THE AQUATIC BACKBONE

Ecological values & Climate adaptation in the Binnenveld
Bachelor Thesis

Supervisor dr.-ing. Wirth, M
Sara Almeloo (1038630)
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ABSTRACT

The Binnenveld, often considered an aesthetically pleasant and peaceful area between the Utrechtse Heuvelrug and the Veluwe, is facing complex stressors. The area distinguishes itself from the high, sandy surroundings by the occurence of seepage and therefor could have a high ecological value and large adaptive and mitigative capacity to climate change. However, lower groundwater levels and pollution decrease those qualities (van den Broek and Beltman, 1994).

This design-led research aims to strengthen the water quality and quantity in the system in order to create ideal circumstances for the settlement of wet target habitats. Those habitats play an important role in reducing the impact of human on climate change and vice versa. By applying two water based development pathways, one focussing on the Grift and one on the upstream water structure, and one vegetation/agriculture based approach, we can uncover potential side-benefits and synergies between water, nature, agriculture and adaptivity to climate change are discovered.

I have formulated sub research questions, touching upon properties and threats of peat habitats, interventions on the water system and vegetation/ agriculture-based solutions. The answers, translated to design results, respond to the overarching question 'How can the water system of the Binnenveld be changed to stimulate its ecological value?'

Wageningen University and Research
Bachelor Landscape Architecture & Spatial Planning
Bachelor Thesis Landscape Architecture, LAR 81812

Author	Sara Almeloo
Registration number	1038630
Examiner	prof.dr. Lenzholzer, S. dipl.ing.MA
Coordinator	ir. Bartelse, G.
Supervisors	dr.-ing. Wirth, M

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I. INTRODUCTION

The Binnenveld is surrounded by natural areas, respectively the dry sandy Utrechtse Heuvelrug National Parc Hoge Veluwe and the floodplains. The area is different from those surrounding areas by properties deriving from the occurrence of seepage and the peat content in the soils. However, during the past decades, stressors related to agriculture and climate change have threatened the ecological characteristics of the area increasingly (van den Broek and Beltman, 1994). The relationships regarding the main geographical properties and stressors are explained in figure 1.1.

The infograpihic shows the negative impact of agriculture and climate change on the landscape of the Binnenveld. The Blauwgraslanden and Trilvenen have specific requirements related to nutrient availability, seepage, groundwater availabilty and soil pH. This makes them highly vulnerable to the consequences of climate change and unsustainable agriculture.
The habitats are important for fostering biodiversity (van Dort, Bax and Zwarts, 2009) and for climate regulation, since they have high water holding capacity, soil cover and capacity for carbon sequestration. As a consequence, degradation of those habitats causes loss of biodiversity and decreasing capacity for climate mitigation and adaptation (Elbersen and de Hullu, 2007). That is why those habitats are recognized as target habitats in design-led research.

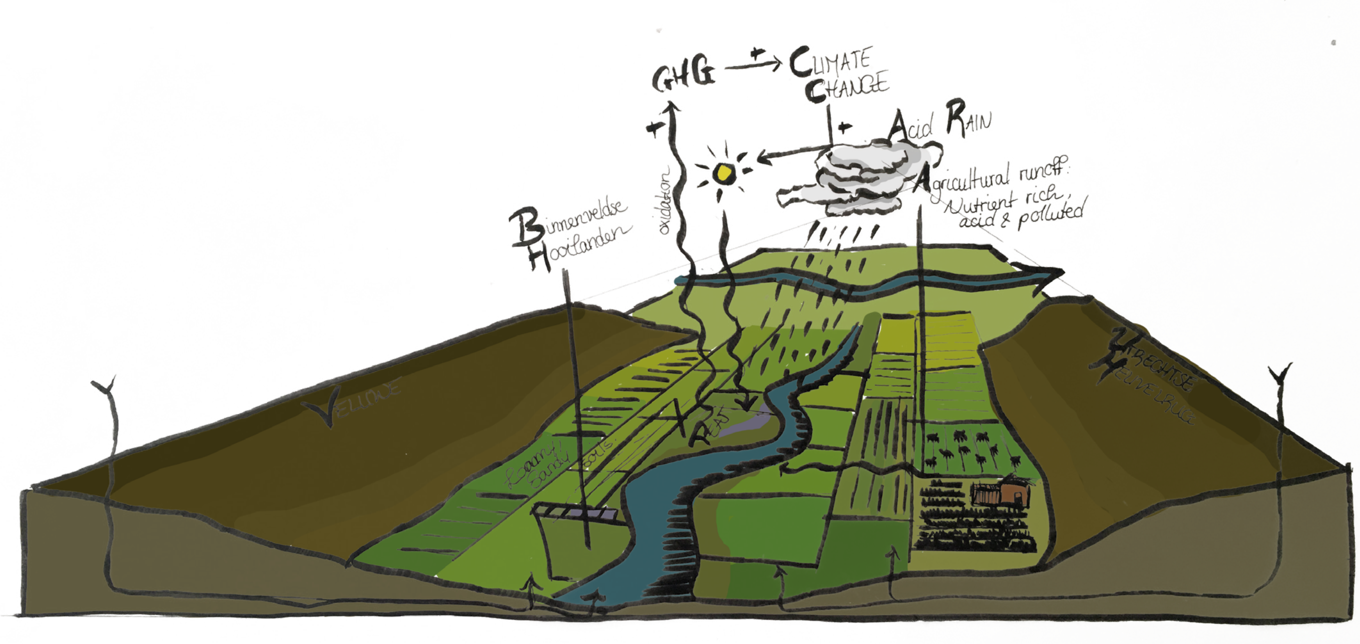

Figure 1.1: Infographic on the environmental properties and issues in the Binnenveld

By redesigning the water and agricultural system, this project is aiming to create favourable circumstances to strengthen and extend those habitats. In order to develop this research project, the main research question was stated:
How can the water system of the Binnenveld be changed to stimulate its ecological value?
I have formulated a number of sub research questions, which touch upon different phases of the project.
1. Which threats to Trilvenen and Blauwgraslanden should be adressed in the design?
2. Which measures for improving the water system have been taken or are planned in the Binnenveld?
3. What are design interventions for improving the water storage capacity and water quality?
4. What are vegetation-based design tools stimulating soil purifying and regulating services?
All four sub research questions will be adressed in the analysis chapter.

The water system in this design is considered as the fluid connection between the landscape of the Binnenveld and the surrounding region. All the small water ways lead the surface water from the far corners of the Binnenveld towards the Grift. That is why in this design the Grift can be seen as the vital backbone of the Binnenveld, the network of ditches as its nerves. In the past, the system is significantly changed due to peat reclamation. In the context of this reclamation, the Grift was broadened for rapid water discharge. Nowadays, this broadening of the Grift causes, together with climate change-induced drought and intensive drainage for agriculture, decreasing groundwater availability.
The trilvenen and blauwgraslanden settle on sites where seepage, an upwards, alkaline flux of groundwater, occurs. Here, seepage brings the right nutrients and abiotic circumstances to the rooting zone (Elbersen and de Hullu, 2007). Nowadays, this is concentrated in the northern parts of the Binnenveld around the Grift. Those sites are protected according to the Natura-2000 guidelines (van Dort, Bax and Zwarts, 2009). Despite these efforts, the quality and quantity of the habitats decreased.

II. METHODS AND MATERIALS

I have used multiple methods and materials to reach the design goals related to rewetting, ecological strength and climate responsiveness.

Methods

On-site visits were an important tool for understanding the genius loci. By visiting organic farm the Hooilanden, I have become familiar with the constraints and opportunities related to transforming agricultural system. Next to that, specific sites were visited to crosscheck the proposed design interventions.

Mapping studies have contributed to understanding of the environmental properties and requirements of the target habitats has been generated. Especially a map, showing the strong decrease of seepage towards 2050, was an important impulse for the design goal.

Literature studies have been important in this thesis for gaining knowledge and as a source of inspiration. Among others themes related to the natural environment and its major constraints and requirements, suitable types of vegetation and agriculture and improvements on the surface water structure were adressed.

I have applied the **Research through Design Framework**. By using this framework for the evaluation of the design options, I have aimed to strengthen the scientific position of the results (Lenzholzer, Duchhart and Koh, 2013).

The planned design process is schematically shown in figure 2.1

Materials

Maps in ArcGis regarding the soil composition and the occurence of seepage and infiltration were important starting points of this design related research. Next to those maps, scientific papers and reports were important materials. Next to a set of fixed/shared criteria, which count for each design pathway, some special criteria were selected per pathway. The next chapter, Design goals and Critera, will elaborate on those.

Personal learning goals

During this project, I want to improve my skills related to the following personal learning goals:

1. During this bachelor thesis, I want to improve my skills related to the development of a clear focus. Narrowing down the scope of a design can in the end contribute to the strength of the design results.
2. The design making process is closely related to the previously mentioned design focus. In order to achieve the previously formulated learning goal, I want to gain insights in my decision-making process. In order to enlarge my understanding of logics behind design choices, I will carefully translate knowledge, gained during the analysis phase, into design criteria. By continuously evaluating design options, I want to unravel patterns which occur while measuring advantages and disadvantages of my design options.
3. This bachelor thesis is the first time I will independently develop a design. Moreover, this is the first time I use the Research through Design framework to strengthen the scientific value of my design.

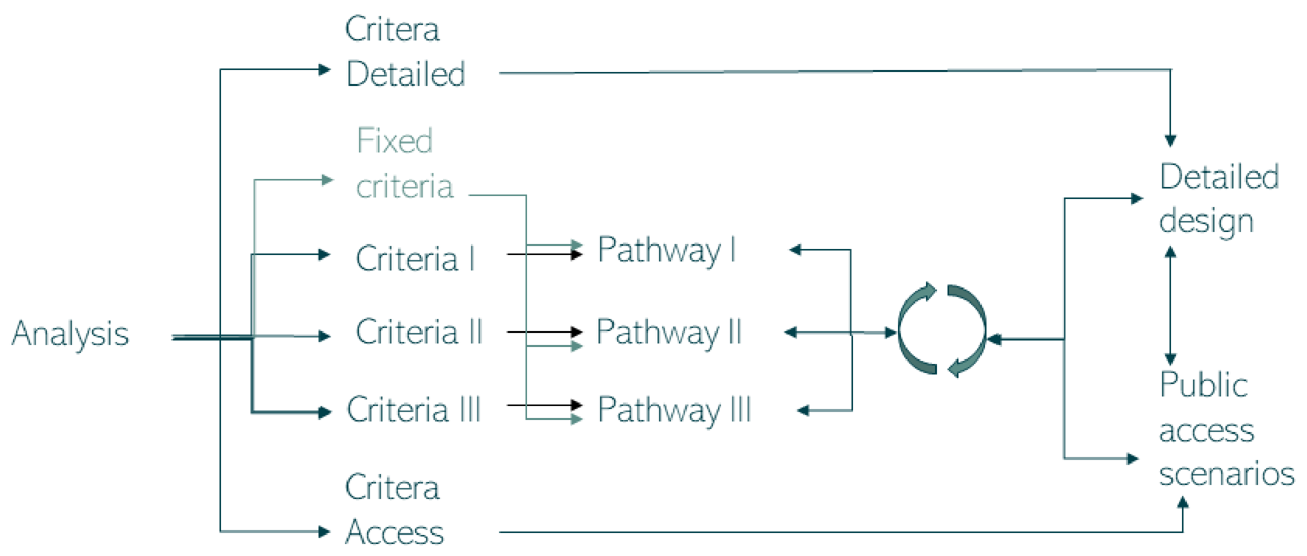

Figure 2.1: Schematic representation of the planned design process

III. DESIGN GOALS AND CRITERIA

Goals of the Design

The main purpose of this design is the redevelopment of the water system in order to strengthen the ecological value of the Binnenveld. By rewetting the landscape, the capacity of the landscape to climate adaptation and mitigation will improve. The design goals and interventions adress the Grift, the network of ditches and the structure of vegetation and agriculture.

Rewetting of the Binnenveld

In order to achieve the desired rewetting of the system, the overall discharge of water via the main water way, the Grift, should be diminshed.
The design uses the introduction of curves in order to lengthen the pathway of the main surface waterbody. A longer pathway increases the opportunities for water absorption by the surrounding peat soil and for natural water purification. In order to stimulate this absorption and purification, another design goal is the development of peat wetlands. Figure 3.1 shows one of the already rewetted peatlands in the study area.

On a global scale, peat wetlands are being drained, which subsequently causes peat oxidation and intensive greenhouse gass emissions. Because of their high organic matter content (Paige and Bird, 2016), those peat wetlands function as natural sponges in the landscape. As a consequence, healthy peat wetlands strongly increase the adaptive capacity to water related stressors (Mitch, 2013).

The design also proposes changes in the network of ditches, aiming to diminsh the water discharge. However, at the same time enough surface water bodies for regulation of the micro climate and for the prevention of eutrophication should be maintained.

Reinforcing seepage flux

For the settlement and conservation of the target habitats, intensification of the seepage is required. I aim to achieve this by proposing design interventions, such as development of depressions in the landscape where seepage can occur.

Soil health management

In order to enable the landscape to achieve the design goals, the health and capacity of the soils to regulate the groundwater vegetation structures and low impact agriculture strategies should be implemented. In order meet the requirements of the target habitats, related to nutrient availability and soil acidity, I introduce natural purification systems.

Criteria

Prior to the development of the design project, I have drawn up a a list of design criteria. All of those listed criteria refer to ecosystem services. Within the concept ecosystem services, four types, respectively the regulating, supporting, provisioning and cultural services have been distinguished (Comerford et al., 2013). I have evaluated the large scale design pathways on criteria related to the first three types. I have taken the cultural value into account in the evaluation of the detailed design.

For the evaluation of the large scale designs, some of the criteria were selected as fixed critera. In other words, each of the design pathways should be evaluated on those. Those fixed criteria address climate regulating services, such as greenhouse gas regulation and the capacity for regulating micro climate. Next to that, all of three of the design pathways are evaluated on biodiversity, which is the basis of all ecosystem services (Comerford et al., 2013) and stimulation of seepage.
The other criteria were devided over the different design pathways. By doing so, there is aimed to investigate both the similarities, contrasts and the supplementing value of the design pathways.

Special criteria pathway I

The first pathway will be evaluated on the capacity for surface and groundwater water storage.

Special criteria pathway II

The set of criteria of the second pathway comprises the ecological water quality and opportunities for water recycling.

Special criteria pathway III

Evaluation of this pathway will adress regulating services, such as capacity for soil stabilization and nutrient cycling. Next to that, the differentation of agriculture is evaluated.

Criteria Detailed design

The design iterations for the detailed design area are evaluated on criteria deriving from conservation ecology (Geneletti, 2002) and cultural ecosystem services (Comerford et al., 2013). The used criteria deriving from conservation ecology are habitat connectivity, habitat diversity, habitat size and disturbance frequency (Geneletti, 2002). The selected cultural ecosystems consist of opportunities for recreation and awareness creation of the ecological value (Comerford et al., 2013).

Figure 3.1: Peat wetlands in the Binnenveld

IV. ANALYSIS

In general, agriculture-induced soil acidification, groundwater extraction and eutrophication are recognized as main stressors to the health of peat soils (Elbersen and de Hullu, 2007). The impact of those stressors is exacerbated by climate change (Ise et al., 2008).
The following paragraphs answer the first sub research question: ‘Which threats to Trilvenen and Blauwgraslanden should be adressed in the design?’
Trilveen is a peat habitat type consisting of a fine, floating layer of vegetation. The composition of this vegetation is highly dependent on abiotic components of the natural environment, such as acidity, mineral and nutrient availability. When the nutrient availability is too high, this vegetation will be replaced by monotonous layers of mosses (Decleer, 2007).
Blauwgrasland settles on nutrient poor environments. This habitat occurs on soils which contain peat or loam and where the groundwater levels are permanently close to the surface. This habitat can tolerate temporal inundation. Due to the rigid water balance, fluctuations in groundwater quality and quantity are the largest threats of this habitat type (Decleer, 2007).

Soil properties

Next to the occurence of peat, mapping studies resulted in some important observation which should be taken into account in the further development of this design related research.

The first map, figure 4.1, shows the occurrence of seepage and infiltration in the Binnenveld. The second map, figure 4.2, refers to the soil acidity and drainage capacity. Those propertes of the soils determine to a large extent the potential nature and agriculture types.

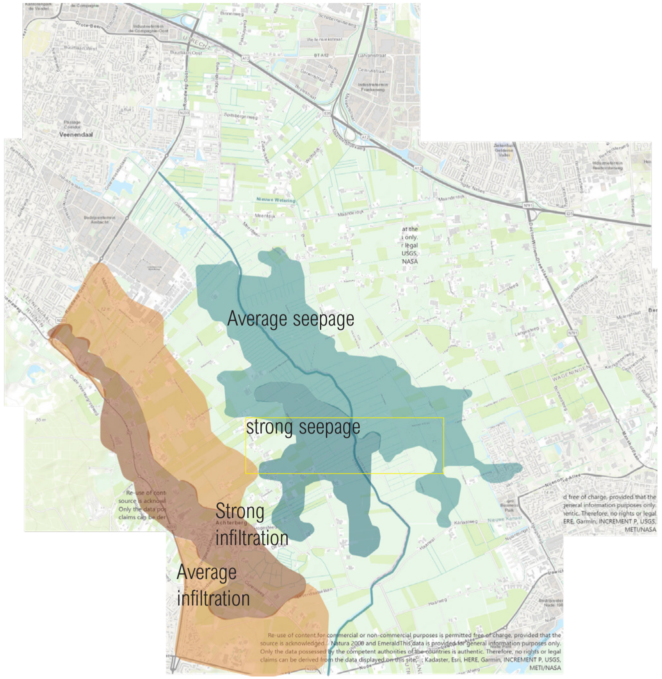

Figure 4.1: Mapping studies on seepage and infiltration (1:50.000)

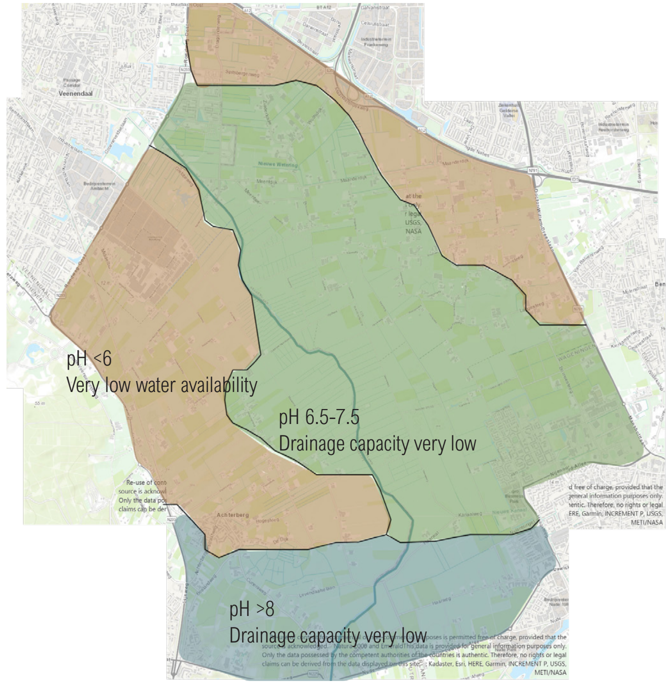

Figure 4.2: Mapping studies on soil acidity and water regime (1:50.000)

Water related interventions

The following paragraphs answer the first sub research questions ‘Which measures for improving the water system have been taken or are planned in the Binnenveld?’ and ‘What are design interventions for improving the water storage capacity and water quality?’
Multiple design interventions have already been taken during earlier projects, aiming to improve the aquatic circumstances. Examples of those interventions are:

Digging of ground level brings the toplayer of peat closer to the groundwater level. Permanent contact between the peat and groundwater is necessary for the prevention of peat oxidation. Next to that, the introduction of micro relief strongly stimulates species richness (Block et al., 2016).
Filling up ditches decreases water discharge (Block et al., 2016). However, this is complex since the border between ‘too many ditches causing groundwater extraction’ and ‘not enough surface water for thermal regulation’ is very thin.

New ditches have been developed to prevent run off of acidic rainwater to the acid-sensitive peat habitats (Block et al., 2016).

Multiple interventions for improving the water quality and storage capacity could be distilled from literature. To me, the most important ones are:

Lengthening the pathway of surface water enlarges the storage time of surface water in the Grift and thereby increases the opportunity of surrounding soils to absorb the water. Longer pathways of the water also increase the opportunities for vegetation-based water purification (Barendregt et al., 2004).
Development of standstill surface waters increases development of vegetation structures with large water holding capacity and opportunities for water recycling. Thereby, this stimulates seepage (Elbersen and de Hullu, 2007).
Redesigning the network of ditches by merging ditches and decreasing their width and depth, this design intervention will contribute to the minimalisation of internal water discharge (Barendregt et al., 2004). Less water discharge stimulates the desired rewetting of the landscape. Next to that, since redesigning the network of ditches decreases the amount of polluted, acid and/ or nutrient rich agricultural run off which enters the target habitats, the health of the blauwgraslanden and trilvenen will increase.
Swales are ditches situated on the natural contours of the landscape. In the zones where strong infiltration occur, for example in the western part of the study area, they could decrease the infiltration speed and increase the quality of the water which enters the soil system. As a consequence, the humidity of the upper layer of the soil increases (Shafique et al., 2018). Although swales are a concept deriving from permaculture, those waterbodies are often applied in landscape architecture (Kim and Song, 2019).

Agriculture & Vegetation-based tools

On a global scale, agricultural practices make use approximately 85 percents of the available fresh water resource. Next to that, they contribute for almost 50 percents to the global greenhouse gasses emissions. That is why agriculture is considered as the main contributor to environmental issues (Hathaway, 2016). Moreover, approximately 10 percents of the globally emitted greenhouse gasses derives from drained peatlands (Paige and Baird, 2016).
the continuation of those sequences. The vegetation types which develop after the continuation of those sequences excrete acids via their roots to the surrounding soils. As a consequence, the continuation of the natural succession sequences of the target habitats is a hardly irreversable process (Elbersen and de Hullu, 2007).

In order to overcome issues related to water quality and quantity in the Binnenveld, I will introduce sustainable types and vegetation structures. The properties and relevance of those agriculture and vegetation types will be introduced in the following sub paragraph. By introducing those agricultural tools and vegetation structures, the fourth sub research question, 'What are vegetation based design tools stimulating soil purifying and regulating services?' will be adressed.

Next to the trilvenen and blauwgraslanden, the vegetation structures are considered to largely contribute to the achievement of the design goals.
Wet mesotrophic forest (Elzenbroekbos) requires a high moisture content in the soils and the occurence of seepage.
By the richness of species settling in this forest type and the strong water storage capacity, the wet mesotrophic forest is seen as the most natural method for peat wetland development and maintainance (Runhaar et al., 2013).
Peat wetlands are generally considered to be one of the most biodiverse landscapes. Next to this ecological value, they function as a strong natural sponge in the landscape and play a vital role in water purification and in adaptation to fluctuations in water supply (Mitch, 2013).

The types of agriculture, which are introduced in the last part of this chapter, are beneficial for both farmers and the natural environment. The benefits to farmers derive from the adaptive capcity of those agricultural types to climate change. All of the proposed agricultural types have their own manner to minimize the risk of yield losses due to heat stress and/ or weather extremes.

Agroforestry consists of agricultural practices with a strong emphasis on relationships between crops, soil and environment and introduces trees in the fields. Trees increase the capacity of the soils to store water and nutrients and diminishes fluctuations in soil acidity and water quality (Pardon et al., 2017).

In the western zone, on the dry, sandy soils of the area, the integrated food forest, I consider the integrated food forest as a benefical agriculture approach. By integrating multiple layers of trees, shrubs and crops following properties of forest ecosystems, this approach will contribute to stabilizing and diversification of agricultural production and to the adaptivity to climate change (Pardon et al., 2017).

Figure 4.3: Intergrated food forest

Silvopasture will contribute to the circular character of agriculture in the zone east from the Grift**.** By integrating livestock and trees or woody perennials, benefits for yields, livestock and environment could be achieved (Jose and Dollinger, 2019)

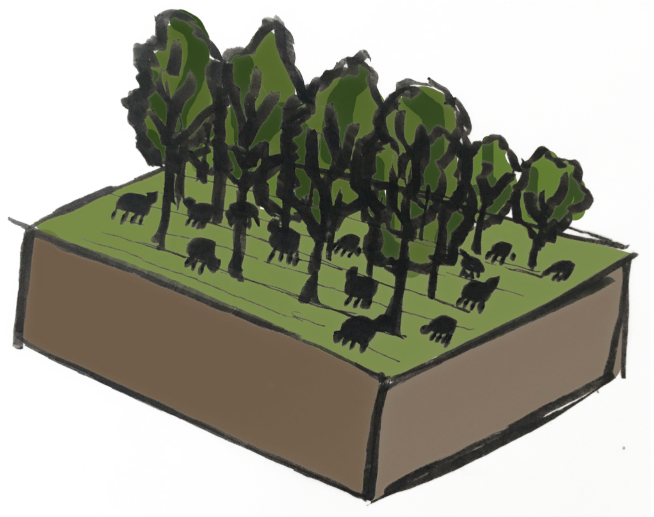

Figure 4.4: Silvopasture

Paludiculture is considered an innovative, sustainable alternative to conventional agriculture in wetlands. By enabling crop production in rewetted peat wetlands, benefits to agriculture and the natural environment could be achieved.
An advantage for agriculture related to the introduction of paludiculture is the production of specific value crops. Among potential value crops, crops for the generation of bioenergy, among others Phragmites australis, Typha latifolia, Phalaris arundinacea and Carex and medicinal crops, for example Drosera rotundifolia are recognzied.
Main environmental benefit deriving from paludiculture are increased biodiversity and the strengthening of the carbon sink in rewetted peat soils (Abel and Joosten, 2013).

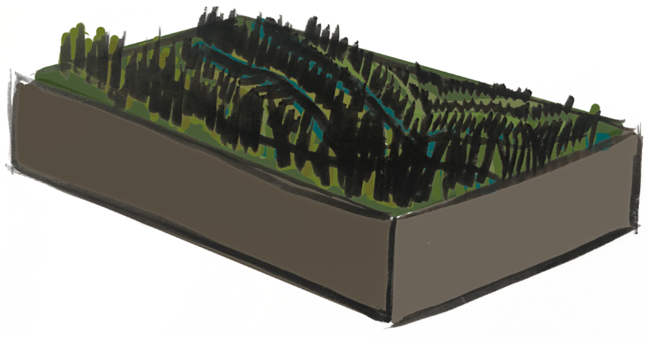

Figure 4.5: Paludiculture

V. DESIGN RESULTS

The results of this design related research consist of three provisional design patways for the complete Binnenveld and one detailed subregion around the Bennekomste Meent.

5.1) Large scale design visions

The aquatic backbone

This first large scale design pathway, shown in figure 5.1, aims to slow down the water discharge via the Grift to the surrounding areas. By stretching the pathway of the Grift and redesigning the landscape around this water body, the storage of water on and underneath the soil surface will increase.

Next to the ecological and climate responsive benefits of this design pathway, also the aesthetic value of the landscape is taken into account. By placing the Grift in a dominant position, this stream will receive a stronger connecting role in the landscape. That is why this design pathway can be seen as the aquatic backbone, by which all landscape entities of the Binnenveld find their cohesion.

Design aims
Increase surface water storage
Slow down discharge via the Grift
Strengthen cohesion between landscape components

Interventions
Widen the Grift where seepage occurs
Lengthening the pathway by introducing curves
Development of peat wetland

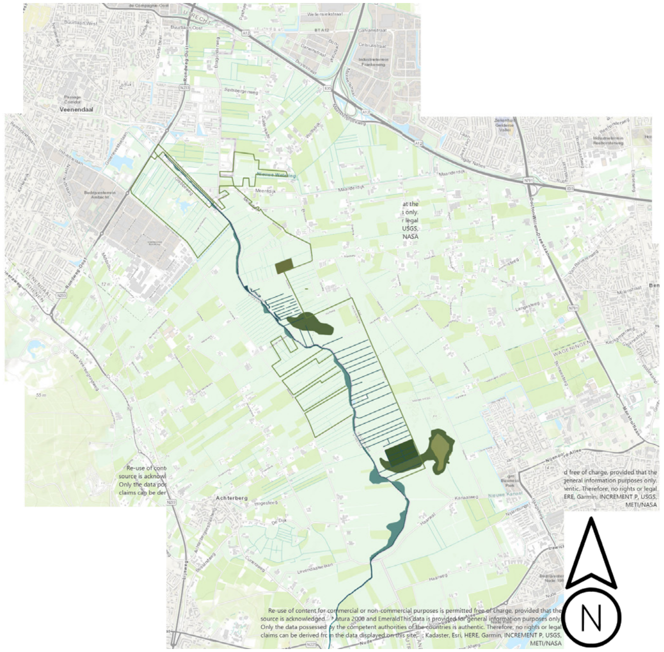

Figure 5.1: Map for design pathway 'The aquatic Backbone' (1:50.000)

Current waterbodies
New waterbodies
New peat wetland
Current peat wetland
New trilveen
Current trilveen

The aquatic nerves

The second design pathway, shown in figure 5.2, focuses on the redevelopment of the network of minor waterbodies, such as ditches, streams and ponds. The title of this design pathway, 'Aquatic nerves' refers to the function of those sub waterbodies as extensions of the aquatic backbone, the Grift.

By improving the efficiency of this network, the total amount of ditches and thereby the run off will decrease. By creating standstill waters and depressions on seepage rich and peat containing sites, this design pathway strongly stimulates the settlement of new trilvenen and blauwgraslanden. By decreasing the ditches in the areas where strong infiltration occurs, we can maximize the input to the groundwater reservoir.

By proposing soil health improving agricultural practices, respectively a food forest in the west and silvopasture on the east from the Grift, both the availability and quality of the groundwater in the area will increase. On the peat containing soils which are situated closely to the Bennekomse Meent, we propose to apply paludiculture. By this land use type, we can integrate agricultural activities and the health of the peat habitats.

Design aims
Improve soil health and thereby stimulate soil regulating services
Increase the occurence of the target habitats
Achieve a closed sustainable and diversified agricultural chain
Increase opportunities for water recycling / slow down surface water discharge via minor water bodies

Design interventions
In zones of infiltration:
- Decrease amount and size of the ditches
- Regulate soil health and thereby groundwater availability
- Development of swales

In zones of seepage:
- Increase standstill surface water
- In parts with peat containing soil, apply paludiculture pracitces to combine agriculture and habitat development and conservation

Figure 5.2: Map for design pathway 'The aquatic Nerves' (1:50.000)

Current waterbodies
New waterbodies
Paludiculture

Mosaic of Agriculture & Vegetation

This third design pathway is an investigation to the ideal vegetation and agriculture strategy for both ecological and agricultural value and climate mitigation and adaptation. This Mosaic of agriculture and vegetation could be seen as an combination of recommended tools, that have already been introduced in the previous design pathways of recommended tools. Some of those recommended agricultural tools have already been introduced in the previous two design pathways.

Design aims

Turn the Binnenveld area into a self-regulating and resilient and dynamic ecosystem, by strongly putting emphasis on the cross scale relationships
Unique nature development and maintainance
Bridge the currently diverging demands from agriculture and nature

Design interventions

Propose food forestry, silvopasture and paludiculture
Create ecological connectivity by corridor of wet mesotrophic forest
Increase amount and size of settlement sites of target habitats
Develop bare grasslands for meadow birds

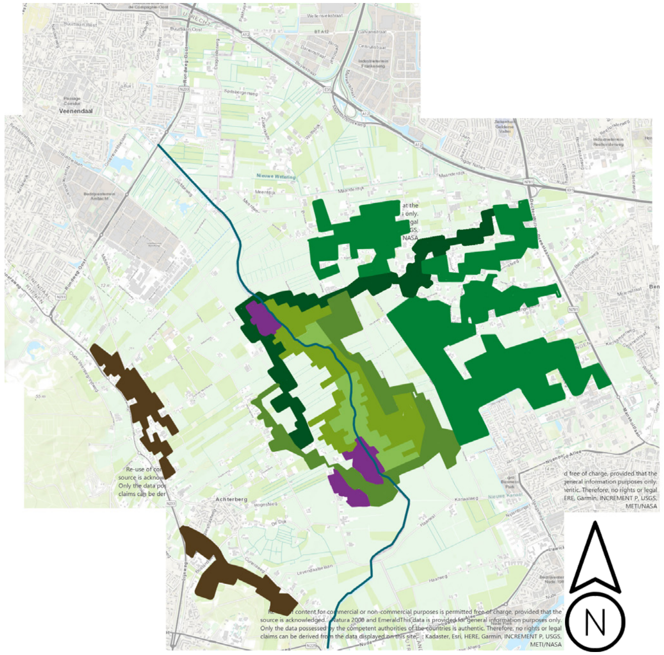

Figure 5.3: Map for the proposed Mosaic of agriculture and vegetation (1:50.000)

Grassland
Paludiculture
Wetland development
Regenerative agriculture
Wet mesotrophic forest
Agroforestry
New areas for target habitats

Evaluation of the large scale design pathways

The large scale design pathways are evaluated by use of the Research through Design framework. A fixed set of criteria, adressing climate adaptive capacity and seepage stimulation, and a pathway-specific set were selected. Those criteria are introduced in the third chapter of this thesis report. To what extent the design pathways contribute to the selected criteria is shown in figure 5.4.

	Aquatic Backbone	Aquatic Nerves	Mosaic of Agriculture & Vegetation
GHG regulation	+	+	++
Micro climate regulation	++	+/-	++
Adaptive capacity to water fluctuations	+/-	++	++
Seepage stimulation	+	++	+
Own criteria	Surface water storage ++ Groundwater storage +/-	Ecological water quality +/- Water recycling ++	Soil stabilization ++ Nutrient cycling ++ Differentation of agriculture ++

Figure 5.4: Evaluation table of the large scale design pathways

Based on this evaluation table, one could recognize the close interrelationship between the three design pathways. The first pathway primarly adresses the quantity of the water in and around the Grift, whereas the second pathway focusses on the network of minor water bodies, dynamics and quality. Nature based tools to meet the goals of those pathways derive from the third pathway. Disentangling the three proposed pathways would be nonsense, they need eachother to meet the goals of this design project.

5.2) Public access

During the design process, I have investigated three different scenarios for public access to the natural areas. Those scenarios are introduced and evaluated underneath. During this evaluation, I took only two criteria into account, respectively awareness creation / meaninggul experiences and opportunities for nature development and conservation.

Option I: Hard border between people and nature
In this scenario, people can only see the natural areas from pathways and roads surrounding the fields.

Option II: Selective access
In this scenario, people can entre a selected set of the fields in the Binnenveld. Protected nature areas, for example settlement sites of the target habitats, can only be seen from a distance.

Option III: Fully accessible nature
In this third scenario, people can freely move into the natural areas of the Binnenveld. Involvement of people in the natural surroundings and awareness creation are benefits of this scenario.

	Nature Conservation	Awareness creation
Scenario I	++	+/-
Scenario II	+	+
Scenario III	+/-	++

Figure 5.5: Evaluation table of the public access scenarios

Considering the large potential for the development of meaningful experiences, I have a preference for option III: fully accessible nature. However, the main focus of this design project is the development and conservation of peat nature for ecological and climate adaptive values. This scenario for public access requires design interventions to combine full access and ecological strengthening. That is why a proposal for a soft infrastructure network. This network comprises amongst others stepping stones over seepage ponds and plank bridge pathways over the peat wetlands. Figure 5.6 shows an impression of the experience of the proposed soft infrastructure over the peat wetlands.

Figure 5.6: Artist impression of experience of the peat wetlands

5.3) Detailed design

The area of interest is indicated by the black-lined rectangle on the map in figure 5.12. Since interventions of all three of the large scale design pathways come together here, this site is selected for further and more precise development of the design.

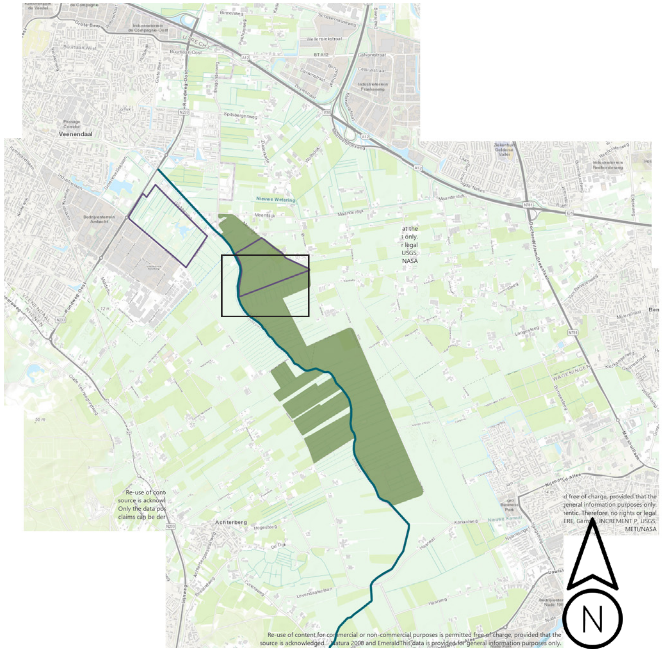

Figure 5.12: Location of the area of interest for detailed design (1"50.000)

Site specific analysis

By the development of the Binnenveldse Hooilanden, the peat and seepage dependent habitats in the northern area around the Grift have been stimulated (Block et al., 2016).

We have done mapping studies and on-site observations to determine where target habitats and interesting, protected, habitats are located in the area of interest. The results of this vegetation analysis have been summarized in figure 5.13.

Figure 5.13: Habitat types in the area of interest (1:10.000)

In the context of the same project, parts of the area have been digged off. By the creation of micro relief and depressions, spatial and temporal differences in inundation patterns and the settlement of target habitats were aimed to increase (Block et al., 2016). The spatial differences of inundation frequency in the area of interest are shown in figure 5.14.

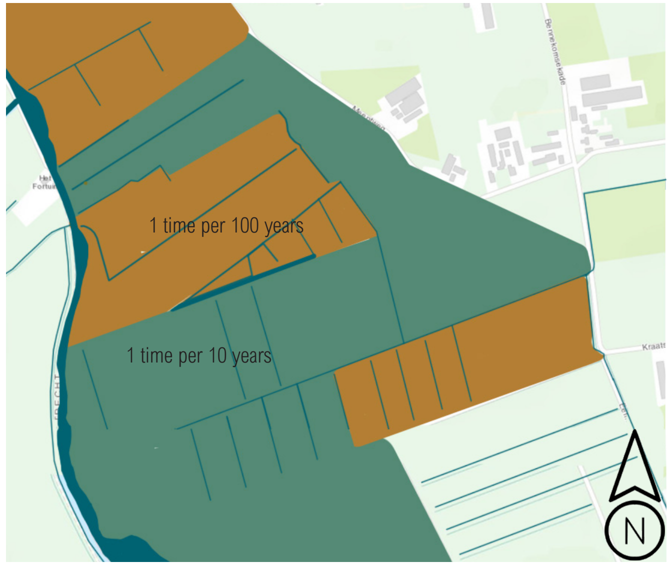

Figure 5.14: Inundation frequency in the area of interest (1:10.000)

Site specific aims and interventions

Integrate peat nature development and agriculture by the introduction of paludiculture
Improve ecological water quality by introduction of helophytic vegetation structures alongside Grift and ditches
Stimulate seepage damming of ditches / development of pond in places where a strong seepage flux can potentially occur
Increase available groundwater by introduction of wet forestry species, such as Salix alba and Alnus glutinosa alongside ditches
Increase biodiversity, water storage capacity and soil C sequestration by rewetting the peat wetland slongside the Grift
Circularity of agriculture by introducing cropping paludiculture (Azolla, Miscanthus, Typha latifolia), livestock paludiculture (water buffalos) and silvopasture.

Design options & Evaluation

During the development of this detailed design, I investigated multiple spatial configurations. I attempted among others a scattered model, one with large patches and one spatial configuration with corridors / axes. Those design options are evaluated based on earlier introduced criteria, deriving from conservation ecology and cultural ecosystem services. The outcome of this evaluation is shown in the table on the next page, figure 5.15.

	Small patches / scattered	Large patches	Corridor / axis
Habitat connectivity	-	++	+/- (Strong in line with axis, weak perpendicular on axis)
Habitat diversity	++	+	-
Habitat size	-	++	+
Recreation opportunity	+	++	-
Awareness	+	+	+/-

Figure 5.15: Evaluation table of spatial configurations detailed design

The detailed design elaborates on the junction of the three developed large scale design pathways. Also the proposed soft infrastructure network, the findings of the site specific analysis and design interventions in the area are taken into account during the development of this design. The map for the detailed design area of the Bennekomse Meent is shown in figure 5.16.

Figure 5.17 shows a healthy trilveen. Strengthening this habitat is one of the design goals. In figure 5.18

Figure 5.16: Provisional map for the detailed design area (1:10.000)

Figure 5.17: Trilvenen in the Binnenveld

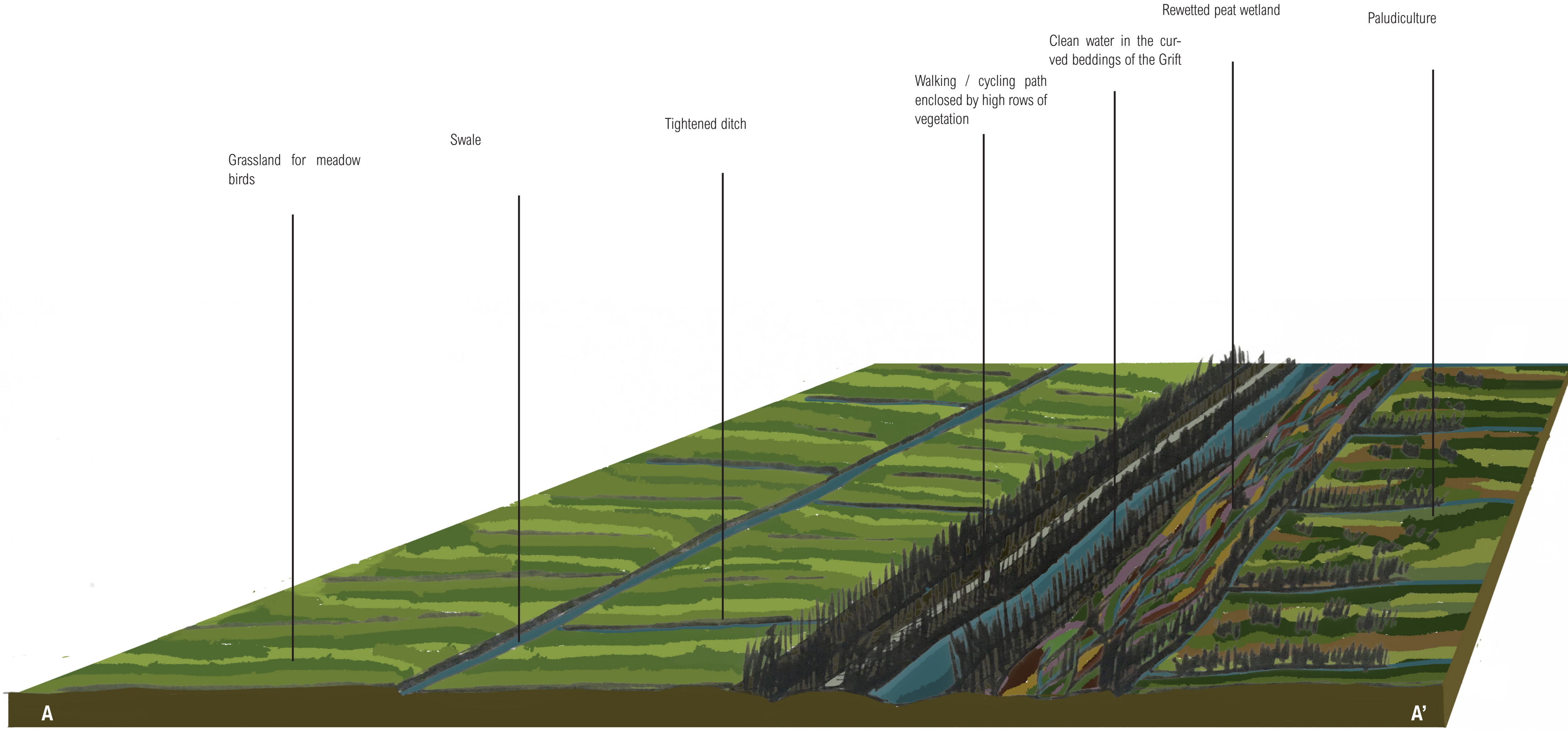

Figure 5.18: Cross section of the detailed design area

VI. DISCUSSION

By the outcomes of this design related research and by the evaluation of different design options, this bachelor thesis gives one potential answer to the question how the water system in the Binnenveld could be redesigned. However, it is important to realize that there is no one single answer. Each site requires another set of design interventions.

Although the results of this project are strongly embedded in scientific knowledge, it is hard to fully exlude intuition from the design process. Personal interpretation, background and the creative mind of the designer are also represented in this design. As a consequence, it is possible that repetition of this research by another designer, possessing the same knowledge, could result in very different design outcomes.

Although I believe that the design results of this thesis contribute to the ecological strengthening and increased capacity for climate mitigation and adaptation in the Binnenveld, the success in real life is not guaranteed. In practice, components such as finance, accessibility and the common interpretation of the design, highly influence to a large extent the success and functioning of a landscape design.

VII. CONCLUSION

Despite of their vital role in climate adaptation and mitigation (Mitch, 2013), peatlands are on a global scale drained for agriultural purposes. As a consequence, those landscapes have turned into a large source of greenhouse gass emissions, lost their biodiverse characterstics and they are strongly subjected to land subsidence (Page and Baird, 2016). This thesis aims to answer the main research question: “How can the water system of the Binnenveld be changed to stimulate its ecological value?”

The answer to this question could be summarized by ‘bridging’, i. e. of combining. By combining land uses, opportunities for synergies and by closing gaps between diverging requirements, mutualism and natural controll mechanisms are created. This is important, since climate change and growing populations are increasingly putting pressure on each land surface. In special paludiculture is generally considered to be a promising tool, bridging agricultural and ecological values, climate change adaptivity and mitigation.

I believe that redesigning complex networks, such as the water system in the Binnenveld, can only be done in a sustainable manner by adressing all components. In the case of this project, those components consist of the main surface water body, the Grift, the network of minor waterbodies and the groundwater resource. Although this design related research proposes guidelines for the Binnenveld, the concepts and packages of design interventions could be translated to peatlands around the world.

Improving the quality of life, now and in the future, requires a new way of thinking and daring to do something else than others did. This design is not the most aesthetic one, but is focussed on the context. On saving lifes in biodiverse peat landscapes.

Need for further research

The accurracy and well-balanced character of current design results can be improved by further research. In special the second pathway requires extra research. Modelling studies, investigating the impact of reduced surface waters on regulation of the thermal properties of the microclimate, will increase the accuracy of this large scale design pathway. Next to that, at this moment the large scale designs, the public access models and the detailed design are evaluated by quite small sets of design criteria. By introducing a larger number and stronger diverging design criteria, the developped designs will cover a wider range of functions and qualities.

At this moment, criteria for the opportunities of visitors and the cultural component of the landscape only adress capacity for awareness creation and meaning for experiences in the public access scenarios and the detailed design. Evaluating the component of visitors to the area by a larger set of criteria and also include them in the large scale design pathways, would enrich the design results.

VIII. REFLECTION

In this chapter, I will reflect on my experiences and the development process of this bachelor thesis. Writing a proposal and thereby imagining the whole process prior to the actual design process, is something I had not done before.

During the stage of proposal writing, I became aware of my strengths and weaknesses in the process. In advance of the design process, I expected to encounter most challenges in the development of my focus. In order to improve my skills in those phases of the design process, I listed personal learning goals. Those learning goals are introduced in the second chapter of this thesis report. They adress the understanding in my decision-making process and strengthening my focus of the design. Although I started with a too broad scope, I succeeded in narrowing down this scope while developping my design. While I was filling in the evaluation tables for the design options, I increasingly understood patterns in my decisions.

In advance of this period, the bachelor thesis felt as a complex and unmanageable thing. However, I figured out that my expectations did not reflect the reality. By carefully developping a scientific knowledge base, the design process felt more organized than I experienced during earlier design studios. From the moment that I experienced this organized pathway, my enthousiasm for my project increased. I enjoyed learning more about the Binnenveld, the area where I love to go for a walk during my breaks. Although I would have loved to do more for this bachelor project, I feel I can be happy with the outcomes of the previous weeks.

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