Watering Dry Landscapes

A design for a climate adaptive moraine landscape near Nijmegen which facilitates a symbiotic relationship between multispecies and the non-living environment

Colophon

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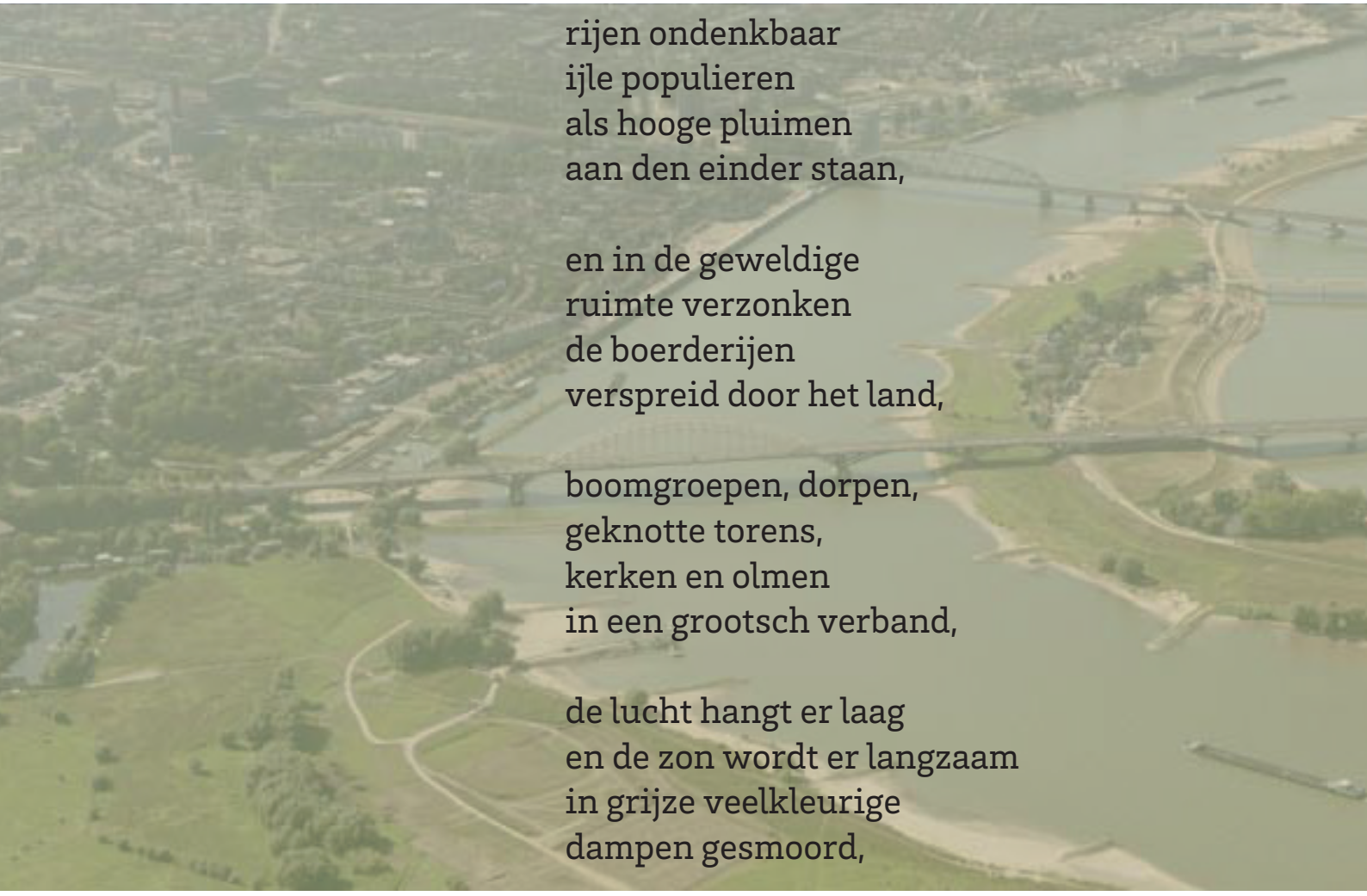

Denkend aan Holland
zie ik breede rivieren
traag door oneindig
laagland gaan,

rijen ondenkbaar
ijle populieren
als hooge pluimen
aan den einder staan,

en in de geweldige
ruimte verzonken
de boerderijen
verspreid door het land,

boomgroepen, dorpen,
geknotte torens,
kerken en olmen
in een grootsch verband,

de lucht hangt er laag
en de zon wordt er langzaam
in grijze veelkleurige
dampen gesmoord,

en in alle gewesten
wordt de stem van het water
met zijn eeuwige rampen
gevreesd en gehoord.

Hendrik Marsman, 1963

Spiegelwaal Nijmegen
(de bastei, n.d.)

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To my graduation lab and other landscape colleagues of 2020-2022,
For being great and inspiring companions.

To my family and friends,
For all the emotional support.

FOREWORD

SECTION I **ANALYSIS**

SECTION II **DESIGN**

SECTION III **CONCLUSION**

ABSTRACT

Key words: drought, ecological enrichment, moraine, symbiose, Lo-TEK

The Netherlands is confronted with drought more and more frequently. Two of the four climate scenarios predict that summers will become drier and extreme weather such as drought will occur longer and more often. Drought is a serious problem for multiple reasons. First of all it concerns large areas. Secondly it can take long before the effects are noticeable. Finally, the longer it lasts, the longer the soil and water system needs to recover.

In the Netherlands the high sandy grounds are the most vulnerable to drought. In comparison with the low-lying peat and clay grounds, it is not possible to supplement water from the rivers. Because supply from external sources is not an option, the sandy grounds are completely dependent on rainfall which makes them more vulnerable.

Humans strengthen the water shortage during drought as a result of spatial planning and water use. The current spatial planning of the landscape and water system ensures a fast discharge during wet periods in order to prevent water nuisance or flooding. So despite the fact that the Netherlands has become averagely wetter over the years, it still faces water shortages because the water is no longer available during dry periods. Furthermore the extraction of surface and groundwater for agriculture, industries and drinkwater companies increase the water shortage further during drought.

Furthermore humans cause desiccation. Desiccation is a consistent damage to nature as a result of structural diminishing of the groundwater level in combination with a reduction of the amount of seepage in groundwater dependent nature. Desiccation is mainly the impact of the modification of the water system to fit the land use requirements': drainage for agriculture (60%), groundwater extraction for drinking water, industry and irrigation (30%) and other factors such as the amount of pavement (10%). So for nature the effects of drought come on top of the desiccation it endures consistently, whereas the quality of nature is already declining rapidly.

The graduation thesis answers the following research question:
In what way can the landscape be used and adjusted to achieve a climate adaptive landscape for the moraine of Nijmegen and provide enrichment of the local ecosystem?

This is done on the basis of literature research, site visits, mapping, reference analyzes and designs. The research is limited to the landscape of the Nijmegen moraine. Conditions for the design is a symbiosis between multispecies

The structure of the graduation thesis is as follows. Chapter 2 describes the fascination from which the research arose. Chapter 3 then provides an explanation of the problem statement. Chapter 4 deals with the research statement. Chapter 5 deals with the methodology. Chapter 6 analyzes the Nijmegen moraine with the associated threats and values. Chapter 7 contains the design. Chapter 8 is the last chapter with the conclusion and reflection.

GLOSSARY

Dry weather
Droog weer

A period in which precipitation does not occur in combination with persistently high evaporation. Dry weather eventually leads to drought, but this is not always the case.

Drought
Droogte

Occurs during a long period without precipitation that deviates from the normal and/or high degree of evaporation. As a result, a disturbance occurs within the normal hydrological patterns. The soil dries out, the groundwater subside and the surface water in brooks, ditches and rivers subside or dries up.

Desiccation
Verdroging

A phenomenon caused by humans in which either a decrease in groundwater occurs and/or a reduction of seepage water in groundwater dependent nature. Desiccation causes structural damage to nature, often during drought.

Morraine
Stuwwal

A ridge in the landscape created by land ice which pushed up deposited material.

Dry valley
Droogdal

A valley in the landscape that was created by erosion of ice or rainwater runoff.

Precipitation shortage
Neerslagtekort

The precipitation shortage is the total precipitation minus the total evaporation. The precipitation shortage is calculated for the months April until September, the growing season in the Netherlands.

Water table
Grondwaterpeil

The depth of the groundwater in the soil.

Brook
Beek

A natural stream or watercourse flowing down.

Spreng
Spreng

A man-made or diverted stream.

References

Images

de bastei. (n.d.). Rondleiding Rivierpark Nijmegen. De Bastei. https://www.debastei.nl/nl/rondleidingen/rondleiding-rivierpark-nijmegen

1

INTRODUCTION


0
1
2
3
4 km

Inhabitants municipalities 2022
Nijmegen: 179.100
Berg en Dal: 34.951
Heumen: 17.175
Mook en Middelaar: 7.989

Source: AlleCijfers.nl

Figure 1.0 Authority borders

1.0 INTRODUCTION

The lateral moraine of Nijmegen is located in the east of the Netherlands on the national border with Germany. Together with the Maas-Waal canal, the two rivers Waal and Maas enclose the moraine. Scopes of multiple authorities from different scale levels converge in this area. Therefore the landscape is divided and managed by a wide range of authorities. Its major part falls under the Province of Gelderland, the two municipalities Nijmegen and Berg en Dal and the waterboard Rivierenland.

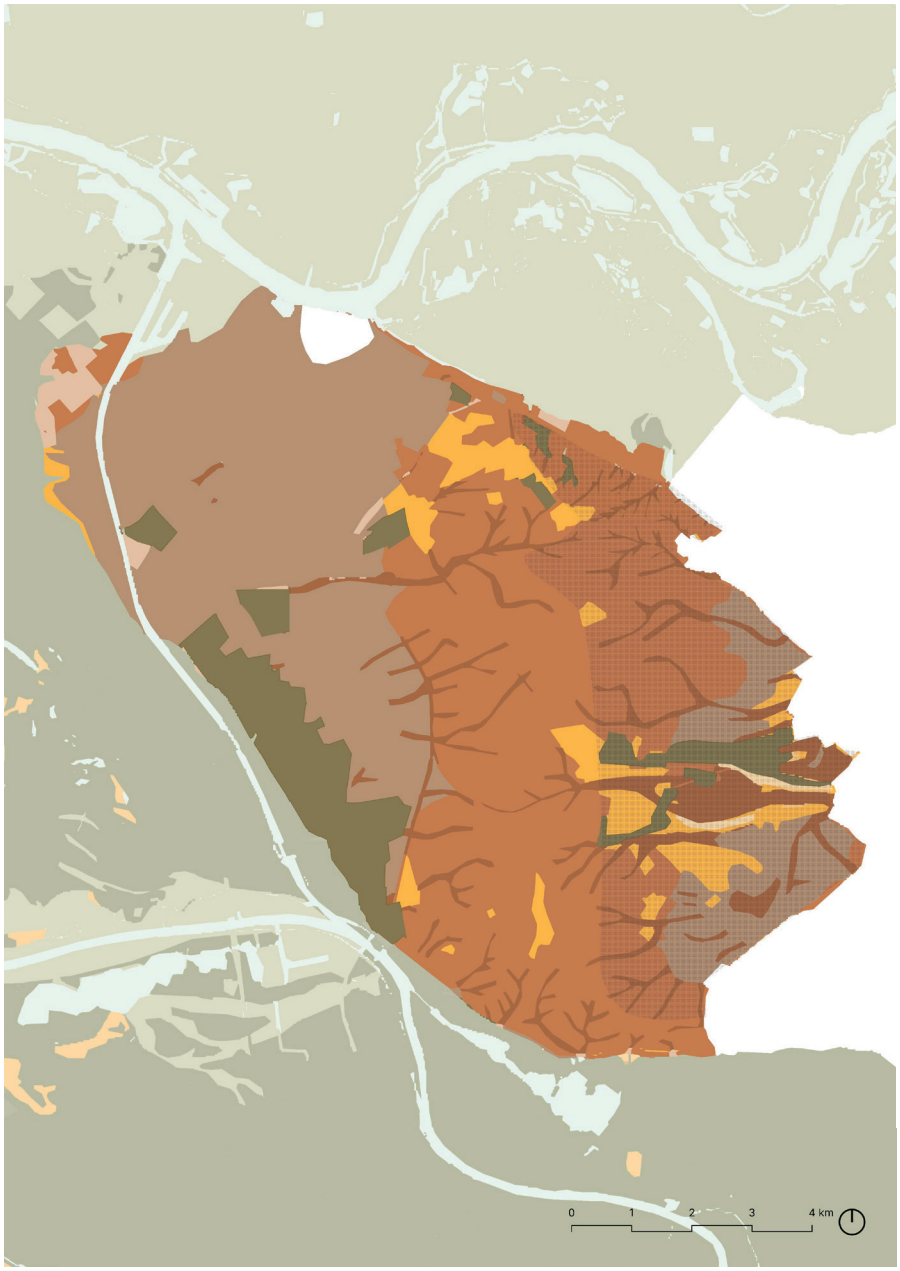


Figure 1.1 Natural system

The natural system is the outcome of the relationship between the topography, the soil and subsoil and the water system.

1.1 Natural system

The lateral moraines in the Netherlands are formed during the second last ice age, the Saalian glaciation, around 150.000 years ago. Land ice from Scandinavia reached up to Haarlem-Nijmegen, pushing up old river deposits as sand, gravel and clay. One of the land ice extensions reached Groesbeek, forming a wall with the shape of a horse shoe. Only half of the moraine lies in the Netherlands, the other lies in Germany. The topography consists of great heights which slightly undulates. Steep slopes are interspersed with flat sections (Klimaateffectatlas, n.d.). Nowadays, the highest point is about 99 meter above sea level.

Towards the Maas-Waal canal and Germany, the moraine continues gradually into the sandr (outwash plain). When the Saalian ice age was over, the ice started to melt causing deep valleys in the landscape. At the end, sand and gravel were deposited forming a fan shape (the sandr). At the foot of the sandr, is a zone with soft inclined slopes and plateaus, the valley erosion plain. Due to century-long agricultural activities with fertilization of the soil, a thick layer of brown, humus-rich soil was formed on the west side of the moraine, the so-called raised farmland (Broks et al., 2021).

During the last Weichselian ice age which took place 116.000 to 10.500 years ago, the land ice did not reach the Netherlands. The landscape consisted of tundras and polar deserts, and what we now know as the North sea was land. This time the wind was the force behind the soil formation. Strong northern polar winds brought sea-bottom sediments and deposited the loess on the eastern side of the moraine. Furthermore surface sand originated from the edges of the moraine descended here too and formed surface sand ridges. Loess consists of smaller particles in comparison to surface sand and retains moisture for a long period (Wesselingh, n.d.).

In the time of the Weichselian ice age, most times of the year the ground was frozen. In summer time the temperatures rose up to 10 degrees, causing a defrost of the top layer. Through the frozen ground, melt- and

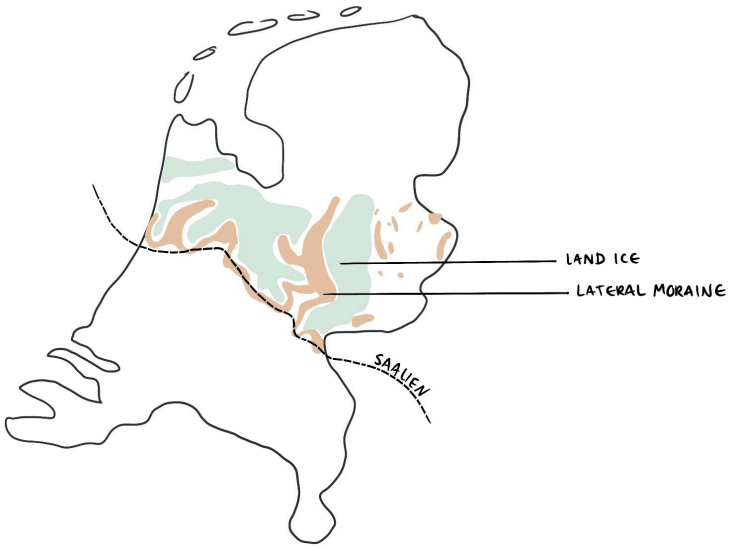


Figure 1.2 Land ice ca. Saalian

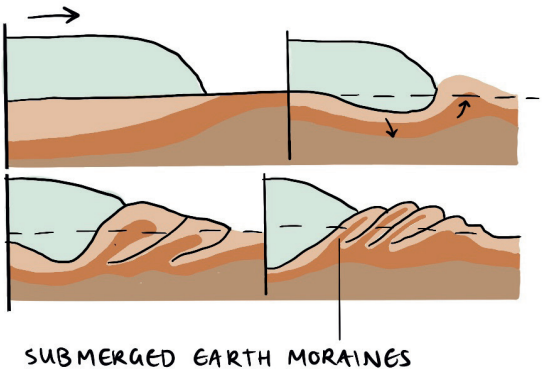


Figure 1.3 Moraine formation

rainwater could not infiltrate. Instead it flew down, causing erosion and created new valleys. These valleys no longer drain water, so they are called dry valleys (Martens, n.d.).

The lateral moraine consists mainly of dry, lean sandy soils (podzol) with a high water permeability. The shallow subsoil contains submerged earth moraines. River sand, river gravel and loam were compressed and pushed upward which resulted in slanted submerged deposits. These submerged layers are impermeable (Klimaateffectatlas, n.d.).

1.2 Cultural history

Since humans started to live in the area, the moraine has been a source for water and wood. Furthermore the loess provided excellent agricultural ground. Nijmegen is one of the oldest cities in the Netherlands. Romans settled in the area around 100 BC because the height and rivers provided a strategic position. A large part of the forest has been used as building material or fuel for their buildings and baths. After the Roman occupation, the condition of the forest varied from time to time. Until the 18th century, the counties from Kleef and Gelre caused a deterioration of the forest. Due to leasing, the borders differentiated frequently. Because the way of living was very expensive, they had to mortgage the land so they could lend money from each other. In these short times in which they possessed the forest it was robbed, because they wanted to gain as much as possible.
In the 16th and 17th century, attempts were done to restore the forest but these failed often.
In the 18th century interventions were done for improvement and efficient management and logging. Around 1730 they parceled out a large part of the forest and created an orthogonal grid. At the end of the 19th century, the focus on logging shifted towards nature development. From the second half of the 20th century, recreation became a goal too.

The Romans made an aqueduct in order to transport water from the moraine towards their settlement. In the 17th century at Beek, water of the moraine was used for the production of paper by the use of watermills. After the collapse of the paper production in the 19th century, the remaining mills were used for the flouring washing industry of the second half of the 19th century. Laundry from Nijmegen was picked up, washed in the clear spring water of the moraine and afterwards bleached in the lawns (NABU-Naturschutzstation e. V. & Werkgroep Milieubeheer Groesbeek, 2007).

10.000 BC
End Ice Age
Primal forest Ketelwoud starts to develop

800 - 15 BC
Increased deforestation for agriculture and firewood

4.000 BC
Start human influence
Primitive agriculture and lifestock farming on loess grounds

100 BC
Romans settle in the area

1.500 - 1.700
Attempts of restoration
Planting new forest fails often
Illegal logging and grazing

17th century
Water mills were build to use the water of the moraine for the production of paper.

1.300 - 1.500
Dynamic period in which the property boundaries of the Ketelwoud frequently shifted between the counties through leasing.

Leasing caused detoriation of the forest.

1.400 - 1.500
Final division of forest Ketelwald in Ober-rijkswald and Nederrijkswald

16th century
Staten van Gelderland becomes the owner of Nederrijkswald

Forest consists mainly of heathland and scrubland

Eighty Years' war
Raising demand for wood ensured improvement of the forest management. However, attempts for improvement still largely failed.

ca. 1850
Almost all forestplots of the realm were sold.
The government lost control of the wood production, while the need for wood rose.

19th century
Both the German and Dutch forest is mainly focused on woodproduction.
The forest and heathland functioned as meadowland and as source for fertilizer. Inhabitants from surrounding villages were allowed to gather dead wood.

Mid-19th century
Paper production collapsed due to high competition.
Most mills disappeard. The reaming ones formed the base for the flourishing washing industry in the village Beek in the second half of the 19th century.

(NABU-Naturschutzstation e. V. & Werkgroep Milieubeheer Groesbeek, 2007)

500 AD
End Roman empire

1.100 - 1.300
Counties of Gelre and Kleef expand their territory towards the moraine

500 - 1.000 AD
Forest recovers gradually
German monarchs use the area for hunting.
Except for the small urban centres, the area is uninhabitated.

1720
Forest management became more effective
Forest condition was checked anually

ca. 1780
Before 1780 the oak was the most popular. In the 18th and 19th century, the production of pine wood increases and oak tree declines.

1730
Implementation of the rectangle grid.
Large area of the Nederrijkswald is herorganized with the aim for improvement. Management, control, logging and distribution becomes more efficient.

1740 - 1750
Introduction Scots pine
Large area of the Nederrijkswald is herorganized with the aim for improvement. Management, control, logging and distribution become more efficient.

ca. 1800
European spruce follows

Pieces of forest were leased. The private owners build estates, farms summer cottages. They decorated the forest through ‘star forests’ and marked their roads with lanes of beech, lime or robinia.

1960
Shift to more a more ‘natural’ forest

Selective logging, aim for a mixed forest with high nature values

Recreation becomes slowly part of program and is an aim on it self.

1899
Establishment of Staatsbosbeheer

Gradually Staatsbosbeheer gained more and more land of Nederrijkswald

End 1980
The laundry industry come to an end due to the arrival of the washing machine.

References

Broks, K., Grond, V., Kosian, M., Maas, G., & Vreenegoor, E. (2021, November). De stadsgenese: Cultuurhistorie en het natuurlijke systeem als gids voor klimaatadaptatie en stedelijke ontwikkeling. In https://www.stadsgenese.nl/ (No. 978-90-5773-923–1). STOWA and RCE. Retrieved June 10, 2022, from https://grondrr.nl//downloads/De%20Stadsgenese.pdf

Klimaateffectatlas. (n.d.). Basemap of the Netherlands Natural System : Lateral moraine. Retrieved June 10, 2022, from https://www.klimaateffectatlas.nl/en/base-map-of-the-netherlands-natural-system

Martens, A. (n.d.). Droog dal. Geologie Van Nederland. Retrieved June 16, 2022, from https://www.geologievannederland.nl/landschap/landschapsvormen/droog-dal#head2

NABU-Naturschutzstation e. V. & Werkgroep Milieubeheer Groesbeek. (2007, oktober). Toekomstvisie Ketelwald. In Ketelwald. Bureau Centaurea. Geraadpleegd op 20 juli 2022, van https://www.ketelwald.de/Download-Dateien/Toekomstvisie_Ketelwald-A4kl.pdf

Wesselingh, F. (n.d.). Laat-Pleistoceen. Geologie Van Nederland. Retrieved June 16, 2022, from https://www.geologievannederland.nl/tijd/reconstructies-tijdvakken/laat-pleistoceen

2

FASCINATION

2.0 FASCINATION

2.1 The Netherlands, a waterland

Water is an integral part of the dutch landscape. The present landscape is the result of the centuries-long abundance of water and fight for dry feets. Everywhere you look, you can find landscape elements such as sluices, pumping stations and wind mills. The two European rivers Rhine and Meuse cross the country, split up and culminate eventually in the North sea. The western part of the Netherlands is called the low-land and lies beneath sea level. The presence of the many rivers and lakes together with the low elevation makes the country vulnerable for flooding.

Hendrik Marsman describes in his poem 'Denken aan Holland' the dutch landscape. In the final paragraph he says: "en in alle gewesten wordt de stem van het water met zijn eeuwige rampen gevreesd en gehoord". The Netherlands has a long history with water and has gone through multiple tragedies. The biggest natural catastrophe of the 20th century was the Watersnoodramp of 1953. A great storm in combination with spring tide led to a powerful force which broke the dikes. Big parts of the Netherlands were flooded. Many people died or lost their homes (Rijkswaterstaat, 2022).

Nowadays we still face these problems. Heavy rainfall together with high water levels caused a flood of the river in Limburg july 2021. In a short period of time, the province of Limburg and some areas of Gelderland and Brabant had to deal with serious water nuisance. The estimated damage was 350 to 600 million euro (Jonkman, 2021).

Figure 2.1 Watersnoodramp 1953 (Rijkswaterstaat, 2022)

Figure 2.2 Limburg after the flood of 2021 (Jonkman, 2021)

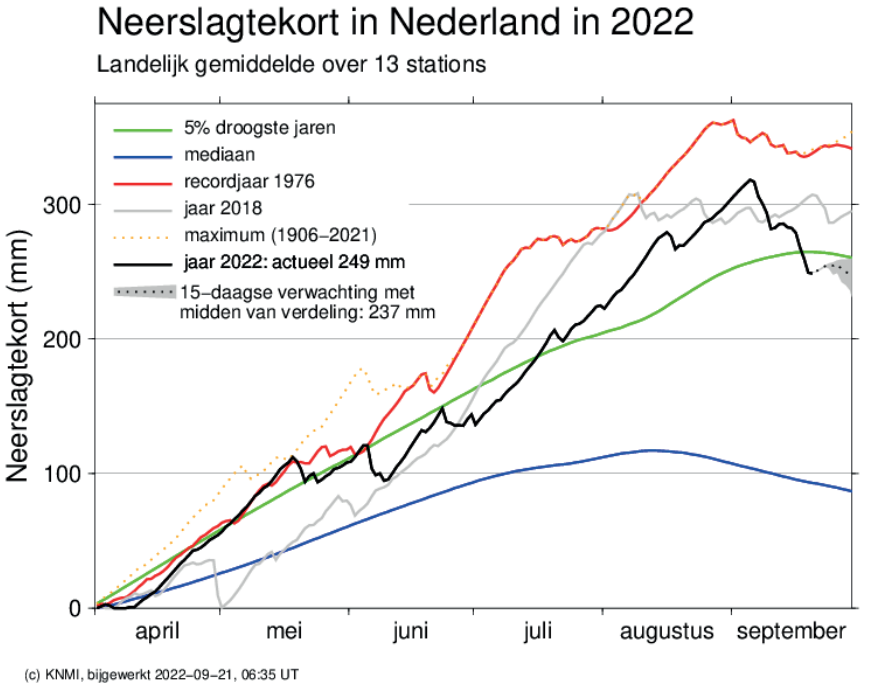


Figure 2.3 Precipitation shortage 2022 (KNMI, 2022)

2.2 Extreme drought in the Dutch delta

The Netherlands is facing a big change. The last couple of years news items announce periods of extreme drought. Dutch inhabitants have to be careful with their water use and farmers are not allowed to irrigate their land with surface or groundwater. The periods of water shortage last longer and happen more frequently. However, this does not only happen in the Netherlands. Drought is a worldwide problem.

Summer 2022, once again the Netherlands experiences extreme drought. The year 2022 belongs to 5% of the driest years since 1906 (figure 2.3). From water nuisance we switch to water shortage. What is happening in the Netherlands?

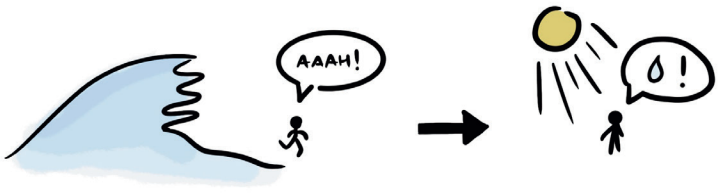


Figure 2.4 From water nuisance to water shortage

References

Jonkman, B. (2021, September 21). Hoogwater Limburg zomer 2021 ingrijpender dan rivieroverstromingen in 1993 en 1995. TU Delft. Retrieved June 21, 2022, from https://www.tudelft.nl/2021/citg/hoogwater-limburg-zomer-2021-ingrijpender-dan-rivieroverstromingen-in-1993-en-1995

Rijkswaterstaat. (2022, March 9). Watersnoodramp 1953. Retrieved June 19, 2022, from https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/watersnoodramp-1953

Images

KNMI. (2022, September). Neerslagtekort in Nederland in 2022: Landelijk gemiddelde over 13 stations. Droogtemonitor. https://www.knmi.nl/nederland-nu/klimatologie/droogtemonitor

3

PROBLEM FIELD

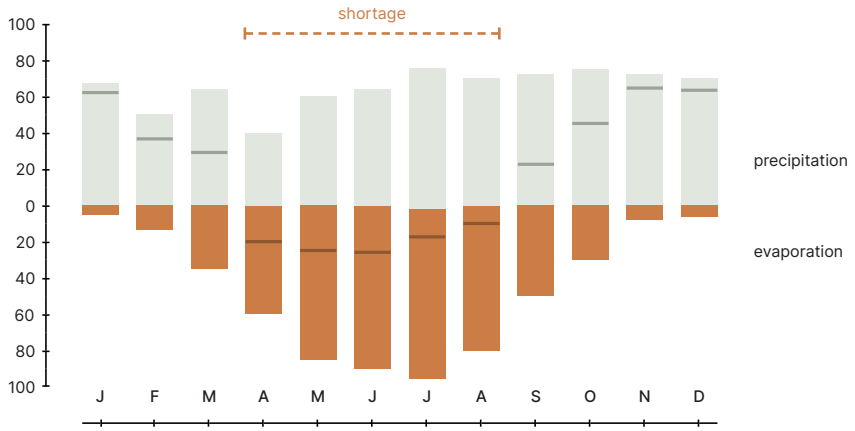


Figure 3.1 Water balance in the Netherlands (Buienrader, 2022) edited by author

3.0 PROBLEM FIELD

3.1 Drought

3.1.1 The four phases of drought

Drought starts with dry weather. There is no precipitation combined with high evaporation. You speak of drought when the period of dry weather lasts too long which results in a disruption of the hydrological patterns.The situation deviates strongly from the normal situation (van den Eertwegh et al., 2021). If the evaporation rate is higher than the amount of precipitation that falls, there is a precipitation shortage. The precipitation shortage is used to measure drought. In the Netherlands, the term drought is often used for situations in which problems can arise due to water shortages (Kennisportaal Klimaatadaptatie, n.d.-a).

In the Netherlands there is an average precipitation surplus over the year. This means the amount of precipitation is higher than the evaporation. The reason why precipitation shortages do arise is because the rain and evaporation are not evenly distributed over the country and over the year. For example, evaporation is the highest on the coast due to the longer period of sunshine. Over the year, it is common to have a precipitation surplus in autumn and winter, and a precipitation shortage in spring and summer (fig. 3.2). Drought is very serious when the precipitation shortage is more than 200 mm (Leenaers, 2021).

Van den Eertwegh et al. (2021) describes four phases in which drought permeates the soil and water system (fig 3.1).

1) Meteorological drought
There is little to no precipitation combined with high evaporation. When evaporation is higher than the amount of precipitation, there is a precipitation shortage.

2) Soil drought
The top layer of the soil dries out as a result of the precipitation shortage. The roots of plants ultimately have less water available, so eventually the actual evaporation decreases.

3) Groundwater drought
There is a stronger subsidence of the groundwater level than normally would happen. How much it subsides depends on the depth of the groundwater table, water management and water use.

4) Drainage drought
Rivers, ditches and streams drain less water or dry up.

Each phase (2 - 4), it takes longer for dry weather to penetrate into the soil and water system. In the same order, it also takes longer for the system to recover. The depth of the groundwater level plays a role in this case. The deeper it is located in the soil, the longer the recovery takes (van den Eertwegh et al., 2021).

Drought can be very insidious. It takes weeks before the effects are noticeable. Subsequently, the recovery can take months or even years. Furthermore it often concerns large areas and goes beyond national borders. With persistent drought, not only the Netherlands is dry. Other countries in Europe also have to deal with it (Didde, 2021).

3.1.2 The Dutch high grounds

The level of sensitivity to drought differs between the higher and lower parts of the Netherlands. In the low clay and peat grounds located in the west and north, the groundwater level is established by artificial water level management. It is possible to allow river water flow into the area in case it is necessary. In contrast, the higher sandy grounds in the east and south are much more sensitive to drought because they are completely dependent on precipitation and groundwater. Supply from the river is not possible here, so water shortages arise faster (Kennisportaal Klimaatadaptatie, n.d.-b).

Because the high sandy soils are more sensitive to the effects of drought, this landscape type was the first delineation in the graduation thesis. For that reason no further attention will be paid to the low-lying Netherlands. The moraine of Nijmegen belongs to the high sandy soils and is the project location on which the design focuses.

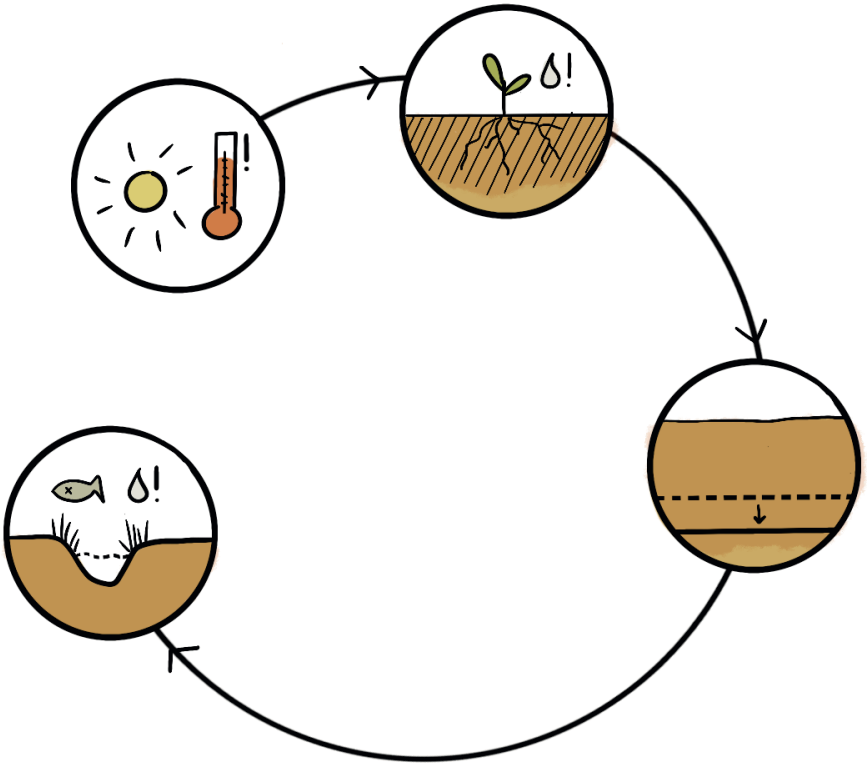


Figure 3.2 The four phases of drought
Impact on the soil and water system

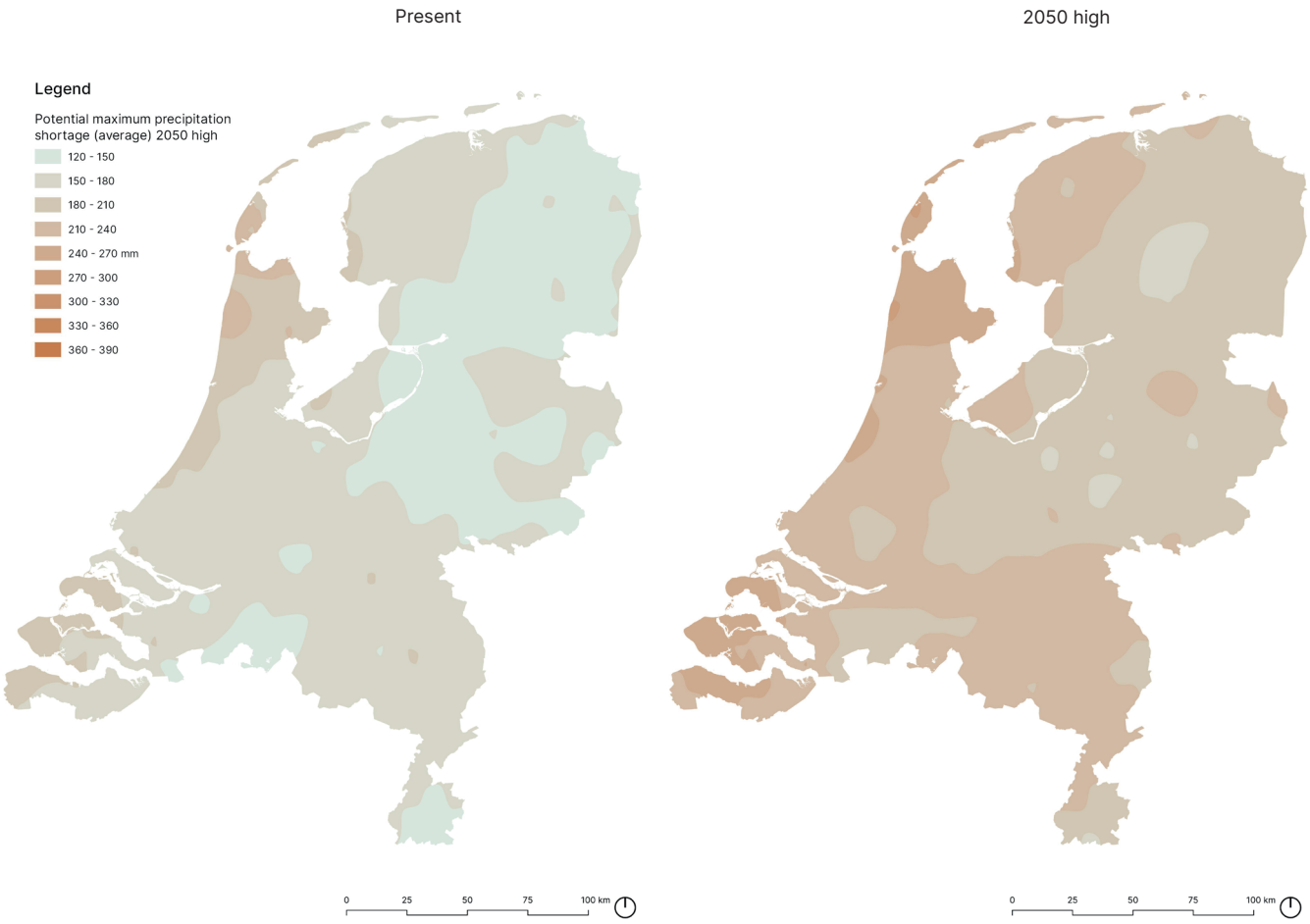


Figure 3.4 Increasing annual precipitation shortage (Klimaateffectatlas)

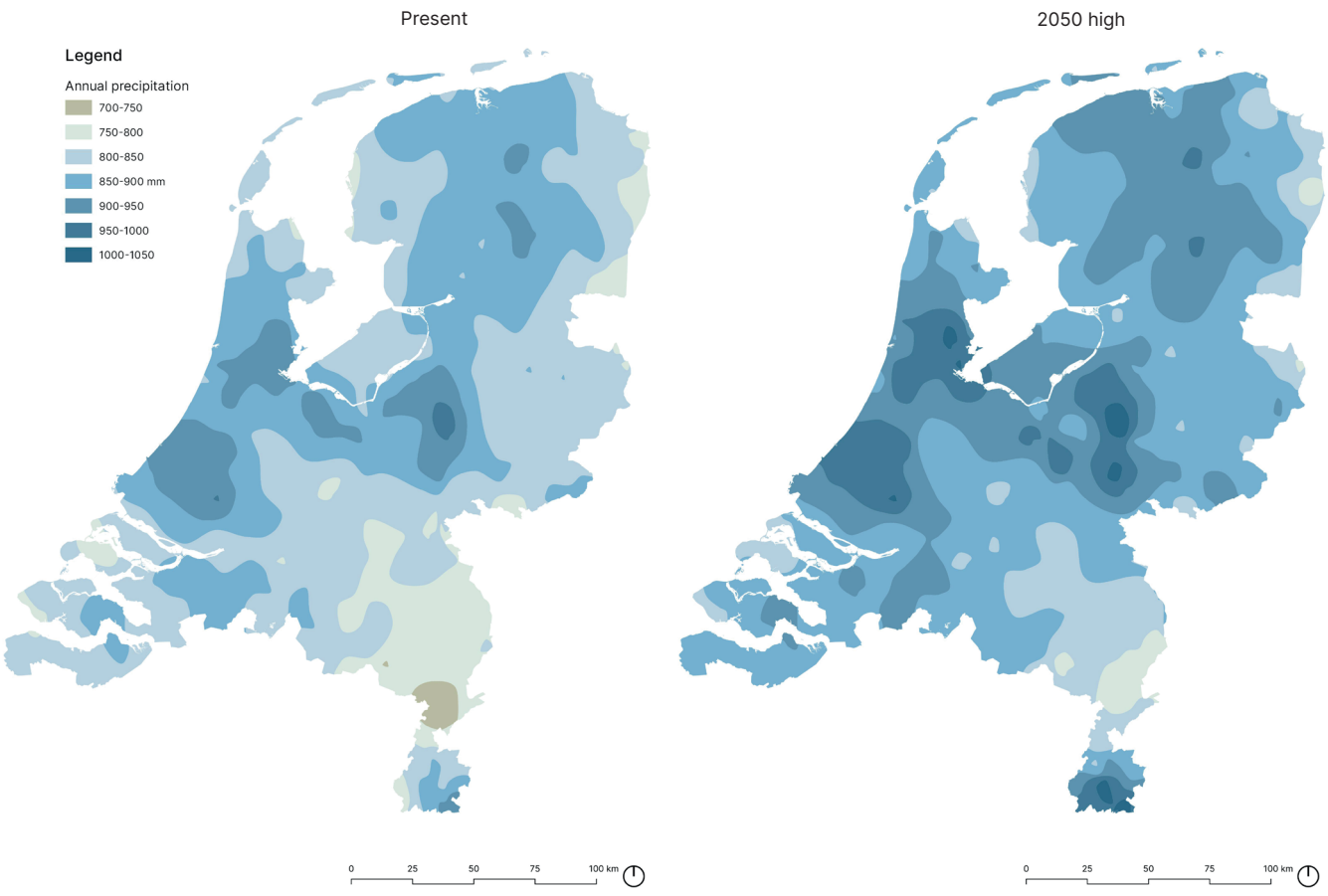


Figure 3.5 Increasing annual precipitation (Klimaateffectatlas)

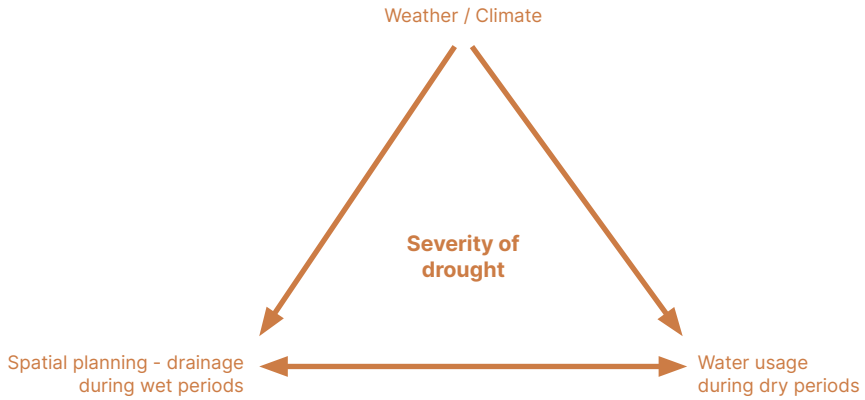


Figure 3.3 The severity of drought (Van den Eertwegh et al., 2021) edited by author

3.2 Causes

Van den Eertwegh et al., 2021 states that the severity of drought is caused by the interplay of:

A) the weather and climate
B) the spatial planning
C) the water use in times of drought

3.2.1 Climate change

The KNMI produces climate scenarios approximately every eight years. They do this by translating the IPCC scenarios for the world into scenarios for the Netherlands. The scenarios predict that temperatures will rise further, winters will become wetter and downpours will become heavier. Scenarios GH and WH also predict that the maximum precipitation shortage will increase in the summer (fig. 3.3) and therefore become drier. However, the predictions for the future are uncertain. The north of Europe will become wetter and the south drier. The Netherlands is located exactly in between (Leenaers, 2021).

Research shows that winters have become wetter since the beginning of the last century. In addition, there has also been an increase in the number of downpours in summer as a result of the warm weather. But not only did the amount of precipitation increase, so did the amount of evaporation. This is due to the rise in both temperature and amount of sunshine. The increment of evaporation is greater than precipitation, which means the precipitation shortage in summer has increased (fig. 3.4) (Leenaers, 2021).

Besides the change in average climate, the risk of extreme weather is also growing. So is the risk of extreme drought. The year 2018 is one of the five driest years ever measured since 1906. There was a precipitation shortage of more than 300 mm. This weather extreme now occurs once every 30 years and will happen more often in the future (Leenaers, 2021).

Other climate effects are heat and water nuisance. Drought is closely related to this and the three influence each other. However, this graduation thesis will mainly focus on drought.

3.2.2 Spatial planning

The Netherlands has been dewatered on a large scale over the last 150 years. The long water history and associated flooding made sure the prevailing ideology within water management has long focused on the drainage of water (Rijkswaterstaat & Unie van Waterschappen, 2019). So despite the fact that it has become wetter due to the increased average annual rainfall, water shortage arises because the water is no longer available in times of need. The desired water is long gone and discharged into the sea when it is needed. In addition, factors such as bottom cover and compaction of the soil due to the increased amount of pavement in urban areas also play a role. Rainwater is prevented or hindered from infiltrating into the soil.

3.2.3. Water usage during drought

With dry weather farmers irrigate their land with water derived from streams or groundwater. A decrease in surface water due to both the weather and abstraction through irrigation ultimately results in more groundwater abstraction. Irrigation therefore ensures that the situation around groundwater and drainage deteriorates.
The water demand from citizens and industry also enlarges during dry weather. Two thirds of the extracted water comes from groundwater and one third from surface water. Due to the increasing demand, offer and demand are out of balance. The same happens as with irrigation. It ultimately leads to a decrease in groundwater level (van den Eertwegh et al., 2021). In the most extreme scenario, het Rijksinstituut voor Volksgezondheid en Milieu (2015) predicts that national consumption for drinking water in 2040 will have increased by 30 percent.

Heuvelink et al. (2021) have done a research Klimaat en Watervraag Stedelijk Gebied and investigated the development of the water demand in urban areas due to climate change (WH2050 and WH2085). They have done this for various landscape types, including the sandy landscape. The graph (fig. 3.4) shows the maximum water demand per ten days for three different urban agglomerations (A metropolitan with a lot of buildings and little greenery - B urban with more greenery - C suburban in which the amount of greenery is equal to the pavement). From the graph it can be concluded that climate change will increase water demand in all three agglomerations (5 - 10%).

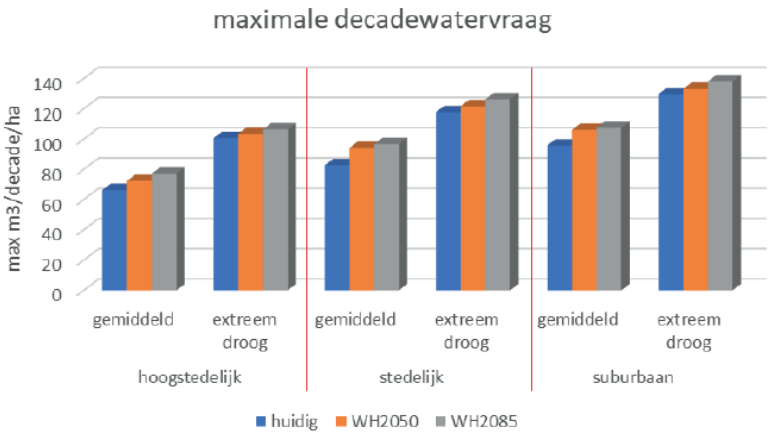


Figure 3.6 Max. water demand each 10 days (Heuvelink et al., 2021)

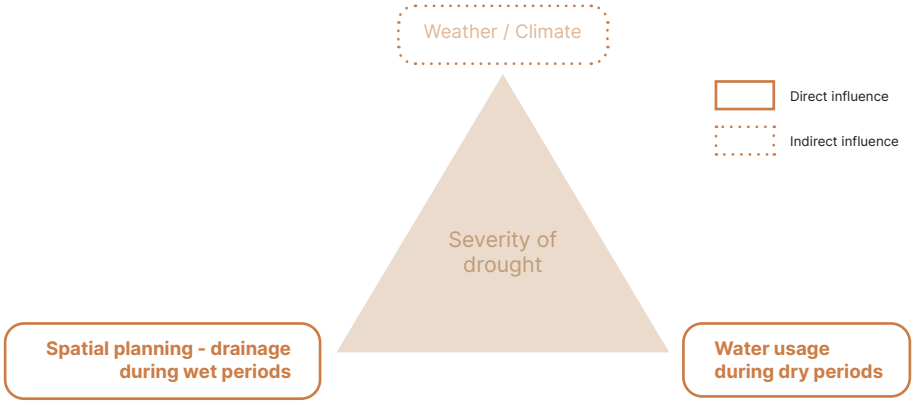


Figure 3.7 Humans strengthen drought

3.3 Humans strenghten drought

The spatial design of the dutch landscape in combination with the water usage in times of drought, ensures that humans strengthen the effects of drought. This leads eventually to desiccation. Desiccation is related to nature. The term desiccation is used to either indicate a subsidence of the groundwater level or a reduction of the amount of seepage in nature reserves. It means there is not enough water to guarantee the characteristic groundwater-dependent ecological values. The term is also used when water with a lower quality has to be supplied into the area (van den Eertwegh et al., 2021).

Desiccation due to drainage and abstraction is a structural problem for Dutch nature. Furthermore it has to face plenty of other (structural) problems. The Netherlands is one of the most densely populated countries in the world which mainly consists of highly productive agricultural land. The adjustments to the landscape to make this high production possible, in combination with urbanization and pollution, has led to a drastic decline in biodiversity. 40% of the species on the Red List in the Netherlands are threatened to a greater or lesser extent (Wageningen University & Research, 2018).

3.4 Problem statement

The Netherlands is confronted with drought more frequently. Two of the four climate scenarios predict that summers will become drier and due to climate change, extreme weather such as drought will occur longer and more often.

Drought is a serious problem which concerns large areas. It can take long before the effects are noticeable. The longer it lasts, the longer the landscape needs to recover. Because the high sandy grounds in the Netherlands are completely dependent on rainwater, this landscape type is more vulnerable to drought.

Humans strengthen the effects of drought as a consequence of the spatial planning and water usage. As a result nature desiccates. It is systematically drained so it is severely affected in times of serious water shortages. Besides, nature is already having a hard time. In the last centuries biodiversity has declined drastically in the Netherlands.

To conclude, the Netherlands becomes slowly dryer and humans strengthen this process.

References

Didde, R. (2021). Nederland Droogteland (1st ed.). Uitgeverij Lias B.V.

Heuvelink, D., Jensen, I., Hulsman, R., & Stapel, W. (2021, January). Klimaat en Watervraag Stedelijk Gebied. Royal HaskoningHHV. https://klimaatadaptatienederland.nl/publish/pages/188683/klimaat-en-watervraag-stedelijk-gebied-eindrapport_1.pdf

Kennisportaal Klimaatadaptatie. (n.d.-a). Droogte. Retrieved 29 April 2022, from https://klimaatadaptatienederland.nl/thema-sector/droogte/

Kennisportaal Klimaatadaptatie. (n.d.-b). Wat zijn de gevolgen van toenemende droogte? Retrieved 30 April 2022, from https://klimaatadaptatienederland.nl/thema-sector/droogte/gevolgen-toenemende-droogte/

Leenaers, H. (2021). De Bosatlas van weer en klimaat (1st ed.). Noordhoff.

van den Eertwegh, G., de Louw, P. G. B., Witte, J. P., van Huijgevoort, M. H. J., Bartholomeus, R. P., van Deijl, D., van Dam, J. C., Hunink, J., America, I., Pouwels, J., Hoefsloot, P., & de Wit, J. A. (2021). Droogte in de zandgebieden van Nederland: Effecten op en oplossingsrichtingen voor natuur, landbouw en het bodem- en watersysteem. https://edepot.wur.nl/560629

Rijksinstituut voor Volksgezondheid en Milieu. (2015). Scenario's drinkwatervraag 2040 en beschikbaarheid bronnen - Verkenning grondwatervoorraden voor drinkwater. https://www.rivm.nl/bibliotheek/rapporten/2015-0068.pdf

Rijkswaterstaat & Unie van Waterschappen. (2019). Watermanagement in Nederland. https://klimaatadaptatienederland.nl/publish/pages/168609/watermanagement_in_nederland.pdf

Wageningen University & Research. (2018, October 28). Nederland haalt de biodiversiteitsdoelen in 2020 niet. Retrieved July 22, 2022, from https://www.wur.nl/nl/nieuws/nederland-haalt-de-biodiversiteitsdoelen-in-2020-niet.htm

Images

KNMI. (2022, September). Neerslagtekort in Nederland in 2022: Landelijk gemiddelde over 13 stations. Droogtemonitor. https://www.knmi.nl/nederland-nu/klimatologie/droogtemonitor

4

RESEARCH STATEMENT

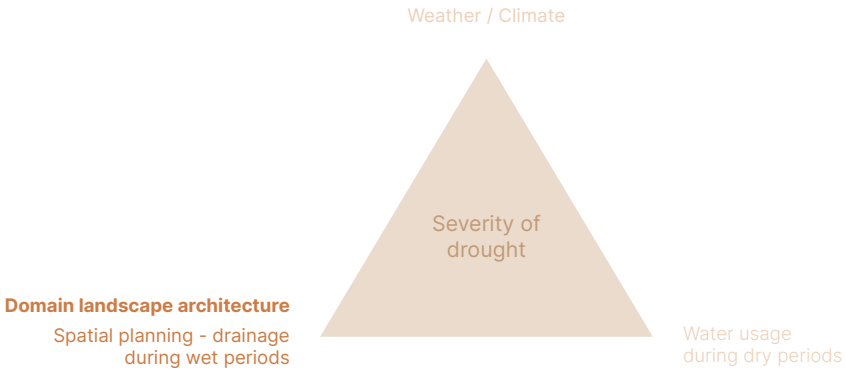


Figure 4.1 Domain landscape architecture

4.0 RESEARCH STATEMENT

4.1 Research objective

Currently humans have a negative impact on the landscape which strengthen the effects of drought. The landscape deteriorates through desiccation and biodiversity is declining. The drought challenge asks for a different way of how we look and make use of the landscape. At the moment humans take a central position. The relationship with the landscape is mainly one of exploitation. Part of this drought challenge lies in spatial planning, which is the domain of the landscape architect.

The drought challenge will be used to seize the opportunity to improve the ecosystem of the landscape while humans still make use of it and even learn from it. In this way, the relation becomes a symbiose. The aim is to generate a spatial quality which provides both ecological enrichment and creates added value for humans at the same time.

4.2 Research questions

The moraine landscape of Nijmegen is defined as the base to achieve the design objectives. From this acknowledgement, the research question arise:

In what way can the landscape be used and adjusted to achieve a climate adaptive landscape for the moraine of Nijmegen and provide enrichment of the local ecosystem?

The following sub questions arise:

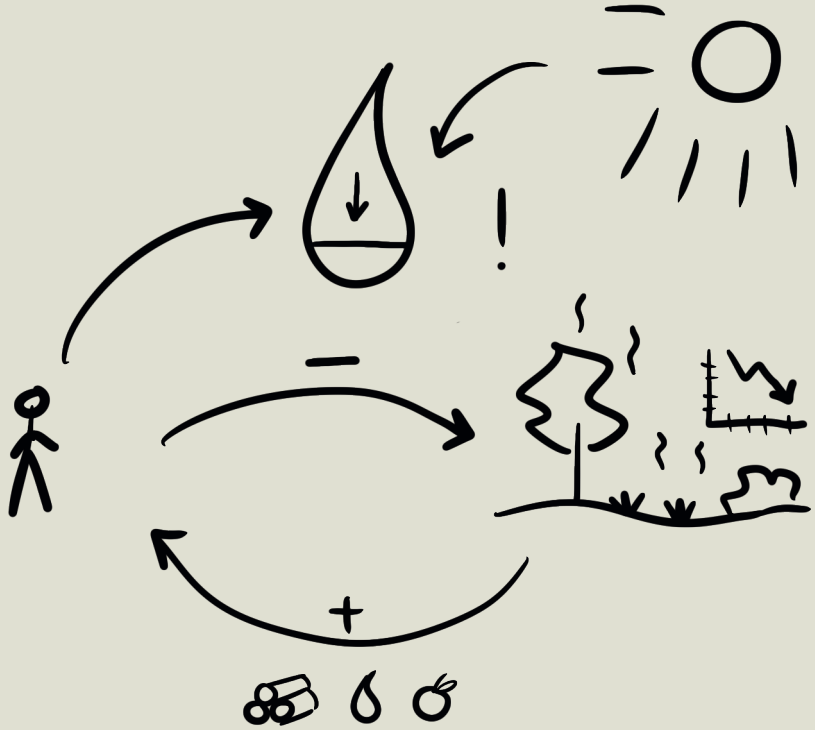
1. How does the soil-water system of the moraine work?

2. How to increase the water availability in the landscape?

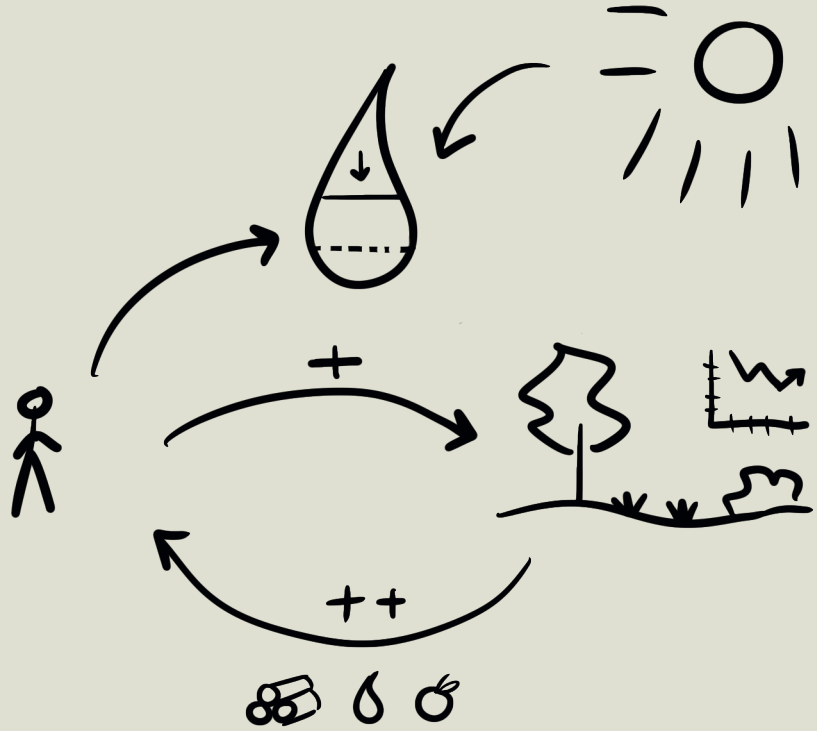
3. What is the current status of the local ecosystem?

4. Which landscape elements provide both ecological enrichment and create added value for humans?

Present



Desired



5

METHODOLOY

"While we are drowning in the Age of Information, we are starving for wisdom."

Julia Watson, 2019

5.0 METHODOLOGY FRAMEWORK

5.1 Theoretical framework

5.1.1 Lo-TEK design

Lo-TEK is about designing for sustainable, climate-resilient infrastructures. It is a movement which analyses local technologies, traditional ecological knowledge (TEK), indigenous cultural practices and mythologies (Watson, 2019).

It is about ..

.. working together with nature instead of trying to conquer it in the name of progress (symbiosis).

.. evolving humanism with radical indigenism.

..exploring the intersection of design and radical indigenism.

.. renew the relationship between place, nature and the physical places humans construct and inhabit.

.. use of simple, local materials.

5.2 Methods and approaches

The graduation thesis is approached through 4 layers: the natural layer, the cultural layer, the urban layer and the trends layer. The gathered information is subsequently filtered through four lenses: process, palimpsest, scale continuum and perception (Nijhuis, 2013)

5.2.1 Layer approach

The natural layer is the result of the natural processes of living and dead matter.

The cultural layer is the effect of artificial manipulation on the natural layer from the industrial revolution to now. Since the whole landscape in the Netherlands is man-mad, these two layers in the Netherlands are strongly interconnected.

The urban layer is the effect of civil engineering on the underlying cultural and natural layer.

Trends Layer is the result of the different processes that are happening in time.

5.2.2 Four lenses

Perception is about the perception of the urban environment and the landscape. The way it could be experienced by an observer moving through space. This concept entails the sensory experience of open and closed spaces, surfaces and volumes, and their place and order.

Palimpsest is looking at the landscape as a result of multiple processes through time, where traces of these activities have laid over the landscape, a palimpsest. Knowledge of these layers is important to design for new interventions on the landscape and city.

Scale Continuum means looking at the in different scales and its relations between the scales, a scale continuum. The outcome of the intervention is looked at in a broader context or in a smaller site.

Process states the landscape is not static, but dynamic. It is part of systems that take place in the landscape. It is a process of the dynamic interaction between ecological, social, and economic processes. These processes constantly change the landscape.

5.2.3 Current, future and desired situation

Elements of the current situation are validated. If this leads to the future situation, which is unwanted, it needs to be adjusted or removed. If the elements contribute to the desired situation, it will be kept and maintained.

5.3 Scope and relevance

Urban Ecology focuses with its design and research on the interaction between organisms and their (built) environment with the goal to "improve the quality of life and environmental performances in cities at all scales". The graduation thesis explores the conditions for both a climate adaptive landscape and enrichment of the local ecosystem. This will contribute to the quality of life for both humans and nature.

In the larger social framework my graduation project has the ability to improve the environmental performances of flora, fauna and humans. Thee design may be able to mitigate the effects of drought and prevent biodiversity loss.

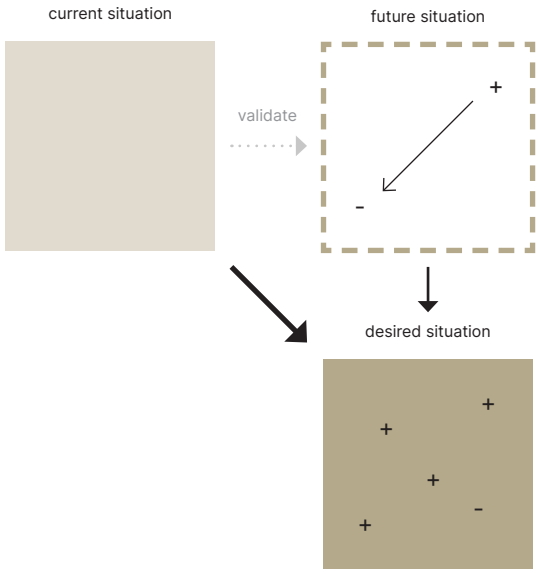
In the larger professional framework my graduation project can be an inspiration for other students to do research on drought and explore the potentials. It provides insights for designs in similar places facing the same drought issues. They can build upon the findings and continue the process of research and design for drought landscapes.

In the larger scientific framework graduation project can inspire to do more research on the effects of drought on the landscape and its future perspective. The landscape framework may work as an example of how the results of scientific research can be implemented in practice.

LAYER APPROACH

FOUR LENSES

CURRENT, FUTURE AND DESIRED SITUATION



5.4 Overview

Fascination

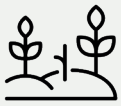
Drought in waterland

Analysis for Staatsbosbeheer

Problem statement

Extreme drought in the Netherlands happens more frequently.

Humans strenghten the effects of drought.



Quality of nature in the Netherlands is declining.

Research question

In what way can the landscape of the moraine of Nijmegen be adjusted and used to generate a climate adaptive landscape and achieve enrichment of the local ecosystem?

Condition

Symbiose between human and nature

Sub questions

1. How does the soil-water system of the moraine work?

2. How to increase the water availability in the landscape?

3. What is the current status of the local ecosystem?

4. Which landscape elements provide both ecological enrichment and create added value for humans?

Answer the research question

Methods

Collecting data and Site analysis

Site visit

Literature review

Case study

Consulting experts

Policy study

Process

Threats
Values

Design strategies

Toolbox with design principles

Outcome

Reflection

Spatial design

References

Nijhuis, S. (20.12.2013) Principles of Landscape Architecture. Landscape architecture TUdelft observations.
from https://landscapearchitecturetudelft.nl/principles-of-landscape-architecture/ at 16-02-2022

Watson, J. (2019). Lo-TEK, Design by Radical Indigenism. Taschen.

6

ANALYSIS

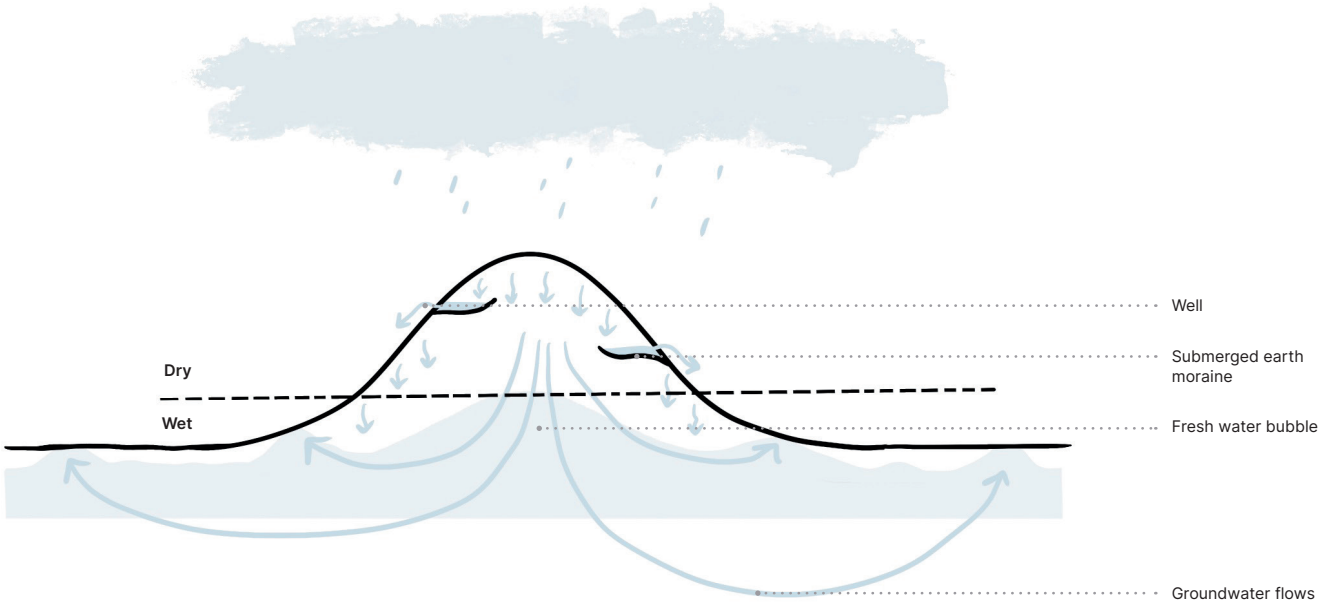


Figure 6.2 Soil and water system

6.0 Site analysis

6.1 Water source

6.1.1 Fresh water bubble
Rainwater infiltrates into the sandy soil of the moraine. There it slowly sinks through a thick unsaturated layer to the groundwater packages which lie deep below the surface. The place where the water collects is called the freshwater bubble of the moraine. The freshwater bubble is used for drinking water extraction (Thissen, 2009).

6.1.2 Wells, brooks and sprengen
Groundwater moves through groundwater flows. After a number of years, some of them reach the surface as local seepage water via the skewed impermeable layers. At places where these layers come to the surface, arise wells and streams (fig. 6.1). The remaining flows go further and after a decade to a century come to the surface kilometers away. This is called regional seepage water. This water has become alkaline because of the long period under the ground. Special vegetations depend on this alkaline-rich seepage water. Places where the seepage water rises are the Bruuk and in the valleys on the edge of the moraine (Thissen, 2009).

Springs and streams can be found mainly on the edges of the moraine. Sint Jansberg and the Duivelsberg are mainly known for it. The loam layers are closer to the surface due to river erosion. The same applies to the dry valleys, due to the erosion of melt and rainwater. In addition, there are also sprengen in the area. These are water sources that have arisen in an unnatural way through human excavations (Brinkhof, 2009).

6.1.3 Adaptation qualities
The soil structure ensures the moraine works as a big sponge. It infiltrates and can hold a lot of water. In addition, the dry valleys are very suitable for water storage as a result of the loam layers close to the surface.

6.1.4 Water system
Waterboard Rivierenland manages most of the moraine. They operate in places where there are streams or seepage water rises and take care of drainage. The surface of their management area is 4,417 ha.

The drainage within the sub-area of the waterboard takes place via two points:
- het Meertje in the Ooijpolder
- via Germany
The drainage to Germany happens in a natural way. At het Meertje, the water eventually ends up in the Waal via the Dutch-German pumping station.
On the western side of the moraine, most seepage water rises in the districts Dukenburg and Lindenholt. The construction of the Maas-Waal Canal in 1927 has ensured that part of the moraine has been cut off. Due to the water level pressure of the canal, most of the water passes under the canal. There, 1000 liters of water are pumped out each day via pumping stations. There are also two pumping stations on the east side of the Maas-Waal Canal. They are turned on in wet periods (Waterschap Rivierenland, n.d.).

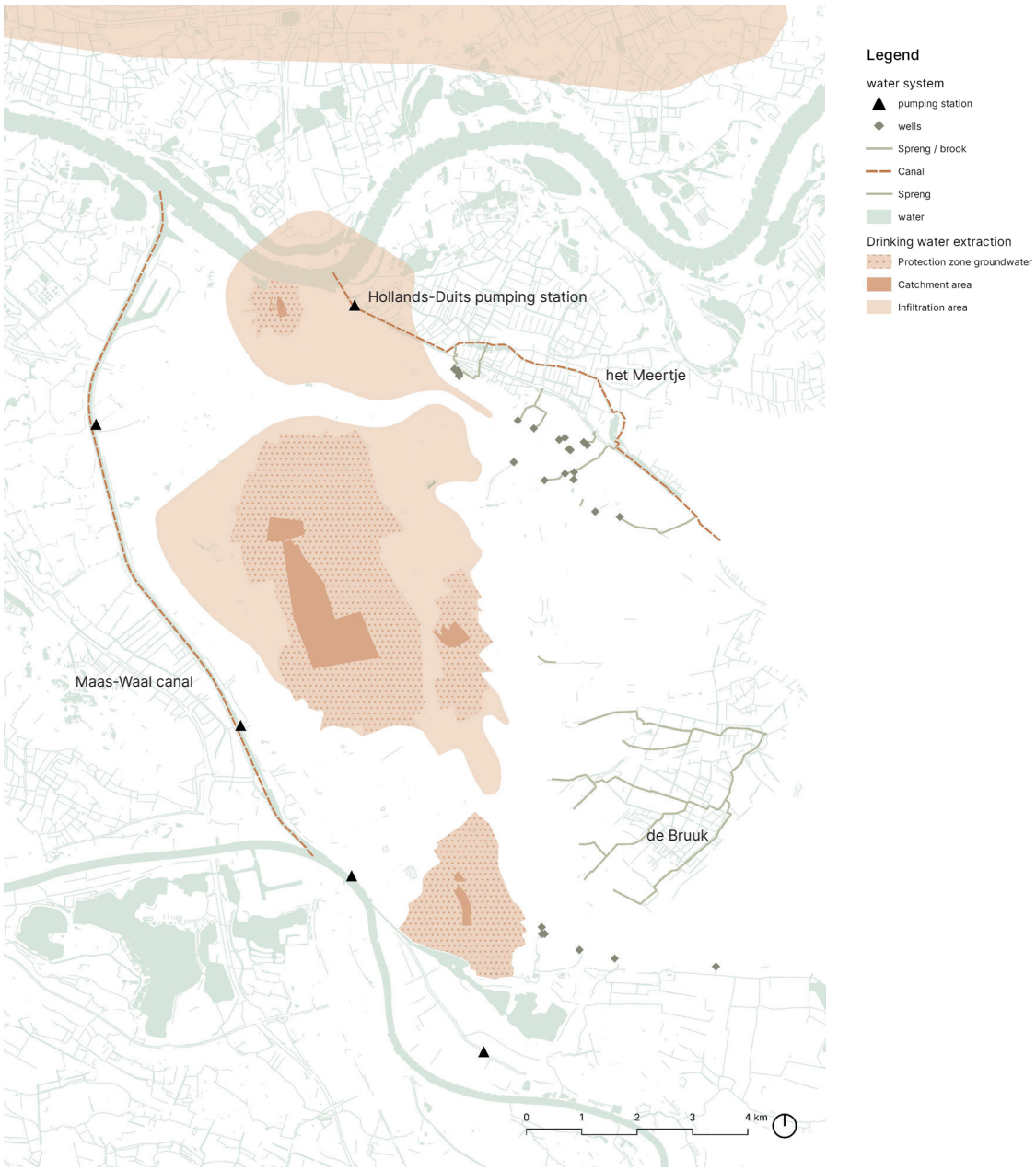


Figure 6.3 Water system

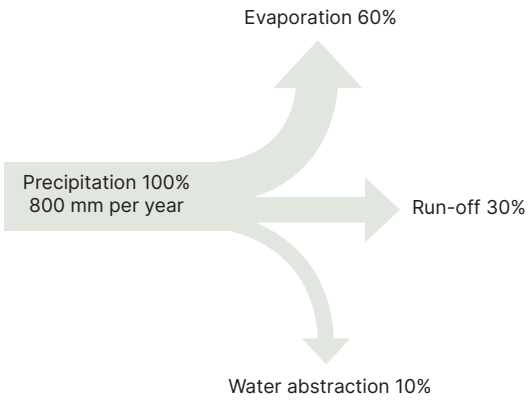


Figure 6.4 Flow chart moraine landscape (H+N+S, 2020)

6.1.5 Water flowchart

The flow chart shows how much water enters the area and how it leaves the area (fig. 6.4). The flow chart is based on a research and illustration of H+N+S for another moraine landscape in the Netherlands, the Sallandse Heuvelrug. Most water leaves the area through evaporation. 30% of the water leaves the area through drainage and run-off.

Figure 6.5 Forest logging forst Groesbeek (Santen, 2019)

6.2 Wood supply

Since humans started to live in the landscape, the forest has been used as a wood supply. Present day, Staatsbosbeheer manages this for a large area of the moraine.

Forest Groesbeek is a multifunctional forest in which nature protection, recreation and logging are combined. The forest is characterized by old beech lanes and rhododendrons. There are multiple reasons for logging. The first one is for creating space by removing trees so other trees can grow. In this way, trees get more space and light so they can better develop. Secondly, they aim to renew the forest to make it more resilient through multiple species and different ages. Forest Groesbeek is divided up into 4 working areas. Every year they harvest wood in one of the working areas in a fixed order. So every 4 years they harvest in each working area (Santen, 2019).

Staatsbosbeheer does the harvest in three ways:

Dunnen: Some trees are selected as 'future trees' and are allowed to stay. Surrounding trees will be removed.

Uitkap: Harvesting of the trees which are ready and old enough, with attention for the young trees which still need to further develop.

Groepenkap: All trees on a specific area will be harvested at the same time, in order to 'younger' this area of the forest.

The logging can cause unattractive views. The cut down of a forest plot due to 'groepenkap' leaves big empty spaces.

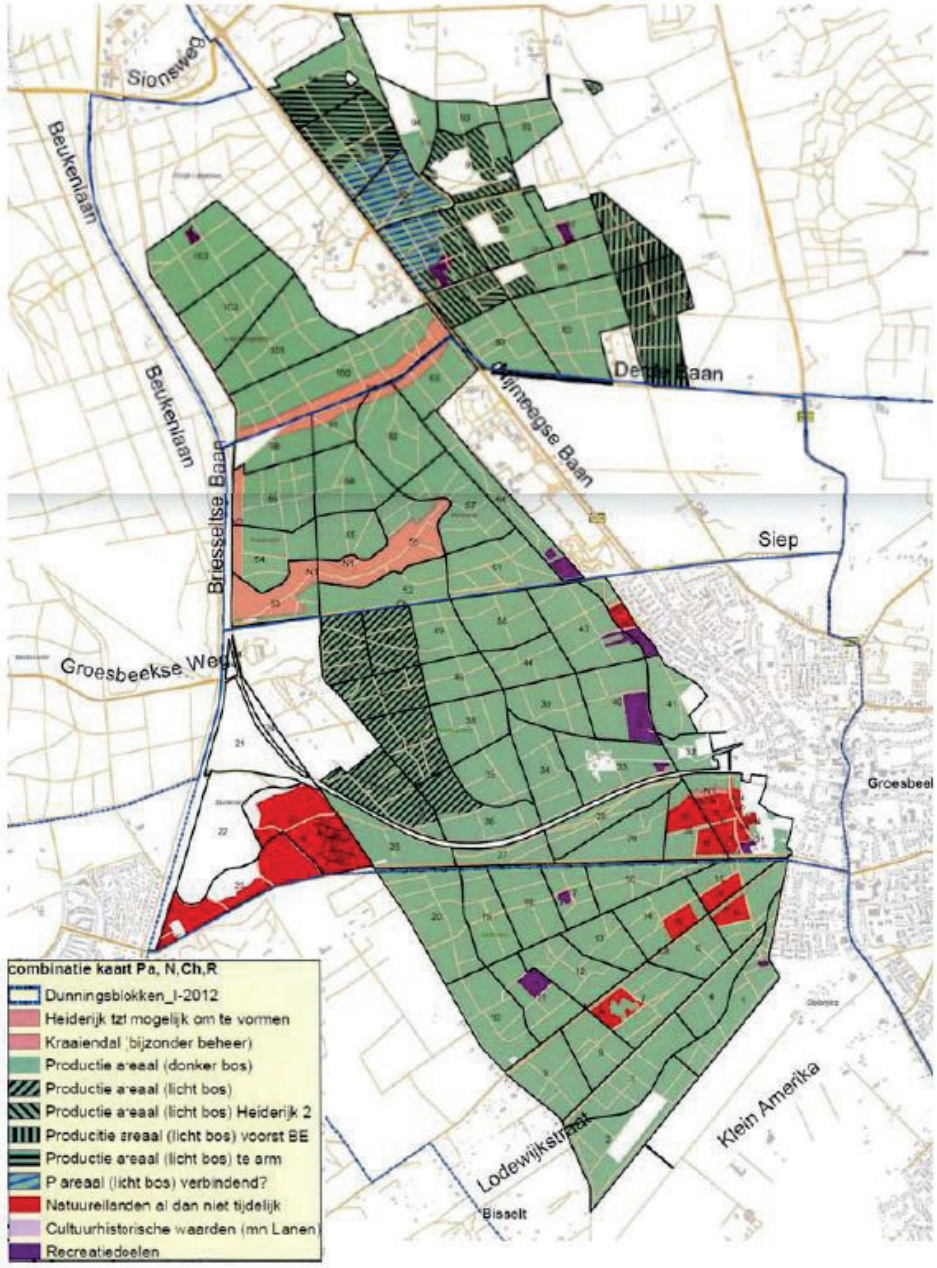


Figure 6.6 Working areas Staatsbosbeheer (Brinkhof, 2015)

6.3 Challenges and threats

6.3.1 Causes and effects

Drought has major consequences for people and nature. It is the result of a complex interplay of multiple causes and effects that are interconnected. It often takes some time before the impact of drought is visible or noticed. Damage can be the result of processes that have lasted for years. It is a complex problem in which the causes of an effect are not always clear to distinguish (Kennisportaal Klimaatadaptatie, 2022).

Kennisportaal Klimaatadaptatie (2022) has made a Droughtchain tool available to gain a better insight into the causes, the consequences and the mutual relationship of drought. It shows the problems within different sectors and areas. This instrument is used for the figure 6.7. Causes and effects for the moraine landscape are shown here.

... for industry and the energy supply, serious problems can arise due to a lack of cooling water. In addition, low water levels in the rivers can make shipping difficult (Kennisportaal Klimaatadaptatie, n.d.-b).

... an irrigation ban can be imposed for agriculture in times of drought. Lower crop yields and crop damage are the result (Kennisportaal Klimaatadaptatie, n.d.-b).

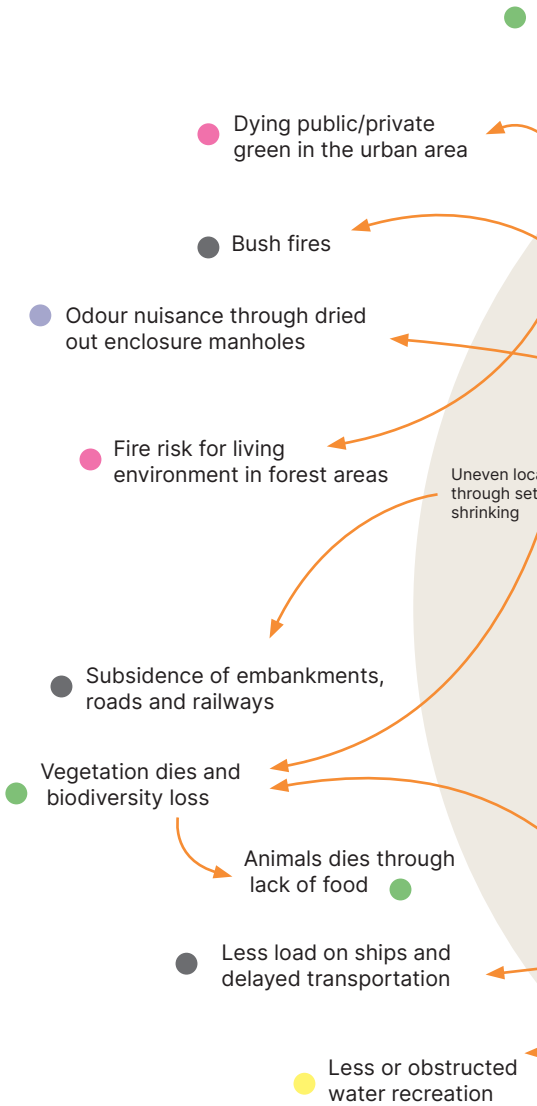
... for the built environment, drought damage can occur to (public) green spaces. In addition, management and maintenance costs may increase (Kennisportaal Klimaatadaptatie, n.d.-b).

... moderate to major damage is caused to nature. Wells, streams and fens are hit the hardest. In addition, the risk of wildfires increases. Extreme weather conditions, such as intense or prolonged drought, lead to rapid changes in nature. There is death among plants and animals and it becomes more attractive to invasive species. Due to the heavy pressure that nature is currently undergoing, nature has become much more vulnerable (Kennisportaal Klimaatadaptatie, n.d.-b). Due to the changing climate, the habitats of species are shifting. Cold-loving species give way and shift north. They will be replaced by heat-loving species from the south (Leenaers, 2021).

... for water quality, drought leads to a decrease. There is an increase in blue-green algae, botulism and fish mortality. When it is warm in combination with little to none water flows, the water quality deteriorates. Bacteria get into the water causing botulism. Birds and fish get poisoned and die. In addition, the higher temperature of the water causes the growth of blue-green algae and oxygen deficiency. People and animals get sick, fish die and the water starts to stink (Rijkswaterstaat, n.d.).

... for flood risk management, drought on the moraine has no direct influence. However, due to climate change, the chance of downpours in summer is increasing. Dry soils are less able to absorb water, which increases the risk of flooding. Higher groundwater levels on the flanks of the moraine are also possible because the winters in the Netherlands are becoming wetter.

The damage caused by drought depends on the condition of the soil and water system. A healthy soil and water system sustains less damage than a system that has already been damaged which makes it vulnerable (van den Eertwegh et al., 2021).



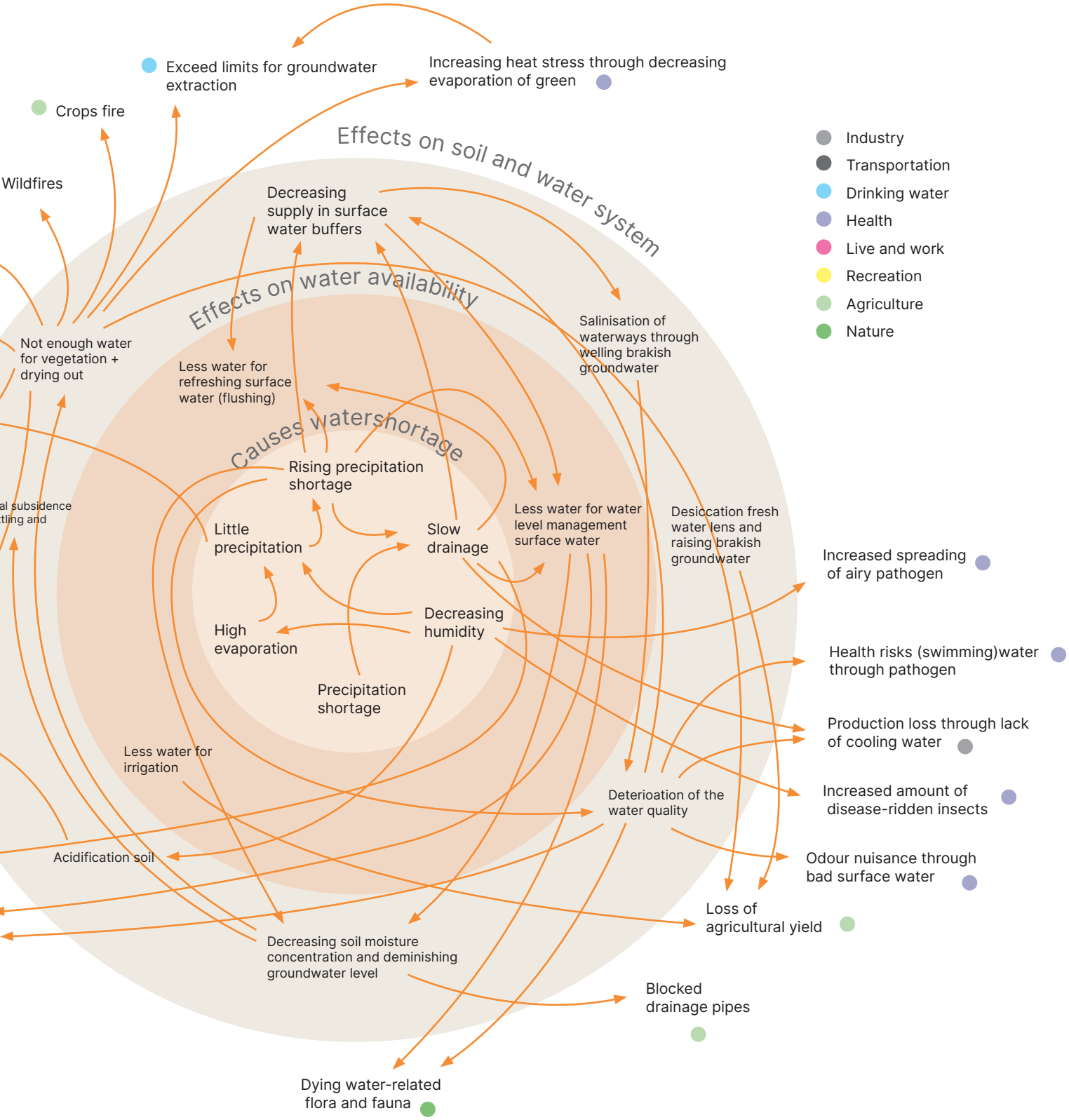


Figure 6.7 Causes and effects drought and their mutally correlation in the moraine landscape (Kennisportaal Klimaatadaptatie, 2022)

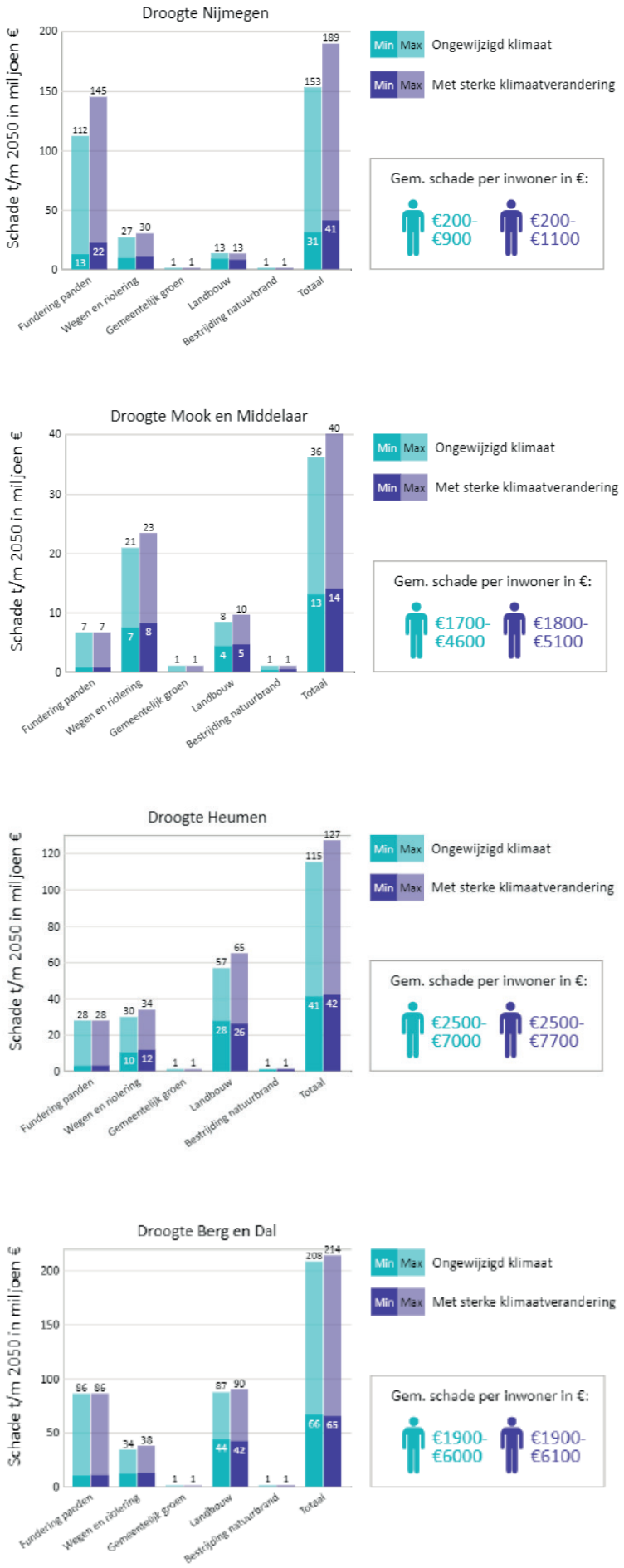


Figure 6.8 Costs drought municipalities moraine (NKWK, 2022)

6.3.2 Climate damage estimation

The tool Klimaatschadeschatter from NKWK (2020) has made an estimate of the damage costs for the following two situations for the period 2018-2050:

1. An estimate of the damage costs if the current climate were to remain the same until 2050. This will probably not happen, but we show this situation to make the impact of climate change more visible.
2. An estimate of the damage costs if the climate changes significantly: the WH scenario.

The four different graphs show the damage costs for drought for the four different municipalities of the moraine. The numbers indicate the lower limit, because it does not include all damage costs. The acutal damage costs will be higher. The tool has currently taken into account:

- Lower crop yields
- Increased risk of wildfires/roadside fires
- Increase in damage and higher costs due to maintenance of infrastructure and built environment

6.3.3 Effects on nature

Natuurmonumenten et al. (2020) have made an inventory of the consequences of the drought of 2020 for the species that also occur in the moraine landscape of Nijmegen. This shows:

- There were water shortages in stream systems and (seepage) water dependent habitats. Damp meadows and blue grasslands had a hard time. As a result of the drought, marine life died and special water-bound species such as brook lamprey, burbot and amphibians such as tree frog, garlic toad, great crested newt and midwife toad were under pressure.

- Death and weakening of forests. This is not only due to desiccation, other factors such as tree diseases (including typesetter) and nitrogen deposition also play a role. Tree species that fall under this category are species such as Norway spruce, Scots pine and (old) oak and beech. In addition, there is also the death of young planted trees.

- damage to heathland or even death. A number of herbs, on the other hand, do well.

- damage to reptiles due to drought is difficult to estimate.

- drought has a major impact on butterfly species. Silver moon, heather blue, moor butterfly and comma butterfly. Water-bound insects such as dragonflies are vulnerable.

- also impact on soil life such as bacteria, fungi, worms, etc.

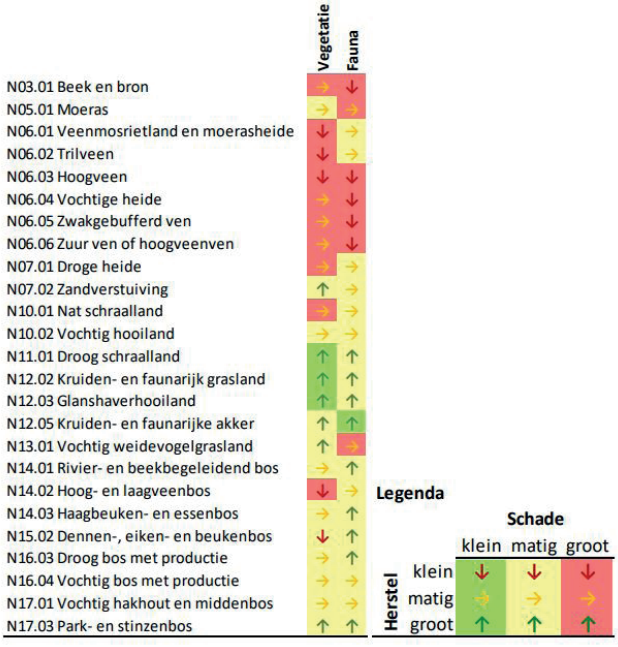


Figure 6.9 Effects of 2018 and 2019 on nature types (Witte et al., 2020)

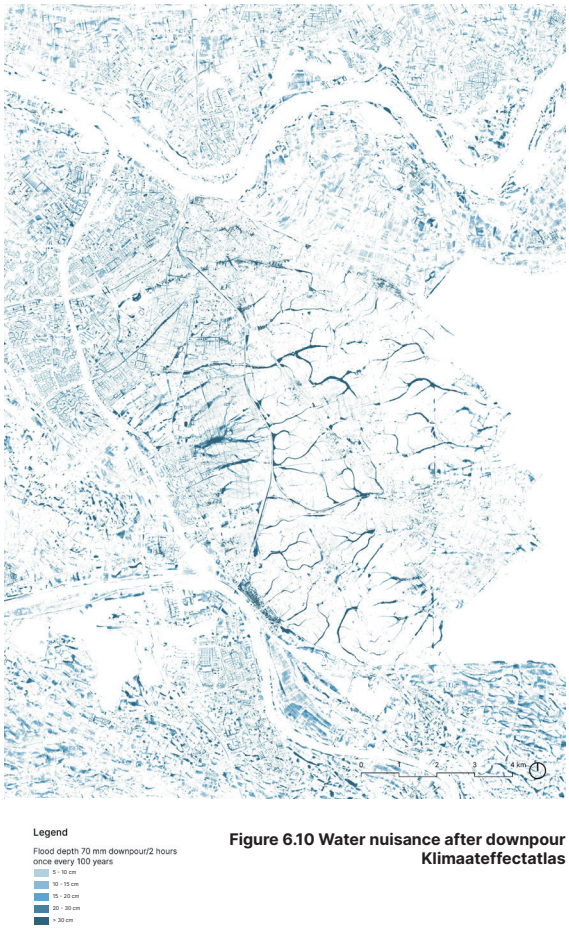


Figure 6.10 Water nuisance after downpour Klimaateffectatlas

6.3.4 Moraine of Nijmegen

The klimaateffectatlas by Rijk van Maas en Waal (n.d.) describes the following problems for the Nijmegen moraine because it is becoming drier:
- wildfires
- desiccation (wet) nature
- soil erosion

Prolonged drought increases the risk of wildfires. The forest of the moraine is vulnerable to this, particularly the evergreen plots. Besides, the evergreen worsen the desiccation. Because of the density, less rainwater reaches the ground. Secondly it has a high evaporation degree. In comparison to deciduous trees which lose their leaves in winter, evergreen keep their needles so the evaporation is higher. The average amount of precipitation which reaches the ground is 400 mm a year. This causes a lower water availability. But not only worsen the evergreen drought, they worsen the deposition of fertilizers too. They catch air pollution twice as efficiently as deciduous trees (NABU-Naturschutzstation e. V. & Werkgroep Milieubeheer Groesbeek, 2007).

The desiccation creates an increased risk for flora and fauna in both urban and rural areas. Wet nature areas such as the Bruuk are the most vulnerable due to the lower water levels. However, there are also plant and animal species to which this threat does not apply. In the long term, the desiccation also poses a risk to water extraction in the area (Rijk van Maas en Waal, n.d.).

Soil erosion is a problem that regularly occurs on the moraine. It is a natural and geological phenomenon in which the top layer of the soil is washed away or blown away by (rain) water or wind. Bare soils erode the hardest. The connection of the following factors lead to soil erosion: steep slopes, climate characteristics (long dry period followed by heavy rainfall), land use, land cover patterns and natural disasters (forest fires). More frequent prolonged drought therefore increases the risk of soil erosion (Atlas Natuurlijk Kapitaal, 2013).

Soil which is dried out can absorb less water than normally. As a result, water flows away. For the moraine landscape of Nijmegen, water collects in the dry valleys during downpours, causing water and mud streams.

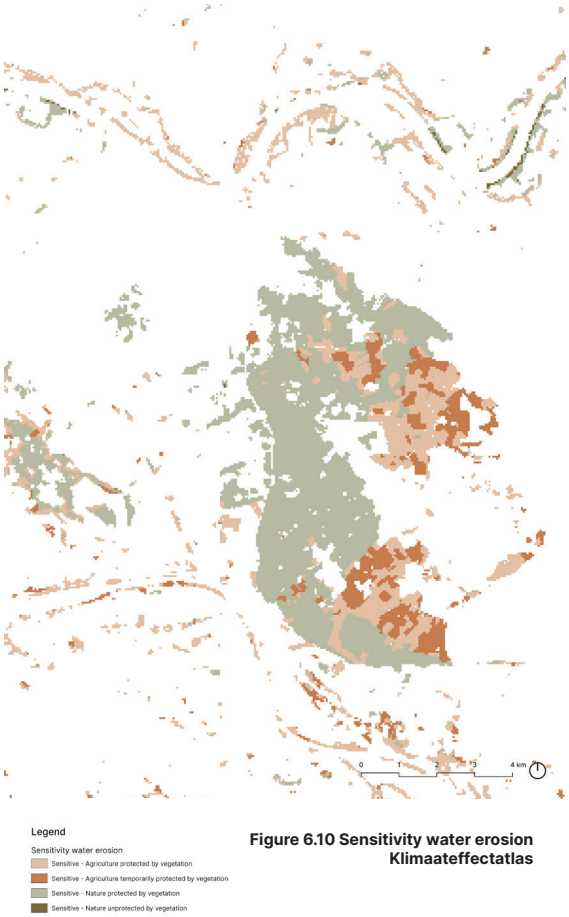


Figure 6.10 Sensitivity water erosion
Klimaateffectatlas

Figure 6.11 Risk droughtstress
Klimaateffectatlas

Figure 6.12 Drough sensitivity wet nature
Klimaateffectatlas

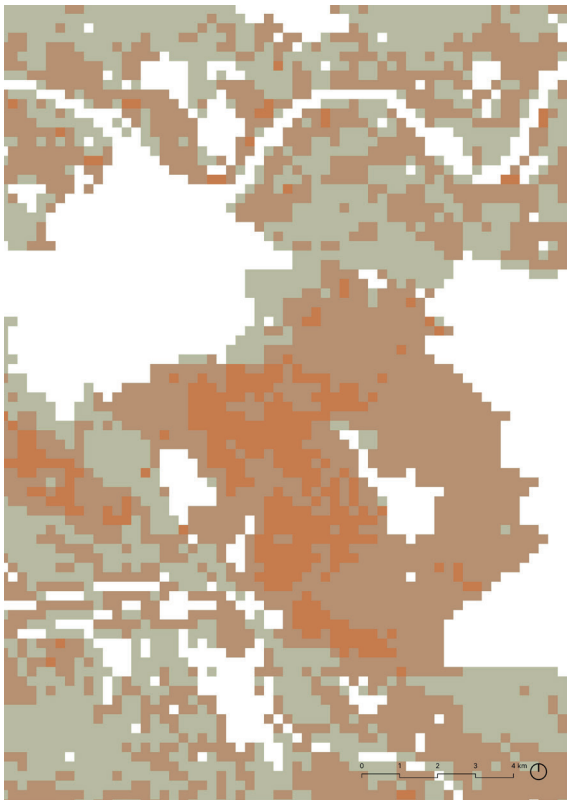


Figure 6.13 Sensitivity wildfires
Klimaateffectatlas

Figure 6.15 Duivelsberg
From https://indebuurt.nl/nijmegen/genieten-van/mysteries/mysterie-opgelost-hier-aan-dankt-de-duivelsberg-zn-onheilspellende-naam~77763/

Figure 6.14 Sint-Jansberg
From https://www.vakantiebijmeeussen.nl/nl/bijzonder/wandelen/sintjansberg/

Figure 6.16 de Bruuk
From https://www.staatsbosbeheer.nl/wat-we-doen/werk-in-uitvoering/rijk-van-nijmegen-natuurherstel-bruuk

Figure 6.17 Mookerheide
From https://www.natuurmonumenten.nl/natuurgebieden/mookerheide

6.4 Values

6.4.1 Nature reserves

The moraine of Nijmegen has a lot of beautiful nature. It functions as a natural gem in the region. The seepage water creates special nature, such as the natura2000 area de bruuk with its blue grasslands, swamp brush and orchids. In addition, you have the Sint-Jansberg, which is known for its many slopes, swamps and fields. De Duivelsberg consists of an old deciduous forest where many different plant species and breeding birds can be found. You will find springs or sprengen at both the Sint-Jansberg and the Duivelsberg. Finally, there is also the mookerheide with heathland. The moraine is part of the ecological corridor for red deer moving between the Oostvaardersplassen, via the Veluwe, and Germany.

6.4.2 Recreation area

The moraine is a popular recreation area for the surrounding villages and towns. There are many walking and cycling routes. In addition, the area is known for the Vierdaagse every year. On the moraine you will find various museums, campsites and there is also a play forest.

6.4.2 Health care

On the moraine you will find many care institutions that are part of the identity of the area. Nijmegen has an academic hospital, the Radboudumc. One of the locations is in the Dekkerswald.

References

Atlas Natuurlijk Kapitaal. (2013, May). Erosie. Rijksoverheid. https://www.bodemambities.nl/sites/default/files/2018-04/Factsheet%2520Erosie.pdf

Brinkhof, H. (2015, June). Houtkap in het Groesbeeks bos. In Groesbeeks Milieujournaal. Werkenrode. Retrieved July 12, 2022, from https://wmg-groesbeek.nl/milieujournaal/Milieujournaal159-160.pdf

Brinkhof, H. (2009, November). Water op de stuwwal van het Nederrijk. Werkenrode. https://www.wmg-groesbeek.nl/milieujournaal/Milieujournaal137.pdf

van den Eertwegh, G., de Louw, P. G. B., Witte, J. P., van Huijgevoort, M. H. J., Bartholomeus, R. P., van Deijl, D., van Dam, J. C., Hunink, J., America, I., Pouwels, J., Hoefsloot, P., & de Wit, J. A. (2021). Droogte in de zandgebieden van Nederland: Effecten op en oplossingsrichtingen voor natuur, landbouw en het bodem- en watersysteem. https://edepot.wur.nl/560629

H+N+S. (2020, July 28). Eeuwige bron: vasthouden van het neerslagoverschot in het gebied [Illustratie]. H2Owaternetwerk. https://www.h2owaternetwerk.nl/h2o-actueel/vitens-zoektocht-naar-de-eeuwige-waterbron

Kennisportaal Klimaatadaptatie. (2022, April). Droogteketen. Retrieved 30 April 2022, from https://klimaatadaptatienederland.nl/thema-sector/droogte/gevolgen-toenemende-droogte/droogteketen/

Kennisportaal Klimaatadaptatie. (n.d.-b). Wat zijn de gevolgen van toenemende droogte? Retrieved 30 April 2022, from https://klimaatadaptatienederland.nl/thema-sector/droogte/gevolgen-toenemende-droogte/

NABU-Naturschutzstation e. V. & Werkgroep Milieubeheer Groesbeek. (2007, oktober). Toekomstvisie Ketelwald. In Ketelwald. Bureau Centaurea. Geraadpleegd op 20 juli 2022, van https://www.ketelwald.de/Download-Dateien/Toekomstvisie_Ketelwald-A4kl.pdf

Natuurmonumenten, LandschappenNL, & Wereld Natuur Fonds. (2020, May 18). Terugblik op de droogte van 2020. Natuurmonumenten. Retrieved June 9, 2022, from https://res.cloudinary.com/natuurmonumenten/raw/upload/v1598532801/2020-08/TerugblikDroogte2020_0.pdf

NKWK. (2020, December). Schade door wateroverlast, hitte en droogte. Klimaatschadeschatter. Retrieved 5 May 2022, from https://www.klimaatschadeschatter.nl/

Rijk van Maas en Waal. (n.d.). Klimaateffectatlas Rijk van Maas en Waal. Arcgis. Retrieved 2 May 2022, from https://climadapserv.maps.arcgis.com/apps/MapSeries/index.html?appid=141dc8934ba849cfb1dac8e8da5a94e3

Santen, B. L. van. (2019, September 27). Houtoogst in het Groesbeekse bos. Rivierengebied. Retrieved September 29, 2022, from https://www.boswachtersblog.nl/rivierengebied/2019/09/27/houtoogst-in-het-groesbeekse-bos-2/

Thissen, J. (2009, November). Grondwaterafhankelijke flora en fauna in en rond het Ketelwald, vroeger en nu. Werkenrode. https://www.wmg-groesbeek.nl/milieujournaal/Milieujournaal137.pdf

Waterschap Rivierenland. (n.d.). Streefpeilenplan Groesbeek & Ooijpolder. Retrieved 4 May 2022, from https://www.waterschaprivierenland.nl/streefpeilenplan-groesbeek-ooijpolder

Images

Vereniging Geopaden Stuwwal. (n.d.). Geologie. Geopaden. Retrieved 4 April 2022, from https://geopaden.nl/portal/stuwwal/index.php/nl/geologie

Witte, J. P. M., D. Van Deijl, & G. A. P. H. Van den Eertwegh, 2020. Gevolgen voor de natuur van de droge jaren 2018 en 2019; resultaten van een enquête onder deskundigen. Deelrapport van het project: Droogte in zandgebieden van Zuid-, Midden- en Oost-Nederland. FWE & KnowH2O, Oosterbeek.

7

DESIGN

7.0 DESIGN

7.1 Desired future

The desired future is a moraine landscape which is resilient to water shortages in the Netherlands in 2050. In this landscape, coexistence of multispecies and their relation to the landscape has been taken into account in spatial planning on several scales.

7.2 The concept

The soil and water system of the moraine functions as the base for the design to deal with the lacking water quantity and enhance the spatial quality of the environment. Therefore, the water fluxes function as primary design tools to propose the required shift in the current spatial planning.

The design will be developed through the implication of landscape elements which are either derived from the Lo-TEK lexicon or the outcome of cultural historic research. Together they form a landscape system. The landscape system experiences regular change throughout the year (seasons) and through the weather (downpours). The time span of the design is from present until 2050. The design consists of urgent interventions of immediate necessity, and secondary interventions which derive from these.

The first part of design considers the whole moraine landscape and is a set of design strategies for climate resilience. The strategies are either applicable to spatial planning or water use. Accordingly the design zooms in on forest Groesbeek, located at the top of the moraine. This meso scale refers to the location which has been concluded in chapter 6 as strongly threatened by drought. Here, the design strategies are translated into site-specific interventions. Together they form a landscape system. This new layer of the landscape responds to the natural layer of the moraine. The landscape system catches the runoff allowing water to circulate in the area. At the same time, it provides ecological enrichment by generating food, safety and connection for flora and fauna. Furthermore it strengthens the recreational character as extension for the surrounding urban areas through the development of a sport route and cultural hub.

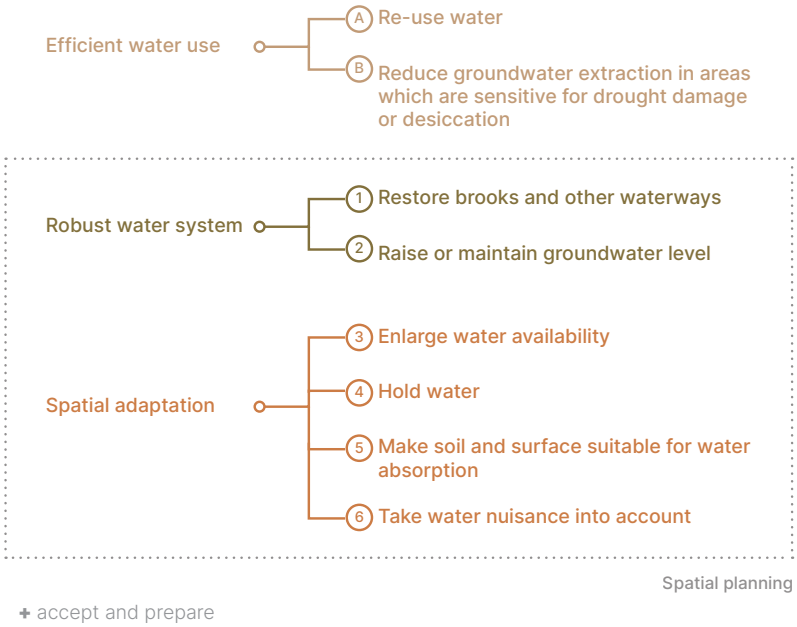
The design establishes relations on several scales. The first relation is on the national scale. The moraine is part of an ecological corridor and functions as a link between the Oostvaardersplassen in the Netherlands and the Reichswald in Germany. Through the implementation of the landscape system, some parts of forest Groesbeek have become more quiet, providing silent areas for fauna. This improves and contributes to the quality as a stepping stone.

The second one is on the province scale. Forest Groesbeek provides a new connection between the surrounding urban areas through its new function as a sports park. Furthermore the relation between the urban areas and forest Groesbeek gets strengthened. The forest no longer only acts as a source for water and wood, it also helps to mitigate climate effects regarding drought and water nuisance. For example the reduced risk of wildfires or the prevention of water and mud streams in (sub)urban areas.

The last relationship is between multispecies. The landscape system allows coexistence and combines different needs.


Oostvaardersplassen
Forest Groesbeek
Reichswald
0
5
10
15
20 km


Nijmegen
Beek-Ubbergen
Berg en Dal
Malden
Forest Groesbeek
Groesbeek
Heumen
Molenhoek
Breedeweg
Mook
Plasmolen
0
1
2
3
4 km



7.3 The climate adaptive moraine: design strategies

The climate adaptive moraine is established through the implementation of a set of design strategies developed by Ministerie van Infrastructuur en Waterstaat (2022). They are either applicable to spatial planning or water use. The strategies contribute to three different approaches: robust water system, spatial adaptation and efficient water use.

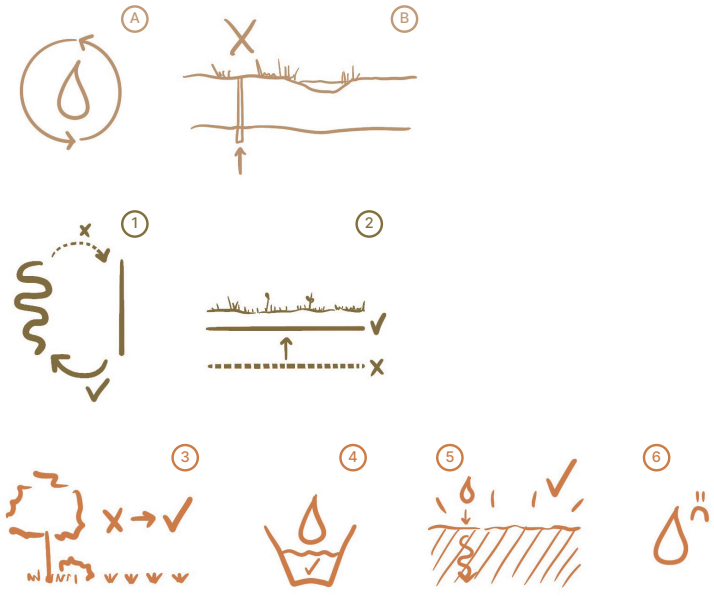


Figure 7.1 Strategies


6
A
5
5
1
2
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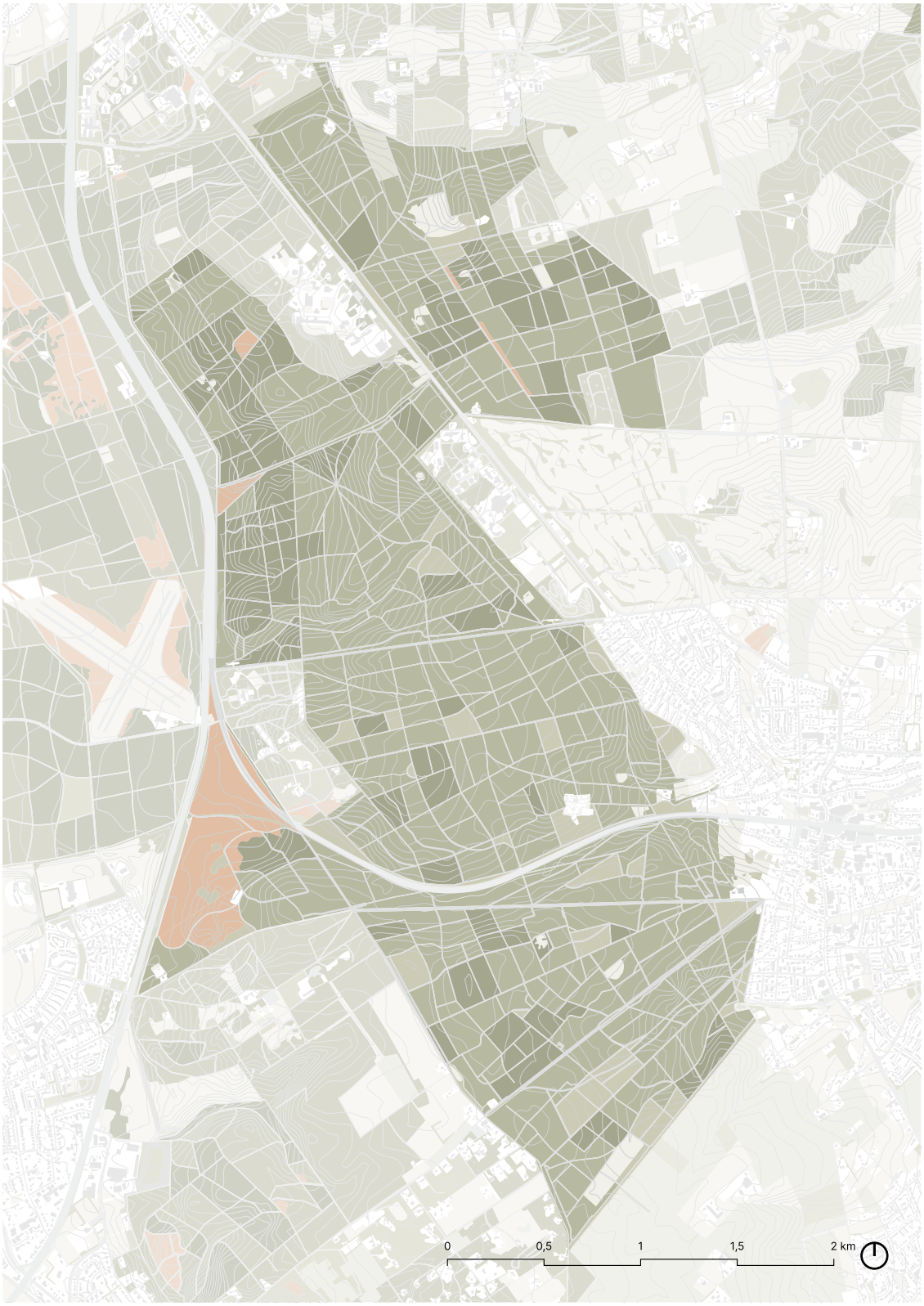
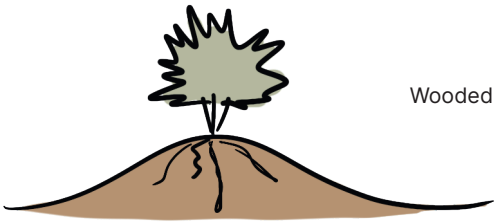
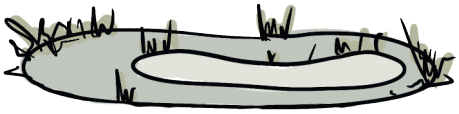
2
4
3
B
5
1
5
2
5
1
5
2
5
0
1
2
3
4 km


0
0,5
1
1,5
2 km
Legend
Cropland
Mixed forest
Decidious forest
Evergreen forest
Grassland
Heathland
Building

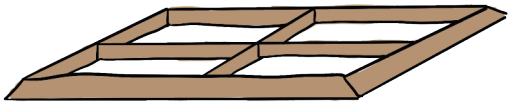


Wooded bank

Amphibian pond



Micro basins



7.4 Forest Groesbeek

The area Forest Groesbeek from Staatsbosbeheer located on top of the moraine is the location the design focuses on. First, as concluded in chapter 6, this area is strongly threatened by drought through the combination of risks of wildfires, desiccation and erosion. The Regional Adaptation Strategy has put the dry forests of the moraine for this reason high on the agenda. Second it is the infiltration area for seepage of groundwater dependent nature below the moraine. Wet nature, such as the Bruuk, experiences the most (irreversible) damage after a long period of drought. Third, humans use the forest as a source for both water and wood, which means the degree of influence is high. Part of the forest is used for the extraction of groundwater by drinking water company Dunea. Staatsbosbeheer maintains the forest and cuts down a few hectares of wood every year, causing regular changes in the forest. Fourth, the forest has a lower ecological value in comparison to other forest areas such as Duivelsberg or St-Jansberg. The ecological value has the potential to increase.

4.7.1 Landscape system

The landscape system consists of wooded banks, amphibian pools and micro basins. Together they catch the rainwater which leaves the area now unused (runoff), so water starts to circulate in the area. The wooded banks and the micro basins fulfill another function. They also help to preserve the

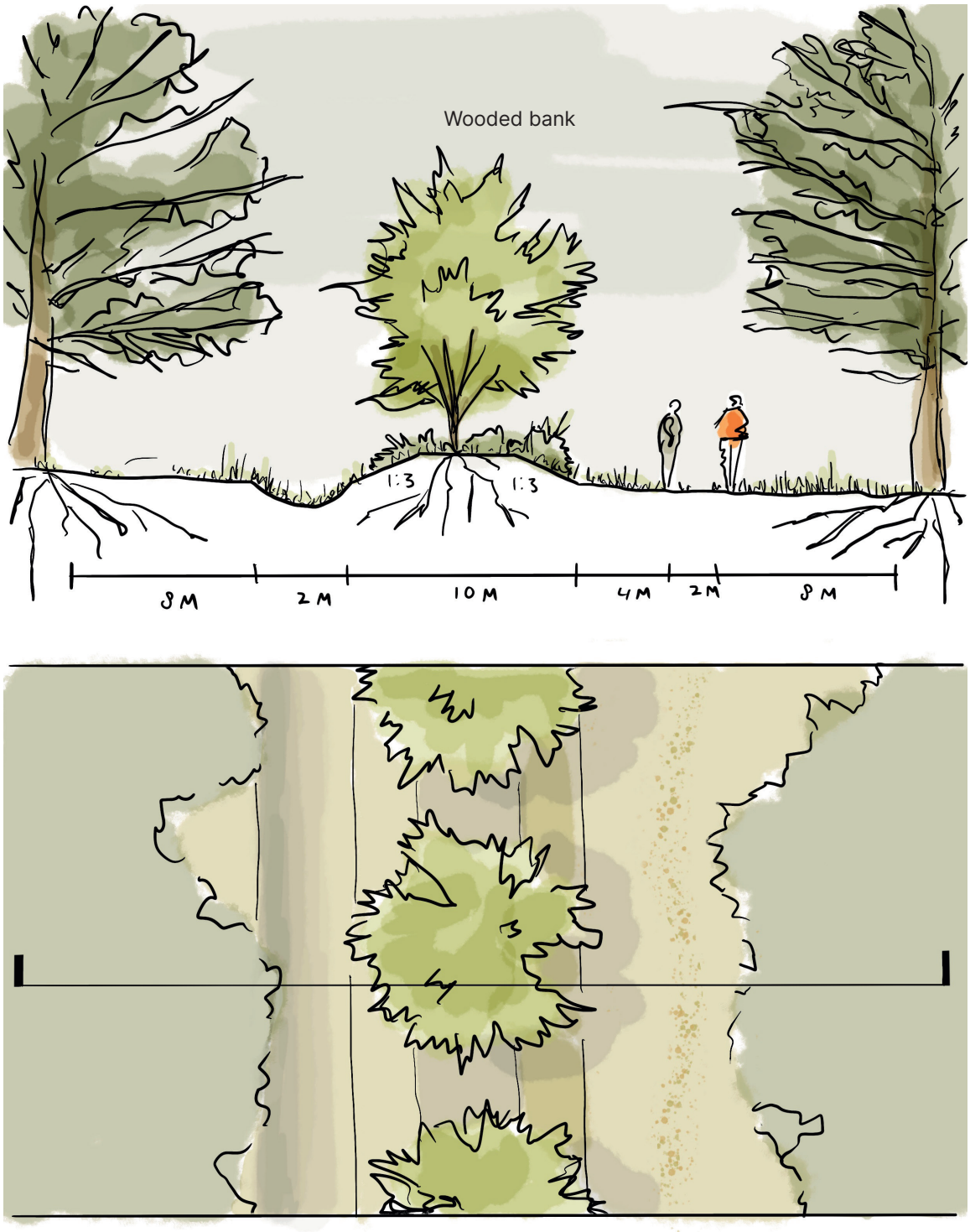


Figure 7.6 Section wooded banks

Wooded banks
The wooded bank is a common local landscape element. Before the invention of the barbed wire, wooded banks were used as enclosure for agricultural plots. It is composed of raised earth, covered with trees with horned branches. The tree species which are used for this are hawthorn (Crataegus), blackthorn (Prunus spinosa), elder (Sambucus nigra). The wooded banks are placed on the slope and follow the contour lines. They have a width of 10 meters. The wooded bank is established together with a ditch, so the catched runoff has time to infiltrate.

To realize the wooded banks, the surrounding forest is cleared to improve the growth conditions of the trees in the beginning stages. The degree of maintenance is low, since the wooded wall itself requires little to none maintenance. Growth of other species is desired to establish diversity. However, the area around the wooded banks need to stay open and this will be done through regular grazing.

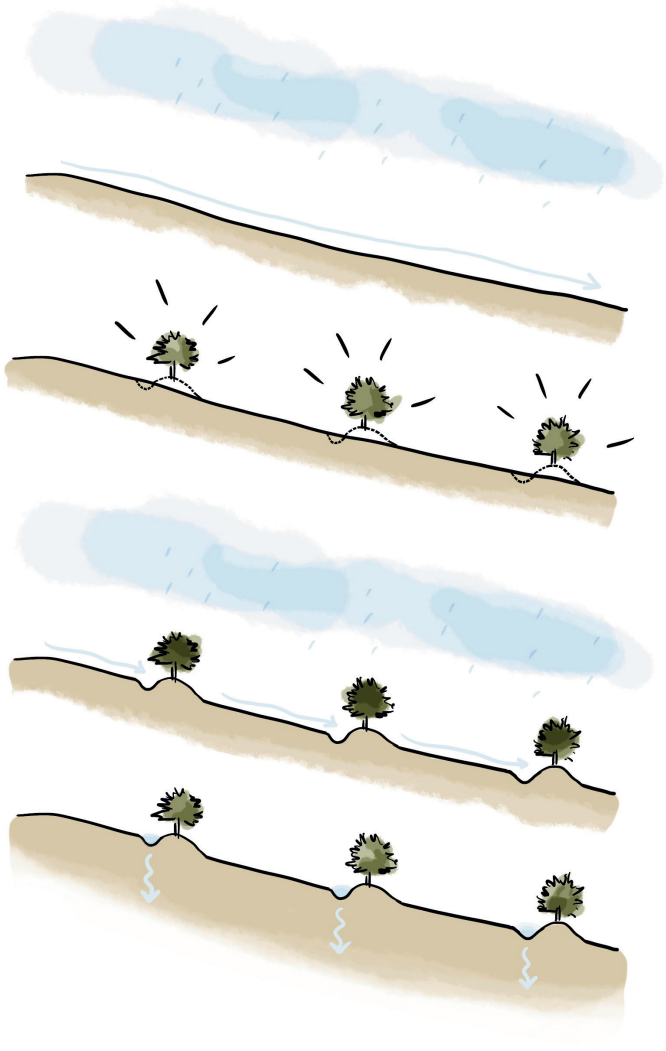


Figure 7.5 Wooded banks catch runoff

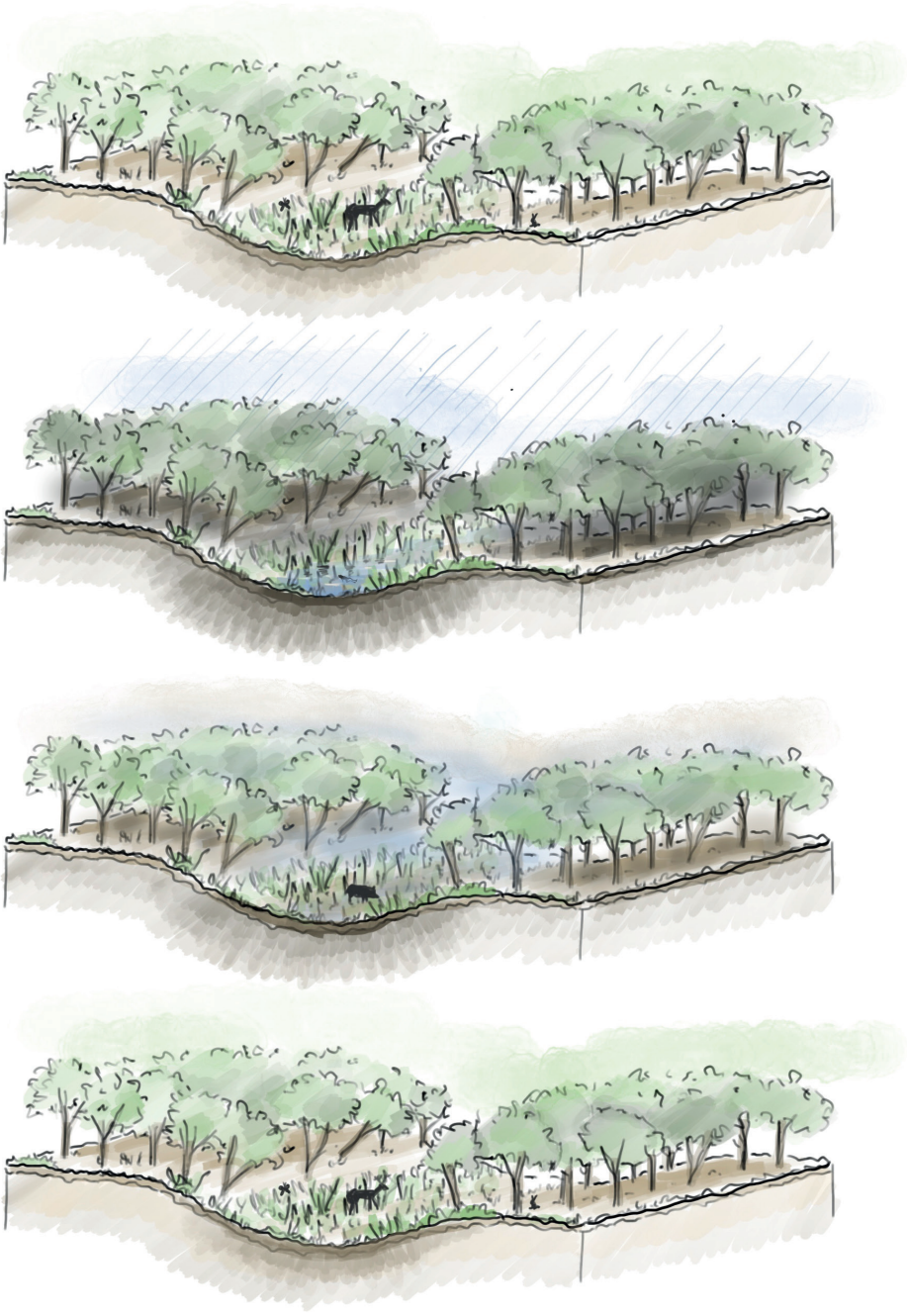
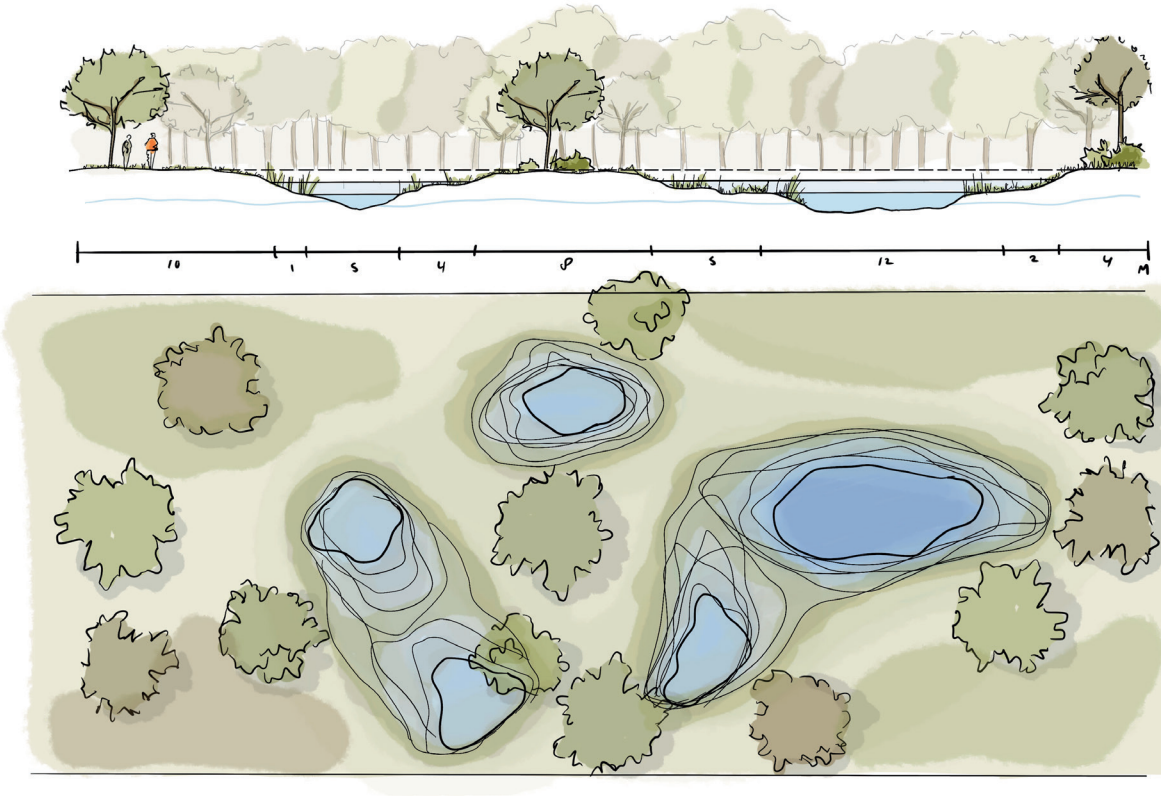


Figure 7.9 Cyclus pool before and after rain



Amphibian ponds

The amphibian ponds are created at the intersection of the wooded banks with the dry valleys. The presence of submerged earth moraines close to the surface, ensures a high water level. The topsoil will be excavated until it reaches the water level. As a consequence, the excavated hole fills with groundwater. The water supply in the ponds is either coming from groundwater flows, or rainwater.

The amphibian pond is composed of one big pond and a few smaller ones to provide resilience. It has a total surface between 200 and 500 m2 and the depth differs between 0,5 and 2 m. During dry periods, the smaller ponds will be dry, while the big pond has more chance to remain wet. In times of downpours or wet periods, the ponds will emerge. So throughout the year it brings different appearances, allowing both wet and dry conditions.

The maintenance of the ponds is low, but they are vulnerable to nitrogen deposition. If the ponds close through the nitrogen concentration, mowing and dredging is necessary. Around the ponds it needs to remain open for at

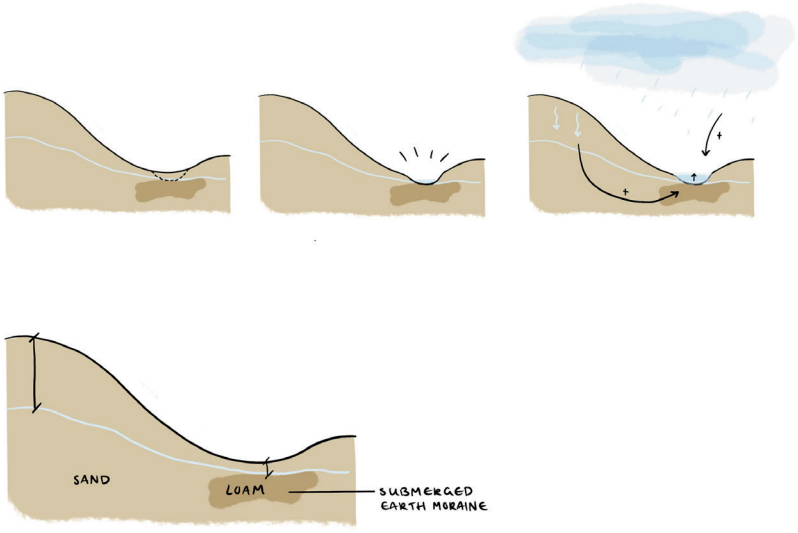


Figure 7.9 Supply pond via groundwater and rainfall

Figure 7.10 Microbasin with negarim for runoff reduction https://sswm.info/index.php/ar/sswm-solutions-bop-markets/improving-water-and-sanitation-services-provided-public-institutions-0/micro-basins

Runoff mirco basins

The annual logging of Staatsbosbeheer causes soil disturbance. This offers the possibility to create runoff micro basins. The technique is suitable for small scale tree-planted areas, so it matches nicely with the tree planting of Staatsbosbeheer after logging. Micro basins are low earth bunds in the shape of a diamond. The low earth bunds create a catchment area. Inside, rainwater is collected at the lowest tip of the diamond shape. The point where it is collected and infiltrates is where the trees are planted. The size of the catchment area can differ from 10 m2 to 100m2, depending on the type and amount of planted trees.

In this way, the logging of Staatsbosbeheer promotes and facilitates the new landscape system. It is important to notify that the contribution of the micro basins will be small, because it will be only a few hectares a year.

7.4.2 Evergreen forest

As concluded in chapter 6, the evergreen forest strengthens the drought effects and does not contribute to the desired future. Towards 2050, the amount of pine trees has to be strongly decreased. This can be mostly induced by the current logging policy of Staatsbosbeheer. However, the current percentage of evergreen in the forest is high and includes forest plots consisting purly of pine trees. Because the share of the pine trees is strong and determined, the pine tree process is accelerated through big scale clearance for some of these plots. This will be done at three locations. They are replaced with other nature types: heathland and meadow forests. They are nice examples of how humans can provide enrichment of nature through the realization of new ecosystems. These half natural biotipes have developed by long-term repeated human interventions, in this case grazing. They only exist due to humans and only remain with human's doing. Heathland and meadow forest have a more open character with low vegetation. In comparison to forest areas, the low vegetation needs less

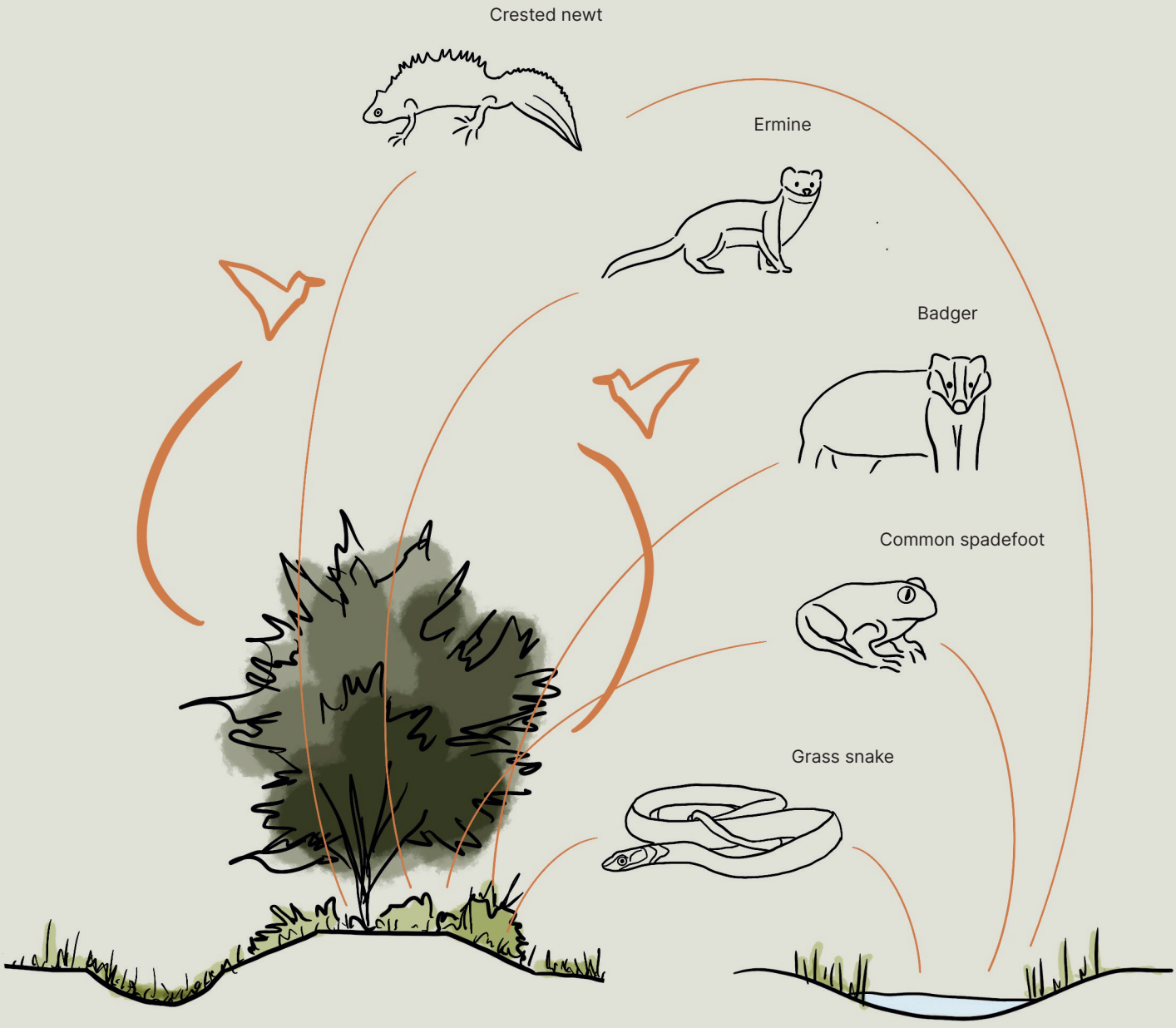


Figure 7.11 Ecosystem enrichment

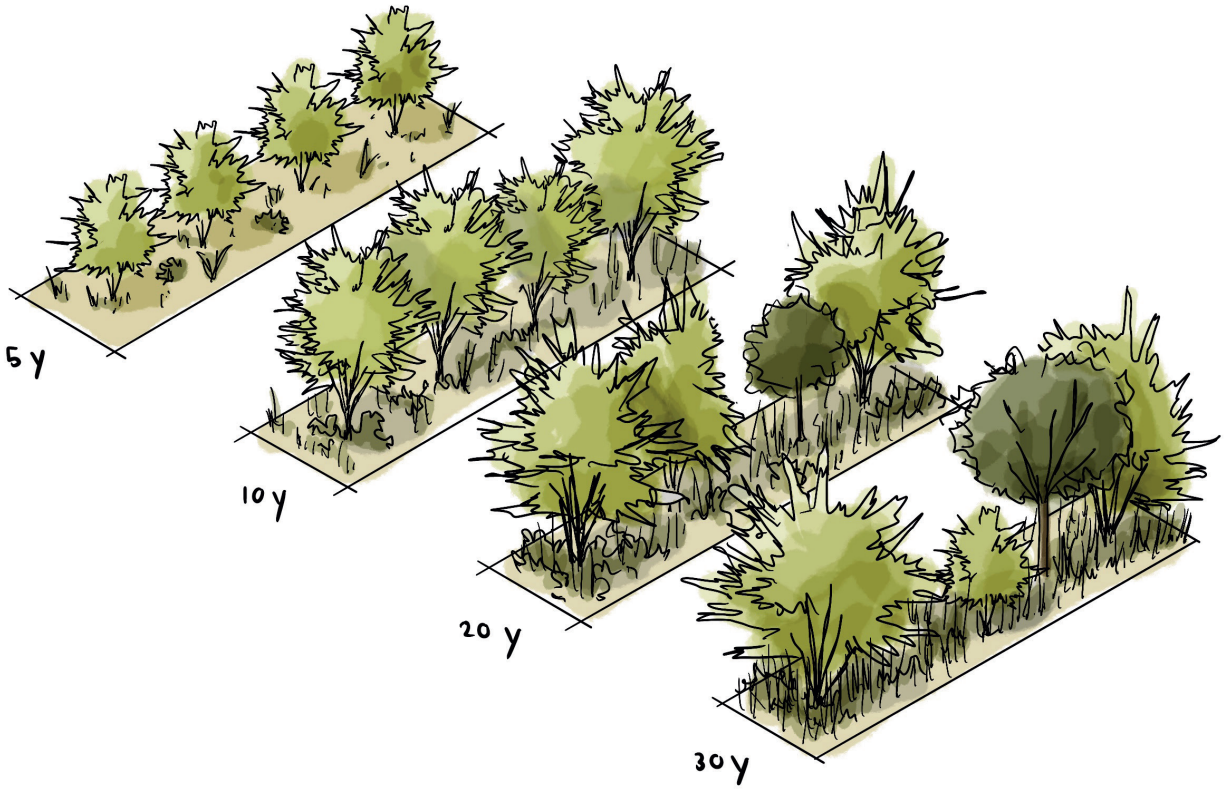


Figure 7.8 Development over time wooded banks

7.4.3 Landscape system x Ecology

While the main purpose of the wooded bank is to catch the runoff, it at the same time provides food and safety for five key species of the dry sandy landscape: the crested newt, the badger, the ermine, the common spadefoot and the grass snake. For the crested newt, common spadefoot and the grass snake it is necessary to connect the wooded banks with amphibian ponds.

Water structures like amphibian ponds are rare in the dry sandy landscape, and therefore valuable. Even more valuable is flowing water. For this reason, some ponds allow water to flow and let it infiltrate further down. These ponds, or so called sprengen, have a high ecological value.

The berries of the hawthorn are beloved among birds. It is the start of an exchange of seeds, causing diversity in both the wooded banks and the surrounding. So over time, the wooded banks will become more diverse and house other tree and plant species.

An additional positive side effect of the wooded banks is the development of silent areas. The current path structure is cut off at several points, making the criss cross walking through the forest no longer possible. As a result some areas become more quiet, which is beneficial for flora and fauna and contributes to the ecological corridor for red deers.

Despite the large areas with young forest as a result of the logging, some parts contain very old trees. In order to bring more balance to the forest, two areas which are seen as old become nature reserves.

Figure 7.12a Reference the Lint from Maximapark
https://www.west8.com/projects/maximapark/

Figure 7.12b Reference the Lint from Maximapark
https://www.ontdek-leidscherijn.nl/parels/het-lint/

7.4.4 Perception

The current recreation consists of pathways which make it possible to walk through the whole area. There are several routes, which stop at some of the cultural historic relics. Furthermore there is a 'play forest' for kids. In order to make the forest more attractive in terms of recreation, a new route will be established which makes it possible to cycle, skate and do other sports in the forest. The wooded banks function as backbone, and determine the course of the new sport route. A new sport route will provide a new way of experiencing the forest. It enhances the sport and health identity of the landscape.

Over the seasons, the wooded banks provide colorful changes. Especially during spring, when the hawthorn and blackthorn have white flowers. As a result, white ribbons penetrate the forest.

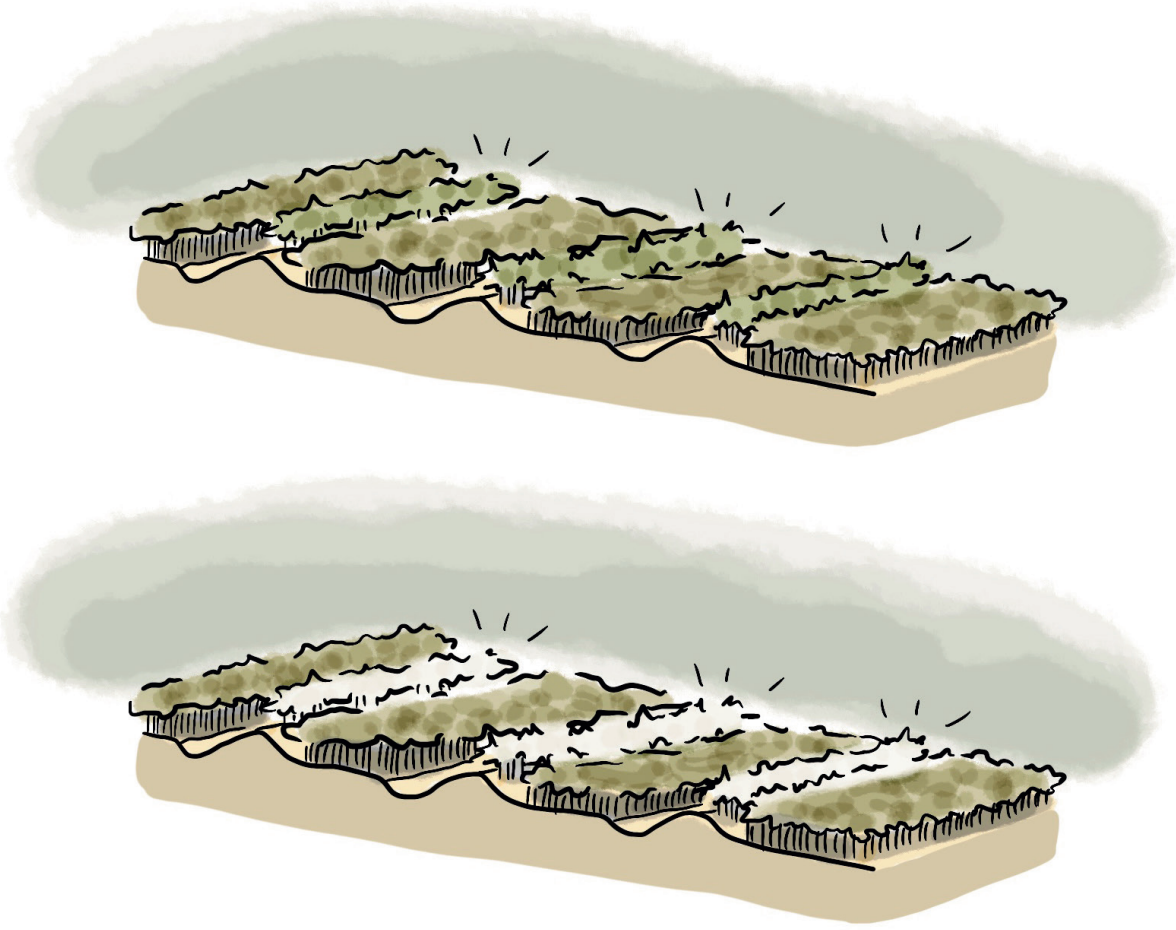


Figure 7.7 Wooded banks seasonal changes

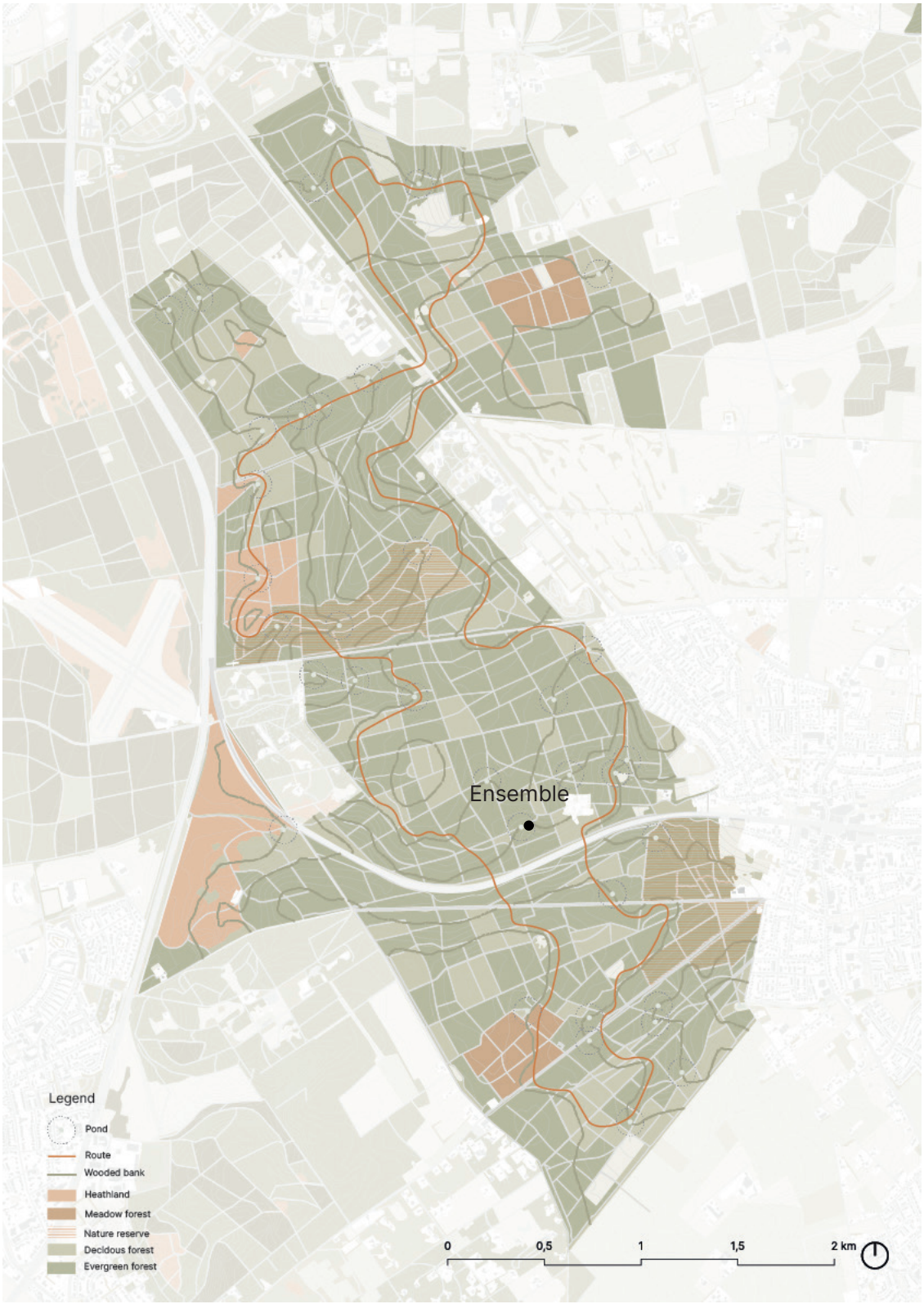


Figure 7.13 Masterplan

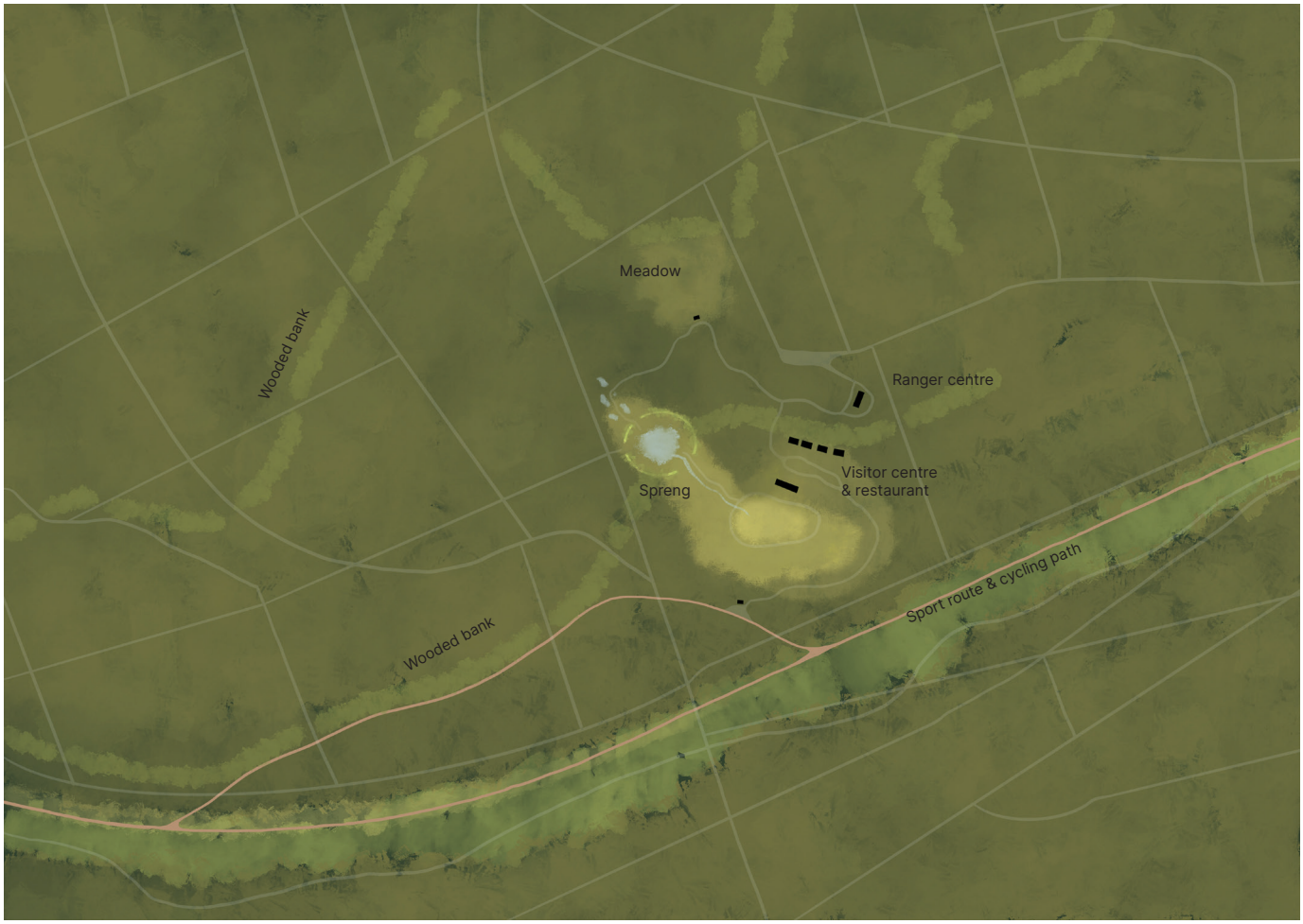


Figure 7.14 Plan ensemlbe

7.4.5 Ensemble

Through the increased recreation pressure, a new visitor center will be developed in the forest. The location is alongside a new side route of the existing cycling road, at the location of a former estate. Here, the culture and the landscape system come together.

References

Ministerie van Infrastructuur en Waterstaat. (2021). Deltaprogramma Zoetwater 2022-2027: Weerbaar tegen watertekorten in het Nederland van 2050. In Kennisportaal Klimaatadapatie. Rijksoverheid. https://klimaatadaptatienederland.nl/overheden/deltaprogramma-zoetwater/

8

SYNTHESIS

8.0 CONCLUSION AND REFLECTION

8.1 Conclusion

The graduation thesis started with the following research question: In what way can the landscape of the moraine of Nijmegen be adjusted and used to generate a climate adaptive landscape and achieve enrichment of the local ecosystem?

Through the application of a new landscape system consisting of wooded banks, pools and micro basins, the water supply will increase. The walls and mirco basins catch the runoff and prevent at the same time water and mud streams. The landscape sytems provide food and savety for 6 key species of the dry sandy landscape: the crested newt, the ermine, the badger, the common spadefoot and the grass snake. At the same time, a new sport route 'rondje stuwwal' will be connected to the walls. It enhances the walking and sporting identity of the place. While the walls guide the routes and its users, the walls function at the same time as a barrier. As a result some areas of the forest become more isolated, which is beneficial for nature and supports the movement of red deers through the forest. The landscape system works as a multifunctional structure, providing resilience for drought, ecological enrichment and added value to humans.

8.2 Reflection

One of the lessons I learned during my master's is that the landscape architect designs for humans, flora and fauna, the landscape itself and the client. Given this inner essential part, the landscape architect functions as a spokesman for the silent users of the landscape in the domain of the built environment. In comparison to the other departments within the greater field, landscape architecture inherently goes beyond the prevalent interests of humans. The landscape architect acts as an agent of the landscape, which is now a more urgent matter than ever concerning the age we live in.

Because landscapes deteriorate. The oceans are full with plastic, the atmosphere full of CO2 and there is a great extinction of species. The present age, the Antropocene or so called Age of Humans, thanks its name to the increasing influence humans have on both earth and atmosphere which has become irreversible. The consequences for the world happen at an ever-increasing pace. They show that the time has come to adapt our way of living and take responsibility. Because the other side of this story of destructing, indicates the ability to change and turn these processes. Working in the domain of the built environment and spatial planning means I can have direct influence on this transition. As a landscape architect I want to utilize my position and contribute to this livable future.

I chose drought as the topic of my graduation thesis because it is a good example of how we as humans cause deterioration of the landscape. Climate change makes us realize that the present spatial planning in the Netherlands no longer suffices. The beauty of the water issue is that it unites the different parties which normally stand against each other, through the common interests with water. This made the design objective more interesting. Furthermore, I am a Dutch person. Water is an essential part of our relation with the landscape. Because I find the relation between humans and the landscape so important, it was an obvious theme for me to work with.

I started my graduation thesis with the question: 'What is the quality of life?'. As a response, I told the anecdote of a pale, sick fish which was neglected at the pet store. When a girl takes the fish home, it heals and after some time and care it transforms into a beautiful red fish. The fish represents our world, our landscapes and the environments we live in. I have a strong desire to heal the deterioration we cause. Change can start with little things and with the right conditions perhaps lead to unexpected advantages. Quality of life

means to me an environment in which multispecies are provided with their needs and co-exist. I aim to take this a step further with providing symbiotic relationships. The lab Urban Ecology and Ecocities provided the framework to work with this and aims to establish sustainable designs with coexistence.

However, I can't determine what people should do or behave. But what I can do is guide people. In my design, the wooded banks are a nice example of my vision. The wooded banks help us to position ourselves in the landscape. Right now humans have a prominent position, so is the case in forest Groesbeek. The current pathway structure makes it possible to cross the whole forest. Through the implementation of the wooded banks, the movement becomes more limited and guided. As a result, some places become more quiet which is beneficial for flora and fauna.

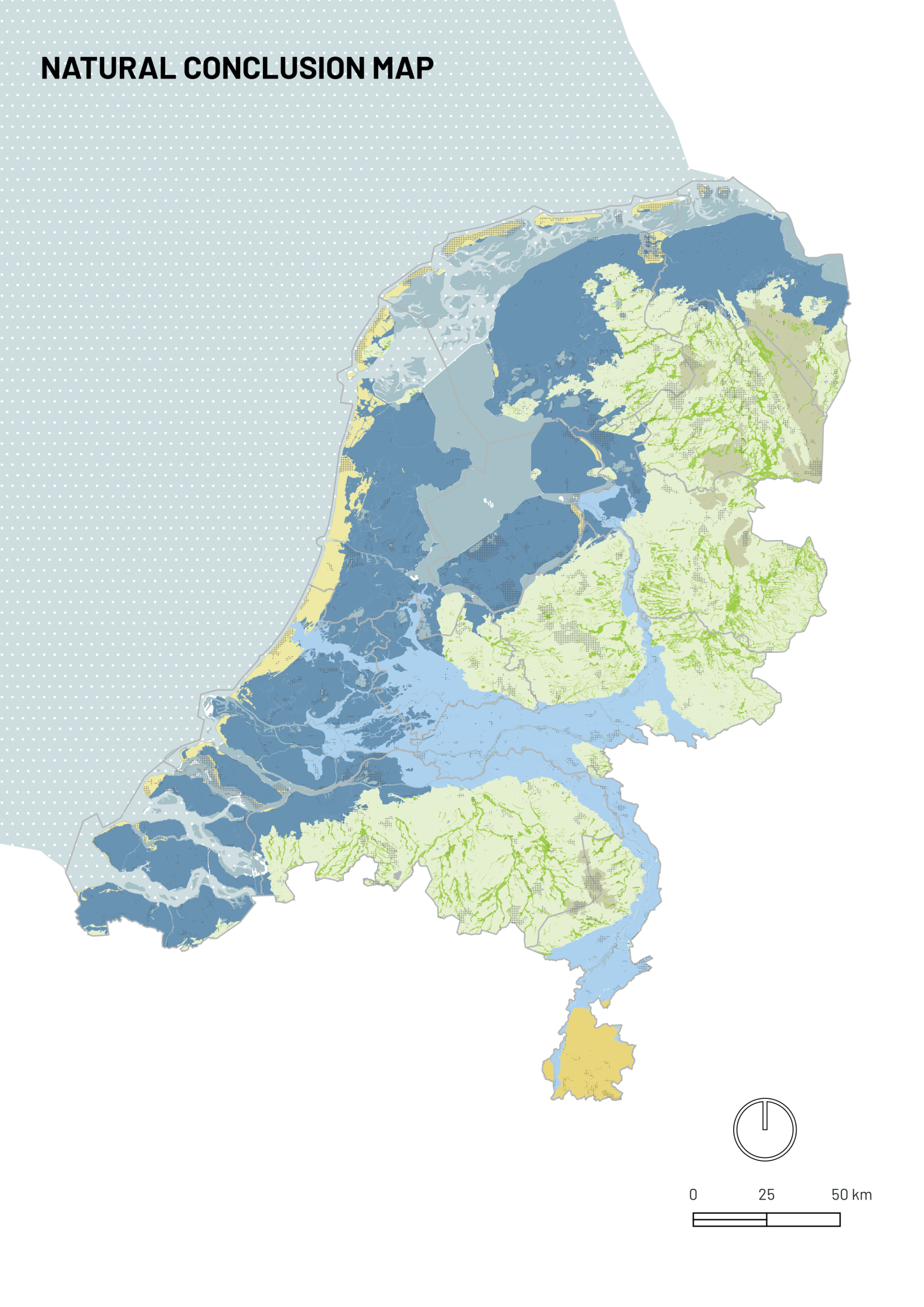
Looking back at my personal process, I realize I have the tendency to have a negative image of humans. I still carry the opinion that we live in an unbalanced world. However my graduation has helped me to establish a more positive outlook on people. Lo-TEK showed me beautiful examples of symbioses between humans and landscapes. The wooded bank is a local landscape element which I could relate to some of the discussed cultural systems Lo-TEK puts forward.

During the process I struggled with the degree of intervention of my design. First I strongly had the feeling to let nature take its course. In the Netherlands everything is planned until the last square meter. I found it interesting how I could provide more unexpected developments in my design. In the end, I didn't pay enough attention to this aspect. But I know I want to continue researching this in my future career. Instead, I developed another interest through Lo-TEK. The implementation of simple interventions which cause symbiotic relationships while minimizing disturbance.

At the end I zoomed in on forest Groesbeek located at the top of the moraine landscape. The graduation thesis has the aim to design for a climate adaptive landscape. It focuses on drought and takes water nuisance into consideration, but pays no attention to heat because this is mainly a problem within cities. However, the implementation of the design can have an indirect positive influence on cities in terms of heat.

APPENDIX

NATURAL CONCLUSION MAP



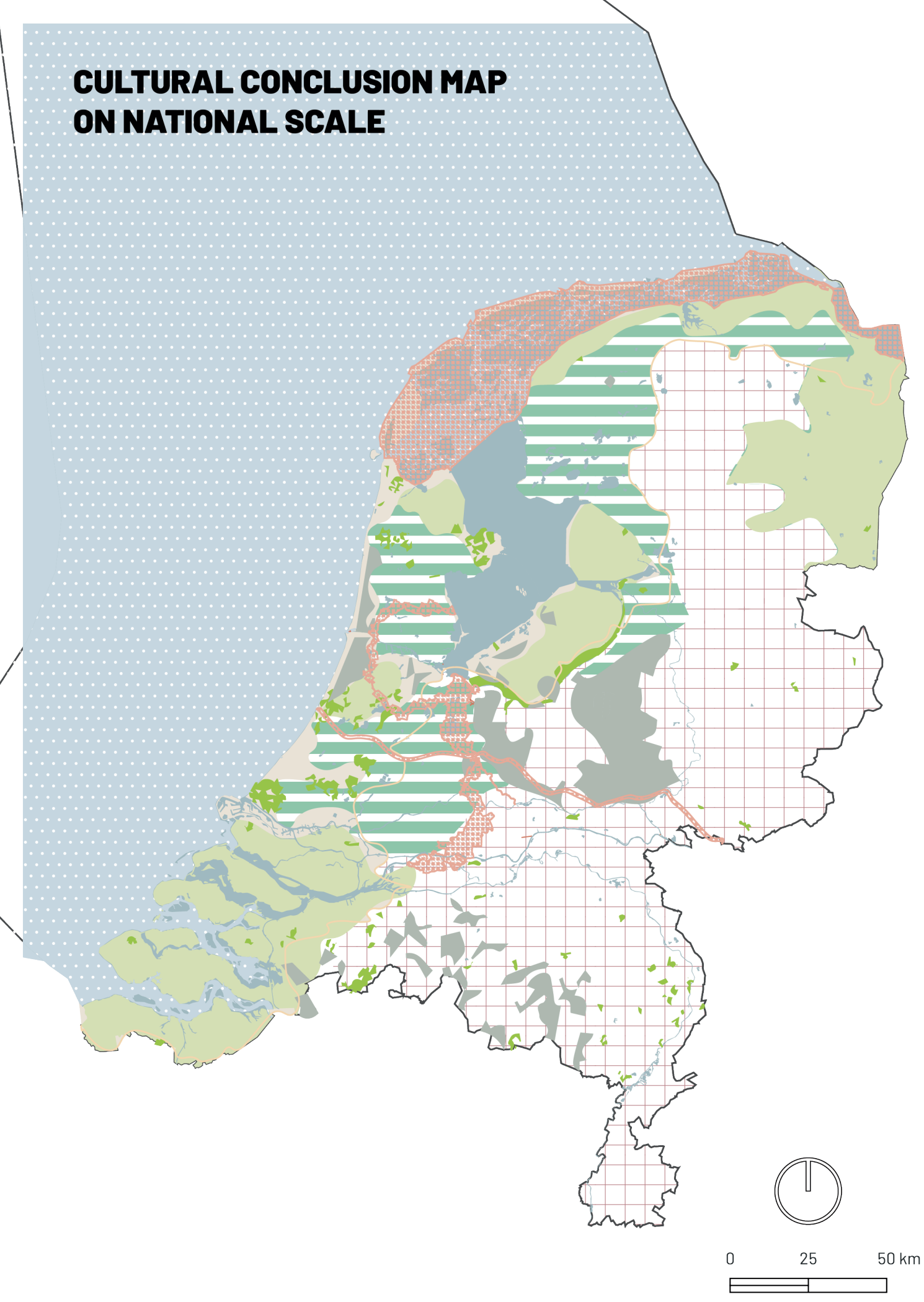
LEGEND

- SBB property
- Province boundary
- Sea
- Water

Landscape types

- Brook valley landscape
- Dry sandy landscape
- Dune and coastal landscape
- Big fresh waters
- Hilly landscape
- Low peat and sea clay landscape
- Wet sandy landscape
- River landscape
- Sea and mudflat

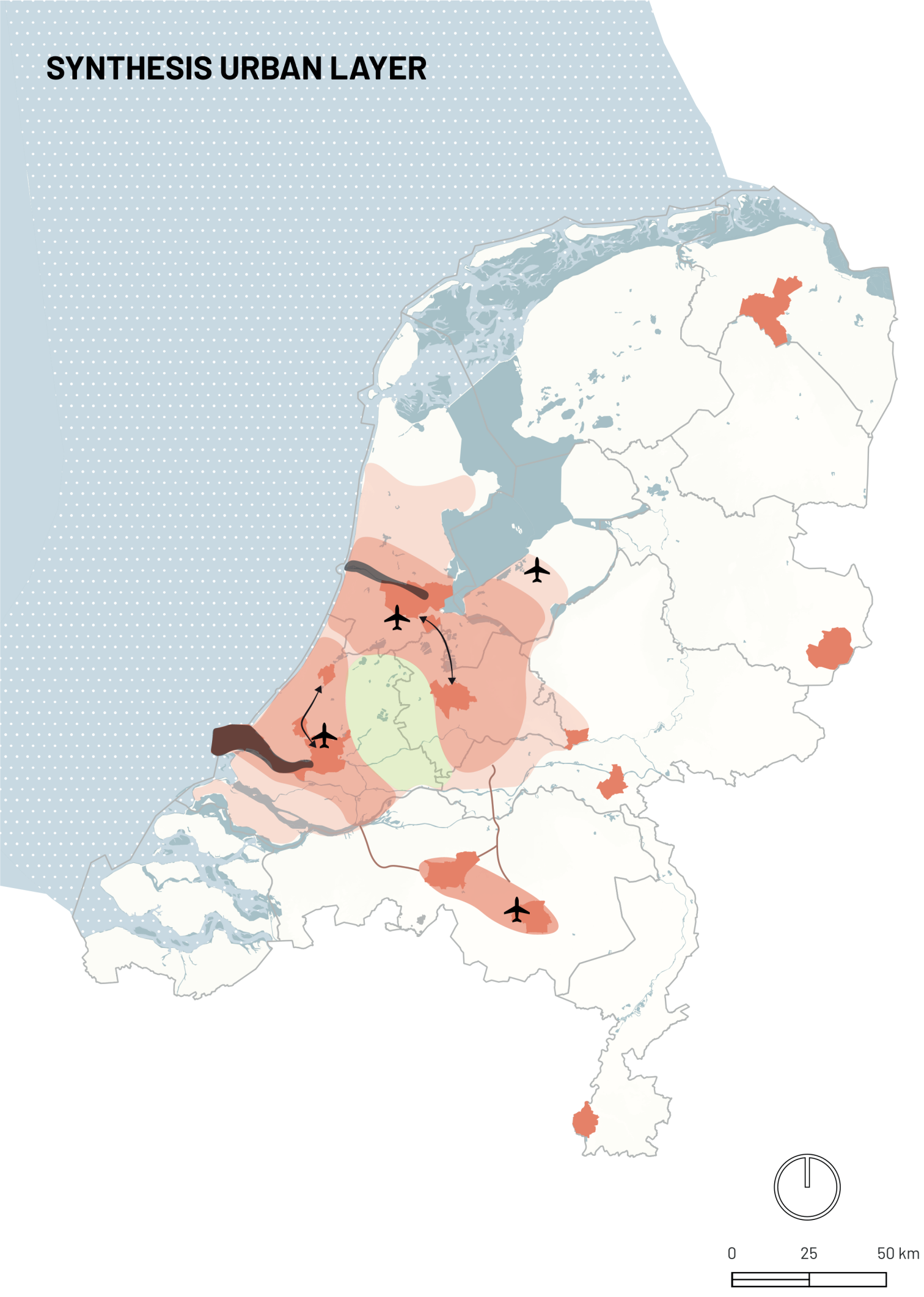
CULTURAL CONCLUSION MAP ON NATIONAL SCALE



LEGEND

- Outland water
- Inland water
- Polder system
- Boundary of polder
- Cultural heritage (Wadden sea, NHW, Roman lijn)
- Forest
- Crops
- Greenhouse
- Mixed agriculture
- Livestock farming

SYNTHESIS URBAN LAYER



LEGEND

Water

Province Boundary

Synthesis Urban Layer

Randstad

Main Wings Randstad

Groene Hart

University City

Main Ports

'Kennisas'

Public Transport Connection

Airport

VISION

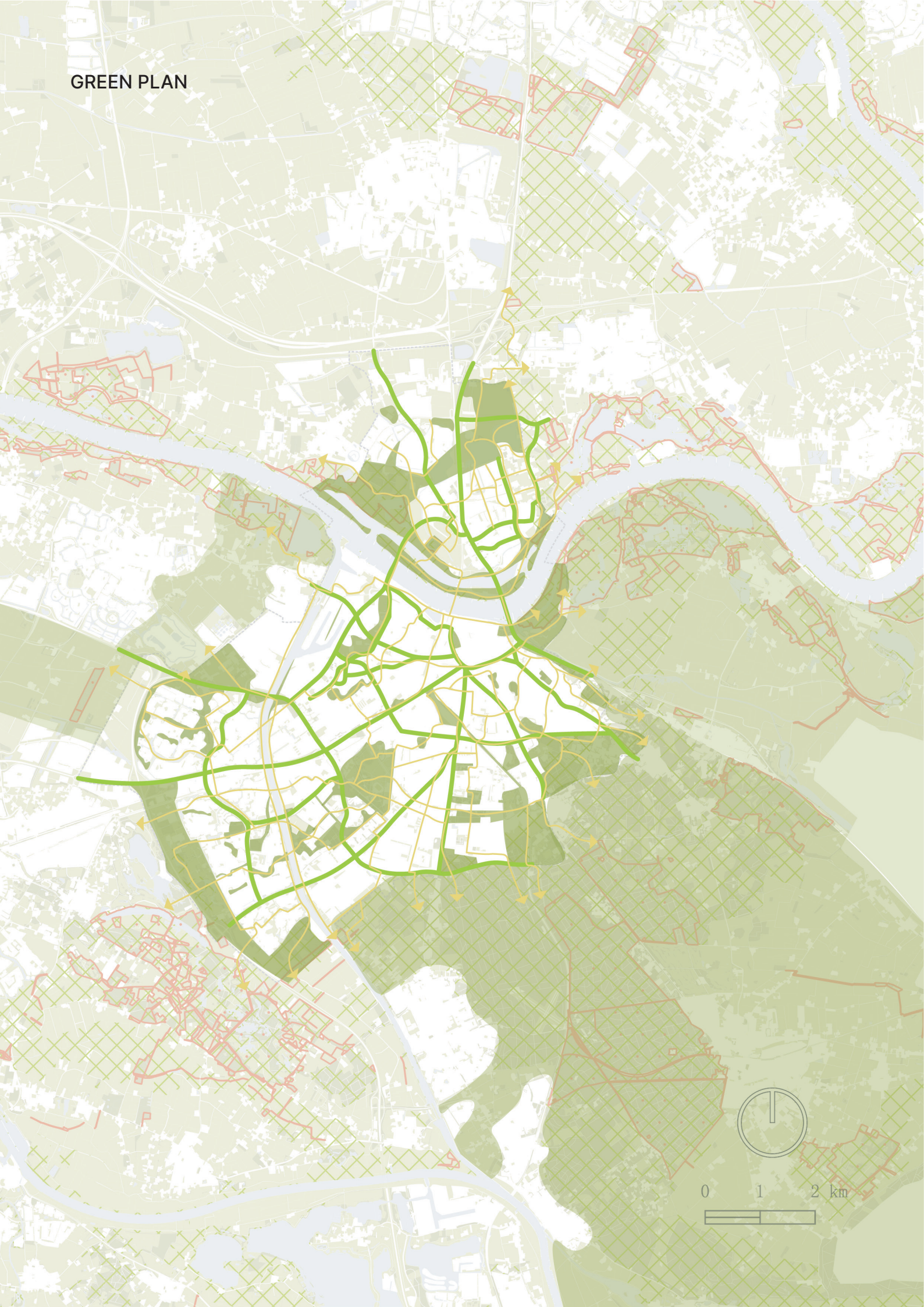
LEGEND

SBB property
Municipality boundary
Ecological green structure
Water
Agriculture
Nature

Strategies

Greening canal
New recreation point (view point)
Greening campus
Potential expansion for SBB
New route
Ecological river banks
Areas between ecological gradients
Ecological gradients
Connection between SBB properties
New green structure
Potential bridge for cyclists and pedestrians
Green fingers

GREEN PLAN



LEGEND

State Forest property

Municipality boundary

Ecological main structure

Water

Agriculture

Nature

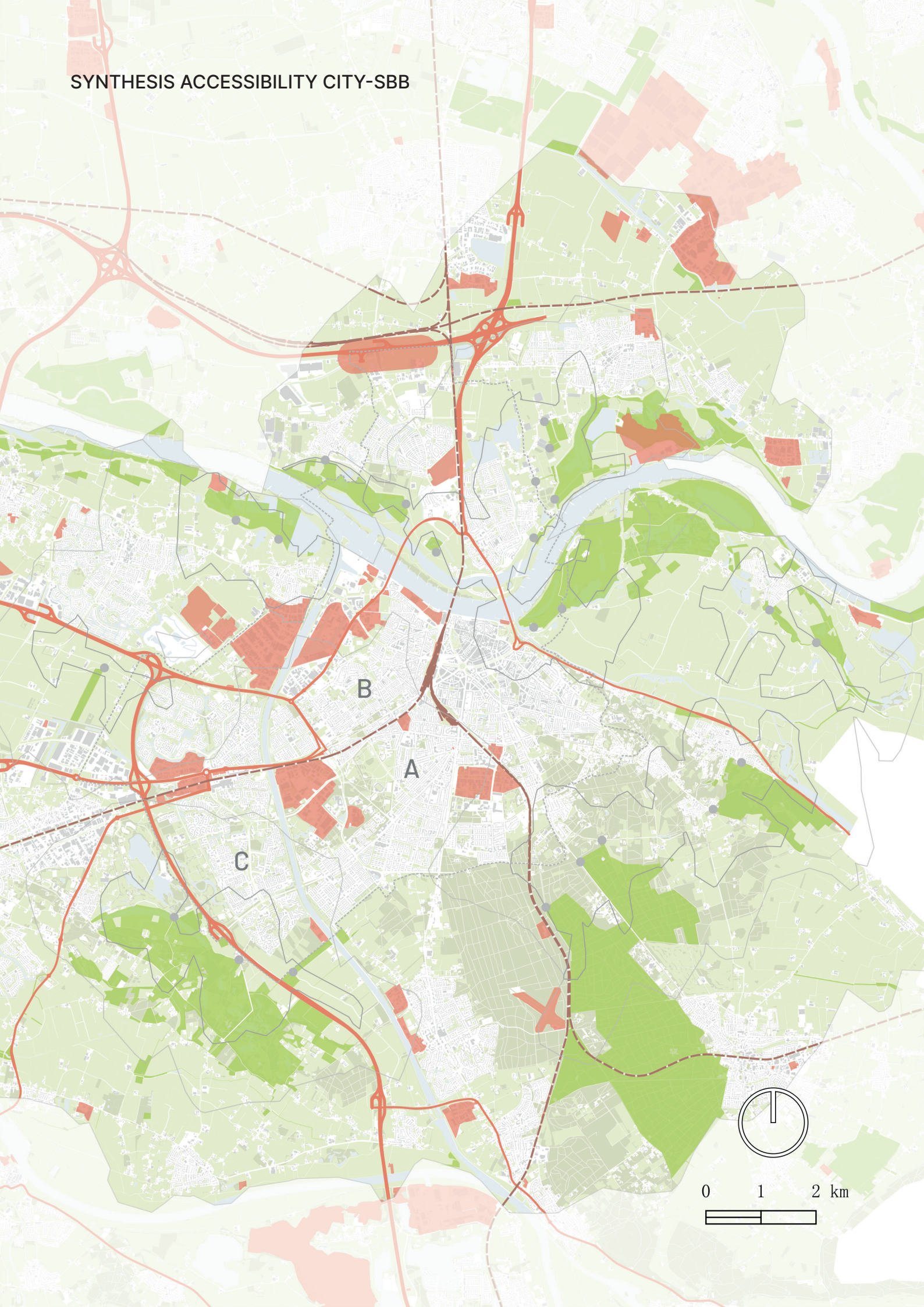
Green plan

Avenue structure

Urban green area

Route

SYNTHESIS ACCESSIBILITY CITY-SBB



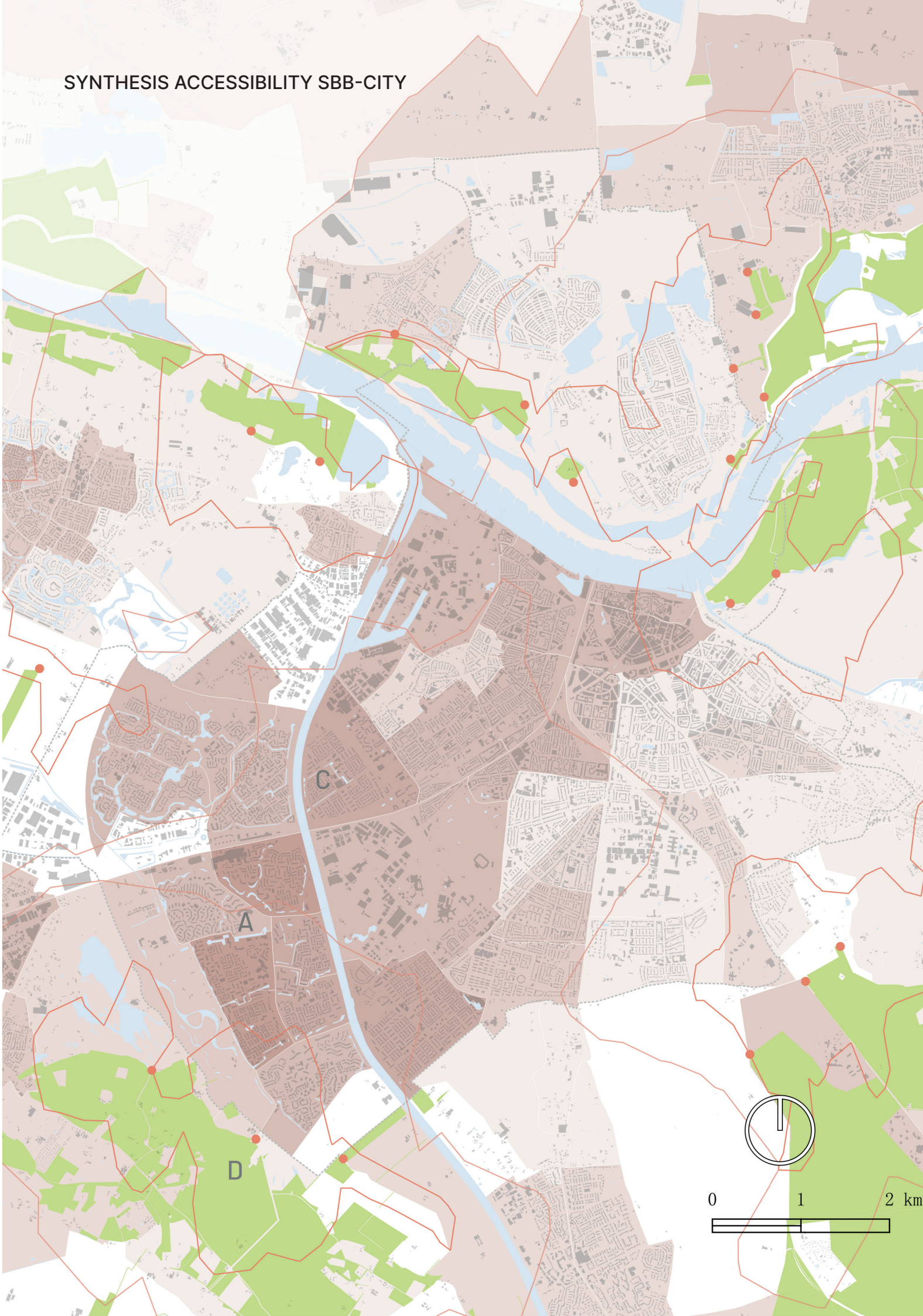
LEGEND

- SBB property
- Municipality boundary
- Buildings
- Water

Accessibility and blockages
(minutes)

- Blockages
- Train
- Highway
- Main road
- Regional road
- 5 min
- 10 min
- 20 min
- Accessibility point

SYNTHESIS ACCESSIBILITY SBB-CITY



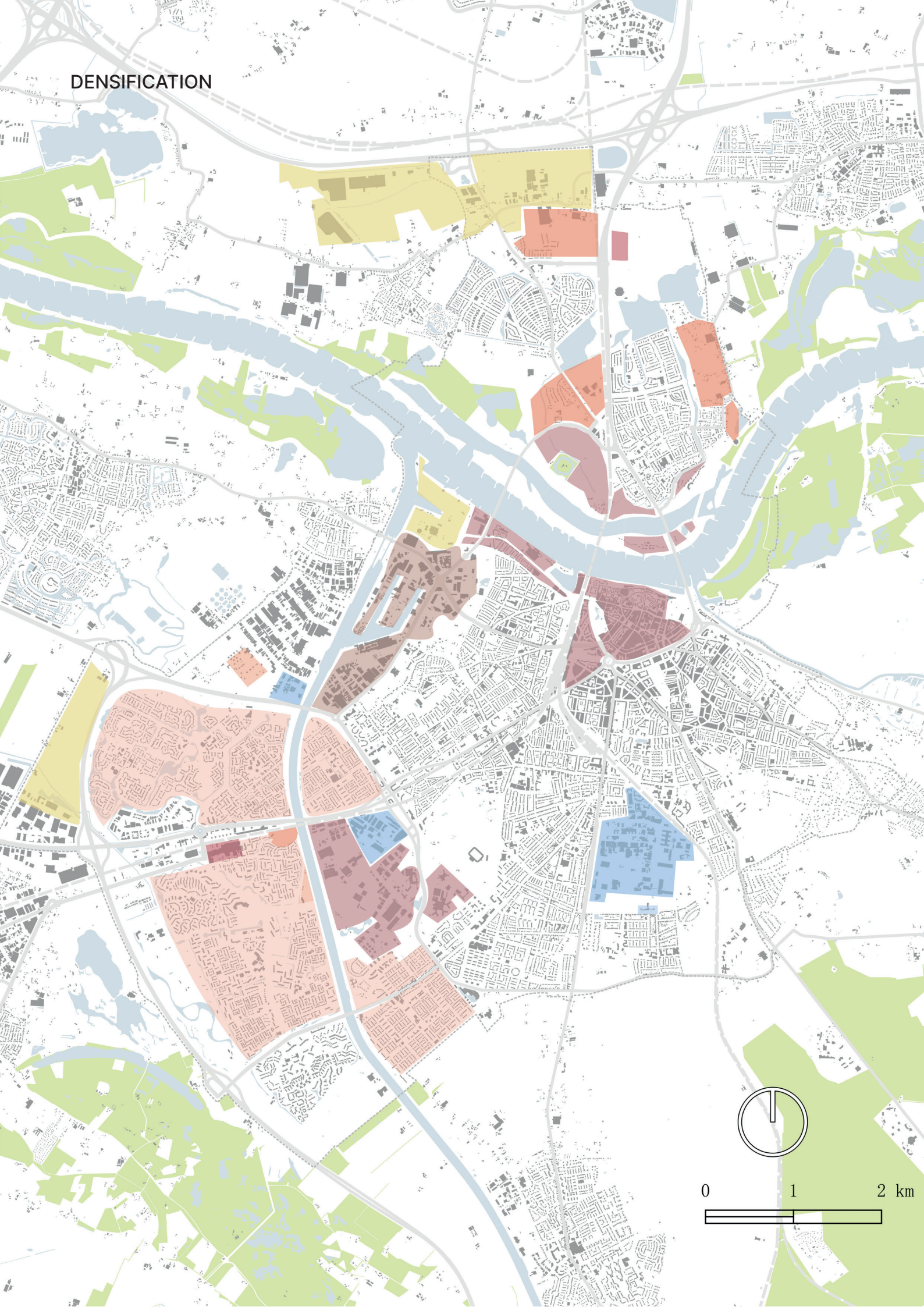
LEGEND

- SBB property
- Municipality boundary
- Buildings
- Water

Liveability neighbourhoods & accessibility
(from low (1) to high (9) & minutes)

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 5
- 10
- 20
- Accessibility point

DENSIFICATION



LEGEND

- SBB property
- Municipality boundary
- Buildings
- Water
- Train
- Highway
- Main road
- Regional road

Urban development

- Intensify city centre and shopping areas
- New residential area
- New energy areas
- Potential for transformation in the future
- Make neighbourhoods future proof
- Strengthen campus
- New shopping district