Growing With Cooler Green

To create a climate mitigating city through forest urbanism

Ailin Han

Urban Forest

2023
Graduation Project

Student	Ailin Han
Student Number	5528429
Course Information	Flowscape Studio - Urban Forestry Lab
First Mentor	Dr. Ir. René van der Velde
Second Mentor	Dr. Ir. Stefan van der Spek

TU Delft Delft University of Technology Faculty of Architecture and the Built Environment

2022-2023 Msc Graduation thesis report

MSc Architecture, Urbanism and Building Sciences
MSc track Landscape Architecture

Abstract

The urban heat island effect refers to increased temperatures in highly developed urban areas and has negative impact for human activities and the social environment. This project aims to address this effect by integrating urban forests into the cityscape, while enhancing the living experience of residents.

The project focuses on analyzing cool vegetation characteristics in existing areas and incorporating them into subsequent designs to utilize trees' cooling capabilities, in order to combating the urban heat island effect and promoting city climate mitigation ability.

Through analyzing the urban ground surface temperature and its relationship with trees, a positive correlation existes. The further design strategy considers tree types, leaf cooling rates, appropriate tree arrangements, and species selection, while addressing factors like shade coverage and adaptability to the urban environment.

Except involves improving existing climate weak areas, this project also formulating a climate mitigation urban development strategy around the urban forest for the city future development.

It's important to note that the temperature discussed in this project refers specifically to urban surface temperature.

CONTENT

Chapter 1 INTRODUCTION

1.1 Problem Statement

Facing the global warming, cities, including the Zwolle region, are anticipated to experience rising temperatures in the coming years. Climate change has posed significant challenges to the Zwolle region in the recent year, it is necessary to design a new strategy to mitigate climate stress.

According to the Netherlands Meteorological Service, the surface temperature in the Zwolle region has shown a consistent increase since 1960.

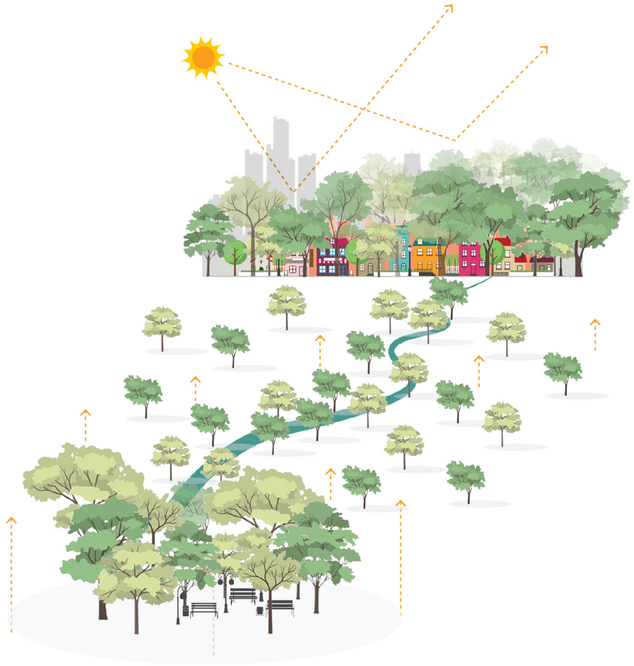
This concerning trend can be attributed to the increase of hard surfaces during the city's development and construction, with buildings and other structures absorbing and keeping heat, resulting in increased temperatures.

In addition, it is important to recognize that the large majority of development surrounding the Zwolle area consists of high-density residential areas, which often lack open areas with abundant vegetation and public green spaces.

Therefore, to keep the quality of life for residents in these neighborhoods, it is crucial to create a climate mitigating and life attractive environment in the Zwolle region. These measures facilitate climate mitigation ability while also enhancing the overall life experience.

Fortunately, the Zwolle region can use large areas of vegetation and public open spaces to mitigate the effects of heat stress within the city.

The main issues to be attended to are the need to enhance the vegetation in the Zwolle area by creating new green spaces and expanding existing ones, as well as ensuring the availability of open public areas. By doing so, the region can effectively address the challenge of high temperatures induced by heat stress.



1.2 Research Question & Project Goal

Research Question

How to transform cities from utilizing cool forest features to become cities within cool forests while also improving the urban forest system to mitigate the urban heat island effect and enhance the living experience of the neighborhood?

Sub-question

Sub-question 1:
How to create a climate mitigation city through forest urbanism solution?

Sub-question 2:
What kind of urban forest morphology is effective in reducing urban surface temperature?

Sub-question 3:
How can we strengthen the connection between the city and the surrounding communities through forest urbanism?

Sub-question 4:
How to improve the urban forest to benefit people's living experience?

Project goal

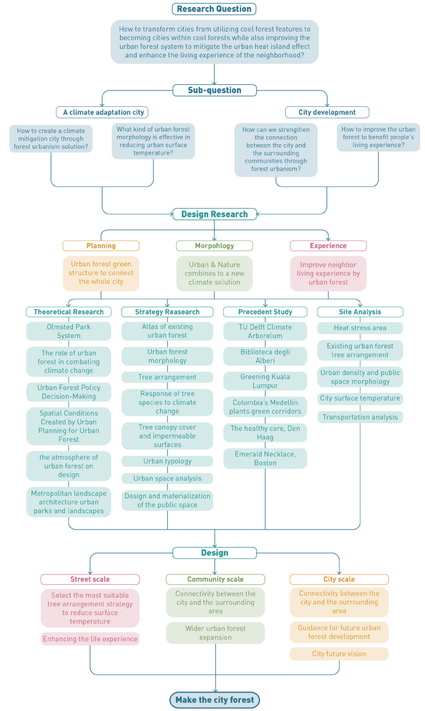
The project focuses on establishing a robust and varied forest in Zwolle that promotes urban well-being and effectively responds to challenges posed by the urban heat island effect and climate change. By honoring established urban forest planting methods, analyzing and shaping the growth and trajectory of the forthcoming urban forest. The project goal is to forge a mitigating, and diverse landscape that caters to the needs of society. In the end, the project aims to cultivate a sustainable and inhabitable city through the development of an adaptable landscape. Basically, the final vision is to transform Zwolle into a greener city, where the urban environment goes harmoniously with the forest, rather than incorporating fragments of greenery.

1.3 Methodology

The research direction of this project encompasses two primary aspects. Firstly, it seeks to address the impact of climate change on cities through the implementation of urban forests. Secondly, it aims to enhance the quality of life for citizens while mitigating urban climate issues.

To begin with, the project will analyze how the existing urban forest in Zwolle affects the urban surface temperature. This analysis will involve visualizing different types of sites and comparing the arrangement and combination of trees in each site to assess the shading effects produced. The objective is to determine the most effective urban forest layout and tree selection that can significantly reduce urban surface temperatures. This analysis will address sub-questions 1 and 2.

The second aspect focuses on how the urban forest can enhance the living experience of residents and foster stronger community connections. The design phase plays a crucial role in achieving these goals. The proposed design scheme considers the upgrading of sites across three scales: small, medium, and large. Small-scale designs aim to improve the green spaces within specific areas. Medium-scale designs explore how urban forests can enhance connectivity between communities. Large-scale designs investigate the potential of urban forests to guide future urban development. These design considerations will also address sub-questions 3 and 4.



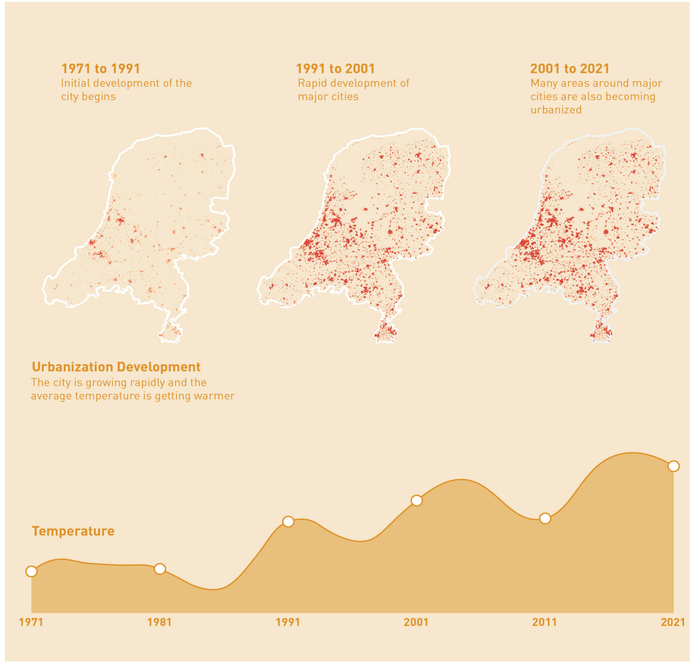
Chapter 2 THEORY FINDINGS

2.1 Project Background

Climate Issue and Urban Development

Since the early 20th century, Dutch cities have experienced rapid development, with both major metropolitan areas and smaller towns in the surrounding regions undergoing substantial urbanization. This growth has resulted in diverse and multi-level urban functions.

Correspondingly, KNMI data reveals a consistent increase in the average temperature of the entire Netherlands since the early 1900s. Notably, there have been 28 heatwaves in the country from 1900 to 2020 (Rød et al., 2021), with only 7 occurring before 1970 and the remaining 21 happening thereafter. In 2019, the Netherlands recorded its first instance of a temperature exceeding 40 degrees Celsius. These statistics clearly demonstrate a strong correlation between urban expansion and the urban heat island effect.



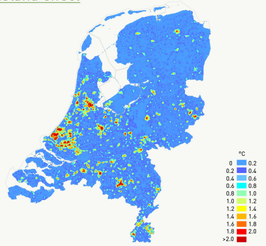
How to Reduce UHI?

While the Netherlands may not have megacities, the prevalence of heat islands is widespread across almost every city in the country, as revealed by satellite images capturing heat wave patterns since 2006. The urban heat island effect poses a significant challenge, leading to sweltering temperatures and posing health risks. The difficulty in dissipating heat due to blood vessel dilation and reduced perspiration at extremely high temperatures puts vulnerable populations, such as older adults, pregnant women, young children, and individuals with pre-existing health conditions, at greater risk of adverse health effects.

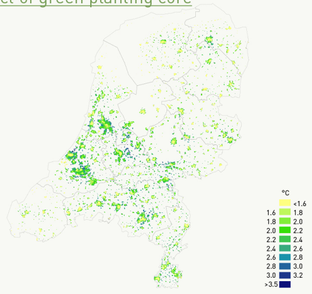
Recognizing the urgency about climate change, the Dutch government has implemented appropriate measures. Increasing the presence of greenery within urban areas stands as a primary strategy. This includes extensive tree planting initiatives, the development of additional urban green spaces, and the expansion of green roofs and walls. By augmenting the ratio of green spaces, these efforts contribute to lowering urban temperatures on a city-wide scale. The RIVM's data on the cooling effect of green and blue spaces demonstrates the substantial positive impact of urban vegetation in reducing regional climate temperatures.

These measures highlight the commitment of the Dutch government to adapt to climate change and mitigate the urban heat island effect. By prioritizing the integration of green infrastructure, the Netherlands strives to create a more sustainable and resilient urban environment, safeguarding the well-being of its residents and mitigating the adverse consequences of rising temperatures. At the same time, it also shows that increasing the proportion of green in the city does help to improve the urban heat island effect.

Urban heat island effect



Cooling effect of green planting core



What is Urban Heat Island?

In recent years, the impact of urban heat waves has become increasingly apparent worldwide, exacerbated by the rising global climate and rapid urbanization. Cities around the world are experiencing intensified urban heat island effects, leading to a steady decline in the quality of the urban thermal environment. Consequently, addressing the urgent problem of mitigating the urban heat island effect caused by high temperatures has become imperative.

The concept of the "heat island effect" was first introduced by British climatologist Luke Howard in the early 19th century. In his book "The Climate of London", he meticulously measured and documented temperature variations across different areas of the city over a span of forty years, ultimately formulating the concept of the heat island effect. (Howard, 1818)

In modern society, the rapid advancement of urban construction has significantly amplified the urban heat island effect. Factors contributing to this phenomenon include the concentration of population in cities, industrial development, and the prevalence of stone and concrete structures. The dark surfaces of these buildings absorb a substantial amount of solar radiation, resulting in higher daytime temperatures within urban areas compared to suburban and rural regions. (Solecki et al., 2005) Furthermore, the low heat capacity and high heat transfer rate of these materials, coupled with the blocking and wind-dampening effects of buildings, disrupt the energy balance in urban areas, often causing higher temperatures than in the surrounding rural areas. (Oke, 1982) Consequently, the spatial distribution of temperature resembles that of a warm island, giving rise to the urban heat island effect.

Another significant contributor to the urban heat island effect is lack of transpiration in urban areas. Green spaces play a crucial role in cities by absorbing solar radiation, with a large portion of the absorbed energy utilized by plants through transpiration and photosynthesis, thereby reducing the ambient temperature.

However, due to the reduction of green areas, forests, and water bodies in urban environments, the city lacks the natural elements capable of releasing heat. As a result, the capacity to alleviate heat stress is significantly diminished.

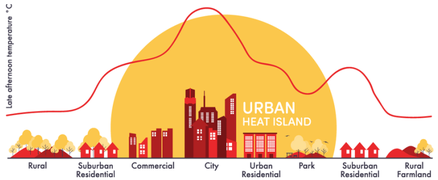


Figure is a courtesy from Kamyar Fuladlu

What is Urban Forest?

Urban forest as one that is located within or near an urban area, where the main function of the forest is to facilitate recreational activities. (Grebner et al., 2022) These forests are established through human efforts, whether through spontaneous or planned greening activities.

Urban forests are typically located on paved surfaces, adjacent to buildings, or within designed parks. They serve as a prominent and tangible form of green infrastructure in urban areas, often being the most prevalent. While trees form the backbone of urban forest,

they are accompanied by a diverse range of vegetation, including shrubs, grass lawns, and gardens. These green features contribute to the overall composition and functionality of urban forests, adding layers of biodiversity, visual interest, and ecological benefits.

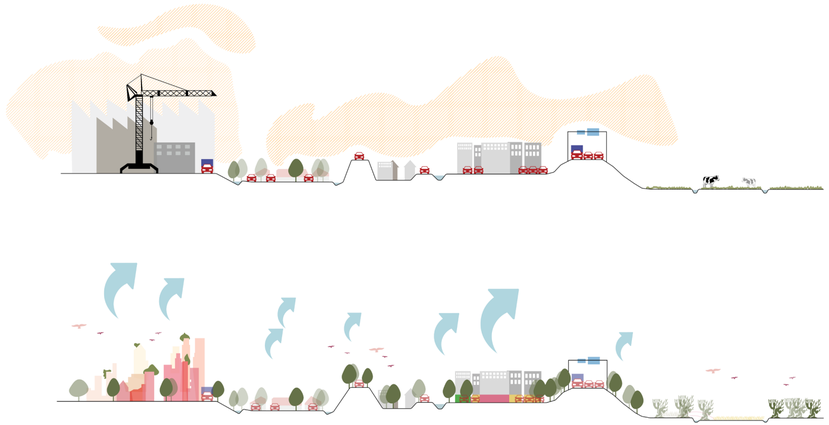
In summary, urban forests are intentional and dynamic green spaces that bring the benefits of nature into the heart of urban areas. Their strategic placement, diverse plantings, and multitude of ecosystem services make them an indispensable component of sustainable urban planning.

2.2 Theoretical Framework

The Role of Urban Forest in Reduce UHI

There is a clear relationship between urban green coverage and the intensity of the heat island effect. Researchers have shown that if a green area with a scale greater than 3 hectares and a greening coverage of over 60%, it can yield temperature levels comparable to those found in natural suburban areas.(Li et al., 2004)

It means the green coverage increases, the effect of the heat island decreases. Li's research also said when the green coverage exceeds 30%, there is a significant weakening of the heat island effect. Furthermore, when the coverage is over 50%, the reduction in heat island intensity becomes pronounced. There are more detailed data derived from Kong's experiments said that a 10% increase in forest cover can result in a decrease in the Earth's surface temperature of approximately 0.83C.(Kong et al., 2014)



How Tree Works in Reduce the Urban Surface Temperature

Trees play an important role in mitigating the urban heat island effect by two mean ways: transpiration and shading. Shading and radiation filtration by trees reduce the surface temperature.(Brown et al., 1995)

Additionally, the trees acts as a shield, it blocks a part of solar radiation and reducing the amount of heat absorbed by the shaded areas. This shading effect helps minimize the intensity of daytime heat and further contributes to temperature reduction in urban spaces.(Lindberg et al., 2011)

By lowering surrounding temperatures, trees significantly enhance the comfort and livability of urban environments, providing cooler opportunity under the high temperature. Another research shows the presence of trees in a given area can lead to a significant reduction in daytime air temperature, with differences of up to 5 °C lower compared to reference stations.(Semenzato, 2023)

Except their cooling properties, trees serve as natural air purifiers, playing a vital role in improving air quality. They act as filters, absorbing pollutants such as nitrogen dioxide, ozone, and particulate matter from the air.(Anderson et al., 2020) In addition, as trees absorb carbon dioxide during photosynthesis, they help mitigate the effects of greenhouse gases, contributing to climate change mitigation efforts.

The net cooling of a young healthy tree is equivalent to **10 room-sized air conditioners**

Tree **block sunlight**, helping to keep the ground below cool

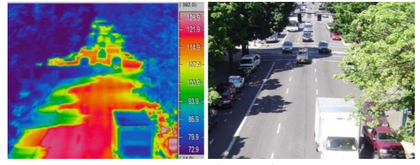
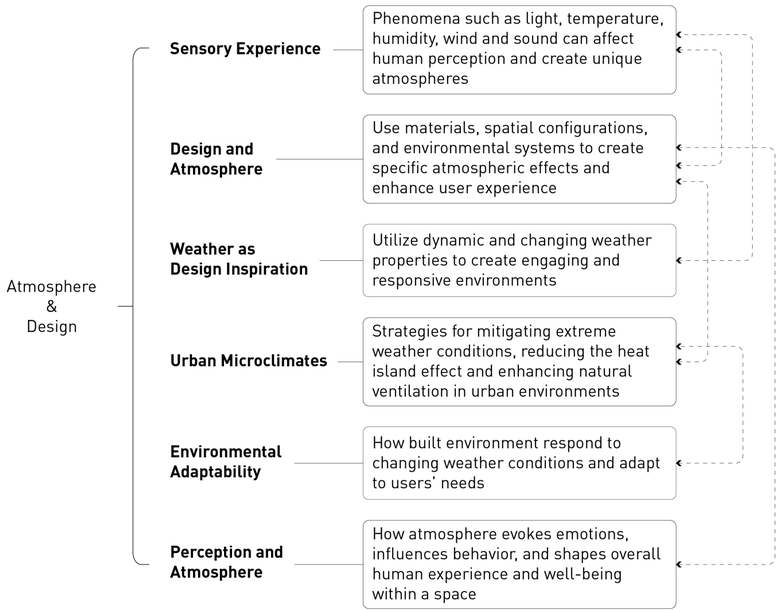


Image resource: Houston Advanced Research Center. (2009, March). Dallas Urban Heat Island. U.S. Environmental Protection Agency.

Urban Forest Design Framework

There is a relationship between design, weather, and the senses, with the built environment interacting with atmospheric conditions to shape our perception and experience of space.(Benedito et al., 2021) Therefore, design plays an important role in enhancing and shaping people's sensory within surrounding environment. While it is confirmed that urban forests can mitigate urban ground surface temperatures and reduce the urban heat island effect, future urban forest design should not only think about the physical cooling. It should also consider different forest arrangements and plant selections that provide a different nature atmosphere for people. Therefore, future designs should also think about human senses. Creating urban forests that not only cool but also give the senses, making a profound connection between human and nature.



Future Urban Forest Development Design Framework

Frederick Law Olmsted said the creation of a composition in which all parts were subordinated to a single, coherent effect.(Dean et al., 1886) This concept highlights the significance of green and natural spaces in enhancing the urban environment and improving the public living experience. It is not only about connecting people to the natural environment but also about establishing a stronger connection between humans and nature within the city.

Taking inspiration from one of Olmsted's famous designs, the Emerald Necklace, incorporating nature into the city can enhance urban cohesion. By using urban forests as a guiding principle, we can also think about the future development of the city. Therefore, when designing the project and giving the future urban expansion vision, it is necessary to consider not only the urban green within specific communities or areas but also to plan the future development needs of the entire city.

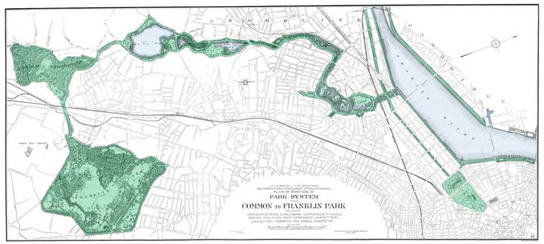
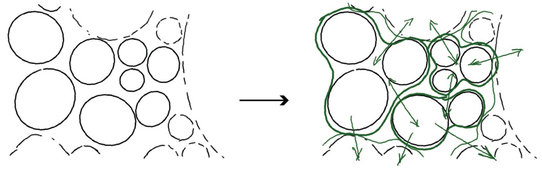
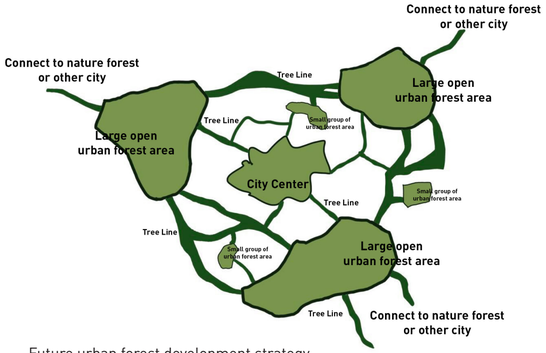


Image resource: Masterplan of Emerald Necklace drawn by Frederick Law Olmsted.



Seperate urban area

Connecting by urban forest



Future urban forest development strategy

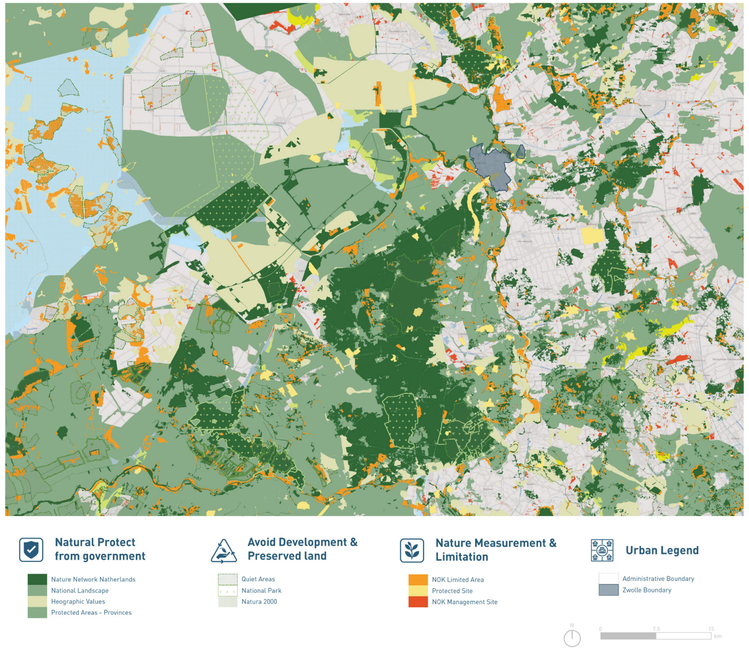
Chapter 3 SITE FUNDAMENTAL RESEARCH

3.1 Project Background

Zwolle Geographical Conditions

The project is situated in Zwolle, a city located in the IJsseldelta region of the Netherlands. Zwolle is an integral part of the Dutch city network and faces diverse challenges in terms of urbanization, climate, and economy. One pressing issue is the severe urban heat island effect experienced in Zwolle, which necessitates urgent solutions.

Fortunately, Zwolle possesses abundant natural potential that can be leveraged to create forest cities in the future and mitigate the urban heat island effect. The surrounding areas of Zwolle boast valuable natural resources, including the Natura 2000 area and the Netherlands Nature Network. In considering the future of Zwolle's urban forest, an intriguing possibility arises: the integration of the urban forest with the existing natural areas. This concept holds the potential to establish a more comprehensive and interconnected forest system for the city.



3.2 The Policy

The demand for landscape in urban climate development at the present stage:

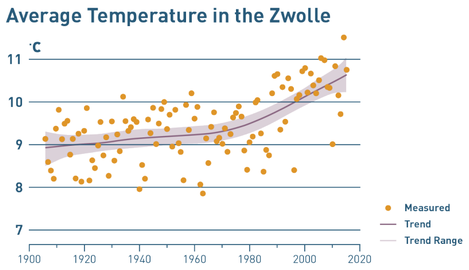
Regarding the climate issue, the government has introduced various strategies to address the challenges. Firstly, they aim to engage residents in creating small-scale micro-climate environments akin to community gardens. This approach empowers individuals to contribute to climate mitigation efforts. Secondly, the government intends to enhance existing urban blocks by incorporating more green paving on streets, as well as implementing green roofs and facades. These measures not only improve the aesthetic appeal but also contribute to climate resilience. Additionally, the government is actively envisioning and planning for future climate communities, incorporating green elements into their design. However, there remains a need for comprehensive guidelines to address climate issues in the existing older urban areas.

Future Urban Climate Development Requirements for Landscape:

Simultaneously, the Zwolle government has embarked on the formulation of distinct urbanization strategies to establish long-term adaptive cities. By 2040, the government aims to construct a minimum of 50,000 homes across the Zwolle region while generating 20,000 jobs. (Regio Zwolle, 2022) The focus is on creating livable and comfortable environments capable of withstanding the challenges posed by climate change, including extreme humidity, dryness, and heat. The recently adopted urbanization strategy, known as "Warme Harten in een Klimaatadaotieve Delta", provides crucial guidance for this endeavor. The strategy emphasizes that areas of high natural or landscape value should be safeguarded from the impacts of urbanization, infrastructure development, and large-scale economic expansion. The government's vision encompasses climate-proofing the entire city, ensuring its resilience to future climate conditions.

3.3 Regional Analysis

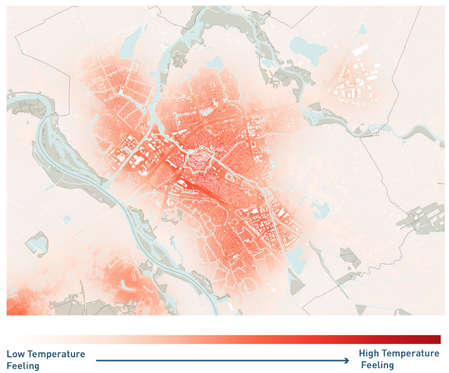
The UHI in Zwolle



In recent years, the Netherlands has witnessed a significant increase in temperatures, and the Zwolle region is no exception to this trend. Year after year, temperatures in Zwolle have shown a consistent upward trajectory. By examining historical climate data, it becomes evident that this pattern of temperature rise is likely to persist in the coming decade to three decades. Through the utilization of urban heat maps, it becomes apparent that the closer one gets to the city center, the more pronounced the climate pressures become. This phenomenon can be attributed to the scarcity of vegetation and green open spaces, which presents unique challenges for mitigating the temperature rise in the old town of Zwolle.

The absence of adequate vegetation and green spaces amplifies the urban heat island effect in the old city. The urban heat island effect arises when urban areas, characterized by concrete, asphalt, and limited greenery, absorb and retain more heat, leading to higher temperatures compared to the surrounding rural areas. In the case of the old town of Zwolle, the lack of sufficient vegetation exacerbates the situation, making it more challenging to alleviate the temperature rise. This phenomenon poses a significant challenge to the future well-being of the old town area.

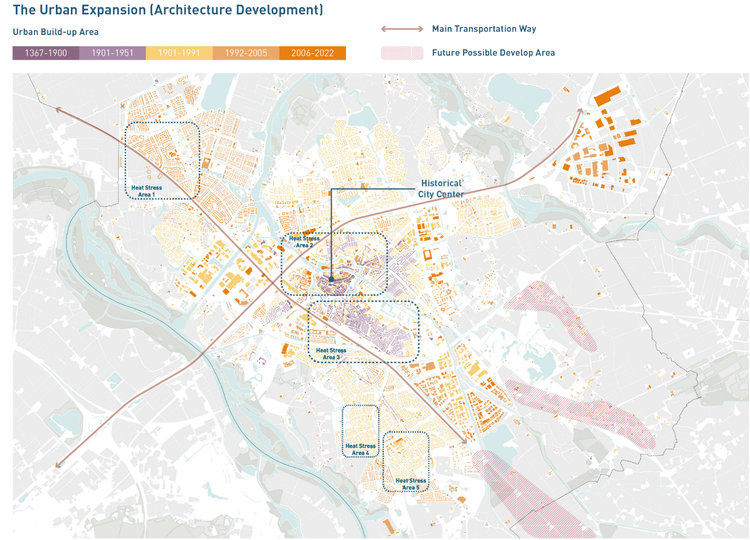
How Warm Feel in Zwolle?



Zwolle City Expansion History

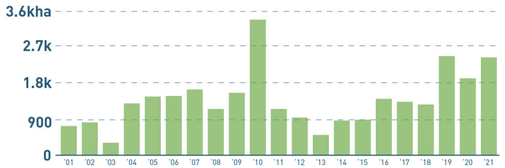
Zwolle's development history highlights key transformations over time. Prior to 1900, the city's growth was concentrated within the central fortress area, resulting in an ultra-high-density urban environment that offered limited space for urban greenery. By 1950, the city began to expand, but the new areas also suffered from high density and lacked a proper integration of green spaces. Consequently, these developments in both periods faced significant climate challenges.

However, a notable shift occurred after 1990 when city planning endeavors commenced to harmonize urban and natural elements. Subsequent developments focused on reducing residential density and increasing the distance between communities. This approach has had a positive impact by alleviating some of the climate pressures faced by the city.



Zwolle Landscape Potential

Tree Cover Loss in Netherlands



From 2001 to 2021, Netherlands lost **29.1kha** of tree cover, equivalent to a **4.9%** decrease in tree cover since 2000.

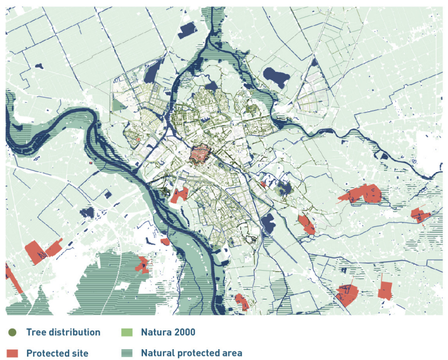
A data by global forest watch said that from 2001 to 2021, Netherlands lost 29.1kha of tree cover, equivalent to a 4.9% decrease in tree cover since 2000. The disappearance of trees in Netherlands is primarily attributed to the rapid pace of urbanization. As the city expands, more land is allocated for infrastructural development, leading to the removal of trees and green spaces. Consequently, it becomes imperative for future urban development in Zwolle to address this issue by not only preserving the existing natural state but also actively incorporating more trees into the cityscape. This endeavor aims to forge a harmonious union between the urban environment and nature.

There is a great deal of natural potential around Zwolle, which is largely surrounded by natural forest systems on all sides. These areas are protected by the government and no further urbanization is allowed. Several regions within Zwolle fall within these protected areas, further enhancing their significance.

This natural context presents a favorable foundation for the future development of urban forests in Zwolle, potentially bringing additional greenery from the surrounding areas to the city. By combining the urban forest with the surrounding natural areas, Zwolle can enhance the ecological value and resilience of its green spaces.

This integration would not only expand the overall forested area but also foster a seamless transition between urban and natural environments, and also can transform the city into a greener, more resilient, and ecologically vibrant place to live.

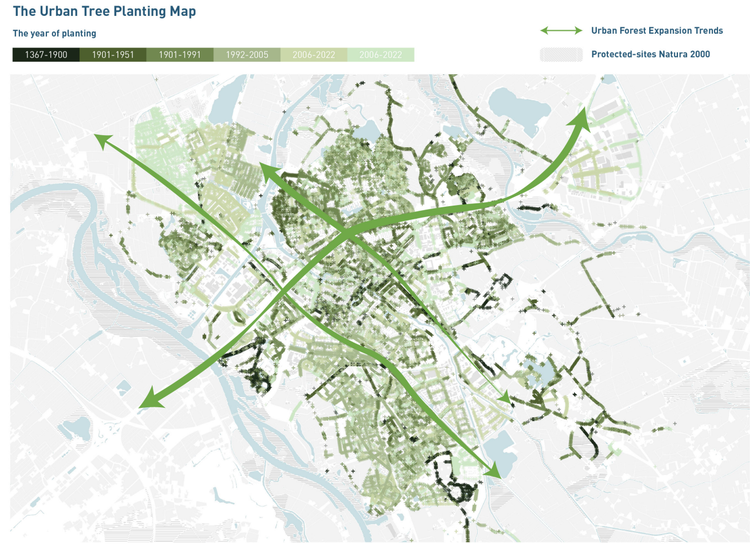
Current Landscape Potential



Zwolle Urban Forest Development History

Prior to 1900, the city of Zwolle exhibited minimal forest development within its boundaries. Instead, trees were selectively planted in locations situated away from the city center and alongside roadways. This approach aimed to utilize the presence of forests as a means to guide people towards the central areas of the city. By 1950, as the city underwent systematic and extensive expansion, a growing understanding and appreciation of the urban forest system emerged. This led to the inclusion of tree planting within the scope of urban planning. Consequently, as the city developed, the tree count within Zwolle witnessed a progressive annual increase. Interestingly, a notable shift occurred after 2006, wherein trees not only continued to be integrated into the expanding urban forest but were also reintroduced to the city center. This transformation reflects a heightened awareness of the neglected natural development, which was overshadowed by an excessive focus on urban expansion in the earlier years.

The Urban Tree Planting Map



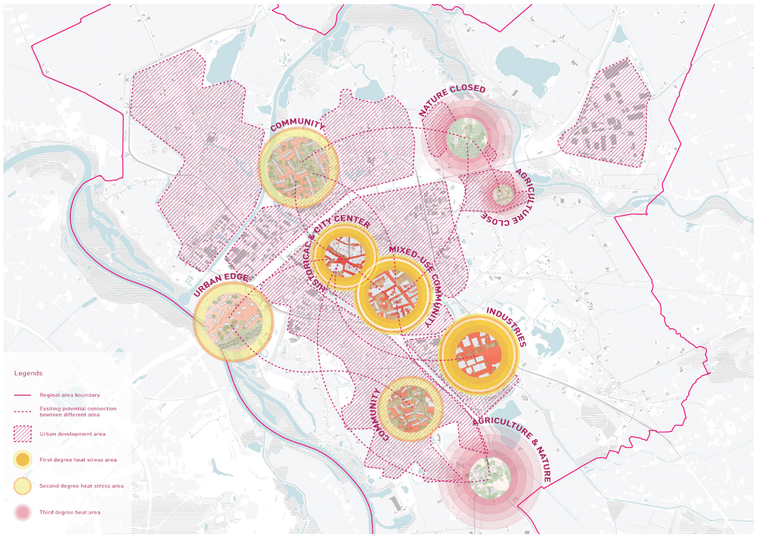
Chapter 4 ANALYSIS

4.1 Analysis Introduction

Typology Site Selection

Within the urban development area of Zwolle, variations in surface temperature can be attributed to urbanization and the distribution of urban vegetation. To investigate this further, a study was conducted, selecting nine diverse locations throughout the city. These sites encompassed a range of typologies, each exhibiting distinct characteristics.

Analyzing surface temperatures, the selected sites were categorized into three groups: high surface temperature, medium surface temperature, and low surface temperature. This classification provided a basis for assessing the relationship between vegetation arrangement, urbanization patterns, and surface temperatures. By visually examining the plant distribution and urban development layout in each site, valuable insights were obtained to inform future urban forest construction strategies.



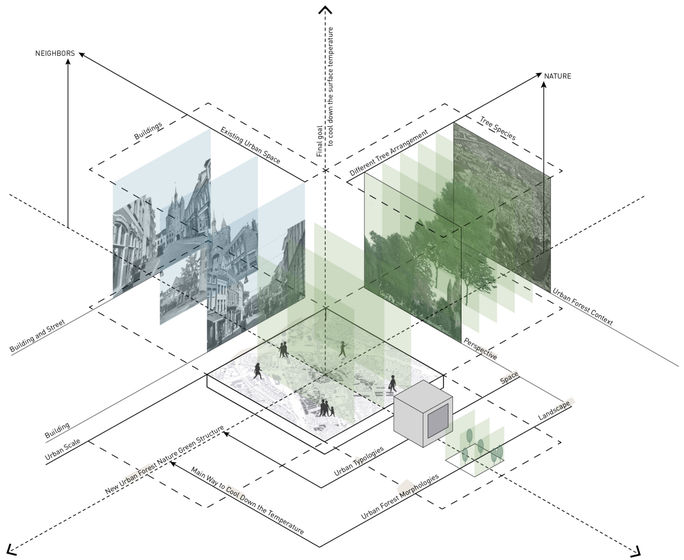
High surface groud temperature

Low surface groud temperature

Typology Analysis Introduction

A city's composition is primarily a blend of urban and natural elements. The urban environment caters to our fundamental needs, providing spaces for daily living and activities, while nature offers diverse sensations and experiences. Analyzing the interplay between these two components within a city is crucial, particularly for a project aimed at integrating them to create a climate-mitigate urban forest.

The study identified planting methods and plant types that could prove beneficial in the establishment of urban forests. These findings emerged from a comprehensive analysis of the selected sites, considering their unique characteristics and environmental conditions. By understanding the correlations between vegetation, urbanization, and surface temperatures, recommendations were derived to guide future efforts in urban forest development.



4.2 Typology Analysis

Typology 1

Site properties

Single ● ● ● ● ● Multiple

Surface ground texture

Soft ground ● ● ● ● ● Hard ground

Tree coverage

Low ◐ ○ ○ ○ ○ High

Urban density

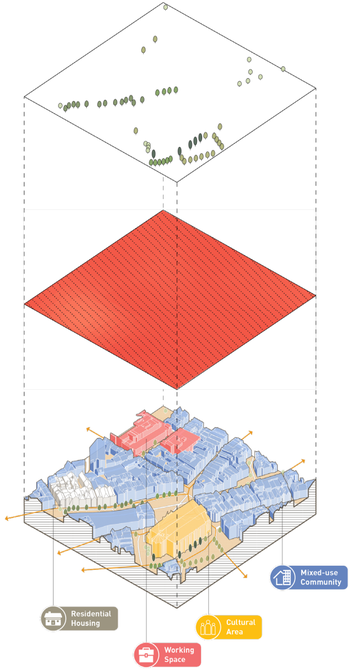
Low ● ● ● ● ● High

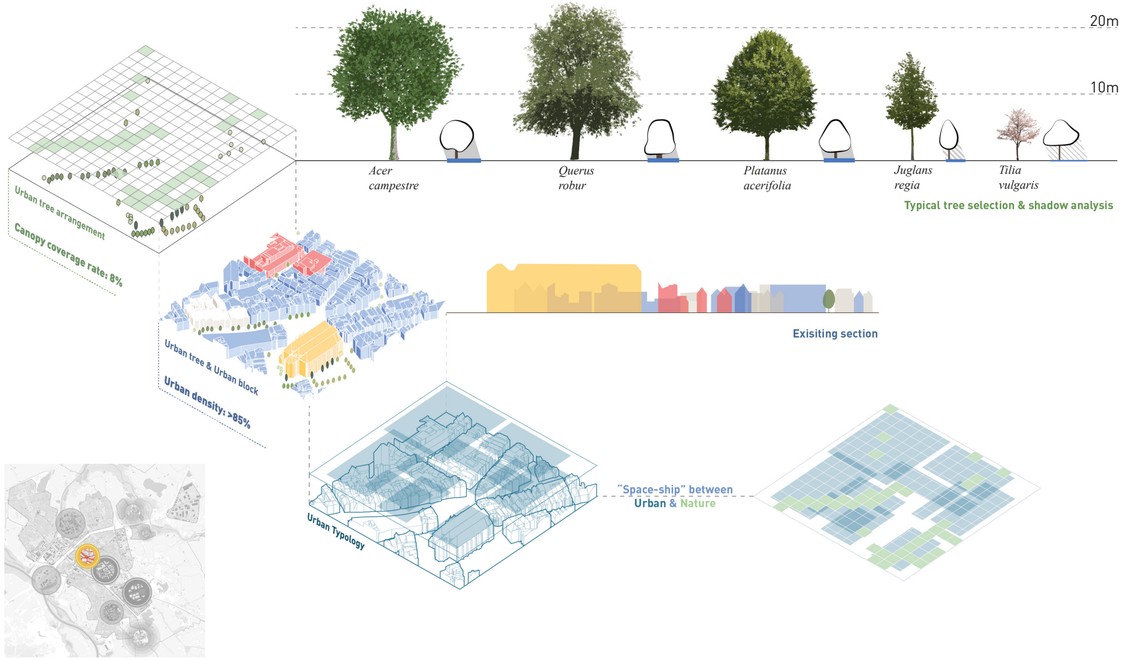
Surface ground temperature

Low ● ● ● ● ● High

The site is situated at the origin of Zwolle, which started to take shape in the 14th century and has since evolved into its present-day form. The downtown area is now recognized as a protected cityscape due to its numerous historic buildings. The primary characteristic of this area is a cohesive block of buildings that are interconnected yet independent, featuring diverse architectural structures and irregular distribution. Private and public spaces often merge together, and the public areas are designed with distinctive paving materials. And being a historic district with its diversity of historic buildings, special buildings and public spaces makes the city center a special place to live.

But early on, nature was not included in the development policy of this area, so few trees existed.





Typology 2

Site properties

Single ● ● ● ● ● Multiple

Surface ground texture

Soft ground ● ● ● ● ● Hard ground

Tree coverage

Low ● ○ ○ ○ ○ High

Urban density

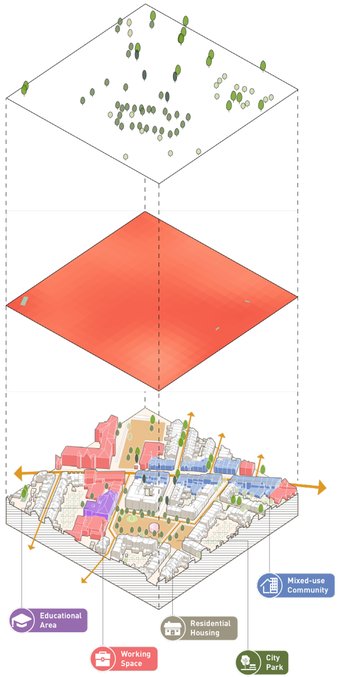
Low ● ● ● ● ● High

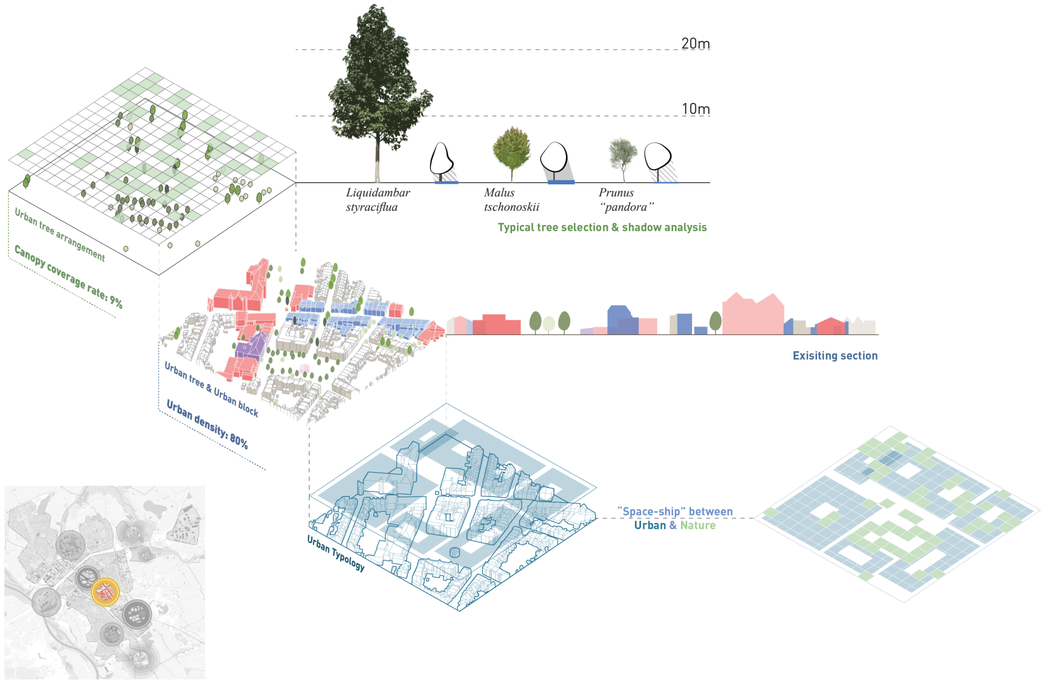
Surface ground temperature

Low ● ● ● ● ◐ High

This area experienced gradual development over time, following an ancient path of land reclamation. As a result of this historical progression, nearly every block within this area boasts historical walls. Subsequent architectural advancements have followed the contours of these walls, resulting in a compact and densely built structure. Consequently, the plots of land are clearly demarcated, the streets are narrow, and a distinct separation exists between private and public spaces.

Moreover, the boundaries of this area are in close proximity to major transportation networks, including railways and expressways. This proximity to urban infrastructure has had a significant impact on the process of urbanization within the area.





Typology 3

Site properties

Single ● ○ ○ ○ ○ Multiple

Surface ground texture

Soft ground ● ● ● ● ◐ Hard ground

Tree coverage

Low ● ○ ○ ○ ○ High

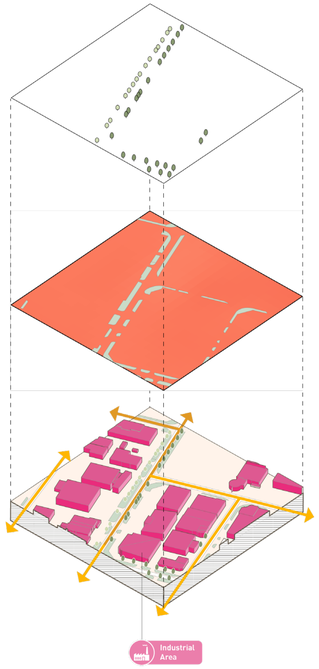
Urban density

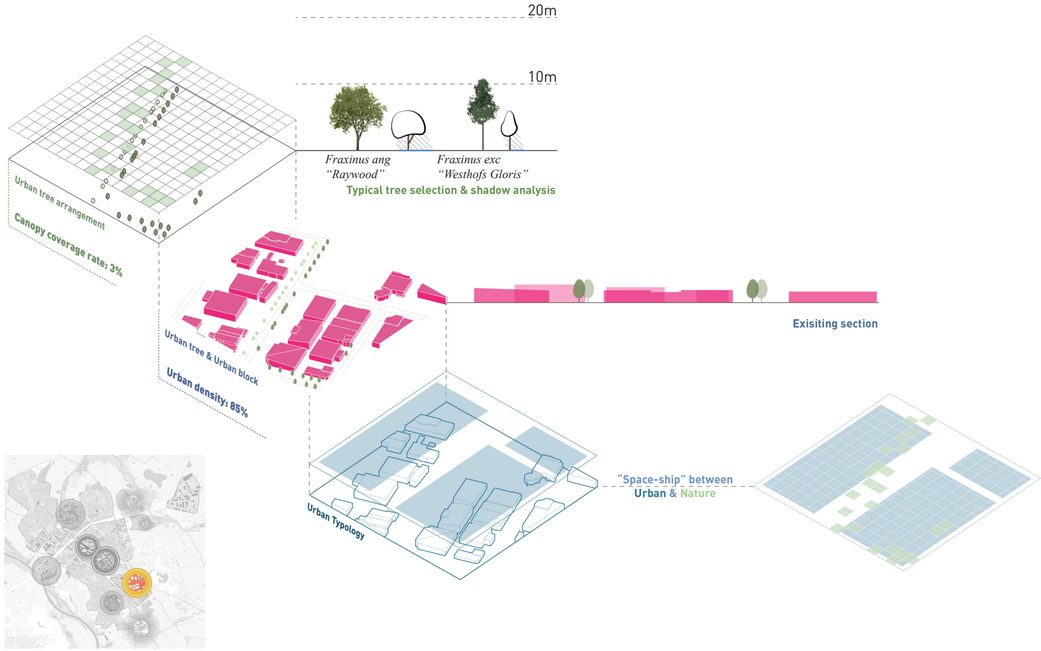
Low ● ● ● ○ ○ High

Surface ground temperature

Low ● ● ● ● ◐ High

The area under consideration is one of the business areas in Zwolle. The growth in size and freight capacity of major corporations has been a driving force behind the establishment and expansion of these expansive industrial parks. The park's location in close proximity to railway and road networks is essential, as it heavily relies on efficient transportation connections for its operations. The spatial organization of the area is predominantly influenced by the arrangement of public areas and the integration of green spaces. Consequently, the industrial park's periphery aligns with the surrounding countryside, resulting in a distinctive transition from the urban to rural landscape. However, due to the emphasis on open spaces and functional requirements, the presence of medium and large-sized trees within the park is relatively limited.





Typology 4

Site properties

Single ● ● ○ ○ ○ Multiple

Surface ground texture

Soft ground ● ● ● ◐ ○ Hard ground

Tree coverage

Low ● ● ○ ○ ○ High

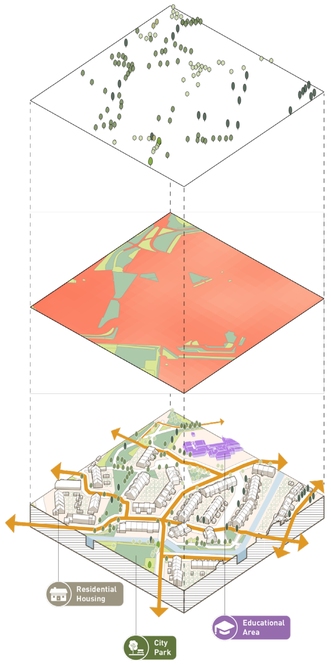
Urban density

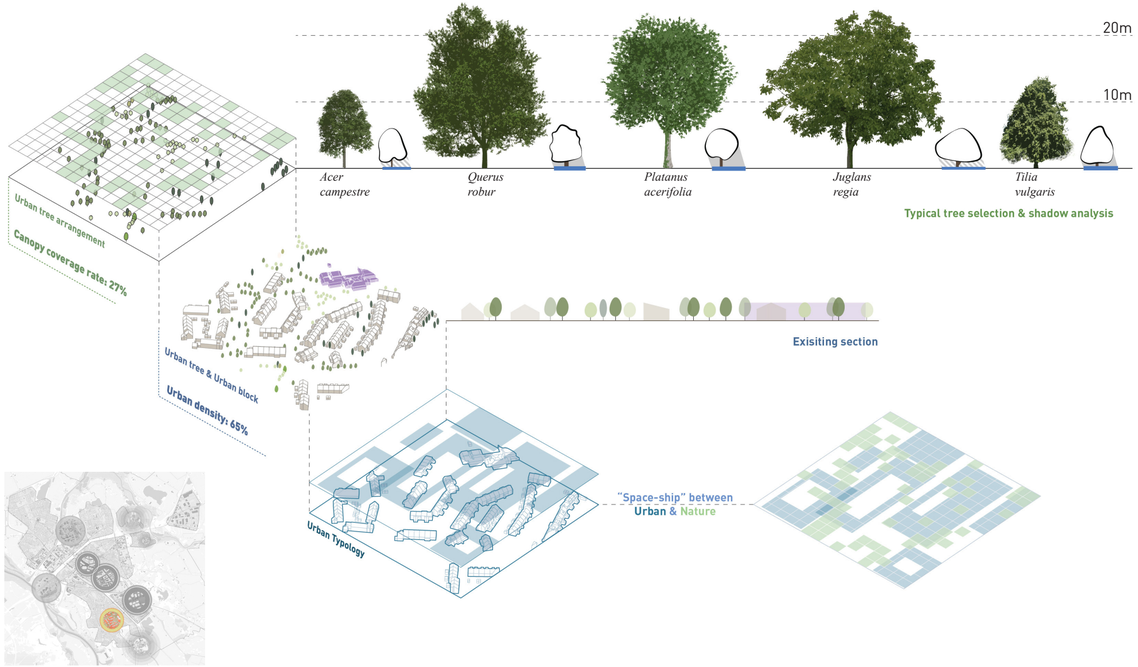
Low ● ● ● ○ ○ High

Surface ground temperature

Low ● ● ● ● ○ High

Since the 1980s, this area has undergone substantial development, with each section being developed as an independent residential zone, resulting in a complex and somewhat disorderly structure. The design of public spaces within these residential areas exhibits irregularity, primarily influenced by the intersections of buildings, houses, and multiple roads. In such a chaotic environment, the inclusion of trees in the design has been overlooked, and only select streets feature green belts, serving as decorative elements for the overall area, and lack a unified aesthetic or coherent green infrastructure.





Typology 5

Site properties

Single ● ○ ○ ○ ○ Multiple

Surface ground texture

Soft ground ● ● ● ● ○ Hard ground

Tree coverage

Low ● ● ○ ○ ○ High

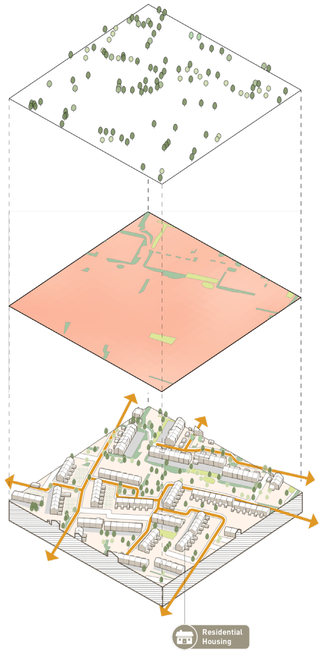
Urban density

Low ● ● ● ○ ○ High

Surface ground temperature

Low ● ● ● ◐ ○ High

This area is an extension that is embraced by fragments of the original agricultural landscape and is adorned with lush greenery along the Zwartewater. The natural landscape of the region serves as a cohesive and verdant foundation, lending a sense of harmony and continuity to the area. Careful attention has been given to seamlessly integrate the edges of the neighborhood with the surrounding natural environment. Within the residential area, family households and low-rise buildings take center stage, characterizing the neighborhood's ambiance. The houses are clustered within the residential zone, surrounded by an uninterrupted green framework. As a result, the distribution of trees in this area appears more scattered and organic, allowing for a sense of free and natural variety.



Typology 6

Site properties

Single ● ○ ○ ○ ○ Multiple

Surface ground texture

Soft ground ● ● ● ● ○ Hard ground

Tree coverage

Low ● ● ● ○ ○ High

Urban density

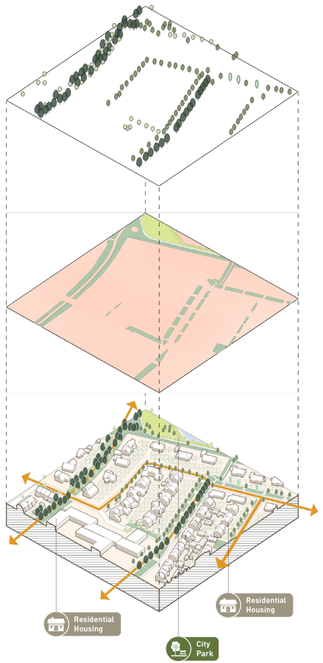
Low ● ● ● ○ ○ High

Surface ground temperature

Low ● ● ● ○ ○ High

This area was initially a traditional agricultural settlement, with buildings dispersed across higher ground. The layout of these communities is characterized by spaciousness and abundant green vegetation. The area holds a unique position within the agricultural landscape, which led to its gradual integration into the expanding city of Zwolle. Consequently, the landscape and arrangement of trees in this area still retain elements reminiscent of the agricultural environment.

Although the urbanization and expansion of Zwolle, the landscape and tree arrangement have been consciously preserved to maintain the essence of the agricultural landscape. This retains the rural aesthetics fosters a sense of continuity and connection with the area's heritage.



Typology 7

Site properties

Single ● ○ ○ ○ ○ Multiple

Surface ground texture

Soft ground ● ● ○ ○ ○ Hard ground

Tree coverage

Low ● ● ● ◐ ○ High

Urban density

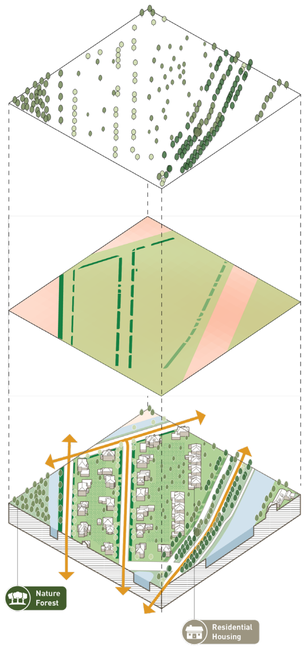
Low ● ● ○ ○ ○ High

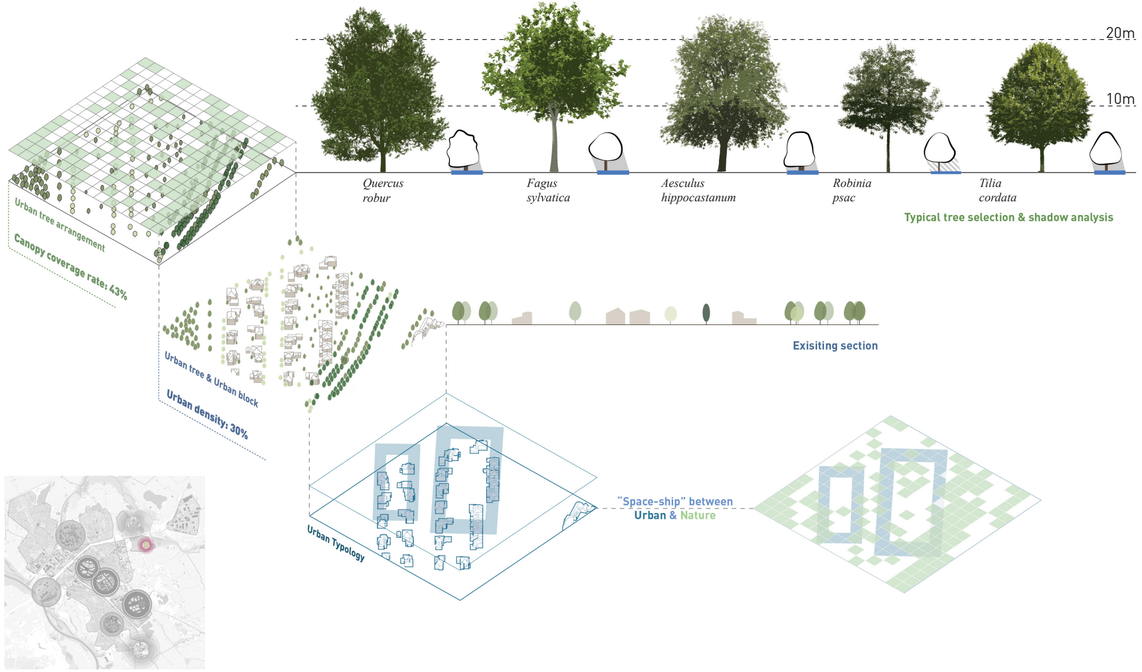
Surface ground temperature

Low ● ● ● ○ ○ High

This area represents the urban landscape zone of Zwolle, primarily encompassing a landscape park that holds significant cultural value due to its historical relics. Surrounding the park are various residential areas and urban infrastructure, harmoniously blending with the natural surroundings. The area is distinguished by its exceptional green features, highlighting the commitment to maintaining a high standard of environmental quality.

Due to its proximity to the agricultural region, the government has made concerted efforts to enhance landscape continuity in this area. As part of this initiative, a forest background has been constructed to further enrich the natural scenery and ensure a seamless transition between the urban and rural landscapes.





Typology 8

Site properties

Single ● ○ ○ ○ ○ Multiple

Surface ground texture

Soft ground ● ○ ○ ○ ○ Hard ground

Tree coverage

Sparse ● ● ● ● ◐ Close

Urban density

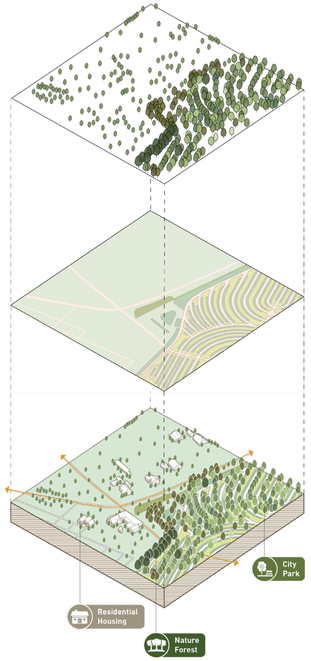
Low ● ○ ○ ○ ○ High

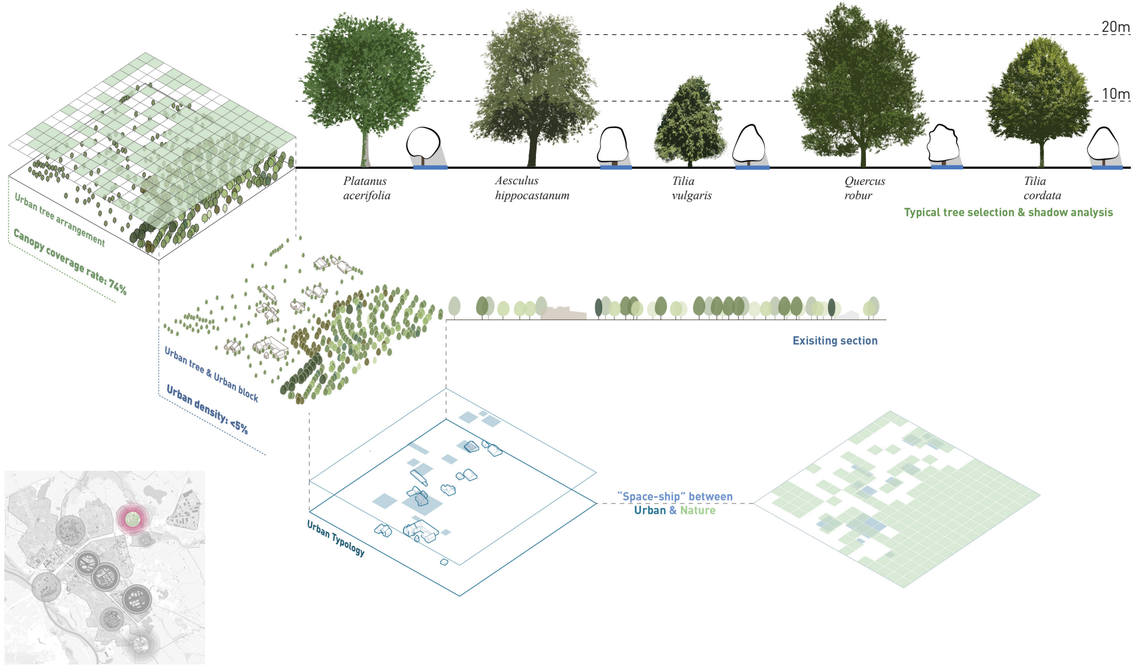
Surface ground temperature

Low ● ● ○ ○ ○ High

Unlike other areas, this site showcases a remarkably low building density, offering a stark contrast to the bustling urban environment. The site is close proximity to a vast man-made forest, and exemplifies an alternative approach to bridging the gap between agricultural land and urban development through landscape integration.

The presence of the large man-made forest serves as a critical component in the transition from agricultural to urban land. It acts as a verdant buffer zone, closely blending the surrounding rural landscape with the emerging urban area.





Typology 9

Site properties

Single ● ● ● ○ ○ Multiple

Surface ground texture

Soft ground ● ○ ○ ○ ○ Hard ground

Tree coverage

Sparse ● ● ● ○ ○ Close

Urban density

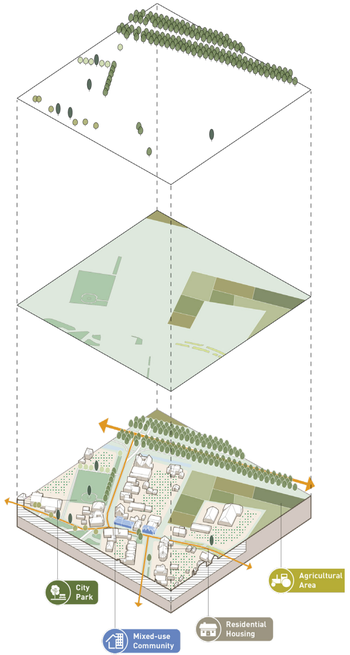
Low ● ● ○ ○ ○ High

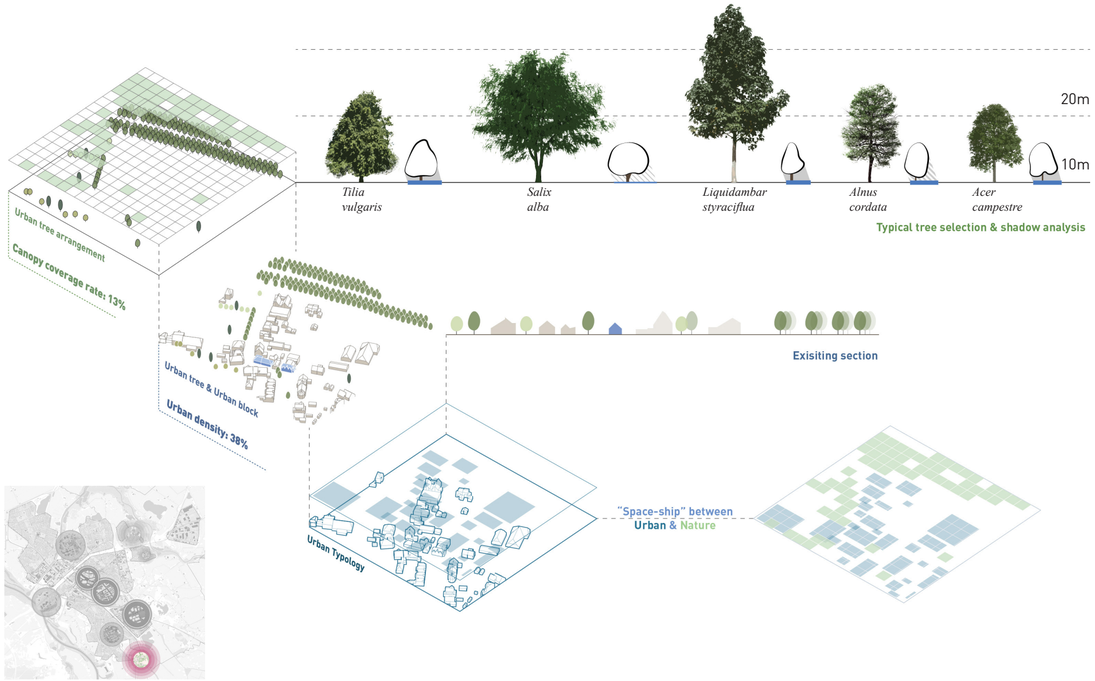
Surface ground temperature

Low ● ○ ○ ○ ○ High

This small rural residential area, located in close proximity to Zwolle, serves as a future target for urban expansion as per the plans of the local government. Presently, the area is in an early stage of development, characterized by small-scale extensions within the rural landscape. The original agricultural practices in this area originated on the elevated sand ridges, establishing a strong connection between the core settlements and the surrounding natural features.

From the core settlements, the visual relationship between the buildings and the landscape is remarkably pronounced. The buildings in this area have been positioned to create a harmonious interaction with the natural surroundings.





4.3 Analysis Conclusion

Based on the analysis of the nine different urban typologies, a final conclusion can be drawn. Areas with higher urban surface temperatures tend to exhibit higher urban density and lower tree coverage. Conversely, areas with lower urban surface temperatures display relatively lower urban density and higher tree coverage.

These combinations often manifest as linear arrangements or large-scale groupings. However, it is important to note that while some areas may have similar urban densities, those with low tree coverage experience lower surface temperatures due to the presence of open green spaces, such as agricultural land.

From this perspective, it becomes evident that open green spaces can contribute to reducing urban surface temperatures to a certain extent. Consequently, in subsequent design phases, it is crucial to apply these conclusions to the site. Efforts should be made to incorporate the identified patterns and principles, such as promoting tree planting and maximizing green spaces, to mitigate surface temperature and enhance the overall climate resilience of the city.

4.4 Analysis Result & Planting Design Principle

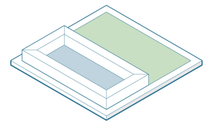
4.4.1 Urban Typology and Natural Space

Based on the aforementioned findings, six common spatial distribution relationships between cities and nature have been identified. These models serve as beneficial frameworks for constructing climate-mitigating urban environments. These six types, they all share a common feature: Having a close connection between large open green spaces and the urban developed area. This connectivity is vital as it enables significant evaporation and absorption even in the presence of extensive urban hard pavements. As a result, it helps alleviate the pressure of high temperatures on the urban surface.

By strategically establishing large-scale green spaces that are seamlessly linked with the city, the adverse impacts of urbanization, such as heat accumulation, can be mitigated.

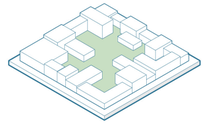
01

Large open green



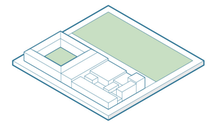
02

Center core green



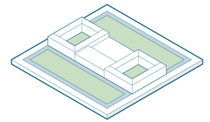
03

Open and dotted green combination



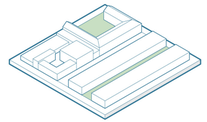
04

Street and community interaction



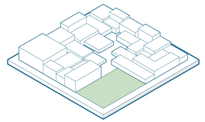
05

Decentralized interlaced



06

neighborhood green node creation

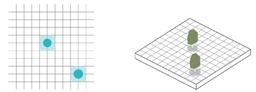


4.4.2 Tree Arrangement Result

Point

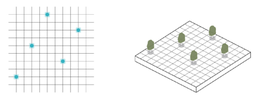
The arrangement of trees has a significant impact on the shadows cast on the ground, which, in turn, affects the urban surface temperature. Various tree arrangements, whether singular or in linear or group formations, generate different amounts of shade. Through the analysis of the nine city types and their associated urban forest types, it has been possible to identify the tree combinations that are most effective in mitigating the urban surface temperature. By considering factors such as tree density, distribution, and canopy coverage, optimal tree arrangements can be determined.The findings reveal the specific tree combinations that provide the greatest cooling effect on the urban surface temperature.

Regarding single tree arrangements, they can be categorized into two situations, large single point, and the small single point.



Large single point

These trees are typically old and massive, found in open green spaces within urban areas. They cast significant shadows.



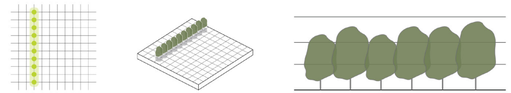
Small single point

These trees are commonly found in dense urban spaces, offering limited shade. However, they contribute to the diversity of urban greenery.

Linear

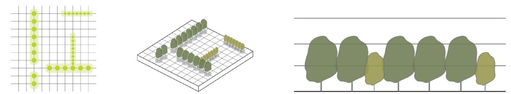
There are four primary situations for linear tree arrangement and combination: single linear alignment, segment, parallel and interlaced. Linear tree arrangements are commonly found along various types of roads. However, the specific conditions of the road determine the variations in linear tree arrangements, with tree distribution designed in accordance with road width.

Linear tree arrangements are characterized by trees of equal height, creating vertical planes reminiscent of columns or walls. The density and height of the tree canopy can be strategically manipulated to achieve different spatial effects. Moreover, the linear tree arrangements also play a crucial role in defining pedestrian and vehicular spaces, enhancing safety, and creating a more pleasant and enjoyable environment for road users.



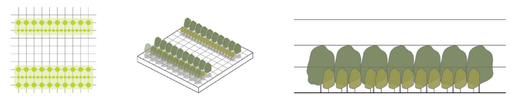
Single linear alignment

This tree arrangement type is commonly found on well-developed traffic roads, with trees positioned on both sides or in the middle of spacious roads. Typically, it serves as a visual and physical partition between the traffic and pedestrian spaces.



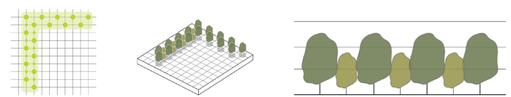
Segment

This arrangement is often seen on community roads following development, featuring trees of varying sizes. The inclusion of trees of different heights adds a sense of natural diversity and interest to the surroundings, enhancing the overall aesthetic appeal.



Parallel

Usually found along larger roads such as expressways, this tree arrangement serves multiple purposes. It acts as a buffer between the bustling traffic and residential areas, reducing noise and enhancing the quality of the living environment.

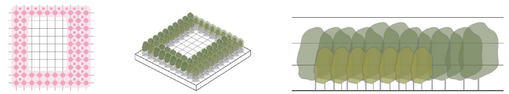


Interlaced

This type of tree arrangement is typically adjacent to large-scale buildings. In addition to enhancing the visual appeal and beautifying the landscape, these trees also help absorb the heat generated by hard surfaces in the city.

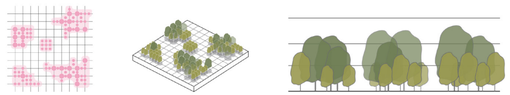
Group

In the previous studies, the group tree arrangement has demonstrated their effectiveness in reducing urban surface temperatures. The four situations where these tree formations commonly occur are as follows frames, scattered, random distribution, and solid group. These tree formations, typically consisting of relatively old and large trees, not only create ample shade that mitigates surface heat but also contribute positively to the environment through evaporation effects. However, it is worth noting that these trees predominantly exist in areas with lower levels of urban development, often in the outskirts or surrounding regions of the city. This is because the incorporation of large-scale tree clusters was not initially included in early urban planning designs.



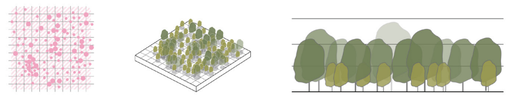
Framed

They are often found in modern developed communities, where they enclose residential areas to create a cooler microclimate. These intentional tree arrangements contribute to improving the comfort and livability of the community.



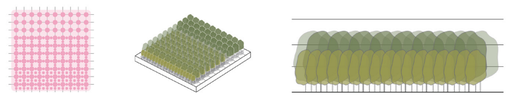
Scattered

These arrangements are frequently encountered in communities located on the outskirts of cities. Rather than being completely artificially planted, they typically exist in natural forest conditions that predate the community's development.



Random distribution

These tree arrangements are prevalent in areas near agricultural land on the city's periphery. Due to their scattered distribution, a substantial number of trees are required to form a significant impact. They serve as transitional zones between urban and agricultural areas.



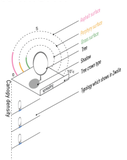
Solid group

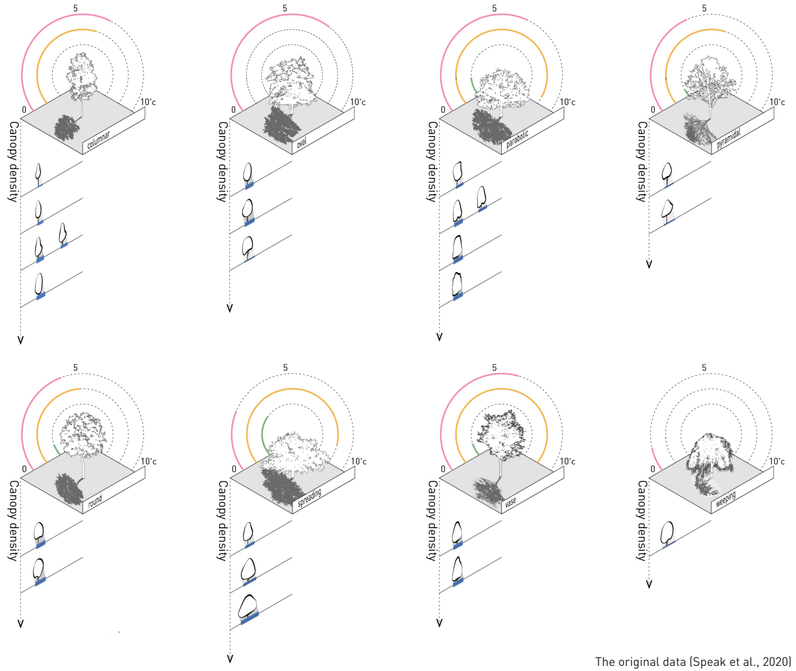
They are commonly utilized as a buffer or screen between cities and agricultural land. This large green screen, partially natural and partially planted, serves as a visual and physical separation while integrating natural elements into the urban fabric.

4.4.3 Tree Selection Result

Tree Crown

Tree type selection is crucial in addition to the arrangement of trees, the specific ability of trees to reduce urban temperature is mostly dependent on the number of trees, the leaf density and the shape of the crown. (Tamaskani Esfehankalateh et al., 2021) The research of the impact of tree types on urban surface shading and cooling by Speak says wider tree crowns are associated with higher cooling. (Speak et al., 2020) They employed thermal imaging cameras to monitor surface temperature changes of 85 tree species across three typical urban surfaces in Italy. Drawing from these findings and considering the plant species already present in Zwolle's urban area, the cooling potential of the city's existing tree types was summarized to inform design decisions.



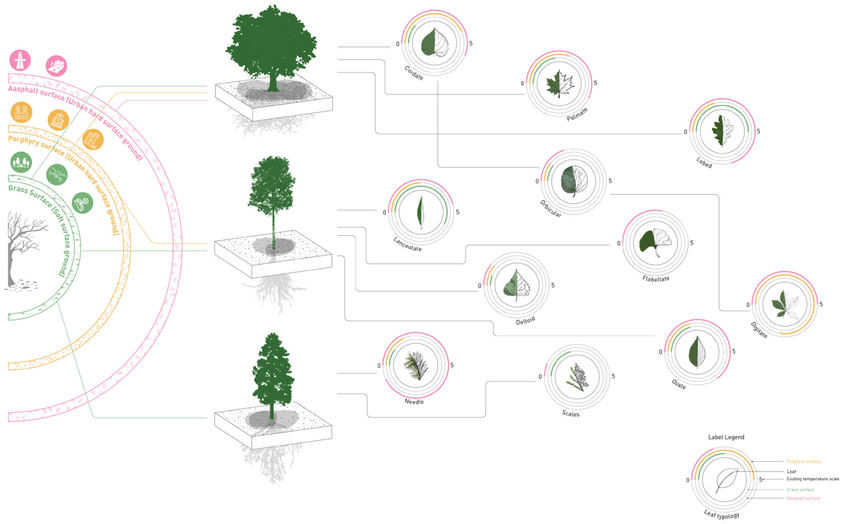


The original data (Speak et al., 2020)

Leaf Shape

Except for tree types, the size and shape of leaves also play a crucial role in mitigating urban surface temperatures. The research by Rahman said that Leaf area index showed a positive correlation with all three mechanisms of cooling. (Rahman et al., 2020) Therefore, leaf characteristics serve as significant criteria for selecting tree species in future design considerations.

This research by Speak shows that needle-shaped leaves exhibited one of the highest cooling effects compared to other leaf shapes. Therefore, it is advisable to consider a slight increase in the proportion of coniferous trees for future development in Zwolle city.

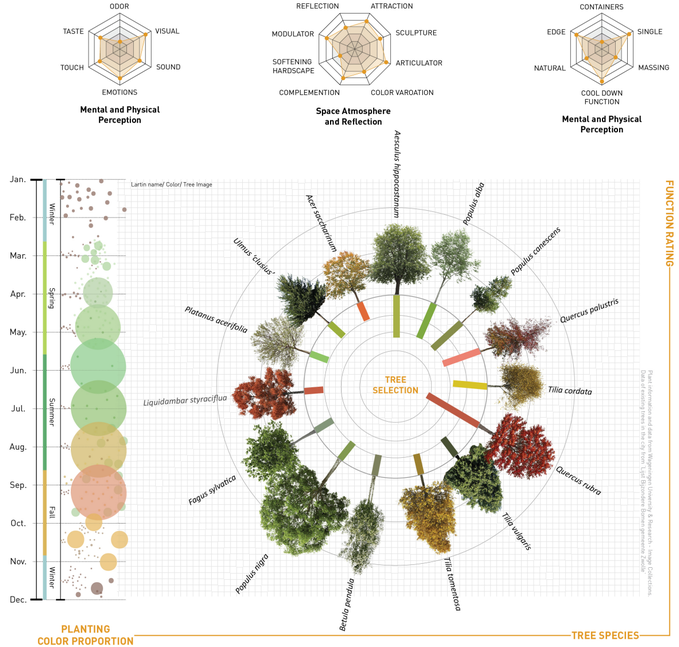


The original data (Speak et al., 2020)

Normal Tree Selection

The selection of plants for the study was primarily influenced by the existing tree system in the city of Zwolle. However, considering the imperative of climate mitigation in cities, it is essential to prioritize trees with relatively large canopy areas for future plant selections. By opting for tree species with expansive canopies, the aim is to maximize the reduction of urban surface temperatures in Zwolle through strategic plant choices.

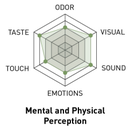
In the context of climate change and the associated urban heat island effect, trees with larger canopies offer numerous advantages. Their broad coverage provides extensive shading, allowing for more effective cooling of urban surfaces. This helps to mitigate the heat absorbed by buildings, pavement, and other infrastructure, thereby reducing overall surface temperatures, and enhancing the comfort of the urban environment.

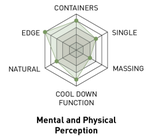


Evergreen Tree Selection

During the winter season in Zwolle, many of the existing trees display bare branches, which can create a stark and barren appearance in the urban landscape. To address this, it is benefit to plant evergreen trees into the city's green spaces. Evergreen trees retain their foliage throughout the year, offering a refreshing burst of color and visual interest, even during the colder months.

Meanwhile, Zwolle can enhance the appeal of its surroundings, enrich the cityscape and create a sense of vitality, particularly during the winter months when natural colors tend to be muted.

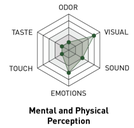


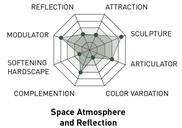


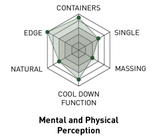
Conifer Tree Selection

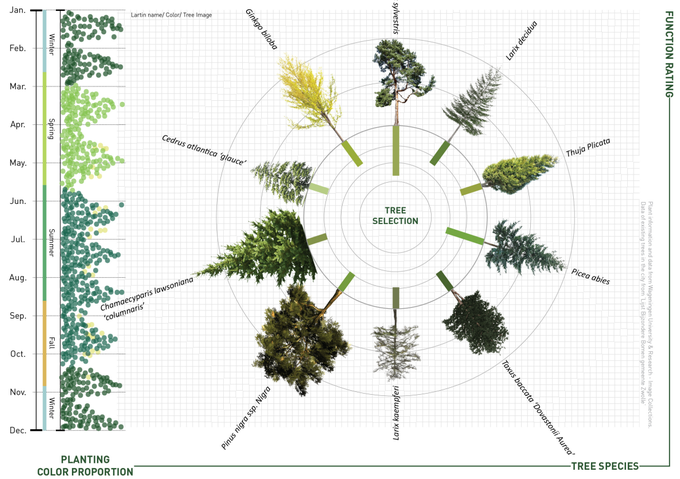
As discussed in the previous findings, coniferous trees have been identified as particularly effective in reducing urban surface temperatures. However, it is noteworthy that the presence of coniferous trees in the Zwolle area is currently limited. Therefore, it is crucial to incorporate a greater number of coniferous trees into future urban planning and development in the region.

Coniferous trees, characterized by their needle-like or scale-like leaves, offer distinct advantages in climate mitigation efforts. Their unique foliage structure allows them to retain moisture and maintain their green color throughout the year, making them well-suited for Zwolle's climate, including the colder winter months.







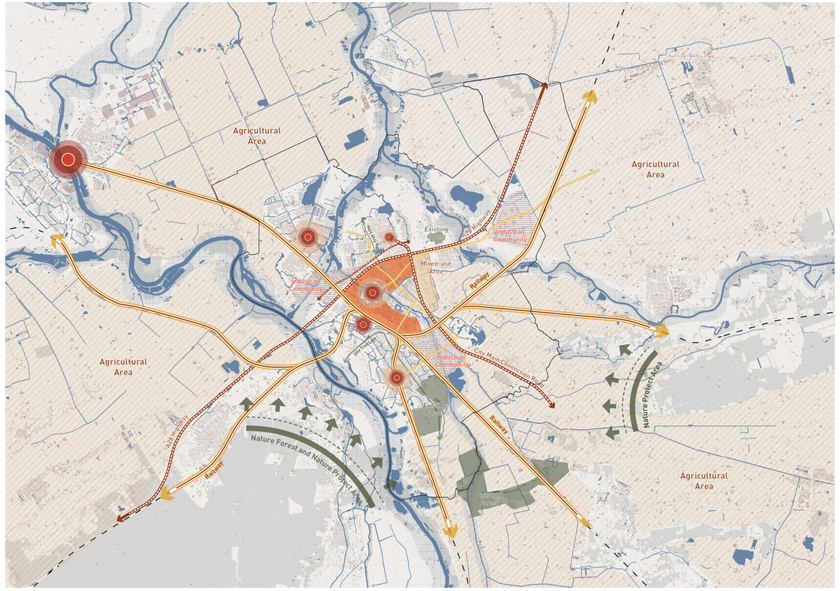


Chapter 5 DESIGN

5.1 Site Analysis

Regional Analysis

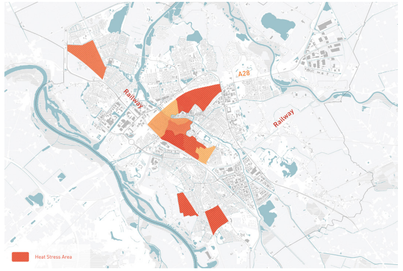
The analysis of the urban situation in Zwolle reveals that the city is situated in a delta area and stands as a major city in this area. It benefits from relatively good connectivity through the A28 highway leading to Utrecht and various train lines. However, the analysis indicates that the city is segmented due to these prominent transportation routes, resulting in limited connectivity between different areas. This is particularly evident in the central part of the city, which was developed earlier and is encircled by railroads and highways, leading to a loss of its connection with the surrounding region.



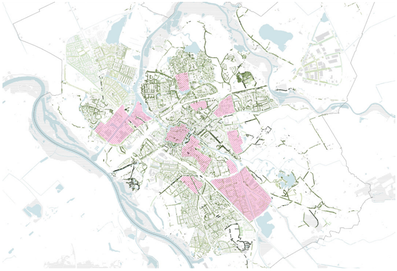
Understand the Urban Forest Need

When choosing a site for design, three primary factors to consider are climate, distribution of vegetation, and availability of urban green spaces. If a site is experiencing climate stress, exhibits sparse vegetation, and lacks public open green spaces, it becomes crucial to prioritize its design, and also a high demand for urban forests in the area. Taking these factors into analysis, an early developed high-density area near the city center was selected as the design area.

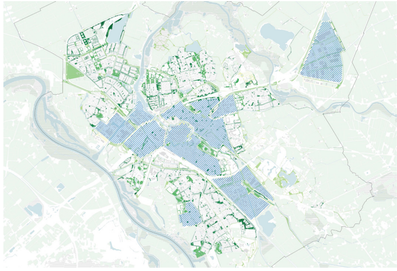
Climate risk area



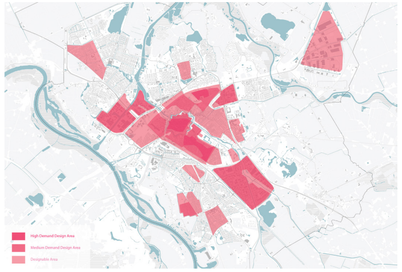
Tree lack of area



Open green space lack of area

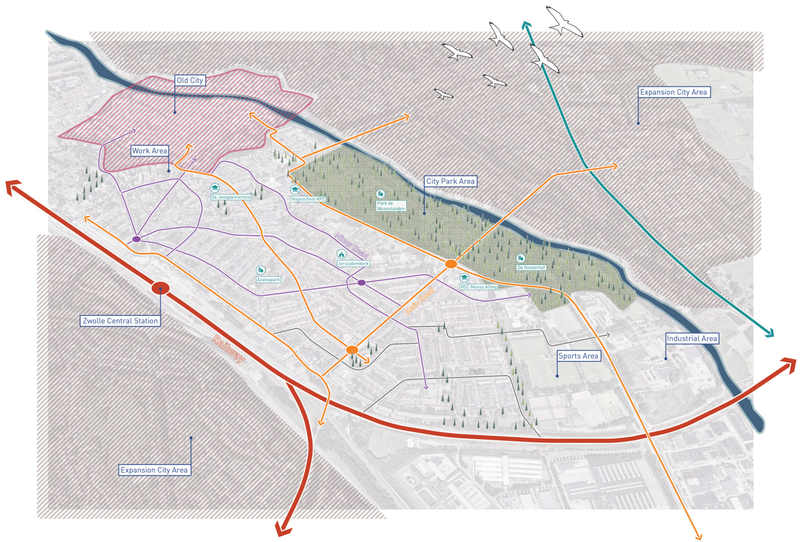


Site selection conclusion



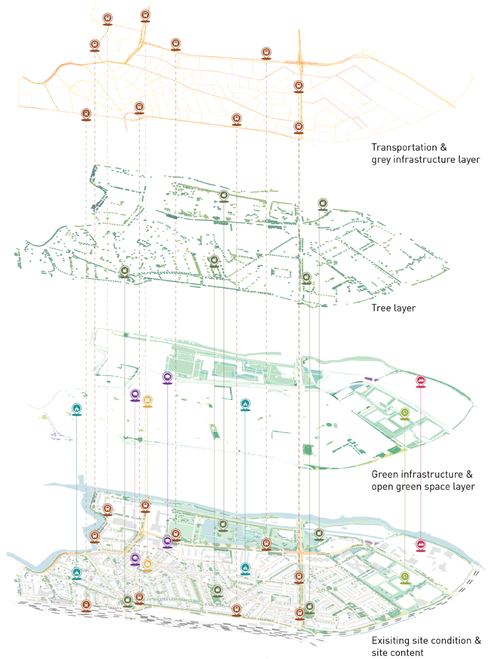
Site Introduction

The selected site under the Zwolle's historic city center, characterized by its dense residential population and significant vulnerability to the urban heat island effect. This area lacks sufficient public open green spaces, with only a few functional areas and large-scale residential housing. There is a notable scarcity in vegetation, which hinders effective reduction of urban surface temperatures. This area holds natural potential due to its proximity to a large urban park. However, due to its peripheral location, the park fails to integrate nature into the neighborhood and is inconveniently distant from certain residential areas, resulting in limited accessibility to this natural forest for some neighborhoods.



Site Analysis

Located in a well-established residential area, this site is characterized by a remarkably high building density. The main feature of this locality is its central region, which comprises residential structures, unfortunately lacking in green spaces. Scattered throughout this area, one can find a few buildings with diverse functions. Fortunately, the surrounding proximity compensates for this deficiency with a range of highly functional sites, including educational institutions, office buildings, urban parks, and outdoor sports area. Furthermore, the surrounding area has a higher vegetation coverage compared to the central residential zone.



LEGENDS

Exisiting road condition
- Street Level 1
- Street Level 2
- Street Level 3
- Street Level 4
- Bike Lane

Exisiting tree distribution (Planting year)
- 1827 - 1899
- 1900 - 1949
- 1950 - 1999
- 2000-2023

Exisiting planting area
- Companies and industry
- Cemetery
- Inner city
- Outside area
- Main green areas
- High-quality office facilities
- Park
- Sport
- Mall
- Residential area, offices and schools

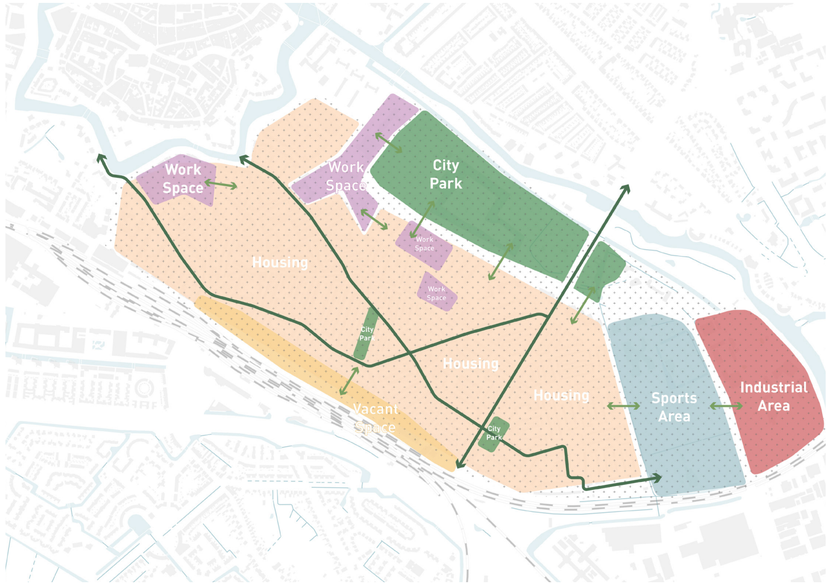
Exisiting grassland area
- Companies and industry
- Cemetery
- Inner city
- Outside area
- Main green areas
- High-quality office facilities
- Park
- Sport
- Mall
- Residential area, offices and schools

Exisiting site content
- Industrial area
- Sports area
- City park
- Bus stop/station
- Church / Cultural area
- School / campus
- City plaza
- Train station

Landuse Analysis

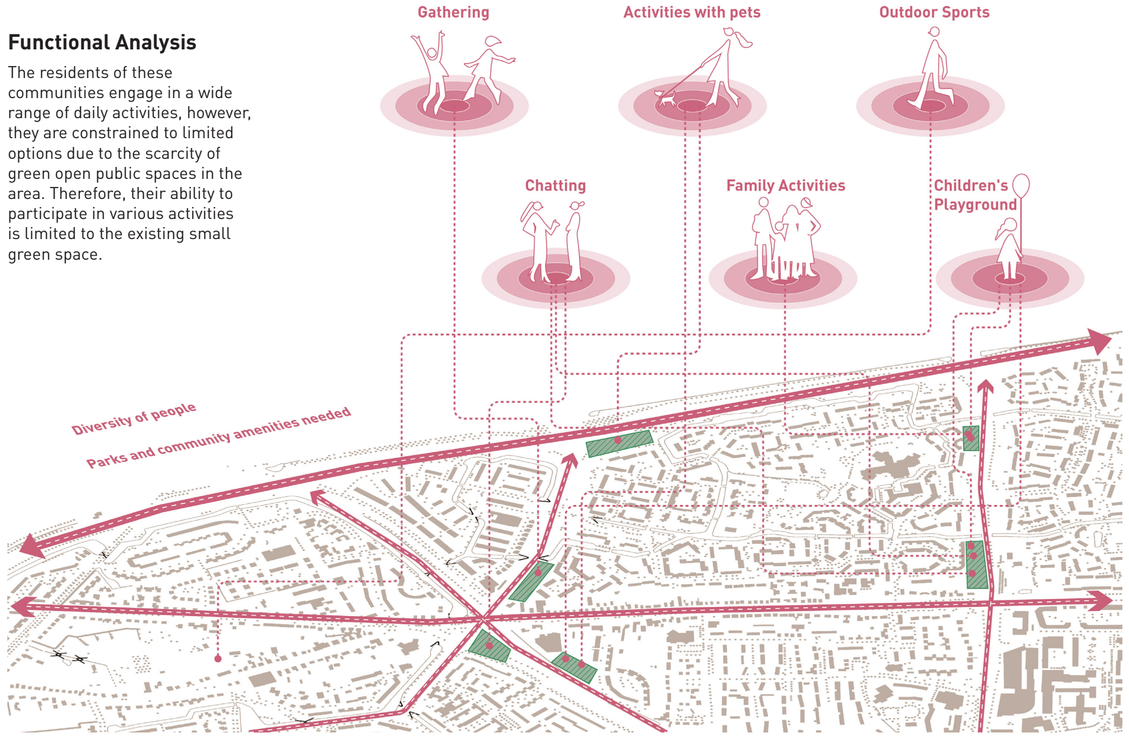
Upon closer examination of the site, it becomes evident that despite the presence of a sizable urban park adjacent to it, there is a noticeable absence of an effective connection to the city. As a result, the lush greenery of the park fails to extend its reach into the urban landscape. Furthermore, each distinct area within the locality suffers from a lack of vegetation connectivity, further exacerbating the issue. The high-density urban environment hampers the potential for seamless integration with the neighboring urban park.

Additionally, the inclusion of urban forest elements within the central residential area could serve as a stepping stone towards establishing a seamless transition from the urban park to the heart of the city. This approach would help mitigate the disruption caused by the high building density and enable residents to enjoy the benefits of nature within their immediate surroundings.



Functional Analysis

The residents of these communities engage in a wide range of daily activities, however, they are constrained to limited options due to the scarcity of green open public spaces in the area. Therefore, their ability to participate in various activities is limited to the existing small green space.



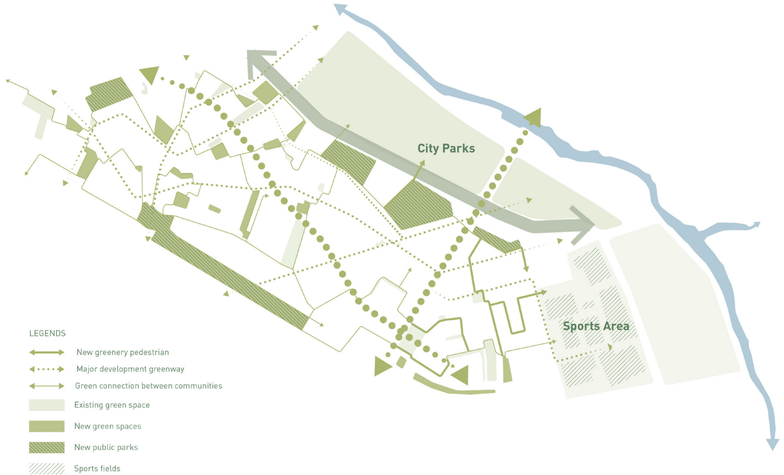
5.2 Design Strategy

Green Loop

The initial step in the design process involves deliberate consideration of how to enhance the natural green conditions of the community, addressing three key objectives: improving the community as a whole, mitigating urban surface temperature, and enhancing the residents' living experience. Therefore, the primary focus is to expand nature's presence in as many locations as possible, fostering a stronger connection between nature and people while simultaneously addressing residents' daily needs.

Exisiting green loop

New Green Loop Framework



The primary approach to increasing green spaces entails transforming the existing hard surfaces of the city into natural materials, utilizing methods such as adding extensive lawns and similar features. Furthermore, the city will witness an increase in the number of trees, while planting arrangements and vegetation choices for different community environments will be determined based on the conclusions of 4.4.2 which from the previous analysis, ensuring design the most effective and impactful urban forest.

Activity space/ social hub

G1. Large open green spaces

Impact: €

G2. Optimization of hard-surfaced parking lots

Impact: €

G3. Pollinator gardens

Impact: € €

Leisure/relax space

G4. Plaza and parks

Impact: €

G5. City plazas

Impact: €

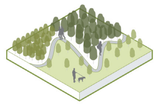
G6. Enriched circulation parks

Impact: € €

Nature atmosphere

G7. Straight line urban forest

Impact: €



G8. Multi-experience urban forest parks

Impact: € €

G9. Large group of tree near urban area

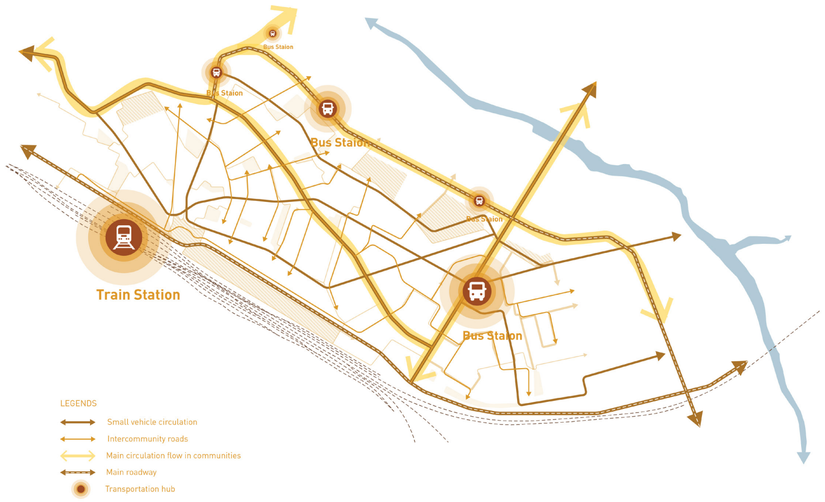
Impact: € €

Transportation & Circulation

However, it is also important to address the issue of integrating urban traffic and circulation through natural means after improving the urban forest situation. Finding effective strategies to harmonize urban mobility and natural elements is essential for creating a sustainable and balanced natural urban environment.

Exisiting Transportation & Circulation

New Transportation & Circulation Framework

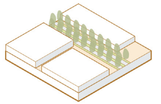


One approach to better integrate urban traffic and circulation is to use tree to make the connection between each road. For instance, incorporating green infrastructure elements such as vegetated medians, tree-lined streets, and green corridors can help manage traffic, reduce congestion, and enhance the overall aesthetic appeal of the city. By locating green spaces and pathways in a sufficient way, residents can enjoy pleasant walking and cycling experiences while promoting sustainable modes of transportation.

Street

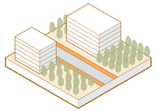
C1. Trees along the road

Impact: €



C2. Adding more green to industrial areas

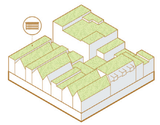
Impact: €



C3. Urban forest group near the high building density area

Impact: €

Community/ residential

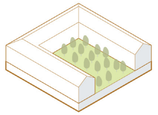


C4. Green roofs/green facades

Impact: € €

C5. Adding more green to community area

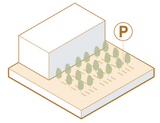
Impact: €



C6. Open the closed residential `circle`

Impact: €

Mixed-use

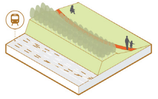


C7. Optimization of hard-surfaced parking lots

Impact: €

C8. Trees in front of the large building

Impact: €



C9. Large trees isolate the railroad

Impact: € €

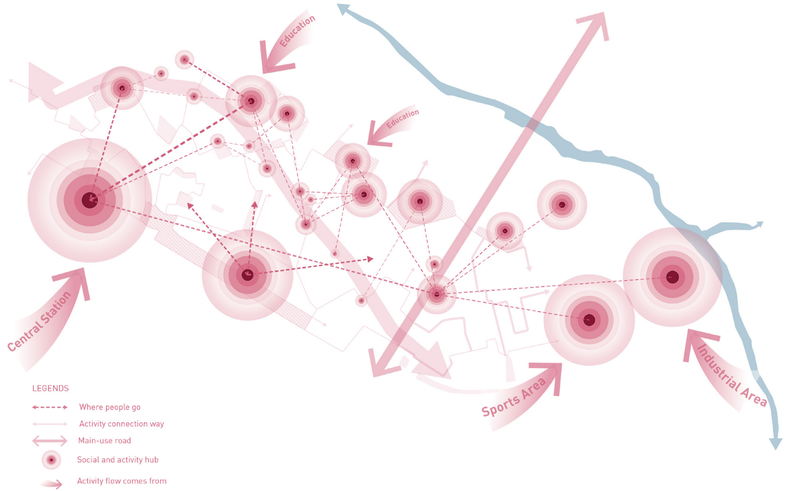
Activity & Social Hub

Program is also an important aspect of the design process as it contributes to the vitality of the area. Increasing the diversity of activities can bring a renewed vibrancy to the community. Based on the previous analysis, it shows that the remaining social hubs in the community are primarily centered around the train station and the school area near the city park, indicating a scarcity of activity areas. Therefore, enhancing the activity experience through nature becomes a key focus in the design process.

Currently, the distribution of activity areas within the city is uneven. To address this, the design aims to add more nodes and expand the city's activity area, ensuring that people can have exceptional experiences in different locations.

Exisiting Activity & Social Hub

New Activity & Social Hub Framework



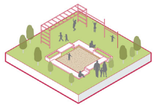
The primary approach to increase activities involves enhancing open activity areas, such as gathering spaces and community parks. These spaces can serve as focal points for various recreational and social activities, increasing a sense of community engagement and providing opportunities for residents to connect with nature.

By developing and expanding open activity areas throughout the city, the design aims to create a more balanced and inclusive environment. This approach ensures that residents have convenient access to spaces where they can engage in a wide range of activities, fostering a sense of well-being and community cohesion.

Community activity space

A1. Neighborhood parks

Impact: €



A2. Children play areas

Impact: €

A3. Dog parks/pet friendly parks

Impact: €

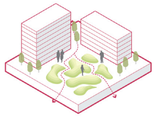
Open public activity space

A4. Gathering spaces/parks

Impact: € €

A5. Event/celebration plaza

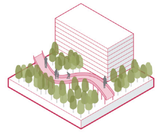
Impact: €



A6. Parks inspired from regional landscape

Impact: € €

City connection



A7. Bridges connect with different function area

Impact: € € €

A8. Bridges over traffic

Impact: € € €

A9. Connection to the city center

Impact: € €

5.3 Design Framework

Overall Framework

The overall design framework is derived from the three previously strategies, focusing on adding more possibilities to the neighborhood and enhancing connections within the community, extending from the center to the surround. This is achieved by introducing urban green spaces and increasing the presence of urban trees.

Design Layer

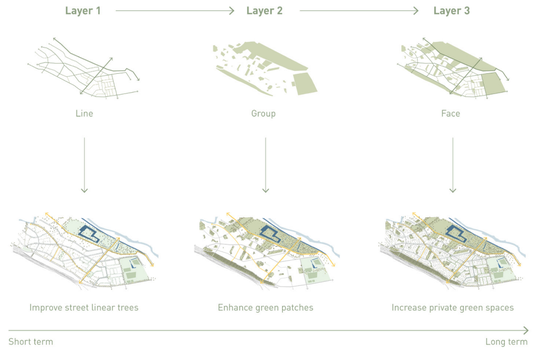
The design process to achieve the desired outcome consists of three main layers: line, group, and face. These layers are interconnected and contribute to the overall success of the project.

The first layer, line, involves the development of green corridors and the implementation of different planting strategies for existing city roads.

The second layer, group, focuses on creating urban natural areas, including open green spaces and tree groups. This aspect holds significant importance in the project, as it forms a pivotal element of the design. By carefully integrating these natural areas into the community, the design aims to enhance the overall green experience.

The third layer, face, involves connecting the green corridors established in the first phase with the urban natural areas developed in the second phase. Furthermore, by involving the residents in the process, the design aims to enhance their green experience and promote the expansion of green spaces within the central area of the community buildings.

By implementing these three phases, the design achieves a desired outcome where the community benefits from increased greenery, improved aesthetics, and enhanced ecological values.



Site Exisiting Condition

The current situation of the community reveals two issues: a lack of vegetation and a high density of built-up areas that contribute to the urban heat island effect and heat stress problems.

Future developed

The addition of urban green spaces and urban trees plays an important role in connecting different parts of the community. By strategically placing these elements, pathways and corridors can be established, creating a network that seamlessly integrates the neighborhood with its surroundings. This enables residents to explore and access the community periphery, further expanding their interactions with nature and neighboring areas.

5.4.1 Street Design

Street level & Design Principle

For roads wider than 20 meters, the design aimed to increase the number of trees on both sides of the road. In cases where the road was spacious enough, additional trees were also considered for planting in the center of the road. Preference was given to larger tree species to create a more prominent visual impact and provide ample shade and environmental benefits.

Roads with a width ranging from 14.5 to 20 meters were also targeted for increased tree planting on both sides. In this class, the selection of tree species was more flexible, accommodating a variety of options beyond large spreading trees. This approach allowed for a diverse and visually appealing streetscape.

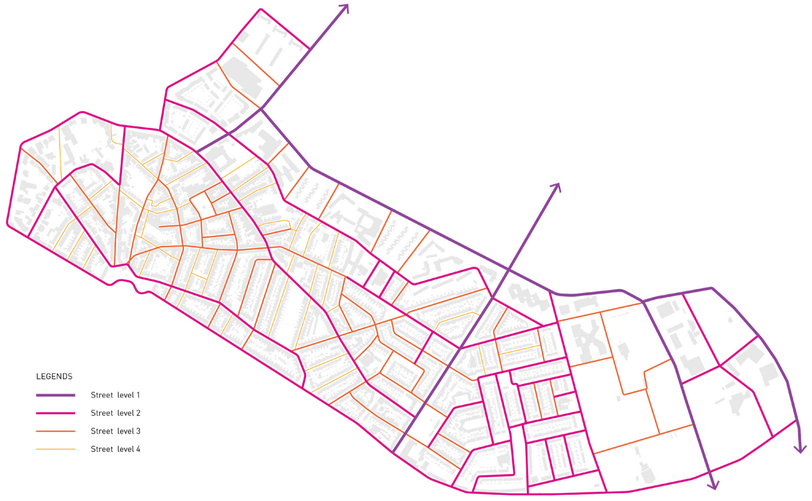
For roads with a width between 8.5 and 14.5 meters, the design focused on planting arrangements that prioritized the limited space available. Smaller diameter trees were preferred in these areas to maximize the green potential within the confined space. Attention was given to selecting species that would thrive and contribute to the desired greening effect.

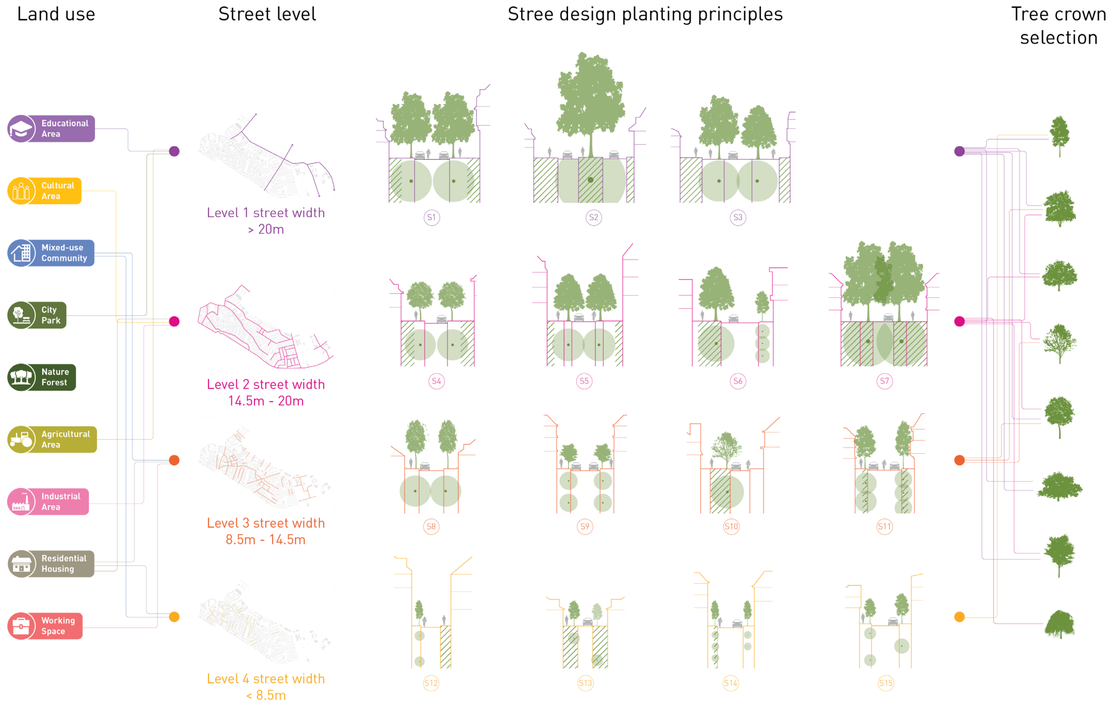
Lastly, roads with a width of less than 8.5 meters presented unique challenges due to their limited space. In these cases, the design proposed planting either a single row or a double row in a staggered arrangement. Given the restricted area, only very small tree species were suitable for these narrow streets, ensuring that growth and maintenance would not impede pedestrian movement or obstruct the visual openness of the area.

By following these guidelines and considering the specific characteristics of each road class, the design aimed to optimize the greening potential of the street network, resulting in enhanced aesthetics, increased shade, and improved environmental quality throughout the community.

Street level & Design Principle

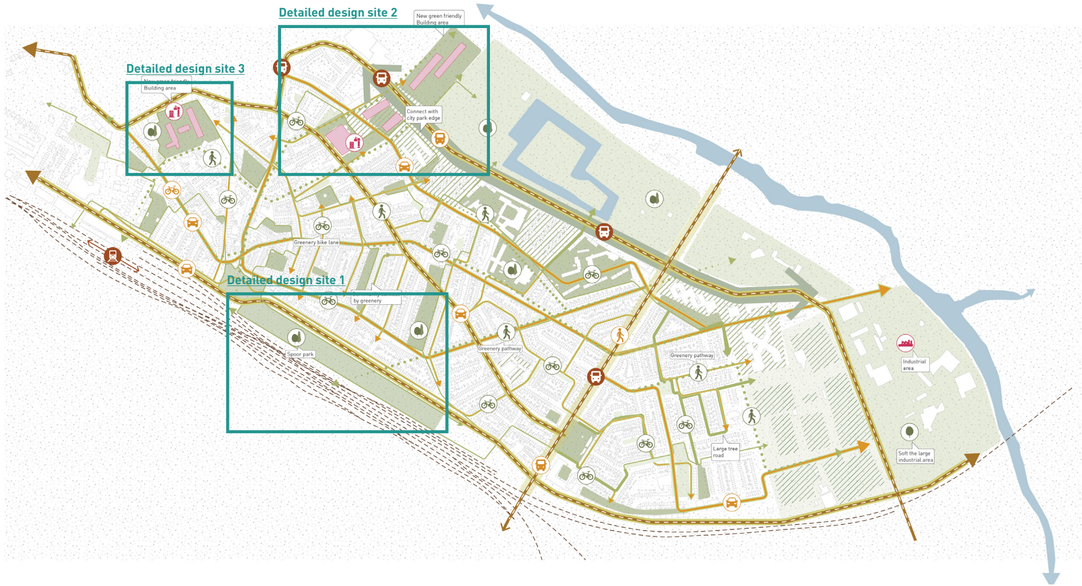
The first stage of the design process focused on road alignment. Utilizing the road network information provided by the Municipality of Zwolle, I divide the existing roads in the area were categorized into four classes based on their width. Each class was then assigned specific guidelines for tree planting and species selection.





5.4.2 Detailed Design

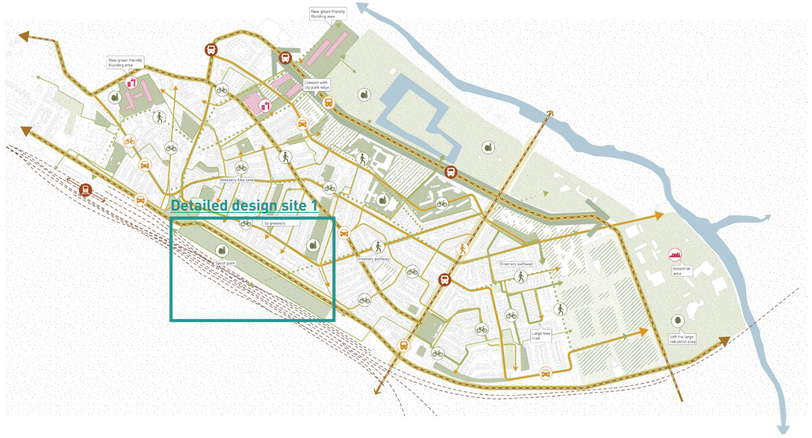
Detailed Site Selection



SITE 1

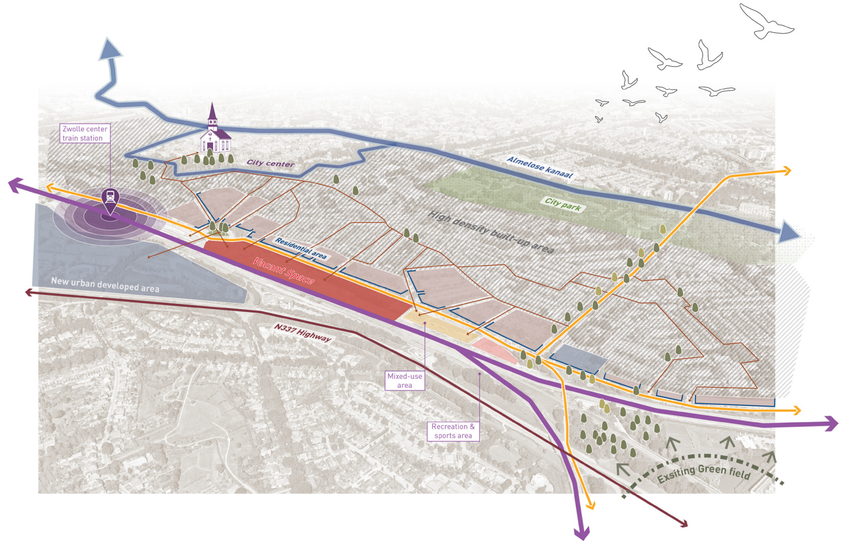
Site1 Introduction

Situated near the bustling Zwolle Central Station, the first site is an open lot without any trace of lush vegetation. This undeveloped land presented an opportunity to transform the area into a thriving green space with numerous benefits for the surrounding urban environment.



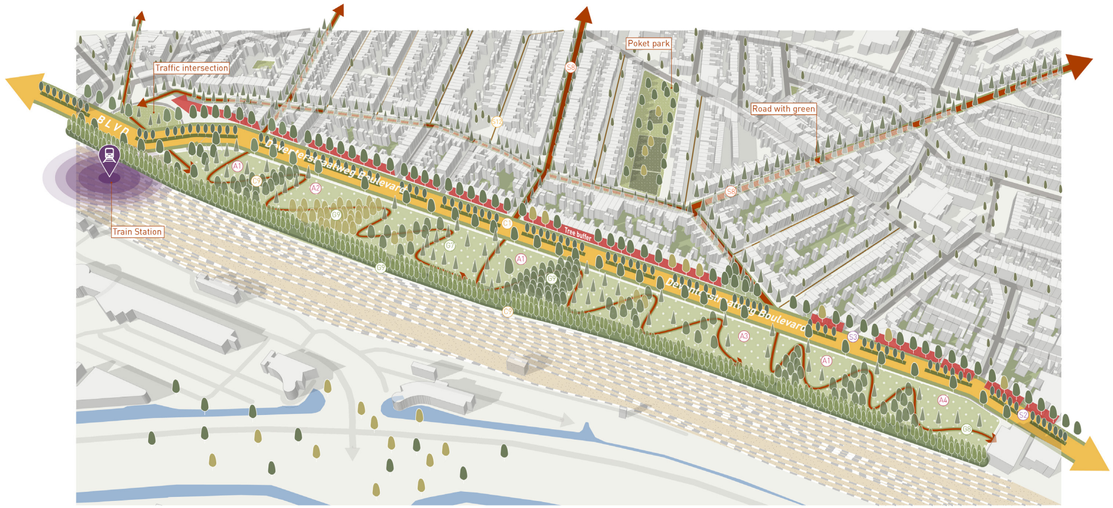
Site1 Analysis

The proximity of the site to the train station holds immense potential for creating a vibrant and accessible green corridor that seamlessly integrates with the transportation hub. By carefully designing the space, it can be transformed into a welcoming oasis, providing a refreshing respite for commuters and visitors alike. Incorporating a diverse array of plantings, such as trees, shrubs, and flowering beds, will not only enhance the aesthetics but also improve air quality, mitigate noise pollution, and contribute to the overall well-being of the community.



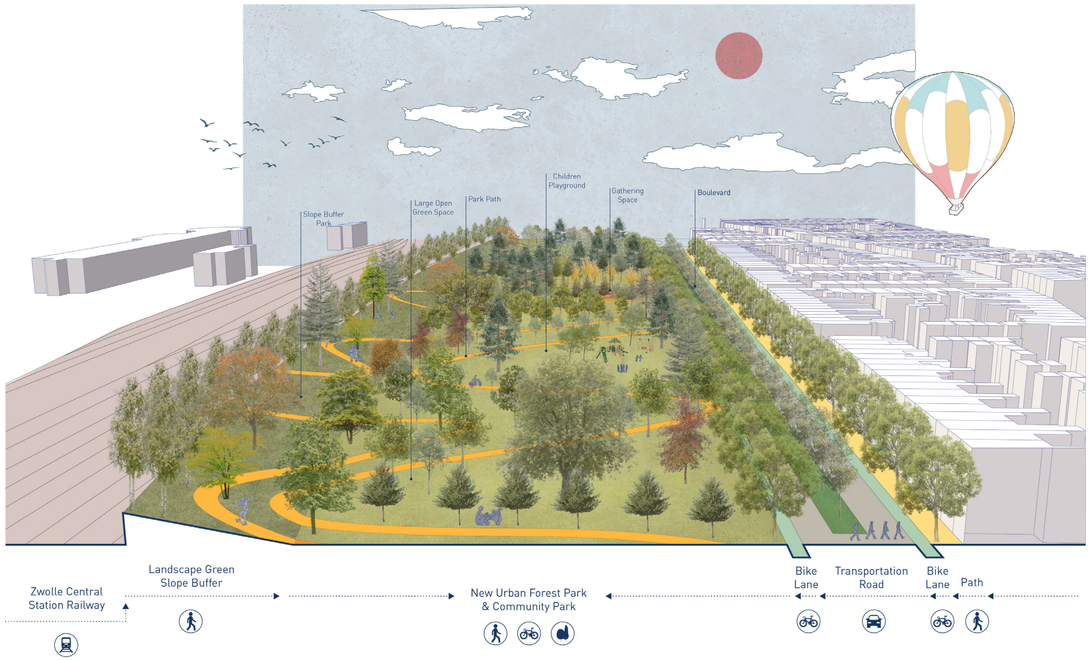
Site1 Design Process

When contemplating the design approach for this site, envisioning it as a new urban community park emerges as an excellent solution. Such a park would not only enhance the quality of life for neighboring residents but also function as a verdant buffer, effectively mitigating the noise emanating from the nearby train station and shielding the residential area from its disturbances. The park's design should prioritize creating a seamless and immersive experience for users, while simultaneously addressing the need for environmental sustainability. In addition, a wealth of streamlines has been created in the park, and the arrangement of plants is designed from closed, semi-closed to fully open. It can not only bring a different visual experience to people who come to the park, but also greatly help to reduce the surface temperature of the city.

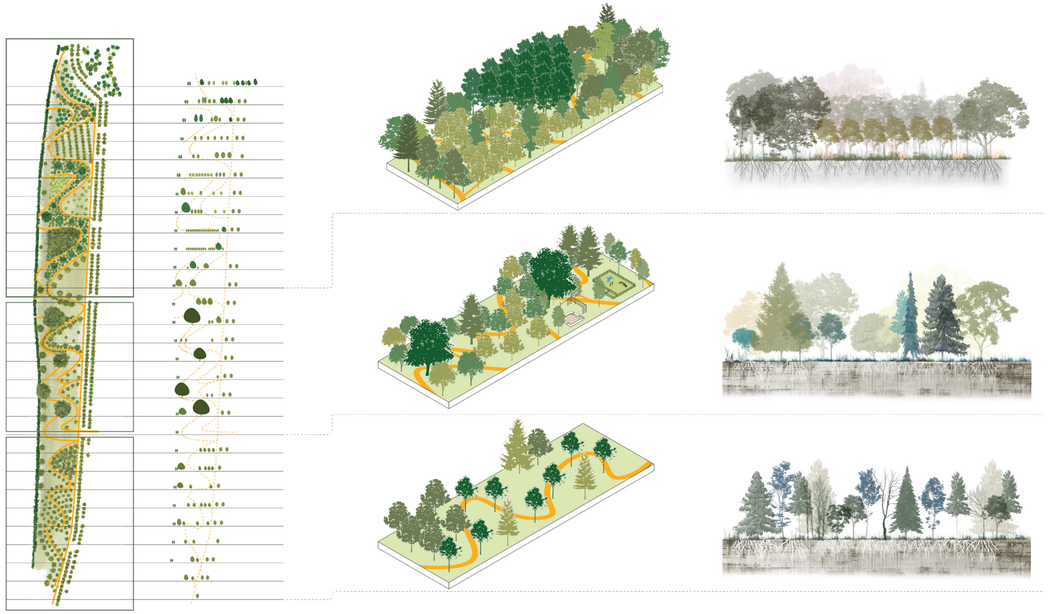


Site1 Masterplan

Site1 Section Elevation



Site1 Planting Plan/Design



Chapter 5. Design

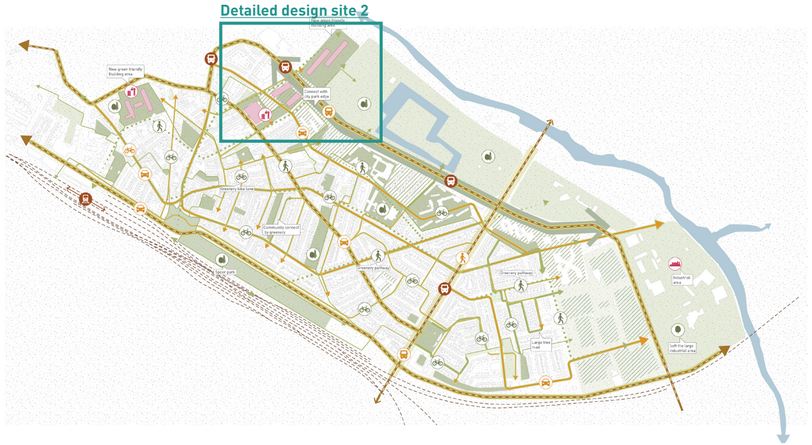
Site1 Street Level Design

Site1 Perspective

SITE 2

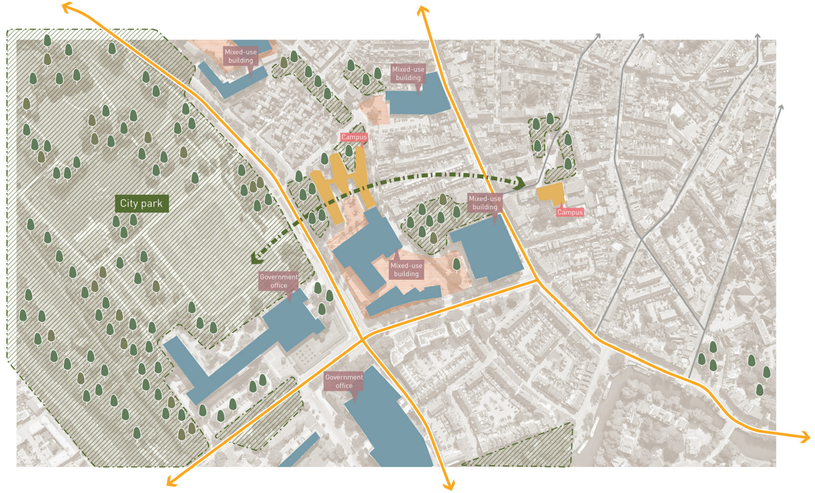
Site2 Introduction

The second site, conveniently situated adjacent to the city park, offers a blend of office areas and school facilities as its primary components. While some vegetation exists on the site, the presence of substantial buildings and an extensively paved parking lot has limited the amount of greenery available.



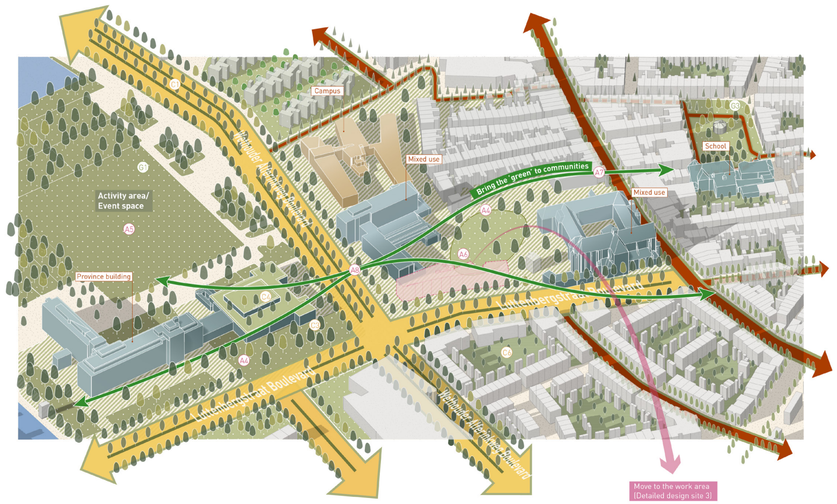
Site2 Analysis

Despite the presence of some vegetation cover, the overall greenery on the site remains relatively sparse. The imposing structures and the expansive parking lot, constructed with hard paving materials, dominate the landscape, creating a visually concrete-heavy environment. Consequently, the site lacks the lush green vegetation typically associated with natural surroundings.



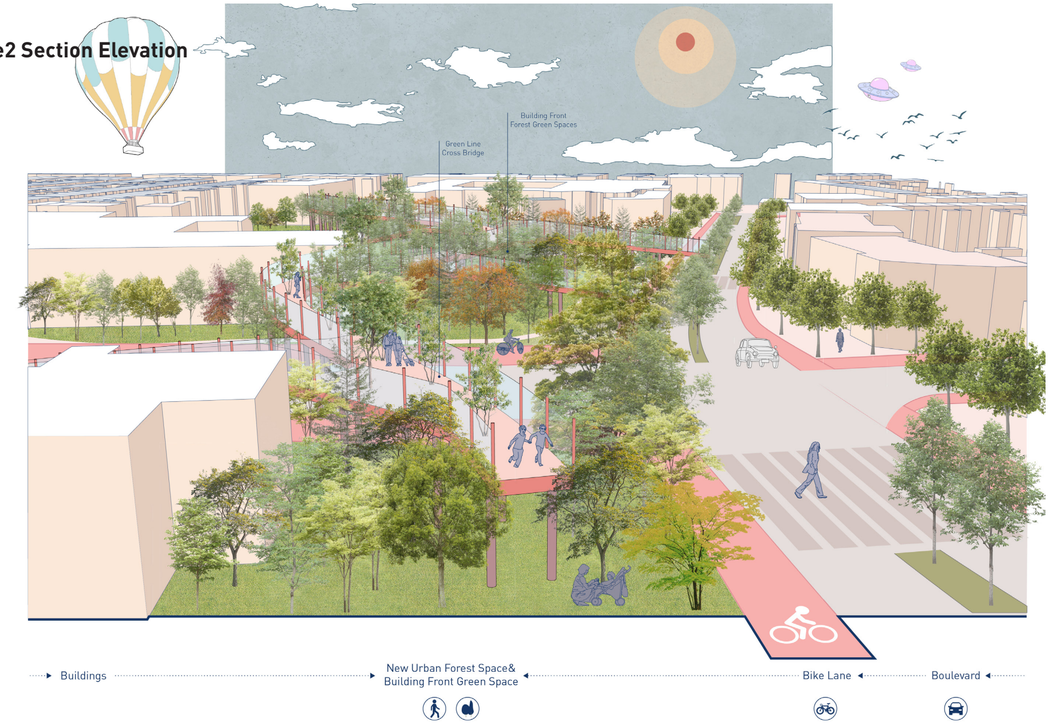
Site2 Design Process

During the design process for this area, a key question that arose was whether it could serve as an urban forest transition zone, facilitating the integration of the abundant natural resources from the adjacent urban park into the high-density cityscape. Recognizing its location within a bustling traffic zone, it became imperative to establish a pedestrian-friendly walking environment. To achieve these goals, an effective approach would be to introduce an array of green vegetation and consider the construction of a green high-line flyover as a means of infusing greenery into the urban fabric.

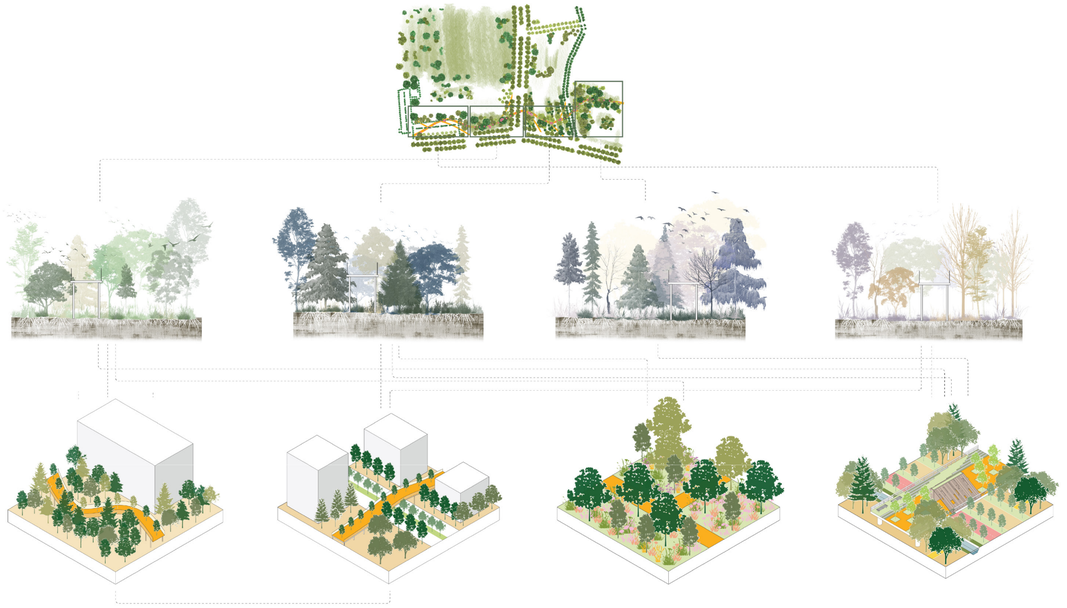


Site2 Masterplan

Site2 Section Elevation

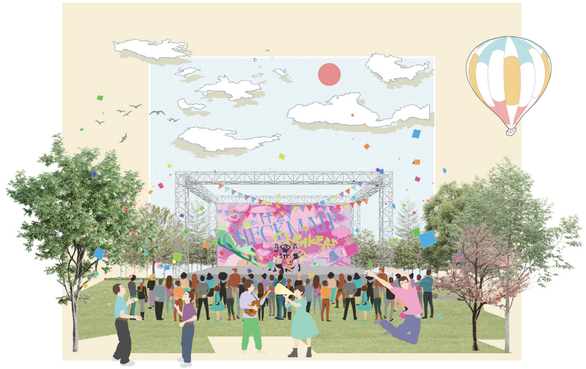


Site2 Planting Plan/Design



Site2 Street Level Design

Site2 Perspective



SITE 3

Site3 Introduction

The proximity of the site to the historic center brings forth unique possibilities for blending modern functionality with the city's rich cultural heritage. As the site lies on a necessary route between the city center and this area, it assumes an important role in facilitating connectivity and accessibility.

Site3 Analysis

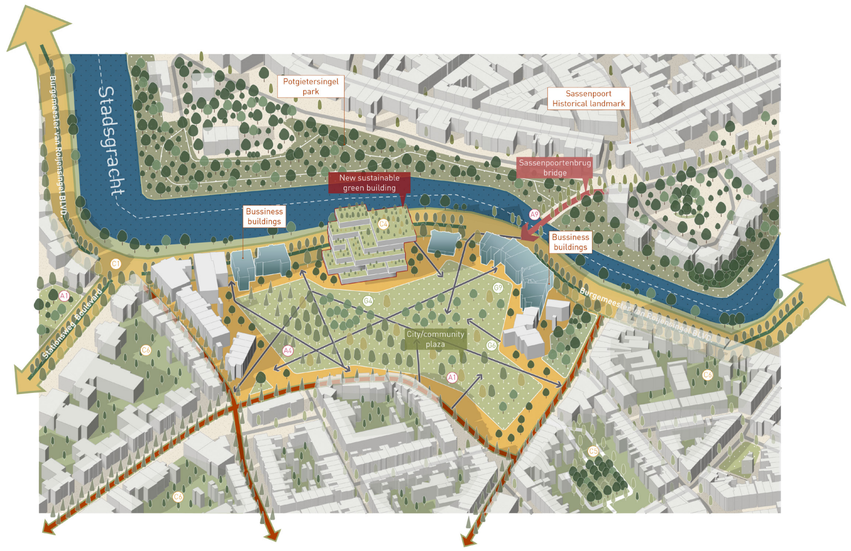
In addition to its proximity to the historic city center, the location of this area near Zwolle Central Station further enhances its accessibility and potential.

Currently, the buildings in this site primarily consist of office buildings, while the central area comprises hard pavement designed for parking purposes. The scarcity of vegetation on the site is evident. A closer examination of the urban surface temperature map reveals that this area experiences higher surface temperatures compared to other locations. This presents an imperative to address the heat island effect and create a more inviting and comfortable environment.

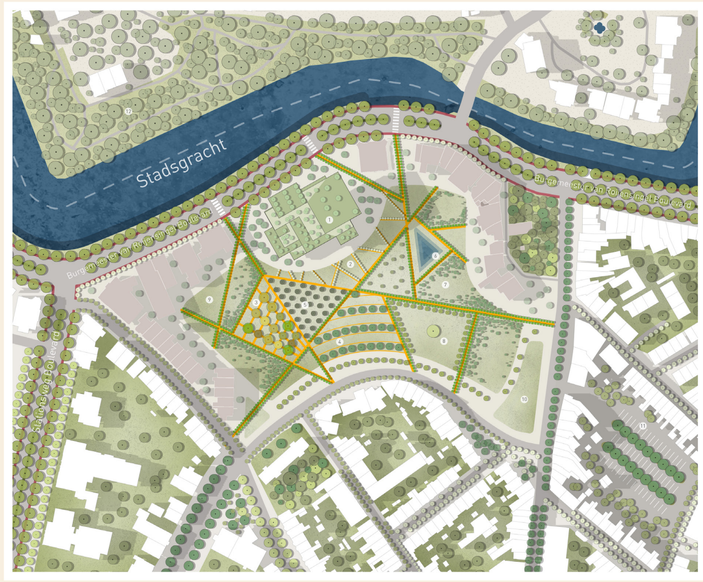
Site3 Design Process

To fully maximize the potential of this area, it is essential to design a multi-functional city square that not only caters to the needs of the working population but also attracts and engages tourists. By transforming the central area, currently dominated by parking, into a vibrant city square, the site can become a lively hub that fosters social interaction, community engagement, and economic activity.

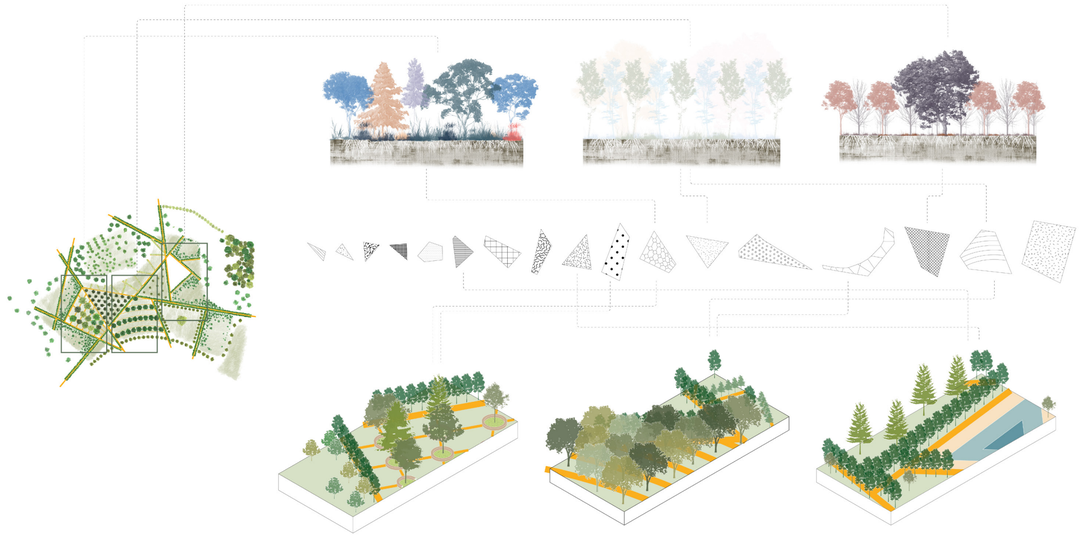
Therefore, a multifunctional and pedestrian-friendly urban plaza is designed with the current flow analysis of the site. Also some design suggestions are given in terms of architecture, which can transform the current building into a sustainable green building.



Site3 Materplan



Site3 Planting Plan/Design



Site3 Street Level Design

Chapter 5. Design

Site3 Perspective

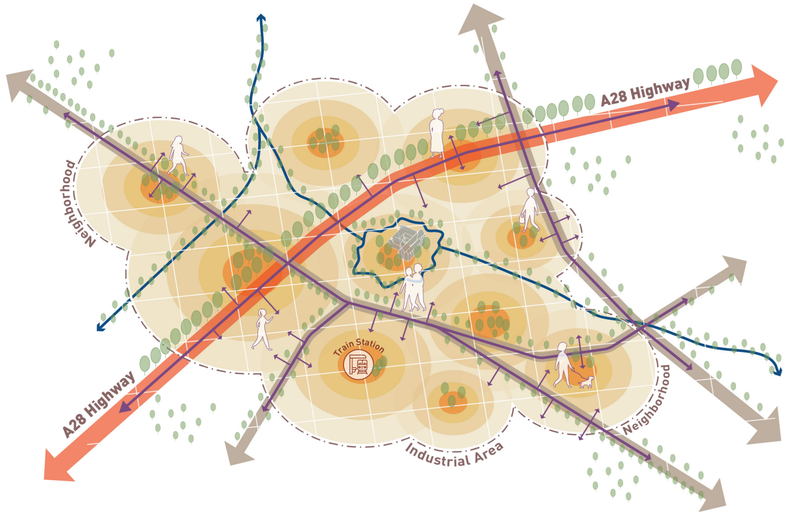
Chapter 6 FUTURE DEVELOPMENT

6.1 Regional Vision Design Framework

The Future Urban Forest Connection

After the current site design, it is imperative to envision the future development of the entire city. The concept of "forest urbanism" emerges as a compelling solution, not only capable of linking communities and urban parks but also serving as a unifying force for the entire city.

Forest urbanism presents a visionary approach to connect scattered areas within a city, creating a harmonious network that extends beyond individual neighborhoods. By integrating green spaces and urban forests, this concept facilitates connectivity between communities and enables a smooth transition from urban areas to the natural environment of the urban periphery.



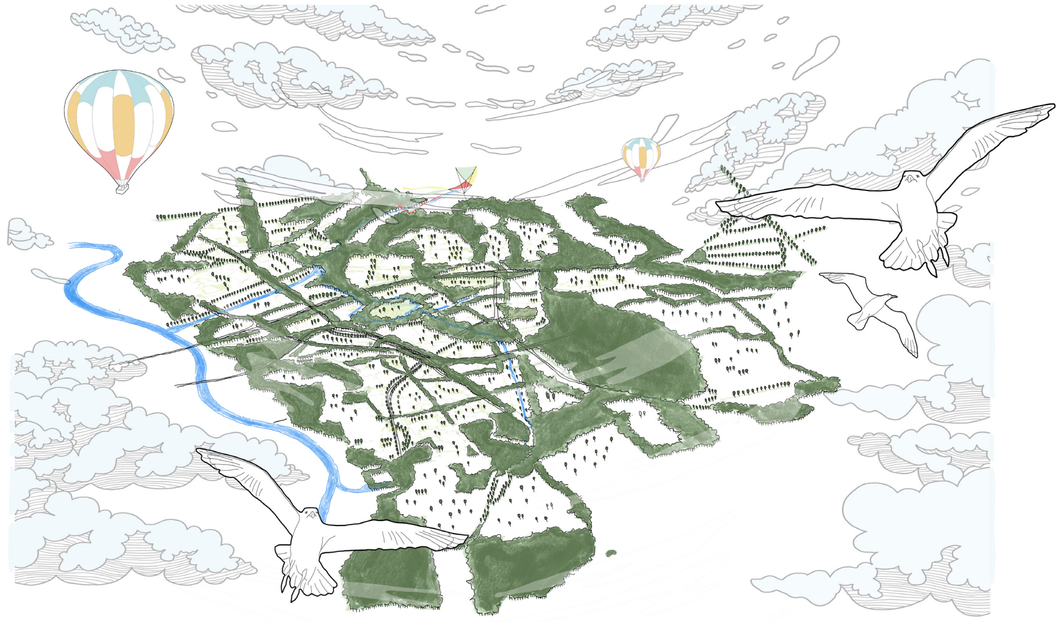
Regional Vision Design Concept

At its core, forest urbanism emphasizes the creation of green corridors or tree-lined pathways that traverse the urban landscape. These corridors serve as green arteries, providing not only physical connectivity but also fostering a sense of unity and continuity throughout the city. Through careful planning and design, these corridors can effectively link various neighborhoods.

In addition to connecting communities, forest urbanism extends its reach to the outskirts of the city, where a more natural environment awaits. By establishing green buffers and transitional zones, it ensures a smooth interface between the urban fabric and the surrounding natural landscapes. These transitional zones can consist of green belts, nature reserves, or ecological corridors, seamlessly blending the urban and natural realms.

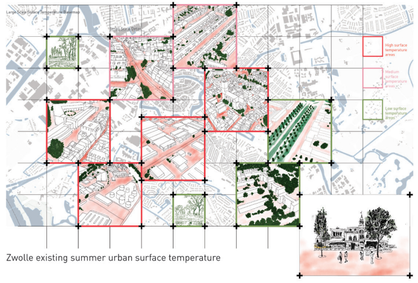
6.2 Regional Vision

The new urban forest infrastructure

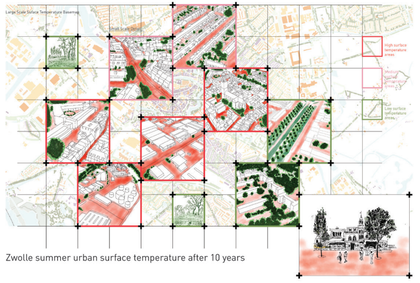


6.3 Vision Design Comparison

Future Urban Surface Temperature Change Without Intervention

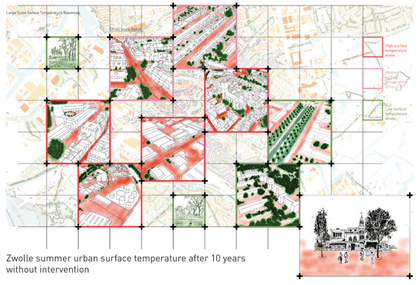


Zwolle existing summer urban surface temperature

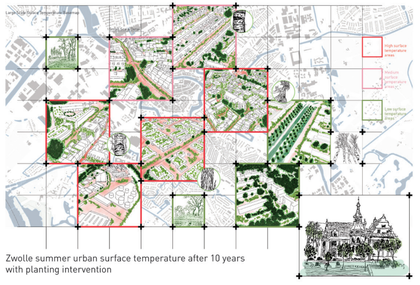


Zwolle summer urban surface temperature after 10 years

Future Urban Surface Temperature Change With Intervention



Zwolle summer urban surface temperature after 10 years without intervention



Zwolle summer urban surface temperature after 10 years with planting intervention

Chapter 7 CONCLUSION & REFLECTION

Chapter 7. Conclusion & Reflection

7.1 Conclusion

In conclusion, the project centered around the concept of creating a climate mitigating city through forest urbanism has demonstrated the immense potential of integrating nature and built environments to address the pressing challenges posed by climate change. By incorporating forests into the urban fabric, we can not only enhance the aesthetic appeal of cities but also foster a sustainable and resilient urban ecosystem.

Through careful analysis and design, we have shown that forests can serve as powerful tools for climate mitigation and adaptation. Forest urbanism provides multiple benefits, including carbon sequestration, improved air quality, reduced urban heat island effect, enhanced biodiversity, and increased resilience to extreme weather events. Moreover, the integration of forests into cities promotes human well-being, providing spaces for recreation, relaxation, and connection with nature, thus improving the overall quality of life for residents.

To maximize the benefits of forest urbanism, it is important to consider factors such as the selection of appropriate tree species, planting locations, and maintenance practices. Integrating forests and green spaces into urban planning and design can create more sustainable and resilient cities with improved thermal conditions.

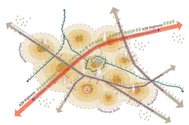
How to create a climate mitigation city through forest urbanism?

Incorporate forest urbanism principles into city planning and zoning regulations. Allocate suitable areas for the creation of green spaces, urban forests, and tree-lined streets. Ensure that these areas are well-distributed throughout the city to maximize their climate mitigation benefits. Implement reforestation and afforestation initiatives to increase the tree cover within the city.

By designing and intervening at different scales, the urban forest throughout the city exudes a new vitality that permeates every aspect of urban life. At the regional scale, strategic planning and landscape design create a cohesive framework for the integration of green spaces and urban forests.

By carefully considering the city's layout, connectivity, and land use patterns, we can ensure that the urban forest becomes an interconnected network, spanning across neighborhoods, districts, and even entire cities.

Large Scale Intervention
Regional Scale



At the medium scale, urban forests are integrated into the fabric of the city through the design of streetscapes, plazas, and urban squares. Tree-lined streets create shaded pedestrian pathways and encouraging active modes of transportation. Green spaces within neighborhoods and around public buildings foster a sense of community and provide opportunities for recreation and relaxation. These carefully designed interventions ensure that the urban forest is easily accessible, inviting residents to immerse themselves in nature, improving their physical and mental well-being.

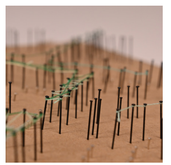
Medium Scale Intervention
Community Scale

On a small scale, the design of the urban forest focuses on individual streets or even smaller pieces of green space within the city. These smaller interventions contribute to the overall urban forest network and have a significant impact on the immediate surroundings.

Small Scale Intervention
Street Scale

Street /Small Scale Research and Analysis Model

Community/Medium Scale Research and Analysis Model



Chapter 7. Conclusion & Reflection

7.2 Reflection

In this project, my main design objective is to integrate the urban environment with nature, effectively merging the city and natural elements.

The essence of this project is the harmonious coexistence of urban and landscapes, highlighting the significance of design and keeping a balance between human activities and the surrounding natural environment. By expanding the potential of landscapes within an urban background, this project opens a new opportunities for the approaches.

As a student specializing in landscape backgrounds, this project has broadened my opinion on the importance of landscapes at different scales, unveiling the untapped potential they possess.

Research

Although there are several theories proving that trees can lower the surrounding temperature, there are not many cases of using them in real design, so how to translate the basic theory into meaningful analysis for the design of the project was the main thing I did in the analysis. Combining exposure to theoretical knowledge with the current site situation allowed me to draw several conclusions that are useful for the design step. Starting from the most basic plants, the final goal is to create a safer and more comfortable human living environment through the planting design principle no matter how drastic the external changes are. This is also one of the challenges I encountered in this project.

Design

To reduce the urban heat island effect in highly urbanized areas, it is necessary to design in these area. In my design process, I focused on a densely populated residential area that Zwolle had developed since 18 century. Increasing the urban forest within this high-density community to mitigate the urban heat island effect is a challenge. Due to the longstanding existence and established integrity of these communities, it is difficult for the urban forest to be introduced from the outset. Therefore, I ultimately decided to preserve the original community as much as possible while redefining the layout and functionality of the surrounding area. This involved improving a substantial portion of the surrounding urbanized land and removing some redundant and unnecessary houses to make new space for the new urban forest. The ultimate goal is to hope that the urban forest can bring better impact to this community and the whole city.

Although many designs emphasize the priority of respecting nature, I think that in this project, both people and nature are equally important. Because the future development of this area requires both to progress together, it needs to grow from an area that mainly emphasizes the urban to an area where the urban and nature develop harmoniously. If only a single aspect is emphasized, it is not the final goal of this project.

Future

This project, although focused on a specific area in the city and of a modest scale, holds the potential to make a significant impact on future urban development. It can serve as a valuable reference for other cities undergoing transformation. This project seamlessly integrates three crucial aspects: urban development, natural value, and climate change. By merging landscape architecture with urban planning, it explores the contributions that a broader perspective on the landscape can make to the city climate problem and urban heat island effect.

References

Anderson, V., & Gough, W. A. (2020). Evaluating the potential of nature-based solutions to reduce ozone, nitrogen dioxide, and carbon dioxide through a multi-type green infrastructure study in Ontario, Canada. City and Environment Interactions, 6, 100043. https://doi.org/10.1016/j.cacint.2020.100043

Benedito, S., & Baan, I. (2021). Atmosphere anatomies on design, weather, and sensation. Lars Müller Publishers.

Bosch, J., Veenenbos, H., & Loohuis, S. (2013). Straten Maken: Hoe Ontwerp je een goed straatprofiel? SUN.

Brown, R. D., & Gillespie, T. J. (1995). Microclimate landscape design ; Creating thermal comfort and energy efficiency. John Wiley & Sons.

Dean, B., Maguire, P., & Andrew, J. F. (1886). Notes On the Plan of Franklin Park and Related Matters. City of Boston.

Fuladlu, K. (n.d.). Urban heat island; World Meteorological Organization.

Grebner, D. L., Bettinger, P., Siry, J. P., & Boston, K. (2022). Urban Forestry. Introduction to Forestry and Natural Resources, 387–407. https://doi.org/10.1016/b978-0-12-819002-9.00016-x

Howard, L. (1818). The climate of London: Deduced from meteorological observations.

Kong, F., Yin, H., Wang, C., Cavan, G., & James, P. (2014). A satellite image-based analysis of factors contributing to the green-space cool island intensity on a city scale. Urban Forestry & Urban Greening, 13(4), 846–853. https://doi.org/10.1016/j.ufug.2014.09.009

Li, Y., Zhang, J., & Gu, R. (2004). Research on the Relationship between Urban Greening and the Effect of Urban Heat Island. Chinese Landscape Architecture, 72–75.

Lindberg, F., & Grimmond, C. S. (2011). Nature of vegetation and building morphology characteristics across a city: Influence on shadow patterns and mean radiant temperatures in London. Urban Ecosystems, 14(4), 617–634. https://doi.org/10.1007/s11252-011-0184-5

Marando, F., Heris, M. P., Zulian, G., Udías, A., Mentaschi, L., Chrysoulakis, N., Parastatidis, D., & Maes, J. (2022). Urban heat island mitigation by Green Infrastructure in European functional urban areas. Sustainable Cities and Society, 77, 103564. https://doi.org/10.1016/j.scs.2021.103564

Oke, T. R. (1982). The energetic basis of the urban heat island. Quarterly Journal of the Royal Meteorological Society, 108(455), 1–24. https://doi.org/10.1002/qj.49710845502

Rahman, M. A., Stratopoulos, L. M. F., Moser-Reischl, A., Zölch, T., Häberle, K.-H., Rötzer, T., Pretzsch, H., & Pauleit, S. (2020). Traits of trees for cooling urban heat islands: A meta-analysis. Building and Environment, 170, 106606. https://doi.org/10.1016/j.buildenv.2019.106606

Regio Zwolle, DZH, & Studio Bereikbaar. (2022, September 29). Warme Harten in een Klimaatadaptieve Delta. Zwolle; Municipality of The Zwolle.

Rød, J. K., & Maarse, M. J. (2021). Using citizen sensing to identify heat-exposed neighbourhoods. Urban Science, 5(1), 14. https://doi.org/10.3390/urbansci5010014

Semenzato, P., & Bortolini, L. (2023). Urban heat island mitigation and Urban Green Spaces: Testing a model in the city of Padova (Italy). Land, 12(2), 476. https://doi.org/10.3390/land12020476

Solecki, W. D., Rosenzweig, C., Parshall, L., Pope, G., Clark, M., Cox, J., & Wiencke, M. (2005). Mitigation of the heat island effect in urban New Jersey. Environmental Hazards, 6(1), 39–49. https://doi.org/10.1016/j.hazards.2004.12.002

Speak, A., Montagnani, L., Wellstein, C., & Zerbe, S. (2020). The influence of tree traits on urban ground surface shade cooling. Landscape and Urban Planning, 197, 103748. https://doi.org/10.1016/j.landurbplan.2020.103748

Tamaskani Esfehankalateh, A., Ngarambe, J., & Yun, G. Y. (2021). Influence of tree canopy coverage and leaf area density on urban heat island mitigation. Sustainability, 13(13), 7496. https://doi.org/10.3390/su13137496

References

Growing With Cooler Green