart, connected and green solutions. Meeting the infrastructural needs of South Holland will be approached as a strategic opportunity to rethink the overall network.

In 2060, the province of South Holland will thrive while respecting the planetary boundaries.



connected + green + smart

As the vision map shows, in 2060, the hard infrastructure of South Holland will form an integrated spatial structure at the provincial scale, with the movement corridors connecting the major cities of the province in a convenient, efficient and clean way, and the ecological corridors connecting natural habitats to make room for ecological restoration and biodiversity development. Renewable energy generation in areas with solar, wind, and geothermal energy potential will deliver clean, green energy to the whole region. The naturalized water storage area will address the hydrological impacts of climate change and sea level rise. The Innovation hubs, which study different hard infrastructure technologies such as circular material production, innovation of energy-saving systems, optimizing maintainability, etc., will be implemented in key locations and aim to provide a smart future for South Holland. In total, this vision uses smart, connected, and green solutions, with hard infrastructure as a medium and circular economy as a tool, to create an innovative, resilient, accessible, just, and sustainable future for the province.



4.2 | Connected

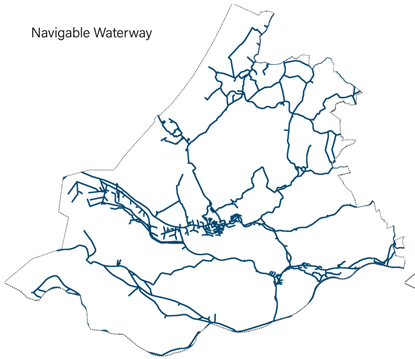
The maps below are the three most important maps in the connected category and are a guide to an energy efficient future.

The navigable waterways shows where potential corridors can be created that are specifically designed for heavy freight. As can be seen, the waterways already connect the largest cities in the province. These waterways will then be transformed into either green, or transportation, corridors. The second map shows the fastest route via a highway or train. These lines show how public transport is organized and clearly show where empty spaces arise. This can be addressed by, for example, applying micromobility and paying more attention to how these lines are organized, in order to adjust them if necessary.

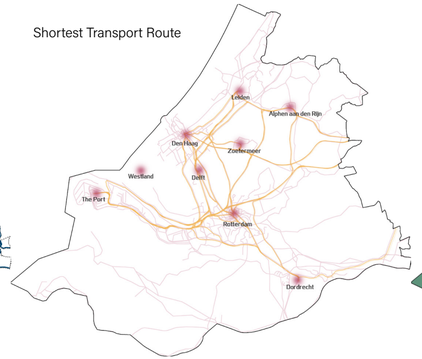
The third map shows where the natural habitats are located and illustrates how these can be, as it were, a boundary between nature and infrastructure.

These maps are combined into the vision map on the right page. Here it can be seen that the waterways are transformed into connecting links between cities. What also needs to be noted is that everything is connected to the manner in which cables are organized underground. These will be examined in each city and adjusted where necessary.

Navigable Waterway



Shortest Transport Route



Natural Habitats

Enhanced use of public trasports and micromobility

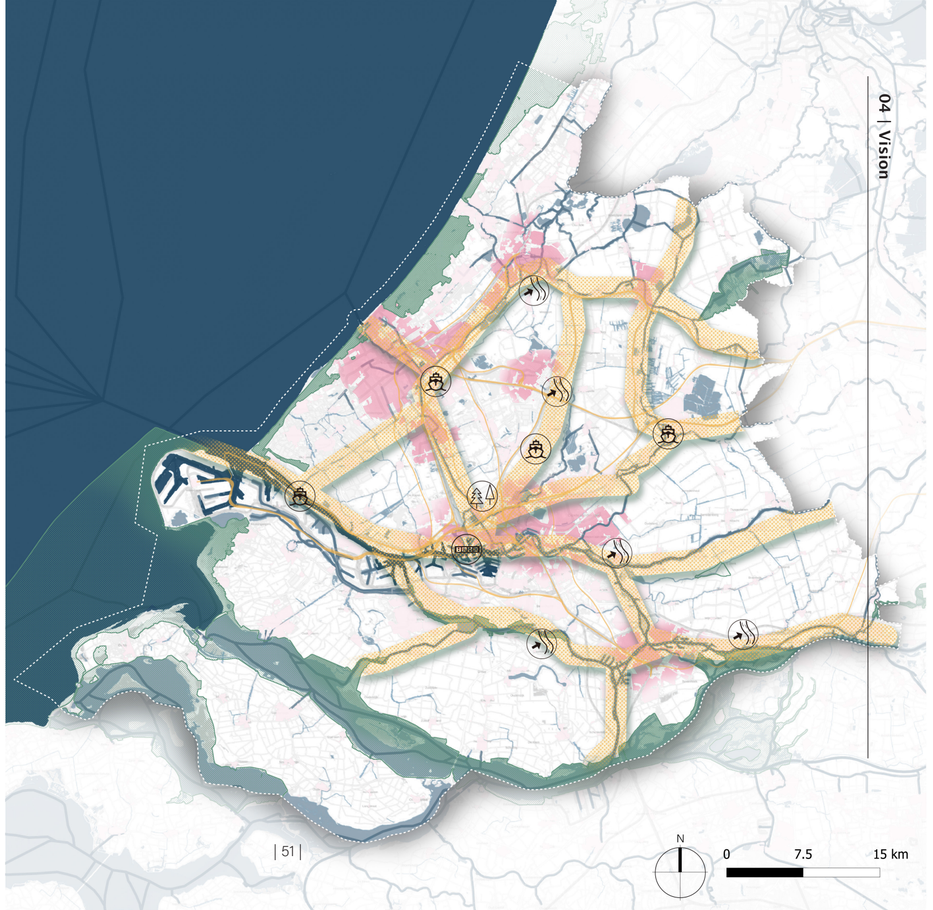
Emphasize importance of water network

Capitalize natural qualities

Organize Underground Cables

Legend

- Waterway
- Railway
- Transportation network
- Transportation corridor
- Natural habitats
- Cities connected



4.2 | Green

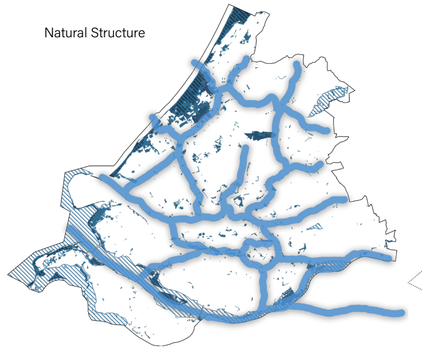
The first analysis map shows where the waterways are, and therefore where first to look to for the formation of potential green links or corridors. In the vision map, these waterways are transformed into green connections between cities, which can be part of a larger natural structure inside the province. This change alone will already tackle most of the targets, and therefore is one of the most important consierarionts in this category.

The second map shows where the naturalized green areas are. The result of this map is that the areas are not connected to each other, and are therefore connected together using the green corridors in the vision. They will also act as reinforcing elements to improve the corridors themselves. More attention will also be paid to these areas in order to increase biodiversity and allow people to make new connections with the nature around them.

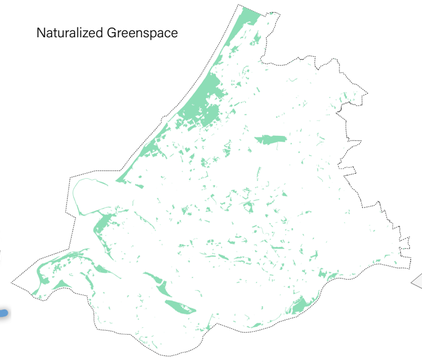
The conclusion of the last map shows that an area adjacent to Zoetermeer is the most low-lying piece of land in the Netherlands. Therefore, this area is extremely suitable to serve as a water storage. New and innovative agricultural practices, such as fish farms, can also be realized here to complement the water storage. This area will be connected to the green corridors to purify the water for these farms and will reduce the pollution of the drinking water in the region.

The conclusion of these maps come together in the vision map shown on the right page. As can be seen, the green areas connect to each other, and the green lines are the aforementioned connections between cities. The water storage site is surrounded by these corridors and is thus cleaned from all sides.

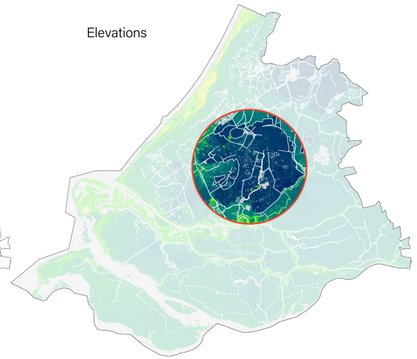
Natural Structure



Naturalized Greenspace



Elevations



- Naturalize water management
- Emphasize importance of water network
- Reduce drinking water pollution
- Capitalize natural qualities
- Renewable energy domination
- Sustainable materials

Legend

- Waterway
- Railway
- Ecological corridor
- Natural habitats
- Potential water storage area

N

0 7.5 15 km

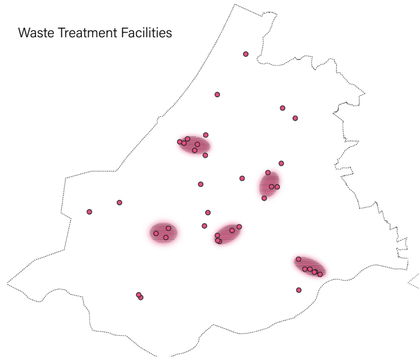
4.2 | Smart

The first map shows a conclusion of where there is a cluster of waste treatment facilities. These clusters are also found on the vision map and can be directly linked to the innovation hubs. The clusters are in fact ideal locations to place circularity hubs, since they are then close to the industries. The knowledge gained in the hubs can be directly applied to the industry next door.

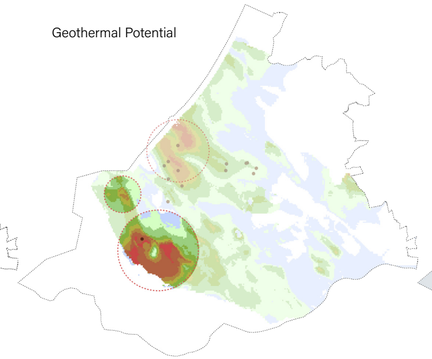
The second map shows where there is the most potential for geothermal energy. As can be seen, the largest source is south-west of Rotterdam. This connects perfectly to the third map which shows the potential space for other green energy. In this area, there is also plenty of room for solar panels and wind turbines. This is the place where the energy hub will be located. The conclusion map shows the areas where there is the most potential renewable energy generation. This is not to say that there are not other areas where this can also be generated, but rather where the highest potential is.

Therefore, the vision map shows that there are several places designated to generate renewable energy. For example, redundant highways can be used for solar energy and corridors (pink strips) become areas where renewable energy can be generated. For example, the North Sea is used for wind turbines and large areas in the east and north of the province are allocated for solar panel parks. Innovation hubs are placed in strategic locations so that they are close to the source of knowledge, production and implementation.

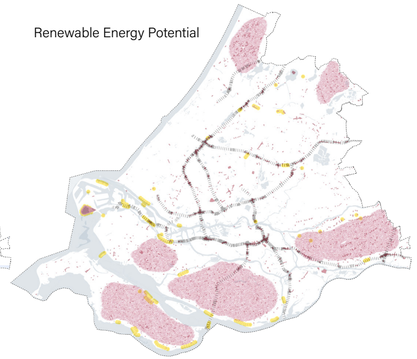
Waste Treatment Facilities



Geothermal Potential



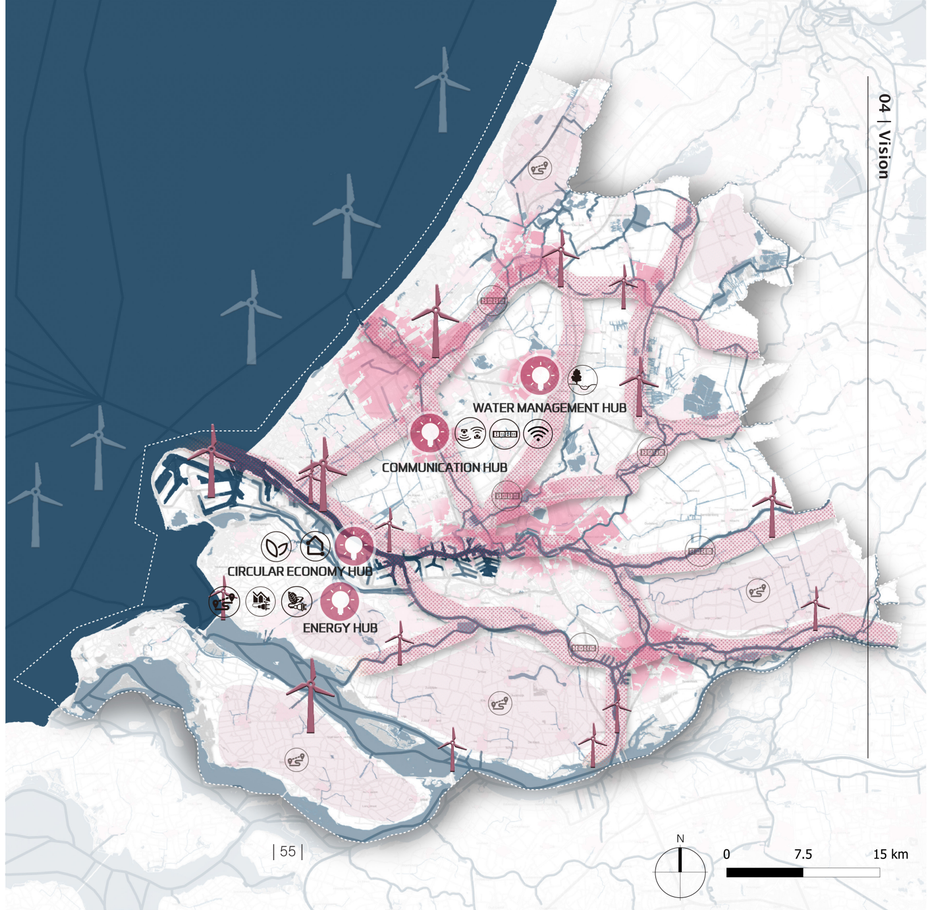
Renewable Energy Potential



- Innovation hubs for future HI
- Self-sufficiency maximization
- Innovation of Energy-Saving Systems
- Renewable energy domination
- Energy transmission in short distance
- Optimize maintainability of infrastructure and urban nature
- Naturalize water management
- Innovation of internet network

Legend

- Waterway
- Railway
- Communication corridor
- Cities connected
- Renewable energy generation
- Innovation hubs



4.3 | Vision Image

In the vision statement it was stated that in 2060, the province of South Holland will thrive while respecting the planetary boundaries. The human sphere and the ecosphere exist in symbiosis through an innovative, resilient, accessible, just and sustainable framework. For this there a future image is made, based on how the future can be projected out of the vision.

The image shows a integrated and combined vision of the future can look like and will implement the smart, connected and green solutions. The images is a collection of different solutions on different scales. On a provincial scale it shows a flow from the industrialized areas, where geothermal energy and communications are highly valued, to a emphasized public transport system that will connect city centers as well as suburban areas. Also the road infrastructure is a Is a large part of the infrastructure in the province and therefore needs to be addressed.

Going in to a city scale, attention is again given to how public transportation is organized, but also how buildings can generate energy, or even be self-sufficient.

The smallest scale will focus on street level, where micormobility will be implemented and a shared mobility system will be put in place in order for people to travel as efficient and sustainable as possible. Redesigning streets is necessary to complement the micromobility.

These solution will be put in a form of interventions that will be highlighted in the province, and will be further elaborated on in the next chapter. The intervention are connected to the statement set in the vision and will have several ways of tackle the problems.

It must be noted that this is a way of how this vision can look like in 2060, but it one of a thousend way to visualize it. Also not every intervention in the next chapter is visable in this collage but will be elaborated on in different sub-chapters.

5.1 General Strategy
5.2 Approaches
5.3 Key Projects

5.1 | General strategy

The general strategy was developed by first identifying four approaches that could address the project targets generated during the analysis phase. Then, the approaches were compared with the results of the visioning to understand the concepts behind the necessary interventions, and the interventions themselves. This approach ensured that all of the findings of the analysis and vision would be appropriately incorporated into a holistic strategy.

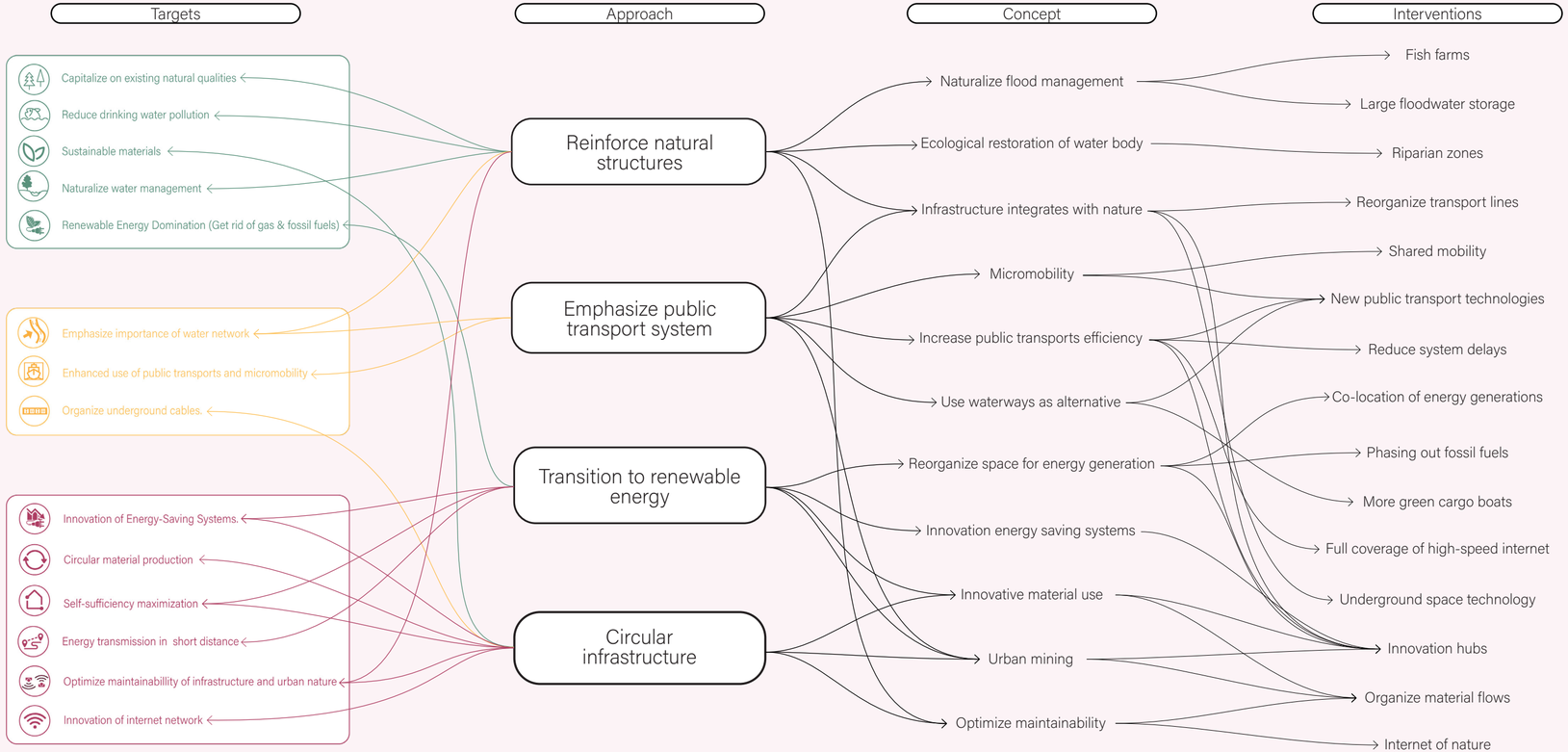
The reinforce natural structures approach focuses on ensuring that we are working with nature, rather than against it. The natural structure represents the basis for all natural flows in the world. Human survival is dependent on these flows functioning properly. Without them, we would lose access to fresh air, clean water, food, etc. Much of the existing infrastructure does not reinforce the natural structure, but works in direct contention with it. The proposed interventions under this approach work to change this, and ultimately allow for a harmony between anthropogenic and environmental flows.

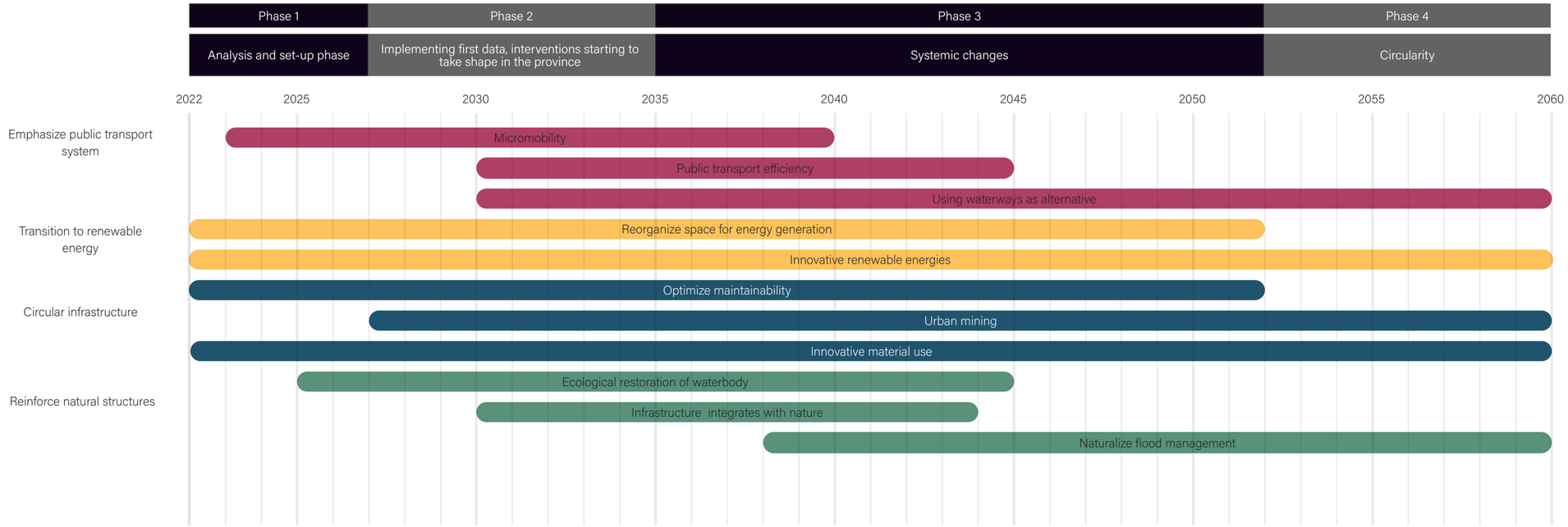
The emphasize public transport system approach recognizes that, for human society to continue to function properly, we must be able to move around freely. As such, movement must be done in a method that causes the least harm to the planet as possible while also maximizing the convenience. By rethinking how public transportation can work for people in all circumstances, a system that is better for all living things is possible.

The transition to renewable energy approach recognizes the fact that the future is one that will require even more energy, especially electricity, than we currently use, and that current methods of electricity generation are devastating for the environment. A fast and comprehensive shift to renewable energy generation is a necessity to responsibly usher in the infrastructure of the future.

The circular infrastructure approach closes the material loop. For truly sustainable and just infrastructure to be possible, the materials used can no longer be produced in a linear manner. Circularity will mean that the new infrastructure will be resilient in the long term. The construction of new infrastructure to improve communities can be accomplished in a sustainable manner.

Throughout this chapter, each intervention will be described in detail. Then, a look into their physical and spatial qualities will be completed through the lens of key projects to understand the impact that this spatial strategy will have on the province.





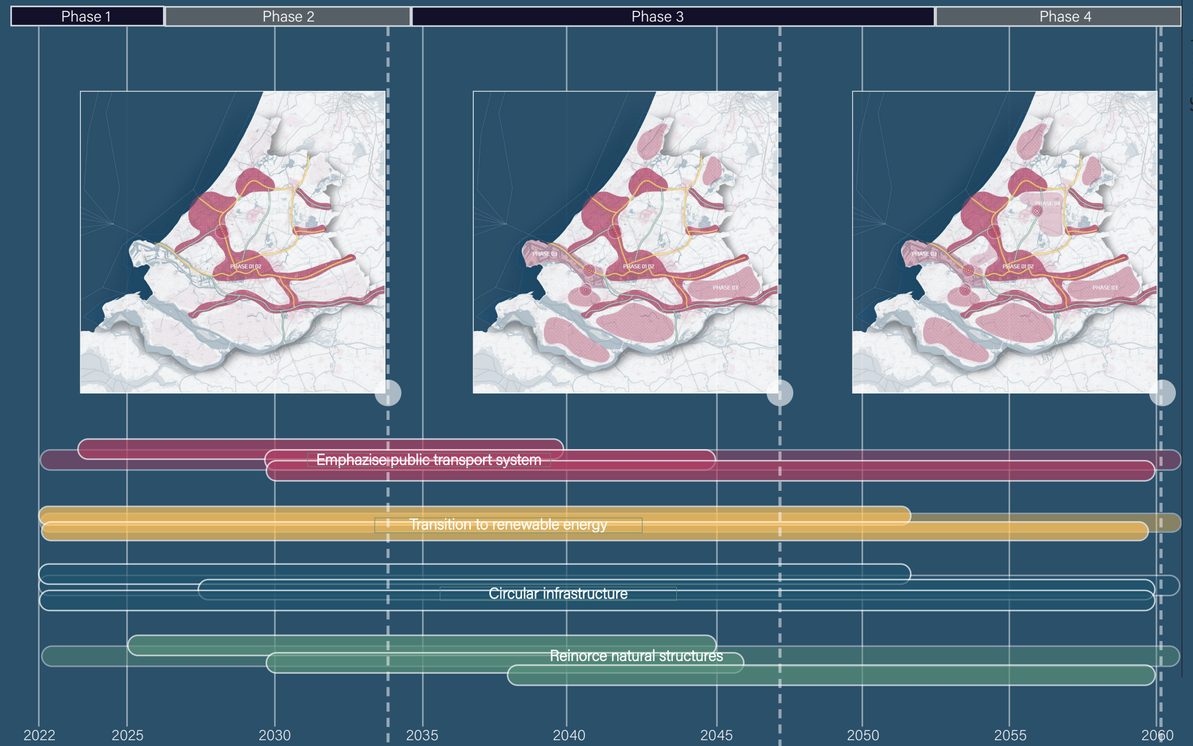
5.1.1 | Phasing

Related to the vision it can be stated that the emphasizing of public transport can be done right away, because placing a small shared mobility system at strategic locations takes the least time. While this is happening, a start can also be made to reorganize space for energy generation, since there is already a lot of free space available. Because urban mining needs further research, this will start a somewhat later than the rest. After beginning the reorganizing of transportation lines and creating space for energy generation, ecological restoration alongside waterbodies, and the integration between nature and infrastructure can proceed. The naturalization of the flood management will come last, since this needs the most preparation time. However this can be still be accomplished within a 20 year timeframe in order for us to be prepared for coming storms and sea level rise.

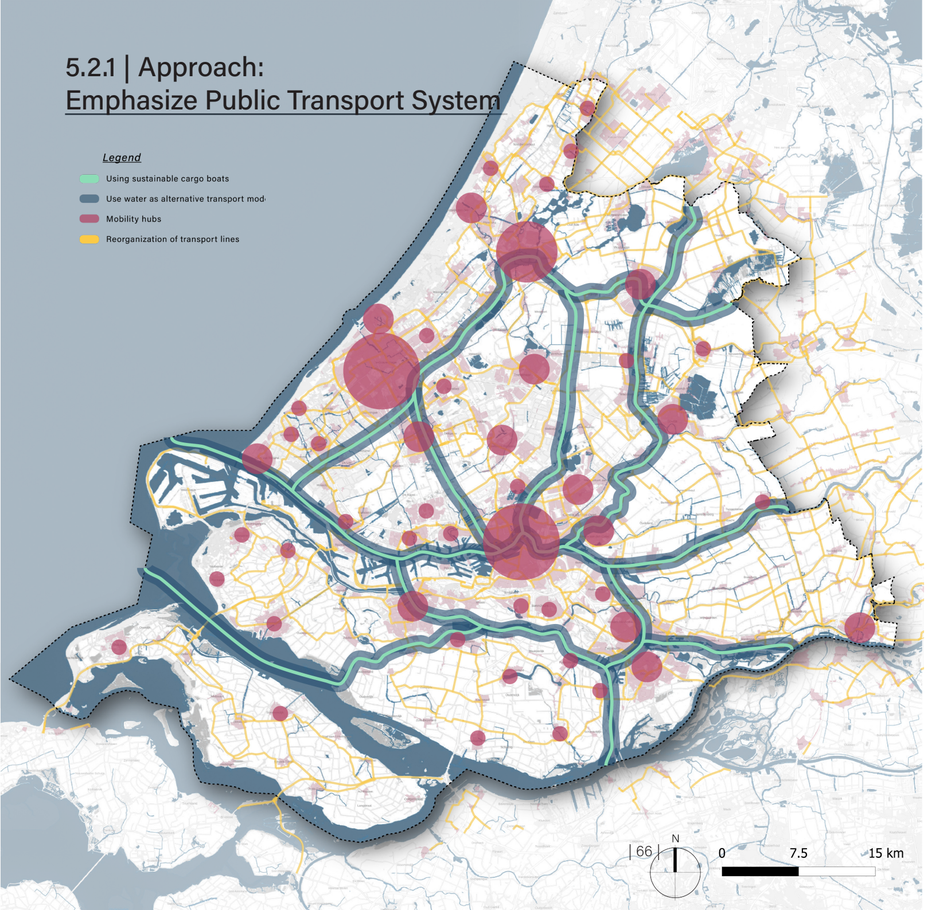
5.1.2 Phasing Map

As described in the timeline, the transformation of public transport, installation of micromobility, and ecological restoration of water bodies will take the lead. Spatially, this means that the movement corridors and the ecological corridors will form a relatively complete spatial structure around 2035, connecting the whole province of South Holland in terms of public transport and ecology.

With the completed corridors as a spatial backbone, circular infrastructure manufacturing, mainly urban mining and renewable energy generation, will be implemented in the port area and in the renewable energy potential areas in the south and north of the province. Naturalizing flood management tools such as floodwater storage area creation and fish farm conversion will be located mainly in the central part of the province at low elevations during the third and fourth phases.



5.2.1 | Approach:
Emphasize Public Transport System



As shown in the phasing scheme before, the first intervention to accomplish is the emphasis on the public transport system. All other approaches can be more easily elaborated on if the public transport system is working in its optimal form. Therefore this approach is divided in four concepts:

- Usage of sustainable cargo boats
- Using waterways as transport
- Create mobility hubs in ever city
- Reorganization of transport lines

The vision stated that there will be both green and movement corridors introduced in order to connect the green, the city and anything that is in between. They will be alongside the existing waterways. Therefore it is convenient to not only use these corridors for leisure, but also as a viable and a more sustainable method of transportation that will relieve some of the pressure off the road network. In this case, sustainable cargo boats will be the main transport line on the corridors. However, these boats will have restrictions in order to ensure the least impact on the nature around it.

Another important part of this approach is the redesign of streets in order to improve the safety for SEV (Small Electric Vehicles). This has a direct connection to the micromobolity hubs. When the first stage of micromobility is completed, many more people will choose SEV's over the car, which will mean a lot more activity in bike lanes than there is now. In some areas the bike lanes are already packed with cyclists. Therefore it is necessary to think about how we can create more space for SEV's while slowly phasing out the space the car has right now.

The concepts will be supported by policies, regulations and subsidies, which are described on the right. In order to get the transformation going, strict laws and regulation will be applied so that there are no gaps in the implementation of the vision.

All these changes are a start to complete the other approaches and will therefore make the other approaches stronger and more feasible to execute.

Concepts	Interventions	Supporting Actions
Micromobility	Street design will be transformed into safe, bikable and green corridors.	
		New contracts between shared mobility companies will encourge them to improve their quality and range of shared vehicles
		An application on the mobile phone will give you every option there is for you to travel to the destination as soon as possible
	Every train or bus station is required to have at least two forms of shared vehicles. Larger stations should have at least 4	
Public transport efficiency		Subsidies from the government should increase the number of employees that work for public transport companies.
	Redesigning the street will be the first priority for efficient public transportation. Therefore large investements should be implemented in order to change the street profile	
Waterways as alternative transport modes		The speed of the water vehicles will be determined by the amount of damage it can do to house boats. They will be categorized.
	Some waterways will be prohibited to use for leisure, where others will have designated zones for water activities	

Emphazise public transport system

The first priority is to engage with stakeholders, understand their issues, and ensure we can work together to execute on the vision. What can get done quickly is the implementation of micromobility Regulations will have to be in place, and monitored for effectiveness, to help the introduction of a shared mobility system. The shared mobility system will give a huge boost to micromobility over the long term. After six years the performance of every mobility hub will be analyzed and the results from this will be implemented in Micromobility 2.0

Again, For the public public transport efficiency, the first priority is contact with the stakeholders. The vision applies for a longer time period of conversations between stakeholders before there can be an implementation of the reorganizing of transport lines. This will also be at the same period that infrastructure integrates with nature. Subsidies will give a boost to this concept.

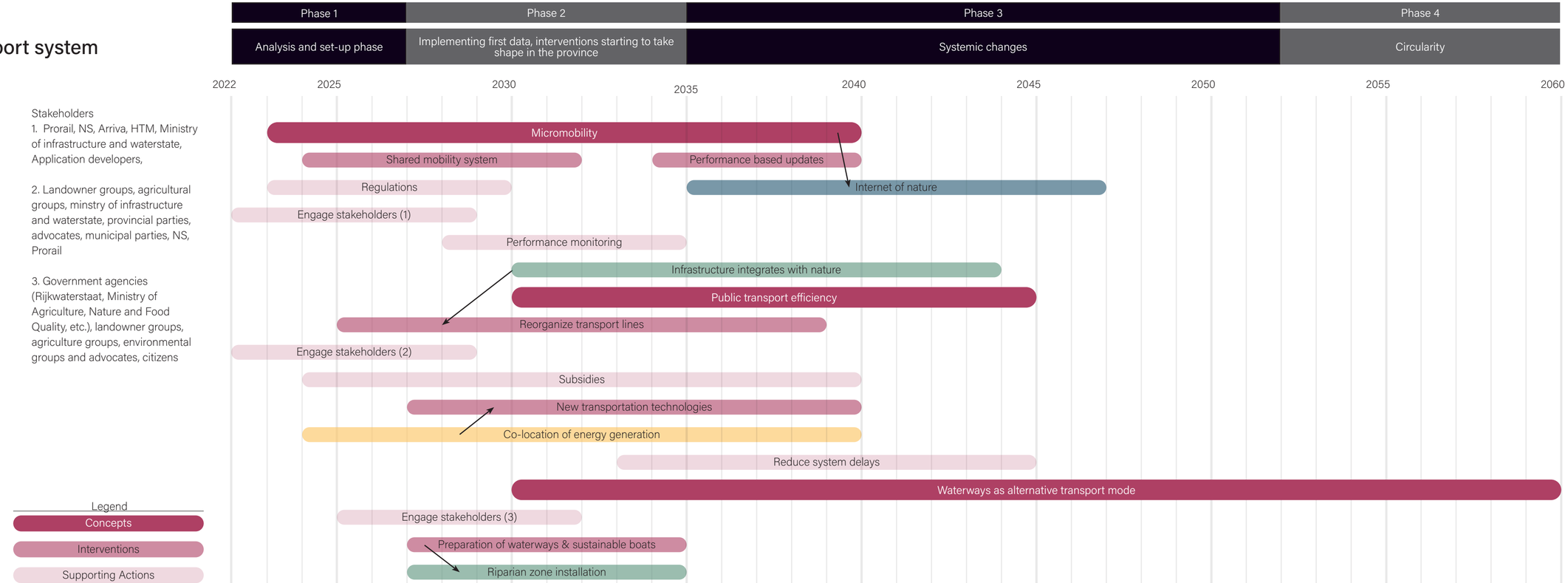
The usage of waterways as an alternative transportation mode can be prepared relatively easily. After engagement with stakeholders, the preparation of the waterways can be done simultaneously with the installation of riparian zones. After this, the waterways that are being highlighted in the vision can be used for sustainable cargo boats and other forms of transportation.

Stakeholders

1. Prorail, NS, Arriva, HTM, Ministry of infrastructure and waterstate, Application developers,

2. Landowner groups, agricultural groups, minstry of infrastructure and waterstate, provincial parties, advocates, municipal parties, NS, Prorail

3. Government agencies (Rijkwaterstaat, Ministry of Agriculture, Nature and Food Quality, etc.), landowner groups, agriculture groups, environmental groups and advocates, citizens



Shared Mobility System

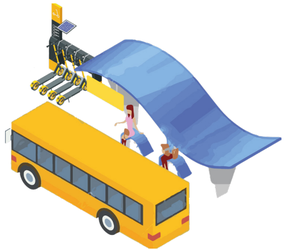
In order to emphasize more on the public transport system, a shared mobility system is vital. Since the phasing out of the car will have a huge impact on our way of transportation, alternatives have to be upgraded in order for people to use them. In cities, the majority of congestion is created from car use; a shared mobility system can solve this. By integrating several shared vehicles into strategic places inside a city, people don't feel the need to use the car and rather would travel with more convenient shared options. By introducing the mobility hubs people can choose different options which are shared and therefore don't rely on their own personal vehicle. This will decrease the space a car needs in the city and will also lead to the vehicles that are on the road being more compact

The mobility hubs can change in size, depending on the strategic location. Where large central locations inside the city center will have almost every form of transportation, small bus stops for example may only offer you bikes or scooters.

For this to work properly, software needs to be available to get an overview of what is the fastest transportation mode in your specific timeframe.

How we design streets is also directly linked to the shared mobility system. In order for people to choose another transport mode instead of the cars, the roads need to be suitable for this change of transportation flows. Right now, most streets are car focused and are not safe enough for walking and biking. However, by phasing out the cars the space demands for roads will be reduced, and therefore more space can be reserved for smaller transportation modes. By redesigning, more emphasis will be put on space for pedestrians and Small Electric Vehicles (SEV). This can mean an electric scooter, electric bike, segway, monowheel, electric car, steps or a hoverboard.

Image Source: https://mobility-as-a-service.blog/mobility-hubs/



Green Cargo Boats

By introducing green and movement corridors between cities, new opportunities to use space in a more efficient manner will present themselves. While the waterways are already being used for cargo transportation, more emphasis will be placed on water transportation through the use of sustainable cargo ships.

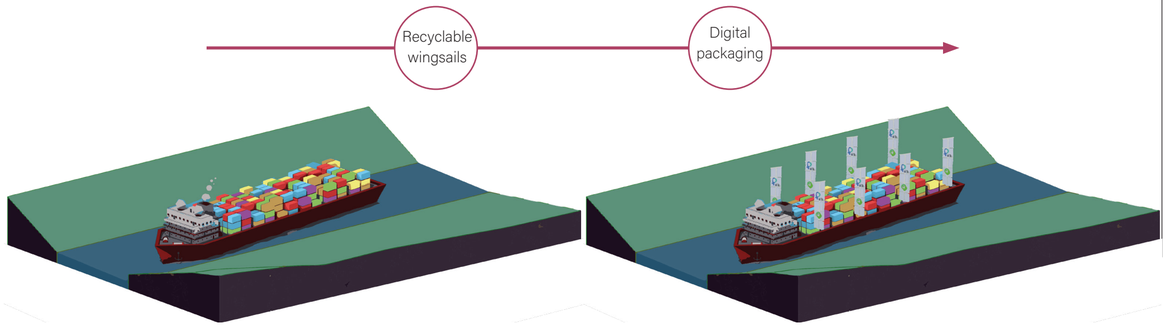
The challenges that come with using water transportation consists of two aspects: Ocean freight is a slow and time-consuming mode of transportation, which can be a competitive disadvantage. Furthermore, there may be delays due to weather conditions.

A lot of goods are already being transported by the waterways which has a significant environmental impact. Even though maritime freight is less polluting than land or air freight, it still emits greenhouse gasses and pollutes the environment with sound and oil. Furthermore, for economic reasons, the shipping industry continues to use highly polluting bunker fuels such as heavy fuel oil (HFO). The threat it poses is very real. First and foremost for the marine environment, but also for the people who live alongside the rivers, because fine particles emitted by ships can travel hundreds of kilometers.

One of the most important aspects to improve is the making of boats more sustainable and eventually even circular. Therefore recyclable wingsails need to be implemented on every ship, which will yield a reduction of GHG emissions by at least 20%. Extra shipping crew are not even needed to utilize these wingsails.

Making sustainable boats should not be limited to just the physical boats, but should also include the packaging process behind it. By making packaging design fully digital and intelligent, packaging engineers can make informed design decisions that maximize packaging sustainability, lower costs, and accelerate market readiness.

By implementing these two solutions, a big step can already be taken for sustainable cargo boats that will roam our waterways.



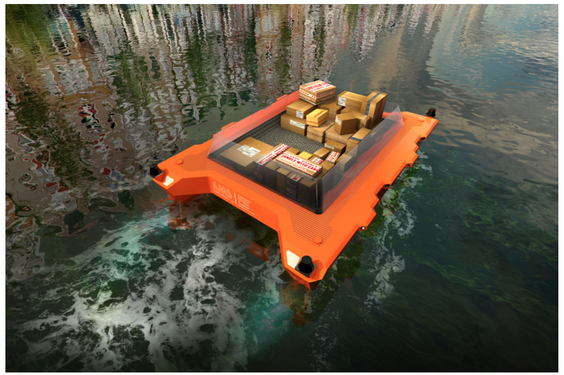
New public transport technologies

Alongside the transforming of the public transportation system and implementing SEV's, new technologies should be included in this systemic change. There are many examples around the world on how new technologies help to improve the public transportation system, but not all of them are applicable in the Netherlands. However, some of the new technologies are already being researched and slowly put to use in the Netherlands.
This page will explore these technologies and highlight how they work and how they will strengthen the concept.

Vanpool

One of the technologies that can be implemented now is a Vanpool system. This system provides safe and reliable vans so groups can commute together to save time and money. While the most important consequence is having fewer cars on the road, there is also more flexibility in traveling together. Also traveling with family, friends or co-workers will improve the enjoyment of your traveling time.

Image Source: https://www.communitytransit.org/vanpool/about



Roboat

Because the previous intervention emphasized the use of waterways as an alternative transportation mode, the Roboat can be a perfect example on how to use them inside a city. While the waterways between cities are used for larger transportation, small-scale transport modes can be used inside the city center. The roboat is an autonomous boat that uses radar sensors to navigate.

The roboat can be implemented for multiple uses. It can be used to transport a maximum of six people around the city as an on-demand mobility solution, or on a fixed route as a ferry.
It can serve as a floating dumpster that autonomously transfers household waste in cities. Research shows this system substantially reduces the need for heavy garbage trucks and also reduces congestion, pollution and noise.

Roboat can be deployed as a fine mesh network of mini-hubs for delivering goods throughout the city. Combined with an overarching hub strategy, large trucks could offload on the outskirts of a city into a fleet.

Roboat units can join together to create temporary bridges, alleviating congestion on Amsterdam's centuries-old bridges and canal-side streets.
Image Source: https://roboat.org/use-cases/

Image Source: Steeman, A. (2009, 31 december)

Energy generating solutions

By using innovative technologies for energy production, small stations or even complete mobility hubs can operate using their own generated energy. There are several examples around the world that are already being used. The image on the left shows a power generating bus stop in Poland and on the far right a pathway is shown. This tile will produce energy while people walk on it. Placed at strategic locations in a station, a lot of energy can be produced in a day.

Image Source: Fermoso, J. (2008, 17 december)

Cultivated in transit

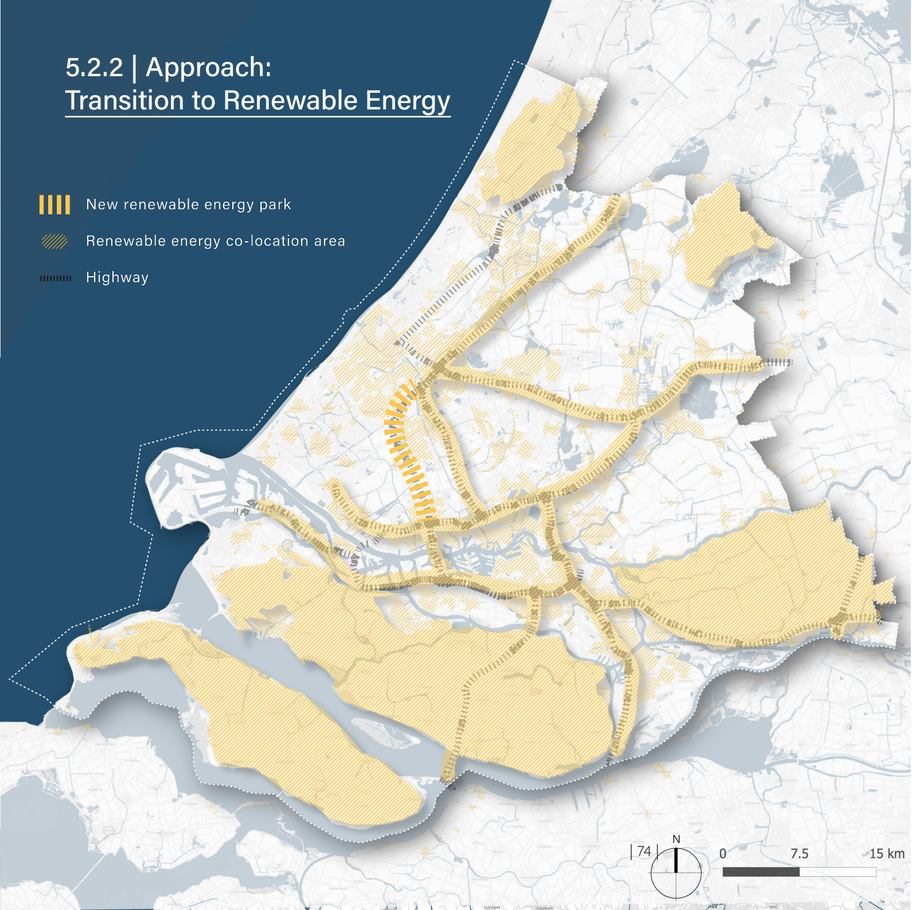
This technological advancement is focused on a new method of growing (oyster) mushrooms that is fully integrated into the supply chain. One of the functions of the distribution chain, preventing perishable product degradation through refrigeration, is transformed into an active role in the cultivation process with consumer interaction through harvesting at the point of consumption with this concept. It not only changes the labeling from "best before" to "harvest on," but it also eliminates harvest labor, which can account for up to 40% of a mushroom's total cost. This technique will therefore fit perfectly in the overall vision of circularity.
Image Source: https://bestinpackaging.wordpress.com/2009/11/13/cultivated-in-transit/

Internet of roads

Since the road network of South-Holland is the most dense of the Netherlands, a huge opportunity exists to make the roads suitable for more than just driving. Some examples, like self-driving cars, connected cars, GPS navigation, route optimization apps and ride-hailing services already exist today. The road can serve as a platform for a variety of further innovations.To support sustainability, increase safety, and improve efficiency, roads can be upgraded with communication, lighting, and power transmission technologies, all of which will help to transform the driving experience.

Image Source: https://vrioeurope.com/en/smart-road-technology-digital-high-ways-of-the-future/

5.2.2 | Approach:
Transition to Renewable Energy



Renewable energy facilities have great potential for both environmental protection and social development, but the construction of new energy facilities requires a lot of space compared to traditional energy sources. Solar and wind power needs around 40-50 times more space than coal and 90-100 times more space than gas(Van & Behrens , 2018). In order to use limited urban space more efficiently, energy transition will be mainly done by integrating new energy facilities into existing urban space.

There are two main means of co-location of renewable energy generation: changing low usage areas into a centralized renewable energy production area, or integrating power generation facilities into existing space without taking up more space.

Based on the frequency of use analysis of the freeway and the layout of the alternative, parts of the A4 freeway could be completely converted for sustainable energy production and no longer allow car traffic, which enables large-scale energy production. This measure is introduced after public transportation becomes the dominant mode, private cars are used less frequently, and waterways become the main mode of freight transportation. In the future, perhaps all highways will be eliminated, but a complete change in transportation mode is something that will take a lot of time to complete, so we only plan to take out this one section before 2060.

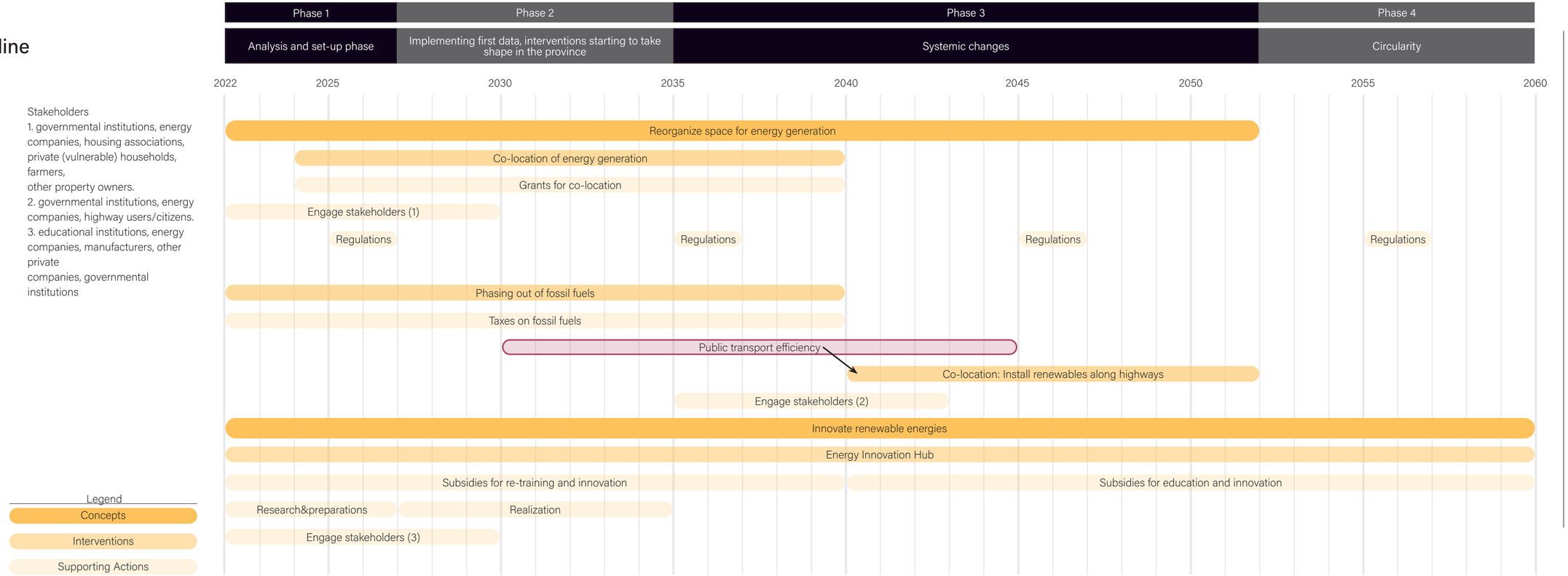
For renewable energy generation integration, in order to guarantee sufficient energy production to allow renewable energy to dominate the market, this measure covers almost the entire artificial area of the province of South Holland. Among them, farms are the largest producers of solar energy which have the potential to contribute significantly to national electricity production, but there have been concerns about the amount of land required for solar projects and the impact of solar projects on local habitat. During the site preparation phase for utility-scale solar facilities, developers often grade land and remove all vegetation to minimize installation and operational costs, prevent plants from shading panels, and minimize potential fire or wildlife risks. However, the common site preparation practice of removing vegetation can be avoided in certain circumstances, and there have been successful examples where solar facilities have been co-located with agricultural operations or have native vegetation growing beneath the panels(Macknick, Beatty & Hill, 2013). With innovative facilities, instead of hindering local ecology and agricultural production, the solar installations and wind turbines can bring more opportunities for economic development and social transformation.

Concepts	Interventions	Supporting Actions
Reorganize space for energy generation	In order for space to be used multifunctional a **grant** will be given to property owners to install renewable energy generators on their buildings and/or land.	
	The **regulations** for buildings and energy use will be increasingly strict. All buildings have to be energy-neutral by 2060, starting with all new buildings and step by step including other buildings by renovations. Also, industries have to be more energy-efficient (energy saving-systems innovation), for which the regulations will be established by research per sector. Furthermore, all energy use will be renewable by 2060. The percentages of renewable energy used by industries will also be increased step by step.	
	By levying **taxes** on fossil fuels the subsidies and grants for renewable energy generators will be funded (whenever possible).	
Innovate renewable energies	The Energy Innovation Hub will be **subsidized** to support education and research. Practical and theoretical education is necessary for the transition. Employees in industries that will be phased out have to be retrained, like in the fossil fuel industry. Theoretical education is needed to stimulate research on several renewable energy generators and how to implement this into the province is needed. Besides that, energy-savings systems should be further developed.	

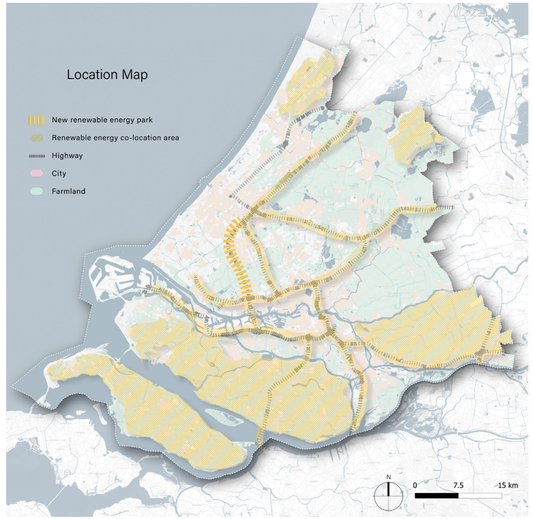
Detailed Approach Timeline

Since renewable energy generation needs more space than the current non-renewable sources, the province is in urgent need of a reorganization of space (van Zalk & Behrens, 2018). So, in order to expand the renewable energy infrastructure, several interventions will be implemented. First of all, the co-location can start immediately after engaging the first stakeholders. This way, space in the province will become more multifunctional. Moreover, the phasing out of fossil fuels needs to start as soon as possible for both environmental and spatial reasons.

The improvement of public transport will mean that highways will be utilized less, freeing up space for renewable energy generation. While installing the renewable energy generators, industry needs to keep innovating to increase efficiency, which will happen at the Energy Innovation Hub. This way, the space problem is approached from two sides, addressing the pressing need. Finally, since the energy generation will cover the whole province, the environmental impacts could be huge if unmitigated. So, to create a sustainable future, a transformation towards a circular economy is necessary.



Intervention: Energy Co-Location



Energy co-location is one of the primary methods for enabling the transition to a green energy system. Through a variety of installation locations and methods, a comprehensive and resilient green energy grid can be built.

Urban Highway: The highway through the city will be transformed into a renewable energy park, not only for power generation but also for enriching people's daily activities. The power generation facilities will be aesthetically pleasing and multifunctional.

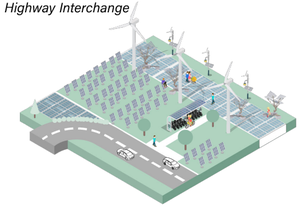
Rural Highway: The highway was once a barrier that separated farmland in the countryside, but when it is no longer used as a motorized transportation facility, farmland, villages and green spaces are able to be stitched together again in the form of greenways, and the remaining blocks are used for renewable energy production on a large scale.

Highway Interchange: Considering that other highways will still support motorized traffic, more consideration has to be given to how to interface power generation with other highways so as not to impede traffic. Interchange sections therefore use the most conventional power generation facilities.

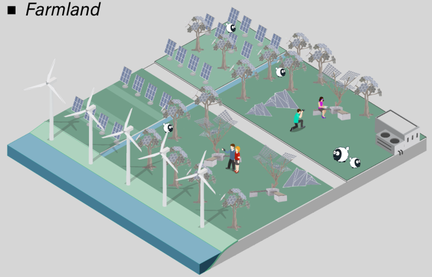
■ *Urban Highway*

■ *Rural Highway*

■ *Highway Interchange*

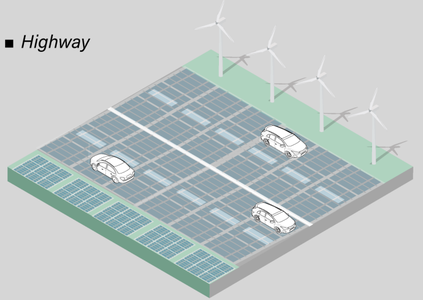


■ *Farmland*



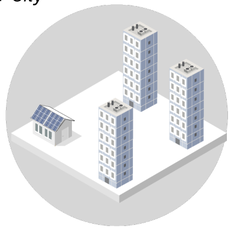
Farms are one of the preferred locations for solar panel installation, with a large area, plenty of light and no interruption to pasture operations. Additional renewable energy facilities can also be combined with recreational facilities and placed on farms to stimulate more economic activity, such as camping.

■ *Highway*



The highway is a preferred location for solar panel installation because it is generally not surrounded by tall buildings and has a single function. As a result, solar panels can be installed on the road to produce electricity on a large scale.

■ *City*

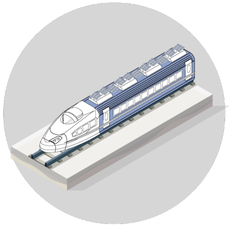


Buildings

Solar panels can be installed on sloped roofs in cities, and high-rise building facades are covered with solar panels.

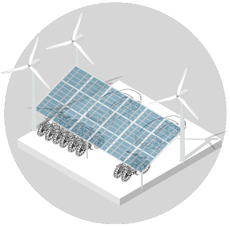
Street

Renewable energy facilities are integrated with urban public services to the maximum extent possible, without overly dominating the urban space.



Public transportation

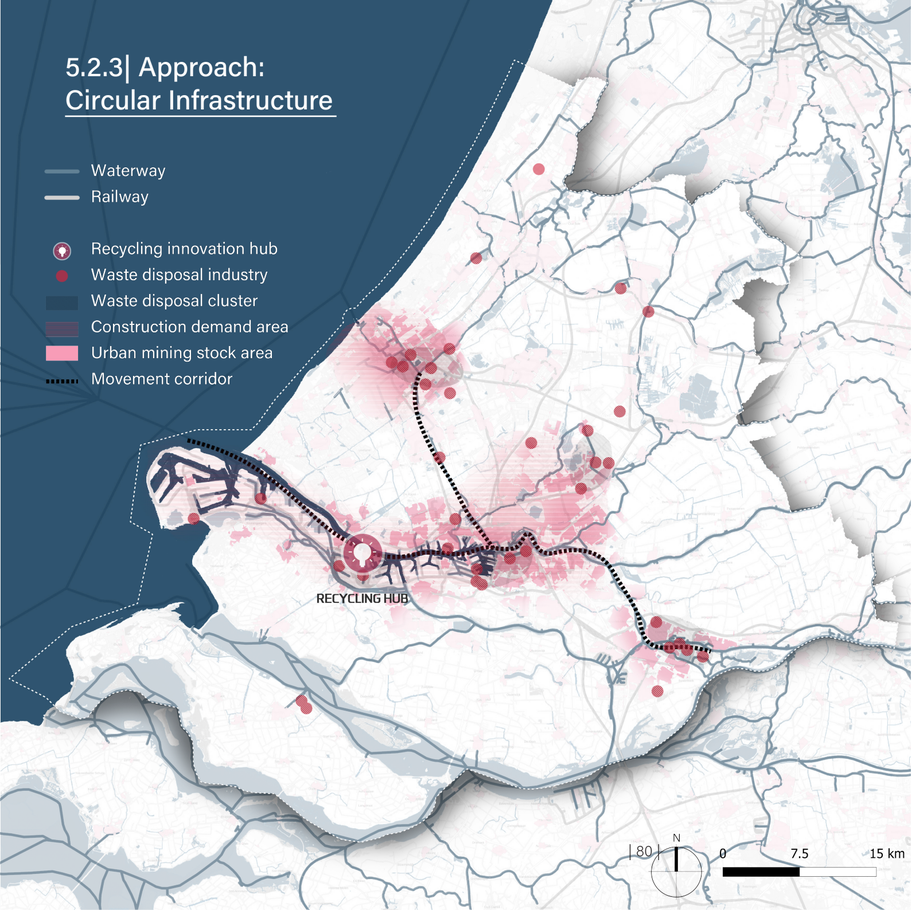
Exterior skins of existing public transportation vehicles that are not underground have significant power generation potential and can be replaced with solar panel skins at the end of their useful life.



Parking lots

Making full use of the vertical space of the outdoor parking lots, by installing solar panels as canopies and wind turbine as framing elements.

5.2.3| Approach: Circular Infrastructure



The approach of circular infrastructure is optimized by addressing the three aspects of circular manufacturing; maintenance, management and recycling. The three concepts of innovative material application, urban mining and maintenance optimization, are implemented spatially, technologically and policy-wise through the integration of material flows, underground space technology and natural networks.

For circular manufacturing and recycling, a series of pilot projects and subsidy policies for innovation hubs that study the application of innovative materials will be proposed. These will encourage the production and use of new renewable and widely available raw materials. In addition, urban mining is considered an important strategy to replace primary raw materials in the construction sector, and the generation of construction waste and demand for materials will be concentrated in the large cities of South Holland (Xining et al, 2022).

Therefore, the establishment of a construction waste recycling network and a digital materials platform based on the spatial and temporal distribution of waste and demand will maximize the spatial and temporal connection between the outflow and inflow of materials, allowing for efficient recycling of infrastructure construction. Innovative projects to study deconstructable design will also be implemented to reduce the cost of demolition and recycling from the aspect of new infrastructure construction. By joining their forces, the manufacturing and waste disposal companies will facilitate a secure position of recycling companies within the future system.

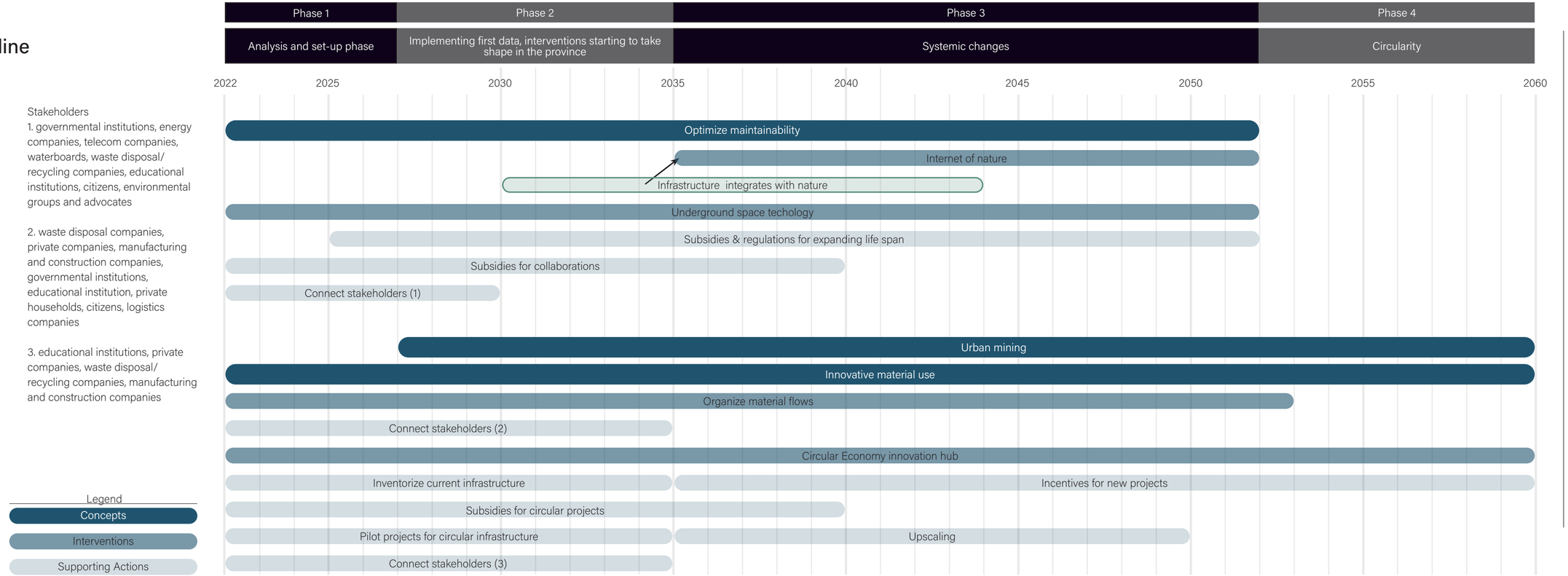
In the area of maintenance and management, a large number of underground space technologies and the internet of nature will be used to integrate infrastructure, such as underground pipes, in South Holland to monitor and analyze the operation of infrastructure and urban nature in real time and to assign maintenance strategies based on data. The design of a more maintenance-friendly infrastructure in the innovation hubs will also be studied.

Concepts	Interventions	Supporting Actions
Innovative Material Usage		Pilot projects of innovation hubs that encourage knowledge development and sharing on design for circular infrastructure and new, more efficient production methods.
		Pilot projects of innovation hubs that develop innovative usage of sustainably produced, renewable and widely available raw materials, like biomass.
		Provide subsidies for projects in innovating and purchasing new material use.
Urban Mining		Pilot projects of innovation hubs that design for disassembly.
		Create construction waste recycling network linking the material outflows and inflows in space and time.
		Digital material platform that provides material passports for construction and demolishment.
		Create network between stakeholders in order to organize material flows.
Optimize Maintainability		Pilot projects of innovation hubs that design for inrastructure with better maintainability.
		Pilot projects of innovation hubs that develop the internet of nature which allows infrastructure to better integrate with nature and management of urban nature.
		Provide subsidies and incentives for implementing utility tunnels, sensors and internet of nature, and regulations for expanding life span of existing infrastructure.

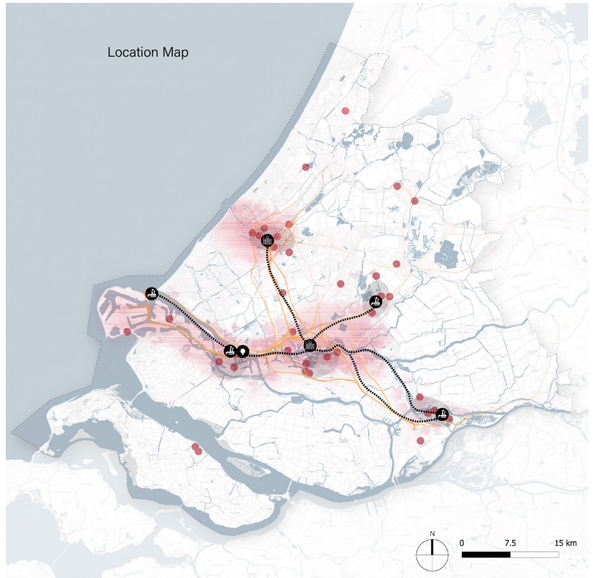
Detailed Approach Timeline

For the transformation of a linear economy based infrastructure towards a circular economy, certain concepts were identified. First of all, the maintainability will be optimized to expand lifespans. This will be done by implementing underground space technology. However, to start this, stakeholders need to be engaged. Furthermore, elements of the Internet of Nature will be installed while infrastructures are integrated with nature. For example, sensors will be placed in newly built ecoducts. Digital systems will also need to be set up to fully utilize the Internet of Nature in the future.

Finally, the innovation of material use and urban mining go hand in hand, since they are closely related in the cycle of the circular economy. To start mining, extensive preparation is required, like inventorization of the infrastructure and connecting of stakeholders. Meanwhile, the reviewing and redesigning of the current infrastructures can start at the Innovation Hub.



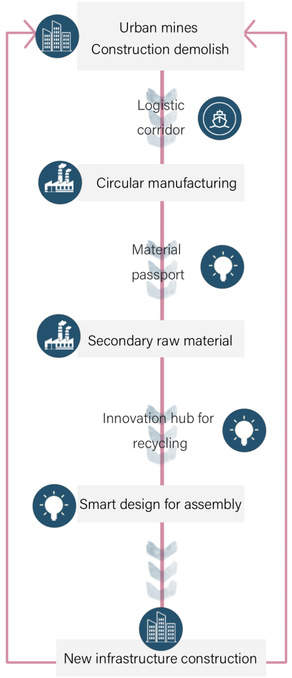
Intervention: Organize Material Flows



Rotterdam, the port and The Hague, are the main sources of waste for urban infrastructure construction. This flow of 'waste' is matched to the new infrastructure construction demand areas by connecting the inbound and outbound flows of infrastructure materials in space and time.

By means of efficient logistic corridors by water and public transport, the demolishing of existing infrastructure, output and recycling of materials, sorting, secondary production and new construction are connected in a complete chain. By combining this spatial structure with a digital materials management platform, demolished and new construction materials will be identified and tracked to ensure the demand for raw infrastructure inputs can be met by using recycled materials, rather than new materials

The Innovation Hub for recycling will work on smart assembly infrastructure design to create the conditions for future material recycling. The recycling of infrastructure materials, such as concrete and asphalt, will also be studied as a pilot project. This will contribute to the integration of material flows for the production and recycling of circular infrastructure.

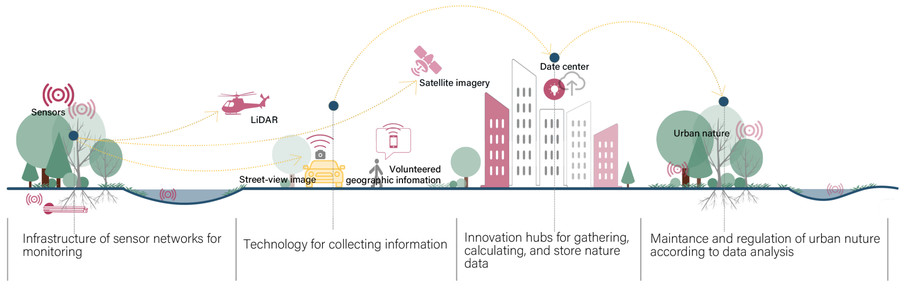


Intervention: Internet of Nature

The internet of nature is created based on the dynamics of natural ecosystems and urban infrastructure. Its purpose is to monitor and communicate the dynamics of urban nature in real time as part of the infrastructure.

This system includes, but is not limited to,
(1) sensor networks for monitoring stormwater, urban heat island and air pollution absorption, and the effectiveness of stormwater management strategies and soil quality,
(2) LiDAR for monitoring canopy volume and forest structure, remote sensing and satellite imagery for monitoring canopy cover,
(3) street-view imagery for green cover quality and management, and artificial intelligence for enhancing biodiversity through voluntary geographic information, to provide accurate, real-time and comprehensive data for monitoring, research and conservation of urban nature.

After monitoring and collecting information on urban ecosystems using infrastructures and technologies, the analysis and cloud storage of data on urban nature will be performed in data centers to understand the state of urban ecosystems and to model and predict the operation and impacts of urban nature. The information and data obtained will inform management and planning decisions to optimize the maintainability of urban nature. With the help of the Internet of nature, environmental features will be digitally connected to the larger social-ecological system of the city. The benefits of urban nature will be enhanced and self-organisation, self-regulation and automation can be achieved.



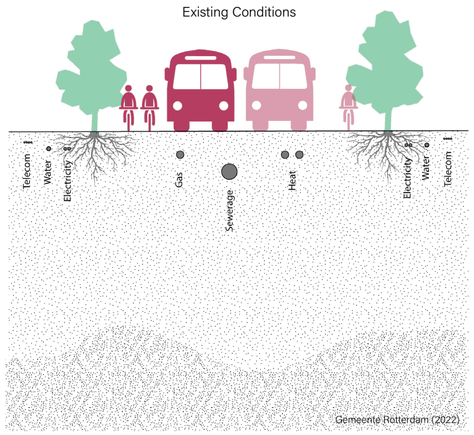
Sensor networks for monitoring stormwater, urban heat islands and air pollution uptake. Plants as biosensors for ecosystem resilience.

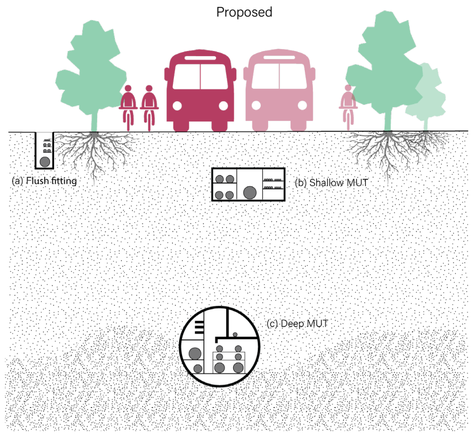
LiDAR for monitoring canopy quantity and forest structure. Remote sensing and satellite imagery for monitoring canopy cover

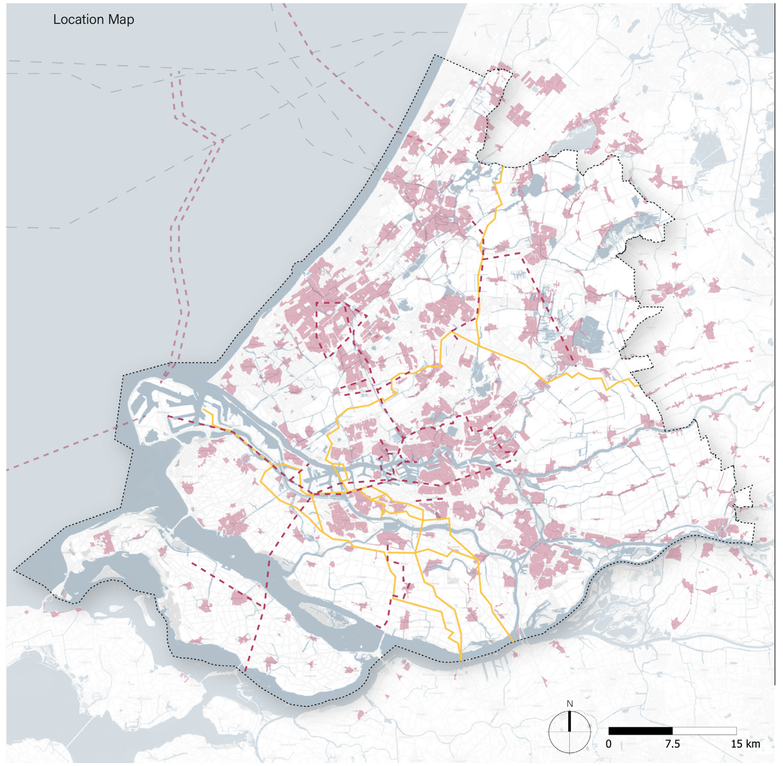
Street-view imagery and AI for green cover quality and management. Biodiversity enhancement through volunteered geographic information

Intervention: Underground Space Technology

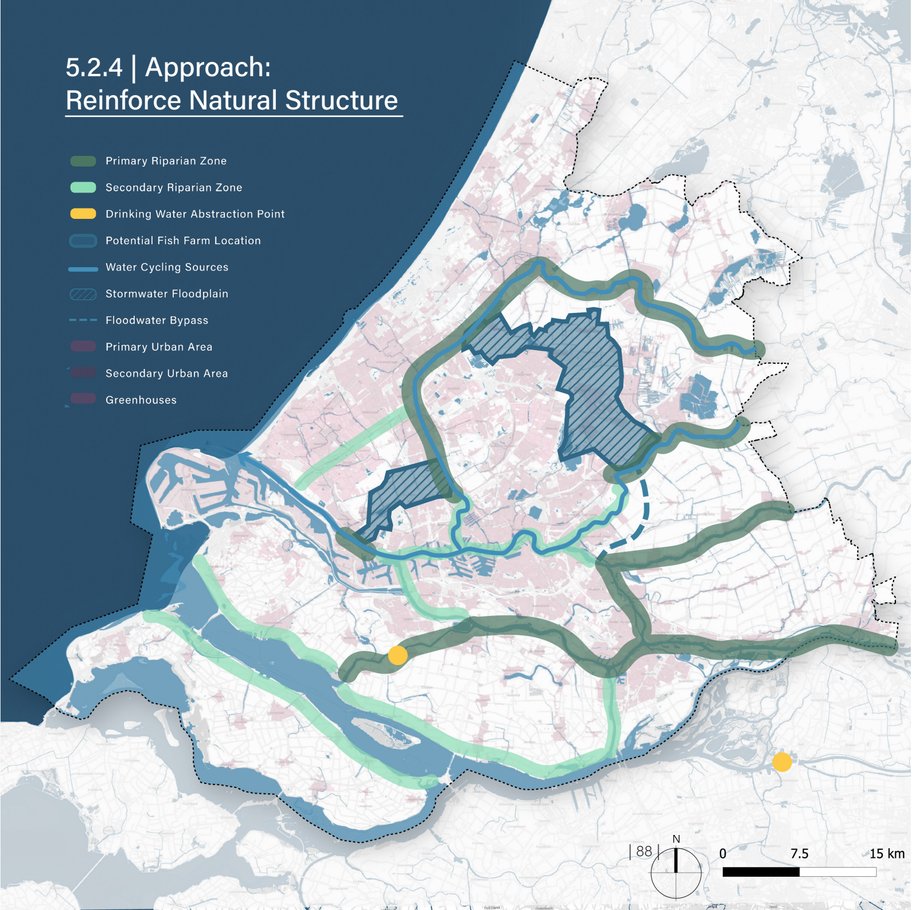
Starting from the early project stages of urban development, the underground conditions need to be recognized. By transitioning from the poorly organized placement of utilities in the soil (existing) to a combined placement in Multi Utility Tunnels (MUTs), the surface and subsurface will both benefit. In 2020, 5,9% of excavations caused damage to cables and pipelines, meaning a direct loss of approximately 38eu million per year (Rijksoverheid, 2021)
MUTs become most valuable in densifying areas, since they allow for a decrease in the total required underground space and reduce surface disruptions when maintenance, or new installation, of cables and pipes occurs. The improvement of accessibility means saving time and money in the long term, but also makes it easier to implement new technologies, like digital monitoring by sensors. It will also provide better mapping of the subsurface networks, which is needed for urban mining. Furthermore, the freed up underground provides space for innovative new infrastructures of the future, like a heat network and also provides options for more flexible use of the surface space. A close collaboration of the involved parties is needed to grasp this opportunity to improve the city.
(Hooijmeijer et al, 2016)
This intervention also strengthens the strategic approach to reinforce the natural structures. Not only will there be more free soil for nature to thrive, but also less trenching is needed. This is important, since trenching to reach or install utilities is a major cause of tree damage and subsequent decline. (Jim, 2003)
In the future, the MUTs will become smaller, since robots can be used to maintain and install cables and pipes over long distances. Entrances for people will only be needed for workers to control those technological tools, rather than performing all maintenance and installation fully manually. This will result in a lower requirement for materials.
In the every city or urban area, step by step the cables and pipes will be relocated into utility tunnels. Based on the amount of cables and pipes, the flush fitting MUT (a) or the Shallow MUT (b) will be utilized. On a provincial scale, the structure of the old underground cables and pipes will be used for the new deep MUTs (c).







5.2.4 | Approach: Reinforce Natural Structure



At the core of the reinforce natural structure approach is the alignment of infrastructure with natural processes, rather than having infrastructure disrupting, or even completely eliminating, those processes.

In the context of South Holland, water management is perhaps the most important natural process, and especially so considering the extensive engineering of the water network to create the current conditions in the province. With virtually all of the province being under sea level, and some parts being up to 7 metres below sea level, extensive flood defenses and water pumping is required to keep the province dry. This requires a significant amount of energy, and means that waterways are constantly re-routed.

Further, the surface water network is what provides the vast majority of drinking water to the province. While drinking water quality is good right now, the realities of climate change mean that the necessity to monitor and manage water quality will only increase over time. This is coupled with the fact that the major river system that feeds into the province is highly vulnerable to flood events. The Waal and Meuse rivers travel long distances through Europe, and as shown in the floods in the summer of 2021, can have devastating floods that affects thousands of families in major storms.

To address these challenges, 3 concepts are used: ecological restoration of water bodies, infrastructure integration with nature, and the naturalization of flood management.

The ecological restoration of water bodies primarily focuses on bringing natural elements back to waterways and riverbanks. The intervention under this concept is riparian zones, which will see those zones being established along all of the major waterways, with special care paid to waterways upstream from the drinking water abstraction points.

The integration of infrastructure and nature is intended to change the layout of hard infrastructure features to better work with natural structures. This will mean the installation of ecoducts and the conversion of surface elements to either tunnels or bridges.

The naturalization of flood management both allows for space for water to safely overflow in flooding events, and reduces the burden of dewatering during normal conditions. This will reduce the energy necessary to maintain current land needs, provide for new economic and agricultural opportunities, and ensure that flood events can be adequately and safely managed.

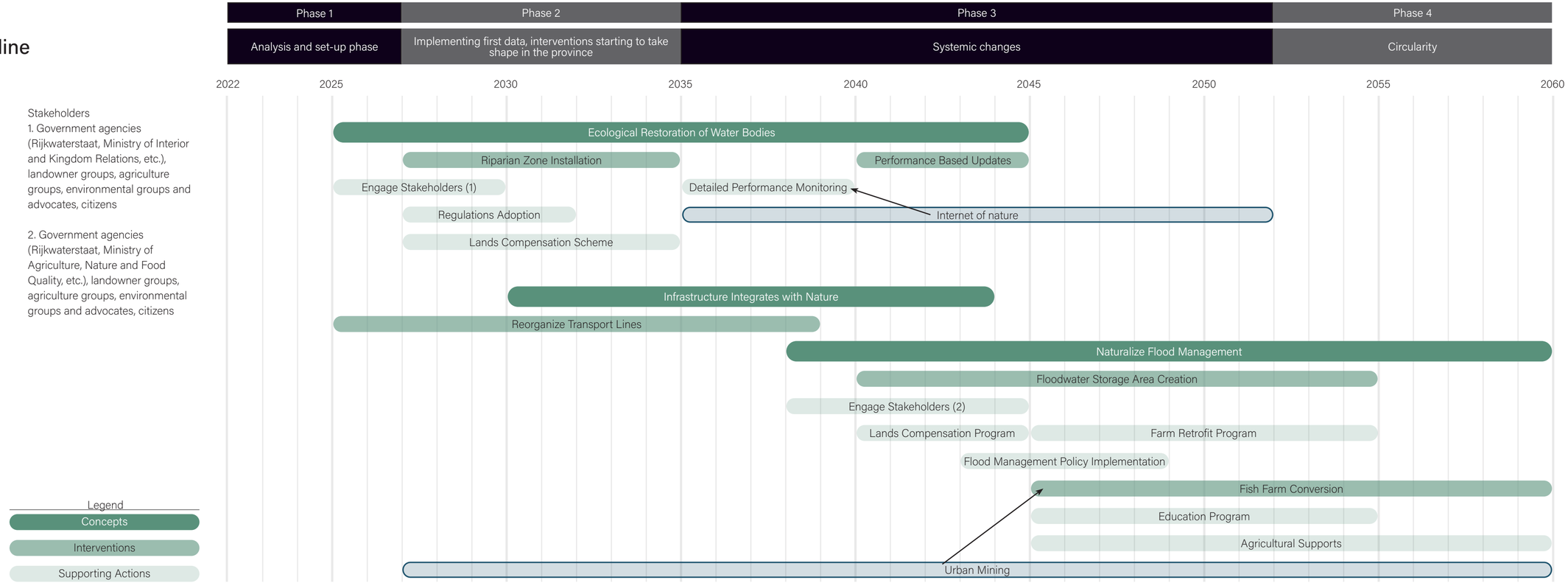
Concepts	Interventions	Supporting Actions
Ecological Restoration of Water Bodies	Riparian Zones	In considering that large amounts of private lands will be repurpose for riparian zones, a compensation scheme will be introduced to ensure that landowners are treated fairly during this transition.
		New regulations will be instituted to ensure that the riparian zones that are installed will work as intended, and protect their long term viability. They will ensure that no physical harm be done to the zones, and that harmful chemicals not be used on the surrounding lands.
Infrastructure Integrates with Nature	Research	Subsidies will be given to get a boost on research for the impact of infrastructure on the natural structure in the province. Further research will be done on the strategic positions of the interventions.
	Large Natural Overpasses/ Underpasses or Bridges	More funds will be given to create large natural overpasses/ underpasses or bridges in order to protect the nature around it.
	Zone 4 Highways	A green zone will be implemented on highways allowing cars lower than zone 4 not to drive on highways.
Naturalize Flood Management	Flood Management Area	A joint compensation and retrofit scheme will be created to assist landowners and farmers to manage the land use changes that are necessary to introduce the flood management area. This will provide direct funding to upgrade agricultural lands to be suitable for co-location with flood management, with the key method being conversion of lands to fish farms. Opportunities for direct government purchase, or buyer-seller (with subsidy) matching will also be provided.
		To further ensure a successful transition to a new agricultural paradigm in the province, extensive educational programs will be provided to farmers who are following the shift.
		Further financial support, such as subsidies or supply management, will also be introduced to encourage this agricultural transformation. Constant monitoring of both the success, and necessity, of these supports will take place to ensure that they are accomplishing their intended goals.

Detailed Approach Timeline

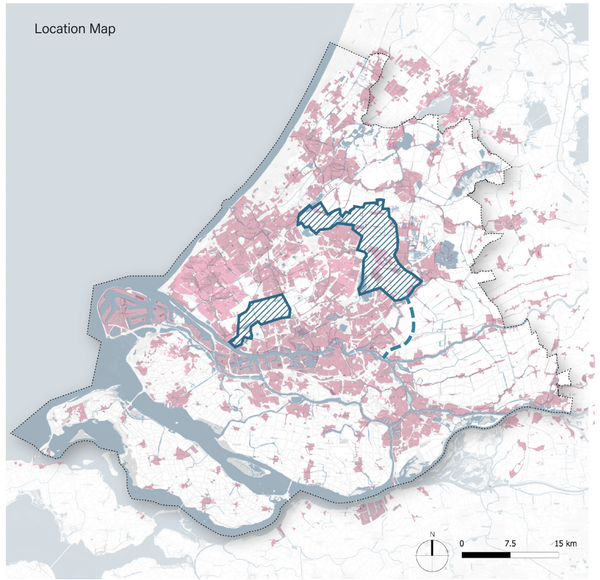
The first concept to get started in this approach is the ecological restoration of water bodies. The installation of riparian zones is an intervention that can begin relatively easily, as riparian zones are well understood concepts, and will enable many of the other proposed interventions to occur more sustainably. The installation of riparian zones early will also ensure that the process of drinking water purification can mature prior to other interventions being installed.

The infrastructure integration with nature concept is next to get underway. Significant lead time will be necessary to understand exactly where changes can occur, and to perform the relevant environmental impact assessments and other necessary project work.

Finally, the naturalize flood management concept work will begin. The formal work for this concept must start later, as the creation of the floodwater storage areas and fish farms are reliant on other infrastructure changes taking place. This work will also take a significant amount of time to complete, as the proposed floodwater storage and fish farm areas are very large.



Intervention: Floodwater Storage Area



Legend

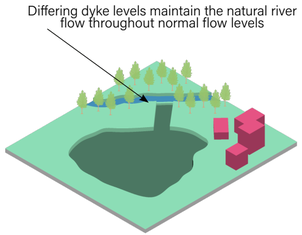
- Stormwater Floodplain
- Floodwater Bypass
- Primary Urban Area
- Secondary Urban Area
- Greenhouses

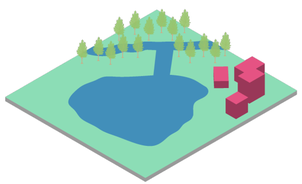
A major challenge in South Holland is the management of floodwater. With a high water table throughout the province, and large rivers running through, major rainstorms pose a serious threat of causing significant flooding.

If unmanaged, this could cause significant damage to the population centres of the province, and especially those that are located along the major waterways, such as Rotterdam and Dordrecht.

The introduction of large floodwater storage areas takes advantage of the existing topography - the chosen areas are surrounded by existing flood defences and are up to 4m lower than the lands outside of said defences. A floodwater bypass allows for flexibility in managing the water levels of different river systems

The identified areas can provide up to 0,58 cubic kilometres of floodwater storage, which will significantly increase the resilience of the province to flooding events. Working in tandem with the fish farm intervention (next page), the identified lands can remain productive even while providing these defensive capabilities.





Intervention: Fish Farms

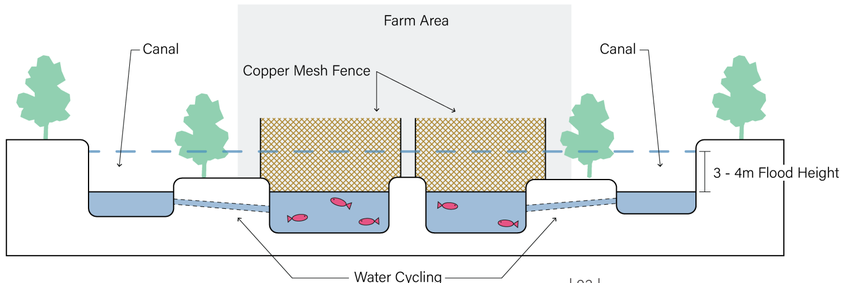
Legend

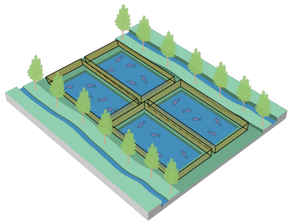
- Potential Fish Farm Locations
- Water Cycling Sources
- Primary Urban Area
- Secondary Urban Area
- Greenhouses

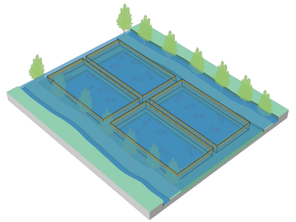
Complimenting the floodwater storage area is the introduction of a new type of farming for South Holland - on shore fish farming. The design of the farms is intended to work in tandem with periodic flooding while still ensuring the productivity of the land. In traditional agricultural floodwater storage, farmland is engineered to store floodwater during major storm events, and then farmers are compensated for the damages caused to the lands. With this typology, the farms are designed to continue to work as usual even during flooding events. Furthermore, by allowing more water into the area in compared with the existing conditions to engineer the farms, less energy consumption will be necessary to meet the overall dewatering needs province wide.

Copper fences surround the fish ponds and will be built tall enough to contain the fish in the pond areas throughout floods. Copper is chosen for the fences as it is a naturally antibacterial material (widely used in aquaculture for other, similar purposes). A major source of the copper for the farms will be the reclamation of unused copper that is currently sitting in the ground having been abandoned by telecommunications companies (see page XXX).

Fresh water is cycled through the large farm areas by using the existing major waterways. Water quality is ensured through the extensive use of riparian zones, both directly adjacent to the fish farms, and more broadly throughout the province (see next page).





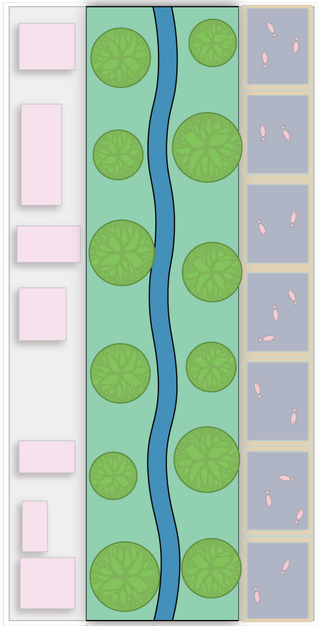


Intervention: Riparian Zones

Of critical importance is the maintenance, and improvement of, the drinking water quality in the province. The majority of the drinking water of South Holland is abstracted from surface water sources (rivers) rathern than groundwater sources. As a result, water that runs off from land into the rivers will directly affect the drinking water.

To ensure the quality of the water, riparian zones of a minimum of 20 metres wide, but ideally up to 60 metres wide where possible, are proposed. These zones will consist of naturalized areas directly adjacent to the major waterways. Dense vegetation will be installed to act as a natural filter for water that flows through the zones and eventually into the waterways.

While installing riparian zones across the province will create significant changes to the land uses adjacent to the major waterways, the maintenance of a clean drinking water supply is of critical importance. Access to clean drinking water is one of the most important attributes necessary for creating and maintaining healthy societies. All human and economic development relies on access to clean water, so the future of the province can not be secure without it.



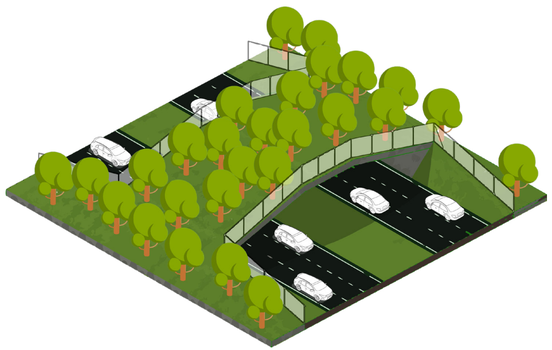
Intervention: Reorganize Transport Lines

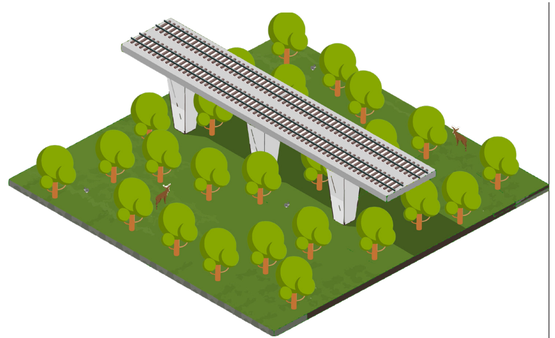
Because of the huge infrastructure network it is inevitable to have intersection between nature and infrastructure such as highways or traintracks. They will interupt the natural structure that will be a connection between the cities. In order to have as less impact of infrastructure on the nature network there must be a reorganiziastion of the transport lines, which basicly means trying to get as less interaction between nature and infrastrcutre. In order to do this three typologies will be implemented in the province. They will differ in size but will be implemented on strategic intersection between nature and roads

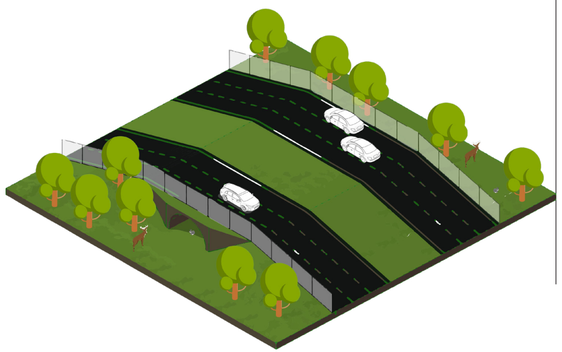
Below here the most common intervention is create a overpass over the highway, where nature and animals can cross. The largest overpasses will be reconized by its huge impact on connecting landscapes.

On the right you see the most expensive option, where a bridge is being built that goes over the intersection between nature and infrastructure. Therefore nature can thrive underneath the bridge and animals can shelter here.

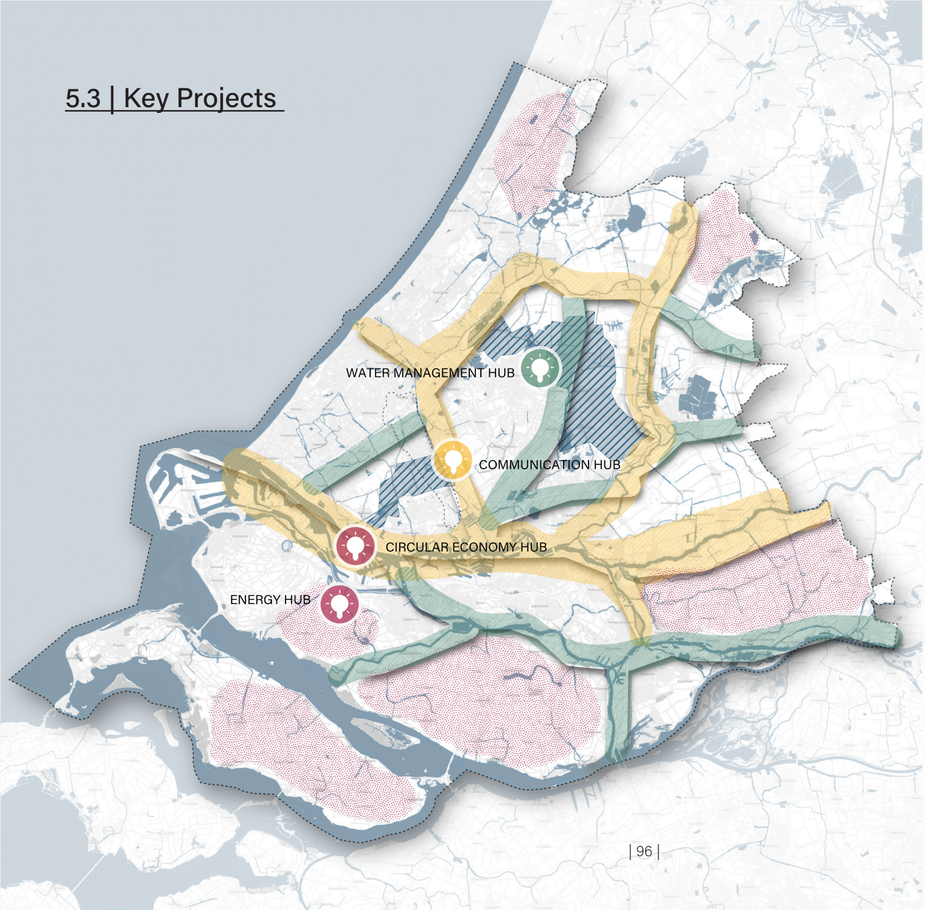
The third option is to create an underpass for animals, where they will find natural shelter and a safe passage, without being disrupted by sound or emissions.







5.3 | Key Projects



The application of the new hard infrastructure system in the province of South Holland will eventually result in four typologies. These result from the visioning exercise and the location of the intervention implementations. The typologies are supplemented by the introduction of innovation hubs located at strategic locations across the province. The innovation hubs provide knowledge support for hard infrastructure systems as places for information exchange and new technology generation. The key projects will also act as real-world labs for the hubs by providing opportunities to implement new technologies in transportation, energy, water and communications.

These come together to form the basis of the implementation of the spatial strategy. Each typology will be explored in detail in this section as demonstrations for how the interventions come together. The ultimate implementation of this spatial strategy in the province will create countless other projects and interactions between the interventions. All taken together, these will create the new hard infrastructure of South Holland.

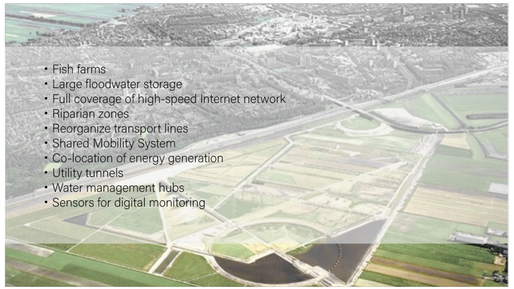
Ecological restoration corridor

Drinking water sources and habitats.

Movement corridor

Waterways connecting the port, Rotterdam, The Hague, Leiden and several other major cities.

Water storage area

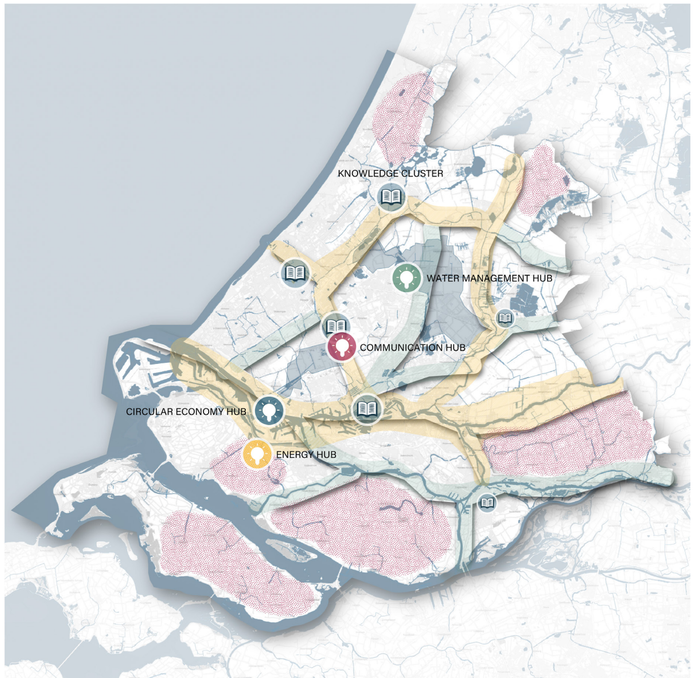


The lowest areas of South Holland with extensive flood protection networks.

Renewable energy production area

Farmlands with high energy generation potential.

5.3.1 | Key Project: Innovation Hubs

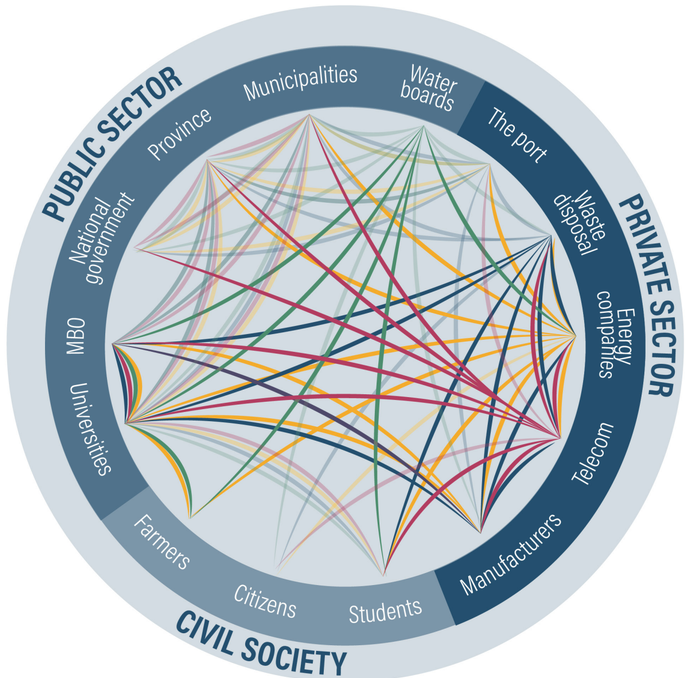


Sharing and implementing knowledge.
To keep innovating South-Holland and secure our vision in the future, four Innovation Hubs are introduced in the province. Each Hub is focused on a current issue that is not only in urgent need of renewal, but needs to continue developing in order to create a sustainable future. The Innovation Hubs will expand the existing network of knowledge clusters indicated on the map. The main focus of the Hubs is to facilitate a close collaboration between education and practice and ensure that both the practical and theoretical disciplines can work closely together. Every Hub is working towards the same vision: creating 'green, smart and connected solutions.' Offices, education, industry-related and research facilities can be found at each Hub. Also, there will always be a site reserved for pilot projects at each location. In addition, all Hubs are accessible by public transport.

Connecting stakeholders.
The Innovation Hubs consist of a public-private collaboration, in which educational and governmental institutes, the private sector and civil society work together to create a robust, interdisciplinary network to truly yield groundbreaking results. The darkest lines in the stakeholder diagram (Co-operations at Hub) represent the collaborations that are strengthened or created at the Hubs. Since the private sector will play a major part in implementing knowledge into practice, doing research and realizing projects, the emphasis on the right side of the diagram is apparent. However, their collaboration with the educational institutes is essential, which can be seen on the left of the diagram.

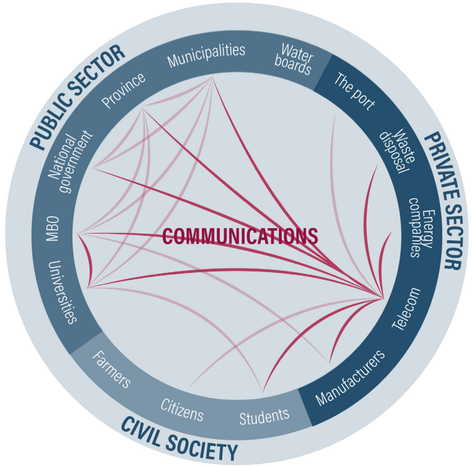
There are several ways that this translates into practice. First of all, in order to establish a multidisciplinary approach, all students are welcome, from secondary vocational education (MBO) to university and from social to technical backgrounds. The courses will allow them to gain experience in a real-life setting and engage with stakeholders within the Innovation Hub Network to explore the regional challenges together. To find the green, connected and smart solutions that can be implemented at a larger scale, projects will be developed and tested at the four locations. Besides supervising students, the educational institutes will also help retrain employees in transitioning sectors. Furthermore, it will also be possible for students to do internships, (graduation) projects and traineeships focussed on innovation. This will be facilitated by the businesses involved and stimulate the private sector to keep innovating.
The government will subsidize the educational programs and use their connections to expand the Innovation Hub Network.
Lastly, appealing conditions will be created for the private sector to gather or settle at the Hubs. Offices and meeting spaces will be provided and research spaces can be shared with the educational institutes. The governmental institutes will organize events, like workshops, to inform businesses about grants/ subsidies and create mutual connections.

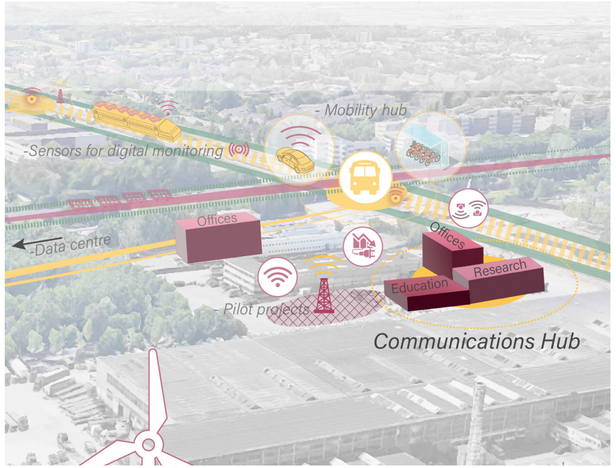

= Existing cooperations
= Cooperations at Communications Hub
= Cooperations at Energy Hub
= Cooperations at Circular Economy Hub
= Cooperations at Water Management Hub



Communications Hub

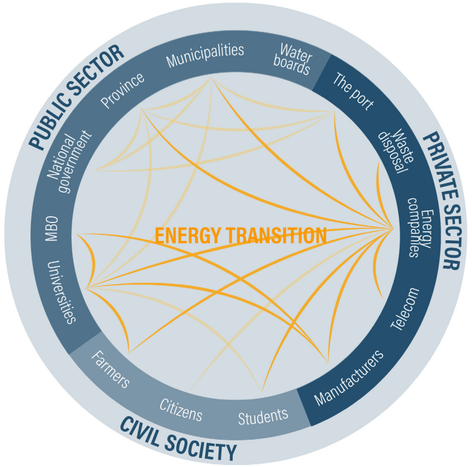
Since virtually everything is connected to the internet, the importance of the communications sector will only increase. The corresponding infrastructure needs to keep up with the technological changes and growing use of mobile data, which is why the Communications Hub is established. Due to its interconnectedness to other sectors, the hub is centrally situated in the province at the TU Campus train station. The Delft University of Technology and the local technology businesses will play a major role in the development of this sector. The current infrastructure needs to be used more efficiently - energy saving systems are essential for the growing use of data centers. Research will be done on digital monitoring by the use of sensors for various purposes, like maintenance or the health of urban nature. In addition, it is necessary to work together with manufacturers and recycling facilities to transform this sector into a circular one. Besides that, a collaboration is needed with the government and other companies to organize the cables and pipes underground.

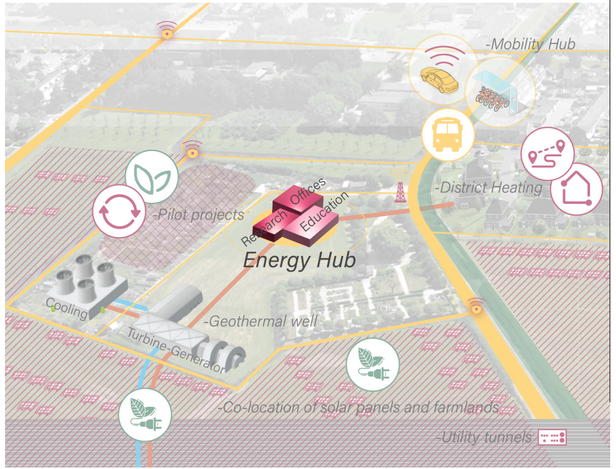




Energy Hub

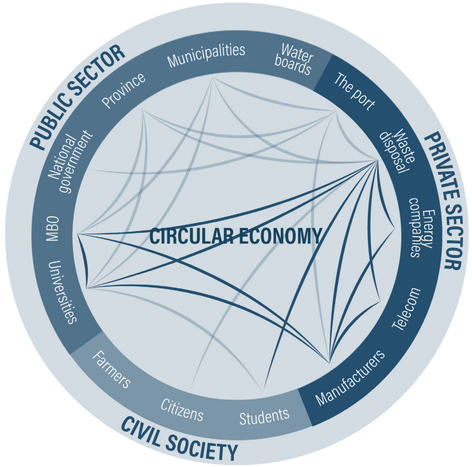
To transition to a renewable energy based society in the near future, the Energy Hub will be realized. This location is a high potential area for geothermal and solar energy generation, so the research at the trial sites can be immediately implemented. Since large high potential areas are in the countryside, a meeting place is needed here to share knowledge and engage with land owners, especially farmers. This Hub is also located near the port, since the retraining of employees in the fossil fuel industry will be an important task. For this transition, research will be done on new technologies, how to manufacture them in a sustainable way and how to implement them on the regional scale. Also, for this infrastructure a close collaboration between the government and other stakeholders is needed to organize the subsoil.

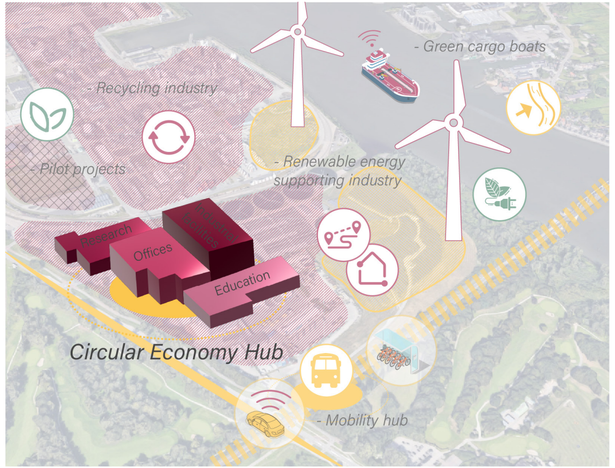




Circular Economy Hub

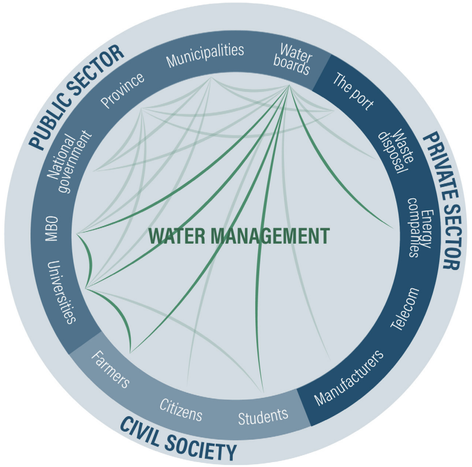
The CE Hub is founded to create a circular economy within South-Holland and beyond. In order to implement knowledge into practice, the hub is located at a cluster of waste disposal and recycling facilities. It is located along a main waterway to stimulate sustainable transportation of the large amounts of materials. Besides improving the waste flows at the facilities, any company is welcome to tackle their problems in this field. Although this huge task relates to every material flow in the province, the same principles can be applied. Starting at the beginning of the cycle, the use of renewable raw materials will be examined and design will be made with the future in mind, e. g. design for disassembly. In addition, maintenance is an important topic to extend the lifespan of products. Lastly, the recycling of waste plays a major role too. Since, this was not the case in the past, many leftovers of infrastructures remain untouched, resulting in a precious urban mine throughout the province. So, to improve a flow, all stakeholders throughout this process (designers, manufacturers, operators, etc.) will be connected at the CE Hub. This Hub will also help the other Hubs to transform their material flows.

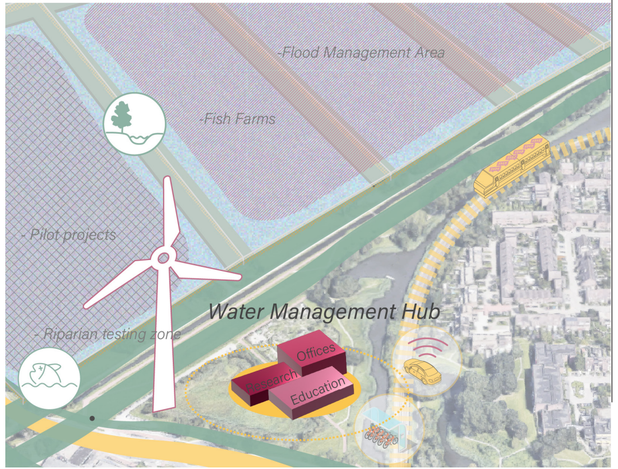


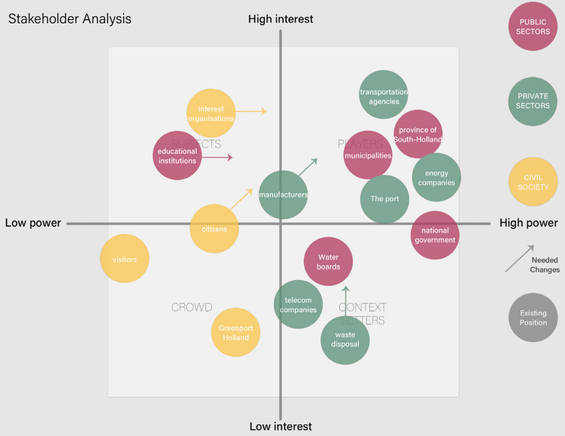


Water Management Hub

With the rising sea levels and climate change, the province needs to rethink its water management system. The Water Management Hub is located in the new blue heart at the edge of a flooded water storage area. By partly naturalizing the water management, new opportunities and challenges reveal themselves. Therefore, a place is needed to discuss and investigate this new intervention in the landscape of South Holland. Like for energy, this topic also involves engaging and educating landowners, especially farmers, in order to get to a successful result for all stakeholders. At the trial site next to the Hub, pilot projects are situated; including riparian and fish farm testing zones and the deployment of new sensor technologies for agriculture. Since people need to be educated or retrained for this new paradigm, collaboration with the universities and the secondary vocational educational institutes (MBO) are essential.





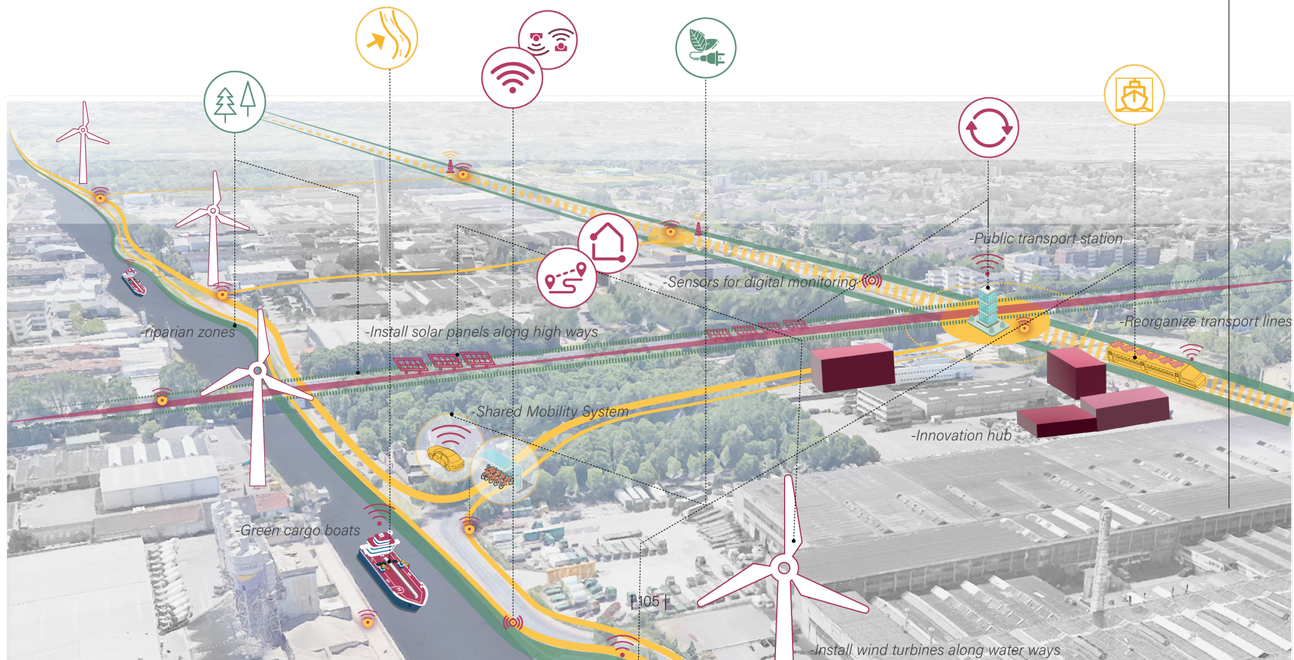


5.3.2 | Key Project: Movement Corridor

The movement corridor connects several major cities and ports in the province of South Holland, and the planning concept is to highlight public transport and microbility to form a green transport-led traffic system. Based on the location of the communication hub, Schieweg-Noord, Delft was chosen as the pilot site for this design. It is located at the junction of urban and rural areas, and is near the water, which can fully encapsulate the form of a movement corridor.

According to the national government, container transport to and from the main port of Rotterdam is expected to grow significantly over the next 20 years. If this growth is accommodated by road transport, our roads will become completely blocked. There is a lot of unused capacity in the system of inland waterways and inland shipping is capable of transporting large volumes. Compared to transport by truck or plane, inland shipping produces far less CO2(Government of the Netherlands, n.d.). Moreover, inland shipping accidents are rare. Therefore, in the future province of South Holland, the waterways will carry more sustainable cargo ships to reduce the frequency of motor vehicle use.

At the same time, the dominant public transport and freight vehicles will be powered by electricity instead of traditional energy sources, which will significantly reduce carbon emissions and environmental pollution. On top of that, the microbility and shared system will also be promoted and improved, working in synergy with the public transport system to make all parts of South Holland accessible without cars. In the long run, the use of private cars will decrease in value and some of the roadways used for car traffic will be abandoned to make room for other urban services, such as converting highways into renewable energy parks.



Existing Conditions

Previously, the roads outside the city were designed almost entirely for private cars, leaving no room for alternative modes of transportation. But when the future public transportation system is sufficiently accessible, freight will be transported by electric boats as much as possible, and private cars will be phased out, so the roads will be replaced by trails and bicycle paths. In order to enhance the accessibility of the public transportation system, a shared bicycle rental point will be set up every 700 metres to maximize car free access.

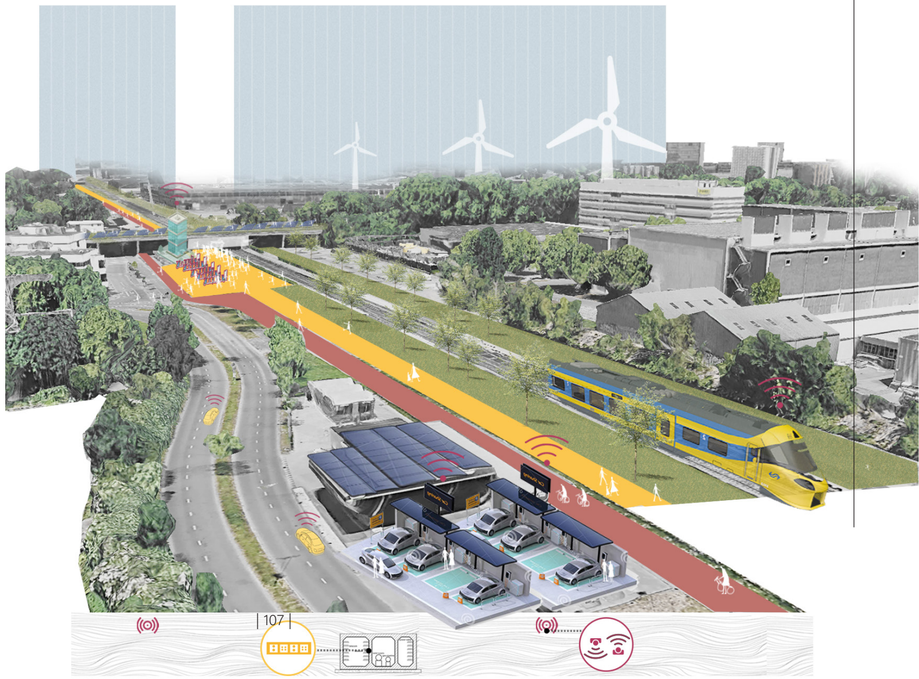
In these places, zero-carbon transportation and richer layers of green space transform the relationship between built-up areas and nature from complete fragmentation to harmonious coexistence.

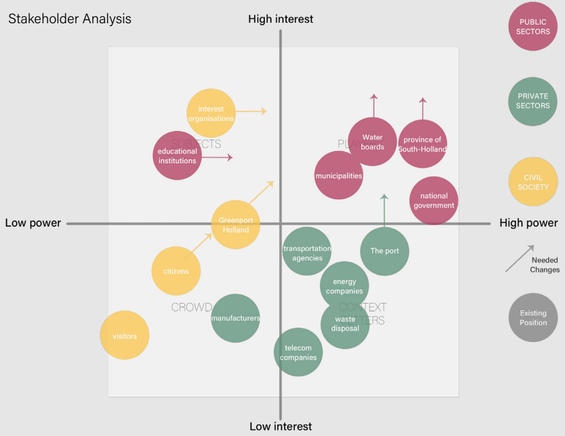
Movement Corridor - Waterway

Existing Conditions

Movement Corridor - Railway

In major sections of the city, transportation options may seem diverse, but public transportation lacks connections to both private cars and microbility. Switching between modes is a hassle that few people would choose, which greatly reduces the willingness to use public transportation. At the same time, it is impossible to completely eliminate the car as a long-distance transportation vehicle that is not restricted by driving routes, so incorporating electric vehicles into a shared public transportation system would be a more practical option. Our design aims to integrate the shared transportation system into the existing public transportation, so that people can rent electric cars and use shared bicycles near the stations extremely conveniently, thus enhancing the accessibility of the public transportation system in a pragmatic sense.



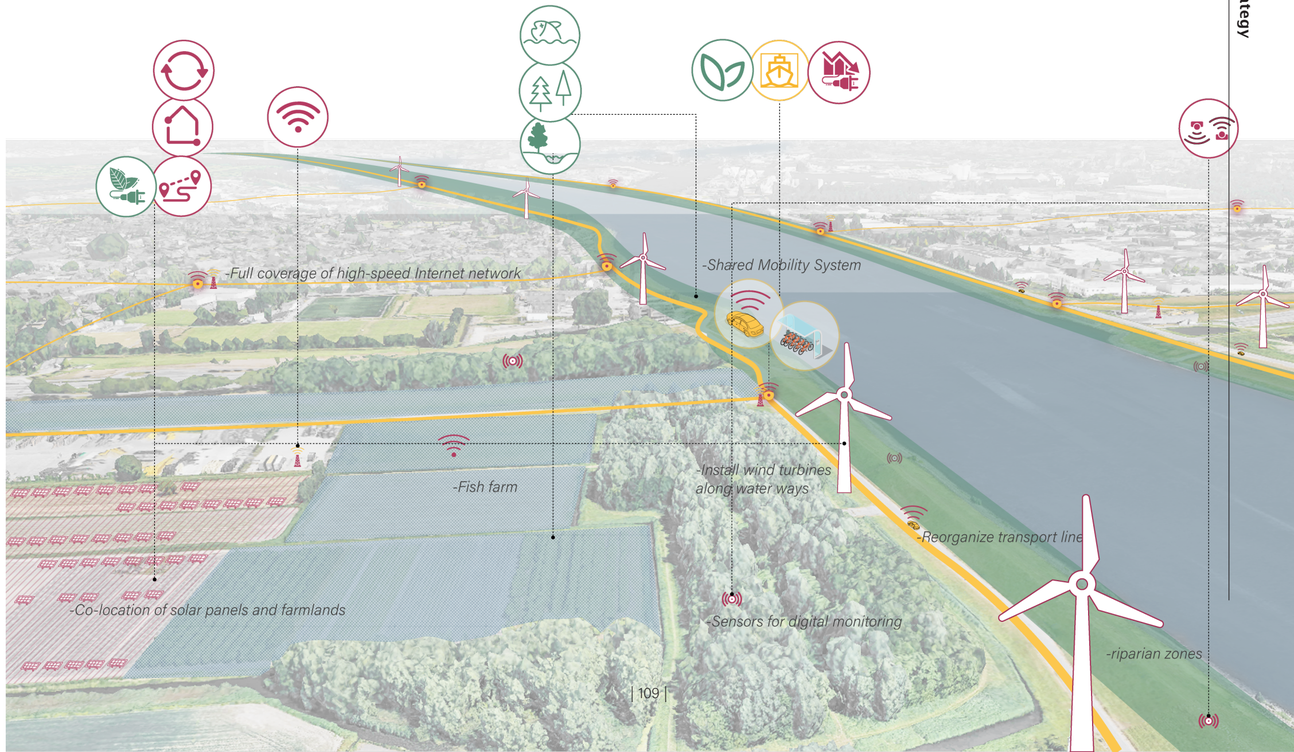


5.3.3 | Key Project: Ecological Restoration Corridor

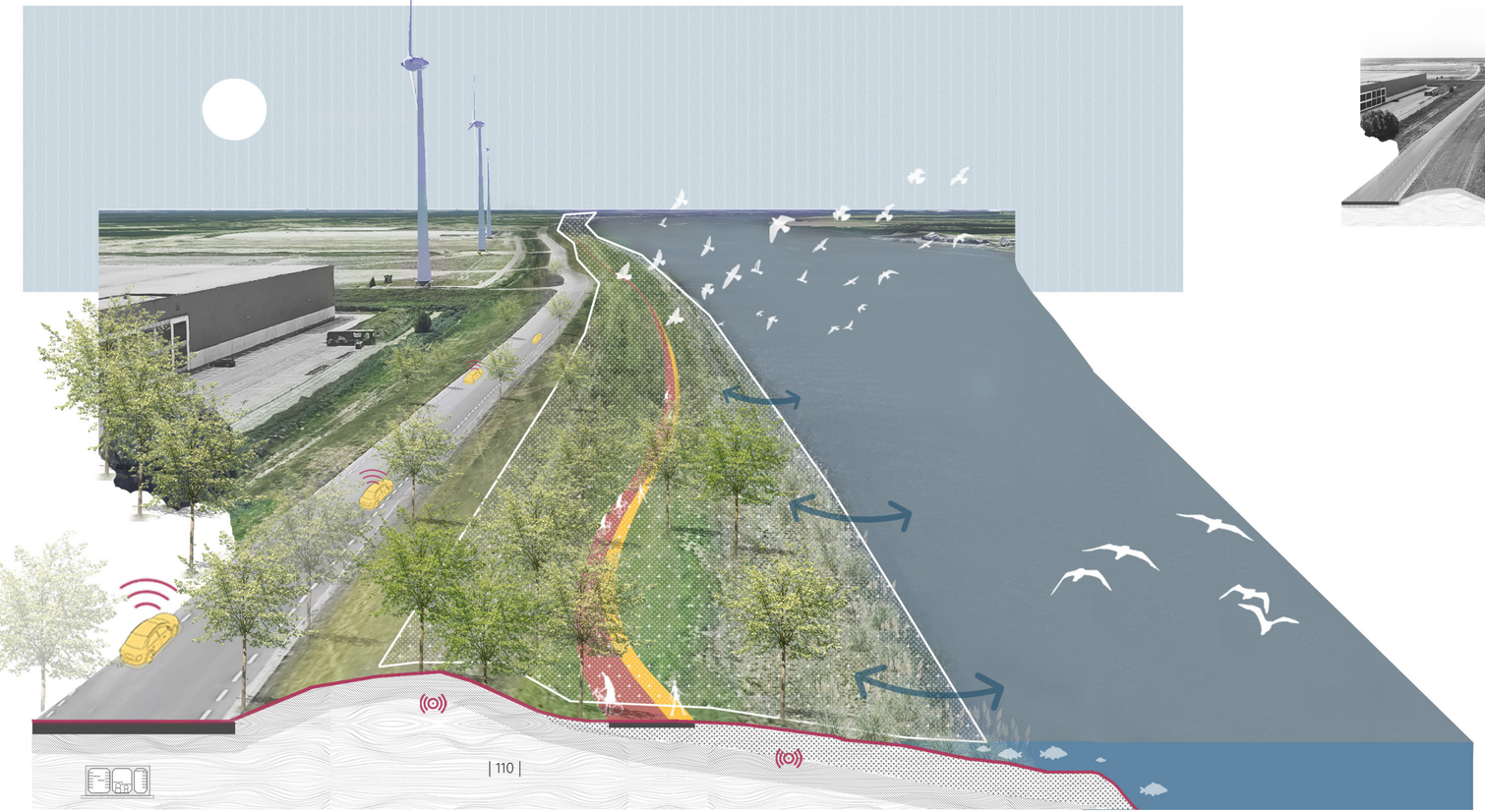
The watersheds where drinking water sources and habitats are located are the main basis for selecting ecological restoration corridors. In the Netherlands, drinking water is made from groundwater or surface water. It is true that these sources are increasingly polluted with all kinds of substances, such as pesticides and medicines, and climate change impacts the chloride concentrations in a variety of ways(Bonte & Zwolsman, 2010). If no changes are made, there will be fewer and fewer fresh water resources available in the future, and the cost of purifying water will become higher and higher.

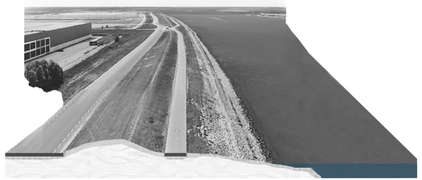
The core idea of the ecological restoration corridor is to widen the natural waterway barge and use multi-level vegetation to enhance the purification effect of the water flowing into the river by using the plant root system. At the same time, part of the agricultural land near the river is transformed into a fish farm to reduce the impact of land salinization on water quality. In addition, sensors will be used to monitor the growth of plants to reduce the maintenance cost of the barge.

In this way, the water purification process will involve much less human resources, energy and materials, and the waterways in South Holland will show greater resilience. As for the stakeholder connection, the public sectors of Water Boards and other government agencies are players in the key project of ecological corridor. Their interest needs to increase in order to better implement the interventions, and the interest and power of the port, Greenport Holland, citizens and educational institutions also needs to be strengthened.



Ecological Restoration Corridor



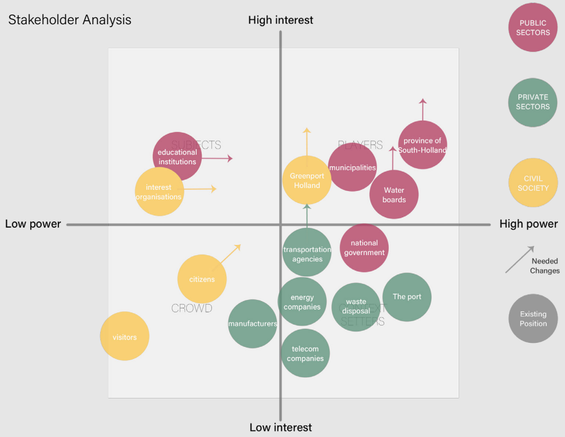


Existing Conditions

The core idea of the ecological restoration corridor is to widen the natural waterway barge and use multi-level vegetation to enhance the purification effect of the water flowing into the river by using the plant root system.

Most of the waterways in the Netherlands are bordered by dikes, which are the main targets for ecological restoration. Dikes play an irreplaceable role for urban flood protection, especially in a lowland country like the Netherlands, so their maintenance is particularly important. However, in the process of designing the ecological restoration area, the additional shrubs and trees would interfere with the maintenance of the dike. To solve this problem, sensors could be installed in the root system of the plants for water purification to facilitate real-time monitoring of plant growth and soil conditions without the need to dig up the dike. This will greatly reduce the maintenance cost of water purification and flood control facilities.

On the other hand, multi-layered vegetation and a more natural dike environment can provide diverse and extensive habitats and thus increase biodiversity. Meanwhile, the walkway through the barge provides an opportunity for humans to get close to nature



5.3.4 | Key Project: Water Storage Area

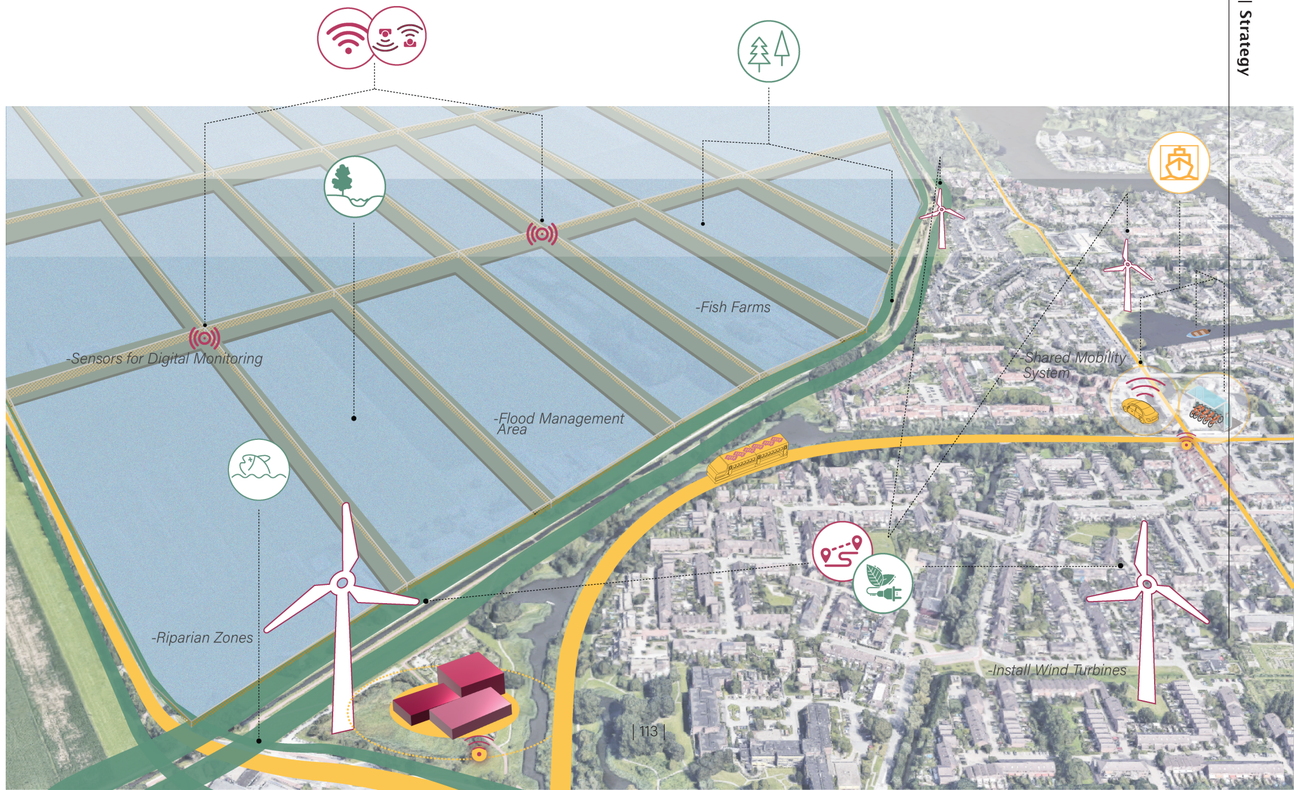
The water storage area key project is located to the north of Zoetermeer and is the coming together of floodwater storage areas, fish farms, riparian zones, transport line reorganization, co-location of energy generation, full coverage of the high-speed internet network, sensors for digital monitoring, utility tunnels and the water management innovation hub.

In this key project, you can clearly see the impact that the floodwater storage project will have on urban areas. Rather than pushing water management facilities to the periphery, citizens will come face to face with the realities of water on a daily basis.

The extensive fish production will also impact our food system. The price of fish should reduce, in considering the large supply that will be provided. Likewise products produced in the existing context will likely increase in price (dairy, beef, etc.). This shift should help to reduce the climate impact of the food system, but may also lead to some challenges in getting adoption of a modified diet.

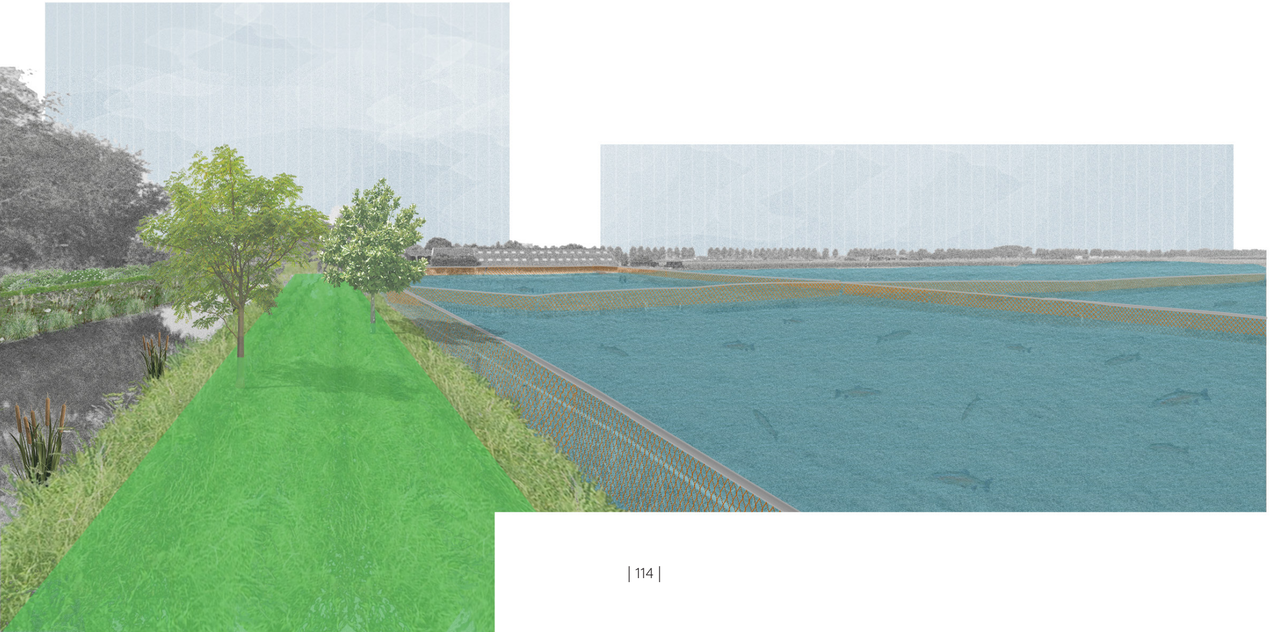
Adjacent to the water storage area will be the water innovation hub. The hub will benefit significantly from its close proximity to the water as there will be an ability to monitor the dynamics of water in real time. This way, innovation of both materials and water management practices will be much faster than what would otherwise be possible. The installation of sensors for digital monitoring will help to both advance innovation even further, and ensure that the farming practices used are as efficient as possible.

The most important stakeholders for this key project are the government agencies that are responsible for managing water, and must be better complemented by the educational institutions and related interest organizations that represent the affected landowners. To manage this transition properly, it will be critical to properly engage with the farmers and other groups that own lands in these areas.



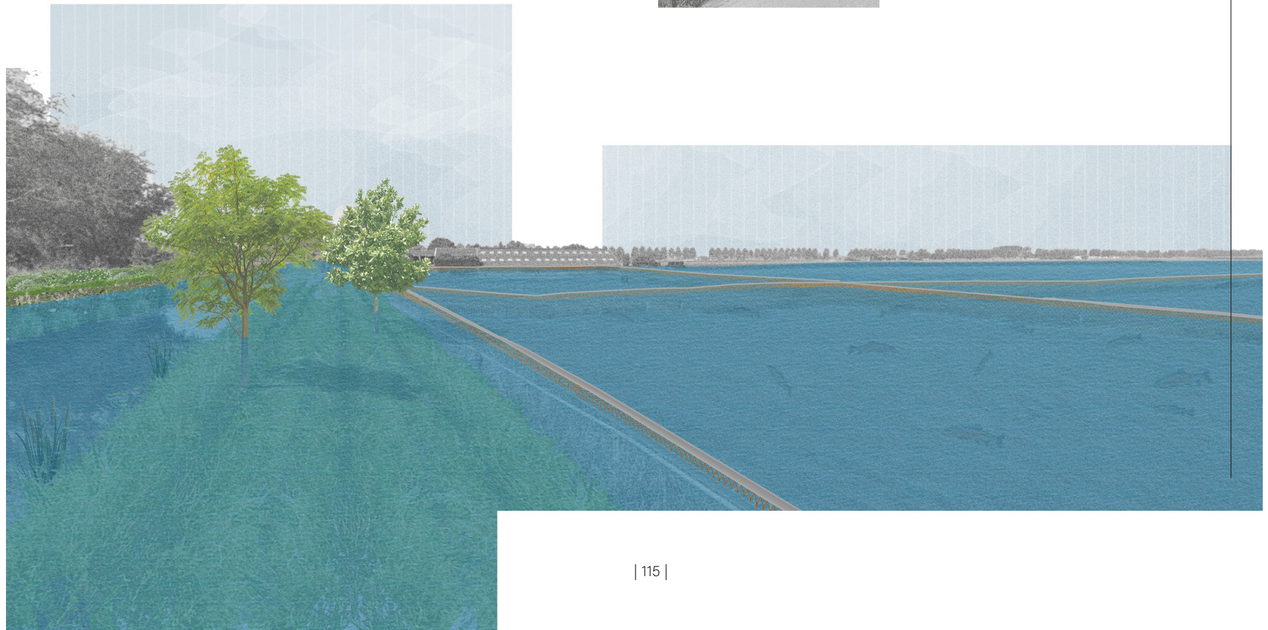
Further visualized here is the functioning of the fish farms in both normal and high water scenarios. In a normal condition, the riparian zones act as buffers between the canal and the fish farms. The riparian zone is lower than the berm on the opposite side of the canal, which ensures that during flooding events, water spills into the fish farm area and not into the protected urban areas. The copper fences surrounding the fish pens are built to the same height as the berm to ensure that fish cannot escape during floods. By combining these uses together, lands can be multifunctional. Agriculture can continue while floodwater is being managed, and subsequently much more agricultural land can be used as floodwater storage.

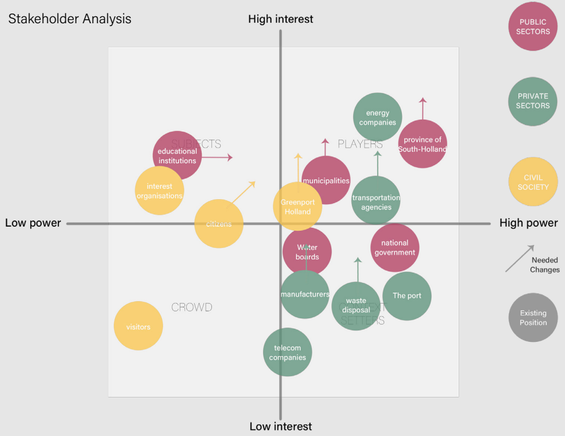
Riparian Zone and Floodwater Fish Farm - Normal Conditions



Existing Conditions

Riparian Zone and Floodwater Fish Farm - Flooded Conditions



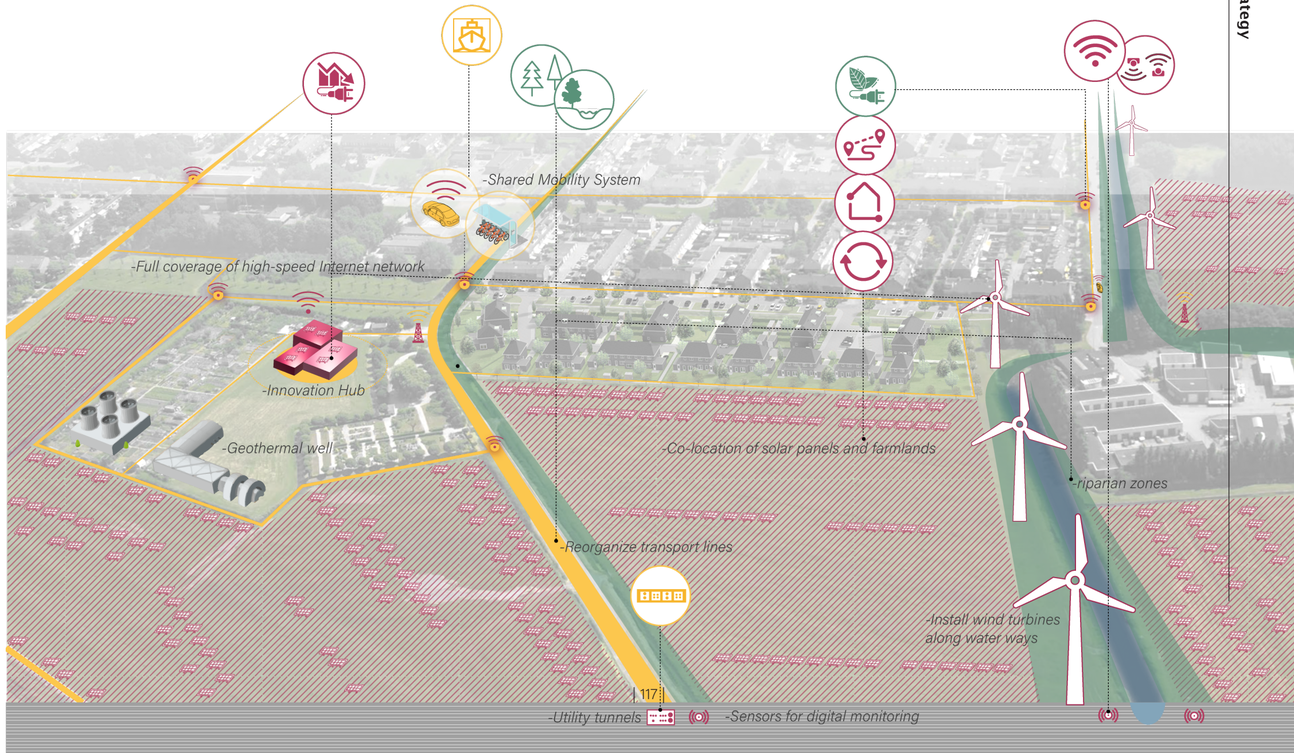


5.3.5 | Key Project: Renewable Energy Production Area

Farms have the greatest potential to produce renewable energy on a large scale. While the farm area is vast and the large-scale production of renewable energy would take up a lot of space, the western farm area in the province of South Holland is rich in geothermal energy resources, which allows it to develop wind, solar and geothermal energy at the same time.

The farm near Heenvliet, where the energy hub is located, was chosen for this design experiment. The core idea of the design is to integrate renewable energy facilities into the farm environment with minimal disruption to agricultural production, thus achieving the goal of local production without transmitting power over long distances and reducing energy loss and carbon footprints. In addition, the underground pipe network was re-integrated and sensors were installed to monitor the crop growth and power generation facilities in real time, thus reducing the maintenance cost of the system and maximizing the efficiency of the energy use process.

In the stakeholder matrix analysis for renewable energy generation area, energy companies and government departments are the main players. The interest of transportation sector, agriculture related institutions such as Greenport Holland, manufacturers, and waste disposal companies will increase significantly. Educational institutions will be more involved in the research of new energy technologies, and citizens will be more exposed to, and involved in, the generation of renewable energy, thus increasing their interest and power.



Co-location of renewable energy generation on farms should take advantage of the vast area of the farm and the abundant sunlight, while avoiding the negative impact of power generation facilities on the farm area, such as obstructing livestock activities, disturbing the flight of birds by wind turbines and damaging the farm landscape.

With these in mind, this design will primarily use new renewable energy facilities, such as flower turbines, solar trees and solar tents to integrate power generation with the socio-economic activities of the farm. While creating eco-kinetic art, flower turbines can be seen by birds and thus limit harmful interactions. Other solar generators do not take up space on the ground and can change the angle of the solar panel according to the orientation of the sun to increase the efficiency of power generation. In addition, the tree-like power generation facilities and solar tents with tables and chairs form a new field landscape that can stimulate the possibility of new economic activities. Near-urban farms can become parks or campgrounds for weekend breaks for urbanites, and farmers can benefit from the range of opportunities that result from this action, making them more willing to support the conversion.

Existing Conditions

Renewable Energy Generation Area

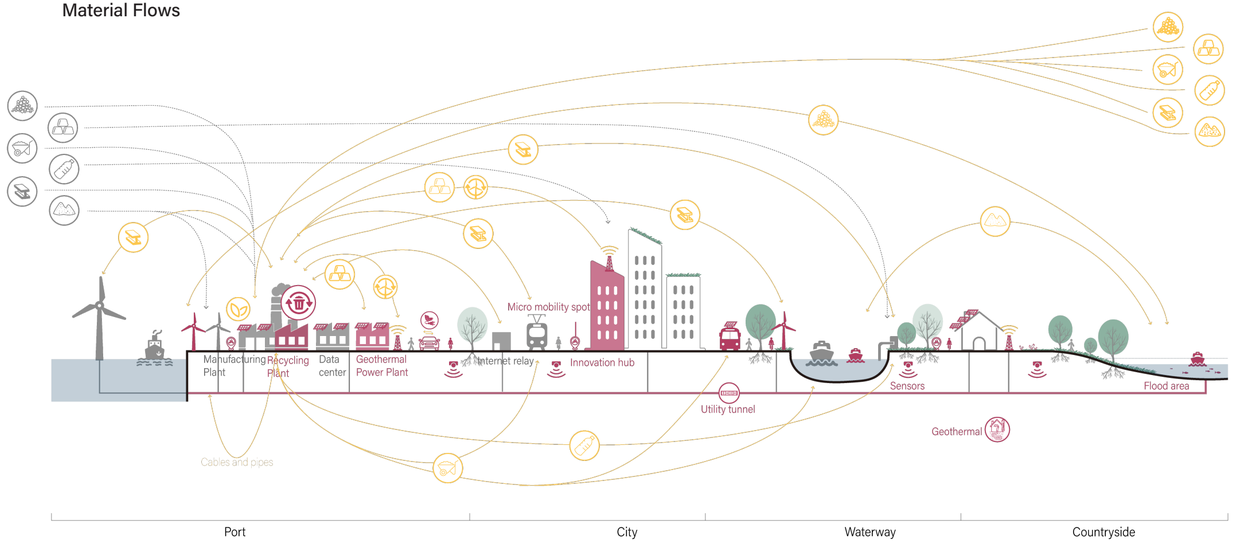
6.1 | Systemic Flows

In the context of the transition from a linear economy to a circular economy, the importance of hard infrastructure was apparent, since it supports the functioning of the entirety of society. Based on the analysis sections, the future versions were made.

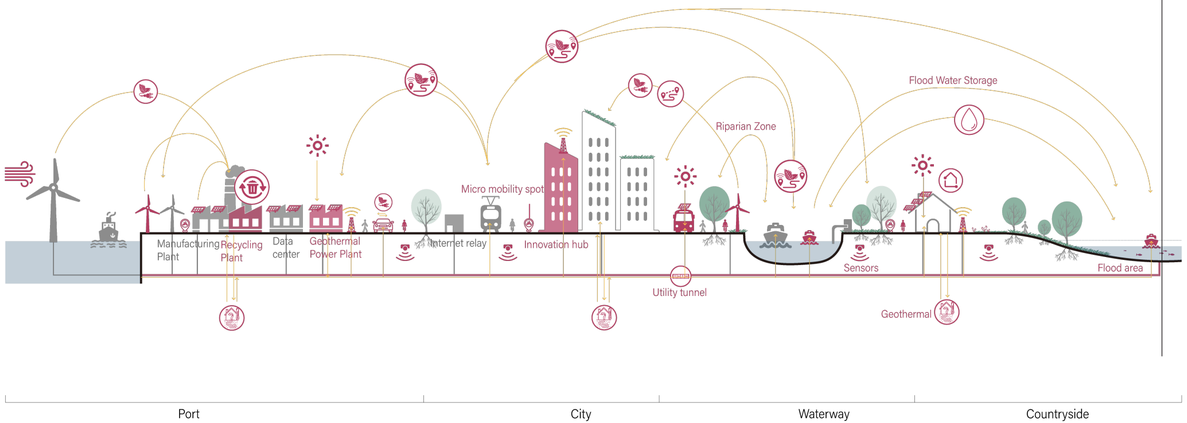
In the sections below, the green, connected and smart future is shown, where the four elements of infrastructure, water, transportation, energy and communications, are all integrated. The current material flow is largely based on a linear system, with significant imports from other countries. In the new flow, the three aspects to optimize circular infrastructure are represented. First of all, for manufacturing, the import of materials will be greatly reduced for both environmental and political reasons. The Netherlands will be less dependent on other countries by connecting material flows and increasing efficient use of the already available resources. Smart design for disassembly and urban mining are the main elements, which leads to the improvement of the recycling system. By joining their forces, the manufacturing and waste disposal companies will facilitate a secure position for recycling companies within the future system. Furthermore, maintenance and management are of greater importance in order to expand the lifespan of the infrastructures and increase the efficient use of resources.

At the moment, fossil fuels and car use dominate the usage flow. Below, the transition to renewable energy can be seen, which forms the foundation for most other flows, like the circular economy and transportation. Besides that, the change of systems will induce a transformation of the lifestyle of the citizens. This social transition will mostly include a shift in the use of transportation and an increase of the integration of the natural and digital world into daily life. For the labour market, this will mean a shift to sustainable industries, less physical labour and more specialized jobs working with ICT systems.

Material Flows



Usage Flows



6.2 | Provincial Perspective

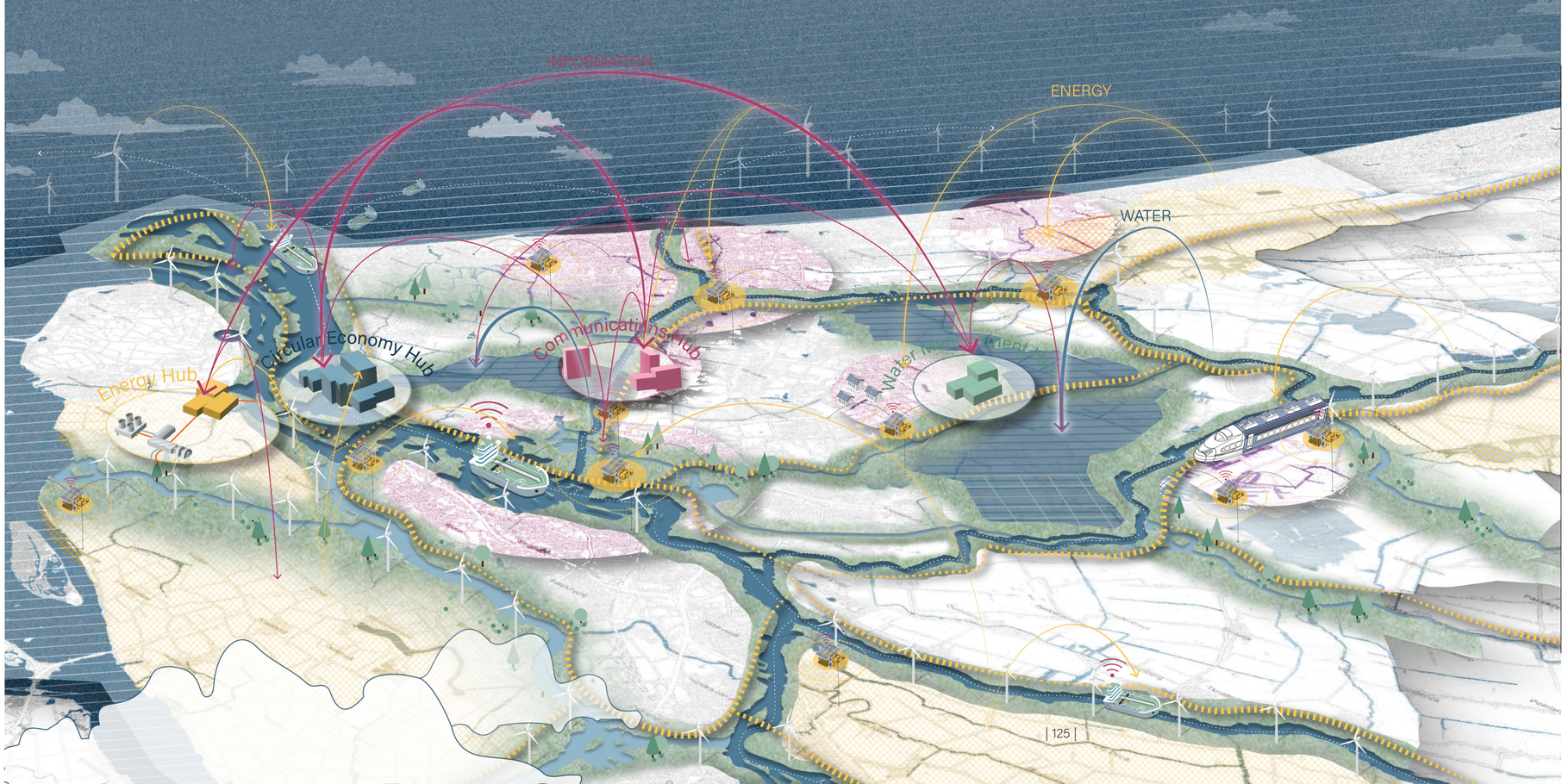
Humans are consuming resources at a rate that the natural world cannot sustain, with hard infrastructure being a main facilitator. We are proposing green, connected and smart solutions to the hard infrastructure system to enable the province to thrive within the planetary boundaries.

Hard infrastructure is divided in four categories: energy, water, communications and transportation. Based on the analysis of these categories, it is not hard to find that almost every type of infrastructure is linear economy-driven. As such, specific intervention targets were set for each category that defined the most important issues that needed to be addressed. They come together to form a green, connected and smart hard infrastructure system. Among them, public transportation as a driving factor will be the starting point of our transformation.

To explore ways to optimize hard infrastructure in spaces, a large part of South-Holland will be researched. After finding a high degree of overlap between the existing hard infrastructure system and natural structures, we decided to take full advantage of the natural corridor connectivity and ecological services to transform the hard infrastructure system using natural structures as backbone.
Specifically, there are four approaches that will be implemented at different stages: reinforce natural structures, emphasize the public transport system, transition to renewable energy, and circular infrastructure.

Firstly is the developing of improved public transportation and shared systems to replace private cars. This will reduce the use of motorways and provide space for renewable energy facilities, which in turn provide increased energy for the operation of infrastructure systems. At the same time, the intensity of urban mining will be enhanced to provide materials for new infrastructure. After the initial establishment of the new hard infrastructure network, the focus will shift to restoring natural structures and replacing engineering measures with natural ones as much as possible, so that the infrastructure is truly integrated into the natural circulation.
In this process, innovation hubs serve as a platform for information exchange, and continue to provide new technologies, talent development and awareness dissemination for the transformation of hard infrastructure systems.

In our future, technology and resources will be used more efficiently. Interdisciplinary collaborations will be created and strengthened, natural qualities will be utilized, and the circular economy will thrive.



6.3 | Discussion

The subject of our studio project was initially maritime manufacturing. However, after our analyses and discussions, we moved away from this and focused on the hard infrastructure of South Holland. Within this, we addressed four topics. Since our topic was quite broad, our project was given a wide field of research directions. All four research directions could fill the ten weeks with their own research but we felt we would miss too much if we only looked in one direction.

The result of our research means a new perspective on what the future of South Holland could look like. Since hard infrastructure is a big part of the province, big steps can be taken towards a circular future. But since our topic was so broad, it was almost impossible to work out every issue in detail. So, after a thorough analysis, we set up a number of targets to narrow down our scope, and then to elaborate on them. In this way we were still able to tackle a large part of the hard infrastructure. These targets gave rise to the interventions. Some interventions are small-scale but others are applicable on larger scales. This does not take into account already existing projects that the province is working on. Our result is not directly opposed to these projects, but rather an extension of them, and should strengthen the current projects with a potentially different insight into the future. Nevertheless, we can conclude that not every intervention is directly applicable in the present context, as much more research into certain fields is likely required, and the financial realities of existing technology can make some interventions cost prohibitive.

However, the results from the research can do their part to change the way we look at the future. Because our strategy is divided into three categories, we were able to address many issues that are related to the current problems in the Dutch infrastructure. The results will not be an immediate solution to this, but it is a step in the right direction. The project has shown that some parts of the hard infrastructure in South Holland are not being used or reused in the most efficient way. It has also become clear that there are many opportunities to improve the cycle of infrastructure.

The issues are not only applicable in the Netherlands, but also in other parts of the world where people are thinking about how to solve the problems of climate. Our strategies have now been applied to South Holland but, with some modifications, can also be applied to other areas. For example, micro mobility can be applied in almost any city in the world to partially solve the problems given by cars. In many parts of the world there is a lack of connection between nature and people, where, for example, green corridors can provide a solution. Also, problems with sea level rise are applicable in other countries and the different interventions in relation to water can be applied in these areas.

The project has mainly focused on physical aspects of hard infrastructure and goes into more detail about parts of it. What has not been fully addressed is how the strategy impacts the social aspects of society. The strategy that is applied is physically a very nice way to project the future but the human aspect could still yet be explored further. This is where further research should be done, to see what the impact is on the mental state of the residents of South-Holland.

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Casper van Duuren
Daniel Watchorn
Danyi Xiang
Ke Zhou
Mayke Giesen

Reflection: Casper van Duuren

Having done a year of architecture and the previous projects being more focused on a city or an area of a city, I thought this project would be extremely interesting because the scale is much larger than anything I have ever worked on. Especially since there was now a circular aspect to the project, this instilled good courage in me to begin the project. Despite this good cheer, I had no idea how difficult it would be to work on such a large scale. The site visit didn't help either, as we had only seen a very small part of South Holland, so I couldn't yet imagine how our project would contribute to a better future for the province. Still, it was very interesting to work on this scale.
In the first weeks we were figuring out exactly what to do, and had a hard time getting a grip on the situation. Especially because a provincial scale brings many challenges and aspects. While searching for a topic, it became clear that there are so many things to research and so many things that I found interesting, that it was hard to pick 1 thing. Also, with five people, it was difficult working together in the beginning because we all have to come to a decision and everyone would like to see their interests reflected the project. As the project progressed, we still struggled to really find our bearings in the project. We did a lot of research as a group on what we thought about the situation, but still didn't really come out of it. Luckily, we started discussing things with each other and after Alex recommended that we get a writing board and sit around it to talk, we finally came to a unified topic after a rough start. This was a hard lesson that instead of discussing everything online, actually seeing each other and having live discussion helps a thousand times more. Now we had a good research question and could move forward with the project.
Once we had fleshed out our topic, I found that everything went pretty smoothly. We always divided the tasks in a structured way and we had a good discussion about how to do things. We sat around the writing board more and more to discuss things in detail sometimes. Here we found out that the process would not be as linear as I had thought it would be, but that we had to make a lot of feedbacks to the research question and analysis. This is where I learned that once you have a research question drawn up, it doesn't necessarily have to be the same for the rest of the project. I always like to look forward and look back as little as possible.
After we arrived at a vision, everything actually went naturally and we moved on to a way of working out the strategy. In the process, I was amazed at how we were all able to uncover our own qualities and didn't expect that we could give so much input to a project we didn't know what we were doing in the first place. So I can only describe our final sprint as a huge learning process about not judging people equally.
My personal conclusions for this project are therefore that:
- I find it difficult to work with more than 3 people since you have to take into account so many opinions that it is difficult to come to a unified topic
-I should not judge people immediately by what they show in the first few weeks, because some people need more time to get used to each other.
- This scale is very interesting to work out because there are so many possibilities in which direction you can work.

Reflection: Daniel Watchorn

Coming into this quarter, I was quite excited at the prospect of working in a realm that is somewhat different from a typical urbanism course. Rather than simply designing a space that is nice for people to enjoy, we had to take a systematic approach to understanding an entire province. This meant a completely different set of circumstances and research.
When diving into the topics for the quarter, I became overwhelmed at the sheer scope of knowledge that I realized I would have to attain in order to be able to create a comprehensive project. In other projects, I had a relatively high level of background knowledge that I could lean on. In this case, while my knowledge of urbanism certainly helped, things like the manufacturing of steel, or import/export reporting was something I had never really researched before. Over the course of the quarter, I actually learned that, while there is a lot to learn, the system is not overly complex once you dive in. It really became a matter of being patient and willing to dive into the details, rather than having a concept that was too hard to understand.
Once I gained enough understanding to explore solutions, I thoroughly enjoyed the creative freedom that we are afforded when working on this scale. An intervention like the conversion of a water management area to fish farms would only be possible when working at such a large scale. It was also very rewarding to be able to link that intervention to our other concepts, like urban mining. It was only by having such a broad topic that I was able to make connections like this.
Getting through this design phase also greatly changed my understanding and appreciation for infrastructure itself. Of course, prior to the course, I was aware that infrastructure was critically important to the functioning of society, but I never appreciated the depth of what infrastructure can be. The concept of urban mines is fascinating and something that I am quite surprised is not more apparent in urbanism generally. The fact that there are thousands of kilometres of unused copper cables in the ground, while copper theft at construction sites is a major problem, is truly intriguing. There are far more layers to our society than meets the eye, and I am quite happy that I was able to uncover some of these layers through this project.
In hindsight, my only regret for the course is that it's not longer. It took our group a few weeks to find our groove with this quarter, so we weren't fully able to explore all of the depths that this topic offers. While I am quite happy with how our project turned out, there is plenty more that we could have explored which would have made the final product that much more rich.

Reflection: Danyi Xiang

During the regional design study on the theme of circular economy, my understanding of this concept has changed considerably. Before that, circular economy was only a vague concept to me, but now I realize a circular economy is not limited to the market, but a economic system of closed loops in which raw materials, components and products lose their value as little as possible, renewable energy sources are used and systems thinking is at the core. The project also show me that how to use spatial design as a means of resource allocation plays an irreplaceable role in the economic system.

Meanwhile, we did an in-depth study of the hard infrastructure, and I was mainly responsible for the energy part, and I was surprised by how little renewable energy was actually used, especially in South Holland where windmills and solar parks can be found everywhere. This is in large part because the large-scale application of new technologies takes some time and requires the cooperation of many parties. It was in the process of doing the key project that I felt it was extremely difficult to reconcile multiple interests, especially when it comes to private property. I still have questions about how solar panels can be applied on a large scale on farms, because the most cost effective solar panels do damage the farm landscape, and the more functional solar art installations cost more materials and are not in line with the concept of circular economy. I'm sure these issues will be solved reasonably after deep research and thought, but I don't have much time to spend on a small project at the regional scale of design, and I hope I will figure that out in the future. But for movement corridors and ecological corridors, things are much easier and realistic since public property improvements are easier to implement. But another issue was that if the province of South Holland were to emphasize projects like public transportation and shared systems in the future, they would necessarily require significant funding and grants, and these policy issues should have been factored into the design. But we eventually found ways to fund these new projects by reducing road maintenance costs, for example.

In addition, I find current complex society necessitates finding inclusive arrangements for delivering sustainable hard infrastructure integrating design, construction and maintenance stages of the project lifecycle. Space design is closely related to social and economic development, and focusing on a single issue can lead to limited perspectives and over-idealization. Therefore, during the design process, we should fully consider what kind of chain reaction will be caused by each intervention step, and continuously pay attention to the timeline changes and stakeholder needs to make sure the system can keep working. This is the difficulty of the area design, all the interventions cannot exist independently, especially for our chosen theme of hard infrastructure, which is a dynamic system from the beginning to the end.

Reflection: Ke Zhou

Spatial Strategies for the Global Metropolis is a new experience for me in an unfamiliar context of regional-scale design and strategy development. In this quarter, my team and I developed a regional design vision and strategy for the province of South Holland. Trying to answer the question of how hard infrastructure in South Holland enables us to live within planetary boundaries, with a circular economy and sustainable attitude, after recognizing that humans are consuming resources at a rate that nature cannot sustain and that hard infrastructure is one of the main facilitators, a problem that is widely faced by human society as well as the province of South Holland.

The identification of this research question was crucial for this project. I was able to look at the macro-environment of the province of South Holland from the perspective of climate change, resource consumption, and the natural environment and thus recognize the role of the hard infrastructure subject. This set the starting point of the project and the tone for the development of the vision and strategy. With a clear and strong research question, the next research and planning can be carried out with clarity.

In order to further understand and analyze the hard infrastructure, we started with four hard infrastructure categories: transportation, energy, water, and communication, and analyzed and elaborated on their material flows and usage flows using systematic sections and SWOT analysis. This enabled me to identify clear targets for the specific problems of different infrastructures. These targets are indicative of the construction of the vision and strategy and lead to a consistent concept of green, connected, and smart. At the same time, these targets are used as a means of evaluating whether the decisions I make are valid, whether they solve the hard infrastructure problems, and whether they achieve our goals so that we can continually make adjustments to ensure that I do not deviate from the direction of the research questions.

The identification and analysis of the problem provide a clear direction for our vision that South Holland will thrive while respecting planetary boundaries and that this will be facilitated by integrating the use of natural structures and transforming hard infrastructure networks with green, connected, and smart solutions. Meeting the infrastructure needs of South Holland will be seen as a strategic opportunity to rethink the entire network. This vision is further deepened and elaborated on the basis of spatial analysis into three dimensions: green, connected, and smart.

This narrative structure allows for a clear storyline to organize the development strategy and its timeline. The subsequent process of developing the regional development strategy through the creation of a timeline, policy formulation, interpretation of interventions, and design of key projects allowed me to review and refine the vision continuously. I realize after this project that the regional design plays an overarching role, integrating the many stakeholders and the complex environment of South Holland to provide a vision and policy direction and framework for the future development of different scales of projects and planning of the region.

Reflection: Mayke Giesen

Although I thought regional planning and design would not be my favourite part of urbanism, the course really surprised me. My disinterest was probably caused by my inability to imagine a detailed project at this scale. However, it actually finally answered my desire for more in-depth research, which I missed especially during my bachelor at this faculty. For me, the spatial and abstract thinking felt more in balance. Especially the connection between those two is where it got interesting.

My knowledge about certain concepts was definitely broadend. Obviously, I gained a better insight into hard infrastructure. In the beginning of the project, my knowledge about the communications infrastructure developed in particular, since I had to do research on this and I knew very little about it beforehand. For energy and transportation, I also learned more throughout the project. I was least involved with the water infrastructure, but there still were some general things I learned from my team members. In the future, I would like to elaborate more on (micro)mobility and social systems. Furthermore, I learned to understand the circular economy and its corresponding aspects better. By examining the material flows and different stages of the cycle, my interest was sparked since small interventions in this cycle could have a big impact on the whole system. Each time I discovered new connections, it became more apparent that everything is part of a bigger system. Consequently, I started to be able to imagine how a project on this scale would actually work. In addition, the methodology course showed me that there is so much more to think about and information available on those topics.

The group work taught me a lot about group dynamics, since it was the first time working together in a large group of 5 people. One of the things I will remember is to definitely invest time at the beginning of group work to get to know each other. This will help to build a strong foundation for the project and understand each other's strengths and weaknesses. Also, you have to pick your darlings, which means you should choose the things that are most important for you. This worked really well in this project, creating a surprisingly harmonious collaboration. However, some friction is also necessary in order to develop ideas. In my opinion, the lack of this was obviously the reason for our rough start. So, this should absolutely be stimulated earlier in the process in the future.

There were several things I learned about my interests. Apparently, my enthusiasm for systematic/critical thinking and academic writing is not necessarily shared. Therefore, in the future I will use this again in (group) projects. Besides that, since my interest was aroused into this field, I am considering to enroll in courses of the master track Master track Metropolitan Analysis, Design and Engineering next year.

Lastly, I got a better understanding of what our graduation project is going to look like. This enabled me to actually explore my fields of interest already, making me feel more at peace thinking about this final project.