BARBABRABANT

Collaboration as foundation for a robust hydrological future.

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Commissioner: Rob Brinkhof, municipality Den Bosch

LUP-60309 (Atelier)

INTRODUCTION AND PROBLEM STATEMENT

Het begint bijna gewoon te worden. Weer valt er nauwelijks regen, en kleurt het gras geel in plaats van groen. Al voor het derde jaar op rij is het extreem droog. En uit onderzoek van het KNMI blijkt dat dit niet de laatste keer zal zijn. 'Zie hoe voorzichtig ze in Italië en Griekenland omgaan met water, daar moeten we van leren.'

Water vloeit niet langer in overvloed, gratis en voor niets

PEILING
WATERTEKORT

Boeren lijden eronder, maar ook andere beroepsgroepen kampen met het tekort aan regen. En wat zijn de gevolgen voor de natuur?

Hendrik Jan ten Cate, akkerbouwer in Tholen
'De droogte is dramatisch. Er is al een maand nauwelijks regen geweest, de gewassen zijn aan het verdorren en verdrogen op het land. Sommige boeren kunnen waterkanonnen inzetten om het land te besproeien, maar dat is niet voor iedereen hier een optie, want er is in Zeeland bijna nergens genoeg oppervlaktewater. Water uit de kraan is duur en soms is dat ook verboden. Al met al gaat het om enorme hoeveelheden water. Een oplossing? Er moet zoet water naar Zeeland komen. Het sieltje van sloten zou moeten worden ingericht om zoet water door te gaan pompen. Het is een zorgelijke situatie.'

Jan Peter van der Hoek, hoogleraar drinkwatertechniek TU Delft
'Nederland heeft lang een overschot aan neerslag gehad, dus we hebben nooit de noodzaak gehad om water op te slaan. Wij voerden water bijvoorbeeld gewoon via het riool af naar de zee. In een land als Namibië – haast een woestijn – of Singapore wordt gebruikt douchewater teruggezet in de toiletten. In een land bestaat de kringloop dit te doen, maar de noodzaak ontbrak. We we drie jaar achter elkaar deze droogte ervaren, wordt de vraag plotseling relevant: hoe kunnen we slimmer omgaan met water?

Zo gebruikt de fabriek van DOW in Terneuzen afvalwater voor haar productieproces.'

Robert-Jan Brummelkamp, binnenvaartschipper op weg naar Duitsland
De binnenvaartschipper wordt direct geconfronteerd met een lage waterstand: je vaart meer in een bocht dan een rivier. Onze capaciteit neemt dan navenant af. De schepen kunnen minder lading meenemen, zodat ze langer liggen. Daardoor heb je meer diesel en schepen nodig om dezelfde lading te vervoeren. Onze vrachtprijs gaat dan omhoog, dat is wettelijk zo geregeld. Maar het wordt ondanks de erigende inkomsten steeds moeilijker dieper Duitsland in te varen. Na twee maanden extreem lage waterstand kiezen mijn klanten ervoor om over te gaan op treinen en vrachtwagens. Bij de productie van nieuwe schepen is houden we rekening met een toekomst vol lage waterstanden. De schepen worden lichter gebouwd, met kleinere schroeven. Ze krijgen we conca'ervieren met het spoor.'

Arina van Leenen, wijndruiventeler
'De afgelopen paar jaar zijn dankzij het weer goede wijnjaren geweest hier in de Betuwe. Wijnboeren hou-

den van experimenteren, maar druiven houden van een gematigd en saai klimaat. Het droge weer is geen stijl geweest voor de Nederlandse wijn. Hoe droger, hoe minder kans op schimmels. In wet kunnen zeeuwse bodem niet ongeren.'

Peter Voren, ecoloog Natuurmonumenten
'De natuur is weerbaarheid, maar zelfs een elastieke kan je niet blijven uitrekken. Iets wat voorheen een in de 25 jaar voorkwam, houdt nu al twee jaar op rij aan. Het lijkt dit jaar niet anders te zijn. Ik zag vandaag 22 graden 's ochtends in de slapen. De bakken deze tijd van het jaar op een nest moeten broeden. Aan de droogte kunnen we weinig doen, maar er wordt in toenemende mate omgegaan; er wordt hier in Brabant rants grondwater opgepompt en gesproeid. Alsof het gratis en voor niets is. Op die manier gaat het in de natuur helemaal mis. Zie hoe voorzichtig ze in Italië en Griekenland omgaan met water. Als we daar niets van leren, trekt het natuur aan het kortste eind.'

Hendrik Jan ten Cate, akkerbouwer in Tholen
'Je loopt er in de polder niet mee te koop als je oogst mislukt. Zij die de hulp het hardst nodig hebben, schamen zich. Mensproberen het tot het bitterend toe zelf op te lossen. Maar rijd een rondje in Zeeland: alle velden zouden er groen moeten zijn. Als je niets te verkopen hebt, blijf je nog wel kosten houden voor het zaaien. Het jaar 2011 was droog, met kunst- en vlagwerk winnen we het in 2019 te rooien. Maar als de stem en bieren dit jaar niet willen groeien, dan is dit het derde jaar op rij. Er zit aanzoede in onze sector verschoven. En dat is geen onderneemersrisico meer. Klimaatverandering hebben we feitelijk met 2% allen veroorzaakt, de lasten die het met zich meebraagt, moeten we samen verdelen.'

Ashwani Nandram

Maestuinen in het Brabantse Helvoirt. Zander gieteren groeit er weinig. Foto's Marcel van den Bergh / de Volkskrant

Een landbouwer in het Gelderse Altforst besproeit zijn dorre land.

KNMI: Zomers worden steeds droger

Cor Spaksnijder
Amsterdam

Nederland heeft sinds de jaren vijftig van de vorige eeuw steeds vaker droge zomers. Dat wil zeggen: in het binnenland. In de kustgebieden is dat niet het geval, daar valt juist meer neerslag. Dit blijkt uit onderzoek van het KNMI en de Universiteit Utrecht. De wetenschappers verwachten dat deze trend zich voortzet.

Het onderzoek, deze maand gepubliceerd in *Environmental Research Letters*, is gebaseerd op metingen van weerstations tussen 1951 en 2019. Het KNMI ging er steeds vanuit dat Nederlandse zomers natter zouden.

In dit onderzoek is meer naar regionale verschillen gekeken, legt eerste auteur Sjoukje Philipsen uit. 'Als je naar het gemiddelde van heel Nederland kijkt dan neemt de hoeveelheid neerslag nog steeds toe, maar als je gaat inzoomen is er een ver-

Grote verschillen tussen kust en binnenland

schil tussen het binnenland en de kust ontstaat. Aan de kust neemt de neerslag toe, maar dat zien we niet in het binnenland. Daar is de neerslag gelijk gebleven, terwijl de verdamping toenam.'

De oplopende temperatuur is aan of meer gelijkmatig verdeeld over heel Nederland, maar de zonneinstraling is in het binnenland iets meer is toegenomen dan aan de kust. Hoe dat komt weten de onderzoekers niet. Ze voorspellen dat droge zomers zich in de toekomst steeds vaker zullen voordoen.

Sectoren die worden getroffen door droogte, zoals de landbouw, zullen daarmee 'moeten leren omgaan', schrijven ze. Het KNMI gaat uit van twee toekomstscenario's. Of de huidige trend van meer droogte en deze of er komt zonder ingrijpen van bijvoorbeeld afgebroken nog meer droge en warme jaren naar Nederland. In dat laatste geval zou de droogte nog sterker kunnen worden.'

Het binnenland, hoger gelegen dan de kust in stuk, is extra gevoelig voor neerslagtekorten in de zomermaanden omdat dit deel van het land voor de waterreservoir voornamelijk afhankelijk is van regen. De kustregio's kunnen daarnaast putten van het water dat de grote rivieren aanvoeren.

Nederland droogt uit

Na drie droge jaren staat het grondwater op veel plekken in Nederland veel lager dan normaal, blijkt uit een omvangrijke Volkskrant-inventarisatie. De schade voor de economie (landbouw en scheepvaart) en de natuur loopt snel op. Nederland zal moeten leren water vast te houden, in plaats van tegen te houden en af te voeren. P7-9

Figure 1: a selection from the stream of articles about drought (Volkskrant, 2020)

Figure 2: a selection from the stream of articles about drought (Volkskrant, 2020)

Water management

The Netherlands is a country of water. Due to its position in the delta of several international rivers, the Netherlands has always known the need to relate to water. We use it to travel, trade and protect ourselves. This position in the delta also urges the need to defend ourselves against the water. With the development of technology, this results in major hydraulic engineering projects, such as the Delta works. Without the elaborate polder systems with windmills and pumping stations, great parts of the Netherlands would be covered in water (Jongmans, Van den Berg, Sonneveld, Peek, & Van den Berg van Saparoea, 2013).

Due to population growth over the centuries, there was a focus on discharging water, making more land suitable for living. On top of that, after World War II the urgency arose for domestic food production (Jongmans, Van den Berg, Sonneveld, Peek, & Van den Berg van Saparoea, 2013). Under the direction of Sicco Mansholt, an elaborate land consolidation plan was spread over the country to make this plan reality. This upscaling was a general plan, less focussed on local differences, both in land use and hydrological systems. Nevertheless, it was not without success, since the Netherlands is now one of the largest agricultural exporters in the world (M. Kuijpers, personal communication, June 24, 2020).

Climate change

Due to the current climate change, the country is facing new challenges. Almost daily, there are news articles about drought (Figure 1 and 2). After a wet start of the year 2020, top soils are already drying out to a big extent. At the same time, more and more groundwater and surface water is being extracted for purposes of agriculture, industry and drinking water, adding to the water shortage.
The climate change makes peaks and droughts alternate quickly, but the Dutch hydrological system is only designed for quick discharge to avoid flooding risk. Yet the real problem seems to be surfacing now; drought is a much more extensive and complicated problem to solve. Currently water boards are responsible for maintaining ground water levels for agricultural systems in place and the (artificial) hydrological system follows the land use (Geelen, 2020), but this is not enough to solve structural droughts.
This is partly caused by the Dutch hydrological system that became more and more artificial (Rijkswaterstaat, 2019), and partly by the general way of food production that lost its focus on local typologies (Jongmans, Van den Berg, Sonneveld, Peek, & Van den Berg van Saparoea, 2013). To handle the alternating peaks and droughts, a robust system regarding both hydrology and land-use is needed.

Hydrological system around Den Bosch

The urgency for a robust hydrological and land-use system are especially present on the higher sandy soils in the east and south of the Netherlands (Spek, Kiljan, Moorman, Geertsema, & Steingröver, 2010). These regions are characterized by its variety of landscapes due to the presence of highlands, ridges and valleys. These regions face great water discharges in the winter and severe droughts in the summer.
The city of Den Bosch, in the south of the Netherlands, is a place where the urgency is already tangible. The city is built on a sand ridge in the middle of the delta of the rivers Dommel and Aa, which run off in the Maas on the north side of the city. From this position, trade was possible via the Dieze up to the Maas, which allowed the city to develop further (E. Nijhof, personal communication, June 16, 2020). The city could use the available water in its advantage; ,for example in her defence as part of the Southern Defence Line (Studio Marco Vermeulen, 2018). However, there is also a risk in this position in the delta of the rivers, since the Dommel and the Aa can not discharge their water in the Maas when the water levels are already at maximum level. Therefore, the water stays in the area, creating flooding in and around the city. The Drongelens channel is part of the solution for this problem. This channel transfers water from the Dommel on the south side of the city and runs off in the Maas several kilometers west of the city. It is one of the examples of the complex artificial system that is formed

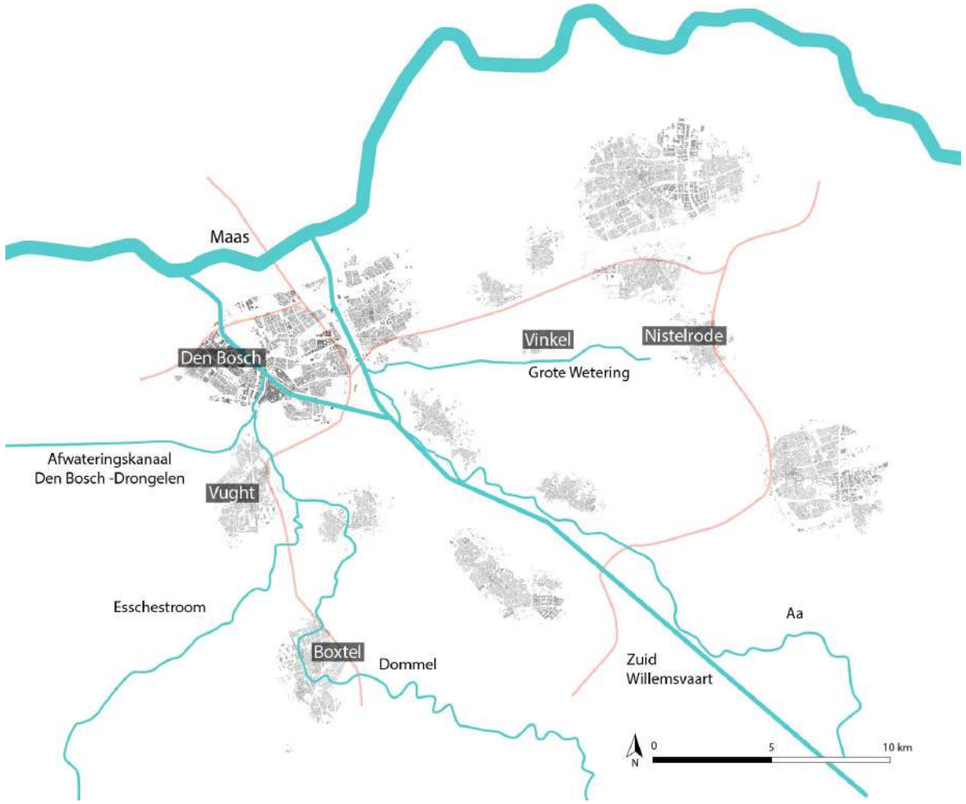

Figure 3: map of important elements in the hydrological system

throughout the years. The watercourses form an elaborate system of knots and lines around the city of Den Bosch, such as the several crossings of different water bodies around the Aa and the Maximakanaal (Waterschap Aa & Maas, 2020).

The municipality of Den Bosch is working on a vision to balance-out these water-related issues, by becoming a "sponge-city". This vision assumes that each area must find its own balance in the water supply. By speaking out ambition to function as such a "sponge-city", Den Bosch sets the example, catching its own water and putting it into use. But the problem is not limited to the territory of the city of Den Bosch. The polders around Den Bosch are also closely related.

Problem statement

So, in the current hydrological system around Den Bosch there is a mismatch between the water demand and supply, because of:

- Seasonal peaks that intensify due to climate change
- Increase of severe droughts in the summer
- Intensive general agricultural land use
- The complicated hydrological system, serving the user functions
- Dependence on a larger hydrological system
- Modern wishes for the landscape that do not correspond with the area's history

Commission

These challenges ask for a new perspective on water management in the area. Therefore the municipality Den Bosch asked us to explore a future climate-resilient hydrological system for the Grote Wetering and the Dungense Polder, two important areas in the hydrological system, that restores the balance between land use and the hydrological system, inspired by historical water management.
Historical water management principles, whereby the focus was on the local possibilities, might be well applicable in today's climate change challenges. Historical water management also receives renewed appreciation now we need to develop plans for the future. The Southern

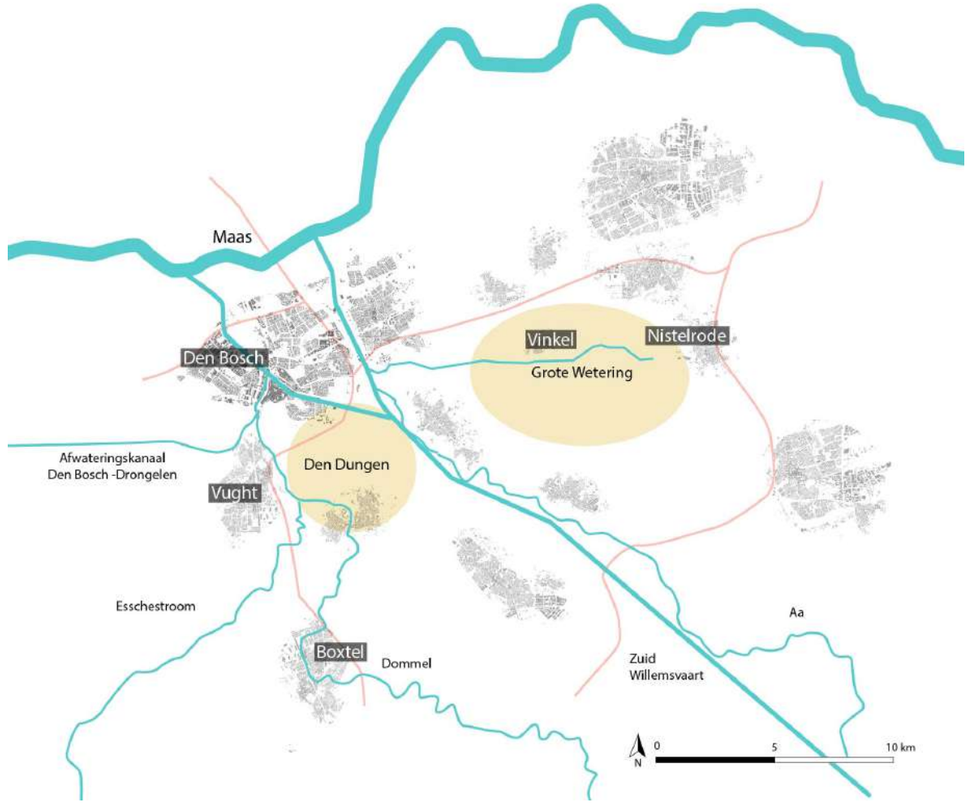

Figure 4: the areas of the Dungense Polder and Grote Wetering

Defence Line that is located south of Den Bosch plays an important role in the Landschapstriënnale 2021 that is hosted in Brabant with the theme 'High Green, innovating the landscape' (Landschapstriënnale, 2020). 'The Beerze op waterbasis' is another example of a project in this area that focuses on reintroducing historic water management tools in a modern context. With these projects there is already a clear view on tools that could contribute to a more sustainable hydrological system.

However, making a new hydrological plan requires a lot of detailed knowledge about the hydrological system. So, realizing a comprehensive plan like 'the Beerze op waterbasis' or 'Klimaatrobuust Aa-dal" is a very complicated task, especially for landscape architects and planners who do not have the expert knowledge about hydrological systems.
Analyzing these documents we noticed that even though these plans are really appreciated, they are not always carried out. It is hard to involve local stakeholders and convince them of the added value of the plan.
Therefore, this report focuses only partially on what the area of the Grote Wetering and the Dungense Polder could look like in 2050 and which water tools would be suitable for that, but mostly on the way stakeholders can work together on a robust hydrological system.
This unique online situation allowed us to talk to many local experts and resulted in a plan on how stakeholders in the region themselves can create a robust and sustainable hydrological system in the future. With this plan we contribute to local responsibility and collaboration.

Figure 5: ambience images of the varied landscape of Noord-Brabant (author: Tim den Duijf)

In 2050 the landscape of the Dungense Polder and the Grote Wetering will have a flexible and robust hydrological system fitting in the characteristic Brabant mosaic landscape. However, the unlying system will be supported by modern technology and inspired by local history. Modern hydrological techniques are used to strengthen the historical landscape qualities.

The area is known for the several characteristics that are directly linked to the long history of the area. Various fens and streams, as well as larger rivers such as the Aa and the Dommel, flow through the area. Various castles and villages have been built along these streams throughout history, which are now striking landmarks in the region. These castles, along with the Southern defense line in the area, show the strategic location on the edge of high to low. The diversity of the subsurface, with the alternation of higher, dry soils and lower, wet soils, has created the mosaic landscape, which is so characteristic for Brabant. All kinds of land use, separated by historic hedgerows, can still be found here.

Robust hydrological system

To preserve this characteristic landscape regarding future climate change, a more flexible hydrological system and its related land-use and the way stakeholders interact is needed. The landscape has to become robust, in order to deal with the effects of climate changes. According to RWS (n.d.) a robust hydrological system is characterized by:

"*Its aim to create the optimal balance between water supply and demand; a greater supply of fresh-water; its urgency for collaboration; the fact that it is adaptable to the characteristics of the region; the synergies it creates between different sectors (industry, nature, culture, urban, agriculture and recreation); its cost-effective approach regarding water management and maintenance*." (RWS, n.d.)

This robust system, a combination of the hydrological system, land use and stakeholder interaction will be created based on the concept of flexibility. Hydrological, this is divided into four principles: water catchment, addition, retention and division (see figure 6). These principles will

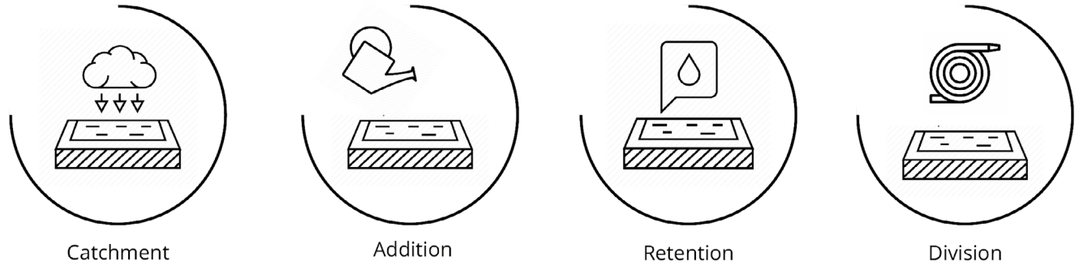

Figure 6: four principles to restore the balance of water supply.

restore the balance of water supply and demand in the area. In the toolbox in the appendix, these principles are translated into practical interventions.

Historical hydrological management

With these principles we also want to relate back to the historical use of water and landscape. Not in a way of 'the good old days', but we are inspired by the clever interventions and principles that were already used by the pioneering farmers in the Middle Ages. In the future we want to build on the good things that history has taught and brought us. Technical wonders from more recent history can also help us to reintroduce the flexible character of the Middle Ages in a contemporary setting.
Another important source of historical inspiration is the local scale. Working on the small scale, with local knowledge and shared responsibility with neighbors is typical for the medieval approach of farming and using water.

Barbapapa collaboration

What hasn't changed over time in the mosaic landscape is that there are still many different functions, many different landscape types and many different stakeholders bordering each other. These stakeholders work together, share resources and build on each other's strengths. A parallel can be drawn between this mosaic of different stakeholders and qualities and the popular tv show Barbapapa. Inspired by Winy Maas and his ideas of the barbapapa cities, we envision a Barbapapa landscape in Brabant (MVRDV Research, n.d.). Flexibility and fluidity are key concepts in this idea. It will be a landscape in which the qualities of each stakeholder and each landscape type will be recognized.

The Barbapapa concept stands for flexibility and collaboration. The debate between different stakeholders in the future will be: "who needs water?" and "who can provide water?". Keeping this conversation lively at all times means that in the future we can continuously adapt to the most suitable land use in specific situations.
Barbapapas keep their own color and therefore their own identity while changing shape. In this project, we recognise the importance of doing what you are good at and using each other's strengths. In some cases, this might translate to changing the means in your work, but the goal can stay the same: a farmer can still work on his land, but instead of producing cattle feed in the shape of corn, he can also change to a new crop like cattail; just like a barbapapa changes shape but keeps his own identity.

With this concept in mind, we can translate the old characteristic mosaic landscape into a modern flexible version: the flowsaic landscape; with renewing focus on the water balance, landscape qualities and local stakeholders. A combination of strengths of the historical mosaic landscape and the flexible approach of the Barbapapa concept.

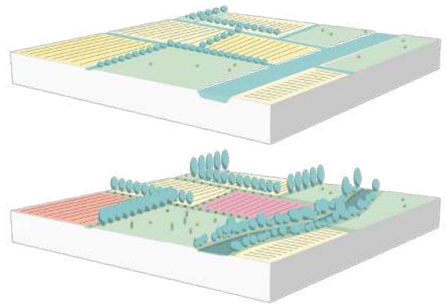

Figure 7: the change from the mosaic landscape to a flowsaic landscape, based on the historical landscape characteristics.

METHOD

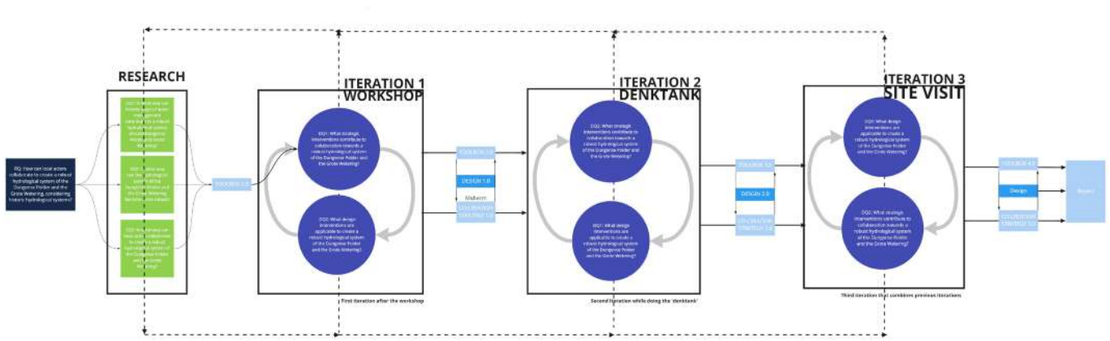

Figure 8 Methodology scheme

Within this Atelier project, we had two months to focus on the balance in water supply and demand in the Dungense Polder and the area of the Grote Wetering. To do so we raised the following research questions, focussed on collaboration, a robust hydrological system and historic hydrological systems:

Research questions

RQ: How can local stakeholders collaborate to create a robust hydrological system of the Dungense Polder and the Grote Wetering, considering historic hydrological systems?

SQ1: In what way can historic ways of water management contribute to a robust hydrological system around Dungense Polder and Grote Wetering?

SQ2: In what way can the hydrological system of the Dungense Polder and the Grote Wetering become more robust?

SQ3: In what way can local stakeholders collaborate to create a robust hydrological system of the Dungense Polder and the Grote Wetering?

DQ1: What strategic interventions contribute to collaboration towards a robust hydrological system of the Dungense Polder and the Grote Wetering?

DQ2: What design interventions are applicable to create a robust hydrological system of the Dungense Polder and the Grote Wetering?

Methodology scheme

The three sub questions were researched first, to get a grip on the material and get a sense of a possible outcome. The two design questions, linked to each other within the iterations, examined the possible spatial implications of a robust hydrological system. Several iterations took place, based on different collaborative activities such as: a workshop with students, a so called 'denktank' with stakeholders and a site visit to validate our outcomes. Every iteration gave new input for our sub questions. In between many separate interviews with stakeholders took place.

We started the project with an exploratory workshop, in collaboration with heritage students of the VU Amsterdam. This workshop made us quickly familiar with the area. This allowed us to explore options early on in the proces. This first iteration gave us a renewed focus on the research. The second iteration was our 'denktank', which we organised to learn from local experts. We presented a toolbox, based on the outcome of our ongoing research. Herein we discovered more and more the importance and key role of collaboration, next to technical solutions of a toolbox. To validate the outcomes of our interventions, we held a site visit where we visited different actors, as the last iteration.

Products

At the start of our research, we saw the outcome of a toolbox as the main product of our project. However, this shifted through the several iterations we made. We discovered that solely the technical solutions for the hydrological system are not sufficient and that there are a lot of solutions present already, but that they are difficult to implement. In order to solve the problem, collaboration is needed to finally implement these technical solutions. Therefore, our products of the toolbox, the collaboration strategy and the design of the cooperations function equally and coherently in this project.

Designing for places you haven't been

Within this project, we had the need to mainly work digitally. In order to get a grip on the region we were working on, we had intensive contact with several local stakeholders and experts. Besides the different iterations, we held several interviews. This resulted in a thorough understanding of the area, the mutual relationships and possible solutions.

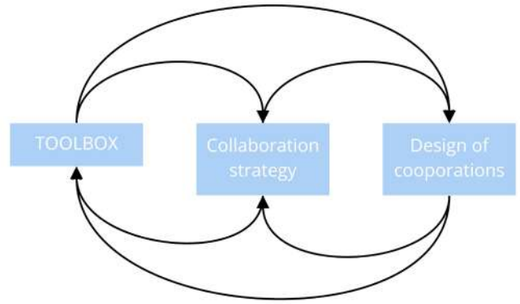

Figure 9 Products scheme

Workshop	Denktank	Site visit	Interviews	
Rob Brinkhof Commissioner	Rob Brinkhof Commissioner	Rob Brinkhof Commissioner	Rob Brinkhof Commissioner	Eric Brinckmann Landgoed Lankheet
Joeri de Bekker Landscape Architect	Joeri de Bekker Landscape Architect	Joeri de Bekker Landscape Architect	Joeri de Bekker Landscape Architect	Melle Nikkels PHD candidate
Tonny Steenbakkers Waterboard Aa & Maas	Tonny Steenbakkers Waterboard Aa & Maas		Tonny Steenbakkers Waterboard Aa & Maas	Michaël van Buuren Researcher WUR
Jan Willem Burgmans Waterboard Aa & Maas	Jan Willem Burgmans Waterboard Aa & Maas		Jan Willem Burgmans Waterboard Aa & Maas	Bertram de Rooij Researcher WUR
	Nico Miedema Dairy farmer	Nico Miedema Dairy farmer	Nico Miedema Dairy farmer	Hans Willems Historian
		Paul Verkuijlen Water board Dommel	Ernst Jan Melissie Waterboard Aa & Maas	Eddie Nijhof Archaeologist
			Erik Oomen Waterboard Aa & Maas	

Figure 10: Overview local experts we approached in our project.

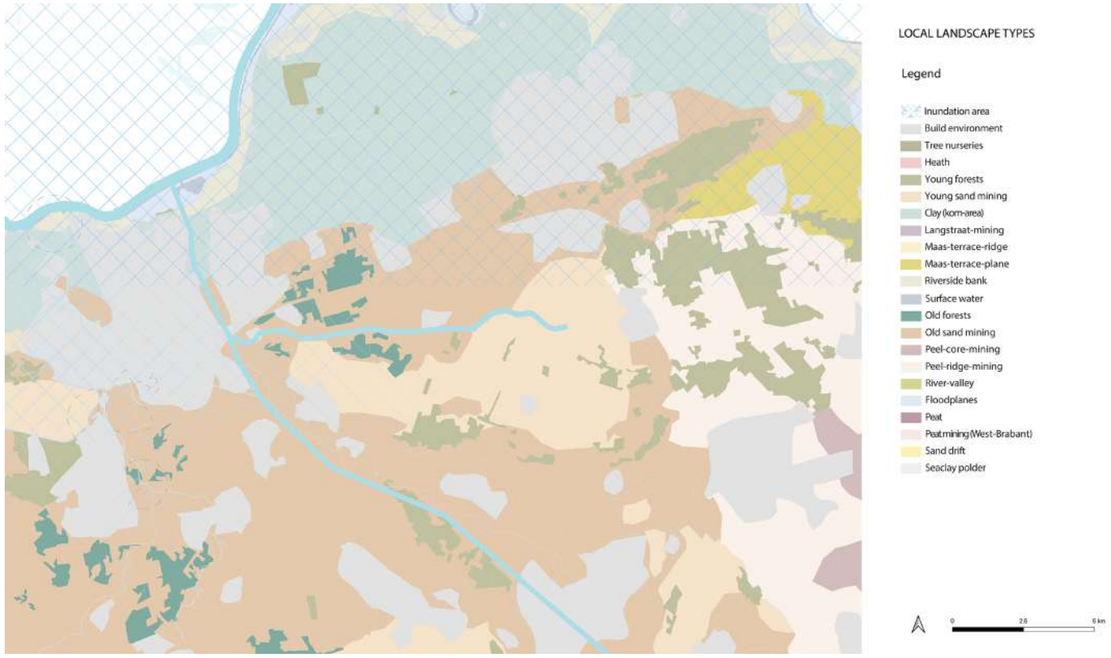

Figure 11: local landscape types (adapted from: Provincie Noord Brabant, 2010)

Position in the landscape

Historic ways of water management can be of inspiration for creating a robust hydrological system around the Dungense Polder and the Grote Wetering. Surprisingly the name Brabant is derived from 'Braecbant', referring to a 'broek', a wet and swampy area and 'bant', referring to a region (Onze Taal, 2020). The landscape of Brabant consists mainly of high sandy soils, interrupted by geological fault lines, which are named horsten and slenken. On these horsten, the higher parts, water infiltrates and in the slenken the water comes up as seepage (Brabant in zicht, 2020). The Peelrandbreuk, the geological fraction forms such an impermeable layer, wherethrough a special type of seepage is generated, namely wijst, creating the wijstgronden (Geologie van Nederland, 2020). The geological fractions are intersected by streams. The higher grounds in and along the stream valleys are called donks. These donks are the tops of the sand plateau, which rise out of the submitted river clay deck (Bijhouwer, 1971). A characteristic of the landscape of Brabant is the mosaic shape in which the land use is divided. Parcels of conifer forests on the higher sandy soils, interrupted by a fen, are neighbouring the slightly lower deciduous forests. Streams ran through the area and hamlets were built on the larger high donks. Agricultural activities arose on the more sandy soils.

Figure 11 shows the local landscape types of the research area. In the direction of the larger rivers - the Maas and Waal - the high and dry sand soil turns into low and wet clay. The city of Den Bosch is situated on this transition of the higher sandy soils and the lower clay swampy soils near the river Maas (Figure 12). The Romans already encountered this transition and came no further than the Maas, due to the inaccessibility of the swampy area up north (Joeri de Bekker, personal communication, June 5, 2020).

Southern Defence Line.

After the roman empire, the area around Den Bosch continued to play a major tactical role in the defence of the city and region through the Zuiderwaterlinie (Southern defence line) (Feddes/Olthof Landschapsarchitecten, 2014). In 1591 the city used inundation of the surrounding lower areas for the first time to defend herself; it turned out to be an excellent defence technique, proving Den Bosch' nickname 'Dragon of the swamp'. In 1629, the city was attacked by prince Frederik Hendrik. By making dams in the Aa and Dommel, the Spanish had flooded the surrounding

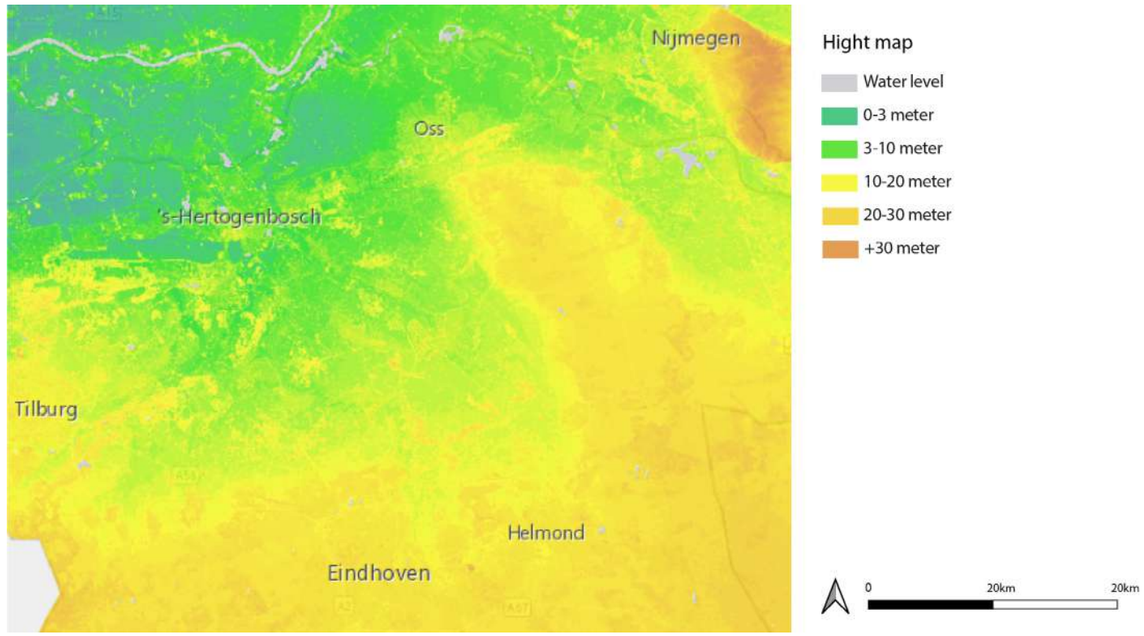

Figure 12: Height map that shows the delta position of the Den Bosch and the vicinity of the Maashorst (AHN, 2020).

areas of Den Bosch (Figure 13). As a counterattack, Frederik Hendrik, in collaboration with thousands of farmers, made a 50 kilometer long dike around the city and drained the area using rosmills. Via Vught he could now access the city and take control (Studio Marco Vermeulen, 2018). These local interventions became the inspiration for the Southern defence line, using water as a defence mechanism on a national scale.

Several military inundations together formed a line to keep the more northern provinces of the Netherlands safe. The southern defence line is the longest and most used water defence line of the Netherlands (Studio Marco Vermeulen, 2018). It stretches over the full width of Brabant, 1-4 kilometer in width, almost 200 kilometer long, located on the edge of sand and clay soil, the edge of high and low, dry and wet; the seam of Brabant (Figure 14) (Zuiderwaterlinie Noord-Brabant, 2020).

As the military inundation was imposed from above, the farmers in the area had to take part. However, the landowners still wanted to make use of their land. By digging more ditches in their plots, they made sure that whenever the inundation was not active, they could quickly discharge the water from their land (H. Willems, personal communication, June 29, 2020).

Figure 13: a painting by W.C. Staring, 1916, siege of Den Bosch (Van der Ven, 2017)

Figure 14 : Map of the Southern Defence Line (Zuiderwaterlinie Noord Brabant, n.d.)

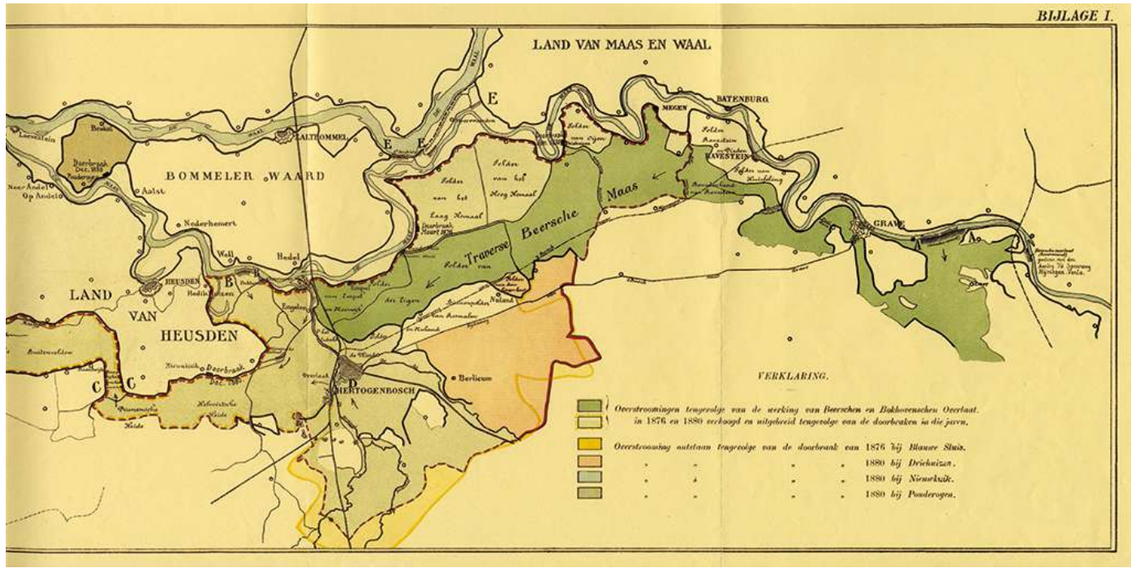

Figure 15: the location of the Traverse Beersche Maas (Willems and Steketee, 2013)

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Water management techniques

In this region of Brabant, south of the Maas, east of Den Bosch, water safety has been a topic of debate for a long time. Protection against the water took shape in roughly three ways: river dikes and city walls, which are still in function today; spillway systems; drainage channels (H. Willems, personal communication, June 29, 2020).

The spillway systems make use of the natural lows in the area. An example of such a spillway system is the Beerse Overlaat. This gave room to a surplus of Maas water (E. Nijhof, personal communication, June 16, 2020). Near the village of Grave used to be a lowering in the dike where the extra water could flow into the farmlands behind the dike. Via the so-called 'Traverse Beersche Maas', the water flowed across the lower farmlands in the direction of Den Bosch (Figure 15). Near the city, the water went into the Dieze, which runs off in the Maas again. When the water level in the Maas was still too high here, the water went further west to Heusden and Geertruidenberg (H. Willems, personal communication, June 29, 2020). This spillway system of the Beerse Overlaat could take the shape of a huge inland lake.

The farmers were partly satisfied with this spillway system, since the river water was very fertile. However, to continue working on the land, water discharge was needed (H. Willems, personal communication, June 29, 2020). In collaboration with several farmerers drainage channels were made, such as the Grote Wetering. However, during drier summers, the farmers did want to retain the water on their lands. They used to close the drainage sluices. This could be done since the water level of the Maas used to be lower than the water level in the farmlands during the summer (H. Willems, personal communication, June 29, 2020).

Besides this large scale intervention, farmers also made clever use on a smaller scale. Taking a close look at the natural conditions of their parcels, the farmers came up with meticulous systems of watercourses to influence the water flow. They used the technical solutions of weteringen, leijen, lopen and graven, adjusted to the qualities of their parcels (E. Brinckmann, personal communication, June 4, 2020). At this time, in the fifteenth century, groups of farmers started to manage their water collectively; this can be seen as the start of the Dutch water boards (T. Steenbakkers, personal communication, June 17, 2020). During the years, these collectives merged and in the meantime these organisations grew to a large scale with a lot of influence and power.

Regional development

This upscaling happened in different directions. In the aforementioned national plans of Sicco Mansholt, an elaborate land consolidation plan was spread over the country to enable and stimulate domestic food production (M. Kuijpers, personal communication, June 24, 2020). Areas such as the Dungense Polder, which used to be part of the swampy area of Bossche Broek, were drained (J. de Bekker, personal communication, June 5, 2020). Local differences were overruled by a general plan to save the country.

In this style, the landscape has been further developed. Technological development is accelerating, making water even more manipulable. Everything is arranged to drain the water as fast as possible. However In this time of ongoing climate change, this approach results in more and more water shortage in summer time (J. de Bekker, personal communication, June 5, 2020).

Balance of interest

When taking a close look at the development of this landscape on the east side of Den Bosch, one can recognise a shift in the balance of interest. On this edge of sand and clay, there is an urgency for water management. The position of Den Bosch on the sand ridge in the delta of the Aa and Dommel, with the Maas streaming close up north, makes the city vulnerable for flooding. But the city also used the water into her advantage; for trade and for protection. Fort Isabella, the Vughtse Lunetten and the Pettelaarse Schans in Den Bosch still show today how far the power of the city extended (Zuiderwaterlinie Noord Brabant, 2019). Some wet areas around the city are still present and in function, such as the area of the Moerputtenbrug and the Bossche Broek. However, some areas, such as the Dungense Polder and the area of the Grote Wetering, have changed greatly in both the land use and the hydrological system.

Collaborations suchs as they occured around interventions of the past, like the Zuiderwaterlinie, can be still beneficial on a smaller scale today. As long as the local qualities are carefully considered. Farmers together made clever use of the combination of the available technique and the natural qualities of their land to balance their water supply. This historical approach of water management might be reconsidered in future water challenges.

The general solutions in agriculture, water management and regulations, that were laid over the country in the past century, generate more and more disbalance in the water supply and land use. Modern demands are now being made on the landscape. As a result The change that seems necessary can not simply be imposed. An example of the resistance evoked by general regulations are the farmers protests of 2019 (Essink, 2019). Besides, farmers as land users know the qualities of their land the best. Small scale cooperations, who also have proven their success in the past, seem to be the future.

Figure 16: historical maps Grote Wetering (1900/2000) (topotijdreis, 2020)

Figure 17: historical maps Grote Wetering (1900/2000) (topotijdreis, 2020)

HYDROLOGICAL SYSTEM ANALYSIS

Figures 18: Grote Wetering near Vinkel *Josselin Snoek

The city Den Bosch is built on a sand ridge in the middle of the delta of the rivers Dommel and Aa. These rivers are rain-fed and therefore their water systems discharge a lot of water during wet seasons. In dry seasons, water is scarce. These Dommel and Aa merge in the Dieze which flows through the city of Den Bosch and runs off in the Maas up north. This position in the delta gives the risk of flooding, because when the water level in the Maas is high the water system around Den Bosch cannot get rid of the water (Eddie Nijhof, personal communication, June 16, 2020) . Therefore, water management is evident in this region. The area around the city has a complicated hydrological system. Water is provided through precipitation, seepage, groundwater, the rivers Aa & Dommel and man-made 'weteringen'. The streams on the higher sandy soils are dependent on rain water, which results in high variations of water availability throughout the seasons (T. Steenbakkers, personal communication, May 18, 2020).

Function of the Grote Wetering

During wet periods, the 'weteringen' like de Grote Wetering and the Leijgraaf discharge the water from the agricultural areas into the rivers in the area. After that, these rivers, the Dieze and the Drongelens channel discharge the water towards the Maas. However, during dry seasons, water becomes scarce in this system. Therefore, during dry periods, the water board makes sure that water from the Zuid-Willemsvaart will stream into the Aa. The water from the Aa is again used to pump water into the Leijgraaf and the Grote Wetering (Waterschap Aa & Maas, 2020). So, the area around the Grote Wetering has an artificial dependency on the water of the Aa during these dry periods.

Seepage

Besides that, the area around the Grote Wetering is characterized by seepage coming from the Maashorst. Especially at the 'Peelrandbreuk' this seepage reaches the surface (J.W. Burgmans & T. Steenbakkers, personal communication, June 4, 2020). Because of these fractions the water level there is pushed up to the soil surface. Even during dry periods, the water levels there are very high. However, below these fractions, the groundwater level is significantly lower (see figure 19), which results in high varieties of groundwater availability in a small area (Jongmans, Van den Berg, Sonneveld, Peek, & Van den Berg van Saparoea, 2013).

Seepage currents have a special water quality, because they are low in oxygen and ferrous. These conditions make seepage really suitable for special types of flora, but less suitable for irrigation of agricultural land, because the iron gets attached to the leaves and hampers photosynthesis (N. Miedema, personal communication, June 10, 2020).

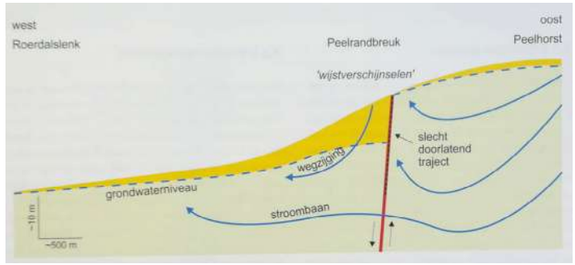

Figure 19: Seepage currents at the Peelrandbreuk (Jongmans, Van den Berg, Sonneveld, Peek, & Van den Berg van Saparoea, 2013; p. 128)

Maashorst

The Maashorst is the main source of these seepage currents, because on this higher 'horst' water can infiltrate and reach the lower and deeper groundwater layers. This is important for seepage in the area, but also for water extraction by Brabant Water and some larger groundwater-depending businesses (J.W. Burgmans & T. Steenbakkers, personal communication, June 4, 2020). However, the Maashorst has become dryer over the years due to agriculture that takes place there. So, the availability of groundwater is decreasing (E. Oomen, personal communication, June 3, 2020). However, this infiltration function can be restored in both natural and artificial ways. For example by limiting groundwater extraction by farmers at the Maashorst, or by pumping water from the Maas into the Maashorst, which is inspired by project 'The Nationale Gieter' at the Veluwe (Deltares, 2020).

Figure 20: Dungense Polder *Josselin Snoek

Dungense Polder

At the Dungense Polder seepage does not have a large effect on the hydrological system, so the hydrological system mainly depends on precipitation and surface water. The excess water in the area streams into the Dommel via the 'Segersgemaal'. The hydrological system at the Dungense Polder is designed for wet conditions. However the modern agriculture demands on the land require that more water is drained into the Dommel than the system is designed for. (P. Verkuijlen, personal communication, June 29, 2020). Namely, originally the Dungense Polder was to a large extent part of Bossche Broek. Furthermore, it functioned as a floodplain, being part of the Southern Water Defense Line. So, at the moment, there is a mismatch between the land-use and hydrological system.

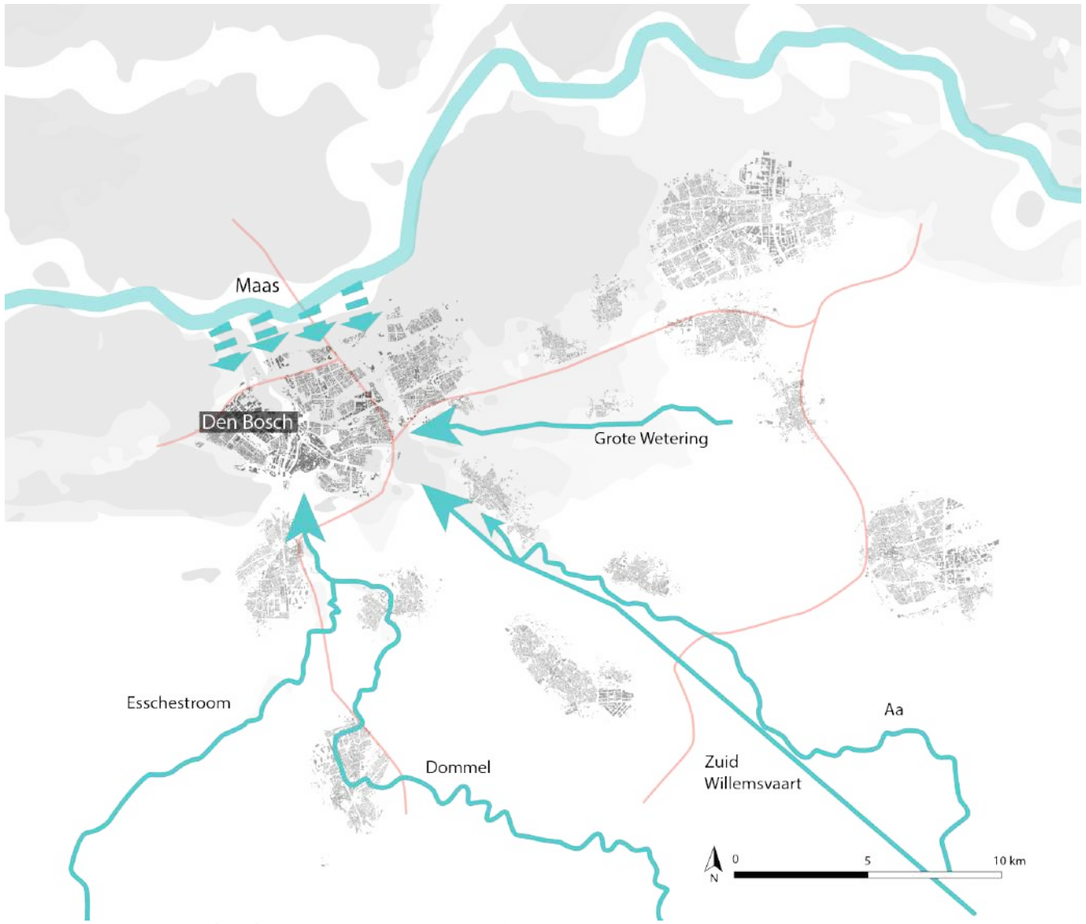

Figure 21: main sources of surface water around Den Bosch

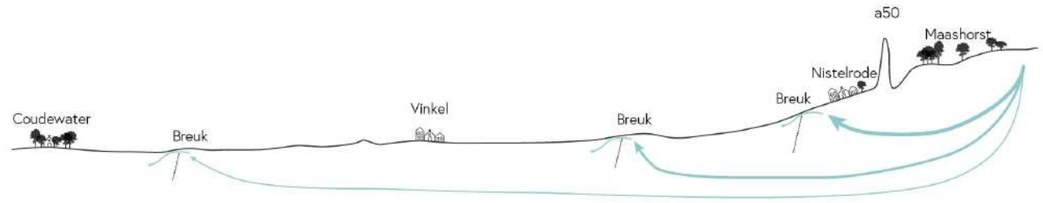

Figure 22: Visualisation of the seepage current coming from the Maashorst

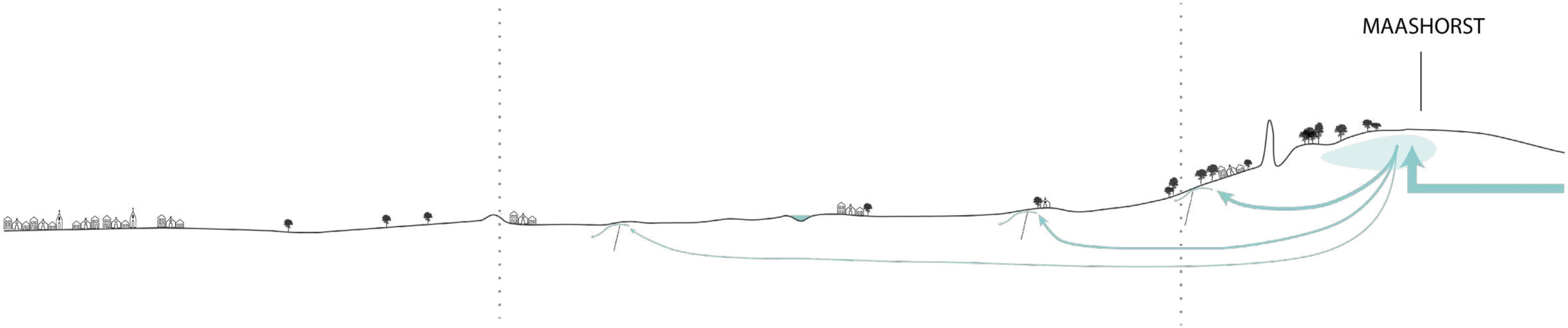

Figure 23: Visualisation of the seepage current coming from the Maashorst

STAKEHOLDER ANALYSIS

Beside the land use and the hydrological system, one of the main aspects of our vision is the collaboration between stakeholders in the area. This chapter will analyse which stakeholders are present and which interests they have. To do this, a 'stakeholder quadrant' is used, that separates stakeholders based on their role and level of involvement.

Interests

The stakeholders that have been defined are:

Water board Aa en Maas & water board De Dommel
The water boards manage the hydrological system in the area. They control water levels, hydraulic structures, water quality and availability. The water board consists partly of elected members and partly of appointed members from the various interest groups. Water board Aa en Maas is responsible for the Grote Wetering and water board De Dommel is responsible for the Dungense Polder.

Brabant Water
Brabant water is the drinking water company of Brabant. So its aim is to have a guaranteed availability of good quality drinking water.

Farmers
The interests of the farmers are focussed on food supply and a financially stable business. When it comes to water, they now have little to arrange for it, because the water board in particular bears the responsibility that they have enough water during the summer and that water is discharged during the winter, to create optimal conditions for farmers crops.

Brabants Landschap
Brabants Landschap is focussed on the quality of nature and recreation.

Dutch Government
The Dutch government is responsible for national policies regarding amongst others public space, water management and environmental quality.

-Recreational entrepreneurs
Recreational entrepreneurs are interested in an environment that attracts tourists, because it is beneficial for their enterprises and income.

Residents
Residents want a nice and safe living environment. They expect that the municipality and water board will make sure that they do not experience flooding or severe droughts.

Groundwater extracting companies
Companies that extract ground water make use of the deep groundwater layers. Their main stake in this project is secured ground water availability. One specific example in this area is Heineken.

Province of North Brabant
The Province of North Brabant makes decisions related to spatial policy on the transboundary level, protects nature and enforces environmental laws.

Municipalities
The municipalities in the region want to create a nice and safe living environment for their inhabitants. They are responsible for urban water.

Industry
The industry creates employment in the area. Requires good infrastructure and the availability of resources.

ZLTO
The Zuidelijke Land- en Tuinbouworganisatie is an organisation of farmers and growers that protects their interest in the area.

Rijkswaterstaat
Implementing organization of the Ministry of Infrastructure and Water Management. Responsible for the main water bodies like the Maas.

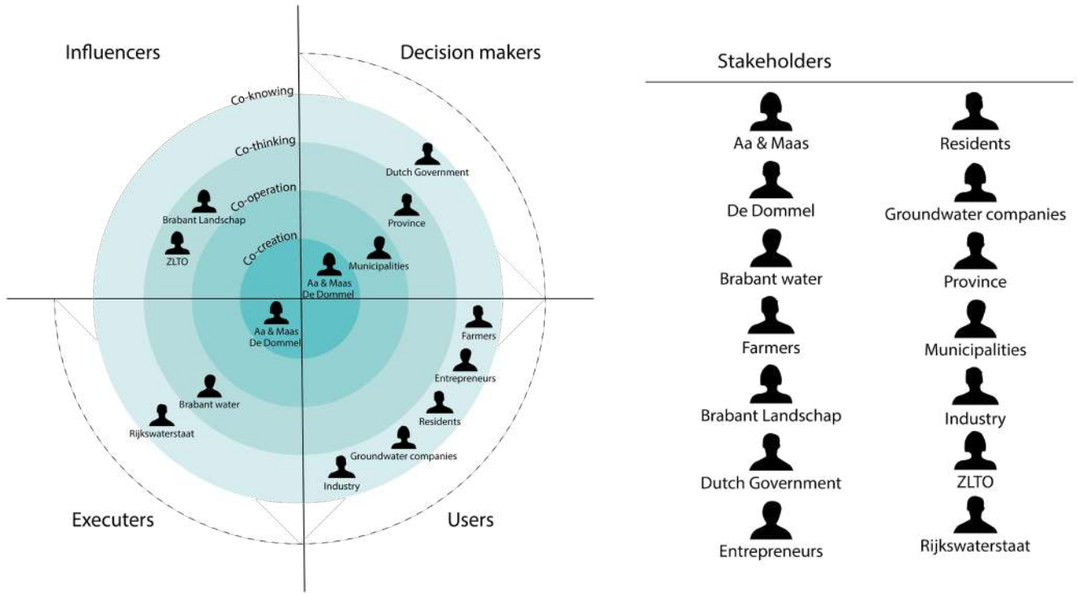

Figure 24: Stakeholder quadrant

Role/involvement

It is a diverse group of stakeholders. Not all of these stakeholders have the same role and position in the process. In order to further zoom in on these roles and positions, a stakeholder quadrant has been drawn up in which the current role and position is shown.

The quadrant is primarily characterized by four planes. These distinguish themselves as: Influencers, Decision makers, Executers and Users. We then distinguish four levels of involvement within the quadrants, namely: co-knowing, co-thinking, co-operating, co-creating.

What is striking in the quadrant is that it is mainly the water board that takes responsibility and that makes decisions. While there is a large group of users who are on the edge of the quadrant, who bear little responsibility and who actually benefit from the current situation.
Over time, a situation has arisen in which the water board meets the demand from users. Until now, this has always gone well and the water demand corresponded quite well with the water that the water board could supply. As a result, users do not always feel the urgency of increasing drought. Farmers and groundwater extraction companies in particular have benefited for years from the good care provided by the water board.

PARADIGM SHIFT

Our vision to create a robust hydrological system is based on flexibility and collaboration, with the focus on local scale. However, looking at the analysis there are some challenges that will need further attention.

From an historic point of view the link with local circumstances seems lost. Production capacity is the main driver of the contemporary landscape and the hydrological system is shaped to serve this function. However, this causes a bigger and bigger mismatch between the hydrological system and the current land use. The waterboards have grown into regional scale businesses, which do not have the capacity to look at the capillaries of the system (Tonny Steenbakkers, private communication, June 17, 2020). On the contrary, the farmers have an expert view on these parts of the system; they have the local knowledge. Collaboration is an important driver/factor in this process: joint responsibilities instead of a clear division between providers. This will create mutual understanding and the ability to profit from each others' knowledge.

Responsibility can only be divided if the view on water management changes. Nowadays water is seen as a resource where the water boards will take care of. However in order to create shared responsibilities a shared view on the scarcity of water and its increasing value is needed. If you want water in the future you should also contribute to the system to manage supply and demand, because water is the fundament of land development.

However, we will not reach a robust hydrological system only based on local collaboration. A paradigm shift on a national or even transboundary scale is needed as well. Due to all strict regulations farmers need to fulfill, it is hard for them to adapt their land use to a more robust hydrological system (P. Verkuijlen, personal communication, June 22, 2020). On a national scale regulations have to become more flexible, so farmers have the ability to match their land-use with the local hydrological system. This flexibility on a national scale is needed to create regulations that suit the features of the landscape and the natural hydrological system on a local scale. No national generic 'one size fits all' solutions, but custom made solutions (B. de Rooij, personal communication, June 29, 2020). Examples of these custom made solutions are crop rotation, adding multifunctionality into a farmers business or experimenting with innovative water solutions.

Collaboration will take place on a local scale by sharing local knowledge. Shared responsibility will be created by bringing people together on a local scale, which will shape their view on water. Thereafter steps can be made towards regulatory and spatial change and ultimately a robust hydrological system.

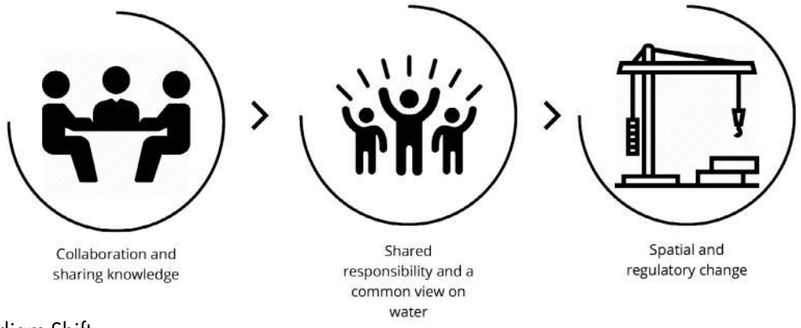

Figure 25: Paradigm Shift

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COLLABORATION STRATEGY

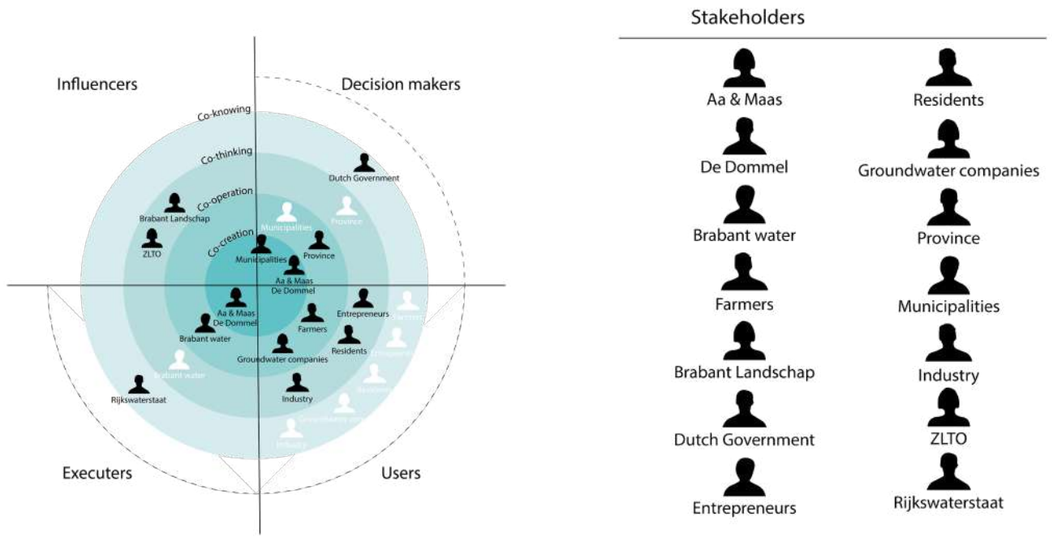


Figure 26: the new roles of local stakeholders as a result of the collaboration strategy

Our vision is to create a robust hydrological system for 2050. Important aspects of our vision are joint responsibility and collaboration between stakeholders. Stakeholders should not only know about problems, they have to be actively involved in trying to find solutions and applying tools that can be used. Collaboration is a core value. This will be a long haul process, with different iterations to ensure a broadly based approach with the support of all stakeholders.

Shared responsibility

Nowadays the water boards are responsible for the hydrological system while many other stakeholders make use of it. However, in 2050 this might not even be possible anymore. The hydrological systems at the Grote Wetering and the Dungense Polder are namely already complicated systems based on water pumping, sprinkling and artificial water supply by the Grote Wetering. These systems now serve the land-use in the area, but they are not robust enough to deal with climate change. This will have large consequences for many interests and especially agriculture. So, there is a need to share this responsibility and make users part of a new strategy to develop a robust hydrological system. They have to start co-thinking and co-operating to guarantee a match between water supply and demand in the future.

Therefore, we propose local systems, cooperations, that are based on the small scale water management back in the days. This is actually a contrary response to the trend of the last couple of years where the amount of water boards decreased and water was handled on a larger and larger scale. Due to this increasing scale, the water board is no longer able to manage the small details of the systems. However, this small scale plays an important role in these complex hydrological systems.

This local scale has to be re-appreciated to be able to work together and use local knowledge as an input for finding solutions to make this complex hydrological system robust. The intended co-operations are quite similar to the water boards in the late Middle Ages, when the water boards were just groups of farmers who worked together and had a close connection with the hydrological system.

Cooperation typologies

Based on the types and details of landscape in the area and the tools that can be used there, three general types of cooperations can be defined: urban cooperations, rural cooperations and a groundwater cooperation. These cooperations all represent different stakeholders and have different aims. Finally, a fourth, regional cooperation is created, which forms the foundation and connection of the other cooperations (see figure 27).

Rural cooperations

The rural cooperations aim to meet the water needs of The rural cooperations aim to meet the water needs of farmers and growers. The water requirement can differ for each farmer. Dairy farmers have different water needs than for example asparagus growers. The main stakeholders in this cooperation are farmers and the water board. Other stakeholders, with a smaller role, are Brabants Landschap and the municipalities. Together, these parties have to collaborate within this cooperation

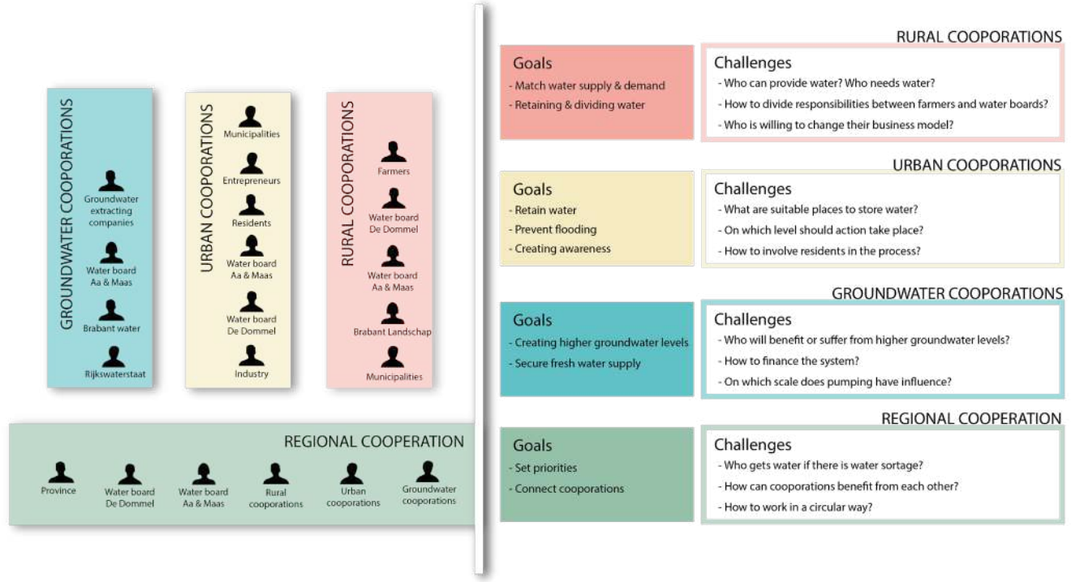


Figure 27: overview of the different cooperation types.

to ensure good water management that fits their needs. Retaining and distributing water are the main challenges and responsibilities of those co-operations. Strategies of the different cooperations may vary from place to place, depending on the local conditions of the landscape and the local land use. Because of the shift of responsibilities from the large water board to a more local scale, the water board will initiate this cooperation, but the process will have to be taken up jointly by the various parties.

Urban cooperations

Urban cooperations are focussed on the liveability in the cities and villages by preventing flooding and retaining water in the neighbourhoods. The stakeholders that work together in an urban cooperation are the municipality, citizens, local businesses and the water board. Together they make plans on how and where to retain water and start initiatives to create awareness amongst citizens. The municipality and the water board will initiate these cooperations, but it will also be a place for citizens and local businesses to come up with their own bottom-up initiatives.

Groundwater cooperation

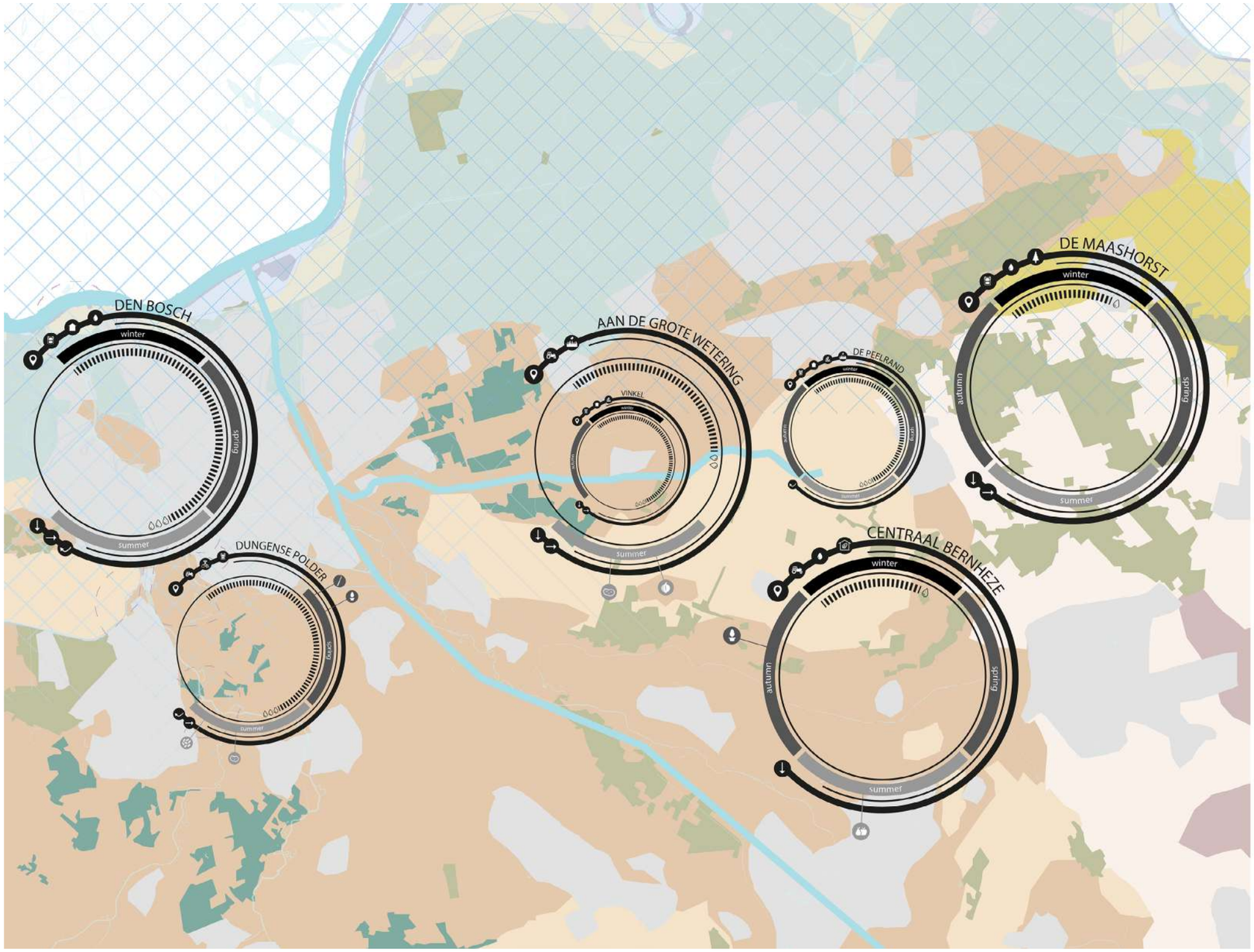
The groundwater cooperation will be a collaboration of large regional stakeholders that are involved in and benefit from pumping water into the Maashorst. They all depend on the availability of sufficient groundwater, so together they can finance and manage this new system. Water Board Aa en Maas will initiate this cooperation that also exists of Brabant Water, large businesses that extract groundwater (a.o. Heineken) and Rijkswaterstaat. Rijkswaterstaat does not benefit from this system, but has to be involved, because the water has to be transported from the Maas to the Maashorst.

Regional cooporation

Collaboration within the cooperations is necessary, but collaboration is also necessary between the various cooperations. An organized regional cooperation will form a base and must build a bridge between the water demand and water supply of the various cooperations and set priorities in case of major water scarcity. Water from one cooperation could, in a circular way, be used by another cooperation. For example, urban water could be used by the rural cooperations at certain times if the urban water supply is higher than the urban water demand.

In addition to the various cooperations, large parties such as the province are involved in this regional cooperation. This is in line with the large scale on which this cooperation is focussed. The questions that constantly have to be asked on this scale are: who needs water and who can provide water?

Figure 28: Location of the cooperations around Den Bosch



COOPERATIONS INCL. LANDSCAPE TYPES NORTH-BRABANT

Legend

Functionality
- Location
- Agricultural land
- Horticultural
- Vegetable gardens
- Grassland (natural)
- Residential
- Retaining rainwater
- Recreational
- Nature (wet)
- Nature (dry)

Water Quality
- Seepage
- Percipitation
- Surface water

Water Quantity
- Low
- Medium
- High

Landscape Elements
- Inundation area
- Build environment
- Tree nurseries
- Heath
- Young forests
- Young sand mining
- Clay (kom-area)
- Langstraat-mining
- Maas-terrace-ridge
- Maas-terrace-plane
- Riverside bank
- Surface water
- Old forests
- Old sand mining
- Peel-core-mining
- Peel-ridge-mining
- River-valley
- Floodplanes
- Peat
- Peat mining (West-Brabant)
- Sand drift
- Seaclay polder

Seasonality
- Winter
- Spring
- Summer
- Autumn

Distinctive Crops
- Rice
- Asparagus
- Potatoes
- Onions
- Orchards
- Tree nurseries

0 2.5 5 km

Figure 29: Location of the cooperations around Den Bosch

In addition to the various cooperations, also large parties such as the province are involved in this regional cooperation. This is in line with the large scale on which this cooperation is focussed. The questions that constantly have to be asked on this scale are: who needs water and who can provide water?

Cooperation Design

In the hydrological system of the area in 2050, we aim for water catchment, addition, retention and division. This implies a number of interventions. The Grote Wetering will not be fed with extra water anymore. Furthermore, the Grote Wetering and the Leigraaf will not be in connection anymore. The Grote Wetering will act like a distributor, rather than a discharge or supplying channel. Because of this, the hydrological system has to be supplemented by strong groundwater flows and water catchment and retention. Cooperations can take responsibility of the capillaries of this system.

Different types of cooperations have their own place depending on landscape features. Attention has been given to local qualities of the landscape. An urban cooperation is founded in the city of Den Bosch. On a larger scale, the groundwater cooperation will be focused on the Maashorst. As can be seen in the section (Figure 23), this cooperation is of great influence to the other cooperations, due to the seepage it evokes. The bigger rural area will be divided into several rural cooperations.

In our elaborate contact with local experts and stakeholders, we recognised the importance of local knowledge. Therefore spatial integration of the interventions are in the hands of the participants of the cooperations. This cooperation design can function as a perspective for the future. Through this design, we explain the preconditions on which the cooperation can be formed. These preconditions are constructed by the characteristics that define the hydrological system and land use of that area.

Functionality: With functionality the main functions of these cooperations are defined, based on the landscape characteristics and surrounding facilities. Different functionalities can complement each other in contributing to a robust hydrological system.

Seasonality: With seasonality the question is: "When does the cooperation need water?" This is an important question to determine the water source and type of water storage. It is about fitting the water supply and need together. When agricultural fields need water in summer, a cooperation has to store water in advance, when there is water supply (winter, spring) in order to fulfill the need in the summer.

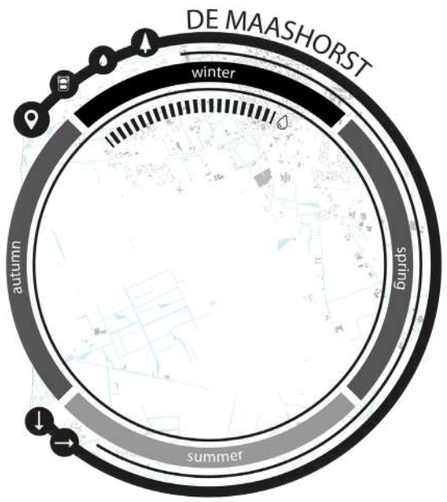
Water quality: Is based on the type of water that is available. Seepage water is more suitable for natural development while surface and rainwater is a valuable water source for agriculture. Water quality defines the functionality of the cooperation.

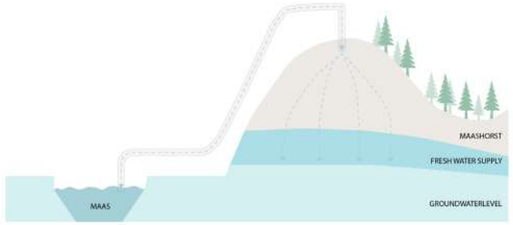
Water quantity: The quantity of water is about the amount of water. This has implications for the land use. When there is not much water available and the groundwater levels are low, there is the risk of droughts. When there is a lot of water there is the risk of flooding. For example, grassland could be more suitable in an area with a lot of water.

Distinctive crops: With distinctive crops, an indication is given about the type of farming that is suitable within this cooperation. Not all farmers should yield these crops, they could also contribute to the cooperation in another way. Surrounding farmers could for example store water to supply the crop growing farmers when they need water.

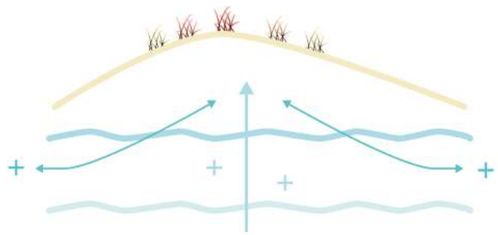
Maashorst

The cooperation of the Maashorst is a special kind of cooperation because it focuses on the larger hydrological system, with infiltration on the Maashorst and seepage in the deeper groundwater flows. Nowadays big companies such as Heineken make use of these deep layers. Moreover, Brabant Water has an interest, since it is using the deeper groundwater flows for drinking water supply. However even these deep groundwater layers will suffer from droughts in the long run. Therefore the stakeholders that are using these layers should collaborate in order to contribute to a robust hydrological system, especially in these invisible layers. To guarantee this groundwater supply, a pumping system has to be realised from the Maas to the Maashorst, where the water can infiltrate (as explained in the Toolbox). Because these stakeholders profit from the water that is pumped into the Maashorst, they should invest in this pumping system in order to have access to the deep groundwater layers. With this investment, they also gain a share in the decision making. Furthermore, current draining measures will be reduced by investing in restoring the historic wet character of the area.





Tool: Pump water out of the Maas into the Maashorst



Tool: Restoring the old function of the Maashorst as higher wet area

(VisitBrabant, n.d.-a)

(VisitBrabant, n.d.-b)

(Schook, n.d.)

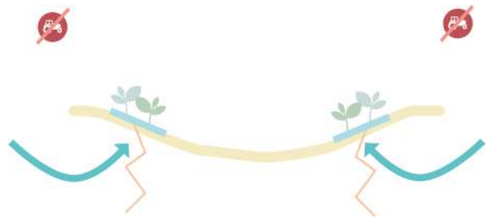
Peelrandbreuk

The Peelrandbreuk is a cooperation which reintroduces a unique piece of nature combined with historical water management in a region that is now dominated by intensive agriculture. Because of the fault lines the area around the Peelrandbreuk is characterized by high varieties in ground water levels. Above and around the fault lines, seepage water reaches the surface, creating the special 'wijstgronden'. This phenomenon will be stimulated by the intervention of adding water into the Maashorst.

Seepage water is iron rich and can facilitate nature development such as wet meadows (blauwgraslanden) which will increase the biodiversity within the region. Moreover it creates the opportunity to combine nature development with recreational functions such as walking and cycling.

The plots below the fault line will be used for natural grassland. These areas are mainly dryer because of the low ground water level. Farmers can use a combination of rain water and the available seepage to irrigate these plots in a historical way. Because of this continuing flow of seepage, these grasslands will become less vulnerable for droughts. Implementing these ancient characteristics of seepage again will result in a new and multifunctional area, making it attractive for both farmers and tourists.

Tool: Historical irrigation system (Bevloeiing)



Tool: Nature as a sponge and water divider in the region.

(Nederlandse Heidemaatschappij, n.d.)

(De Potter, 2020)

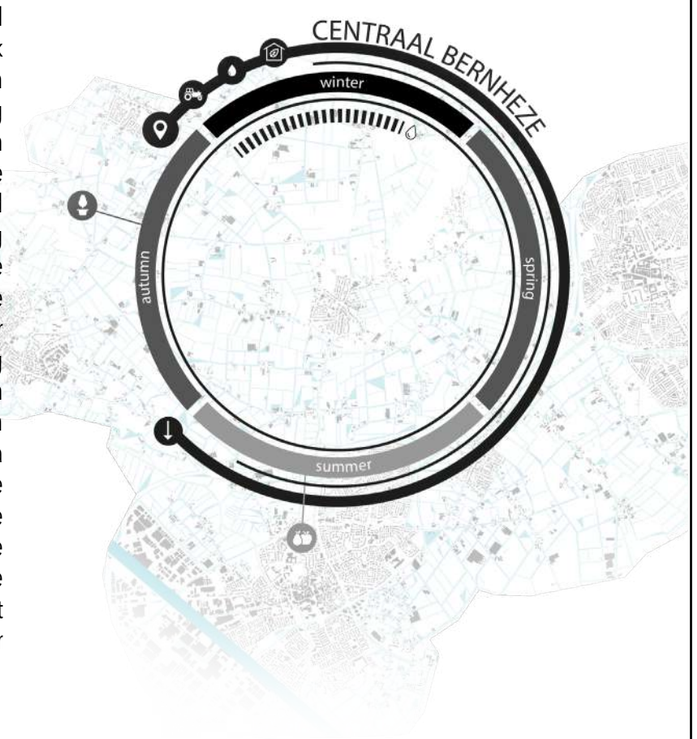
(De Groot, 2014)

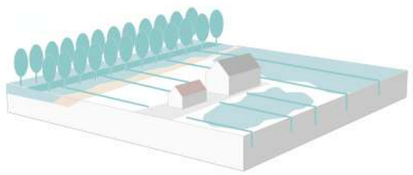
(Duijf, 2020)

(Kenniscentrum Immaterieel Erfgoed Nederland, n.d.)

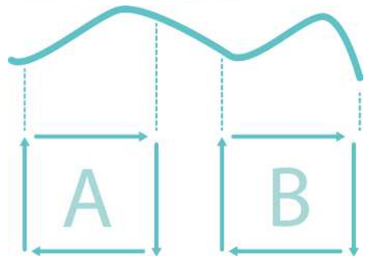
Centraal Bernheze

Centraal Bernheze is an area that is not connected to a canal or stream. The intervention at the Maashorst will increase groundwater levels in the area and will work out favorably here. Moreover, this region has to rely on rainwater as their source of water. Catching and retaining this rainwater is key for the region. This corresponds with the paradigm shift of treating water as a scarce source. The catchment and distribution of rainwater will be regulated with a waterfarm. This farm is responsible for retaining water and distributing it to the surrounding farmers. The farmers have to invest in the waterfarm in order to assure water supply on their lands. In return, the waterfarmer who gave up his farming land, can make profit by selling water. An adjacent farmer can join and collaborate with the waterfarmer by setting up a distribution system on its own land or retain extra water, in this way he can get a share of the collective water management investment. The cooperation of farmers and waterfarmers are responsible for their own, local water management resulting in more involvement in the hydrological system. Because the cooperation is responsible for their own water management they can independently decide to innovate and share their experiences with surrounding cooperations.





Tool: Waterfarm



Tool: Local (parallel) hydrological systems

(Waterschap Aa en Maas, n.d.)

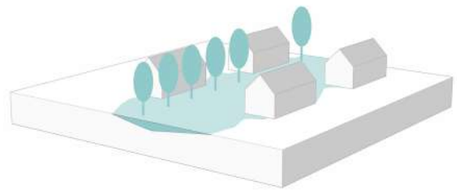
(Waterschap Aa en Maas, 2018)

(InnovatieNetwerk, 2009)

Vinkel

This cooperation mainly connects the Grote Wetering with Vinkel by creating water storage for the surplus of water from the Grote Wetering. This water storage will decrease the risk of flooding the surrounding area. Moreover this water bassin can serve recreational use by providing walking and bicycle paths. In winter there can be ice skating and residents can go fishing. This storage of the water surplus gives a possibility for nature development. On and around the water housing development takes place, enabling residents to live at an unique spot along the water. The recreational, natural and residential functions can substitute the lost value of the agricultural land and even increase the value through the multifunctional use.

Tool: Citizen initiative



Tool: Combining water retention with living and recreation

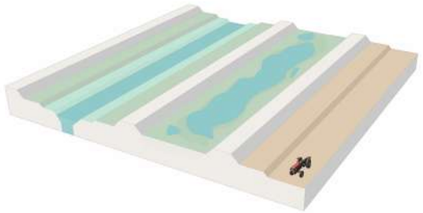
(Frans Commandeur Tuinontwerpen (n.d.))

(Fotobank NA (n.d.))

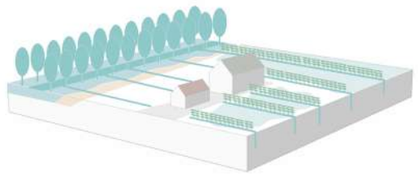
(J. Leenes, januari 31, 2020).

Aan de Grote Wetering

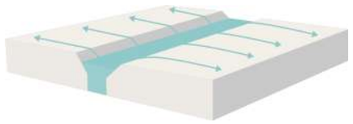
Distinctive crops: Vegetables such as potatoes, onions. At Many agricultural fields are located along the Grote Wetering. Nowadays they use the Grote Wetering as a water source to sprinkle their land. However with extreme weather events water is quickly discharged through the Grote Wetering. While in summer this water could have been useful to sprinkle the agricultural land. In this cooperation farmers work together creating a hydrological system focussed on retaining water that nowadays is discharged in and around the Grote Wetering. The water demand in summer will be fulfilled by retaining water supply in winter and spring. Each farmer can decide to invest a part of their land in retaining water on or under surface level in combination with wet agriculture. The different water plots will be connected to each other. This enables farmers to exchange water. The farmers will therefore manage the capillaries of the hydrological system. This shared responsibility results in more involvement and collaboration among farmers.



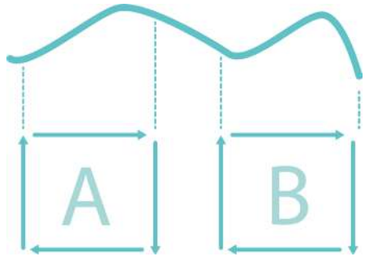
Tool: Creating inundation and emergency zones



Tool: Wet agriculture



Tool: Grote Wetering as a divider



Tool: Local (parallel) hydrological systems

(Buitendijk , 2018)

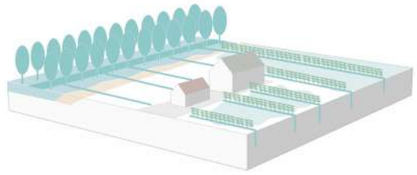
(Asmussen, 2020)

Dungense Polder

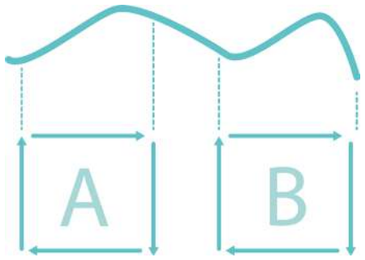
The Cooperation of the Dungense polder was formerly known as the 'kitchen garden' of Den Bosch. Moreover it has been part of the Southern Defence line as an inundation zone. The military infrastructure enabled controlled flooding of the land. This controlled flooding can be re-introduced, in order to protect Den Bosch from flooding and to provide the agricultural fields with water.

This is an interesting possible development, since (fresh)water will become scarce and valuable in the future. Due to its location and functionality, Den Dungen becomes the ultimate location for innovation and experimental agriculture. A future crop suggestion could be rice, increasing the profit of this wet land by multifunctional use. This creates the opportunity to show the importance of incorporating water management in the farmers' business model. Furthermore crops that could make use of the wet fields are asparagus which need water at specific moments.

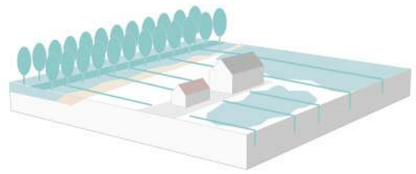
The municipality of Den Bosch will also be part of this cooperation and contribute to the development of the Dungense polder, since the municipality owns ground in the polder. Moreover collaboration between the farmers of the Dungense polder and the municipality can attract people from the city to the Dungense polder to learn about food production and buy local products. This will give an impulse to the recreational function of the Dungense polder.



Tool: Wet agriculture



Tool: Local (parallel) hydrological systems



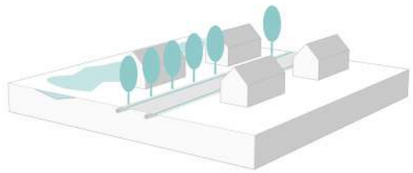
Tool: Waterfarm

(R. Steenwinkel, september 30, 2016)

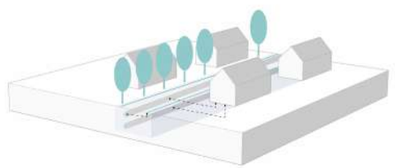
(Proeftuin Krimpenerwaard (s.d.))

Den Bosch

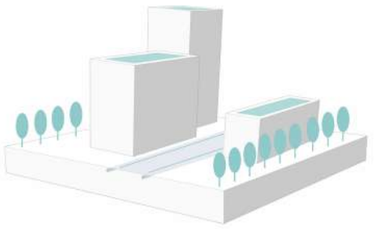
All cooperations mentioned above take interventions to protect the city from flooding. However the Den Bosch itself also has and wants to take responsibility. Due to the interventions of the other cooperations, less water will flow to the city but she also has to deal with more extreme weather. The hydrological system in the city needs to become more robust by reducing paved surface and enlarging water catchment areas. These catchment areas can take the shape of places where water can infiltrate or be stored for a while, such as wadi's. The municipality is a big stakeholder in this cooperation. However, only with thorough engagement and initiatives of the residents a robust system can be enhanced. Residents can come up with interventions for their own property and discuss them with the municipality to collaborate and get finance. They can also submit proposals for interventions the municipality can take and participate in decision making. In this way a fluid partnership can emerge between the residents and the municipality, where responsibility is taken and collaboration takes place.



Tool: Using Wadi's to store rainwater in urban areas



Tool: Separate sewage system



Tool: Collecting rainwater on roofs and rainwater-tanks

Tool: Citizen initiative

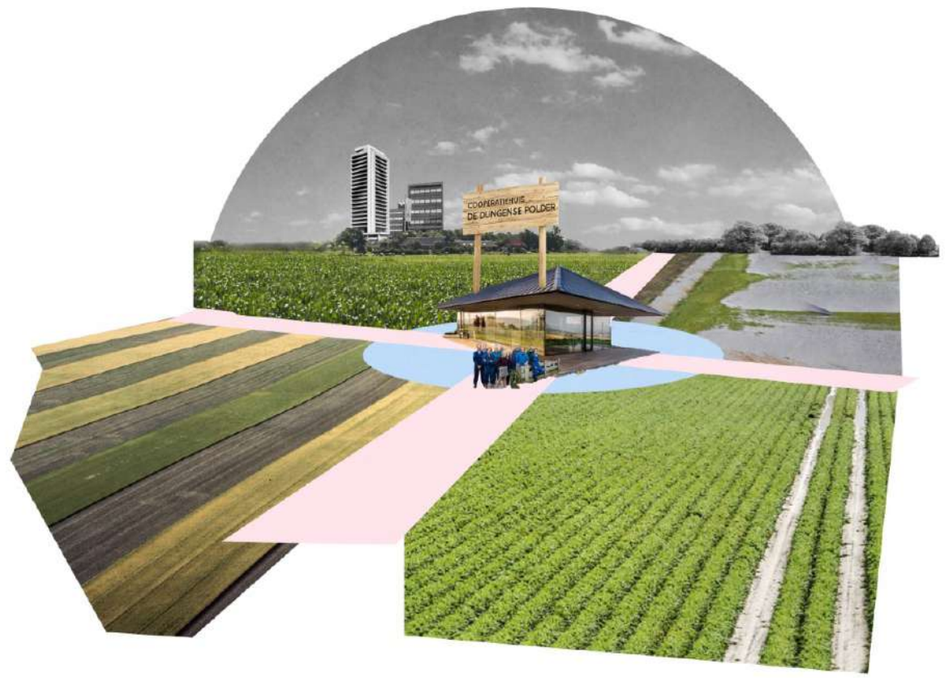
(Forten.nl, n.d.)

(Forten.nl, n.d.-a)

(Architectenweb, 2015)

(Waterschap Vechtstromen, n.d.)

(JML, 2005)



CONCLUSION

Collaboration is an essential, but often missing element in hydrological plans. With our strategy, we aim to add this new layer to the already available hydrological tools and plans in the area.This report provides a strategy on how the stakeholders in the area of the Grote Wetering and Dungense polder could collaborate towards a robust hydrological system. Central elements to this strategy are based on the Barbapapa concept: being flexible, collaborative and at the same time robust.
Flexible in terms of providing / using water and land-use. Collaboration translated into several cooperations that work together to manage their water. With the final goal of creating a robust hydrological system that uses both history and innovation to match the water supply and demand.
The collaboration strategy is the fundament of the three elements. It explains the social and physical preconditions on which cooperation can be formed. Based on this proposition, local experts and stakeholders can start several types of cooperations and take responsibility for the capillaries of the hydrological system. This focus on the local qualities makes the approach robust and flexible, answering to the challenges that this region of Brabant is facing.

DISCUSSION

These eight weeks allowed us to talk to many stakeholders in the area and gave us a lot of insights in both the landscape qualities and problems at stake. Because of this online situation, our project is almost entirely based on the perspective of these stakeholders, instead of our own landscape architecture or spatial planning bias. With this different approach we were able to incorporate a lot of local knowledge. Especially our organised 'denktank' gave us a lot of insight in the dynamics between stakeholders.
So, even though we were not able to visit and get very familiar with the area, we did also benefit from this situation. This unique online situation made clear to us that the key to a successful project can be found in collaboration with and between stakeholders. Therefore, we did not make a masterplan, but instead a strategy that allows stakeholders to collaborate and create their own robust region.

So, this report must be seen as one of the first steps in an ongoing process. As already mentioned we do not describe the final design, but we marked a dot on the horizon. Further steps can be taken by testing and evaluating one of the suggested cooperations.
To do this, a clear overview should be made of how the new hydrological system could look like and how this influences both water supply and water demand in the region. Exact numbers are needed to make sure that the intended interventions will restore the balance between supply and demand and consequently lead a robust system. Furthermore, these numbers can give insight in the role that a stakeholder can play in the system, for example as a water provider.
These numbers can also be used as an input for research on the financial costs and benefits for the several stakeholders, especially the farmers. As they are highly dependent on the financial aspects as well, it will be more likely that they will contribute when the project has financial benefits.
Moreover, the social structures could be further researched in order to realize optimal collaborations. Examples could be mutual communication, the structure of a cooperation and shared responsibility. This is a useful addition to our project because collaboration is fundamental in the construction of the new hydrological system.

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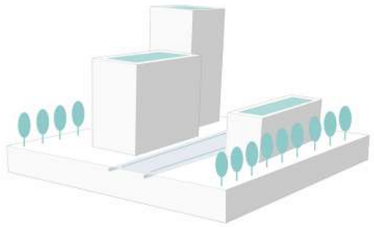
ANNEX

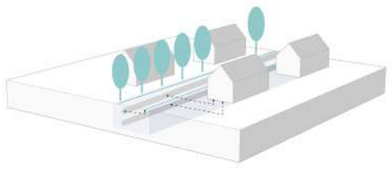
In the analysis we focussed on the historical and current hydrological system and the stakeholders that play a role in this. However, in order to realize a system change towards a robust hydrological system in 2050 interventions are needed.
This appendix is a global exploration of possible solutions and tools to tackle water problems. The tools are focused on the four main principles of our vision: Water catchment, addition, retention and division.

Collecting rainwater on roofs and in rainwater tanks
- **Intervention**: Collecting and storing water on (green) roofs and in private rainwater tanks.
- **Impact**: spread the discharge of water over time and save water for dryer times. A positive side effect is the cooling capacity in hot times.
- **Participation**: Municipalities, water board and inhabitants
- **Goal**: Water catchment

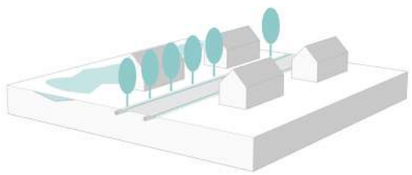


Historical irrigation system (bevloeiing)
- **Intervention**: Using a combination of rainwater and seepage water at the Peelrandbreuk to irrigate dry grasslands.
- **Impact**: Combining water with different qualities for the purpose of irrigating dry grasslands
- **Participation**: Water board, farmers
- **Goal**: Water division

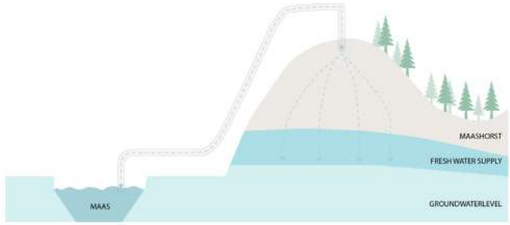
Separated sewage system
- **Intervention**:Disconnecting rainwater drainage from the sewer.
- **Impact**: Opportunities to reuse rainwater in the area. Positive side effect is the reduction of wastewater.
- **Participation**: Municipalities, water board and inhabitants
- **Goal**: water catchment, water division



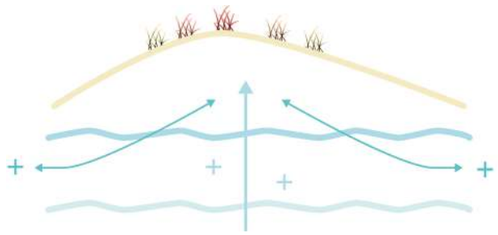
Using wadi's to store rainwater in urban areas
- **Intervention**: Removing paved surface and replace them with green/blue structures that store rain water.
- **Impact**: Water storage on site, reduction of heat stress
- **Participation**: Municipalities, Water Board and inhabitants
- **Goal**: Water retention



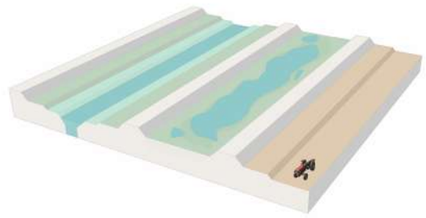
Pump water out of the Maas into the Maashorst
- **Intervention**: Pumping water out of the Maas into the higher located Maashorst, where it will be filtered and infiltrated to increase the amount of water in the higher and lower water layers
- **Impact**: Increased amount of seepage in the plan area and more fresh water in the lower water layers in Brabant. Higher groundwater levels result in increased water availability throughout the year, especially useful in summer
- **Participation**: Water Board Aa en Maas, drinking water company Brabant Water and other companies that make use of the water that is available in the lower water layers (Coca Cola, Heineken, Bavaria etc.)
- **Goal**: water addition



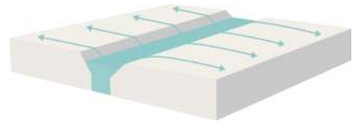
Restoring the old function of the Maashorst as a higher wet area
- **Intervention**: Remove the ditches that drain the area
- **Impact**: The Maashorst becomes more wet
- **Participation**: Farmers, water board
- **Goal**: Water retention



Creating inundation and emergency zones around the smaller Grote Wetering
- **Intervention**: Decrease the capacity of the Grote Wetering itself, but increase the area around it for inundation and emergency/water storage
- **Impact**: Less drainage during summer, more space for storage and inundation during winter
- **Participation**: Water Board, farmers
- **Goal**: Water retention

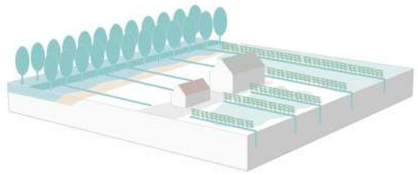


Grote wetering as a divider
- **Intervention**: Creating inlets so that water can flow from the Grote wetering to agricultural land.
- **Impact**: The Grote Wetering will not be used anymore as a stream that drains the area, but as a stream that divides the water throughout the area.
- **Participation**: Water board, farmers, municipality.
- **Goal**: Water division



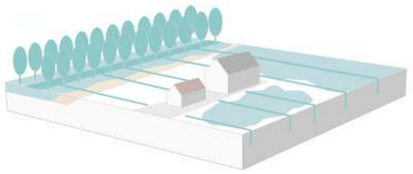
Nature as a sponge and water divider in the region
- **Intervention**: Replacing agricultural land with 'wet nature' around the fault lines
- **Impact**: Water storage in the region
- **Participation**: Water Board, farmers, Brabants Landschap
- **Goal**: Water division, water storage

Wet agriculture
- **Intervention**: Transformation to other crops that do fit the hydrological system and a healthy revenue model.
- **Impact**: New business model for farmers and a switch from 'user' to 'cooperator' within the hydrological system.
- **Participation**: Farmers, water board
- **Goal**: Water retention

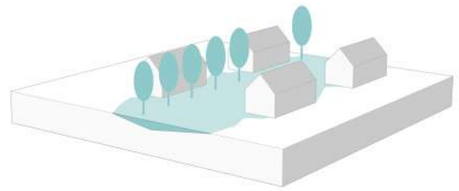


Local (parallel) hydrological systems
- **Intervention**: Separating the area around the Grote Wetering and the Dungense Polder in several zones, that are all responsible for managing the water available within the area
- **Impact**: Large responsibility for the farmers, more space for water needed throughout the entire plan area
- **Participation**: Farmers, water board
- **Goal**: water retention, water division

Waterfarm
- **Intervention**: transforming a farm into a waterfarm, that collects water from its surrounding area, so water is preserved for dry seasons. The original farmer is now responsible for the amount and quality of water for the cooperation of surrounding farmers.
- **Impact**: Increased water availability in dry seasons
- **Participation**: farmers, water board
- **Goal**: Water catchment, water retention, water division



Combining water retention with living and recreation
- Intervention: Make water retention zones for living and recreation
- Impact: Creating a business model out of water retention
  Participation: Water board, municipalities, recreational entrepreneurs, inhabitants
- Goal: Water retention



Citizens' initiatives
- Intervention: Stimulate and create room for citizens to come up with their own initiatives
- Impact: Shared responsibility, awareness and engagement
- Participation: Inhabitants, municipality, water board
- Goal: Water catchment, water retention