adaptive landscape

towards a climate robust future for the 'Blauwe Bron'

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"It is not the strongest of the species that survive, nor the most intelligent that survive. It is the one that is most adaptable to change."

Charles Darwin

Preface

This thesis report is the result of a research on climate change adaptation of the sandy rural areas of the Netherlands, which we conducted as part of our Master study Landscape Architecture and Planning at the Wageningen University. Our research is part of the CARE project, within the comprehensive 'Knowledge for Climate' programme. During our research we worked on one of the two case study areas within the CARE project called the 'Blauwe Bron', which consists of a beautiful gradient on the eastern slope of the Veluwe. It is a landscape with a complex soil formation and water system, which is under influence by the effects of climate change. We analyzed the potential effects of climate change from the perspective of different scenarios, after which we adeveloped a 'toolbox' of adaptation strategies consisting of adaptation measures to make the 'Blauwe Bron' area resilient to the effects of climate change. Our findings illustrate the possibilities to integrate these measures on different scale levels in the 'Blauwe Bron' landscapes, while enhancing the spatial quality of its landscape structures. The results form an interesting basis for future climate change adaptation in the sandy rural areas of the Netherlands.

We would like to express our gratitude to our tutor Sven Stremke for his support, enthusiasm and guidance during the past ten months. He inspired and motivated us during our meetings, which significantly helped us to improve our work. We want to thank our supervisor Adri van den Brink for his insights and critical feedback regarding our research proposal and green light presentation.

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Furthermore, we would like to thank Jan van de Velde of 'De Bekenstichting' and Richard Meijer of the Water board 'Veluwe' for their enthusiasm and helpful information, which helped us to understand the complex water system and the many qualities of the 'Blauwe Bron' area.

We also want to thank our fellow students who participated in our weekly morning presentation sessions for their support, useful feedback and pleasant company during the time of our thesis project. Thanks for the experience!

Wageningen, June 2012
Mikel Minkman
Jentse Hoekstra

Guide to the reader

chapter 1

Climate change is a well discussed item. The Dutch already have an interesting history in dealing with the effects of climate change, which is a constant threat. The national climate programme 'Knowledge for Climate' is constantly improving new and different approaches and methods in dealing with climate change. This chapter elaborates on the context of our research, our fascination towards this item and the context of our study area, which is the 'Blauwe Bron' area in the Province of Gelderland. Landscape architecture and climate change adaptation also share an interesting history in different kind of projects worldwide and on multiple scale levels. We see a significant contribution for us as landscape architects in both the theoretical and practical approach of climate change adaptation in the sandy rural areas of the Netherlands.

chapter 2

In the literature and field analyses we derived some problems that occur in the 'Blauwe Bron' area, which deal with extremes in water availability, water quality and clutter. The presence of these and future problems stimulate us to act and to solve these issues. For this reason we developed one main question that is divided in five sub questions, which all contribute in the search to find potential climate change adaptation measures for the sandy rural landscape of the Netherlands and to solve the deterioration of the 'Blauwe Bron' area.

chapter 3

Our methodology describes the five steps we took in our process from landscape analyses to spatial implementation. Each step demanded a specific approach. Our theoretical framework, which forms our scientific basis, is formed by the theory of landscape services, which is derived from the ecotsystem services theory. Our analysis of the theory of landscape services resulted in the development of climate change adaptation services, which are closely related. The 'Blauwe Bron' area provides services and goods due to the combination of landscape functions and human values. The new developed climate change adaptation services provide in the needs for climate change adaptation and hereby increasing the amenity value of the area. In this chapter these services and their application are further elaborated.

chapter 4

In the first step we analyzed the present 'Blauwe Bron' area with area visits and literature studies, which resulted in a clear understanding of the soil formation, the water system, its history, but also its qualities and problems, which acted as a solid basis for our next steps. We learned the importance of the unique water system and the possibilities to use it for future climate change adaptation.

chapter 5

We analyzed the near and far future landscape of the 'Blauwe Bron' area with use of one KNMI climate scenario (W+) and two socio-economic scenarios, which are the Global Economy and Regional Community scenarios, to derive an image of the 'Blauwe Bron' region in 2050. These studies are exogenous and will happen nonetheless, whether they describe positive or negative developments. The results are objective and are therefore usable to derive future problems and qualities. This step in our process is characterized by the separation of the two socio-economic scenario's. The two directions show each a different future due to changes in policy, society and economy.

chapter 6

After the development of the scenarios we developed a 'toolbox' of different climate change adaptation measures that could be applicable in the 'Blauwe Bron' area. The development of the visions hereafter are endogenous, in which our visions for the 'Blauwe Bron' area are elaborated. In these visions we built upon the qualities and propose solutions for the problems, which are related to the effects of climate change and the diminishing of spatial quality. The visions are written in text as well as visualized in two vision maps. Each vision is characterized by a guiding concept that steers future developments. At the end we made a comparative analysis between both visions to find out which climate adaptation measures would be the most robust if applied.

chapter 7

The next step was to develop landscape plans for each vision that would visualize the spatial developments on a more detailed scale at two specific locations in the 'Blauwe Bron' area. Specific location were then chosen, within each landscape plan, to be worked out as a detailed design to illustrate the implementations of climate change adaptation measures and were worked out to fit the human scale.

chapter 8

The final chapter discusses the limitations of our research, reflections upon our work and recommendations for future research studies for the possible implementations of climate change adaptation measures in the sandy rural landscapes of the Netherlands.

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introduction 1

effects of climate change

The climate is changing! Be aware, it is coming and it is coming fast without remorse! You probably have heard it before. The effects of climate change are discussed in the newspapers, talked about on the TV and radio and are on the priority list of both policymakers and governments. It is probably one of the most discussed topics of the last decade. We cannot ignore the fact that the climate is indeed changing with more frequent and intense climate extremes in the future, which is proven by countless of documents and reports. Still, most of these predictions, on both the global as well as the regional scale, remain uncertain (Kabat et al., 2005).

When a society is confronted with a new and strange phenomenon such as climate change it can do four things. They can eradicate it, assimilate it, embrace it or adapt to it (Sijmons et al., 2008). Eradication of the problem (climate change mitigation) is simply not conceivable on a short notice, as was underlined by the disappointing 'Rio+20' Earth Summit that recently took place. Assimilation of the issue by changing the societal rules that define the problem, which is a common strategy in the Netherlands. Thereby trivializing the risks of climate change is a regrettable but still common practice. The problem will not be dealt with nor will it be solved. Embracing and accepting the problem is the first step in working towards a solution. The amount of attention that governments and organizations pay to the issue reveals, according to us, their acknowledgement and embracement. Climate change is a fact and we have to deal with it. Though, as Goethe ones wrote: "it is not enough to know, one should also apply", followed by the statement "it is not enough to want, one should also act" (de Pater et al., 2011, p. 9). So the next step in this process, which is realistic and viable, is to adapt.

The increasing fluctuations in drought and precipitation, which can cause serious damage to agricultural crops, nature areas and the urban context, are clear signs of the changing climate (van Bakel et al. 2008). For this reason nations such as the Netherlands put their attention towards the possibilities of climate change adaptation.

adaptation

Adaptation, as defined in the Oxford dictionary, states that it is the process of change by which an organism or species becomes better suited to its environment. In line with this definition the Dutch have set up national climate research programmes such as the 'Klimaat voor Ruimte' and 'Kennis voor Klimaat' programmes, that investigate the effects of climate change on the landscape and which appropriate adaptation measures can be taken to reduce these effects (Klimaatonderzoek Nederland, 2011). The resulting interventions, which are of spatial, technical, management, political and societal nature, make us better equipped to cope with the imminent effects of climate change on for instance the water regime, nature and the agricultural sector (Blom et al., 2008). Climate change adaptation is already implemented in several hundreds of projects in the Netherlands along the main rivers, the coastline, in the polders, but also in the urban and rural landscapes (Pijnappels et al., 2010), which illustrates the human capacity to adapt.

climate research

This report builds further upon this on-going process towards a more adapted future for the Dutch landscape, in our case the sandy rural areas of the Netherlands. Instead of looking to climate change as a threat we choose to look further and identify possibilities and chances that this phenomenon brings; a strategy that has been quoted nicely by Pavel Kabat: "Climate proofing should be driven by opportunities for technological, institutional and societal innovations, rather than purely by fear of

opportunities for innovation

the negative effects of climate change" (Kabat et al., 2005, p. 283).

We see opportunities to apply new knowledge in practice, to make the Dutch landscape more beautiful and at the same time making it more resilient to future climate extremes. Our work is a testimony to this way of thinking.

resilient

1.1 Fascination and motivation

Climate change is a topical threat. Its negative effects are constantly in the news and in the last few years more and more innovative ideas and developments have come forth from research and climate ateliers to balance these effects (de Pater et al., 2011). There is an urgent need for new ways of thinking regarding to the effects of climate change. As mentioned before we focus ourselves on the possibilities instead of the threats. So we have got ourselves a current problem and a need to solve it. We are fascinated by the positive approach of thinking in solutions to solve future problems. We are capable of envisioning different kinds of futures instead of solely focussing on the present conditions of the landscape. This motivates us to put our knowledge into practice by developing a landscape that is more resilient to the effects of climate change and in which the cultural landscape, that we love, is maintained and strengthened. We want to do our part in solving this issue. It is our ambition to leave a better world behind and herewith a legacy for our children. Doing nothing is not an option.
So we act!

envisioning futures

1.2 Research context

CARE

climate proof

The context of our research is shaped by the CARE (Climate Adaptation for Rural arEas) project, a research project that is a thematic subproject within the comprehensive 'Kennis voor Klimaat' ('Knowledge for Climate') research programme. 'KvK' is a joint venture between Dutch universities, specialised research centres and enterprises and several layers of government, to develop knowledge and services that make it possible to climate proof the Netherlands. This programme is aimed at supporting the national programme 'Adaptatie Ruimte en Klimaat' ('Adaptation Space and Climate') not only to climate proof the Netherlands, but also to exchange and transfer knowledge to other universities and Delta areas in the world. Cooperation between stakeholders all over the world is essential to enlarge the range of creative and innovative solutions.

"The aim of this programme [KvK] is to assess the effects of climate change and adaptive strategies (i.e. sets of concrete adaptation measures) on agriculture, nature and other land-use functions in the rural landscape of the Netherlands. The strategies are meant to:

- Achieve a climate proof ecological structure that allows meeting high standard climate proof nature targets
- Give positive perspectives to agriculture, the drinking water sector and other land-use functions
- Optimize the overall functionality of the landscape, in terms of water management, biodiversity, agriculture, drinking water and recreation" (Kennis voor Klimaat, 2012)

The 'KvK' programme is further divided into nine so-called hotspots with their own set of climate-related problems that (are expected to) occur. We have chosen to investigate the hotspot of the dry, rural sandy areas of the Netherlands in which two case studies are present, 'Blauwe Bron' and 'Baakse Beek'. We have chosen the 'Blauwe Bron' case study area for further analysis and research, because we believe this region offers us a more dynamic landscape due to its unique gradient and differences in landscape types. We have also been inspired and awed by this specific region in the past, which motivated our decision to choose this case study for our research.

case study area 'Blauwe Bron'

The CARE project consists of three work packages with the following proposed research scopes:

1) "Integration: multifunctional adaptation to climate change"
2) "Water and biodiversity in the future climate"
3) "Drivers and consequences of adaptation by farmers"

Research on the subtopics strives to develop effective climate adaptation strategies and the resulting influence on scientific and societal aspects.

Work package 1, which focusses on the integration of multifunctional climate adaptation strategies, is divided into three projects. Project 1.3, "Design options for integrated multifunctional adaptation strategies" is the umbrella under which we will perform our research and design. The aim of this project is "... to explore design options for the implementation of integrated multifunctional adaptation strategies at the regional level" (van den Brink, 2010).

design options

The aim of project 1.3 is far too comprehensive to take on in our thesis research, which made us decide to focus on the challenge posed by the second research question, "How to apply these criteria in the development of design options for integrated multifunctional adaptation strategies in the case study areas? How should landscape planning, design and management be organized in order to be effective, efficient and sustainable?" In order to be able to answer this question effectively, we will have to look into the other questions nonetheless, and formulate our own research questions that fit both our ambitions and the timeframe. Our research questions will be discussed in chapter 2.

1.3 The 'Blauwe Bron' case study area

The province of Gelderland commissioned a study towards the potential effects of climate change within the two case study areas that are part of the before mentioned 'KvK' programme 'hotspot dry, rural sandy areas of the Netherlands' and includes our chosen 'Blauwe Bron' case study area. These areas were chosen for the strong differences in landscape structures, problems and their representativeness for large parts of Gelderland. Large-scale regional developments are also planned in these two areas. So a connection between these large scale developments and possible climate adaptation measures would be a strong collaboration (Spek et al., 2011).

regional developments

The boundaries of the 'Blauwe Bron' study area are defined and illustrated within the CARE project (Geertsema et al., 2010). It is more or less physically bound as it covers the watershed of the brook 'de Grift', which includes all the brooks and 'sprengen' of the eastern ridge of the Veluwe, and its path to the IJssel river.

Figure 1.1 The Veluwe can be clearly seen in the middle of the Netherlands, the 'Blauwe Bron' case study area covers the northern half of its eastern gradient
source: Bing maps, 2012

Veluwe

unique landscape

streams

amenity value

The area stretches over 25.000 ha in a North-South direction, and includes the villages of Heerde, Epe and Vaassen. The area is characterized by the articulated gradient from the glacial ridge of the Veluwe in the west to the flood plains of the IJssel river in the east. It is the complex geological history of the area that makes that the plains, slopes and brooks of the Veluwe form a landscape that is unique on an European scale, which is one of the reasons why we have chosen this area. Also unique for the Netherlands is the semi-natural water system of dug streams ('sprengen') that spring from the eastern ridge and flow to the IJssel valley, originally intended to drive water mills for local industry and to feed the canal. These 'sprengen', of which parts are elevated, were a source of energy for the water mills in the past and were considered to be of great economic value.

The two main landscape types of the area contrast in both land use and atmosphere. The western part consists mainly of forest, heath, stream valleys, villages, estates and scattered small pastures, whereas the eastern half is a more large-scale and open 'typically Dutch' lowland polder landscape with meadows, corn production, canals and farmyards. Both landscape types together form the highly valued landscape of 'wedges' in the eastern ridge of the Veluwe, and the entire case study area belongs to the 'National Landscape Veluwe'. Some specific qualities that have been defined are the 'amenity value' of the gradients, the small-scale mosaic landscape, the diversity of occupation patterns, the various estates and the network of typical 'sprengen' brooks and its relics. The elevated as well as natural streams together with the estates and mills that are scattered over the landscape, provide many cultural-historical, ecological and aesthetic values and significantly contribute to the region's unique character.

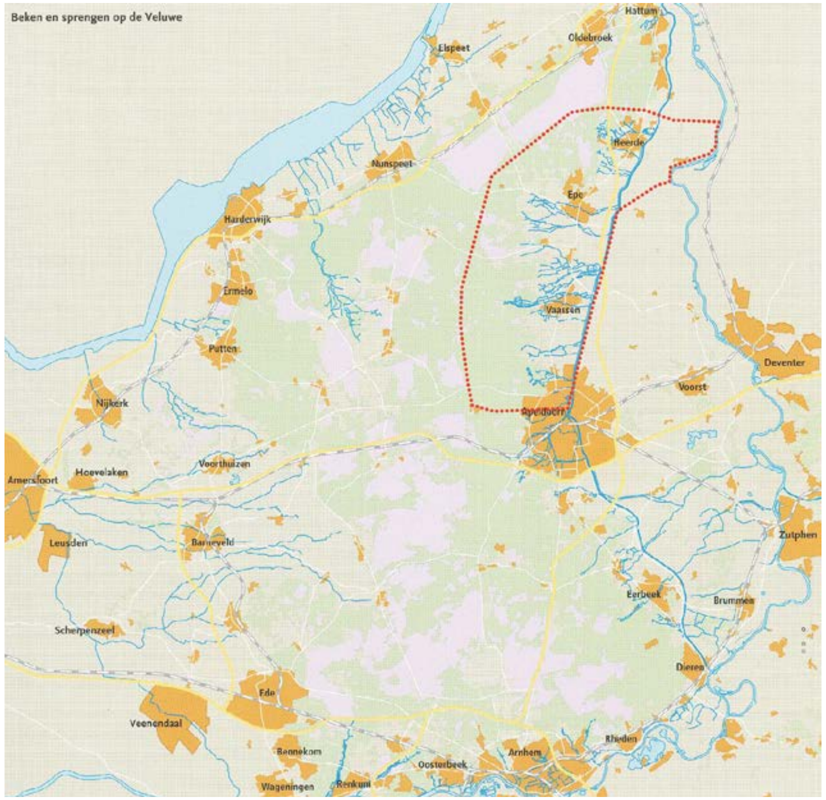


Figure 1.2 The many streams that flow from the Veluwe, with a notable concentration of streams in the 'Blauwe Bron' area

source: Menke et al., 2007

There are several issues and projects that play a role in the spatial development of the 'Blauwe Bron' area. The most important tasks for this region are the development of a vital agricultural sector, landscape development for nature and recreation and the development of a robust ecological and hydrological corridor for the EHS ('ecological main structure'). This corridor, called 'De Wisselse Poort', will be developed between the Veluwe and the IJssel river near Epe. A public initiative is to revive the currently unused 'Apeldoorns Kanaal' with facilities for water recreation and tourism.

1.4 The role of landscape architecture in climate change adaptation

flooding

Delta Works

The destructive force of water as well as its ability to sustain life are well known by the Dutch for thousands of years. In those early times, when large parts of the Netherlands were covered with peat lands, our distant ancestors already dug ditches to bring these grounds into cultivation. Over the last centuries the ground gradually started to subside due to more intensive draining. Due to the digging of ditches, large scale cultivation, land reclamations and the rising sea level, the risk of flooding from both the sea and the rivers increased nonetheless. The Dutch started to protect the low lying lands with innovative masterpieces such as dikes, dams and eventually after the storm flood of 1953 the famous Delta Works. The development of the storm surge barrier in the Eastern Scheldt estuary was the first project in which civil engineers worked together with ecologists to create a dynamic, lockable flood barrier. As quoted by landscape architects Adam water management

comprehensive projects

framework

Hofland and Arjen Meeuwsen: "This was a turning point in Dutch water management, moving away from a technical sector-based approach and toward a more comprehensive solution. Landscape architects worked on the 'scenic fit' of the new situation: on the layout of the dams, with forests and recreational islands. Yet a marked change in the role of landscape architects in these comprehensive water management projects was not far off into the future" (Hofland & Meeuwsen, 2011, pp. 18-19).

In 1985 the 'Plan Ooievaar' was the winning entry of the 'Eo Wijers competition', proposing a new structure and water management strategy for the Dutch river landscape. It was one of the first projects in which the casco-concept was used in practice. The casco-concept can be seen as a designed landscape framework, existing of a network of areas, in which optimal conditions are offered for the development of high-dynamic land use forms (van Buuren, 1997). The use of this concept in the river floodplains of the Dutch rivers has led to the formation of a coherent framework of self-regulating natural processes, which also made exceptional forms of recreation possible within these floodplains. The importance of the 'Plan Ooievaar' and the casco-concept is illustrated nicely by Hofland and Meeuwsen: "The casco-concept and the 'Plan Ooievaar' were milestones in the involvement of landscape architects in the integral design of water and land on the regional scale" (Hofland & Meeuwsen, 2011, p. 19).

In the early nineties of the twentieth century water managers became more aware of a possible climate change (de Pater et al., 2011). Frequent water nuisance and the high water levels of the rivers in 1993 and 1995 were reason to investigate the Dutch water system for its capacity to cope with the appearing effects of climate change. It appeared that the Dutch were not ready (de Pater et al., 2011). It was the start of the national 'Ruimte voor de Rivier' programme to protect the entire river area from potential future flooding, and to offer at the same time opportunities for spatial development for the region. Within this programme Dutch engineers started to collaborate with spatial planners and landscape architects to develop and design climate change adaptation measures, which were implemented in the first river widening projects in the Netherlands. The programme started in 2006 and is scheduled for completion in 2015 with more than 30 completed projects along the major rivers. Landscape architects all over the world are now part of the on-going process in developing and implementing climate change adaptation measures into integral plans on all scale levels, thereby translating abstract climate models and governmental programmatic ambitions into durable and attractively designed landscapes.

climate change adaptation measures

integral plans

1.5 Knowledge gap and significance for andscape architecture

There are significant gaps in both theory and practice with regard to climate proofing the sandy rural areas of the Netherlands. On the one hand regional stakeholders identified knowledge gaps for the development of climate proof rural areas. There is for instance a need for more fundamental knowledge about the effects of climate change on the hydrological system, such as ground water recharge, and the role of geomorphology in these areas (Geertsema et al., 2010 and 2011), but also between future water management policy and EHS-targets (Didderen et al., 2010).

knowledge gaps

On the other hand there is a significant gap between the plans for future climate change adaptation and the introduction of actual spatially designed solutions in the Netherlands, the 'Veluwe-IJssel' region in particular. The study of the possible effects of climate change in the two case study areas in 2010 had the aim to reduce the gap between science and practice and to

identify gaps

identify gaps that require further investigation (Spek et al., 2011). Landscape architectural visions and guidelines are yet absent within the CARE programme, limiting the practical applicability of its scientific findings. This project therefore invited and enabled

landscape architecture

us to introduce landscape architecture in the process, which contributes to the on-going process of the translation of climate adaptation measures into concrete spatial interventions. The

'no-regret' measures

challenge, then, was to find so-called 'no-regret' measures that benefit both society and nature under different future scenarios (Geertsema, 2010).

Apart from the contribution that our research offers to the region and the knowledge base of the CARE programme, the introduction of landscape architecture in the development of integrated climate adaptation strategies is also a desirable contribution for the profession of spatial design itself. The knowledge and experience gathered that way is twofold; some of it is utilized

research and design

in the research and design process, where the more practical knowledge is applied through spatial design itself. Either way, we believe that our work helped to decrease the existing knowledge gap between climate adaptation theory and implementation.

1.6 Role and position of report, aim and perspective

toolbox

guide for development

This report offers a toolbox of measures and preconditions for the adaptation of the 'Blauwe Bron' area, which is under influence by the negative effects of climate change. This report should be interpreted as a guide on how to steer future spatial developments, the results from our study can be used and implemented in other sandy rural areas in both the Netherlands and abroad.

Before continuing, we want to clarify some of the choices we made during the research and design process. In this report different scenarios and visions will be discussed. Experts and scientists from different disciplines have collaborated to anticipate on the uncertain future by developing four different national climate and socio-economic scenarios. These scenarios give us a heads-up of what might happen by 2050 in order for us to be prepared and to take appropriate actions. The regional scenario developments that will be described in this report, which are derived and translated from the existing scenarios, are exogenous and are beyond our control. We have interpreted them from an objective point of view and they will happen nonetheless. In this report we are building further upon the positive scenario developments and hereby offering solutions for the negative ones.

exogenous scenarios

Our solutions for the present problems and adverse future developments are combined and formulated in our visions, which are subjective and anticipate on the developments of the scenario study. The visions are endogenous and present our personal input to develop the landscape of the 'Blauwe Bron' area towards a more desirable future by using guidelines for spatial interventions.

endogenous visions

explore solutions

However, the fact is that we do not know exactly how the future will look like. Nobody knows. The results from both the scenarios and visions must therefore not be taken as fixed future developments. Our visions and their subsequent spatial interventions are a way to explore possible solutions for specific, but uncertain futures. We are convinced that there are more solutions for the negative effects of climate change, that we have not yet found or which are not yet present, but we hope that others will continue to expand the amount of knowledge and solutions for climate change problems in the future.

2 problem definition research questions

2.1 Current problems defined

drought

The most urgent problems that the 'Blauwe Bron' area faces today as well as in the future are related to climate change, but decline of spatial quality is also a recurring theme. The rural landscape is suffering from opposing and yet related issues. On the one hand the high grounds are suffering from drought due to the increasing temperature and the possible impact of the drinking water company 'Vitens', while on the other hand lower lying stream valleys and plains will have to deal with increasing water discharge and water nuisance due to peaks of rainfall (KNMI, 2006; Blom et al., 2009; Geertsema, 2010). Most nature areas are prone to the negative effects of drought. Especially the nature types that are found in the stream valleys (Blom et al., 2009).

water nuisance

The effects of water nuisance are illustrated nicely by different newspaper articles and amateur recordings in the last couple of years. Examples are water nuisance footages made in both July 2008 and 2009 of flooded streets and basements in Vaassen and Epe (Youtube, 2009 and 2011) and the following news flash written in 2011:

"Downpours lead to water nuisance - Parts of the Netherlands are suffering from water nuisance due to downpours. The problems are the greatest in the middle and eastern regions of the country. The fire department in Ermelo, Epe and Harderwijk has received dozens of emergency calls of flooded houses and streets" (translated from: NOS, 2011)

It is clear that the problems caused by increasing peaks of rainfall are well known in the villages in the 'Blauwe Bron' area. According to KNMI climate scenario's, heavy cloudbursts such as these will likely occur more often in the future, a solution for this problem is therefore needed.

groundwater

A second threat in our study area is related to the quality of the groundwater, which is especially on the Veluwe of great importance given its close relationship with ecological values. According to the province of Gelderland 38% of the land is in use for dairy farming, which makes it the largest branch of production in the province. Of this percentage a large acreage (80% of the agricultural grounds) is used for the production of hay and has been fertilized for many years (Provincie Gelderland, 2012). Eutrophication and different types of pollution as a result of such agricultural practices poses a threat to water quality in nature areas and the brooks.

spatial quality

A third threat is the loss of landscape quality and its amenity value. The most important spatial problem is both notorious and persistent: 'verrommeling' (clutter) manifests itself in various ways but always results in a degradation of the typical qualities of the old landscape, which is also the case in our study area. In the past, prior to the industrial revolution, people were guided by natural logic and shaped their environment accordingly, which we call vernacular design. Houses and farms were built on the high grounds using local tradition with use of area-specific materials (de Jong, 2011). Due to progressive techniques and methods, we now live in a society in which natural limitations no longer force us to build on the most suitable locations. The resulting increase of illogical developments such as houses in peat lands and stream valleys threatens the coherence and contrasts between the different landscape types in a former logically structured landscape. A stream valley for example is characterized by open grasslands, the placing of new houses in it would drastically decrease its openness and visual appeal. The threat of an unstructured and illegible landscape arises due to such developments (de Jong, 2011), which is also detrimental for EHS targets. Without a logical landscape structure, the amenity value and quality of the different landscape types in the 'Blauwe Bron' will most likely diminish, which is unacceptable from our point of view.

2.2 Aim and research questions

Aim

Our ambitions are to develop methods and examples on how to design a landscape which corresponds to our interpretations of the three famous values that Vitruvius formulated. Utilitas - functionality, Venustas – beauty and amenity, and Firmitas, which most appropriately translates to robustness, a key property of sustainability. In the specific case of the 'Blauwe Bron' case study area this ambition can be translated to the aim of our study:

robustness

'To explore and develop ways in which flexible adaptation to a changing water regime can be provided by and integrated in the landscape'

This statement is formulated to be in line with the aim of CARE project 1.3 as stated before. Parallel to our investigation on adaptation strategies, we strive to create a landscape design that can act as a source of inspiration for those who want to participate in developing a more resilient landscape in the future and herewith enhancing the spatial quality in the sandy rural areas of the Netherlands.

investigation

inspiration

Main research question
Following our problem statement, we have formulated our main research question as follows:

integrated adaptive landscape design

'In what way can integrated adaptive landscape design contribute to a sustainable water system in the 'Blauwe Bron' area while enhancing spatial quality?'

Research and design subquestions
We will study this complex question by investigating several of its subtopics through the use of sub questions. Some of these have been adapted from research questions that are proposed within the CARE project, and some were developed by ourselves in order to meet our aim.

adaptation strategies

1. Which adaptation strategies to climate change can be applied in the 'Blauwe Bron' case study area?
2. What are the design principles by which the sandy rural areas of the Netherlands can be adapted to climate change?
3. What are the opportunities to use the system of brooks in the development of an adaptive water (management) system for the 'Blauwe Bron' case study area?
4. How can we utilize the water system to realize a multifunctional landscape that incorporates values for ecology, agriculture and recreation?
5. How can we find and develop opportunities to reverse the degradation of the old landscape by means of the water system? (after: Witte, 2010)


frameworks for research and design
3
adaptive landscape

3.1 Theoretical framework

connections with research

For our study and design to be as useful as possible, it is important to have it firmly anchored in a theoretical basis. By making connections with scientific research and relevant insights, we hope to widen the scope of this study and increase its value to others. The theory described below has been useful to discover and interpret knowledge that provides a deeply systematic support for the functional aspects of the climate robust landscape we aim to develop.

Ecosystem services and landscape services

integration

The principle of integration is a key property of the landscape when we look at it as a functional entity. Almost any landscape has a multiplicity of functions that are integrated simply because they coexist, so in that sense integration is not something that spatial scientists have invented. To explain what the ecosystem services concept is and what its potential significance to the development of (integrated) climate adaptation strategies and policy is, we will first explore what it consists of.

functions

The landscape has always had several functions to humanity, and any landscape offers a mix of those depending on its characteristics. All living creatures are dependent on those functions being provided, and making use of those functions has enabled humanity to survive and thrive. The complex ecological structures and processes have been translated to a range of ecosystem functions and ordered in five categories by Rudolf de Groot.

"(1) Regulation functions: This group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through biogeochemical cycles and other biospheric processes.

(2) Habitat functions: Natural ecosystems provide refuge and reproduction-habitat to wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes.

(3) Production functions: Photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures, which are then used by secondary producers to create an even larger variety of living biomass.

(4) Information functions: Because most of human evolution took place within the context of undomesticated habitat, natural ecosystems provide an essential 'reference function' and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, re-creation and aesthetic experience.

(5) Carrier functions: Most human activities (e.g. cultivation, habitation, transportation) require space and a suitable substrate (soil) or medium (water, air) to support the associated infrastructure. The use of carrier functions usually involves permanent conversion of the original ecosystem" (De Groot, 2006, pp. 177-178).

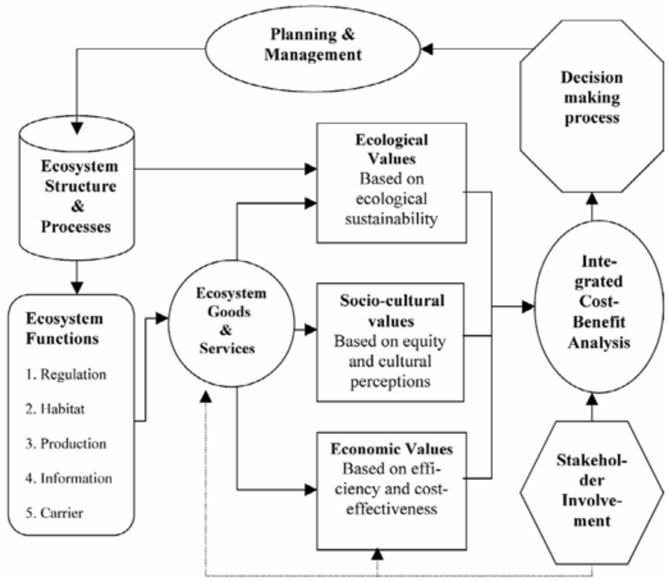


Figure 3.1 The five categories of ecosystem functions and their valuation process
source: De Groot, 2006, p. 177

services

values

natural capital

Ecosystem functions are intrinsic properties of the landscape and will always be present, also in the absence of people, as Termorshuizen and Opdam point out. However when people connect a socio-cultural, ecological or economic value to such functions, they can be regarded as 'services' since the values recognize that a function can provide one or more benefits and/or goods to humanity. The 'services' concept includes a social aspect that emphasises the connection between physical systems and human values (Termorshuizen & Opdam, 2009). All those services are to some degree indispensable for our existence and convenience since they offer safety, nutrition and the means for enforcement and progress, such as energy.

While that may seem obvious, the significance of understanding landscape functions is emphasized and repeatedly clarified. Theoretical scientific insight in the provision and use of ecosystem services allows us to link the physical landscape structure to the economic, sociocultural and ecological values that that are relevant now or in the future (Termorshuizen & Opdam, 2009). In the context of the current global crises regarding the climate and environment, a team of leading scientists has attempted to quantify and assess the economic value of all ecosystem services and 'natural capital' on earth in a very extensive study for Nature (Costanza et al., 1997).

It has been argued by scientists from different fields that this concept being labeled 'ecosystem services' might not be a good idea. Their main argument relates to communicative expressiveness; because of how the word 'ecosystem' is generally understood it sounds like something of a more scientific nature, hence the notion triggers associations with natural sciences and nature management. However, by connecting human value to

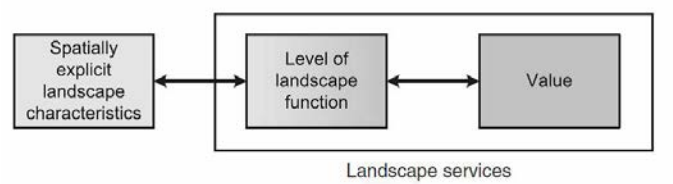


Figure 3.2 The strucutre-function-value chain
source: Termorshuizen & Opdam, 2009, p. 1041

landscape ecology, the scientific pattern-process paradigm is extended beyond the exact sciences towards a paradigm that includes social influences.

landscape services

spatial component

The concept of 'landscape services' that has been proposed before is more fitting because it transcends the individual paradigms of natural sciences and recognizes a spatial component. Because of its more inclusive character it can help facilitate "an interdisciplinary knowledge base that is suitable for collaborative planning" (Termorshuizen & Opdam, 2009, p. 1042), therefore we encourage a general adoption of the term 'landscape services' and will continue to do so in this study.

recognizable

framing

It is crucial for successful spatial development that the concept is widely understood by being more relevant and recognizable for both experts and local actors. It can facilitate the 'framing' of socio-spatial issues with actors and thereby help setting a collective goal of adding value to the landscape. Despite the fact that the researchers Melman and van der Heide still used the term 'ecosystem services' in their assessment of its potentials for Dutch spatial policy, they confirmed that framing is highly important for increasing awareness of the environment. "Explicitly identifying ecosystem services – i.e. the benefits ecosystems can produce for humankind – can greatly reinforce people's awareness of the extent to which humans depend on the environment in which they live" (Melman & v/d Heide, 2011, p. 16). When yielding recognition and support for 'landscape services' across society succeeds, the concept can fulfill its promise to be a bridge between spatial policy and sustainable, collaborative development.

sustainable development

Sustainable development is of course a hot topic because experience taught us that too many socio-spatial developments

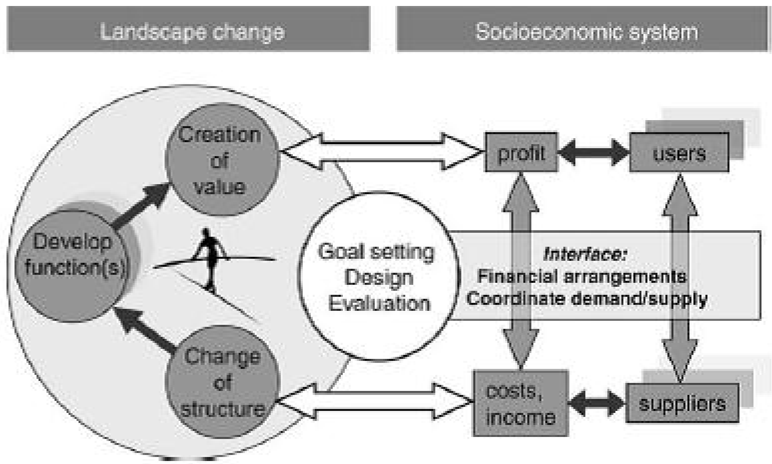


Figure 3.3 A conceptual framework for collaborative spatial development
source: Termorshuizen & Opdam, 2009, p. 1046

have been taking place in an unsustainable way. Well-known publications that revealed the ways and rate at which we impoverish our planet with our current practices are 'Limits to Growth' published in 1972 by the Club of Rome and 'Our Common Future', the 1987 report of the World Commission on Environment and Development (WCED) by G.H. Brundtland. The latter defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p. 41). Brundtland thereby includes poverty, population growth, environmental degradation and climate change. Within the scope of this study and our case study area, we will limit ourselves by stating that unsustainable development leads to landscape degradation and decreasing resilience. Landscapes and ecosystems will then risk no longer being robust enough to withstand the current and/or future environmental conditions.

landscape degradation

We believe that unsustainable development can be considered as the result of an imbalance between desirable and present landscape functions. Many rich and multi-functional landscapes haven been or are being converted into mono-functional and depleted landscapes, sometimes with little hope for restoration (De Groot, 2006). Regarding only to the economic value of landscapes can impoverish our planet and its resources, which is basically nothing else than destroying 'natural capital'.

imbalance of functions

To avoid the decline of the environment, actors should be aware of what a landscape can endure. The definition of ecological sustainability is a good starting point for understanding this tolerance. Ecological sustainability can be defined as the natural limits set by the carrying capacity of the natural environment

decline

natural processes

ecosystem approach

carrying capacity

multifunctionality

(physically, chemically and biologically), so that human use does not irreversibly impair the integrity and proper functioning of its natural processes and components (de Groot et al., 2000). The stability of an ecosystem or landscape can also be described as its resilience, meaning its capacity to withstand or recover from external influences. As climatic changes occur, natural resource management techniques can be applied to increase the resilience of ecosystems. Increasing resilience is consistent also with the 'ecosystem approach' developed by the Convention on Biological Diversity (CBD) which is "a strategy for management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (Smith and Malthby, 2003, p. 4).

Ecological sustainability and resilience can be coupled to landscape services to determine what the carrying capacity of a certain landscape is, by seeking for the optimal sustainable combination of services and goods that it can provide. Although multifunctionality results in a greater capacity to provide various ecosystem services, it also results in a reduced capacity for each of the individual services (Willemen, 2010). Therefore it is a challenge for future spatial practitioners to realise an optimal ratio between efficiency and multifunctionality regarding sociocultural, ecological and economic values.

Climate change is, as we all know, a global biophysical process that affects every place and every creature on our planet one way or the other. "Changes in landscapes together with the demand for and use of their services are driven by a range of demographic, economic, political, cultural, and biophysical processes" (Willemen et al. 2012, p. 86), so climate change is inevitably influential on the landscape. Despite the fact the we do not know yet how certain and how big this influence will be,

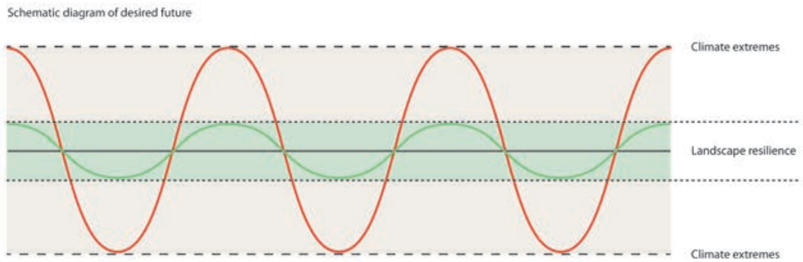


Figure 3.4 Graphical representation of landscape resilience. An adaptive landscape can 'absorb' some of the negative effects of climate change

precautionary principle

the precautionary principle demands us to take action to prevent irreversible damage. Therefore, making deliberate and balanced use of landscape services is even more important if we want to make the landscape resilient to a changing climate. Especially the regulation- and habitat functions are crucial for the implementation of climate adaptation strategies. Regulation functions include all abiotic and biotic processes that regard soil, air and water regulation, whereas habitat functions are important to maintain biodiversity and possibilities for migration.

To facilitate an optimal allocation of landscape functions, we have established which services we expect to be required in times of climatic change. "For scientific knowledge that has an impact on landscape-development processes, therefore, the first prerequisite is that desired landscape values can be related to intended changes in structure and functioning of the physical landscape" (Termorshuizen & Opdam, 2009, p. 1038). In other words, desired landscape values - such as resilience, are to be determined for future situations and translated back to specific intentions for current spatial development.

intended changes

To emphasize the spatial component of climate adaptation, to clarify the tasks at hand for involved actors and to substantiate the often poorly understood notion of 'climate adaptation', we propose the introduction of 'climate change adaptation services' as a subcategory of landscape services. It should be noted that this concept is clearly not a new type of landscape function, but rather a range of climate-related services and goods stemming from several landscape functions which potentials are already present. This is illustrated by appendix I, which presents an extract of the landscape services presented by Rudolf De Groot. Shown in the table are only the functions and services that are applicable

climate change adaptation services

to the case study area. The presented climate change adaptation services are in many cases part of existing landscape services (e.g. 3.2, flood prevention), but some are new (e.g. 5.3, drought prevention).

climate robust design

What using 'climate adaptation services' has helped us with during the design process might certainly prove helpful in regional sustainable development and climate robust design. "By effectively governing and guiding land management actions, undesired trade-offs in supply of different landscape services could be minimized" (Willemen et al., 2012, p. 86). This means that beforehand defining what climate adaptation services a certain area most likely will need and/or provide is an important step in determining the most appropriate mix of climate adaptation measures that should be taken. Important thereby is that since it is part of a larger whole of landscape functions and services, careful consideration and setting of policy targets helps to balance climate adaptation measures with other services regarding for example recreation and agriculture.

balance

"Adjusting the use of the environment we live in by improved utilisation of ecosystem services offers some attractive prospects: making use of regulating and supporting services in particular will reinforce sustainability and reduce environmental impacts. Areas usually offer multiple ecosystem services simultaneously, and are thus multifunctional. Ecosystem services can often be utilised by combining physical functionalities (reinforcing sustainability) and cultural significance (attractive landscapes, amenity value)" (Melman & v/d Heide, 2011, p. 14). The authors here emphasize that functional aspects of climate adaptation multiply the potential array of landscape services when they are linked to cultural significance, in other words increasing societal relevance

the societal relevance of sustainable development. The social component of 'services' also involves policymakers and local actors to recognize their opportunities and duties, making the services concept a potentially powerful tool in climate governance. In short, landscape services are both a means to and expressions of optimal utilization of the landscape's potential.

3.2 Methodological framework

To structure the research and design process, using methods that clarify individual steps and design choices is very helpful.

Milburn & Brown

complex itellectual activity model

layer approach

The article 'The relationship between research and design in landscape architecture' by Lee-Anne Milburn and Robert Brown (Milburn & Brown, 2003) is greatly clarifying in describing different research-design models that are useful for a spatial (design) research strategy. They elaborate on the 'complex intellectual activity model' as first presented by Ledewitz (Ledewitz, 1985), which we found a very suitable research design model for this study. It describes how a design problem can be dissected by treating it as a series of separate, interrelated components. The principle of this model forms the basis of the well-known 'layer approach' that we use today to dissect and analyse the landscape, which is also elaborated by Tom Veldkamp in the article "The layer approach as a basis for landscape design in a changing environment" (Veldkamp, 2008). The complex intellectual activity model dissects a discovered problem and reveals underlying structural relationships. The process behind the model is meant to provide a clear vision of the inter-relationships between all components and moreover to contribute to the development of an integrated solution.

Stremke

Defining the major (potential) problems and their interrelationships for the current and future landscape of the 'Blauwe Bron' is the main purpose of our landscape analysis and scenario study.

To structure this process of assessing potential futures, we make use of the five-step approach as constructed by Sven Stremke. The five-step approach has been developed through the analysis and adaptation of three previously developed approaches, which all provide important building blocks for a joint approach toward long-term visions. This framework has been developed to further advance long-term thinking in regional planning and design. The objective of this approach is to analyse an array of possible futures and to compose imaginative, yet realistic, desirable futures in integrated visions. According to Stremke, the following three modes of change should be integrated in the design process: change due to current, projected trends such as near future developments (step two), change due to critical uncertainties on a longer term such as climate scenarios (step three), and endogenous input through intended change such as integrated visions in the fourth step (Stremke, 2010). Our personal adaptation of the five-step approach, as can be seen in figure 3.5, shows how the different steps of analysis and future assessment lead to the development of integrated visions and ultimately landscape design. This approach functions as a guardrail in a work process that is more complex in reality because of an iterative character, with movements back and forth between research and design, as well as between different spatial scales.

joint approach

future assessment

guardrail

The five-step approach consists of the following steps, to be taken subsequently:

1. Present conditions. How does the region function at present and how can it be evaluated?

2. Near future developments. How will the region change in the near future?

3. Possible far-futures. What kind of possible long-term developments can be expected in the study area?

4. Integrated visions. How to turn a possible future into a desired future, what should be done?

5. Spatial interventions. Which possible interventions should be implemented, what should the landscape look like?

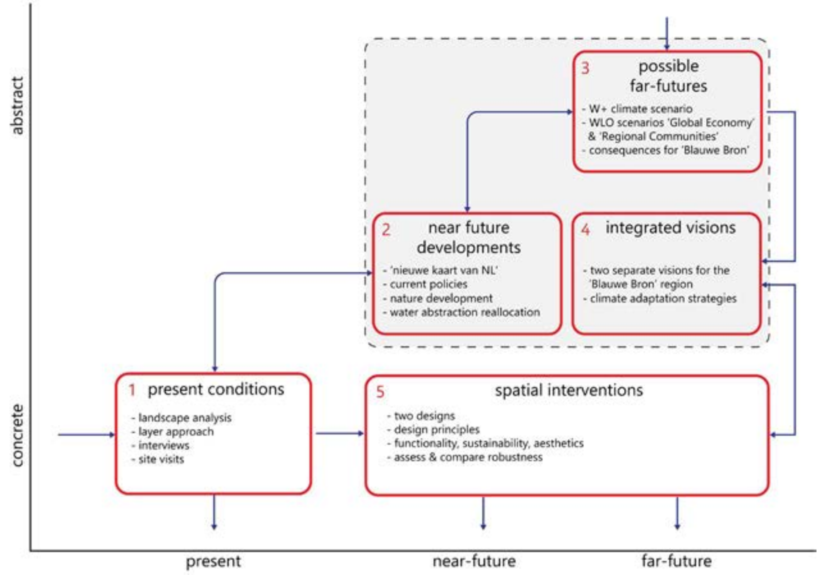


Figure 3.5 Methodological framework based on the five-step approach adapted from: Stremke, 2010

3.3 Work process

Our methodology of the five-step approach has greatly structured our work process, which is roughly divided in three phases.

Phase 1 – landscape analysis

analysis

The first phase consists of the analysis of current conditions and therefore equals the first step of the five-step approach, as can be seen in the workflow diagram in Appendix II. With the use of the layer approach we analyse the different systems such as the water system, the topography, elevation and cultural historical artefacts. This helps us to understand the coherence between the different landscape types and functional relationships between layers.

Phase 2 – vision development

exploration

The second phase is dedicated to the exploration of the future and hence encompasses the second, third and most of the fourth step of the five-step approach. Here we first explore the short-term developments, considering the timeframe up to 2020 based on expected trends and current policies. As will be clarified later, we will mostly make use of current policy documents and currently progressing spatial developments to determine the baseline situation of 2020.

assessment

Thereafter comes the assessment of possible futures as we expect them to develop in the light of projected scenarios. The choice of scenarios helps us limit our scope to two likely futures. Figure 3.6 illustrates how our approach is set within the overlapping 'spheres' of possible, likely and desirable futures that possibly lie ahead. It can be seen that both the climate scenario of the IPCC and Royal Netherlands Meteorological Institute (KNMI) and the two socio-economic scenarios (WLO) are within the boundaries of 'likely futures'. The boundaries and opportunities posed by the two WLO-informed socio-economic situations are taken as exogenous factors ('a given thing') that the case study area has to deal with, combined with the consequences of the 'W+' climate scenario. We will give a more detailed introduction on the origins and purposes of the two scenario studies that we use in chapter 5.

To be able to make informed decisions on the influence of climate change and socio-economic developments on the case study area, we gather and analyse scientific knowledge regarding climate change and its scenarios. This input is then used to define region-specific parameters by informed interpretation of national and regional data, and translated to spatial consequences as we expect them to manifest themselves.

scenarios

With this knowledge, we both envision how the area should develop to adapt to either one of the expected futures. Here endogenous influence starts to become important; through the input of personal ideas, promising scientific knowledge and inspiration, our two visions sketch two alternative desirable futures. Solutions to the issues mentioned heretoforth are brought forward, and suggestions for (water) management and spatial design imply how to possibly deal with future circumstances. Those advices are translated into sets of climate adaptation measures, known as adaptation typologies, and to maps showing the spatial component of adaptation strategies.

visions

spatial component

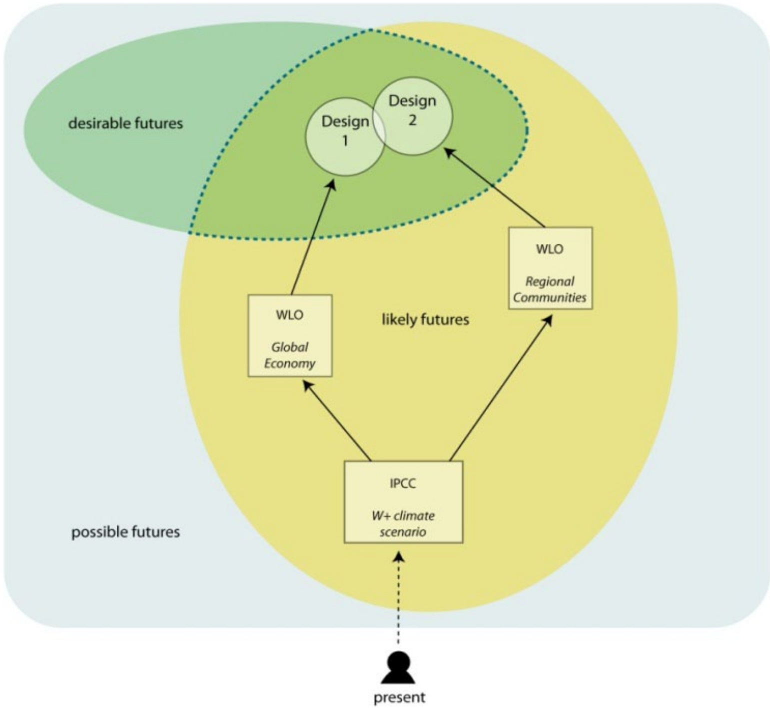


Figure 3.6 How this study looks to the future: to turn likely futures into a desirable future

adapted from: Sijmons & Eekhout, 2008

Phase 3 – design development

landscape designs

The visions are illustrated and supported with corresponding landscape designs in the final phase of the work process. With the designs we aim to envision how robust climate adaptation strategies can be translated into attractive and effective real-world spatial interventions and how it can contribute to spatial quality. The iterative design process leads to visualizations of different types over multiple scales that together provide a complete and accurate impression of our intentions for the area.

comparative analysis

Finally, the two visions and designs are compared to each other to judge their relative robustness, in order to define the best direction for future actions and current policy. Points at which they overlap reveal robust measures and/or design interventions that are favourable regardless of possible future developments sketched by the 'Global Economy' and 'Regional Communities' scenar ios. With the final landscape design we hope to reveal how an integrated approach to climate adaptation can result in a flexible and resilient water system that can support an attractive and coherent landscape.

4 landscape analysis

The first step of our research, following the five-step approach, is to analyse the historical developments and the present conditions of the 'Blauwe Bron' region. The first part elaborates on the abiotic developments in the area, while the more anthropogenic influences in the region are clarified in the second part. Both type of developments have drastically changed the landscapes of the 'Blauwe Bron' area and explain the different systems that make these landscapes work, which are not always visible to the human eye. To clarify these systems we describe the landscapes in different layers that describe the soil, the landscape types, the water system and the different stream sequences. The combination of these layers explains the character and image of the 'Blauwe Bron' area.

Figure 4.1 Wet conditions result in high ecological values at the peat lands

4.1 Historical development

historical values

logic of the landscape

The 'Blauwe Bron' area is characterized by a high concentration of cultural historical values and landscape qualities, which are intertwined in a unique and harmonic setting. The unique composition of the soil and the locations of the villages, streams, nature and agricultural areas and water artefacts share an interesting and coherent history. To understand the logic of this landscape we had to look back to two major geological periods, which have been decisive for the development of the 'Blauwe Bron' landscape. The first period is called the Pleistocene, which was characterized by the ice ages. The second period is called the Holocene in which we are still living now.

Figure 4.2 The open character of the 'Apeldoorns Kanaal's southern trajectory

ice age

soil composition

Pleistocene

The Veluwe region was once crossed by the major rivers in the area. This took place before the entering of the ice masses in the Saalian period (approx. 200.000 – 130.000 years ago). During that time the rivers deposited a thick layer of fluvial deposits in the area existing of sand, grit and clay. During the Saalian period the Scandinavian ice cap expanded and covered the Northern part of the Netherlands with an ice mass of hundreds meters thick. Along the edges of the ice cap large lobes of ice slid to the south into the present IJssel valley in the east and the valley of the 'Gelderse vallei' at the western side of the Veluwe. These lobs pushed the frozen layers of sand, grit and clay sideways, hereby creating glacial ridges called thrust block- or pushed moraines ('stuwwallen'), that enclose both valleys today. The frozen layers were pushed upwards in an almost vertical angle, which resulted in not only a varied soil composition, but also in a complex ground-water system due to vertical clay bulkheads ('kleischotten'), which will be described later in more detail.

The north and west slopes of the Veluwe are quite gentle due to the eroding effect of a predominant western wind, on the contrary to the south side of the Veluwe, which is formed by a steep slope due to the strong eroding effect of the Rhine river (Menke et al., 2007). The eastern slope, which is part of our study area remained pretty much intact. Though, the wind, soil movement and melt water deposits did change the appearance of this landscape by creating fluvial sand deposits ('puinwaaiers') and sand ridges. The last of which were formed during the last ice age, the Weichselian, approximately 120.000 – 10.000 years ago.

Figure 4.3 Historical map of the Veluwe, made by Christiaan Sgrooten between 1568 and 1573

source: Menke et al., 2007

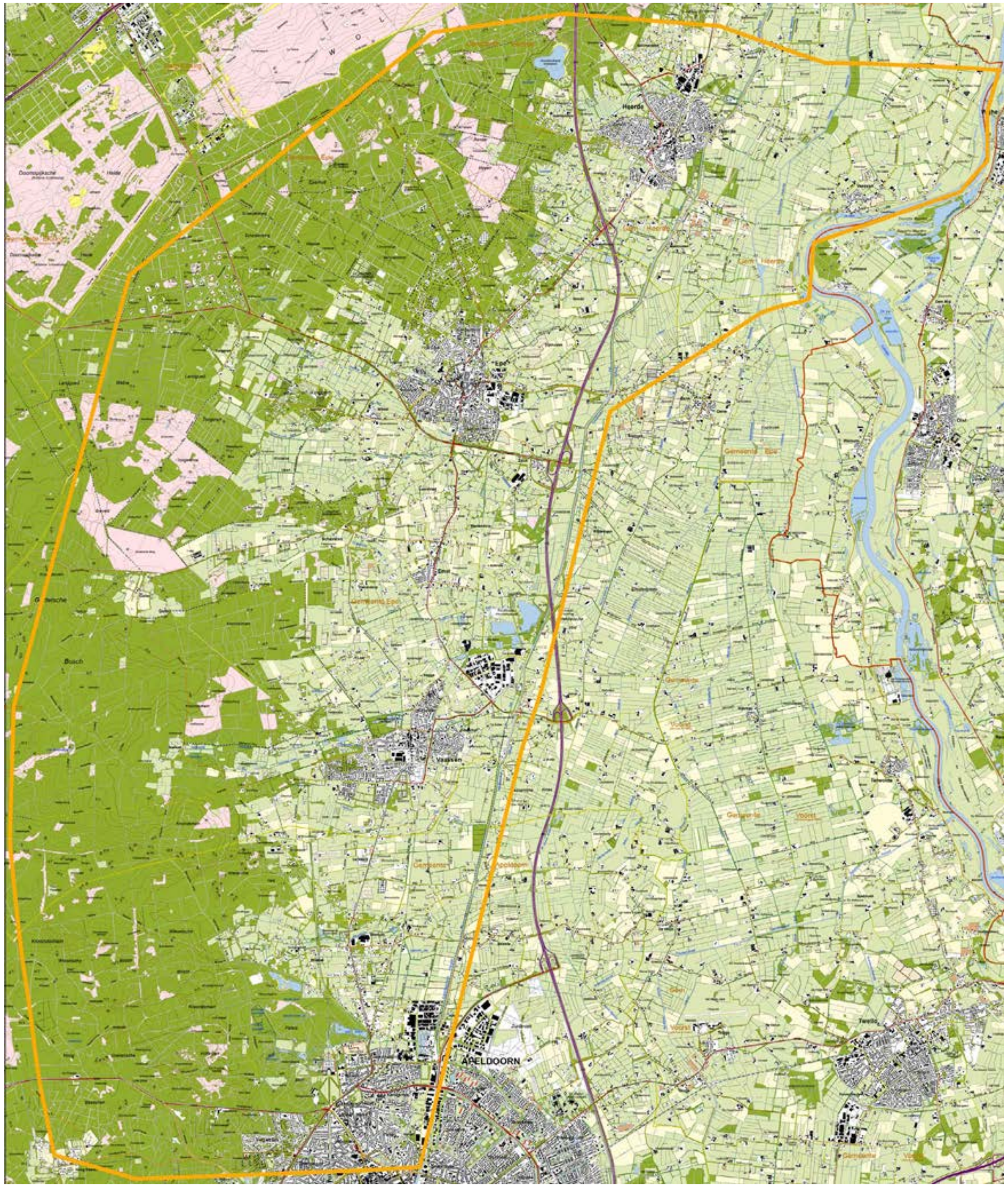


Figure 4.4 Topographical map of the 'Blauwe Bron' area, with the plains of the Veluwe in the west and the IJssel river valley to the east
1:125.000

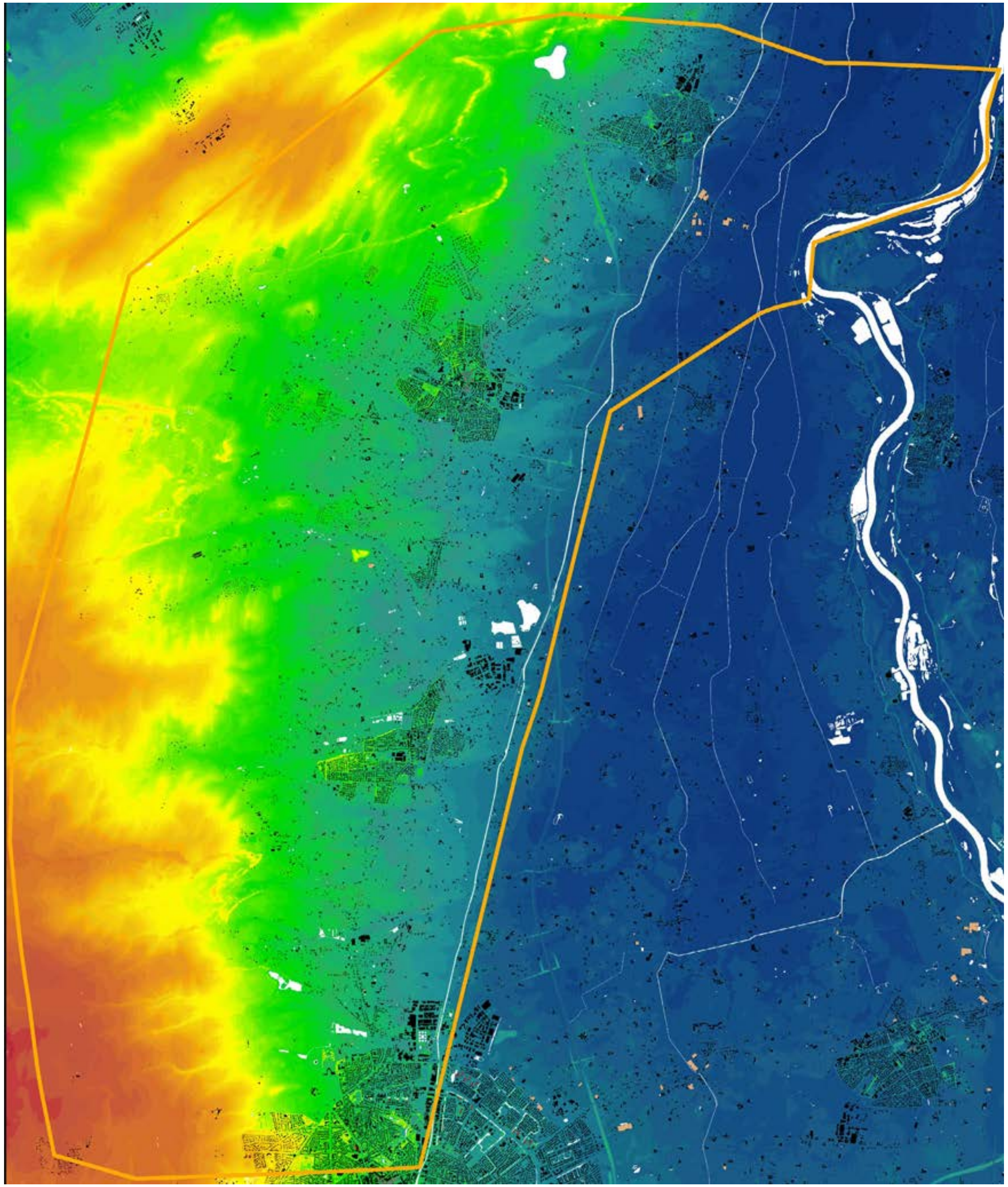


Figure 4.5 Elevation map of the 'Blauwe Bron' area, revealing the relatively steep gradient from the Veluwe to the IJssel flood plains. Note the wedge-shaped stream valleys

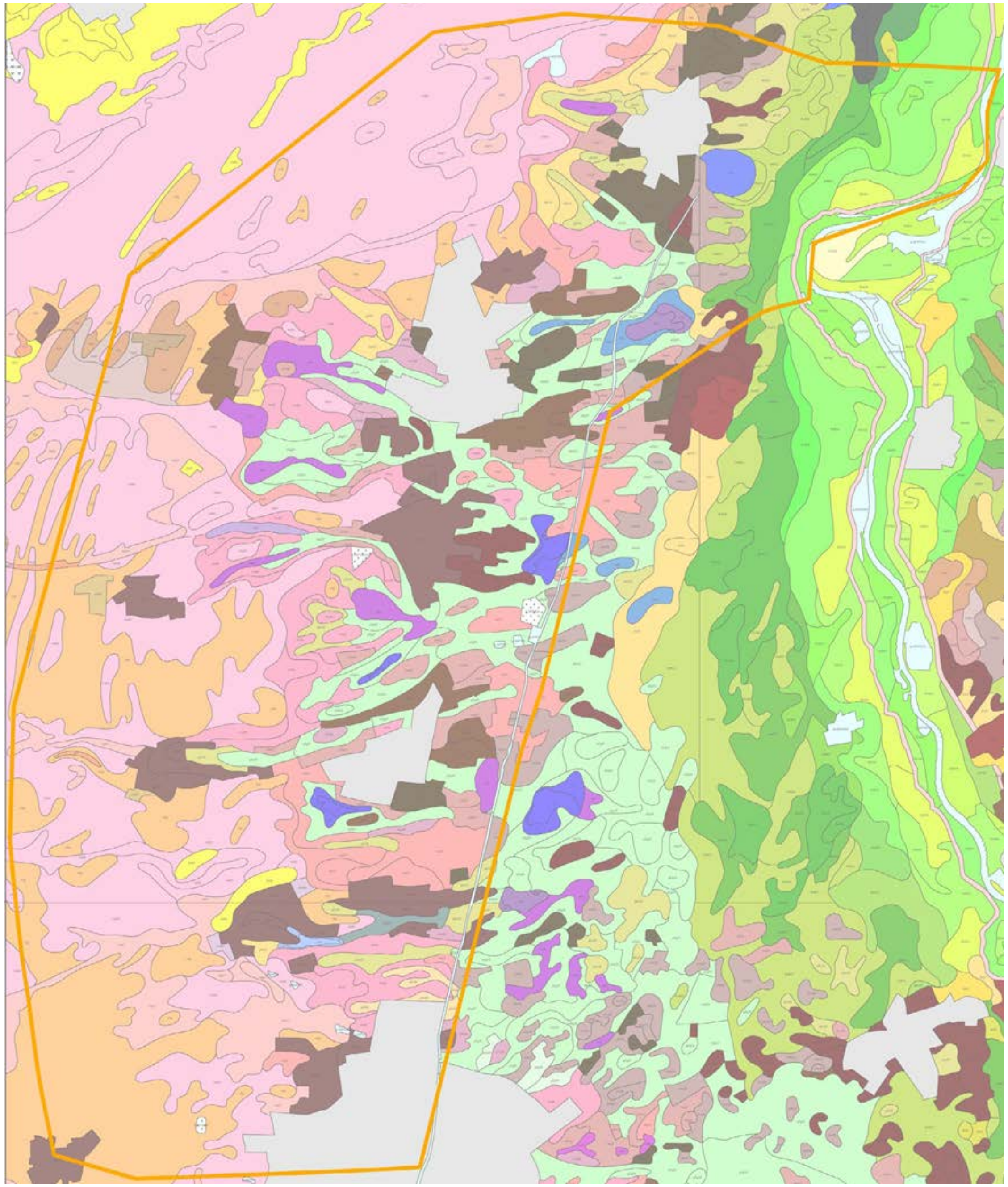
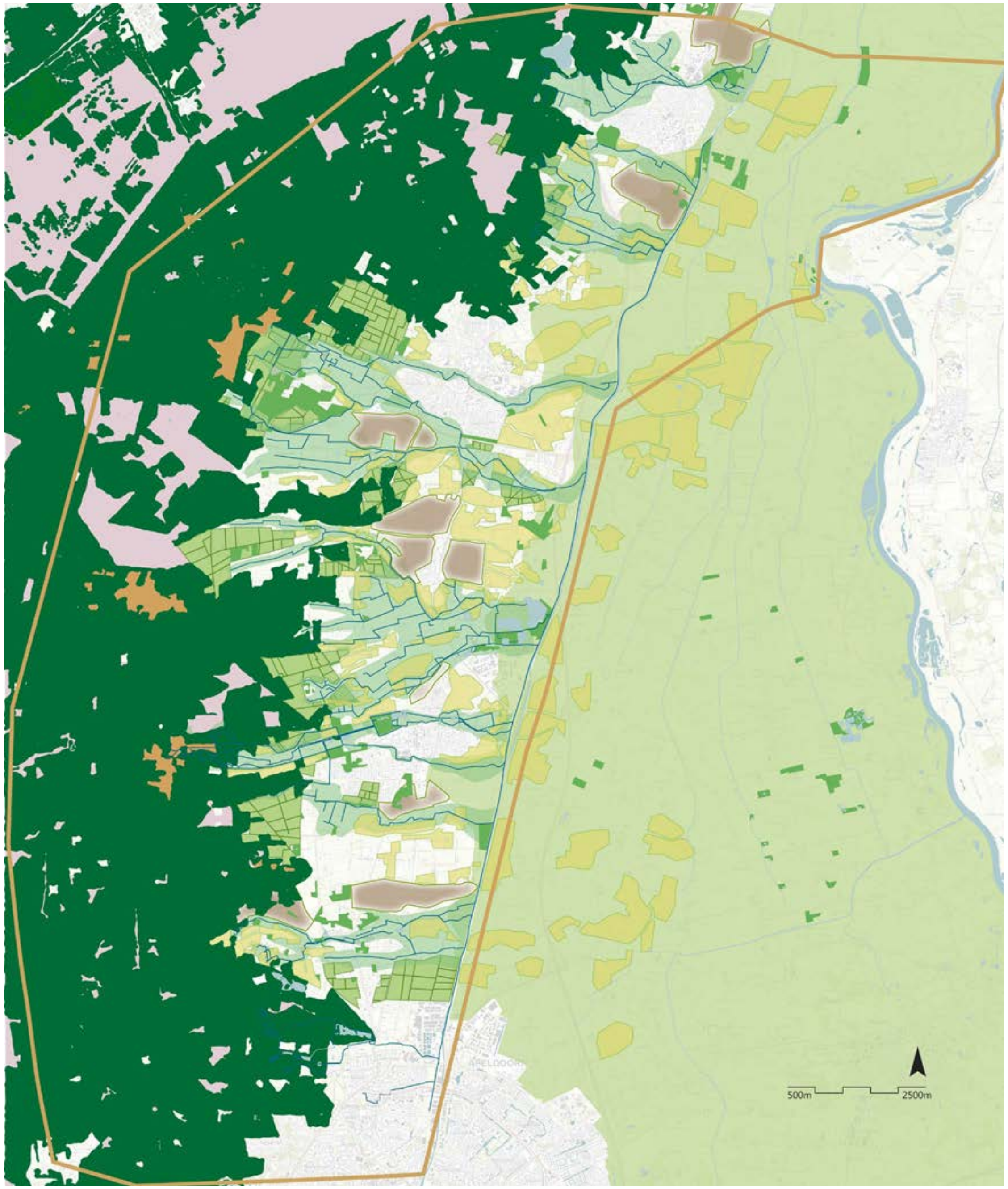


Figure 4.6 Soil composition map of the 'Blauwe Bron' area, showing its complex geomorphology as a result of the ice age
1:125.000



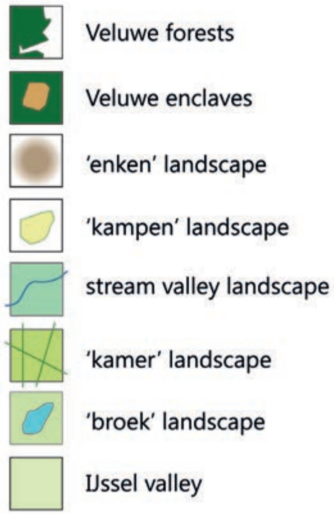


Figure 4.7 Map with the main landscape types of the 'Blauwe Bron' area, as described in paragraph 4.2
1:125.000

anthropogenic influences

Holocene

The last 10.000 years until now are more characterized by anthropogenic influences than abiotic ones. In the middle ages most of the cities, villages and townships arose on the higher parts in the landscape that still exist today. They are situated along the edges of the Veluwe accompanied by estates and artificial, elevated streams ('sprengenbeken'), that powered the water mills in the region. The history of occupation and land uses in the 'Blauwe Bron' area during this period has been strongly influenced by differences in height, soil conditions and the water system, which explains the development of different landscape characteristics that are still present today.

4.2 Present conditions

Landscape types

In the 'Blauwe Bron' area a distinction of seven different landscape types was made by landscape architect Harro de Jong (de Jong, 2011). Each of them is characterized by specific landscape elements, structures and soil compositions that explain human behaviour and land uses over time. The strong contrasts between them contribute to the unique division of the regional landscape. Every description is accompanied by a sketch that shows the location of the landscape type on the Veluwe's gradient and a picture that underlines its characteristics.

contrast

Veluwe forests

For thousands of years the grounds of the Veluwe were covered with forests. Pollen data verified the presence of forests and the absence of large, open fields in the 8th century (Menke et al.,

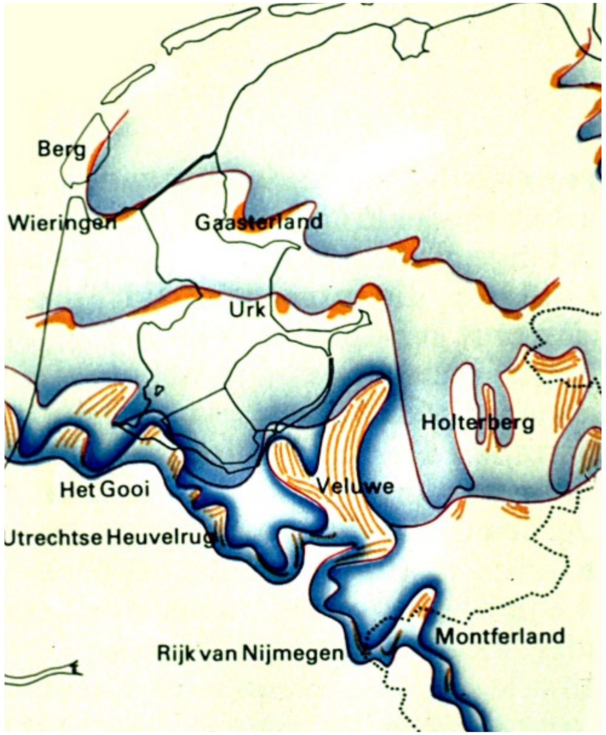


Figure 4.8 The Dutch landscape is greatly influenced by the ice age
source: http://aardrijkskunde.hlz.nl/BN2%20map%20H2/BN2%20H2P7/BN2%20H2P7%20main%20U1.htm

logging

royal domains

townships

2007). These higher parts of the Veluwe where unsuitable for arable or grass lands due to the dry, sandy grounds and were used in this period for logging and the intensive grazing of livestock, which caused the original forests to gradually change into vast, open heath lands. Wood was used for building materials and to produce charcoal for the mining of iron. Overgrazing eventually resulted in shifting sands. The estates located on the east and south edges of the Veluwe started with the reforestation in the 18th century for logging, which also stopped the shifting sands from spreading. During the next two centuries private investors and governments planted large acreages of coniferous forests on the shifting sands and heath lands. Today, large parts of the Veluwe are part of the royal domains and are the property of nature and private organizations and the drinking water company Vitens.

Veluwe enclaves

One of the oldest descriptions of the presence of townships on the Veluwe dates from 1050 AD and belonged to the enclave Tongeren. These townships or enclaves are concentrated along the edges of the Veluwe and have an important historical value, because of their strong rural character, their historical location on the transition from higher to lower grounds and their connection to the surrounding landscape. These enclosed, small-scale communities are surrounded by enclosed elevated fields ('kampen') and exist of confined spaces of both parcels and residential lots, which are formed by the forest edge and hedgerows. The farms are hidden in the forest edge or placed in the centre of the enclave.

Figure 4.9 Extensive forests and scattered heath lands typify the Veluwe

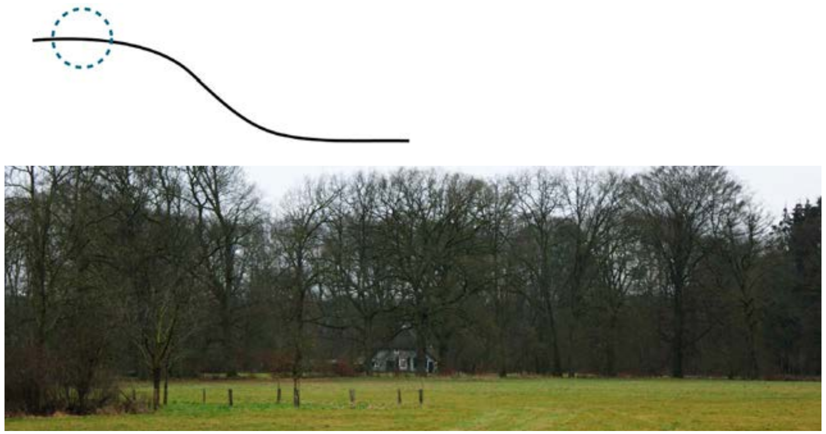


Figure 4.10 The mysterious and picturesque image of an old enclave, Niersen

'Enken' landscape
During the 16th and 17th century turf ('plaggen') fertilization made it possible to intensify the production on arable lands. This was the beginning of the formation of the typical landscape of elevated fields ('enken'). This type of landscape as well as the 'kampen' landscape arose due to a clear spatial division between agricultural uses. The arable plots were situated on grounds with the most favourable ground water level, which were the fluvial sand deposits and sand ridges located on the lower part of the Veluwe gradient. These large consecutive parcels remained open for an optimal use of the available land such as the 'Wisselsche enk'. The farms were situated along the edges and disappeared out of sight due to the impressive height of the 'enken'. Along the edges of the fields planted ridges ('enkwallen') were developed to protect the arable land from shifting sands and wild animals.

spatial division

Figure 4.11 Open and slightly elevated 'enk'

'Kampen' landscape
Around isolated farms and enclaves a new kind of landscape arose called the 'kampen' landscape. The formation of this kind of landscape had the same history as the already mentioned 'enken'. Turf fertilization on top of the present arable plots resulted in elevated arable fields. For instance, the old arable lands of the enclaves such as Tongeren (west of Epe), Gortel (west of Emst) and Niersen (west of Vaassen) were elevated using this method, which gave these plots their curved appearances. The only major difference between 'enken' and 'kampen' is the seize and the connection of the parcels. The 'kampen' exist of individual, small-scale and enclosed plots with hedgerows surrounding each individual parcel, while 'enken' exist of consecutive, large-scale and open fields with only hedgerows along the edges. Large areas in the 'Blauwe Bron' area still characterized by this landscape type.

curved fields

Figure 4.12 Elevated and enclosed field of the 'kampen' landscape

streams · **seepage** · **values**

Stream valley landscape

During the melting of the ice lobs in the valleys, melt water flowed down the moraines in the form of streams, which eroded broad areas in the slopes and created the stream valleys. As explained earlier melt water deposits created fluvial sand deposits and sand ridges on the lower parts of the slopes at the edges of the stream valleys. The low-lying stream valleys themselves were covered with sandy and loamy deposits, which made them more swampy and therefore unsuitable for arable uses, but perfect for grass and hay lands. The presence of seepage on the lower parts of the stream valleys resulted in the formation of peat lands such as the Tongerense and Wisselse veen near Epe and Kortenbroek near Vaassen. The formation of the two broad stream valleys near Epe and the beautifully intact stream valley west of Vaassen are good examples of the cultural historical and ecological values of these valleys represent. A valuable collection of water mills, elevated streams and nature areas still characterize these landscapes and are protected by nature and private organizations such as ‘De Bekenstichting’.

Figure 4.13 A wide vista along the direction of a stream valley

cultivation · **meadows**

‘Kamer’ landscape

The cultivation and draining of former dry and wet heath lands resulted in a new type of landscape, which is characterized by enclosed grasslands (‘kamers’). The edges of these flat parcels were planted with hedgerows and tree lanes, which resulted in a connected structure of individual chambers, hence the name ‘kamer’. These sandy plots were and still are rather infertile due to the high permeability of the soil. Nutrients can thus flush away quite easily. These grounds were therefore primarily used as meadows.

Figure 4.14 The intimate character of the landscape chambers

'Broek' landscape and IJssel valley

IJssel valley

The streams on the slopes of the moraine ended in low-lying lands in the IJssel valley, characterized by wet grasslands and marshy grounds with alder forests ('broekgebieden'). These vast floodplains were drained and cultivated to make them suitable for meadows, which started with the digging of the Grift in 1300 (Vista & Lantschap, 2011). Today the present streams flow into the Grift itself.

unique water system

The formation of the different landscape types and spatial developments in the last few centuries in the 'Blauwe Bron' area were and still are closely related to the presence of an unique and complex water system. The development of arable lands for instance took place on dry grounds, but not to dry, for the simple fact that crops need water as well as human beings. So these lands were positioned half way down the slope on sandy soils; far enough from the ground water level to remain dry, but close enough for the roots to get the necessary amount of water to stay alive. Thus the balance between dry and wet grounds, which is determined by the height of the ground water level, explains each type of land use in the area.

Water system

The different land uses are closely related to the underlying water system as described in the previous paragraph. The presence of this system made the development of the present landscape possible and is for this reason described in more detail hereafter.

When precipitation falls down up upon the moraine, parts of it is discharged through streams, rivers and canals by surface runoff. Another part evaporates, while a large part seeps into the

Figure 4.15 The open landscape of the IJssel valley
source: Google Earth, 2012

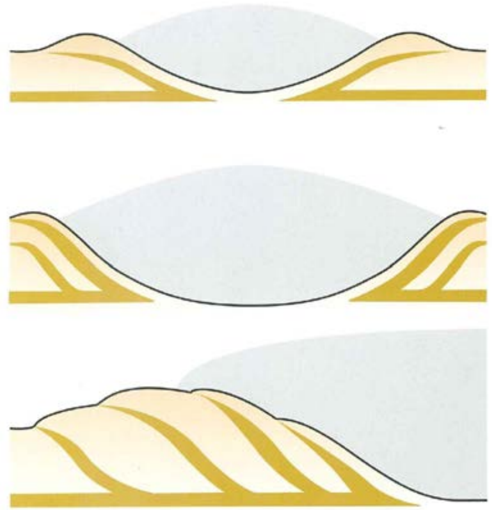


Figure 4.16 Glacial lobes had a big impact on the geomorphology of the area
source: Menke et al., 2007

drinking water extraction

seepage

watermills

ground where it is retained in the topsoil, used by vegetation or supplements the groundwater. The Veluwe region is capable of storing a large amount of water due to the high permeability of the sandy soil. Underneath the Veluwe exists a huge freshwater bubble which is, due to the filtering capacity of the sandy soil, of high quality. It is therefore not a surprise that there are multiple drinking water extraction sites located on the Veluwe. The complexity of the ground water system underneath the Veluwe is caused by the presence of impermeable layers of clay in the form of the before mentioned, mostly vertical, clay bulkheads. These layers delay the discharge of groundwater, but are also responsible for the dome shaped ground water table underneath the Veluwe, which is in a natural balance with the discharge of groundwater to the lower lying areas where local groundwater emerges at the surface as seepage.

Furthermore the clay bulkheads cause leaps in the ground water level, but also create smaller, elevated ground water tables on places where one would not expect them in a homogenous geological situation (literally: sham groundwater tables or 'schijngrondwaterspiegels'). The presence of seepage and these exceptionally high local ground water tables in the 'Blauwe Bron' area are the source of natural seepage-fed streams ('kwelbeken') such as the 'Verloren Beek' south of Epe and the 'Egelbeek' south of Vaassen.

The streams present in the 'Blauwe Bron' area have been used as a source of energy for centuries. They were used to power up the watermills, which started to arise on the Veluwe during the middle ages. The earliest listings of watermills on the Veluwe dated from 1025 AD (Menke et al., 2007) and were placed on the lower parts of the stream valleys where some naturally occurring

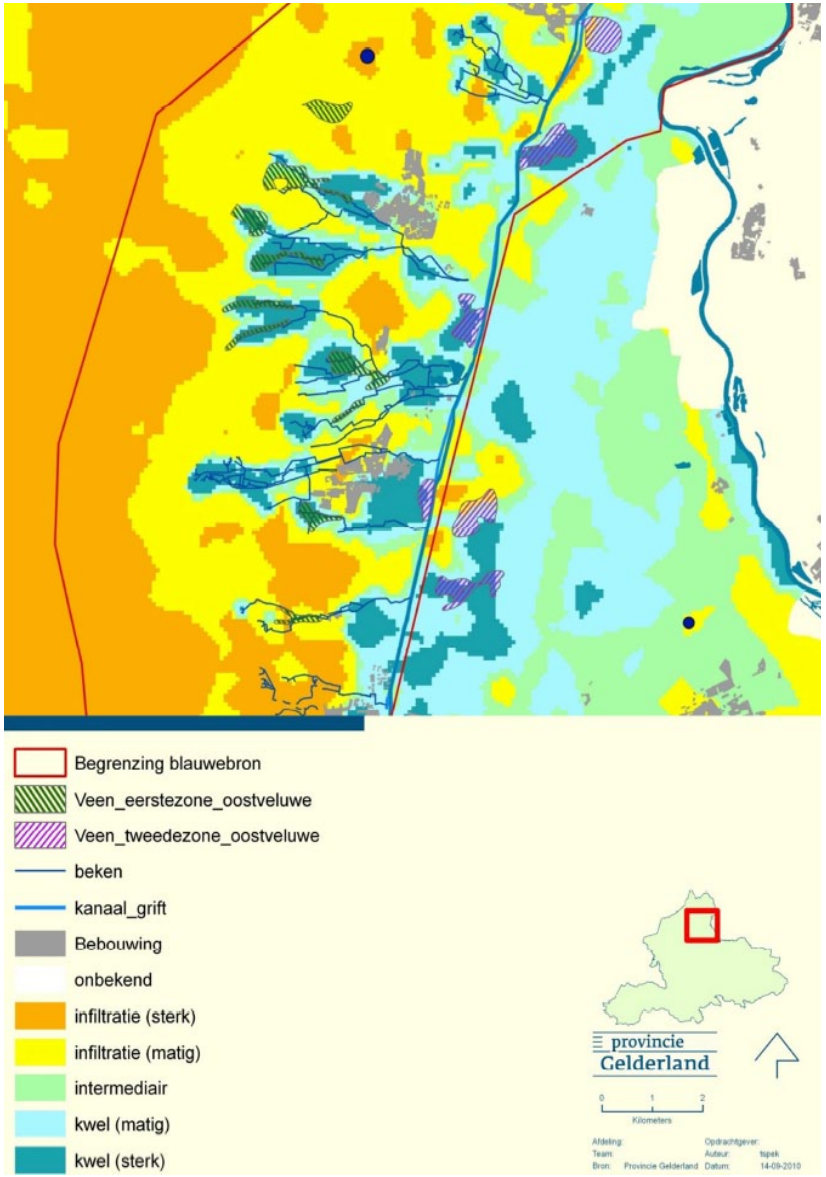


Figure 4.17 Map with infiltration ('infiltratie') and seepage ('kwel') in the 'Blauwe Bron' area

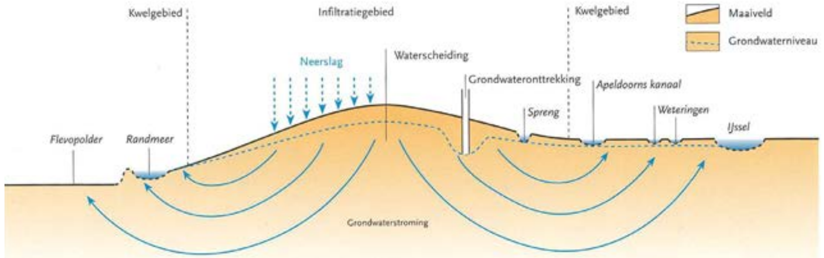


Figure 4.18 Schematic cross-section of the Veluwe and its water system
source: Menke et al., 2007

Figure 4.19 Map of the 'Blauwe Bron' area and its surface water system. The complex structure of streams with a mix of natural and man-made courses is clearly visible

artificial streams

elevated

energy

relief was present. During the centuries the use of the streams intensified and more mills arose in the more upstream regions, but the absence of enough height difference demanded a new approach to power the mills. For this reason artificial streams ('sprengbeken') were made. Their source was an artificial well ('sprengkop') dug horizontally into the moraine to tap the ground water. Further downslope, the streams were artificially elevated in order to create the necessary height difference to provide mills with energy. These streams were also used to supply moats, ponds and laundries of fresh water, such as the ponds at castle Cannenburgh north of Vaassen and the 'Van Delden' laundry

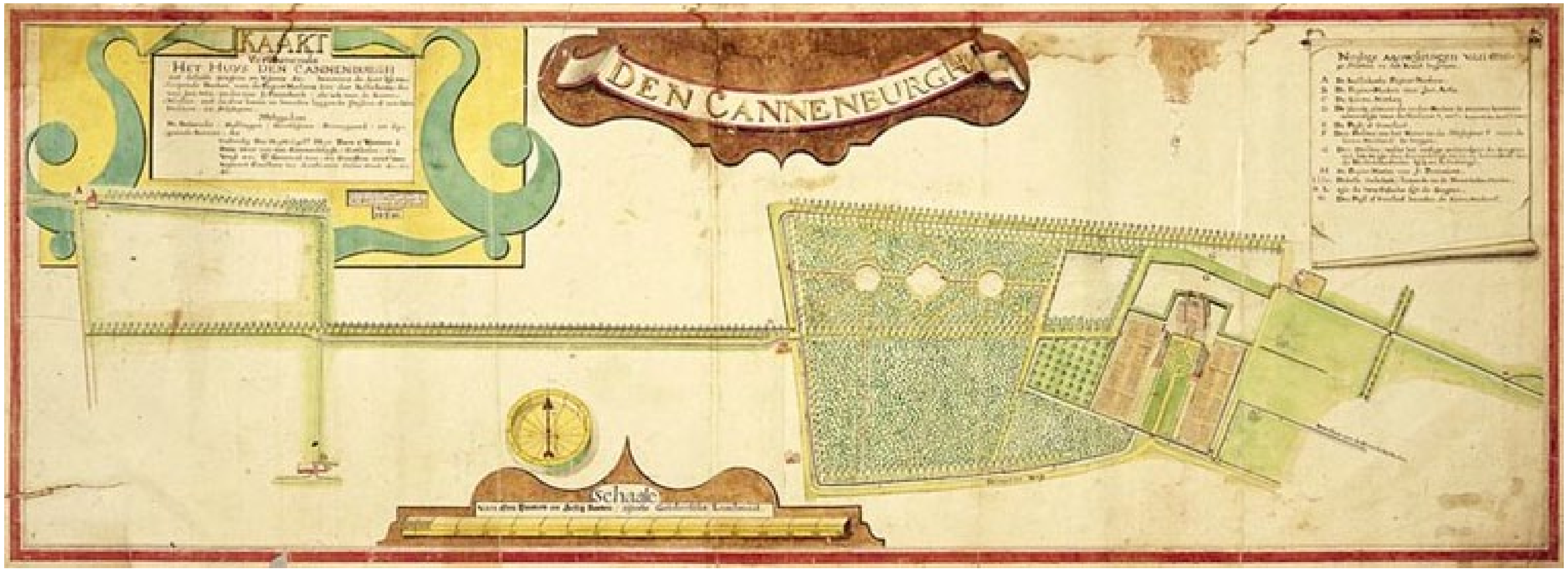


Figure 4.20 Historical map from 1761, showing the gardens and the artificial streams of castle 'Cannenburgh' in Vaassen.
source: Gelders Archief

north east of Vaassen. Many of these streams benefit from an evenly distributed discharge thanks to the clay bulkheads and were artificially constructed with a bedding of clay to prevent them from leaking. To make sure that the smaller streams would provide enough water to keep the mills running during warmer seasons, water buffers were created in the form of accumulation ponds ('wijers'), which could store water overnight. Some of these 'wijers' have disappeared in the past, but some are still in use such as the water buffer next to the 'Wenumse korenmolen'.

'wijers'

The expansion of the stream system contributed significantly to the amount of water mills that were developed in the area. At the end of the 16th century the most important paper manufacturers moved from the 'Zaan' region north of Amsterdam to the Veluwe, resulting in an increase of the paper industry in this region. During the following centuries approximately 200 watermills were built on the entire Veluwe area for the corn, paper and copper industry and made the Veluwe one of the most important economic areas in the region (Menke et al., 2007).

industry

Stream sequences

The watershed of the mostly artificial streams in the 'Blauwe Bron' area differs in character at different locations along the way down the slope. Some of these characteristics have been discussed in the sections above, but they still miss a coherent structure. For this reason this section is reserved to elaborate on the intertwined structure of the different parts of the watershed, which can be divided into three main parts: the upstream, middle stream and downstream regions.

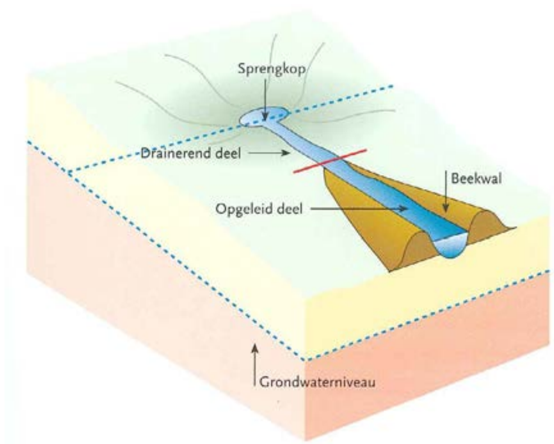


Figure 4.21 Illustration of an artificial well ('sprengkop') and elevation of the stream
source: Menke et al., 2007

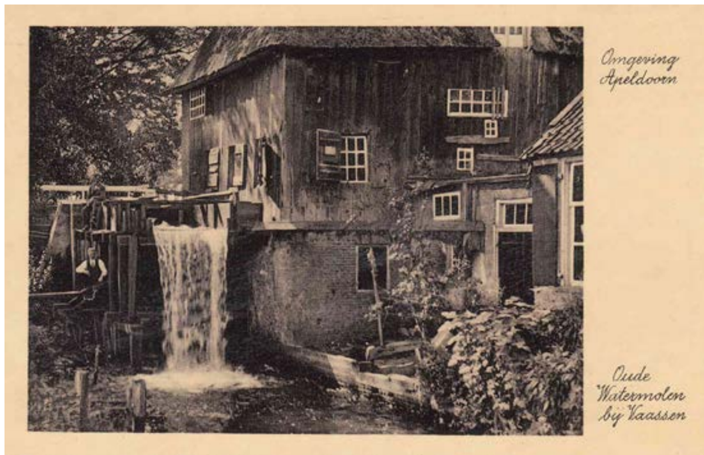


Figure 4.22 Picture of the water mill of the 'Cannenburgh' castle, Vaassen
source: W. Noorlander, archives 'De Bekenstichting'

sources

elevated streams

hedgerows

villages

Upstream

The artificial source of the dug stream ('sprengkoppen') is located in the upstream regions where it touches the dome shaped ground water table, from which ground water flows into the stream. Most streams are fed by more than one source, which are often hidden in the forest. They lay deepened in the landscape and are often strengthened along the edges with wooden revetments to canalize the watercourse, which prevents the silting up of the dug streams.

Middle stream

The middle stream region starts at the location where a dug stream leaves the moraine and is from that point gradually elevated to reach the necessary height of approximately 3 meters to power up the watermills down the slope. The walls of the elevated streams were strengthened with vegetation types such as alder to protect the banks from breaching. The elevated streams in the middle stream region are thus characterized by thick planting such as hedgerows, which are illustrated by the 'Tongerense Beek' west of Wissel and the 'Klaarbeek' south of Epe. Open grasslands, inundation fields and water artefacts such as weirs, aqueducts and fish ladders characterize the rest of the stream valley.

Downstream

When a stream passes the last mill it enters the downstream region, which is quite flat. From this point the low-lying streams continue their course through the villages, some estates and finally end up in the Grift, which guides the water to the 'Apeldoorns kanaal' that is connected to the IJssel river in the north.


Figure 4.23 Artificial source ('sprengkop') at Niersen


Figure 4.24 Upper brach of artificial stream at Heerde


Figure 4.25 Separation of two streams with different water quality

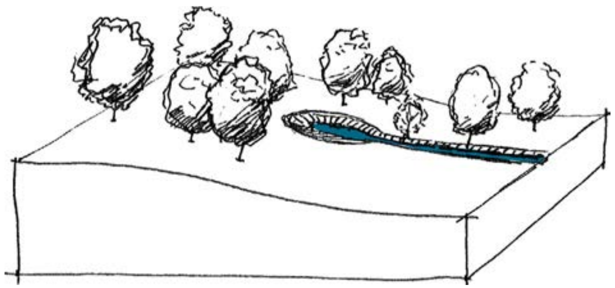

Figure 4.26 Elevated stream crossing meadows near Emst

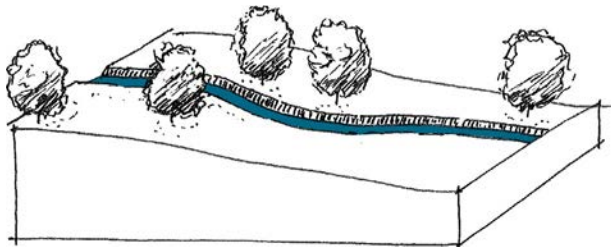

Figure 4.27 Double water mill at Zuuk

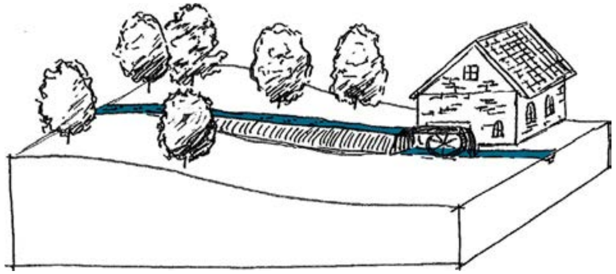

Figure 4.28 The end of the 'Grift' stream, nearthe ' Apeldoorns Kanaal'

upstream

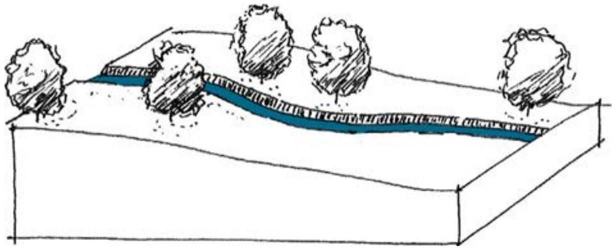
middle stream

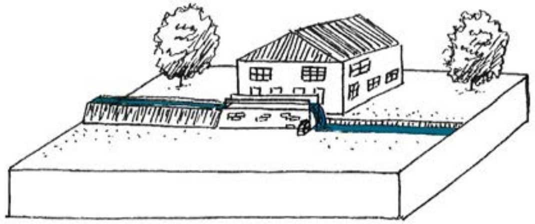


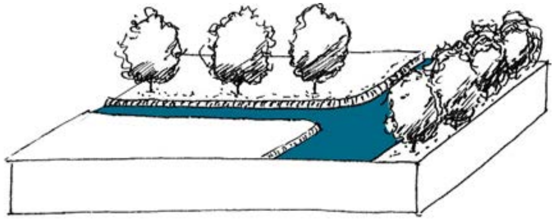




downstream







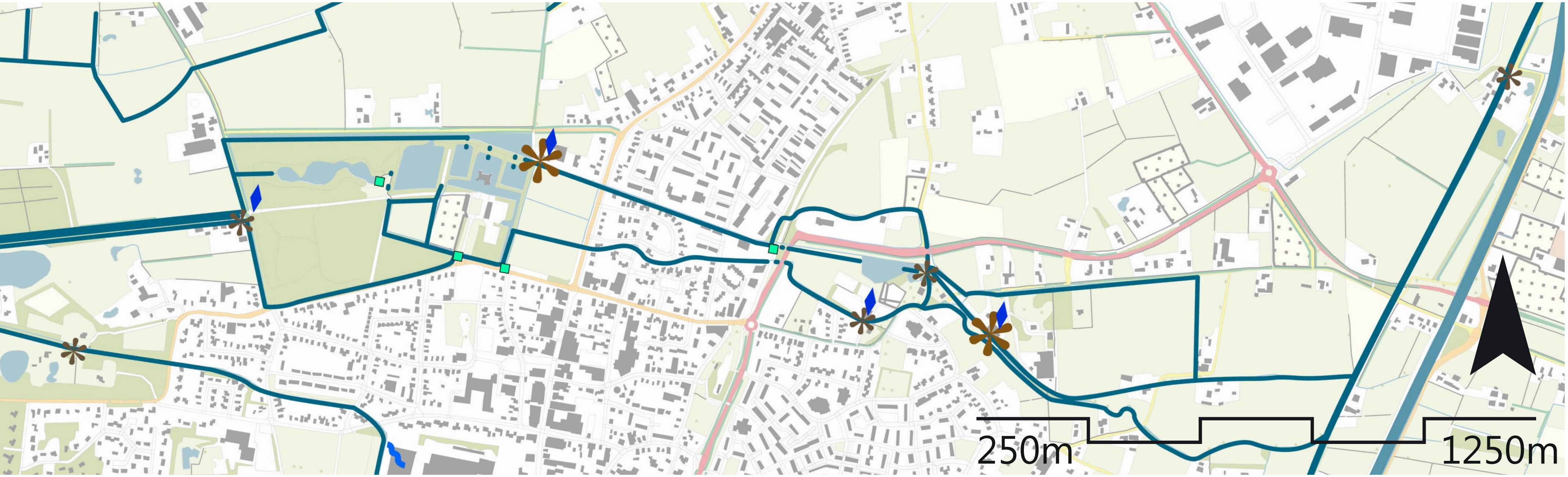


Figure 4.29 Cross-section of the complex stream system and its cultural-historical artifacts at the village of Vaassen

1:12.500

Analysis conclusions

The results from the landscape analysis can be divided into two main subjects, which are the qualities and problems of the 'Blauwe Bron' area (de Jong, 2011). The qualities illustrate the strengths and chances of the area, while the problems illustrate the weaknesses and threats. This report builds further on the qualities, while creating solutions for the problems as stated in the introduction.

Spatial quality potentials

The landscape of the 'Blauwe Bron' area is diverse and varied thanks to a long history of abiotic and anthropogenic developments, which was described in the above section. The unique Veluwe with its complex ground water system, nature areas and landscape types are of high ecological and cultural-historical value, which also applies for the associated artificial dug stream landscape with its mills, estates and water artefacts. This assembly of co-operative natural and anthropogenic processes and systems is unique in its kind and deserves to be protected as well as strengthened.

unique assembly

Figure 4.30 Spatial quality: beautiful little worlds of their own scattered along the streams

Figure 4.31 Spatial quality: urban stream in an appropriate 'habitat'

clutter

fragmentation

decay

decline of legibility

Spatial quality problems

The most important spatial problem is clutter, which is caused by a number of factors. Random placed farms or other buildings in former open fields such as 'enken' and stream valleys drastically decreases the open character of these landscapes as well as the strong contrast between them. These landscape types are than less or no longer recognizable. The fragmentation of connected old lanes of trees, which formerly acted as a framework, results in a slowly, but surely decay of the old structure that holds these landscapes together. Without such a coherent and complete green structure, houses, farms and other elements seem to float in the landscape (de Jong, 2011). This decay of the 'Blauwe Bron' area negatively influences the legibility and amenity value of the different landscape types, which is even further continued due to the increasing clutter of fences in front of streams that obstruct their visibility and decrease their accessibility.

It is clear that the 'Blauwe Bron' area exists of unique ecological and cultural-historical landscapes, but also knows some problems. We are now building further upon these results in the next chapters to increase the landscape qualities and to solve its problems.

Figure 4.32 Decline of spatial quality in the forests: unattractive fencing and inaccessibility

Figure 4.33 Decline of spatial quality: streams are cluttered or hardly visible in the villages

5 future developments

Since our analysis does not serve the development of visions and designs that accommodate the current landscape of the 'Blauwe Bron' but rather that of 2050 and beyond, we also have to determine how the future landscape could look like when no action is taken. Most important in this case are of course the

climatic consequences

consequences of the anticipated W+ climate scenario on the outlook of the landscape and processes in the area. The preconditions, limitations and opportunities to then deal with climate change are strongly determined by the outcomes of the 'Global Economy' and 'Regional Communities' WLO scenarios. Rather than only the current situation in the 'Blauwe Bron' area, the 'near future map' presents the starting point from which the scenario study departs.

5.1 Near future developments

The near future has its scope up to the year 2020 and encompasses all the spatial plans and other developments that have already been set in motion. Its information is mostly based on the 'new future map of the Netherlands' (Nirov, 2012) but also includes points from current nature and environmental policies.

urban development

Urban developments are already planned out to and perhaps beyond 2020 due to their complex nature, we will assume that all these plans will be realised because it is too unreliable and difficult to anticipate recent economic and political developments. By 2020 the villages of Heerde, Emst and Vaassen will have developed a new housing development site, whereas Epe divides its urban expansion over two locations. The city of Apeldoorn is a municipality with stronger growth and will have realised a large housing development project along the northeastern fringe of the city. At the northern edge of the city, close to the highways, is also the most obvious location at which the city will expand its industrial- and business area. Heerde and Vaassen will be the only two smaller urban centres with some significant expansion of business parks.

nature development

The second most explicitly planned spatial development is that of nature and ecological areas. All of the current valuable nature areas, such as the 'Wisselse Veen' bogs were originally designated for further development and/or expansion. However, in the light of current economic constraints the EHS has recently been revised and the plans for expansion of nature areas have been drastically diminished so the progress up to 2020 will be limited. As a result, the planned developments of stream valleys with seepage-dependent grasslands and the ecological corridors between the Veluwe and the IJssel valley are delayed. One of the concrete plans that is currently being worked on is the ecological connectivity of the 'Grift' in a north-south direction, the water board has plans to make this stream an important ecological entity. Apart from the efforts of nature development, the province has assigned a number of target areas for future development, most likely in conjunction with the national ecological structure (EHS). Those areas will not have been developed within the foreseeable future but might still influence other potential developments in the coming decade.

dessication

Securing the availability of water for wet nature areas and human consumption presents the main challenge for water management in the coming decade. By 2020 the drinking water extraction near Epe is likely to be more durable than nowadays through infiltration and careful selection of wells. It is also a target to stop the problems of desiccation in the Wisselse- and

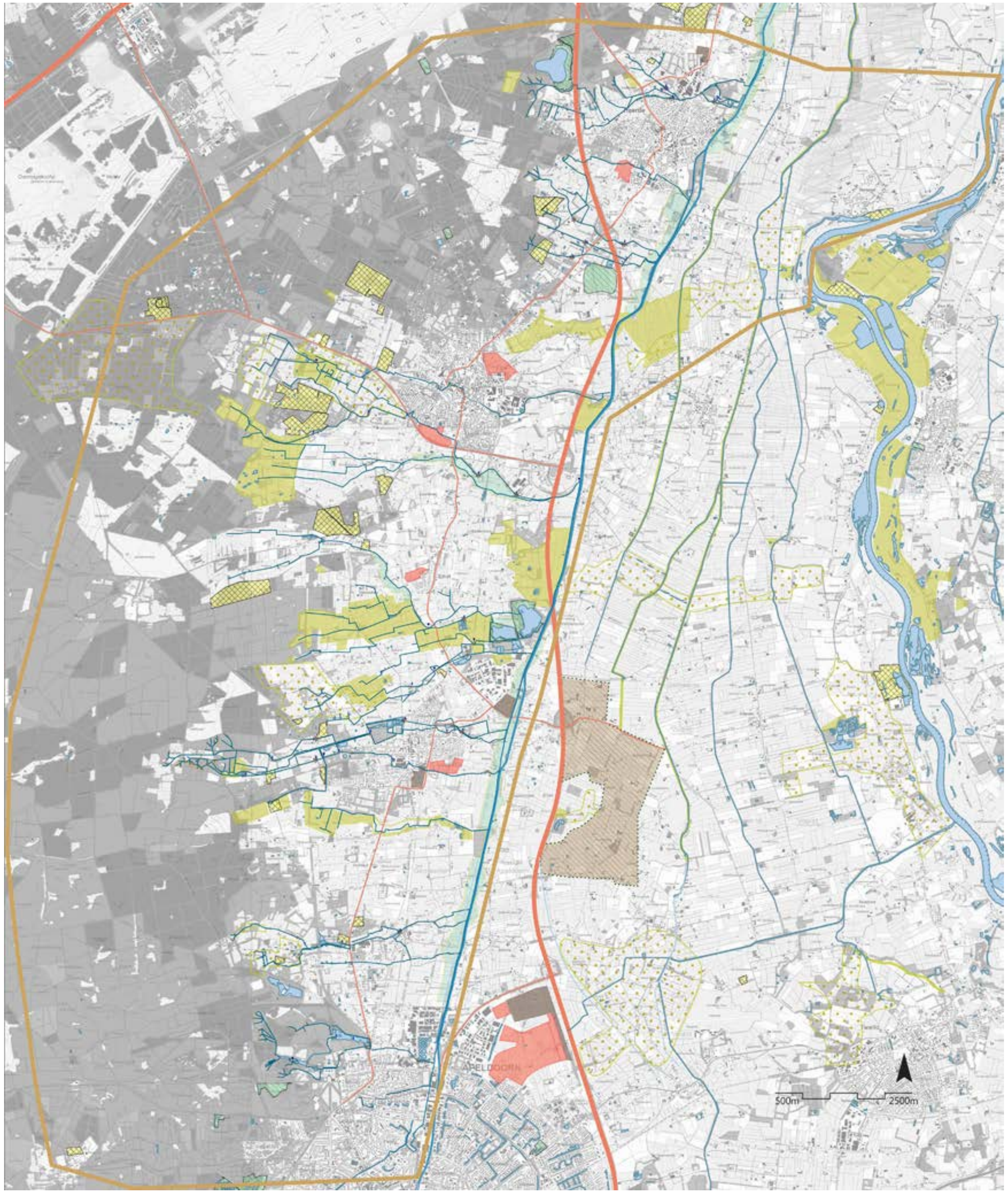


Figure 5.1 Near-future developments map of the 'Blauwe Bron' area
1:125.000

stream discharge

Tongerense Veen areas and the Vossenbroek area. This can partly be realised by decreasing the negative effects of the aforementioned water extraction, but it is unlikely that these issues will be tackled sufficiently due to the diminished opportunities for nature development. The water discharge of some of the streams may therefore remain lower than the water board and 'De Bekenstichting' would like to see. Proposed large-scale interventions such as the raising of IJsselmeer water levels and deepening of the IJssel's river bed are not expected to be of significant influence on the water system of the Veluwe.

5.2 Climate change: 'W+' scenario

Climate scenarios

Despite that consensus over the probability of climate change is increasingly strong, only the future will tell what developments will take place. It is however necessary to be able to act upon the developments we anticipate, and our limited knowledge on climate change and subsequent consequences has to be increased and structured. Scenarios are consistent and plausible visions of a possible climatic future and a vital tool in assessing our global future for the coming centuries.

scenarios create images

These scenarios cannot predict, but rather create images of how temperature, precipitation and wind patterns can change as a result of global climatic shifts (Verbout, 2008).

The global climate scenarios are drawn up every five years by the Intergovernmental Panel on Climate Change (IPCC), based on assumptions on greenhouse gas emissions and population and economic growth forecasts. The global climate scenarios however don't provide enough detailed information to estimate the effects on a smaller specific area.

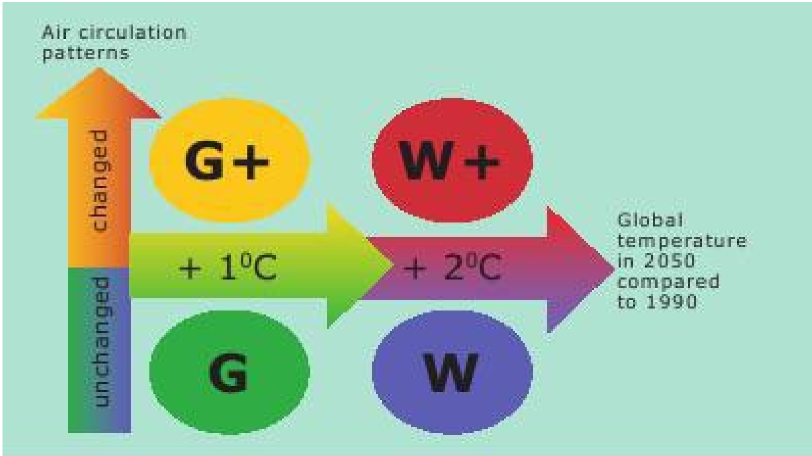
regional scenarios

The Royal Netherlands Meteorological Institute (KNMI) therefore produces regional climate scenarios for the Netherlands, derived from the IPCC scenarios and own data. The latest information is provided by KNMI '06 climate scenarios, which are soon to be updated again.

mean temperature

wind patterns

The climate in the Netherlands is subject to shifts in the global mean temperature and changing wind flow patterns in Western Europe. These two factors are therefore the main variables on which the four KNMI scenarios are based. Aspects that the four scenarios have in common are continuing global warming, changing winds, wetter winters and more extreme rainfall events. The 'G-scenarios' G and G+ stand for moderate climate change and are the lower limits of what we can expect with 1°C mean



G	Moderate*	1°C temperature rise on earth in 2050 compared to 1990 no change in air circulation patterns in Western Europe
G+	Moderate +	1°C temperature rise on earth in 2050 compared to 1990 + milder and wetter winters due to more westerly winds + warmer and drier summers due to more easterly winds
W	Warm	2°C temperature rise on earth in 2050 compared to 1990 no change in air circulation patterns in Western Europe
W+	Warm +	2°C temperature rise on earth in 2050 compared to 1990 + milder and wetter winters due to more westerly winds + warmer and drier summers due to more easterly winds

Figure 5.2 Overview of the four KNMI'06 climate scenarios and their major effects
source: KNMI, http://www.knmi.nl/climatescenarios/knmi06/index.php

global warming

temperature rise . The 'W-scenarios' W and W+ take into account a more serious global warming of 2°C and represent the upper boundaries of what to expect (KNMI, 2006).

The 'W+' scenario

W+ climate scenario

For the exploration of future climate change consequences and appropriate adaptation strategies for the 'Blauwe Bron' area, we will make use of one of the proposed KNMI climate scenarios as they are used throughout the 'Knowledge for Climate' programme. Given the scope and timeframe of our study we have chosen to limit ourselves to just one climate scenario. The W+ scenario is the most extreme and therewith the 'safest' choice for us since it covers the biggest range of possible climate-related futures. Our far-future assessment looks at the year 2050, therefore we will disregard the figures for the year 2100. The main climatic changes for 2050 compared to the base year 1990 are displayed below for all four scenarios. The main consequences of the W+ scenario are an increase of the average regional temperature of approximately 2,5°C and an expected sea level rise of 20-35 cm. Precipitation amounts are expected to decrease in summer but increase in the winters, hence widening the difference between extremes. Higher mean temperatures will also bring about increased rates of evaporation, being another influence on the regional water balance.

Reasoned consequences for the 'Blauwe Bron' area

How the 'Blauwe Bron' case study area will be affected by climate change is of course subject to more uncertainties than the climate scenario itself, and the precise effects and consequences will only become clear over time as research advances. To create a solid

Table 5.1 Climate change in the Netherlands around 2050 compared to the baseline year 1990, according to the four KNMI'06 climate scenarios
source: http://www.knmi.nl/climatescenarios/knmi06/index.php

2050		G	W+
Global temperature rise		+1°C	+2°C
Change in air circulation patterns		no	yes
Winter	average temperature	+0,9°C	+2,3°C
	coldest winter day per year	+1,0°C	+2,9°C
	average precipitation amount	+4%	+14%
	number of wet days (≥0,1 mm)	0%	+2%
	10-day precipitation sum exceeded once in 10 years	+4%	+12%
	maximum average daily wind speed per year	0%	+4%
Summer	average temperature	+0,9°C	+2,8°C
	warmest summer day per year	+1,0°C	+3,8°C
	average precipitation amount	+3%	-19%
	number of wet days (≥0,1 mm)	-2%	-19%
	daily precipitation sum exceeded once in 10 years	+13%	+10%
	potential evaporation	+3%	+15%
Sea level	absolute increase	15-25 cm	20-35 cm

base for our visions, we have assessed how the conditions in the region change by means of reasoned interpretation of scientific data and models. Apart from the national data that the KNMI provides in its climate scenario assessments, some documents already exist in which effects are interpreted on a regional scale. The province of Gelderland has commissioned a consortium of the KNMI, Alterra, DHV and the VU University of Amsterdam to draw up a 'Klimaateffectschetsboek' that provides insight in the spatial consequences of climate change in Gelderland (Verbout, 2008). The 'climate effect atlas' is a website of Wageningen University where Alterra, DHV and Deltares also present a lot of data, maps and reports with valuable information about the spatial consequences of the four climate scenarios (Klimaateffectatlas, 2011).

reasoned interpretation

spatial consequences

Based on these studies that describe the expected primary effects of climate change and the regional assessments described above, we were able to sketch an image of how the region will be affected by the secondary effects like drought and changing ground water dynamics. These developments subsequently have effects on for instance nature, spatial quality and tourism, which are also briefly described.

effects

Hydrology

Given the fact that the quantity of precipitation is expected to decrease in the W+ scenario, a subsequent decline of ground water recharge should seem evident. Hydrological models contradict each other on this point because not all correlations are completely certain or clear yet. Therefore we base our actions on assumptions made in the extensive research to ecohydrological consequences of climate change by the KWR watercycle research

ground water recharge on the Veluwe +

institute (Witte, 2009). Because of a feedback caused by expected vegetation change, an increase of the Veluwe's groundwater recharge is expected due to three coinciding developments. Due to the deep groundwater table of the Veluwe, drought will be more common and lead to a larger surface of bare soil which is known to have a low evaporation rate. Higher concentrations of atmospheric CO2 will also slightly reduce vegetative evaporation. Thirdly, since precipitation will occur more in the form of rainfall peaks, the evaporation through interception is expected to be lower. These factors combined will cause a higher amount of water to infiltrate the soil and reach the groundwater system of the Veluwe.

upward seepage from Veluwe +

As a result of the increasing ground water recharge, we can expect a correspondingly bigger flow of upward seepage on the flanks of the Veluwe as well as further away. De increase in seepage might be small, but it will nevertheless be a stable and thus structural addition to the water system. This structural supply of water is very valuable for the drought-prone areas in the case study area. Especially the peat bogs and stream valleys will benefit of this whereas drought will become a bigger problem elsewhere. The increasing seepage is unlikely to cause problems of water surplus since its contribution will be small when compared to events of peak rainfall. Regional seepage to the IJssel valley will for instance increase with 1 mm/day, which is marginal in comparison with precipitation which can sometimes exceed 30 mm/day.

'sprengen' and brooks water discharge +

Both the natural brooks and the artificial streams that spring from the Veluwe are fed by (local) groundwater, hence we expect that the streams' water discharge will increase in conjunction with the groundwater recharge. The soil of the Veluwe consists mainly of sand with a high infiltration capacity, so rainwater reaches the ground water quickly. Peaks in rainfall that will occur mostly during the winter season will therefore hardly influence the stream systems through surface runoff. The streams' discharge is mostly supplied slowly by the deep groundwater and their infiltration areas are rather small. As a result, their discharge has a very flat and gradual response to precipitation.

ground water dynamics +

The high infiltration capacity in combination with the more extreme precipitation patterns will result in a more dynamic groundwater system. Especially the local ground water will react quickly to heavy rainfall and periods of drought, its response is only slightly dampened by the constant streams' discharge. The deeper, regional ground water table is much more stable and hardly reacts to short-term fluctuations.

drinking water availability +

Thanks to its stable character and enormous size, the groundwater body under the Veluwe is a very valuable source of fresh water. The increasing groundwater recharge will further contribute to this water provision, thus extending the opportunities for Vitens to extract high-quality drinking water from the area.

Agriculture

The climate as predicted by the W+ scenario is quite unfavourable for the current agricultural practice. Especially arable farming is susceptible to the negative effects of higher temperatures in combination with temporal wet conditions. Such moist and warm conditions stimulate outbreaks of diseases and plagues that decrease the quality and yield of crops and increase the need for pesticides.

agricultural diseases and plagues +

water shortage ++

Periods of water shortage during summer are more likely to occur, crops will therefore be more prone to drought stress

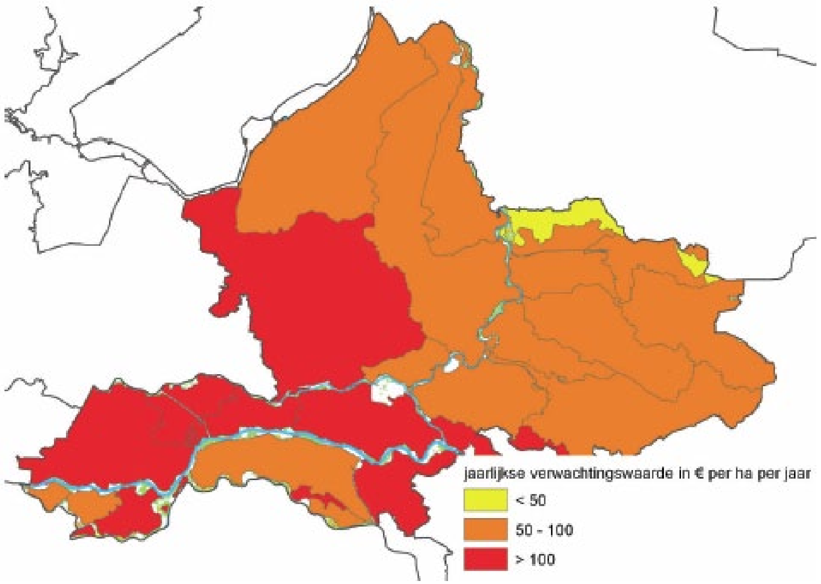


Figure 5.3 Estimated agricultural annual yield loss in €/ ha per year due to drought in scenario W+ in the province of Gelderland

source: Verbout, 2009

heat stress +

than they are now, again decreasing productivity. Heat stress is likely to be a reoccurring factor that goes hand in hand with water shortage. Both developments together can lead to a shift in agricultural practice moving from arable farming to cattle breeding and cultivation of fruit.

water surplus +

In sharp contrast therewith but also in support of the predicted changes in agriculture, are the problems with water surplus that will increasingly emerge. Plots with insufficient infiltration or drainage capacity are at risk of when heavy rainfall occurs during the growing season. Even brief inundation of plots can make crops suffer from oxygen stress with a decrease in productivity as a possible unfortunate result. We expect the damage to be fairly limited nonetheless since most of the heavy rainfall will occur in winter, beyond the growing season.

Nature

water quality -

eutrophication +

The nature areas and ecological values of the 'Blauwe Bron' region are likely to encounter several negative impacts from climate change when no adaptation is applied. Water quality, always the result of a delicate balance, is likely to deteriorate when more nutrients get into the surface water. The increasing infiltration and runoff of rain water will increase the leaching of nutrients into the streams, fens and bogs. The eutrophication that results is a serious threat to the ecological potential of such vulnerable systems. Secondarily, periods of drought also increase the degree of eutrophication in especially stagnant water. Because more water will evaporate following the higher temperatues, the relative concentration of nutrients in the water will rise.

acidification +

An effect that is closely related and also derives from desiccation is acidification. Eutrophication can lead to sulphate stress when its concentrations become too high as a result of contaminated surface- or groundwater. Combined with high temperatures and periods of drought, acidification of the water and soil can pose a serious threat to delicate species (Lamers, 2001 & Lucassen, 2004 in: Verbout, 2008).

vegetation change

shifting species mixtures

Climate change will of course change the living conditions of species in the area since they are subject to the meteorological and biophysical processes that are affected. Patterns and types of vegetation are likely to change as a reaction to those changing factors. The mixture of species will change, however it is yet unclear in what direction and with what correlations that will occur. As mentioned before, it is to be expected that parts of the Veluwe will lose their vegetation and will transition to bare and dry 'shifting sands'. A higher share of bare soil, mosses and lichens in the natural vegetation of the higher sandy soils of the Veluwe will also provide a habitat for new species.

presence of evergreen species +

It is likely that the higher amount of water reaching the ground will result in an increased vegetation with evergreen understory, consisting of species such as yew and holly. The forests will thus become more densely vegetated with shrubs. Whether or not this is seen as a negative development depends on the nature management paradigm one wishes to maintain.

upward seepage +

The increasing flows of upward seepage are of positive influence on the biodiversity of the streams, bogs and the seepage-fed, nutrient poor grasslands that occur in the sloping landscape of the 'Blauwe Bron' area. The deep ground water in question is nutrient poor and therewith of very high quality for delicate ecosystems and sensitive species.

Winter GW levels in wet ecosystems +

The higher input of water results in higher ground water levels in groundwater-dependent ecosystems during winter, in conjunction with the higher water discharge of the streams. This is a stable but seasonally dependent water provision to fragile areas that would otherwise potentially suffer from desiccation throughout the year.

Water provision however does not always come gradually, and the chances that sudden heavy rainfall leads to short-term water surplus problem will increase. On the slopes of the Veluwe this will not become a problem thanks to quick infiltration and the retention capacity of the soil. However in the low lying natural areas along the IJssel valley this can potentially cause damage to some vulnerable species.

sudden water surplus extremes +

Water-dependent ecosystems will however remain prone to desiccation because of the rising temperatures and their high evaporation rates. When we only take these factors into account we can expect to see increasing damage from drought during the summer and a subsequent decline of ecological value. The desiccation might however not be as severe as projected due to the feedback loop of vegetation change that we described before, which compensates the evaporation with a higher input of groundwater. There is moreover a suspicion that the mean lowest groundwater level might have been calculated incorrectly low and that the actual levels are higher and thus less of a threat (Witte et al., 2009).

Summer GW levels in wet ecosystems 0/-

The dry season will still have severe consequences for other, more vulnerable landscapes that aren't sufficiently fed by ground water. Especially fens, wet heatlands and bogs will come under greater threat of desiccation and irreversible impoverishment of their ecosystems when their water provision becomes less reliable.

water shortage ++

It is nonetheless certain that the summer ground water

Summer GW levels in dry ecosystems --

heat stress ++

levels will strongly drop in the sandy soils underneath the groundwater-independent ecosystems of the Veluwe. Combined with the coupled heat stress this drought stress will, again, lead to temporal but severe damage and considerable parts of the Veluwe's fields and heath might turn into bare soil. The growing season of many species will also shift toward the spring, a trend that is already being observed nowadays.

risk of forest fires +

Wildfires have always been a lurking threat to dry nature areas during the summer season. As one can imagine, rising temperatures in combination with dryer conditions will only increase this threat. Not only does the chance for disaster increase, the acreage of threatened forest also grows since the fires will spread easier and further.

shifting 'climate envelopes' +

A climate envelope can be described as the range of habitat or territory in which a certain species naturally occurs. Such an envelope is characterized by a range of preconditions regarding thins like temperature and moisture under which the species can optimally live. When the mean temperature rises and precipitation patterns change such as in the W+ scenario, climate envelopes will change accordingly. For many species the climate envelope will shift to the north; some envelopes will partly move out of the Veluwe while other envelopes might move into the area. Many species are however not mobile enough to keep up with that pace and therefore are at risk of ending up outside of their optimal envelope. In the end this means that a number of species is likely to become under pressure within their current habitat if their migration is hampered.

coherence of ecological networks -

The ability of a species to migrate is dependent on the coherence of their habitat, which is diminished by fragmentation. The aforementioned threats to nature areas will however decrease not only the local ecological values, but also threat to deteriorate the coherence of the ecological corridors and the quality of the national ecological network specifically.

Settlements

water nuisance/ flooding +

Events of water nuisance like the occasional flooding of streets and basements will be an increasingly recurring phenomenon in the built up areas of the region. Especially the urban areas of Apeldoorn, Vaassen, Epe and Heerde are likely to suffer from more and more frequent damage and disturbance as a result of heavy rainfall. Such events can occur during both winter and summer because the extremes between wet and dry conditions will grow.

Environmental health

surface runoff +

sewer overflows +

The flooding of public space does not only bring economic and societal costs, it also poses a twofold threat to environmental health. During heavy rainfall, runoff water will collects pollutants from the surface of streets, roads and squares. This contaminated water will eventually end up in public green space, ditches and streams, where the pollution accumulates and disrupts the water quality. A greater and more severe threat to surface water quality and ecological balance are sewer overflows. Urban sewer systems will more often lack capacity to adequately handle the amounts of water from heavy rain showers. When the sewers are overloaded, spillways allow excessive sewage to be dumped in the surface water. This is a source of strong pollution that can strike serious damage to the delicate ecological balance of the streams even when it occurs only sparsely.

In sharp contrast with heavy rainfall but also a threatening

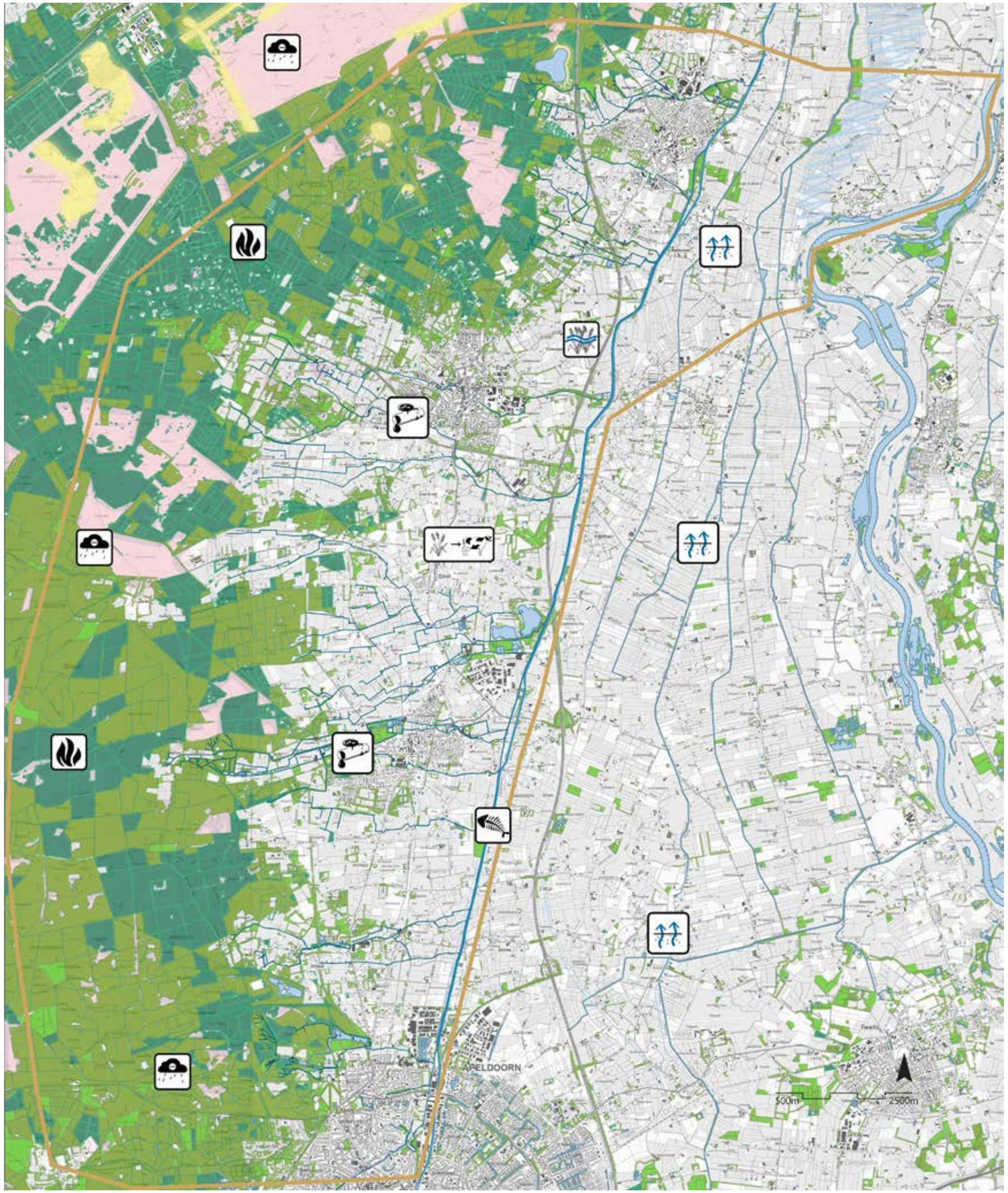


Figure 5.4 The major spatial consequences of the W+ climate change scenario 1:125.000

water quality -

water quality is the expected increase in temperature. Longer and more intense periods of warm weather during the summer season will amplify the growth of blue-green algae in stagnant, mineral-rich water such as the swimming lakes, fishing ponds and the Apeldoorns Kanaal. These algae are in fact cyanobacteria which can secrete toxic substances. Rapid growth of blue-green algae and the phenomenon of botulism can lead to high mortality among fish and water birds.

Tourism

water quality -

drought +

The toxic effects of the cyanobacteria make that the growth of green-blue algae is also expected to be a growing problem for recreation. Popular swimming waters are mostly stagnant water bodies prone to algal growth, and increasing danger to swimmers will negatively affect the recreational value of those waters. Affected water bodies will also be seen as unhealthy and unappealing, and together with an impoverished vegetation and desiccated outlook of the landscape, the amenity of the region is likely to decline in the summer season that is most important for tourism.

Table 5.2 Assessment table with the expected consequences of the W+ climate scenario for the case study area

W+ 2050 - Temperature +2 °C - Changing wind direction patterns	Aspects under expected influence	Effects on the 'Blauwe Bron' area
Hydrology	ground water recharge on the Veluwe	0/+
	seepage from Veluwe	0/+
	ground water dynamics	+
	sprengen' and brook water discharge	0/+
	Drinking water availability	0/+
Agriculture	diseases and plagues	+
Summer	water shortage	++
	heat stress	+
Winter	water surplus	+
Nature	water quality (nutrients)	-
	coherence of EHS	-
	vegetation change, shifting species mixtures	n/a
	shifting 'climate envelopes'	+
	desiccation	+
	acidification	+
Summer	water shortage	++
	heat stress	+
	ground water level (in GW-dependent (=wet) ecosystems)	-
	ground water level (in GW-independent (=dry) ecosystems)	--
	risk of forest fires	+
	presence of evergreen species	+
Winter	sudden water surplus extremes	+
	ground water level in GW-dependent (=wet) ecosystems	+
Settlements	water nuisance, flooding	+
Environmental health	sewer overflows	+
Summer	water quality	-
Tourism	water quality	-
	drought	+

5.3 Socio-economic scenarios

government involvement

public/private responsibilites

Two of the 'likely futures' in terms of socio-economic development are presented by the 'Welfare and Living Environment' (WLO) scenarios developed by the Netherlands Environmental Assessment Agency (PBL) in 2006. We have chosen to define the consequences for the region of the two most different scenarios; 'Global Economy' and 'Regional Communities', which are also used within the CARE project. These scenarios are on the two most opposite sides of the two key uncertainties: the degree to which countries cooperate and the degree of government involvement, dividing public and private responsibilities. Other major factors that influence spatial development are population- and economic growth (Janssen et al., 2006).

The socio-economic developments that we foresee for the 'Blauwe Bron' area are based on assumptions that are made in the national WLO scenarios as well as the 'Hedenmorgen 2006-2040' scenario study for the province of Gelderland (Walsweer, 2006). Identically to our approach to the W+ climate scenario, we will apply educated guessing to translate the outlook provided in those scenarios to make assumptions on how the area most likely will develop in either of the two scenarios.

Figure 5.5 The four WLO scenarios for Europe and their main factors adapted from Janssen et al., 2006

Global Economy scenario

In the Global Economy scenario written by the WLO, governmental interference has decreased. More power and initiative has been left to the private sector when it comes to the development and regulation of public goods. The facilitation of public goods and the control over external effects are expected to be realized by market-controlled regulation, with the associated advantages and disadvantages. The personal responsibility of citizens toward society and progress is emphasized by the government.

private sector

Knowledge exchange is stimulated and the labour productivity is increasing due to the strong worldwide economic integration and collaborations. The global trade market is expanding and prosperous thanks to economic liberalisations and international cooperation, partly initiated by successful WTO negotiations. The Dutch GDP has more than doubled since 2001, having elevated material prosperity to a higher level. As a result of the flourishing global trade, the Dutch export and transit of goods increase. The Dutch competitive strength, stimulated by the presence of large multinationals, grows at a fast pace.

prosperous trade

European Union

The European Union will have expanded further toward the east, having incorporated countries such as Turkey and Ukraine. The participating countries will nevertheless fail to further integrate their politics, hindered by the unwillingness to be subject to cross-border policies. International cooperation is therefore failing when it comes to issues such as environmental policy and legislation. EU environmental standards fixed at the beginning of the 21st century are still being used as mere guidelines. No improvements or developments concerning environmental policy have been made since. The competitive and

pollution

societal deterioration

population growth

water management

agricultural area

market oriented society is focused on quick profit, comfort and egocentric thinking. This results in on-going pollution of considerable severity worldwide. The individual enrichment enlarges the differences in income between low and high educated people, hence increasing social inequality. Developments as described above are detrimental for the social unity, sense of well-being, environmental health and sovereignty of the country.

Due to the growing economy and welfare the Dutch population will have reached 19,7 million inhabitants by 2050, a yearly growth of 0,5% on the national scale. The province of Gelderland will also benefit from the economic developments, its economy has grown by 2,8% per year. Another increasing factor can be seen within the population of Gelderland, which has grown with 0,6% per year. This population growth, which is higher than the national growth rate, is caused by an increasing wish of people to live in a green and natural environment instead of a densely populated urban environment. The province of Gelderland stimulates this development and is committed to accommodate the influx of new residents.

In the Global Economy scenario water management still plays an important role from the perspective of water safety and -availability. Most of the solutions and innovations in terms of water management come from non-governmental agencies and private companies, but are implemented in the Dutch water system by the Ministry of Infrastructure and Environment ('Rijkswaterstaat'), who also maintain it.

Agriculture

The total amount of agricultural area in the Netherlands has decreased by 15% by 2050. The remaining agricultural areas are

efficiency

focused on efficiency and intensification, because there is less space and yet a higher demand for agricultural products. Agricultural development is stimulated by the agricultural organisation LTO and the Ministry of Economic Affairs, Agriculture and Innovation, who cooperate intensively as can be seen in figure 5.6. The search for yield optimization combined with the economic welfare and scientific progress lead to the rise of innovative technologies such as gen-technology. Innovations such as these are being developed in specialised regions and institutes, resulting in initiatives such as 'Food Valley' in and around the Veluwe area.

innovation

The intensification has changed the agricultural landscape. The remaining agricultural plots have become more mono-functional and optimized for efficient production. The quota limitations have been lifted by the EU, resulting in an increase in dairy farming activities. The amount of dairy farming livestock in the Netherlands has increased by 25%. The province of Gelderland benefits from the abolition of the quota arrangements, dairy farming will remain its most important branch of production. Large 'mega farms' have made it possible to realise more yield with the use of less space, profiting from combined efficiency measures. The agricultural market will be dominated by fewer but significantly bigger companies. Considerations on efficiency and emission have altered the traditional image of the agricultural landscape; cows will be held inside permanently and no longer define the view of rural Holland. The appearance of the IJssel river valley will be determined by industrialised mega farms, while the remaining meadows higher on the Veluwe's slopes are used to produce feedstock. Efficient hay production on these pastures, which is more extensive than dairy farming, proves to benefit the farmers and both recreational and ecological values.

dairy farming

'mega farms'

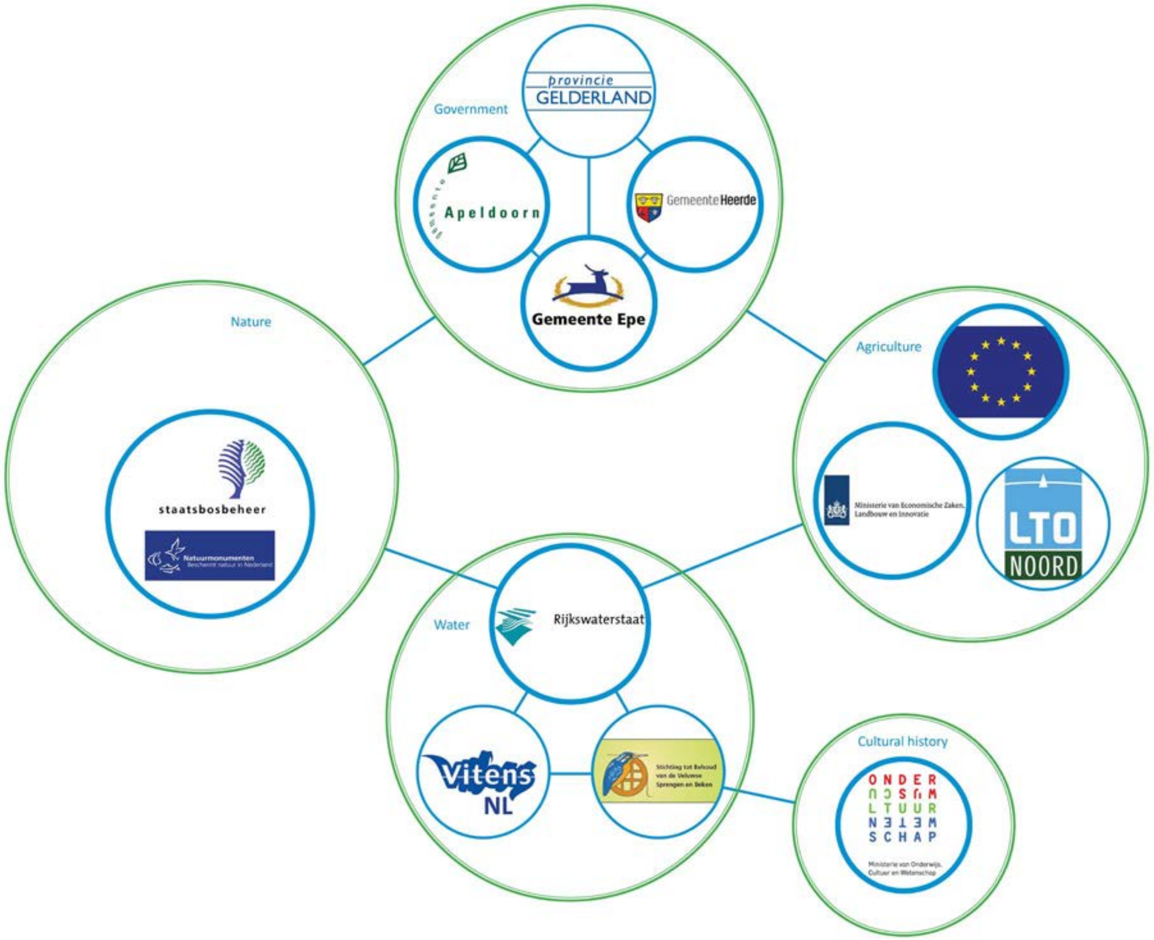


Figure 5.6 Diagram of expected regional stakeholder interrelationships in the Global Economy scenario

Recreation, nature & environment

On the national scale, the amount of nature acreage will increase with 22%, mostly as a result of the decreasing agricultural acreage. In our study area, some agricultural areas will also be given a primacy of nature development, but nature development will be fairly limited due to the lasting value of agricultural plots. Due to the economic growth, increase in energy consumption and the lack of interventions in environmental issues, pollution will occur on a large scale. 'De Bekenstichting' is an organisation, albeit with a specific focus, that will continue to initiate small scale interventions to improve the qualities of the area and fight negative impacts. The drinking water consumption will increase with 35% due to the growing population and increasing industrial needs (Witte et al., 2009), which results in the increase of water abstraction on the Veluwe by the drinking water company Vitens.

nature acreage

water abstraction

On the national scale the amount of sport- and recreational areas will increase with 74%. An increase in welfare enables people to spend more time for recreational purposes. People with a lower income will not be able to afford holidays abroad, but therefore are likely to spend more time in trips towards the touristic areas of the Netherlands. The Ministry of Education, Culture and Science in collaboration with the nature conservation organization 'Natuurmonumenten' subsidize the development of ecological, cultural and recreational hotspots. The Veluwe is one of the key areas of the Dutch tourism sector, its nature and countryside will be among the most attractive areas for both residential and daytime recreation. Hence the Veluwe will provide the means for intensive recreation with scattered bungalow parks and attractions such as spas and amusement parks, aside from the existing networks for extensive recreation.

tourism

nature development

intensive recreation

Urbanization & Infrastructure

The attractive landscape of the Veluwe has become one of the most desired living areas in the Netherlands, which fits in the general trend of increased migration of townsfolk towards the rural areas. The diverse spatial and natural qualities of the area, the tranquil and healthy environment and its central, easy accessibility make the area very attractive. Trade, business, good healthcare facilities and beautiful nature are the key factors for the success of the region. All municipalities in the study area show a growth in the number of residents in the Global Economy scenario. This enlargement of the population in the 'Blauwe Bron' region is caused not only by young professionals, who want to escape the city, but also by wealthy elderly. In fact, in all WLO scenarios, ageing of the population is a general trend. Due to the better economy and increasing welfare more people are able to purchase properties in the countryside in the Global Economy scenario. Many of these new residential areas are located at the villages on the eastern ridge of the Veluwe. Furthermore a number of 'new estates' have been developed in response to the demand for premium housing. On the other hand, reduced social security perpetuates the demand for lower-class dwelling. Real estate prices force people with low incomes to move to cities such as Apeldoorn, where social housing projects are being developed. The socio-economic inequality described before is clearly reflected by an increasingly conspicuous contrast between residential environments of different socio-economic classes.

population growth

residential areas

premium housing

inequality

Living in the rural areas is partly made possible by the rise of 'flex working' arrangements and other innovative forms of business. Regions in Gelderland such as the municipalities of Apeldoorn, Epe and Heerde stimulate such combined living/

working environments. Due to the growing villages and cities and increasing mobility, the infrastructure will however be used more intensively and therefore will have been upgraded. Other more recreational types of infrastructure such as networks of bicycle paths and hiking trails will also be expanded.

Energy

On the national scale the use of energy has increased with 55% in 40 years due to the growing population, industries and economy. Wind energy, biomass and solar power will only deliver 10% of the required amount of energy, due to a lack of governmental regulation and international agreements. Therefore other (fossil) energy sources are still being exploited to meet energy demands, ignoring the environmental deterioration. A relatively new technology but still a conservative source of energy is shale gas, the extraction of which was approved at three locations in the Netherlands. The Veluwe is one of the locations where a large amount of the gas is available in the deep soil, which will be exploited by large energy companies (Geopersdienst, 2012). The extraction of shale gas on the Veluwe results in environmental pollution by chemicals, deterioration of nature areas and disturbance of the soil structure. The extraction of the gas requires the use of ground water, hence posing a threat to water quality and -availability to natural and agricultural areas. However, such apparent negative influences in the area are likely to trigger people to engage in local environmental protection. The Veluwe will also be used for the development of production forests; large plots will once again be in use for the production of wood, both for materials and biomass. The State Forestry service will coordinate the development and management of these forests.

fossil energy sources

shale gas extraction

timber production

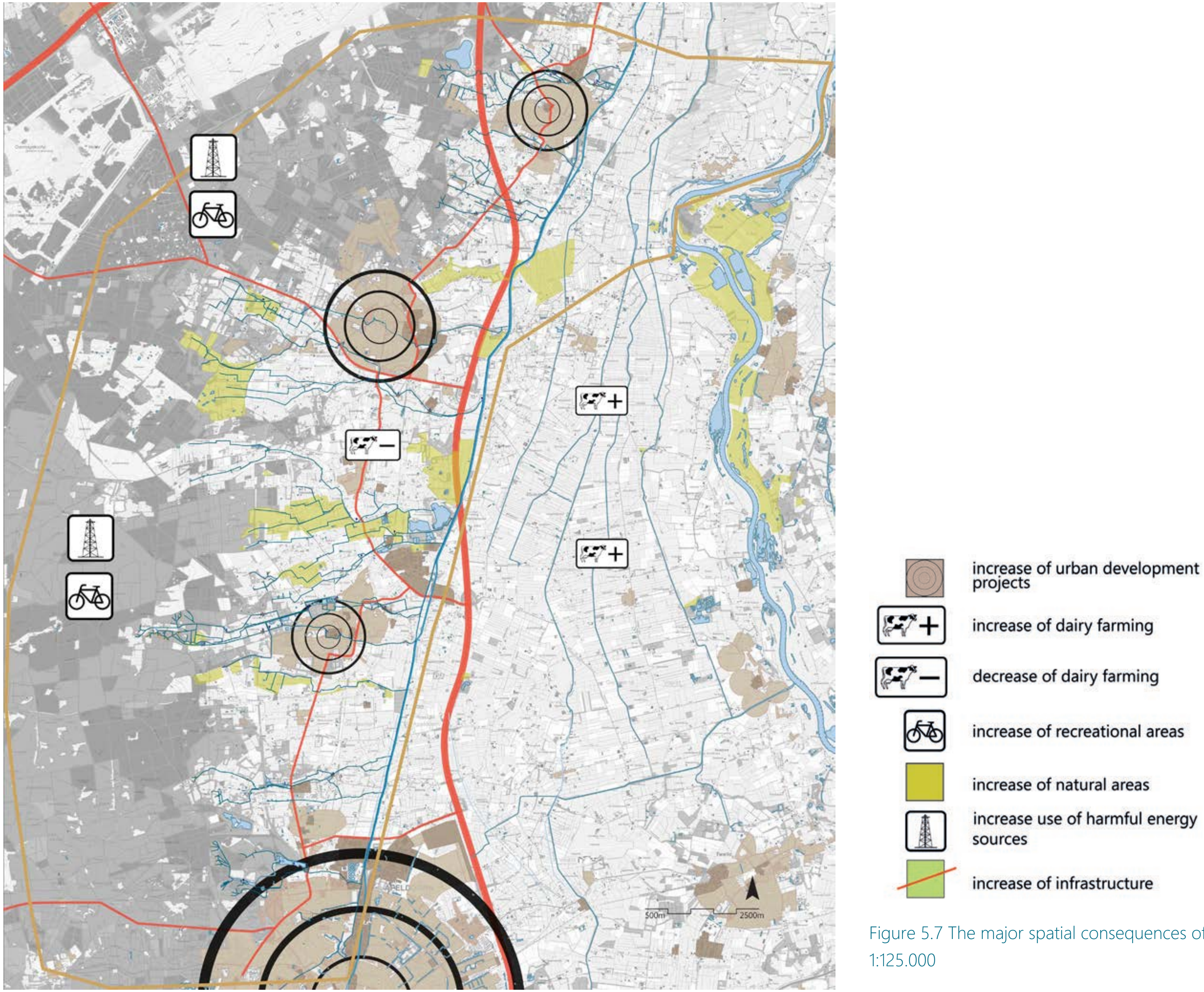


Figure 5.7 The major spatial consequences of the 'Global Economy' scenario 1:125.000

Summary of developments in the 'Global Economy' scenario

- Expansion of urban development projects (growth)
- Decrease of agricultural area
- Increase of dairy farming (scale enlargement)
- Increase of recreational areas
- Increase of natural areas
- Increase in use of fossil fuels (i.e. shale gas)
- Increase in infrastructure

Table 5.3 Assessment table with the major expected changes for The Netherlands and Gelderland in the Global Economy scenario

GLOBAL ECONOMY Themes	Scale	NATIONAL	PROVINCIAL Gelderland
Introduction (government, economy, trade, demography)	Economic growth	++	2,8%
	International trade	++	+
	Total inhabitants *(growth)*	(0,5%) 19,7 million	0,6%
	Social coherence	--	-
	Environmental policy	+/-	+/-
	Water management	+/-	+
	Drinking water consumption	35%	++
Agriculture	Agricultural area	-15%	--
	Dairy farming	25%	++
	Crop cultivation	+	-
	Secondary functions (agrotourism, care farming etc.)	-	-
Urbanization & infrastructure	Urban expansion	++	++
	Growth of infrastructure	+	+
Recreation, nature & environment	Recreational areas	47%	++
	Natural areas	22%	+
	Pollution	++	+
	Water quality	-	-
Energy	Energy consumption	55%	++
	Region based energy (resources)	+	++

Regional Communities scenario

In the Regional Communities scenario the world trade liberalization has failed, whereby the world's economy is shattered into regional trade blocks, one of them being the European Union. The Dutch economy barely grows in this scenario, and the population decreases. The governmental arrangements are still largely as they were in previous decades; the public sector has not seen any big reformations. Sovereignty is paramount for the majority of individual countries. Therefore there is little or no international collaboration between the different nations concerning environmental issues, but because of the limited economic growth and the stagnating population the pressure on the environment remains low. Due to the crumbled international markets, knowledge exchange is limited between governments, but also between private companies worldwide. The necessary stimuli for companies to innovate usually arise from the 'exchanges of knowledge' through competition, international conferences and for instance contests. However the absence of these stimuli inhibits the progress of innovation. The national government still has a regulatory power and operates to keep collective and social schemes in place. In general, people share a more common interest as opposed to a previous focus on individualism. Solidarity plays a key role in society, incomes will be more evenly divided.

European Union

sovereignty

regulatory government

By 2050, the Dutch population will have declined towards 15,8 million. The growth of the population in Gelderland has come to a stop with shrinkage and aging in the cities and villages as a result. Despite this shrinkage the Gelderland economy still grows with 0,7% per year in the Regional Communities scenario. This

urban shrinkage

small economic growth exceeds the population growth and the pressure on collective goods decreases, resulting in a net increase in welfare in Gelderland.

self-sufficiency

The increasing welfare causes people to put more attention to their direct environment. Self-sufficiency has become an important aspect. Instead of remaining a market oriented society, the Dutch society will change into a society based on cultural and social values. The collective good is more important than individual profit. As a result, the care sector is expected to thrive especially in Gelderland with its specialized regions 'Care Valley' and 'Food Valley'. Within this societal change an effective environmental policy is developed, stretching from the national to local scale. The regions and municipalities in the provinces such as the municipalities of Apeldoorn, Epe and Heerde in the province of Gelderland will then live up to the expectations of this policy and its environmental targets. Offence to this policy on any scale will be punished by the local authorities. More value and preponderance is also given to water management to ensure a healthy and safe water system for decades. The result is that the water boards are intrusted with more power and responsibility to overcome water-related issues on a regional scale. Improvements made here will positively affect the water system on a larger scale. As is shown by figure 5.8, regional actors and collaborations take initiative in the development of the 'Blauwe Bron'.

care sector

environmental targets

water boards

Agriculture

agricultural decline

The main expectation regarding agriculture is that the total amount of agricultural area will have decreased in the Netherlands by 10%, mainly due to a shrinking population and redistribution of primary agricultural production within Europe. The

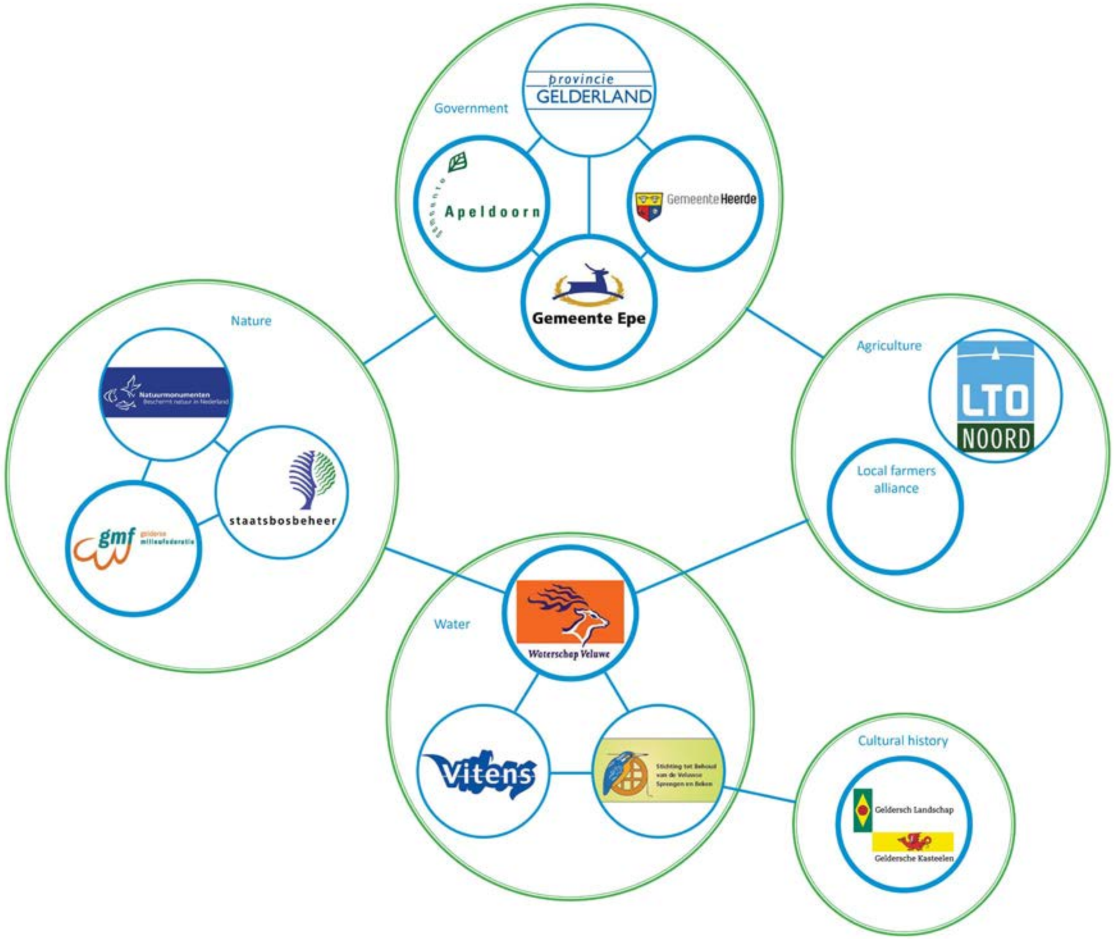


Figure 5.8 Diagram of expected regional stakeholder interrelationships in the Regional Communities scenario

latter means that the EU more or less assigns countries to focus on a certain branch of agriculture to increase the total productivity. Dairy farming will remain one of the pillars of the Dutch sector, which is stimulated by the LTO. The milk quota will be maintained, one of the exemplary European policies to protect regional economic interests. Despite such policies and enhanced support measures for the sector, the total amount of dairy farms will have decreased by 15% on the national scale. The province of Gelderland and the 'Blauwe Bron' area have a significant share of dairy farming; it will remain the largest and most important branch of agricultural production in Gelderland. The decreased spatial pressure leaves room for the development of extensive and more environmentally conscious combinations of agriculture and other (secondary) functions. Increasing economic pressure on the sector has also rendered it more economically beneficial to address new functions to the rural areas, such as agro tourism and healthcare-related agriculture, which is steered in the municipalities by local farmers alliances. Farmers remaining active in the region might also take an interest in agricultural nature management, but with the development of all those secondary activities might struggle to actually achieve a desired management strategy (Provincie Gelderland, 2012).

dairy farming

alternative incomes

struggle

As explained above, society will develop into a society based more on cultural and social values, whereby more value is assigned to our direct environment. This change in perception reflects in a demand for local and regional products, such as organically grown vegetables and fruit. A clear set of rules and preconditions described in environmental policy are aimed to maintain the rural outlook of the landscape, it will for example demand that cattle should be able to walk outside, being considered an

regional products

iconic part of the rural landscape. This will result in the characteristic image of grazing livestock in the landscape, which has a positive effect on landscape affection and tourism. The drop in number of dairy farms present in the region is however likely to cause problems for landscape management; with less 'managers' available, spatial quality of the agricultural landscape is prone to decline.

spatial decline

Recreation, nature & environment

nature acreage increase

On the national scale the acreage of nature areas will have increased by 24%, largely as a result of the 10% decrease in agricultural acreage. These numbers suggest that a major shift in function will have occurred in the rural areas of the Netherlands. While Gelderland will remain an important province when it comes to agriculture, this shift will also take place in the case study area. Many dairy farms, possibly the smaller companies or those without succession, will disappear in favour of nature. Many of the pastures that lose their agricultural function will be subject to new management regimes with a stronger focus on ecological values.

The newly developed nature areas, which are maintained by farmers, State Forestry and nature conservation organizations such as 'Gelders Landschap' and the 'Gelderse natuur en milieu federatie', can flourish rapidly. Firstly this is caused by the low environmental pressure and the increased interest in environmental health. These changes in society reduce its negative effects on the rural landscape and its qualities. Furthermore a decrease of 15% in drinking water consumption is expected due to shrinkage and a more conscious way of living among inhabitants, limiting the stress that water extraction will impose on

water abstraction decrease

the area’s hydrology and water-dependent nature. The drinking water company Vitens remains the most important supplier of water in the region. Recreation is not expected to impose a more serious threat to spatial quality and the liveability for the same reasons. Environmental consciousness and a strong appreciation of the value of the area, which is stimulated by organizations such as ‘De Bekenstichting’ and ‘Natuurmonumenten’, will likely result in branches of recreation and a type of tourists that enjoy the ‘Blauwe Bron’ without negatively affecting it.

environmental consciousness

Urbanization & infrastructure

shrinkage

Shrinkage will be a large-scale and almost general trend in the Netherlands by 2050. In our case study area all municipalities (Apeldoorn, Heerde and Epe) will show decreasing numbers of inhabitants in the Regional Community scenario. Due to this development no new urban development projects are being carried out. The drain of inhabitants brings along the risk of impoverishment and further socio-economic deterioration in districts with an above-average amount of vacancy. Expansion of industrial activities and business areas will be limited. Since it is not one of the ‘core activities’ in the region, a number of enterprises will move elsewhere for efficiency reasons. For instance, the packaging enterprise of VFP in Vaassen will have moved to an industrial site at Apeldoorn, still in the region in support of their employees. Their wish to take care of ‘people, planet & profit’ has made them decide to remediate and redevelop their old location in the centre of Vaassen.

impoverishment

decreasing traffic

The amount of traffic will decrease thanks to the limited economic growth and a decrease in industrial and urban development in combination with the stagnating population and increased use of public transport. This means that no new large infrastructure projects will be realized. However the amount of bicycle paths and hiking trails will increase due to the ageing population, an increased appreciation of the landscape by the inhabitants and the consequent increase of recreation in Gelderland. The total amount of recreational areas will increase with 19% on the national scale. Especially the Veluwe region has a large attraction on locals, but also on townsfolk. People from major cities love to recreate in the weekends and on holidays in this beautiful landscape, which expands due to the increase of nature acreage.

increasing recreation

Energy

energy consumption

renewable energy

energy neutral region

The consumption of energy in the Netherlands has dropped with 5%. People are much more aware of the impact of excessive use of harmful energy sources. Therefore people will make use of an increasing amount of sustainable and renewable energy. It is also stimulated by the local governments through local refitting projects, subsidies and use of renewable energy sources. This development is also meant to contribute to the region's independence, increasing its self-sufficiency. When it comes to energy production, countries and regions will preferably utilize the sources of sustainable energy that are most present and that match local identity. For the Netherlands, wind energy, solar energy and locally produced biomass are the primary sources of energy, which production is directed through targets of the European Union. The 'city triangle' region to which Apeldoorn belongs is among the first energy neutral region in Europe. A group of involved stakeholders strives to maintain this key role, among which are the province of Gelderland, LTO, municipalities

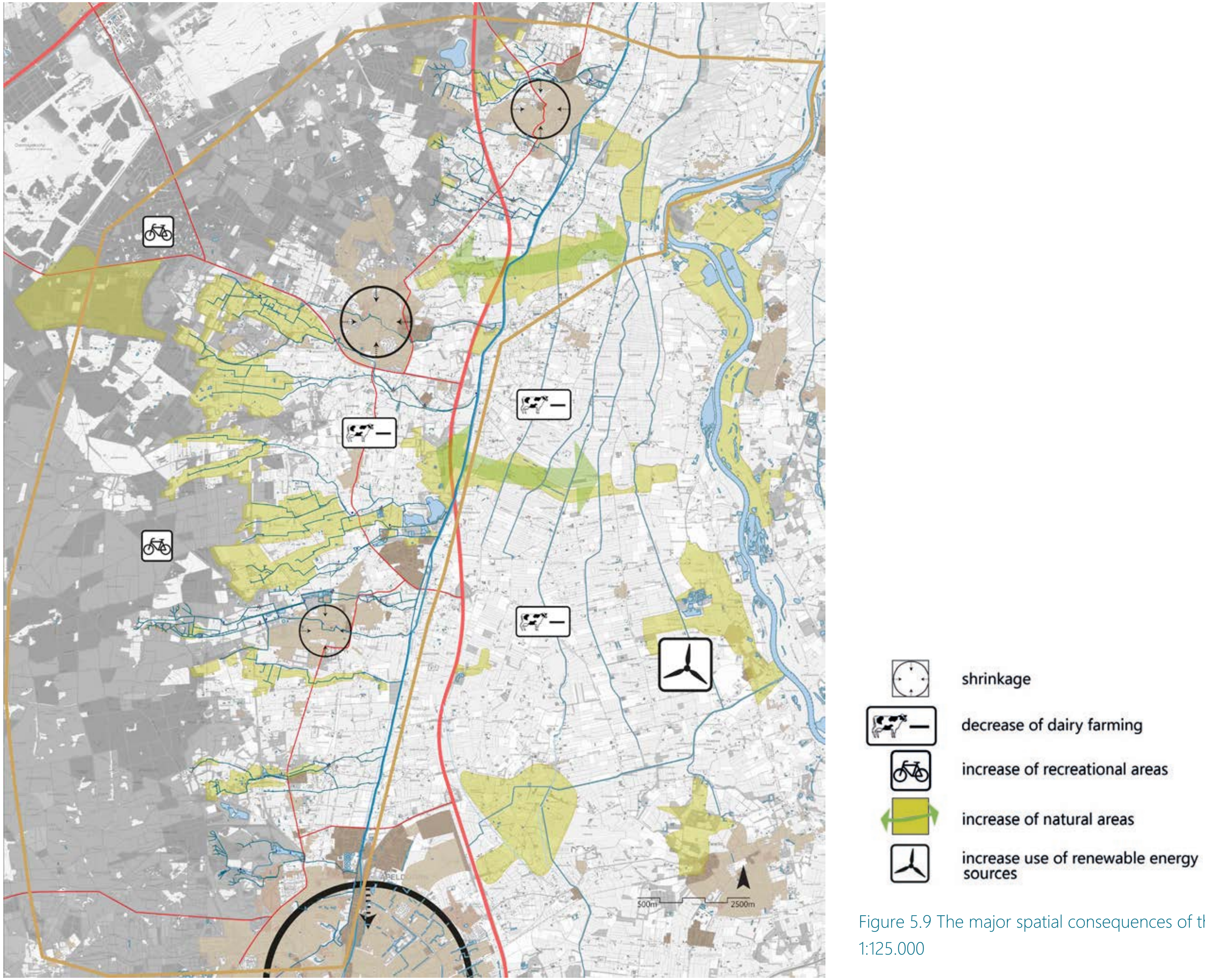


Figure 5.9 The major spatial consequences of the 'Regional Communities' scenario 1:125.000

and water board 'Veluwe'. The IJssel river valley is a designated landscape for the development of a few small-scale wind parks.

subsidised installation

Governmental subsidies stimulate the installation of PV panels on houses and agricultural and industrial buildings. Alongside conventional agriculture and nature management there will be production of biomass in the rural areas.

Summary of developments in the 'Regional Communities' scenario

- Population shrinkage
- Decrease in agricultural area
- Decrease of dairy farming
- Increase of secondary functions
- Increase of recreational areas
- Increase in natural areas

Table 5.4 Assessment table with the major expected changes for The Netherlands and Gelderland in the Regional Communities scenario

REGIONAL COMMUNITIES Themes	Scale	NATIONAL	PROVINCIAL Gelderland
Introduction (government, economy, trade, demography)	Economic growth	+/-	0,7%
	International trade	-	-
	Total inhabitants *(shrinkage)*	(0%) 15,8 million	0%
	Social coherence	++	++
	Environmental policy	++	++
	Water management	+	++
	Drinking water consumption	-15%	-
Agriculture	Agricultural area	-10%	-
	Dairy farming	-15%	-
	Crop cultivation	-	-
	Secondary functions (agrotourism, care farming etc.)	++	++
Urbanization & infrastructure	Urban expansion	-	-
	Growth of infrastructure	-	-
Recreation, nature & environment	Recreational areas	19%	+
	Natural areas	24%	+
	Pollution	--	--
	Water quality	+	++
Energy	Energy consumption	-5%	-
	Region based energy (resources)	+	+

visions 6

endogenous factors

long-term focus

climate change adaptation measures

With the WLO scenarios we have sketched two futures for the 'Blauwe Bron' area that each project a different range of developments. We consider those scenarios as future settings with different preconditions and limitations from within which climate change adaptation strategies have to be chosen. In this chapter, endogenous factors come into play; our knowledge, ideas and inspiration are applied to turn these possible futures into desired features. "Impacts of climate change on ecosystems also show strong interrelationships with ecosystem processes and human activities at various scales over time. Addressing these impacts requires a co-ordinated, integrated, cross-sectoral policy framework with a long-term focus" (Brown, 2003. In: Fischlin et al. 2007, p. 248). The long-term focus is exactly what our two visions offer; a clear view on how we think the region should respond to climate change in order to make the landscape resilient and flexible.

6.1 Climate change adaptation strategies and measures

To understand in which ways we can tackle the problems mentioned in the climate scenario, we gathered all available climate change adaptation measures that are applicable in the case study area.

Appendix III represents the collection of climate change adaptation measures that can be used to tackle the climate-related problems we defined in the W+ scenario and which are suitable for implementation in one or both of the WLO scenarios. The rows of the table represent different categories in which climate adaptation is desirable. Apart from 'water quantity' and 'water

technical measures

spatial measures

management regimes

policy measures

societal measures

quality', those are all types of land use that are suffering from climate change issues and/or concerned with the implementation of adaptation measures. The columns represent the different categories or ways to accommodate climate change actions. There are measures with a technical character that concern the use of technologies, innovations or installations to tackle specific climate-related issues. Many other measures are of a spatial nature and are therefore of special concern for landscape design. Climate change adaptation measures are in some cases applied by adopting new management regimes or by changing existing management, for example when the water board adopts a new maintenance regime for the streams. Some climate change issues can be limited or prevented by minor changes in policy and legislation by public authorities, drinking water provision and vulnerable aquatic nature can be guarded by stricter norms in groundwater protection. Finally, there is a number of measures that require societal adoption and public involvement, with the types of 'private water retention', such as subsidised water barrels as most explicit example.

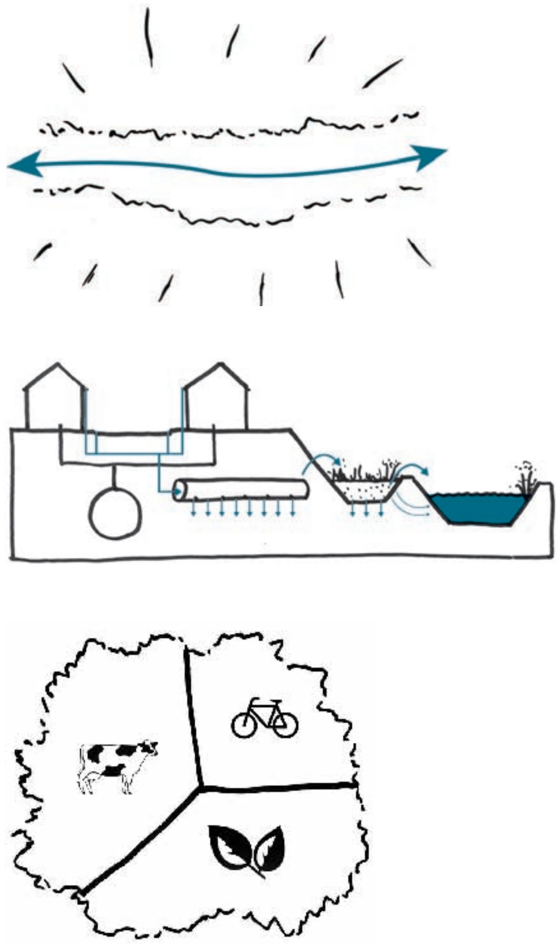


Figure 6.1 Examples of very different climate change adaptation measures: robust corridors, separated sewer systems and flexible multifunctional land use

‘Toolbox’ of spatial adaptation measures, ‘climate change adaptation services’

From the large collection of potential adaptation measures, we have made a selection of measures that we expected to be the most useful with regard to spatial design. That is because all of these measures have a spatial component; most of them are spatial interventions themselves, and some are of a more technical or societal nature but are still interesting to work with. All of them, then, fit within our vision of what sustainable development should entail for the ‘Blauwe Bron’ region.

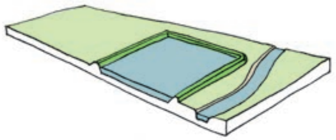
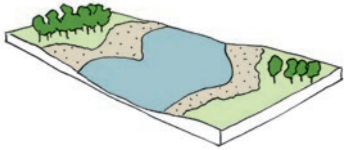
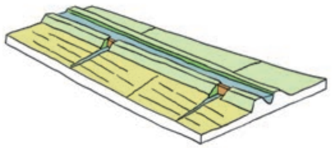
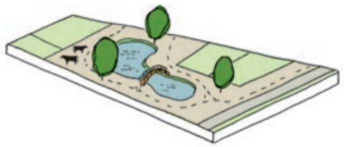
sustainable development

The adaptation measures in this ‘toolbox’ moreover can be typified as ‘climate change adaptation services’ that a climate-robust landscape ought to provide. The adaptation measures in the overview are subdivided into five typologies that each provide a specific theme or collection of climate change adaptation services. Thereby these adaptation typologies and measures provide a vital bridge between the theories of ‘ecosystem services’ and ‘landscape services’, described in chapter 3, and the climate change adaptation targets that the visions express. Finally, the adaptation measures can be seen as building blocks that can be combined and stacked together in our landscape design.

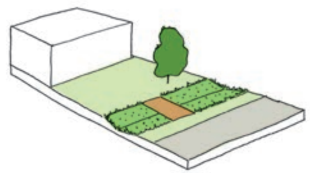
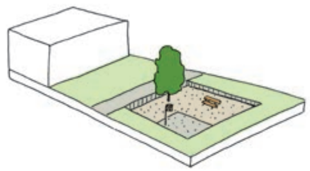
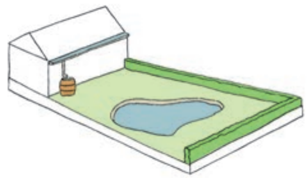
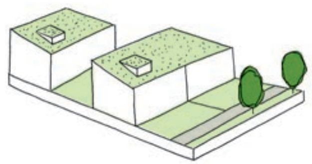
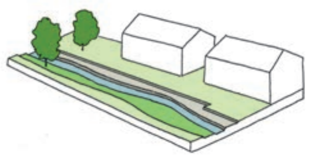
five typologies

building blocks

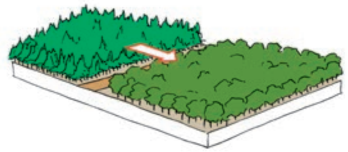
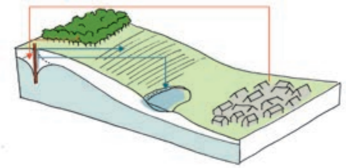
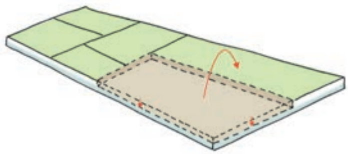
strategy: rural water retention and infiltration

c.c. adaptation measure	description	vision		locations	domain
artificial water buffer	Designated areas that are diked or excavated for the purpose of water retention in events of extreme precipitation.	Both		Agricultural area of Veluwe gradient Urban living areas Rural living areas	Spatial
natural water buffer	Natural occuring sites with surface water bodies that can hold extra water in events of extreme precipitation.	Both		Agricultural area of Veluwe gradient Wet terrestrial nature areas	Spatial
inundation of hay pastures	Natural or agriculturally used hayfields on low lying grounds that are, sometimes historically, designated to be occasionally inundated. The inundation of these fields can be used to store water from elevated streams.	Region in Balance		Agricultural area of Veluwe gradient Wet terrestrial nature areas	Spatial Management
multifunctional retention areas	Designated water retention areas in the rural landscape are developed to host functions regarding nature, recreation, water retention and/or agriculture.	Both		Agricultural area of Veluwe gradient Wet terrestrial nature areas	Spatial

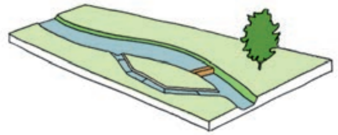
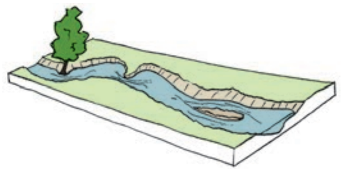
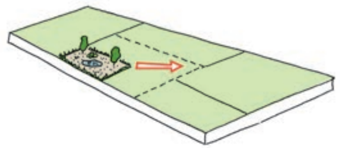
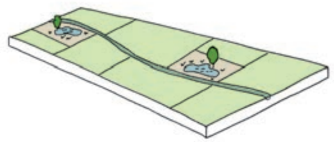
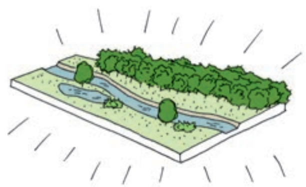
strategy: urban water retention and infiltration

c.c. adaptation measure	description	vision		locations	domain
dedicated infiltration spots	Designated spaces within the urban context are designed to provide increased drainage and/or infiltration capacity. Construction of wadi's is an examplary measure in urban landscaping.	Region in Balance		Urban living areas	Spatial
public space infiltration spots	Temporal flooding of urban spaces such as squares, streets and parks are made possible to store and infiltrate water during events of exceptional rainfall.	Region of Benefits		Urban living areas Residential recreation areas	Spatial
private water retention	Rain water barrels and ponds enlarge the capacity to temporarily store water in people's own backyards.	Both		Urban living areas Rural living areas Residential recreation areas	Societal
water retention on green roofs	More water retention within urban areas is realised through the construction of green rooftops in housing projects. Sedum has the capacity to absorb rain water and thus to smoothen urban surface runoff and discharge peaks.	Both		Urban living areas Residential recreation areas	Societal Technical
flowing water retention	Small areas along the streams in the villages are reserved for occasional flooding during heavy rainfall, also to smoothen runoff and drainage peaks. These areas can be integrated with the green 'framing' of the streams.	Both		Urban areas	Spatial

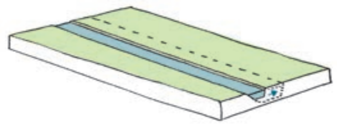
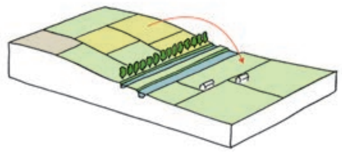
strategy: increase water availability

c.c. adaptation measure	description	vision		locations	domain
increased soil 'sponge effect'	Enlargement of the water retention capacity of the soil in the upslope areas to retain water and prevent drought stress. It is mainly achieved by removing or raising artificial draining and by vegetation change.	Both		Upstream agricultural area of Veluwe gradient Wet terrestrial nature areas	Management Technical
forest conversion to deciduous	To reach a larger infiltration capacity on the Veluwe, designated parcels of coniferous forest can be transformed into deciduous forest through the application of active or passive management.	Both		Veluwe forests	Management
Aquifer Storage and Recovery	Water can be pumped in or out of a deep soil aquifer underneath an impermeable layer of clay. During periods of surplus, water can be stored there, while during dry periods water can be recovered for irrigation with agricultural or ecological purposes.	Both		Veluwe forests Agricultural area of Veluwe gradient	Technical
excavated soil toplayer	Designated patches of nature or agricultural pastures can have the top layer of soil removed. By bringing the vegetation closer to the groundwater level, one can prevent drought stress.	Region of Benefits		Agricultural area of Veluwe gradient Wet terrestrial nature areas	Management Spatial

strategy: increase ecological robustness

c.c. adaptation measure	description	vision		locations	domain
fish ladders	Artificial hydrological element that is developed for aquatic life to be able to pass barriers of differences in water level resulting from obstructing artifacts in the streams such as mills.	Region in Balance		Brooks and dug streams	Spatial
micromeandering in streams	Natural elements and situations resulting from dynamic processes contribute to the formation of micro habitats in and along the streams. Fallen trees, eroded banks and such influence the water flow dynamics and offer shelter for fauna.	Both		Brooks and dug streams	Management
increased size of nature patches	Designated nature areas can be enlarged for eco-logical purposes, since larger patches are more resilient to negative influences and can hold more species.	Region in Balance		Terrestrial nature areas	Spatial
ecological stepping stones	In between the patchwork of agricultural plots, patches of nature can be developed to provide water retention and to offer ecological values. They offer shelter and resting places for flora and fauna and facilitate migration.	Region o fBenefits		Agricultural areas Wet terrestrial nature areas	Spatial
robust green-blue corridors	The streams will be 'framed' by corridors of nature to withstand negative external influences. Those are developed with landscape elements such as pools, hedgerows and bushes to create ecological variety.	Region in Balance		Terrestrial nature areas Brooks and dug streams	Spatial

strategy: agricultural c.c. adaptation

c.c. adaptation measure	description	vision		locations	domain
increased drainage capacity	The excavation of existing canals and ditches to enlarge their volume and thus increase drainage capacity in areas prone to flooding. Modern drainage systems moreover allow for flexible water level management.	Region of Benefits		Agricultural area of Veluwe gradient Agricultural area of IJssel valley	Technical
remote hay production	Highly productive dairy farms will have moved to the IJssel valley. To increase productivity, biomass from the haylands and meadows on the slopes of the Veluwe will be harvested for an additional supply of fodder.	Region of Benefits		Agricultural area of Veluwe gradient	Management

In-depth elaboration on a climate change adaptation strategy: forest conversion to deciduous forest

One climate change adaptation strategy that has a specific potential in the case study area adjacent to the Veluwe is that of forest conversion, better known as 'verloofing' in Dutch nature- and water management.

evaporation rates

The principle of forest conversion relies on the fact that, on a yearly basis, coniferous forest has a higher evaporation rate than deciduous forest (Dolman et al., 2000). Of the rain that falls, less water therefore reaches the groundwater. In other words, coniferous forest 'wastes' more rainwater that is extra precious in the W+ scenario where rainfall slightly decreases. Changing the composition of the forests on the Veluwe means changing the volume of groundwater recharge. When done in the right way, i.e. by converting plots of forest from a coniferous or mixed composition to a deciduous vegetation, the groundwater recharge increases. And as a result, the flows of high-quality water to the streams and seepage-dependent nature areas will also increase. This is a very constant and therefore structural measure that can counter the desiccating conditions of a W+ climate regime.

groundwater recharge

structural measure

To illustrate how forest conversion can be applied, we performed a case study where forest conversion is applied. As an example, we took a small and plain watershed, the upper course of the 'Smallertse Beek' near Emst, between Epe and Vaassen. The upper course consists of the streams draining the 'Pollense Veen' bog and the meadows around Hanendorp. By estimating the stream's discharge at that point and starting with average groundwater recharge numbers, we made an estimation of the size of the infiltration area of the course.

stream discharge

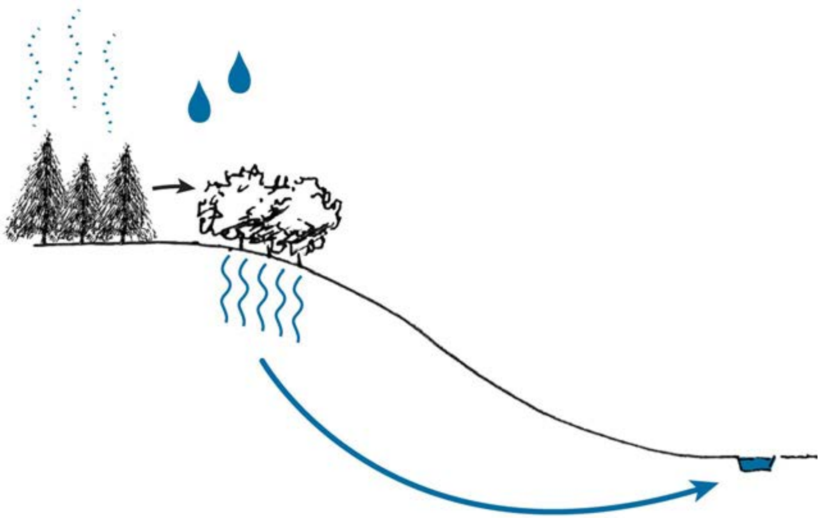


Figure 6.2 Schematic cross-section of the Veluwe and the main water flows affected by forest conversion

Table 6.1 Fact sheet showing the most important variables, units and figures used as input for the calculations

FACT SHEET

Mean precipitation in W+ scenario: 780 mm/yr

Estimated size of infiltration area: 1300 ha

Q = stream water flow rate	l/sec
A = surface of infiltration area	ha
R = ground water recharge	m3/ha/yr

vegetation/land use type	**average evaporation**	**average groundwater recharge** (R)	
forest, coniferous	730 mm/yr	50 mm/yr	= 500 m3/ha/yr
forest, mixed	550 mm/yr	230 mm/yr	= 2300 m3/ha/yr
forest, deciduous	450 mm/yr	330 mm/yr	= 3300 m3/ha/yr
heather	320 mm/yr	460 mm/yr	= 4600 m3/ha/yr
wet nature development	450 mm/yr	330 mm/yr	= 3300 m3/ha/yr
meadows	500 mm/yr	280 mm/yr	= 2800 m3/ha/yr

watershed

With the use of an elevation map and the isohypses of the groundwater level, we roughly determined the contours of the watershed and recalculated its size. We then calculated the surface of all vegetation and land cover types in the watershed and subsequently their respective contribution to the groundwater recharge. Table 6.1 is a fact sheet with the information that was used as input for the calculations

forest conversion

The groundwater recharge of the initial situation matched the estimated discharge Q of 100 l/sec, so the defined watershed and its groundwater recharge were calculated correctly. To assess the influence of forest conversion we then made the same calculations with new acreages, with a number of forest plots converted to deciduous, as can be seen in figures 6.4 and 6.5.

water provision

The results of the case study can be seen in the right column of table 6.2; the climate change adaptation measure can structurally contribute to the area's water provision by over 10%.

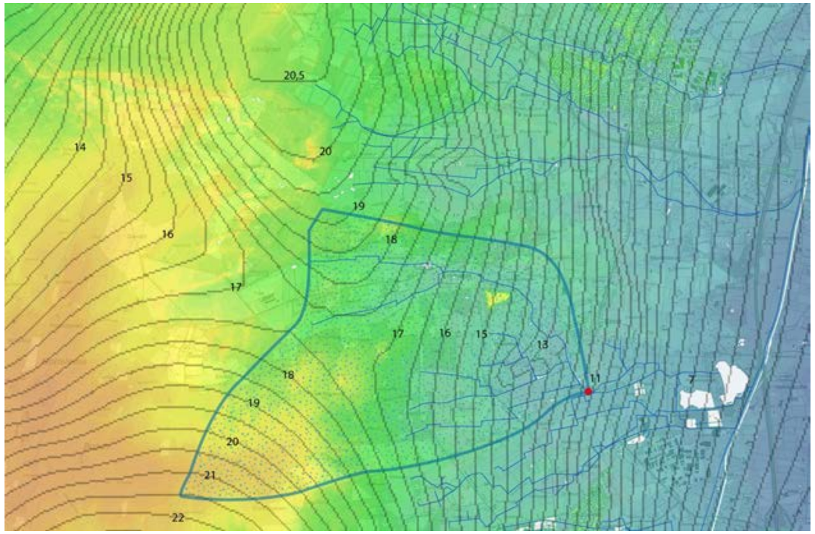


Figure 6.3 Map of infiltration area of the upper course of the 'Smallertse Beek' with surface elevation and ground water isohypses in m above A.O.D. (NAP)

CALCULATIONS

Table 6.2 Calculations of the forest conversion measure at the upper course of the 'Smallertse Beek' stream and a resulting discharge that increased over 10%

vegetation/land use type	**before conversion measure**				**'verloofing' conversion**	**after conversion measure**			
	A (ha)	**x**	**R (m3/ha/yr)**	**= annual R (m3)**		**A (ha)**	**x**	**R (m3/ha/yr)**	**= annual R (m3/yr)**
forest, coniferous	200	x	500	= 100.000	**- 100 ha**	100	x	500	= 50.000
forest, mixed	500	x	2300	= 1.150.000	**- 60 ha**	440	x	2300	= 1.012.000
forest, deciduous	n/a				**+ 160 ha**	160	x	3300	= 528.000
heather	20	x	4600	= 92.000		20	x	4600	= 92.000
wet nature development	360	x	3300	= 1.188.000		360	x	3300	= 1.188.000
meadows	220	x	2800	= 616.000 +		220	x	2800	= 616.000 +
total annual R				3.146.000 m3					3.486.000 m3
total Q				100 l/sec					110,5 l/sec

Figure 6.4 Map of infiltration area of the upper course of the 'Smallertse Beek' and current land cover

Figure 6.5 Map of infiltration area of the upper course of the 'Smallertse Beek' after forest conversion

Visions for the future

climate robust

long-term developments

climate change adaptation measures

main concepts

Our visions illustrate how we imagine that the 'Blauwe Bron' area should look like by the year 2050 to be sufficiently adaptive to climate change and thus 'climate robust'. The Region of Benefits vision is our answer to the Global Economy scenario, while the Region in Balance vision illustrates how we suggest to respond to the Regional Communities scenario. We explain our intentions divided over three spatial themes, which are (a) agriculture; (b) nature, recreation and environment; and (3) urbanization, infrastructure and energy. Each theme starts with a part on long-term developments, after which a second paragraph is reserved to explain the climate change adaptation measures. The spatial developments for each vision are guided by a main concept, which are the cluster concept in Region of Benefits and the green/blue network concept in the Region in Balance. The importance of such clusters and networks for climate proofing the rural areas of the Netherlands is noted in the following statement: "Strengthening the National Ecological Structure and the connections with the European network of Natura 2000 makes nature more climate change proof. The researchers advise to concentrate extra measures in so-called climate corridors or clusters" (translated from: Vos, C. in: de Pater et al., 2011).

6.2 Vision - 'Region of Benefits'

The rural landscape of the 'Blauwe Bron' region presents a landscape with a powerful agricultural sector that is influenced by the potential effects of climate change as explained in the 'Global Economy' scenario. The region has a primarily mono-functional land use, while a number of multi-functional clusters enhance ecological and social values. We propose to integrate climate change adaptation measures in the patchwork landscape to enhance spatial quality and to enlarge the productivity and efficiency of these areas that contribute to the region's economic competitiveness.

Agriculture

dairy farms

We propose a revision of the agricultural activities in the region, after which the farms on the Veluwe gradient produce the required hay for the dairy farms that are to be concentrated in the IJssel valley. There are less farms, but those which remain are bigger and clustered together for considerations of efficiency and spatial quality. The hay required by these farms can for a large part be grown on the meadows on the slope of the Veluwe, outside of the intensive agricultural area of the valley. The movement of dairy farms hereto might detract from the characteristic image of the old agricultural landscape with grazing cows in the fields, but will strengthen both the dairy sector in the valley and the efficiency of hay production on the Veluwe's slopes.

The government and LTO stimulate efficient agricultural management for the production of hay, to come in line with the demand for high quantities of feedstock mentioned in the Global Economy scenario. To reach this level of efficiency in a landscape of primarily hay meadows, we suggest the careful appliance of

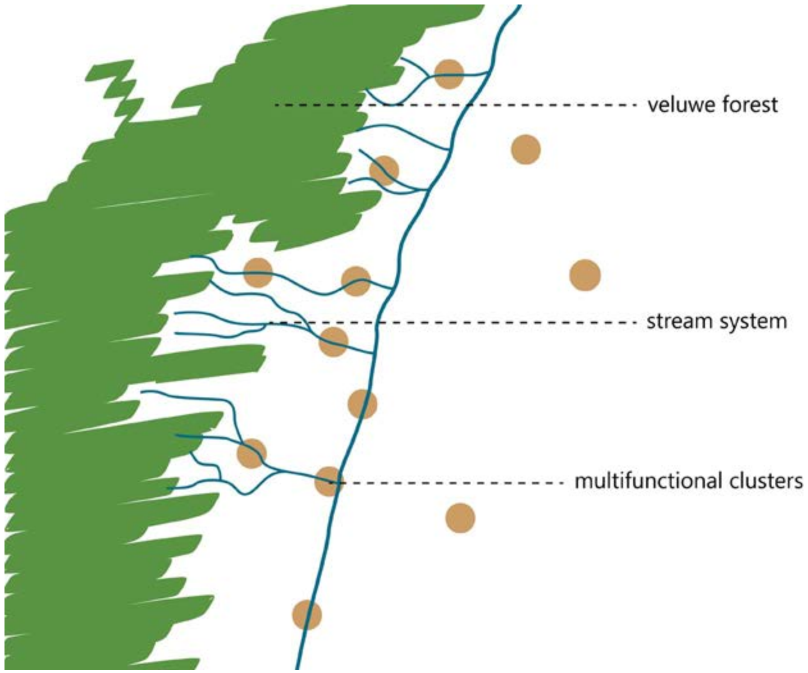


Figure 6.6 Vision concept map of 'Region of Benefits' and its main spatial element; multifunctional clusters

land consolidation

land consolidation. This way the large farms can divide the hay fields to facilitate their demand for hay, however within strict directives to guard spatial quality. The new distribution of plots is seized to improve the plot boundaries, which are maintained by the state forestry service through the application of directives for spatial development. For instance the contours of the historical 'Wanenk' south of Vaassen are strengthened with hedgerows and tree girths. On the other side of the 'Apeldoorns kanaal' the increased number of large stables in the IJssel valley could result in the demise of the vast openness and large-scale character of this landscape. To prevent such spatial decline and to increase the landscape structure we advise to cluster the farmyards together on the vegetated higher parts in the landscape. These clusters then form green islands in a vast open space. Plantation is otherwise only allowed along the main roads and canals ('weteringen'), and in the form of alder hedgerows (de Jong, 2011).

Climate change adaptation in the agricultural landscape:

precipitation peaks

water nuisance

hay production

In the low lying agricultural area there is an increased risk of water damage on agricultural plots due to the increase of precipitation peaks as predicted by the W+ climate scenario. When such peaks occur, they can cause losses in yield for the farmers in business. Wet conditions are also less desirable because they limit the carrying capacity of the soil and thus the use of heavy machinery. The IJssel valley is more sensitive for water nuisance than the Veluwe gradient due to its lower altitude and different soil composition. For this reason we propose that the government and LTO stimulate the allocation of hay production on the Veluwe gradient. To ensure an optimal hay production on the agricultural plots we advise that the drainage tubes are placed deeper in the

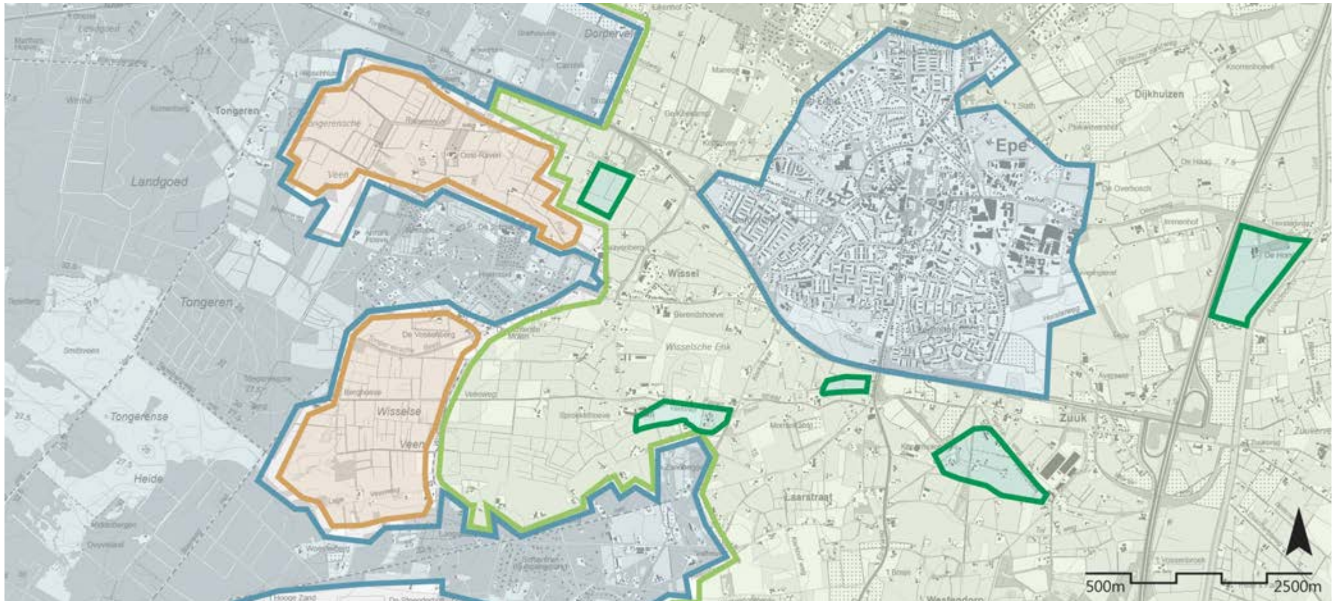
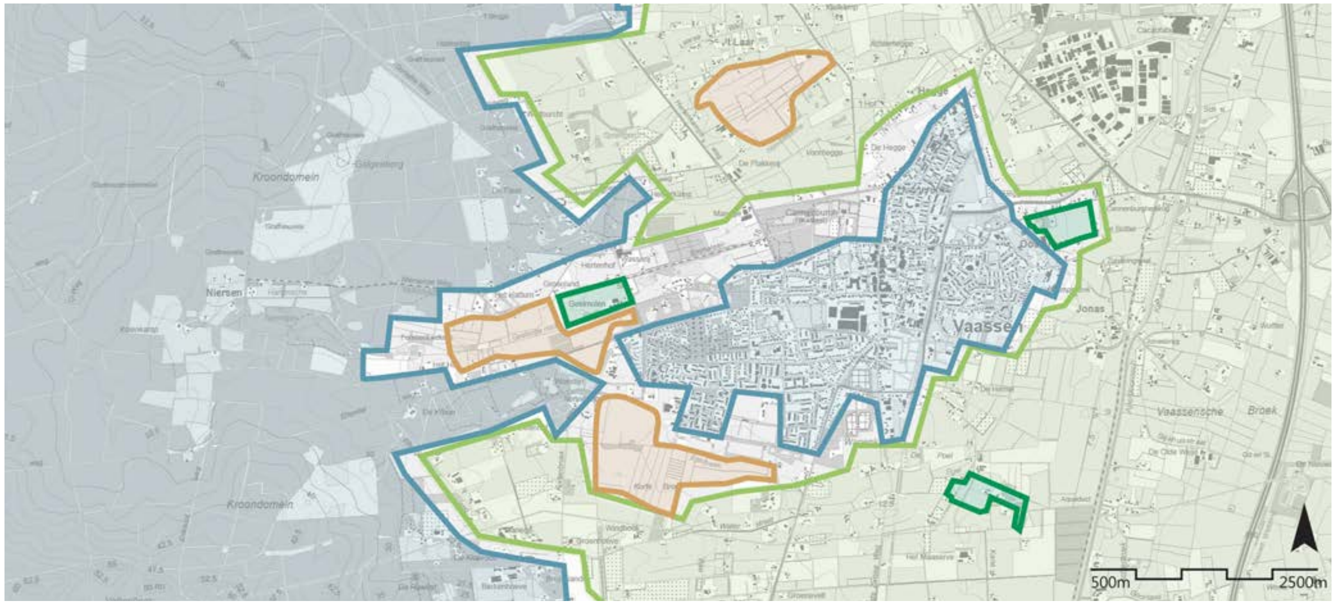


Figure 6.7 Climate Change Adaptation Targets map for the landscape around Epe
1:50.000



- increase infiltration capacity
- enhance sponge effect
- ecological stepping stone
- agriculture: increase efficiency agriculture

Figure 6.8 Climate Change Adaptation Targets map for the landscape around Vaassen
1:50.000

drainage capacity

controlled-level drainage

ground so that more water can be collected and discharged to the drainage canals. On places prone to water nuisance canals and ditches that separate the parcels are broadened and deepened to enlarge their volume and thereby the drainage capacity. However, increasing drainage makes agricultural plots more vulnerable to drought during dry periods. For this reason we suggest that the farmers in the region invest their money in the development of controlled-level drainage in association with weirs to keep the plots from dessicating.

Recreation, nature & environment

Recreation plays an important role in the entire Veluwe area. We suggest that recreational areas such as bungalow parks expand to accommodate the influx of visitors, in a response to the described scenario development. We advise that these touristic residential areas are kept out of sight within the forest, but well connected to recreational networks. Each location offers viewpoints and different landscapes such as the open heath lands, peat lands and forests. It is suggested that the facilities for recreation primarily focus on the development of bicycle paths, hiking trails and resting places including benches and pick nick tables on strategic places where people can enjoy the beauty of the scenery.

We foresee three changes in nature development targets that build upon the described scenario developments. First of all we suggest that the province of Gelderland should stimulate the development of 890 ha of upstream nature areas, among which are the 'Wisselse' and 'Tongerense veen' bogs near Epe. These nature development areas have a high biodiversity in vegetation and wildlife such as the brown beak-sedge ('bruine snavelbies'),

nature areas

biodiversity

Figure 6.9 Brown beak-sedge

source: http://www.biopix.com/brown-beak-sedge-rhynchospora-fusca_photo-35434.aspx ivy-leaved crowfoot ('klimopwaterranonkel'), the natterjack ('rugstreeppad') and the small whiteface ('venwitsnuitlibel'). The new and further developed nature areas moreover provide new opportunities for recreation.

Second, we propose that selected former agricultural plots along the streams are designated to make room for nature development. Though these areas are limited in size and numbers due to the lasting value of agricultural plots in the region as mentioned in the Global Economy scenario. To optimize utilization and yield and to enhance of spatial quality of the rural landscape, we suggest to develop a number of

multifunctional clusters

multifunctional clusters of 3-30 ha in size, to compensate for the primarily mono-functional landscape in which these patches are located. They are separated from each other and have different functions. Among these clusters are for instance new nature development areas and a couple of new estates near Epe and Vaassen to meet the demand for new rural dwellings on the one

ecological stepping stones

hand and to create ecological stepping stones on the other. The clusters show an increase in nature development and biodiversity. Common vegetation types in these patches are alder, willow and birch, while in the more open zones wet natural hay lands such as 'dotterbloemhooilanden' and 'blauwgraslanden' occur. Valuable target species of fauna for the streams and natural clusters are for example the brook lamprey ('beekprik'), the grey wagtail ('grote gele kwikstaart'), the northern crested newt ('kamsalamander') and the scarce large blue ('pimpernelblauwtje'). We suggest that the municipalities pay for the maintenance of these clusters and that the state forestry service performs the actual maintenance. The accessibility of these places is improved by the development of new cycling, walking and parking facilities, while the amenity

Figure 6.10 Natterjack
source: http://zoom.nl/foto/112681/dieren/rugstreeppad.html

Figure 6.11 Brook lampreys
source: http://www.ravon.nl/Fotos/tabid/224/AlbumID/392-43/Default.aspx

Figure 6.12 Grey wagtail
source: http://vwglosser.nl/vogels/ggkwikstaart/ggkwikstaart.htm

value is enhanced with the development of lingering and seating places.

hedgerows

The third change that we suggest is the strengthening of plot boundaries with use of hedgerows and tree girths that consist of area specific vegetation types, which can be used by animal species for migration. This measure enhances the quality and amenity of the landscape. The 'Wanenk' south of Vaassen and the 'Wisselsche Enk' southwest of Epe are nice examples of such interventions. The many hedgerows create more diversity and strengthen the character of the rural landscape types. Opportunities should also be taken to restore old fragmented tree lanes.

People are able to spend their leisure time in the nature development areas as well as in the multifunctional clusters. To create more environmental awareness information signs are placed to explain adults and children the different succession phases of nature development, and which types of wildlife and vegetation are present.

Climate change adaptation in the natural landscape:

'verloofing'

fire breaks

The forests on the Veluwe play a major role in the hydrological system of the region. We propose to convert an acreage of approximately 1850 ha coniferous forest to deciduous forests ('verloofing'). Deciduous forests have a smaller interception rate, but also consume and evaporate less groundwater than coniferous forests. More water can thus infiltrate the soil. The conversion of plots of coniferous forests to deciduous forests is therefore an important adaptation measure to make the study area more resilient to the effects of drought. Due to the drought, forest fires will occur more often and therefore we advise to leave fire breaks of at least ten meters open between the forest patches

Figure 6.13 Fire break

source: http://seekingalpha.com/article/204934-how-does-greece-affect-the-united-states

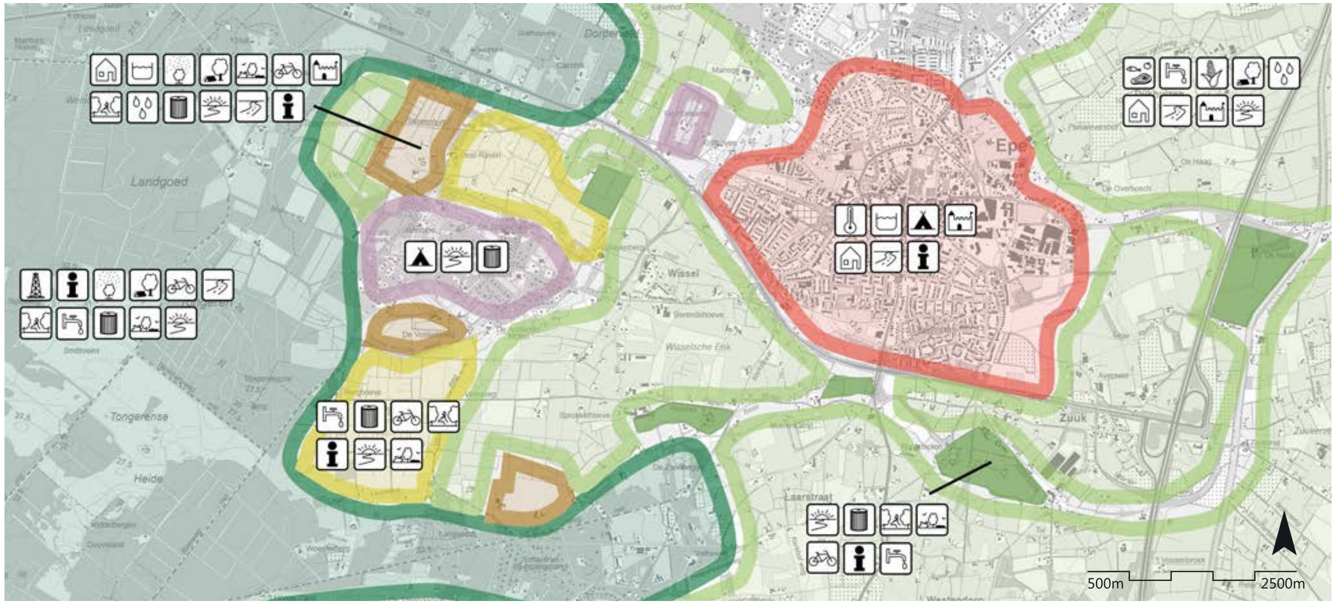


Figure 6.14 Landscape Services map for the landscape around Epe

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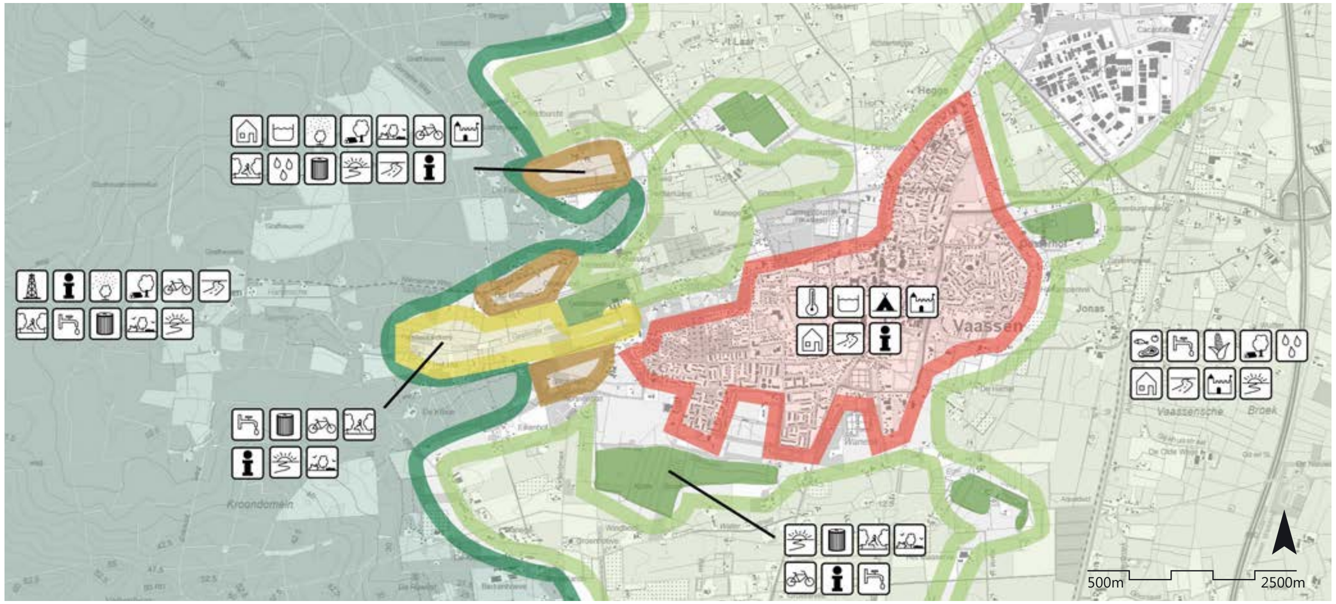

Figure 6.15 Landscape Services map for the landscape around Vaassen

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to prevent fires from spreading and to facilitate the fire fighting itself.

ASR

Another adaptation measure that we suggest on the Veluwe is used to balance the seasonal fluctuations in availability of water during the year. It is called the ASR method (Aquifer Storage & Recovery). During periods of surplus, water is pumped in a deep soil aquifer underneath an impermeable layer of clay to store it here. During dry periods water is recovered from this aquifer for irrigation of agricultural fields, ecological purposes, drinking water or for other uses.

sponge effect

We advise to enlarge the water retention capacity of the soil (the 'sponge effect') in nature development areas and former hay fields in the upper stream regions of both Epe and Vaassen. The soil retains more water to prevent drought stress. It is achieved by removing or raising artificial draining, changing the vegetation and by controlled-level drainage. Natural occurring water bodies within these nature development areas are used for the temporal storage of water, such as low-lying areas where seepage emerges.

artificial water buffers

We moreover suggest to construct artificial water buffers in the multifunctional clusters to serve water retention purposes where natural retention capacity is absent. They can be designed for instance as natural ponds, or constructed to act as artificial accumulation ponds ('wijers') upstream of a formerly obsolete mill.

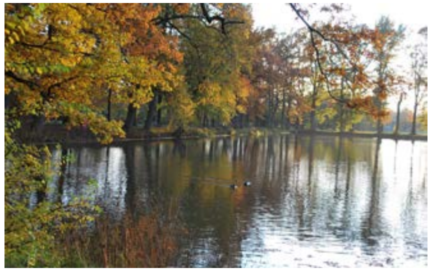

Figure 6.16 'Wijer' accumulation pond

top soil excavation

The excavation of the soil top layer in the multifunctional clusters roughly between the villages and the Apeldoorns kanaal, brings the vegetation closer to the ground water level and thus creates a wetter environment, which is suitable for different species of sedge. In the top layer of the soil in these former agricultural plots nutrients are present caused by fertilization in the past.

Our suggestion to remove this top layer includes the removal of some of these nutrients, which benefits the development of nutrient poor vegetation species such as lesser pond-sedge ('moeraszegge') and purple moor-grass ('pijpenstrootje') instead of nutrient rich species such as soft rush ('pitrus'). We advise the province of Gelderland and the municipality of Epe to subsidise the development of these excavation areas, in collaboration with private organizations such as the 'Bekenstichting' and 'Natuurmonumenten'. 'Rijkswaterstaat' operates as mediator between these public and private organizations and the site managers who implement extensive landscape management in these areas.

Figure 6.17 Lesser pond-sedge

source: http://www.freenatureimages.eu/plants/index.php/Flora-C-150923338/Carex-acutiformis/Carex-acutiformis-4-Moeraszegge-Saxifraga-Hans-Boll

Figure 6.18 The Wisselse Veen bog

Urbanization, infrastructure & energy

'new estates'

New estates are spread along the slopes of the Veluwe forests, with sizes varying between 5 and 20 ha. They are realized at former agricultural plots where previously no buildings were present, following a revised set of guidelines (Derckx et al, 2010). The application of the 'Rood voor rood regeling' also allows the replacement of obsolete or landscape disfiguring buildings on these new estates. These estates, always located at transition zones between the forests and the stream valleys, are ecologically and economically functional and attractive. Functions such as nature development, agriculture, recreation, timber production, infrastructure and dwelling are combined in these landscapes (de Jong, 2011). The houses are located on the higher parts of the transition zone of the new estates, hidden in the forest edge with a clear view over the stream valley. Many estates revolve around a specific concept to provide more variety, identity and purpose for these areas. Each location has a specifically chosen concept that characterizes and contributes to the identity and history of the spatial context of the landscape in which the estate is integrated. A care estate, an equine estate or an educational estate are possible concepts for these new estates.

Improved infrastructure satisfies the demand for mobility as mentioned in the Global Economy scenario. A better understanding and more awareness among the public for topics such as climate change and adaptation measures is generated, which is in line with the wishes of the government and ourselves about emphasizing and stimulating local initiatives of citizens. The recreational routes make the streams and the integrated adaptation measures more visible to the public. The paths lead people through the multifunctional clusters in such a way that they can fully experience the scenery. Information signs with simple and clear principles and drawings help visitors to understand the adaptation measures even better.

We advise to design two unique and recognizable types of bridge railings with specific shapes, materials and colours to mark the crossings of streams by main roads in the urban as well as the rural landscape. The design of the ground surfaces of these crossings, using colour and texture, indicates the differences in character of the streams in the rural and urban setting. Within the villages of Vaassen and Epe another measure should be implemented on a small scale to emphasize the presence of the streams among the public. At the trajectories where streams flow underground the ground surface can be equipped with blue coloured LED lighting. A strip of LED illumination of 570 meters long through the centre of Epe can reveal the trajectory of the 'Dorpsbeek'. Locations for the extraction of shale gas are chosen according to environmental and safety directives given by the

LED illumination

shale gas extraction

Figure 6.19 Boardwalk through a marsh

source: http://www.natuurmonumenten.nl/node/4256

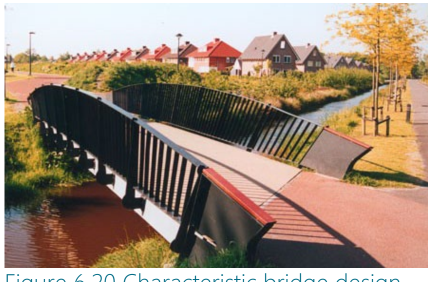

Figure 6.20 Characteristic bridge design

source: http://www.doelbeelden.nl/index.asp?ct=bruggen&sc=&c=3&s=0&o=0&oc=&currentpage=10

Figure 6.21 Boardwalk through a marsh

source: http://www.natuurmonumenten.nl/node/4256

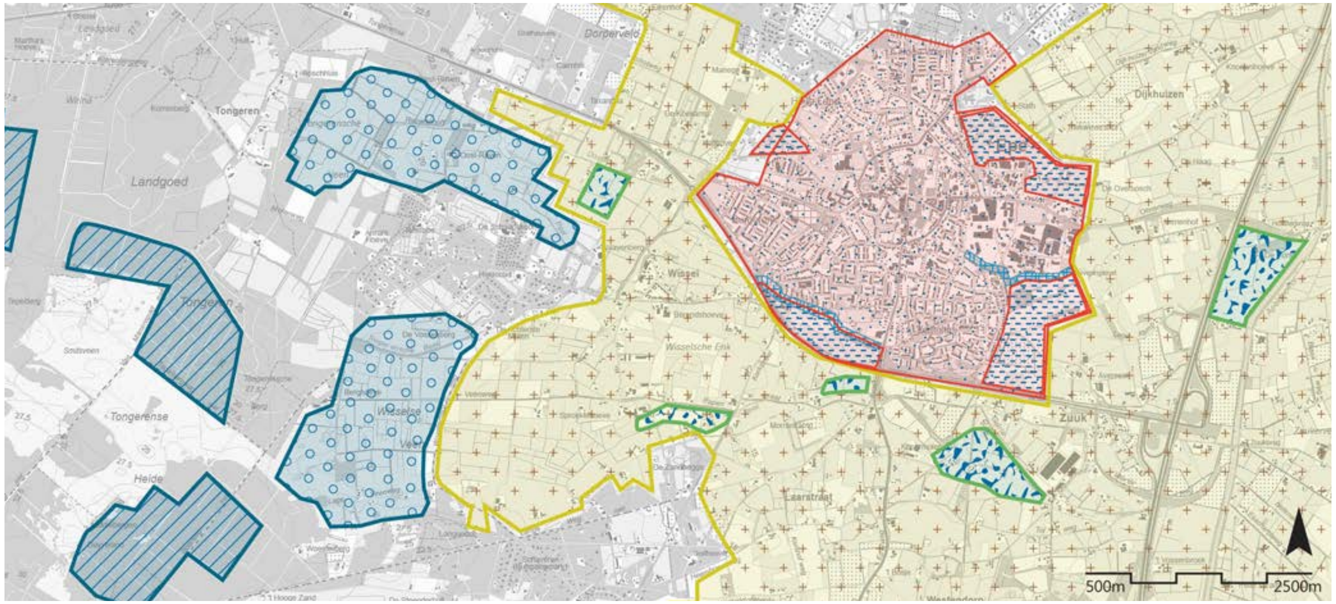

Figure 6.22 Climate Change Adaptation Services map for the landscape around Epe
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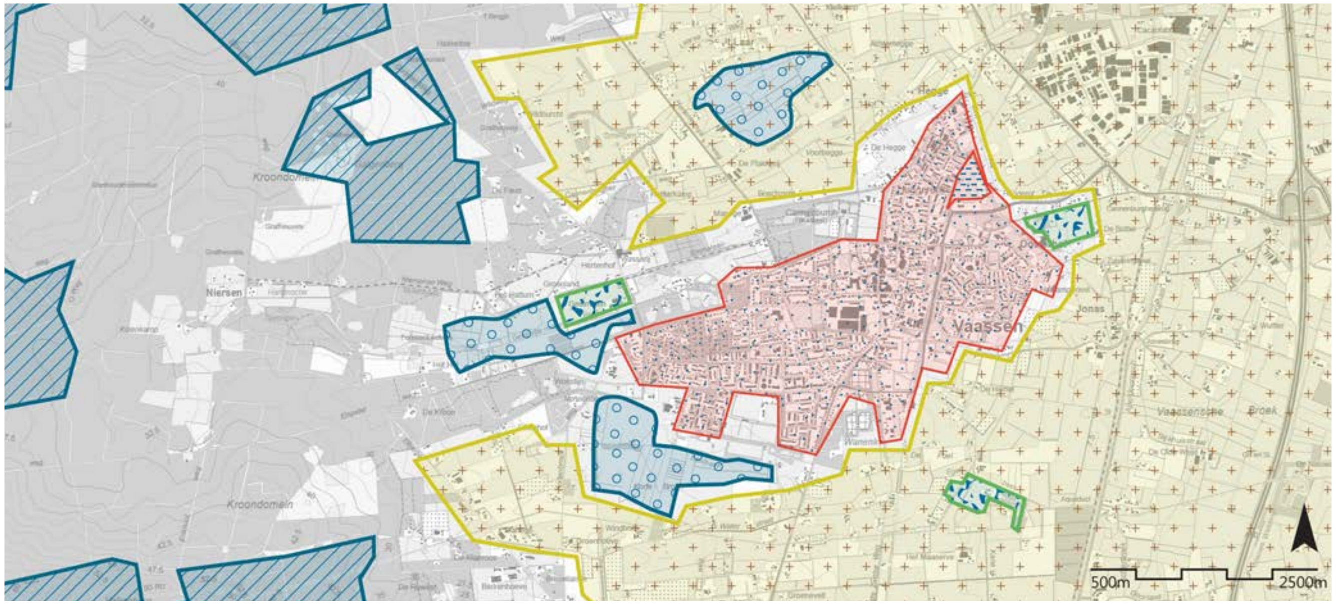

conversion coniferous/ deciduous
increase sponge effect
increase drainage capacity
multifunctional retention areas
private water retention
flowing water retention
green roofs

Figure 6.23 Climate Change Adaptation Services map for the landscape around Vaassen
1:50.000

province of Gelderland. For this reason we suggest to situate the extraction sites in sparsely populated areas to reduce the risks for residents, but also to limit visual pollution and noise. Wastewater is stored in containers and tanks on the surface to prevent it polluting the ground water. According to spatial directives, set up by the province of Gelderland, the gas companies are obliged to apply artificial waste water treatment to purify the polluted water, which is a necessity to ensure spatial quality.

artificial waste water treatment

Climate change adaptation in the urban landscape:

There are multiple adaptation measures possible to prevent water nuisance within the urban context of the villages. The infiltration capacity in the villages is increased by our proposal to install green roofs within new housing projects and bungalow parks as well as in existing houses. These roofs, overgrown with sedum species, absorb a part of the rainwater which would otherwise run down the drainpipes on the streets and into the sewer system. The risk of sewer overflow hereby decreases. Another measure is the active stimulation of 'private water retention'. Provided rain water barrels and ponds in peoples' own backyards are used to store water temporarily and therefore contribute to the diminution of the sewer overflow rate. Another adaptation measure is found in the use of a separate sewer system. In this system rainwater is disconnected from the wastewater; only the waste water flows to the water treatment plants while the rainwater is stored in collecting basins and can be used for the watering of gardens or other uses.

green roofs

private water retention

Figure 6.24 Green roof with sedum vegetation
source: http://www.natuurwacht.nl/thema.php?id=38

flowing water retention

We advise to develop multifunctional public spaces within the villages to become more suitable for the storage and infiltration of water in case of heavy rainfall. Flowing water retention is applied at designated places in the villages along the streams. Small areas are reserved for occasional flooding to smoothen discharge peaks. During dry periods these areas are used for public activities, while during the winter season they can occasionally be flooded.

Figure 6.25 Flowing water retention along an urban stream
source: http://www.bplusb.nl/?project=wijkeroogpark-velsen

6.3 Vision - 'Region in Balance'

landscape services

The potential influences of climate change and the implementation of adaptation measures are ubiquitous in the future landscape of the 'Blauwe Bron' region. The agricultural sector is economically less powerful but of great spatial and social value. We propose an integrated approach to rural land use and management to make optimum use of those values. Therefore we introduce the concept of landscape services to our study, as a framework for meeting demand and supply of functions that contribute to climate change adaptation and spatial quality.

Agriculture

subsidies
guidelines

The government and agricultural organisations such as the LTO play a role focused on stimulating the development of additional tasks and potential revenue for agrarians. A clear set of subsidies, guidelines and exemplary projects are realised to promote the functional shift and extensification that offer opportunities for a viable agricultural sector. The broader set of duties and services that farmers engage in will expand their base of income while enhancing spatial quality and the societal value of rural areas.

organic farming

The most important agricultural transition that we foresee is for the 'Blauwe Bron' and IJssel valley regions to take a leading position in organic, seasonal and region-specific production. The area adapts to the conditions of the Regional Communities scenario by responding to the increased demand for genuine and fresh food products while simultaneously strengthening its own identity. Organic farming is an excellent way of responding to the decreased pressure on yield (due to the production quota) since the generated revenue and turnover can be higher with lower production volumes. Quality over quantity is the main adagio for

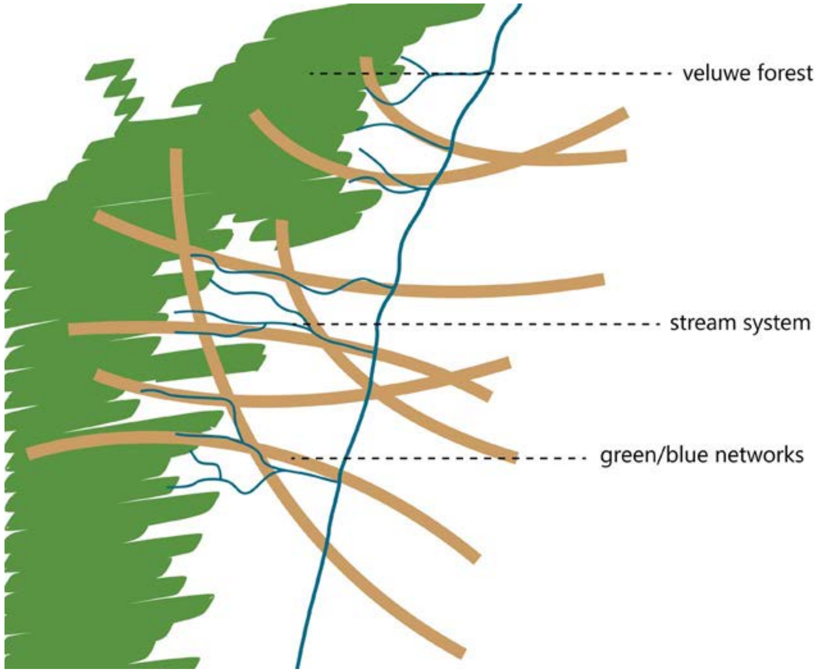

Figure 6.26 Vision concept map of 'Region in Balance' and its main spatial element; a green-blue network

agricultural entrepreneurs in the 'region in balance'.

What is also in line with a changing agricultural conduct of business, is a more conscious approach to the use and construction of farm buildings. Upgrading and retrofitting allows for efficient reuse of barns, hence limiting the need for newly constructed farm buildings. Farms and farmyards that no longer serve a functional purpose provide opportunities for the development of small-scale rural housing development. We suggest that a number of farmyards should be redesignated to serve a residential function. Such 'residential farmyards' are a category of small-scale, high quality dwelling typology much alike the typical rural 'enclaves' that are already present. A concept that could serve as inspiration is that of 'node farmyards' ('knooperven'), where obsolete farmyards are revived and catalyse rural landscape development (Moerkamp, 2010). In the 'Blauwe Bron' area, (partially) abandoned farmyards and enclaves have the same potential to host two to four rural dwellings, with the potential to strengthen landscape structures and contribute to green-blue networks. Initiatives such as these will be supported by means of governmental directives on the treatment of monumental buildings, landscape management and sustainability targets.

residential farmyards

Figure 6.27 Redeveloped residential farmyard

source: http://www.franzziegler.nl/index.php?pageid=portfolio_info&catid=053_Oostermaet_info

The extensive and environmentally conscious forms of agriculture are not only beneficiary to nature and ecological values of the rural landscape. Recreation also flourishes in this landscape that leaves more room and a more attractive context for 'being there'. In this vision where multifunctionality is the keyword, recreational co-use of the rural landscape offers vast possibilities for both visitors to experience the landscape and farmers to generate revenue. A farmer could for instance allow a hiking trail or cycling path to cross his fields, rent an apartment on

hiking trail

his yard to tourists or local entrepreneurs, or allow people to use an adjacent canal for fishing and canoeing.

fish hatcheries

With the aspects of self-sufficient production and multifunctional secondary use in mind, we foresee a valuable and exemplary role for the fish hatcheries in the villages of Emst and Vaassen. In Emst already lies the hatchery "'t Smallert", where fish production is combined with recreational fishing, a cafetaria, a playground and a candle workshop. We propose an expansion of its activities toward sustainable production, with great care for its environmental influence given its direct interaction with the stream 'Smallertse Beek' at which it is located. This means stopping the administration of medication through the water and implementing a tailored feeding scheme. The hatchery "het Hol" at the 'Geelmolensche Beek' upstream of Vaassen is advised to move to a location downstream at the hamlet Oosterhof. The first reason for this measure is the potential risk of water contamination. Moving the hatchery downstream significantly reduces the risk that large parts of streams potentially suffer from disease or pollution in case of an unfortunate event at the hatchery. Other reasons to move the hatchery are the opportunity of expansion at the new site and to make desired improvements in spatial quality and touristic values around Vaassen. With environmental consciousness being highly promoted, there are strict directives which the design and management of the hatcheries have to meet.

natural filtering

The quality of output water is monitored and improved through the implementation of natural filtering by means of helophyte wetlands, before the water flows back in to the streams.

Figure 6.28 Reed helophyte filter
source: http://nl.wikipedia.org/wiki/Bestand:Helofytenfilter.jpg

The agricultural practices increasingly contribute to spatial and environmental quality in the region, influenced by a conduct of business that is more conscious of environmental values

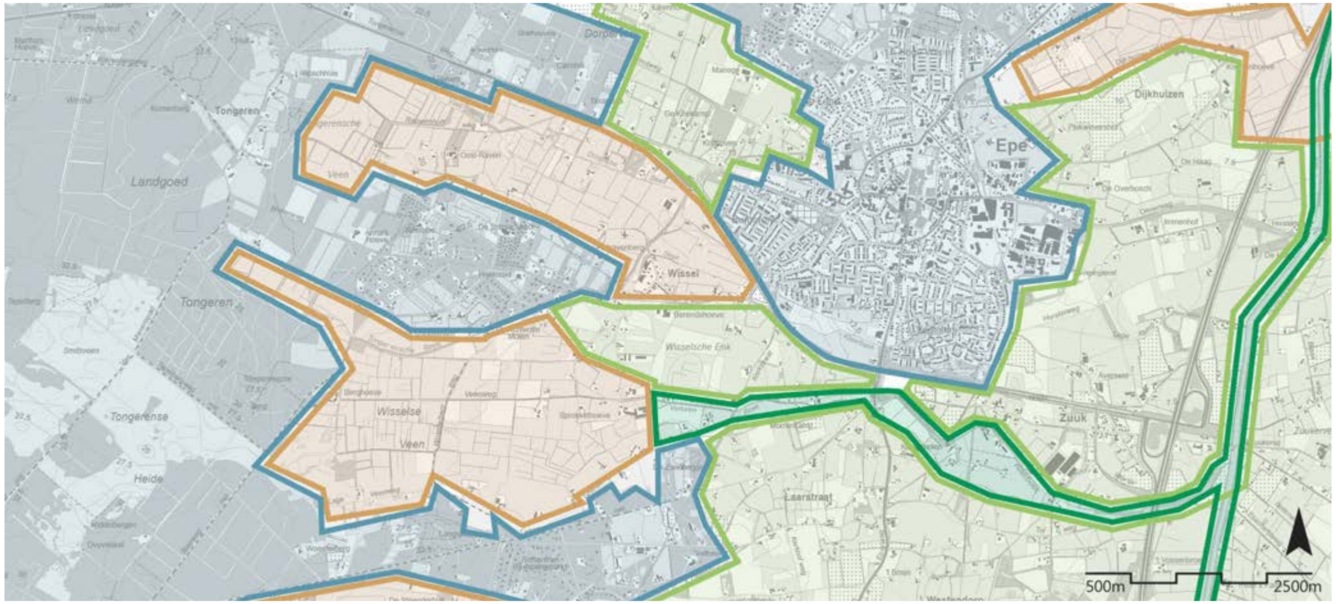

Figure 6.29 Climate Change Adaptation Targets map for the landscape around Epe
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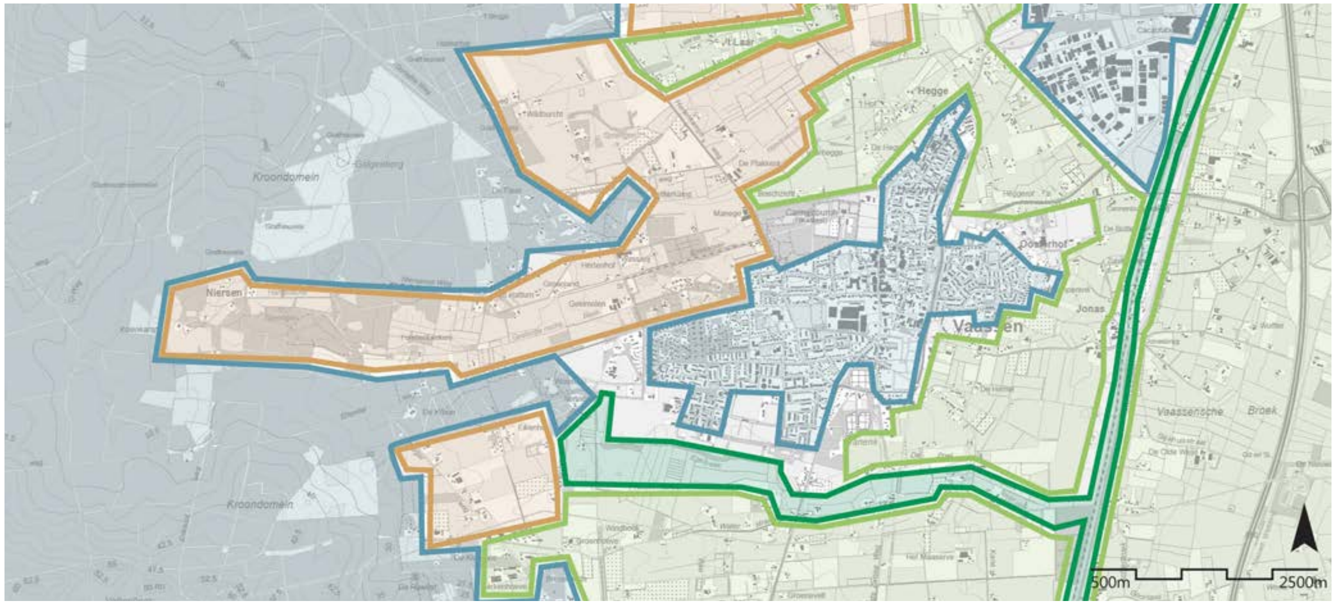

Figure 6.30 Climate Change Adaptation Targets map for the landscape around Vaassen
1:50.000

and more capable of realising those values through landscape management.

small-scale character

legibility

rural enclaves

spatial quality

The 'Blauwe Bron' area on the eastern gradient of the Veluwe is recognizable for its small-scale character that is the result of many centuries of occupation and agricultural activities. The conservation and improvement of spatial structures enhance the legibility and coherence of the typical landscape types. New housing projects are advised to take place on a very small scale, to utilize the local design characteristics and materials and to create additional value through the redevelopment of existing ensembles if possible. Redevelopment of no longer functional farmyards generates attractive and high-quality ensembles of dwellings, thus creating new rural enclaves that contribute to rather than deteriorate spatial quality .

openness

The IJssel valley on the other side of the 'Apeldoorns Kanaal' is the exact opposite, where agricultural production has conceived a more rational shape. The vast openness and large-scale character is emphasized through the application of spatial guidelines as recommended by landscape architecture firm Buro Harro for the landscape vision of Apeldoorn. In the vision, new building is limited or allowed in clusters on the transition to the higher parts, like islands in the open space. Plantation is otherwise only allowed along the main roads and canals ('weteringen'), and in the form of alder hedgerows (de Jong, 2011).

Figure 6.31 Clustered farmyards in the IJssel valley
source: http://www.siebeswart.nl/nieuws/2012/nr-1-beeldessay-in-opdracht/t

Climate change adaptation in the agricultural landscape:
The necessity of a functional shift in and extensification of agricultural activities in the region is even more apparent in the context of climate change, so much has become clear in our exploration of the W+ climate scenario.

The rural landscape of the 'region in balance' provides a wide range of functions that gain societal and economic value in the search for climate change adaptation strategies, and thus can be marked as climate change adaptation services, a specific branch of landscape services. Those climate change adaptation services or 'typologies' consist of a variable mix of adaptation measures that can be hosted by the landscape in question.

rural water retention

Rural water retention is one of those services with a significant role in the 'region in balance', as we propose to integrate climate change adaptation measures with agricultural production and landscape management by farmers. The opportunities and preconditions for implementing an adaptation strategy such as water retention will vary depending on its intended location, thus leading to a set of different types with a varying balance between efficiency and multi-functionality. Retention areas will be designated on the locations that suit best, primarily on the lowest pastures along a stream. Dedicated artificial retention areas will not be very necessary, but especially along the Grift it might be a wise measure since its peak discharges are likely to become more extreme due to the combined discharge of urban area and multiple stream systems. The artificial retention areas, being excavated or surrounded by a small ridge, will serve agricultural or ecological purposes most of the time, so no part of the landscape will be truly mono-functional. Climate change adaptation measures are only taken if ensured that their presence will improve rather than diminish spatial quality, thus contributing to the legibility of the landscape types.

Figure 6.32 Artificial water retention pond

inundation pastures

biomass production

discharge peaks

With the landscape management aimed at multi-functionality, adaptation measures are integrated with landscape services such as agricultural production, ecological development and recreation when possible. The inundation of hay pastures and alder groves for instance, is a form of retention that is based on the centuries old principle of temporal inundation of pastures ('vloeiweiden') for fertilization and irrigation. The stream valley at the 'Tongerense Heide' near Epe still possesses the historical structure of streams related to this principle of inundation, which is utilized once again but this time for water retention purposes primarily. The hayfields serve an agricultural purpose for the production of hay for organic farmers, while the extensive management of alders groves allows for ecological development as well as biomass production. Information panels educate tourists on the principles of inundation and other forms of water retention or landscape management, pointing out the cultural-historical and ecological values that are present.

The secondary main argument of realising new recreational fishing ponds downstream of Vaassen at Oosterhof is that the numerous ponds of the hatchery are designed in such a way that they can provide a backup-buffer for water retention in extreme cases when heavy rainfall entails a discharge peak from Vaassen. The ponds and their banks are slightly lower than their surroundings, thus forming one large basin of approximately 22890 m3 when flooding. Mountable grates will keep the fish in their ponds in such occasions.

Figure 6.33 Water passage to inundation pasture

source: http://www.projectenbankcultuurhistorie.nl/projecten/herstel-vloeiweiden-landgoed-hof-espelo

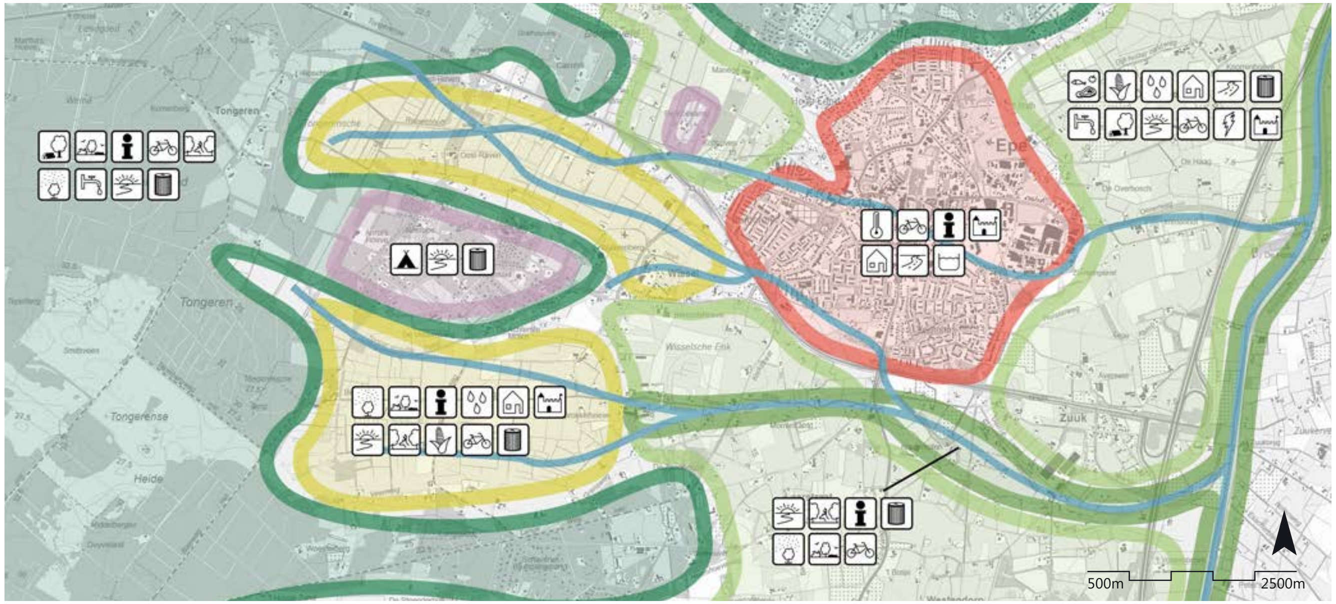

Figure 6.34 Landscape Services map for the landscape around Epe
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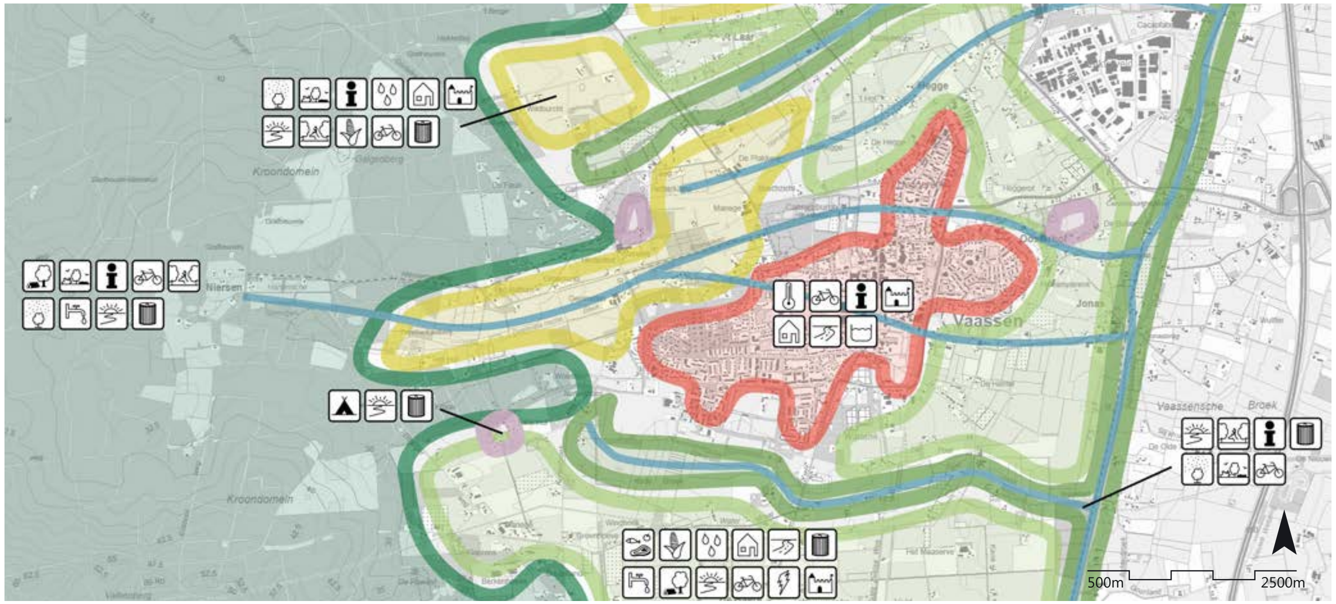

Figure 6.35 Landscape Services map for the landscape around Vaassen
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Recreation, nature & environment

As described before, the outlook of the agricultural landscape is maintained by means of spatial guidelines, thus avoiding spatial deterioration and clutter ('verrommeling'). Characteristic landscape types such as the elevated fields ('enken') are not merely conserved; we suggest actions to expand and strengthen their character. The specific structures that form the landscape types thus provide a strong spatial backbone that is able to support a considerable amount of human activity and defend itself to spatial decline. The stronger spatial structure has enabled the Veluwe landscape to host the changes that the Regional Communities scenario projected while improving overall spatial quality.

spatial backbone

The modes and facilities of extensive recreation in the area are mainly aimed at creating awareness and enabling the experience of the valuable water system among both tourists and residents. The streams are no longer carelessly or humbly tucked away behind fences and hedges, but neither is their presence overly exaggerated or disproportionally emphasized. Simple and clear interventions bring forth their characteristics and make the associated structures visible. Specific designs of bridge railings and elements emphasize the stream 'habitats', unify the stream systems and depict the omnipresence of flowing water throughout the landscape of the 'Blauwe Bron'.

recreational routes

Our advice is to create recreational routes that connect the forests of the Veluwe with the agricultural landscape and the villages, thereby running through all the characteristic landscape types of the area. Cyclists and hikers are guided through the landscape as by an invisible hand, revealing the characteristics and beauty of the landscape. The routes form a network of paths in the rural landscape that connects highlights and characteristic places such as the redeveloped farmyards, enclaves and mills, inspired by the ‘knooperven’ concept.

Dedicated ‘stream paths’ (sprengenpaden) repeatedly follow and cross the course of a stream, running in a west-east direction along the direction of the streams. The paths expose the entire sequence of stream-related typologies and elements to cyclists and hikers and reveal the logic of the landscape. From the artificial sources at the heads of the brooks, along the middle course with its mills and artificial elevations down to the connection with the green-blue corridor of the ‘Grift’ and the ‘Apeldoorns Kanaal’. Information panels and other explanatory elements are present to illustrate both those artifacts and the application of climate change adaptation measures, of which many are linked to the streams.

Figure 6.36 Information panel at nature development project
source: http://www.mooigelderland.nl/index.php?pageID=3281&n=&categoryID=2023

historical structure

The green-blue network of streams moreover has historically been the structure along which other functions have developed. As shown in the analysis of the area, the majority of cultural-historical ensembles such as estates, manors, mills and hamlets are located around or close to the streams. The multiplicity of cultural-historical, climate change adaptation- and water system-related landscape elements are all existing because of, and tied together by the stream systems. The area possesses an array of qualities that need little more than a stronger spatial framework that serves as a showcase.

Figure 6.37 Castle ‘Vosbergen’ near Heerde

attractiveness

Nature development, as we suggest, will bring about the biggest changes in landscape layout, highly contributing to spatial quality and the attractiveness of the rural landscape that it interlaces. Due to developments described in the scenario, space is more easily available in the rural areas, leaving opportunities for a significant development of nature areas. The target is to

increase nature acreage

increase the overall acreage of nature up to 2170 ha, especially by the connection of existing areas, striving for one continuous 'ecological fabric'. The ecological corridor along the 'Grift' follows the entire course of the stream from within the urban centre of Apeldoorn up to the village of Heerde, making it the central ecological north-south axis that connects all the west-east oriented streams. Crossing the 'Grift' are two ecological corridors that extend the east-west connections from the Veluwe down to the IJssel river, which's floodplains are ecologically valuable corridors on a higher scale.

ecological corridors

Apart from its purpose on a higher scale, the green-blue network of the stream valleys is ecologically very valuable by itself as well. The streams, now all robustly connected and no longer polluted, provide an extensive habitat for typical species. The brook lamprey (beekprik), rhine sculpin (beekdonderpad), stone loach (bermpje), the great wagtail (grote gele kwikstaart), the kingfisher (ijsvogel) and a wide range of rare flora are thriving as a result.

extensive habitat

solid frame

The green-blue network provides the streams with a solid frame of vegetation and landscape elements that makes the streams more resilient to negative impacts such as pollution. The network will furthermore enrich the agricultural landscape and the villages on the slopes of the Veluwe, contributing to spatial quality and sense of place.

Climate change adaptation in the natural landscape:

Nature development projects are dependent on appropriate and effective climate change adaptation for their success. Nature management strategies therefore include adaptation strategies so that nature development areas are always host to one or more

Figure 6.38 Stone loach

source: http://anw.inl.nl/article/bermpje?searchtype=desctoword&description=dier%2C+gevlekt%2C+geeft+melk%2C+loeit

Figure 6.39 Kingfisher

source: http://www.kattensite.be/forum/speeltijd/34-ik-wil-foto-van-107.html

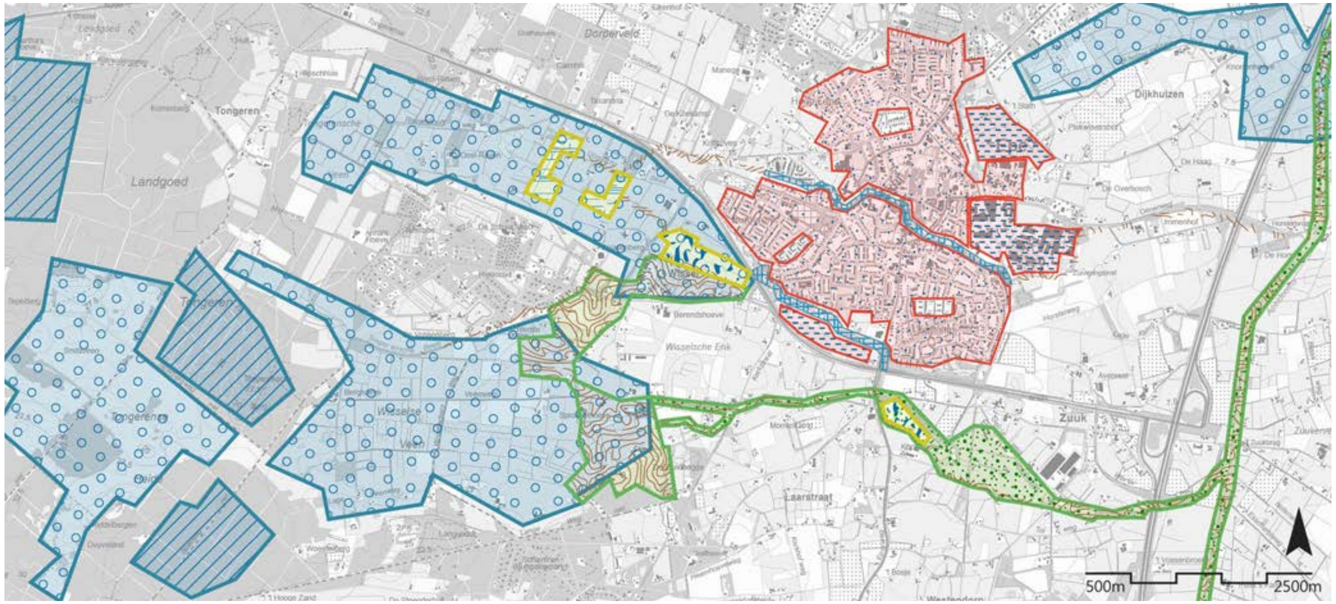

Figure 6.40 Climate Change Adaptation Services map for the landscape around Epe
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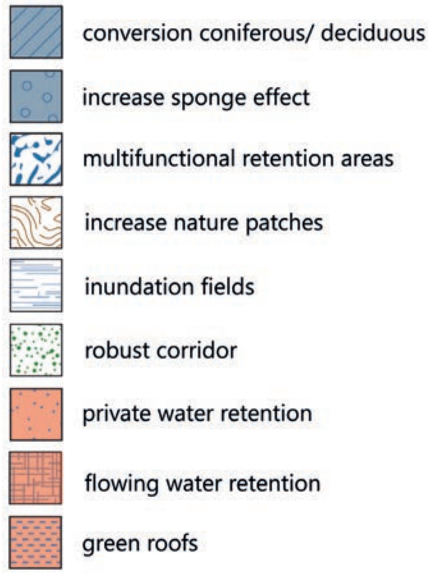


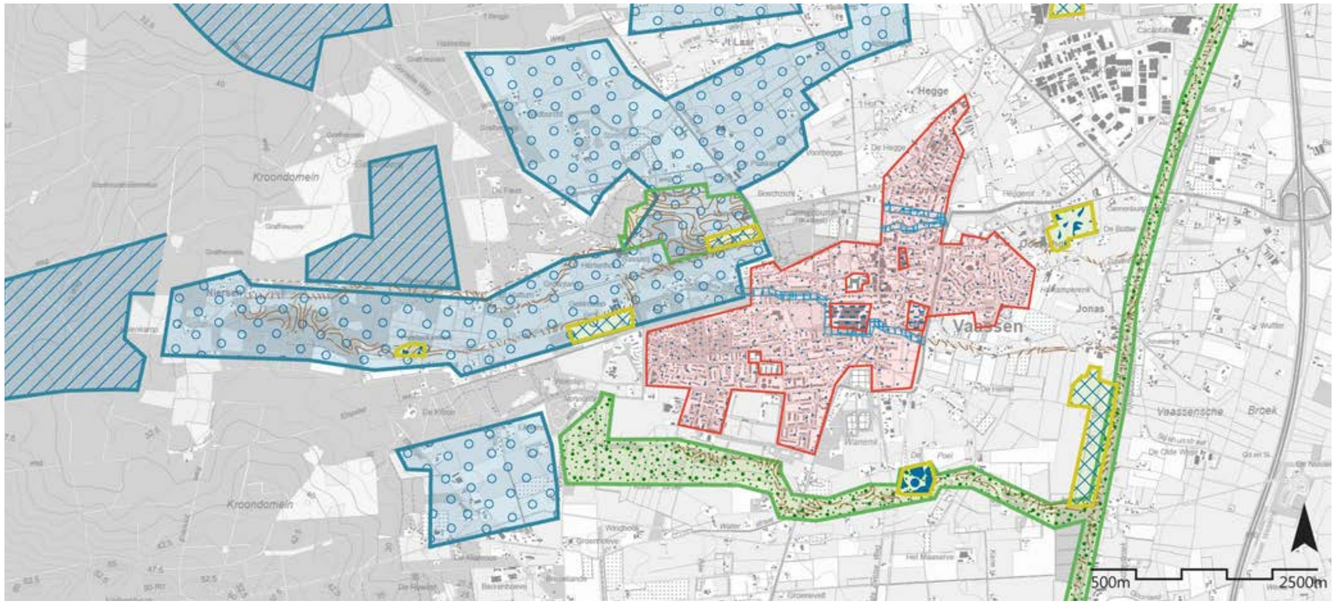


Figure 6.41 Climate Change Adaptation Services map for the landscape around Vaassen
1:50.000

adaptation measures. All strategies are aimed at making the streams and vulnerable nature areas, such as the peat bogs of the Wisselse Veen, climate change robust or, in other words, able to withstand changing climatic conditions.

Patches of nature should be enlarged in order to make them more resilient to external influences and to increase their ecological carrying capacity. Increasing the internal heterogeneity by means of a more differentiated landscape composition, will help to provide a solid and climate change proof home to more species. The nature areas are connected to each other and the overarching ecological context by the green-blue network that is suspended to the stream system, as proposed before. The nature corridors improve the opportunities for migration and thus greatly reduce the risk of ecological fragmentation and local extinction.

green-blue network

Ecological barriers that obstruct migration of aquatic species, such as mills and weirs, are suggested to be removed by the construction of fish ladders. The ecological value and overall 'liveliness' of streams is to be enhanced by the managerial application of 'micromeandering'. This involves a management strategy that tolerates a limited degree of natural fallowing in the streams' course to increase water dynamics and the formation of micro habitats. This includes leaving fallen branches in the water and allowing banks to erode where possible.

fish ladders

micromeandering

Since the population of the area has declined and therefore drinking water consumption has accordingly, there is less functional necessity to abstract water from the Veluwe's soil. However to reverse measures from the past, such as the large-scale afforestation of the Veluwe, and to prevent periodic events of drought, it is important to increase the availability of water in the soil. We suggest to take several adaptation measures to increase

Figure 6.42 The Wisselse Veen peat area

Figure 6.43 Micromeandering in a brook

source: http://www.panoramio.com/map/#lt=52.333556&ln=5.963838&z=0&k=2&a=1&tab=1&pl=all

the water provision to as well as by the soil, or simply formulated to 'soak' the Veluwe like a sponge. This serves to ensure a constant and higher discharge by the streams and to prevent periodical drought stress in areas of nature and agriculture.

forest conversion

One of the most robust climate change adaptation measures that we propose is to convert numerous plots of forest from a largely coniferous to a deciduous plantation to ensure a continuous and therefore reliable increase in ground water recharge. This process of 'verloofing' can be executed rather passively in case of the Regional Communities scenario; the application of specific forest management and a time-bound natural succession will gradually bring about a transition of 1276 ha toward deciduous forest without the need for large investments. Forest management should also deal with the higher risk of forest fires by creating and maintaining fire breaks. Those are lanes of approximately 10 metres wide that divide the forest in smaller patches, delaying fire distribution and making fire fighting easier.

fire breaks

sponge effect

Enhancing the 'sponge effect' is also a climate change adaptation target we propose for the open parts of the Veluwe's slopes, aimed to increase water availability to wet terrestrial nature areas and the areas of extensive agriculture. Ditches and artificial draining are dimensioned smaller and more shallow, so that the soil will retain more water and thus provide a hydrological buffer to nature and agriculture.

Urbanization, infrastructure & energy

The trend of urban shrinkage due to population decline has manifested itself in the demolition of some socially declined neighbourhoods from which the residents had largely already departed. The shrinkage should be seen as an opportunity to boost spatial and residential quality with the development of new public space and urban restructuring.

For instance, the large plot of remediated land that the company VFP has left behind in the centre of Vaassen is restructured to a park, thus providing the village with a green core of over 6 hectares. The stream of the 'Dorpsche Beek' is shifted back to its traditional trajectory, hereby crossing the park diagonally. This puts the stream back into its natural 'habitat', increasing its visibility and attractiveness and thereby its overall amenity value. In the village of Epe, the stream of the 'Dorpsbeek' is suggested to be restored to its old course above ground, thus reconnecting this vital part to the cultural-historical identity of the village. It provides an attractive blue-green ribbon across the urban fabric of Epe, which benefits from the added values for leisure and sense of place. The stream itself will benefit from the operation mostly because it (re)connects to the green-blue network of streams to which it originally belongs.

blue-green ribbon

Despite the fact that mobility and traffic intensity haven't increased, efforts should be made to minimize the obstruction that large infrastructure poses to ecological networks and migratability. The two ecological corridors toward the IJssel river leap the barrier of the highway A50 by means of ecopassages. We also advise the government and nature organizations to equip the highway and the main secondary roads with 'silent asphalt' to reduce sound nuisance and ecological disturbance. A number

ecopassages

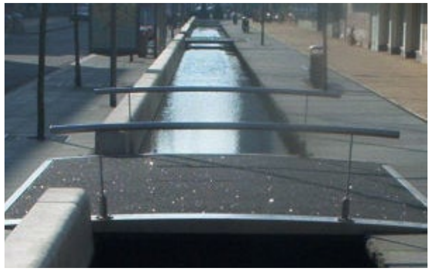


Figure 6.44 Urban stream: the 'Grift' in the centre of Apeldoorn
source: http://forum.fok.nl/topicchain/780

of roads crossing the green-blue corridors should moreover be equipped with green coloured LED lighting, which is energy-efficient and does not disturb nocturnal wildlife.

While this study only focuses on the application of climate change adaptation strategies, it is interesting to explore briefly what the opportunities for climate change mitigation might be. The following notions regarding the generation of renewable energy are therefore more speculative but no less conceivable. Sustainable energy provision, meaning the use of energy from renewable sources, is subject to certain European directives and targets that are imposed on the Netherlands, as mentioned in the scenario.

climate change mitigation

sutainable energy provision

wind turbines

Three 6 MW wind turbines at the designated site near the village of Terwolde can be incorporated in the landscape with the application of new notions in landscape architecture aesthetics, supported by the society-wide ambition for sustainability. The turbines can provide a visual beacon for the region and emphasize the open, large-scale character of the IJssel valley without posing much visual disturbance to the more enclosed area westerly of the highway A50. Besides the financial support for energy-saving measures, local governments can also stimulate the investment in highly efficient PV panels by companies and individuals. Especially the large agricultural buildings and warehouses are therefore fitted with solar (PV) panels in our vision, providing both cheap electricity to the net as well as an additional income to the farmers.

Figure 6.45 Wind turbines in the agricultural landscape
source: http://zoom.nl/foto/663318/landschap/koeien-en-windmolens.html

PV panels

The multifunctional retention areas, the inundable meadows ('vloeiweiden') and alder groves not only provide water retention capacity but also produce a significant quantity of region-specific biomass, mostly short-rotation coppices and wood. Leftover timber and prunings from the Veluwe's forests is

biomass

on hand in large quantities, providing another sizeable source of biomass. These products are valuable resources for the generation of renewable energy. The foresee the ‘Blauwe Bron’ region to have its own biomass energy plant to utilize its resources, located at the sewage treatment plant of Apeldoorn. Here the biomass is fermented together with the sludge residue from sewage, making the sewage treatment process produce rather than consume energy, through the application of principles of the ‘energy factory’ concept (www.energiefabriek.com, 2012).


Figure 6.46 Biomass energy plant
source: http://www.djc.com/news/en/12014737.html

Climate change adaptation in the urban landscape:
The ‘central park’ that enriches the urban fabric of Vaassen and the other vacant green spaces in the villages provide valuable opportunities for climate change adaptation measures of the typology ‘urban water retention & infiltration’. The abundance of public space allows for dedicated infiltration measures, avoiding the necessity for sub-optimal combinations with public services. Alongside streets and parks there are dedicated infiltration zones consisting of wadi’s, ponds and infiltration gutters that hold and infiltrate water that is gathered through runoff from paved surfaces.

dedicated measures

In densely built up areas such as the centre of Epe, the banks of the streams are constructed slightly beneath ground level to reserve space for increased maximum discharge capacity. Heavy rainfall might cause sudden peaks in surface runoff that otherwise would overload sewers and public space. The measure of ‘flowing water retention’ allows the stream to hold and drain more water, smoothening those peaks. Besides these rare events, the lowered banks increase the degree of human interaction with the water and contribute to the sense of place and urban spatial quality.

surface runoff


Figure 6.47 ‘Wadi’ as urban infiltration area
source: http://www.water-in-zicht.nl/projecten/kronsberg-hannover


Figure 6.48 ‘Wadi’ as urban infiltration area
source: http://www.water-in-zicht.nl/projecten/kronsberg-hannover

municipal stimulation

urban microclimate

Other possible water retention measures are of a small scale but have significant implications thanks to their possibilities of extensive application. Those are socially rooted measures realised through municipal stimulation such as subsidies and refitting programmes. As a result of such measures, many houses and gardens are accommodated with rainwater barrels and/or small wadi's that buffer rainfall peaks and disburden the otherwise overloaded sewer system. Many newer houses and larger buildings have been fitted with green roofs, which asides from water buffering also contribute to energy efficiency, ecological values and a pleasant urban microclimate.

Figure 6.49 Rain water barrel as private water buffer
source: http://www.ikleefmetwater.nl/de-regenton_11_33.html

6.4 Comparison of regional visions

multifunctional clusters

green-blue networks

The ‘Region of Benefits’ vision is characterized by multifunctional clusters existing of nature development areas and recreation facilities in which climate change adaptation measures have been integrated. These clusters are located at specific places along the streams, while the ‘Region in Balance’ vision is characterized by multiple green-blue networks that follow the streams from Veluwe to IJssel valley. In the ‘Region of Benefits’ nature areas are present, but condense, while in the ‘Region in Balance’ the networks are broad and intertwined. The networks have an integrated recreational network that leads people from stream source to the ‘Grift’, which is in contrast to the recreational hotspots that are located inside the multifunctional clusters.

Both visions show an increase in the conversion of coniferous to deciduous forest. This is however much more present in the ‘Region of Benefits’ vision, which is necessary due to a higher demand for high quality water for both consumption as well as agricultural use. The villages grow in the ‘Region of Benefits’ vision, while the villages in the ‘Region in Balance’ shrink, which translates to the differences in the demand for space and water, as stated in chapter 6. A last clear difference between the regional designs is the growth of new estates in the ‘Region of Benefits’ vision in contrary to the small-scale housing development at residential farmyards in the ‘Region in Balance’ vision.

Region of Benefits

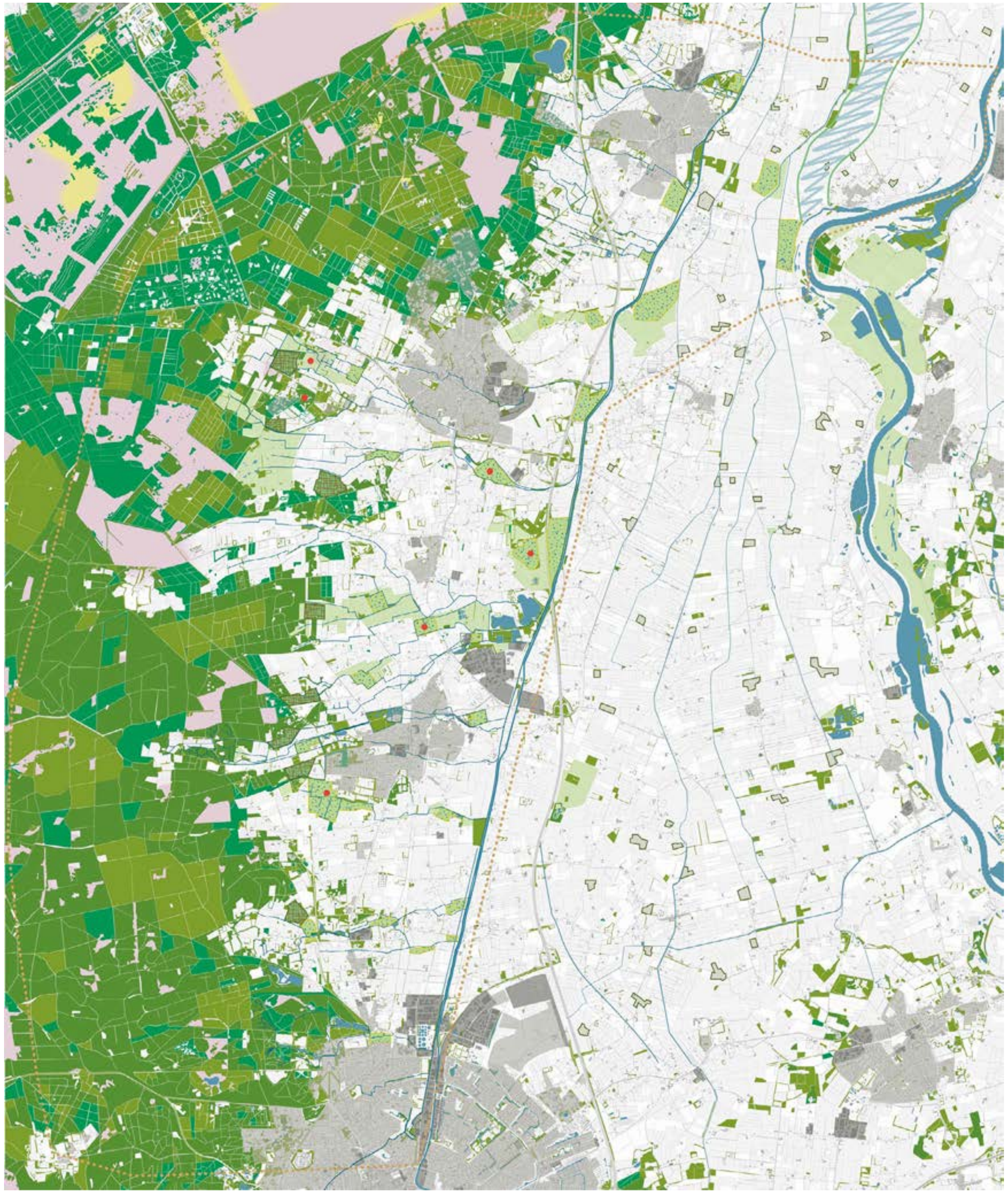


Figure 6.50 Vision map of the 'Region of Benefits' 1:125.000

Region in Balance

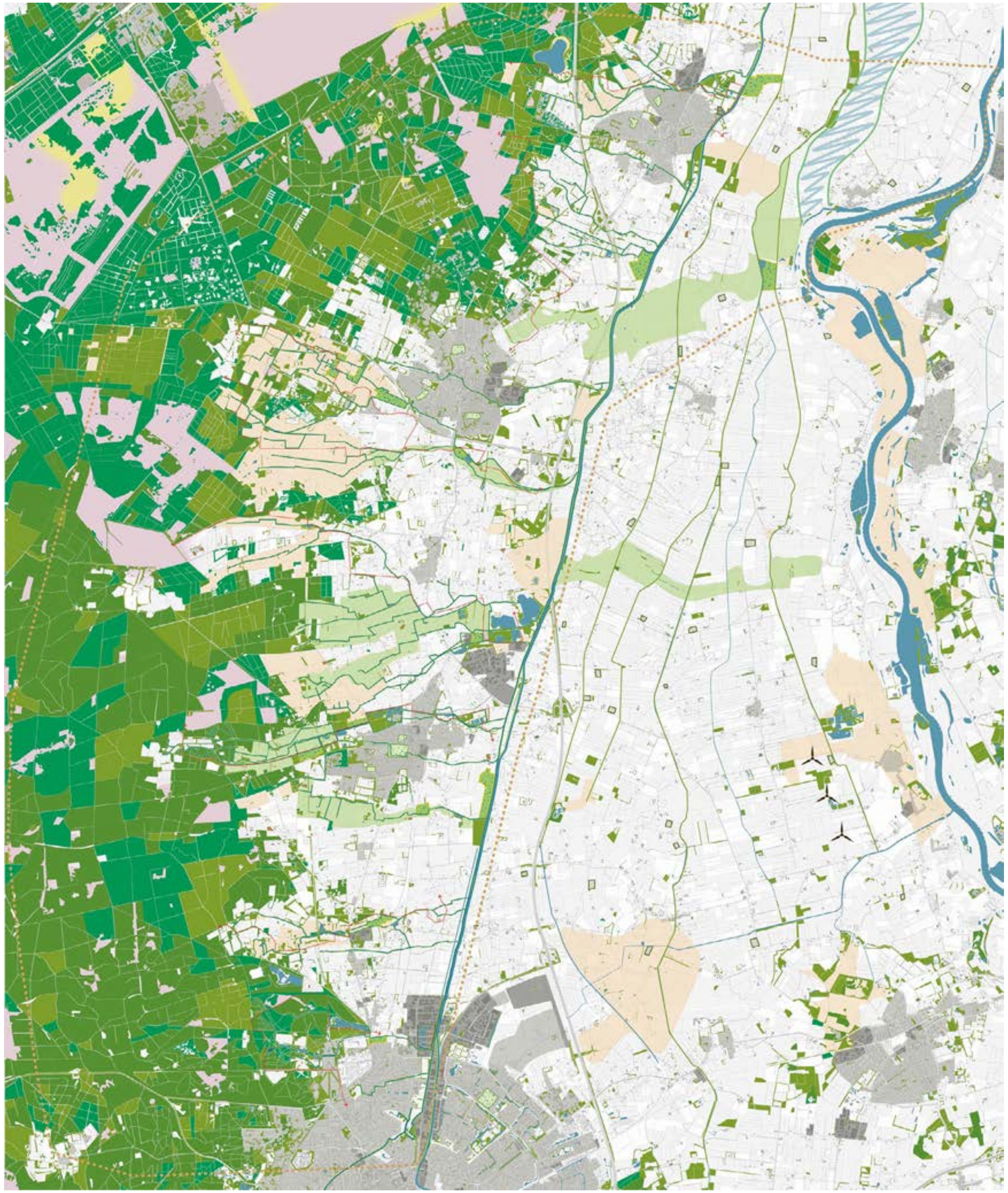


Figure 6.51 Vision map of the 'Region in Balance' 1:125.000

6.5 Comparative analysis of visions

Vision robustness assessment

future proof

degree of overlap

'no regret' measures

To determine which of the visions and adaptation strategies are the most robust, or in other words future proof, we performed a comparative analysis. It is however difficult to do so in an elaborate and scientific way since the visions are developed for two totally different socio-economic scenarios, thereby slightly making it a matter of 'comparing apples and pears'. Secondly, our visions are propositional designs of how we suggest that the 'Blauwe Bron' area should cope with climate change and look like. Our analysis is therefore not comparable to, for instance, a qualitative conflict analysis or a full-fledged economic valuation of currently provided landscape services.

We nevertheless made a comparison that provides some insight in how a range of climate change adaptation services is applied in the two visions, and to what degree they overlap. The real value of those services is namely where they overlap; that indicates how much the implementation of these services can be seen as robust 'no regret' measures. "'No regret' decisions based on the 'precautionary principle' appear preferable. Actions to reduce the impact of other threats, such as habitat fragmentation or destruction, pollution and introduction of alien species, are very likely to enhance resilience to climate change" (e.g., Goklany, 1998; Inkley et al., 2004; Opdam & Wascher, 2004. in: Fischlin et al., 2007, p. 246). To accommodate this comparison, we made a selection of the climate change adaptation services from the four biggest adaptation typologies that are advised to be implemented in both visions, with the exception of the vision-specific measures 'ecological clusters' and 'ecological corridors'.

estimation of potential

robustness

In table 6.3 we see twelve climate change adaptation services, three from each of the major climate change adaptation typologies: rural water retention, urban water retention, water availability and ecological robustness. The third and fourth column show the 'factor of implementation' ; a normative indication on a scale from 0 to 5 that shows to what degree the climate change adaptation services are utilized by both visions. This degree is based on an estimation of its potential in the light of the limitations and opportunities posed by the scenarios and the propositions we made in the visions. The 'mean factor of implementation' is the average of the implementation factors of the two visions together, which is a rough indication of the robustness of the twelve services on a scale from 0 to 5. The higher this number, the more the corresponding adaptation service can be robustly implemented regardless which scenario unfolds in the coming decades.

Table 6.3 Normative assessment of robustness of climate change adaptation measures/services

typology	c.c.a. measure	Region of Benefits factor of implementation	Region in Balance factor of implementation	service robustness, average degree of implementation	Region of Benefits robustness score	Region in Balance robustness score
1.1	artificial water buffers	2	4	3	6	12
1.2	natural water buffers	1	1	1	1	1
1.4	multifunctional water buffers	3	2	2.5	7.5	5
2.3	private water retention	2	5	3.5	7	17.5
2.4	green roofs	4	3	3.5	14	10.5
2.5	flowing water retention	1	4	2.5	2.5	10
3.1	increasing sponge effect	3	5	4	12	20
3.2	forest conversion	4	3	3.5	14	10.5
3.3	ASR	3	1	2	6	2
4.2	micromeandering	1	4	2.5	2.5	10
4.4	ecological clusters	5	0	2.5	12.5	0
4.5	ecological corridors	0	5	2.5	0	12.5
				TOTAL SCORE:	**85**	**111**

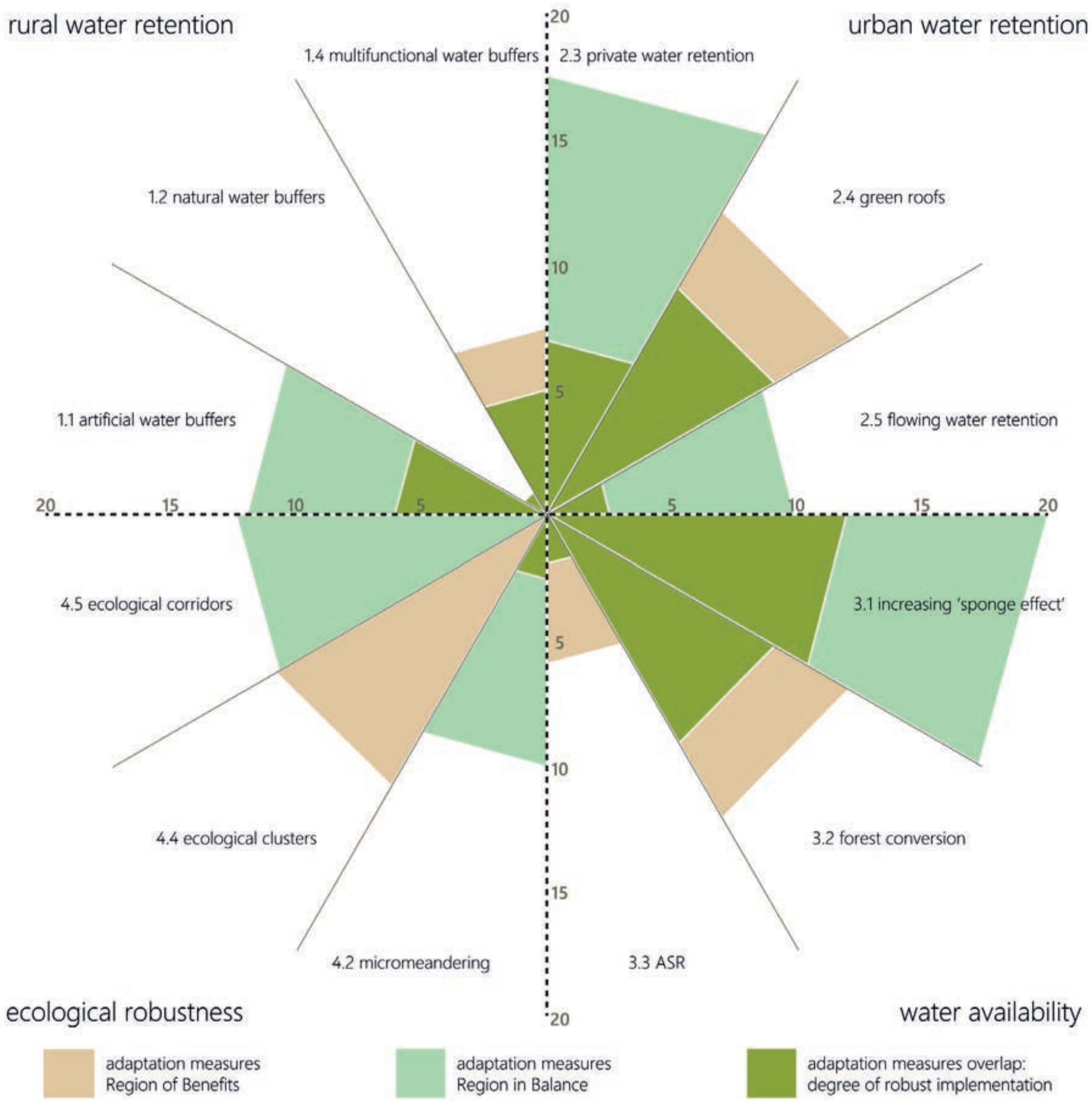


Figure 6.52 Robustness assessment diagram of twelve adaptation services in two visions. The dark green surfaces where the services are implemented in both visions; a measure for robustness

robustness score

When we multiply the 'factors of implementation' with the 'service robustness', we acquire a value that gives the services with the most potential a higher rating. This reveals per vision the degree to which any climate change adaptation service contributes to the vision's robustness, as well as the total 'robustness score' of both visions. The robustness score of each service is graphically represented in the diagram of figure 6.52. This shows how the two visions distinguish themselves with a different mix of services, but also clearly reveals the degree to which the services can be called 'robust'.

normative estimation

insights

development of a scientific method

The method of comparative analysis above does not rests on scientific theory. The reason for that is twofold. Most importantly, as mentioned before, our analysis concerns the assessment of a future and fictional situation, on which basis an elaborate or measurable comparison cannot be made. Performing such an analysis moreover does not fit with the means, time and knowledge at our disposal. Within the scope of our study, this comparison is based on normative estimation in order to serve two goals. For this study it is primarily done to make insightful to what extent the visions overlap when it comes to implemented climate change adaptation services, and what that reveals about 'robustness'. Secondly, we think that it reveals that the above evaluation method is not (yet) suitable to be used for application outside the academic domain. We therefore want to emphasize that it might be a valuable topic of future research that can lead to a scientific and/or quantitative method to determine the 'robustness score' of climate change adaptation strategies. Especially in economic uncertain times, carefully choosing only the most robust and thus cost-effective climate change adaptation strategies is a must.

spatial design 7

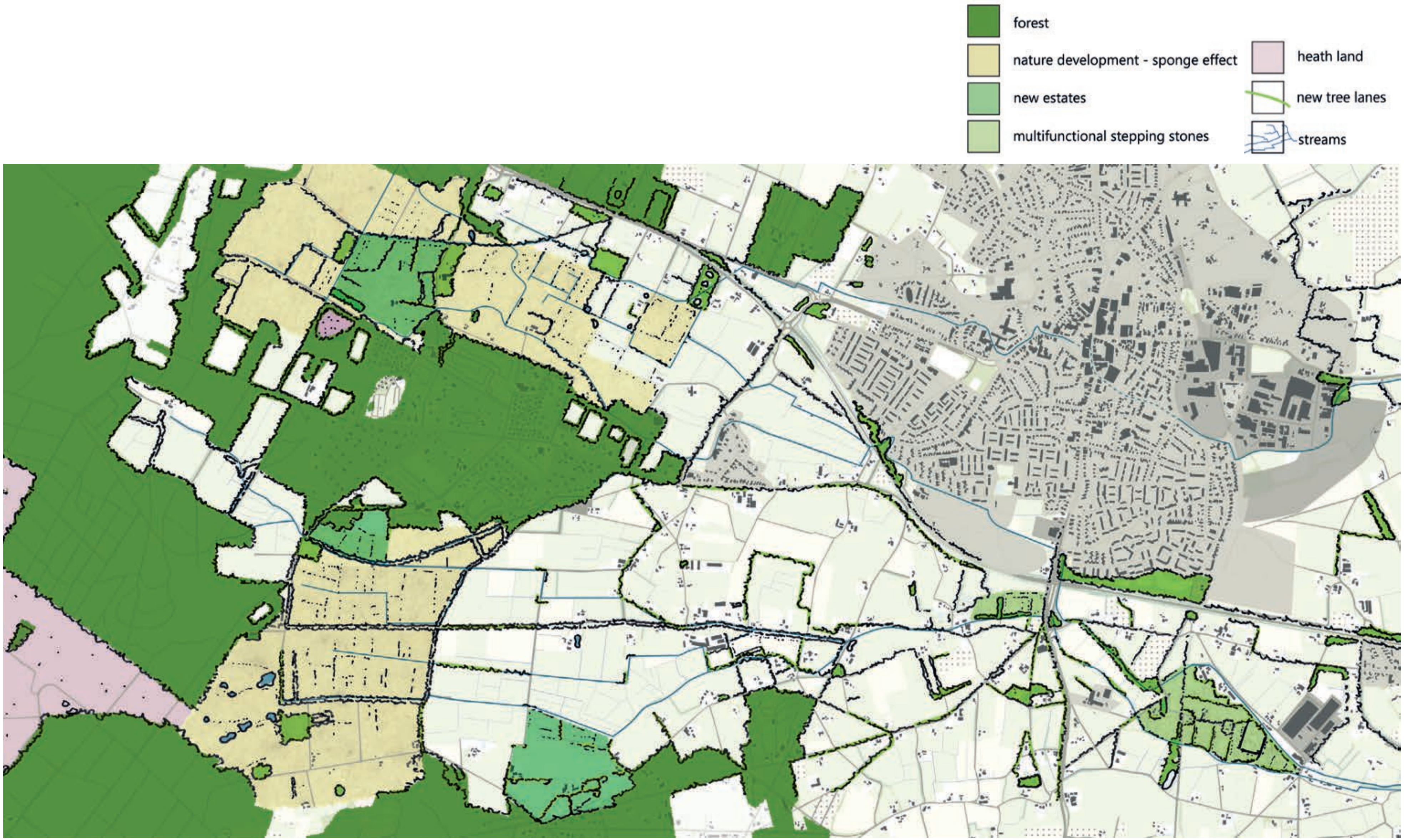


Figure 7.1 Landscape plan of Epe in the 'Region of Benefits'
1:125.000

7.1 Comparison: Landscape plans

spatial interventions

landscape plans

At the end of chapter 6 we described and visualized our two visions, Region of Benefits and Region in Balance, which resulted from the two scenario studies Global Economy and Regional Communities described in chapter 5. The spatial interventions that we propose and described heretofore for the 'Blauwe Bron' area are visualized in more detail by the landscape plans and the detailed designs in this chapter. Two landscape plans were made for each vision to illustrate our proposed spatial interventions along two stream sequences; one near Epe and one near Vaassen. A comparison was made to identify their differences and similarities. For the local designs we worked out two upstream sites for the Region of Benefits vision and two downstream sites for the Region in Balance vision. We made the choice to work out these sites due to their potential and our own preferences. Each design illustrates a characteristic combination of spatial interventions and climate change adaptation measures.

gradients

clusters

Epe - Region of Benefits

In the upstream region of Epe new estates are located along the gradients of the Veluwe on the transition from the Veluwe forests to the stream valleys. These locations, which have clear views over the open and lower lying stream valleys, offer transition gradients in the landscape with on the higher parts the new or restructured villa's and lower down the slope nature development areas. The water retention capacity of the peat lands 'Wisselse veen' and 'Tongerense veen' is enlarged with the stimulation of the 'sponge effect'. The development of multifunctional clusters upstream as well as downstream are strengthened with the improvement of landscape type characteristics such as the restoration of old, fragmented tree lanes. Clusters of nature development, which lie within a landscape of large scale hay production, provide ecological stepping stones and recreational hotspots. Together the clusters create the image of a patchwork landscape.

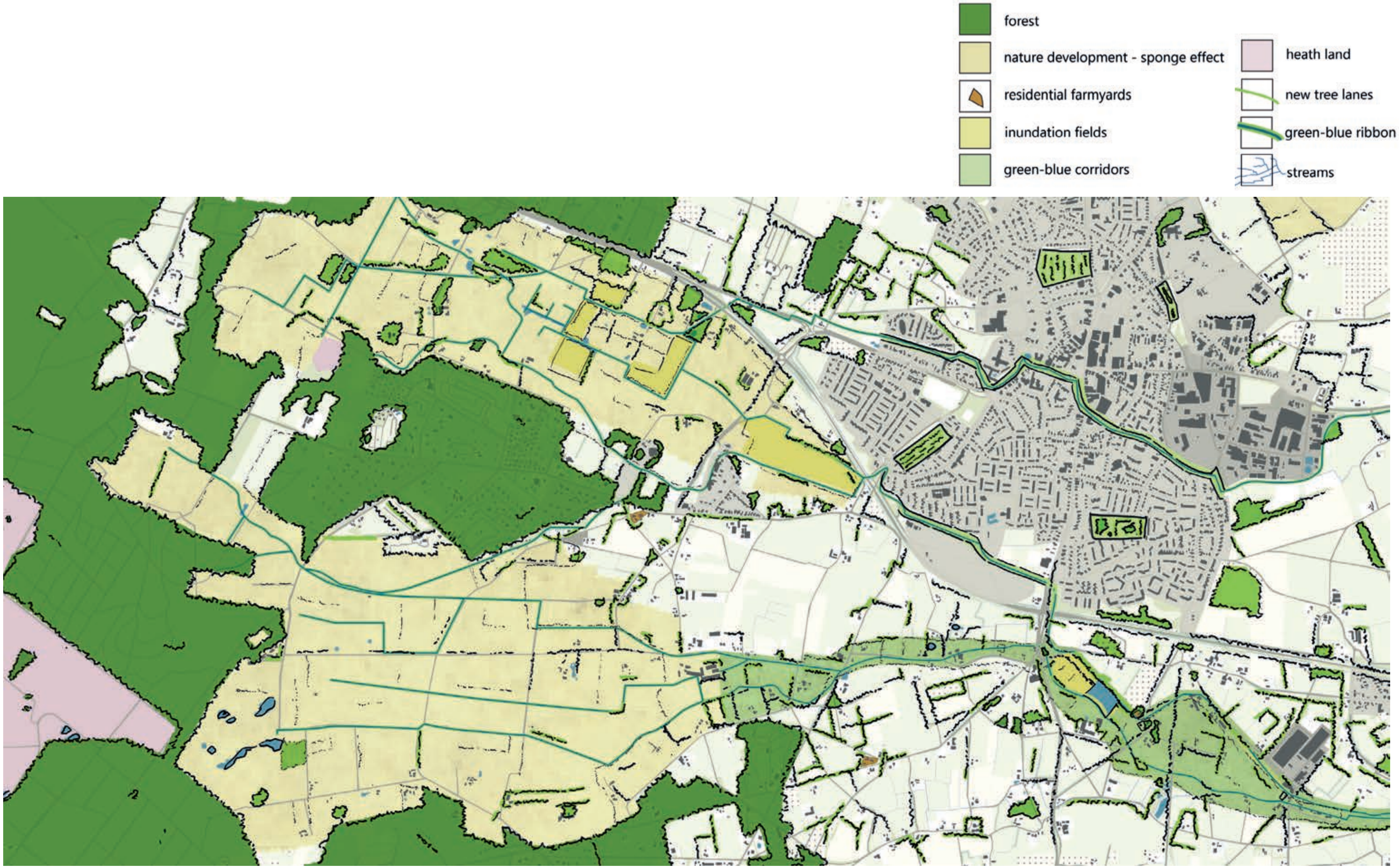


Figure 7.2 Landscape plan of Epe in the 'Region in Balance'
1:125.000

Epe - Region in Balance

The upstream region of Epe is in use for organic farming, which is combined with recreational and ecological functions. Nature development is stimulated in the peat lands and along the streams, while the connection of the Veluwe with the IJssel valley is made by ecological corridors and recreational routes, which are clearly visible. Nature areas have been enlarged along the streams, which strengthens the quality as well as the robustness of the network landscape. 'Residential farmyards' are scatterd over the landscape and provide high quality rural dwellings and new means of landscape management. Vacant places in the villages have been restructured into park landscapes in which the streams are visible and where peaks of precipitation can infiltrate, which is even more strengthened by flowing water retention along the streams in the village.

ecological corridors

residential farmyards

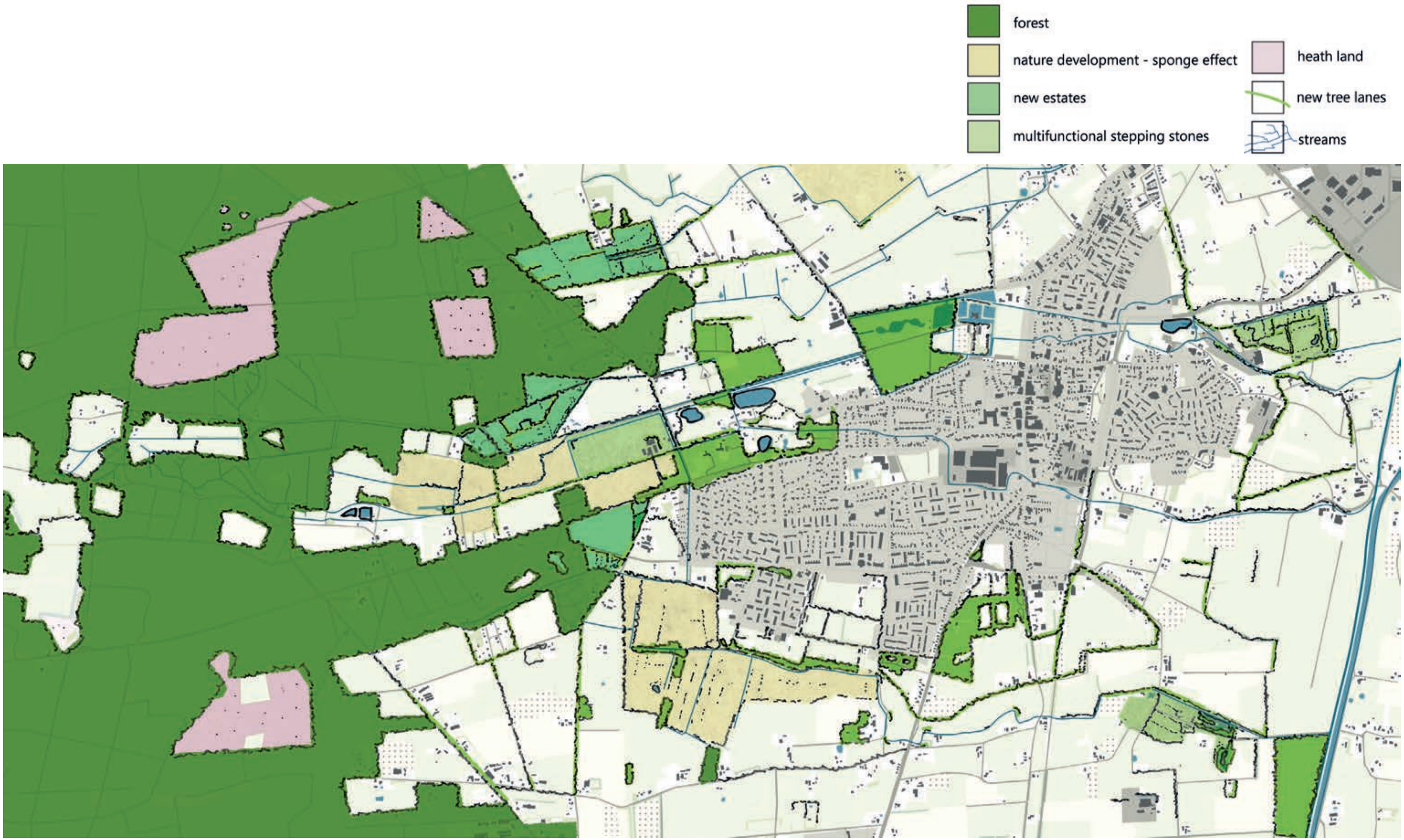


Figure 7.3 Landscape plan of Vaassen in the 'Region of Benefits'
1:125.000

Vaassen - Region of Benefits

The narrow stream valley in the upstream region of Vaassen is characterized by estates on the edges and hay pastures in the lower parts of the valley. Along these pastures some plots are reserved for nature development that enhance the water retention capacity of the soil. Nature development areas in the lowest parts of the landscape, where seepage emerges, are improved with recreational utilities to improve their amenity such as the peat land 'Korte Broek'. In these areas the 'sponge effect' is enhanced to improve their water retention capacity. The edges of the different landscape types are strengthened to enhance the contrast between for instance the stream valley and elevated, arable fields. Multifunctional clusters of nature development in the lower lying plains offer a collaboration of recreational and ecological functions, which contribute to the amenity value of the area and increases its resilience to the effects of climate change.

amenity

resilience

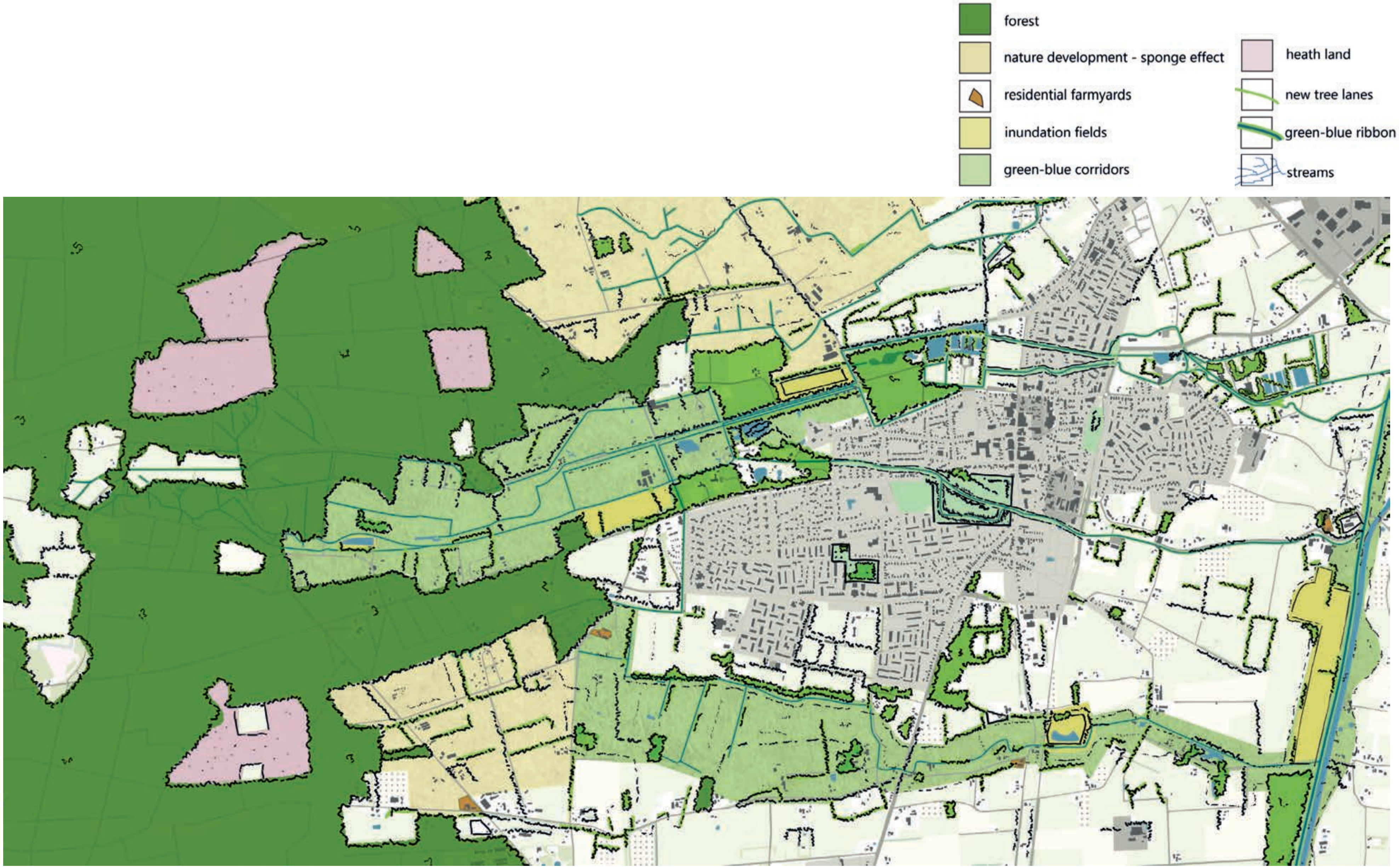


Figure 7.4 Landscape plan of Vaassen in the 'Region in Balance'
1:125.000

Vaassen - Region in Balance

organic farming

park landscape

In the stream valley west of Vaassen nature development is stimulated for both ecological and recreational purposes. New residential farmyards, linked to rural roads, enrich the landscape with fitting architecture and strengthen spatial structures. Organic farming in combination with recreational uses is applied on the arable plots north and south of the stream valley characterized by specific landscape types, while the connections between the Veluwe, nature development areas and organic farmyards are made by ecological corridors that lead from east to west. In the east these corridors are connected with the nature development areas along the Grift, from which the corridors lead to the IJssel. In the centre of Vaassen a large plot of remediated land, which was formerly owned by the company VFP, is restructured into a park landscape hereby creating a green core inside the village. The displacement of the fish hatchery to the east side of Vaassen improves the quality of the streams in the upstream area.

Figure 7.5 Bird's eye view of the 'Region of Benefits' landscape west of Vaassen. The productive landscape is visible in the many hay fields that are used intensively. Besides agricultural use there is place for multifunctional clusters with nature development, and scattered 'new estates'

Figure 7.6 Bird's eye view of the 'Region in Balance' landscape west of Vaassen. The beautifully intact stream valley is an important link in the region's green-blue network, rich of historical and ecological values. The landscape has a small-scale and diverse appearance, a nice setting for the scattered residential farmyards

7.2 Detailed design: Estate 'Vossenberg'

Figure 7.7 Detailed design of the new estate 'Vossenberg' and its surroundings, west of Epe
1:5000

rich and integrative

The essence of new estates is quoted nicely by Erik de Jong: "The idea of new estates is excellent when it comes to the improvement of the sometimes bleak agricultural mono-culture in landscapes, because their typology is rich and integrative in character" (translated from: Erik A. de Jong in Derckx et al., 2010, p.17).

Along the slope of the Veluwe forest multiple estates of different sizes are developed as mentioned in the vision Region of Benefits. One of these estates is located west of Epe near the estate 'Tongeren' on a gradient, which was created by fluvial sand deposits in the Pleistocene. The estate is developed as ecological stepping stone and strengthened in quality by the stimulation of the sponge effect and micro-meandering. The north and south side are enclosed by the peat lands 'Wisselse veen' and 'Tongerense veen'. The estate of 7,5 acres is positioned on a gentle slope and offers a beautiful panorama view along the slope towards the stream valley in the south with one beautiful oak tree in the middle. Its south border, which divides the estate from the peat land, is shaped by the elevated stream called 'Tongerense Beek', which powered the water mill 'Achterste Molen' in the past.

panorama

The estate accommodates one villa of allure and two subordinate villas, a new planted oak forest, oak lanes along the access roads, a horse pasture, plots for hay production, a nature development area and hiking trails. Ten percent of the estate is private property, while 90 percent is open to the public (Derckx et al., 2010).

open to public

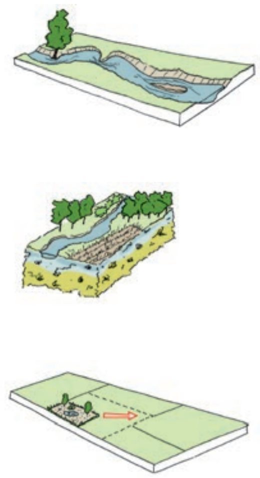


Figure 7.8 Applied mix of site-specific climate change adaptation measures

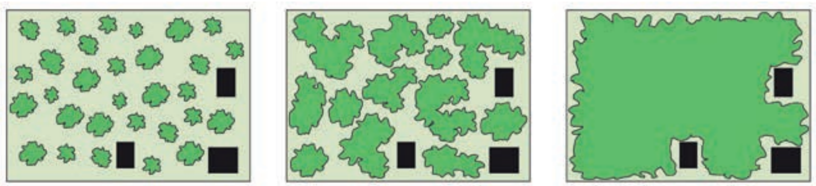


Figure 7.9 Succession stages of the multi-trunk forest at the new estate

Main elements

The forest
In 1850 a large part of the estate was planted with forest, which has disappeared over time due to wood production. One beautiful oak tree was all that remained. The highest grounds on the estate, which were part of the old forest are planted with oak in which the new villas are positioned. This forest is designed to show a development through time in which the phenomenon of the multi-trunk solitary tree is introduced. Four to five small oak trees are planted close together, which will grow over time into one big solitary oak tree. A forest existing of multi-trunk solitaries is more robust than normal forests (H+N+S landschapsarchitecten, 2012). The new oak forest offers a refuge for migrating species, who can take shelter on the estate for a while. All three villas, which are hidden in the edges of the forest, have a clear view towards the stream valley and are built in the style of local houses.

robust forest

The gradient
The highest open part of the gradient of the estate consist of a horse pasture enclosed by a chestnut fence, while the lower parts along the elevated stream are divided in plots for both hay production and nature development. The harvesting of the hay is a seasonal activity and happens once or twice per year. The rest of the year the hay plots are covered in grasses and flowers, which can be used for smaller types of wildlife. The other plots are used for nature development, which will gradually expand from the lower parts to the higher parts of the plots. The increase of grass species and shrubs along the edge of the stream improves the water retention capacity of this soil. More vegetation types

hay fields

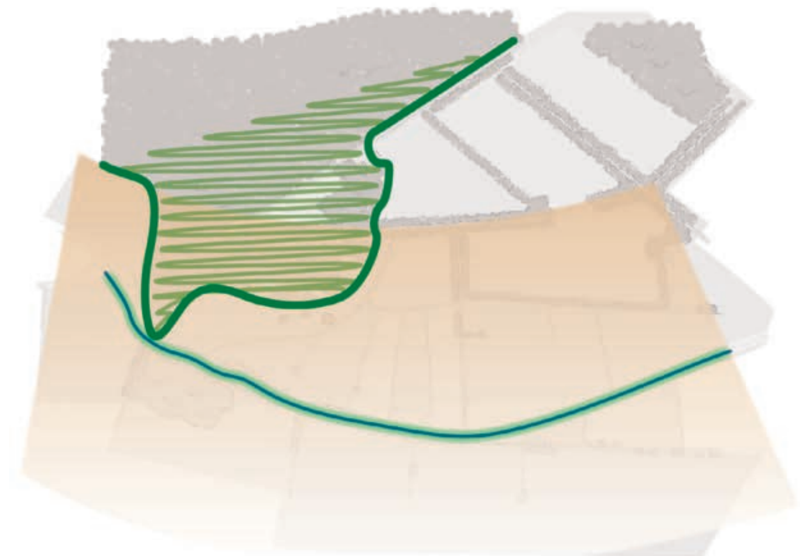


Figure 7.10 The main elements of the design: the forest, the gradient from forest to valley and the 'Tongerense Beek' stream [no scale]

hiking trails

micromeandering

peat lands

means more roots that can hold water. The contrast between the nature and hay plots offers a nice variety on the estate and shows recreants what will happen when nature takes its course. Along the plots hiking trails connect the estate with the surrounding network of paths of which one is shaped by a so-called 'Haha', which is a deepened path that is invisible for the residents.

The 'Tongerense Beek'
The elevated stream, that is covered in alder, shapes the southern border of the estate and guides human vision along the stream towards the lower lying hay lands in the east as a result of a slight deflection of the stream. Micro-meandering in the stream is stimulated by a less intensive management, which results in the development of micro habitats around for instance fallen branches. One slightly raised path at the edge of the stream leads the visitors along the 'Tongerense Beek', who can cross it at the south east corner of the estate with use of a small bridge, which accentuates the height of the stream, and connects the estate with the southern peat lands.

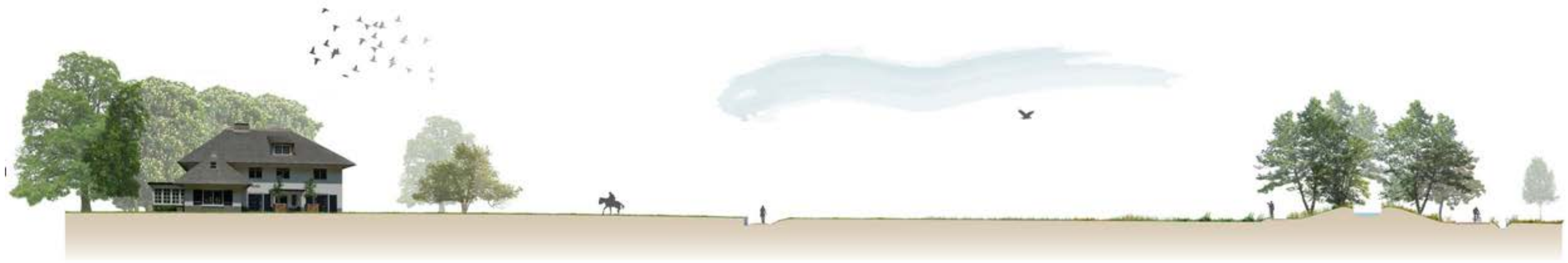


Figure 7.11 Section of the gradient of the meadows near 'Vossenberg' 1:750

Figure 7.12 Impression of the new estate 'Vossenberg' between forest edge and the 'Tongerense Beek'

7.3 Detailed design: Nature area 'Korte Broek'

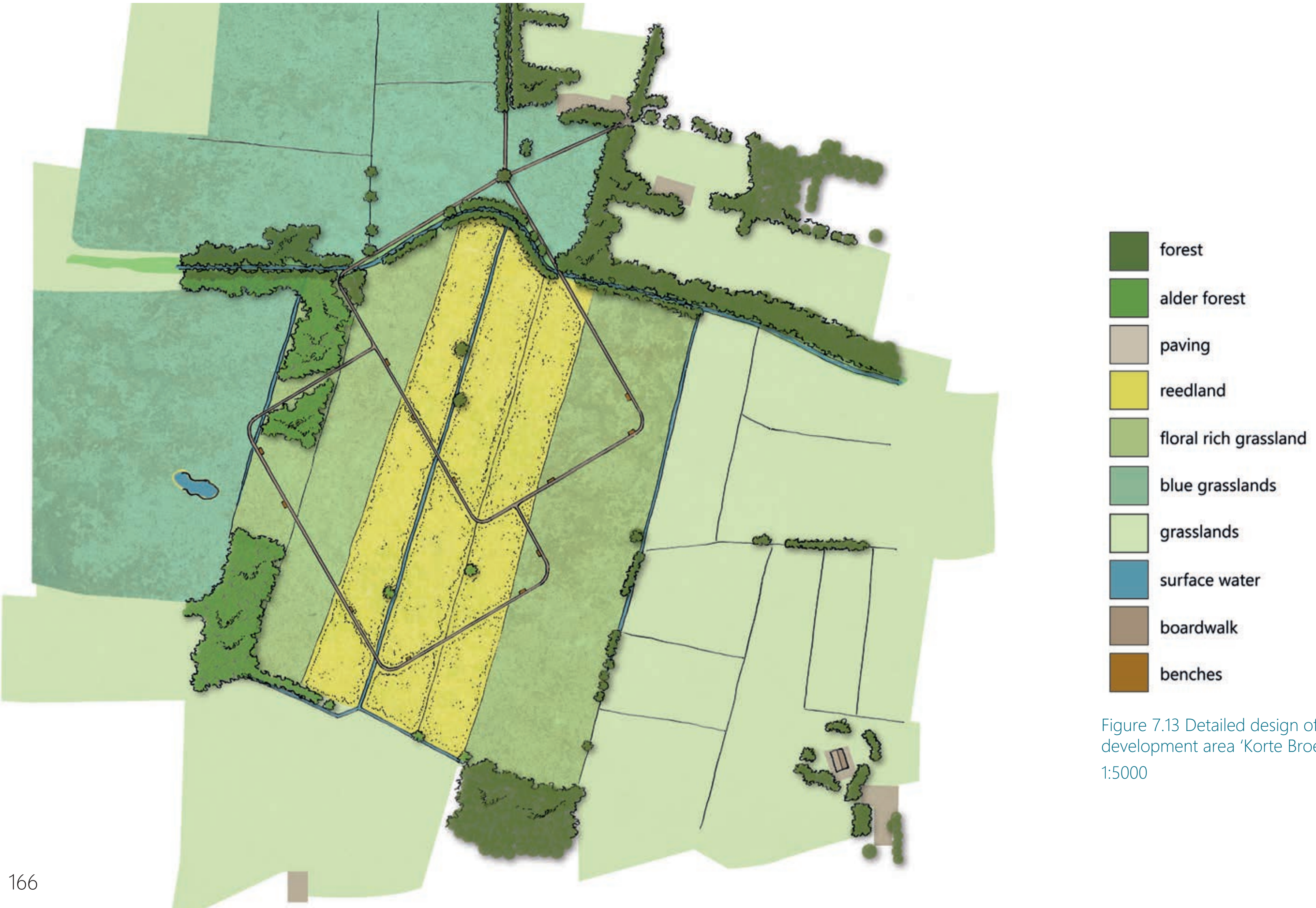


Figure 7.13 Detailed design of the nature development area 'Korte Broek', south of Vaassen
1:5000

nature development

seepage

sponge effect

succesional stages

Along the south west corner of the village of Vaassen lies a low-lying nature development area of approximately 48 acres in which the climate change adaptation measures multifunctional retention areas, micro-meandering , the sponge effect and ecological stepping stone have been integrated. It is one of the larger areas where seepage emerges of high quality water and offers wet conditions for the development of wet nature types, which makes this area ideal for the stimulation of the sponge effect and as ecological stepping stone.

The area lies approximately five meters below the sub urban areas of Vaassen and is the birth place of the seepage stream ('kwelbeek') the 'Egelbeek'. The stimulation of micro-meandering increases its natural character. The 'Korte Broek' area was used in the past for hay production and was for this reason drained. The plot directions of its agricultural past are still visible in the landscape. The landscape of 'Korte Broek' is improved by the development of an old meander and is made accessible for recreants by the development of a path structure. Nature types on the former agricultural plots develop in different stages over time, which results in a more divers landscape and a multifunctional retention area.

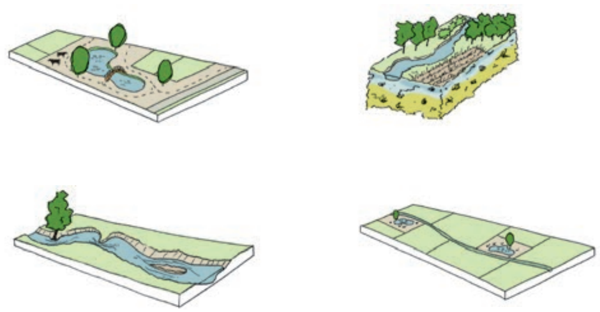


Figure 7.14 Applied mix of site-specific climate change adaptation measures

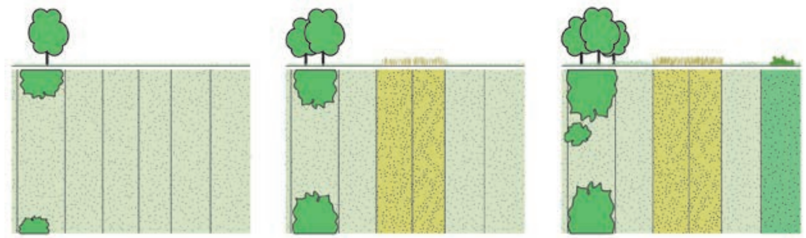


Figure 7.15 Successional stages in nature development at 'Korte Broek'

Main elements

boardwalk

vistas

meander

contrast

The path structure
In the ‘Korte Broek’ area visitors are able to descend into a whole different world. A sand path leads them downwards, from a height difference of approximately five meters, after which they are guided further, by a boardwalk, into this beautiful landscape of nature development. The path structure is shaped by the form of a deck of cards, which is shifted diagonally to create full experience when people cross the different plots with nature development. The north eastern path is directed towards a beautiful farmhouse on top of a mound in the south eastern corner of the ‘Korte Broek’ area, which is a real treat for the eye when gazing over the open fields. It takes a human being approximately 15 minutes to complete the longest route, when walking on a fast pace.

The ‘Egelbeek’
The historical meander is brought back to improve the amenity value of the former straight stream, which adds a central location in the ‘Korte Broek’ area, which was missing in the past. Oak trees dominate the higher northern bank of the ‘Egelbeek’, while alder trees dominate the southern bank. The boardwalks are placed parallel to the new meander of the stream and crosses it twice, which improves the awareness of people about the presence of the stream. The enclosed character of the stream and its banks, which people experience when walking through it, is in nice contrast to the open fields behind it.

Figure 7.16 The main elements of the design: the path structure, the ‘Egelbeek’ in its original course and the ribbons of succession at the bog [no scale]

succession stages

Nature zone

The former agricultural plots in the 'Korte Broek' area divided into different nature development areas, which are developed through stages of succession. The soil of the central plots along the main drainage canal is wetted by raising or removing the drainage pipes. Species such as sedge and reed start to grow due to the wet conditions and the removing of the top soil in the past. The drainage of another plot more to the east is removed a few years later. These plots are enclosed by plots where the drainage is still present. These two plots are stimulated in the forming of floral hay fields. The plot most to the west was in the past overgrown by alder forest. The development of alder forest on this plot is therefore seized to show the succession from marsh land towards alder forest. The path structure leads people through all stages of succession hereby increasing the amenity value of the 'Korte Broek' landscape.

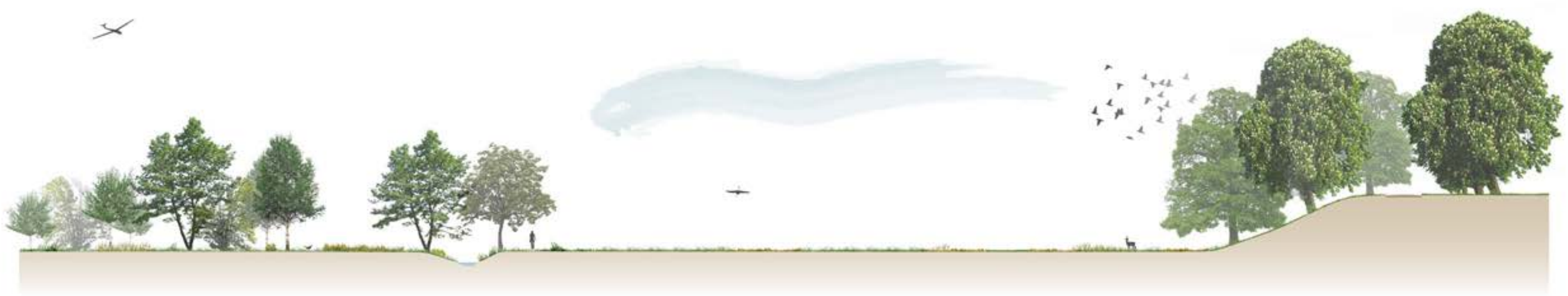


Figure 7.17 Section of the low-lying peat lands of the 'Korte Broek' and the 'Egelbeek' stream

1:750

Figure 7.18 Impression of the boardwalk through the 'Korte Broek' peat lands and their successional development

7.4 Detailed design: Fishing ponds at Oosterhof

Figure 7.19 Detailed design of the fishing ponds and the recreational landscape at Oosterhof, east of Vaassen

1:5000

artificial water buffer

The new location of the fish hatchery and fishing ponds, just downstream of Vaassen at the hamlet of Oosterhof offers multiple benefits for both the hatchery itself and Vaassen. Its main climate change adaptation measures are the development of an artificial water buffer, a multifunctional retention area, the construction of fish ladders, micro-meandering and the development of a robust green-blue corridor. It is located north-eastern of the village, where the streams 'Hartense Molenbeek' and 'Rode Beek', which are improved in quality by the stimulation of micro-meandering, shortly meet after leaving the urban fabric of Vaassen.

spatial structure

tree lanes

The site, formerly degraded by cluttering and decay, now strengthens the spatial structure of the rural outskirts of the village. The ponds of the fish hatchery act as artificial water buffer and multifunctional retention area. It provides a framework for preservation and development, detracting the laundry company from view and bringing back the alluring setting that fits the old mansion. A path, part of the larger recreational network, guides cyclists and walkers through the tree lanes, along the fishing ponds and into the picturesque hamlet of Oosterhof that is part of a robust green-blue corridor.

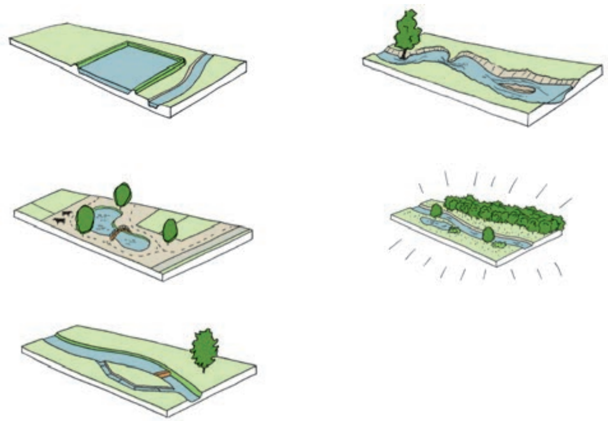


Figure 7.20 Applied mix of site-specific climate change adaptation measures

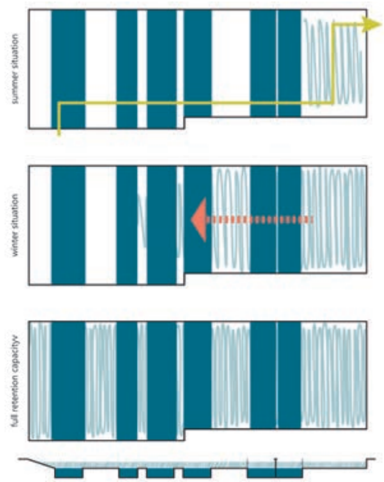


Figure 7.21 Design systematic of the Oosterhof fishing site: natural water refreshment and purification through input from the stream (yellow arrow) and gradual flooding, following elevation (red arrow), as emergency retention buffer

Main elements

rhythmic pattern

natural water flow

filtered

Orthogonal structure
The most striking feature of the design is the strictly orthogonal but rhythmic pattern in which the ponds, reed beds and grass ribbons alternate. It strengthens the spatial structure of the hatchery and prevents potential clutter, hence maintaining a clean but attractive outlook. The varying size of the ponds also enables fishing on different types of fish and a flexible arrangement of the hatchery ponds. Water is fed into the first pond in the left from the stream that has been slightly elevated to enable a water flow that doesn't require pumping. The water then flows through the subsequent ponds and is then fed into the large helophyte reed field in which the water is naturally filtered before it re-enters the stream of the 'Hartense Molenbeek'.

original planting structure

Restored spatial structure of tree lines
The arrangement of tree lines, which brings back the structure and intimate character of the original 'kampen' landscape, is inspired by the original planting structure that surrounded the mansion at Oosterhof over 150 years ago. It brings back the 'habitat' the house and the village deserve. The diagonal tree line that visually connects the mansion and the new pavilion is interrupted by the ponds but remains a strong visual element thanks to a wooden boardwalk continuing the line.

Figure 7.22 Old spatial structures of planting and the streams at Oosterhof, 1890
source: 'Bonneblad' no. 374, www.watwaswaar.nl [no scale]

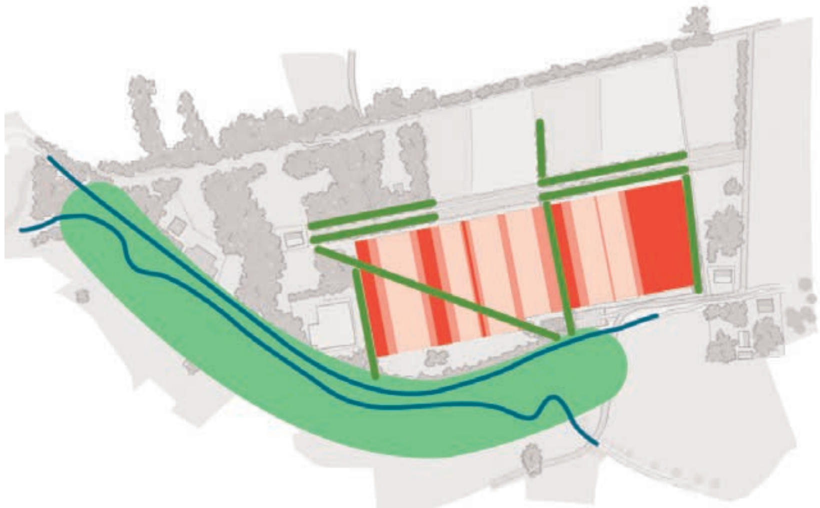


Figure 7.23 The main elements of the design: the orthogonal rhythm of ponds and vegetation, the structure of original tree lines and the green belt along the urban fringe [no scale]

Green belt urban fringe

small-scale character

green-blue network

A desire already expressed in current spatial visions of the region is to develop and protect the spatial structure that surrounds the village of Vaassen. The small-scale and genuine character of its edge are valuable properties. This design fixates the urban fringe and thus prevents unwanted spatial development from spoiling the rural character around Oosterhof. The two parallel running streams are the backbone of the green belt, which is part of the regional green-blue network that has protects historical and ecological value.

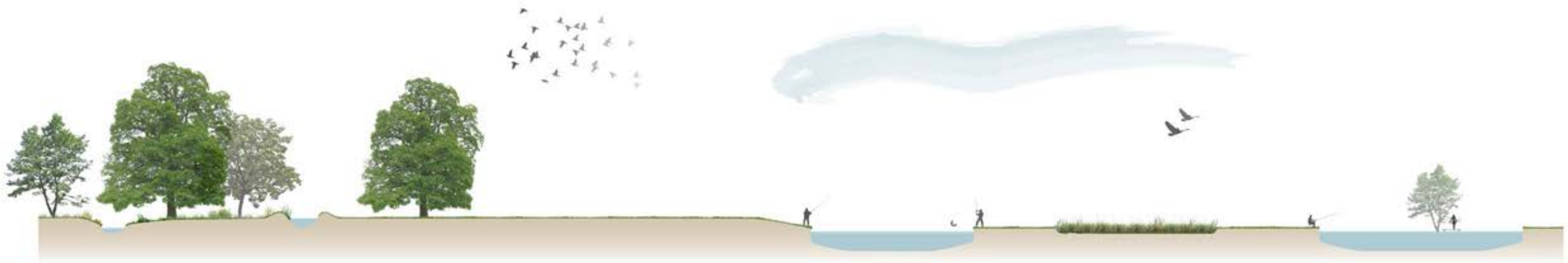


Figure 7.24 Section of the two parallel streams and the low-lying fishing ponds at Oosterhof 1:750

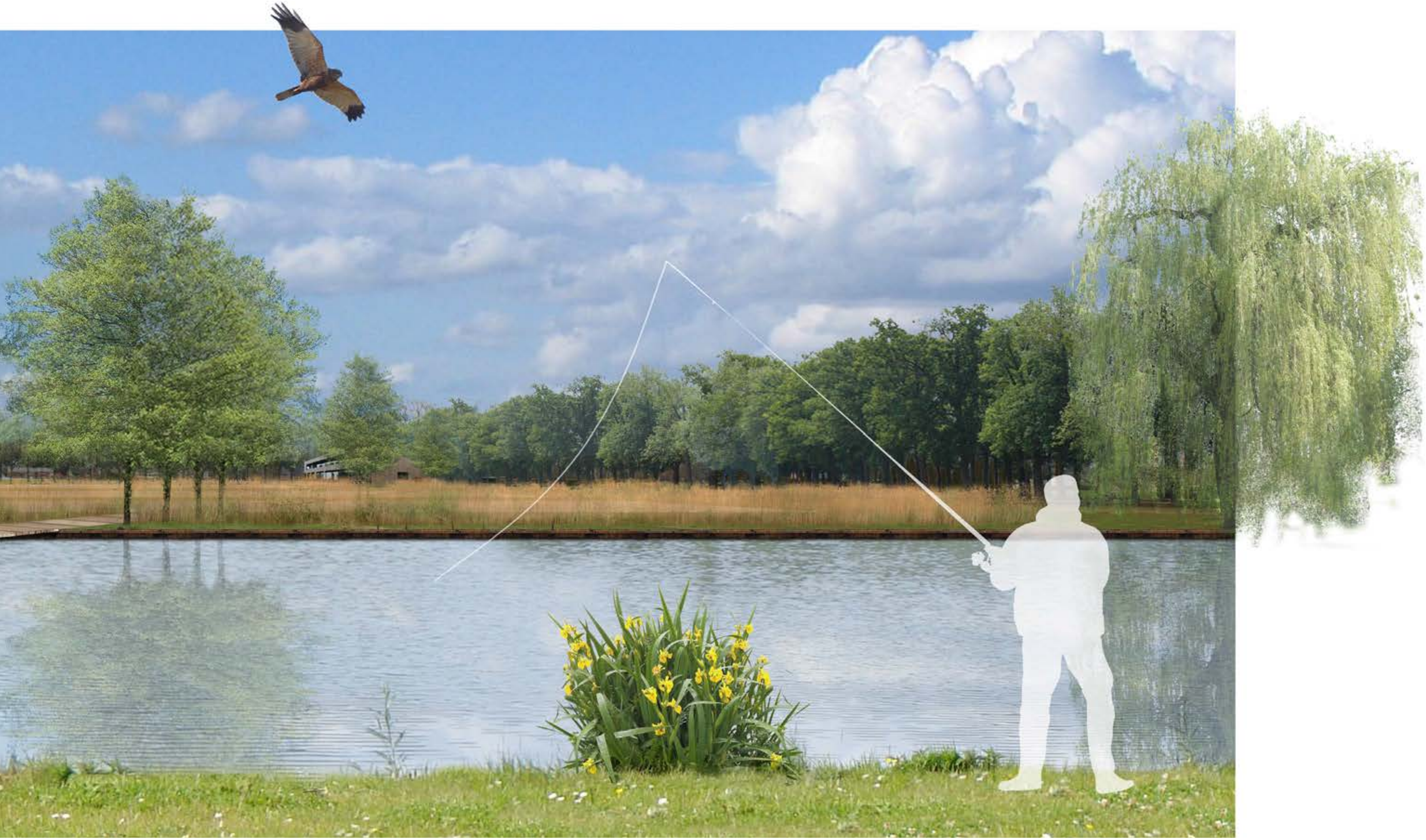


Figure 7.25 Impression of the tree lanes and boardwalk framing the orthogonal fishing ponds and reed beds at Oosterhof

7.5 Detailed design: Copper mill at Zuuk

Figure 7.26 Detailed design of the 'Klaarbeek' and 'Verloren Beek' stream valley and the copper mill of Zuuk, south of Epe
1:5000

restore watermill

recreational routes

green-blue corridor

The copper mill at the township of Zuuk, just south of Epe, is one of the most cultural-historically valuable water mills in the region thanks to its long and eventful history. The mill has been out of functional service for a long time due to a shortcoming water discharge by the 'Klaarbeek' stream and insufficient funds for proper restoration of the mill and related artefacts. The design strives to bring back life to the mill and its surroundings once again by restoring the possibilities of interaction with the streams by implementing an artificial water buffer, stimulating micro-meandering, increasing the size of the nature patch and develop a robust green-blue corridor.

The mill is part of an ensemble of adjoining buildings and monumental house. The design preserves the ensemble through development; the existing structures will be renovated if necessary such as the development of an artificial water buffer and at the northern part of the yard a new house will be built in a design consistent with the existing architecture. The yard will become one of the highlights in the 'node farmyards' rural structure of recreational routes, streams and hedgerows. The recreational network benefits from the recreational stimulus of the renovated mill and the adjacent playground and petting zoo 'De Koperen Ezel', both characteristic rural attractions. The network is closely linked to the valley of the 'Klaarbeek' and 'Verloren Beek' streams, which form the spine of the green-blue corridor that runs from east to west connecting the upstream peat bogs with the 'Grift' stream and the IJssel valley. The characteristics of the brook valley are strengthened in the design by stimulating micro-meandering, the development of the green-blue corridor and the increasing size of the nature patch. It combines elements in the longitudinal direction (streams, paths) that emphasize the continuous character with perpendicular landscape elements (hedgerows, tree lanes) that visually divide the landscape into smaller spaces.

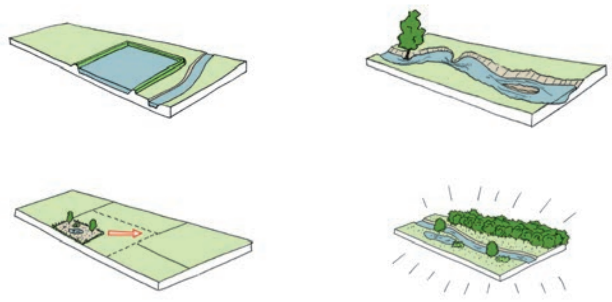


Figure 7.27 Applied mix of site-specific climate change adaptation measures

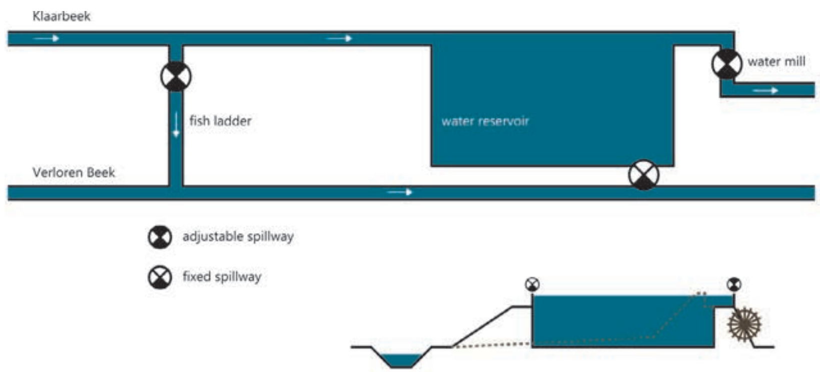


Figure 7.28 Design systematic: schematic representation of the stream system and water management mechanisms at Zuuk, enabling flexible water management

Main elements

'Wijer' accumulation pond

water supply and buffer

exploitation

The main feature of the site design is the accumulation pond or 'stuw wijer' that is brought back to its largest historical form, as found on a map dating back to 1746. It serves two main purposes: to collect a water supply to provide the mill with more water for operation, and to buffer and attenuate a peak discharge of water from the urban centre of Epe in events of extreme rainfall. Three separate spillways in the 'Klaarbeek' enable the water board to manage the water flows to prevent damage to the mill or pond and to facilitate ecological migration at the fish ladder. The pond enforces cultural-historical, educative, scenic and economic values through exploitation of the mill and tourism.

Continuous green-blue ribbon

rich nature

longitudinal direction

Of the two streams in the valley south of Epe especially the 'Verloren Beek'is of very high ecological value, it offers a valuable ecological connection between the 'Grift' stream and the 'Wisselse Veen' bogs because there are no mills or other obstacles. The valley provides a rich variety of terrestrial nature such as wet brook meadows, floral hay fields and alder hedge rows. The important role of the ecological corridor is underlined by the design by emphasizing the continuous character that suggest it is part of a larger network. The contrast with the adjacent rural landscape is enlarged by the lush vegetation of the valley meadows and the wet zone along the brook. The views along the longitudinal direction of the valley are guided by planting along the streams.

Figure 7.29 Historical map dating 1746/1747 with the old accumulation pond and the Copper Mill ensemble near Zuuk

source: Gelders Archief, www.geldersarchief.nl [no scale]

Figure 7.30 The main elements of the design: the 'Wijer' or accumulation pond as a central element, the continuous ribbon along the brook, and the 'stream valley chambers' [no scale]

Stream valley chambers

intimate

chambers

various functions

Lowland stream valleys are at the same time characterized by their intimate and small-scale character. As can be seen on the historical map, the accumulation pond already divides a part of the valley near the copper mill into three separate spaces. Scattered planting, extended tree lines and different forms of agricultural management visually divide the valley into smaller chambers with their own characteristics. Chambers along the brook valley can be set up differently with various types of appropriate vegetation and functions, such as small-scale organic livestock farming with grazing on meadows, or swampy grasslands with a look-out for wildlife observation.

Figure 7.31 Section of the stream valley, the elevated 'Klaarbeek' and new dwelling at Zuuk

Figure 7.32 Impression of the flowery meadows, ecological corridor and reactivated water mill along the 'Verloren Beek' and 'Klaarbeek' at Zuuk

site specific

amenity value

inspiration

Each of the four propositional designs provides a range of climate change adaptation services for the 'Blauwe Bron' area, which has been accomplished by the implementation of site specific climate change adaptation measures. We have described 20 different spatial adaptation measures in the 'toolbox' in chapter 6, which can be combined. The specific combinations of measures that we applied in the designs, illustrate the flexibility of the adaptation strategies, while strengthening the qualities and structures in the 'Blauwe Bron' area.

Our designs illustrate that climate change adaptation does not necessarily have to be a bleak political instrument but could eventually, if designed well, contribute to a beautiful landscape with a high amenity value. The detailed designs are meant to inspire those who will work in future climate change adaptation projects that are focussed on the sandy rural areas of the Netherlands. Chapter 8 elaborates further on the discussion and the limitations of our project.

Figure 7.33 Sketch impression of a recreational route in the landscape of the 'Region of Benefits'; high grade boardwalks guide hikers through the scenery

Figure 7.34 Sketch impression of a recreational route in the landscape of the 'Region in Balance'; subtle paths lead hikers to close interaction with the landscape

8 conclusions, discussion and recommendations

Climate change adaptation is a comprehensive and complicated topic, but it is also an interesting and challenging one. We defined a number of research questions to connect to the CARE research aims and to make them applicable. There is a need for new ways of thinking about the effects of climate change and the implementation of climate change adaptation measures in the 'Blauwe Bron' area. In this report we discussed our vision for the region, how we see a brighter future in the face of the potential harmful effects of climate change. The below research questions guided us through the process of finding solutions and guidelines for the adaptation of the sandy rural areas in the Netherlands. We will now elaborate and draw conclusions on each question starting with the set of five subquestions.

8.1 Conclusions

1 Which adaptation strategies to climate change can be applied in the 'Blauwe Bron' case study area?

We developed a table containing climate change adaptation measures applicable for the sandy rural areas of the Netherlands; measures that we had found in the literature or that we thought of ourselves. These are divided to technical, spatial, management, policy and societal measures, which can be found in appendix III. The next step was to make a selection of adaptation measures for each vision that could solve the problems described in the respective scenario. As landscape architects we focused on most of the adaptation measures, but had a special interest in spatial implementation. We hereby worked out the spatial adaptation measures that are found in the toolbox on page 100, which became building blocks for the 'Blauwe Bron' area. These building blocks were then divided between five different adaptation typologies or strategies. Rural water retention, urban water retention and infiltration, increase of water availability, improvement of ecological robustness and agricultural adaptation. We qualify typologies and adaptation strategies as the same, because both provide in the needs for climate change adaptation by offering a multitude of adaptation measures.

toolbox

multitude of adaptation measures

We have integrated the climate change adaptation measures in our vision maps, landscape plans and detailed designs as described in chapter 7.

2 Which are the design principles by which the sandy rural areas of the Netherlands can be adapted to climate change?

internal logic

We developed design principles that could steer the internal logic of our designs and that helped us to make decisions in the design

amenity value

aesthetic value

wider applicability

robust interventions

process. These principles are based on different characters of the stream system in each vision such as the amenity value of streams and their visibility in both the rural and urban landscapes. They guided our choices for robust spatial interventions present in both visions, which are described in the 'toolbox' of spatial adaptation measures in chapter 6, which present building blocks for the 'Blauwe Bron' area. These measures can help making the landscapes climate robust while, at the same time, increasing aesthetic value to human beings and can therefore be typified as 'climate change adaptation services'.

The combination of these 'services' enhance the climate-robustness of the 'Blauwe Bron' area as well as its spatial quality and landscape character. The different spatial measures should therefore not be seen as individual and isolated interventions, but rather as pieces of a large puzzle that provides a significant contribution to the realization of adapted and robust future landscapes of the 'Blauwe Bron' area. Some of these measures are also applicable in other sandy rural areas, but do not always fit due to their site specific application. However they do provide a number lessons that can be learned. These measures are also applicable in other sandy rural areas, which are than made resilient to the negative effects of climate change. The robust spatial interventions are the implementation of artificial and natural water buffers, the development of multifunctional retention areas, the use of private water retention and water retention on green roofs, flowing water retention, the increase of the sponge effect of the soil, the conversion from coniferous to deciduous forest, aquifer storage and recovery, and the application of micro-meandering in streams.

3 What are the opportunities to use the system of brooks in the development of an adaptive water (management) system for the 'Blauwe Bron' case study area?

The water system has been very important for the 'Blauwe Bron' area and its development, such as for the formation of the stream valleys and the formation of nature areas due to seepage (described in chapter 4).This is the reason that we decided to use the system of streams as a 'coat rack' that accommodates our proposed spatial interventions, such as the development of multifunctional clusters and green-blue networks (described in chapter 6). The solutions for climate change problems, which are mostly related to growing extremes in water availability should therefore also be sought in the use and the redevelopment of the water system. The framework that is offered by the streams can thus be used as a guiding tool for spatial interventions.

spatial framework

spatial interventions

4 How can we utilize the water system to realize a multifunctional landscape that incorporates values for ecology, agriculture and recreation?

The distinction between the two visions in chapter 6 is based on the differences in spatial pressure, the political agenda, ecological directives and economic growth in both scenarios. Each vision contains a concept that guides a part of the future ecological and recreational developments, namely the multifunctional cluster concept in the 'Region of Benefits' vision and the multifunctional green-blue network concept in the 'Region in Balance' vision. These concepts are directly linked to the water system of the 'Blauwe

cluster concept

network concept

Bron' area. The clusters are attached to the streams at strategic locations, while the networks are guided by the streams from the Veluwe forests to the IJssel valley. In both variants, the clusters as well as the networks, combinations of climate change adaptation measures are integrated such as multifunctional retention areas, the increase of the sponge effect of the soil, natural and artificial water buffers and the increase of the drainage capacity, which incorporate values for ecology, agriculture and recreation.

combinations of climate change adaptation measures

5 How can we find and develop opportunities to reverse the degradation of the old landscape by means of the water system? (after: Witte 2010)

The 'Blauwe Bron' area is known for its landscape qualities, but there are also problems present which degrade the spatial quality of this touristic area. We propose to improve the landscape structure of the 'Blauwe Bron' area by means of the restoration of old tree lanes and the clustering of dairy farming in the IJssel valley. Such development could answer to the problems caused by clutter, while anticipating climate change. The improvement of the visibility of the streams in both the rural and the urban landscapes can enhance the value of this unique and beautiful stream system for the people. We proposed spatial interventions to stimulate awareness, because we believe that the more people are aware of their environment, the more they will start to appreciate the landscape in which they live and the more they will nurture it. The strengthening of the landscape structures in combination with the implementation of climate change adaptation services, such as robust corridors and multifunctional clusters, can stop the degradation, while enhancing the legibility of the landscape and the amenity value of the 'Blauwe Bron' area.

restoration

visibility

awareness

legibility

Main research question

'In what way can (integrated) adaptive landscape design contribute to a sustainable water system in the 'Blauwe Bron' area while enhancing spatial quality?'

The implementation of climate change adaptation services, which are attached to the stream system and guided by the use of the cluster and green-blue network concepts, offered us the tools to make this area more resilient to the negative effects of climate change (see table 5.2). Our visions and designs propose spatial interventions to balance the growing extremes in water availability in the 'Blauwe Bron' area, while strengthening the historical landscape structures and increasing the legibility and amenity value of this region. We offer possibilities to increase more awareness among the public and to strengthen the regions robustness. Overall we can say with confidence that the proposed combinations of spatial interventions contribute significantly to the adaptation of the 'Blauwe Bron' area and make this area more resilient to the effects of climate change.

balance

robustness

more resilient

8.2 Discussion

Reflection on theory

´services´ theory

The 'ecosystem services' and 'landscape services' theories, from which we derived the climate change adaptation services provided us with the theoretical support for our research. The climate change adaptation services concept is newly introduced in the discussion regarding to climate change. It must therefore be noted that the application of this concept is still in a primary stage potential application

further research

stakeholder coalitions

comparative analysis

robustness score

of development. Our own research results and the theoretical base are the only proof of its potential application in future design assignments. We derived a total of twenty spatial climate change adaptation measures from our literature research, but we are convinced that this is just the top of the iceberg. We believe that there are more spatial adaptation measures applicable in the sandy rural areas of the Netherlands, that have yet to be found or developed. It must be mentioned that we focused in the design process on the spatial and technical implementation of the adaptation measures. We did not neglect the others in our research, but further research is needed in the search for better and improved management, policy and societal measures that can guide future spatial developments with regard to climate change.

Reflection on content

In scenario storylines and visions we have elaborated on the role of the stakeholders in general, but this is still to superficial. The integration of stakeholders in the design process and the forming of coalitions in the different scenarios should therefore be further investigated. This also applies to the method of comparative analysis that we used. It does not rest on a basis of scientific theory, but is merely a normative estimation as described in chapter 6, which is not (yet) suitable to be used for extensive scientific research. However, we believe that this method might be a valuable topic of future research that can lead to a scientific method to determine the 'robustness score' of climate change adaptation strategies.

Our proposed vision maps, landscape plans and detailed designs visualize how the 'Blauwe bron' landscapes can be adapted to climate change. However these designs are only one way how climate change adaptation measures can be implemented in this area. They are not the only solution. It is our opinion that an open and broad perspective is required when trying to find new solutions. Not only in the search for climate change adaptation, but also in the search for climate mitigation, which could be difficult due to old, persistent habits.

broad perspective

8.3 Recommendations

knowledge gaps

There are significant knowledge gaps in the application of spatial climate change adaptation measures. The theoretical findings and experience presented in this report can be utilized in future research and design, while the more practical knowledge can be applied in future design assignments. We believe that our work helped to decrease the existing knowledge gap between climate adaptation theories and their spatial implementation, but we also believe that this gap is still far from resolved.

climate change adaptation services

We recommend that the concept of 'climate change adaptation services', as introduced in chapter 3, is used and developed further in the future for regional sustainable development and climate robust design. To determine goals for climate adaptation services beforehand is an important step in finding the most appropriate mix of climate adaptation measures in different kind of landscapes. However, climate change adaptation services are part of a larger context of functions and services. It must be noted that climate change adaptation services should be used in a balanced way with other functions and services. We also recommend the use of the described adaptation strategies, such as rural water retention and the increase of water availability, to

balanced

no-regret measures

uncertain futures

make the sandy rural areas climate robust. The robust adaptation measures that are derived from these strategies, mentioned as no-regret measures in section 1.5, are especially interesting for further research due to their applicability in both visions.

It should also be noted that the described scenarios and visions in this report are based on uncertain futures. We do not know exactly how the future will look like. Again we state that the results from both the scenarios and visions must therefore not be taken as fixed future developments. For this reason we hope that others will continue to expand the amount of knowledge concerning climate change in order to be prepared for the future.

structural solutions

climate change mitigation

To conclude, this project does present possible solutions for future climate scenarios, but adaptation remains nothing more than a temporal fix for future problems. We solve some of the mistakes that people made in the past by anticipating on the future, but we do not solve the core of the problem. We need to mitigate climate change rather than 'just' adapting to it like we discussed in our report. If we do not change our way of living, which resulted in the acceleration of climate change, the effects of climate change may become even more severe than projected by any climate scenario.
It is not too late to make a change!

Figure 8.1 Fishing and water accumulation pond at castle 'Cannenburgh', Vaassen

Appendix I - landscape services table

function		*services and goods*	*vision examples*
Regulation functions - maintenance of essential ecological processes and life support systems			
1.	Air purification		
	1.2	maintenance of good air quality	
2.	Climate regulation		
	2.2	maintenance of good micro climate	streams through urban areas
3.	Disturbance prevention		
	3.2	flood prevention	water retention areas
4.	Water regulation		
	4.1	drainage	
	4.2	irrigation	
5.	Water supply		
	5.1	provision of consumptive water	Vitens drinking water extra
	5.2	water provision	ASR, water infiltration ponc
	5.3	drought prevention	'verloofing', sponge effect
7.	Soil formation		
	7.1	maintenance of agricultural productivity	
8.	Nutrient regulation		
	8.1	nutrient and carbon sequestration	
9.	Waste treatment		
	9.1	pollution control: helophyte filtering	
	9.2	filtering of dust particles (air quality)	
	9.3	abatement of noise pollution	

Habitat functions – providing habitat for wild plant and animal species

12. Refugium function

12.1	maintenance of biological diversity	increase internal heterogeneity
12.2	allow for ecological migration	robust corridors

13. Nursery function

13.1	maintenance of wildlife species	

Production functions – provision of natural resources

14. Food production

14.1	hunting, fishing, gathering	
14.2	small-scale subsistence farming	

15. Raw materials

15.1	building and manufacturing	timber production
15.2	fuel and energy	shale gas, biomass production
15.3	fodder and fertilizer	hay production

Information functions – providing opportunities for cognitive development

19. Aesthetic information

19.1	spatial quality	
19.2	landscape experience	

20. Recreation

20.1	extensive recreation	hiking trails, cycling paths

21. Cultural and artistic information

21.1	nature experience	

22. Spiritual and historic information

22.1	historical value	value of stream ensembles
22.2	cultural historical identity	
22.3	'sense of place'	Veluwe identity

23. Science and education

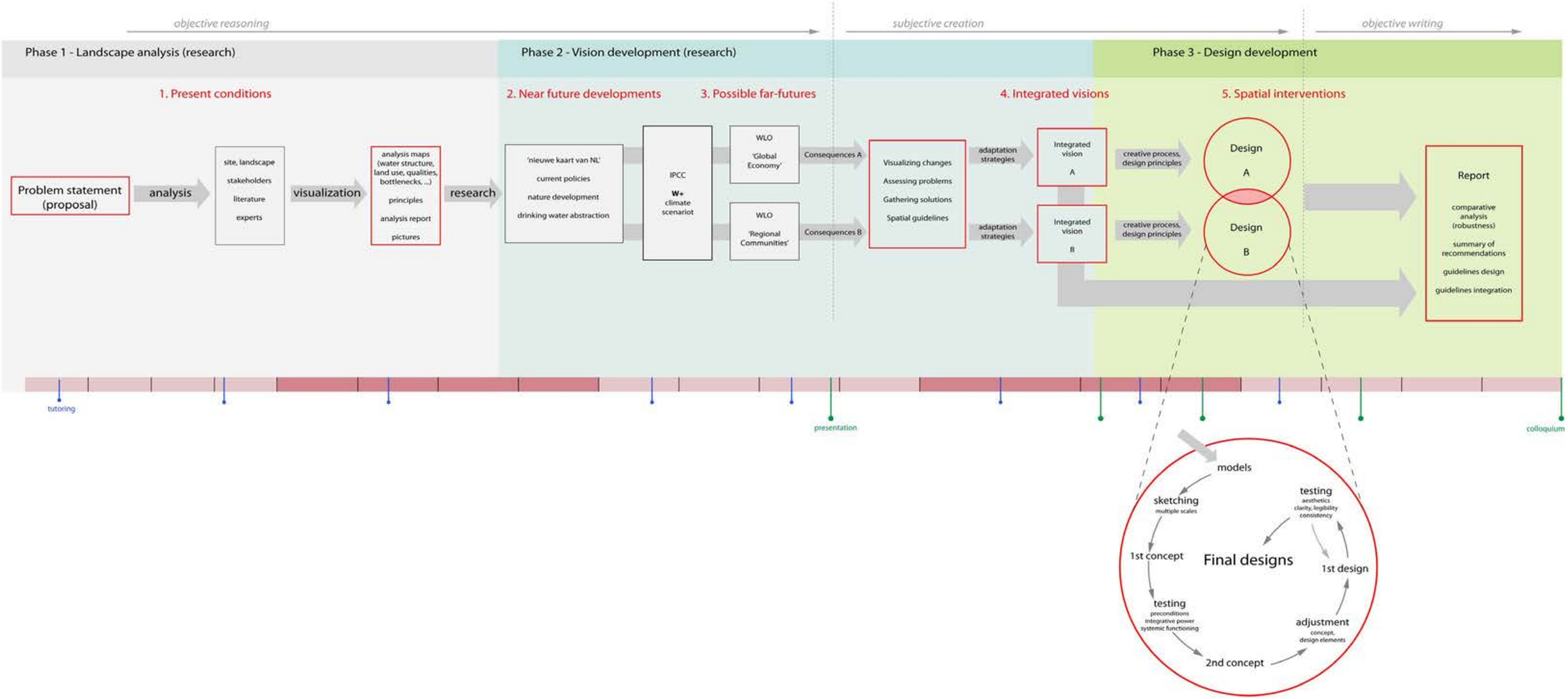
23.1	knowledge and awareness	climate change awareness

Carrier functions – providing a suitable substrate or medium for human activities and infrastructure

24.	Habitation		
	24.1	urban dwelling	
	24.2	rural dwelling	new estates, new farmyards
25.	Cultivation		
	25.1	conventional agricultural production	
	25.2	organic agricultural production	
	25.3	aquaculture	
26.	Energy conversion		
	26.1	solar energy conversion	
	26.2	wind energy conversion	
	26.3	biomass energy conversion	
27.	Mining		
	27.1	gas production	shale gas extraction
29.	Transportation		
	29.1	infrastructure	
30.	Tourism facilities		
	30.1	intensive recreation	'Wissel' zoo, fishing ponds
	30.2	residential recreation	bungalow parks, camping sites

adapted from: de Groot, 2006

Appendix II - workflow diagram



Appendix III - overview of potentially applicable c.c. adaptation measures

Climate Change Adaptation Measures sector:	TECHNICAL	SPATIAL	MANAGEMENT	POLICY & LEGISLATION	SOCIETAL
WATER QUANTITY	- reallocate water abstraction - increase infiltration with exogenous water - increase infiltration SWTP effluent - apply Aquifer Storage & Recharge - increase 'sponge effect' upstream: raise drainage level (shallow) - increase 'sponge effect' upstream: remove drainage - increase broader and shallower discharge canals and ditches - increase storage in sewers or streets - increase broader and deeper discharge canals and ditches	- increase water buffers - improve streams, passive meandering, actively stimulate micromeandering - increase water retention storage: ponds, wadi's, etc. - increase multifunctional water retention areas; parks, squares, streets, etc.	- increase 'blue services' - apply fish ponds as auxilliary retention basins - use hayfields as auxilliary inundation and infiltration areas - offer slightly purified water from SWTP's (containing nutrients) for agricultural irrigation	- utilize water system hierarchy in management - improve (sub)soil protection - improve requirements for the use of and action in an area in event of a flood	- use rainwater storage in private gardens ('regenton') - use water of lower quality to flush toilets (f.i. rainwater)
WATER QUALITY	- construct separated sewer systems - detach sewer overflow at source - detach sewer overflow at de Grift (stream direction) - filter sewage overflow: plate separator (lamellenafscheider) in sewage system	- increase water buffers	- reduce sewage overflow rates - separate high & low quality water for Grift & Apeldoorns Kanaal	- improve groundwater protection	
NATURE, ECOLOGY	- 'neutralize' ecological barriers - prevent drought: excavate soil toplayer	- increase nature buffers - apply green-blue 'veining' - create robust corridors - increase size of nature patches - increase multifunctional ecological 'stepping stones' - provide water retention areas - construct fish ladders - construct pools	- provide 'green services' - increase internal heterogenity - improve abiotic conditions - use hayfields as auxilliary inundation and infiltration areas - diminish eutrophication: more frequently mow and remove biomass - increase multifunctional land use around nature areas		
AGRICULTURE	- increase 'precision agriculture': optimize irrigation and fertilization with GPS technology - grow crops 'semi-artificially': by the use of LED-lighting, in industrial buildings (or underground) in business areas (f.i. near Apeldoorn)	- increase crop plague-resistance: diversify pasture distribution - reserve space for water retention: take land alongside streams out of (primary) production	- provide 'green services' - provide 'blue services' - use hayfields as auxilliary inundation and infiltration areas - apply land resting - increase soil moisture retention capacity: growing 'groenbemester' or adding organic matter - grow alternative (energy/short rotation) crops - keep dairy cows inside permanently - keep or ennoble 'resilient livestock' (disease-resistant) - sell grass to horse owners (secondary production) -use slightly purified water from SWTP's (containing nutrients) for agricultural irrigation	- apply farm reallocation (province and LTO) - set up a cost unit for climate nuisance events, f.i. compensation or insurance	
FORESTRY		- increase conversion coniferous > bare soil - increase conversion coniferous > deciduous ('verloofing') - prevent forest fires: create firebreaks			
RECREATION			- improve swimming water quality: increase input Apeldoorns Kanaal to ensure flushing	- improve swimming water quality: reach quality goals of EWD	
INFRASTRUCTURE	- reduce rutting at important roads: apply harder substratum		- reduce rutting at important roads: more maintenance		
URBANIZATION, dwelling	- increase storage in sewers or streets - construct green roofs	- increase urban water retention areas; 'capillaries', wadi's, etc. - increase multifunctional urban water retention areas; parks, squares, streets, etc.		- improve requirements for the use of and action in an area in event of a flood	- increase rainwater storage in gardens ('regenton') - construct green roofs - use water of lower quality to flush toilets (f.i. rainwater)
CULTURAL HISTORY		- remove ecological barriers: construct fish ladders			

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