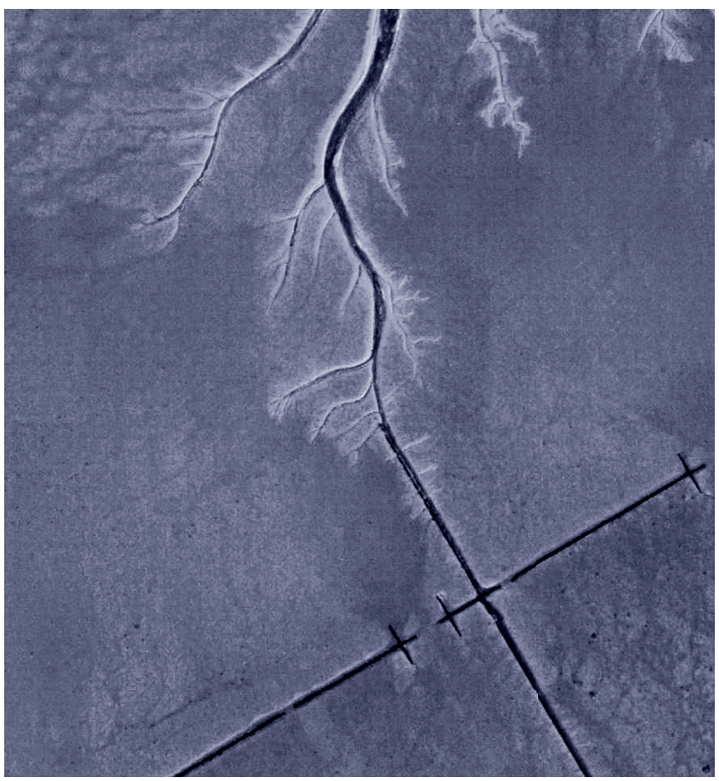
Reflecting on:



GROW WITH THE FLOW

Developing a dynamic coastal interface for the Wadden Sea Region

Venne van den Boomen

Conclusion

RQ.1: How to understand the formation of the Wadden Sea Region's interface and its current system workings from a landscape perspective, and what challenges and potentials belong to the current natural and cultural conditions of its coastal interface?

The landscape development of the Wadden Sea region is largely controlled by maritime processes, where waves and tides are the dominant land-forming forces. It is a relatively young coastal system and thousands of years of sea level fluctuations have moved the coastline hundreds of metres. As part of the larger hydrological system of the North Sea, the coastline of the Wadden Sea has shifted as a result of centuries of alternating periods of sea level retreat (regression) and rise (transgression). Behind and between the beach walls, large amounts of silt, transported by the rivers and sea holes, have settled, resulting in one of the largest interconnected mudflat systems in the world, the Wadden Sea. The Wadden Sea is 500 kilometres long, stretches across three countries from Den Helder in the Netherlands to Esbjerg in Denmark and is on average 20 kilometres wide. Its littoral landscape consists of a complex of deep channels and shallow water with sand and mud banks, large parts of which are dry at low tide. These banks are intersected by a finely branched system of channels that run between a series of barrier islands, remnants of beach walls that have grown over ten metres high over time due to wind action and overgrowth by Elytrigia juncea subsp. boreoatlantica. The mainland and the islands are interspersed with salt marshes which, due to the large differences in moisture and salinity, contribute to a very diverse flora and vegetation.

In the past, the influence of the sea was much greater throughout the Wadden Sea region and along its interface, which used to be more gradient, with a much greater presence of different habitats and ecotopes. Today, the dynamic hydrodynamics and geomorphology are only present within the Wadden Sea and some estuaries in Germany and Denmark, where natural processes ensure the maintenance and development of characteristic ecotopes and habitats. The mainland, or Waddenland, along the Wadden Sea coastline has historically been subject to the land-forming presence of the sea, whose dynamics have constantly altered the boundaries between land and water. Traces of the interaction between the region's early settlers and the dynamic environment of the past can still be seen in the landscape, expressed in the presence of terps throughout the area of sea clay and archaeological evidence of the presence of maritime resources. The presence of rows of historic dikes running parallel to the sea reveals the gradual extensive land reclamation and artificial development of the coastline seaward from the 11th century onwards, which fixed and fragmented much of the historic interface.

Today, almost the entire existing coastline has been cut off from the influence of the sea; only within the Wadden Sea littoral landscape do dynamic natural processes remain. The former gradient between land and sea has been fragmented by the construction of dikes, while the land behind the dikes has been controlled by changes in the hydrological system. The contrasts in the landscape have been accentuated by the change in the inland hydrological system to a freshwater-based system with a focus on agricultural productivity.

The diverse marshland and peatland habitats diminished and were replaced by productive arable land, pasture and reclamation. This shortening of the gradient along the interface has separated the hydrological, ecological and social systems behind the dikes from the threats and benefits of the sea, while making them static and dependent on human-driven systems to function according to human interests. Livelihoods behind the dikes have become completely dependent on freshwater driven practices, while the artificial drainage that enables these practices increases the immediate threat of sea level rise. Overall, the static nature of the existing landscape is being challenged by more extreme conditions that are constantly being exacerbated by climate change, such as sea level rise, more extreme droughts and increased rainfall. There is little or no room to grow with this evolving challenge.

Within this overall systemic challenge lies the potential for overall systemic change. Climate-related challenges, which are treated as separate issues, require a holistic and transboundary approach that is more in balance with natural landscape conditions. Natural and cultural systems need to be brought closer together and balanced to enable sustainable development of the interface.

RQ. 2: What landscape architecture-based design strategies and principles are capable of enhancing interface features and resilience within the Wadden Sea Region?

Recognising that the Wadden Sea interface should be viewed as a system, rather than as separate regions separated by boundaries, each with its own problems, is the first step in developing a strategy for resilient interface development. An interconnected system, rather than a fragmented one, is better able to regulate itself in the face of adversity and re-establish a new steady state of being. Learning from systemic and regional analysis, local practice, recent local case studies and theory, guidelines for interface development consistent with a landscape-based approach will be established. These guidelines for the systems strategy of the whole region are: 1) Extend the interface by lengthening and softening existing barriers within the landscape through the development of a spatial framework based on hydro-morphological structures aimed at promoting sea-land interaction and developing the coastal gradient; 2) Strengthen the spatial framework by providing space for hydro-morphological structures, allowing natural and dynamic processes to move more freely within the landscape. 3) Following a function-follows-form approach to land use planning, the aim is to create landscape compositions that recognise the presence of natural processes within the landscape, use them to further strengthen the spatial framework and overall create a better balance between natural and cultural layers within the landscape. Landscape elements thus follow the coastal gradient and form a gradient themselves, which is much more flexible because it can move with possible future fluctuations along the interface system; 4) The final step is to integrate the spatial framework and land use at different scales. This is essentially the role of regional and local planning. Different integration measures are required in different parts of the Wadden Sea Region's coastline.

The next step would be to approach the interface system from a landscape-based perspective to make regional and local design more manageable. The components of the interface system are identified on the basis of their landscape characteristics rather than political boundaries, in order to get a grip on the systemic scale of the Wadden Sea Region and its interface, which varies along the coastline depending on the underlying geomorphological formations. A total of six typologies have been identified along the coastal interface of the Wadden Sea Region: dunes and moraine islands, littoral landscapes, embanked coastal marshes & tidal river marshes, polder landscapes and drained lakes, fen landscapes and cut-off raised bogs, and upland moors. Most of these typologies are present throughout the interface of the Wadden Sea region, but to varying degrees depending on the location. Each typology has local challenges that are interrelated, and by identifying local characteristics and associated problems, local solutions can be linked to them, and the overall system of the interface can be improved, connected and made more resilient.

1) Dunes and moraine islands mainly consist of the barrier islands between the Wadden Sea and the North Sea and the beach barriers directly between the sea and the mainland, which take the form of a thin strip. Aeolian dynamics allow the dunes to rise with the sea level, improving the distribution of the coastline and allowing water to be stored in the deep sandy soils.

2) The littoral landscape consists of canals, shoals, sandbanks, mudflats and unembanked natural and cultivated salt marshes, such as the artificial kwelder marshes and the Halligen. Raw sands, raw alluvial soils and unripe grey soils predominate. Important for this area is the ability to keep up with sea level rise by retaining transported sediment. More space and local sediment storage capacity should be created to ensure the development of these valuable natural areas and to improve flood protection through a sustainable nature-based approach.

3) The embanked coastal marshes & tidal river marshes are the most widespread landscape type in the Wadden Sea Region, dominated by marine clay deposits adjacent to the existing coastline, which was once subject to the dynamics of the sea. The embanked coastal marshes are culturally very valuable, characterised by medieval settlements on artificial dwelling mounds (terpen, wartfen of wierden) and villages built on historic drumlins, beach ridges or natural embankments. It is essentially a man-made landscape, shaped by centuries of human intervention. As a result of the area's maritime past, there are deep-seated primal saltwater infiltrations. Combined with the more immediate seepage from sea level rise, there is increasing pressure on the current agricultural and hydrological network, which is currently entirely dependent on fresh water. Adaptation of existing land uses is necessary to enable agricultural production areas and to secure the livelihoods of the area's inhabitants.

4) The polder or dike landscape and drained lakes have been systematically reclaimed. Along the historic dikes and roads, farms are surrounded by shelterbelts, while the intervening landscape consists of block or strip parcelling according to geometric rules. Most of the polders are suitable for arable and pasture farming, which also depends on a supply of fresh water in the summer, but needs to be drained in the wetter months to enable

productivity. More space must be reserved to store water during floods, which can be used during arid months.

5) The fenlands and the cut-over raised bogs are the remnants of a belt of former marshes and fens that ran between the coastal marshes and inland. They have been systematically drained and reclaimed since the 9th or 10th century AD. Drainage led to severe subsidence of the peatlands, leaving large areas well below sea level rise, which continues to subside due to continuous drainage, releasing the CO2 stored in the peat soils. Groundwater levels need to be managed to reduce further subsidence and consequently CO2 emissions.

6) The upland moors form the most elevated parts of the interface as they sit on the Pleistocene moraine sand plateaus and fringes. Previously, the upland areas were characterised by long stretches of heathland, peat bogs, sand drifts and patches of woodland. The expansion of agricultural land and large cities has led to the reduction of these natural areas. Stream valleys cut through the Pleistocene margins, acting as vital veins of fresh water through the other downstream landscape types. Canalisation and straightening have changed the fine network of stream valleys to be oriented towards water drainage. Fresh water plays a vital role within the balanced interface and in order to strengthen its structures, more space needs to be created to increase the storage and retention capacity of the landscape.

Together, these interface features form the overall interface of the Wadden Sea region. By analysing each component and making it more resilient, the interface system as a whole becomes more resilient. The result is a set of 15 operational design principles based on the landscape typologies applied along the whole interface. These operational design principles correspond to the overall system vision, as they all aim to improve the spatial framework that promotes land and sea connectivity and interface functionality.

RQ. 3: How can these strategies and principles be translated into landscape architectural design interventions on a regional and local scale?

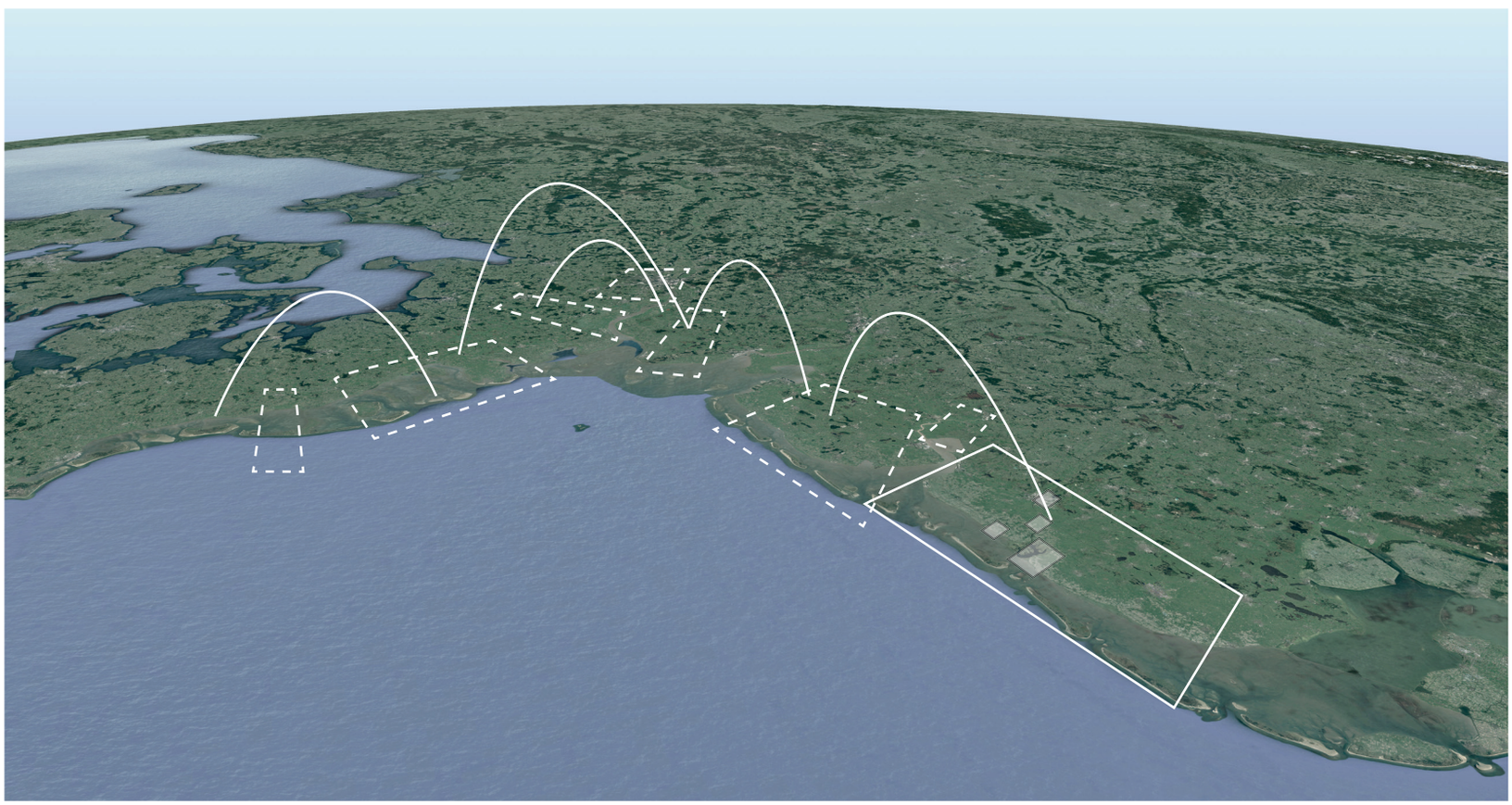
Due to the vast size of the Wadden Sea region, a regional design site was chosen to explore the spatial possibilities of the operational principles. Located in the Dutch part of the Wadden Sea Region, the region bordering the provinces of Friesland and Groningen was chosen because of its inherent potential for interface development. It is a region known for its rural and agricultural identity, due to the fertile sea clay soil deposited in the past by the Wadden Sea. Estuaries used to exist within larger bodies of water, such as the Lauwerszee, but have diminished over time due to infrastructure development.

The regional design acts as a showcase of how landscape architecture design from a landscape-based approach can play a role in increasing the overall resilience of the interface. Based on the identification of the six landscape typologies of the interface and the analysis of different landscape layers, targeted operational interventions can be linked

to site-specific conditions. The result is a regional design that takes into account important landscape structures, reconfigures and mixes existing and new land use functions to create spaces that follow the logic of the landscape, while providing opportunities for human and non-human life. Direct barriers between sea and land are softened by the development of a flexible buffer zone that can evolve both seaward and landward as sea levels rise, taking advantage of sedimentary processes and natural succession. The buffer zone is multi-faceted, acting not only as an extended and self-expanding flood barrier system, but also as an interconnected belt of nature and adaptive agriculture along the entire Wadden Sea coastline. Estuaries that have lost their dynamism due to embankments are reopened in a controlled way by creating a storm surge barrier that allows sediment to pass. Historic and new dikes ensure that natural processes can safely enter the landscape, while at the same time creating space for natural processes to move more freely. As saline water is allowed back into the region, fresh water infiltration zones recharge the aquifers and increase the flow of fresh water to the sea, supported by an intricate network of stream valleys, rivers and historic creeks. The link between the sea and the land is revitalised.

The design itself is open-ended, which means that as this research is an exploration of the potential of an adaptive landscape strategy for designing a resilient dynamic coastal interface, the design can evolve based on future challenges. It is important to provide a flexible approach that can move with these developments. The essence remains focused on improving a resilient interface by giving it space to actually be so; space for self-organisation; space for change; space for a more sustainable future for the Wadden Sea Region.

Local designs, or zoom-ins, are produced to demonstrate the potential of the operational principles at a smaller scale through landscape architectural design. A small number of distinctive sub-regions are selected based on their thematic elaboration of new synergies within the larger context of regional design: innovative agricultural practices combined with improved flood protection; reintroducing dynamism into the historic estuary system combined with reinvented vernacular rural living practices; future-proofing the expanding urban fringe through multifunctional buffer belts. Local design explorations will work out crucial details to make the interventions more tangible, such as the materialisation of sediment traps or the new possible crops along the new river corridors. This step is important to support the landscape explorations and the more abstract systemic vision; the lessons learned can then be scaled up to a larger scale. In this way, abstract goals are linked to tangible elaborations.



Lessons learned through regional and local design explorations can be implemented at similar areas throughout the Wadden Sea Region (satellite image from Google Earth, edited by author)

Discussion

Ethical dilemmas within contemporary complex systems

As mentioned in the previous reflection, the choice of a spatial framework based on a resilience-oriented and landscape-based approach implies a specific positioning. In the pursuit of this positioning and the establishment of large-scale systemic change for the sake of the interface, it is crucial to pause for a moment and reflect on the ethical considerations and complications that have arisen during the project.

Accepting change for the greater good? Regional landscape planning as spatial mediator

Major structural changes that restore natural dynamics to an unnatural landscape bring drastic changes in a relatively short period of time. The Wadden Sea Region has been changing for the past 2500 years and has been shaped by human needs and desires. As the effects of climate change on our global systems and regional landscape have only recently become apparent, there is a great urgency to adapt our existing systems to these changes. However, taking this stance and implementing changes in accordance with natural conditions also means giving up other assets. Some people's private space, goods and livelihoods have to be sacrificed for the common good. Where do you draw the line in terms of sacrifice? How do you accommodate people who are experiencing these changes more drastically? As landscape architects, we are obliged to consider not only the ecological benefits of systemic interventions, but also to include people in these interventions, because these systems cannot be seen as separate entities. In this sense, spatial planning is about creating frameworks that negotiate and adapt ecological processes with social and cultural levels in a mutually beneficial way, using innovative tools.

Investing in the uncertain future

Investing in an uncertain future requires an overall vision in the present. Implementing change on a territorial scale involves complex tasks not only in terms of physical space. Political, regulatory and economic actors are major drivers within the spatial planning of the landscape and are not in a position to make large-scale changes to the landscape if there are no immediate socio-economic benefits. At the same time, however, pressing climate-related challenges are forcing governments to think actively about the allocation and adaptation of landscape functions in relation to future risks. The trade-off is between the costs of investing now or paying for the potential catastrophic consequences of the future. Landscape architecture can act as a navigator between different stakeholders and as a mediator within spatial planning. But to what extent can a vision within landscape systems shape tomorrow's political agenda? Should we, as landscape architects, become politicians in a sense?

Navigating uncertainty, the role of flexible management and adaptive policy making

When discussing tomorrow's agenda, it is not only vision that is needed, but also flexibility within that vision. Designs are created with a particular dot on the horizon, but that dot may

change course over time while the interventions do not move with it. there is a mismatch between the evolution of reality and the design outcome. This is why designs should also leave room for change. To what extent are you actually designing or not designing a site?

Limitations within the profession and societal responsibility

As the climate crisis continues to grow, it is increasingly difficult not to have a negative outlook on the future of the planet we live on. Moving away from a visual profession inherited from garden design and reorienting ourselves towards serving communities, nature conservation and protection, agricultural system development and an overall concern for the whole landscape creates an overwhelming sense of responsibility for the profession. The feeling that landscape architects have to fix everything runs the risk of overestimating our craft. It is the task of society as a whole to critically re-evaluate our relationship with the earth, to co-evolve with nature and to take responsibility for the damage we have done. Landscape architects can set an example through design and inspire without being naive, it is important to try to make people think actively about their relationship with the environment. intervention in the landscape must be done in a deliberate way, based on the value of living within the limits of available renewable resources, to create sustainable landscapes that serve humans and non-humans without degrading the environment. Furthermore, designing without considering the aesthetic consequences of these forms would result in shallow forms, writes Lyle (1991) in his essay Can Floating Seeds Make Deep Forms? Human creativity, the ongoing rhythms and harmonies of nature's evolving order, and analytical thinking are deliberately combined to create deep forms that can make the underlying order visible and meaningful in human terms. Landscape architects can direct the outcome of these deep forms by being able to understand and work with these elements intentionally through knowledge gathering, research into natural processes and human interventions throughout history, landscape analysis, design experimentation through scale and time, while also considering aesthetic qualities.

Measurability

The exploratory nature of this study allows assumptions to be made about the future development of the area and the impact of interventions on the interface. Measuring the quantifiable effects of interventions on the landscape is something that requires further expertise, data, modelling and scenario development. This is not possible within the scope of this project, so assumptions are made derived from theory, case studies, analysis of the landscape at different scales, desktop research and the application of general logical thinking.

Reflection

An interface approach as base for this research

The original motivation for this research was to understand how landscape architecture could contribute to the problem of sea level rise in relation to the drowning of the Wadden Sea and its hinterland. However, during the first phase of this research, it was concluded that addressing isolated issues such as sea level rise or drought would not contribute to the sustainable development of the region as a whole. In the face of significant climate change, mitigation can only be adequately implemented if the whole landscape functions as an interconnected network of performative spaces. The challenges along the interface are interrelated and require a systemic approach. For this reason, the original design brief was broadened to include a general imbalance in the coastal interface. The research objective became To explore the potential of an adaptive landscape strategy for designing a resilient dynamic coastal interface for the Wadden Sea Region.

Within this research, socio-ecological resilience plays a crucial role in the sustainable development of the interface across different spatial and temporal scales. It means that when faced with disturbance, a system is able to absorb it and reorganise itself over time. A system therefore needs the tools to arm itself to face adversity. This requires a different way of looking at how we interact with the landscape, from a more adaptive and holistic spatial planning perspective that takes the natural processes present as a robust framework and negotiates and adapts them with the social and cultural layers. The landscape-based approach, which takes the biosphere as the context for social and economic development from a landscape-first epistemology, is consistent with the basic principles of resilience theory and is consistent with the desired outcome of this research. The decision to develop a spatial framework from a landscape first mentality allows for the exploration of new structures within the Wadden Sea landscape, but at the same time excludes other possible outcomes. For this approach to be successful, acceptance of the exclusion of these outcomes must be established in order to move forward. By examining the interrelationships between these theories and adapting them to the regional context of the area and the objective of this study, a set of theoretical guidelines has been established. These theoretical guidelines point towards a more resilient interface system, but still lack the spatial specificity to make effective changes. They do, however, provide theoretically based support throughout this project. .

The operational principles and overall vision of the area are consistent with the theoretical principles. Further examination of the alignment of the spatial qualities of the regional and local designs with the theoretical principles shows that there is potential for improvement in terms of opportunities for self-organisation and in terms of indeterminacy and flexibility. In terms of self-organisation, space is given to the reintroduction of natural processes, but the design links ambitions to the outcome of this reintroduction. Thus the flexible coastal buffer zone is also linked to the goal of a productive landscape. If the system were purely self-organising, this would not be the outcome. Landscape conditions are linked to a particular direction by design. This is also the case with regard to indeterminacy and flexibility. There is room in regional design for non-designed areas where there will also be more dynamism, where natural processes determine the direction of development, but where more purposeful design plays a stronger role. Dynamics can take place more freely, but

within areas defined by the author. It should also be recognised that while the designs allow for flexibility, there is no further elaboration with possible other alternatives, with what other futures might look like.

Design evaluation

The research shows the implementation of interface principles across all operational scales and the corresponding products show the potential of the new interface of the Wadden Sea region. The design proposal moves through several scales to elaborate how separate entities function within the interface, but at the same time are integrated within a robust framework. Due to the scale of the project, the design needs to define the importance of each scale in relation to the overall interface development of the Wadden Sea Region. A set of broad principles will work for an interface strategy at a systemic scale, but will need to be redefined and evaluated when tested at a much smaller scale. The detailed design zoom-ins are essential within the research as they show how the different design principles work within the existing landscape and demonstrate the overall aim of the research through plan maps, impressions, sections and collages.
At the same time, it's important not to lose sight of the big picture when zooming in to a smaller scale. *'How does this relate to the overall interface?'* is a question that came up frequently throughout the process of this research. The common theme should resonate throughout the research and each product should attempt to relate to it.

Reflecting on design in an academic context

Within TU Delft, the basis of the curriculum consists of four themes that also form the basis of landscape architecture design: process, perception, palimpsest and scale continuum. These themes play an important role in the field and should be reflected in research and design.

The complexity of processes and the dynamics of systems within a landscape, or process, is The complexity of processes and the dynamics of systems within a landscape or process is closely related to the nature of this research. In fact, it is an important starting point within this research. The spatial reintegration of natural processes into a landscape, where they used to move freely but are now lost due to unconscious infrastructural interventions, is reflected throughout the interface design. Perception, the experience of space, is present through zoomed-in design elaborations. The design interventions, which form a landscape-based approach, acknowledge humans and non-humans as users of space. Interventions are integrated into the design to highlight the aesthetics of the more dynamic landscape and impressions are used to show the experience of new landscape synergies. Palimpsest, the attempt to understand and design the landscape from a landscape-based approach, requires reading the landscape as a biography. Multiple scales are analysed to understand the logics in the landscape, vernacular practices are studied and historical knowledge is reinterpreted in a contemporary and future-oriented context. The scale continuum plays an important role in the design of the interface. The research recognises that in order to address local and regional challenges, their interrelationships and interdependencies must be recognised and

addressed. Problems at a local scale are often caused by interventions in the landscape elsewhere, so to properly improve these local problems, changes must also be made in the connected areas. And in order to improve the overall system, it is desirable that all local problems are resolved so that the system can function properly. This is reflected in the project by the establishment of operational principles based on interface characteristics representing all components of the coastal interface.

Relationship between research and design

The graduation project employed the research-through-design methodology to produce a spatial systemic and regional design. Research and design are intrinsically linked, with research providing the reasoning behind a design and enriching its potential by providing knowledge. This research process demonstrates how early settlers in the region used interface dynamics to gradually improve their housing structures. These principles can be applied to address weak spots along the coast. Additionally, the establishment of salt marsh along the coastline requires specific hydrological criteria to be met. The design utilises this knowledge to investigate spatial configurations in physical space.How does this intervention fit within the current physical context? What are the consequences for the existing structures in the landscape? Do I need to adjust my intervention because of it? The iterative process involves design instigating research and research refining the design throughout the project process.

Scope and scale

Because the common thread touches on so many issues at so many different spatial and temporal scales, the goal of the project has sometimes felt overwhelming; much of this feeling stems from the urge to do so many things in so little time. '*You can work on this subject your entire life and still don't know everything',* was another phrase that came up a lot during this final project. Part of the design process is to be able to (re)evaluate the possibilities within the project and still be able to communicate the goal of the research. Within the framework of this final project, due to time constraints, it was decided to test the strategies and principles for one of the identified regional coastal typologies, namely the northern Netherlands, instead of designing each typology.

For future reference

As previously mentioned, the scale of this project is very large. The operational principles are explained in detail in the northern Netherlands region, but can be further elaborated in other regions and other characteristic sub-regions of the entire Wadden Sea Region in order to achieve a more specific spatial integration between strategies and actual space. Further research could focus on creating a spatial and tangible design for the entire region, instead of the current vision. Additionally, the set of operational principles could be expanded by researching local challenges to further enhance the overall interface.

The main takeaway from this project is to identify the bigger picture, rather than just the separate challenges of an area. At the start of this research, I focused on local issues and discovered that seemingly local issues can be interconnected with other places. Recognising that the landscape acts as a system and that processes within it are connected provided deeper insight into the potential impact of regional and local landscape design interventions. Gaining knowledge about the historical development of the landscape and its changing interface system over time provides valuable insights for dealing with today's landscape. This systemic thinking was enabled by moving through various scales during the research process and acknowledging the importance of moving past political and cartographic boundaries. This approach will prove valuable for my future projects as a landscape architect.

Personal growth

During the past year, this graduation project has taught and tested me a lot. It is the most extensive project I have worked on so far, both in terms of complexity and scale. I learned the concept of a systemic approach and effective design by moving through different spatial scales during the research process. This helped me turn conceptual and abstract strategies into feasible design explorations. I have also learned that there is much to gain from the traditional practices and wisdom passed down by our ancestors. Exploring the rich historical landscape of the Wadden Sea Region and the cultural processes that have shaped our current landscape has been a truly fascinating experience. The freedom to explore over the past year has been both exciting and challenging. In landscape architecture, multidisciplinary knowledge is essential for proper design. As landscape architects, we must keep our general objective in mind and avoid straying too far from the focus of our work.

This research has many uncertain elements and unexplored fields. It should be considered an open-ended story that encourages dialogue about our future landscape, rather than a final conclusion.

I look back on this journey with excitement and gratitude. Working on this graduation project has changed my attitude towards landscape architecture as a profession for the better. It has provided me with tools for my future professional endeavours.