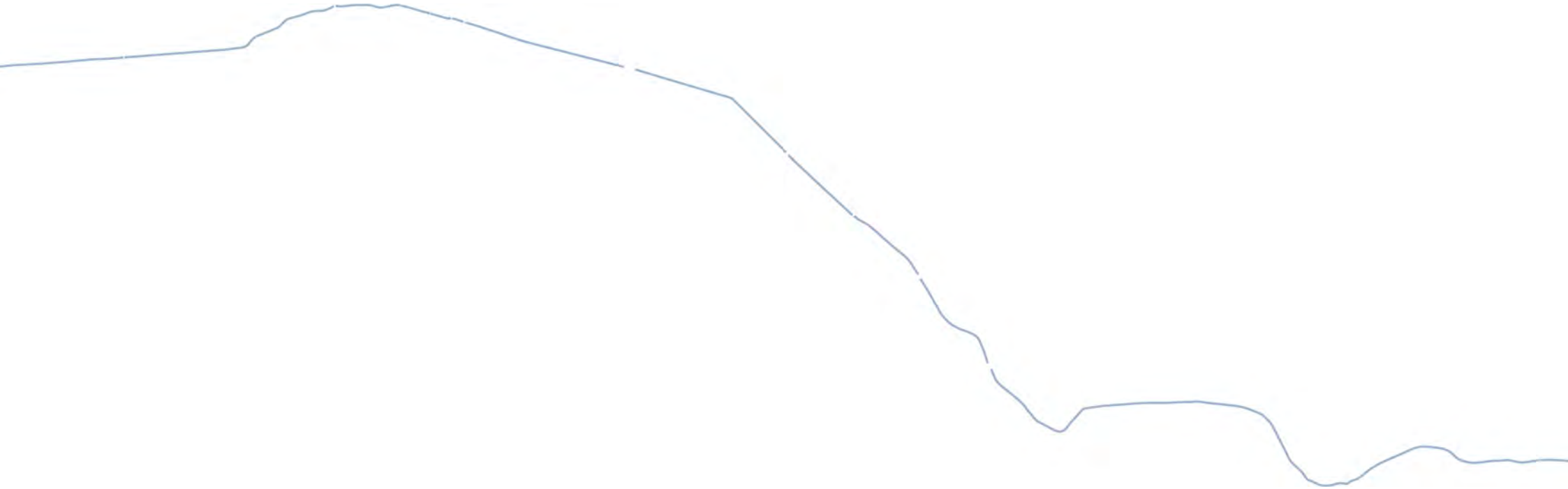


A NEW LINGE ZONE

Redesigning the Linge area in Stadsregio Arnhem-Nijmegen using a diversity of forest types

by Sanne Maring

Master thesis

Delft University of Technology

Master thesis
Delft University of Technology

Sanne Ilse Maring
4614127

20-6-2024

Landscape Architecture
UF-FU lab

1st mentor:	René van der Velde (LA)
2nd mentor:	Ronald van Warmerdam (MBE)
Graduation committee delegate:	André Mulder

Table of contents

1 INTRODUCTION

1.1 Fascination

I am fascinated by the relationship between the city and the surrounding landscape. I myself grew up in a small village in Drenthe called De Wijk (see image 1), and moved to the Randstad for my studies. The spatial interpretation of these two places is substantially different because the scale is so different. Delft (image 2), where I now live, is a city of about 100 thousand inhabitants and is separated from The Hague only by administrative municipal boundaries; the two cities seem to have grown together.
De Wijk, on the other hand, is a detached village where the next town is 6 kilometers away by bicycle. The relationships these places have with the surrounding landscape and to what extent they are part of it differ on a fundamental level. One seems to have a contrasting relationship, while the other is more a part of the landscape.
Despite the fact that the two are so different, I still often wonder how large urban areas such as The Hague and Delft can establish a more harmonious relationship with the surrounding as well as the underlying landscape.

Another issue that fascinates me is the relationship between a green environment and mental health. In 2020, I suffered from panic disorder, and two of the things that helped me recover from it, besides going to therapy, were a lot of walking in nature and keeping myself busy with a vegetable garden. This experience taught me that a green environment can be essential for one's health. One could say that this is purely a personal experience, but the relationship between a green environment and health is supported by extensive scientific research, and is also taken as a given in society today.

I would like to see a nice, healthy, and green environment for everyone, and that is something I want to be involved with for the rest of my career.

This thesis combines these two fascinations into one spatial issue for the Arnhem-Nijmegen City Region.

Image 1, Satellite image of De Wijk and surroundings, PDOK Luchtfoto 8mm, 2023.

Image 2, Satellite image of Delft and surroundings, PDOK Luchtfoto 8mm,

1.2 Problem statement

The United Nations' (2018) expectation is that 68% of the world's population will live in cities by 2050 compared to 55% in 2018, so it can be assumed that the number of polycentric metropolises will increase. The UN also states that sustainable city development is essential for this transition to happen smoothly and successfully. Therefore, it is also important to consider the development of green structures, because this has a positive effect on the health of residents and the city and environment, and can contribute to climate adaptation and mitigation.

Green cities are becoming increasingly important. Cities are growing bigger and fuller, and high-quality green spaces are essential to keep the city liveable. Spending time recreating in a natural environment can reduce stress (de Oliveira, 2020; Kaplan & Kaplan, 1989; Ulrich 1979), be beneficial for physical health, and a green environment also provides ecological benefits that can reduce the challenges caused by climate change, such as increased water infiltration and evapotranspiration from trees (Selin-Norén, 2022).

In 2020, the Ministry of Agriculture, Nature and Food Quality concluded the Forest for the Future (Bos voor de Toekomst) plan, which sets the target of adding 10% more forest to the surface area of the Netherlands before 2030. This means that 37,000 hectares of forest will have to be added to the current share of forest in The Netherlands. The Province of Gelderland (2020) has committed to contributing 1,700 hectares of forest plus one million trees to this plan but has currently only found room for 500 hectares (Staatsbosbeheer Gelderland, 2023).

In the Dutch context in particular, there is a fierce battle for space going on at the moment. There are many challenges that demand a spatial solution, but the available space is scarce. The location of the country in a river delta makes it perfect for agriculture and as a trading hub, both of which functions are still a main staple of the country. However, the agricultural sector is heavily intensified, which has negative effects on nature reserves in the country, mainly as a result of high nitrate deposits. This will be expanded upon in chapter 2. If the sector is going to be extensified to solve these issues, farmers would need more space to ensure the same amount of yield from their crops or livestock.
Furthermore, currently there is also a high demand for more housing after several previous waves of urban expansion in the second half of the twentieth century. This means that in the past decades, cities have grown from individual centres into urban agglomerations, leaving a minimal amount of space between the different centres. These could also be considered a polycentric metropolis. Examples in the Dutch context are Utrecht-Nieuwegein, the Amsterdam region, the Rotterdam-The Hague-Dordrecht region, and the Stadsregio Arnhem-Nijmegen.
Finally, it is likely that the challenges caused by climate change will also need a spatial solution. For example, solar panels and wind turbines for the generation of electricity need to be located someplace, while the planting of vegetation for carbon capture also demands space. Furthermore, water storage during periods of prolonged rainfall to keep residential areas dry, and water buffers for prevention of drought during summers also need space.

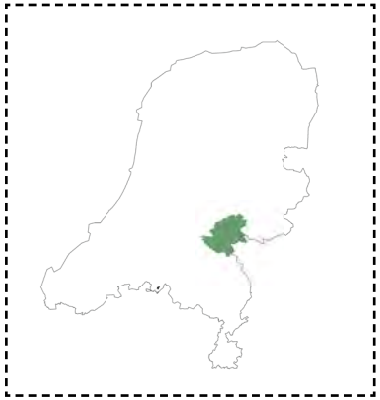
In short, there are many challenges on a national scale that demand a spatial solution. These include, housing, agriculture, and climate change solutions.
Taking all of these spatial challenges into account, it is likely that various government bodies will give less priority to finding space for new forests despite the goals described in the Forest for the Future plan. However, there is an opportunity to tackle multiple challenges at once by applying Forest Urbanism at the regional scale by creating a multifunctional forest structure.
An integral green structure between the centres of a polycentric metropolis can possibly structure the urban fabric on a regional scale and partly provide a partial solution to today's and tomorrow's challenges.

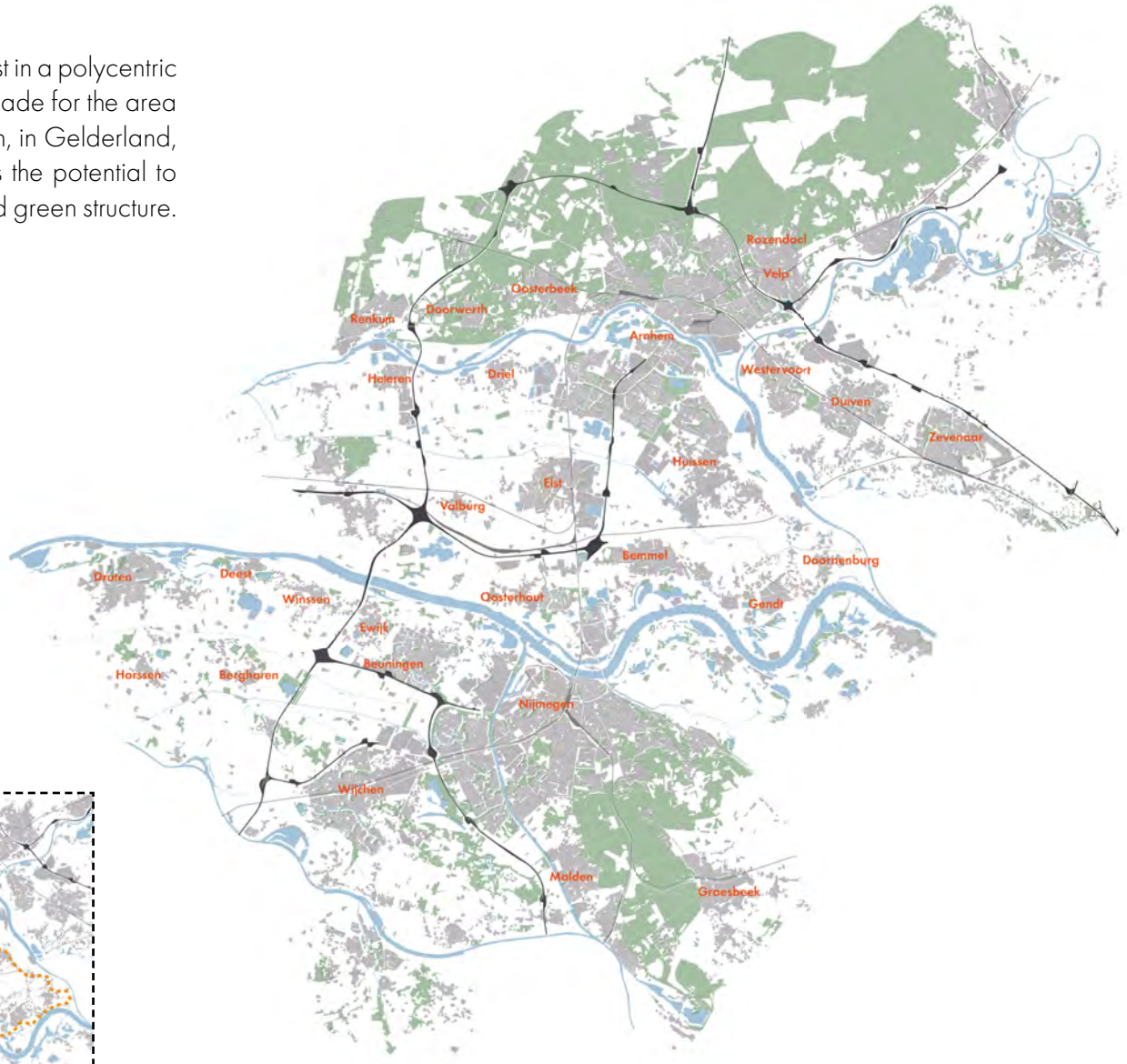
1.3 Design location

This research will focus on the creation of an interurban forest in a polycentric metropolis. To demonstrate the concept, a design will be made for the area between the two cities in the Stadsregio Arnhem-Nijmegen, in Gelderland, the Netherlands. The location was chosen because it has the potential to grow into a cohesive metropolitan region with an integrated green structure.

As can be seen on the image to the side, the Stadregio Arnhem-Nijmegen in much larger than just the two cities alone. It also includes several villages surrounding the two cities. However, since both cities have expanded heavily across the river into the interurban area in recent years, this is the area that will be discussed in this thesis, outlined in orange in the image below.

However, this does not mean that the design made in this thesis should be a standalone design. It will be part of the bigger regional spatial layout, directly influencing the design choices made in the rest of the region.





Stadsregio Arnhem-Nijmegen

Figure 3, satellite image of the Betuwe.

1.4 Research questions

This thesis explores the creation of an integrated forest structure in a polycentric metropolitan region. The challenge is to provide a new spatial view of the area and ensure it is future-proof, on an environmental level, but on a human level as well. This is captured in the following research question:

"How can forestry be used to create an interurban green structure in the Stadsregio Arnhem-Nijmegen to structure the existing polycentric metropolitan landscape, while simultaneously providing a solution to future climate and ecological challenges and improve the health and well-being of the inhabitants?"

To be able to answer this question, the different challenges of the area need to be explored in order to create a sustainable design. These challenges and their possible solutions will be determined by answering the following subquestions:

- **What are the climate challenges of the City Region Arnhem-Nijmegen?**
- **How do natural environments improve health and well-being?**
- **What is agroforestry and how can it be applied?**
- **What is an interurban forest, and what does it look like?**

1.5 Design assignment

The design assignment of this thesis is to make a proposal for the redevelopment of the interurban area between Arnhem and Nijmegen with the main focus on creating a comprehensive green structure that heavily incorporates trees and forestry. The design should be future-proof and support a sustainable lifestyle. The design should provide a solution to the challenges found in the analysis and research, specifically focused on health and wellbeing, agriculture, and climate challenges.

1.6 Methodology and theoretical framework

This thesis will focus on the creation of an interurban green structure as a form of landscape urbanism in a polycentric metropolis.

Research

The research that is conducted during this project consists of three parts, namely literature research, site analysis, and precedent research. Together, the results of these investigations will provide a design framework for the whole area.

Literature research

The literature research will focus on answering the first three subquestions of this thesis. The topics that will be discussed are the climate challenges for the region, the concept of agroforestry and its possibilities, and the link between a green environment and health.
The climate challenges of the area will be determined by researching the Regionale Adaptatie Strategie (2021) for the area that falls within the water board of Rivierenland, the Klimaateffectatlas (2018), and a KNMI report on climate change (2021).

The concept of agroforestry will be explored by discussing an extensive publication by

the Wageningen University and Research (2022) on this topic. The university published a number of factsheets for the general public, but especially focused on farmers who are considering to incorporate agroforestry in their businesses in the context of the Netherlands.

The connection between mental health and a green environment is explored through the Attention Restoration Theory of Kaplan & Kaplan (1987), supported by the research of Ulrich (1973). The research of these theories also attempts to determine principles of a healthy environment that can be translated into the design.
The relation between a green environment and physical health is explored through a report of the Dutch ministry of Health, Wellbeing, and Sports (VWS) (2022).

Site analysis
The site analysis will start with a extensive historical analysis based on the spatial development of the area and the region's governance during this development. This process from the 1980s onward is described in the book Regionale gebiedsontwikkeling by Guus Steenbergen (2022), which will be the main source of information. Additionally, the Vierde Nota Ruimtelijke Ordening (1986) published by the Dutch National Government will act as an additional source. Furthermore, information published by the foundation Park Lingezegen about their development will be used.

Then, through mapping, a spatial analysis of the area will be made to explore the characteristics of the area and determine its strengths and weaknesses. This analysis will act as the basis for a new spatial vision for the whole design area. The vision on the scale of the whole area will contain multiple smaller design areas, which will deal with the challenges that were concluded from the literature research.

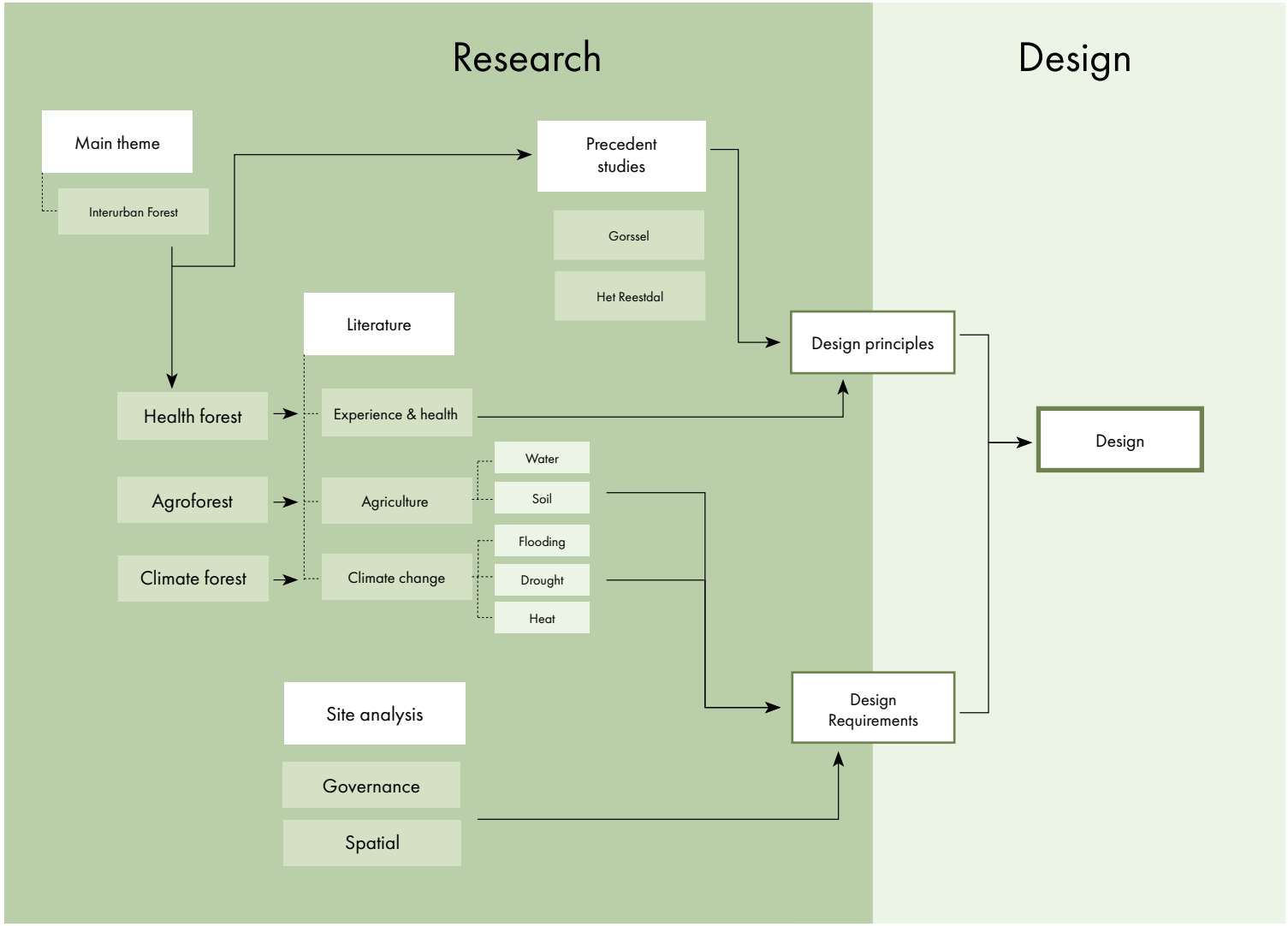
Precedent research
The precedent research will provide insights for both the new spatial vision and the smaller design areas. The principles used in the precedents can be directly translated into the new design.
The following precedents will be discussed for the design. These are:
- The Reestdal, De Wijk-IJhorst, the Netherlands.
- Gorssel, Gelderland, the Netherlands

There are two more precedent researches done, but the principles from these precedents will not be translated into the design. These can be found in Appendix B.

These precedents are:
- Delftse Hout, Delft, the Netherlands
- Bentwoud, Zoetermeer, the Netherlands

Design
Based on the conclusions from the different researches and new vision for the area, different forest types will be designed and integrated into the existing landscape. These forest types need to provide a solution to the challenges found in the research.

Theoretical framework



2 LITERATURE RESEARCH

2.1 Health and green environment

The history of natural spaces in cities in a social and health context can be traced back to the nineteenth century with the appearance of public parks. When cities became more populated and polluted as a result of the industrial revolution, the concern for the health of inhabitants increased. Before, visiting green spaces was an activity for the richer classes in society.

The relationship between nature and general health has been argued for many years. The two main branches of this theory are physical and mental health and well-being. In this chapter, both will be discussed. The paragraph on physical health will discuss quantitative research that has been done on the theory that a more natural environment can cause better health. The paragraph on mental health will discuss two main theories that are still considered important in the discourse on the subject. The first is Stress Reduction Theory, and the second is Attention Restoration Theory. The second theory provides spatial concepts for restorative environments that will be used in the design.

Physical health

There are several benefits of a green environment on physical health. The Ministry of Health, Wellbeing, and Sports in the Netherlands has outlined the various benefits in the Green and Health report (2022). They describe a conceptual model in which both the benefits for mental and physical health are identified.

According to this report, there are multiple benefits to physical health, both direct and indirect. An example of a direct benefit is improving air quality because plants can remove many contaminants from the air. This means that people with respiratory complaints will have less trouble with their lungs. In addition, trees cool the environment through shading and evapotranspiration, which in hot summers can ensure that people experience fewer physical complaints due to the heat.

An indirect positive consequence of a green environment is a reduced risk of diabetes and cardiovascular disease. It is very likely that this is also related to lifestyle, but a positive correlation can be assumed. A green environment reduces stress and this is beneficial, because large amounts of stress can eventually lead to a higher risk at cardiovascular disease. According to the same report from the Dutch ministry, a green environment can also encourage physical activity, such as running, cycling or walking. This can also reduce the risk of cardiovascular disease and type 2 diabetes. The report does state that this relationship can only exist if the right facilities for physical activity are also available. It is therefore important that the right facilities are provided for physical activitiy in future regional urban and landscape design.

Mental health

There are many theories about the relationship between a natural environment and good mental health. Two of the main theories are the Stress Reduction Theory (Ulrich, 1979) and the Attention Restoration Theory (ART) as described by Kaplan & Kaplan (1987).
Ulrich's research focused on proving the then assumed causal link between a natural environment and a reduction in stress. He shows that people who participated in his research felt less stressed after seeing images of natural scenes than when they see images of an urban environment without greenery. Thus, this study shows that the correlation between the two subjects can be considered a correlation. In short, Ulrich has scientifically demonstrated that natural environments are healthy for people in terms of stress reduction. However, he does not provide a possible explanation for this causal link.

A theory that may describe why this causal link exists is the Attention Restoration Theory by Rachel and Stephen Kaplan, two environmental psychologists. The theory operates on the

Figure 4, picture of a natural environment used by Ulrich in his research.

Figure 5, picture of an urban environment used by Ulrich in his research.

assumption that people have two types of attention: directed attention and undirected attention. Directed attention is what one uses in everyday life when a task needs to be undertaken. This often involves turning away from distractions and focusing on one thing. In the real world, this could be as mundane as a having a job that requires the worker to focus to complete tasks, which is very common in the western world nowadays, since knowledge- and service-based sectors are the biggest drivers of the economy.

If one has to perform a task using directed attention for a long period of time, one will eventually become exhausted. Kaplan & Kaplan call this 'directed attention fatigue'.

They argue that the remedy for this exhaustion lies in finding a place where one can conduct undirected attention, which according to their theory, is easiest to do in a natural environment. Undirected attention means that one may become distracted and be fascinated by and interested in the environment. This fascination can be considered as involuntary attention towards the direct environment. This involuntary attention causes a decrease in directed attention and helps to restore people's mental rest and increases one's ability to perform tasks adequately when necessary.

The text of Kaplan & Kaplan already states that directed attention is becoming increasingly essential in "current" society (m. nt. 1987), because work tasks are becoming increasingly specialized and specific. This trend has continued into the 21st century and is expected to increase even more, further enhancing the necessity for relaxation in nature.

Conditions

Kaplan (1995) describes three requirements for a successful restorative experience in a natural environment in his follow-up paper on the Attention Restoration Theory. These requirements are Extent, Being away, and Compatibility. These concepts will be described in the paragraph below.

Extent describes the need for a specific driving range in the environment. Kaplan says that the environment must be "...rich enough and coherent enough that a whole other world can be formed. An endless stream of stimuli both fascinating and different from the normal would not qualify as a restorative environment." He goes further and states that an endless stream of stimuli is not an environment, but merely an unrelated collection of impressions. A restorative environment should be on a scale that can engage the mind, and there should be enough to show that experiencing the environment takes up enough space in the mind. This means that there is a fine line between too little and too much stimuli.

This is also referred to in the first research by Kaplan & Kaplan (1987). Various images are shown and people are asked which image they prefer. These are images from a relatively open forest to a relatively closed forest, but also images of an empty meadow and houses. This research showed that many people prefer

Figure 6, Image from Kaplan & Kaplan (1987) illustrating an environment where there are too many stimuli.

Figure 7, Image from Kaplan & Kaplan (1987) illustrating an environment where there are too few stimuli.

Figure 8, Image from Kaplan & Kaplan (1987) illustrating an environment where the extent for restorative purposes is sufficient.

images with natural scenes that show neither too little nor too much. An empty meadow offers too few stimuli, but a dense forest offers too many stimuli. A forest with a relatively good overview is generally preferred.

Being away refers to the fact that, according to Kaplan, one must be away from the activity to which he draws directed attention. This applies to both the physical and mental aspects of being away from the task. It is stated that simply being physically away from a task is not enough for nature's restorative effects to work, one must also refocus in mind. According to Kaplan, there is no point in doing another activity if one is constantly thinking about the task on which so much attention was previously paid. However, this is a task that designers cannot achieve, it must be done by the person themselves. What can be achieved is a green environment that feels 'away' from the rest of the world.

One last condition that Kaplan (1995) introduces is "compatibility between the environment and one's purposes and inclinations", or compatibility in short. This concept was already briefly introduced in the paragraph on physical health benefits. What this means is that the environment must provide the opportunity to reach a certain goal. For example, when a person wants to go cycling it is necessary that there is a path where this can be done. Without the path, the person could not go cycling and thus not reach their goal. In the context of an urban green structure for mental health purposes where people will come to relax, based on Kaplan's theory the structure needs to provide an environment that supports the feeling of being away and have the right amount of extent. These concepts will be used in the new design for the project area to incorporate the restorative properties of natural environments into the design.

Preferences

Van den Born (2007) in her research on the different views of lay people on nature, describes that people prefer environments that they perceive as more natural. The perception of the research subjects of what was a more natural environment was based on their assumed level of cultivation of an area. Examples given by van den Born of places that are perceived as very natural include "the sea" and "a decidious forest". It did not matter whether the forest was

planted or not.

In the research by Tyrväinen et al. (2014) the relationship between stress relief and urban green spaces is explored. The research uses a questionnaire to let people compare the forest, a park, and the city on their respective capacity to provide mental rest. In most cases, the forest seemed to come out on top for all of the questioned categories and proved to have the most perceived restorative benefits.
Despite these clear preferences for forested areas, it is important to note that Kaplan & Kaplan mention in their research that people have a preference for environments that are closer to their place of residence. This means that some people might have a preference for a different type of environment. However, since forested areas are perceived to be the most restorative, a new design for the interurban area between Arnhem and Nijmegen could provide the inhabitants with a new kind of environment that could have more restorative properties than the existing context.

Conclusion
A green environment has positive effects on both physical and mental health. The positive effects on physical health include reduced risk of cardiovascular disease and type 2 diabetes. Also, green environments reduce air pollution leading to cleaner air, which is beneficial for everyone but especially for people with respiratory problems. Thirdly, green environments enjoy are cooler in summers than non-vegetated areas, which is more favourable for people's physical health.
Positive effects on the mental health include stress reduction and attention restoration. However, the researchers who introduced the Attention Restoration Theory state that for a natural environment to be succesfully restorative it needs to meet three specific requirements. These are Compatability, Being away and Extent. These principles will be translated into spatial design principles which will be used in the design.
People experience environments as more natural when the level of cultivation is lower, with the forest and the sea mentioned as two of the most natural. Also, the environment that

Figure 9, bridal couple in Nijmegen during high water

2.2 Climate

According to the Regional Adaptation Strategy (RAS) for the Rivierenland Water Board (Regionale Stuurgroep Samenwerkende Netwerken Regio Rivierenland, 2020), there are three themes that are relevant to the area when it comes to climate change. These themes are flooding, drought, and heat.

Flood risks
The area faces risk pf flooding due to its location between two major rivers, the Waal and the Lek. The area has a long history of high water and flooding, but the one that is remembered by most people in the Betuwe is the evacuation of the area in January 1995, as a result of extremely high water levels in the surrounding

Figure 10, Army soldiers helping residents evacuate.

rivers. Heavy rainfall in Germany, Belgium and France caused the water to rise to the top of the dike in the Dutch delta. The expectation was that if the river dikes could not hold the enormous amount of water, that the water levels in the polder would rise to 5 meters above normal, which would mean that most of the houses would be flooded. As a precaution, 250,000 people and 1 million animals were evacuated (NOS, 2015; Ministry of Infrastructure and Water Management, 2023).

Already during this crisis, the national government made a proposal for a river delta plan that later grew into the large-scale Room for the Rivers project. Since the implementation of this project, the risk of flooding has decreased significantly. However, due to climate change the frequency of heavy showers, like the ones that caused the high water in 1995, is expected to increase (KNMI, 2021). This means that the risk of flooding is also increasing. In the winter of 2022-2023, the Linge already overflowed its banks around Leerdam after prolonged rainfall (De Gelderlander, 2023), and the winter of 2023-2024 caused high water levels in the whole country as a result of a long period of rainfall (Deltares, 2024).

Due to global warming, the general humidity increases and therefore relatively more precipitation falls (KNMI, 2021). In addition,

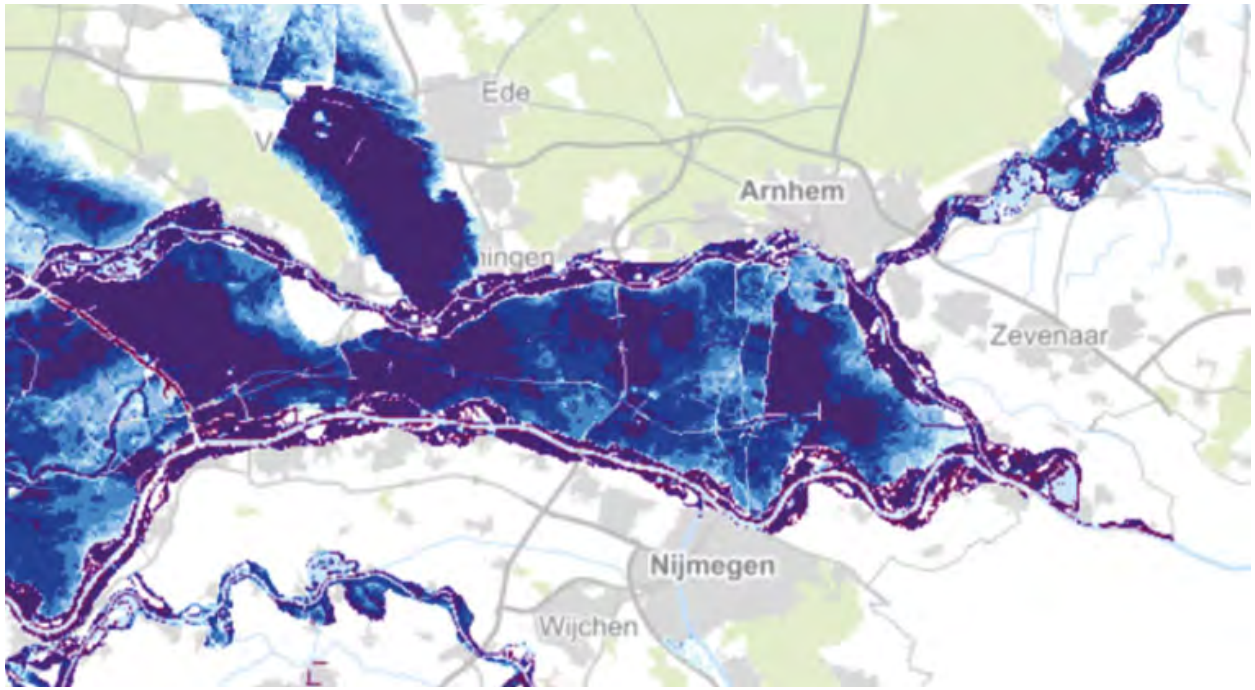


Image 11, Flooding scenario once every 100 years

there will be more peak precipitation (IPCC,2021).

The Climate Effect Atlas (2018) shows that there is a chance that certain low-lying places in the city region could flood up to 5 meters once every hundred years.

In addition, there is a scenario in which the sea level rises to such an extent that there is more pressure on the rivers and dikes in the hinterland, says Professor of Rivers and Deltas Maarten Kleinhans of Utrecht University (NOS, 2022), which reduces the discharge capacity of the rivers. This means that the flow of the water from the rivers into the North Sea becomes more difficult, since the water from the North sea is pushing inland at the same time as the water of the rivers is pushing outward. Currently, the effects of the tide are already detectable up to Gorinchem (ARK Rewilding, 2024), which lies approximately halfway from Stadsregio Arnhem-Nijmegen to the North Sea. The increase of pressure from both sides means that flood risks become higher.

Drought

According to the KNMI (2021), the chance of longer periods of drought in the Netherlands will also increase. This is often seasonal due to a difference in precipitation amounts and potential evaporation. The KNMI says: "In autumn and winter, the amount of precipitation is greater than the potential evaporation; This is why there is a precipitation surplus. In these seasons, both variables have increased over the past century. In summer there is more potential evaporation than precipitation, causing a precipitation deficit." In short, the chance of drought is greater in summer than in autumn and winter.

There are a number of negative effects of long-term drought for the region according to the RAS (Regionale Stuurgroep Samenwerkende Netwerken Regio Rivierenland, 2020). The first is the subsidence of the soil due to a shortage of water. This can lead to cracks in houses and other buildings. Secondly, prolonged drought will also reduce crop yields. Thirdly, the Rivierenland Water Board has an important task in extracting fresh drinking water. When there is not enough water to maintain the rivers, this is in danger. A lower level will also reduce the supply of water, causing certain areas to experience water shortages and a decline in the quality of surface water.

Also, as a result of longer periods of drought, the dikes in the area are at risk of tearing. This is a risk because

Heat

According to the Regional Adaptation Strategy (2020) for the Rivierenland water board, there are a number of major consequences due to the expected increased heat in the future. The first is that prolonged heat has a negative effect on physical health. According to the RIVM (SOURCE), people with vulnerable health have a greater risk of negative effects, but if it is warmer than thirty degrees Celsius for several days, anyone can suffer from the heat.

For example, heat can cause headaches, fatigue, thirst, lack of concentration and many more. In extreme cases it can cause nausea, exhaustion and unconsciousness.

Secondly, the urban heat island effect can be enhanced by prolonged heat. This means people in cities are more affected by hot temperatures than people in more rural areas. This thesis focuses on the zones between metropolitan centres, where the urban heat island effect is not a main challenge. However, by creating a strong green recreational network outside the cities, it provides the inhabitants from within these cities with a place to escape to in case of prolonged heat.

2.3 Agriculture

The current agricultural system in the Netherlands has several challenges. The most important challenge at the moment is the nitrate crisis. Dutch agricultural companies emit high levels of nitrate, which negatively impact nature reserves in the Natura 2000 network that are poor in nitrogen. The flora in these reserves have evolved to grow efficiently without nutrient rich soils, resulting in a specific local ecosystem.
The threat to these ecosystems is for the most part posed by nitrate emissions from agricultural companies, and especially livestock farms. These livestock farms produce nitrate unintentionally. It happens when the excrements from animals get mixed, more specifically when faeces and urine from livestock animals blend. This creates ammonium gasses, which flow into the outside air. The gasses settle on the landscape as a result of precipitation, such as rain, and flow into the soil with the water. However, only 10% of a company's nitrate emissions occur within a radius of 500 meters of the source, after which the origin can no longer be traced (Tietema et al., 2023). The other 90% will end up in a higher layer of the atmosphere and settle elsewhere.

This is a natural process that has taken place for hundreds of years, but it has caused problems over the past decades since the ratio of nature to agriculture has changed. After the Hunger Winter of 1944-1945 during the Second World War, the Netherlands installed policies to ensure food security, which meant that agricultural practices needed to become more efficient. The main politician responsible for instating these policies was Sicco Mansholt, who was minister for agriculture from 1945 to 1956. Afterwards he became the European Commissioner for Agriculture in 1958.
His ideas for intensification of the agricultural sector still hold strong to this day. These include ruilverkaveling, or land consolidation, the increase of use of pesticides, and intensification of agricultural practices by subsidising them with European funds.

Another reason for the increase of nitrates in the soil is the use of agricultural toxins and pesticides.
Agricultural toxins have been used extensively to increase crop yields and reduce the risk of a bad harvest. Even though the use of agricultural toxins and pesticides is decreasing in the European Union, a negative side effect of these methods is the decrease in biodiversity. Pesticides do not only extinguish the unwanted organisms, but also the species that are valuable. For example, many plant species depend on natural pollinators, such as wild bees and butterflies, but one third of the species of natural pollinators are in decline (EEA, 2021). One of the main causes of this decline is the use of pesticides.

Also, pesticides decrease soil quality by exterminating most of the fungi in the soil (EEA, 2024). This results in problems, since plants and fungi exchange nutrients in the soil, which is no longer possible without the presence of the fungi. A cascading effect of this problem is that the crops need more nitrogen rich fertilization, since their connection to nutrients from the soil has been severed. As mentioned above, too much nitrogen in the soil can result in serious issues for nitrogen-sensitive plant species.

An important thing to note is that the European Union nowadays is mostly self-sufficient when it comes to food security, so the need for the use of pesticides has decreased (EEA, 2024). However, since farmers' income largely depends on their crop yield, the economic push to continue using pesticides remains, which explains why they continue to be used. Thus, the solution to the overuse of pesticides is not only a matter of switching to a more eco-friendly way of farming, but also a political choice on the economic position of farmers.

A second challenge for agriculture in the Netherlands is adaptation to climate change. It is expected that during the growing period of crops, spring and summer, there will be less precipitation compared to 30 years ago (KNMI, 2021). This means that farmers will suffer from drought and water shortages, and therefore

reduced crop yields. Higher temperatures can also burn and dry out crops.

A third challenge is to make agriculture more nature-inclusive. Currently, agricultural lands are often monocultures, making agricultural areas deserts for vulnerable animal and plant species. This is maintained because the current system in the Netherlands and Europe does not reward farmers enough for nature inclusive practices. This makes it financially more advantageous for them to use their land as efficiently as possible, which means that plots of land often only contain one type of crop.

One method of farming that offers a solution to two of these challenges is agroforestry. The intention is to combine agricultural crops with trees on the same piece of land. This concept is already being used in developing countries to increase crop yields. The benefits of agroforestry include improving soil biodiversity, reducing wind speeds, lower temperatures in summers due to shade and evapotranspiration, better water infiltration in the soil, and better water retention (Selin-Norén, 2022; Keur & Selin-Norén, 2022). In addition, trees can remove carbon dioxide from the air through the photosynthesis process, making them an effective means of climate mitigation.

Many of these mentioned benefits offer an adaptive way of dealing with climate change as well as supporting climate adaptation. For example, shading reduces the impact of the hot sun in the summer, better water infiltration means less flooding in wet periods, and better water retention means that plants are less affected by drought.
Trees are also places where new habitats can be created for animals and plants. The tree itself provides space for various animals and insects in the crown, bark and around the roots, and in addition, a microclimate is created around the tree that benefits many plant species. This also attracts different animal species, creating a small ecosystem in and around the tree.

The tree can also exchange nutrients with other organisms through Mycorrhiza, a collaboration between plant roots and fungi in the soil, creating a more robust ecosystem (van der Kaa, 2021). An additional advantage is that trees are often more deeply rooted than other plants, and can therefore obtain nutrients more easily. However, as mentioned before, this process is under threat as a result of pesticide use, which means that in order for the tree to effectively exchange nutrients, the amount of pesticides used needs to decrease significantly.

A problem that agroforestry cannot solve is the current nitrogen problem in the Netherlands, because there is no control over nitrogen deposition in different areas.
In places where nitrogen would precipitate, trees could possibly remove it from the soil, but since the location of nitrogen deposition is very unpredictable and this practice requires a strict ecological policy, it is more likely that the solution will be found at the source, namely intensive livestock farming. This is a political issue, so no statement will be made in this thesis about how it will be implemented, but one of the most plausible scenarios is the extensification of livestock farming around nature reserves. It is not yet clear what this "new" form of agriculture will look like, but agroforestry can play a role because of all the benefits it offers. For that reason it is relevant to discuss it in this context.

What does agroforestry look like?
What agroforestry looks like depends on the context, because there are several variables that one can assume. Several variables are discussed in a set of fact sheets developed by Wageningen University for farmers who are considering implementing agroforestry (Selin-Norén, 2022). These will be discussed below.

First, it is important to note that the type of agriculture practiced on a piece of land is an important variable, and often underlies the spatial configuration choices a farmer makes. However, no specific agroforestry advice for different types of farming is given in the fact

sheets, this is left to the owner of the land. For the Over-Betuwe area, the most common types of agriculture are livestock farming, arable farming and fruit growing.
Second, the spatial configuration of the trees on the plot of land. Three options are outlined here, namely: strips, loose trees, and small groves. Strips are especially useful in places where the land is worked with heavy machinery, because the trees will not interfere with the most efficient driving line. Loose trees are most useful on land with livestock farming, because the animals can then easily seek shelter around and under the trees. Loose clumps of trees can be useful in both cases, depending on the size.
Third, the distance of the trees from each other. There are several distances that are important to consider here, and these distances largely determine the spatial appearance of a piece of land. First, the distance of the rows from each other, indicated in image In the case of detached trees, the vertical distance (d) is also a variable. The next variable is the planting direction of the trees. This is related to the amount of sun that is needed on the land. In the Dutch context, it is recommended to plant the trees in a north-south direction if you want the maximum amount of sun on the land, because then shadow effect is minimal at the time of the most sun (Selin-Norén, 2022). When more shade is needed, the opposite can be chosen.
Fourthly, in the case of a strip pattern, multiple rows next to each other can also be chosen for a stronger ecological effect.
A choice must also be made for the type of trees you want to plant. These can be trees that yield something financially, such as fruit trees, but a specific shape or species with a strong ecological profile can also be chosen. There is also the possibility that a species is chosen from an aesthetic point of view. However, in this thesis only functionality is considered, because personal aesthetic choices cannot be predicted.
The last variable is the intended height of the trees. As mentioned earlier, a microclimate is created around the tree and this also has an effect on the crops that grow around it. Immediately around the tree, the crops will have to compete with the trees for nutrients and water, which will likely decrease the yield from those parts of the land. However, the tree can also result in a higher yield by improving the microclimate, lower wind speeds, and creating a higher chance of pollination due to the possible increase in biodiversity, as well as providing an increase in nutrients in the soil (Selin-Norén, 2022). In short, agroforestry could lead to a decrease in productivity in the immediate vicinity of the tree, but an increase in productivity on the rest of the plot. This can also be seen in the image below (from Selin-Norén, 2022).
The average distance from the tree to the profitable part of the plot is 1.6 times the height of the tree. The gains are greatest at about 3 times the height of the tree, and decrease up to 10 times the height of the tree. At distances further from the tree the yields are negligible.

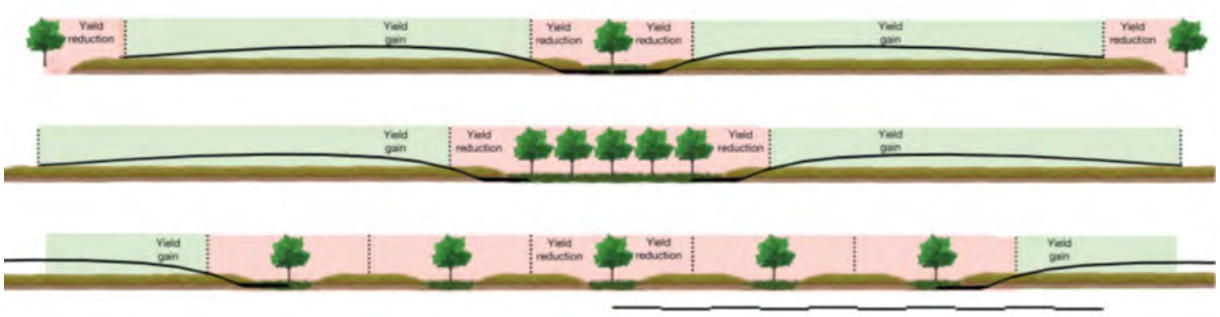


Image 12, crop gain and loss, from Selin-Norén (2022).

Conclusion

There are a number of reasons why the agricultural sector at large is not sustainable at the moment. First and foremost is the nitrate crisis in the Dutch context, which is caused by intensive livestock farming and over-fertilization of the soil. Also, biodiversity is decreasing as a result of heavy pesticide use in the past, and the lack of species variation in agricultural areas due to monocultures. Also, climate change poses a threat to food security due to an expected of extreme weather, like flooding through heavy rainfall, or long periods of drought.

Agroforestry can provide a solution to most of these challenges by making use of the natural properties of trees, like shading, cooling properties, and the support of biodiversity through the creation of microclimates.

However, there are many variables that can be considered in the implementation of agroforestry on a plot of land. These are the type of agriculture, the spatial configuration of the trees, the distances between the trees, the species, the number of strips, and the height of the tree. Each variable changes the functionality of the tree(s) on an agricultural plot, which means that it is practically impossible to state at this point in time what the exact benefits of the implementation would be.

This means that the implementation of agroforestry in a design for the Stadsregio Arnhem-Nijmegen will be conceptual, rather than being able to provide a quantitative measure of the benefits agroforestry claims to bring.

This is also caused by the need for the farmers' involvement in the implementation of agroforestry on their land. In this thesis, the inclusion of farmers in the design process falls outside the scope of the project, but it is a necessity if it were to be implemented in the real world.

3 SITE ANALYSIS

3.1 History

Nijmegen and Arnhem are two large cities in the Dutch Rivierengebied that are relatively close to each other. These two cities have long operated separately, but currently have a partnership with nine other municipalities in the region. The history of this area and its development is discussed in this chapter.

Beginnings

Nijmegen is generally regarded as the oldest city in the Netherlands. In the first century AD, the Romans founded a fort on the site of the present city, which they inhabited for almost two centuries. Its location on the river made it a strategically important site, as the river defined

Figure 13, the Roman Limes.

Figure 14, Map of Arnhem from 1649.

the border of the Roman Empire. Today, the line of forts along the river is also called the Roman Limes, and is a UNESCO world heritage site. After the Romans left around the year 400, the place was taken over by local rulers and Nijmegen was able to grow into a city of reasonable size in the following centuries. It was formally granted city rights in 1230 and became part of the Duchy of Gelre from 1247.

Arnhem's origins are less well recorded than Nijmegen's. There are stories of Roman defence works in places around the present city, but it is not clear whether any of these grew into a settlement site. The Romans left the area around the year 400 and little is known of what happened in the area between then and the ninth century AD. In 893, the town is first mentioned in a writing of a nearby monastery as Arneym. In the centuries that followed, Arnhem grew into an increasingly large town. In 1233, Count Otto II granted it city rights.

In the Middle Ages, the cities of Arnhem and Nijmegen were part of the Duchy of Gelre, until it merged into the Dutch territories of the Spanish branch of the Habsburg family in 1543. During the Eighty Years' War, seven provinces declared independence from the rule of the Habsburg family, including Gelderland, and the province has belonged to the Netherlands ever since.

Reclamation of the Betuwe

The area between the two cities, the Over-Betuwe was a dynamic river landscape in Roman times. The rivers could flow as they wished, shaping the landscape.
Changes in the climate meant it became drier and warmer across western Europe around the year 1000. This made more agricultural land available in the area between cities, and so there was more food. This caused population growth that only stopped when Europe faced the plague epidemic (National Geographic, 2023). This population growth created an increasing demand for space for new settlements and agricultural land. In the

case of the Over-Betuwe, this caused the first wave of reclamations in the area by dewatering the bowl grounds through small dug ditches (Mentink & van Os, 1985). However, with the settling of the drained land and the onset of a wetter period from around the 13th century, these areas also flooded again. The land was still needed to support the population, so this posed a problem. A need arose for stopping incoming water while excess water also had to be drained away.
First, small-scale constructions were built under local administration, but in 1327 the Count of Gelre, Reinald II, managed to completely impolder the area and build the Linge as the main drainage canal.

Figure 15, Elst in 1966.

Figure 16, Map of Elst in 1966.

Reconstruction and urban expansion
After World War II, both Arnhem and Nijmegen were partly in ruins and the cities had to be rebuilt. Because many houses had been destroyed during the war and then the population had grown, there was a huge need for more living space. This could not be realised within the city's existing boundaries, so expansion was needed. For Arnhem, this meant a number of new neighbourhoods attached to the existing city, such as Presikhaaf, and a jump across the river with the development of the Malburgen neighbourhood, and for Nijmegen an expansion towards the south. Housing demand remained after the development of these new neighbourhoods and, as a result, further expansion took place in the 1970s. This period also saw the first expansions in the in-between area in the Over-Betuwe. Among others, new neighbourhoods were built in Elst and Bemmel.

The KAN-area
In 1986, the Vierde Nota Ruimteiljke Ordening was published. In the previous years, plans for a European Monetary Union (EMU) and the unification of the European market had been made and would come into effect in the foreseeable future. Major manufacturing industries had left the Netherlands, such as shipbuilding. This means that from that moment on the Dutch economy focused more on providing services. Due to the facilitation of trade within the new European economic system, the need for these services to take place in the Netherlands disappeared, which made the economic situation of the Netherlands seem less positive than expected (de Klerk & van der Wouden, 2021). Countries and cities started to compete with each other to acquire branches of large companies, because they could provide a lot of employment. Urban areas in particular did not seem to be able to compete enough with their European counterparts. The Vierde Nota Ruimtelijke Orderning attempted to prevent

the possible decline of the Dutch economy by introducing strongly economically oriented spatial planning.
One of the concepts this report introduced was the Stadsregio, or "urban hub". According to the government, these urban nodes "...are aimed at strengthening their central position for services" (van Steenbergen, 2022) and "...at utilizing the national and international potential of the economic core area, especially with a view to the significance of the Netherlands as a transport and distribution country..." (Ministry of Housing, Spatial Planning and the Environment, 1988).
Main ports are also being installed that strengthen the economic position of the country, such as Schiphol and the port of Rotterdam.

One of these newly developed urban nodes is the Knooppunt Arnhem-Nijmegen (or the KAN area). The area is located between the port of Rotterdam and the German Ruhr area and therefore has the potential to become an important logistical hub. Both the waterways and the highways were well suited for this purpose, and a national plan was drawn up to build a high-speed freight line between Rotterdam and the Ruhr area, now better known as the Betuwelijn.
In the KAN area, places were also designated for industrial estates to develop the economic position. The Vierde Nota Ruimtelijke Ordening

Figure 17, Integratiekaart Vierde Nota.

Extra (1991) also included additional spaces for the development of new residential areas, which are now called Vinex neighborhoods. For the area in the Over-Betuwe, between Arnhem and Nijmegen, these were an extension of Arnhem to the southwest, an extension of Elst to the northeast, and an extension of Nijmegen across the Waal to the north.

The parties directly involved in the development of the area are the province of Gelderland, local municipalities, the Chamber of Commerce, the Agricultural Board, government representatives, the Gelderse Ontwikkelings Maatschappij, and neighbouring German municipalities (van Steenbergen, 2022).
These parties agree that the spatial plans until 2015 for the KAN area will focus on supporting economic development and maintaining and improving the living environment of the residents. In more detail, this plan entails the creation of 12,000 new homes, new business park locations along the A15, the development of greenhouse horticulture at Huissen, the

Figure 18, Nieuwbouwwoningen aan het stratenmakersveste in Schuytgraaf - buurt Vestingstad.

Betuwe line, and the connection of the A15 and A12 highways (van Steenbergen, 2022). Also included is a regional city park that would have to be realized between Arnhem and Nijmegen in the Over-Betuwe area. This will be expanded upon further below.
Almost all plans have been implemented, with the exception of connecting the A12 and A15 motorways. This plan is still with the Ministry of Infrastructure and Water Management, but according to the ministry it cannot be put into use until 2029 at the earliest (Heller, 2023).

Until 1995, the policy for the Stadsregio was actively implemented by the national government. This changed in 1995 when the municipalities in the region were encouraged to take charge of spatial development themselves. This is also officially recorded in the Bestuur Op Niveau memorandum (BON). This change in governance goes hand in hand with the introduction of the Wet gemeenschappelijke regelingen (Wgr), which included the urban nodes, such as the KAN-area.
In 2005, the Wet gemeenschappelijke regelingen plus (Wgr+) was introduced. This law makes it possible for administrators of different municipalities in a region to implement joint policy. This is further reinforced by making the KAN-area a plus-region, which gives the region extra powers to implement spatial policy by itself. However, this did not sit well

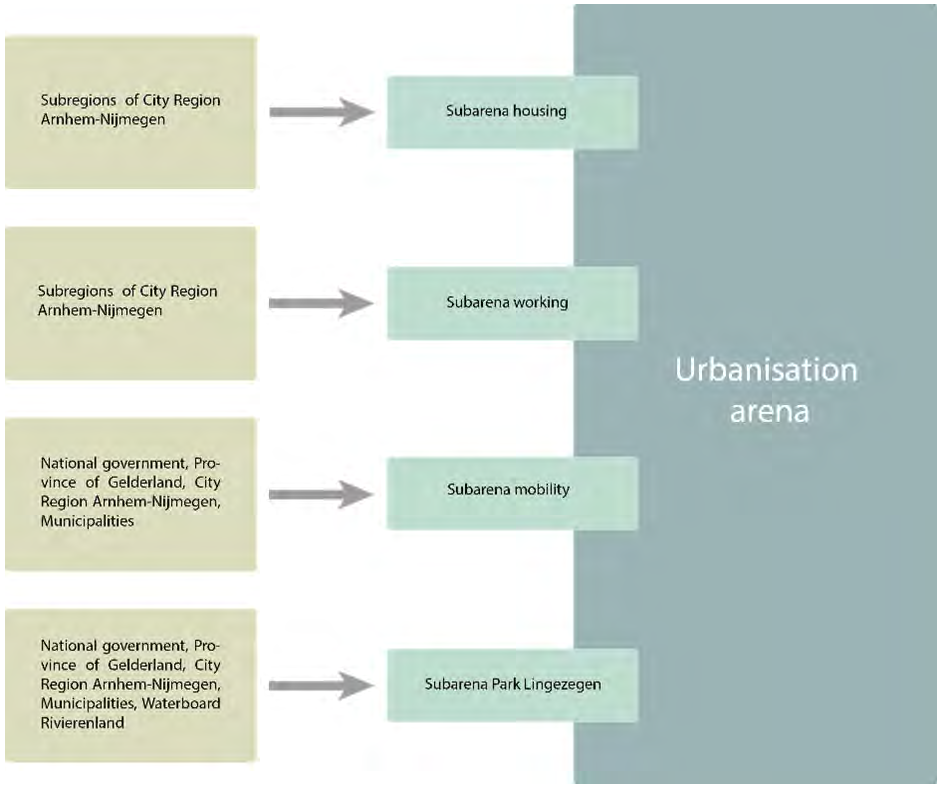


Figure 19, Urbanisation arenas based on plans from the Vierde Nota Ruimtelijke Ordening.

with various parties, because the region is not a democratically elected institution, unlike all other governments.

Park Lingezegen

Part of the Knooppunt Arnhem-Nijmegen plan is an area that offers space for greenery, recreation and ecology. This is called Park Over-Betuwe in the earliest plans and later renamed to Park Lingezegen. From 2005 onwards, the landscape park would be developed separately from the other parts of the regional plan. The other so-called sub-arenas are living, working and mobility. They are also developed separately. By disconnecting the sub-arenas, there is a lack of an integrated plan for the area (van Steenbergen, 2022).

The Park Lingezegen arena decided to divide the plan for the park into two parts: the so-called 'basic equipment' that is implemented by public parties, and a target for the future for

which no clear implementing parties have yet been appointed. The basic equipment of the park consists of the construction of recreational paths, road plantings, ecological connecting zones and water storage (van Steenbergen, 2022).

During the planning phase, in addition to the various authorities, the city region, Staatsbosbeheer, the land development committee and private parties are initially involved. This changes after two years and from 2010 only the four municipalities involved (Nijmegen, Lingewaard, Overbetuwe, Arnhem), the province Gelderland and the water board Rivierenland are involved in the development. As mentioned earlier, the Stadsregio has no legal means to enforce the spatial planning, so the legal responsibility for the realization of the plan lay entirely with the municipalities and the Province of Gelderland.

The design for the basic equipment of Park Lingezegen was divided into five separate parts: Landerij de Park, Waterland, Landbouwland, de Buitens, and de Woerdt (image x). Each part has its own perspective, design and formal language. Landerij de Park will become a mosaic landscape attractive to walkers, Waterrijk will become a new reed land to be created, Agricultural land will remain mainly an agricultural area with minimal adjustments,

Figure 20, Parts of Park Lingezegen.

the Buitens will become a mosaic landscape with an agricultural approach, and the Woerdt will become an urban estate (Municipality of Lingewaard & Municipality of Overbetuwe, 2011). The different parts are connected by cycling and walking networks.
What is striking here is that the angles for the separate areas have a high contrast with each other and there is no common denominator that connects the areas.
Various design firms are hired for the sub-areas to design the park. There is no design assignment for developing a coherent green structure, the various agencies only have to develop their assigned sub-area. Access to the area from the various residential areas is also not an explicit design assignment. The basic equipment was completed in 2020.

In 2015, the partnership in the Arnhem-Nijmegen City Region was terminated with the abolition of the plus regions under the Wgr+ law. The development of the park was then in full swing, and the joint arrangement called foundation Park Lingezegen was established by the four participating municipalities in order not to let the ongoing project come to a standstill (Park Lingezegen, 2023). Since then, the landscape park has been under the management of this foundation.

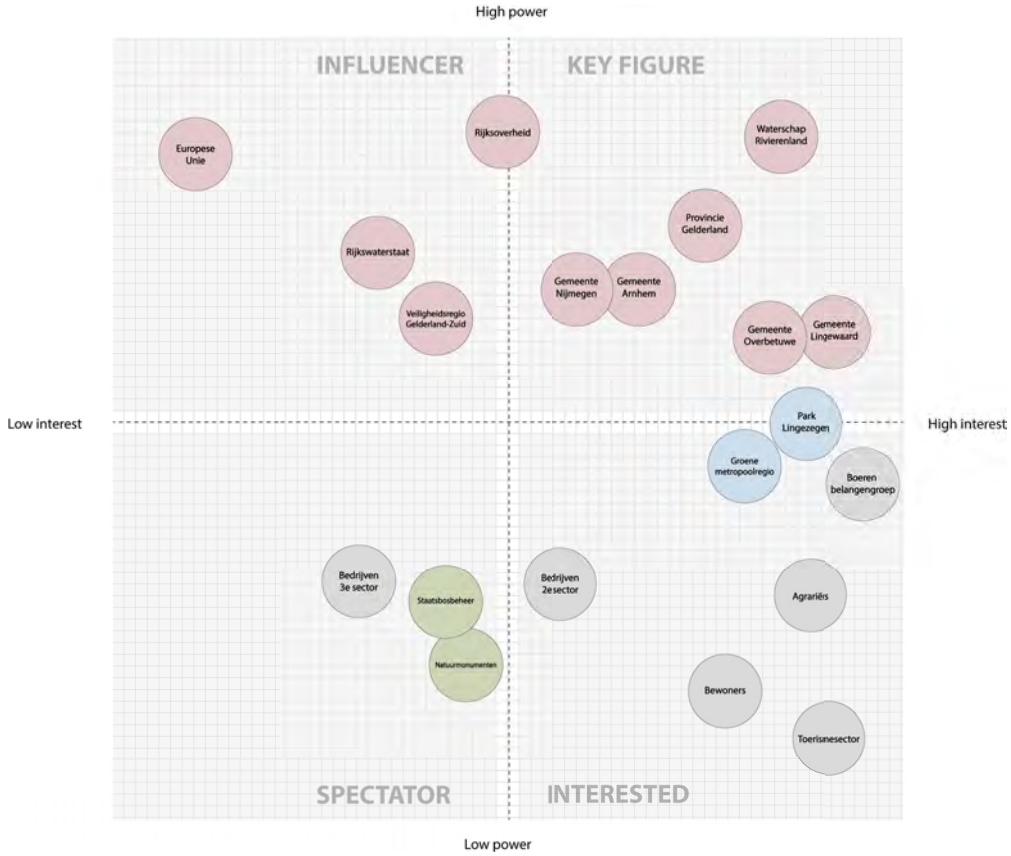
Green Metropolitan Region Arnhem-Nijmegen

Since 2021, the region's previously ended partnership has been revived by eighteen municipalities in the region (image x), the province, and The Economic Board, a collaboration between governments, businesses and knowledge institutions. The aim is to collaborate in the areas of housing, mobility, circularity, economy and recreation. However, because this is a very recent collaboration, there have not yet been any spatial developments that can indicate whether this will be a successful collaboration. However, it appears that the development of Park Lingezegen is left to the

Park itself, as no statements are made in the most recent regional deal of the Green Metropolitan Region about strengthening the green structure or landscape elements (Groene Metropool Regio et al., 2022).

There are currently several parties active in the area that can influence local policy on the development of a green structure. These parties have been put into a stakeholder analysis scheme that can be seen above. The colour of the circle indicates their function. Red is for administrative parties, blue is for foundations, green is for nature conservation parties, and grey is for other functions.

Figure 21, Groene Metropoolregio.



3.2 Park Lingezegen

As mentioned previously, Park Lingezegen has five parts that all have their own design and purpose. Despite these factors, the intention of the structure is that it functions as one park.
In the map to the right, the elements of the park can be seen. These were introduced and enhanced after the plan was forged to create Park Lingezegen.
However, the great difference in spatial experience between all of the parts, as well as the scale of the structure, result in a lack of coherence in Park Lingezegen.

Elements of Park Lingezegen

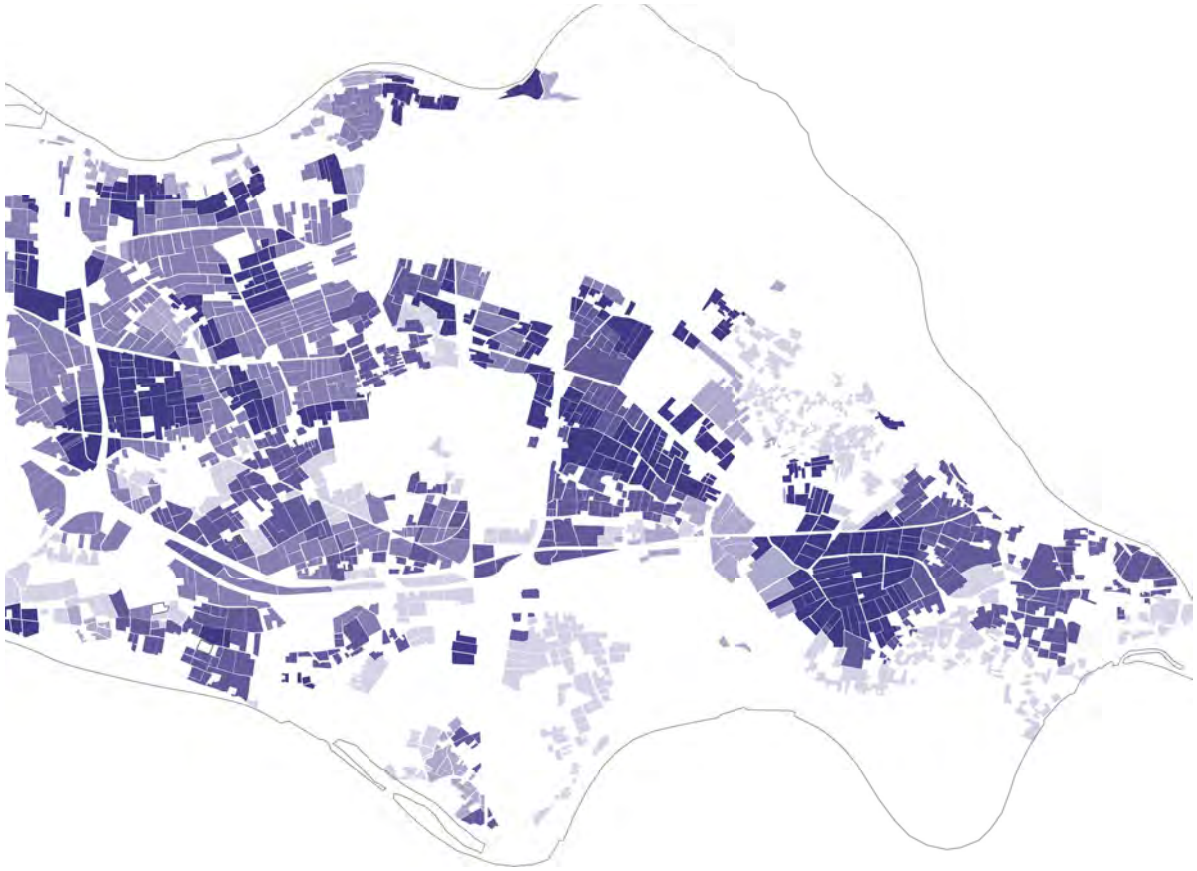
3.3 Mapping

3.3.1 Soil types

The area has different compositions of soil types, but the main components are clay and a sand-clay mixture (Dutch: zavel). These soil types are very fertile, as clay soil holds many nutrients. As a result, the river area, or Rivierengebied, is one of the most fertile in all of the Netherlands. This means that agriculture is part of the genius loci. The area of the project, the Betuwe, is mainly known for orchards and fruit growing. However, on the next page it is shown that the biggest part of the project area is used for livestock farming and agriculture that supports livestock farming.

3.3.2 Groundwater levels

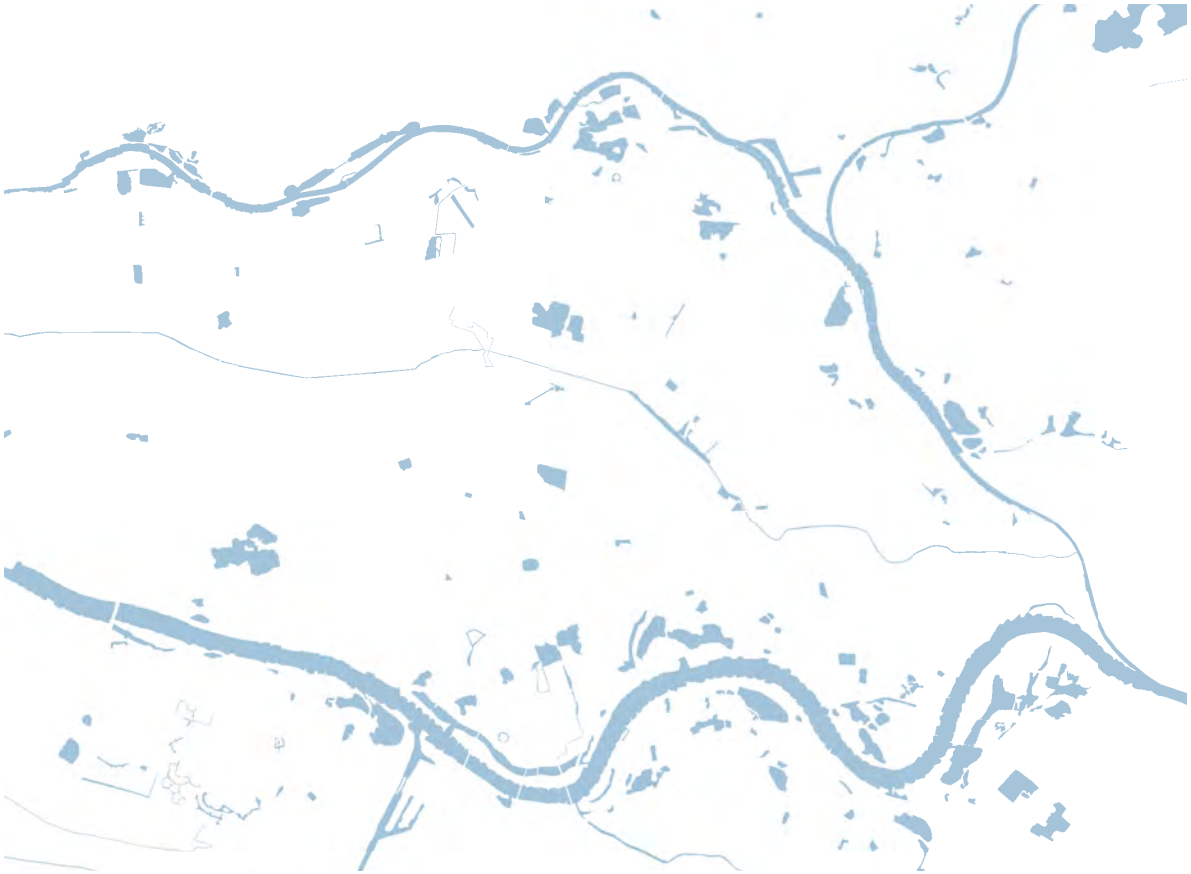
The groundwater level in this area is determined by the soil type and the amount of drainage from the Over-Betuwe polder. The amount of drainage is regulated by the Water Board Rivierenland and can change based on the weather conditions. There are defined targets for the different water levels, so if there is more precipitation the drainage of the polder is enhanced, but if there is less precipitation the amount of drainage is lowered. An important thing to state is that the Water Board only has limited control over the water levels, especially during summers. The expectation is that drought will increase as a result of global warming, which will mostly occur during the summer (RAS, 2020). At a certain point, the volume of water that evaporates and drains is larger than the body of water that is supplied by rain and water from the rivers. The only thing the Water Board and municipalities can do at that time is to reduce the use of water by enacting a limitation on water use.



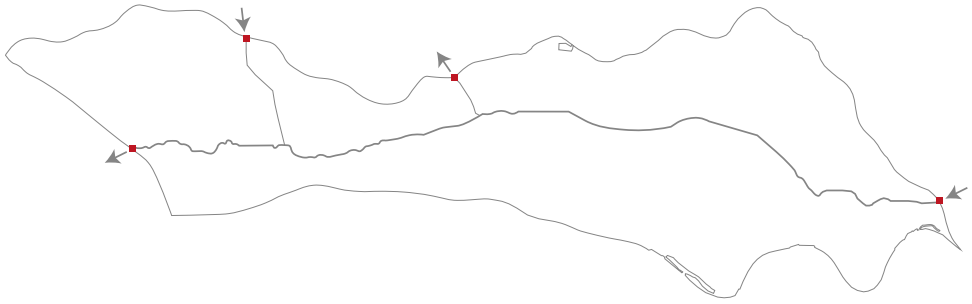
Groundwater levels on agricultural lands

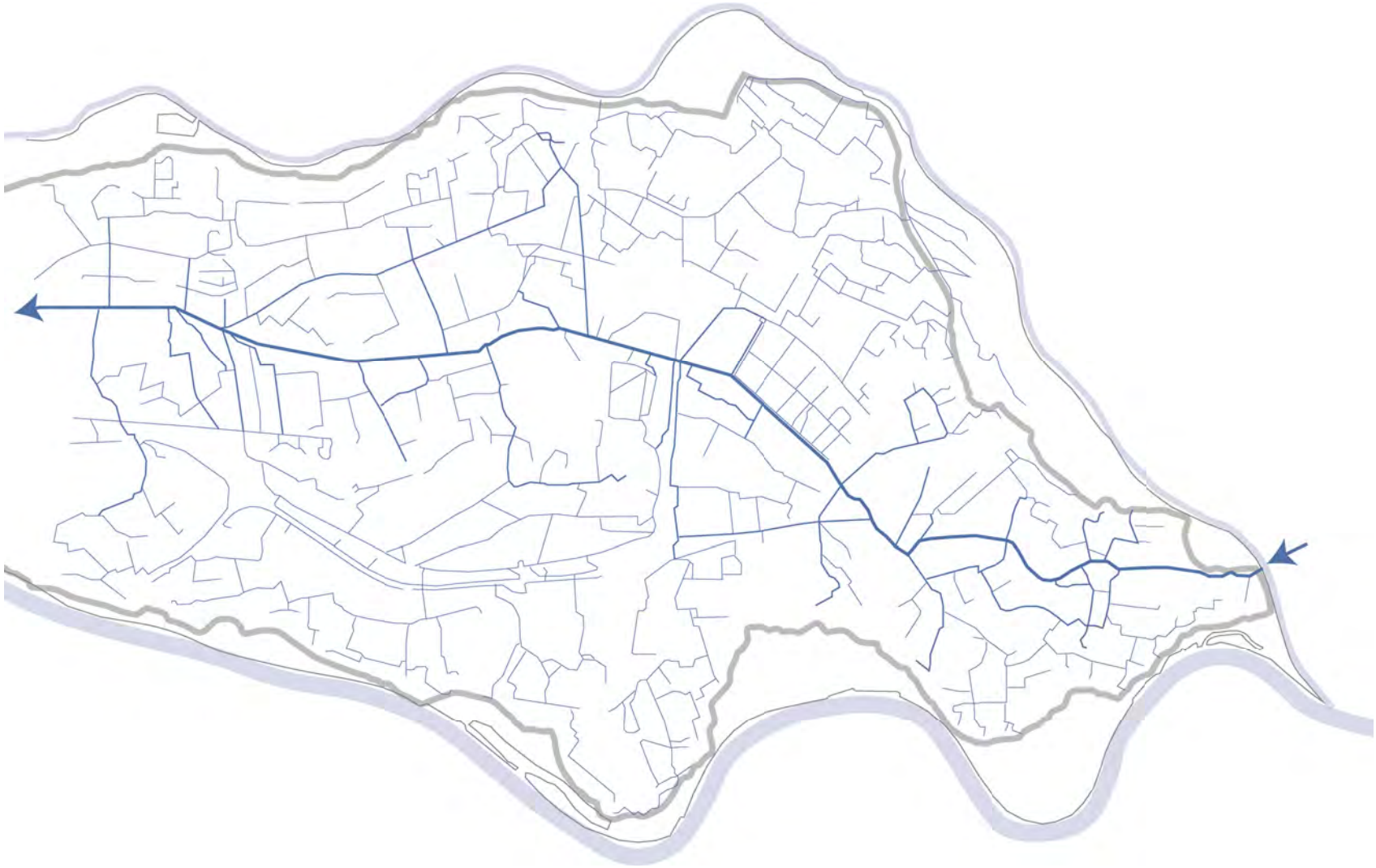
3.3.3 Water system

The water system of the Over-Betuwe polder starts at the Pannerdensch Kanaal. Since there is a relatively large height difference compared to sea level, the water tends to drain faster from the area than in a polder which is below sea level (source). Consequently, extra water needs to enter the polder to prevent it from becoming too dry. Before the area became a polder, the river would supply the soil with water by overflowing. Currently, the water is supplied from the Pannerdensch Kanaal by a pump that floats in the water. The pump is being updated to a more permanent solution, which is expected to be completed in the summer of 2024 (Waterschap Rivierenland, 2023). This is officially the start of the artificial river Linge, which is the main drainage canal in the polder. It runs through the middle of the polder uninterrupted to the Amsterdam-Rijnkanaal. The Linge continues as a small river in the Tielerwaard, but it is officially unconnected to the drainage canal in the Over-Betuwe polder.



Water pattern





Water system

Legend

River

Dike

Ditches

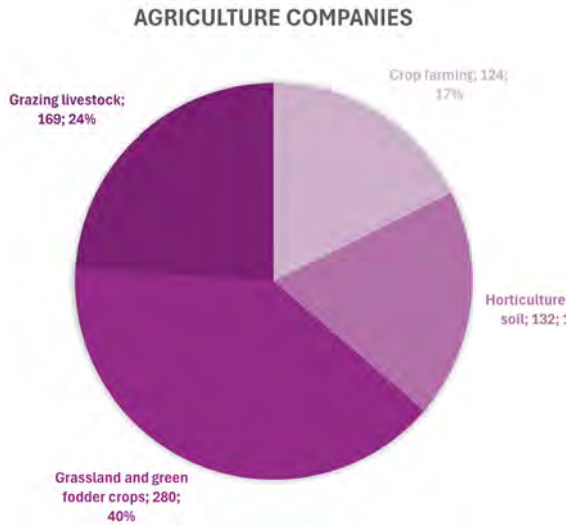
0 0 0 0

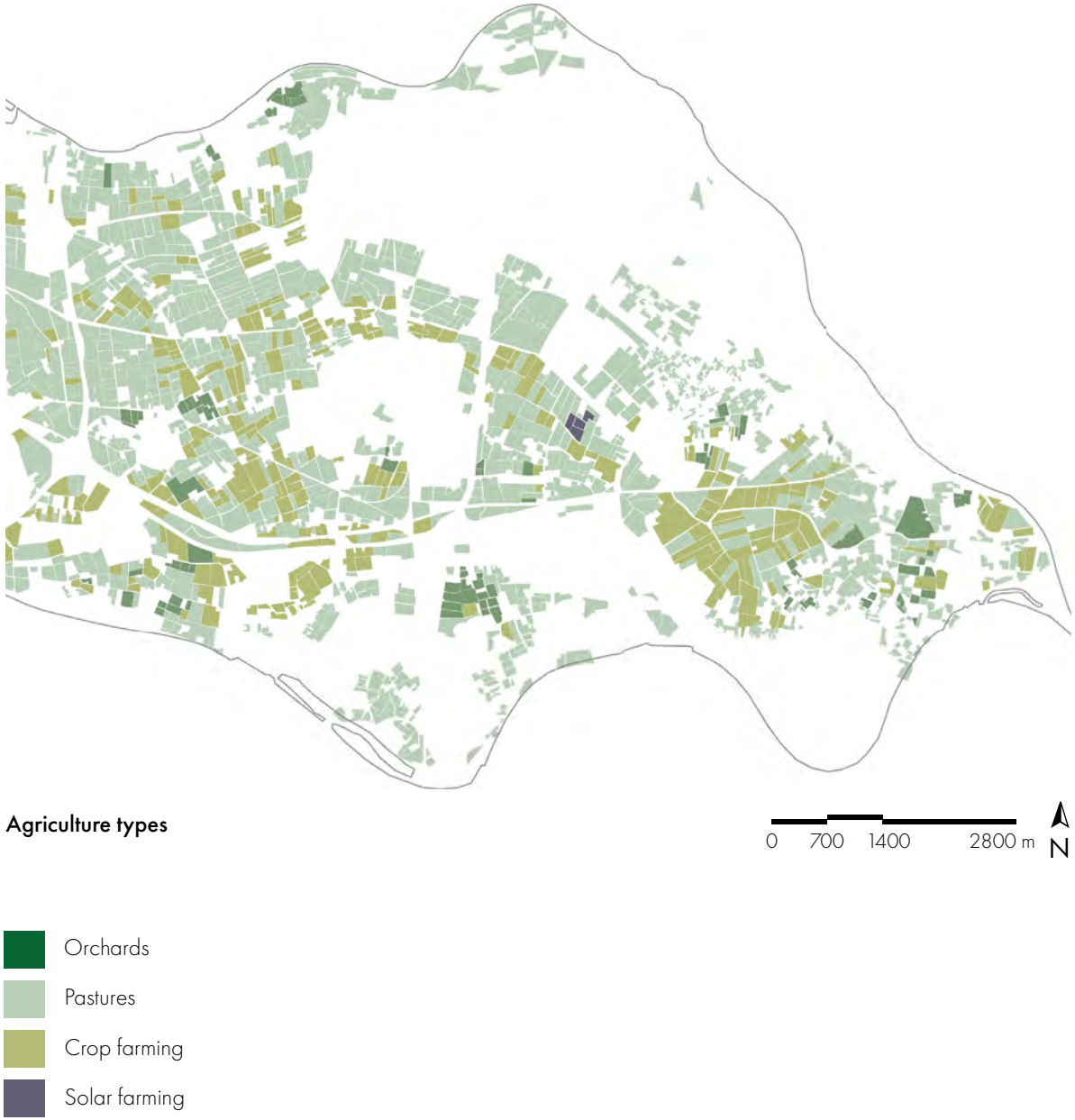
N

3.3.4 Agriculture

The diagram to the right shows the number of agricultural companies in the municipalities in the project area. The data was taken from the CBS. They use different categories than are shown in the map, but it shows the distribution of land use. Grazing livestock and grassland are included in the category pastures as shown in the map above.

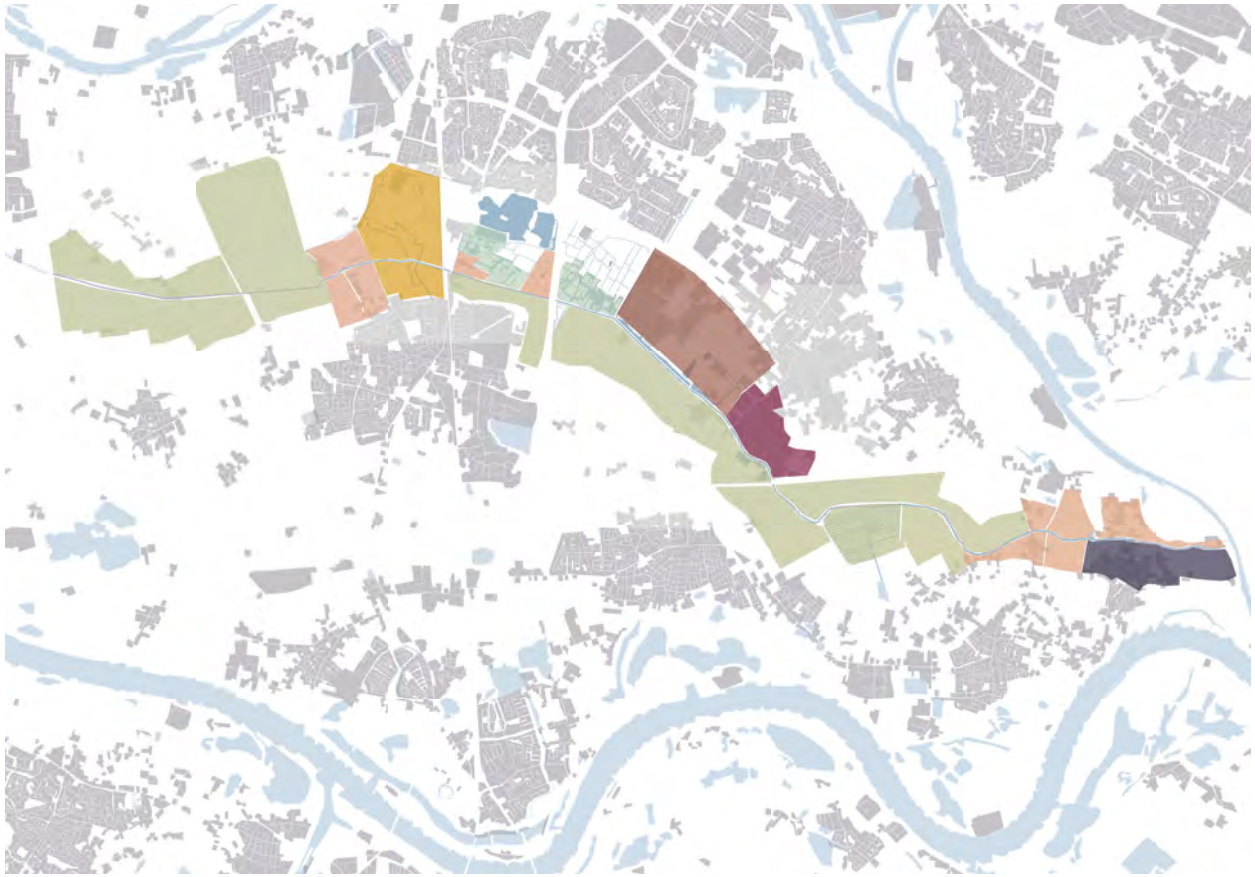
In the project area, there are four types of agriculture: crop farming, livestock, orchards, and solar farming. The different types are scattered across the landscape, there is no clear pattern. The most common type of farming in the area is grassland and green fodder crops farming. These pastures are meant to supply farmers with food for their livestock. Thus, it can be stated that 64% of the agricultural companies in the area are strongly connected to livestock farming. More numbers on agriculture can be found in appendix x.





3.4 The Linge

The Linge is the main connecting landscape element in the area. There are different types of experiences that can be found around the Linge. They are listed and shown in the map to the right and explained on the next pages. The different functions determine the experience of the area, which is explained in a more detailed manner on the next pages.



Existing functional layout

0 700 1400 2800 m

- Wide open landscape
- Small scale agriculture
- Mosaic landscape
- Water landscape
- Greenhouses
- Business park
- Village

Figure 22, View on an open pasture 1.

1. Open wide agricultural landscape

In the areas located in the bowl grounds, where heavy clay is the dominant type of soil, there are large-scale pastures that visually blend together. This creates a kind of infinite void that makes the scale of the area very grand. However, due to the absence of breaks in the field of view, there is no clear delineation of the area. This creates a cluttered horizon and the connection to the Linge is lost.

In addition, the area is an ecological desert due to the lack of varied vegetation.

Figure 23, View on an open pasture 2.

Figure 24, View on an open pasture 3.

Figure 25, View on the Linge.

Figure 26, view on an orchard across the Linge.

2. Small scale agriculture

The small scale agriculture in the area is characterized by the mixing of farms with regular dwellings. Gardens and agricultural patches are intertwined with one another. The agricultural plots are often invisible from the road as they lie behind the house. The patches are also significantly smaller than the surrounding largescale lands.

Figure 27, View on the water landscape from the cycling path.

Figure 28, View on the Linge from the cycling path bordering the water landscape.

3. Water landscape

The water landscape, also known as Waterrijk, is part of Park Lingezegen and mostly consists of reedlands. The old pastures were excavated and flooded with water. These parts of the landscape were designed to be a nature area for water birds. The old pasture pattern is followed in the design, the existing borders of a plot now form the main ditch pattern and the reed patches are shaped after the old pastures. The area is maintained by humans through Staatsbosbeheer, who actively remove tree saplings to prevent forestation of the area (Reith, 2023).

Figure 29, View on the greenhouses from the cycling path 1.

Figure 30, View on the greenhouses from the cycling path 2.

4. Greenhouses

The area around Huissen-Zand is characterized by the presence of greenhouses. Since the 1960, these greenhouses have been a part of the landscape. At first, the greenhouses mainly occurred on a small scale, but nowadays the production scale of the sector has increased, so the scale of the greenhouses has also grown. It is not uncommon for the greenhouses to measure 200 meters along the road. This means that the greenhouses can form an uninterrupted glass wall along the road.

However, along the Linge between the greenhouses and adjacent cycling path lies a body of water with vegetation that masks most of the greenhouse glass, which creates a vegetated experience on both sides of the Linge. This means that the contrast between the two sides is also decreased.

Figure 31, View on the business park from the cycling path.

Figure 32, View on the Linge and business park.

5. Business park

The business park in Huissen is also located next to the Linge. The cycling path next to it is bordered by a line of trees separating the buildings from the path. At some points, there is some undergrowth as well, which means the business park cannot be seen from the path, directing the cyclist's full attention towards the Linge and landscape on the other side. However, at other points the undergrowth is not present or the cycling path runs on the other side of the tree line. At these points, the experience of the cyclist shifts from agricultural landscape to manufacturing landscape and back again.

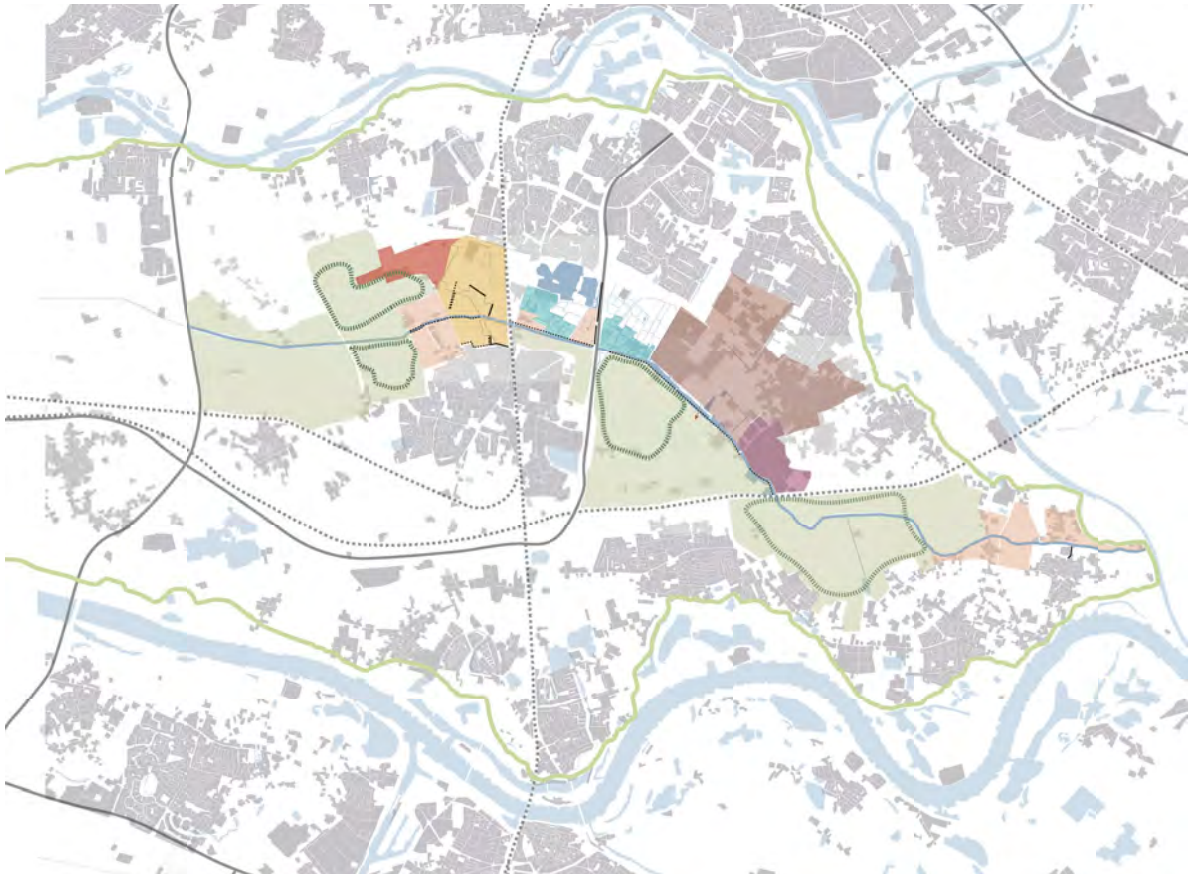
Figure 33, View on road near Doornenburg.

Figure 34, View on Doornenburg Castle.

6. Village

The only village that is directly adjacent to the Linge in the design area is Doornenburg, which lies at the beginning of the canal. The football fields and local castle Kasteel Doornenburg border the Linge, the rest of the village lies approximately 200 meters from the water. The village cannot be seen from the water, and the Linge cannot be seen from the village, because the view is blocked by a row of large trees. This can be understood as a kind of camouflage to prevent the view of the castle from the water from looking messy and chaotic.
Also, at the beginning of the Linge, it is not possible to ride alongside it. The road that follows the Linge turns towards the river dike, away from the canal.

3.4 The Linge



Analysis conclusion map

0 700 1400 2800 m

N

Legend

- Largescale agriculture
- Smallscale agriculture
- Golf course
- Mosaic landscape
- Greenhouses
- Business park
- Waterland
- Water
- Highway
- Railroad
- Dike
- Emptiness

4 PRECEDENT RESEARCH

4.1 Het Reestdal

This precedent as can be seen in figure x, shows the green structure between two villages, De Wijk and IJhorst, in the provinces of Drenthe and Overijssel. It was selected based on sixteen years of personal experience in the area.

The focus will not be on the entire Reestdal, as seen on figure x, but on an area of approximately one kilometre wide and four kilometres in length. The scale of the structure is significantly smaller than in the Stadsregio Arnhem-Nijmegen. Still, the area can offer many insights as the feel of a continuous forest can be experienced here. This precedent can provide principles relevant to designing on a smaller scale.

Image 35, Satellite image of the Reestdal.

Image 36, Satellite image of the Reestdal between de Wijk and IJhorst.

The image to the right show the area between the village De Wijk (top of the image) and the village of IJhorst (bottom of the image). This area connects the two villages through tree lanes which will be the focus of this chapter.

As mentioned before the area is part of a larger area called the Reestdal. The basic form of the area is shaped by the river Reest. This small river, categorised as a lowland stream, has largely retained the same shape for the last 800 years (Landschap Overijssel, 2023). This means the stream has room to flow freely, and has many curves and bends.

The stream and directly surrounding patches of land are called the Reestdal, or 'vale of the Reest', and are considered a nature area (Het Drentse Landschap, 2023). The Reestdal can differ in width from one hundred to six hundred metres. The Reestdal is a long line in the landscape that starts in Dedemsvaart and ends at Meppel. The length of the vale is approximately 37 kilometres long.

What is notable about this precedent is that it was not designed, it consists of elements that refer back to the traditional cultural landscape of the area. This cultural landscape arose in the nineteenth century around the river. Nowadays, the function of the area is mostly a natural recreational space.

Outside the Reestdal are areas of agricultural land and patches of forest. The shapes of these agricultural land and forest patches are based on the shape of the Reest and its bends and curves. These areas are not placed coherently but are connected by lines of trees in the landscape, which used to be wooded banks.

These tree lines were used by farmers to demarcate the border of their property (Stichting Drents Plateau & Het Oversticht, 2004). This

precedent has two types of forest patches: the estate forest and the agricultural forest. At the western edge of the village of de Wijk lies the estate Dickninghe. A part of the forest belongs to this estate. It is accessible to the public but is privately owned and maintained. The other forest patches to the east were planted for timber harvesting. This practice was abandoned in the twentieth century and the forest patches have become part of the local landscape. However, the owners of a part of the land decided to cut down many of the trees in the year 2020 without notifying the community. This worried local residents, because it caused very visible emptiness in the forest structure. After some back and forth, the land owners decided to plant fifteen hundred new trees with the help of local students (Spin, 2022).

Routing and movement

The tree lines are often accompanied by an unpaved path under or along the trees. This means that movement through the area is guided by tree structures. What stands out is that the experience relies heavily on the differentiation between open and closed. The forest patches are denser than the agricultural pastures, and the views from the paths along the tree lines stop at the following tree line. This differentiation provides a sense of scale. Also, multiple viewpoints provide a broad outlook on the landscape.

Besides traversing the paths underneath the trees it is also possible to walk Inside the forest patches, where there is the ability to wander around freely. The paths are unpaved, which makes them blend in with the forest floor. This gives the impression of truly walking around in nature. A picture from the forest can be seen in figure x.

Conclusion

The Reestdal is a landscape surrounding a natural stream with spatial remnants of the historical cultural landscape that used to be there and in part is still there.

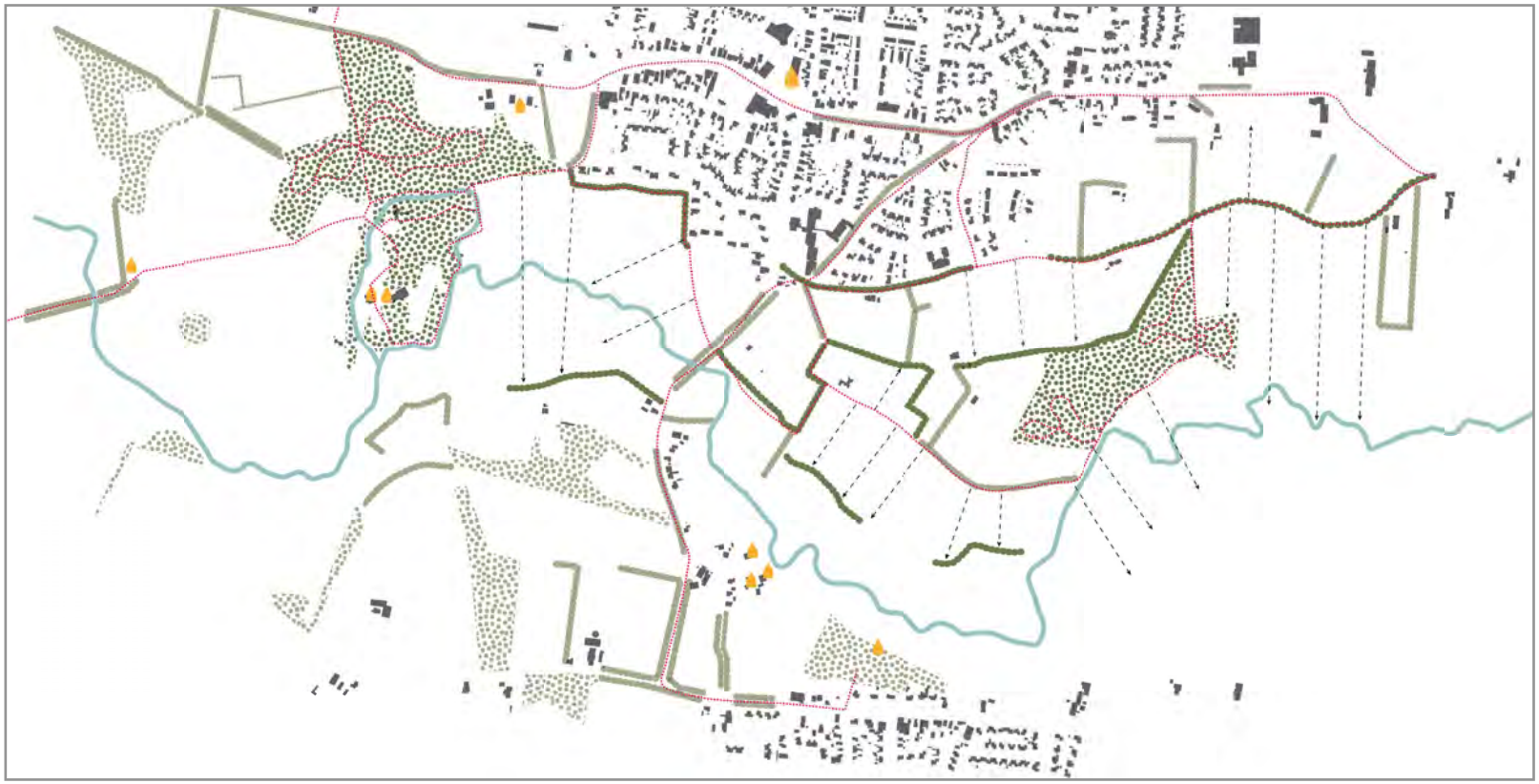
The area between the two villages de Wijk and IJhorst has a continuous forest experience which is shaped by tree lines, forest patches, and viewpoints over the stream the Reest. The variety between agricultural land and patches of forest provide the area with a pleasant scale and makes it beloved by the local population.

The transition from the residential area to the forest landscape is made in a gradual way through a two step visual transition. First, the spectator encounters a lane of trees without undergrowth, which makes the lane semi seethrough, which is then directly followed by an arcadian space that seems relatively empty. The combination of these two ingredients makes for a smooth transition from one area to the other.

Image 37, Path inside the estate forest.

Image 38, Path along a tree line.

Image 39, Path inside the planted harvesting forest.



Cognitive map of het Reestdal near de Wijk

Water
Path
Landmark
Tree canopy
Tree line
Sight line

4.2 Gorssel

Gorssel is a small village between Deventer and Zutphen in the Netherlands. It is located in close proximity to the river IJssel to the west, and to the east lies the Gorsselse Heide (or Heath of Gorssel).
The village is surrounded by many wooded areas that almost seem to infiltrate the village itself.
The wooded patches were planted in the nineteenth century as a production forest for the use of wood in the mines (Marke Gorsselse Heide, 2024).

This village is particularly interesting in terms of the transition from the urban village to the surrounding forest areas.

There is one main lane going from the village into the forest, the Joppelaan. There is also a secondary lane, the Elfuursweg. This is a smaller, unpaved road parallel to the Joppelaan.
Both lanes create a connection between the two parts that is so strong it seems as though the forest is pulled into the village as well as the other way around; the village gradually flows into the forest.
An important factor in this case is the proximity of the forest to the village on the east side. At some points, the backyard of a house directly borders the forest, and other times the forest is

Image 40, satellite image of Gorssel and surroundings.

Location of the Joppelaan and Elfuurslaan

less than a hundred meters away. This means the forest is relatively close to the village, which make it easier to create a connection.

The way the Joppelaan is laid out is with a double tree row on each side. Underneath lies a road of approximately five meters wide with cycling strips on each side (included in the five meters). The canopy of the trees form a ceiling, about seventeen meters above the road. The species used are Fagus sylvatica (Beech) for the first part of the road, from the village, and Quercus robur (Oak) is used on the second part of the road. Despite the use of two different tree species, the transition is almost unnoticeable.

Image 41, the Joppelaan in Gorssel in a heavily wooded part.

The Elfuursweg is an unpaved road of approximately three meters wide. The trees along the road are planted in a single row on each side with more space between them then on the Joppelaan.
The tree species used is Quercus robur (Oak).

Image 42, Elfuursweg in Gorssel.

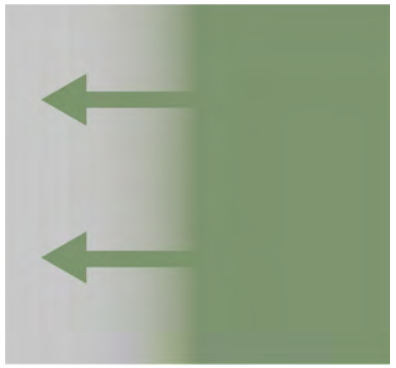
These two lanes differ from each other in experience, because of multiple factors. First of all, the Elfuursweg has a strong visible connection to the open landscape next to it. In comparison, the Joppelaan is surrounded by forest patches that are visible from the road, which makes the experience more forest-like.
Secondly, the difference in paving between the two lanes causes one lane to feel more rural

than the other.
Thirdly, the difference in tree spacing creates a more spatious feeling at the Elfuursweg compared to the Joppelaan, where the canopy of the trees are strongly interwoven as a result of their closer proximity to one another.

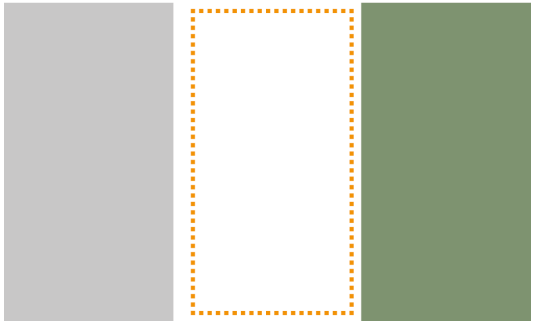
To conclude, both lanes draw the forest into the village, but accomplish this in very different manners. The experience of both lanes is vastly different, as a result of the differences described above. Nevertheless, they provide a strong connection between the forest and the village.

4.3 Conclusion

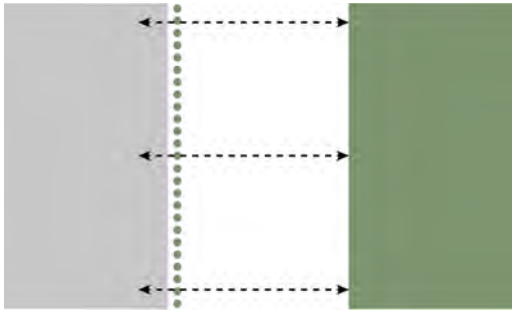
To the side, three conclusion drawings can be seen that represent the main things that were learned from these precedents.
These are the connection made from forest to urban area by using tree lanes, the arcadian empty space, and the two step transition. These findings can be used directly in the design.



Principle: connection from forest to urban



Arcadian empty space



Two step transition

5 DESIGN

5.1 Regional vision

The area around the Linge houses a number of different functions. From east to west there is a village, largescale agricultural land, a business park, greenhouses, a nature area with reedland, a park structure, and more agricultural land. At the moment, these functions do not have a clear spatial connection to each other.

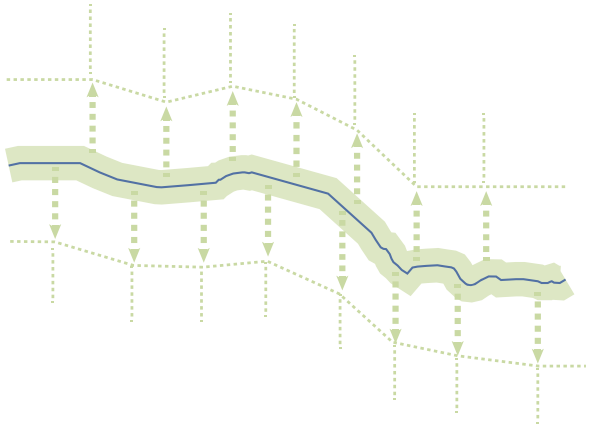
The objective is to use the Linge as a connecting element in the region supported by tree structures, which will make the Linge the backbone of a new forest zone that will provide the region with a strong green wedge that will also be the new recreational network on the regional scale. The main target group for this recreational network will be cyclists and long distance hikers. The routing will pass through the different functional zones around the Linge. The different zones will also accommodate shorter hiking routes.

Since the new green structure also needs to provide a solution to future challenges, new functions will be added to the existing context. Namely, the climate forest, which will function as a water buffer for agricultural use, the agroforest, which will improve the ecological conditions of the agricultural land, and the health forest, which has the aim to provide the inhabitants of the region with a space to benefit from the restorative properties of a natural environment.

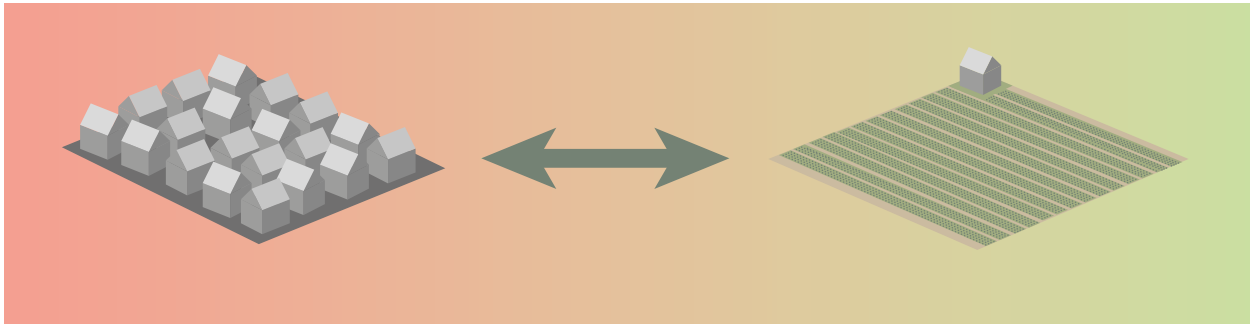
The location of these new functions is determined by different factors. The location of the climate forest is decided by the soil type, the location of the health forest is determined by the proximity to a residential area, and the agroforest will be applied in the agricultural areas around the Linge and has the potential to expand outward in the future.

To conclude, the new spatial vision for the Linge has two main objectives. Firstly to connect the existing areas around the Linge, and secondly to add new functions which will make the area more resilient to future challenges.

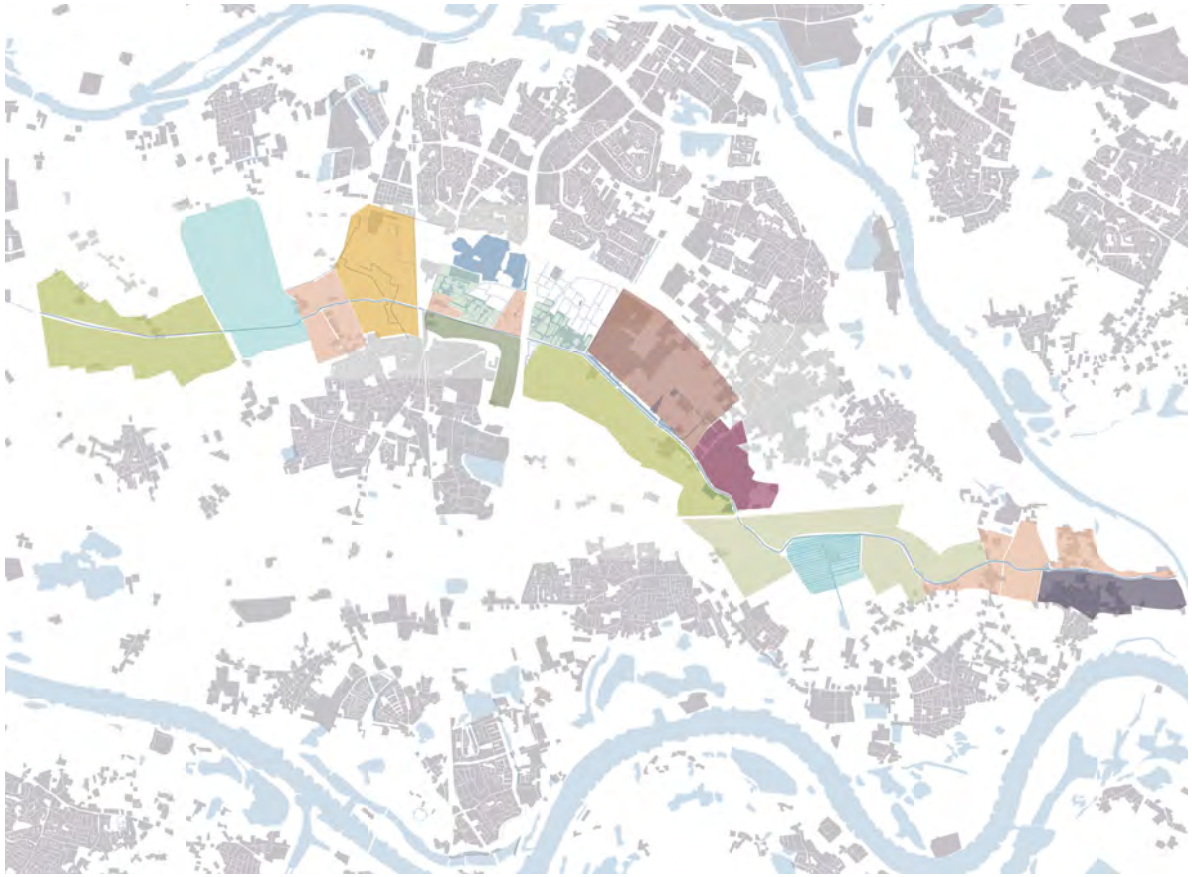
The new layout of the area around the Linge is shown in the map to the right. The newly added functions will be expanded upon in the next chapter. The design interventions to connect all of the functions to each other will be discussed in the design chapter.



Linge as backbone



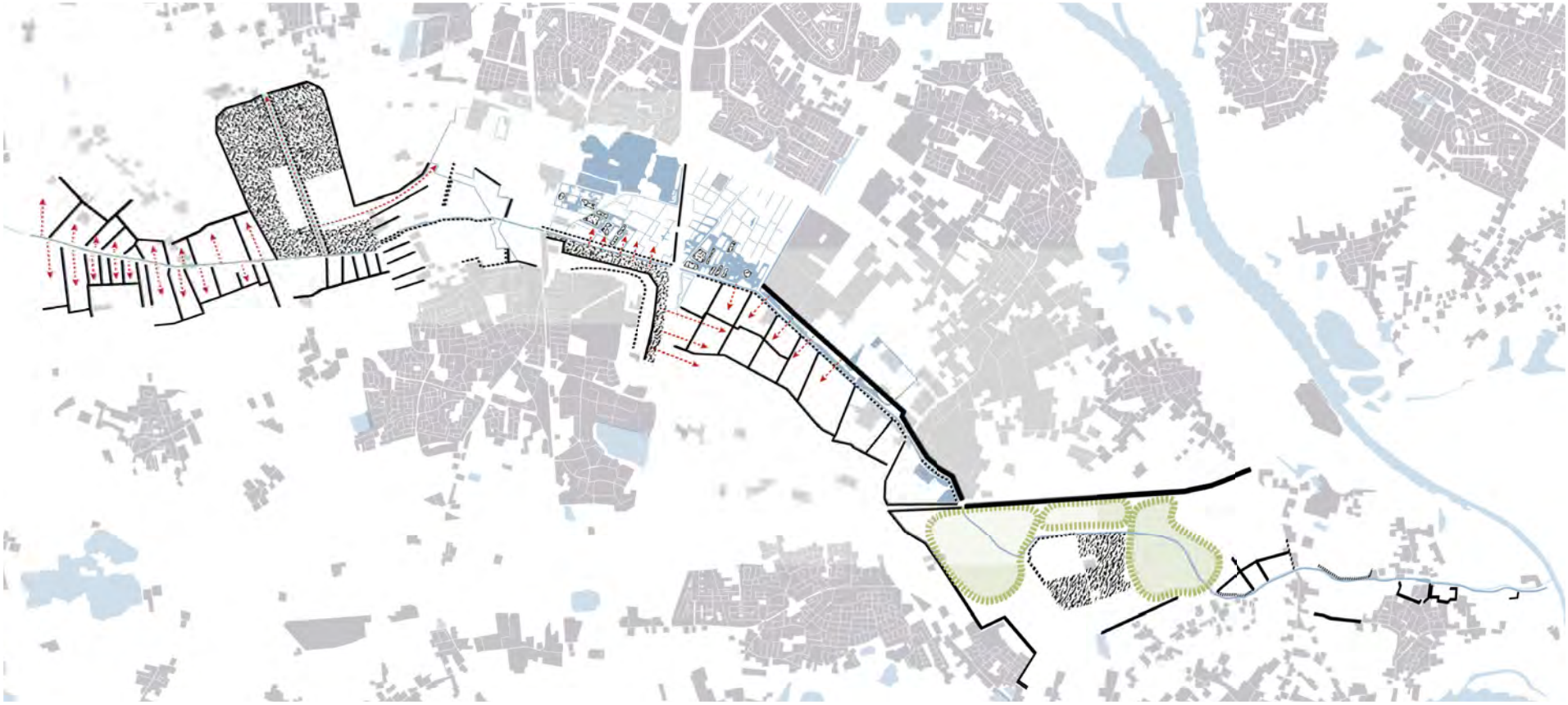
Connect the urban to the agricultural



New function layout of the area

Legend

- Agroforest
- Climate forest
- Small scale agriculture
- Mosaic
- Health forest
- Water landscape
- Greenhouses
- Business park
- Village



Spatial vision for the new Linge area

0 0 0 0 N

Legend

- Wall
- Discontinuous wall
- Sight line
- Open landscape
- Canopy ceiling

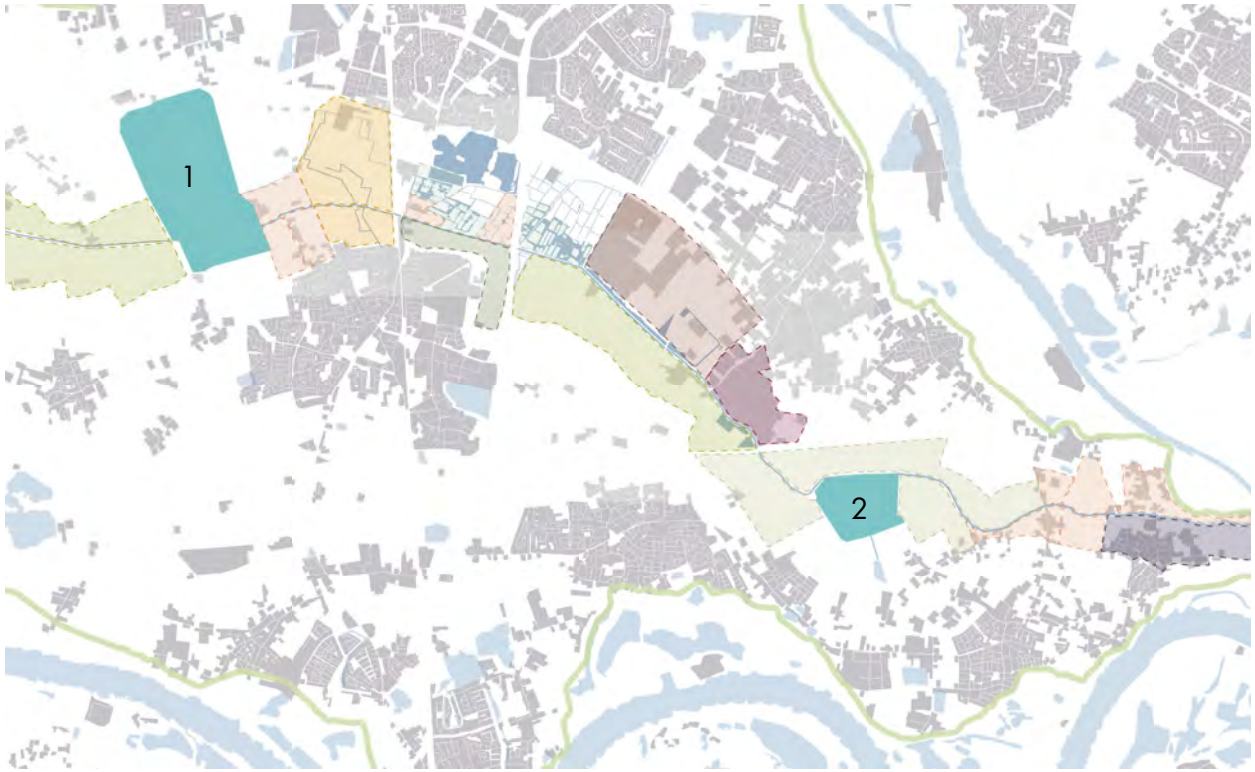
5.2 Design principles

Based on the research of the previous chapters, there are a number of principles that will lay the foundation for the design of the inter-urban green structure. These principles will be aligned with the previously identified forest types that will appear in the final structure, namely climate forest, health forest and agroforest. Some principles apply to all forest types and will fall under the general heading and be applied to the entire design.

5.2.1 Climate forest

The objective of the climate forest is to provide water storage for the agricultural sector in the four municipalities that stretch Stadsregio Arnhem-Nijmegen. At the same time, the climate forests will double as recreational areas.

The two climate forests are located in the lowest parts of the design area. Together, they can provide the municipalities of Arnhem, Nijmegen, Lingewaard, and Overbetuwe with all the water to supply the agricultural sector for a year. The amount of water that can be stored is based on the water use in the agricultural sector in these municipalities from 2019 as reported by the Central Bureau of Statistics, which was a relatively dry year (CBS, 2023). To ensure this, fifty percent of the surface area should become water. This results in water surfaces that are 1,4 meter deep. Further calculations can be found in appendix A.

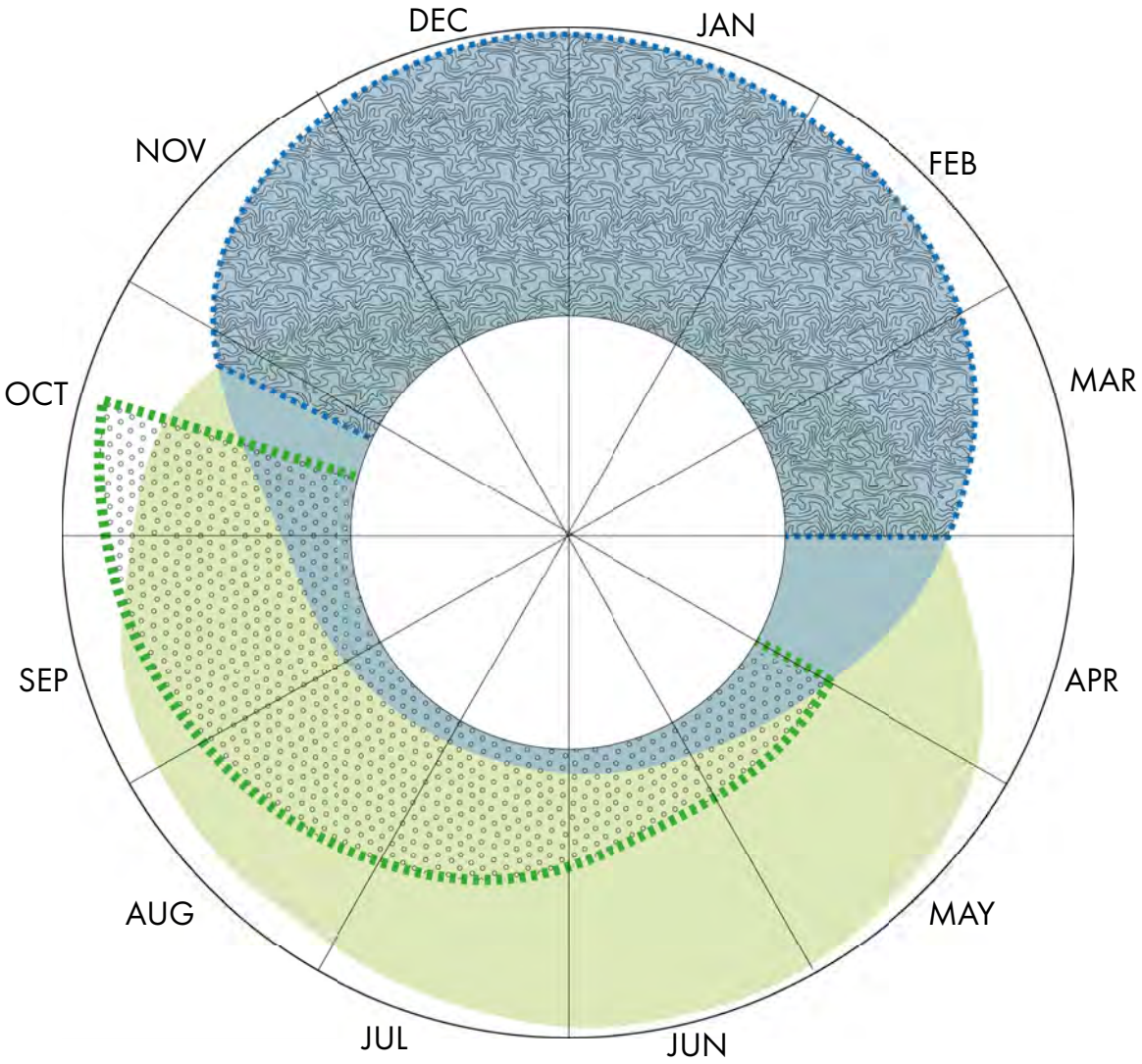


Legend

Climate forest

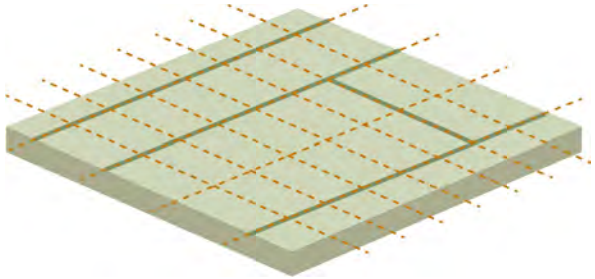
The objective is to store water during winter, when rainfall is more prevalent as a result of climate change. Also, there is less water use during this season, because there is less agricultural activity. In the following seasons, the water can be gradually used when it is needed. In the case of a dry summer, most of the water will be used

The new areas should connect to the already existing recreational areas that belong to the structure of Park Lingezegen. In the case of area 1, this means making a connection to the mosaic section of the park. Area 2 lies outside the boundaries of Park Lingezegen, which means

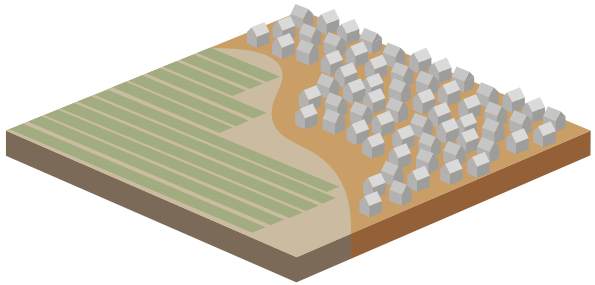


Legend

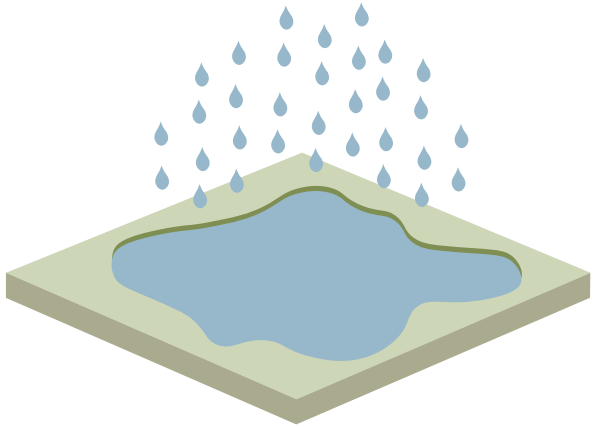
- Heavy rainfall period
- Crop growth period
- Water collection
- Water use



Grid based on underlying plot structure



Position of functions based on underlying soil type



Water storage

5.2.2 Health forest

The health forest is a type of recreational area, specifically focused on mental restoration and relaxation. The main part of the health forest is located to the north of Elst, connecting to Waterrijk of Park Lingezegen.

The main design principles that will be represented in this design are based on the literature research and precedent studies. These principles are: the feeling of getting away, sufficient extent, and a visual transition from home to forest. Also, the highway A325 is part of this section of the design. As concluded in the analysis chapter, the highway is a major obstacle and divides the design area into two pieces. This needs to be resolved by overcoming the highway.

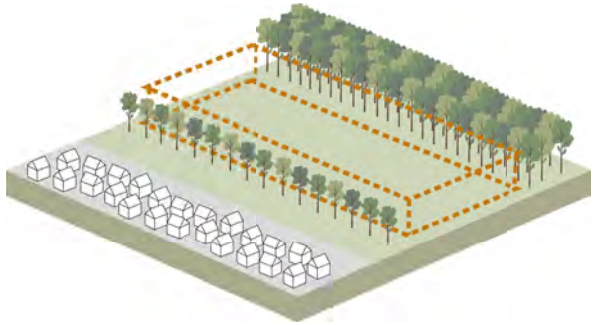
It is meant to provide a place for local residents to take a short walk of approximately thirty minutes to an hour.

As mentioned in the research chapter, there are two main principles for a successful restorative environment. These are the feeling of being away, and extent, which describes the amount of stimulation that the brain finds pleasing. In short, there needs to be a middle ground between too much stimulation and too few. In terms of forestry we can compare these with a jungle, which has dense and highly varied vegetation, or an open field, where there is hardly any vegetation. The best restorative forest will lie somewhere in the middle of those two ends of the spectrum.
As far as the feeling of being away can be described in spatial terms, it is clear that a transition will need to be created from an urban area to the forested area. Also, the contrast between the experience of the two environments needs to be high.

The paths inside the forest body will not be straight, to emphasize the feeling of being away and wandering inside the forest. An additional effect of this design principle is the everchanging point of view. This gives the spectator a different perspective at different points during their walk. This contributes to the extent that the area needs to sufficiently function as a place for mental restoration according to Kaplan & Kaplan's (1987) description.

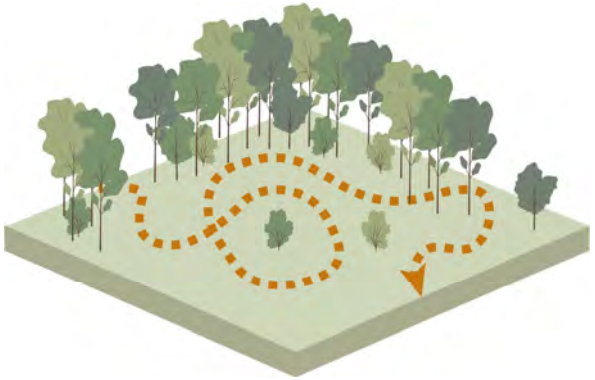
The health forest itself will have some similarities to a box. It will have a floor, walls, and a ceiling. This will create the feeling of an secluded environment, away from the rest of the world. The walls will consist of wooded banks to block the view from inside out as well as outside in. The floor of the forest is composed of vegetation in the moss and herbaceous layer up to approximately hip length. This means that people from a young age on can have an overview of the inside of the forest. The combination of these planting patterns creates a forest that has enough extent, but not too much. This ensures that the restorative properties which the health forest is meant to have can occur.
The ceiling of the box will be shaped by the canopy of the trees. The species of trees that will be used will have a canopy density that lets light through, so the forest does not feel dark and uninviting.

The transition of the edge of the urban area to the forest needs to strengthen the feeling of the forest being 'away' from the regular world. This will be done in three ways. First of all, by planting a row of trees on the edge of the urban area, it signifies the border between the two worlds. Secondly, a lane should lead a path into the 'forest box'. This is based on the Gorssel precedent where a tree lane draws the forest into the village and the other way around. In this case however, it is meant to draw the forest up to the previously described edge. Thirdly, between the row of trees at the edge of the urban area and the forest box, there should be a large empty space. This will strengthen the visual transition from the urban area to the forest. This also occur in the Reestdal precedent. The visual transition happens in two steps, namely the view of the spectator first falls on the tree line, and only afterwards on the forest behind it.

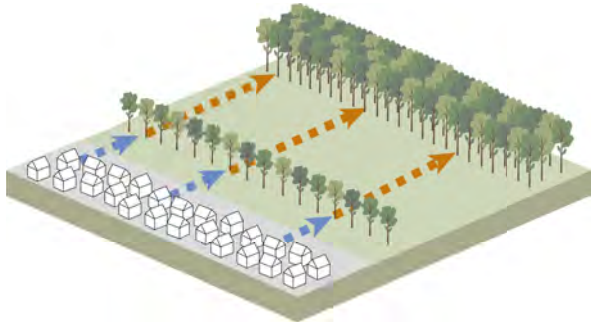


Arcadian emptiness

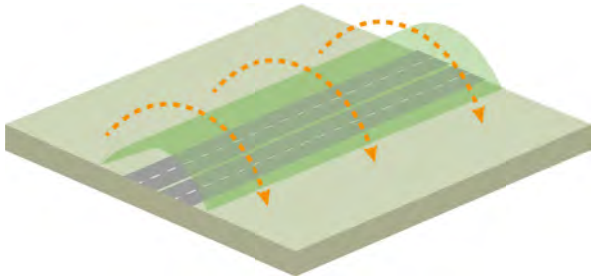
Being away



Wandering around



Two-step sightlines



Bridging the highway

5.2.3 The Agroforest

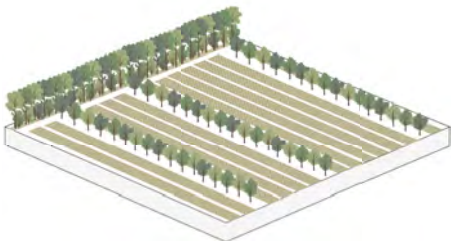
The main spatial objective of the agroforest is to continue the forest experience from the climate forest and health forest into the agricultural part of the design area. However, in contrast to the two other forest types, there is no new function introduced. This also means that the changes to the existing landscape are not as radical as in the two aforementioned forests.
However, the agroforest is indeed intended as a tool to strengthen the spatial connection of the whole design area. To accomplish this goal, the agroforest should function as one structure.

The other goal of the agroforest is to improve the biodiversity of the agricultural landscape. As mentioned in Selin-Noren (2022), trees have the ability to create microclimates that allow various plant species to thrive, and as a result making the area attractive to insects and birds.
This microclimate can also result in better crop yield from arable farming.

Since the function and use of the land are for the most part dependent on the choice of a farmer, there is no clear design that can be made without any consultation with the farmers. They should be involved in the process that could lead to a definitive design.
Additionally, as mentioned in the research chapter, the benefits of agroforestry in the Dutch context are assumed, but not yet quantitively proven. These two factors result in the decision to not present a definitive design for the agroforest, but to present a proposal that can be adjusted accordingly.

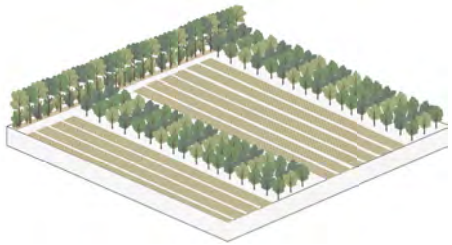
As mentioned at the beginning of this page, the agroforest is also meant to support the climate forest and health forest. This will be done by continuing the forest structure along the existing borders of the agricultural plots by planting wooded banks on these borders. Since all borders connect to each other, the wooded banks will also. Within these borders, more trees can be planted in a configuration fitting with the type of agriculture practiced on the land.
This combination of wooded banks on the borders of a plot and trees creates a sequence of chamberlike spaces that together form the structure which weaves the agroforest, the climate forest, and the health forest together.
However, these so-called chambers should be open towards the main roads and paths to make the agroforestry visible and incorporate these spaces into the recreational network.

This proposal uses four different tree configurations for the agroforest. The placement of these different configurations is based on the function of the underlying plot. This information comes from the Copernicus Urban Atlas (2018). The different types of configurations are shown and discussed in the images to the side.



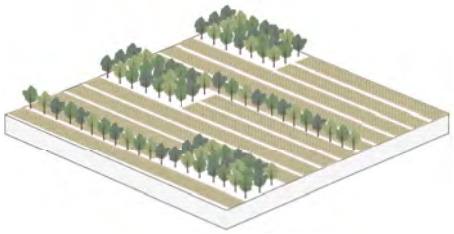
1. Single rows

The single rows are suitable for plots with arable crops. It is likely that the farmer in question uses heavy machinery to work on the land. In this specific case, the trees are best planted in rows, since they will then minimally interfere with the most efficient driving route. Single rows of trees are best suited on plots that are relatively small, since they take up the least amount of space.



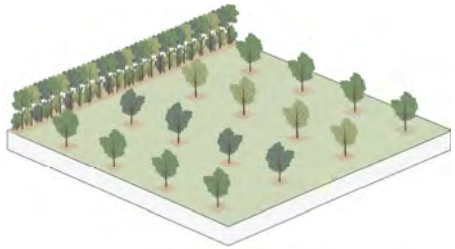
2. Double rows

The double rows are suited for the same type of agriculture as the single rows. The difference between the two configurations is the fact that double tree rows likely provide a better microclimate for biodiversity increase and possibly better crop yield. Also, double tree rows are better suited for larger plots than single tree rows are.



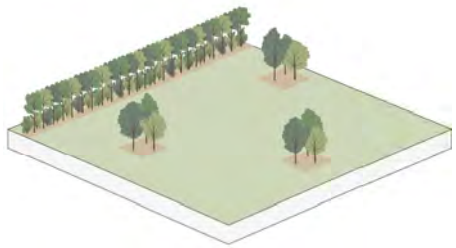
3. Volumes

This type of configuration can be implemented in both arable crop farming and livestock farming. The volume of trees acts as a small forest patch, which means that



4. Single trees

The single tree configuration is best suited for plots where livestock farming is practiced. When the animals are outside on the plot, they can find shelter in times of rainfall or bright sun. Because the trees are planted as single trees, there is a possibility of shelter on all sides.



5. Groups of trees

The groups of trees are suited for livestock agricultural plots for the same reason as the single trees. However, similar to the double rowed configuration, there is more space for development of a beneficial microclimate.

5.3 THE DESIGN

5.3.1. Linge design

Legend

- Agricultural land
- Forest
- Water
- Buildings

N

5.3.2. New bicycle routing

New bicycle routing

N

Legend

- Bicycle routes
- Dike
- Forest
- Water
- Urban area

5.4.1. The health forest

As mentioned before, the health forest will be located around Elst, making a connection to the Linge at the same time. In the design principles chapter, the observations from the literature study on the correlation between natural environments and mental health, and the precedent studies can be translated into the design. This is what has been done here.

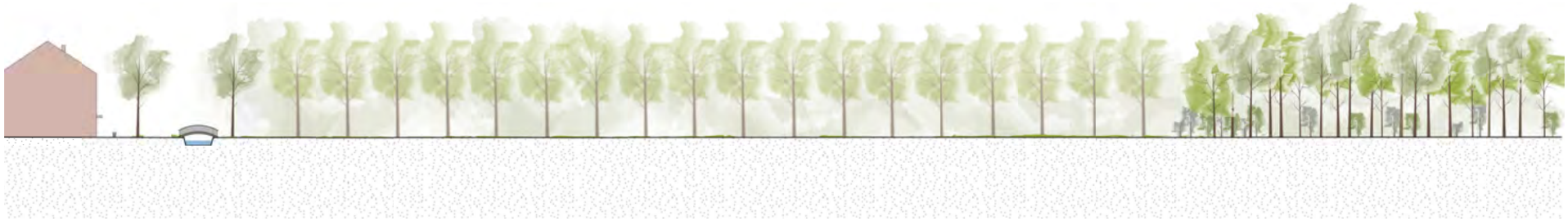
A tree lane goes from the neighbourhood to the forest, connecting the two as seen in the Gorssel precedent. The entrance paths to the forest connect to the existing street pattern in the adjoining neighbourhood. Inside the forest, the vegetation should provide the visitor with sufficient extent to allow for a restorative experience.

When the health forest touches the Linge, there is an interesting transition from the forest to the water landscape across the Linge and the street. As a result of the introduction of the forest, the open experience of the water landscape becomes more pronounced, because the surrounding areas are not as open as itself.

Furthermore, the A325 highway that caused fragmentation in the area has been bridged by putting an ecoduct in place. The health forest will transition slowly into the ecoduct which will provide the visitor with a view over the adjacent agroforest, connecting the two forests by means of sight. The additional benefit of the viaduct is that the height difference can cause a visitor to experience an enhanced feeling of being away, which is one of the main goals of the health forest itself.

The Health Forest

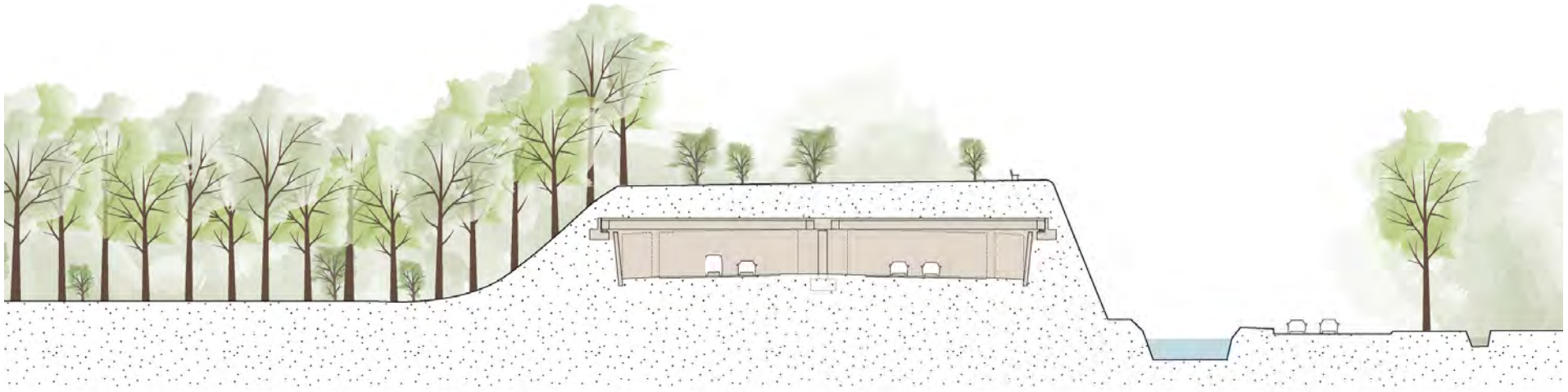
5.4.2. The health forest: sections



SectionA

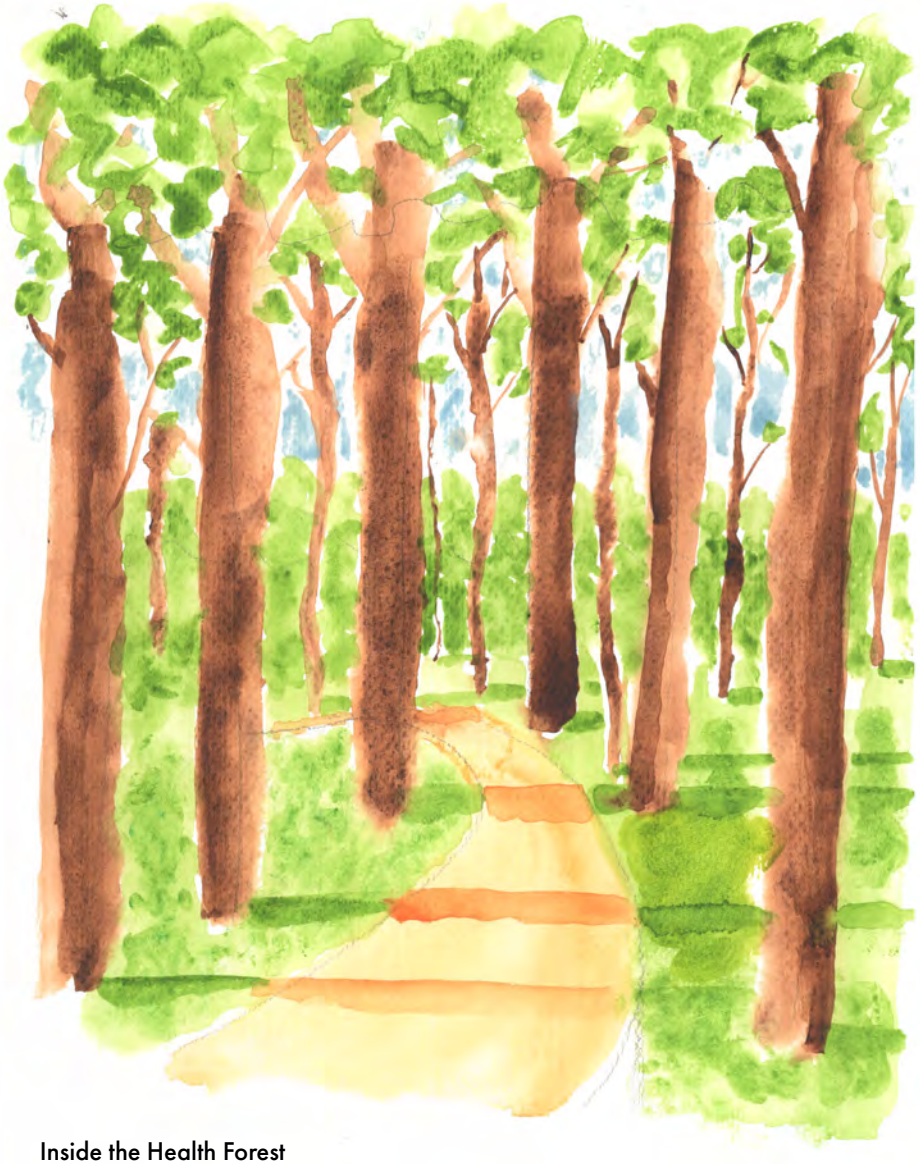
Section B

5.4.3. The health forest: sections

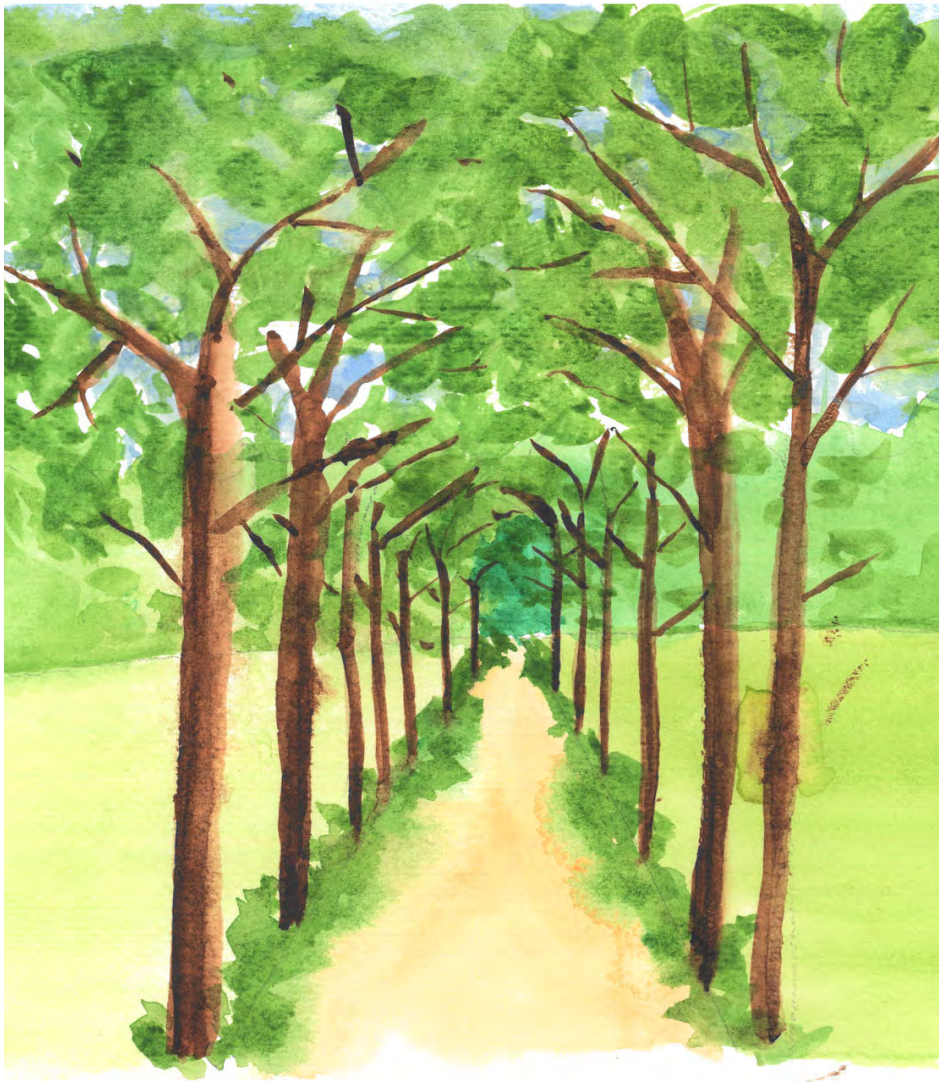


Section C

5.4.4. The health forest: impressions



Inside the Health Forest



The tree lane from the village to the forest

View across the Linge with the health forest on the left and the water landscape of Park Lingezegen on the right

5.5.1. The climate forest

The climate forest is located to the northwest of Elst. It is located along the Linge, providing the area with a sufficient supply and drainage canal. Besides the Linge, to the north the area is also connected to the Eldensche Zeeg, another drainage canal. From the Linge the main axis can be followed to enter the climate forest. The forest is also connected to the mosaic landscape that is part of Park Lingezegen. This is done through a second axis that is perpendicular to the main axis. This second axis leads to a clearing, acting as an ending to the parts of Park Lingezegen that were not enclosed as their own entities.

Climate forest design

5.5.2. The climate forest routing

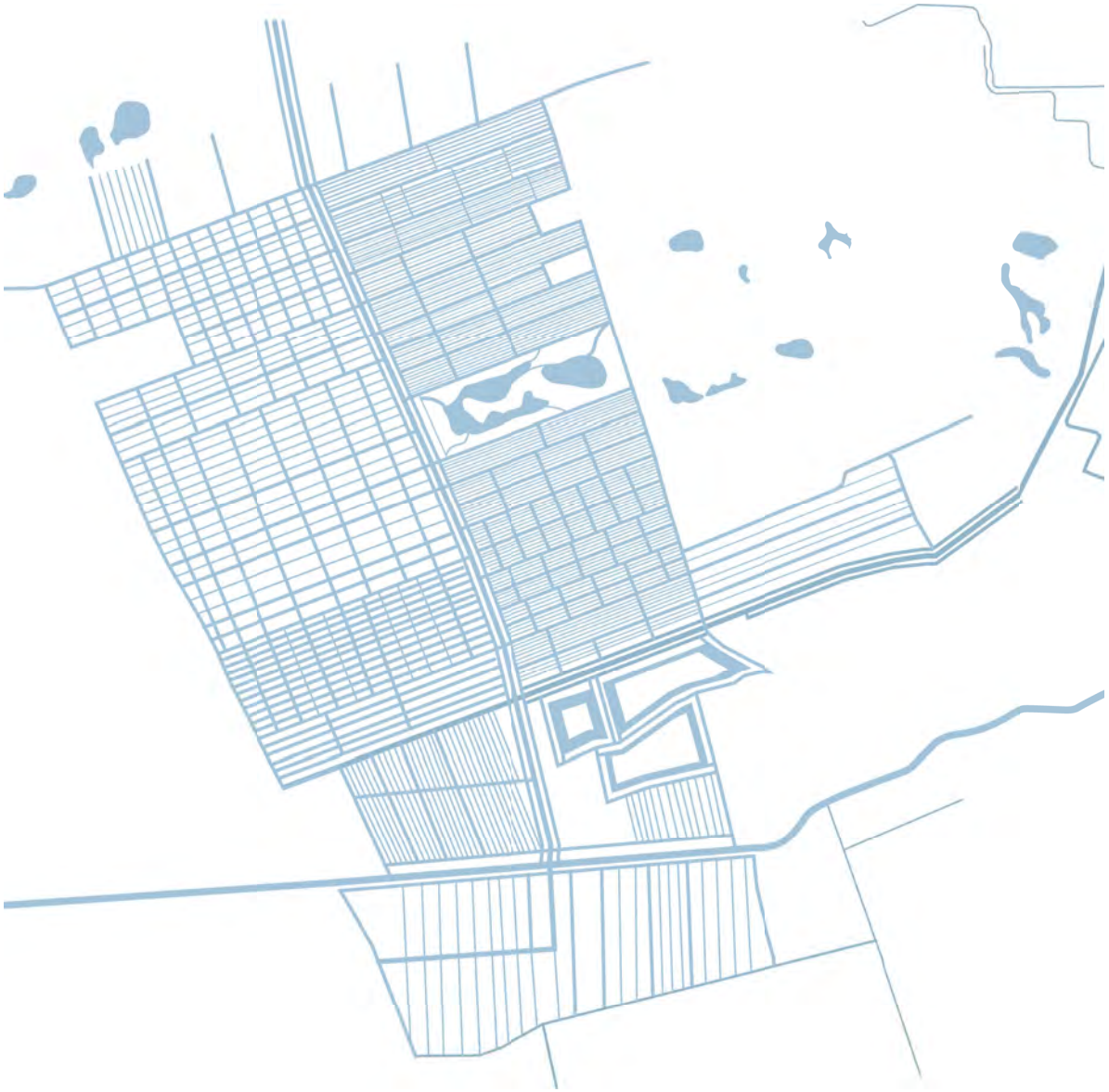
The routing of the climate forest is defined by the main axis. From this axis, access is provided into the forested parts of the design.
All of the walking paths will be executed as wooden floorboards, raised above the surface level of the climate forest. This is done to ensure dry feet for the visitors to the area. This can be seen in sections on page 78.

Routing in the climate forest

5.5.3. The climate forest: water pattern

The area should have a fifty percent water coverage, which should be reached by the introduction of new ditches. The old pattern of the agricultural pastures is used to define the patterns of the ditches. On one side of the main axis, the pattern is more rectangular, and on the other side the pattern follows a strip pattern. There are two exceptions to this principle, that both occur on the right side of the axis. One instance is the old golf course, which layout is exaggerated to create a small picturesque garden. The other instance happens near the Linge, where islands are created surrounded by a moat based on the shape of the existing pastures.

From the main axis through the middle, a horizontal axis makes a connection between the climate forest and the mosaic landscape. This ensures that the new forest landscape is not only connected by the Linge, but also more widespread across the landscape. This connection is made by emphasizing an existing ditch, making it wider and adding a guiding tree line.



Water pattern

N

5.5.4.The climate forest: water system

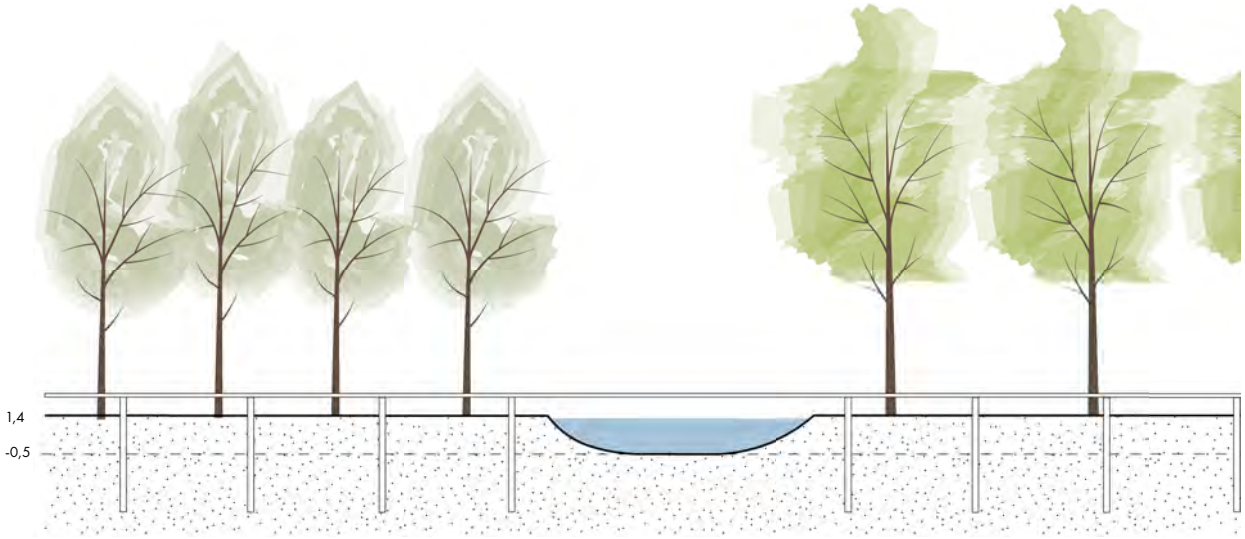
The climate forest demands a new water system. The objective of the forest is to provide the farmers in the four bordering municipalities with enough water to use for crop growth during a dry year. This means that water will be collected, but it should not drain from the area before the farmers have a chance to use it. The solution to this issue is to introduce a closed water system that uses pumps to regulate the flux of water into and from the climate forest. Around the two sections lays a small dike that closes the parts off from the surrounding water bodies. Since the area is divided into two separate sections, and is connected to two drainage canals, the two sections divided by the main axis will both have two pumps that regulate the water levels.

The choice of the location of the climate forests is based on their relative height in the landscape. This means the water will naturally flow towards these locations. However, these locations have challenges when it comes to water buffering. As a result of their low lying location, the groundwater levels are higher, which means that the capacity for water storage is only as large as the difference between the surface level and the groundwater level. In the case of both locations, this is only 0,5 meters. The calculations in appendix A state that in a case of 50% water coverage of the climate forest area, a depth of 1,4 meters is needed to reach the sufficient amount of water.

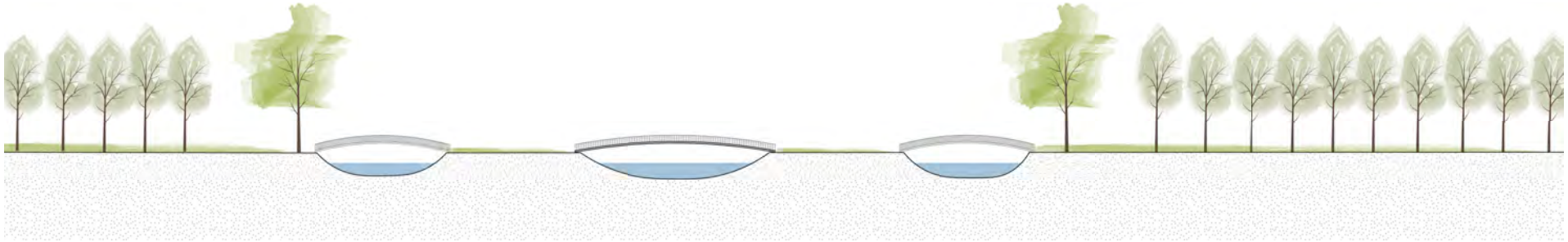
Water system climate forest

5.5.6. The climate forest: sections

The solution to this problem is to increase the height of the area to 1,4 meters above the groundwater level, so the water storage will be sufficient for agricultural use. Since the groundwater level in the location of the climate forest is 0,5 meters below the surface level, 0,9 meters of soil should be added to the existing land. This soil can partly be sourced from the digging of the new ditches, reusing the soil on the same land it came from.
This solution does result in a difference in water level between the climate forest and the surrounding water bodies. This difference can be seen in section X.



Section D



Section E

5.5.5. The climate forest: tree species

As mentioned before, the species used in the climate forest are based on the ash-elm forest. These species can be seen in the legend below the map.

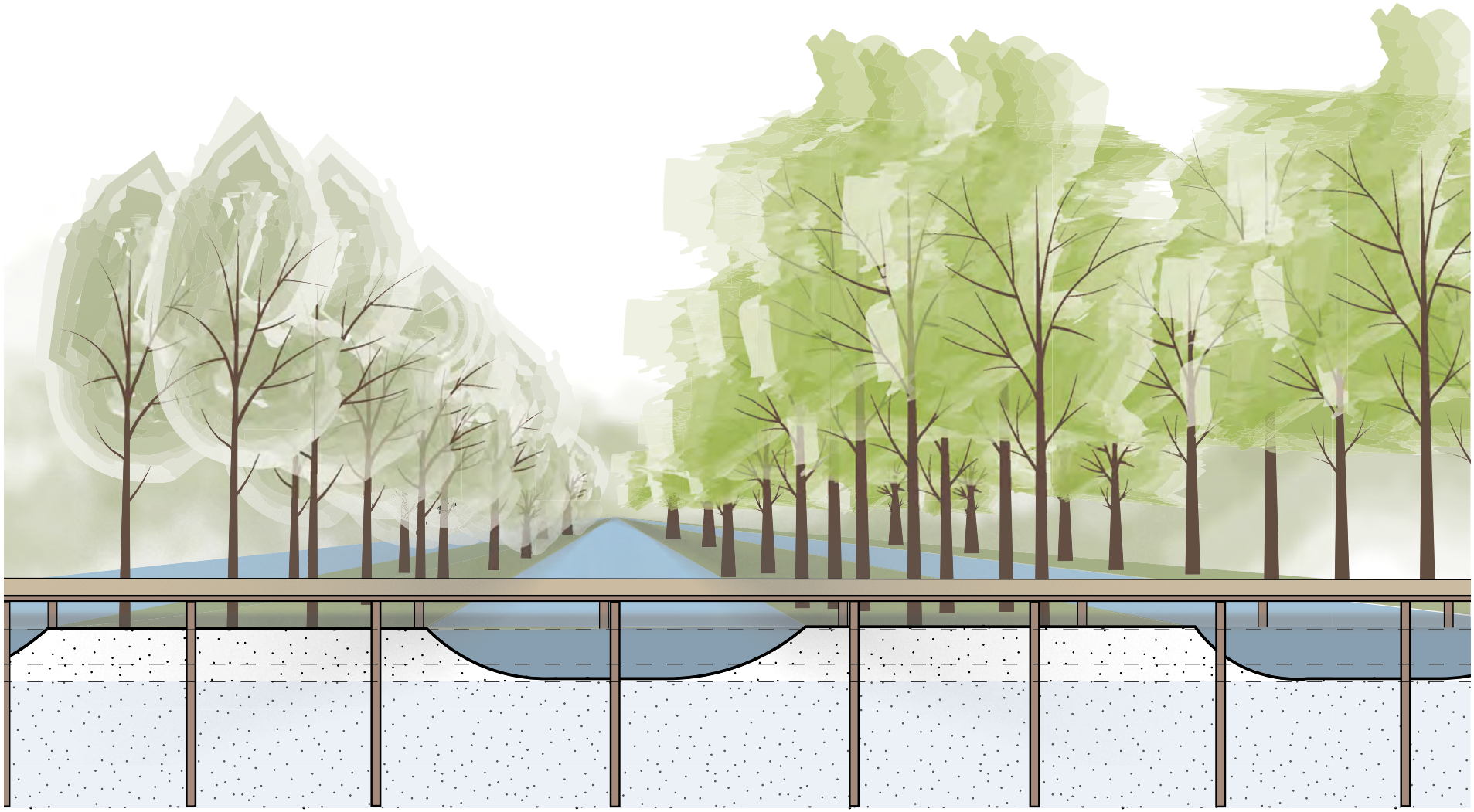
Tree species

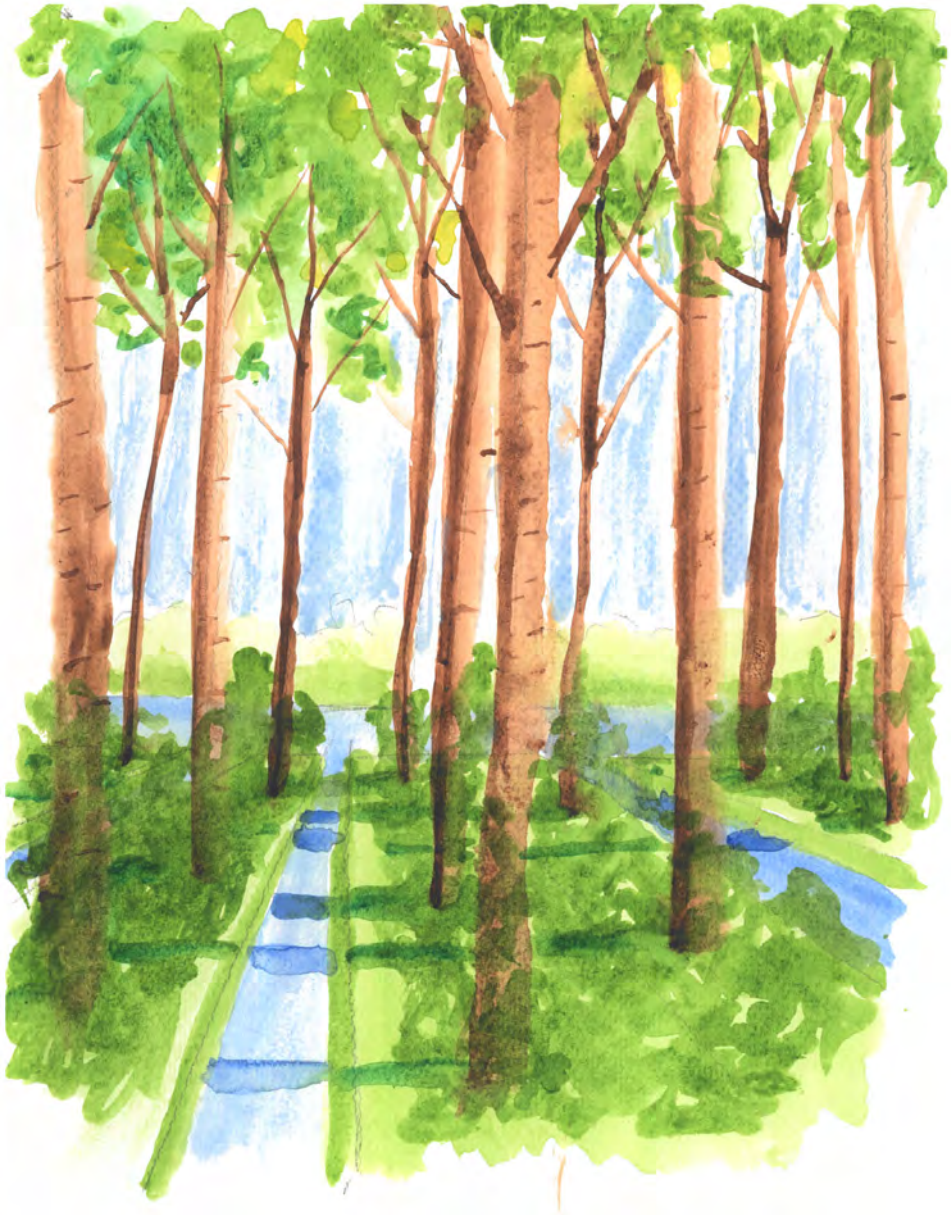
N

Legend

- Acer pseudoplatanus
- Quercus robur
- Fraxinus excelsior
- Ulmus minor
- Fagus salvatica
- Aesculus hippocastanum
- Alnus glutinosa
- Salix alba
- Populus × canadensis

5.5.7. The climate forest: impressions

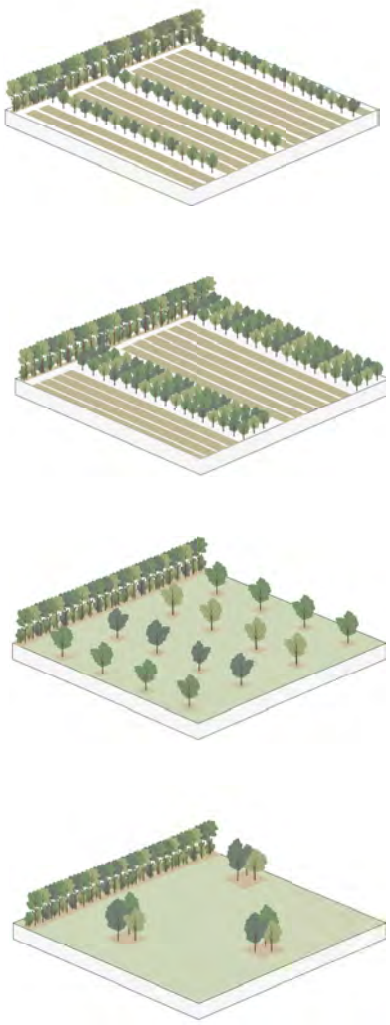


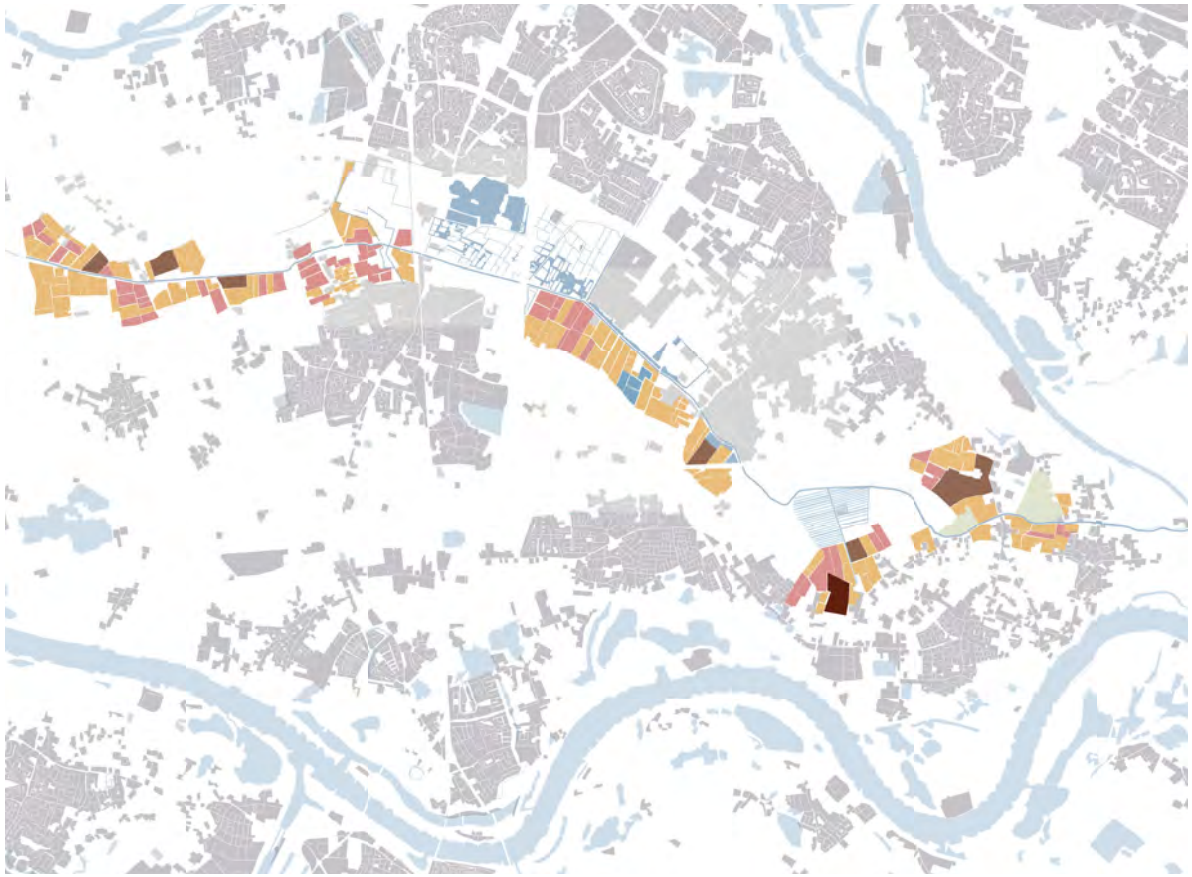


Inside the climate forest

The picturesque garden part of the climate forest

5.6.1. The agroforest: forest types





Forest types

N

Legend

- Single trees
- Single rows
- Groups of trees
- Double rows
- Orchards

6 CONCLUSION

6.1 Conclusion

"How can forestry be used to create an interurban green structure in the Stadsregio Arnhem-Nijmegen to structure the existing polycentric metropolitan landscape, while simultaneously providing a solution to future climate and ecological challenges and improve the health and well-being of the inhabitants?"

The answer to this question as presented in this thesis, lies in acknowledging the multiple functions that a largescale forest can have. In the case of Stadsregio Arnhem-Nijmegen the three main functions of the newly designed structure will be agriculture, water buffering, and recreation for health purposes. For these specific functions, forest typologies have been designed to meet the specific needs that these functions require.

The agroforest is a structure that uses agriculture and trees to enhance the forest experience of the area. The agroforest serves multiple advantages over regular agriculture, because it makes use of the ecosystem services a tree can provide. These include soil improvement, shading, decreasing wind speeds, and cooling the air through evapotranspiration. Besides these ecosystem services the agroforest is also a great enabler for a more biodiverse and futureproof way of farming. Due to the great number of natural systems at work in a agroforest it is more of a concept that a set in stone design. The vegetation and the spatial configuration that supports the agriculture is dependent on many factors, most importantly the needs of the farmer.

The climate forest is designed to provide water storage for surrounding agriculture. During the winter, water will be stored here, which can be used for agricultural purposes when it is needed. At the same time, the area will be a recreational space where the relationship between forest and water can be experienced. As a result of climate change, there will likely be longer periods of drought during the summer months, which means a forest like this will be an invaluable resource for farmers.

The health forest is designed based on the Attention Restoration Theory by Kaplan & Kaplan (1987). This forest will be located close to urban areas, so residents can benefit from the restorative properties that a forest can provide. In this forest, they can feel as though they have left Stadsregio Arnhem-Nijmegen while remaining close to their homes.

To establish a comprehensive interurban green structure comprised of the above-mentioned elements, the existing landscape elements have been examined to provide a starting point for the new design. In the case of Stadsregio Arnhem-Nijmegen, the Linge is a landscape element that has the ability to connect the whole area, because it is the main drainage canal. Through the many ditches in the Overbetuwe polder the Linge is connected to everything in the polder, and can thus be seen as the backbone of the interurban area between Arnhem and Nijmegen. Because of the many different forest typologies that will be visible from along the Linge, it will also serve as a showcase of what is possible with the use of trees and their implementation in different kinds of forests.

To conclude, because of the lack of coherent greenery the area between Arnhem and Nijmegen feels as patchwork of loose elements. The area provides the ability to recreate but certainly not to its full potential, farmers cannot farm in a future-proof manner and residents cannot escape the city life in a satisfactory way. Through redeveloping this area and using the Linge as the backbone combined with the usage of different types of forests, an

area can be created that can fulfil all needs. By addressing the limiting elements in the landscape, like the A325, and highlighting the connecting elements, like the Linge, the structure is connected throughout the whole design area. The interurban area between Arnhem and Nijmegen will become an area where the forest is central and where all stakeholders can find their place.

7 REFERENCES

REFERENCE LIST

Bruinsma, F. R., & Koomen, E. (2018). Ruimtelijke ordening in Nederland. Vrije Universiteit Amsterdam.

Centraal Bureau voor de Statistiek [CBS]. (2023, November 30). Landbouw; gewassen, dieren en grondgebruik naar gemeente. CBS Statline. Retrieved December 6, 2023, from https://opendata.cbs.nl/#/CBS/nl/dataset/80781ned/table

Cornelis, J., Hermy, M., De Keersmaeker, L., & Vandekerkhove, K. (2007). Bosplantengemeenschappen in Vlaanderen : een typologie van bossen op basis van de kruidachtige vegetatie. In www.vlaanderen.be. Instituur Natuur en Bosonderzoek (INBO). Retrieved May 19, 2024, from https://www.vlaanderen.be/publicaties/bosplantengemeenschappen-in-vlaanderen-een-typologie-van-bossen-op-basis-van-de-kruidachtige-vegetatie

De Gelderlander. (2023, January 13). Linge treedt buiten oevers door overvloedige regen, water op kade in Geldermalsen. Retrieved September 26, 2023, from https://www.gelderlander.nl/west-betuwe/linge-treedt-buiten-oevers-door-overvloedige-regen-water-op-kade-in-geldermalsen~a788a8bf/?referrer=https%3A%2F%2Fwww.google.com%2F&cb=4f030f45d3eb783fdc6df0328d85aae5&auth_rd=1

De Klerk, L., & Van Der Wouden, R. (2021). Ruimtelijke ordening. Geschiedenis van de stedelijke en regionale planning in Nederland, 1200-2020 (1st ed.). nai010.

De Oliveira, F. L. (2020). Green Wedge Urbanism: History, Theory and Contemporary Practice (Paperback). Bloomsbury Visual Arts.

Deltares. (2024, January 9). Terugblik hoogwaterpiek kerstvakantie 2023-2024. Deltares. https://www.deltares.nl/nieuws/terugkijken-op-hoogwaterpiek-kerstvakantie-2023-2024

Den Hartog, F., Kruize, H., Van den Hout, K., Brombacher, N., Gootzen, A., & De Jongh, D. (2022). Kennisbundeling Groen en GezondheidInleiding. RIVM.

Etzold, S., Ferretti, M., Reinds, G., Solberg, S., Geßler, A., Waldner, P., Schaub, M., Simpson, D., Benham, S., Hansen, K., Ingerslev, M., Jonard, M., Karlsson, P. E., Lindroos, A. J., Marchetto, A., Manninger, M., Meesenburg, H., Merilä, P., Nöjd, P., . . . De Vries, W. (2020). Nitrogen deposition is the most important environmental driver of growth of pure, even-aged and managed European forests. Forest Ecology and Management, 458, 117762. https://doi.org/10.1016/j.foreco.2019.117762

European Environment Agency [EEA]. (2023, April 26). How pesticides impact human health and ecosystems in Europe. European Environment Agency. Retrieved December 4, 2023, from https://www.eea.europa.eu/publications/how-pesticides-impact-human-health

Gemeente Delft. (n.d.). Delft Oost (Delftse Hout): 9.2 Cultuurhistorie. Retrieved September 27, 2023, from https://www.planviewer.nl/imro/files/NL.IMRO.0503.BP0007-2002/t_NL.IMRO.0503.BP0007-2002_9.2.html

Heller, A. (2023, September 20). A15 pas op z'n vroegst verlengd in 2029, en moet er überhaupt nog tol betaald worden? Algemeen Dagblad. Retrieved December 1, 2023, from https://www.ad.nl/zevenaar/a15-pas-op-zn-vroegst-verlengd-in-2029-en-moet-er-uberhaupt-nog-tol-betaald-worden~aa26def78/

IPCC. (2021, August 9). Climate change widespread, rapid, and intensifying. Retrieved September 26, 2023, from https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/

Kaplan, R. & Kaplan, S. (1989). The experience of nature: a psychological perspective. Cambridge University Press. https://archive.org/details/experienceofnatu00kapl/page/6/mode/2up?view=theater

Kaplan, S. (1995). The restorative benefits of nature: toward an integrative framework. Journal of Environmental Psychology, 15(3), 169-182. https://doi.org/10.1016/0272-4944(95)90001-2

Klimaateffectatlas. (n.d.). Kaartviewer - Klimaateffectatlas. Retrieved September 26, 2023, from https://www.klimaateffectatlas.nl/nl/

KNMI (2021). KNMI Klimaatsignaal'21: hoe het klimaat in Nederland snel verandert. KNMI, De Bilt, 72 pp. https://cdn.knmi.nl/knmi/asc/klimaatsignaal21/KNMI_Klimaatsignaal21.pdf

Marke Gorsselse Heide. (2023b, March 31). Over de marke - Gorsselse Heide. Gorsselse Heide. Retrieved May 21, 2024, from https://markegorsselseheide.nl/over-de-marke/#geschiedenis

Middendorp, H. (2020, May 10). Het water stijgt! Evacuatie uit het rivierengebied in 1995 - Boek: Niet Bang Voor Water. Niet Bang Voor Water. https://nietbangvoorwater.info/evacuatie-rivierengebied/

Ministerie van Infrastructuur en Waterstaat. (2023a, May 30). Ruimte voor de rivieren. Rijkswaterstaat. https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/ruimte-voor-de-rivieren

Ministerie van Infrastructuur en Waterstaat. (2023b, September 7). Amsterdam-Rijnkanaal - informatie en waterdata. Rijkswaterstaat. Retrieved September 25, 2023, from https://www.rijkswaterstaat.nl/water/vaarwegenoverzicht/amsterdam-rijnkanaal

Ministerie van Landbouw, Natuur en Voedselkwaliteit. (2020). Bos voor de Toekomst. Rijksoverheid. https://open.overheid.nl/repository/ronl-d6ac7db2-0d36-45b0-9507-f76638a48c0d/1/pdf/Bos%20voor%20de%20toekomst_Uitwerking%20ambities%20en%20doelen%20landelijke%20Bossenstrategie%20en%20beleidsagenda%202030.pdf

NOS. (2015, December 3). Ontruiming bij wateroverlast in 1995 [Video]. NOS. Retrieved September 26, 2023, from https://nos.nl/video/2072008-ontruiming-bij-wateroverlast-in-1995

NOS. (2022, November 6). Dit zijn de gevolgen voor Nederland als de zee 2 of 5 meter stijgt. NOS. https://nos.nl/nieuwsuur/collectie/13917/artikel/2451244-dit-zijn-de-gevolgen-voor-nederland-als-de-zee-2-of-5-meter-stijgt

Provincie Gelderland. (2020). Uitvoeringsprogramma Bomen en Bos. https://media.gelderland.nl/Uitvoeringsprogramma_Bomen_en_Bos_vastegesteld_15_dec_2020_d6c1740ce6.PDF
Provincie Gelderland. (2020). Uitvoeringsprogramma Bomen en Bos.

Reijers, O., Buijs, B., Van Hellemondt, M., Kruiger, J., Ritz, R., Stichting Drents Plateau, & Het Oversticht. (2004). Van Sober naar Rijk: Visie op de gebouwde omgeving in het Reestdal (1st ed.). https://epos.staphorst.nl/van-sober-naar-rijk-visie-op-de-gebouwde-omgeving-in-het-reestdal

Reith, J. (2023, August 22). In het Waterrijk in Park Lingezegen staat nauwelijks water. Hoe kan dat? De Gelderlander. Retrieved May 9, 2024, from https://www.gelderlander.nl/lingewaard/in-het-waterrijk-in-park-lingezegen-staat-nauwelijks-water-hoe-kan-dat~a5ab618d/

Rijksoverheid. (1986). Vierde nota over de ruimtelijke ordening.

RIVM. (n.d.). Gezondheidsklachten door hitte. Retrieved May 21, 2024, from https://www.rivm.nl/hitte/gezondheidsklachten-door-hitte#:~:text=Mensen%20die%20tot%20een%20kwetsbare,goed%20op%20elkaar%20te%20letten

Russell, J. C. (1972). Medieval Sourcebook: Tables on Population in Medieval Europe. Fordham University. Retrieved May 21, 2024, from https://sourcebooks.fordham.edu/source/pop-in-eur.asp

Selin-Norén, I. (2022). Factsheet 9 - Hoe kan agroforestry bijdragen aan klimaatadaptatie van de landbouw? Wageningen University and Research.

Selin-Norén (2022). Factsheet 7 – Designing agroforestry systems: Tree planting patterns. Wageningen University and Research.

Spin, B. (2022, December 10). Vijftienhonderd bomen geplant in Dunninger Bos. De Wijk.info. Retrieved May 21, 2024, from https://www.dewijk.info/2022/12/vijftienhonderd-bomen-geplant-in-dunninger-bos/

Staatsbosbeheer Gelderland - Feiten en cijfers. (n.d.). Staatsbosbeheer. https://www.staatsbosbeheer.nl/over-staatsbosbeheer/feiten-en-cijfers/gelderland#:~:text=In%20Gelderland%20planten%20we%20500,compenseren%20we%20in%20eigen%20terreinen.

Stuurgroep Samenwerkende Netwerken Regio Rivierenland. (2020). Rivierengebied Klimaatbestendig Samen aan de slag!: Regionale Adaptatie Strategie Rivierenland. Retrieved September 26, 2023, from https://klimaatadaptatienederland.nl/publish/pages/198497/ras-rivierengebied-klimaatbestendig-samen-aan-de-slag.pdf

Tietema, A., Barmentlo, H., Van Loon, E., Bol, R., Ebben, B., Tulp, T., Tromp, M., Schwennen, C., Maas, J., & Averkamp, J. (2023). Nitrogen deposition around dairy farms: spatial and temporal patterns. Universiteit van Amsterdam.

Tyrvaïnen et al. (2014). The influence of urban green environments on stress relief measures: A field experiment. Journal of Environmental Psychology (38) 1-9.

Ulrich, R. S. (1979). Visual landscapes and psychological wellbeing. Landscape Research 4 (1) : 17-23. https://www.researchgate.net/publication/277953355_Ulrich_1979_Visual_landscapes_psych_well-being

United Nations. (2018, May 16). 68% of the world population projected to live in urban areas by 2050, says UN | UN DESA | United Nations Department of Economic and Social Affairs. Retrieved September 27, 2023, from https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

Van Den Born, R. J. (2008). Rethinking Nature: Public visions in the Netherlands. Environmental Values, 17(1), 83–109. https://doi.org/10.3197/096327108x271969

Van der Kaa, R. (2021). De onderwereld van de tuin: Van microbe tot mol (3rd ed.) [Gedrukt boek]. Atlas Contact.

Van Der Meer, R. W. (2021). Watergebruik in de land- en tuinbouw 2019. In Wageningen University and Research (No. 552247). Wageningen University and Research. Retrieved December 6, 2023, from https://wur.on.worldcat.org/search/detail/1265532013?queryString=552247&clusterResults=false&groupVariantRecords=true

Van Der Meer, R. W. (2023). Watergebruik in de land- en tuinbouw, 2021: Berekeningen op basis van het Bedrijveninformatienet. In Wageningen University and Research (No. 630351). Wageningen University and Research. Retrieved December 6, 2023, from https://wur.on.worldcat.org/search/detail/1391416419?queryString=630351&clusterResults=false&groupVariantRecords=true

Van Os, J., & Mentink. (1985). Over-Betuwe : geschiedenis van een polderland (1327-1977) (1st ed.) [Printed book]. De Walburg Pers Zutphen.

Van Steenbergen, G. (2022). Regionale gebiedsontwikkeling: De invloed van de provincie op ruimtelijke planning in tussenstedelijke gebieden.

Wageningen University and Research [WUR]. (2023, May 12). Watergebruik door de land- en tuinbouw daalt fors in nat 2021. Agrimatie - Informatie Over De Agrosector. Retrieved December 6, 2023, from https://agrimatie.nl/ThemaResultaat.aspx?subpubID=2232&themaID=2288#:~:text=In%202021%20bedroeg%20het%20gemiddelde,de%20jaren%20heen%20vrij%20constant

Waterschap Rivierenland. (2023, July 18). De Linge krijgt een nieuw gemaal. Waterschap Rivierenland. Retrieved September 26, 2023, from https://www.waterschaprivierenland.nl/de-linge-krijgt-een-nieuw-gemaal

IMAGE REFERENCES

Chapter 1

1. Satellite image of De Wijk and surroundings. Retrieved from PDOK Luchtfoto 8mm (2023).

2. Satellite image of Delft and surroundings. Retrieved from PDOK Luchtfoto 8mm (2023).

3. Satellite image of the Betuwe. Retrieved from PDOK Luchtfoto 8mm, 2023.

Chapter 2

4. Picture of a natural environment used by Ulrich in his research. Retrieved from Ulrich, R. S. (1979). Visual landscapes and psychological wellbeing. Landscape Research 4 (1) : 17-23. https://www.researchgate.net/publication/277953355_Ulrich_1979_Visual_landscapes_psych_well-being

5. Picture of an urban environment used by Ulrich in his research.Retrieved from Ulrich, R. S. (1979). Visual landscapes and psychological wellbeing. Landscape Research 4 (1) : 17-23. https://www.researchgate.net/publication/277953355_Ulrich_1979_Visual_landscapes_psych_well-being

6. Image from Kaplan & Kaplan (1987) illustrating an environment where there are too many stimuli. Retrieved from Kaplan, R. & Kaplan, S. (1989). The experience of nature: a psychological perspective. Cambridge University Press. https://archive.org/details/experienceofnatu00kapl/page/6/mode/2up?view=theater

7. Image from Kaplan & Kaplan (1987) illustrating an environment where there are too few stimuli. Retrieved from Kaplan, R. & Kaplan, S. (1989). The experience of nature: a psychological perspective. Cambridge University Press. https://archive.org/details/experienceofnatu00kapl/page/6/mode/2up?view=theater

8. Image from Kaplan & Kaplan (1987) illustrating an environment where the extent for restorative purposes is sufficient. Retrieved from Kaplan, R. & Kaplan, S. (1989). The experience of nature: a psychological perspective. Cambridge University Press. https://archive.org/details/experienceofnatu00kapl/page/6/mode/2up?view=theater

9. Army soldiers helping people evacuate, retrieved from Https://nietbangvoorwater.info/evacuatie-rivierengebied/ (10-6-2024).

10. Image x, bridal couple in Nijmegen during high water, retrieved from Https://www.gld.nl/nieuws/2435486/bruidspaar-op-laarzen-in-de-waal-haalt-internationale-tv-in-1995 (10-6-2024).

11. Flooding scenario once every 100 years, Klimaateffectatlas. Retrieved from https://www.klimaateffectatlas.nl?config=84dc5fa9-ebc0-426d-88de-389530f51db2&divisionId=YWFMLMWERURF&gm-x=183005.5289288761&gm-y=436717.2327169585&gm-z=6&gm-b=1600876569061,true,1;1640186538247,true,1 (10-6-2024)

12. Crop gain and loss in case of agroforestry implementation, from Selin-Norén (2022).

Chapter 3

13. The Roman Limes. Retrieved from https://www.canonvannederland.nl/nl/romeinselimes (30-5-2024).

14. Map of Arnhem from 1649. Retrieved from https://www.historischekaart.nl/steden/oude-kaart-arnhem-kopen.html (11-6-2024).

15. Elst in 1966. Retrieved from https://marithaime.nl/topografische-ontwikkeling/topografische-ontwikkeling-van-elst-deel-6-1966/ (11-6-2024).

16. Map of Elst 1966. Retrieved from https://marithaime.nl/topografische-ontwikkeling/topografische-ontwikkeling-van-elst-deel-6-1966/ (11-6-2024).

17. Integratiekaart Vierde Nota, from Rijksoverheid (1987).
Vierde Nota Ruimtelijke Ordening, p. 145.
Retrieved from https://repository.overheid.nl/frbr/sgd/19871988/0000104863/1/pdf/SGD_19871988_0006940.pdf (11-6-2024).

18. Nieuwbouwwoningen aan het stratenmakersveste in Schuytgraaf - buurt Vestingstad. Retrieved from

https://www.geldersarchief.nl/bronnen/foto-s-en-films?mivast=37&mizig=284&miadt=37&miview=gal&milang=nl&misort=unitdate%7Casc&mistart=75&mizk_alle=Schuytgraaf (11-6-2024).

19. Urbanisation arenas based on plans from the Vierde Nota Ruimtelijke Ordening. Retrieved from van Steenbergen (2022). Regionale gebiedsontwikkeling : De invloed van de provincie op ruimtelijke planning in tussenstedelijke gebieden. (fig 5.36, p.227)

20. Parts of Park Lingezegen. Retrieved from https://www.gelderlander.nl/lingewaard/er-komt-meer-en-strenger-toezicht-in-park-lingezegen~abc80d75/152650917/

21. Groene Metropoolregio. Retrieved from https://www.gmr.nl/over-ons/(11-6-2024).

22. View on the greenhouses from the cycling path 1, own image (2024).

23. View on the greenhouses from the cycling path 2, own image (2024).

24. View on an open pasture 1, own image (2024).

25. View on an open pasture 2, own image (2024).

26. View on an open pasture 3, own image (2024).

27. View on the water landscape from the cycling path, own image (2024).

28. View on the Linge from the cycling path bordering the water landscape, own image (2024).

29. View on road near Doornenburg, own image (2024).

30. View on Doornenburg Castle, own image (2024).

31. View on the Linge, own image (2024).

32. View on orchard, own image (2024).

33. View on the business park from the cycling path, own image (2024).

34.View on the Linge and business park, own image (2024).

Chapter 4

35. Satellite image of the Reestdal. Retrieved from Google Earth, https://earth.google.com/eb/@52.64860404,6.33970985,4.23198007a,13091.64857267d,57.56623563y,24.69786767h,0t,0r/data=OgMKATA (11-6-2024).

36. Satellite image of the Reestdal between de Wijk and IJhorst. Retrieved from PDOK Luchtfoto 8mm (2024).

37. Path inside the estate forest, own image (2023).

38. Path along a tree line, own image (2023).

39. Path inside the planted harvesting forest. Retrieved from https://www.wegvanwandelen.nl/weg-van-de-wijk-11-km/(11-6-2024).

40. satellite image of Gorssel and surroundings. Retrieved from PDOK Lucthfoto 8mm (2024).

41. the Joppelaan in Gorssel in a heavily wooded part. https://svwmakelaars.nl/joppelaan-57a-gorssel/ (11-6-2024).

42. Elfuursweg in Gorssel. Retrieved from Google Earth (n.d.). https://earth.google.com/eb/@52.20797434,6.21500499,11.50003883a,0d,60y,248.59874784h,84.2287574t,0r/waWpsT2M3dWUzckFtY0xvbVhra0EQAjoDCgEw (11-6-2024).

Appendix A: Calculation of climate forest storage capacities

The quantity of water that will have to be buffered for agricultural use is based on calculations made with data from Centraal Bureau voor de Statistiek and Wageningen University and Research. The purpose of these calculations is to determine how much surface area of current land will need to be converted into water, and how deep this water needs to be. The ambition is to realize the total water requirement for all agricultural companies in the area.

The average water consumption per company in 2021 was 2400 m3, of which 800 m3 was tap water (van der Meer, 2023). 2021 is considered a relatively wet year, so the question that arises is what the average consumption per company was in a dry year. A recent dry year was 2019, and the total water use that year in the Netherlands in the agricultural sector was 297 million cubic meters (van der Meer, 2021). This number will be used as a base number for a dry year.
In 2019, the Netherlands had 53,233 agricultural companies (CBS, 2023). This means that the average water use per company in 2019 is: 297,000,000 / 53,233 = approximately 5600 m3 per farm. This is more than twice as much water as in a wet year.

In 2022, the municipalities of Arnhem, Nijmegen, Overbetuwe and Lingewaard together had 409 agricultural companies (CBS, 2023). This means that in a dry year a total volume of water is required of:
5600 · 409 = 2,290,400 m3.

To calculate how deep the water needs to be, the total volume of water required is divided by the number of square meters that the designated area covers. The total number of square meters is:

Area 1 = 2,086,066 m2
Area 2 = 1,039,571 m2

2,086,066 + 1,039,571 = 3,125,337 m2

To consider different design options, several percentages of total water surface were considered, namely 50%, 70% and 100%.

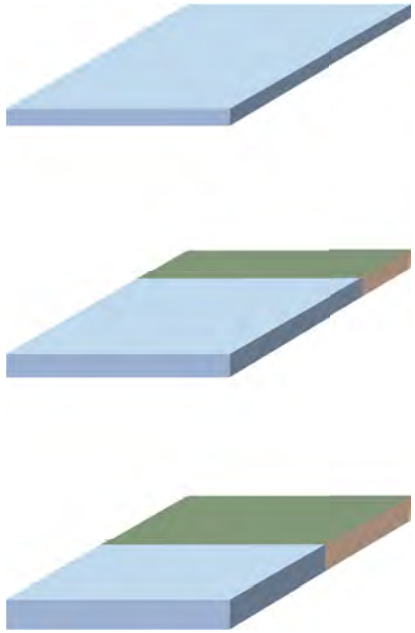
The formula used to calculate the depth of the water at a certain coverage percentage is:
(totaal benodigd aantal kubieke meters water)/(totaal oppervlak ×percentage in decimaal)=-diepte van het water

This produces the following depths:
2.290.400/(3.125.337 ×1)= 0,7 meter bij een dekkingspercentage van 100%

2.290.400/(3.125.337 ×0,7)=1,04 meter bij een dekkingspercentage van 70%

2.290.400/(3.125.337 ×0,5)=1,4 meter bij een dekkingspercentage van 50%

These depths are all reasonable and realistic, which is why a coverage percentage of 50% is chosen, as this has the least effect on the landscape.



Appendix B: Precedent Delftse Hout

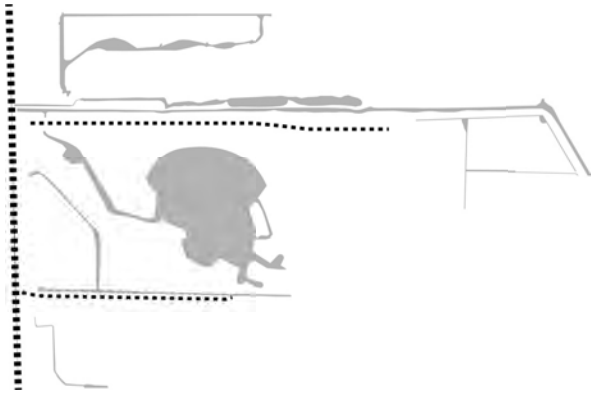
The Delftse Hout is a recreational area meant for the leisure of the inhabitants of Delft. It is situated next to the city, wedged between other residential areas, like Delfgauw and Ypenburg. It is separated from the urban fabric of Delft by the highway A13. This precedent was selected based on its design philosophy, which is heavily influenced by modernist ideas of spatial arrangements based on function. In addition, the selection of the precedent is also based on personal experience in the area.

HISTORY

The recreational area started to take shape in the 1960s. Before this time it used to be a rural area with agricultural functions, a few farms, and windmills (Gemeente Delft, 2023). In 1921, it was decided that the municipality of Delft would merge with the surrounding municipalities to make room to expand the city. In the expansion plan made by the new municipality a new city park on the location of the current park was included. This was meant to be a landscape park with open and more vegetated areas, with water and meandering paths in between. However, the design for this park was only partly executed, mainly to provide inhabitants with work during the Great Depression of the 1930s (Gemeente Delft, 2023). This included the Hertenkamp which is still part of the current layout.

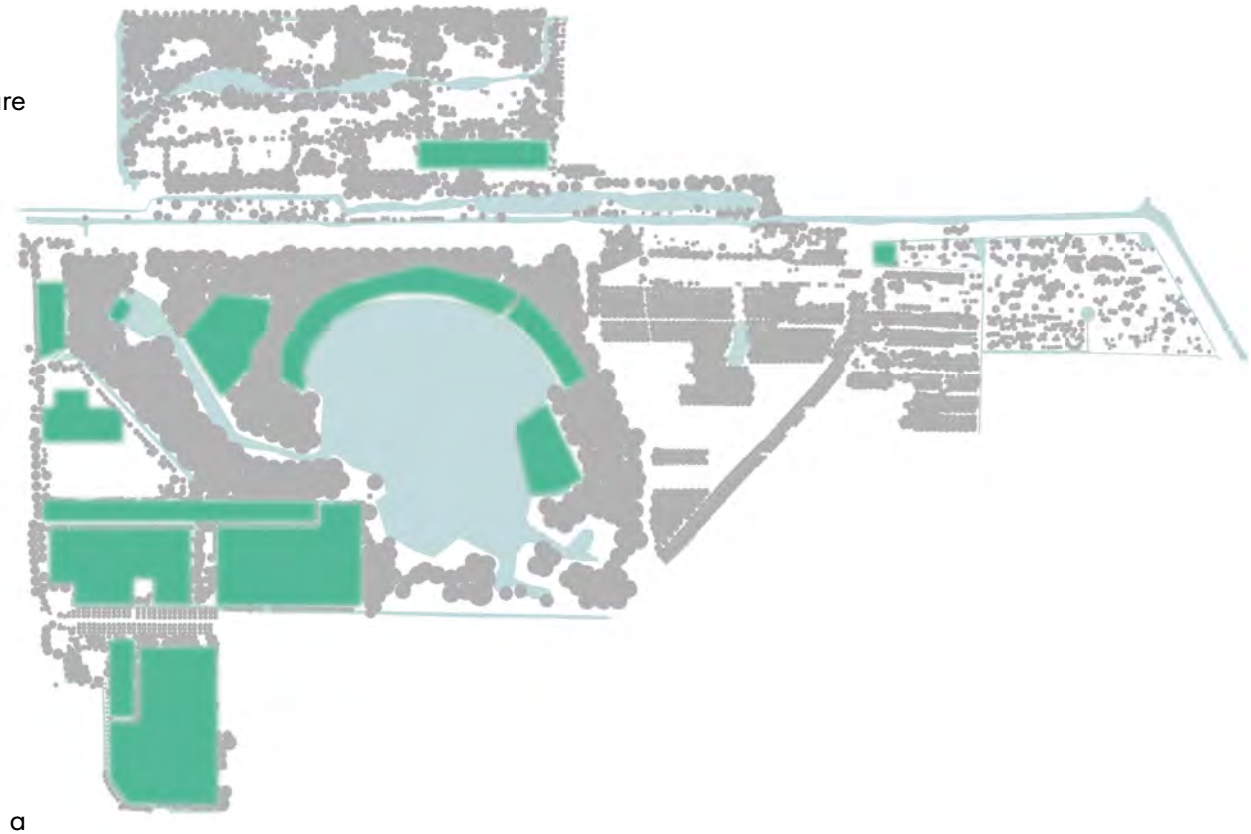
After the Second World War in 1965, new plans were made for the area and it was decided that the area would be expanded and create a "multifunctional activities park" (Gemeente Delft, 2023). Sand excavations for new neighbourhoods in the surroundings created the body of water referred to as the lake, around which the functions were laid out. This included a beach, playing fields, a public pool, a petting zoo, and an arboretum. At a later time, a cemetery and allotment gardens were also included in the plan for the area. After the pool's closing in 1989, a camping ground was opened which is still there today.

The basic form of Delftse Hout consists of the A13 highway on the left, the Tweemolentjeskade and Korftlaan highways, and the landscaped water features.



In the map below the functions in the current design are laid out.

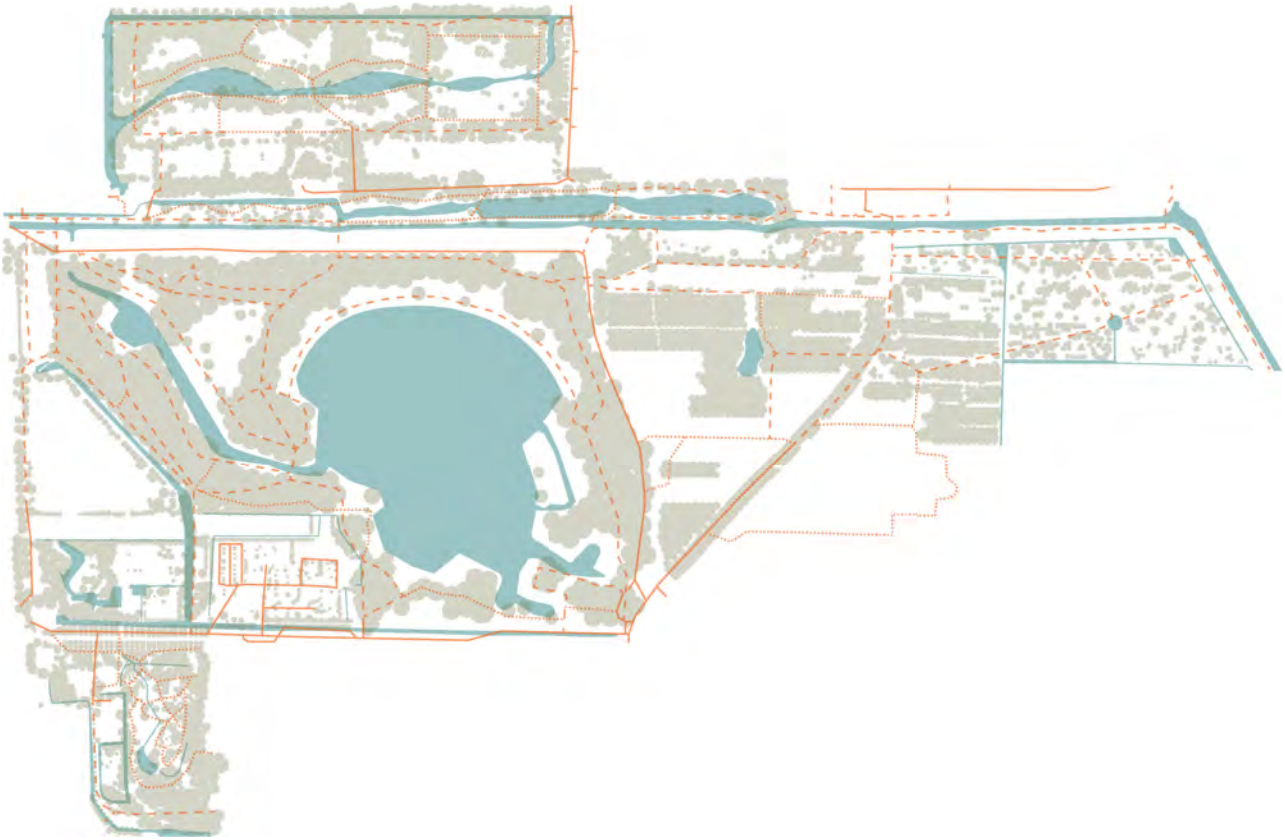
1. Arboretum and native garden (heemtuin)
2. Sustainability Centre de Papaver
3. Camping and vacation park Delftse Hout
4. City farm BuytenDelft
5. Allotment gardens ATV Biesland
6. Korfball fields
7. Playing and barbecue field
8. Beach
9. Nudist beach
10. Watersports clubhouse
11. Clubhouses
12. Playground Biesbush
13. Estate Buitenleeft



It is clearly visible that the program of the area has a leading role in the spatial configuration. The various functions were first given their place in the design and the other elements were added afterwards. The different functions are clearly demarcated and the trees are used as a kind of filler for the remaining space. This creates a disconnect between all the different parts of the area.

As can be seen below, the routes mainly run through the wooded area. The routes mainly have a mobility function, to get from one point to another as quickly as possible. There is no staging of the design. An exception are the paths within the Hertenkamp. There are sight lines over the water and walks along open and closed areas.
This can be explained by the difference between the periods in which the two sub-areas were designed and built.

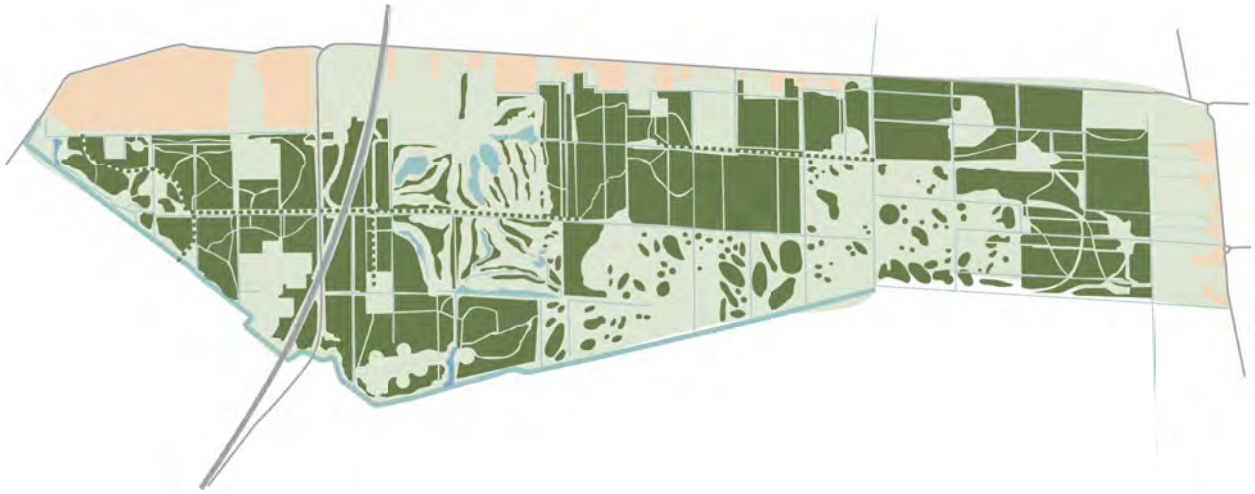
The Delftse Hout is a good example of a modernist landscape design. After creating the basic conditions, recreational functions are placed in the design and the remaining space is filled with wooded area. The constructed paths are mainly there to get from point A to point B and not to stroll along.



Appendix C: Precedent Bentwoud

Bentwoud is a recreational and nature park between Zoetermeer and Boskoop. It was selected based on its recent design and realization in 2016. Bentwoud is situated in a typical Dutch polder landscape. The idea for the park was to separate the Green Heart of the Randstad from Rotterdam and The Hague and create a spatial division.

The design of the recreation park is based on the existing polder structure. The water structure has been left virtually unchanged with the exception of the addition of water features on the golf course.
This structure creates rectangular plots. It is decided for each plot how it will be laid out. In the north the plots are denser and in the south there are more open spaces with groups of trees.
The design can be divided into three main parts: Triangle Benthuizen, Kernbos Rijnwoude, and the northern part of Waddinxveen. The triangle consists of a playground and several sports facilities. The core forest contains a golf course and a children's tree forest, and the northern part of Waddinxveen mainly has cycle and pedestrian paths.

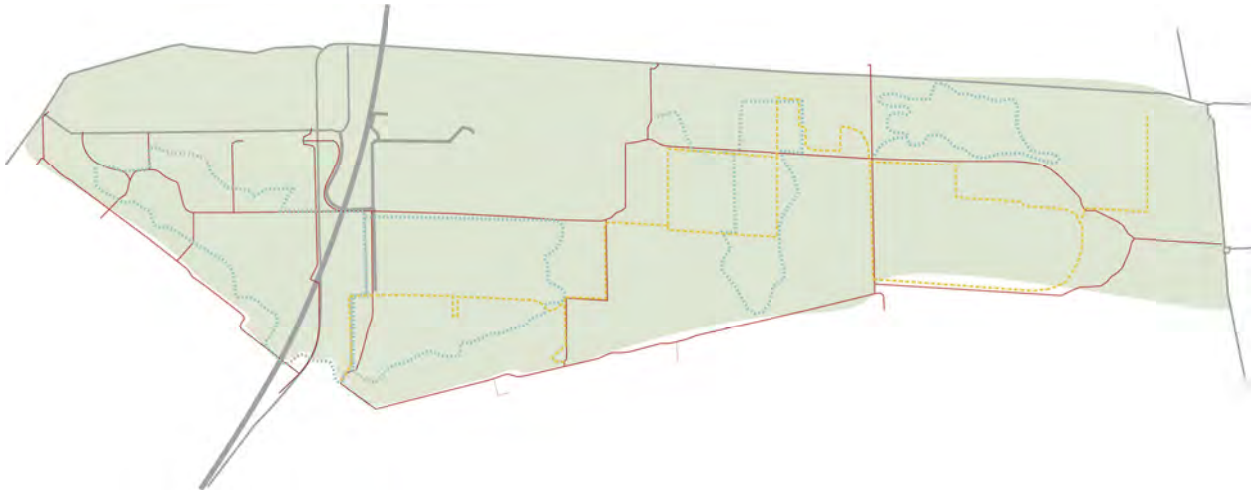


It can be seen that placing demarcated functions is the most important principle, as in the case of the Delftse Hout. The tree structure is placed on

plots where no function is applied.

Functions
The park contains the following features:
- Golf course
- Playground
- Sports fields
- Children's tree forest

The area also has a dog field and multiple types of routing. These routes include horse riding paths, footpaths, and cycling paths.
These can be seen below.



Yellow – Horse riding path
Blue – Walking routes
Red – Cycling path

Conclusion
Bentwoud has a design based on function with routing for movement through the park.