Sandy Rural Landscapes and its Water System in times of Climate Change

A case of Baakse Beek Watershed

Milan Mallinath

Master Thesis Report Landscape Architecture, 2017
TU Delft

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Preface

Becoming more fascinated with the Dutch landscape, my starting point for the thesis revolves around the constant struggle against changing climate and especially for water systems in rural areas. Today we often underestimate the importance of dealing with climate change and its consequences on depletion of the rural landscape not only in terms of environmental issues, but also in terms of its scenic and cultural value. Recent studies have however predicted the many downsides of rural landscape characteristics, for it needs constant attention with extreme climate changes in future.

My thesis focuses on one of the potential watersheds of the sandy rural landscape: The Baakse beek, connected to the Ijssel River in the east of Netherlands. This thesis searches for new ways of dealing with environmental issues, which is not just based on the technical solutions to adapt to climate change, but in a way that it fits and also offers opportunities and added value for the ecological and cultural identity of the landscape. The end results of this quest hopes to achieve the ambitions of many parties involved in this rural area like farmers, estate owners, residents, visitors, nature organizers and water authorities. I hope that this climate resilient, more functional and sustainable landscape will provide you inspiration.

Finally, I would like to thank my supervisors, Gerdy Verschuure and Teake Bouma for their comments and inspiration throughout the guidance moments. Thanks go to Louisa Remesal and Marian Koskamp from the regional water authority of Baakse beek region for giving me their time and educating me with their local expertise. Special thanks go to my parents who have always supported and provided wise counsel. I would like to thank my classmates and friends who were there to give me a boost during tough moments, and distracted me from work to keep the moral high.

Abstract

The importance of coping with climate change and its consequences on depleting sandy rural landscapes and their water systems is often underestimated. The seasonal imbalance of rise in temperatures and precipitation leading to both drought and flood under extreme circumstances, has deteriorated these landscapes. Attempts to regulate this area, in order to make way for rural development related to agriculture and water management, have led to numerous environmental issues and loss of a beautiful scenery. A global solution addressing the environmental issues and scenic and cultural values is required. In this thesis, an attempt is made to rebuild the lost relationship between landscapes and water systems for a climate scenario that is predicted for the year 2050.

This is elaborated in the thesis with research by design in the case study area situated in the Baakse beek watershed of Gelderland province. Climate change prompts a re-examination of the potentials of Baakse beek stream with regards to its rich and diverse landscapes. A fitting solution thus not only lies in solving the climate related problems of this area, but responding with creative articulation of environmentally sustainable landscape design, in a way which allows people to maintain a connection with it. The proposed sustainable solution involves improving the stream water structure, realizing ecological connection zones and enhancing the agricultural structures with the help of a climate corridor. This thesis specially focuses on changes in land use so new estates in the Estate Landscape Zone can co-exist with water systems and Rabat forests for recreation.

Keywords: Sandy rural landscape, streams, climate change

▲ External Source Images

△ Drawings By The Author

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Fig. 1 Baakse beek Stream

(Photograph: De Regiegroep Baakse Beek en Veengoot, 2014)

Baakse beek stream affected by climate change regularly in summer resulting in drought. The dry stream is surrounded by the irrigated grasslands and meadows in the nearby lands.

Table of contents

1. Introduction
- 1.1 Fascination
- 1.2 Problem introduction
- 1.3 Choice of study area
- 1.4 Problem statement and research question
- 1.5 Research approach

2. Methodology
- 2.1 Introduction and basic structure
- 2.2 Choice of strategies
- 2.3 Stages of research
- 2.4 Conclusions

3. Analysis of study area (Stage 1)
- 3.1 Introduction
- 3.2 Existing and Historical data
- 3.3 The uncertainty of climate change
- 3.4 Conclusions

4. Synthesis (stage 2)
- 4.1 Introduction
- 4.2 Landscape character classification
- 4.3 Baakse beek landscape typology
- 4.4 Conclusions

5. Application (stage 3)
- 5.1 Introduction
- 5.2 Impression of future ideal vision map
- 5.3 Design principles of ideal landscape types
- 5.4 Conclusions

6. Design opportunity

6.1 Introduction

6.2 Test for landscape spatial configuration

Intermezzo: climate change impacts on land use

Intermezzo: climate change impacts on Natural environment

6.3 The climate corridor

6.4 Design interventions

6.5 Conclusions

7. Design: Estate Landscape

7.1 Introduction

7.2 Strategic design: Re-meandering the stream

7.3 Detail design: Restoring Rabat forest structures

7.4 Local design: Constructing new estates

8. Reflection

9. Bibliography

1

INTRODUCTION

1.1 Fascination

Rural landscapes reflect the effects of physical and cultural processes. It is crucial to know that most of these landscapes have transformed from wilderness and that water systems have shaped and influenced rural landscapes of how they look and how they function today. Climate is by far the dominating feature in any landscape and will be in the upcoming years. The characteristic variations in temperature and precipitation has the greatest impacts in rural areas reflecting mainly on the landscape, water management, settlement and land use. Curiosity about these environmental issues that rural landscapes in Netherlands face today with respect to climate led to the framing of this thesis topic. The situation in the sandy rural landscapes of Netherlands which are vulnerable to climate change and face environmental issues, is the central focus of the study.

1.2 Problem introduction

It is only possible to respond to the forecasted climate changes if we are fully conversant with the way the main water system works. The Netherlands can be divided into two parts approximately based on their soil elevation. The western and northern parts which are the low-lying areas, are dominated by the young deposits of clay and peat. This region has an image of being covered with rivers, polders and coastal land. On the other hand, the eastern and southern parts which are relatively higher, have air-borne sand deposits (Fig. 1.1).

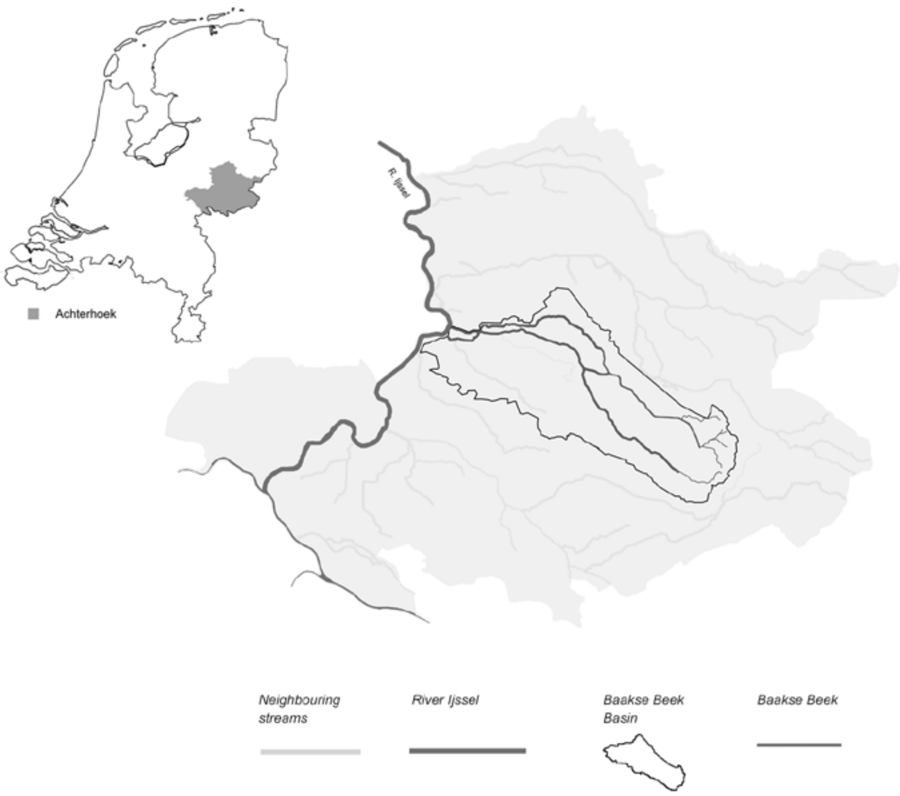
The dry sandy areas have undulating landscape due to the sand that was deposited during the Ice Age. This area lies between 1-30m above the average sea level. The drainage of the surplus water takes place under the influence of gravity by different watercourses which are partly natural and partly artificial. Due to an uneven distribution of rainfall and water discharge over the seasons in sandy areas, a lack of storage capacity and a growing water demand has resulted in a competition for distribution of the available water between various land use functions. Moreover, it is found specifically that 'water' plays a decisive role in the landscape development of the sandy areas (Kerkstra and Overmars, 1985). The adaptations made in the past by interventions in the water systems of this region, have led to water reaching the big rivers much faster than before. This behavior can be attributed to modern day interventions such as digging of new watercourses and expanding the stream networks in rural areas. The climate change together with the changes in the past have influenced the operation of streams and reduced the sponge function of the landscape today. This has indirect consequences for the beauty of landscape for inhabitants, animals, vegetation and visitors thus weakening the character of rural landscapes. A typical sandy region of Baakse beek watershed is chosen in this thesis to closely understand the further problems and address it through landscape design. A large part of the research is thus committed to understanding the issue, what the causes are, the consequences and possible future actions. This report will handle these topics step by step, working towards a sustainable landscape.

△
Fig. 1.1 Soil elevation in The Netherlands *(Based on: Arnold, 2010)*

Baakse beek watershed is situated on the higher grounds with wind- borne sand deposits.

1.3 Choice of study area

The Baakse beek situated in the Achterhoek, The Netherlands (Fig. 1.2) is one of the case study areas of the 'Knowledge for Climate Research Program' (KfC). This government initiated program develops scientific knowledge and services that are intended to make the Netherlands immune to the effects of climate-change. KfC selected nine hot-spots in the dry rural areas for research based on the expected climatic impacts. These areas are a part of the CARE (Climate Adaptation for Rural Areas) project with Baakse beek as one of the study areas. Baakse beek has a rich context in which land use (nature conservation, water extraction and agriculture) is positioned in a landscape structure of streams and an analysis of this area would be an elaboration of the problems encountered generally in all dry sandy areas of the Netherlands. Most of the environmental problems encountered in Baakse beek are similar to the problems experienced in many parts of sandy areas. Relatively larger amounts of data and calculations were performed at Baakse beek for the period between 1850-1900. Hence, Baakse beek forms an excellent testing site for design.



△
Fig. 1.2 Location of the Baakse beek watershed in Achterhoek region
(Source -base map: www.arcGIS.com; Accessed on: September 2016)

Baakse beek watershed is centrally located in Achterhoek region and is dominated by a system of water streams which drain into River Ijssel on the west.

1.4 Problem statement and research questions

This paragraph holds the problem statement and research question that forms the guidelines during this study and will be answered throughout the thesis.

Problem statement

The rapid and radical environmental problems apart from the climatic issues are primarily the result of the intensity and dynamics of rural and agricultural land-use in sandy areas. The major problem concerns the surface and ground water levels which in turn have consequences on the beauty of the rural landscape. The combination of the agricultural and water management practices is responsible for eutrophication and drop of the groundwater level. The extensive agricultural practice has resulted in the disappearance of contrasts between the different landscape types. The diverse landscapes with its identity is not self evident anymore. Most of the lakes and artificial ponds in the estates dry up during summer and have consequences for recreation. Accessibility and visibility of streams have decreased. Plants and animals bump into barriers due to new weirs in the streams. These problems are caused by insufficient atonement of the interests of water in nature and agriculture. From the point of view of landscape architecture in the context of climate change, the problems faced in the sandy areas can be defined as an inadequate siting of the various land-use types. Therefore, it is necessary to develop an approach that allows for the sustainable development of the relevant land use which is resilient to the effects of climate change.

Research goal

Normally water systems result in a spatial coherence in a landscape. However, recent developments and climate change have resulted in a change, or even a loss of hydrological relationships between landscape components. It may be gradual, but the landscape around Baakse beek is changing continuously. The interpretation of the designing task for the sandy areas has given rise to a lively debate with the publications of Kleefmann and Kerkstra (1986) and Van Buuren (1997). Van Buuren also states that the hydrological processes and associated spatial relationships play a crucial role. In this way the concept of Van Buuren can be interpreted as a hypothesis on the contribution of landscape planning to solving the problems in the sandy areas. Besides the already mentioned choice of water and climate change as a central point, attention is needed for the subsequent statement of the problem for landscape planning in Baakse beek. For a possible solution to these problems the following research question is formulated. The goal of the thesis is to obtain a detailed understanding of the impacts of climate change on sandy landscapes and develop an environmentally sound design approach for the water systems for their adaptation through local landscape interventions.

Research question

To achieve these goals the following research questions must be answered:

In what way can the landscape be used and adjusted, in an integrated manner, to achieve a climate resilient landscape of Baakse beek watershed and enhance its spatial experience?

The following sub-questions help to answer this question:

1. What is the historical background of Baakse beek watershed area?
2. What are the current conditions in the area?
3. What kind of problems are faced by the watershed area?
4. How to address climate change within Landscape Character Assessment?
5. How can the landscape types be changed or steered to avert the current and future climate challenge?
6. What are the impacts of climate change on land use and natural environment?
7. How to deal with the problems faced in terms of design?

In this perspective, the research question points towards improving the relationships that exists between the diverse landscapes of sandy areas to its water system. This leads to the formulation of the first sub question. To make this area resilient to climate change, its essential to first understand its historical background related to its physical influences. Furthermore, the second question aims to study the human influences on the landscape that had a considerable effect on the micro climate of the area. Multiple problems in the area specific to each landscape type are recognized in the following question. Historical and current data together with the approach of landscape characterization, the use of design as a method of research is explored.

1.5. Research approach

This thesis follows design-research and research by design approach with a clear research question and goal that needs to be achieved during the research process. The starting point is to understand the Baakse beek landscape and its characteristics that make them distinctive. This research is devoted to the explanation of this phenomenon by using relevant methods of data collection and analysis in an integrated manner with the help of classification and typology study. Furthermore, this research sets out how to develop and use Landscape Character Analysis as a tool in three stages and informs future developments in nature and water management but as a response to the impacts of climate change. The design proposal is constantly tested for its spatial configuration with the help of computer generated models. The next chapter elaborately explains the stages of research and methodology which is undertaken during the thesis period.

2

METHODOLOGY

2.1 Introduction and basic structure

This chapter sets up a theoretical framework for the research process. The first section provides an introduction to the basic structure of the methodology which is followed throughout the thesis. The choice of Landscape character assessment as research strategy as mentioned in the previous chapter is explained and conducted in three sequential stages of research. The results of the three stages of research is further elaborately explained in chapter 3, 4 and 5.

In an exploratory phase of the research, the characteristics and inter-related functions of the sandy landscapes of the eastern Netherlands is studied at a bigger scale. The aim is to gain insights about how the physical and human influences on landscapes led to the formation of the sandy landscapes at first. Based on the understanding of the above studies at a regional scale of Baakse beek, an outline of Landscape Character Analysis is sketched. This approach includes a number of procedural stages on how climate change impacts can be used in three key elements of design process- analysis, synthesis and application (Fig. 2.1).

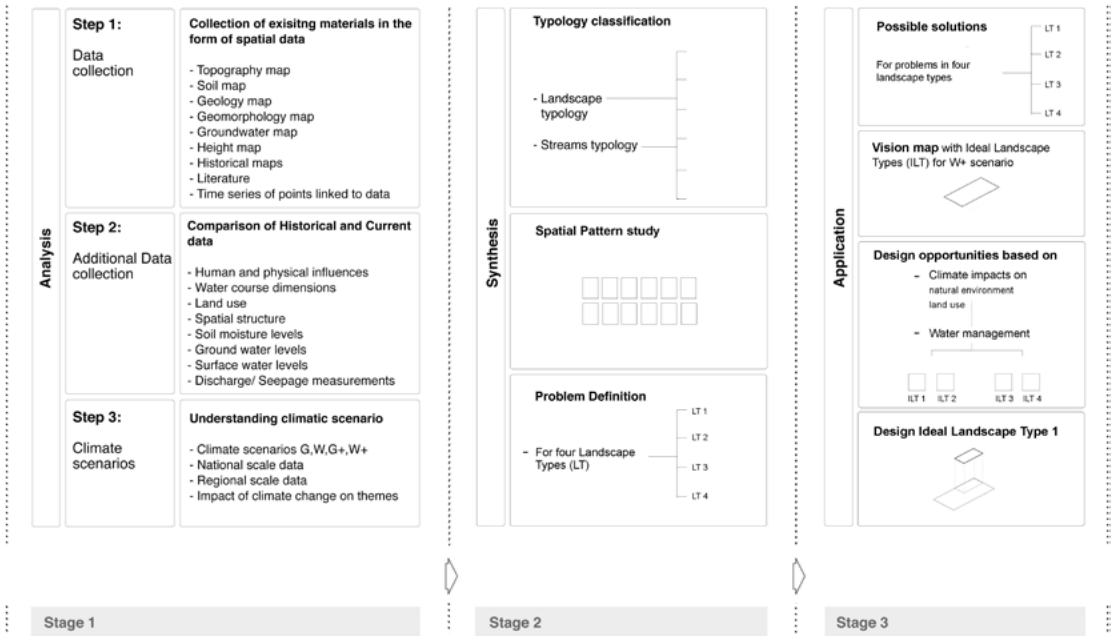


Fig. 2.1 Stages of Research Methodology

In the procedural design processes: analysis, synthesis and application, the central area of focus is limited to the regional boundaries of the Baakse beek watershed. The first stage, which corresponds to analysis, involves collection of existing material in the form of spatial data. The second stage, which corresponds to the synthesis, involves the problem definition through an examination of the current tools concerning the: typology study and climate which have an effect on the area directly or indirectly. This phase also gives insights on the problem solving strategies based on climatic knowledge. In the third stage of application, new plans are formulated to solve the problems defined in the synthesis stage. This stage also involves an examination of how the method of 'Landscape Character Analysis' as in context and framework be used to inform a range of applications in the local areas.

2.2 Choice of landscape character analysis (LCA)

Evolution

For many years, and especially in the 1970s, more importance was giving to the idea of Landscape Evaluation, i.e., what makes one area of landscape 'better' than the other. In 1980s Landscape Assessment emerged as a unique concept. Specifically, it was formulated to separate and divide the classification and description of the character of the landscape, i.e., what makes one area 'different/distinct' from another. In the 1990s, Landscape Character Analysis emerged as a tool. It focused more on landscape character and divided the process of making characterization from judgments (Countryside Agency, 2002).

Potentials

Climate change affects the characteristic of landscapes and influences the natural (for example vegetation and land use patterns, associations of species and habitats) and man made landscape attributes (all type of human interventions for instance the siting and style of settlement, heritage structures) (Countryside Agency, 2002). Direct impacts of climate change on landscape character might be longer growing seasons, flooding or low river flows. Increased summer temperatures may not influence landscape character directly but there could be downstream effects on landscape components such as agricultural land use. It is essential to incorporate climate change into the Landscape Character Analysis process at various stages. The guidelines of the Countryside agency of England and Scotland Natural Heritage provides major cues for the formulation of the approach. Stage 1 - "Characterization" forces for change pertinent to a specific landscape are identified. Stage 2 - "Making Judgments" the possible effects of climate change impacts on landscapes are further identified. Subsequently in the last stage, the need for any appropriate planning and management measures at local scale are envisioned.

2.3 Stages of research

This paragraph holds the three stages of research which are used as a basis for the search of a solution in the thesis.

2.3.1 Stage 1 - Analysis of study area

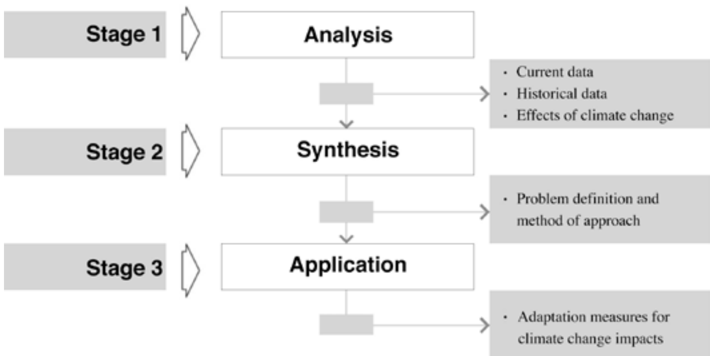


Fig. 2.2 Stages of Research Methodology

Step 1

First stage is divided further into three steps (Fig. 2.3). The starting point was the collection of the existing material in the form of spatial data. This desk analysis included collection of data regarding the historical, topographic maps, soil maps, geological profile maps, landforms and water maps. Based on this, certain qualitative characteristics of the location was analyzed. The analysis also included thorough understanding of physical and human influences on the landscape.

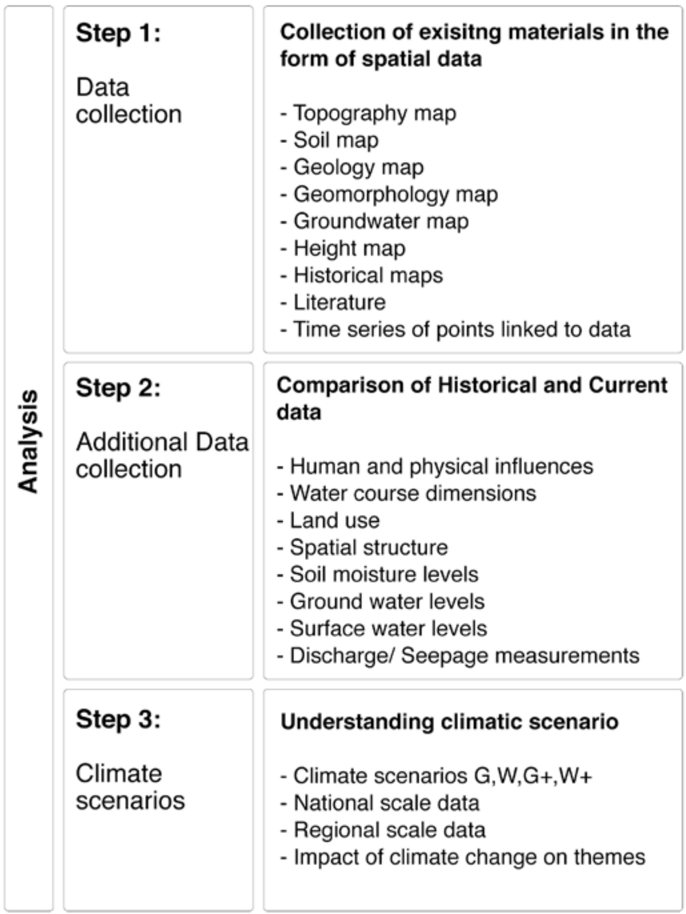


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Fig. 2.3 Schematic representation of analysis process

Step 2

The previously analyzed maps of desk study and field visits were further reviewed and revised. Thereafter, photographs, sections and notes were made on the site. The results of the historical situation and calculations were then compared to the current situation to formulate the current character analysis of the area. Gaast and Massop's (2007) detailed information on the hydrological data of the Baakse beek basin in two specific periods of 1850 and 2000 for used as a reference.

Step 3

This step was followed by understanding the climatic scenarios on the national and regional scale. The climatic scenario development by the meteorological department of Netherlands was used as reference (Fig. 2.4). W+ scenario of the 2050 was considered to be the most extreme scenario with predictions of 2 degree rise in temperature resulting in extremely hot/dry summers and wet/cold winters. The occurrence of the flood and drought was determined by the climate and watershed characteristics. Most droughts occur when expected precipitation fails and evaporation rates are higher than normal, most times related to sunny and warm conditions (Teuling, 2013). In the case of Baakse beek, the water collected from the precipitation in the upstream was discharged quickly resulting in the flooding of downstream areas. Therefore, precipitation was considered as the main element of drought and flood scenarios (Fig. 2.5). Stream flow (runoff) and groundwater levels was considered as the last two indicators of the occurrence of a drought (Changnon, 1987). The results of this analysis is explained in chapter 3.

	G	W+
Winter		
Mean temperature	+0.9C	+2.3C
Mean precipitation	+4%	+1.4%
Summer		
Mean temperature	+0.9C	+2.8
Mean precipitation	+3%	-19%
Potential evaporation	+3%	+15%

▲
Fig. 2.4 Predicted local climate change effects for the Netherlands for G and W+
(Source: van der Hurk, 2006)

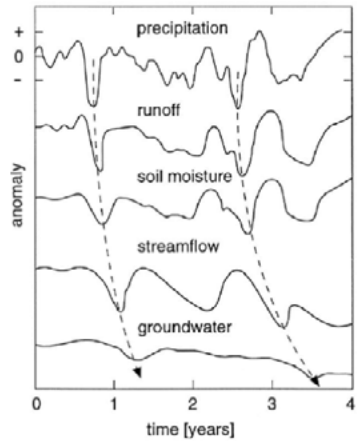

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Fig. 2.5 Drought propagation in different hydrological variables
(Source: Changnon, 1987)

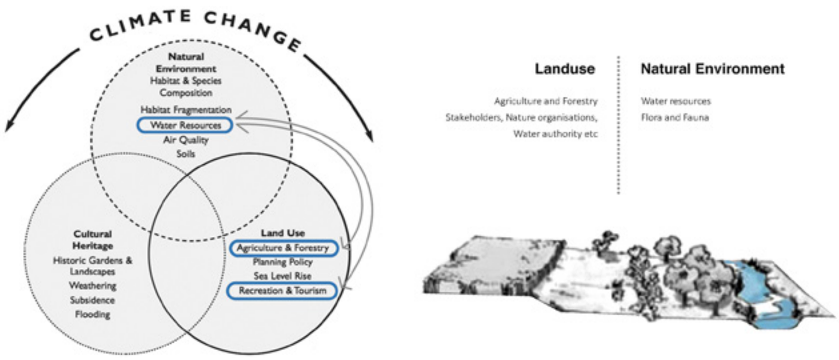

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Fig. 2.6 Climate Change: Principal Impact Themes- Natural Environment and Land Use
(Source: Country side Agency, 2002)

Conclusions

The predictions of W+ scenario in the step 3 was combined with the principal variables of natural environment and land use in the Fig. 2.6. They identified interactions with one another to a greater or lesser degree and gave insights about climate influences on vegetation, animal species and land use attributes (Involvement of stakeholders, nature organizations etc).

1. As a result of climate change, potential impacts on the natural environment component of landscape character include variations in water resources and habitat connectivity for the survival of vegetation and animal species in the W+ scenario conditions.
2. Climate change has a negative impact on the future land use in rural areas with changes in farm sizes and reduction in the diversity of land uses. This is further elaborated in chapter 6.

2.3.2 Stage 2- Synthesis

Step 1

Synthesis phase of the research is schematically shown in the Fig. 2.7. At this stage a broad overview can be made at the regional scale where the character description along with the typology classification provided a starting point. The different provincial landscape typology

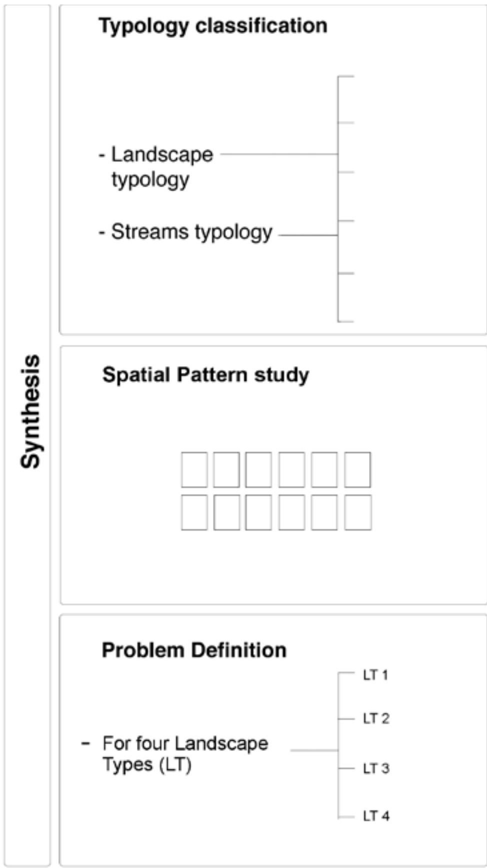

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Fig. 2.7 Schematic representation of synthesis process formulated by the water authority of the area is discussed and further stream typology was formulated as a supporting data.

Step 2

With the combination of the above knowledge and the conclusions reached in the previous climatic change impact studies, a spatial study was conducted to understand the spatial quality and diversity of the current landscape with the help of a matrix (Fig. 2.8). The climate change impacts are set along the x-axis and landscape character features listed on the y-axis. The matrix focuses on both short and long term, wide and small range of landscape character features. The results were obtained from incorporating climate change within the landscape assessment. They presented a summary of climatic variables, key receptors and the likely associated impacts.

Step 3

The problematics recognized in the area are categorized under their respective landscape types. Six different landscape types were found to exist in the area of which four types (Estate landscape, Sand ridge landscape, Peat landscape, Camp landscape) are thoroughly explained in in the chapter 4.

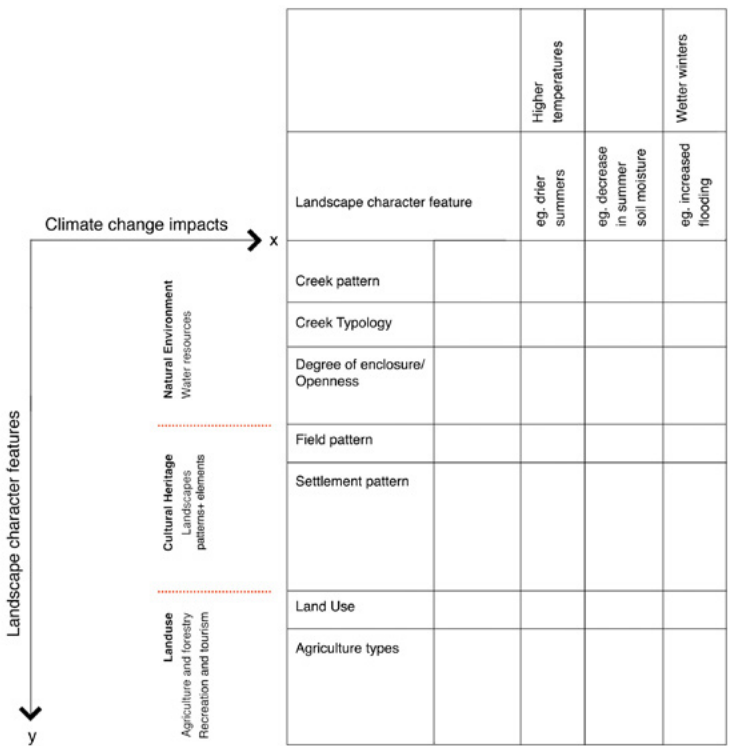

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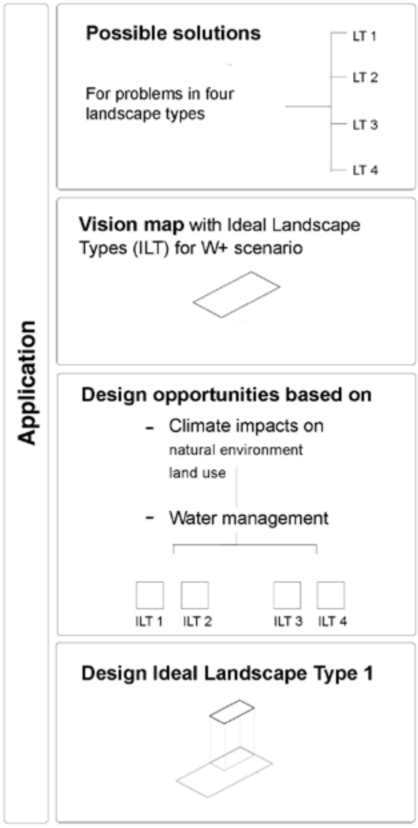
Fig. 2.8 Matrix for the Climate Change Impacts in Landscape Character Assessment

2.3.3 Stage 3- Application



△
Fig. 2.9 Schematic representation of application process

Step 1

The previous stages of the methodology were to identify the landscape attributes. In this stage (Fig. 2.9), a possible solutions to the problems were listed for each landscape type as an ideal condition for achieving a sustainable landscape. The solutions aim to solve the problems related to climatic issues and the associated loss landscape quality.

Step2

The solutions were mapped showing a new vision for the existing landscape character of the Baakse beek area. The ideal landscape types shown in the vision map, sets goals to achieve a sustainable landscape system. It shows room for new developments to harmoniously co exist.

Step 3

The climate impacts on water management, nature and land use as mentioned in analysis stage of Fig. 2.6, was tested for the vision map. Four interventions in different landscape types are proposed to work together with the larger landscape.

Step 4

A small plot scale design intervention is proposed as a landscape design in the Estate landscape type. The design task was not just to create a technical solution to the climate problems, but by using the cultural aspects it gave an impulse for the degrading region. The interventions lead to more than this. It transcends the discussion between climate issues and goes further than water management and ecology. Thus doing more than restoring and transforming the landscape situation to provide spatial experience. The design elaboration is explained in chapter 7.

2.4 Conclusions

The research framework has presented ways to interpret, understand and work with dynamic water system, and strategies for implementing these in the cultural landscape of Baakse beek. The Framework shows how research by design can be used and how to deal with the uncertainty of climate change. The theories and concepts used in this framework will not always literally return in the rest of this thesis, but they form the basis for the project. The three stages of design process - analysis, synthesis and application, are each explained in the chapters 3, 4 and 5 respectively. The results of each stage relates to the subsequent stages and simultaneously answers the sub research questions while leading to the main design intervention.

3

ANALYSIS

STAGE 1

3.1 Introduction

The analysis stage in the first step, focuses on a thorough understanding of the Baakse beek landscapes and its context while answering the first, second and third research questions:

1. What is the historical background of the Baakse beek area?
2. What are the current conditions in the area?
3. What kind of problems are faced by the watershed?

The causes for the current situation lie in the past physical changes as well as the way that men have changed landscape and in the way it is used now. Any interventions must thus find its place in the landscape of Baakse beek and its surroundings. And as the main research question is:

In what way can the landscape be used and adjusted, in an integrated manner, to achieve a climate resilient landscape of Baakse beek watershed and enhance its spatial experience?

Engaging all problems and potentials in the Baakse beek, making the design, not only an alien intervention to fix the climate change problem, but also a design which is veined with the potentials and problems of the landscape of the Baakse beek and surroundings.

This chapter will discuss the problems and potentials of the Baakse beek in two sections:
1. Current and historical conditions of the area
2. Future scenario for climate change in the area

3.2 Existing and historical data analysis

In sandy landscapes, water systems are important elements to which other elements are connected. Therefore, we have to research the main water system not only the current water system but also its historical one, to understand how the current system works. This chapter includes a characterization of the manner in which the water system manifests itself in the landscape. Emphasis will be on describing the spatial relationships created by the flow of groundwater and surface water in the Baakse beek watershed area. Although the descriptions are general in nature, the situation in the sandy areas of Baakse beek region is the starting point.

Context

The context of the study area (Fig. 3.1) consists of a large part of the province of Overijssel (Salland and Twente) and the eastern part of the province of Gelderland (Achterhoek). It is defined by the rivers Vecht (north), IJssel (west) and Oude IJssel (south) and by the border with Germany in the east. The landscape in large parts of Twente is dominated by ice-pushed ridges (Fig. 3.2), with a considerable variation in size, height, structure and orientation. In particular, the origins and character of the eastern part of the Achterhoek is markedly different due to the presence of 'Eastern Netherlands Plateau' which formed during the Mesozoic Period and was further shaped by glacial processes during the Saalian Period. In the period of penultimate glaciation, the Netherlands was covered by ice sheets and huge glaciers moved slowly from north to south resulting in the formation of several streams like Vecht, Regge, Dinkel, Dortherbeek, Buurserbeek, Berkel, Slinge, Baakse beek and Oude Ijssel (Fig. 3.1) today, of which Baakse beek is located on the lowest reaches of the ice ridges. The eastern side the Baakse beek watershed is a part of the eastern plateau where a layer of boulder clay was deposited under the ice. In the last Ice age, the Netherlands were not covered by ice, but instead had a cold and dry climate, with heavy wind. The wind-carried sand deposits, covered a large part of the Baakse beek resulting in a very high degree of diversity and variations in its landscapes (Bloemers, 2010).

Past landscape processes

Various studies have been undertaken to reconstruct hydrological developments, particularly tracing the disappeared bogs since the Medieval Period (De Rooi, 2006). Expansion of the areas covered with peat was one of the most important landscape processes during the Holocene, especially from the Atlantic Period onwards. It has been demonstrated by interdisciplinary research based on a combined study of soil information, ancient topographical maps and old historical documents, that nearly 30% of the Achterhoek region was at one point covered with peat (Fig. 3.2) (Bloemers, 2010). It implies that, the importance of peat extension as a factor within landscape has been severely underestimated and has negatively affected the water system and landscapes especially of the Baakse beek region in the south as the stream cuts across the peat region on a large extent.

▲

Fig. 3.1 System of streams in the eastern sandy areas of the Netherlands

(Based on: Bloemers, 2010)

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Fig. 3.2 Peat areas and ice pushed ridges during Holocene covers a major part of Baakse beek area

(Based on: De Rooi, 2006)

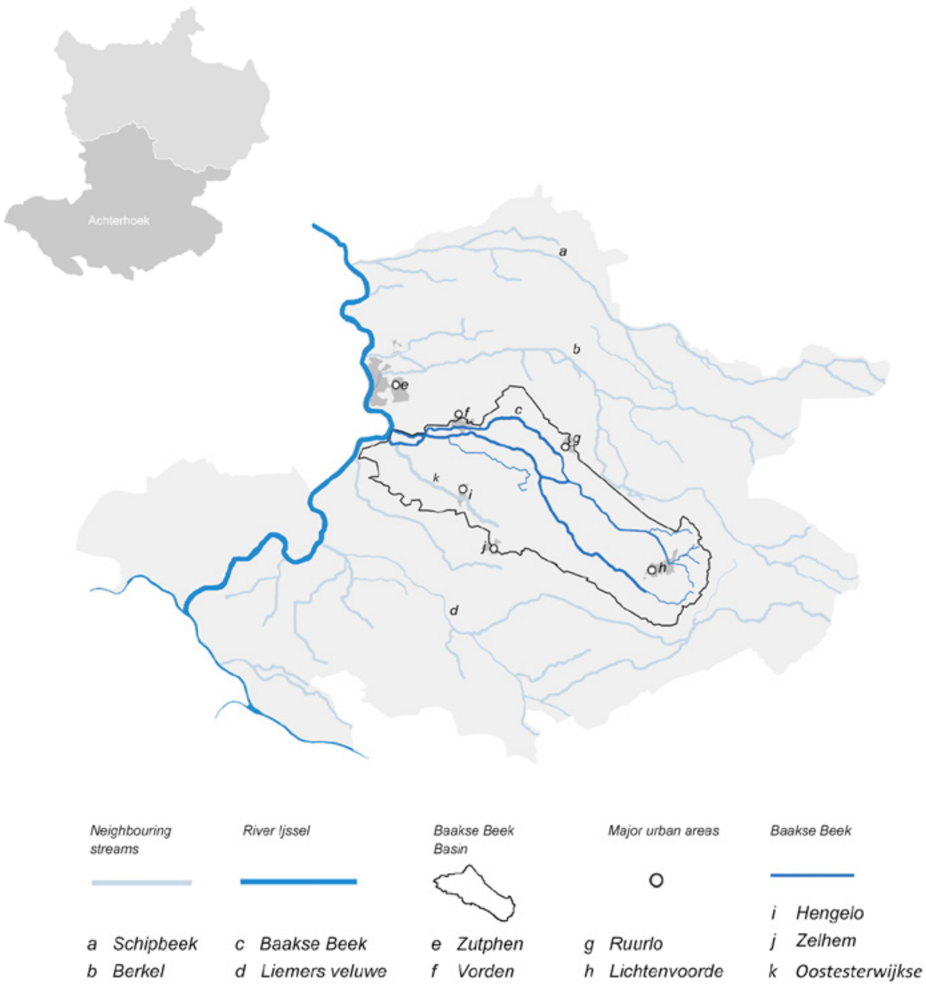

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Fig. 3.3 Location of Baakse beek watershed connected to the neighboring streams in Achterhoek, The Netherlands *(Source -base map: www.arcGIS.com; Accessed on: September, 2017)*

Watershed description

The stream of Baakse beek shown in the fig. 3.3, has grown and become more spread out with many streams which were added to combat the effects of climate change. One major drainage added on the southern edge of Baakse beek is Veengoot, which drained excess water during heavy precipitations thus trying to reduce the effects of flood. Both the waterways flow parallel towards the west together. On the way to the river IJssel, the water flows past several types of landscapes. A sand ridge cuts across the region between Zelhem and Ruurlo, after which they flow through the estates landscape between Ruurlo and Vorden. Eventually the water passes in the river landscape around the river IJssel. All together, the current area includes 300 sq km (30,000 hectares). The rivers gush at a height of about 35 meters above sea level on the plateau in the east and flow approximately 8 meters above sea level at the mouth of the river IJssel. The network of streams in the Dutch sandy areas are either dendritic or barbed pattern (Buuren, 1997). The density of the network is linked to the intensity of the ground water flow. Fig. 3.4 shows the pattern of Baakse beek in 1900s and the modifications done to the pattern due to land consolidation of 20st century which is explained in detail further in this chapter.

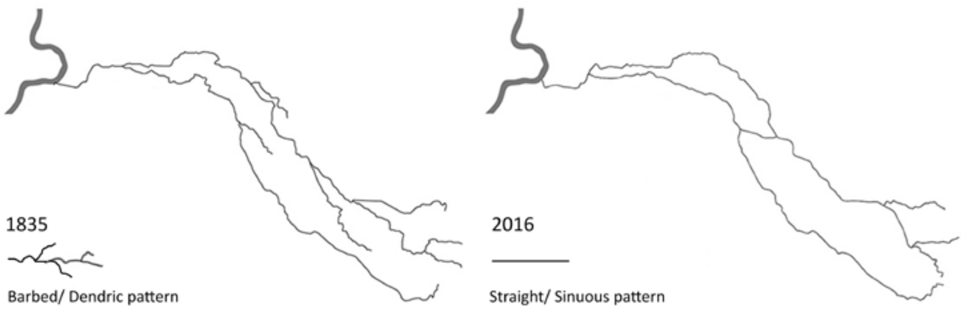

Fig. 3.4 The streams of Baakse beek- characterized by a dendritic or barbed drainage pattern until 1900s after which they were straightened due to land consolidation *(Source -base map: www.arcGIS.com)*

Geology and soil

The geological form of the country landscape of the Baakse beek and Veengoot is for the most part, formed during the last two Ice ages. Between Ruurlo and Zelhem (Fig. 3.5) was a large sand ridge. East of this ridge, large dekzandvlakten (cup-shaped landforms) were created separated by small dekzandruggen like the Halle and Harreveld. West of the sand ridge with Ruurlo and Zelhem, had a more erratic pattern of cup-shaped landforms. After the end of the last Ice age, the climate was warmer and wetter. In the most western part of the area, clay and sandy clay were deposited by the river IJssel. On the eastern Dutch Plateau near Lichtenvoorden, boulder clay layers are found, from which the streams flowed down to the cover sand plains. In these plains also was a strong seepage current to the surface, in particular on the edge of the plateau. The sand ridges hampered the upper mono planar runoff of all the water to IJssel. As a result, the vast swamps/bogs of the Wolfersveen, Aalten Goor and Ruurlose beek emerged (Fig. 3.5).

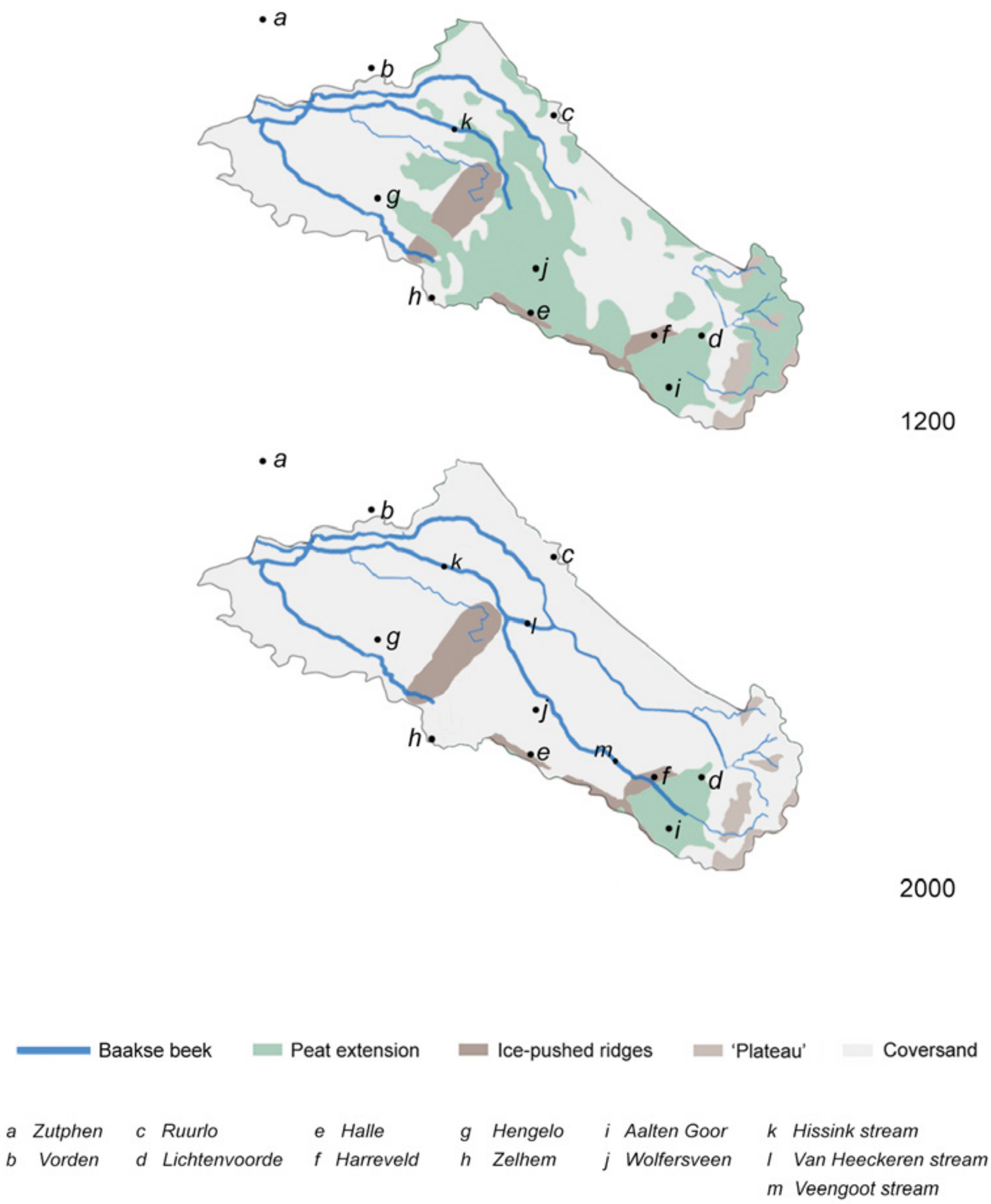

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Fig. 3.5 System of peat areas and ice pushed ridges in Baakse beek area in 1200 (above) and 2000 (below) led to the formation of streams *(Based on: De Rooi,2006)*

Mining wastelands

In the 19th century the areas in the stream and peat lands were disbanded and divided. After that, the peat lands were systematically exploited for the benefit of agriculture. Fig. 3.6 shows the sequence of peat mining from 1200s to present day. There is almost no trace of the original peat left today except for Aalten goor on the south east. Good drainage was an important prerequisite for successful reclamation. To make way for this, the barrier of the sand ridge was pierced. In 1835, the Hissink stream (Fig. 3.5) was extended. Later this stream formed the basis for the Veengoot, which was largely dug to drain the bogs. Baakse beek was extended and connected to the Veengoot at Lichtenvoorde (refer Fig. 3.5). Thus the peat lands were drained with an extensive network of new streams which only grew wider and wider (Vista landscape, 2010).

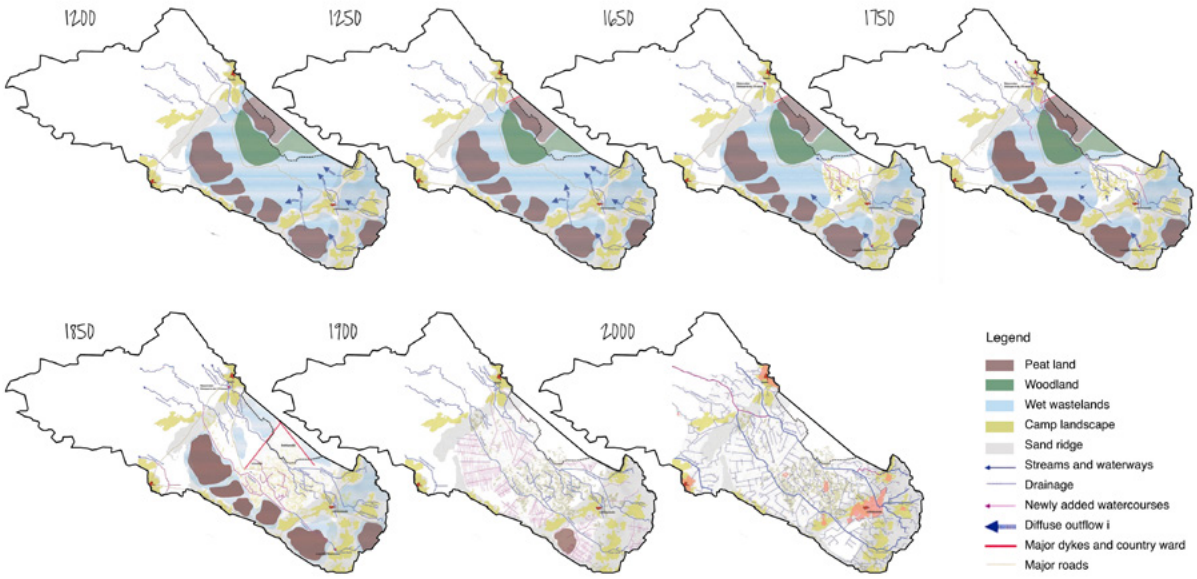

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Fig. 3.6 Timeline of the peat mining in Baakse beek area *(Source: Vista landscape and urban design, 2010)*

Land consolidation

The next transformation was during Land Consolidation Act (Driessen, 2000) which was started in the 70s during the reconstruction after World War II and went up to the 90s. The purpose of the land consolidation was to improve the production in agriculture. The Van Heeckeren stream (refer fig. 3.5) was dug in 1967 as a link between the Baakse beek and Veengoot, because a connection was needed to discharge excess water out of the Baakse beek quickly into the river Ijssel. Other significant changes in the stream pattern is shown in the figure 3.7. The emphasis was on reducing fragmentation of land property, raising lots and improving drainage. While doing so, several smaller streams vanished and the bigger ones were widened. The agricultural plot sizes increased making way for more productions and profits. This changed the original character of the landscape (Fig. 3.8). Figure 3.9 shows how the Baakse beek stream which evolved as a meandering stream is now deepened, widened and straightened. The form of the streams due to the above mentioned land alterations, changed from a dendritic pattern to a straight pattern.

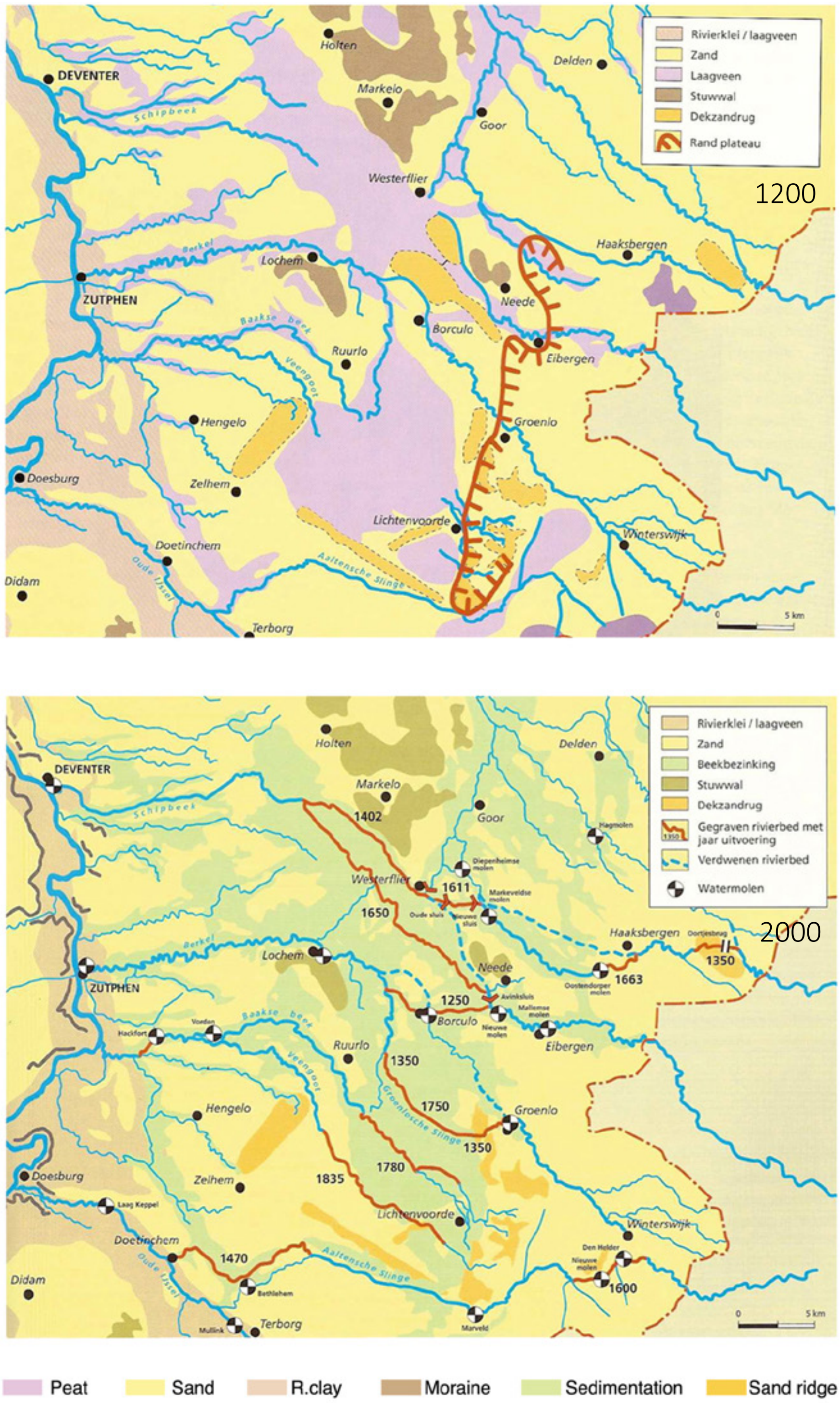

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Fig. 3.7 The water system in Baakse beek during 1200 (top) and 2000 (bottom) *(Source:Driessen, 2000)*

The streams which originated on the edge of the East Dutch plateau, flows in the vast marsh area between Lichtenvoorde and Ruurlo. The Meibeek, the Baakse beek and the Hissinkbeek (the current Veengoot) flow on the northwest.

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Fig. 3.8 Visual of the Baakse beek in 1200 (top) and 2017 (bottom)
(Source: www.wrij.nl; Accessed on: 10th June 2017)

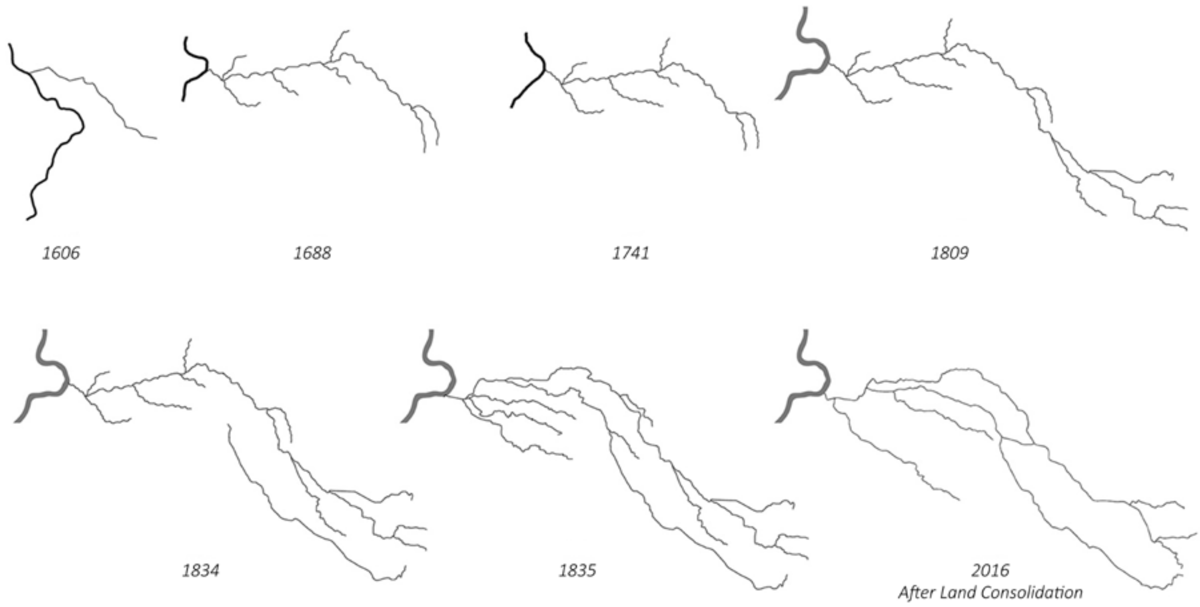

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Fig. 3.9 Evolution of Baakse beek stream structure before and after (bottom right corner) land consolidation

Emergence of Country Estates in the area

It is believed that Baakse beek landscape arose because of the inhabitants of many castles and estates. In the period between 13th-16th century, many estates were built along side the Baakse beek stream (Fig. 3.10). The main purpose of their location was the availability of water for the purpose of drinking and defense. During 17th – 19th century, the dwellers slowly conquered large pieces of heath, which were partly converted into agricultural lands, but were largely planted with forests, which previously barely occurred in the landscape. In the 20th century, they managed to prevent the loss by land consolidation (explained in the previous segment) by controlling their property's not only agricultural interest but also taking into account the natural beauty and hunting. In addition to the creation and management of the landscape and estates, the other aspect that also included was the socio economic aspects such as the land owners image. Gradually due to increased economy, several estates disappeared because of the land owner's inability to maintain the plot. Today, apart from the rising land prices and growing agricultural land use in the area, the once intimate, small- scale, fields and meadows alternated with woods and tree lined roads are loosing their cultural value. With climate change, the changes taking place around the region has had a direct impact on the scenic value and economy of the region.

This thesis research focuses more and more on how the country estates like Estate Medler, De Weirsse and Wientjesvoort in the north of estate landscape zone contributed to the current Baakse beek landscape. One of the important ideology of the project is that, in times of climate change and when agriculture seems to be not very prospering, the estate landscape zone can act as a precious property for experimenting with water and nature management.

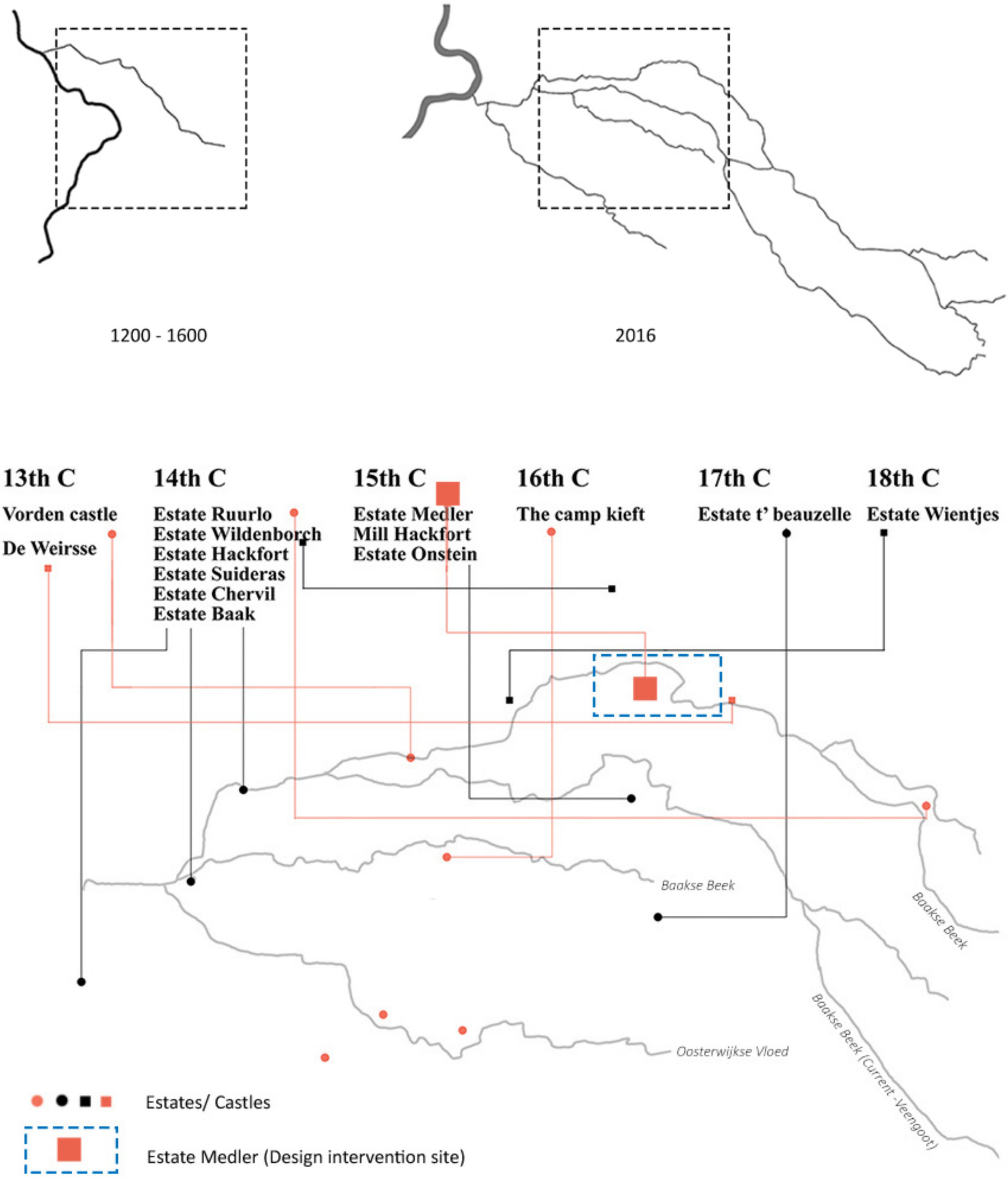

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Fig. 3.10 The location of country estates and castles in the Estate landscape zone in the west of Baaske beek watershed (Based on: Cruyningen, 2005)

Comparison of existing and historical type of data

This historical data indicates several things which are directly relevant to the current problem of climate change and the increased water it is likely to bring. The detailed land use maps were used to produce nationwide maps on a scale of 1:25,000. These maps reflect the situations in the years 1880 (Massop, 2007) and 2000. The following paragraphs expand the problematics with respect to the dimensions and length of Baakse beek watercourses, land use in the area, surface and ground water levels of the stream, discharge and infiltration levels and evaporation rates.

The description of watercourses by Staring (1847) shows that the average bottom depth of watercourses was 1.05 m below soil surface in the basin of the Baakse beek. In 2000 the average depth varies between 1.15 m and 1.70 m (Fig. 3.11). The average width in 1847 was 1.45 m (Staring, 1847). Larger watercourses were both broader and deeper. The average width of the Baakse beek in 1847 was 6 m (Staring, 1847). The smaller profiles in 1847 meant that the watercourses could carry and store less water than in the current case. The profile has increased nearly fivefold resulting in more discharge of water in the present day and less water storage for bigger flows which has in turn changed the pattern of the stream. This situation can get worse due to climate change in future with excess and scarcity of rains which demands more areas of water retentions.

Fig. 3.11 Dimension of the watercourse of Baakse beek *(Source: Massop, 2007)*

From the density of watercourses around 1880 and the current density (Fig. 3.12), the large increase in the length of the water courses becomes clear. The total length of the watercourses has quadrupled. Information on surface water levels covers a much longer period. In 1890s, the smaller dimensions of the watercourses meant that the water level reacted more strongly to wet periods than it currently does. With the future climate changes, dense network of streams drain the water more quickly leading to drier upstreams.

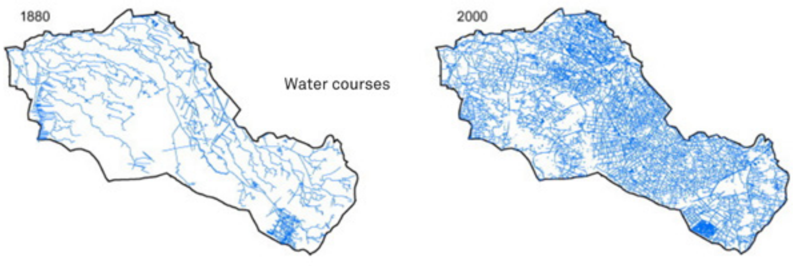


Fig. 3.12 Length of the watercourse of Baakse beek *(Source: Massop, 2007)*

A large shift in land use occurred between 1900 and 2000 (Fig. 3.13) as areas of wood and heath land strongly decreased while areas devoted to grass, roads and cities increased strongly. Today the variation in land use has disappeared and mono-agricultural practice is dominant (Fig. 3.8). This is likely to have a consequence in W+ scenario which is explained in chapter 6 (Intermezzo: climate change impacts on land use).

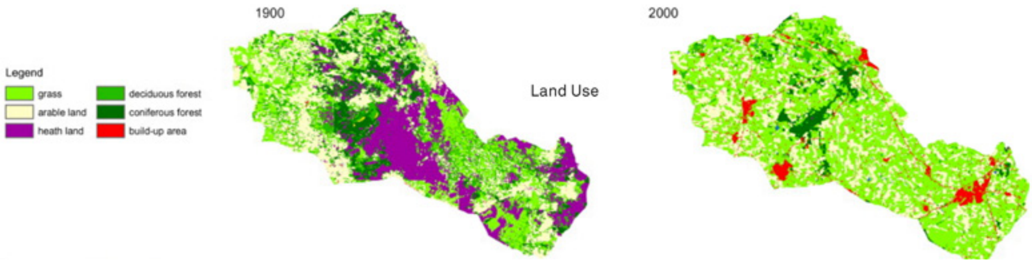


Fig. 3.13 Land use of Baakse beek area *(Source: Massop, 2007)*

The surface water level influences the groundwater level. Lowering the surface water level will lower the groundwater level. The groundwater level, meanwhile, determines plant growth. Fig. 3.14 and Fig. 3.15 indicates that the ground water levels today have been reduced greatly and has affected the vegetation in the region to a large extent resulting in extinction of certain vegetation species. With change in future climate, this can have a severe effect on the ecology. This topic is further explain in chapter 6 (intermezzo: climate change impacts on land use).

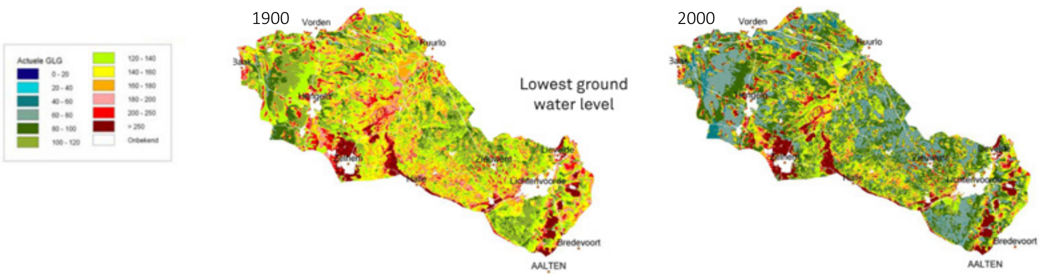


Fig. 3.14 Lowest ground water levels of Baakse beek area *(Source: Massop, 2007)*

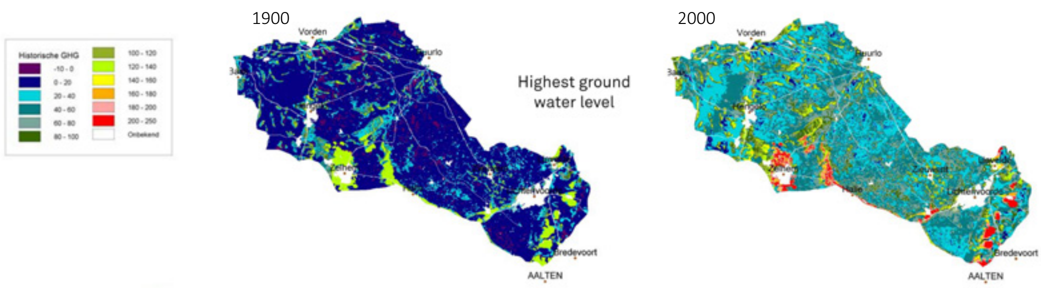


Fig. 3.15 Highest ground water levels of Baakse beek area *(Source: Massop, 2007)*

The historical discharge with a frequency of exceedance of less than one day a year is smaller than the similar discharge nowadays. This was due to water storage possibilities since before the reclamation activities were carried out within the river basin. In local depressions, areas above semi impervious layers, along streams and in other watercourses, water could be stored temporarily and discharged slowly over a longer period. Currently, the water is discharged more directly reducing the spongy-ness of the landscape (Fig. 3.16).

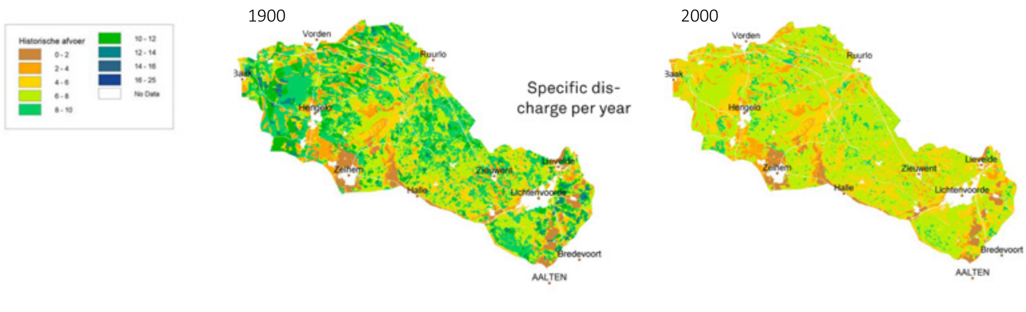


Fig. 3.16 Specific discharge levels of Baakse beek area *(Source: Massop, 2007)*

Comparisons between the historical and present conditions indicated a relatively less amount of water infiltration levels in the present day scenario (Fig. 3.17). This directly led to deep water tables. The soil's moisture holding capacity is very low leading to dry areas and quick discharge of water in the streams. Evaporation rates in Baakse beek- Increase in the area of grass; disappearance of heath and forest areas; increase in the area of roads and construction has led to a increase in the evaporation levels today (Fig. 3.18).

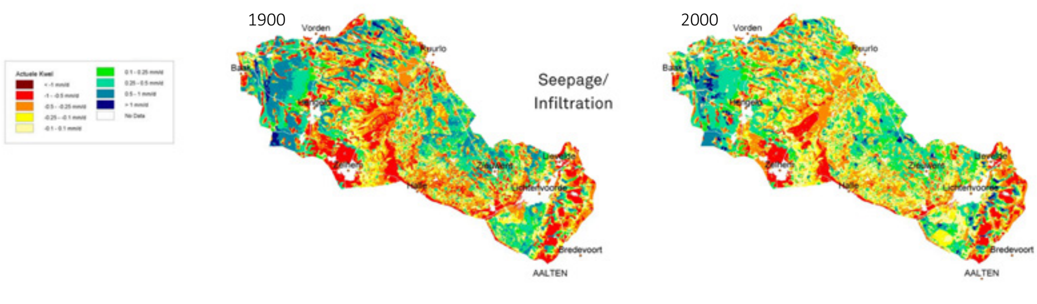


Fig. 3.17 Infiltration levels of Baakse beek area *(Source: Massop, 2007)*

Conclusions

The results of the analysis proves that Baakse beek landscape has gone through several transformations (Fig. 3.19) in the past due to physical and human influences. Because of climate change, the land use will be further changed reducing the diversity, ground water levels will be lowered, discharge speeds will increase due to excess precipitation and leading to drought conditions in upstreams, infiltration levels will lower due and have effects on soil moisture. The effects of these transformations on the cultural heritage of specific areas in Baakse beek

Description	Historical situation	Current situation	Difference/ Factor

Waterway dimensions	L(m)	D(m)	B(m)				Depth x2
Lievelder beek	2300	0.74	1.04				Length x4
Lichtenvoordensche beek	8000	1.16	1.84				Breadth x
Hissink beek	14400	1.55	1.88				
Veengoot	22000	1.12	2.59				
Lindensche lake	13800	1.13	1.45				
Haller lake	7000	0.92	1.16				
Baakse beek	8300	1.44	2.54				
Oosterwijksche vloed	12700	1.10	1.34				

DIMENSIONS
Data of Baakse Beek basin derived from Staring(1845)

Length of watercourses	Length water courses1850(m)			Length water courses2000(m)			%	
	ontwat	afwat	total	ontwat	afwat	total	afwat	total
2900309	150794	40190	190984	818763	253296	1072059	15.9	17.8
2900313	115483	53625	169108	353661	135762	489423	39.5	34.6
2900312	19559	11403	30962	353661	353661	707322	18.5	14.3
2900319	81636	32290	114126	353661	84561	438222	38.2	47.2
2901009	9466	3106	12572	353661	18462	372123	16.8	23.6
2901012	2654	2396	5050	353661	10777	364438	22.2	15.2
2901013	17696	5357	23053	353661	14082	367743	38	53.1

LENGTH OF WATER COURSES
Comparision of historical and present situation of Baakse Beek basin (Gaast and Massop, 2007)

Land use	Ha	%	Ha	%	%
Grass	5588	21.2	14969	56.7	35.6
Arable land	7319	27.7	7315	27.7	0.0
Heath land	5981	22.7	6	0.0	-26,00
Decidious wood	4614	17.5	1373	5.2	-12,3
Coniferous wood	2727	10.3	1092	4.1	-6,2
Roads and cities	35	0.1	1568	5.9	5.8
Water	7	0.0	52	0.2	0.2
Sand	17	0.1	5	0.0	0.0
Other	90	0.3			-0,3

LAND USE
Comparision of historical and present situation of land use of Baakse Beek basin (Gaast and Massop, 2007)

Groundwater level	Historical	Current	Desiccation
GHG - Highest	44	62	18
GVG - Average	77	95	18
GLG - Lowest	133	152	19

GROUNDWATER LEVELS
Comparision of historical and present situation of groundwater levels of Baakse Beek basin (Gaast and Massop, 2007)

Discharge	Climate Change		Restricting peaks	Increase in open water	Increase in flow resistance
Baakse Beek	2 C	4 C			
	7	19	-7	-7	-8

DISCHARGE LEVELS
Change in discharge % relative to the present situation and three mitigation measures (Gaast and Massop, 2007)

Evaporation rates			
Vegetation types		Current E (mm/year)	
Wet heath		500-520	
Rewetted bog		654	
Grassland on leftover bog		491	
Decidious wood		506-654	
Coniferous wood		520	
Grass		535	
Field		515	

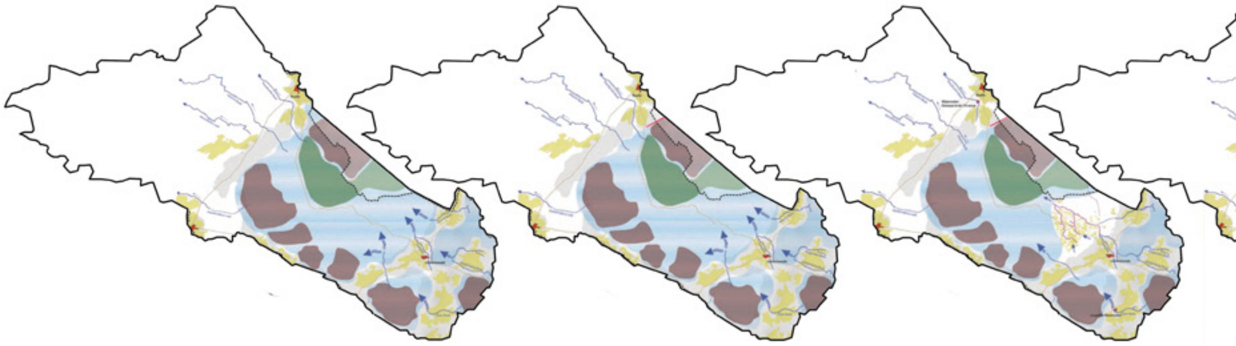
EVAPORATION RATES
Some evaporation rates of natural vegetation in the current situation (Gaast and Massop, 2007)

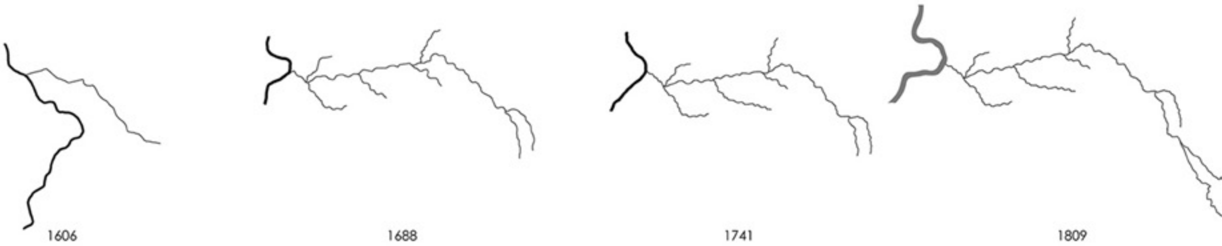
Infiltration level	Historical	Current	Difference
Seepage mm/day	-0,028	16	0,0034
Seepage mm/year	-10,3	6	16.3

INFILTRATION LEVELS
Comparision of historical and present situation of average infiltration of Baakse Beek basin (Gaast and Massop, 2007)

▲
Fig. 3.18 Tabulation of historical and current data

landscape is elaborated in chapter 4. This along with change in climate has affected not only the water system of the area but has also hampered the sustainability of the landscape. There is a need for recreating the lost balance in the water system to achieve the sponginess of the landscape. This can be partly done through readjusting the water system to store more water in the landscape and reduce the discharge speed of the streams. However, its necessary to consider the climatic predictions for the future to understand the amounts of water to be dealt with. This is further explained in the next section.





13th C
Dike construction
Dike ring 49 constructed in east of the river ijssel between Doetinchem, Doesburg and Zutphen.

14th C
Flooding
Dike reclaimed shallow Ijssel bedding causing regular flooding.

1606
Hondius map
Stream originates in Vorden, runs along castle Hackfort and flows south of Zutphen and not yet in Baak, the Ijssel.

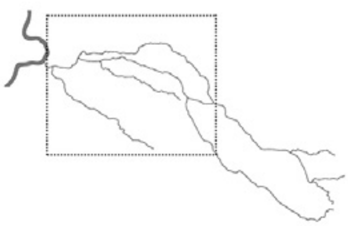
1688
Baakse Beek in 1688
Baakse beek rises through two branches near the Halsche peat and Marpat. Woodlandsin the upper reaches. Also from the Lochemsepeat near Wildenborch rises an offshoot of Baakse beek which comes between Baak and Wichmond into Ijssel.
In Baakse beek four mills are shown - Ruurlo, Wiersse, Vorden, Hackfort.
Peatlands- Des Heerenveen, t'Halsche peat, Wolboomsveen, Lochemse peat, Ruurlosche peat, Zelhemer Heijde.

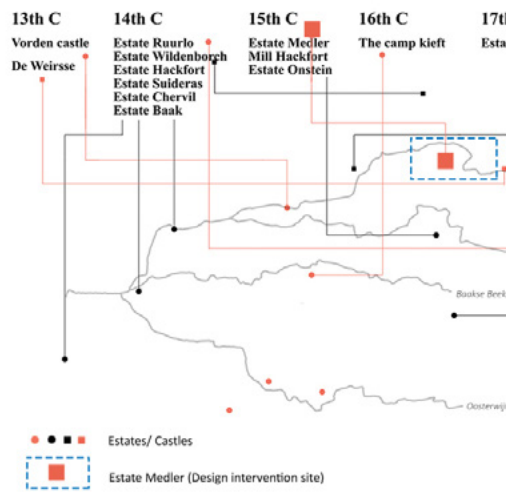
1741
Baakse Beek in 1741
Map shows three mills - upstream of Ruurlosche watermill is Sneppendijk. Downstream of this dike ruurlo and upstream ruurlo and it is Ruurlosche veen and Ruurlosche broek. Apparently, the dyke was necessary to protect Ruurlo against flooding from the brook. The map also shows the peatlands.

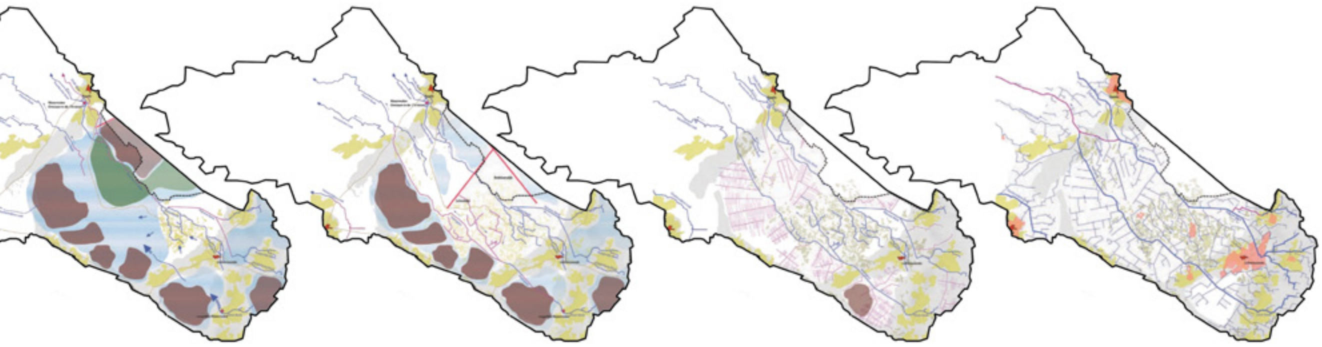
1809
Flood
Baakse spillway constructed

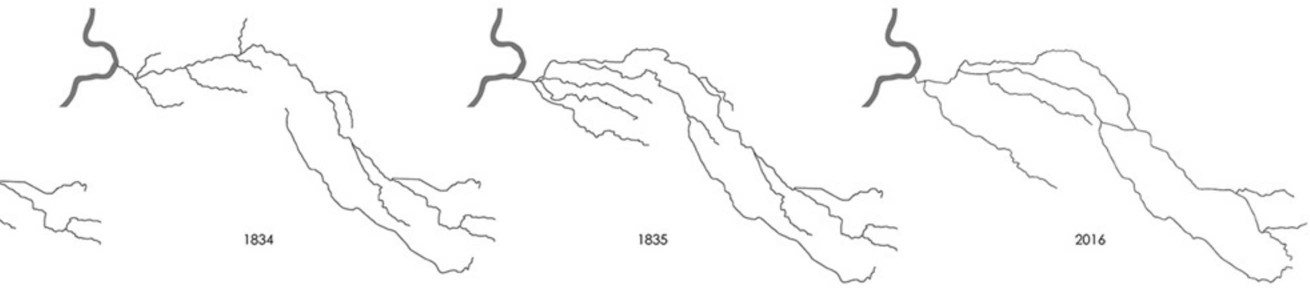
1834
New stream
Veengoot was dug.

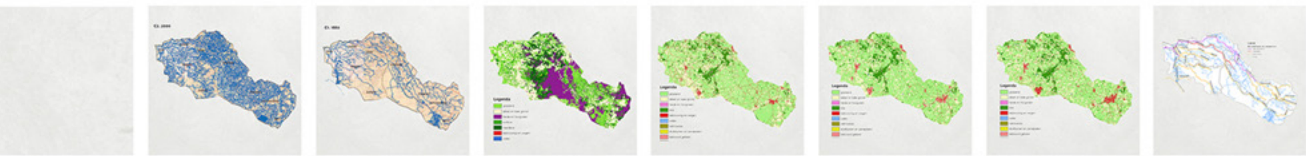
1835
New stream
Hissink beek w
dug.











1845
Soil depth alterations
vas Average soil depth in downstream part of Baakse Beek is 1.75 m, Hissink beek is 1.50 m and veengoot is 1.10 m. Current average soil depth in midcourse part of Baakse Beek is 2.2 m; downstream part is 3.0 m. Midcourse of Veengoot is 2.20 m and downstream is 2.55 m.

1850- 1980
Peat mining
Little desiccants present because a large area is not very extensive or agriculturally used until 1900.

1880
First water management plan was made - water density map. Aalten goor and Hengelo stream- start has been made for the development of peat.

1900
Arrival of fertilisers
Improved dewatering. moors could be put into production.

1950
Crop yield development and evaporation increased. Soil underwent changes which had an impact on water management. Peat land disappearance evident. mining of soil layers (iron core). Grasslands intensified increasingly. later corn made its appearance in agricultural areas. Excavated peat which were overgrown with heather long time, or reclaimed as farmland or became deciduous and coniferous forests.

Lowering of water tables since 1950 is increased by the artificial wells for drinking water supply. artificial ponds in estate dry up more in summer.

Land consolidation

1965
New stream
New main line of Veengoot was dug to canal Hackfort.

1976
Changes in course
Widening and realignment of Baakse beek streams.

90 dams were built to control water drainage.

h C
te t' beauzelle

18th C
Estate Wientjes

Fig. 3.19 Timeline of the origin and development of Baakse beek over the years in terms of its biophysical (natural influences), cultural (Estates constructions) and infrastructural (human influences) changes

▲

Fig. 3.20 Photographs of Baakse beek during drought (top) and flood (bottom) situations
(Photographs: De Regiegroep Baakse beek en Veengoot, 2014)

3.3 The uncertainty of climate change

The development of our climate in the future is perhaps difficult to envision. The most important changes in the climate in the Netherlands are that the average temperature rises and that the precipitation pattern becomes more violent. Because the development of a number of key factors is uncertain, four climate scenarios are being used by the Dutch Meteorological Institute KNMI.

Overall scenario

The scenarios G and G+ (G-moderation scenarios) give 1° C temperature increase. While the scenarios W and W+ (W-warming scenarios) give 2° C temperature increase (Fig. 3.22). The scenarios G + and W + have milder and wetter winters, hotter and drier summers compared to G and W scenarios. The W + scenario of 2050 is considered to be the most extreme scenario with greater risk of drought in the summer than now. Hence W+ scenario is used for further analysis at local scale.

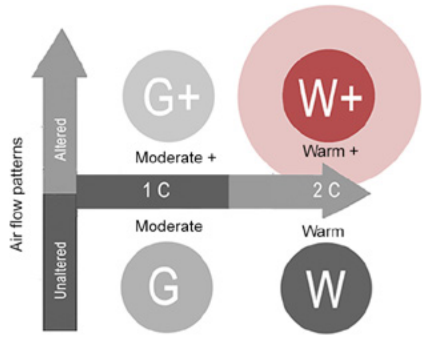


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Fig. 3.22 Overview of KNMI's climate scenarios by 2050 *(Source: Van der Hurk, 2006)*

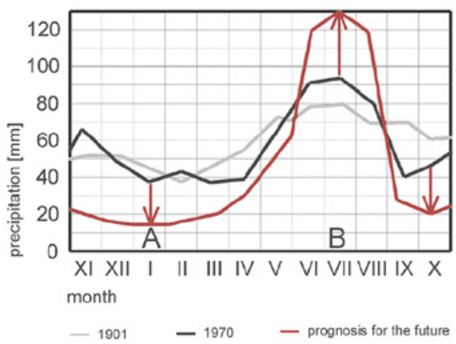

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Fig. 3.21 Precipitation trends- Periods of "drought" are lengthening (A) and the time period of most precipitation is getting shorter (B).

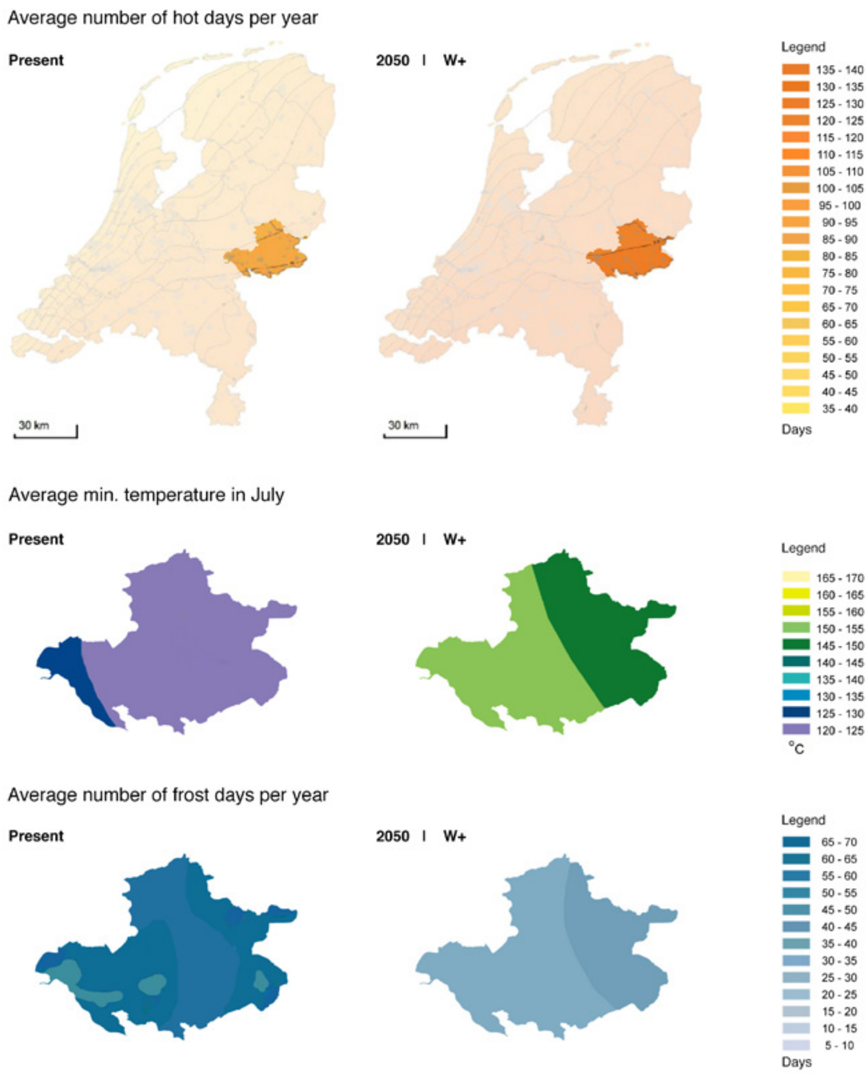

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Fig. 3.23 Temperature change specific to the Achterhoek region

(Source: http://klimaateffectatlas.wur.nl/)

Temperature change specific to the Achterhoek region

Average number of hot days in the Achterhoek region increases from 90- 95 days per year in the present conditions to 130- 135 days per year in the W+ scenario of 2050. Average minimum temperature in July increases from 120- 125 to 145- 150. Similarly, the average number of frost days per year varies from 60- 65 days in the present scenario to 30- 35 days per year in the W+ scenario of 2050.

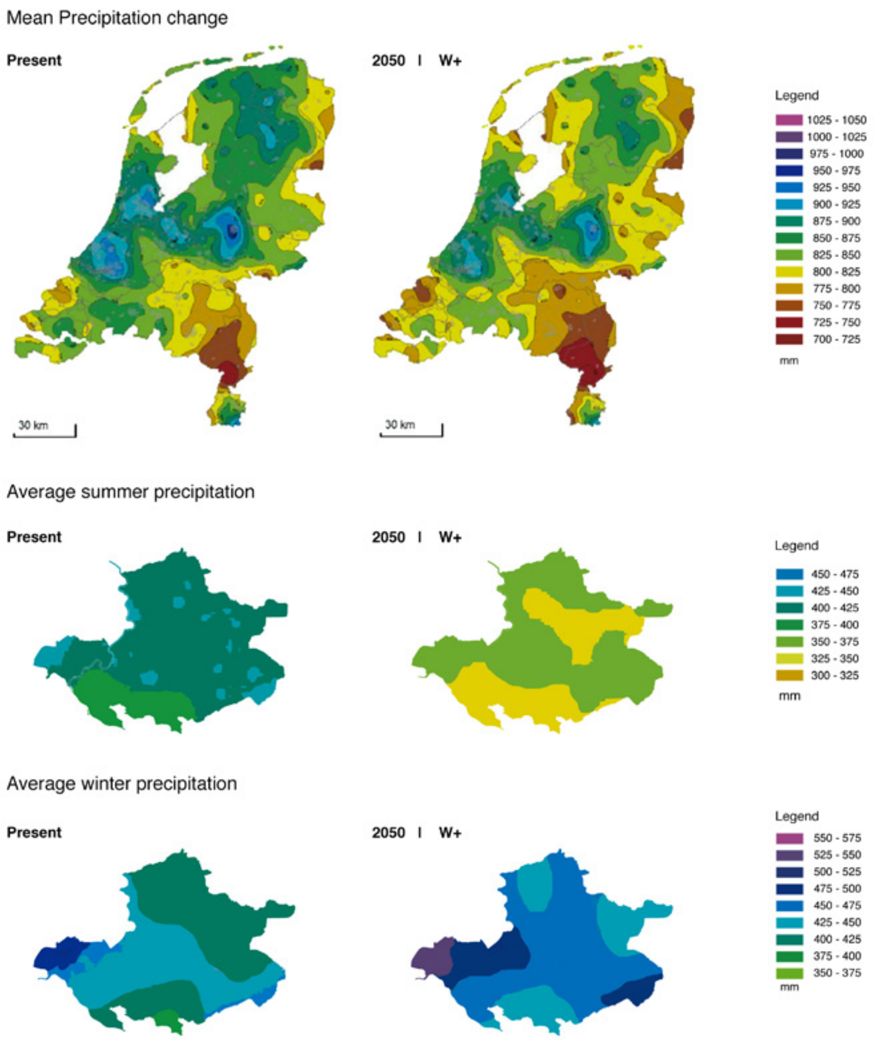

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Fig. 3.24 Precipitation change specific to the Achterhoek region
(Source: http://klimaateffectatlas.wur.nl/)

Precipitation change specific to the Achterhoek region

Mean precipitation in the Achterhoek region decreases from 850 - 875 mm in the present conditions to 800 - 825 mm in the W+ scenario of 2050. Average summer precipitation decreases from 400 - 425 mm to 325 - 350 mm in the W+ scenario. Similarly, the average winter precipitation varies from 425 - 450 mm days in the present scenario to 450 - 475 mm in the W+ scenario of 2050.

1 YEAR

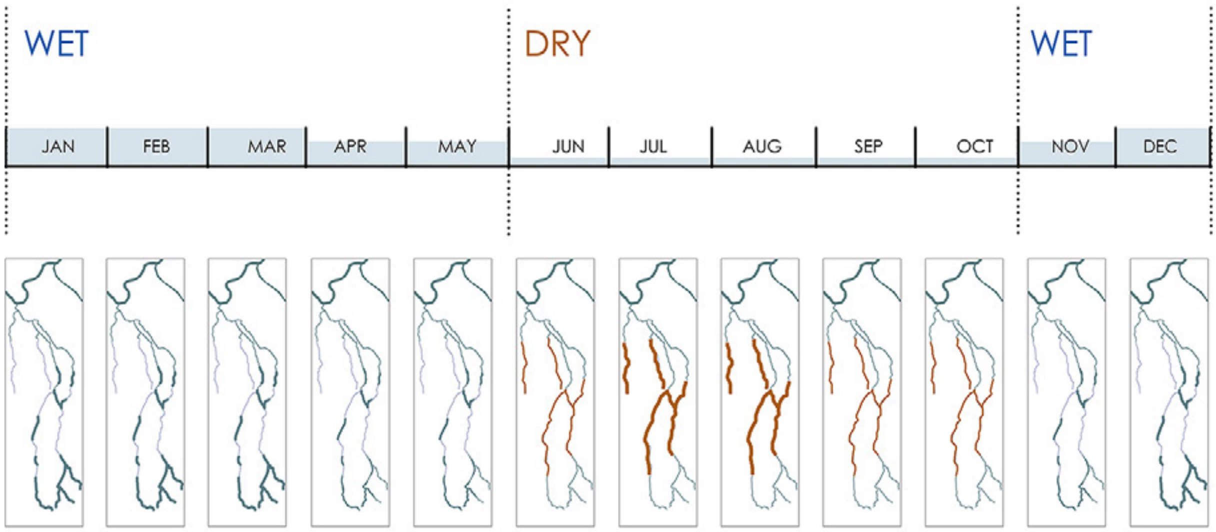
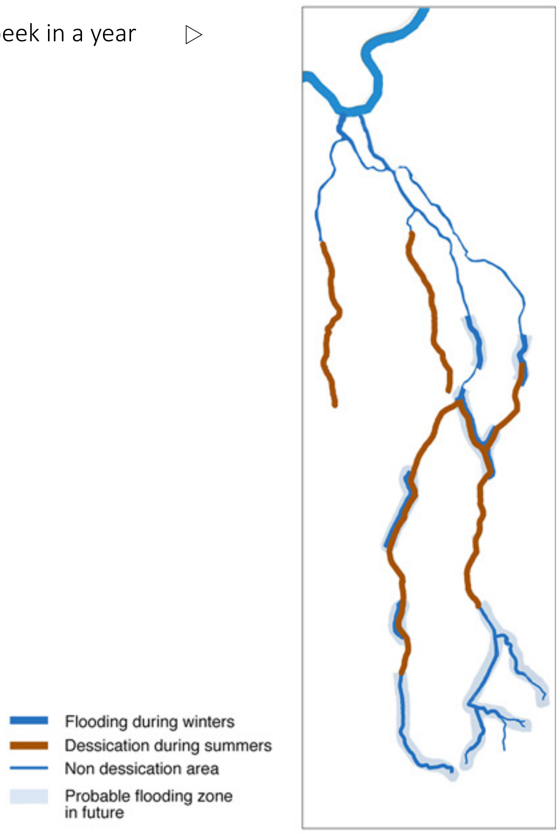


Fig. 3.25 Seasonal flood and drought regions of the Baakse beek in a year ▷
(Based on: De Regiegroep Baakse beek en Veengoot., 2014)

The upstream and downstream region increasingly suffers from flood during winters. While the mid stream region suffers from both drought and flood during summers and winters respectively.



Effects of temperature rise

Due to the temperature rise associated with climate change, the growing season starts earlier and lasts longer. When there is enough water even during the growing season, it offers more opportunities for increased crop production. This is a very favorable condition for agriculture. Temperature rise also offers opportunity for longer summer season for recreation especially in the countryside. But flora and fauna cannot adapt quickly to changing circumstances. Therefore it probably will change. In periods of high temperatures and prolonged drought, surface will warm more and thus be more susceptible to deterioration of water quality. In addition to the increase in average temperature, there is also an increase in the number of tropical days. This will lead to more heat stress. Animals such as cattle and certain crops are susceptible to heat stress, and generate less revenue.

Effects of extreme precipitation and wetter winters

In the winter, precipitation levels are higher. Some parts of the region will therefore be increasingly dealing with flooding, for example, the areas near the plateau edge. Lichtenvoorde, due to its location at the foot of the eastern Dutch Plateau, and the high degree of hardening in the urban area, is sensitive to flooding. This has negative effects on water quality. The Wolfersveen and Ruurlo stream cannot rapidly carry a lot of water due to its flat ground conditions. This increases the risk of reduction in yield.

Effects of extreme drought

The study area also has places that are prone to increasing drought. Because of the rainfall deficit, there is a decline in groundwater level. The peat lands of Wolfersveen is prone to drought since podzol soil holds little moisture and the areas has a deep water table in the summer. The Ruurlo stream is less sensitive because the soil retains more moisture. The sandy areas between Hengelo and Zelhem are also prone to drought, because rain water quickly sinks to deep groundwater. Rabat Forests, lakes and groundwater-dependent nature of the estates zone and nature areas with grassland and pasture between Lichtenvoorde, Ruurlo - Zelhem, are in a verge of damage from the current low groundwater levels. With a greater precipitation shortage during the summer (which only occurs in the G + and W + scenarios), watercourses dry up more often and earlier in the year. This will certainly happen in the part of the Baakse beek and Veengoot between Ruurlo and Lichtenvoorde.

3.4 Conclusions

On the basis of the information of the previous analysis stage, four conclusions could be drawn:

1. Climate change impacts not just the water system of the Baakse beek area but also its ecology, biodiversity and cultural heritage.
2. Future climate scenario of W+ will have a drastic effect of the landscape of Baakse beek by 2050 if no changes is made to the way the water system works.
3. The historical water system worked sustain-ably and by attempting to recreate a similar scenario in terms of water storage systems in the past, today, the problems of drought and flood could be combated.
4. The technical solutions to the water system separately can solve the issues of water problems related to climate change but not its impacts on cultural heritage.

As the previous chapter already revealed this thesis has chosen to work towards a combination of technical solutions to water issues and solutions to the problems encountered for cultural character of the rural area through landscape character analysis. When considering all the facts this would be a logical choice:

1. No single technical solution of water system has a complete answer to the problems of the entire region. To prevent the landscape from changing too drastically, the water system needs to be designed sensitively for the future.
2. The scale of solution should fit the scale of the problem. The whole Baakse beek has been transformed and every human intervention has added to the rise in the problems of landscape character.
3. The upstream region suffers from both drought and flood while the downstream region has major issues of drought. The interventions should address these both.
4. Decreasing the speed of stream water is most effective where it runs wide and deep near the newly constructed Veengoot stream in the upstream. And an increase of stream length has more effective downstream, because this will result in a relatively longer and delayed flow.

This model could theoretically be fitted to any sandy regions which has comparable problems, but this thesis wants to create a condition for the Baakse beek landscape. Chapter 7 expands on the technical solutions to water systems, which is to increase the water retention areas in both upstream and downstream and to increase the stream length in the downstream. In order to carry out such interventions, its essential that it is adapted to its social, ecological and economical needs. Chapter 4 and 5 expand on the challenges of the landscape types and their respective issues as were largely, but shortly, introduced in the earlier parts of the thesis.

4

SYNTHESIS

STAGE 2

4.1 Introduction

In the previous chapters, the focus was on the main problems of the water system of Baakse beek. The synthesis stage (chapter 4) focuses further on understanding the situation of the Baakse beek landscapes. The problem of climate change also worsens the landscape because the system moves further from its balance, thereby not only damaging the water system but also the cultural and ecological functions. The aim here is to keep the cultural and also ecological identity of these landscapes more or less intact. To do so, the water system has to be changed like it has been in the past.

This chapter combines the system knowledge of chapter 3- Analysis stage, with landscape character analysis. Searching for a growing strategy of problem solving and answering the fourth research question:

4. How to address climate change within Landscape Character Analysis?

The end result of this chapter will be a set of problematic specific to the small scaled landscape types and its cultural heritage as a consequence of climate change. Chapter 5 thus continues from this and adapts it for the specifics of the Baakse beek for the future ideal scenario.

This chapter takes the following steps:

1. Understanding the different landscape types and its features through landscape character analysis.
2. The functions and processes of landscape types, both from a cultural and natural standpoint.
3. Recognizing the problems and searching for solutions which could achieve a new balance.

4.2 Landscape character classification

As explained in the previous chapter, the landscape of Baakse beek has been transformed several times in the past due to physical and human influences. This has led to the formation of diverse types of landscapes. The Fig. 4.1 shows the landscape conditions before and after the external influences. It also indicates the boundaries of the current landscape types. The nomenclature of these landscape types are based on the prominent historical activities and physical conditions.

The landscape character analysis included a study of the typological and morphological classification which revealed the physical and spatial structure of the Baakse beek. They are typological and morphological because they describe the rural form based on detailed classifications of farms, open spaces, trees, streams by types. The emphasis is thus not so much into the study of individual farms or nature types in isolation, but in the study of the relationship between them. This approach is sensitive to the historicity in the rural form as well it understands the needs and aspirations of the watershed. A non static attitude to the rural area is central to this idea hence analysis and synthesis in the history and evolution of the spaces are the prime aspects. The results were categorized under a typology scheme (Fig. 4.2) of six landscape types and is introduced in the next segment. The end results are mapped in the form of collage of sections, plan and visualization of the area (Fig. 4.3).

4.3 Baakse beek landscape typology

The Terrace-edge Landscape is located on the eastern edge just outside the eastern plateau. With its high altitude and boulder clay underneath, the area in the past has a strategic importance as it formed the source of Baakse beek and Veengoot streams. The stream type is recognized as 'Terrace-edge Stream' which is a water bearing stream with meandering character due to the transition from east plateau with diverse banks. Flora and fauna and aquatic species are largely absent. However, stream fauna includes species of fast-flowing water. This stream has a relatively short journey but heavily dependent on exchange of water with nearby streams. It is prone to desiccation and is moderately sensitive to water pollutants and recreation (Baker, 2002).

The Camp Landscape is the oldest landscape of all and was mined in the Middle Ages. This landscape has a 'Wetland Stream' with a meandering/ braiding system. It has strongly concave banks with varied rich flora and fauna. Its mostly stagnant and slow flowing water is quite susceptible to drought (Baker, 2002).

The Peat Landscape was a flat landscape which was completely mined. The Peat Stream in this landscape has a strong organic character and a very superficial and shallow slow drain. It has hardly cut landing with faint to peaty shores. Certain species of flora and fauna are missing due to absence of habitat. it is very sensitive to changes in water quality, interference due to recreation (trampling) and quantity of water (dehydration).

The Sand Ridge Landscape is higher and drier than its surroundings due to the presence of sand ridge formed during Holocene. It largely consists of soft wood forests. With a Temporary Stream

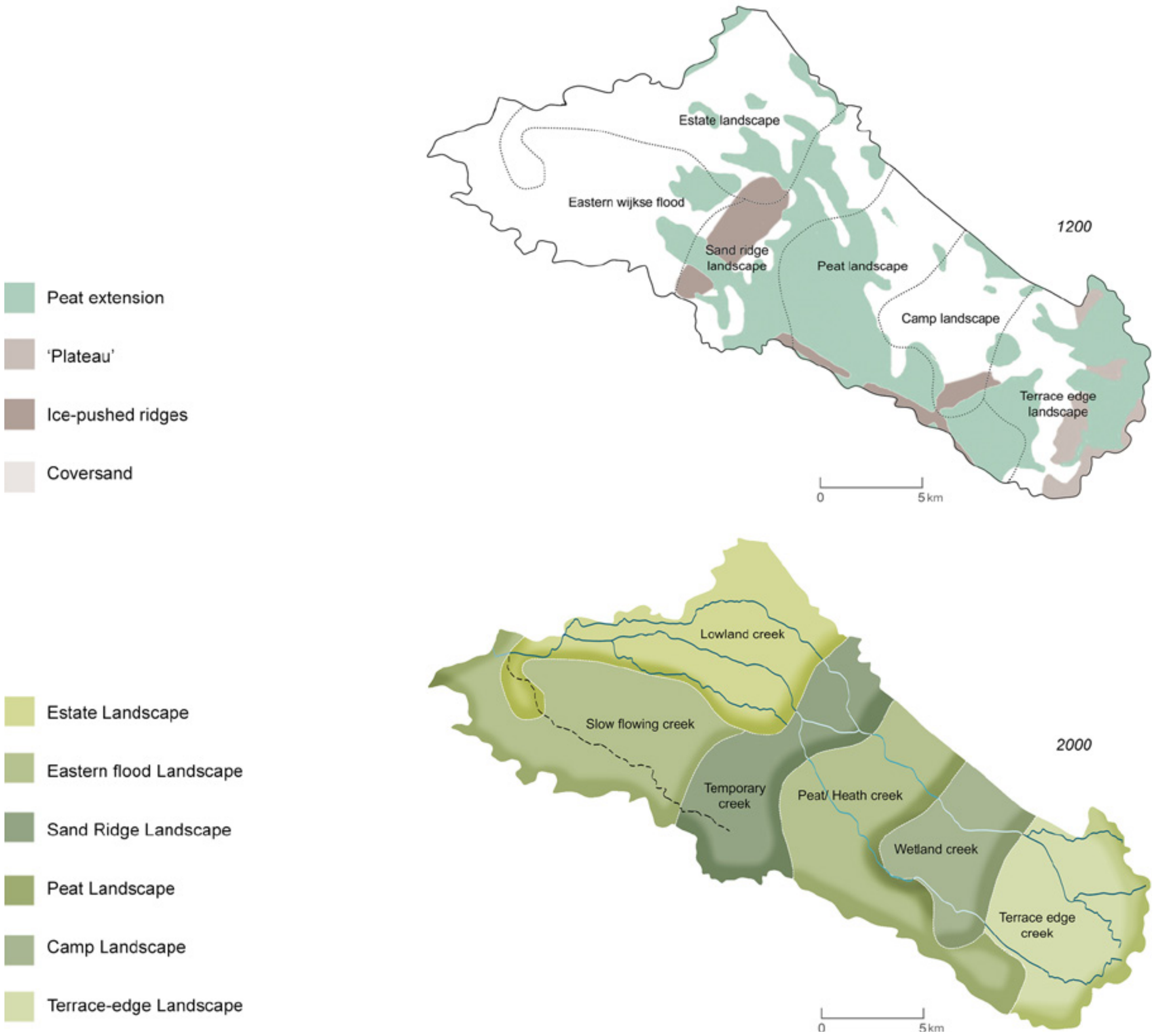


Fig. 4.1 Baakse beek landscapes before (above) and after (below) physical and human influences.
(Based on: De Regiegroep Baakse beek en Veengoot., 2014)

type, the watercourse meanders (often upper reaches of stream), and has holes and hollow banks. It is very sensitive to desiccation and changes in water quality and recreation. Very few stream vegetation is found.

The Estate Landscape in the northern boundary is known for the number of castles and estates interspersed with agriculture and forests. This is one of the most diverse landscapes of the regions with many landscape elements and has a culturally rich heritage. Lowland Stream of this region has a slow flowing winding course with variable shores. Dams and barriers in the streams have stopped fish migration. This stream historically passed through marshes, and was shifted, shortened to better regulate water for supply for mills and castles. Today the stream is straightened in order to regulate the drainage. Some streams are fed only with large rainfall surpluses of water.

The Eastern Flood Landscape has the lowest altitude and is situated next to the river Ijssel. This typical agricultural area contributes the most to the environmental quality of the area with a Slow- flowing Stream with a wider base-flow.

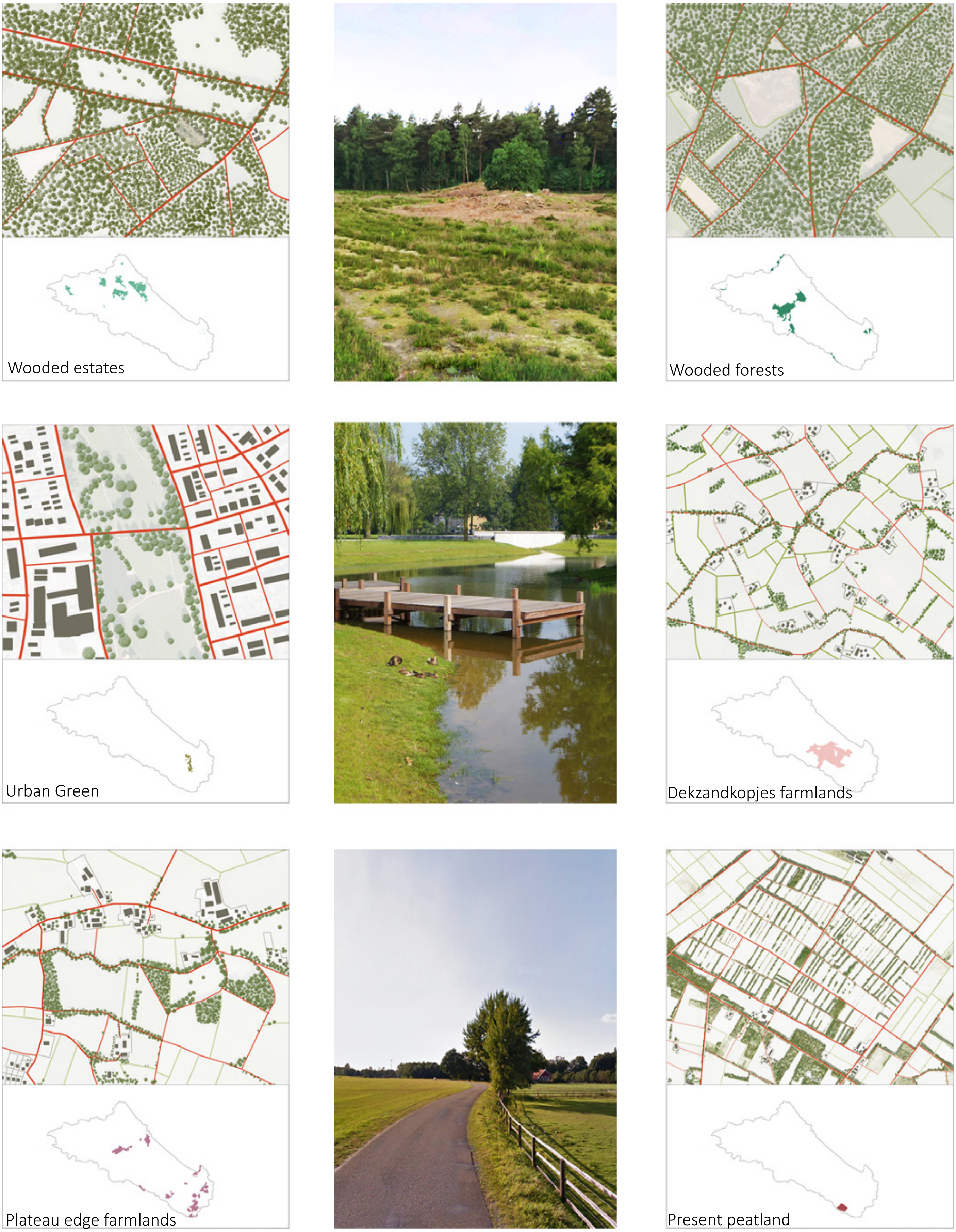
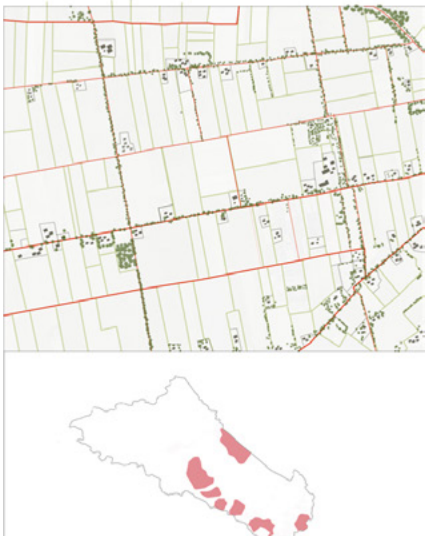


Fig. 4.2 Baakse beek landscape spatial pattern typology ▷

Ancient woodland farms



Ancient peatbog farmlands

Rolling valley pastures

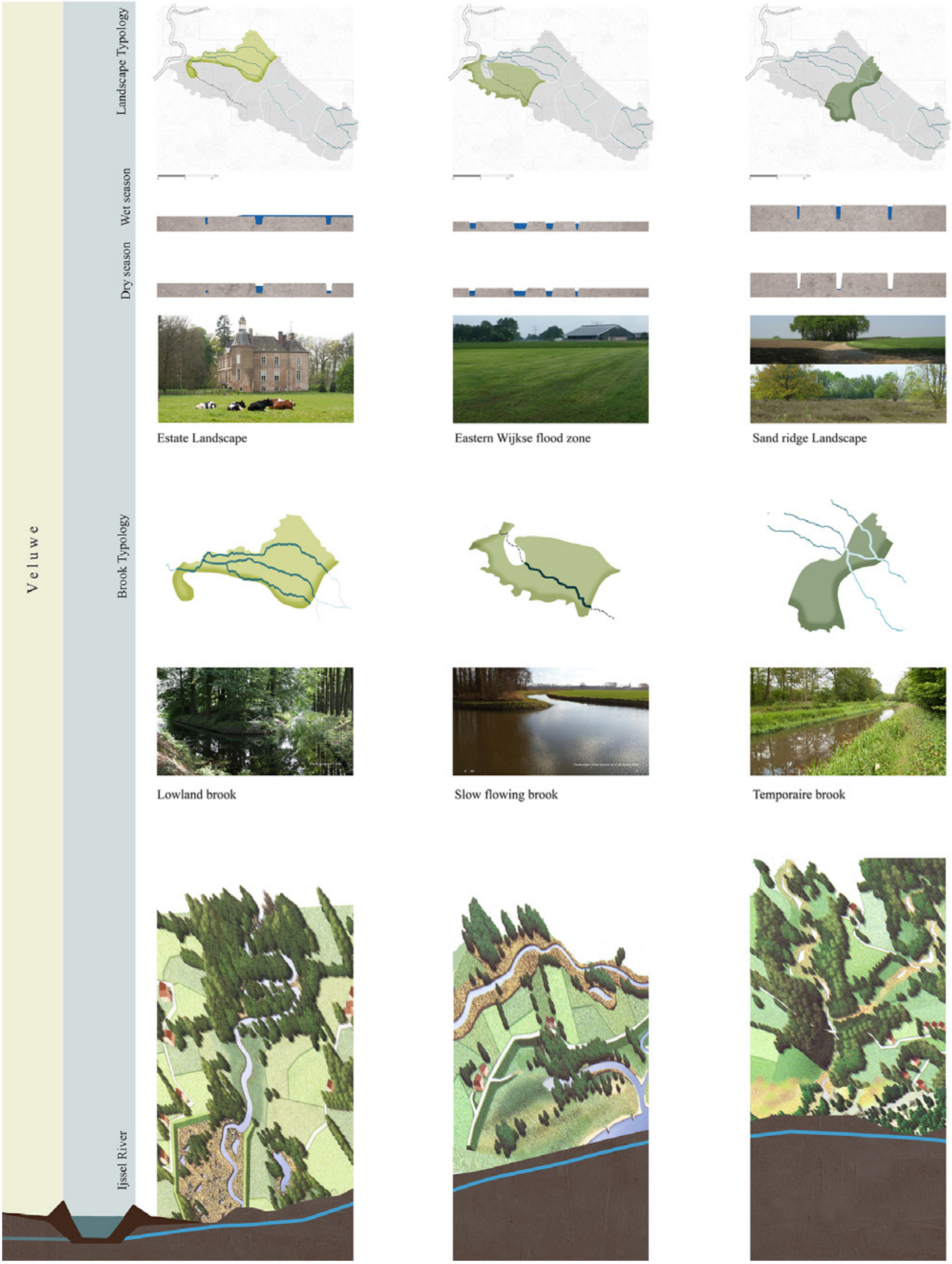
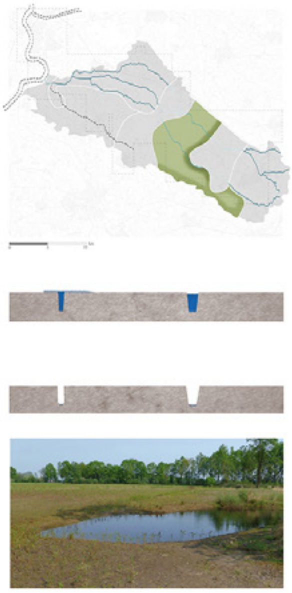
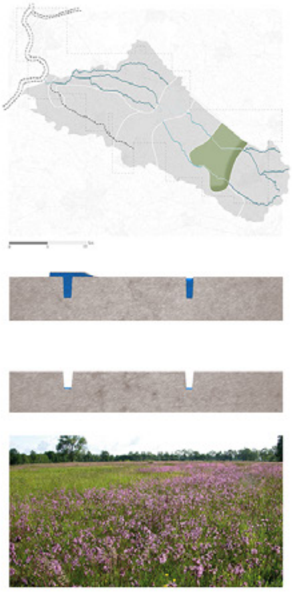


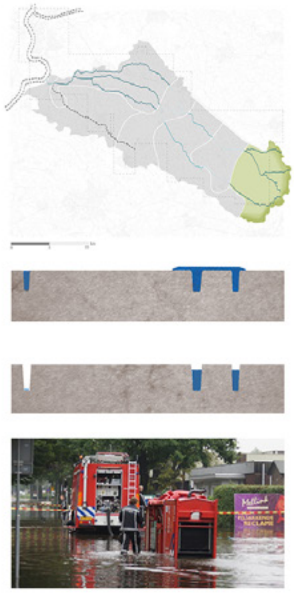
Fig. 4.3 Baakse beek landscape typology overview ▷



Peat mining Landscape



Camp Landscape



Terrace edge plateau Landscape

Peat or heath brook

Wetland brook

Terrace edge brook

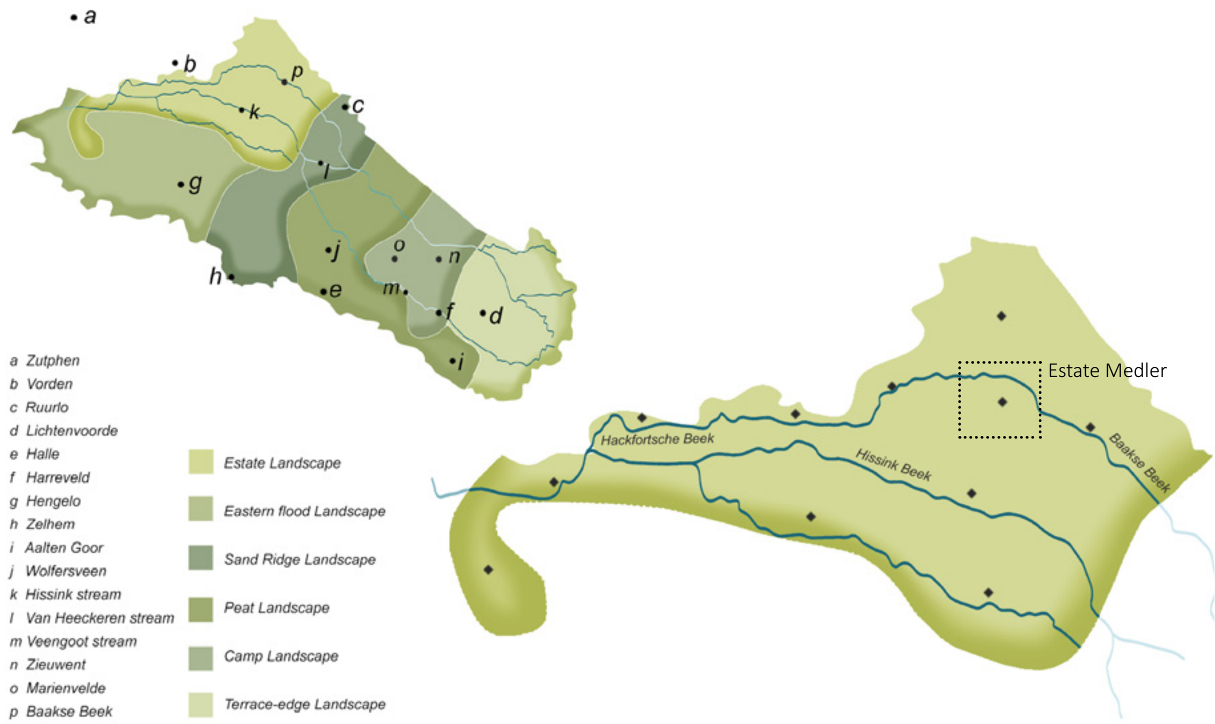


Fig. 4.4 Estate Landscape with streams and estate locations

Estate landscape

Estate landscape is located on the downstream part of the Baakse beek stream which flows through this landscape between Ruurlo and Ijssel in the west of the basin (Fig. 4.4). Landscape elements like water mills, pastures, grasslands, avenues, deciduous forests, Rabat forests, lakes, vineyards, nature reserves and small scale farms dominate this landscape (Fig. 4.5). This culturally and historically rich area with a large number of medieval castles and estates, which have a large bond with the stream virtually, is very attractive for tourism and recreation. At first, the stream was primarily a key element in the defense of the houses. Later on, it was important for energy generation and an essential condition for irrigation in agriculture. Thereafter, water was important as an aesthetic element in the parks and gardens.

Today, however, the bond has faded out with the stream with no visibility. There is a major impact on the water balance in the streams due to the irregular precipitation during summers and winters which have consequences on the entire landscape. In summer, streams and estate moats dry up more often and earlier in the year. The precipitation shortage slows the flowing speed of the streams leading to standing water conditions. Higher water temperatures, kill fishes and also dry streams impact all the aquatic life. Nature desiccation is a huge problem

Fig. 4.5 Schematic section of Estate Landscape

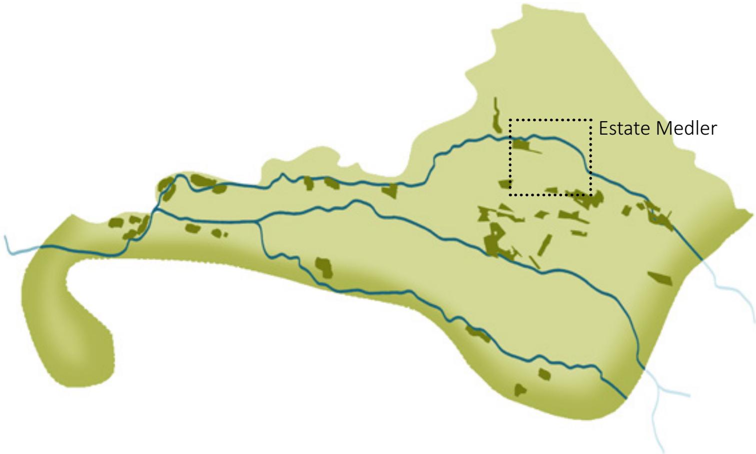


Fig. 4.6 Estate Landscape with dried 'Rabat forest' locations

especially affecting the culturally rich forests like Rabat forests which were designed in the areas of marshes with poor draining abilities are now mere wastelands with no access due to bad conditions (Fig. 4.7). These problematic are further addressed in this thesis as a design intervention at Estate Medler (Fig. 4.8), to improve the resiliency of the landscape in future with excess and less rainfall and further strengthen the landscape experience with new Rabat forest structure.

Fig. 4.7 Dried 'Rabat forest' near Estate Medler *(Photograph: author)*

Fig. 4.8 Estate Medler and tree avenue *(Photograph: author)*

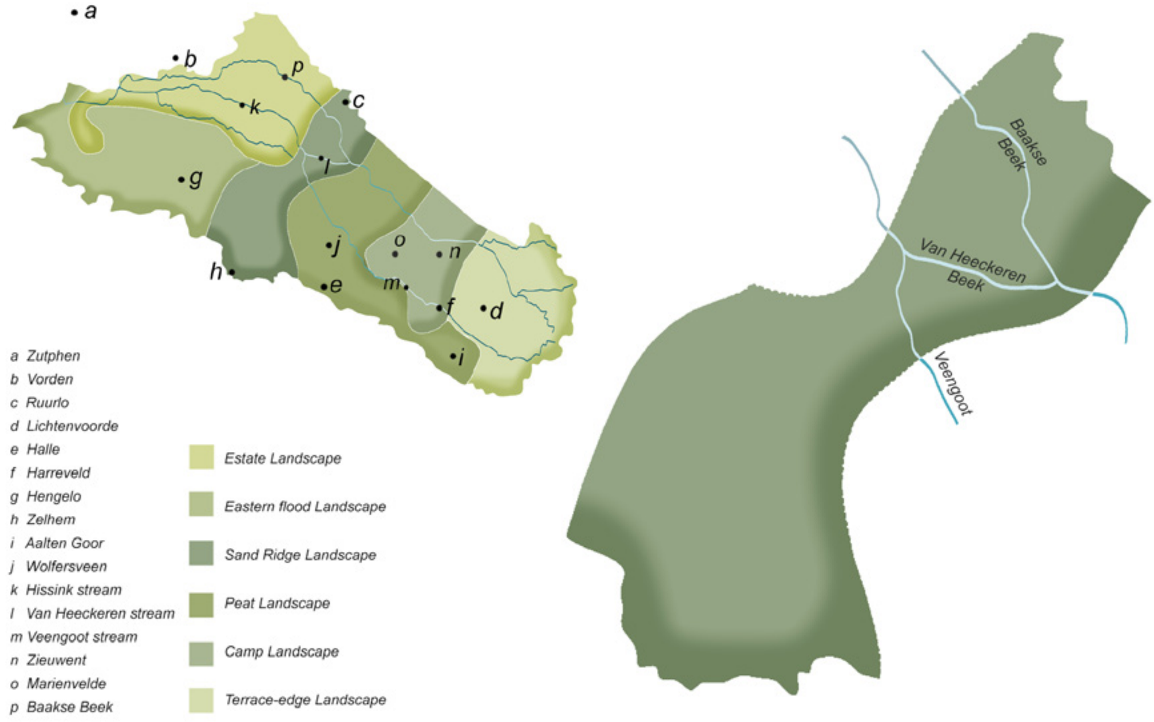


Fig. 4.9 Sand Ridge Landscape- Van Heeckeren stream connects Baakse beek and Veengoot

Sand Ridge Landscape

Sand ridge landscape is located on the higher and drier grounds between Ruurlo and Zelhem. This was formed in the last Ice Age under the influence of wind and snow. In the Middle Ages, the higher sand ridge which were initially inhabited, had fields which were fertilized with manure, turf and sand. The area is mainly used as a nature reserve. The landscape elements consist of several parks, meandering streams, farms and forests, largely consisting of softwood and moor. In the past, the sand ridge was a natural barrier to the Baakse beek water from the east to the IJssel. In 1967 Van Heeckeren beek was to added to quickly dissipate and send more water from the Baakse beek to Veengoot.

Under normal circumstances, water in the Baakse beek flows through the estate zone. Van Heeckeren stream and Veengoot acts as a bypass and reduces the risk of flooding during peak rainfall but not completely eliminate it. This stream often dries up during dry periods due to high temperatures and no precipitation. The scenic value of this stream for sand ridge and estate zone is very limited during dry season. Similar conditions of the sand ridge of Zelhem and Ruurlo explained above persists in the sand ridge of Halle and the sand ridge of Harreveld and Lichtenvoorde.

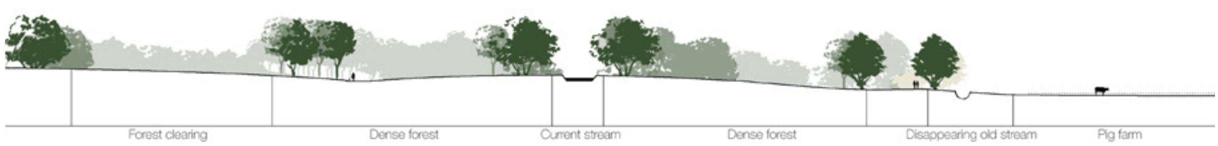


Fig. 4.10 Schematic section of Sand Ridge Landscape

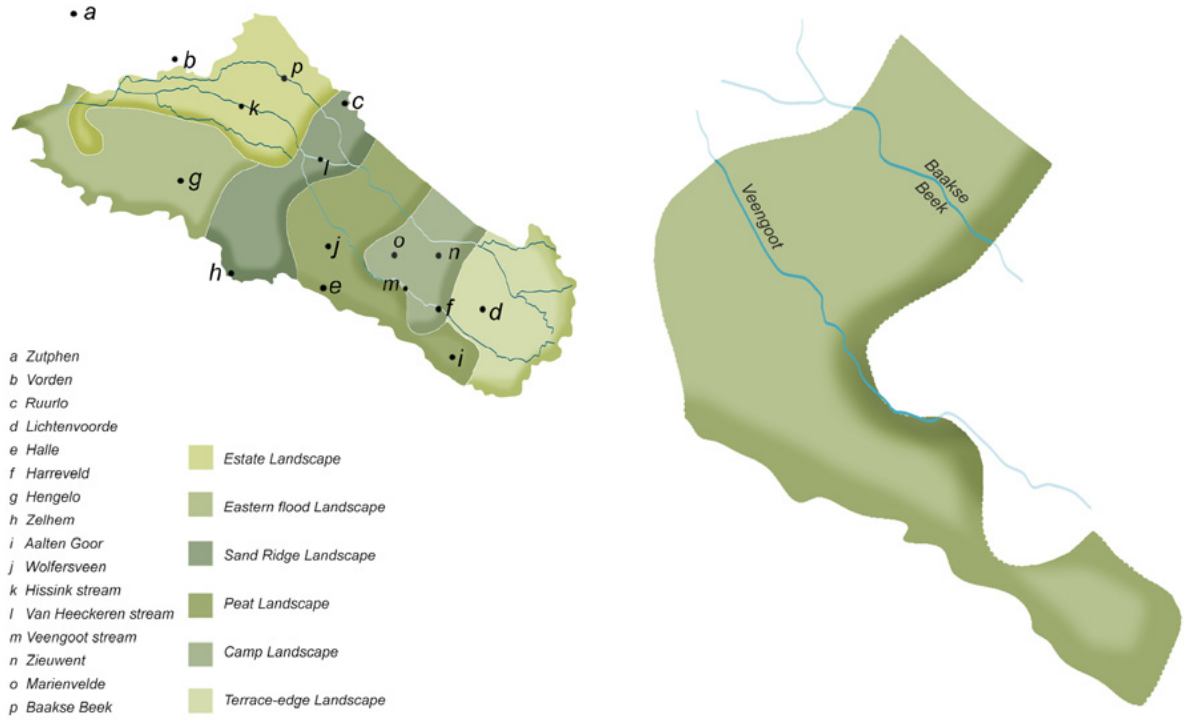


Fig. 4.11 Peat Landscape with Baakse beek and newly dug Veengoot

Peat landscape

Peat landscape is located on the upstream part of the Baakse beek stream which flows between Zelhem, Ruurlo and Zieuwent (Fig. 4.11). Landscape elements like crops fields, plant nurseries, large scale dairy farms and small marshes dominate this landscape. Some wind turbines are located near Aalten goor as alternate energy sources. Furthermore, there are hardly any special cultural heritage or nature reserves present in this region. Because of its flat land conditions, the whole region was a former wasteland with bogs during 1200s and were mined and extensively drained in 19th century to make way for agricultural practice (Fig. 4.12). Veengoot stream was dug in this landscape as additional drainage stream for Baakse beek.

Today, the former peat lands of Wolfersveen, Hengelo and Zelhem are prone to drought, since the soil holds little moisture and the water sinks quickly into the deep water table during summers. Because of the flat conditions, water cannot run off quickly and the expected consequences such as drier summers, wetter winters and more extreme rainfall is felt in this landscape. During heavy and prolonged rainfall, flooding damages the crops. The surface water which is extensively drained, dries up the waterways quickly due to high discharge speed and can hardly be used for irrigation. These problematic are further addressed in this thesis as a design intervention to enhance the natural values by making better use of the stream water and to find a balance between discharge and retention of water to improve the resiliency of the landscape.

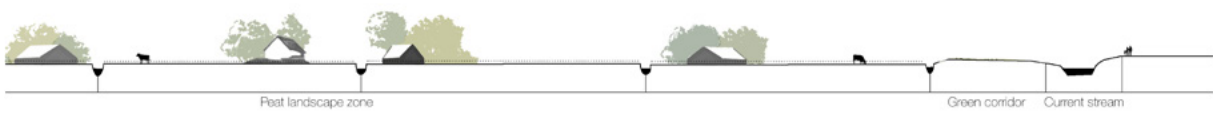


Fig. 4.12 Schematic section of Peat Landscape

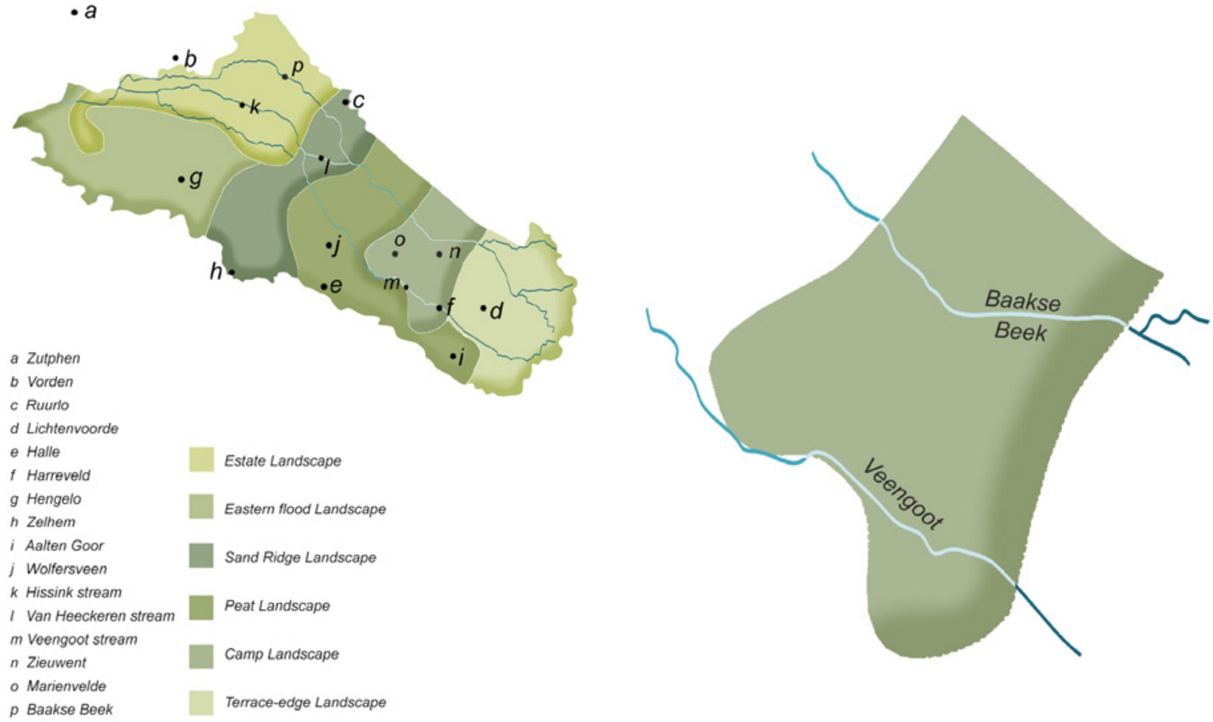


Fig. 4.13 Camp Landscape with Baakse beek and newly dug Veengoot

Camp landscape

Camp landscape is located between the upstream part of the Baakse beek stream on the north and Veengoot stream on the south around Zieuwent and Marienvelde (Fig. 4.13). Landscape elements are traditionally characterized by large and small fragmented, irregular allotments of nature and agricultural plots interspersed with meadows, pastures, hedgerows, solitary trees, tree line plantations around droebels (cup shaped land structure with settlements- Fig. 4.14), stream valley and farmhouses along the organically shaped plots. After the land consolidation in 20th century, the extensive network of church trails and the small scale agricultural structure of the landscape have disappeared and scaled up with large agricultural businesses. A majority of the above mentioned traditional landscape features have lost their importance today and diversity of the landscape has reduced.

Parts of Baakse beek stream are dry or carry very little water in summer periods. The landscape around the valley suffer from very low ground water levels and predictions of climate change will particularly affect this area where plants and vegetation are so dependent on rain water. Due to the absence of any kind of water storage areas like ponds and lakes, there is a poor habitat linkage for rare animal species. Negative effects on habitat conditions due to unpredictable annual rainfall happen faster than species can adapt. These problematic are further addressed in this thesis as a design intervention to enhance this small scale landscape.

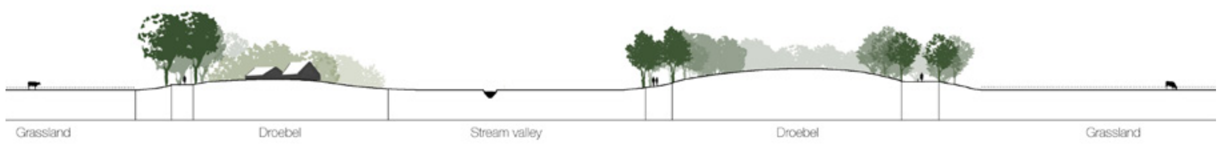


Fig. 4.14 Schematic section of Camp Landscape

4.4 Conclusions

To this point in the thesis the following has been deduced:

1. The Baakse beek landscape is dealing with problems specific to each landscape type.
2. The different landscape typologies are unable to co exist together and retain their special characteristics because of the new advancements in agricultural and economic sector. Estate Landscape offers more potential for new developments in ecological and cultural aspects.
3. Over the centuries, economic growth has caused major changes in the natural system of Baakse beek and until the eighties, the resilience of Baakse beek system could still absorb the human interventions and move towards a new equilibrium. But from 1900s on, the interventions had a devastating effect on the natural system and the gradual change in the landscape activities prevent the landscape types from finding a new balance.

This chapter, continued from this standpoint of working with climate change with cultural and natural processes, suggesting that if dynamics of the rural world of Baakse beek is reintroduced, they save to be integrated with present and future. In order to revitalize the troubled landscape types of Baakse beek region conflicted by environmental challenges we thus have to make a new vision and strengthen the existing characteristics instead of working against them. Chapter 5 expands the proposal of a new vision map for the Baakse beek area in the future thus creating a hybrid landscape typology.

5

APPLICATION

STAGE 3

5.1 Introduction

From chapter 4 it became clear that due to climate change the amounts of water will decrease in the streams and therefore the landscape characteristics will change. In order to keep the characteristics as it is, it is necessary to make sure there is enough water. New developments in the water system are recommended in a new vision map to strengthen the Baakse beek landscape. This chapter will revolve around designing the future ideal vision map for the Baakse beek area. The vision map for the Baakse beek, however, goes beyond the formulation of the technical solutions for the water system, and uses the landscape types and its natural and cultural features to improve the biodiversity of the region. This chapter defines the design principles for four landscape types that would benefit the Baakse beek area the best. While doing so, it answers the fifth research question:

How can the landscape types be changed or steered to avert the current and future climate challenge?

5.2 Impression of ideal vision map for future

In the ideal vision map (Fig. 5.1), the Baakse beek stream has a strong connection to the surrounding landscapes. The vision plan has been developed with a parameters in mind: Environmental sustainability, in close connection to the landscape, water system and its future climate. The changes in climate affects agricultural and rural development of Baakse beek (Reidsma, 2015). Therefore, the main structure of the vision map shows room for new developments to harmoniously co exist. It introduces new nature and recreation to the existing landscape. It gives spatial allocations of landscape features and guides on what is possible and not in a particular place. This landscape vision does not lead to the restoration of an original situation but it seeks to strengthen the identity of the landscape features.

With respect to its water systems, the vision map is conceptualized by historic awareness but contemporary translations of water structure of the streams. Effort is made to get as close as possible to historic water patterns to achieve a sustainable water system. Baakse beek in the vision plan, will be the main driver and meeting point for both locals and visitors. The stream is adjusted and the layout is changed in certain areas to balance the surface and ground water.

5.3 Design principles of ideal landscape types

The next segment provides the design principles for four landscape types of the region at the regional scale. In addition to solving the problems explained in the chapter 4, it closely explains the new additions and changes which will be the key to create a strong identity and an awareness of the estate landscape, sand ridge landscape, peat landscape and camp landscape in detail. These principles are crucial to attract new visitors and residents and together with the transformation of the landscape, the vision plan for each landscape type will provide clues to social and ecological improvement possibilities which is elaborated further in the chapter 6.

Green areas: Additional continuous network along Baakse beek and Veengoot

Stream Landscape: Ensure access; ponds every 500 m; remove barriers; natural banks

Peat Landscape: Water retention in old peat parcels; single tree lines towards Tolhut

Camp Landscape: Densify farm edges with hedges, tree lines, flower margins

Estate Landscape: Restore Rabat forests for water storage; link streams and estate moats

Urban: Storm water management; rain water harvesting

Enken: Open lands- ensure villages and forest edges do not grow together

Broekland: Ponds recharge ground water; link Veengoot and Baakse beek; restore rare vegetation

Urban Green: Green landscape revolves through the city

Additional areas of inundated fields in old bogs and marsh areas

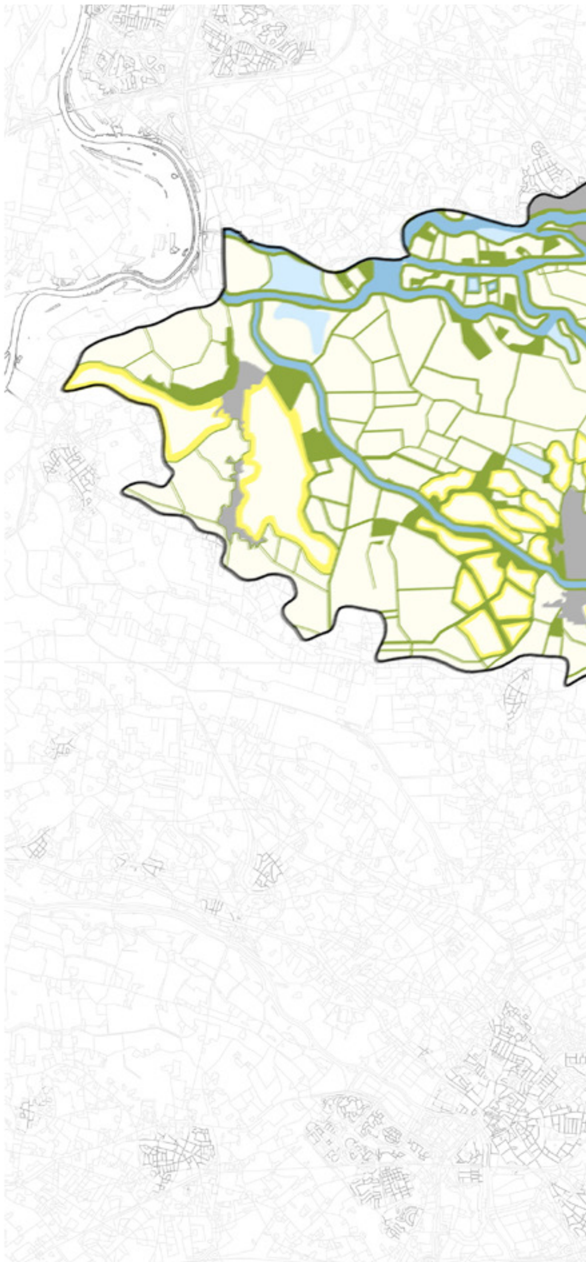
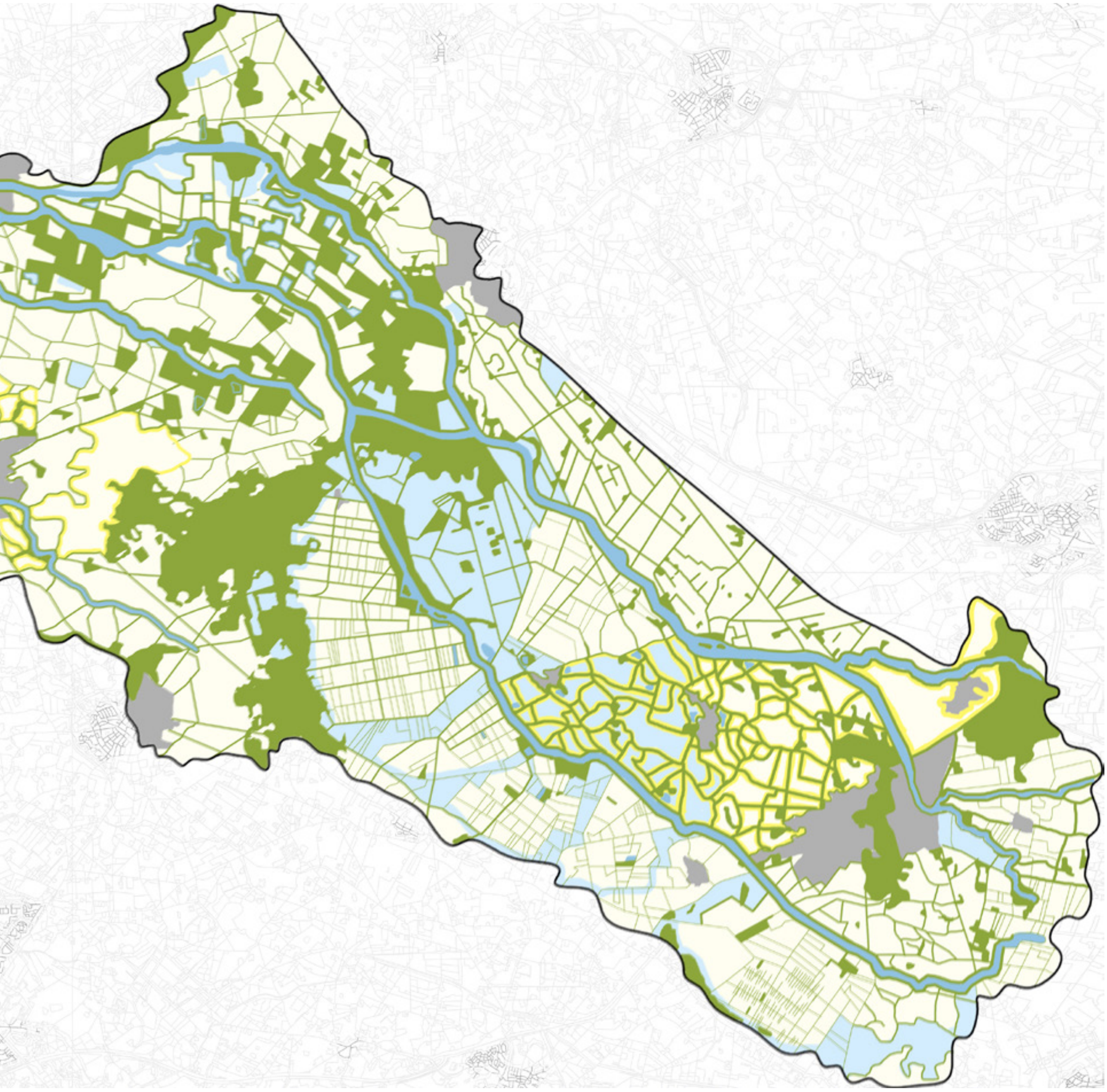


Fig. 5.1 Ideal Vision map for Baakse beek area for W+ scenario of 2050 ▷

The ideal vision map sets goals to achieve a sustainable landscape by introducing new nature to the existing landscape and shows room for new developments while solving the current problems.



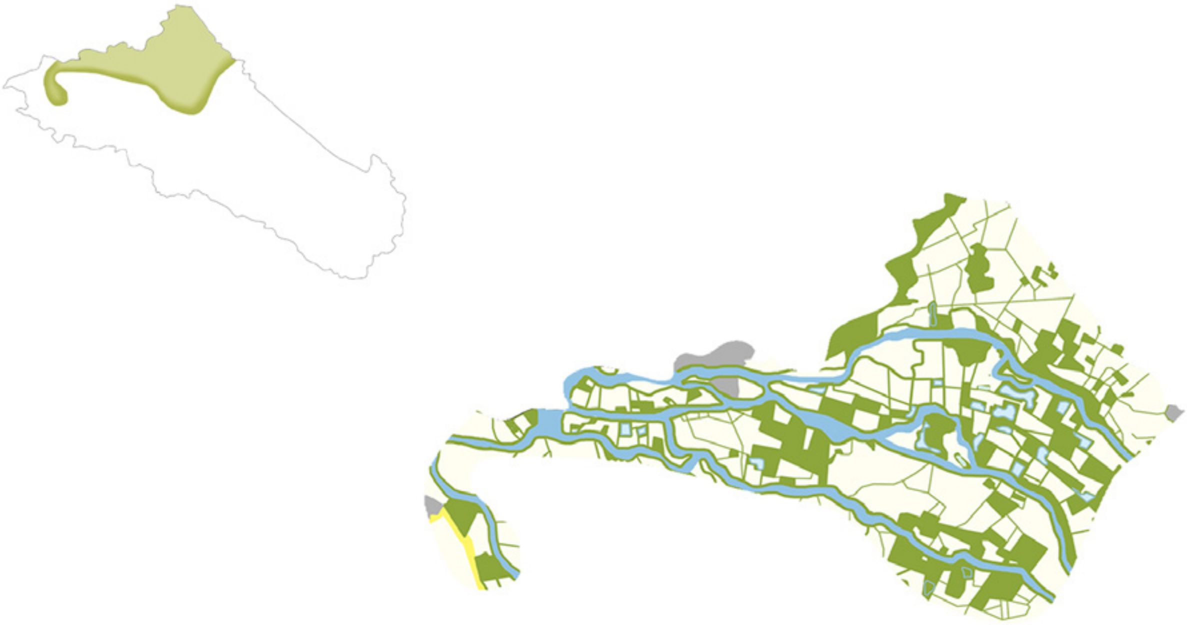


Fig. 5.2 Ideal Vision map of Estate Landscape for W+ scenario in 2050

Estate Landscape

The vision map for estate landscape seeks to rebuild the lost bond between the castles and estates with respect to the Baakse beek stream. At the same time it resolves the problems of the streams due to the climate issues with changes to the integrated water management by retaining the water for longer periods to prevent dehydration in the summers and allocating catchment areas as inundation sites for excess water during heavy rains. The natural quality of the Baakse beek is increased by restoring the meandering course with natural banks to cut through the estates and castles to maintain perennial water in the moats. Weirs are replaced by fish ladders to allow fish migration without any barriers. Provisions for storage of rain water in villages, gardens, public green spaces for further usage in dry climate is proposed. The map seeks to restore the historical Rabat forests and make it visible to visitors as water storage forests. With the small scale agricultural allotment proposal, authentic character of the area is strengthened. This avoids the effects of large scale agricultural activities compared to other areas. The vision map also proposes funded revenue from recreation and smaller portion of lease income for the maintenance of the estates. The recreation possibilities like over night accommodations and theme packages in historic buildings, leasehold dwellings, small farmhouses or retail and hospitality functions with breweries, coffee houses at water mills, restaurants with local produce, sailing routes, riding, etching, hiking, cycling, skating etc are some of the proposed options to strengthen the leisure economy.

Fig. 5.3 Schematic section of Estate Landscape for W+ scenario in 2050

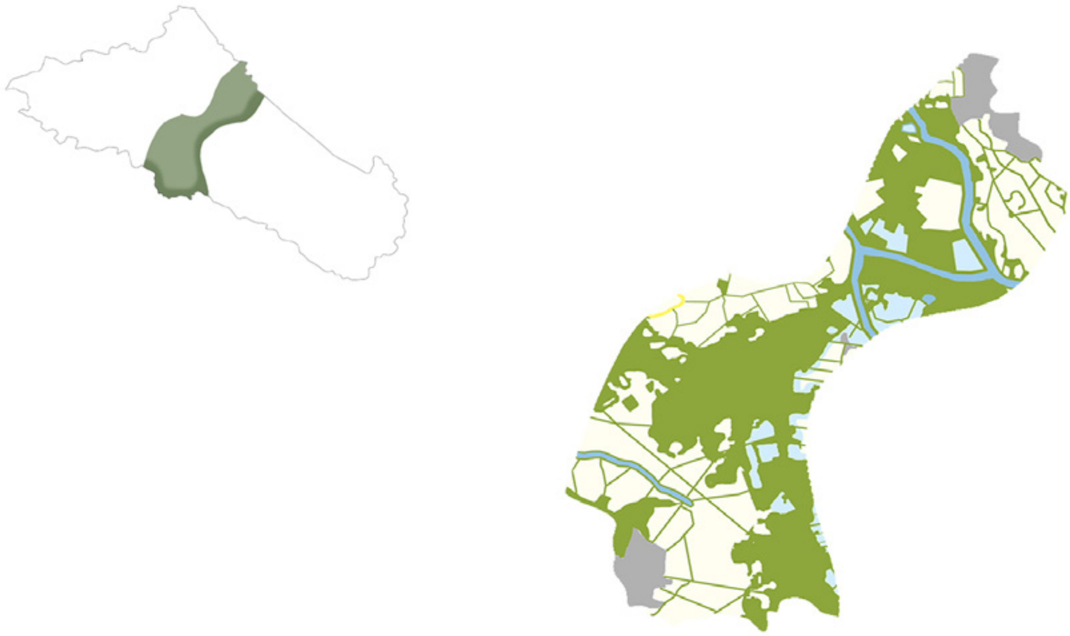


Fig. 5.4 Ideal Vision map of Sand Ridge Landscape for W+ scenario in 2050

Sand Ridge Landscape

The vision map for sand ridge landscape seeks to retain more water for the benefit of the nature and a higher water table. Higher infiltration capacity with water retention in this area can contribute significantly to the sustainability of the groundwater in the area. Additional task for the stream in this area is to provide a more natural character and to improve the ecological and water quality. It is suggested to start buying land for nature close to pig and poultry area in this region. Vision map further suggests redirection of rainwater collected in Van Heeckeren stream to wetlands around pig and poultry farms, which are considered negatively related to social sustainability. Opportunities to experience the water retentions in the form of wetlands and nature is enhanced by including a natural route for nature lovers, joggers, cyclists, hikers and riders through the forests and clearings.

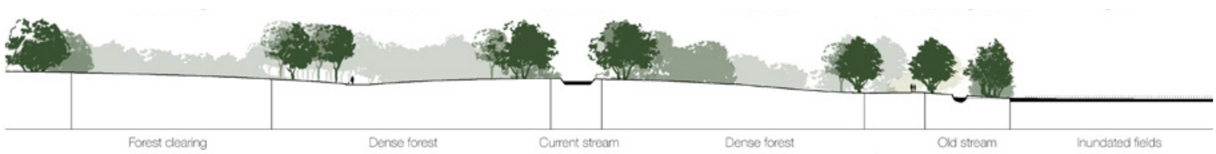


Fig. 5.5 Schematic section of Estate Landscape for W+ scenario in 2050

Fig. 5.6 Ideal Vision map of Peat Landscape for W+ scenario in 2050

Peat Landscape

The vision map for peat landscape seeks to enhance the natural values by strengthening the outline of the old peat extraction structure for a strong habitat connectivity and at the same time finds a better balance between the discharge of surplus water in winter and retention of water to prevent dehydration in summer. By exploiting Veengoot stream as flood discharge with a specific combination of retention, storage and disposal, effects of flooding and can be reduced. With plot level adjustments by landowners and farmers to hold water in the long farm parcels for longer time, drought damage can be prevented with increase in higher groundwater levels and slower discharge. Opportunities to experience the water retentions in the form of wetlands and nature is enhanced by including a natural route for cyclists and pedestrians. The single tree lines emphasize the outline of the landscape structure especially the routes leading to Tolhut and Aalten goor nature reserve.

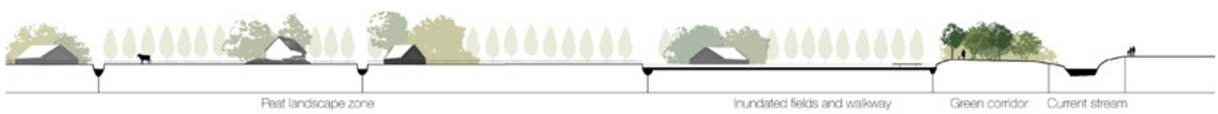


Fig. 5.7 Schematic section of Peat Landscape for W+ scenario in 2050

Fig. 5.8 Ideal Vision map of Camp Landscape for W+ scenario in 2050

Camp Landscape

The vision map for camp landscape seeks to reinforce the authenticity and cultural elements in the landscape. New connection between Veengoot and Baakse beek through the landscape can make way for more water retention in the landscape to allow fluctuations in water table which will reduce the peak flows. Additional landscape features like field margins and wetland strips are envisioned to establish the connectivity for fauna and flora between habitats. This increased diversity also eases typical problems of mono-cultures and reduced usage of pesticides. This explores relationship between landscape, agriculture and public space. The extensive network of church trails in Zieuwent, Harreveld, Marien, Beltrum and Marienvelde which were the public space of the country side, have disappeared largely through land consolidation. This vision map suggests accessibility of the landscape through recreational possibilities for land use dynamics by recovery and creation of new trail networks with plantations and adding resting areas. The cup shaped clusters of connected farms called droebels are the characteristic feature of this landscape. The droebels fulfilled a social function, especially in winter when the occupants were thrown together by floods and bad roads. The increase in farm sizes in W+ climate scenario is compromised by strategic planting of bushes, hedges, solitary trees near stream valley and tree plantings around these droebels overlooking the open and enclosed fields thus emphasizing the surviving remnants of the former droebels.

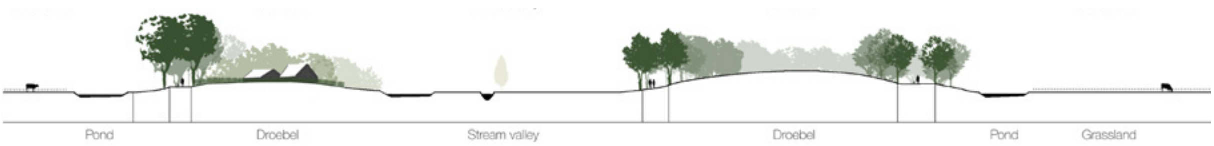
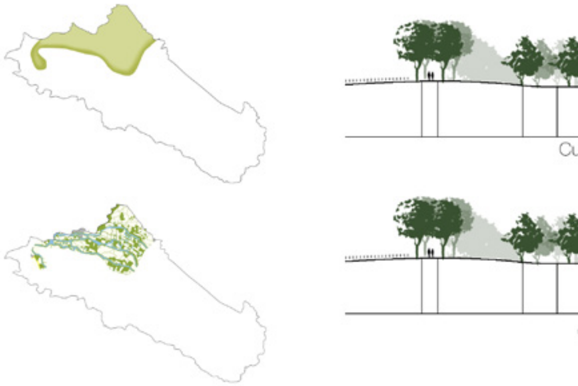


Fig. 5.9 Schematic section of Camp Landscape for W+ scenario in 2050

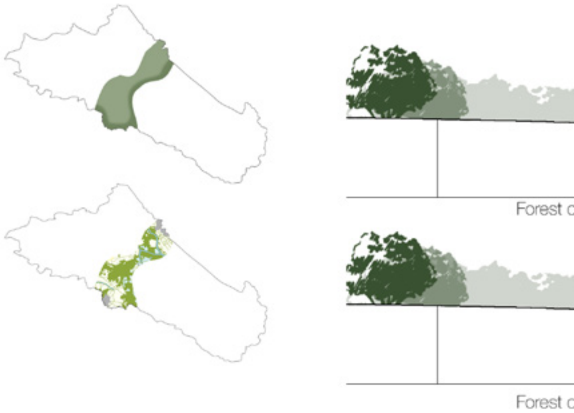
Estate Landscape:

Current stream is redirected to the old meandering course to flow through the estate moat. During extreme wet climate, meadowland inundates. During extreme dry climate, restored Rabat forests acts as water storage forests. With new estates and strengthened green structure, it makes for a new tourist destination.



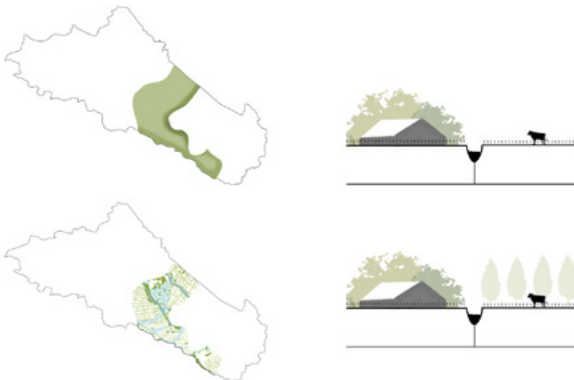
Sand Ridge Landscape:

Almost disappearing old stream course is activated to accommodate excess water and delay the discharge by inundating the fields (sometimes for recreation) next to pig farms. The added nature around pig farms cut down the odor nuisances, which is an important aspect of social well-being.



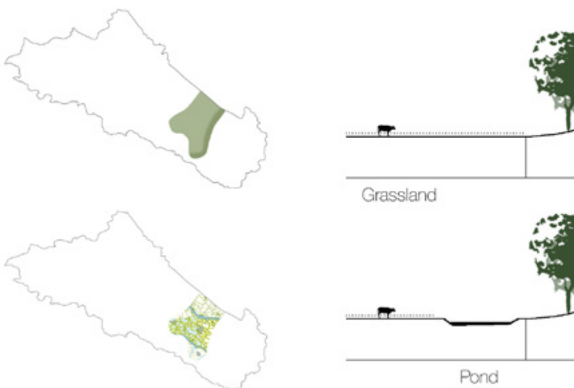
Peat Landscape:

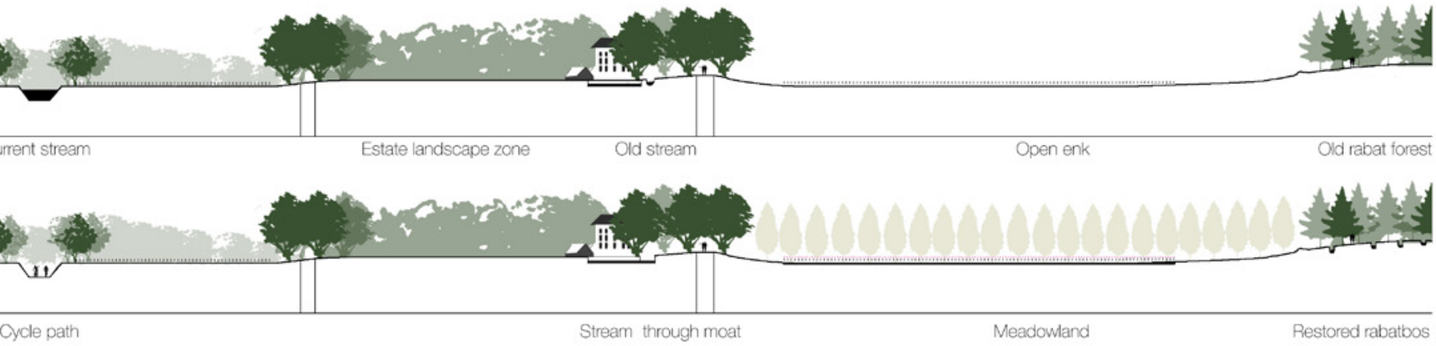
Climate corridor follows the current stream while providing the much required habitat links for species. Thin parcels of old peat grasslands near stream is turned into an experiential wetland to retain the excess water through the stream and delay the discharge speed.

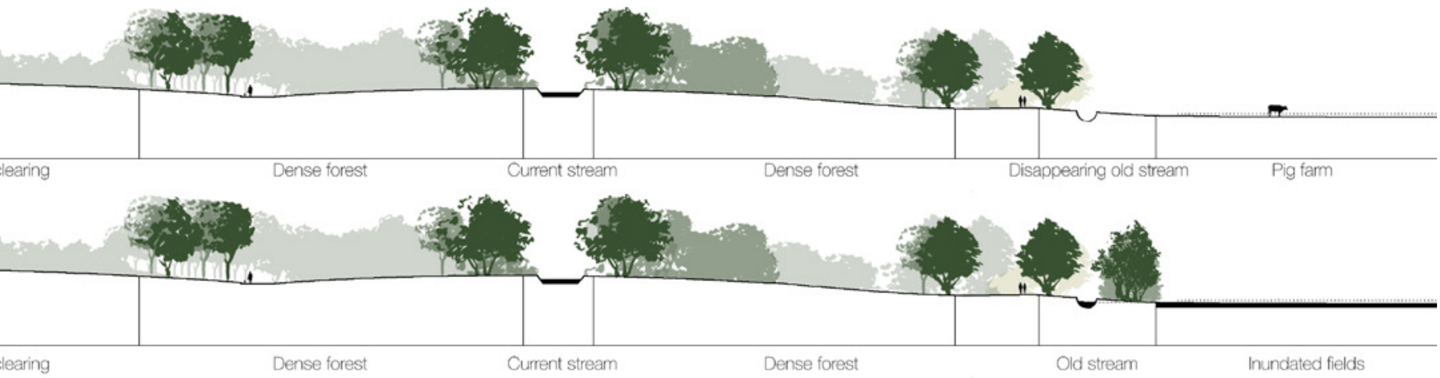


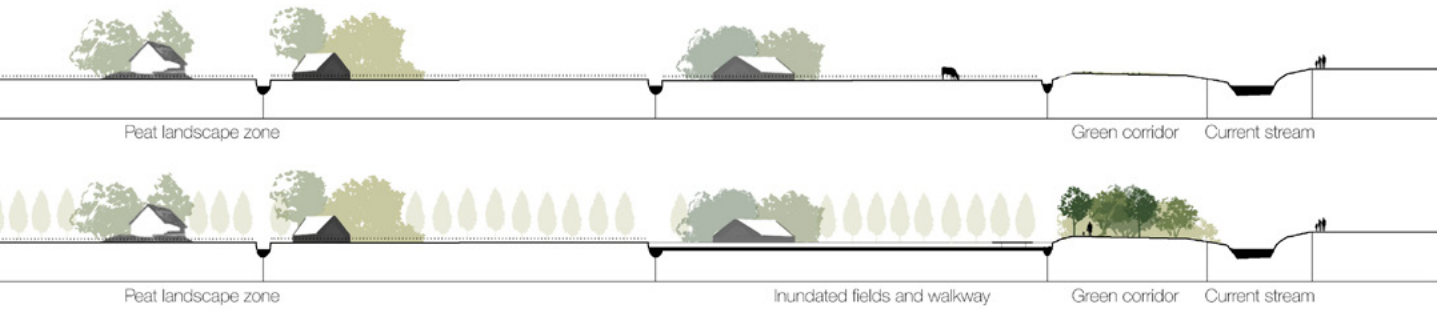
Camp Landscape:

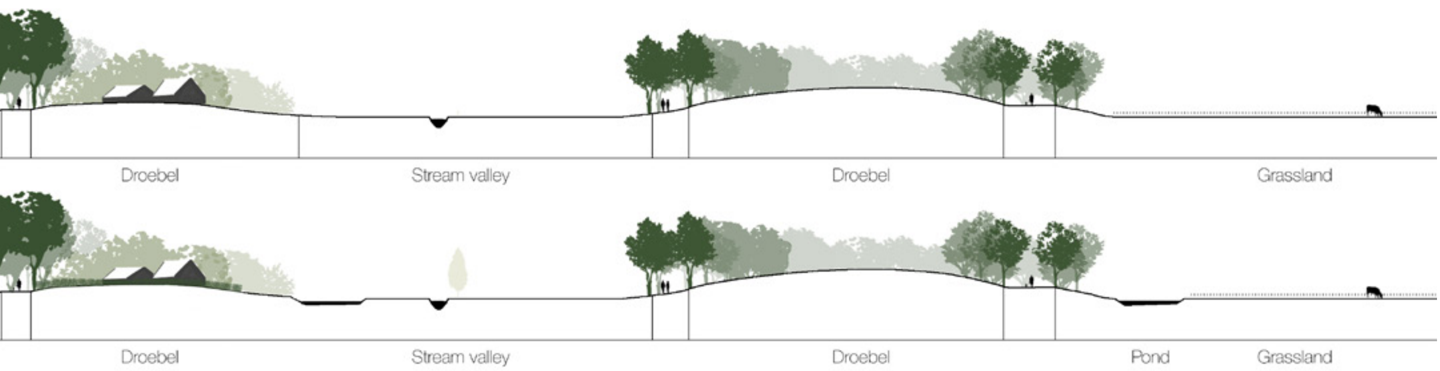
Stream valley which connects the Veengoot and Baakse beek is designed to capture the plantings around the droebels. The landscape elements like hedges and solitary trees are given more importance to retain the identity of the landscape. Droebels drain into retention ponds to recharge ground water level.




urrent stream
Estate landscape zone
Old stream
Open enk
Old rabat forest
Cycle path
Stream through moat
Meadowland
Restored rabatbos


learing
Dense forest
Current stream
Dense forest
Disappearing old stream
Pig farm
learing
Dense forest
Current stream
Dense forest
Old stream
Inundated fields


Peat landscape zone
Green corridor
Current stream
Peat landscape zone
Inundated fields and walkway
Green corridor
Current stream


Droebel
Stream valley
Droebel
Grassland
Droebel
Stream valley
Droebel
Pond
Grassland

5.4 Conclusion

On the basis of the information of the previous segment, two conclusions can be drawn:

1. Because of the climate change and to keep more and strengthen the characteristics of the, more water is needed to be stored in this area. Therefore changes in the water system is suggested in the vision map.
2. For the implementation of the vision plan, few agricultural lands will have to be converted to nature.
3. The vision plan along with slight changes to water system, it proposes change of land use pattern and land use change around the stream area which are critical for sustainable environment. The functioning of the proposed interventions needs to be tested. Hence computer generated models are needed to understand the feasibility of such proposal where involvement of stakeholders, farmers, animals, vegetation etc. needs to be considered.

The next step to this project is strengthening a portion of the vision map to closely understand the proposals and how it benefits the different users of the area in the current and future scenario. The chapter 6 illustrates how the principles suggested in this chapter 5 can be converted to design interventions.

6

DESIGN OPPORTUNITIES

6.1 Introduction to design process

As discussed in the previous chapter, the changes in climate affects agricultural and rural development of Baakse beek. Searching of the impacts of climate change and answering the sixth research question:

6. What are the impacts of climate change on land use and natural environment?

Although the vision map provides the most ideal conditions for the future development of Baakse beek, it is essential to evaluate whether these proposals are sustainable, and needs to be tested at farm and landscape level. The first segment 6.2 illustrates the results of these tests which could later guide the decision makers in spatial planning of Baakse beek and its climate change adaptations. Different land users are interested in different dimensions, for example, income is more important for a farmer, whilst biodiversity values may interest a nature manager and landscape amenities for a citizen. This implies choices between production and income on the one hand and social and environmental services on the other hand. This chapter focuses only on the environmental and social services in the Estate landscape zone, Sand ridge landscape zone, Peat landscape zone and Camp landscape zone. Ultimately, these services create new potential hot-spots in the vision plan of Baakse beek keeping in mind the needs of the end-users.

The information derived about the feasibility of the nature and land use targets under future climate obtained in the previous segment, is used to timely design a climate corridor for the adequate measures in the segment of 6.3. It is further visualized in four specific landscape types.

6.2 Test for landscape spatial configuration

The Baakse beek was an excellent testing ground for the use of a number of scientific models (Fig. 6.1) for landscape development. Large amount of data was calculated on what changes will occur in the physical environment of Baakse beek in the W+ scenario. This resulted in a majority of negative economic (dairy gross margin, arable gross margin, economic efficiency, milk production), environmental (global warming, terrestrial and aquatic eutrophication) and social impacts (farm size, number of farms, nature area, odor) (Reidsma, 2015). In order to make sure the new proposal to be designed benefits the economy, environment, society and biodiversity, results of a set of computer generated models is used.

Spatial model -RULEX (RUral Land EXchange) (Reidsma, 2015) – focuses on climate change effects on land use and aims to integrate agriculture and nature (land use change; changes in land ownership; farm size; budget for nature development). Scientific model -PROBE (PRObability Based Ecological target model) (Witte, 2015) predicts the effects of climate change on natural vegetation at a regional scale of this region and calculates whether, changes in water management attitude and climate are natural. Scientific model –METAPOP (METAPOPulation model) (Van Teeffelen, 2015) calculates how well animals can survive nature network with climate change.


Agricultural Systems

Sustainable agricultural development in a rural area in the Netherlands? Assessing impacts of climate and socio-economic change at farm and landscape level

A probabilistic eco-hydrological model to predict the effects of climate change on natural vegetation at a regional scale

Is green infrastructure an effective climate adaptation strategy for conserving biodiversity? A case study with the great crested newt

▲
Fig. 6.1 Research articles of RULEX, PROBE and METAPOP scientific models

Intermezzo- Climate change impacts on land use

Climate change of W+ scenario has an impact on the future land use in rural areas. The catchment area of the Baakse beek consists of 85% of farmlands. With agriculture being the major land use type, effects of climate change were calculated (Fig. 6.2) (Reidsma, 2015). Based on W+, the dairy gross margin, farm sizes and aquatic eutrophication has negative impact. Therefore under these extreme conditions a choice was made to study only the negative impacts of climate change on social dimensions i.e., the change in the future farm size and type to achieve a sustainable agricultural and nature development in the Baakse beek area.

Dimension	Indicator	Unit	Current	Sign of impact
Economic	dairy gross margin	euro/farm/year	98000	+
	arable gross margin	euro/farm/year	40854	+
	dairy output/input	euro/euro	1.90	+
	milk production	ton/year	333491	+
Social	farm size	ha	22.5	-
	number of farmers	#	1349	+
	nature area	ha	1731	+
	area pigs & poultry (odour)	ha	1341	-
Environmental	global warming	kg CO2eq/ha/year	13510	-
	terrestrial eutrophication	NH3 emission/ha/year (in kg N)	65	-
	aquatic eutrophication P	kg P/ha/year run off	1.9	-
	aquatic eutrophication N	NO3 leaching/ha/year (in kg N)	15.5	-

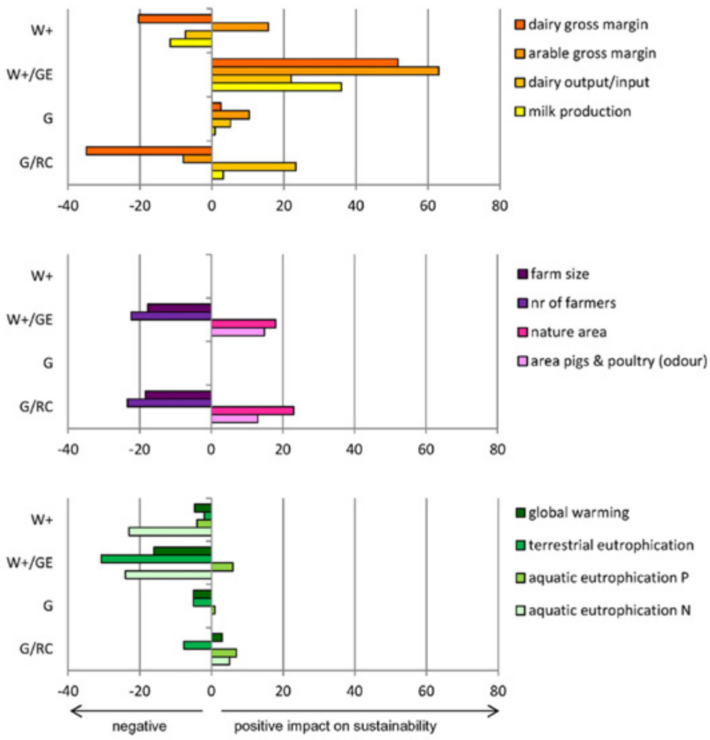


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Fig. 6.2 Impacts of the W+ scenario on three dimensions of sustainable development in the Baakse beek area (Reidsma, 2015).

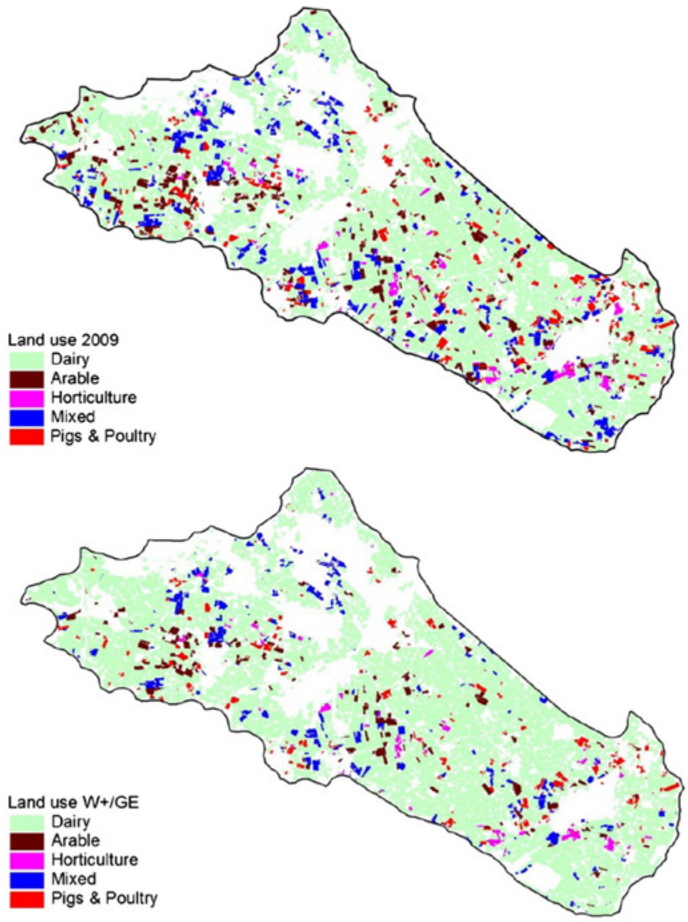

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Fig. 6.3 Current and projected land use in the area for the W+ scenario for 2050 as simulated with the RULEX model *(Source: Reidsma, 2015)*

The majority of farmers in this area are dairy farmers, amongst other crop farmers, horticulture farmers, pig breeders, and poultry farmers. The area of pigs and poultry farming is based on RULEX, and is considered negative for sustainable agricultural development. The pig and poultry farms, which are known for odor nuisances and an important aspect of social well-being, showed that the probability of people in that surrounding area are sick easier and pig and poultry farms expanding in that area was high and hence, it is suggested to start buying land for nature close to them for nature development.

According to the predictions for W+ scenario, the landscape diversity in the current landscape

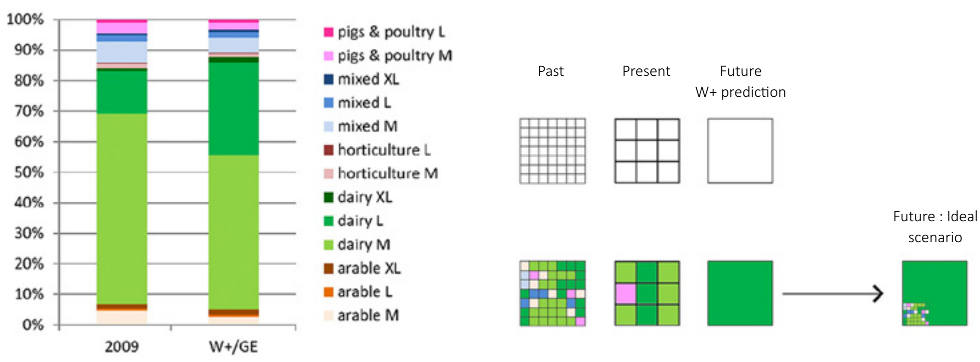

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Fig. 6.4 Baakse beek's projected farm structural change based on land use type and size category according to RULEX, in W+ scenario for 2050 *(Left- Source: Reidsma, 2015)* Own illustration for an ideal scenario *(Right)*

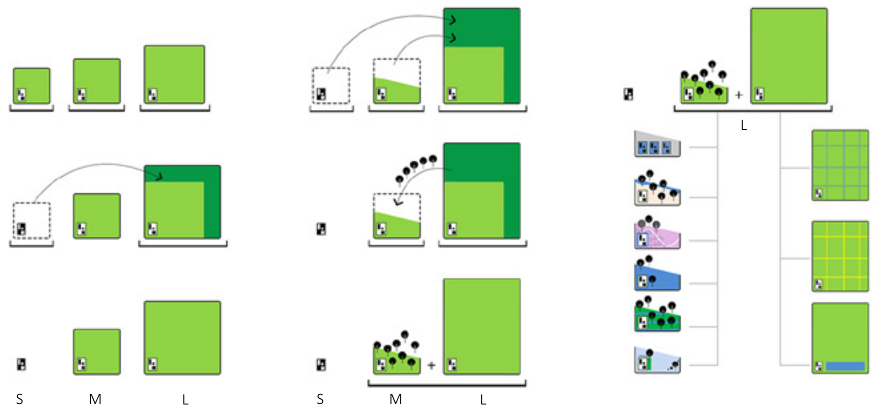

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Fig. 6.5 Scheme of small and medium-sized farmers sell their land to the large-scale land farmers in exchange for landscape features that are not profitable *(Based on the illustrations by R. van Paridon & K. de Groot, 2004)*

(farming type) will reduce further if nothing is done(Fig. 6.4) and the size of the farms will increase by 2050. In the perception of many, smaller farms are better for rural vitality and the landscape; while larger farms are associated with larger fields and fewer linear elements such as hedgerows. Moreover, although larger farms may be more economically viable, large capital investments may also make them more vulnerable to shocks. By a mutual exchange of valuable landscape features (Fig. 6.5) for barren lands with large farms, small and medium sized farms can profit and also contribute to the objectives of nature organizations of maintaining the landscape elements like hedgerows, solitary trees, rebate forests, water retention areas etc. that are present in the large farms.

Intermezzo- Climate change impacts on vegetation

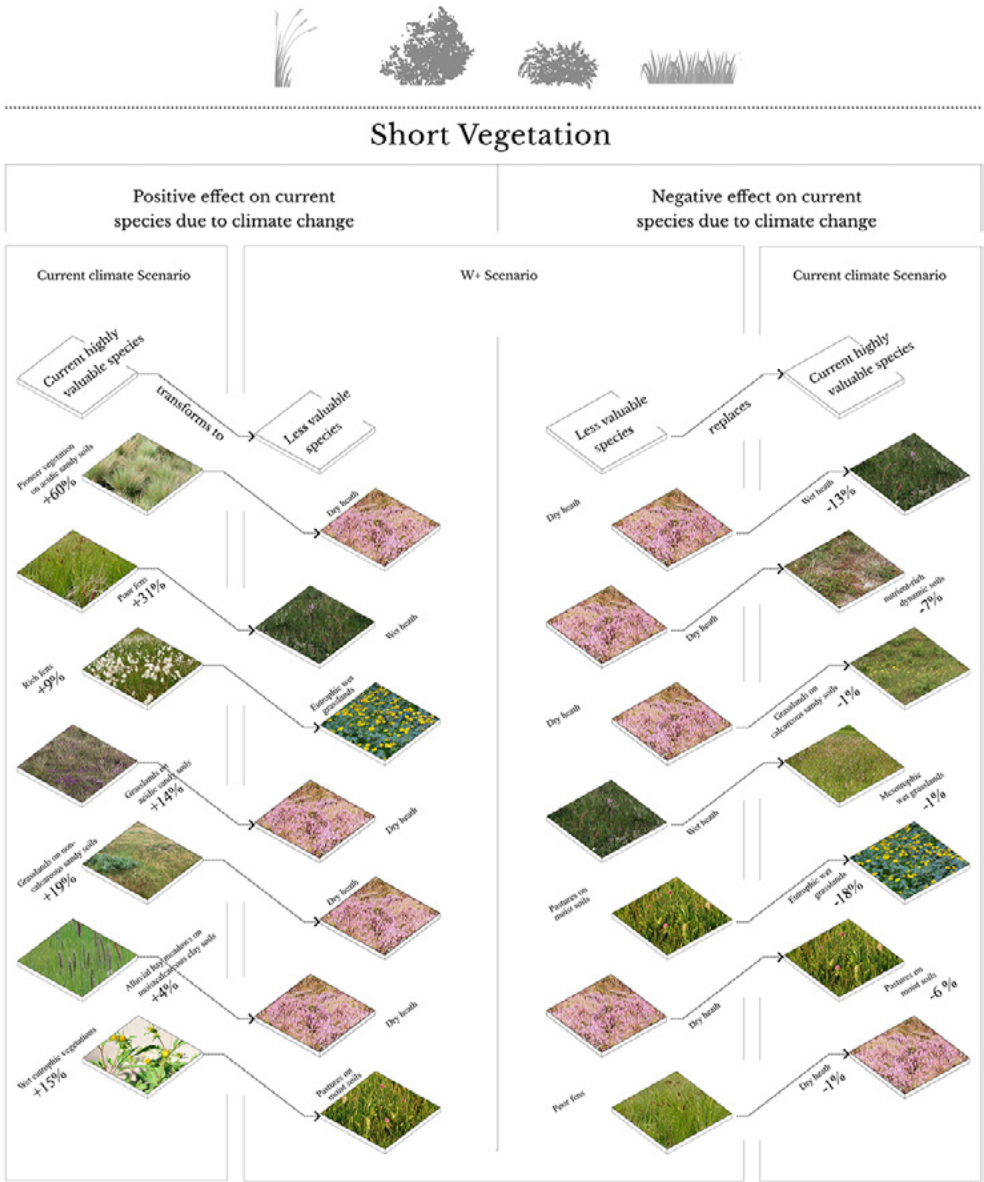

Fig. 6.6 (a) Short vegetation typology and valuation matrix *(Own illustration)*

Climate change impacts on natural environment - Flora

Scientific model -PROBE (PRObability Based Ecological target model) (Witte, 2015) predicts the effects of climate change on natural vegetation at a regional scale and calculates whether, changes in water management attitude and climate are natural. The model shows that the drier summers in the warm W +-scenario, can cause damage to wet grasslands rich of species. It mainly indicates where valuable vegetation can thrive. That may be the best land for nature.

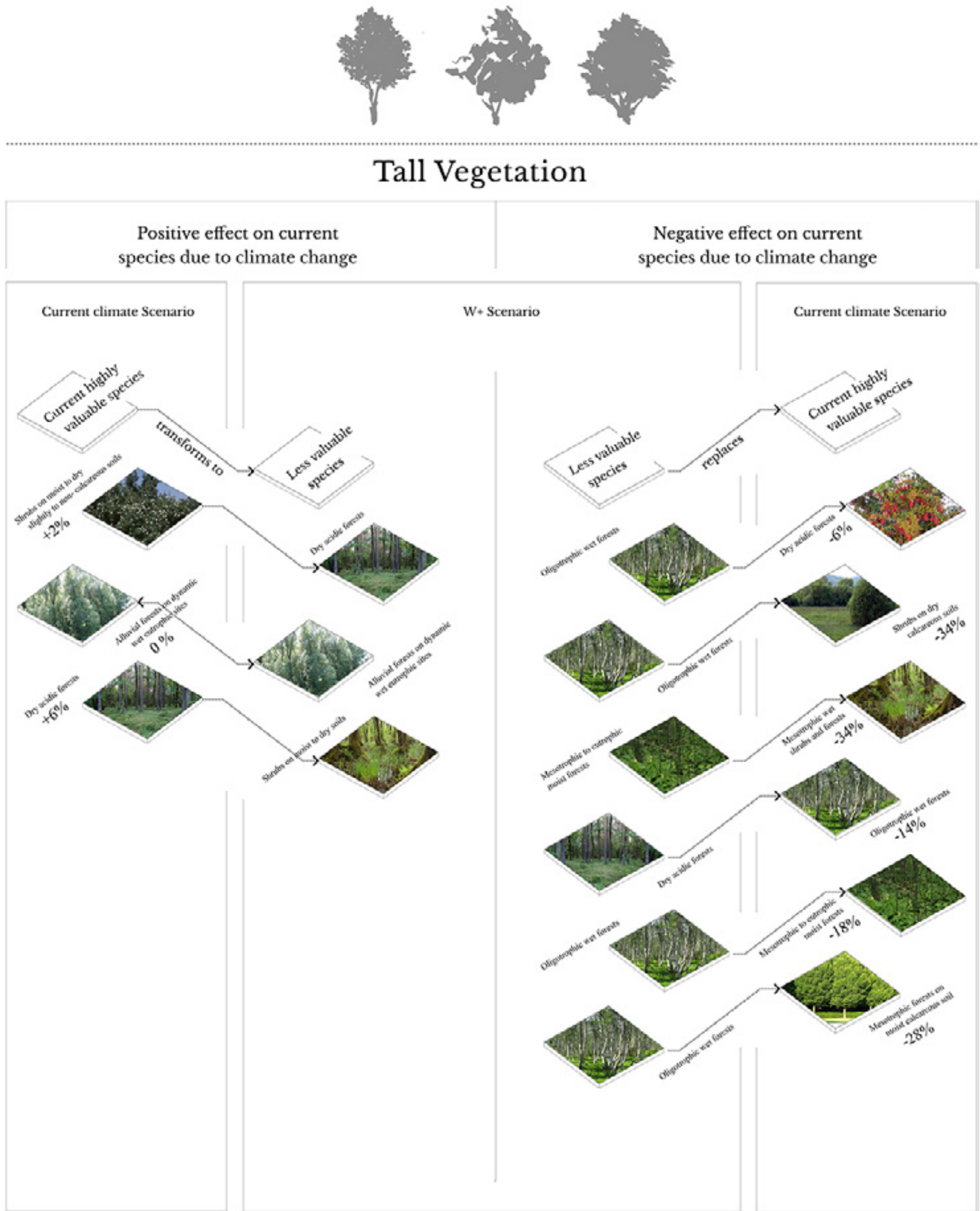

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Fig. 6.6 (b) Tall vegetation typology and valuation matrix *(Own illustration)*

A couple of typical short and tall vegetation of the area were classified in a typology table (Fig. 6.6 a and b). The table shows the current rich species might be replaced by a less richer species in the W+ scenario thus posing a threat to the rich species and simultaneously changing the way the landscape will look in the future. The conclusion is that, the W + scenario is going to be very difficult for the wet nature types such as Junco-Molinion and Calthion palustris grasslands, while vegetation of dry and acidic soils seems to profit from this scenario.

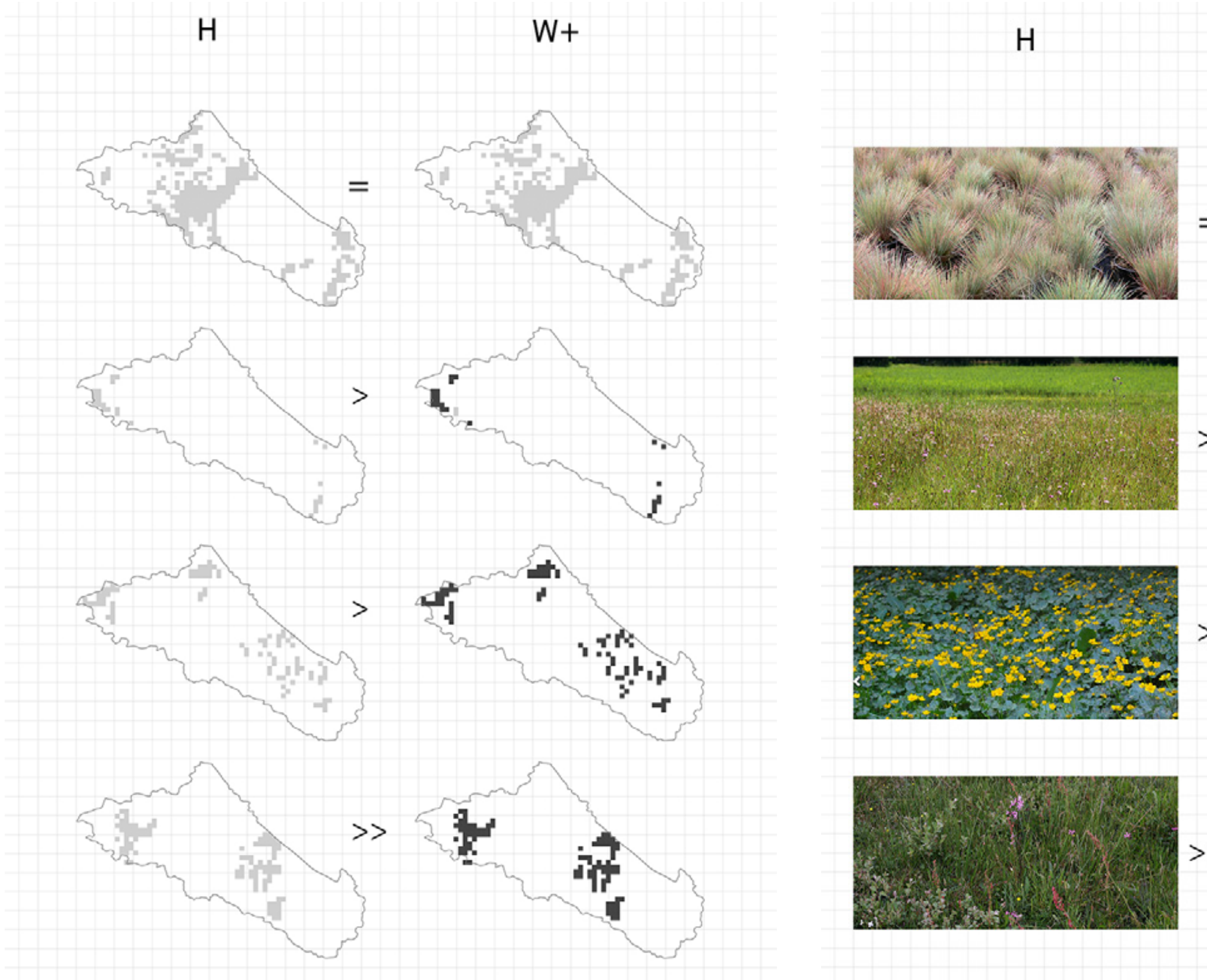
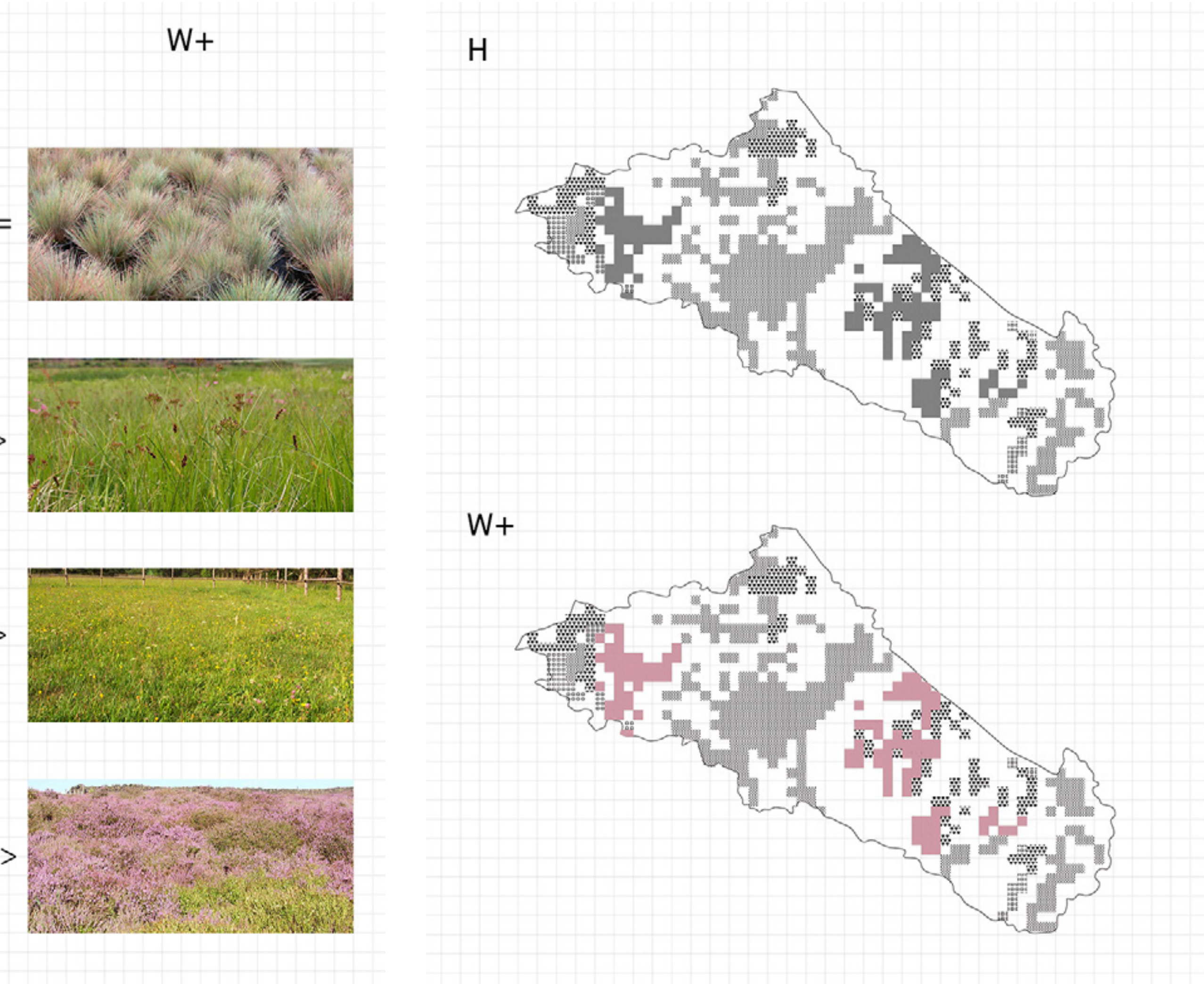


Fig. 6.7 Potential occurrence probability of short vegetation Corynephorion canescentis (A), Junco-Molinion (B), Calthion palustris (C), and Ericion tetralicis (D) (left, center) *(Based on: Witte, 2015)*, as well as absolute change in vegetation as a result of the W+ scenario (2050) *(right- own illustration)*

▷

In order to recognize the areas that are going to be affected in W+ scenario by 2050, above maps were produced by PROBE which helps in recognizing the nature targets and direct the land-purchasing activities to those areas with the highest potential for nature development. The above maps (Fig. 6.7) show that out of the four vegetation types, three of them will be replaced by a less rich vegetation in future due to climate change



(represented in pink color in the map on the right). In terms of abiotic conditions, the ground water level at the central part of the study region is relatively low to facilitate agriculture. Thus indicating a highest potential for vegetation development and water management in the east of the Baakse beek watershed.

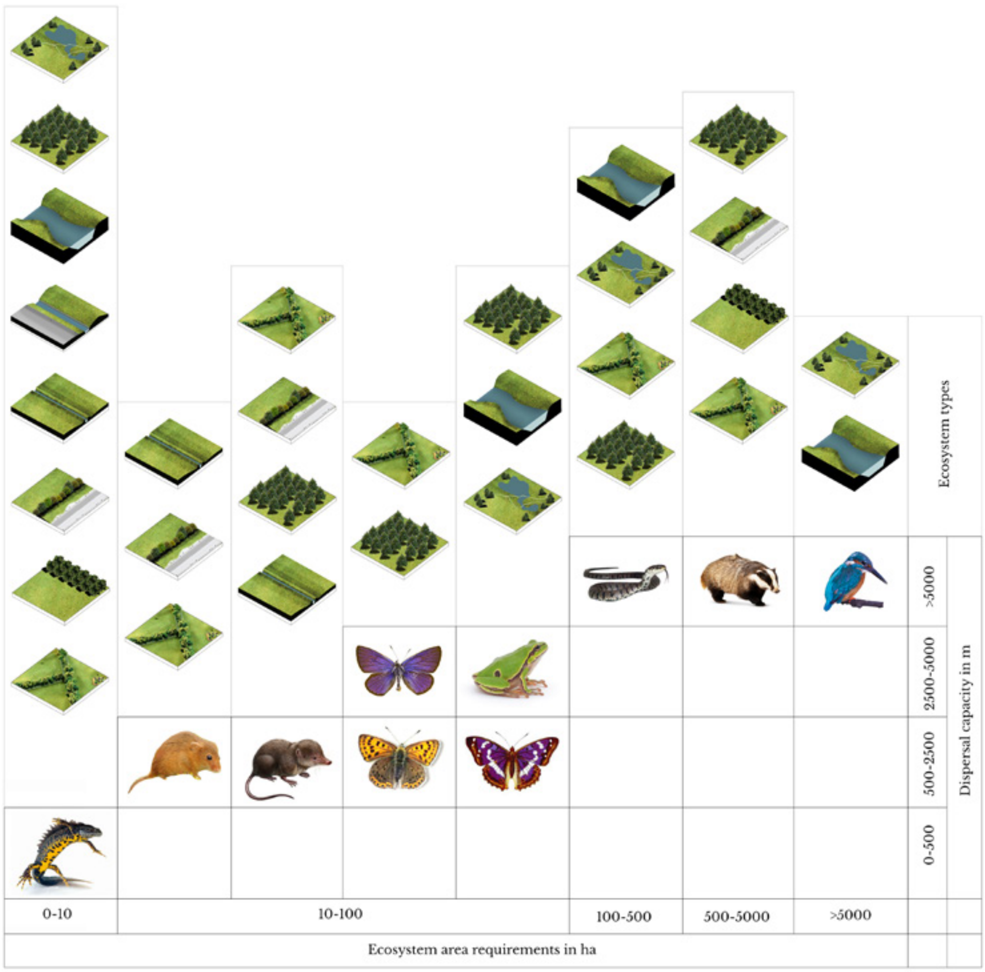


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Fig. 6.8 Matrix of ecosystem types of characteristics species of Baakse beek, ordered according to dispersal capacity and ecosystem area requirements

Climate change impacts on natural environment - Fauna

Scientific model-METAPOP (Van Teeffelen, 2015): suggests a nature network path for animals to survive in Baakse beek area with climate change. This approach also forms a useful tool for the predictions about the spatial conditions of the landscape. Of the elaborate Eco-profile matrix of the species found in Baakse beek area (Fig. 6.8), the Great Crested Newt and Badger were selected as a model species, because they are the characteristic species for the Baakse beek area who are 'vulnerable' on national red list. They are amphibians and depend on terrestrial and aquatic habitats and are sensitive to climate change. Fig. 6.9 shows the missing link between key habitat areas of great crested newts and badger in the central area of Baakse beek watershed according to the W+ scenario predictions. This indicates that when a water body is lacking after 500m, the distance between the habitats becomes an obstacle for dispersion. To identify in what spatial configuration additional habitat would be effective as a climate adaptation

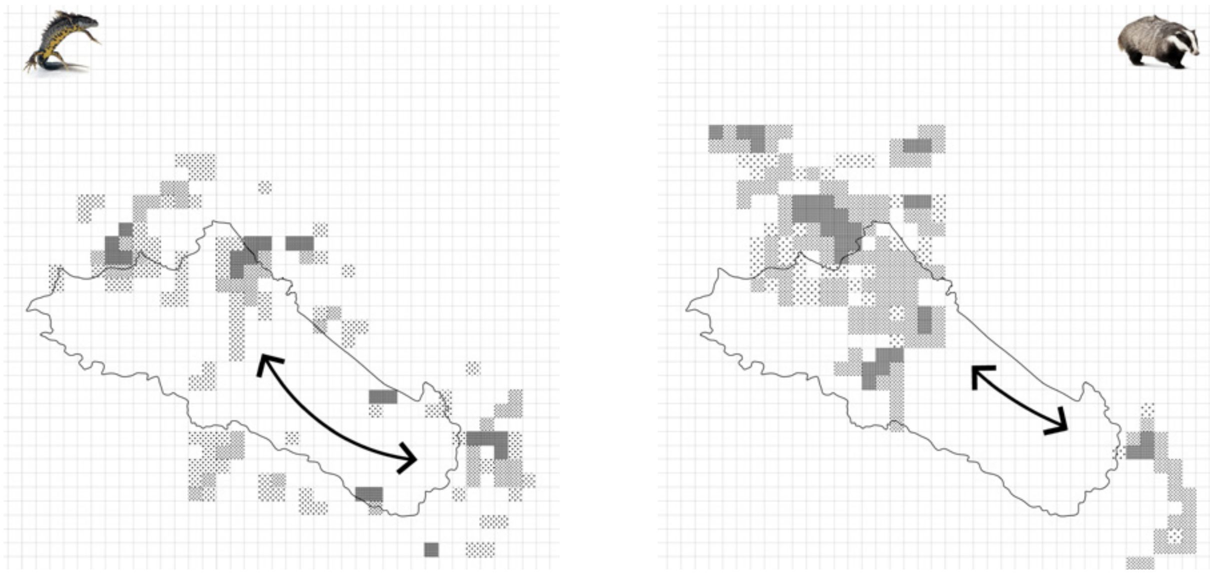

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Fig. 6.9 Missing link between key habitat areas of Great crested newts (Left) and Badger (Right)
(Based on: Van Teeffelen, 2015)

▲
Fig. 6.10 Spatial configuration of additional habitat in four different landscape scenarios- A: Narrow zone; B: Broad zone; C: Enlarge areas; D: Optimal zone *(Source: Van Teeffelen, 2015)*

strategy, four different landscape scenarios were tested as shown in the Fig. 6.10. In the Narrow Zone (A) and Broad Zone (B) scenarios, habitat was added in the form of green infrastructure, which resulted in relatively low terrestrial habitat density. Subsequently, the ponds that were added to these zones, had mostly low carrying capacity. Hence, although potential connectivity increased, meta population viability did not improve despite these additional ponds. Habitat density and associated pond quality was higher in the Enlarge areas scenario (C), and particularly in the Optimal scenario (D). In response to these findings, Optimal scenario (D) was developed as a potential solution for the Baakse beek area, which provided both dispersal habitat and reproduction habitat to the central part of the thesis area, and the occupancy patterns indicated a functional link between the southern and the northern strongholds in the region, also under more severe climate scenarios.

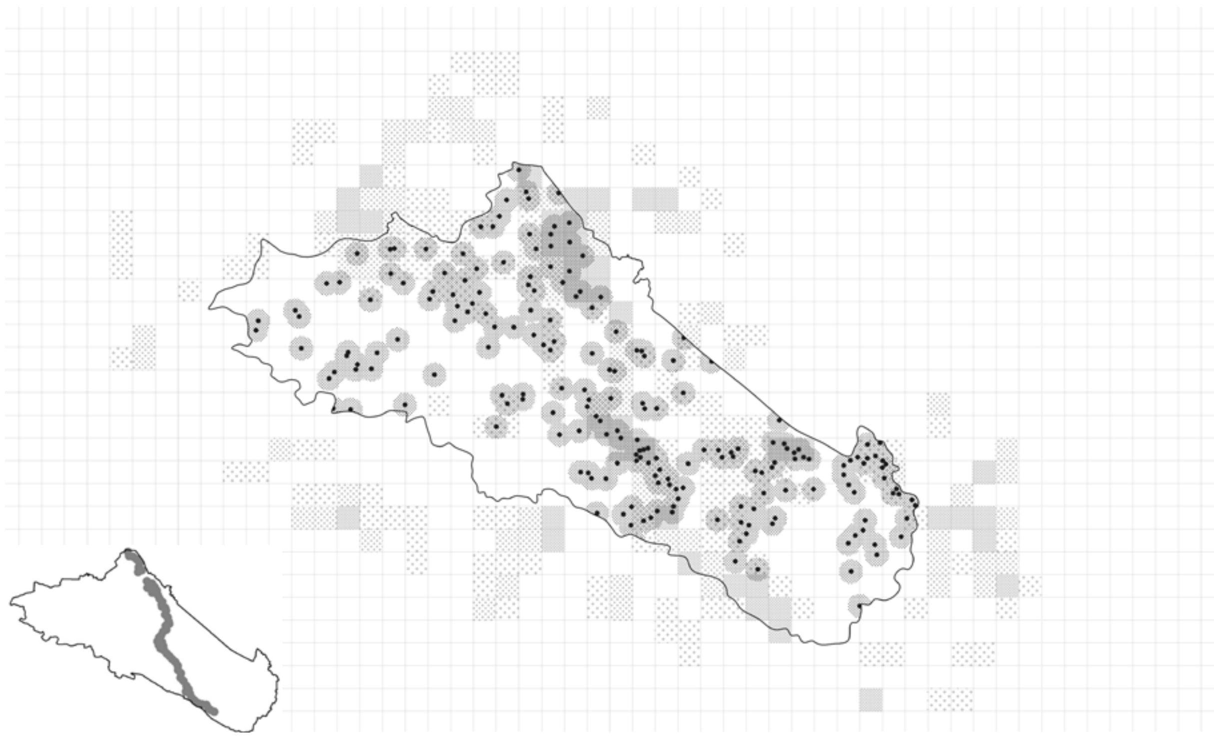

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Fig. 6.11 Concentration of ponds in the Baakse beek area; Optimal landscape scenario (D) for the habitat connectivity (inset) *(Source: Van Teeffelen, 2015)*

Metapop study revealed that, pond desiccation as a result of summer drought is a concern in the Baakse beek area. Its impact is expected to become a serious bottleneck in the W+ climate change scenario. A map with current locations of ponds (Fig. 6.11) was made, which is surrounded by a rich terrestrial habitat for the considered species. Strategically locating new ponds and improving the terrestrial habitat around ponds with suitable abiotic conditions is therefore of crucial importance. For those one square kilometer grid cells within the zone that did not contain at least two ponds, one or two additional ponds were added in a random manner, to ensure that in every square kilometer of the zone a minimum of two potential reproduction sites was present. In this way a pond network is established in this project to connect the ponds in the core zone with the key habitat area of the Eco-profile Great Crested Newt and Badger in the southwest of Marienvelde.

An alternative measure to overcome these impacts, however, would be the elevation of the ground water table which would reduce the vulnerability of ponds to desiccation. Such a measure might conflict with short term agricultural objectives for the region, but also agriculture will benefit from higher groundwater tables at the longer term, especially in the W+ scenario where summer drought decreases agricultural yields, esp. in the camp landscape zone.

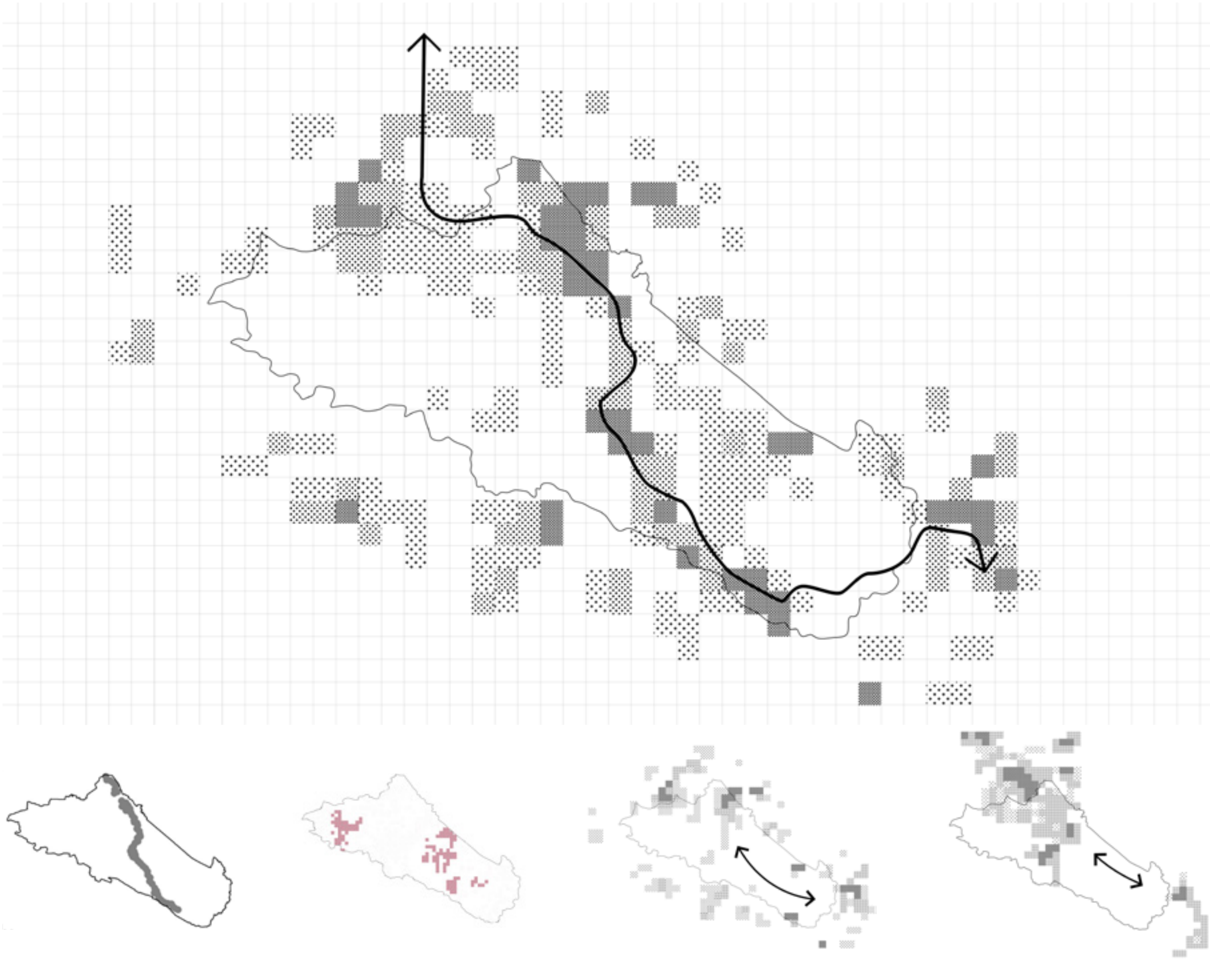

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Fig. 6.12 Spatial configuration of the climate corridor (above) based on the results of climate impact studies on land use and natural environment (below)

6.3 The climate corridor proposal

The climate change impacts on land use and natural environment allowed a deduction of a set of landscape design rules that incorporated both spatial and abiotic requirements that can be expected to result in more effective climate corridor through Baakse beek watershed. The above Fig. 6.12 shows the results of all the approaches. The approach allows to assess concrete spatial configuration options in the face of climate change, as it mechanistically combines the following to form a climate corridor which aims to provide a complete infrastructure when combined with water management.

1. Land use strategies involving stakeholders to deal with small and large farm exchange approach.
2. Potential spatial habitat for vegetation types.
3. Potential spatial habitat for animal species.

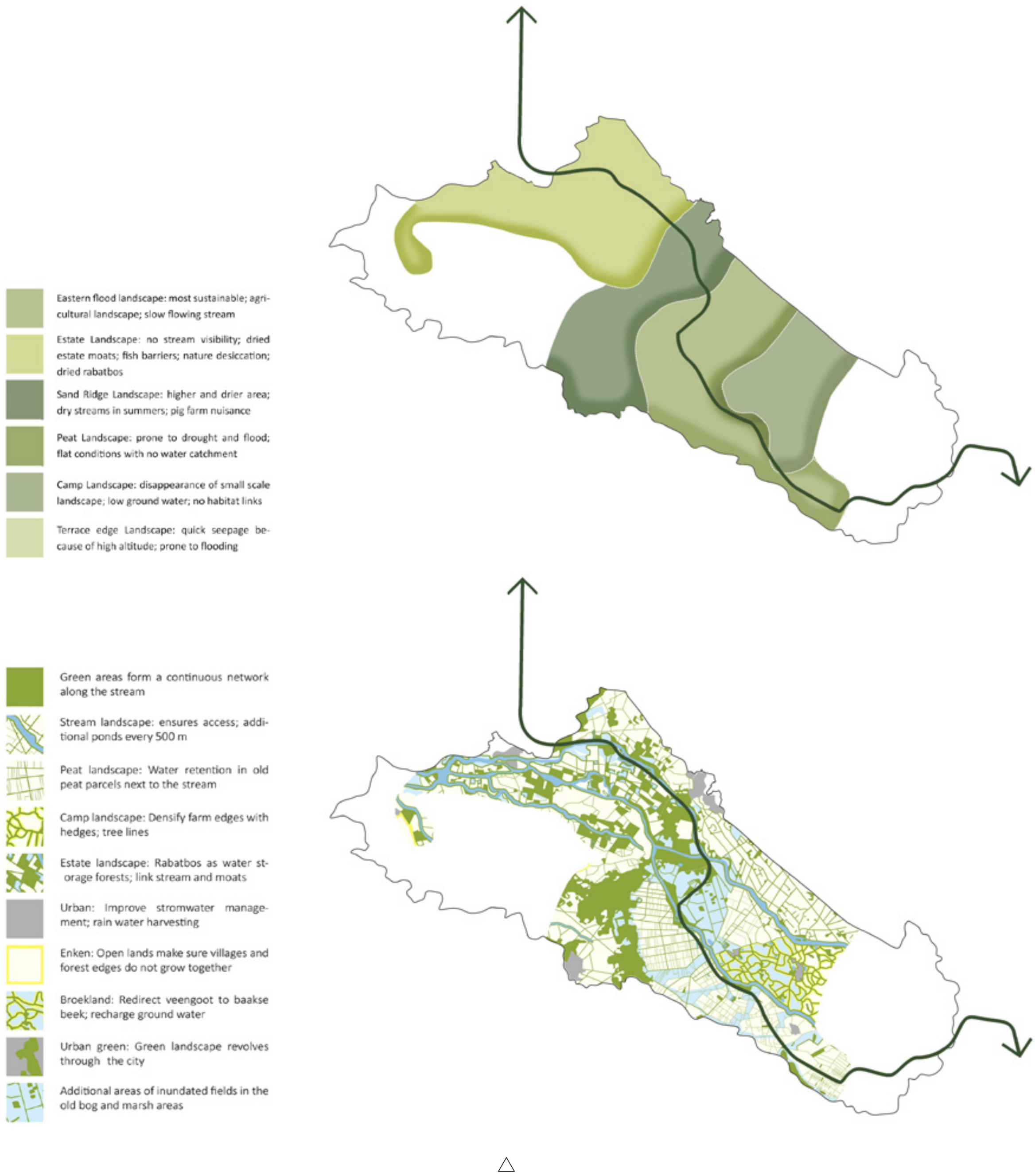

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Fig. 6.13 Spatial configuration of the climate corridor through current landscape types (above) and future ideal vision map (below)

The climate corridor proposal explained in the previous segment is overlaid on Baakse beek landscape typology cutting across four landscape types. Fig. 6.13 shows the corridor aligned on the vision map. The area around the corridor in the vision map alone is further strengthened in this thesis. The corridor aims to achieve all the principles set by the ideal vision map. The corridor's width varies and merges to take the shape of the respective landscape type. The overview of the corridor and the design opportunities at four spots is shown in the fig. 6.15.

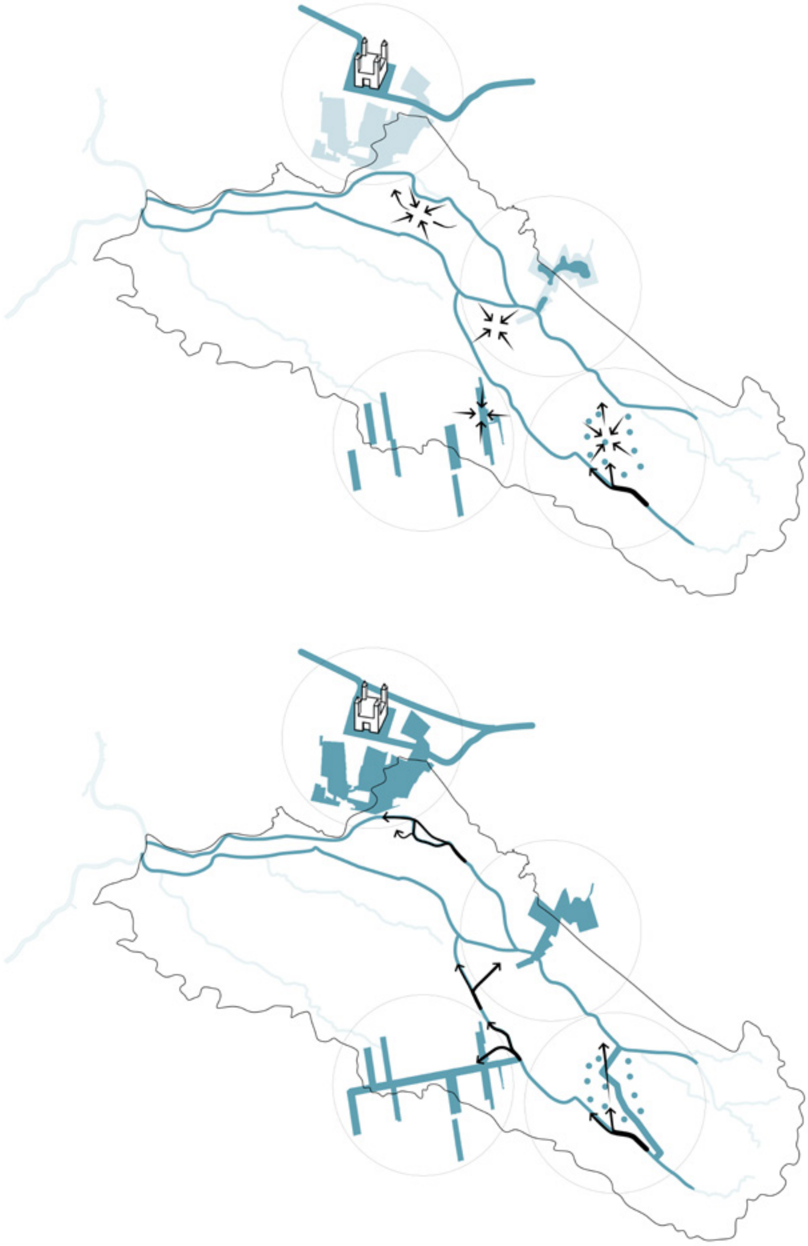

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Fig. 6.14 Proposed water management at Estate, Sand ridge, Peat and Camp landscape for Baakse beek during dry (above) and wet (below) season

Water retention, storage and discharge

According to the vision plan, the water system is designed to minimize the risk of seasonal drought and flood and retain more water to balance the surface and ground water levels. Four hot spots shown in the fig. 6.14 is focused on the retention of water in the streams and also in the soil. The adjustments in the streams also work with the surroundings so that water contributes to an attractive rural environment. Where possible the excess rainwater to allowed to sink into the ground, in order to replenish the groundwater reserves. The retention zones in the four spots varies in shape and merges with the respective landscape type. This is visualized in the next segment of this chapter.

Fig. 6.15 Overview of Baakse beek climate corridor and four design intervention sites ▷


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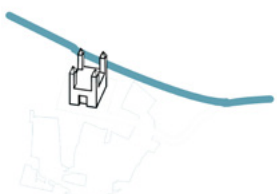


Fig. 6.16 Existing conditions in Estate Landscape

Moist forests Baakse beek Houses
Rabat forests Inundated field

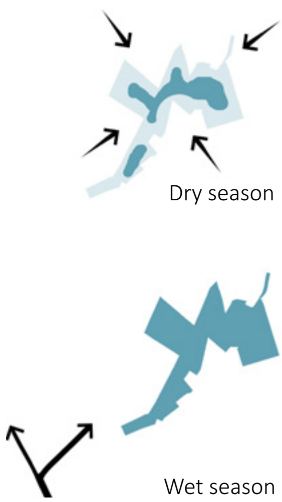
Fig. 6.17 Proposed conditions in Estate Landscape

Estate landscape - Site 1

Dominated by estates and castles, the estate landscape is known for its heritage and cultural value. The problematic associated with this zone and possible solutions to that were earlier explained in the chapter 4 and 5 respectively. The dry estate moats in the current conditions (Fig. 6.16) have become a common scenario and will continue to exist in future. By allowing the stream to flow through the estate moats (Fig. 6.17), the dry moats can be avoided and the scenic value of the estate can be restored. In the historic times, the culturally rich Rabat forests were planted for the production purposes. However, the design suggests a restoration of these forests and emphasizes on achieving a strong habitat connectivity between them as part of the climate corridor. A natural bank for the stream edge is also suggested which is a prerequisite for the dispersal of climate sensitive species like great crested newts and badger.

◁ Fig. 6.18 Existing conditions of stream in Sand Ridge La

Forests | Stream | Houses
New nature | Water retention



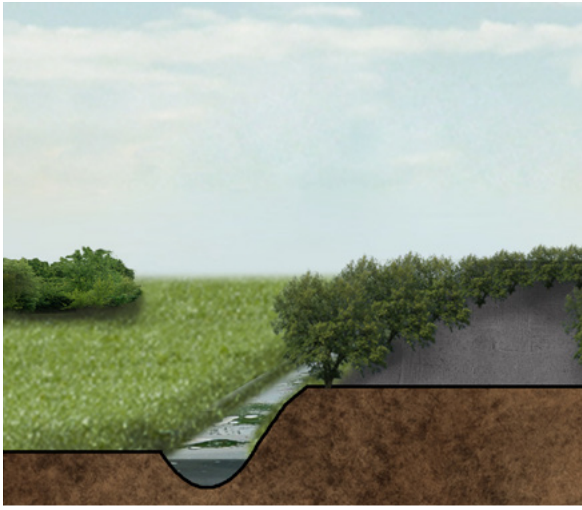
◁ Fig. 6.19 Proposed conditions of stream in Sand Ridge

Sand ridge landscape - Site 2

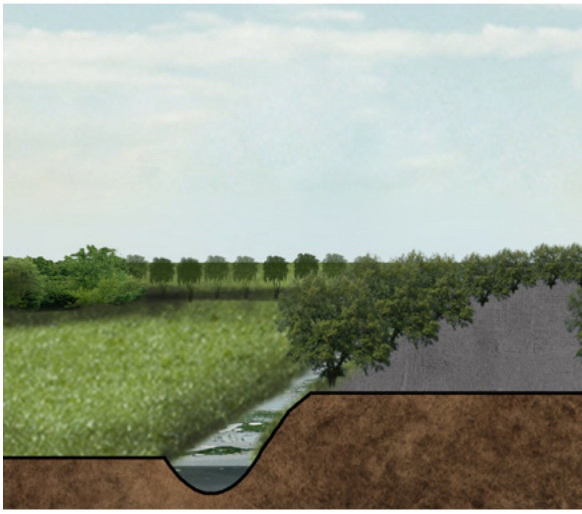
The sand ridge landscape as explained in the chapter 4 and 5 is dominated by the moist and deciduous forests. The presence of multiple poultry and pig farms in this area (Fig. 6.18) and its positive development in the future for W+ (climate impacts on land use) is a matter of concern for the surrounding residents and visitors of the region. The low infiltration capacity of this region (analyzed and studied in chapter 3) and the necessity for water retention areas is taken into account while proposing new nature as part of the climate corridor next to pig and poultry farms (Fig. 6.19). The added nature around these farms cut down the odor nuisances, which is an important aspect of social well- being while providing space for water storage to improve soil moisture holding capacity.

andscape

Landscape



◁ Fig. 6.20 Existing conditions of stream in Peat Landsca



◁ Fig. 6.21 Proposed conditions of stream in Peat Landsc

Peat landscape - Site 3

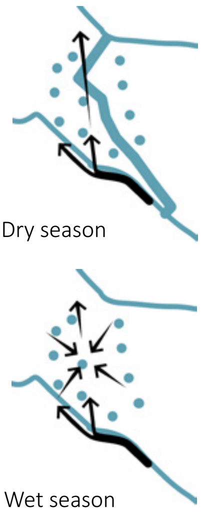
The Peat landscape with its flat conditions and high ground water table, is prone to drought during summers. The Veengoot stream which passes through peat landscape, has a very high discharge speed (chapter 3). This is dealt with in design by proposing experiential wetlands next to the streams on the thin parcels of ancient peat grasslands to delay the speed. This corridor also provides the much required habitat links for species like Great Crested Newts and Badgers. The climate corridor also takes the shape of single tree lines that emphasize the outline of the landscape structure especially the routes leading to Tolhut and Aalten goor nature reserve.

pe

cape

◁ Fig. 6.22 Existing conditions of stream in Camp Landsc

Droebels
Field margins
Stream
Ponds
Farm houses



◁ Fig. 6.23 Proposed conditions of stream in Camp Land

Camp landscape - Site 4

The design proposals of more water retention to improve ground water, field margins, ponds and wetland strips for biodiversity connectivity, restoring church trails and strategic plantings around the droebels (chapter 5) are coupled with the climate corridor. The corridor also suggests a link between Veengoot and Baakse beek with a new stream valley that follows the small scale agricultural structure of the landscape. A part of Veengoot water is redirected to join Baakse beek to delay and reduce the water quantity in Veengoot so more water can be stored in the camp landscape for longer period to benefit the vulnerable vegetation (results of impacts of climate change on natural vegetation in W+). The increased farm sizes predicted for this landscape for W+ is assumed to be an inevitable change which is compromised by strategic planting of bushes, hedges, solitary trees near stream valley and tree plantings around droebels overlooking the open and enclosed fields.

ape

scape

6.4 Conclusions

To this point in the thesis the following has been deduced:

1. This thesis accommodates numerous approaches as explained in this chapter for the aim in a climate corridor project which will benefit Baakse beek watershed in achieving a sustainable environment.
2. Several approaches in terms of land use and natural environment were used to fulfill the demands of stakeholders, vegetation, animal species and nature conservationists in the area.
3. The climate corridor made a strong connection through all landscape types of Baakse beek and sought to achieve cultural, ecological, agricultural and social sustainability. The important design opportunities like restoration of Rabat forests, meadows, revival of ancient bogs/ marshes as inundation fields and reactivating estate moats additionally helped in strengthening the heritage value of the Estate landscape zone (this is further designed in detail in chapter 7).

This chapter provided a clear coordination between land use and water system along the corridor. The effects of climate change at finer spatial scales and how these will play out for tourists will be further illustrated through small scale design interventions in Estate landscape zone in chapter 7.

7

DESIGN

ESTATE LANDSCAPE

7.1 Introduction

Chapter 7 will focus on one of the most intriguing parts of the design at the Estate landscape zone. There are two times a year when the Baakse beek region attracts a thousands of visitors in the estate zone. It gives an impressive sight of rural landscapes and being perceivable from miles away. However, at the moment, the tourists go away, having remained only in a small portion of the estate landscape due to less connectivity. This is a missed opportunity. The potential that the Estate landscape has to attract people on to the estates is not to be neglected and there lies an opportunity in using the streams. This landscape intervention seeks to regain a lost physical, hydrological connection, but also create a new social and cultural connection.

The new design for the stream in estate zone is founded on the technical aspects of the solution, as discussed in chapter 6, which stated that in order to reduce the discharge speed and retain the water during extreme wet seasons, avoid the dry moats at estate, the best choice is to connect the stream to the estates and give the required meander to increase the length of the stream. A landscape architectonic design, however, goes beyond the formulation of a technical solution, but uses the landscape and the reality of estate landscape and explores the surroundings of Estate Medler.

The first paragraph defines the design principles for re meandering the stream and associated additional ecological, recreational and hydrological functions in the context, which would fit the Estate Medler the best. The next paragraphs deal with the restoring and re creation of old Rabat forests in the Estate Medler area to its fullest potential. The last paragraphs deal with implementation of new estates based on the specific characteristics and design potentials of the Rabat forests in the estate landscape zone. This would not only create a technical solution for streams, but by using the cultural aspects it can give an impulse for the heritage of estate region.

7.2 Strategic design: Re-meandering the stream

Understanding the context

As explained in chapter 3, Baakse beek flows through Estate De Wiersse, Estate Medler and Wientjesvoort in the north (Fig. 7.1) of Estate Landscape. Until recently, due to land consolidation, the Baakse beek stream was moved 200 meters north of Estate zone to make way for agricultural land. This design intervention reactivates the old meandering course (Fig. 7.2) of Baakse beek and makes it visible again in the estate zone.

Fig. 7.1 Existing conditions of Baakse beek through Estate Landscape

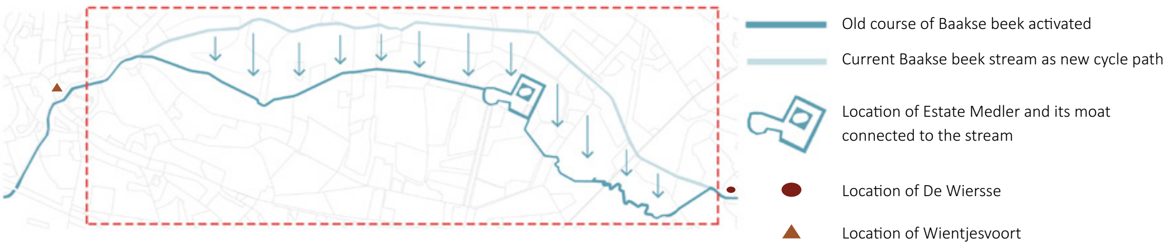


Fig. 7.2 Replacing the existing straightened stream with old meandering stream

Natural topography

The meandering stream incorporates the natural depressions (Fig. 7.3) of the old flood plains of the swampy estate landscapes. It is carefully graded to direct the flow of water across the farms, to give the stream the required delay with the increased length of the water course and room for excess water as it flows downstream.

Green network

The native forests are linked to each other for to encourage wildlife dispersion and to build a continuous habitat for vulnerable species. While doing so, the meandering stream with green corridor strings the different Estates together and connects the moats that prevents them from running dry during hot summers. The restored Rabat forest (Fig. 7.4) is an autonomous element that structures and connects the stream at the three estates considered. At the same time, it creates possibilities for water storage and recreation.

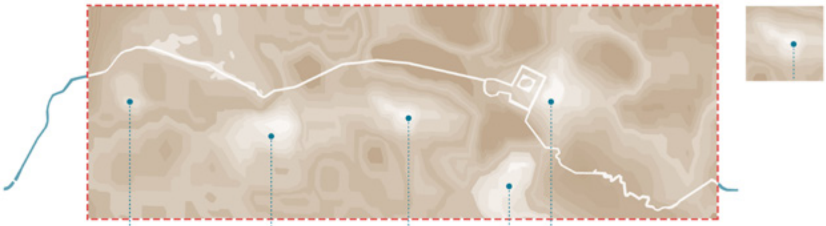


Fig. 7.3 Natural topography: a system of land depressions direct the water flow

Fig. 7.4 Green network: a system of connected forests encourages wildlife dispersion

Ecology

The re-meandering stream has natural banks that vary in width. The bank gradient creates interesting habitat for plants and aquatic animals like fishes, badgers and great crested newts. The stream has a rough base that catches sediment. These ecological conditions are repaired especially near the Estate Medler (Fig. 7.5) where the design is further elaborated.

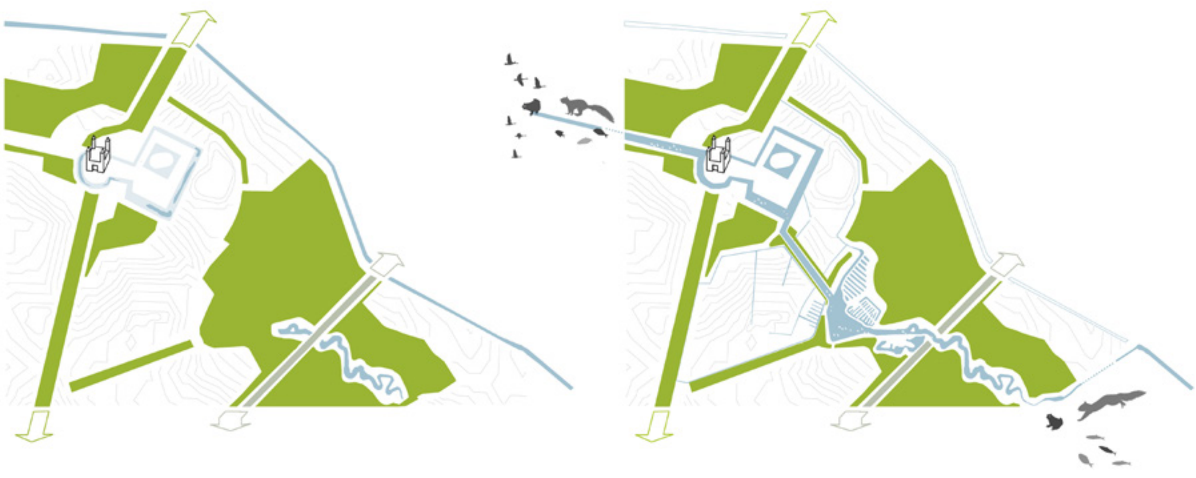


Fig. 7.5 Existing (left) and proposed conditions (right) at Estate Medler

Recreation

The surrounding areas of Estate Medler is a composition of tree avenues, woodland areas and open grasslands. The meandering stream is staged in these spaces, together with a new walking and biking path. The estate extends its tree lanes onto the entrance area and between the meadow lands thus making the routing more distinct. Sometimes the paths run alongside the meandering stream, and they separate, only to meet again. The low and narrow bridge across the stream connects to the nearby Rabat forests. The secondary walking routes which are wild and unpaved, provide a different experience while acting as a short cut (Fig. 7.6).

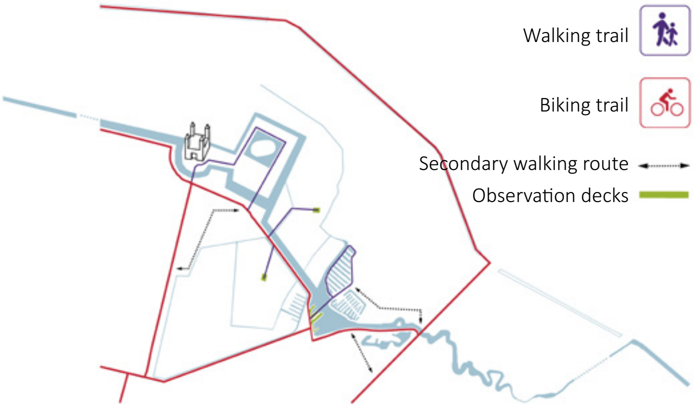


Fig. 7.6 Proposed walkways and cycle paths at Estate Medler

Hydrological function

Fig. 7.7 shows the flow of meandering stream from east to west as it changes its functions seasonally. The water from the stream flows into a pond which is connected to the stream by a fish siphon. On the location of the Rabat forest, the stream discharges and stores some of its water into the ditches of Rabat forests for usage in dry season. The stream water partially inundates the proposed meadow lands in the land depressions during extremely wet seasons.

Fig. 7.7 Proposed functions and changed directions of the stream

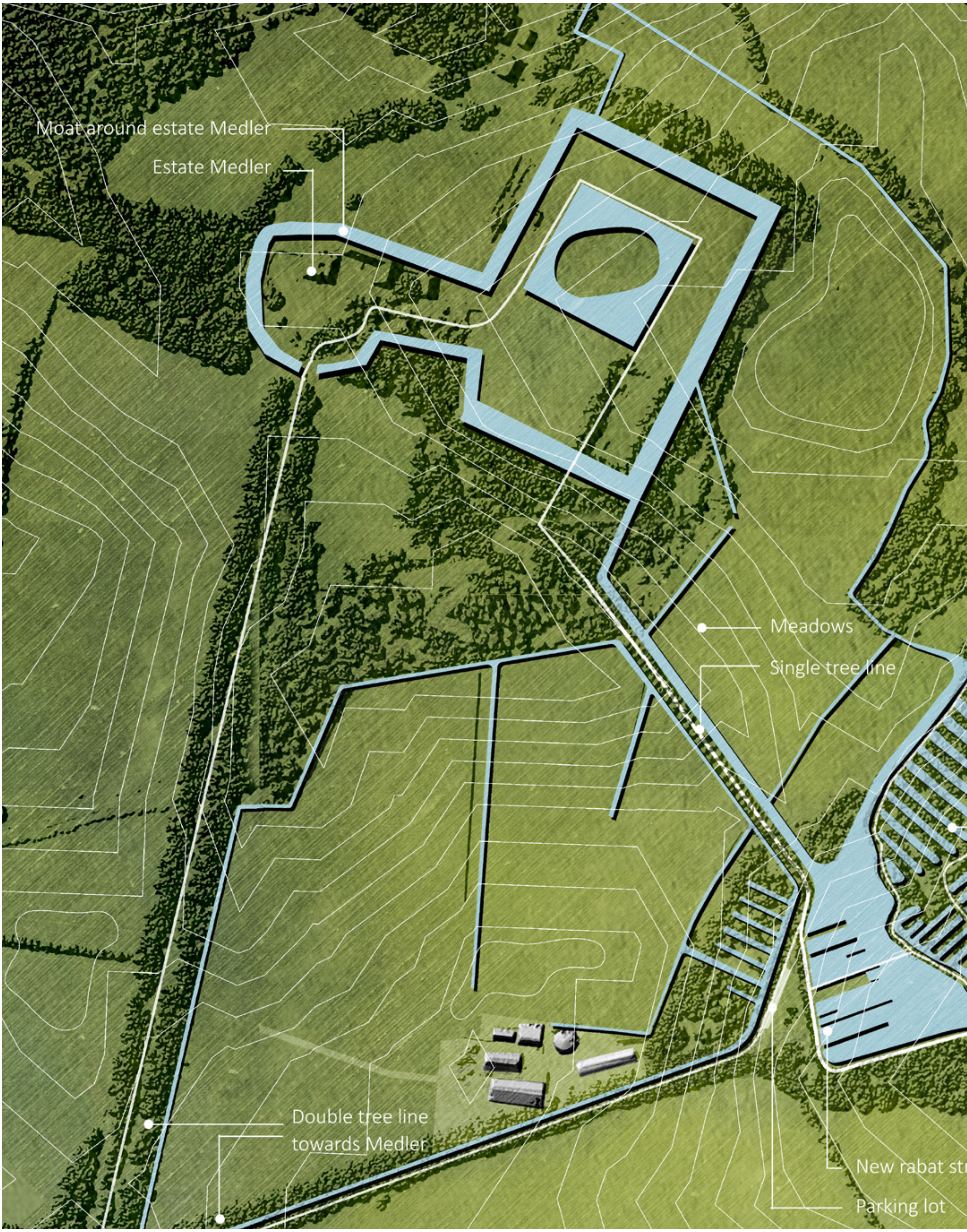


Fig. 7.8 Master Plan of Estate Medler ▷


Current Baakse beek stream
as cycle path
Walking trail
Old rabat forest
Road
Pond
Old meandering stream
ructure

7.3 Detail design: Redesigning Rabat forest structures

Historic structure

Rabat forests are incremented strips of trees in wet areas. Wet sandy soils are drained by the digging of ditches and the soil that is excavated from these ditches is used to raise the levels around the ditch over which trees like willow, oak, elder, birch and poplar are grown in strips (Fig. 7.19). In 19th Century, there was a great demand for tanning oak crust and oak for permanent or periodic high groundwater levels for which Rabat forests were grown in this estate area. The stub that was created by regular cutting of the logs were sold every five years. A disadvantage of this method, however, was that not only excess water was discharged, but also nutrients. The walls of the ditches had to be kept steady.

Today, very few Rabat forests are left and are dying due to desiccation. Due to the high maintenance costs and the relatively low yields, many Rabat forests are no longer maintained. In certain places this system could be restored, not only from a historical viewpoint, but also for a better water management. Hence, the restoration of the Rabat forests with wood rows and ditches is combined with a new contemporary structure of Rabat with modern functions. Rammed earth lining which is a nature friendly material is provided for the ditches for less maintenance. A visitor gets to see the new and old structures of the forest as part of the estate trail. The construction of the new Rabat structure of the ensemble distinguishes itself clearly from the old parts by the materialization.

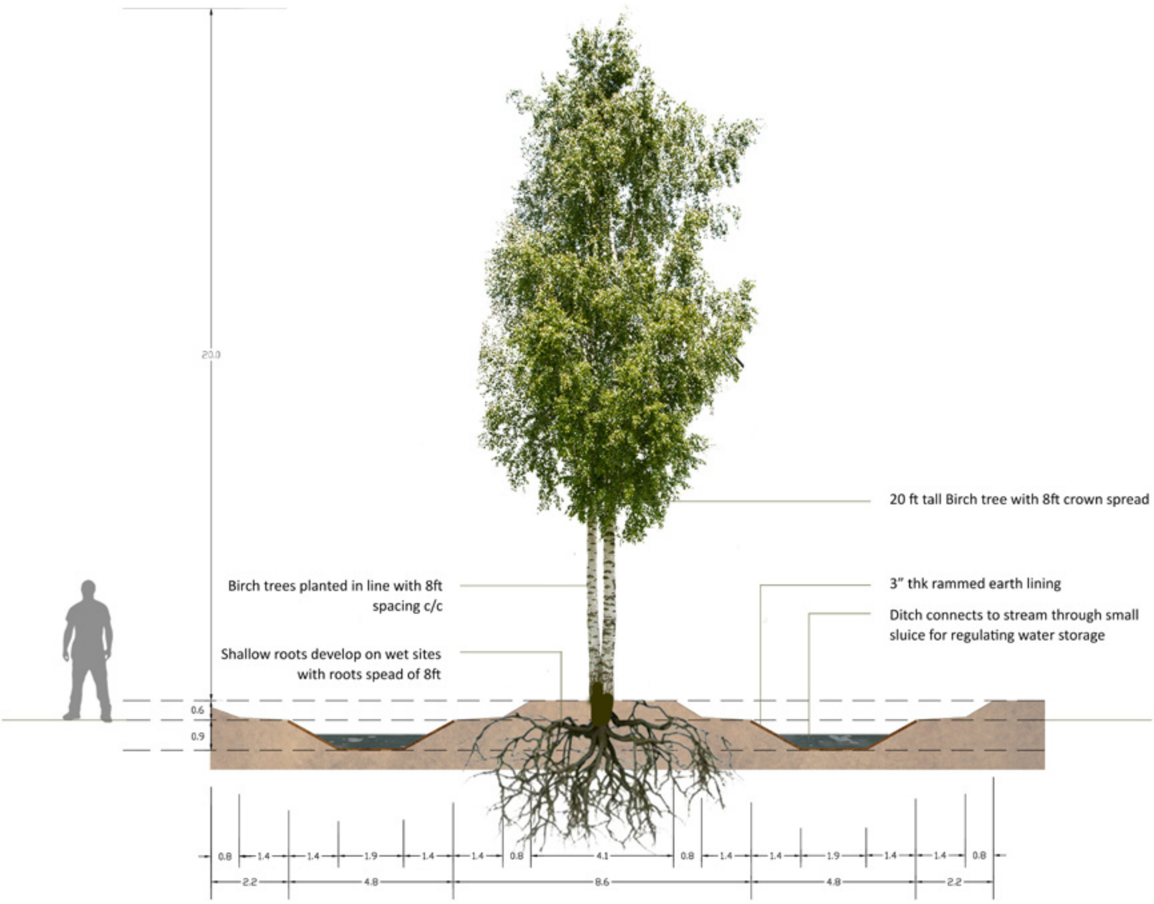
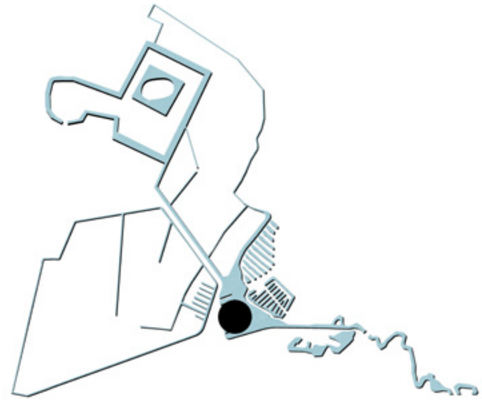


Fig. 7.9 Rabat Forest detail ▷



New structure

The proposed Rabat forest structure regains their function as water buffer, wetlands, water infiltration system and natural swimming pool (Fig. 7.11). Alongside the ecological value, the Rabat structure also forms a component of the economy of the area. For a bird as the woodcock a Rabat forest is a suitable habitat and the alternation of sun and shade also get all kinds of mosses, fungi and plants especially clumps of ferns.

Fig. 7.10 Traditional structure of Rabat Forest ▷

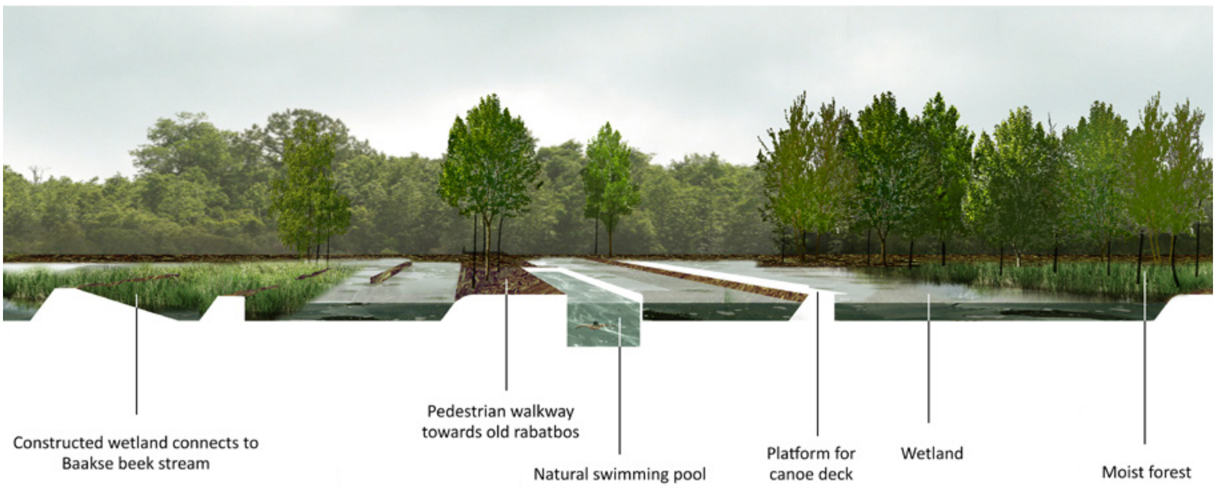
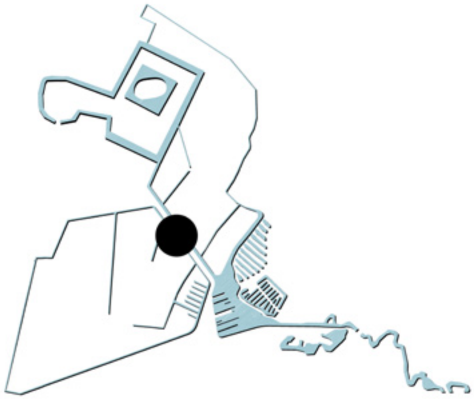


Fig. 7.11 Proposed contemporary translation of Rabat Forest structure ▷



The existing path along the stream connecting Estate Medler and Rabat forest is shown in the Fig. 7.12. It is emphasized by a single row of poplar trees for the directional appeal and separates the paved walking and biking path while over looking at the meadows (Fig. 7.13). The meandering stream along the path has no weirs for the free passage of fishes.

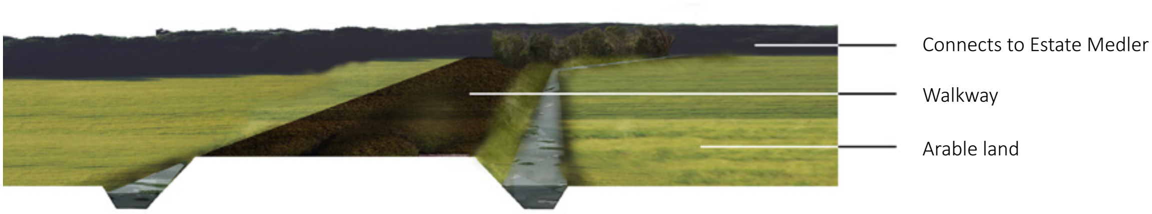


Fig. 7.12 Existing path connecting Estate Medler and Rabat forest ▷

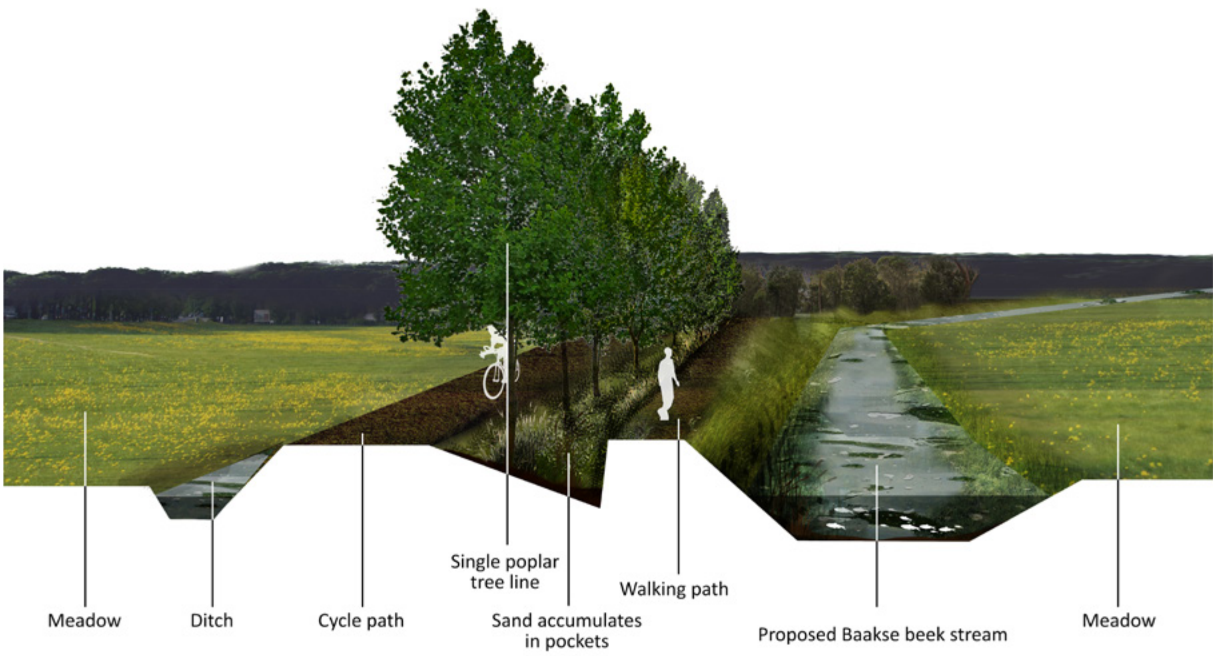
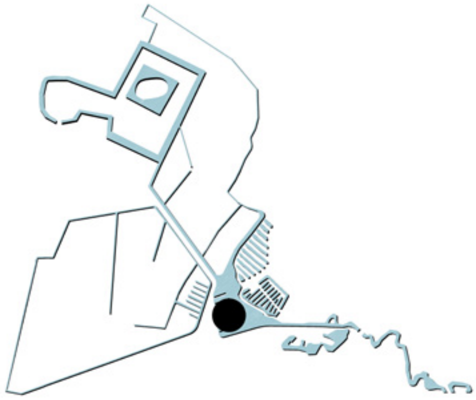


Fig. 7.13 Proposed path connecting Estate Medler and Rabat forest ▷



The meandering stream banks will largely be renovated into natural slopes, with special attention paid to revitalizing riparian habitats. The slopes of the stream for recreation, play, and contemplation are given equal consideration together with reducing the flow of run-off. Fish ladders are included at inlet locations, allowing the animals to still be able to freely move upstream. The outward slopes (Fig. 7.14) towards the stream edge collects extra water during wet season. Rest of the excess water flows into the ditches of the Rabat forests which are lined with rammed earth. The leaf litter of the Rabat forest trees builds soil over time making the drier raised beds more fertile.

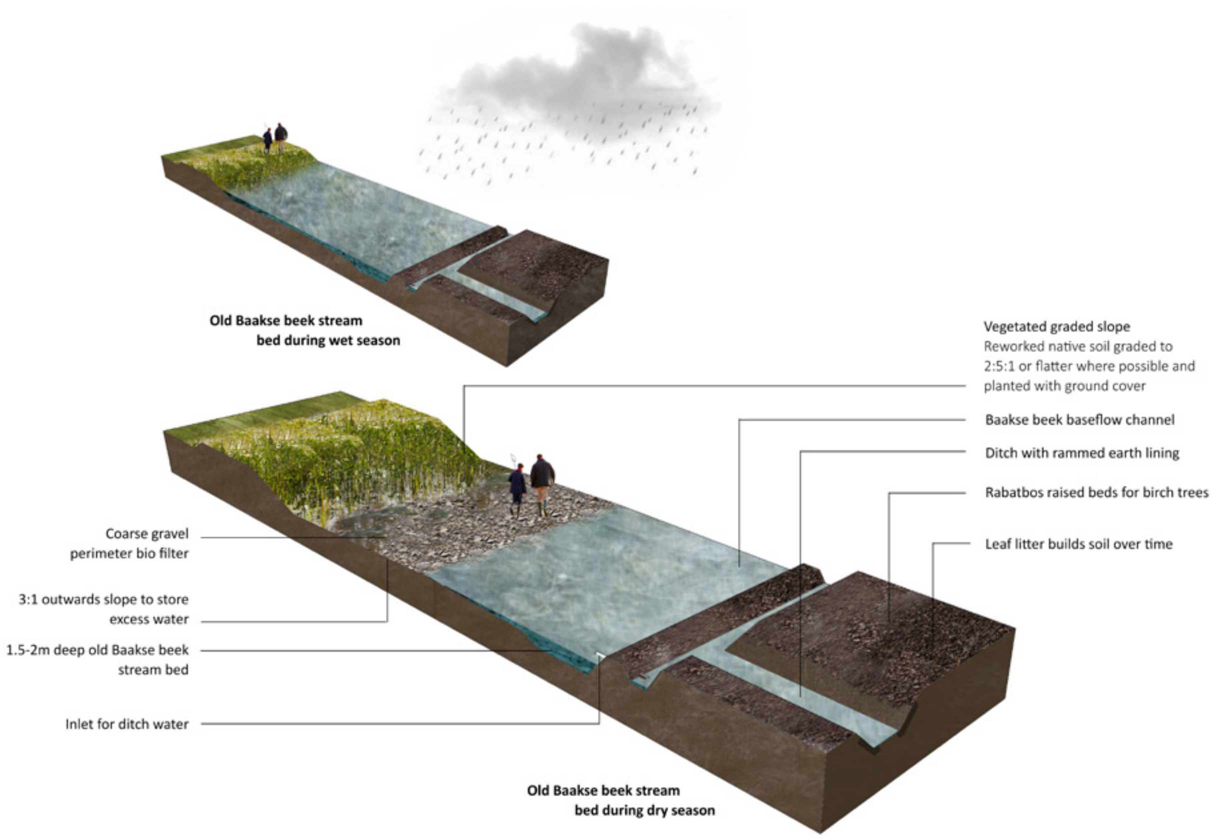
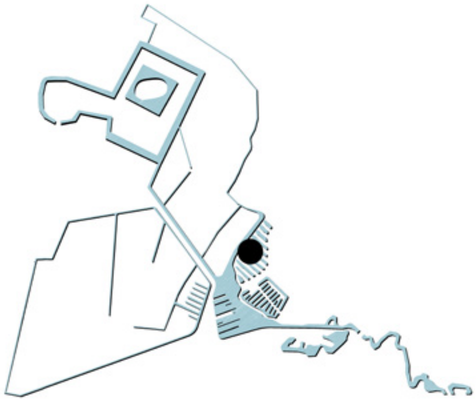


Fig. 7.14 Baakse beek stream cross section typical for Estate Landscape ▷

7.4 Local design: Constructing new estates



New estates can greatly contribute to a more beautiful landscape. Through new estates, its possible to introduce more accessible nature reserves through private initiatives. The idea of building new estates to profit the rural landowners is not new. A desire for more freedom, also more nature, and holiday landscape arises, whether it is possible to retain the atmosphere of the landscape types while at the same time develop marketable housing conditions in the Rabat forests is experimented. The design created in this thesis investigates how optimally interweaving Rabat forests and habitation can lead to a renewed type of dwelling: the Rabat forest estate dwelling - which at the same time seeks to build a new connection with the stream water.

With the sloping roof (Fig. 7.15), the new estate is an archetype of the original Estates and castles in the area. The elevated vertical structure of new estate borrows the monumentality aspect from the original estates of the area. The moats which were once designed around the original estates and castles for the purpose of defense, is now a mere ornamental pond with no function. These water bodies are contemporarily iterated in the new estate in the form of Rabat forest ditches which behave as water storage spots during wet seasons.

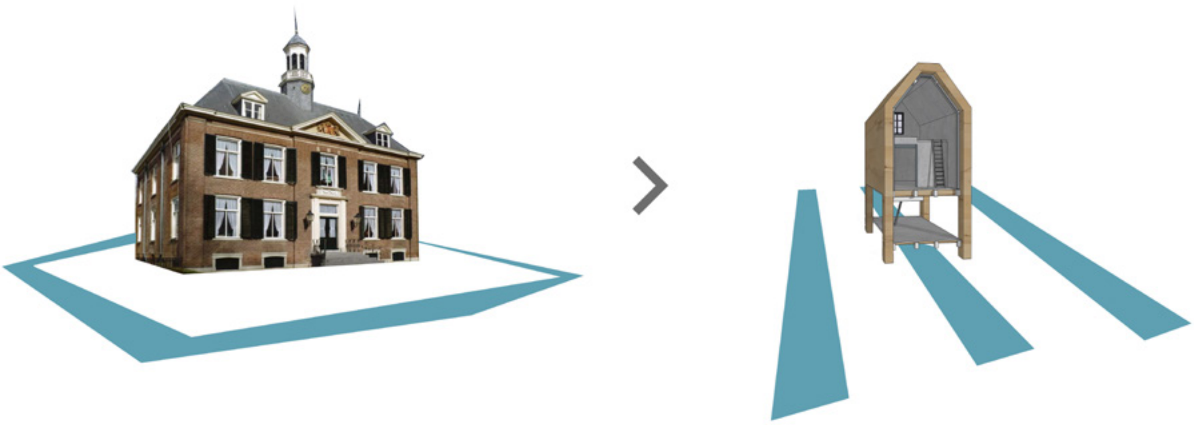


Fig. 7.15 Form and composition of a new estate ▷

Fig. 7.16 Surviving remnants of Rabat forests are a valuable land for new estates and water storage

In this design proposal, the new estate in suggested to behave as a new recreational house for the visitors. Design principles for the suggested recreational house are as follows:

1. House recedes between the whimsical trunks of the Rabat forest trees (Fig. 7.17).
2. The structure of the house is made to be compact with clear shape, whose isolated wooden structure forms a unit which can be prefabricated.
3. It is designed such that it can plug and take positions between ditches or over them.
4. The house ultimately borrows the typical window design with green shutters and the white frame of Estate Medler to blend in with the estate ensemble.

Fig. 7.17 Proposed Rabat forest: a land for new estates with a suggestion for a new recreational house ▷

Fig. 7.18 View from the green shutter window of the new estate overlooking Estate Medler and meadow during dry season

The recreational house is located at the edge of the Rabat forest and views through the green shutter window over the wet meadow fields with Estate Medler in the background. The whimsical trunks of Rabat forests contained in this setting provides a stunning contrast to the open meadow fields which merges seamlessly into its surrounding tree avenues. The scenery changes as meadowland turns into a marshy land during wet seasons (Fig. 7.19) and stays as flowery bed during dry seasons (Fig. 7.18). The feeling of being on holiday for the residents is generated by making the actual presence of the new estate house clearly felt.

Fig. 7.19 View from the green shutter window of the new estate overlooking Estate Medler and meadow during wet season

7.5 Conclusions

This chapter is the result of a landscape architectural approach to the situation of the Estate landscape zone. The complete design shows that, by using different natural, technological and economical elements, the estate landscape can be revitalized in both economic as well as ecological aspects. Smart designs within the estate zone can house human activity and ecological diversity. However, to achieve an active estate landscape, a paradigm shift is needed. With the important and surprising role for new estates and forests in the design, this thesis reveals a paradigm shift, wherein nature can be productive and economics can produce nature. With this in mind, the main research question can be answered:

'In what way can the landscape be used and adjusted, in an integrated manner, to achieve a climate resilient landscape of Baakse beek watershed and enhance its spatial experience?'

8

REFLECTION

8. Reflection

Relation of the research to the academic framework of Flowscapes

The graduation studio “Flowscapes” explored infrastructure as a type of landscape and landscape as a type of infrastructure. Its objective was to engage with the environmental issues by means of design oriented approaches that shape the urban and rural environment. It highlighted one of the facts that today’s contemporary challenges like climate change and its resulting ecological crisis demand attention particularly in relation to sustainability.

With respect to the guiding theme of “Flowscapes”, I found it extremely fascinating and challenging to understand the complex range of environmental issues due to rapid and radical changes that are taking place in sandy rural landscapes of the Netherlands. A variety of problems faced in the Baakse beek watershed, is relevant to the transformation of a majority of rural landscapes over the next two decades. It was essential to answer the current global question of how to initiate, solve and guide this change in times of climate change. My main goal was to explore this challenge through readjusting blue-green infrastructures to coexist with adaptive environments. I interpreted the dynamics between the typo morphological aspects of the Baakse beek area and its water system as *Flowscapes*. I realized that the strength of the thesis was in addressing the ecological-functional significance of water system and its associated spatial relationships together, coupling with landscape experience. I believe that such a relation with a multi-layered understanding of landscape is essential and has a universal value.

Integration with wider social context

As a landscape designer I looked for the transformation of a landscape, which extends beyond the physical environment to include social and cultural values. Although this is a universal phenomenon of the twentieth century, what made the case different in the Baakse eek is the general lack of public consciousness on environmental issues.

The proposed climate resilient corridor in Baakse beek, tries to seamlessly merge the adjacent land uses and natural systems, creating a symbiotic relationship between the stream and surrounding landscapes. This allows for a creation of a vital habitat for native flora and fauna, stimulates more beautiful and functional landscape for locals and tourists, and raises the bar for sustainable development. I aimed to offer a link between humans and their environment by fostering a community relationship to the stream and opportunities for environmental, cultural and ecological education in the estate zone of the study area while offering space for new estates and restoring culturally rich Rabat forests. Such architectonic interventions contribute to people’s sense of belonging to a particular place and can be seen as an embodiment of their cultural, historical and regional identity.

Research - Design relation and evaluation

My thesis combined the design related research strategy of the graduation lab: Design-Research and Research-by-Design into a coherent research approach. Design-Research in the first stage of analysis involved mapping of the existing and past conditions in relation to the datasets of the water system. It helped me in understanding that Baakse beek apart from its historical processes, possesses a characteristic diversity. Research-by-Design involved the study through design with a series of important modes of research like typo morphological classification strategy, landscape character analysis, and results of a mechanistic modelling approach.

Typo morphological classification
The widely used category of classification based on typology, provided a hands-on approach to elaborate aspects of spatial quality of the landscape types and the associated water system, examining the ways in which they behave seasonally. This step brought forth a new understanding of 'type' and based it on history, nature and use. As part of this research step, I further studied the individual nature types, farm types, open and enclosed spaces, settlement types etc. of the region in isolation. However, it didn't prove to be of great use until I was guided to study the relationship between them.

Landscape character analysis
This research step offered a way of evaluating and designing landscapes. The benefits from using the landscape character analysis methodology as opposed to traditional mapping is that it allowed to see and understand the landscape in terms of its present and past qualities. This helped me in envisaging the Baakse beek landscape as the product of the layered interaction of all phenomena- climatic, geological, geomorphological, ecological and cultural- which characterized the area. A set of twelve different landscape types that I discovered based on the layered approach, proved to be of little use. I further reduced them to a logical framework of only six types which proved to be of significant importance and strengthened a part of them to behave as a climate corridor for a sustainable landscape. The design of a corridor was further assessed with the help of mechanistic modelling approach.

Mechanistic modelling approach
By using the scientific models for assessing the landscapes types based on ecological concerns meant that the design doesn't rely just on my perceptions. Sustainable landscapes do not conform to common expectations of resilient landscapes alone, but I argue that their dispersal into the landscape could happen by exposing the ecological features rather than losing them. The fact that I had applied the above researches to six areas of Baakse beek provided an opportunity to test, exemplify and illustrate common themes in more than one context and, far from being a problem, this added to the force of my arguments. The mechanistic modelling approach assessed the potential effects of climate change on natural environment and land use, and tested climate corridor options that differ in the spatial configuration of additional habitat for the Baakse beek study area. On the whole it offered me many lessons in ecological and environmental appropriateness.

The above mentioned- combined and hybrid research strategies used for this thesis provided an intermediate position between subjective-objective duality as I shifted back and forth between the strategies to understand the landscape better.

Process

The knowledge I gained during the entire process of the project was a fulfilling experience. It helped me in understanding the rural cultural landscape better, in finding new research paths, stimulating debate, formulating environmental solutions and above all raising the awareness of the value of landscape and the consequences of climate change.

Although my methodological approach was initially very structured, I constantly made several changes to it as I progressed with the project. More precisely, my search for climate resilient, sustainable, ecological and cultural appropriateness was effective at two levels. First, it rooted in the reality of the Baakse beek landscape, its history and its natural and cultural landscape. The climate corridor is a representation of the applicability of the proposed methodologies. Second, it can be extended elsewhere, since at a conceptual level the methodological frameworks are in themselves models that can be used in other regions of sandy rural landscape.

Apart from the climate corridor in the Baakse beek, new directions and recommendations for the future climate scenario were presented at four regions, aiming at a balance between nature and climate. My first attempt at working on the 'camp' landscape type was unsuccessful due to the poorly documented information on the changing land use and farm sizes because of economic development. While in the final design at estate landscape zone, if in one sense cultural values can contribute to the development of this zone's identity, in another ecological values are a path for valued cultural landscapes that are vanishing. Along these lines, approaches to prompting ecological awareness to deal with climate and coupling with recreation values seemed promising.

Its necessary to acknowledge that, in one way or another, it is about trying to control nature. After all landscape architecture is a human attempt to manipulate natural elements for cultural and environmental benefits.

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