High-speed Railway as Landscape Bonanza

TU-Delft Alternative Lelyline: A case study from Zwolle to Groningen

Bai Fazhong

Colophon

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LANDSCAPE ARCHITECTURE

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Thank TU Delft, it's a high-speed society while I enjoyed 2 years' academic slow paced tranquil life. Everything is beautiful only because all the stories just belong to Delft.

Abstract

Key words: landscape architecture, high-speed railway, innovative infrastructure implementation, Dutch cultural landscape, national park, Zwolle, Groningen

Long-term, large-scale empirical studies on the simultaneous development of transport infrastructure and the built environment are scarce. This thesis provides a future high-speed railway infrastructure implementation alternative based on the Dutch cultural landscape from Zwolle to Groningen. Our design goal is to better connect Amsterdam and provinces in the north of the Netherlands including Overijssel, Drenthe, Groningen by using a faster, more efficient and sustainable high-speed railway solution to replace the Lelyline solution proposed by the Dutch government based on traditional trains. The author has systematically evaluated the advantages and disadvantages of various railway routing options, and based on this, proposed an optimal alignment.

Then, the landscape typologies alongside the optimal alignment are concluded and the sustainable landscape interventions with the high-speed railway viaducts on those landscape typologies are elaborated into a catalogue, which will be not only meaningful for Zwolle-Groningen, but also will provide inspiration and guideline for future high-speed rail design projects in similar landscape context worldwide.

Afterwards, following the principles of sustainable development and theory of infrastructure as landscape, five unique sites along the optimal alignment are chosen to showcase the landscape architecture interventions in relationship with the rich Dutch cultural landscape. The outcome is a design proposal of the high-speed railway itinerary and landscape mitigation measures to its surroundings including both built and natural environment.

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1. Introduction

1.1. Preface:
Innovative Infrastructure Implementation

The future of Dutch Metropolitan landscape needs innovative solutions for urban development and infrastructure. TU Delft started with the unique Cross-Campus research-and-design project for innovative railroad technology and alignment. The project will bring together Master students from Civil Engineering and Landscape Architecture. The alternative TU Delft Lely Line via Zwolle, will offer students three opportunities for the ideal implementation of one of the portions of the new alignment into the cultural landscapes.

The research will be based on the innovative engineering of a self-extending railroad line elevated 8-12m. above the ground. The viaduct will take the trains, alike Shinkansen, over the vulnerable landscape. Each module of the viaduct will be built from the previous. The construction promotes a maximum of repetition. As such the line needs to be aligned in long linear stretches, this engineering approach for the line allows a few curves only. No doubt these parameters will offer the opportunity for a new railroad typology that can be cheaper and progressive.

This new prototype will be tested and designed within the context of the rich and layered Dutch cultural landscape. The alignments have to be implemented in the landscape and to be connected to the existing stations. Landscape mitigation need to be designed and station areas need to be proposed. As a result , the new investments will provoke tremendous new urban development that need to be elaborated. To ensure a more sustainable future, infrastructure should be elegant. Fragmentation of the landscape and its communities will be avoided. The line cannot be a barrier. (Adriaan 2022)

Fieldtrip at Zwolle, fellow student: Juul ten Hove andGiordana Credendino, photo by Author

1.2. Challenges for the rail system in the Netherlands

The Dutch economy is thriving, a fact that is evident in the robust employment and housing sectors, as well as the congestion experienced on roads, bike paths, and across all forms of public transport. However, the surge in transport demand isn't uniform: urban areas see more demand than others (Figure 1-1). Concurrently, as economic activity accelerates, the country is tasked with the significant challenge of drastically decreasing CO2 emissions.

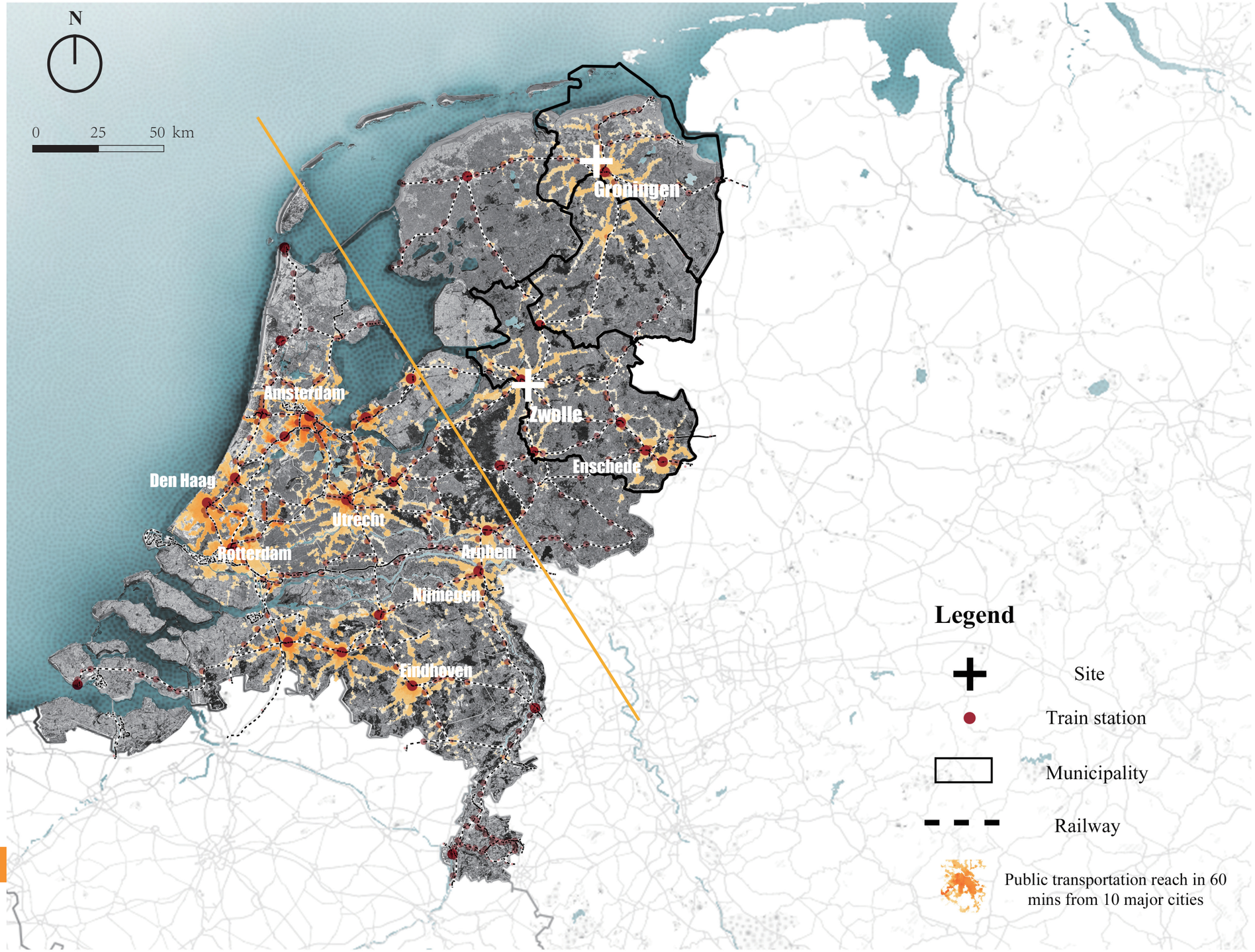
Public transport, especially when complemented by cycling, serves as a crucial part of daily commutes for millions. In 2017, passengers clocked a total of 25 billion kilometers traveling by public transport. Particularly in and between towns and cities, public transport is vital. The government anticipates a 30-40% spontaneous growth in public transport by 2030 and 2040, along with substantial growth in rail freight transport, projected to increase from the current 41 million tons to 54-61 million tons in 2030.

Due to this expansion in passenger and rail freight transport, the public transport network, including railways, buses, trams, and metros, is nearing saturation in certain areas, potentially compromising service quality. Users particularly feel this strain during peak rush hour times . Major transport bottlenecks post-implementation of the ongoing Multiyear Infrastructure, Spatial Planning, and Transport (MIRT) programme were identified by the 2017 National Market and Capacity Analysis.

From governmental projection, by 2040, people in the Netherlands will enjoy rapid, sustainable, safe, comfortable, reliable, and affordable travel. To commute to work, school, and leisure or social destinations, they will use their own transport, public transport, or a mix. Connectivity within the Netherlands and with neighboring countries will be efficient; large cities will boast well-structured collective transport systems with minimal travel times. These excellent transport links for individual users have established the Netherlands as one of the world's most competitive, livable, and sustainable countries. Public transport is a critical part of this holistic transport system, focused on passengers and their door-to-door journeys.

In 2016, the central government, regions, ProRail, and transport operators established their future ambitions for public transport. Since then, the challenges the Netherlands is facing have only intensified. Considering the lengthy preparation and execution period often needed for infrastructure projects, coupled with the relatively short terms for public transport contracts, it is imperative that the country establish consensus now on several key principles for the future of public transport as a critical component of overall transport system.

1-1 Anticipated growth in number of train journeys, *Public Transport in 2040 Outlines of a vision for the future*



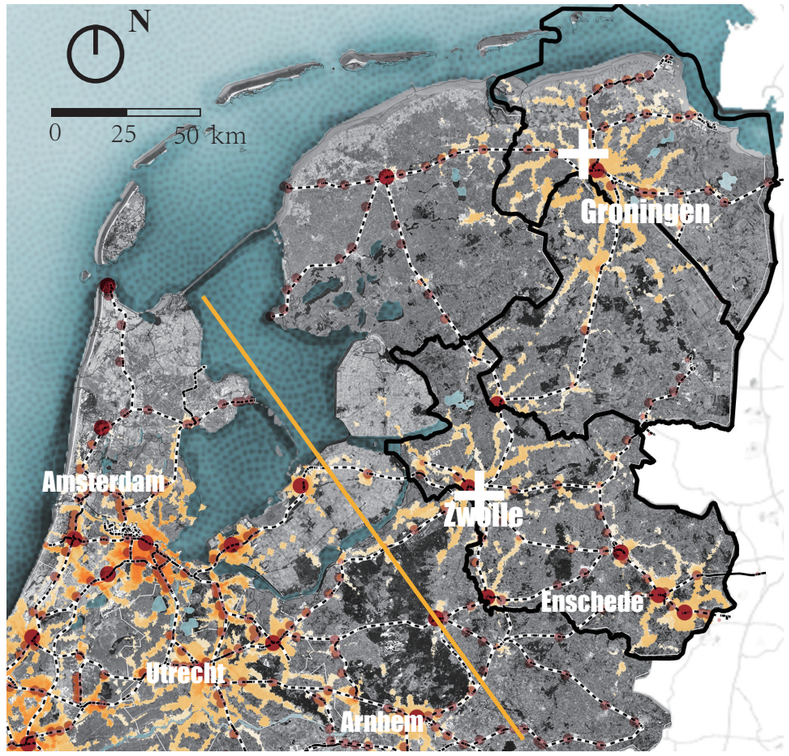
1-2 Pubic transportation reach from 10 major cities in 60mins. Drawn by author
Date source: PDOK. https://www.pdok.nl/

1.3. Problem field

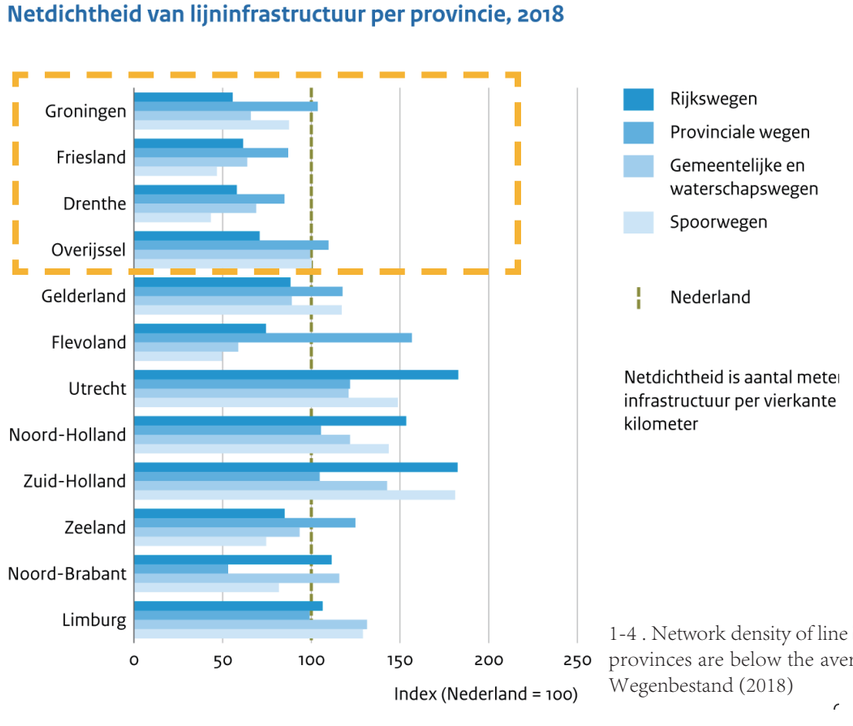
The Netherlands had built a high density and comprehensive national railway network since 1938, which benefited both economically and socially in the past century. It is highly embedded in the rich Dutch cultural landscape, however, nowadays, the railway infrastructure is becoming not efficient enough to meet the increasingly high punctuality and less time consuming commuting demand.

1.3.1. Uneven development between north and south

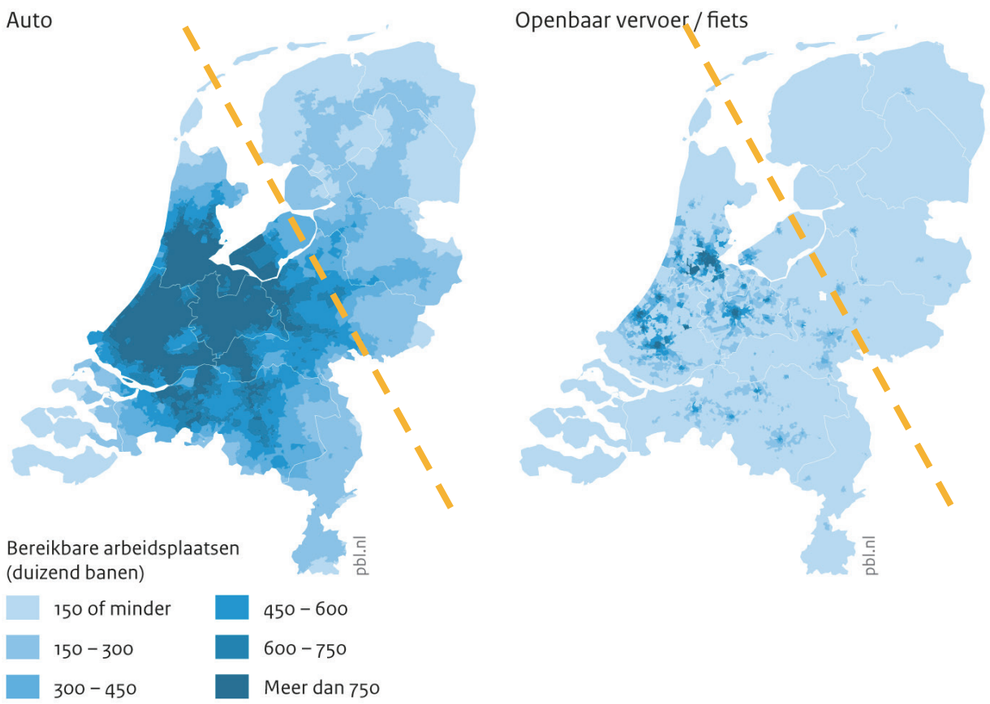
The orange sprawl parts represent the area that can be reached by public transportation means within one hour. We can clearly see that the accessibility of the north provinces of the Netherlands is much weaker in comparision with south. The railway infrastructure development in the north provinces(Groningen, Friesland, Drenthe, and Overijssel) is left behind. And official reports released by the national transportation research institutions also lead samethis conclusion.



1-3 Uneven distribution between north provinces and south provinces. Drawn by author
Date source: PDOK. https://www.pdok.nl/



1-4 . Network density of line infrastructure per province, North provinces are below the average level. Image: RWS Nationaal Wegenbestand (2018)



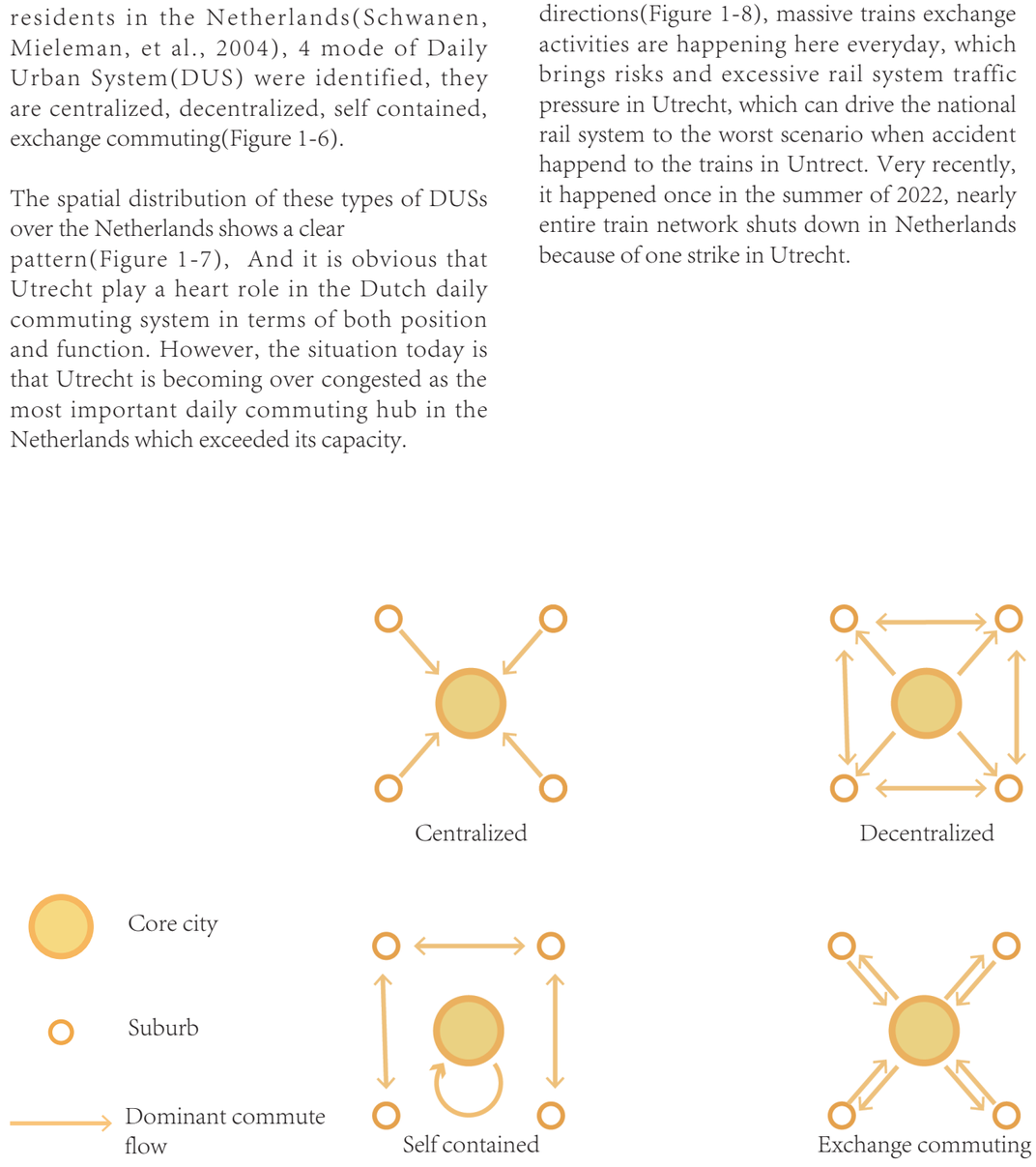
1-5 Accessibility of workplaces between 7 and 9 AM by car (left) and public transport and bike (right). North of the Netherlands is left behind. Image: ANP (2022)

1.3.2. Excessive traffic pressure in Utrecht

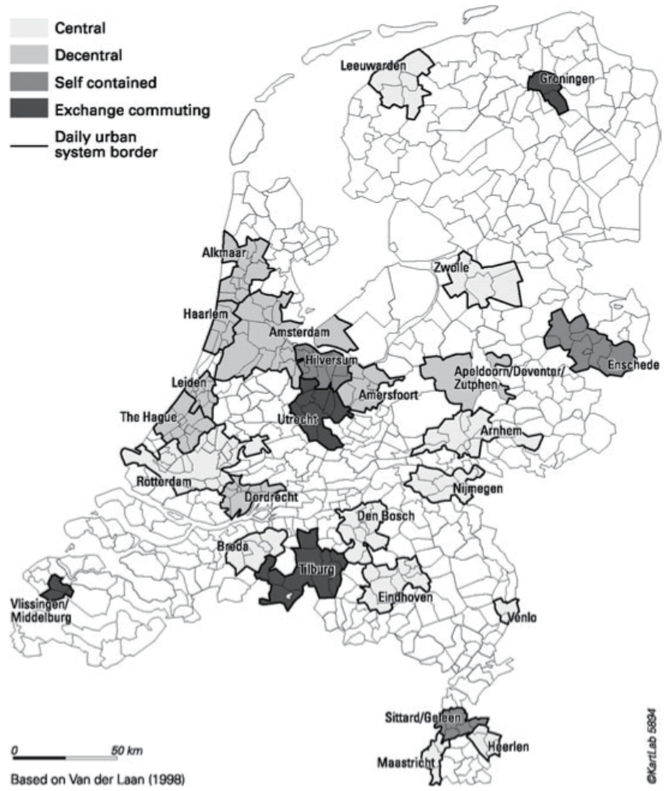
From an impact research of metropolitan structure on the commute behavior of urban residents in the Netherlands(Schwanen, Mieleman, et al., 2004), 4 mode of Daily Urban System(DUS) were identified, they are centralized, decentralized, self contained, exchange commuting(Figure 1-6).

The spatial distribution of these types of DUSs over the Netherlands shows a clear pattern(Figure 1-7), And it is obvious that Utrecht play a heart role in the Dutch daily commuting system in terms of both position and function. However, the situation today is that Utrecht is becoming over congested as the most important daily commuting hub in the Netherlands which exceeded its capacity.

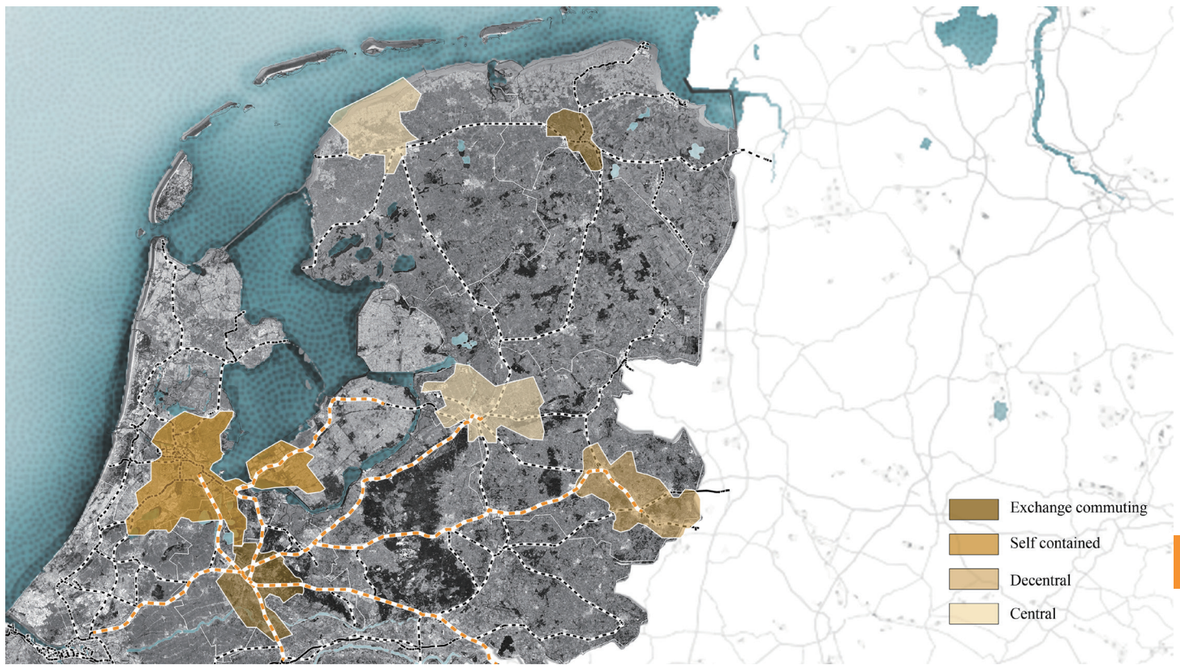
Utrecht's rail network spread out to seven directions(Figure 1-8), massive trains exchange activities are happening here everyday, which brings risks and excessive rail system traffic pressure in Utrecht, which can drive the national rail system to the worst scenario when accident happend to the trains in Untrect. Very recently, it happened once in the summer of 2022, nearly entire train network shuts down in Netherlands because of one strike in Utrecht.



1-6 Schematic reprenseentation of types of Daily Urban System (DUS), by Schwanen, Mieleman 2004. Redrawn by Author



1-7 Spatial distribution of DUSs over the Netherlands, by Schwanen, Mieleman 2004



1-8 DUSs model intrepted with existing railway network of the Netherlands, Drawn by Author
Date source: PDOK. https://www.pdok.nl/

1-9 All trains listed were marked cancelled in red at Utrecht Centraal station, photo by Peter Dejong/AP, 2022

1.4. The Lelyline proposal

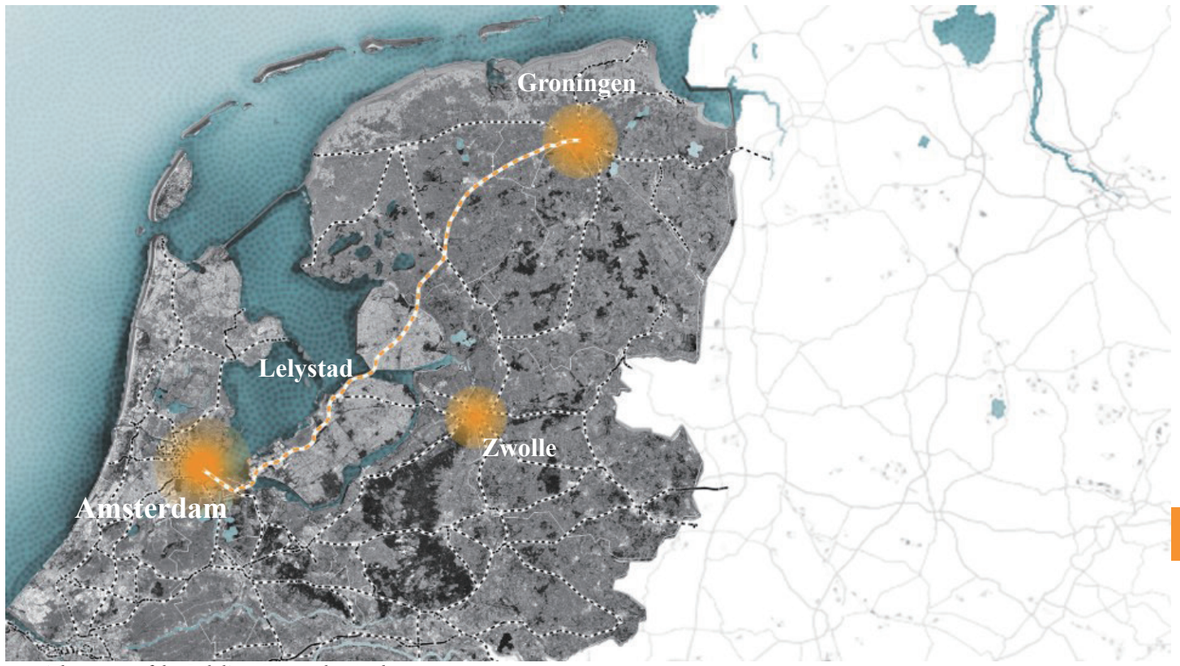
1.4.1. Project introduction

The government is aware of the current situation. The Lelylijn is a proposed Dutch railway line between Lelystad and Groningen with at least stations in Emmeloord, Heerenveen and Drachten with trains capable of reaching speeds of up to 160 kilometers per hour. It was named after Cornelis Lely, gained significant support and momentum through various initiatives and lobbying efforts. Initially introduced by Frisian Member of Parliament Dirk Pool in April 2018, with the endorsement of Pier Eringa, the president of ProRail at the time, the project faced initial opposition from the province of Groningen. However, by November 2018, the lobby for the Lely line expanded to include a majority of the Flevoland States, several municipalities, business organizations, and influential bodies.

Support for the project continued to grow throughout 2019, with backing from local and provincial departments of political parties like VVD, D66, and CDA, as well as participation from MPs Maurits von Martels and Rutger Schonis. A social media poll conducted in March 2019 revealed significant public support for the Lely line. Despite some resistance, particularly from State Secretary for Infrastructure and Water Management Stientje van Veldhoven, who rejected the Zuiderzee line, there was increasing support within the D66 party and the provincial and local departments.

In September 2019, two professors from the University of Groningen challenged previous studies and claimed that a high-speed line from Lelystad to Groningen would be profitable. In October 2019, an alliance formed by the Provincial States of Friesland, Groningen, and Drenthe advocated for the Lely line, with support from various political parties.

On December 5, 2022, the Ministers of Transport of the EU member states approved including the Lely line in the TEN-T network, increasing the chances of receiving European subsidies. The European Parliament's consent is still pending.



1-10 The route of the Lelyline, Drawn by Author
Data source: mijnvormgever.nl

1.4.2. Voice against the Lelyline

HowThe Lely line project has faced concerns regarding its high cost. In February 2019, the estimated cost of the project was EUR 3-4 billion. However, proponents of the Lely line argue that the project would save the 2 billion euros that the North received as compensation for the cancellation of the Zuiderzeelijn, which could be used for alternative rail improvements. Some have expressed hesitation in seeking additional major investments from the national government.

Profitability is another factor under scrutiny. The profitability issue was the reason behind the cancellation of the previous Zuiderzee Line in 2007. Extending the Lely line further to the German town of Leer and beyond has been deemed unprofitable, as the current train connection is underutilized. The existing railway lines between Groningen and Bremen also require significant investments to transform them into high-speed lines.

The construction timeline of the Lely line is another concern, with some suggesting that optimizing the current railways may be a more efficient and cost-effective solution.

At the same time, alternative options have been proposed, such as a bus connection between Lelystad and Groningen, Drachten and Groningen, which would be cheaper and offer considerable time savings.

Also the NS is experimenting with
A faster train between the northern provinces and major cities. The exploration of higher speeds on existing lines and skipping certain stations has also been suggested as a way to save way more travel time without requiring significant investment.

Even more,
the Lelyline would traverse several nature reserves, including Van Oordt's Mersken, which would potentially have irreversible harm to the vunlerable habitat and vegetation there.

Overall, the main debate on the Lelyline is, it can be **faster** and **more environmental friendly**

1.5. High-speed railway approach

1.5.1. Advantages for high-speed railway

High-speed trains offer a range of advantages that make them an appealing mode of transportation:

It excels in speed and time savings, enabling passengers to cover long distances in significantly less time compared to other modes of travel. They prioritize passenger comfort with spacious seating, onboard amenities, and conveniently located stations that are well-connected to other transport options.

Additionally, high-speed train is environmental friendly, consuming less energy per passenger-kilometer and emitting fewer greenhouse gases compared to airplanes or cars. High-speed trains contribute to sustainability by using electricity as energy supply instead of fossil fuels, it's a big improvement in the long term taking the chanllenge of global warming and climate change.

These trains also prioritize safety and reliability through secure tracks, advanced signaling systems, and rigorous maintenance procedures. Economically, high-speed rail systems stimulate growth by generating employment opportunities, boosting tourism, and enhancing regional connectivity. They also alleviate congestion on roads and at airports by providing an efficient alternative for medium-distance travel.

They improve accessibility, serving as an inclusive mode of transport by accommodating individuals with disabilities. In summary, high-speed trains offer advantages such as time efficiency, comfort, environmental friendliness, safety, economic growth, reduced congestion, and enhanced accessibility. These benefits collectively make high-speed rail an attractive and sustainable option for travelers, while promoting efficient and interconnected transportation networks.

1-12 Advantages of the high-speed railway
Data source: mijnvormgever.nl

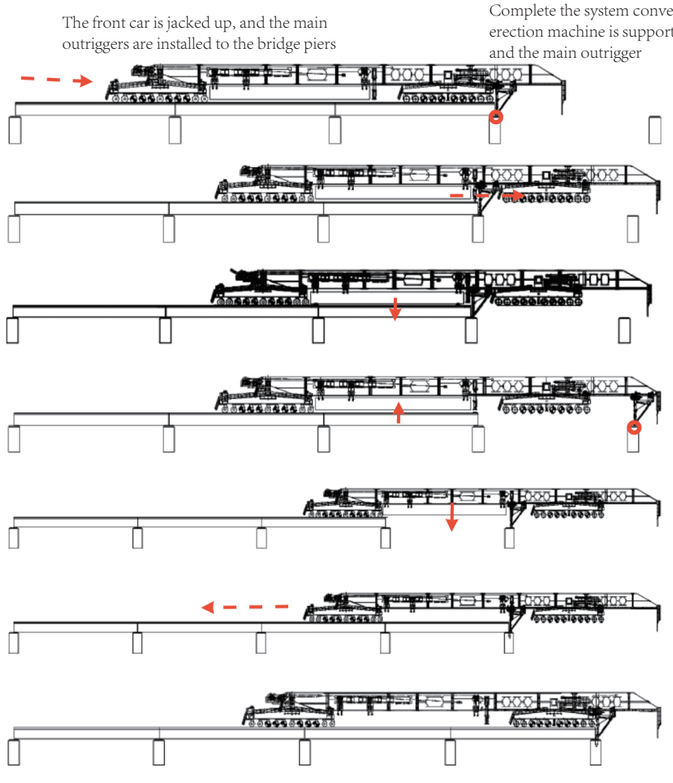
1.5.2. Innovative high-speed railway girder transporting and erecting technology

High-speed railway girder erection machines play a crucial role in the construction of high-speed railway infrastructure. These specialized machines are designed to efficiently and precisely lift and place concrete or steel girders, which form the foundation of railway bridges and viaducts. With their advanced capabilities, these machines significantly expedite the construction process and ensure the structural integrity of the railway infrastructure.

High-speed railways require sturdy and reliable bridges and viaducts to support the weight of trains traveling at high speeds. Traditional methods of girder erection, such as manual labor or cranes, are time-consuming, labor-intensive, and often pose safety risks. The introduction of high-speed railway girder erection machines has revolutionized the construction process, offering increased efficiency, accuracy, and safety.

These machines are equipped with specialized lifting mechanisms, including hydraulic or mechanical systems, capable of lifting and placing heavy girders with precision. They are designed to adapt to various site conditions, including uneven terrain or limited access points, ensuring flexibility in the construction process.

The use of high-speed railway girder erection machines offers numerous benefits. Firstly, it significantly reduces construction time, enabling the swift completion of railway bridges and viaducts. Secondly, it enhances safety by minimizing manual labor and reducing the risk of accidents. Moreover, these machines improve the quality and accuracy of girder placement, ensuring the long-term stability and durability of the railway infrastructures and they have become indispensable in the construction of high-speed railway networks. Their advanced capabilities, including efficient lifting and precise placement of girders, streamline the construction process, enhance safety, and contribute to the development of robust and reliable railway infrastructure.



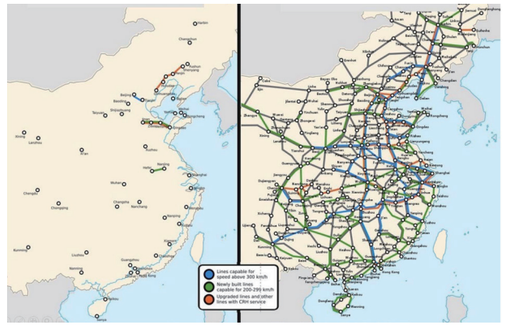
1-13 Construction process of high-speed railway viaduct with innovative girder erection machine, He Jianhua, China Railway Fifth Survey and Design Institute Group Co.Ltd. Annotated by Author

1.5.3. Chinese approach as poossible solution to the railway in the Dutch cultural landscape

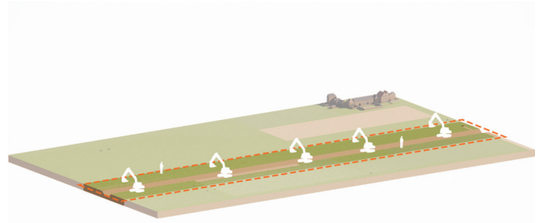
The construction process will be gentle to the environment, with minimum intevention to the landscape. In comparasion with traditional railroad on the surface of land, the viaduct way is not causing new fragementation, the space below the viaduct will turn back to its original property after construction, or even functon in a better way with landscape interventions (will be discussed in the coming chapters). Another incomparable advantage is the efficiency and economicality, the beams and viaduct units will be prefabricated with highly automated producing procedure, approximately 70% of the labour cost will be saved, and with 20% of the saving give back to spend on the landscape mitigation will give a huge benefit to the built environment and nature.

The construction process of the railway viaduct is simplified into four steps, the modular technique mentioned above will be used (Figure 1-14). To apply this technique efficiently, the alignment of railroad tracks should be as straight as possible, so that there is maximum repetition of straightmodules. Only a few curves in the train tracks are allowed.

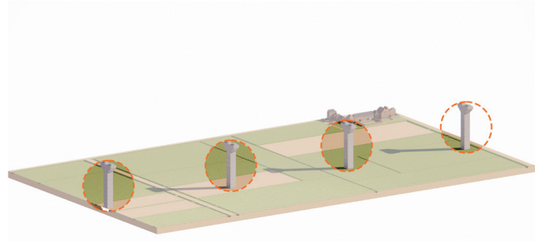
On the other side of the world, in China, this picture has been on for the past decade. From 2008 to 2020, 42,000 kilometers high-speed railway operating mileage were already implemented into the railway network within 12 years.(Figure 1-15) Although the gigantic railway girder machine looks terrifying (Figure1-16), and the Netherlands does not have height differences like China, yet building viaducts for high-speed trains can be a promising solution to the problems we encounter in the Dutch railroad network today.



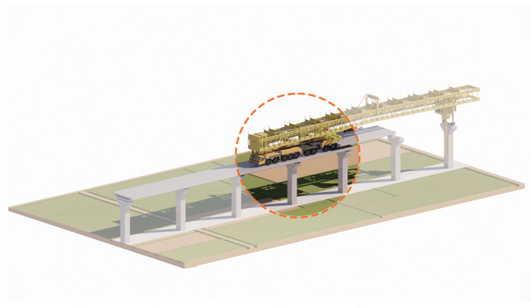
1-15 Comparation of Chinese high-speed railway map between2008 and 2020, Wikipedia



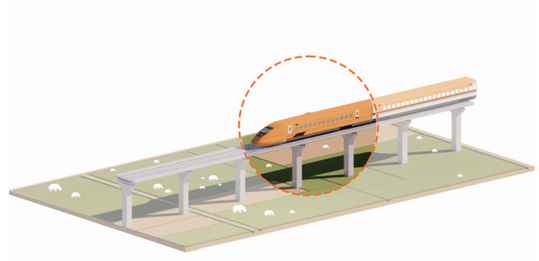
1. Preparation with minimum surface impact



2. Preefabricated beams



3. Installation of 40-60 meter long viaduct components



4. High-speed railway in commission

1-14 Construction process of a self-extending modular railway viaduct. Drawn by Author

1-16 Girder Kunlun Bridge Erecting Machine (1000t/40m) in use. Photo by Fengle Chen, 2021

1.6. Case study worldwide

1.6.1. East Europe: Germany, France and Spain

France, Germany, and Spain are also at the forefront of high-speed railway technology, each having developed advanced networks that have revolutionized transportation within their respective countries and across Europe. Here is an overview of high-speed railway technology in these nations:

Germany: Germany's high-speed rail system, known as InterCity Express (ICE), provides efficient connections within Germany and to neighboring countries. The ICE trains can reach speeds of up to 330 km/h (205 mph) and offer advanced features like tilting technology for increased speed on curves and sophisticated onboard amenities.

France: France's high-speed rail system, known as Train à Grande Vitesse (TGV), is renowned worldwide. The TGV trains operate at speeds of up to 320 km/h (200 mph) and connect major French cities, including Paris, Lyon, Marseille, and Bordeaux. France has pioneered various technological advancements, such as the use of dedicated tracks, streamlined designs, and advanced signaling systems.

Spain: Spain's high-speed rail system, known as Alta Velocidad Espanola (AVE), has rapidly expanded in recent years. The AVE trains can travel at speeds of up to 310 km/h (193 mph) and connect major Spanish cities, including Madrid, Barcelona, Seville, and Valencia. Spain has developed cutting-edge infrastructure, including dedicated tracks and advanced signaling systems.

These countries continue to invest in research and development to enhance high-speed railway technology. They are focused on improving energy efficiency, reducing environmental impact, and further increasing speeds to enhance travel times and connectivity. The high-speed railway systems in France, Germany, and Spain serve as global benchmarks, showcasing the technological advancements achieved in the field of high-speed rail.

1.6.2. East Asia: China, Japan and Korea

East Asia and have witnessed significant advancements in the development and implementation of high-speed rail networks. These regions have recognized the benefits of high-speed rail in terms of efficient transportation, economic growth, and enhanced connectivity.

China: China boasts the world's most extensive high-speed rail network, with thousands of kilometers of dedicated tracks connecting major cities. The country's high-speed trains, such as the CRH series, reach speeds of up to 350 km/h (217 mph) and provide reliable and comfortable transportation options.

Japan: Japan introduced the world's first high-speed rail system, known as the Shinkansen or "bullet train." The Shinkansen network spans the country, connecting major cities at speeds exceeding 300 km/h (186 mph). The trains are renowned for their punctuality, safety, and technological innovations.

South Korea: South Korea operates a high-speed rail system called KTX (Korea Train Express). The KTX network connects major cities, including Seoul, Busan, and Incheon, at speeds of up to 305 km/h (190 mph). The trains offer modern amenities and provide efficient travel options.

1-17 Bullet train crossing Mount Fuji, elegantly implemented in Janpanese cultural landscape, photo by Maeda Akihiko

1-18 Gallery of railway engineering worldwide, collected by Giordana, Juul and Bai

2. Methodology

2.1. Research objective and questions

Our research objective is:

To design an innovative high-speed railroad alternative from Amsterdam to Groningen and be superior to the Lelyline

My research question is:

“How can the portion between Zwolle to Groningen of this innovative high-speed railroad be implemented in a sustainable way respecting the Dutch cultural landscape?”

MAIN RESEARCH QUSETION	SUB-RESEARCH QUESTION	METHOD
Research objective To design an innovative high-speed railroad alternative from Amsterdam to Groningen and be superior to the Lelyline	Why do we need a high-speed railway-implementation from Zwolle to Groningen?	**Analysis** Mapping(L), Fieldtrip **Literature review**
Research question "How can the portion between Zwolle to Groningen of this innovative high-speed railroad be implemented in a sustainable way with minimal intervention respecting the Dutch cultural landscape?"	Where can be better options than the Lelyline?	**GIS research** Literature review, Mapping(M), Fieldtrip **Wire method** Mapping, Desk discussion, Sketching, Modeling **Parameter based evaluation** Systematical assessment
	What are the spatial possibilities for the alignment between Zwolle and Groningen?	**Fieldtrips** Landscape typologies research **Research by Design** 3D modeling, Landscape interventions catalogue, Design through scales (L, M, S)
	How to design the railway and landscape aliong the itineraty in a sustainable way?	**Research by Design** Sections, Master plans, Bird eye view, Perspectives Design through scales (L, M, S)

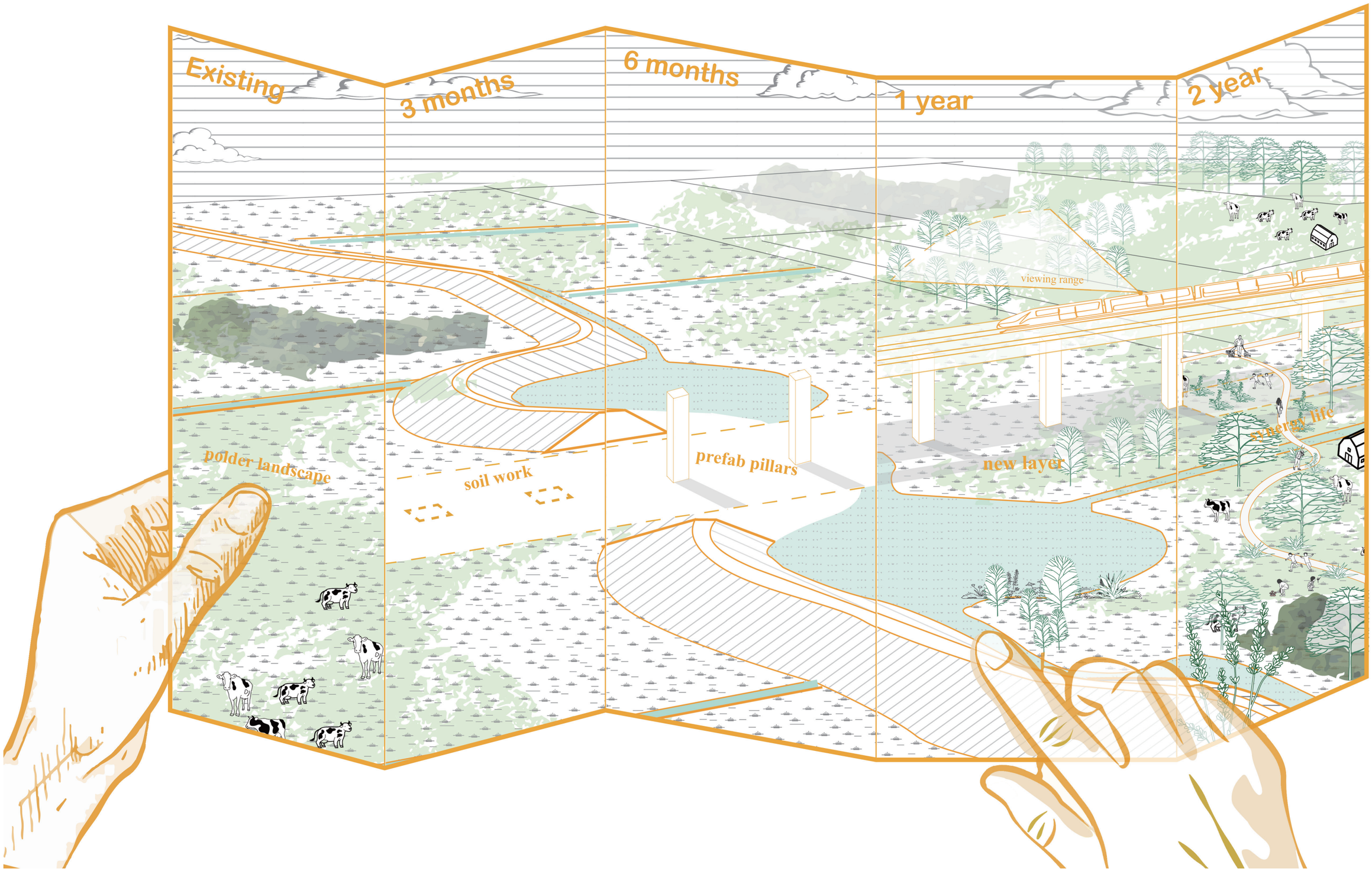
2.2. Theory: Infrastructure as landscape

The notion of conceiving infrastructure as landscape or landscape as infrastructure is not new. Since the latter half of the 18th century, infrastructure has been considered an integral part of the landscape by landscape designers. At this time, they participated in the route and scene design in English landscape gardens. In the 19th century, during the Industrial Revolution in Europe, parks were regarded as essential infrastructure for healthy cities. By the end of the 19th century, with the increasing use of automobiles and the urbanization of the northern United States, the development of metropolitan parks and parkways was initiated. Green spaces were considered the green infrastructure of the city, and routes were "moving landscapes," related to the scenic experience of the natural environment during travel. In the early 20th century, these ideas had a profound influence on the planning of metropolitan parks and highway design in Northwest Europe.

From the 1940s, landscape and urban designers began to participate in the design and transformation of infrastructure such as power generation and flood prevention, as well as the design of brownfields (former industrial zones), highways, or urban agriculture. Nowadays, treating infrastructure as a type of landscape is a common practice in design disciplines, and they have developed specialized professions for it. Seeing infrastructure as a landscape can be said to be an object-oriented approach, in which the infrastructure is the object and is considered as an interdisciplinary landscape design outline, emphasizing the "landscape."

At least four discourses on infrastructure design can be identified, viewing infrastructure as a landscape from spatial, ecological, technological, or social perspectives. In practice, these discourses are usually overlapping, but they differ in their primary objectives. The spatial approach adopts expertise, phenomenological and psychological principles to allocate and design infrastructure, such as roads, dams, and wind turbines, based on formal-architectural features and spatial-visual experiences. The ecological approach uses nature and environmental-based techniques as operating tools to create green infrastructure (also known as greenways, ecological corridors, etc.), which are combinations of open spaces, woodlands, wildlife habitats, parks, and other natural areas, maintaining clean air, water, and natural resources for sustainable cities.

In technologically oriented methods, civil and agricultural technologies form the foundation for infrastructure landscape design. Examples can be found in route design, flood prevention design, and urban agriculture. The characteristic of the social approach is its human-centricity, adopting participatory or anthropometric design strategies, such as by involving people in the development of infrastructure or the design of public spaces, to achieve social engineering and healthcare objective. (Nijhuis, 2015)



2-1 Leaflet illustration of the effecient construction process and landscape mitigation, Drawn by author

2.3. Research framework and time planning

After arrived with the research question, the methodology can be described in four sections as elaborated on the diagram.

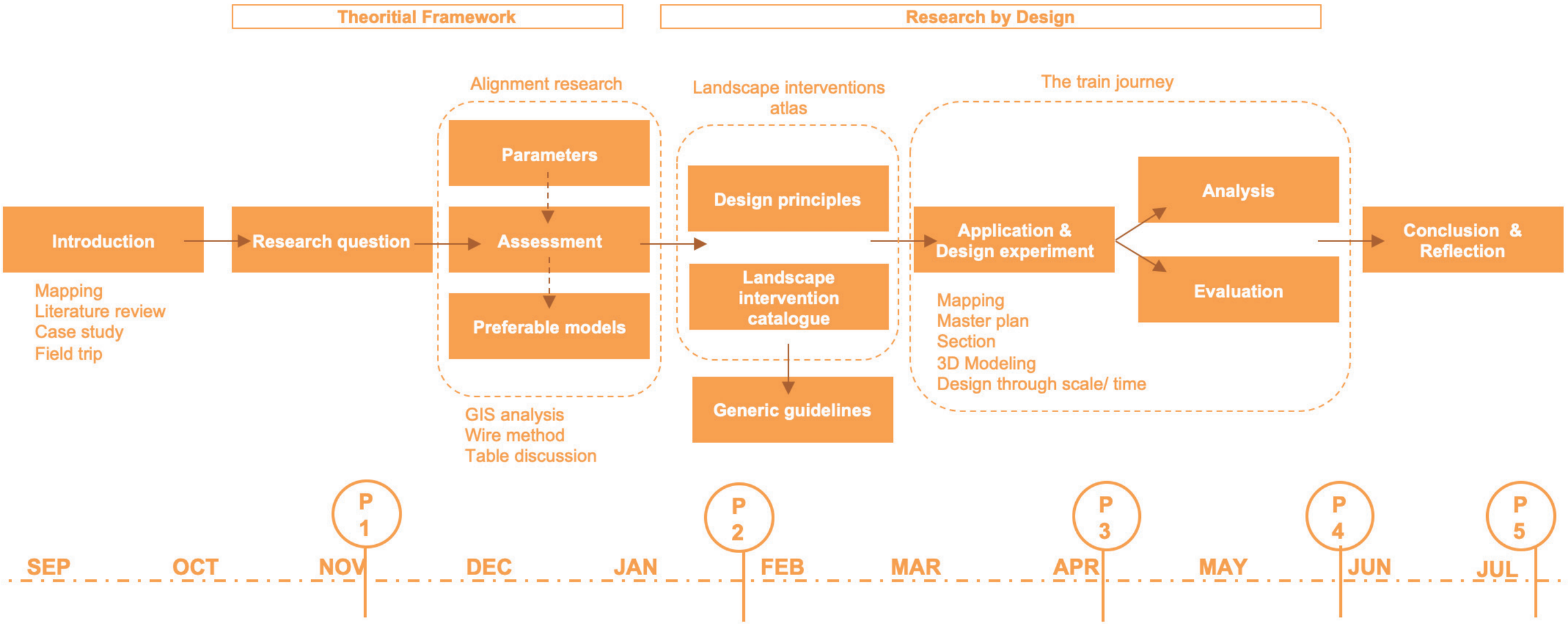
The description of the overall conditions of the research region which includes the provinces of Overijssel, Drenthe and Groningen will be discussed in the earlier part of the first section. Then first section will be investigated through mapping, literature review, field trip, and case study of the high-speed railway development worldwide.

In parallel with the first section, the second section will be focusing on the alignment research. This second section has done in a systematic way through the process of desk discussion, layer analysis, parameter based assessment, and the outcome is an optimal model of the alignment.

In the third section, the landscape typologies alongside the optimal alignment will be studied and possible landscape interventions will be developed into catalogue. The two relevant theories which are the "Infrastructure as Landscape" and "Transit-oriented development" will be applied and elaborated to the design principles and manifesto in a further stage.

The fourth section will be focusing on the design explorations. This process will be done by different design tools, such as sketches, 3D model and physical study model through a variety of scales, which covers urban design scale, neighborhood scale, road scale (set of interventions) and unit scale. The design section will be a back and forth, trial and error as well as scenario-based design. Besides, the design will be developed not only from the experiment but also from the feedbacks of the critics (supervisors, fellow students, non-design background students, local residents) until the design will ultimately answer the research question. Until the last section, the final design will be evaluating and assessing by the framework from the earlier stage. The outcome of the fifth section is the final report that has been included the entire mentioned knowledge from the beginning of the research, the final design and the reflection from the author.

Research framework and time planning



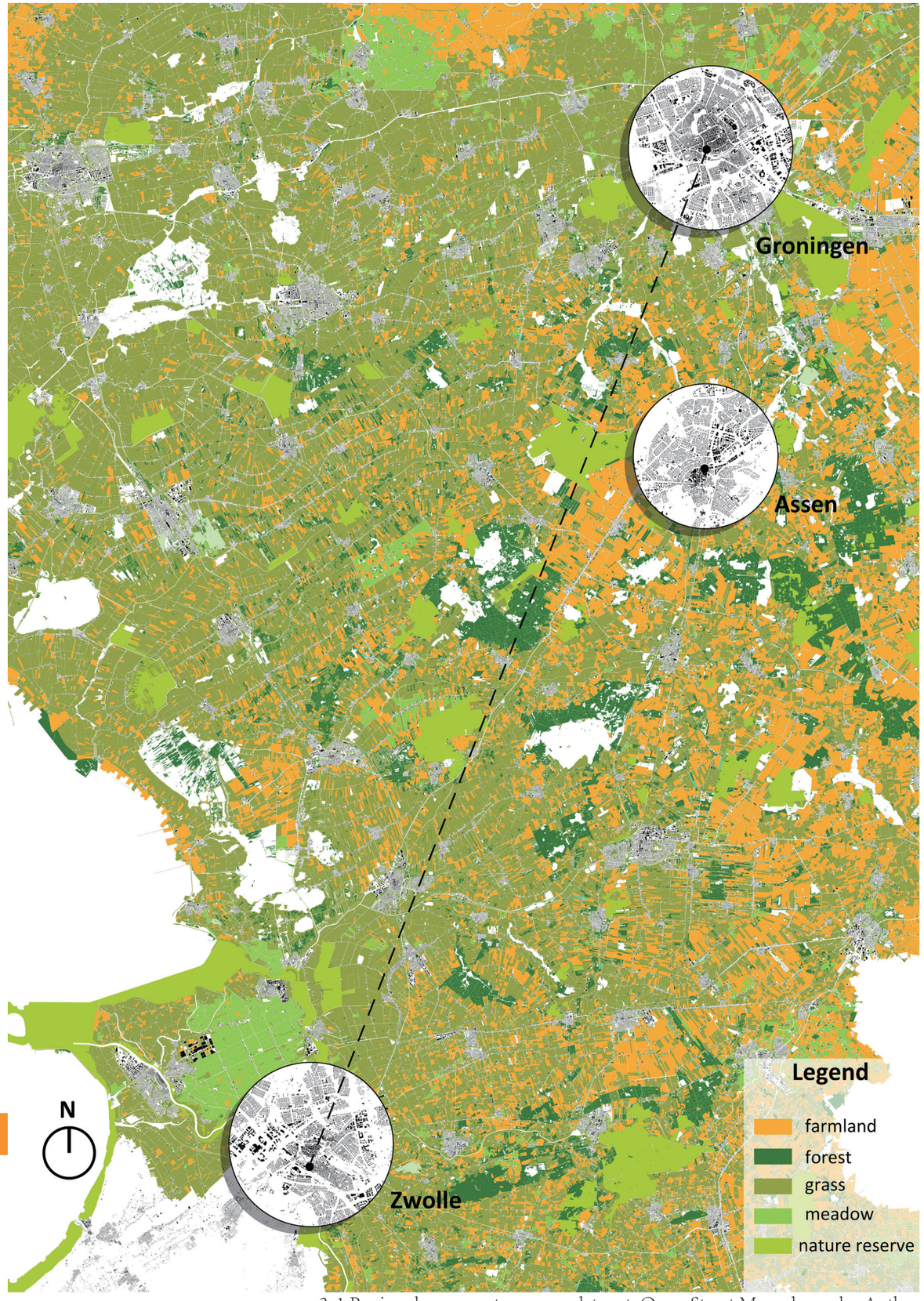
2-2 Conceptial diagram of the research methodology, Drawn by author

3. Alignment research

3.1. Read the landscape by layer analysis

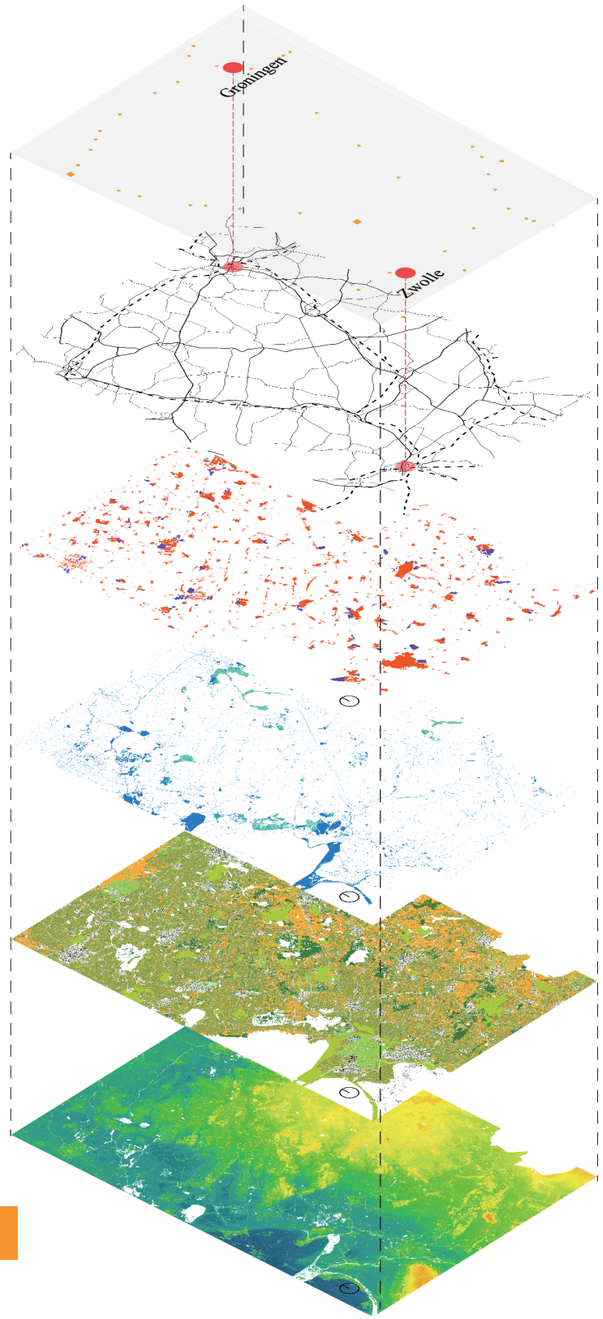
Geographical information system data of the study area are obtained and collected through various channels (including OpenStreetMap, PDOK, municipal government websites, etc.), and individually analyzed layers such as railway stations, traffic infrastructure, built environment, water bodies, and green systems. This allowed us to understand the city and landscape system of the study area from multiple dimensions.

For example, the distribution map of train stations shows the accessibility of different towns, and the mapping of the built environment helps us preliminarily identify the possible alignments for the railway, as new alignments cannot invade residential and commercial areas. The water body map of the area helps us understand the hydrological conditions of the region and the railway should not cross the protected area. The map of the green system allows us to understand the composition and structure of the regional green space, which plays a crucial role in helping us propose routes that benefit the green space system rather than splitting it. The topographic map of the region helps us to evaluate the difficulty and cost of the project; we will prioritize routes with smaller height differences.



3-1 Regional green system map, data set: Open Street Map, drawn by Author

3-2 Valuable nature assets in north provinces of the Netherlands, collected by Author



RAILWAY STATIONS

The distribution of the stations shows the accsessibity to the suroundings

TRAFFIC INFRASTRUCTURE

The existing traffic infrastructure network can be take good use of in the new solutions

BUILT ENVIRONMENT

New alignment is supposed to get rid of cutting through the built environment

WATER BODY

Identify the river, old canel, wetland, lake, ditch and etc. in the regional water tissue

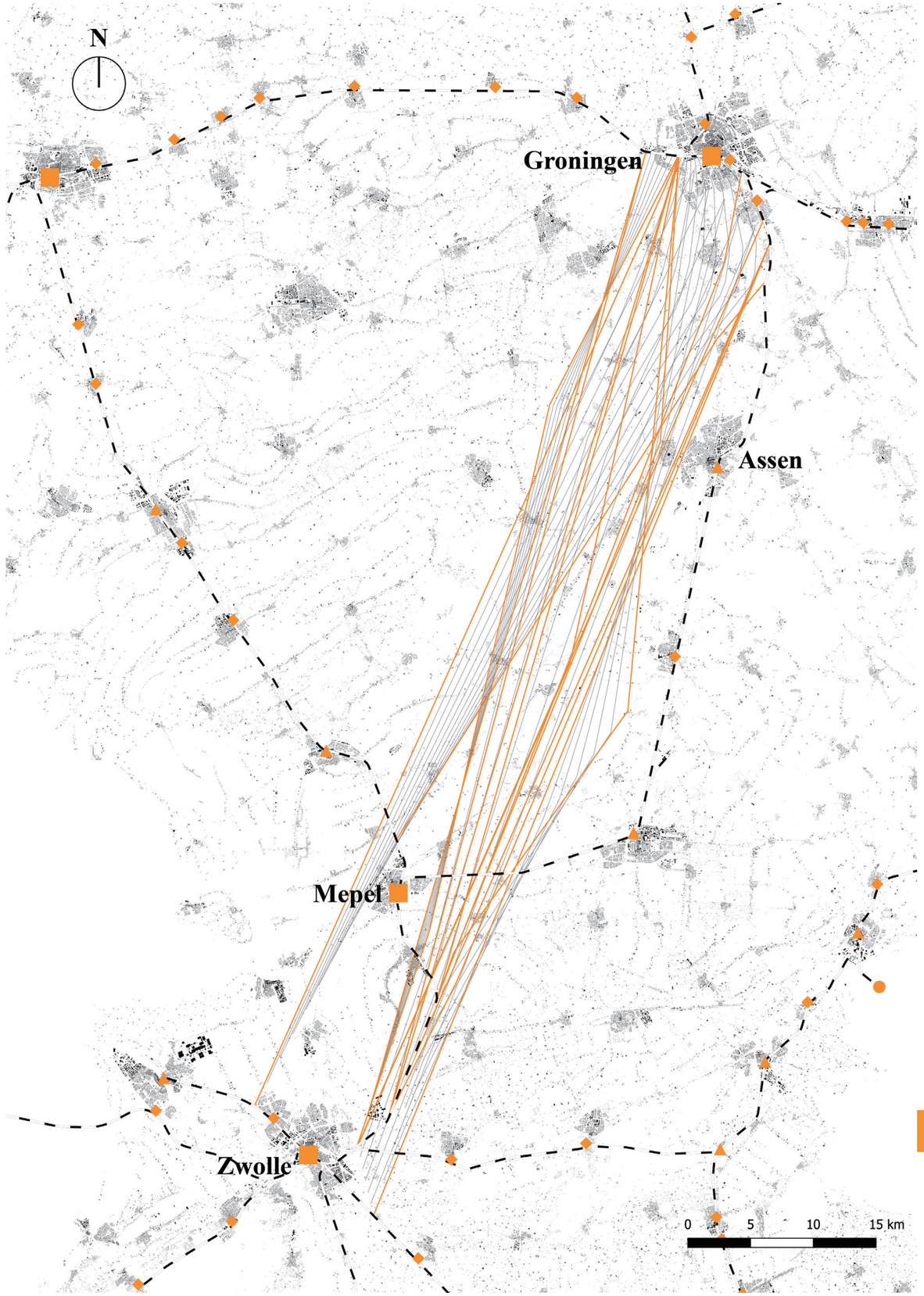
GREEN SYSTEM

Look for the possibility of connect different green element, improve the sustainability and resiliency

HEIGHT MAP

Find economical solutions with less height difference on the route

3-3 Layer analysis of the regional built environment, traffic infrastucture and nature, drawn by Author



3-4 Layer analysis of the regional built environment, traffic infrastucture and nature, drawn by Author

3.2. Wire method

In order to discuss the various possibilities for the alignment in an intuitive, operable, and understandable way, we printed and operated on Top25NL from PDOK (2022) map of the study area at scale of 1: 30,000. This 5 meters long and 1.2 meter wide map of regional provinces, was hung on the wall of landscape architecture studio, the faculty of architecture and built environment, TU Delft, making it readable for all macro information of the research area.

Colored cotton strings (Figure 3-5), scissors, paper tape, those simple tools, together with all the information map collected and drawn, pin up on the map, a creative method for alignment research and discussion is invented.

Like in the movies, FBI agent standing behind a detective board, investigating evidences of crime suspects (Figure 3-6). Our four lab members, Adriaan, Bai, Juul and Giordana (Figure 3-7), worked as a studio, spent two months together, from October to December, researching like a detective team, looking for all the potential alignments that could possibly work in the real space, at the same time, eliminating the suspects that are doing crime to the built and nature environment.

At this stage, the discussion and evaluation is mostly verbal, interdisciplinary and in fusion. Intense brainstorming inspired us with hundreds of news ideas. Some were given up and some remained through this process. The result came out to be 15 potentially feasible alignments between Zwolle and Groningen.(Figure 3-10)

3-5 Colored cotton strings, simple tools but works perfectly at the scale of 1:30,000
photo by Juul ten Hove

3-6 FBI Agent behind detective board, , Source: getty images

3-7 Research team: Adriaan Geuze, Bai Fazhong, Juul ten Hove, Giordana Credendino (from left to right)
Illustration by Wanning Liang

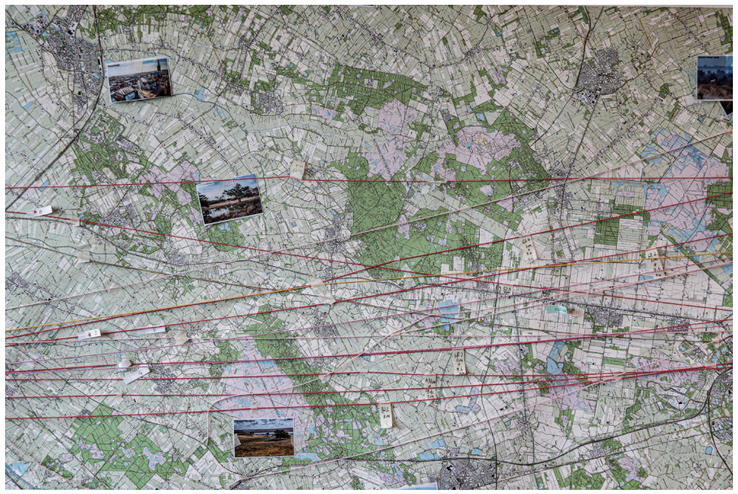
3-8 Researching on the 1:30,000 topographic map, which contain both good overview and sufficient detail
Photo by Wanning Liang

3-9 Options for entering Groningen, documented in the introduction video of the Master track Landscape Architecture TU Delft
Source: Youtube

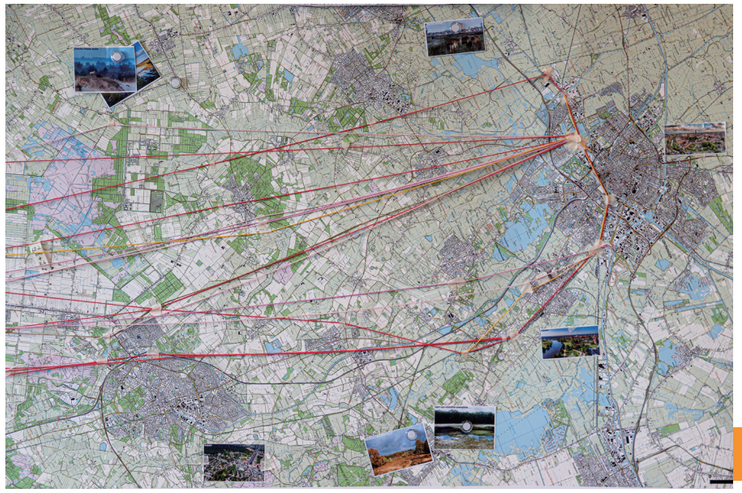
High-speed railway alignment between Zwolle to Groningen research wall
BK West 600, TU Delft

Overview

Zwolle - Staphorst



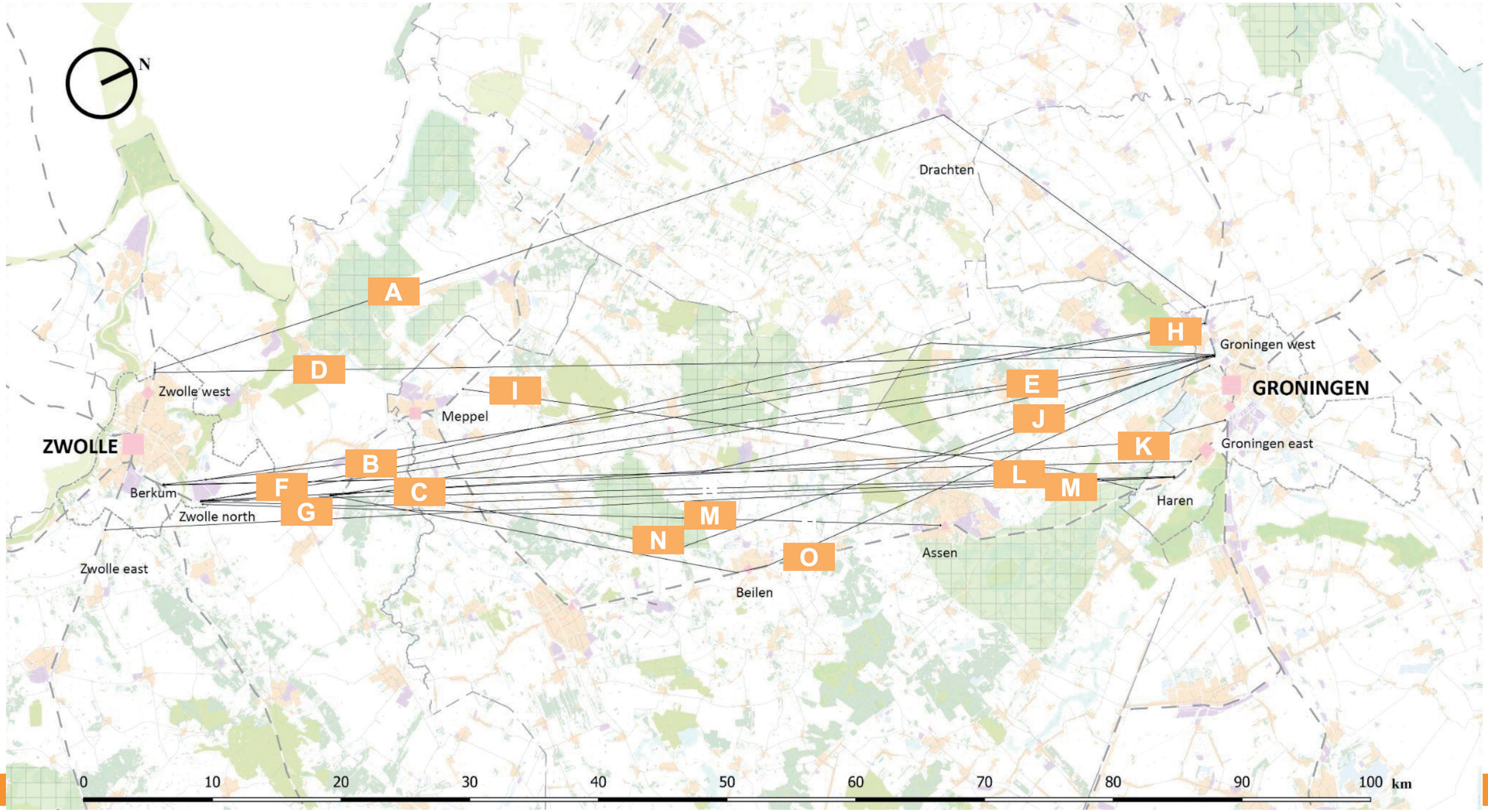
Dwingelderveld



Fochteloerveen - Groningen

3-10 Result of the exploration by the "wire method", made by Author

Digitalization of the feasible alignments



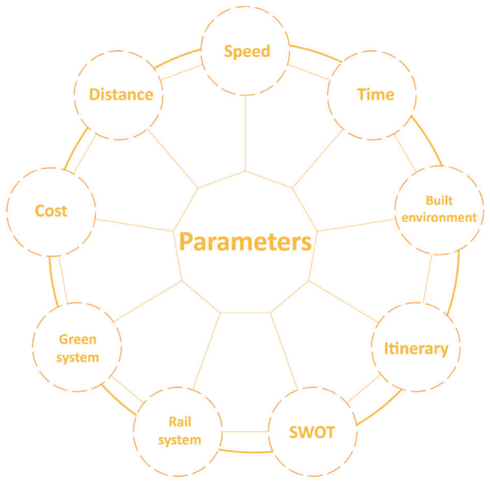
3-11 Result of the exploration by the "wire method", drawn by Author

3.3. Parameters based assessment

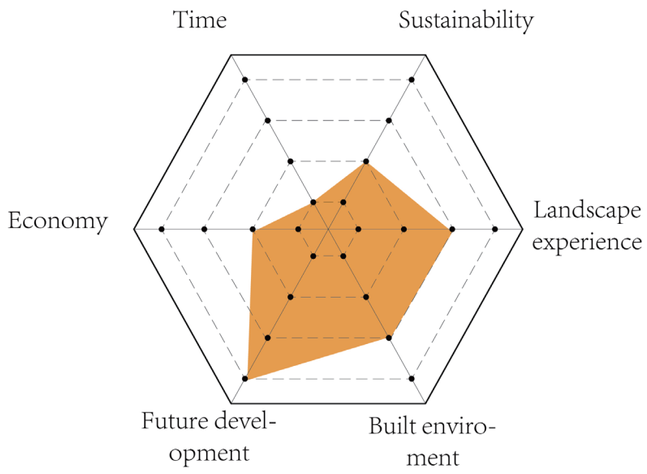
Subsequently, we systematically introduced multiple parameters to quantitatively evaluate these feasible alignments, including distance, required time, the number of villages passed, the number of national parks traversed, cost estimation, intervention of the built environment, and landscape journey along the itinerary, etc (Figure 3-12, excel sheet attached in Appenddix). These parameters help us to quantitatively compare the pros and cons of these alignments.

Inspired by Janpanese TV channel, who shows the skill map of the table tennis athletes before the game strarts, which give the TV viewers a intuitive impression to know players' strength and weakness, it's understandable no matter you are professionals or amateurs.(Figure 3-13)

It works as a good reference. To make those parameters more comparible and understandable insteads of only numbers in the excel sheet, scoring board with 6 dimensions is created including time, sustainability, landscape experience, built environment, and future development. Grade from 0-5 is given to each alignment on every criteria so that the area size of the scoring board shows a comprehensive benefits that the alignment could bring. The coverage is larger, the overall performance is better.



3-12 Parameters used for the assessment of feasible alignments
Drawn by Author



3-14 Scoring board of the feasible alignments from six dimensions
Drawn by Author

3-13 Skill board of world rank No.1 table tennis player, Ma Long, who is so-called a hexagonal warrior, Tokyo Olympics 2022
Source: Tokyo Pingpong News

3.4. Alignment groupings

Based on the evaluation results, these potential feasible alignments are grouped and classified according to their different characteristics.

The first category consists of alignments **via Drachten**. As the name of this group indicates, the biggest advantage of these paths is that they pass through Drachten. an important city in Flevoland, which is not yet connected by rail. If this route passes through Drachten, it will greatly stimulate the economic and urban development of the city of Drachten and its surrounding areas. However, these alignments also have some drawbacks. The main one is that the detour is comparatively too long, and the high-speed rail's requirements for the turning radius make these routes much slower in Drachten; the second is that these routes will inevitably pass through the Weeribben-Wieden conservation area, which is not acceptable from the ecological perspective (Figure 3-15).

The second category is the shorter alignments **via national parks** in the middle. There are seven national parks and conservation areas in different sizes distributed between Zwolle and Groningen, and the alignments in this group are going to pass through at least two and as many as four of them. Therefore, it is crucial to find a route in these numerous options that elegantly deals with the relationship with those nature conservations and national parks (Figure 3-16).

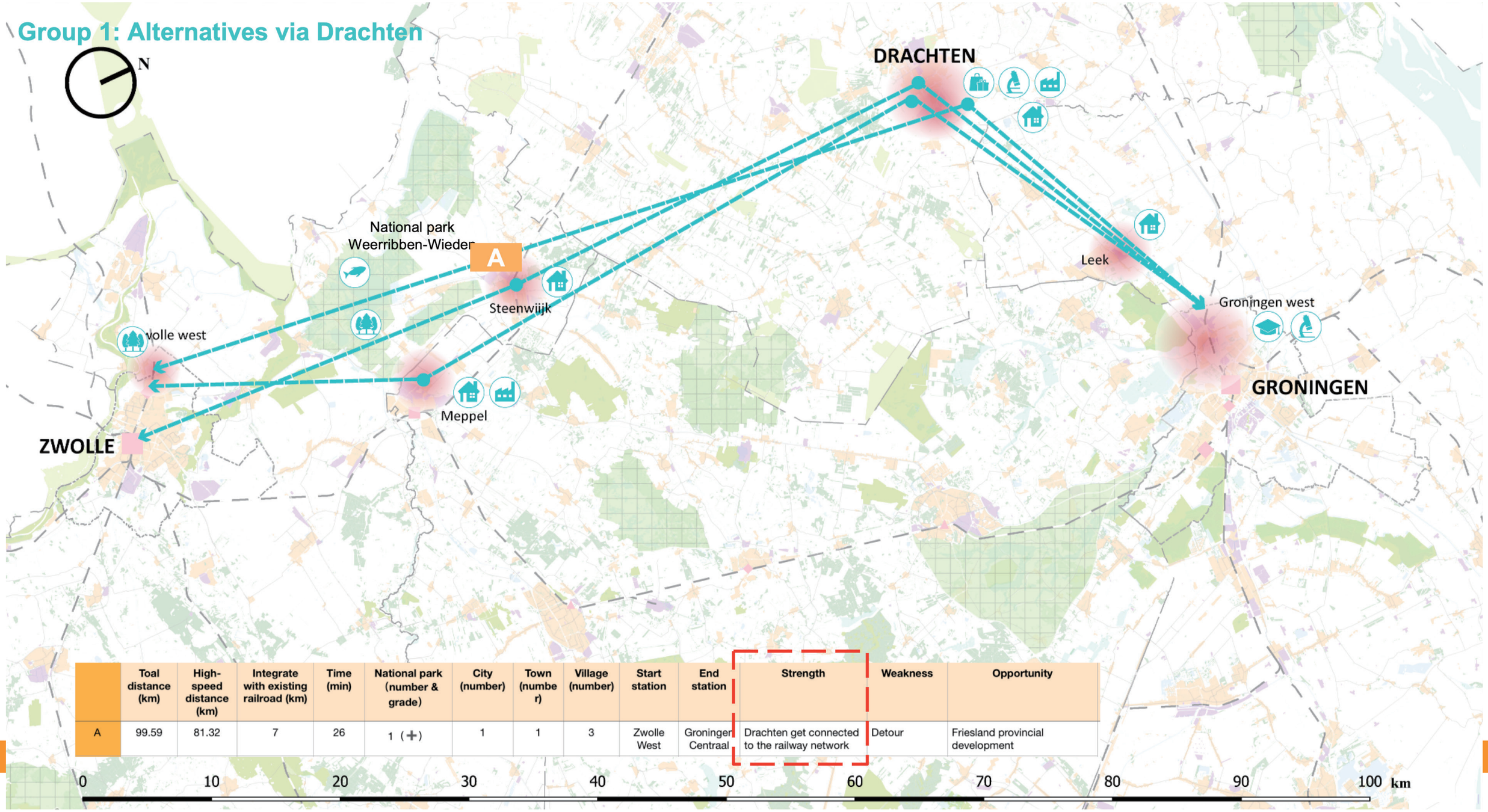
To be more explicit, within this category, three sub groups are further divided, which are:

Shortest alternatives: The starting and ending stations of the two routes are Zwolle west - Groningen west and Zwolle east - Haren. These two routes can be connected by a straight line, making them the most efficient routes (Figure 3-17).

Least touch to the built environment alternatives: In this group of routes, by setting 1 or 2 kinks, the number of villages they affect does not exceed 1, making them the most local resident-friendly routes (Figure 3-18).

Integrated with existing railway alternatives: This group of routes maximizes the use of existing railways, making them the most economical routes(Figure 3-19).

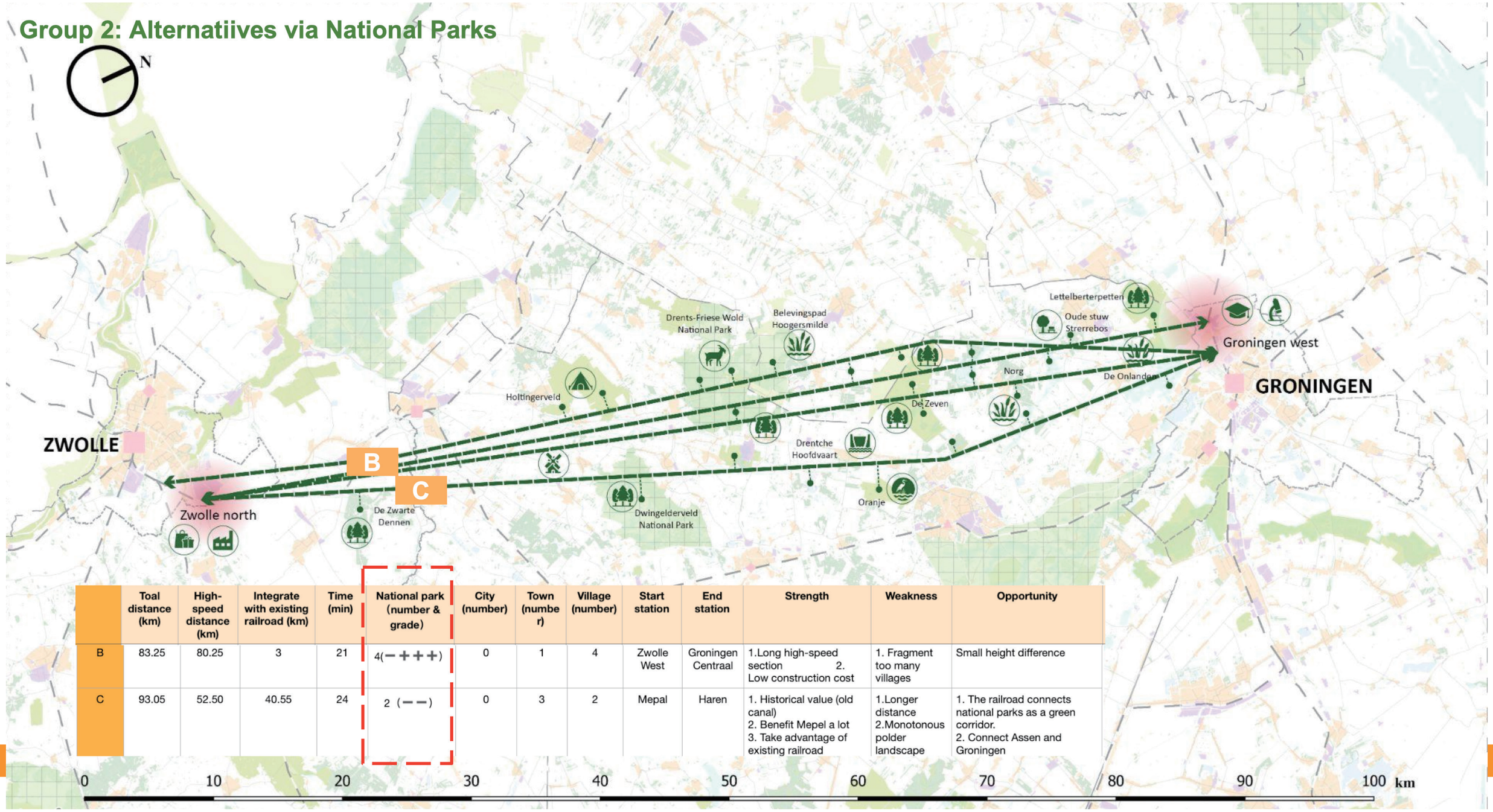
Group 1: Alternatives via Drachten



	Toal distance (km)	High-speed distance (km)	Integrate with existing railroad (km)	Time (min)	National park (number & grade)	City (number)	Town (numbe r)	Village (number)	Start station	End station	Strength	Weakness	Opportunity
A	99.59	81.32	7	26	1 (+)	1	1	3	Zwolle West	Groninger Centraal	Drachten get connected to the railway network	Detour	Friesland provincial development

3-15 Feasible alignments via Drachten, drawn by Author

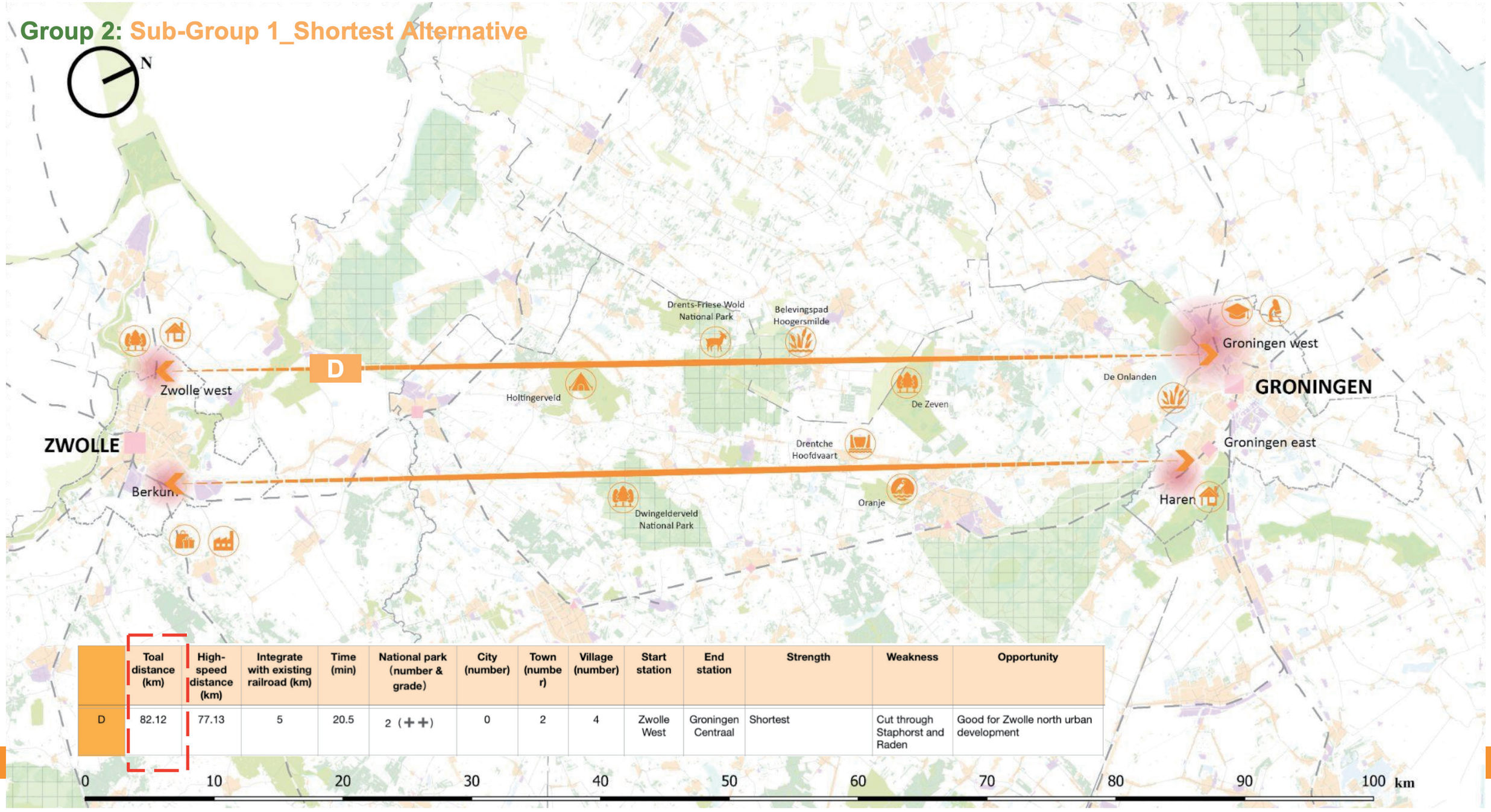
Group 2: Alternatiives via National Parks



	Toal distance (km)	High-speed distance (km)	Integrate with existing railroad (km)	Time (min)	National park (number & grade)	City (number)	Town (numbe r)	Village (number)	Start station	End station	Strength	Weakness	Opportunity
B	83.25	80.25	3	21	4(−+++)	0	1	4	Zwolle West	Groningen Centraal	1.Long high-speed section 2. Low construction cost	1. Fragment too many villages	Small height difference
C	93.05	52.50	40.55	24	2 (−−)	0	3	2	Mepal	Haren	1. Historical value (old canal) 2. Benefit Mepel a lot 3. Take advantage of existing railroad	1.Longer distance 2.Monotonous polder landscape	1. The railroad connects national parks as a green corridor. 2. Connect Assen and Groningen

3-16 Feasible alignments via National parks, drawn by Author

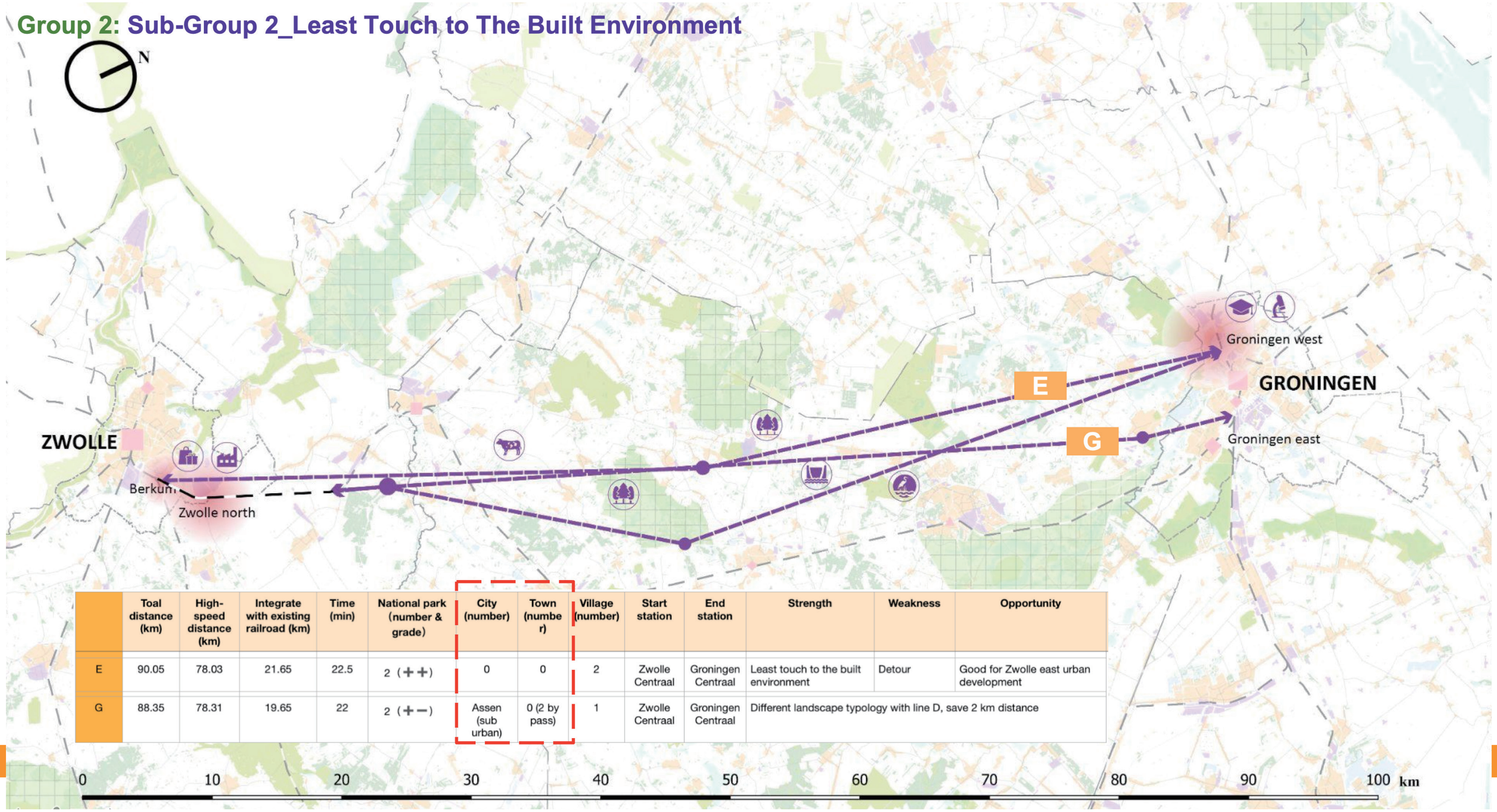
Group 2: Sub-Group 1_Shortest Alternative



	Toal distance (km)	High-speed distance (km)	Integrate with existing railroad (km)	Time (min)	National park (number & grade)	City (number)	Town (number)	Village (number)	Start station	End station	Strength	Weakness	Opportunity
D	82.12	77.13	5	20.5	2 (++)	0	2	4	Zwolle West	Groningen Centraal	Shortest	Cut through Staphorst and Raden	Good for Zwolle north urban development

3-17 Feasible alignments via National parks, shortest alternatives, drawn by Author

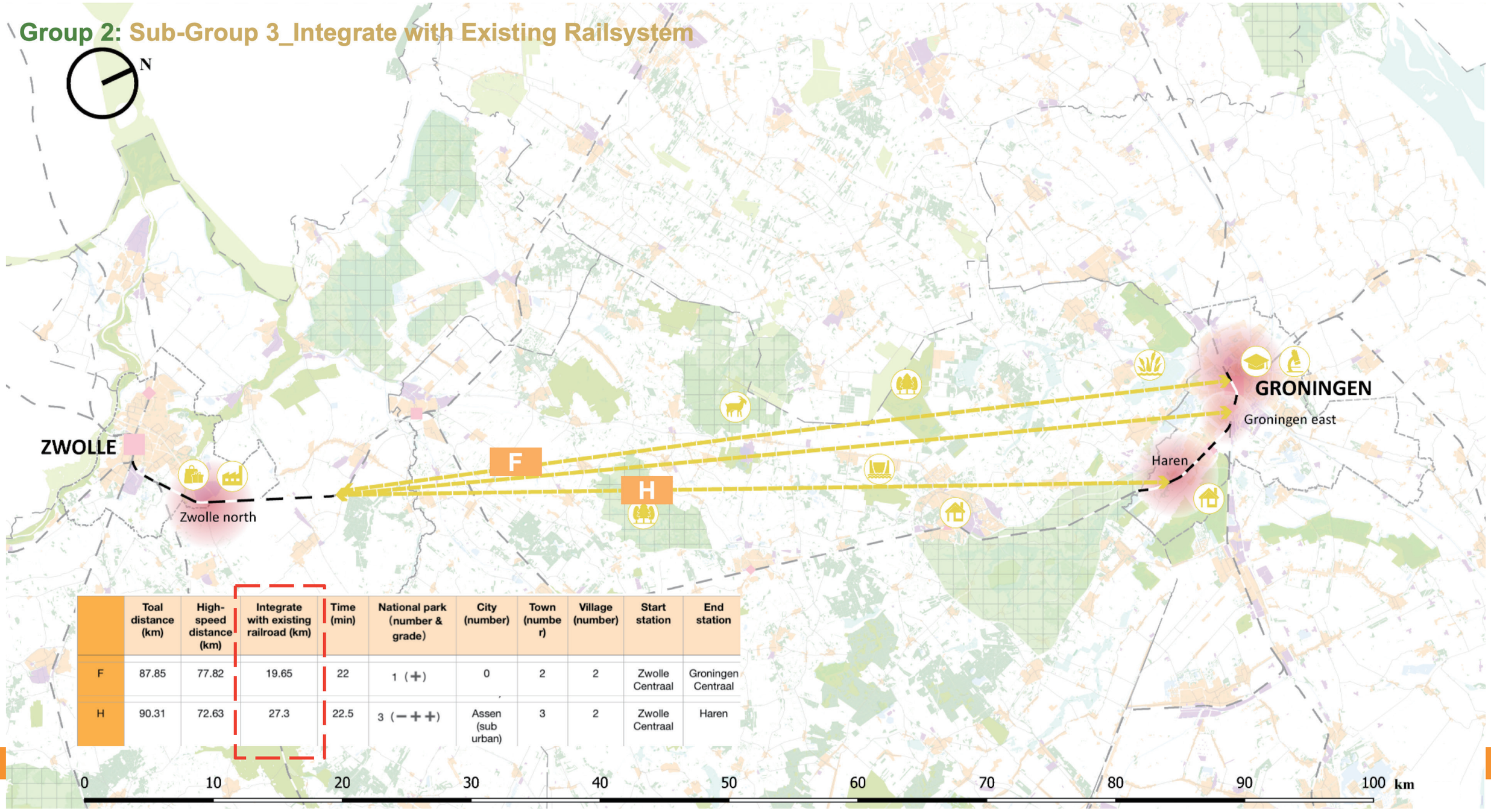
Group 2: Sub-Group 2_Least Touch to The Built Environment



	Toal distance (km)	High-speed distance (km)	Integrate with existing railroad (km)	Time (min)	National park (number & grade)	City (number)	Town (number)	Village (number)	Start station	End station	Strength	Weakness	Opportunity
E	90.05	78.03	21.65	22.5	2 (++)	0	0	2	Zwolle Centraal	Groningen Centraal	Least touch to the built environment	Detour	Good for Zwolle east urban development
G	88.35	78.31	19.65	22	2 (+−)	Assen (sub urban)	0 (2 by pass)	1	Zwolle Centraal	Groningen Centraal	Different landscape typology with line D, save 2 km distance		

3-18 Feasible alignments via National parks, least touch to the built environment, drawn by Author

Group 2: Sub-Group 3_Integrate with Existing Railsystem



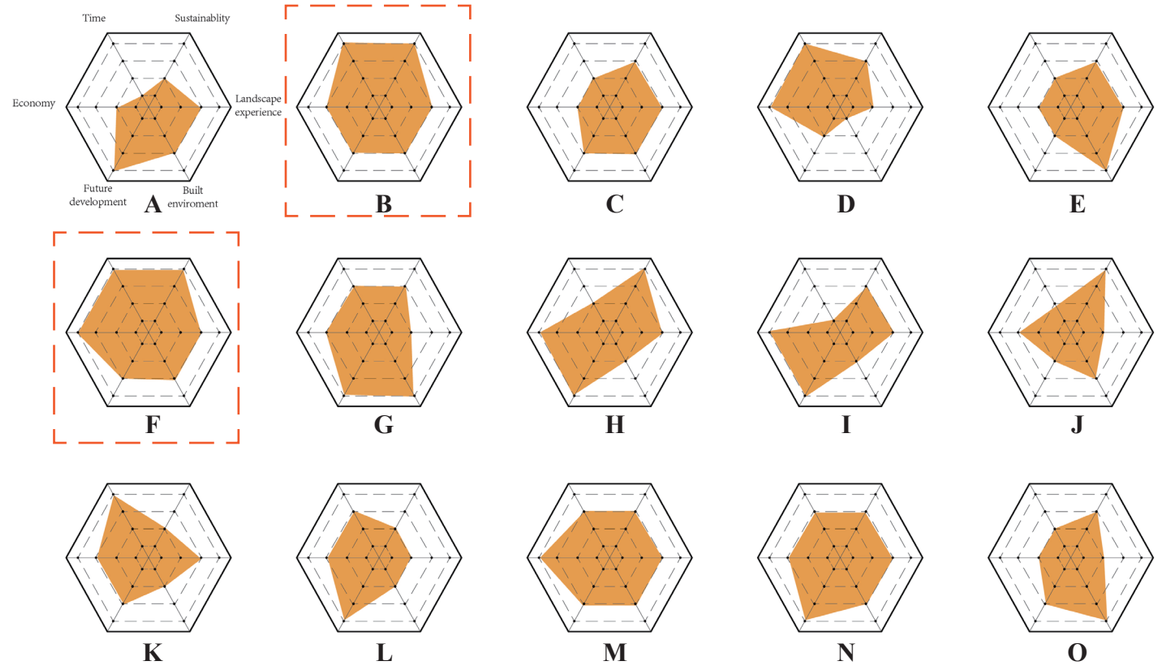
	Toal distance (km)	High-speed distance (km)	Integrate with existing railroad (km)	Time (min)	National park (number & grade)	City (number)	Town (number)	Village (number)	Start station	End station
F	87.85	77.82	19.65	22	1 (+)	0	2	2	Zwolle Centraal	Groningen Centraal
H	90.31	72.63	27.3	22.5	3 (− + +)	Assen (sub urban)	3	2	Zwolle Centraal	Haren

3-19 Feasible alignments via National parks, drawn by Author

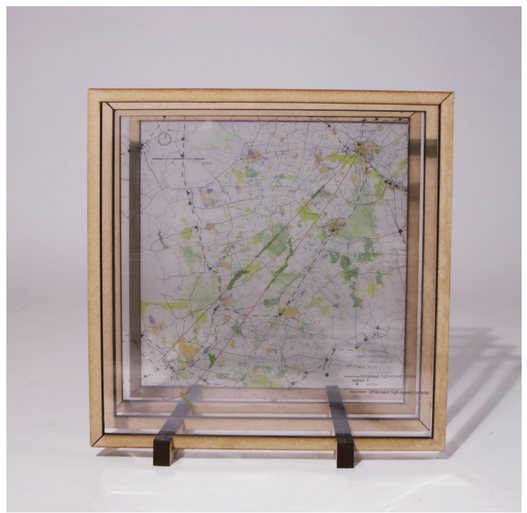
3.5. Optimal alignment

The overview for the scoring board of feasible alignments is shown on the right page (Figure 3-20), alignment B and alignment F got the comparatively highest score. Spatially, it is possible that to make adjustment to combine advantages for both high score alignments, which turned out to be the optimal alignment of this research stage. The optimal alignment therefore will be no longer a single straight line anymore, but a combination of multiple straight lines and subtle curves that meet the requirements of high-speed railway curves radius.

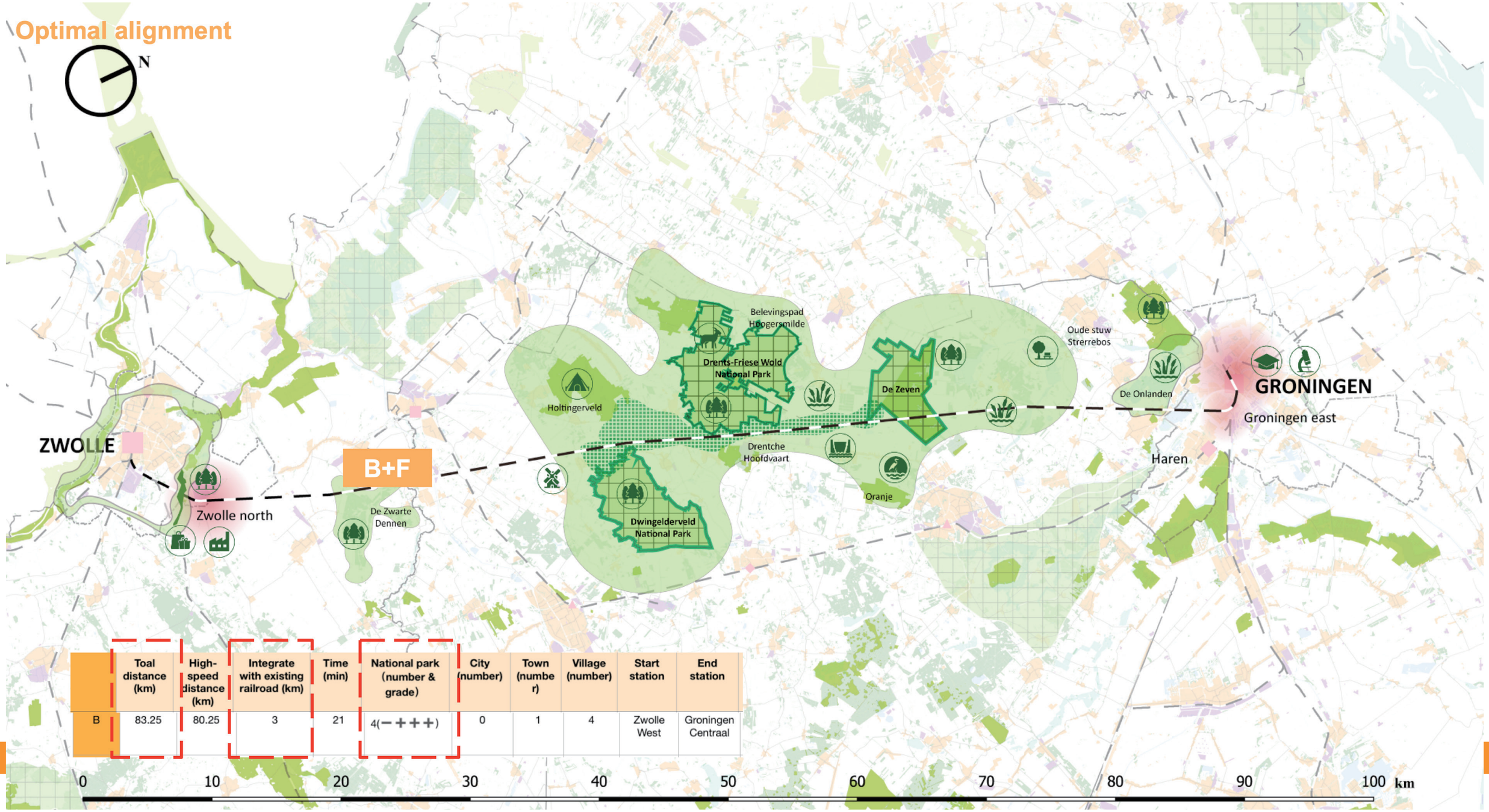
What's more? The optimal alignment will be so gentle to the regional cultural and natural landscape, which suprised us all.(Figure 3-22)
This alignment is not going to disrupt national parks, causing fragmentation, but elegantly pick up the in-between farmlands space of three nationaal parks including Drents-Friese Wold National Park and Dwingelderveld National Park. It will provide opportunity to spatially and ecologically connect three national parks and unify them as a grand national park system.



3-20 Scoring board of feasible alignments, drawn by Author



3-21 Physical model of the optimal alignment, made by Author
Photo by Borui Xiong



	Toal distance (km)	High-speed distance (km)	Integrate with existing railroad (km)	Time (min)	National park (number & grade)	City (number)	Town (number)	Village (number)	Start station	End station
B	83.25	80.25	3	21	4(−+++)	0	1	4	Zwolle West	Groningen Centraal

3-22 Optimal alignment, vision for regional greensystem
Drawn by Author

Nationaal Park
Drents-Friese Wold

The Drents-Friese Wold is the largest contiguous forest area in the Netherlands.

In 2000, more than 6,000 hectares of forest, wasteland, shifting sand and valley grassland were designated as national parks. The Drents-Friese Wold is one of the most beautiful and important nature reserves in Europe

Nationaal Park
Dwingelderveld

Rare plants such as broom and bell gentian also feel at home in the Dwingelderveld National Park here. Nearly three hundred species of birds can be seen in the area, The conditions in the Dwingelderveld are also favorable for dozens of species of butterflies and almost all Dutch reptiles.

The cultural history of about a century ago is still tangibly present because of surrounding picturesque ash villages.

Holtingerveld

Together with Dwingelderveld and Drents-Friese Wold it forms the natural and cultural landscape of the Drents-Friese border region.

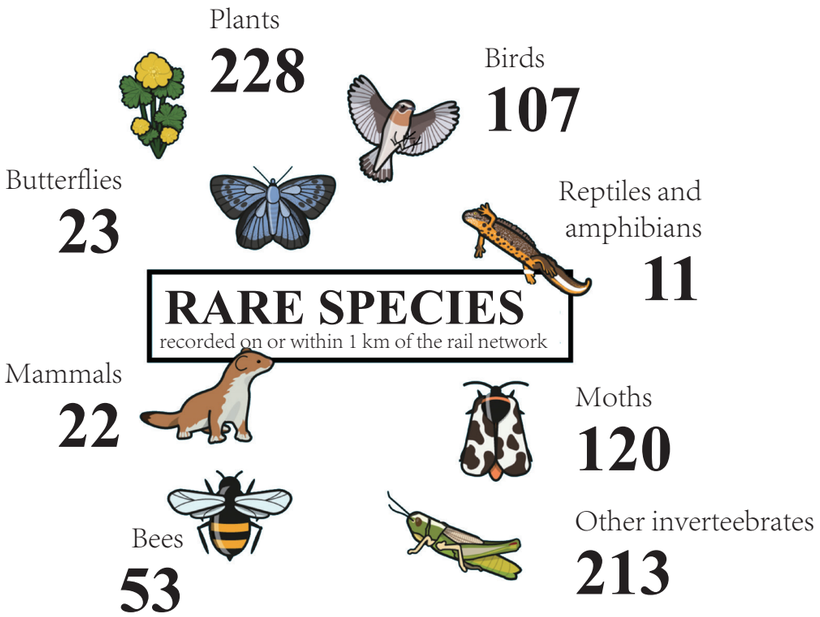
The slogan of the area is "primeval landscape molded by ice and war". This indicates that the past was important for the formation of the area.

3-23 Introducction of related National parks, 2022
Source: official website of each national park

3.6. Railway as corridor

Usually, the railway is seen as a barrier, and the earthworks of the railway often forcefully cut a continuous landscape and lead to ecological and spatial fragmentation. Mike O'Connor, the environmental and ecological manager from the British national railroad company Network Rail, points out that 'There is distinctiveness about the natural environment of railway, its linear network lends itself to particular assemblages of plants and animals.' This is because usually the law requires that general access is prohibited at the railway land and its borders, therefore, the space about 10 meters wide on both sides of the railway becomes a highly-protected area, which makes the railway a linear habitat shared by a wide range of birds, invertebrates, small mammals and plants (Figure 3-24).

Railway land therefore is a secret treasure of extensive matrix of habitat. The social and economic value of railway is obviously recognized as a common sense, while the environmental value of railway has been underestimated for a long history.



3-24 Rare species recorded on or within 1 km of the rail network, redrawn by Author
Source: Network Rail

3.7. Manifesto: railway as landscape bonanza

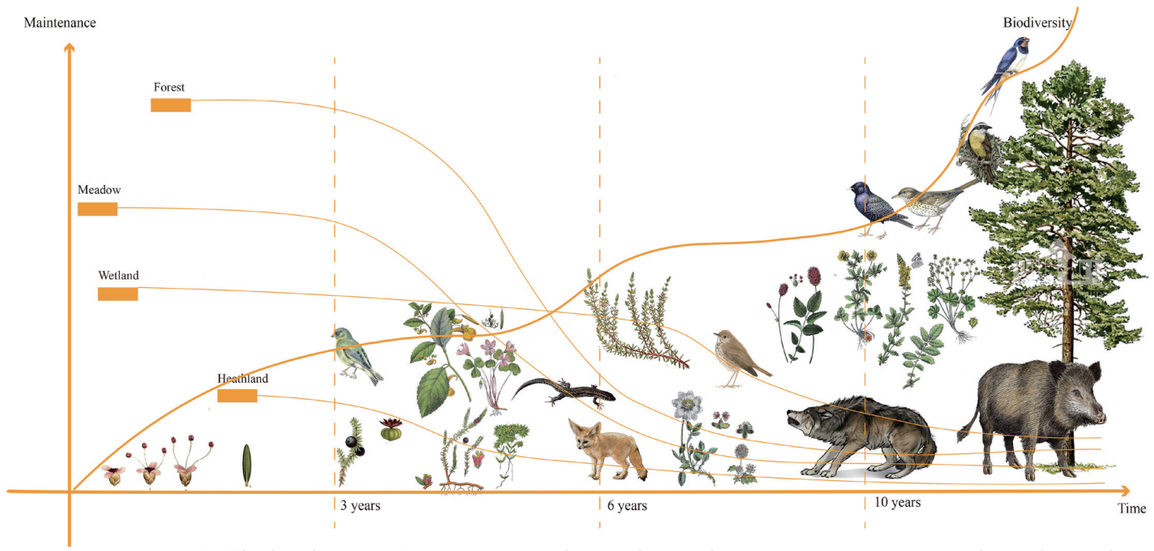
Trees are often the primary natural components that come to mind when envisioning railways, with around 1 million individual trees, representing over 70 distinct species, spread across railway territories. Moreover, the presence of over 1,600 varieties of plant species, some of which form unique associations within the railway context, enriches this traffic infrastructure.

Of the 600 avian species cataloged in the Netherlands, at least half have been sighted in and around railway environs, from pigeons setting up nests under bridges to red kites foraging along the exposed railway edges. Multiple categories of Dutch mammals, inclusive of insectivores, carnivores, and ungulates, have been sighted in close proximity to railway tracks. Burrowers like badgers, rabbits, hares, foxes, rodents, and moles commonly inhabit railway cuttings and embankments. Additionally, bats make extensive use of railway-associated edifices, including depot buildings, tunnels, bridges, retaining walls, and trees. The entire roster of 12 native Dutch amphibian and reptile species, including the endangered Sand Lizard, are known to inhabit railway lands. An estimated 7,500 invertebrates are present within the Netherlands, and though it remains uncertain how many make use of the diverse railway habitats, it's clear that these spaces serve as a refuge for a suite of species prioritized for conservation, including various rare and endangered species.

The administration of the railway holds responsibility for hundreds of legally protected regions, termed Sites of Special Scientific Interest (SSSI). These areas are earmarked to safeguard and augment our most vital examples of habitats, species, natural features, and characteristic environments, underlining the significance of the preservation of these rare species. So, we can say that the railway environment itself has definable natural character and supports a wide diversity of living things and valuable habitats, and that' s important in itself

How we design and manage the habitat that exists on the railway is central to unlocking multifunctional natural benefits for the operator and wider industry. Key to this is to cultivate an approach to railway land management that develops a montage of different ecological features, improving the structural diversity of lineside habitats so that they support a wider range of species and deliver multiple ecological services.

Moreover, in addition to ecological services, people can thus participate in the experience of the railway line, in the construction and protection of habitats, and cultural, ecological, sporting and social programmes can be designed into the linear space associated with the railway, making the railway line an integrated project in which transport infrastructure, green infrastructure, public activity space and ecological corridors are thriving together. Now it' s really the time to rethink and evaluate the ecosystem of railway corridor.



3-25 The biodiversity & maintenance change during the ecosystem succession , drawn by Author

Nationaal Park
Drents-Friese Wold

+

Nationaal Park
Dwingelderveld

+

Holtingerveld

Grand National Park

BUILT ENVIROMENT

Lettelberterpetten

Oude stuw
Strenrebos

GRONINGEN

PEIZE

De Onlanden

NORG

MEDIUM SENSITIVITY

De Zeven

Drentche
Hoofdvaart

Drents-Friese Wold
National Park

Holtingerveld

HIGH SENSITIVITY

BEILEN

MEPPEL

STAPHORST

MEDIUM SENSITIVITY

DE WIJK

Dwingelderveld
National Park

De Zwarte
Dennen

ZWOLLE

LOW SENSITIVITY

BUILT ENVIROMENT

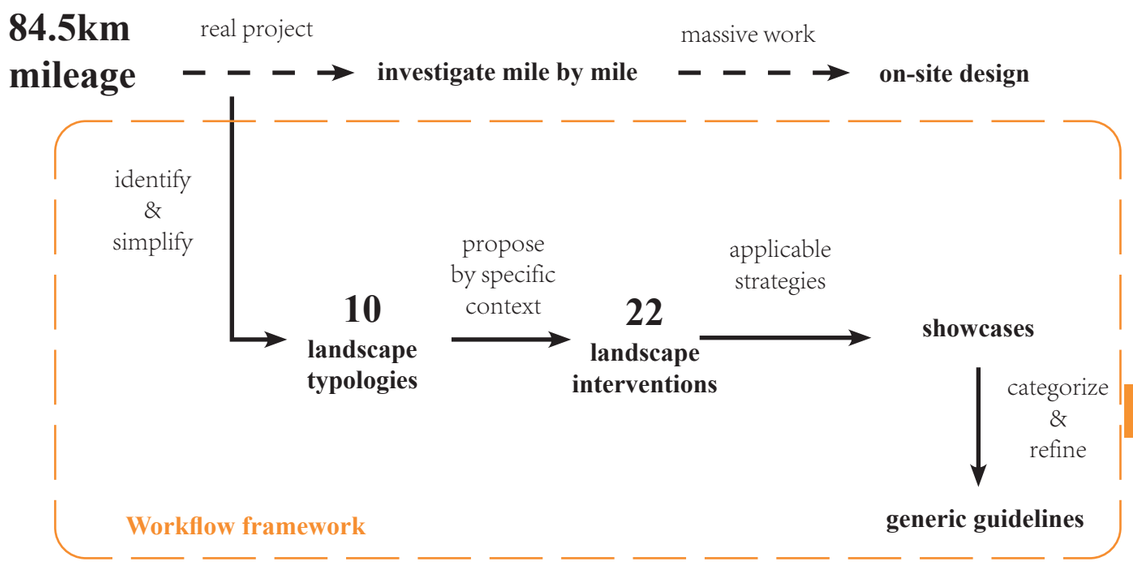
3-26 Conceptial vision for the high-speed railway between Zwolle and Groningen, drawn by Author

4. Design principals

4.1. Design challenges

This chapter is a **zoom in process** of the 84.5 km optimal alignment. However, it's almost impossible to investigate the land mile by mile, I first identified the landscape typologies along the optimal alignment, which means similar strategies could be applied to the same or related typologies.

Since there is no precedent case in the world for cases where landscape architects take the lead, synchronizing the design tasks of high-speed railway from planning to detailing. This chapter's landscape intervention s outcome can potentially have a generic meaning to this field worldwide as well.

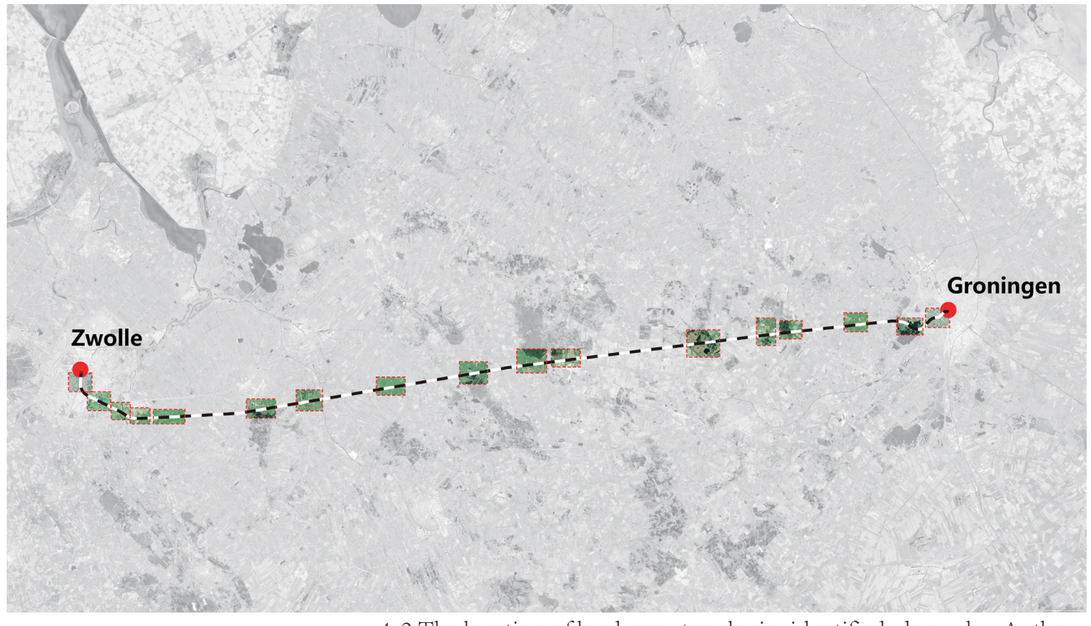


4-1 Conceptual workflow diagram of the chapter, drawn by Author

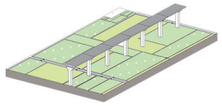
4.2 Landscape typology along the optimal alignment

Following the alignment research conducted in Chapter 3, it's crucial to comprehend the types of landscapes the optimal alignment traverses. This will provide a foundation for subsequent design work and will also offer valuable insights for other high-speed railway designs facing similar site conditions.

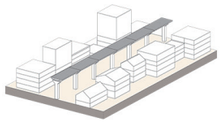
Different and unique landscape typologies are found alongside the optimal alignment. Leveraging GIS data and field trips observation, the landscapes along the 84.5km of the optimal alignment are identified and summarized, including six basic typologies, which are poder, forest, heathland, urban and rural context landscapes. At the same time, unique spatial phenomena often occur when the railway approaches other kinds of infrastructures. These have also been separately listed as landscape typologies. Those are existing railways, canals, highways, and wind farms.



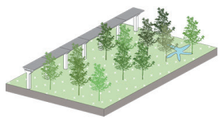
4-2 The location of landscape typologies identified, drawn by Author



Polder cultural landscape
- Nieuleusen
- Staphorst
- De Wijk
- Dwingeloo
- Norg

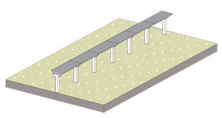


Urban context landscape
- Zwolle
- Groningen

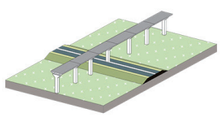


Forest natural landscape
- De Zwarte Dennen
- National Park Dwingelderveld
- Drents-Friese Wold National Park
- Hoogersmilde

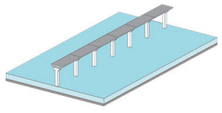
Onshore wind farm
- Hessenpoort



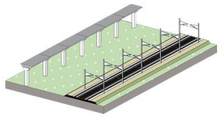
Heathland natural landscape
- Leggelderveld
- Esmeerwijk



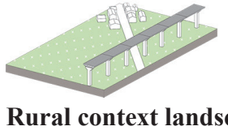
Existing road/highway
- N377
- A28
- N375
- N371
- N919
- N373
- N386



Lake natural landscape
- Achterste Plas
- Hoornsemeer



Existing railroad
- Zwolle - Staphorst east



Rural context landscape
- Geeuwenbrug
- Hoogersmilde
- Norg

Historical canal
- Drentse Hoofdvaart

4.3 UN Sustainable Development Goals (SDGs)

The 2030 Agenda for Sustainable Development, unanimously adopted by all United Nations Member States in 2015, presents a comprehensive framework for fostering peace and prosperity for both humanity and the planet, both presently and in the years to come. Central to this agenda are the SDGs, which serve as an urgent global call to action,

From the 17 total UN SDGs, there are nine that could be applied to high-speed railway and viaduct development: number 2 (zero hunger), number 3 (good health and well-being), number 7 (affordable and clean energy), number 8(decent and economic growth), number 9(industry, innovation and infrastructure), number 11 (sustainable cities and communities), number 13 (climate action), and number 15 (life on land).

On the right side, each icon is accompanied by a description highlighting the areas to which the goal pertains and can be implemented along the viaduct.

Zero hunger
- Greenhouses
- Community farming unit

Good health and well-being
- Sports facility
- Sunken garden
- Linar park
- Children playground

Clean water and sanitation
- Rain water collection and purification
- Resilient sponge for irrigation

Affordable and clean energy
- Energy consumption reduce
- Electric charging space
- 3rd generation wind farm co-development

Decent work and economic growth
- Create new job positions
- Stimulate urban/rural development
- Efficient daily commuting

Industry, innovation and infrastructure
- Prefabricated materials
- Automated high-speed railway girder erection machine

Sustainable cities and communities
- Public space in urban context
- Social space and events
- Inclusive living programme

Climate action
- Recyclable materials
- Less CO2 emission
- Flooding adaptive space

Life on land
- Ecological corridor
- Habitat for small animals
- Shelter for wildlife

4.4 Types of viaducts

Inspired by the types of rooftops categorized by the municipality of Rotterdam, the programme for multifunctional rootops (www.rotterdam.nl/english/multifunctional-roofs), the future sustainable high-speed railway viaduct design can be assessed by using similiar criterias.

Following on the right side, the type of viaducts are categorized in six groups based on its programmes and functionality. Red viaduct refers to the viaduct design with social and pubic functions. Blue viaduct and space below the viaduct have water related functions. Green viaduct provides extra space for greenery. Yellow viaduct takes the chanllenge of energy transition. Grey viaduct contributes to public services at the same time. Orange viaduct allows space for other means of transportation.

It's possible that a specific section of viaduct satisfy multiple category. The categorizations represent a theory based conclusion of the vision of sustainable high-speed railway viaduct design. This also intend to evoke further thinking and discussion on how to design and build innovative infrastructure implementation in a sustainable way, and what criterias it should meet so that can be called a sustainable infrastructure. This framework should be applicable in the generic field of high-speed railway viaduct design. The principles should be used are still under development and open to further ellaboration. Especially quantitative and explicit parameters on this topic shows a promising future to research.

Red viaduct
The space below viaduct has social and public functions, such as sports, recreation, and events holding.

Blue viaduct
The viaduct itself and space below have water related functions, such as rain water recycle and reuse.

Green viaduct
The space below the viaduct provides extra greenery, contribute to biodiversity and nature environment.

Yellow viaduct
The surrounding of the viaduct and viaduct itself produce or supply renewable energy.

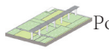
Grey viaduct
The viaduct co-develop with utility services and other installations.

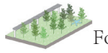
Orange viaduct
The viaduct develops in a mutifunctional way, allows space for other mobility.

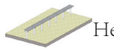
"Below the viaduct,
so much more possibilities unfolds,
exceeding we all think and have now."

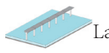
Legend

Landscape typologies


Polder landscape


Forest landscape

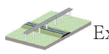

Heathland landscape

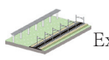

Lake landscape

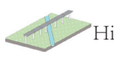

Rural context landscape


Urban context landscape


Wind farm landscape


Existing highway/road


Existing railroad


Historical canel

UN Sustainable Development Goals

2 Zero hunger

3 Good health and well-being

6 Clean water and sanitation

7 Affordable and clean energy

8 Decent work and economic growth

9 Industry, innovation and infrastructure

11 Sustainable cities and communities

13 Climate action

15 Life on land

Type of viaduct

Red viaduct

Blue viaduct

Green viaduct

Yellow viaduct

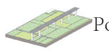
Grey viaduct

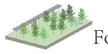
Orange viaduct

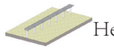
How to use this catalogue

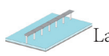
The catalogue consists of a collection of landscape interventions in relation with high-speed railway viaduct and its surroundings. Of course, the options are numerous. In this case each option is proposed based on specific context along the optimal alignment.

Each option is classified and weighted according to criterias introduced above: Landscape typologies, SDGs, Type of viaduct. One option can also be applicable in other lanscape typologies. The catalogue represent a subjective categorisation from my interpretion of the site. These examples are grounded into the contxt of the rich dutch cultural landscape from Zwolle to Groningen, which at the same time are notably relevant for similar landscape context.


Polder landscape


Forest landscape

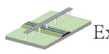

Heathland landscape

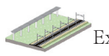

Lake landscape


Rural context landscape


Urban context landscape


Wind farm landscape


Existing highway/road


Existing railroad


Historical canel

2 Zero hunger

3 Good health and well-being

6 Clean water and sanitation

7 Affordable and clean energy

8 Decent work and economic growth

9 Industry, innovation and infrastructure

11 Sustainable cities and communities

13 Climate action

15 Life on land

Red viaduct

Blue viaduct

Green viaduct

Yellow viaduct

Grey viaduct

Orange viaduct

Cycling lane

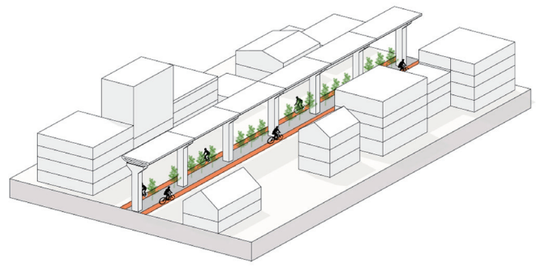
Location: Zwolle central, 1.2/84.5km

Cycling lane below the viaduct is not new, it's a pratical way to make the space below into good use. Also extra greenery will make the viaduct softer in urban texture. Additional function layer makes the viaduct more affiinitive.

Landscape typologies: 

SDGs: 3 6 9 11

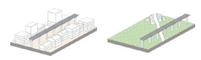
Type of viaduct: 



Eletric vehicle charging terminal

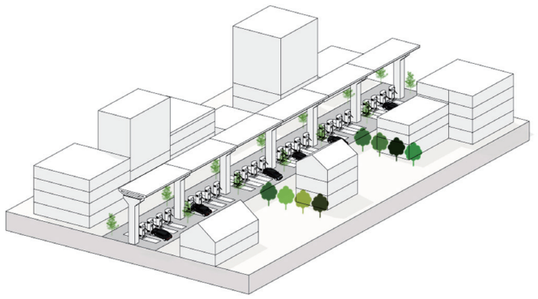
Location: Zwolle east, 3.8/84.5km

The 2040 vision of Zwolle has a statement of taking the chanllenge of energy transition and climate change. Electric vehicle is an important step, and linar space below the viaduct has a large potential for charging.

Landscape typologies: 

SDGs: 7 9 11 13

Type of viaduct: 



Skateboard park

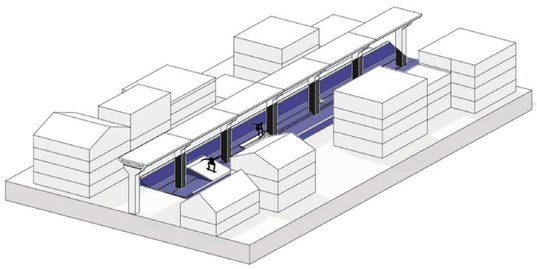
Location: Zwolle east, 6.3/84.5km

Zwolle east is an vibrant and long history community, skateboard park will stimulate the community's energy of youth

Landscape typologies: 

SDGs: 3 6 11

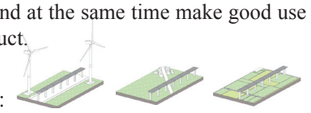
Type of viaduct: 



Greenhouse unit

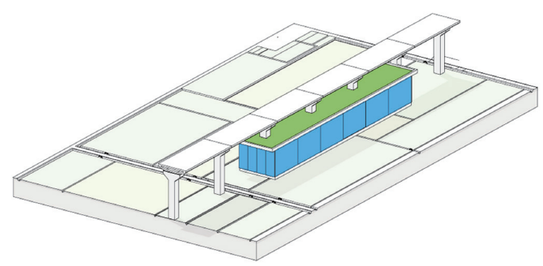
Location: Polder outside Nieuwleusen, 13.3/84.5km

The shade of viaduct has a side influence on the growing of grass. Greenhouse comes as a compensation solution for the production of the field, and at the same time make good use of the space below the viaduct.

Landscape typologies: 

SDGs: 2 6 8 11

Type of viaduct: 

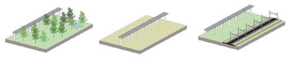


Ecological corridor

Location: Staphorst - Nieuwleusen, 14.1-18.3 /84.5km

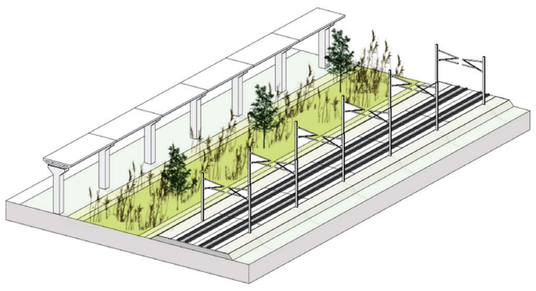
Here, the proposed railroad will go in parrellel with the existing road track, leaving a 80 meters width corridor for wildness, it will act as a soft barrier for the traffic iinfraastructure and diversify the local founa and flora.

Landscape typologies:



SDGs: 3 6 13 15

Type of viaduct:

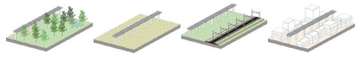


Outdoor swimming pool

Location: Staphorst - Nieuwleusen, 15.1/84.5km

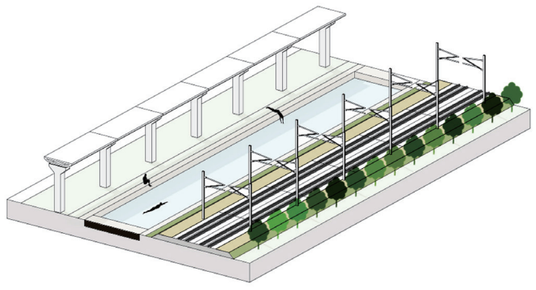
Close to De Meele and Nieuwleusen, ouutdoor swimming pool is an experimental programme to provide space for sports and recreation, In winter, it will turn into a skating playground.

Landscape typologies:



SDGs: 3 6 11 13

Type of viaduct:

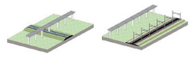


Traffic control room

Location: intersection with N377, 20.1/84.5km

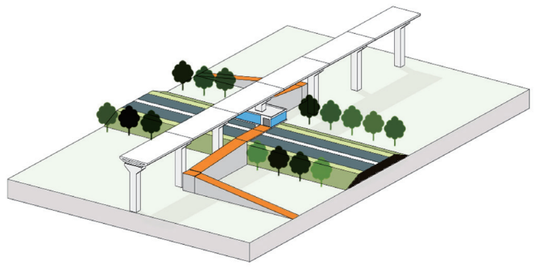
An on-site traffic control room is neccessary and emergency avoidance space is on demand. It can also be a restroom for regular mantainance workers.

Landscape typologies:



SDGs: 8 9

Type of viaduct:

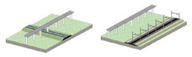


Viewing platform

Location: intersection with A28, 26.1/84.5km

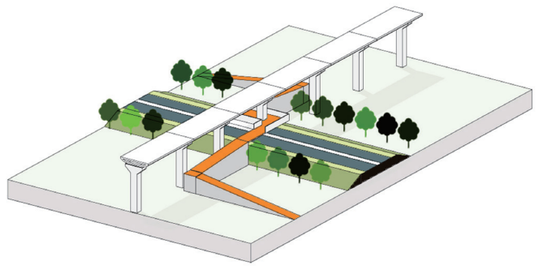
The intersection of the viaduct and A28 highway is going to showcase the harmony of contemporary traffic infrastructure landscape. It's going to be an inspiring moment for all the people being here tourists, car drivers, and train passengers.

Landscape typologies:



SDGs: 3 9 11

Type of viaduct:

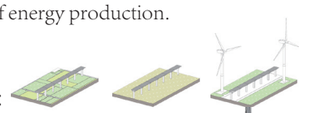


Energy research center

Location: Staphorst - Nieuwleusen, 17.0/84.5km

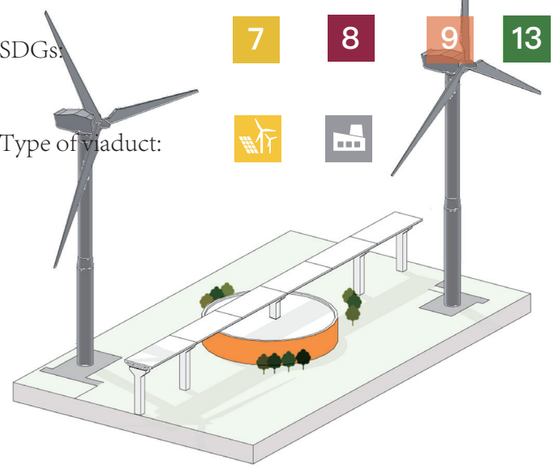
Renewable energy industry requires consistent investiment, wind farm is already built in this area, a research lab can monitor and promotes the eifficiency of energy production.

Landscape typologies:



SDGs: 7 8 9 13

Type of viaduct:

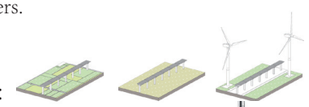


Warehouse & restroom

Location: Staphorst - Nieuwleusen, 17.8/84.5km

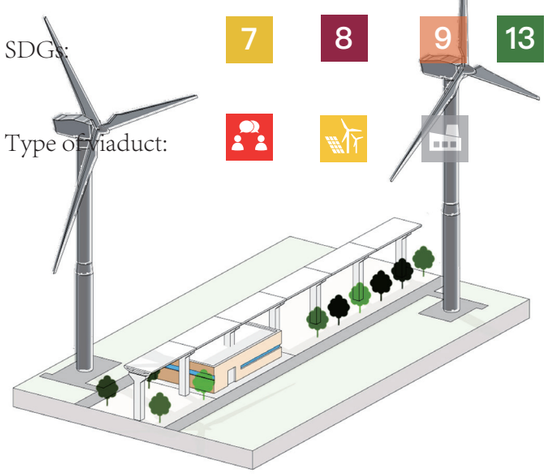
Energy infrastructure need maintenance and regular check, staff restroom can be embedded below the viaduct, offering better weelfare to outdoor workers.

Landscape typologies:



SDGs: 7 8 9 13

Type of viaduct:



Wildlife shelter & corridor

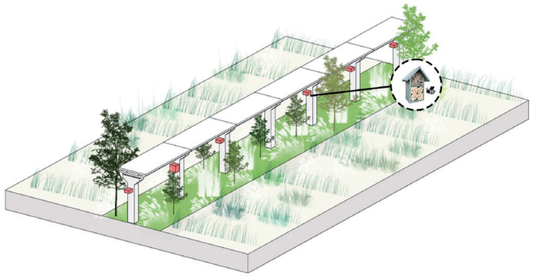
Location: Dwingelderveld - Drents-Friese Wold, 42.5-52.7/84.5km

Instead of fragement two national park, the viaduct will turn the in between space into a corridor and bring two national parks both spatially and ecologically. It will play an important role as shelter for small mammals, insects ands ome rare specics of plants.

Landscape typologies:

SDGs: 3 6 13 15

Type of viaduct:

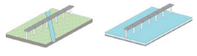


Switchable bridge

Location: intersection with Drentse Hoofdvaart, 49.7/84.5km

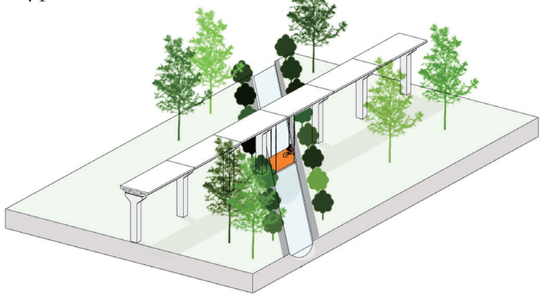
When the viaduct travel across the Drentse Hoofdvaart, a bridge for pedestrian below the viaduct will be a romantic dialogue engineering project for the two infrastructure.

Landscape typologies:



SDGs: 9 11

Type of viaduct:



Suburban bootcamp

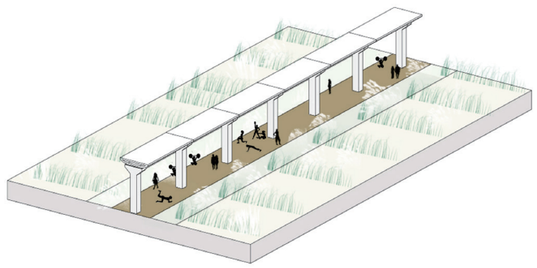
Location: Leggelderveld, 50.4/84.5km

Leggeldveld is close to two national park, but with different landscape type. It can connect better to the nearby villages by the high-speed railway, providing a new destination for daily recreational and sports activities.

Landscape typologies:

SDGs: 3 11

Type of viaduct:



Watching tower

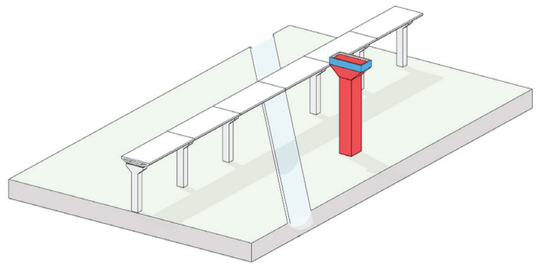
Location: intersection with Drentse Hoofdvaart, 49.7/84.5km

A iconic landmark is proposed at the crossing point of the viaduct and Drentse Hoofdvaart, which is the most important infrastructure for Drentse in history. It will be a drama point of the collision of contemporary and history.

Landscape typologies:

SDGs: 3 11

Type of viaduct:



Lake wind farm

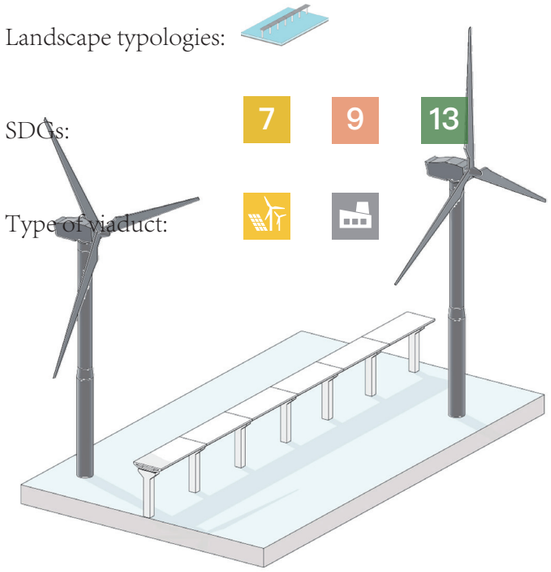
Location: Groningen Hoornsemeer, 78.2/84.5km

The water surface of Hoornsemeer still remains a possibility for renewable energy production, it's possible to co-develop wind farm here along with the viaduct. The energy it produces can be serve to the residential area nearby as a long term compensation.

Landscape typologies:

SDGs: 7 9 13

Type of viaduct:



Slow traffic bridge

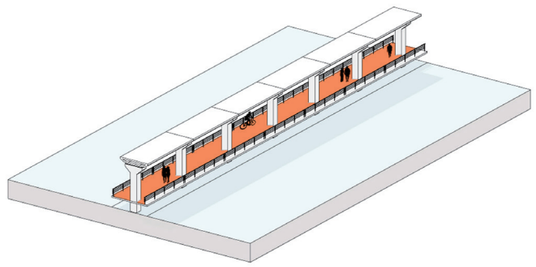
Location: Groningen Hoornsemeer, 78.2/84.5km

There is not yet a bridge to cross the Hoornsemeer lake from the west side to the east side. A double deck bridge is a good way to make this section extraordinary, the second deck is for slow traffic, which means walking and cycling

Landscape typologies:

SDGs: 3 9 11

Type of viaduct:



Forest buffer

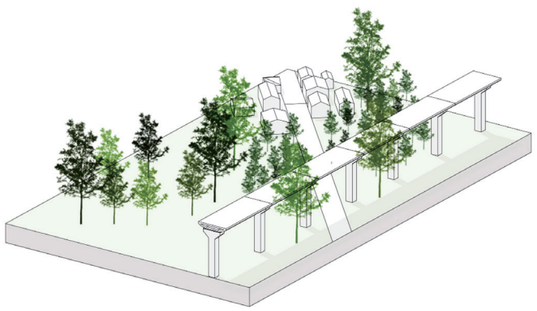
Location: Norg, 65.9/84.5km

The high-speed railway route is offseted 500m from the original route in respect of the cultural landscape at Norg, forest buffer zone will grow here to mitigate the noise from the viaduct and provide recreational space for the local.

Landscape typologies:

SDGs: 3 11 13 15

Type of viaduct:



Mutifunctional slope

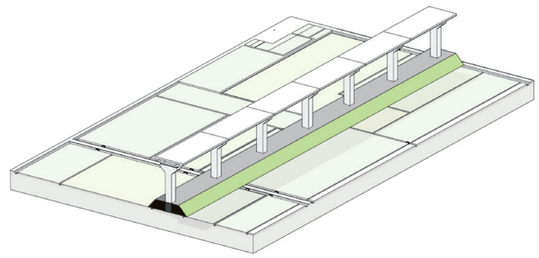
Location: Norg, 66.4/84.5km

The grass slope function as a dike if there is flood to come, while simultaneously enabling other uses. Slope can have roads on top, cables and/or pipelines running through them, or structures on them or are part of a historic landscape.

Landscape typologies:

SDGs: 6 9 11

Type of viaduct:



Lake solar farm

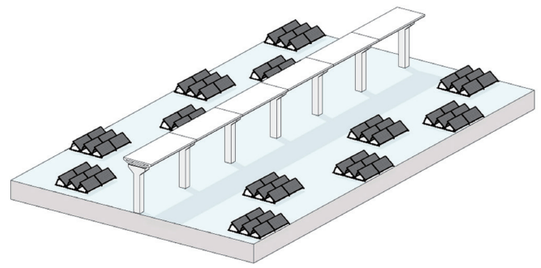
Location: Groningen Hoornsemeer, 79.5/84.5km

Similarly, ro the wind farm option, solar farm is also possible on the water surface.

Landscape typologies:

SDGs: 7 9 13

Type of viaduct:



Linar park

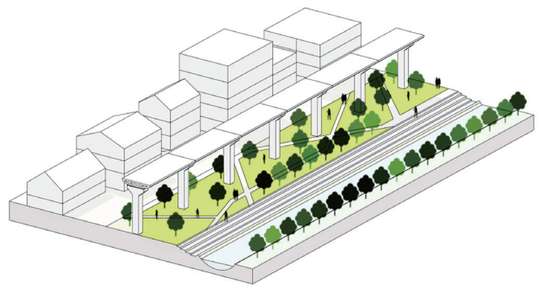
Location: Groningen canal, 80.7/84.5km

The high-speed railway viaduct will travel through the space between highway and canel in Groningen. This provides an unique chance to turn the in-between unused space into a linar park, which will have a profound impact to the whole city.

Landscape typologies:

SDGs: 3 6 11 15

Type of viaduct:

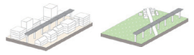


Sunken garden

Location: Groningen Julianplein, 83.2/84.5km

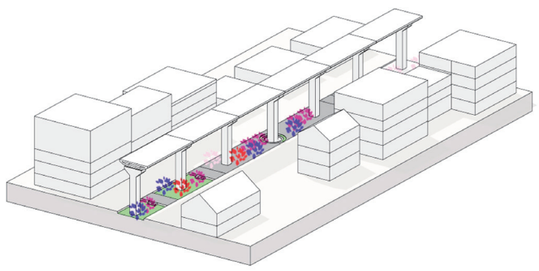
Julianplein is the most busy and problematic intersection in Groningen, public and recreational space is very limited. Sunken garden below the viaduct will provide a connection space for the community around.

Landscape typologies:



SDGs:

Type of viaduct:



Noise insulation tube

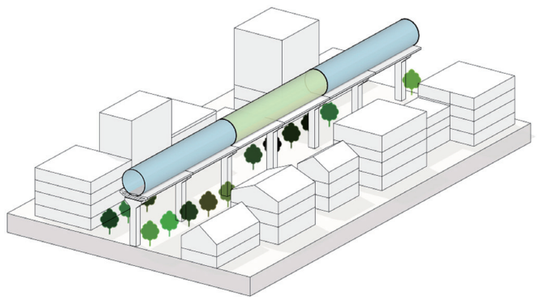
Location: Groningen central, 84.0/84.5km

The train is approaching the end station Groningen Centraal, which locates at the most high density residitial area of the city. In this case, noise insulation tube is suggested to reduce the side effect.

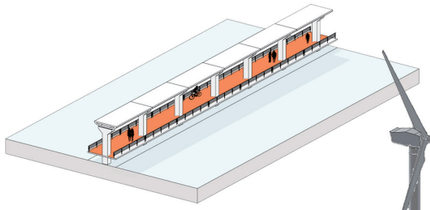
Landscape typologies:

SDGs:

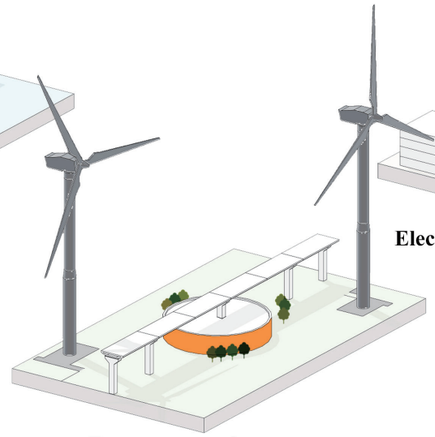
Type of viaduct:



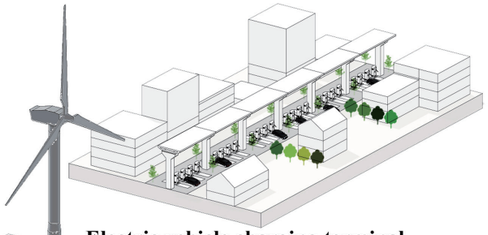
Landscape interventions catalogue



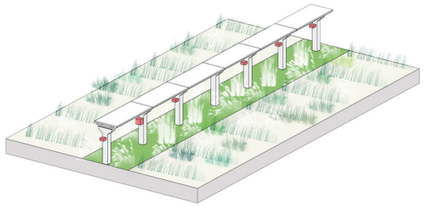
Slow traffic bridge



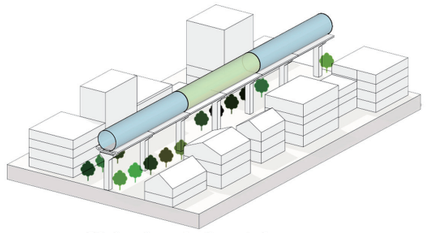
Energy research center



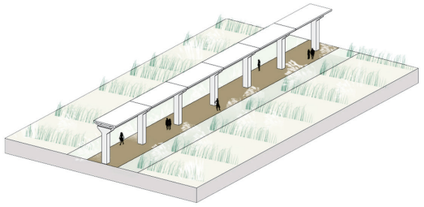
Electric vehicle charging terminal



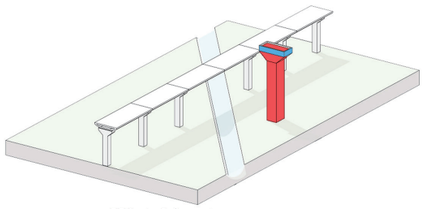
Wildlife shelter



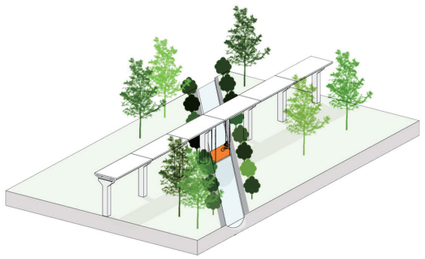
Noise insulation tube



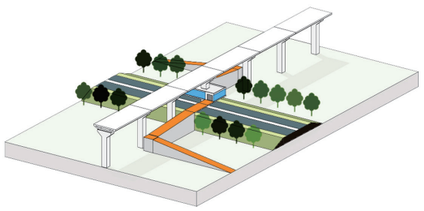
Suburban bootcamp



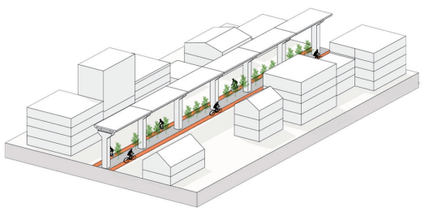
Watching tower



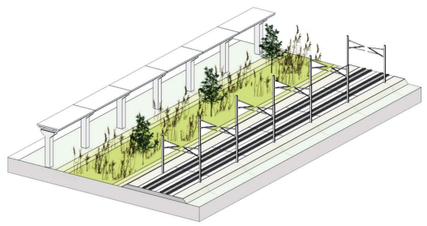
Switchable bridge



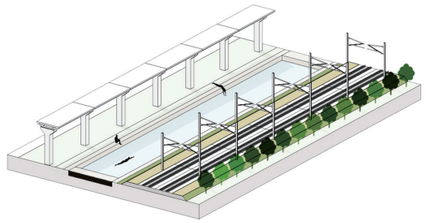
Traffic control room



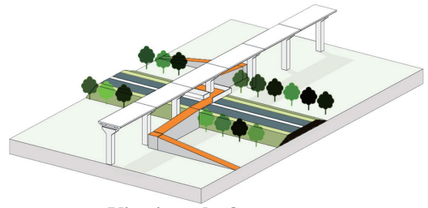
Cycling lane



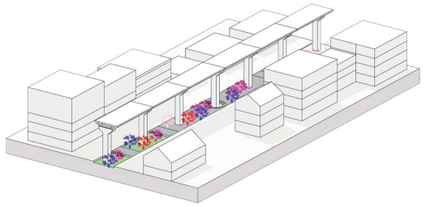
Ecological corridor



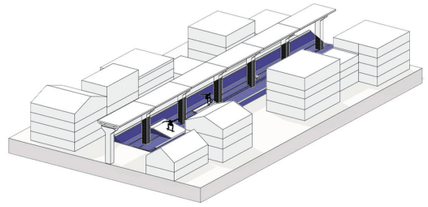
Skating & swimming pool



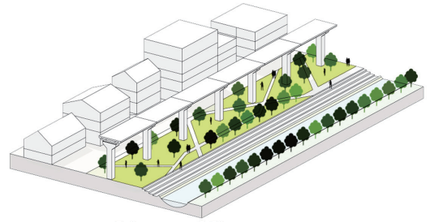
Viewing platform



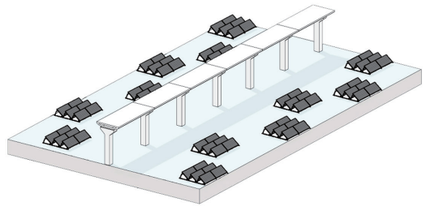
Sunken garden



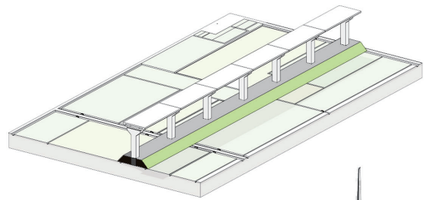
Skatboading park



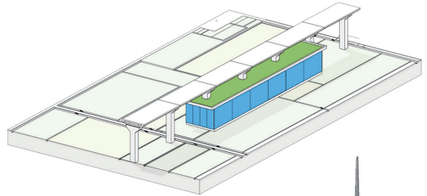
Linar public space



Lake solar farm

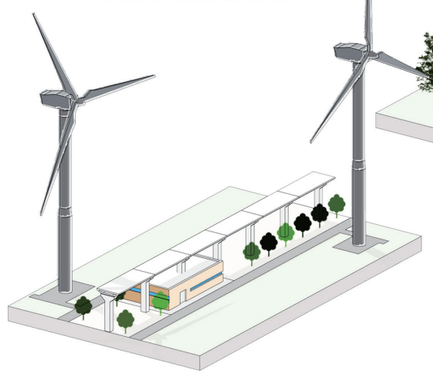


Mutifunctional dike

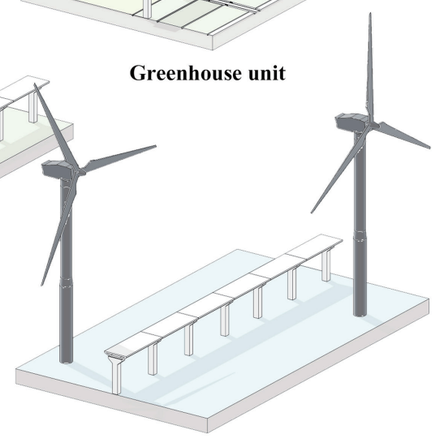


Greenhouse unit

Forest buffer

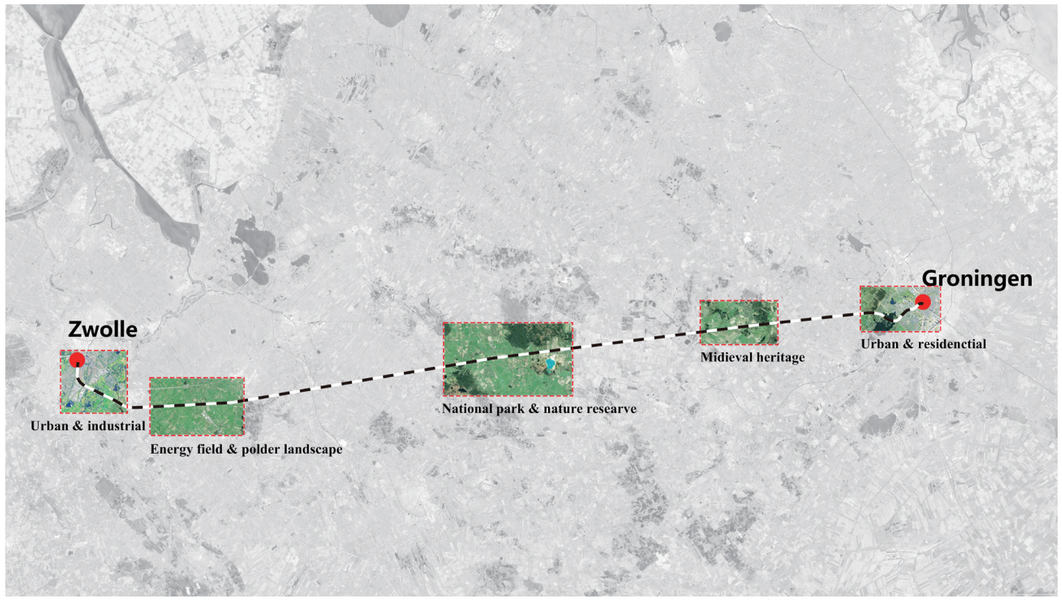


Warehouse & restroom



Lake wind farm

5. The journey



5-1 The location of five detailed design, drawn by Author

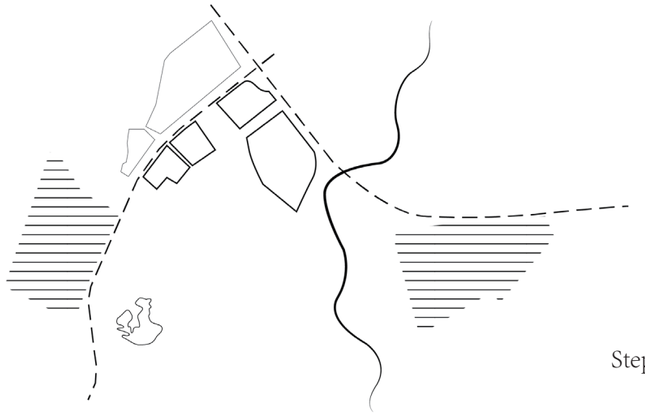
5.1. Zwolle - No more fragmentation

The decision has been made to retain the existing railway tracks. The necessity for high-speed trains to decelerate when approaching stations removes the need for additional power transmission or specialized routes. Consequently, the trains can run on the existing tracks within the city, precluding the fragmentation that new railways would introduce.

Simultaneously, an envisioned green plan is proposed for the northern part of Zwolle. The park east of the railway is set to be expanded into an inclusive sports park. To the west, a new park - projected to be Zwolle's largest - is to be developed, thereby accommodating the city's expansion and providing leisure spaces for its residents. Upon crossing the Vechte River, the train will rise onto an elevated track and speed directly towards Nieuwleusen. The banks of the Vechte River will metamorphose into a resilient wetland park, incorporating into the Zwolle green belt. These three interconnected green spaces will harmonize and unify, creating a connection between the city and the countryside and extending their influence across the region.

5-2 The options for entering Zwolle, drawn by Author

The context of the site, existing railroad on surface, high voltage line, solar farm, highway casued fragementation to the landscape, photo by Author

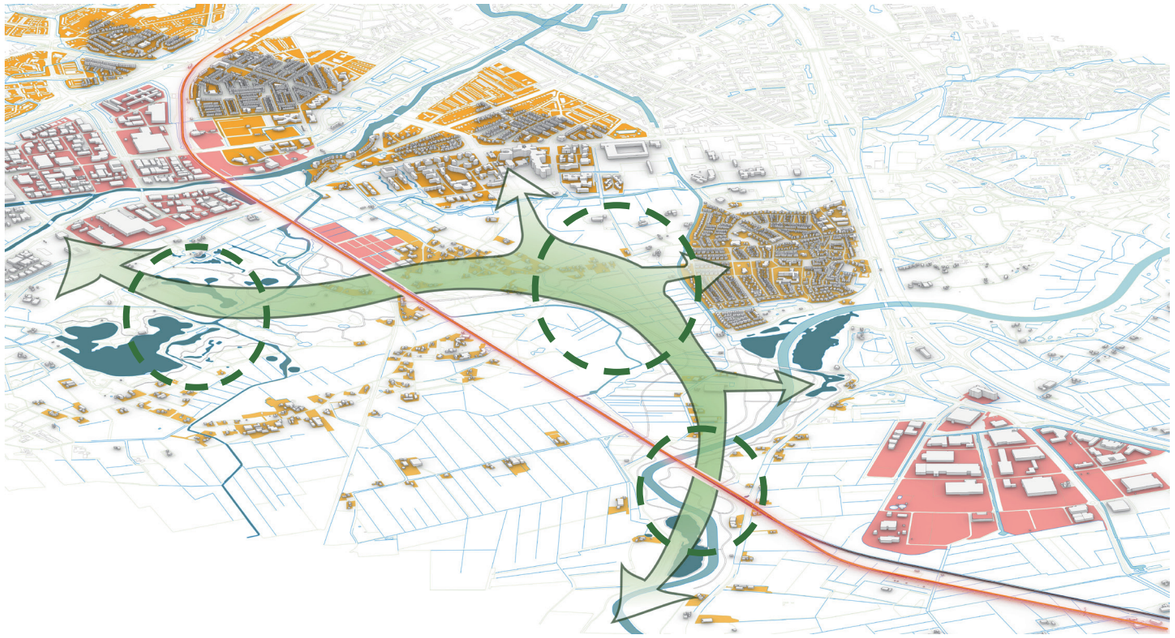


Step 1 Indentify the fragemence

Step 2 High-speed railway & green system co-development

Step 3 Merge

5-2 The formation process of design Zwolle, drawn by Author



Three interconnected green open spaces will harmonize and unify, creating a connection between the city and the countryside.

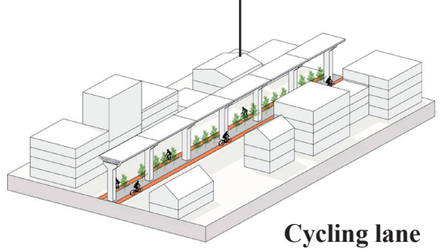
1. Veldhoek
2. suburban sports park
3. golfclub
4. lakeside cablepark
5. Park Zwolle
6. riverfront wetland
7. Hessenpoort industrial area
8. in-between eco corridor

N

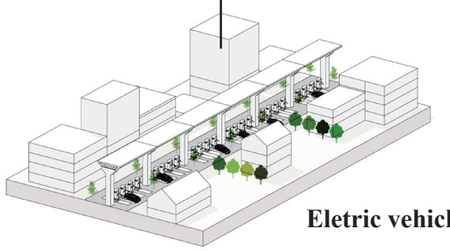
0 200
100 600 m

2

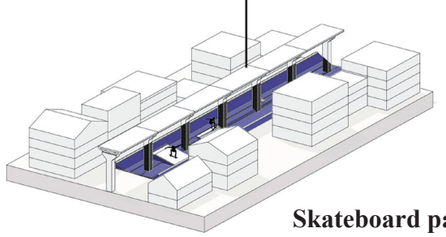
2



Cycling lane



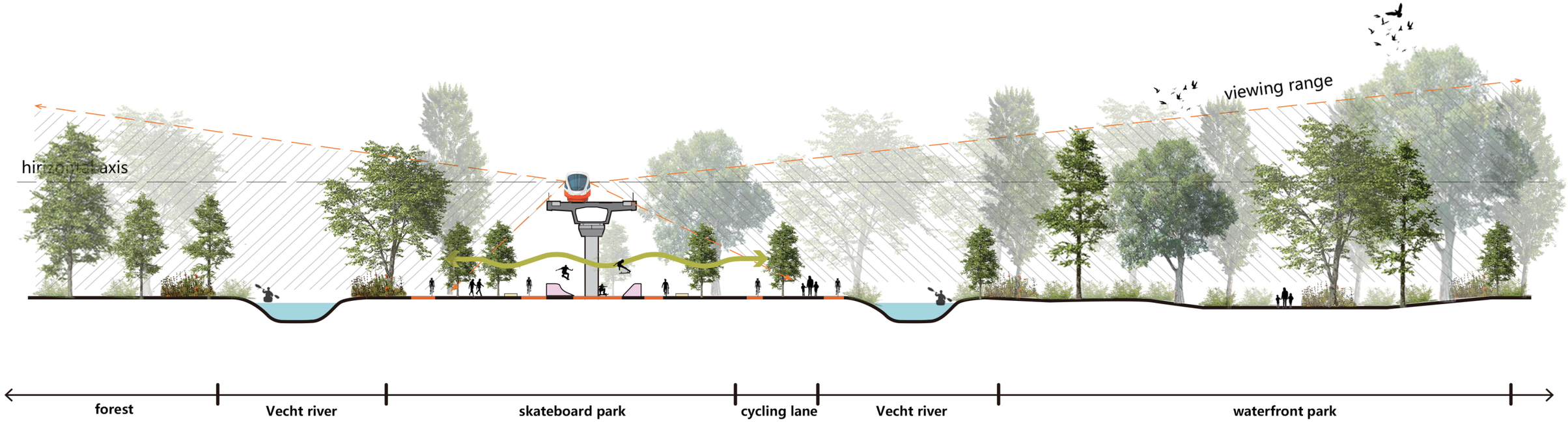
Eletric vehicle charging terminal



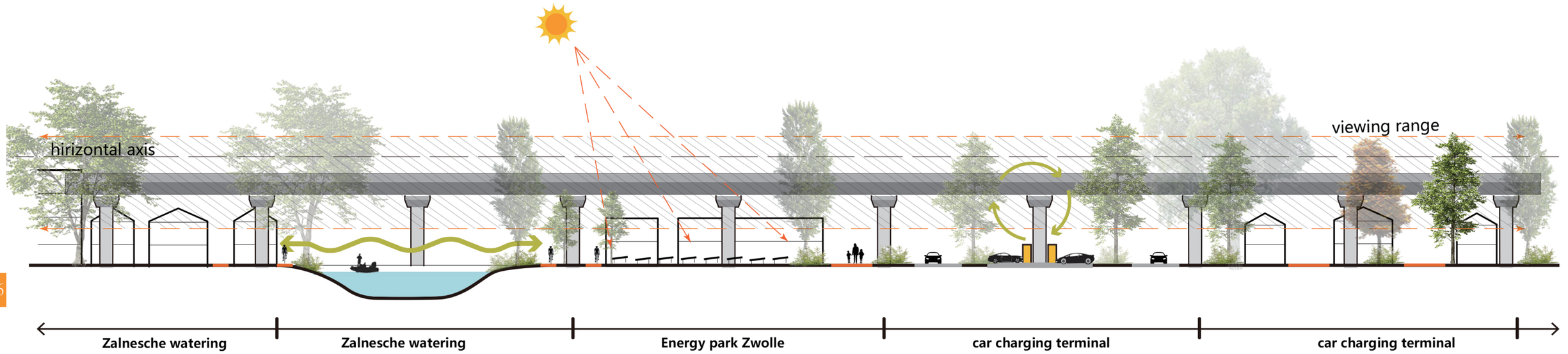
Skateboard park

5-2 Master plan of Zwolle, drawn by Author

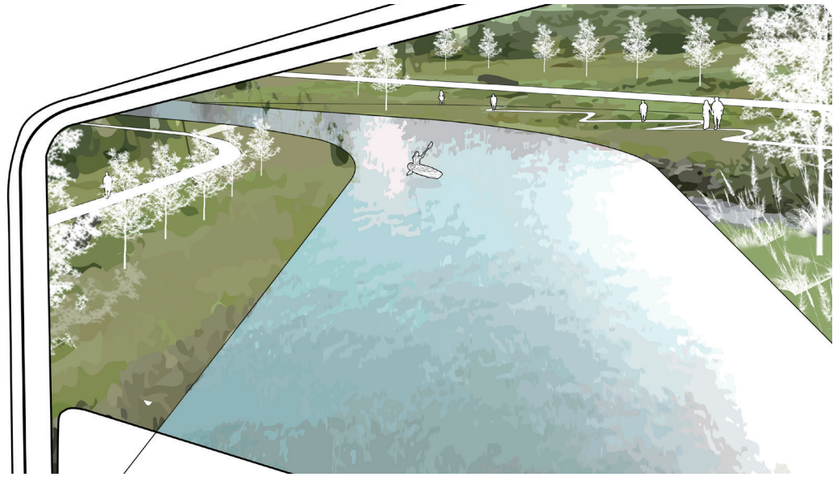
5-3 Birdeye view, high-speed railway brings the regional fragmented landscape into a coherent system, drawn by Author

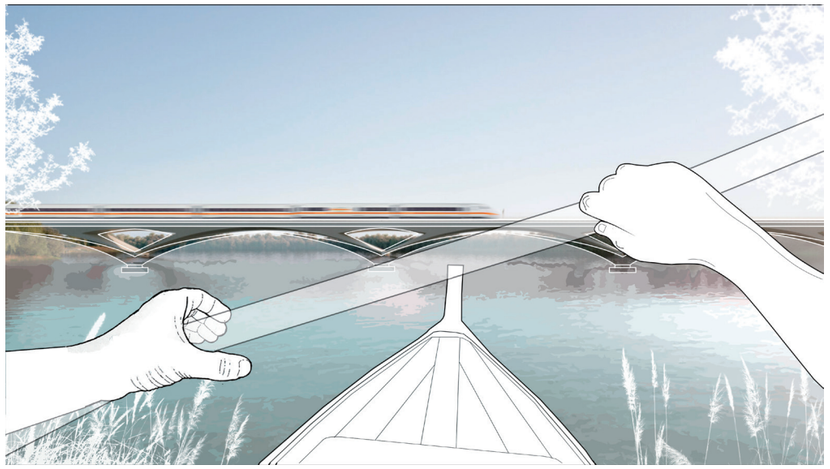


5-4 Section 1-1 skateboard park below the viadduct and revitalized wateerfront, drawn by Author



5-5 Section 2-2, Zwolle urban context energy related transformation, drawn by Author





5-6 Passengers on high-speed train and boater on Vecht river in dialogue
drawn by Author

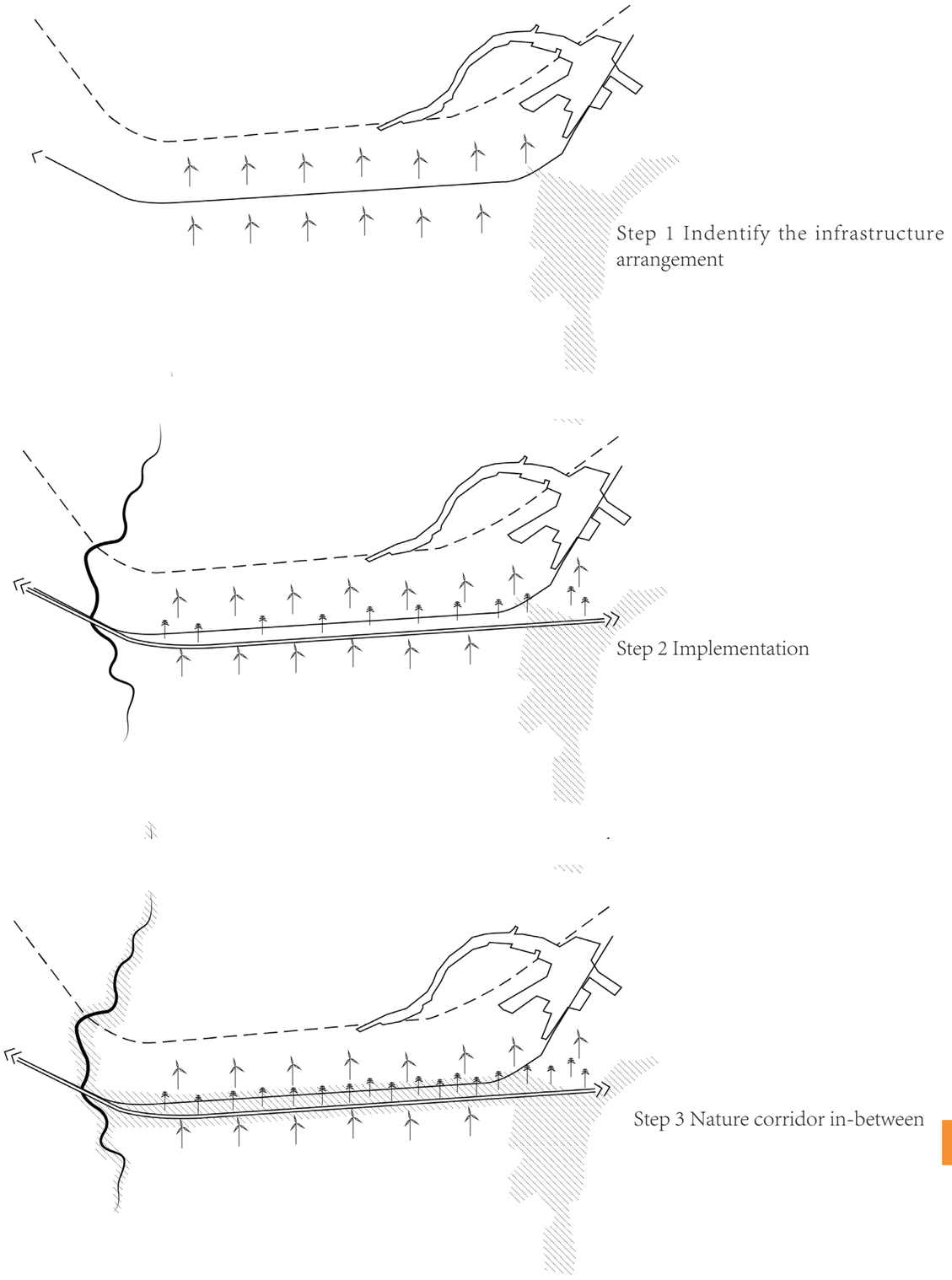
5.2. Nieuleusen - harmony of traffic and energy infrastructure

Nieuleusen is a town in the Dutch province of Overijssel. To the north is the Staatsbos state woodland in the municipality of Staphorst. To the west, provincial road N377 and existing railway from Zwolle to Mepel meet there, and wind farm is located at the southwest border of Nieuleusen. The high-speed railway will go through its territory and cross the provincial road N377.

At the same time, the existence of the existing railway line is the most important factor affecting the selection of the viaduct line in this area, because of speeding up of the high-speed train, it has more strict requirements on the railway structure, power supply and signal system. So when the train speed exceeds 150km /h, using a separate railway track is a safer and more economical option than upgrading the existing track. The railway viaduct is designed to be as close as possible to the existing railway to avoid extra fragmentation to the surrounding polders, which is been tested 130 meters away from the existing railway and maintaining a parallel extension with the existing railway is the most appropriate option here.

The middle of the two railway tracks space will be transformed into an ecological corridor and spread to the north, and the wind turbines arrayed in grid on both sides are the unique landmarks of the site. The beauty of the infrastructure order and the beauty of the wilderness are in harmony. which form an elegant poetry of the advanced engineering technology and nature blooms.

5-7 Location and main element on the site, drawn by Author



5-8 The formation process of design Nieulesen, drawn by Author

1. wind turbines
2. existing railway
3. in-between eco corridor
4. canel to Zwartsluis
5. industrial area
6. high-speed railway
7. De Zwarte Dennen national park
8. Hondenspeelbos Punthorst dogs park

N

0 100 200 600 m

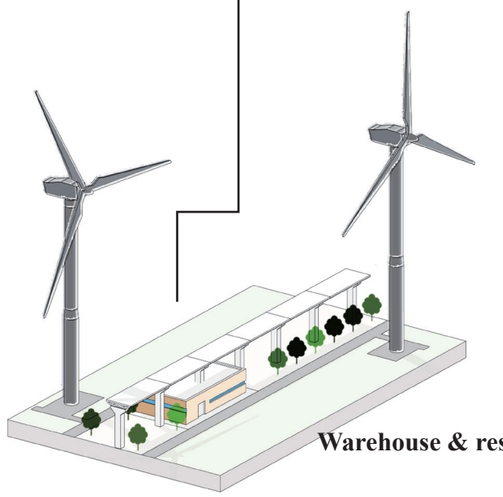
Zwartsluis

1

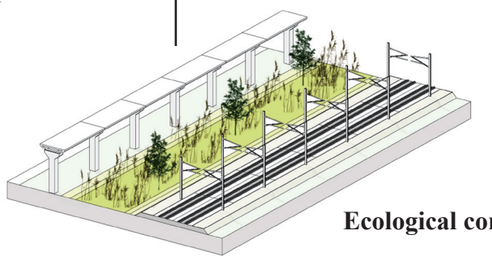
1

2

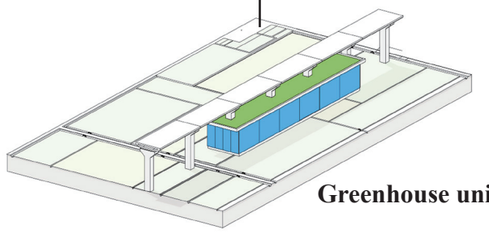
2



Warehouse & restroom

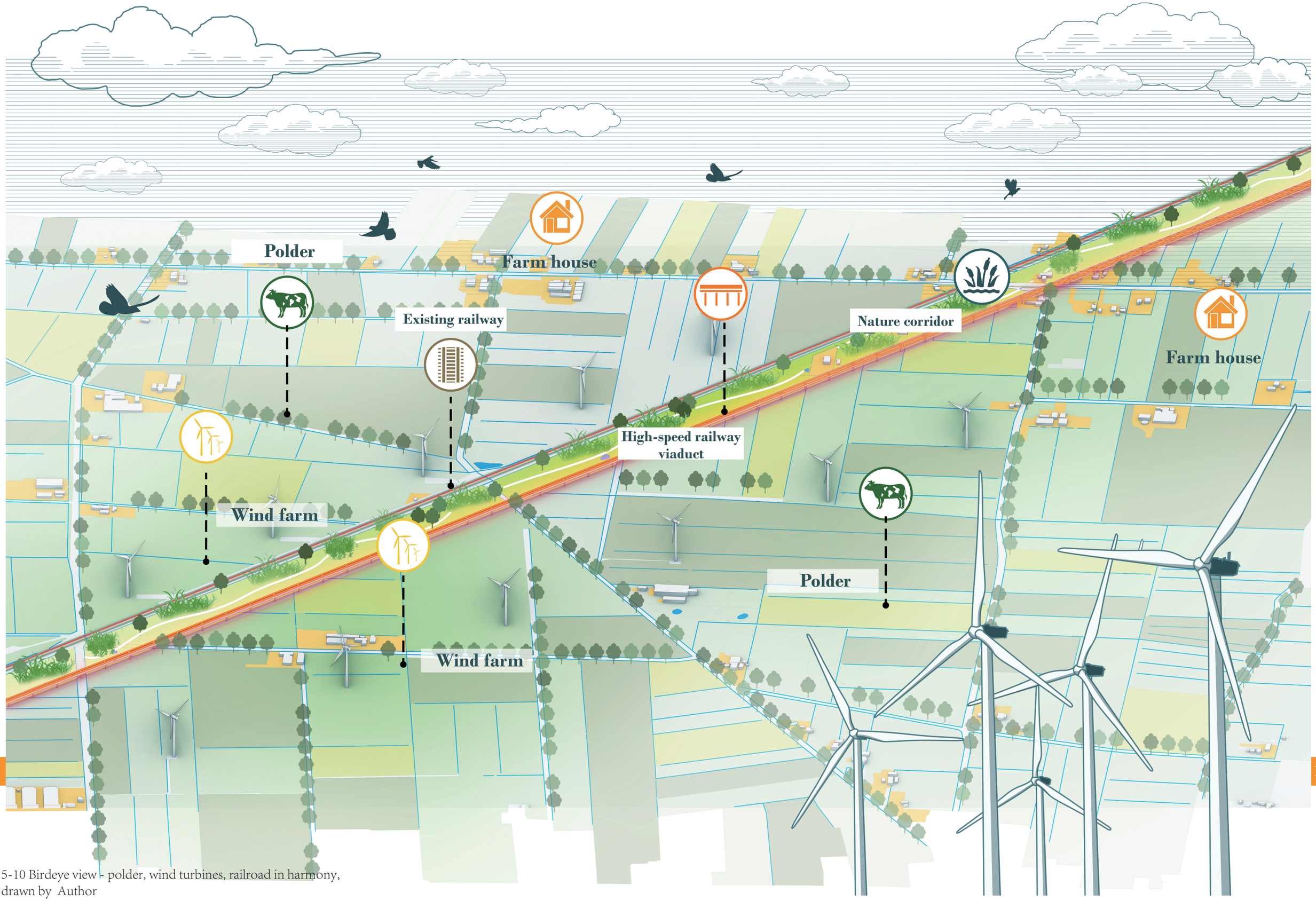


Ecological corridor

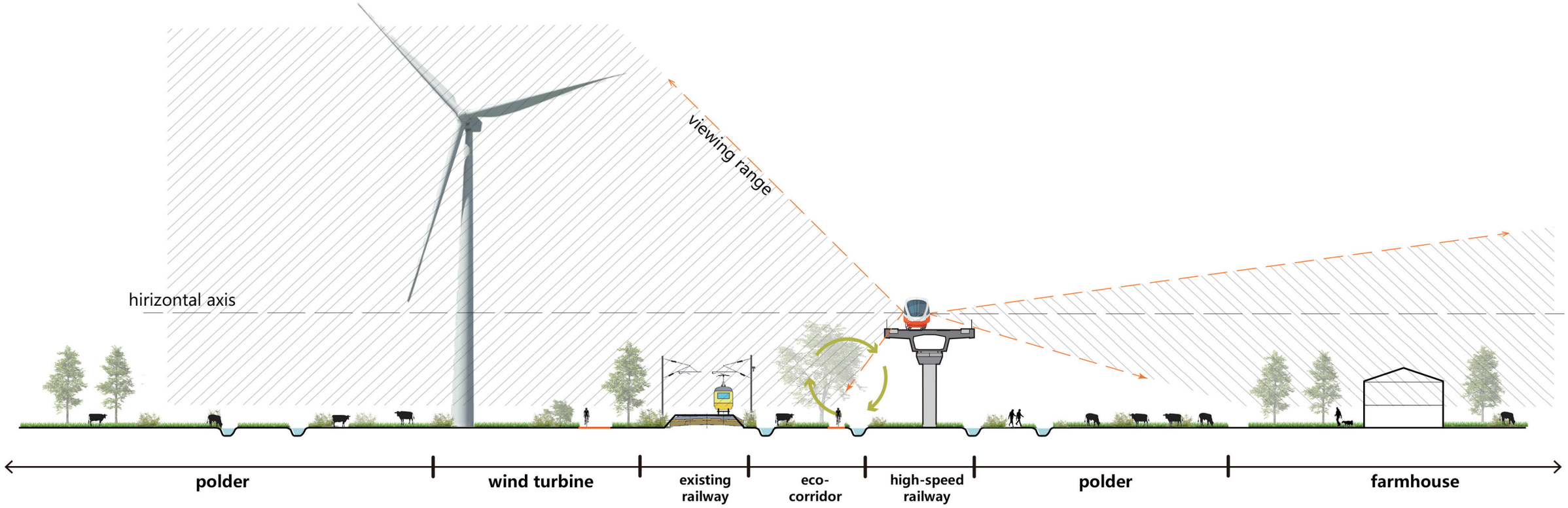


Greenhouse unit

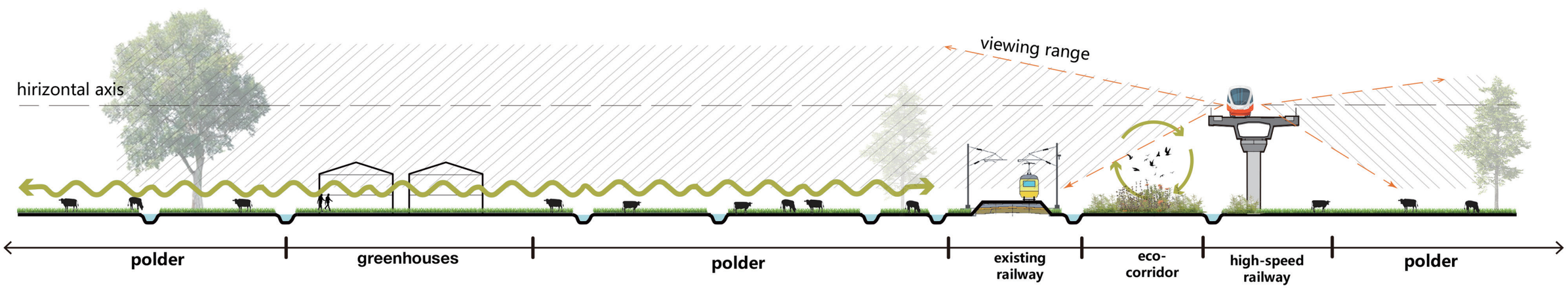
5-9 Master plan of Nieulesen, drawn by Author



5-10 Birdeye view - polder, wind turbines, railroad in harmony, drawn by Author



5-11 Secction 1-1, wind turbine and high-speed railway in contrast, drawn by Author



5-12 Secction 2-2, eco-corridor thrive in between the existing railway and high-speed railway viaduct, drawn by Author

Pespective, viaduct in harmony with wind farm and polder,
drawn by Author

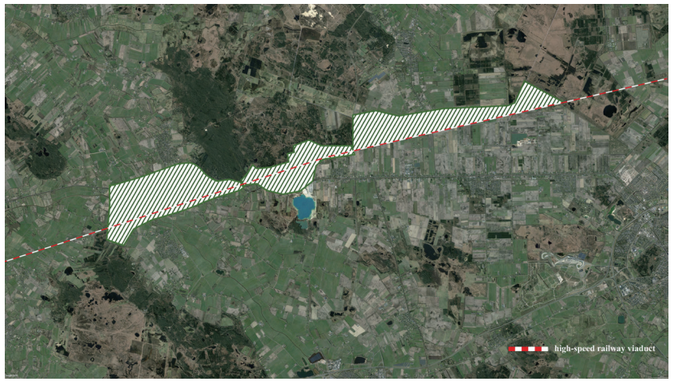
Pespective, nature corridor thrive in between viaduct and existing railway track,
drawn by Author

5.3. Grand national park

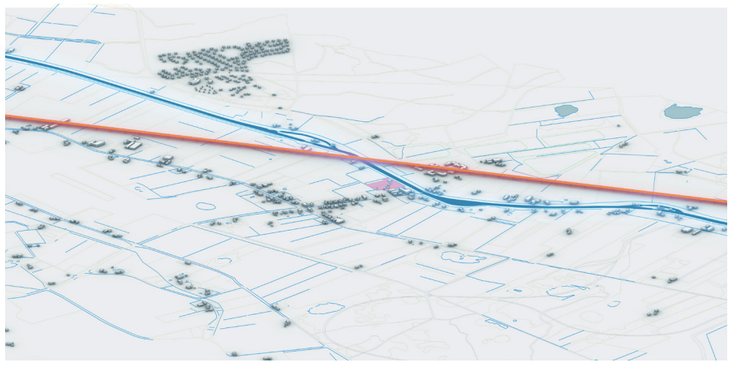
Afforestation will take place to connect the two national parks. The forest will continue to grow and be built in several phases in 50 years since the construction of the high-speed railway construction started, and will eventually be integrated into the two national parks (Drents-Friese Wold and Dwingelderveld in terms of both ecological continuity and spatial connection. At the same time, this forest will also play the role of noise barrier and buffer zone for the villages alongside the railway. The pink area in the master plan are the trigger area to activate its surroundings. For example, in the area between two villages (Dieverbrug and Dwingeloo), I reserved open public space for daily recreation and sports, meanwhile a bicycle lane alongside the main road which connect the two villages will come as a co-development. Because in the foreseeable future, both villages will continue to grow, which means that better recreational facilities are also needed.

Another point is the intersection of the Drenthe Grand Canal (Drentsche Hoofdvaart) and the high-speed railway viaduct, which will be a dramatic collision point between contemporary and history, and the viaduct approach will ensure that it will not ruin the cultural landscape and historical value of the Drenthe Grand Canal. This will very likely to be a highlight of the 20 mins high-speed journey. The foreground outside the train window will be this historical canal. One side of the background view will be the forest landscape of Drents-Friese Wold, and the other side will be the heathland landscape, blue lake and the traditional polder landscape. And the two pink areas close to the nature reservation will be camping and hiking base and the resort of the blue lake respectively.

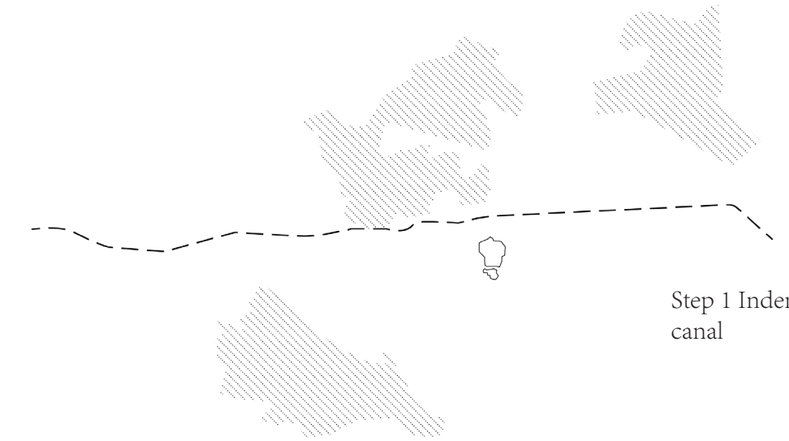
Overall, this whole region will get not only better accessibility and ecological sustainability, but also better landscape experience and living environment because of railway development. It will be an utimate destination for locals' daily recreation, tourists' yearly hiking, for camping in the summers , skating in the winters, It's the paradise habitat for wildlife, and spiritual homeland for people.



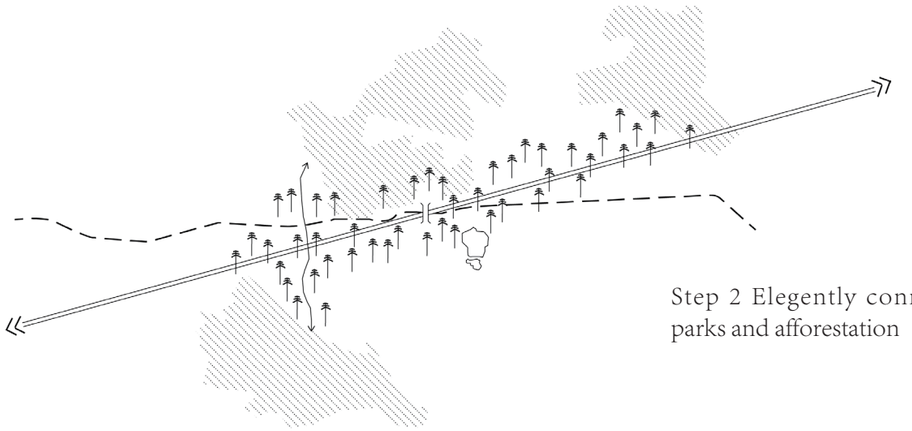
5-13 Ideal implementation, connecting the national parks from the farmland in between, instead of fragement them drawn by Author



5-14 The dramatic moment, contemporary infrastructure encounters the historical infrastructure Drentche Hoofdvaart (Drenthe Grand Canal) , drawn by Author



Step 1 Indentify the national parks and canal



Step 2 Elegently connect national parks and afforestation

Step 3 Ecological and spatials measures to make the national parks merge

5-15 The formation process of Grand national park, drawn by Author

1. private villa
2. nursery
3. mystery forest
4. viaduct sports park
5. cycling route
6. suburban orchard
7. agro-forest
8. camping base
9. Drenthe canel viewing point
10. tourist center / museum
11. open grassland
12. pond & garden
13. heathland pavilion & cafe
14. heathland
15. wetland
16. Achterste Plas lake
17. swimming beach
18. factory renovation resort

N

0 200 100 600 m

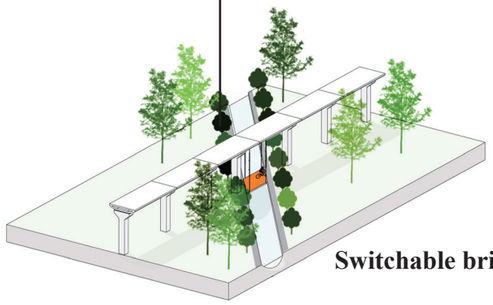
1

1

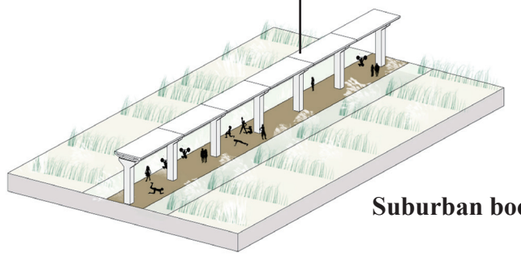
2

2

Wildlife shelter & corridor

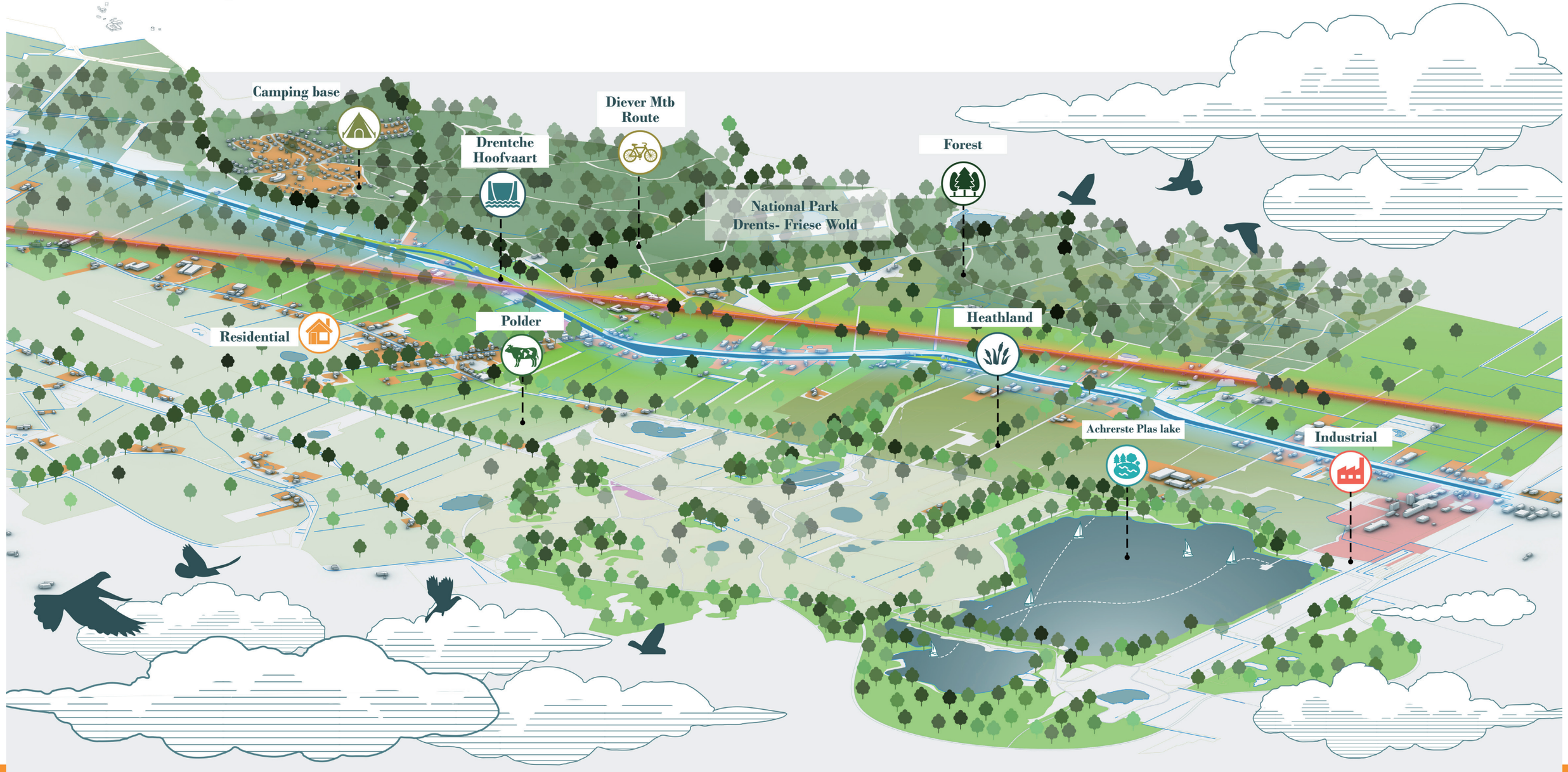


Switchable bridge

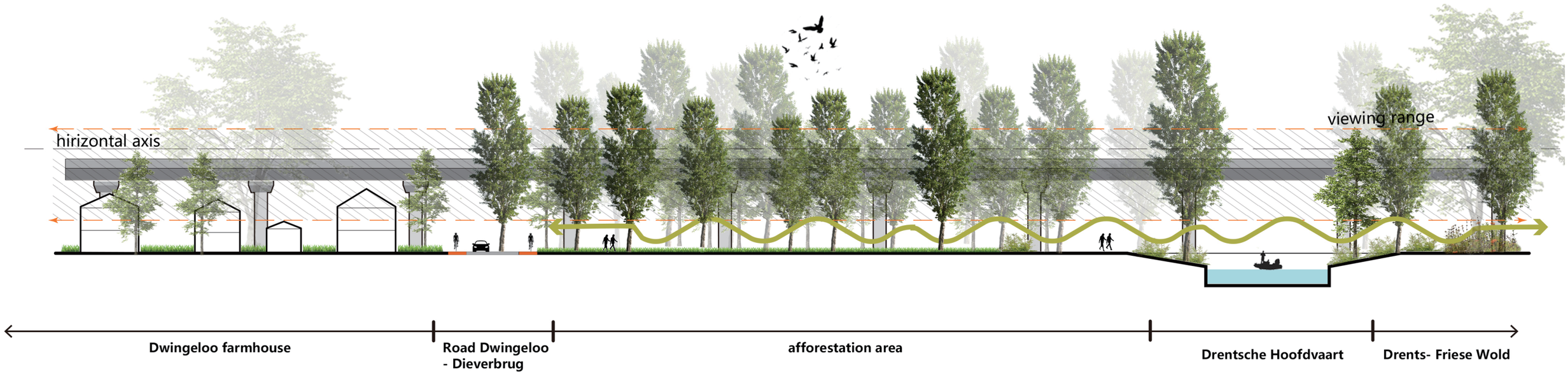


Suburban bootcamp

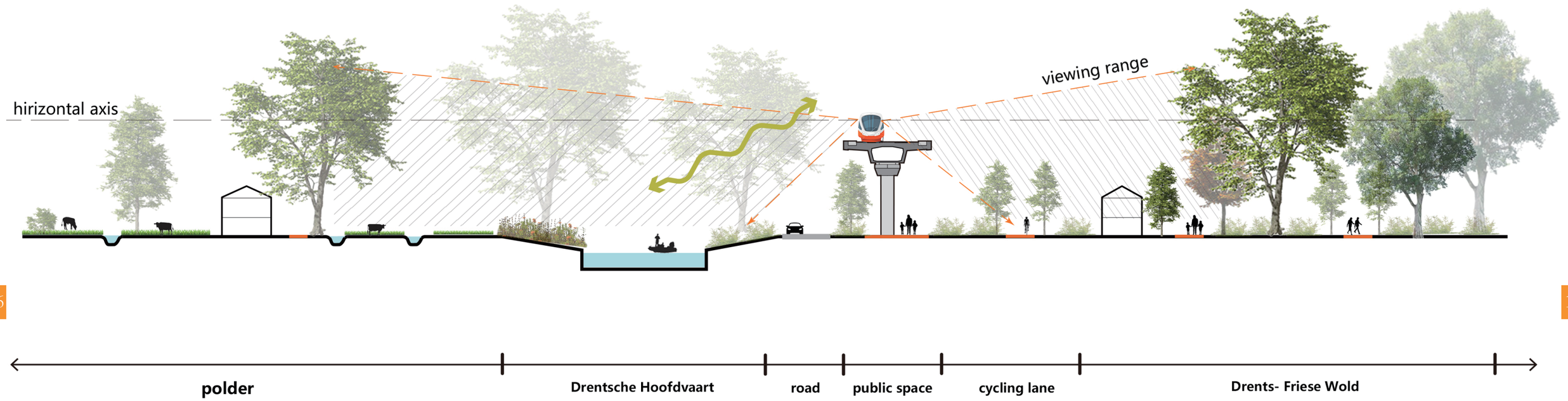
5-16 Master plan of the in between area of the national parks, drawn by Author



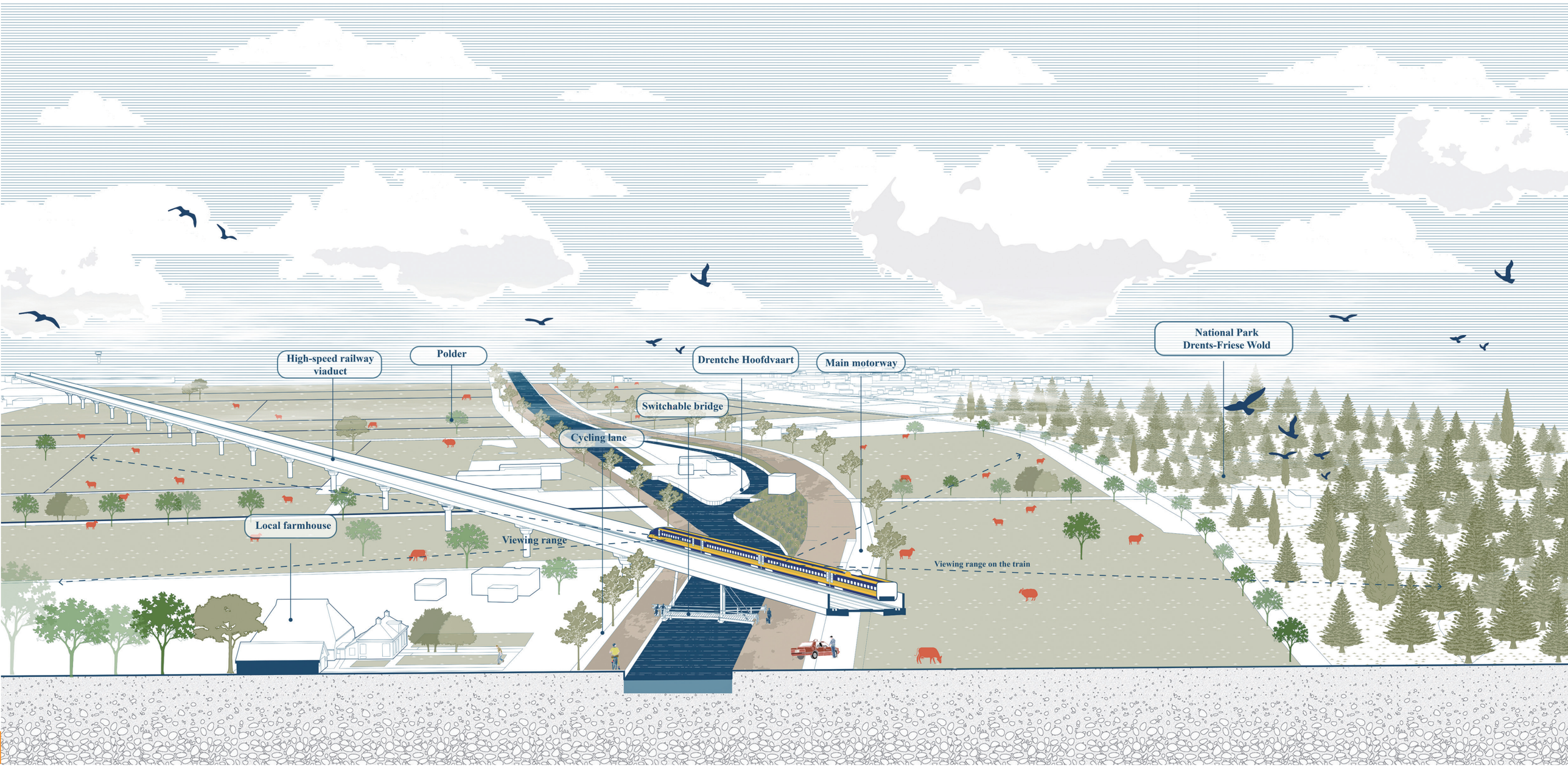
5-17 Birdeye view, farmland turning to forest, bring together national parks, drawn by Author



5-18 Secction 1-1, viaduct kissing through the afforestation area, drawn by Author



5-19 Secction 2-2, contemporary high-speed railway viaduct encouters historical canal, drawn by Author



Pespective section, the junction point of high-speed railway viaiduct and Drenthe Grand canal, drawn by Lei and Bai

5-20 Perspective, impression of the intersection point of the viaduct and canal
drawn by Author

5.4. Norg – 500m offset for the cultural landscape

The history and evolution of Norg exemplify the characteristic progression of most sand villages in Drenthe. The esdorp (village built on a raised field), along with its encompassing landscape and various elements, stand as some of the best-preserved examples in the Netherlands. The initiation of this style of agriculture dates back to the 7th or 8th century and was further expanded in the late Middle Ages. These settlements focused on permanent habitation with a diverse utilization of surrounding land, an approach which has remained intact for centuries. Typically, settlements were founded on elevated, dry sand ridges close to a stream. Houses were constructed around a central point, providing water supply for the sheep. These sites are still recognizable as the greenlands today.

Overgrazing led to the disappearance of the heath and initiated sand drift, resulting in dune formation. To counteract this, forests, primarily pines, were planted in the early 20th century. This collective effort resulted in self-sufficient communities that remained relatively isolated, akin to peninsulas separated from each other by watercourses and nestled within extensive moors and peat bogs. Given the pristine preservation of Norg and its surroundings, and the absence of large-scale re-parceling, the area has been procured as a protected landscape by Natuurmonumenten, now known as Norger Esdorpenlandschap. Recent land consolidation efforts have aimed to restore the original structure and ensure its preservation.

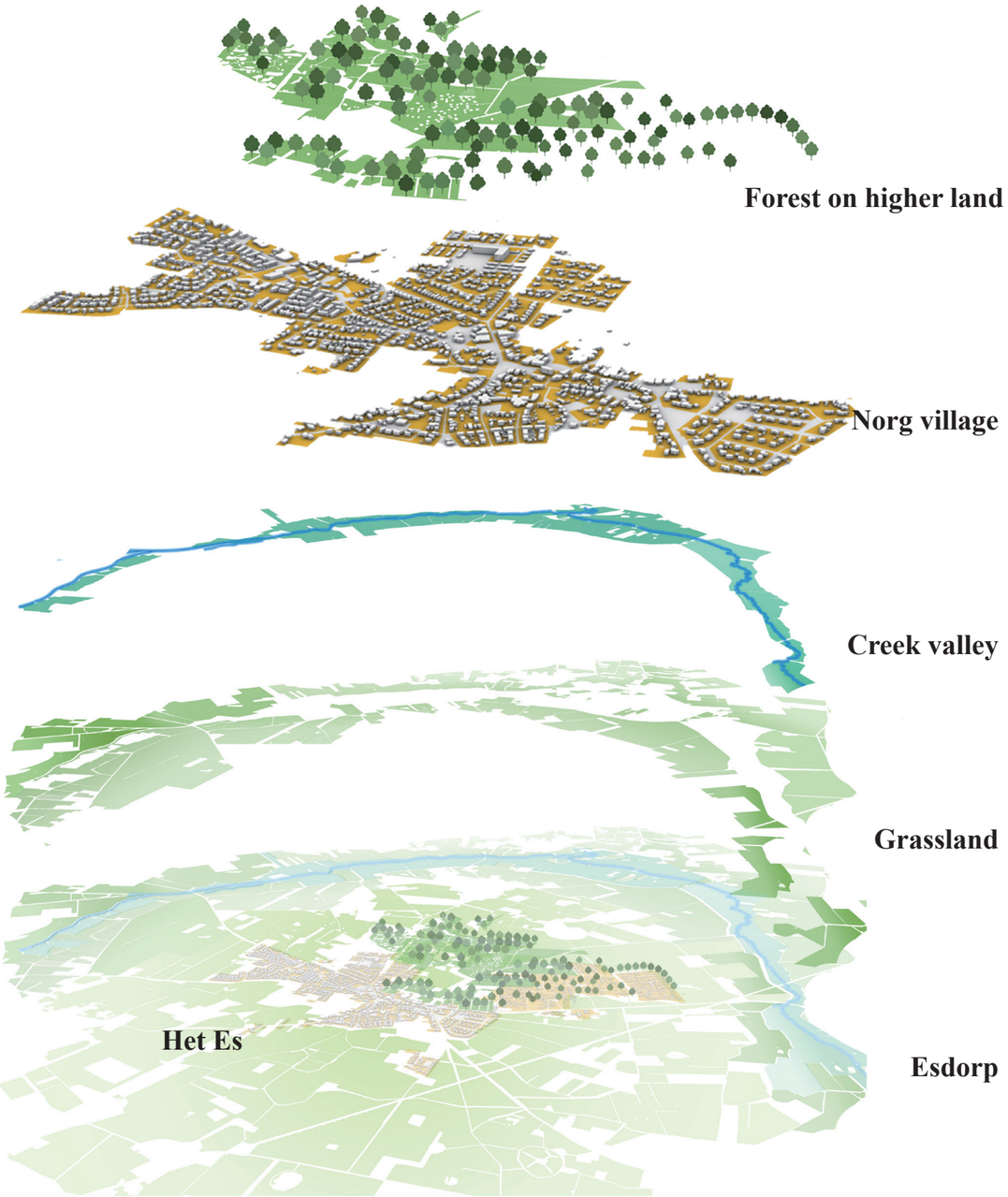
And originally the alignment is supposed to bypass Norg 100 meters away from its territory, but the rich cultural landscape and history here require the infrastructure give way to its value So that the 500 meters offset measure is going to be taken 25km ahead of the village, within the allowance of the high-speed radius respecting the site's historical integrity and the residents' interests.

As such, the high-speed rail line will be located 1km east of Norg, circumventing the village instead of bisecting it. Moreover, there are numerous farmhouses along both sides of the main road encircling the village. The proposed high-speed railway line will be designed to avoid encroaching upon these farmhouses, thereby respecting the site's historical integrity and the residents' interests. Two land plots adjacent to the railway will be cultivated as new pine forests, contributing to water and soil conservation in the area. Furthermore, these forests will also serve as a noise buffer and a recreational space for the benefit of nearby residents.

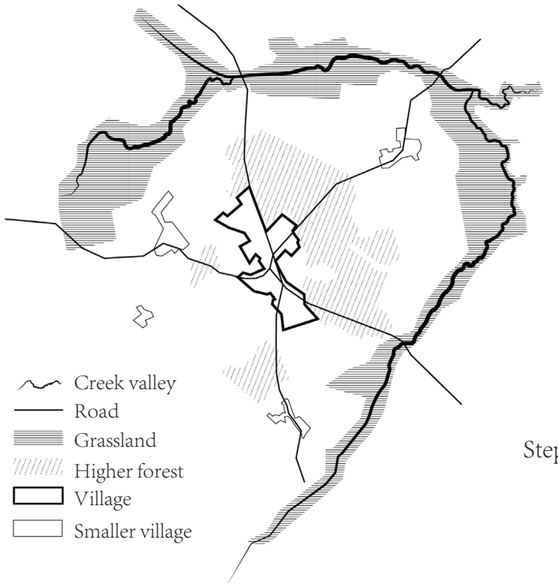
500 meters offset

Action is taken 25 km ahead

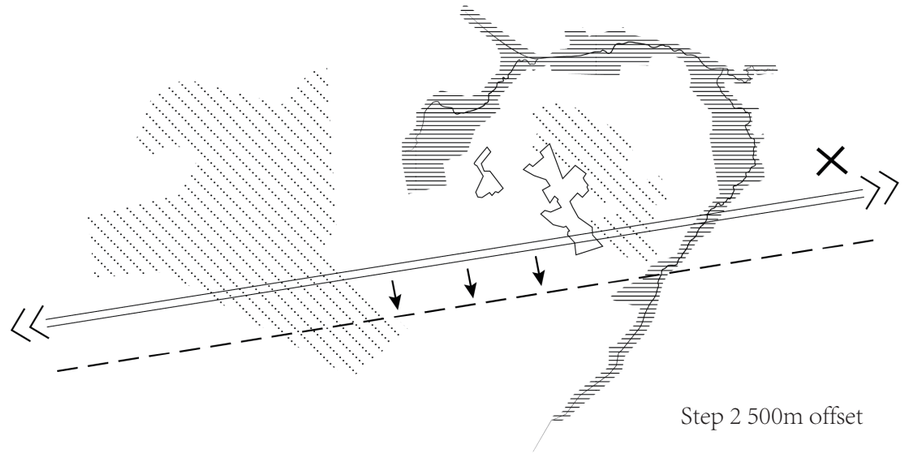
Norg's esdorp spatial structure remains the same for centuries since Middle Ages, 1865
Source: Maps-Print



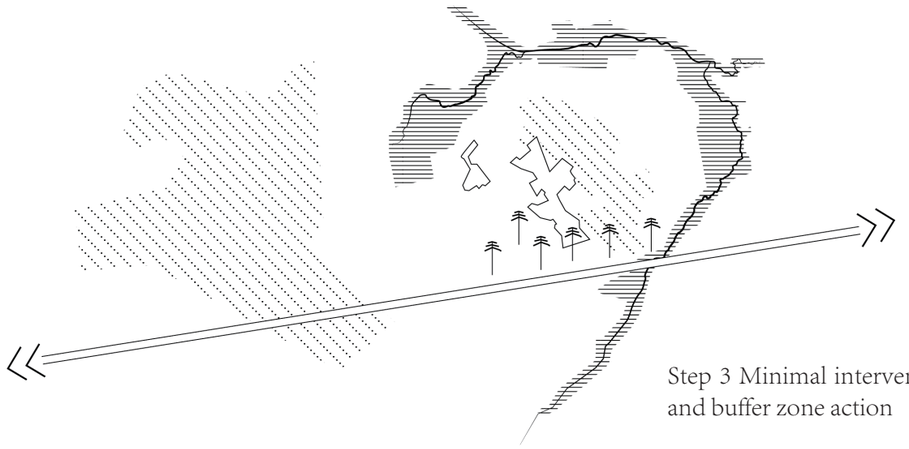
5-21 Spatial elements of the esdorp landscape, Norg, drawn by Author



Step 1 Read the esdorp landscape



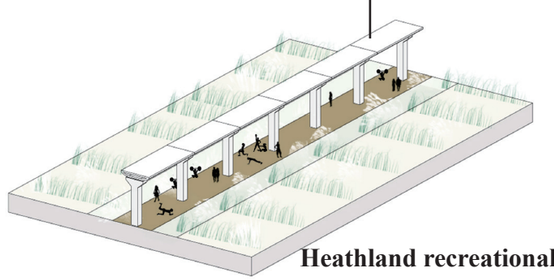
Step 2 500m offset



Step 3 Minimal intervention and buffer zone action

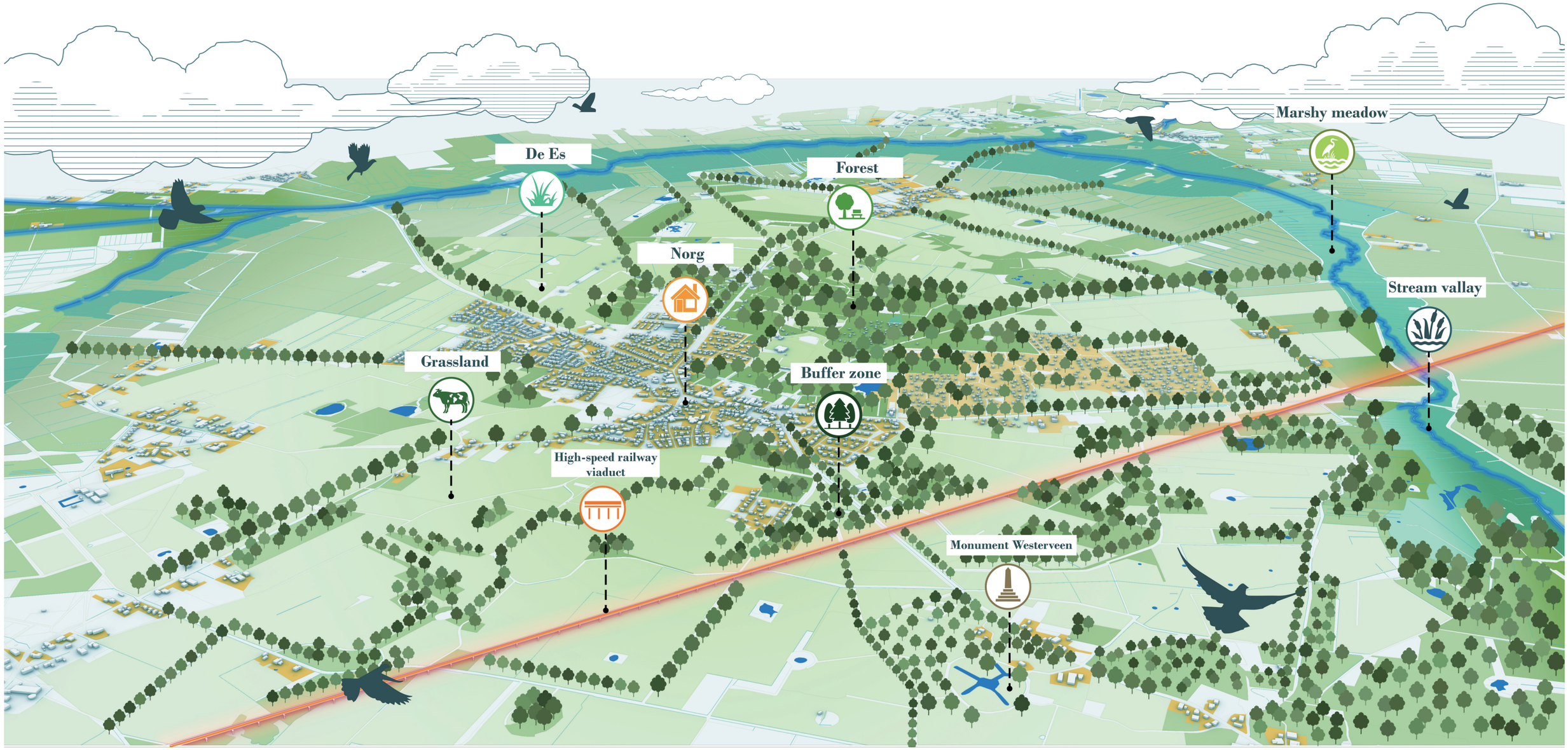
5-22 The formation process of design, Norg, drawn by Author

5-23 Master plan of the minimal intervention design, Norg
drawn by Author

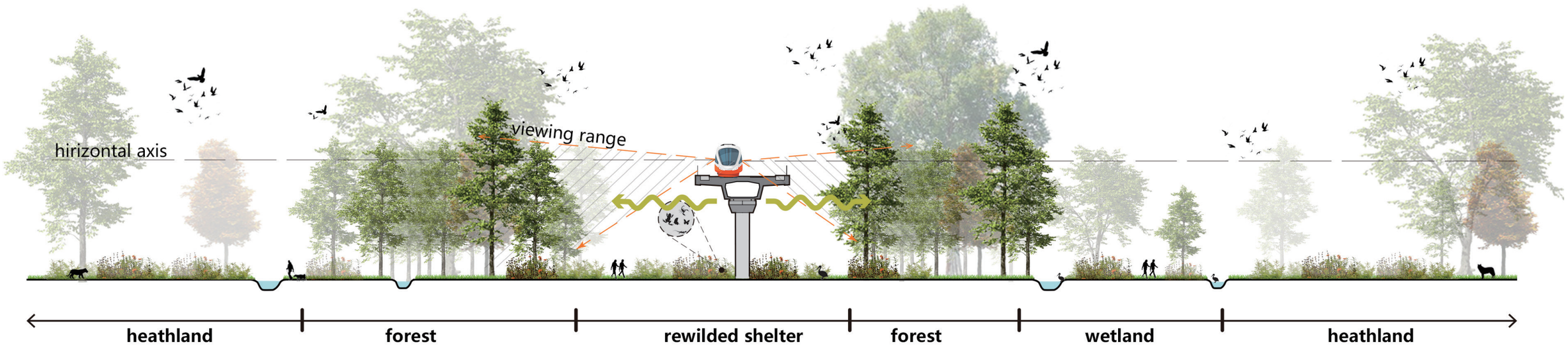


Heathland recreational bootcamp

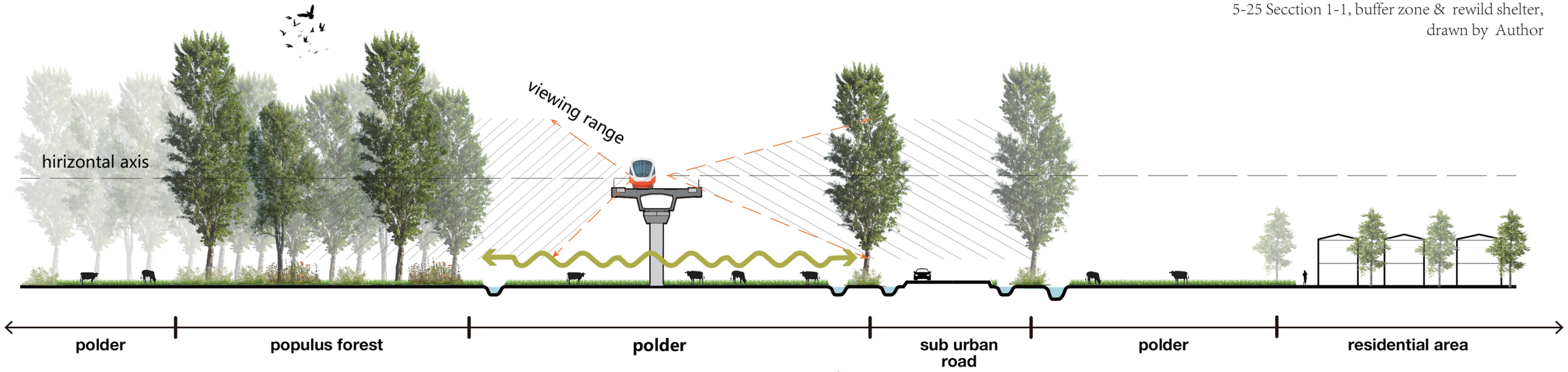
Forest buffer



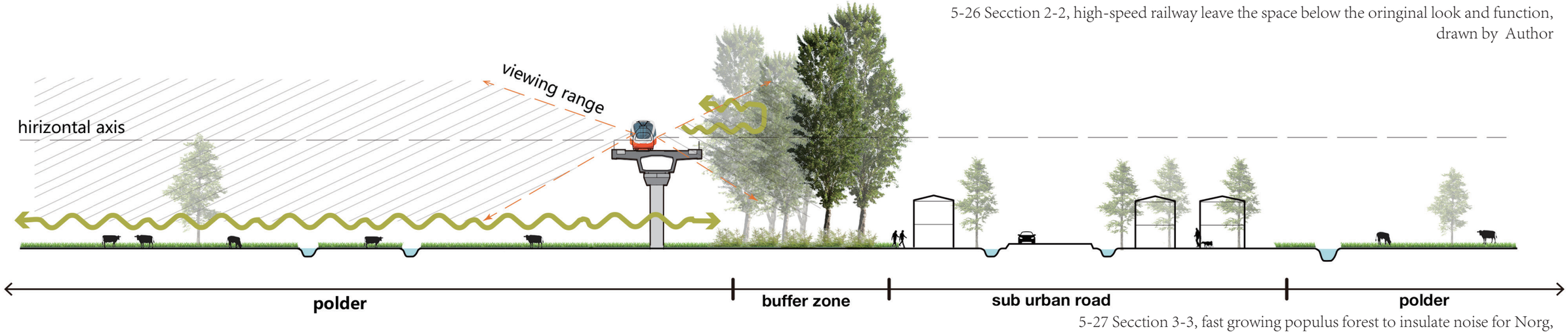
5-24 Birdeye view, high-speed railway in dialog with esdorp stream valley, drawn by Author



5-25 Secction 1-1, buffer zone & rewild shelter,
drawn by Author



5-26 Secction 2-2, high-speed railway leave the space below the oringinal look and function,
drawn by Author



5-27 Secction 3-3, fast growing populus forest to insulate noise for Norg,
drawn by Author

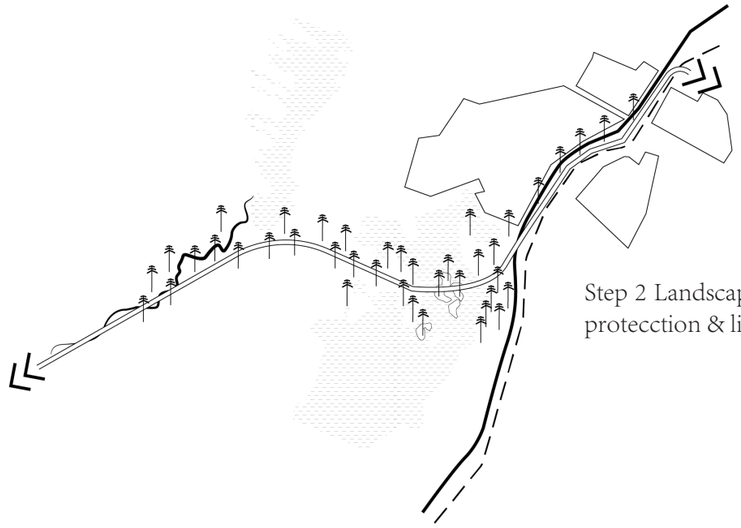
5.5. Groningen - City cruise in 3 minutes

Groningen is the end station of this high-speed railway line. There were three options for entering the Groningen Centraal station in the beginning. The first was to join the existing railway network from the south, the second was to join the existing railway network from the north, and the third was to integrate into the urban environment from the middle.

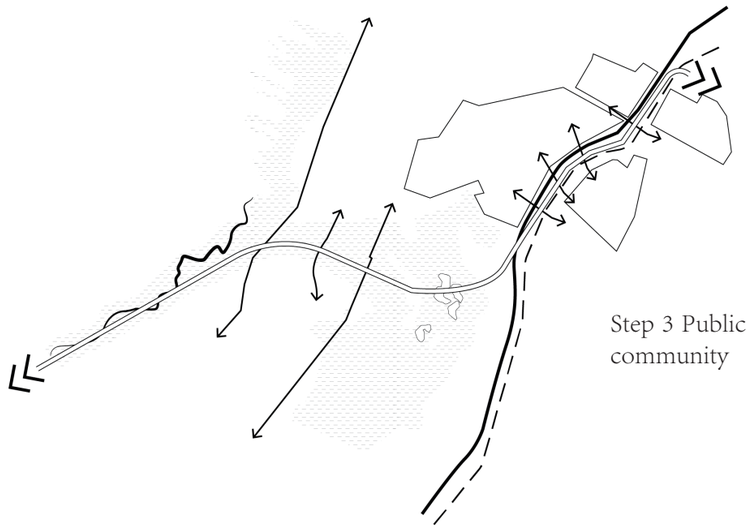
The biggest difference of the railway line between the urban context and rural context is that the land in the city were already built mostly, which makes it very complicated conditions in term of selecting the viaduct alignment. The biggest difference of the railway line between the urban context and rural context is that the land in the city were already built mostly, which makes it very complicated conditions in term of selecting the viaduct alignment.

However, there is an advantage in the urban context is that the train should slow down in advance before entering the city, which makes it possible for the viaduct to follow a curved line. That’ s why I choose the locate the viaduct line between the canal and the existing highway following the curve of current infrastructure, and space below the 2-kilometer-long viaduct section will be developed into a waterfront linear park to stimulate the vitality of Groningen city. Later, the shortest cut was chosen to pass through the Hoornse Lake, which minimized the construction cost and intervention to the natural area, and at the same time enriched the visual experience for both passengers on the train and tourists in the wetland park around the lake, which will leave a unique impression of the city image of Groningen from this journey.

Step 1 Pick up the minimal intervention route



Step 2 Landscape mitigation with bird island protecction & linar park connection below



Step 3 Public space to activiate surrounding community

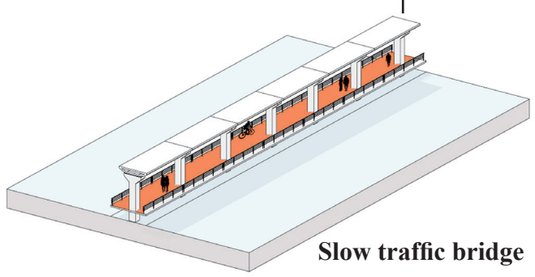
5-28 The formation process of design Groningen drawn by Author

1. hoornse plas park
2. wetland grove
3. village
4. Hoornsemeer
5. bird-watching islands
6. wetkland park
7. forest
8. noise buffer
9. waterfront linar park
10. Groningen centraal

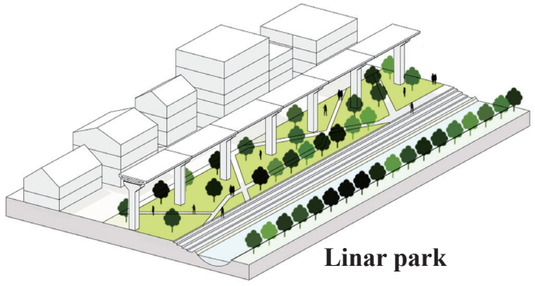
N

0 200 100 600 m

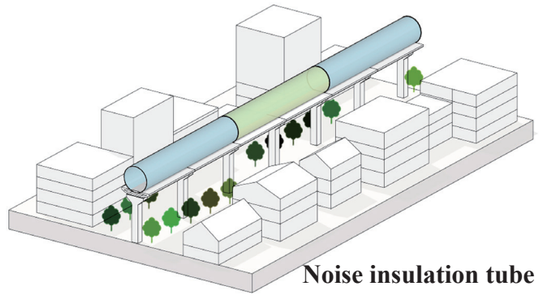
5-29 Master plan of the last 3 minutes journey in the urbaan context of Groningen, drawn by Author



Slow traffic bridge

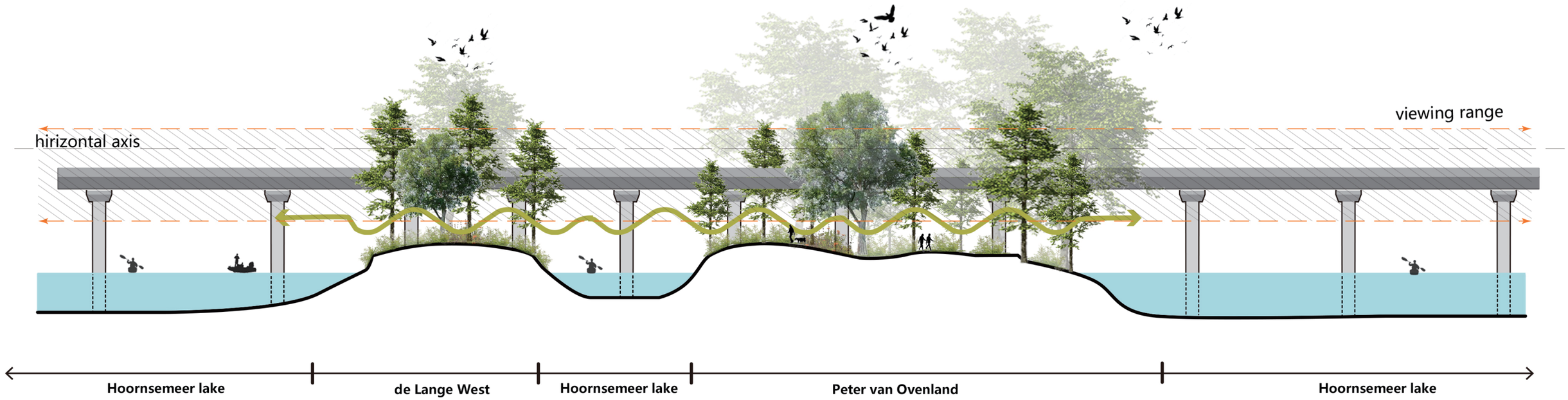


Linar park

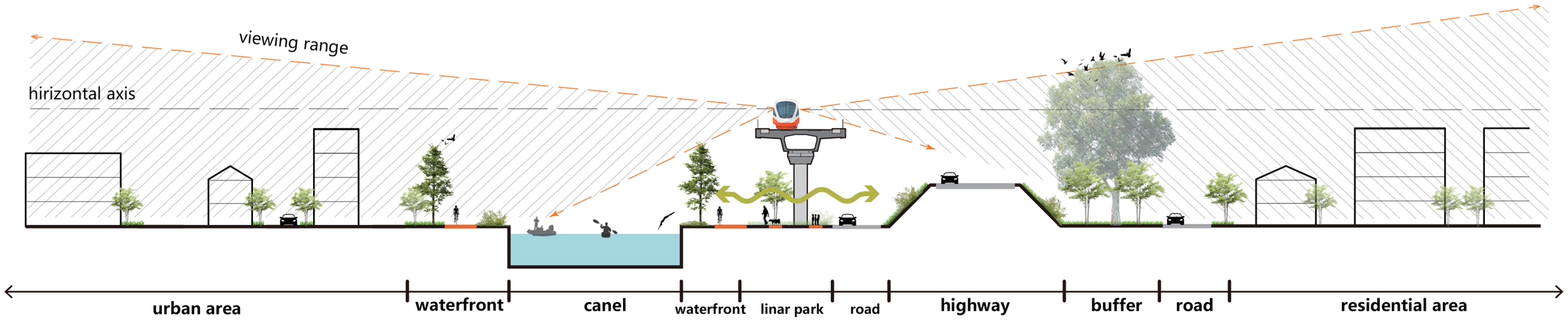


Noise insulation tube

5-29 Birdeye view of the last 3 minutes train journey at Groningen, giving passengers a unique impression of this antique city
drawn by Author



5-30 Section 1-1,high-speed railway viaduct crossing the lake Hoornsemeer
drawn by Author



5-31 Section 2-2, high-speed railway viaduct pick up the space
between the canal and existing highway to join the urban context,
drawn by Author

5-32 Viaduct abouve the lakeHoornsemeer
Reference: BEAM Architects

5-33 Viaduct in urban context Groningen
drawn by author

5-33 Linar park below the viaduct in Groningen
Reference: JCFO

6. Conclusion & reflection

6.1 Conclusion

Research objective and questions

The core objective of this master's thesis is to harness existing high-speed rail technology to conceptualize a rail line that is more cost-effective, efficient, and sustainable than the Lelyline. I have undertaken comprehensive research and compiled considerable theoretical knowledge on high-speed rail technology. My Chinese background provided me with the firsthand experience of the substantial convenience of high-speed rail and its instrumental role in fostering urban and rural development. However, it is noteworthy that high-speed rail designs frequently orchestrated by civil engineering designers which often lead to a massive detriment to spatial quality.

Embarking on this task from the perspective of landscape designers, as opposed to civil engineering designers, our strength lies in our attention not just to the engineering's quality, but also to the spatial quality and human experience. Our guiding principle is to honor and safeguard the natural environment while crafting better living environments. As part of the TU Delft Innovative Infrastructure Implementation graduation lab, this thesis substantiates that high-speed rail can offer a more economical, sustainable, and visionary design proposition for the portion from Zwolle to Groningen when compared to the Lelyline. In response to the four proposed sub-research questions, each chapter provides a distinct answer.

Sub-research question 1: **Why do we need a high-speed railway implementation from Zwolle to Groningen?** To understand Zwolle's significance as a future Dutch railway hub connecting the northern provinces, this project delves into the challenges currently faced by the Dutch railway system. A nation-wide mapping effectively illustrates the accessibility gap in the Netherlands' northern provinces and Utrecht's overburdening as the transport hub, reinforcing previous urban studies.

Sub-research question 2: **Where can be better options than the Lelyline?**

Compared to the government-suggested Lely line, we exhaustively evaluated all potentially superior route options by the wire method, incorporated intuitive quantifiable parameters, and carried out a hierarchical analysis of each alignment. The final route grouping outcomes prominently underscore the unique advantages of each category, making our evaluation results more understandable. The proposed optimal alignment isn't a "point-to-point" subjective conclusion but an outcome of comprehensive enumeration and systematic comparative analysis.

Sub-research question 3: **What are the spatially possibilities for the alignment between Zwolle and Groningen?**
The third sub-research question involves studying and categorizing the site's current landscape conditions, providing substantial support for future design explorations, And the landscape interventions are proposed based on specifc on-site context between Zwolle and Groningen, but the outcome also offering guidance and inspiration for future railway designs in sites with analogous land conditions.

Sub-research question 4: **How to design the railway and landscape along the itinerary in a sustainable way with minimal interventions?**
In the concluding chapter, I endeavored to explore this optimal alignment's design and responded to the 'infrastructure as landscape' theory. Future high-quality infrastructure should foster dialogue and interaction with the surrounding built and natural environments. Landscape infrastructure serves as a significant catalyst in shaping human living environments' quality and natural spaces. This innovative high-speed rail line will propel the development of surrounding areas, creating a new robust structure of gray, green, and blue infrastructures. This benefits the transportation system, urban space, and natural ecology, paving the way for a regional long-term sustainable development blueprint (Figure 6-1).

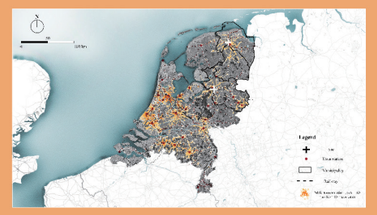
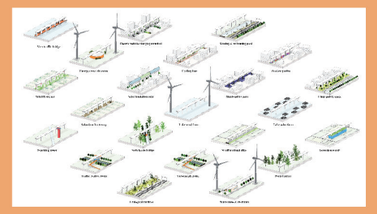
Limitation of the study

In this study, the scale of the project posed the biggest challenge. The constraints of the research timeline make it infeasible to conduct exhaustive plan-to-section studies for every section of the line. Consequently, my efforts were concentrated on the design for five crucial and representative areas. However, the reality remains that every kilometer of this alignment possesses its unique site conditions and identity.

Furthermore, due to disciplinary orientations, this thesis wasn't able to discuss more details on transportation knowledge. Nevertheless, it is my hope that this thesis can stimulate meaningful reflections for future civil engineering and transport system-related research, thus broadening the scope of discourse on this subject.

The last limitation I want to mention is about the design communication, a challenge that gradually surfaced throughout the research process. For a big civil engineering project like this in reality, engaging in discussions and maintaining communication with all stakeholders is critical. These stakeholders include local residents, factory workers, policymakers, and experts in ecology and wildlife conservation, among others. Efficacious communication with these parties can often spur designers to devise solutions that truly meet the real-world needs.

Outlook
This research aims to help readers understand the potential for freedom and utility in spaces beneath high-speed rail viaducts, while also appreciating the efficiency of high-speed rail compared to traditional railway. It further discusses the possible ecological connectivity arising from the rational use of these spaces, which turns out to be a better alternative than the traditional railway.
Beyond the research question itself in my thesis, I explored how the construction of high-speed railway infrastructure can stimulate the value of urban environments, rural cultural landscapes, and ecology. I intend to delve into how transport infrastructure can positively influence the surrounding environment. The city of Zwolle and Groningen, which this study focuses on, is not the only case of high-speed rail routes traversing nature conservation areas. In the ongoing urbanization process worldwide, countless cities face issues of environmental and ecological fragmentation due to transport infrastructure development. This project offers a new perspective to address this issue, proposing landscape intervention strategies to mitigate the spatial quality disruption caused by transport infrastructure. This design opens up the possibility for sustainable transport infrastructure design and can provide guidelines for other similar projects.

MAIN RESEARCH QUSETION	SUB-RESEARCH QUESTION	METHOD	SAMPLE PRODUCT
Research objective To design an innovative high-speed railroad alternative from Amsterdam to Groningen and be superior to the Lelyline	Why do we need a high-speed railway-implementation from Zwolle to Groningen?	**Analysis** Mapping(L), Fieldtrip **Literature review**	
Research question "How can the portion between Zwolle to Groningen of this innovative high-speed railroad be implemented in a sustainable way with minimal intervention respecting the Dutch cultural landscape?"	Where can be better options than the Lelyline?	**GIS research** Literature review, Mapping(M), Fieldtrip **Wire method** Mapping, Desk discussion, Sketching, Modeling **Parameter based evaluation** Systematical assessment	
	What are the spatial possibilities for the alignment between Zwolle and Groningen?	**Fieldtrips** Landscape typologies research **Research by Design** 3D modeling, Landscape interventions catalogue, Design through scales (L, M, S)	
	How to design the railway and landscape aliong the itineraty in a sustainable way?	**Research by Design** Sections, Master plans, Bird eye view, Perspectives Design through scales (L, M, S)	

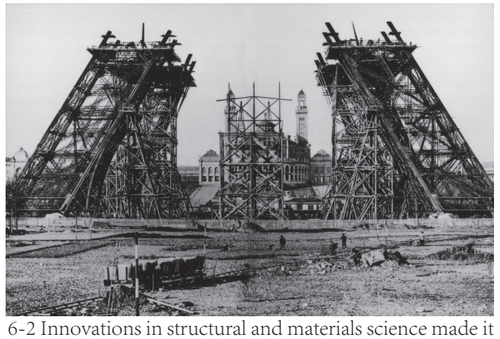
6-1 The research framework overview, drawn by Author

6.2 Reflection

Infrastructure as landscape — A potentially better decision making model

What exactly is "infrastructure as landscape"? In the academia field, there has been an iteration and renewal from the initial concept, from landscape urbanism in late 90s, to landscape infrastructure, and now we are talking about infrastructure as landscape.

Historically, this can be well understood. We had the industrial revolution, followed by the development of architecture and the innovation of landscapes. For example, let's think aabout the Eiffel Tower in Paris. It was constructed as a result of the industrial revolution in the late 119th century, serving as infrastructure for lighting and communication. It was entirely cast by structural engineers. However, at that time, society did not understand or accept it, and everyone was criticizing it. But more than a century later, now everyone visiting Paris will go to the Eiffel Tower. It has become a cultural symbol that transcends both landscape and architecture itself (Figure 6-2).



6-2 Innovations in structural and materials science made it possible for the construction of Eiffel Tower, 1889
Source: Toureiffel

Still, there are a few projects that truly achieve infrastructure as landscape, and this is especially true for high-speed railways today. However, this master's thesis explore a possibility for infrastructure as landscape. From the beginning to the end, from the alignment research to the vision at the regional scale, to the design principles at the site-specific scale, landscape designers are in charge of these discussions. We organize and integrate information from all relevant disciplines. For example, my second mentor, Dr. Aksel Ersoy, who has a background in urban planning and strategy making, provided me with constructive suggestions for refining guiding principles, specifically the elaboration of the landscacpe intervention catalogue. Simultaneously, we also communicated with teachers from the Faculty of Civil Engineering, Dr. Hans de Boer, who supported us with knowledge of technical requirements for railway construction.

However, during the process of communication with experts from civil engineering background, we found it hard to reach a consensus because, from civil engineering perspective, they couldn't understand space or spatial quality. For them, they will conduct research on the ground surface, soil, hydrology, environmental assessments,etc.

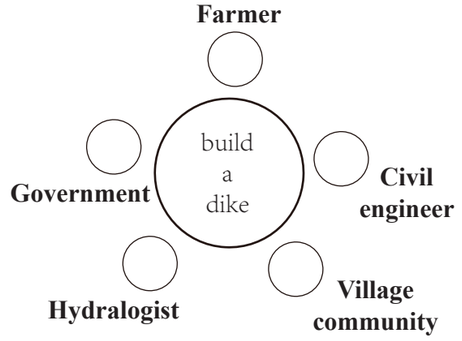
These studies are valuable, but they have two main issues. Firstly, they are detached from people perspectives; they do not consider human aspects. Trains are just trains, environment is just environment, but what about the human experience? It's missing. Secondly, they lack of scale thinking. they focus on surface-level research. However, in an actual living environment project, it's all about scale. Humans always consider themselves as the center of the world. Protagoras said, "Of all things, man is the measure." Everything is about scale, human scale. We can't ignore that, it's the biggest contradiction.

The design outcome we are delivering is completely opposite. We prioritize people as our first concern. Everything is based on human behavior, perception, and experience. The high-speed rail is no longer just infrastructure; it has become the landscape itself. We are delivering the result, and you will see how it gently kissing through the esdorp landscape of mideval town Norg. And you will witness the interaction between contemporary innovative infrastructure and historical cultural landscapes Drentsche Hoofdvaart. At the same time, you will observe how it elegantly pick up the in-between area of two national parks, creatively connecting them with afforestation measures.

Chinese efficiency mindset encounters Dutch pioneering spirit

Chinese mindset is about efficiency, copy paste. Dutch sprite is about pioneering, facing the chanllenge.

A very simple question: Does the Netherlands, as it stands now, need better railways? The answer is definitely yes! At least over 80% of people would say so. The Netherlands is a wealthy country that values a high quality of life. The Dutch have always cherished their lives on this lowland. Generation after generation, step by step, they have created the Netherlands. The Dutch dike system was created through the collaboration of civil engineers, hydraulic engineers, landscape designers, government officials, and villagers. It is the result of negotiation. It's so elegant and beautiful. The entire society unites as a community. We face challenges together and thrive together (Figure 6-3).



6-3 The model of building a dike in the history, drawn by Author

The Netherlands is a country that strives to be the best. So what's the way out for the high-speed train in the Netherlands? Compared to speed, the Netherlands can't be as fast as Japan. Compared to efficiency, it can't be as efficient as China.

The advantage of the Netherlands lies in resource integration. When it comes to high-speed rail, the Netherlands should be KPMG rather than ASML (Figure 6-4).

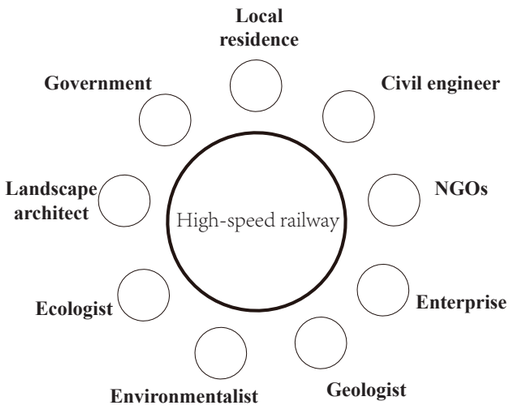
6-4 Dutch high-speed railway need to be like "KPMG", instead of "ASML"

The Netherlands has a group of designers who are the best at negotiation, despite being such a small country, the Netherlands has nourished the most outstanding generation of living environment designers in the world since World War II. The potential way out for the Dutch high-speed railway is to take advantage of the knowledge of the built environment experts, making it best in terms of experiences, the relation with cultural landscape, instead of the fastest one in terms of speed.

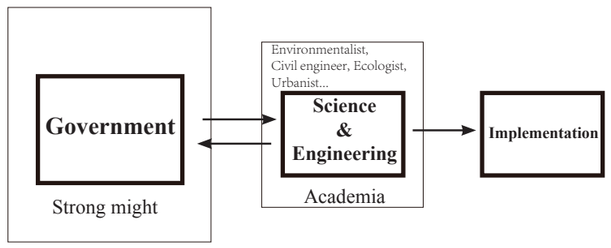
I do not expect that, because of this thesis, there will truly be such a high-speed railway in the future of the Netherlands. After all, as a foreigner, I have only been in the Netherlands for two years, I still know little about this country. But if there has to be a meaning for my research, since it will stay forever in the repository of TU Delft, there might be some guys read this report who are in related fields or even in charge of it, I won't say, please look at my proposal, it's much better than the Lelyline, please tell the government, do it in my way. I won't say that.

But, I would plea, please take it as a reminder, Dutch people were the most amazing pioneers in the world before, you were coachman on sea in the golden age, you created the Flevoland, you were scripting around the world.

Now, I am not sorry for that, but I have to question, why is the Netherlands so slow? why the government is still thinking about build a 160 km/h train (Figure 6-4)while the neighbors France and Germany having 300km/h. I dont get that, from a Chinese all about efficiency eye (Figure 6-5).



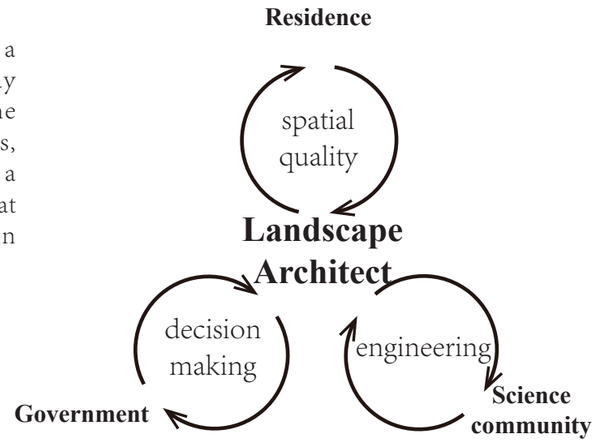
6-4 Dutch high-speed railway decision making model, slow in process and too much internal meaningless friction, drawn by Author



6-5 Chinese high-speed railway decision making model, which is efficient but sometimes can be intrusive to locals and no spatial concern, drawn by Author

Technology changes the world, and the Netherlands cannot close its eyes and ignore the world. Saying that our land is too precious and high-speed rail is an insult to our land is like covering our eyes. We refuse to look at Japan's bullet train, how elegantly it crosses Mount Fuji. We refuse to look at China's efficiency, how it has built over 40,000 kilometers of high-speed rail in the past decade. Refusing to look at it does not make it disappear. This is not wise. To make ourselves feel nothing so as not to feel anything. It's a waste,what a shame.

And outcome is to tell there could be a much better way to implement the railway infrastructure that REALLY needed in the REAL world. The even more lucky thing is, we are landscape architects, we are delivering a solution respecting the cultural landscape that every Dutch people cherish (Figure 6-6), in compasion with the Lelyline.



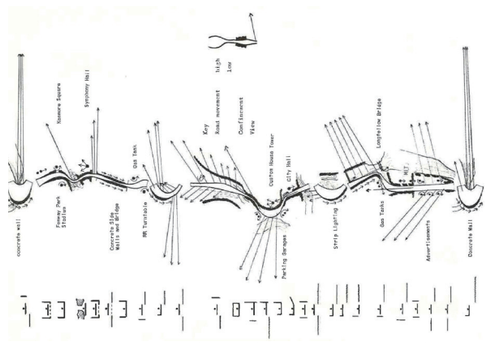
6-6 The optimal model of infrastructure decision making in the future, drawn by Author

Personal growth—In dialog with seniors

During this year in the graduation lab, learning and personal growth were not limited to thesis writing and creating drawings. Literature reviews and field trips provided me with infinite inspiration and enlightenment.

After World War II, the US was developing at an amazing speed, and Henry Ford's vision of "making cars affordable for everyone" completely transformed the landscape of the automobile industry. The construction of expressways was happening rapidly. In the 1960s, Kevin Lynch, in his book "*The View from the Road*," first time start to discuss the aesthetics of urban highways: how they appear to the driver and passengers and what implications this has for their design. The highway offers a good example of a design issue typical of the city: the problem of designing visual sequences for an observer in motion (Figure 6-7).

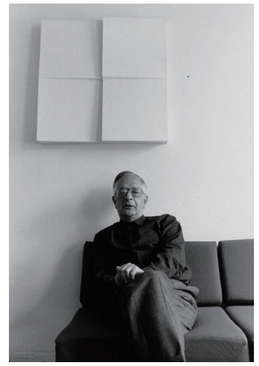
Almost a century later, vehicles in this world have become faster and faster: high-speed railways, hyperloop, etc. However, our perception of beauty has not changed. Through the reading process, I became convinced of the value of researching the landscapes in motion, the changing sequences of external space, and even the sound. These are all topics worthy discussing.



6-7 Space-motion and view diagram, Kevin Lynch, 1965

Occasionally, I had a chance visit to Darwin Park, it was such a tiny park but I was so touched by its purity and orderliness. It was designed by Hans Warnau, 20th century's important landscape architect, educator, thinker in the Netherlands (Figure 6-8).

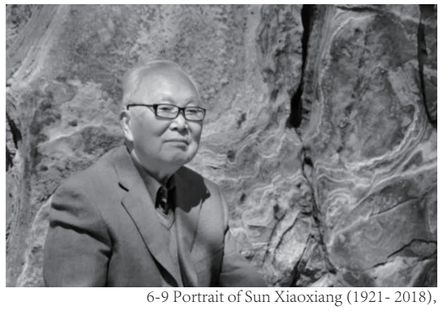
During the post-World War II, baby boom era, he was an allegiant pioneer of de stijl and minimalism in the field of landscape. Although currently I am still unable to fully express my interpretation of society and cultural landscape, I have to say that the essence of de stijl has given me the inner courage to complete the most complex part of the thesis, the landscape intervention catalogue. The chapter on "the journey" also has an inseparable connection to minimal intervention and minimalism.



6-8 Portrait of Hans Warnau (1922 - 1995)
photo by Jaap Egmond, 1971

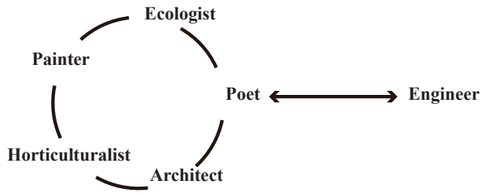
Last but most importantly, my supervisor, Adriaan Geuze, though I have to admit that every weekly session was a huge chanllenge for me, both mentally and verbally, unremarkable design is very likely to be abused. But to the very end, I felt more than privileged to work closely with Prof. Geuze for the whole year. His sharpness for design,

mighty wording, ways of generating new ideas, how to influence people have very much wshaped me permanently, not only in terms of landscape architecture. After the whole year journey, I couldn't help think about the first lecture of my landscape study in my bachelor, which was given by Prof. Sun Xiaoxiang (Figure 6-9),



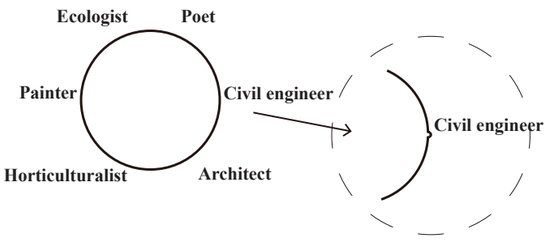
6-9 Portrait of Sun Xiaoxiang (1921- 2018), landscape architect, educator

who told us, you have to walk with "five feet" to be a landscape architect: first one is as a painter, second is as a horticulturist, third is as a architect, fourth is as an ecologist, fifth is as a poet. Coincidentally, Prof. Geuze emphasized about the role of landscape architect similarly, landscape architect is where engineer meets poet (Figure 6-10),



6-10 Sun Xiangxiang & Adriaan Geuze 's model about the role of landscape architect, drawn by Author

and I feel grateful to say, this thesis is a tiny step forward for exploring the role of landscape architect as an engineer (Figure 6-11).



6-11 A tiny step further for landscape architect as an engineer, drawn by Author

Landscape architect - Participate the contemporary geek world in a poetic way

The contemporary world is a highly digitalized world. Big data, artificial intelligence, virtual reality, information explosion, etc., it seems the world is increasingly belonging to geeks, and many topics appear to be detached from the control of landscape architecture. Intellectuals are transforming into cyber intellectuals. When artificial intelligence can generate 100 exquisite perspective drawings in a few second, landscape designers seem to become tragic heroism on the verge of being replaced.

However, I have reservations about this, as the work of landscape architects involves not only collecting data, scientific analysis, deductive reasoning, and construction management but also infusing human emotions. The best landscape project have the power to touch people, and I always believe that human emotions cannot be digitized at any time. Landscape architecture is about participating in the contemporary geek world in a poetic way.

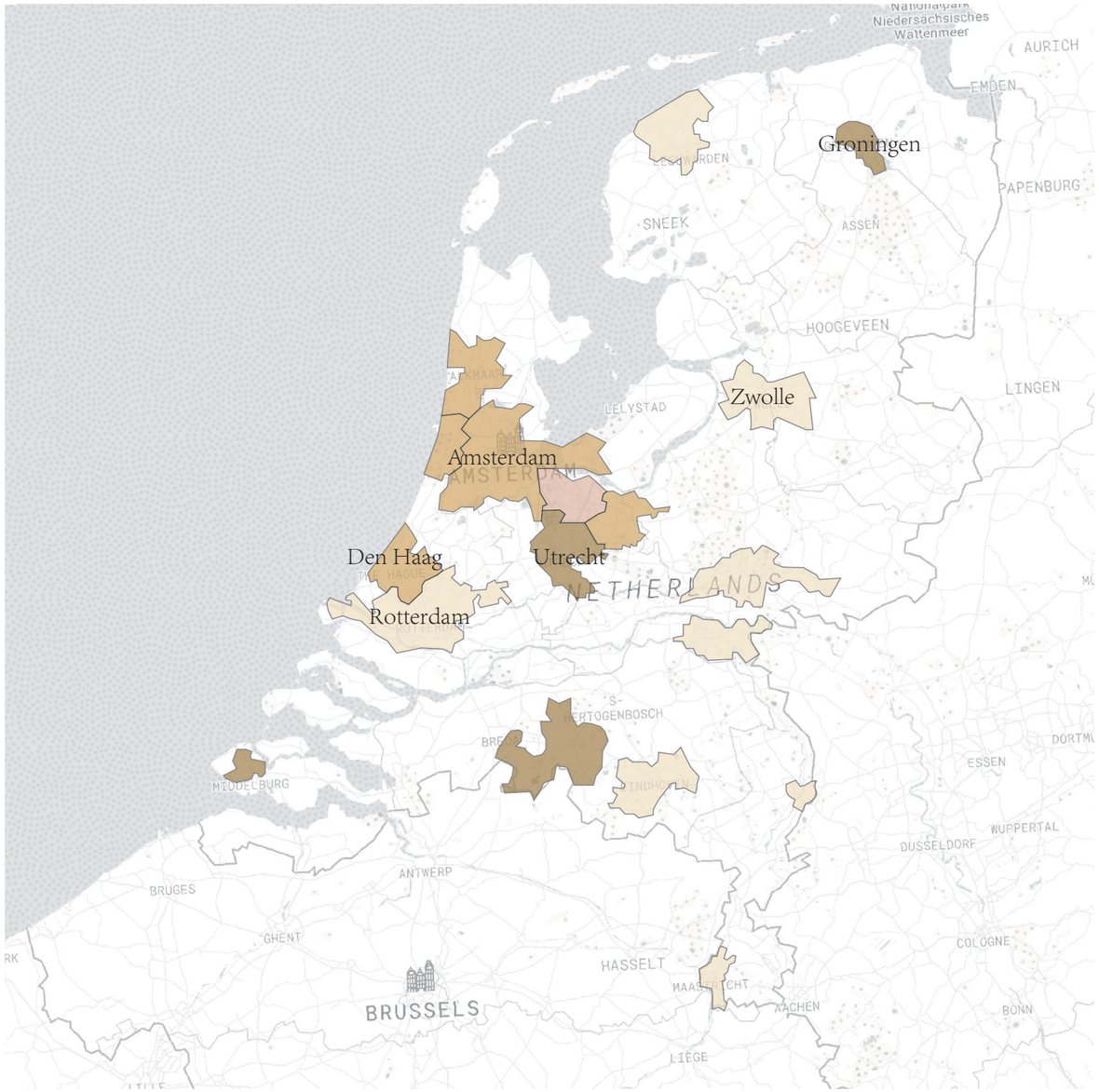
Appendix

Appendix 1: Alignment assessment chart

Assessment Chart

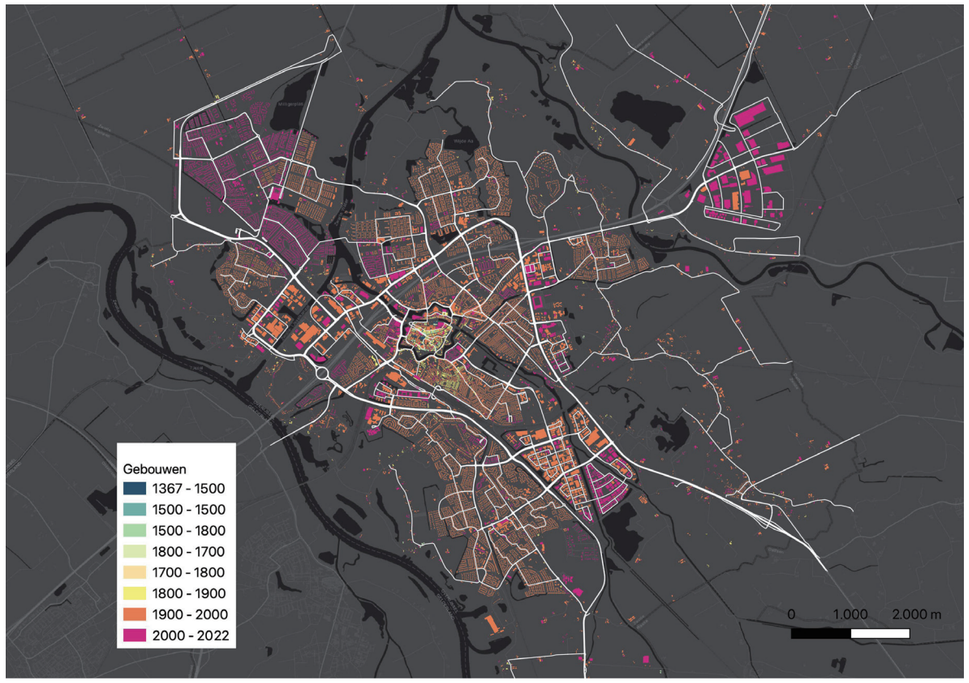
	A	B	C	D	E	F	G	H	I	Note
Toal distance (km)	83.25	93.05	82.12	90.05	87.85	88.35	90.31	90.31	92.85	
High-speed distance (km)	80.25	52.50	77.13	78.03	77.82	78.31	72.63	72.63	82.20	
Integrate with existing railroad (km)	3	40.55	5	21.65	19.65	19.65	27.3	17.7	17.05	
Time (min)	21	24	20.5	22.5	22	22	22.5	22.5	23	
Cost (rank)										
National park (number & grade)	4(－＋＋＋)	2 (－－)	2 (＋＋)	2 (＋＋)	1 (＋)	2 (＋－)	3 (－＋＋)	3 (－＋＋)	4 (＋－＋＋)	＋ Long distance － Short distance
City (number)	0	0	0	0	0	Assen (sub urban)	Assen (sub urban)	Assen (sub urban)	Assen (sub urban)	
Town (number)	1	3	2	0	2	0 (2 by pass)	3	2	3	
Village (number)	4	2	4	2	2	1	2	2	1	
Start station	Zwolle West	Mepal	Zwolle West	Zwolle Centraal	Zwolle Centraal	Zwolle Centraal	Zwolle Centraal	Zwolle Centraal	Zwolle East	
End station	Groningen Centraal	Haren	Groningen Centraal	Groningen Centraal	Groningen Centraal	Groningen Centraal	Haren	Haren	Haren	
Strength	1.Long high-speed section 2. Low construction cost	1. Historical value (old canal) 2. Benefit Mepel a lot 3. Take advantage of existing railroad	Shortest	Least touch to the built environment	Similar to line D	Different landscape typology with line D, save 2 km distance	First draft of line F	1. Interrupt less built environment 2. Connect Assen	1. Longer national park viewing time (compare with line H	
Weakness	1. Fragment too many villages	1.Longer distance 2.Monotonous polder landscape	Cut through Staphorst and Raden	Detour						
Opportunity	Small height difference	1. The railroad connects national parks as a green corridor. 2. Connect Assen and Groningen	Good for Zwolle north urban development	Good for Zwolle east urban development						
Threat	Flooding, Erosion, Habitat lose, Relocation of the villages, Conflicts with both urban and rural area									

Appendix 2: DUS(Daily Urban System) of the Netherlands

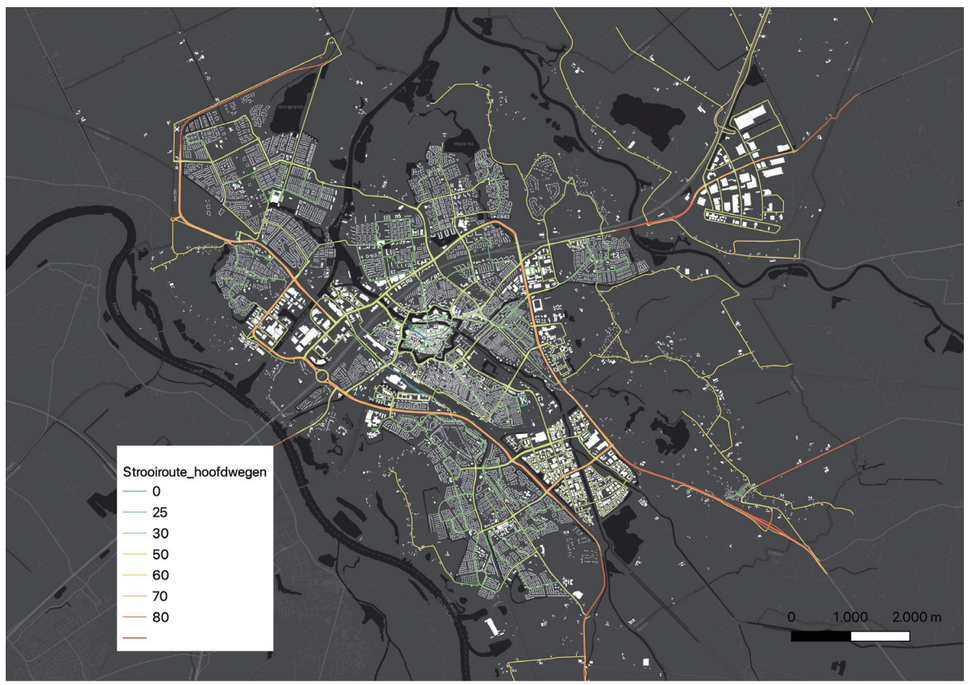


redrawn by author

Appendix 3: Zwolle urban expansion mapping

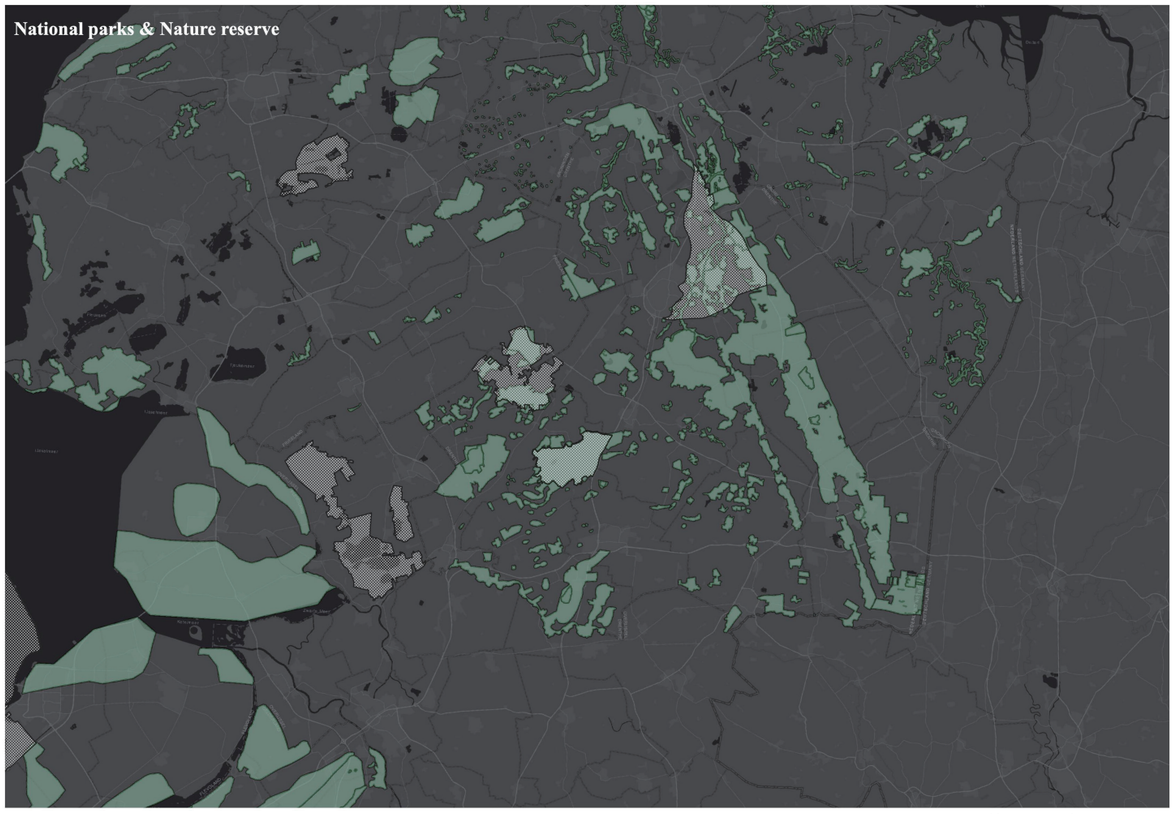


Zwolle urban expansion



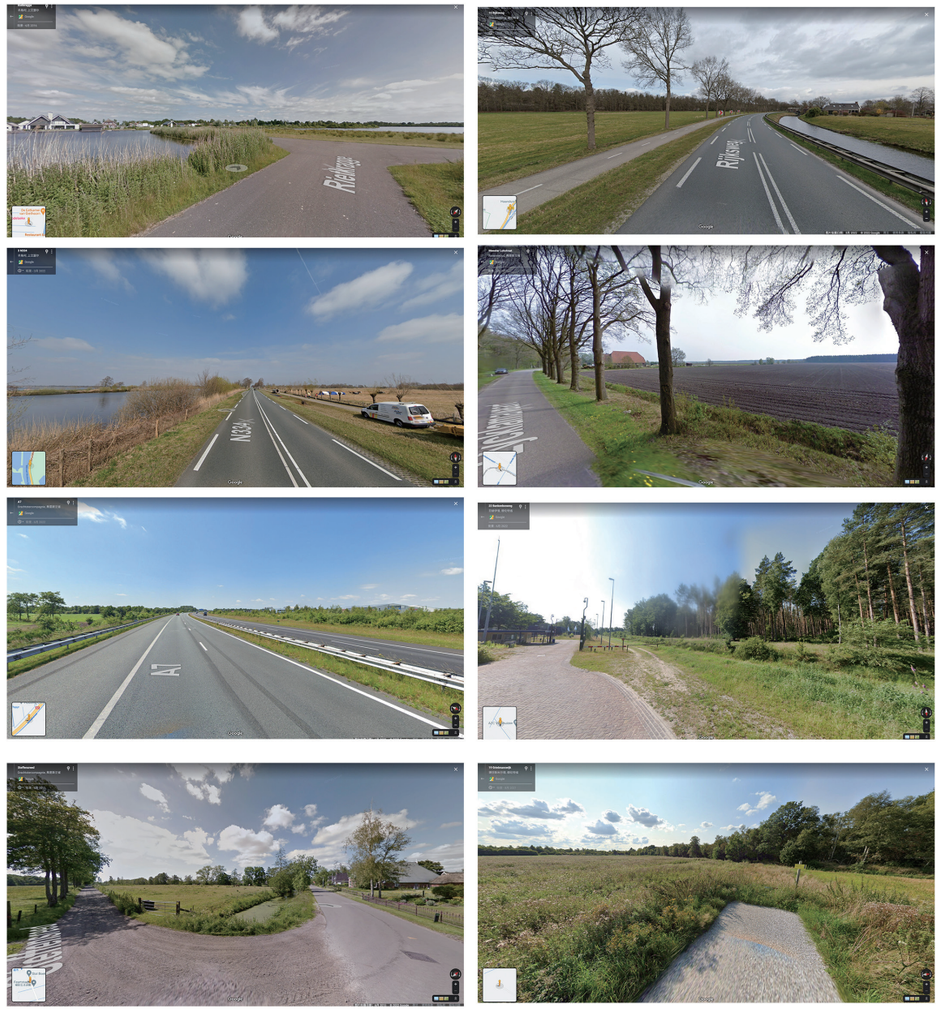
Zwolle road system development,
drawn by author, data sourc: Gemeente Zwolle

Appendix 4: Distribution of national parks and nature reserves in north provinces



Zwolle road system,
drawn by author, data sourc: PDOK

Appendix 5: Collection of existing street views of the optimal alignment



Source: Google street map








photo by Author

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