Building a productive, future proof landscape

A spatial framework for a future proof water system of the Dommel watershed that provides local, natural building materials for the future building program.

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Abstract

Drought is a current problem in North-Brabant and might become more severe by climate change. Water board 'The Dommel', managing the drainage basin of the Dommel brook, aims for a future proof water system by 2050. At the same time, the urbanization agenda for North-Brabant anticipates a growing need for houses in the near and far future. A switch to local, biobased construction could ecologically justify the current and future housing assignment, and potentially boost the local landscape with a more local oriented architecture as by-catch.

This thesis combines both challenges by answering the question: 'What spatial framework for the drainage basin of the Dommel supports the move towards a future proof water system that simultaneously provides local, natural construction materials for the future building program?'

Within the graduation lab of Urban Ecology and Ecocities, the landscape is approached as a system of layers that interact. Therefore, a regional framework is made using the water system as base, informed by the 'layer approach' and 'a hydrological approach to landscape planning'. The framework is informed by a landscape biography of historical local building materials. By design-through-scales, the general framework is translated to a local design of a high pressure zone in between Eindhoven and Helmond, and site specific design experiments evaluate the spatial and perceptual value of the framework.

The foundation of the resulting spatial framework is the natural system layer and its preferred hydrological conditions. Strategies to improve the water system are based on retaining water, buffering of water, and delaying drainage. Potential pairing opportunities simultaneously providing local building materials are: a productive tree network that acts as a sponge network by increasing the soil organic matter, surface water basins that provide loam by excavation of land, expanded heathland on the dry surface sand ridges to provide wool of sheep maintaining the heathland and sods for roofing, winter grains that improve the water retaining capacity of soil by increase of the organic matter as well as providing straw, raised forest that buffers water and provides timber, countryside wadi's that provide reed/willow/cattail fibers, hydrated brook valleys that provide reed for roofing and additional fibers, and use of wastewater for cultivating fibers. These findings show that a combination of both strategies can provide a win-win situation. The design experiments result in a landscape that is diverse, more healthy and is aligned with the regional program. A landscape in which new houses do not invade, but integrate into the landscape and therefore strengthen the local identity of the place.

keywords: productive landscape, drought, future proof water system, place-based approach, biobased building materials

Content

1.

Introduction

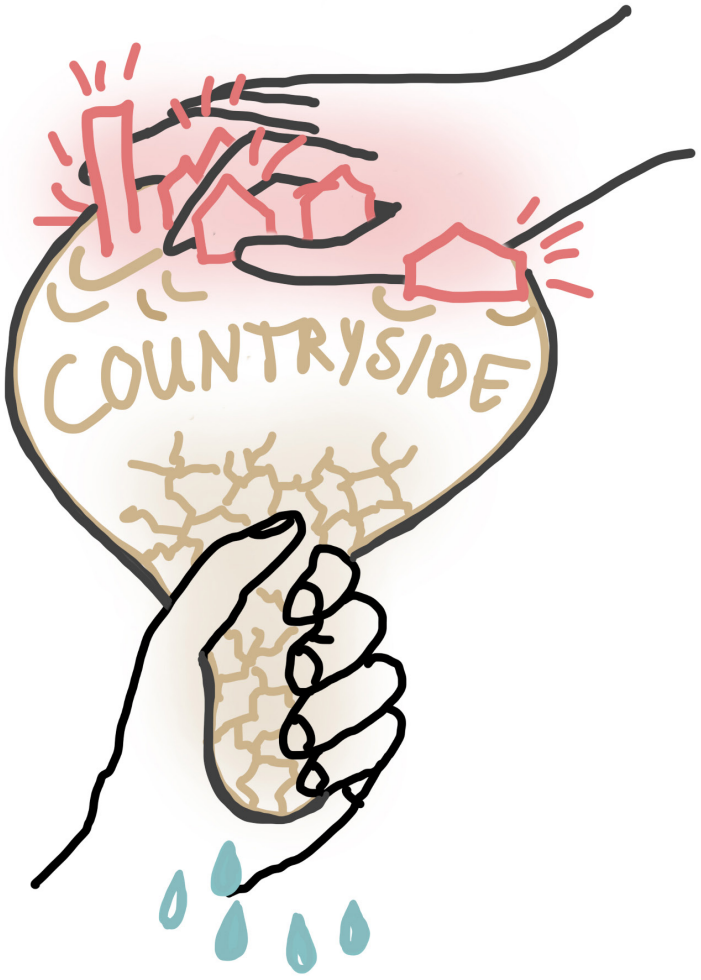


FIGURE 1 State foresty analysis, illustration by graduation lab

1.1 Context

This thesis is a successional phase of a research project that has been conducted for client State Forestry. The previous study was a collective effort by the students of the graduation lab Urban Ecology and Ecocities 2021-2022 to answer the question: how can State Forestry, by the use of their properties, contribute to quality of life? 16 Dutch cities and their surroundings were studied, including the region of Eindhoven. The results are the motivation for a more in-depth research in this thesis for the countryside of Eindhoven.

State Forestry

State Forestry is a nature organization in the Netherlands managing 273.000 hectares of land, of which several properties are located in close proximity or on the edge of cities. State Forestry protects and develops the green heritage of the Netherlands. The research question 'how can State Forestry, by the use of their properties, contribute to quality of life?' originates from State Forestry's reframed mission to ensure that current and future generations can experience the many important values of nature and to balance sustainable use with society (State Forestry a. 2021). A mission that deviates from their previous focus on ecological value. 'De Groene Metropool' is a program introduced by State Forestry to contribute to a healthy and attractive living and business climate in Dutch cities. State Forestry (2021b) pursues: "a green (nature) and blue (water) network that flows through the whole country, from the city centers to the nature reserves". Nature areas should be: "logical, attractive, diverse and multifunctional, with space for nature, recreation, entrepreneurship". (State Forestry b., 2021).

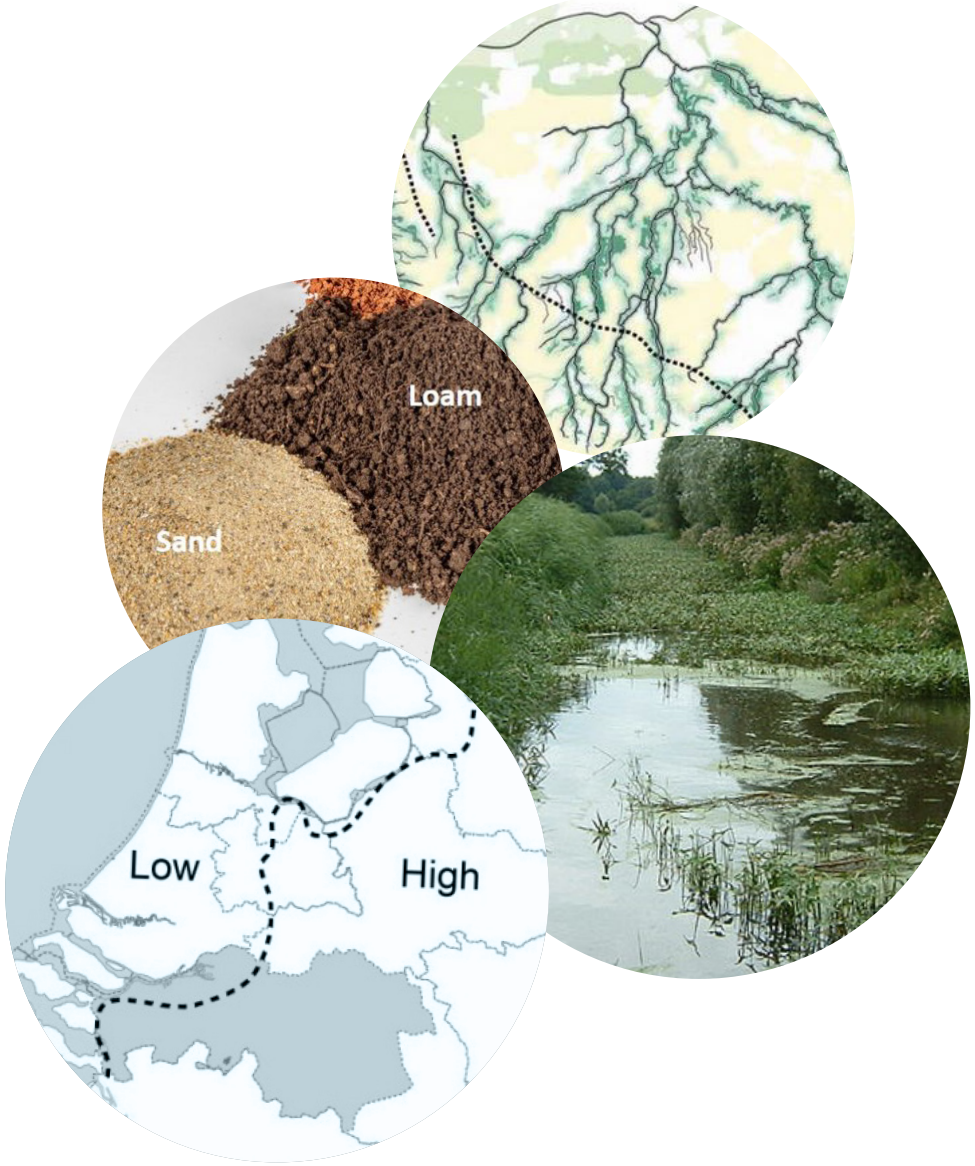
1.2 Regional introduction

The natural, cultural, and urban layer of the landscape of North-Brabant are explored to provide input for the problem statement. Prominent aspects are listed, which are most urgent for the region or align well with the fascination that motivated this thesis.

Natural layer

The natural layer includes the natural system of the landscape: “the interconnection between the geographic relief, the soil and subsoil, and the water system. The natural system constitutes the basis for living nature.” (Maas et al., 2022).

The largest part of North-Brabant consists of a surface sand landscape and belongs to the Maas watershed. Brabant belongs to the high part, above NAP, of the Netherlands. Soil deviates from loamy soils to loam-poor sandy soils and small parts of peat are located along the brooks. The landscape is shaped by brooks and sand ridges. The drainage basins of the brooks De Dommel, De Marke, and The AA divide the landscape into hydrological units. The topography is characterized by horsts and grabens.



Cultural layer

The cultural layer includes how land has been cultivated by mankind. It includes agricultural practices, nature areas, surface water system, and important cultural heritage in the Netherlands. Nature is included since nature areas in the Netherlands are maintained and planned.

The sandy surface soil has been cultivated for mixed agricultural use, dominated by arable land and grassland. Farmland is reclaimed by dewatering ditches. Patches of heathland and former production (pine) forest dominate the nature areas. (Green) heritage consist of estates, water mills, raised farmland, and burial mounds. Several nature areas are assigned as Natura 2000 areas and/or ‘natte natuurparels’ for water dependent nature.

Urban layer

The urban layer includes includes cities, villages, and main infrastructure. It is mainly shaped by industrialization and urban sprawl.

Brabant consists of relatively small, closely connected urban agglomerations. It is the second economic center of the Netherlands (Brabantstad, 2021) and has a manufacturing and knowledge industry. High tech is specialized in food technology amongst other themes.

1.3 My fascination

This project is set in the countryside of Brabant, recently branded as Van Gogh national park. In this national park, "more than 50 Brabant partners work on a beautiful, healthy and green living environment.[...] With the guts and imagination of Vincent van Gogh, we are building the landscape of the future together" (Van Gogh NP, 2022). Is it just a fancy title or can we indeed learn from Van Gogh's observations for future strategies?

Van Goghs paintings

Between December 1883 and November 1885, 188 paintings were made by Van Gogh (Brooks, 2022). Van Gogh's paintings show his fascination towards how people lived and worked with nature in the countryside. His paintings captured the atmosphere of the countryside, often showing the hard living conditions of peasants (Museum Van Gogh Brabant, 2022). Van Gogh was lingering on to the image of a pure countryside, which can be concluded by the absence of any painting showing industrialization at that time. The countryside painted by Van Gogh reassembled:

- Working on their land for food
- Collecting wood to create warmth
- Living in a modest, functional dwelling made from local materials
- Living in accordance to the circle of life, that is sowing, maintaining, harvesting and resting until life starts again
- People being dependent on and taking care of their local ecosystem

FIGURE 2 Van Gogh's paintings made in Nuenen.
http://www.vggallery.com/painting/by_period/nuenen.htm

A future build on Van Goghs fascination

With this graduation project, I want to show a new future that leans on Van Gogh's observations of local life in the countryside. I foresee a future of a community that has become more native to their land again. A future in which the countryside flourishes by its local boost, supported by new technologies. A future where:

- We not only eat local food from the surrounding countryside but also use local resources to create our build environment.
- We once again use materials as timber and straw amongst others to build our homes.
- Residents have basic knowledge of local species that are the backbone of their home.
- Local farmers are appreciated for their products.
- Residents and educational institutes are invited to help along building this flourishing landscape.
- The beauty of the circle of life will be experienced and appreciated, including the ritual of returning construction materials to nature after their duty.

FIGURE 3 Impressions of future paintings in Van Gogh's style, generated by artificial intelligence. https://openai.com/dall-e-2/

How does this relate to current theory?

Manschot (2020) in his search for a future oriented, new, local, ecological ethic, builds on the way of thinking of Nietzsche and therefore uses the term 'becoming indigenous'. Becoming native is presented by Manschot (2020) as "to strive to creatively build and sustain connections between local culture and ecological awareness". Living in harmony with the place on earth that one resides. A strong connection between culture and land is the essence, as it was the case in Van Gogh's observations.

FIGURE 4 Book Blijf de aarde trouw

1.4 Problem field

Apart from alienation as described in the previous paragraph, the countryside of North-Brabant faces several challenges today. Based on prior joint lab research, a SWOT analysis including various themes has been conducted for the province of North-Brabant.

Based on this SWOT analysis in table 1.1, two challenges have been selected since they are urgent and have my interest: drought and the housing assignment. More context of these challenges will be described in the following paragraphs.

TABLE 1.1 SWOT analysis

	Natural layer	Cultural layer	Urban layer
Strenghts	• Diversity of the hydrological conditions, featuring loamy and/or low-lying wet sandy soils alongside dry and loam-poor sandy soil on ridges. • Presence of natural gradients which offer suitable conditions for a high ecological value. • Peat soil along the brooks.	• Many clusters of (production) forests. • A rich (green) heritage. • Collaboration between 50 Brabant partners that work together on a beautiful, healthy and green living environment within the Van gogh national park.	• Fine-mesh of relatively small cities and villages interwoven with the countryside. • Brainport is a well established manufacturing and knowledge industry. • Eindhoven international airport stimulates national transportation.
Weaknesses	• Dependence of the water system on rainwater by upstream position in the watershed. • Incapability of sandy soil to attract and retain water or nutrients.	• Scattered and/or fragmented forest patterns and ecological structures. • Monotonous and exhausted agricultural fields. • Drought caused by current land use and the dewatering system of ditches. • Excessive nitrogen deposit in nature areas including Natura 2000 areas. • Small acreage of surface water.	
Opportunities		• Potential of diverse vegetation due to gradients in geographical relief, water system and soil. • Planned expansion of Nature Network Brabant to be achieved by 2027 and guaranteed finance by Groen Ontwikkelfonds Brabant (Provincie Noord-Brabant, 2022a)	• Urgency for an attractive landscape and living environment to attract employees for the high tech industry
Threats	• Precipitation deficit of more than 300 mm at its height during last summer (KNMI, 2022) • More extreme summer showers, chance of fall winds will increase, and the chance of dry springs and summers will also increase according to climate scenarios (KNMI, 2021).	• More depriving forest and heathland as a result of increasing drought.	Urban sprawl can negatively influence the interwoven city and country-side.

Drought

Drought has been a problem during previous summers. North-Brabant is vulnerable to drought due to multiple factors. First of all, the province deals with a precipitation shortage in the summer. At its peak in the summer of 2022, the percipitation deficit was more than 300 mm (KNMI, 2022). Next to that, water supply by surface water is limited, due to a relatively small surface water acreage in North Brabant. The province is lacking large water basins for buffering water for instance. Only the brooks and canals can provide water. Moreover, Brabant faces drought due its dominant surface sand soil which has the lowest water retention capacity of all soils. A next factor is current land use that worsens the situation by extracting large amounts of ground water and by fastening the drainage of surface water.

According to climate predictions of KNMI (2021), the chance of drought during spring and summer increases in the future.

percipitation shortage during summer + limited supply of surface water + sandy soil

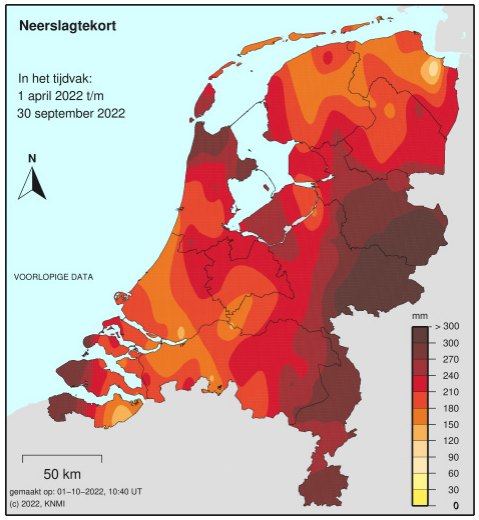


FIGURE 5 Main factors causing drought in North-Brabant KNMI (2022)

Housing assignment

Similar to several other provinces, North-Brabant is faced with a substantial housing assignment. 154.000 new houses should arise before 2040 in North-Brabant (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021), partly as densification and partly to become new edges of cities and villages, see figure 7. As a result, the countryside tends to get swallowed up by urban expansion, which is a concern of Van Gogh NP (2022), see figure 6. Especially the countryside in close proximity to the urban areas is indicated as vulnerable.

In future visions 'Natuurrijk Nederland' (Roggema et al., 2021), 'Een natuurlijkere toekomst voor Nederland in 2120' (Baptist et al, 2019), additional urbanization is envisioned on the long term since the sandy soils of North-Brabant are not vulnerable to sea level rise.

FIGURE 6 Countryside under pressure, NP VG (2022)

2040: + 154.000 houses

FIGURE 7 Housing agenda 2040 (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021)

2100: + ... houses

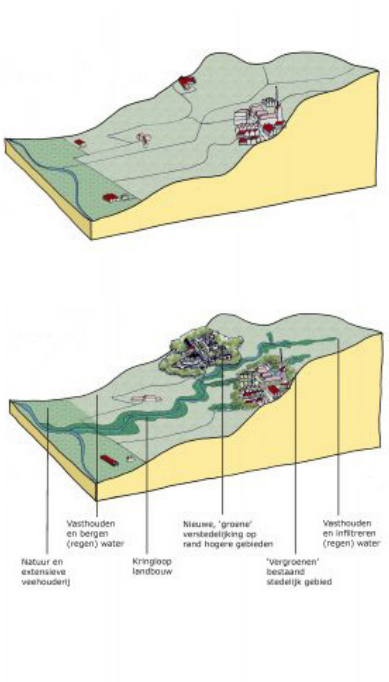


FIGURE 8 Expansion of housing on higher sandy soil (Baptist et al. 2019)

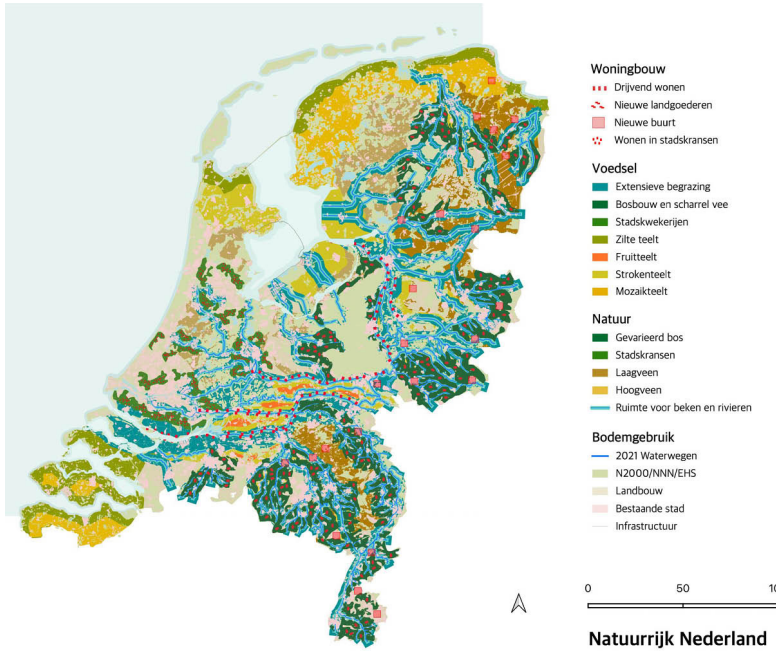
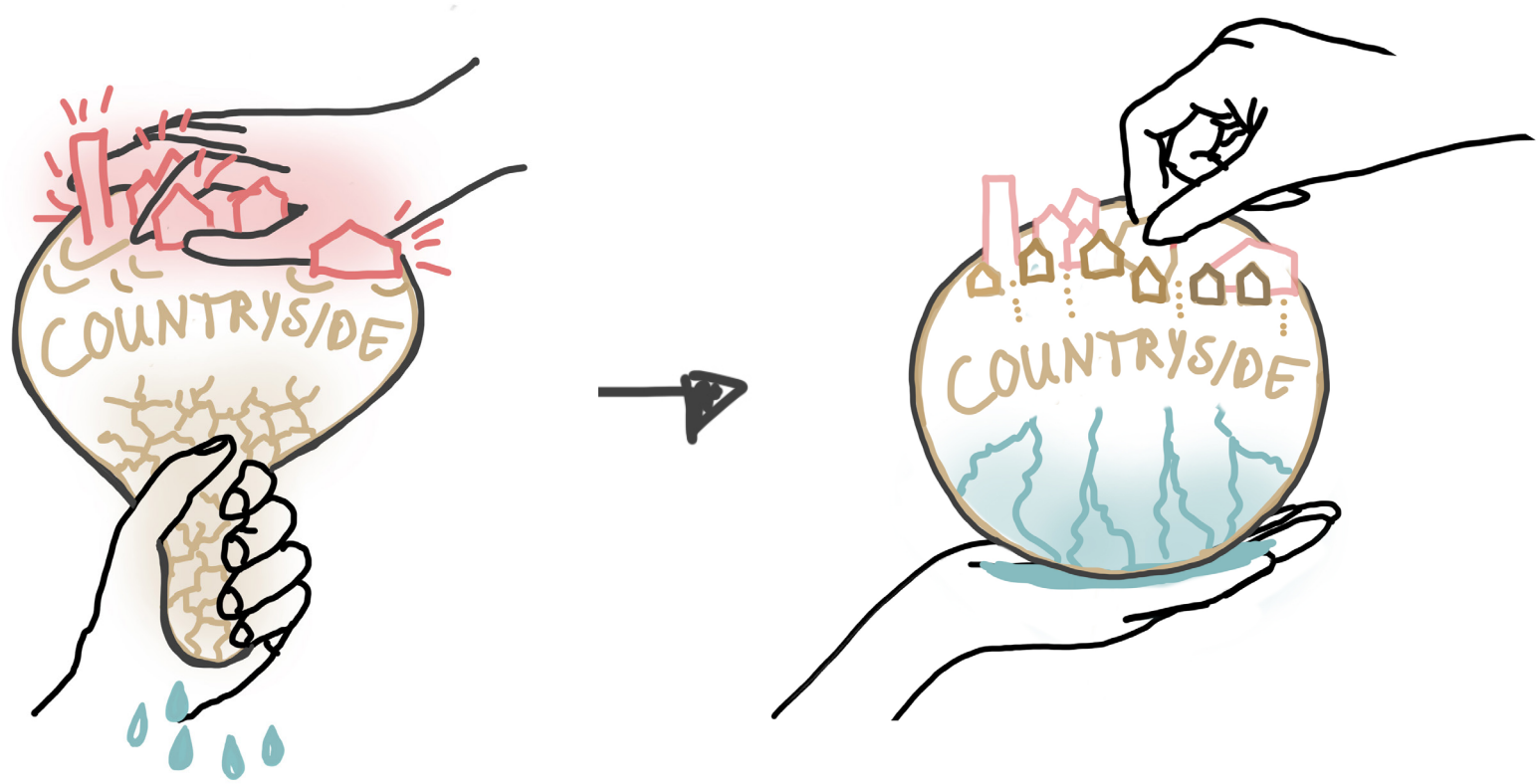


FIGURE 9 Natuurrijk Nederland (Roggema et al., 2021)



Combined urgencies

To summarize, the countryside is under pressure from both the housing assignment as well as drought. What if both challenges can be combined to result in a win-win situation? This thesis will envision a combined strategy that works towards a landscape with a healthy water system as the basis that at the same time creates opportunities for new housing to strengthen the character of the countryside.

1.5 Political context and existing visions

The initial strategy for this thesis has several common grounds with current policies and existing professional visions. The most relevant policies have been studied to come to a more precise strategy. Existing visions are checked to indicate what knowledge is lacking.

Policies

- Aim for a future proof water system by 2050 by Water board the Dommel (Waterschap De Dommel, 2021). Meaning: groundwater recharge and extraction are in balance and the groundwater level shows a positive trend; the groundwater is no longer exhausted.

- Aim for a biobased economy, stimulated by policy of the province of Brabant (Provincie Noord-Brabant, 2022b).

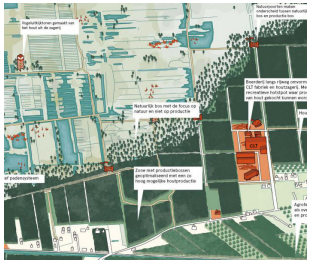
- Forest strategy by the national government to have 10%, 37.000 hectares, more forest in 2030, of which 19.000 hectares of forest should be located outside Nature Network Netherlands (Ministerie van Landbouw, Natuur en Voedselkwaliteit & Interprovinciaal Overleg, 2022)

- Aim of Van Gogh national park to boost the local sales of agricultural products (Van Gogh NP, 2022)

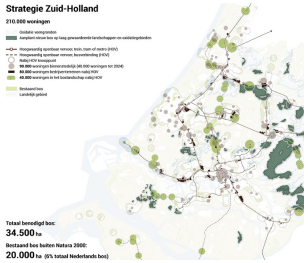
- Policy to enrich the diversity of residential choices by the province of Brabant.

Existing visions

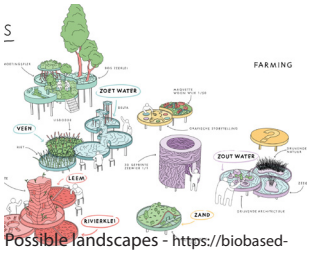
An accepted strategy for integrating housing into the countryside can be found in the usage of local, natural building materials. Biobased materials have caught attention during the last years as several existing visions show. Some are general visions, others more in-depth masterplans or spatial frameworks. An overall vision for North-Brabant is still missing.



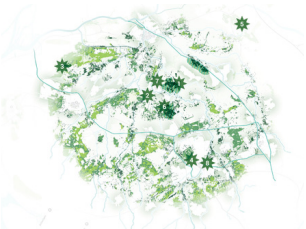
Forests for building - http://www.flux-landscape.nl/en/forests-for-building



BIOBASED ZUID-HOLLAND - https://boomlandscape.nl/work/biobased-zuid-holland/

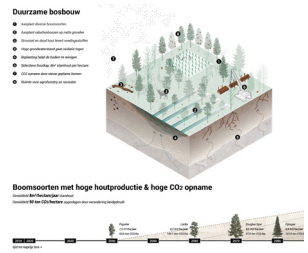


Possible landscapes - https://biobased-creations.com/project/possible-landscapes/

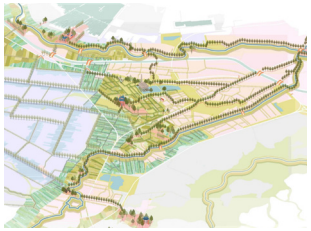


Human nature - https://www.marcovermeulen.nl/nl/projecten/human+nature/

DUBBEL OOGST - https://www.collegevanrijksadviseurs.nl/adviezen-publicaties/publicatie/2022/07/11/dubbel-oogst



Bouwen met bomen - https://www.marcovermeulen.eu/nl/projecten/bouwen+met+bomen/



Biobased (ver)bouwen in stadsranden Utrecht - https://www.collegevanrijksadviseurs.nl/actueel/nieuws/2022/07/14/economisch-rendement-biobased-verbouwen

FIGURE 10 Biobased building visions

1.6 Concluding problem statement & research question

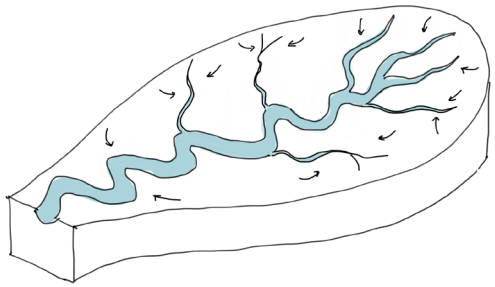
Based on the existing visions, it can be concluded that a spatial framework for the sandy soil landscape of North-Brabant to provide local, natural building materials which aligns with the natural system of the landscape and is connected to the large threat of drought is absent.

As a spatial framework requires a well defined boundary, this thesis will focus on 1 hydrological unit as base layer. Since Water board the Dommel, who manages the Dutch part of the drainage basin of the Dommel, has taken on the ambition for a future proof water system by 2050, the study area of this thesis will be the drainage basin of the Dommel. The drainage basin of the Dommel has a reasonably autonomous working water system.

The resulting problem statement
A spatial framework is lacking for the drainage basin of the Dommel as part of North-Brabant to move towards a future proof water system that simultaneously provides local, natural construction materials for the future building program.

Drainage basin = watershed

The whole area that is drained by the Dommel



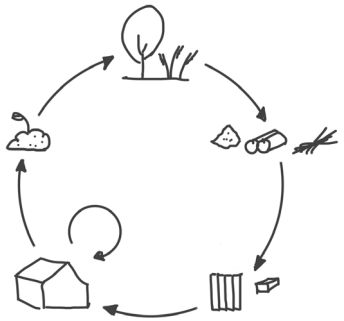
Future proof water system (by Waterboard De Dommel, 2021) =

- Groundwater recharge and extraction are balanced
- Groundwater level shows a positive trend

Local, natural building materials (by Bouwtuin, 2021) =

- Trees
- Grass & fibers
- Earth, stone & shells
- Algae and fungi

Can be composted at the end of lifespan



Research question
What spatial framework for the drainage basin of the Dommel facilitates the move towards a future proof water system that simultaneously provides local, natural building materials for the future building program?

Sub questions:

- What are effective measures to improve the water system of the Dommel drainage basin?

- Which local, natural building materials that were historically used in North-Brabant are suitable for the future building program?

- What strategies benefit the local water system and provide suitable, local, and natural building materials?

- What are the potential implications for local architecture?

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2.

Theoretical framework

2.1 Theories

The larger context of this research is the field of regional design and place-based perspectives. The new ecological ethic that is presented in the fascination is based on a stronger connection between culture and place. This fascination can be placed within the frame of several theories, including 'regional design', 'biophilic design', and 'bioregionalism'.

Regional design
Hough (1990) theory of regional design. He indicated loss of rootedness in a place as a factor amongst others. In the past, people were limited in his control of the natural environment, causing a sense of being rooted in a place. Hough (1990) suggests connections between regional identity and the sustainability of the land are essential and fundamental. The building blocks of his theory include:

- knowing the place; it's natural & social processes
- maintaining a sense of history; reuse and integration of old into the new
- learning about a place through direct experience; awareness as part of people's everyday lives
- doing as little as possible; by giving direction, capitalizing on existing opportunities, or by setting a framework
- sustainability; applying principles of energy and nutrient flows
- start where it's easiest; focus on proven, and achievable interventions.

Place-based perspective
Biophilic design is "achieving long-term sustainability of restoring and enhancing people's positive relationship to nature in the built environment" (Kellert et al., 2008 p5). One of the design elements of biophilic design is place-based relationships, consisting of eleven attributes. This element of place-based relationships refers to the bond between ecology and culture in a geographical context. The connection of humans to places derives from the human need to establish territorial control. Familiarity with a location, in other words longing for home, remains a deep-seated need for most people, but is far from being satisfied today. The attributes:

1. Geographic connection to place
2. Historic connection to place
3. Ecological connection to place
4. Cultural connection to place
5. Indigenous materials
6. Landscape orientation
7. Landscape features that define building form
8. Landscape ecology
9. Integration of culture and ecology
10. Spirit of place
11. Avoiding placelessness.

Bioregionalism
Bioregionalism is a response to the environmental crisis and has its essence in an ecological perspective on place and planet. "By foregrounding natural factors as a way to envision place, bioregionalism proposes the human identity may be constituted by our residence in a larger community of natural being - our local bioregion" (Lynch et al., 2012 p4). Bioregionalists ask questions such as the following: What does it mean to be a resident of a certain river watershed? Bioregionalists propose that this shift in perspective can have a major and ecologically positive influence on how we choose to relate to the world around us. Thayer Jr. (in Lynch et al, 2012 p3) defines a bioregion as "a unique region definable by natural (rather than political) boundaries with a geographic, climatic, hydrological, and ecological character capable of supporting unique human communities. Bioregions can be variously defined by the geography of watersheds, similar plant and animal ecosystems, and related, identifiable landforms (e.g., particular mountain ranges, prairies, or coastal zones) and by the unique human cultures that grow from natural limits and potentials of the region. Most importantly, the bioregion is emerging as the most logical locus and scale for a sustainable, regenerative community to take root and to take place."

Human needs
Three theories have been studied. The overlapping aspect in these theories is the need of humans for geographic connection, historical & cultural connection, and ecological connection. These needs will be taken into account.

2.2 References

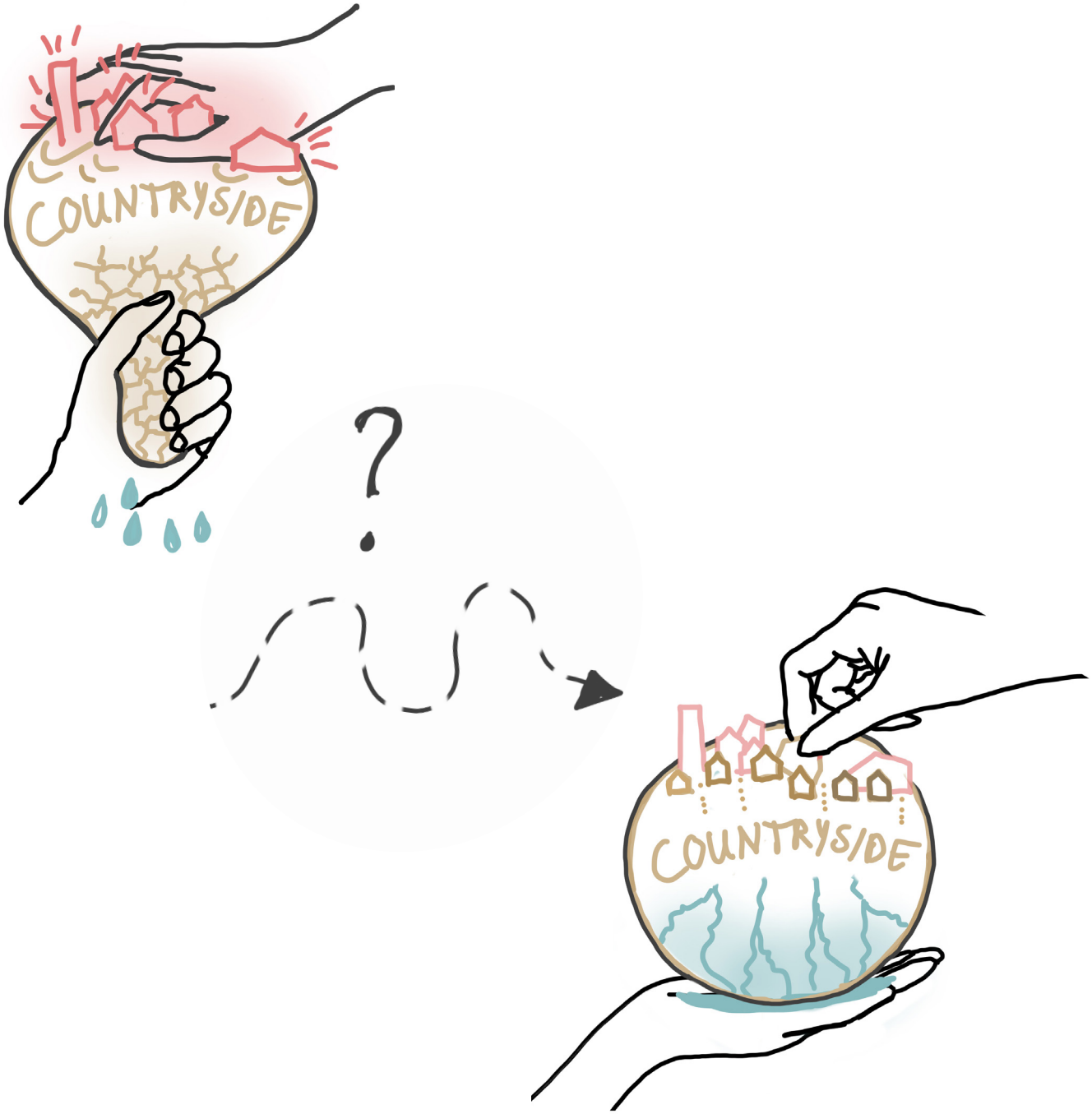
Hough, M. (1990) Principles for Regional Design. In Swaffield, S. (ed 2002). Theory in Landscape Architecture: A Reader. (pp 209 - 213). Philadelphia : University of Pennsylvania Press

Kellert, S., Heerwagen, J. & Mador, M. (2011). Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life. Wiley.

Lynch T. Glotfelty C. Armbruster K. & Zeitler E. J. (2012). The bioregional imagination : literature ecology and place. University of Georgia Press.

3.

Methodology



3.1 Research approach

The strategy to set up a regional framework within this thesis, is informed by two approaches: the layer approach and a hydrological approach to landscape planning. These approaches propose to use the substratum or water system layer as a basis for analysis and design, resulting in a framework.

Layer approach

The layer approach of Frieling et al. (1998) includes 3 layers: substratum, networks, and occupation, as is depicted in figure 16. The substratum, transforming slower than networks, sets conditions and priorities for the upper layers. The network layer in its turn sets conditions for the occupation layer.

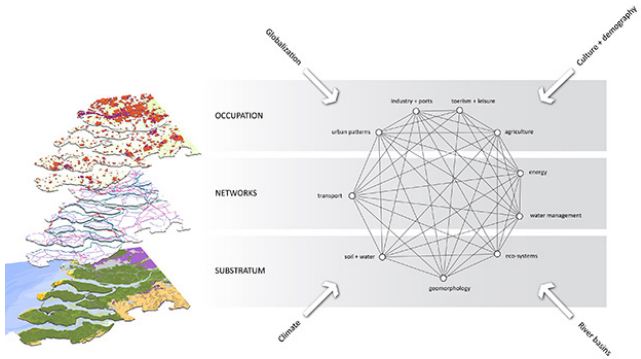


FIGURE 16 Layer approach
https://steffennijhuis.nl/landscape-based-regional-design

A hydrological approach to landscape planning

A more specific instrument is the hydrological approach to landscape planning. Van Buuren (1991) presented the approach involving the planning of a framework based on water flows. Analyzing groundwater flows and surface water flows as is depicted in figure 17 and 18, helps gain insight into how water flows contribute to the cohesion between landscape units and their conditions. As a consequence, it facilitates the identification of conflicting types of land use and distinguishes areas in which dynamic or gradual development is suitable (Van Buuren, 1991). Van Buuren (1991) argues that water flows are indicated as a crucial factor in the connectivity and interaction of landscape parts and their use.

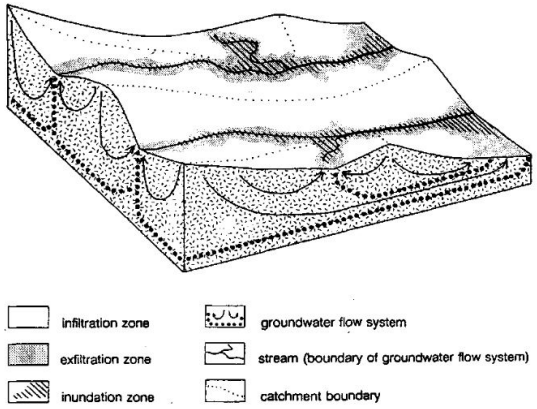


FIGURE 17 Scheme of groundwater flows in the landscape
(Van Buuren & Kerkstra, 1993).

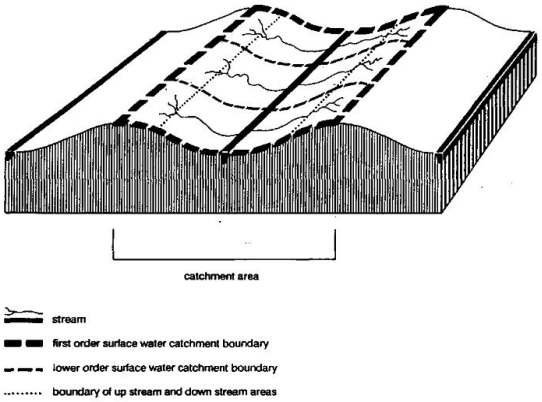


FIGURE 18 Scheme of the surface water system
(Van Buuren, 1991).

Landscape biography approach

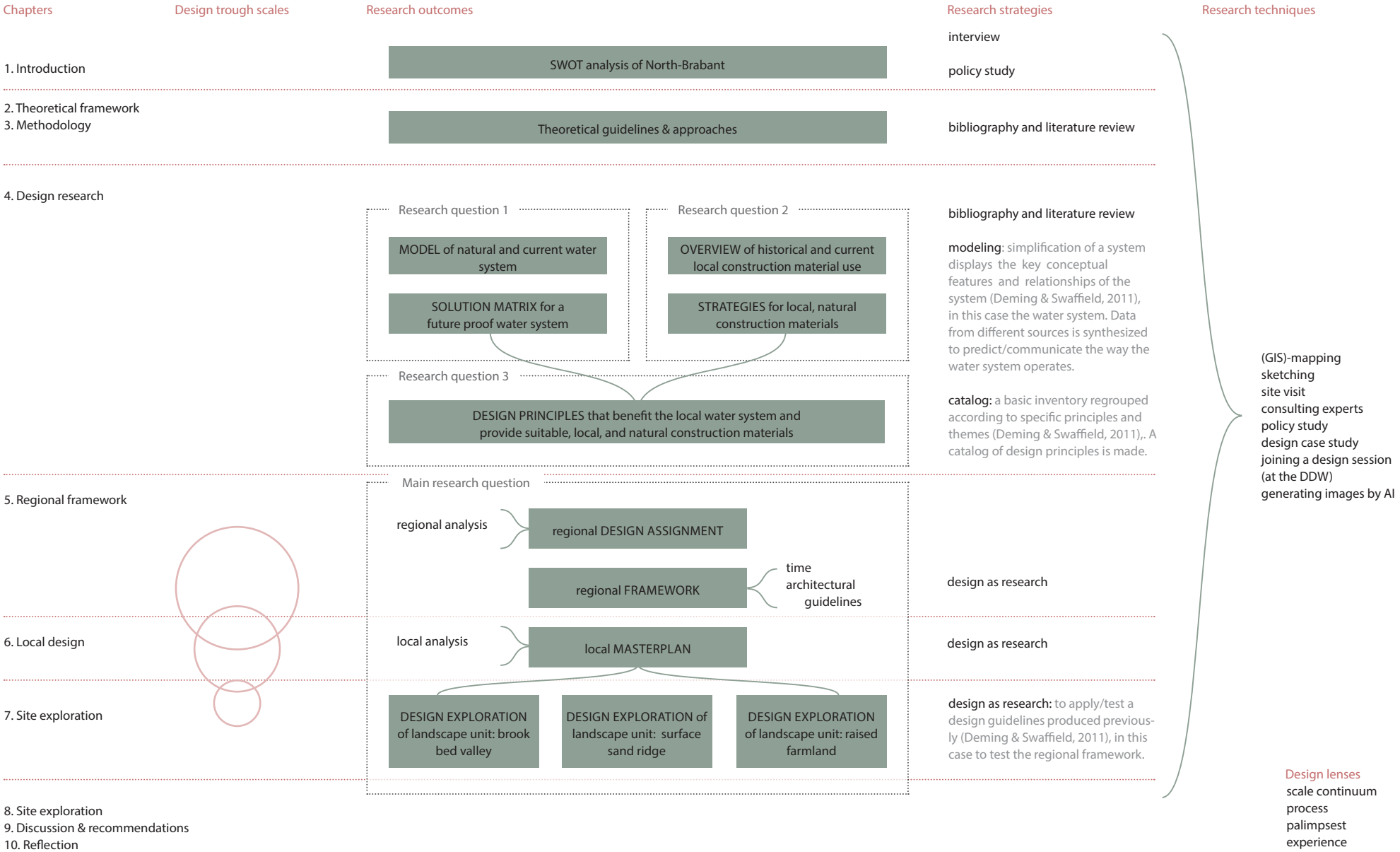
Landscape biography is a research approach for exploring the memories of place as well as for localizing unexpected and deep histories that may contribute to the understanding of the ways in which human space has come about (Kolen, Renes, Bosma, 2016). For a designer, inspiration can be derived for stories of past generations about long-term processes for instance. Landscape biographies are particularly useful in the purpose of considering future landscape transformations. Landscape biography principles are (Kolen, Renes, Bosma, 2016):

- Historicising approach, understanding of the making of the present-day landscape.
- The development of the human-made landscape is understood as a continuum or succession of transformations in which the past is experienced and processed in ever changing ways.
- No discipline-specific method, combined use of archaeological, geographical, historical, social, architectural and other methods and sources.
- Starts from a dwelling perspective on the landscape. Impart place is given to 'authorship' of the landscapes.
- Aims at making historical research and reflection relevant and productive for current issues of designing.

The use of a landscape biography about local construction materials is useful for two reasons. Firstly, historical use of materials is often aligned with the natural system, the local ecosystem, as control over the local environment was limited in the past. Secondly, the materials used in previous times needed little adjustment as industrial processing was absent. Materials were used with least modification. In order for local materials to be promising, a supporting industry must be established locally. The less modification needed, the easier it is for local industry to start at a small scale.

Within this thesis, the landscape biography of local building materials is used as inspirational input to set up strategies. However, compiling this landscape biography was part of a separate module next to the graduation project.

3.2 Overview


Chapters
Design trough scales
Research outcomes
Research strategies
Research techniques
1. Introduction
SWOT analysis of North-Brabant
interview
policy study
2. Theoretical framework
3. Methodology
Theoretical guidelines & approaches
bibliography and literature review
4. Design research
Research question 1
MODEL of natural and current water system
SOLUTION MATRIX for a future proof water system
Research question 2
OVERVIEW of historical and current local construction material use
STRATEGIES for local, natural construction materials
Research question 3
DESIGN PRINCIPLES that benefit the local water system and provide suitable, local, and natural construction materials
bibliography and literature review
modeling: simplification of a system displays the key conceptual features and relationships of the system (Deming & Swaffield, 2011), in this case the water system. Data from different sources is synthesized to predict/communicate the way the water system operates.
catalog: a basic inventory regrouped according to specific principles and themes (Deming & Swaffield, 2011),. A catalog of design principles is made.
5. Regional framework
Main research question
regional analysis
regional DESIGN ASSIGNMENT
regional FRAMEWORK
time
architectural guidelines
design as research
6. Local design
local analysis
local MASTERPLAN
design as research
7. Site exploration
DESIGN EXPLORATION of landscape unit: brook bed valley
DESIGN EXPLORATION of landscape unit: surface sand ridge
DESIGN EXPLORATION of landscape unit: raised farmland
design as research: to apply/test a design guidelines produced previously (Deming & Swaffield, 2011), in this case to test the regional framework.
8. Site exploration
9. Discussion & recommendations
10. Reflection
(GIS)-mapping
sketching
site visit
consulting experts
policy study
design case study
joining a design session (at the DDW)
generating images by AI
Design lenses
scale continuum
process
palimpsest
experience

3.3 Relevance & scope

The context of the graduation lab within the master program and its larger relevance.

Academic relevance - graduation lab
This thesis takes place in the context of the Urban ecology and Ecocities (UECL) lab, which is part of AR3LA031 Graduation Studio Landscape Architecture: Flowscapes. In the graduation lab, the lens of urban ecology is used to improve quality of life and environmental performance in cities through planning. Urban ecosystems are the main study subject. The urban ecosystem expands the borders of the city, as flows of required matter and energy are sourced elsewhere. Ecosystem services are potential outcomes of Urban Ecology. This graduation thesis primarily focuses on the supporting ecosystem service of healthy soil, including water, the provisional service of water supply and materials, and the cultural aspect of sense of place. Indirectly, other ecosystem services are also involved. That is, moving towards a more future proof water system that supports the hydrological gradient of the sandy soil landscape in North-Brabant, provides suitable conditions for local ecosystems and therefore biodiversity can benefit. In this context, this thesis can be seen as a tool to test the graduation lab principles and to inspire others to reflect on what the extent is of urban ecology and ecocities.

Academic relevance - master program
The Flowscapes Studio that is based on the principle of 'landscape as infrastructure'. Transportation, green and water infrastructures are important agents that facilitate processes that shape the built environment and its contemporary landscapes. Flowscapes are interpreted as: "with movement and flows at the core, these landscape infrastructures facilitate aesthetic, functional, social and ecological relationships between natural and human systems." (Nijhuis et al., 2015) Two flows are leading in this thesis: water and biomass (construction materials) as flow, defining the core of the landscape structure. A structure that in its turn shapes the built environment directly and indirectly.

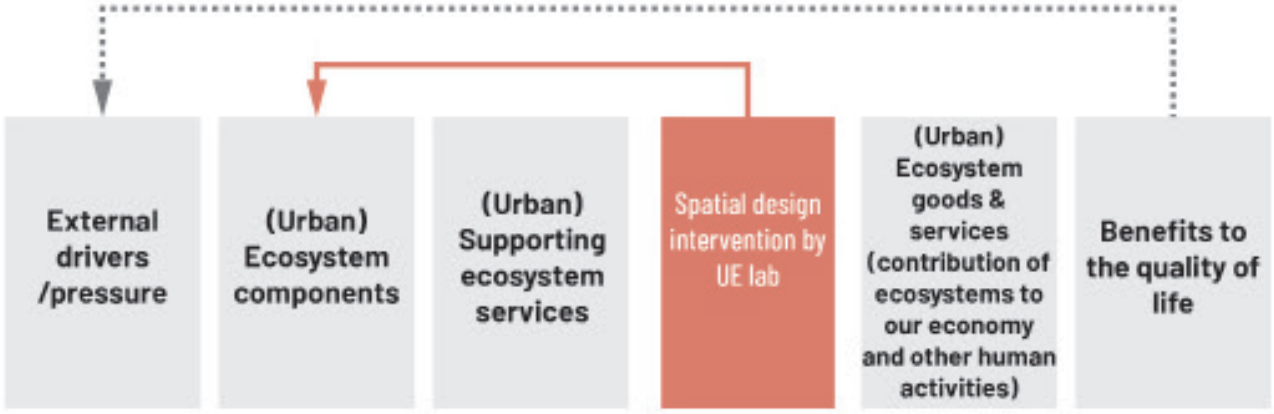


FIGURE 19 Strategy of Urban Ecologylab by graduation lab

Scientific relevance
In the larger scientific framework, my graduation project can inspire others to do more research on design principles that combine challenges of tomorrow. The methodology presented in this thesis can work as an example of the translation of scientific research to spatial interventions. The study might contribute to a better understanding of the relationships between the current situation of the landscape and the potential productive landscape that is projected in the research.

Professional relevance
In a larger professional framework, this thesis can be of inspiration for others who research within the domain of the global challenges addressed, being: making landscape resilient / future proof for climate change, enriching local identity in globalized systems, and moving towards a sustainable building ethic / the biobased trend.

By using the existing perspective and guidelines of professionals, in this case of Van Gogh national parks masterplan, the design can potentially enrich the insight on these concepts for professional organizations.

Societal relevance
First of all, the results are relevant for State Forestry. The outcomes can be used for inspiration for a future vision. The vision presented in this thesis aligns well with their knowledge of managing nature and production forest and their willingness to provide for the local market.

The results of this thesis are to a certain degree transferable to other sand surface landscapes. The main design principles to improve the water system and suitable

vegetation for construction materials can be applied, while taking into account local differences. The geomorphology will be slightly different and the historical building culture will also deviate.

For larger societal purposes, the results of this thesis can function as an image that evokes a conversation. The framework and local designs can trigger questions for a larger audience: is this a future we want to move towards? Especially the strategy of the use of local, natural construction materials for one's home can be of interest to people, as a home is such a defining element in life. Personally, I hope this thesis adds to the awareness of the urgency of use of local materials. Here, in this region, we can make a difference. By attempting to build as much with local resources in an efficient way, we diminish the negative impact elsewhere. Moving society closer to the limits of the earth's resources. Stimulance to act smart with the available land.

Scope

This thesis is not solely focused on properties of State Forestry in order for the results to be relevant to a larger public. State Forestry is treated as one of the stakeholders.

In addition, the focus of this graduation thesis is to envision a landscape that is more future proof than the current situation. It explores the potential consequences for land use. A next step would be to calculate the exact yields for each construction material. However, this is beyond the scope of this exploratory thesis.

3.4 References

van Buuren, M. (1991). A hydrological approach to landscape planning: the framework concept elaborated from a hydrological perspective. Landscape and Urban Planning, 21, 91-107. https://doi.org/10.1016/0169-2046(91)90035-k

van Buuren, M., Kerkstra, K. (1993). The framework concept and the hydrological landscape structure: a new perspective in the design of multifunctional landscapes. In: Vos, C.C., Opdam, P. (eds) Landscape Ecology of a Stressed Environment. Springer, Dordrecht. https://doi.org/10.1007/978-94-011-2318-1_10

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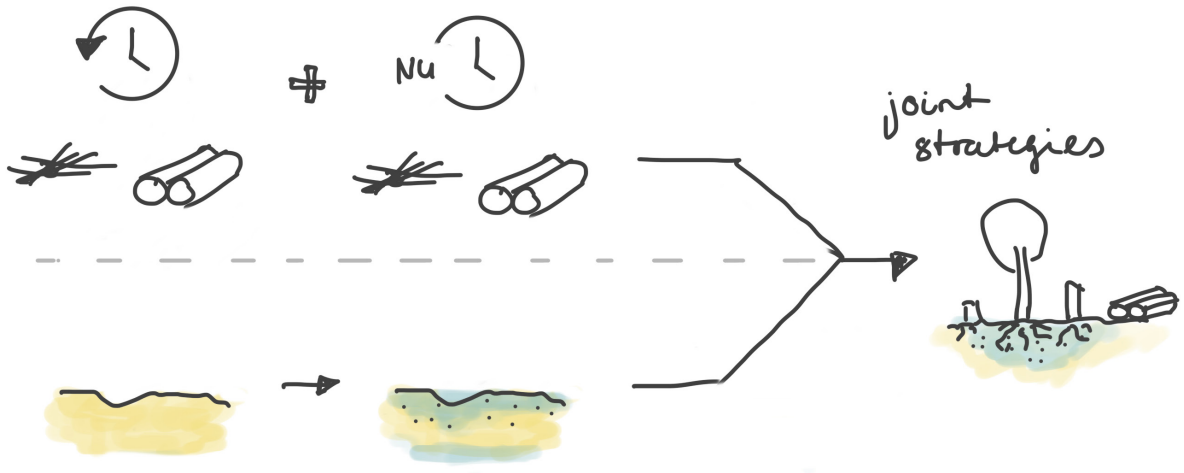
Kolen, J., Renes, J., & Bosma, K. (2017). Landscape biography. In A. van den Brink, D. Bruns, H. Tobi, & S. Bell (Eds.), Research in landscape architecture; methods and methodology (pp. 120-135). Routledge.

Nijhuis, S. Jauslin, D.T., Van der Hoeven, F.D. (2015). Flowscapes: Designing infrastructure as landscape. http://resolver.tudelft.nl/uuid:15505481-89e1-491c-848b-953291833c40

4.

Design research



Formation of the land by natural, cultural and urban processes.

Formation of the natural system

Roerdalslenk
Fractures in the soil layers of North-Brabant have been decisive for the local landscape. Eindhoven is located in the Roerdalslenk, a large valley area that extends into Germany. This valley was formed in a number of phases that started 150 to 200 million years ago. Level differences arose along the fractures in the earth's crust, which still influence the flow of (ground) water. The subsidence area of the Roerdalslenk was later, during the Ice Age, filled with deposits of coarse river sand and gravel by precursors of the Meuse and Rhine, which later moved eastward. These gravelly deposits in the Roerdalslenk were more recently covered with loam and cover sand. The Roerdalslenk in Noord-Brabant features surface sand beds of up to 50 m thick.

Cover sand deposits
During the last ice age (the Weichselian) the layer of loam, the brook valleys and the cover sand ridges were formed. North-Brabant was a polar desert at the time. Thermokarst lakes formed in low areas in which blown sand and loam were being held and run-off loamy melt water was retained. As a result, large plates of loam were formed, such as the central loam area between Veldhoven, Son, Oirschot and Schijndel, where wet forests later developed on loamy soils. These layers of loam belong to the Liempde layer package from the formation of Boxtel. The layers of loam that are still present today in the region vary in thickness and size.

Stream valleys
Subsidence of the Roerdalslenk created meltwater flows that carved wide valleys in the top layer of loam. These flows are precursors of the brook de Dommel, originating in Belgium and ending in s'Hertogenbosch.

Cover sand ridges and fens
In the Late Glacial, sand was supplied by predominant northwesterly winds from, among others, the dry North Sea, and created the Central Brabant cover sand ridge and the more northerly located Brabant cover sand ridge, and smaller sand ridges along the brooks, resulting in local elevation differences of several meters. Sand supply led to clogging, diversion, and bending of stream valleys. Parts of the former streams that had not been covered by sand were the beginning of the formation of fens. At the beginning of the Holocene, peat started to grow in abandoned gullies.

Vegetation and deposits during the Holocene
Due to temperature rise, closed forests could develop. Elm, common ash, willow and black alder grew in the brook valleys. Reeds started to grow in the lower stream of the Dommel due to wetting of the valley bed. Stream valleys deposited fine-sanded brook loam and iron-rich seepage water in the stream valleys caused the formation of bog iron. On higher parts, mixed oak forest with lime trees and elm grew, alternated with clearings of heather, bracken and wormwood. A richer soil than today started to develop here. In addition, further development of peat formation in fens and swamps was taking place.

This chapter is a summary derived from: (Ecologische Kring Midden-Brabant, 2011).

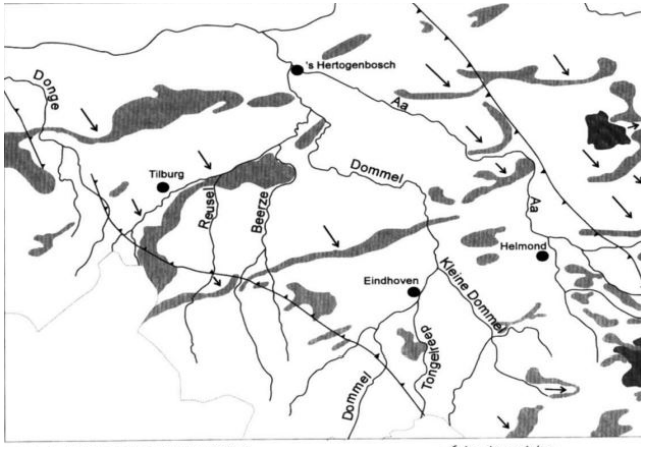


FIGURE 20 formation of surface sand ridges

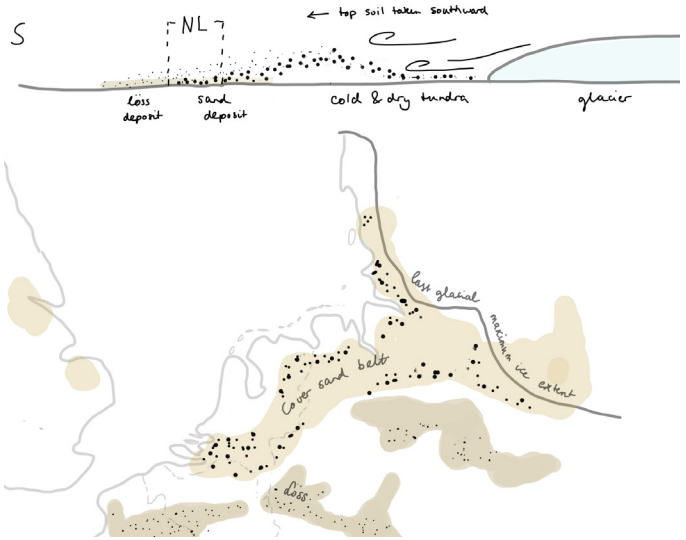
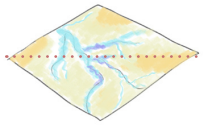


FIGURE 21 cover sand deposit

Cultural & urban interventions

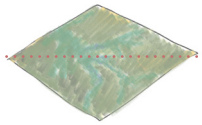
Interventions which are still visible today are described. Most of these interventions started during the Middle ages.

Natural system



surface sand ridges
planes
brook valleys
partly with peat soil.

Before human settlement

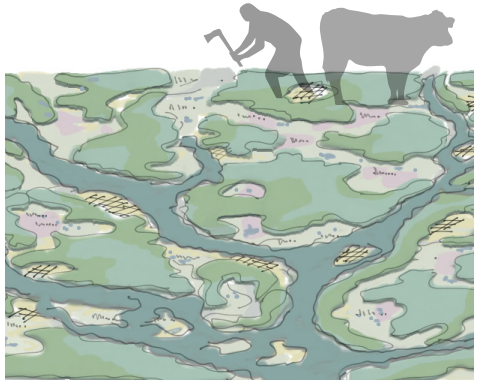


main land use
forest

First settlement

Settlement & deforestation
Around 4300 BC, farming most likely started in North-Brabant. Activities of arable farming and livestock farming were combined by shifting cultivation on nutrient-rich forest soil for which forests were cleared (Ecologische Kring Midden-Brabant, 2011).

Around 2000 BC, midway the Bronze Age, the landscape of North-Brabant was partly forest and partly open grassland or heathland, alternated with arable fields (Arts, 2020). Settlements were located nearby water, where soil was more fertile (Historisch openlucht-museum Eindhoven, 2022). Lime tree forests on higher areas and mixed forest of elm, hazel, ash in other areas (Ecologische Kring Midden-Brabant, 2011).



Legend

water
settlement & arable fields
brook valley forest
open grassland & heathland
forest

FIGURE 22 An impression of main landscape elements around 2000 BC.

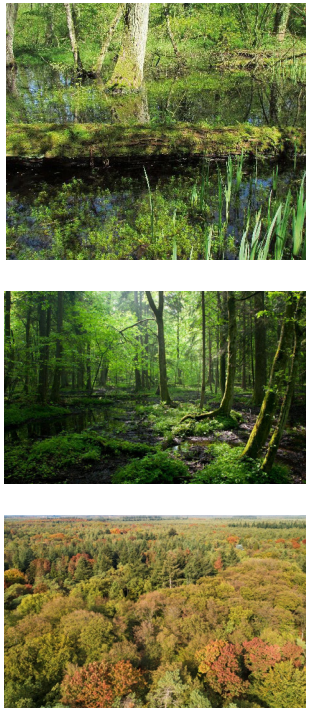


FIGURE 24 Impression of the land use

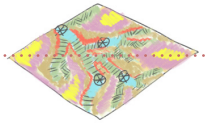
Around 500 BC, the landscape was dominantly open grasslands/heathlands, fixed arable fields, wooden walls, mostly forest on wet soils. In addition to the smaller fields that were used for arable farming, the landscape consisted for a very large part of uncultivated grass- & heathland. Large clearance of forests resulted in sand drifts (Ecologische Kring Midden-Brabant, 2011). The amount of forest fluctuated in this time period, due to changes in population.

Legend

water
settlement & arable fields
brook valley forest
open grassland & heathland
forest
sand drifts

FIGURE 23 An impression of main landscape elements around 500 BC.

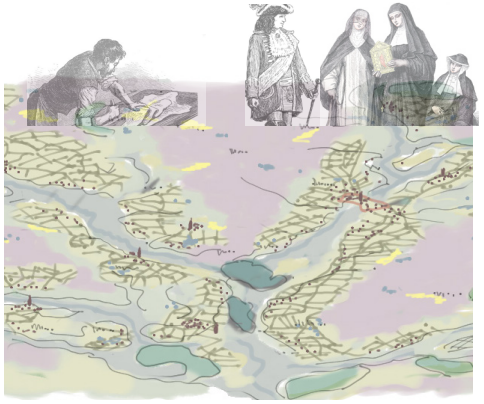
Middle ages



main land use
- drifting sand
- raised farmlands (essen)
- heathland
- grassland in brook valleys
- swamps created by water mills

Raised farmland & heathlands
City expansion had a minor influence on the larger landscape elements. The city of Eindhoven remained remarkably small. At the same time, agricultural settlement relocated from the highest parts to the flanks, at the boundary of sand ridges and swamp or brook valleys. Brook valleys were transformed to grasslands for livestock grazing and water mills were introduced. In addition, these lands were claimed by noble and monastic orders for build castles and monasteries. Arable fields (Dutch: essen) expanded by sod fertilization was introduced early in Brabant and were heightened over time up to a meter. At the peak of the system in the beginning of the 19th century, the landscape was dominated by large heathlands with patches of drift sand due to sodding. (Ecologische Kring Midden-Brabant, 2011).

The introduction of 'Voorpootrecht' in the 14th century had a major influence, resulting in an enormous network of tree lanes.



- water
- settlement
- reclaimed brook valley
- waste lands (grassland & heathland)
- forest
- sand drifts
- 'esdekken' with surrounding tree lanes

FIGURE 25 An impression of main landscape elements around 1800 AD.

FIGURE 28 Impression of the land use

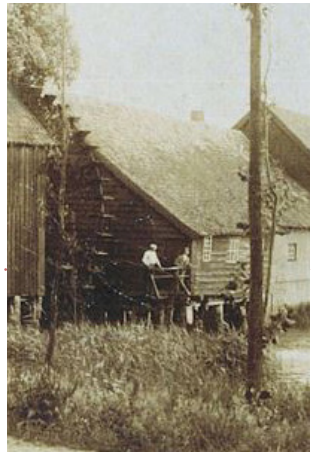
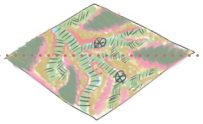


FIGURE 26 Miller
http://www.watermolenopwetten.nl/

FIGURE 27 Voorpootrecht landscape

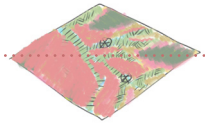
FIGURE 29 Rabat forests in the brook valleys

Industrialization



main land use
- large production forests
- raised farmlands (essen)
- heathland
- grassland in brook valleys

Urbanization

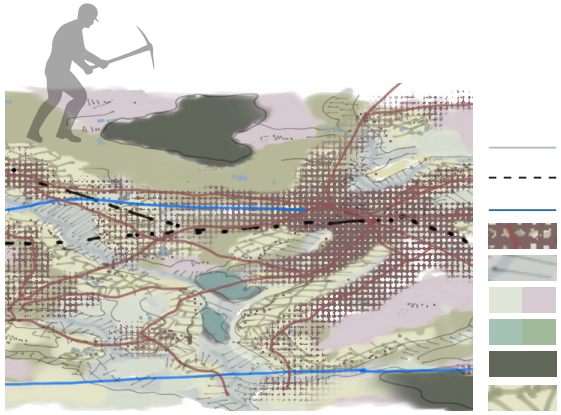


main land use
- city
- large production forests
- raised farmlands (essen)
- heathland
- grassland in brook valleys

Industrialization & urbanization
The system of sod fertilization fell into disuse by the emergence of artificial fertilizer, the introduction of mechanization, and import of wool. Interactions between fields, pasture and wasteland expired. As a consequence, large-scale reclamation of wastelands took place. Wastelands inappropriate for arable fields was reforested by monotonous conifer plantations.

As the farms became increasingly petrified, the need for oak and willow wood decreased. That is why the plant rights holders gradually switched to the production of poplar wood, which could be sold to the emerging clog and match factories. This is how the typical poplar landscapes arose in the 18th and 19th centuries.

Early 20th century: Afforestation plans for wasteland in the municipality.



- water
- train
- canal
- urban environment
- reclaimed brook valley
- waste lands (grassland & heathland)
- forest
- coniferous forests
- 'esdekken' with surrounding tree lanes

FIGURE 30 An impression of main landscape elements around 1950 AD.

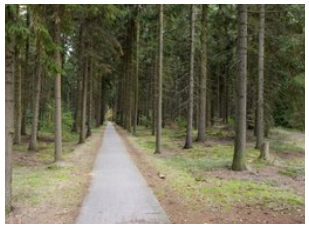


FIGURE 31 Large scale afforestation of waste lands
https://www.knhm.nl/historie-knhm/

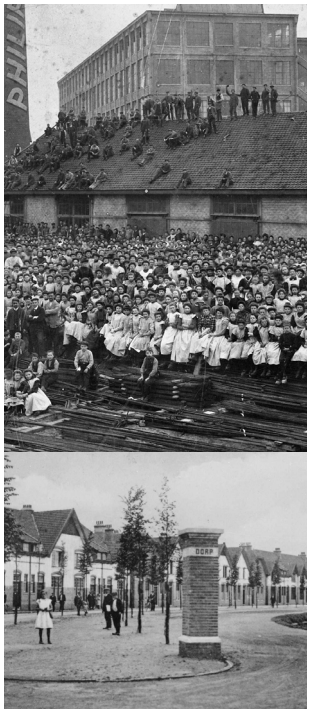


FIGURE 32 Philips factory & village established by Philips
First photo: Royal Philips

Natural water system

A model has been made to understand the relation between water flows and landscape units. The landscape units are linked by groundwater flows. The higher areas are infiltration zones. In these areas, the groundwater recharges, whereas the brook bed valley is the place where water enters the surface again.

FIGURE 34 brook system of the Dommel

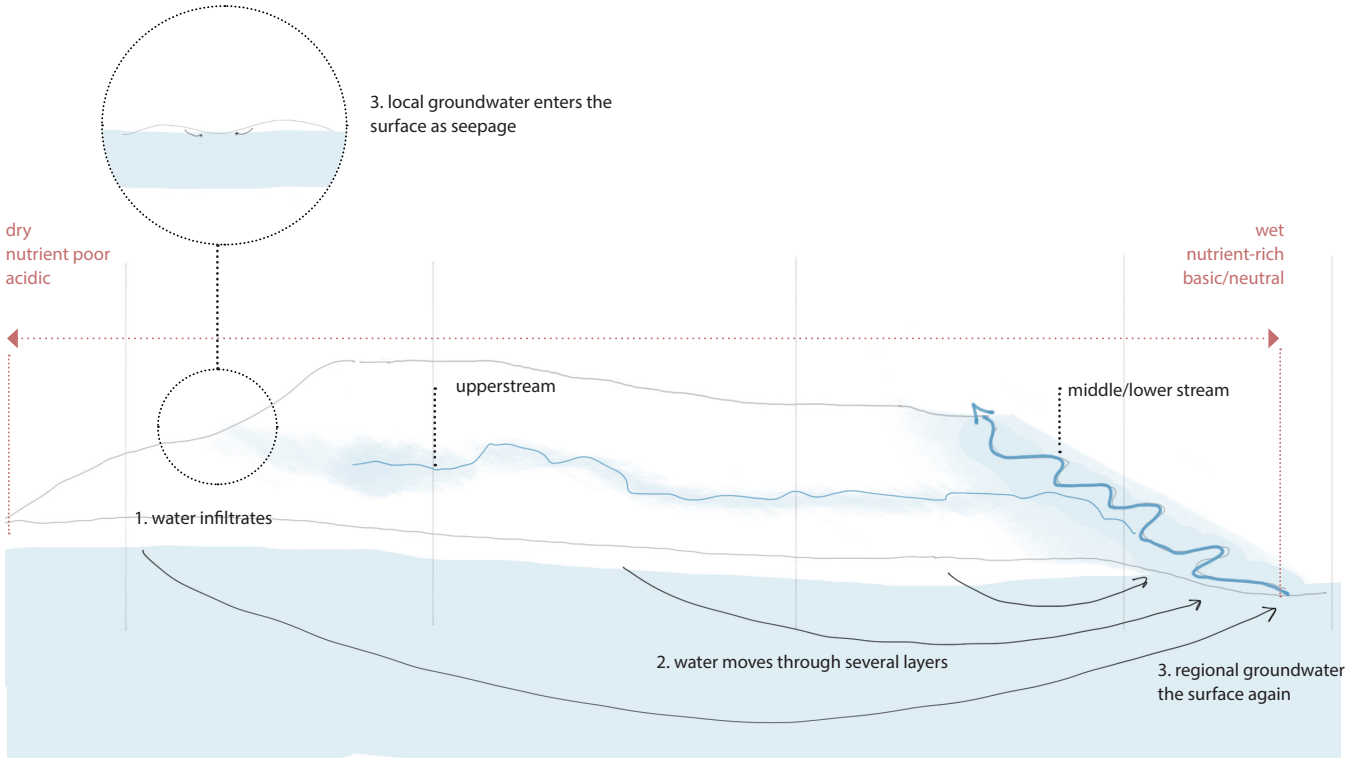


FIGURE 33 Scheme of ground water and surface water flow of brook valley landscape

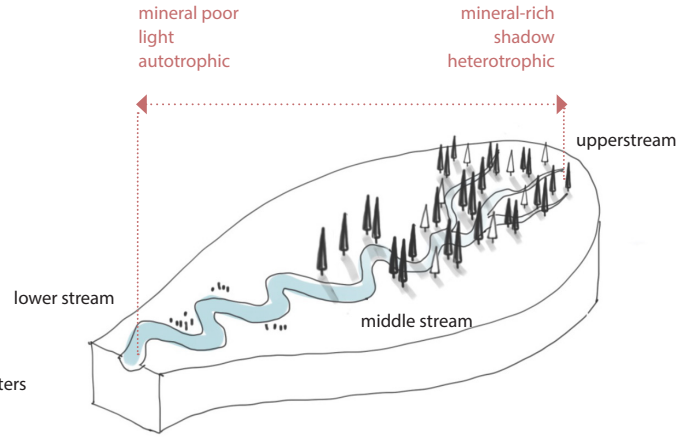
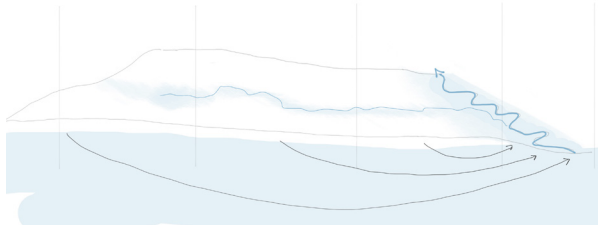


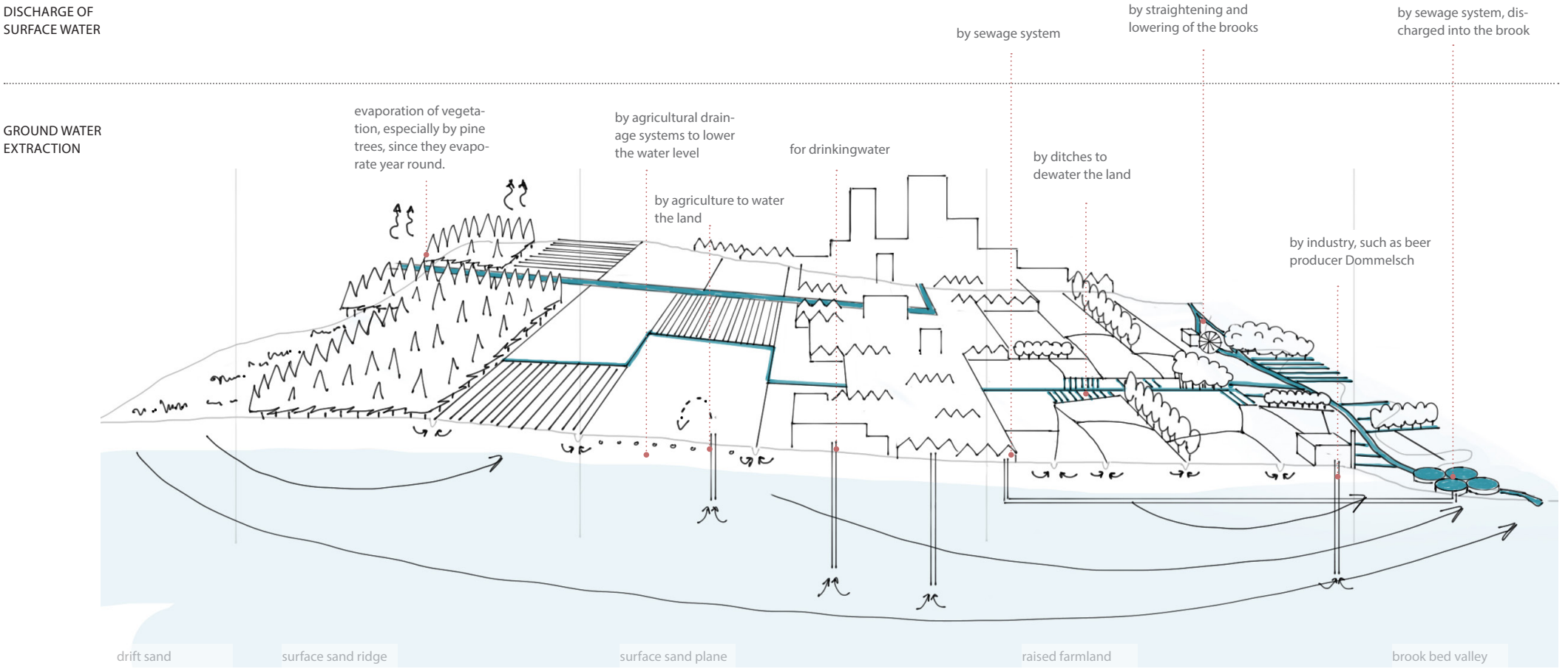
FIGURE 35 Gradients in water system, based on (Verdonschot, 2009)

Landuse influencing water system

By human intervention, the interrelated system has changed. Several analysis maps have been made which can be found in the appendix. The tension that today's water system faces is mainly caused by:

- excess ground water extraction by industry, agriculture and for drinking water
- (pine) forest evaporation in the driest areas whilst these areas have the highest potential of charging groundwater.
- accelerated drainage by ditches.





Potential solutions

Several strategies are composed or derived from existing studies (Projectteam Droogte Zandgronden Nederland, 2021), which include:

- retaining water
- store and supply of water
- minimize usage
- recharge of groundwater supply

1. Retain water

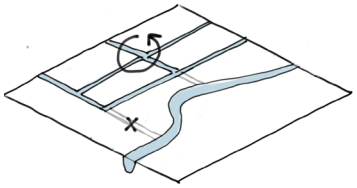


FIGURE 36 Water retention in tertiary water system

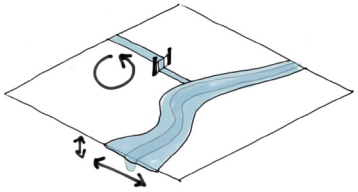


FIGURE 37 Water level management and

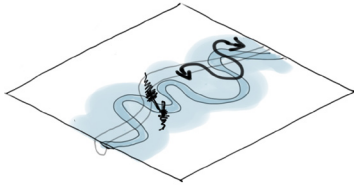


FIGURE 38 Reduction of drainage in brook valleys

2. Store and supply water

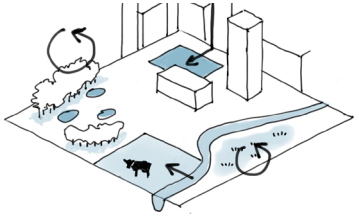


FIGURE 39 Storage of surface water in waterways, retention areas and (old) fens

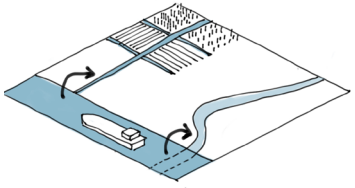


FIGURE 40 Supply by surface water

3. Minimize groundwater

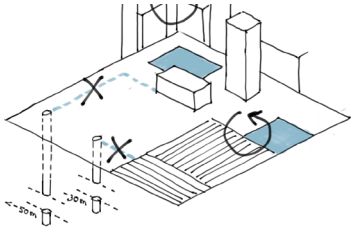


FIGURE 41 Minimize extractions of groundwater for process and drinking water

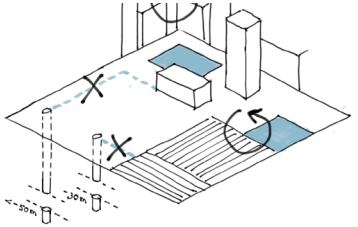


FIGURE 42 Minimize extractions of groundwater for sprinkling

4. Recharge of groundwater

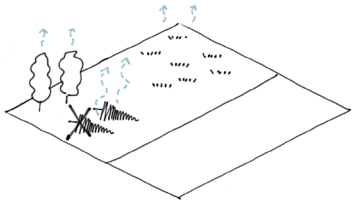


FIGURE 43 Change of land use

FIGURE 44 Disconnection of rainwater from

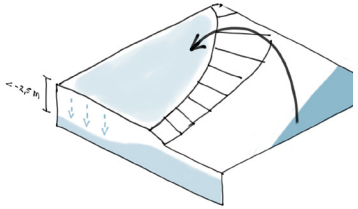


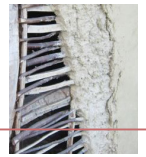
FIGURE 45 Underground storage of water

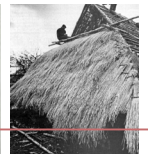
4.5 Historical building material use

The extended version of the landscape biography for local building materials can be found in the appendix.

This timeline shows an overview of historical, local construction material use.

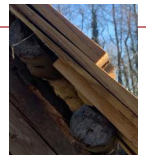
DOMINANT USE OF LOCAL, BUILDING MATERIALS

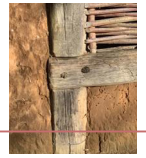




Use of wooden frame, wickerwork with loam as fill and a roof of straw

Additional use of wood for roof, oak shales





Changed use of wooden frame, influenced by Romans: planed beams

MAIN HOUSING TYPOLOGY

First residential barns, housing farmers & their livestock

New type of residential barn

Boot shaped residential barn (from ± 900)

AUTHORS & THEIR INFLUENCES

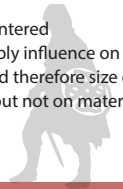
farmers living of land with cattle

± 4300 BC

farmers living of land with cattle

± 500 BC

± 50 BC (till 400 AD)



Vikings entered
Presumably influence on shape and therefore size of houses, but not on material use

± 850 AD

Shifting farms

Permanent yards and settlements

± Bronze age
Population growth during the Bronze age

± 700 BC
Introduction of iron tools, again population growth

Legend

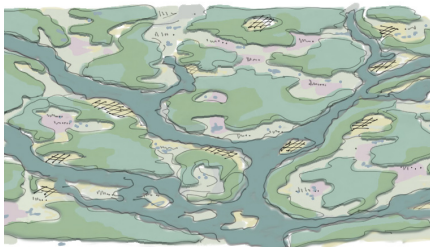
main local materials

wood

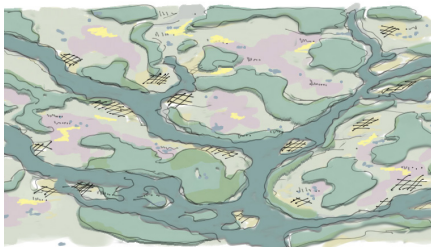
loam

straw

MAIN LANDSCAPE ELEMENTS



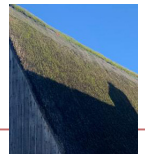
Lime tree forests on higher areas and mixed forest of elm, hazel, ash in other areas.



Dominantly oak trees & alder trees. Growth of Beech and Hornbeam. Lime dissapeared.

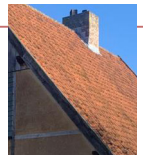
MAIN VEGETATION

Continuous use of three elements for town houses

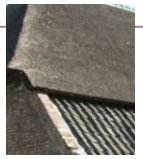


Additional use of wood for walls

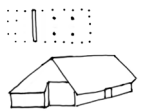
Additional use of loam as bricks, *first meter of bricks and roof tiles, to prevent fires in city*



Complete use of loam as bricks for town houses

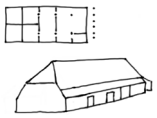


City: Rectangular town houses with a deep yard



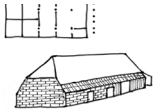
Aisled hall farm (Dutch: Hallehuisboerderij)

City: Rectangular town houses

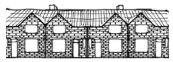


Extended long facade farm (Dutch: langgevelboerderij)

City: Rectangular town houses



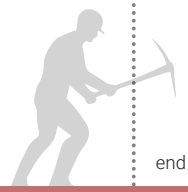
Extended long facade farm (Dutch: langgevel-boerderij)



row houses of brick, work-ing-class houses

from 12th century onwards

13th century onwards



end of 19th & 20th century

Transition towards fabricated houses

Industrialised city expansion

13th century onwards

Frequent fires dam-aged the city

1396

first 'voorpootrecht' granted in Meierij by ruling duke to plant trees on municipal grounds

18 century

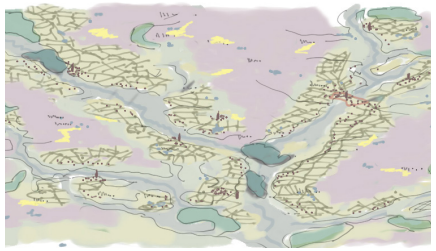
introduction of sawing by water mill

18 / 19th century

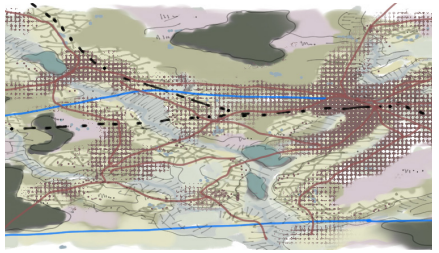
Transition of right to plant land-scape to poplar trees, as bricks became more popular.

19th century

Accessibility of area by roads, train and canals



Oak trees & willows.



Coniferous forest & poplar trees

FIGURE 46 Timeline: historical use of local building materials

Summary of tradition of building locally
What characterizes the history of use of local building materials and matching building techniques in this region is that the local nature of it has been retained for quite some time. It can be called a solid tradition. One of the factors involved is the remoteness of the region in relation to major access rivers. For a long time, the Dommel was the only connection from Eindhoven to the more advanced city of 'sHertogenbosch. Intensified transport became only possible after the construction of the paved road from Liège to 's Hertogenbosch via Eindhoven, the construction of the Wilhelmina Canal and the railway in the 19th century. Another factor is the presence of loam as a reliable source, and has been used throughout the entire local history. In addition, because of the naturally poor soil that yielded little, the area has been less attractive to conquerors such as the Romans, so that external influences have been limited.

The local character described above applies to the urban environment but even more so to the countryside. Farmers in the region of Eindhoven were often forced to rely on sober construction with materials that were cheaply available, such as loam or agricultural waste streams such as straw. They did not have the luxury of using more expensive building materials. Even far into the 20th century, the use of a thatched roof, most likely local sources as affordable material, is still very common for agricultural farms.

Main local building materials
Three local materials have been dominantly used in this region: loam, wood and straw

Wood
The use and availability of wood shows a more dynamic course. Until the late Middle Ages, this material was available in the primeval forests still present at that time. After the clearance of all primeval forest, people were forced to start planting oaks and willows for housing construction, initiated by the Duke of Brabant through the so called 'voorpootrecht'. This made it possible again to use wood for the construction of houses. The local use of wood also led to the innovation of a water mill with a sawmill. However, as soon as the city faced many fires and the more combustible and rot-proof bricks became affordable, the use of wood decreased to a minimum. Only in recent years, there has been a revival of the use of local construction timber, through initiatives such as Peppelhout. This organization has set up an entire chain around poplar wood within the former contours of the Meierij area. In doing so, they both strengthen the local cultural landscape that was created by 'voorpootrecht' and offer a sustainable alternative to foreign wood.

Loam
The use of loam can be seen as a stable factor in local construction. This material is naturally available and has therefore proven to be a reliable source. In every period, from fixed settlements, the material has been used in some way. In the first instance by applying the vitselstek technique. Even after the connection of the region of Eindhoven via rail, canal and paved road, there has been a revival in loam mining through local brick factories. The improved technique of heating loam made it again a useful product. Only today, the use of loam in the region is minimized.

Straw (and later reed)
Straw has been widely available as a residual material and has been used in various ways. It was mixed with loam used for 'vitselstek' walls and used as roofing material, sometimes alternating with sods. The limited availability of local reed has long made straw the most commonly used roofing material in this area. Only late did roof tiles and reeds replace straw as roof materials.

Other materials
As described, other materials have been used to a lesser extent. Sod and reed for instance for roofing. Until the 20th century, local reed most likely came from the banks of the Dommel and the banks of the fish ponds south of Eindhoven. It is remarkable that certain materials are not mentioned in the sources consulted. For example, the use of sheep's wool for insulation. Sheep wool was an important raw material for the clothing industry in the middle ages, but no source refers to it as building material. Was it maybe too expensive for that? And iron ore that has been dug out in the brook valleys and used for various purposes such as nails.

creating wickerwork of willow brances; → mixing of loam with straw → loam mixture is put on the wall → roof attached

https://historisch-openluchtmuseum-eindhoven.nl/ijzertijd/Brabant/Slifferthuis-ontwerp_en_bouw.html

https://ijzertijdboerderij.wordpress.com/2017/09/28/vitsen-en-lemen-van-wanden/

https://ijzertijdboerderij.wordpress.com/2017/09/28/vitsen-en-lemen-van-wanden/

https://www.eindhoveninbeeld.com/photodetail.php?id=38369

Vilselstek technique with loam straw and willow brances;

Wood

- Cultivation: several, small production forests are present in Brabant. Most of these forests are located in the nature network.

- Processing: several sawmills and companies that take care of the production process from tree trunk to end product are located in Brabant. These companies process local wood as well as foreign wood. The remnants of local wood sawing, however, need to be processed abroad. A fiber industry is absent here (Staatbosbeheer, 2022). Afterwards, plate material is shipped back to the Netherlands. Brabant has a local wood chain specialized in processing poplar wood. Cultivation, management, harvesting, transportation, sawing, drying, profiling, and thermal modification, all steps in the processing chain are locally executed. The resulting timber products are labeled 'Peppelhout'. Poplar is a pioneer tree and therefore fast growing (Bosgroep Zuid Nederland, 2015).

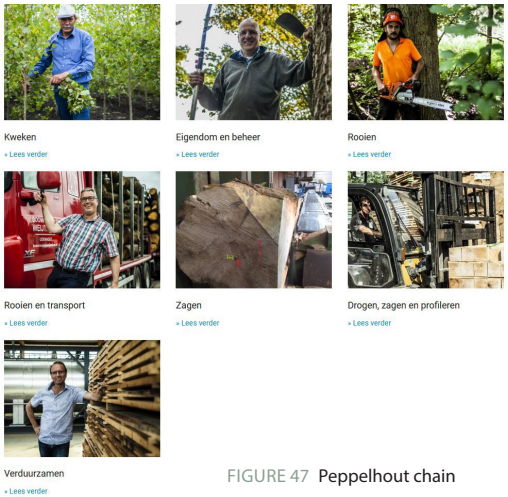


FIGURE 47 Peppelhout chain

Loam

- Cultivation: Loam delving is absent today in North-Brabant.

- Processing: The traditional technique of vitselstek requires a lot of patience and is therefore not attractive today. An example of a suitable processing technique is to press loam, resulting in pressed loam stones, pressed loam walls, and loam slabs. Local materials such as straw can be added to strengthen the stones. Small machinery can be used for this process.

FIGURE 48 On site processing technique for making pressed loam stones

Straw

Cultivation: Grain is cultivated in North-Brabant most often as a winter crop. Grain is mostly cultivated to feed livestock (Nederlandse Akkerbouw Vakbond, 2017).

Processing: Bales of straw can be purchased from local farmers and used in low-tec constructions after being pressed. A chain for prefab straw panels is absent in North-Brabant.

Gewassen	2022* Beteelde oppervlakte ha	Geoogste o
Tarwe (totaal)	11 659	
Tarwe, winter	10 191	
Tarwe, zomer	1 468	
Gerst, winter	1 247	
Gerst, zomer	1 465	
Rogge	316	
Haver	99	
Triticale	192	
Maïs, korrelmaïs	4 696	
Maïs, snijmaïs	42 477	
Maïs, corn cob mix	3 526	
Koolzaad (totaal)	61	
vezelvlas	128	
Lijnzaad	128	
Cichorei	1 391	
Hennep	28	

Bron: CBS

https://opendata.cbs.nl/#/CBS/nl/dataset/7100oogs/table

Reed

- Cultivation: reed suitable for roofing is only provided today as residual flow from nature maintenance, such as in de Brand near Tilburg or the Urkhovense Zegge near Eindhoven. However, these reed fields are managed for optimal ecological value and their value for construction is of less importance (Rijksdienst voor het Cultureel Erfgoed, 2022).

- Processing: multiple thatchers work within Brabant who often use reed from abroad due to limited, high quality local reed.

Sods

- Cultivation: sods from heathlands are not used anymore. Today, sedum plants and herbs are cultivated for green roofs.

- Processing: multiple nurseries are located in North-Brabant.

Future potentials

The first Dutch CLT factory is planned in Hapert, south/west of Eindhoven. It is expected that the first products will be available in 2024. The new factory can produce panels for approximately 2,500 homes per year (Redactie Houtwereld, 2022). Initiator Boerboom Hout Groep hopes to give an impulse to forestry in the Netherlands in order to be able to use local wood. A connection with State Forestry has already been made (Ommen, 2022).

Another future potential is the future biobased economy boosted by GreenTech Park Brabant in Boxtel. Nine hectares of allocable land are available for companies within the field of circularity (Gemeente Boxtel, 2022).

New use of natural products such as cattail, flex, reed, hemp, miscanthus, and willow for isolation. Fibers of these plants are processed into isolation sheets. Another example is the use of cow dung in 3D printing houses. The industry for these applications is still in development.

4.7 Strategies to boost local, natural building

Based on the historical use of local material and todays potentials, a list of strategies has been composed. In order to be able to make a transition to the use of local building materials today, it is important to use primarily the materials currently available.

Proven strategies:

Local timber

- The current landscape is not yet geared for large-scale logging. However, the use of local wood has been on the rise for some time, as initiative Peppelhout shows. Reintroduction of 'voorpootrecht' can play a role, as well as development of new forest. As poplar wood can be harvested in a relatively short period of time, this tree is well suitable.

- Cultivation of materials by boosting 'the right to plant' (Voorpootrecht).

- Logging conifers from monotonous pine forest to reinforce a more dynamic forest.

- New timber plantages on current arable fields or in brook valleys (rabatbos) to enhance the attractiveness and historical variation of the landscape

Local loam

- Loam has proven itself to be a stable factor in the past and could provide a solution as already available material in the near future. Pressed loam stones, walls or slabs require little processing and are therefore relatively suitable.

- Use of residual loam of excavated land for housing and infrastructure.

- Excavating loam at places that offer a win-win situation, such as nature development.

Local straw

Use of local straw bales for isolation

Local reed

Limited local, natural materials are available for the purpose of roof material. In order to secure enough materials, local reed production can be stimulated. Reed requires a poor soil such as sandy soil and clean, lightly flowing, not too nutrient-rich, fresh to brackish water (Rijksdienst voor het Cultureel Erfgoed, 2022). Not too nutrient-rich water suggests that water affected by agriculture is not suitable for growing reed for the building industry.

- Extent current reed fields

- Develop new reed fields

Local sedum / herbs

In addition to the previous strategy, a boost can be given to the cultivation of sedum or herbs for ensuring enough materials as roofing material.

Stimulate cultivation of herbs and sedum.

Experimental strategies:

Future or small-scale materials

- Reuse of fibers from current agricultural residues and byproducts, such as cattail, flex, hemp, miscanthus, and willow. In addition, reed as residual flow from ditches, can be used for isolation.

- Use of wool from sheep grazing and maintaining local heathlands.

- Use of sodded heathland/grassland.

- Re-operating historical sawing machine in water mill can have a recreational value.

- Reintroduction of logging/cultivated groves where local residents can collect small-scale building materials for their own use. The traditional technique of pollarding can ensure regular harvesting.The management system relies on the ability

- of broadleaved tree species to regenerate quickly from cut stumps and root systems following felling

- This could provide materials for, for example, the manufacture of smaller parts such as garden sheds, furniture, etc.

Mutual strategies

The overlap in strategies is bundled in an overview called the toolbox (next page). Retaining of water, where the raindrop falls, is supported by:

- Heathland/grassland optimal for major infiltration areas, delivering primarily wool.
- Increasing the capacity of soil to retain water by adding litter by mixed production forest or by winter grains.

Next, buffering of water supplied by rainwater, canals and ditches can be achieved by:

- excavating land at strategic places to create water basins and provide loam.
- production forest on raised land (reversed rabatbos).
- wadi's alongside agricultural fields. These wadi's can host cattail and reed (for fiber) and timber to increase the infiltration capacity.

Finally, delaying drainage in the brook valley can be achieved by:

- excavating land to create water basins, supplied by the brook. Specifically where a thick layer of loam is present in the soil.
- riparian forest zone of alder and willow that slows down water.
- raising the water level (of water mills) which in its turn creates a wet zone ideal for cultivating qualitative reed for roofing material.
- and finally: reed/willow/cattail harmonica's at places where water is drained, for instance from the sewage treatment.

These strategies are based on characteristics of the involved landscape elements. Trees have specific effects that benefit the water system. Trees can increase retention capacity compared to grassland or arable land by first creating interception of water drops, by improving infiltration due to lager macropores by their thick roots and thirdly by increasing soil organic matter by litter (Veraart et al., 2020). What should be noted is that trees evaporate water which makes them less suitable for the most dry sands.

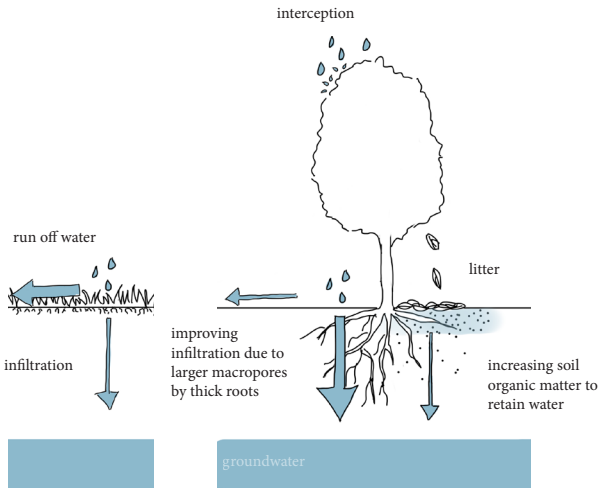


FIGURE 49 Influence of trees on the water system

Loam is beneficial for the water system in the sense that it can retain more water than sand and it slows down infiltration, causing wet zones. Because of this, it is not wise to excavate all the loam as it will dehydrate the land. Therefore it is proposed to only delve loam at spots with thick layers of loam to create strategically located water basins to buffer water. Finally, straw as winter grain increases the organic matter in the soil of arable land without substituting the intended crop

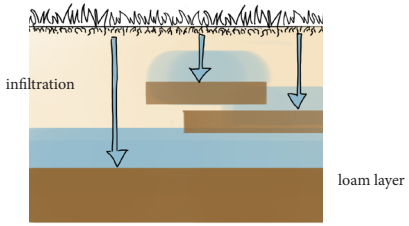


FIGURE 50 Influence of loam on the water system

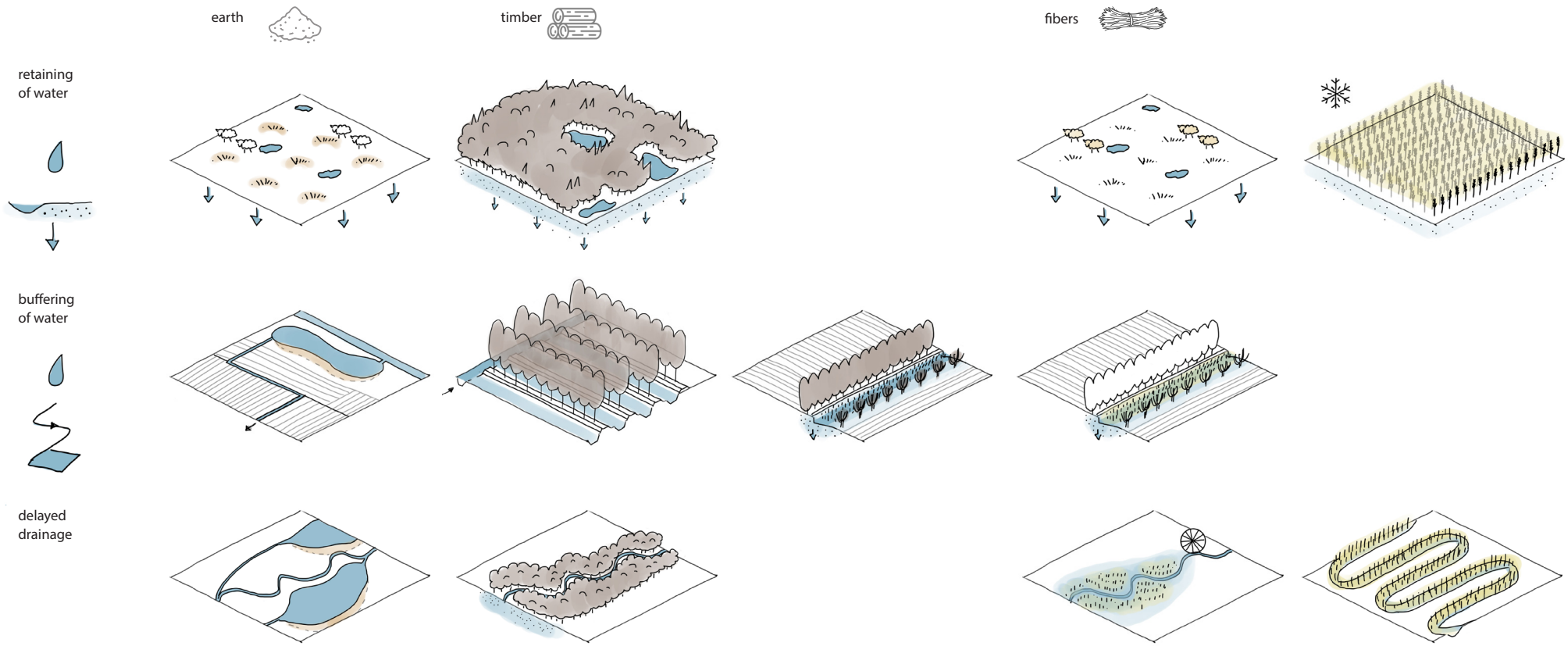


FIGURE 51 Joint strategies toolbox

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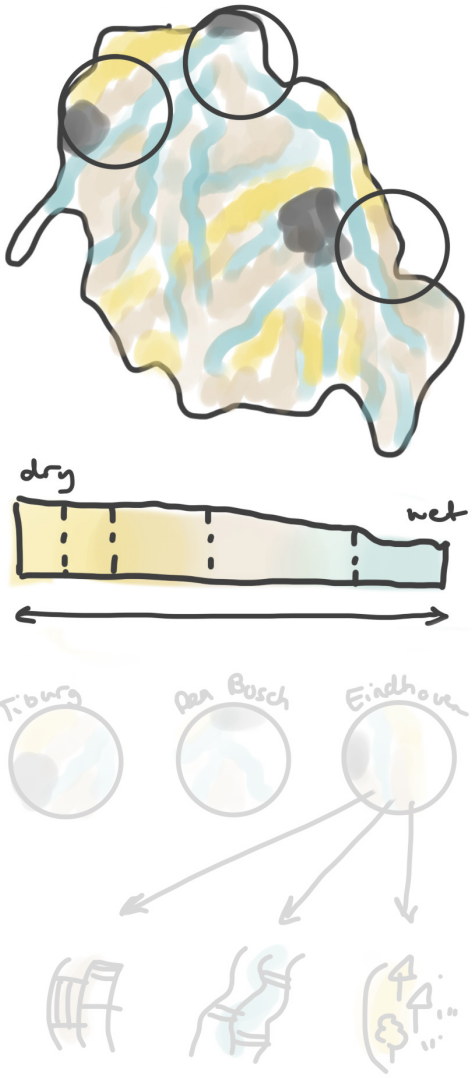
5.

Framework



Regional framework

↓

Local testing

↓

Site testing

5.1 Study of spatial distribution of production

For the spatial distribution of productive landscape domains, theory has been studied. Distinctives strategies have been compared. These include theories from nature conservation disciplines, since these theories look at the integral picture of the planet.

Half Earth approach

A spatial distribution which separates half of the earth from human pressure by protecting nature and wilderness (Immovilli & Kok, 2020). The remaining half of the earth includes an agricultural system that requires sustainably intensified food production to feed the world and spare land. Its protection based on the intrinsic value of nature refers to the framework by IPBES called Nature Futures.

Shared Earth approach

The Sharing the Planet scenario envisions human-nature systems in which humans and nature can live and thrive together (Immovilli & Kok, 2020). Mixed working landscapes that integrate human and nature systems are the essence, with optimization of ecosystem services as aim, see figure 53. Agriculture is interwoven with natural elements. The agriculture approach dominating in this scenario is one centered around the ecological intensification of food production and the delivery of ecosystem services.

Half-nature

The Van Gogh time period is a suitable reference for the 'sharing the planet' approach. In earlier times, farmers opened up a forest landscape with fields, meadows and heaths. A more fine-scale spatial pattern with many transitions and therefore a diversity of flora and fauna arose. The time period of Van Gogh represents the final phase of this complex distribution of the landscape. All parts of the landscape were part of the productive landscape. Today's remaining elements such as wooden banks or the heathlands are often referred to as 'half-nature', culture and nature working together. Without human interference, these landscapes would transform to forest by succession and lack of large animals. The beneficial influence of this collaboration can be seen in figure 52 (Zanden & Goethem, 2022). The period prior to industrialisation shows a peak in biodiversity values.

Three zones

A spatial distribution in which man and nature both have their own domain. Until the last century, every village in India distinguished three types of 'forest' in the vicinity of the settlement (Schouten, 2013):

Shrivan: 'forest of prosperity', for harvesting wood and fruits and planting new trees. Wild plants and animals were welcome as long as they did no harm.

Tapovan: "forest of the wise", the area in which seclusion for spiritual reasons took place, without harming wild plants and animals.

Mahavan: 'the sanctuary', the forest that belonged entirely to nature. No man entered it.

Conclusion

Different distributions are described. For this thesis, the distribution of a mixed landscape is chosen as a design strategy. This approach shows its potential to result in a diverse set of ecosystem outcomes, and aligns well with the Van Gogh time period.

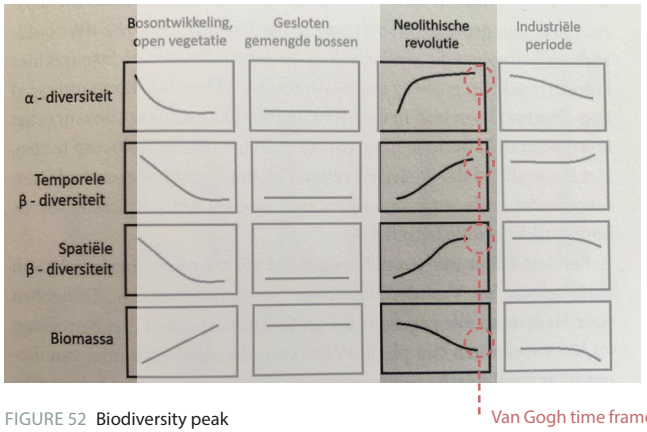


FIGURE 52 Biodiversity peak
(Zanden & Goethem, 2022)

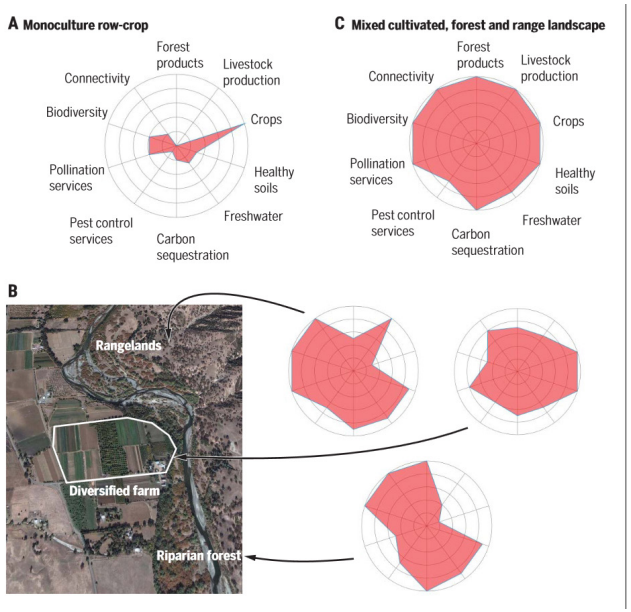


FIGURE 53 Mixed working landscape
(Kremen & Merenlender, 2018)

5.2 Regional design brief

In order to align the framework with the regional program, a regional design brief has been composed.

Key development themes by Van Gogh national park (2022):

- robust, connected and resilient nature areas
- attractive agricultural landscapes
- climate-robust brook valleys
- visibility and readability of the Brabant brook landscape
- perspectives for farmers and sustainable (food) production for a future-proof agriculture
- strong connection between producers and consumers (city-country)
- city and countryside structurally connected and developed in conjunction
- Nature and landscape to the heart of the city and village
- Development of nature experience and sustainable (cultural) tourism
- Recreational value for both residents and visitors
- Experience of accessible nature, landscape and heritage
- Education and recreation connected

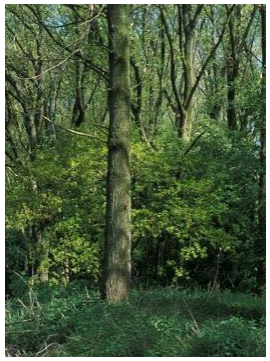
Supplemented by strategy from theory:

- generate a nature/culture intertwined, productive landscape
- blue infrastructure at the basis

An abstract framework based on the natural system is composed in order for it to serve as inspiration for the whole watershed. The strategies are projected on the base layer. The framework is explicitly abstract to serve as an exemplary format for the larger regional landscape.

Blue infrastructure
The blue infrastructure will consist of infiltration areas, wet zones, countryside wadi's and water basins to increase the amount of surface water and to stimulate infiltration.


main infiltration zones


'sponge' forest


countryside wadi


water basins

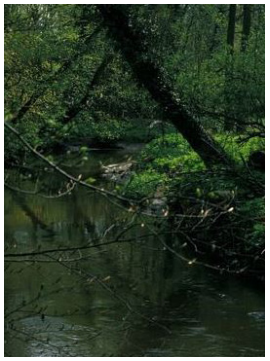

brook valley as sponge

FIGURE 55 potential water basin spots on loam soil and brook valley as sponge.

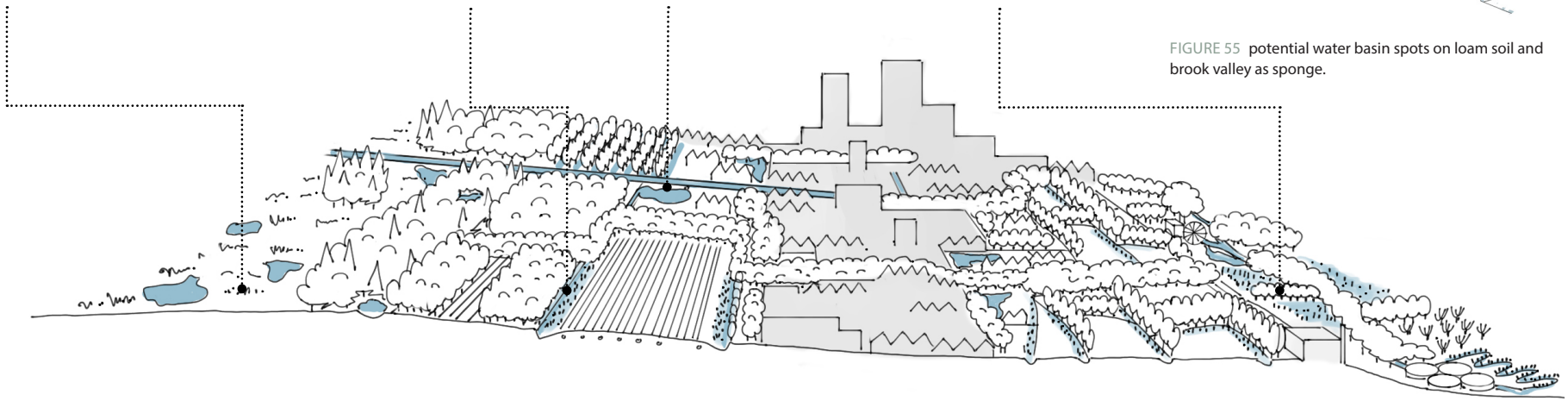


FIGURE 54 Framework - blue infrastructure

Robust tree network

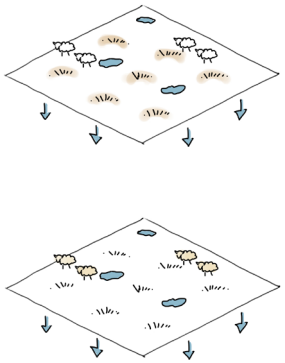
By increasing the number of trees, a robust network of trees can be created that will become part of the European climate adaptation zone. Lanes of trees can be alternated with patches of forest.

FIGURE 57 potential robust tree network

FIGURE 56 Framework - robust tree network

Robust heathland network

The strategy to increase heathland/grass on the driest soils benefits the resilience of the network of heathland, which is protected as Natura 2000. Connecting and increasing the protected areas is the most efficient strategy to climate proof biodiversity.



heathland

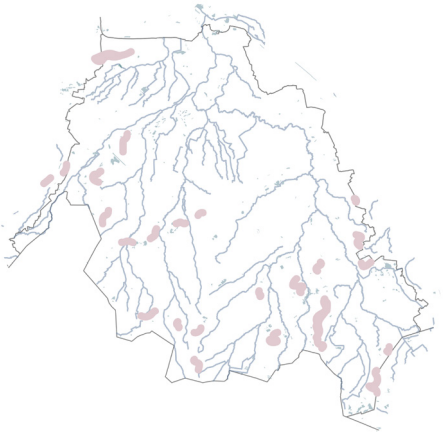
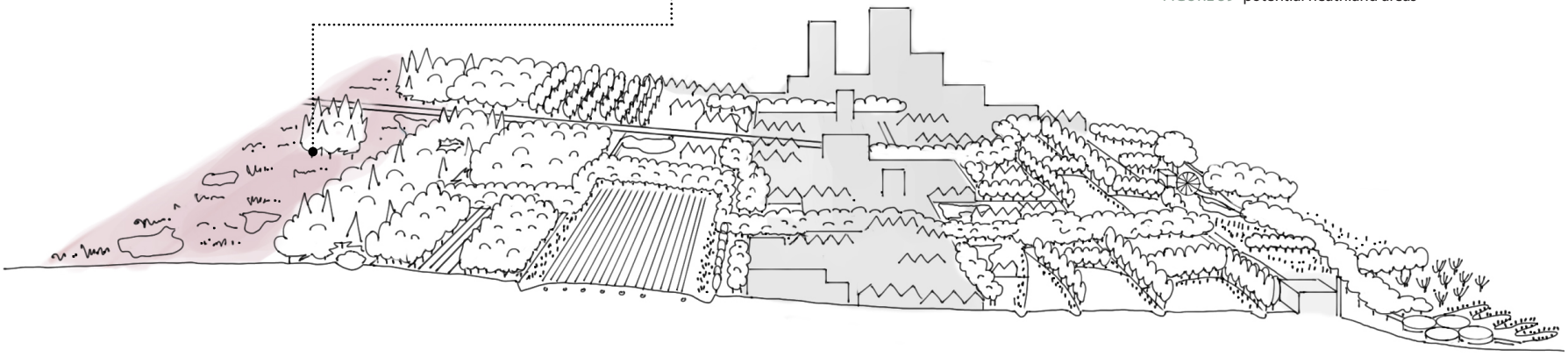


FIGURE 59 potential heathland areas



drift sand surface sand ridge surface sand plane raised farmland - brook bed valley

FIGURE 58 Framework - robust heathland network

Readability brook landscape

The brook valley landscape will become recognizable by accentuation of the different zones as the framework suggests. Heathland/grassland as a poor, dry zone and the wet, rich/abundant brook bed valley as opposite characters.

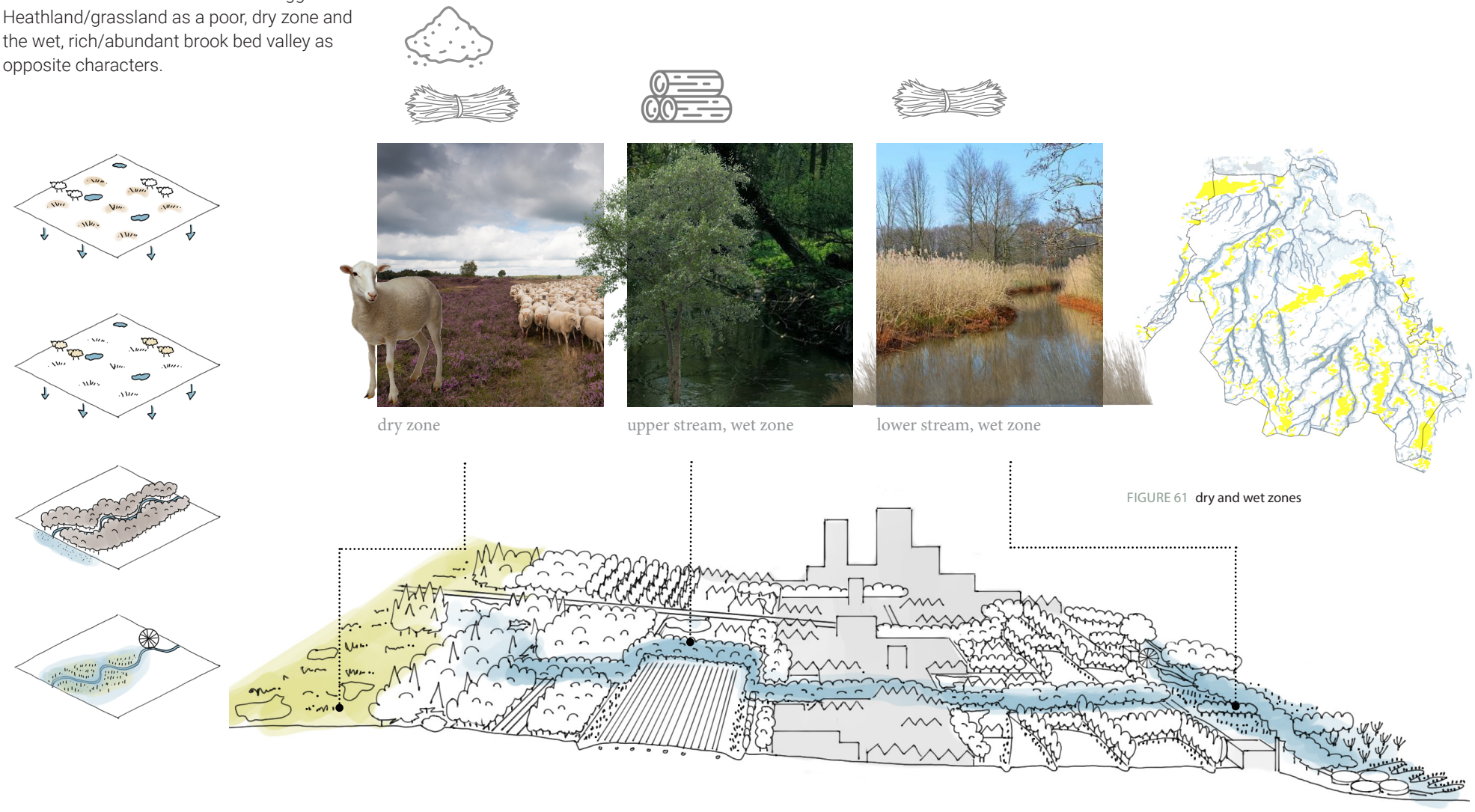
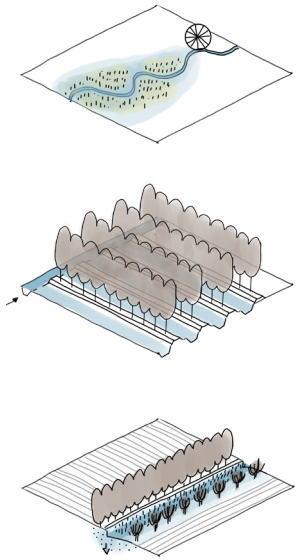


FIGURE 60 Framework - readability brook landscape

FIGURE 61 dry and wet zones

Heritage

Heritage can be experienced by an intensified poplar landscape and water mills that can play a role in slowing down drainage of the brook. Raising their water level creates wet zones which benefit reed cultivation.



poplar landscape

water mill biotope

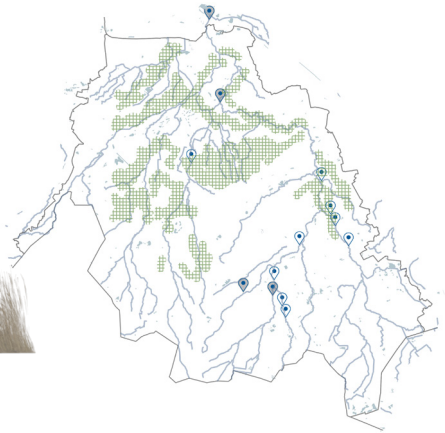
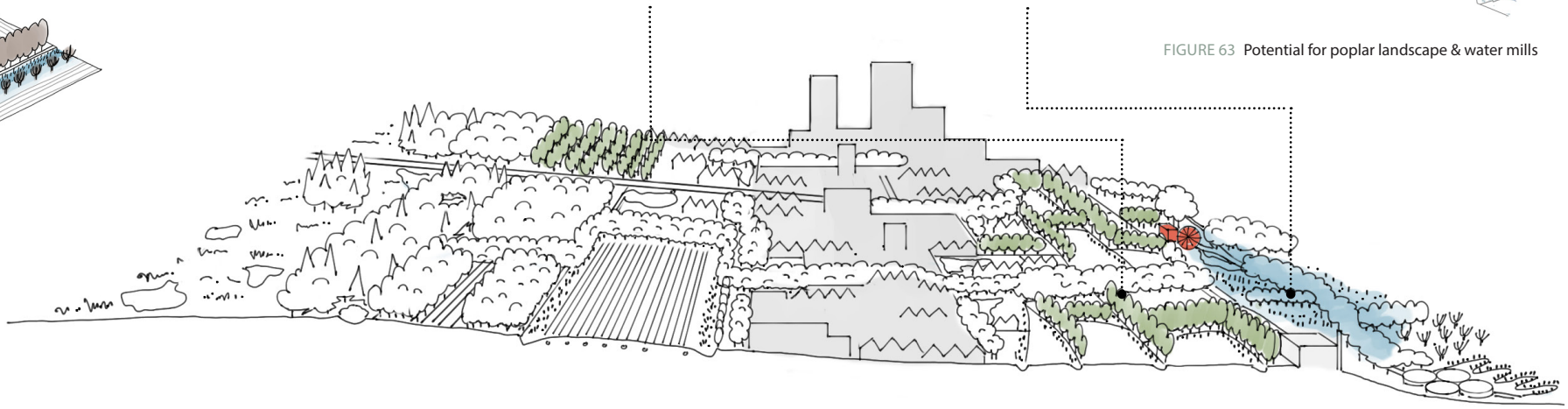


FIGURE 63 Potential for poplar landscape & water mills



drift sand surface sand ridge surface sand plane raised farmland - brook bed valley

FIGURE 62 Framework - heritage

Accessibility
The countryside can become more accessible by walking paths along the countryside wadi's and by potential communal groves for low key use.

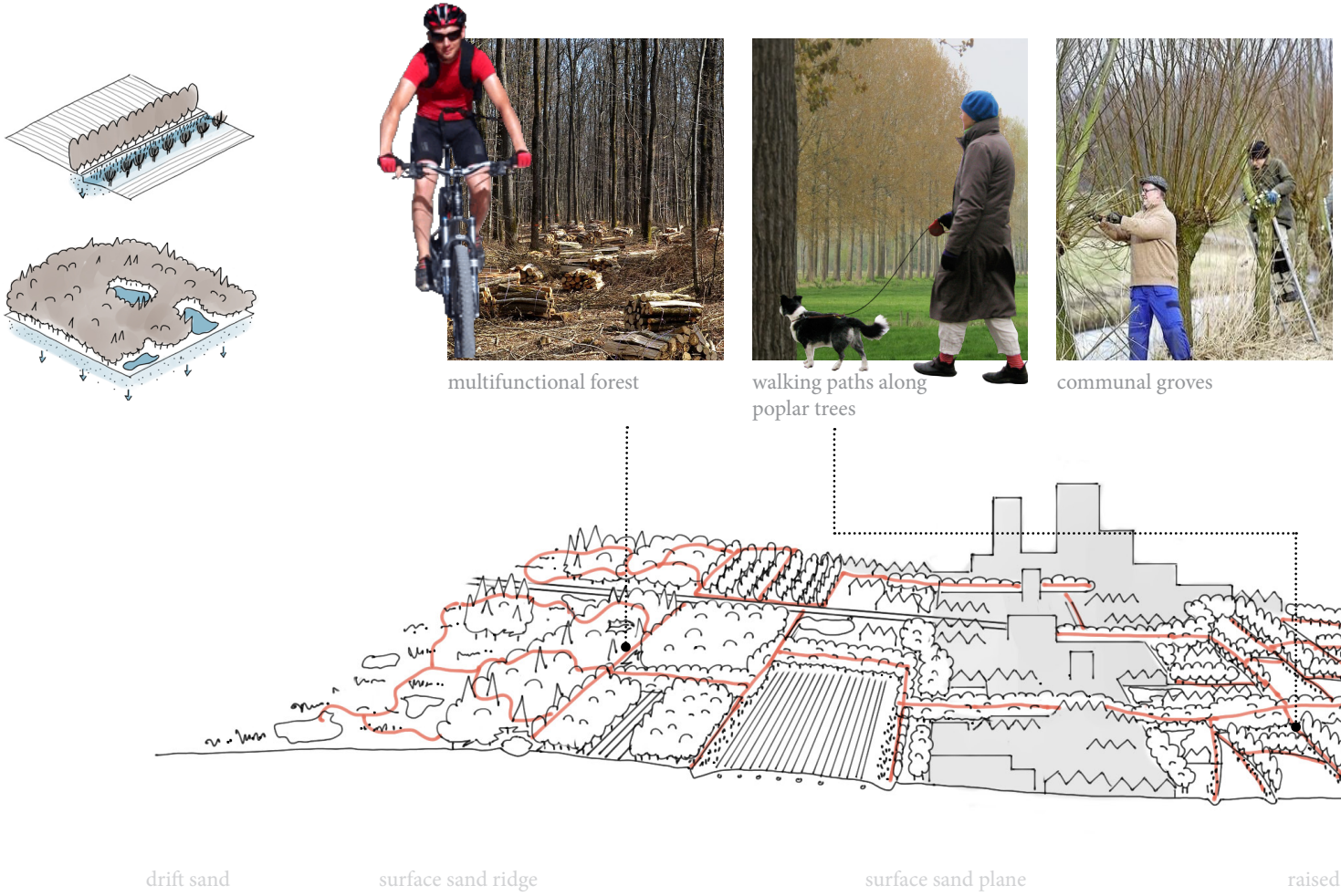
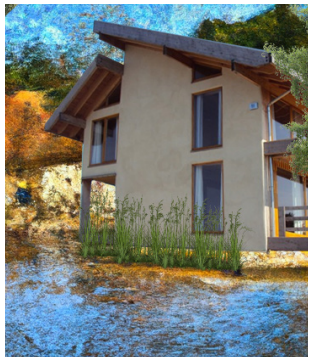


FIGURE 64 Framework - city edge

City and countryside

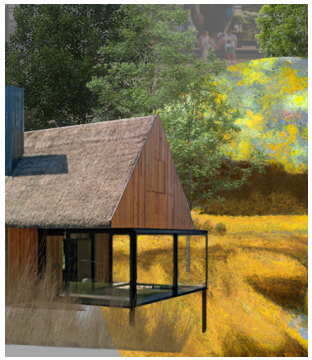
The city edge will develop as part of the previous strategies and simultaneously include houses that mark the transition from city/village to countryside.

dry edge



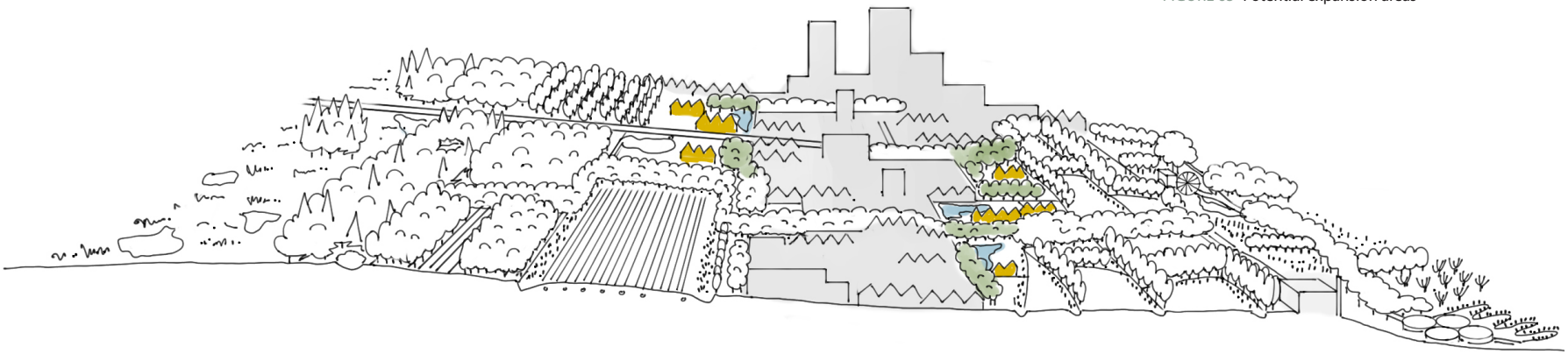
loam excavation edge

agricultural edge



wet edge

FIGURE 65 Potential expansion areas



drift sand surface sand ridge surface sand plane raised farmland - brook bed valley

FIGURE 66 Framework - city edge

Overview

The framework results in a landscape that potentially produces a spectrum of materials. The higher surface sand ridges and planes within the watershed can provide existing pine wood and wool from grazing sheep, and on the longer term additional wood types of deciduous trees. The central area of the watershed has the potential to dominantly provide poplar wood. Several small areas next to villages/cities and canals are indicated as potential zones for loam excavation to buffer water as well. The spread out arable land provides straw as residual material and finally the brooks crossing the landscape can provide more high quality reed and wood.

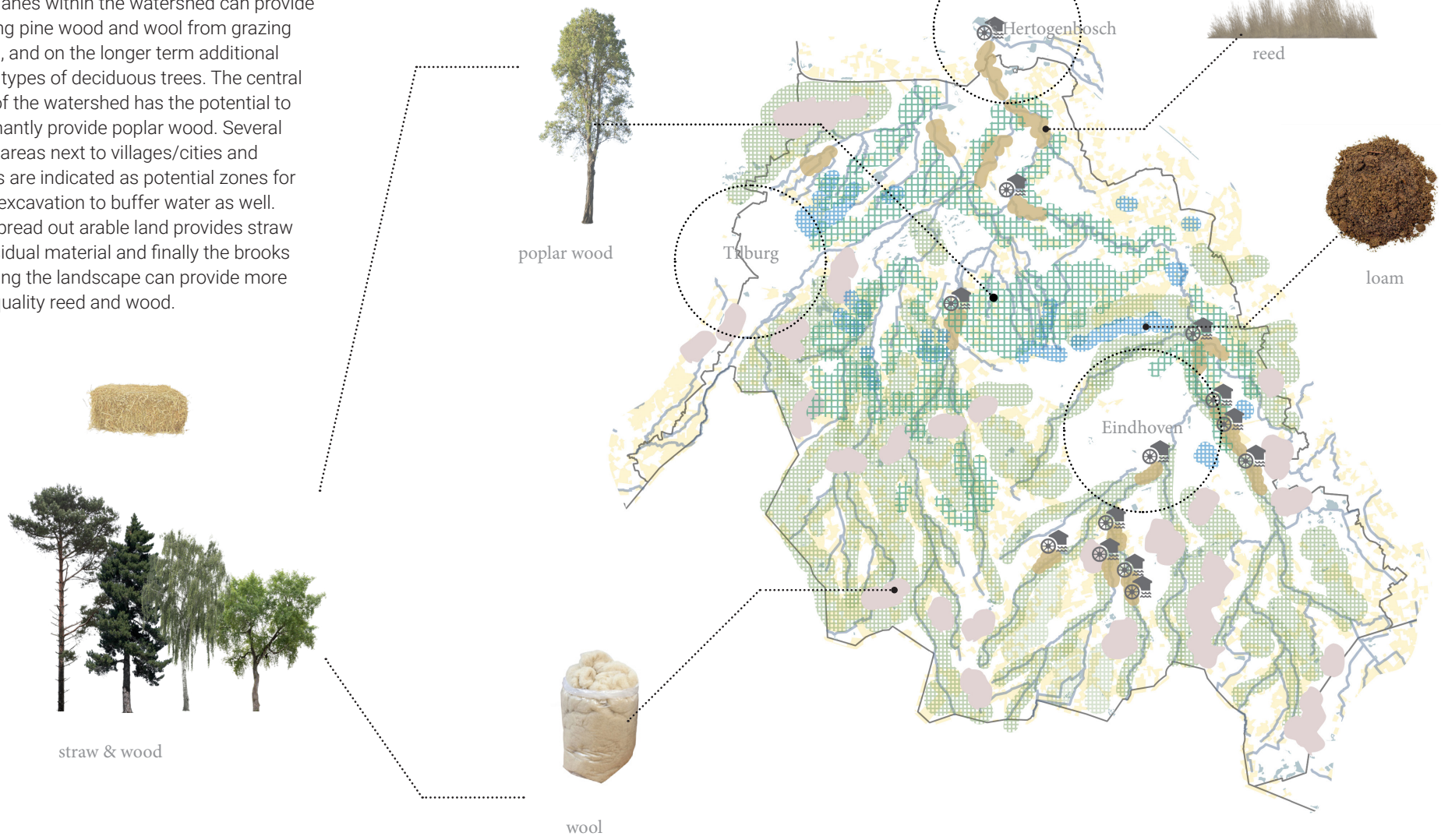


FIGURE 67 Overview of materials potentially provided by the landscape

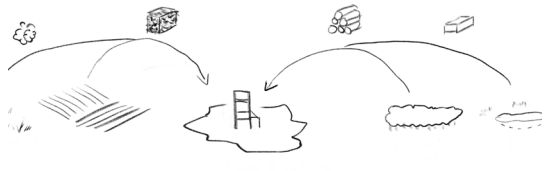
Positioned in the landscape
Most urgent zones for the use of local, natural materials are edges of cities and villages, since these transition zones can strengthen the character of the countryside. A free location of the building or building complex in the landscape is advised, so that the architecture blends optimally with the countryside.

A standard regional frame with local specific accents
A timber frame construction with straw for isolation and loam for thermal mass is the advised regional standard for buildings, since these materials are most accessible and proven. A CLT-frame would consume a larger amount of timber in comparison to a timber frame construction, and is therefore a secondary choice.

Local specific accents can be added, such as reed or wooden slats for roofing, to make the architecture blend in with the landscape. An additional example of local character is depicted in figure 68. Pressed loam bricks are supplemented with additional local materials.

Biophilic design
Take into account biophilic design principles for place-based relationships (Kellert et al., 2008) in particular:
- Indigenous materials, by using local, native materials.
- A historical connection to place; by buildings that elicit continuity with the past. Note: an exact replica of a 'langgevelboerderij' is to be questioned, since the shape of this building does not correspond with current use any longer.
- Landscape orientation, by emphasizing landscape features such as slope, aspect, sunlight etc.
- Landscape features that define building form; by letting prominent geological features, natural objects, and water embellish and distinguish building form.
- Spirit of place; by striving for a built environment that becomes a cherished component of individual and collective identity, more than simply inanimate matter.
- Avoiding placelessness, by connecting architecture to its biocultural context.

Regional standard framework



local accents

Treatment & time aspect
Materials should be naturally treated, such as a heating or a fungal wood coating. Materials are allowed to transform over time, for instance by changing color. At the end of their lifespan, materials should be allowed to be transferred to nature for compost purposes to end the life cycle.

Involvement
Let people help build their home, narrowing the gap between building and its residents.

FIGURE 68 Local specific pressed loam bricks by Chrith architects

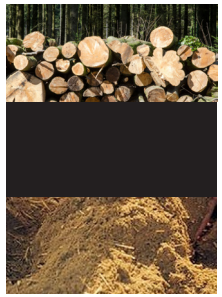
insulation

First choice: straw

Alternatives:
- wool
- insulation panels of willow, cattial, hemp, flax, mycelium

frame

First choice: timber & loam



Alternatives:
- CLT panels

facade & roof

First choice: local specific materials:
- reed
- wood
- sods

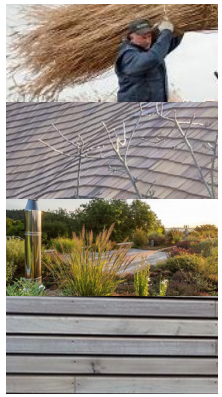


FIGURE 69 Guidelines for materials

Impression of potential local architecture in accordance to guidelines.

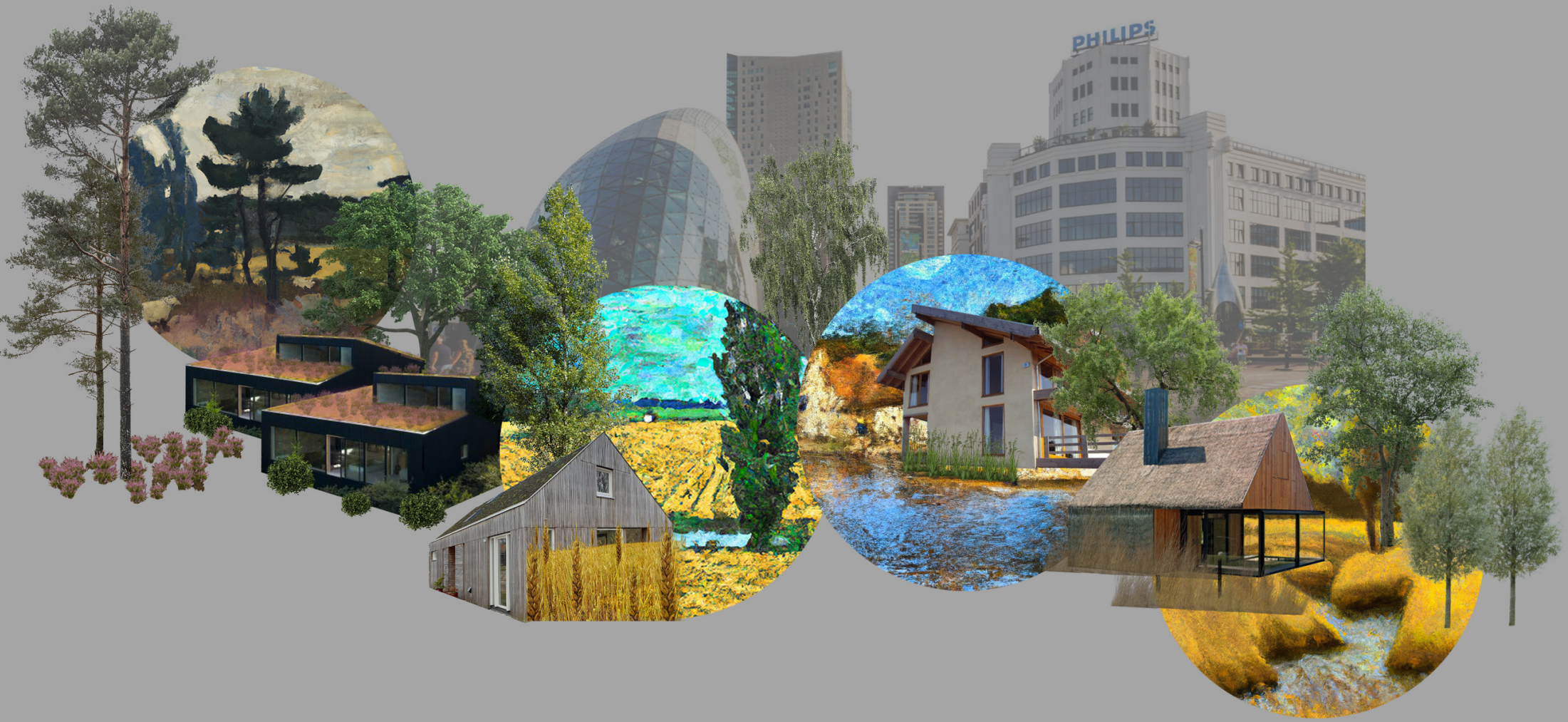


FIGURE 70 Impression, based on: https://www.peppelhout.nl/projecten/, http://www.proarh.hr/projekti/hiza/ & https://krads.is/build/

Availability

The aspect of time will define the building possibilities. For instance, timber from existing pine trees will be available on short notice, whereas newly planted poplar trees need 25 - 30 years to grow. Due to the strategy to include multiple materials that can substitute each other, such as straw and wool, the framework offers some flexibility over time.

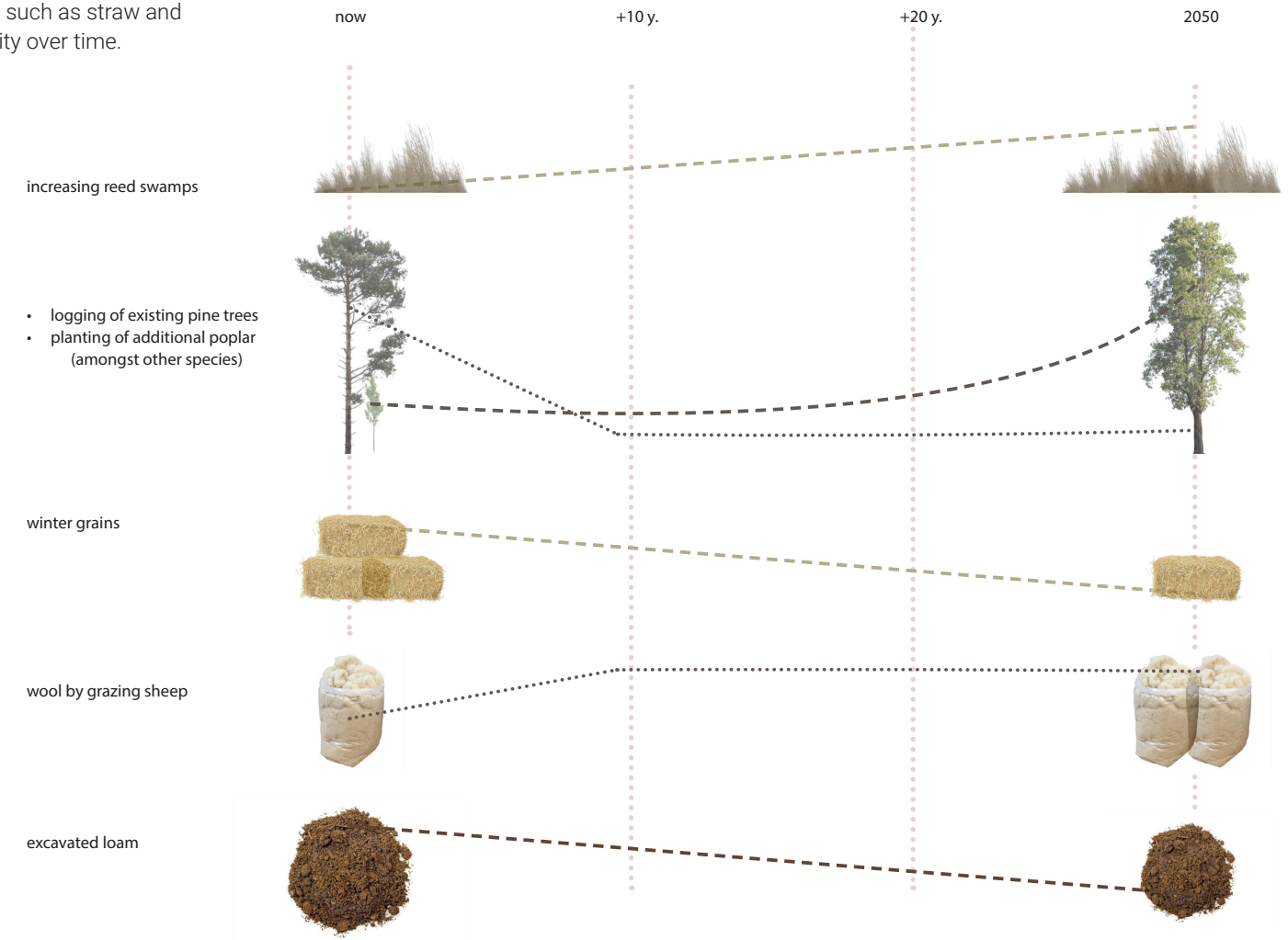


FIGURE 71 Availability of materials over time

Number of houses
Since timber is assumed to be the limiting source for future houses built from local, natural materials, a calculation is made to estimate the number of houses that can be provided by local wood.

Leenderbos, a property of State Forestry, provides each year 6000 m3 of wood (State Forestry, 2023). Leenderbos is a former production forest for the mining industry consisting primarily of scots pine.

Two scenarios are taken into consideration, one that shows a maximum estimation and one that shows a minimum estimation.

Timber frame
Assumptions for calculation (Smit et al, 2022):

- small house (56 m2 gross)
- 3000 m3 quality beam wood
- 5 m3 wood per house

± 600 houses per year

CLT
Assumptions for calculation (Lugt van der & Harsta, 2022):

- large house (120 - 150 m2)
- 1500 m3 quality wood for CLT & timber frame
- 60 m3 wood per house

± 25 houses per year

Both numbers give a rough estimation. The actual number might be somewhere in the middle. These estimations suggest that local provision of materials would be suitable for relatively small development of city edges spread out over multiple years. For the entire building program of North-Brabant, it is far from sufficient.

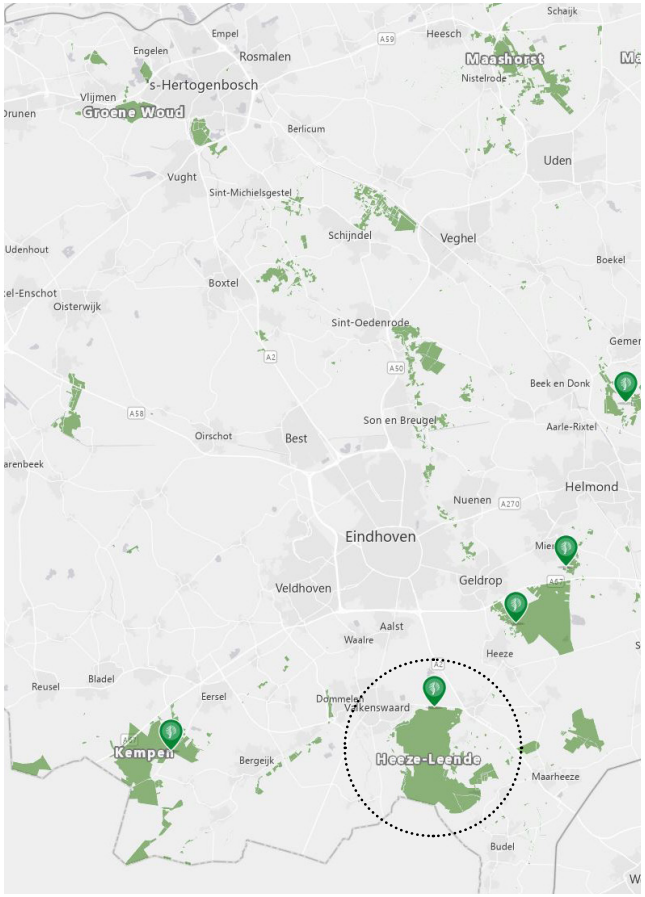


FIGURE 72 State Forestry properties including Leenderbos

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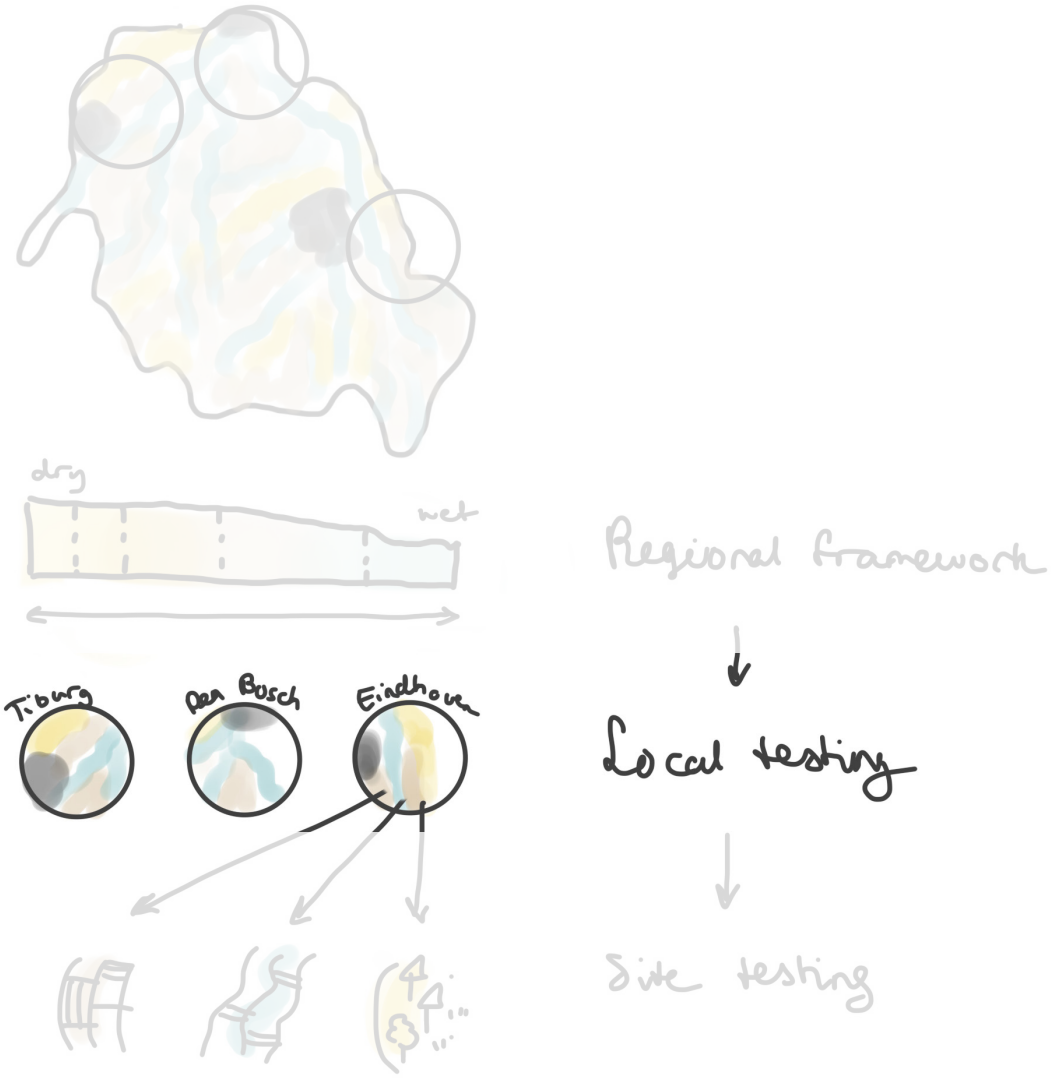
6.

Local design



Countryside under pressure
A location is chosen to test the framework on a local scale. This location is a transition zone in between Eindhoven en Helmond. Due to planned expansion, it is of interest to see how this landscape can change and how architecture could strengthen the area.

FIGURE 73 Pressure on cultural landscape
k https://digitaalpubliceren.com/vangoghbrabant/18437/3/116-117/

The current location

The current landscape is dominated by grassland/arable land and parts of forest. The sand ridges and drift sands are partly covered with pine forest. The brook bed valley is currently partly grassland, especially the upper stream brook. Several water mills are located in the brook bed valley. Former loam excavation left a large pond. Several areas are indicated as potential expansion areas or housing is already planned.

The projected interventions

The projected design on local scale shows a diverse landscape consisting of opened up grassland/heathland to act as main infiltration zone, an expanded forest zone that retains water, intensified poplar lanes and patches of poplar forest surrounding arable land, humid forest and reed in the brook bed valleys, and new loam excavation to potentially store water from the village.

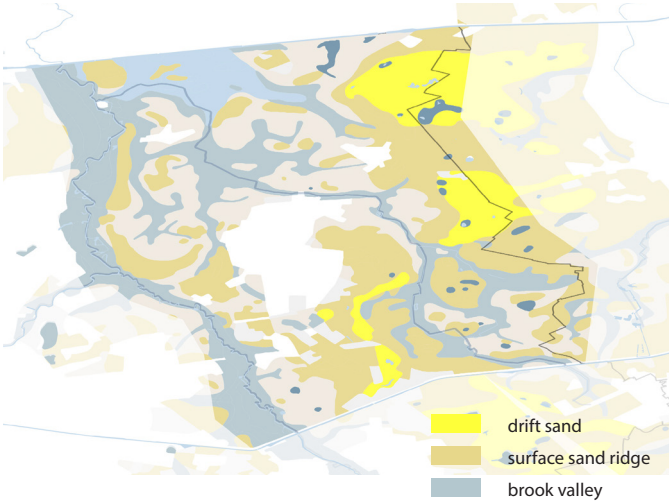


FIGURE 78 Geomorfology

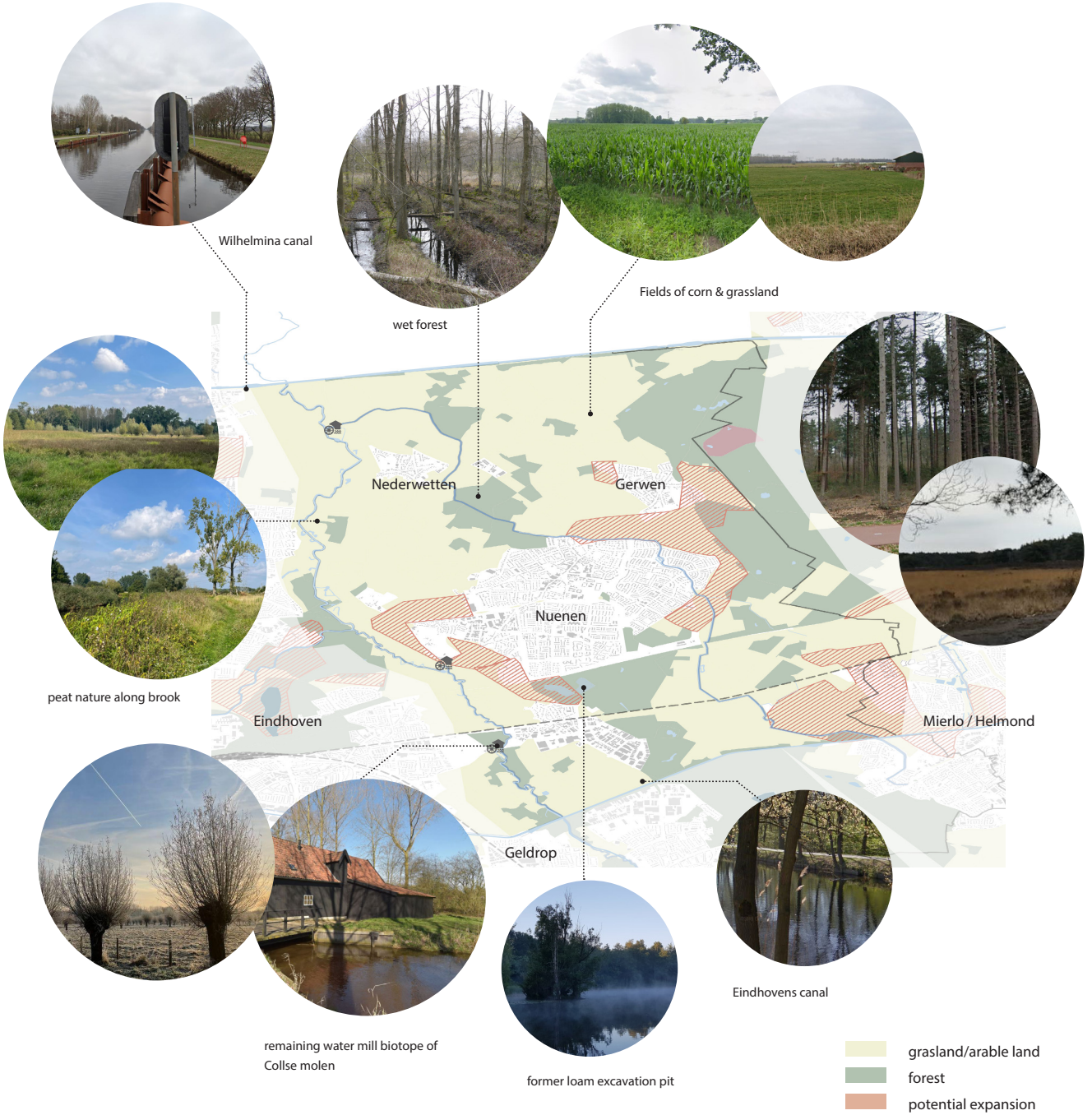
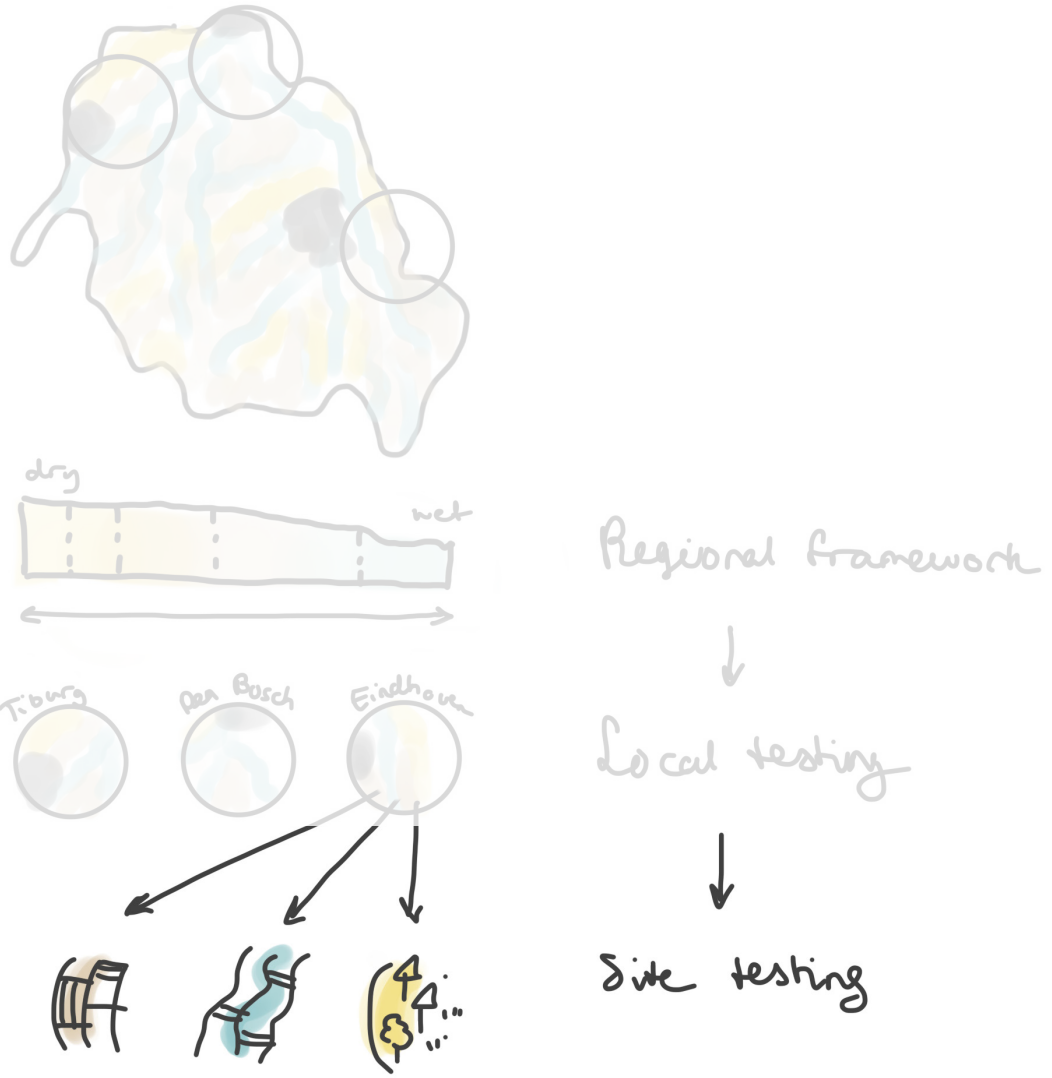


FIGURE 77 Current land use

FIGURE 79 Impression of landscape

7.

Site exploration



7.1 Brook bed valley

The selected site is located on the edge of Eindhoven. It belongs to the brook valley bed landscape of the Kleine Dommel. The tested strategies of the general framework are:

- Water buffering by 1) raising the water level of the historical mills, 2) limit the number of ditches that currently dewater the area, and 3) increasing forest
- Increasing reed provision
- Increase (wet) production forest

FIGURE 82 Site selection

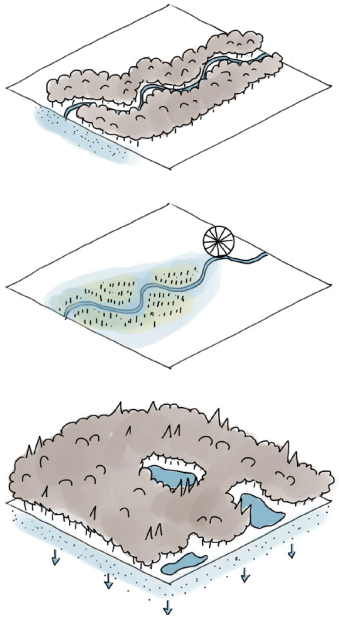


FIGURE 81 Strategies involved

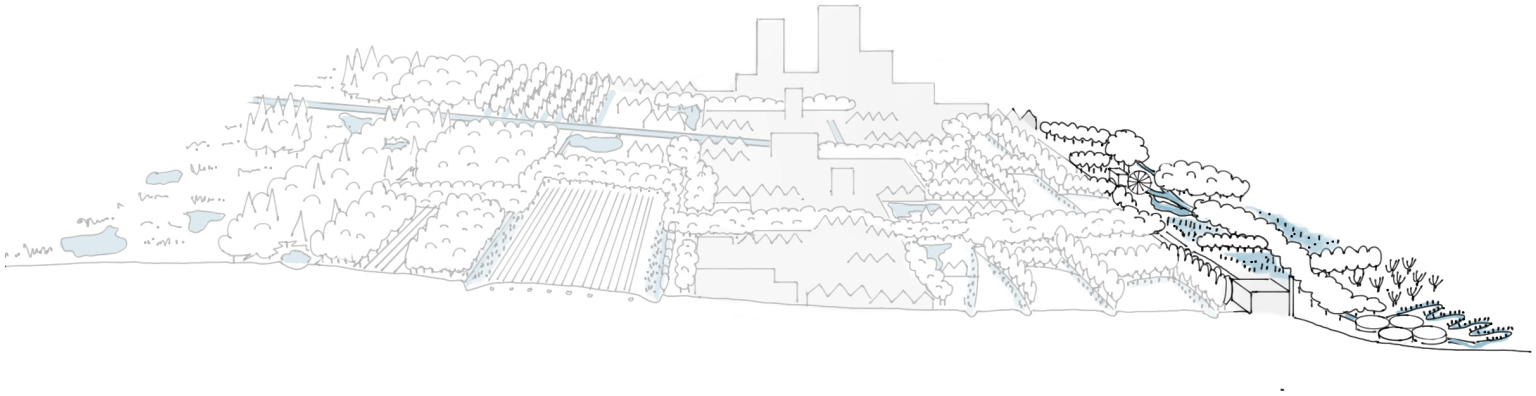


FIGURE 80 Framework

The current site

Currently, the site is dominated by grassland and arable land. Several plots of which the majority belongs to State Forestry are part of Nature Network Brabant, others still need to be transformed to nature and will be financed by the Groenontwikkelfonds. The intended vegetation belongs to the category 'moist meadow' (N10 Vochtige schraalgraslanden). Two highlights within the area are the Opwettense water mill and the Van Gogh-Roosegaarde cycle path. The area is accessible through two cycling highways.

The Opwettense Molen is selected for a pilot project concerning resilient water mill landscapes (Molenstichting Noord-Brabant, 2020). The mill in Nuenen was equipped with a wood sawing mechanism. This feature was first mentioned in 1764, when the mill had to be rebuilt after a fire. Potentially, the wood saw could have been used earlier as well (Geboers, 2020). The miller influenced the ease of wood processing in the region.

cycling highway

A270

cycling highway

Kleine Dommel

Boundaries of water mill biotope; area influenced by water level of water mill

Agricultural land - to be transformed to nature

Nature land owned by State Forestry

FIGURE 83 Current situation

The projected interventions

The projected design includes a diversity of landscape elements: reed fields, wet production forest, communal coppice forests, protected riparian zone, grassland, water pools, wooded banks, and experiential wood seasoning pools. Rewetting the area benefits the character of a water mill landscape and in larger context the wet character of the brook bed valley. A new walking path brings visitors close to the brook, along a diverse route.

high quality reed fields

common zone, cutting allowed by residents, school classes, students etc.

a wooden bridge connects both sides

furniture made of local resources

a wooden boardwalk enables year round accessibility of the wet zone

water pools for aquatic species

FIGURE 84 New situation

Water system interventions
Water is buffered by creating a ditch-free zone that allows clean seepage water to reach the surface and creates an ideal habitat for qualitative reed to grow.

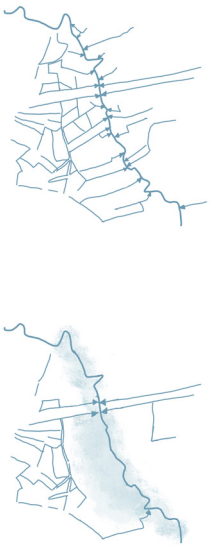


FIGURE 86 Current surface water system of brook and ditches (above) and potential surface water system (below)

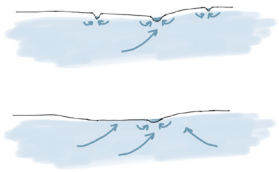


FIGURE 85 Current ground water flows (above) and potential water flows (below)

Materials & zoning plan
Three zones provide different natural, construction materials, and a variety of habitats for various species. The riparian zone is not accessible for visitors and creates a safe eco corridor for several species.

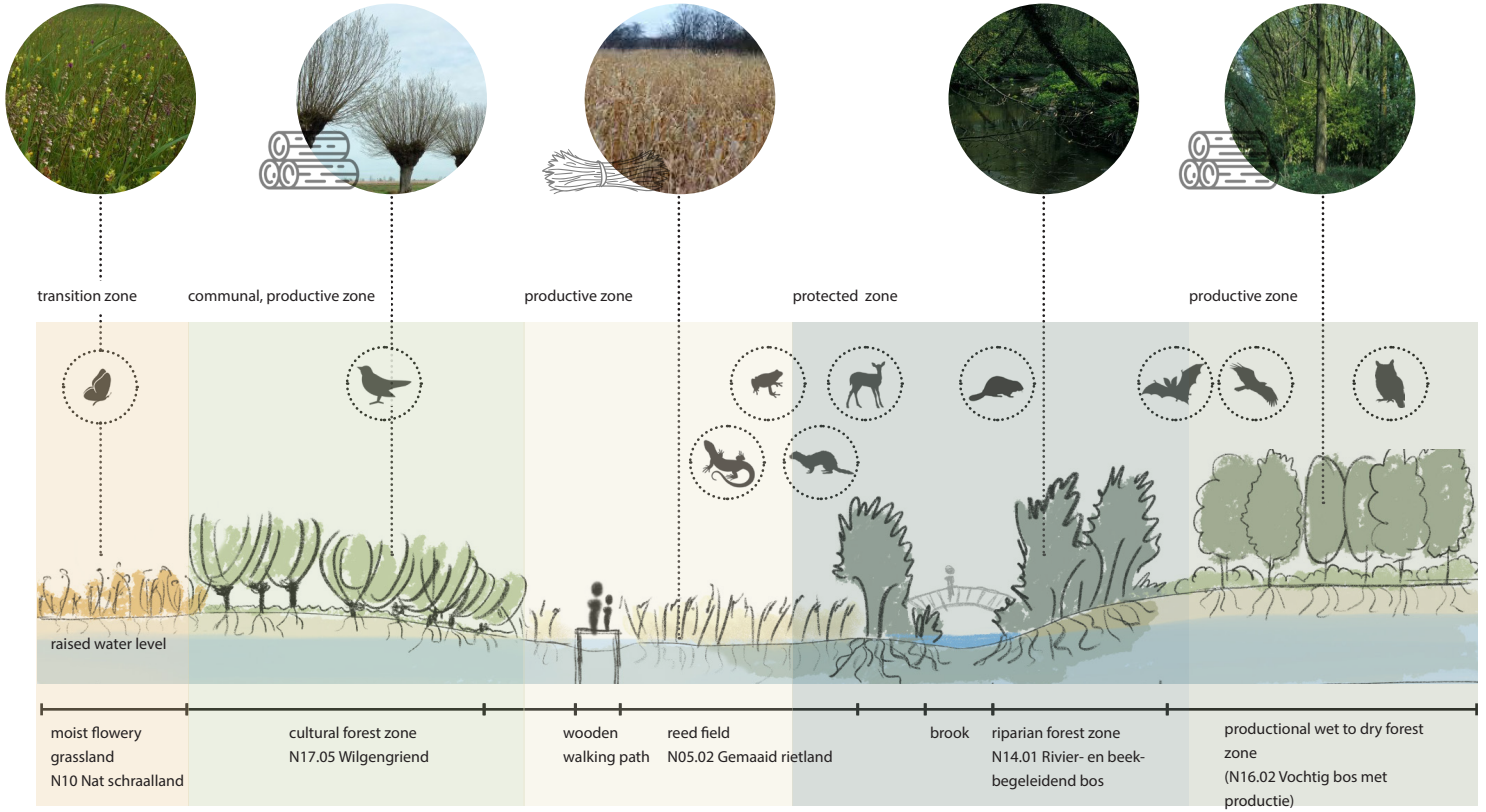


FIGURE 87 Wet, productive brook bed valley

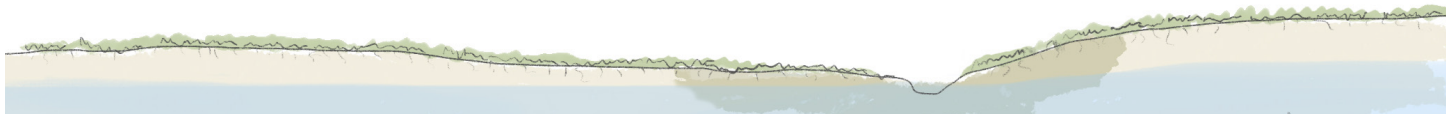


FIGURE 88 Current brook bed valley profile

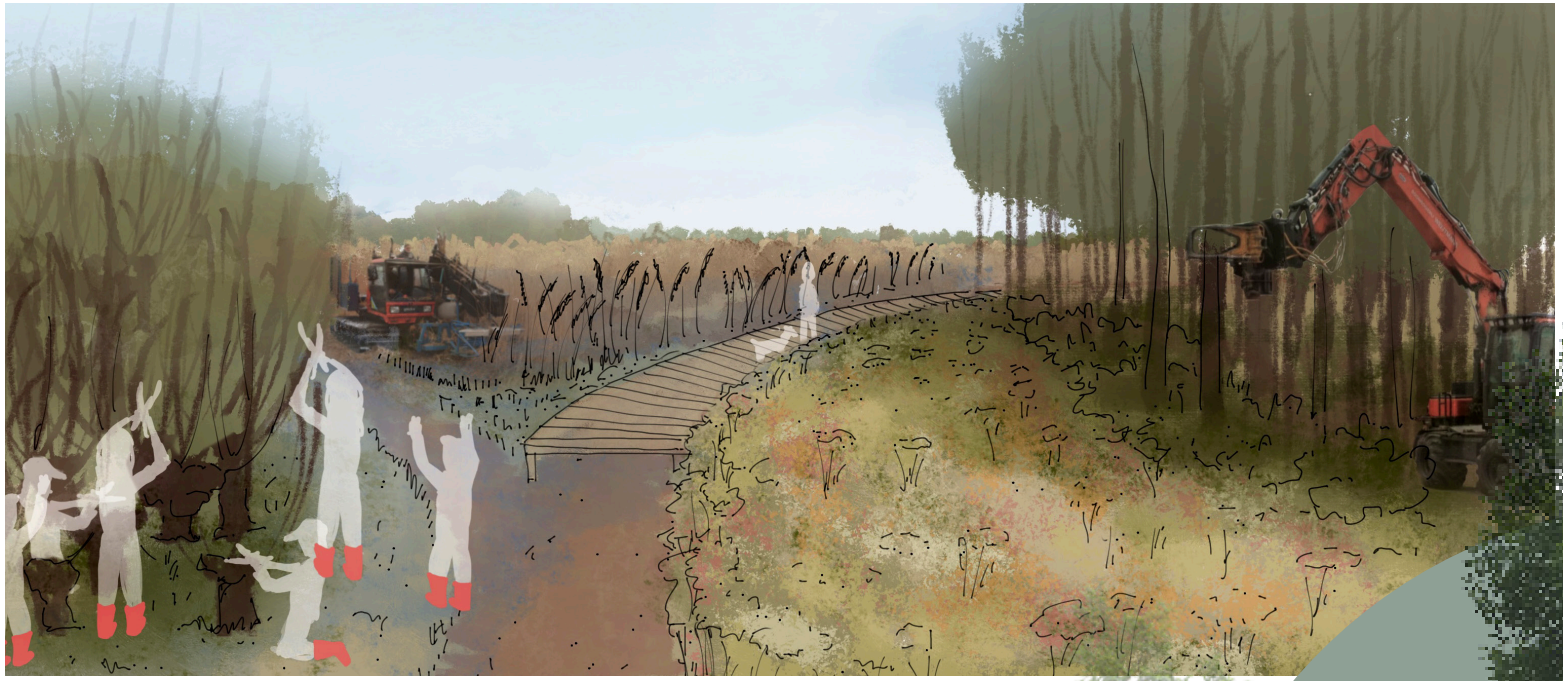


FIGURE 89 Current situation

FIGURE 90 Atmospheric impression of the landscape

Value

A landscape is created that potentially buffers water and enables seepage water to reach the surface. It provides different habitats for target species and several natural construction materials. The proposed landscape benefits the recreational value of the water mill biotope as well as it potentially enables the local community to connect and contribute.

7.2 References

Geboers P. (2020) De watermolen van Opwetten. http://www.watermolenopwetten.nl/

Molenstichting Noord-Brabant (2020) Pilot Watermolenlandschappen in Het Groene Woud. https://molenstichtingnoord-brabant.nl/groenewoud/

FIGURE 91 Potential architecture of nearby city edge based on: http://www.proarh.hr/projekti/hiza/

8.

Conclusion

RQ: What spatial framework for the drainage basin of the Dommel facilitates the move towards a future proof water system that simultaneously provides local, natural building materials for the future building program?
The spatial framework for the watershed of the Dommel uses a blue infrastructure as the basis, consisting of primary infiltration areas, water basins, and wet zones to stimulate infiltration, to increase the amount of surface water, and simultaneously to create opportunities to increase the provision of local, natural building materials. The higher surface sand ridges and planes within the watershed can provide existing pine wood and wool from grazing sheep, and on the longer term additional wood types of deciduous trees. The central area of the watershed has the potential to dominantly provide poplar wood. Several small areas next to villages/cities and canals are indicated as potential zones for loam excavation to buffer water as well. The spread out arable land provides straw as residual material and finally the brooks crossing the landscape can provide more high quality reed and wood. The framework results in a landscape that potentially produces a spectrum of materials of local, natural building materials with a regenerative character. The framework suggests several additional values, including recreational value, contribution to climate adaptation, increasing visibility and readability of the brook landscape, increasing attractiveness of the landscape and the experience of heritage.

SQ1: What are effective measures to improve the water system of the Dommel drainage basin?
The Dommel watershed is faced with today's pressure on the current water system. Main influences are excess of ground water extraction by agricultural use, industry, and for drinking water, (pine) forest evaporation in the driest areas, and accelerated drainage by ditches and brooks. This situation asks for strategies to retain and buffer water and to delay drainage. As a consequence, more water can infiltrate and therefore recharge the groundwater supply and supplemented with an increase of surface water it can reduce the need for groundwater extraction.

SQ2: Which local, natural building materials that were historically used in North-Brabant are suitable for the future building program?
The use of wood, loam and fibers including straw has been a constant factor during history. Wood can be indicated as an ideal material for the purpose of constructing the body of a house since processing of wooden beams to create a timber frame can be executed locally. The long history of the wooden shoes industry and subsequently the match industry left a coulisse landscape with poplar trees concentrated between the 3 cities Tilburg, Eindhoven and 's Hertogenbosch. Planting more poplar trees can enhance the landscape, boost the local production chain and provide wood within a short time due to the fast growing character of poplar trees. In addition, the former production forests of pine trees offer opportunities for logging wood immediately. Next to that, planting of new douglas fir, birch and aspen trees can supplement on the longer run to provide several options in beams and planks. In a few years, hybrid CLT can be used from a combination of wood types once the CLT factory South West of Eindhoven is installed.

Besides trees, loam can be used as a partial replacement for the timber frame. Loam has been locally dug intensely for former brick production. In contrast to the former process of making brick, loam can be pressed to stones so that the material remains reusable and can be given back to the landscape after use. Small scale, transportable machines on site can be used to make the stones.

And finally, straw, reed and wool can be provided locally. Straw as residual material from agricultural activities can be used for isolation directly as straw bale or by being blown into wooden installations. High quality reed for roofing material can be cultivated in wet nature areas. In addition, wool from sheep that maintain the heathlands can provide alternative isolation to straw.

SQ3: What strategies benefit the local water system and provide suitable, local, and natural building materials?
Retaining of water is supported by increasing the acreage of heathland/grassland which is optimal as primary infiltration areas as well as delivering wool from the sheep maintaining it. Water will also be retained by increasing the capacity of soil to hold water by adding organic matter by mixed production forests, tree lanes or by winter grains.

Next, buffering of water supplied by rainwater, canals, and ditches (from agricultural and urban areas) can be achieved by excavating land at strategic places with thick layers of loam to create water basins as well as providing loam. In addition, production forest on raised land can buffer water, as well as wadi's alongside agricultural fields. These wadi's can host fibers such as reed and timber to increase the infiltration capacity. Buffered water can be used for agricultural purposes or to keep nature areas wet.

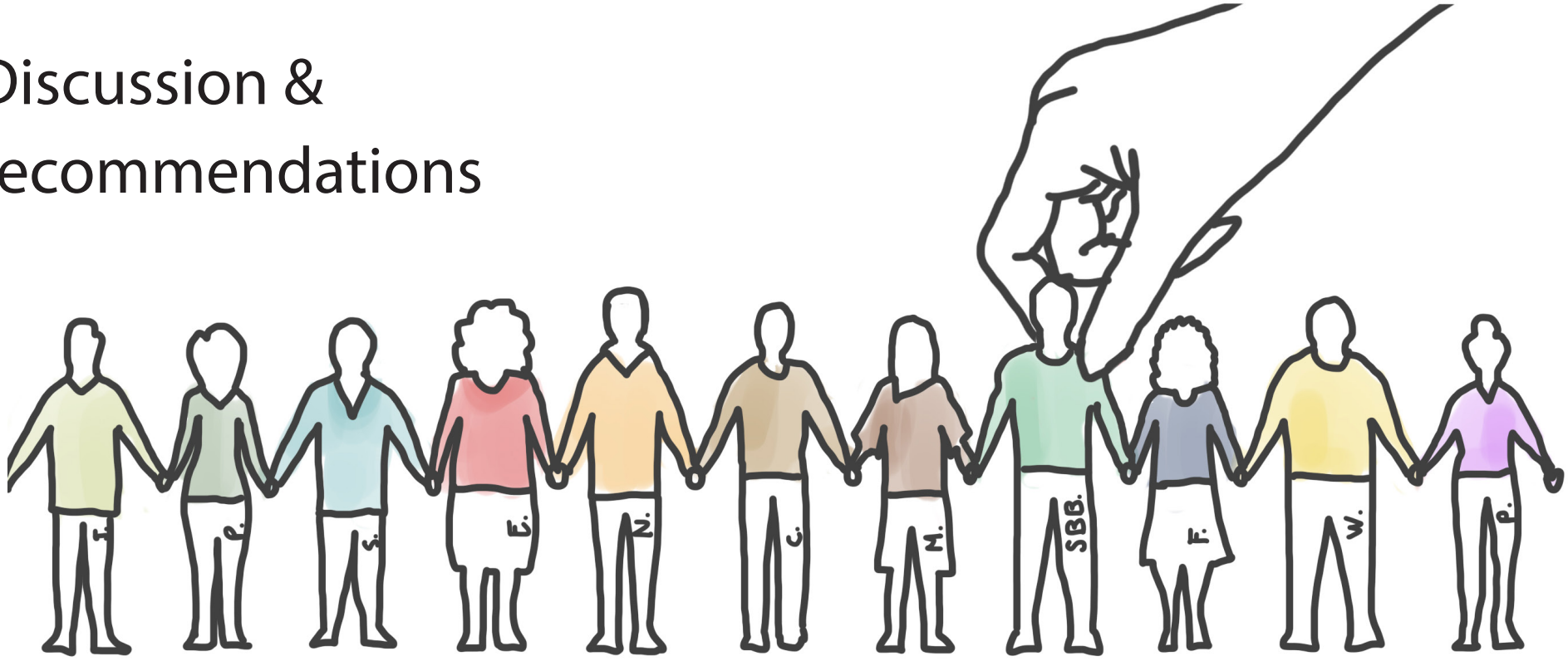
Finally, drainage of water can be delayed by riparian forest zones of alder and willow that slows down water in the brook bed valleys and provide wood chips. In addition, raising the water level in brook bed valley creates a wet zone ideal for cultivating qualitative reed for roofing material. And last, reed/willow harmonica's can be created at places where water is drained, such as sewage treatment plants.

SQ4: What are the potential implications for local architecture?

The results suggest building the body for a dwelling from regional sources, whilst the facade or roofing can be locally adapted to align with the specific landscape it resides in. A village edge that is located near the brook could for instance have accents of reed, whereas a edge nearby the poplar landscape can be executed with a facade and roof made of poplar wood. The resulting houses will not invade but integrate into the countryside. New edges of villages can be built according to the local vegetation and by that means enriching the appearance and strengthening the identity of the countryside. The limited availability of local materials will also influence choices made in efficient use of materials by smaller layouts and attached houses or apartments but also limiting the use of CLT which requires a high amount of wood per dwelling.

9.

Discussion & recommendations



Retrospect on expectations of results
As expected and based upon the chosen approach, the spatial framework presented in this graduation project is based on the natural system of the surface sand landscape consisting of infiltration zones and seepage zones. Additionally, it takes into account how land use interacts with the landscape units of the surface sand landscape by assessing the influence of natural building materials including trees, loamy soil and vegetation such as reed on water flows and what that implies with regard to their potential positioning in the landscape.

The output of the suggested landscape interventions does not cover the required materials for the entire building assignment. It is assumed based on initial calculations that only a part of the future building assignment can be developed from local, natural building materials. Therefore, it is proposed to use local, natural building materials in the new to develop edges of villages such that it benefits the transition from city to countryside.

Results in respect to place-based theories
Geographical connection to place is one of the primary connections addressed by the results. By creating a direct link between someone's home and the surrounding landscape, this connection is believed to be strengthened. Dwellers of locally, naturally built homes will be given the opportunity to learn about the place through direct experience. Awareness about their environment might become part of people's everyday lives, as these dwellers get to see and touch materials at home that can be traced to their origin.

This thesis deviated from theory with regard to the aspect of the use of indigenous materials, as the biophilic design dictates. The results deviated from this aspect by proposing the continuous use of Douglas Fir and Canadian poplar. Both species are not indigenous from a bioregional point of view. However, pine trees and poplar trees have a strong local connection by historical use and are of great use for the strategy to provide local houses. The choice has been made to integrate both indigenous and non-indigenous species in the proposed framework, from a more practical point of view.

Deficiency & recommendations for future research
The water system is in reality a complex system of flows. For the purpose of constructing an abstract framework, a simplification of the water system has been composed. The framework is explicitly abstract and simplified to serve as an exemplary format for the larger regional landscape. As a consequence, the water flows and the interrelationship of landscape units are not entirely accurately depicted. Next to that, testing of the framework has only been done on 1 location, whereas supplementary testing would have given more insight into the usability of the framework. Performing more tests was however beyond the scope of this graduation project.

For future research, it would be of interest to involve additional challenges and land uses. The countryside is under pressure by the need to generate energy and food as well. Adding these themes would result in a more integral vision. Next to that, a more thorough calculation of output per material will be of value for society. Calculations in this thesis are limited to a single nature area and only one type of material.

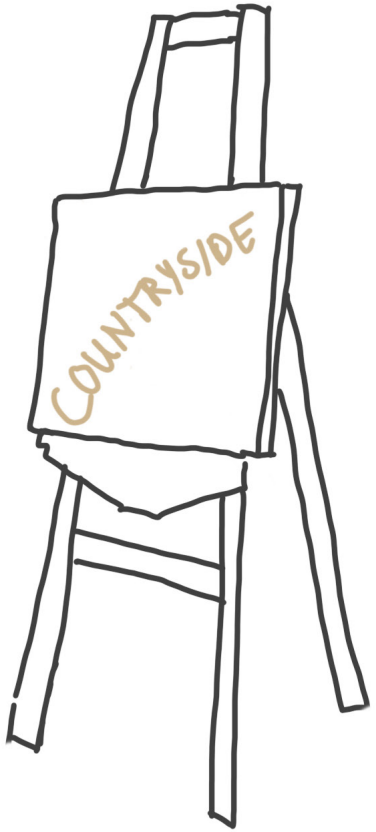
Local timber industry
The primary advice for client State Forestry is to play a larger role in the local timber industry by providing materials directly to local contractors and architects in order to stimulate building of local, natural building materials. Potentially, State forestry can have a significant role in this industry due to its large nature areas in North-Brabant. In order to stimulate collaboration and increase local awareness, it is additionally advised to initiate design competitions for local architects to use specific materials including pine wood, wool and sods from heathland. These designs can even be executed on State Forestry properties for the purpose of a pavilion or shelter. Design competitions can create publicity which potentially also increases awareness amongst visitors of the nature areas.

As current pine forest is being transformed to deciduous forest, it would be beneficial for future building practices to continue planting pine trees such as Douglas fir because of their suitability to create timber frames. A mixed forest of deciduous and pine trees would be a suitable compromise of ecological values and productive values. Especially if State Forestry desires to supply wood for the future CLT factory in North-Brabant.

Education
Finally, education is seen as an important aspect to make the use of local, natural building materials a success. Collaboration with educational institutes is the foundation. Students of design schools could for instance use locally harvested wood for their study projects. Younger students can be involved by planting ‘new homes for the future’.
In addition, educating visitors of nature areas about the purpose of the harvested wood is important. The resistance against logging of trees might decrease in case people get informed about the local purpose of the wood. It is of interest to investigate this from a psychological point of view. Knowing the overall benefit of local resourcing, but also the benefits for the forest by rejuvenation, might create more empathy for the practice of logging trees.

10.

Reflection



10.1 Reflection - design synthesis

Feedback loop
From the start to the end, a feedback loop of research and design was present, constantly informing each other, even in small steps. The synthesis of research and design are the foundation of this graduation project. Research often helped to clarify the focus and guidelines for the design, whereas designing brought to light what additional information about systems/phenoma/spatial characteristic etc was required. In that sense, design served as a tool to check the relevance and accuracy of the research guidelines. Some exemplary examples of this feedback process are:

- Initial sketching of what a potential landscape of North-Brabant could look like helped me to understand the structure of the landscape and its spatial characteristics. Starting with early sketching helped to grasp the essentials of the landscape. It also directly led me towards literature again. I couldn't figure out on paper how to deal with the fragmented landscape of Brabant. How to deal with the nature network? Should it be a separate entity or could it be part of the productive landscape? This research of approaches of nature broadened my perspective of our relation with nature.

- By research, the dysfunction of the current water system became clear. In order to make this information practical, a simplified model was made. Designing this simplified model of the water system raised new questions about the exact water flows and interrelated components of the landscape. The resulting model, highly supported by research outcomes, together with the design principles based on research provided clear guidelines for the design of a future proof landscape.

10.2 Value of methodology & strategy

Introduction phase - Collaborative phase
The first half of the graduation year was primarily focused on the analysis for State Forestry. It provided insights into the Dutch landscape types and urgencies for each of these landscapes. In addition, it raised awareness of policies, especially after consulting local policy makers. It set a clear outline of challenges for the surface sand landscape of North-Brabant in the larger context in the Netherlands.

Combined strategy in a research by design project
The combination of envisioning a landscape that takes on the challenge of moving towards a future proof water system and providing local, natural construction materials resulted in specific, unexpected choices. For example, the strategy of maximal reforestation of North-Brabant, as reference to earlier historical phases when North-Brabant was fully covered with forests, would align well with the local CLT-factory that is planned. However, a maximal coverage of forest would increase drought by high evaporation rate, resulting in less suitable hydrological conditions for agriculture and existing wet nature. Therefore, this strategy did not prove to be effective with regard to the chosen strategy. Another interesting finding is to use loam only as a waste product of urban or infrastructural interventions, since loam increases the capacity of the sandy soil to retain water and nutrients. Therefore, delving loam for its pure means of collecting a building material was not further explored within this context.

A hydrological approach to landscape planning & layer approach
Both approaches supported a design proposal for land use that corresponds to the natural physical structure, which is the basis for a resilient / future proof landscape.

Landscape biography informed approach
The use of a landscape biography as a starting point showed its value in the project. The historical use of local materials showed a dominance of materials such as straw and loam, which were easily accessible materials. Wood on the other hand, was used in lesser amounts, due to its limited availability. The somewhat isolated location of the region of Eindhoven resulted in a long history of use of local building materials, which provided several historical strategies to work with.

Shifting perspectives

As State Forestry primarily has properties within the nature network of Brabant, I was confronted with the question: to what extent should we use land assigned as 'nature' for production of building materials? Intrigued by the ideas of Bruno Latour, French philosopher, anthropologist and sociologist, who addressed the principle of giving rights to nature, I initially chose the strategy to only use potential waste that is related to required maintenance of nature. This aligns with the approach of nature as a sanctuary. If you follow this line of thinking, then it might even be unethical to cut a tree, as it is an entity having its own right. I am still convinced some parts of the world should be nature reserves. However, after reading several theories, it came to a more refined strategy in which working together with nature is central. Especially since in Brabant, all 'nature' areas are in fact 'half-nature' or even 'cultural' landscapes, such as the heathlands which were maintained purely for their value within the historical agricultural system.

Another insight I really appreciate is that I realized that the landscape for me is often purely a décor for an activity, such as walking, chatting or cycling. Not consciously sensing and therefore connecting with my surroundings, which is often the case. Dominantly by mind, I felt connected to nature, logical reasoning that we are part of it and rely on it. The perspective of van Gogh as a painter made me realize that he must have had full sensational experiences in a landscape. Staying on a spot for a long time. Seeing, hearing, feeling the landscape. Noticing the changes. I think this perspective can bring you closer to nature.

My process & planning

This project was conducted within an academic program, meaning that it required a systematic procedure to research a problem with clear intentions and corresponding methods, guided by existing theories and approaches. Even though I acknowledge the value of the academic approach, I struggled pursuing the academic approach through the process. My husband's words describing my graduation process: "chaotic, being stuck in a 'roundabout' of thoughts, and moving into many side tracks". My personal clarification of this process starts from not having a sufficiently narrowed down problem statement, research question and clear approach at the beginning. The initial project plan was missing a clear hierarchy. I wanted to explore nature development, local stewardship, and the productive landscape. In a later stage, the project was narrowed down to a two-fold strategy of a future-proof water system and a productive landscape for local building materials that gave clear guidance. It would have helped to discuss my methodology and plan in more detail with my mentors and fellow students. Secondly, it is in my personality to work in a less structured way, due to enthusiasm amongst other reasons. This is the result of having a mind that is fueled by new information, consequently, creating in a process that can be marked by many side paths taken to explore new knowledge. I spent a great amount of time reading papers, articles, and books about topics that were of interest to me. I also sketched plans for a new neighborhood and distribution hall only realizing afterwards that it was not within the scope of my thesis. It will be my challenge to use my personality to my advantage at certain phases of the process and maybe allow more guidance during the initial phase to ensure a clear design intention in future projects. What helped me in the process was the suggestion of my mentor to make a dummy version of the presentation early in time. It supported me to rethink the story I wanted to tell. In addition, using a sufficient number of deadlines in the beginning of the project was an effective tool to keep enough flow. In retrospect, the second half of my graduation process would have benefited from more strict deadlines I set myself.

My potential role as designer

Based on my graduation process, several strengths and weaknesses linked to my personality can be indicated. In an attempt to indicate my value as a designer in future projects, I compared my working mode with the Belbin team roles. The Belbin team role model is a social psychological model, based on years of empirical research by Dr. Meredith Belbin, a British scientist, and his collaborators on the interactions in successful and unsuccessful teams (Belbin NL, 2022). I used these roles in my classroom as a teacher and during my internship the company was implementing the model.

My dominant role within the Belbin model is the 'Resource Investigator'. Described as: "The Source Investigator is strong in exploring and introducing ideas and sources from outside the group. He can make connections, explore areas and conduct negotiations. Because of his pragmatism and presence of mind, he knows where the opportunities lie and how to use them. Bustle and variety are essential for a BO. If he is recommended and reinforced by his environment, for example when he reinforces a one-man position, he quickly becomes bored and ineffectual." (Belbin NL, 2022)

This role aligns well with my ability to quickly gather information, my broad interest, and tendency to explore new paths. My strength of reflection, being critical, and thinking throughout is reflected in a second dominant role: monitor. Described as: "The Monitor evaluator is of great value for analyzing problems and evaluating ideas and suggestions. His critical attitude and thoughtfulness can save many a

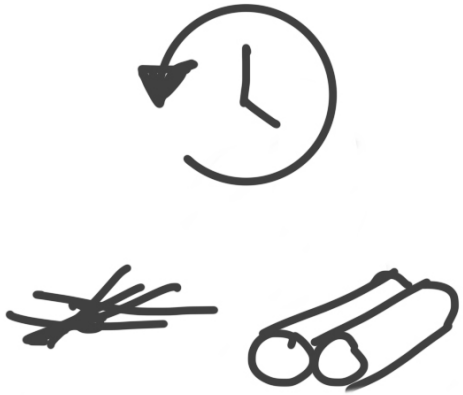
team from making incorrect and hasty decisions. Good at pointing out and weighing the pros and cons of a proposal, the MO can end up in important strategic positions, especially where one has to guard against the smallest misstep." (Belbin NL, 2022)

Roles that are less present in my personality are 'completer finisher', who is outstanding in polishing and scanning work for errors and ensuring quality, and 'shaper', who is assertive and keeps focus on the goal.

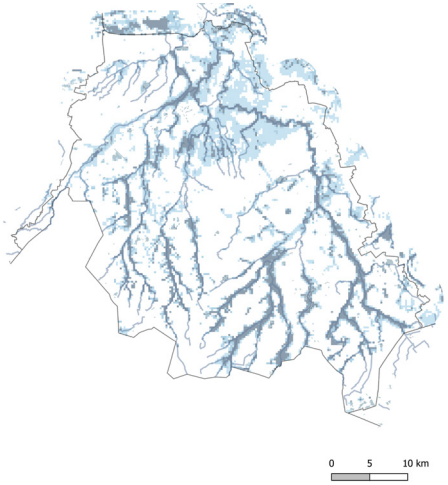
10.4 References

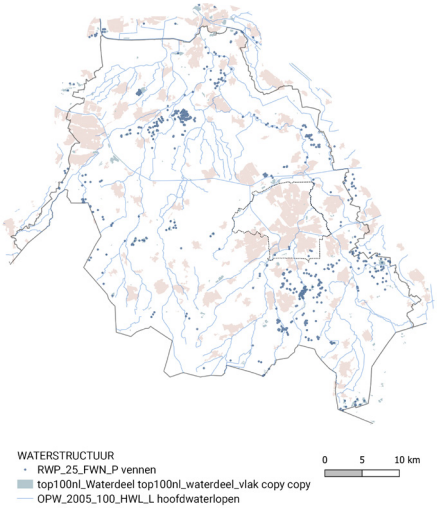
Belbin NL (2022) Teamrollen. https://www.belbin.nl/teamrolmodel/teamrollen/

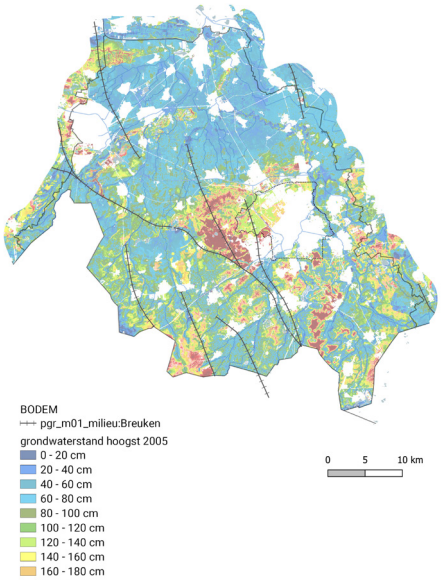
Appendix

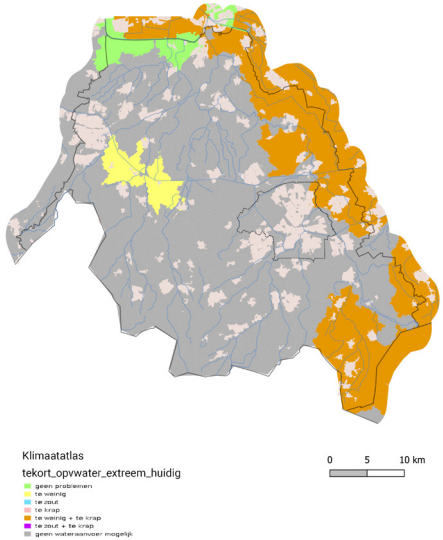


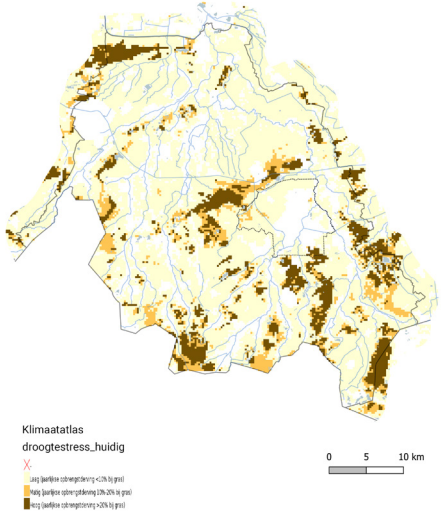
Water system analysis maps

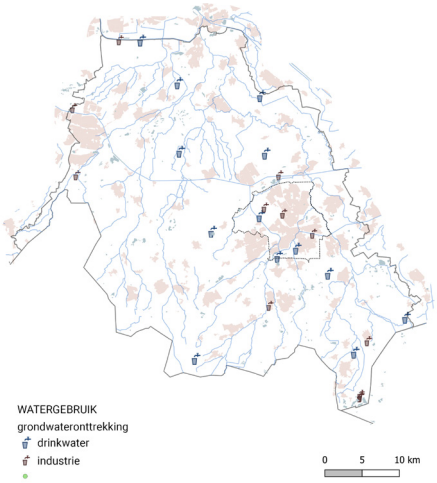


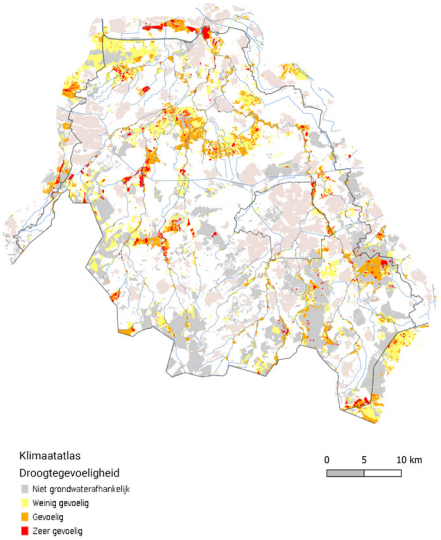












Landscape Biography of Eindhoven region

Local building materials

as part of:
AR1LA061

Martine Schull - 4429508

Content

1. Introduction

Context
Eindhoven region has a long history of building with local materials. For a long time there has been a direct link between the activities of residents in the landscape, the location residents chose for living and the natural building materials extracted from the local landscape. The local culture of living in relation to the local landscape has vanished largely today, due to the introduction of artificial fertilization, industrialisation and the resulting rapid urbanization of the last two centuries. How should we cope with the current and future building assignment of the region to live again more aligned with the local landscape and its resources? This landscape biography was created with the aim of using historical knowledge to shape the future landscape. The biography aims to be a tool for landscape architects in spatial design assignments, by translating historical information into a graphic, concise narrative.

To answer this question, this landscape biography focuses on the use of local building materials in relation to local culture.

Research method
The basis of the biography is a literature study, a map study of historical maps, and an exploratory visit to Prehistoric Village Eindhoven.

First, factual information was collected through literature and historical maps. Subsequently, a number of periods were identified that mark a new time frame in terms of settlement or use of local, natural building materials. For these periods, the main characteristics are studies, such as main labor activities, land use, landscape characteristics, housing typology, the use of local building materials, and the meaning of the landscape for its authors. The images that are made to represent the landscape and buildings should be seen as an impression. Their goal is not to be entirely historically accurate.

Next, based on the historical course, several historical strategies have been indicated. Finally, future development strategies have been created to live more aligned with the local landscape as we used to do in the region of Eindhoven. That is, strategies to harvest local building materials in the footsteps of local tradition.

Reading guide
Chapter 2 presents the genesis of the region to understand the natural capital of the region. Chapter 3 presents the time frames with settlement changes and use of local building materials, clustered together in a overview timeline that summarizes the time frames in chapter 4. In chapter 5, the historical strategies and links are described. Chapter 6 presents strategies for the future. Finally, chapter 7 contains the discussion.

2. Regional landscape genesis

Roerdalslenk

Fractures in the soil layers of North-Brabant have been decisive for the local landscape. Eindhoven is located in the Roerdalslenk, a large valley area that extends into Germany. This valley was formed in a number of phases that started 150 to 200 million years ago. Level differences arose along the fractures in the earth's crust, which still influence the flow of (ground) water. The subsidence area of the Roerdalslenk was later, during the Ice Age, filled with deposits of coarse river sand and gravel by precursors of the Meuse and Rhine, which later moved eastward. These gravelly deposits in the Roerdalslenk were more recently covered with loam and cover sand.

Cover sand deposits

During the last ice age, the Weichselian, the layer of loam, the stream valleys and the cover sand ridges were formed. North-Brabant was a polar desert at the time. Thermokarst lakes formed in low areas in which blown sand and loam were being held and run-off loamy melt water was retained. As a result, large plates of loam were formed. These layers of loam belong to the Liempde layer package from the formation of Boxtel. The layers of loam that are still present today in the region vary in thickness and size.

Stream valleys

Subsidence of the Roerdalslenk created meltwater flows that carved wide valleys in the top layer of loam. These flows are precursors of the brook Dommel. Eindhoven today is still located within the water catchment area of the Dommel, originating in Belgium.

Cover sand ridges and fens

In the Late Glacial, sand is supplied by predominant northwesterly winds from, among others, the dry North Sea, and created the Central Brabant cover sand ridge and the more northerly located Brabant cover sand ridge. This led to clogging, diversion, and bending of stream valleys. Parts of the former streams that had not been covered by sand were the beginning of the formation of fens. At the beginning of the Holocene, peat started to grow in abandoned gullies.

Vegetation and deposits during the Holocene

Due to temperature rise, closed forests could develop. Elm, common ash, willow and black alder grew in the brook valleys. Reeds started to grow in the lower stream of the Dommel, north of Eindhoven, due to wetting of the valley bed. Stream valleys deposited fine-sanded brook loam and iron-rich seepage water in the stream valleys caused the formation of bog iron. On higher parts, mixed oak forest with lime trees and elm grew, alternated with clearings of heather, bracken and wormwood. A richer soil than today started to develop here. In addition, further development of peat formation in fens and swamps was taking place (Ecologische Kring Midden-Brabant, 2011).

Natural capital of the region

To conclude this chapter, the natural capital of the region of Eindhoven consists of:

- loamy soil; mainly supplied as aeolian material and partly by streams.
- large patches of primeval forest consisting of different species varying in the low/wet areas and the high/dry areas.

What is absent, or at least not accessible by its depth, is stony material which had a great influence on the construction of houses as will become apparent in the next chapters.

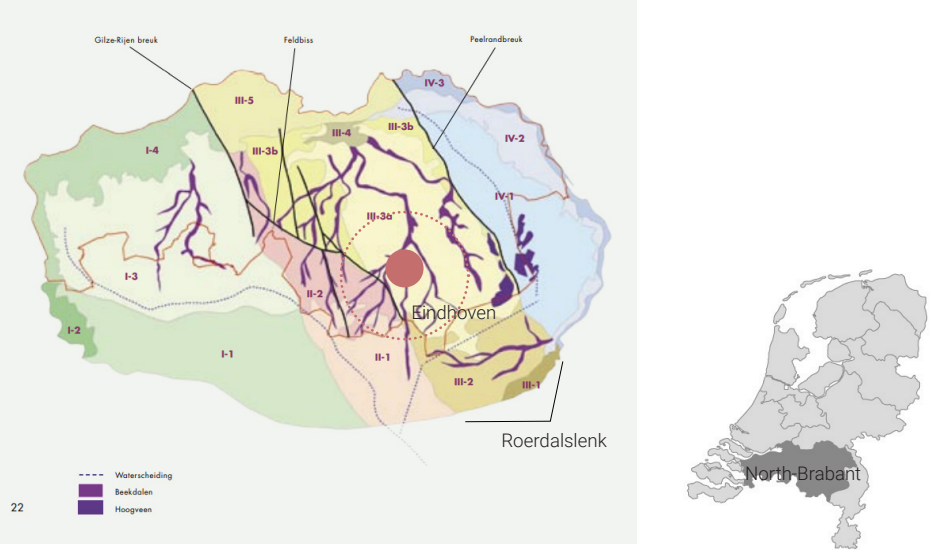


FIGURE 93 Roerdalslenk within loamy top profile in the province of North-Brabant (Provincie Noord-Brabant, 2007)

3. Habitation history

Introduction
The biography starts at the time of the land being cultivated through agriculture, the moment that marks the start of more permanent settlements. A number of periods are identified that mark a new time frame in terms of settlement or use of local, natural building materials. The time frames presented in this chapter are:

1. Shifting farms

2. Permanent yards and settlements

3. Transition towards fabricated houses

4. Industrialised city expansion

Each time frame is introduced by a brief statement of the way of living in that specific time frame. Information about usage of other building materials than local materials has been left out, as it exceeds the extent of this study.

Shifting farms *Early Neolithic - Middle Iron Age*

Historical context

Since the start of the Holocene, the climate became more humid and warmer than previously. People gave up the nomadic, hunter-gatherer lifestyle to start farming. Around 4300 BC, farming most likely started in North-Brabant, although no limited traces of this period have been found. Around 3000 BC, a new group of immigrants entered the area of which plenty of traces have been found nowadays. Activities of arable farming and livestock farming were combined by shifting cultivation on nutrient-rich forest soil for which forests were cleared. The introduction of bronze led to an increase of population (Ecologische Kring Midden-Brabant, 2011).

Paleogeographical development

As the transition between maps in figure 94 show, the area became wetter since the start of the Holocene, resulting in peat formation. Blockages and relocations of the brook caused the development of swamp and sedge peat.

Start of Holocene

500 BC

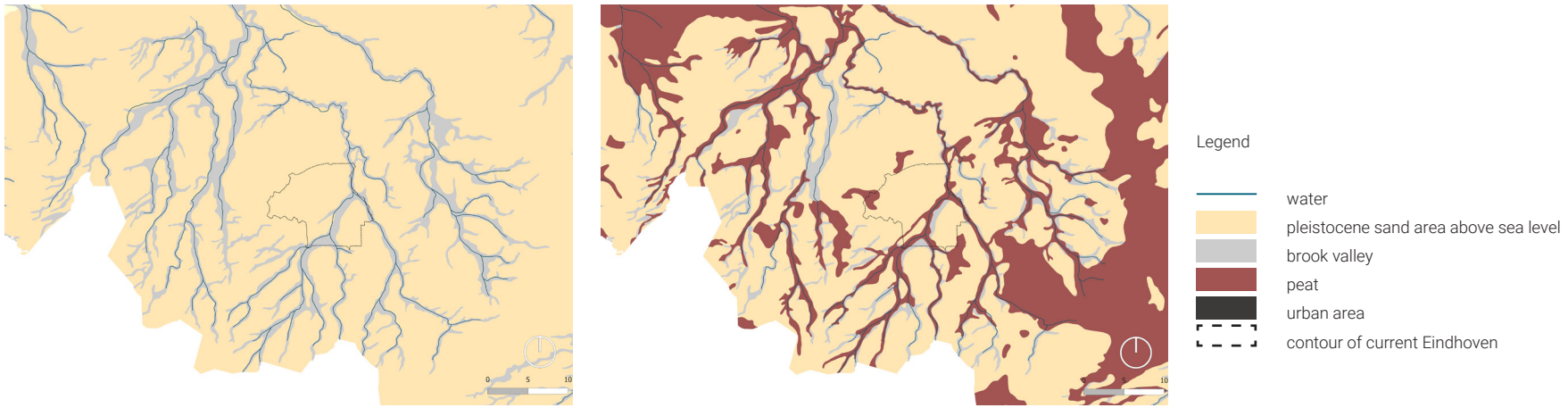


FIGURE 94 **Paleogeography (Van der Meulen et al, 2020)**

Landscape elements

The population growth during the Bronze Age led to larger deforestation of the area. Around 2000 BC, midway the Bronze Age, the landscape of North-Brabant was partly forest and partly open grassland or heathland, alternated with arable fields (Arts, 2020). Settlements were located nearby water, where soil was more fertile (Historisch openluchtmuseum Eindhoven, 2022).

Main vegetation

Lime tree forests on higher areas and mixed forest of elm, hazel, ash in other areas (Ecologische Kring Midden-Brabant, 2011).

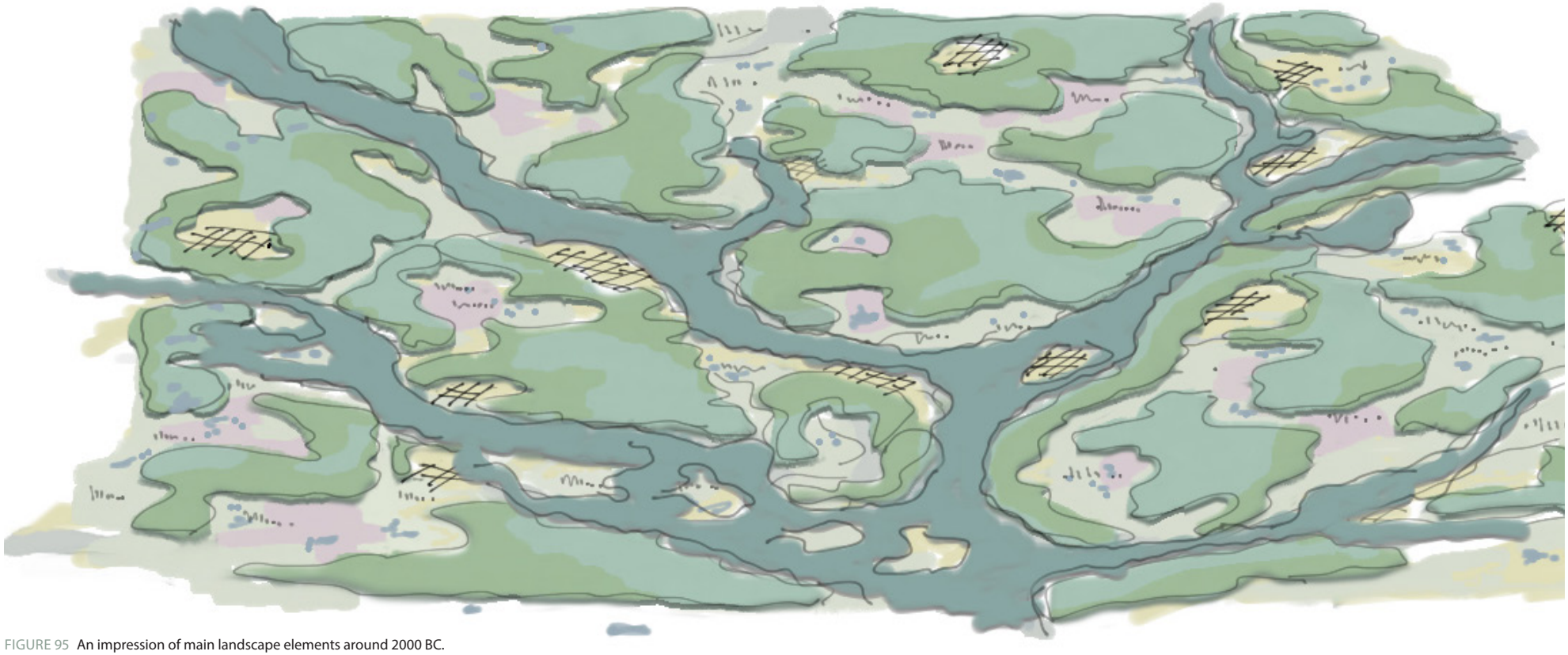


FIGURE 95 An impression of main landscape elements around 2000 BC.

Authors & ownership
Farmers dominated the land during these times. Settlements consisted of 3 to 5 farming families together (Historisch openluchtmuseum Eindhoven, 2022). Natural resources could be harvested without regulations.

During the Iron Age, cattle were not only kept for food value for the people, they played an enormously important role in transactions between different tribes (Janssens, 2010).

Activities

Arable farming by slash & burn. Crops: wheat, barley, millet, and flax. Livestock farming, mostly cattle

Livestock was used for fertilization. Once production of land diminished, a new patch of forest was cleared to serve as fresh farmland. The nearby brook provided fresh water.

Loam excavating

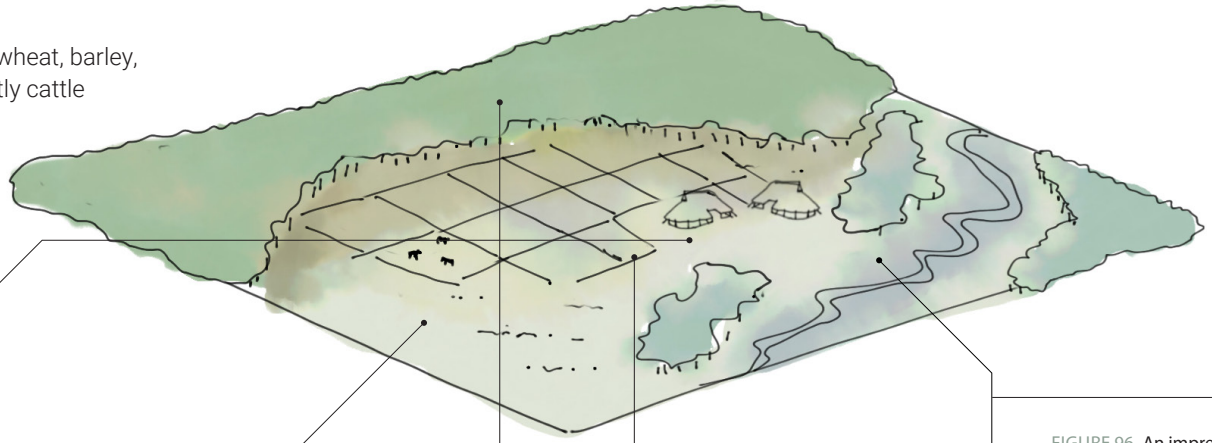


FIGURE 96 An impression of settlements around 1000 BC.

local, natural resources collected/ harvested for building

dug out loam, excavated from local pit

Grassland/heathland sods

Large wooden poles (mainly oak) by primeval forest clearing

https://www.eikenhoutenbalken.nl/eiken-palen/eiken-palen-geschild/

Straw as byproduct of arable farming

Wikimedia Common

Cutting of reed from brook edges, limited availability

Wikimedia Common

Cutting of willow near wet areas

https://dewilgenstudio.nl/over-de-wilgenstudio/

construction method

creating wickerwork of willow brances; → mixing of loam with straw → loam mixture is put on the wall → roof attached

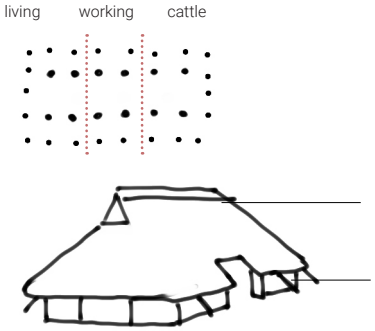
https://historisch-openluchtmuseum-eindhoven.nl/ijzerti-jd/Brabant/Slifferthuis-ontwerp_en_bouw.html

https://ijzertijdboerderij.wordpress.com/2017/09/28/vit-sen-en-lemen-van-wanden/

https://ijzertijdboerderij.wordpress.com/2017/09/28/vit-sen-en-lemen-van-wanden/

https://www.eindhoveninbeeld.com/photodetail.php?id=38369

resulting houses



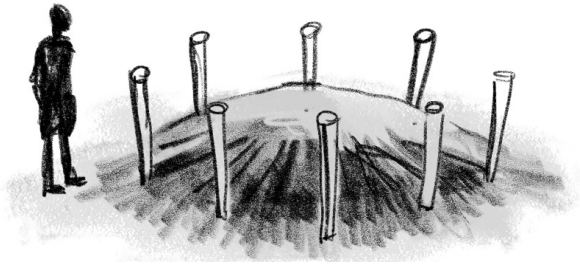
roof: straw / reed / sods

frame: timber, partly covered with wood tar
&
fill: wickerwork of willow brances + mixture of loam and straw

material details

loam wall

straw roof



Use of resources
Influence of anthropogenic activities on the ecosystem was limited. Mainly local sources were used. Only flintstone was obtained from elsewhere, most likely form South Limburg (Ecologische Kring Midden-Brabant, 2011). Local ecosystems were temporarily affected by slash and burn of forests, logging of wood, and shifting reclamation of land for agriculture. There was enough wood to use it for the large amount of wooden poles needed to construct a house. Due to soil degradation by anthropogenic activities and wetting of the area, fertilization was needed in the Bronze Age.

Mythology & rituals
In the course of the Bronze Age and later on, the landscape was increasingly seen as land of ancestors (Schuyf, 2019). Three practices can be identified:

- Important figures were buried in a burial mound. The burial fields developed into core places that functioned as territory demarcation and around which activities were organized for centuries to connect with ancestors. Later on, this tradition shifted to cremation and burying in a pit, creating vast urnfields.

- Metal artifacts have been deposited in wet zones.

- After leaving a farm, residents built their new home nearby, but not on the foundations of their old home. This practice is probably related to the founding of a new family or the death of the head of the household, from a symbolic perspective. (Janssens, 2010).

Permanent yards and settlements *Middle Iron Age - High Middle Ages*

Historical context

The system used from the late Iron Age, and further into the Roman period, was one of permanent yards and settlements with more permanent fields and fallow areas. Lands were already partly depleted by previous farming activities of shifting cultivation and the iron industry led to major deforestation activities. The Romans entering the Netherlands had a relatively limited impact on the region of Eindhoven. Cattle farming became a necessity as it was a suitable usage of the increased acreage of open grasslands (Janssens, 2010).

This period started initially with growth of population. After the 3rd century a decline of settlements took place due to various reasons (Janssens, 2010).

Paleogeographical development

Little changes in the conditions of the landscape, as the maps of different time frames show in figure 97.

500 BC

800 AD

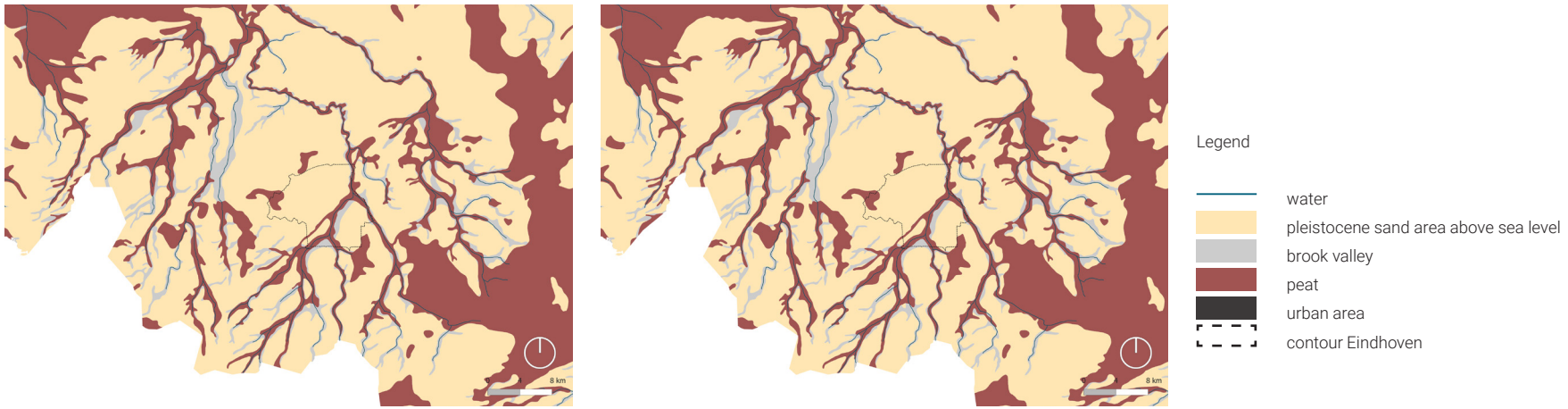


FIGURE 97 **Paleogeography (Van der Meulen et al, 2020)**

Landscape elements

Dominantly open grasslands/heathlands, fixed arable fields, wooden walls, mostly forest on wet soils. In addition to the smaller fields that were used for arable farming, the landscape consisted for a very large part of uncultivated grass- & heathland. Large clearance of forests resulted in sand drifts (Ecologische Kring Midden-Brabant, 2011).

The amount of forest fluctuated in this time period, due to changes in population.

Main vegetation

Mainly oak trees on higher areas and alder trees in wet areas. The population of Beech and Hornbeam expands and Lime dissapears (Ecologische Kring Midden-Brabant, 2011).

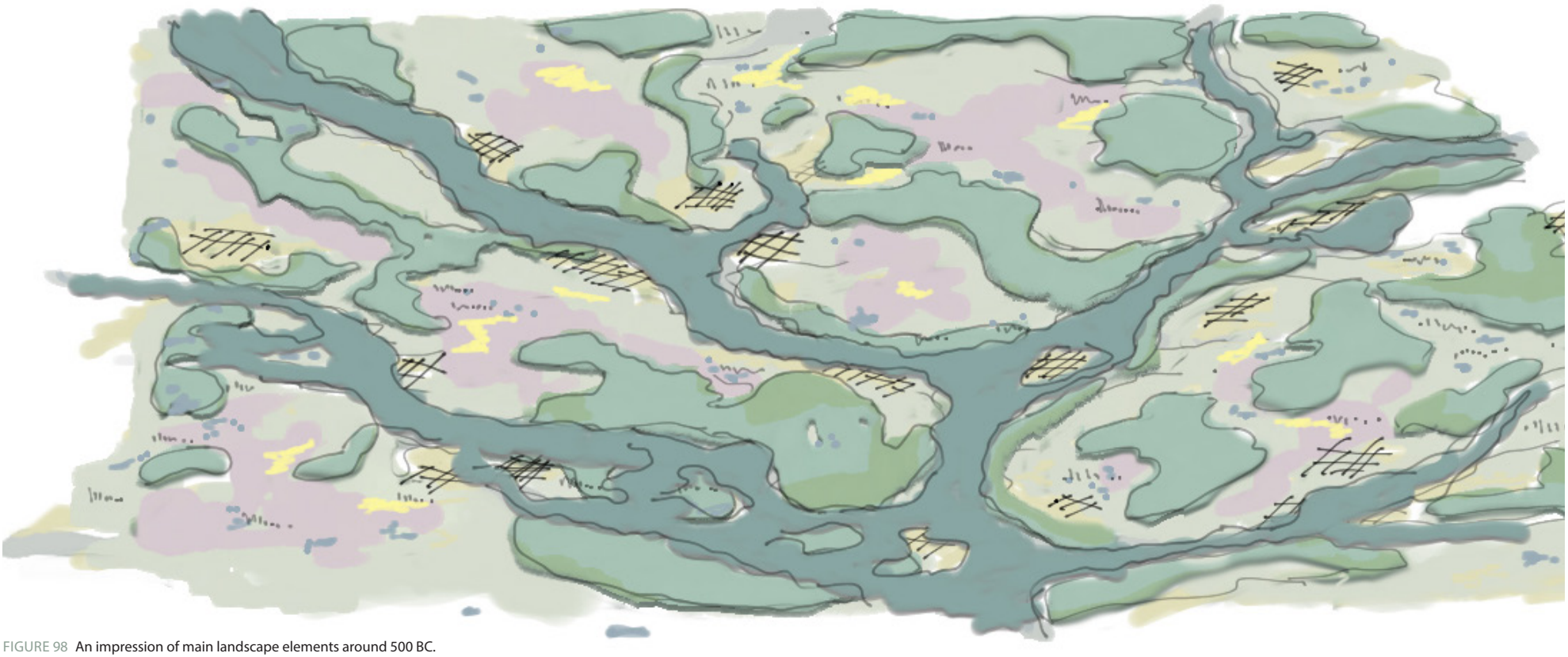


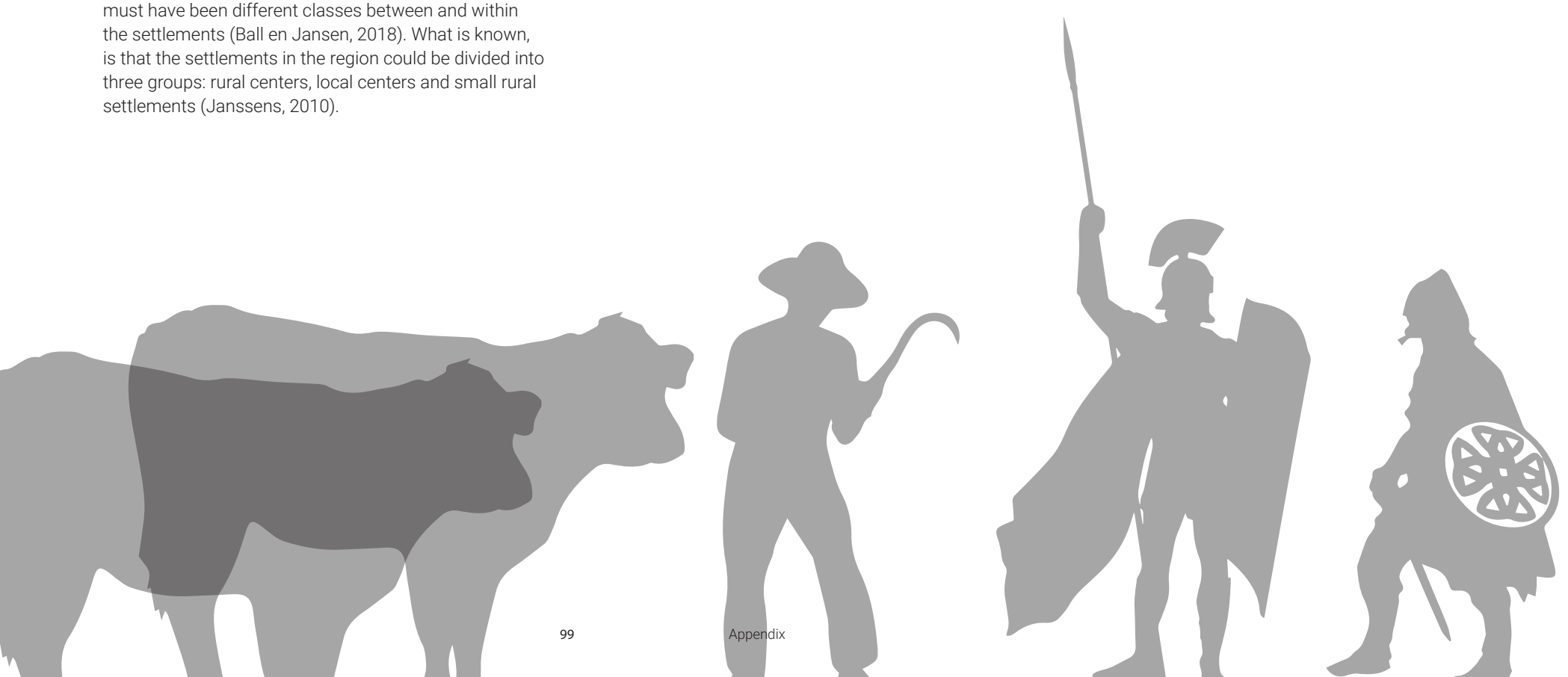
FIGURE 98 An impression of main landscape elements around 500 BC.

Authors & ownership

Farmers still dominated the land. Despite the arrival of the Romans in the first part of this time frame, the vast majority of the population continued to live in rural settlements. Partly due to the limited production by arable farming on the poor sandy soils, a more traditional manner of agricultural production was sustained and other locations were chosen for large scale villa's. The growth in production, which was accompanied by the growth in population during the Roman period, mainly continued in the livestock sector in the Maas Demer Schelde area (Janssens, 2010).

The social stratification of Roman society with landowners, free and dependent farmers, agricultural workers and also enslaved people cannot be read from the settlements that were found in Brabant. Undoubtedly, however, there must have been different classes between and within the settlements (Ball en Jansen, 2018). What is known, is that the settlements in the region could be divided into three groups: rural centers, local centers and small rural settlements (Janssens, 2010).

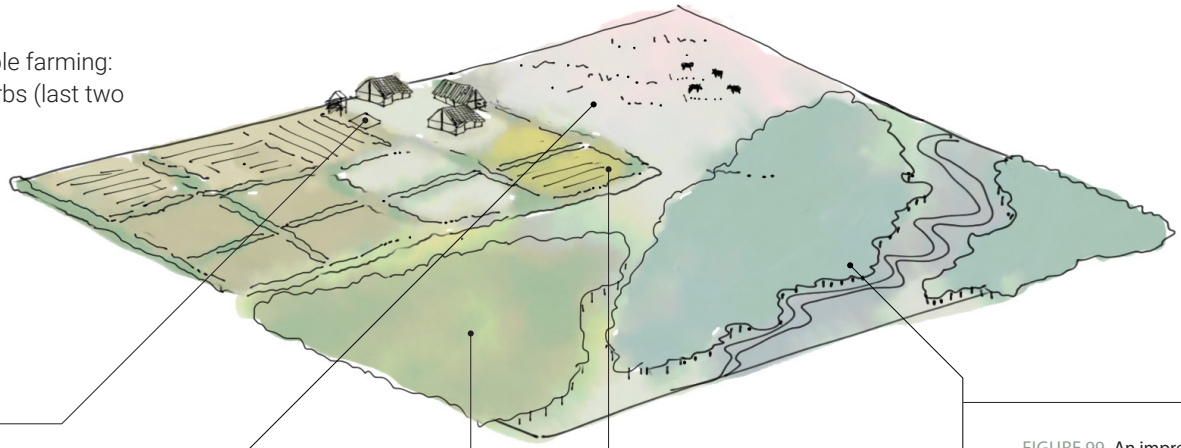
A while after the Romans left, a new group of outlanders entered: the Vikings. Their influence was mainly one of looting in the entire region from their settlement in Breda (Strater, 2022). What they probably did bring, was inspiration for shaping residential barns.



activities

Due to depletion of the sandy soils, the system of ‘celtic fields’ arose, consisting of permanent arable fields and fallow areas. 100 fields served a household of 6 people, of which 25 fields were used annually (Ecologische Kring Midden-Brabant, 2011). The surrounding wastelands grounds were probably used in two ways, on the one hand to allow cattle to graze and on the other hand, it might be possible that they were already used in this time to put out sods, which were then placed in the sunken parts of the stables, to later serve as fertilizer for the fields (Janssens, 2010). Settlements were located on higher grounds. The invention of shored water wells made settlementation no longer dependent on open water.

Livestock farming (mostly cattle) and arable farming: barley, rye, millet, pulses, flax, beet and herbs (last two introduced by Romans)



Loam excavating

FIGURE 99 An impression of settlements around 500 BC

local, natural resources collected/ harvested for building

dug out loam, excavated from local pit

Grassland/heathland sods

Large wooden poles (mainly oak) by primeval forest clearing

https://www.eikenhoutenbalken.nl/eiken-palen/eiken-palen-geschild/

Straw as byproduct of arable farming

Wikimedia Common

Cutting of reed from brook edges, limited availability

Wikimedia Common

Cutting of willow near wet areas

https://dewilgenstudio.nl/over-de-wilgenstudio/

construction method

creating wickerwork → mixing of loam with straw → loam mixture on the wall → splitting oak wood into shakes → attaching the roof elements

https://historisch-openluchtmuseum-eindhoven.nl/ijzertijd/Brabant/Slifferthuis-ontwerp_en_bouw.html

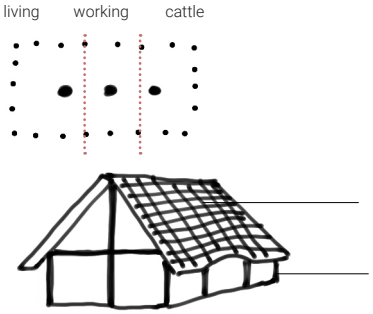
https://ijzertijdboerderij.wordpress.com/2017/09/28/vitsen-en-lemen-van-wanden/

https://www.youtube.com/watch?v=UZA1J8RHltY

https://blog.lostartpress.com/2012/03/29/breaking-the-riving-rule/off-kilter-froe-split/

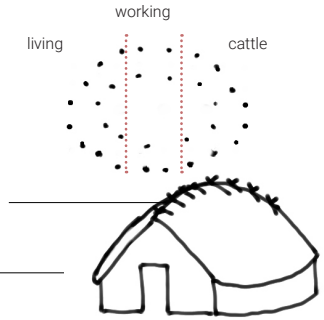
https://historisch-openluchtmuseum-eindhoven.nl/ijzertijd/Brabant/bewoning.html

resulting houses



roof: straw / reed / sods / oak shakes

frame: timber, partly covered with wood tar
&
fill: wickerwork of willow brances + mixture of loam and straw



material details

oak shakes

planed beams, introduced by Romans

Use of resources
Influence of anthropogenic activities on the ecosystem became larger. Mainly local sources were used, but overused. The sandy cover soils in the region of Eindhoven are vulnerable for leaching of nutritious minerals. This process was accelerated by logging of trees (Janssens, 2010). This led to degration of soil and sand drifts.

Due to a relatively small population in the Middle Iron Age, trees did have the chance to continue growing. At the beginning of the late Iron Age there was, as a result, plenty of wood for construction. This enabled people to use wood for various purposes, even a wooden roof. However, deforestation continued afterwards, leaving the area with dominanlty grasslands in stead of forests at the end of the period.

All parts of the landscape were being exploited by this time, as iron ore was taken from the brook valleys.

Mythology & rituals
Regardless of the arrival of Romans and Vikings, local cult sites remained. In this period, close relationship with nature was prominent: trees, natural or beaten water sources, stones were cult sites. Nature/landscape had a special meaning for man as a manifestation of the supernatural, the mythical, the sacred (Schuyf, 2019).

Transition towards fabricated houses

High Middle Ages - beginning of 19th century

Historical context

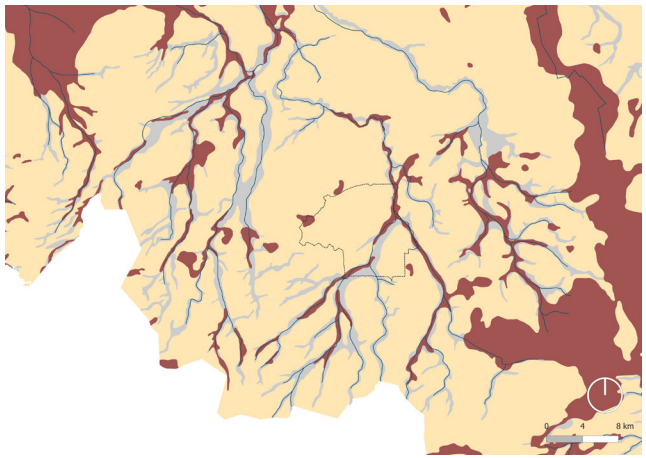
The growth of cities started in the Middle Ages, which Eindhoven joined slightly later. Trade in wool, provided by local sheep farmers, and crafts such as tanning and the clothing industry were the basis for city life. Eindhoven was founded in 1225 and was very small for that time. Homes were primarily given a residential function, sometimes combined with workshops for crafts. Estates as castles and monasteries were constructed in the wet brook valleys, setting an example of brick constructed buildings (Arts, 2020). The introduction of the fabrication process markes this time frame, as well as the long subsequent implementation period. It took untill the end of the time frame for brick work to become more or less common in all areas of the region. At the end of the period, innovations in other fields arose as well, such as the use of watermills for mechanised wood sawing.

Paleogeographical development

On the left image, the start of reclaiming brook valleys and swamps has already started, as grazing lands in brook valley were needed for livestock. On the right image, at the end of this time frame, large drifting sands are shown, causes by digging sods from wastelands.

Due to continuous population growth, a drier climate and lowering of the groundwater level, the need for water increased a drier climate and lowering of the groundwater level, the need for water increased.

1250 AD



1800 AD

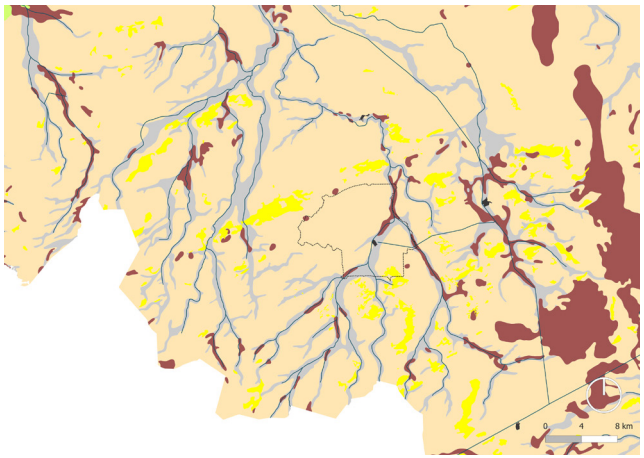


FIGURE 100 **Paleogeography (Van der Meulen et al, 2020)**

Landscape elements

City expansion had a minor influence on the larger landscape elements. The city of Eindhoven remained remarkably small. At the same time, agricultural settlement relocated from the highest parts to the flanks, at the boundary of sand ridges and swamp or brook valleys. Brook valleys were transformed to grasslands for livestock grazing and water mills were introduced. In addition, these lands were claimed by noble and monastic orders for build castles and monasteries. Arable fields (Dutch: essen) expanded by sod fertilization was introduced early in Brabant and were heightened over time up to a meter. At the peak of the system in the beginning of the 19th century, the landscape was dominated by large heathlands with patches of drift sand due to sodding. (Ecologische Kring Midden-Brabant, 2011).

Main vegetation

Grasslands and heathlands (Ecologische Kring Midden-Brabant, 2011) and cultivated willows and oak trees.

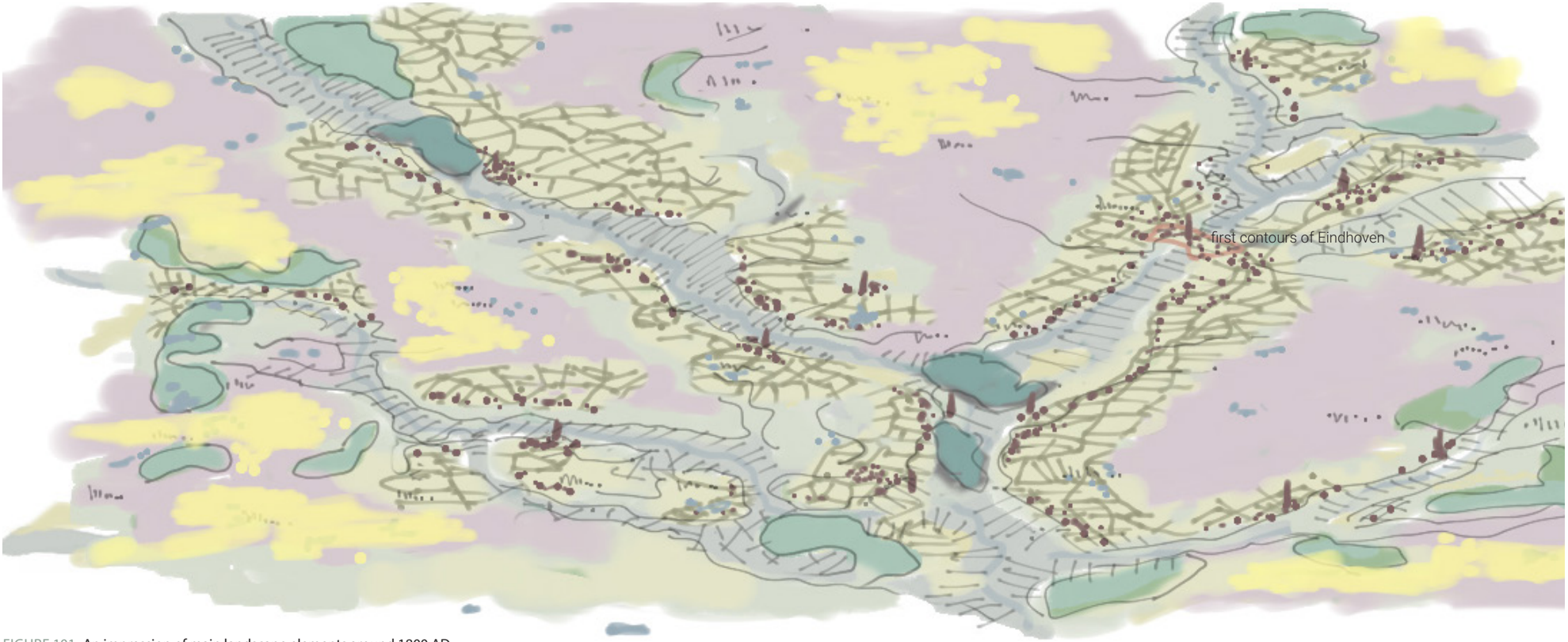


FIGURE 101 An impression of main landscape elements around 1800 AD.

Authors & ownership
Various authors influenced this period.

Dukes of Brabant (1190 - 1795)
In the late Middle Ages, the region of Eindhoven was part of the Meierij - roughly the region between 's Hertogenbosch and the Belgium border south of Eindhoven. The Meierij belonged to the dukes of Brabant. The dukes considered themselves the owners of all land that was not private property ('vroenten en gemeinten'): forests, heaths, moors, waters, also roads and paths between the villages. It was mostly land that yielded nothing. For various reasons the dukes grant the villagers 'voorpootrecht'. That was the right to plant and cut trees and shrubs on the vroenten en gemeinten for private use (Vera, 2014). Sometimes it was granted out of generosity, see example of Duke hilips van Brabant. For other dukes, it was out of economic gain, as they asked for part of the harvest as payment. And there was environmental policy avant la lettre: planting trees and bushes had to stop the advancing drifting sand.

Nobility and monastic order
The nobility and monastic orders started to settle in and near the city. Estate and castles were build in the brook valleys. Presumably, the knowledge of fabricating bricks was brought by Monastic order.

Townsman & -woman
As an alternative for livestock farming on rural sites, the city offered a place for living partly from trade & crafts, such as leather tanning (Arts, 2020). These town citizens marked a new type of authors for the landscape.

FIGURE 102 Duke Filips de Schone
Wikimedia Commons

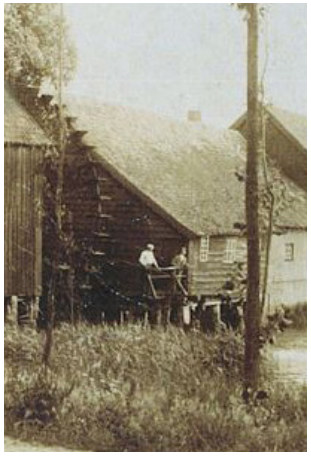


FIGURE 103 Miller
http://www.watermolenopwetten.nl/

Example of 'Voorpootrecht'
1491 - "Maximilian, King of the Romans, and Philip, Duke of Brabant at that time, declare that in they have learned that the inhabitants of Helvoirt (a village in the Meierij) in the last war with Gelre and Liège, as good subordinates, helped with footmen, chariots and horses, as well as having incurred many expenses and also taken into consideration that the village is small and most of the goods belong to Bossche burghers, allow the residents to plant the 'vroenten' in front of their property up to 80 feet inland, on condition that they will give the tenth penny of the sold wood as a timber treasure." (BHIC, 2020)

Water mill the 'Opwettense Molen' in Nuenen was equipped with a wood sawing mechanism. This feature is first mentioned in 1764, when the mill had to be rebuild after a fire. Potentially, the wood saw could have been used earlier as well (Geboers, 2020). The miller influenced the ease of wood processing in the region.

Urban life

Main labor activities were trade in wool, working in the textile industry and tanning (of leather).

Town houses surrounded the main streets of the city and had deep yards for cattle, fruit trees and crafts (Arts, 2020).

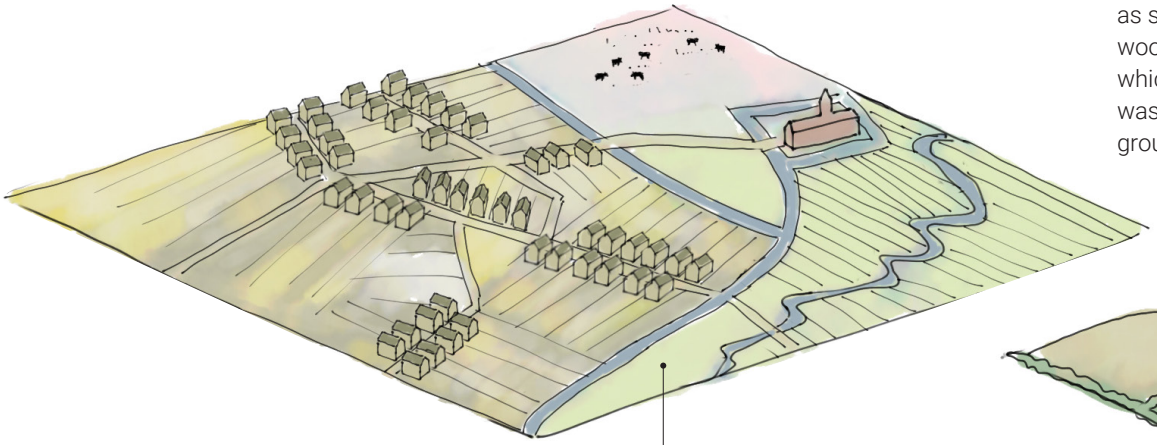


FIGURE 105 An impression of urban settlements around 1600 AD

Rural life

Main labor activities were livestock farming of cattle and sheep. Arable farming: grain and oil crops.

Due to population growth, a drier climate and lowering of the groundwater level, the need for water increased. Grazing lands in brook valley were needed for livestock. Rural houses were therefore relocated to the edges of brook valleys. Arable fields (Dutch: essen) expanded as sod fertilization was intensified. In the barn, manure was mixed with sod. Cultivation of wood took place on walls surrounding the arable fields (esdekken) and on common land which was firstly mainly used for oak trees. Estates arose in the brook valleys. This location was chosen to make sure the moat surrounding the estates would always be filled with groundwater.

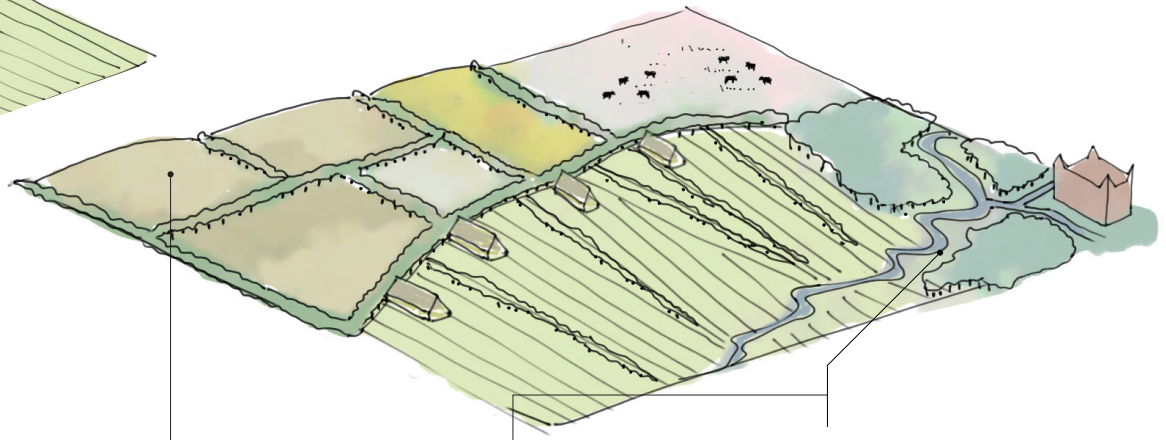


FIGURE 104 An impression of rural settlements around 1600 AD

local, natural resources collected/ harvested for building

dug out loam, excavated from local pit

Grassland/heathland sods

Large wooden poles (mainly oak) by cultivated tree lanes and patches

https://www.eikenhoutenbalken.nl/eiken-palen/eiken-palen-geschild/

Straw as byproduct of arable farming

Wikimedia Common

Cutting of reed from brook edges, limited availability

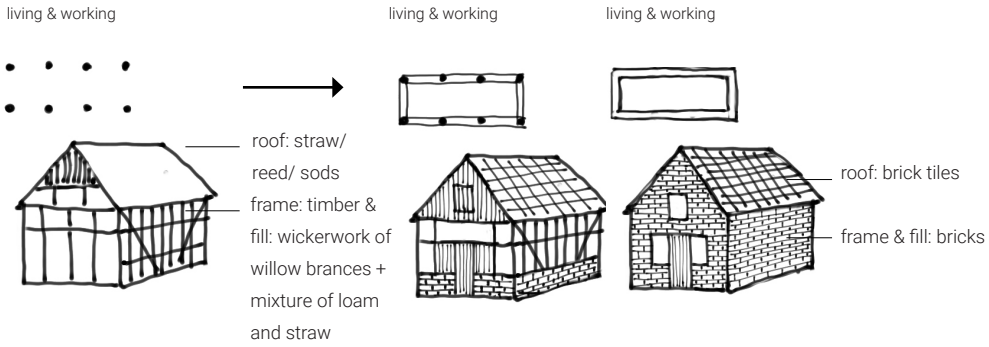
Wikimedia Common

Cutting of cultivated willow near wet areas

https://dewilgenstudio.nl/over-de-wilgenstudio/

Town houses

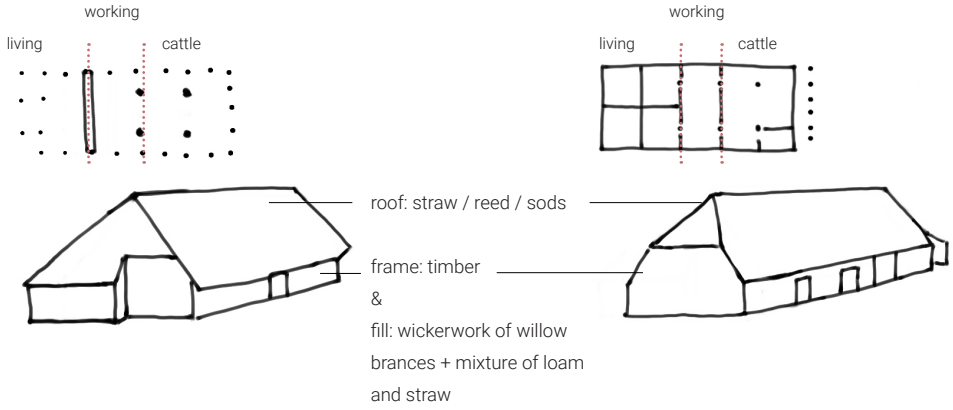
Town houses were firstly build from wood and half timbered frame filled with loam-covered wickerwork. work. Their proximity to another caused them to be fire-prone. Construction in the city soon required adjustments. Loam bricks were provided by small scale factories which mined local loam. After repeated fires, roof tiles and the first meter of masonry from the ground were made mandatory, as explained by one of the volunteers of Prehistorisch dorp Eindhoven (Rooij de, personal communication, 23 february 2022).



Rural barns

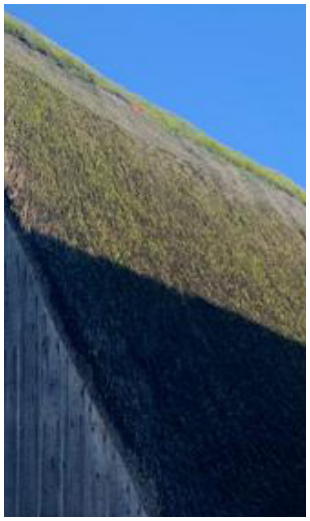
Limited changes could be noticed on the rural areas, aside of improved floor plans of the 'langgevelboerderij' in the 17th century to house more cattle.

First the foundations and side facades where constructed in brick at some point. This was probably related to the construction of the deep stable (Kort, Zweers & Brinkkemper, 2016)

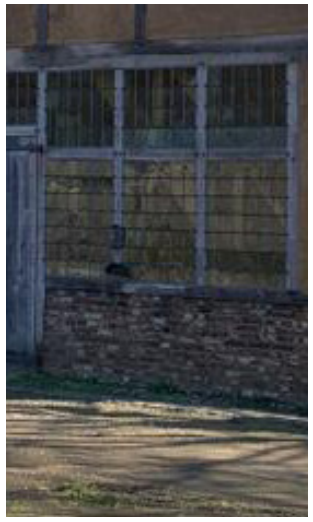


material details of town houses

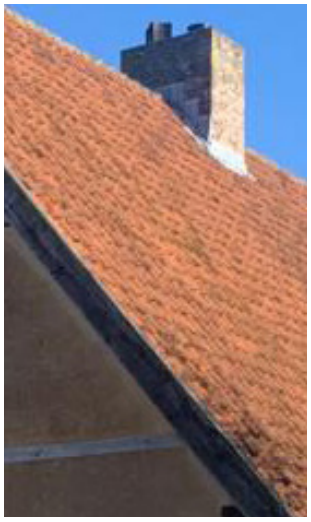
wood & wickerwork with loam



straw roof



First meter of bricks & stained glass



brick roof tiles

Meaning of the land

Use of resources
The largest effects of the use of resources in this time frame, were deforestation and heigtening of arable fields along the brook valleys. The agricultural sod system resulted in new reliefs in the landschape, actually influencing the geography and soil conditions. Due to a lack of litter in Brabant, sandy grass and heather sods were used, which raised the land with minimum thickness of 50 cm. This system continued until halfway the 19th century. Arable fields had heightened up to a meter, also in the brook valley. Simultaneously, overgrazing and digging of sods at the wastelands let to large drifting sands at the end of the time frame. In addition, the use of wood for charcoal as fuel for various purposes, led to large deforestation. The influence of anthropogenic activities on the land was very large, however, the nutrient flows were stil in balance.

For building material..
Building materials had to be intentionally cultivated for the first time in local history. The right to plant secured a provision of oak wood and willow twigs for construction.

Mythology & rituals
*U*rnfields disappeared underneath the 'esdekken'. Landscape elements still had a special meaning though. Stories told at that time, about gnomes for instance, were often linked to striking places in the landscape, such as the moors. It is possible that the world of these stories corresponds to pre-Christian thoughts and customs, which survived until after the Middle Ages in the region This also includes building offerings and offerings of objects in swampy areas (Arts, 2020).

The healthlands were specifically known as residence of pagans. Their relationship to supernature was mostly instrumental, involving mutual obligations: man sacrificed, and the supernatural power returned what was desired (Schuyf, 2019). of Eindhoven.

Industrialised city expansion

19th century - 20th century

Historical context

The region became accessible by road, train and canals. The introduction of artificial fertilizer, mechanization, and import of wool made a big impact. Rapid development of the city of Eindhoven took place due to industrialization, still a small city in the middle of five much more extensive peripheral villages: Woensel, Tongelre, Stratum, Gestel and Strijp, transformed to a large urban structure. Industry and large scale farming became the main labor activities.

Paleogeographical development

Large scale urbanisation took place and the need for fuel resulted in the removal of peat.

t

2000 AD

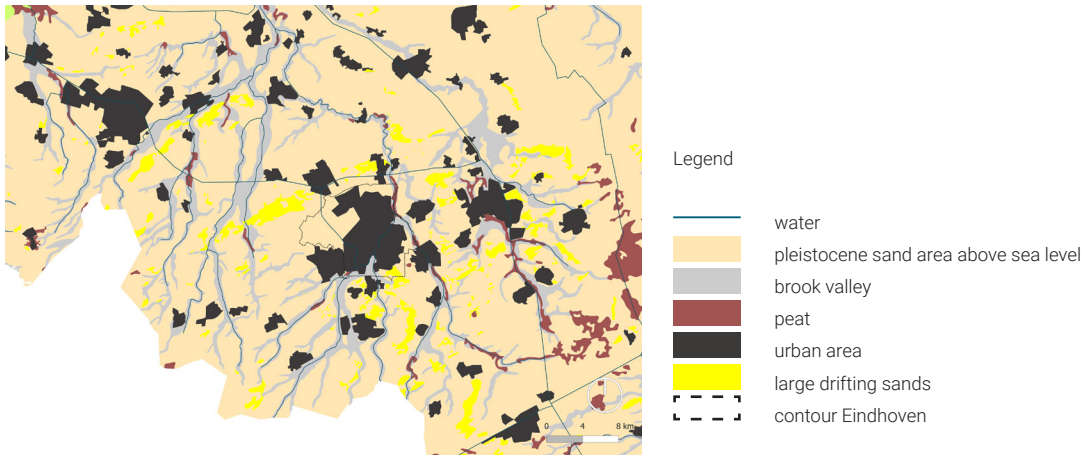


FIGURE 106 Paleogeography (Van der Meulen et al, 2020)

Landscape elements

The system of sod fertilization fell into disuse by the emergence of artificial fertilizer, the introduction of mechanization, and import of wool. Interactions between fields, pasture and wasteland expired. As a consequence, large-scale reclamation of wastelands took place. Wastelands inappropriate for arable fields was reforested by monotonous conifer plantations.

As the farms became increasingly petrified, the need for oak and willow wood decreased. That is why the plant rights holders gradually switched to the production of poplar wood, which could be sold to the emerging clog and match factories. This is how the typical poplar landscapes arose in the 18th and 19th centuries.

Early 20th century: Afforestation plans for wasteland in the municipality. Forestry plants of Staatsbosbeheer in Eindhoven and Helmond, among others..

Main vegetation

Conifers & poplar trees

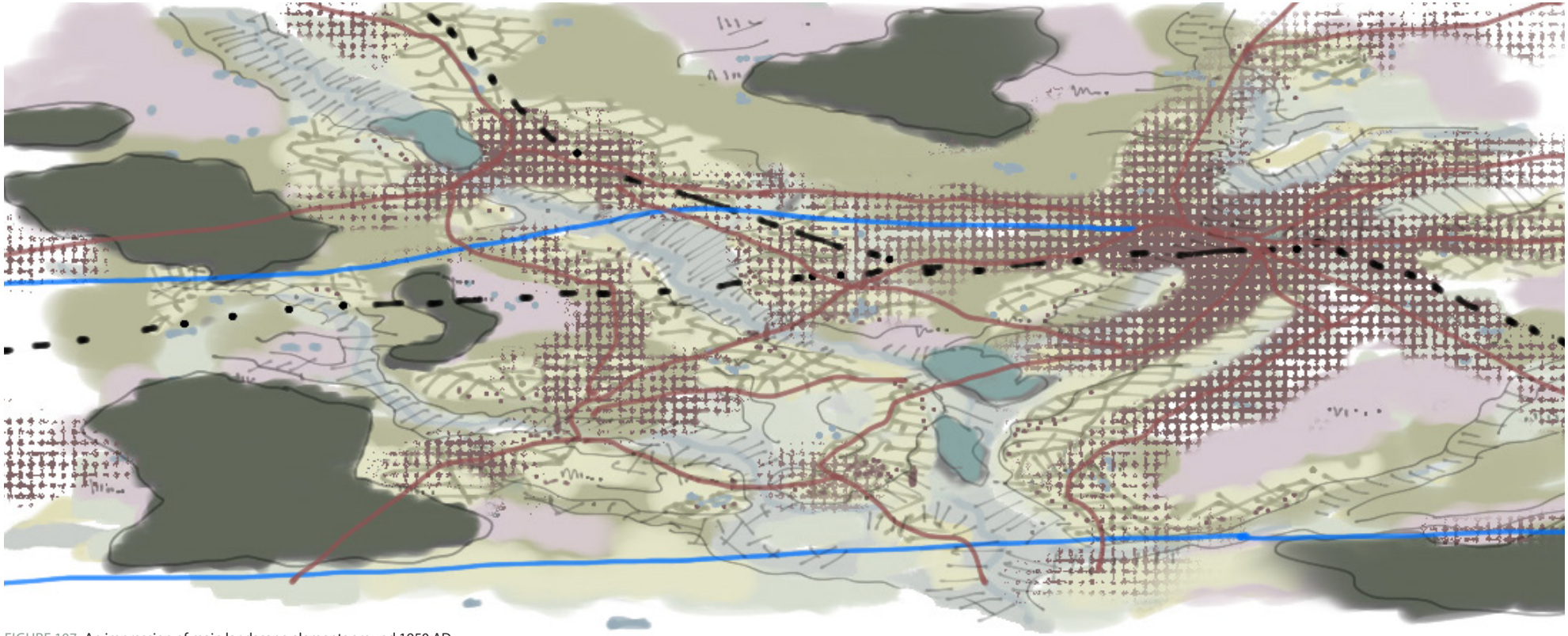


FIGURE 107 An impression of main landscape elements around 1950 AD.

Authors & ownership
Various authors influenced this period. The working class increased significantly in numbers due to industrialization. Relatively less people worked as farmers, although this group of authors was still an important group in the region.

Authors with a larger influence in this region were parties as Staatsbosbeheer, Koninklijke Nederlandse HeideMaatschappij, and Philips. Philips boosted the industrialisation and played a role in city expansion. As for Staatsbosbeheer (State Forestry) and Koninklijke Nederlandse HeideMaatschappij (Royal Dutch Heath Company), both parties stimulated large heathland reclamation, which was transformed into tree plantations and large scale arable plots.

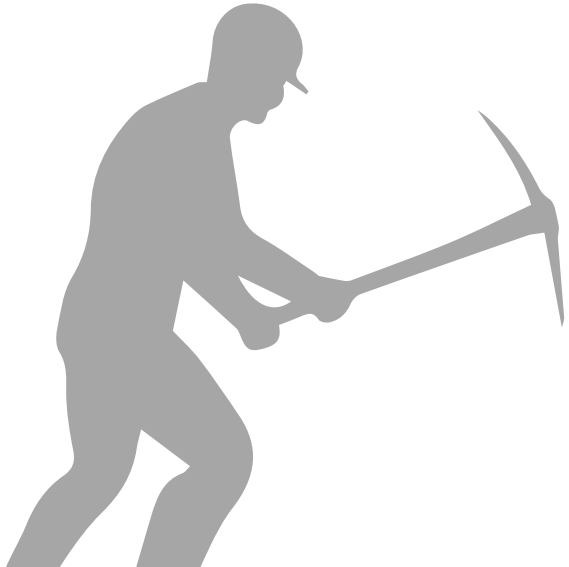


FIGURE 108 **Large scale afforestation of waste lands https://www.knhm.nl/historie-knhm/**

At the time interest in heather as part of the agricultural business declined around 1900, the Dutch government started to plant forests on heathland. Both Koninklijke Nederlandse HeideMaatschappij, founded in 1888, and Staatbosbeheer, founded in 1899, were drivers in the cultivation of waste lands. Reclamation and afforestation of the moor provided welcome employment, especially in the 1930s, known as the Depression years.

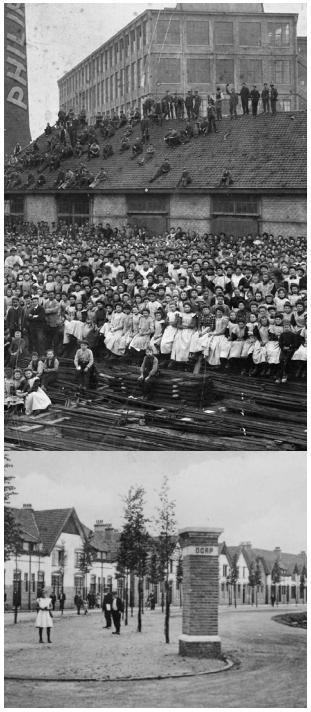


FIGURE 109 **Philips factory & village established by Philips**
First photo: Royal Philips

The success of Philips brings prosperity to Eindhoven. More than a thousand employees worked in the factories in the beginning of the 20th century. In 1910 Philips founded a factory village called Philipsdorp in which employees were provided with all comforts. He builds 'healthy' homes with vegetable gardens and a community is created in the village with various facilities such as a Philips bakery, drugstore and a sports field (NPO, 2022)

FIGURE 110 Brick factory De Leeuwerik, Best (North of Eindhoven)
https://www.geschiedenisvanbest.nl/?page_id=110

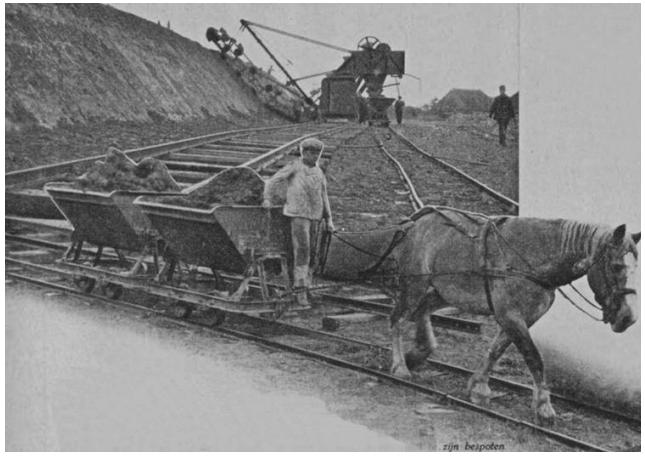
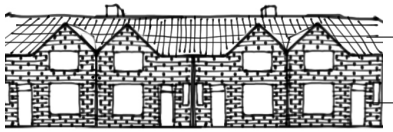
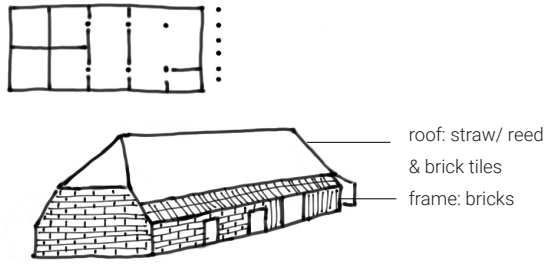


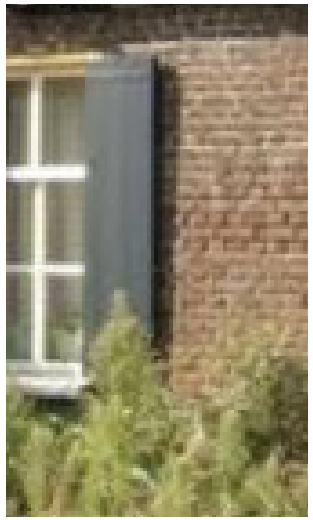
FIGURE 111 Delving of the loam
http://www.industriespoor.nl/Haasje.htm

These factories were all closed in the 1960s. In the course of the 19th century, with the invention of the ring kiln and the opening up of the Meierij through the Zuid-Willemsvaart, brick became so cheap that the vitselstek walls were replaced by brick walls.At the beginning of the 20th century several brick factories were established in the region of Eindhoven.





material details of town houses



wood & wickerwork with loam

straw roof

bricks

brick roof tiles

Use of resources
This time frame is characterized by looting of natural resources. Import of goods marks the disbalance of nutrient flows. Machinery intensified livestock farming.. Resources at an increasingly distant were being used.

For building material
Large scale loam delving activities resulted in traces in the landscape. Nowadays, we still find open water as the result of excavating land. The use of local bricks continued up untill the 60'ies.

4. Timeline overview

Introduction
The timeline shows how the construction of housing with local building materials has developed in this region. Only major changes are displayed. An attempt has been made to link this development to:

- Main authors of the landscape and their influence
- Main landscape elements
- Main vegetation

An estimation has been made how long certain materials and construction methods have been applied. Mythology is left out, because it appeared to be of less relevance for the time line.

DOMINANT USE OF LOCAL, BUILDING MATERIALS

Use of wooden frame, wickerwork with loam as fill and a roof of straw

Additional use of wood for roof, oak shales

Changed use of wooden frame, influenced by Romans: planed beams

MAIN HOUSING TYPOLOGY

First residential barns, housing farmers & their livestock

New type of residential barn

Boot shaped residential barn (from ± 900)

AUTHORS & THEIR INFLUENCES

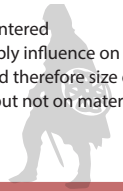
farmers living of land with cattle

± 4300 BC

farmers living of land with cattle

± 500 BC

± 50 BC (till 400 AD)



Vikings entered
Presumably influence on shape and therefore size of houses, but not on material use

± 850 AD

Shifting farms

Permanent yards and settlements

± Bronze age
Population growth during the Bronze age

± 700 BC
Introduction of iron tools, again population growth

Legend

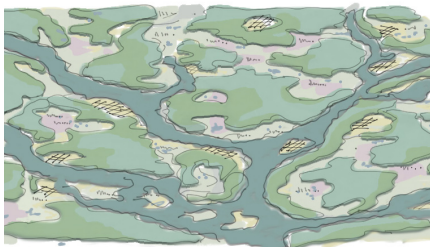
main local materials

wood

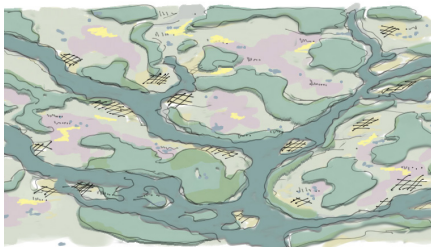
loam

straw

MAIN LANDSCAPE ELEMENTS



Lime tree forests on higher areas and mixed forest of elm, hazel, ash in other areas.

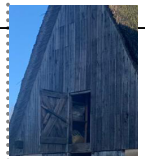


Dominantly oak trees & alder trees. Growth of Beech and Hornbeam. Lime dissapeared.

MAIN VEGETATION

Continuous use of three elements for town houses

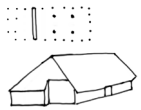
Additional use of wood for walls



Additional use of loam as bricks, *first meter of bricks and roof tiles, to prevent fires in city*

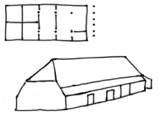
Complete use of loam as bricks for town houses

City: Rectangular town houses with a deep yard



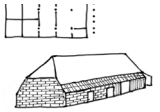
Aisled hall farm (Dutch: Hallehuisboerderij)

City: Rectangular town houses

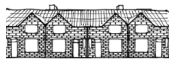


Extended long facade farm (Dutch: langgevelboerderij)

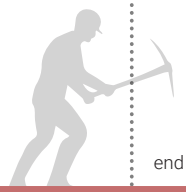
City: Rectangular town houses



Extended long facade farm (Dutch: langgevel-boerderij)



row houses of brick, work-ing-class houses



from 12th century onwards

13th century onwards

end of 19th & 20th century

Transition towards fabricated houses

Industrialised city expansion

13th century onwards

Frequent fires damaged the city

1396

first 'voorpootrecht' granted in Meierij by ruling duke to plant trees on municipal grounds

18 century

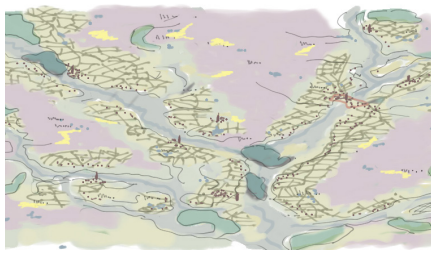
introduction of sawing by water mill

18 / 19th century

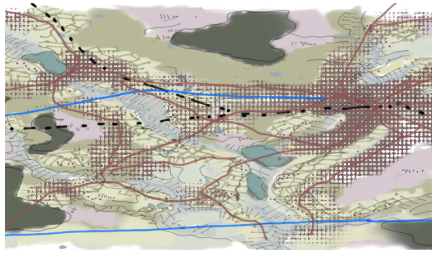
Transition of right to plant landscape to poplar trees, as bricks became more popular.

19th century

Accessibility of area by roads, train and canals



Oak trees & willows.



Coniferous forest & poplar trees

FIGURE 112 Timeline: historical use of local building materials

Conifers

Tradition of building locally

What characterizes the history of use of local building materials and matching building techniques in this region is that the local nature of it has been retained for quite some time. It can be called a solid tradition. One of the factors involved is the remoteness of the region in relation to major access rivers. For a long time, the Dommel was the only connection from Eindhoven to the more advanced city of 's Hertogenbosch. Intensified transport became only possible after the construction of the paved road from Liège to 's Hertogenbosch via Eindhoven, the construction of the Wilhelmina Canal and the railway in the 19th century. Another factor is the presence of loam as a reliable source, and has been used throughout the entire local history. In addition, because of the naturally poor soil that yielded little, the area has been less attractive to conquerors such as the Romans, so that external influences have been limited.

The local character described above applies to the urban environment but even more so to the countryside. Farmers in the region of Eindhoven were often forced to rely on sober construction with materials that were cheaply available, such as loam or agricultural waste streams such as straw. They did not have the luxury of using more expensive building materials. Even far into the 20th century, the use of a thatched roof, most likely local sources as affordable material, is still very common for agricultural farms.

Main local building materials

Three local materials have been dominantly used in this region: loam, wood and straw

Loam

The use of loam can be seen as a stable factor in local construction. This material is naturally available and has therefore proven to be a reliable source. In every period, from fixed settlements, the material has been used in some way. In the first instance by applying the vitselstek technique. Even after the connection of the region of Eindhoven via rail, canal and paved road, there has been a revival in loam mining through local brick factories. The improved technique of heating loam made it again a useful product. Only today, the use of loam in the region is minimized.

Wood

The use and availability of wood shows a more dynamic course. Until the late Middle Ages, this material was available in the primeval forests still present at that time. After the clearance of all primeval forest, people were forced to start planting oaks and willows for housing construction, initiated by the Duke of Brabant through the so called 'voorpootrecht'. This made it possible again to use wood for the construction of houses. The local use of wood also led to the innovation of a water mill with a sawmill. However, as soon as the city faced many fires and the more combustible and rot-proof bricks became affordable, the use of wood decreased to a minimum. Only in recent years, there has been a revival of the use of local construction timber, through initiatives such as Peppelhout. This organization has set up an entire chain around poplar wood within the former contours of the Meierij area. In doing so, they both strengthen the local cultural landscape that was created by 'voorpootrecht' and offer a sustainable alternative to foreign wood.

Straw (and later reed)

Straw has been widely available as a residual material and has been used in various ways. It was mixed with loam used for 'vitselstek' walls and used as roofing material, sometimes alternating with sods. The limited availability of local reed has long made straw the most commonly used roofing material in this area. Only late did roof tiles and reeds replace straw as roof materials.

Other materials

As described, other materials have been used to a lesser extent. Sod and reed for instance for roofing. Until the 20th century, local reed most likely came from the banks of the Dommel and the banks of the fish ponds south of Eindhoven. It is remarkable that certain materials are not mentioned in the sources consulted. For example, the use of sheep's wool for insulation. Sheep wool was an important raw material for the clothing industry in the middle ages, but no source refers to it as building material. Was it maybe too expensive for that? And iron ore that has been dug out in the brook valleys and used for various purposes such as nails.

5. Historical strategies & links

Based on the presented historical course, some key strategies have been identified with regard to habitation and use of local building materials in relation to the landscape and the culture.

Strategies of settlement locations

For a long time, buildings had a relationship with the landscape and followed the landscape structures. Settlements started on higher cover sand ridges in the vicinity of water from a brook or fen. Later on, settlements moved to the edge between dry and wet in order to be able to use the land optimally, in the vicinity of meadows in the brook valley, in the middle of arable fields and near wastelands. Urban development started on a sand ridge, nearby a brook. After that, the wealthy built in the brook valley and used the high groundwater level for defense by a moat. Very little of the logic behind these historical choices can be seen in modern times.

Strategies of collecting local building materials

Formerly used strategies of harvesting natural, local building materials are:

- Usage of 'wild' grown renewable sources (such as reed beds and primeval forests)
- Excavation of soil material (such as loam, iron ore, and sods)
- Usage of agricultural waste & byproducts (such as straw)
- Cultivation of building materials (such as pollarded trees)

Cultivation started after the wild nature was exhausted. For trees, this was done roughly in 2 ways: letting the tree reach full growth and then clearing it or pollarding trees for the use of twigs, whereby regular harvesting can be done. People were able to make optimal use of the growth potential of deciduous trees. And also applied multiple uses, such as tannin from the skin for tannery and residual wood as firewood.

Of the four strategies mentioned, one left a larger imprint on the landscape than the other. Some of the formerly excavated loam areas in Brabant have been developed into wetland nature reserves. The cultural landscape with the many avenues of poplar trees in the Meierij is also an still visible example. The supporting processes of construction work have also had a negative impact on the landscape. Such as excavating peat that was needed as fuel for the local brick factories. This was obtained from brook valleys, fens, and swamps, which has led, among other things, to drainage of the landscape.

Variations in Ownership

The type of ownership shows a variable course during history. Initially, materials were available to everyone. Later, common grounds of the municipality could be used for planting trees. Such constructions were not strange in those days. The waste lands were also available for collective use, as were coppice forests. What marked the most influential transition was the transfer of ownership, or at least the grant to use, of the communal land to the municipalities in the beginning of the 19th century when the Kingdom of the Netherlands was declared.

Mythology

There are some possible links between local mythology and the building method. The first residents chose to build a new home nearby, but not on the foundations of their old home. This practice was probably related to the founding of a new family or the death of the head of the household, from a symbolic perspective. In addition, there may be a link between the centuries-old use of oak trees, first from primeval forests, later planted via 'voorpootrecht', for large construction beams of houses and the worship of these specific trees. Even today worship takes place, such as in the chapel of Our Lady of Eik in Veldhoven, where a church has been built around an oak.

Use of resources

What can be seen as remarkable, are the degrading activities of people when it comes to the natural environment, while at the same, close relationship with nature were prominent. For a long time, trees, natural or beaten water sources, stones were seen as cult sites and trees for instance were worshipped. At the same time, forests were taken down brutally for fertile soils and construction materials. This contradiction is an interesting given.

the use of heather as a fertilizer supplier fundamentally changed the use of resources, although it was still restricted by local nutrients. But, the new gradients created by people between wet grasslands, arable fields, heathlands, and small patches of forest also resulted in high biodiversity.

Today, we have lost the locallity entirely.

6. Future perspectives

This biography shows how the residents of the region of Eindhoven dealt with habitation and local, natural building materials in the past. It shows various possibilities that can serve as a starting point for a future based on a historically anchored culture. Based on the presented historical course, some key strategies for the future have been identified. These strategies are focused on using local loam, wood and residual flows.

vision map

The map below shows the combination of the potential future strategies. A landscape that is rich in variety and consists of (partly) productive brook valley forest in the lower areas, tree lanes and patches as part of a reactivated 'right to plant' combined with living or agriculture, increased surface water areas by loam delving activities, and mixed forest on the higher grounds.

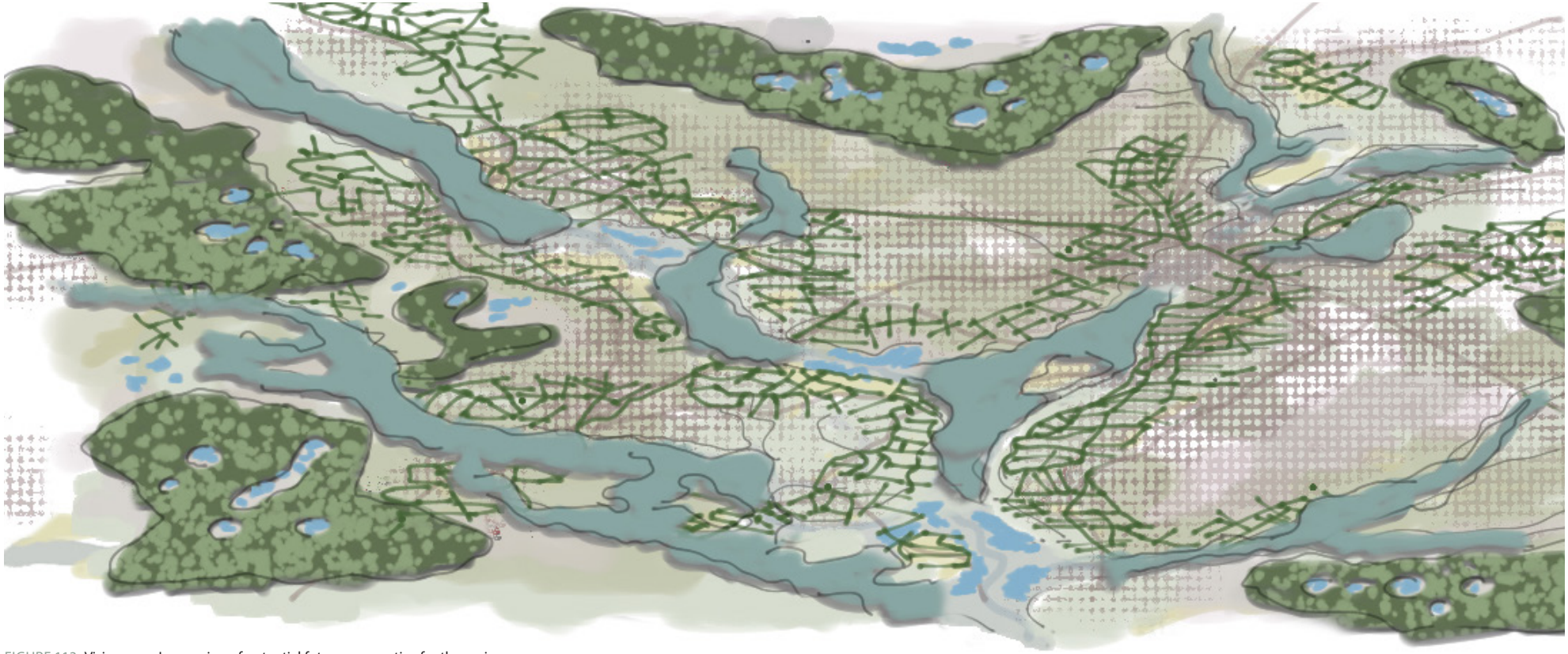


FIGURE 113 Vision map; Impression of potential future perspective for the region

Prespectives for local loam

In order to be able to make a transition to the use of local building materials today, it is important to use the materials currently available. Loam has shown itself to be a stable factor in the past and could provide a solution as already available material in the near future. An existing example for reference is loam mining on the Hondsrug in the north of the Netherlands by family business Oskam. This could potentially be reintroduced in Brabant as well, on a smaller scale. Favorable places for excavating loam are places with a decent thickness of the loam package and that can possibly be linked to another urgent program, such as nature development, recreational areas, a climate-adaptive water buffer area or reed production. Ofcourse, residual loam of excavating land for housing and infrastructure can be used as well. The processing of loam does require an adjustment to fit the current building industry. The traditional technique of vitselstek requires a lot of patience and is not suitable for today's demand, and bricks are not sustainable. An example of suitable products for today are pressed loam stones, pressed loam walls, and laom slabs. The great advantage of these materials is that they could be returned to the landscape after use.

In line with the previous development line, there is an opportunity to create a pressed loam stone with a reinforced local character. A collaboration between Chrith architects and Stephan Schagen shows an example of this practice. They develop wind-dried stones with local vegetation added to the earth stone, for example bulrush, straw, hemp, reed, sea grass, flax. For the region of Eindhoven, in addition to the commonly used straw, it is of interest to experiment with::

- Heather plants
- Aquatic plants from the brooks, the connecting veins through the landscape
- Buckwheat hulls, a crop that was widely used in the 19th century and is now getting attention again
- Corn, as the dominant crop of today.

Minerals such as lime, silt and fine gravel are also added to the stones by Chrith architects and Stephan Schagen to improve their properties. An alternative to lime should be sought to make the loam stones suitable for outdoor use. Lime is not naturally present in Brabant. In the past, cow manure and horse urine were used for this purpose.

Another interesting aspect to experiment with, is the difference in loam from brook valleys and higher areas.The different sources and processes in the ground (wet/dry for instance) might cause differences in character of the loam. Maybe in texture and looks.

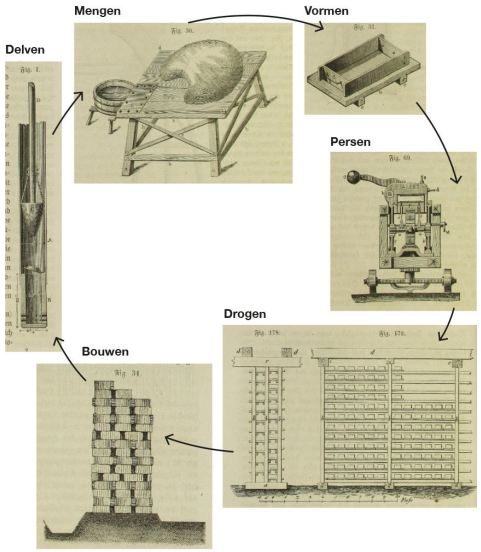


FIGURE 116 Production process of loam earth stones.
http://www.chrith.com/projecten/kijken-in-de-grond/

FIGURE 114 Examples of pressed loam stones by Chrith architects & Schagen.
http://www.chrith.com/projecten/kijken-in-de-grond/

FIGURE 115 historical loam pits, such as in Nuenen, are now fishing ponds and nature reserves
https://www.hsv-tpluimke.nl/

Prespectives for local timber

Developing a vision of how wood can play a greater role in the region in the future. The landscape was dominated by forests until the Middle Ages. By contrast, hardly any forest remained in the 19th century. The minimal increase in forest since the 19th century can potentially be boosted by the recovery of the local timber construction industry. The current landscape is not yet geared for large-scale logging. Future wood can supplement or partially take over the potential use of local loam. The use of local wood has been on the rise for some time, as initiative Peppelhout shows. The possibility of bringing old trees such as the Lime tree back into the landscape more dominantly is also interesting. Trees that we now mainly see in the center of the villages. Reintroduction of 'voorpootrecht' can play a role, as well as current larger forest areas such as the large pine forests created for mining in the early 20th century. As far as it is known, the wood yield from these areas is currently not processed and offered locally.

In addition to the previous development time, it is also interesting to continue building on the historically used methods. Re-operating the sawmill in the Opwettense watermill on the Kleine Dommel, for example. This can be directly linked to rewetting of the brook valley, which could lead to the creation of a valuable mill swamp in the future as a result. Another example is the principle of shared use. One possibility is the reintroduction of logging/cultivated groves where local residents can collect small-scale building materials for their own use. The traditional technique of pollarding can ensure regular harvesting. This could provide materials for, for example, the manufacture of smaller parts such as garden sheds, furniture, etc. Such initiatives require a commitment from local residents. Examples of collective initiatives such as Heerenboeren, where a collective takes care of a piece of land and is allowed to harvest, show that residents are willing to commit.

Specific potentials:

- Cultivation of materials by boosting right to plant (example of Peppelhout timber).
- Logging conifers from monotonous forest to reinforce a more dynamic forest.
- New timber plantages on current arable fields or in brook valleys (rabatbos) to enhance the attractiveness and historical variation of the landscape
- Re-operating historical sawing machine in water mill.

In addition, today's manufacturing techniques enable us to strenghten the durability of local, natural building materials, which is for instance the case for thermal ash or poplar wood. Local wood that was not suitable for facades in the past, can be used today

FIGURE 117 Opwettense mill
https://www.visitbrabant.com/nl/locaties/2691860269/de-watermolen-van-opwetten

FIGURE 118 Landscape by plant to right
https://natuurbouw.com/populieren-in-brabant/

FIGURE 119 Pollarding trees together
https://hetreestdal.nl/?p=742

Perspectives for residual flows

This perspective incorporates reuse of fibers from current agricultural residues and byproducts. Straw has always been linked to agricultural activities. It is interesting to look at the perspectives of current residual flows from the fields. What do maize, potatoes and beets offer for residual flows? Experiments are already taking place with the surplus of cow manure by 3D printing houses with cow dung. In addition, wool from the heath sheep in Brabant could be used more as insulation material.

Specific potentials:

- Use of current residual flows, such as maize waste
- Use of nutrient-rich stream water for reed growth.

7.Discussion

For a long time, buildings in the region of Eindhoven had indeed a relationship with the local landscape as the timeline shows. The more remote location of Eindhoven and the constant availability of loam made this possible.

Leaving aside the fact that we currently do not have sufficient materials for the large building program of the region, building with local, natural materials could be of great significance for regional architecture. Unity in use of material and form ensures recognisability. A wooden frame and/or loam as basis resonates well with the locality of the region of Eindhoven. Todays improved techniques to improve endurability of materials, increases the possibilities for future homes to incorporate regional identities. Another interesting study would be to indicate possible site specific characters. This might also be the case for loam, effected by processes underground, to have a site specific character. This will contribute to the perception of the local landscape and its recognisability.

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