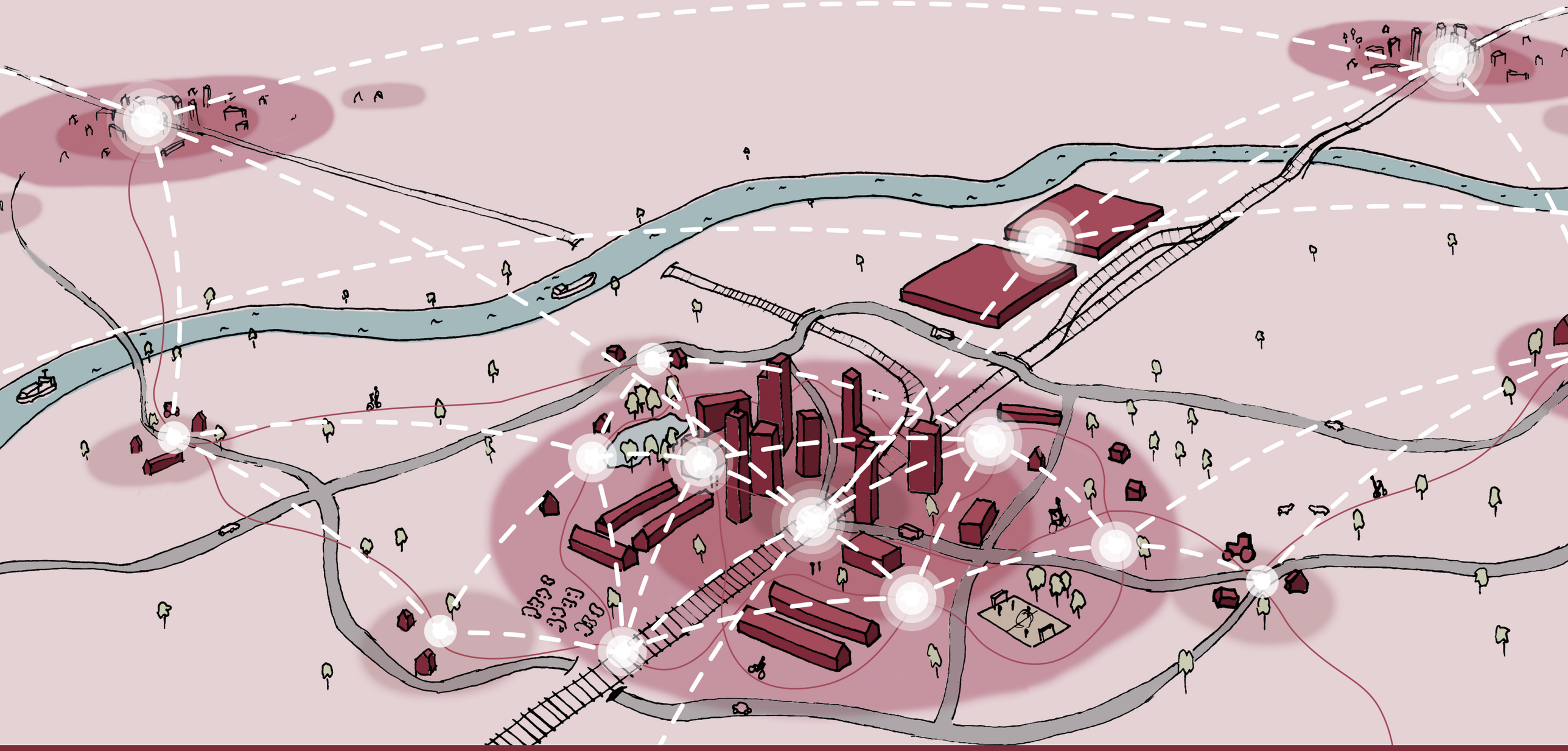

CO_2 BY MOBILITY = 0

NETWORK APPROACH FOR REDUCING CO_2 EMISSIONS

IN PERI-URBAN AREAS IN THE RHINE DELTA REGION BY 2050

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AR2U086 Research and Design Studio: Spatial Strategies for the Global Metropolis
AR2U088 Research and Design Methodology for Urbanim

MSc Urbanism I Q3 2023-2024

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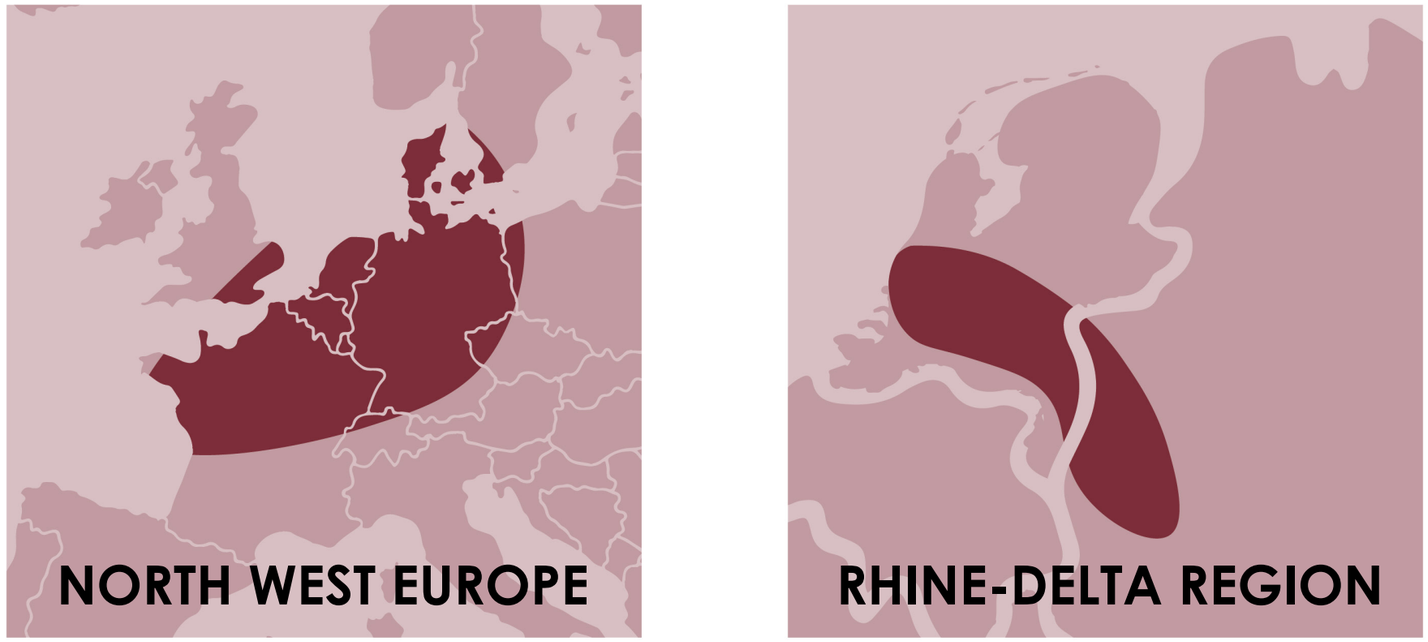
PREFACE

This report is written for the Course Research and Design Studio: Spatial Strategies for the Global Metropolis. The assignment is to create a vision and spatial strategy for the Rhine-Delta Region by exploring how sustainable transitions affect peri-urban areas in the Rhine-Delta Region. From this Rhine-Delta scale, we zoom in to two local regions (the Nijmegen-Arnhem region and the Rotterdam-The Hague region). After that we zoom in even further to local interventions. Since there are a lot of ways to look towards sustainability, we chose to limit our research to focussing on reducing the CO2 emissions by the mobility network in the Rhine-Delta Region.

In the first chapter we give an introduction about CO2 and the mobility sector. In the second chapter we dive into the methodology and the research questions. After that we have a chapter with analysis about the Rhine-Delta Region. In chapter four we elaborate on our problem statement. In the fifth chapter we elaborate on our vision statement and goals. In the next chapter we explain how we want to achieve this vision with our spatial strategy. We do this by working out two case studies. In our seventh chapter we end with a conclusion on our project.

Lastly, we would like to thank our tutors Lei Qu and Francesca Rizzetto for their insightful feedback during the process.



ABSTRACT

The emission of CO2 is a significant contributor to global warming, with the mobility sector being a major source. The EU has set a goal to achieve climate neutrality by 2050, requiring substantial CO2 reduction efforts, particularly in densely populated regions like the Rhine-Delta (RDR). This region's extensive mobility network, serving both urban and global trade needs, generates significant CO2 emissions.

To address this, a research initiative aims to make the Rhine-Delta's mobility network CO2-neutral by 2050 through reimagining its design and operations. The focus lies on peri-urban areas, where urban and rural landscapes intersect. These areas are essential for economic and social functions but are currently reliant on polluting road transportation.

The research identifies the need to rethink connectivity to peri-urban areas for sustainability. Traditional urban-focused transportation concepts often overlook peri-urban needs. Therefore, the initiative proposes developing context-based mobility nodes tailored to peri-urban requirements. These nodes aim to promote sustainable transportation and enhance network efficiency.

The approach involves creating an interconnected network of such nodes throughout the Rhine-Delta region, addressing the specific needs of lower-density areas like peri-urban zones. By considering local contexts, these nodes can effectively serve peri-urban areas, promoting sustainable transportation practices.

To demonstrate the feasibility of this approach, the research zooms in on a representative area within the Rhine-Delta region, focusing on peri-urban patches around Arnhem-Nijmegen. By showcasing how context-based mobility nodes can be implemented in such areas, the research seeks to pave the way for a broader transition towards a CO2-neutral mobility network by 2050.

In conclusion, the research aims to transform the Rhine-Delta's mobility landscape by making it CO2-neutral through the implementation of sustainable transportation solutions tailored to peri-urban areas. By recognizing and addressing the unique challenges and opportunities presented by peri-urban zones, the initiative seeks to contribute significantly to the EU's climate neutrality goal by 2050.

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1.

INTRODUCTION

CO_2 AND THE MOBILITY SECTOR

Mobility is the second largest CO_2 emitting sector (just underneath the energy industries), and in the Netherlands the transportation infrastructure has an impact on the whole continent, housing the biggest port in Europe. Free and easy movement of people and goods across the country and inland is a fundamental pillar in the Dutch economy and social life. From daily commuting, visiting family, leisure, and tourism, to the proper functioning of global supply chains for the goods in the shops and for industrial production in European countries and worldwide (Sustainable and Smart Mobility Strategy, 2020) .

"*Travelling in the EU has led to greater cohesion and a strengthened European identity. As the second-largest area of expenditure for European households, the transport sector contributes 5% to European GDP and directly employs around 10 million workers.*" (European Commission, 2020)

However, the mobility sector has been in the top three biggest polluters for more than 30 years. (Olivier, 2022) These include greenhouse gas emissions, air, noise and water pollution, but also accidents and road crashes, congestion, and biodiversity loss – all of which affect our health and wellbeing. The Energy Industry as well as the manufacturing and Construction Industries show a strong decline in emittance, but the mobility sector does not.
Past efforts and policy measures have not yet sufficiently addressed these costs for our society, like the application of ZEZ (ZERO EMISSION ZONE) in the city of Rotterdam.

The physical infrastructure in the Netherlands ranked 3rd worldwide, according to the World Economic Forum* , from roads to train services and public transportation. The Netherlands has around 140 thousand kilometers of paved roads, 6.3 thousand kilometers of waterways, 3.2 thousand kilometers of railways and 38 thousand kilometers of cycle paths. This includes a total of more than 186 thousand kilometers of traffic infrastructure, which equals nearly 11 meters per inhabitant (Melvin, 2024).

* The Global Competitiveness Report, released by the WEF, ranks 137 countries on a scale where 7 points are the highest.

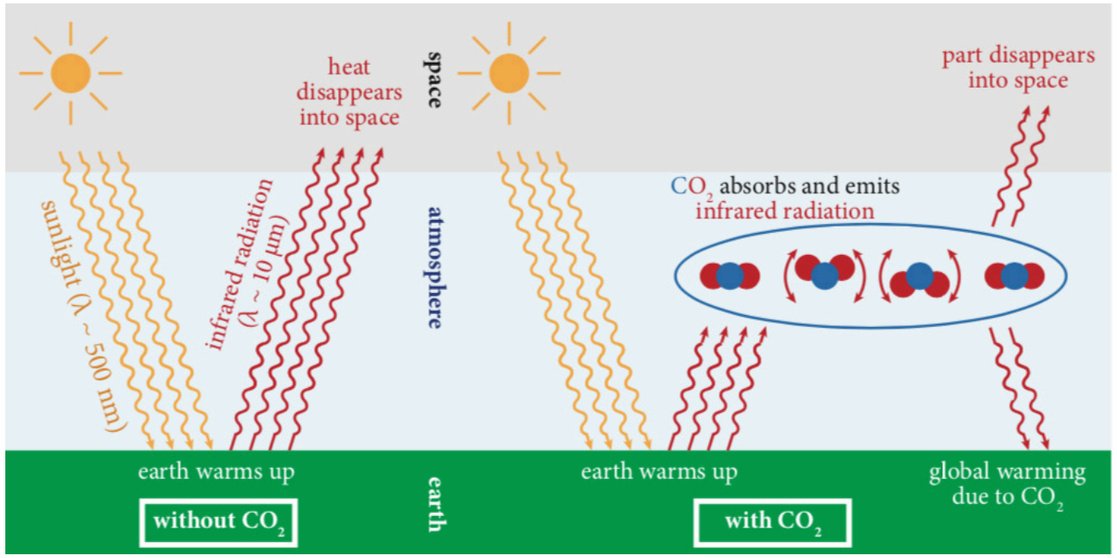

Figure 3. CO2 principle

Source: Betase BV, 2021

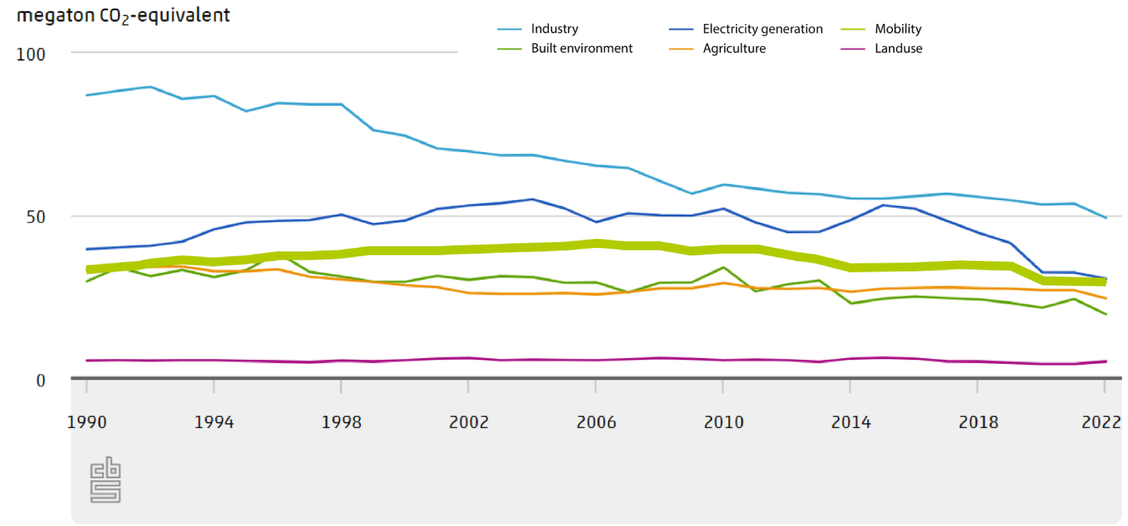

Figure 4. Emission of CO2 for different sectors

Source: Centraal Bureau voor de Statistiek, n.d.

Figure 1. Climate change is burning the earth

Source: Getty Images, 2024

Figure 2. CO2 emissions by urban fabric

Source: Shutterstock, 2024

CO_2 AND THE MOBILITY SECTOR

Additionally, the Port of Rotterdam serves as the primary entry point for goods into the European continent (Notteboom, Pallis, Rodrigue, 2024). Therefore, the Netherlands must maintain excellent infrastructure to efficiently transport these goods within the country and across Europe. This network is also very well maintained and used, due to a very dense level of urbanization (especially in the Holland provinces), dedicating almost 50% of the land to accommodate this infrastructure: streets, parking, service stations, driveways, signals, etc (MacArthur Foundation, 2015).

Currently operating within a linear economy framework, the sector's reliance on large infrastructure like waterways, highways, train tracks, and airports creates barrier effects, often cutting off urban spaces and disrupting ecological structures. Europe's current linear growth model depends on finite resources, exposing countries to resource volatility, limited gains in productivity, and huge loss of value through waste (Ellen MacArthur Foundation, 2015).

In the most densely populated areas of the Netherlands, 36% of residents rely on cars, whereas in peri-urban and rural regions, this figure is nearly double at 64% (KiM Netherlands Institute for Transport Policy Analysis, 2022). However, the European car is parked 92% of the time, and it is never fully utilized, being an average passenger of 1,5 per trip in a 5-seated car. (MacArthur Foundation, 2015).

Outside major cities in the Netherlands, car dependency and ownership is growing since public transport is not always a (good) option for commuting or leisure and prices are getting cheaper and cheaper. This decrease in prices is likely to increase demand in personal car transportation, which may lead to a shift from public transport to private and new consumer demographics (such as the young and elderly) , to rely more on individual transportation options, especially in peri-urban and rural areas.

The mobility sector, while essential for societal functioning, poses significant negative impacts on the environment and human health. Production of cars carries environmental consequences, including the emission of approximately 6.7 tonnes of CO2 per car and substantial consumption of raw materials like iron, aluminum, rubber, and oil. Furthermore, with the transition to electric vehicles, this demand will only increase, leading to local environmental impacts associated with their mining. The sector's heavy reliance on fossil fuels further exacerbates environmental degradation, leading to deforestation, more extreme weather occurrences, and disruptions in ecological balance.

Moreover, the emission of CO_2 by the mobility sector contributes to global warming, leading to detrimental consequences such as the urban heat island effect, increased air pollution, forced population displacements, and decreased land use opportunities, particularly in agricultural areas. These impacts extend beyond environmental concerns, affecting the functioning of built environments and societies at large through destruction, disruption, and destabilization. Additionally, car ownership promotes increased car usage, resulting in significant societal effects and more congestion.

Ensuring that our transport system becomes sustainable and resilient must also be a key objective of the European Green Deal for 2050. Our research project aims to explore if the Euro Delta Region could be moving forward towards the EU's ambitious targets of reducing greenhouse gas emissions by at least 55% by 2030 and achieving climate neutrality by 2050 through an improvement of public transport and a demotivation of car use.

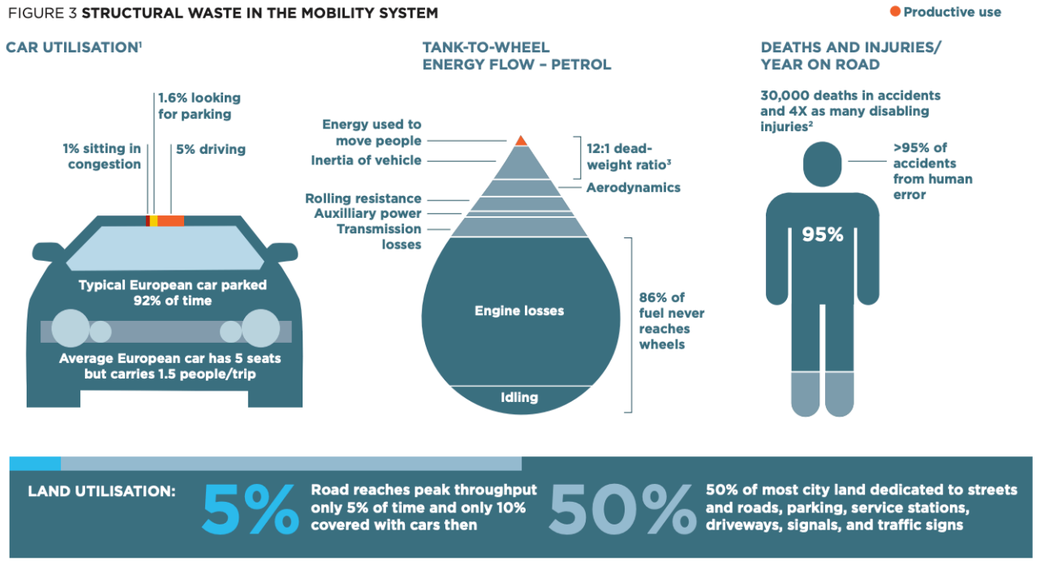

Figure 5. Structural waste in the mobility sector
Source: Ellen MacArthur Foundation & McKinsey Center for Business and Environment, 2015

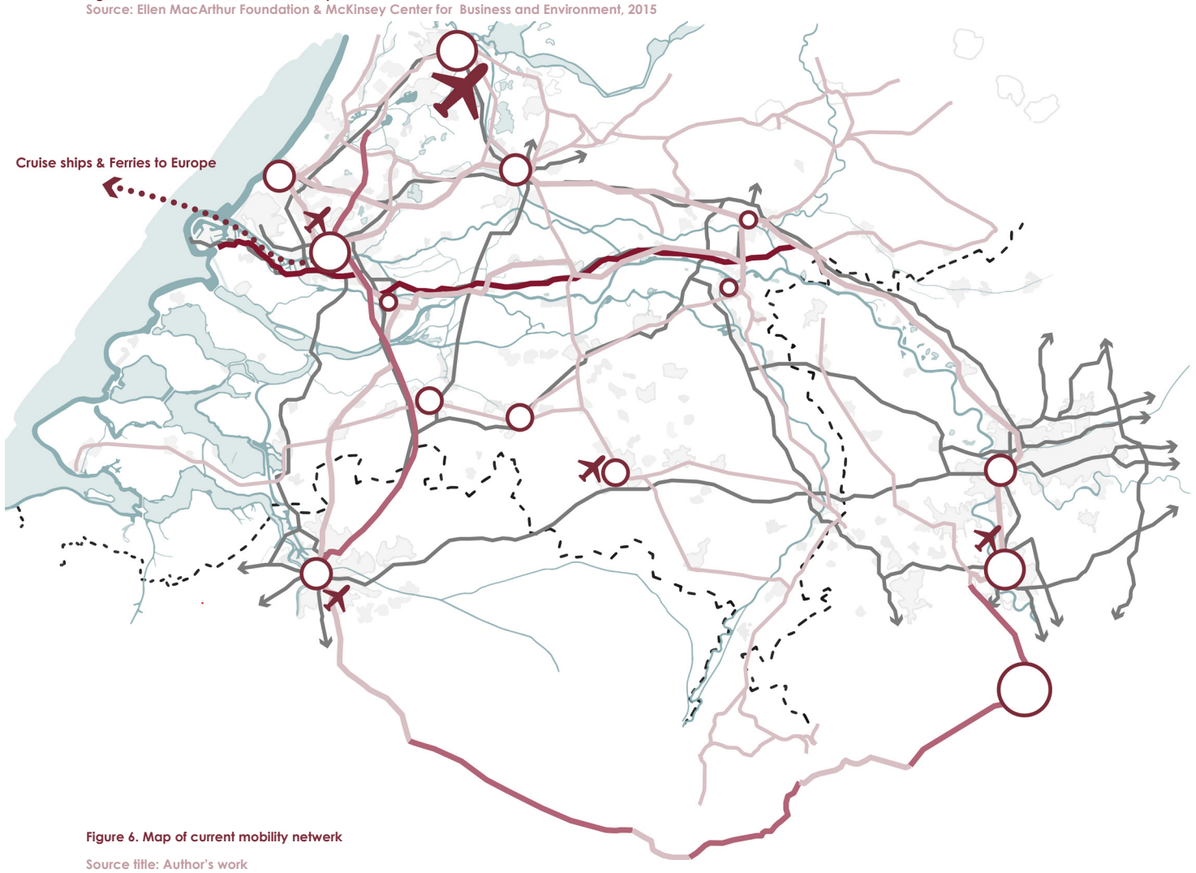

Figure 6. Map of current mobility netwerk

Source title: Author's work

2.

METHODOLOGY

FLOWCHART RESEARCH AND DESIGN METHODOLOGY

The flowchart below illustrates the basic structure of our research and design methodology:

1: Analysis: In this part of our research and design process, we will analyze the current situation of the Rhine delta region. Problems and opportunities will be identified. The results of this phase can be found in Chapter 3.

2: Problem statement: Here we will summarize the main problems we want to solve. The problem statement can be found in Chapter 4.

3: Development of solution strategies: In this phase, we will develop a strategy to tackle the challenges and take advantage of the opportunities in the region. This leads to 5 principles for the development of connections and the concept of "Context-based TOD (Transit-oriented Development)" for the transportation nodes. The results of this can be found in Chapter 5.

4: Implementation: In this step, we will apply the 5 principles and the concept of Context-Based TOD to the region and two zoomed-in case studies. The results of this step can be found in Chapters 6 and 7.

5: Reflection on solution strategy: In this chapter, we reflect on our solution strategy. We assess how well our solutions were implementable in the design studies. This can be found in Chapter 8.

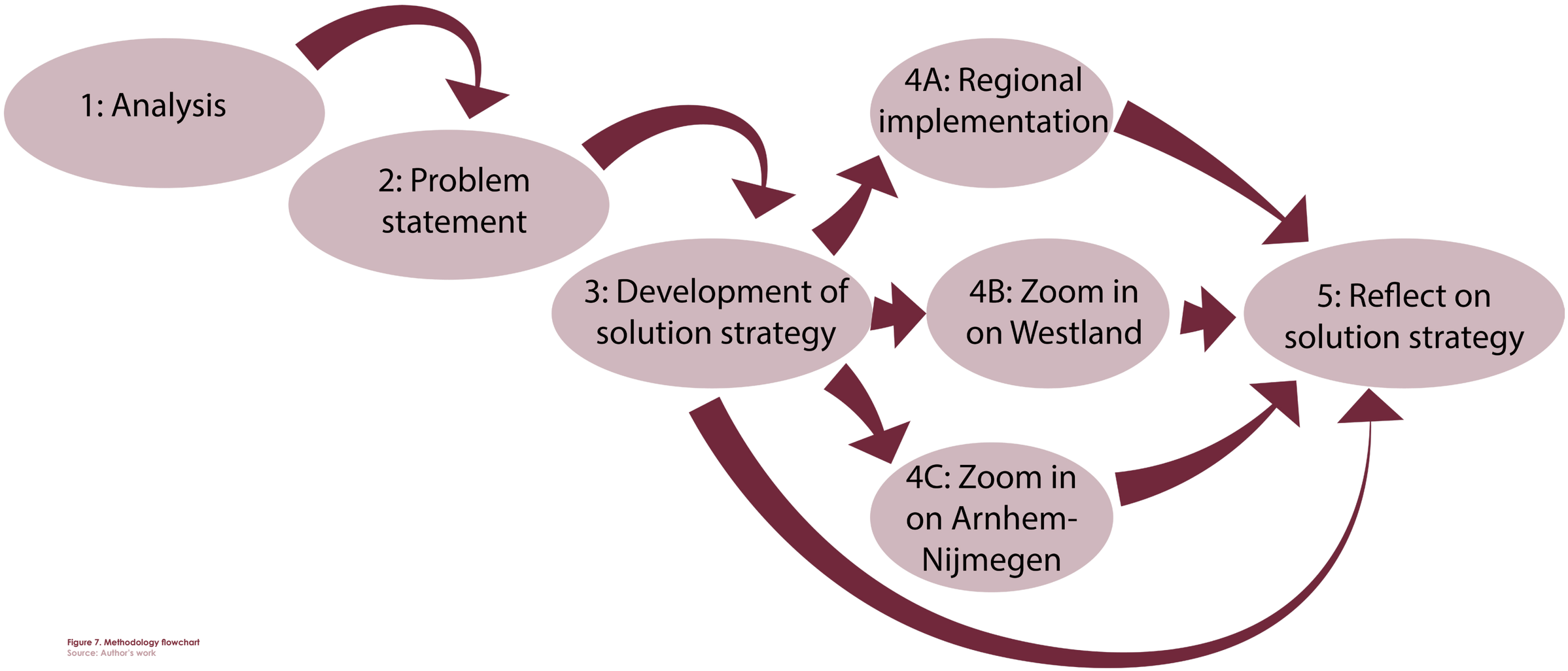

Figure 7. Methodology flowchart
Source: Author's work

RESEARCH QUESTION

In order to do this research in a well conducted manner, a more in-depth analysis has been conducted. The research starts off with an in-depth look into the region. For this we zoom in on the characteristics on the region, with a special focus on it is mobility network. In the second phase the focus lies on the impact the mobility network has on these characteristics of the region. Finally the research aims to answer the questions on how this network can be redesigned in order to become more sustainable. For this, the focus does not only lie on reducing CO2 emissions, but also on how this can be done in a sustainable, spatial and social manner.

''How do we redesign the mobility network of the Rhine-Delta region to be CO2-neutral in 2050?''

The region

- What are the current characteristics of the Rhine-Delta region?
- How does the mobility network of the Rhine-Delta region currently function?

The impact of the mobility network

- What is the impact of CO2 pollution on the quality of life in the Rhine-Delta region?
- What is the spatial and social impact of the mobility network on the region?

A sustainable mobility network for the region

- How do we reduce the CO2-emittance by the mobility network in the Rhine - Delta region?
- How do we apply spatial trends and concepts to promote the use of sustainable transportation on peri-urban areas?
- How do we apply these spatial trends and concepts in a socially justified way on the mobility network of the Rhine-Delta region?

CONCEPTUAL FRAMEWORK

HOW TO APPROACH THIS PROJECT?

The emission of CO_2 is a significant contributor to global warming. One of the major sources of CO2 pollution is the mobility sector. The EU has set a goal to achieve climate neutrality by 2050. This requires substantial CO_2 reduction efforts, particularly in densely populated regions like the Rhine-Delta Region (RDR). This region's extensive mobility network, serves both urban and global trade needs, generating significant CO_2 emissions.

To address this, a research initiative aims to make the Rhine-Delta's mobility network CO_2-neutral by 2050 through reimagining its design and operations. The focus lies on peri-urban areas, where urban and rural landscapes intersect. These areas are essential for economic and social functions but are currently reliant on road transportation, which emits a lot of CO_2.

The research identifies the need to rethink connectivity to peri-urban areas for sustainability. Traditional urban-focused transportation concepts often overlook peri-urban needs. Therefore, the initiative proposes developing context-based mobility nodes tailored to peri-urban requirements. These nodes aim to promote sustainable transportation and enhance network efficiency.

The approach involves creating an interconnected network of such nodes throughout the Rhine-Delta region, addressing the specific needs of lower-density areas like peri-urban zones. By considering local contexts, these nodes can effectively serve peri-urban areas, promoting sustainable transportation practices.

To demonstrate the feasibility of this approach, the research zooms in on two representative areas within the Rhine-Delta region. By showcasing how context-based mobility nodes can be implemented in such areas, the research seeks to pave the way for a broader transition towards a CO2-neutral mobility network by 2050.

In conclusion, the research aims to transform the Rhine-Delta's mobility landscape by making it CO2-neutral through the implementation of sustainable transportation solutions tailored to peri-urban areas. By recognizing and addressing the unique challenges and opportunities presented by peri-urban areas, the initiative seeks to contribute significantly to the EU's climate neutrality goal by 2050.

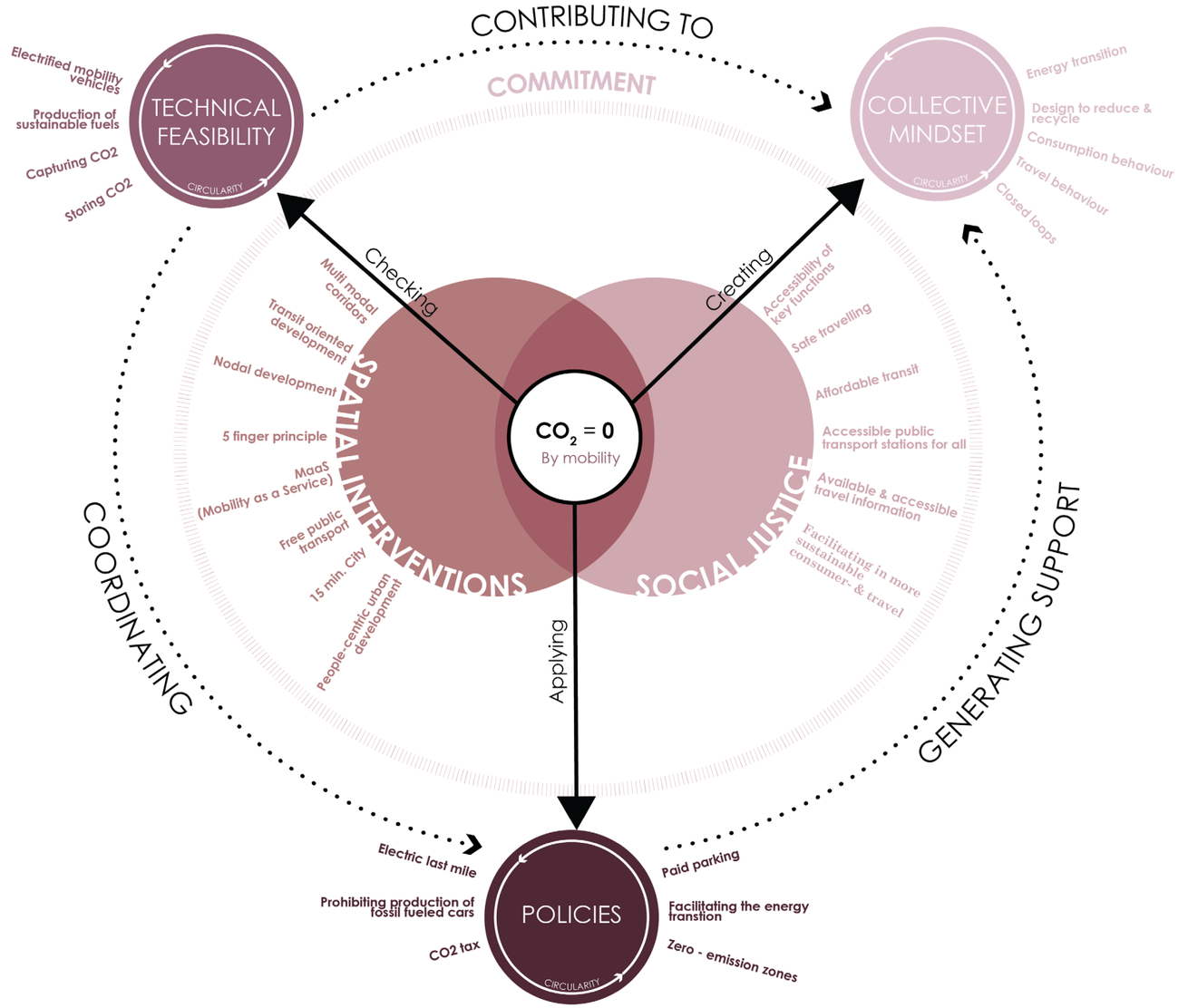

Figure 8. Conceptual framework

Source: Author's work

CURRENT POLICIES
AND HOW IS THIS FACILITATED?

Sustainable Development Goals
The United Nations developed in association with many countries developed 17 Sustainable Development Goals (SDGs). They meet urgent calls for action in a wide global partnership. The SDGs knows a wide range of different strategies all while tackling climate change. The SDGs are important and form the base for other policies (United Nations, n.d.).

Current policies
The EU is striving to be to transform the EU into a modern, resource-efficient and competitive economy. This comes clear in their most well-known policy the European Green Deal. The most important goal is to have no net emissions of greenhouse gas emissions by 2050 (European Commission, n.d.-a). In the Netherlands this policy is translated into the Klimaatakkoord. To achieve this zero emission goal in the mobility sector there are several aims taken into account. The main approach is to stimulate electrical vehicles (Klimaatakkoord, n.d.). Different regions in the Netherlands have their own strategy to achieve the goals of the Klimaatakkoord that come together in the Regional Mobility Programme (RMP) (CROW, n.d.).

Another policy on EU scale is the EU Cohesion Policy (2021-2027) that is reducing economic and social differences by ensuring that there are no gaps within and between countries. The policy supports the EU goals by green and digital transitions and contributes by strengthening social cohesion in the European Union (European Commission, n.d.-b).

SHAPING
- in 2030 there should be 1,7 million electrical charging stations for vehicles
- zero-emission zones within cities

REGULATING
- in 2030 the Netherlands need to emit 49% less CO2
- in 2050 the Netherlands need to emit 95% less CO2
- energy labels for vehicles to display their emissions

STIMULATING
- kilometre charge as important sustainable instrument
- subsidies for electrical cars
- lower car taxes (bpm, mrb) for sustainable transport

CAPACITY BUILDING
- help people make the transfer to sustainable mobility
- *Klimaatwijzer*: involve and educate people about sustainable energy.

Figure 9. Planning of existing policies
Source: Author's work

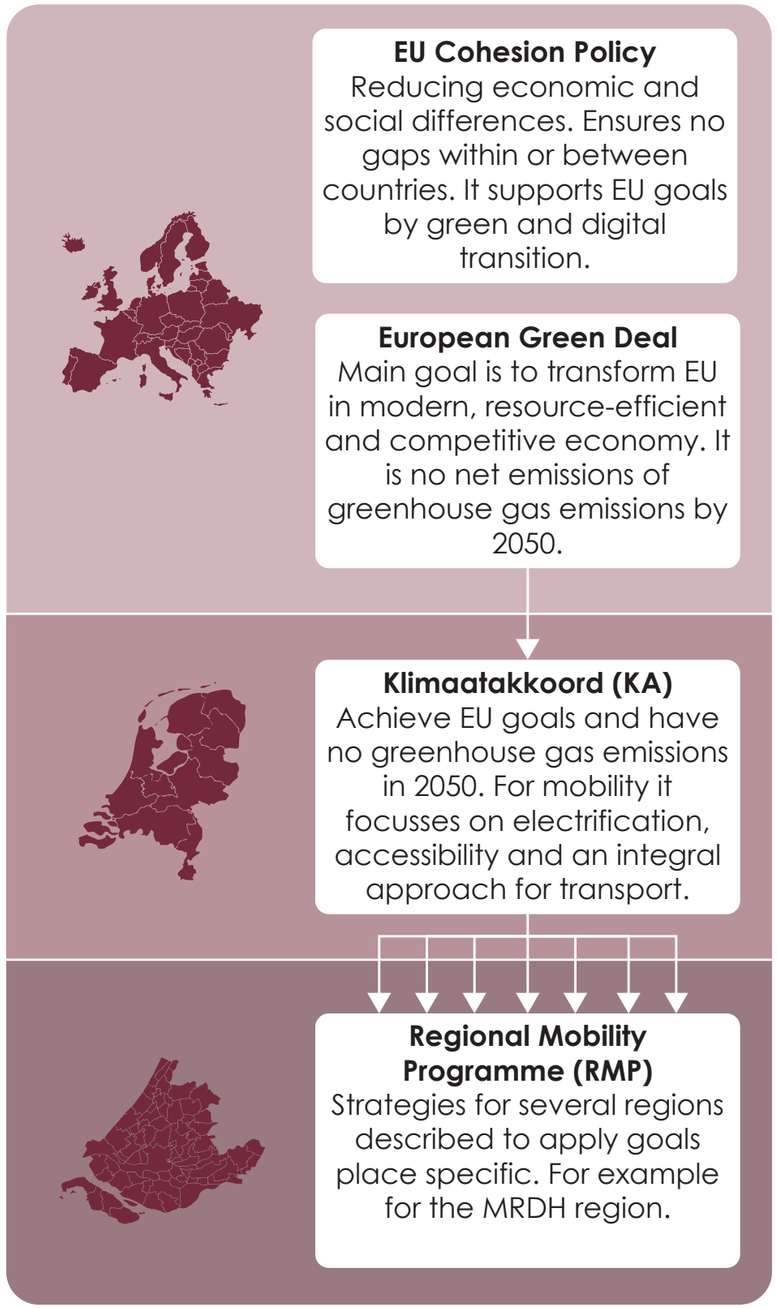

Figure 10. Existing policies
Source: Author's work

3.

THE RHINE - DELTA REGION

A REGIONAL ANALYSIS

CONTEXT

As stated in the introduction, creating a CO_2-neutral mobility network is a difficult task. In order to create a well established vision that improves the quality of life and reduces the CO_2- emissions, it is important to get a better understanding of the specific region that we will be working on. Therefore an in-depth analysis has been done into how the mobility network of the Rhine-Delta network has come to be. This analysis attempts to give insight into the characteristics of the region and how the mobility network was developed over time. This will be followed up by an analysis of what implications the mobility network has had on the characteristics of the region. These implications can be categorized into three main categories: 1. Impact of CO_2, 2. Spatial impact 3. Social impact. The chapter concludes with the main challenges the mobility network of the Rhine-Delta region will face in trying to become CO_2-neutral.

Related to this research, a list of key definitions has been created to define often repeated terminology. This list holds high value to helpmaintain clarity within the research.
It is important to note that this terminology applies strictly to this research. Outside of the context of this research one can have its own interpretation of these defintions.

Key words/definitions

Rhine-Delta region:
The geological area surrounding the rivers Rhine, Waal and Lek roughly between Rotterdam, Antwerp, Cologne and Amsterdam.

Mobility:
The ability to freely move or be moved

Mobility network:
The networks that facilitate movement of people and goods.

Infrastructure:
The physical structures that facilitate transportation.

Transportation: The act of moving goods and people.

Transit:
The movement of people from one place to another

Logistics:
The movement of goods from one place to another

Sustainable transportation:
The use of sustainable forms of transportation that reduce the emittance of CO_2.
Forms of transporation such as public transit, walking, cycling, micro-mobility and shared mobility.

Micro mobility:
Small, low-speed, electric-powered transportation devices
Devices such as scooters, electric bicyles, one-/monowheels, etc.

Shared mobility:
Transportation services and resources that are shared among users.
Transportation forms such as shared (electric) bicycles, shared (electric) cars, public transit bicycles, etc.

Transit & mobility poverty:
The lack of transport options in order to access essential socioeconomic services and activies.
For example, the lack of a bus stop or train connection in close proximity inaccessible public transit stations for disabled people, high costs of transport, no access to to (online) timetables, fear for personal safety in public transit.

Sustainable mobility network:
CO_2-neutral mobility network

CO_2-neutral mobility network:
A network that stores as much CO_2 as it emits.
It does not mean a network that emits zero CO_2, but it is a network that has reduced CO_2 emissions and is part of a larger network that makes sure that the CO_2 still being emitted is being captured or stored otherwise to bring the total balance to zero.

Transit Oriented Development
A type of urban development that maximizes the amount of residential, business and leisure space within walking distance of public transport. It is based around public transit nodes and promotes the use of sustainable transportation.

Context based Transit Oriented Development
Transit oriented development that appreciates the local context of it is surroundings.

THE RHINE DELTA REGION

AN OUTLET FOR EUROPEAN WATERWAYS

The Rhine-Delta region can immediately be recognized by it is extensive network of waterways. This is due to the fact that many European waterways find their outlet into open waters in this region. Rivers such as the Rhine, Waal and Lek find their estuaries in the Nieuwe Maas, Oosterschelde and Westerschelde and will lead them into the North Sea. Most of these rivers are branches from the river Rhine. The Rhine stretches all the way from the Netherlands to Swiss Alpes. The extensive water network that is being formed by the Rhine and it is branches in the Rhine-Delta region is also known as the Rhine-corridor (Boelens & Taverne, 2011 and De Roo & Boelens, 2016).

This extensive water network has ultimately led to two main developments in the region. (1) it formed the foundation for a very densely populated region and (2) the water network resulted in the region to become a logistical gate to the hinterland of Europe.

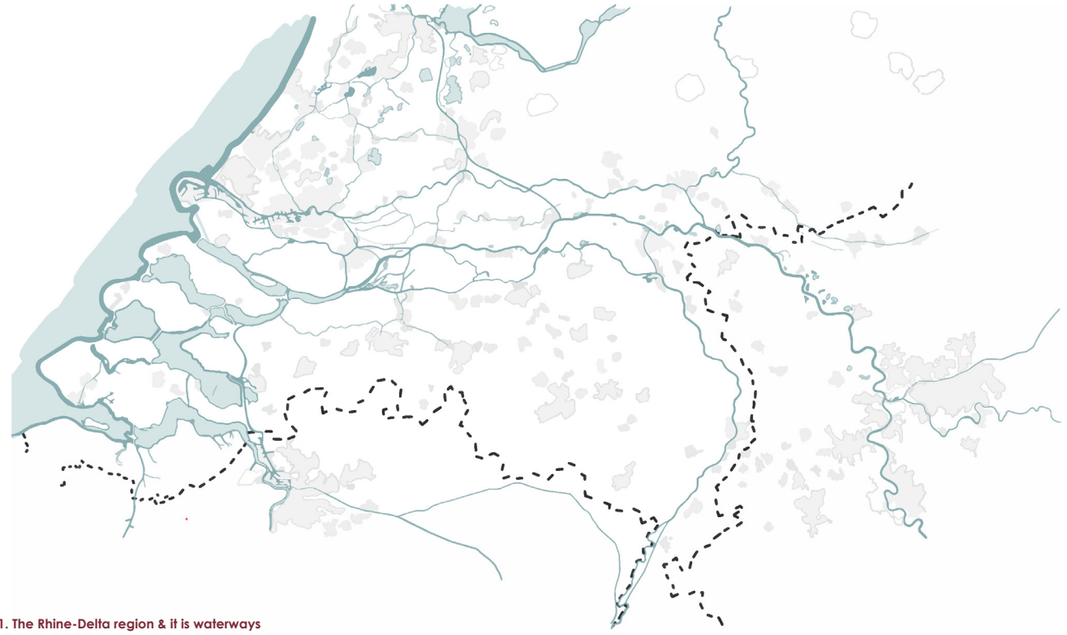

Figure 11. The Rhine-Delta region & it is waterways

Source title: Author's work

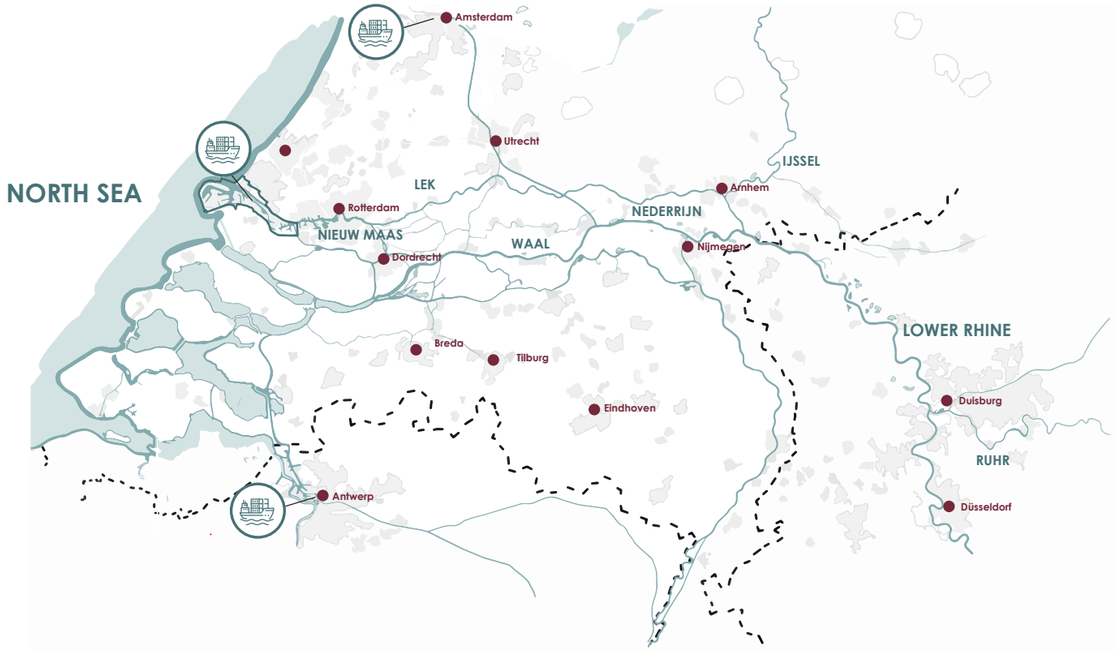

Figure 12. Larger settlements along the waterways of the Rhine-Delta region

Source title: Author's work

THE RHINE DELTA REGION

1. A DENSELY POPULATED REGION

Patchwork of urban areas
The extensive water network has resulted in the creation of many settlements spread out over the Rhine-Delta region. Historically, intersections between waterways held high strategic value for economic opportunities. Therefore, looking back at history, many settlements worldwide have been found at the intersections between waterways (Koteshwar, n.d.).

Since the Rhine-Delta region is home to an extensive network of waterways, it stands to reason that the region also houses a large number of intersections between these waterways. And thus, making the region full of suitable sites for settlements.

Moving forward to today, many of these settlements have grown into cities of considerable size. These settlements are in close proximinity to one another. This has resulted in a high amount of urbanization over the whole region. However, this close proximity is also the reason that the Rhine-Delta region does not know cities of the size comparable to a metropolis such as Paris or London.

In a metropolis like Paris or London, the urban tissue is of very high density, clustered in one place. This results in a very dense population over a relatively small footprint. In the Rhine-Delta region the population is more spread out over relatively smaller cities such as Antwerp, Amsterdam, Rotterdam, Cologne and Duisburg. This creates a vast network of patches of urban tissue. However, the high density of a metropolis creates certain socioeconomic opportunities. In order to gain the same opportunities, the cities in the Rhine-Delta region try to connect and grow towards each other. This results in a very urbanized region, which can be perceived as a vast network of decentralized urban tissue. (Boelens & Taverne, 2011 and De Roo & Boelens, 2016).

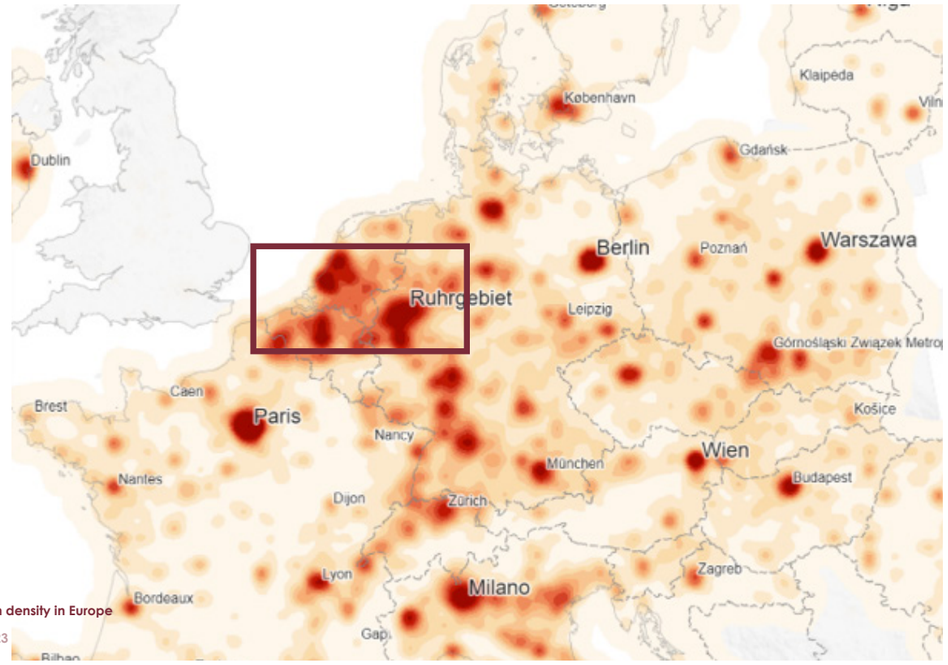

Figure 13. Population density in Europe
Source: Eurostat, 2023

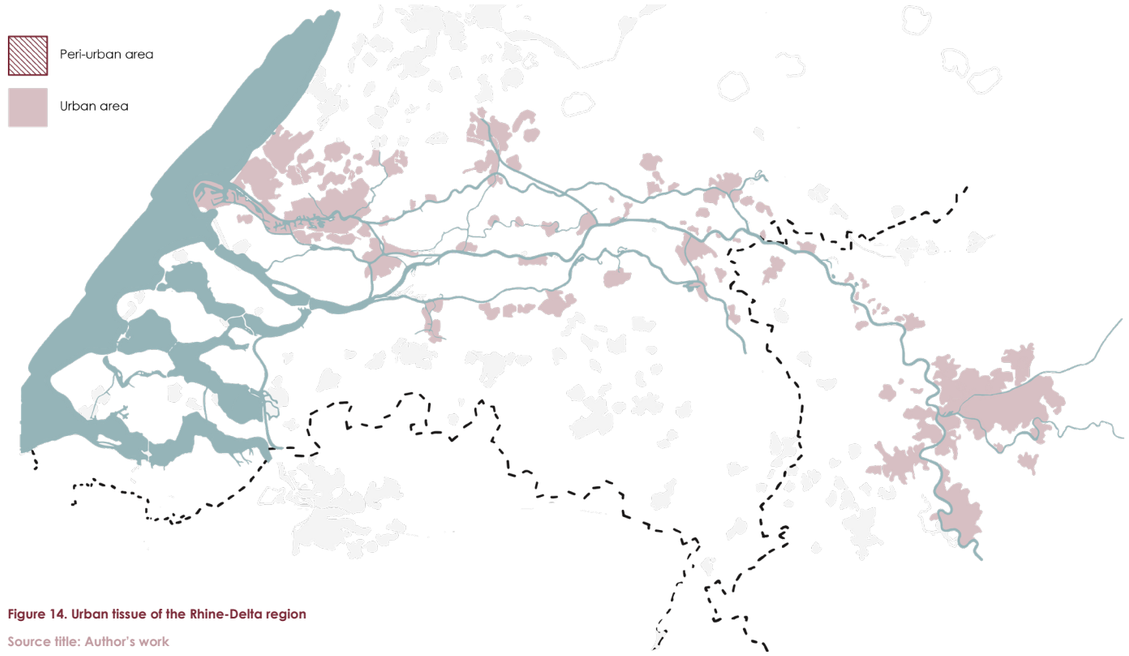

Figure 14. Urban tissue of the Rhine-Delta region
Source title: Author's work

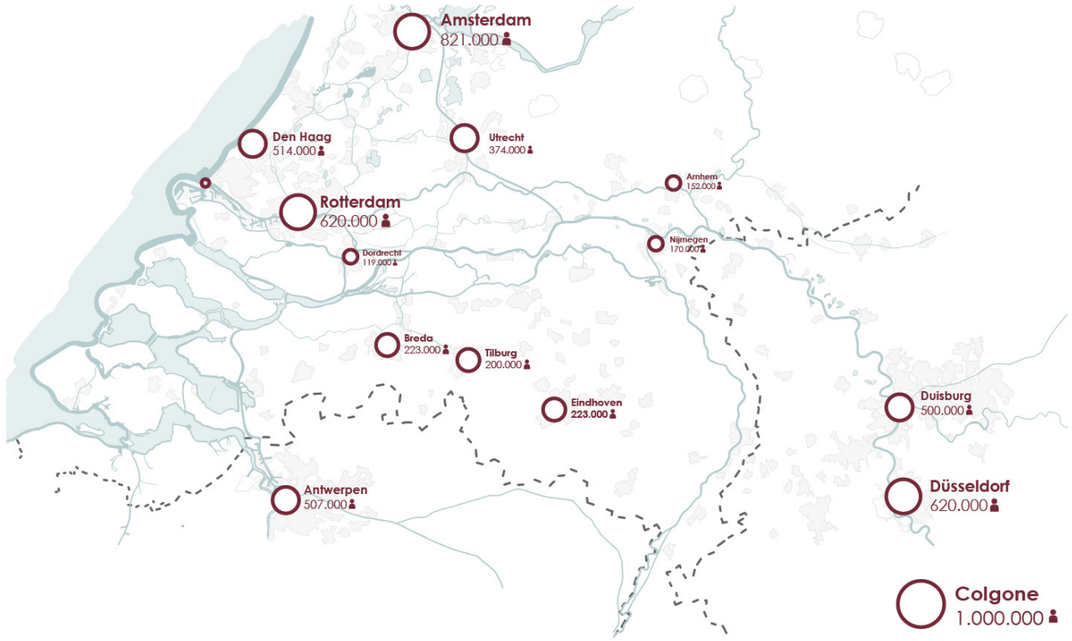

Figure 15. Main settlements of the Rhine-Delta region
Source title: Author's work

Patchwork of urban and peri-urban areas
Because of the vast network of decentralized urban tissue, the Rhine-Delta region consists of many urban, but also peri-urban areas. The urban areas are what we consider to be cities, towns and settlements. Peri-urban areas are the places where urban tissue intersects with rural land covers such as agriculture, industry, nature, semi-natural, marine waters, wetlands, inland waters, etc. Since the region has such an extensive network of spread out urban tissue, it stands to reason that the region also has many peri-urban areas and really characterizes the Rhine-Delta region (De Roo & Boelens, 2016).

The peri-urban areas are formed by the areas where urban land cover intersects with rural land cover. The rural land cover can be divided into many subcategories. However, many of these can be traced back to three main categories; Agriculture, Industry and Nature. To keep this research comprehensible we will start by focussing on the intersection between the urban and these three main categories of rural land cover. Later on the in the research we will specifiy these main categories further.

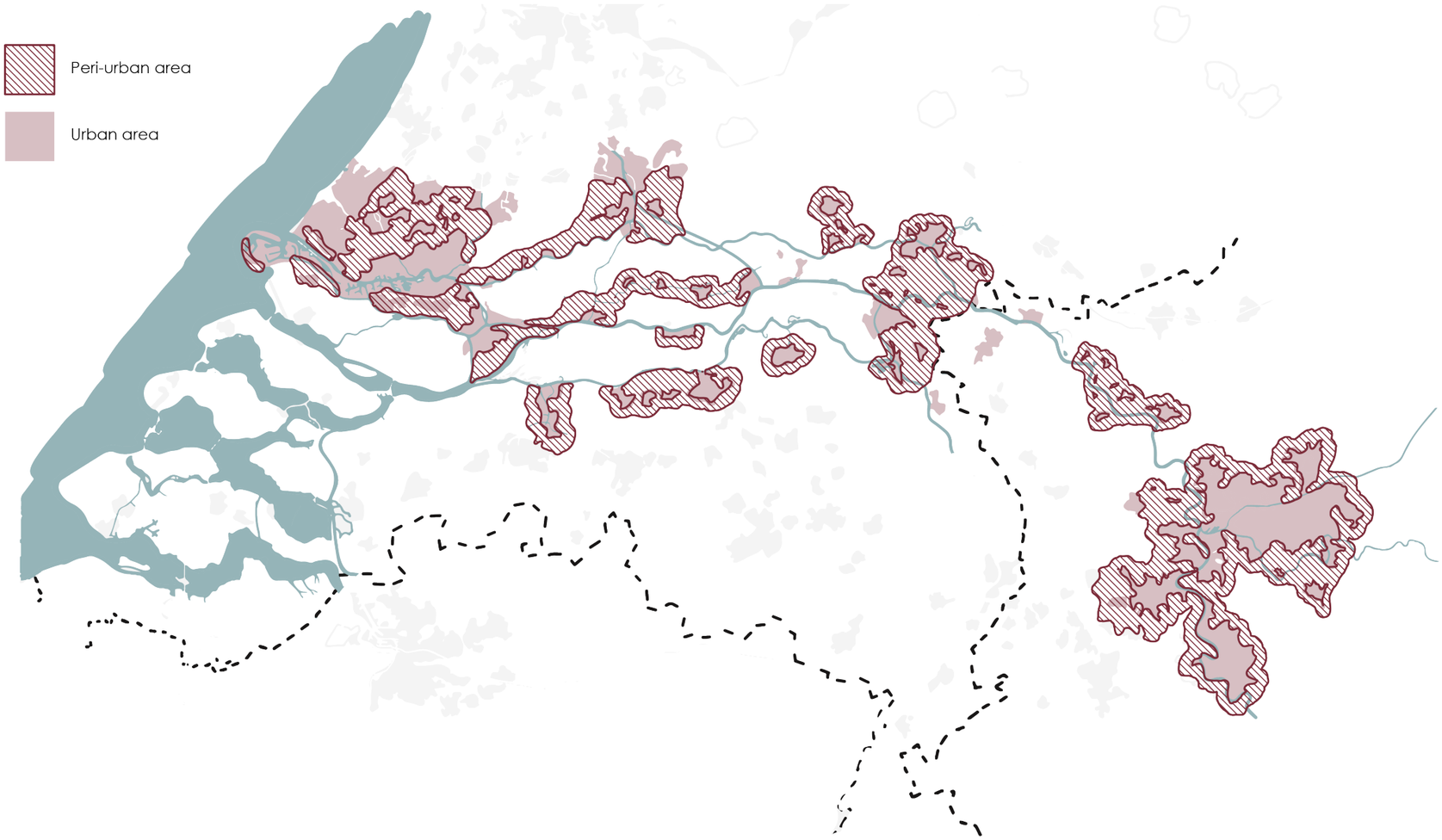

Figure 16. Map of peri-urban and urban areas

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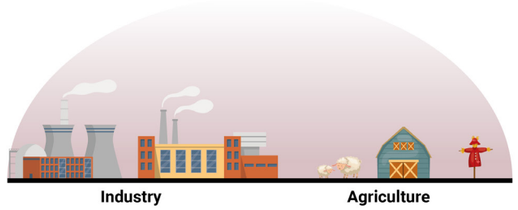
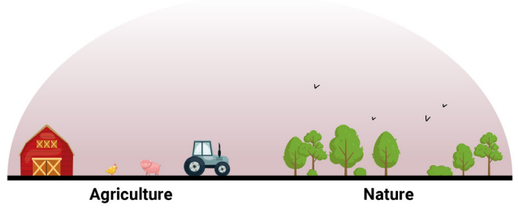
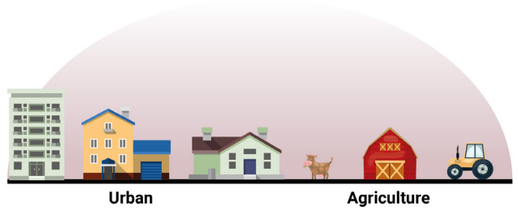
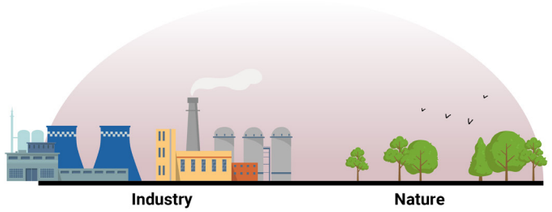








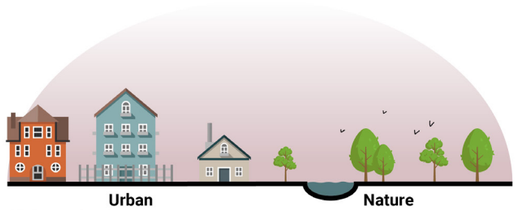


Figure 17. Forms of peri-urban areas

Source: Author's work

THE RHINE DELTA REGION

2. A LOGISTICAL GATE TO EUROPE

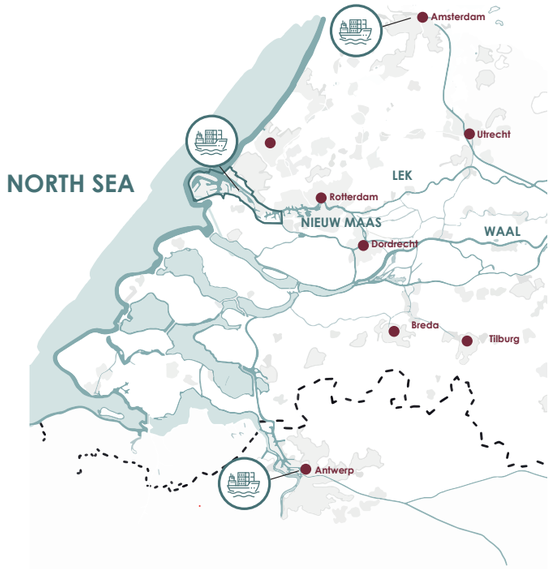


Figure 18. Main ports of the Rhine-Delta region

Source: Author's work

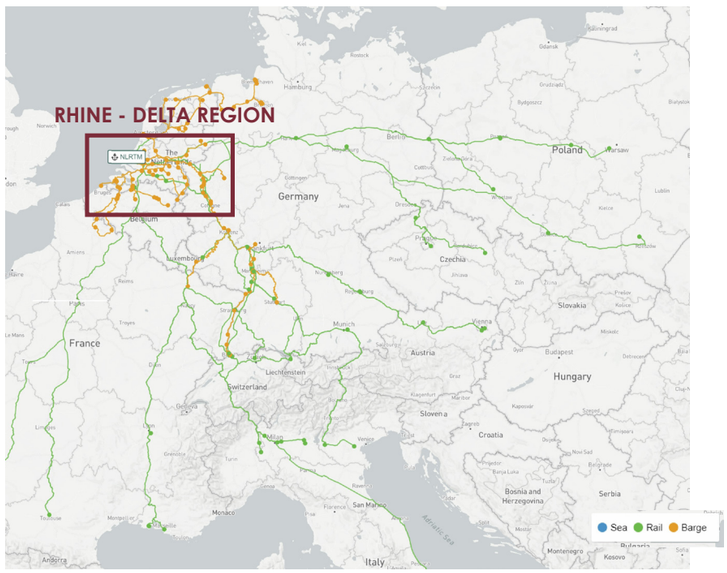


Figure 19. Transportation network from and to the main logistical gates of Europe

Source: Based on Route Scanner, 2024

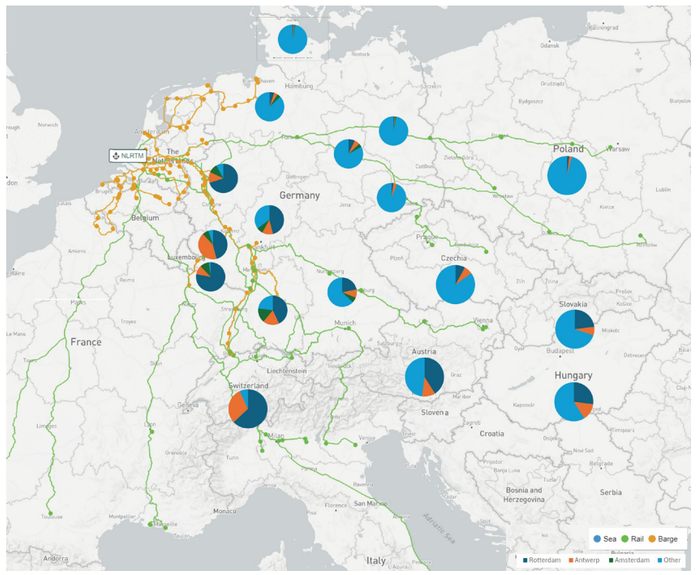


Figure 20. The amount of goods coming through the 3 main logistical gates of Europe

Source: Based on Route Scanner, 2024 and Merk & Notteboom, 2013

Besides making the Rhine-Delta region a very densely populated region, the extensive water network also caused the region to become a logistical gate to Europe. As stated earlier, many European waterways find their outlet into open waters in the Rhine-Delta region.

Historically seen trading and transportation was mostly done over waters. For the globalization of trading goods, the open waters form extremely important trading routes. However, since only a limited amount of countries have direct access to open waters, a lot of countries are heavily dependend on rivers and other inland waterways to be able to trade goods on a global scale. Therefore, these inland waterways form an integral part in the transportation network for global trading. This is not without challengers however.

Ships that are needed to sail open waters are usually much larger in size than ships suited to sail inland waters. This large size was required to safely face the conditions on open water as well as that global trade would only be profitable when large amounts of goods were transportated at once. However, this large size would not allow them to sail comfortably on inland waters. Therefore, the goods needed to be transshipped onto smaller ships which were more well suited for travelling on inland waters. This transshipment would happen at intersections between open waters and inland waters. These intersections gave the opportunity to transship the goods from larger ships onto smaller ships, as well as to make the trading more efficient. The goods could now be transported in bulk over open waters from one intersection with inland waters to another. Then, at these intersections, the bulk could be re-distributed into smaller batches destined for their specific destinations more land-inwards. Therefore, the sites around the intersections between open- and inland waters have become attractive places for the transshipment of goods. This resulted in many important ports we know today, are situated at these intersections (Ocean Vs. Inland Transport: Building End-to-end Efficiency in Shipping, n.d.).
Europe knows many countries that do not border on open waters. Therefore, for global trade, these countries were, before the emergence of road- and air-transportation, heavily dependend on the transportation of goods over inland waters. Many of these waterways find their outlet in open waters such as the Atlantic Ocean and the North Sea. Most inland waterways that have their outlet into the North Sea come together in the Rhine-Delta region. Therefore, the Rhine-Delta region knows a lot of intersections between open- and inland waters, which has resulted in the establishment of multiple important European and global ports such as the Port of Amsterdam, Antwerp and Rotterdam (METREX SURE Expert Group, 2019).

Over the years, especially the port of Rotterdam has developed and established itself as major global port. While both the port of Antwerp and Amsterdam are also of significant size, the port of Rotterdam really stands out because of its size and global function. Therefore, for the remainder of this report, the ports of Antwerp and Amsterdam will be taken into account, but the port of Rotterdam will be the focus point when we speak of the Rhine-Delta region as a logistical gate.

Nowadays, these ports still hold high logistical value. They still serve as transshipment ports that connect other parts of the world to the hinterland of Europe. However, the transportation flows that move land inwards are not only facilitated by waterways anymore. With the introduction of rail- and road transportation, a lot of goods are now being transshipped from ships onto trains and trucks. Because of this, the ports still form vital nodes in the mobility network of the mobility network of the Rhine-Delta region. With the presence of so many important logistical nodes in close proximity to one another, the Rhine-Delta region can be perceived as a logistical gate to Europe (METREX SURE Expert Group, 2019).

THE RHINE DELTA REGION

CONNECTING THE REGION

We have chosen the Rhine Delta Region as our case study because is one of the most densely populated areas of Europe and the house of Port of Rotterdam; therefore, one of the busiest logistics and passenger transportation in the continent. Where the connection with the seaside of the port – a large part of CO2 in air – and the inland ongoing supply demand is a continuous challenge for the current linear economy framework.

The logistics sector of the region is strongly determined by the Port's functions and trades, where 467,5 mln tons of goods are moved between the Netherlands and the rest of Europe, all the way to Hungary and Italy by waterways, train or roads (heavy trucks or vans). (Notteboom, Pallis, & Rodrigue, 2024) Railways constitute a significant portion of the inland transportation network, accounting for 44% of the overall system. These railways extend inland, connecting key destinations such as Germany, Italy and Antwerp. In the Netherlands, freight trains are strategically operated along fixed routes, with the Betuwe Route emerging as a crucial pathway.

This dedicated rail freight corridor establishes a rapid connection between the port of Rotterdam and Zevenaar at the German border, facilitating efficient cargo movement. Additionally, the development of multimodal corridors enhances connectivity and trade efficiency across Europe. For this research project, we focused on three main corridors that we took from the baseline scenario for both freight and passenger growth towards 2050 of the Urban Region Eurodelta (Otten, et al., 2022)

- Lille-Brussels corridor, with a particular interest in its cross-border area, including the relations to bordering regions of London-Paris-Liège
- Rhine-Scheldt corridor, focusing on the relationship between the port of Rotterdam and Antwerp, the cross-border core area between Rotterdam-Antwerp-Ghent, and bordering regions towards Lille-Brussels-Amsterdam;
- Rhine-Waal corridor, our main corridor. With a focus on the cross-border core area between the Randstad-Ruhr area through Arnhem-Nijmegen, including the side-corridor over Eindhoven and the Eastern region of the Ruhr metropolis, and the relations to the southern part of Germany (and the rest of the -freight-continent).

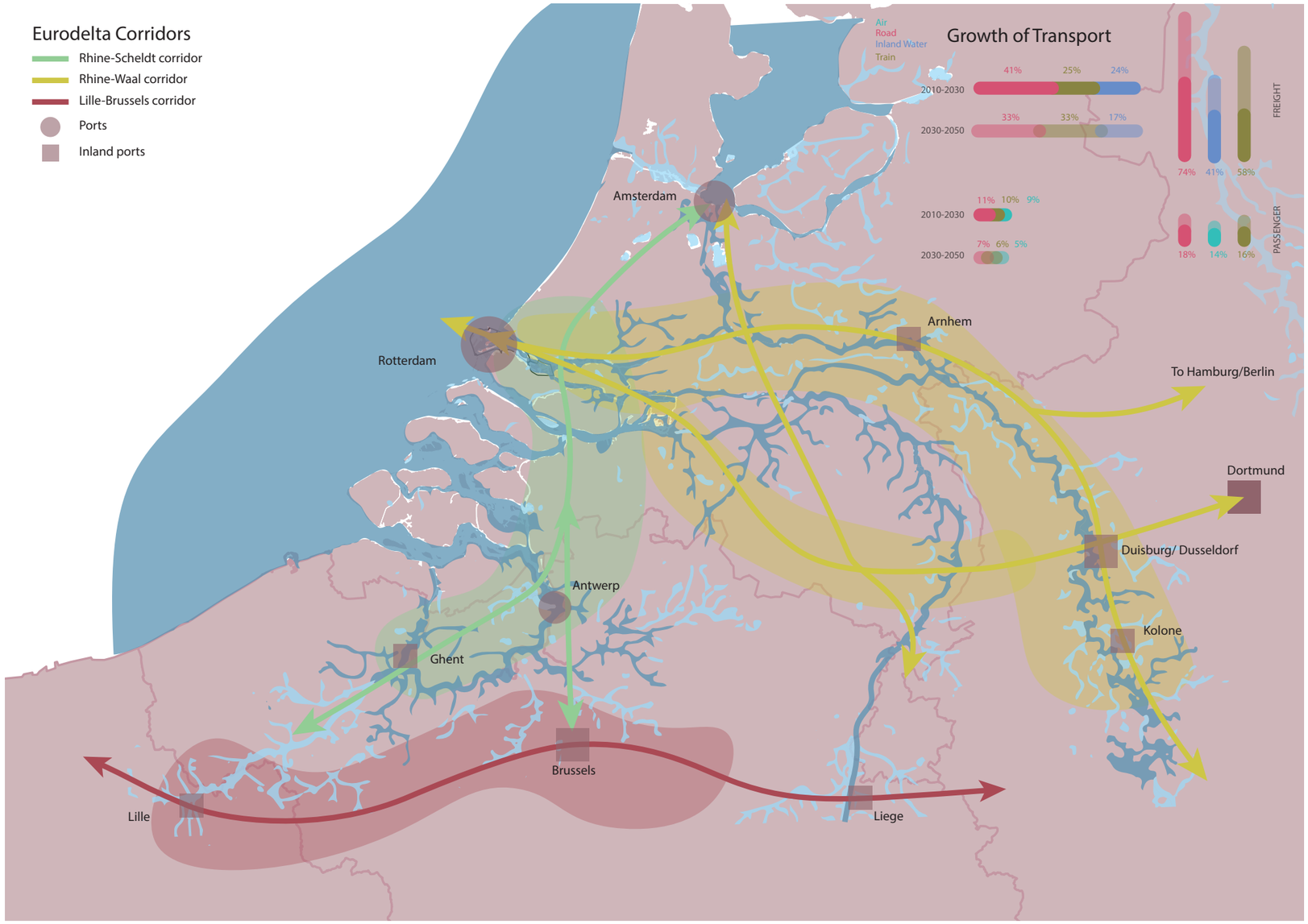


Figure 21. Eurodelta Corridors

Source: Author's work based on information retrieved from STISE – Sustainable Transport Infrastructure in the Strategic Urban Region Eurodelta (2022).

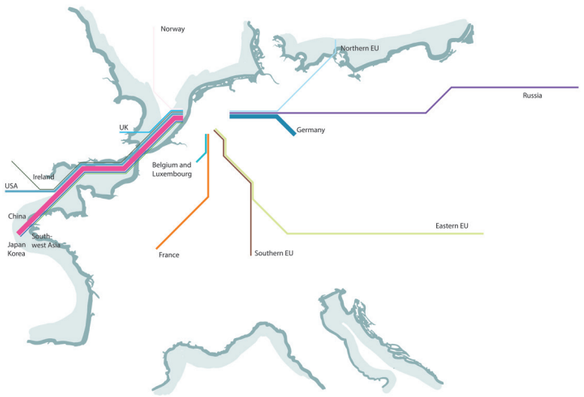


Figure 22. Port of Rotterdam: import flows

Source: based on Centraal Bureau voor de Statistiek, 2021

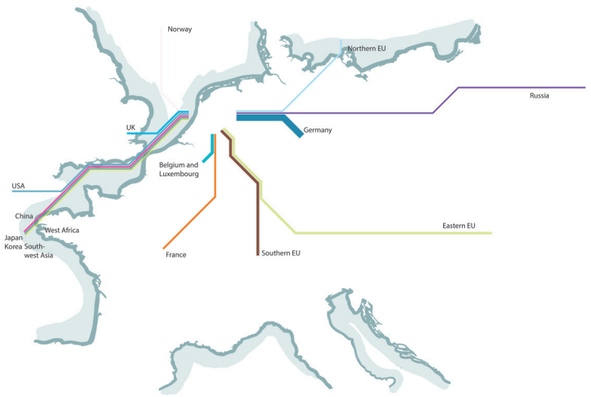


Figure 23. Port of Rotterdam: export flows

Source: based on Centraal Bureau voor de Statistiek, 2021

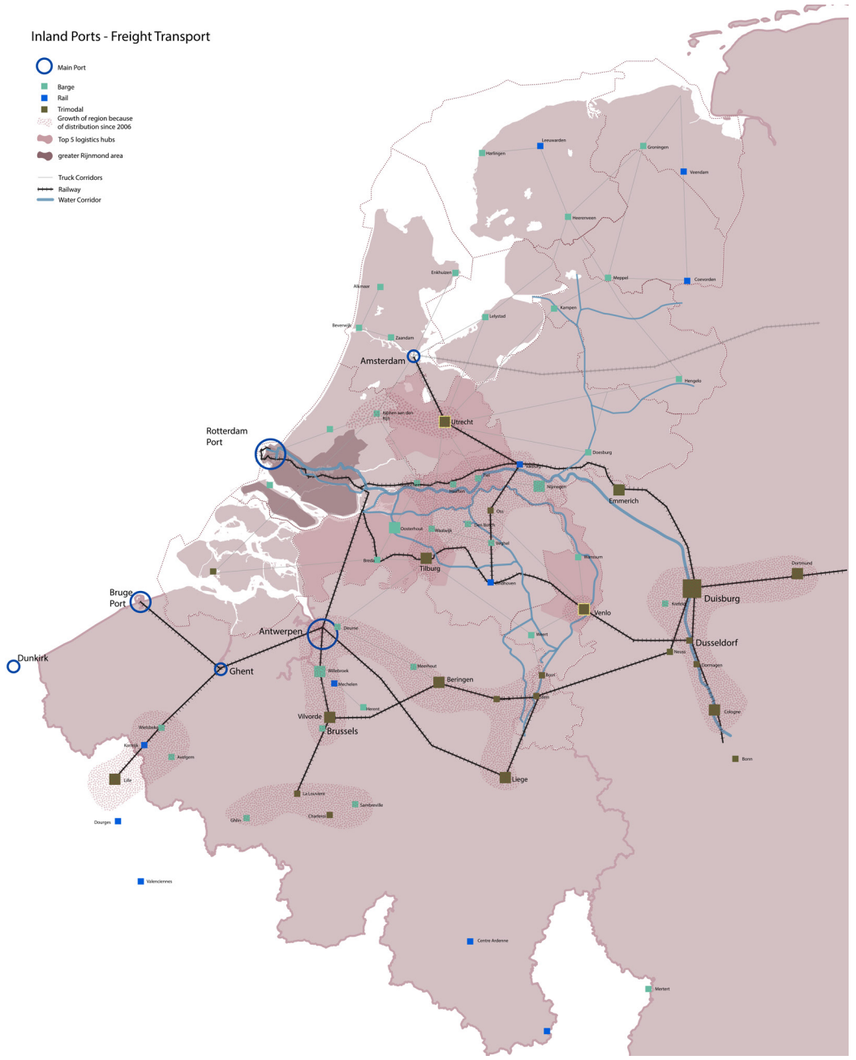


Figure 24. Inland ports: freight transport

Source: Information adapted from Port regionalization in Antwerp and the Antwerp and the Logistieke hotspots van Netheland (2022)

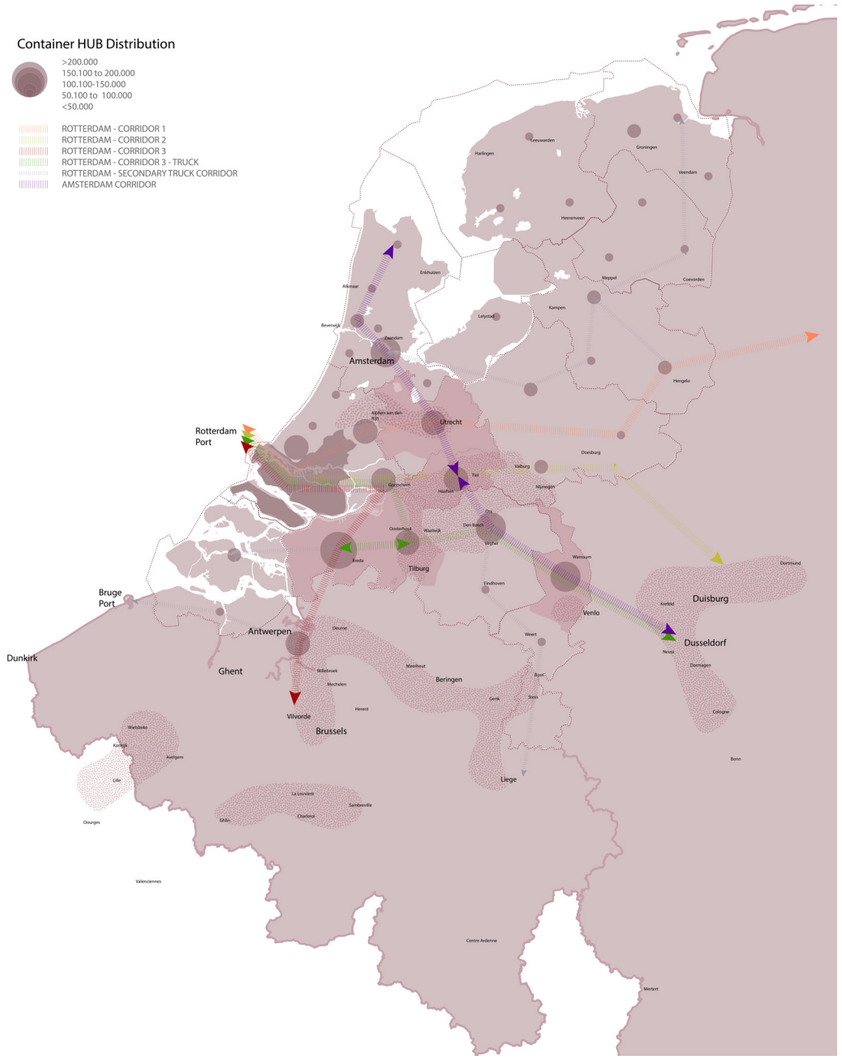


Figure 25. Container nodes

Source: Information retrieved and adapted from Port regionalization in Antwerp and the Antwerp and the Logistieke hotspots van Netheland (2022)

Inland Ports – Freight Transport

This map shows the main connections and distribution centers for freight transport in the Eurodelta region through 3 types of transportation: roads, train and inland waters. Aviation is left out of the map because of the different scale distance of transportation.
It also shows the areas which have developed the most in the last 15 years due to freight growth and the logistics areas along these corridors where most of the import/export is distributed.

Main corridors – Freight Transport

Main corridors of the Rotterdam Port for inland import/export and the relation between the other ports (Antwerp and Amsterdam) within the Eurodelta region.
The yellow, purple and red corridors are a combination between waterways and railways, while the other corridors are mainly heavy trucks (roads).
The bubbles represent the unloaded containers per day carried from the Port of Rotterdam

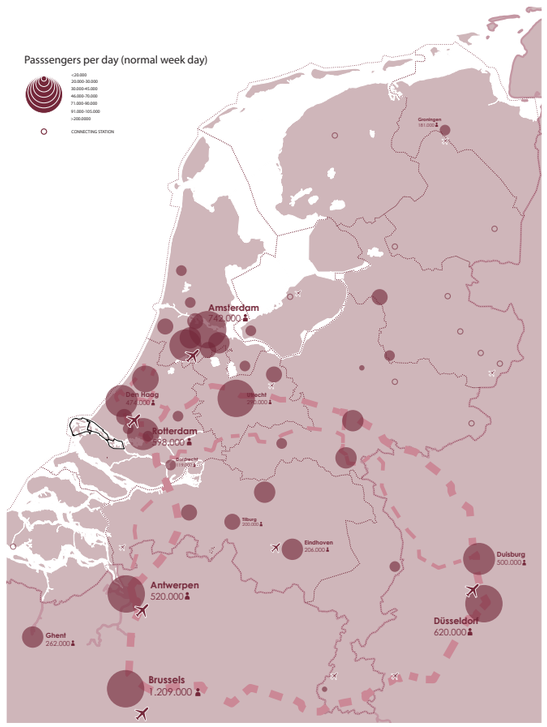


Figure 26. Rails: Main nodes

Source title: Information retrieved from Dutch Railways (NS) passengers per station in 2017 and 2018 (NS, 2019)

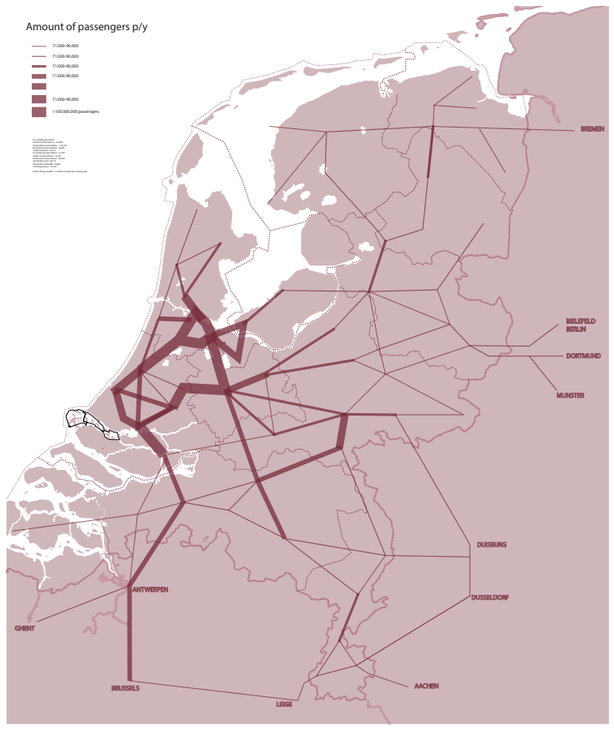


Figure 27. Rails: Main flows

Source title: Information retrieved from CBS 2023

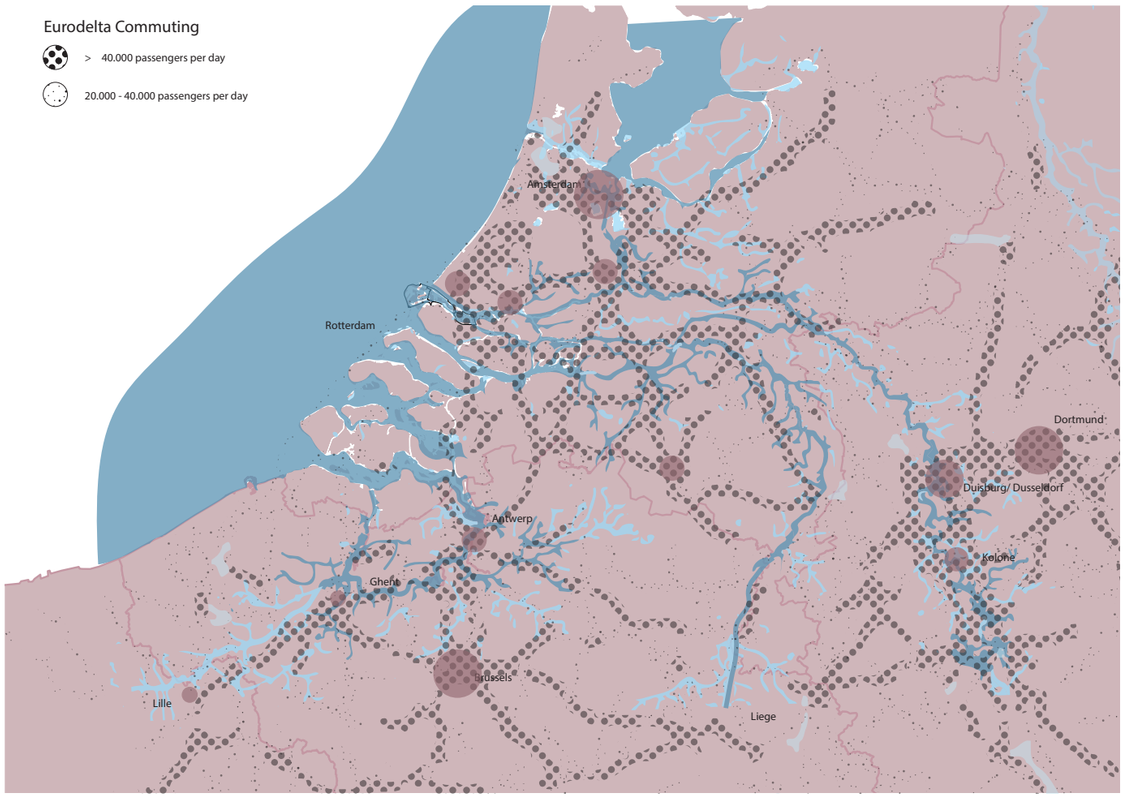


Figure 28. Commuting movements in the region

Source : Information retrieved from STISE – Sustainable Transport Infrastructure in the Strategic Urban Region Eurodelta (Otten et al., 2022).

Eurodelta Commuting:

For passenger transport, accommodating the projected growth in road transport by 2050 will pose challenges on the current network. Most of the highways within the SURE area are heavily used with a daily intensity of over 40.000 vehicles A challenge within the study area is to explore alternative solutions that enable transportation to expand or reuse in a more sustainable manner.

Passengers Commuting – Delta Rhine flows

This map shows the yearly passengers commuting by train within the Netherlands, with some cross-border connections (Antwerp, Brussels, Duisburg and Dortmund). The road commuting is not shown in this map due to a lack of information (origin-destination data) about it.
Information retrieved from CBS 2023

Passenger Commuting – Main stations

This map (in relation with the one before) shows the main train stations and the amount of people movement (arriving and departing) per day for commuting.
It also shows the airports to show the relation between business and commuting travel in the Eurodelta region. However due to a lack of information (origin-destination data) the flows from planes are not shown. (Otten et al., 2022)

Figure 29. Road: Vehicle intensity

Source: Based on Rijkswaterstaat, 2024

Figure 30. Road: heavy traffic intensity

Source: based on Rijkswaterstaat, 2024

THE RHINE DELTA REGION
CONNECTING THE REGION

In the EU, road transport is projected to nearly double by 2050, with expected growth rates of 93% for road, 73% for rail, and 55% for inland waterways. The growth in freight transport is expected to double that of passenger transport, with road freight transport projected to nearly double the volumes of other modalities. Rates across the three modalities from 2010 to 2050, road transport is expected to increase by 58%, rail by 73%, and inland waterways by 41%, with higher growth rates between 2030 and 2050 due to increased quantities of goods transported.

CO_2 emissions and energy consumption from freight transport on roads are significantly lower than those from passenger transportation. A 38% reduction in energy usage by road transport is anticipated by 2050.

In the figure on the right passenger transport towards 2050 is shown in percentages for the entire Eurodelta region for the respective years and the respective modalities. More people are expected to travel in the region by all types of transport (roads, trains, and planes). Roads are getting busier, trains are mostly used within the Euro delta region but also to connect outside areas, and air travel is increasing too (but in a lower percentage than the other two modalities), although the growth might be even bigger than what is predicted because of changes caused by COVID-19.

In our baseline scenario the road transport category -which moves all goods except for bulk goods or containers- is the primary mode of transportation in the Rhine- Waal and Rhine–Scheldt corridors, while rail transport is only 6% and the remaining 37% is moved by inland waterways. Therefore, there is an opportunity for improvement in national and international rail infrastructure and inter-modality nodes for long-distance freight and passenger transport by train.

On the other hand, air and water transport will need significant challenges too to reduce de carbon footprint in the next three decades. "*EU international emissions from navigation and aviation have grown by more than 50% since 1990. Action in these sectors is urgently needed, including as they recover from the current crisis*" (European Commission, 2020) . Especially because there is no innovation in zero-emission technologies, fuels, and life cycles of aircraft and vessels.

Within the European Green Deal, a substantial part of the 75% of inland freight carried today by road needs to shift to rail and inland waterways, promoting short-sea shipping and efficient zero-emission vehicles. Urgent action is imperative considering the limited progress made by now.

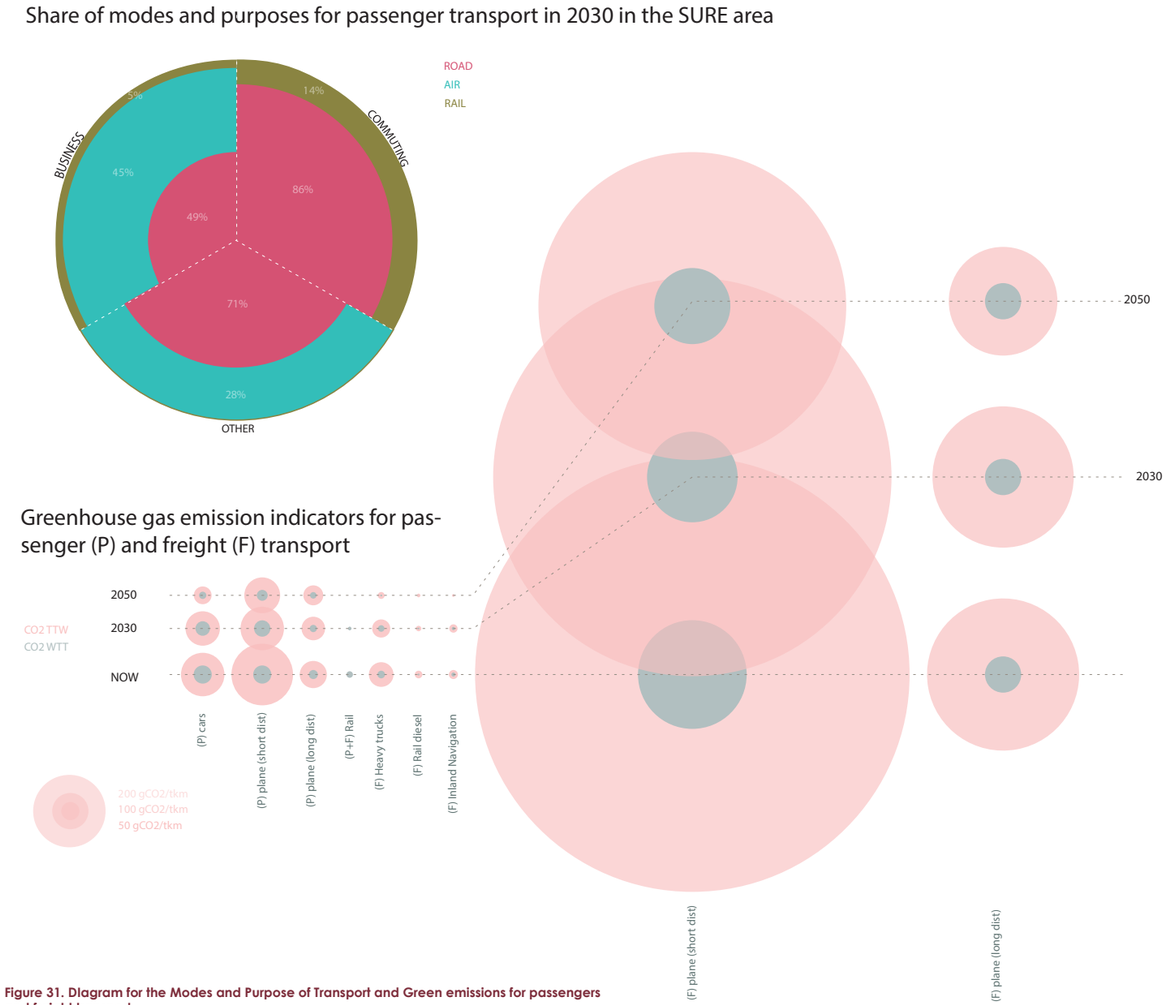


Figure 31. Diagram for the Modes and Purpose of Transport and Green emissions for passengers and freight transport

Made by author based on Information retrieved from STISE – Sustainable Transport Infrastructure in the Strategic Urban Region Eurodelta (Otten et al., 2022)

Modes and purposes for passenger transport in 2030 in the Eurodelta Region
From the figure it can be noticed that the three purposes of passenger movement (business, commuting and leisure-other) use mainly roads, while the train is use only a 6% of the time. Due to the nature of air travel (business and other), the selection of transport combines both internal & internal-external (within the Eurodelta region as well as longer distances travels).

Greenhouse gas emission for passenger (P) and freight (F) transport
The figures show that emissions per kilometer decrease in time for all modes of transport. For both passenger and freight transport, emissions of rail transport are the lowest, emissions by road transport are higher and aviation has the highest emission indicators, but short trips is even worst than longer ones; therfore banning short range planes can be a feasible solution for reducing CO2 emissions in the eurodelta region.

THE RHINE DELTA REGION
AN OVERVIEW

The following chapter summarize the main characteristics of the Rhine-Delta region. It therefore serves as a small recap and be used to get a quick overview of the main characteristics of the region in relation to it is mobility network.

Firstly the Rhine-Delta region is strongly being characterized by it is extensive water network. This water network consists of multiple rivers and other waterways, which reach from the North Sea to the Swiss Alpes. The Rhine-Delta region knows this extensive water network because this region is the place where all of these waterways find their outlet into open waters (the North Sea) (ESPON et al., 2022 and Koteshwar, n.d.).

Mainly, this extensive water network has resulted in two main things that characterize the region. One is that the region has become a very densely populated region. It knows no major metropolis like London or Paris, but knows many slightly smaller cities spread out over the region. This means that the population is not clustered into one large patch of urban tissue, but is rather spread out over multiple patches of urban tissue, spread out over the entire region.
Therefore the region can be perceived as a decentralized network of urban tissue. The vast amount of spread out urban tissue has automatically resulted in a vast amount of peri-urban tissue as well. Peri-urban areas are the areas where urban land cover intersects with rural forms of land cover such as industry, agriculture or nature. All in all results this in the Rhine-Delta region to be strongly characterized by patches of urban and peri-urban tissue (ESPON et al).

The second main element that really characterizes the Rhine Delta region is that it serves as a logistical gate to Europe. As stated before, the extensive water network finds it is outlet into open waters in the Rhine-Delta region. Therefore the region is home to multiple intersections between open water and inland waters such as rivers and canals. The sites around these intersections formed attractive locations for global trade. This has resulted in the development ports such as the port of Antwerp, Amsterdam and Rotterdam. All of these ports have developed into important global logistical nodes, with the port of Rotterdam as it is pinnacle to connect the continent of Europe with the rest of the world. Because these important logistical nodes are in such close proximity to one another within the Rhine-Delta region, the region can be characterized as a logistical gate to Europe (METREX SURE Expert Group, 2019).

Lastly, the region is strongly being characterized by an extensive mobility network. This mobility network has been developed to connect the decentralized network of urban tissue, and to connect the hinterland of Europe to the main logistical nodes. Most of these connections are being facilitated by roads and railways which leave a strong mark on the region. In order to make this mark more clear, the next chapter will focus on the implications the mobility network has on the Rhine-Delta region. In order to make this more comprehensible, we have divided this impact into three main categories.

1. Impact of CO2-emission
2. Spatial impact
3. Social impact

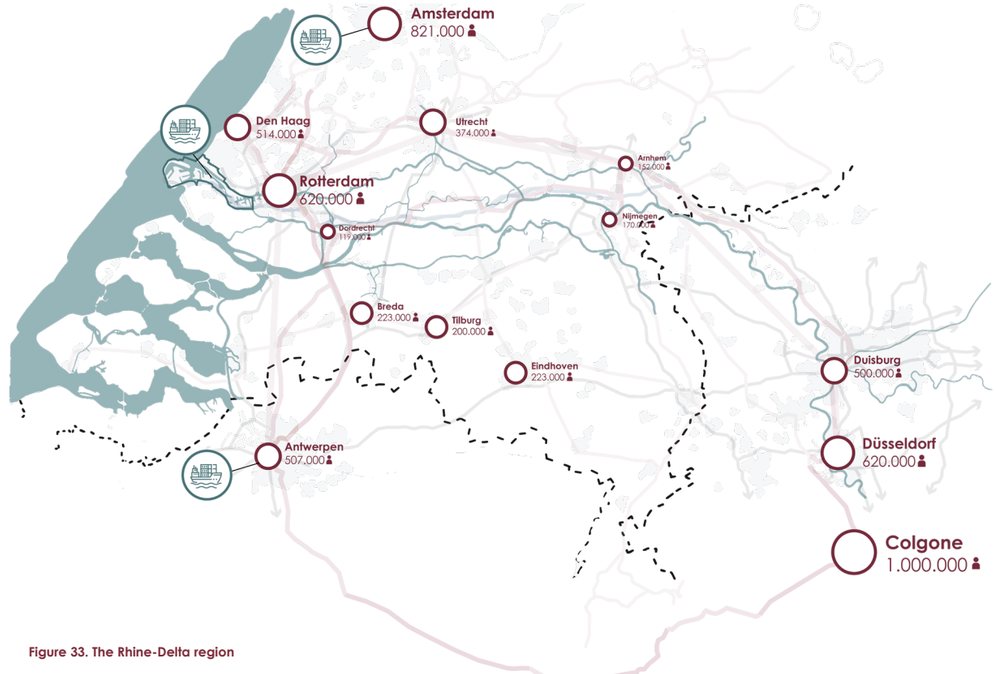


Figure 33. The Rhine-Delta region
Source: Author's work

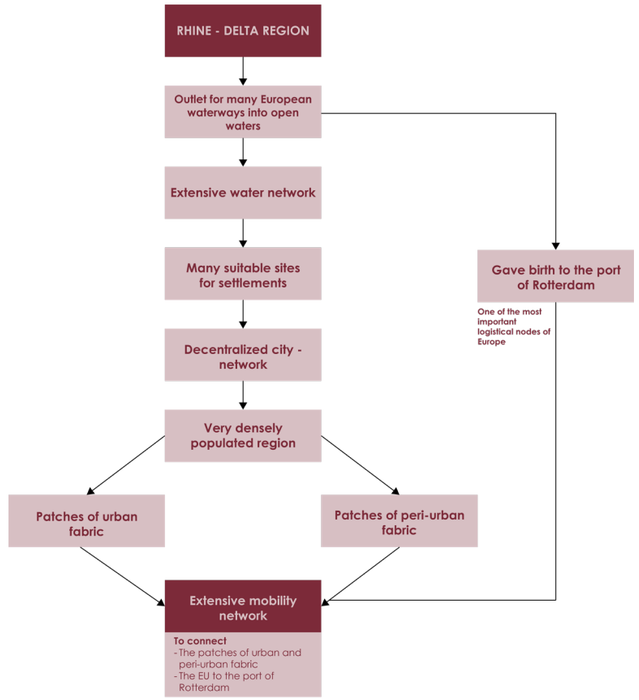


Figure 32. The Rhine-Delta region: a schematic overview
Source: Author's work

IMPLICATIONS ON THE REGION

1. IMPACT OF CO_2

When talking about a CO2 neutral mobility network, we mean a network that emits as much CO2 as it captures. This does not mean the mobility can not emit CO2 at all, but we do have to aim to emit as little CO2 as possible. Looking at the impact of mobility by CO2 there are two main categories of CO2 emissions. There is CO2 emittance during the production of vehicles and the construction of infrastructure and there is CO2 emittance because of the emissions the vehicles produce. For this project we mainly focus on the CO2 emittance from the second category.

CO2 emittance by vehicles

Different types of transportation emit different amounts of CO2. For personal transport the two most polluting types of transportation are the fuel-based car and the car on diesel, as seen in table 39. The hybrid and electric car are better alternatives, but still emit a lot of CO2. Unfortunately, while the car is the most polluting type of transportation, it is also used most. Public transport emits on general less CO2 per travel kilometre. Especially the electric train emits very little CO2 per travel kilometre. Biking and walking emit no CO2 at all per travel kilometre.

For freight transport the three most important means of transportation are by truck, by ship and by train. From these three the most polluting one is the truck. This is also the type of transportation that is used most. This is not the desirable situation. The train emits the least amount of CO2, but is also used significantly less.

Overall, we can conclude that road transport in both personal and freight transport emits the most CO2, but is also the type of transportation that is used most.

Transportation flows

To understand the impact of the mobility network on the CO2 emissions, we also have to understand where most movements take place. For the personal movements in The Netherlands, most (car)traffic takes place from north to south in the Randstad, connecting Amsterdam, Utrecht, The Hague, Rotterdam, Eindhoven, and Antwerpen/Brussels. For the freight traffic there is a stronger focus on the east to west corridor, connecting the harbour of Rotterdam with Germany.

Figure 35. CO2 emittance corridors

Source: based on Climate Action, 2019; Mulholland, Ragon, & Rodríguez, 2023; and Rijkswaterstaat, 2024

Figure 36. Road: Main personal vehicle corridors

Source: Author's work

Figure 37. Road: heavy traffic corridors

Source: Author's work

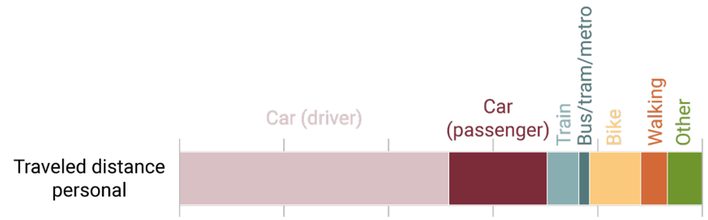


Figure 34. Peronal mobility in The Netherlands from people older than 6 years old in 2021

Source: CBS, 2022

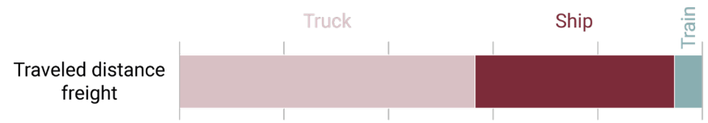


Figure 38. Freight mobility in The Netherlands in 2021

Source: Panteia, 2022

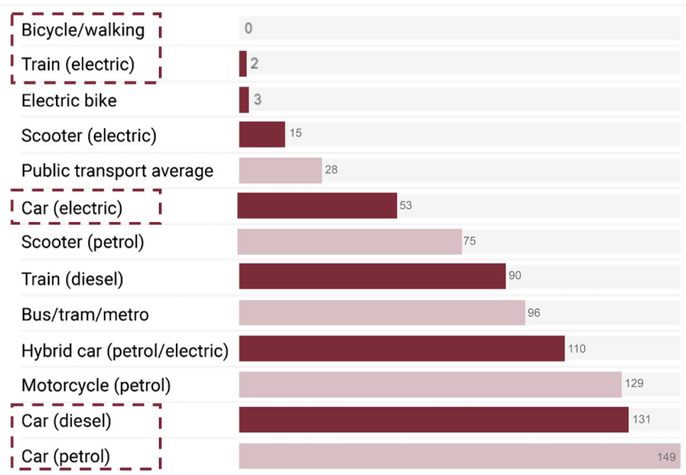


Figure 39. CO2 emittance per travel kilometre (in gram)

Source: Milieu Centraal, 2024

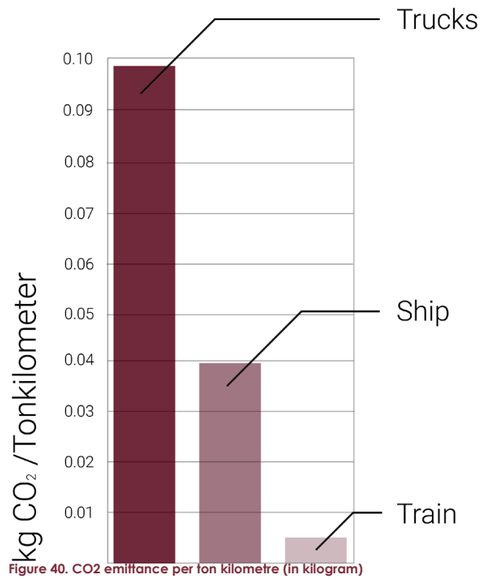


Figure 40. CO2 emittance per ton kilometre (in kilogram)

Source: Panteia, 2022

IMPLICATIONS ON THE REGION
2. SPATIAL IMPACT

Figure 41. TOD principle

Source: Aerial images retrieved from holland.com (for Rotterdm) and ourlandandandwater.nz (for periurban)

Now that we now that the Rhine – Delta network is being characterized by a vast patchwork of urban and peri-urban areas, we can dive deeper into how these characteristics are spatially affected by the mobility sector. Under spatial impact we understand the impact the mobility network spatially has on peri-urban areas. The development of new mobility networks (i.e. infrastructures and buildings) can create both opportunities and threats for urban development. This chapter is divided into three subchapters to give proper insight in the spatial implications on the characteristics of the Rhine-Delta region.

Spatial trends and concepts regarding sustainable mobility

Mobility networks can create spatial opportunities because they create room for spatial trends and concepts that promote the use of sustainable forms of transportation. Examples of this can be multi modal corridors, nodal development or transit oriented development. These concepts focus on clustering key functions such as housing, education, employment, leisure, etc. within walking or cycling distance around public transit networks. The downside of this however, is that these developments only tend to work in urban areas with high density.

IMPLICATIONS ON THE REGION

2. SPATIAL IMPACT

This poses a challenge when trying to apply these concepts on areas that lack this density. This is especially relevant in the Rhine-Delta region because it knows a lot of peri-urban areas. These areas have typically lower density then urban areas. Since they lack this density they are now mainly accessible by cars. As stated before, car-use is one of the most polluting forms of transportation. Therefore, peri-urban areas would strongly benefit from spatial concepts that promote the use of sustainable transportation. Unfortunately the current spatial trends and concepts do not seem to apply to these areas. Posing an issue when trying to apply these concepts on peri-urban areas in order to make them more connected through sustainable forms of transportation (Vanoutrive et al., 2022).

Because concepts such as transit oriented development now only seem to work in dense areas, they seem to have an urban bias. In order to successfully apply these concepts on peri-urban areas now, it would require the peri-urban to transform into a city centre. (Vanoutrive et al., 2022). This would be unrealistic and above all, it would only shift the problem. Developing current peri-urban areas to have higher density would mean that they become urban centre's in itself. This would mean that on the edge of these centres, new peri-urban areas will emerge, which will deal with the same issue as before. To simply state, densifying the peri-urban areas to make spatial concepts such as TOD economically feasible does not solve the real problem.

The root of the problem is in fact that rural areas, such as the peri-urban, have long been neglected and overlooked when looking for solutions to make mobility networks more sustainable. Research suggests that concepts such as TOD solely rely on an urban context. They currently do not take the local context into account, which causes these concepts to not function well in areas with a context other than urban (Vanoutrive et al., 2022).

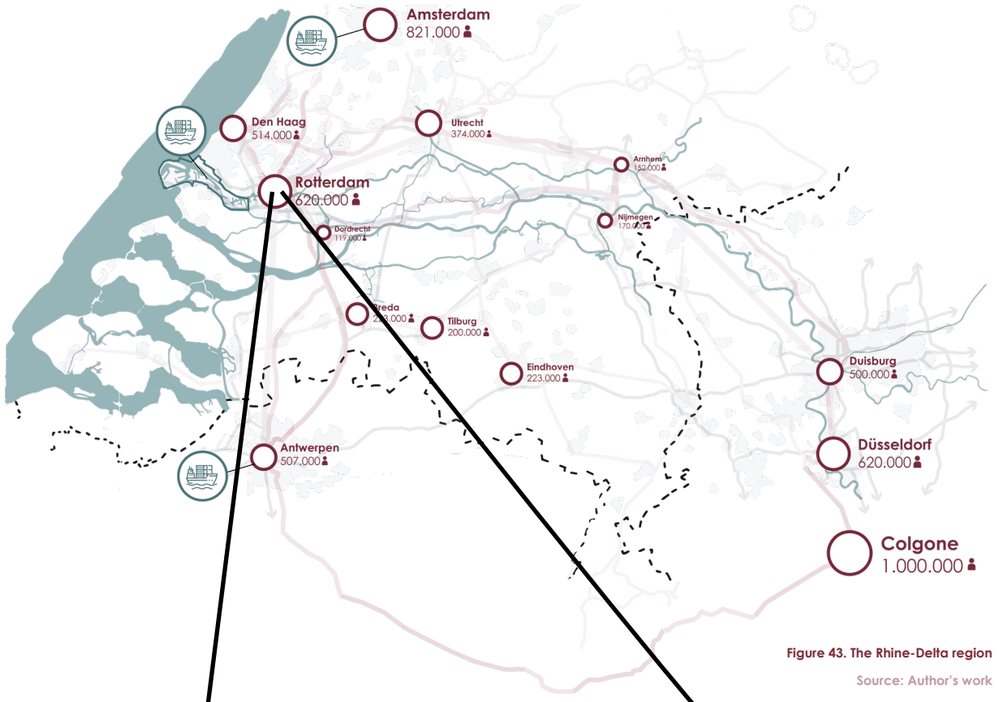


Figure 43. The Rhine-Delta region

Source: Author's work

Figure 42. Spatial concept: 15 min city

Source: Carlos Moreno, 2024

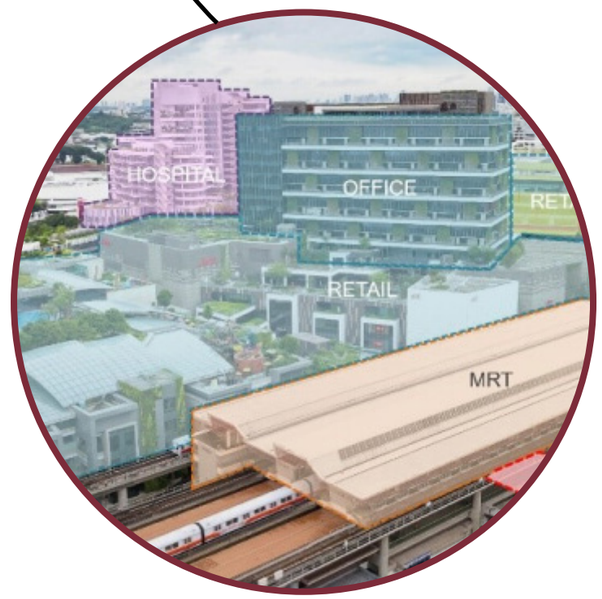


Figure 44. Spatial concept: Transit oriented development

Source: Association of Southeast Asian Nations

IMPLICATIONS ON THE REGION

2. SPATIAL IMPACT

Mobility networks: connecting and disconnecting us at the time
While mobility networks are meant to connect us. They can ironically also disconnect us. Right now, the mobility network of the Rhine-Delta region tends to connect the different patches of urban tissue to each other. But the spaces in between, such as the peri-urban areas are being disconnected by the mobility network.

This is because on the large scale the mobility network consists of large rigid infrastructures such as highways, railways, waterways, ports and airports. These cause the land in between the urban patches (and sometimes even within these patches) to be completely cut off from each other. The phenomenon that occurs when land covers are divided from each other by large infrastructures is called 'barrier effect.' (figure 45 & 46). While the implications of this may strongly be felt on the social level, the core of this issue lies within the spatial domain (Van Eldijk et al., 2022).

Figure 45. Barrier effect
Source: Google Maps

Figure 46. Barrier effect
Source: Google Maps

Car-centric development
Last but not least is the impact the car-centric development has had on the urbanization of the Rhine-Delta region. As stated in the paragraph above, the Rhine-Delta region has many large infrastructures that connect the patches of urban tissue. It is important to note that many of these infratructures are monofunctional highways. They are monofunctional because the highways form a rigid corridor that is only being used for one mode of transportation. The extensive car-infrastructure can be felt throughout the whole region and stretches from the regional scale to the city and neighbourhood scale. This is mainly due to the fact of the car-centric urbanization that has taken place over the last 50 years (Burton, 2024).

Since the emergence of the car the region has been urbanized through the perspective of the car-user. Now that we know that car-use is one of the most polluting forms of transportation, we need to reduce the car use and increase the use of more sustainable forms of transportation such as cycling, walking and public transit. In order to facilitate this large changes in the built environment are required because so much of our urban tissue, as well as the rural areas have been developed through a car-centric perspective. If we want to make these areas better accessible by sustainable forms of transportation we need to rethink and redesign the mobility network through a people-centric perspective. Luckily this trend has already started. In many cities we are already rethinking and redesiging lots of public spaces to feel more comfortable and safer for pedestrians and cyclists (Burton, 2024).

Figure 47. Car-centric vs people-centric development
Source: Burton, 2024

In conclusion:
All in all can be said that the spatial implications play a pivotal role in making the mobility network of the Rhine-Delta region more sustainable. The first main takeaway from this chapter is to find ways on spatial concepts, that promote the use of sustainable transport, can be applied on lower density areas, such as the peri-urban. Secondly it is important to reduce the barrier effect of the current infrastructures and make these infrastructures multifunctional. Through this way the rigid existing corridors can be used more efficiently by using them for multiple forms of more sustainable transportation. Lastly, it is important to develop through a people-centric perspective when rethinking and redesiging the mobility network of the Rhine-Delta region.

IMPLICATIONS ON THE REGION

3. SOCIAL IMPACT

The mobility network has, besides its spatial impact, also a social impact. An interesting aspect is travel behaviour. In this chapter we look into why people choose the transportation mode they choose and what aspects have an influence on this choice. This chapter also includes the influence of the mobility network on inequality. Lastly, this chapter ends with public transport accessibility.

Travel behaviour

Various studies have explored travel behaviour. One of these studies is from Selzer and Lanzendorf (2022) about the context of travel behaviour, to improve understanding of everyday mobility. Their conclusion is that people's emotions and feelings play a significant role in determining their choice of transportation. These feelings get influenced by factors like personal competence, physical environment, personal and social circumstances and daily routines like family, work and leisure. Examples of these personal and social circumstances include attitudes, norms, habits, needs, experiences, and preferences. Cao, Xu, & Fan. (2010) also describe time restrictions, costs and accessibility as factors that affect travel behaviour.

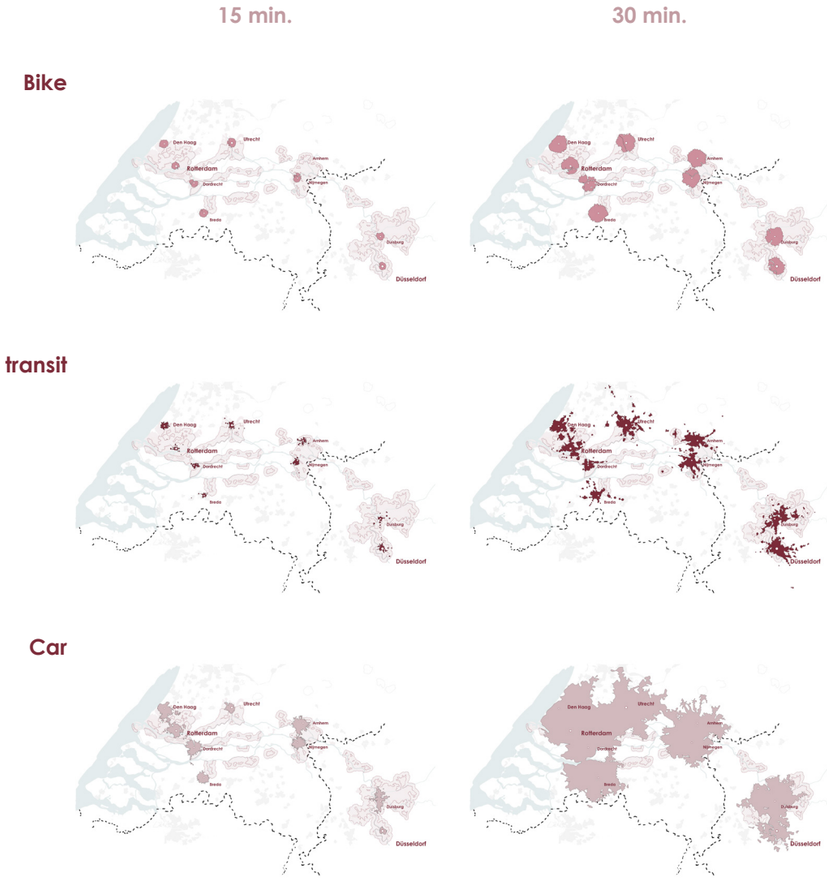


Figure 48. Travel distance with different types of transportation

Author's work based on TravelTime, 2024

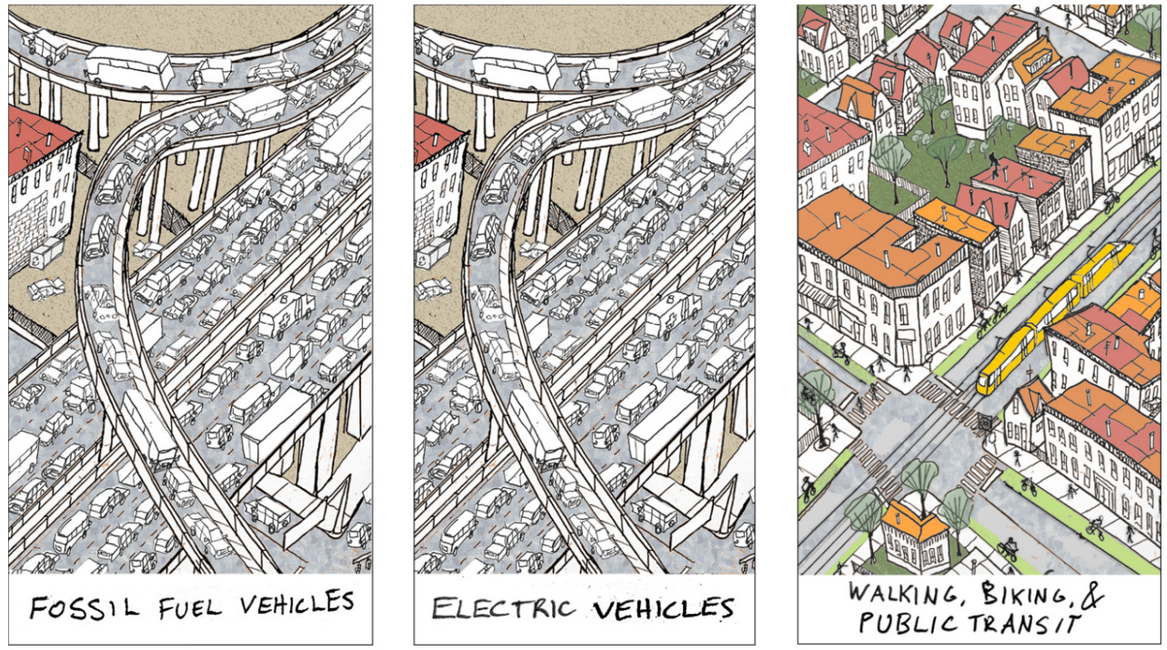


Figure 49. The need to change our travel behaviour

Source: Antonio Huerta

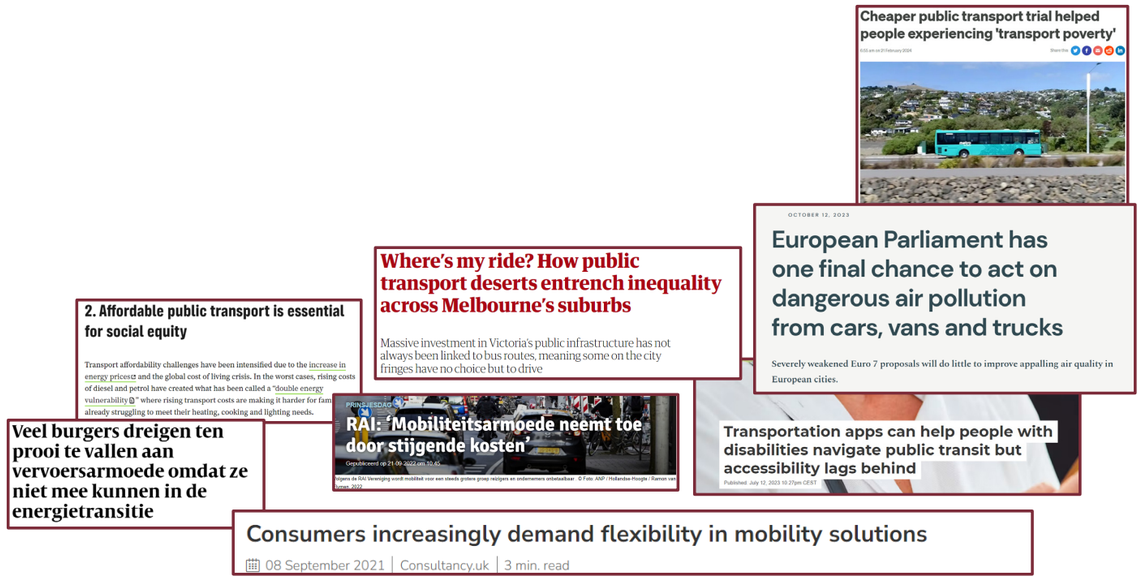


Figure 50. News articles about the social impact of the mobility network

Source: different news sites

IMPLICATIONS ON THE REGION

3. SOCIAL IMPACT

Transit and mobility poverty

When looking at the social impact the mobility network has on people, the mobility network does not serve society equally. This is often described as transit poverty and mobility poverty. These two terms are related to each other, but do have a different meaning. Transport poverty occurs when someone cannot participate sufficiently in social life due to a lack of transport options. Transport poverty is objective; is someone (physically, mentally, financially, etc.) able to use a certain type of transportation. Mobility poverty is subjective. Besides from having the ability to use a certain type of transportation, the person must also want and dare to use this transportation (trust, freedom, experiencing autonomy and cultural preferences) (MuConsult, 2023). Jorritsma et al. (2018) describes a list with causes for mobility poverty; location, economy, physical abilities, mental abilities, time, safety, and digital competence.

Lucas & Jones (2012) found out that certain demographic groups experience more negative effects of the mobility network than others. For example: children and young people, older people, single parents, disabled people and ethnic minority populations are groups that are more vulnerable for mobility poverty. These uneven outcomes reduce people's ability to fully participate in society and can lead to social exclusion. This is very difficult to measure and quantify.

Public transport accessibility

Currently, the car is used most as type of transportation. This is mainly due to travel behaviour and consumer behaviour. The car is usually the fastest way of transportation (especially on longer distances), most people have a car right in front of their house, it is cultural embedded in our daily lives, and the car gives a feeling of independency. However, as seen in earlier chapters, the car emits a lot of CO2, and takes up a lot of space in the city. More sustainable alternatives are public transport, cycling, and walking.

A way to measure how accessible a place is by public transport is with the PTAL (Public Transport Accessibility Level). This is calculated with walking time to a stop/ cycling time to a station, the number and type of modalities, frequency of the modalities, and reliability of the modality. In the map 52 is the PTAL score shown for the municipalities in The Netherlands.

In peri-urban and rural areas there are little alternatives other than the car. In these areas there is limited access to public transport. There is not a lot of public transport, the public transport there is has a low frequency, and is less reliable than in more urban areas. Services (school, work, shops, leisure) are in these areas on average further away, so walking and cycling is not always an option. Our current travel behaviour (mainly car use) maintains this car dependency and will result in more investments in road infrastructure.

Circumstances	Relation with mobility poverty
Location	Important facilities, such as shops, schools, medical care or other facilities, are located far away from the residential location and/or the transport facilities at the residential location are poor (nearest stop far away, low frequency)
Economy	The high costs of transport can prevent or limit access to facilities or work (low income)
Physical	Physical limitations make it difficult to use transport services. The lack of facilities for people with a physical disability and a lack of information about those facilities are also an obstacle
Mental	Mental disabilities, including intellectual disability, social disorders or low literacy make it difficult to use transport services
Time	Work, housework and care for children and/or parents reduce the time available for travel (time poverty)
Safety	Fear for personal safety precludes the use of public spaces and/or transport services (social safety)
Digital	No or poor access to the internet, no or few digital skills, which makes it more difficult, for example, to find information about public transport or to use new (partial) services

Figure 51. Causes of mobility poverty

Source: Jorritsma et al., 2018

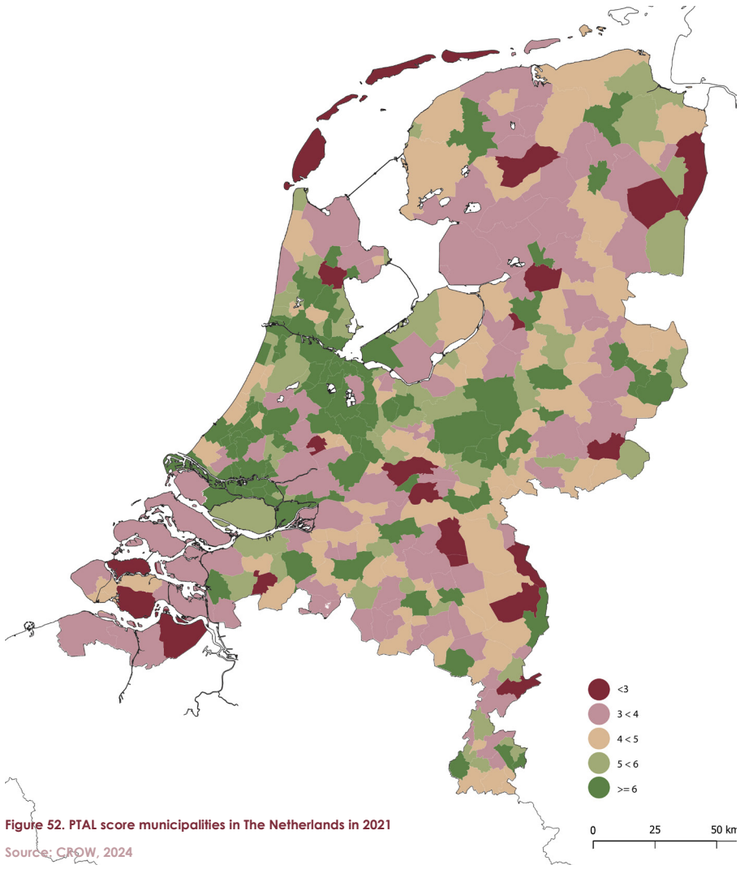


Figure 52. PTAL score municipalities in The Netherlands in 2021

Source: CROW, 2024

4.

PERI-URBAN AREAS

THE KEY TO A CO2-NEUTRAL MOBILITY NETWORK

PROBLEM STATEMENT

Conclusions

What are the current characteristics of the Rhine-Delta region?
The region is strongly being characterized by an extensive water network. This network has resulted the region to be a densely populated region which resulted in a decentralized network of urban- and peri-urban tissue. The region also serves as a logistical gate to Europe. Therefore the region also has a strong logistical character.

How does the mobility network of the Rhine-Delta region currently function?
The mobility network of the Rhine-Delta region as an extensive mobility network. This network mainly consists of roads, rail- and waterways. The patches of urban tissue are mainly connected by road and railway connections. The peri-urban patches are mainly connected by road.

What is the impact of CO2 pollution on the quality of life in the Rhine-Delta region?
The pollution of CO2 causes a significant decrease in the quality of life. It has a direct impact on our health for people living close to the mobility network. The indirect impact comes from CO_2-emittance contributing to global warming.

What is the spatial and social impact of the mobility network on the region?
Both spatially and socially, the mobility network generates threats and opportunities. It is also important to note that spatial- and social impact often go hand in hand. The mobility network offers social opportunities when using the network for spatial concepts that promote the use of sustainable transportation. The threat of this however, is that these concepts do not seem to work well in the peri-urban areas that are characteristic for the Rhine-Delta region.

How do we reduce the CO2-emittance by the mobility network in the Rhine - Delta region?
In order to reduce the CO2-emittance in the Rhine-Delta region we need to focus on making the peri-urban areas better accessible by sustainable forms of transportation. For this we need to find ways on how spatial concepts that promote the use of sustainable transportation can succesfully be applied on the peri-urban.

How do we apply spatial trends and concepts to promote the use of sustainable transportation on peri-urban areas?
Spatial concepts that promote the use of sustainable transportation need to acknowledge and appreciate their local context. The current concepts have an urban bias. Therefore these concepts only work well in an urban context. In order to succesfully apply these concepts on peri-urban areas, they need to be developed while acknowledging the local context. This means that these concepts need to embrace the characteristics of the surroundings of where they are situated.

How do we apply these spatial trends and concepts in a socially just way on the mobilit y network of the Rhine-Delta region?
For this, the mobility network should serve everyone and all functions equally. This means that the mobility network provides equal access to key socioeconomic functions for everyone. While developing spatial concepts that promote the use of sustainable transport, this needs to be taken into account. In specific, an accessible mobility network means that everybody can access affordable, safe and accessible forms of transportation within a reasonable walking-walking distance.

Problem Statement

All in all can be stated that in order to make the mobility network of the RDR CO2-neutral, the focus needs to be on the peri-urban areas. In terms of sustainability, the these are the areas where the mobility network can be improved the most. This is currently a challenging task because the spatial concepts that have been developed to promote the use of sustainable transportation do not work well in low density areas such as the peri-urban. Therefore, we need to rethink and redesign how the mobility network in peri-urban areas can facilitate these spatial concepts.

5.

THE RHINE-DELTA REGION

AN INTERCONNECTED NETWORK OF ‘CONTEXT BASED’ MOBILITY NODES

VISION STATEMENT & GOALS

VISION STATEMENT

Mobility is a huge aspect of the Euro Delta Region, it has one of the best-connected transport networks in the world thanks to the Port cities within (Port of Rotterdam, Antwerp, and Amsterdam), enabling economic and social activities, including commuting, tourism, and supply chain operations. Moreover, this region is the most densely populated area in Europe, with a very compact and urban tissue, where the free movement of people and goods has encouraged economic, social, and cultural interactions, promoting cohesion and strengthening European identity.

However, while mobility within the region offers numerous benefits, it also imposes significant costs on society and the environment. These large road infrastructures built after WWII use more than 50% of the land and lack resilience for climate changes developments, including the heat island effect, flooding, greenhouse gas emissions and pollution, as well as accidents, congestion, and biodiversity loss. All of which impact health and well-being.

The main challenge facing the transport sector is the urgent need to reduce emissions and promote sustainability. Its monofunctional design and use has become obsolete in contemporary cities that are moving towards a more circular way of life and a pedestrian-focused urbanity. Therefore, a transformation of the infrastructure represents an incredible opportunity to accommodate new programs that will help achieve the EU's greenhouse gas reduction targets and climate neutrality goals by 2050.

To achieve this, we have developed a regional strategy for the Euro delta region where we have proposed (1) making all transport modes more sustainable, (2) making zero emissions alternatives widely available in a multimodal transport system, (3) reusing existing infrastructure and redesign it towards a connected multimodal node system for freight and passengers and (4) put in place the right incentives to drive the transition. These are the four pillars of our future actions.

GOALS

- make the mobility network CO2-neutral: meaning that the network captures as much CO2 as that it emits.
- make peri urban more accessible ways through sustainable forms of transportation

ACHIEVING THESE GOALS

In order to achieve these goals 5 principles have been formulated. These principles will guide us in redesiging the mobiltiy network of peri-urban areas in the Rhine-Delta to become more sustainable. The focus on these principles is on making the peri-urban areas better accessible by sustainable transportation, as well as using the current network more efficiently.
The principles are as follows;

1. Bring peri-urban areas within 45 minutes from the urban
2. Connect peri-urban areas through sustainable transportation
3. Manage and reduce the transit- and mobility poverty
4. Build further upon the network that we already have
5. Transform monofunctional mobility corridors into multi-modal corridors

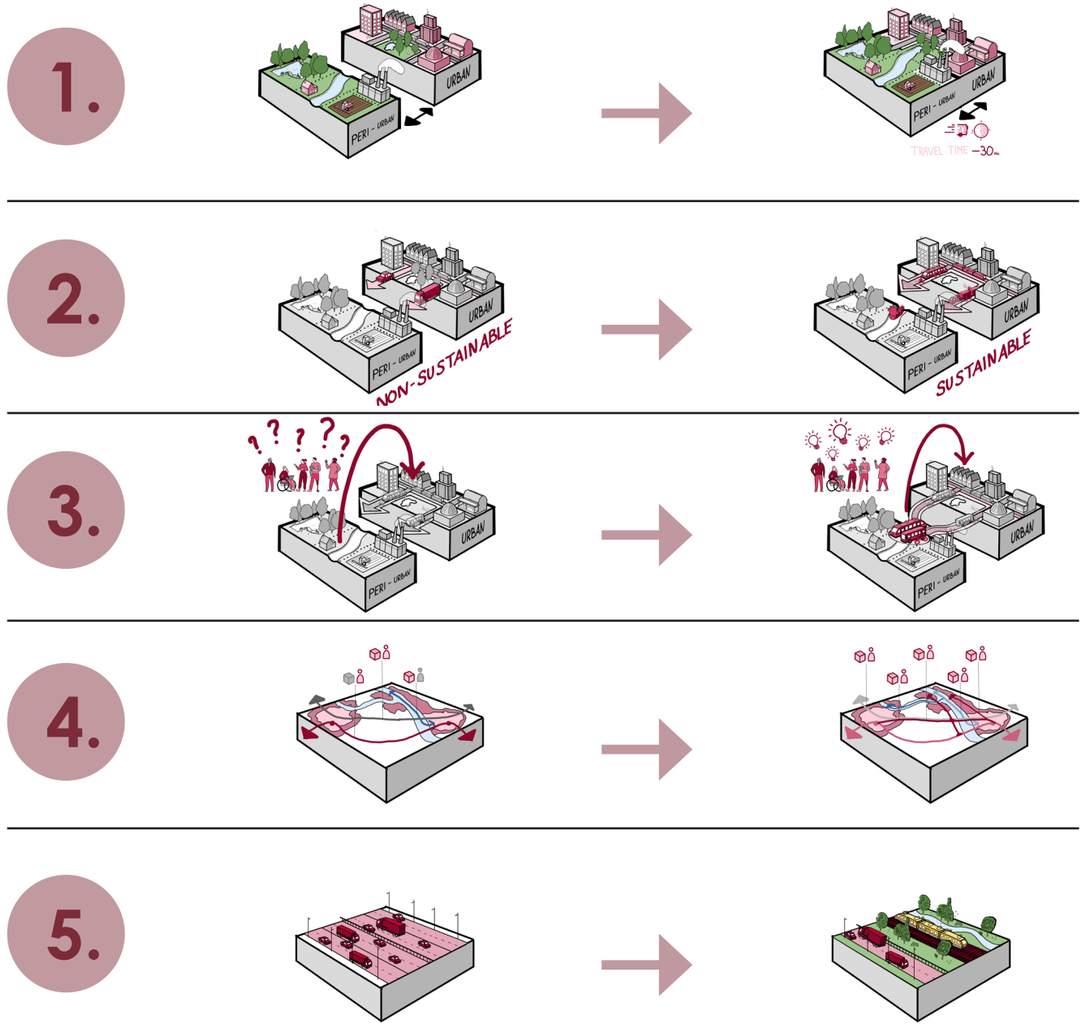


Figure 53. Design principles

Source: Author's work

VISION

AN INTERCONNECTED NETWORK OF CONTEXT BASED MOBILITY NODES

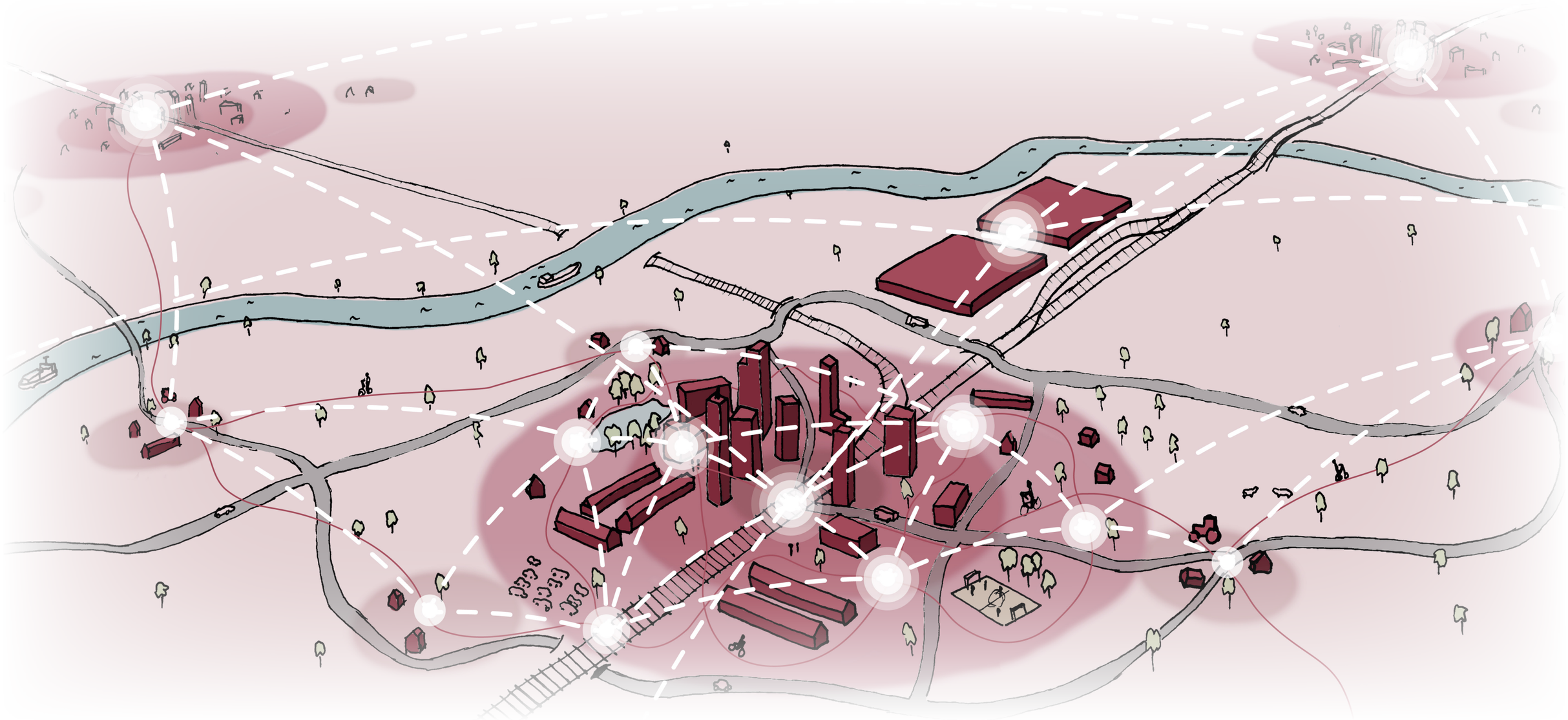
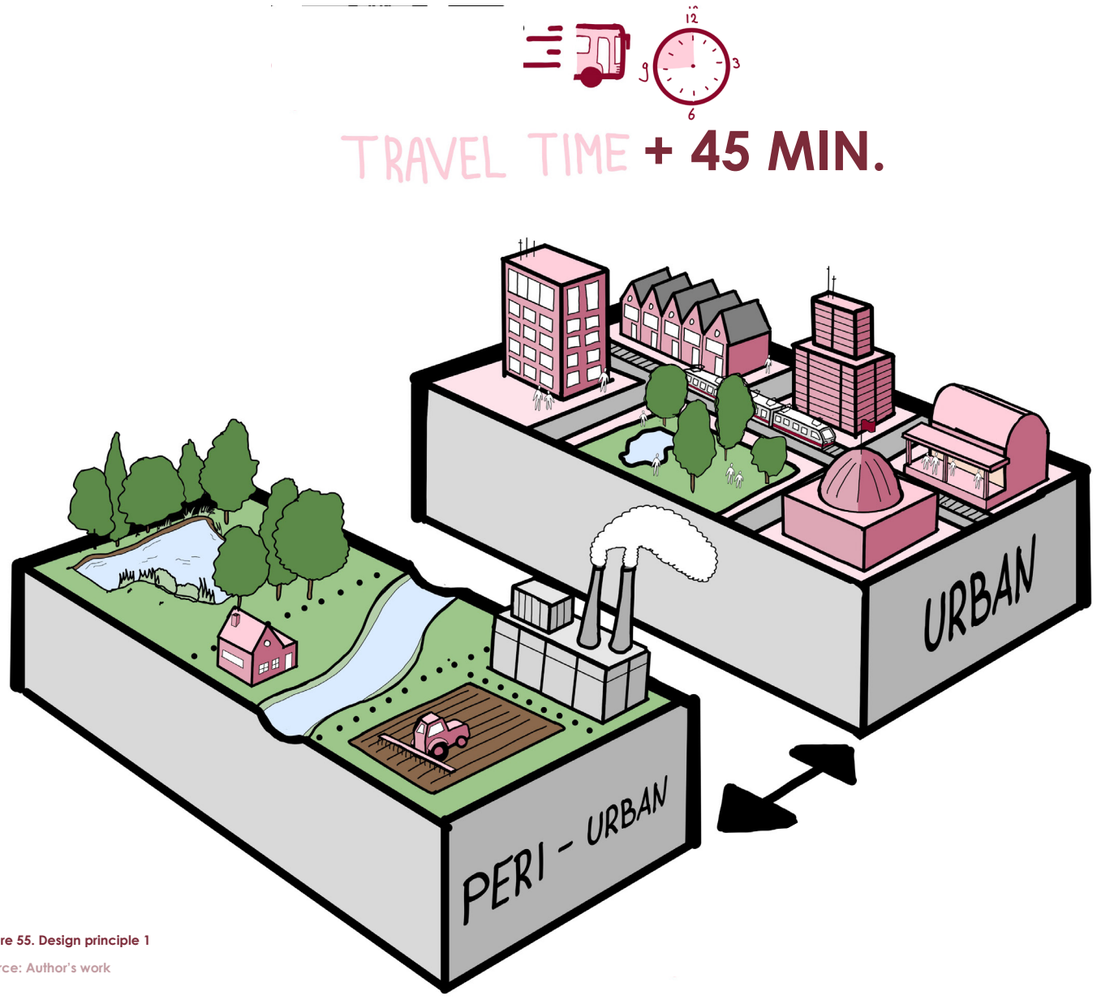


Figure 54. Vision diagram

Sourc: Author's work

PRINCIPLE 1

BRING PERI-URBAN AREAS WITHIN 45 MINUTES FROM THE URBAN



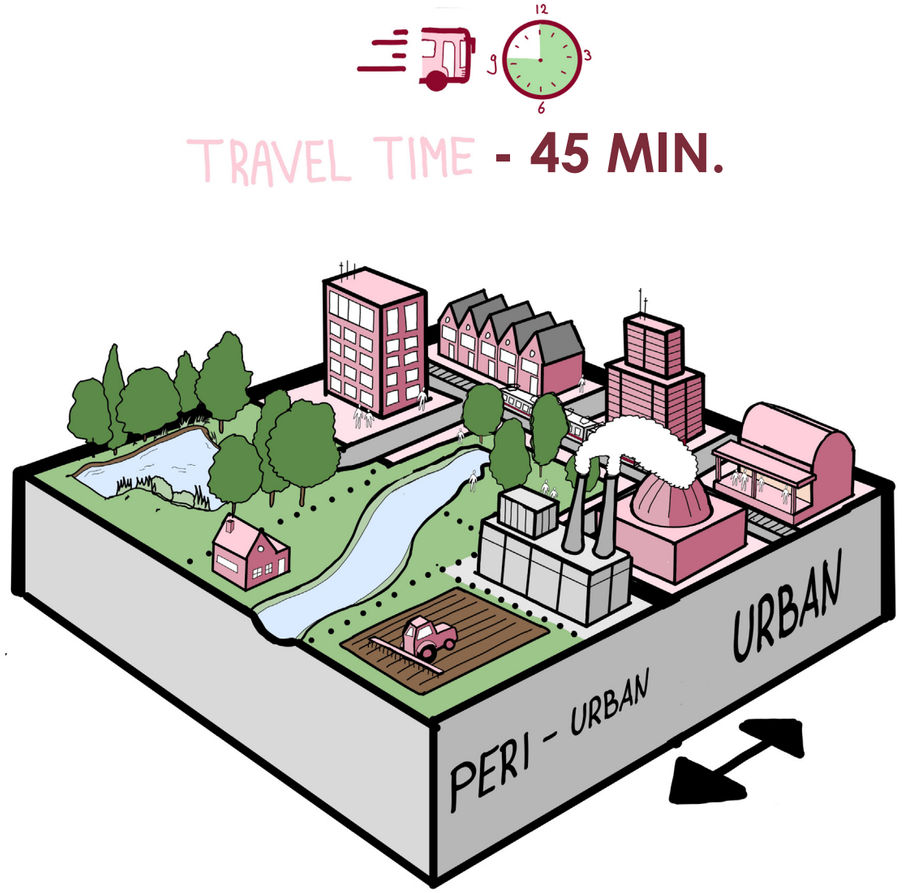


Figure 55. Design principle 1

Source: Author's work

The first principle focusses on making the peri-urban areas of the Rhine-Delta region to be accessible within 45 minutes of the urban at all times. Right now the peri-urban areas are difficult to reach within a reasonable amount of travel time. Therefore these areas feel like they are really far away from the urban, while distance-wise they may not be that far. By making the peri-urban accessible from the urban within 45 minutes the peri-urban areas are brough closer to the urban. Through this the peri-urban will become a more integral aspect of the city.

PRINCIPLE 2

CONNECT PERI-URBAN AREAS THROUGH SUSTAINABLE TRANSPORTATION

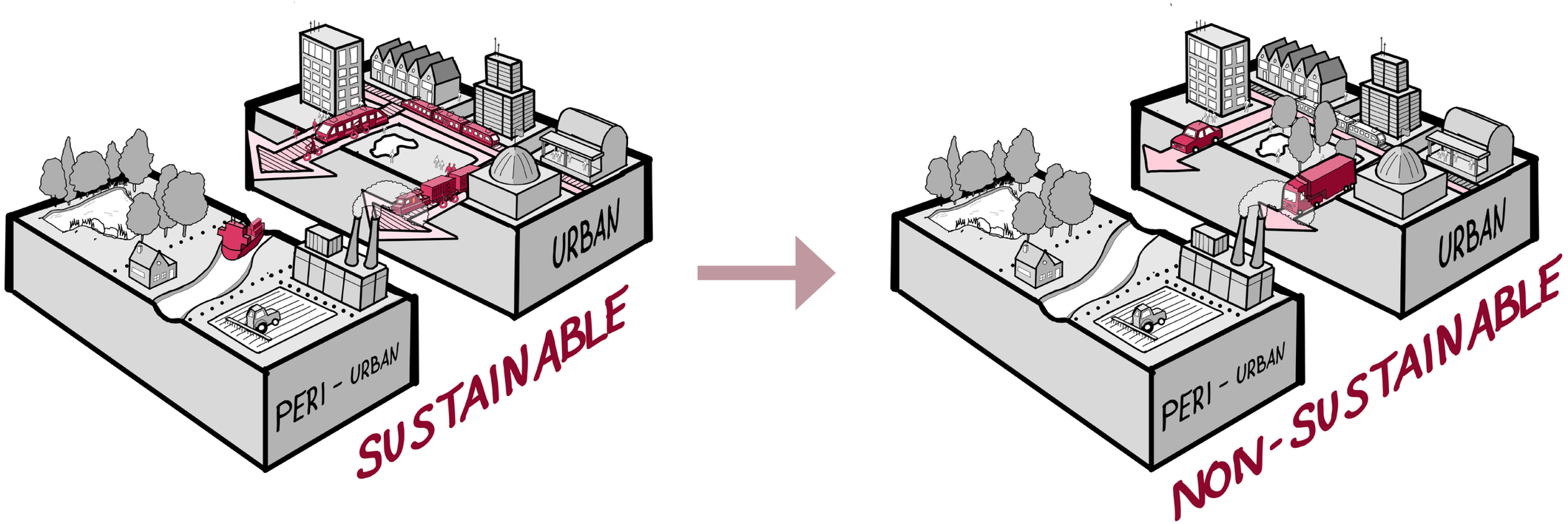


Figure 56. Design principle 2

Source: Author's work

Where the first principle focusses on bringing the peri-urban closer to the urban. The second principle focusses on how this should be done through sustainable transportation. In order to do this the focus on how the peri-urban is not connected needs to shift. In practice, the connections by cars need to make way for more sustainable forms of transportation. For people transit this means better accessibility by public transit, cycling, walking, shared- and micro mobility. For logistical transit this means improved infrastructure for rail- and water transportation.

It is important to note that with the electrification of cars, car-use will still be an important mode of transportation. However, the use of cars will be heavily reduced. But since cars will not completely be removed it is important to still maintain good accessibility for road transportation. This will be a balancing act though. If the car-infrastructure will remain too attractive, it poses a threat that other, more sustainable, forms of transportation might not be utilized to their full potential.

PRINCIPLE 3
MANAGE AND REDUCE TRANSIT- & MOBILITY POVERTY

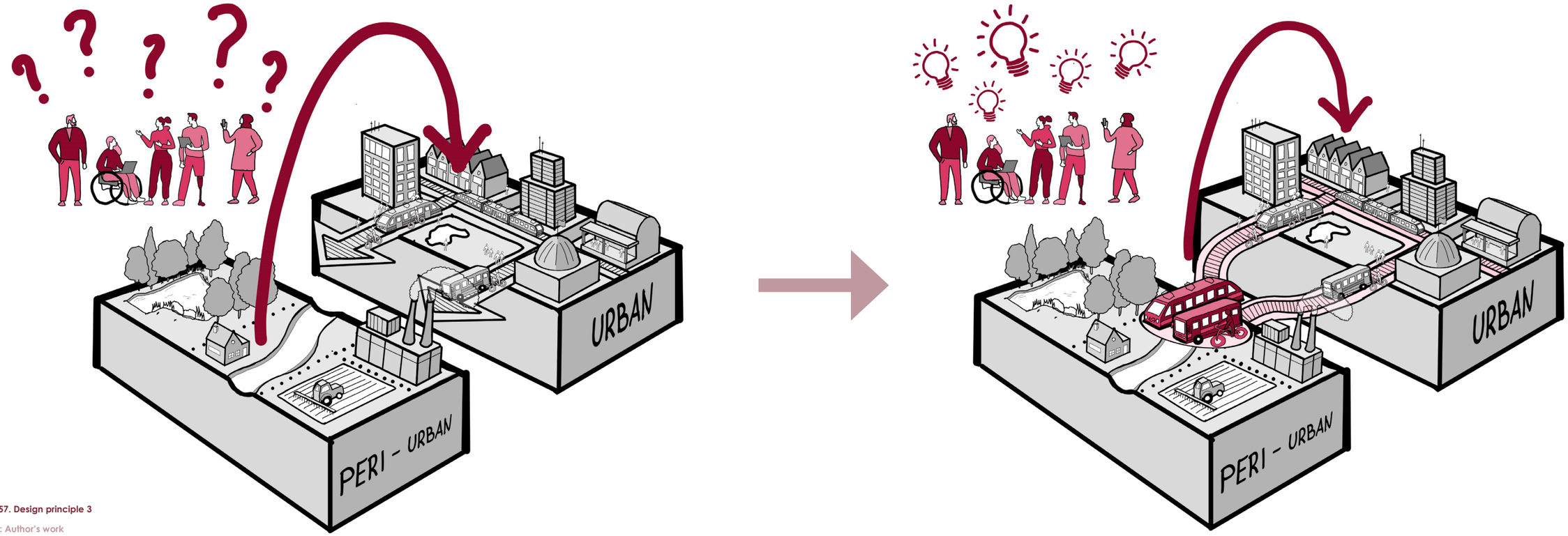


Figure 57. Design principle 3

Source: Author's work

Now that the peri-urban areas have become more accesible by sustainable forms of transportation, it is important to make sure that this accessibility is granted in an equal way for everyone. Equal access means that there is no lack in transportation options in order to gain access to essential socioeconomic activities. This implies that transportation options need to be in close proximity of these functions. This also means that these transportation options need to be accessible for people with a disability, low income, no access to online timetables or fear for safety on public transit.

This will be done through strategic placement of mobility nodes through the peri-urban areas. The nodes will provide a variety of affordable transportation options that offer transportation for all needs and wishes. Through this way there will always be a transportation option available that suits these needs and wishes best. Through this, principle 3 aims to manage the transit- and mobility poverty in the peri-urban and make the mobility network accessible in a socially just way.

PRINCIPLE 4

BUILD FURTHER UPON THE NETWORK THAT WE ALREADY HAVE

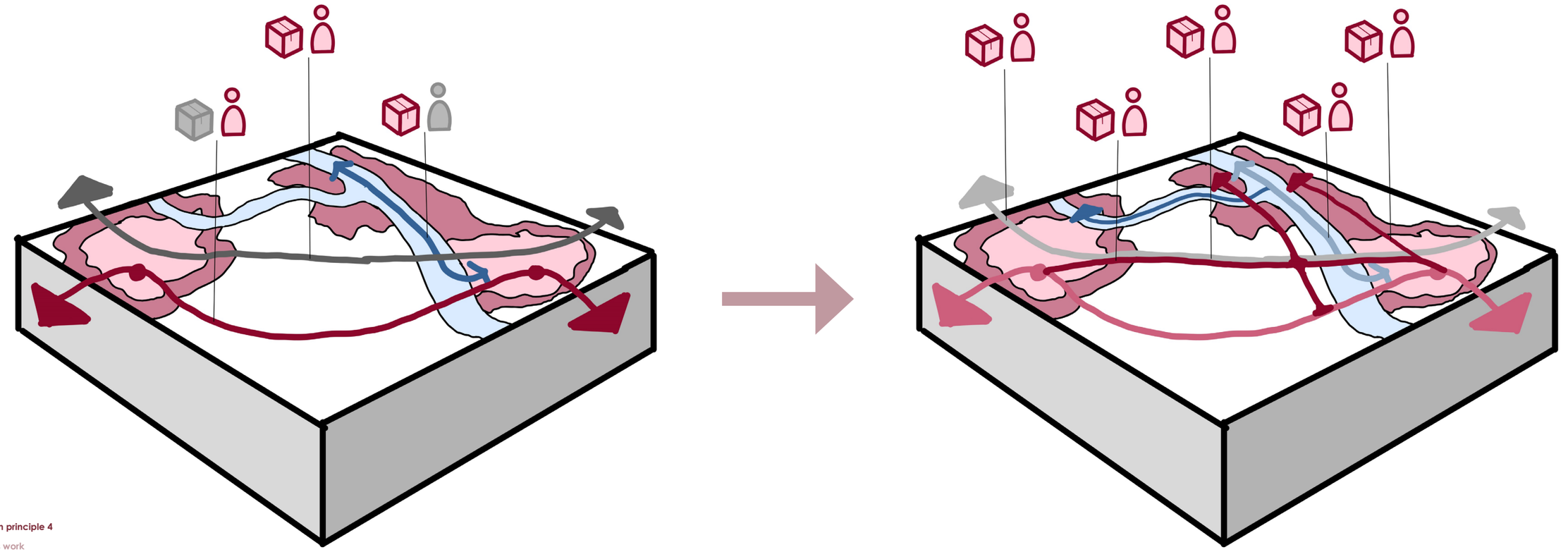


Figure 58. Design principle 4

Source: Author's work

While the first 3 principles focussed on connecting the peri-urban areas in a more sustainable way. Principle 4 and 5 will focus on how this can be achieved. We will do this by making efficient use of the existing network and use this network as base for redesiging it to a more sustainable network. Principle 4 focusses on this. Through this principle we aim to make the mobility network more sustainable in a circular way. Instead of simply adding new infrastructures we first want to make sure we fully utilize the existing network. This mean making the existing transportation corridors more efficient by using them for both people- and logistical transit. We will also use the existing network to see what new connections are needed and how they can be added to the existing network in the most efficient way.

PRINCIPLE 5
TRANSFORM MONOFUNCTIONAL CORRIDORS TO MULTI-MODAL CORRIDORS

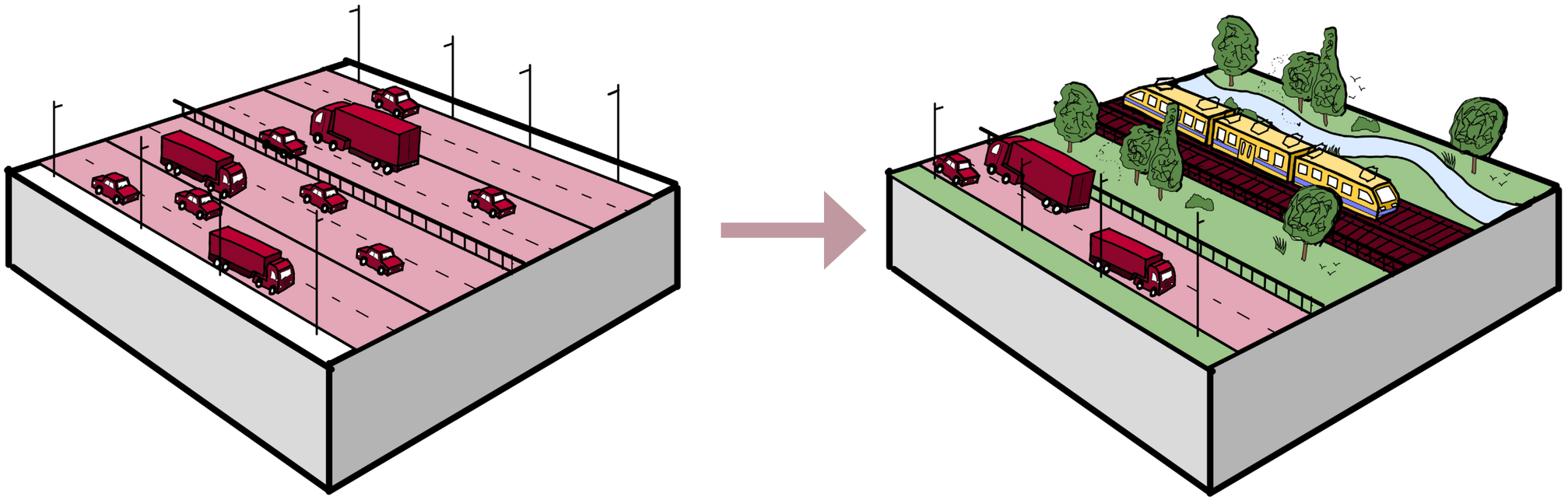


Figure 59. Design principle 5

Source: Author's work

The fifth and final principle zooms in on how to make the existing mobility network more efficient. The focus is on turning the existing transportation corridors into multifunctional corridors.

The transportation corridors in the existing network are form rigid structures and are mostly monofunctional. This means that most corridors are only used for one form of transportation. In the Rhine-Delta region this is mostly car-uses. Since these corridors form really rigid structures they are difficult to remove or move elsewhere. This also means that creating new corridors is a heavy and impactful intervention. Therefore principle 5 aims to turn these rigid monofunctional corridors into multimodal corridors. This means that the existing infrastructure is being used for multiple forms of transportation. Through this way we make more efficient use of the corridor that is already there. Since they would be very hard to move or remove, this is a great way to utilize the exisiting network. It improves the sustainability of the mobility network.
Not only because it facilitates more sustainable forms of transport, it also re-uses the current infrastructure, and by doing so contributes to a circular economy.

6.

APPLYING THE 5 PRINCIPLES TO THE REGIONAL TRANSPORTATION NETWORK

A TOOLBOX FOR A SUSTAINABLE MOBILITY NETWORK

A CO_2-NEUTRAL MOBILITY NETWORK

LONG DISTANCE PASSENGER INFRASTUCTURE

To facilitate a CO2-neutral mobility network, large-scale interventions in both the passenger rail as well as freight rail network are needed. Here we will zoom in on the passenger infrastructure improvements.

Drawing 60 shows the current rail system in the Rhine Delta. Although the network is very dense, it lacks good long-distance connections with the exception of HS South.

Drawing 61 shows our vision for the network. Its backbone will be a high-capacity, high-speed rail triangle connecting the urban agglomerations of the Randstad, Antwerp, Brussels, and the Ruhr area. This main triangle will be supported by an inner grid of semi-high-speed rail and connections to the northeast and west.

Drawing 62 shows how these connections fit in the European context.

Drawing 63 shows how the previously described lines fit into the current rail network.

Figure 60. Rails: Current passenger network

Source: based on OpenRailwayMap, 2024

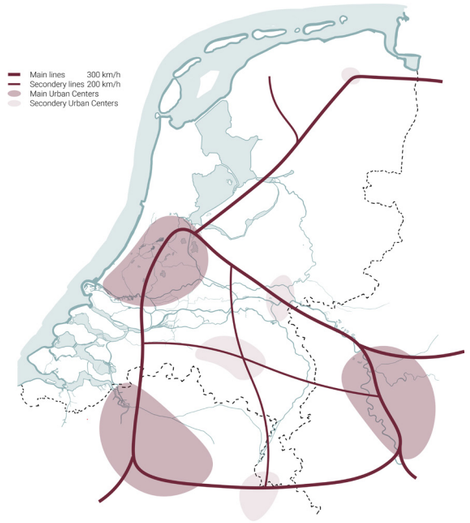


Figure 61. Rails: Scematic Passenger network

Source: Author's work

Figure 62. Rails: Passenger network (zoomed out)

Source: Author's work

Figure 63. Rails: New passenger network

Source: based on OpenRailwayMap, 2024

A CO_2-NEUTRAL MOBILITY NETWORK

LONG DISTANCE FREIGHT INFRASTUCTURE

Drawing 64 shows the current freight rail network. The only dedicated freight rail line is the Betuweroute. All other freight has to use mixed rail lines, which is a problem because the Dutch rail network is already heavily used by passenger trains.

Drawing 65 shows the additions we want to make. There are three main proposals:

1: Improvements to the line south from Rotterdam.
2: A bypass around Utrecht for freight traveling between Amsterdam and the south of the Netherlands, alleviating congestion at Utrecht Central Station.
3: A connection from the Betuweroute to the rail border crossing to Germany near Enschede.

Drawing 66 shows the main freight corridors that these interventions will enable. It highlights how with relatively small interventions, a far-reaching grid of rail freight arteries can be created.

Figure 64. Rails: Current freight network

Source: Based on OpenRailwayMap, 2024

Figure 65. Rails: Planned additions to freight network

Source: Based on OpenRailwayMap, 2024

Figure 66. Rails: New freight network

Source: Based on OpenRailwayMap, 2024

A CO_2-NEUTRAL MOBILITY NETWORK

VISION MAP

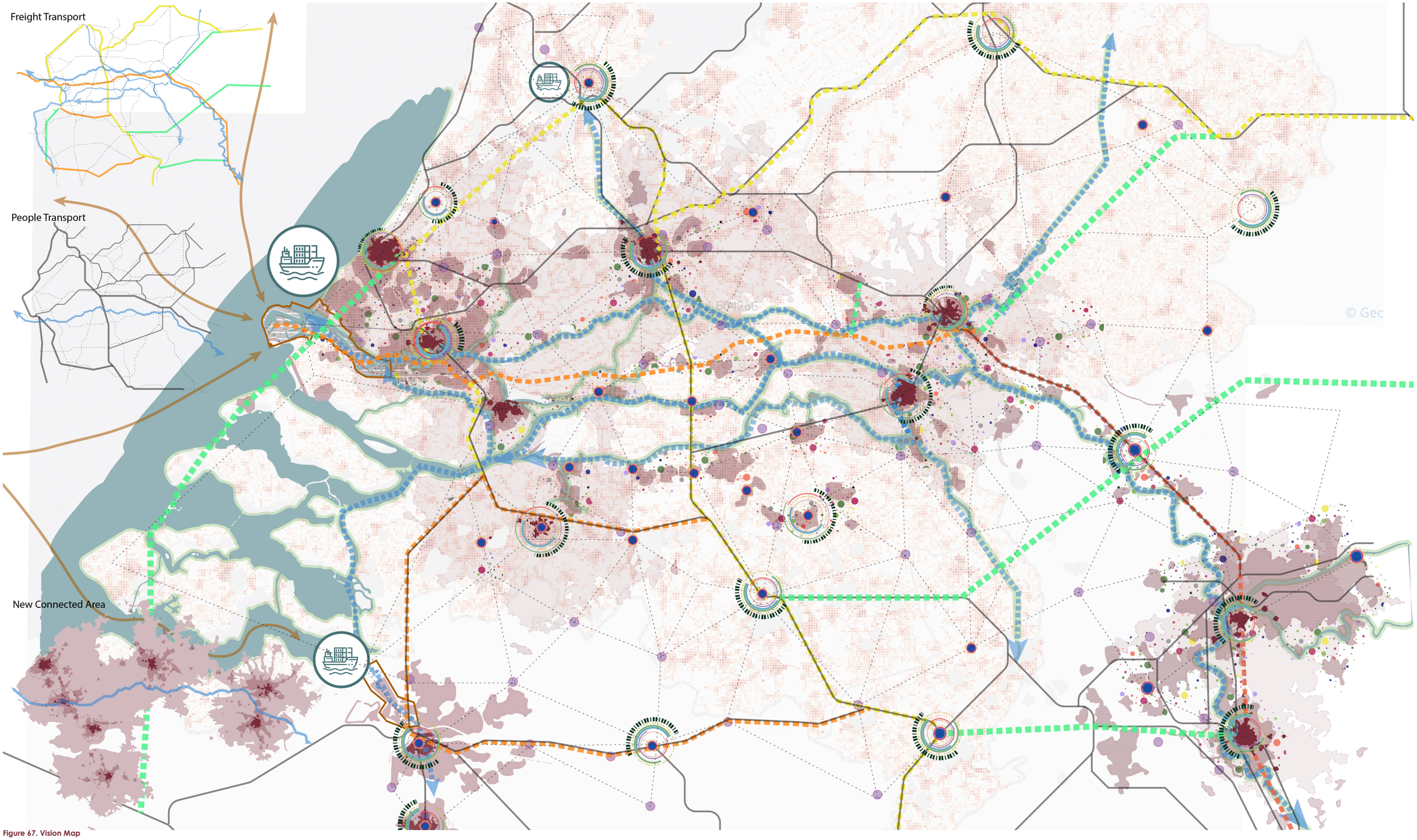


Figure 67. Vision Map

Source: Author's work

A CO_2-NEUTRAL MOBILITY NETWORK

LONG DISTANCE FRAIGHT INFRASTUCTURE

For the mobility sector, we want to tackle two main fronts: People and Freight Transport The existing infrastructure represents an incredible opportunity to accommodate new programmes towards a more circular and sustainable mobility sector. And create alternate modes of transportation in both urban and peri urban areas.

The dark red represents 15 minute city and by potentiating the actual corridors and improving the public transport infrastructure (train, trams, buses, and metro lines) we could enlarge the connecting area within 45 minutes into the light red zone that is shown in the map (

As for the freight transport we want to maximize the use of waterways throughout the Delta Rhine region, reaffirming its structural position for inland freight transportation. The green and blue lines represent the ecological and main corridors for the Delta rhine Region, which will be used to transport 40% of the cargo inland and complemented with a fast and well connected rail network, capable of redistributing the goods from water to the distribution center in a more sustainable way. For this, we propose reinforce (yellow lines) some corridors and create new ones (pink lines) that will enlarge the network of goods distribution without emitting CO2.

All this area will also be connected with an optimized web (triangles in map) of logistic transportation for freight and people through multimodal nodes and distribution center position in strategic points, so the 'last mile' distribution can be done through roads in electric cars but with a lower frequency and more efficiently.

The total overview of the transportation the project consist in the research, design and implementation of public transport, bike infrastructure and smart roads connections with the integration of landscape and different type of land use in the periurban areas. To realize this, our proposal looks for a strategy for long term peoples transport and freight transport
With Adaptive infrastructure that will strengthen the relation between built networks and shared living environments.

To support the greening of cargo operations in the region, the existing framework for intermodal transport needs a substantial renovation and must be turned into an effective tool for passengers and freight. Incentive mechanisms should help shift a substantial part of the 75% of inland freight carried today by road needs to shift to rail and inland waterways, promoting short-sea shipping and efficient zero-emission vehicles

Multimodal logistics must be part of this transformation, for context based for urban and periurban areas. Ports and airports should also become multimodal mobility and transport hubs, linking all the relevant modes and context with clean energy. This will improve air quality locally thereby contributing to improved health of nearby residents.

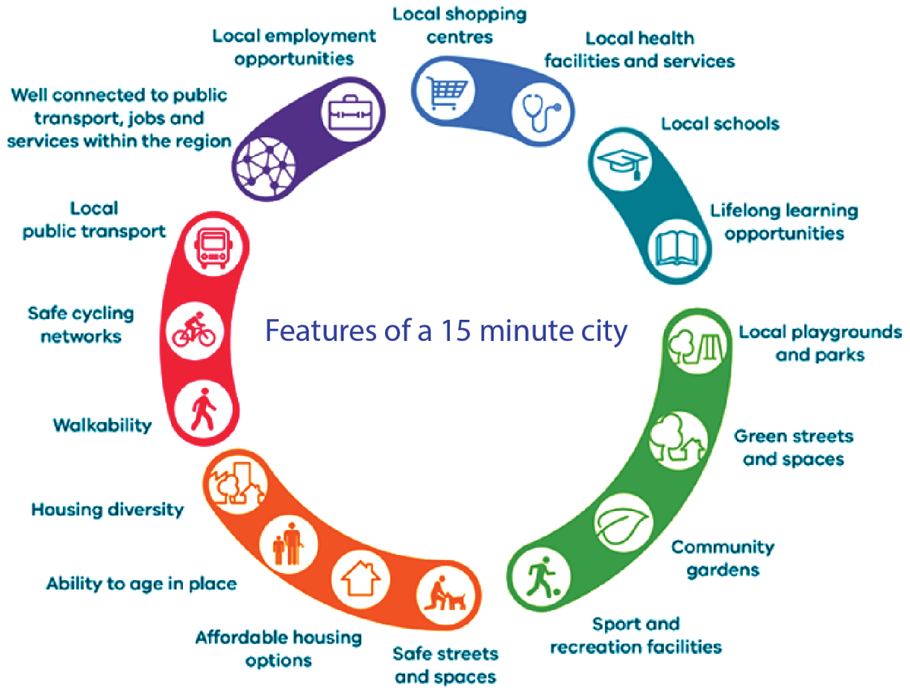


Figure 68. Features for a 15 minute city

Source: edited from the 20 minute neighborhood for Melbourne, (Mobility Learning Center, 2024)

A CO_2-NEUTRAL MOBILITY NETWORK

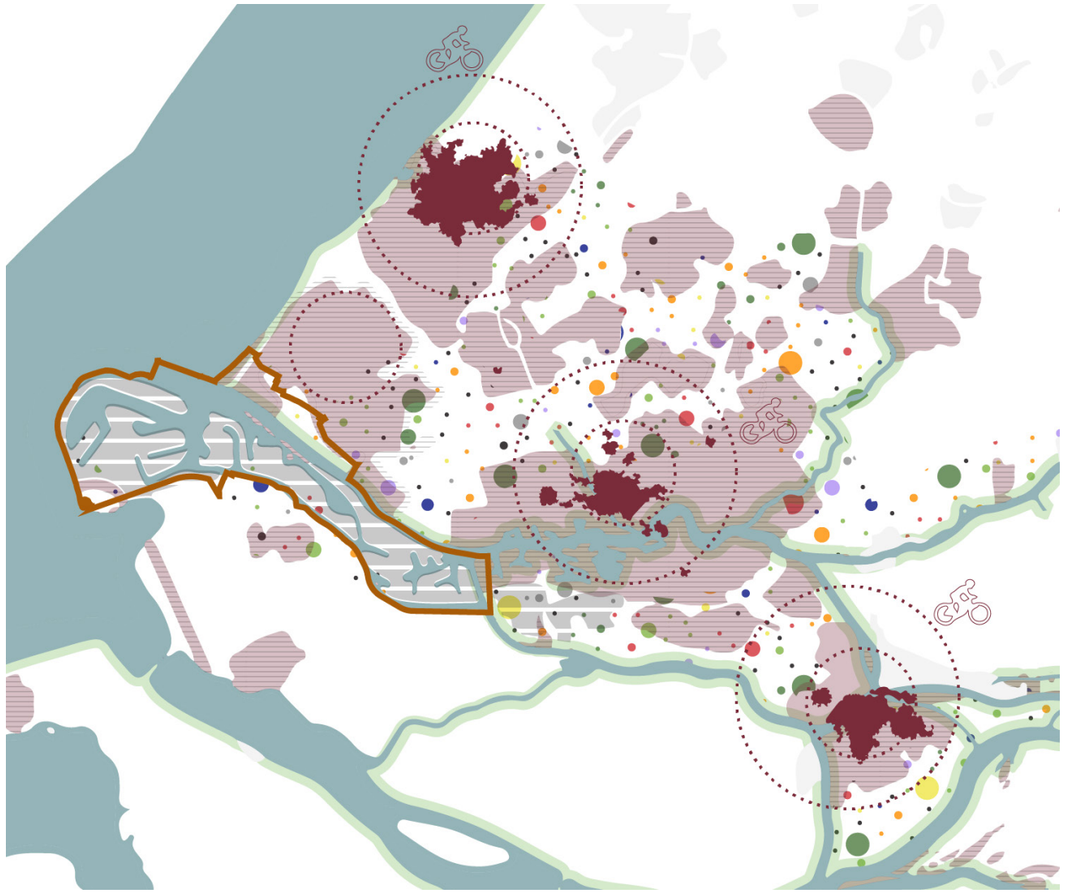


Figure 69. Zoomed area of vision map, showing the peri urban and urban patchwork of Rotterdam- The Hague node

Sourc: Author's work

Embracing sustainable transportation practices within the context of a circular economy offers diverse benefits beyond the environmental aspect. First, the shift towards circularity may lead to a decrease in freight transport, as products and materials are reused, remanufactured, and recycled, reducing the need for extensive transportation networks.

In a sustainable region, circularity aspects would be integrated across various sectors to promote resource efficiency, minimize waste generation, and foster economic resilience. Some key features of circularity in a sustainable region could include:

Circular economy hubs (dark orange): Establishing designated areas within the region where businesses, industries, and communities coexist and collaborate to implement circular economy principles. These hubs would facilitate the exchange of resources, materials, and expertise, promoting circularity at a local level.

Green infrastructure and biodiversity nature access (dark green): These initiatives contribute to ecosystem resilience, mitigate the impacts of climate change and enhance the biodiversity of the region

Circular supply chains of food (light green): Encouraging local sourcing, production, and consumption to reduce the carbon footprint associated with long-distance transportation and promote local economic development. This involves supporting local farmers, producers, and businesses that prioritize sustainable practices and resource efficiency.

Waste reduction and recycling programs (lila): Implementing comprehensive waste management strategies that prioritize waste prevention, reuse, recycling, and composting. This includes establishing recycling facilities, promoting composting initiatives, and implementing extended producer responsibility programs to ensure product stewardship throughout its lifecycle.

Circular design and innovation (light orange): Encouraging the development and adoption of circular design principles across various industries to minimize resource consumption, extend product lifecycles, and facilitate material recovery. This involves incentivizing eco-design practices, promoting product-as-a-service models, and fostering collaboration between designers, manufacturers, and consumers.

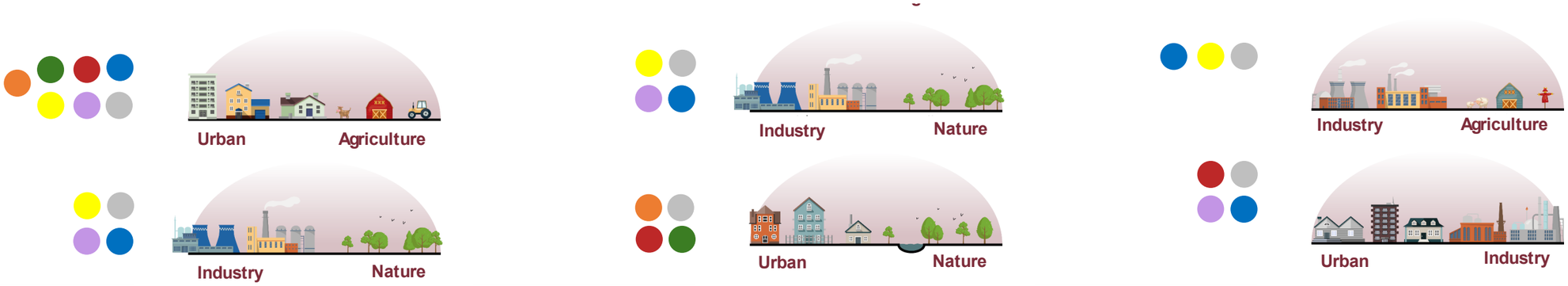


Figure 70. Typologies of urban and periurban inter-sections
Source: Author's work

A CO_2-NEUTRAL MOBILITY NETWORK

A PATCHWORK OF PERI-URBAN AREAS

ELECTRICITY
NATURE - Green Infrastructure
AGRICULTURE/FARM
WATER MANAGEMENT
RAW MATERIALS
HEATING AND CO2
WASTE MANAGEMENT

Peri-Urban
Urban
Higher Education
Industry- Economic Development
Office/Service District - Economic Development
Freight - Economic Development
Recreation

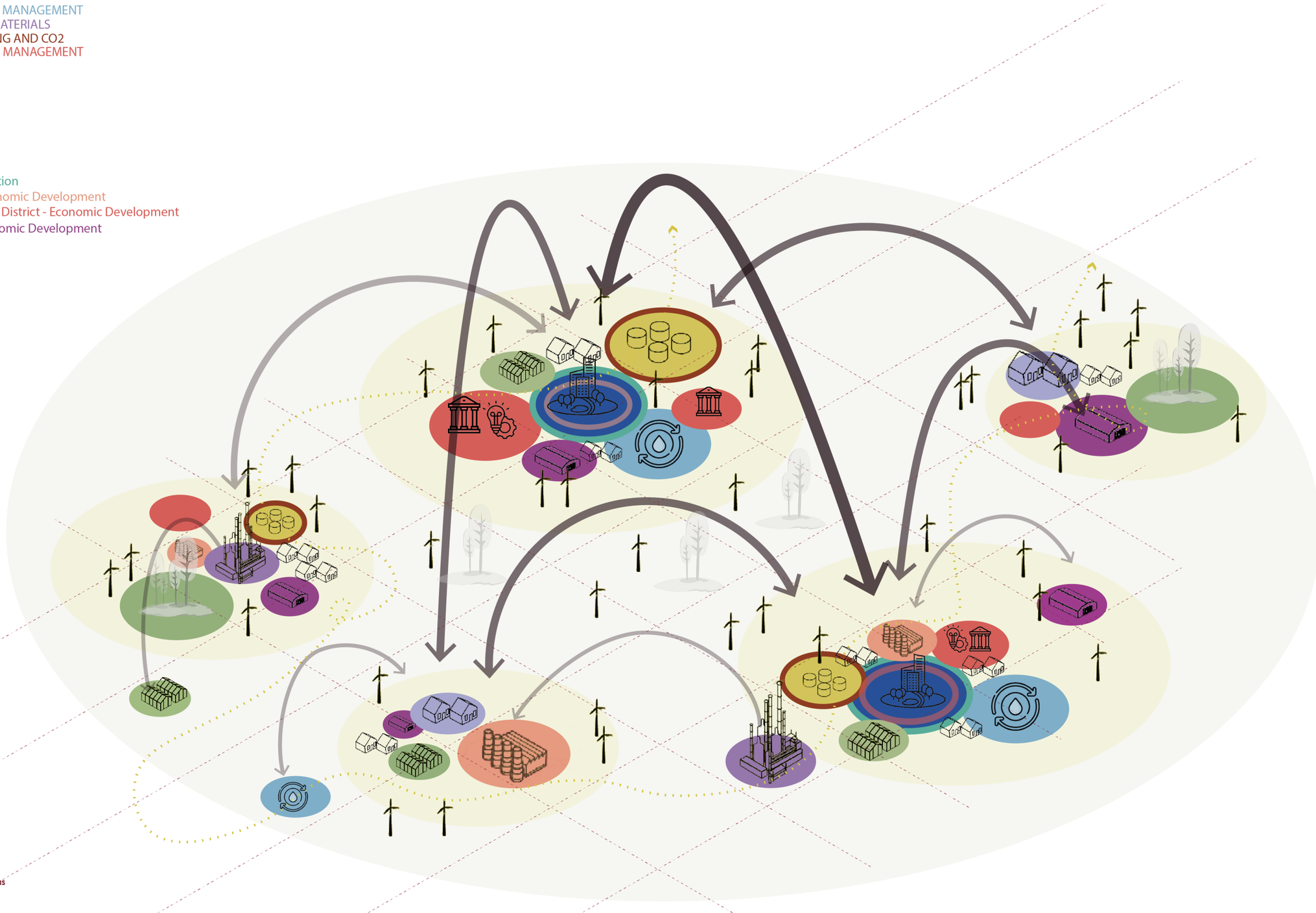


Figure 71. Patchwork of peri-urban areas

Source: Author's work

A CO_2-NEUTRAL MOBILITY NETWORK

A PATCHWORK OF PERI-URBAN AREAS

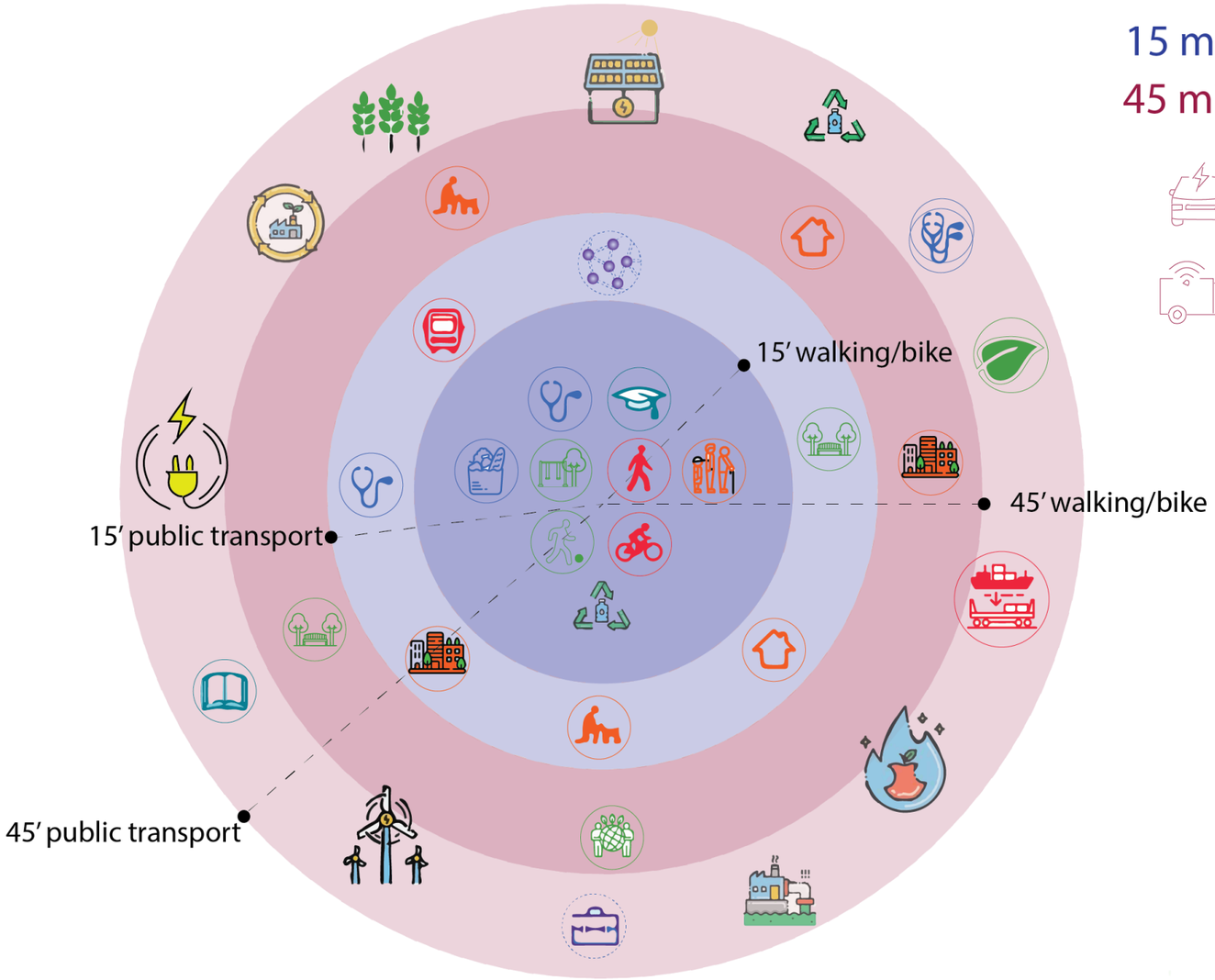


Figure 72. 15 minute city / 45 minute Region

Source: Author's work based on the 20 minute neighborgh diagram for Melbourne

Clean energy supply (yellow and brown): integrating renewable energy sources for electricity and heating, and implementing carbon capture and utilization (CCU) technologies across various sectors. This involves transitioning away from fossil fuels towards cleaner alternatives such as solar, wind, and hydroelectric power, as well as promoting energy efficiency measures to minimize energy consumption. circularity in the energy sector involves the development of decentralized and distributed energy systems that promote resilience and self-sufficiency. This includes the deployment of microgrids, smart grid technologies, and energy storage solutions to optimize energy distribution, improve grid reliability, and facilitate the integration of renewable energy sources into the energy mix.

Last but nt least, our main focus

Sustainable transportation systems: Implementing efficient and multimodal low-emission transportation networks that prioritize public transit, walking, and cycling infrastructure. This includes reusing the existing infrastructure to optimize the logistics of freight and passenger transport as well as promoting shared mobility services, electric vehicles, and alternative fuels to reduce reliance on fossil fuels and minimize environmental impact.

By integrating these circularity aspects into regional planning and development strategies, sustainable regions can increase their resilience, reduce environmental impact, and create more equitable and prosperous communities for current and future generations.

2030 climate target plan, increasing the modal shares of collective transport, walking and cycling, as well as automated, connected and multimodal mobility will significantly lower pollution and congestion from transport, especially in cities and improve the health and well-being of people.

WHAT WILL HAPPEN?
A STRONG REDUCTION IN CO2-EMISSION BY MOBILITY

European CO2 emissions per capita have not declined enough since the 1970's. "European greenhouse gas emissions are 3-4 times higher than they should be to keep climate change below the 2°C threshold that the World Bank agrees would already have considerable consequence" In the Netherlands, these effects are related to extreme weather events, such as flooding and heat waves and changes in environmental and social conditions.

Reducing emissions in the transport infrastructure presents a significant opportunity to mitigate environmental impact. According to TNO, greenhouse emissions from infrastructure can be reduced by up to 40% through the implementation of various strategies: efficient use of materials and energy, reuse, life extension, and adoption of innovative materials, products, and processes.
However, a long-term tactical decision needs a holistic approach of the whole network system for people and freight transportation for reducing CO2 emissions; including multimodal nodes, shipment sizes, types of vehicles, and a shift for fully electrical modes fueled with clean energy. Alongside short-term tactical choices like optimizing public transport and freight logistics based on each context.

A shift is needed from the current linear economy and 'business as usual' thinking towards a more circular scenario which implies more recycling and less intercontinental transports of raw materials and products, translating in a decrease in long-distance flow for plastic, food and feed. Additionally, initiatives such as implementing ZERO EMISSION ZONES (ZEZ) for cities and banning and midrange aviation trips within the continent, biut specially in the Euro Delta region. By embracing these multifaceted strategies, we can significantly curb emissions across infrastructure sectors, paving the way for a greener and more sustainable future.

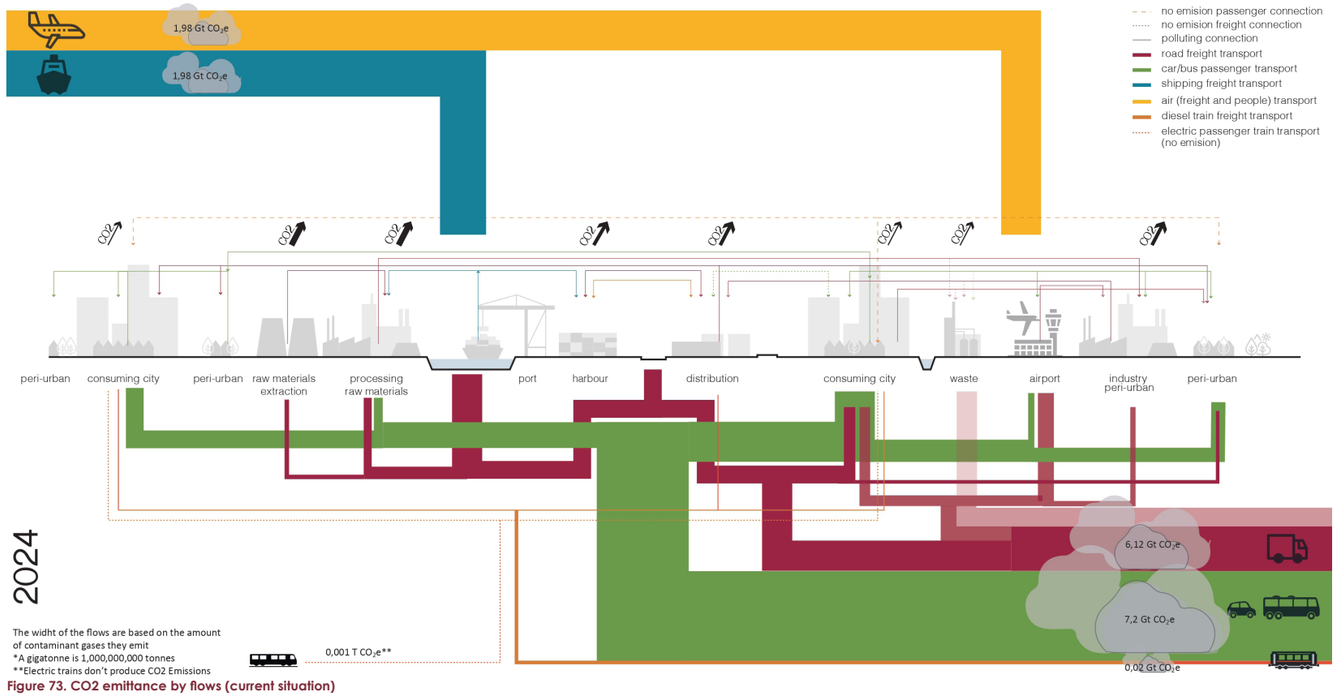


Figure 73. CO2 emittance by flows (current situation)

Author's work based on Buysse & Miller, 2021

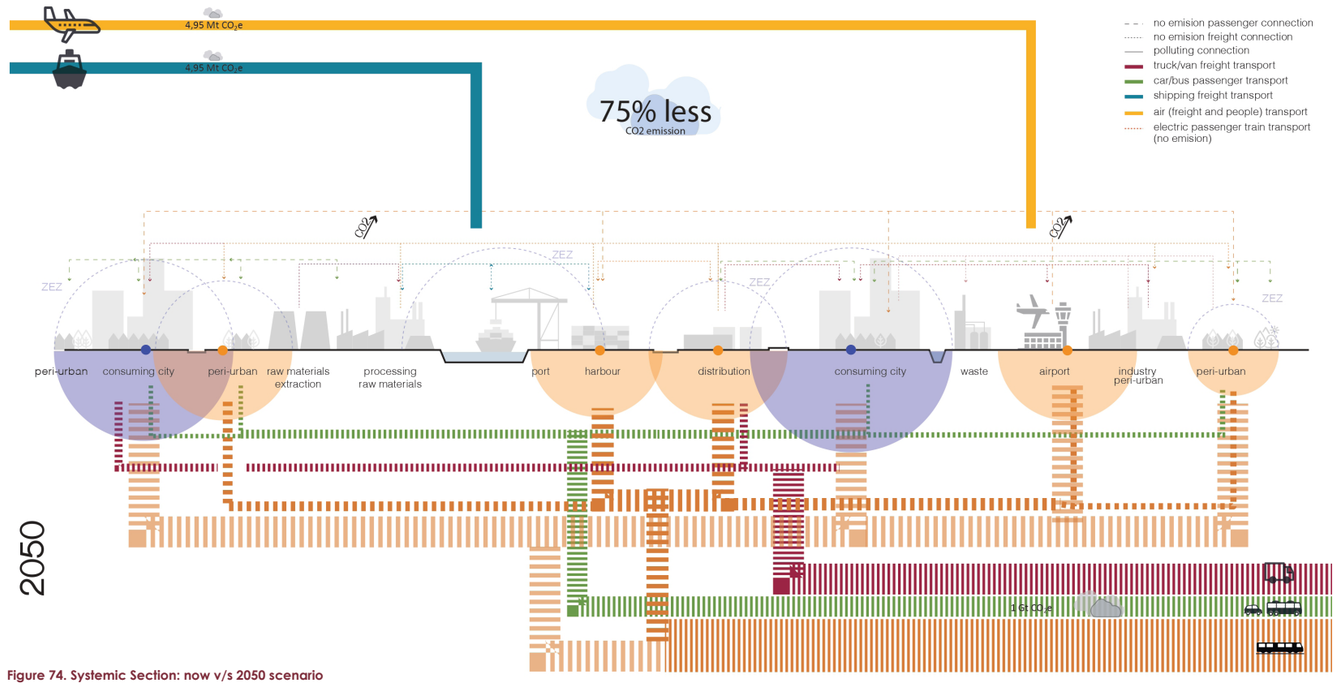


Figure 74. Systemic Section: now v/s 2050 scenario

Source: Author's work based on data retrieved from BLOG: Transport Could Burn Up The Eu's Entire Carbon Budget(Buysse & Miller, 2019)

WHAT WILL HAPPEN?
A STRONG REDUCTION IN CO2-EMISSION BY MOBILITY

This section shows how the transportation system functions nowadays in the Euro Delta Region, and how it can be improved for 2050 towards CO2 neutrality in the region. The top scenario shows in thicker colored lines the amount of emission for each mode of transportation. Airplanes (yellow) and ships (blue) coming from outside Europe are placed on top, while inland land transportation through trucks (dark red), buses (green), car (green), motorcycles (orange), and trains (orange) is represented in the bottom part. These flows represent the total amount of gigaton CO2 emissions from air, water, rail, and road transportation for passengers and freight in the EU.

In thinner lines, it shows the actual connections and movements between the different urban programs for freight and passenger logistics, using the same colors depending on each mode of transportation. For example, from the harbor (blue) it goes to the distribution center (red) and then to the city (red or green).

The bottom scenario is the proposed systemic section which will be improved with our context-based project and innovations on each mode of transportation. By 2030, with half of the passenger-kilometres covered in an optimized system, mobility emissions alone could fall as much as 55 percent. By 2050, the sector could be decarbonized in 75 % as the freight and public transport fleet would be electrified and powered by renewable energy, short-distance air travel would be banned and the node system in the whole delta region will be implemented.

Therewith, the new section shows the 75% decrease in each mode of transportation, where inland transportations are shown as dashed lines because it will be carbon neutral by 2050. You can see an overall reduction of the CO2 emissions in the transportation system, as well as new ways the flows connect.

Also in the new section, it is represented the multimodal nodes for the optimized context-based project:

- blue =urban
- light purple =periurban

Each node is available for passengers and freight and is connected by train and another type of mobility (shared mobility, bus or last-mile delivery).

The pie charts show how the mobility sector shifted towards a more balanced use of modes and infrastructure, prioritizing the rail and waterways for freight and public transport (train, bus, metro and tram) over the car.

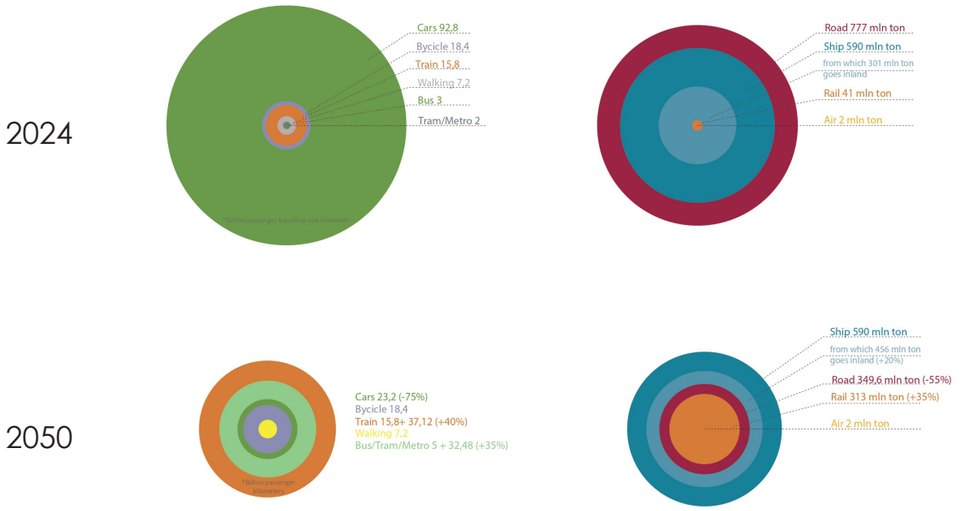
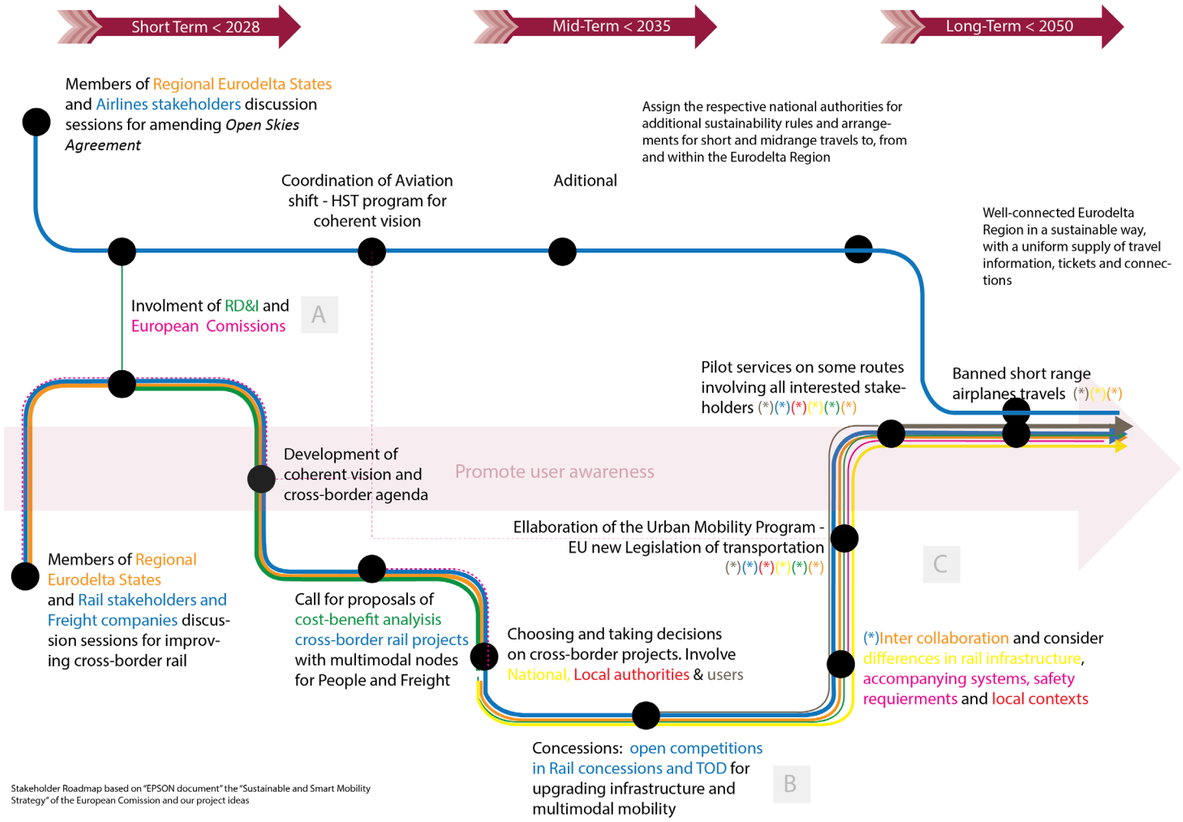
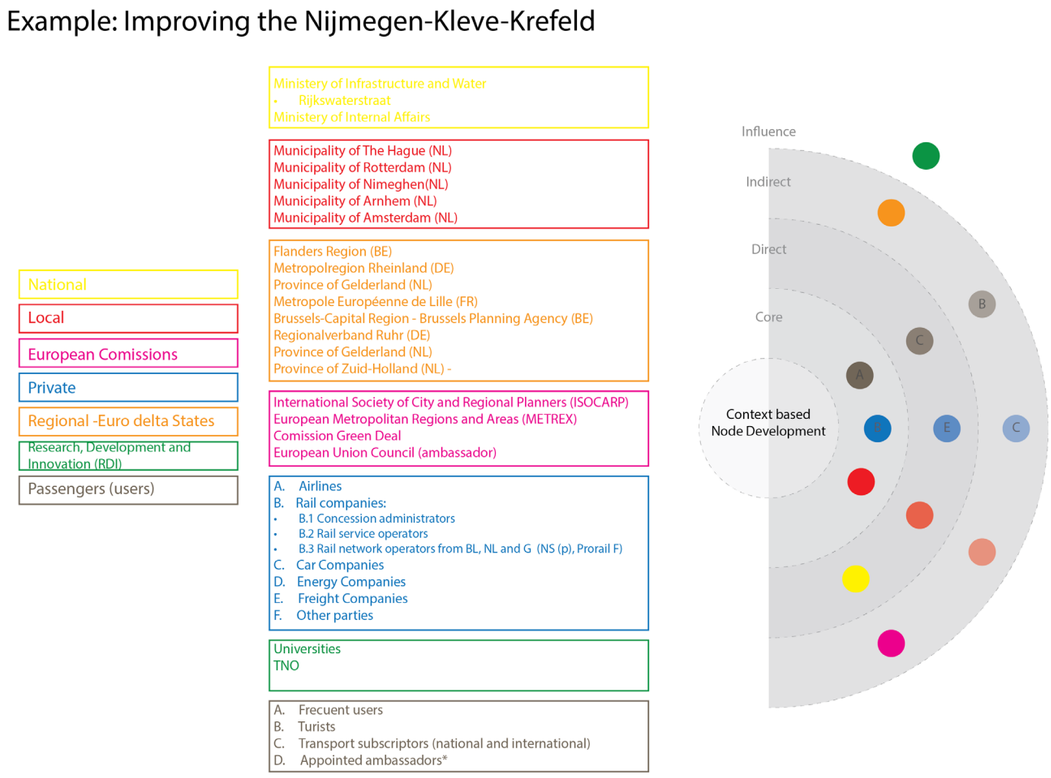


Figure 75: Balanced pie chart for mobility in 2050

Source: Author's work

WHO IS INVOLVED?
AND WHAT DO WE EXPECT FROM THEM?





As an example for the stakeholder analysis, we worked on the High-speed train for the Eurodelta region as our main focus and zoomed in on the Arnhem and Nijmegen node.
However, we think Europe should build a high-quality transport network with high speed on short-range distances to be able to ban properly short and medium-range airplane transportation.

For this roadmap, we propose a boost in long-distance and cross-border passenger rail services, upgrading the necessary infrastructure to enable the shift, including the high-speed lines, new corridors for passengers and freight and multimodal nodes context-based. This roadmap works as an initial framework to provide a preliminary understanding of the logical steps for the implementation of the measures effectively.

This figure shows how the initial framework for the High-Speed Train (HST) in the Eurodelta Region could be, showing the stakeholders and main stages for achieving carbon neutrality for 2050.

Each main category of stakeholder has been given a color, and for each 'level (color) we proposed some specific stakeholders. The steps in the roadmaps and the indicative timings (short-term, mid-term, long-term) mentioned - have been proposed as an exercise based on our knowledge and research throughout this quarter.

In the next image, it is represented which stakeholder will be needed for the implementation of each context-based node, therefore you can see that local authorities, users, and local communities are much more important and have influence along the whole process, while the regional and European commissions have less impact. Each proposed roadmap shows, that cooperation will be necessary, at all levels. For each policy measure - in each context-based node - attention is paid to which stakeholders should be involved in an implementation process. Establishing project-specific cooperation seems more efficient than setting up large structures at the Eurodelta region level.

NEW POLICIES
WHAT IS THE POLITICAL IMPACT?

Sustainable Development Goals
Due to importance of the SDGs they are included in this strategy as well. The strategy focuses on creating a CO2-neutral mobility network while also reducing inequalities and changing mindsets. As seen in figure 76 there are five main SDGs this project will be contributing to (in) directly:
3.4 & 3.9: We want a zero-emissions mobility network with multifunctional and green corridors.
9.1 & 9.4: The project focuses on innovation of infrastructure on different levels
10.3, 10.4 & 10.7: Transportation must be available for everyone, we want to tackle mobility poverty and find options on how to make public transport cheaper (or even free).
11.2, 11.6 & 11.7: The strategic sustainable cities are connected within 15 minutes while the area is accessible within 40 minutes. This will provide inclusive acces to green, health and other public spaces.
12.6, 12.7 & 12.8: Companies will be encouraged to adopt sustainable practices. For people we need a change in mindset and behaviour to make less use of cars and for a modal shift.

Opportunities
In 2022 the Mobiliteitsvisie 2050 was published by the Dutch Ministry of Infrastructure and Water management. This document provides several approaches and a combined vision from different policies that can be used and developed further. They mention the urgency for change of behaviour. This change of behaviour is also mentioned in the Klimaatnota from Economic Business and Climate in 2022. Although a modal shift is urgent, changing behaviour is a difficult process. Policies are currently lacking when implementing such policies. They need to be delivered as a coherent package to facilitate the progression for a sustainable and high-quality transport system. Pedestrianisation, for example, can be an effective tool for decreasing car usage. This can be done by lowering the speed limit or banning cars from the street. To successfully implement these measures a strong political commitment is needed (Batty et al., 2015).

Although the COVID-19 crisis had many negative impacts it also had a sustainable positive impact on mobility. The lockdown showed an enormous decrease of travel and made visible how easy concept such as working at home and hybrid education come into effect (van der Drift et al., 2022). These concepts and new innovative technologies (such as open data to stimulate use of mobility nodes) can help to change mindsets.

Missing links in current policies
Peri-urban areas are ignored as impactful areas. Most of these areas are not well accessible by forms of sustainable transport or public transport. In current policies these areas are not prioritized to improve and therefore will keep creating issues.

The Netherlands knows a policy dedicated to circular economy: The Dutch Circular Economy Programme (2023-2030). This policy focusses on accelerating and upscaling the circular economy. It is based on five transition themes that cover resource-use, waste, land use and effect for biodiversity. However is the mobility sector not included within these transition themes (Hanemaaijer & Kishna, 2023).

3 GOOD HEALTH AND WELL-BEING	**3.4** By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.
	3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	**9.1** Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.
	9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.
10 REDUCED INEQUALITIES	**10.3** Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard.
	10.4 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality.
	10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies.
11 SUSTAINABLE CITIES AND COMMUNITIES	**11.2** By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
	11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.
	11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	**12.6** Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.
	12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities.
	12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.

Figure 76. Sustainable Development Goals
Source: Data from SDGIndicators, n.d.

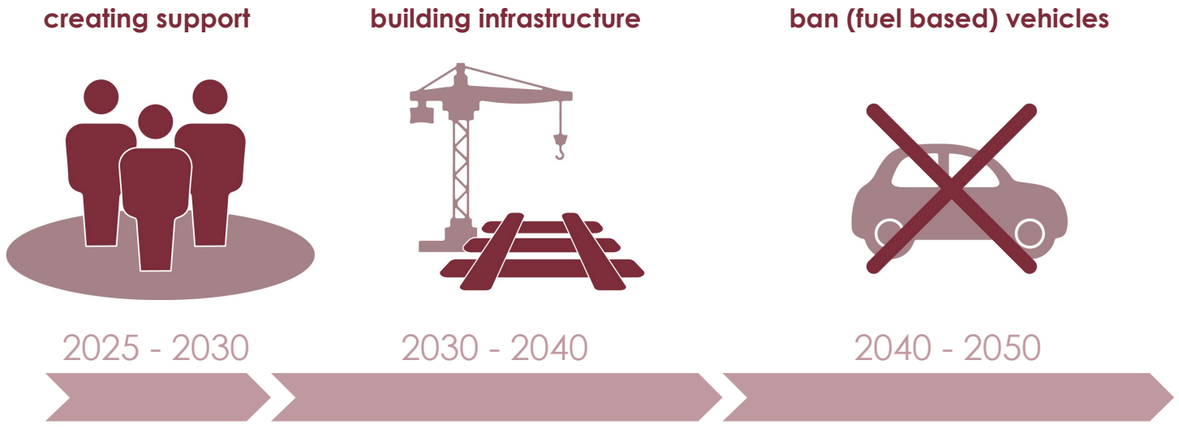


Figure 77. Focus points of timeline
Source: Author's work

Timeline
For the strategy missing links should be connected and opportunities utilized. SDGs need to be incorporated along the way. To improve the mobility network and create strategic policies there should be taken several steps because policies and implementations cannot be undertaken at once. The strategy will have different main focusses over time as seen in figure 77. Firstly, there needs to be created support by society, start by building trust and being transparent as a political organization. Secondly, the hard infrastructure will be built to create good alternatives for the last stage where the car will be banned as much as possible.

X-curve
The show the impacts of new and existing policies on travel behaviour the x-curve is used as a method. Figure 78 show the political influence of existing and new policies over time. From left top to the right bottom existing aspects will be phased out, for example the usage of cars. From the left bottom to the right top a strategy will be strengthen, such as use of public transport and shared mobility. In small steps different kind of policies can show the impact on time. As can be seen are existing policies mainly focused on electrification of vehicles. New policies will amplify this by adding new policies regarding the stimulation of transport nodes, shared mobility and public transport. By the phasing out-curve the use of cars in general will be taken into account as well. This change of mindset is supported by policies.

Existing policies described in figure 78 are mainly based on the Klimaatnota (KA). The zero emission for OV-busses (BAZEB) is also included, as well as the new law vrachtwagenheffing (2023) that states that trucks must pay taxes for the use of Dutch roads.

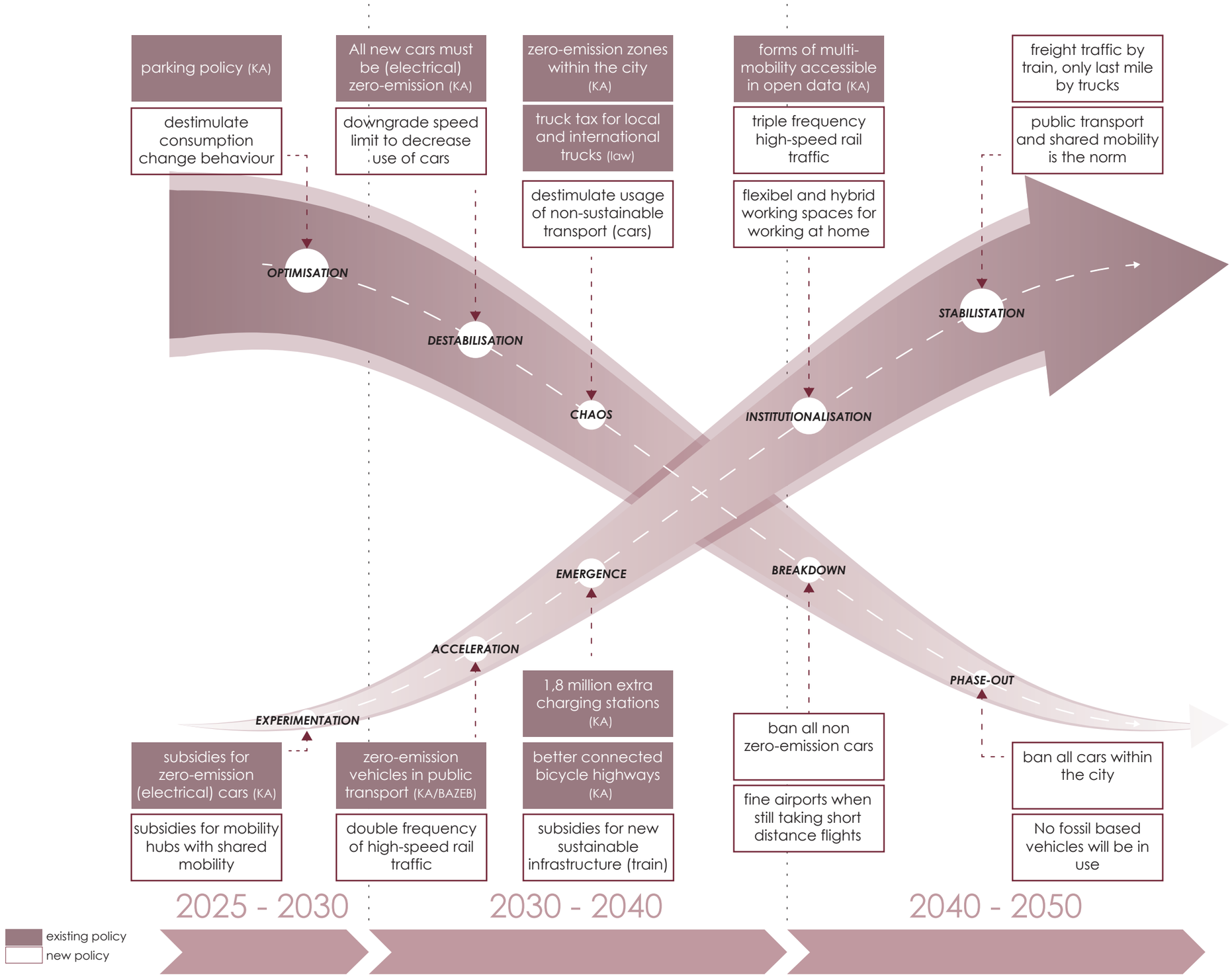


Figure 78. Policies X-curve
Source: Author's work

7.

APPLYING THE ‘CONTEXT BASED’ MOBILITY NODES ON CASE STUDIES

APPLYING OUR TOOLBOX

CASE STUDIES

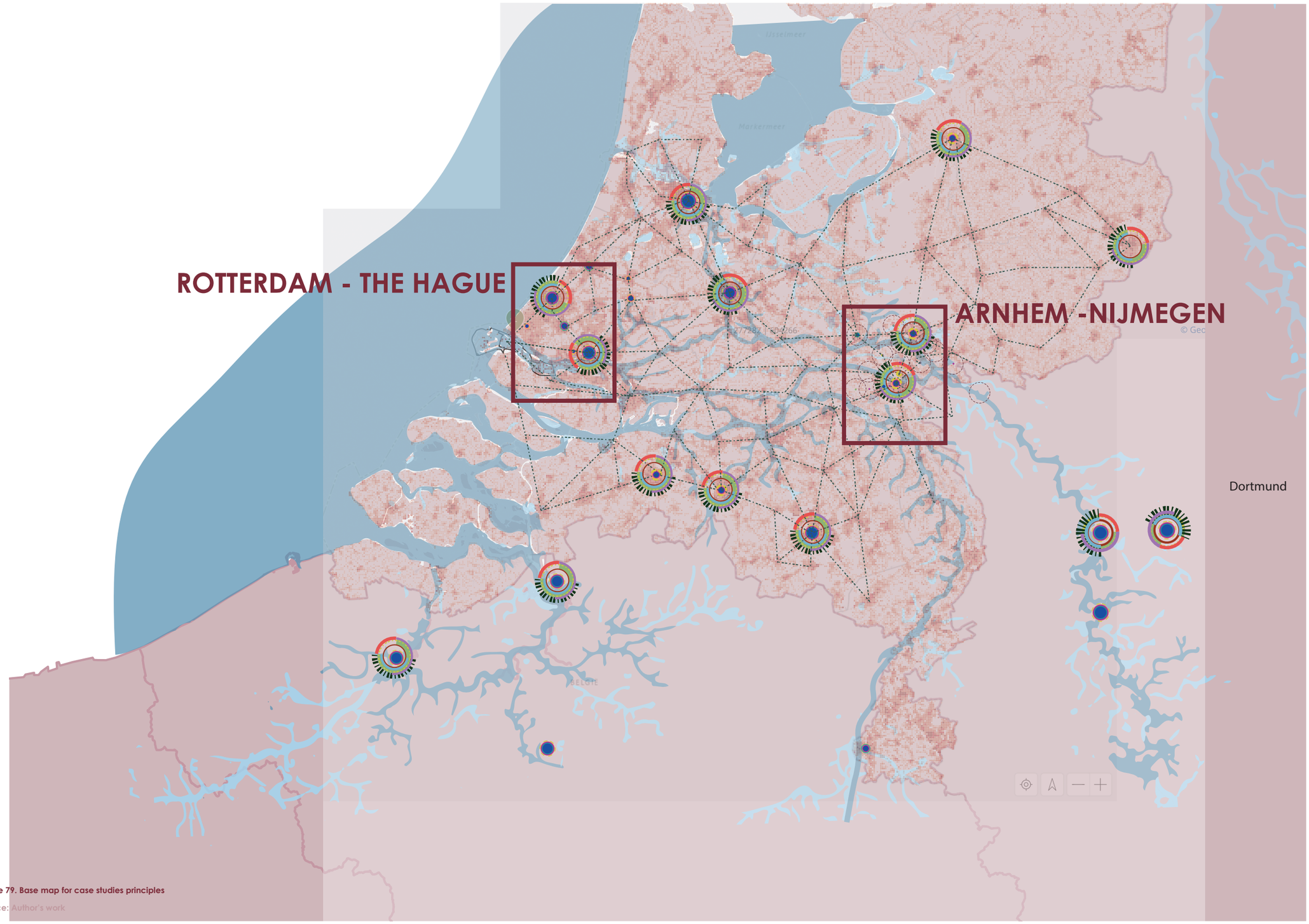


Figure 79. Base map for case studies principles

Source: Author's work

ARNHEM - NIJMEGEN

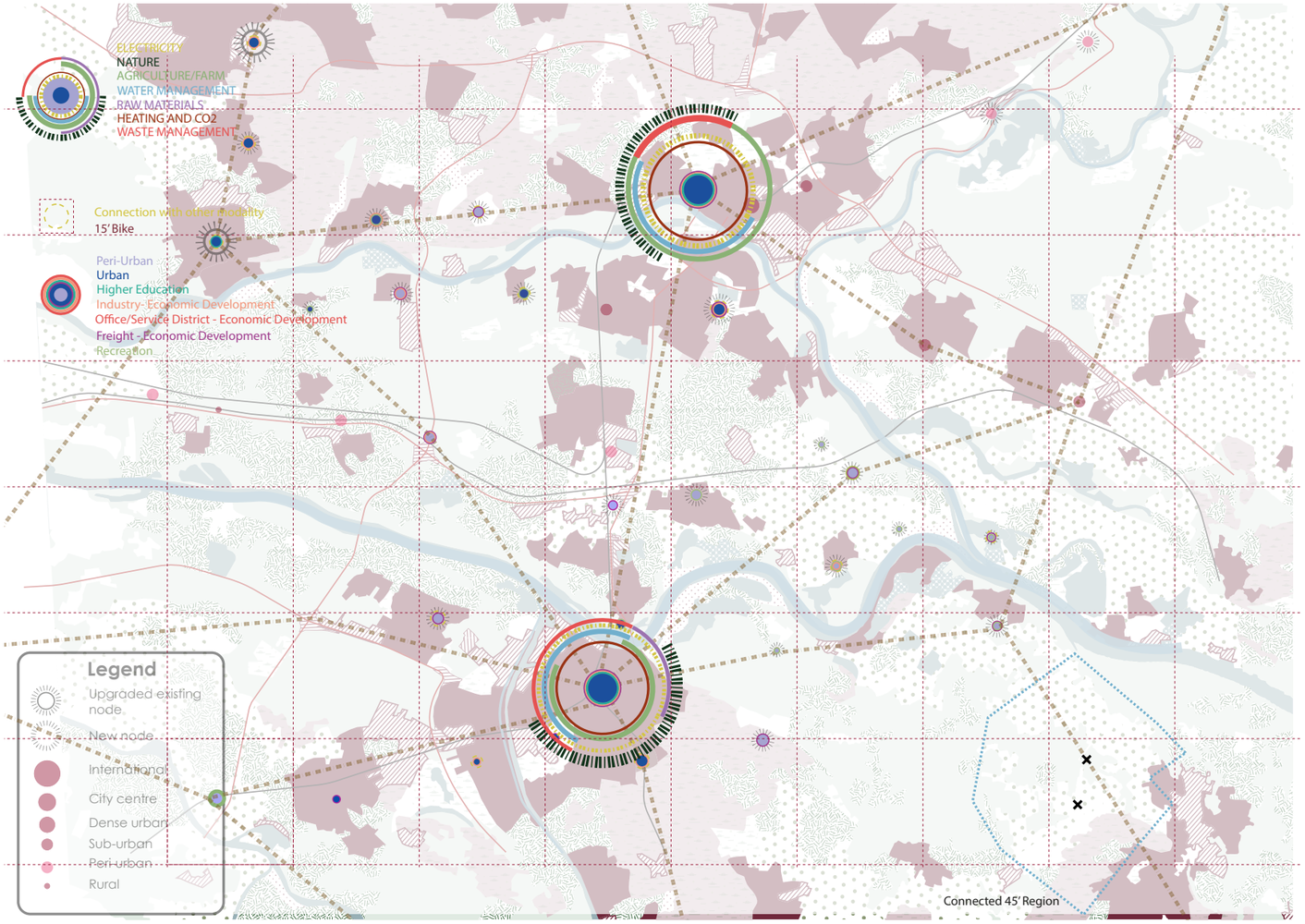


Figure 81: Circular Scenario for Arnhem - Nijmegen

Source: Author's work

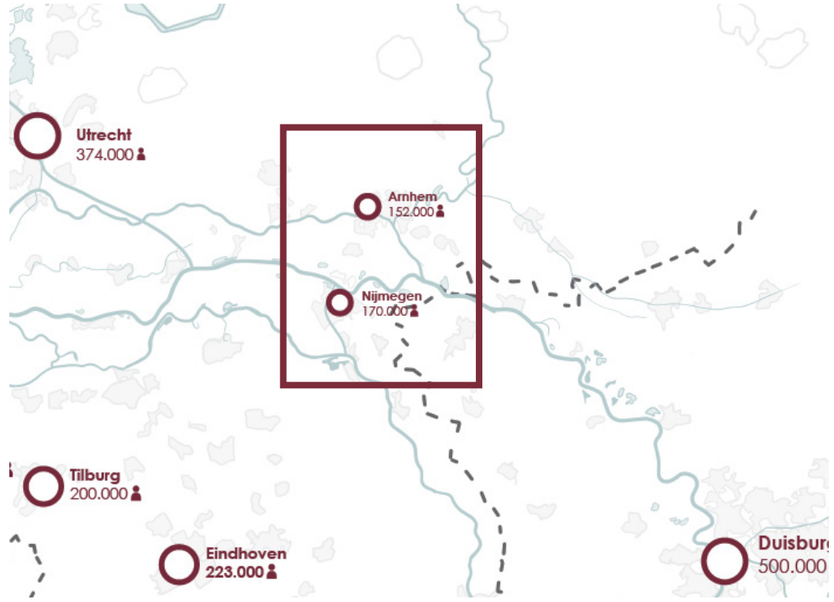


Figure 82. Zoom in area Arnhem-Nijmegen

Source: Author's work

This map represents a circular scenario for the Arnhem - Nijmegen urban and periurban nodes, by embracing sustainable transportation practices and creating resilient and thriving regions for 2050. By integrating circularity aspects (developed in the previous chapter) into regional planning and development strategies, communities can increase their resilience, reduce environmental impact, and foster more equitable and prosperous societies for both current and future generations.

The implementation of sustainable transportation measures aligns with the 2030/2050 climate target plan, which emphasizes increasing the modal shares of collective transport, walking, and cycling, as well as promoting automated, connected, and multimodal mobility solutions.
In the map, you can see how the region can be connected through the different urban and periurban nodes within 15 or 45 minutes. Each node has a color, and the color represents the main characteristic of the node, whether it is urban or periurban. Each line represents max. of 15-minute travel time, and a region is composed of three of those lines (15+15+15). The urban regional nodes (bigger circles) respond to the characteristics of circular scenario explained in the previous chapter and the amount varies depending on the characteristic of each city and context.

By leveraging circular economy principles and sustainable transportation strategies, regions can not only address environmental challenges but also stimulate economic growth, enhance social equity, and promote a higher quality of life for all. Through collaborative efforts and innovative approaches, sustainable transportation in the region can catalyze positive change, paving the way towards a more sustainable and resilient region.

WHAT IS GOING TO CHANGE?

The Arnhem-Nijmegen region knows an educational character. Together with Wageningen the region forms a triangle of higher educational institution. Nijmegen and Wageningen both have large universities while Arnhem has a large university of applied sciences.

These institutions attract a lot of younger people who generally do not own or drive a car. Therefore a large amount of people in this region is dependent on public transit in order to move around.
Therefore the focus in the Arnhem - Nijmegen region will be on improving the public transit network. To achieve this, a network of context-based mobility nodes in the peri-urban areas will be developed. Because Arnhem, Nijmegen and Wageningen are the main nodes, the focus in this region will be on how the peri-urban areas are integrated in this network that facilitate these main nodes. The following paragraphs will dive deeper into this integration, and how the nodes in these peri-urban areas would work.

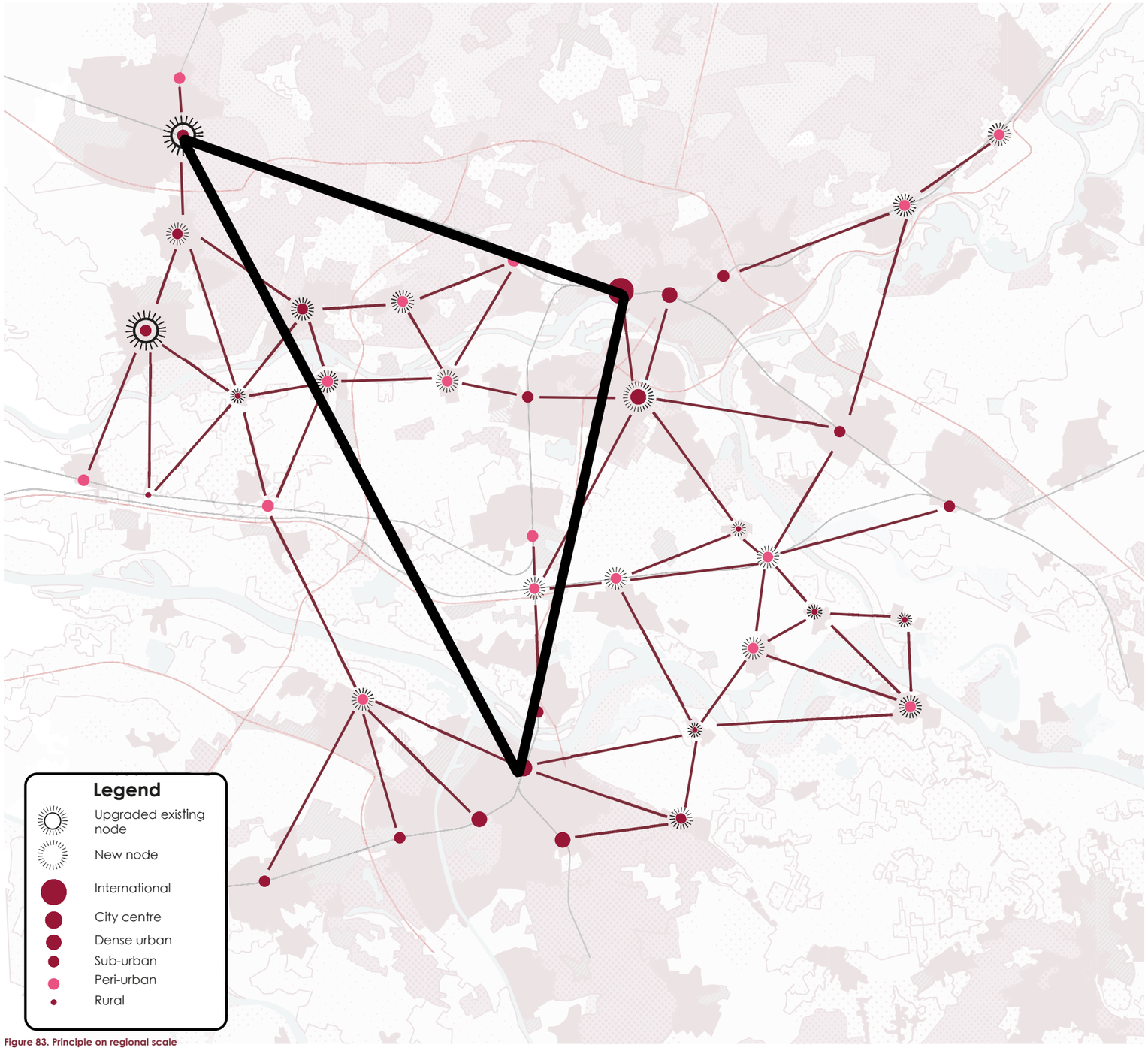


Figure 83. Principle on regional scale

Source: Author's work

THE PRACTICAL IMPLEMENTATION, NEW INFRASTRUCTURE

This map shows the additions we will make to the infrastructure network. On the following pages, we will expand on how we will establish the new connections and what service improvements they will enable.

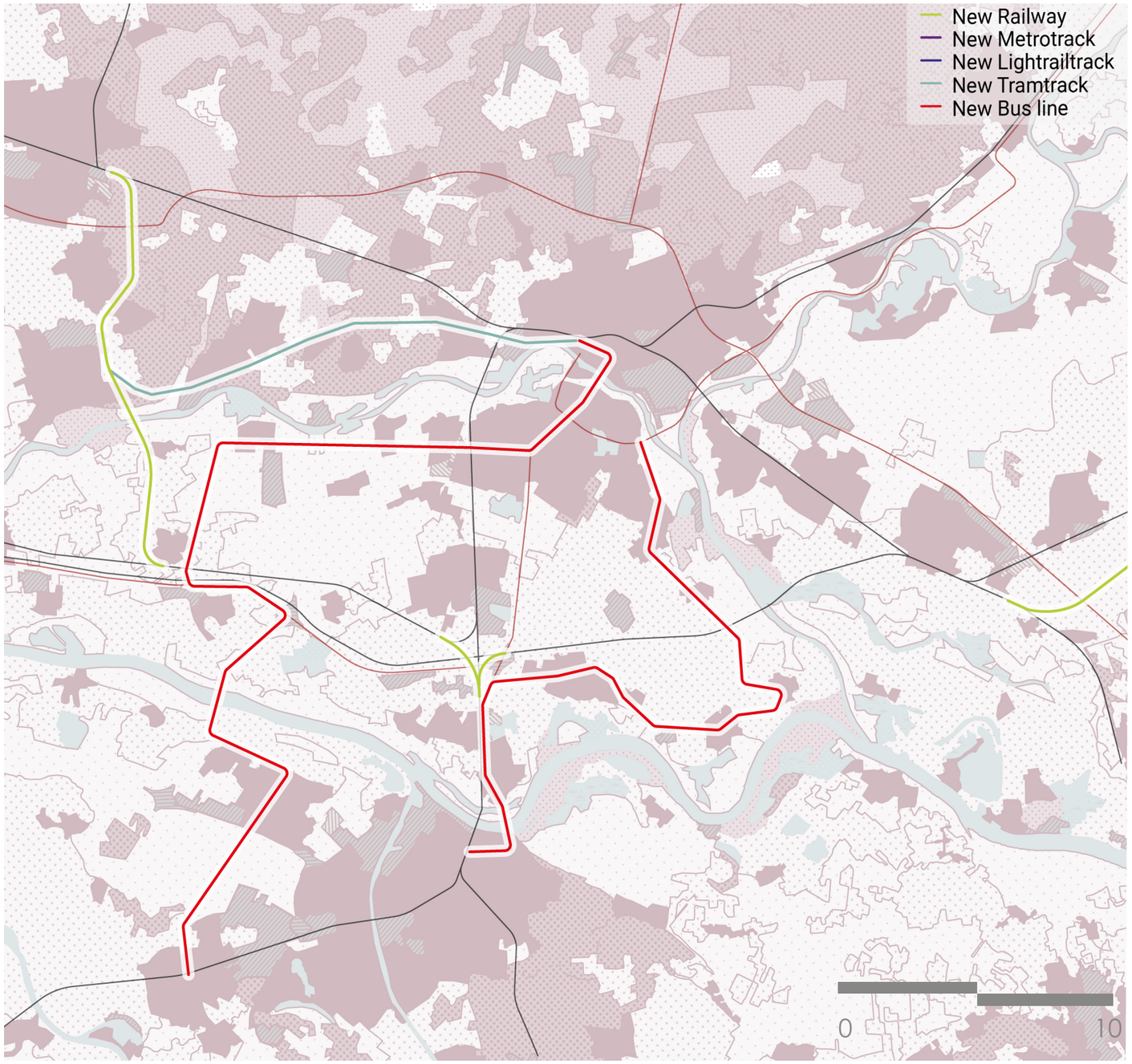


Figure 84. Implementation for Arnhem-Nijmegen

Source: Author's work

THE PRACTICAL IMPLEMENTATION, 2025 - 2030

The first phase of implementation will run from 2025 to 2030. The focus of this stage will be on easy-to-implement solutions to showcase the advantages of good public transit. By doing this, we hope to increase support for the more expensive major interventions of the following stages.

These quick interventions will include improvements in the bus service of the peri-urban areas. This will be done by streamlining the route, removing detours through the villages. Some bus stops will be removed to speed up the service. On busy roads, bus lanes will be added so that buses do not get stuck in traffic during rush hour.

The speeding up of the buses will have the following two positive effects: Firstly, average journey times will decrease, making public transit a more attractive option.

Secondly, and less obvious, the routes will become cheaper to operate. This is because fewer buses and drivers are needed for the same level of service if the journey time is reduced. For example, if you have a route that you want to service two times per hour, and the route takes an hour to complete, you will need two buses and two drivers. If the route now takes half an hour because of improvements, you only need one driver.

This increase in efficiency allows for an improvement in the level of service. More buses can be run each hour.

Other improvements that will be done include improvement to the last-mile transit network. At all major bus stops, electric rental bikes and bike storage will be made available. Additionally, local bike and pedestrian infrastructure will be further improved. This will make the trip from public transit to the final destination as seamless as possible.

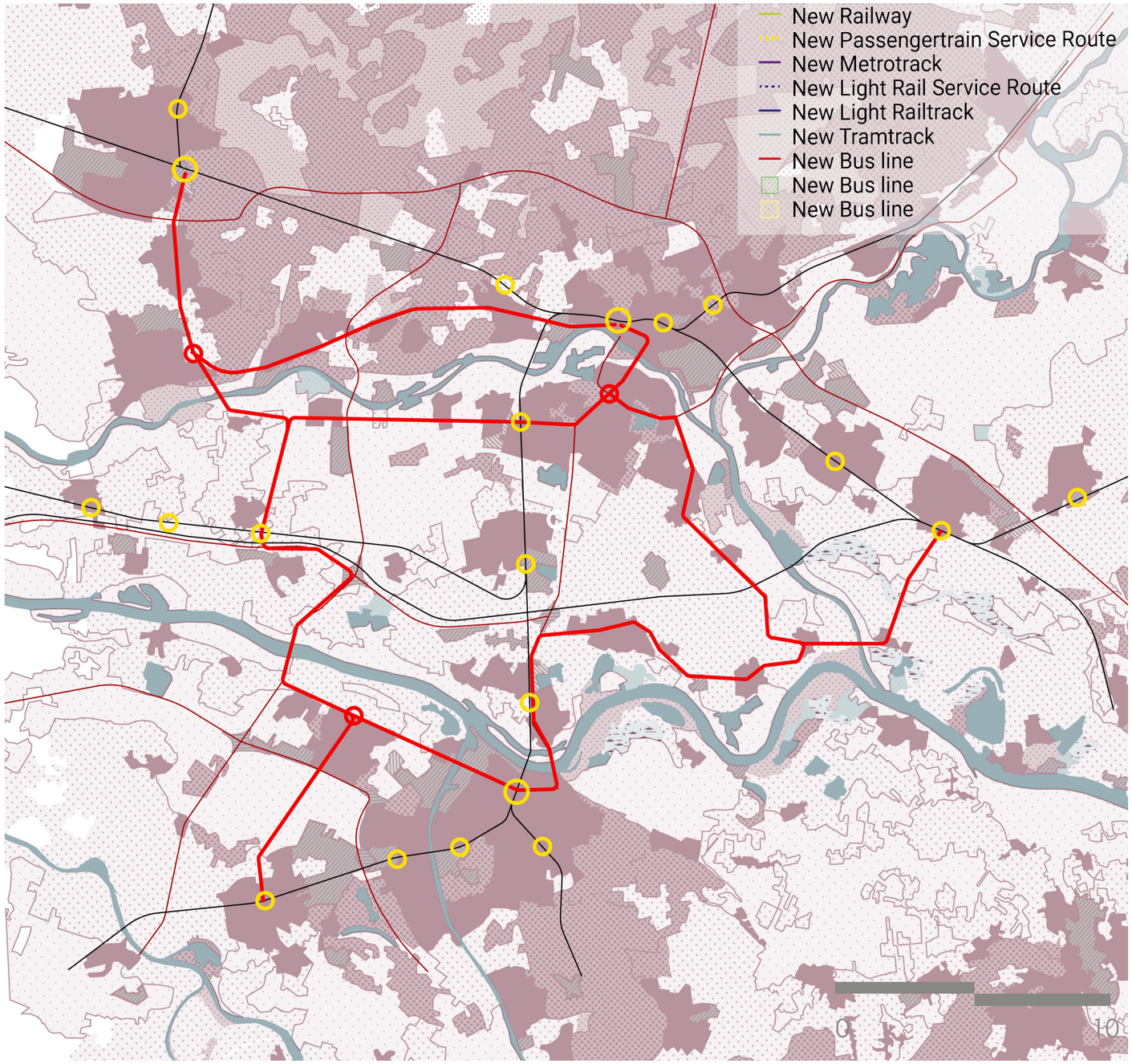


Figure 85. Interventions 2025-2030

Source: Author's work

THE PRACTICAL IMPLEMENTATION, 2030 - 2040

The second phase will run from 2030 to 2040. In this phase, new rail connections will be set up connecting the peri-urban area between Arnhem and Nijmegen to the urban centers. For this purpose, two new rail connections between existing rail lines will have to be built.

One will connect the old passenger line running through the Betuwe towards Nijmegen. The other will connect the recently built Betuwe goods line coming from Germany to Nijmegen.

These two small interventions will enable two new rail services: one from Zevenaar and beyond to Arnhem, the other from Dordrecht via Geldermalsen to Arnhem. This will greatly improve the mobility by public transit of the peri-urban area.

Where the Betuwe route crosses the rail line between Arnhem and Nijmegen, a new distribution hub will be constructed. This hub will have two major functions. It will serve as a supply hub for the local area. Shops will be supplied from here, and farms can ship the goods that they cannot sell locally from here. In addition to this local function, its location on the intersection of two major rail corridors makes it ideal for a role as a recycling hub. Disused goods can be gathered here and can then be redistributed to those who can give them a second life.

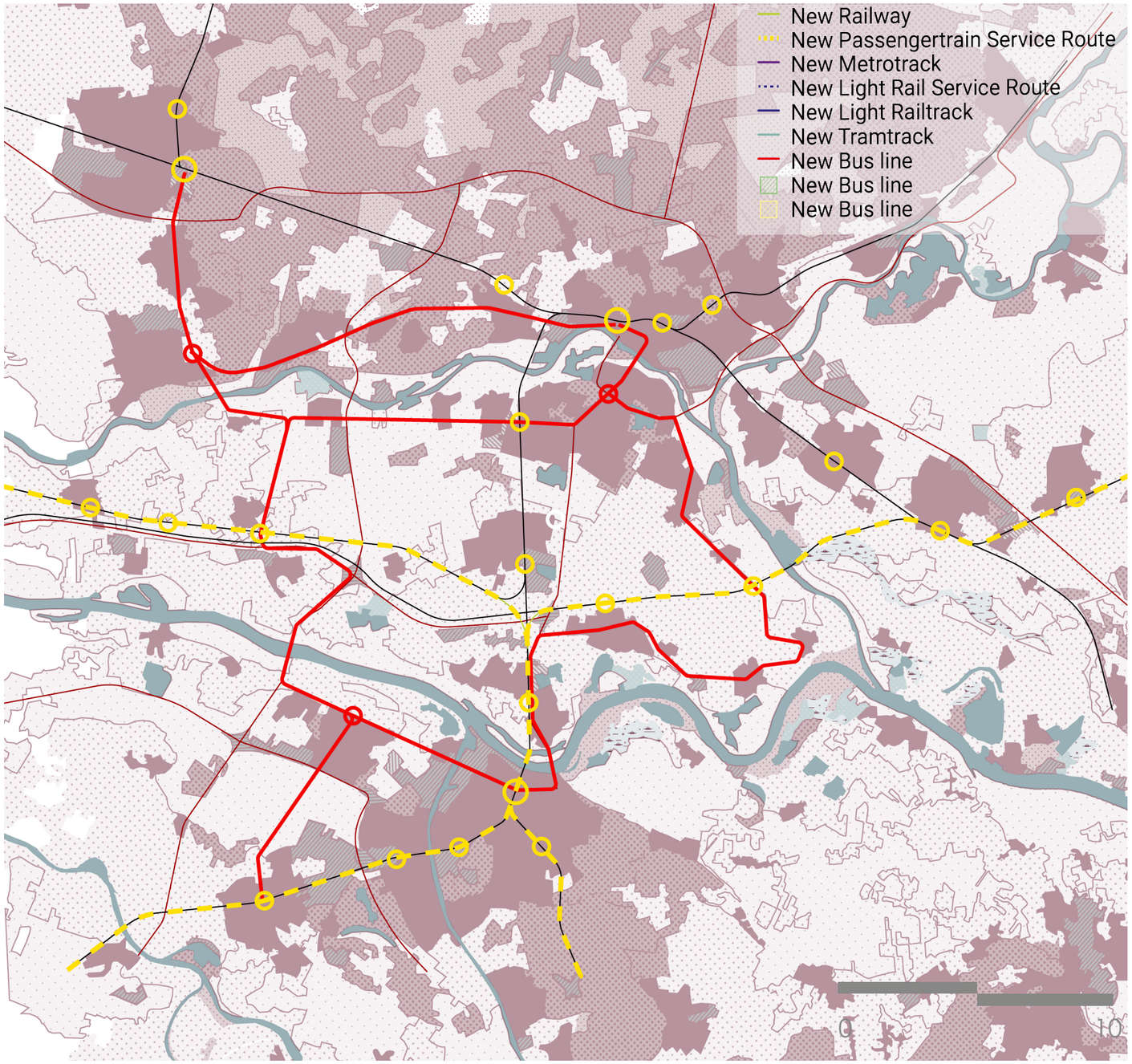


Figure 86. Interventions 2030-2040

Source: Author's work

THE PRACTICAL IMPLEMENTATION, 2040 - 2050

The last phase of the plan runs from 2040 to 2050. In this phase, the last major infrastructure projects will be completed, namely two new heavy rail lines and one new light rail line.

The first heavy rail line will run from Ede to Wageningen. It will then continue over the river towards Zetten, where it will connect to the existing railway towards Arnhem.

This will allow for direct passenger services between Wageningen and Nijmegen. By avoiding Arnhem congestion, this international railway node will be eased. Travel times between the university cities of Wageningen and Nijmegen will also be more than halved.

The second heavy rail line that will be constructed will split from the Betuwe route near Zevenaar. From here, it will run alongside the A18 and N18 alignment towards Enschede, where it will connect to the existing rail network.

This will create a more direct connection between northern Germany and the port of Rotterdam as seen in our regional strategy. This connection will also open up a new direct intercity connection between the Nijmegen, Arnhem, Wageningen agglomeration, and Enschede, which also hosts a well-esteemed university.

Lastly, a light rail connection will be constructed between Arnhem and Wageningen. This will shorten travel times between the cities and improve the connectivity of the peri-urban area in between.

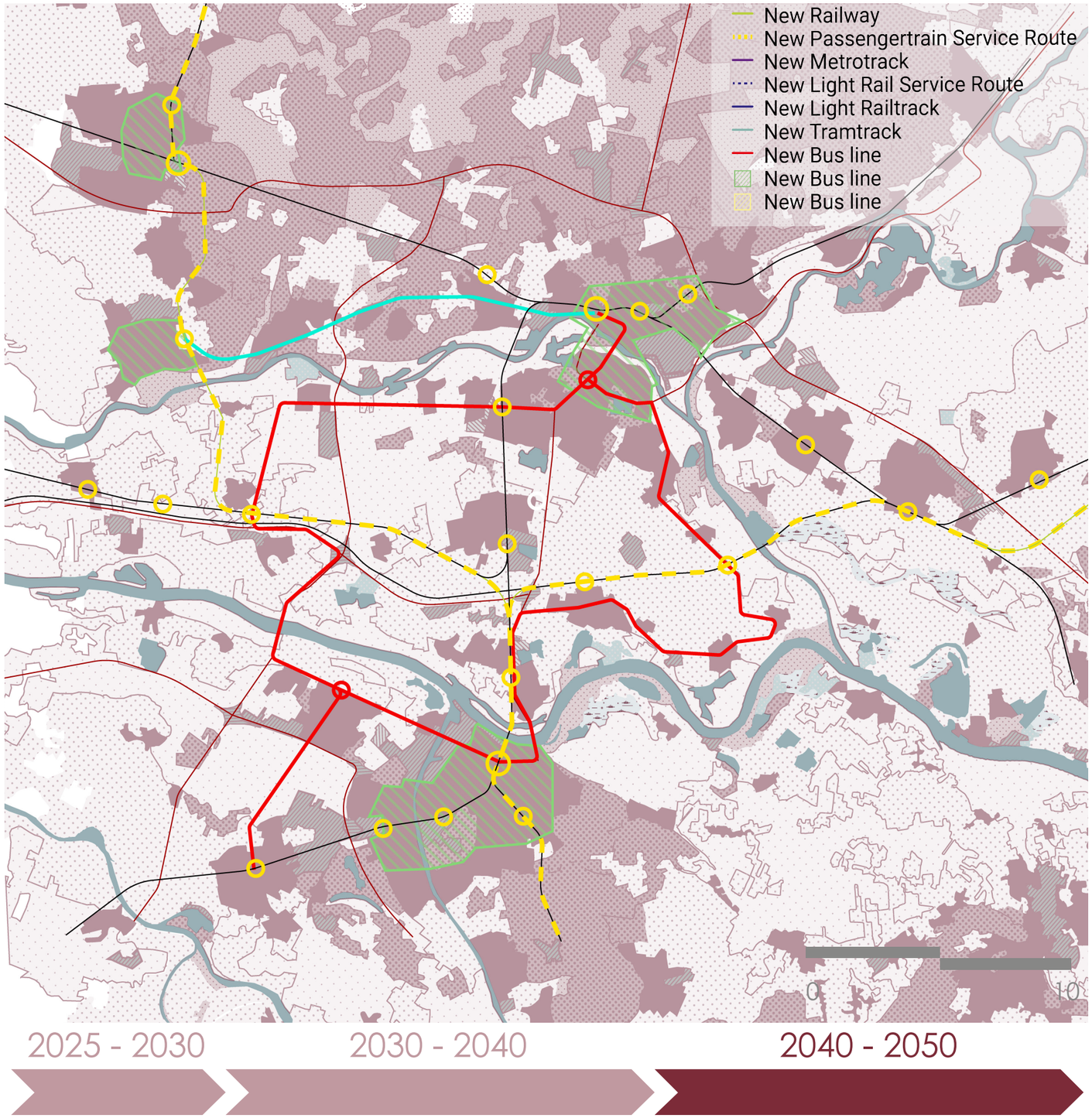


Figure 87. Interventions 2040-2050

Source: Author's work

HOW IS THE PERI-URBAN CONNECTED?

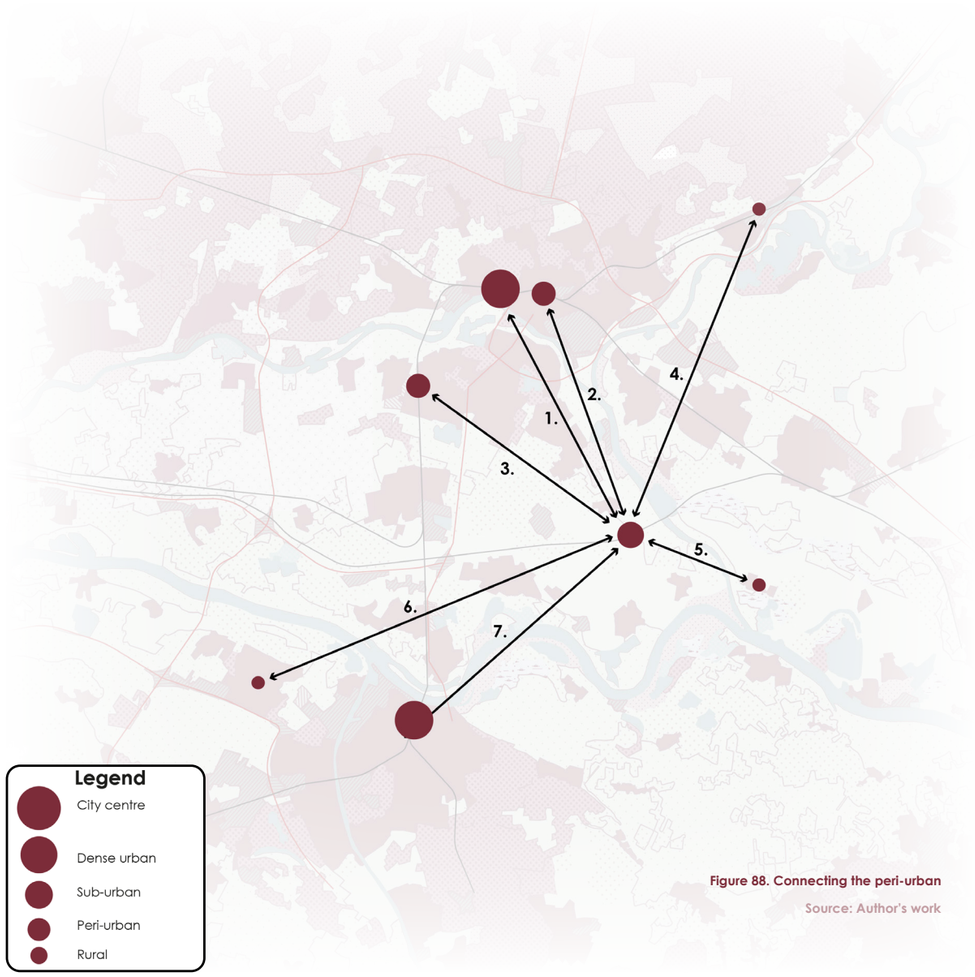


Figure 88. Connecting the peri-urban

Source: Author's work

Figure 74 shows how a peri-urban node in the Arnhem - Nijmegen region is integrated into the larger network of mobility nodes. The table in figure 73 serves as a guideline for connecting peri-urban nodes to the other nodes in the Arnhem - Nijmegen region. The table shows what the desired travel time is between a specific set of nodes, as well as if it will be a direct or in-direct connections. Lastly it shows what transportation options are desired when connecting the peri-urban to the other nodes.

Since the Arnhem - Nijmegen region has an educational character, there are a lot of students in the region. Therefore the transport options are mainly focussed on increasing and improving the public transit. Since the current public transit network is mainly based around bus- and trainlines, the focus will be on utilizing these corridors first. Therefore, the connections between the peri-urban and the other nodes will mainly be facilitated by train, bus, bike and micromobility.

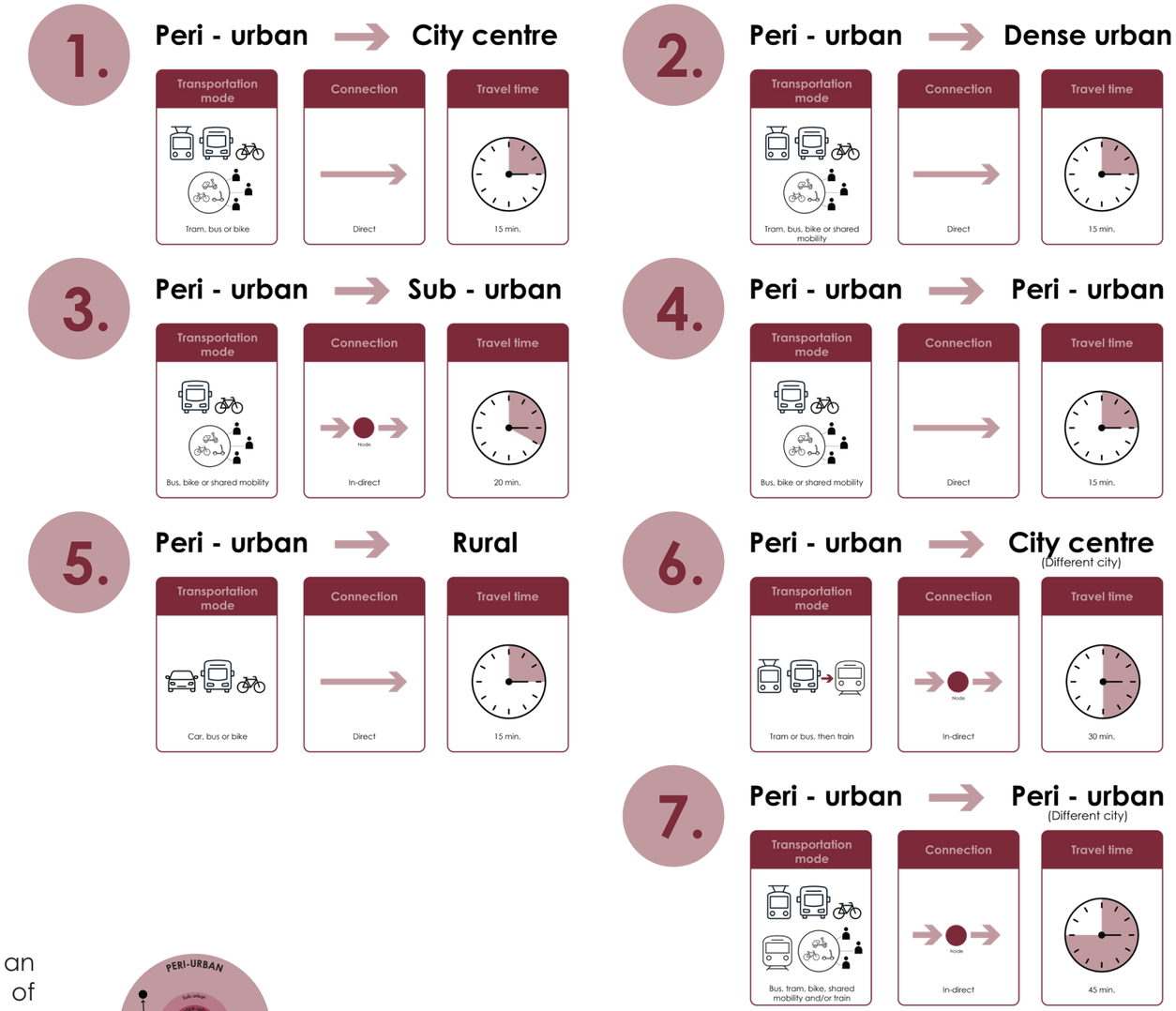


Figure 89. Connections from the peri-urban

Source: Author's work

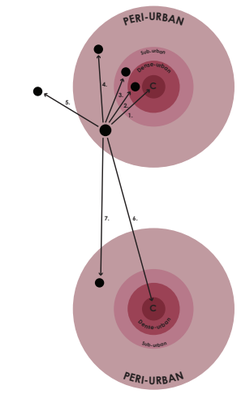


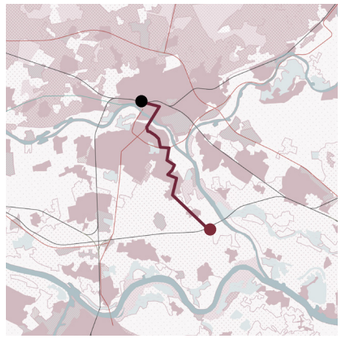
Figure 90. Connecting the peri-urban diagram

Source: Author's work

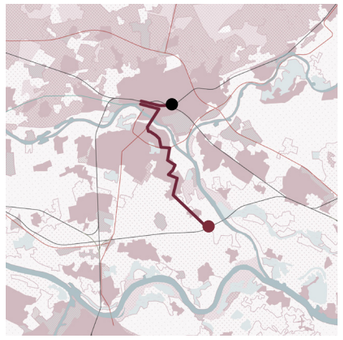
TRAVELLING FROM AND TO THE PERI-URBAN

The drawings on this page show the travel paths and times between the previously described points. On average, travel times have improved by just over 40%.

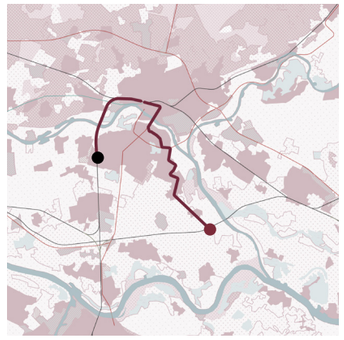
1. PERI-URBAN TO CITY CENTER



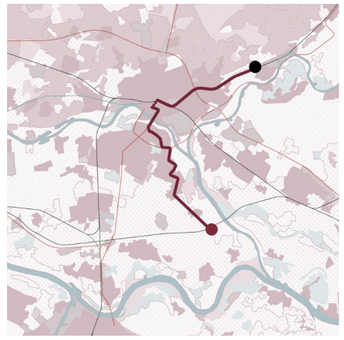
2. PERI-URBAN TO DENSE URBAN



3. PERI-URBAN TO SUB URBAN

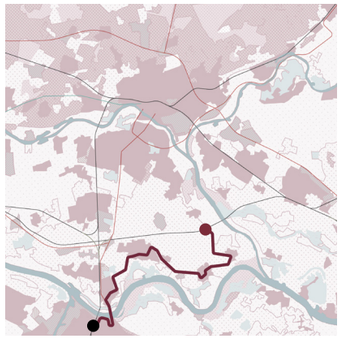


4. PERI-URBAN TO PERI-URBAN



5. PERI-URBAN TO RURAL

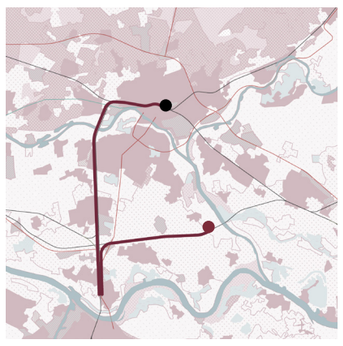
6. PERI-URBAN TO OTHER CITY CENTER



7. PERI-URBAN TO OTHER PERI-URBAN

Figure 92. Old travel routes and times

Source: Author's work



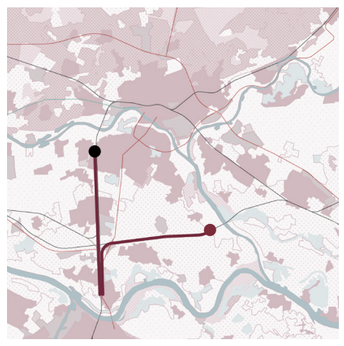


Figure 93. New travel routes and times

Source: Author's work

MOBILITY NODES APPRECIATING THE LOCAL CONTEXT

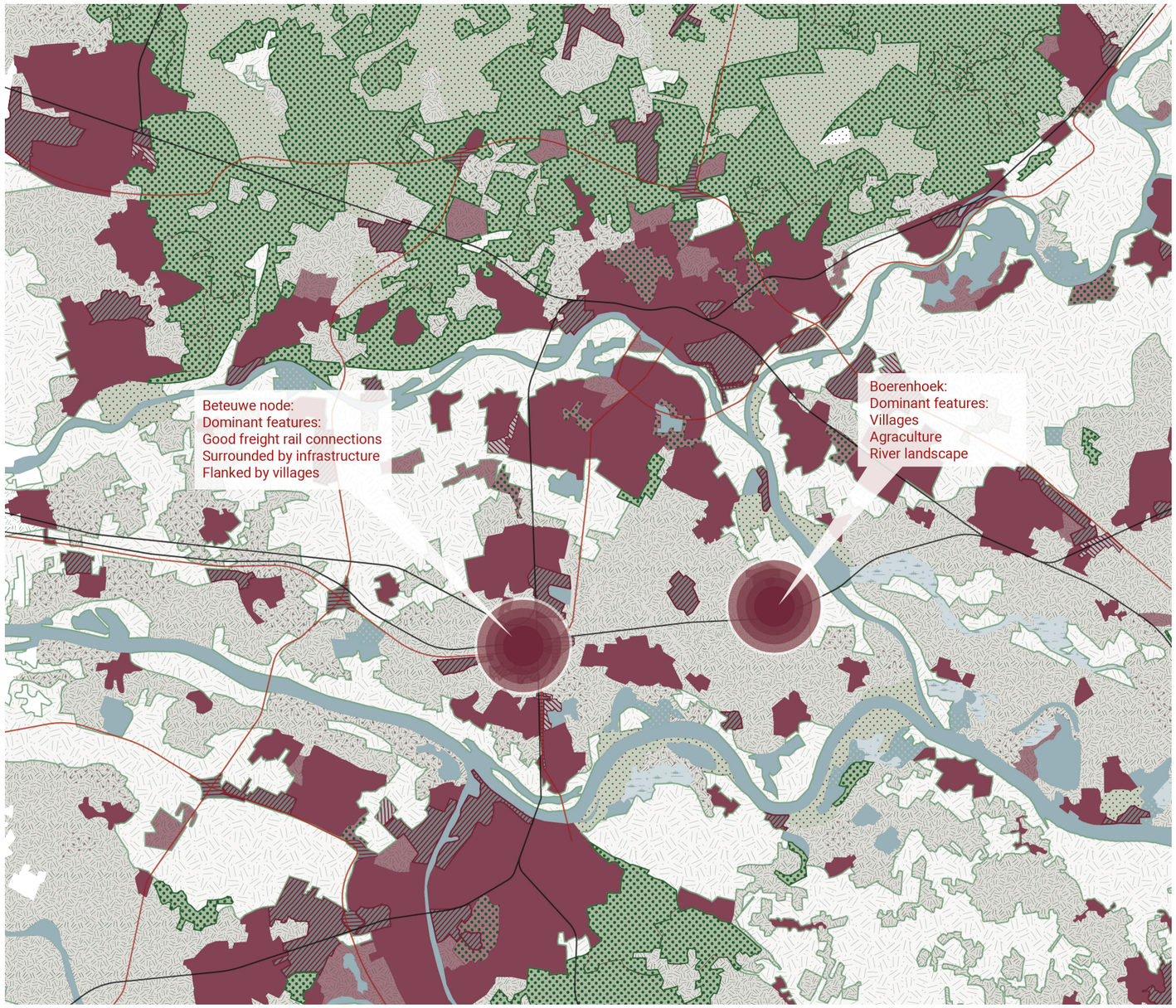


Figure 95. Land covers Arnhem-Nijmegen

Source title: Corine land cover (2018)

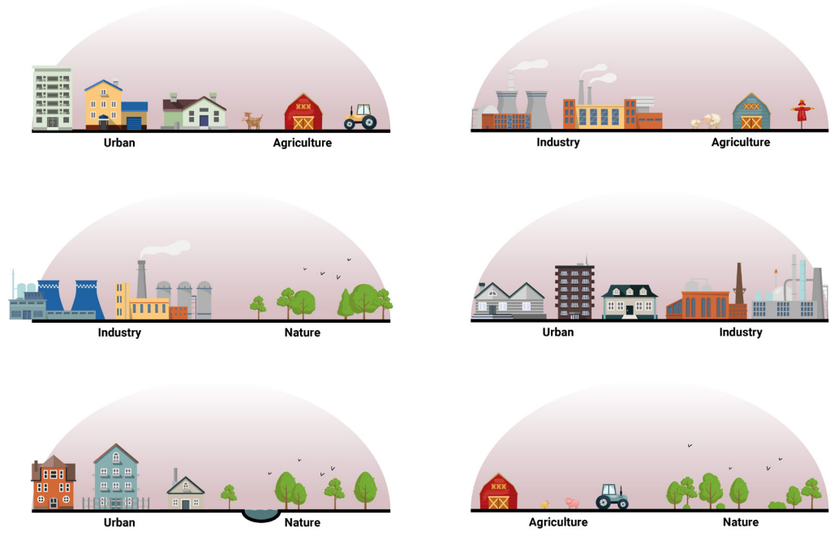
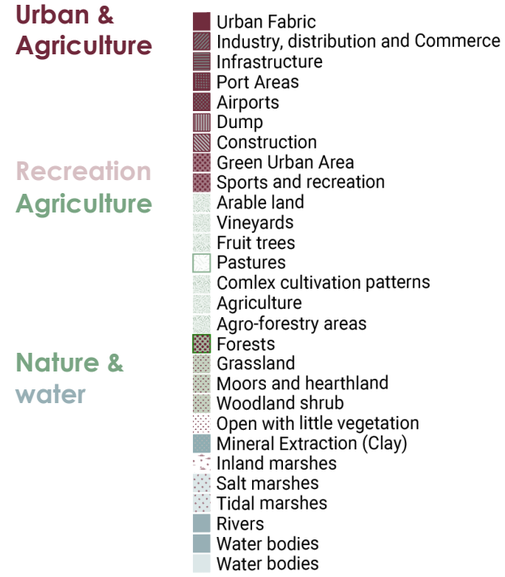


Figure 94. Curernt peri-urban areas

Source: Author's work

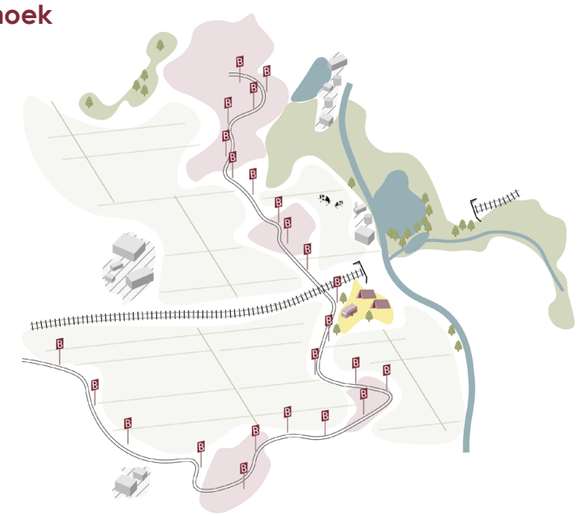


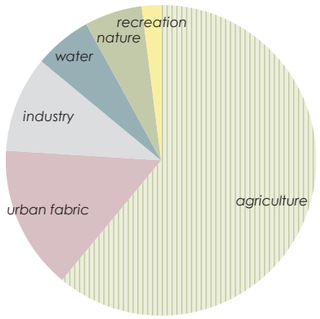
All these new interventions will have an enormous impact, not only for the transport system, as well as for the surrounding area. New nodes will create a better connected network which will provide transport for more people. This intervention will only succeed if it conforms with the potential user's needs (Ministerie van Infrastructuur en Waterstaat, 2023). Therefore it is important to study the characteristics of the new strategic chosen nodes. This will be done mainly by to use of land covers to determine the local context. Figure 95 shows the urban fabric in contrast with the agricultural and nature-based land covers.

In the Arnhem-Nijmegen region there will be added a new node between agricultural lands: Boerenhoek. This peri-urban node will have a new personal train track connecting several villages. The node will be placed where the existing bus line and the existing goods rail track are meeting. Another existing node will be improved this will be done at the point where the rail tracks are meeting near Elst. There are several personal and goods traffic systems using this infrastructure already but a connecting node is missing.

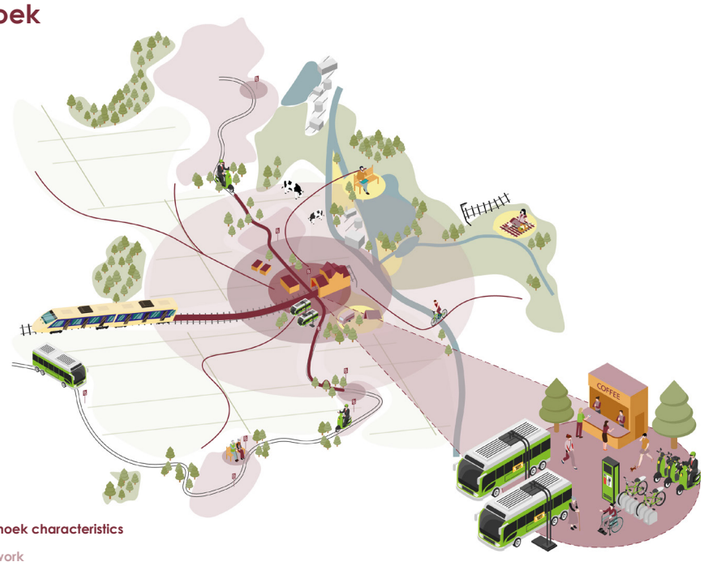
CHARACTERISTICS OF THE NODES

Current situation
Boerenhoek





New situation
Boerenhoek



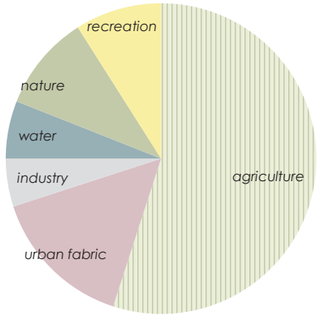
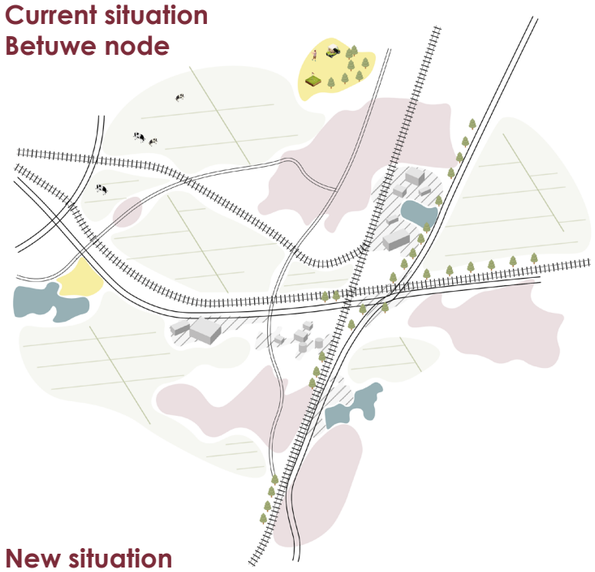
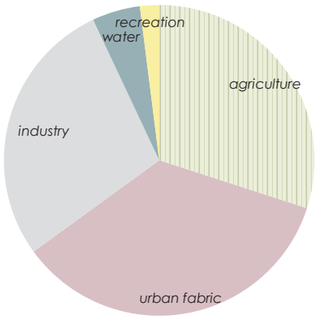


Figure 96. Boerenhoek characteristics

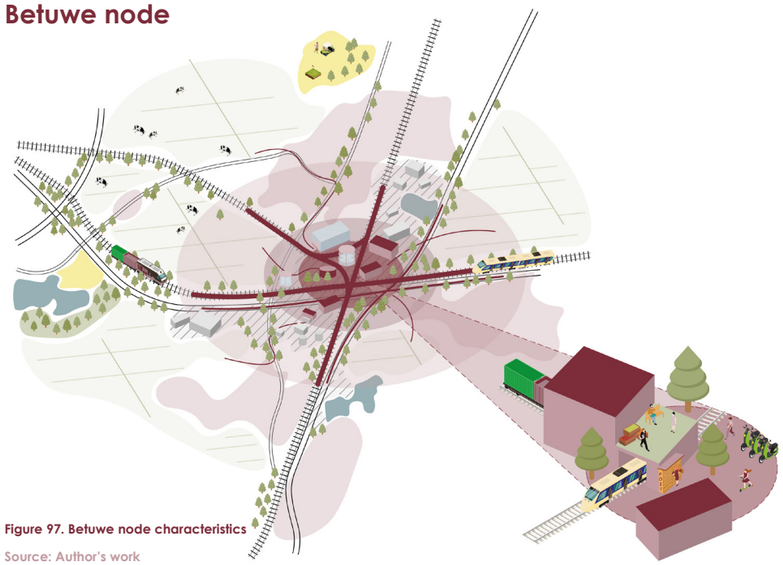
Source: Author's work

Current situation
Betuwe node





New situation
Betuwe node



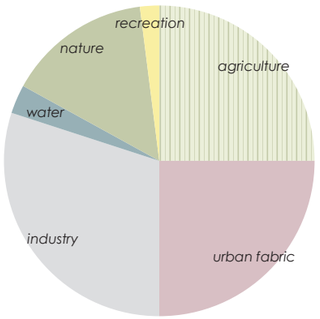


Figure 97. Betuwe node characteristics

Source: Author's work

New node: Boerenhoek

The characteristics of this area is all summarised in its name: Boerenhoek. Literally translated as 'farmers corner'. As shown in figure 96 the river forms a border between the agricultural land cover and a more nature based area. Recreational supported activities, such as a camping and several bed & breakfasts, show existing interest in this place. After connecting this area better by making a new node the area will become more attractive for visitors. Spots of interest, such as a nature park across the river, a castle in the field and the radiating peace of the country side will be easy accessible by sustainable forms of (shared) mobility and public transport. Its agricultural and recreational character will be reinforced and potentials are utilized.

Existing node: Betuwe node

This peri-urban Betuwe node consists of a tangled network of structures where fragmented disconnected distribution land covers are segregated by highways and train tracks as can be seen in figure 97. In between are empty 'agricultural' lands not living up to their full potentials. The improved node will make use of this industrial character by adding new industrial land covers in empty fields and connecting the existing ones. New stations for distribution and people will make short last miles and accessible areas. Local agricultural products can be easy transferred to a global network of goods transport.

PERI-URBAN NODE: IMPRESSION

BOERENHOEK

Figure 98. Impression of Boerenhoek

Source: Author's work

ROTTERDAM - THE HAGUE

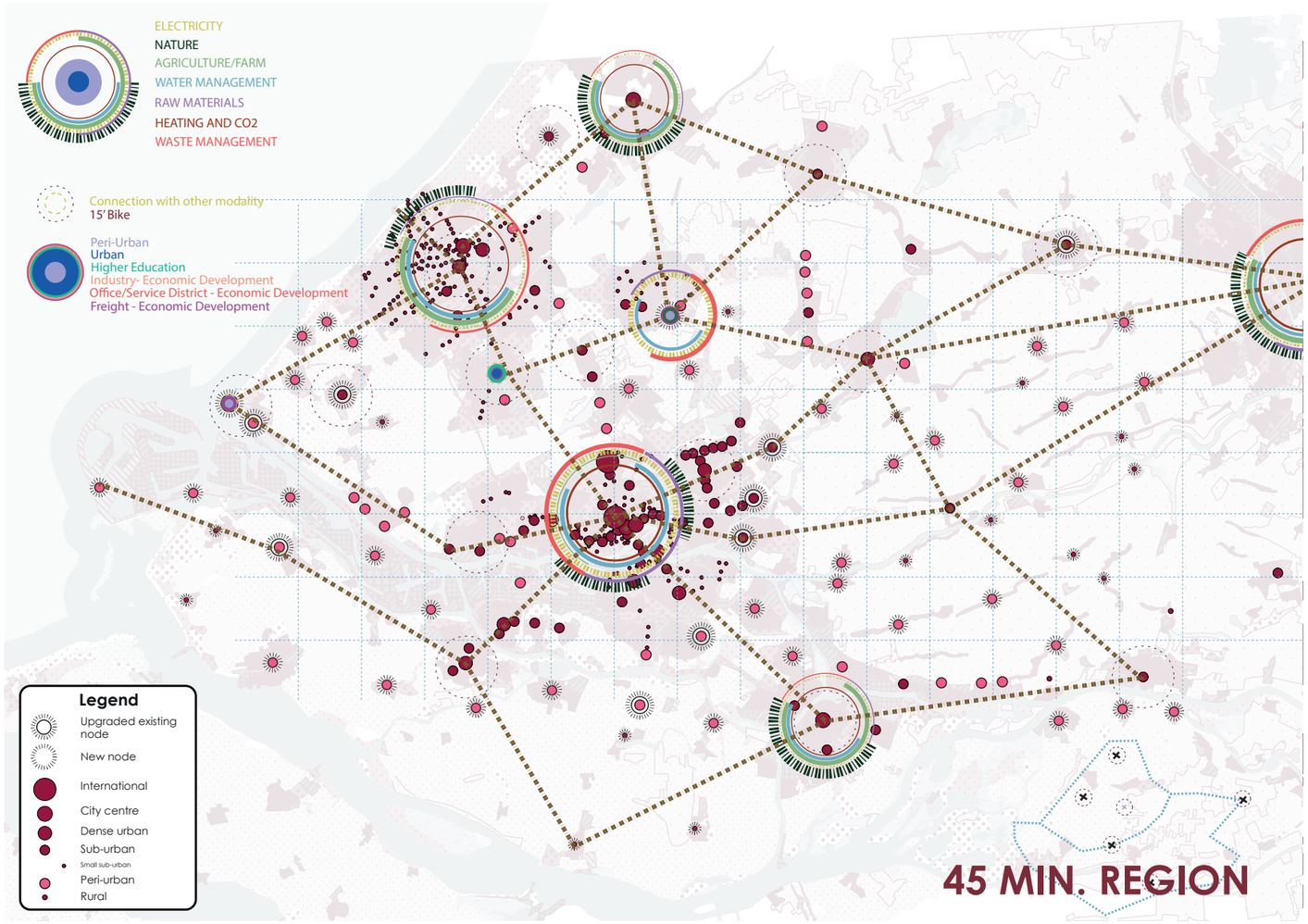


Figure 99. Circular Scenario for Rotterdam - The Hague area

Source: Author's work

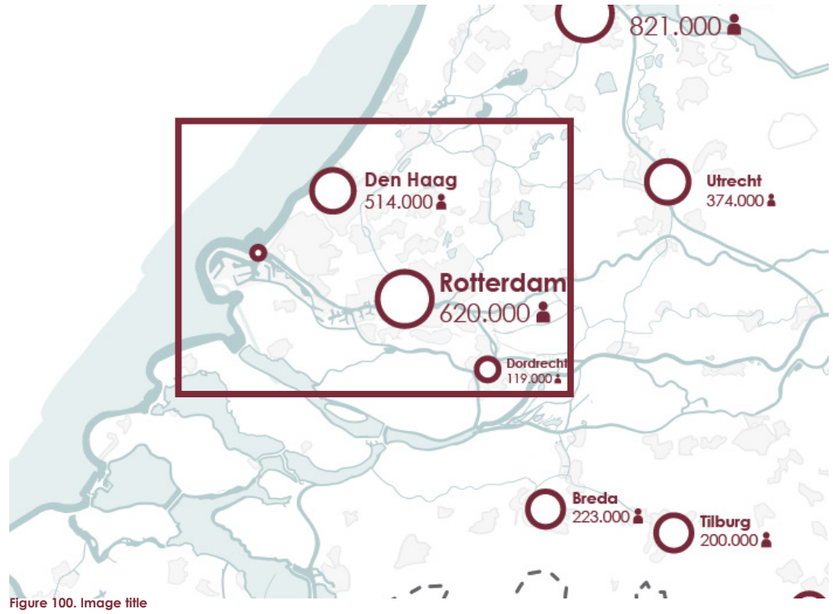


Figure 100. Image title

Source: Author's work

This map represents a circular scenario for the Rotterdam – The Hague urban and periurban nodes, by embracing sustainable transportation practices and creating resilient and thriving regions for 2050. By integrating circularity aspects (developed in the previous chapter) into regional planning and development strategies, communities can increase their resilience, reduce environmental impact, and foster more equitable and prosperous societies for both current and future generations.

The implementation of sustainable transportation measures aligns with the 2030/2050 climate target plan, which emphasizes increasing the modal shares of collective transport, walking, and cycling, as well as promoting automated, connected, and multimodal mobility solutions.

In the map, you can see how the region can be connected through the different urban and periurban nodes within 15 or 45 minutes. Each node has a color, and the color represents the main characteristic of the node, whether it is urban or periurban. Each line represents max. of 15-minute travel time, and a region is composed of three of those lines (15+15+15). The urban regional nodes (bigger circles) respond to the characteristics of circular scenario explained in the previous chapter and the amount varies depending on the characteristic of each city and context. For example, the Arnhem and Nimegen node has a bigger agricultural and green infrastructure aspect, while the Rotterdam The Hague node revolves more in energy and waste management.

Growing circular economy implies more recycling and less intercontinental transports of raw materials and products, wich will mean a decrease in long-distance flow for plastic, energy, food and feed. By prioritizing these initiatives, regions can significantly reduce pollution and congestion from transport, particularly in urban areas, while simultaneously improving the health and well-being of residents.

WHAT IS GOING TO CHANGE?

Aside from being a heavily urbanized region, the Rotterdam - The Hague region can really be described as an industrial region. On the west side of the region the port of Rotterdam and Westland can be found. The port of Rotterdam is one of the largest ports for transshipment of containers in the world. Besides, it also knows quite a large petroleum industry. The Westland area is a large area with a vast amount of green houses. Many crops are produced and transported from here, to all over Europe. On the east side of the region, a vast area can be found of agricultural areas.

The port of Rotterdam, Westland and the agricultural areas generate a lot of logistical transit, as well as employment opportunities. Therefore the focus in the Rotterdam - The Hague region will be on improving both the network for people transit, as well as logistical transit.

To achieve this, a network of context-based mobility nodes will be developed that focus on connecting the port of Rotterdam, Westland and the agricultural to the urbanized areas of Rotterdam and the Hague.
The following paragraphs will dive deeper into how the new and upgraded peri-urban nodes will be integrated in the existing network, and how they would work.

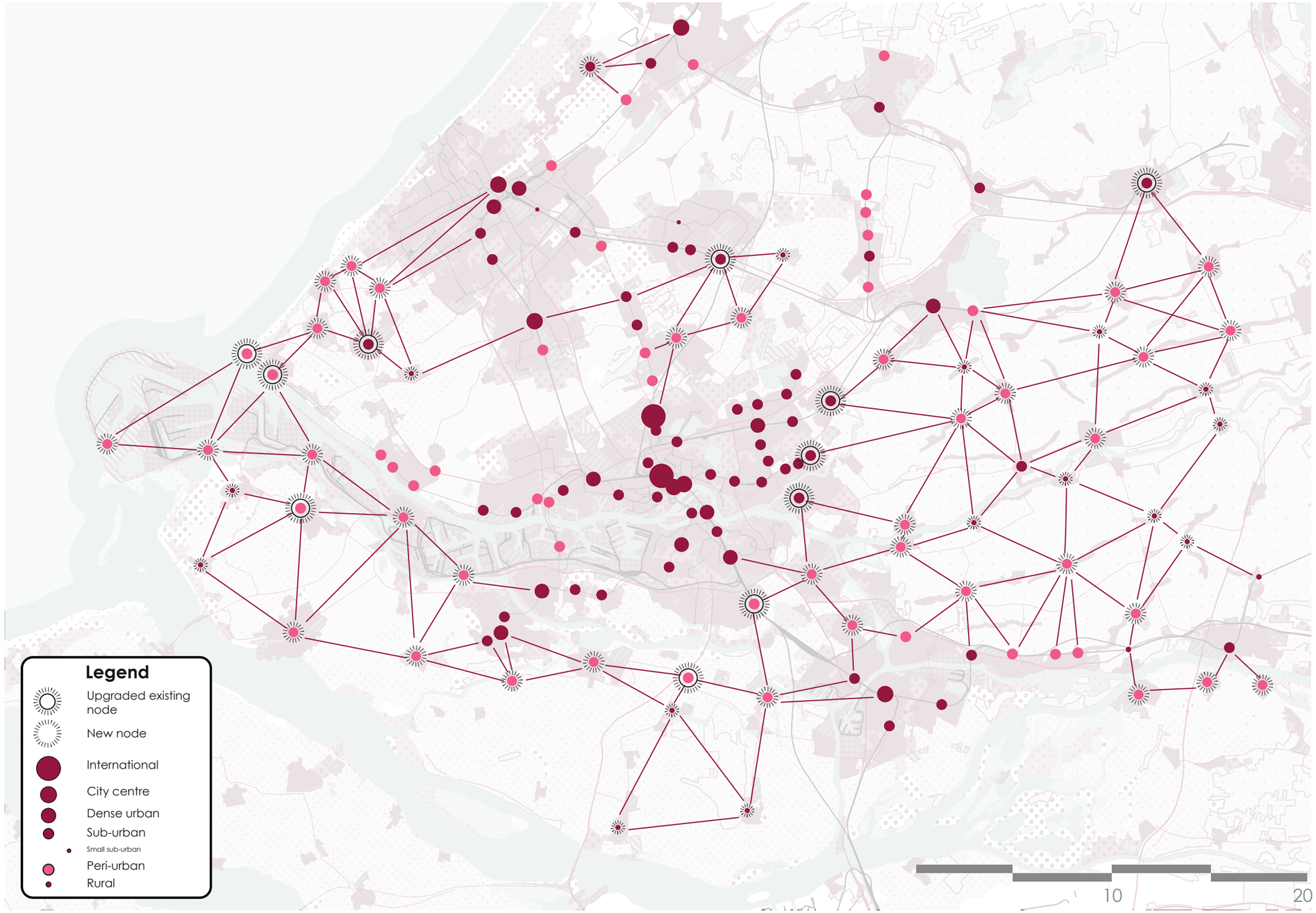


Figure 101. Principle on regional scale

Source: Author's work

THE PRACTICAL IMPLEMENTATION, NEW INFRASTRUCTURE

On this map, the additions to the infrastructure network are shown. On the following pages, we will go into more depth by showing in what order the interventions will be carried out and what improvements in service and connectivity they will enable.

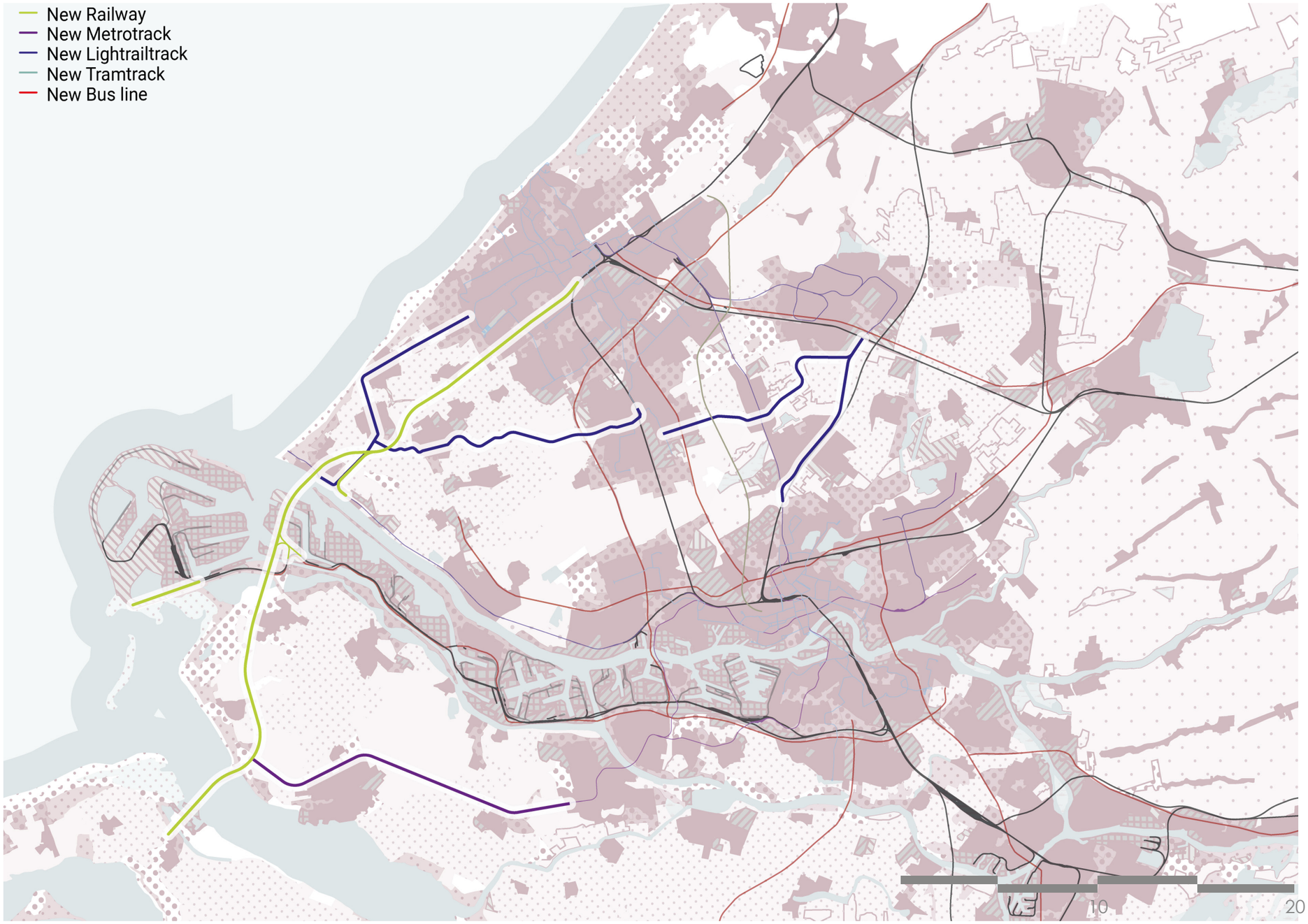


Figure 102. New situation

Source: Author's work

THE PRACTICAL IMPLEMENTATION, 2025 - 2030

This map shows the first phase of our improvements to the infrastructure network of the Rotterdam-The Hague area. The first phase will run from 2025 to 2030 and will focus on quick interventions that improve the connectivity by public transit of the peri-urban areas between the two cities.

This will be achieved by improving the bus connections to the region. Where possible, dedicated bus lanes will be added so that buses do not get stuck in rush hour traffic. In a few cases, more direct routes will be chosen, avoiding large detours through villages.

These interventions will improve journey times and will enable more dense service patterns.

At the same time, last-mile connectivity will be improved by creating last-mile (shared) mobility hubs at major bus stations.

These interventions will make public transit a more attractive option. This will showcase the advantages of public transport to the general public, increasing support for the following phase.

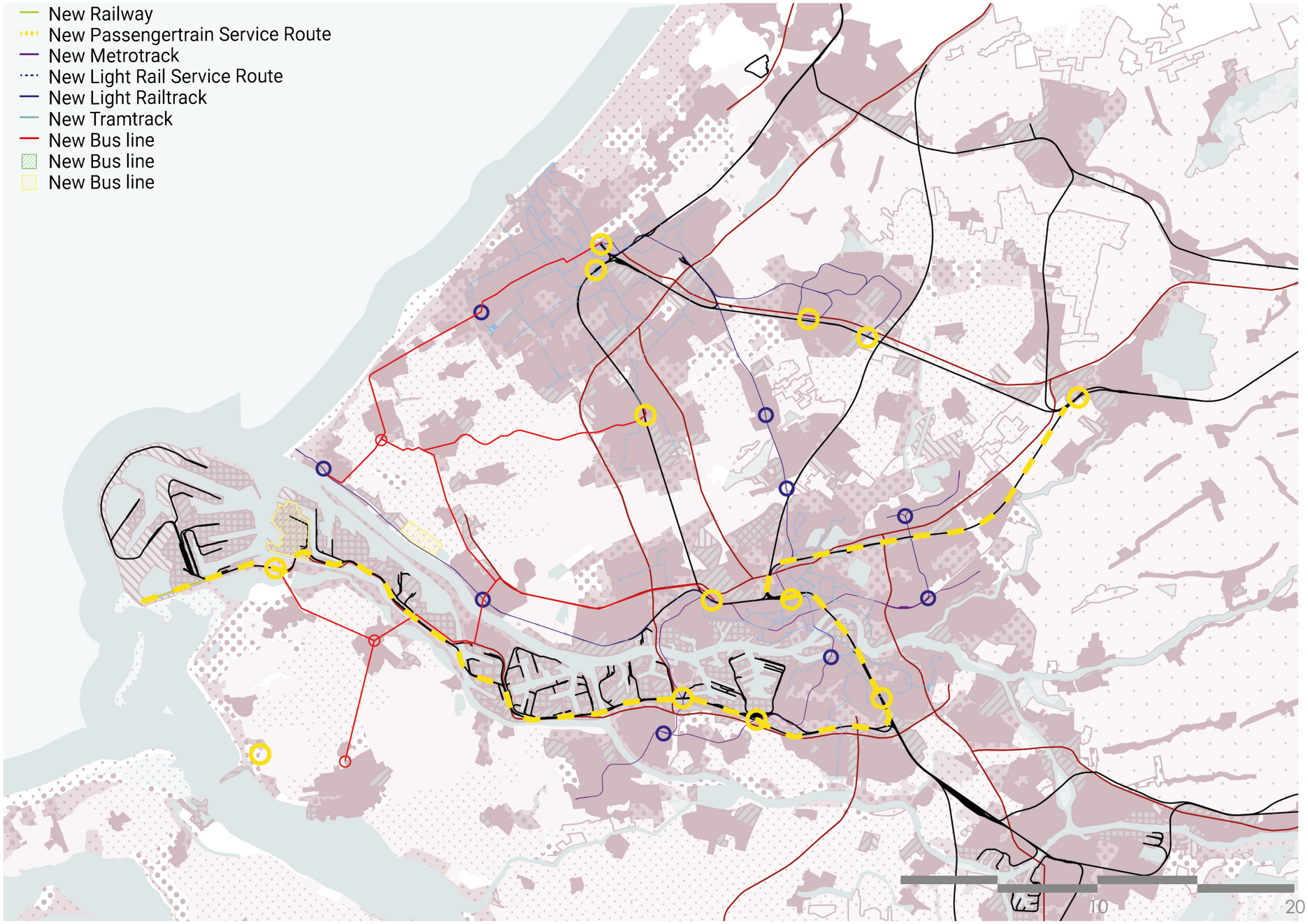


Figure 103. Intervention in 2025-2030

Source: Author's work

THE PRACTICAL IMPLEMENTATION, 2030 - 2040

Phase two will run from 2030 to 2040. This phase will focus on building new infrastructure to further improve the connectivity of the peri-urban areas. This will be achieved by the development of two new fast trams and two extensions to the Rotterdam metro system.

The first fast tram line will start in Hoek van Holland and will run parallel to the coast towards The Hague. Along its route, it will pass through 's-Gravenzande and Monster, improving the connectivity of these villages. Once in The Hague, the tram will pass through the city center and continue all the way to Zoetermeer over existing tracks.

The second fast tram line will run from Hoek van Holland to Delft. Here, it will run along the existing tram network to the university campus before continuing north towards Zoetermeer, where it will terminate at the train station. Along its route, it will service the towns of Naaldwijk and Pijnacker, among others.

The first metro extension will extend the metro from its current southeastern terminus at the Akkers further west to Hellevoetsluis and a new terminus at the beach near Rockanje.

The second extension of the metro network will split off from metro line E after it crosses the HSL South. It will follow the same alignment through Berkel en Bergschenhoek, after which it will head due north, connecting to the existing rail network of Zoetermeer.

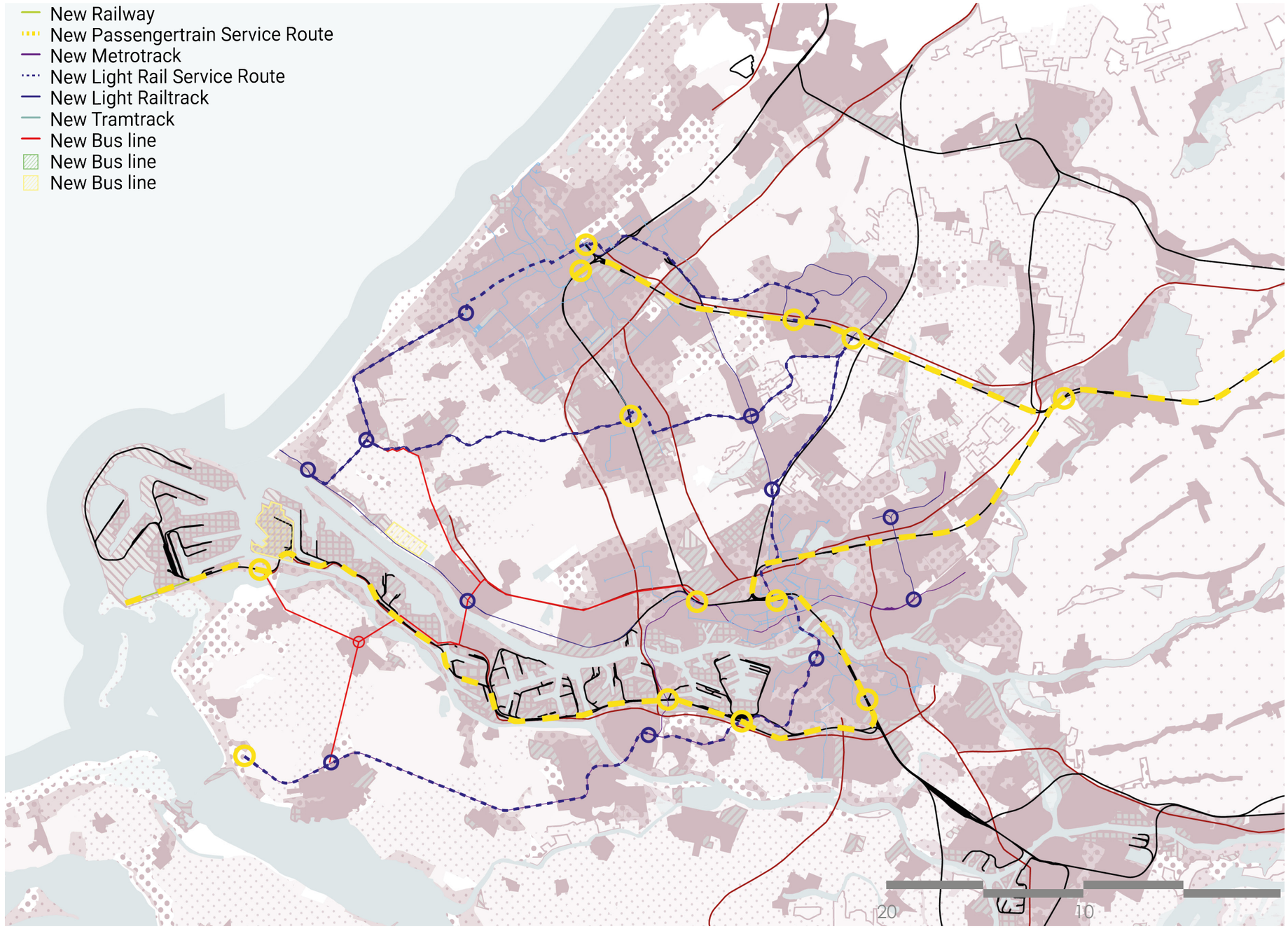


Figure 104. Interventions in 2030-2040

Source: Author's work

THE PRACTICAL IMPLEMENTATION, 2030 - 2040

The last stage will run from 2040 to 2050. This phase will focus on increasing capacity and restricting car use.

The capacity improvements will be achieved by the construction of a new rail link across the harbor. This rail line will split off from the "oude lijn" just south of The Hague HS. From here, it will go underground and follow the Erasmusweg to the edge of the city. Once out of the city, the railway comes up above ground and heads to the new public transit hub between Naaldwijk and 's-Gravenzande.

After this, the railway will enter a tunnel to pass underneath the Nieuwe Waterweg, as to not block tall ships from entering the harbor of Rotterdam. The railway will pop up above ground again on the harbor peninsula where the new reuse center will be located. Here it will also connect with the existing harbor railroad. After a station on the south side of the Hartelkanaal, the line will continue to travel to Zeeland, Western Belgium, and Northern France.

This railway will carry both freight and passenger traffic. This will create an extra north-south axis, lessening congestion at the already busy Willemspoortunnel.

When all these projects are completed, public transit in the region will be so good that cars won't be necessary for city life. Because of this, cars will be banned from urbanized areas, exceptions will be made for delivery vehicles and less mobile people.

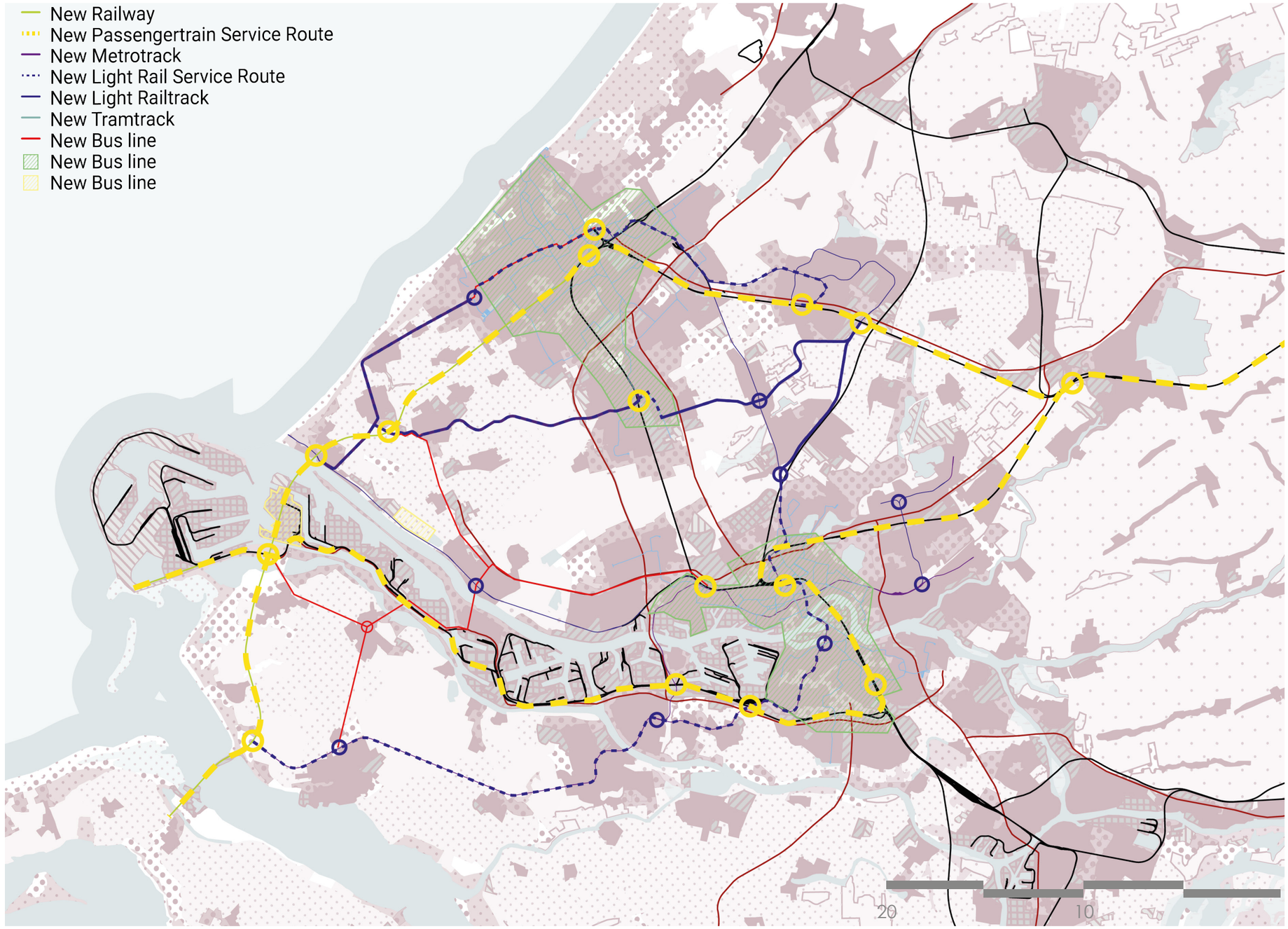


Figure 105. Interventions in 2040-2050

Source: Author's work

HOW IS THE PERI-URBAN CONNECTED?

ROTTERDAM - THE HAGUE

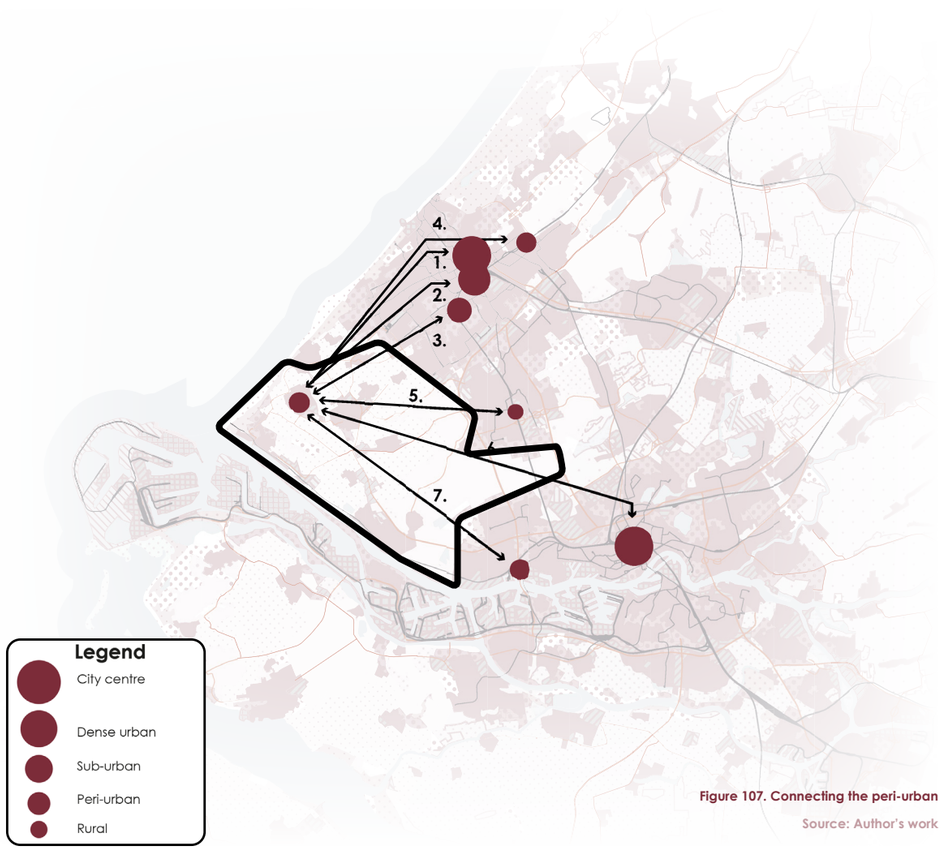


Figure 107. Connecting the peri-urban

Source: Author's work

For this section we will zoom in a bit more on the Rotterdam - The Hague region. We do this because it currently is still such an extensive region. In order to give proper insight in how the peri-urban is connected in the Rotterdam - the Hague region a larger zoom-in was required.

For this zoom in we look at the Westland region. It is a region that houses a vast amount of green houses and forms a large logistical cluster.

Figure 89 shows how a peri-urban node in the Westland region is integrated into the larger network of mobility nodes. The table in figure 88 serves as a guideline for connecting peri-urban nodes to the other nodes in the Westland region. The table shows what the desired travel time is between a specific set of nodes, as well as if it will be a direct or in-direct connections.

Lastly it shows what transportation options are desired when connecting the peri-urban to the other nodes.
region.

Since the region has a more logistical character the focus will mainly lie on the use of railway transportation. The focus will also be on improving the accessibility by public transit because the region offers a lot of employment opportunities. For this we aim to build further upon the existing lightrail, train and tram infrastructure.

1. Peri - urban → City centre

Transportation mode	Connection	Travel time
Lightrail, metro & shared mobility	Direct	10 min.

2. Peri - urban → Dense urban

Transportation mode	Connection	Travel time
Lightrail, metro, bike & shared mobility	In-direct	10 min.

3. Peri - urban → Sub - urban

Transportation mode	Connection	Travel time
Lightrail, bike & shared mobility	In-direct	15 min.

4. Peri - urban → Peri - urban

Transportation mode	Connection	Travel time
Lightrail, bus, bike & shared mobility	In-direct	20 min.

5. Peri - urban → Rural

Transportation mode	Connection	Travel time
Car, bus or bike	In-direct	15 min.

6. Peri - urban → City centre (Different city)

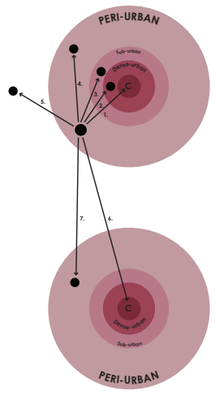
Transportation mode	Connection	Travel time
Lightrail/metro, bus, bike, train, shared mobility	Direct	30 min.

7. Peri - urban → Peri - urban (Different city)

Transportation mode	Connection	Travel time
Lightrail/metro, bus, bike, train, shared mobility	In-direct	45 min.

Figure 106. Connections from the peri-urban

Source: Author's work



1. Peri urban - City Centre
2. Peri - urban - Dense urban
3. Peri - urban - Sub-urban
4. Peri - urban - Peri - urban
5. Peri - urban - Rural
6. Peri - urban - City Centre (different city)
7. Peri - urban - Peri - urban (different city)

Figure 108. Connecting the peri-urban diagram

Source: Author's work

TRAVELLING FROM AND TO THE PERI-URBAN

The drawings on this page illustrate the travel paths and times between the previously described points. On average, travel times have been halved.

1. PERI-URBAN TO CITY CENTER

2. PERI-URBAN TO DENSE URBAN

3. PERI-URBAN TO SUB URBAN

4. PERI-URBAN TO PERI-URBAN

5. PERI-URBAN TO RURAL

6. PERI-URBAN TO OTHER CITY CENTER

7. PERI-URBAN TO OTHER PERI-URBAN

Figure 109. Old travel routes and times

Source: Author's work

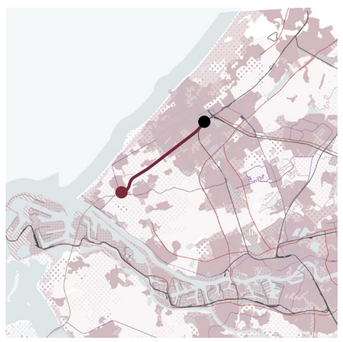
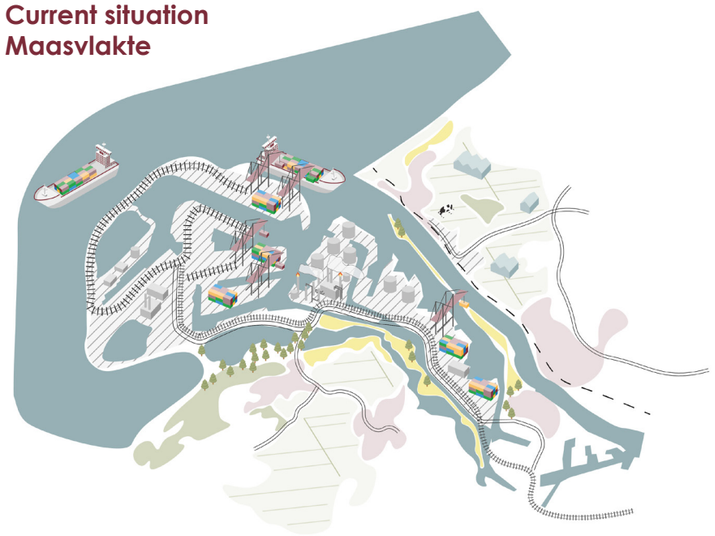


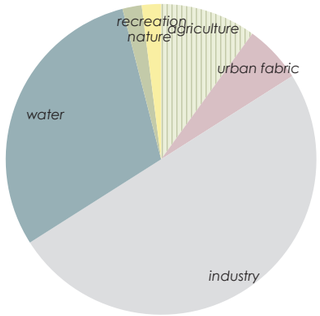
Figure 110. New travel routes and times

Source: Author's work

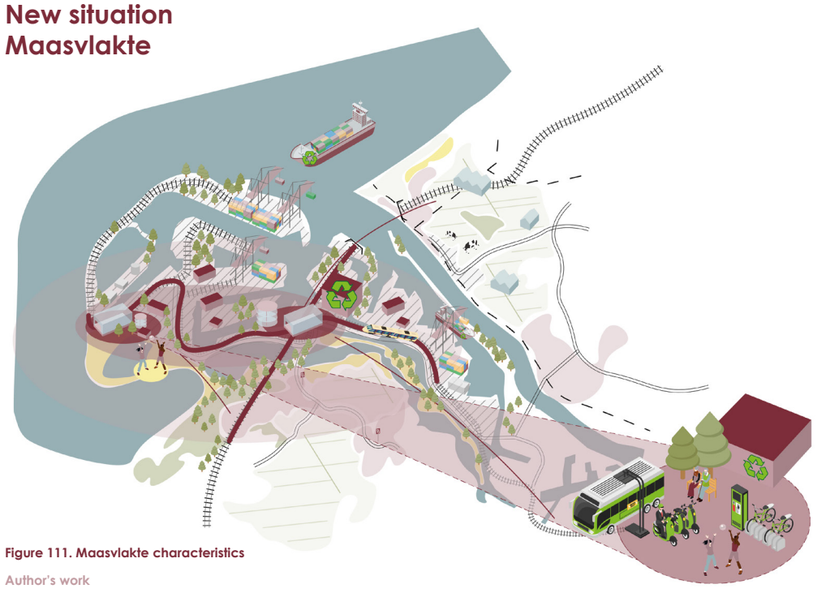
CHARACTERISTICS OF THE NODES

Current situation
Maasvlakte





New situation
Maasvlakte



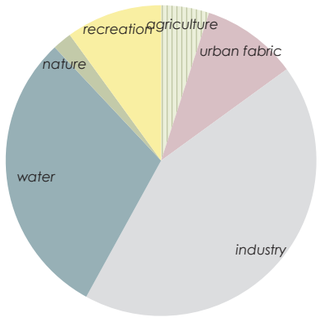


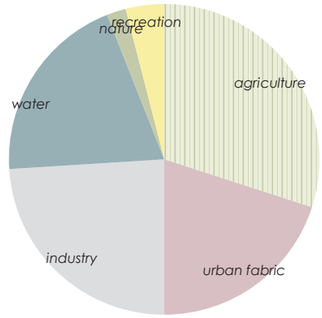
Figure 111. Maasvlakte characteristics

Author's work

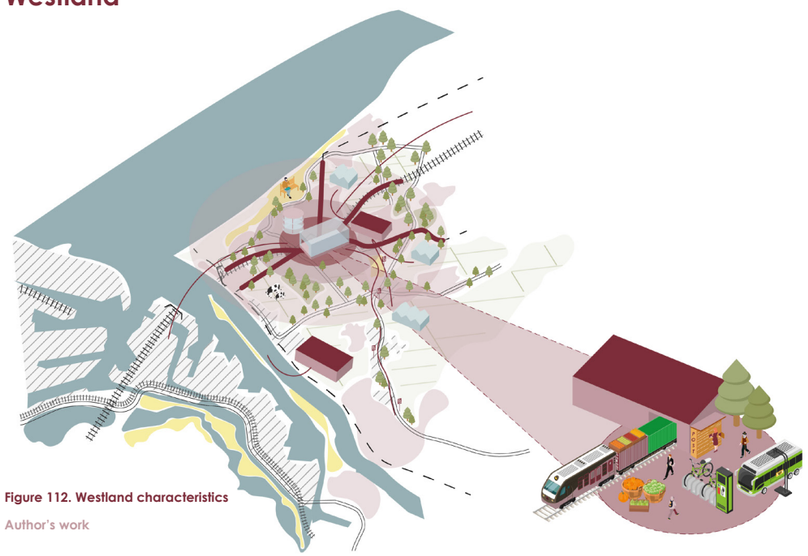
New node: Maasvlakte

In need of more storage for containers the port of Rotterdam started in the 60s with the construction of the Maasvlakte. Water was transformed into land approximately forty kilometres from the city centre of Rotterdam. Although the Maasvlakte seems an hard industrial port area with no space for anything else there are also recreational land covers as seen in figure 111. A new visitor centre, Portlantis by MVRDV, is located near the beach along the coast. Panorama views over the port, beach and the sea will attract visitors. To make this transition possible a new (personal) train station is needed on the existing rails. At the node of the existing and new train connection from north to south will, instead of hard petrol industry, come a new recycle hub that support circular economy in the port and is well connected with the Netherlands.

Current situation
Westland



New situation
Westland



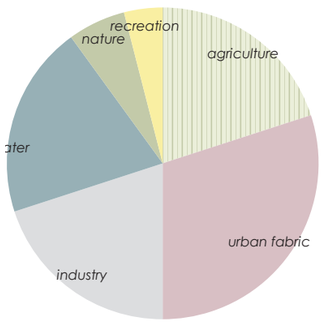


Figure 112. Westland characteristics

Author's work

Existing node: Westland

The peri-urban Westland consists of a mix of fragmented different types of land covers as seen in figure 112. Although there are many jobs in this area it is not connected with the public transport system of the Randstad or accessible by other sustainable forms of mobility from surrounding cities. There are already new development areas (ONW, n.d.) for housing that creates rising demands for well-connected sustainable infrastructure in the future. A train and light-rail connection will make this place more accessible for workers, residents and visitors. For goods new agricultural distribution centres will be located to store local products close to their origin and transport it via the existing metro line in a sustainable and collective way.

MOBILITY NODES APPRECIATING THE LOCAL CONTEXT

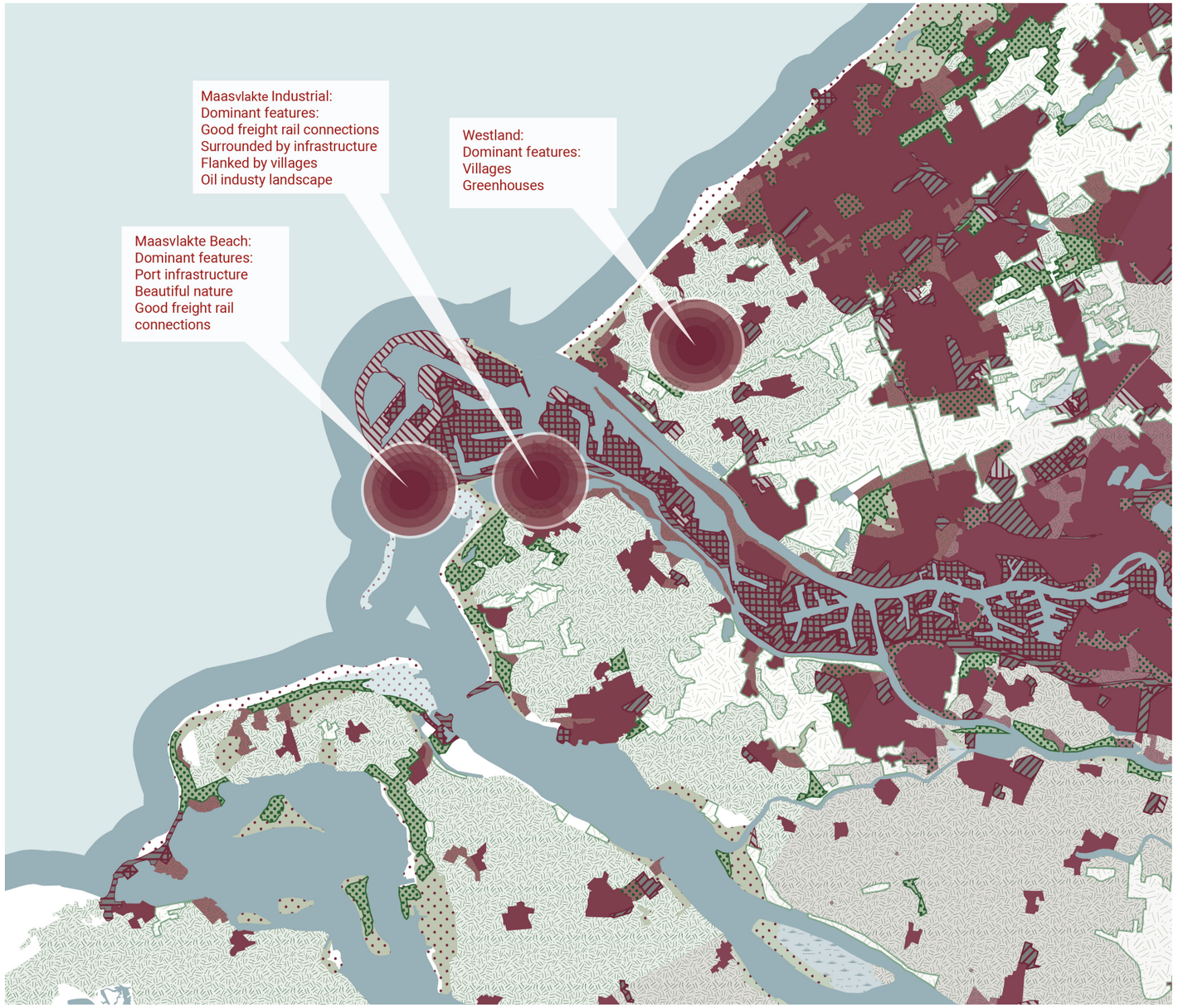


Figure 113. Land covers Arnhem-Nijmegen

Source title: Corine land cover (2018)

In the well-connected Randstad there could be argued that all important places are already accessible. However, the public transport system is not well connected to the port areas or the peri-urban Westland. The Maasvlakte will be made accessible for personal transport, the existing rail tracks for goods will be used for personal transport as well. For the Westland there will be more sustainable transport for goods as that is missing right now.

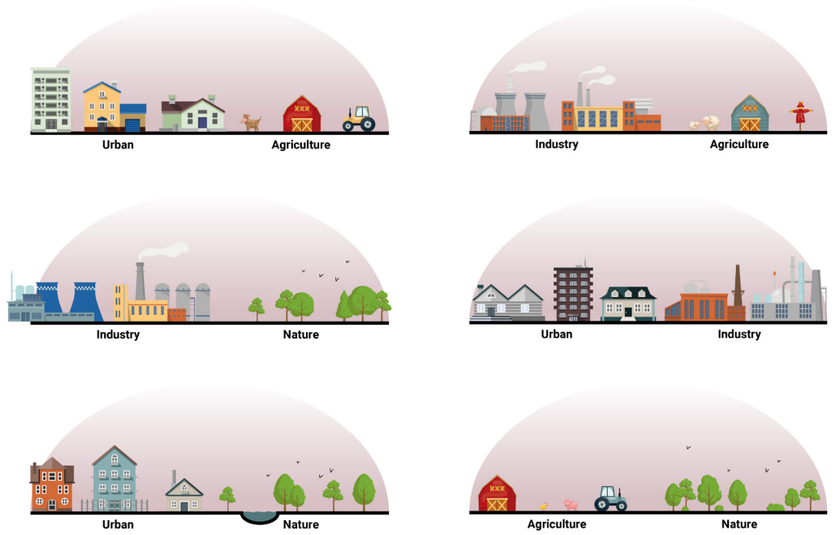


Figure 114. Curernt peri-urban areas

Source: Author's work

Urban & Agriculture

- Urban Fabric
- Industry, distribution and Commerce
- Infrastructure
- Port Areas
- Airports
- Dump
- Construction
- Green Urban Area
- Sports and recreation

Recreation
Agriculture

- Arable land
- Vineyards
- Fruit trees
- Pastures
- Comlex cultivation patterns
- Agriculture
- Agro-forestry areas

Nature & water

- Forests
- Grassland
- Moors and hearthland
- Woodland shrub
- Open with little vegetation
- Mineral Extraction (Clay)
- Inland marshes
- Salt marshes
- Tidal marshes
- Rivers
- Water bodies
- Water bodies

PERI-URBAN NODE: IMPRESSION
MAASVLAKTE STRAND

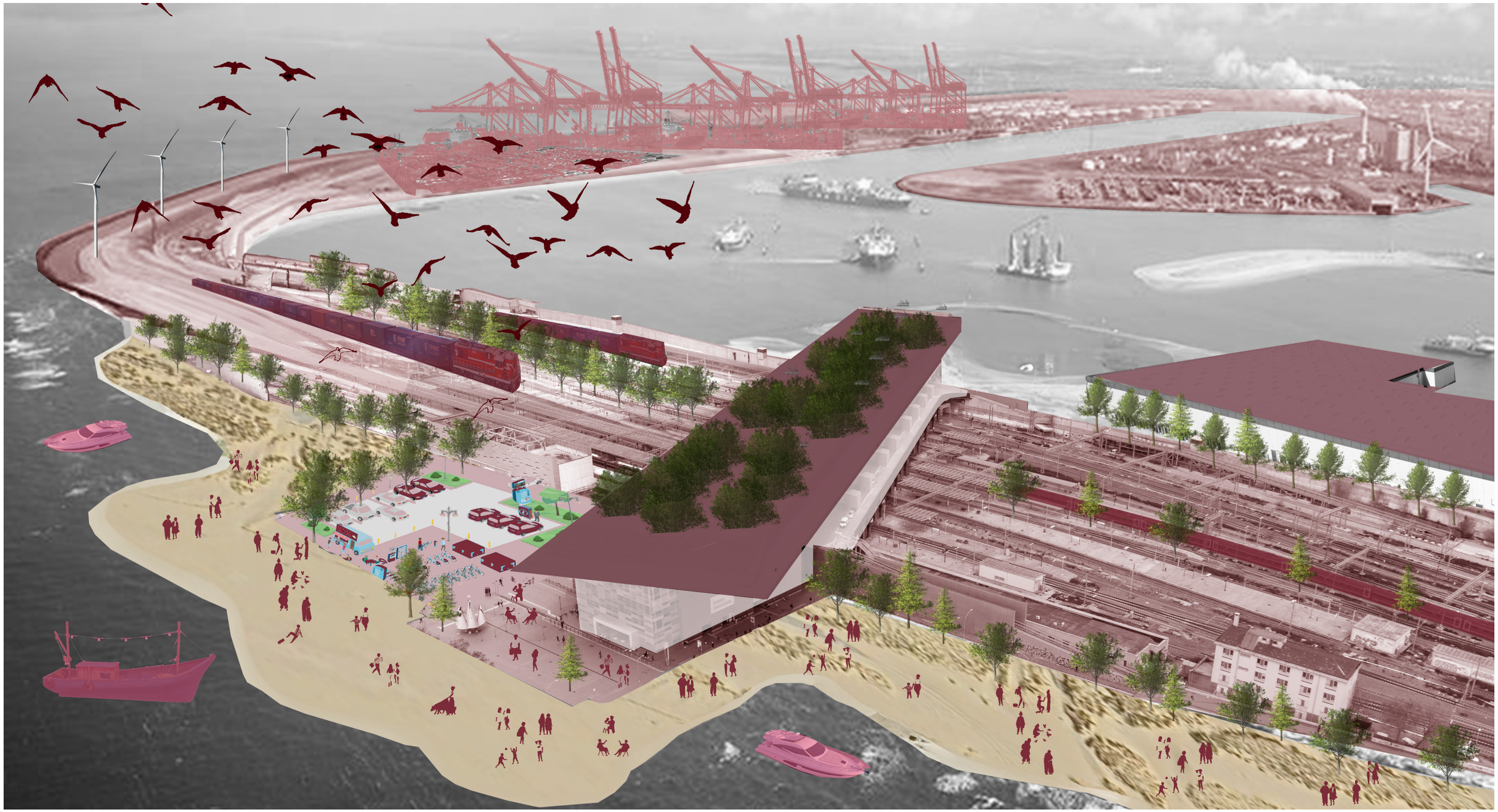


Figure 115. Impression Maasvlakte beach

Source: Author's work

8.

REFLECTION AND CONCLUSIONS

CONCLUSIONS

Peri-urban areas are the key to a CO_2-neutral mobility network

As we know now, the emission of CO_2 by the mobility network of the Rhine-Delta region has a negative impact on the quality of life in the region. Within the mobility network, road transportation is one of the main pollutors of CO_2. Most peri-urban areas are connected by road transportation and are therefore the places where the negative impact of CO_2-pollution by mobility is felt the most.

The Rhine-Delta region knows many of these peri-urban areas. Therefore these are the areas where the mobility network needs to be improved the most, in terms of sustainability. In other words improving the mobility network in the peri-urban areas is the key to a CO_2-neutral mobility network in the Rhine-Delta region.

To put it in simple words, in order for peri-urban areas to have a more sustainable mobility network, the car-use from and to these areas needs to be reduced. A popular way to do this is the use of spatial concepts that promote the use of sustainable transportation. The issue with this approach however, is that these concepts rely heavily of an urban context. They usually require a high density in population and key functions such as housing, education, employment, leisure, etc. Peri-urban areas usually lack this urban context. Therefore most peri-urban areas are ill suited for spatial concepts that promote the use of sustainable transportation. This makes it very difficult to make the mobility network in these areas more sustainable.

Another way of reducing the car-use is re-using the current infrastructures and corridors that are now only used for cars. This can be an efficient way of making the most out of the rigid structures that have followed out of the urbanization over the past years through a car-centric perspective. But unfortunately, simply re-using the current infrastructure will only solve a part of the problem. In order to make the mobility network more sustainable, more radical changes in the built environment are required.

To do this in a succesfull way, we not only need to focus on the spatial consequences, but also on the social consequences. For this it will be important that when redesiging and redeveloping the mobility network, the network should serve everybody in society in an equal way. In addition to this, the mobility network should help to facilitate in changing our current consumer- and travel behaviour. Simply making public transit more available, or make all logistical transit happen over railway will not reach the desired effect of a CO_2-neutral mobility network. In order to really make the mobility network more sustainable, we will need to change the way how we behave. This will mean we will need to be more concious about which transportation mode we use as well as how much we currently consume in terms of food and products. For this we will need to be less materialistic, as well as trying to shorten the transportation cycles for the things we still do consume. Only by doing these things can we truly accomplish real results in creating a more sustainable mobility network in the Rhine-Delta region.

Ethical reflection

In our project we set out to not only create a sustainable transport network, but also to use this massive intervention as a opportunity to make the transport network more equitable. We mentioned before that the peri-urban areas of the Netherlands suffer from mobility poverty. In the peri urban areas, a large contributor to the problem of mobility poverty is the over reliance on cars as a means of transport. In our project we tackled this problem by making the peri urban areas more accessible by public transport. This way people who are not able to travel by car (because of financial or physical reasons) are still able to move around. This makes society more equitable and, in our view, more just. In this sense we achieved the goals we set out at the beginning of our project. There is however room for improvement, because of time constraints we did not have the time to tackle other causes of mobility poverty, like physical disability or lack of knowledge about how to utilize the mobility network. Both causes could be made worse by the increased importance of public transportation in the mobility network. Public transportation can be difficult to use for less physically able people, and it can be harder to navigate for those not familiar with the local language. In further development of our plans these challenges would have to be explored further. We are, however, confident that they are surmountable challenges, and that the plans we laid out in this report form a good starting point for further development.

THANK YOU!

9.

REFERENCES

BIBLIOGRAPHICAL & DESIGN REFERENCES

Batty, P., Palacin, R., González-Gil, A. (2015). Challenges and opportunities in developing urban modal shift. *Travel Behaviour and Society, 2*(2), 109-123. http://dx.doi.org/10.1016/j.tbs.2014.12.001

Boelens, L., & Taverne, E. (2011). Why Cities prosper as Deltas: The urbanisation of the Eurodelta. In *Routledge eBooks* (pp. 200–223). https://doi.org/10.4324/9780203137253-14

Boxcar Admin. (2021, Novembre 24). *Transport could burn up the EU's entire carbon budget - International Council on Clean Transportation* . International Council On Clean Transportation. https://theicct.org/transport-could-burn-up-the-eus-entire-carbon-budget/

Burton, E. (2024, February 26). *The Problem with Car-Centric Cities for Community, Public Health, and More.* Design Dash. https://designdash.com/2024/01/29/the-problem-with-car-centric-cities-for-community-public-health-and-more/

Buysse, C., & Miller, J. (2021, 9 April). *Transport could burn up the EU's entire carbon budget - International Council on Clean Transportation*. International Council On Clean Transportation. https://theicct.org/transport-could-burn-up-the-eus-entire-carbon-budget/

Cao, X., Xu, Z., & Fan, Y. (2010). Exploring the connections among residential location, self-selection, and driving: Propensity score matching with multiple treatments. *Transportation Research Part A: Policy and Practice, 44*(10), 797–805. https://doi.org/10.1016/j.tra.2010.07.010

Centraal Bureau voor de Statistiek. (2021, 3 May). *Internationale goederenstromen in 2019.* Centraal Bureau Voor de Statistiek. https://www.cbs.nl/nl-nl/longread/diversen/2021/internationale-goederenstromen-in-2019?onepage=true#c-Bijlage-1-Landen-per-wereldregio

Centraal Bureau voor de Statistiek. (2022). Banen van werknemers naar woon- en werkregio (2014-2020). https://dashboards.cbs.nl/v1/commutingNL/

Centraal Bureau voor de Statistiek. (n.d.). *Welke sectoren stoten broeikasgassen uit?* Centraal Bureau Voor De Statistiek. https://www.cbs.nl/nl-nl/dossier/dossier-broeikasgassen/welke-sectoren-stoten-broeikasgassen-uit-

Climate Action. (2019, 21 June). *Average CO2 emissions from new light-duty vehicles registered in Europe increased in 2018, requiring significant future emission reductions to meet upcoming 2020 and 2021.* https://climate.ec.europa.eu/news-your-voice/news/average-co2-emissions-new-light-duty-vehicles-registered-europe-increased-2018-requiring-significant-2019-06-21_en

Corine Land Cover. (2018). [Dataset]. https://doi.org/10.2909/71c95a07-e296-44fc-b22b-415f42acfdf0

CROW. (2024). *PTAL - 2021*. https://crow.databank.nl/viewer/?workspace_guid=6ae2698a-4974-4ab8-aaf3-ac0155218477

CROW. (n.d.). *Staat van de mobiliteitstransitie.* https://www.crow.nl/duurzame-mobiliteit/home/regionaal-mobiliteitsprogramma-rmp

De Roo, G., & Boelens, L. (2016). Spatial planning in a complex unpredictable world of change: Towards a proactive co-evolutionary type of planning within the Eurodelta. *In Spatial planning in a complex unpredictable world of change: Towards a proactive co-evolutionary type of planning within the Eurodelta* (pp. 14–27). https://biblio.ugent.be/publication/7408821/file/7901755.pdf

van der Drift, S., Wismans, L., & Olde Kalter, M. J. (2022). Changing mobility patterns in the Netherlands during COVID-19 outbreak. *Journal of Location Based Services, 16*(1), 1–24. https://doi.org/10.1080/17489725.2021.1876259

Ellen MacArthur Foundation & McKinsey Center for Business and Environment. (2015). *Growth within: A Circular Economy vision for a Competitive Europe.* https://unfccc.int/sites/default/files/resource/Circular%20economy%203.pdf

ESPON, Otten, M., Király, J., Leestemaker, L., Grebe, S., De Kievit, M., Vermeulen, A., Kuipers Karin, Boelens, L., Van der Bijl, R., Aernouts, L., Van de Leemput Pierre, Angé, M., & Van den Bogaerde, S. (2022). *STISE – Sustainable Transport Infrastructure in the Strategic Urban Region EuroDelta.* https://trid.trb.org/view/539619

Eurostat. (2023). *Population and Housing Census 2021 - Population grids* [Dataset]. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_and_housing_census_2021_-_population_grids

European Commission. (2020). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. In *EUR-Lex*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789

European Commission. (n.d.-a). *The European Green Deal.* https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

European Commission. (n.d.-b). *New Cohesion Policy*. https://ec.europa.eu/regional_policy/2021-2027_en

Google Earth. (2023). *Maasvlakte Rotterdam*. https://earth.google.com/web/@51.96982531,4.01602818,12.54996614a,20602.23208842d,35y,0h,0t,0r/data=OgMKATA

Google Maps. (2022). *Google Maps.* https://www.google.com/maps

BIBLIOGRAPHICAL & DESIGN REFERENCES

Hanemaaijer, A., & Kishna, M. (2023). *Reflectie op het Nationaal Programma Circulaire Economie 2023-2030* (PBL-report nr. 5197). PBL Planbureau voor de Leefomgeving. https://www.klimaatweb.nl/wp-content/uploads/po-assets/821899.pdf

Jorritsma, P., Berveling, J., De Haas, M., Bakker, P., & Harms, L. (2018). *Mobiliteitsarmoede: vaag begrip of concreet probleem?* Kennisinstituut voor Mobiliteitsbeleid.

Kim, S. (2020). The social justice impact of the Transit-Oriented Development. *Societies (Basel), 11*(1), 1. https://doi.org/10.3390/soc11010001

KiM Netherlands Institute for Transport Policy Analysis. (2022, 22 February). *Difference in car-dependency between urban and non-urban areas is growing in the Netherlands.* KiM Netherlands Institute For Transport Policy Analysis. https://english.kimnet.nl/latest-news/feature/2022/02/22/difference-in-car-dependency-between-urban-and-non-urban-areas-is-growing-in-the-netherlands

Klimaatakkoord. (n.d.). *Afspraken voor Mobiliteit.* https://www.klimaatakkoord.nl/mobiliteit

Koteshwar, N. (n.d.). *Importance of water in the urban fabric - urban design.* Urban Design. https://nclurbandesign.org/water-being-the-source-of-life-and-human-settlement-revolved-around-it/#:~:text=Even%20today%2C%20many%20cities%20around,agriculture%2C%20manufacturing%2C%20and%20tourism.

Lucas, K., & Jones, P. M. (2012). Social impacts and equity issues in transport: an introduction. *Journal Of Transport Geography, 21*, 1–3. https://doi.org/10.1016/j.jtrangeo.2012.01.032

Melvin. (2024, 19 February). *The physical infrastructure in the Netherlands ranked 3rd worldwide, according to the World Economic Forum.* Intercompany Solutions. https://intercompanysolutions.com/infrastructure-ranked-3rd-worldwide/

Merk, O., & Notteboom, T. (2013). The Competitiveness of Global Port-Cities: The Case of Rotterdam/Amsterdam – the Netherlands. In *OECD Regional Development Working Papers*. https://doi.org/10.1787/20737009

METREX SURE Expert Group. (2019). *Strategic Urban Region EuroDelta: Narrative and Strategy for Strengthening the Megaregion of Strategic Urban Region EuroDelta.*

Milieu Centraal. (2024). *Fiets, ov of auto.* https://www.milieucentraal.nl/duurzaam-vervoer/co2-uitstoot-fiets-ov-en-auto/

Ministerie van Infrastructuur en Waterstaat (2023). *Mobiliteitsvisie 2050; Hoofdlijnennotitie.* Ministerie van Infrastructuur en Waterstaat. https://open.overheid.nl/documenten/ronl-d954c7efb64c60233b4000dbc2efe949e84bb7f9/pdf

Mobility Learning Center. (2024, March 22). *20-minute neighborhoods* . SUML MLC. https://www.planning.vic.gov.au/guides-and-resources/strategies-and-initiatives/20-minute-neighbourhoods

MuConsult. (2023, 9 May). *Mobiliteitsarmoede, wat is dat eigenlijk? - MuConsult*. https://muconsult.nl/cases/mobiliteitsarmoede-wat-is-dat-eigenlijk/

Mulholland, E., Ragon, P.-L., & Rodríguez, F. (2023). CO2 emissions from trucks in the European Union: An analysis of the 2020 reporting period. In *ICCT WORKING PAPER* (Working Paper Nr. 2023–14; p. 2). https://theicct.org/wp-content/uploads/2023/07/hdv-co2-emissions-eu-2020-reporting-2-jul23.pdf

Nederlandse Spoorwegen. (2019, 3 July). *Grootste, kleinste en snelst groeiende stations 2018.* Grootste, Kleinste en Snelst Groeiende Stations 2018. https://nieuws.ns.nl/grootste-kleinste-en-snelst-groeiende-stations-2018/

Notteboom, T. (2022) *Port regionalization in Antwerp and the LOGISTIEKE HOTSPOTS VAN NEDERLAND in*: Notteboom, T. (ed.), Ports are more than piers, De Lloyd: Antwerp, pp. 307-328. (2006)

Notteboom, T., Pallis, A., & Rodrigue, J. P. (2024, 20 March). *Port Economics, Management and Policy*. Port Economics, Management And Policy. https://porteconomicsmanagement.org/

Ocean vs. Inland Transport: Building End-to-end Efficiency in Shipping. (n.d.). https://opentug.com/blog/ocean-vs-inland-transport

Olivier, J. G. J. (2022). Trends in global CO2 and total greenhouse gas emissions. In *PBL Netherlands Environmental Assessment Agenc*. https://www.pbl.nl/en/publications/trends-in-global-co2-and-total-greenhouse-gas-emissions-2021-summary-report

ONW (n.d.) *Ontwikkelingsmaatschappij Het Nieuwe Westland (ONW)*. https://onwbv.nl/onw/

OpenRailwayMap. (2024). OpenRailwayMap. https://www.openrailwaymap.org/

Otten, M., Király, J., Leestemaker, L., Grebe, S., De Kievit, M., Vermeulen, A., ... Van den Bogaerde, S. (2020). STISE – Sustainable Transport Infrastructure in the Strategic Urban Region EuroDelta. In *ESPON*. https://www.espon.eu/sites/default/files/attachments/ESPON%20STISE%20Final%20Report.pdf

Panteia. (2022, 23 Septembre). *Vergelijking emissies van binnenvaart, spoor- en wegvervoer* [Presentation slides]. https://open.overheid.nl/documenten/ronl-5f5afcc057073b68c62f92da954b9382308e868c/pdf

BIBLIOGRAPHICAL & DESIGN REFERENCES

Pojani, D., & Stead, D. (2018). Past, Present and future of Transit-Oriented development in three European capital City-Regions. *In Advances in transport policy and planning* (pp. 93–118). https://doi.org/10.1016/bs.atpp.2018.07.003

Rijkswaterstaat. (2024). *INWEVA 2023.* https://maps.rijkswaterstaat.nl/gwproj55/index.html?viewer=Inweva.Webviewer

Route Scanner. (2024). Connections Route Scanner. https://connections.routescanner.com/rotterdam?connectionType=import&countries=DE&label=Germany

Schwab, K. (2019). Global Investment Competitiveness Report 2019/2020: Rebuilding Investor Confidence in Times of Uncertainty. In *Washington, DC: World Bank eBooks*. World Economic Forum. https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

SDGIndicators (n.d.). *SDGIndicators.* https://sdg.tw/

Selzer, S., & Lanzendorf, M. (2022). Car independence in an automobile society? The everyday mobility practices of residents in a car-reduced housing development. *Travel Behaviour and Society, 28*, 90–105. https://doi.org/10.1016/j.tbs.2022.02.008

Tran, M., & Brand, C. (2021). Smart urban mobility for mitigating carbon emissions, reducing health impacts and avoiding environmental damage costs. *Environmental Research Letters, 16*(11), 114023. https://doi.org/10.1088/1748-9326/ac302e

TravelTime Maps. (2024). https://app.traveltime.com/

United Nations. (n.d.) *The 17 goals.* https://sdgs.un.org/goals

University of Barcelona, & Bel Germa. (2017). The impact of socioeconomic characteristics on CO2 emissions associated with urban mobility: Inequality across individuals. *Energy Economics*, 251–261.

University of the Witwatersrand, O Yoro, K., & O Daramola, M. (2020). Chapter 1 - CO2 emission sources, greenhouse gases, and the global warming effect. *Advances in Carbon Capture*, 3–28.

Van Eldijk, J., Gil, J., & Marcus, L. (2022). Disentangling barrier effects of transport infrastructure: synthesising research for the practice of impact assessment. *European Transport Research Review, 14*(1). https://doi.org/10.1186/s12544-021-00517-y

Vanoutrive, T., Klaassen, A., La Rota, S., De Block, G., & University of Antwerp. (2022). *Transit Oriented Development (TOD) for Inclusive and Sustainable Rural-Urban Region.*

Wesseler, S., & Wesseler, S. (2023, Octobre 2). *American society wasn't always so car-centric. Our future doesn't have to be, either.* Yale Climate Connections. https://yaleclimateconnections.org/2023/10/american-society-wasnt-always-so-car-centric-our-future-doesnt-have-to-be-either/

Wet vrachtwagenheffing. (2023). Retrieved from https://wetten.overheid.nl/BWBR0047082/2023-01-01/0/informatie

10.

APPENDIX

APPENDIX 1A

AGUSTINA POGGIONE GARCIA (6053262)

In this reflection, I would like to address the impact of globalization and consumer behavior on transportation and its CO2 emissions. In this quarter we studied the impact that the movement of passengers and goods has on CO2 emissions within the Euro Delta Region, and what was most impressive for me was how complex the relationship between our consumer behavior, transportation and climate change really is.

Breakthroughs in science and technology have led to substantial improvements in our lives and the way we get our products today. Only the internet has made our world much smaller and increased trading worldwide with a click. However, we have been raised in a commodity world, where almost everything is reachable now by a click and within days, and we get very upset when the delivery fails even for a couple of hours. So how do we change those 'traditions' so deeply rooted nowadays towards a co2 neutrality society?

Throughout the quarter we have done research on the impact of passengers and freight transportation in the Co2 emissions, economic and social aspects of the Euro Delta region: from commuting, and tourism to the transportation of daily goods and heavier bulks. And I have to admit that recognizing the 'invisible red line' of the whole mobility logistics is so much bigger than I had ever expected. And is so deeply rooted and tangled with other social and economic aspects that any project for a more sustainable mobility infrastructure needs to have multi focus and be motivated by diverse types of policies.

For a truly sustainable approach we need to (1) make all transport modes more sustainable, (2) make sustainable alternatives widely available in a multimodal transport system and (3) reduce car use at all costs through robust and infallible public transport. These are the three actions to reduce CO2 emissions in them mobility sector. However, these actions MUST come with a change in our mindset through policies and a 're-education' on how's our behavior towards our food (where it comes from), our alimentation (seasonal and local), the way we measure time (for commuting), how we think our leisure activities, holidays (are we traveling? How? Where?) and so many other things.

And honestly this way of thinking is easier in European countries, where the baseline scenario is way more stable and complete than an American context, or an African or Asian one. But the challenges of changing consumer behavior and transitioning towards sustainable transportation are universal and require concerted efforts on a global scale. Because the whole idea of reducing CO2 emissions is to avoid an increase in global temperature, so the local policies and projects needs to align with regional as well as the global. And just like that, the fish gets bigger and bigger and who is in charge? Who takes the global decisions? How do we do it just and inclusive for ALL the contexts, communities, cultures and local systems?

APPENDIX 1B

BRENDA VAN DER MEER (5226155)

In the individual reflection I would like to discuss how working in the different scales and the relation between these scales have with each other influenced our project.

For this project we had to work in the Rhine-Delta Region. We chose to work with the topic mobility, so on this scale aspects like the harbours of Rotterdam, Amsterdam and Antwerpen and the international connections (by plane, ship, train, car and truck) are relevant. Most of our group (including me) did not work on a project with such a big scale before.

Our fist analysis, research and visions were on Rhine-Delta scale. For some data it was only possible to find data about The Netherlands, so we mainly focussed on the Rhine-Delta Region within the Dutch borders. In this bigger scale we also had to look at policies, on both national and international (mainly European) scale. On this scale we mainly looked at the different nodes and their relation. Some main conclusions were that the most important people corridors move from north to south, while the freight flows mainly from east to west.

When we had created a vision and a very global strategy, we decided to zoom in to the more local scale. We zoomed in on the Nijmgen-Arhem region and on the Rotterdam-The Hague region. In this scale level the peri-urban areas became important. We identified five categories of urban fabric: city centre, dense urban, sub urban, peri-urban and rural. On this scale level, we came up with interventions like the concept of context-based TOD and we added some new train and bus lines. It only makes sense to add these trainlines, if they are also connected in the bigger scale and if they are an addition to the network and in line with the bigger vision. For this we really need our zoomed-out vision and design to back up the relevance and feasibility of these interventions.

On an even more zoomed-in scale we worked out some principles for the mobility nodes we want to add. In both the Nijmegen-Arnhem and the Rotterdam-The Hague region we chose two mobility nodes we worked out with diagrams and a vision collage.

In this project we started from the Rhine-Delta scale and zoomed in. This way of working influenced the choices we made. If we would have worked the other way around (from the city scale zooming out to the international scale) our strategy and design would probably look different. On a critical note, it can also be said that when we chose the regions and mobility nodes to zoom-in on, we of course looked at regions and mobility nodes that we thought would have an interesting relation to our bigger vision. We of course tried to create a vision that improves the whole area, but maybe it would also be interesting to zoom-in on a place where this improvement from the vision on the bigger scale is not directly visible.

All in all, the project's progression from the Rhine-Delta scale to more local scales significantly shaped our strategic choices and design outcomes.

APPENDIX 1C

HARMA VAN DER MEER (5322375)

By improving the mobility network and making it CO2-neutral areas that will be better connected will change. Our focus is on the peri-urban areas which will change places with new added nodes. In this reflection I would like to discuss the influence of a general focus and of impact for research and design on different scales.

On this regional scale there are an endless number of possibilities. A designer needs a focus, a coherent whole. Using a guiding theme or (conceptual) framework will give a strategy its character and identity, it creates a context to work in (Van Dooren et al., 2013). Our process started with gathering a lot of information about mobility but it did not fit in a coherent story. Without a focus point I was completely lost with all the information and therefore not able to fully contribute high quality work. Once we decided to work on improving the peri-urban areas, the focus became clear and we head in the same direction. I gained a better understanding of what we were doing and together we tried to create an impactful strategy on different scales.

To really make an impact for the mobility network there should be international agreements. I think that we are in need of an international mindset change. Sometimes it feels like you as an individual cannot solve climate change. It is difficult for people to see the shared negative effects of fossil fuels when they do not experience it as urgent emergency in their daily lives. Rocco (Rocco, n.d.-a) argues that not only changing of behaviour must be changes but also voting preferences. I think that maybe the right policies and regulations can help move us towards a more sustainable future.

On political level different countries should collaborate as well. They can transfer knowledge and policies. However needs to be paid attention to what and why policies are made. They are often place specific with their own urban challenges, different actors and cultural differences (Dąbrowski, 2024). Our strategy for the Netherlands with this 15 and 40 minutes triangle structure is because the Randstad knows a fragmented urban structure. To have an impact for the CO2 level of the mobility network this structure should work on local as well as regional scale. Implementing interventions on local scale is place specific. To meet people diverse needs it is hard to imagine not to include participation and co-creation on local scale to achieve spatial justice on national scale (Rocco, n.d.-b). To really make an impact the structure needs serve the use but people need to make use of it as well, which maybe needs a change of behaviour.

Having a focus helped us to make an impactful strategy. But to really make this impact visible in a spatial justified way there is a collaboration needed on personal, local, national and international scale. Together we can reach the end station of a CO2-neutral mobility network.

Van Dooren, E., Boshuizen, E., van Merriënboer, J., Asselbergs, T., & van Dorst, M. (2013). Making explicit in design education: generic elements in the design process. *International Journal of Technology and Design Education*, 28, 431-449. https://doi.org/10.1007/s10798-013-9246-8

Dąbrowski, M. (2024, March 21th). *From policy transfer to policy translation* [Powerpoint-slides]. Methodology for Urbanism Master Track, Delft University of Technology. https://brightspace.tudelft.nl

Rocco, R. (n.d.-a). *I have a dream* [booklet]. Methodology for Urbanism Master Track, Delft University of Technology. https://brightspace.tudelft.nl

Rocco, R. (n.d.-b). *The idea of Justice* [booklet]. Methodology for Urbanism Master Track, Delft University of Technology. https://brightspace.tudelft.nl

REIN BANGE (4872169)

Does our design have politics?

How do the politics of the designer influence the design solutions?

During the last lecture of the research and methodology course, we talked about whether or not artifacts have politics. We did this based on the very convincing work by Langdon Winner (1980). Winner makes a strong case that they do, not only because artifacts are designed by people with politics, but also more crucially, because artifacts make certain lifestyles more or less easily accessible. For instance, a large highway enables a very individualistic lifestyle, which is strongly related to a more (not US) liberal political worldview.

This notion raises a lot of interesting questions: Does our design have politics? Do my politics influence the design process and if so, is this a bad thing? Am I as a designer open to the best design solutions (if there is such a thing as the best design solution)? In this reflection, I will attempt to answer these questions in relation to the design assignment of Q3. I feel the need to express the futility of this exercise. One could write a book and not do these questions justice.
Let's start with the first question: Does our design have politics? The answer seems very clear to me; Yes! Our design is certainly political in certain ways. Let's quickly look at two examples: Our focus on collective transportation is built on the idea that if we work together and create large infrastructures to satisfy our needs, we are better off than when we work alone.

This emphasis on collective and systematic solutions aligns closely with a more left-wing political leaning. In our project, we also have a pronounced focus on making mobility available to everyone, regardless of their socioeconomic status. This is again closely linked to left-leaning political ideas.

So yes, our design has politics. So the question arises, did the politics of us as a design group influence by our personal political opinions? I can only speak for myself, but I do think my politics influenced my input in the design process.

So, is this a problem? One could say that my political opinions kept me from being neutral and may prevent me from finding the best design solutions. I, however, think that urban design is inherently political. Politics are ultimately the answers we give to how we want to live together, what do we think is fair. The answers that we give to this question should govern how we design our cities. Every urban designer should think about what he thinks is just and apply that in his craft.

Winner, L. (2017). Do artifacts have politics?. In Computer ethics (pp. 177-192). Routledge.

APPENDIX 1E

REFLECTION

RICK KLOOTWIJK (5944260)

In this section I will reflect on our concept on how peri-urban areas can be better connected through sustainable forms of transportation. The challenge of connecting peri-urban areas through sustainable transportation methods is a pressing issue in contemporary urban planning. Currently, these regions often rely heavily on cars due to their low population density, resulting in increased carbon emissions and environmental degradation. Addressing this issue requires innovative approaches that promote sustainable transportation while considering the unique characteristics of peri-urban landscapes.

Transit Oriented Development (TOD) has emerged as a promising concept in promoting sustainable transportation in urban areas. By clustering key functions such as housing, employment, and leisure around public transit nodes, TOD encourages walking, cycling, and the use of public transportation, reducing reliance on cars (Pojani & Stead, 2018; Kim, 2020). However, the implementation of TOD in peri-urban areas poses significant challenges due to their low population density.

One major obstacle is the economic feasibility of TOD in peri-urban areas. Traditional TOD models rely on high population density to attract investment and support infrastructure development (Vanoutrive et al., 2022). However, attempting to densify peri-urban areas to meet these requirements would transform them into urban centers, perpetuating the cycle of spatial inequality and environmental degradation.

Moreover, existing TOD models exhibit an urban bias, overlooking the unique characteristics of peri-urban areas. Research indicates that TOD concepts often fail to consider the local context, hindering their effectiveness in peri-urban environments (Vanoutrive et al., 2022). Adapting TOD to peri-urban areas requires a nuanced understanding of their specific challenges and opportunities.

Addressing these challenges necessitates a paradigm shift in urban planning towards prioritizing sustainability and social value over economic considerations. While economic feasibility remains a crucial factor, prioritizing sustainability and social equity can lead to long-term economic benefits. This requires reevaluating current development practices and embracing innovative approaches that prioritize environmental and social outcomes.

To make TOD applicable in peri-urban areas, it is essential to develop context-based models that account for the unique characteristics of these regions. This may involve integrating flexible zoning regulations, incentivizing sustainable development practices, and fostering community engagement. Additionally, promoting alternative transportation modes such as micro-mobility options and ridesharing services can complement traditional public transit systems in peri-urban areas.

Furthermore, research efforts should focus on generating insights into the adaptation of TOD to peri-urban contexts. By understanding the specific needs and challenges of these areas, planners can develop tailored solutions that promote sustainable transportation and enhance overall livability.

In conclusion, improving connectivity in peri-urban areas through sustainable transportation is a multifaceted challenge that requires a holistic approach. While TOD offers a promising framework, its adaptation to peri-urban environments requires careful consideration of local contexts and a reevaluation of priorities in urban planning. By prioritizing sustainability and social value, we can create more inclusive and resilient communities while advancing towards a more sustainable future for peri-urban regions.

Kim, S. (2020). The social justice impact of the Transit-Oriented Development. Societies (Basel), 11(1), 1. https://doi.org/10.3390/soc11010001

Pojani, D., & Stead, D. (2018). Past, Present and future of Transit-Oriented development in three European capital City-Regions. In Advances in transport policy and planning (pp. 93–118). https://doi.org/10.1016/bs.atpp.2018.07.003

Vanoutrive, T., Klaassen, A., La Rota, S., De Block, G., & University of Antwerp. (2022). Transit Oriented Development (TOD) for Inclusive and Sustainable Rural-Urban Region.

APPENDIX 2

RESEARCH PLAN

A. Title & subtitle

The Rhine Delta region = CO2-neutral by mobility: a network approach for reducing CO2 emissions in peri-urban areas by 2050

B. Abstract

The emission of CO2 is a significant contributor to global warming, with the mobility sector being a major source. The EU has set a goal to achieve climate neutrality by 2050, requiring substantial CO2 reduction efforts, particularly in densely populated regions like the Rhine-Delta (RDR). This region's extensive mobility network, serving both urban and global trade needs, generates significant CO2 emissions.

To address this, a research initiative aims to make the Rhine-Delta's mobility network CO2-neutral by 2050 through reimagining its design and operations. The focus lies on peri-urban areas, where urban and rural landscapes intersect. These areas are essential for economic and social functions but are currently reliant on polluting road transportation.

The research identifies the need to rethink connectivity to peri-urban areas for sustainability. Traditional urban-focused transportation concepts often overlook peri-urban needs. Therefore, the initiative proposes developing context-based mobility nodes tailored to peri-urban requirements. These nodes aim to promote sustainable transportation and enhance network efficiency.

The approach involves creating an interconnected network of such nodes throughout the Rhine-Delta region, addressing the specific needs of lower-density areas like peri-urban zones. By considering local contexts, these nodes can effectively serve peri-urban areas, promoting sustainable transportation practices.

To demonstrate the feasibility of this approach, the research zooms in on a representative area within the Rhine-Delta region, focusing on peri-urban patches around Arnhem-Nijmegen. By showcasing how context-based mobility nodes can be implemented in such areas, the research seeks to pave the way for a broader transition towards a CO2-neutral mobility network by 2050.

In conclusion, the research aims to transform the Rhine-Delta's mobility landscape by making it CO2-neutral through the implementation of sustainable transportation solutions tailored to peri-urban areas. By recognizing and addressing the unique challenges and opportunities presented by peri-urban zones, the initiative seeks to contribute significantly to the EU's climate neutrality goal by 2050.

C. Key words

Rhine-Delta region, Mobility network, Sustainable transportation, peri-urban areas, CO2-neutral

D. Introduction

As we all know we are in a process of global warming. Global warming is caused by CO2 and other greenhouse gases. In recent years, most large CO2 emitting sectors, such as the industry and electricity sectors, have come up with clear strategies on how to reduce emission of CO2. This has resulted in a significant reduction in the amount of CO2 emitted by the energy and industy cector. The mobility sector however, is also one of the largest emitting sectors of CO2, but has not shown any decline over the last 30 years. The mobility sector is with 19% currently the third largest emitting sector and is soon to become second largest(overtaking electricity).

In order to properly deal with global warming we need to focus on reducing the amount of CO2 emissions. Reducing the amount of the largest emitting sectors is a vital part of this. In comparison to the industry- and electricity sector, the mobility sector has a less clear strategy than industry and electricity, that causes a decline in the emittance of CO2. Dealing with the CO2 emission of the mobility sector is a very complex task. If we were to try to locally deal with the emission of CO2 by mobility, we would not solve anything all. The mobility sector consists of a vast network that transcends all borders. Therefore, in order to deal with the emissions coming from the mobility sector, an integral regional strategy is required that transcends the city- and international borders.

An area that has both a high amount of CO2 emittance and a vast mobility network is the Rhine-Delta region. It is characterized by its vast water network of several rivers and is one of the most densely populated areas of Europe (source). In order to provide the population with a strong quality of living, an extensive mobility network has been developed over the years (source). The region is home to Rotterdam and Antwerp, which house the two of the largest and most important ports of Europe. Both ports are really important for the transshipment of container and bulk goods. Goods from all over the world come to these ports by ship, and are then transshipped on to other ships, trucks or trains to move land-inwards to the rest of Europe. This makes large parts of Europe heavily dependent on Rotterdam and Antwerp for their supply of goods. Because of this dependence, logistical corridors have been created from all over Europe. These corridors all lead to Rotterdam and Antwerp. Since both are situated within the Rhine-Delta region, almost all of these logistical corridors pass through this region as well. The presence emits a large amount of pollutants, including large amounts of CO2, in the area it passes through. It also has strong implications on the spatial, social and ecological qualities of the region.

As stated above, the implications of this vast mobility network reaches further than just the emission of CO2. For example , the vast water network of the Rhine-Delta region is not only important for logistical corridors, but also has strong ecological value. So is the river Rhine an important logistical corridor towards Germany and Switzerland. But at the same time, having the largest annual water discharge of all the European rivers, makes it a really important ecological corridor as well.

One could say that the region has conflicting well-functioning mobility network. While at the same time this mobility network has negative impact of the quality of living. Think of the emissions of CO2. But also of the pollution of the water, disturbance of ecology, or the spatial and social impact of the physical structures.

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The implications the mobility sector has on the quality of life goes far beyond just CO2 pollution. The vastness and interconnectedness of the mobility networks cause us to look at the mobility sector as a whole. When tackling the CO2 challenges, one would only focus on the implications the mobility sector has on our health. While at the same time, the sector (and CO2 emission) also has a huge impact of social (in)justice, spatial-, economical, and ecological quality. The above stresses the complexity of the challenges at hand and the need for a regional and systemic approach. Only through this can we properly reduce the impact of CO2 emission coming from the mobility sector and with that, bring us one step closer to successfully dealing with global warming.

Achieving our goals in the transition towards a CO2 neutral mobility network will require immense changes in the built environment. While designing these interventions it is paramount that we think about how these changes will affect the lives of the people living around them. This is why we will dedicate subchapters to the topics of spatial quality and spatial justice.

E. Problem Statement

CO2-pollution has a large negative impact on our quality of life. The mobility network plays an important role in the emittance of CO2. Especially the connections to and from peri-urban areas are facilitated by unsustainable forms of transportation. These connections are mostly facilitated by road transport, which is one of the most emitting forms of transportation. Since the pollution of CO2 is not an issue that can be tackled by a single city, a systemic and regional approach is required reduce the impact of CO2 on our quality of life. Since the connections to and from the peri-urban areas are one of the least sustainable connections in the mobility network, the focus will be on the mobility network in the peri-urban areas.

F. Research objectives

The objective of this research is to create a CO2-neutral mobility network for the Rhine-Delta region by 2050. Since the peri-urban areas form a weak link in the mobility network in terms of sustainable forms of transportation, the focus will be on rethinking and redesigning how the mobility network functions and connects peri-urban areas in the Rhine-Delta region.

G. Research questions

To reach the aforementioned objectives, the following research questions have been drawn up:

''How do we redesign the mobility network of the Rhine-Delta region to be CO2-neutral in 2050?''

In order to do this research in a well conducted manner, a more in-depth analysis is required. For this the following sub-questions have been formulated:

The region

- What are the current characteristics of the Rhine-Delta region?
- How does the mobility network of the Rhine-Delta region currently function?

The impact of the mobility network

- What is the impact of CO2 pollution on the quality of life in the Rhine-Delta region?
- What is the spatial and social impact of the mobility network on the region?

A sustainable mobility network for the region

- How do we reduce the CO2-emittance by the mobility network in the Rhine - Delta region?
- How do we apply spatial trends and concepts to promote the use of sustainable transportation on peri-urban areas?
- How do we apply these spatial trends and concepts in a socially just way on the mobili ty network of the Rhine-Delta region?

H. Conceptual framework

In order to reach the objectives of the research a conceptual framework has been developed. This framework focusses on making the mobility network of the Rhine-Delta region CO2-neutral. It aims to do this by applying spatial trends and concepts regarding sustainable transportation in a socially just way on the mobility network of the Rhine-Delta region. In order to reach these objectives successfully, there are three important factors that need to be carefully taken into account. These factors are the presence of strong and realistic policies, generating a collective mindset among all stakeholders and checking the technical feasibility of the current trends and concepts regarding sustainable transportation.
It general the conceptual framework aims to serve as the base for a more sustainable mobility network in the Rhine-Delta region and that improves the quality of life in a more sustainable way.

I. Scientific- and design methods

For the research a variety of research methods will be applied. The analysis part will mostly be done through desk research, both quantitative and qualitative. This will be supported by a sight visit as well in order to gain more insight in the workings of the mobility network.
In order to develop a spatial vision and strategy the research will be further conducted through research by design. This will be done through sketching multiple variants and scenarios in order to gain the best insights in what could be the most optimal design solutions. Finally, the concepts that have been drawn up from the scenario-studies will be tested by using them as case-study material on multiple areas in the region.

J. Societal, ethical and scientific values

The mobility sector, while essential for societal functioning, poses significant negative impacts on

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the environment and human health. Production of cars carries environmental consequences, including the emission of approximately 6.7 tonnes of CO2 per car and substantial consumption of raw materials like iron, aluminum, rubber, and oil. Furthermore, with the transition to electric vehicles, this demand will only increase, leading to local environmental impacts associated with their mining. The sector's heavy reliance on fossil fuels further exacerbates environmental degradation, leading to deforestation, more extreme weather occurrences, and disruptions in ecological balance.

Moreover, the emission of CO2 by the mobility sector contributes to global warming, leading to detrimental consequences such as the urban heat island effect, increased air pollution, forced population displacements, and decreased land use opportunities, particularly in agricultural areas. These impacts extend beyond environmental concerns, affecting the functioning of built environments and societies at large through destruction, disruption, and destabilization. Additionally, car ownership promotes increased car usage, resulting in significant societal effects and more congestion.

K. Scientific contribution

The mobility sector has been in the top three biggest polluters for more than 30 years. These include greenhouse gas emissions, air, noise and water pollution, but also accidents and road crashes, congestion, and biodiversity loss – all of which affect our health and wellbeing. The Energy Industry as well as the manufacturing and Construction Industries show a strong decline in emittance, but the mobility sector does not. Past efforts and policy measures have not yet sufficiently addressed these costs for our society.

L. Recommendations

In order to strengthen the conclusions, further research is needed in how the mobility network can become more sustainable in other areas than the peri-urban in the Rhine-Delta region. Furtherly we advise to conduct further research in the definition of peri-urban areas and especially how thy can be better connected through more sustainable forms of transportation. There is currently still a lot unknown on how these areas for example can be better connected through public transit because of the low densities these areas often have. In addition we also advise further research in what other spatial concepts can be applied on the region to make it is mobility network more sustainable. As a final recommendation further research also needs to be done in how the mobility network can create more social justice to prevent that the network increases transit- and mobility poverty, instead of the decrease it aims for.

M. Time frame

Week 1.
Analysing spatial and regional development and planning; identification of key issues. Initial framing of the assignment.

Week 2.
Conducting a site visit. Analysing regional spatial structures; developing first ideas for a more sustainable development in groups; defining the region that is at the focus of the project.

Week 3.
Analysing interrelations in regions; diagnosis, framing and defining the assignment.

Week 4.
Synthesis of spatial analysis, first draft vision. Research and design development.

Week 5.
Formulating the vision

Week 6.
Analysing governance and communities for the development strategy. Defining key interventions (projects/policies).

Week 7.
Defining key interventions (projects/policies), key actors and timeline for the development strategy. Development strategies: actors and timeline.

Week 8.
Finalizing the development strategy; illustrating key interventions.

Week 9.
Finalizing and production: submitting the final report; final presentation.

N. References

See chapter 7