Borderscape

- Increasing the level of permeability in between land and sea (at coastal Northern Netherlands)

Colofon

4

Master Thesis

Malou Visser

Delft University of Technology
Faculty of Architecture and the Built environment

MSc Architecture, Urbanism and Building Sciences
Landscape Architecture
Graduation studio Flowscapes 2017-2018

Mentors

ir. Denise Piccinini
dr. ir. Taneha Kuzniecow Bacchin

Delft
June 2018

Cover foto: Marshlands at Holwerd, 2017, Own library

Manifest

The sea dike is a spatial interim in the dialogue between human at land and natural forces at the Wadden sea. Standing on the dike gives me a feeling of conquest but also of separation. It stands out as a green wall between two worlds and stretches in the wide, open landscape as far as my eyes can see. This narrow edge has once been marshlands, a gradual transition between land and sea. Now, the dike abruptly excludes the exchange of the natural phenomena between them. Seawards, the tidal gullies are hardly visible as the sedimentation is too high. On the other side, on reclaimed land, straight ditches regulate the fresh water level to serve the big agricultural plots. The modernization of the last centuries has led to a functional coastal landscape in the Northern Netherlands with hardly any ecological, economic and social development along the dike except from production land. Instead, people have turned their back against the sea and forgotten the existence of, and potential coexistence with, it.

A dialogue is a continuous process. The increasing tidal volume and effect of salinization caused by relative climate change asks for a new perspective on the edge between land and sea. To what extent will we hold on to the belief that the dike as a thin, rigid line will protect us in a sustainable way against change? In my project these effects are not seen as threats but as a stimulus to deal with uncertain outcomes in spatial design and to aim for coexistence. Creating a gradual transition zone will increase the level of resilience and establish ecological and social development.

Looking at natural ecologies, the edge is after all the zone of the highest living activity. Making the dike more permeable has many gradations but in all cases the existing landscape with its traces will be taken as found. Using site-specific differences in topography, soil type and green-blue infrastructure (either shaped naturally or culturally) and the generic processes behind them, will help to locate the suitable level and type of permeability. Revealing and reintroducing natural phenomena in different forms will make the narrative of the coastal dynamics in this landscape legible again.

Malou Visser
June 2018

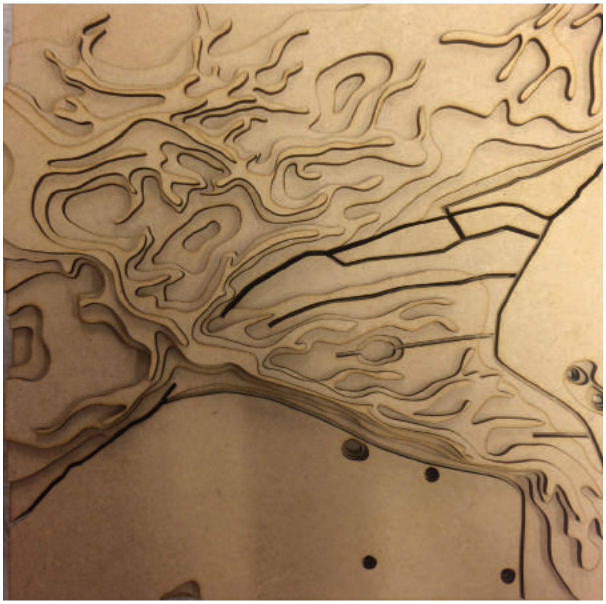


Fig. 1. Negative space: nature's power vs. thin dikes (Own library, D-i exhibition, 12-2017)

Introduction

"A coastal **borderscape** *is an living transition zone that connects land and sea. This zone supports different processes of land and sea to pass and to interact; letting flows in and out selectively by being porous and resistant simultaneously. In time, the zone is nourished and is able to adapt in program, appearance, size and permeability."*

(Sources: M. Eker, R. Sennett, M. Heidegger)

1. The impermeability of the coastal border of Northern Netherlands asks for a new perspective on the spatial organization of the border between land and sea. Currently, the predicted effects of climate change are an increase of the tidal volume of the Wadden sea and salinization inland. Testing the primary dike on water safety, 50% of the current functioning of the dike in Northern Netherlands is rejected. Besides, in spatial planning this dike is seen as the edge of different planning area, giving no space to design the border. Earlier this decade, a set of projects 'room for the River' is established that have intentionally designed the border as a gradual transition zone. In the Northern Netherlands different small developments are taking place experimenting with new spatial dike concepts and functions of experimental agriculture. However, change is seen as hard as the dike is seen as the cultural DNA of the area. This research positions itself into the current developments in the area and aims for the transformation of the existing dike into a coastal borderscape that creates permeable borders between processes and functions of land and sea. Among different steps instrumentental spatial principles are developed to do so.

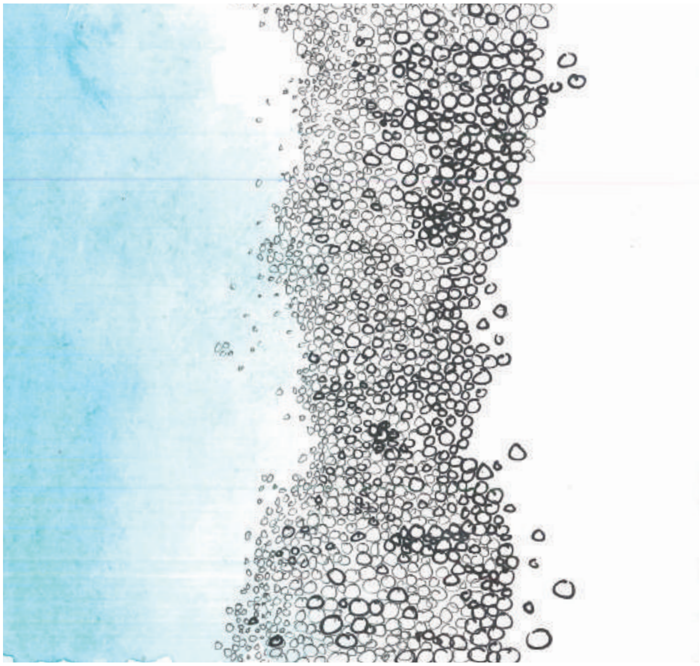


Fig. 2: Mass and activity of a ‘natural’ border between land and sea (Own library)

Context

A rethought on the spatial organisation of coastal borders is high on the list of different countries worldwide. This is due to predicted effects of climate change. According to research, sea level rise and salinization on land are indispensable and different predictions are considered in national planning policies (Deltaprogram, 2018). Another effect is the increase of extreme weather conditions that means the need of more fresh water buffer capacity on land in order to decrease the velocity of water run-off to the sea or to deal with draughts. Consequently, the flooding risk increases in many countries if continuing the current water safety strategy of the land. This leads to a higher risk of human fatalities and economic damage. Therefore, another perspective on coastal borders is relevant.

In natural ecologies, a coastal border between land and sea can be considered as a gradual transition between land and sea. As exchange between processes and functions between land and sea are permeable, a border is nourished in time and able to deal with a possible change of both sides. Currently, in many cases human have interrupted the natural dynamics of a coastal border by planning it fixed in space. Therefore, the coastal border is not able to stabilize itself anymore 'naturally' to the predictions of climate change without causing a lot of damage and is in need of the help of human.

This questioning of a new coastal strategy can be approached by considering the coastal border as a operative system. This way of thinking suits within the field of Flowscapes. Here, infrastructure, in this case the coastal border, is designed as a landscape and vice versa (Nijhuis, 2015). This asks for a operative landscape structure that supports different flows of land and sea to exchange and merge.

An example of a country in which the coastal strategy has started to change, is the Netherlands. In the Netherlands the spatial organisation of the coastal border in the Northern region is a fixed, narrow dike (fig. 4). The sea behind the dike is the Wadden sea. Together with the coastline of Germany and Denmark and the buffer islands in front of the countries the area is called the Wadden area (fig. 3). This is a tidal zone from the North sea and is a protected natural zone. Currently, it is not clear if the Wadden area will drown completely by sea level rise or silt up by sedimentation (Wang et al, 2012). This refers to the question if the increase of sediments, that normally goes together with sea level rise, can keep up with it and can diminish the effect of sea level rise in the Wadden area. Still, it is indispensable that changes will occur.

Taking the dike, the coastal border in Northern Netherlands, as the central point between land and sea it seperates the functions of the two sides visually, spatially and structurally. From the landscape inland, the dike is seen as a endless wall and except for several road ascents there is either no visual and spatial connection with the sea. The (marsh)land outside the dike is given back to the nature organisations and is assigned for the single function of ecological development. On the other side, the main part inland adjacent to the dike in the Northern Netherlands is used for agriculture. According to the Ruyter, these areas can be considered as the best ground for agriculture as the soil, sediments from the sea, is very fertile and the saline air works as a natural pesticide (de Ruyter, 2016). Moreover, there are 3 harbour areas that will become more important in the future concerning the transport of sustainable energy generated in the North Sea (MIRT, 2014) (Noorderzine, 2013).


Fig. 3: Area of Northern NL (orig. Google Maps)

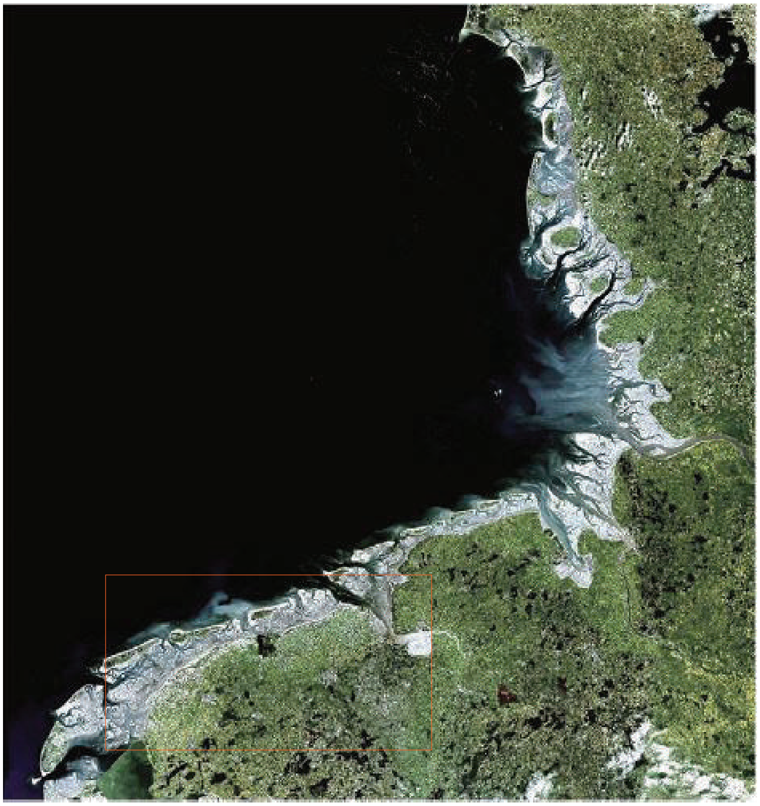


Fig. 4: Protected Wadden area (area between main land and buffer islands), including Northern NL (orig. Google Maps)

Fig. 5a: The sea dike as endless wall enclosing large plots of fresh water production land ; seen from the inside of the dike (Own library)

Fig. 5b: The sea dike as a separate, uninviting element (Own library)

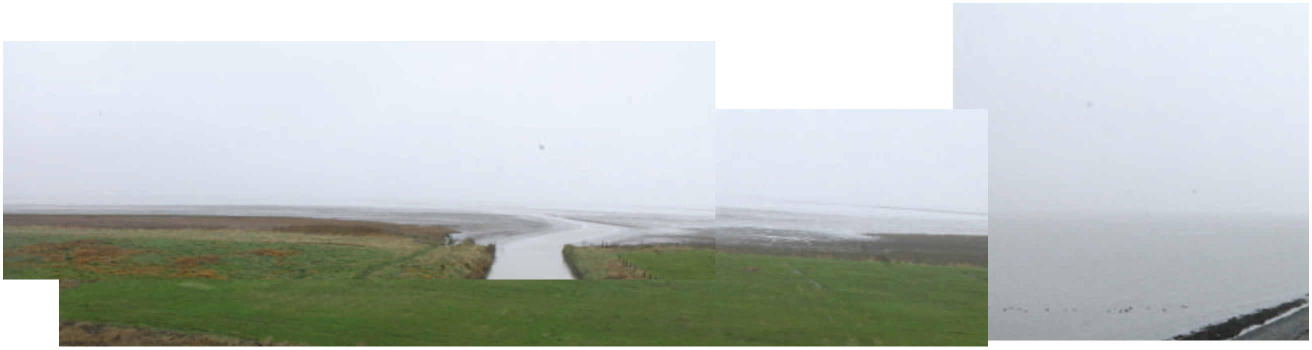


Fig. 5c: A view of the wide horizon of the Wadden area with high marshlands, experience of tides and saline vegetation; outside the dike

Fig. 5d: Zooming out, the sea dike as narrow, monofunctional spatial element separating land and sea abruptly

Problematics coastal border in Northern Netherlands
The spatial problematics of the coastal border are leading for this research. The series of photos on the previous page are taken on a field trip in the Northern Netherlands (fig. 5). They show the narrow dike that spatially and visually separates the system of land and sea in a rigid way. On land the main area is cut in large plots of fresh water production land by straight parcellation. At the sea side, the dynamics of the Wadden sea are visible and/or brackish and salt marshlands are in front of the dike. The dynamic processes of the sea (the tides, deposit of sedimentation, water type and succession of vegetation) are considered as potential later on in this research. The dike stands as an isolated spatial element in-between and does not react much on the spatial characters of both sides. Its one purpose in space is the function of water safety. Moreover, it is not inviting to enter and climb the dike as it is not well-embedded in the public routing system. On top of the dike it does offer the unique perspective of a bird-eye view of the flat area and should be integrated in the borderscape better.

Except from the spatial problematics of the coastal border, it also does not meet the functional requirements anymore. The main purpose of the primary sea dike in the Northern Netherlands is to protect human, the land and fresh water reserves from the powerful and salt sea water. However, taking into account the increasing effects of tidal volume and salinization the functioning of the primary dike strategy in water safety in the future lacks. According to the Delta Program, half of the current dikes along the Northern coastline of Friesland and Groningen does not meet the safety requirements any more based on their prediction of sea level rise (ILT, 2013) (fig. 6). In numbers, the relative climate change increases as the land behind the dike subsides simultaneously. This is the result of extraction of gas in Groningen and the low water levels in the water systems of the polders. A national research shows that the expected subsidence will be between 60 and 20 cm in 2050 (Rijkswaterstaat, NAM, 1997). The height level in the area is roughly between 0 and + 2 NAP. According to the predictions Delta program uses, the sea level can rise to 100 cm in 2100 (2014). At the moment, the high tide is +1.00 NAP in Northern Netherlands. If the sea level rises and soil subsides according to predictions, the sea level will be constantly higher than the height level inland. Following the line of spatial strategy of the last two centuries, the spatial answer to this lack in the system would be to higher and strengthen the dike again. Still, this strategy cannot adapt to change as the dike itself as an element stays static and the strategy only includes one spatial structure. Therefore, taking into account the most extreme scenarios of drowning and silting up of the Waddensea, the primary dike strategy cannot adapt to both.

In the research of Steinweg, the flooding area is modelled based on the current situation if the primary dike would break at 15 points or at each kilometer along this coastline (2008) (fig. 7). This shows large areas of flooding which can cause a lot of damage. Simultaneously, the flooding area when using other water safety strategies was modelled too. These other strategies are the integration of the secondary dike strategy, the partition strategy, protection of the big cores and protection of big and small cores. What these strategies have in common is that it offers an assigned buffer zone for the salt water to intrude in an extreme situation. This differs from the current dike that has no mass to functions as a buffer zone. It shows that using the secondary dike strategy decreases the flooding area most and seems most suitable. The main purpose of this research is not to find a solution to answer the water safety issue in a quantitive way. Instead the research offers a new attitude towards human water safety.

Another research shows the effects of current salinization and the predicted effects of salinization in 2050 in Northern Netherlands (van Staveren, 2011) (fig. 8). As visualized, there are already places of salinization in the land adjacent to the dike. This increasing effect is the result of an higher pressure of a growing salt water tidal

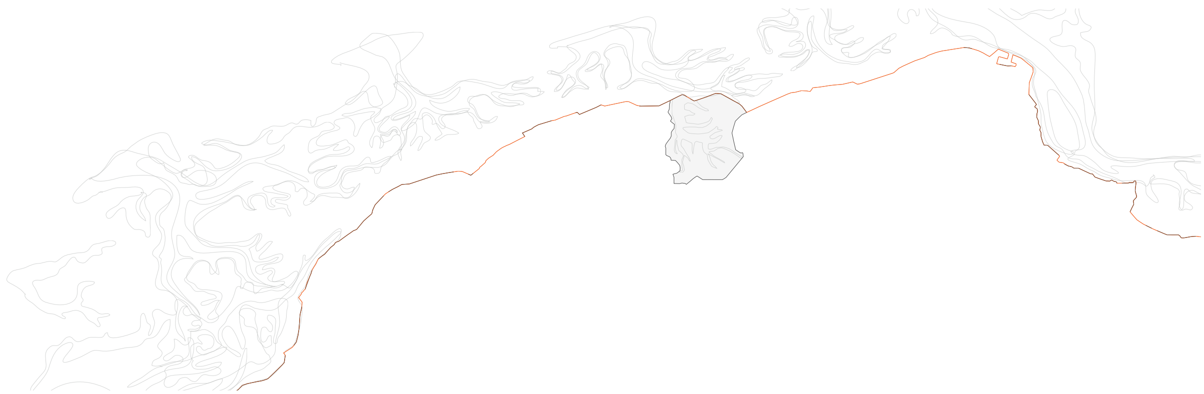


Fig. 6: Rejected length of dikes along coastline of Northern Netherlands (rejected =dark red) (ILT, 2013, p. 16)

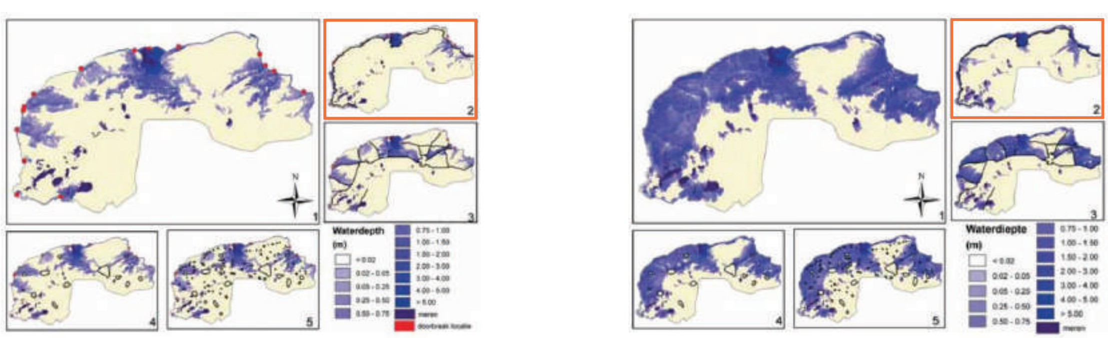


Fig. 7: Secondary dike strategy (2) considered as best (1, 3 t/m 5) concerning modelling flooding patterns if current primary dike breaks at 15 points (left) or each kilometer (right) (Steinweg, 2008, p.40)
1. Current situation - 2. Secondary dike - 3. Partition strategy - 4. Protection big cores (cities) - 5. Protection big and small cores (cities and villages)

volume. Consequently, salt water is pushed under the dike inlands, creating seepages land inwards close to the dike. In the first ditch parallel to the dike the water has become brackish. At the moment, these effects are being diminished by pumping more fresh water through the fresh water polder system (Krol, 2018). This is seen as necessary as the crops that are grown on the polder are dependent on fresh water. The strategy of 'flushing' the polder system with fresh water is debatable on the long term as a sustainable fresh water strategy is considered as important in the Delta Program and this is not in line with it (2018). Besides, the main users of the area, the farmers, do not feel the urge to change the way of growing crops either and cannot adapt their crops with the increasing salinization from the start. Waiting longer, this adaption of crops becomes harder as the starting point will be a higher saline level.

Moreover, overlapping several policy documents of different national spatial planning actors, the thin dike correlates with the outer lines of the planning areas (Natura 2000, 2016) (MIRT, 2014) (pkb Waddenzee, 2007) (UNESCO & WNFF, 2009) (fig. 9). This means that the border from the very start is considered as an outer line rather than as a separate buffer zone with a certain mass. The functions of land and sea adjacent to the dike are organized differently as they belong to different planning areas and there is not enough collaboration between actors yet. An example is the sedimentation that occurs in the Wadden arae. As the Wadden area is protected, it is not possible (yet) to dredge the surplus of sediments outside the Wadden area. This is frequently done in order to keep the transport water deep enough but this surplus could also be a potential in land use, such as fertilizer of the production land and the raising of land inside the dike. Thus, the dike has become the physical translation of this administrative border in the landscape and symbolically separates the functions and processes of land and sea in space. As a consequence, the border itself has stayed un-designed. On the contrast, treating the coastal border as a transition zone with a certain mass brings new potential for human uses and spatial structures in which functions and processes from land and sea can merge (van Eker, 2013, p.16).

This perspective of seeing a border as a fixed line rather than a mass is not only present in administrative documents. Human tend to set clear edges in many fields and disciplines. For instance, this is noticeable in the simple visualization of the permeable cell membrane of a living animal cell. Another example are the territorial lines of a world map. These lines on land and sea seem very fixed but have changed in time enormously. Consequently, human do not see the possibility of being in the border but are always either in one of the both sides. Changing the meaning of borders in human minds can lead to a more meaningful experience of a border. Seeing the border as a transition zone can lead to new human experiences related to different speeds of dynamics (van Eker, 2013, p. 16). Changing this image of the dike as a fixed border into a permeable one, will not be easy. The dike is strongly intertwined in the Dutch culture. It shows the conquest of land from sea in time and some people even claim that the dikes can be seen as the DNA of the country (Schroor, 2017) (fig. 10). At many locations along the coastline, there is a sequence of older dikes in the landscape moving seawards towards the existing location of the primary dike. Letting in processes and functions of sea may be seen as a step back in the battle with sea. Besides, the current image of water safety is set by the impermeable wall of the primary dike. Making the dike more permeable even in a controlled way can be seen as a drastic change. Therefore, the changing of the image needs to happen gradually in time and needs to be integrated well in the current operative systems.

Fig. 8: Current situation salinization (left) and predicted situation 2050 (right) Northern Netherland (van Staveren, 2011, p. 77)
purple: high risk on disappearing fresh water lens during a dry year // orange: risk on disappearing fresh water lens during a dry year

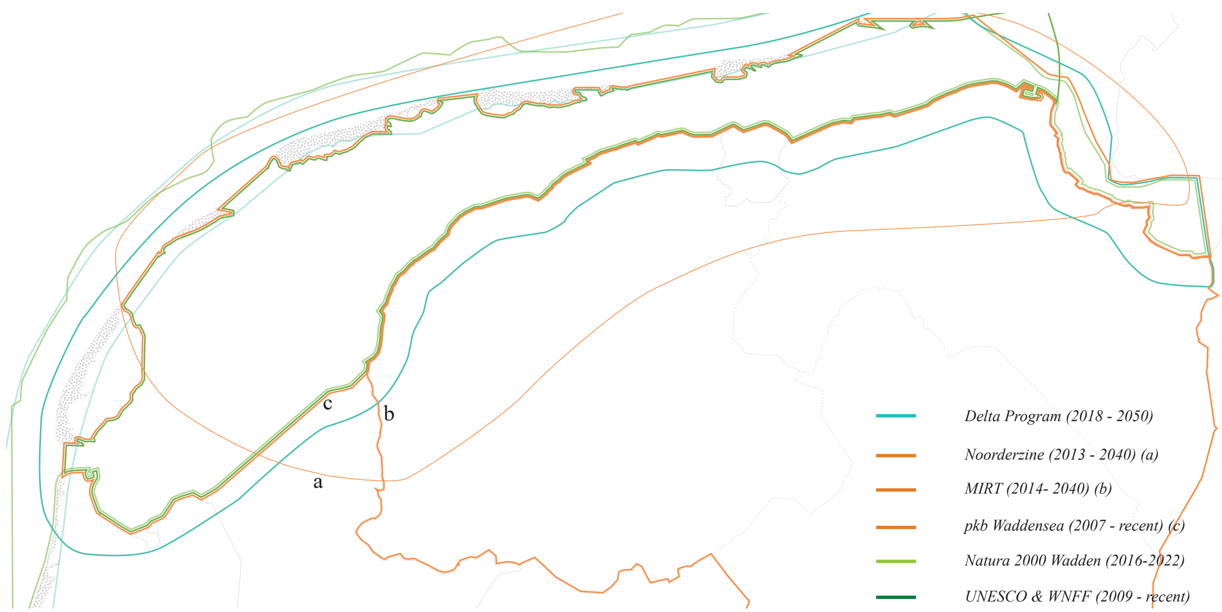


Fig. 9: The dike as outer edge of planning area using existing administrative borders of several spatial planning policies (Own library)

Current developments Northern Netherlands
According to Van der Ham, the spatial outcome of a border changes as the perception of a border changes by social, economic, physical and cultural processes. And this is a constant process (2002). In time, the image of the coastal border has changed and will keep on changing. In response to the predicted effects of climate change, the perception of the coastal borders is slowly changing already.

At the moment, the change of perception is mostly controlled by top-down approaches. Since the newest Delta program, several pilot-projects and proposals are planned that explore new innovative dike concepts and the growth of salty crops from top-down (Delta program 2018) (Wageningen University, 2016). An example is the 'Double dike' close to Delfszijl (fig.11). A new secondary dike is built in which in between functions of sustainable energy generation, sediment catchment and experimental agriculture can take place. This is potential, as new functions arise from merging processes and functions of land and sea. Still, these spatial structures of these concepts are very generic and do not consider the potential existing site-specific structures and sensibilities and their ability to transform. Besides, these concepts arise without having a collaborative spatial strategy on the scale of Northern Netherlands.

On the other side, only a few bottom-up projects from local farmers have arisen. These experiment with the adaption of fresh-water crops to more saline conditions. An example is the experimental farm in Texel (fig. 12). They test the current resistance of crops to saline conditions, try to breed them to higher saline conditions and export the knowledge and seeds of the crops national and internationally. This is a good example of functions of land can be adapted by the processes of the sea. This experiment only happens on the very small scale and a spatial structure on the larger scale could be potential.

Thus, approaches are happening from two directions but collaboration between different actors and areas in spatial planning of on different scales is missing. This collaboration is urgent as there are still significant tensions between them that can complicate the spatial implementation of a new coastal strategy.

Still, the establishment of most of the 'Room for the river projects' this year shows a successful example of transforming the spatial and cultural image of a river border into wider zone in the Netherlands. This borderzone offers more room for water but also giving new human uses, spatial structures and human experiences. An example is the river park at Nijmegen (fig. 13). This project shows to be successful as a buffer zone for water retention, recreation and a human experience of being 'in' a border by the experience of different water heights (Architectenweb, 2018). Moreover, the dune system of the West coastline that functions as a water safety system also integrates other functions of ecology and economy more and is seen as a assigned zone in policy (Deltaprogram, 2018). The sand nourishment for the dunes of the 'Sand Engine project' proves to be beneficial as an increase of water safety for the coast, ecological development and creating a zone that serves as a destination. Simultaneously, it has the ability to adapt as it slowly distributes the sand from one bull along the coastline. These contemporary examples show the potential transformation of a fixed border to a permeable borderzone in the Netherlands.

Such a permeable borderzone is defined as a borderscape in this research. This is a gradual transition zone that merges functions and processes of land and sea offering new functions, human experiences and spatial structures that have the ability to deal with change. At the moment, the spatial impermeability of the sea dike, the inability to deal with changes of sea level rise and salinization and the treatment of coastal borders as fixed lines asks for a different perspective on spatial planning of coastal borders, establishing a borderscape. This research puts focus on the search of a new spatial structure on different scales by transforming the current spatial structure of the border.


Fig. 10: Dike as cultural DNA, damming off Lauwersmeer (Rijkswaterstaat, 2018)


Fig. 11: Render of double dike, Eemshaven and Delfszijl (wur.nl, 2018)


Fig. 12: Experimental farm Texel (ziltproefbedrijf.nl, 2018)


Fig. 13: Room for the river project. Riverpark Nijmegen (Architectenweb, 2018)

Problem statement
The fixed, impermeable border between land and sea in Northern Netherlands, the primary dike, cannot deal with predicted increase of flooding risk and salinization as it does not support the exchange of processes between land and sea neither gives a zone for a gradual transition.

Research objective
To develop instrumental design principles for a spatial structure establishing a coastal borderscape tested by a site-specific design that increases the permeability along the coastal zone of the Northern Netherlands.

Main question
Which instrumental design principles for a spatial structure can be developed that increase the permeability between land and sea establishing a coastal borderscape?

Subquestions

- Which generic design principles can be extracted from the three main attitudes that are included in the design of a borderscape?

- What should be the human meaning of a coastal borderscape in the Northern Netherlands and which physical and administrative conditions support this in line with the current state of thinking?

- Which elements of dynamic and control can be indicated that are potential for the design of the borderscape on the regional scale?

- Locating the site-specific conditions of the coastal line, what are the outlines and spatial structure of the borderscape on regional scale and in which subcategories can it be divided?

- Which site-specific design principles can be developed for one location of a subcategory that establish a spatial structure for a borderscape?

- To what extent does the proposed design perform as a borderscape tested by the level of implementation of the three main attitudes?

- To what extent are the site-specific design principles for the spatial structure of a borderscape of one location applicable for implementation in different locations and among other categories?

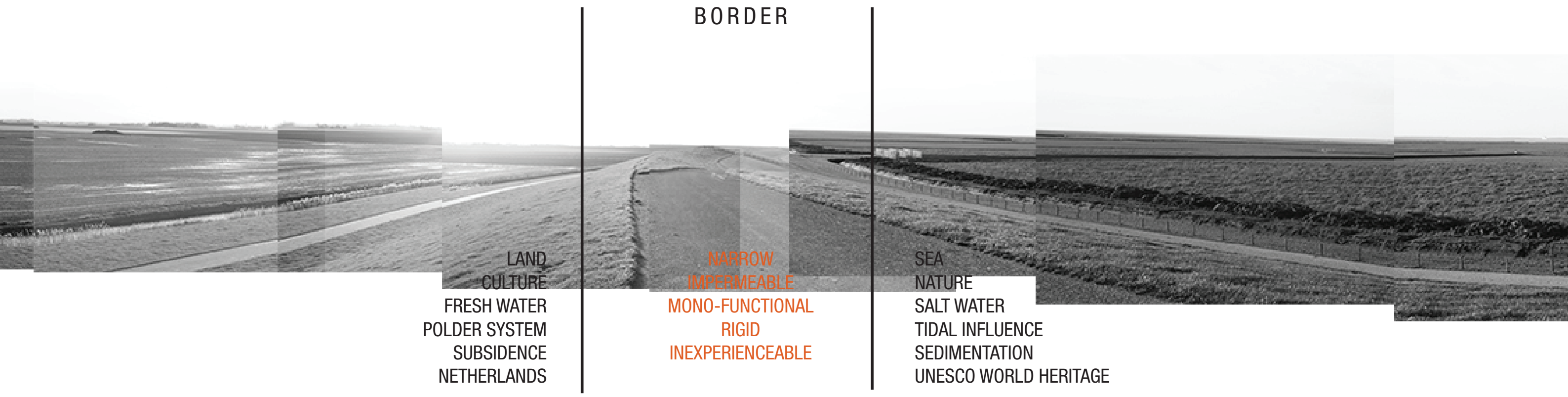


Fig. 14: Problem statement; the dike as a impermeable spatial element seperating functions and processes of land and sea (Holwerd, 2017, Own library)

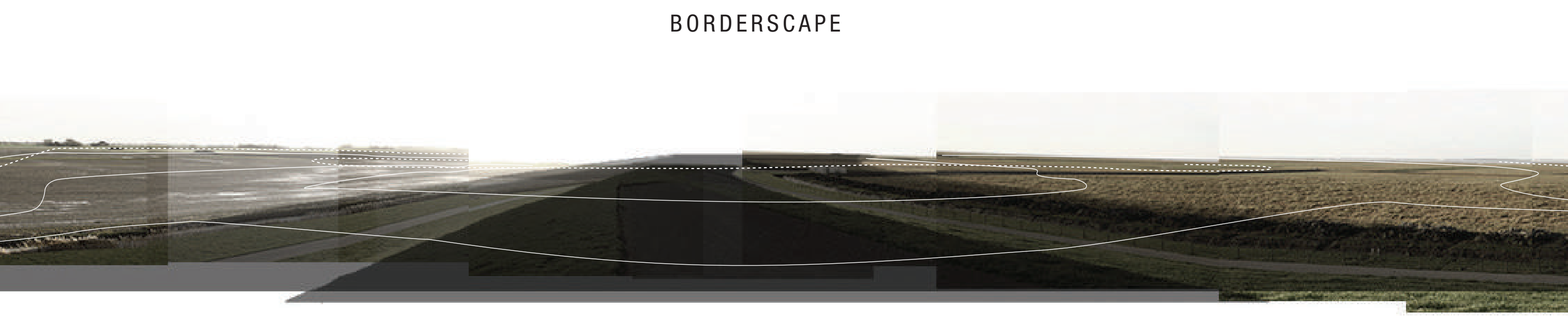


Fig. 15: Hypothesis; a diagram of a wider borderscape that enables exchange between bot sides while setting new outlines (Holwerd, 2017, Own library)

Methodology
In order to do answer the main question, a methodological framework is developed that is divided in several parts that answer sub questions, together creating a research approach and design strategy for this research (fig. 16). Firstly, three different attitudes are framed that are important to borders between land and sea based on theory. The attitudes of multi-functionality, adaptive capacity and seeing the borderscape as dynamic relational construct are translated into four head spatial principles using existing examples of borderscapes. The four generic design principles developed are the allowance of dynamic elements, the use of controlling elements, the need of a definition for human meaning and a set of suitable physical and administrative conditions. Next, the location of Northern Netherlands is introduced that will test the generated design principles on suitability and level of application in one site-specific design (research by design). The design research uses several steps in order to do so. Positioning itself in the current state of thinking in the Northern Netherlands, the potential human meaning of a border is made explicit and a set of suitable administrative and physical conditions are found to facilitate change of the current spatial structure. The next step is to indicate the existing elements of dynamics and control on the regional scale while addressing the regional sensitivities. After, a layer-analysis is done visualizing site-specific conditions of the area adjacent to the primary dike taking the dike as a central starting point between land and sea. From here, the outline and spatial structure of the borderscape on the regional scale are defined and the borderscape is split in three categories. The regional design principles are applied to a site-specific design for the location 'Zwarte Haan' of one category. Still, design experiments and analysis of different locations have contributed to find potential spatial structures for borderscapes. Finally, a spatial structure is developed that considers the primary dike as the starting point of the transformation and uses the exchange of water conditions from the sea to invite new combinations of ecological systems, functions and human experiences on both sides. The last step involves the reflection of the performance of the design as a borderscape and the suitability of the application of the design principles for the developed spatial structure in other locations in Northern Netherlands.

Scope and relevance
This research contributes to another perspective on spatial planning of coastal borders in design but also for humans in general; the image of a border with a certain mass and activity. This acknowledgement gives a potential for new spatial structures that lead to new functions and human experience in general but more specifically to the location of Northern Netherlands. Moreover, the research of seeing design as constant transformation contributes to the field of adaptive planning and climate-robust planning for coastal areas starting from the transformation of existing spatial structures. In addition, the research contributes to a more coherent design strategy of the coastal border of Norther Netherlands in which collaboration between actors and areas is established through different scales. Lastly, considering the coastal border, the dike, as an operative landscape structure adds new methods of analysis and design to the field of Flowscapes.

Reader itinerary
The following chapter will discuss the methodology of the research. Here, from theory three different attitudes on coastal borders are developed. These are multifunctionality, adaptive capacity and legibility of dynamics. In the design approach four head spatial principles are generated: elements of control, elements of dynamics, the human meaning of a borderscape and suitable spatial & administrative conditions. This is followed up by a design strategy for the coastal border of Northern Netherlands establishing a borderscape. Chapter 3 will give insight on different perceptions of the border in Northern Netherlands from different disciplines, focusing on the current state of thinking. The outcome of this chapter are the suitable spatial and administrative conditions of transforming the coastal border of Northern Netherlands into the new image of a borderscape. Chapter 4 will discuss

the potential elements of control and dynamic in the Northern Ne- therlands. The result will be the spatial outline and structure of the borderscape in Northern Netherlands. Besides, it will divide the borderscape in three categories. This helps to test the suitability of the generated design principles to other location later in research. Within the spatial structure of the borderscape on the regional scale a sequence of dense points are present. These are the existing water exchange points and are considered as potential starting points to transform the area into a borderscape. The regional design principles will be applied to 'Zwarte Haan' one location of one category. An extensive design is made for the location that sets a new spatial structure, transforming from the current primary dike, that supports new functions and human experiences. Within the developed spatial structure of the borderscape 'Zwarte Haan' becomes a destination in the borderscape, the primary dike is repositioned and the exchange of water is used to merge both sides of the dike. The last chapter, 5, will test the performance of the design as a borderscape and show the suitability of the developed spatial structure in other locations in Northern Netherlands. At the start of each chapter, a small summary is given with the main outcomes of the content discussed in the full chapter.

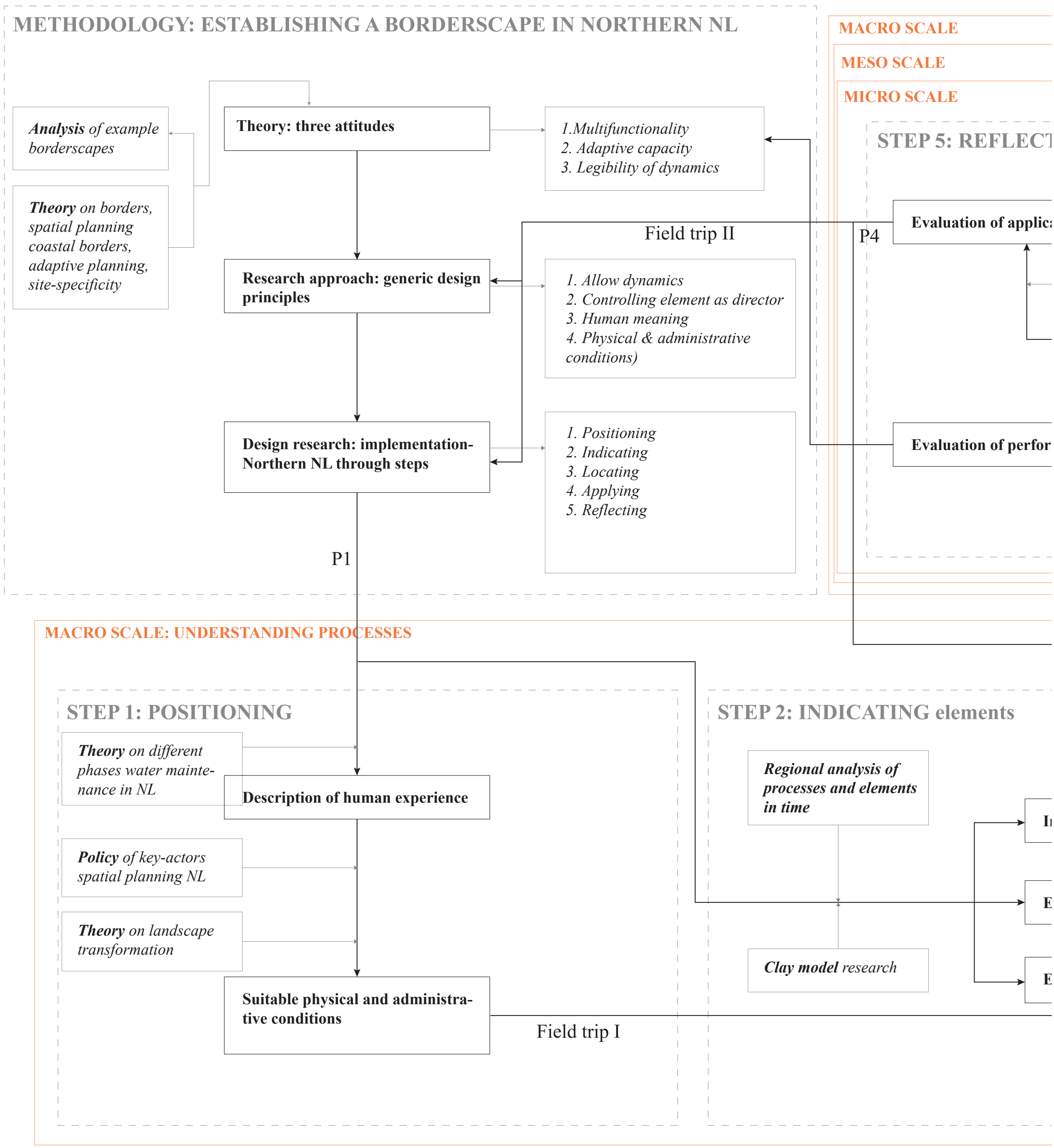
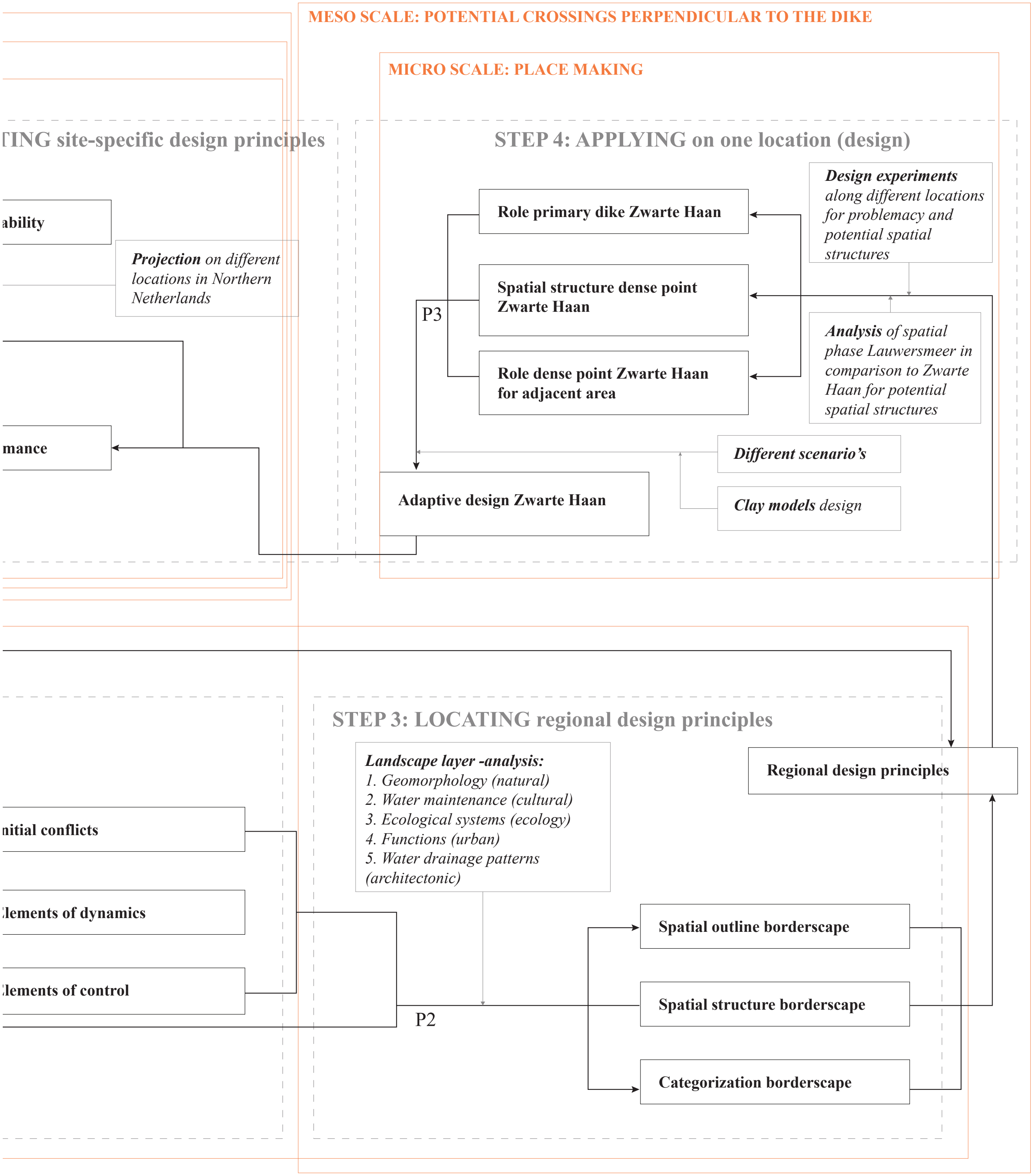


Fig. 16: Methodological framework (Own library)


MESO SCALE: POTENTIAL CROSSINGS PERPENDICULAR TO THE DIKE
MICRO SCALE: PLACE MAKING
TING site-specific design principles
STEP 4: APPLYING on one location (design)
ability
Projection on different locations in Northern Netherlands
mance
Role primary dike Zwarte Haan
Spatial structure dense point Zwarte Haan
Role dense point Zwarte Haan for adjacent area
P3
Design experiments along different locations for problemacy and potential spatial structures
Analysis of spatial phase Lauwersmeer in comparison to Zwarte Haan for potential spatial structures
Different scenario's
Clay models design
Adaptive design Zwarte Haan
STEP 3: LOCATING regional design principles
Landscape layer -analysis:
1. Geomorphology (natural)
2. Water maintenance (cultural)
3. Ecological systems (ecology)
4. Functions (urban)
5. Water drainage patterns (architectonic)
Regional design principles
nitial conflicts
lements of dynamics
lements of control
P2
Spatial outline borderscape
Spatial structure borderscape
Categorization borderscape

Content

Methodology

*"Coastal borderscapes are relevant due to their **multi-functionality**, **adaptive capacity** and ability to **experience its dynamics**"*

2. The definition and design approaches of borders in landscape architecture are various in theory. This is due to the diverse type of borders within the discipline and the multi-disciplinary origin of the discipline itself. In this research generic design principles for a coastal border are developed and implemented establishing a coastal borderscape. Based on theory and examples of existing borderscapes (fig. 17) three attitudes need to be included in the design. Firstly, it is a zone with the highest level of exchange that joins new (human) uses and spatial structures of land and sea and invites new ones. Besides, seeing the borderscape as an adaptive living system enables a new way of control without marking its borders completely fixed. Lastly, the site of the borderscape should be interpreted 'as found' acknowledging the different elements to be in a certain state in time. Based on these attitudes, four categories of generic design principles in coastal borderscapes are generated. Taking different steps, these principles will be made site-specific on a location along the coastline of Northern Netherlands in the design research. The suitability of applying them in other locations will be tested in the reflection showing the importance of site-specificity.

Sluftervalley, Texel

Sand engine Kijkduin (Rijkswaterstaat)

Hondssbosche zeewering, Petten (Own library)

Boulevard Hunstanton, UK (Own library)

Bensersiel, Germany

Southend pier, UK (Own library)

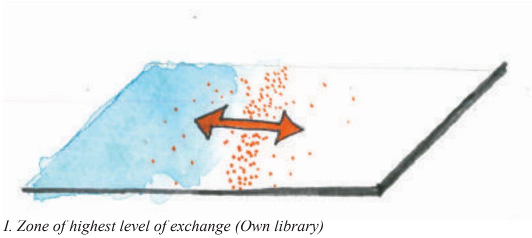
Fig.17 Existing borderscapes; used for the definition of three attitudes

2.1. Theory: coastal borderscapes in landscape architecture

A landscape architect has to deal with countless types of borders in design and this makes the design of it complex. Borders occur on different scale levels, have different levels of visibility and are located in different site conditions. This asks for various approaches to deal with them in design. For instance, a border on a regional scale is worked out less detailed than a border at a location scale. Some borders are marked spatially in the landscape, while others are only visible in policy documents, e.g. administrative and territorial borders. Moreover, the location of the border gives different site-specific conditions. These conditions, such as soil type, water type and topography are incorporated in the design and lead to different starting points. In this research the focus is put on designing a coastal border as a borderscape. This focus is seen relevant as current developments of climate-change, an increase of salinization and tidal volume, ask for a revision of spatial planning of coastal borders. The word 'borderscape' implies a border with a certain mass and dynamic for what is aimed for in this research. As all borders represent a connection between two sides, the coastal borderscape functions as an interface between land and sea. Both sides represent different site conditions and the design of a borderscape decides upon the interaction between these two defining a range of exchange.

Moreover, the combination of disciplines from which landscape architecture derives from contributes to the complexity of dealing with borders. In the essay written by Spirn the confusion of the definition of 'Nature' in the field of landscape architecture is discussed. She explains that the confusion is partly the result of the multi-disciplined character of landscape architecture. The same accounts for the definition of borders. Some disciplines have different and even contradictory definitions of borders. The different disciplines are natural ecologies, architecture, art, engineering and agriculture (Spirn, 1997, p.255). Each discipline treats a coastal border and the range of dynamics differently. According to the field of engineering, the border between land and sea should include a level of control in order to protect the land from sea. The desired range of exchange is low, unless the exchange can contribute to the level of control. The same desire of control low range accounts for agriculture. Most of the crops grow in fresh water conditions. If the exchange of processes from the sea can contribute to the growth of the crops, the range of exchange can increase. Looking at the field of natural ecologies, a coastal border is seen as a high potential for a unique ecological development different than the adjacent ecological systems of land and sea. According to this perspective, the border should be a gradual zone with a high range of exchange. Considering arts as being a reflection of the social and economic processes of a society, the perception of a coastal border is time bound and the image of it changes. The perspective of architecture on a coastal border is to design a spatial structure of the border between land and sea as a built space in the landscape that makes the dynamics of the coast experienceable for human.

Landscape architecture should incorporate these different perspectives into a well-functioning design as all perspectives are equally important. Thus, the borderscape should incorporate a control mechanism for processes of land and sea to interact and a physical zone between land and sea. Moreover, the borderscape has a spatial structure that supports the dynamics of the changing processes of society and conditions of land and sea. Based on this, three perspectives are taken as starting point in developing design principles for coastal borderscapes (fig. 18). Firstly, the borderscape is a physical zone in which functions and processes from land and sea can exchange and merge in a controlled way. The second perspective is to work with change in coastal areas using the different dynamic cycles of processes of land and sea. The third perspective is to bring back the site-specific dynamic character of the coastal border again and to make this legible in the system and experiences.



I. Zone of highest level of exchange (Own library)

II. An adaptive zone in shape and use (Own library)

III. Legibility of dynamics (Own library)

Fig. 18: Three attitudes visualized (Own library)

2.1.1. The zone of the highest level of exchange

The coastal borderscape functions as a permeable and physical zone in between land and sea. This spatial concept of having a zone connecting two systems can be found in natural ecologies. Here, the edge is seen as the zone of the highest potential of living activity. The edge can have two different appearances that lead to a different functioning in permeability; a boundary or a border. A boundary is defined as a static limit beyond which for instance a particular specie of an ecosystem does not occur. On the contrary, a border is an active zone of exchange. Flows of both ecosystems of different species and processes are able to meet and to interchange. This leads to an unique ecological system in between in which the site-conditions differ from the adjacent ecosystems. In time, the permeable border retains what is needs for nourishment and is able to adapt to changing site-conditions on both sides. The definition of permeability does not describe an entirely open flow. Instead permeability points out to an exchange that has a certain level of control enabling to regulate the amount and type of flows on both sides. This level of resistance in the border is present that prevents the border to dissolve into a formless flux (Sennett, 2011, p.324-325).

This ecological concept of a border is used in the spatial planning of the living environment by sociologist Richard Sennett and urban planner Mark Eker. Rethinking the importance of edges in cities, Richard Sennett has translated the ecological border to borders in urbanism. According to him, the borders city-zones offers possibilities for social, cultural and economic processes to mix (fig. 19). In time, the border can keep up with the dynamics of both zones able to change in space and function. This border can also influence the adjacent zones in return. This stands in contrast to the centers of the city-zones that was mostly focused on in urban planning. These centers emphasize the ethnic, economic class and functional activities of each zone separately rather than enabling an exchange (Sennett, 2011). Mark Eker has analyzed the territorial borders of the Netherlands on land with the adjacent countries. Similar to Senett, he sees that the edge land mainly serves to protect the heartland and claims that in many cases the space of the territorial borders stays un-designed (Eker, 2013, p.180). According to him, a territorial border should be treated as a transition landscape. This 'borderland' implies the same adaptive and innovative qualities as the borders of Richard Sennett of finding new spatial and social structures, human uses and shapes (Eker, 2013, p. 180).

Thus, the ecological, social and economic potential of edges are supported in the spatial planning of coastal borderscapes by a physical zone. The mixture of these processes offer innovation for spatial and administrative structures. In this research spatial principles of adjacent systems of land and sea are joint in order to do so while contributing to the level of control. This is based upon the research of Janneke van de Bergen 'Developing sustainable coastal buffer zones' in which she develops spatial design principles that integrates different coastal systems to strengthen coastal buffer zones using Building with Nature (BwN*) as key strategy (Bergen, 2018, p. 13). According to Bergen, the coastal zone is defined as a landscape in which three different systems are interacting; the coastal morphological system, the urban/rural coastal system and the ecological system. Understanding the language and principles of each system individually enables her to join the principles together that include new spatial development and contributed to the water safety task of the coastal buffer zone.

The integration between these systems in design can be explained by looking at an example of a borderscape **Hondsbossche zeewering**. This project is 5,5 km long and is located along the West coastline of the Netherlands (fig. 20). West 8 proposed a design in which the coastal defence of the dune system, that can be considered as the physical zone of the borderscape, became strengthened using BwN approach. The dune system has become wider by the design of new dunes nourished by sand from the sea using the coastal morphological system. The widening of the dunes contributed to more differentiation and has created more diversity in the ecological system. In return, the dunes vegetated with marram grass contributes to the coastal defence. Simultaneously, a network of recreational routes has been implemented to be able to experience the borderscape and to connect the project to the urban/rural coastal system more land inwards.

** Definition BwN: Building with Nature starts with the natural system and uses ecosystem services to meet society's need for infrastructure and encourage the development of nature at the same time. Examples of services provided by nature are the transport of sediment by water, preventing the erosion of the coastline. Incorporating nature in infrastructure design results in flexibility, adaptability and extra functionalities' (Ecoshape, 2018)*

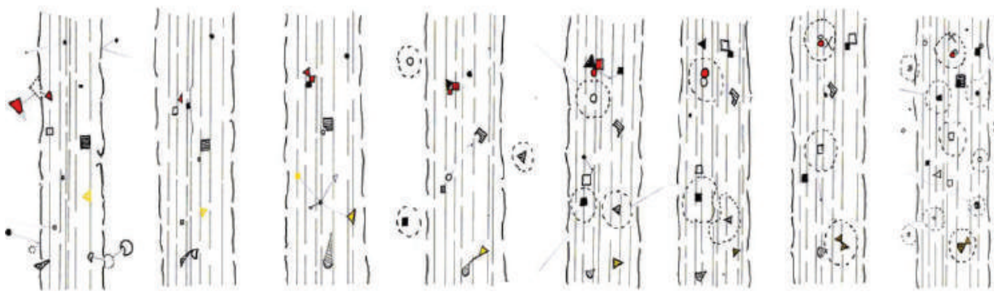


Fig. 19: Exploring mixtures of functions in the border zone (The public realm, Sennett)

Fig. 20: Integration of systems, Hondsbossche zeewering (Own library)

2.1.2. Uncertainties as a stimulus to design with adaptivity

Different time scales are interwoven in a coastal borderscape as it connects land and sea that both different processes each running at its own speed. Processes of the coastal morphological system include the daily tidal range, the annually amount of land deposit brought by the sea and the effects of climate change that has a time span of decades or even centuries. These effects are an increase in the tidal volume and salinization. Rural and urban development tend to occur more slowly and are mostly located on land. The dynamic of the ecological development depends on the site-specific conditions that determine the climate and the level of human interference.

According to Holling, the economic, social and ecological systems that are included in a living system are indeed complex (2001). In order to get grip on the functioning of it, he describes that economic, social and ecological system each have an adaptive cycle that runs next to each other. Moreover, within one of those systems there are several adaptive cycles again running on different time scales. All the adaptive cycles run through four similar phases, only the speed in which those phases are run through differ. The four phases are exploitation, conservation, release and reorganization. Taking the living system of a forest as example, it can grow (exploitation) to a certain stage of succession (conservation) until a fire or insect outbreak mediates between the faster atmospheric and slower vegetation processes (release). After, the living system will search for a new balance and the forest starts to grow again (exploitation) (Holling, 2001)(fig.21a). Thus, the interaction of different adaptive cycles give the living system an adaptive capacity. The smaller cycles that run faster enable innovation, while the bigger cycles at a slower pace keep the system resistant (Holling, 2001). An understanding of the functioning of the adaptive cycles and the interaction between different adaptive cycles that run on different speeds in a borderscape are useful for design. Firstly, the tipping points, the point that tips one phase into another, of an adaptive cycle can be controlled in order to lengthen or shorten a particular phase. Besides, defining the fast and slow cycles helps to locate and control the level of innovation and to mark its borders.

Taking this perspective, a coastal borderscape should be treated as a constant transformation. This perspective suits well to the BwN approach (defined earlier). An example of an adaptive coastal border is the coastal defense system **Sand-Engine** close to The Hague at the Dutch coast (2011 – 2033). This project was initiated in order to strengthen the coastal defense to overcome the various scenarios of predicted sea level rise and to experiment with an adaptive approach. Instead of working towards a spatial end result of one scenario, the different scenarios lead to unclear spatial outcome that could still reach the goal of water safety. At one point 250 million m3 sand is deposited and this will be carried naturally ashore towards north and south to nourish the beach and dunes at the West coastline (fig. 22). Here, understanding the coastal morphological system and its different adaptive cycles enabled to work with a natural sand transport. A big amount of sand is supplied externally and enables the ecological beach and dune system to grow (exploitation and conservation). The nourishment continues to 2033 and prevents the tipping point to a downfall (release) of the coastal morphological system (fig. 21b). Simultaneously, the coastal zone invites new ecological diversity to establish. Moreover, the border between the coastal border zone and sea is unfixed as the land-shape changes over time (fig. x). On the other side, the border to land is marked fixed and impermeable as the line of urban development defined it. According to Bergen, this is due to a lack of integration by joining principles between the urban system and adjacent systems (2018, p.5). Therefore, the clear marking of the border could have behaved differently if principles of the urban system were integrated more. Later in the ‘Application’ chapter, the adaptive cycles on two locations in Northern Netherlands are discussed and compared. It shows that two locations along the same coastline are to be found in different phases.

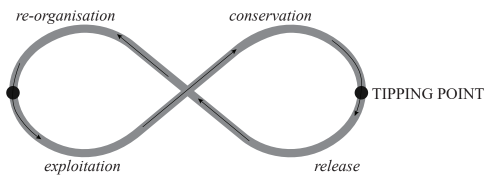


Fig. 21a: Basic adaptive cycle (Holling, 2001)

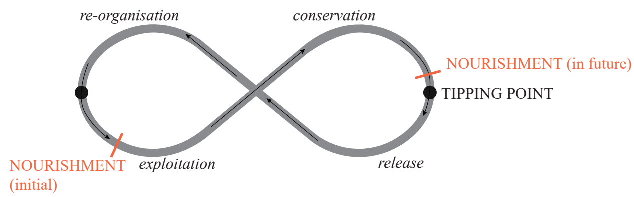


Fig. 21b: Adaptive cycle Sand- Engine project (Own library)

Fig. 22: Development of land-shape Sand-Engine through time from left to right (2011-2014) (Rijkswaterstaat)

2.1.3. The borderscape as relational specificity

Various design approaches include site-specificity in design. All of them imply certain site conditions to be important and work with those in design connecting the design to the location through different scales and time. One of those approaches exists out of seeing the site as a dynamic relational construct or site-specificity as relational specificity (Diedrich, 2015, p.5). The dynamic character of the approach suits well to the adaptive and dynamic character of a coastal borderscape.

Seeing the site as a relational construct, the approach consists out of 'site-thinking' and 'thinking about a site'. Site-thinking includes an analysis of specific conditions of the plot, such as processes, physical structures and immaterial aspects, such as narratives. Thinking about a site includes how the designer deals and translates this gained information about the plot. This is both based on ideas about the site and the personal and/or societal background of the designer. The interpretation of the designer of the site leads to a distinction in existing elements which are found important or not for the design. In the design, the site will then change from one state into another, build upon the existing state of the site. Besides, the transition of the elements in a site can occur on different time scales. At the same time, some elements will change while other will stay static. This contributes to the legibility of the dynamics of the site on different scales by making it experienceable. The acknowledgement of the site 'as found' helps to design as a constant transformation through time and scales (Diedrich, 2015).

The design of a coastal borderscape is an interaction of the existing conditions of the area and of what possibilities the designer sees ahead of him. Thus, the landscape architect functions as a spatial translator of its own or societal perception of a coastal border and what this border could mean. In the design important existing elements are marked by a site interpretation. Within these elements, a distinction is made which elements that should be resistant or are able to change. Acknowledging the site of a coastal borderscape as a constant transformation contributes to the spatial question of how to deal with uncertain developments, such as current threats on coastal borders due to an increase in sea level rise. This requires not only changes in spatial and programmatic terms but also a shift in the cultural image of a coastal border.

A differentiation between fixed and dynamic elements and the approach of taken the site 'as found' is present in the **Southend Pier** in England that is considered as a borderscape. This 2 km long pier, located at the mouth of the Theems, makes a perpendicular connection between land and sea. This pier is considered as a fixed element that has changed its status in time. It used to function as a railway connection to transport the goods from the ship towards land. This length was needed as the zone in front of the land is very shallow. In time, this pier transformed from being a route for transport into a route for recreation. Walking on the pier, the gradual transition from land to sea is visible experiencing the different dynamic processes of tides, light-play and land deposit (fig. 23).

This play between dynamic and fixed in coastal sites leads to different spatial outcomes in time due to site-specific conditions. On the following page a taxonomy is made of different coastal borders that are all located along the Northsea (fig. 24). This taxonomy shows the diversity concerning their difference in colors, land-shape, top surface elements, materialization and overall experience. On the largest scale, the site-specific geomorphology have influence on the land-shape or earthwork of a border. This shape can be gradual but it can also have a certain abruptness, such as a cliff. It has a strong relation with the material that is found on the smallest scale; if the material is hard or soft, heavy or light, permeable or impermeable. Thus, in the design of a borderscape the site needs to be approached 'as found'. The state of different elements are acknowledged by function and level of dynamics. These are selectively changed into another state while fitting in the current timeframe of the site and are left open for the future.

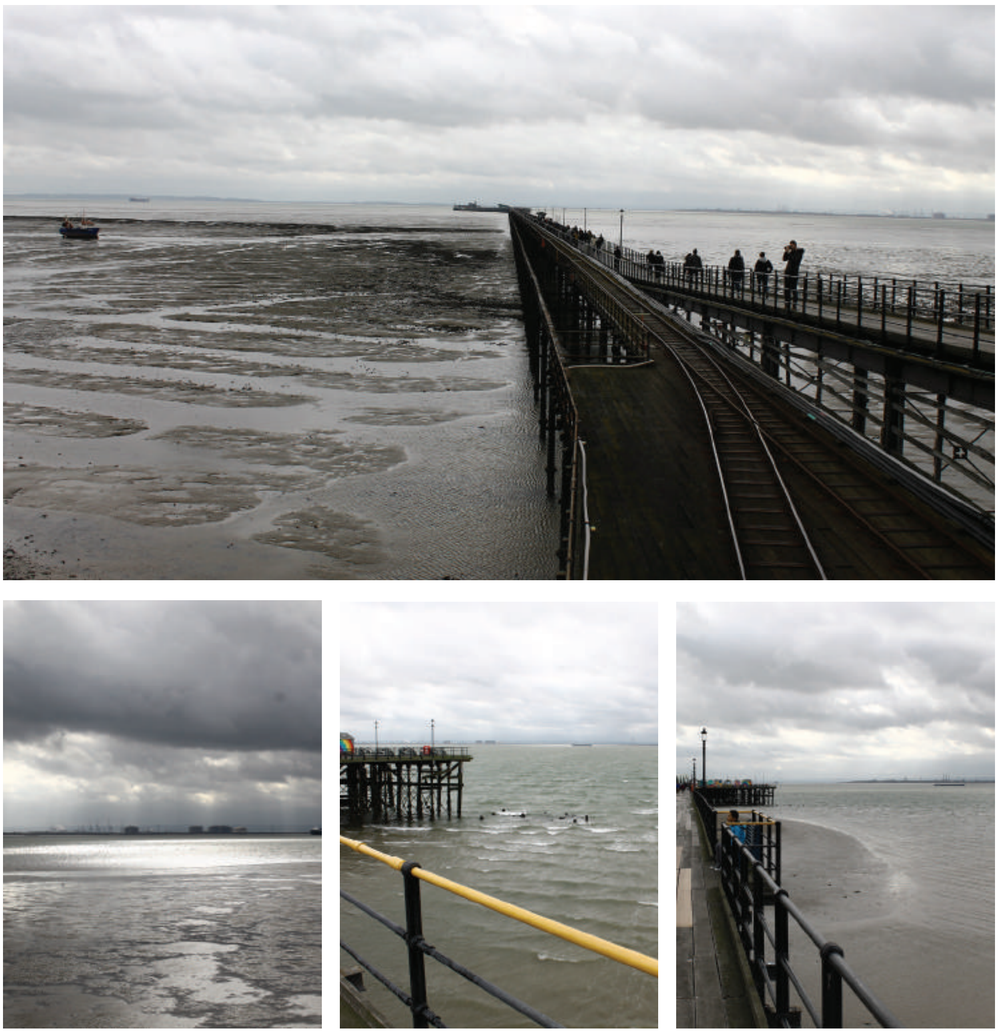


Fig. 23: Fixed and dynamic elements at Southend pier, UK (2017, Own Library)
fixed: wooden pier
dynamic: change of the function of the pier, sedimentation/erosion at the beach, tides, light-play

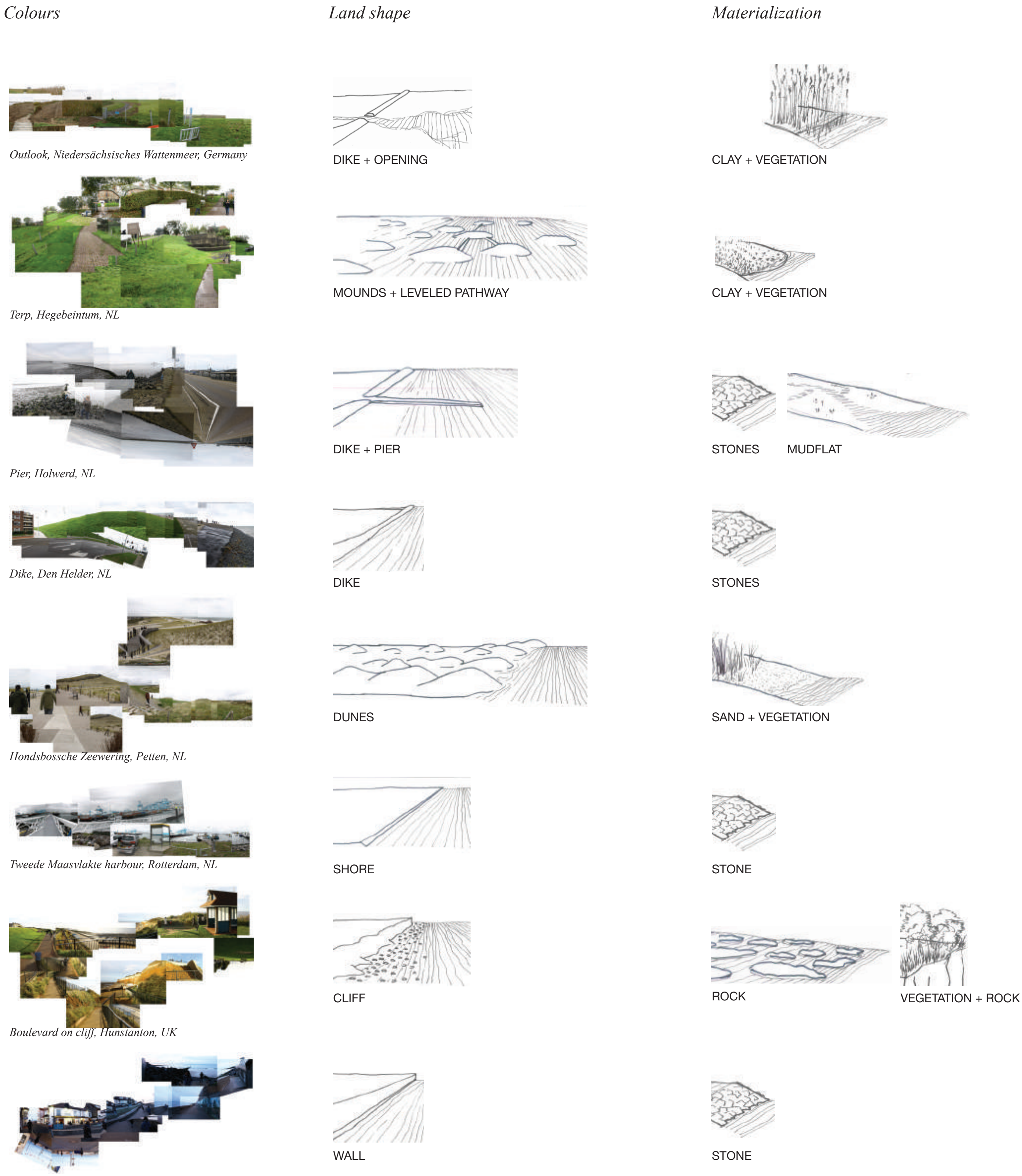


Fig. 24: Taxonomy of coastal borders visited during field trip North sea (Own library)

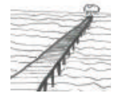
Top surface objects

Land

Edge

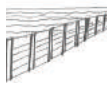
Sea


SLUICE

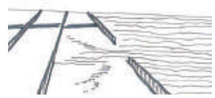

BOARDWALK

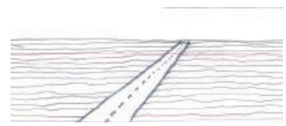

BUILDING ON POLES

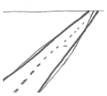

FIXED BUILDINGS


HEDGE


CAR ROAD


RECLAMATION POLES

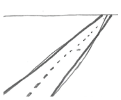

CAR ROAD

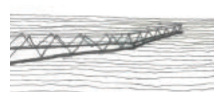

CAR ROAD

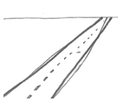

FIXED BUILDINGS


CYCLE + PEDESTRIAN PATH


FLEXIBLE PAVILLION

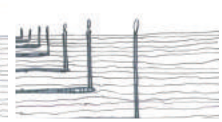

ROAD


JETTY


ROAD

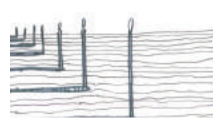

GREEN VOID


RAMP + BOULEVARD


PIERS


FIXED HOUSES


BOULEVARD + RAMP


PIERS

2.2 Design approach
Based on the three theoretical attitudes, four categories of generic design principles are found that are important to include in all borderscapes. These principles are explained by small basic drawings in order to get grip on the set of principles a landscape architect has. They do not show the complexity of possible relations among them yet. During this research the potential relations between the principles become more clear and in the design several principles become interwoven. The elements of dynamic and control will for the first time be indicated in the chapter of Application. The suitable physical and administrative condition and 'a new image' will be discussed before in the chapter of 'Positioning'.

2.2.1. The admission of dynamics in time and space
The first spatial principle is to allow elements of dynamics (fig.25). These contribute to the ability to exchange processes and to adapt. The principles can be experienced in time and through space. In time, a designer can work with different time scales that are present on the site of the borderscape. These scales are tidal and seasonal differences, extreme scales, such as a storm and the slower trend of sea level rise. Different time-scales can be experienced in space by a difference in water level or different type of ecological system related to the level of moisture. The acceptance of the time-scale of the storm can bring across an abrupt change in space, such as a small landslide.

Another understanding of time is to understand and work with the adaptive cycles in design. Human can interfere in the cycle by manipulating a tipping point in order to stretch a certain phase in the cycle or by accepting the run through one succession cycle. Adaptive cycles can also run 'naturally' without any human involvement able to nourish themselves.

Allowing dynamic in space refers to the different processes of water flow, sedimentation, water type and natural succession on land and sea. At sea, a tidal range of high and low tide occur. If the sea is shallow and the ground dries partly during the tides a vein structure of gullies occurs. Through these curvy gullies water and soil is transported that deposits at low velocity. During high tide this gullie pattern disappears. On land the waterways are shaped by the topography running from high to low and the waterlevel is not subjected to the tidal range. In general, the land is used by human and the waterflows are controlled, e.g. canalized. According to the water type, the sea transports salt water to land and fresh water flows from land into the sea. Besides water, the sea also transports soil that can be deposited at low velocities. In return, water at high velocity tends to erode the shores of the waterways. Altogether, the type of soil, water level and water type define the type of vegetation to grow.

Iteration

Infinite cycles

one cycle

one phase

Time scales

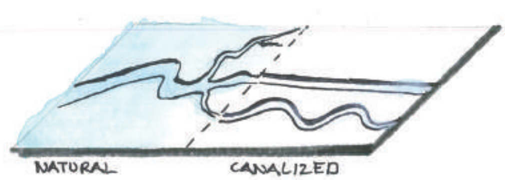
Tidal (2x daily)

Seasonal

Extreme

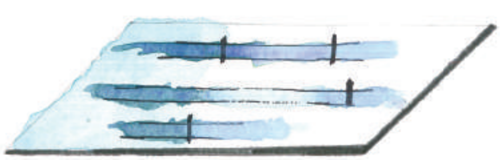
Decades

Space

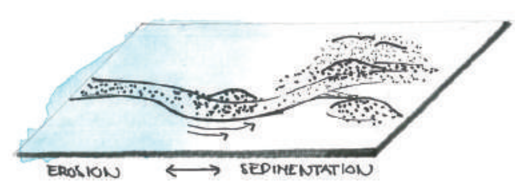


Patterns and shape of waterbodies

Natural succession of vegetation



Connection of watersystems (fresh/salt)



Sedimentation and erosion

Fig. 25: Elements of dynamics (Own library)

2.2.2. Controlling elements as director of change

In all borderscapes, controlling elements need to be present that are more fixed in order to guide the change, establish water safety and to be able to experience the dynamics (fig. 26).

There are several characters of a controlling element that influence the level of control. The different types of materials and use of mass can make a differentiation in permeability. A difference of height in relation to the water level at different time scales can define the level of overflow. Another character is the direction of the controlling element in relation to soil deposit. Positioning an element perpendicular to the direction of the tidal flow will create a different land-shape of soil deposit than a parallel positioning. Lastly, the size of an opening in the controlling element influences the velocity of the water flow and consequently the soil deposit. A small opening can speed up the velocity of the water and creates erosion. In contrast, a big opening decreases the velocity of the flow and sedimentation occurs.

Besides defining controlling elements as individually, several potential controlling systems are considered that either fit in to the existing waterway system or define a zone of water flow controlled by higher topography. In an existing waterway system perpendicular structures, such as dams or sluices, direct the water flow and water type. Another system is to division of the existing water system into smaller disconnected water systems in which a different water conditions is present. The other controlling systems consider a free zone in which the water can flow. The first one is a basin system that divides an area in different sub- areas controlling the water flow by the edges of the basins. A controlling system can also exist out of separate islands that have a higher topography. Another option is wooden (grid) structures that stimulate the land deposit. The size of the openings, e.g. the distance between the islands, wooden structures and the basins, regulate the water velocity and the amount of land deposit.

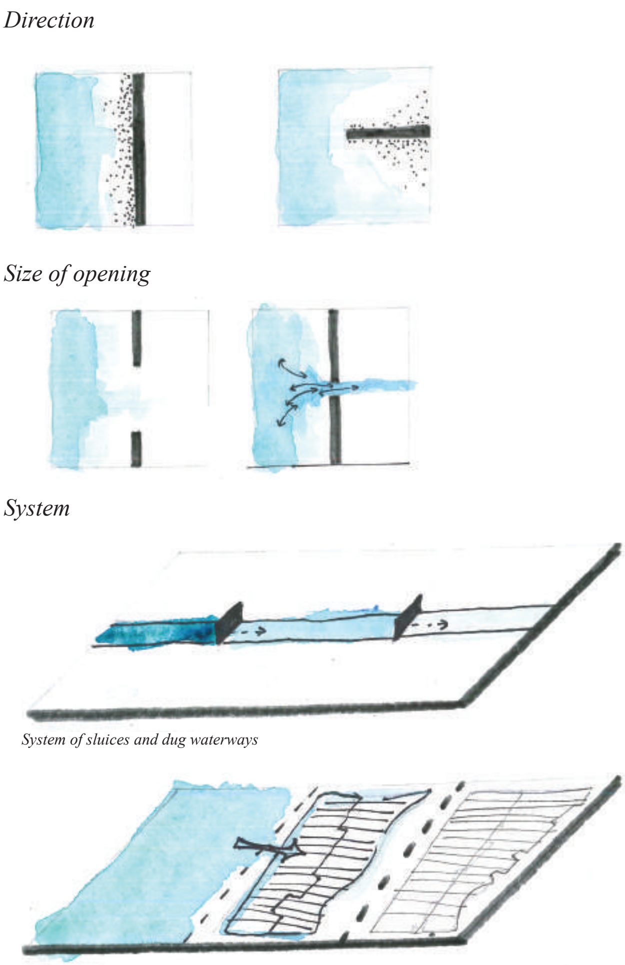
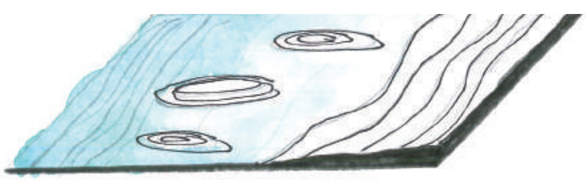


Fig. 26: Elements of control (Own library)

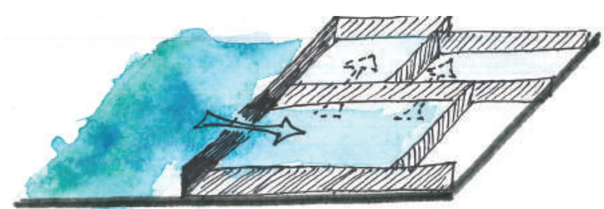
Mass

Height

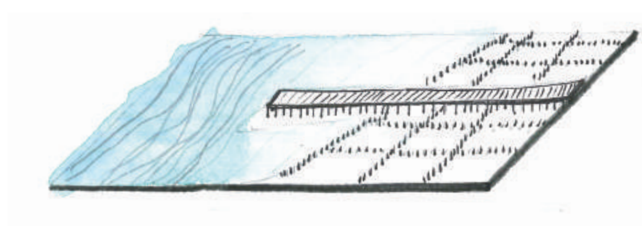
Materialization



Topography as wave breakers and controller



System of basins



Grid of reclemation poles for wave breakers and catchment of sediments

2.2.3. A new meaning for human use and experience

The next principle is that a coastal borderscape should give a new meaning for experience and use of human to be ‘in’ a border, rather being on land or at sea. This generates an image of a border as a wider zone in which different types of dynamics are present. These are the dynamics of ecological systems, human uses and human experiences.

The human uses that take place are the result of merging processes and functions of sea and land. This helps to adapt the functions ‘naturally’ in time if processes of both sides change. Also, several functions can switch easily in to another. All this can lead again to innovative spatial structures.

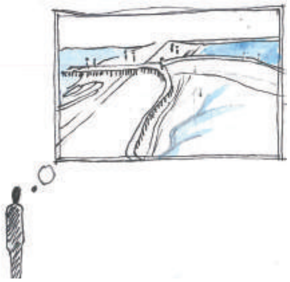
Within the borderscape, the dynamics of processes of land and sea, such as different water levels, water types that lead to different ecological micro climates and functions will be made more legible. This creates a unique physical zone that makes the border between land and sea more gradual. The borderscape should enable to experience these different types of dynamics from different levels of perspective (fig. 27).

2.2.4. Suitable physical and administrative conditions

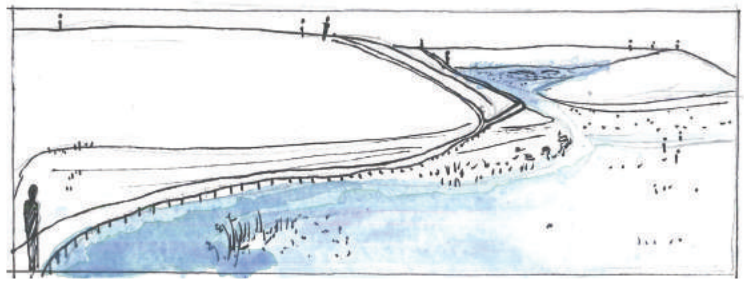
In order to achieve this new meaning for human and use and experience, spatial structures and administrative conditions should be looked at in order to support those.

In time, the spatial structure of the borderscape can expand or decrease, changing the physical zone in width and/or level of permeability between land and sea. Also the curvilinearity contributes to the level of exchange between both sides. A ‘rugged edge, with coves and lobs creates a longer coastal length for ecological development and creates sub-spaces for social activity (Dramstad, 1996, p.30) All this, asks for a spatial structure in the area that consists out of fixed elements and dynamic elements. The fixed elements are resistant, control the change and give the ability to human to experience the dynamics. This spatial structure supports human uses and human experiences to occur within the borderscape in a safe, regulated way.

The borderscape will be more heterogeneous in ecological systems, human uses and experiences. This asks for a dynamic maintenance policy in which to a certain extent the owners have more control of their area instead of national or regional control (fig. 28).

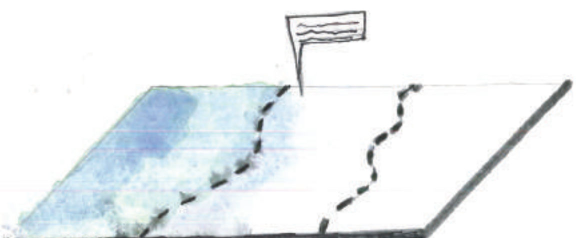


New image of the border as a physical zone and integrated system



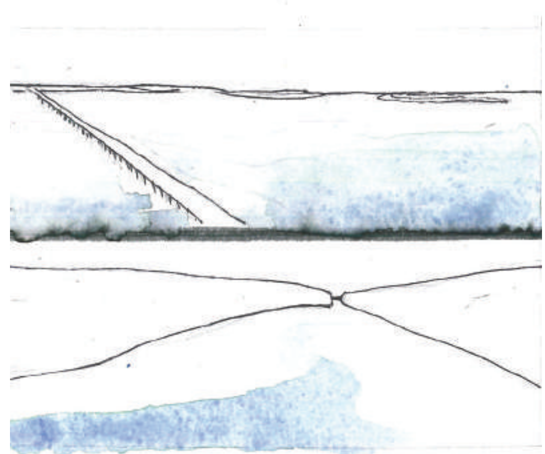
Creating an experience of being 'in' a borderscape which uses correspond to the dynamic character of a border

Fig. 27: A new meaning of a borderscape (Own library)



A seperate administrative status

Suitable physical space: surface, length coastline etc.



Suitable pysical space: wide/enclosed etc.

Fig. 28: Suitable spatial and administrative conditions (Own library)

2.3 Design research

In order to test the suitability and implementation of the generic design principles for coastal borderscapes, a case study is chosen. The case study will be the edge between the Wadden sea and the coastline of Northern Netherlands, Friesland and Groningen. A line of islands from the Netherlands to Denmark function as a row of buffer islands, giving a small inlet for the water and sedimentation carried from the North sea to come in the relatively shallow Wadden sea. The Wadden area, a unique, ecological zone, including the barrier islands, is part of UNESCO World Heritage. Moreover, this area has to deal with high uncertainties as it is unclear if it will drown in the future by sea level rise or silt up by sedimentation. As this zone is relatively shallow, calm and deposits sedimentation it is seen as a potential location for a borderscape.

In comparison to other countries, the Netherlands is located very low in relation to the water level. As a result, the culture history of the Dutch is strongly intertwined with water as they always had to deal with it. In 800 AD, the coastline was more ambiguous and land inwards in comparison to the current line. At that time, bigger zones of marshlands existed that served as a gradual transition between sea and land (fig. 30). In time, the Dutch people have reclaimed land and as a result their land moved towards the sea. In the Netherlands, the tidal range is 1 - 2 meters and the main water flow is from the South-West (fig. 29). The tidal range means the difference in water level during high and low tide. This cycle of high and low tide happens twice a day. Currently, the border is fixed and is reduced to a narrow line, mainly having the single function of water defense. In space, this line takes the shape of a 8-9 m high dike.

In the design research the generic design principles will be implemented on the site of the case study among different steps. At all time, different scales will be taken into account.

Step 1. Positioning

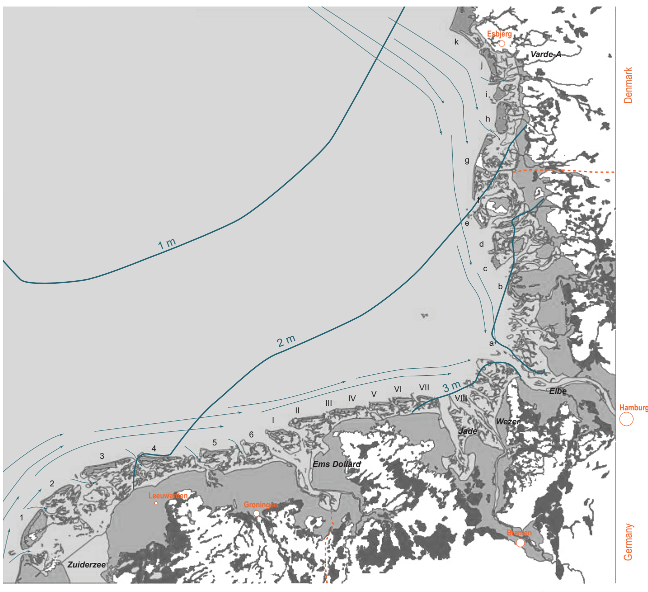
In this step a historic timeline of the different perceptions on the coastal borders is made to understand the current state of thinking in a wider view. This enables to see potential human meanings of borders and to find possible spatial structures and administrative conditions that could be re-used. Next, the current objectives of the coastal border in spatial planning by the main actors are discussed that need to be integrated in the meaning of a border too. Moreover, the mediating role of the landscape architect between different actors is defined to facilitate change in design and to make certain spatial and administrative conditions that support this explicit.

Step 2: Indicating

The next step is to indicate the potential zones of permeability along the coastal line of Northern Netherlands. This is done by analyzing the elements of dynamic and control. Another analysis is done that considers the potential zones of conflict. Dealing with these zones in the design, asks for an approach in which the conflicts are turned into potentials. The different analysis overlapped give an indication of the positioning of different elements in the permeable borderscape. This step stops with a rough indication of the generic design principles on different locations making a first assumption for a categorization of the coastal line.

Step 3: Locating

In this step an analysis is done looking at the site-conditions positioning the existing dike as central point. The layers included are geomorphology, water regulation, land-use, micro-climates and water parcellation patterns. Based on this, the spatial structure of a borderscape in this location is defined. The borders and sizes of the borderscape are set and a differentiation in density is made on the scale of the coastal line. Moreover, the analysis enables to divide the coastline in several categories roughly. The desire is to make a small number of categories as comparison is asked for in the reflection. Now, an extensive design is made for one dense location, de Zwarte



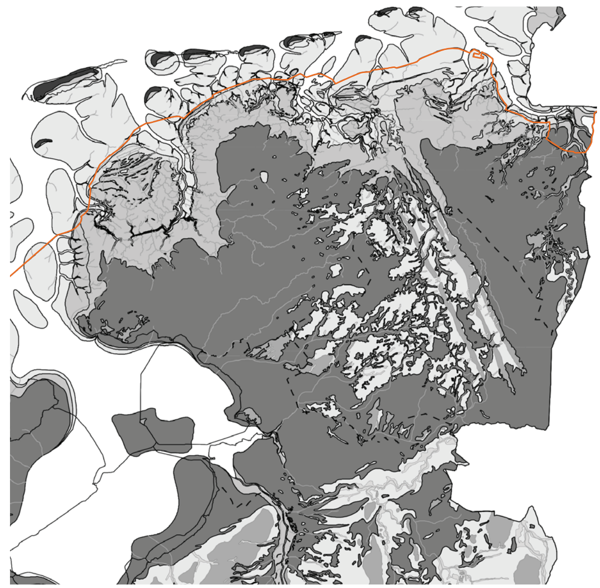
Pleistocene sand

Peat bogs

Embanked area and high marsh

Intertidal area and salt marsh

Fig. 29: Tidal range difference and wave direction Wadden area (Oost)



Water

Peat

Marshlands

Tidal flats

Sand

Fig. 30: Fixed and gradual border Northern Netherlands 800 AD in relation to current fixed narrow border (orange) (Bosatlas Holoceen)

Haan, of a category in order to make the generic design principles site specific.

Step 4: Applying

While only one location is chosen for the design, several analysis and design experiments are done on other locations along the coastline to give input for the implementation of design principles on the site of Zwarte Haan in order to meet the objectives of a borderscape and the potential multifunctional role of the primary dike to fulfill this. The primary dike becomes part of a wider water defense system, is the regulator of water types, the controller of experience and a architectonical element. Besides, the design of the dense point has an leading role for the potential functional and spatial development of the adjacent area. The dense point serves as a destination in which all potential functions and experiences of a borderscape are combined on a smaller scale and made experienceable Lastly, the exchange of water conditions serves as basis to diversify ecological systems and to merge existing and new human uses and experiences. An extensive design of the dense point of Zwarte Haan shows the potential spatial outcomes of the area ending in a timeline where the dense point is placed in the wider area.

Step 5: Reflecting

The last step is to evaluate the design of Zwarte Haan on different levels. Firstly, the performance of the design Zwarte Haan is tested if it meets the requirements of the three attitudes proposed in the methodology and a new attitude of social involvement is added. Next, the design principles are projected on other locations along the coastline. This reveals the level of applicability of the design principles to other locations. Lastly, a general reflection of the research is given zooming out and discussing the relevance of design and research, the approach, the position in education, the transferability of the results to other fields and dilemma's.

In this research, different scales are taken into account as these are interrelated. The largest scale focusses on the understanding of processes taking place in the UNESCO Wadden area and the coastal area of Northern Netherlands. The mediate scale looks at the exchange of processes and systems taking a section perpendicular to the dike. The micro scale zooms in on the place making of the area, in this case the pumping station and the gardens close to Zwarte Haan (fig. 31)

Macro- scale: *Understanding processes*

Wadden sea area UNESCO World Heritage -
Coastal area North Netherlands

Tidal flow, currents, sedimentation & erosion
Socio-economical value, ecological structure, geomorphology, policies

Meso-scale: *Potential crossings of proccesses and systems*

Coastal area zone Northern Netherlands (dike as central point)

Geomorphology, landuse, ecological systems, water regulation, water drainage patterns

Micro-scale: *Place making*

Dense point near pumping station Zwarte Haan

Water safety system: topography
Water gradient: hydrologic transition (fresh/salt, polder/tidal),
Ecological systems: vegetation
Landuse: social involvement of current users, new uses
Human experiences: routing, dynamic/fixed, materialization, atmospheres

Fig. 31: Relation between micro, meso and macro scale (Own library)

State of thinking & Positioning

“The dialogue between water and human is not static, but subjected to ***constant change*** *of physical, social, economic and cultural* ***processes****.”*

(Sources: Van der Ham)

3. In this research a spatial structure for a coastal borderscape is developed that supports site-specific human uses and experiences. Firstly, the state of thinking of key-actors involved in the spatial planning of the coastal border in the Northern Netherlands on (inter)national level is discussed. The separate objectives of key- actors of Delta-program, socio-economic institutions and nature organizations will be joined together into a coherent borderscape that leads to merge of uses. The administrative condition of the primary dike should not be the outer edge of a planning area. The spatial structure of the primary dike should connect adjacent areas rather than separating them. In time, the human meaning, spatial structure and administrative conditions of borders have changed. Dividing the Dutch history of the coastal border in four phases, the potential re-use of spatial structures, re-introduction of dynamic processes and experiences of the sea and administrative condition of giving power back to the local users is discussed. This involvement of the users together with showing possible futures help to transform the spatial structure of the coastal border decreasing tensions between different actors.

Fig. 32: An historic perception: a dynamic coastal border full of events

3.1. Integrating objectives key - actors

The spatial planning of the coastal border of Northern Netherlands starts with guidelines on (inter)national level and among different disciplines. The landscape architect should integrate different objectives and make the edges of different planning areas more permeable in order to gain a coherent regional strategy.

Firstly, several nature organizations have power on international level to protect the ecological structure in areas. The area between the primary dike and the Wadden islands is part of the policy of UNESCO, WNF and Natura-2000. Natura-2000 is considered as the most influential guideline for ecological preservation as in national Dutch policy this is referred most to. This organization protects the size of the area and refuses any seaward developments from the main land. The overall objective for the coastal border of Northern Netherlands is an increase of ecological development (I&W, 2016, p. 11). Firstly, they aim for an increase of softer salt-fresh water transitions along the primary dike that gives a gradient of flora and fauna. Secondly, they aim for rejuvenation of the marshlands that occur at in front of the primary dike as most part has reached the last stage of succession (fig. 33a).

As the spatial planning of the Netherlands is strongly related to water, water issues are being controlled on national level by the Delta program. The regional water boards that manage the coastal border should adapt to this policy. The sea level rise has a negative effect on the flooding risk and an increase of salinization on the fresh water reserves. Therefore, the Delta program strives for a national climate-robust water safety system (Delta programma, 2018). At the moment, the primary dike is considered as the main element of the water safety system along the coastline of the Northern Netherlands. Over 50% does not meet the safety requirements (ILT, 2013, p.16). New pilot projects are running in order to develop new spatial dike concepts that take the primary dike as starting point of the design. These projects experiment with multi-functionality (water-safety, economy and ecology) and use of natural processes, such as the use of sea clay for strengthening of dikes. They strive for implementation of new spatial concepts on several other locations (Delta programma, 2018, 4.7.) (fig. 33b).

According to the policy of the regional socio-economic institutions a new integral economic strategy for Northern Netherlands is needed. At the moment, the region of Friesland and Groningen has a decrease in population and economic activity. This development is seen as an opportunity to strive for innovation in the spatial structure and human use of the spacious coastal border (Noorderzine, 2014, p. 15). Firstly, new developments for windmill parks in the North sea give new economic pulse for the harbors Eemshaven, Harlingen and Delfszijl concerning distribution and processing of sustainable energy. Moreover, the main functions of agriculture, chemistry and energy (gas) should be mixed together and with other fields, such as recreation, to invite new human uses in order to strengthen the economic structure (MIRT, 2015, p. 5) (fig. 33c).

In the design of the borderscape all objectives that consider both sides of the primary dike will be included. Instead of placing the required human uses in separate zones in the design, there will be aimed for a spatial structure that integrates and merges them. Thus, in the borderscape uses of ecological development, water safety, recreation, agriculture, energy and chemistry should be integrated. In order to do so, the primary dike, that is the administrative border in these planning areas, should made more permeable. Therefore, a spatial structure is needed that places the primary dike more towards the middle connecting adjacent areas instead of separating them. Administratively, the primary dike should not be the outer edge of a planning area anymore.

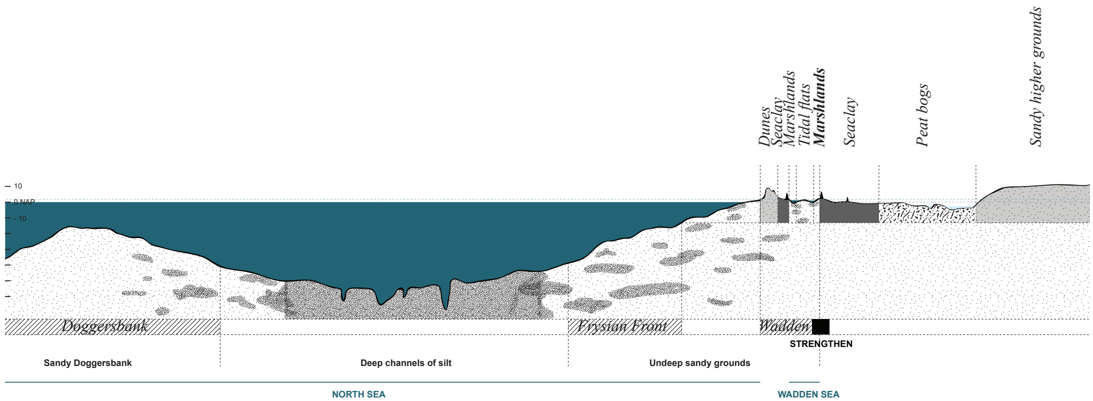


Fig. 33a: Increase of ecological development along coastal border (Sources: Natura 2000)

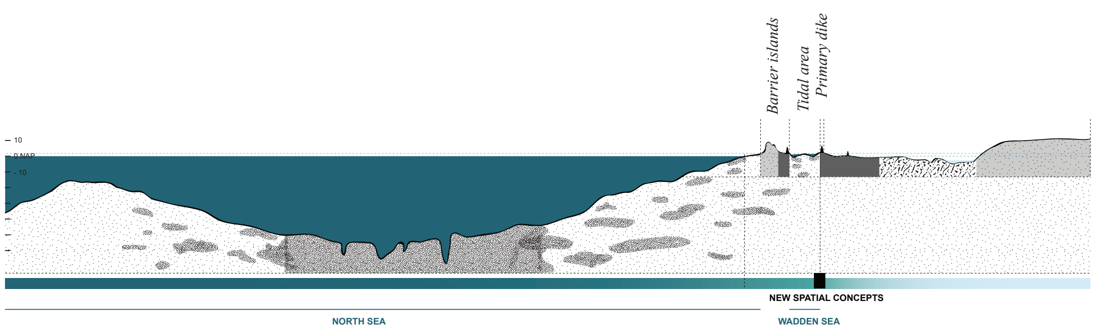


Fig. 33b: New spatial dike concepts that are multi functional and use natural processes (Sources: Deltaprogram)

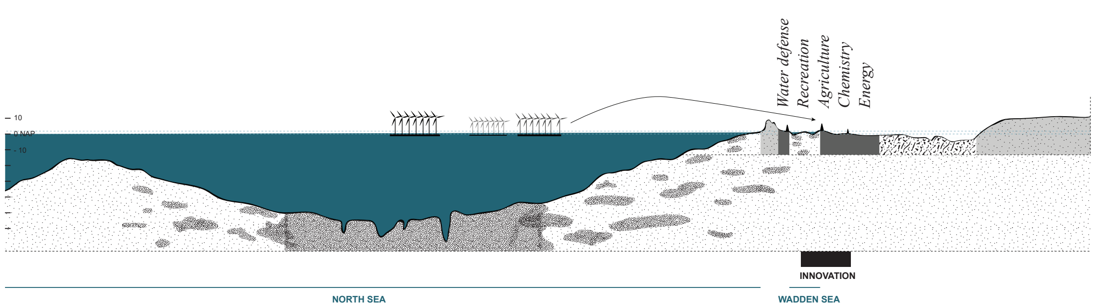


Fig. 33c: Innovation by joining functions of agriculture, chemistry, energy, recreation (Sources:Noorderzine, MIRT)

3.2. Re-use of historical spatial structures

The dialogue between water and human is dynamic due to physical and societal changes. Physical changes are for instance changes in climate, such as sea level rise. Societal changes are related to development of technique, economic status and cultural perception of water maintenance. This has had effect on the spatial planning of the coastal borders and water nationally. The Dutch attitude towards spatial planning of the coastal border of Northern Netherlands can be roughly split up in four different phases each having their characteristic human meaning, administrative and spatial structures of the border(Van der Ham, 2002, p. 33). The description of the phases is complemented with a diagram (fig. 34), a visualization of the landscape characteristics (fig. 35), a set of paintings that reflect the societal perception of a coastal border (fig. 36) and a map that shows the seaward movement of land in time (fig. 37).

I Natural water state > 1000 AD
At this time the natural processes were dominant to human use. At the level of the current coastal border, the land was covered by salt and brackish marshlands. A slight difference in topography left some levees unflooded during high tide. At this location first human settled. In time, the levees were raised and extended by human and started to be called terps. The small community on each terp provided themselves by cattle and agriculture. Using different levels of topography, they were able to regulate the zones of flooding during tides. The relation with the sea was important for water transport, occasional flooding for fertilizing the agriculture lands and the catchment of sediments for the nourishment of the terp.

II Defensive water state 1000 > 1300
The individual terps collaborated and built communal dikes for seawater defense. These dikes, ring dikes or sea dikes, were built on the higher levees on the marshlands. Inside the dike, production land increased and became parcelled in a polder system. As a result, the sea outside the dike had less space to transport water during tides and slowly land started to silt up. Human stimulated this process of land reclamation by putting small grids of wooden reclamation poles, slowly moving more seaward. The relation with the water decreased as inside the dike no occasional floodings occurred. The dike was maintained by the farmers themselves.

III Offensive water state 1300 - 1800 AD
The villages became bigger and asked for more areas of cattle and agriculture. The development in technique resulted in bigger plots of land reclamation outside the dike and the construction of higher dikes. Moreover, the water planning system of polders integrated and the dike started to be considered as a collective good. This integrated water system decided the water level on a higher level.

IV Manipulative water state 1800 > present
Industrialization and population growth asked for a more efficient organization of the land. The dikes were raised again and the polder systems became bigger. Floodings occurred at all phases. The flooding of 1953 that caused a lot of damage, changed the perception into 'hard' water engineering border with the sea. More advanced water engineering structures enabled to regulate water processes on bigger scales in order to prevent sea floodings completely.

Thus, the meaning of the border changed: human have lost the relation with the processes and experience of the dynamics of the sea (fig. 32). Since human have settled on land they have moved seawards in space. Several old spatial structures with higher topography, dikes and terps, are still present in the landscape and can be re-used (fig. 38). The level of the technique in the Netherlands today that achieved to dam off complete sea water bodies enables us to make a controllable permeable border too. In time, the power of water maintenance has shifted from the individual farmer to regional or national water boards. Changing this administrative condition that give more power to the users again can cause more involvement.

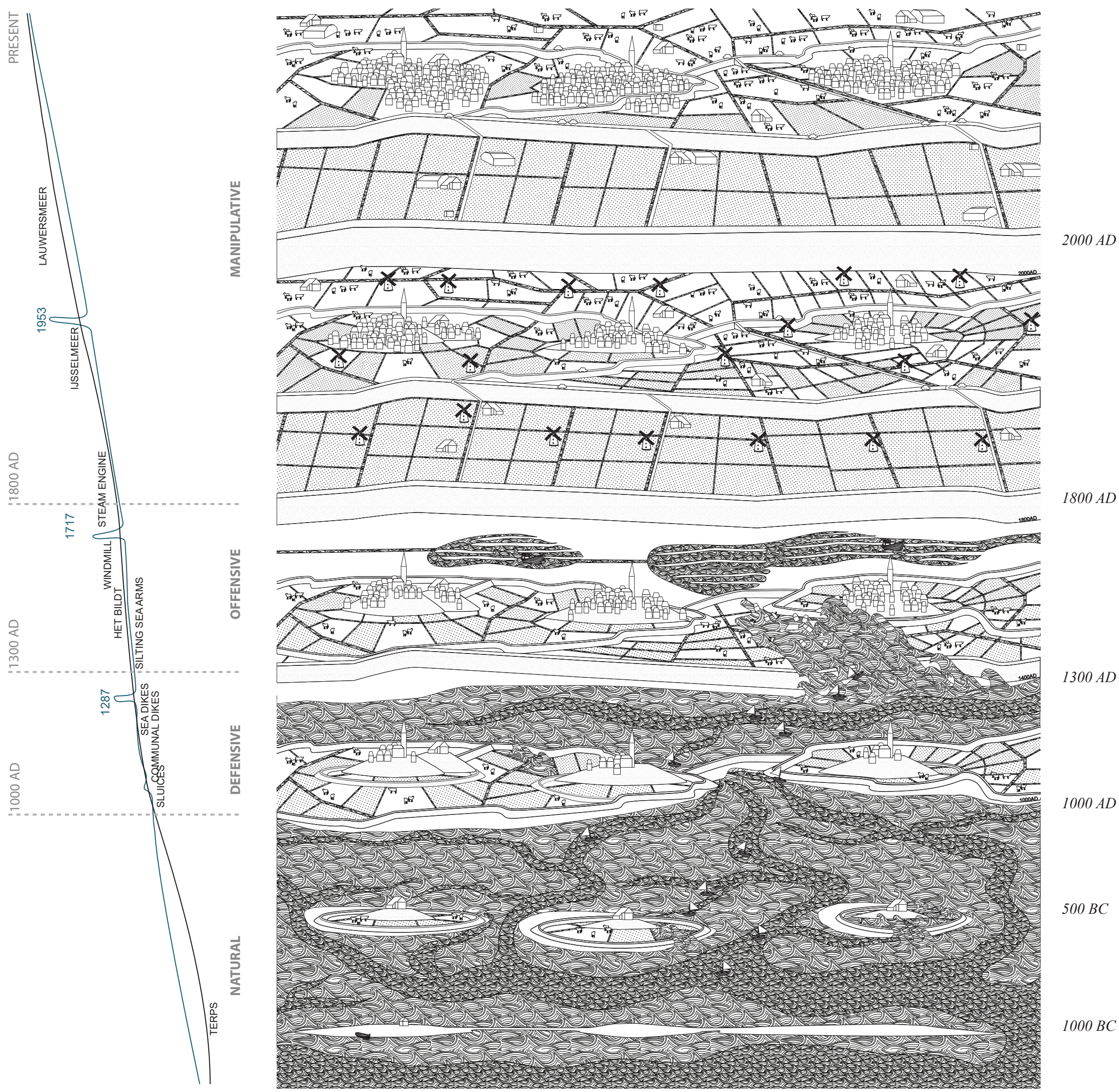


Fig. 34: Diagram and main landscape elements of each phase

Fig. 35a: Landscape patterns through time l-r: marsh levees - terps, ringdikes - larger ringdikes - sleeping dikes (=secundairy safety function) with sea dike further away

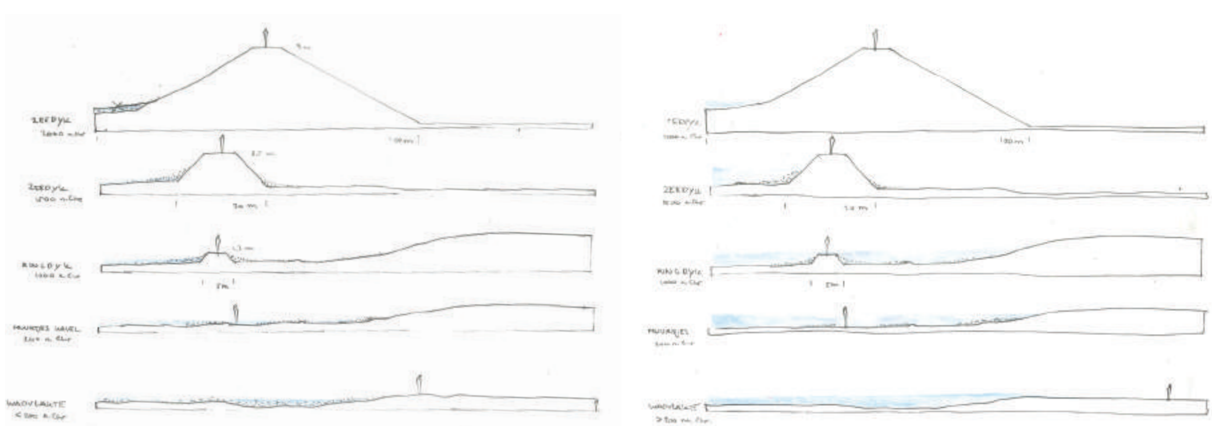


Fig. 35b: Decrease of physical and visual relation with the sea in time during summer low tide (left) and winter high tide (right)

The dike as a wall, seen from land (Jentsje Popma 1921 - now)

The dike as integrated and transformed structure of a landscape, visualized from different perspectives (Dirk Breed 1920 - 2040)

A border subjected to the power of sea (Several artists)

Fig. 36: Paintings of the coastal border in time showing the different perceptions through time

3.3. Facilitating transformation among users

At this moment, the societal attitude in the Netherlands stands at a shift of transformation concerning their perception of coastal borders between water and land. The previous attitude is partly a result of the remarkable flooding in 1953 'de Waternoodsramp' that has caused a lot of infrastructural damage and human fatalities. As a result, the perception of water maintenance changed to hard water engineering structures establishing an impermeable coastal border.

Currently, the predicted effects of an increase of tidal volume and salinization by climate change are already integrated in new strategies of water maintenance on national level that consider a period up to 2050. These strategies apply a more system-based approach in which the natural processes of sea are involved as much as possible contributing to the water safety and other functions, e.g. the project of the Sand-Engine. Thus, spatial planning is to a certain extent ready for a transformation towards more permeable borders with the sea. Still, it seems that the societal perception of the border among the users of the coastal area is still leaking behind. This important actor in spatial planning can cause tensions with other actors and causes emotional damage and delay in spatial planning.

In this transformation towards permeability that is mostly planned on higher levels, the users of the coastal area are uncertain if a change in the current spatial structure of the area will create a better future for them. To a lot of inhabitants of the area, the seaward movement of land represented by dikes, is part of their cultural DNA (fig. 37). Making borders more permeable may seem as a loss of land and increase of safety risk. The main users of the coastal area are the farmers and these already brought tensions to the debate. In the last two decades, a few proposals from above were already done to increase the permeability of the primary dike of 'Lauwersmeer' to bring back the tides in the lake that is dammed in 1969. Farmers have refused this proposal because for them an increase of salt water is bad for their production of crops. Besides, only a few initiatives are taken by the farmers themselves to adapt their crops to more saline conditions although they are aware of the increase of salinization in the coastal area.

According to Sijmons, it is of high importance to involve the users of the area in a transformation of the landscape. In his paper *The emotional landscape* he writes about the current debate of the spatial planning of windmills in the Dutch landscape. This has, similar to a transformation to more permeable borders, also raised a lot of tensions. Together with a shift to sustainable energy sources, the spatial structure of the landscape will change with visible wind mills. The projects in which the users were involved from the start and were given a certain amount of power, such as becoming a co-owner, are more successful (Sijmons, 2014, p. 405). He mentioned that the role of the landscape architect should be mediating between showing potential futures and addressing context-related sensitivities between actors on different levels. This contributes to a new image of the borderscape. In the design, a spatial structure will be developed that supports both on different relevant scales. On the regional scale, the zone of the borderscape will be defined. On the scale of a location, spatial quality should be added to the existing place inviting and mixing new uses and experiences.

At all time, the interventions should softly be integrated in the landscape in order to decrease the 'shock' of change and let transformation happen gradually. A few examples are given of current marks in the coastal landscape of Northern Netherlands that have done so (fig. 38). They are spatial structures that are characteristic to different phases in history. In time, these structures lost their initial function and have gradually evolved in structures with new uses and human experiences. In the 'Let's Talk about Water' symposium, a short movie is made showing a transformation of the primary dike. An open-minded attitude, such as the child, can help finding new spatial structures evolving from the existing dike (fig.39).

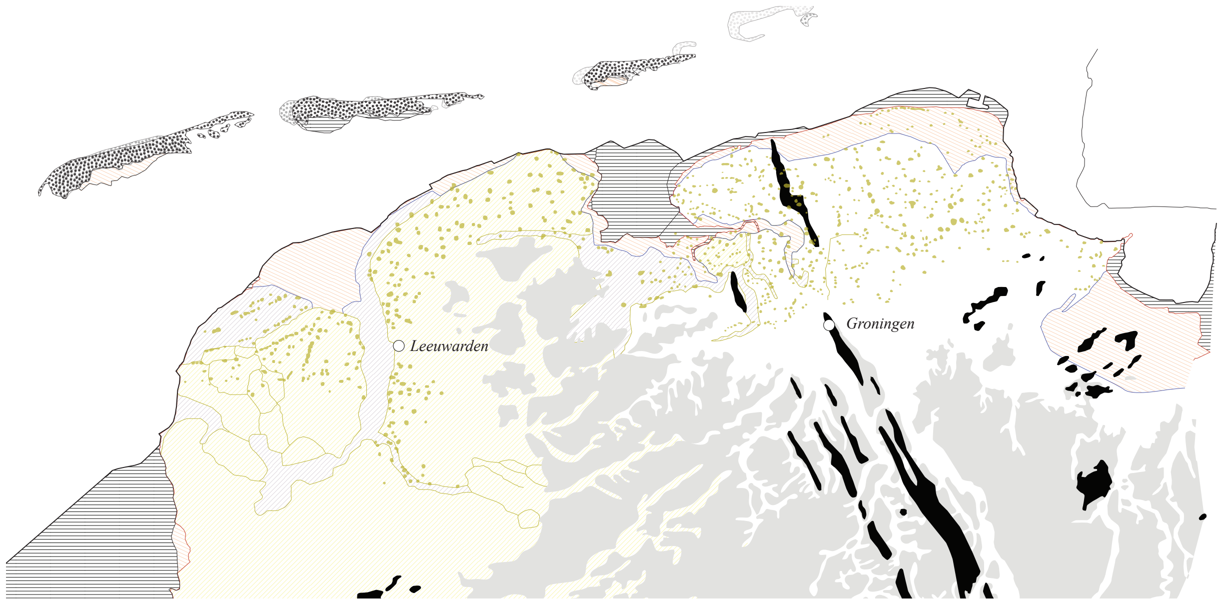


Fig. 37: Indication of seaward movement of land by human interventions and natural movement of islands divided in four phases through time, showing the sea relation of Leeuwarden and Groningen

Old dike as sculpture

Old dike with road

Old gullie as canalized water parcellation in polder system

Old dobbe (fresh water pool) as bird watch look-out

Mound as destination for visitors (spotlights etc.)

Old gullie as canalized recreation route in polder system

Fig. 38: Historical spatial structures integrated in the current landscape

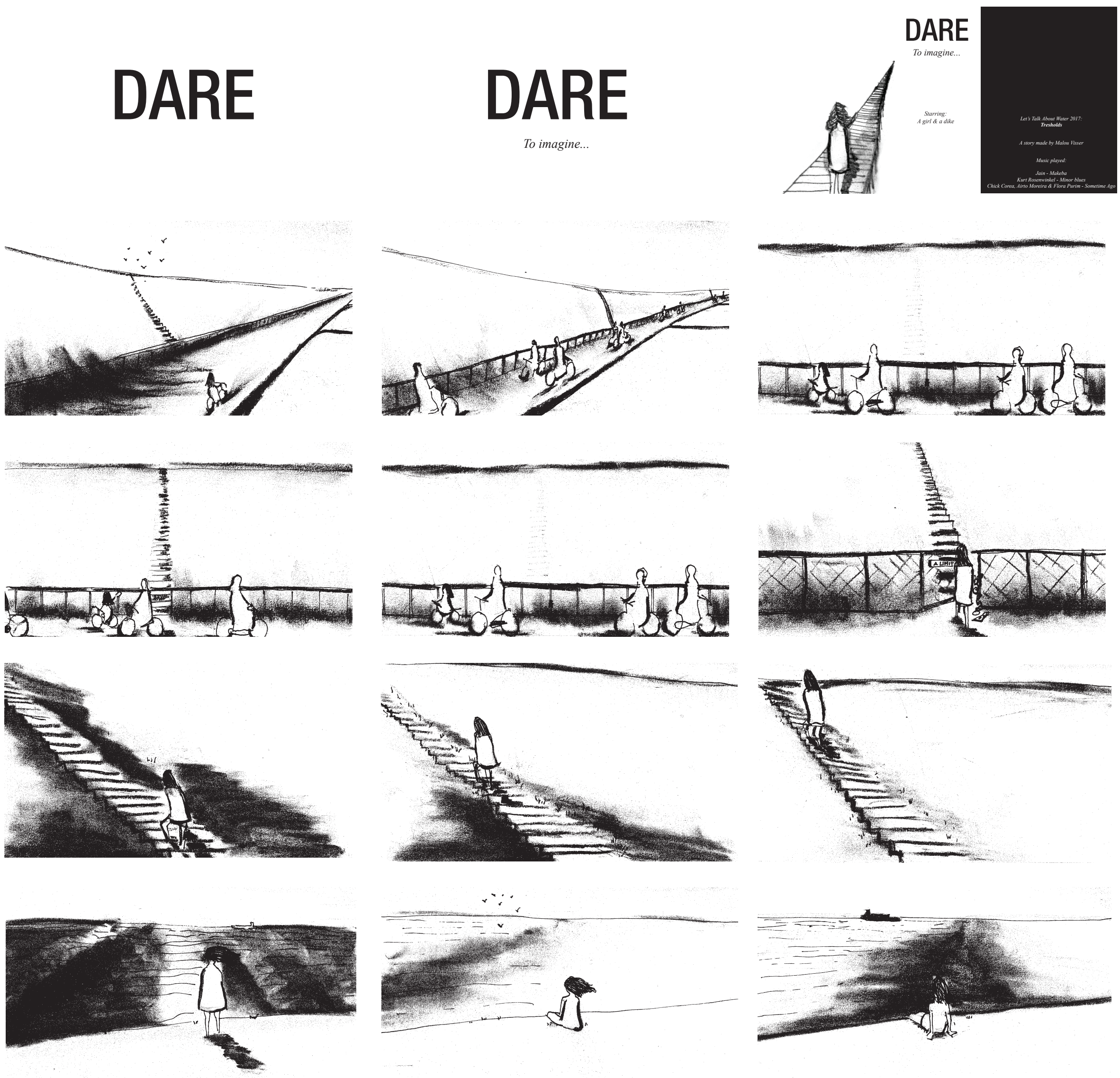
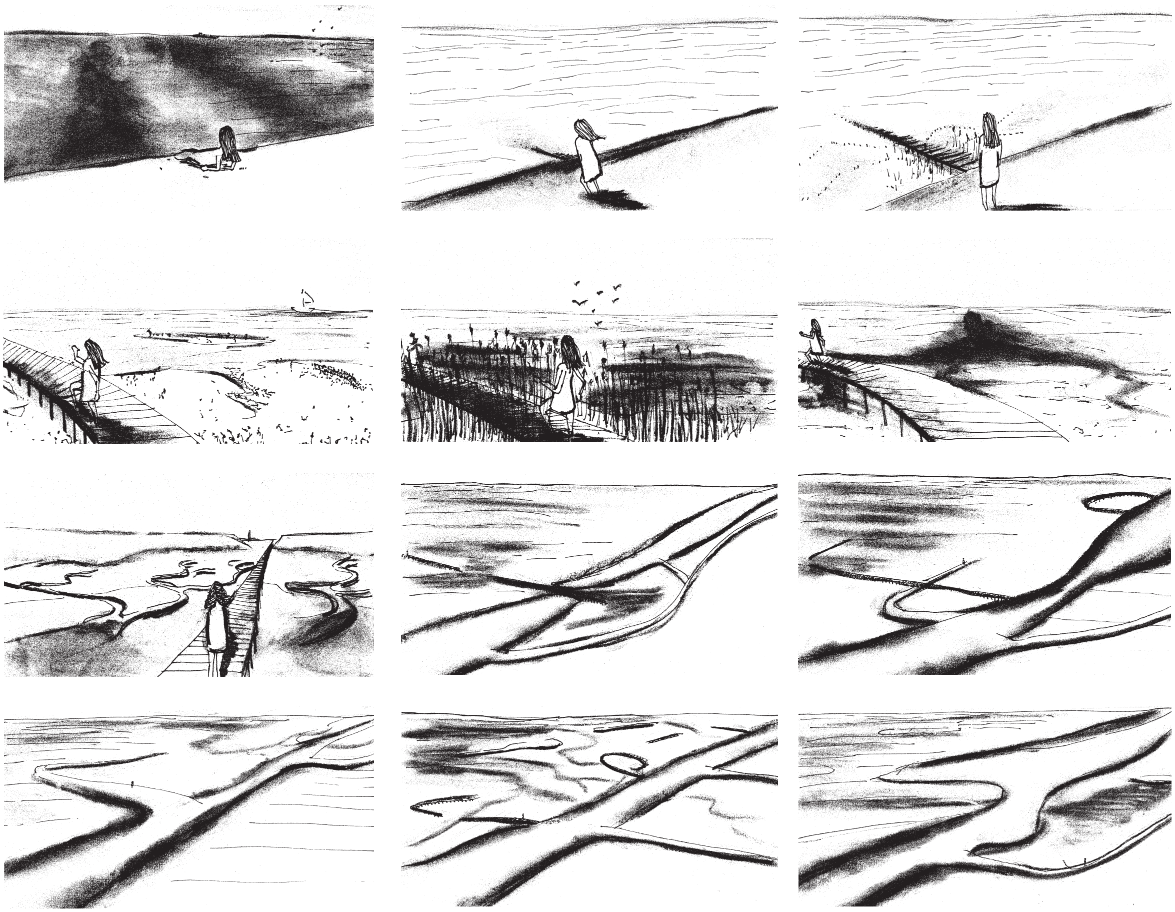
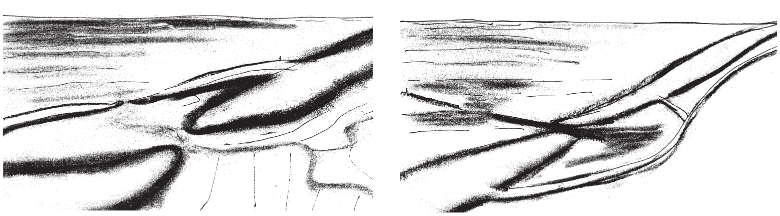


Fig. 39: An open view towards change will lead to new spatial opportunities evolving from existing dike (Storyboard for short movie 'Dare to Imagine' for Let's talk about Water 2018)





DARE

To imagine...

Application

"Design by moving through the scales with a clear direction ahead but allowing design experiments and other research to happen on the side"

4. In several steps the generic design principles for a borderscape will be implemented on the location 'Zwarte Haan' and instrumental design principles developed. On the large scale, analyses are done indicating the location and existence of zones of initial conflict, elements of dynamics and control. Based on this, a rough locating of the generic principles on the coastline of Northern Netherlands is done (fig. 40). During the locating step, the borderscape is categorized and defined more precisely by analyzing the site-specific conditions of dike and adjacent area. The outcome is a spatial concept on the regional scale that will be applied in the location scale too. Besides, a categorization is made to enable comparison between locations. The found design principles for 'Zwarte Haan' are the leading and educative role of the dense point i.r.t. adjacent area, the re-positioning of the primary dike within the borderscape and the exchange of water as basis for a spatial structure that merges human uses and experiences. Design experiments on other locations of the coastline and a comparison analysis with Lauwersmeer is done along the design to find the problematics and potential structures.

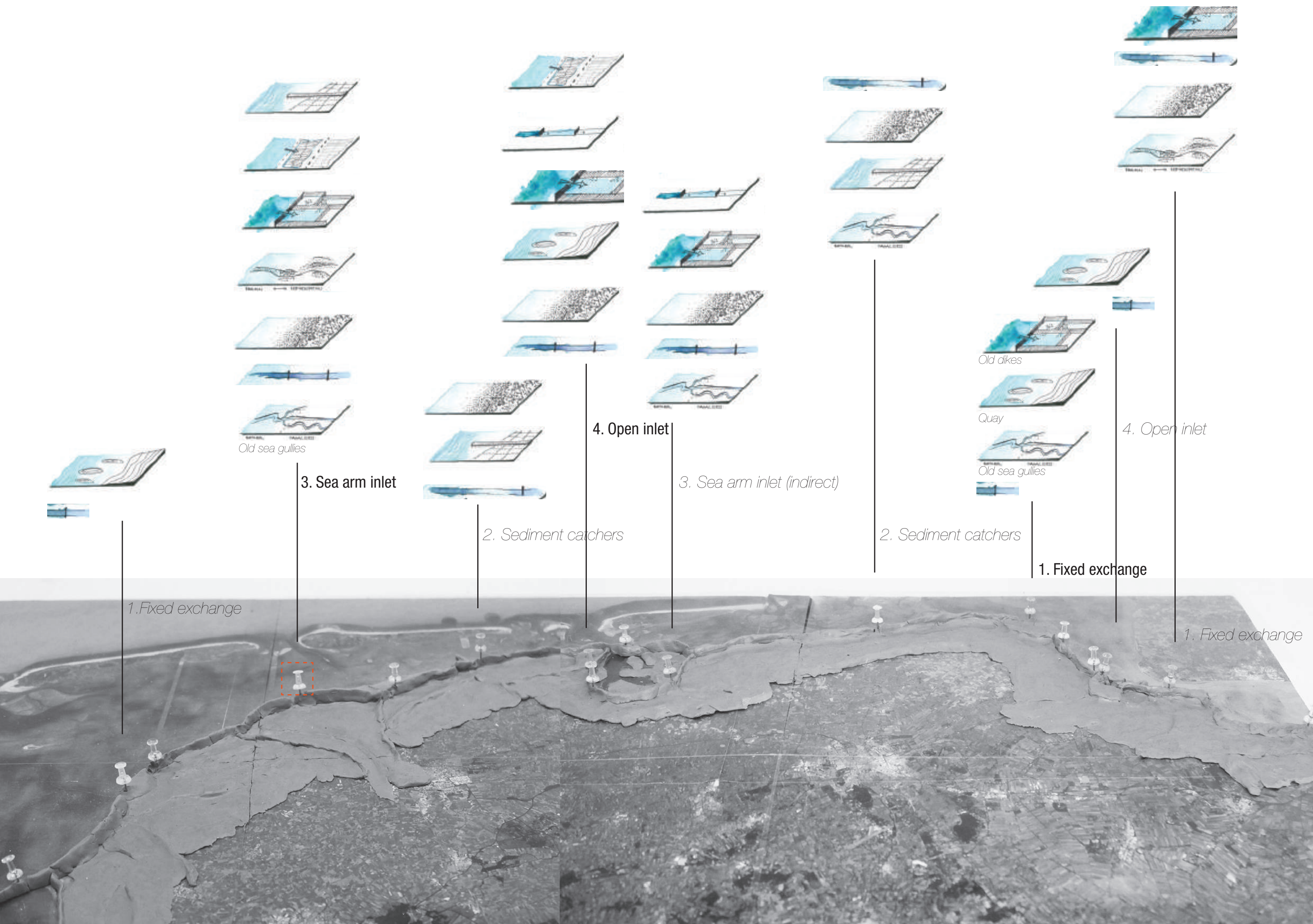


Fig. 40: A first attempt of categorizing generic desing principles to the coastline of Northern Netherlands

Indicating - 4.1.1. Analysis intitial zones of conflict

The first step of the 'Application' is to indicate the potential elements of dynamics and control of the generic design principles of a borderscape and to understand the elements on land and sea that are considered as an initial conflict. Making the existing dike more permeable and wider will have effect on the conditions of the areas that are adjacent to it, e.g. water level, water type, vegetation etc. Sometimes this collides with the current functions (fig. 41&42). The challenge is look from the perspective of the conflictual zones and turn the restrictions to potentials by finding alternatives or find mediating solutions or contributing to defining edges.

Water safety system

The design of a borderscape should contribute to the water safety. Currently, the primary dike holds back the sea water. This relatively 'thin line' needs to coop with an increase of the pressure of the sea. A wider water system helps to divide the pressure. This system is a physical zone contributing to wave reduction and water retention.

Protected Waddenarea

The Wadden area, the zone between the primary dike and the Wadden islands, is protected as an important ecological zone by several nature organizations (previous figures). As in this research the policy of Natura-2000 is considered as most important one, no seaward development from land is allowed. The objective of Natura-2000 is to increase the ecological development along the coastal line. Within the protected zone there are EHS zones. There are only a few places that contribute to this. Here, certain climate-conditions are dominant, such as brackish water and a slight topographical difference between water and land. Thus, increasing ecological development more land inwards can help to mediate between a potential the seaward movement. This will help to lengthen the coastline, which contributes to more ecological exchange.

Production land

The main part of the adjacent area of the existing dike land inwards is used as production land for growing crops and are of economic value for the region. The growth of these crops ask for fresh-water conditions. The increasing effect of seepages along the dike is not noticeable yet as the water board 'flushes' the polders with fresh water. Still, as a sustainable fresh-water maintenance is strategy in the Delta program and salinization will increase, flushing the seepages is not seen as a suitable approach for the long term. Thus, adapting production land to more brackish conditions on a regulated basis is seen as a solution. Bigger waterbodies of fresh water filled by rain water give pressure against seepages and a system of sluices can function as regulators. Also, growing crops or vegetation that are able to grow in more saline conditions will absorb salt out of the ground. The growth of silty crops on the seepage helps to export knowledge and develop the root of crops that can grow somewhere else. The experimental agriculture can happen on small scale and can be combined with function of recreation, agrifood (Texel).

Infrastructure

Generally, the most important road structure is not situated close along the dike. The important parallel line is situated more land inwards, on the level of Leewarden and Groningen. From here, perpendicular connections are made that make a connection to the harbors Delfszijl, Harlingen and Eemshaven. These perpendicular connections are important to maintain as the harbors will increase in importance. The roads that are closer situated to the dike connect the small villages. From here, polder routes perpendicular from the village road arise towards the dike. These intersection points are important as it connects the urban system to the borderscape. Several roads that are located on old dikes contribute to the experience of a borderscape.

Built environment

Generally, the villages are located more than 2,5-3km from the dike. In the polders between the dike and villages, farms are positioned single or in lines. The users that are living in the borderscape are involved in the design.

Fig. 41a: Built environment (Holwerd, 2017)

Fig. 41b: Production land (Het Bildt, 2017)

Fig. 41c: Car road (Harlingen, 2017)

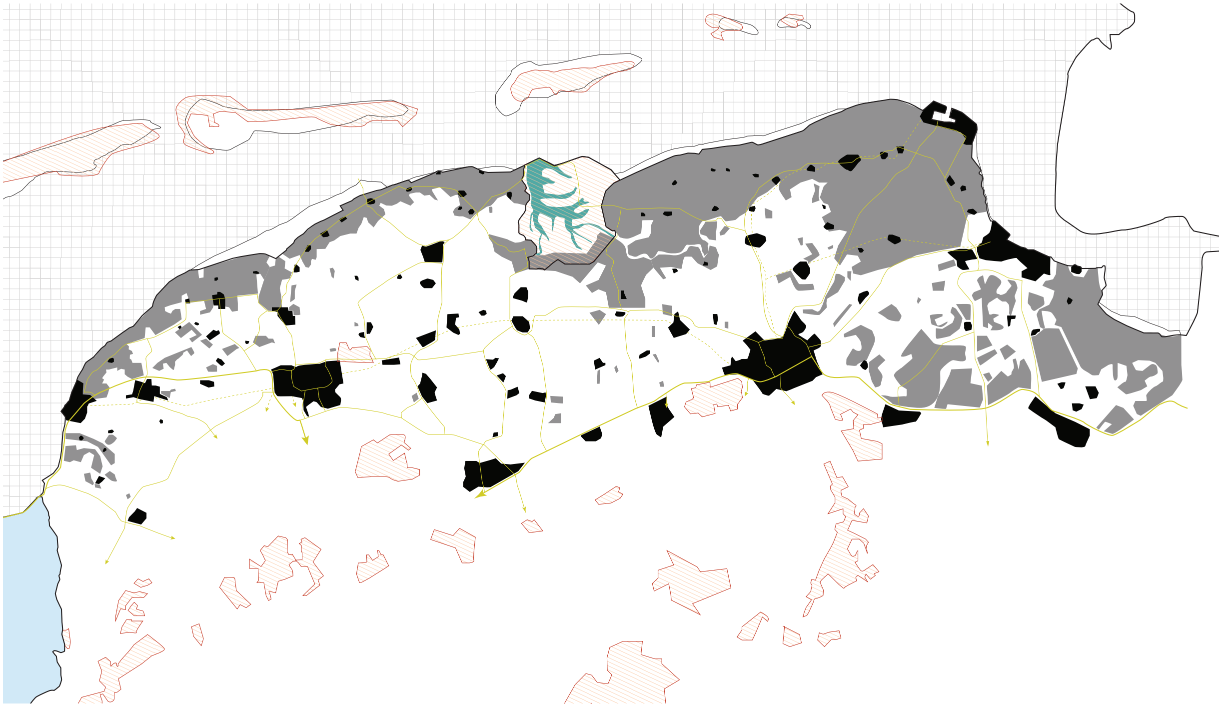


Fig. 42: Current restrictions

Built environment

Production land

High ways (type A- car roads)

Car road (type N- car roads)

Current dike system

Natura-2000 EHS structure zones

Train line

Indicating - 4.1.2. Analysis dynamic elements

The developed generic design principles for borderscapes have defined different elements of dynamic. Taking the large scale as base map, the elements of dynamic and the area of influence occur or have occurred on different scales are indicated along the coastal zone in Northern Netherlands. The different elements are visualized together into one map (fig. 44) and are explained separately (fig. 45 a-d).

Existing exchange through the dike

There are several points along the dike that already facilitate an exchange between two adjacent sides, land and sea. These points can be divided into pumping stations, a road connection and harbor quays. All the pumping stations flush out the superfluous water into the Wadden sea from the fresh water systems that run through the polders inland (fig. 43c). The time of flushing does not correlate to the tidal flow, neither does the water level inland correlate to the tidal levels. Some pumps, flush their water at land in front of the dike. This creates a gradual gradient. At Holwerd, there is an important road connecting the inland road system to the pier from where the water transport to Ameland leaves from. An S-turn minimizes the effect of an open connection of the dike on the water safety. The harbor quays at the harbors are almost enclosed and have hard engineered water arms that create an in-between basin. A closed in-between basin is located at Lauwersmeer in which 3 pumping stations flush their water. Next, a sluice at Lauwersdijk flushes the superfluous water in the Waddensea.

Low topography as director of natural waterflow

Looking at the low topography of the coastal zone on both sides of the dike gives knowledge about the direction of water flow if the dike would not exist. Naturally, the water flows from high to low. This basic principle will be used in the design of a borderscape. On the large scale, there are several low areas. These are indicators of processes that happened in the past. The low areas are either the result of silted old sea arm or of salt mining. As the lower areas are more sensitive to salinization and moisture the main function is cattle or different instead of production land and are. These areas are more suitable for different functions than production.

Old sea arms

The current shape of the coastal border is polished through time. The old sea arms that once had open access to land have slowly silted up or are dammed off (Lauwersmeer). This has decreased the coastal length enormously and therefore the length of potential ecological exchange. Some sea arms have left traces in the landscape. The direction of the pattern of the water parcellation of the adjacent polders are related to it or old smaller gullies have been canalized. These elements can be stressed more in the design, for instance to integrate them in a route system, in order to make the landscape more legible and less homogeneous for experience.

Process of sedimentation and erosion

The movement of tides in the Wadden sea sets in motion sedimentation and erosion of land. Naturally, the main tidal inlet towards the Wadden sea carrier particles that are distributed along a network of smaller water gullies. At higher velocities, so at the start of the inlet system, sand particles are deposited at the inner bends and erosion of land takes place at the outer bends. At locations where the velocity is low, at the end of a small gully or the zone in between two islands where the two tides meet, fine particles are deposited (difference silt and sandy particles). At low tide, the water sucks away particles again as the water direction turns back. In time the length of the network has decreased as the dike has moved seaward and cut off several sea arms. As the length of the network decreased, the total depth of the tidal inlets have decreased. Besides, the current cut-offs of IJselmeer and Lauwersmeer have caused new accumulation in front of the dike. This is problematic for the shipping traffic of ponds and trade. Re-locating the accumulation or integrating it for nourishment of the water safety system can solve this makes it potential for other functions.

Fig. 43a: Canalized old gullie

Fig. 43b: Current gullie, sedimentation and erosion

Fig. 43c: Pumping station

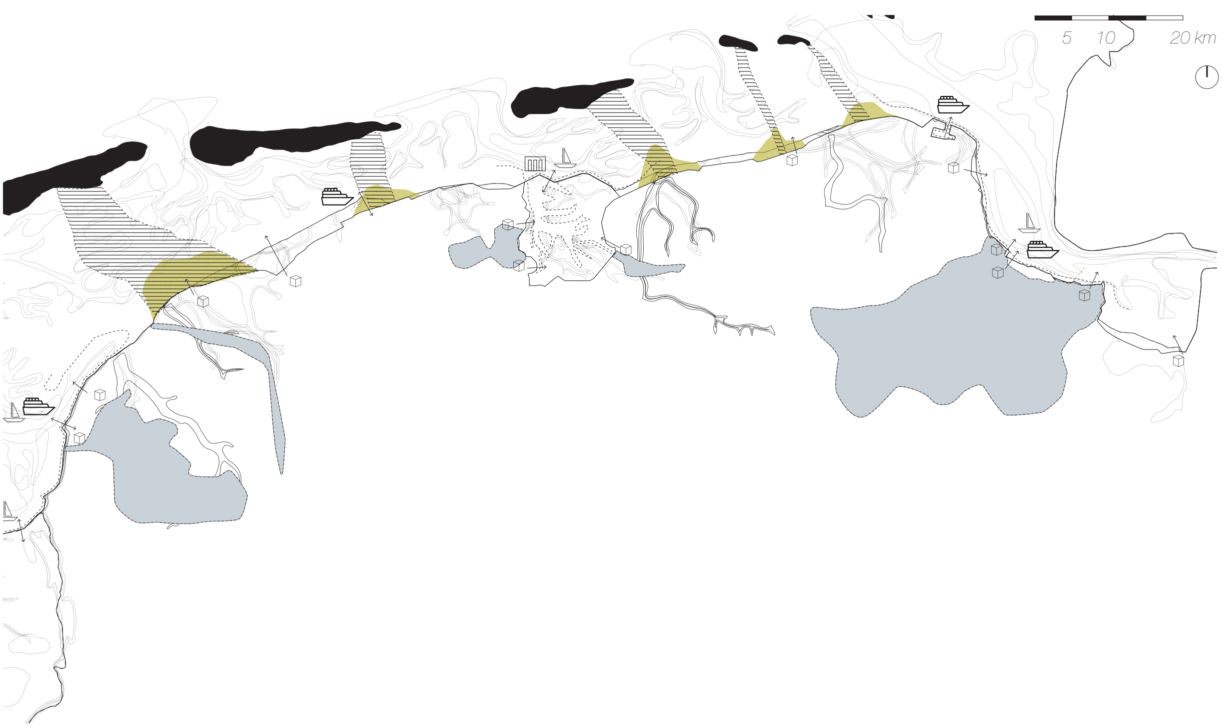


Fig. 44: Elements of dynamics (a conclusion map of fig. 45a-d)

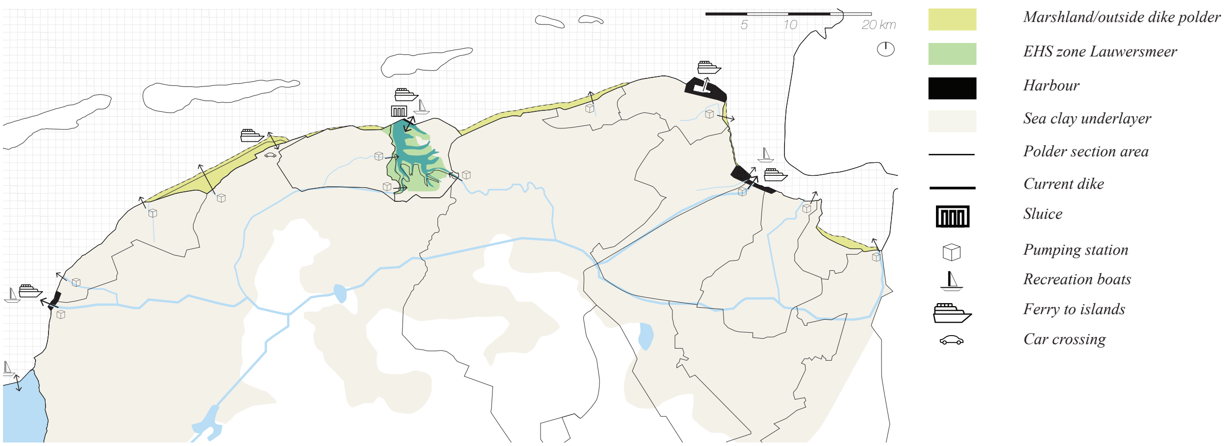


Fig. 45a: Existing exchange in the primary dike

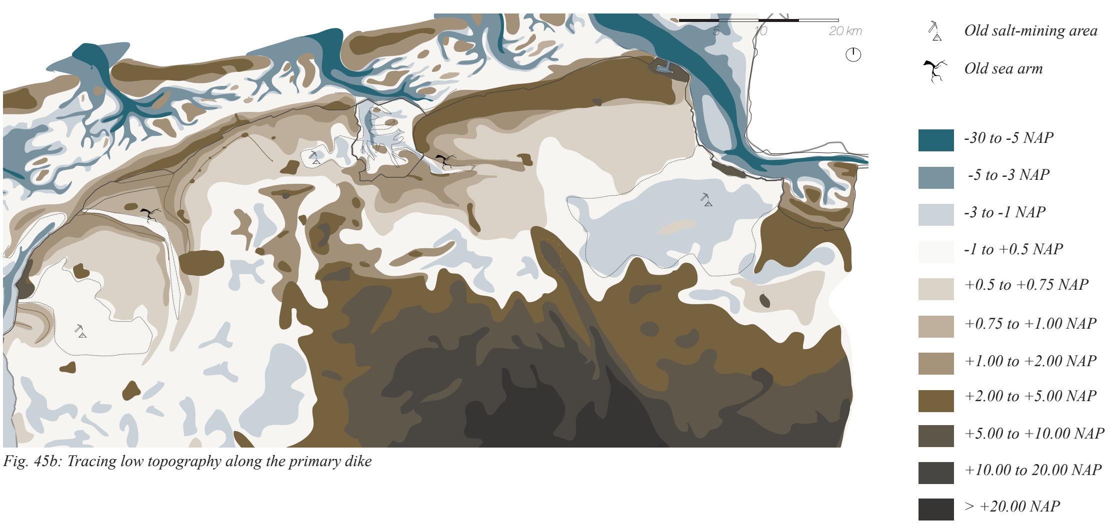


Fig. 45b: Tracing low topography along the primary dike

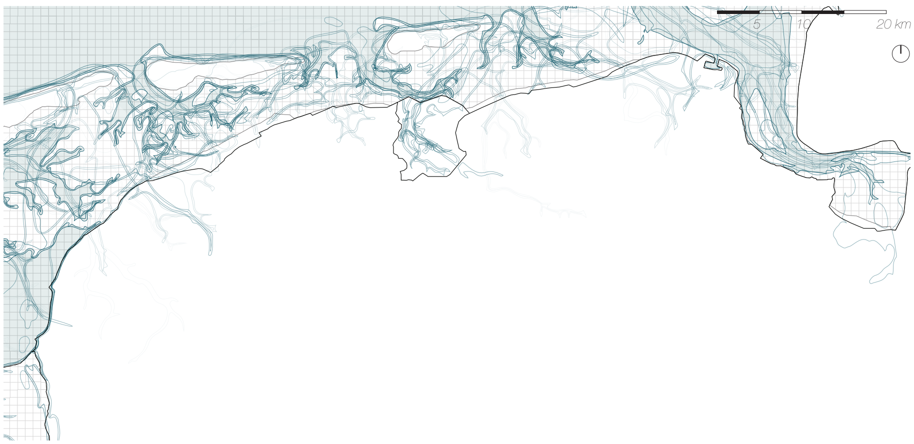
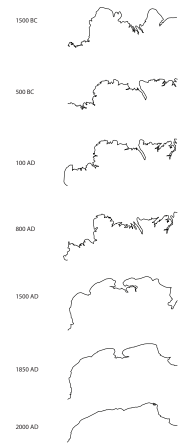
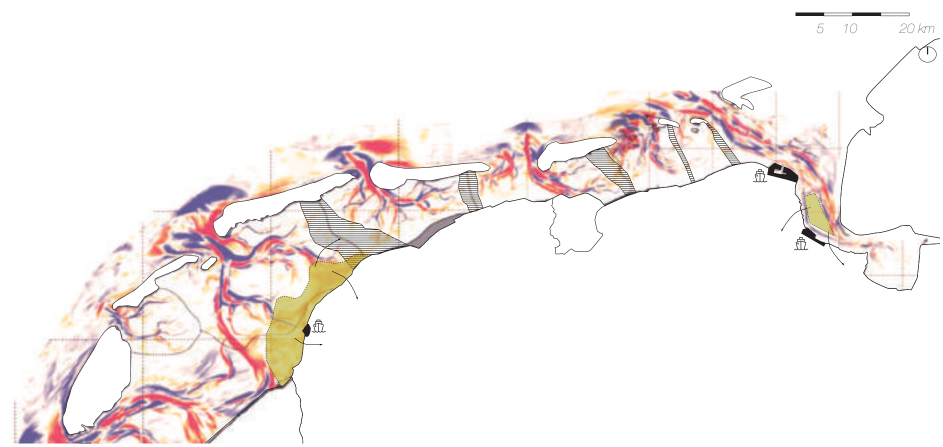


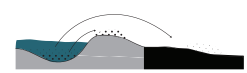
Fig. 45c: Pattern of old gullies creating sea arms in land through time from light to dark blue (1500 BC, 500 BC, 100 AD, 800 AD, 1500 AD, 1850 AD, 2000 AD). The colored blue hatch shows the existing Wadden sea water volume.



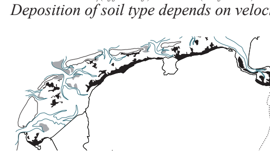
Shrinkage of coastal length (Sources: Bosatlas Holoceen)



Natural sedimentation occurs where v=low

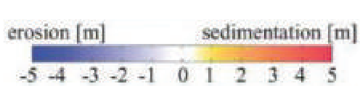


Deposition of soil type depends on velocity



Current division of fine (black) and big grains (grey)

Fig. 45d: Sedimentation and erosion processes in the Waddenarea



current accumulation of sediments

natural places of sedimentation (in between tides)

Important harbours (in future)

Possible directions of accumulation

Indicating - 4.1.3. Analysis elements of control

The developed generic design principles for borderscapes have also defined a diversity of elements of control, singular or in a system. Taking the large scale as base map, the existing or potential elements of control occur on a different level of scale and are indicated along the coastal zone in Northern Netherlands. The different elements are visualized together into one map and explained separately by function, material and spatial structure in relation to the primary dike. At the moment, this is seen as the main controlling element and as the design is seen as constant transformation the evolvement will start from there (fig. 47).

Primary dike

The existing primary is the main controlling element of the coastal border and appears along the whole length. The height of the dike is 8,5 - 9 meters and the width approximately 70m. The dike consists out of layers of sea clay and sand. On the surface the dike is vegetated by grass and at the foot of the dike seawards, asphalt is applied for breaking waves during storms. There is a repetition of ascents each 2-4 km. In policy the primary dike itself should fulfill the safety requirements independently. Therefore, it is considered as an isolated water defense structure.

Harbour quays

At the harbors a quay of high topography is present (4m). Hard materials, such as stones or asphalt are used. During storms the quay breaks the waves and hard material prevents erosion to occur due to the tides. The primary dike continues behind the quay.

Piers/stretching dams

Seawards, there are several structures perpendicular to the primary dike. The stretching dams contribute to breaking the waves of the sea. The pier at Holwerd is constructed to enable water transport between land and Ameland. This extension seaward was needed as the zone in front of the primary dike is too shallow for the ferry to go to land.

Old spatial structures of water defense system

As explained in the previous chapter, there are several old spatial structures still in the landscape that used to serve as a type of water defense structure. These are old dikes and terps. Both have a height difference with the surrounding land that used to prevent them from flooding. Many old dikes have a road on top of them and are vegetated on the sides by grass. Most of the dikes are positioned parallel to the primary dike.

Higher geomorphology

Looking at the geomorphology, the topographical difference in the coastal zone is low. The higher zones have a height difference between 1-2 meters. These zones are the result of the natural process of sedimentation, leaving a pattern of levees. These are mostly parallel to the dike. In history, the dikes are positioned on the highest point of the levees. In front of the dike and along perpendicular structures, dams and piers, sedimentation accumulates.

Water regulators

The existing point of exchange between both sides belong to the elements of dynamic but can also be seen as an element of control. Here, the time and amount of water that is pumped out mechanically through a pipe in the dike in the Wadden sea is regulated. The pumping station is positioned at the end of a water system of an area along the dike. The coastal zone is divided in several water system that each support a polder section. In each system the water levels of the main waterway and smaller water systems are defined. Some water systems are relatively small and could have different conditions without interfering in the whole.

After indicating the elements, the generic design principles are placed roughly. Already do some zones have a similar set of principles, that could be seen as an initial categorization. These could be divided in harbours, ‘old’ sea arms, open inlet and intertidal zones.

Fig. 46a: Mound/terp

Fig. 46b: Secondary dike/ sleepy dike

Fig. 46c: Harbour quay

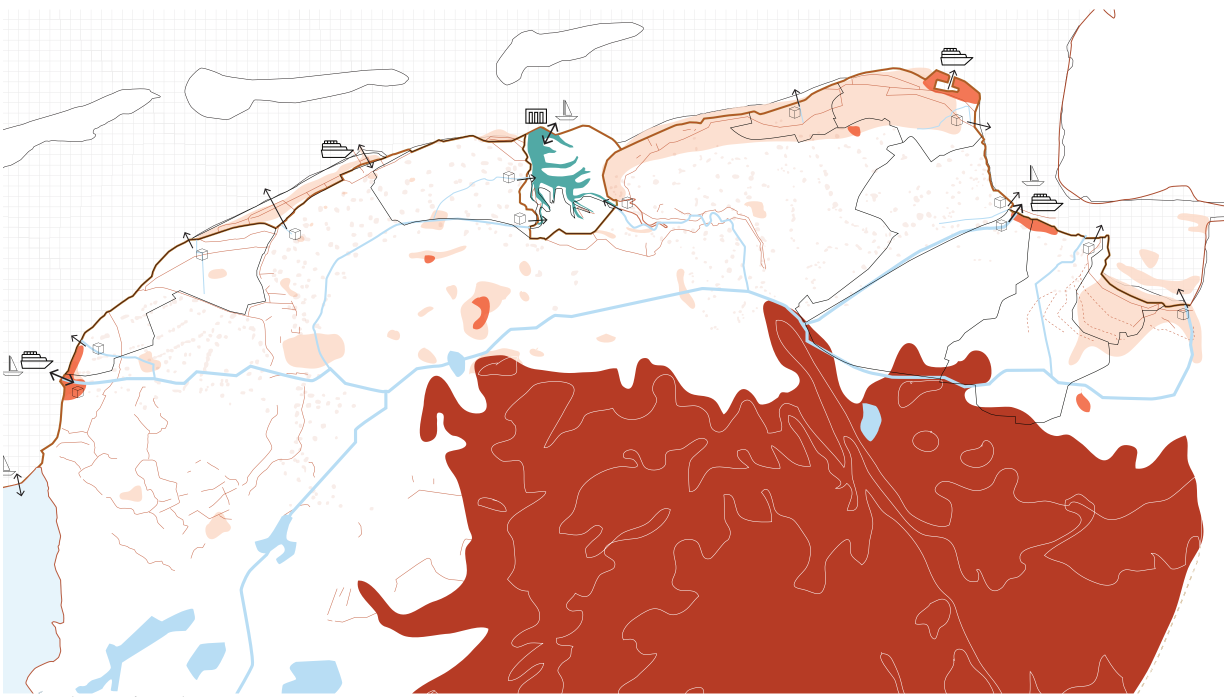


Fig. 47: Elements of control

> +5.00 NAP

+2.00 to +5.00 NAP

+1.00 to +2.00 NAP

Sluice

Pumping station

Recreation boats

Ferry to islands

Car crossing

Small polder section systems

Existing primary (+ 1 secundary at Lauwersmeer) dike

Potential secondary dikes (old)

Disappeared old dike

Locating

During this step, the site-specific conditions of the dike and adjacent area is analyzed on multiple layers important to landscape architecture design; natural, cultural, urban and architectonic layer. This is done in order to locate the borderscape more precisely by defining its borders, the positioning of the primary dike and making a categorization. The aim of this categorization was to have a low number in categories in order to work with it during the research. Moreover, the outcome has given a spatial concept for design on the scale of the total coastal zone that is used on the location scale too(fig. 48). Firstly, the separate layers of the analysis are discussed and visulized (fig. 50a-f).

Geomorphology (natural)

The soil type along the dike is mostly sea clay, except for the sandy soils in Lauwersmeer. The focus in geomorphology is put on topography and soil type. At some locations there is a high deposit of fine grains that enlarges the distance between the primary dike and the tidal gully. At other locations the tidal gully is closer to the dike that increases the chance of erosion along it. According to soil type, there is mainly sea clay (heavy or light) except for the sandy land around Lauwersmeer. The types differ in level of permeability that has effect on the sensitivity to salinization. Sand is permeable and leads quicker to saline conditions.

Water maintenance (cultural)

In general, fresh water conditions occur land inwards and saline water conditions take place outside the dike except for the basin of Lauwersmeer. This lake is a recent cut-off of a sea arm and is still in the transition from salt to fresh water. Currently, the water type is still brackish. However, without interference the water will slowly become fresh. On other locations there is a gradual gradient on the land in front of the dike. This land has a grid of reclamation poles and this positions the dike more to the middle of the Other locations, there is no land in front of the dike having a hard separation between the two water types. Still, the ditch parallel to the dike have brackish conditions.

Landuse (urban)

The land use of adjacent areas along the dike is different. Inside the dike it is mainly homogeneous production land. Outside the dike it is either water or land that has already an ecological value or is or addressed to be so (Natura 2000). At Lauwersmeer there is a big ecological zone inside the dike and at the edged production land. This makes the area heterogeneous. There are three harbors.

Patterns (architectonic)

At the dike the different patterns of water parcellation, gullies and reclamation are stopped abruptly. At some locations the transition is more gradual (fig. 51). The direction of the patterns in the polder system inside is diverse creating fan-patterns. In general the patterns are made perpendicular to the dike. The fan-pattern shows the direction of reclamation in time.

Micro- climate (ecology)

There are several micro-climates: young, middle and old salt marshes and fresh water ecological systems. A part of the fresh water system is highly fertilized as a result of the function of production land. The primary dike is considered as a mix of ecological systems due to difference in topography and water type.

Secundairy dike strategy (cultural)

As explained in the introduction, the secondary dike system is considered as a suitable strategy for the decrease of the flooding risk and contributes to the image of having a wider water safety system. At these locations the borderscape becomes wider, setting its border at the first old dike parallel to the primary dike. The borderscape could become wider in time, moving to the next old dike. At the areas that do not have a secondary dike system the dike remains a thin line.

This analysis have given direction for the borders of the borderscape. Towards land, the borders are set on the secondary dikes with the option to move more landwards to the next dike. Looking at the sea, the borders relate to

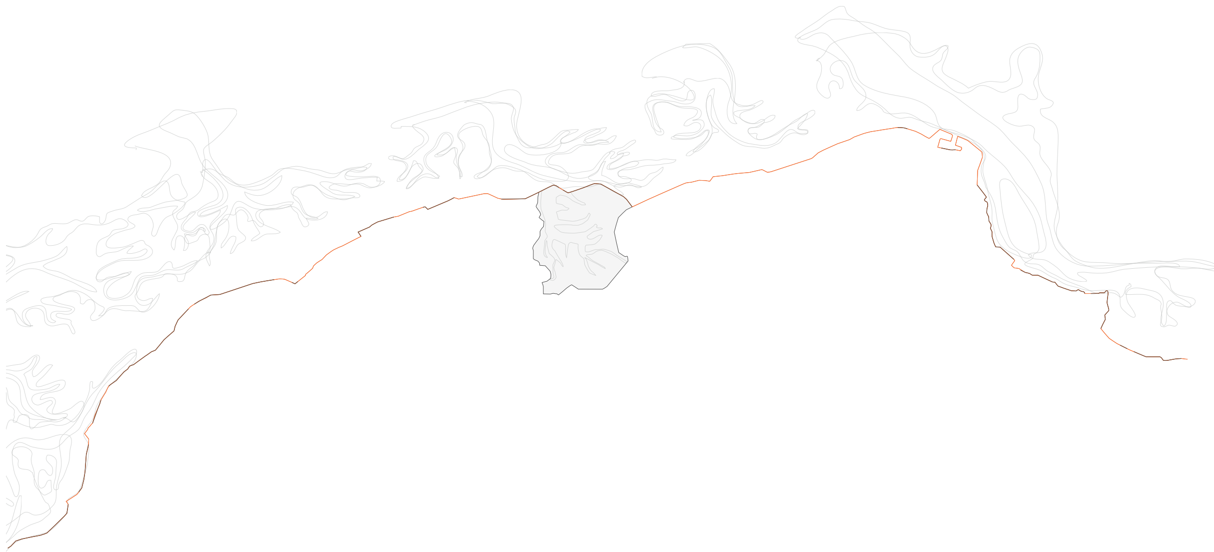


Fig. 48: The current border of the coastal zone, considering Lauwersmeer as a borderscape system already (dark red= rejected following safety requirements set on national level)

Fig. 49: Proposed spatial structure and outlines of borderscape of the coastal zone Northern Netherlands

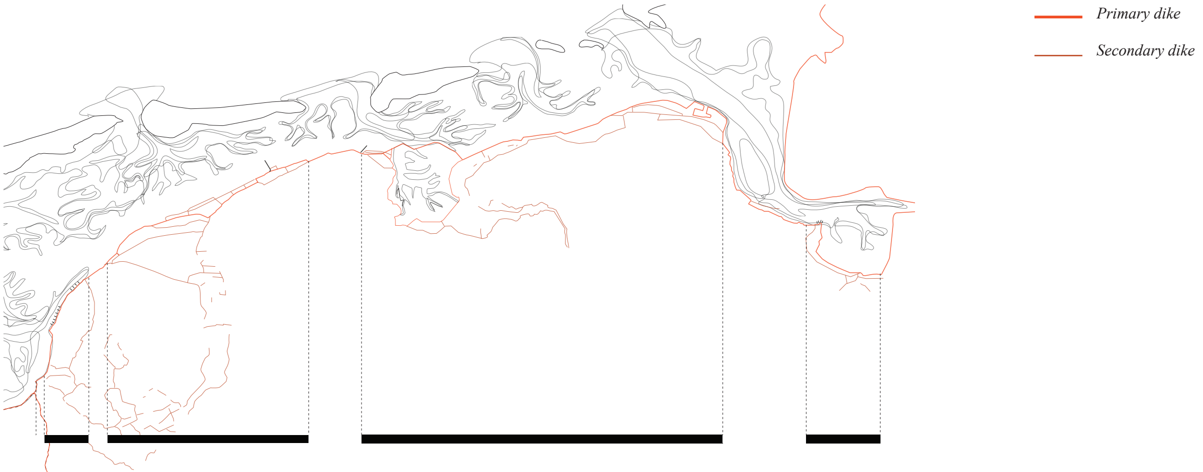


Fig. 50a: Secondary dike system

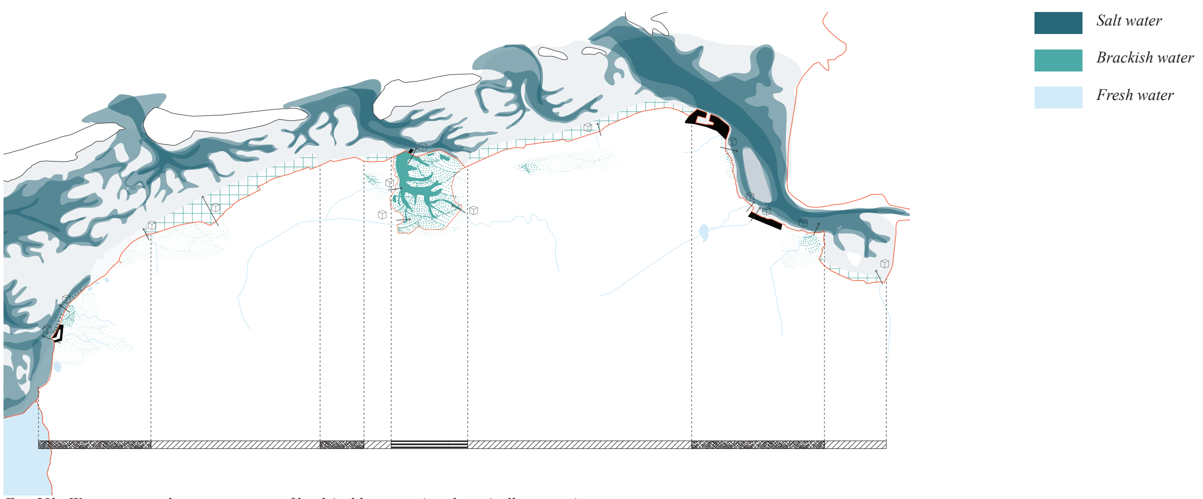


Fig. 50b: Water types in the water systems of land (polder system) and sea (gullie system)

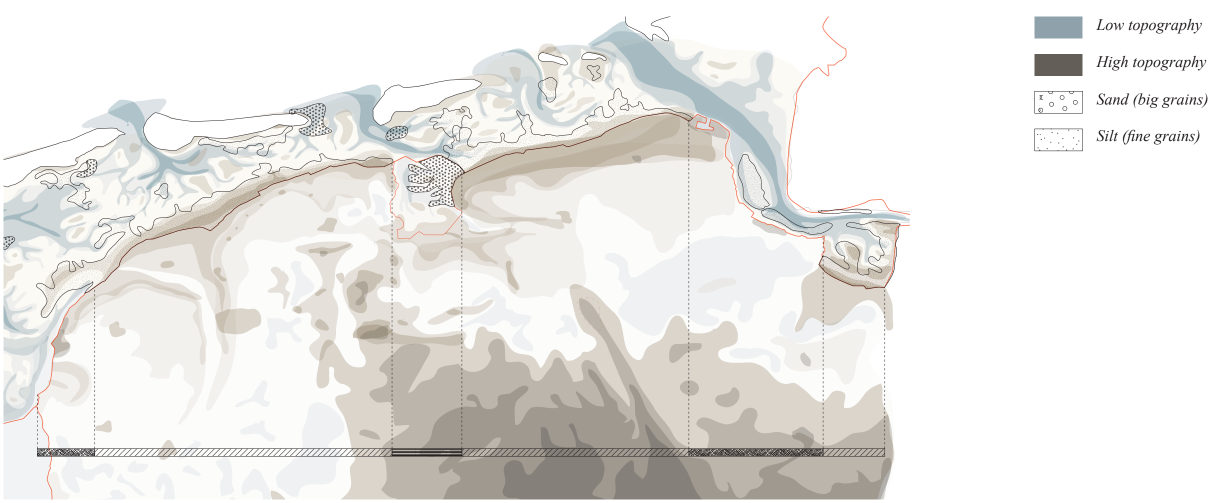


Fig. 50c: Geomorphology and natural sedimentation and erosion

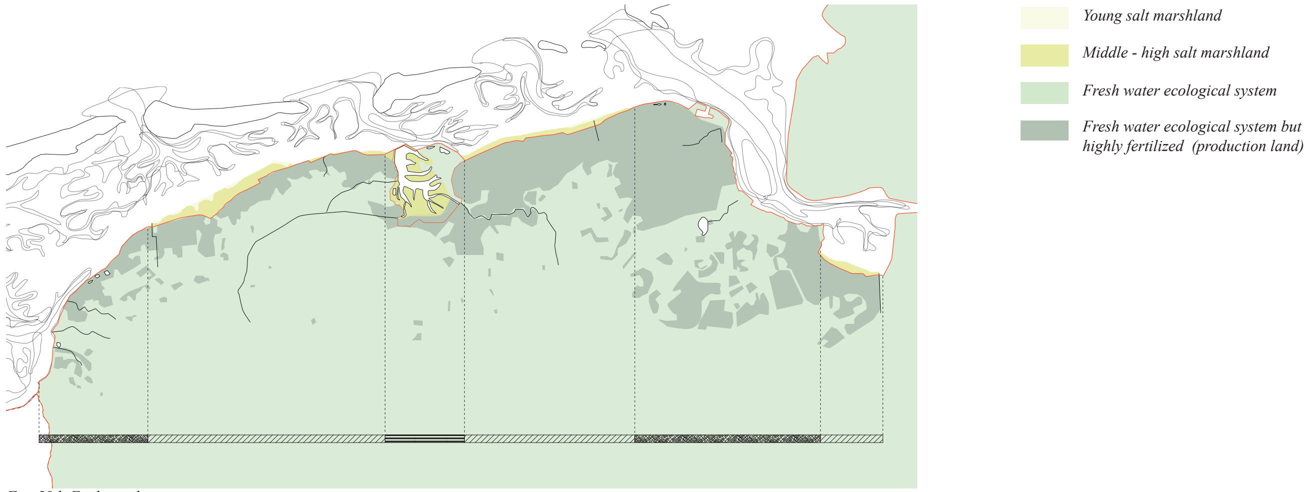


Fig. 50d: Ecological systems

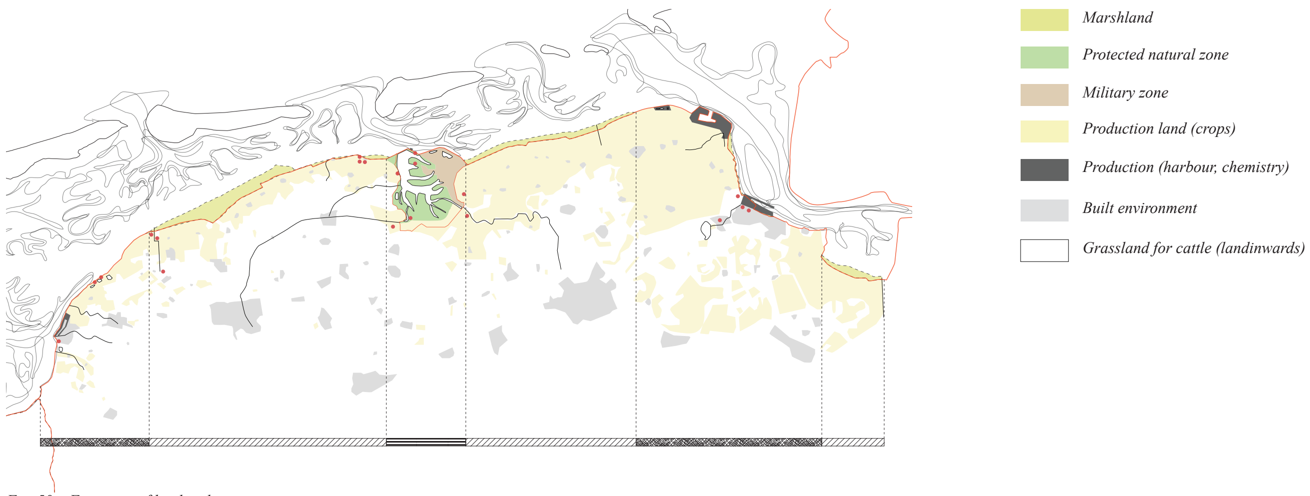


Fig. 50e: Functions of land and sea

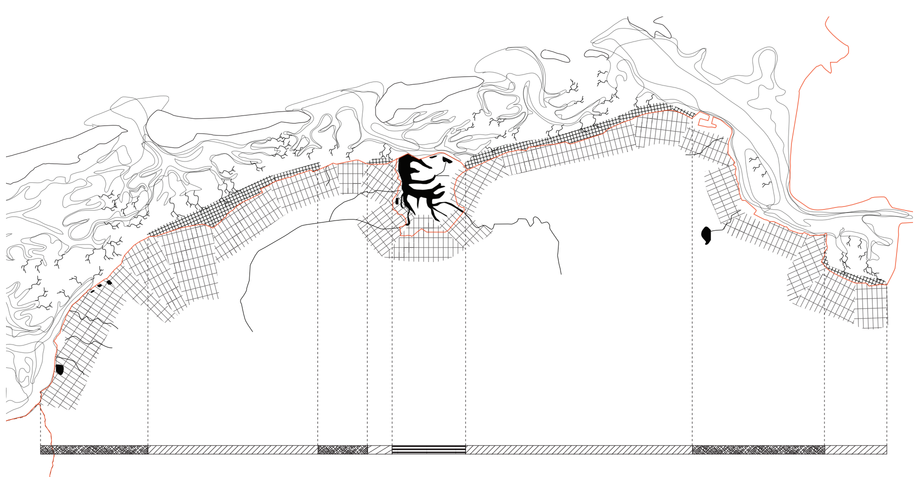


Fig. 50f: Water drainage patterns

the current natural accumulation of soil. These borders are less fixed and can change in time. Changing to two outer borders, positions the primary dike to different locations more to the middle in the borderscape. At several locations the line remains thin, this is where there is no secondary dike structure more land inwards. Along the line there are several orange dots. These refer to the existing water exchange element in the dike. From these openings the water conditions of both sides will be exchanged. As the stations are the end of a water system, a change of conditions in water type or water level will only affect the final part of the water system. Those points are also seen as potential for denser development of functions. At those locations there is already infrastructure towards the pumping station making it an intersection point. Here different functions are experienceable on a smaller, enclosed scale. One of these exchange points is chosen for design of a borderscape on location scale.

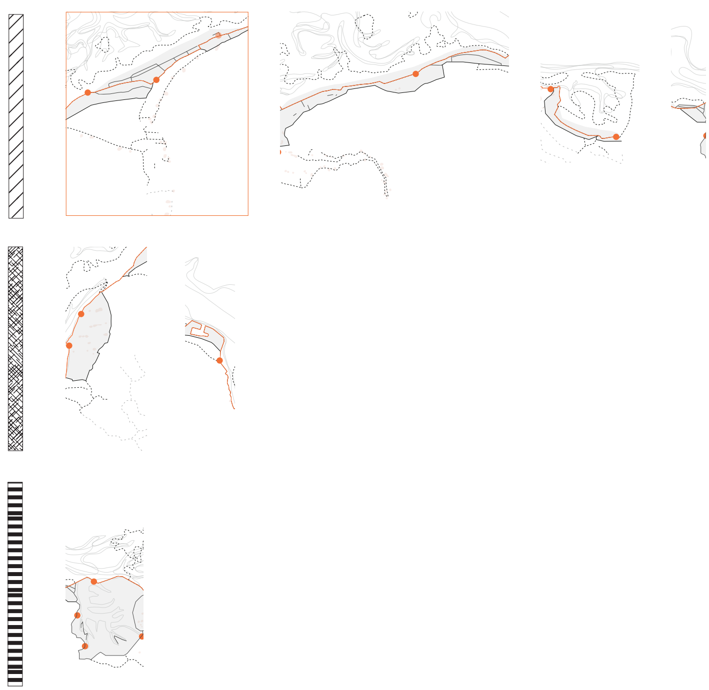
Next, a location is chosen in order to make site-specific design principles. This categorization helps to divide the coastal zone into smaller parts that share the same site-specific conditions (fig. 52). This is useful input for the transformation of the design principles but it also enables to test the applicability of the site-specific principles later on into another location. There are made three categories. The first category are zones in which sedimentation occurs, the tidal inlets are further away, land is reclaimed in front of the dike seawards, that places the dike into the middle of the borderscape. The other category are the zones in which erosion occurs, the tidal inlets are close by and the area in front of the dike is deep. This is suitable as most of the zones are harbors. The positioning of the dike is at the outer edge of the borderscape. The last category defines only one location: Lauwersmeer. This zone has unique conditions in comparison to the rest of the coastline. It can be considered already as a borderscape. The secondary system is connected to the primary dike creating a in-between basin. The conditions of water level and type differ from the zones outside. Functions of agriculture, ecology and recreation are joint and give a gradual transition between different patterns. This location is further analyzed to gain knowledge from present spatial elements.

One location is chosen from the first category. The category in which sedimentation is present, offers more opportunities to position the primary dike at the central point. This gives more potential for creating new spatial structures in design. From this category ‘Zwarte Haan’ is chosen to make a design. This location looks most interesting at first sight as there are many characteristic spatial structures present. It used to be an old sea arm and this resulted in a large system of secondary dikes in time and various directions of water parcellation patterns.

This gives the opportunity to make a comparison analysis with the location of Lauwersmeer which is can also be considered as an ‘old sea arm’. Here, inspiration can be found to use existing spatial structures of Lauwersmeer for the design of a spatial structure for Zwarte Haan. Besides, several design experiments on other locations along the coastline are done too. This has also given more insight in the initial problematics and inspiration of implementing a new spatial structures along the existing border. Both are discussed next in the report.

Fig. 51a: Gradual change from sea gullie to polder drainage pattern, de Ryd (Google maps)

Fig. 51b: Gradual change from marshland to polder drainage pattern, Lauwersmeer (Google maps)



Reclamation land (sedimentation)

Further away from tidal gullies

Positioning of the dike 'in the middle'

Seperation polder vs. reclamation structure

Close to tidal gullies (erosion)

Quays/ harbours

Positioning of the dike 'at the end'

Existing secundairy dike system

Ecological development & recreation

Old sea arm intact

Gradual course patterns

Fig. 52: Categorization of subsystems borderscape on regional scale

Applying - 4.3.1. Design experiments coastline
The spatial structure of the borderscape on the regional scale define dense points (orange dots) along the existing points of exchange. Here, a spatial structure should be made making the place a destination. In order to find important spatial themes and problem issues that are relevant for the scale of the coastline of Northern Netherlands several design experiments are done designing a borderscape in different locations (fig. 53). These themes will be used for the extensive design of 'Zwarte Haan'. The themes are briefly explained and introduced. Later on in the design of Zwarte Haan, the themes will be discussed more extensively. On the next page the collection of design experiments is showed (fig. 54).

Mulficunctional role of the primary dike
Transforming the primary dike into a borderscape may change the current functioning and positioning of the dike. In the design experience the primary dike becomes part of a wider dike system, creating arms and basins. In the primary dike the water exchange is regulated. The dike is integrated in the routing system for experience offering a unique overview perspective of both sides. The higher topography also offers a 'safer' position for the routing. Besides, the dike becomes an architectonic element in the design, widening or emphasizing its thin character. New arms can arise making it adaptive.

Regulated connection of fresh and salt water systems
In the design experiments a softer gradient of salt to fresh water system is proposed. Elements that are used in the experiments are water type, water level, water velocity and transport of sediments. The spatial connection between the two systems is also experimented with. The size of the opening is dependent on the pattern behind. If there is no pattern, an open inlet can be made (bigger scale of intervention is possible). If there is a strong water parcellation pattern this will be connected to it. Topography is used to define the direction of the natural flow and areas of flow. These water systems can grow in time.

Diversification of ecological systems
As fresh and salt water systems exchange more, new ecological environments arise. New types of vegetation will grow on both sides, making the line between land and sea less fixed. Different type of maintenance can help to manipulate the desired atmosphere of vegetation. This can help to keep it to a certain phase, make a distinction between closed and open spaces and avoid domination. Level of maintenance and the change of the water system makes the system adaptive.

Permeability of functions of land and sea
The set of ecological systems and water parcellation structure can help to divide the area in certain functions. The division of the big parcels make smaller plots for experimental agriculture. The mix of open and enclosed spaces are desired for different functions of recreation e.g. agrifood, camping, park. The small plots allow switch functions in time. Areas can also be multifunctional, e.g. combining ecological development with recreation and water safety etc. Also functions of energy and chemistry that are present close to the harbors can be merged more with processes of the sea, such as energy out of algae. Lastly, production land for sediment catchment is introduced.

Social involvement
The main current user, the farmer is involved by showing alternative spatial outcomes for his plots. Besides, the farmer can regulate the water level and water types in his polders by a system of sluices connecting to the main polder system. Other way to involve new users, the recreants, is to make agriculture educative and/recreational (experimental salty agriculture, agrifood, social gardening)

New human experiences
In a borderscape human should be able to experience the diversity of ecological systems, functions and dynamics of water type, level, velocity and the offset of sediments. A connected routing system for different means of transport is considered.

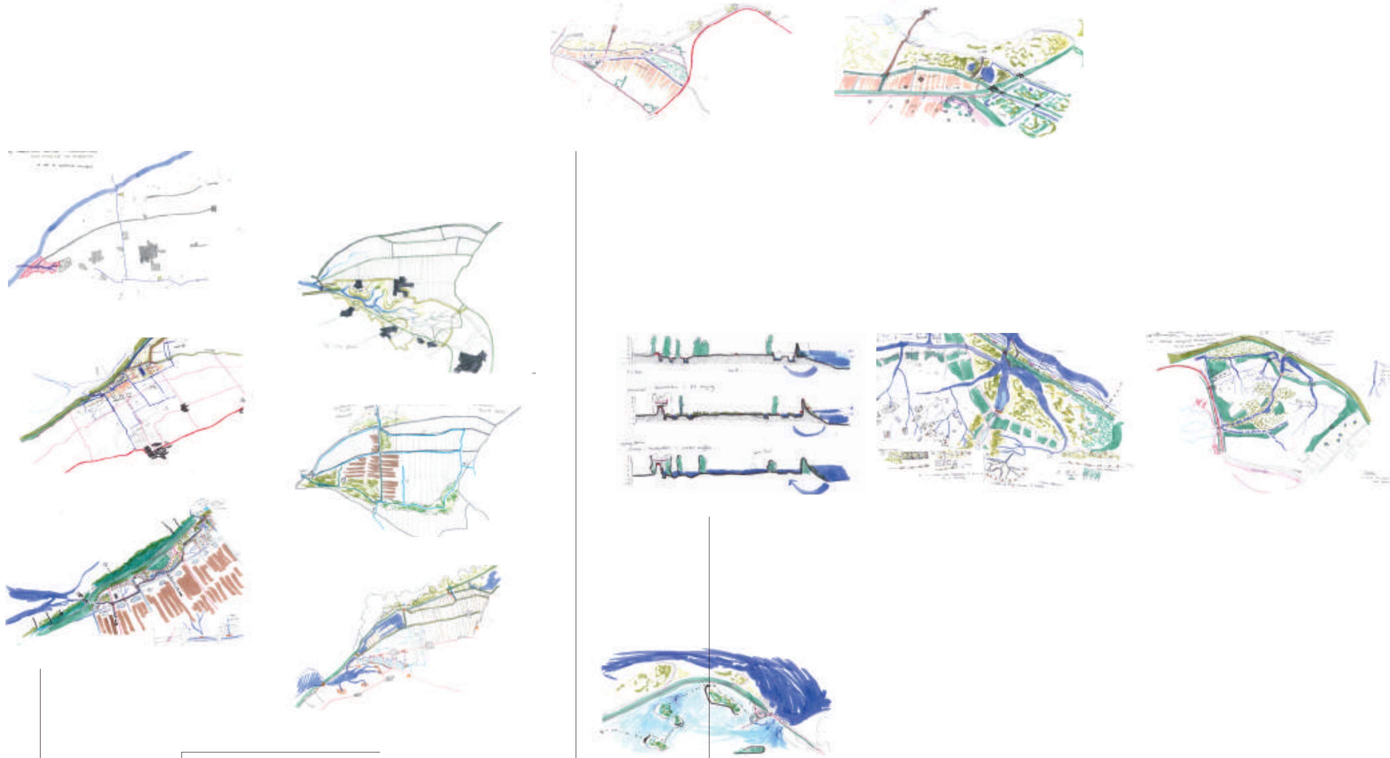
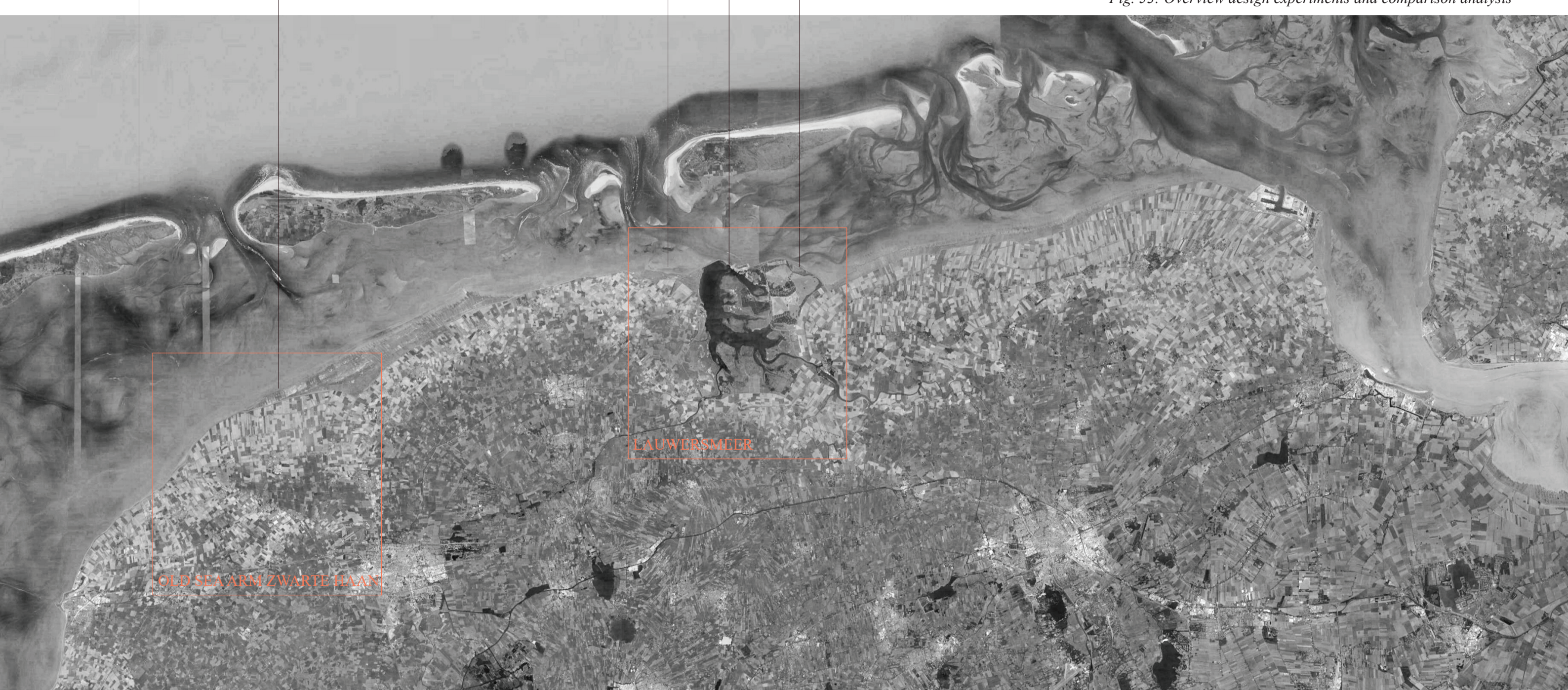


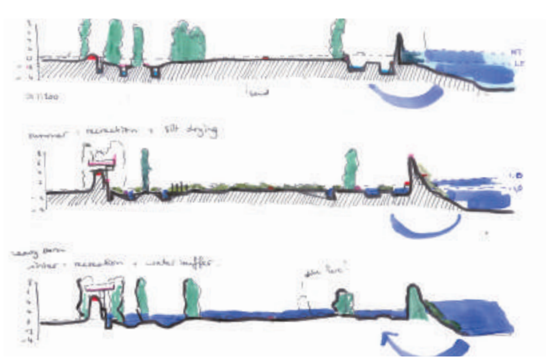
Fig. 53: Overview design experiments and comparison analysis



The basin, Lauwersmeer

A new regulated water opening in the dike, where erosion takes place, close to Lauwersmeer on the existing military terrain is proposed that will transform the area for big scale production of sediments. This new area is considered as a closed-off basin by the dike and road. The current water drainage on the terrain has the shape of the old sea arm that was closed off by a car road (red). A new natural pattern of gullies that will be formed by the opening is connected to it.

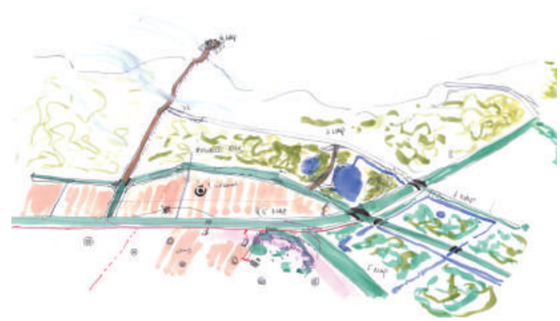
Zooming in, the location where the gully system ends are used for catchment as the water velocity is the lowest there and sediments will sink. The production will be combined with ecological development of new silt and salt environments that are the result of an addition of water type (salt, brackish) and level of moisture (water level) in the area. A part of of the production land (the middle) is used for recreation. Different routes (pink) are drawn through the site and include an ascent of the dike from where the site can be overviewed. This gives different types of human experiences in the borderscape. Close to the inlet, the dike becomes wider enclosing the waterbody.



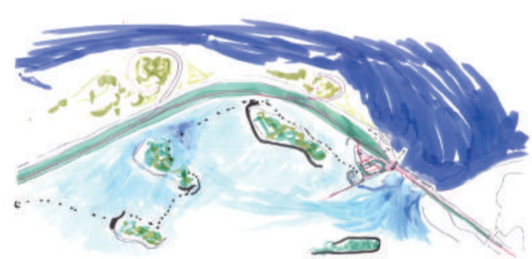
These sequence of sections show the integration of different water levels with the functioning of the area. The first section is the existing situation in which the fresh water is separated from the salt sea water. In the design, the inlet of salt water is used for production, ecological development and recreation. If the water level is higher, for instance during storm, the basin of the military terrain is used as water buffer

The tangle of dikes , Lauwersmeer

At the start of the Lauwersdam the spatial structure of a set of secondary dikes and piers that have evolved from the primary dike are made explicit in the design proposal. This dike system can be considered as a wider system for water safety but also forms smaller basins. Within these basins, different functions takes place that are sometimes connected with each other by water drainage. The functions are experimental agriculture, recreation and ecological development. The curvy shape of the pier is repeated along the Lauwersdam in order to stimulate the growth of marshland. This leads to more ecological development.



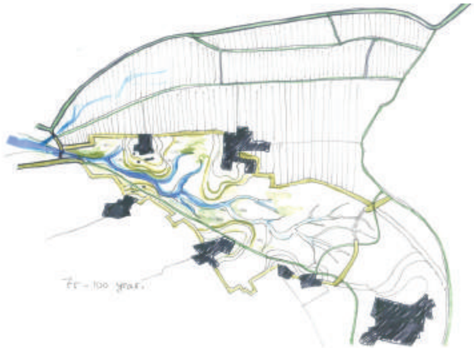
The dike system is also used as a recreational route from which human can have an overview of the different basins but can also enter from it. The existing dikes are sometimes partly pierced to create new passages. New structures, such as the wooden pier, can evolve from the dike system enabling to experience the dynamic marshlands. Salt water from the sea is let in the basins inside the dike, creating new ecological environments. Zooming in to recreation, a new camping site is put in place, a canoe route, walking route are implemented.



On the Lauwersdam new structures are evolved from the primary dam to stimulate sediment catchment and the growth of marshlands. This new salt/brackish environments can simultaneously be experienced with vegetated islands of fresh/ brackish environments. At the location of the sluices the width is kept thin in order to experience the contrast of the two sides more.

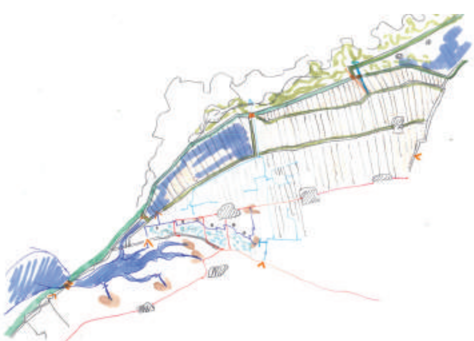
Fig. 54: List of design experiments

Old sea arm, Het Bildt



In this design the old opening of the sea arm is re-opened again. The water parcellation of the area in which the sea gully appears again disappears and the gully pattern takes over. The new inlet is regulated by a basin of dikes. The old sleepy dike is used as a secondary dike and a new dike is shaped at the north side. The villages are positioned as a balcony over the new basin. In the basin new salt, brackish environments appear. Another smaller inlet is regulated close to the opening in case of storms. If opened, the basin of existing dikes will be filled with salt water temporarily, serving as buffer.

This experiment also includes an open connection between fresh water inland and salt water outside the dike. However, the new water system takes place within the existing water parcellation. Within the proposal, a new water system, letting in salt water during high tide, is running next to the fresh water system using several fresh water ditches. Without interfering within the locations from which fresh water is pumped into the area, this salt water system creates new salt, brackish ecological environments and creates plots for experimental agriculture.



In this drawing, the location of the open inlet is shifted towards the left of Het Bildt. This means a closer connection to the sea arms on the bigger scale and no interruption of the total dike system, primary, secondary and sleepy dikes of Het Bildt. The ends of the smaller gullies of the inlet are connected to the existing parcellation structure. The connection of salt water to the fresh polder system is controlled by the farmers. Again, an existing basin enclosed by 4 m high dikes is used for water buffer during storms.

Involving farmers, Koehool

This drawing shows another strategy of making an inlet. From the start, a small area is made as a start for an inlet stopped by sluices of the fresh water system. This sea arm will be connected to the existing water parcellation. However, the plots are controlled by the farmers. Involving the users, the farmers is given the control if they want to change the water type of their plots. If so, the salt water system will grow. This strategy, does not show an preferred end image as the location and structure of the salt water system depends on the decision and willingness of the farmers.

This design shows an alternative of a dynamic salt water system that can grow in time and runs next to the fresh water system. The farmers can decide the mixture of water type by themselves working with a set of sluices. Close to the dike, functions of recreation are extended. New ecological environments arise and social gardening is included that offer human new experiences.

This design is zooms in on the connection of water systems to functions and experience that lead to new spatial organizations of agriculture and recreation. Close to the sluices of salt water intrusion smaller plots are made that are suitable for experimental agriculture. Here, fresh water reserves, water volumes, are positioned that can regulate the level salinity. At some locations the plots are even made smaller to invite human for social gardening and education of the growth of silty crops. This can be combined with agrifood. For recreation, new temporary stays are made, a network of routes is integrated that leads people along different environments. The dike becomes an architectonic element as it becomes wider at several locations offering a balcony of the area. The routes are connected to the dike and it regulates the inlet of salt water.

Applying - Comparison analysis Lauwersmeer

The site 'Zwarte Haan' is located in the area where an old sea arm used to flow. Lauwersmeer, a cut off sea arm, is already considered to be a borderscape. Therefore, these locations are both originated from a sea arm and they are only in a different phase of transformation. In this analysis the adaptive cycles, explained in the methodology, and the landscape elements of both locations in different phases are discussed and compared. The spatial qualities and points of critique of the elements are described giving input for spatial structures for the design of Zwarte Haan. The same phases are used that describe the generic time-line of the coastal zone in the chapter 'Positioning'.

Looking at the phases on the scale of the total coastal line, Lauwersmeer is the only visible water body left from the many tidal inlets that used to infiltrate more land inwards. The others have disappeared in different speeds. The sea arm of 'Zwarte Haan' has silted up relatively quickly in comparison to the sea arms on the right side close to Eemshaven. This is the result of a big land reclamation project in the 16th century 'Het Bildt' (fig. 55) (fig. 56) (fig. 57).

I Natural water state > 1000 AD

In the first phase both locations are marshlands. A tidal inlet reached land inwards leaving a network of gullies. Soil was deposited and created higher levees. Open connection to the sea enabled a gradual gradient between fresh and salt water conditions and a difference in water level giving a unique zone for ecological development. Humans settled on terps on the side of the sea arm.

II Defensive water state 1000 > 1300

In this phase human started to fix the edges of the tidal inlets by building dikes alongside it. This enabled them to extend their polders of agriculture and cattle behind the dike. In return, the gully network and the depth of the tidal inlet decreased as it had less space to flow and deposit its soil. A difference in approach, start to differentiate the two locations. At Lauwersmeer they only enclosed the tidal as a basin leaving the upper side open contact with the sea. Within the lower part 3 openings were left for the 3 main gullies flowing further land inwards in open connection to the basin and sea. Also these gullies were diked. However, a gradual gradient between salt to fresh and the tides was still experienceable and the basin was left for ecological development. At Zwarte Haan the tidal was immediately entirely cut off from the sea, only leaving a small opening for sea water to come in. Therefore, the process of sedimentation and land reclamation occurred at a higher speed than Lauwersmeer. The reclamation was supported by a grid of wooden poles and the land was divided in a very formal water parcellation for the function of production land. The dynamics of the sea were only noticeable at the beginning of the opening.

III Offensive water state 1300 - 1800 AD

At Zwarte Haan they continued with rapid land reclamation. The entire area that used to be a tidal inlet transformed into a very formal and homogeneous production landscape closed off entirely from the sea. At Lauwersmeer the arms of the basin were closed putting different water regulators in the dike. Experience of the dynamics was only left in the basin.

IV Manipulative water state 1800 > present

At the last stage Lauwersmeer, 1969, is cut off from the sea completely by closing of the upper side of the basin by building a dike and sluice system. The tidal, that still remained its natural curvy shape is now enclosed. From now, the water level is fixed and closed off from the salt water. Currently, the lake is still brackish but in time this will become more fresh. Three main drainage channels flush their water still in the basin regulated by engineering structures that are positioned in a secondary dike. Connected to the lake there are several functions of recreation: accommodation parks, recreation harbor, wind surfing on the lake. The spatial structures of several of them are analyzed to get grip on the scale (fig. 58). Most of the zone is still kept as ecological zone. However, the initial brackish conditions are slowly changing into fresh water conditions. Therefore, the vegetation and fauna will change without intervening. On the outer edges of the basin below there is some rectangular water parcellation for polders. Except for these, large zones do not have any patterns and some gullies have been canalized. Considering the Lauwersmeer as a borderscape, the change of diverse brackish and salt ecological systems to homogeneous fresh water conditions is seen as a problem. A solution could be to partly open the sluice more often at the mouth of the lake to the sea again to bring salt water back in but also the different water levels of tides. In time, Lauwersmeer has had a gradual sequence of different landscapes that can return . The functions that are present, recreation and a low density of agriculture, should be joint more with the dynamics of the sea.

The location of Zwarte Haan has not much changed in comparison to the previous two phases. The water parcellation has been up scaled to bigger plots for agriculture. The landscape is very homogeneous and the large-scale plots of agriculture cannot adapt to change, e.g. salinization. A sequence of old dikes are still left in the landscape that mark the history of land reclamation. One of the secondary dikes ends in the high sea dike but are not seen as one structure due to difference in function and appearance. The secondary dike has a road and houses alongside it. The primary dike is higher, does not have a road on top and has no other elements. Turning this location into a borderscape asks for an approach that transform the existing spatial elements. The grid of the water parcellation is very characteristic for the area. Therefore, joining fresh and salt water conditions will fit into the existing polder pattern. The main function of agriculture should be joined more with the dynamics of the sea and the ecological system. New functions, such as recreation, will be invited, as the area will offer more diversity of experiences. The primary dike should be connected more to existing old dikes and can create new arms.

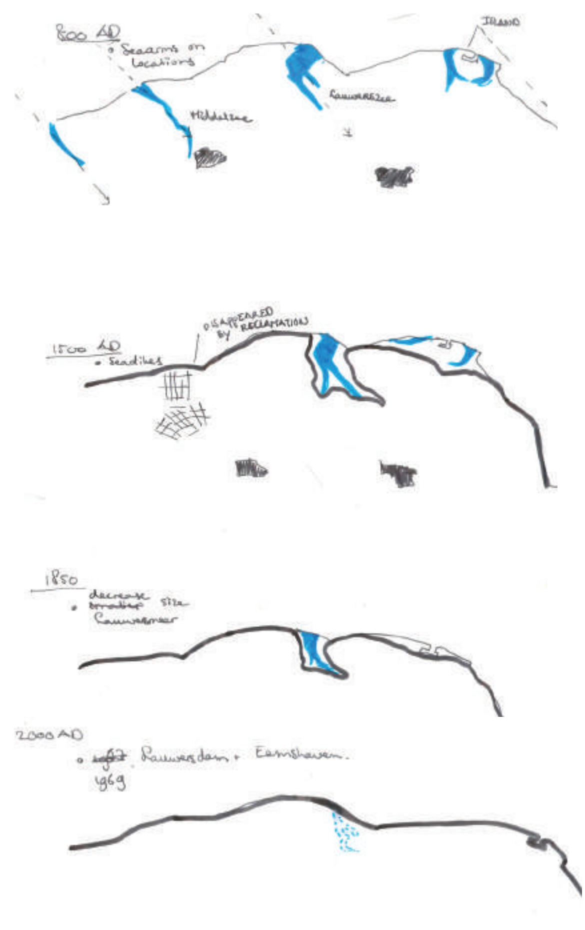


Fig. 55: Spatial phases sea arms in time on regional scale

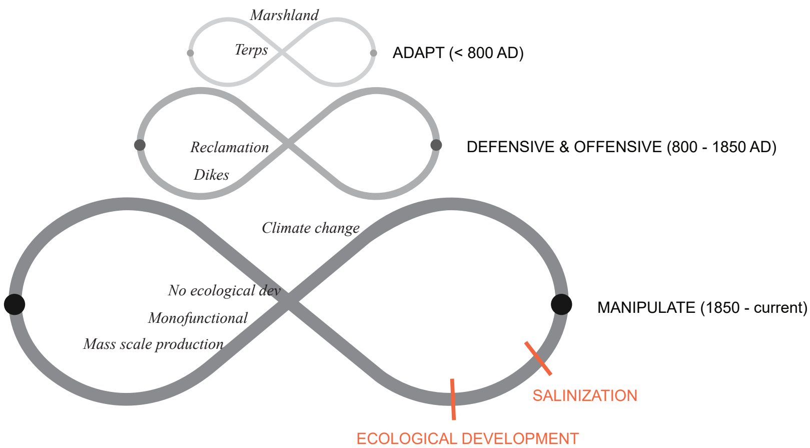


Fig. 56a: Adaptive cycle Zwarte Haan running through different phases

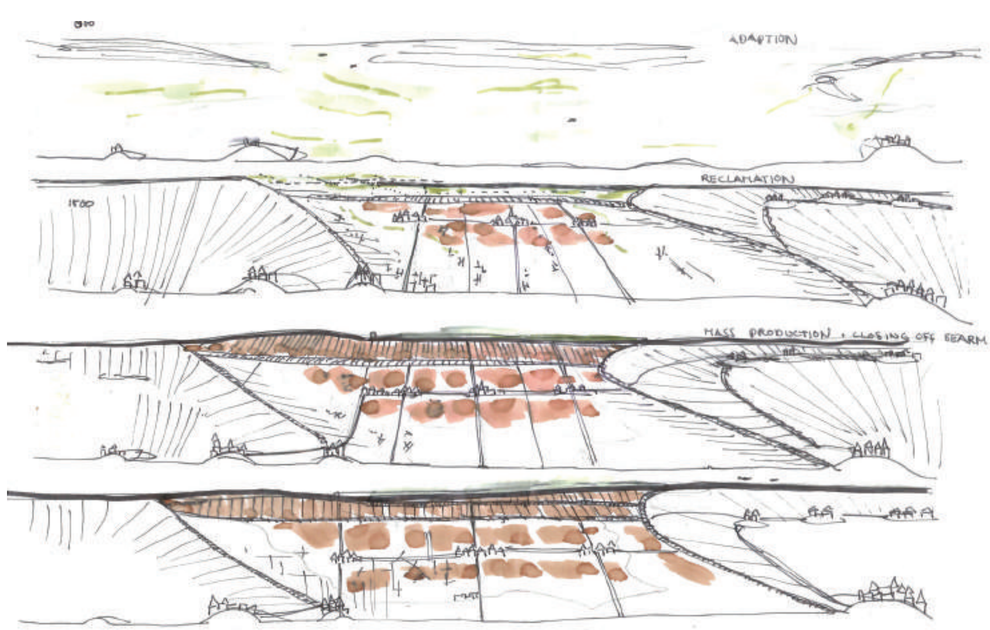


Fig. 56b: Landscape elements for each phase of Zwarte Haan

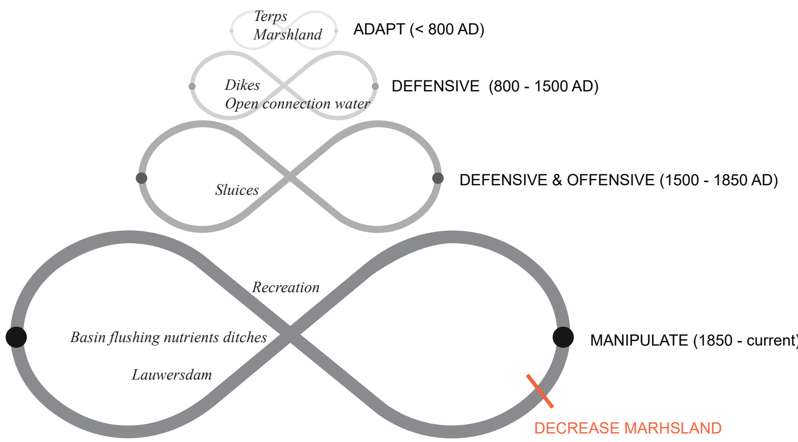


Fig. 57a: Adaptive cycle Lauwersmeer running through different phases

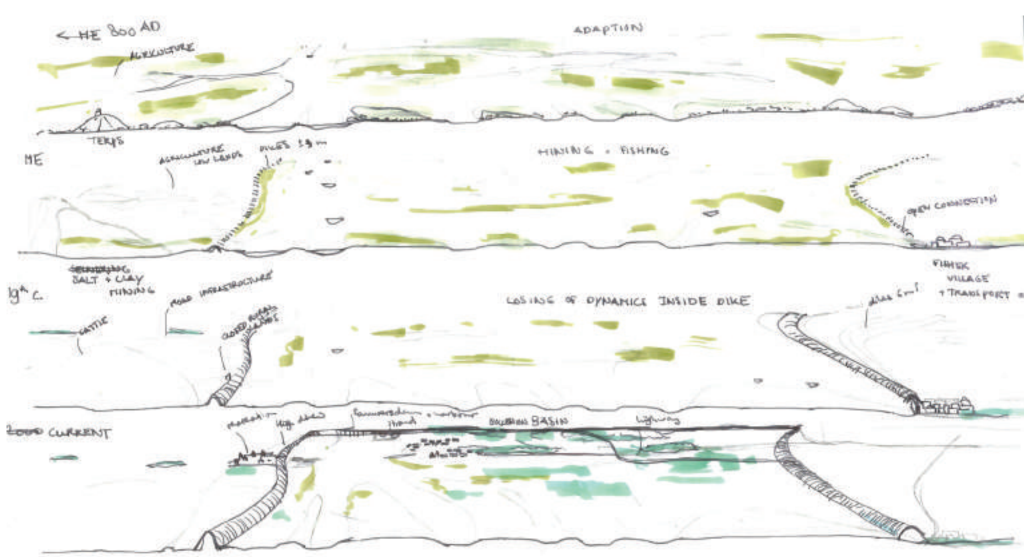
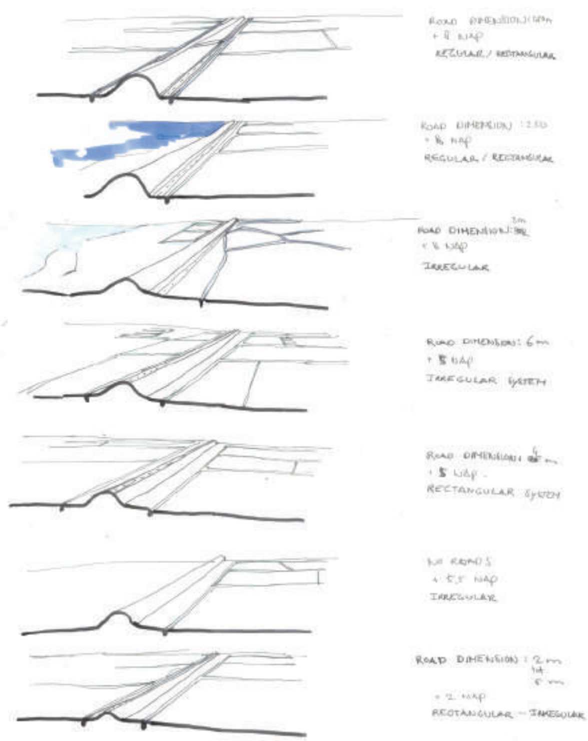


Fig. 57b: Landscape elements for each phase of Lauwersmeer

Dikes



Land shapes

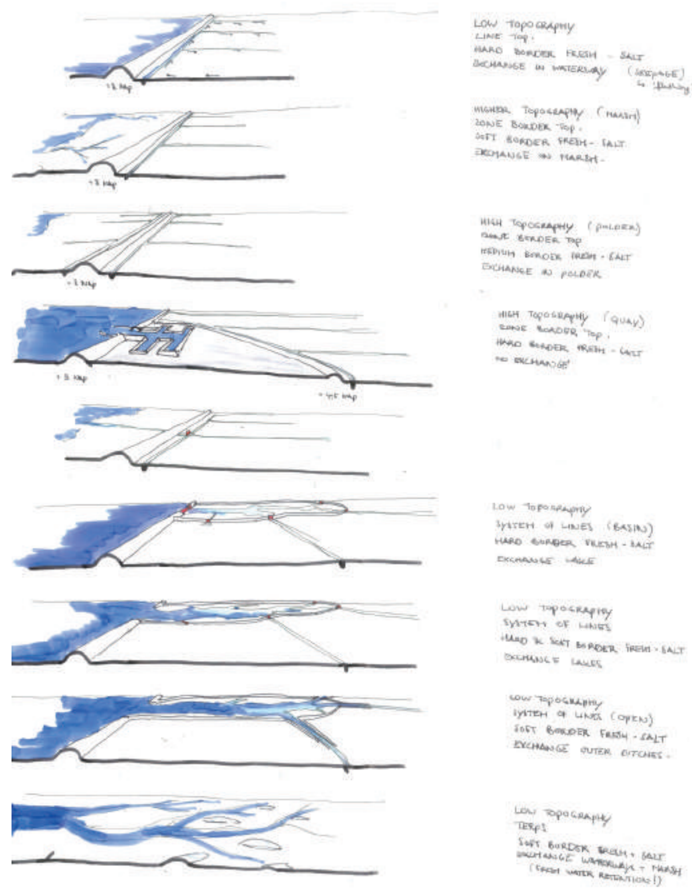
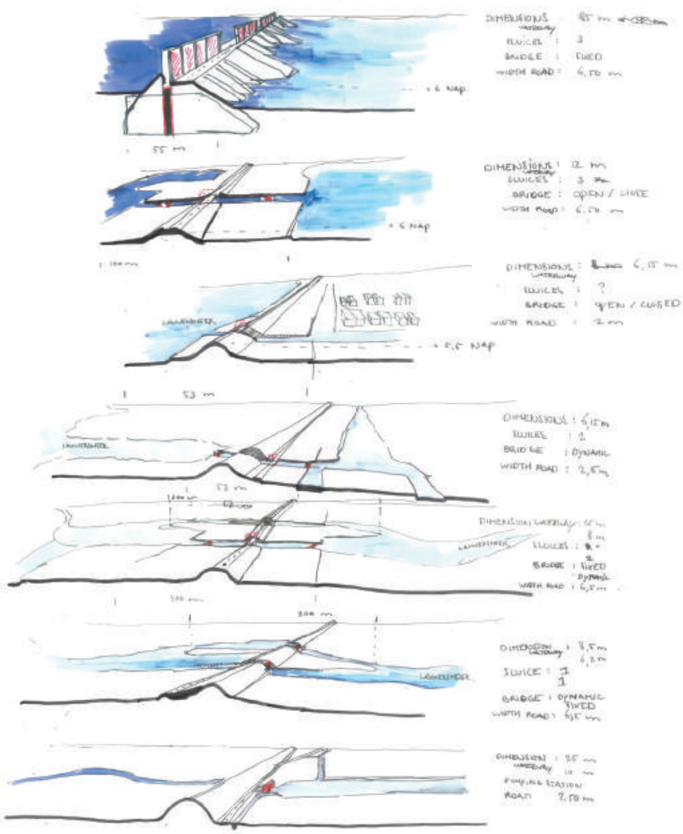
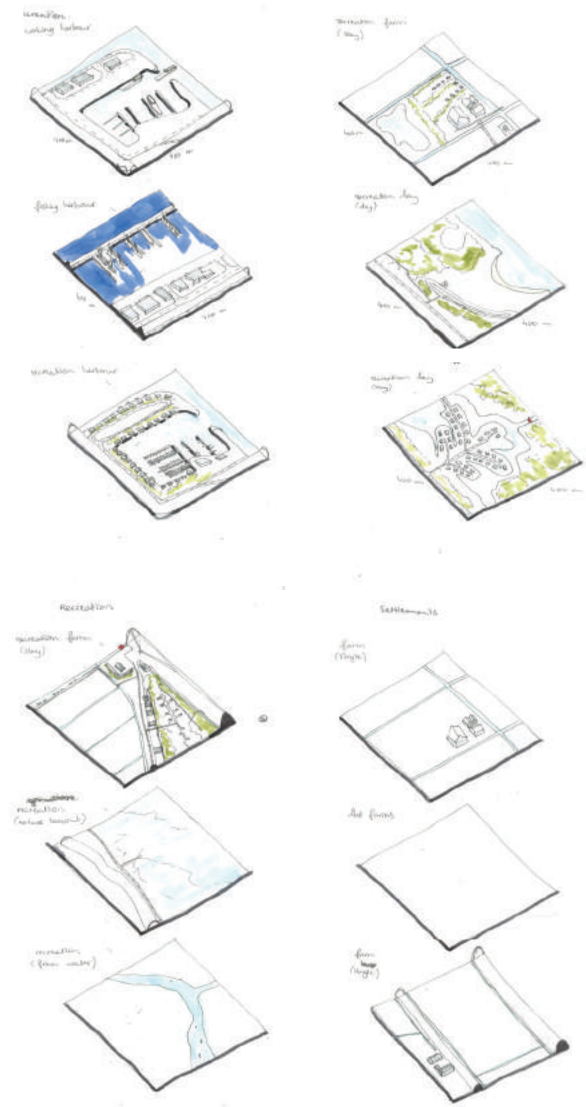


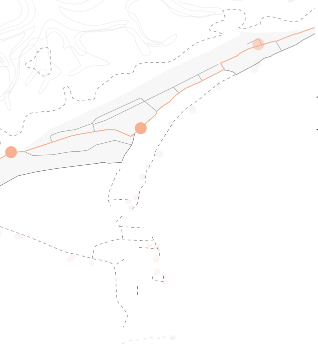
Fig. 58: Taxonomy of spatial structures found at Lauwersmeer and Zwarte Haan

Water regulators



Spatial organisation functions





I. Dense point as destination (Zwarte Haan)

Applying - 4.3.3. Design of Zwarte Haan

These two small researches together with the generated spatial concept for the regional scale enabled to establish a design of a new spatial structure for the area of 'Zwarte Haan' that can function as a borderscape. Several concepts are made for the spatial structure of the area that functions as the basis for the design. These concepts are the role of the dense point vs. adjacent area, the re-positioning of the primary dike and the exchange of water as the basis for multi-functionality in the area.

Firstly, a spatial concept is found for the role of a dense point vs. the adjacent area. The spatial structure of the dense point will serve as an example for the adjacent area. Within the dense point, new spatial structures, experiences and functions are tested first on small scale and can be implemented in a next stage on other locations.

In this design the dense point is located at the pumping station of Zwarte Haan. In the existing situation this point is already an important node where the main infrastructure of water, roads and the dike connect (fig. 59). At the pumping station the fresh water of the polder water system is flushed out into the Wadden sea and serves as an end point. The exchange of water takes place in one direction. Establishing water exchange in two directions is suitable at this location as an inlet for salt water would only effect the last part of the polder water system. On the left side of Zwarte Haan, salinization takes places at the parallel ditch as there is no marshland in front of the dike to diminish the effect of it. Still, this effect does not cause any harm yet for the functions on land, as the ditch is flushed with fresh water if needed. Rather than working against the natural effect of salinization, the design of Zwarte Haan could find potential functions and experiences that work with the increasing effect of salinization. Moreover, a secondary dike also connects to the primary dike at this point. On the side of the primary dike (+1.5m NAP) and on the secondary dike (+4m NAP) roads are located that come together also at this point and makes the location well accessible. Most of the area around the pumping station is used for growing crops. There are a few locations that serve for a public use, some restaurants and two campings.

The dense point will become a place of destination within the borderscape. This means that more public functions will be integrated starting from the few existing ones. Here, human can experience the diversity of human uses and experiences of a borderscape in an aesthetic way. Therefore, the integration of the landscape architectonic layer in the design is important in order to achieve this. In time, the functions and experiences of the dense point can change as the spatial structure gives room for this.

This relates again to the bigger scale in the dense point is located. The outline of the new borderscape including the dense point reaches up to the secondary dike parallel to the primary dike and the marshland in front of this dike. Within, there are some other secondary dikes, dividing the borderscape into several basins (fig. 60). In general these basins are extensive areas with few housing. This is seen as potential to use the basins in extreme scenarios for water buffer zones. In order to do so, some measurements need to be taken to deal with the existing housing and future housing in the area. Also, these basins cannot only create compartments for water buffer zones but also for functions, e.g. sediment catchment areas, ecological development and salty agriculture etc. Thus, within the wider safety system is divided in several basins in which functions can change. Still, the water safety structure can expand and decrease in time but this occurs on a slower pace than the change of functions. At the end of this chapter different collages will be shown of the borderscape in time that shows the multifunctional use within the same spatial structure.

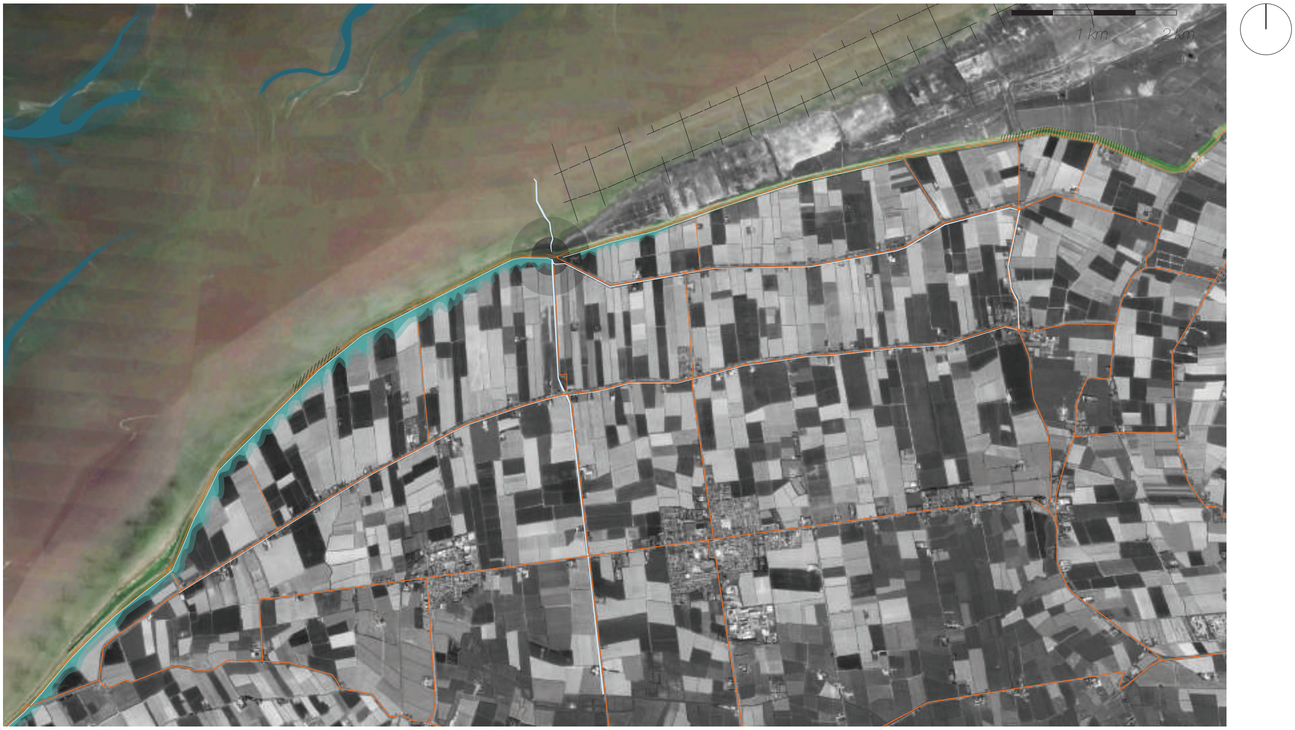


Fig. 59: Overlap of most important water, routing and dike infrastructure in the existing situation

Fig. 60: Spatial concept of outline borderscape with Zwarte Haan as concentrated node within different basins (I to V)

II. Re-positioning the primary dike within borderscape

Establishing a new spatial structure for a borderscape in Zwarte Haan asks for a clear definition of the role of the primary dike in the borderscape. As design is seen as transformation of the existing situation in this research, the primary dike plays an important role. The different functions of the primary dike in the borderscape are described below together with potential spatial concepts.

The primary dike within a wider water safety system

As described before, making the dike higher in order to meet the requirements of new water safety standards is not seen as sustainable. At the location of Zwarte Haan other spatial structures of higher topography are looked for that can be linked to the primary dike instead. This forms a wider water safety system. This new spatial structure creates an assigned outline for the borderscape and offers a buffer zone in between land and sea that can handle extreme situations of floodings. The different elements are the secondary dikes, summer dikes and higher salt marshes inside and outside the dike (fig. 63). Until now, the primary dike is taken into account as single structure meeting the water safety requirements (ILT, 2013). Another research, mentioned in the introduction, has shown that using the secondary dike strategy is a more suitable strategy decreasing the area of flooding. Using the secondary dikes together with the primary dike creates different compartments (Steinweg, 2008). In normal conditions, the secondary dikes do not have to resist water. Looking at Zwarte Haan the primary dike is +8,5 m NAP. There are two secondary dikes in the adjacent area. One is located parallel to the primary dike (+3m NAP) and the other is already connected to the primary dike (+4 NAP). The height of the connected dike shows to be sufficient enough functioning as a secondary dike looking at other projects with the same height in which it also contributes to the water safety. These locations are the secondary dike along Lauwersmeer and the pilot project 'Double dikes' shown in the introduction. The secondary dike parallel to the primary dike is less suitable as the height is below +4 and there are settlements present. In order to make the zone between those dikes a water buffer zone for extreme conditions, the parallel dike needs to be redesigned. Also, some measurements need to be taken to let the scattered farmhouses in the desired water buffer zone meet to the water safety requirements. Creating mounds for the farmhouses in the middle of the zone and integrating the farmhouses located next to the dike on plateaus of the dike are seen as suitable measurements. Summer dikes or other hard structures in front of the primary can contribute to the water safety by breaking waves and making compartments. At Zwarte Haan, some hard structures are left subsurface (+2) that can contribute to the water safety system. Another element are the salt marshes outside the primary dike. A salt marsh will get vegetated if the height of the morphology is a little bit lower than the level of high tide that is around +1,0 NAP (B.K van Wessenbeeck, 2014). Research shows that the desired width of the fixed salt marsh is between 80-100m along the dike contributing to the water safety system (J.M. van Loon-Steemsma, 2012). This width should include a buffer zone that can decrease in time of a storm. In this design the salt marshes that contribute to the water safety system are +1.00 m NAP or higher. Besides, it is important that the salt marshes are vegetated. This can reduce the speed of the waves up to a decrease of 50%. The type of vegetation that can deliver a contribution to the wave reduction, are the types that have long roots holding the sediments and a wooden structure to reduce the waves on land. Types of flora are shown later on in this chapter. Together, all these elements contribute to a wider safety system that mainly controls by topography. In time, the system can expand or decrease in width. Using sediments from the Wadden sea can be used as potential nourishment.

Regulator of water exchange

The existing water exchange takes places along the primary dike flushing the fresh water from the polder system out in the Wadden sea. Establishing dense spatial points along these existing water points is suitable. The engineering structure at the dike at Zwarte Haan is a pumping station. In the existing situation, this structure is mostly decisive upon the water type and the length of the gradient. However, the increasing effect of salinization and tidal volume push-

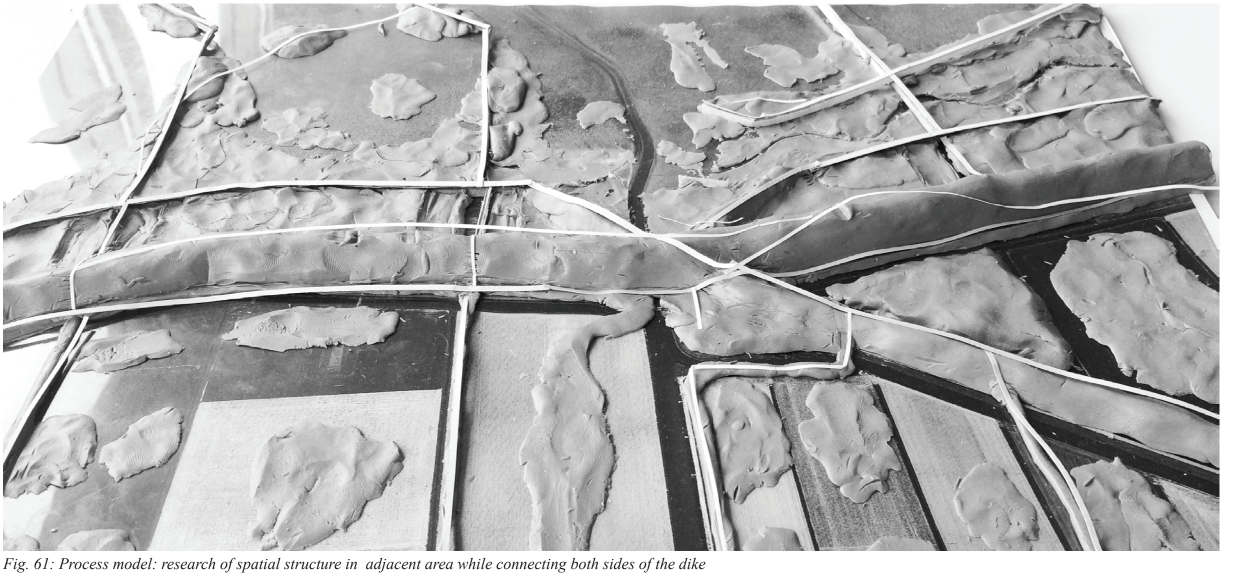


Fig. 61: Process model: research of spatial structure in adjacent area while connecting both sides of the dike

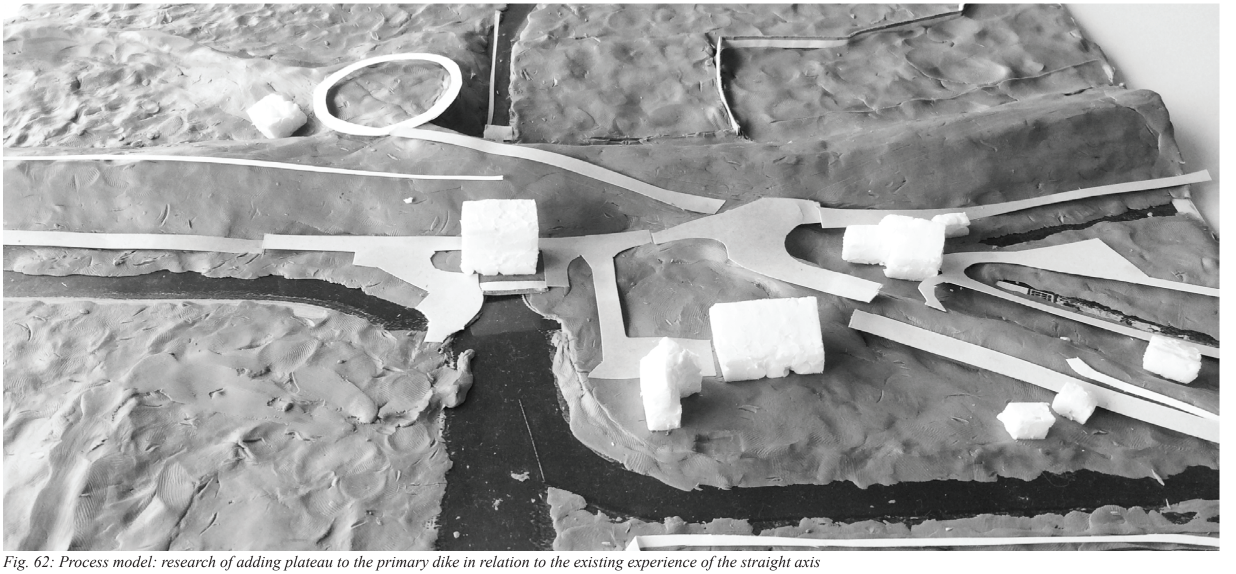


Fig. 62: Process model: research of adding plateau to the primary dike in relation to the existing experience of the straight axis

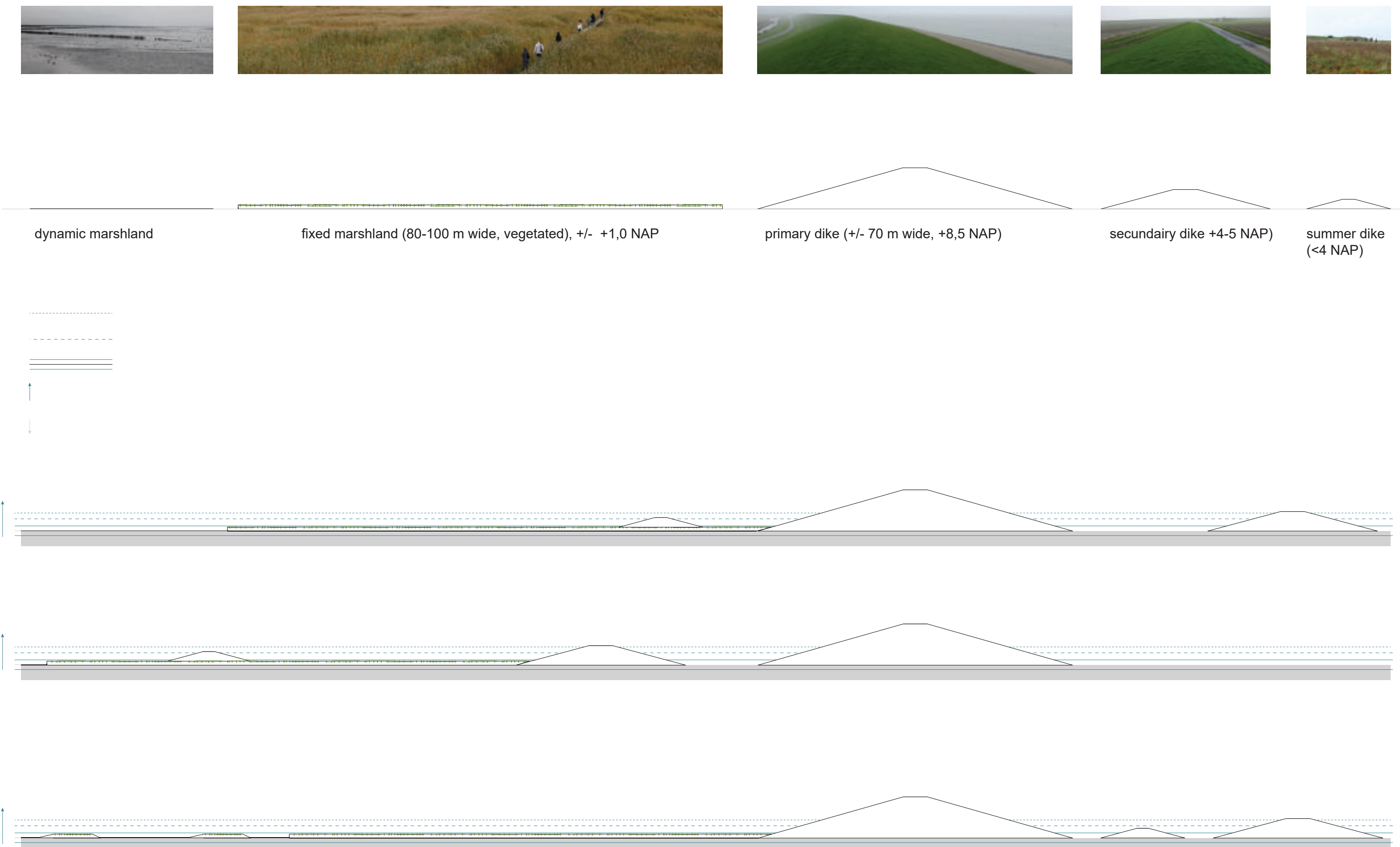


Fig. 63: Primary dike within a wider safety system

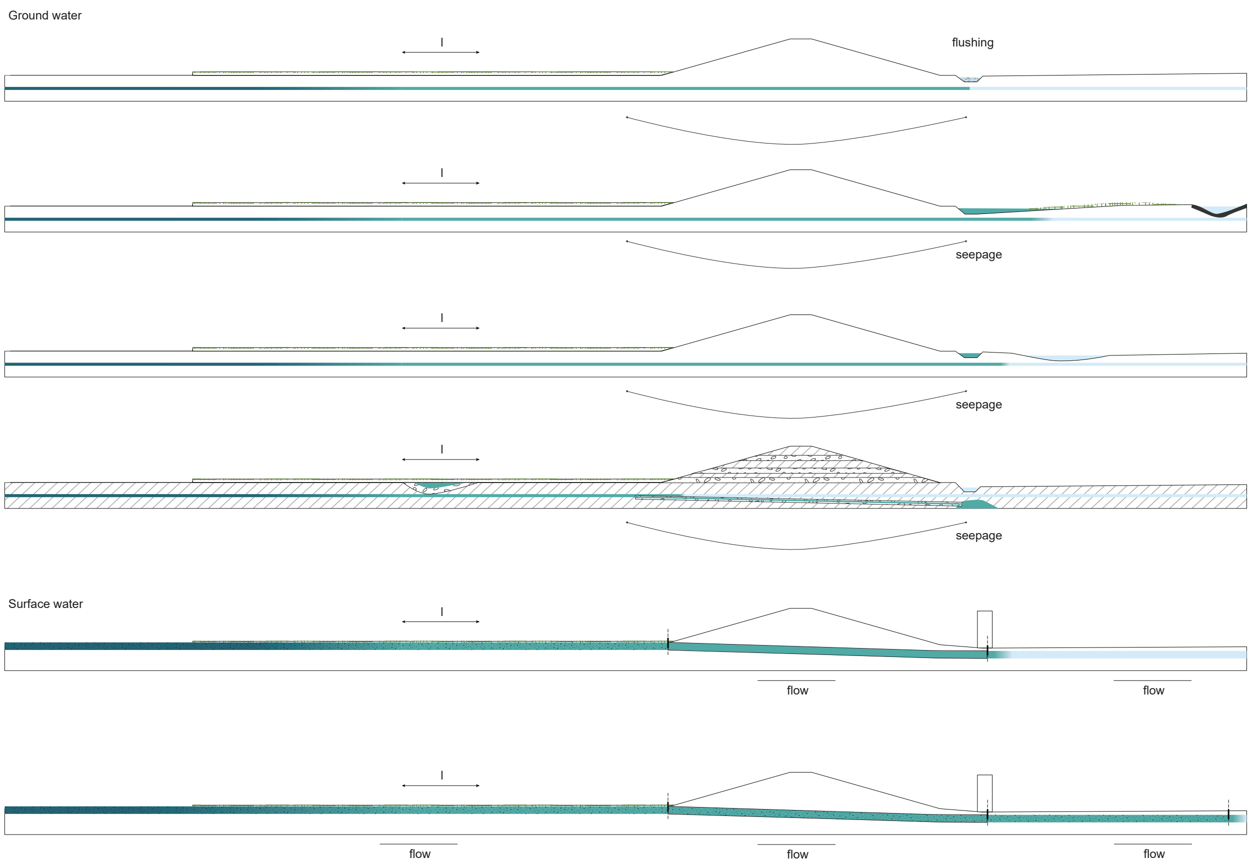


Fig. 64: Dike as regulator of water types

es salt water conditions underneath the primary dike creating seepages inland parallel to the dike. Currently, these effects are diminished by flushing the ditch with fresh water decided on a regional scale. In the same diagram other spatial concepts are shown that either adapt the landscape behind it to more brackish conditions or regulate the water type and the gradient between fresh and salt in different ways (fig. 64). Spatial concepts that can diminish the effect of seepage are the growth of salt-resistant vegetation that absorbs salt, the use of fresh water volumes that pushes back the seepage and the use of impermeable layers of soil, such as heavy clay and permeable soil, such as sand, to steer the volume of the seepage.

Another option is to make a new water connection by letting salt water in on a regulated basis directly. Here, there are two variations. Either preventing the sedimentation that comes with salt water of the Wadden sea to enter inland or to let it in. Naturally, the land would grow together with the sea level rise as an increase of tidal volume carries more sediments. The dike prevents the exchange of sediments from sea to land. And as the Wadden sea area is protected and no sediment is allowed to leave the border lines of this area, sediments cannot be dug up from this area and positioned in the Netherlands. Simultaneously, the land inside the dike is slowly inclining. Letting in sediments, can at this stage work symbolically to let human be acquainted with the idea of using sediments to higher up the polders.

Architectonic element

The primary dike along the Northern Netherlands is + 8,5 NAP with a slope of 1:5. In order to make the dike an architectural object within the landscape the shape and appearance of the primary dike may change, reacting on the landscape around it or rather creating a contrast (fig. 65). According to a new shape, the grade of slopes can be changed, gradually or with terraces. The flat surface on the top can be narrowed or widened creating plateaus. These plateaus can be used for functions that need a certain level of water safety, such as a farm house, or it can give room for a view point. According to appearance, vegetation or other materials can be integrated next to grass and asphalt. Applying vegetation on the dike seems very suitable. Due to different conditions a variety of vegetation can be reached; combination of soil types, sand and clay, and its different relation to water types due to a relatively high topography. Considering the dike as a architectonic element, it contributes to the diversity of human experiences in the area of Zwarte Haan as it offers a unique bird-eye perspective connecting two sides visually.

Controller of experience

The primary dike is an outstanding object in the landscape concerning its high topography. At this moment the dike has ascents that lead to the other side at several points. Also at Zwarte Haan, such an ascent is present. The angular characteristic of the ascent should be kept as it contributes to the legibility of the routing system. More ascents and connections to the ascents help to connect the two sides spatially (fig. 66).

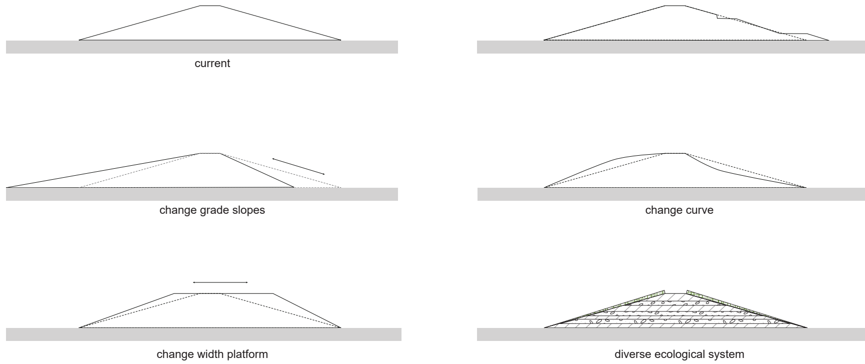


Fig. 65: Dike as architectonic object

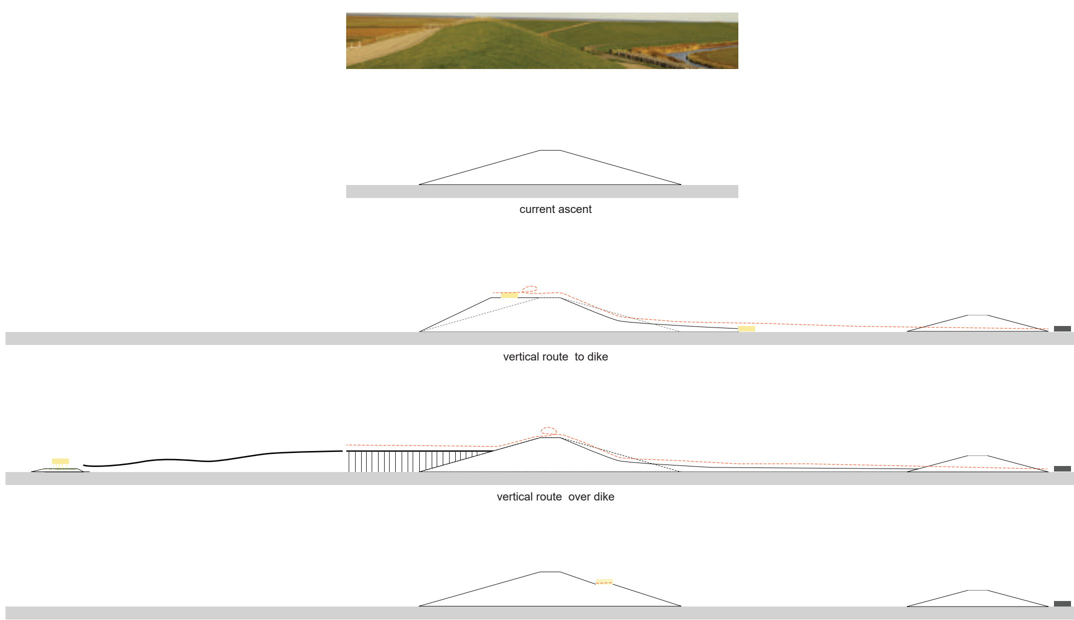


Fig. 66: Dike as controller of experience

III. Exchange of water as basis for borderscape

Within the borderscape, exchange of functions and processes between land and sea takes place. In order to achieve this, the dynamics of water is seen as potential Looking again at a panorama of the Wadden sea the water offers different water types, saline vegetation, difference in tidal levels, transportation of silt particles (fig. 67.). Establishing a connected water system as the basis for the design of Zwarte Haan, leads to more diversity in the subsequent layers of ecological systems, system of human uses and experiences. In order to regulate the dynamics of the water, spatial outlines for control at all time and on different scales are set to do so.

The first attempt in the design process of defining a certain order in layers for establishing a borderscape is shown on the page alongside (fig. 68). Firstly, an assigned physical zone with outlines is given to the desired borderscape. Other spatial structures, the secondary dike and the marshland in front of the dike will be connected to the structure of the primary dike giving the borderscape a mass. The outlines are set by the higher topography on the larger scale. The next step is to exchange water on both sides of the dike in the borderscape. Instead of having one flow towards the sea, there will be a water connection established in both directions. This dissolves the strong separation of fresh and salt water on both sides and creates a gradient of water types on different locations. This creates more diversity in ecological systems that can help to develop more public and recreational uses. Besides, the areas in which brackish water occurs can be used for salty experimental agriculture that generates knowledge and adapted crops for the existing agriculture.

Based on this experiment, the concept of using water exchange as basis layer for merging functions and experiences has evolved (fig. 69). In the design of Zwarte Haan, the pumping station will exchange water to both directions. This means that next to the existing fresh water flow, a new salt water flow is added in the same pumping station. The salt water runs through a regulated salt water channel that opens on certain locations letting the water flow in the area; the gardens. This gives an exchange of salt/brackish water and sediments that leads to a certain type of vegetation. In these areas of exchange, outlines on the smaller scale are set to control the dynamics. The level of control is higher in the gardens inside the dike than outside of the dike. At some point the salt water merges with the existing fresh water polder system, creating a loop. This loop creates a connected water system in which a gradient of water type, sediments and tidal difference is noticeable and made experienceable in the different gardens. The salt water channel adds a new form language of water drainage patterns in the straight ditch system inlands.

Using the water layer as a basis, a design for a borderscape system at the scale of the dense point Zwarte Haan is made that is decomposed in several layers on the next page. The first step is to gain insight in the current water flow system and topography on the macro and micro scale that give insight for the formation of the outline of the borderscape and the establishment of a new water system in the zone.

Secondly, the outline of the borderscape is defined adding spatial structures of higher topography on the macro scale to the primary dike (marshlands and secondary dikes) in a wider water safety system. This positions the primary dike towards the middle of the zone. In time, the dike forms more plateaus on different height levels offering new functions of look outs and housing. At the pumping station, a new water connection is added in the opposite direction next to the existing water exchange, allowing salt water to flow in during high tide on a regulated basis. At some assigned points the salt water flows openly into the plot, adding diversity of water type to the area. The water in the channel flows naturally, following the descending topography of the parcel at the micro scale. At the end of this plot it flows into the existing fresh water system. Slowly, moving upwards towards the dike the gradient of the water changes from salt to brackish.

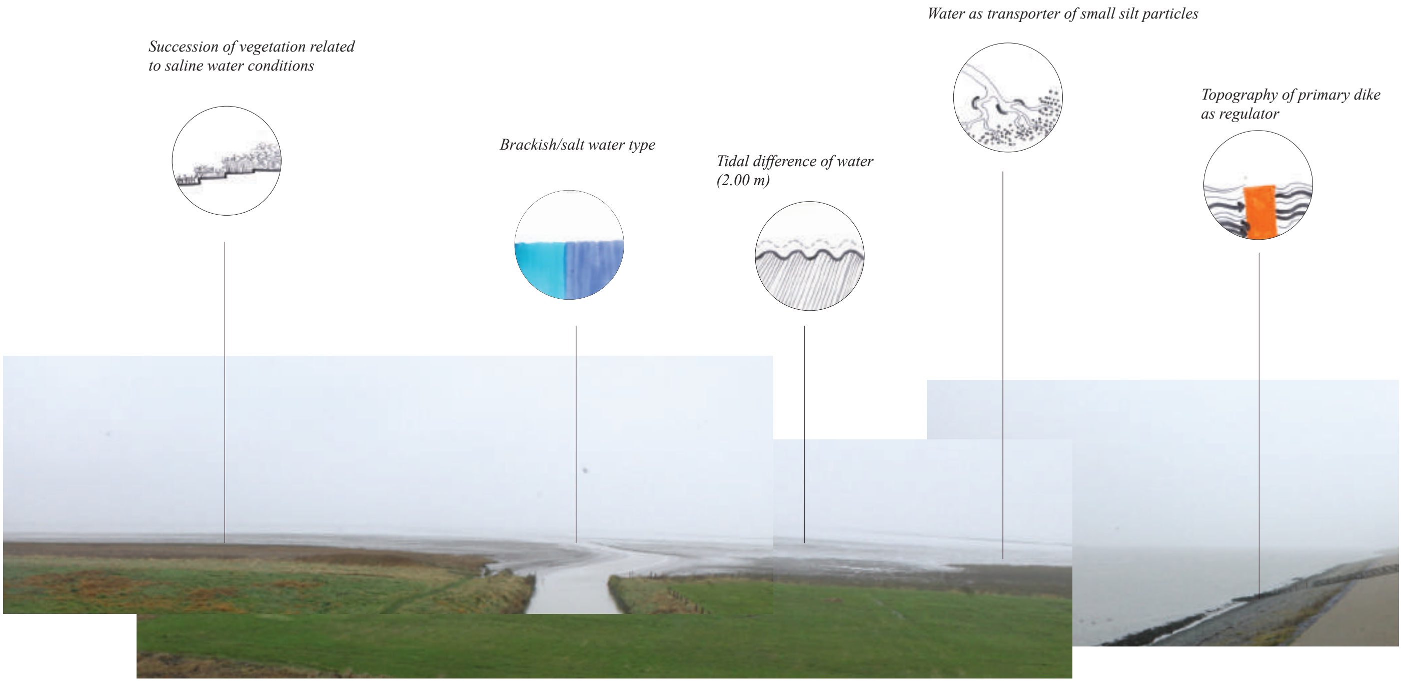
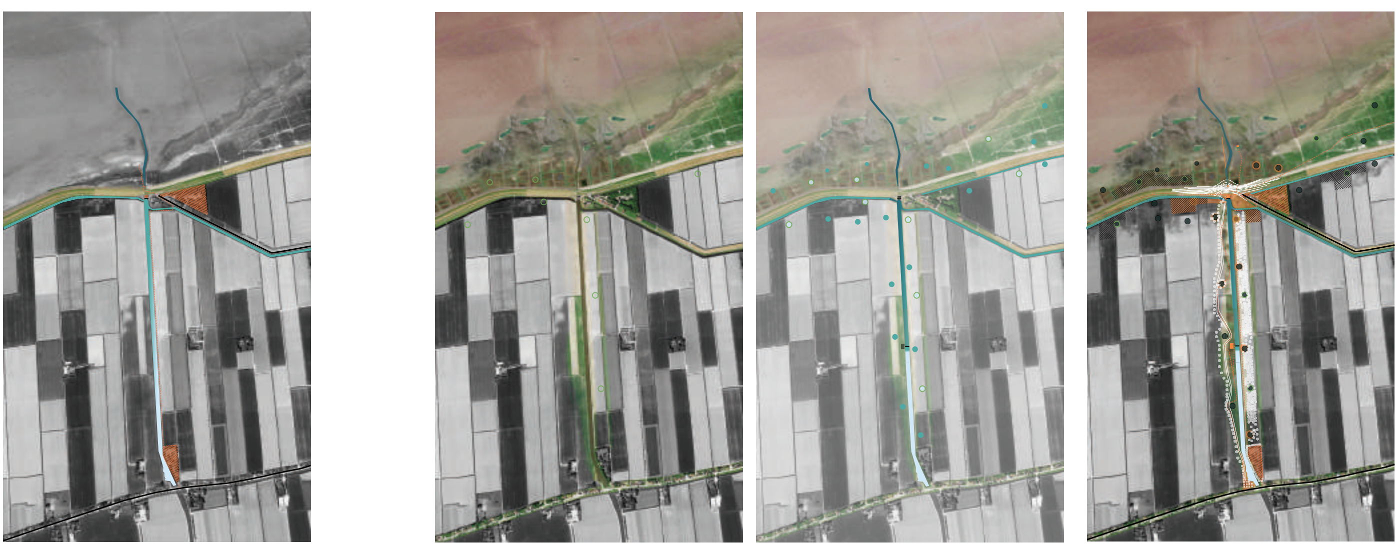


Fig. 67: Potential processes and functions of the sea that are suitable for exchange with land



Existing situation | *Design proposal: wider borderscape* | *Creation of fresh-salt water systems* | *An area of multifunctional use and experiences*

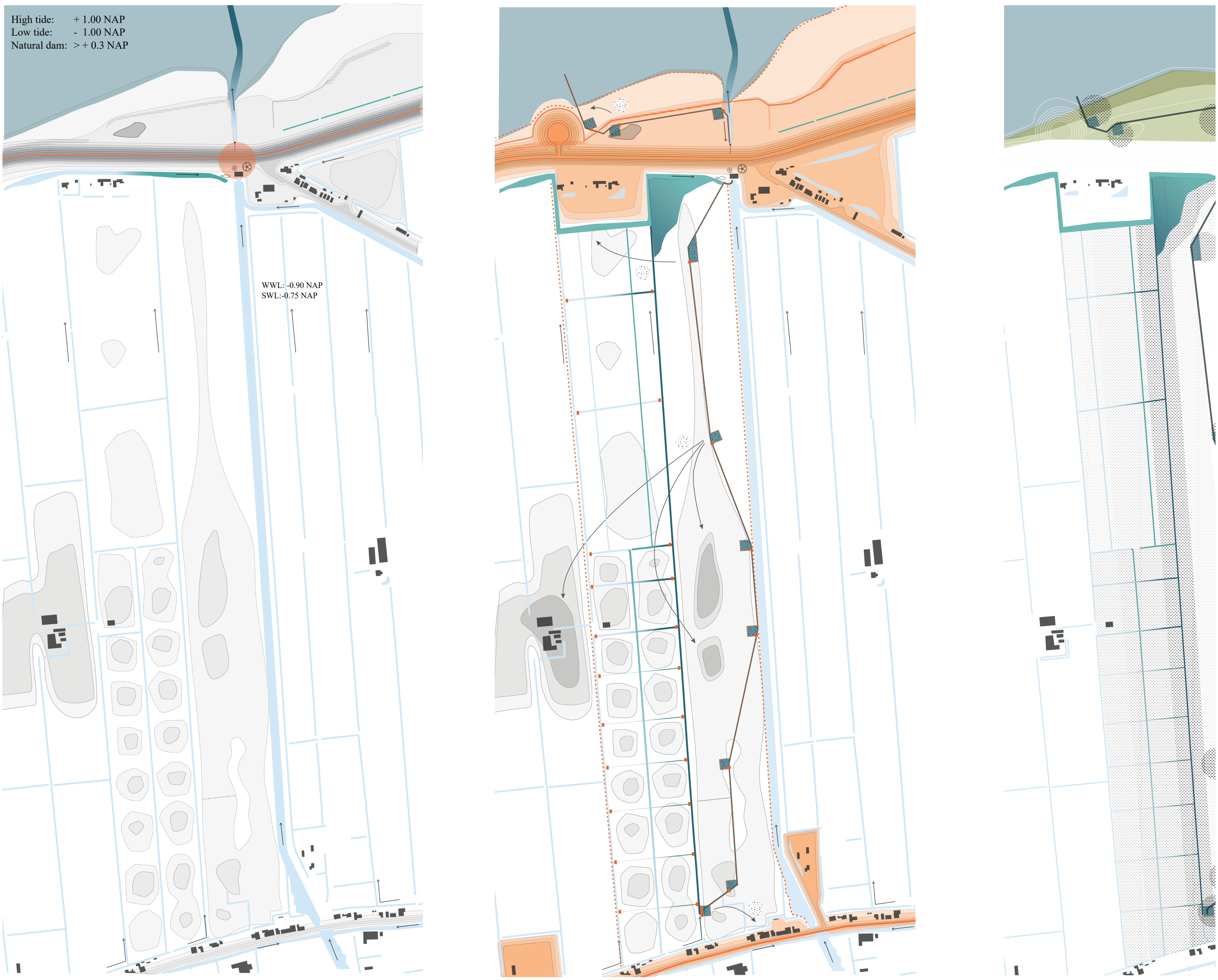
Fig. 68: Design attempt Zwarte Haan

Using regulating water structures at existing and new perpendicular ditches helps to regulate this gradient. The new perpendicular ditches are dug at the locations of the lowest topography of the plots to be in line with the natural drainage. In time, the sediments that are transported by the water, are collected and used for assigned areas to higher the topography again creating an adaptive water system.

Next, the difference in water types and adjacent topography of the polders on the micro scale creates a diversity in ecological systems. This leads to different types of vegetation on that can be found on both sides of the primary dike making it more permeable.

Based on this, diverse human uses and experiences are set. According to human uses, a regulated gradient of salt and brackish water is used for experimental agriculture at several smaller plots. Moreover, public uses are added to the area of Zwarte Haan. The small openings in the salt water channel establish gardens within a wider landscape park for education, recreation and ecological development. Altogether, these functions offers new spatial alternatives for the existing private farms in the area, the main users of the area. Concerning the human experiences the landscape architectonic layer is important. This layer shows the connection between different experiences by a routing system. Simultaneously, a big part of the routing system is located on the structures of the safety system that leaves the routing more fixed. As the experiences on both side of the dike are well connected, the primary dike does not serve as a spatial barrier anymore. The routing system takes into account different types of users: pedestrians, cyclists and car-drivers and visitors or habitants.

Fig. 69: A waterloop of salt, brackish and fresh water as the basis for exchange between functions and processes of both sides of the primary dike

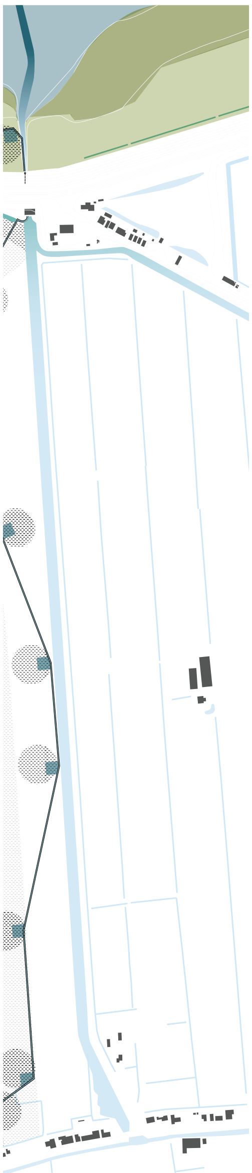


*Layer 1. **Existing** situation: water flow system and macro topography*

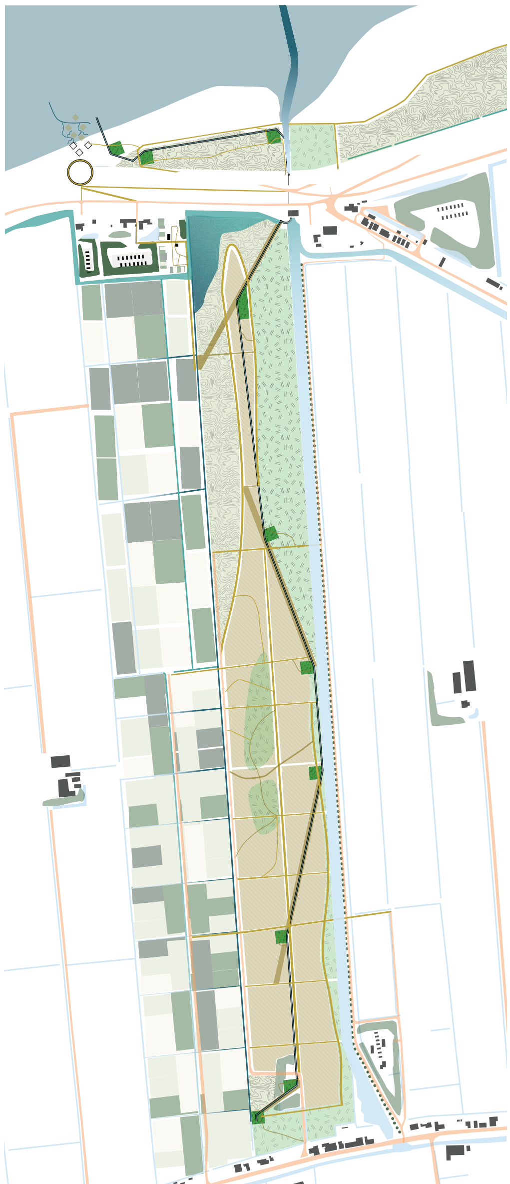
*Layer 2. Addition of a **water system** working with the macro/micro topography*

Layer 3. Areas of salinization support

Fig. 70: Spatial concept of subsequent landscape layers of design Zwarte Haan



diverse ***ecological systems*** *in the area*



Layer 4. ***Multifunctional*** *area: merging of existing functions and new functions*

Layer 5. Connection of human ***experiences of dynamic and fixed***

A connected fresh- salt water system

Circulation

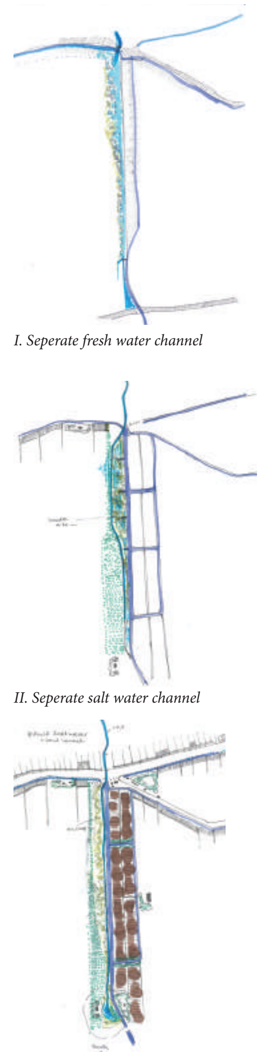
In the existing situation of pumping station Zwarte Haan, there is a water outlet of one direction that flushes out fresh water from the polder system into the Waddensea. The main drainage ditch, 'de boezem', flows into a straight line towards the pumping station that runs on two engines. The ditches parallel to the primary dike drain the water of the adjacent polders of the boezem northwards to the pumping station too (fig. 75). A separate channel, that runs on a separate engine, is used in summer to decrease the effect of salinization of the parallel ditch on the left side.

For the design of the dense point of Zwarte Haan, the exchange of fresh and salt water types in desired in a borderscape. In this case, there was searched for a water system that lets in salt water inside the dike in the borderscape. In the design processes, several design experiments were done to test alternative systems in this location (fig. 71). The options were either to let in salt water in the existing fresh water boezem and to create a separate fresh water channel alongside it or to create a separate salt water channel next to the fresh water boezem. The second option was chosen as the impact of the salt water could be regulated better, zones of highly saline conditions can be created and the impact on the existing fresh water system is less. At the pumping station there is already an extra channel that is used for pumping out the salinization of the parallel ditch along the dike in summer. This channel is transformed into a salt water channel. To enable circulation the separate salt water channel (part I) needs to merged in the existing fresh water system at some point (part II). The salt water channel starts outside the dike but is mainly located inside the dike (fig. 72).

In the first part, the salt water channel in the long plot is running off naturally using the natural descend of the topography of the polder. Here, the water runs through a concrete profile that prevents the salt water to infiltrate at all places where it runs along. At the bends of the concrete profile of the water channel is left open and this causes the salt water to flow in the area creating 'gardens'. In these gardens the depth of the water decreases and the velocity of the water slows down. This enables the sediment that is transported together with the salt water from the Wadden sea to drop down. The difference in water level between the separate salt water channel and the ditches of the fresh water system where it merges is +/- 1.9m. In order to slow down the water in the first part, several dams are places to increase resistance. The gardens differentiate from each other as they are positioned at different moments of the salt water system and different locations (inside/outside the dike). In this chapter three different gardens are discussed.

At the end of the polder the salt water will merge into a fresh water ditch. At this location, sediments will be dropped into the ditch too. Once a year, this ditch needs to be dredged (Zitman, 2018). From here, the salt water will merge with the fresh water creating a gradient of brackish water. The water is pumped up north to the ditch parallel to the primary dike. This gradient is used for experimental agriculture in which fresh-water crops will be slowly adapted to more saline conditions. The large plots are divided into smaller parcels using the low topography of the polders to dig new water ditches that do not interfere with the existing water-run off pattern. Along the ditches there are dams that can be controlled by the farmers in order to regulate the saline level of the water. Lastly, the water in the ditch parallel to the dike becomes brackish. This water is connected to the main ditch and will be flushed out from there creating a loop.

The accumulated sediments will be used elsewhere in the design to make the dikes wider or to higher up areas creating terps for viewpoints or building development. This makes the system adaptive. The section on the next page shows the transformation of the primary dike using the accumulated sediments. In time, the dike becomes wider having several plateaus for multifunctional use (fig. 73)



I. Seperate fresh water channel

II. Seperate salt water channel

III. Seperate salt water channel + circulation

Fig 71: Different design experiments

+ 0.5 - 1.00 NAP

+ 1.00 - 1.5 NAP

> + 1.5 NAP

Sedimentation

Flow of fresh water

Flow of brackish water

Flow of salt water

Control by topography (+1.0 - 8.0 NAP)

Control by concrete channel

Adjustable dams

Fig 72: Watersystem of Zwarte Haan

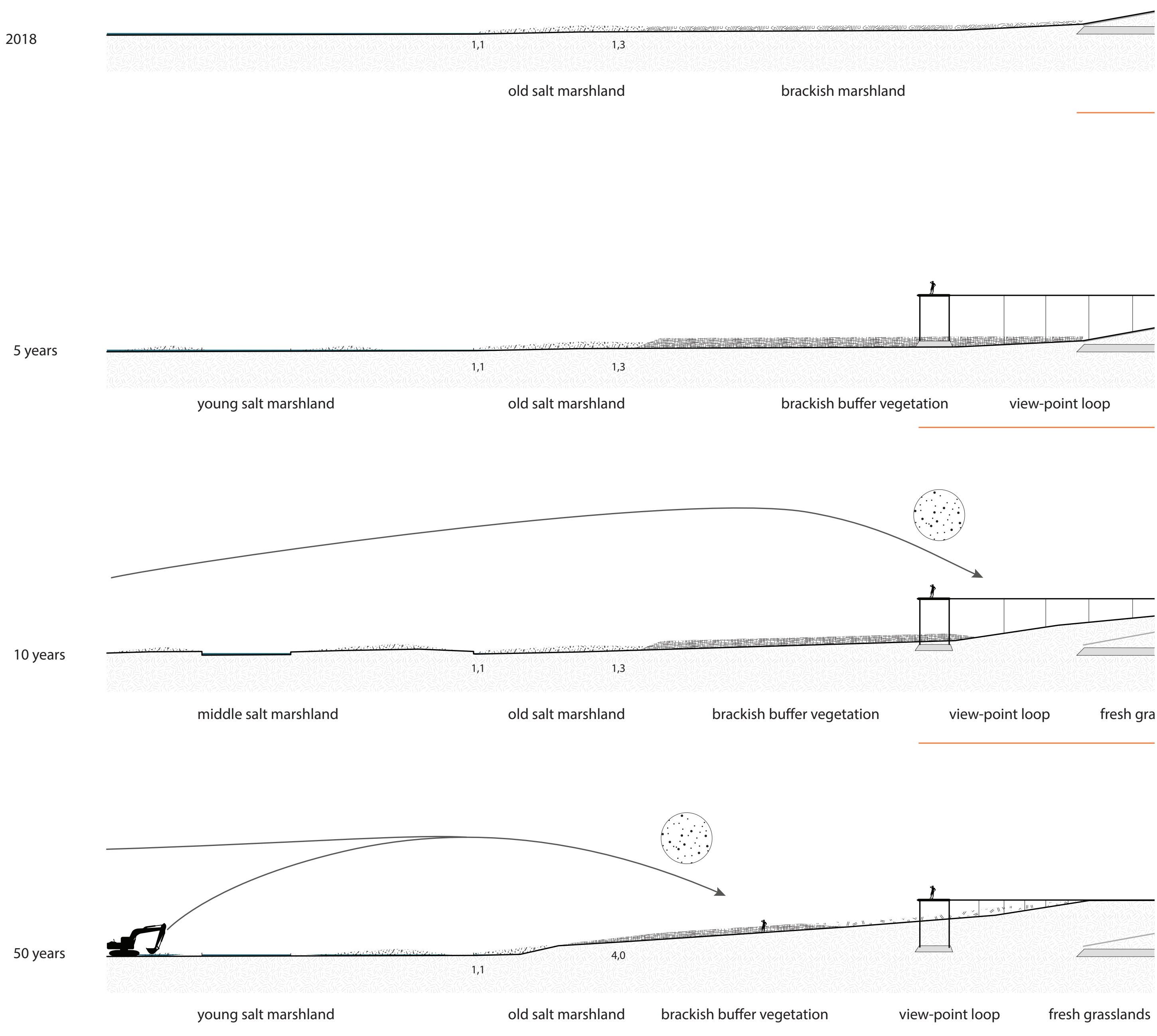
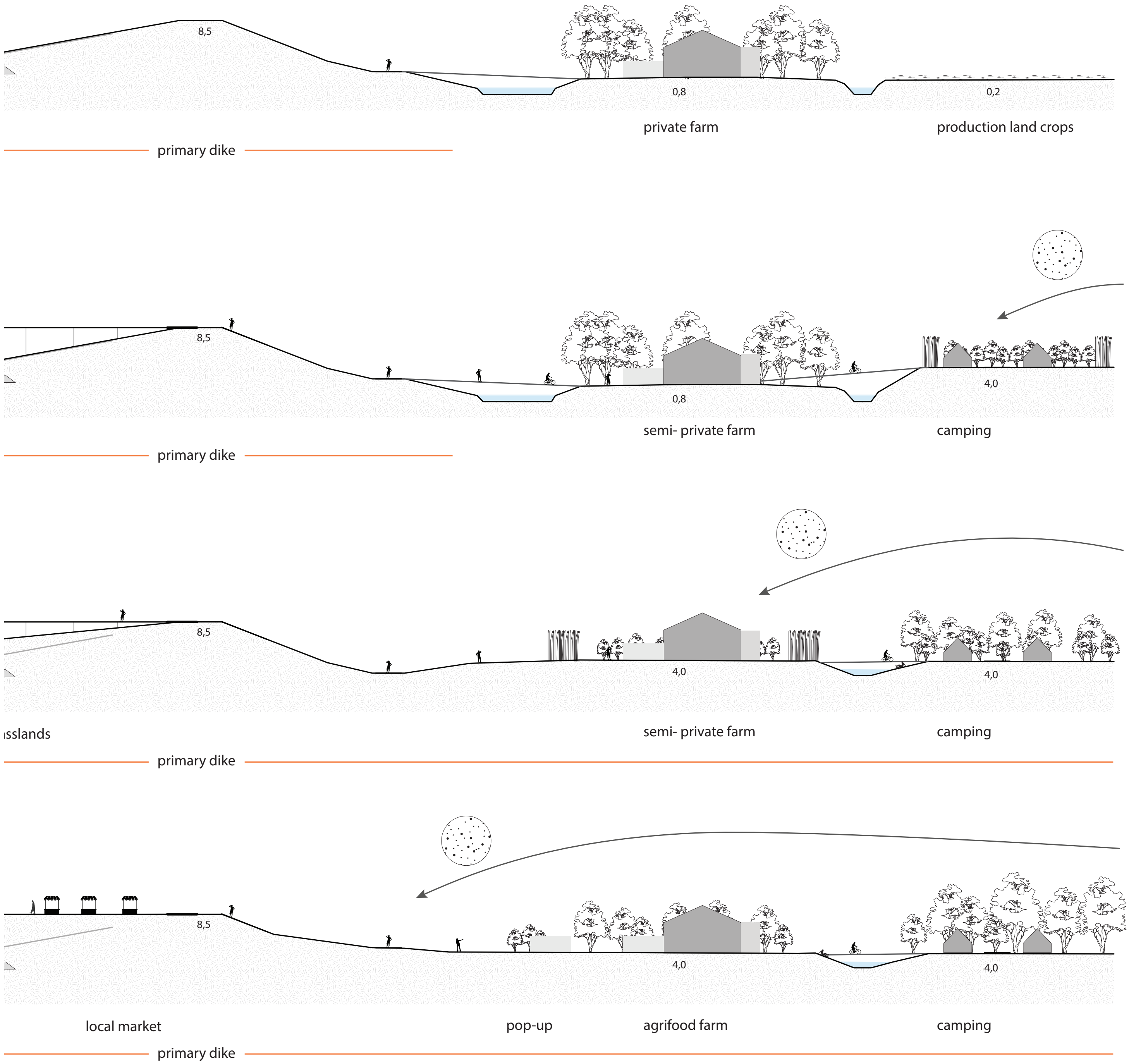


Fig. 73: AA': A connected (water) system that uses the gained sediments in the area to make the primary dike wider by making plateaus for multifunctional use (local market, view point, permanent stay, camping, agrifood) in time


8,5
0,8
0,2
private farm
production land crops
primary dike
8,5
0,8
4,0
semi- private farm
camping
primary dike
8,5
4,0
4,0
sslands
semi- private farm
camping
primary dike
8,5
4,0
4,0
local market
pop-up
agrifood farm
camping
primary dike

The transformation of the pumping station

The existing pumping station has 3 channels that each have its own engine. It flushes out the fresh water from the polder system to the other side of the dike in the Wadden sea. The water level in the fresh water system is fixed by the water boards and is -0.90 NAP in summer and -0.75 NAP in winter. On the other side the water level of the salt water system is changing twice a day according to the tide. At high tide, the water is +1.00 NAP and during low tide -1.00 NAP (fig. 74).

In the existing situation the fresh water is pumped out constantly into the Wadden sea (fig. 75). According to the volume of water 1 or 2 pumps are running. At the moment, the pumps do not work with changing level of the tides. As the water level difference between both water systems is lower during low tide, flushing out at that time would be more efficient (Siebold, 2018). The water board, who regulates the pumps, are considering this in the future. The third pump is used separately in summer. In order to diminish the effect of salinization in the left ditch parallel to the dike, the ditch is closed off from the boezem and a channel flushes out this water separately to the other side of the dike. During storms, flushing the fresh water out is possible until a sea water level of +1.80. If the sea water level gets higher than this all channels are closed off at the sea side and the pumps are shut down.

In the new situation, a salt water channel is established that uses the existing water infrastructure of the separate channel (fig. 76) The salt water only enters during high tide at the level of higher than > + 0.60m. Consequently, in the new situation the ditch parallel to the dike will always run off in the main boezem. This will increase the level of brackish water at the end of the water system. The new functioning of the pumping station takes into account the tides. This means that in normal situations, the fresh water of the polder system is only flushed out during low tide.

The addition of the salt water channel happens in three phases (fig. 77). The first phase is the connection of a new concrete salt water channel to the existing water infrastructure of the pumping station enabling a salt water flow. Next, controlling elements are placed at several points around the channel in order support openings in the channel in a regulated way creating gardens in which the water can flow to a certain extent. In general, these controlling elements are part of the routing system. The last phase is the influence of the exchange of water types to the ecological development of different areas. At the openings of the salt water channel saline vegetation will grow. At the ditch parallel to the dike brackish vegetation will grow and among the fresh water boezem fresh water vegetation. As the same ecological systems on both sides the primary dike becomes more permeable at this location. The permeability between both sides is strengthened by a better and more extensive connection of the routing systems inside, on and outside the dike. Lastly, the materialization of the dike outside changes from asphalt into a vegetated surface in order to blend the dike better into the materialization to both sides.

Thus, the pumping station becomes the moment in which the water types of both sides are exchanged laying the foundation for the functioning of the borderscape. To stress the importance of this moment, the pumping station becomes an architectonic element in the design. The building offers different look out points are created that offer views to both sides of the dike and it serves as an entrance of the landscape park inside the dike (fig. 78). Moreover, both water systems are placed on top of each other making the different water levels and types experienceable. The salt water channel is placed upon the existing fresh water divers and is positioned 0.8m above ground level. This channel can be crossed by a permeable metal bridge stressing the experience of the salt water and the layering of the two systems. As the channel continues in the polder, the channel slowly lowers into the ground.

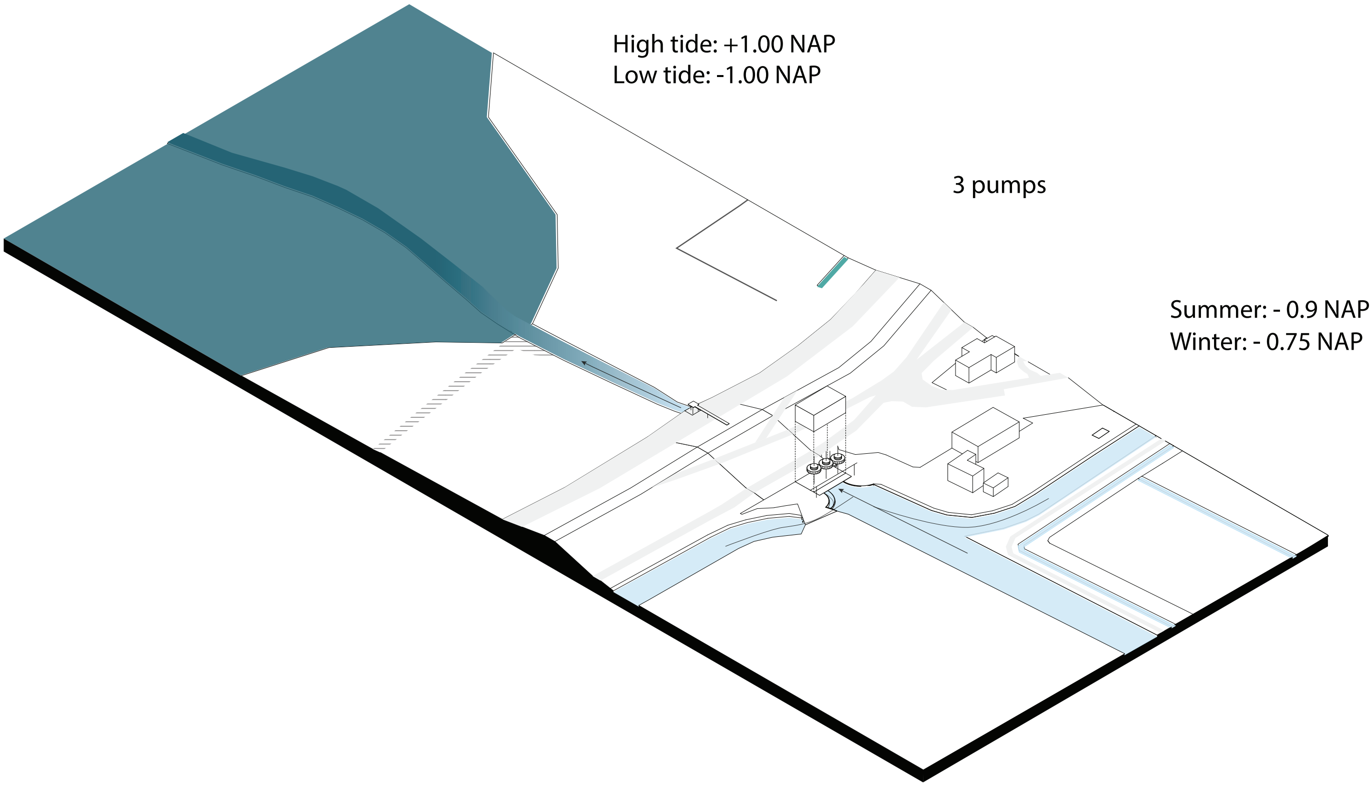


Fig. 74: Axonometry of the pumping station Zwarte Haan in the existing situation

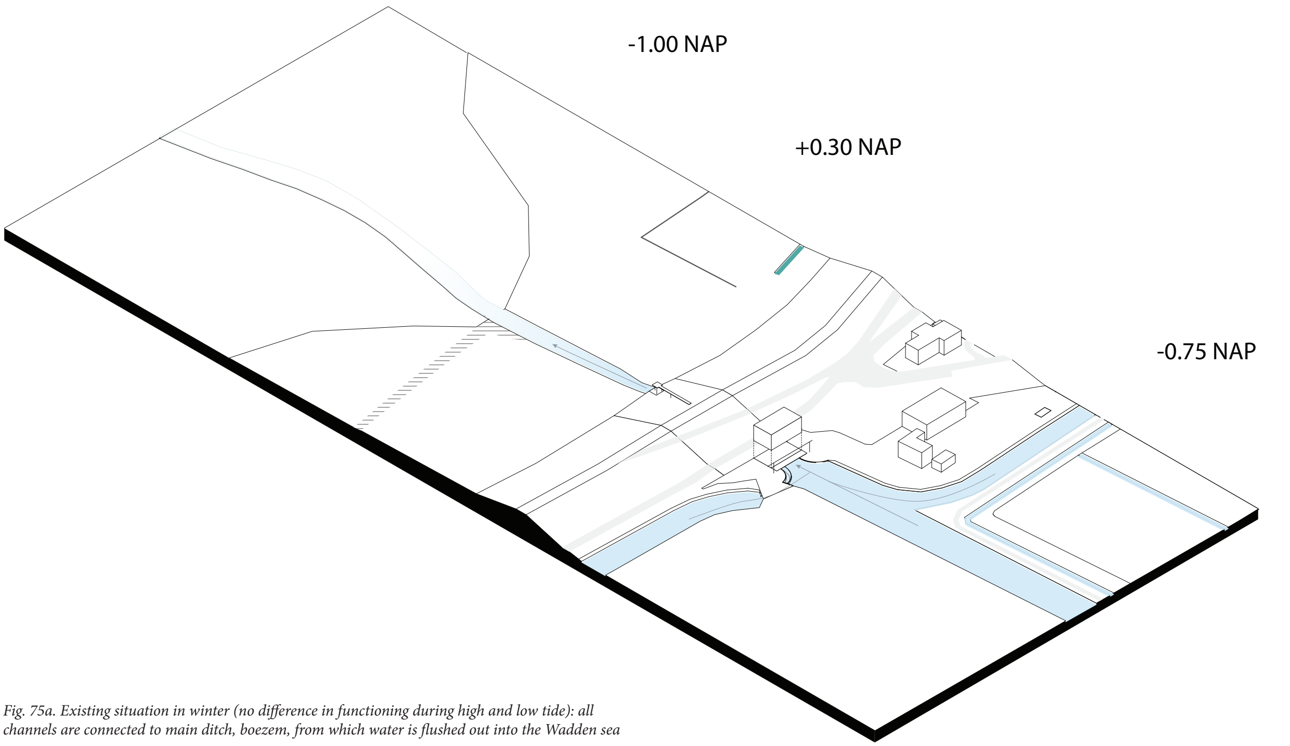


Fig. 75a. Existing situation in winter (no difference in functioning during high and low tide): all channels are connected to main ditch, boezem, from which water is flushed out into the Wadden sea

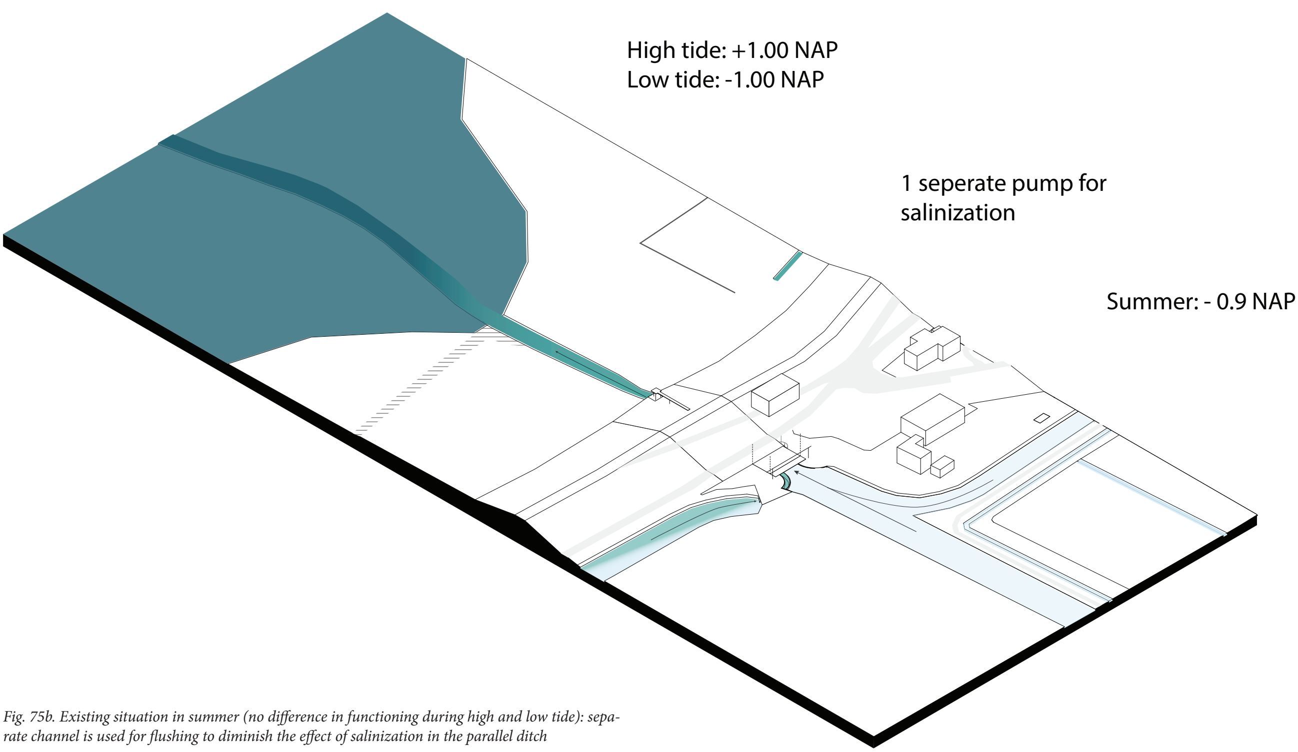


Fig. 75b. Existing situation in summer (no difference in functioning during high and low tide): separate channel is used for flushing to diminish the effect of salinization in the parallel ditch

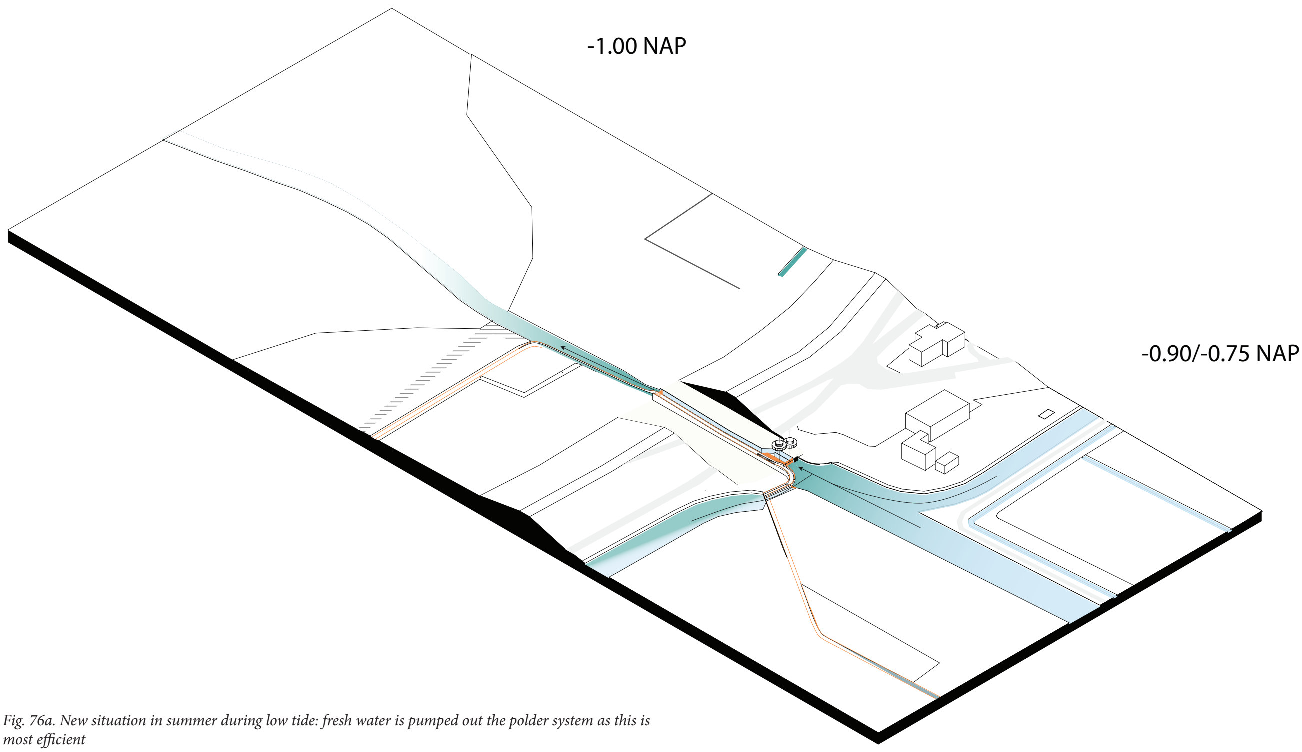


Fig. 76a. New situation in summer during low tide: fresh water is pumped out the polder system as this is most efficient

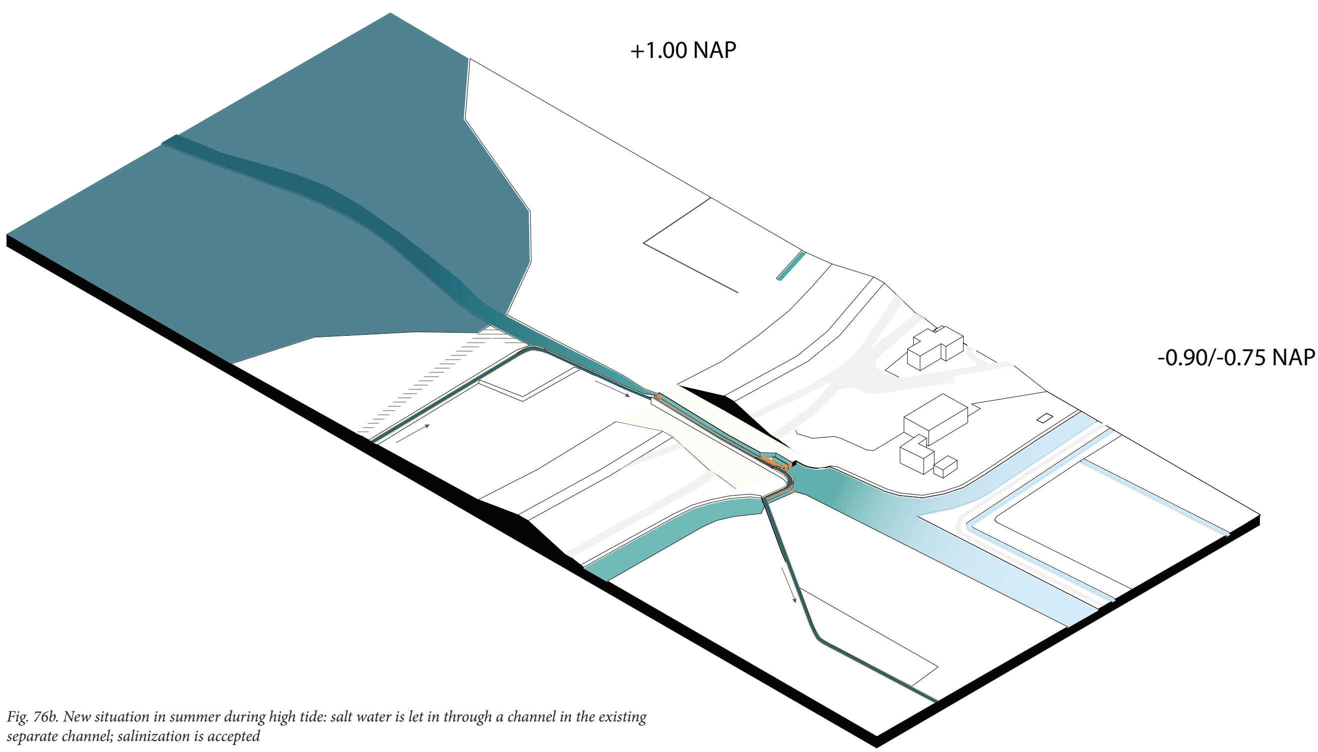


Fig. 76b. New situation in summer during high tide: salt water is let in through a channel in the existing separate channel; salinization is accepted

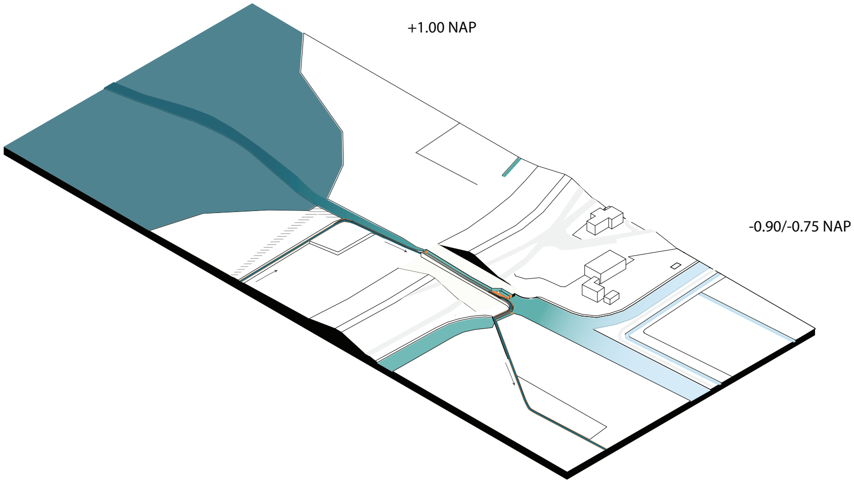


Fig. 77a. Phase I: leading the salt water through the salt water channel

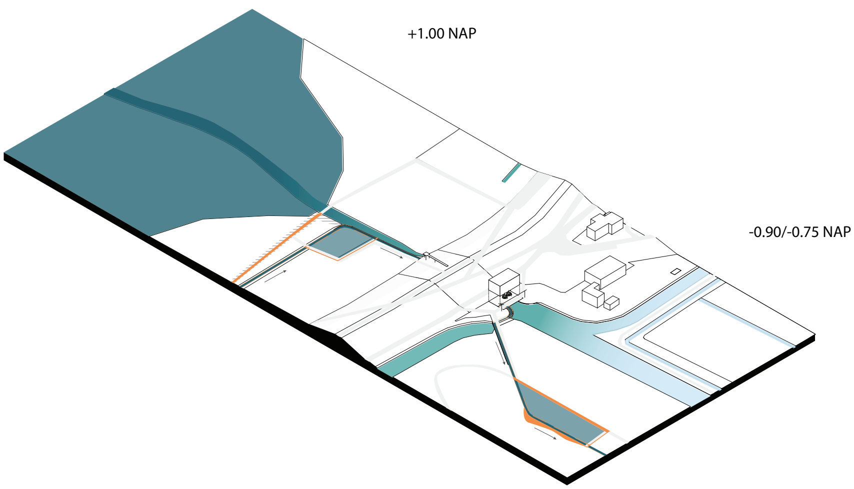


Fig. 77b. Phase II: making openings in the channel to let the salt water on regulated basis infiltrate in a assigned area. Most regulators also function as routing (orange)

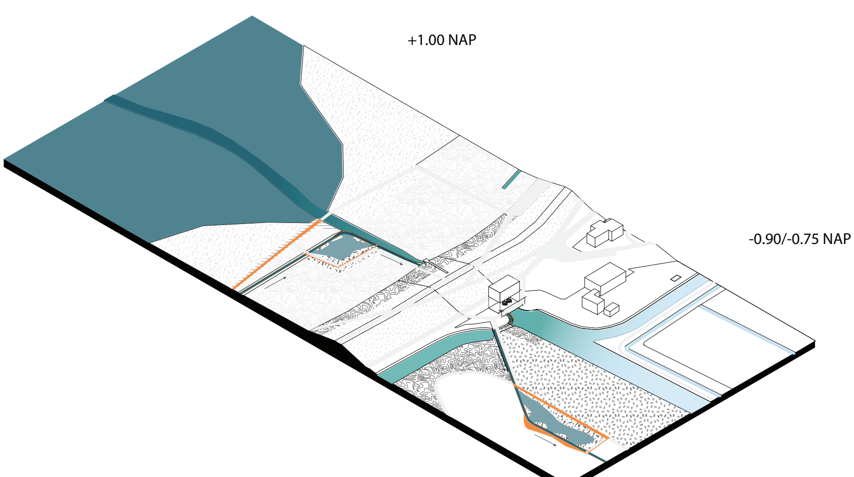


Fig. 77c. Phase III: Due to a regulated open exchange of salt water type and sediments a variety of ecosystems will occur on both side of the primary dike

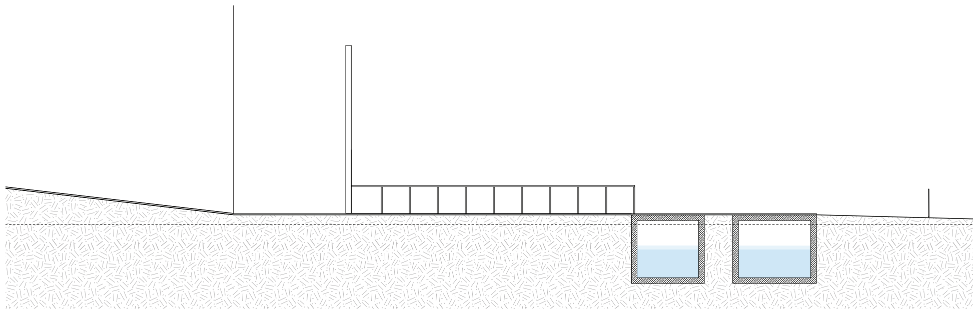


Fig. 78a. Pumping station in the existing situation with to fresh water divers

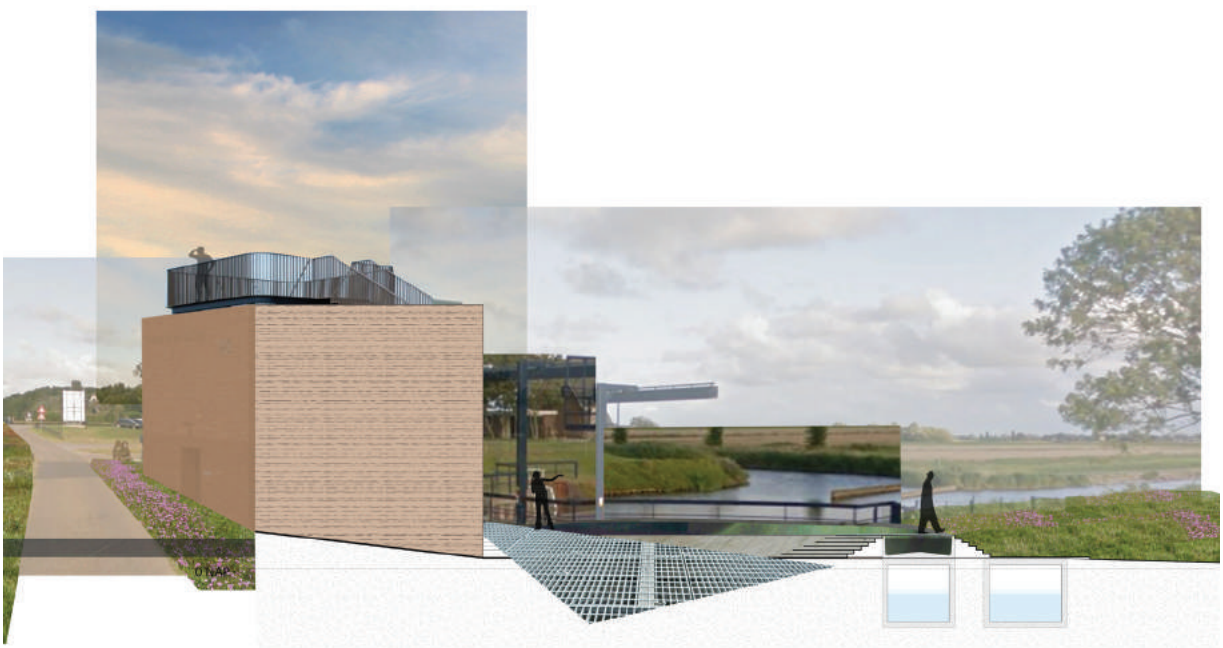
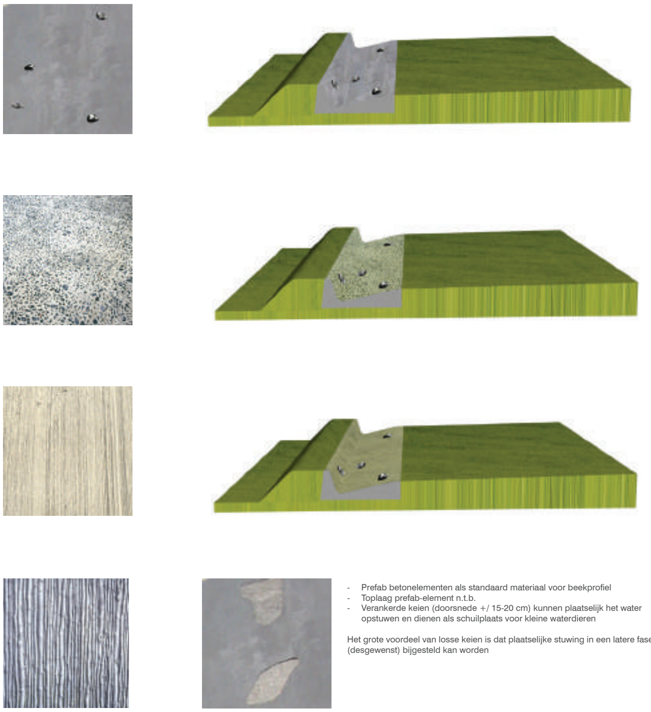


Fig. 78b. Pumping station as an entrance for the landscape park with several view platforms and a close experience of the layered water exchange through the dike

References & Materialization

In the design of Zwarte Haan the salt water channel is made explicit by the concrete profile that runs through the polder. This is done in order to make the exchange of water type and water level in the borderscape more legible. This contributes to the human experience in an aesthetic and educative way. The reference of Wijkeroogpark is used as inspiration (fig. 79). This project shows a similar separation between two water types. Here, a fresh water ditch merges into a brackish water basin. In this project a study of materials is done to establish vegetation on the concrete. This research is used and implemented for the materialization of the concrete salt water channel. On the sides notches in the concrete are made that allow moss and other types of vegetation to grow.

Other elements of the salt water channel are the dams perpendicular in the system that give resistance to the water and regulate the gradient of water type. These elements are located at the edges of the gardens and used architectonically in the design. Apart from their water function, they either offer a view point or are integrated in the routing of the garden (fig. 80).



Material research of concrete allowing vegetation to grow in Wijkeroogpark (Bureau B+B, 2005)

Concrete water profile in Wijkeroogpark as reference project (Bureau B+B, 2005)

Merging of fresh water ditch in brackish basin (Wijkeroogpark, 2017)

Fig. 79: Wijkeroogpark as reference project

Fig. 80a: An example of regulating water structures for the salt water channel for resistance (a dam)

Fig. 80b: An example of an adjustable water structure for the salt water channel for the inlet of of salt water (a dam)

Diversification of ecological systems on both sides

In the existing situation the area inside the dike belongs to a fresh water ecosystem. The ditch parallel to the dike has started to become more brackish as a result of an increase of salinization. Still, this is not experienceable as most area is used for production land and the ditches are flushed by fresh water. Outside the dike, the function of the marshlands that used to be summer polders changed to ecological development as they are given back to the protected Wadden area in the last decade. As the topography is between +2.0 -3.0 m NAP the main part of the marsh lands does not overflow regularly by salt water. The area belongs to the last stage of succession in vegetation of a brackish environment. The area that has a lower topography belong to younger salt marshlands.

In the design the salinization happens in different ways (fig. 81). At the first part the salt water channel runs through a concrete profile. The openings in the profile cause small assigned areas, gardens, with a highly concentrated salt environment. This leads to vegetation that belongs to more saline conditions. The garden outside the dike rejuvenates the surrounding brackish marshlands to young salt marshlands. The gardens inside the dike create a contrast with the fresh water environments that is nourished by the fresh water boezem. As the salt water channel moves more south and covers more distance, the type of vegetation slowly changes. The salt water gradually becomes less saline, leaves less sedimentation and the tidal difference decreases moving from the sea.

In the second part, the salt water channel merges into an existing fresh water ditch that is set at a fixed water level. At the merging point, the tidal difference is still noticeable due to the salt water. After the moment of merging in the fresh water system, the water level becomes more fixed again and the saline conditions dissolves more gradually between fresh and brackish. This water flows north to the ditch parallel to the dike and together with the increasing effect of salinization a brackish environment develops.

The addition of a salt water channel causes places of salinization that lead to more diversity in ecological systems. This diversity is made explicit by the types of flora that will grow each belonging to different types of systems. In time, each ecological system will have different phases of succession that also gives certain types of flora. The level of succession can be manipulated by level of maintenance. Thus, having knowledge of these different phases and systems and the way to regulate them enables to predict flora and atmospheres in certain areas. Working with this in design creates a diversity of human experiences and uses. Moreover, as the same ecological system can occur inside and outside the primary dike it does not function as an boundary anymore between two different ecological systems. The section shows the increase of ecological systems in relation to the primary dike (fig. 82). At this location, the gathered sedimentation in time is not used to make the primary dike wider but elsewhere in the design.

In the design three different ecological systems are used: fresh ecological systems, brackish ecological systems and salt ecological systems. Later on, the succession of each system will be described and the type of maintenance will be discussed. There is also another type of vegetation used that is resistant to all ecological systems: reed. The purpose of using this flora is used for production, to set an agricultural atmosphere, to create enclosed spaces quickly, or to function as buffer vegetation in extreme water conditions in the borderscape.

Fig. 81: Areas of salinization

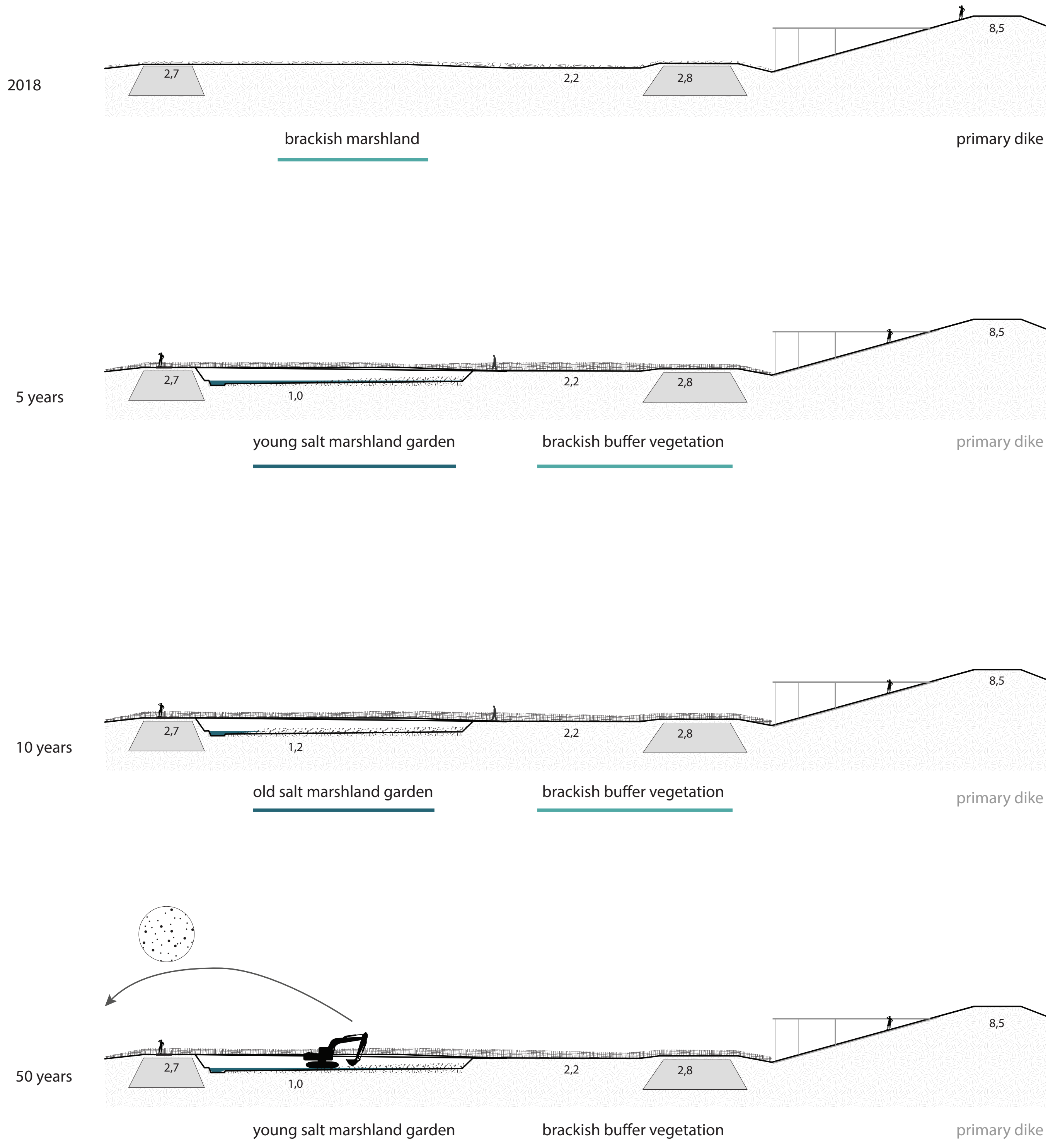
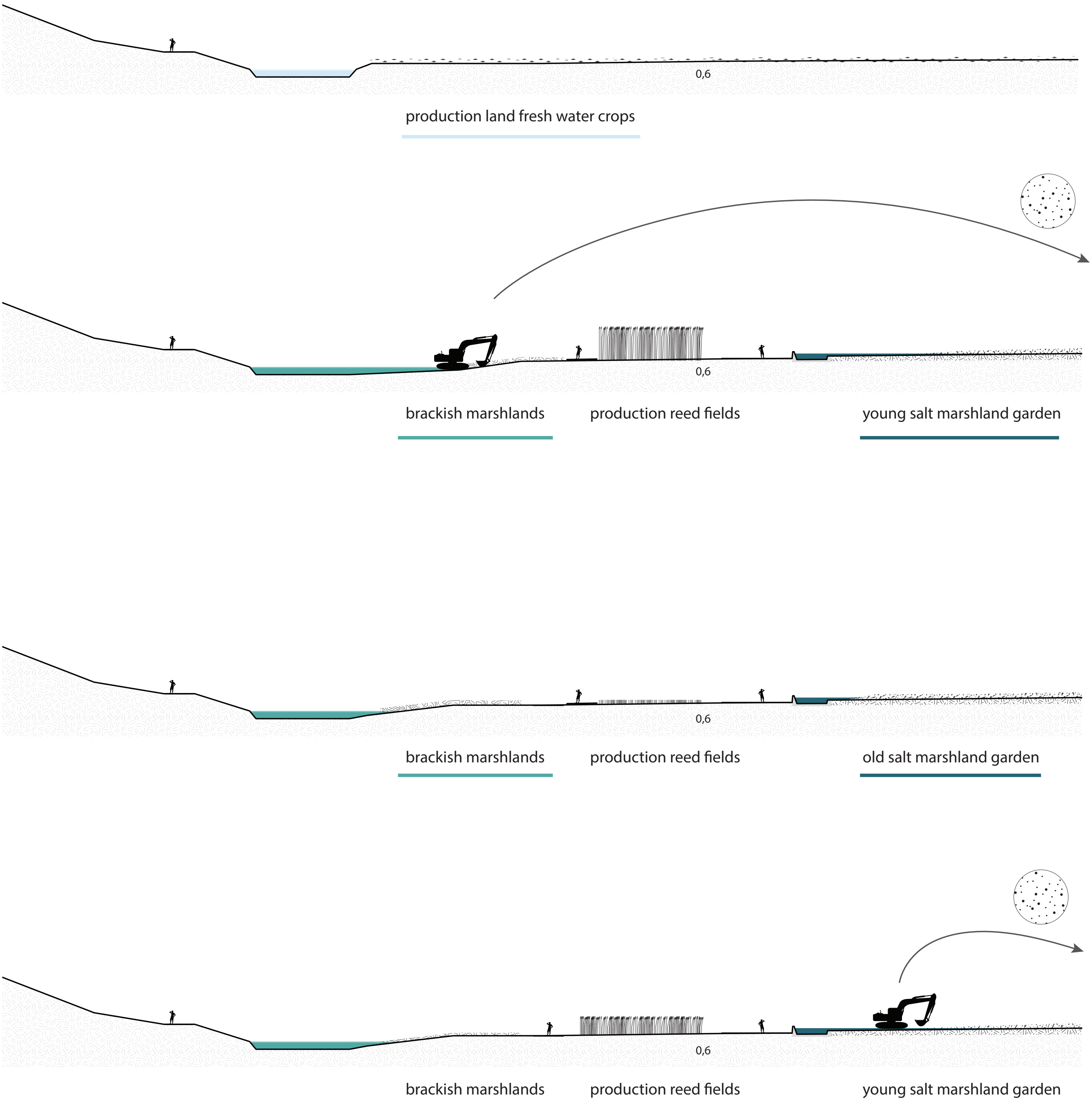


Fig. 82: Section BB'. Ecological variety on both sides of the dike due to exchange of salt, fresh and brackish water types making the border permeable and using the gathered sedimenation elsewhere in the borderscape


0,6
production land fresh water crops
0,6
brackish marshlands
production reed fields
young salt marshland garden
0,6
brackish marshlands
production reed fields
old salt marshland garden
0,6
brackish marshlands
production reed fields
young salt marshland garden

Fresh water ecological systems

The succession of the fresh water ecological system in this area differs from wet grasslands into higher ash forests. The wet grasslands are full of herbs and flowers such as *Silene flos-cuculi, Valeriana officinalis, Cirsium palustre, Rumex hydrolapathum etc*. The level of maintenance shows different atmospheres. If maintained frequently, by a machine, grass lanes are made. If maintained frequently, by sheep, the grassland is kept short and domination of a certain species is prevented. If maintained less frequently, the height of the plants are higher creating a different atmosphere. In time, the wet grassland can evolve to a ash forest.

In the design, at several areas long grass lanes are desired asking for frequent maintenance with a machine. On other locations the maintenance can be less. On a few locations, functions that ask for an enclosed environment, the flora is let grown higher in time.

Lanes of short grass, frequently maintained by machines

Short wet grassland, frequently maintained by sheep

Long wet grassland, less frequently maintained by cutting machine

Essenbos

Zilverschoon (Pontentilla anserina), frequently maintained by sheep

Zulte (Aster tripolium), frequently maintained by sheep (more dominating)

Fioringras (Agrostis stolonifera), dominating

High plants of Heen (Bolboschoenus maritimus), dominating

Brackish marshland

In this ecological system, brackish water is present. The level is succession is related to the level of moisture and if dominating species occur. In the first phase a variety of small flowers occur, such as *Eleocharis uniglumis, Potentilla anserina, Centaurium pulchellum, Festuca arundinacea etc.* If maintained frequently enough, species such as *Agrostis stolonifera, Aster tripolium, Bolboschoenus maritimus,* are less eager to occur as these type of flora will dominate the area. The images show the level of domination in time dependent on the level of maintenance.

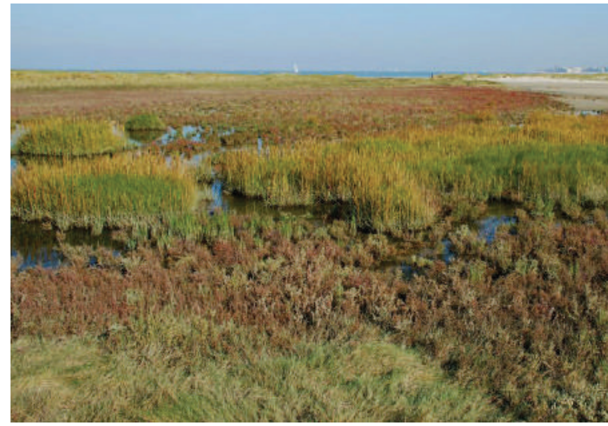
In the design brackish marshland occurs at the shores of several polders inland and on the marshland outside the dike. At the marshlands outside the first width of 80 meters will be vegetated by the last stage of succession explained on the next page. The other locations will have lower vegetation.

Salt marshland

In this ecological system, salt water is dominant. The frequency of moisture relates to different stages of succession. In the first stage of young salt marshlands, that most of the time of the tide is above sea level (+0.8 NAP), flora as sea coral and *Spartina anglica* are present. If land is lower than +0.8 m, vegetation cannot grow, the sediments are to dynamic and it is not considered yet as a salt marshland. In time, the flora of the first phase catch sediments and higher themselves up that leads to a lower frequency of moistening. The next phase, middle marshlands, contains flora of *Aster tripolium, Limonium vulgare, Atriplex portulacoides and Maritima puccinellia.* As the marshland grows in height and the level of moisture becomes lower, species as *Elytrigia atherica* starts to dominate.

In the design, highly concentrated salt environments are created that are moistened in the beginning. In time, the sediments can help to lift up the topography of the area and can settle new types of flora. At the end of succession cycle, maintenance is done to restart the salt marhsland from the beginning. During the cycle, frequent maintenance of sheep can help to keep the marsh land at a certain phase.

Young marshland, sea coral and Spartina anglica(T=1)



Middle marshland, Lamsoor (Limonium vulgare) (T=2)

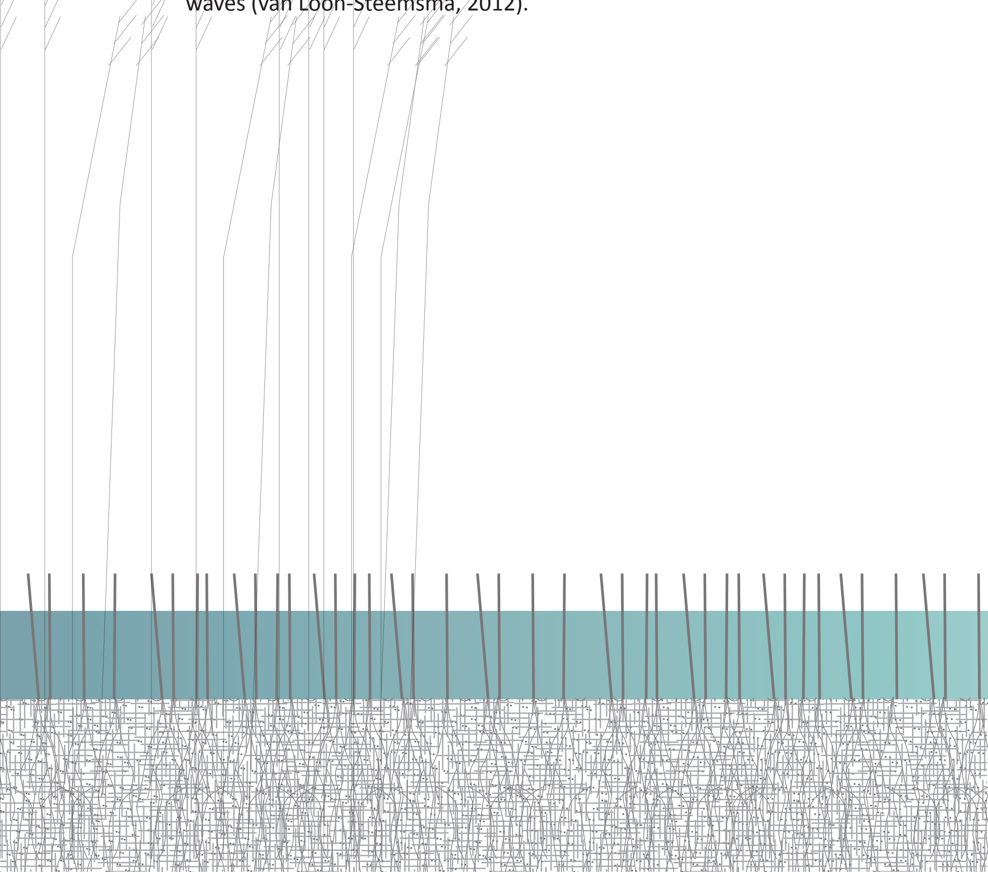
Middle marshland, zoutmelde (Atriplex portulacoides) (T=2)

Grown marshland (Elytrigia atherica) (T=3), dominating

Reed fields

In the design there are reed fields on several locations on both sides of the dike. Reed fields are suitable as buffer vegetation, production for biofuel, an agricultural atmosphere and the quick establishment of enclosed spaces.

Different reed types are used in the design: *Pragmites Australis, Bolboschoemus Maritimus, Schoenoplectus Tabernaemontanis* and *Miscanthus x giganteus.* In general, reed is a strong type of flora that is resistant changes in water type. Still, each specie prefers certain site-specific conditions, such as level of moisture and level of salinity. They can grow between 3-4 meter high. For example, *Miscanthus x giganteus,* has an annual cycle of a growth of 4 meter. In the winter the reed will be cut and in spring it will start to grow again. In spring, summer and autumn the reed will change from colour giving different atmospheres all year round. Moreover, the reed fields contribute to water safety in the marshlands. Reed fields forms a dense root structure that prevents erosion and the stems break waves (van Loon-Steemsma, 2012).

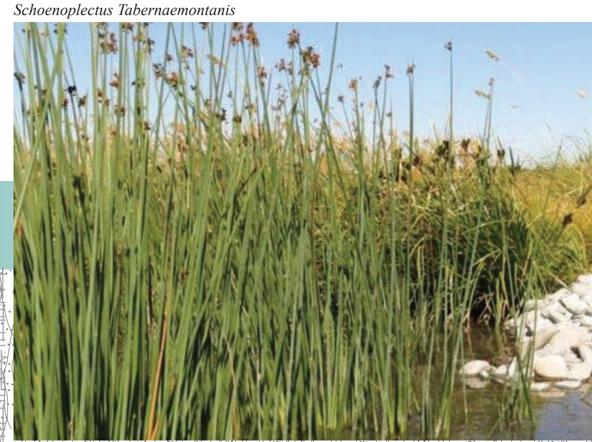


Pragmites Australis

Bolschoemus Maritimus

Miscanthus x giganteus, end summer (Schloss dyck park)

Schoenoplectus Tabernaemontanis



Multifunctional borderscape

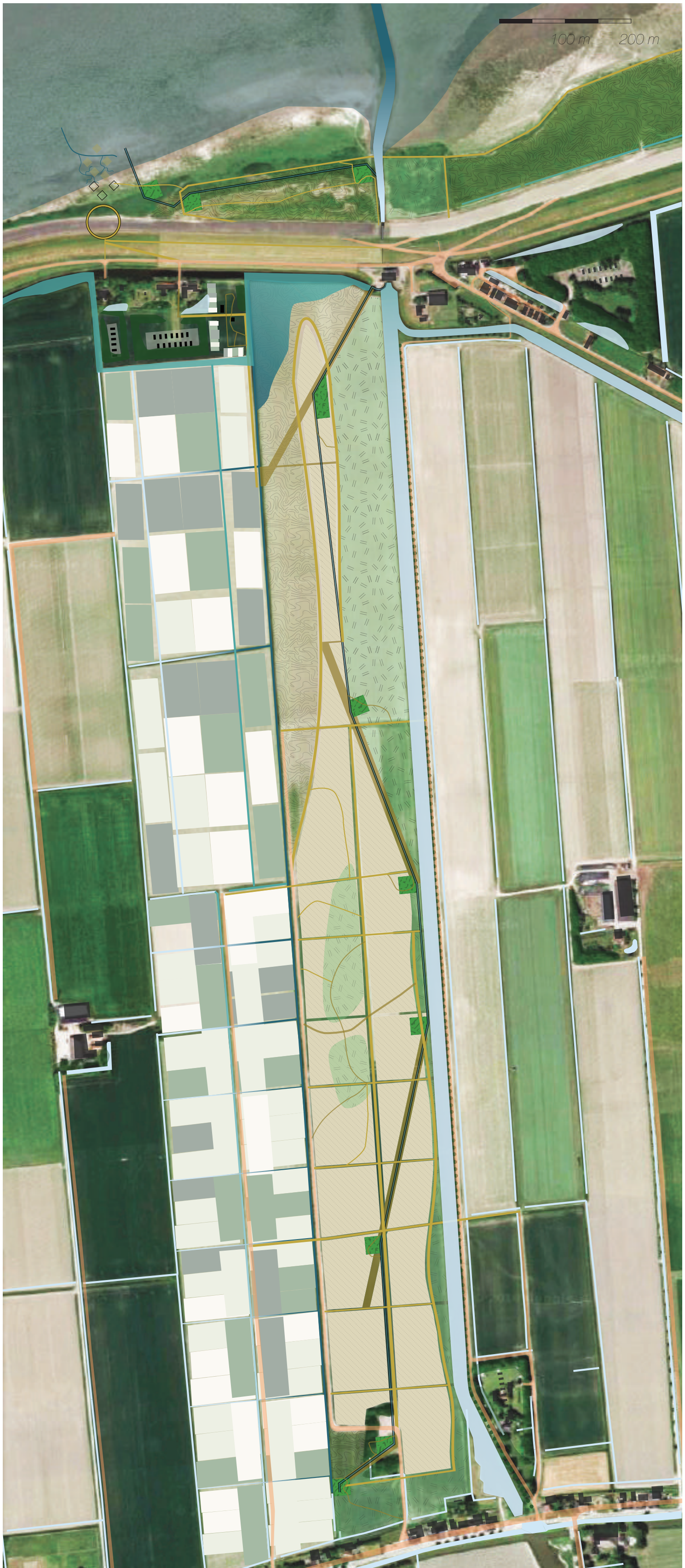
The increase of permeability in the design of Zwarte Haan merges existing functions to processes of land and sea within the area and new functions arise. This leads to a multifunctional zone that also merges the different functions together. This multi-functionality contributes to the adaptive capacity of the borderscape. In the existing situation the zones within the area are assigned to separate functions. The land inside the dike is mainly used for production. The marshland outside the dike functions as an brackish ecological zone and the primary dike in between for water safety. In the design proposal these functions merge into experimental agriculture, diverse ecological zones related to different levels of salinization, multifunctional primary dike and the functions of education and recreation are added to the area (fig. 83). The increase of ecological diversity is explained previously and the primary dike will be discussed later in the chapter.

Involving the current users: farmers

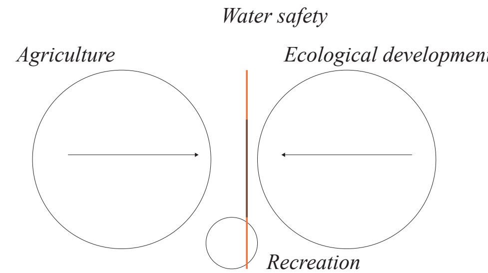
In the existing situation the land adjacent to the primary dike in Zwarte Haan is divided in big scale plots that serve for the production of crops, mostly seed potatoes. These are alternated with sugar beets, onions and grain (Krol, 2018). In the proposed design one big parcel is divided in smaller plots by new water drainage patterns and a gradient from fresh to salt water occurs (fig. 84). This makes the area suitable for experimental agriculture. By a system of adjustable dams, the farmer can decide the saline level of the water for each area (fig. 72). In general, in the middle of the plot brackish conditions occur. On the left side of the plot fresh water and on the right side salt water conditions. Plots. In time, these crops gradually adapt to more saline conditions. Each plot can switch from type of crops offering a diverse palette of colors. The silty crops are initially not used for production but for the export of seeds and knowledge of salty crops to the adjacent area. Besides, the crops can also be used locally for functions of agrifood, social farming and/or local markets. Here, agriculture becomes combined with the function of recreation and education. Spatial and functional alternatives to production land are shown to the current user, the farmers, in order to involve them better in the transformation to the borderscape. Moreover, the farm close to the ditch asks for stricter water safety measures if the borderscape functions as a water buffer zone in extreme weather conditions. As the farm is adjacent to the dike, the dike expands by a plateau of +4.0 m offering a higher location for housing or temporary stays, such as campings.

Destination for recreation

The dense point of Zwarte Haan should become a destination for recreation and education of a borderscape. Therefore, the processes that occur within, diversity of water types, water level, succession of vegetation and sedimentation are made explicit aesthetically in order to experience them. The diversity of processes are programmed within the landscape park through which the salt water channel flows. In the landscape park recreation is combined with ecological development of different ecological systems and production land of reed fields. The sequence of gardens alongside the salt water channel makes the processes of the borderscape explicit. This contributes to the education of the functioning of a borderscape as a system. The primary dike is positioned within the landscape park. Besides water safety, the dike offers view points from which both sides can be experienced from a bird-eye perspective.



Seperate functions



Merging functions:
- Education
- Recreation
- Agriculture
- Ecologcial development
- Water safety

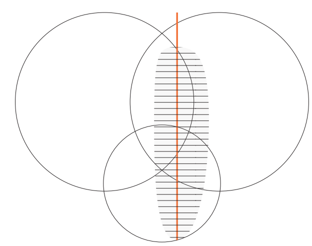


Fig. 83: Diagram merging functions

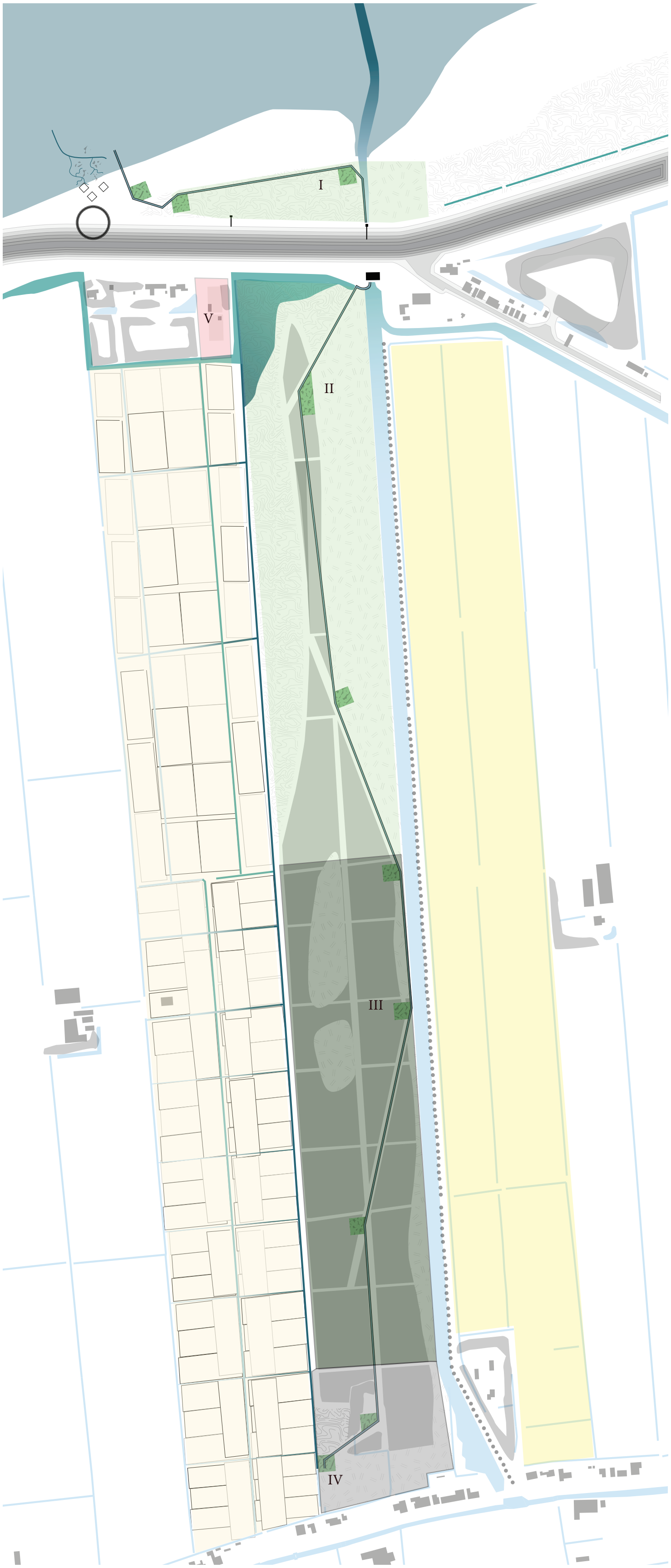
Reed fields (closed)
Brackish marshlands (open)
Fresh water grasslands (open)
Gardens (salt water)
Camping
Experimental salty agriculture
Existing roads/paths
New roads/paths

Fig. 84: Map of human uses

Landscape Park
The existing long-stretched polder (2km x 185m) adjacent to the boezem will be transformed into a landscape park that functions At several points the concrete of the salt channel opens. These openings are used as starting points to divide the big park into smaller gardens that are positioned around these openings. The gardens are a geometric shapes, squares of 25 x 25m to 30 x 30m and a rectangular shape of 40 x 20m. These geometric forms contribute to the artificial character of area, such as the existing dike, and gives a contrast to the more 'natural' processes that occur within the gardens.

A part of the agricultural plot is kept for production land of reed. Different types of reed are used that are related to the water conditions on specific locations. In general, reed is a type of flora that is resistant to different water types and level of moisture. The different types of reed are already discussed in the paragraph on ecological systems. The use of reed helps to divide the landscape park into open and closed spaces. Besides, it preserves the agriculture character of the former production land. Also it forms a more gradual gradient between the open land and higher vegetation. Normally, trees mark the edges of the plot and open fields in between. One of the species used is Miscanthus x giganteus. This type of reed grows up to 4 meters annually and could be used as biofuel. The grass should be cut in winter and starts growing in spring again. Other type of reed can be used as building material or craft material too. The reed fields also make the highest topography of the polder explicit. On top of that, the highest lines of topography are turned into open grasslands again.

The landscape park is a play of open and closed. Within the park a sequence of gardens is located that all make the processes of the borderscape explicit. These are the difference in water level, deposit of sediments, succession of vegetation sedimentation, play of water velocity and saline level of the water. Due to positioning of the garden within the open and/or closed fields, inside/outside the dike and the location along the water system, the experience in each gardens differs. According to the water system, the tidal difference is experienced first at the gardens close to the sea as the tides are in fact a wave. The amount of sediments decreases moving landwards. The landscape park can be divided in several atmospheres in which the gardens can be positioned (fig. 85). These are *The Cut Out Garden, The Open Garden, The Enclosed Garden(s)* in the middle of the dense reed fields, *The Gathering Garden* and *The Agricultural Garden*. This means the connection of the landscape park to the settlements on the secondary dike and the merging between the salt and fresh water system. Still, even within the same category the garden can differ due to site-specific characteristics. On the following pages two gardens are explained and shown extensively: *The Open Garden* and *The Gathering Garden*. The order of the gardens are related to the flow of the salt water channel, starting with the *Cut Out Garden* outside the dike.



I. The Cut Out Garden

- Outside the dike: extreme and less controlled conditions (strong wind, high water level during storms, erosion, strong vegetation)
- The gardens are cut(+1.00 NAP)out the high marslands (+2.00 NAP)
- Deposit of sediments: ++
- Experience of tides: 1st location
- Salt water

II. The Open Garden

- Inside the dike: controlled conditions
- Composition within the open fields from differ ent view points
- Deposit of sediments: +
- Experience of tides: 2nd location
- Salt water

III. The Enclosed Garden

-Inside the dike: controlled conditions
- Enclosed by reed
- Deposit of sediments: +/-
- Experience of tides: 3rd location
- Salt water

IV. The Gathering Garden

-Inside the dike: controlled conditions
- Close to settlements on the secondary dike
- Deposit of sediments: -
- Experience of tides: 4th location
- Fixed level of fresh water system
- Moment of merging salt and fresh water

V. The Agricultural Garden

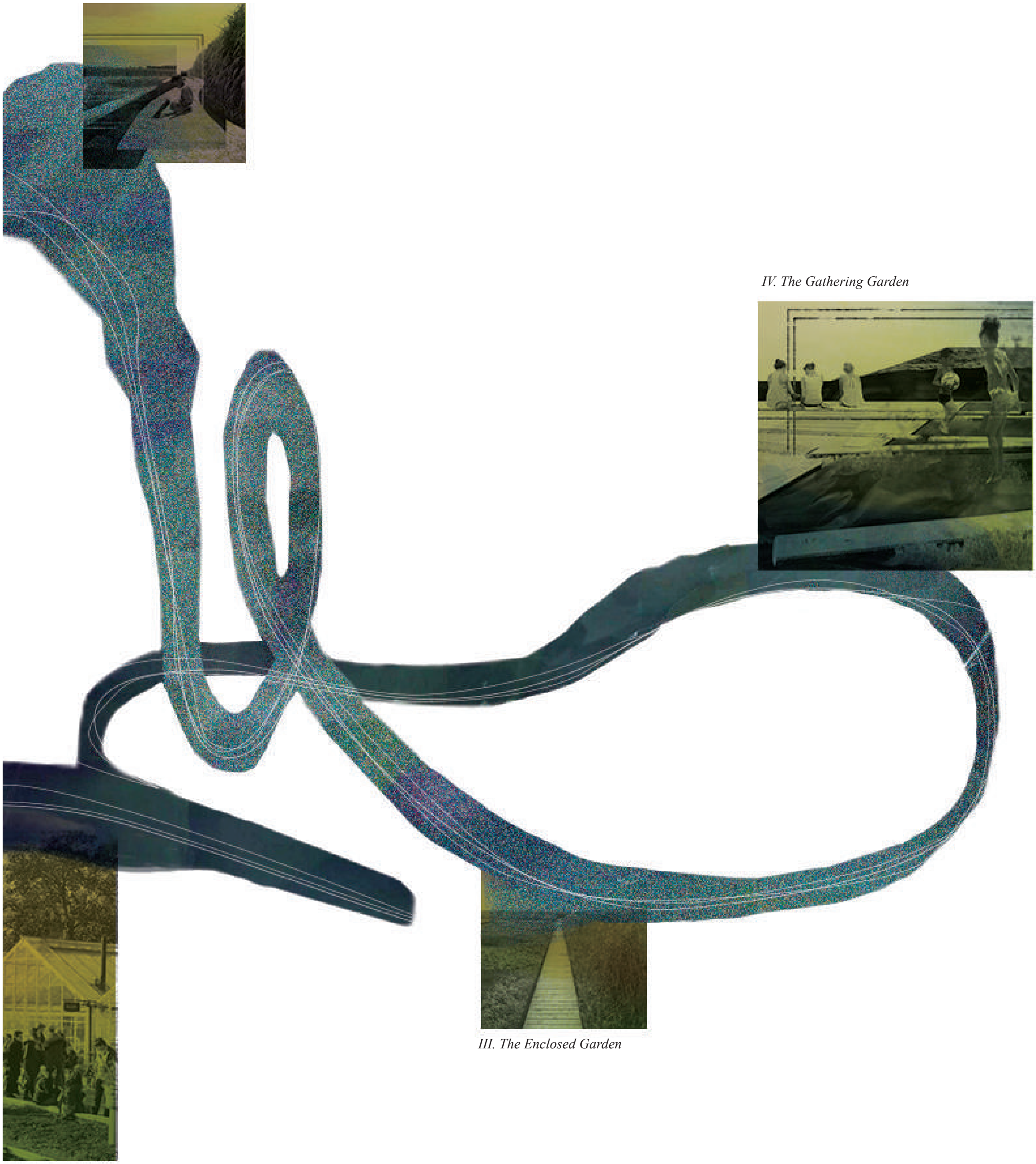
- Inside the dike: controlled conditions
- No deposit of sediments
- No tidal experience
- Adjustable gradient of water types from fresh to brackish

Fig. 85: Different atmospheres when moving through the landscape park

V. The Agricultural Garden
(Trädgården, Stockholm)

Fig. 86: Overview different gardens at different moments along the waterloop

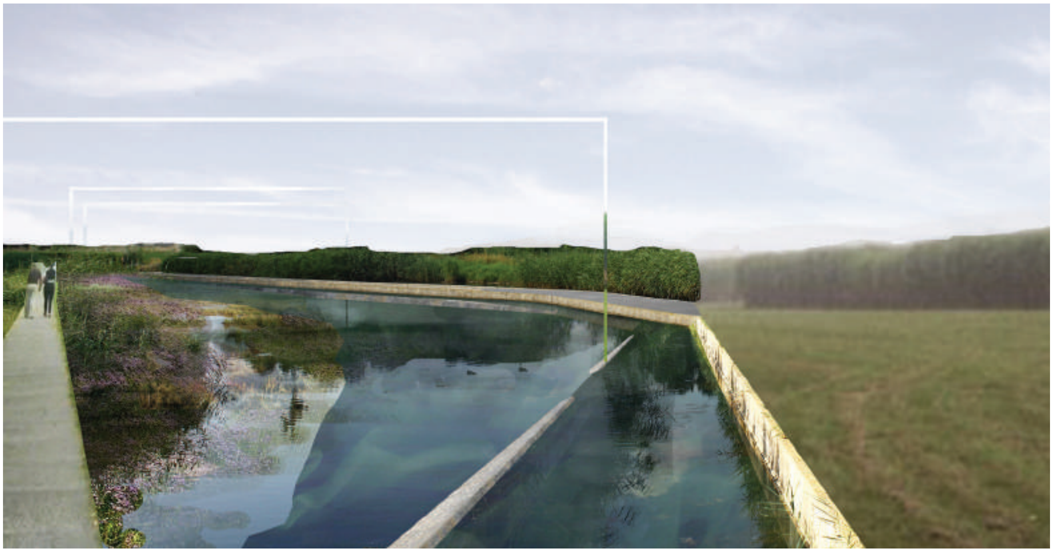
II. The Open Garden



IV. The Gathering Garden

III. The Enclosed Garden

I. Open garden as a composition at the entrance of the park during low tide/start high tide



I. Open garden as a composition at the entrance of the park during high tide

Garden II: The Open garden

The open garden is the first garden along the salt water channel inside the dike. From the entrance of the landscape park at the height of the pumping station, the garden is viewed from a distance, located in the open fields and at the start of denser reed fields. This creates an aesthetic composition from the entrance of the park.

In this garden the change of water level of the tides is first experienceable inside the dike and a deposit of the sediments occurs. The intrusion of salt water in the garden leads to the growth of salt marshlands. The deposit of sediments contributes to the process of succession of the saline vegetation in time.

The salt water flows along the garden from north to south. At some locations at the inner side of the bend of the channel openings are made and water can flow in the garden. The first map shows the garden and flow of water during the start of high tide. At the first moment small waterbodies will be created that slows down in velocity moving towards the edges (fig. 87a). At the edges the velocity is the lowest until the water is stopped by the topography of the garden. The second map shows the garden during high tide. The main part of the garden is overflown by salty water. In both situations the water dam on the lowest part of the garden offers resistance holding the water longer in the garden.

Around the garden clear outlines are set that control the dynamics of the water. These are materialized by concrete elements. Some of them also are part of the routing system and give human the ability to experience the dynamics of the garden from close by.

Fresh water vegetation

Salt marshland vegetation

Grass lanes

Reed fields

Elements of control (defines routing too)

Flow of salt water

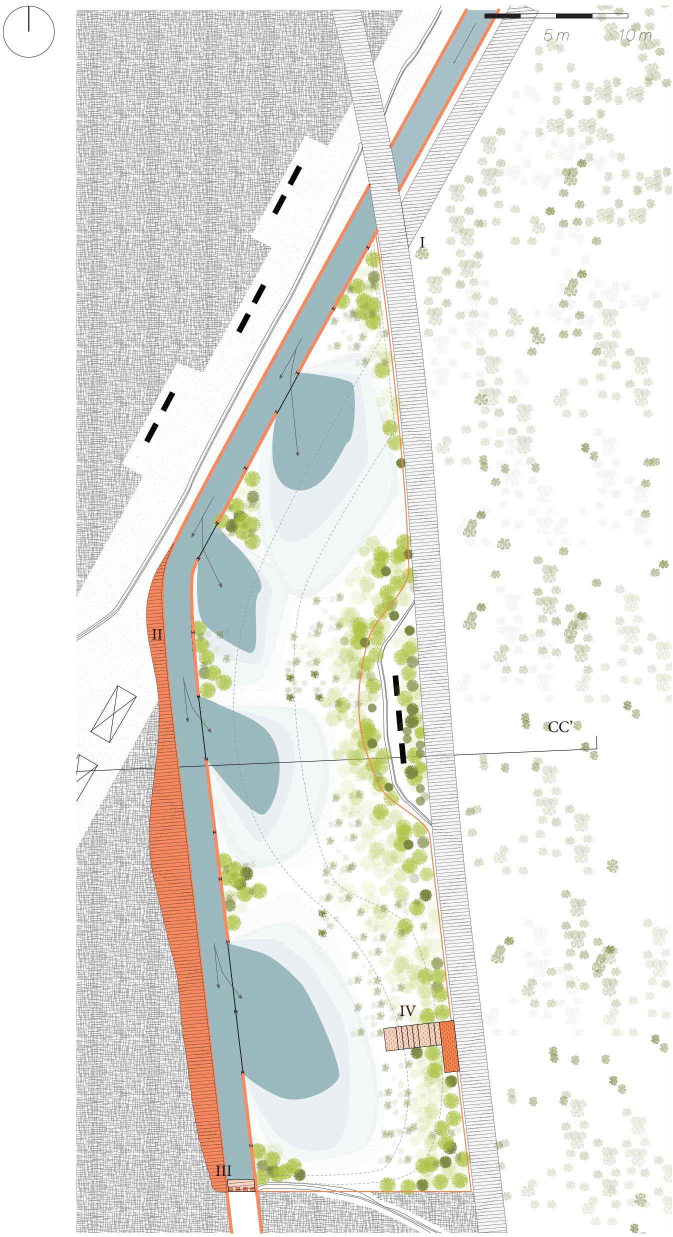


Fig. 87a: Flow of salt water in the garden at the start of high tide

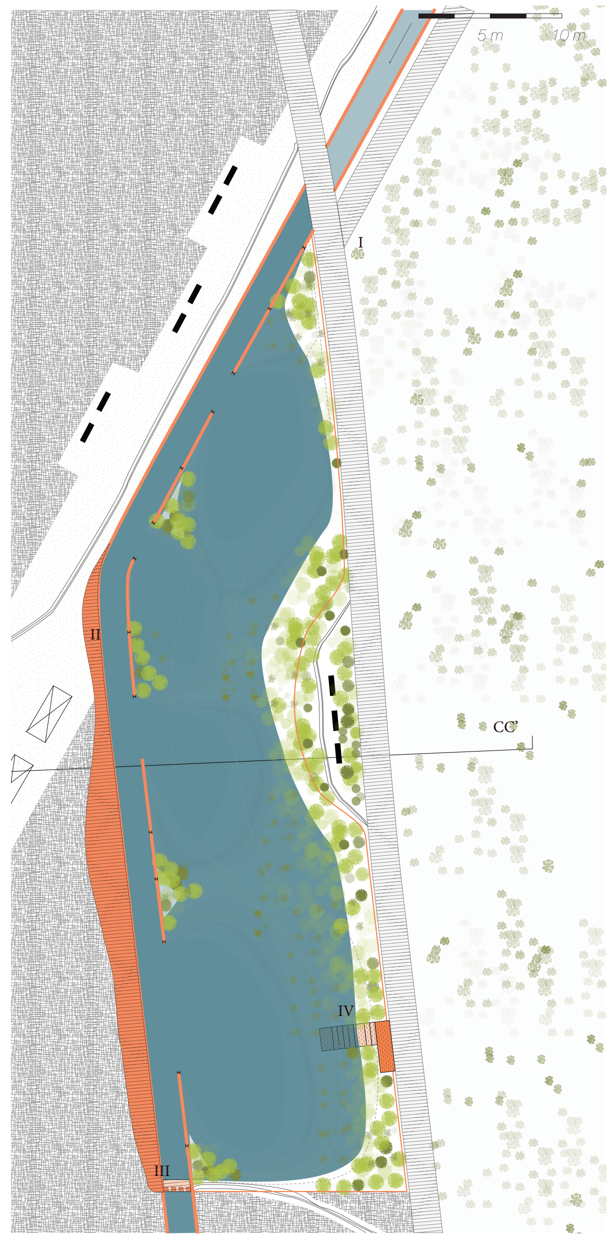


Fig.87b: Overflown garden at high tide

This zoom in shows the locations where the deposit of sediments takes place (fig. 88). These locations will get vegetated first in time as the topography is the highest here. These locations will be the borders of the garden at the slope of the basin (right side) but also the locations behind the salt water channel at the inner bend that is not open. This sedimentation occurs where the velocity of the water is low. At the map it is shown that this takes place at the edges of where the salt water reaches. In time, this zone of overflow will decrease as the lifting of the topography stops the water sooner.

The rise of topography brings different levels of succession through the years. This is related to different types of flora and this influences the palette of colors and atmosphere in the garden.

The daily difference of tides, the rise of the topography, salt water conditions, play of water velocity and succession of saline vegetation can be experienced by human from close by. This is experienceable from several fixed elements in the garden. Left of the salt water channel the concrete profile extends giving space for a 2-3 water front. It is also possible to cross the salt water channel at the south of the garden. The water dam that offers resistance to the water velocity does also function as a crossing. This crossing is accessible at both tides and during high tide it turns into a playful crossing element of stepping stones. The other fixed element is look-out plateau in the garden accessible by metal stairs. During high tide the plateau and a part of the stairs is overflown by water experiencing the difference in water level. All these different fixed elements are spread out around the garden helping to experience the dynamics from different perspectives. Different collages are made that show the experience on eye-level. The locations of the collages are shown in the overview map on the previous page.

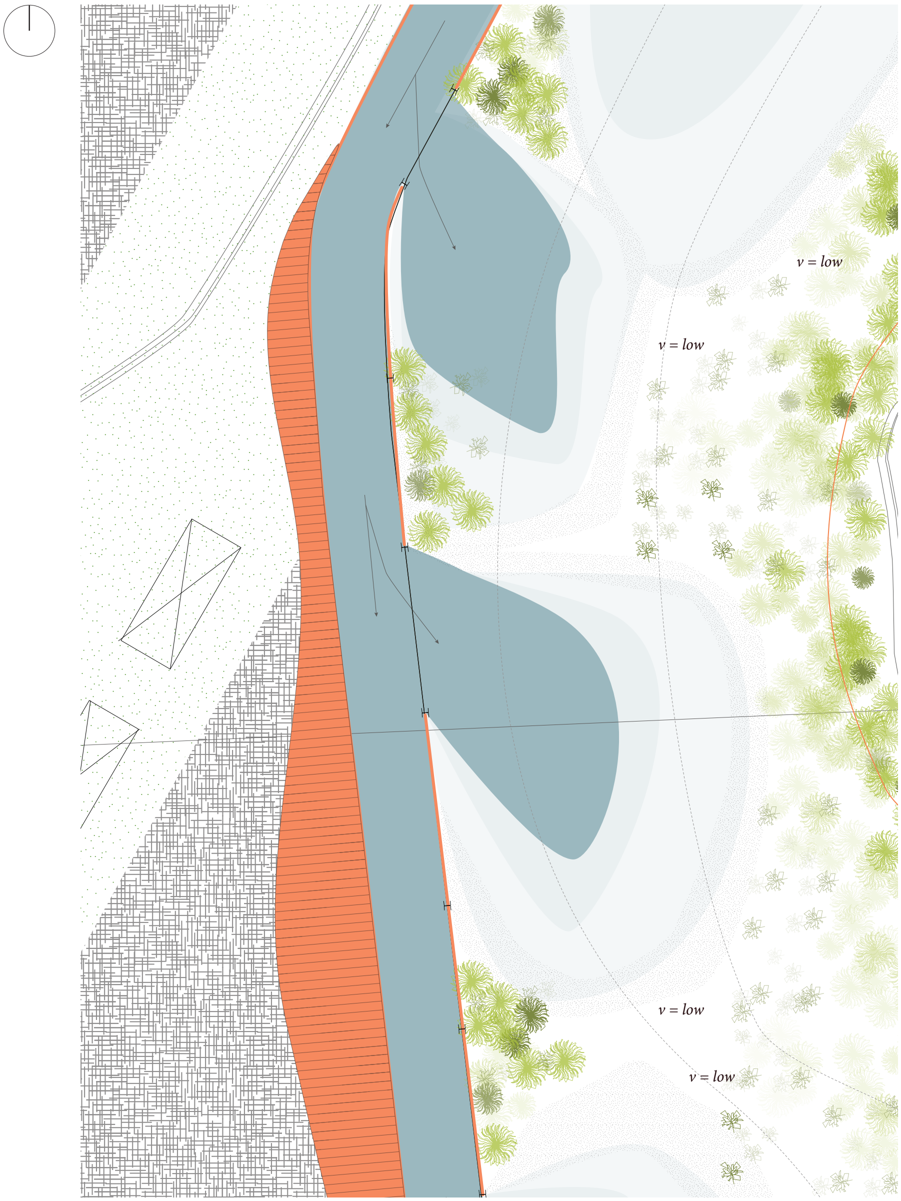
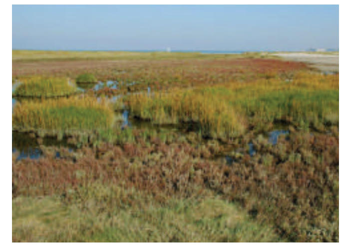


Fig. 88: Location of adjustable dams, openings and sedimentation

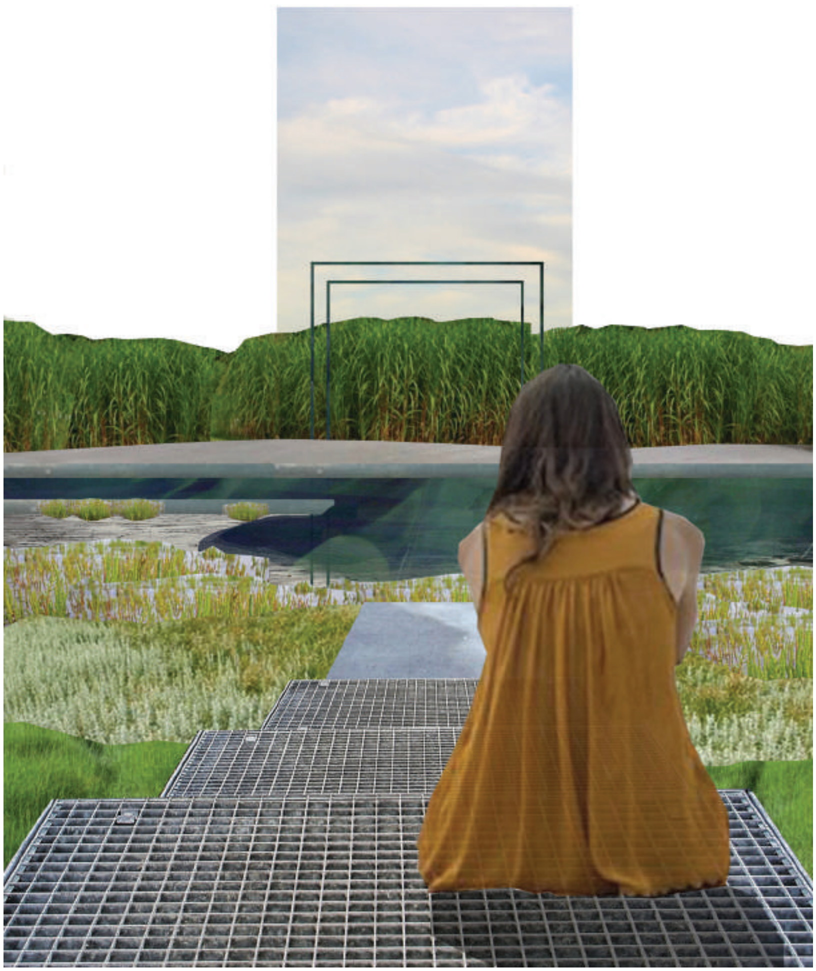


Palette of saline vegetation

II. View from fixed concrete path along salt water channel experiencing succession in vegetation in time

II. View from fixed concrete path along salt water channel experiencing different tides

III. Dam as resistance structure and architectonic element accessible during low and high tide as stepping stones



IV. Fixed plateau accessible during low tide experiencing the start of high tide

In time, the deposit of sediments and saline vegetation lifts the topography of the garden. This enables succession of the vegetation and it decreases the zone of overflow. In time, the garden will change of atmosphere as each stage of succession have different types of flora that each have its own characteristics again (fig. 89). These characteristics can also change as in autumn it can have a different color than in spring. For example, sea coral, a flora type that occurs at the first stage of succession, is green in spring and turns red in autumn. Moreover, in the garden different types of maintenance are applied. The reed fields are cut annually in winter. This gives the garden even a more open character during that season. When the saline vegetation reaches the last stage of succession, the basin can be dug out again to restart the cycle of vegetation and sedimentation.

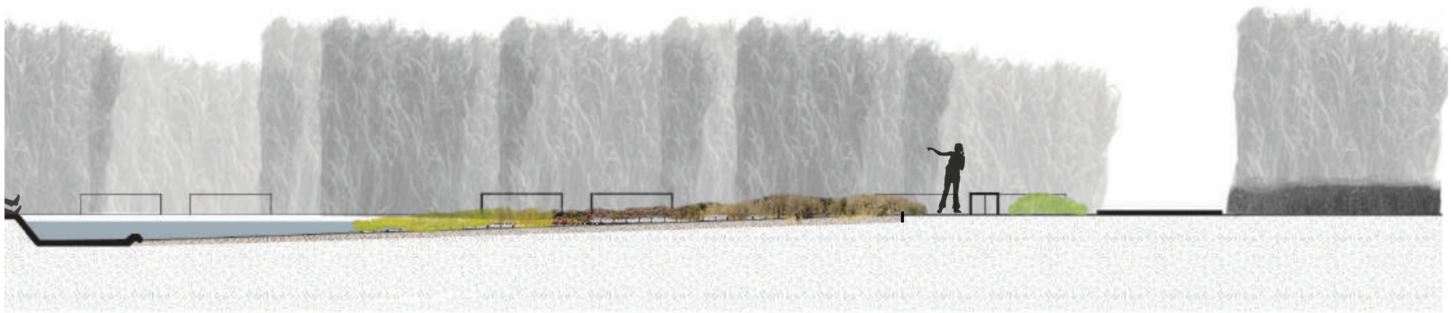
5 years, winter

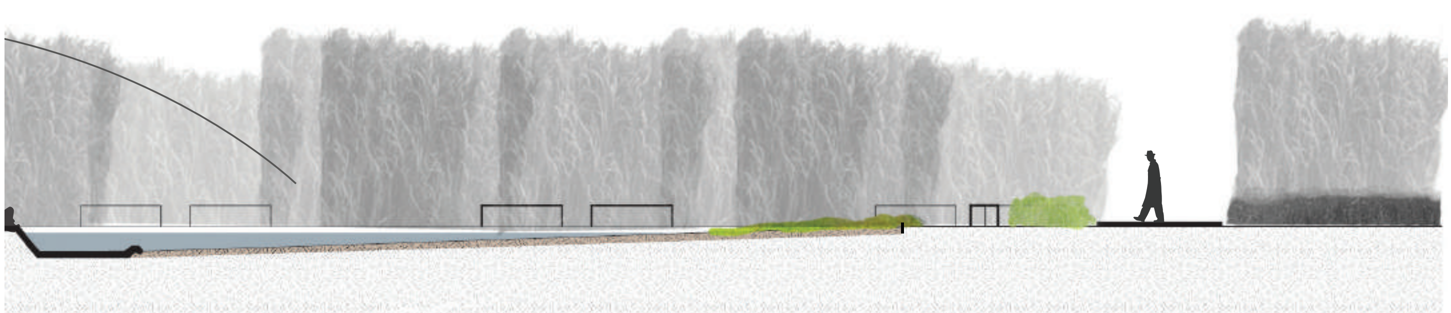
10 years, summer

20 years, winter

50 years, summer

Fig. 89: Cycle of succession of vegetation & sedimentation in the open garden (CC')





I. Playing or sitting at the fixed salt water stairs experiencing the salt water merging in the fresh water dtich during high tide

I. Playing or sitting at the fixed salt water stairs experiencing the artificial made gully pattern by openings in dams

Garden III: The gathering garden

The gathering garden is located at the location in the landscape park where the salt water channel merges in the fresh water ditch. The deposit of sediments is low as it is the 10th garden the channel opens up to. This garden is close to the secondary dike on which housing is built and should offer a connection between the settlement and the landscape park. In comparison to other gardens, the change of water level due to the tides is experienced last in line.

On the next page, the two maps show the garden during two different moments in time (fig. 90). In both situations the salt water flows from the channel down into the fresh water ditch. In the fresh water system the water becomes brackish as it merges with the fresh water and it flows towards the north again in the direction of the ditch parallel to the primary dike. Therefore, this point becomes a node in which different ecological systems merge.

The moment of the salt water flow into the fresh water ditch is manipulated and emphasized by the concrete water stairs. This stairs is composed by different perpendicular dams at different heights of the slope creating basins on different levels. These dams helps to slow down the water velocity. In the dams several openings are made that create a gully pattern of the salt water during the start of the high tide. During high tide the water level becomes too high the amount of water too big and the basins get fully filled. In this situation the concrete dams are still visible and slow down the salt water to flow in the fresh water ditch. Adjacent to the water stairs, concrete stairs are made on which human can stand or sit. The concrete stairs simultaneously function as an outline to where the dynamic water can come. The water stairs are also accessible at all time offering a playful object for children. On the other side of the fresh water ditch a natural shore is made, offering a gradual slope on which vegetation can grow. Topography becomes the border of the garden on this side. On the north side of the garden an adjustable dam is located giving the farmer the opportunity to decide the saline level of the polders. This becomes an architectonic element as a concrete plateau is positioned on the opposite side of the fresh water ditch offering a view point of the dam.

Agriculture plots
Fresh water vegetation
Brackish marshland vegetation
Salt marshland vegetation
Grass lanes
Elements of control (defines routing too)
Flow of salt water
Flow of brackish water
Flow of fresh water

Fig. 90a: Gully pattern of the salt water during the start of the high tide

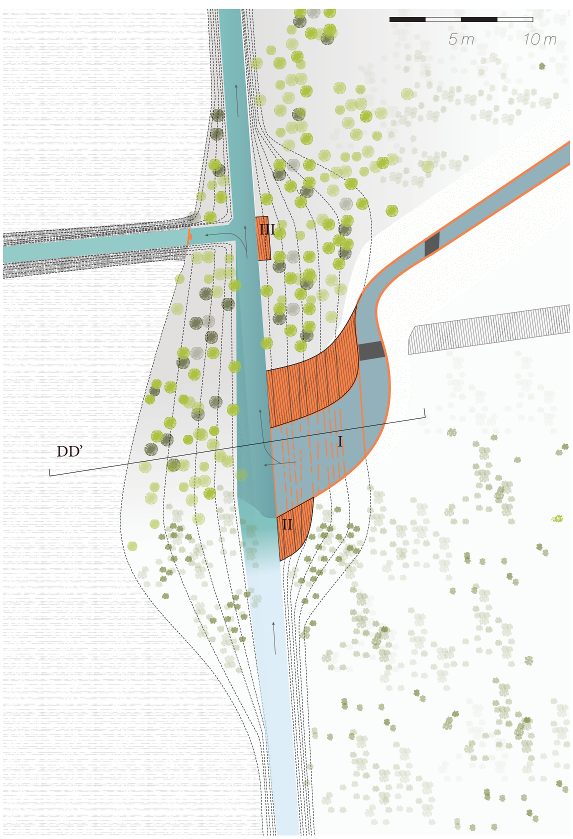


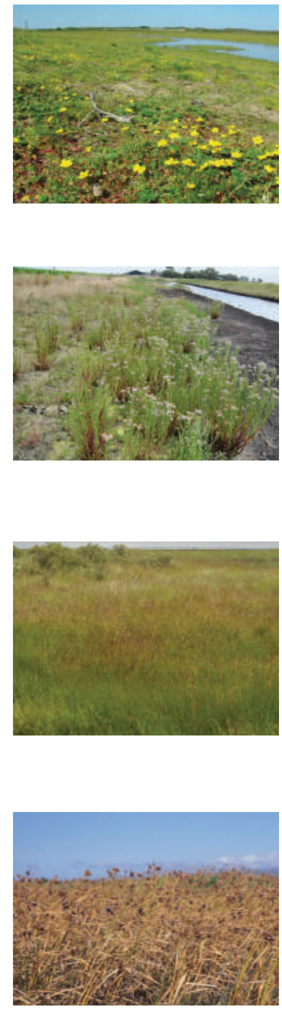
Fig. 90b: Merging of salt water with fresh water ditch during high tide

II. View from fixed water stair towards the gradient of fresh to brackish water vegetation

III. View from concrete plateau towards the regulable dam as architectonic element and distant experimental agriculture polder plots

As explained the garden becomes a node in which different ecological systems occur. This leads to a gradient from fresh to brackish water vegetation at the shores at the fresh water ditch. Before the merging of the salt water the type of flora will mostly be fresh water types. As soon as the water merges this creates brackish conditions and the type of flora will slowly change to brackish. In the basins of the water stairs, sediments will deposit behind the dams. Here, saline vegetation will grow (fig. 91).

Fresh water vegetation palette



Brackish water vegetation palette

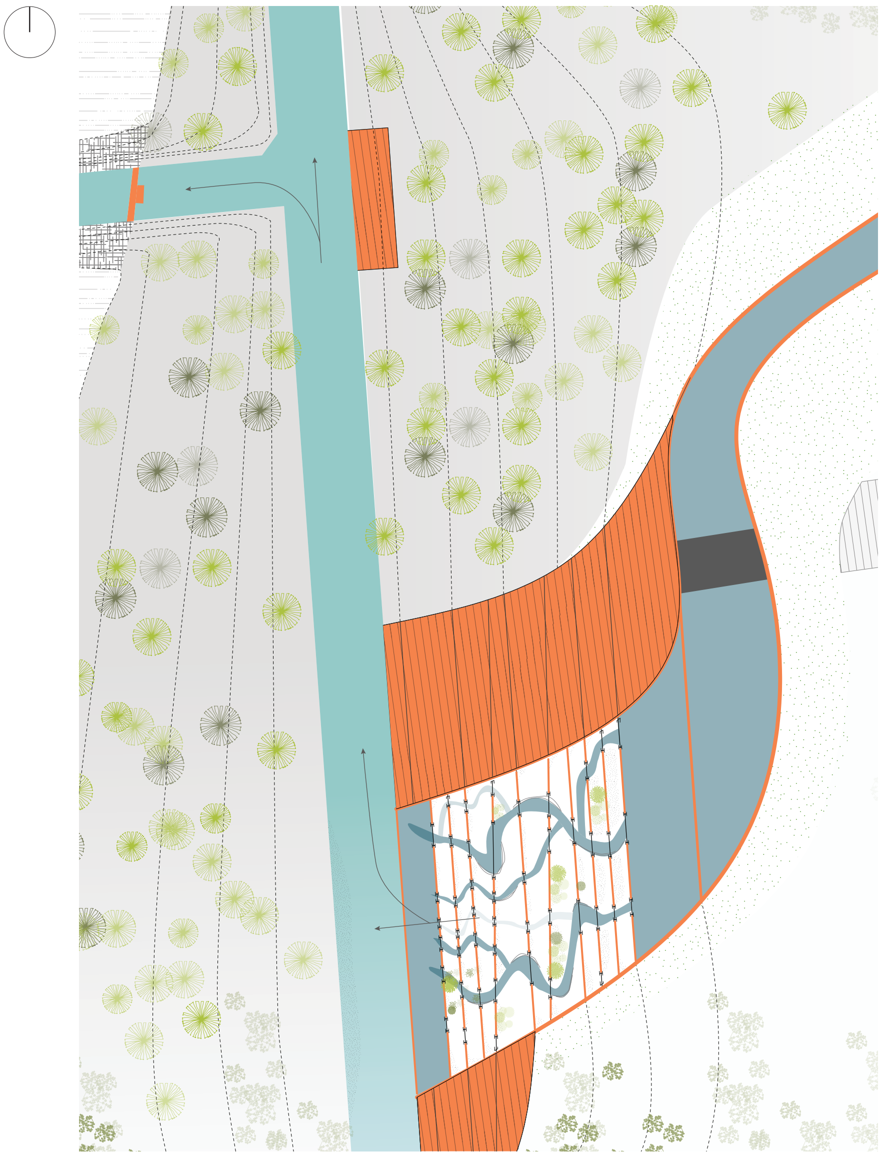


Fig. 91: System of adjustable dams in fixed water stair element

Salt water vegetation palette

At the water stairs succession will occur but it will happen at a slower pace than the previous garden as the amount of sediments is lower in the water (fig. 92). At the opposite side the natural slope of the polder will get vegetated too. In time, the sediments of the basins can be dug out in order to restart the cycle of sedimentation and succession of saline vegetation. Here succession occurs in brackish marshlands or fresh water lands depending on the level of salinity in the water.

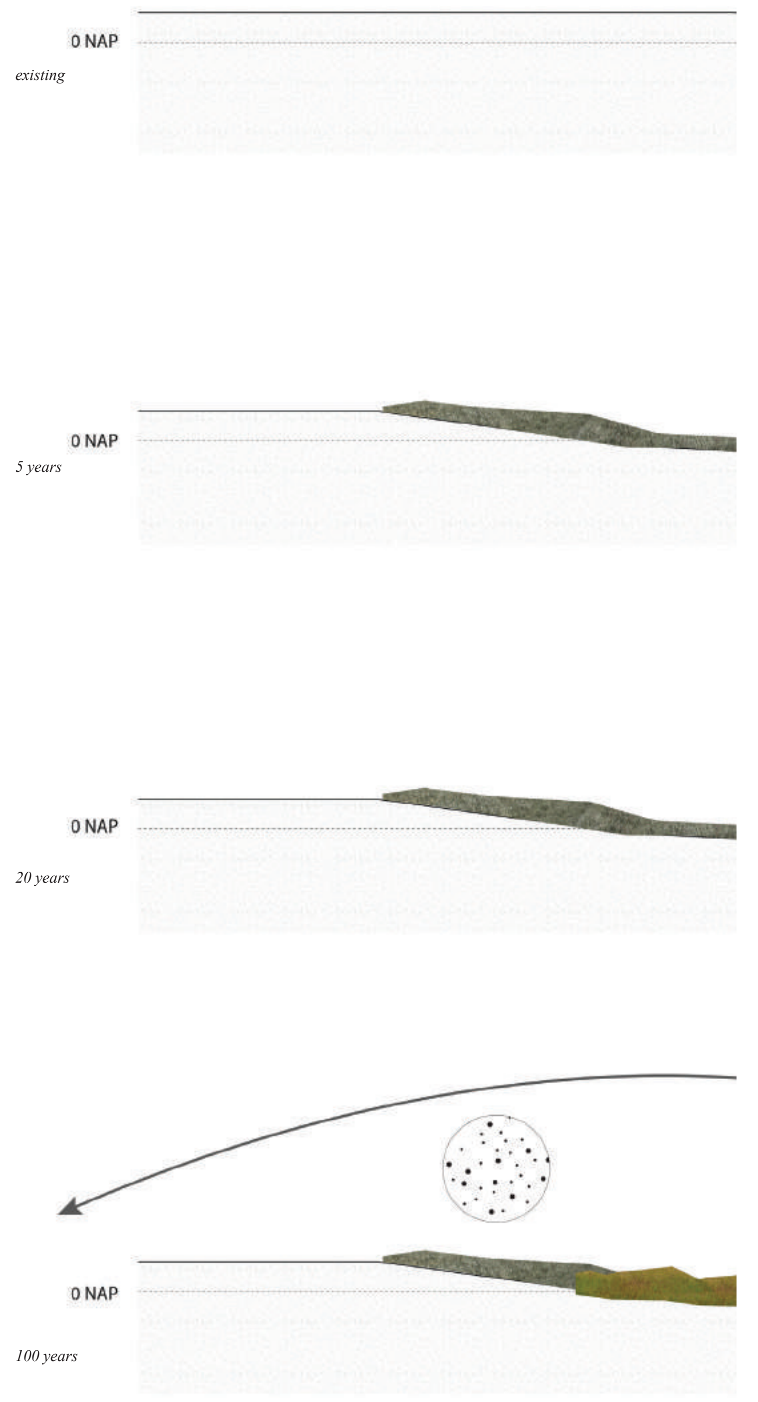
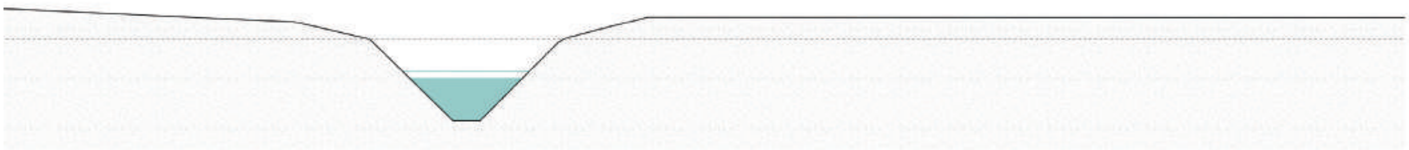
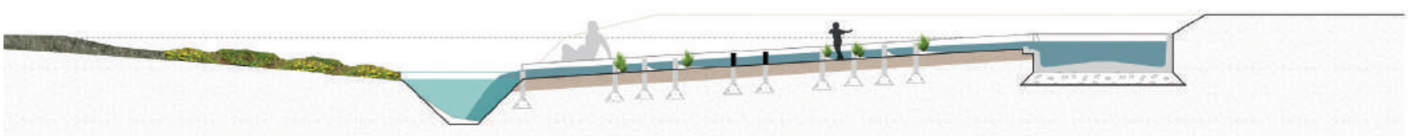
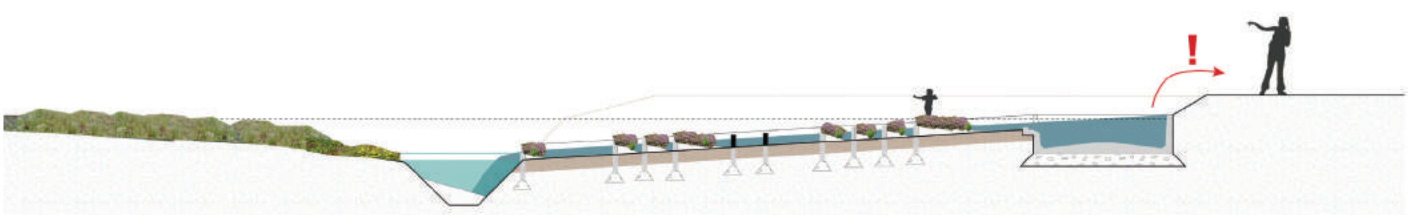
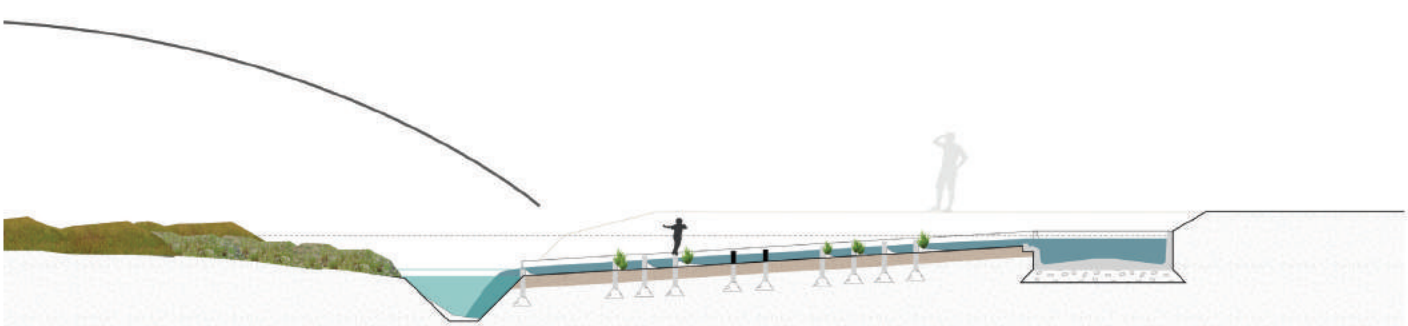


Fig. 92: Cycle of succession of vegetation in the gathering garden (DD')



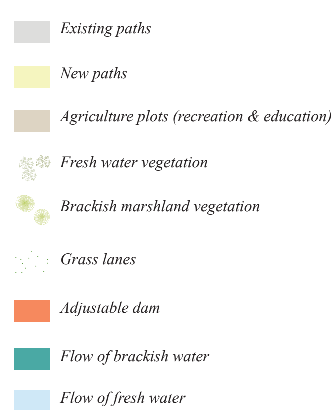






Garden V: The agricultural garden
The agricultural garden is located last of the sequence of gardens along the water loop. At is positioned along the parallel ditch of the primary dike where salinization occurs. There is no deposit of sediments or experience of the tides as the salt water is already merged within the fresh water system at The Gathering Garden. In the landscape park this garden is located on the plot of a farmhouse. This farmhouse will change part of its production land into smaller plots for experimental agriculture with saline conditions. The experimental agriculture will not be used for production. It does generate knowledge about growing crops in more saline conditions and it breeds crop seeds. These seeds can be exported to the areas adjacent in the borderscape that all have to deal with the increasing effect of salinization in the future. To adapt the fresh water crops to more saline conditions the water type has to be slowly changed to a higher saline level. A set of dams that can be regulated by the farmer himself enables to regulate the gradient of salinity in the water for different plots. The smaller plots that each experiment with different crops will give a palette of colors in the area (fig. 96).

This garden will make the function of experimental agriculture on the smaller scale recreational and educative. In time, the farmhouse will be positioned on a plateau on a higher level becoming part of the primary dike. The agricultural garden makes use of different height levels that defines the level of salinity (fig. 93). In general the water in the polder system at this location is brackish due to the seepage. A higher topography and fresh water reserves create a gradient from fresh to brackish water in the sequence of small plots. These small plots help to make the process of experimental agriculture more understandable. Besides, the crops that grow on these smaller crops can be used for agrifood or a local market. Human could stay on the camping on the same plot. All these functions show options how to connect the function of agriculture to education and recreation (fig. 95). This design gives new spatial opportunities for the farmers offering alternatives than production land.



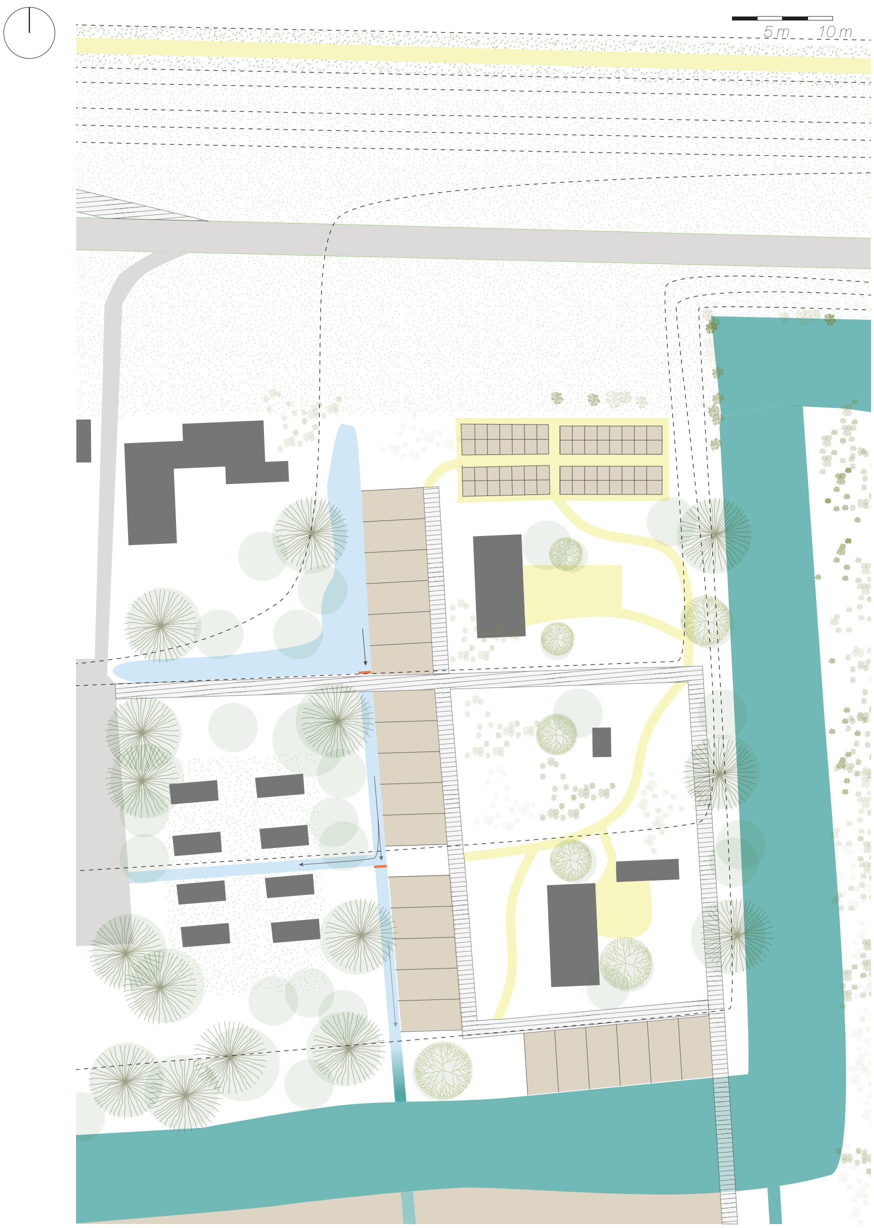


Fig. 93: Small experimental agriculture plots in the agricultural garden located on different plateaus

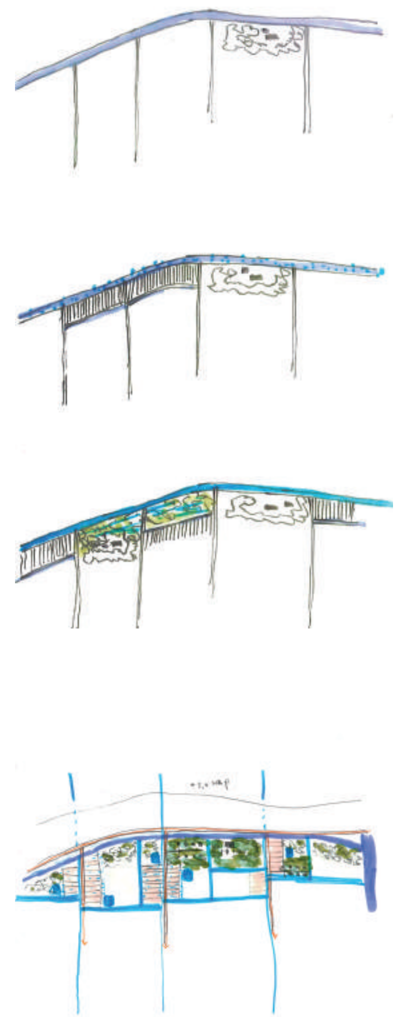


Fig. 94: Design experiments showing new spatial structures for coastal agriculture along ditch parallel to primary dike

Local market

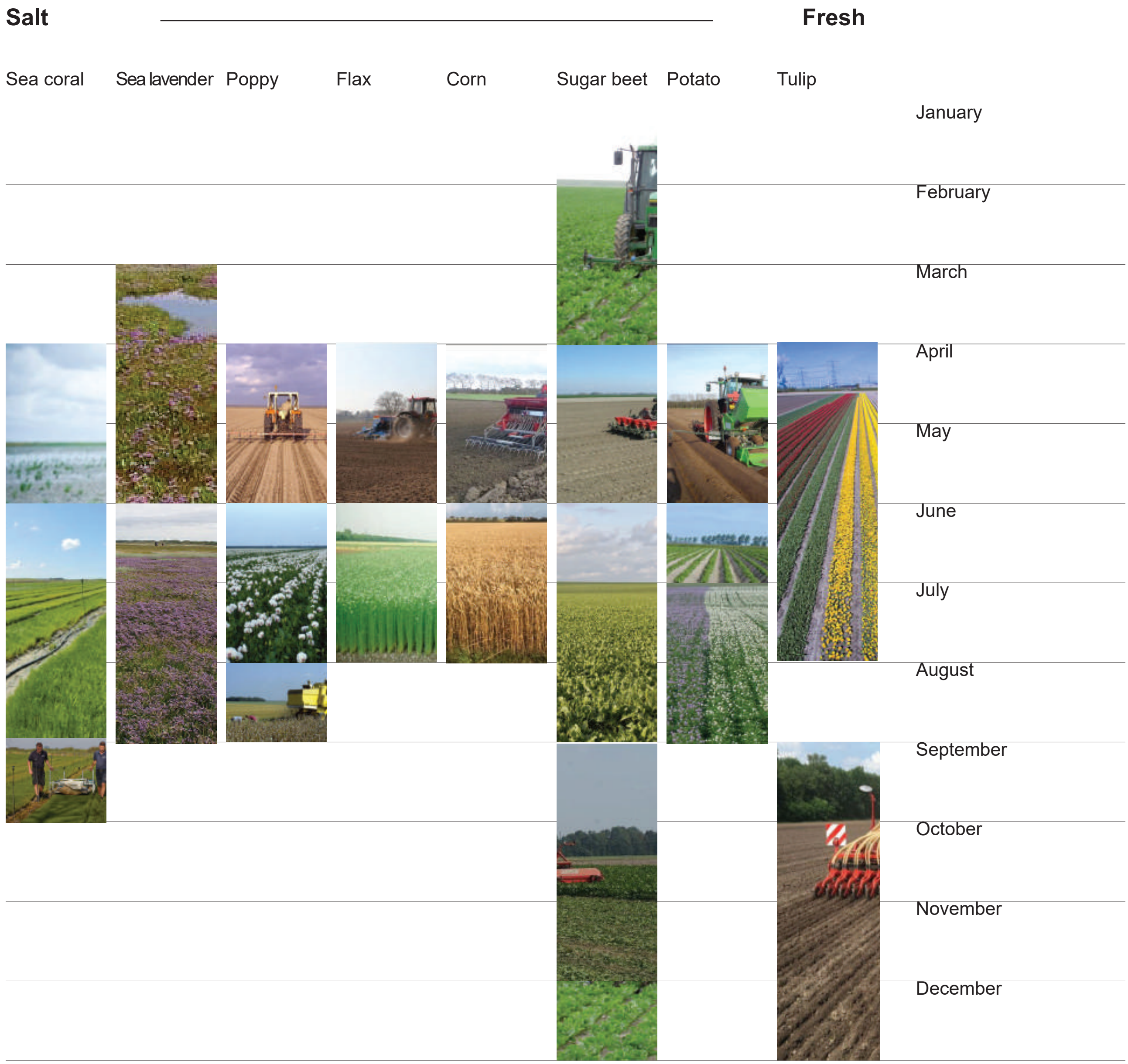
Education and agrifood (Uit je eigen stad, Rotterdam)

Education and agrifood (Rosendals Trädgård, Stockholm)

Pop-up restaurant within cornfields (Wolvertem, The Netherlands)

Salty agriculture (Proefboerderij, Texel)

Fig. 95: Merging of functions of agriculture, recreation and education



Sea coral	Sea lavender	Poppy	Flax	Corn	Sugar beet	Potato	Tulip	Ecological parameters
4 - 5	5	6	5 - 6	5 - 6	?	6 - 7	7	Richness soil
7	7	7	7	4 - 6	?	5 - 7	5 - 7	Acidity
6	5	4	4	4	?	4	4	Moisture
								(Source: floravannederland.nl)
						1x / 4 year	1x / 4 year	Other

Fig. 96: Variety of atmospheres growing crops (fresh/salty)

Routing of human experiences

Connection to existing site-specific qualities
In the existing situation there are several elements that already give a qualitative human experience and could be stressed more (fig. 97). In the existing situation the boezem inside the dike gives a strong straight axis in the landscape. At the end of the axis, close to the dike, there is a private pumping station with a platform viewing towards the boezem. Moving towards the dike a straight stair ascent or a an angular ascent enables human to climb the dike. On the other side of the primary dike there is a metal pier from which a wide view of the marshlands can be experienced and the straight axis continues in the drainage ditch. The axis is made more experienceable by making the platform at the pumping station a public space. Trees are added along the straight boezem stressing the line. The idea of placing more viewing platforms along the dike is used in further design, the use of steel is repeated and the form language of the ascents is used to establish more ascents.

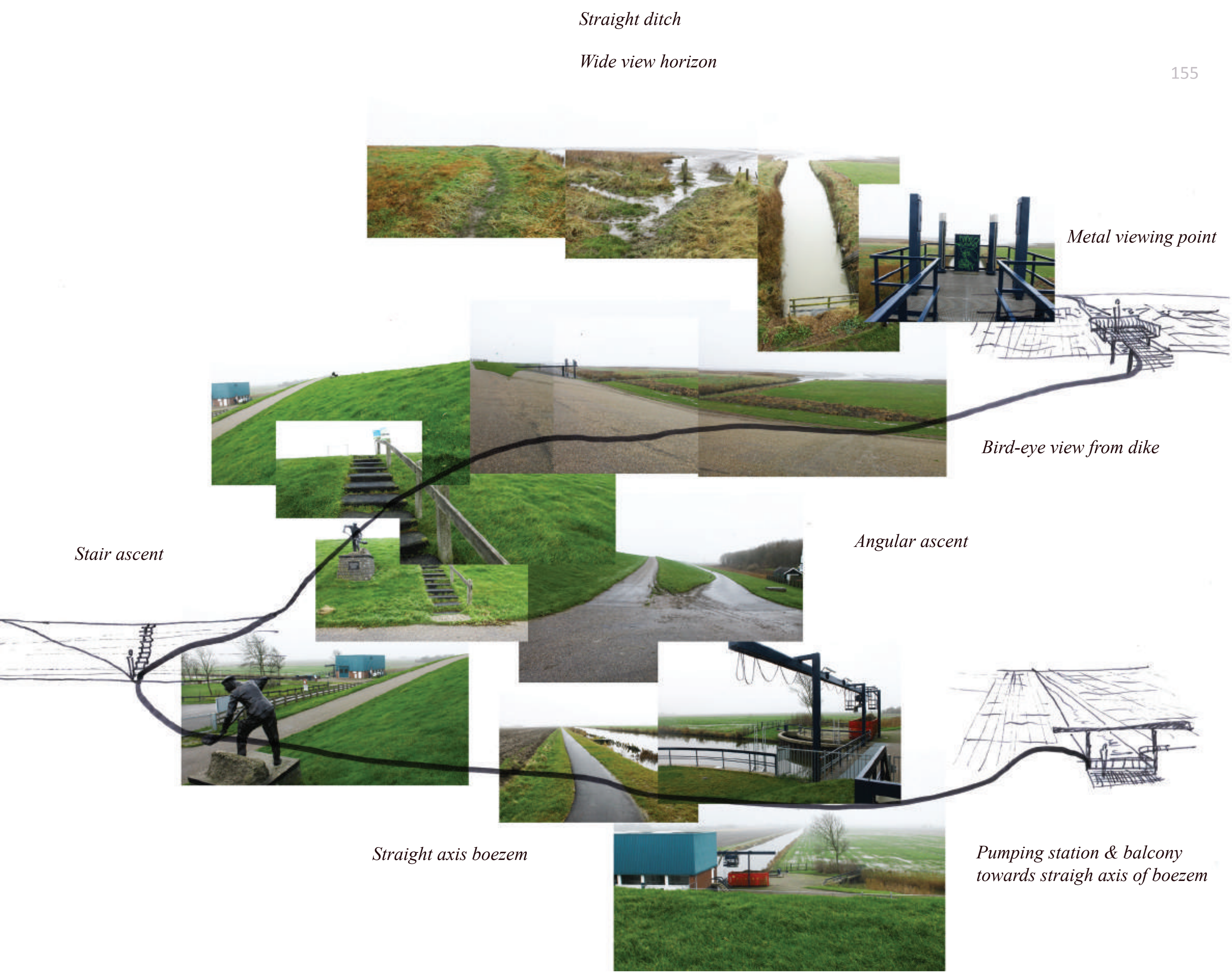


Fig. 97: Existing spatial qualities at pumping station Zwarte Haan

The dike as integrated part of the routing system
The primary dike offers a potential for a bird-eye view experience. In the existing situation except for the ascents, the dike does not connect both sides well spatially. At the end of the ascent there is no clear routing going down outside the dike. Except from the viewing platform at the drainage ditch outside the dike, it does not offer more viewing points. In the new situation on top of the dike a pedestrian route is added (fig. 98). This route ends in a metal viewing platform at the same height of the dike that has the shape of the loop. This stresses the quality of having a panoramic view on the height of the primary dike. In time, this metal skeleton becomes part of the dike as topography is being added. Eventually it turns into a circular plateau which stresses the architectonic character of the dike. Besides, new paths are added from the primary dike into the landscape park outside the dike. This changes the role of the primary dike from being a spatial boundary into an accessible outlook point in the landscape park giving a unique perspective to both sides. On the map a potential routing is given (fig. 99). Using this route several moments are shown when walking this route. The first moment (1) of the design is already shown (fig. 78b). Moment (2) and (3) are visualized and discussed next.

At moment (2) human are on the path on the dike and can see the Cut Out Garden and Open Garden at the same time (fig. 100&101). The asphalt of the dike outside is changed is broken and gives space again to get vegetated. The routing from this path is made clear. In the distance the metal loop that is already partly covered by soil is visible. Continuing to moment (3) the metal loop is entered (fig. 102). People will walk a circle that enables them to experience a 360 panoramic view. This loop offers a unique experience at different weather conditions and moments in time. As the metal loop has been 'swallowed' up by the primary dike the plateau can be used for other functions, e.g. offering a stage for a local market. The collages from left to right give the development in time (10, 20 and 50 years).

Fig. 98: Connection of existing and new human experiences on both sides of the primary dike

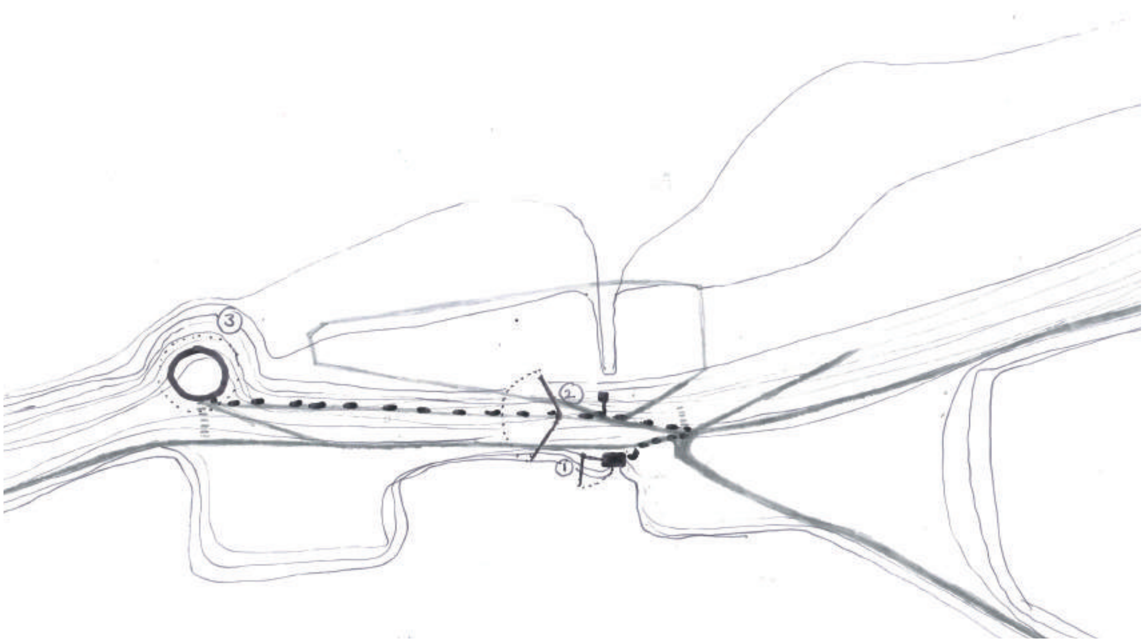


Fig. 99: Primary dike integrated into the routing system connecting both sides offering diverse experiences

Fig. 100a: Existing panorama view of production land inside the dike from the primary dike

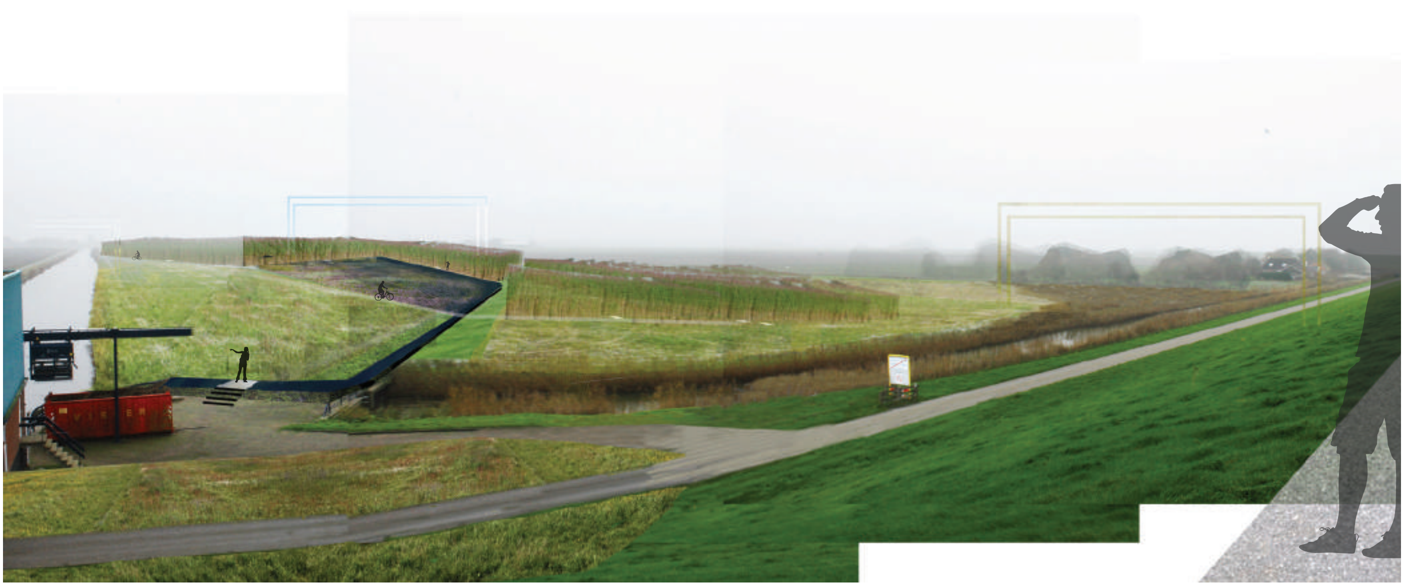


Fig.100b: New panorama view of landscape park inside the dike from the primary dike

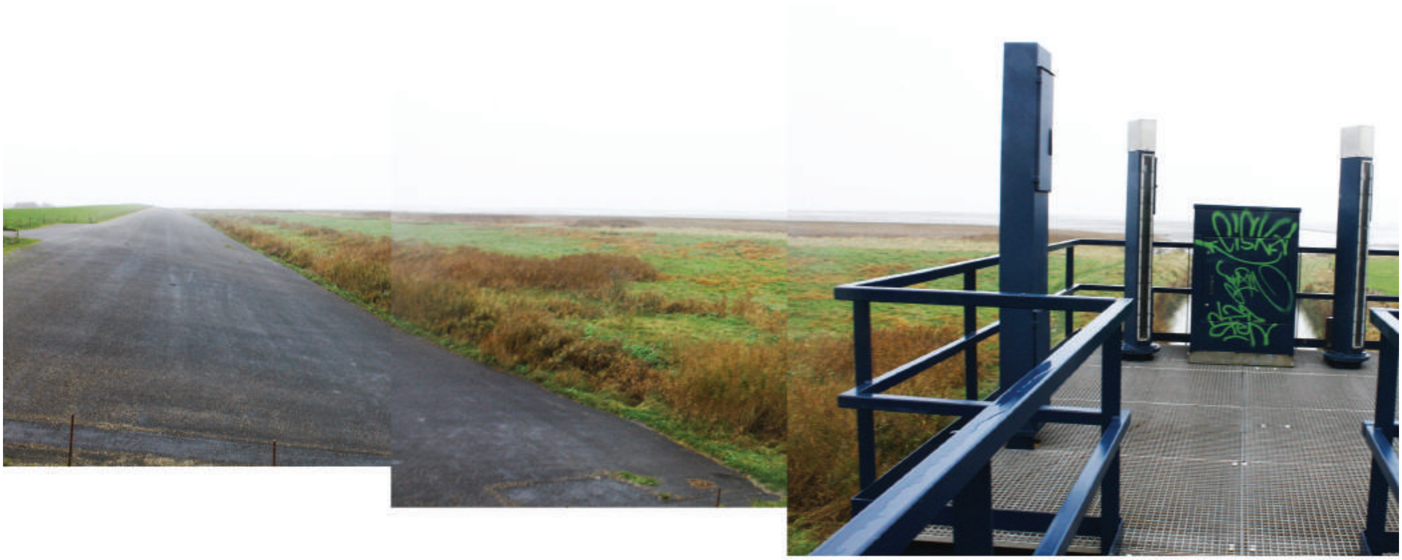


Fig. 101a: Existing panorama view of high marshlands outside the dike from the primary dike

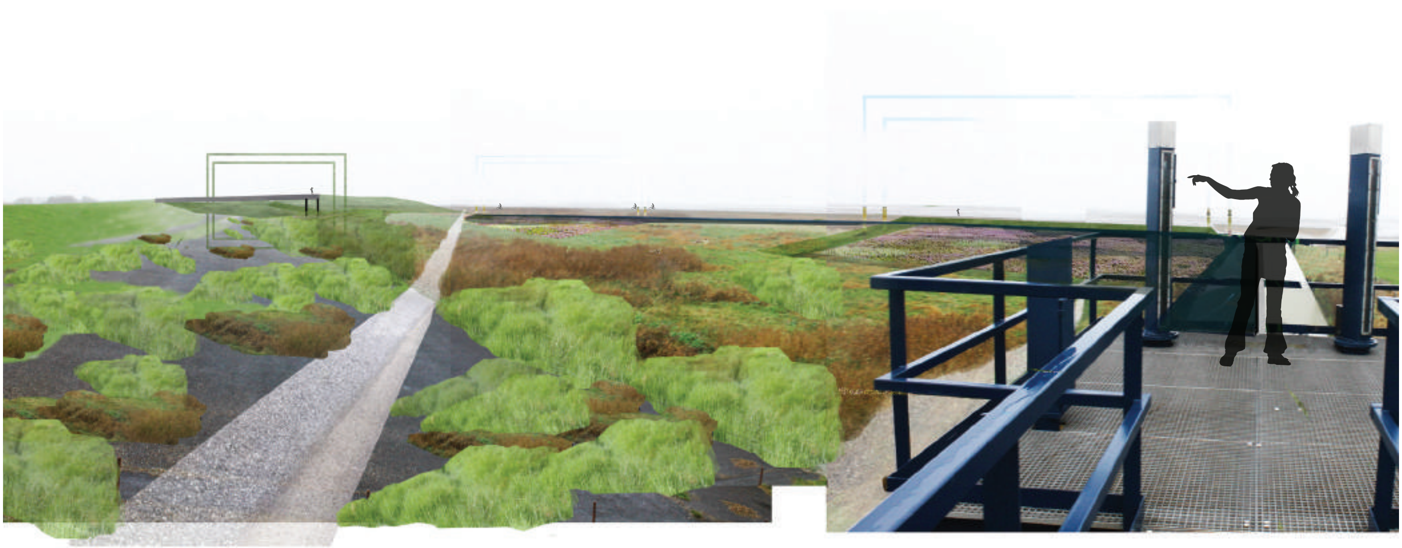


Fig. 101b: New panorama view of landscape park outside the dike from the primary dike

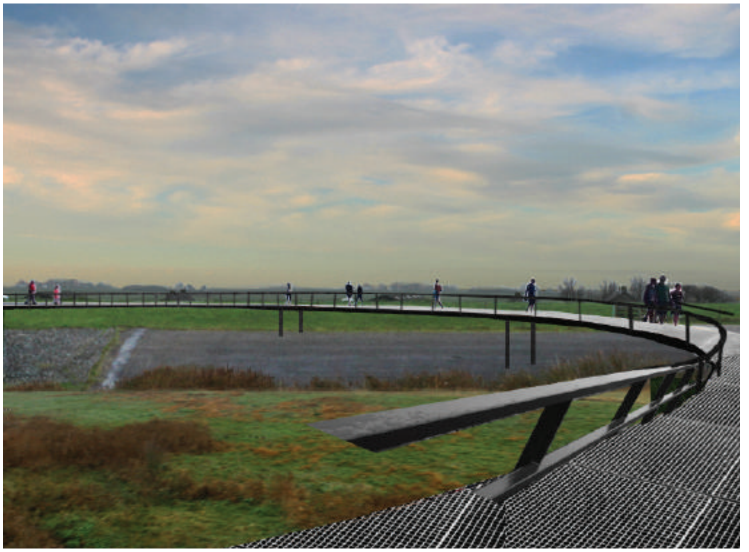


Fig. 102b: Metal loop giving a panorama view from the other side to the primary dike & main land behind (10 years)

Fig. 102a: The metal loop as destination of the path on the primary dike

Fig. 102c: Metal loop giving a panorama view from the dike to the dynamic Wadden sea (10 years)

Fig. 102e: Metal loop giving a panorama view from the dike to the dynamic Wadden sea during storm (10 years)

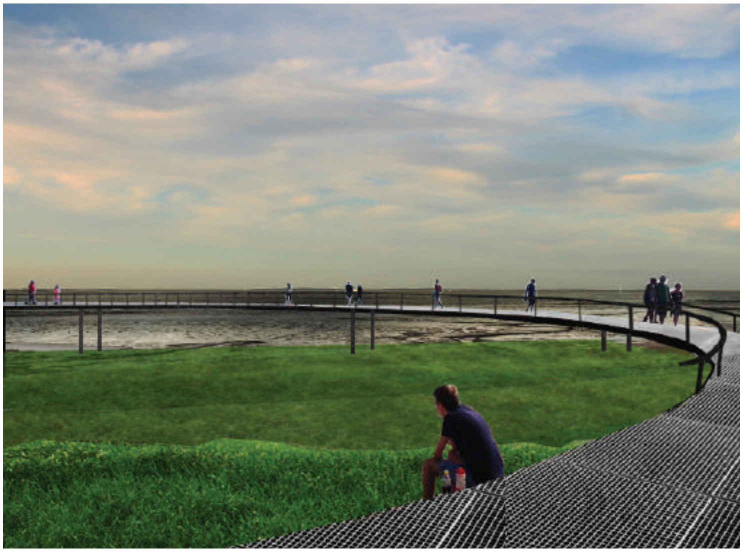


Fig. 102d: Metal loop as skeleton of the dike that becomes slowly part of it (20 years)


Fig. 102f: Metal loop integrated in circular dike plateau, descending to the marshlands (50 years)


Fig. 102g: Metal loop integrated in circular dike plateau, recreational (50 years)

Routing of the landscape park
The landscape park has a rectangular shape. Its outlines reaches from the marshlands outside the primary dike to the secondary dike inland. The length is around 2km long. The role of the dike in the routing system and the experiences alongside it are showed and explained on the previous pages. Still, there are many more experiences in and around the other gardens that need to be connected in order to make it an attractive landscape park at the whole length.

In the design a routing system is made connected to the existing routing system. Along this route a diverse range of human experiences is experienceable. In the route there is made a distinction between pedestrians, cyclists, cars, visitors and habitants (fig. 103). The cars can access the park from the dikes. From here, the means of transport transforms to walking or cycling. Both means of transport are supported by many paths and different loops can be made. Along the park the gardens tend to be a place to rest and stop. Therefore, the routes within the garden are only accessible for pedestrians.

On the next page one potential route is chosen for a pedestrian and different experiences that the visitor comes across are drawn alongside (fig. 104). The time between the subsequent experiences is between 5-10 minutes to make sure that the park keeps on surprising the visitor sufficiently at the complete route.

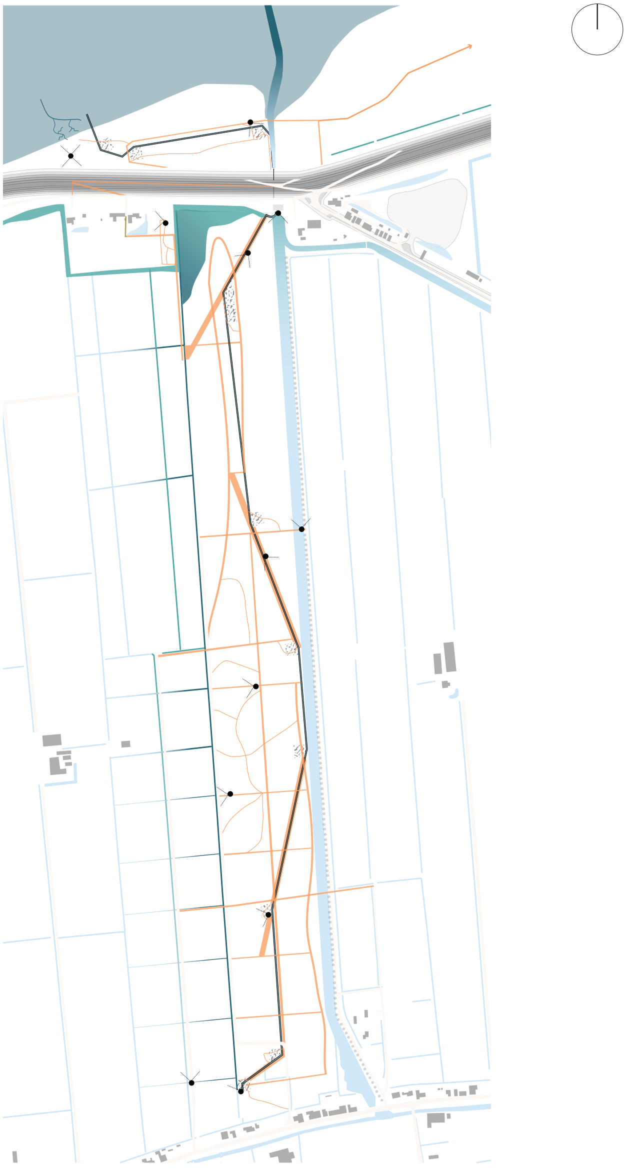


Fig. 103a: Routing system for pedestrians

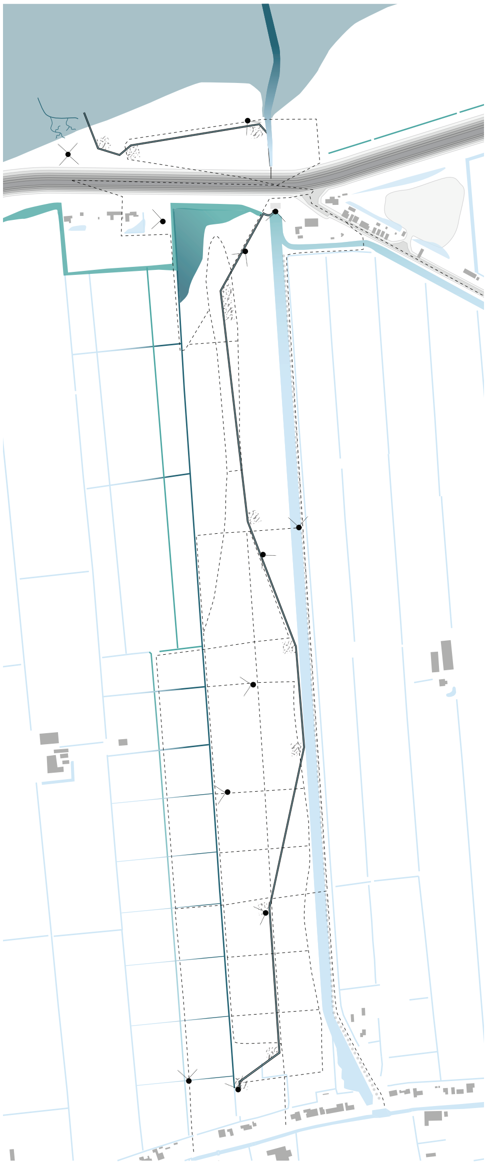


Fig. 103b: Routing system for cyclists

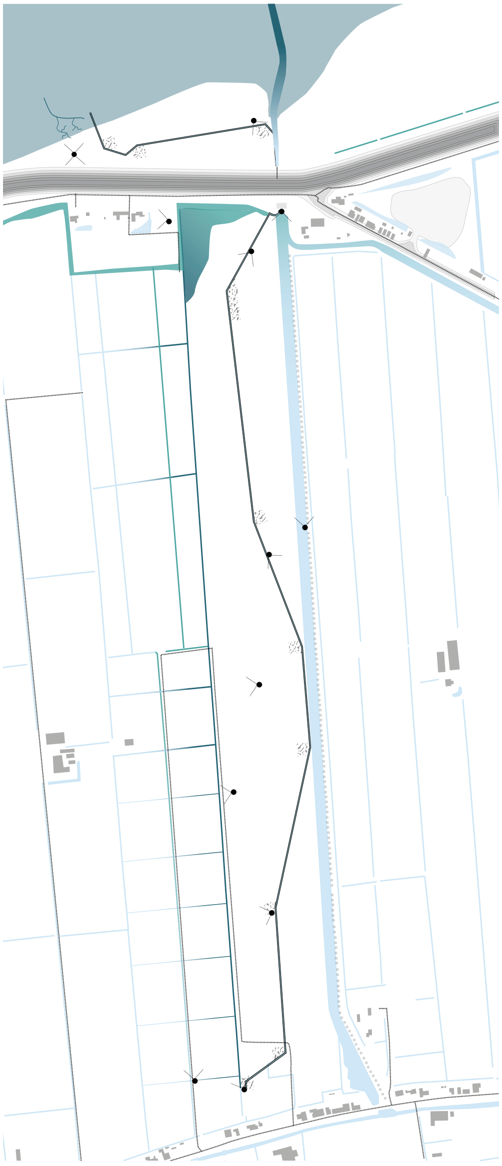
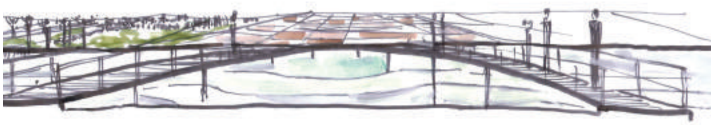


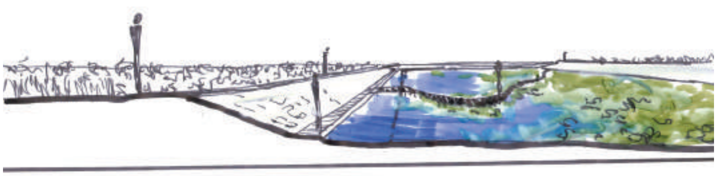
Fig. 103c: Routing system for cars

I. Enclosed space for agrifood and education of experimental agriculture

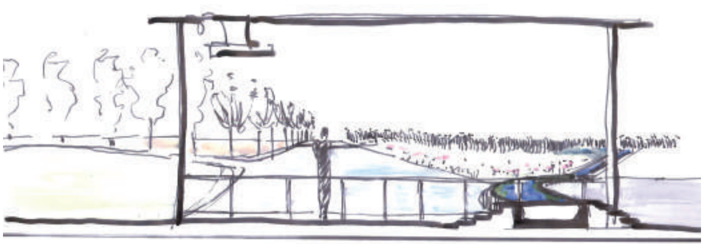


II. View from circular, metal pier towards inland with the primary dike in the composition

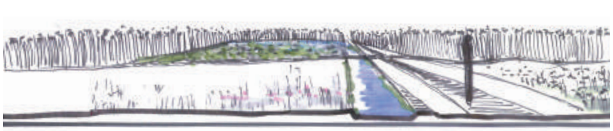
II. View from circular, metal pier towards dynamic marshland



III. Cut out garden outside the dike in the high marshlands creating a salt marshland environment



IV. View from balcony in front of pumping station showing straight axis, difference in water level and salt water channel



V. Open garden with young salt marsh

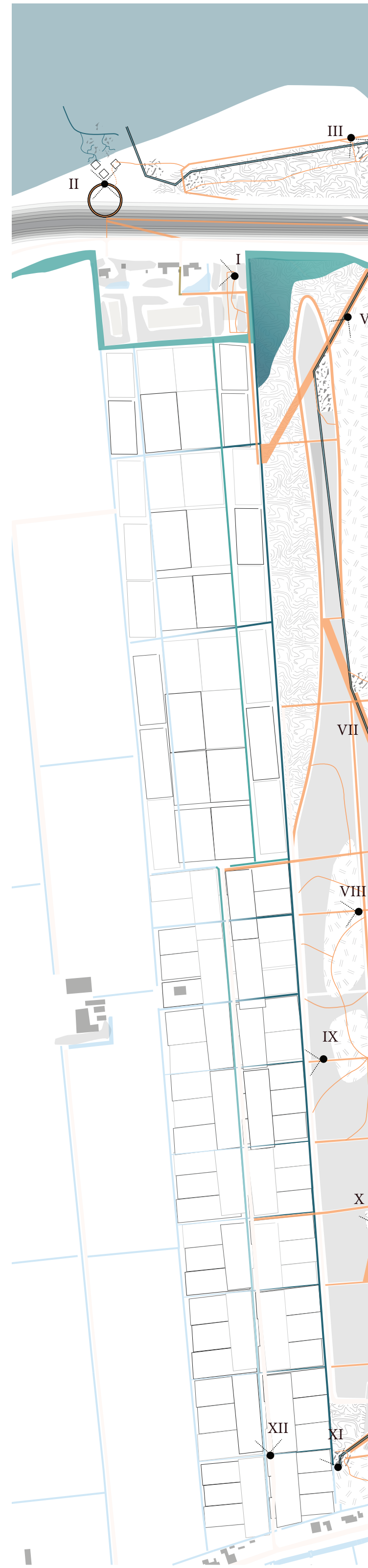
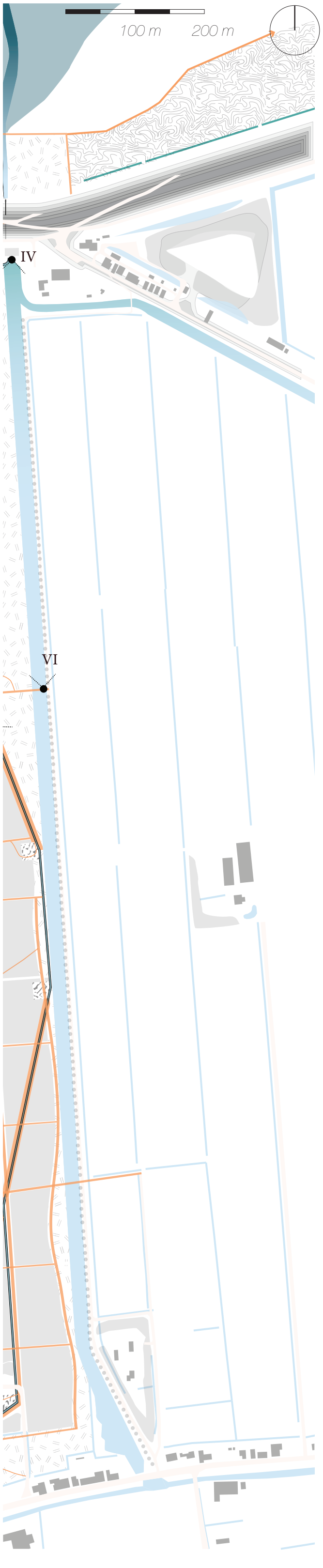
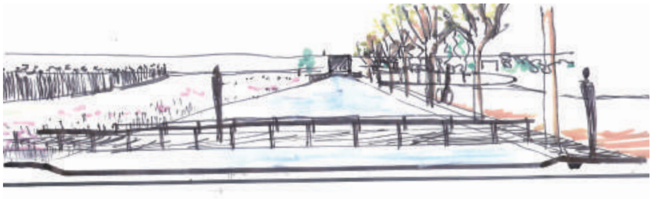
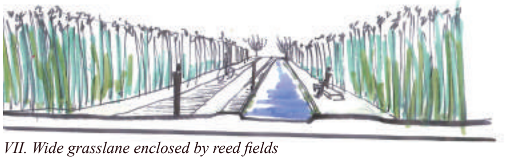


Fig. 104: One possible walking route

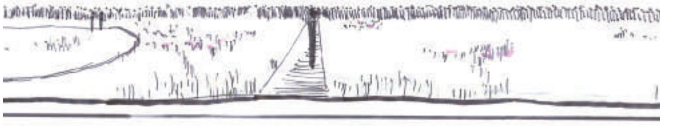




VI. View from the crossing of the boezem; atmosphere landscape park vs. production land

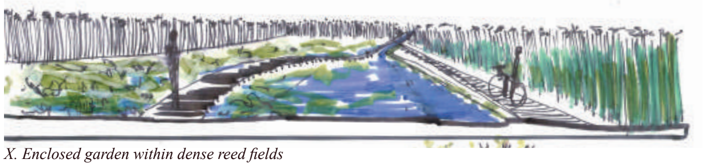


VII. Wide grasslane enclosed by reed fields

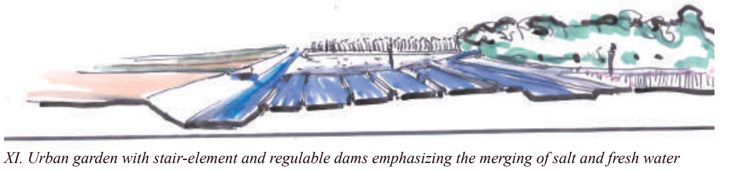


VIII. Open grassland within the reed fields as growing view points of the park

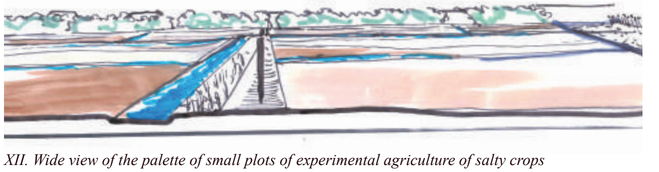
IX. Enclosed path in the reed fields viewing towards the agricultural plots



X. Enclosed garden within dense reed fields



XI. Urban garden with stair-element and regulable dams emphasizing the merging of salt and fresh water



XII. Wide view of the palette of small plots of experimental agriculture of salty crops

Adaptive capacity of the borderscape

As mentioned before, the design for dense point of Zwarte Haan will adapt in time changing its functions and landscape appearance. This happens within the new framed spatial outline of the borderscape that covers not only the scale of the dense point but also the adjacent area (fig. 105).

The new framed spatial outline of the borderscape reaches from the dynamic outline of the high marshlands up to the secondary dike. As a result, the primary dike is placed within the borderscape. In time, the outlines of the borderscape can change. The outline stays at the secondary dike but the dike itself can grow by adding platforms to it. The outline of the marshlands is less fixed as new gullies will be formed that rejuvenate the marshlands increasing the level of ecological quality. The primary dike grows in a similar way as the parallel secondary dike. New plateaus will be shaped lifting up functions from beneath and it changes the form language of the parallel ditch. Next to water safety, the dike fulfills functions of housing and recreation (viewpoints, camping site, agrifood) too. In this way the dike becomes an architectonic element reacting on the landscape on both sides. This makes the primary more integrated in the borderscape. The composition of all the dikes divides the borderscape into several basins (fig. 60). The formation of new plateaus along the dike happen on a slower pace than the change of functions of the basins within.

Within the basin the design of the dense point Zwarte Haan is located. The design will be established in different phases as explained before. First, the desired water infrastructure will be implemented for the landscape park and ditches will be made to create smaller plots. As a result, different ecological systems, human uses and experiences occur that can keep on changing in time. The phasing of this project is ahead of the adjacent area as it serves as an experimental garden on a small scale for generating knowledge about functions and spatial structure for a bigger scale. For example, the knowledge generated about salty agriculture can be implemented in the adjacent area in a later stage.

In the adjacent area of Zwarte Haan the functions and appearance of the landscape can also change on the bigger scale. In the existing situation the whole area is used for production land. As the level of salinization the production land is merged to processes of the sea (experimental salty agriculture) or new functions arise that embrace the potential processes of the sea. These functions are sediment catchment farms, ecological zones, water buffer zones in extreme weather conditions and recreation. The sediments are useful for raising the topography in the borderscape and to use as fertilizer for the agricultural lands. The outlines of the functions can cover a whole basin or a part of the basin. If it covers a part of the basin water bodies are used to serve as outline. This changes the existing form language of straight parcellation into a more homogeneous one that corresponds more to the multi-functionality of a borderscape.

Fig. 105: Spatial structure of the borderscape raising existing topography of polders and adding plateaus

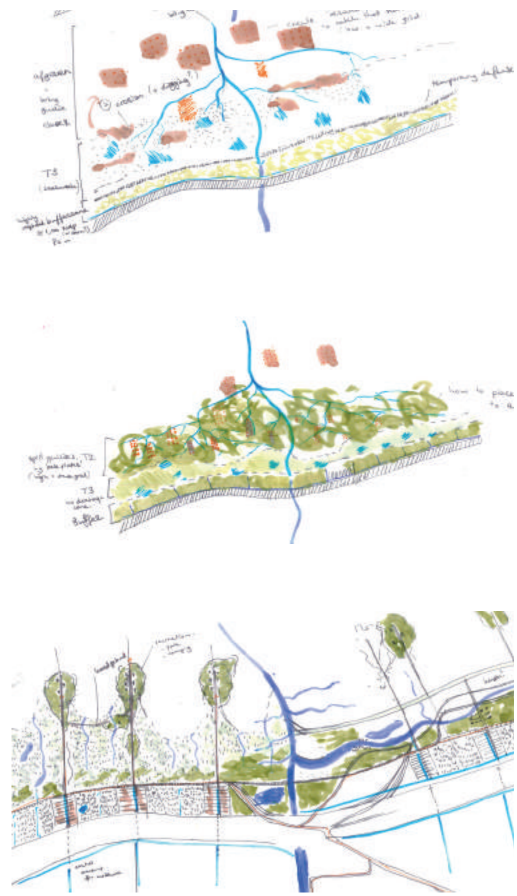


Fig. 106: Design experiments of seaward extensions

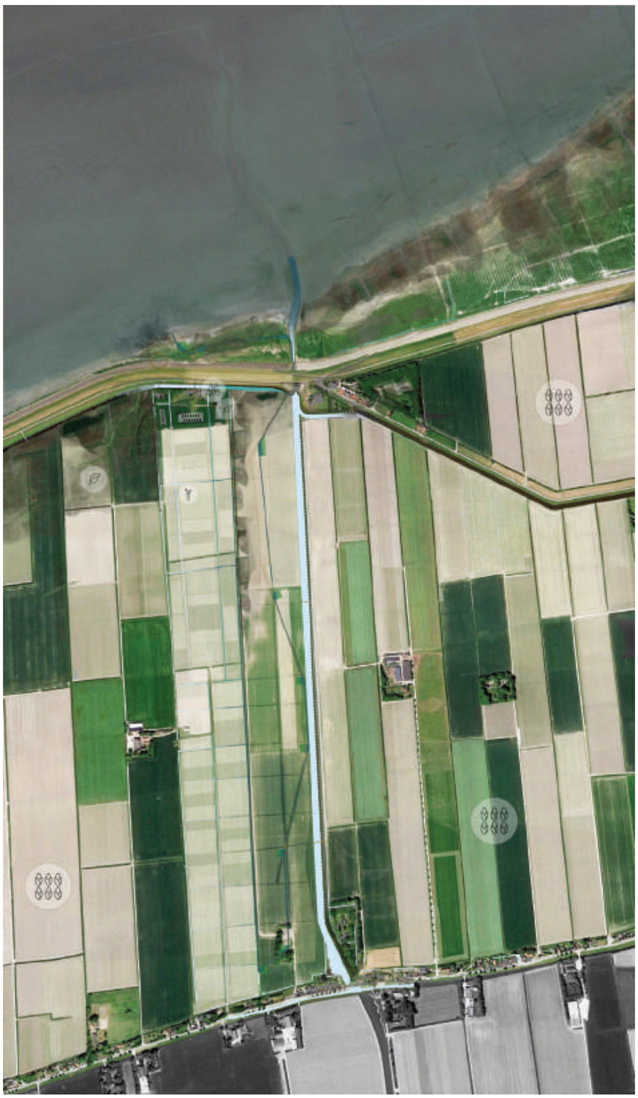


Fig. 106a: Borderscape in 5 years

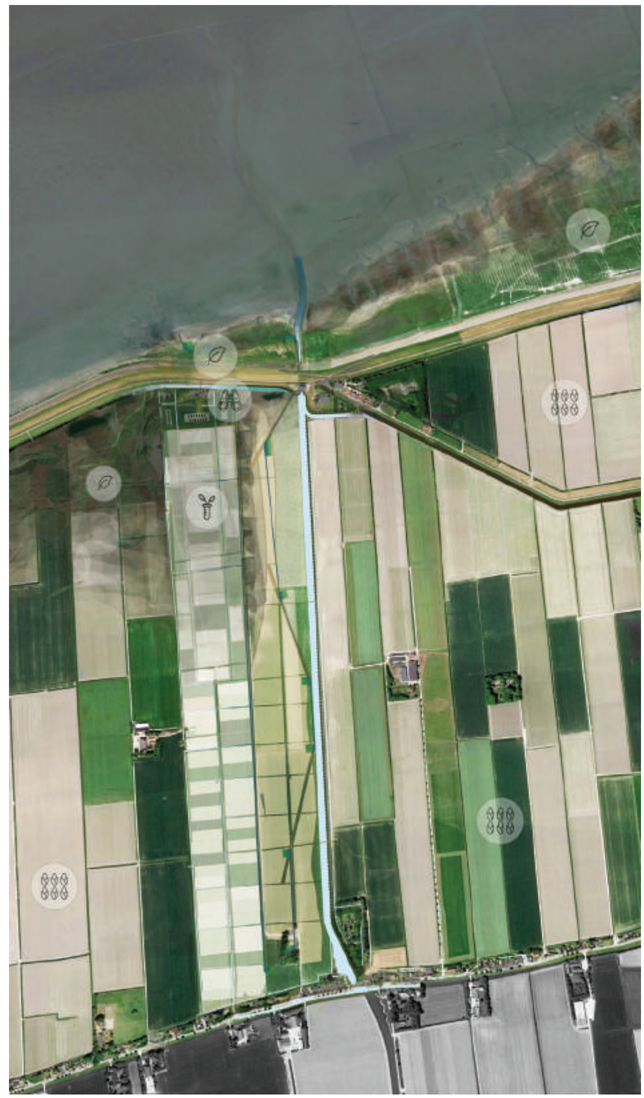


Fig. 106b: Borderscape in 10 years


Knowledge salty agriculture


Ecological development


Sediment catchment farm

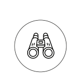
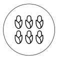

Recreation & Education

Fig. 106c: Borderscape in 20 years

Fig. 106d: Borderscape in 50 years

 *Water buffer*

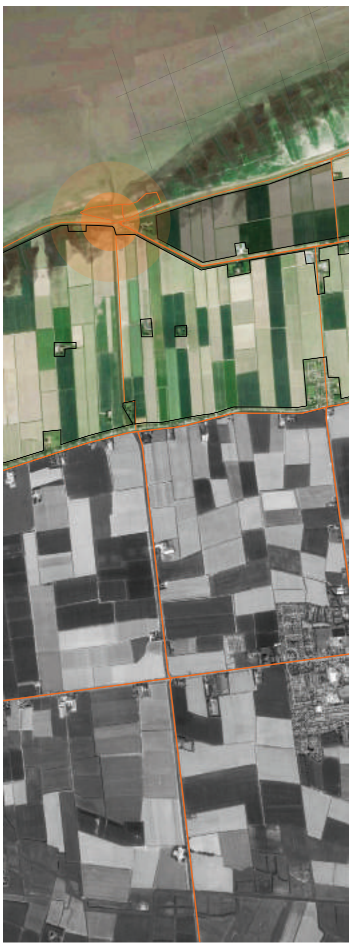
 *Experimental salty agriculture*

 *Production agriculture*

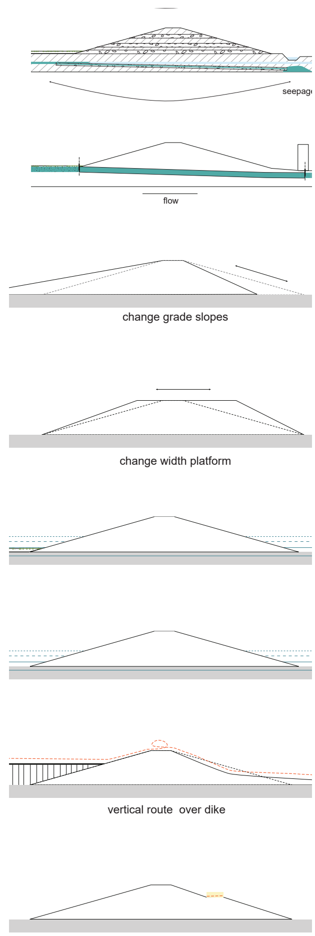
Reflection

"In this research the landscape design has given potential spatial structures for the future visualizing the vision of a borderscape even if some may not seem fully applicable in the present yet"

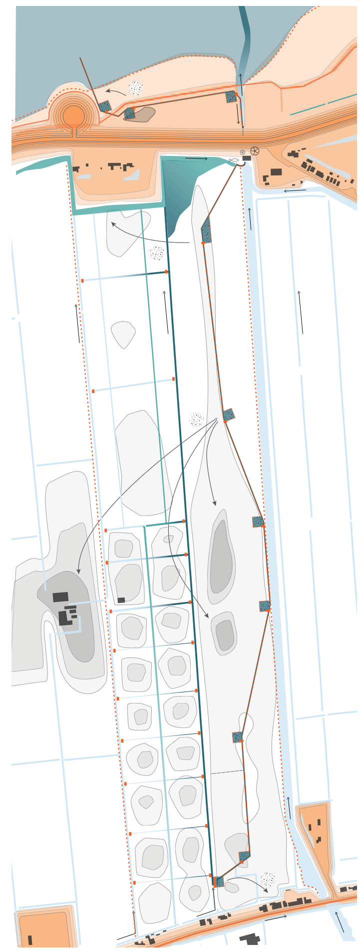
5 The design of the dense point at Zwarte Haan is evaluated on its performance of being a borderscape and conclusions are drawn. The design is multifunctional, includes experiences of dynamics and is adaptive to a certain level. The proposed spatial structure is used on different scales, puts it focus on the area inside the primary dike and adds a new social attitude. After, the applicability of the design principles of Zwarte Haan to other locations in Northern Netherlands is tested. The principles are the leading role of the dense point vs. the wider area, the re-positioning of the primary dike towards the middle and using the exchange of water as basis for a spatial structure of a borderscape. The categorization that is made in the Application chapter is used. The projection shows that the principles are suitable for implementation in the other locations within the same category. In other locations the design principles are less implementable and should be adapted. Here, the dike is positioned on the edge of the borderscape and other functions are present (harbor and/or intensive built area) that ask for another spatial structure. Lastly, a conclusion map is drawn for Northern Netherlands showing the spatial impact of the research.



I. Dense point as experimental garden of adjacent area



II: Re-positioning of the role primary dike



III: Water exchange as basis for merging uses and experiences of both sides

5.1. Evaluation of the performance design Zwarte Haan

Conclusion

The essence of this research is to find design principles for a spatial structure establishing a borderscape. This spatial structure should support the merging of functions and processes of land and sea, should give experience of dynamics, and be in itself adaptive and able to transform. Taking the 'Zwarte Haan' as case study, the design of a borderscape is considered as a constant transformation. For that account the role of the existing spatial structure of the border, the primary dike, is redefined in a borderscape. Through the research, locations that already offer an existing water exchange between both sides are seen as potential starting points for a dense point in a borderscape. For one of the dense points, Zwarte Haan, a design is made for a borderscape and design principles are developed. The first step is to evaluate the performance of the proposed spatial structure of this design and the influence it has to what level in scale. Defined in the theoretical part of this research a borderscape should integrate three attitudes; multi-functionality, adaptive capacity and legibility of dynamics.

Throughout the research and design the spatial structure and outline of the borderscape in Northern Netherlands is framed on different scales that should support these three attitudes. At all scales, the elements of control are defined and the outlines to what extent the dynamics can reach are set giving the borderscape a physical zone (fig. 107).

On the micro scale the (re)design of the gardens and pumping station, the flow of salt water is controlled by the channel and slope of topography. In this scale, the dynamic processes are used in design to make them experienceable to human in an aesthetic and educative way. The dynamic processes used are products of the sea and are being exchanged with land by using water. These are difference in water level due to tides, deposit of sediments, different water types, succession of vegetation. Succession of vegetation is the result of topography and water type. The deposit of sediments in the gardens is used elsewhere in the system on the mesoscale. This use of the sediments can be seen as an attempt of BwN on a very small scale. The open exchange of sea water to land and the deceleration of water at certain points enables to steer the sediments towards the gardens. The process of sediments continues as the sediments are dug out after a period of time and used elsewhere. This allows the process of sedimentation to continue.

On the mesoscale the same processes of dynamics are being used to create a borderscape as a system within a set of clear outlines. The borderscape reaches from the high marshlands to the secondary dike positioning the primary dike within the borderscape. On this scale the borderscape is divided in basins surrounded by dikes. The system has two areas of influence: the system of the dense point and the system of the basin. The system of the dense point uses the exchange of water of both sides as a basis to create a multifunctional area. The current functions of production land inside the dike and ecological development outside the dike are merged by the exchange of processes. A part of the production land is changed into experimental agriculture that adapts crops to saline conditions. The marshlands outside also become a water buffer zone and contribute to the water safety system of land. New functions of recreation, buffer zones, small sediment farms, ecological development, experimental salty agriculture are being merged within the dense point. Not only the dense point but also the adjacent area on a bigger scale is made multifunctional. The dense point is related to the area at the scale of the basin as it serves as a experimental garden for the area. In time, functions in the basins can change adapting to the needs of that time. The same functions occur as in the dense point but at a bigger scale. The borderscape uses the deposit of sediments in the area to create mounds for farms and viewpoints that are located in the middle of the area or to add plateaus to the dikes. As a result the primary dike becomes multifunctional too, as it adds functions of recreation, routing and housing to the existing

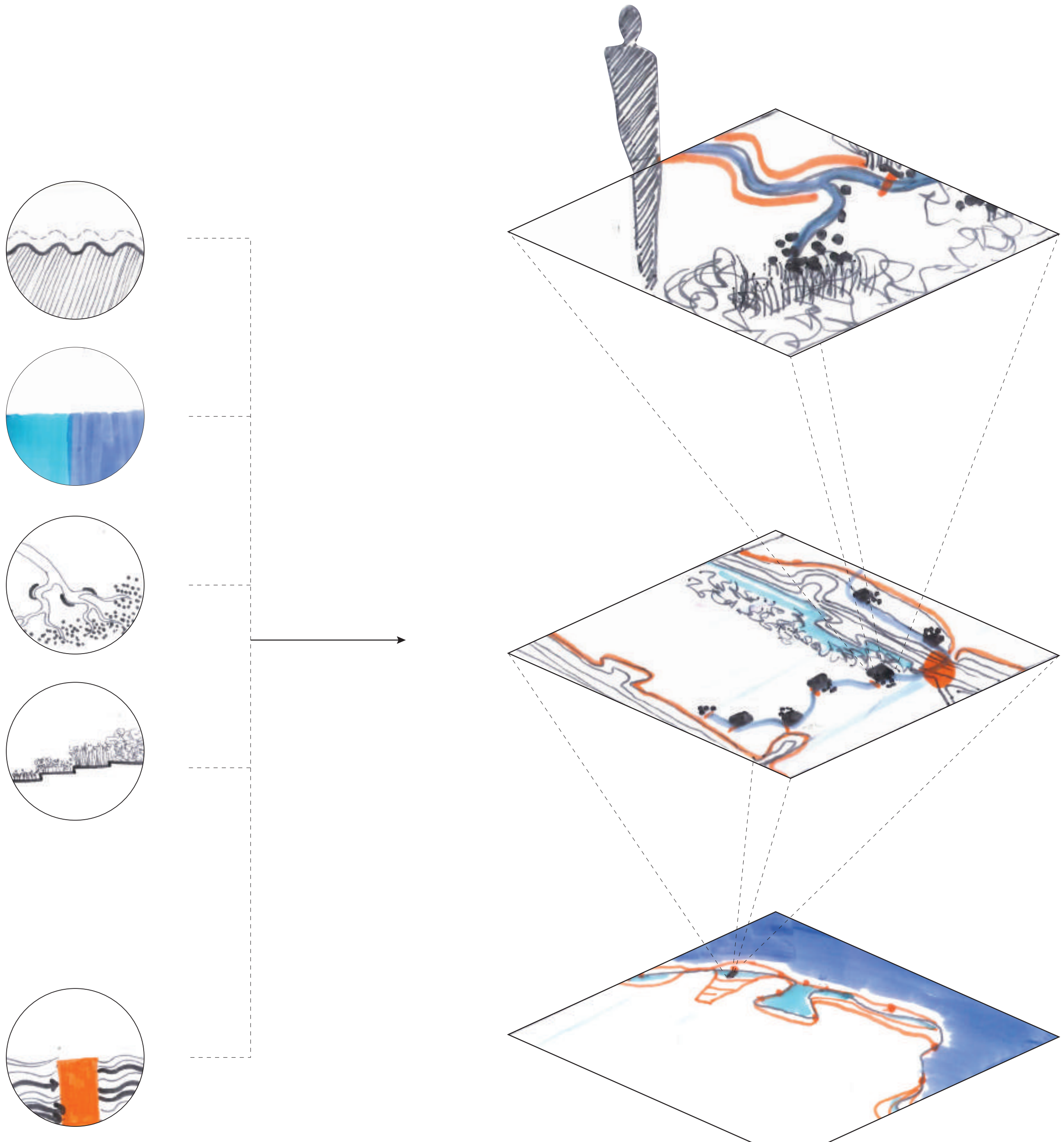


Fig. 107: A spatial structure of dynamic and control in the borderscape on different scales

function of water safety. It also becomes an architectonic element within the borderscape that reacts by shape on both sides. The multi-functionality and the adaption of functions themselves to processes of land and sea contribute to the adaptive capacity of the borderscape on the mesoscale. Moreover, the consideration of the border as a wider safety system set up by different basins helps to adapt. Lastly, the use of sediments contributes to the adaptive capacity but it is doubtful if the pace of deposit is fast enough to the speed of a change (fig. 108a).

On the macro scale the outlines of the borderscape are the secondary dikes, the marshlands and the locations where the deposit of sediments occurs naturally. The process of sedimentation and erosion also has influence on the borderscape as it defines the positioning of the primary dike. At the locations where sedimentation occurs, the primary dike shifts towards the middle of the borderscape. In the zones where erosion takes place, the primary dike stays located at the edge of the borderscape. The borderscape can adapt in time by changing its outlines. The proposed spatial structure of the borderscape at this scale does not show the spatial relations yet such as the other two scales do. The spatial structure of this scale is used to test the design principles of Zwarte Haan on other locations.

Discussion

The performance of the design is being measured by the integration of the three attitude that were developed in the theory research. After, another attitude has evolved during the research: the importance of social involvement in the transformation towards a borderscape. The main existing users, the farmers, have been involved in the design from the start. As the design is seen as a transformation of the existing situation, it is important to give spatial alternatives to them. In a borderscape power is given back to the users. The level of water type and water level can be decided by the farmers themselves. Another aspect of social involvement is education. The potential processes and potential functions of making the border more permeable towards the sea are made experienceable on a smaller scale. This can contribute to a cultural acknowledgement of the potentials of the sea and embracing permeability of borders between land and sea.

In the design the focus is put on using the potentials of the sea and bringing them land inward rather than the other way around. Outside the primary dike there are hardly any interventions except from gardens in the existing marshlands and a view point towards the dynamic Wadden sea. In this research the restricting policy of seaward extensions in the Wadden area is followed acknowledging the buffer ability and ecological quality of the Wadden area. Still, it is useful to put more focus on the potential spatial structure of the seaside in the research of borderscapes. On this side the conditions are different as it is less controlled (strong wind, high water levels, erosion after storm etc.) (fig. 108b). Moreover, it is interesting to find the potential processes on land that can merge outside the dike.

5.2. Evaluation of applicability to other locations

Conclusion

The next part is to check the suitability of the abstract site-specific design principles for the spatial structure of Zwarte Haan to other locations. The principles are the leading role of the dense point vs. the adjacent area, the re-positioning of the primary dike towards the middle and using the exchange of water as basis for a new spatial structure of a borderscape. The design principle of the dense point Zwarte Haan derived directly from the spatial structure of the borderscape on the regional scale. Therefore, this principle is left out of regard at the evaluation to other locations along the coastline of the regional scale. The other two design principles are tested on different locations. The first test location applies the principles in the location Noordpolderzijl that belongs to the same category as Zwarte Haan in the borderscape, earlier defined in research. As the categories are based on an analysis that took the site-specific conditions of the dike and adjacent areas into account, the locations share similar conditions.

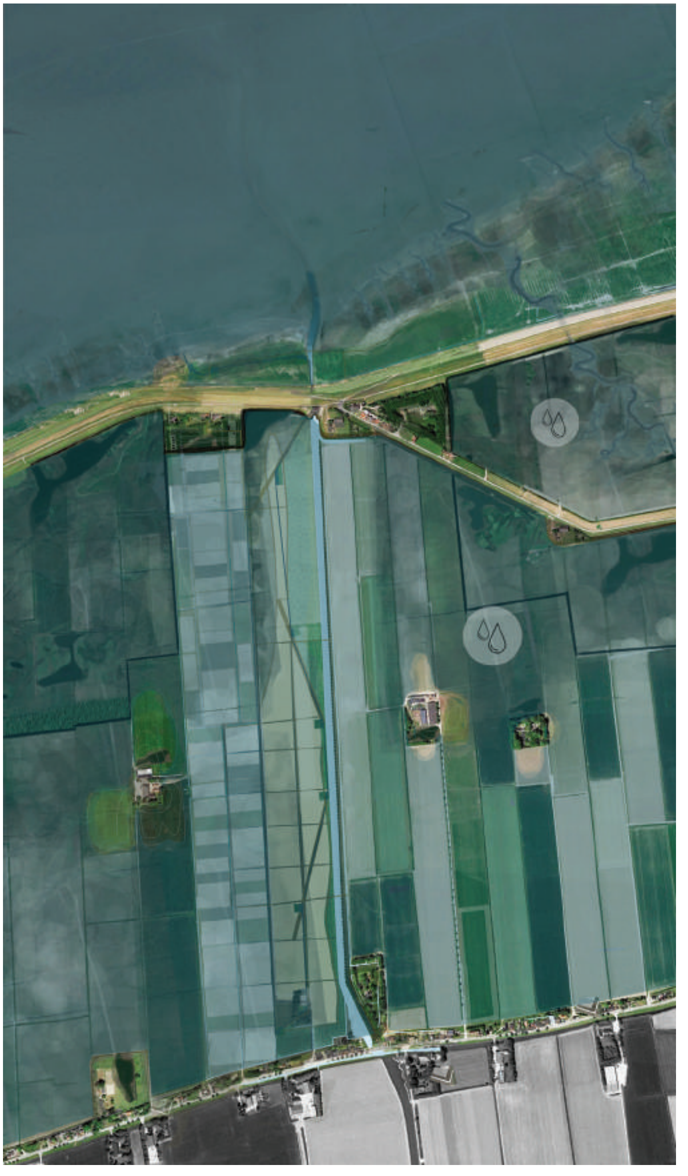


Fig. 108a: Conclusion: Multifunctionality and legibility of dynamics are well embedded in design but it is doubtful if adaptive capacity is as well. For example, is only multi-functionality, basins and use of sediments enough to serve as water buffer zone 50 years?

The second test is placing the principles in a location from a different category. This is done at two locations, Eemshaven and the area near Harlingen. On the following pages these three locations are shortly discussed.

In conclusion, the dense points that belong to the same category of Zwarte Haan share similar conditions. In these locations primary dike is also location within the borderscape. These locations do also share the same existing functions on land, production land. Therefore, the found design principles are implementable. The locations that belong to the other category have different conditions and functions. At these locations erosion takes place outside the dike. In a borderscape the positioning of the primary dike will then stay at the outer edge. The functions that are located at these locations of erosion are harbors as they stay well accessible. Using the exchange of water as a basis for merging human uses and experiences is potential in these locations too but needs to be adapted more to their site-specific characteristics and conditions. These locations include functions of intensive built environment, energy generation, chemistry and trade.

Discussion

Among several steps of the design research the regional scale of the Wadden area is scaled down to a design proposal of one dense point along the coastline Zwarte Haan. Next, the applicability needed to be tested among other locations. In order to scale down and do the last testing analysis, a categorization of dense points along the coastline was needed. Still, this categorization stands in contrast with the high acknowledgement of the site-specificity of each place that is used in this research. Therefore, the categorization of the coastline should be used as a basis for the design and the site-specific conditions of each site should leading after. Moreover, the scaling down the coastline into spatial concepts for a borderscape should be seen as an attempt. An improvement of finding more precise design principles for a region is to start with a smaller scale, thus a smaller part of the coastline. However, the attempt of starting from the scale of the total coastline has given a potential collaborative spatial strategy of all areas.

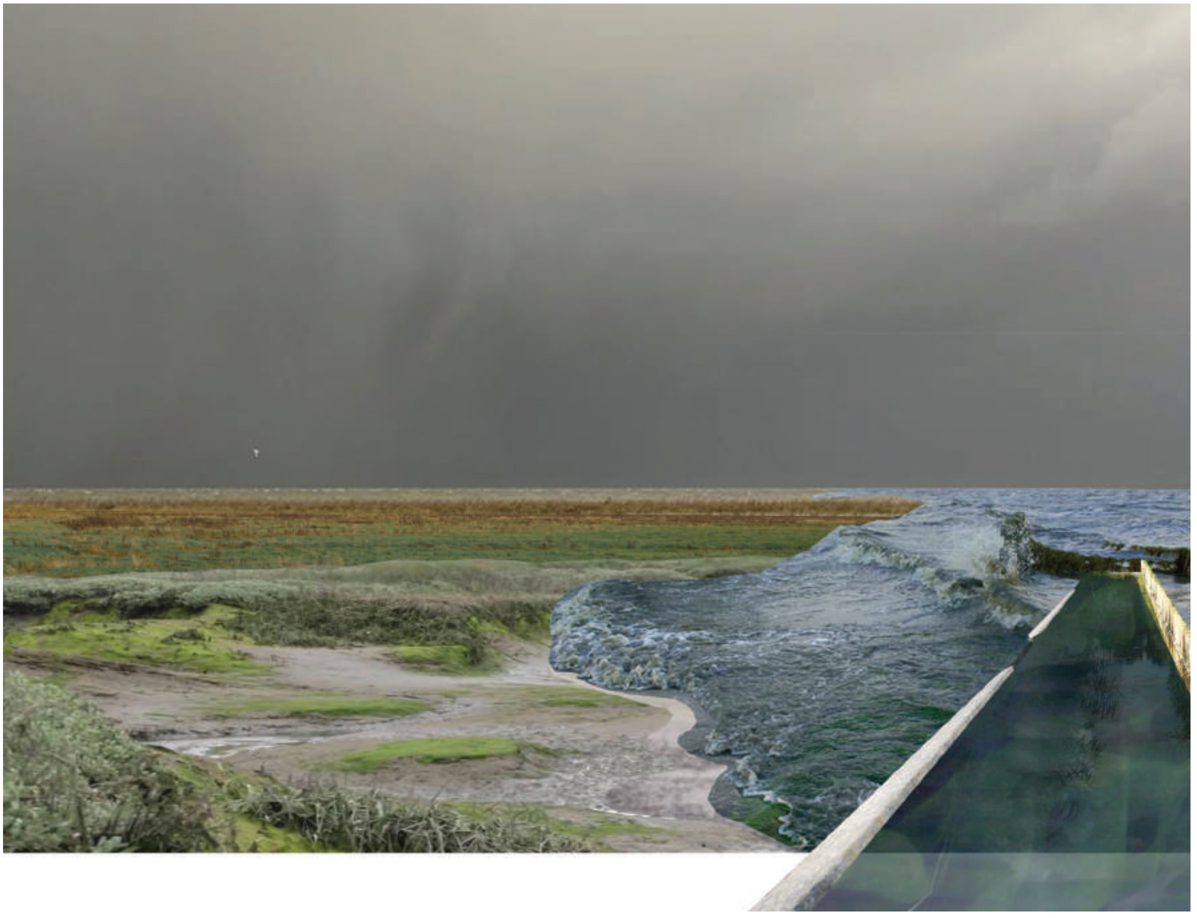


Fig. 108b: Collage of garden outside the dike in a less controlled environment (high water level during storm, erosion, wind, stronger vegetation)

Noordpolderzijl
The first location is Noordpolderzijl which is located in the same category as Zwarte Haan. As predicted, the spatial structure of the existing situation is comparable to Zwarte Haan. In the area there is hardly any built environment except from a few scattered farms. The overall function is production land too (fig. 109).

The role of the primary dike in the transformation to a borderscape is comparable to the role of the dike in Zwarte Haan. Outside the primary dike the marshlands are wider positioning the primary dike even more towards the middle in the wider water safety system. Inside the dike, there is a secondary dike that creates a separate compartment around the pumping station Noordpolderzijl. This secondary dike has no settlements on it, different than Zwarte Haan, and this makes the secondary dike strategy even more suitable here.

The other principle is the use of water to exchange processes of the sea inland. Looking at the water regulation, there is also a straight boezem running to the pumping station. Unlike Zwarte Haan, there is no extra fresh water ditch in the pumping station. Creating a salt water ditch asks for a new channel through the dike. At this location, the opening is wider and is has a water basin in front. A potential could be to create a an extra sluice at the mouth of the basin land inwards to create a brackish lake in between. The difference in topography of the surrounding polders on micro scale is more flat than Zwarte Haan. This is functional to give direction lines for new drainage lines which divided the big plots into smaller parcels for experimental salty agriculture and defined the location of the salt water channel that runs on natural flow. Still, either creating a salt water channel or using an existing ditch for flowing in salt water can be implemented. This can likewise create more diversity in ecological systems, inland and outland, and lead to a wider range of functions of agriculture, recreation and ecological development.
In this location, there are also already a few places of recreation; a cafe next to the pumping station and an accommodation more southwards. Close to the pumping station and along the parallel ditch of the dike, there is 1 farm that can change its function. The other farms are placed more land inwards.

Moreover, the location of Noordpolderzijl also offers the same potential architectonic experience to stress the straight axis. Still, site-specific elements need to be taken into account as well. Here, the boezem ends in a waterbody and can offer other experiences. Here, the dike already has become more architectonic as the slope of the dike has changed from material offering a viewing platform of the axis. Thus, these small elements offer other starting points for the dike as a architectonic element.

Overall, the design principles are suitable for the other locations of the same category. Still, site-specific elements should be addressed and form other starting points for desired human experiences in the area. This contributes to the site-specific experience of a location, creating diversity along the coastline.

View of straight axis outside the dike

View from tiled dike to water basin, straight boezem and pumping station

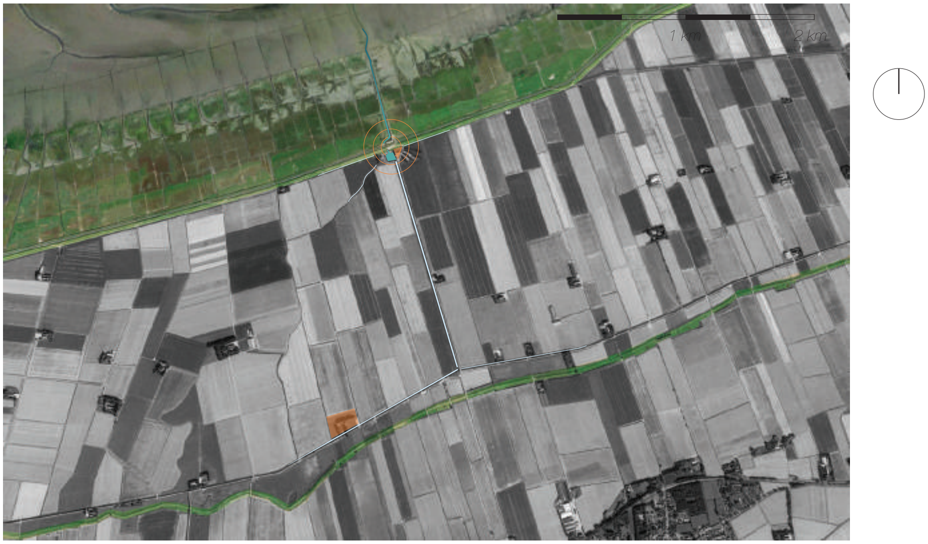


Fig. 109: Suitability of design pricniples in Noordpolderzijl

Eemshaven

In this location the design principle of the role of the primary dike is not directly implementable as the conditions are different. This area hardly has any marshlands in front of the dike as the area is prone to erosion. Besides, this is also not preferred, as the channels should support the accessibility of the harbors. Therefore, the primary dike is not positioned towards the middle but becomes the outer edge of the wider borderscape. In this case, the primary dike should needs more changes in order to meet the new water safety conditions. Moreover, the role of the primary dike in connecting both sides of the dike in their routing becomes different. Still, the dike has potential in becoming an architectonic element, such as a balcony to the sea as the dynamic tides are experienceable close by. According to water regulation the area offers space for new water connections (fig. 110).

The use of water to exchange processes of land and sea is potential in this area. The area offers enough space for the implementation of new water structures. These can give more diversity in ecological systems. As a result new human uses can arise. As the harbour is so close by, other functions of energy and chemistry should be integrated too. Together, these functions can be connected with a new routing system offering a diverse range of human experiences. At the moment, there are no places of recreation yet. Adjacent to the pumping station, there is a gas station. If out of use, this can be transformed to a more meaningful public use.

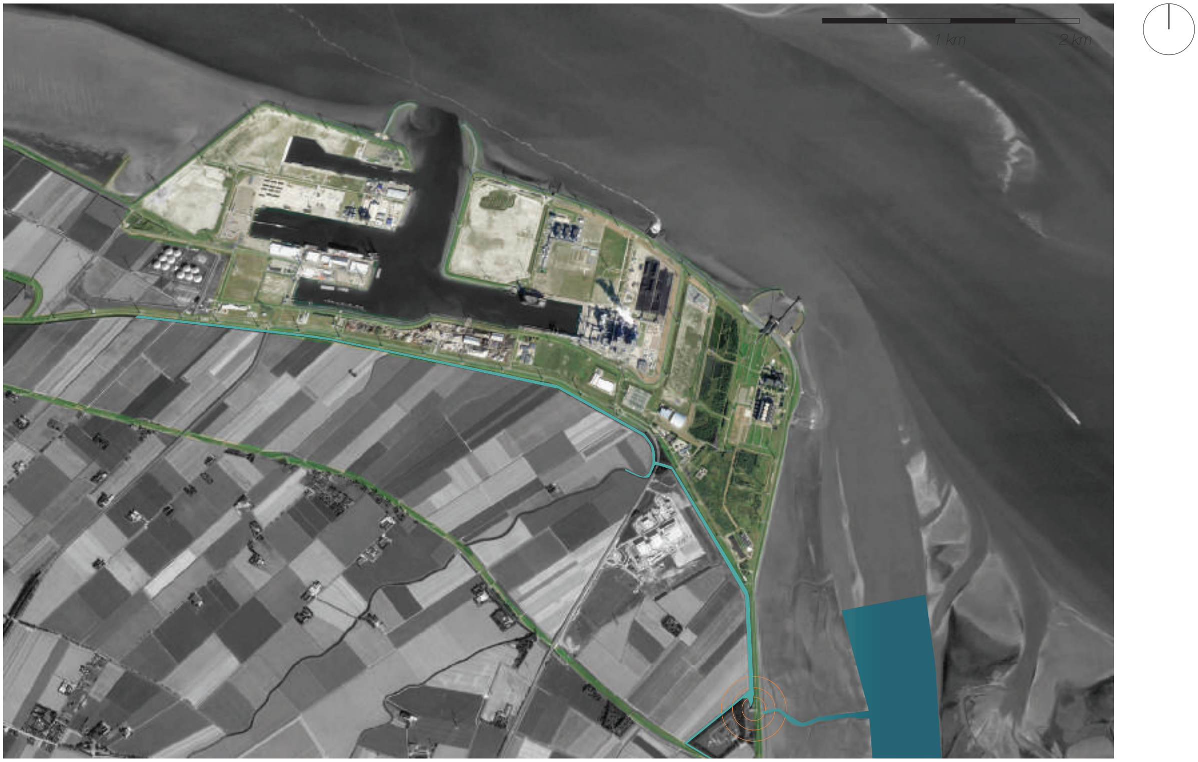


Fig. 110: Unsuitability of design pricniples in Eemshaven

Harlingen & Roptazijl

This area has two existing water exchange points. One exchange point is at Harlingen where three different waterways flow along the environment and flow into the Wadden sea. The other one is located in the production land close by at Roptazijl (fig. 111).

This area is also prone to erosion an puts the primary dike at the outer edge of the borderscape. Besides, the secondary dike inside is complete anymore and is positioned far behind the built environment. This makes the secondary dike unsuitable as an inner outline of the borderscape. Thus, at this location the borderscape does not have a physical zone. The principle that considers the primary dike within the borderscape is not suitable for this location.

Next, using water as the basis for the exchange between both sides in order to merge human uses and experiences is only potential in Roptazijl. In Harlingen there is a lot of built environment and there is no space for merging functions of ecological zones, water buffer zones, recreation and experimental agriculture. At Roptazijl, water can help to merge functions but will start from other conditions of energy generation, chemistry and trade.

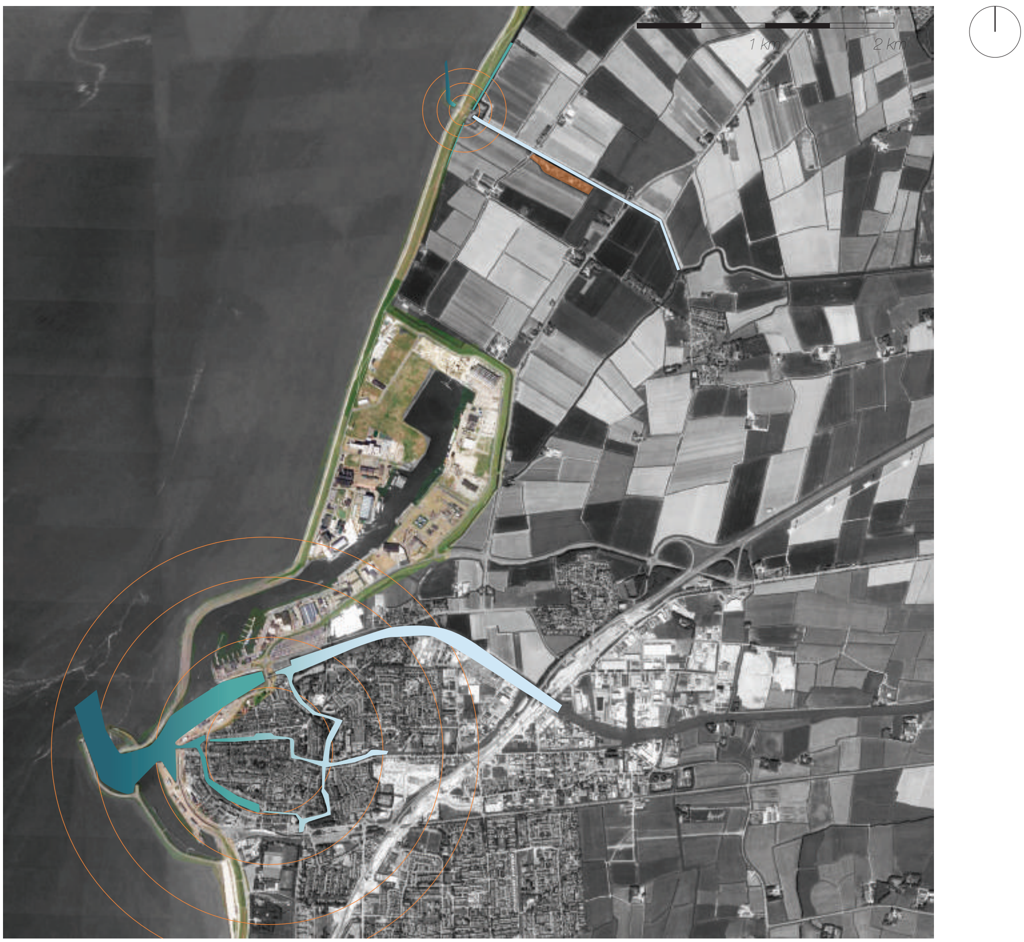


Fig. 111: Unsuitability of design pricniples in Harlingen

General discussion

Research and design

This research gives another perspective on the spatial planning of coastal borders. The design of the dense point Zwarte Haan along the coastline of Northern Netherlands gives a spatial structure that transforms the narrow fixed dike into a wider borderscape. Research by design and design by research is used through the project at different stages. Research by design is applied in the methodology to conclude the four generic principles that should be used in all borderscapes. In Europe, several projects along the North sea have been analyzed that are considered as borderscapes that each have a different spatial outcome. Still, four generic principles came across in each project. Moreover, research and design is combined in several steps along the design research of Northern Netherlands. Small design experiments on different locations of the coastline and the extensive design experiment have resulted in several instrumental design principles for establishing borderscapes. The last design research was to test the found instrumental design principles of Zwarte Haan into other locations along the coastline. This has given insight into the applicability of the found instrumental design principles.

Positioning of the research in education

The research topic is in line with the graduation studio 'Flowscapes' of the Master track Landscape Architecture. Rather seeing the border as a fixed element, the research approaches the border as an operative system. Different analysis are done in order to integrate the existing processes on both sides, land and sea, into the borderscape. Another important aspect is the integration of the site-specific conditions of the coastline on the regional scale but mostly of the location of Zwarte Haan. As the name 'Flowscapes' already implies, the design should not be a fixed end image. In time, the spatial structure can support change of flows. Lastly, in this research there is touched upon many scales, starting from the scale of the Wadden area zooming in to an eye-level perspective in the design of Zwarte Haan.

Transferability of results (to other fields)

The design of the borderscape in Zwarte Haan does not work with one desired end image but gives a spatial structure that includes adaptability in the area. This spatial visualization could contribute to the field of adaptive spatial planning or climate-robust planning. Also the use of processes of land and sea for the merging of human uses in the rural system, could add to the method of Building with Nature. According to van Bergen, this field could improve of integrating of the urban/rural systems with the coastal morphological coastal system and ecological systems more. Moreover, it contributes to the spatial planning strategy of the Northern Netherlands. It gives a potential spatial structure of a division of concentrated points along the coastline and it gives a potential administrative condition of involving users from bottom-up together with top-down policy. Moreover, the research stresses the importance of social involvement at the transformation of landscapes, e.g. a borderscape. At the design of Zwarte different spatial alternatives are given to the existing users of the area, the farmers. Lastly, this research has given a different perspective in the cultural value of borders between land and sea. In a borderscape the potentials of the sea are acknowledged and uses for functions and experiences on land. On the next page, a conclusion map is drawn that shows the spatial impact of this research. At the water exchange points that are considered suitable after this research the border fades symbolically to let in the potential processes of sea to land.

Ethical issues and dilemmas

Through the design, there is one main dilemma that was present during the whole process. This is the role of the landscape architect. Throughout the year, the discussion if a design should be suitable for the current situation or if a design should show possible futures came back frequently. In the end, the vision of showing potential spatial and administrative outcomes which are not present yet was stressed more. In this research the policy of Natura 2000 was used in design preventing seaward extension. On the other hand, it is assumed that the regional institutions, such as the water boards, will give power back to the users of the area and the water safety system will be acknowledged as a wider system that is constructed by different structures (secondary dikes, marshlands etc.).

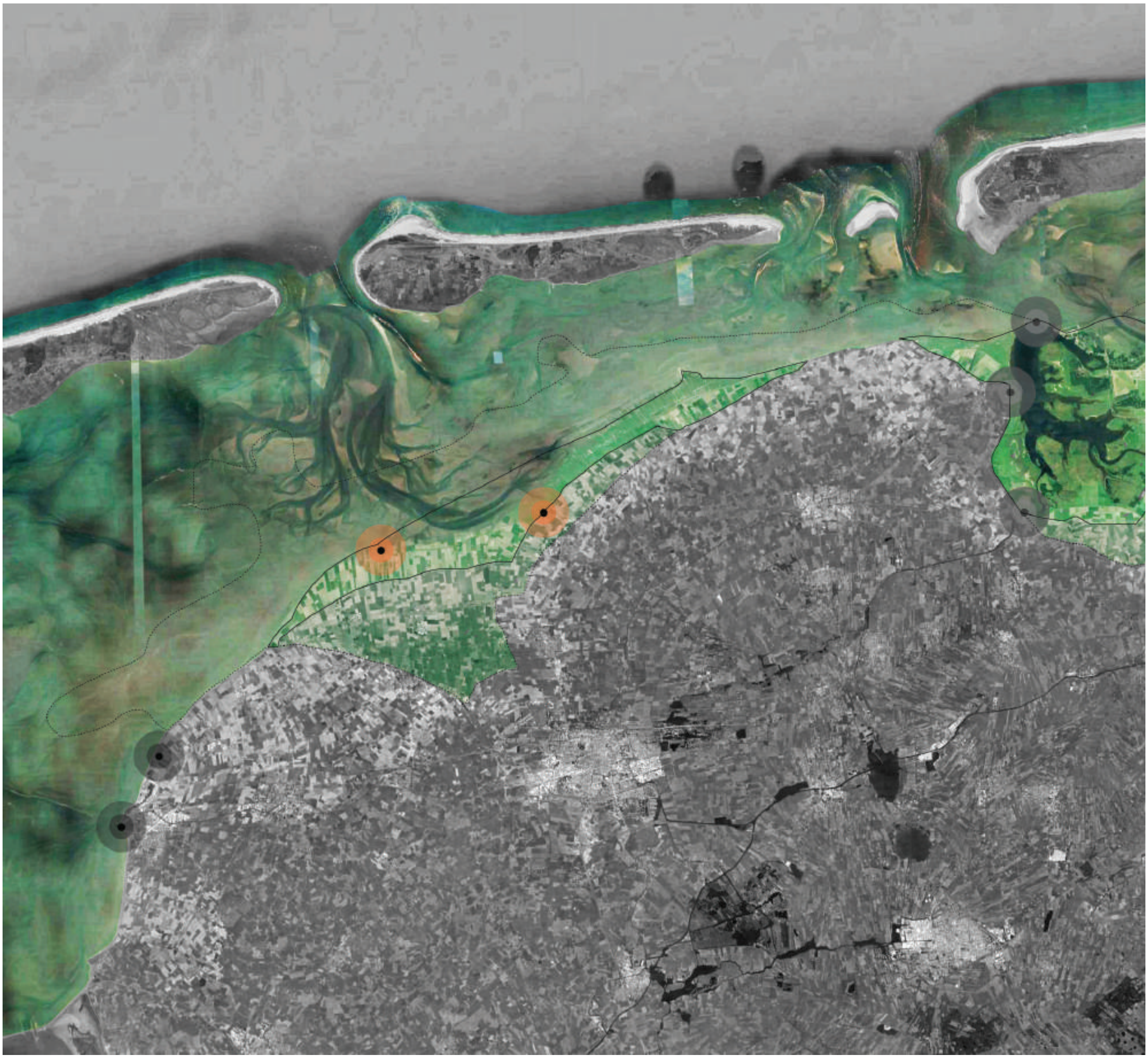
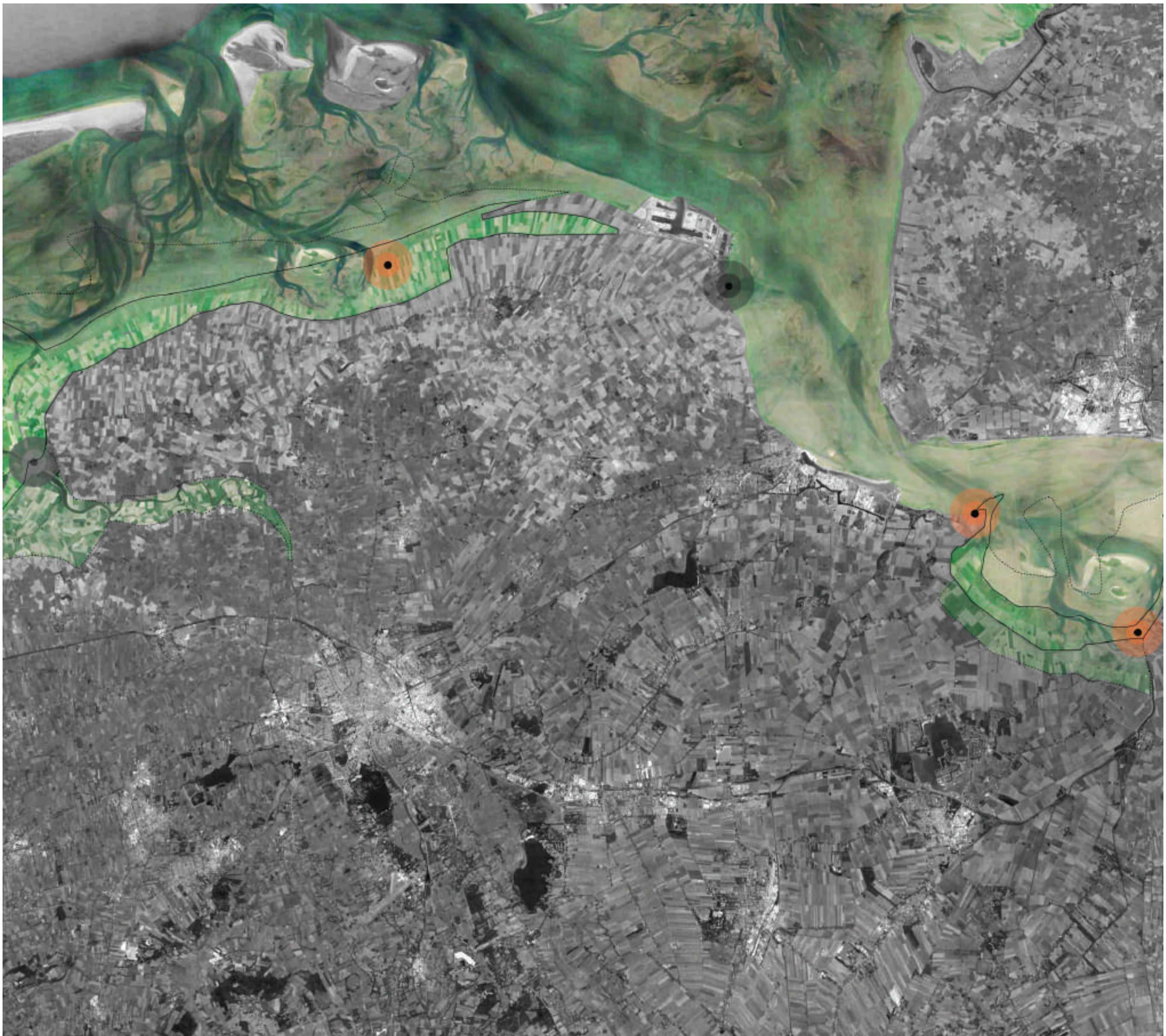


Fig. 112: Spatial impact map of this research: The outlines of the zones the borderscape among suitable points showing symbollically the fading of the border letting in potential processes of sea in land



References

Bureau B+B (2005). Definitief Ontwerp Wijkeroogparkzone Velsen. Amsterdam

Bergen, J. (2018). Shorescape. Designing Sustainable coastal bufferzones. TU Delft, Delft

Braae, E. (2017). Approaching the 'as found'. Delta Dialogues. ETH, Zurich

Diedrich, L. (2015). Site-specific landscape architectural approaches in contemporary European harbour transformation. University of Copenhagen, Copenhagen

Eker, M. (2013). Borderland. Blauwdruk, Wageningen

Deltaprogram (2018). Deltaplan Ruimtelijke Adaptatie

Deltaprogramma (2018). Deltaprogramma 2018: Doorwerken aan een duurzame en veilige delta. Den Haag

ILT (2013). Verlengde derde toets primaire waterkeringen. Utrecht

I&W, (2016). Ministerie Infrastructuur en milieu. Natura 2000-beheerplan Waddenzee. Periode 2016-2022. Noord-Nederland

van der Ham, W. (2002). Waterlandschappen. De cultuurhistorie van de toekomst als opgave voor het waterbeheer

Holling, C.S. (2001). Understanding the Complexity of Economic, Ecological, and Social Systems. Ecosystems 4: 390–405. Department of Zoology, University of Florida, Gainesville

Kaplan, R (2005). Preference, Restoration, and Meaningful Action in the Context of Nearby Nature.

Krol, S. (2018). Emai conversation

van Loon-Steemsma, J.M. (2012). Een Dijk van een Kwelder
Een verkenning naar de golfreducerende werking van kwelders. Wageningen UR, Wageningen

van Oost, A. et al (2013). Noorderzine 2040. University of Groningen, Groningen

MIRT (2014). MIRT-Gebiedsagenda Noord-Nederland 2040. Natura-2000.

Nijhuis, S. (2015). Flowscapes: designing infrastructure as landscape. TU Delft, Delft
de Ruyter, P. (2016). Vloeiend landschap. 20 Leafdesdicht& Bv Bornmeer

Sijmons. D. (2014). The emotional landscape. Landscape and Energy. Nai010, Rotterdam

Sennett, R. (2011). Boundaries and borders. Living in the endless city. Phaidon press, London

Spirn, A. (1997). The Authority of Nature: Conflict and Confusion in Landscape Architecture. Nature and Ideology: Natural Garden Design in the Twentieth Century. Dumbarton Oaks, Washington

van Staveren, G., Velstra, J.(2011). Klimaatverandering, toenemende verzilting en landbouw in Noord-Nederland. Acacia Water.

Steinweg, C. M., Hoekstra, A. Y., & Booij, M. J. (2008). Compartimentering in Friesland en Groningen om het overstromingsrisico te verminderen. H2O, 41(14/15).

VROM (2007). pkb Waddenzee: Ontwikkeling van de wadden voor natuur en mens

Wang Z.B. et al. (2012). Morphodynamics of the Wadden Sea and its barrier island system. Ocean & Coastal Management 68; 39-57

van Wessenbeeck, B.K (2014). VBNE: Verjonging van half- natuurlijke kwelders en schorren, Driebergen