Tree-Ways for Water Issues

Urban Forestry as a way to better connect
the old & new in Zwolle

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Flowscapes: Urban Forestry

The green buffer next to the A28, Zwolle

PREFACE

Before you lies the graduation project 'Tree-Ways for Water Issues'. This project is made within the Urban Forestry Lab as part of the Flowscapes Graduation Studio of the master track Landscape Architecture at the TU Delft.

This graduation project for Zwolle investigates how the revision of the tree and blue structure, necessary for climate change, can be used simultaneously for a number of future spatial challenges for the city as a healthy living environment. The motivation for this is the demand for more space for water storage and the improvement of greenery by adding and transforming it in conjunction with landscape and urban challenges.

Based on the morphological analysis of the entire city, current policy documents, research into water issues, and the landscape architectural concept of Urban Forestry, an Urban Forestry Plan has been created for the area enclosed by the city ring road, with a detailed plan for the neighborhood Kamperpoort, where greenery, traffic, urbanization, and water challenges converge.

This report presents a literature study, site research, and a design proposal for a new tree structure in Zwolle. The purpose of this project is to showcase how a potential forested structure in an urban environment can help alleviate waterproblems.

Keywords: Urban Forestry, Urban challenges, water issues, water storage, healthy environment.

Kari Stam
Amsterdam, June 2023

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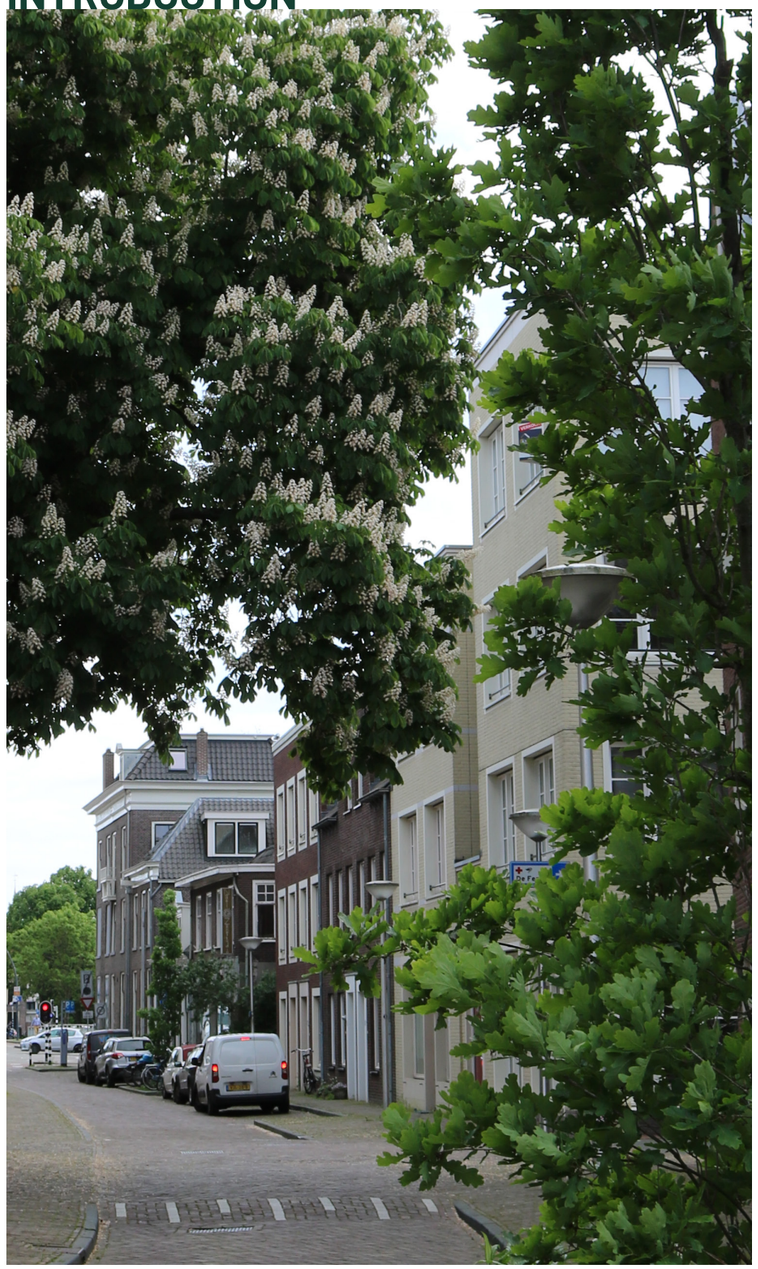
INTRODUCTION



The Hoogstraat, Zwolle

Urban Forestascination

The starting point of this project was my fascination about trees and what they can mean for our urban environment.

Trees are more than just a beautiful addition to the environment. They are an essential component of the earth's ecosystem, providing a wide range of services that benefit both humans and wildlife. As a nature lover, I am fascinated by the intricate and complex relationships that trees have with their surroundings, and the invaluable role they play in sustaining life on earth.

Next to that, the underground system of trees is a fascinating and intricate network that is essential for the growth, survival, and health of trees. Many people tend to overlook the importance of the roots, as they are hidden from view, but the root system is just as important as the visible parts of the tree.

Trees in urban environments have a crucial role in managing water resources by capturing, storing, and releasing water. However, in urban environments, trees face several challenges in their capacity to store water. Pavement and other impervious surfaces can prevent rainwater from reaching the soil, reducing the amount of water available to trees. Additionally, soil compaction and pollution can also affect the ability of trees to absorb and store water.

Not only storing water, but the many other ecosystem services a tree can provide will help urban environments to become more climate proof. Landscape designers can help to achieve this, but the question is how?

the water Suol - Zwolle

Zwolle, located in the province of Overijssel in the Netherlands, is a city with a rich history and a strong connection to the natural environment. Surrounded by open and diverse landscapes, the city is known for its beautiful parks, green spaces, and waterways (Regio Zwolle, 2020).

The city has a long history with water, as it is situated at the confluence of several rivers, including the IJssel and the Vecht. This has led to the development of a unique water management system that has helped the city thrive for centuries. Today, the city continues to embrace its water heritage and has implemented several measures to protect against flooding and other water-related issues.

In addition to its water heritage, Zwolle is also known for its green spaces. The city is home to several parks. The city has also implemented several green initiatives, such as the 'Groene Agenda 2015-2025' (Gemeente Zwolle, 2015), which aims to create a sustainable and healthy living environment through the preservation and development of green spaces.

Furthermore, the city is committed to becoming climate-proof and aims to increase the city's resilience to extreme weather events such as heavy rainfall, flooding, and heatwaves (Gemeente Zwolle, 2020).

Urban Forestry Goal

The goal of this project is to turn Zwolle into an Urban Forest by integrating tree-ways and greenery not only in new urban expansions but also in existing urban environments. We should look beyond traditional urban planning approaches and consider innovative solutions that can enhance the quality of life for its residents while also addressing future challenges.

water Problems

The world's population is concentrated in densely built urban environments, and this trend is expected to continue and intensify in the coming decades. By 2050, it is estimated that 70% of the world's population will live in urban areas. However, this rapid urbanization has led to the disappearance of green spaces around and in cities itself, as they are replaced by new neighborhoods to accommodate the growing population.

Zwolle, with its population of over 130.000 and rapidly growing, the city has to built at least 1000 houses a year in their region (Gemeente Zwolle, 2020).

Not only is Zwolle dealing with space for the urbanization, it also has to deal with the climate change and the deterioration of its living environment.

One of the major challenges which Zwolle is facing climate change. The city experiences an increase in extreme weather events, including heavy rainfall, flooding, and heatwaves, which have led to damage to infrastructure, property, and public health. According to a study by the Royal Dutch Meteorological Institute (KNMI) (2023), the frequency of extreme rainfall events in the Netherlands is projected to increase by up to 25% by 2050.

Research question

How can a tree-way network be designed in a way that it contributes to improving water management in the urban environment of Zwolle?

Sub questions:
- How can tree-ways contribute to improving water management?
- Which spatial qualities can be used to design a tree-way structure that improves water management?
- What are the site specific water issues in Zwolle?
- What are the future traffic challenges that can contribute to a new design?

Relevance

Despite the growing awareness of the significance of green spaces in urban areas, urban forests have yet to receive much attention. While there are numerous designs for green spaces in cities, such as city parks, the concept of urban forests is still relatively new, and few examples of urban forest designs exist. This makes the focus of this thesis interesting.

The development of knowledge regarding Urban Forestry is not only interesting for landscape and urban designers but it can also be inspiring for the inhabitants of our densely built urban environments.

Methodology

This project is based on the idea that Urban Forestry is much more than only trees. The research methodology used for this project starts by separating it in 3 different approaches: the theoretical framework, site analysis and the design. Where on each level new knowledge will be gathered to strengthen the design.

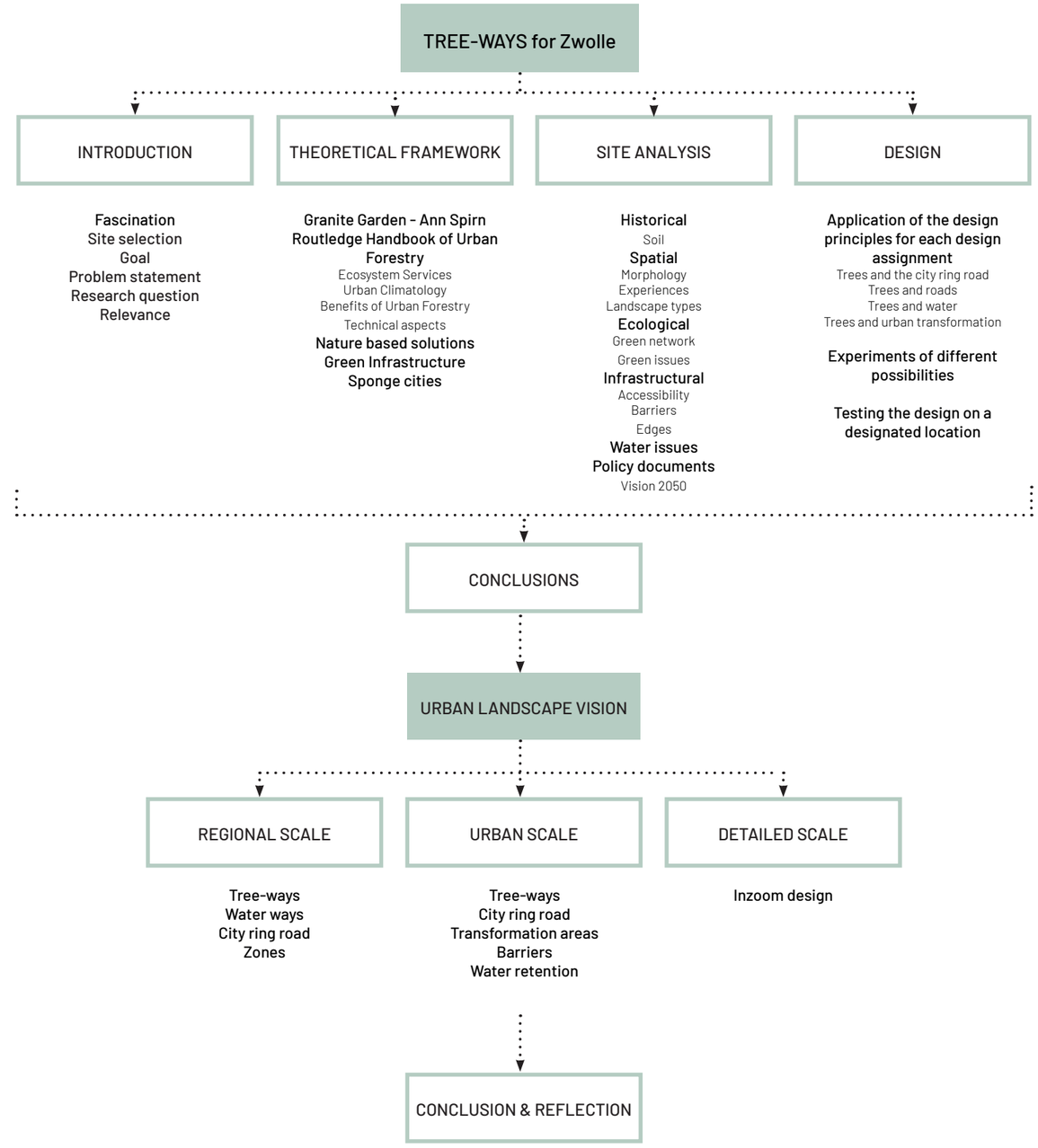
For the theoretical framework, different theories are used related to Urban Forestry. The purpose of this literature study, was to research the benefits of Urban Forestry and what they can mean for water issues in cities. The starting point of this literature study was the theory of Ann Spirn about Urban Nature coming from the book 'The Granite Garden', where she shows how cities can be transformed into more livable and sustainable spaces by incorporating green spaces, parks, and natural features. The Routledge Handbook of Urban Forestry could be used to gain more knowledge about Urban Climatology and the more technical aspects of the trees itself. All these theories can be used to design a new tree and blue structure, necessary for climate change.

Simultaneous with the literature study, the site analysis started in which GIS desk analysis, experiential analysis, case studies, policy documents and design experiments are used. In order to develop a comprehensive and layered understanding of the site's landscape, these 5 different dimensions form the basis of this analysis: spatial, social, environmental, ecological and economic. In the end, this analysis will define what the unique characteristics of this specific site are.

The last step in this process is the research by design. Research by design is an approach that combines research methods with design thinking. It involves using the process of design as a means of generating knowledge, exploring possibilities, and solving complex problems. By doing this, the design will continually be refined, gather feedback and make new decisions based on new insights.

In the end, the design should respond to the qualities of the location and enhance them. This will translate into a design on the regional scale, where an Urban Landscape vision will be made for Zwolle with a detailed design for a designated location where all the design assignments come together.

The conclusions and reflection at the end will give a review of the final design.



THEORETICAL FRAMEWORK

Newly planted trees in the Kleine Baan, Zwolle

THEORETICAL FRAMEWORK

The aim of this literature study was to gain more knowledge about Urban Forestry; why do we need more of them? What are the benefits of Urban Forests? How can we implement them? What is their connection with the urban environment? What is their relation to water issues? This literature study started by reading 'the Granite Garden' from Anne Spirn, which gave me a lot of inspiration for this thesis project.

The Granite Garden

'The Granite Garden' (Spirn, 1985) offers several important insights and ideas related to urban nature and the integration of natural elements into urban environments. Here are some key takeaways from the book:

Importance of Urban Nature: The book emphasizes the significance of incorporating natural elements, such as green spaces, parks, and water features, into urban areas. It highlights the numerous benefits of urban nature, including improved air quality, enhanced mental and physical well-being, and increased biodiversity.

Role of Community Engagement: "The Granite Garden" underscores the importance of involving communities in the design and revitalization of urban landscapes. It highlights the positive impact of community engagement in fostering a sense of ownership, promoting social cohesion, and creating spaces that reflect the needs and desires of the residents.

Sustainable Urban Planning: The book advocates for sustainable urban planning practices that consider the long-term ecological, social, and economic impacts of urban development. It encourages city planners and policymakers to prioritize environmentally friendly approaches, such as sustainable transportation, energy-efficient buildings, and the preservation of green spaces.

Designing with Nature: Anne Whiston Spirn argues for a design approach that integrates nature seamlessly into the built environment. She demonstrates how thoughtful design can transform urban spaces into vibrant, harmonious landscapes that benefit both humans and the natural world.

Holistic Perspective: The book promotes a holistic view of urban environments, considering the interconnections between ecological systems, human well-being, and the cultural and historical context of a place. It encourages designers and planners to approach urban design with a multidimensional perspective, taking into account social, cultural, and ecological factors.

Overall, 'The Granite Garden' underscores the importance of creating sustainable, livable, and nature-rich urban environments. It offers inspiration for designers, planners, policymakers, and community members interested in transforming cities into more resilient, inclusive, and environmentally conscious spaces.

This book was the inspiration for this project by gaining more knowledge about how nature can transform urban environments into a sustainable and livable city and how necessary it is do so for our future. In this project, Urban Forestry will be used as the natural element to incorporate. But what is Urban Forestry exactly?

Urban Forestry

In this project, the next definition is used for Urban Forestry, defined by the Routledge Handbook of Urban Forestry (Ferrini et al., 2017). It is the;

'art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic and aesthetic benefits trees provide society'.

It is about *all* trees, it is multi-disciplinary and it is about growing trees in densely built environments where growing space is limited and can become even more limited in the future.

The primary goal of urban forestry is to improve the quality of life for urban residents by enhancing the urban environment through the strategic use of trees.

Urban forests provide numerous ecosystem services, plays a role in mitigating climate changes and provides economic benefits.

The Routledge Handbook of Urban Forestry gave a clear explanation of the subject and gave even more inspiration to work with trees in cities. The question highlighted in this book was, how can we develop inclusive, safe, resilient and sustainable cities? Where the answer lies, at least part of it, in Urban Forestry.

~ Our urban world needs urban forests ~

But what are trees actually providing us?

Ecosystem Services

Ecosystem services refer to the benefits that humans derive from natural ecosystems, including trees. Trees provide numerous ecosystem services that are essential for human well-being and the functioning of the ecosystem. Some of the ecosystem services of trees include:

Provisioning services
products from ecosystems, such as food and water.

Regulating services:
benefits from ecological processes, such as air purification, regulation of water flows, climate regulation and lifecyle maintenance.

Supporting services:
necessary for the production of other eco system services, such as soil and oxygen formation.

Cultural services:
the non-material benefits from ecosys tems, such as aesthetic, inspiration for culture and information development.

Trees and other green spaces, such as wetlands, streams, lakes, green roofs, green walls, and gardens, have the capacity to provide all of these services. Additionally, individual trees themselves are capable of delivering these ecosystem services (Ferrini et al., 2017).

Numerous studies have examined both the positive and negative impacts of urban forests and trees, recognizing their potential to influence human well-being across various scales.

This literature review highlighted the diverse ecosystem services offered by trees and emphasized their significant value. In this project a focus point is the densely built environment, where new approaches are necessary to implement more trees.

Nature Based solutions

With the variety of benefits produced by trees and other vegetation, you would expect to have a lot of vegetation in cities. But the opposite is true. Urban green spaces are more and more under pressure. A trend in the the urban planning is that of densification. Densification is considered a solution to address the ongoing issues caused by urban sprawl and its numerous negative impacts.

When examining urban areas, it becomes evident that they impose limitations on the growth and survival of trees. Factors such as drought, poor soil quality, soil compaction, uneven distribution of light, transplanting shock, pollutants, salinity, pathogens, and conflicts with human activities frequently contribute to premature plant mortality, ultimately diminishing the overall advantages that trees can provide (Ferrini et al., 2017).

What measures can be taken to ensure that urban vegetation and green spaces are integrated into our goals to build inclusive, safe, resilient, and sustainable cities? Urban Forestry, a nature based solution, is again the answer.

Nature based solutions defined by The Routledge Handbook of Urban Forestry (Ferrini et al., 2017):

'Actions which are inspired by, supported by or copied from nature. Nature-based solutions use the features and complex system processes of nature, such as its ability to store carbon and regulate water flow, in order to achieve desired outcomes, such as reduced disaster risk, improved human well-being and socially inclusive green growth. Maintaining and enhancing natural capital, therefore, is of crucial importance, as it forms the basis for implementing solutions'.

Trees are seen as the green solution in which they are the key provider of ecosystem services that help cities. However, to achieve this, a good structure is necessary.

In addition to nature-based solutions, another approach that emerges is the green infrastructure approach.

Green Infrastructure

The green infrastructure approach is described as "the integration and strategic planning and delivery of networks of connected greenspace" by Ferrini et al. (2017). This approach has gained widespread acceptance as a valuable policy and planning instrument in a short period of time.

~ "**As a network, Green Infrastructure can include parks, open spaces, playing fields, woodlands, but also street trees, allotments and private gardens. It can also include streams, canals and other water bodies and features such as green roofs and walls.**" ~
(Ferrini et al., 2017)

In the urban green infrastructure planning, the next 7 principles are identified.

Network/connectivity

Multifunctionality

Grey-green integration

Multi-scale

Strategic

Inter- and transdisciplinary

Socially inclusive

From Davies et al. (2015)

In short, it is important; to interlink green spaces; to have ecological, socio-cultural and economic benefits; to coordinate urban green with urban infrastructures; on different spatial level; as a long-term spatial vision; to link between science, policy and practice and to aim for collaborative processes (Davies et al., 2015).

This approach inspired this project to include the bigger vision on the regional scale as well. Not only to connect green spaces but also to know more about the how. In this case, by coordinating it with infrastructural elements. In line with using infrastructural elements, the sponge citie is a new paradigm in urban water managment.

Sponge Cities

A sponge city is a city that is designed to absorb and manage rainwater and stormwater runoff, in order to reduce flooding and improve water quality. The concept of a sponge city originates from China, where many urban areas have experienced rapid urbanization and increased risk of flooding due to climate change and inadequate urban infrastructure.

Sponge cities are designed to mimic the natural hydrological cycle by incorporating green infrastructure, such as parks, green roofs, rain gardens, and wetlands, into urban landscapes. These features help to slow down and absorb rainwater and stormwater runoff, reducing the amount of water that enters the stormwater system and preventing flooding.

Overall, the concept of a sponge city represents a new paradigm in urban water management, shifting from traditional "gray" infrastructure, such as concrete channels and storm drains, to a more sustainable and resilient approach that incorporates green infrastructure and enhances the natural environment. (Campbell, M., 2022)

The purpose of this literature study, was to research the benefits of Urban Forestry and what they can mean for waterissues in cities. To conclude, Urban Forestry is an important instrument to mitigate and adapt to climate change. To do this, new urban planning approaches are necessary, in which landscape design should take a much bigger part. This inspired this project to transform gray infrastructure into green infrastructure, by using Urban Forestry.

THE HISTORICAL-WAY OF ZWOLLE

The Peperbus, Zwolle

Timeline

The title 'tree-ways of Zwolle' is based on the lines that are visible over the whole city. And to show you these lines, the history is very important.

The history of Zwolle starts on a sand ridge along the Zwarte Water. They called it Zwolle which literally translates to Swollen.

In 1230 Zwolle obtained city rights and started to built a wall around the city with 3 entry's to Assendorp, Kamperpoort and Dieze.

In the 17th century, the fortifications made the center independent. The Nieuwe Vecht was dug and made it possible to transport the peat to Amsterdam.

In the 18th century, multiple tree-lined alleys were constructed for the beautification of the city. The early use of trees was mainly because of necessity and sometimes nicety. They planted them for food and valued them for shade and aesthetics (Ferrini et al., 2017). The tree-lined paths, allées, developed around the 17th century for relaxation and walking as part of big villas. After that, it moved from the rural to the cities, as public promenades along canals, earthwork fortifications and for recreational activities (Ferrini et al., 2017).

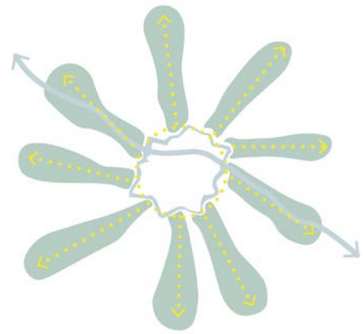
In the 19th century, the Willemsvaart was dug to connect the inner city with the IJssel.

After that, the railway was constructed, which made Zwolle the second junction of the Netherlands, also called the turntable of the North. In 1930 the IJsselbrug was constructed.

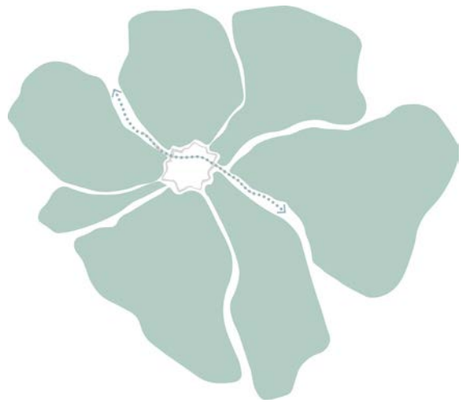
In 1980-2000 Zwolle-South was mainly expanding and some worklocations were realised.

Around 2000 the building of Stadshagen was started which is now still expanding.

Due to the parallel location of the sand ridge along the IJssel and the Vecht, Zwolle originally had a linear shape. It reoriented itself several times towards the water but with a basis of some city streets it made a form like a small flower.

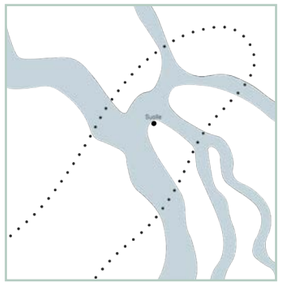


All the expansions along and between these lines made it then look like a grown flower.

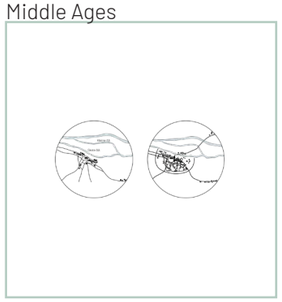


It went from moving with the water to moving along the streets. Which resulted into different isolated areas, which are connected to the outer areas but not connected with eachother.

These streets were beautiful tree lined streets but are now taken over by cars which makes the interconnection even worse.



Middle Ages



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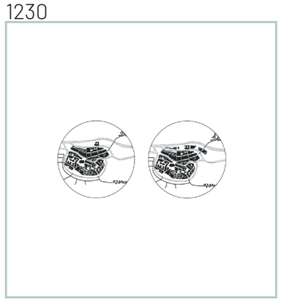
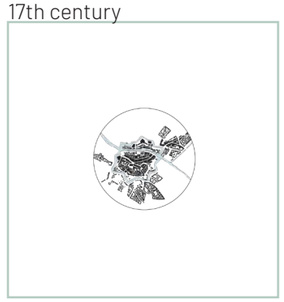
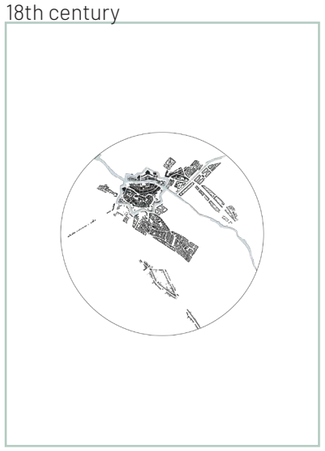


17th century

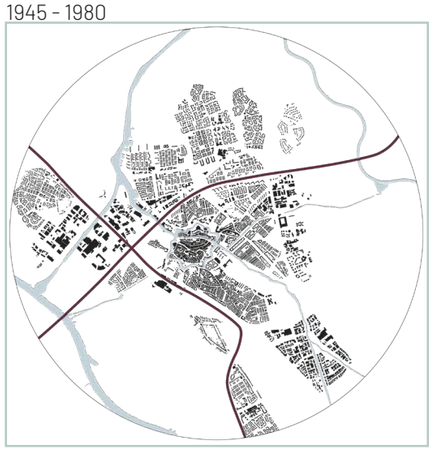


18th century



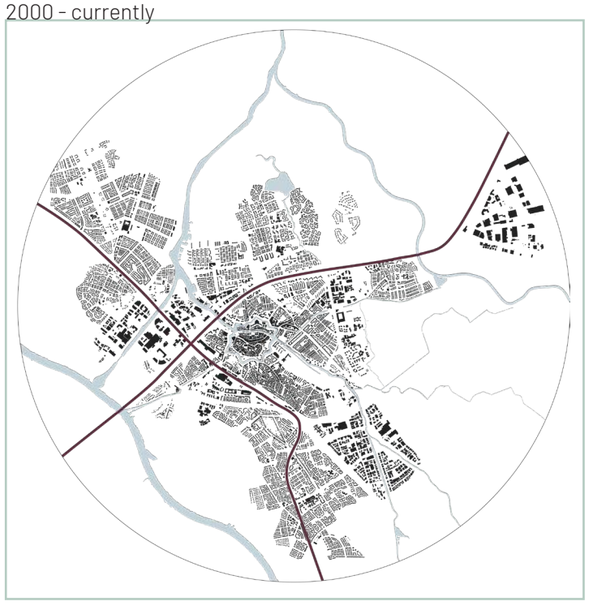
19th century - 1930

1945 - 1980



1980 - 2000

2000 - currently



Old tree-ways

The old tree structures that lined the streets of the city were not merely static elements of the urban landscape. They served as more than just providers of shade or aesthetic beauty. In fact, they played a big role in shaping the city and its relationship with nature.

As the guiding lines of the city, the old trees stood as resilient witnesses to the passage of time. Their presence offers a tangible connection to the past.

Beyond their historical significance, the trees acted as vital connectors, linking the urban population with the natural world. Amidst the concrete and steel, they provided a breath of fresh air, both literally and figuratively. Under their canopy, people found comfort, shelter, and a temporary escape from the urban life. They became meeting points, gathering spots, and spaces for reflection. The old tree structures provided a sense of calm amidst the chaos.

Understanding the intricate relationship between the city and the forest was made possible through the presence of these old tree structures. They served as a visual reminder that nature and urban development are not mutually exclusive but rather interconnected. The trees demonstrated that a harmonious coexistence between the built environment and the natural world is not only possible but essential for the well-being of both.

This tree structure also formed the green network of today.

The old tree structures lining the city streets played a multifaceted role in the urban fabric. They were the guiding lines of the city, connecting its inhabitants with nature and offering a tangible link to the past. But nowadays the car has taken over the streets and trees had to make space for them...

Cars taking over the streets.
from https://www.archieven.nl/

Old tree structures lining the city.
from https://www.archieven.nl/

Zwolle as a city of lines

Transforming Zwolle into an urban forest requires more than just scattered pockets of greenery. What is crucial is the establishment of a comprehensive network of green lines throughout the city. But how can this be achieved?

Zwolle's original linear nature provides a foundation on which to build. The city's historical linearity can serve as a guiding principle for future development. Embracing this concept of lines is not just about decoration; it is about adding spatial quality and structure to the urban environment.

The transition from mere decoration to ecology is essential. It entails embracing concepts such as rewilding and nature inclusivity. By giving structure to the city through the implementation of green lines, Zwolle can create a thriving urban forest that not only enhances its aesthetics but also promotes biodiversity and ecological resilience.

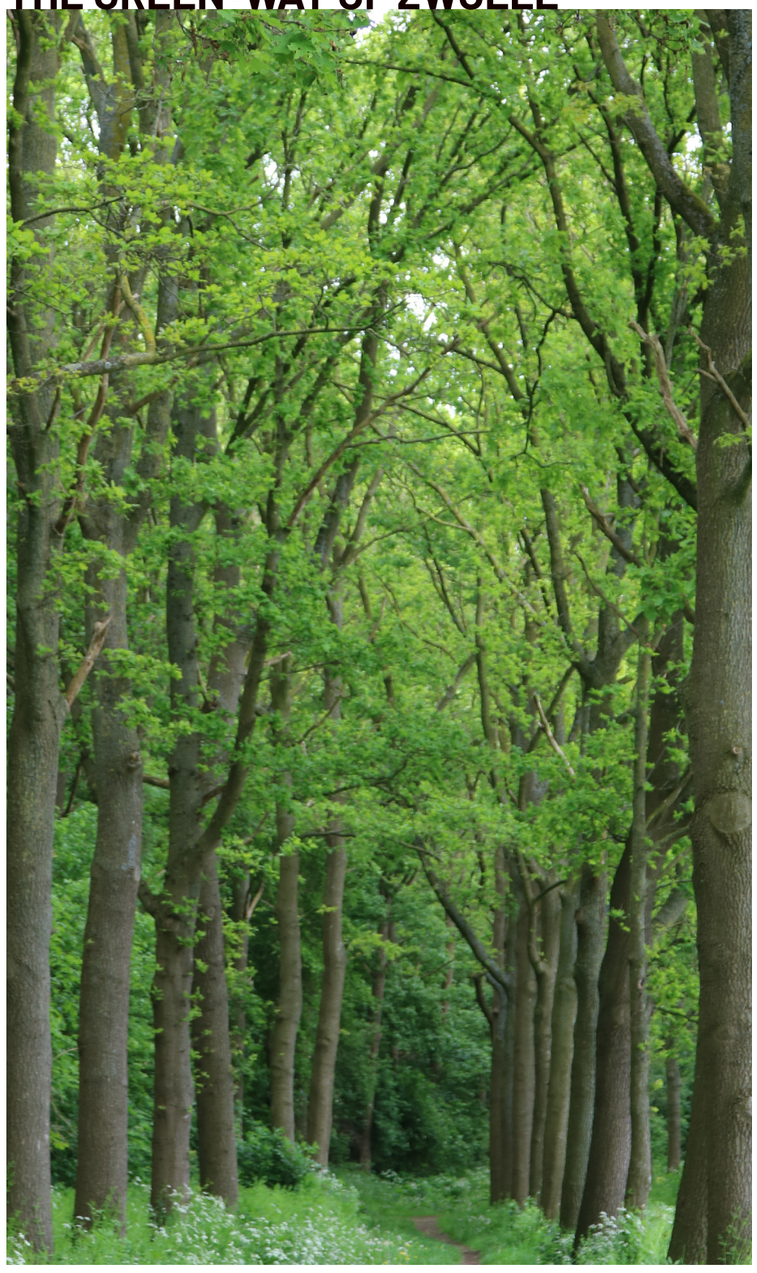
The upcoming chapters will further explore the importance of lines in reshaping Zwolle. The city must once again adapt and move forward, just as it did in the past. Growing along lines is not enough; there must also be a focus on connecting different areas. Strengthening these connections will foster a sense of unity and cohesiveness within the urban fabric.

Zwolle's transformation into an urban forest requires a holistic approach, encompassing both the creation of green lines and the establishment of meaningful connections between them.

In the coming chapters, the green-way, the water-ways and the mobility-way will be discussed. These chapters primarily focus on the current existing lines and the ones that have disappeared. They will also examine the issues faced by these lines, with the aim of finding solutions to address them in the future design.

Branch network, Meeuwenlaan, Zwolle

THE GREEN-WAY OF ZWOLLE



An elephant path in the green buffer zone along the A28, Zwolle

Big green infrastructure

Zwolle, known for its green surroundings, is a city that embraces nature within its urban landscape. Situated in the province of Overijssel in the Netherlands, Zwolle is blessed with plentiful green spaces, parks, and gardens. Zwolle is a green city, but it can be much greener.

It not only can, but it must.

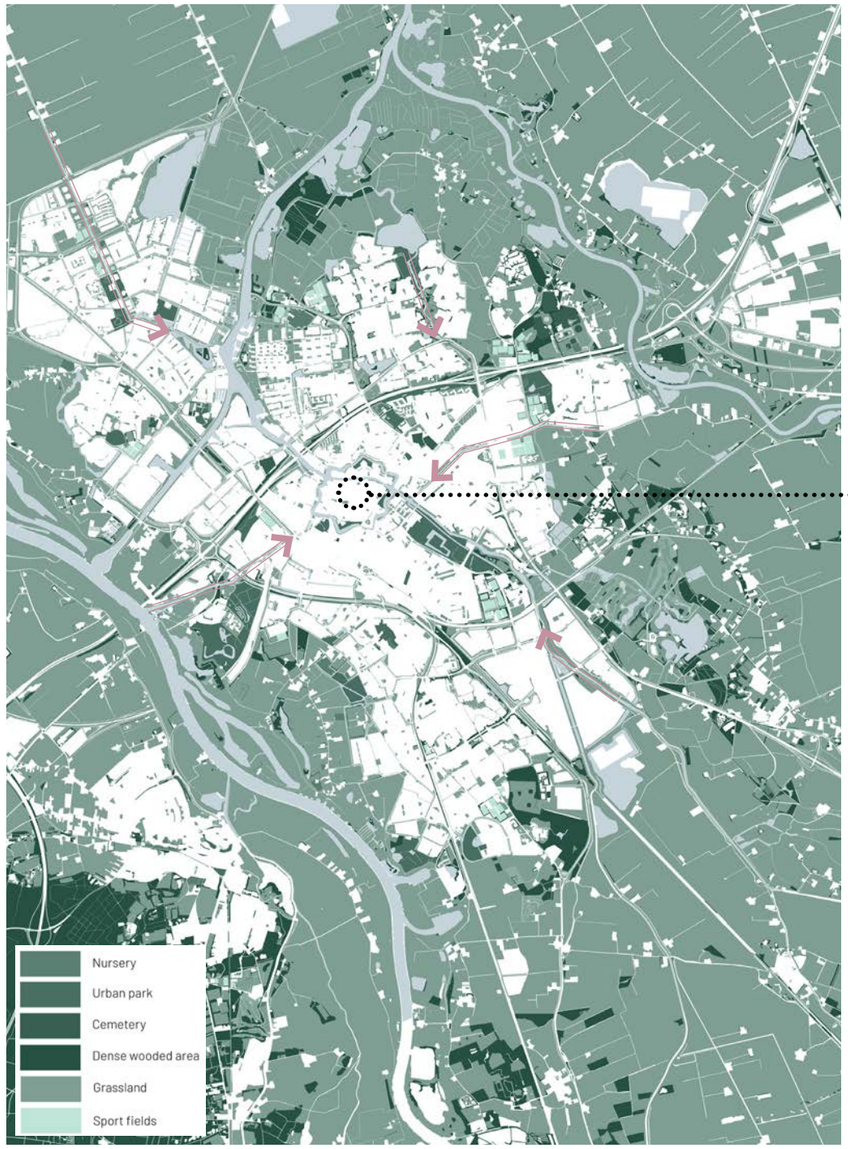
Starting at the biggest scale, the Zwolle region is home to six different landscapes. They are all within relatively short distances of each other and exists of: peat excavation, sandy landscapes, marshland, river clay landscapes, glacial hill landscapes, and reclaimed polders.

When we look at the green structure of Zwolle itself, we see on the large-scale a main green structure that is divided into four layers:

The three rivers: IJssel, Vecht and Zwarte Water.
The Green Fingers: these are the main green guiding zones in the city.
Most green fingers are located along the waterways (pink arrows).
Green along infrastructure lines: it con sists of narrower green zones along roads and canals.
Recreational areas: such as the 44 parks within Zwolle.

What we can see is that green is present in the entire urban fabric, but it often forms isolated spots and bears no continuity, although it looks like they are well connected in the 'Hoofdgroenstructuur' map on the right (Gemeente Zwolle, 2020). They do have the green fingers and the green zones along the infrastructure lines as a way of connecting it, but they consist of very low quality green such as a grassland.

This network looks quite well connected on an ecological level, because of the big rivers they included in the map and the low quality green that connects everything. But for example on the social level, the green is not accessible for people. Along the river, there is no continuous path. Along the infrastructural lines (black arrow in the map), such as the train track, there is no attractive route to walk or bike. Only the parks are truly designed for people. From a spatial point of view, the parks are well spread over the city.



'Hoofdgroenstructuur' of Zwolle
From: Gemeente Zwolle, 2020

Lastly, if we look at the environmental dimension. Zwolle is one of the forerunners, with big ambitions and operates from a climate-resilient approach. They continually adapt to the spirit of the times. The central ambition for Zwolle is to preserve and enhance its spatial, cultural-historical, and landscape qualities.

To achieve a greener Zwolle, it would be beneficial to enhance the connectivity and accessibility of green spaces, creating a more continuous and attractive network. This would not only improve the social dimension but also contribute to the overall environmental quality of the city.

By continuing their sustainable efforts and embracing nature, Zwolle can further strengthen its position as a green and liveable city.

Small green infrastructure

The small green infrastructure of Zwolle refers to the network of smaller-scale green spaces and features within the city. These green elements, such as neighborhood parks, gardens, green squares, and street trees, contribute to the overall green fabric of Zwolle and provide important benefits to residents and the environment.

These small green spaces play a significant role in enhancing the livability and well-being of the city's residents. They offer accessible and inviting areas for relaxation, recreation, and social activities. Neighborhood parks, for example, provide opportunities for children to play, families to gather, and individuals to enjoy nature in their immediate surroundings.

Zwolle, despite its progress in greening the city through the establishment of parks, still experiences the presence of isolated spots. While efforts have been made to enhance the urban green infrastructure, there are areas within Zwolle where the absence of a park is felt and considered necessary. These specific areas include the Spoorzone/Hanzeland, Assendorp, and Kamperpoort, all situated in the heart of Zwolle's city center. These neighborhoods, characterized by their central location and dynamic communities, would greatly benefit from the creation of parks.

This vision of greening the city by parks can be strengthened by also thinking of how they can be connected. And even more important, the accessibility towards these parks, to make it spatially and visually more inviting.

Right now, the mainly forested parks are quite diverse in their spatiality. Sometimes they form a border, sometimes it is a big park, sometimes just a row of trees, all there to make the city more green.

Those street trees and green squares/parks are not only there to enhance the aesthetic appeal of Zwolle but also provide numerous environmental benefits. They help to improve air quality, reduce the urban heat island effect and mitigate the impact of heavy rainfall.

Different isolated green spots in the neighbourhood
From: Google Earth

Recognizing the value of green spaces and the desire to meet the needs of these specific areas, efforts to address the lack of parks in these locations could be considered in future urban planning and development initiatives. By integrating new parks into the Spoorzone/Hanzeland, Assendorp, and Kamperpoort areas, Zwolle can further enhance its urban green infrastructure, promoting a healthier and more sustainable urban environment for its residents.

'Wijkgroenstructuur' of Zwolle
From: Gemeente Zwolle, 2020

Green connections

A green connection refers to a physical or conceptual link between different green spaces or natural areas. It is a pathway or corridor that allows for the movement of people, wildlife, and ecological processes, while also promoting the continuity and accessibility of green areas.

Green connections can take various forms, such as walking or cycling paths, trails, green corridors, or linear parks. They can traverse urban, suburban, or rural landscapes, connecting parks, gardens, forests, wetlands, and other natural areas.

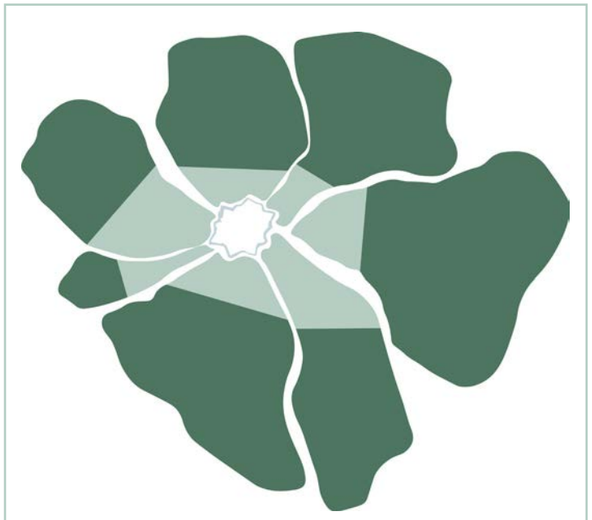
These connections are part of the main and neighborhood green structure.

As we can see on the map, the parks are distributed throughout the whole city. The pink circles indicate a distance of 1 km around large parks and 400 meters around small parks. This shows that many neighborhoods are within walking distance of a park. However, it also highlights that the Spoorzone/Hanzeland, Assendorp, and Kamperpoort areas stand out in a negative way. The existing parks in these areas are small in size and limited in number.

The map below shows the current connections between the parks. These are mainly green zones along the infrastructure and sometimes accompanied by rows of trees. In the inner center, the white areas stand out and once again, the Spoorzone/Hanzeland, Assendorp, and Kamperpoort areas stand out negatively in this regard. Compared to the inner city, the expansion neighborhoods of Zwolle have many alleys and avenues, although these roads are still primarily designed for cars.

Lastly, it is also worth noting that the current connections are primarily through waterways and not, for example, through linear parks.

In summary, when looking at the green infrastructure, the Spoorzone/Hanzeland, Assendorp, and Kamperpoort areas stand out negatively. The old rows of trees that were once present have disappeared or are no longer recognizable. The existing rows of trees are mainly found in the expansion areas. Zwolle should focus more on green spaces in the city centre and most importantly, on connecting them.



In the flower metaphor, it can be said in a very abstract sense that the center of the flower lacks sufficient connections. These are the areas where the green structure is not optimal and where more attention should be given in the future.

Old green connections

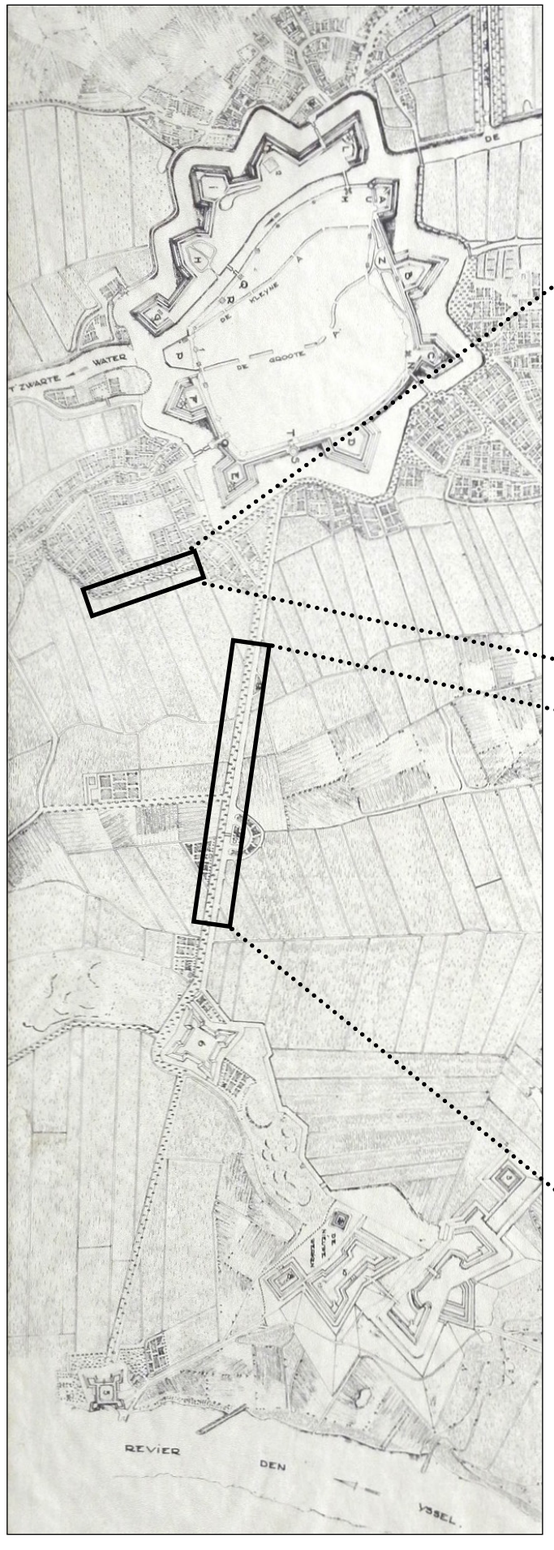
As mentioned before, the first tree-lined alleys were constructed in the 18th century as a public promenade along canals, fortifications and for recreational activities. They made the streets more beautiful and made the visual connection better.

Two examples of old green connections can be found in the city. Some of them still exist, but their nature has changed over time. The focus has shifted towards accommodating cars, and the once-prominent role of these connections as pedestrian promenades has been diminished.

While some streets still retain their green character, they have become more car-oriented, with less emphasis on creating pleasant walking environments. The original vision of these streets as inviting and pedestrian-friendly spaces has been eroded.

Unfortunately, some green connections have been completely removed. Trees that once lined the streets, serving as the foundation of the city's expansions, have been lost. These trees not only provided aesthetic beauty but also contributed to a nature-based and environmentally friendly urban environment.

It is important to reflect on these changes and consider the value of returning to a more nature-based approach in urban planning. By revisiting the principles that guided the initial design and expansion of the city, we can strive to reintroduce green connections that prioritize pedestrians and create a more sustainable and enjoyable living environment.



The single tree left from the double rowed old veemarkt, Zwolle

The double row of trees along the Veerallee, Zwolle

Importance of trees

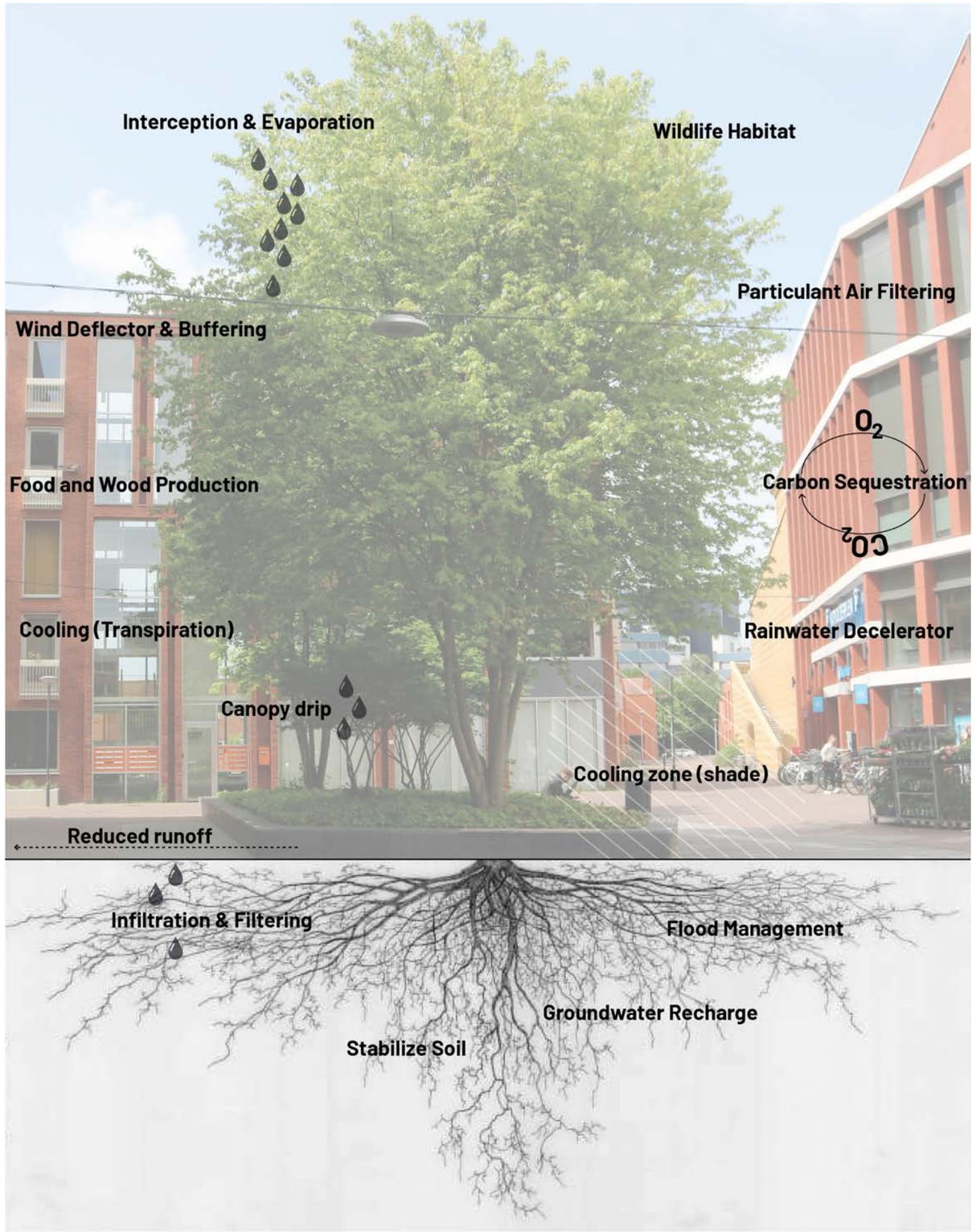
Trees play a crucial role in our urban environments, and their importance cannot be overstated. As previously mentioned, trees provide numerous ecosystem services that benefit both humans and the environment. However, it is worth diving deeper into their significance to gain a better understanding.

When considering the importance of trees, it is helpful to examine them through the lens of the five dimensions: social, spatial, ecological, environmental and economic.

The **social dimension** recognizes the role of trees in enhancing the well-being and quality of life for residents. They provide shade, improve air quality, reduce noise pollution, and create inviting spaces for recreational activities and community gatherings.

From a **spatial perspective**, trees contribute to the aesthetic appeal of the urban landscape. They add visual interest, soften the built environment, and creates a sense of tranquility and connection with nature. Moreover, they define and structure urban spaces, forming green corridors and boundaries that guide and shape our experience of the city.

In the **ecological dimension**, trees are vital for supporting biodiversity. They provide habitat, food, and nesting sites for various organisms. Additionally, trees play a role in mitigating climate change by sequestering carbon dioxide and reducing the urban heat island effect.



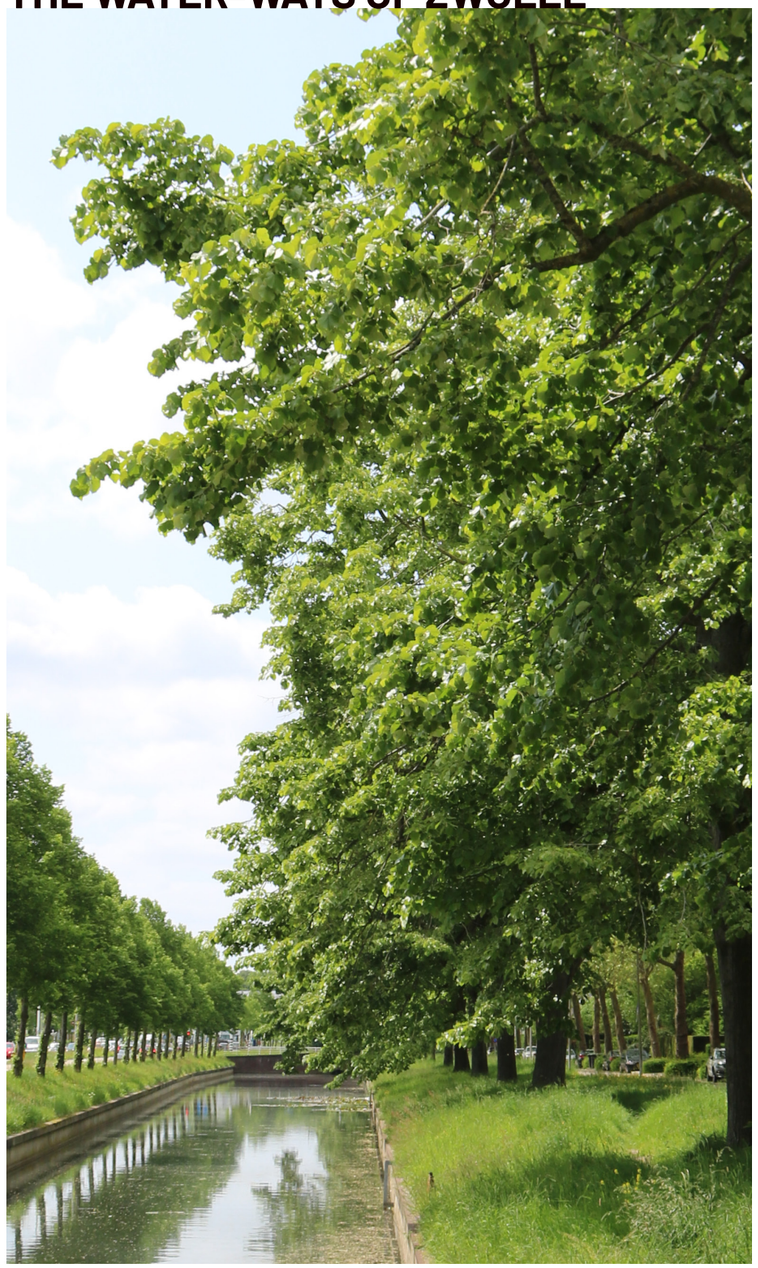
The **environmental dimension** encompasses the broader impact of trees on the environment. They help to improve air quality by filtering pollutants and producing oxygen. Trees also contribute to the overall health of ecosystems by retaining water and preventing soil erosion.

Lastly, trees have **economic value**. They enhance property values, attract businesses and tourists, and contribute to the overall economic vitality of cities. Studies have shown that tree-lined streets and green spaces can increase retail sales and property prices.

In terms of water retention, trees act as natural sponges, absorbing rainfall and reducing the risk of flooding. Their roots help to stabilize the soil and prevent erosion, while their canopy intercepts rainwater, allowing it to slowly infiltrate into the ground. This function is particularly crucial in urban areas where hard surfaces, such as concrete and asphalt, impede natural water absorption.

Understanding the multi-dimensional benefits of trees reinforces the need to prioritize their preservation, planting, and management in urban planning and development. By recognizing and valuing the diverse roles that trees play in our cities, we can work towards creating more sustainable, resilient, and liveable urban environments for present and future generations.

THE WATER-WAYS OF ZWOLLE



The Veerallee, Zwolle

The watersystem

In addition to researching the green structure of Zwolle, the water structure is equally important. Zwolle has grown due to its proximity to the IJssel, Zwarte Water and Vecht, which allowed for transportation. Not only Zwolle, but all cities are currently facing the challenges of climate change and its associated problems. For Zwolle, the issues primarily revolve around water, where there is insufficient space for the rivers and the inability to effectively drain rainwater.

This research is done to identify the water problems that Zwolle faces and their locations, in order to design solutions that address them effectively.

Water in the region flows from the elevated lands in the east and south (Veluwe, Sallandse Heuvelrug, and Drents Plateau) through streams and a network of waterways. The IJssel and Vecht rivers naturally drain water towards the IJsselmeer. However, due to climate change and decisions regarding the national water system, this regional system is facing challenges. Altering the existing water management directly conflicts with current land usage, both in urban and rural areas, thereby posing risks to housing, livelihoods, and nature (INFRAM, 2018).
Three key "water buttons" play a crucial role:

- The IJsselmeer water level;
- The river discharge distribution;
- The water management in the hinterland of the Zwolle Region.

These challenges are already high on the priority list of the municipality of Zwolle.

The municipality of Zwolle (2015) is tackling these challenges with a possible new blue/greenstructure.

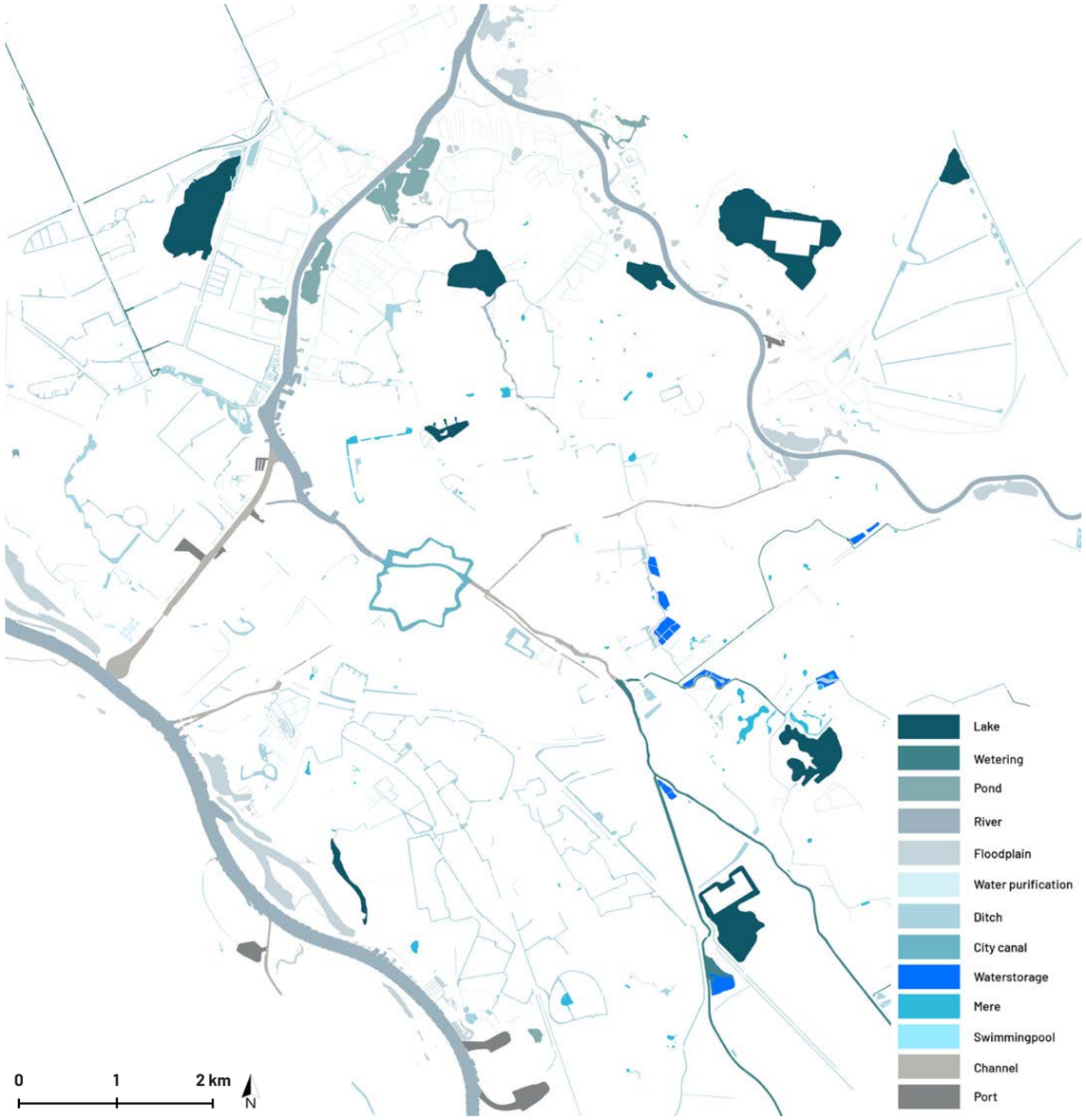
This blue/greenstructure is based on:

- Utilizing, retaining, and slowing down water at the neighborhood level to enhance its sponge effect.
- Implementing a green-blue infrastructure that facilitates water drainage and storage, reducing the risk of heat stress.
- Establishing emergency outlets for the green-blue infrastructure and designated overflow areas to redirect water during extreme situations.

This seems like a good idea, but they cannot provide further explanation yet. There is, however, an initial design concept, primarily focused on increasing surface water and connecting these bodies. Specifically, the emphasis is on the blue structure.

In addition to the three water buttons, climate change plays a significant role in the water management of Zwolle. There is more rainfall in the summer, more frequent rainfall, but also more drought. The drought mainly leads to a decrease in groundwater levels and the associated problems. Meanwhile, extreme rainfall situations result in water on the streets, where the water cannot drain away.

To conclude, the water comes from four different waterflows: climate change, groundwater, river and the sea level. And from these waterflows, different challenges occur. The challenges posed by climate change vary across different areas. Some neighborhoods experience minimal or no issues due to factors such as higher elevation, abundant green spaces and efficient drainage systems. However, in other parts of the city, the impact of waterlogging and heat stress is noticeably increasing.



Risk areas

Some neighborhoods experience minimal or no issues and in other parts of the city, the impact of waterlogging and heat stress is noticeably increasing. But what are the neighborhoods which do experience issues? And what kind of waterissues do they have?

The municipality of Zwolle did a climate stress test to determine the sensitivity to various climate stress indicators, such as waterlogging, heat, drought, and flooding consequences.

The map shows the neighborhoods which scored the highest on this test. And just like in the green infrastructure study, Kamperpoort and Assendorp show negative results.

They have the highest amount of pavement and almost no surface water, which results into the highest score on waterissues on the street.

These two neighborhoods scored the lowest on the 'sponge effect'.

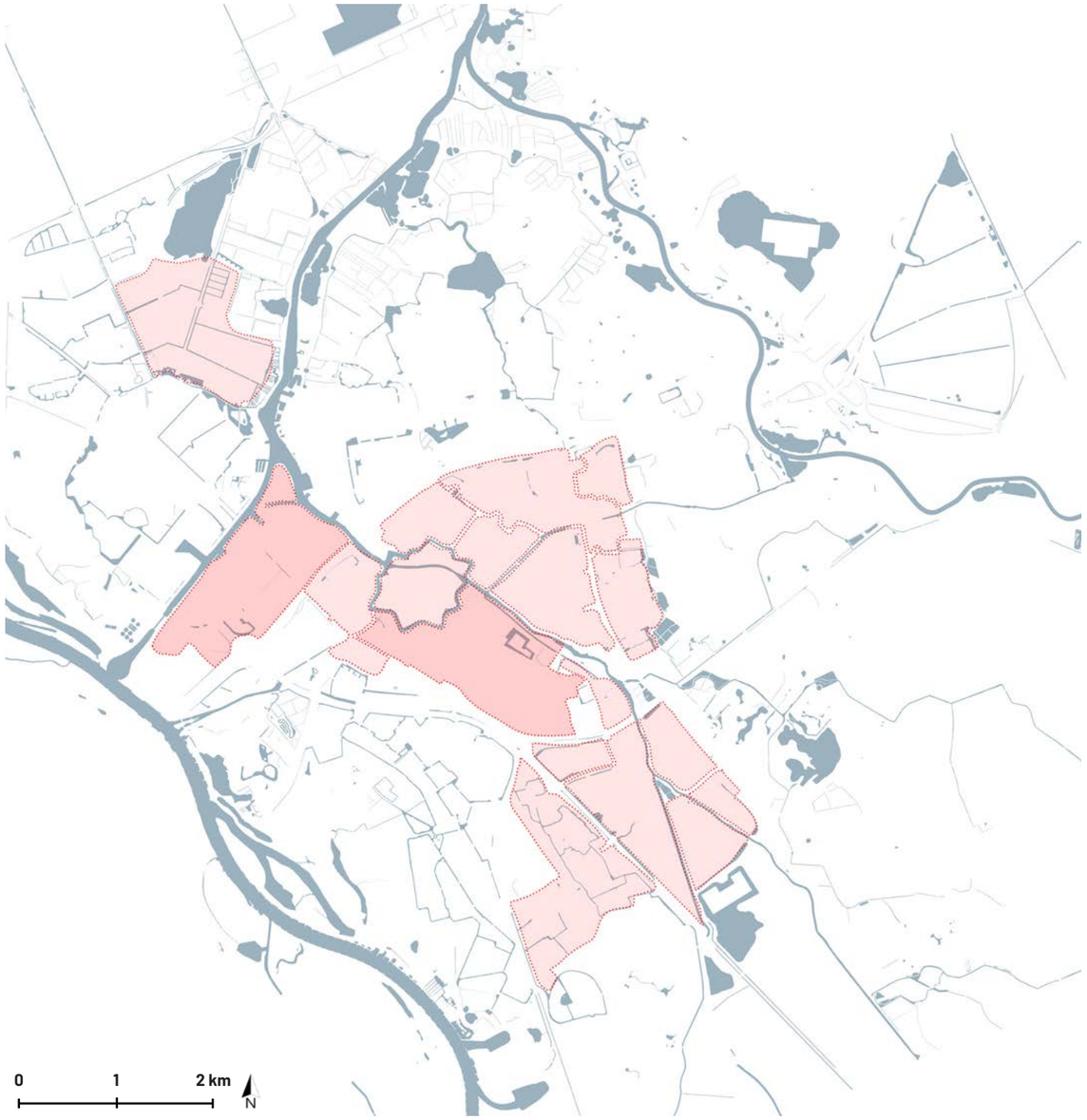
Zwolle has the ambition to develop into the most blue-green city in the Netherlands, acting as a super sponge (Zwolse Adaptatie Strategie, 2017). To achieve this, living with water is central, with a focus on retention, storage, and drainage.

Zwolle also has ambitions to address the consequences of drought, but these ambitions do not go much further than setting a maximum limit for lowering the groundwater level by 15 cm. The how, where, and who are not specified.

As mentioned before, there is an initial design concept, primarily focused on increasing surface water and connecting these bodies. And to get Zwolle climate proof, they want a proper connection to the main water system, a good sponge effect and overflow areas.

The term sponge effect also refers to a green structure, but the various explanations are primarily focused on the water system.

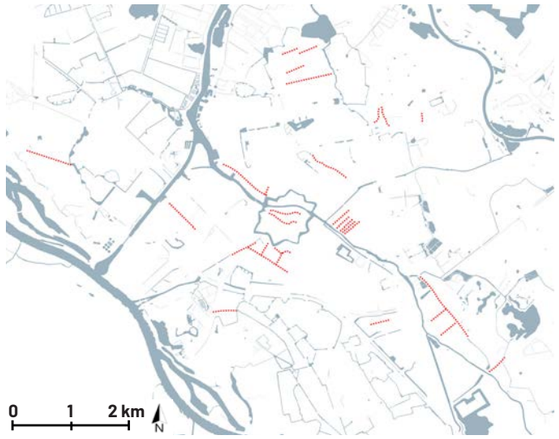
The water issues occur throughout the entire city, but a few neighborhoods stand out in a negative way. Considering the municipality's focus primarily on the water system, I believe it is important to emphasize the sponge effect and give the green structure a more significant role.



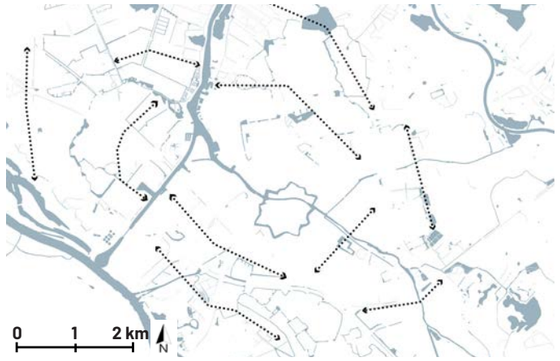
The waterways

The municipality provides a lot of information about the watersystem but what are my own conclusions based on the waterways? This part will go deeper into the existing waterways, the waterways from the past and which waterways are the most important for Zwolle.

Historically, Zwolle had a more extensive network of waterways compared to the present. Some waterways were filled in earlier due to diseases, while others disappeared later due to urban expansion. But the two old waterways, which were used for transportation to Amsterdam and other places, are still there. These are the Nieuwe Vecht and the Veerallee. The Veerallee is shortened a little bit compared to the past. Especially in the city center, many waterways had to make space.

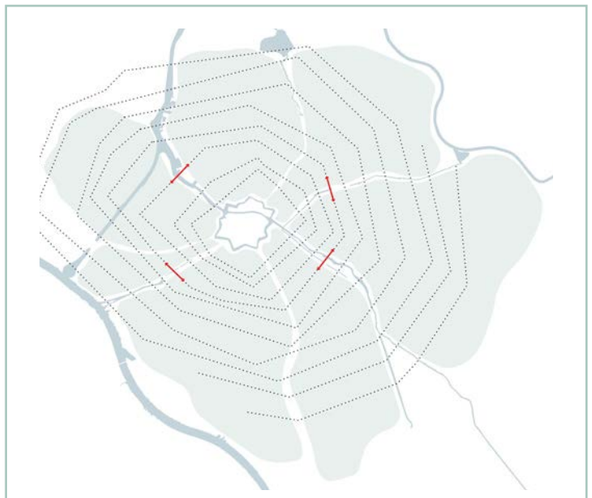


What is interesting is that all the waterways are circularly oriented around the old city center. This gives the impression that the waterways provide good connectivity throughout the city. However, many of these waterways are relatively short, and the opposite is actually true.



Zwolle considers water to be very important, but the focus is primarily on the major bodies of water such as the IJssel, Zwarte Water, and Vecht. Within the city itself, there have only been statements about wanting more water. A new water network is mentioned, but what would it look like?

Zwolle itself primarily envisions a network based on the larger bodies of water, with improvements and widening of these waterways. However, I believe it is crucial for this city to utilize water as a means to connect different neighborhoods. By following the direction of the old waterways, new connections can be established between neighborhoods, enhancing both connectivity and climate resilience.



In the current flower, the focus is on the connections. The existing major waterways provide a connection to the outside of the city, but the internal connections are lacking and need to be added to improve the city. This can be achieved by adding more waterways, restoring old waterways, or improving, extending, and widening existing waterways. This approach aligns with the city's ambition to enhance its sponge effect.

THE MOBILITY-WAY OF ZWOLLE

The train track along the Rieteweg, Zwolle

Gray infrastructure

The third 'way' which is important for Zwolle, is the mobility-way. Mobility refers to the ability to move. It includes various modes of transportation, including walking, cycling, driving, public transportation, and other forms of travel. As this infrastructure forms the basis of the network in Zwolle, it is important to do more research on it.

To start with the different infrastructural elements. Zwolle has a well-developed infrastructure for cars, with a network of roads and highways that efficiently connect different parts of the city and provide access to neighboring regions. The road system includes both local streets within neighborhoods and larger arterial roads that connect to major highways.

At the same time, these major roads also form barriers within the city. Particularly, the highway and the inner ring road are designed to be wide, and the highway is further separated by a green buffer zone. As a result, these roads create not only visual but also functional barriers.

Parking facilities are available throughout Zwolle, including both on-street parking and designated parking lots and garages.

Zwolle also encourages sustainable transportation options for cars. The city has implemented car-sharing initiatives, electric vehicle charging stations, and supports the use of environmentally friendly vehicles.

Like many cities in the Netherlands, Zwolle promotes a multi-modal approach to transportation, encouraging residents to use alternative modes such as cycling, walking, and public transportation. This approach aims to reduce reliance on cars and promote a more sustainable and livable urban environment.

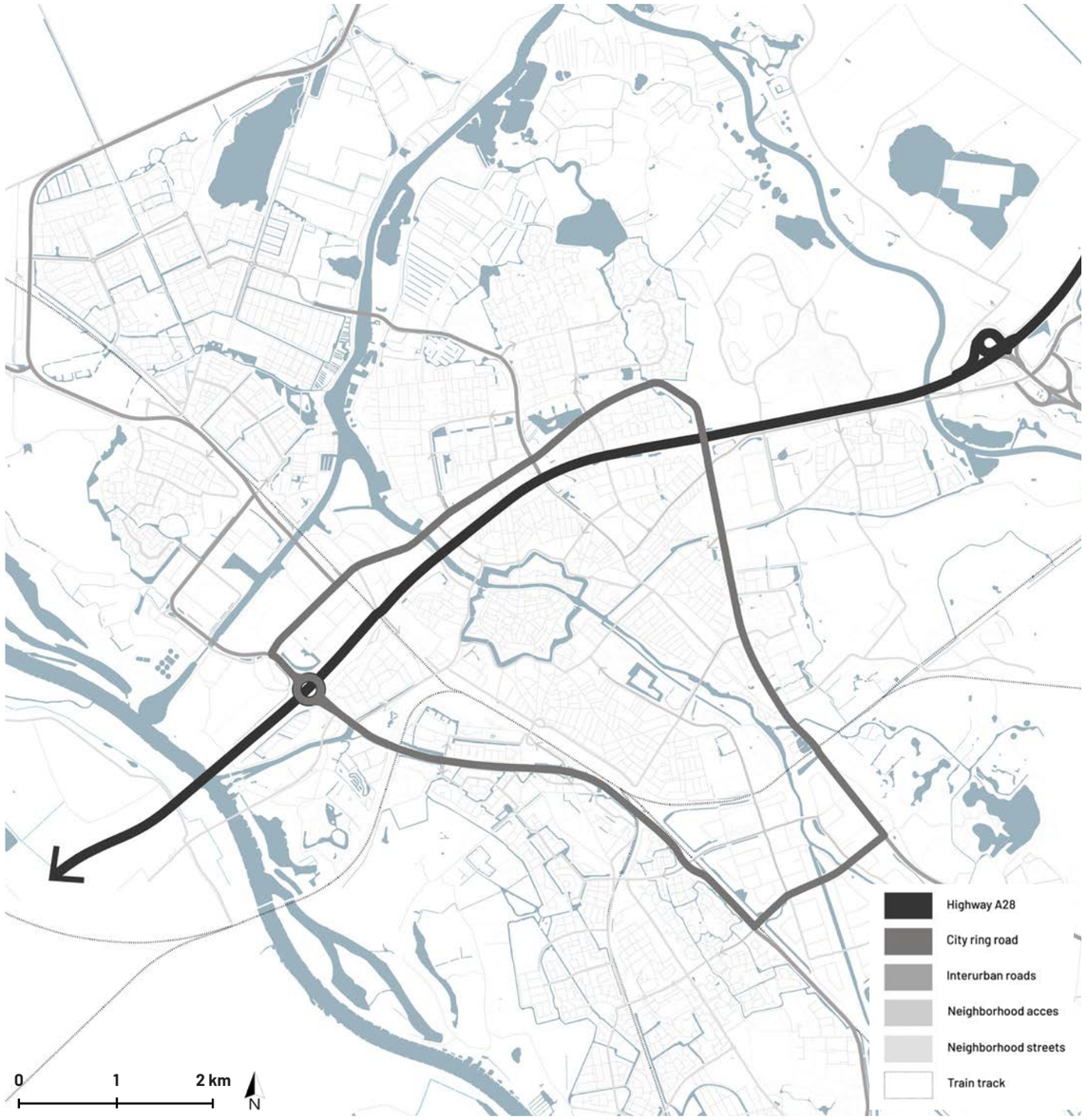
Also the public transportation in Zwolle is well-developed and plays a crucial role in the city's transportation system. The primary mode of public transport in Zwolle is the bus network. It has an extensive bus network that connects various neighborhoods within the city and provides convenient access to neighboring towns and villages.

The central train station, located in the heart of the city, serves as a major transportation hub. It provides excellent connectivity to other cities in the Netherlands, including frequent train services to destinations such as Amsterdam, Utrecht, and The Hague.

The train station also offers connections to international destinations.

Zwolle is also known for its bicycle-friendly infrastructure, and many residents combine cycling with public transport for their daily activites. The train station and several bus stops have bicycle parking facilities to encourage their multi-modal approach. (Gemeente Zwolle, 2020)

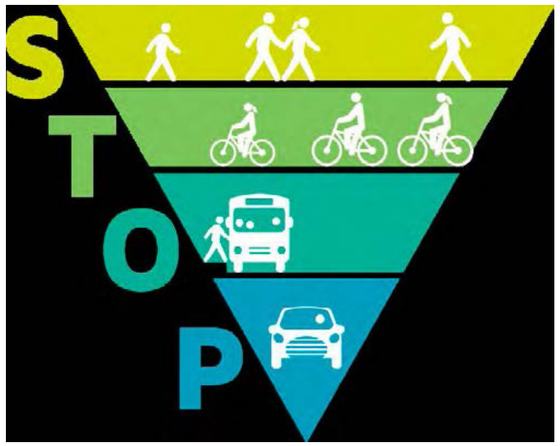
Overall, public transport in Zwolle provides residents and visitors with efficient and reliable options for commuting and traveling within the city and beyond. The comprehensive network and integration with other modes of transport contribute to a sustainable and accessible transportation system in Zwolle.



Gray infrastructure vision

To facilitate the continued growth of the city while maintaining its attractiveness, accessibility, and livability, a transformation of the traffic and transportation system is essential. In Zwolle, they embrace two guiding principles to prioritize walking and cycling, either independently or in conjunction with bus and train travel, as the preferred modes of transportation in all future developments (Gemeente Zwolle, 2020).

The STOP method is the guiding principle in Zwolle for all infrastructural transformations.



From Gemeente Zwolle (2020)

The main challenge is to create more space for cyclists and pedestrians.

What can actually be concluded is that it is not feasible to let car usage grow in tandem with the expansion and densification of the city (Gemeente Zwolle, 2020).

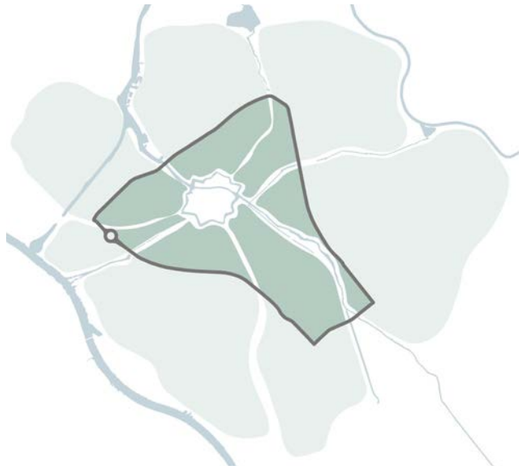
The second principle is about sustainable mobility. In all transformations, Zwolle strives for a minimal ownership and usage of cars (Gemeente Zwolle, 2020). However, in order to achieve this, it is crucial that public transportation is well organized and that there are good footpaths and bike lanes.

But what is most important is that car usage needs to decrease. Some predict that car usage will be reduced by 50% in the future. Others predict no decrease but rather an increase in shared and cleaner cars. I believe it varies by location, but what everyone can conclude is that currently, in a city, a car is not faster than, for example, a bicycle or public transportation.

And I believe that this is primarily a good challenge to address in cities. The densely populated cities have become less livable due to cars, where cars always took priority over cycling and walking. This has led to the situation we are in now, where the car is no longer attractive.

For Zwolle, this primarily occurs within the city ring road. All expansions outside the city ring road are designed with green zones along the infrastructure. Particularly, the city center is mostly paved, whith the initial expansions such as Assendorp, Kamperpoort, and the Dieze. They are now mainly designed for cars and mostly paved.

In the future, this could be effectively addressed by transforming the space that will be created by the decrease in car usage into for example, an urban forest, where trees and greenery become increasingly prominent in the urban landscape, replacing the grey pavement.



What is important is that in our designs we have to think of the future. And in Zwolle, the future design should focus mostly on the area within the city ring road. This is the part where the infrastructure will change the most and where the most future challenges will be. So this is a good place to tackle the challenges together.

With the decrease in car usage, the center of Zwolle can respond to the demand for improving the sponge effect.

Conclusions

To continue the story of lines in Zwolle, the past four chapters have primarily focused on examining the existing lines in the city, the problems they face, the lines that have disappeared, and the potential opportunities they offer to improve the city. From this, various challenges have emerged.

The **first challenge** that emerged from the research is that the green spaces in Zwolle can be better connected and improved. The current connections are of low quality and often inaccessible for people. However, from an ecological perspective, the network is well-established.

The **second challenge** is that of water storage. Currently, Zwolle lacks sufficient waterways and emergency outlets to drain excess water. However, even more crucial is the fact that the city centre (within the city ring road) is excessively paved, preventing any sponge effect.

The **third challenge** pertains to mobility, where in the future, we may require less space for cars, which can have a positive impact on making the city more sustainable. It provides a good starting point for the design.

The **fourth challenge** also relates to mobility, but in a negative way. In addition to requiring less space in the future, it is necessary to address the barriers posed by the city ring road and the highway through the city. The large design of these roads creates visual and functional barriers for different parts of the city. Especially with the highway which is surrounded by a talud with a tree buffer zone.

The **final challenge** concerns urbanization. As the city grows, there is a desire to avoid sacrificing all the surrounding landscapes for construction. Therefore, a combination of densification and expansion is being pursued. However, with the already densely built city center, this approach leaves even less space for green areas, which the city desperately needs.

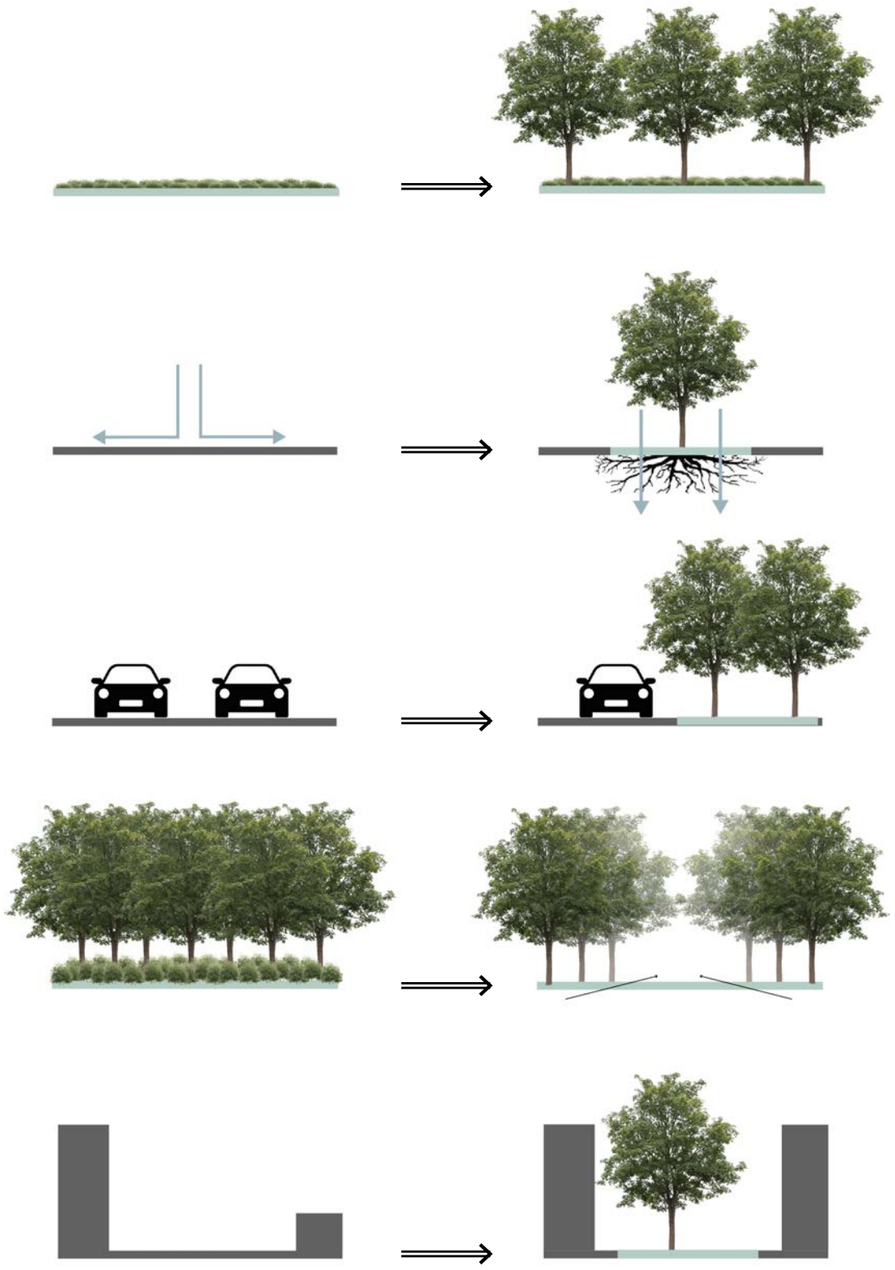
To come up with a solution for these challenges it is important to take into account the line concept of the city and the Urban Forestry principle. In most cases the Urban Forest can be the solution, but the question how will be shown in the next chapters.

They will include:

- Trees and the big infrastructure
- Trees and the small infrastructure
- Trees and the waterstructure
- Trees and urban transformation

They will built upon an urban forestry framework to optimize the sponge effect.

The identified challenges can be described in a more site-specific manner. To begin with, there is a need for a spatial structure in Zwolle to address infrastructure barriers. Additionally, on the nature layer, many tree lines have disappeared, trees are fragmented across the city, and there is a shortage of trees. On the water layer, the Nieuwe Vecht and Willemsvaart stand out negatively as they have lost their glory. At the social level, it can be said that Zwolle has inclusive neighborhoods with everything nearby. However, this also leads to people staying within their own neighborhoods and not connecting with surrounding ones. Moreover, the various parks form isolated spots and are not interconnected with each other, which results in people always using the same park and not socially connect with other people.



URBAN FORESTRY PLAN

The Meeuwenlaan, Zwolle

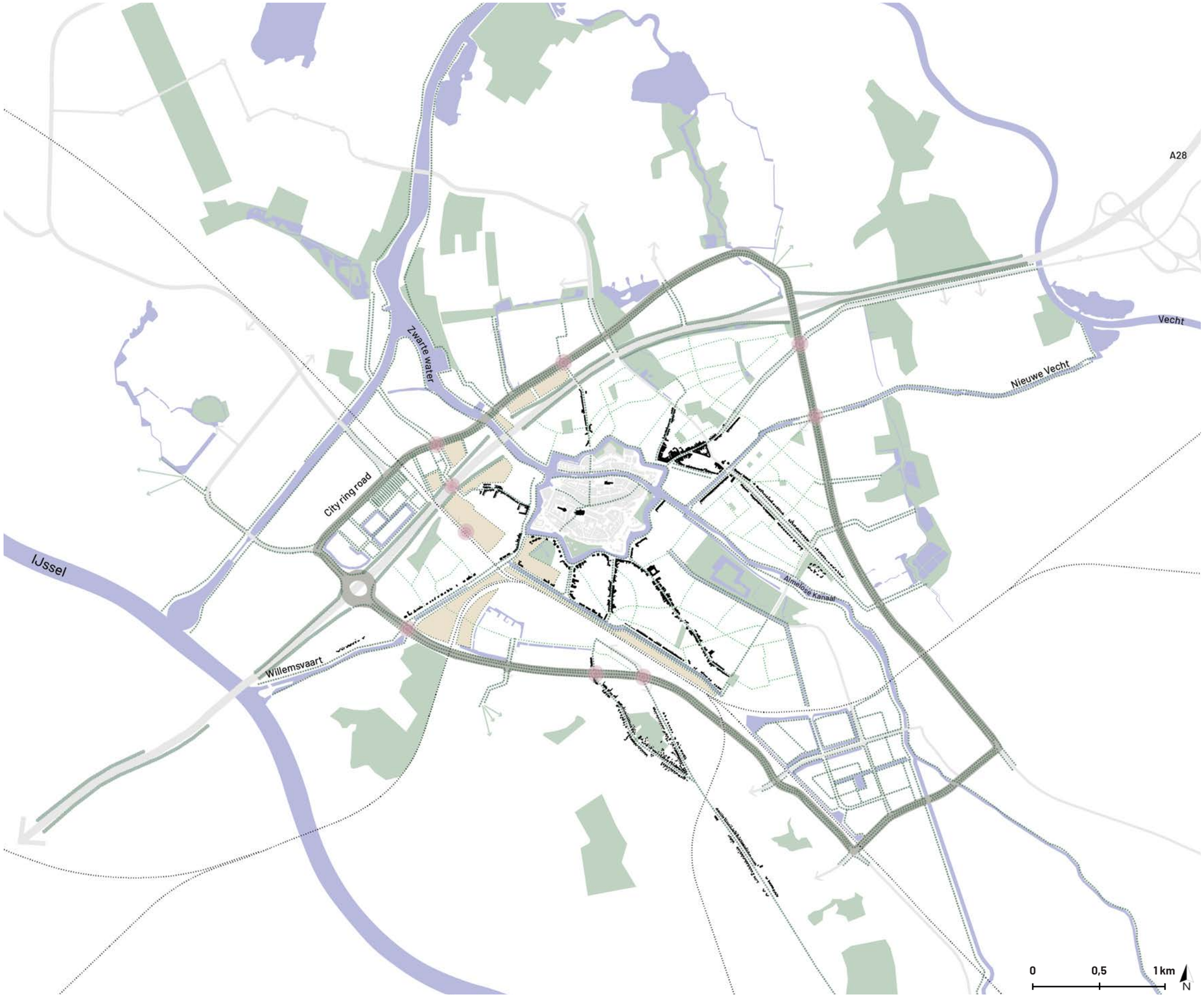
Urban Forestry Plan

The tree-ways for Zwolle.

This graduation project for Zwolle explores how the revision of the tree and blue structure, necessary for climate change adaptation, can also address various future spatial challenges for creating a livable city. The main drivers are the need for increased water storage capacity and the enhancement of green spaces through addition and transformation, in alignment with landscape and urban development goals.

Based on a comprehensive morphological analysis of the entire city, existing policy documents, research on water issues, and the landscape architectural concept of Urban Forestry, a structural vision has been developed for the area enclosed by the inner ring road.

The plan includes a detailed plan for the southwest area of the historical city centre, where challenges related to green spaces, infrastructure, urbanization, and water management intersect.



The tree-ways for Zwolle

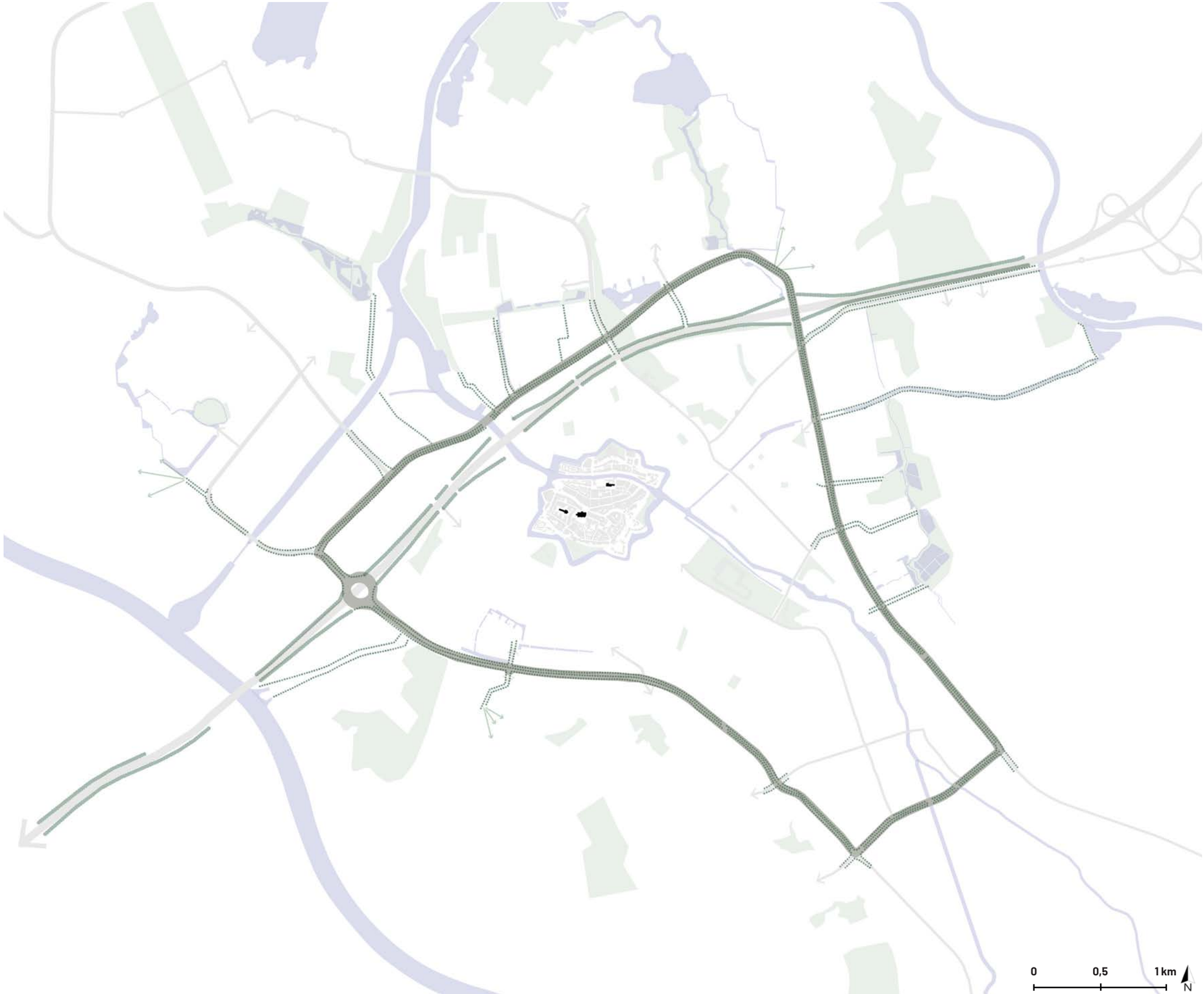
Trees and the big infrastructure.

Zwolle is easily accessible because of the A28 highway, the inner ring road, multiple neighborhood access routes, and the railway. However, these infrastructure elements currently exist as separate entities. The questions that arise are:
- How can this infrastructure space contribute to the city's green/water structure and overall spatial quality?
- What barriers currently exist and need to be overcome?
- How can the new tree structure contribute to the transformation of outdated industrial areas into new neighborhoods with good access to the city center?

With the expected decrease in car usage, there will be available space, particularly along the inner ring road, while the railway may require more space in the future. Both of these changes can be utilized to address the need for additional water storage and improve green spaces.

The inner ring road primarily serves automobiles and acts as a barrier between different neighborhoods in Zwolle. By heavily greening these areas, it can instead become a connector and a place of cohesion.

Moreover, the inner ring road passes through many outdated industrial areas, providing ample space for increased water storage and the opportunity to create a new tree structure that enhances the spatial quality of these areas. This transformation can potentially turn them into healthy and accessible urban neighborhoods in the future.



The tree-ways for Zwolle

Trees and the small infrastructure.

The old tree-lined roads are currently invisible due to the current paved design. These roads used to be the main routes and the backbone of the city. Along these lines, Zwolle grew, but their significance is hardly noticeable anymore. The street has transformed from a social gathering place into a traffic artery, where trees have had to make space for cars. Through the establishment of new rows of trees, these roads will regain their visibility and liveliness.

The city center, suburbs, and the surrounding landscape of Zwolle can be better connected ecologically and spatially through recognizable tree structures. This involves redesigning main roads and streets in residential areas to connect isolated neighborhood parks into a network.

Currently, there are not enough parks in Assendorp, Wipstrik, Diezerpoort, and the Hanzekwartier. The existing parks are scattered across the neighborhoods, but the fine-grained network is missing. This tree network can be realized through the reprofiling of existing streets and by anticipating the decrease in car usage in the future. The paved streets need to be transformed into green oases to enhance urban resilience.

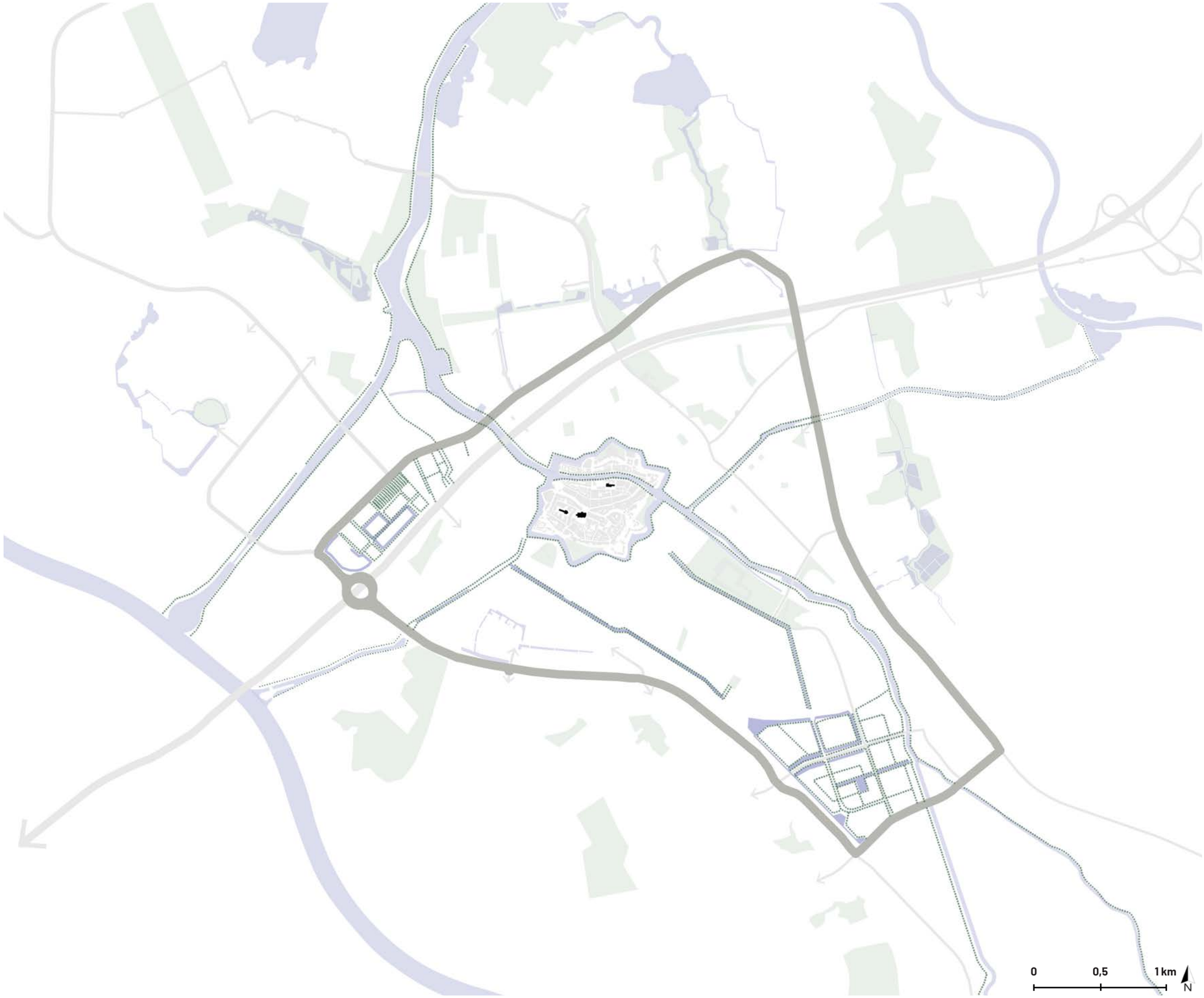
The tree-ways for Zwolle

Trees and the waterstructure.

Zwolle needs more space for water, so the existing watercourses need to be widened and greened. This will better connect neighborhoods and create pleasant outdoor spaces for walking and playing. The current Willemsvaart and Nieuwe Vecht, with their high cultural value, can be expanded, extended, and greened to improve the attractiveness of the connection. This will connect the neighborhoods along these watercourses.

In the predominantly paved neighborhoods close to the city center, space can be created for new watercourses at the ends of the access roads. Examples of this are Wethouder Alferinkweg, Oosterlaan, and Deventerstraatweg. These new watercourses can collect water from the surrounding neighborhoods (lower-lying roads). This will improve the spatial connection between the different neighborhoods, such as Assendorp, Hanzekwartier, and Nieuw-Assendorp. Adding these water storage areas also provides an opportunity to bring the IJssel River closer.

Furthermore, the open structure of the industrial areas Grote Voort and Marslanden offers ample space for new water storage. In Marslanden, more space can be allocated to the river, and the addition of a new tree structure presents a green future for future urban plans. In Grote Voort, the emphasis is on a new tree structure that can strengthen the connection with surrounding neighborhoods and establish a green foundation for future transformations. The new tree structure will also contribute to better water retention in these areas.



The tree-ways for Zwolle

Trees and urban transformation.

The concept of Urban Forestry calls for new types of healthy, green, and beautiful cities. A sustainable green structure serves as an important foundation for this. To determine where this green structure should be implemented, we can look at the old structure of the city. Old watercourses and arterial roads formed the main framework of Zwolle (and other cities), including a tree structure along these lines. By reintroducing this tree structure and carrying out urban transformations with a green foundation, the city can better withstand climate change. From this green structure, a more intricate network can emerge, gradually transforming the city into a green oasis.

The important transformation areas designated by the municipality itself are indicated here. In these areas, existing commercial buildings are mainly being removed to make room for residential construction. This further intensifies the development of the city centre, making it even more crucial to have a robust green structure, especially within these transformation areas.

The tree-ways for Zwolle

Own perspective.

To truly help Zwolle, I believe that more is needed than just identifying and attempting to solve problems. Currently, the focus is primarily on reducing negative impacts rather than **creating** positive ones.

The solution needs to be broader than addressing the current problems alone. I think it is important for solutions to be comprehensive and operate at various scales.

An already comprehensive approach is the nature-inclusive approach, which also encompasses Urban Forestry. In this approach, nature serves as inspiration, with trees being a specific focus in this research.

Trees help shape the identity of a city, and they are also crucial for the identity of areas beyond cities. Just imagine a world without trees, it would feel quite empty.

I also believe that our current cities are often designed in a monotonous manner. Streets often have rows of the same trees (although different streets may have different trees), and green spaces between roads are primarily grass. Even the architecture of the buildings is monotonous. It is static and doesn't change. Once built, it is considered finished. In contrast, designing with greenery is a spontaneous process that constantly evolves. It changes throughout the year with each season, and it grows over the years. Always giving you a different experience.

These are all aspects that we observe at eye level. Therefore, I believe that the solution lies there, particularly on the streets. There are thousands of streets, and they are always evolving. Applying a small solution a thousand times can lead to a significant transformation (StraaD, 2013).

So, if we provide trees on every street, I think we can take a progressive step forward.

Additionally, I think the design should start with the green structure rather than first constructing buildings and then filling the open spaces with greenery. Greenery, especially trees, should be the starting point, and I even believe that trees can be planted before construction begins. The earlier, the better, as reflected in the Chinese saying;

The best time to plant a tree is 20 years ago.
The second best time is now.

Inspiration from Singapore

Singapore is a city-state located in Southeast Asia. Despite its small size, Singapore has made a remarkable transformation from a humble fishing village to a global economic powerhouse and a leading financial and technological hub. It is renowned for its commitment to green spaces and sustainability. Despite being a metropolis, the city-state has made remarkable efforts to incorporate nature into its urban landscape.

Due to its small size of only 720 square kilometers and the lack of natural resources and drinking water, Singapore had to make bold political choices. As early as the 1960s, the decision was made to prioritize a clean and green city, with industries relocated outside the central area or even out of the country. This led to relatively clean waters, clean air, and abundant greenery.

Already in 1975, Singapore implemented measures to make car ownership very expensive while developing an excellent metro system. By the 1990s, the city-state had earned the status of a tropical city with its numerous parks and beautiful waters.

As climate change became a growing concern around 2000, environmental sustainability became a top priority also in Singapore. Their approach aimed to go "beyond clean and green".

Extensive research played a crucial role in achieving these goals, but that was no problem with them having more than 47 institutes and research centers dedicated to environmental and sustainability studies by 2015.

This new focus on the environment significantly influenced urban planning. In the late 1990s, the concept of a "garden city" evolved into a "city in a garden," incorporating ecological considerations alongside aesthetic enhancements. Plans for wild parks and waterways that promote ecological connections quickly followed.

Singapore views vegetation as a simple way to provide cooling, improve air quality, and create a pleasant climate.

Singapore's rapid greening over the past decades can be attributed to a well-executed policy approach. This approach combines significant government investments with mandatory regulations and attractive incentives for the private sector. And Singapore is determined to continue in this direction.

I believe that Singapore is a great example of a city that not only designs and thinks but also takes action. The strict rules are effective, and I think there is much we can learn from them. These rules are forward-thinking and not focused on minor adjustments, which means that designers are expected to think outside the box.

I also see Singapore as a good example that demonstrates how reducing car usage can be successful "if" there is a well-developed public transportation system. I believe Zwolle is already making good progress in that regard.

Lastly, I take away the importance of inspiring residents and users of the city to incorporate green elements on private property.
For me personally, it was a great inspiration.

Problems in Kamperpoort

To test the Urban Forestry Plan, this area in the neighborhood Kamperpoort is chosen because of the challenges related to green spaces, infrastructure, urbanization, and water management that intersect.

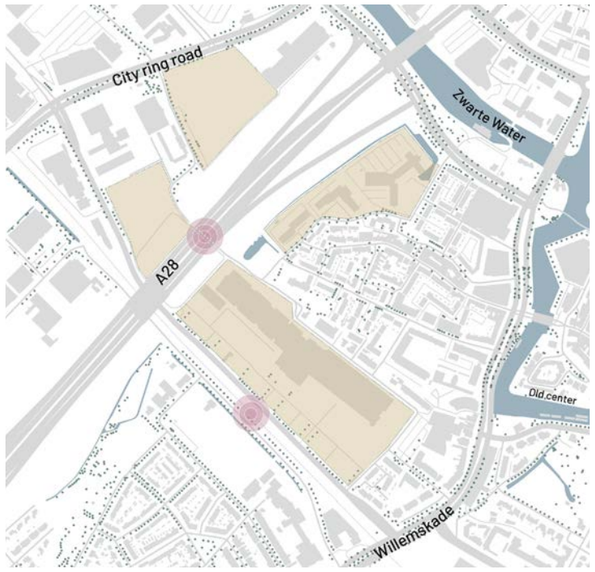
The neighborhood is enclosed by the Zwarte Water, the inner city center, the highway, the old Willemskade and includes a big transformation area.

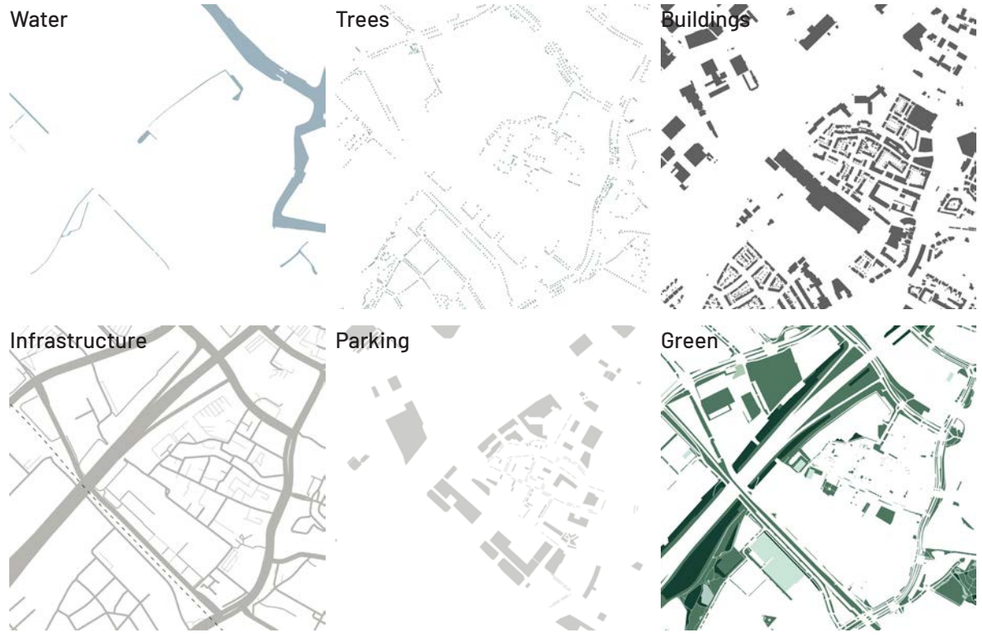
It also has the potential to improve the current A28, which creates a major barrier, at the location where an underpass already exists. This underpass can be made more organized and attractive to encourage people to use it more. By doing so, the adjacent industrial area can be better connected to the city. Several plots have already been designated for transformation. The future urban district would then have a better connection.

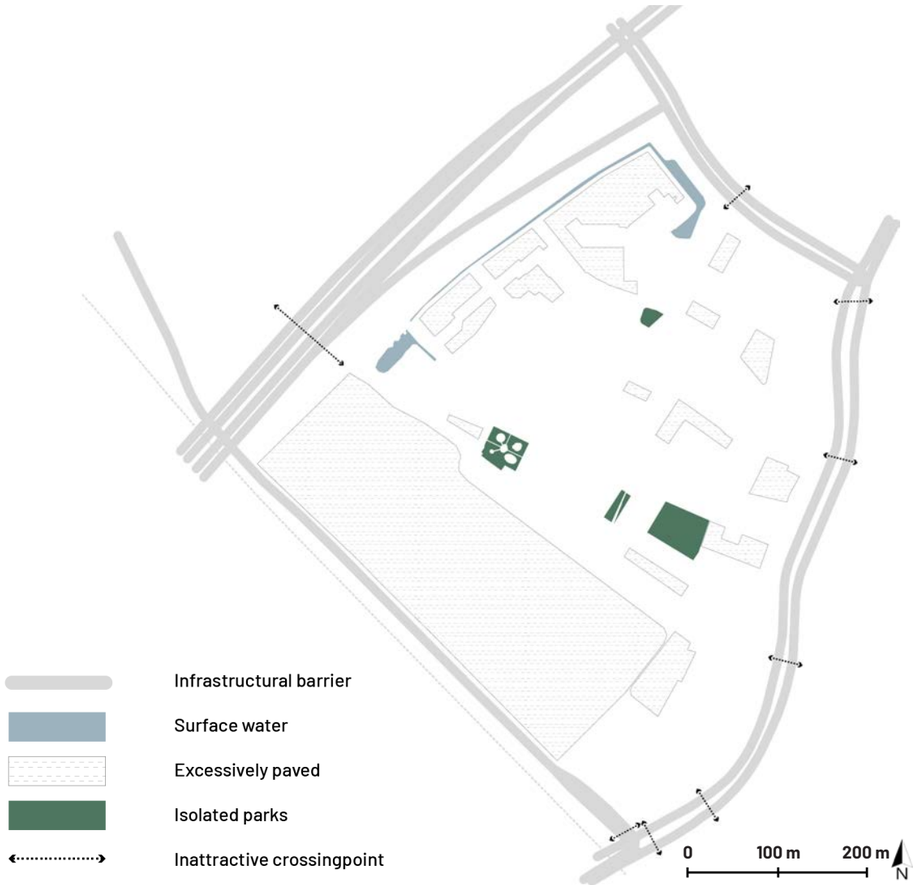
Furthermore, the neighborhood of Kamperpoort lacks connection with the southern part of the Kamperpoort district due to the railway track. There is currently no underpass and connection in place.

But most importantly, this neighborhood is facing water-related issues. The streets are excessively paved, have almost no surface water and lacks a good amount of trees which causes the struggle to effectively drain water.

With the designated transformation areas, a significant step can be taken towards establishing a green foundation in this neighborhood, allowing for the development of a green network along the existing streets.







The concept of tree-ways for Kamperpoort

The concept of lines is carried forward in the development of Kamperpoort. It is important to have a coherent narrative visible, which is achieved through the incorporation of various lines. Some lines are based on existing ones, while new lines are created in the transformation areas.

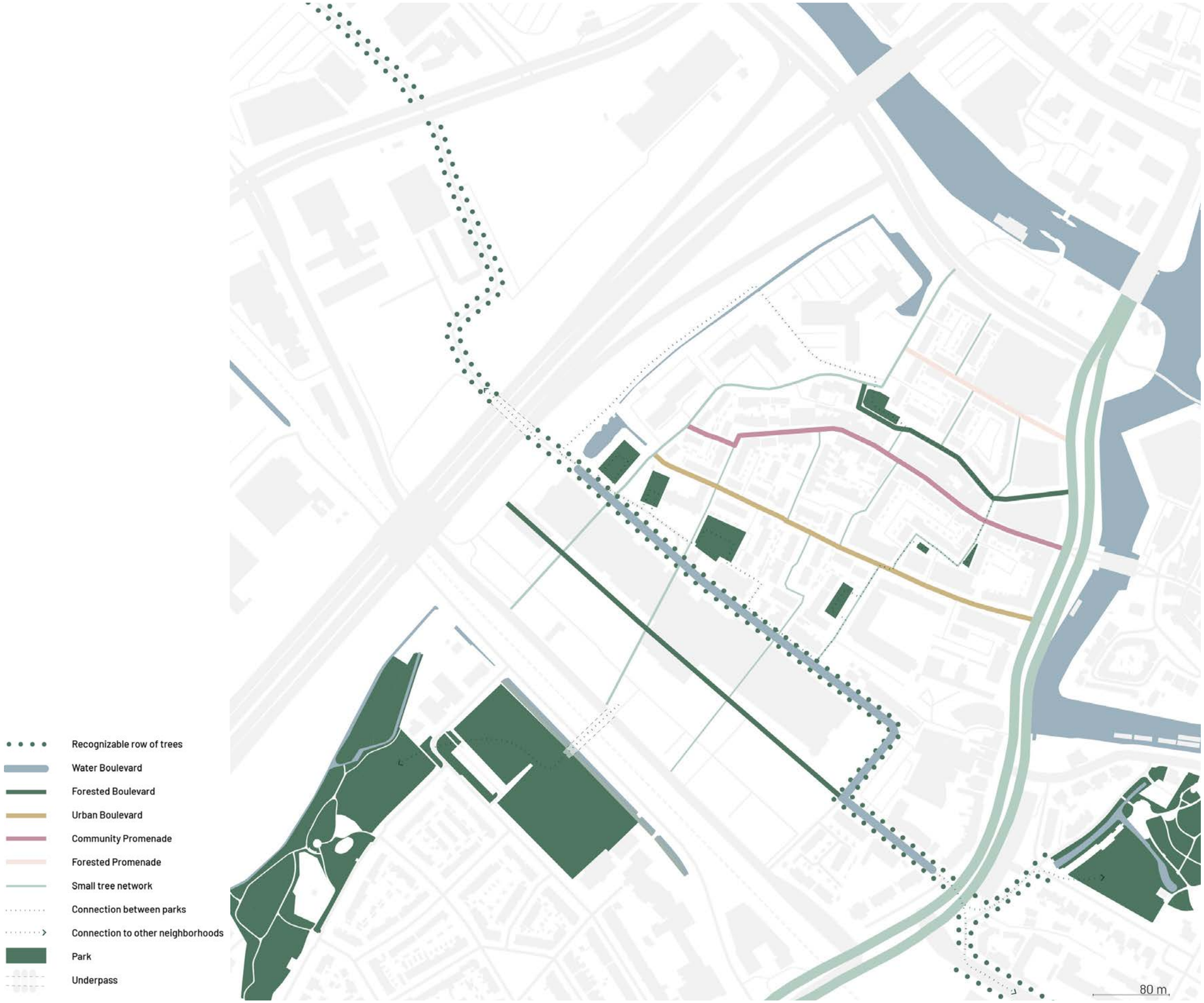
Each street will adopt its own distinct line, with some streets exhibiting a more urban character than others, based on their unique characteristics. Additionally, each street will feature a different quantity and type of trees, including diverse surfaces.

The interconnectedness of these various lines will create a comprehensive network throughout Kamperpoort, simultaneously eliminating barriers and enhancing connections. As a result, the green network will serve as a foundation for the transformation areas and ultimately improving the livability of the existing streets.

What is also important, is the location of Kamperpoort. It is situated between the historic city center and a future residential area. In the future, this neighborhood can serve as a green connector and a social link between the old and new.

To create this connection, the horizontal lines are designed to be the most important. These will all have a different experience, whereas the vertical lines will also have trees but are there to make the connections between the important lines and parks.

The new waterway between the existing houses in Kamperpoort and the transformation area will serve as the most important new tree-way. It is at the lowest part of the neighborhoods which can therefore catch water from the neighborhood and it forms a new recognizable tree-way to connect East and West. It will also serve as a meeting place between the transformation area and the existing houses.



Future tree-ways for Kamperpoort

Each horizontal line has a different purpose based on its current characteristics.

The **water boulevard** is the main street. The new waterway lies on the border between the old part of Kamperpoort and the future residential area. The Veemarkt, once of great historical value, has lost its glory due to automobiles. Due to various water-related issues, it is important to add more surface water. By placing it here, water will play a more central role, which is crucial for the future. This street also connects with surrounding neighborhoods, improving connectivity through the new waterway.

The **urban boulevard** provides access for cars, cyclists, and pedestrians. The focus on cars is due to the history of this street, as the Lijnbaan was the first street in Kamperpoort to be designed for automobiles.

The final boulevard is the **forested boulevard**. The Nachtegaalstraat is currently mainly designed for cars and parking. While car accessibility can be maintained, more space is needed for greenery and trees, requiring the transformation of parking spaces.

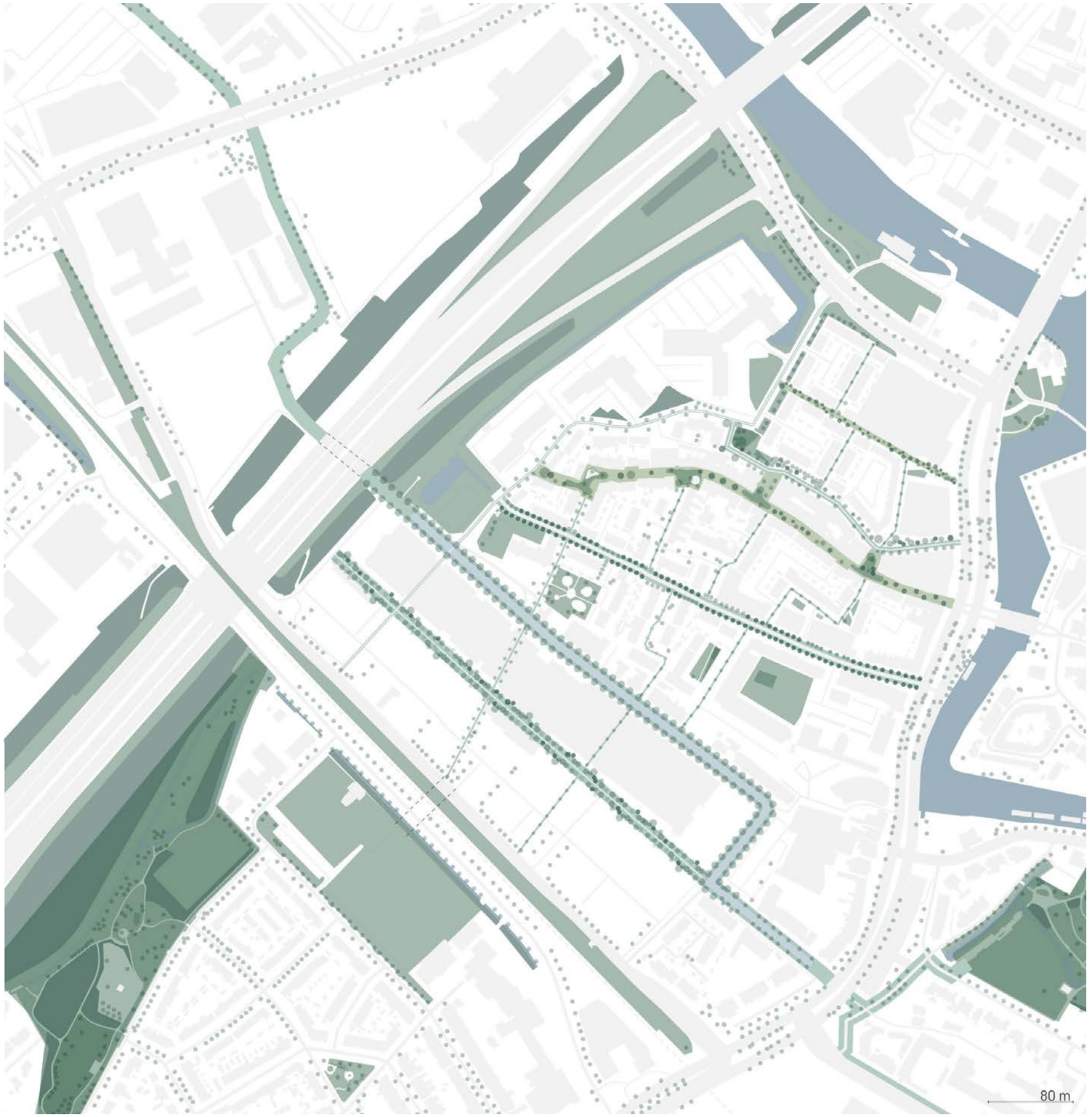
The Hoogstraat will be transformed into the **community promenade**, accessible only to pedestrians. Hoogstraat was the first-ever street in Kamperpoort. It used to be a meeting place, but it has lost its glory due to automobiles. The narrow street will regain its glory by adding organic lines and creating meeting spots within green spaces.

The last street, the Reigerstraat, will become a **forested promenade**. Currently, it is accessible only to pedestrians, and it will remain so. However, it is currently fully paved, which is not ideal for the future. Transforming it into a forest experience will make the street more climate-proof and enhances the liveability.

The **connecting tree-ways** aim to create a network of trees, enhancing spatial, ecological, and social connectivity.

It is important to provide more space for trees (often existing trees) by sacrificing parking spaces, because all trees should always have open surface around them to make the water management function possible.

It is also important to preserve existing trees. The more mature the tree, the more ecosystem services it provides, and it adds a layered appearance to the street.



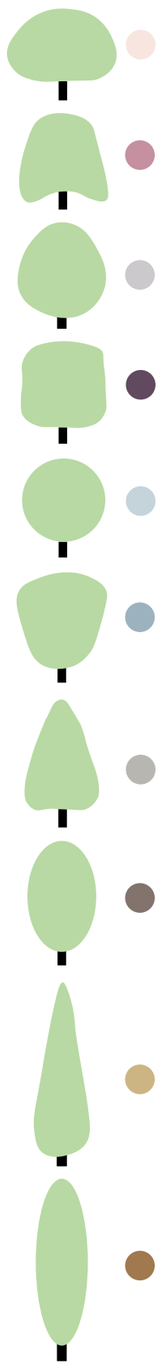
Choice of tree-ways

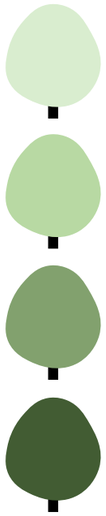
Each different line has different existing characteristics. To keep the historical value it is important to use these characteristics in the design.

To decide the which trees fits best, this table shows some steps that could be taken. It starts with the goal of the future street, after deciding the goal, different ecosystem services are shown which indicates the services that are necessary. After that, the spatiality should be chosen, where for example, in some streets small and high trees fits better than a wide tree.
To combine these characteristics, the last table shows the recommended trees for the different goals.

Goal of the future street	Ecosystem Services
Infrastructural Urban Boulevard Connecting Boulevard	Withstanding drought Trapping fine dust Trapping NOx 03
Water Water Boulevard	Moisture toleration Attract pollinators (restrict mowing)
Natural Forested Boulevard Community Promenade Forested Promenade	Temper the temperature CO2 Capture (optimal growth) Attract birds Food for us

Spatiality (Crown)	Spatiality (Foliage)	Recommended trees (the Green City Guidelines)





Withstanding drought
- Acer campestre
- Gleditsia triacanthos
- Gymnocladus dioicus
- Koelreuteria paniculata
- Morus alba
- Populus tremula
- Robinia pseudoacacia
- Syringa reticulata
- Sorbus aria
- Styphnolobium japonicum
- Zelkova serrata

Trapping fine dust
- Cedrus atlantica
- Callocedrus decurrens
- Crataegus x lavalleei
- Fagus orientalis
- Gleditsia triacanthos
- Paulownia fortunei
- Metasequoia glyptostroboides
- Picea abies
- Pinus sylvestris
- Populus x canadensis
- Sorbus aria
- Styphnolobium japonicum
- Sequoiadendron giganteum
- Tilia platyphyllos
- Thuja plicata
- Ulmus 'New Horizon'

Trapping NOx 03
- Acer platanoides
- Aesculus indica
- Betula pendula
- Catalpa speciosa
- Castanea sativa
- Gingko biloba
- Ilex aquifolium
- Koelreuteria paniculata
- Liquidambar styraciflua
- Liriodendron tulipifera
- Paulownia fortunei
- Pinus strobus
- Platanus
- Populus
- Prunus
- Sorbus aria
- Tilia heterophylla

Moisture toleration
- Acer freemanii
- Alnus glutinosa
- Betula nigra
- Gleditsia triacanthos
- Ilex aquifolium
- Metasequioa glyptostroboides
- Nyssa sylvatica
- Platanus occidentalis
- Populus berolinensis
- Pterocaria stenoptera
- Salix
- Taxodium distichum
- Ulmus laevis

Attract pollinators
- Aesculus indica
- Cornus mas
- Heptacodium miconioides
- Lagerstroemia indica
- Maackia amurensis
- Parrotia persica
- Populus
- Picea abies
- Robinia
- Styphonolobium japonicum
- Salix
- Tetradium daniellii
- Zanthoxylum simulans

Temper the temperature
- Acer cappadocicum
- Aesculus flava
- Castanea sativa
- Celtis sinensis
- Fagus orientalis
- Juglans nigra
- Liriodendron tulipifera
- Platanus hispanica
- Populus berolinensis
- Prunus avium
- Styphnolobium japonicum
- Salix alba
- Tilia x europaea
- Ulmus laevis

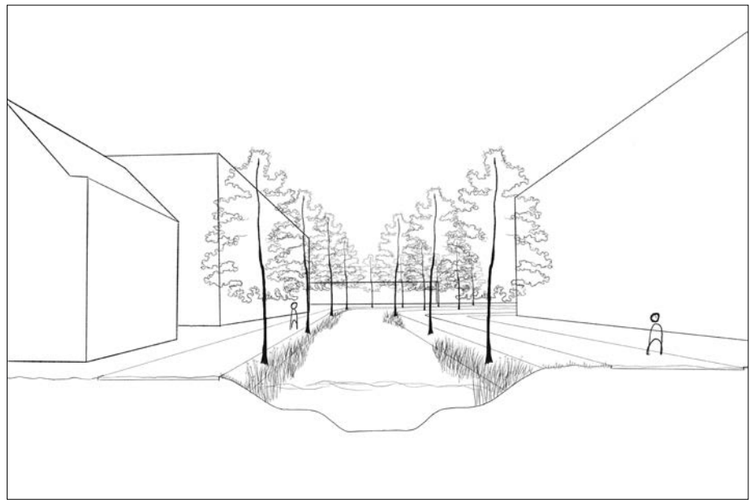
CO2 Capture
- Acer platanoides
- Aesculus indica
- Betula maximowicziana
- Carpinus betulus
- Catalpa speciosa
- Gymnocladus dioica
- Ilex aquifolium
- Larix decidua
- Liquidambar styraciflua
- Liriodendron tulipifera
- Pinus nigra
- Platanus
- Populus canadensis
- Prunus avium
- Robinia pseudoacacia
- Salix babylonica
- Tilia heterophylla
- Ulmus laevis

Attract birds
- Amalanchier
- Cornus
- Crataegus
- Euonymys europaeus
- Frangula alnus
- Hippophae
- Ilex aquifolium
- Malus sylvestris
- Morus
- Prunus
- Sorbus
- Viburnum

Food for us
- Amelanchier (june berry)
- Castanea sativa (sweet chestnut)
- Cornus mas (dogwood)
- Corylus (hazelnut)
- Crataegus (hawthorn)
- Cydonia oblonga (quince)
- Juglans regia (walnut)
- Malus domestica (apple)
- Mespilus germanica (medlar)
- Morus alba (mulberry)
- Prunus (cherry and plum)
- Pyrus (pear)
- Sorbus (rowan)

The tree-ways for Kamperpoort

Current situation



Water Boulevard - Veemarkt

This fully paved street will be transformed into a significant water boulevard. It is enclosed by straight walls and could benefit from natural elements to soften its appearance. The new rows of trees will create a recognizable line. This street will serve as the connection between the old and new parts of the neighborhood and will capture water from the surroundings.

Therefore, it is important that the trees are not too close together and not too dense, to not create a barrier between the two parts. The trees should have a semi-open structure, be able to withstand moisture, and still form a recognizable line. Therefore, the Gleditsia triacanthos has been chosen.

Future situation

Current situation

Urban Boulevard - Lijnbaan

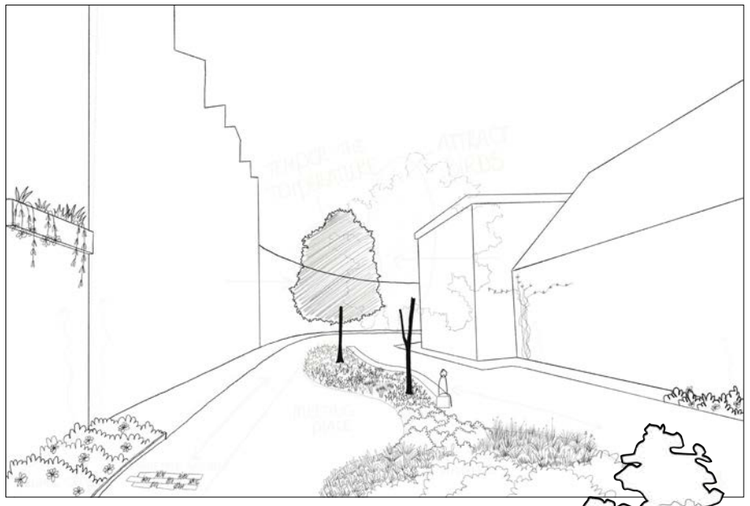
This street, oriented towards cars, will remain accessible to automobiles. However, it is important to introduce new trees to accompany the street and create more space for surface permeability. This will enhance water retention within the street and improve livability simultaneously.

For this purpose, the majestic Populus nigra italica has been chosen. This tree can withstand drought and effectively trap fine dust, thereby improving the street's air quality. Its tall stature also complements the surrounding tall buildings, and the tree's structure prevents it from enclosing the street, allowing it to retain fine dust. This tree opens up the view and guides you towards the end of the street.

Future situation

Pedestrian zone	Landscape zone	Travel lane	Landscape zone	Pedestrian zone	Private green zone
2,5 m	2,5 m	4,0 m	2,0 m	3,0 m	2,0 m

Current situation



Community Promenade - Hoogstraat

The Hoogstraat, which used to be the main street in Kamperpoort, no longer reflects its former importance. The attractiveness for staying has faded and needs to be restored. The street will become car-free and provide space for a diversity of greenery and trees. Areas will be created where people can sit, and the new trees will provide shade. The mix of trees will attract birds and other animals, while the semi-permeable paving will allow water to infiltrate the ground.

The Tilia x europaea and Sorbus aucuparia are two selected trees that moderate temperature and attract birds. The openness of the trees ensures sufficient light in the street and the trees invites people to go outdoors.

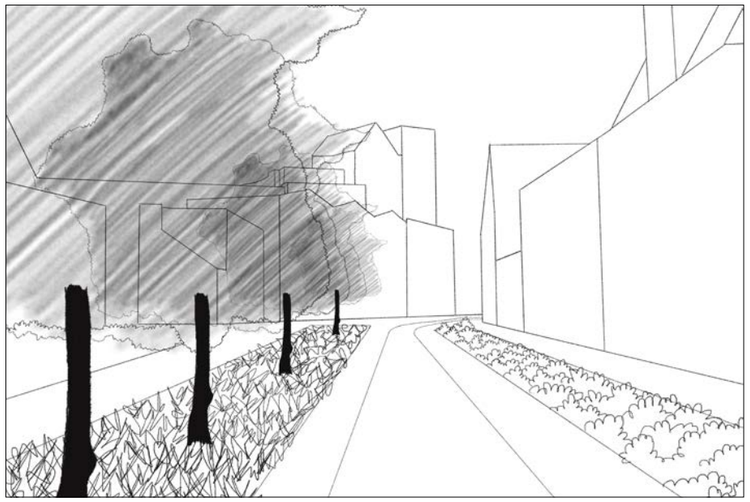
Future situation

Pedestrian zone
3,0 m

Landscape zone
2,5 m

Pedestrian zone
2,5 m

Current situation



Forested Boulevard - Nachtegaalstraat

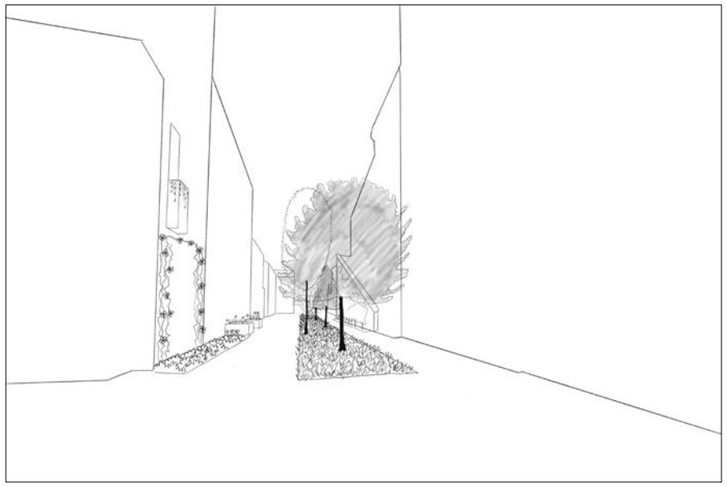
This street, currently oriented towards cars, will be transformed into a street where cars can still access but with a greater focus on cyclists and pedestrians. Currently, the sidewalks are narrow, and the presence of cars makes it an unattractive route.

By creating space for trees instead of parking spaces, the street will become a more attractive route, resembling a small forest. The large trees will arch over the sidewalk, providing ample shade. You will feel enclosed by the experience of a forest.

The rounded shape of the Carpinus betulus will soften the straight walls and bring a new dimension to the street.

Future situation

Current situation



Future situation

Forested Promenade – Reigerstraat

This street is already designed for pedestrians only, but unfortunately, it is completely paved. However, there is an opportunity to create space for a forest experience here by sacrificing a portion of the pedestrian area. By narrowing the footpath, there will be room for an open surface that allows water to infiltrate the ground, and trees can be planted with ample space. These trees will enclose the street, providing sufficient shade and creating a feeling of being in a forest.

Suitable trees for this purpose include Juglans nigra, Amelanchier, Liriodendron, Salix alba, and Larix decidua. This mix of trees with different shapes and densities will give it a natural appearance contrasting with the hard walls of the street.

Current situation

Connecting Boulevard - Kleine Voort

Between the major horizontal lines, a small network will also be established to connect all these lines spatially, ecologically, and socially. Many of these streets already have existing trees, which will be preserved. In streets where there are no trees yet, new ones will be added. These will be small, open trees that may appear less significant compared to the larger lines. In most cases, the streets already have fruit trees or other small trees. The new network will align with the existing streets.

A suitable tree, for example, could be the Koelreuteria paniculata, which is drought-tolerant and flowers beautifully. Paving limits the amount of water that can infiltrate the ground, so it is important to ensure that the trees in these streets have enough open space as well.

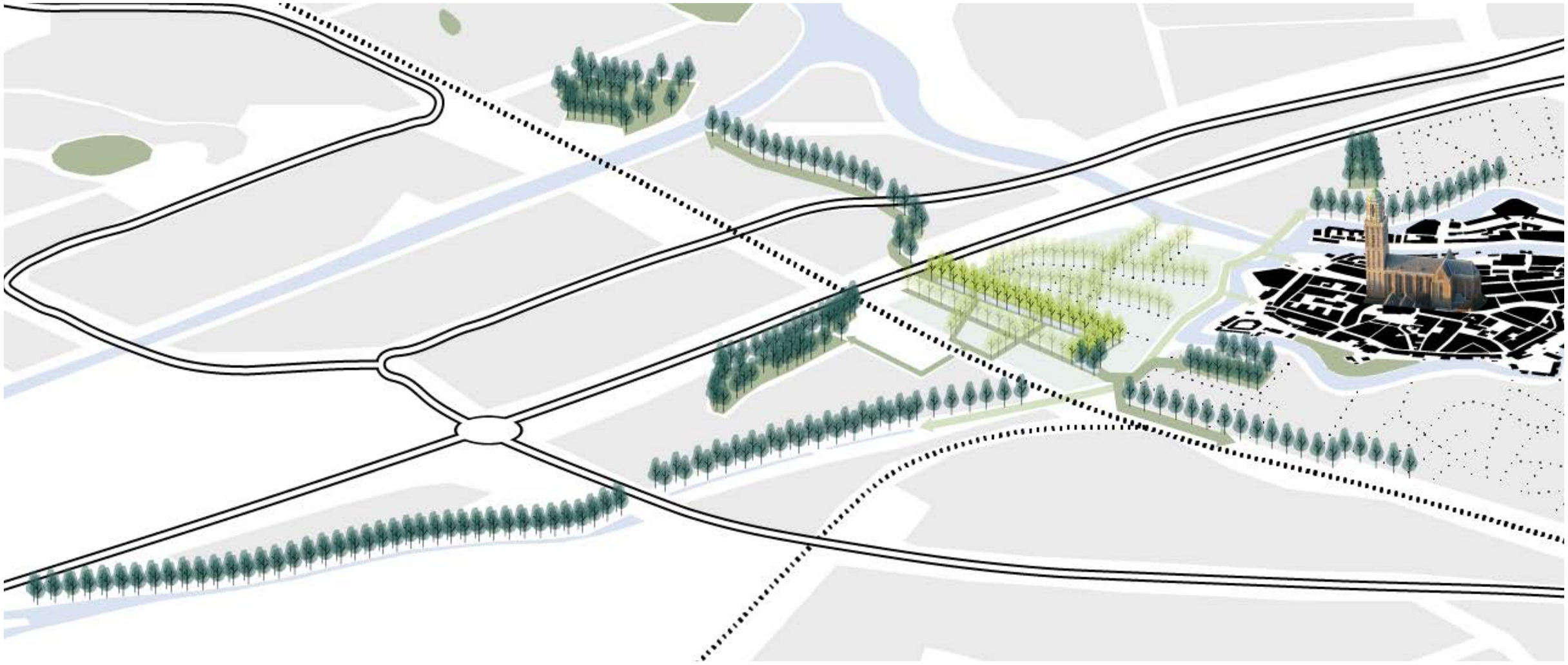
Future situation

The intermediate Kamperpoort

The new tree-ways for Zwolle will transform Kamperpoort into a green neighborhood that can manage its own water. It will have a strong foundation of trees and a central waterway that will serve as the backbone of the neighborhood.

It will set an example for other neighborhoods, with Kamperpoort acting as the green intermediary between the surrounding areas and within the city itself. It is centrally located, next to the historic center. On the intermediate scale, and just like within the neighborhood itself, it can form a green and social link between the old and the new.

In conclusion, Urban Forestry will connect the old and the new while simultaneously mitigating climate change impacts.



CONCLUSION & REFLECTION

The Willemskade, Zwolle

Conclusion

The goal of this project was to turn Zwolle into an Urban Forest by integrating tree-ways and greenery not only in new urban expansions but also in existing urban environments. In a way that it improves the connections in the city and promotes climate mitigation.

Therefore, new approaches in urban planning have to be considered to enhance the quality of life for its residents while also addressing future challenges.

The following research question was the main focus of this project:

How can a tree-way network be designed in a way that it contributes to improving water management in the urban environment of Zwolle?

The outcome of this project is an urban vision for a new tree-way network in Zwolle with a design proposal for the neighborhood Kamperpoort North.

The literature research demonstrated that tree-ways can play a significant role in urban water management and provide various positive ecosystem services.

Trees act as natural sponges, absorbing rainfall and reducing the risk of flooding. Their roots help to stabilize the soil and prevent erosion, while their canopy intercepts rainwater, allowing it to slowly infiltrate into the ground. This function is particularly crucial in urban areas where hard surfaces, such as concrete and asphalt, impede natural water absorption.

They also contribute spatially to better connecting the city.

While the city has always been well connected to the surrounding landscape, the connections within the city itself are insufficient.

The design of the tree-way network should therefore aim to improve: **the interconnections** of the green net work, **water retention** in the most paved areas, overcoming current **barriers** created by wide-ranging infrastructure, the **livability** of the city despite limited space due to densification.

To address these aspects, consideration has been given to the space that will become available through the anticipated decrease in car usage.

The transformation areas also play a crucial role in the design as they offer the opportunity for a nature-based approach, allowing for the creation of a new tree network among the existing buildings.

The design not only showcases how a new tree-way network could look but also emphasizes why the network is designed in that particular way. A long time ago, along these roads, ribbon-like suburbs emerged, and this linear form, forms the identity of Zwolle.

The old structure, primarily serving as recreational routes, used to form the foundation, but it has been lost due to densification and urban expansions. In this design, old tree-ways and water lines have been reintroduced to restore their recognizable presence.

First subquestion: **How can tree-ways contribute to improving water management?**

This research gave me more knowledge about what a tree really means for us. Not only about the above ground world but mostly about what a tree does underground. They store water, they let the rainwater infiltrate and guide along their roots. This is one of the main reasons why urban planning should use an urban forestry approach in future designs.

Second subquestion: **Which spatial qualities can be used to design a tree-way structure that improves water management?**

Based on this subquestion, I have concluded that the old arterial roads were the main routes where everything happened. They served as avenues for recreation, housing, and social gathering places. However, currently, they primarily function as thoroughfares for cars. They used to connect various aspects of the city, but now they mainly serve as conduits for automobiles.

Third subquestion: **What are the site specific water issues in Zwolle?**

The water issues can be divided into three categories: the rivers that lack sufficient space, the rising water levels in the IJsselmeer, and the high or low groundwater levels. However, the most crucial aspect is climate change, which leads to more frequent and intense rainfall. The research primarily highlighted that Zwolle lacks sufficient sponge effect to store and drain water effectively.

Fourth subquestion: **What are the future traffic challenges that can contribute to a new design?**

In this question, the existing vision for the future of cars in Zwolle was examined. Zwolle is a cycling city and aims to reduce the number of cars within the city ring while improving the public transportation network. In line with this, I believe that in the future, car usage in city centers should be reduced by at least 50% to create more space for urban forestry and enhance livability in dense areas.

To finish, urban transformations should always be accompanied by the development of public green spaces, with the focus on urban forestry, to create a better connection between nature inside the city. This will make cities more livable and it will inspire people to become more sustainable themselves.

Reflection

Design research and research-by-design

This graduation project primarily focused on Ur¬-ban Forestry and its benefits for cities in relation to water issues. Zwolle was chosen for this project due to its water-related situations. The entire city is affected by water and requires a strategic plan on a large scale.

The research began with a focus on the lar-ge-sca¬le context, as it is important to explore all aspects at the initial stage. Additionally, several visits were made to the site. During the first visit, I noticed a significant number of open spaces whe-re trees could have been planted. As I approached the site from a landscape perspective, I found streets to be most beautiful when trees are inte-grated.
Furthermore, it was evident that accessing the city centre by car was extremely convenient, which inadvertently encouraged car usage. The highway cuts through the city, and it seems that the city is designed more for cars than pede-stri¬ans and cyclists.

During these initial visits, the Veerallee and the Wipstrikkerallee caught my attention due to their beautiful rows of old trees, despite the presence of a busy road... This sparked several questions in my mind: Did these streets always look this way? Are there more roads with beautiful rows of old trees? Moreover, I felt it was a shame that cars seemed to dominate these streets.

Considering the city's rich history and the pre¬-sence of beautiful tree-lined avenues, I felt com¬pelled to approach the research from a historical perspective. Through desk research, I gained in¬sights into the water problems faced by Zwolle. Unfortunately, I only visited Zwolle during favora¬ble weather conditions and did not wit-ness any potential street water issues first-hand. However, the historical perspective became ap-parent when examining the city's origins, where water played a significant role. The Nieuwe Vecht and Veeral¬lee were once crucial for water trans-port, which prompted me to explore these areas during the site visits. However, the reality did not live up to the idealized vision, as there were no proper wal¬king paths, and once again, cars do-minated the streets.

I also explored the potential solutions to Zwolle's water problems that the municipality had already considered. Although the city had commissioned numerous studies and incorporated various op-ti¬ons into its vision, none of the options were ful-ly developed. However, they all agreed on the need for an enhanced green-blue infrastructure.

My research into urban forestry deepened my fas¬cination with trees. I discovered that trees offer not only above-ground benefits but also play a crucial role underground, including water ma¬-nagement. This valuable information became a key aspect that I wanted to incorporate into my design.

However, the question remained: How should they be included in the design? While randomly adding trees throughout the city is a possibility, I believed it was important to have a solid justification for their specific placement.

To address this, I conducted further desk re-se¬arch and zoomed in on the different neigh-bor¬hoods within Zwolle. This provided more in-sights into the specific problems experienced in each neighborhood, as not every neighborhood faced the same issues. Consequently, it became clear which neighborhoods required the most at-tenti¬on in the design. I also discovered that the city's expansions were already quite green and ex-peri¬enced minimal water-related issues. There-fore, my focus shifted primarily to the areas within the city's ring road, where the oldest neighbor-hoods are located and the historical perspective became prominent once again.

An additional layer was added when I examined vacant plots and areas earmarked for future re¬-sidential development in Zwolle, most of which were also within the city's ring road.

Towards the end of the research phase, I felt the need to further investigate the city's infrastruc-tu¬re. The wide roads and excellent car accessibi-li¬ty had caught my attention during the initial site visit. Despite being labelled as a bicycle-friend¬ly city, I believe Zwolle is more oriented towards cars. With the projected decrease in car usage in the future, there are significant opportunities for Zwolle in this.

In summary, the design is a result of integrating the findings from literature research, site ana-ly¬sis, and case studies. This iterative process invol¬ved a continuous dialogue between the the-oreti¬cal framework, site research, and design process in developing an Urban Forestry Plan for Zwolle.

But gave this design research and research by de-sign the desired outcome?
It has been successful to design a network that contributes to improving water management in Zwolle, but it is not possible to completely solve the water problems. Making the city completely waterproof requires more than just trees. Diffe-rent disciplines need to collaborate effective-ly here. However, trees can make a significant contribution if the street is well designed for it. This means ensuring that water can also flow towards the tree and that there is enough open space around the tree. This implies that current streets with existing trees, in most cases, need a redesign because many current trees have limited open space. Redesigning costs a lot, but when you consider the amount of ecosystem services pro-vided by a mature tree, it is multiple times greater compared to young trees.

The Landscape Architecture discipline

This new network of trees is connected to the discipline of Landscape Architecture. The goal of this discipline is to make cities more resilient during climate changes through mainly human interventions. The problem is that not all of the human interventions were beneficial for our cities and their livability. As landscape designers, nature and trees can be used to make cities livable again. Another connection with the Landscape disciplin-e is that the research is interscaler. Different scales are analysed and the design encompasses different scales, but it is site specific. This design only improves the livability of Zwolle with the new network. But the method used to achieve this de-sign is applicable to other cities as well, in order to develop a potential new network there. The following four perspectives have been applied to create the new network: palimpsest (rich history of Zwolle), scale continuum (beyond boundaries), process (complex processes through interventi-ons), and perception (experience). This has resul-ted in an inclusive design.

An urban forestry plan like this could also be ap¬plied in other cities, where a historical per-spec¬tive can provide a solid foundation. Good lo-cati¬ons for this could be old city districts where there used to be many trees, but have now made way for more housing and cars. It could also be im¬plemented in areas undergoing transforma-tions or experiencing significant water-related issues. The most important aspect is that it re-lies on the unique conditions and site-specific characteris¬tics of a particular area.

Social relevance

While cities often have numerous designs for pu¬-blic green spaces, there is a notable absence of design proposals specifically focused on urban forests. This project aims to fill this gap by con-tri¬buting to the knowledge and understanding of de¬signing urban forests within densely built are-as.

Moreover, it serves as an effort to raise awareness among residents, landscape architects, and urban planners about the beneficial effects that trees can have on the environment and urban spaces. By doing so, it can contribute to the future de-ve¬lopment of the standardization of public green networks in cities that prioritizes the presence of trees.

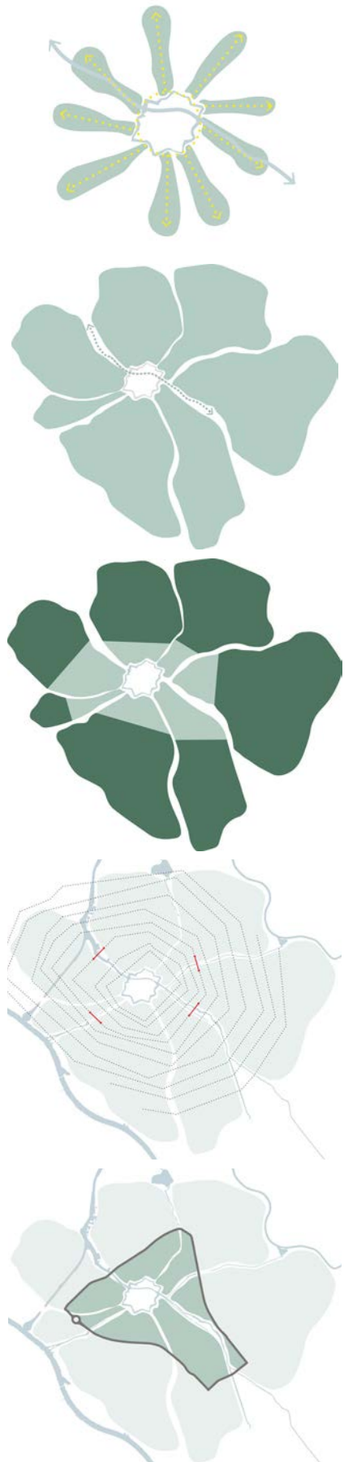
Intermediate scale

What emerges from this research is the "middle scale". There is an area of influence, which affects the design but which is not within the interventi-on scale; also called the regional scale. This scale is analysed to find wider processes and to under-stand the historical development and processes. Then there is the area of effect, also called the intermediate scale, where hydrology plays a cru-cial role. It gave me a better understanding of the

water system, green networks and roads, which created a relation between the design area and the surrounding. The smallest scale which is used is the area of control, where the design on the intermediate scale is implemented in Kamperpoort, with spatial boundaries. This scale also consists of details and materialisation.

The biggest part of my research was on the intermediate scale and the biggest intervention is at this scale as well. To really make a change for Zwolle, it is necessary to come up with a whole new network and not only a small intervention for one specific site.

This projects scale is in between a spatial strategy and a system. It is more than only Landscape Architecture. The disciplines of urban planning, spatial planning, and landscape architecture intersect here. It is a site specific structural vision, where visions normally only give the main outlines. It is a spatial structure, with multiple layers (water, nature, infrastructure) but still site specific.



The flower metaphor changing its focus through the design process.

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