



time moves tide

Exploring a resilient future for
small islands in the Wadden Sea

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Time moves tide
Creating a resilient future for small islands in the Wadden Sea

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23rd of June, 2026

All references are listed in the chapters and reference list. The remaining images are created by the author and may be used only while referencing this report.



▲ Honkenstorf, Langeneß
Brouwer (2026)

To the readers

Growing up in the Netherlands the identity of water and water infrastructure has always been present. During holidays to Friesland the trip across the Afsluitdijk was even more exciting than the holiday itself. The dike, which connects North Holland and Friesland, offered endless views: the Wadden Sea on one side and the IJsselmeer on the other. It all adds to the Deltaic character that this country is famous for.

Visits to the Wadden islands let me experience the always so present conditions of water and wind. It was through these experiences that I started to understand the power, both as forces of nature and as externalities that shaped human daily life. It was only during my years of studying at the faculty of Architecture that I realised how much infrastructure had been created to protect us from these externalities. I also learned to be critical and question the amount human exploitation of the land. Our water defence system not only made sure our feet are kept dry but also made sure we could remain using the land as we pleased; the land that we partially “reclaimed” from nature. Or should I say “claimed”. Although the Dutch have a tradition of manipulating the land and water, we might should investigate how we as humans can adapt more, just like nature does.

And we should keep adapting. Personally, I believe that a design for the future can never be final, especially when the future itself remains uncertain. Just as the Wadden Sea is in motion, a design should constantly evolve and readapt to meet the ever-changing conditions of its time. Even with a plan made for the future, we should keep sketching, ensuring its conditions align with the shifting relationship between humans and nature.

I hope with this project to encourage you, as reader, to think critically about our current water defence management and to position yourself adaptable towards changes in our landscape. Moreover, I hope to expand your view on the Wadden Sea and will leave with the hope for you to ever experience the beautiful region yourself.

I want to sincerely thank my first mentor Fransje Hooimeijer and second mentor Francesca Rizzetto for their help and insightful meetings. They motivated me to think outside the box and with that really let me explore my interests. Even when I got lost at some points during the process, their reassurance helped me to find my way back. I also want to express my appreciation to all the people around me for their support. From the ones tagging along for coffee breaks, to the ones being my travel companions to the Wadden islands and so on. Their support was especially felt in the last phases, when their encouragement, as well as them being a healthy distraction, was needed the most.

Glossary

NL	Netherlands
DE	Germany
DK	Denmark
NI	Niedersachsen (a state in Northern Germany)
SH	Schleswig-Holstein (northernmost state in DE)

NAP	Normaal Amsterdams Peil Amsterdam Ordnance Datum
NHN	Normalhöhenull German Mean Height Reference System
DVR	Dansk Vertikal Reference Danish vertical Reference

The maximum difference between the three vertical datums is at most 2 cm, therefore they are considered equal in this report.

Baptist et al. (2019) and Strykowski et al. (2011)

Warft Artificial dwelling mound
Also *terp*, *wierde*, *wurt*, *warf*, *værft* (etc.), depending on language and dialect.

Palimpsest A layered text or landscape where traces of past eras persist beneath newer layers, creating a visible stratification of history.

Longue durée A method of examining history through its longest, slowest, and most profound trends and patterns.

Abstract

The Wadden Sea is an intertidal system that stretches from the Dutch northern coast to the western coast of Denmark, all alongside the North Sea. The Wadden Sea and its islands are under pressure of climate change and face accelerated rising sea levels, threatening its islands and communities, while current policies often overlook their cultural and livelihood needs. In this study, through a *research by design* approach, the following question will be looked into: what are the characteristics of a spatial design methodology in which the *longue durée* is at the base of projecting a climate resilient future for small islands in the Wadden Sea? The theory of *longue durée* will be used to define the long-term changes and their influence on human behaviour. Influenced by Deltares, three solution directions (protect, seaward and move) are explored and expanded onto the Wadden Sea, to create a preferred alternative solution direction in which more human adaptation is envisioned. This translates to spatial interventions for three island typologies (salt marsh, polder and dune islands) that have been distinct during the *research by design* process. The preferred solution direction, Islands in Motion, emphasises the notion that people should stop manipulating water and land, and adapt more to it, just like nature does. This solution direction combines adaptive strategies tailored to each island typology, balancing preservation of cultural heritage while stressing the need for people to adapt to the dynamics and *longue durée* of the Wadden Sea.

Key words: *longue durée*, *research by design*, sea level rise, solution directions, Wadden Sea islands

	To the readers	5			
	Glossary	6			
	Abstract	7			
1	The Wadden	11	4	Solution directions	71
	Introduction to the Wadden Sea	12		Protect	72
	Problem statement	17		Seaward	78
	Research question	20		Move	84
	Objectives, scope and relevance	21	5	Island typologies	91
2	Approach	23		Islets	94
	Methodology	24		Salt marsh island	96
	Research by design	24		Langeneß	100
	Solution directions	26		Polder island	108
	Design workshop	29		Nordstrand	112
	Theoretical background	30		Dune island	118
	Socio-ecological system	30		Schiermonnikoog	122
	<i>Longue durée</i>	30	6	Islands in motion <i>Design phase</i>	131
	Resilience	32		Wadden Sea	134
3	Value of the area <i>Pre-design phase</i>	35		Salt marsh island	138
	Heritage value	37		Polder island	144
	UNESCO World Heritage	38		Dune island	150
	Monumental value	40	7	Conclusion <i>Post-design phase</i>	157
	Languages and dialects	44		Conclusion	158
	State of nature	46		Reflection and evaluation	162
	Dynamics	46	8	Appendix	167
	Flora and fauna	56		Design workshop trial	168
	Soil	60		Data management list	171
	Economy	62		References	172
	Challenges	66		Image sources	179
	Sea level rise	67			

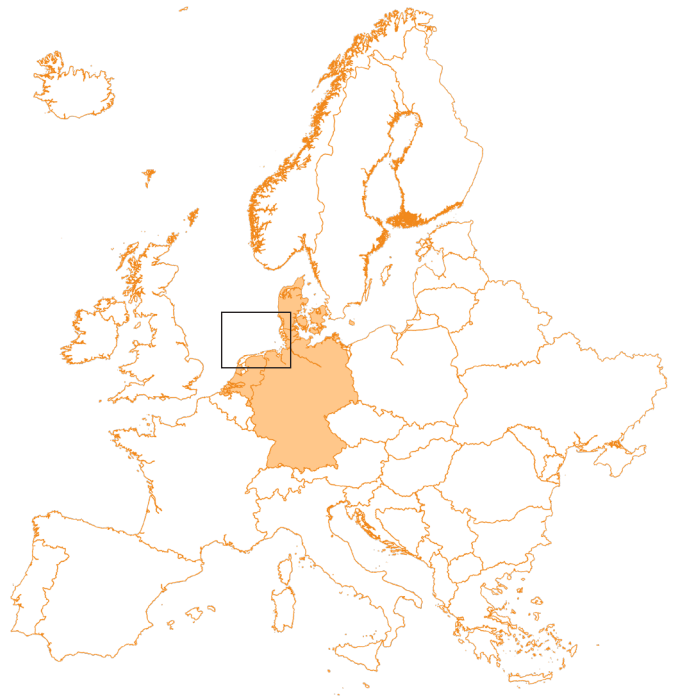
Contents

The Wadden

Introduction to the Wadden Sea

The Wadden Sea is an intertidal zone in the southeast of the North Sea, which is part of the Netherlands, Germany and Denmark. There are 61 islands in the whole of the area of which 28 are inhabited. Others differ from sand- and mudbanks to islands that are considered nature reserves (Prins, 2020). The islands are also known as the Frisian islands or, in this project, the Wadden islands. Around 75,000 people live on the islands of the Wadden Sea (Wadden Sea World Heritage, n.d.) and are affected by the effects of climate change, being in close contact with the natural elements; water and wind. The Wadden Sea is a transition zone between the North Sea and the mainland (Trilateral Scientific Community, 2018) consists of a shallow body of water with tidal flats and wetlands, containing a lot of biodiversity. The Wadden Sea is considered an natural UNESCO World Heritage Site (UNESCO, n.d.-b). This has been the case for the Dutch and German parts since 2009; the Danish part was added in 2014. The site meets the criteria of a natural heritage, according to UNESCO (n.d.-b) because it is a uniquely large and varied coastline formed by the buildup of sand and mud with almost uninterrupted dynamic natural processes. It's even one of the last remaining intertidal ecosystems of this size. Furthermore, there is a huge amount of flora and fauna species. The site is, for example, a popular spot for migrating birds.

Being considered as a UNESCO World Heritage means continued protection and conservation of the natural environment (UNESCO, n.d.-b). This is also where the Trilateral Wadden Sea Cooperation (TWSC) comes into place. This is a collaboration between the three countries: the Netherlands, Germany and Denmark. They have an agreement on the protection and conservation of the area. The official cooperation on the protection of the Wadden Sea started in 1978, was initiated because of ecological concerns in the 60s and 70s, and with the goal to strengthen the collaboration between the three countries (Slob et al., 2016).



Wadden Sea area in Europe ▲

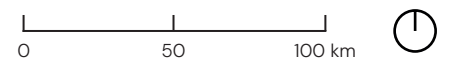


UNESCO World Heritage: Wadden Sea property
Adapted from UNESCO (n.d.-b) ▲



Wadden Sea area and its islands, divided by country

 Wadden Sea



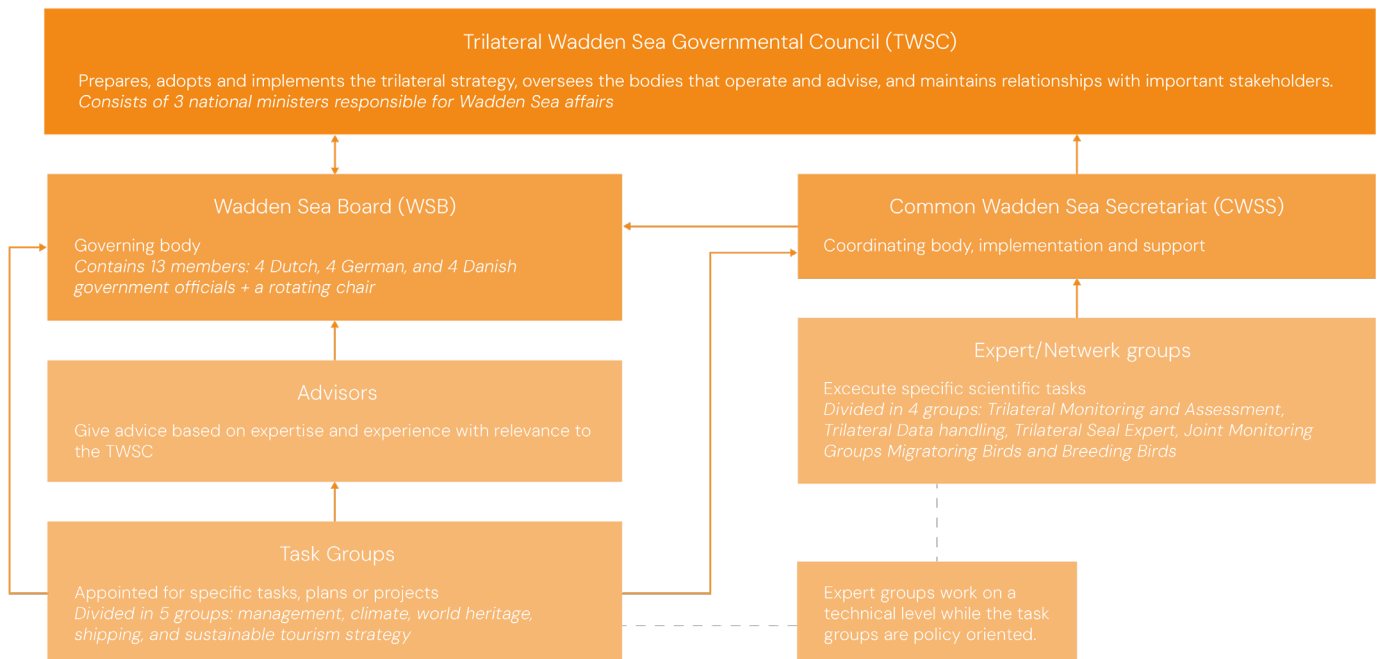


▲ Participating countries in the TWSC

The TWCS is supported by its governing body, the Wadden Sea Board (WSB), its coordinating body, the Common Wadden Sea Secretariat (CWSS) and several technology and policy oriented experts (Slob et al., 2016).

Next to the protection and conservation of the Wadden Sea, the aim of the TWSC is to assess the quality of its ecology, educate the public and raise awareness amongst them on the protection of the area. Furthermore, the TWCS makes sure the Wadden Sea is developing while taking its natural and cultural values into account (CWSS, 2017).

The agreement on which the TWSC is based, is not legally binding and because of this it is sometimes difficult to come to common terms with plans for the whole Wadden area and resolute conflicting issues. 'Time consuming [...] negotiations and consultations between the three countries on these issues' (Slob et al., 2016, p. 327) are needed to make progress regarding the future of the Wadden Sea heritage.



Overview of organisational structure of the TWSC ▲
Adapted from CWSS (2017); Slob et al. (2016)

Living on the Wadden islands

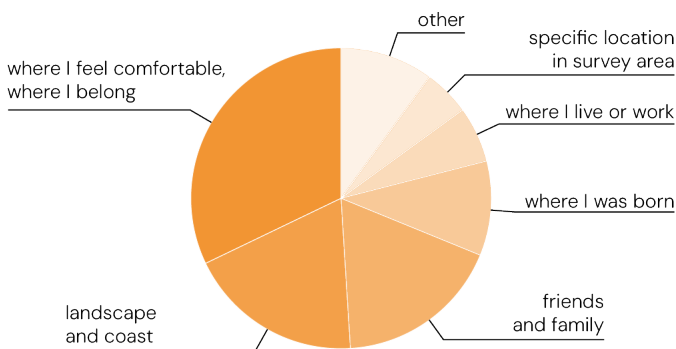
The sea has been a commonality on the Wadden islands for centuries. During their lives inhabitants have been involved with water, with threats of being surrounded by water, but also with the positive aspects. Throughout history they were able to make a living because of the water, i.e. fishing, trade through shipping. The constant struggle to live in the natural landscape co-existed with their respect for that same nature. This Wadden perspective is still common today. In a survey of Coenders and Schriek (2013), a big group of participants coming from both Dutch, German and Danish Wadden islands, described the region that they come from as the entire Wadden area instead of being from their country.



Inhabitants of the Dutch Wadden Islands
Stills from Prospektor (2018) ▲

The powers of nature play a significant role in the inhabitants' feeling of being at home and part of their *Heimat/Thuis/Hjemsted* (DE/NL/DK). The German concept of *Heimat* 'draws on perceptions of place, the values assigned to place, the emotional connectedness to place that arises from social interaction and also (historical) narratives of place' (Ratter & Gee, 2012, p. 136). It entails the somewhat intangible aspects of living on the islands in the Wadden Sea. The inhabitants want to do their best to preserve the nature. 'It is their dedication to a natural environment as the basis for sound social conditions that keeps the Wadden Sea region alive, not only as a historical and ecological important area, but even more as the region where giving and taking should remain defined by nature and much less by industries' (Coenders & Schrieck, 2013, p. 36).

The common worries of the islanders are mostly the threat of losing territory. The Wadden area is getting smaller and shallower. The horizon that was made up of sea and sky is changing, with the development of industrialisation, CO2 storage and power plants. The group *Ökologisch Wirtschaften!* ('*Ecological Economy!*') on Pellworm (DE) calls for 'action and transition from rather unsustainable farming practices, depopulation and mainland dependence, towards a decent livelihood for all islanders gained from renewable energies, organic farming and soft on-farm tourism within a unique and vulnerable ecosystem' (Lorenzen, 2019, p. 107). This proves that people on the islands want a combination of being able to make a living on the islands in combination with preserving their ecological surroundings.



Results to the question: 'What is *Heimat* to you?'
Adapted from Ratter and Gee (2012) ▲

Problem statement

The future of the Wadden

The Wadden islands are frequently in the media, concerning high water levels and extreme weather conditions. There are many signs in the landscape that indicate occasional high water levels and images of flooded areas are not uncommon.

Global warming is expected to increase the change in weather patterns, extreme storm events and rising sea levels will probably proceed in the coming decades or even coming centuries. At the same time, land subsidence may further enhance the relative rise in sea levels (Trilateral Scientific Community, 2018). The Wadden Sea in the territory of the Netherlands, Germany, and Denmark is also being affected by this climate change. Because of rising CO₂ and other greenhouse gas emissions, global temperatures are increasing. In the Paris Agreement, all parties made the agreement to limit global warming to 2 °C by 2100, although it is still uncertain whether this goal will be reached. As the climate warms, sea levels rise. Scientists are unsure how fast this will happen, mainly because the amount of future emissions and melting ice in Antarctica is uncertain. What we do know is that sea level rise is already happening and is accelerating. At the moment, the sea level in the Wadden Sea rises with about 3 mm per year (Philippart et

al., 2024). However, parts of the Wadden Sea may no longer cope if this increases too much (Deltaprogramma, n.d.). By 2100, sea levels could rise by up to 2 meters (KNMI, 2023). The map projects a water level of 2 meters above high tide line, which could be reached through combinations of rising sea levels, storm surges and pressure on the engineered coastal defence system.

Despite governmental plans to protect the Wadden Sea against climate change, the future of its islands remains uncertain and inhabitants feel neglected (Coenders & Schrieck, 2013). Current national policies largely treat the islands as a buffer protecting the mainland (van der Brugge & de Winter, 2024), as they form a barrier chain for the mainland, but the perspectives and livelihoods of island communities are often overlooked. The UNESCO World Heritage focusses on the natural landscape of the Wadden Sea and its ecologies, while neglecting the cultural heritage. 'The land in between and around it is grosso modo not part of the protected zone' (Egberts et al., 2018, p. 26). Looking into these islands, the natural changes that they have undergone and how islanders have adapted to the those, could be of quality to research a more resilient future of the Wadden Sea.



'Do not park regarding high water', Terschelling (NL) Geerts (2025) ▲

NYHEDER

Turist-ø truet af massiv oversvømmelse: Nyt kort sætter spot på de største danske risikoområder

Rømø er blandt 11 nye stærkt oversvømmelsestruede områder i Danmark, Kystdirektoratet netop har udpeget. Udpegningerne er sendt i høring hos de pågældende kommuner.

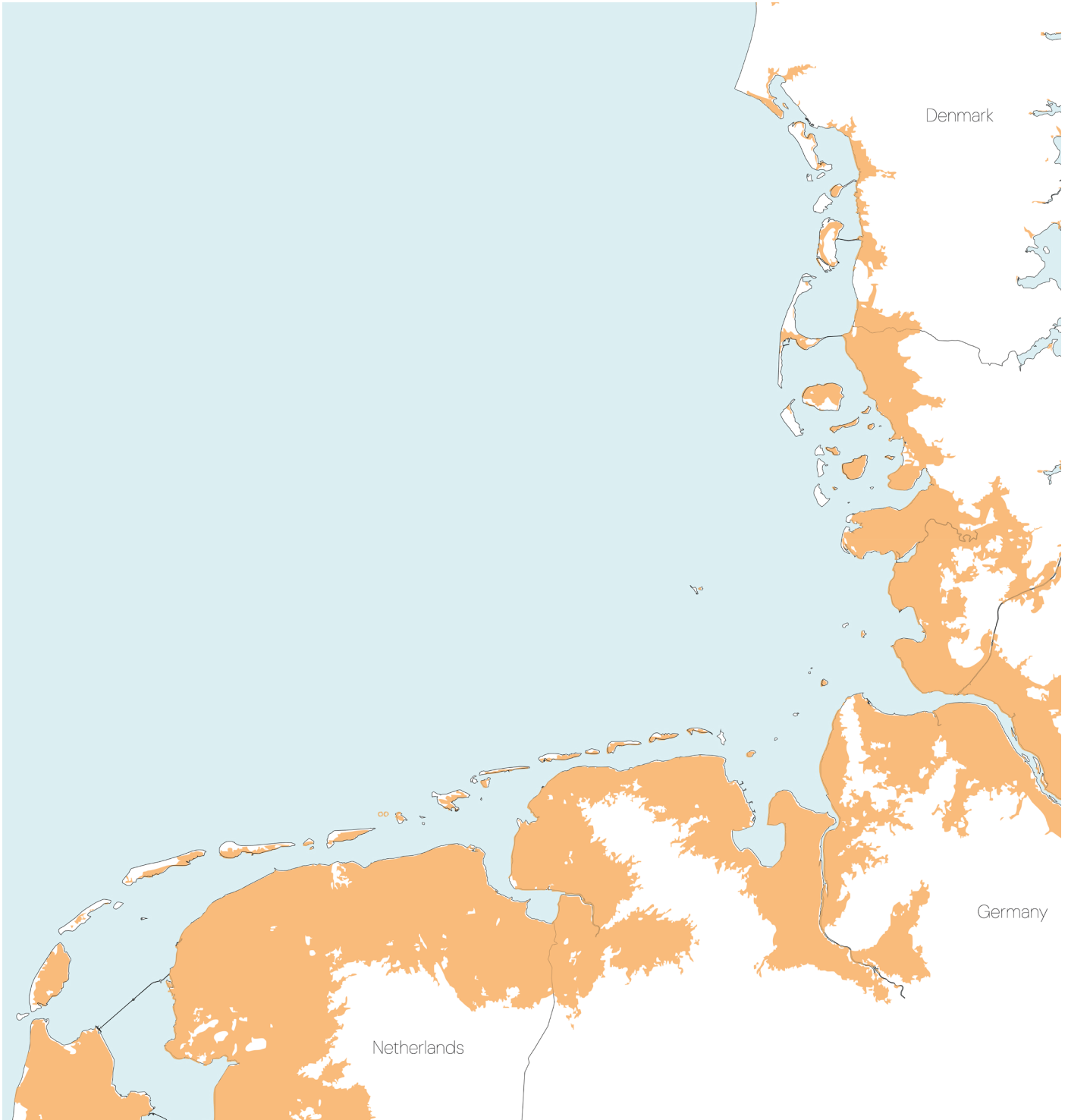
'Tourist island threatened by massive flooding', Rømø (DK) Hansen (2024) ▲




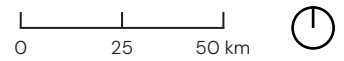
Flooding in the port of Oudeschild, Texel (NL)
Texelse Courant (2019) ▲



Flooding in the ferry port of Fanø (DK)
Hansen-Christensen (2025) ▲



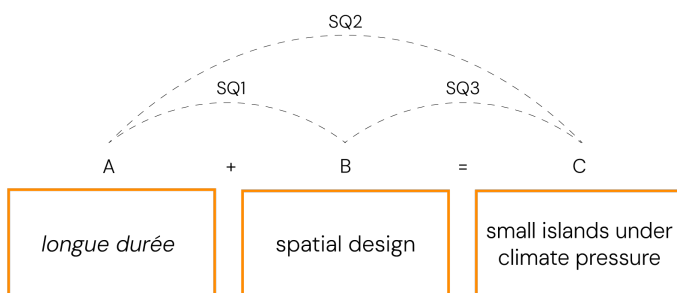
 Flooded area (water level 2m above high tide line)
Climate Central (n.d.)



Research question

Using *research by design* methodology this research and design project will produce an approach for the whole Wadden Sea and design for one of the island. Through *research by design*, proposals will be made for the area of the Wadden Sea and its islands. With this question I emphasise what I envision for the future: a climate resilient future for small islands in the Wadden Sea. I want to see if I can use the theory of the *longue durée* for this. The main research question is:

What are the characteristics of a **spatial design methodology** in which the ***longue durée*** is at the base of projecting a climate resilient future for **small islands in the Wadden Sea**?



This research question is explored through the following sub-questions, that have been derived from the three domains of the main research question.

SQ1: What is the theory of *longue durée* and how could using this be beneficial in spatial design?

This question combines the domains of *longue durée* and spatial design. Answering questions on *longue durée* and physical designs for spatial adjustment intervention.

SQ2: How can spatial design be used to design for a climate resilient future of small islands?

This question combines the domains of spatial design and small islands under climate pressure. Emphasising the need for a resilient design, as opposed to resistant. Exploring the effects of climate change on the small islands of the Wadden Sea and proposed solution directions for the future.

SQ3: What changes have been made over time to small islands in the Wadden Sea to adapt to climate pressure and how could this be used for the future?

This question combines the domains of *longue durée* and small islands under climate pressure. Exploring the cultivated landscape of the small islands of the Wadden Sea and the particular value of *longue durée* on small islands.

Objectives, scope and relevance

Objectives

The aim of this project is to learn about the complex relation that is within the socio-ecological system of the Wadden Sea area. Through the execution of *research by design* this relation is explored and will create a better understanding of the workings of the Wadden Sea, its problems and the possible future of the islands. Eventually the goal of this project is not to explicitly solve the problems that are occurring in the Wadden Sea, but to develop a methodology to design with these problems as variables, to explore alternative realities and steer up a discussion about our human role in the future of socio-ecological systems.

Scope

The scope of this project is the whole of the Wadden Sea, with additional focus on its inhabited islands, as human interventions to control the sea have been taken place mostly here. What started with an interest in the Dutch Wadden area, progressed into a project that exceeds the Dutch borders to Germany and Denmark. The reason for this is that natural systems are not bound to administrative boundaries. The Wadden islands and waterbodies along the three countries, as a whole, are considered a natural UNESCO World Heritage (UNESCO, n.d.-b) and next to national governing, a trilateral collaboration is established among the three countries to discuss and decide on matters that include the Wadden Sea (*Trilateral Wadden Sea Cooperation / Wadden Sea*, n.d.). The final vision will focus on the whole Wadden Sea and will be projected onto characteristic island typologies on scales, ranging from the whole Wadden area to individual islands. Therefore, firstly the Wadden Sea is inquired through its historical value and heritage, the values of its ecology, the economic and connective activities, and the occurring challenges. This knowledge will help establish the most important values to design with and create the base to research how people can adapt their livelihoods to the dynamics of the ecosystem in which they live. Nature habitats play a vital role in this and with the attention of UNESCO, these natural systems are addressed.

Societal relevance

Climate change is a hot topic and frequently discussed in the field of Urbanism. The Wadden Sea is an interesting site concerning climate change, as it is a big natural system, with an important ecosystem and natural habitat for species. The system is very depended on the externalities that are influenced heavily by climate change. Within this natural system a lot of cultural heritage exists as well. The society on the islands is formed through the changes of the *longue durée*. Many residents inhabit the islands and the Wadden Sea is a field for economic drivers, attracting many tourists throughout the year. As UNESCO regards the natural ecosystem of the Wadden Sea area, the question arises how people play a role in that natural system, and how they will do so in the future. Furthermore, the current political climate underscores the importance of strong international cooperation. The existing trilateral agreements between the Netherlands, Germany, and Denmark offer valuable lessons to create a plan crossing the boundaries of the three countries.

Scientific relevance

This project contributes to further research on possible methodologies to incorporate theoretical and practical application of *longue durée* thinking in spatial design for small islands. There has been numeral broad research on the ecological consequences of climate change in the Wadden Sea, for instance by UNESCO. This study, however, adds, next to research of nature-human heritage, to urban design through multiple scales, that is characterised by interdisciplinarity. While there is a trilateral collaboration between the three countries that share the landscape of the Wadden Sea, there is limited research on cross-border spatial designs for climate adaptation. Furthermore, the aim of this study is to use the islands not as protections for the mainland, but to see the islands as objects to protect. This study tries to find a design methodology to see the Wadden Sea system as a borderless landscape and to reinterpret our relationship between nature and time on the road to climate adaptation.

Approach

Methodology

Urbanism is an interdisciplinary field which addresses problems in the urban context by combining design, physical sciences and social sciences (Rocco & Gonçalves, 2025), alternating which aspect weighs heavier depending on the subject. The research group Delta Urbanism at TU Delft can be pinpointed between the pragmatic and positivist perspective, addressing both the creative and practical aspects of the urban context and the environmental and technical aspects. This concerns for instance combining urban planning and design with the technical foundation of hydrological workings in Deltaic context. However, this project also leans to constructivism, as the relationship between people and the defence against the effects of climate change is of significant importance.

Research by design

This project is executed through the process of *research by design*. Both research and design have their own definition. Research aims to illustrate how things are. Design aims to explore how things could be (Van Cleempoel & Pint, 2015). Combining these fields establishes the method of research by design, design being a part of a research process (Rosemann, 2000). There occur to be many perspectives on its definition and the way research and design are connected. Hauberg (2011) acknowledges this by calling the term *research by design* a strategy to define the numeral ways in which both fields interact while obtaining new knowledge about the context through the process of designing. The methodology aims for unexpected exploration to test spatial potentials. De Queiroz Barbosa et al. (2014) define *research by design* as a form of academic research where design serves as a methodology for investigation, involving the development and the exploration of the design project, through sketches, mapping etc., to generate knowledge. Through the process of designing, questions to be discussed in research become clear and 'the testing of the context by focussing on specific goals for a new future will

bring insights of quality and potential' (Hooimeijer, 2023, p. 18).

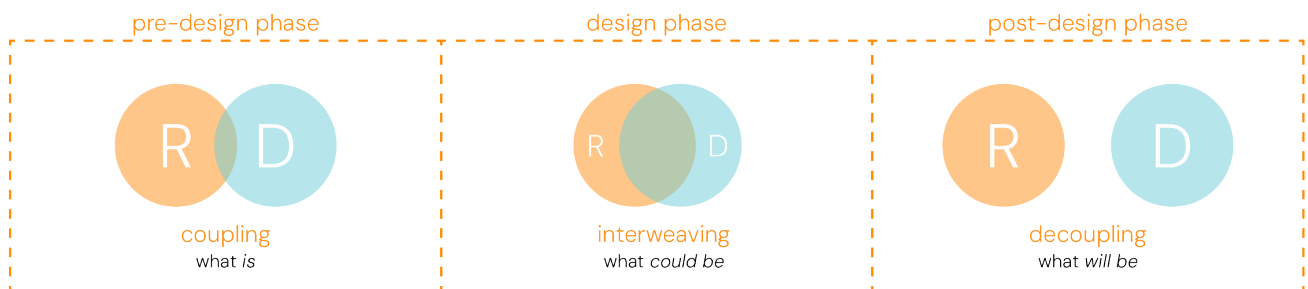
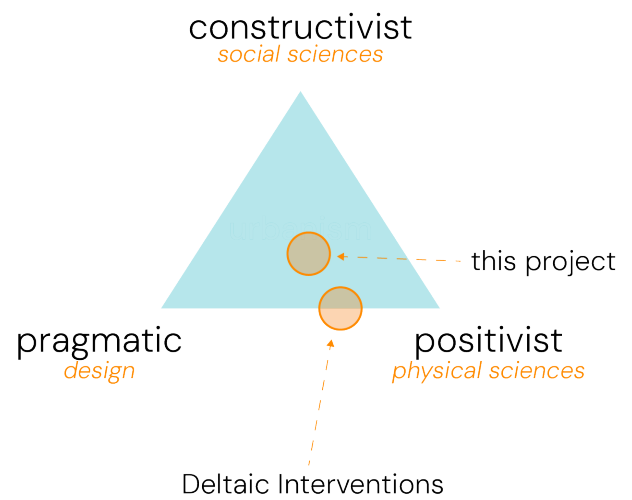
Both Jonas (2007), and Nelson and Stolterman (2012) see *research by design* as a transformation from what *is*, to what *could be*, to what *will be*. When combining this with the relations between research and design, defined by Basballe and Halskov (2012), a great base for *research by design* is set. They address three dynamics between research and design: coupling, interweaving and decoupling. Coupling aligns the design and research interests, establishing a shared framework and constraints for the next steps in the process. Interweaving is a dynamic where insights simultaneously inform design interest, as well as research interests, while also influencing each other. Decoupling modifies the focus by prioritizing either design or research as the central element of the process. Both aspects are discussed through evaluation and reflection.

The process of *research by design* is summarised in the diagram which, aligning with Roggema (2016), is distinguished in three phases: pre-design, design and post-design. The fields of research and design are both present during the whole project, however, their relation changes. In the pre-design phase, the research and design interests couple up to understand what is. This means understanding the current state, stating the problems, and aligning research and design (coupling) to establish a shared foundation of knowledge on which the project will be based. The design phase follows and possibilities are explored to see what could be. Here research and design start to co-evolve, interact and inform each other, in a process of iteration (interweaving). The post-design phase includes creating this new reality as it looks at what will be. This part of the process separately evaluates both research and design (decoupling) and focusses on the implementation and reflection of the design process, after which outcomes will be synthesised. The three phases are incorporated into the methodology framework (next page) which shows the relationship between

sub-questions, theories and methods. The main method for the design is extreme solution direction exploration. Incorporating this into the research by design process creates a does not create a specific outcome, but multiple principles that could create an alternative future.

Urbanism
Adapted from Rocco (2025) ▶

Research by design
Adapted from Nelson & Stolterman (2012), Jonas (2007) and Roggema (2016) ▼



Pre-design phase

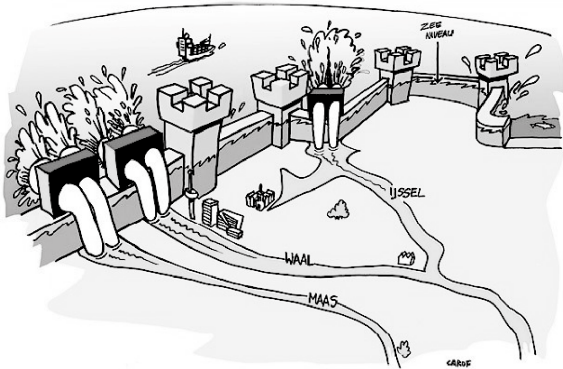
Firstly the study area is researched on the Wadden Sea scale throughout the period from 1500 until the future. Researching the *longue durée* is done through comparing different time scales, creating a palimpsest of the islands. The analysis is executed through a study of several spatial layers, loosely based on the Layer Approach (De Hoog et al., 1998). The first layer of this approach is the natural systems (Sijmons, 2002), the substratum, the soil and water. 'Here the dynamic of change is very slow' (Meyer & Nijhuis, 2013, p. 163). This layer is effectively mapping the *longue durée* of the Wadden Sea. Applying the *longue durée* within a multi-scalar approach for spatial design for the Wadden area can highlight the interplay between the slow, long-term ecological processes and the cumulative effects of human interventions over time. With this historical insight, a palimpsest is created, to reveal the future social behaviour, the engineered impact on nature, landscape and society and what lessons this can teach us for designing a resilient future for the Wadden Sea's small islands.

Design phase (solution directions)

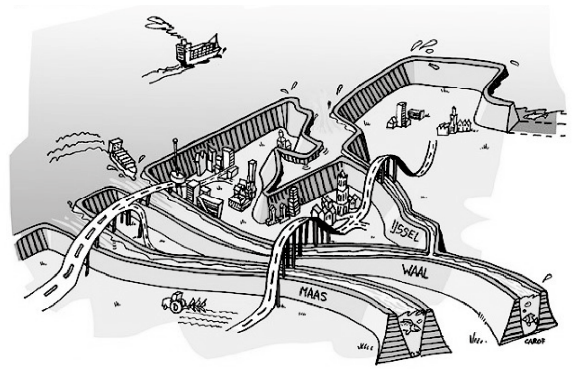
The Dutch government works on protecting the Netherlands against floods and freshwater shortages for now and future generations. She does this under the National Delta Programme, led by the Delta Commissioner, which entails the way in which the Dutch government plans to do this the Delta programme is an annually revised proposal of the Delta commission concerning water safety, fresh water supply and spatial adaptation (Staf Deltacommissaris et al., 2025). As part of the Delta Programme further research has been done between 2019 - 2026 on sea level rise (Deltaprogramma, n.d.). Deltares, an independent institute that executes research in the field of water and subsurface, came up with four cornerstones, or solution directions, of what the Netherlands could look like in the scenario of an accelerated sea level rise (Deltares, 2019), based on internationally legitimised ideas to deal with this (IPCC, 1990). These solution directions are defined

as: protection-open, protection-closed, seaward and accommodate (or move along). This project uses this approach as the main design method in exploration of extreme alternatives. The explored solution directions are renamed in this study as: Protect, Seaward and Move. They are based upon those of Deltares and their spatial explorations through consortia. However, they have been altered to fit the Wadden islands and have been extended to the whole area of the Wadden Sea.

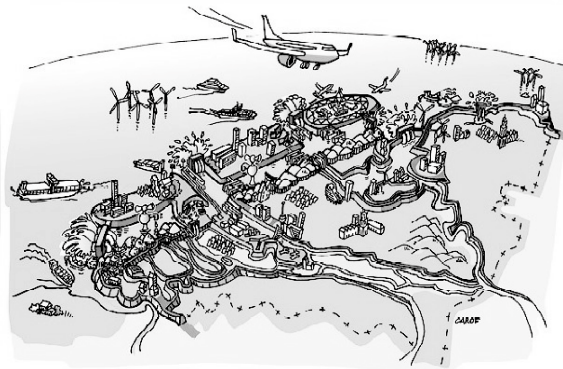
With this design-driven method, extreme alternatives are being explored. Some might seem excessive, but this helps activating the dialogue about the subject. An example of such an extreme exploration is the North Eastern Enclosure Dam (NEED), which was conceived by Groeskamp and Kjellsson (2020). They created the idea of a dam that fully enclosed the North Sea as a thought experiment. While the plan is extreme and might feel impossible, their aim was mostly to vocalise what extreme measures are needed if climate mitigation is not taken seriously, or as they put it 'mitigation now, or NEED later' (Groeskamp & Kjellsson, 2020, p. 1182). Especially in the climate change cases sometimes it is needed to discuss the extremes to explore solutions but also create awareness on the importance of climate mitigation.



Protect-closed



Protect-open

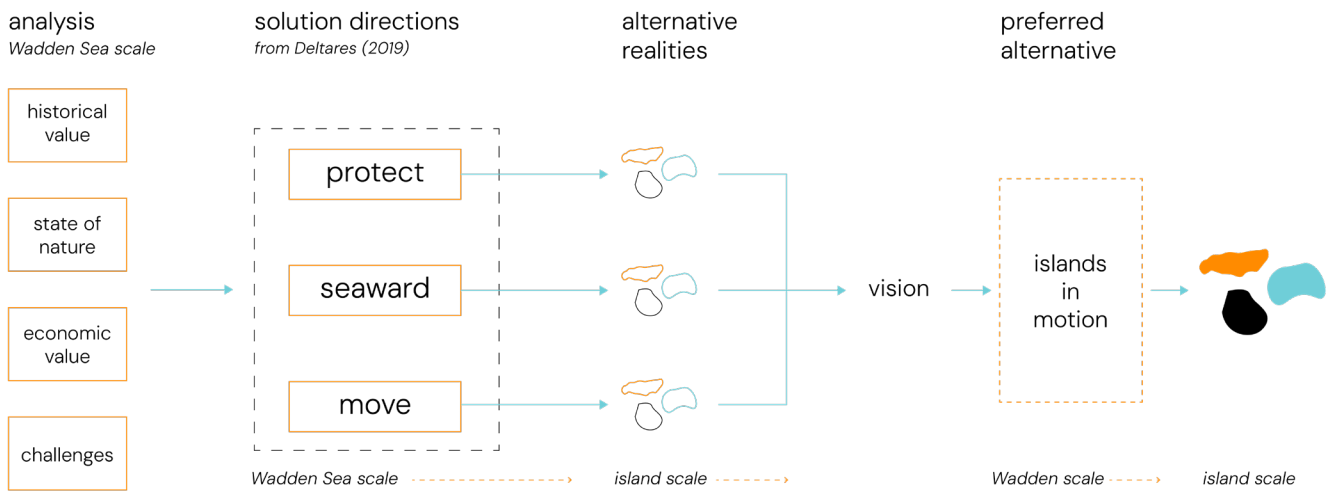


Seaward



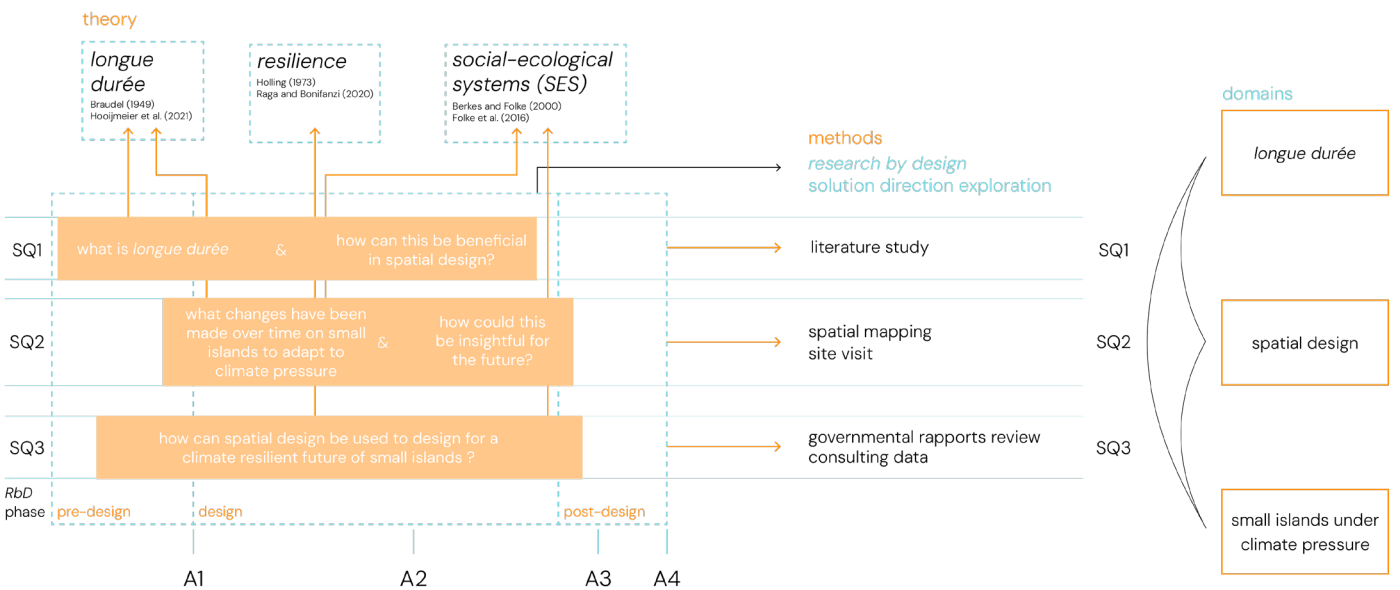
Accomodate (move along)

▲ Deltares solution directions
Adapted from Deltares (2019)



▲ Design framework

In addition to the exploration of the Deltares-solution directions, the following methods are used to answer the main and sub-questions and to create a knowledge base upon which the domains of the research questions are build. With the literature review different theories on spatial design, historical layers and resilience are researched. The exploratory method of mapping is used to get a clear idea of the islands and the Wadden Sea, what happens there, but also how it has evolved and is constantly changing. Reports are consulted to learn about the sites' values and future governmental plans for the Wadden Sea give insight into what is already planned, what aspects are taken in consideration, and which aspects might be forgotten. Data is collected to learn about current and future effects of climate change and finally, through site visits to a few of the Wadden islands, various aspects of the site are explored.

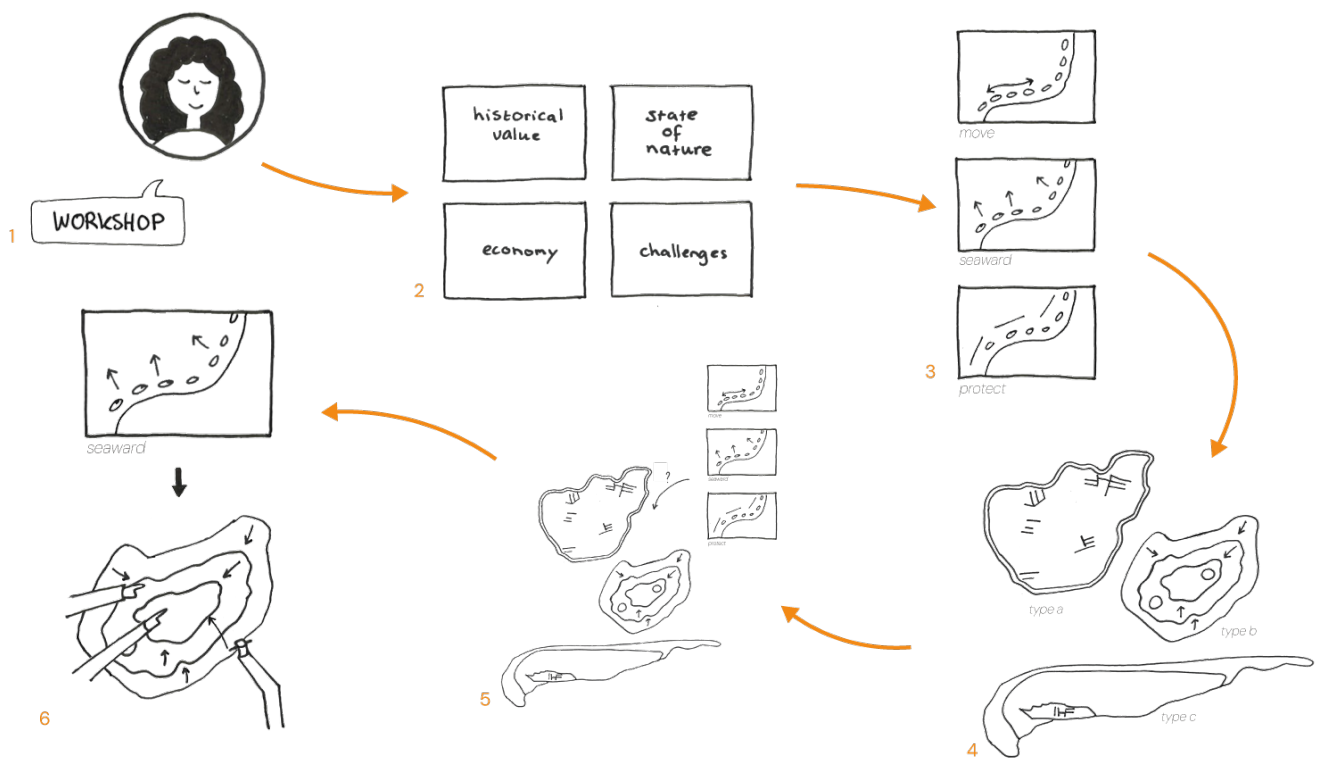


▲ Methodological framework

Design workshop

Through a design workshop with fellow students with a background of Urbanism and Water management, it is studied how the *longue durée* can be used in the design process of a resilient future for small islands in the Wadden Sea that are threatened by sea level rise and increasing water temperatures. A minizine will be distributed amongst those taking part to explain the flow of the workshop. The workshop gives way for fellow students to give feedback on this project and their insights of their own work can be valuable to further design.

1. The goal of the workshop is explained along with some background information on the project to establish an informed basis for the participants to help designing.
2. Four maps show the important conclusions of the analysis of the area of the Wadden Sea.
3. The three different solution directions are shared with the participants.
4. Participants will be informed into which three island typologies the Wadden Islands are distinguished.
5. The question arises to what it would mean for these three typologies to be part of the solution directions.
6. All participants discuss and sketch together to project the solution directions onto the island typologies.



▲ Steps of the workshop

Theoretical background

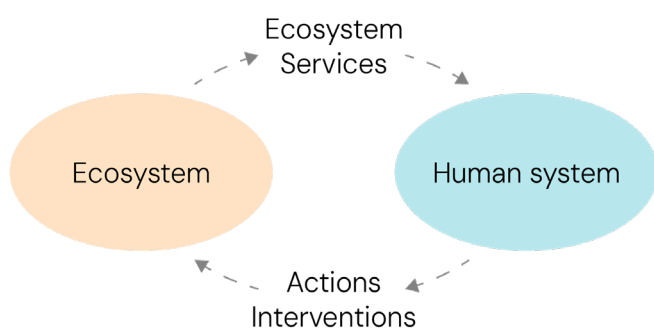
Socio-ecological system

The Wadden Sea is a socio-ecological system (SES). A SES is an 'integrated concept of humans-in-nature' (Berkes & Folke, 2000, p. 4). The natural ecosystems and human societies are tightly interconnected and constantly influencing each other. Folke et al. (2016) even go as far as to emphasise that human societies and natural ecosystems cannot be separated. Human well-being is dependent on the interaction with the biosphere. Leaving out the consideration of natural ecosystem and its stewardship in social problems will not create 'long-term sustainability for people on Earth' (Humanity [...] Precondition section). Furthermore, human actions, on the one hand, change the ecosystem, like how dikes alter sediment flows and land cultivation affects biodiversity. On the other hand, the ecosystem dynamics also influence human behaviour and shape human decisions. The changes in the ecosystem have for instance initiated the development of coastal defence strategies. This links back to the theory of the *longue durée*, which describes how slow changing conditions and natural systems influence human action over extended historical periods (Grote, 2015).

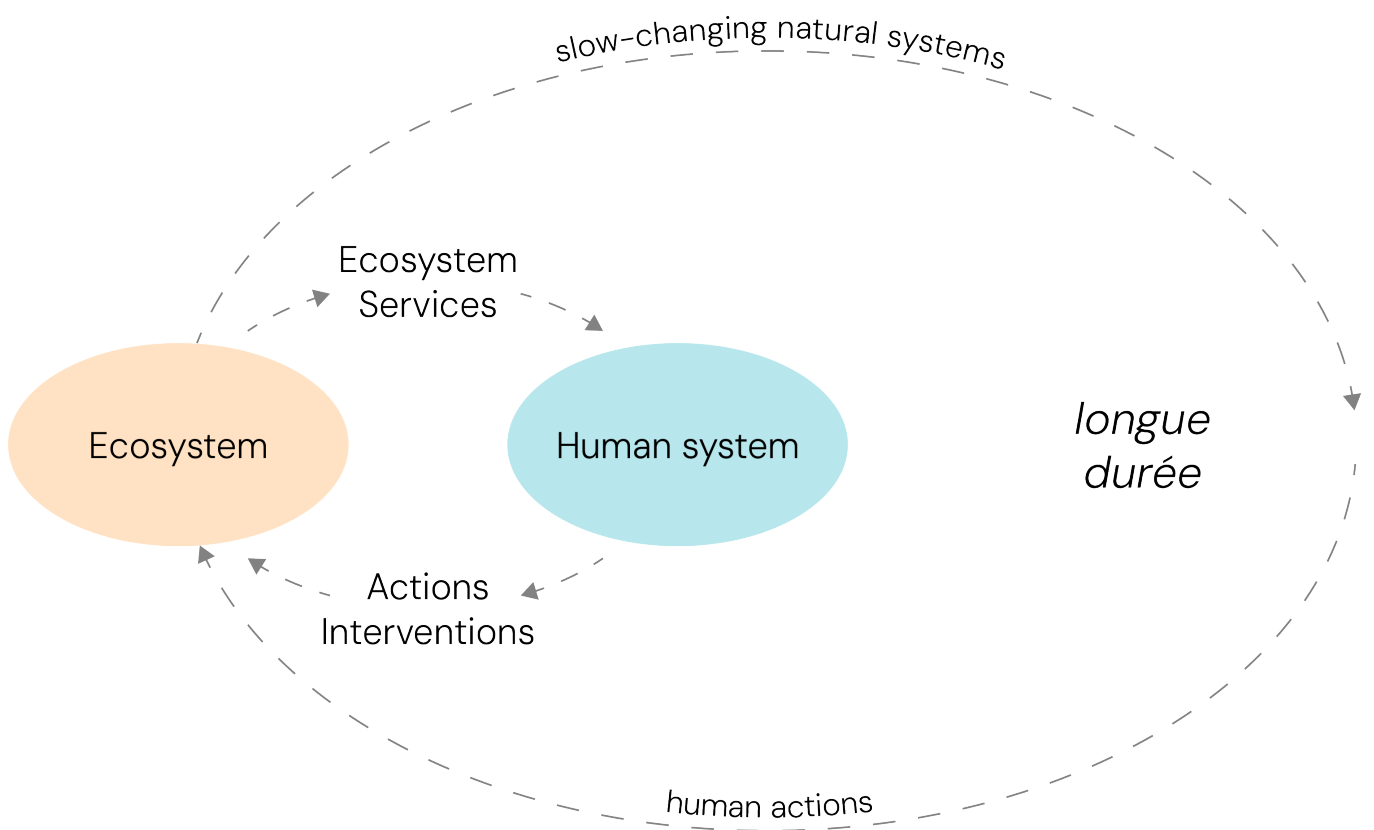
Longue durée

This links to the concept of the *longue durée*, which is used as a contribution to the design process in this project. The idea of the *longue durée* (long duration in French) stems from Fernand Braudel (1902-1985), who took part in the Annales school of history. *Longue durée* is a method of looking at the long lines of history, focusing on the long-term, slow, and deepest temporal layer of history (Braudel, 1949/1990). He distinguishes the *longue durée* from the 'traditional history of events' (Grote, 2015, p. 5); meaning the short-term history in which separate events are studied, also called the *histoire événementielle*. Braudel describes with the *longue durée* the geography, the relationship between the dynamics of the landscape, and how humans have reacted to this, effectively mapping the socio-ecological system at a macro scale. This historical perspective shows how cultures have developed when people had to react to changes in climate and soil (Braudel, 1949/1990) and, therefore, gives information on how the landscape has been influenced by human cultivation (Hooimeijer et al., 2021).

Using *longue durée* in spatial design for the Wadden area could help understand the relationship between the slow, long-term layer of the Wadden Sea and the consequences of the interventions that humans have done because of it. The historical insight that the *longue durée* and the analysis throughout history teaches us, could tell us something about the future social behaviour, the engineered impact on nature, landscape and society and what could be learned from this to design for a resilient future for small islands in the Wadden Sea.



◀ Socio-ecological system (SES)
Adapted from Resilience Alliance (2007)



▲ Visualisation of the *longue durée*
Adapted from Resilience Alliance (2007)

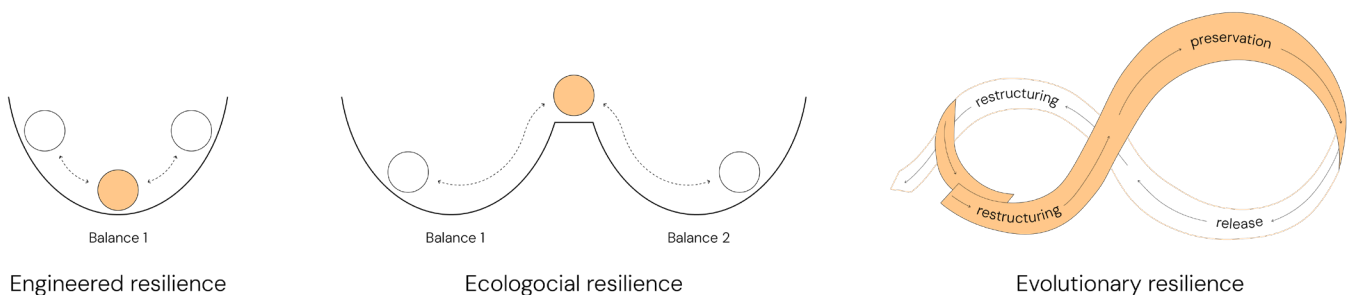
Resilience

While throughout history there have been examples of people living in close contact with the sea, an impressive defence system has developed in the Wadden area with an aim to separate us from it and to be resistant against the sea. Liao et al. (2016) advocates for a paradigm shift from resistance to resilience, from trying to manipulate water to adaptation. The current flood control infrastructure might not be able to cope with the more extreme weather conditions and the increasing floods. In some situations, frequent storm surges and events of flood may surpass the capacity of design. Resilience should be the guiding principle in future planning, as opposed to resistance, as it enhances understanding of the underlying conditions, improves risk awareness, and ultimately strengthens the connection between humans and nature. But how is resilience defined?

The idea of resilience was originally introduced by Holling (1973) as a way to analyse how ecosystems with multiple possible stable states, called alternative attractors, can maintain their original condition despite disturbances. Resilience in a SES refers to its capacity to withstand disturbance and adapt when changes are happening within the system, but also the ability to reorganise and transform (Reyers et al., 2018).

According to Holling (1996) there are two types of resilience. The first, more traditional definition, concerns efficiency, predictability and constancy. It wants to achieve a 'stability near an equilibrium steady state' (p. 33). This is called engineering resilience. The second defines resilience as the capacity of a system to absorb disturbances up to a certain threshold before its structure fundamentally changes, altering the variables and processes that govern its behaviour. This concerns more persistence, unpredictability and change, concerning 'conditions far from any equilibrium steady state' (p. 33). He calls this definition of resilience is the ecological resilience. Rega and Bonifazi (2020) take it even further and add a third one: the evolutionary resilience. This type of resilience addresses a focus on a dynamic, and even a non-balanced system, which is able to bounce back, but adapt and transform as well. Evolutionary resilience states that systems are constantly changing and have no stable state.

The Wadden Sea could be considered an ecological resilient system. It adapts to disturbances by shifting its structure, while remaining a constant functional ecosystem. Due to the tidal circumstances and dynamic processes, the Wadden Sea is an unstable system, yet resilient to shocks and disturbances. The Wadden Sea system is far from equilibrium

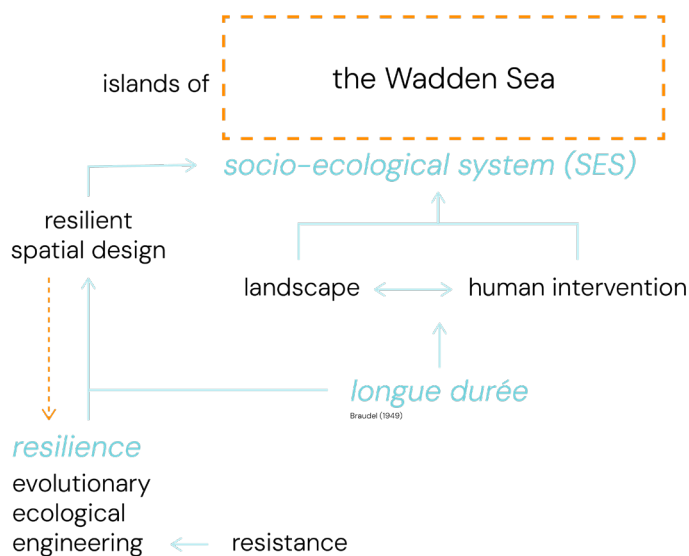


Engineered, ecological and evolutionary resilience
Adapted from Wu et al. (2022) ▲

steady, which matches with Holling’s description of an ecological resilient system.

However, evolutionary resilience could be a partial relevant definition as well. Rega and Bonifanzi consider evolutionary resilience to aim at a system which could transform as well. Their idea of resilience embraces ever-evolving systems, which, in light of climate change, concerns the Wadden Sea, having to adapt or even having to transform into natural system with different conditions.

This framework shows the studied theories. Resistance to water should be replaced by resilience. This is preferably evolutionary or ecological resilience in which a system does not have to always return to its original state. As the Wadden Sea system fits well with these two types of resilience. Water defence strategies should incorporate this as well in a resilient spatial design. Together with the theory of *longue durée*, which shows the interaction between landscape and human interventions, a new alternative future for small islands in the Wadden Sea, a socio-ecological system, is explored.



Value of the area

Pre-design phase

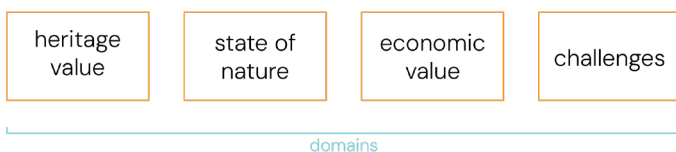
Value of the area

To clearly understand the area and its islands, the heritage value, economic activities, the state of nature and the challenges are analysed. These emphasise the value of the islands and at the same time form the base on which decisions are made.

To explore the *longue durée* in the Wadden Sea area, it is important to look at the historical value and heritage. UNESCO describes which aspects of the area are considered when appointing the heritage of the area. Furthermore, the monumental value of the islands is discussed to demonstrate how the islands have an historical significance which influences the cultural identity of the island communities. Additionally, the development of languages and dialects of the islands offer insights into their historical isolation and evolving connectivity.

The dynamics of the Wadden Sea are studied to learn how the area is changing and will change in the future. The flora and fauna give an insight in the ecological value and might be able to show how it is a key area of study. Researching the main economic drivers of the islands and the activity in between them adds to this. Moreover, it might identify how people have cultivated the islands.

Lastly the challenge of sea level rise is discussed. The problem statement (page 17) already pointed out the significance of it. A comparison between the current state and the future prognosis gives more insight.



Heritage value

To explore the *longue durée* in the Wadden Sea area, it is important to look at the historical value and heritage. UNESCO describes which aspects of the area are taken into account when appointing the heritage of the area. Furthermore, the monumental value of the islands are discussed to demonstrate how the islands have an historical significance which influences the cultural identity of the island communities. Additionally, the development of languages and dialects of the islands offer insights into their historical isolation and evolving connectivity.



▲ East of Vlieland
Betzy Akersloot-Berg (1850-1922)

UNESCO World Heritage

The Wadden Sea property is appointed as one of UNESCO's Natural World Heritages. The Dutch and German part were admitted in 2009 and this was later on extended to the Danish Wadden Sea area. To be included as a natural heritage on the World Heritage List, a property should meet at least one of the ten criteria, which test their outstanding universal value (UNESCO, n.d.-a). The Wadden Sea even complies with three (viii, ix and x) of the ten criteria. These criteria are cited below (CWSS, 2012) and explained.

Criterion viii:

'Be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features'.

The Wadden Sea is a globally unique coastal system, defined by its vast tidal flats, barrier islands, and minimal river influence. Over 8,000 years, it has evolved into a dynamic network of islands, channels, salt marshes, and sedimentary features, shaped entirely by natural forces. It stands out for its scale, ecological complexity, and the interplay of physical and biological processes, making it a prime example of Holocene coastal geomorphology. Despite human intervention, the natural dynamics drive land formation, habitat renewal, and ecosystem resilience. As the only tidal flat and barrier island system of its kind, it provides critical insights into coastal evolution, biodiversity, and climate adaptation, serving as a living laboratory for research and conservation. Its outstanding universal value makes it essential for understanding Earth's dynamic coastal systems.

Criterion ix:

'Be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals'.

The Wadden Sea is one of the world's last remaining large-scale, natural intertidal ecosystems, where undisturbed natural processes continue to shape its landscapes and biodiversity. Its geological and geomorphological features, tied to biophysical processes, provide a living record of how coastal environments adapt to global changes like rising sea levels and climate shifts. This unique ecosystem thrives in zones of transition between sea, land and freshwater, hosting diverse species. Its exceptional productivity supports vast populations of fish, shellfish, and millions of migratory birds along the East Atlantic Flyway, with ecological influence extending far beyond its borders. The Wadden Sea features habitats like coastal dunes, salt marshes, tidal flats, mussel beds, and seagrass meadows, shaped by tides, salinity fluctuations, temperature extremes, and occasional ice cover. Its unparalleled biodiversity and ecological functions make it a vital reference for resilience studies and a cornerstone for conservation and scientific research.

Criterion x:

'Contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation'.

The Wadden Sea is the world's biggest continuous stretch of tidal flats and salt marshes, covering 60% of Europe's and North Africa's tidal areas. It is rich in biodiversity, hosting up to 10,000 species, including 2,300 in salt marshes, 2,700 in marine and brackish zones, and 30 breeding bird species. Its global significance is most evident as a critical hub for migratory birds: up to 6.1 million birds gather at once, with 10–12 million passing through annually along the East Atlantic and African–Eurasian flyways. The Wadden Sea's abundant food resources and low disturbance levels make it essential for moulting, staging, and wintering, sustaining global biodiversity. Diverse environmental gradients, from tidal flats to salt marshes, create unique microhabitats, fostering ecological specialization. This vast, interconnected landscape allows species to adapt and thrive, supporting migratory wildlife on a massive scale. Recognized for its natural, scientific, and economic value, the Wadden Sea is a biodiversity stronghold and a lifeline for dependent species, making its protection vital for global conservation.

Operational Guidelines (year)	Cultural criteria						Natural criteria			
2002	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(i)	(ii)	(iii)	(iv)
2005	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(viii)	(ix)	(vii)	(x)

The Criteria for Selection
Adapted from UNESCO (n.d.-a) ▲

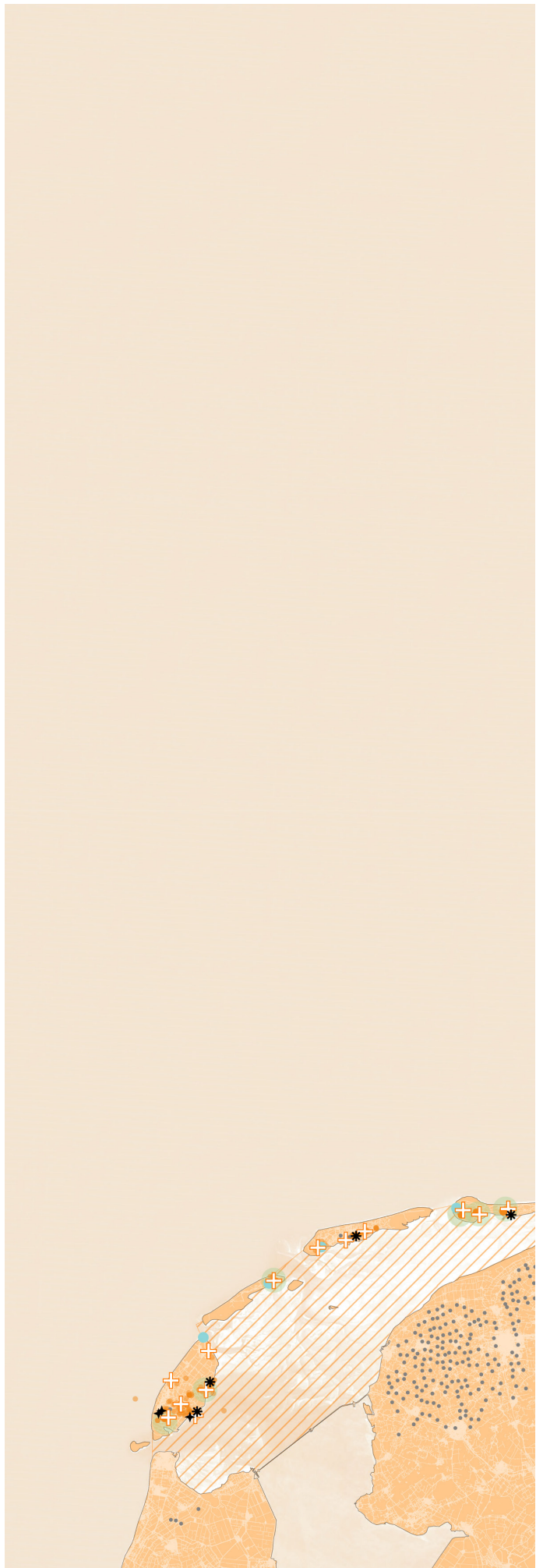
Monumental value

The Wadden Sea area contains numerous buildings and locations of monumental value. In the Netherlands, the Cultural Heritage Agency of the Netherlands (2024) maintains a national register of significant monuments, while Germany protects its monuments through the *Denkmalschutz* law, safeguarding sites of general national importance (*Kulturgutschutz – Denkmalschutz*, n.d.). Denmark also preserves many monuments; in Syddanmark, the region which encompassing the Danish Wadden Sea, there were a total of 7,075 protected ancient monuments last year across various categories (StatBank Denmark, 2025). The Agency for Culture and Palaces oversees these cultural properties in Denmark, protecting not only buildings but also landscapes of national value.









Monumental value extends beyond physical structures to include valuable views. The Netherlands maintains a register of protected town and village views prized for their historical beauty and character (Rijksdienst voor het Cultureel Erfgoed, n.d.), with many located on the Dutch Wadden islands. The island of Texel, for example, features the old village centres of Oosterend and Den Hoorn, where the churches, surrounding buildings, and sheep pastures possess such cultural and historical significance that they have been added to the national protected town and village views register. The map on page 42 illustrates the monumental value across the Wadden Sea area.



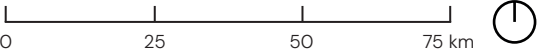
- ◀ *Lorenbahn, island railway, Langeneß*
- ◀ *Noordertoren lighthouse, Schiermonnikoog*
- ▶ *Interior of church on Langeneß*

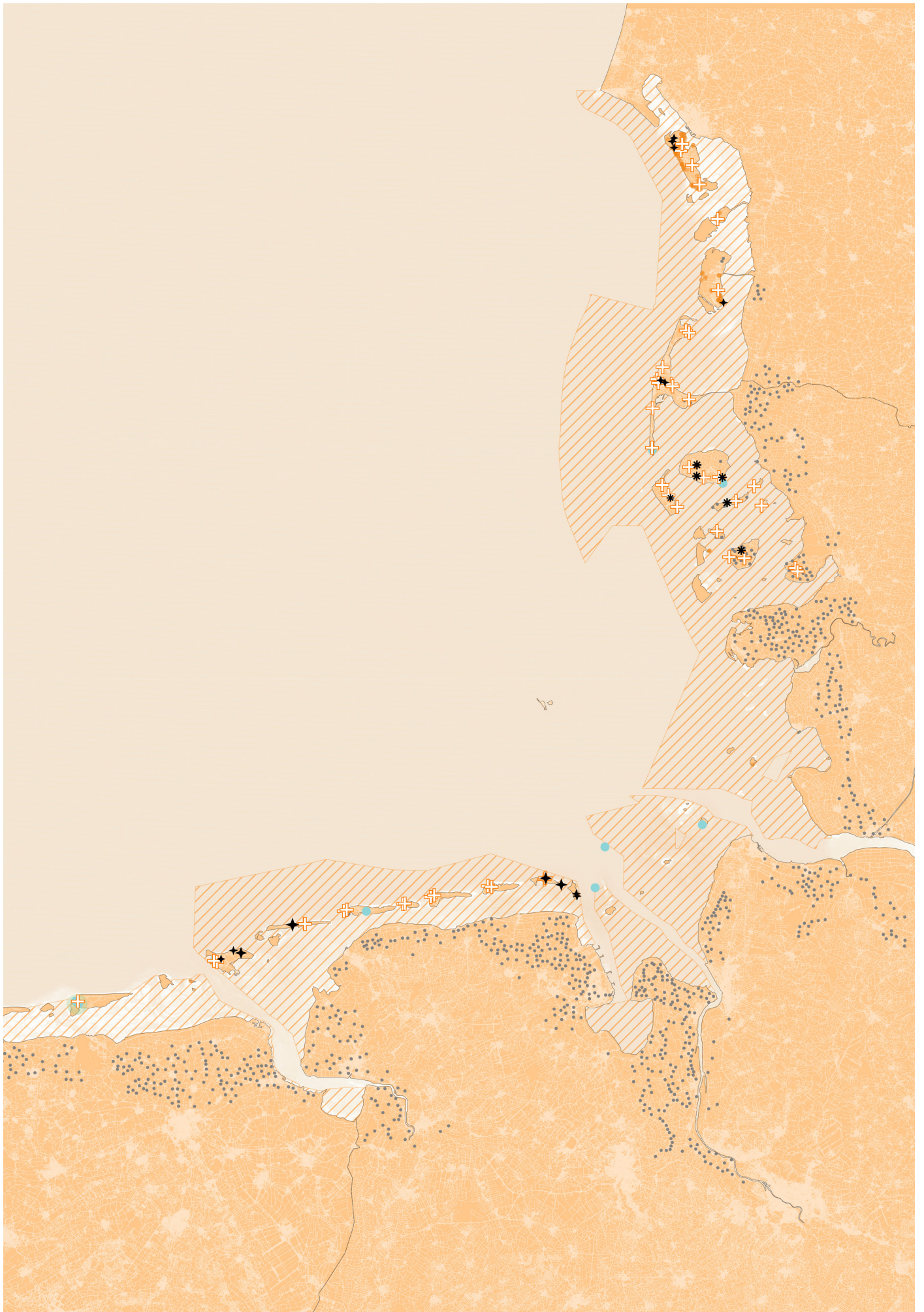


Heritage

-  Religious building
-  Lighthouse
-  Defensive structures
-  Windmill or pump
-  Mound
-  Other monuments
-  Protected town and village views (NL)
-  UNESCO World Heritage

Nationaal Georegister (2019), OSM (n.d.), Slots- og Kulturstyrelsen (n.d.), StatBank Denmark (2025), Frederiksen (2012)



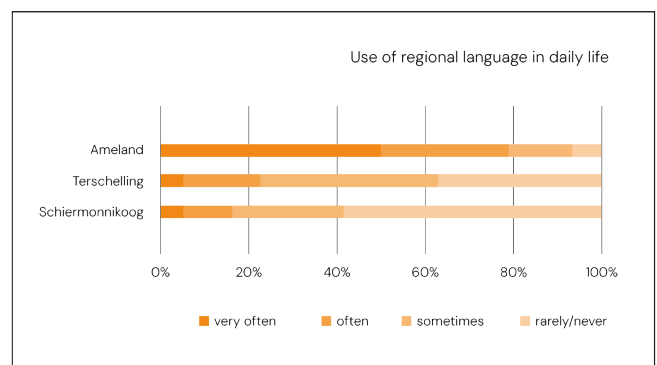
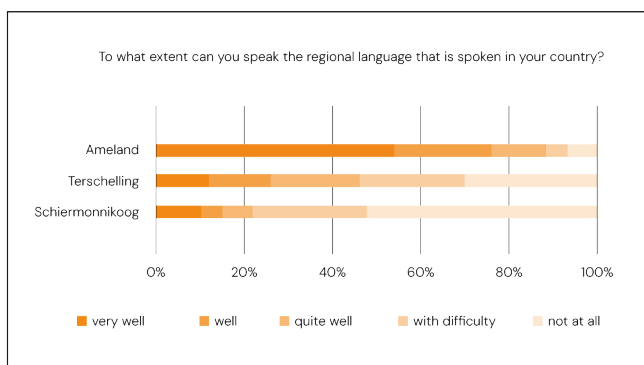


Languages and dialects

The local languages and dialects also serve as indicators of historical development. Although the Wadden Sea islands belong to three different countries, which each have its own official language, the residents do not merely speak Dutch, German, or Danish. Visitors to the islands will encounter various dialects with diverse origins from across the region and neighbouring countries. The map illustrates the distinct dialects on each island.













On the Wadden islands of Schleswig-Holstein, including the Halligen, different dialects of Low German and North Frisian are spoken. However, all the islands have developed their own dialect. For instance, on Sylt *Söl'ring* was spoken, *Öömrang* on Amrum and *Fering* on the island of Föhr (DE) (Iotta, 2022). 'Geographic conditions made contact between the North Frisians [...] difficult and were favourable in the independent development of the individual dialects' (Institute for Frisian, 2024). There was no centre of the North Frisians, so it was not needed to combine or standardise the dialect. People belonged to their own island and just spoke its dialect.

However, with the improvements of connections between islands, many dialects and their independent identities are being threatened and some have even become extinct, with the amount of younger generations speaking the local dialects is decreasing quickly (Haider Munske, 2001). The dialect of the Vlieland (NL) has lost its independence in the last 75 years, has merged into the more general colloquial language and is therefore erased as spoken language (Scholtmeijer, 2000). The Frisian language of the island of Wangerooge (DE) has become extinct as well. The last person speaking this dialect, has died in the 1950s (Haider Munske, 2001). On the German Wadden islands of Niedersachsen, East Frisian Low German is spoken. Yet a study in 2007 showed that younger people tend to be able to speak or understand this dialect less and less (Plattdüütskbüro, 2022). Fortunately, some dialects have fared better. When looking at the languages of some of the Dutch islands, results of a study by the Province of Friesland (Provincie Fryslân, 2022), show that the dialect of Ameland has been preserved the best. As is visible in the diagrams, more than 50% of the people say to be able to speak the Ameland dialect and the same amount uses this dialect still in daily lives.



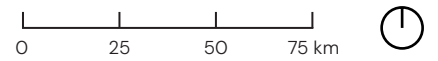
Diagrams adapted from the Streektaalatlas 2022 ▲
Provincie Fryslân (2022)



- | | |
|---|---|
|  South Western Jutland |  Schiermonnikoog dialect |
|  Western South Jutland |  Vlieland dialect |
|  Low German |  Aasters/Westers/Meslânders (Terschelling) |
|  North Frisian |  Ameland dialect |
|  Wangeroog Frisian (extinct) |  West Frisian |
|  East Frisian |  unknown |

Languages and dialects

Jansen & van Oostendorp (2004), Scholtmeijer, (2000), Haider Munske (2001), Provincie Fryslân (2022), Plattdüütskbüro (2022), Institute for Frisian (2024)

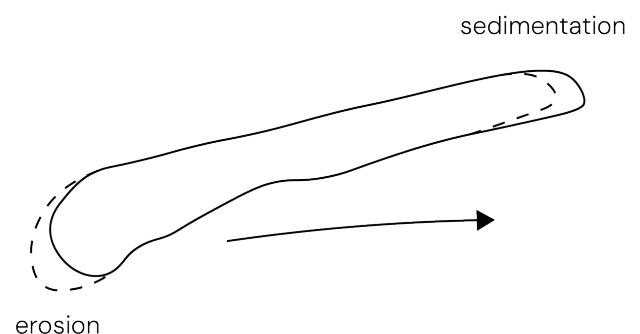


State of nature

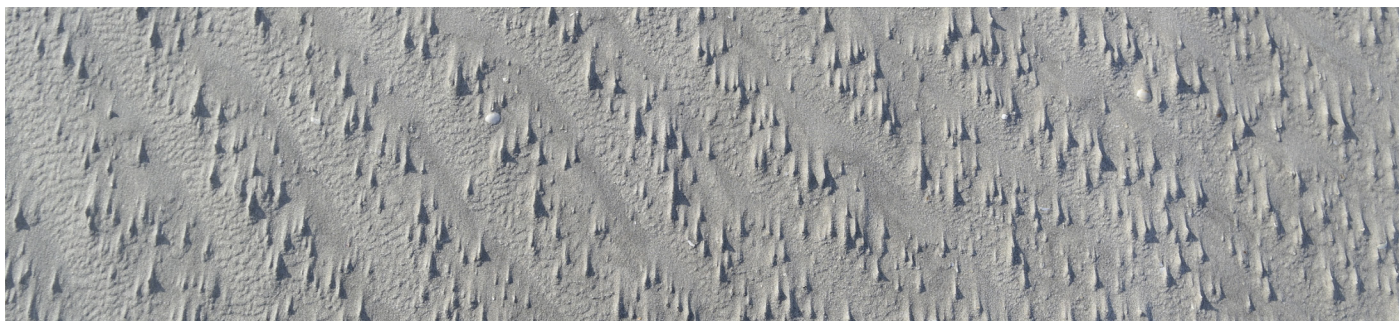
Dynamics

The Wadden Sea is a shallow inland sea, enclosed by islands and the diked Wadden Sea coast. Between the islands lie deep tidal inlets, through which the tide from the North Sea flows inward' (Vroom et al., 2014, p. 3). Due to its tides, the Wadden Sea is known for its dynamic character. Everything is moving. This is shown in the documentary Silence of the Tides (Kroon, 2020). The time-lapse show how the tides are changing the landscape every six hours; around six hours of ebb and six hours of flood. When experiencing the islands it's also noticeable how the externalities shape the island. Wind is one of the drivers of sand transportation. It forms the landscape and forms the dunes (Vroom et al., 2014). The images on the right are all taken on the beaches of Schiermonnikoog (NL) and show how the wind and water have made different patterns in the sand. The wind also influences the water movement. Waves are being initiated. The height of the waves depends on the velocity of the wind, the wind fetch (the distance of which the wind blows) and the water depth (Vroom et al., 2014).

These dynamics are also visible on a bigger scale. The map on page 54 is a palimpsest map of the dynamics and shows the distribution of land and water in the years 1500, 1850, and 2000. The changing boundaries between land and water can be seen. This is a clean example of the *longue durée*. Researching this helps 'understanding the landscape as a long-term structure which is changing slowly' (Meyer & Nijhuis, 2016, p. 293). The map shows, in a time-scale of several centuries, the islands have extended mainly to the east, this is the phenomenon also known as the "walking" of the islands. The islands are not really walking, but the form of the island is changing with sand transportation and a phenomenon called the littoral drift. Sand erodes from one side of the island and is supplied to the other through wind and water flows (Ministerie van Economische Zaken, Landbouw en Innovatie & Ministerie van Infrastructuur en Milieu, 2012).



"Walking" islands ▲



▲ Patterns on the beach of Schiermonnikoog (NL)
Brouwer (2026)



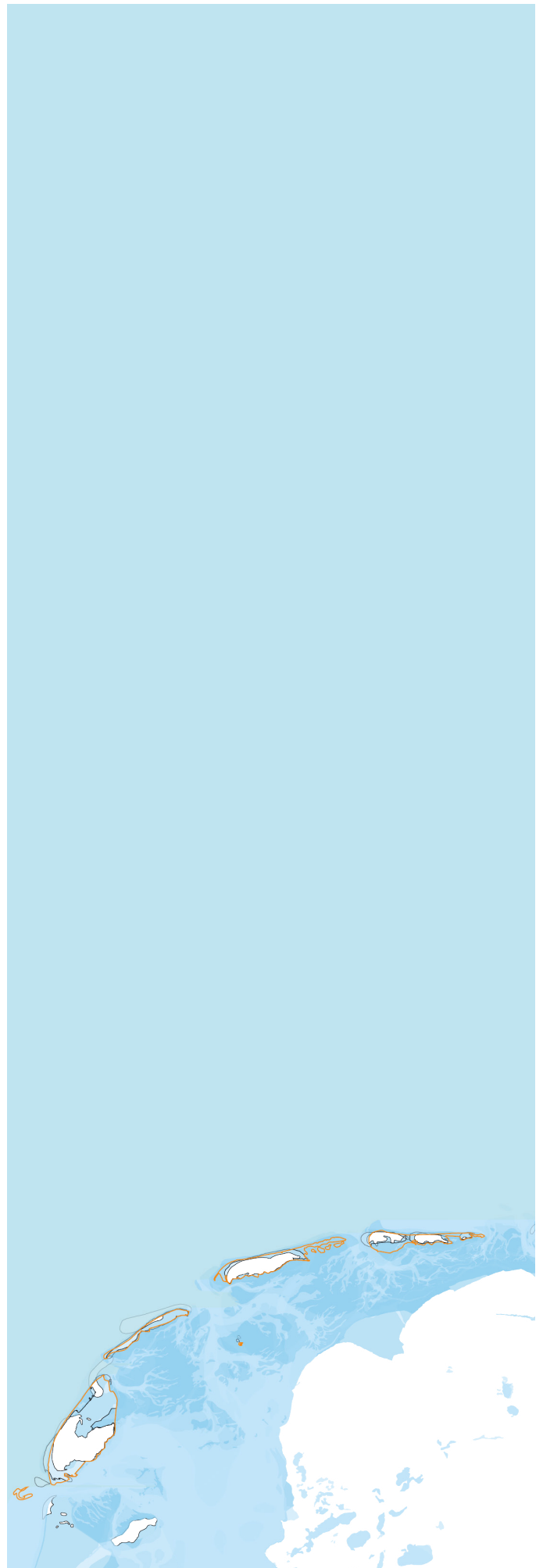
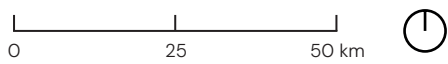
Tidal timelapse of Wadden Sea
Stills from NaturePicsFilms – Yvonne & Tilo
Kühnast via Youtube



Changes in morphology

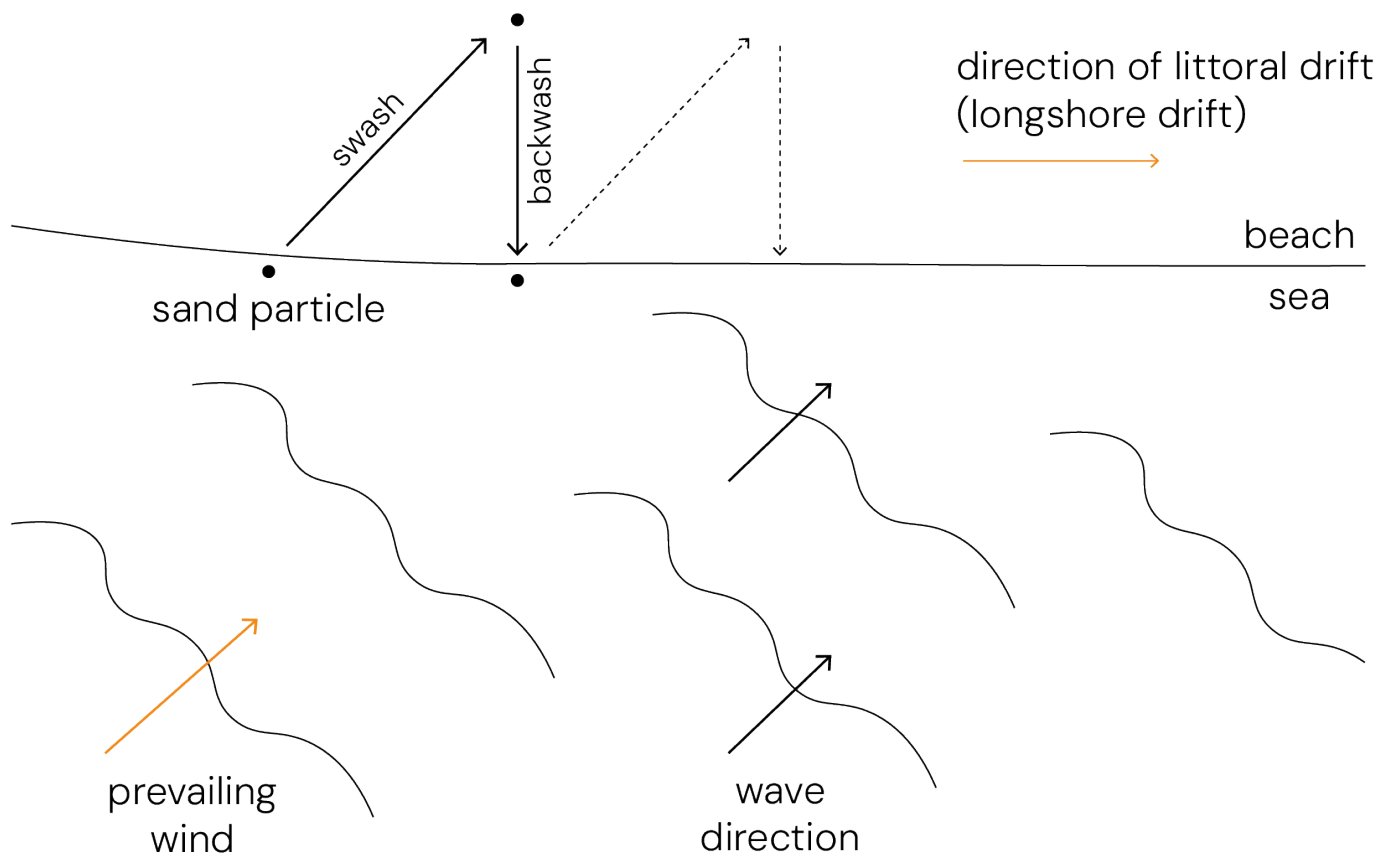
- Island edges (2000)
- Island edges (1500 and 1850)
- Water
- Intertidal areas and salt marshes

Data from Frederiksen (2012)

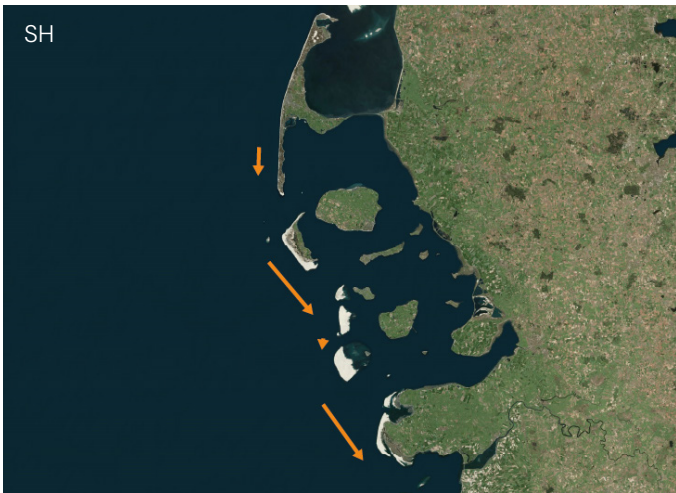




The littoral drift, or longshore drift, indicates the direction of sand particle movement and is influenced by the wave direction through prevailing wind and therefore, plays a huge role in the formation of especially sandy islands (McHarg, 1969). The maps show the littoral drift in the Wadden Sea. These are simplified maps, moderated from (Ridderinkhof, 2016). The arrows show the direction and magnitude. The directions are kind of similar as the changes that have occurred on the other big map.

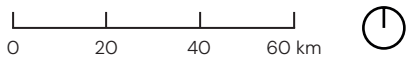


Littoral (or longshore) drift
Adapted from van Zyl (2018) ▲



➔ Angle and relative strenght of littoral drift

Simplified maps, adapted from Ridderinkhof (2016), Bing satellite

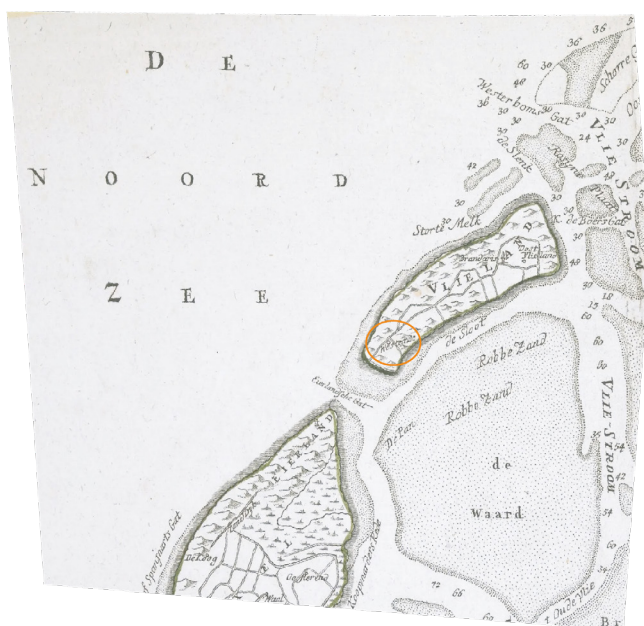


On this map of Vlieland (NL) from 1787 the current Oost-Vlieland (East-Vlieland) is visible, on the western part of the island also West-Vlieland (or here Westeinde) is shown. However, this village is not there anymore. It has slowly been taken up by the water in the slow change of island form.

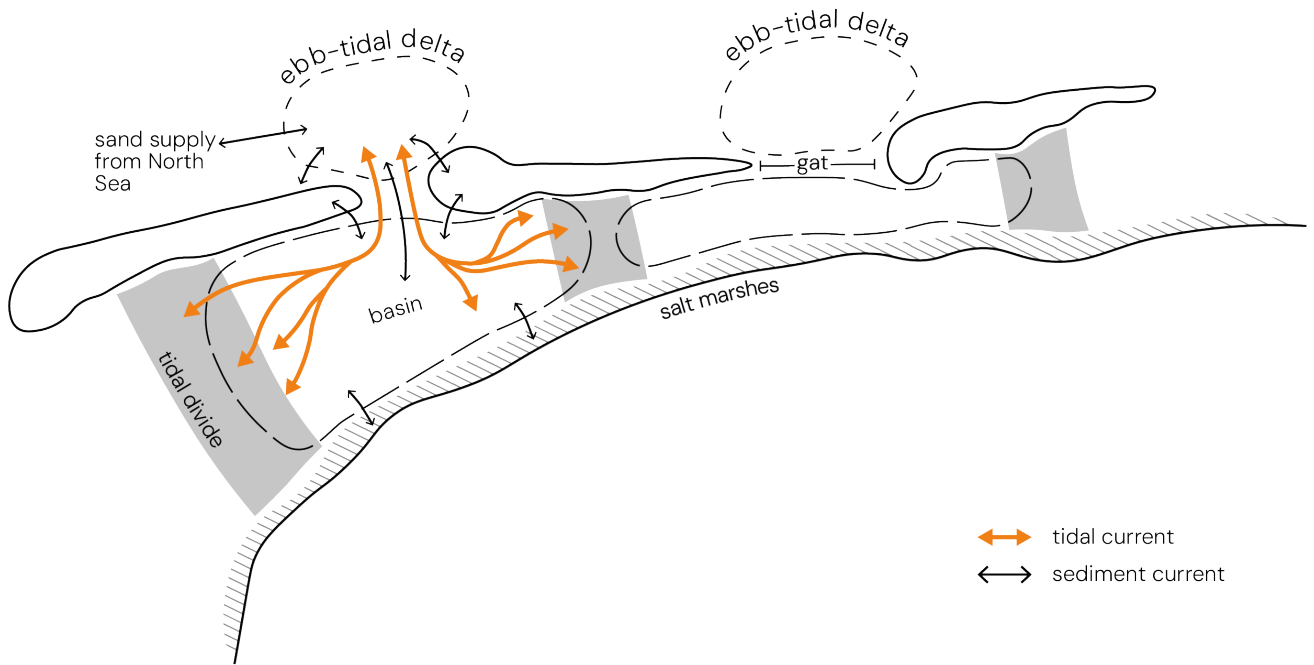
Another example of how the islands have changed due to the dynamics is the case of Rottumerplaat and Rottumeroog (NL). Rottumerplaat is currently located at the same place where the island Rottumeroog had been in earlier centuries. According to a story of Mathijs Deen (2016) there was a guard that tried everything to keep Rottumeroog at its place, but the wind and sea were stronger. The island disappeared in the West and appeared in the East. At its old place a new island emerged, what is now known as Rottumerplaat.

The diagram on the right shows the workings of the tidal system around the islands. This system of tidal currents and sediment movement, also called the “sweep-effect” is constantly moving and every big change, every human intervention such as closing of the Zuiderzee in the Netherlands, causes the

system to readapt and even transform. Sand supply from the North sea moves via the ebb-tidal delta, which consists of sandbanks, to the islands and therefore contributes to the forming of the dunes. It works like the sand motor (Huisman et al., 2021), withstands storm waves and supplies the islands with sand, after which the sand is discharged through sedimentation into the basin (Ministerie van Economische Zaken, Landbouw en Innovatie & Ministerie van Infrastructuur en Milieu, 2012). The tidal current moves through the gullies to the tidal divide. This is the area where the water from two gats meet each other, it divides the basins and here, in which the Dutch call the *wantij*, is where shoals and sandbanks lay at their highest, where the tidal difference is minimal, and sand and silt settle. The salt marshes contribute to the protection of the land. Their development is an interaction between vegetation increase and hydrodynamic processes (CWSS, 2008). This is where the sediment accretion and ecological development come together. The more plants are able to be a stable factor in the salt marshes, the more erosion can take place and the more it works as a buffer for strong waves (Ministerie van Economische Zaken, Landbouw en Innovatie & Ministerie van Infrastructuur en Milieu, 2012). Some salt marshes are evolved naturally, but some however, are artificial. ‘During the last centuries, many salt marshes along the mainland coast were reclaimed, with subsequent creation of new salt marshes in front of the dikes, or were intensively grazed by cattle or sheep.’ (CWSS, 2008, p. 92).



◀ Fragment of old map showing West-Vlieland Weigel and Schneider, *The British Library* (1787)



Tidal workings

▲ Adapted from Ministerie van Economische Zaken, Landbouw en Innovatie & Ministerie van Infrastructuur en Milieu (2012)

Distribution of deep and shallow subtidal and intertidal areas
Adapted from Ricklefs et al. (2022)

- North Sea
- Deep subtidal
- Shallow subtidal (< 4% exposure time)
- Intertidal (> 4% exposure time)



Flora and fauna

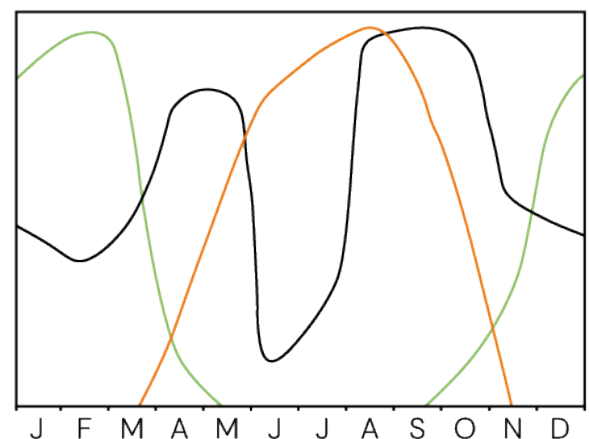
As explained in the justification for admitting it as an natural heritage, the Wadden Sea is an area with a huge amount of flora and fauna species and a great level of biodiversity. The Wadden Sea is for instance a stop for migratory birds. As the diagram shows, different species visit the area during all months of the year. The Wadden Sea is especially an important stop along the East Atlantic Flyway. Every year these waterbirds migrate from Antarctica and Siberia to South Africa and more than 1.000.000 birds make a stopover in the Wadden Sea for breeding and wintering (van Roomen et al., 2022).

The diagram on the right shows a few common species and in which area they are the most present during their stay in the Wadden Sea. It's for instance the most important spot in Northwest-Europe for the Eurasian Spoonbill and the Gull-billed Tern. The Eurasian Spoonbill is mostly breeding in Dutch coastal areas of the Wadden, while the Gull-billed Tern is mostly staying in the coastal waters of Schleswig-Holstein (DE). Flooding is one of the most important reasons for failure of breeding (Koffijberg et al., 2022). This occurs along the coasts of the mainland as well as along the coasts of the islands. This has increased due to sea level rise and increasing storm surges, especially in breeding season (van de Pol et al., 2010).

Threats to these birds in the North Sea area are sea level rise, recreational tourism, agricultural effluent, and the disruption high-tide roosts by for instance people (van Roomen et al., 2022 and Kleefstra et al., 2022). Apart from this, the birds also have a very important role in helping the Wadden area remain. According to a study of scientist Floris van Rees (et al., 2026), their guano (their droppings and their containing nutrients) help vegetation grow. This is important for dune formation, the roots of the vegetation help with the stabilization of the dunes (McHarg, 1969). The Wadden islands are dynamic, with the sand being transported by the wind and sea, the breeding birds and their guano, keep the islands more in their place.



Black-headed Gull flying above the Wadden Sea around the Halligen islands. ▲



- summer residents
- winter residents
- year-round residents

Bird species visiting the Wadden Sea during the year ▲
Adapted from Burbridge et al. (2012)

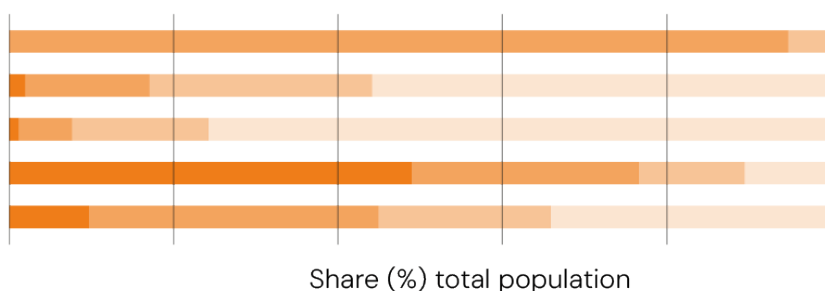
Five important bird species and their spread across the Wadden Sea regions ▶
Adapted from Kleefstra et al. (2012)

There are three main species of marine mammals present in the Wadden Sea are the following. One of them is the harbour porpoise (*Phocoena Phocoena*) is a small whale. There is a whale conservation area in Schleswig-Holstein, western to the islands of Sylt and Amrum, extending up to 12 nautical miles (CWSS, 2012). In this area set net fisheries are banned to protect the whales. Just like the hunting of waterbirds (Kleefstra et al., 2022), the practice of whaling has been discontinued (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas, 1992). Also the harbour seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*) can be found in the Wadden Sea. Both seals use sandbanks as haul-out spaces for breeding, moulting and resting (Unger et al., 2022).

However, there is more happening in the Wadden Sea. Especially in the Dutch tidal areas an in Niedersachsen, blue mussel beds are located. They improve biodiversity and have a huge ecological significance. Although their ecological values, the mussels are cultivated as well. Regulation is therefore needed to increase the amount, distribution and natural development of blue mussel beds in the intertidal (CWSS, 2012). The shallow water are also an important habitat for several fish species, as it provides a transition zone between the North Sea and the river estuaries for temporary visitors. For some resident species, the Wadden Sea tends to be their habitat during most of their life, as for some this area has an important nursery function (Van Der Veer et al., 2022), such as flat fish. They



East Atlantic Flyway
Adapted from CWSS (n.d.) ▲



- Gull-billed Tern
 - Lesser Black-backed Gull
 - Eurasian Spoonbill
 - Common Snipe
 - Black-headed Gull
- DK
 ■ SH
 ■ NI
 ■ NL

spend their juvenile phase in the Wadden Sea, as there is a good amount of food and the possibility to find shelter against predators (Tulp et al., 2022). However, the increase in sea water temperature threatens their habitats.

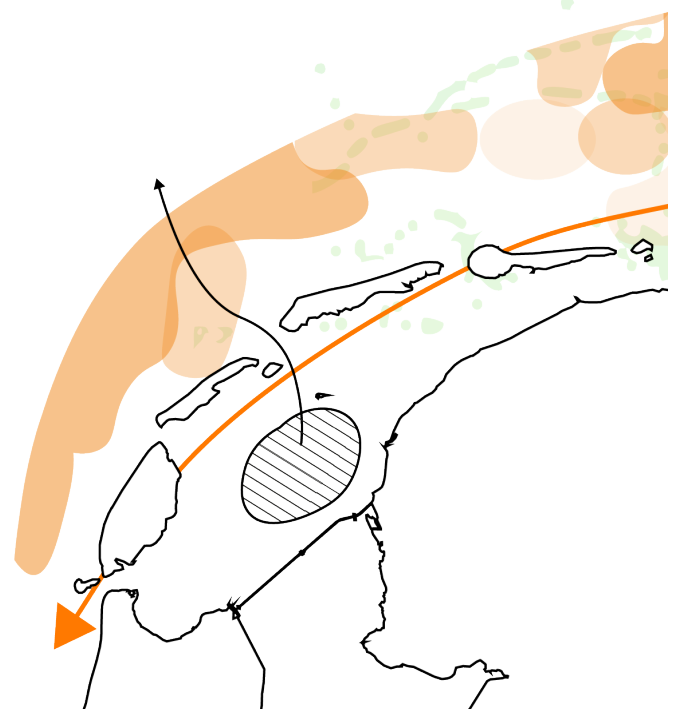
Nature is quite able to adapt. The natural world is evolving in response to climate change far more dramatically than any human system (Marley, 2024). Due to changes in the environment (e.g. temperature) some species tend to be adapting to rapid climate change. Their timing of reproduction or hibernation changes for instance (Bonamour, 2021). Nature is very resilient. It will find its way. This links back to the ecological resilience as Holling (1996) described it. Nature will adapt. A negative consequence of the changes in climate for human societies is, however, that our current way of life gets harder. The ecosystem services that are provided by the socio-ecological system in which we live, will be threatened (Kapos et al., 2019). We as humans, could learn from nature, to adapt.

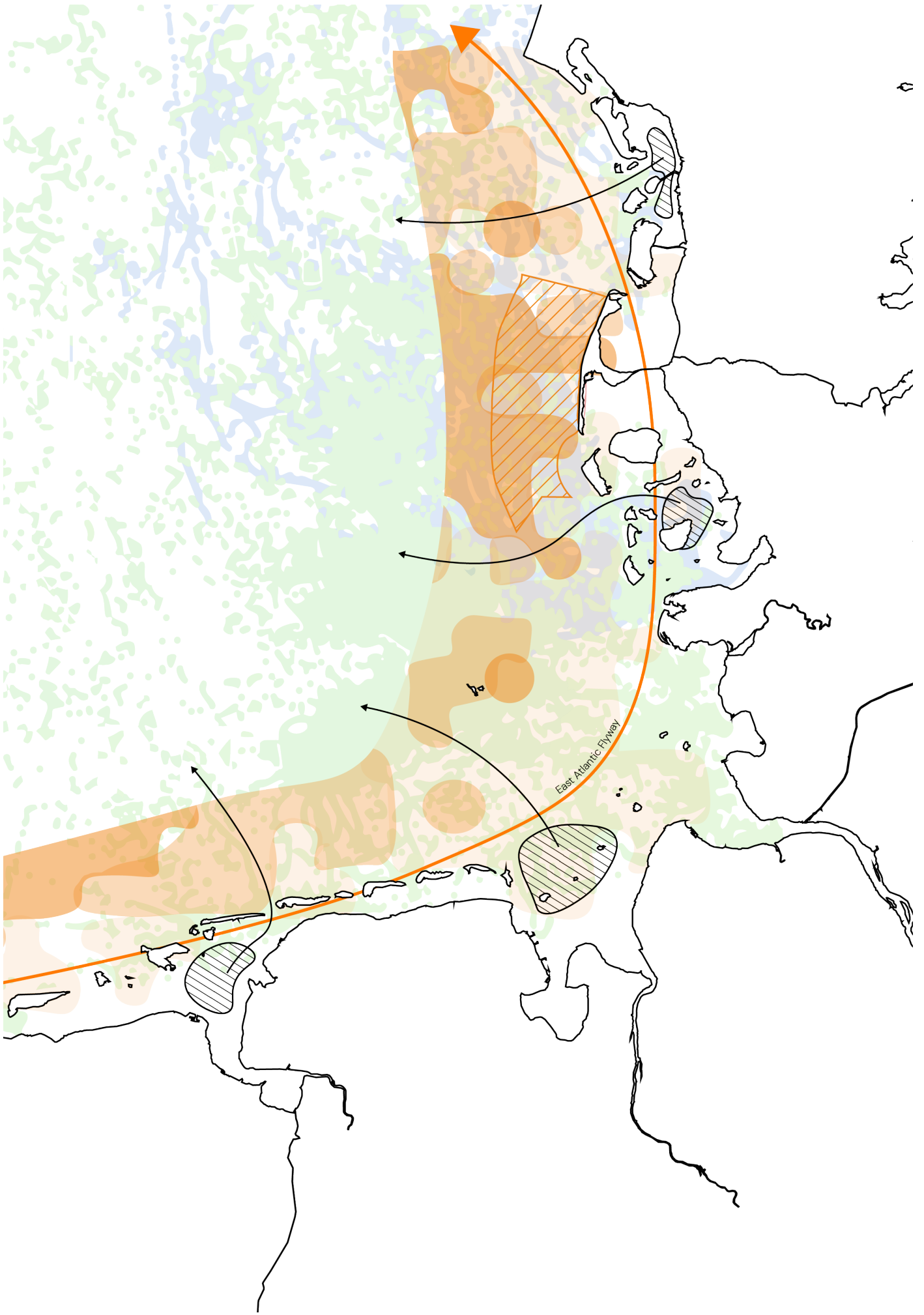


Flora and fauna in the Wadden Sea

- Grey seal
- Harbour seal
- Whale conservation area
- Porpoise density (0 to 4 individuals/km²)
- Wadden Sea as nursery for juvenile fish

Scheidat et al. (under review), CWSS (n.d.), BSH (2021), Unger et al. (2022)










Soil

This map shows the current situation and upper soil types. The islands consist mostly of dunes and higher shoals and embanked marshes. The Wadden Sea consists of intertidal areas and salt marshes. The three maps together show how these soil types were distributed over time. Especially on the Danish coast and islands more marshes were embanked. This shows how people increased the area of cultivated land.



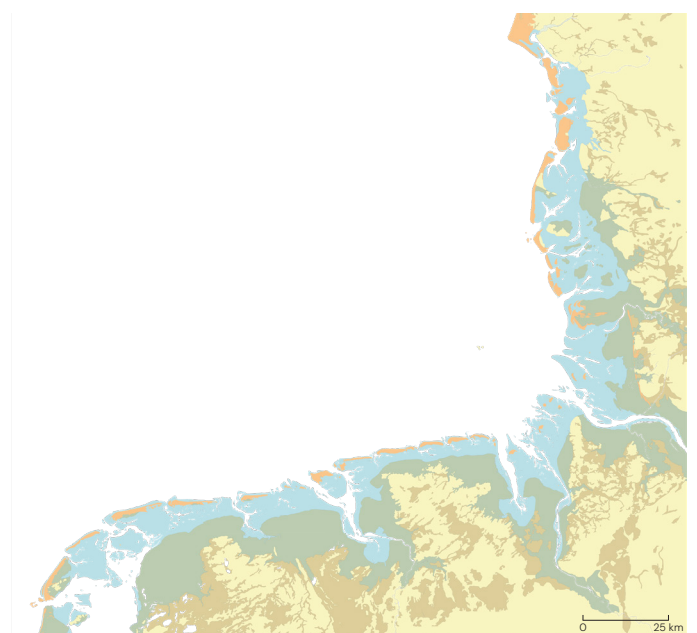
1500

Soil types

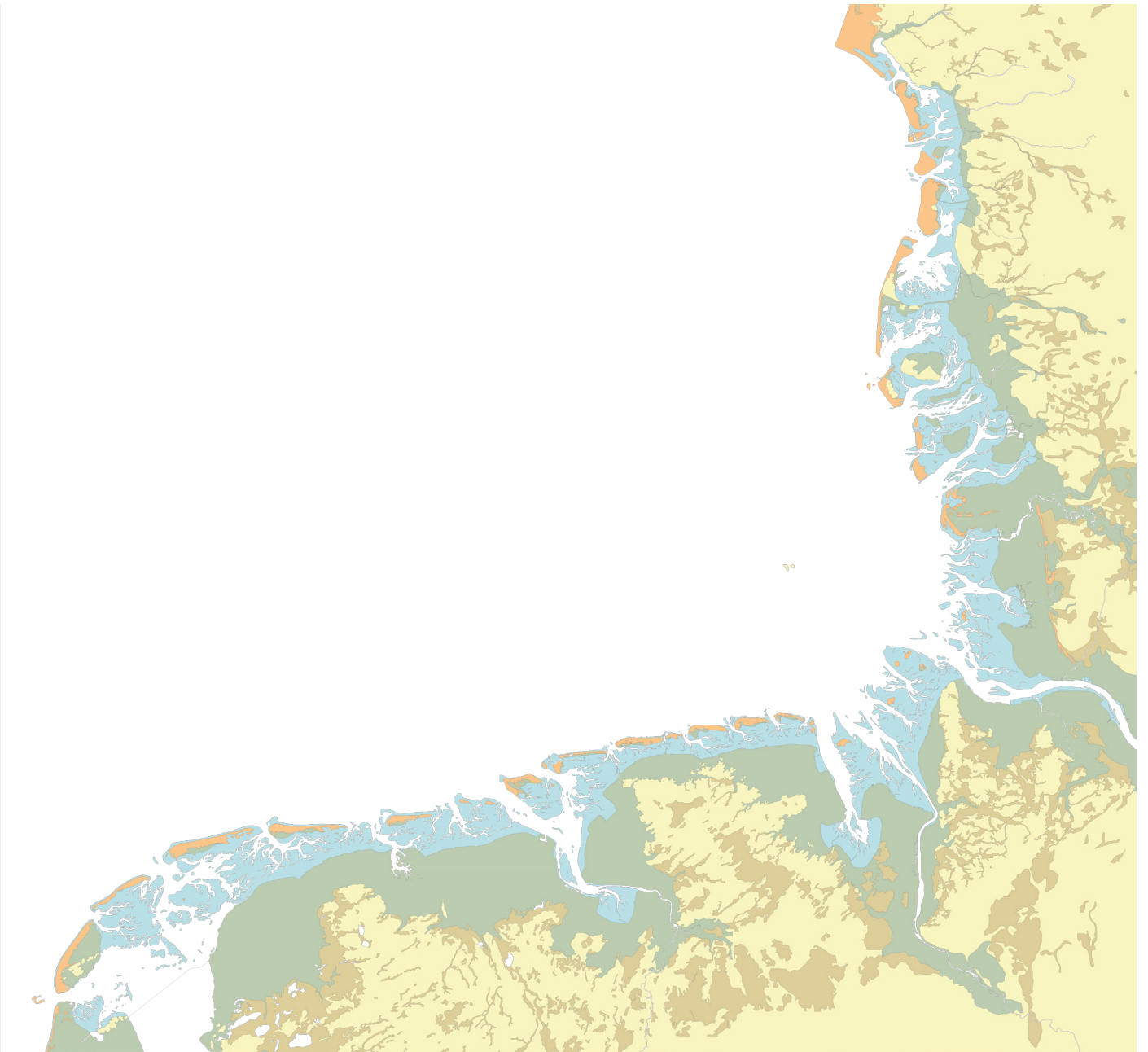
-  Dunes and higher shoals
-  Intertidal areas and salt marshes
-  Embanked marshes
-  Peat bogs
-  Pleistocene or older

Frederiksen (2012)

0 25 50 km



1850



now

Economy

Tourism is one of the most important economic drivers in the Wadden Sea region (Hartman et al., 2022). Due to her unique natural landscape the region attracts many tourist during the year (Vroom et al., 2014). Many islands and their local economy therefore depend on it (van Raalte, 2026). One of the early cases of tourism was when the first German North Sea resort opened on the island of Norderney in the year 1797. Since then tourism has increased.

The first economical activities centred around small-scale cultivation of the land, fisheries, and trade. On the Danish Wadden islands from the late 17th until the early 19th century, many men took part in annual migration to work in whaling. The women stayed on the islands and took care of the agriculture. However, the effect of farming was minimal and the main incomes were collected during fishing and whaling at sea (Ax, 2015).

The deep tidal inlets in the Wadden Sea historically served as the most important shipping routes, connecting harbours to the sea. Amsterdam, for instance, became one of the most important harbours in the economic market in Europe. Starting in the 17th century, the Dutch began heavily trading luxury goods like tea, coffee, and tobacco with the East and West Indies. The Dutch East India Company (VOC), founded in 1602, was a key actor in this trade. Because of the shallow coastal waters, ships often anchored at the Texel roadsteads in the western Wadden Sea to load and unload their cargo (CWSS, 2012).

To this day the Wadden Sea still plays a key role in the economic activity in Europe and its waters remain to be heavily trafficked. The map on page 64 also shows the main ports that are connected to the Wadden Sea. All these ports differ in size, but their main type of transit is cargo (Hein et al., 2023). These ports either lay in the area of the Wadden Sea or have their main traffic routes through the Wadden Sea. The latter is important to know, because when studying the current activity

in this area (Vesselfinder, n.d.) it is clear that, these ship traffic routes are very busy and therefore have an influence on the ecology of the Wadden Sea. The other important naval routes are the ferry ways. The islands are connected to the mainland via these ferry ways, which are crucial for their daily lives.

After 1900 the agricultural cultivation and fishery scaled-up. The landscape became more redesigned to fulfil peoples wishes. Apart from tourism, agriculture is still an important economic driver on the islands as well. Some island have been heavily cultivated and now mostly exist of arable land. However, since the 50s, 60s, and 70s there has been a shift on many islands from traditional industries to tourism, as the main income, such as on the islands of Ameland (NL) (Visser et al., 2024) and Neuwerk (DE) (Leiacker, 2017). This is shown on the map on page 64. However, tourism is both a threat as well as a resource for the inhabitants of the Wadden islands (Coenders & Schrieck, 2013). Many islands depend on tourism, and it is not so much that the inhabitants do not like tourism itself, but more the tourism behaviour that it brings and the changes it brings to the from origine modest character of the Wadden region.



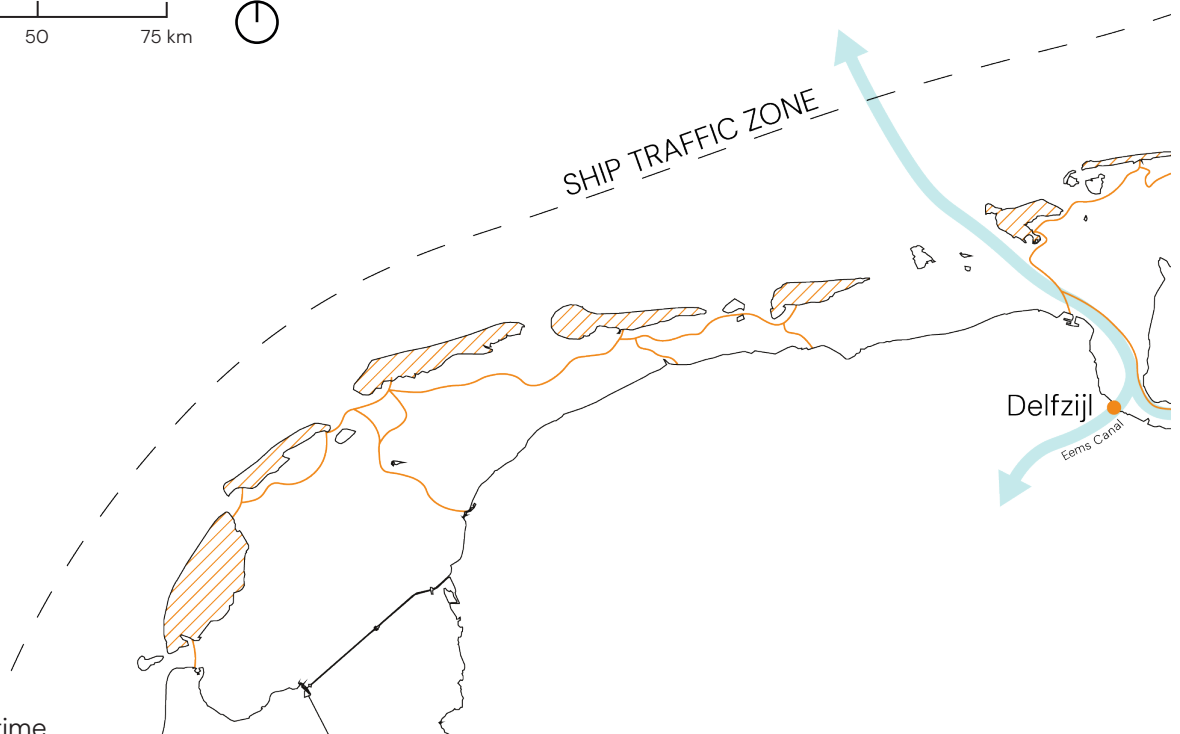
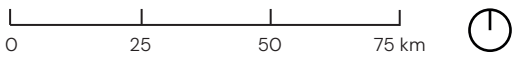
▲ Fishing boat on the Wadden Sea of Schleswig-Holstein
Brouwer (2026)

▲ Whale jaw in the centre of Schiermonnikoog village
Brouwer (2026)

Economical activity Wadden Sea

- Relative size of port
- Ferry way
- ↔ Ship traffic route
- ▨ Economic driver: tourism
- ▩ Economic driver: agriculture

Hein et al. (2023), BSH (2021), PDOK (2024)





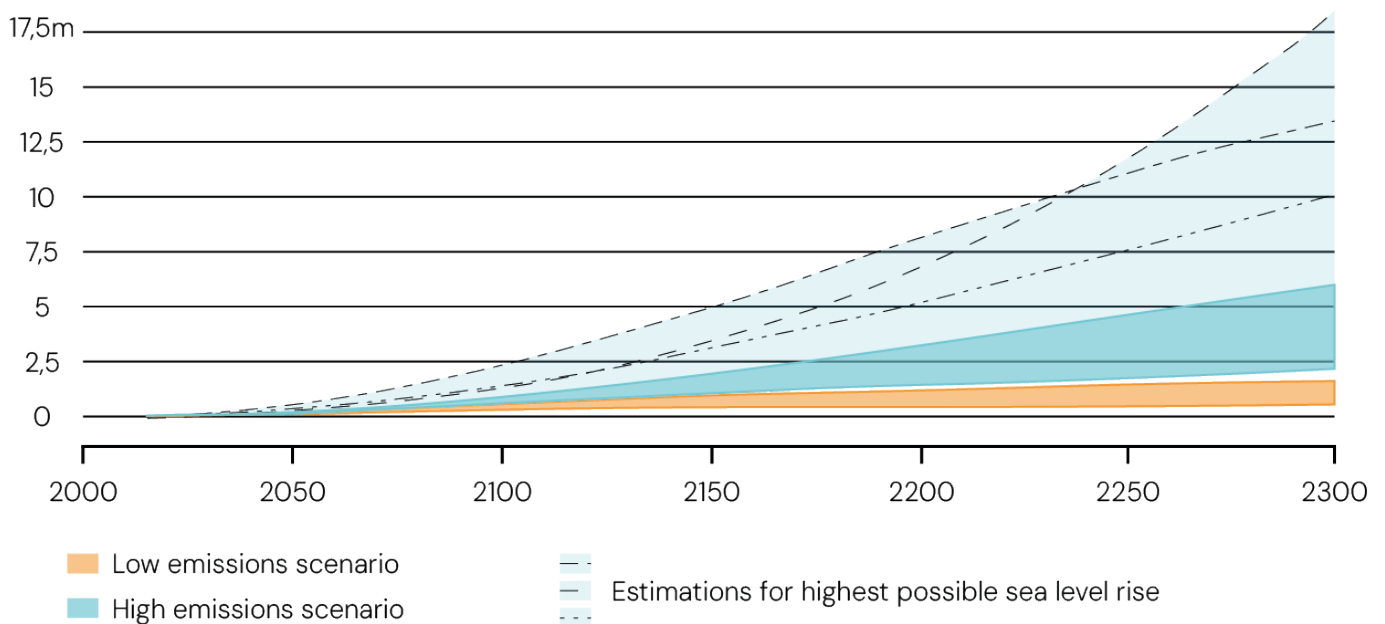
Challenges

Global warming will lead to rising sea levels, as well as more extreme weather conditions to occur in the future. At the same time land is subsiding, further enhancing the trend of relative sea level rise. This process, has long-term consequences and is therefore one of the main challenges of the Wadden Sea region. It affects the flood safety of societies on the islands, affects economic activity in the region and impacts the ecosystems present in the area (Trilateral Scientific Community, 2018).

Climate change is for a great deal caused by human influence, which effects are happening in all regions of the earth (IPCC, 2023). Unless big reductions in CO2 emissions and greenhouse gas emissions are made in the upcoming decade, global warming will exceed temperatures of 1.5 °C and 2 °C in the 21st century (IPCC, 2023). In the Paris Agreement (UNFCCC, 2016), all parties agreed to act upon global warming, limiting the rising temperature to 2 °C by 2100, but whether or not this will be achieved, is yet to be proved. Many countries are struggling to reach their climate goals. For instance, even before being initiated as new parliament

in the Netherlands, it was already clear that the current parliament would not be able to reach their own set of objectives relating to climate change (Brandsma, 2026). This is increasing the challenges that the Wadden Sea faces and the uncertainty about its future.

Due to global warming, the frequency of extreme weather events increases (Seneviratne & Zhang, 2021). These increasing storms and floods put pressure on the current defence system of the islands of the Wadden Sea; pressuring dikes and ports. These conditions of higher sea levels and worsening weather conditions result in increasing financial costs to secure the safety of livelihoods on these Wadden islands that are being more and more threatened. That's why, for example, the island of Rømø is now added to one of the eleven new highly flood-threatened areas in Denmark by the Danish Coastal Authority, which means that in the event of extreme weather, such as storm surges, these areas are particularly exposed and in danger of being flooded (*Turist-ø truet af massiv oversvømmelse*, 2024).



Sea level scenarios until 2300
Adapted from KNMI (2023)

Sea level rise

Global warming causes relative sea levels to rise. 'Relative sea level rise is the combined effect of absolute sea level rise and land subsidence or uplifting. It therefore is the locally perceived sea level change' (Bosboom & Stive, 2023, p. 54). The thermal expansion and the melting of the ice caps are direct stimulants for the sea levels to rise. the amount of sea level rise, as this significantly depends on the future CO2 emissions and their influence on the melting of the ice caps in Antarctica (Deltaprogramma, n.d.). Worldwide the rising sea level is accelerating. Between 1971 and 2018 it was 2,3 mm a year. Between 2006 and 2018 it was already 3,7 mm a year (KNMI, 2023).

The Paris Agreement was set to limit global warming and with that sea level rise. However, when assuming that there is an aspiration to reduce the amount of human induced emissions, it will not mean that the sea level rise would come to a halt. Even when, suddenly, all emissions would be diminished, the sea level would continue to rise, maybe even for a hundred more years, because an equilibrium between the ice caps and the climate will not be reached yet. So whatever the prognoses for sea level rise will be, it is clear it will be rising (KNMI, 2023).

Current

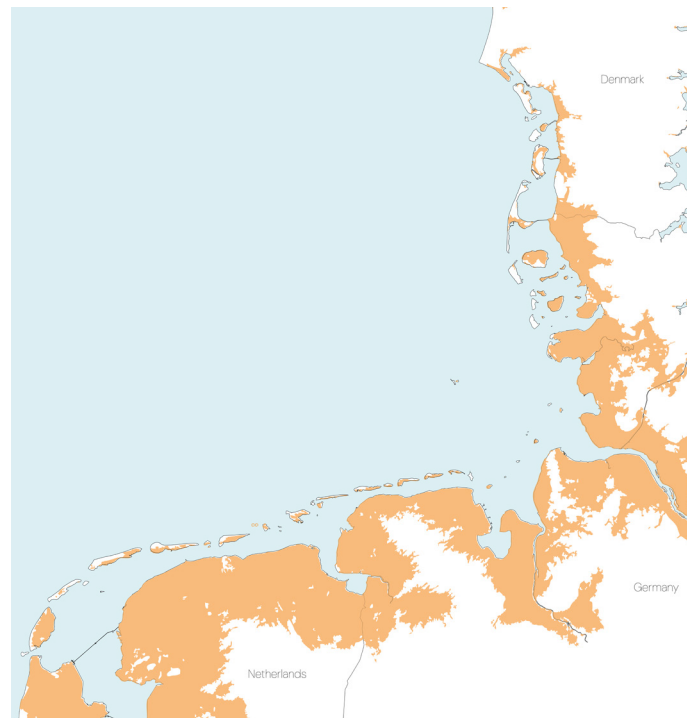
In the Wadden Sea the acceleration is slightly slower, but also there the sea level rise is alarming. The current sea level rise in the western Wadden Sea is 2 mm a year according to the Dutch National Delta Programme (Deltaprogramma, n.d.). However, Philippart et al. (2024) claim that the whole of the Wadden Sea is already rising with around 3 mm per year, taking the variability due to wind conditions and tidal differences into account, and this is increasing.

Future

In the unlikely event that the global warming won't exceed the limit of 2 °C, the sea level will rise with 1 (or 1,2 m, according to the KNMI (2021)) or 2 meters in the Dutch seas by 2100 (Deltaprogramma, n.d.).

In that case 240.000.000 m³ sand would have to be used for suppletion to compensate for erosion and to keep the coasts protected (KNMI, 2021). In 2200 sea levels would be a meter higher (Deltaprogramma, n.d.).

According to the Dutch National Delta Programme (Deltaprogramma, n.d.) the western Wadden Sea will not be able to cope, if sea level rise exceeds 6 mm per year. This means that sedimentation happens slower than the sea level rise. For the eastern part, this rapidity is 10 mm per year, which is possible scenario, already in 2050. By 2100 the sea level in the Dutch seas could rise to a maximum of 2 meters, and by 2300 to 2 – 6 meters, or in high scenarios even more (KNMI, 2023).



Flooded area (water level 2m above high tide line)
Climate Central (n.d.)

0 25 km

Values of the Wadden Sea

The UNESCO appointment underscores the Wadden Sea's significance as a rare example of a landscape shaped by natural geological processes. Despite human intervention and climate change, this area demonstrates a remarkable resilience of its ecosystem and highlights its persistence in forming the landscape. The islands' monuments and historical landmarks, on the other hand, show reveal how people have lived there for centuries and used the landscape. Windmills, for example, reflect the need to drain land for agriculture, lighthouses point to maritime activity and the challenges of navigating treacherous waters, and churches often mark the historical centres of island communities. Where the islands were once isolated, the decline of local dialects and languages suggests a growing interconnectedness over time, driven by increased ferry connections and technological advancements.

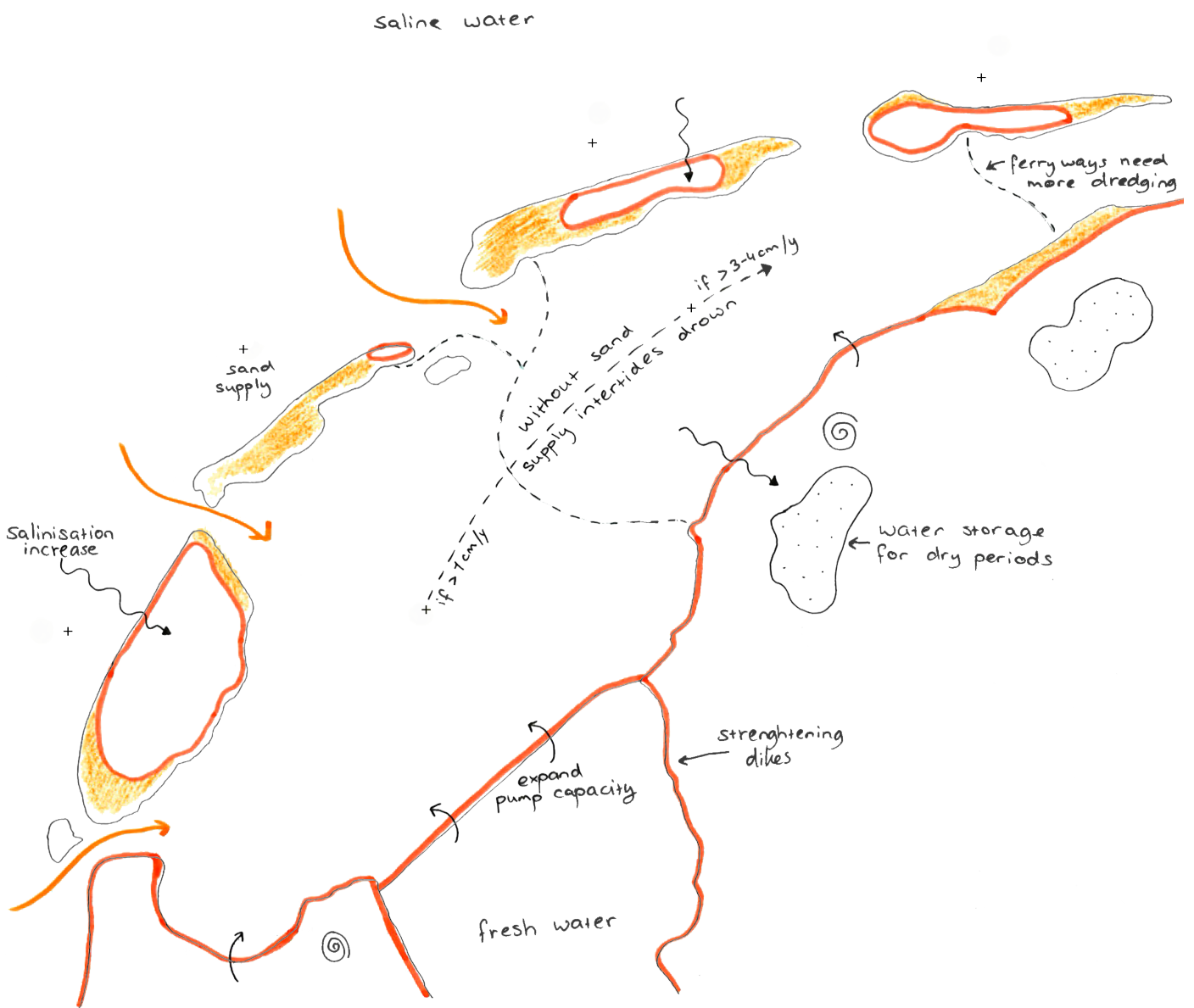
The natural state of the Wadden Sea reveals a landscape in constant motion, where the islands themselves are constantly shifting and reshaping. This dynamic environment hosts a rich diversity of species. Many of them face threats from climate change and human activity. Yet, remarkably, there are cases of species demonstrating an ability to adapt to these changes. This resilience offers a powerful example for how we might approach design. The movements and rhythms of the Wadden Sea could be embraced, creating environments that align with its ever-changing nature rather than resisting it.

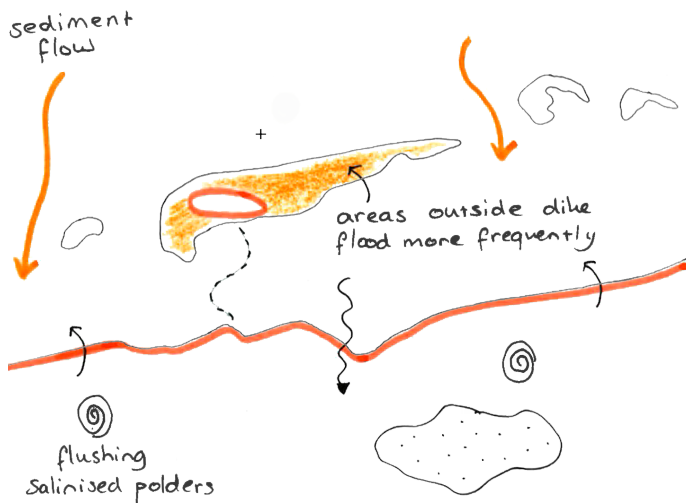
The economies of the Wadden islands have evolved over time, shifting from a focus on whaling, fishing, nautical trade, and agriculture to an economy where tourism and agriculture dominate. This historical adaptation demonstrates the resilience of local communities in adjusting their economic activities and when looking into the future, this capacity for change offers hope that people will continue to adapt their livelihoods in response to different conditions due to climate change.

The rising sea level is an indicator of the challenges that the Wadden Sea region will face in the future. The predictions for sea level rise should be considered when spatially designing for the future of Wadden islands. For 2100 this is a rise of 2m.

**Solution
directions**

Protect Netherlands





0 5 10 15 km



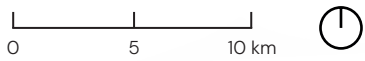
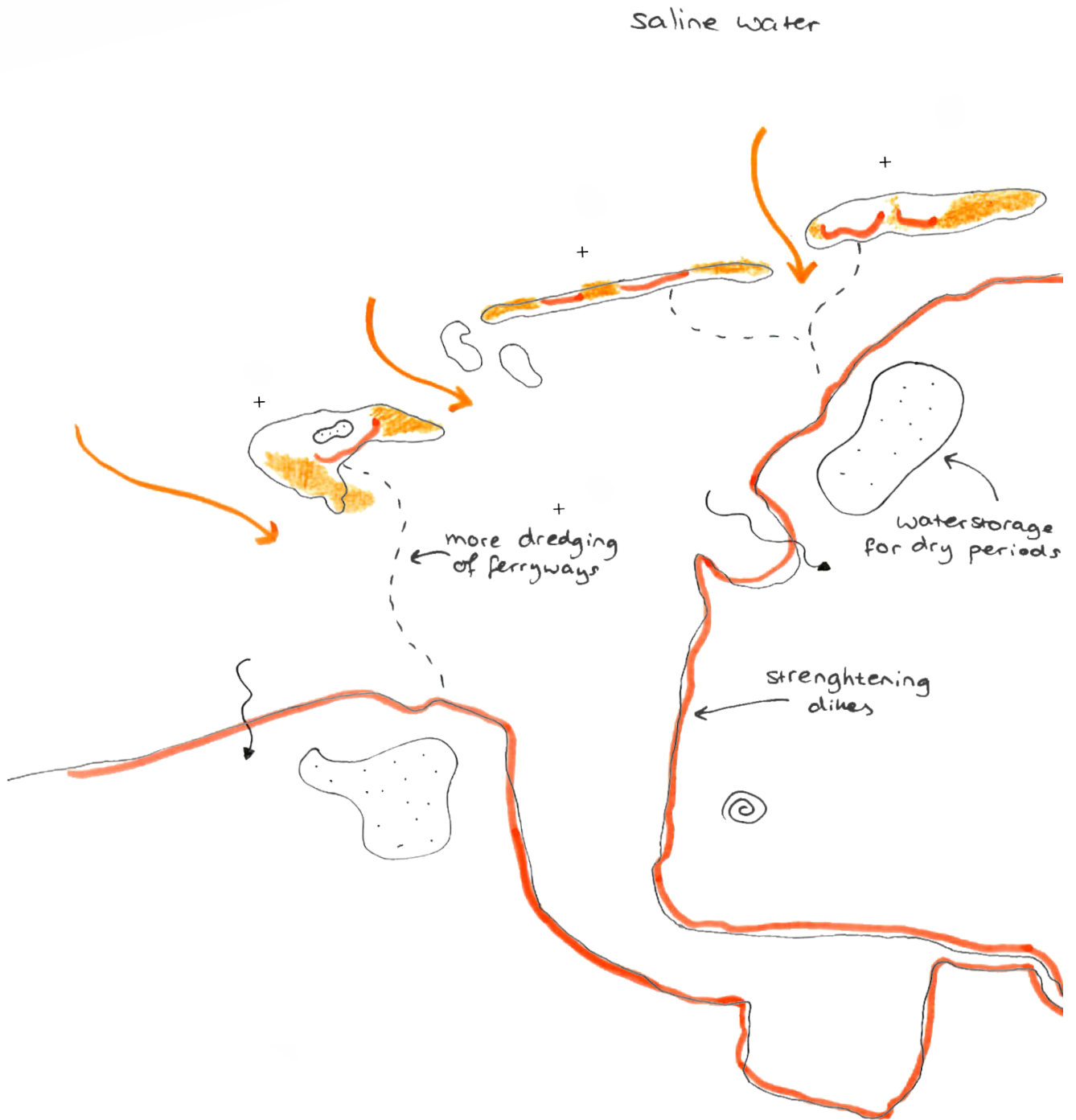
The four solution directions of Deltares (Deltares, 2019) for sea level rise in the Netherlands have been the base for the three solution directions (page 26) in this project through which a more resilient future for the Wadden Sea area and its islands are explored. The explored solution directions are named in this project as follows: Protect, Seaward and Move.

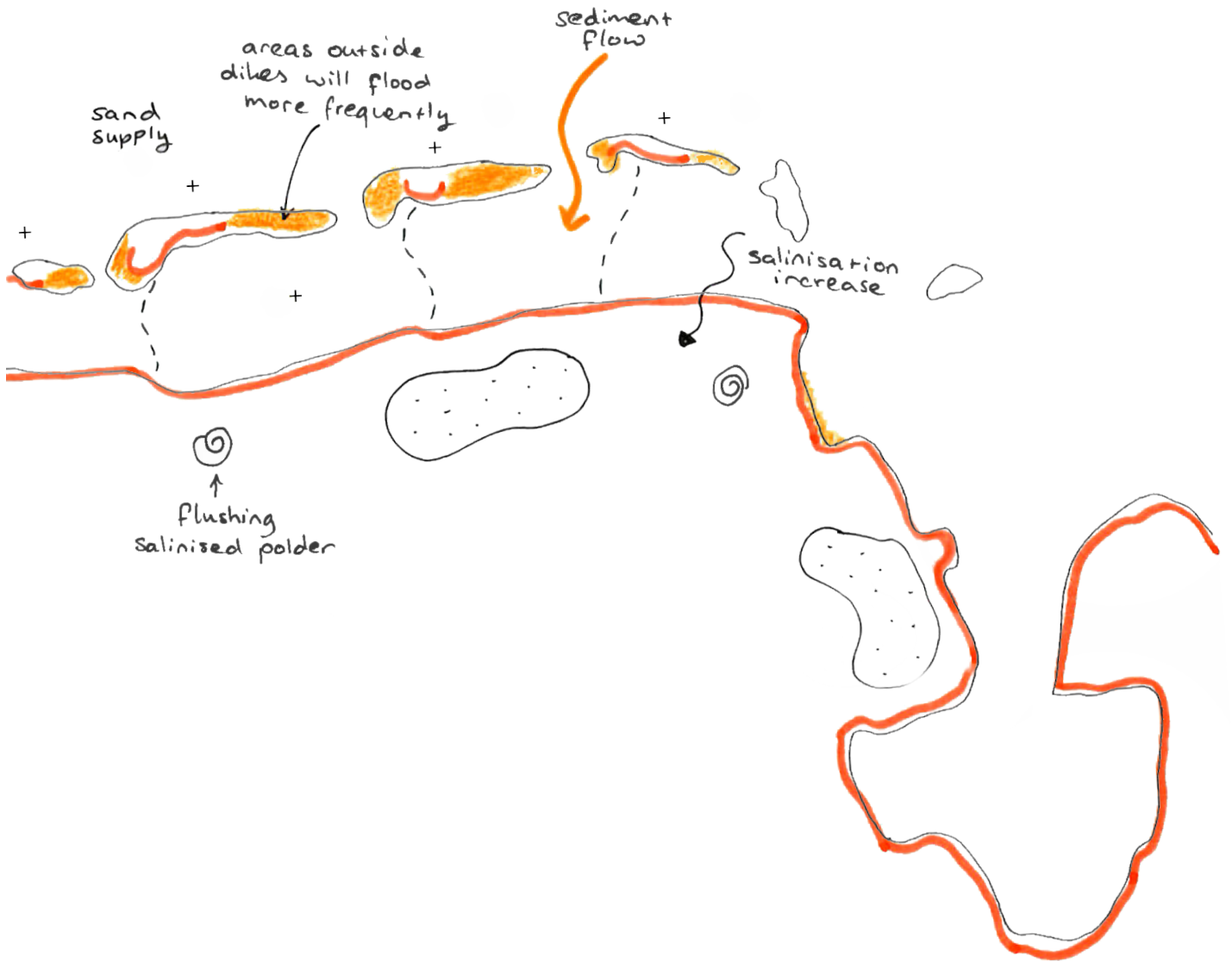
Natural- and water systems follow the current and/or wished land-use.

The first solution direction of Deltares are protection-closed and protection-open. These strategies aim for full protection of the Dutch coast against floods and erosion with both hard and soft measures, but all active protection measures. The water- and natural systems follow and facilitate the current and/or wished land-use. The difference between the two is the choice to connect the rivers to the sea. Protection-open is similar to the current Dutch protection strategy, where land and sea is formed to the preferred land-use of the people. Improving the dikes would mean more space needed for flood defences and more pumping capacity is crucial for keeping the land dry and get river discharge out to sea. Although an important water system, the riverine system of the mainland lies outside the scope of this project and therefore these two solution directions are combined in Protect, a solution direction based on protection-closed. Active protection measures are implemented. Dikes will be reinforced and the pump capacity will be expanded to keep the land dry and to flush out salinized polders. In the future the capacity should be increased to cope with the challenges, but whether this exceeds the limits of design and technology is unclear and the question if land should be formed to human needs arises.

Protect

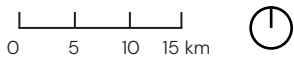
Niedersachsen



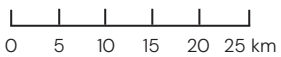
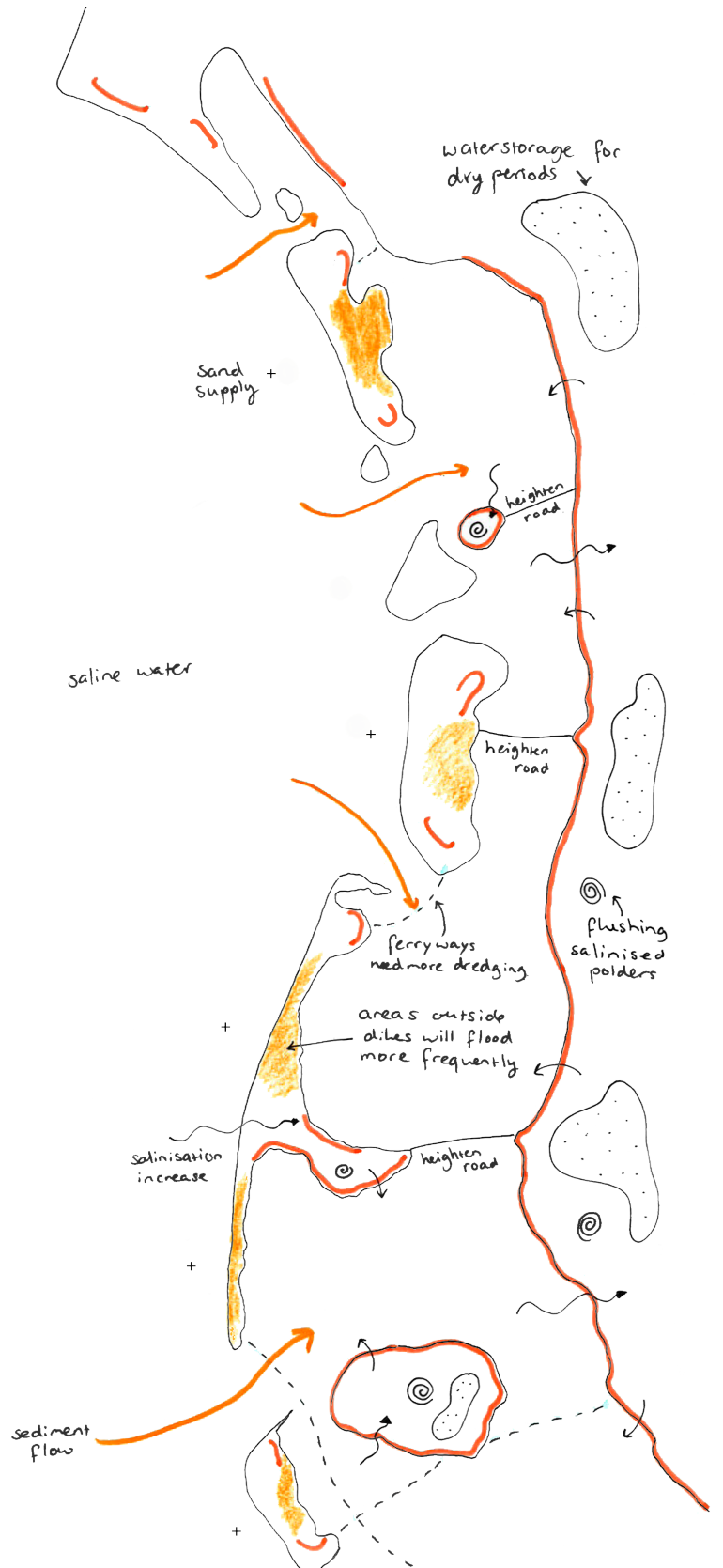


Protect

Schleswig-Holstein

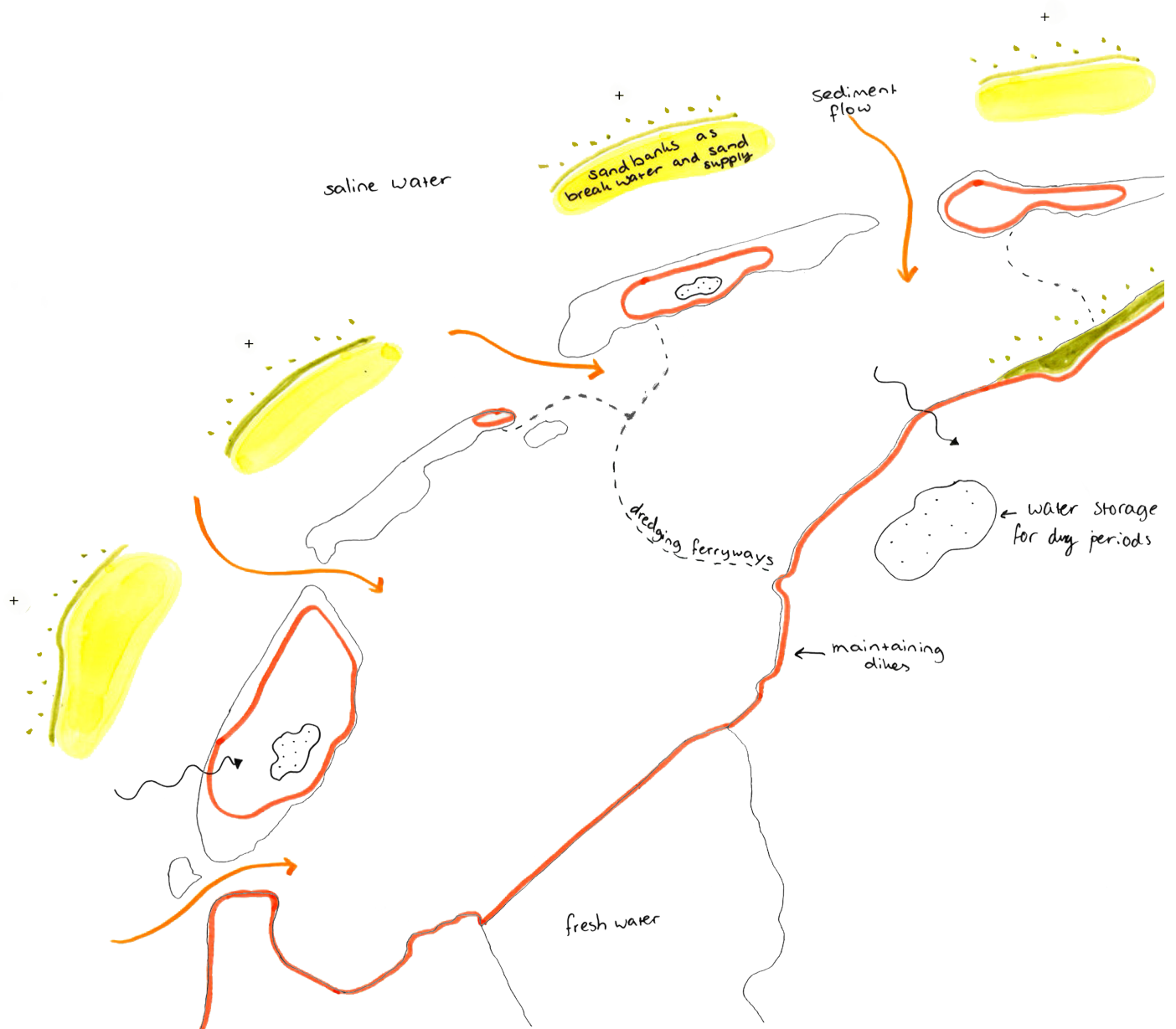


Protect Denmark



Seaward

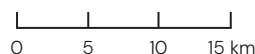
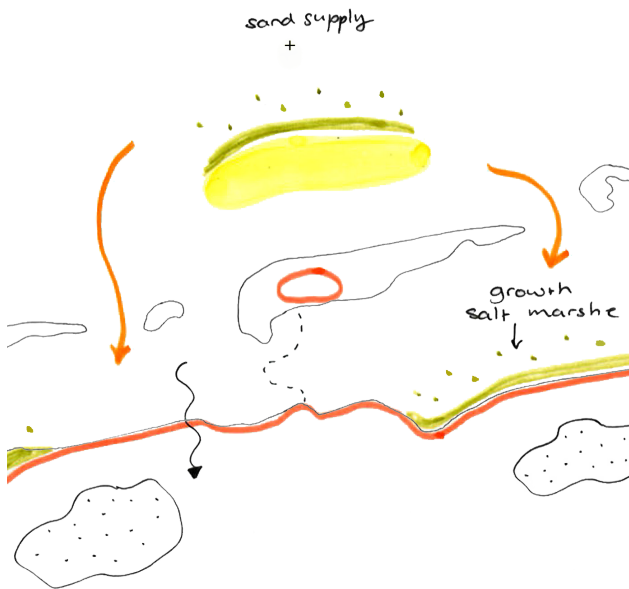
Netherlands



Protecting the islands from the outside.

The solution direction Seaward, as proposed by Deltares focusses on protecting delta from floodings by shifting flooding defences seaward. This could be either by expanding the land into the sea and moving the current coastline towards the sea. This is envisioned through the addition of a new shoreline or through the use or addition of islands. The most efficient way would be to create a closed system in which the islands are connected and the inner sea or lagoon is enclosed.

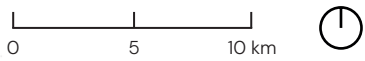
In case of this project, Seaward means connecting the Wadden islands to close off the sea entirely. However, a big consequence of this is the loss of tidal movement. The Wadden Sea would no longer rise and fall every six hours. Since these tides are a defining feature of the Wadden Sea, shaping its identity and supporting both nature and human activities, this outcome is undesirable. In Deltares' proposed vision, the Wadden islands would act as natural breakwaters, shielding the mainland from rising sea levels and storm surges, but by considering the islands as the "main land", they should be protected by breakwaters outside the chain of islands. With the use of sand suppletion, like the sand motor (Huisman et al., 2021), large sandbanks can be created on the outer edge of the Wadden Sea's open system. The sandbanks would work as breakwaters for the Wadden islands and reduce the pressure on the current island defence. Over time, wind and water flows would transport sand to the islands, reinforcing the dunes and increasing their protective capacity. However, to create many sandbanks along the island chain, this method would require vast amounts of sand, a resource that is not infinite.

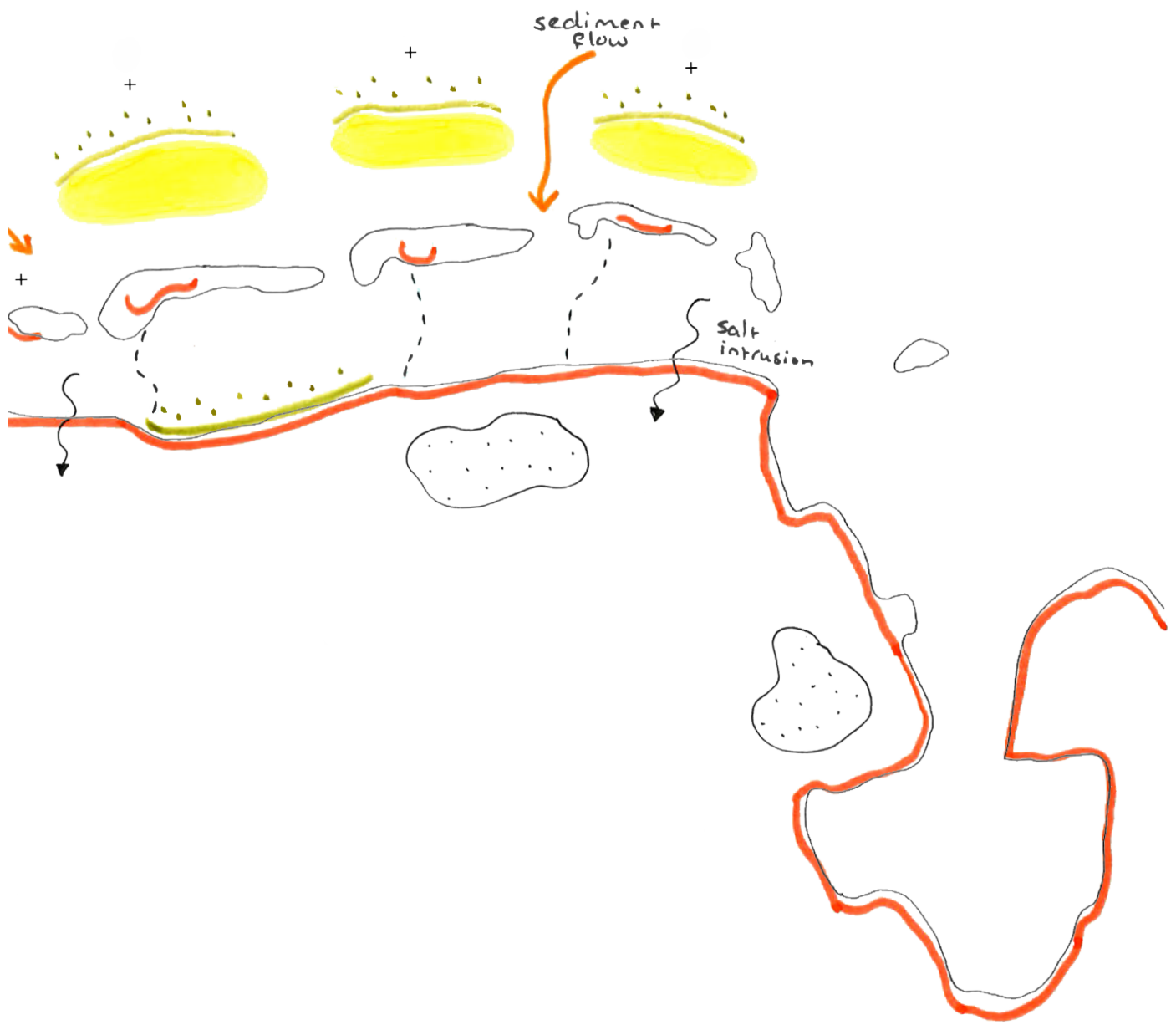


Seaward

Niedersachsen

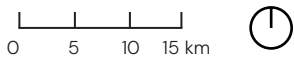
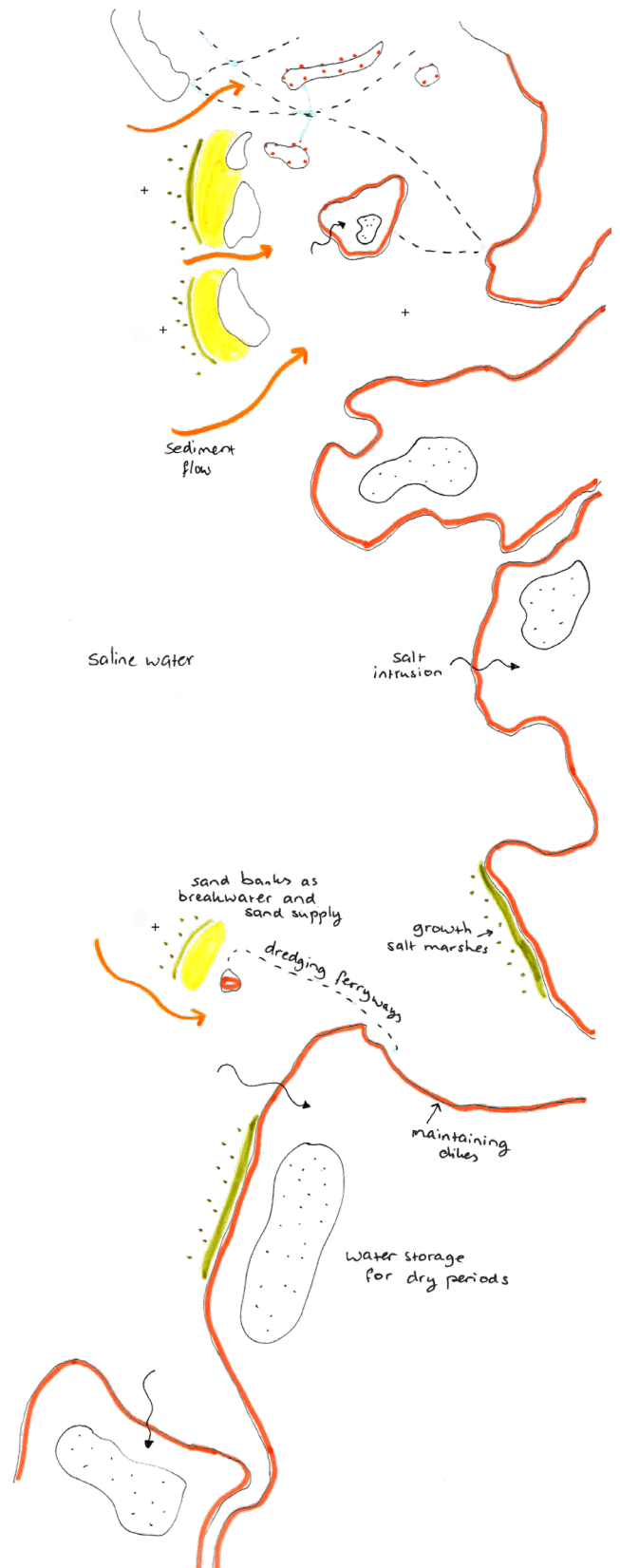
saline water





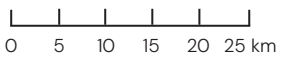
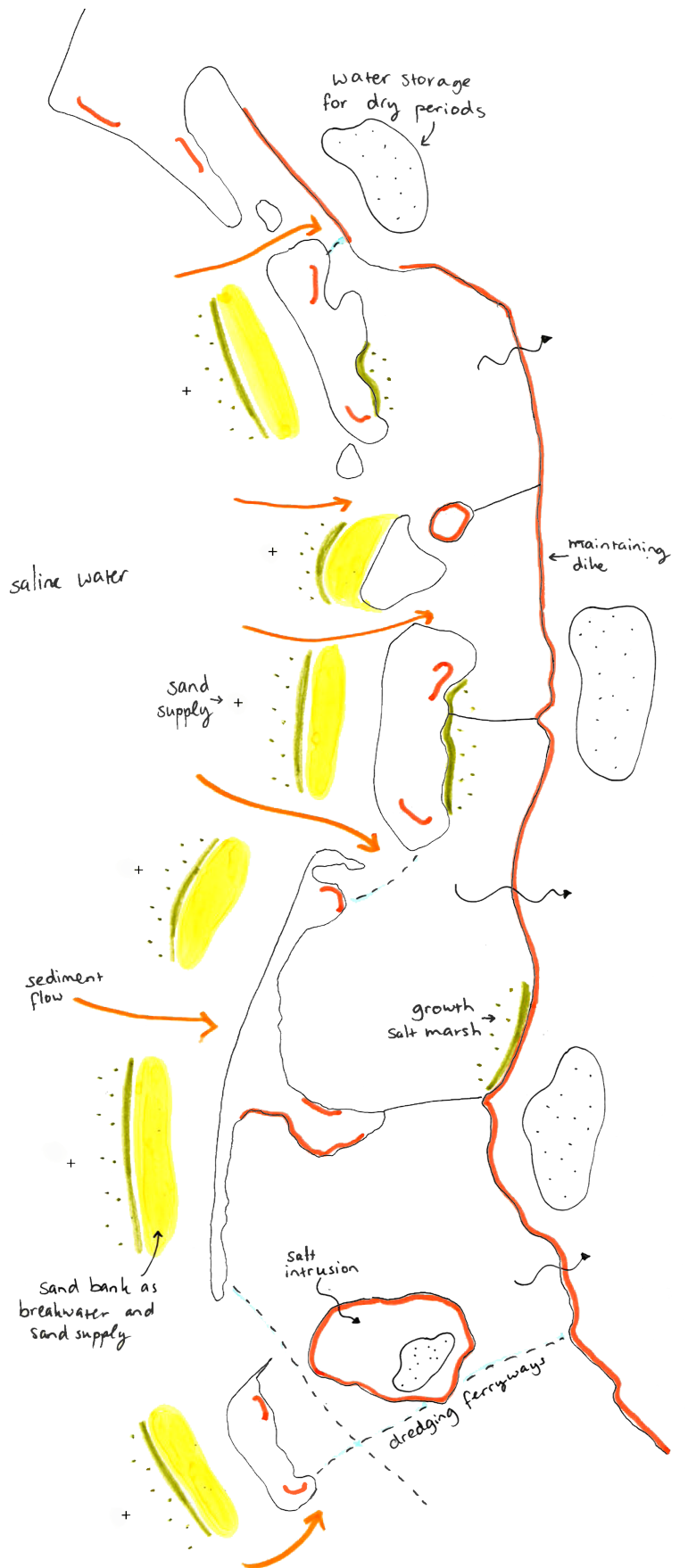
Seaward

Schleswig-Holstein



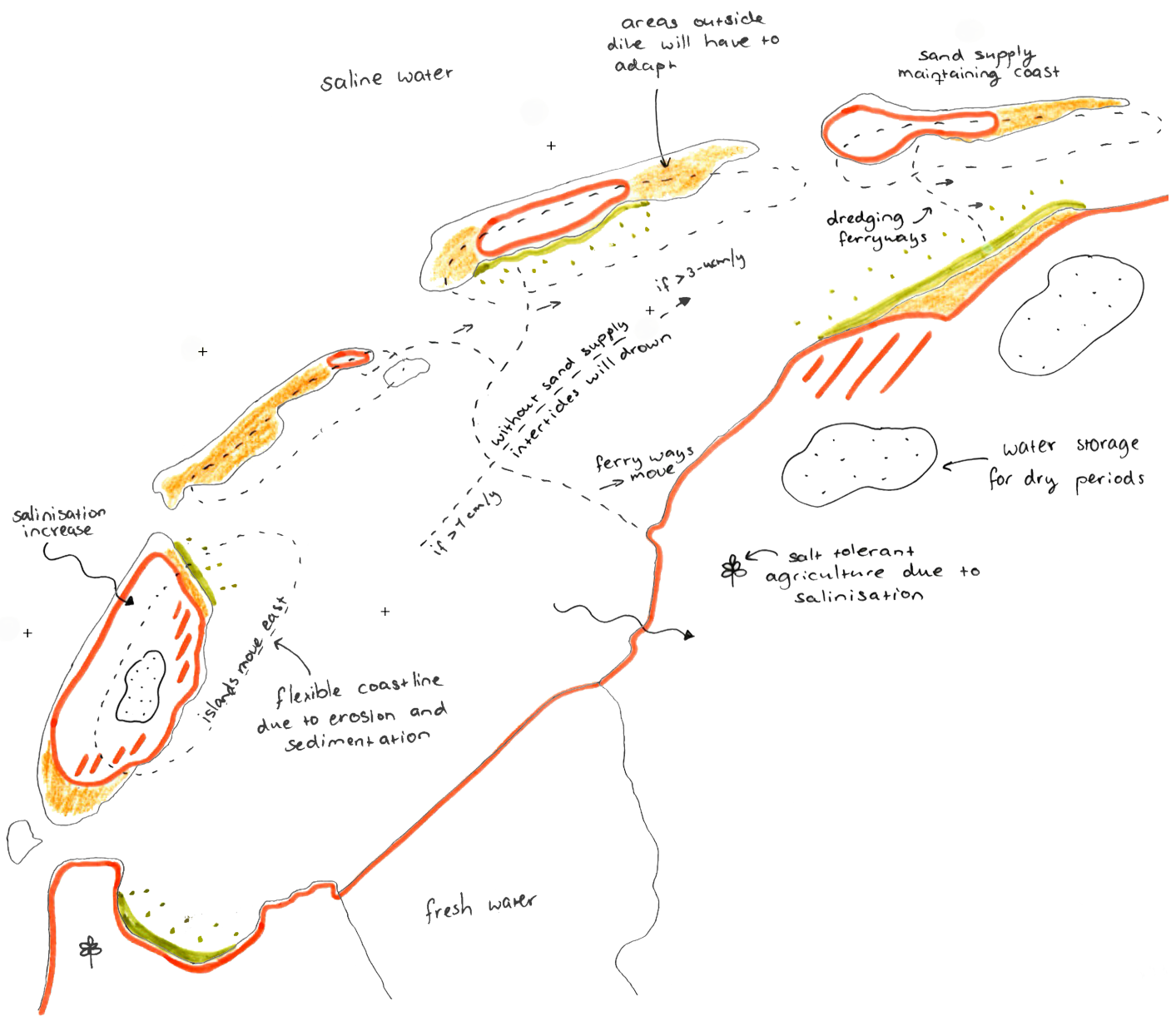
Seaward

Denmark



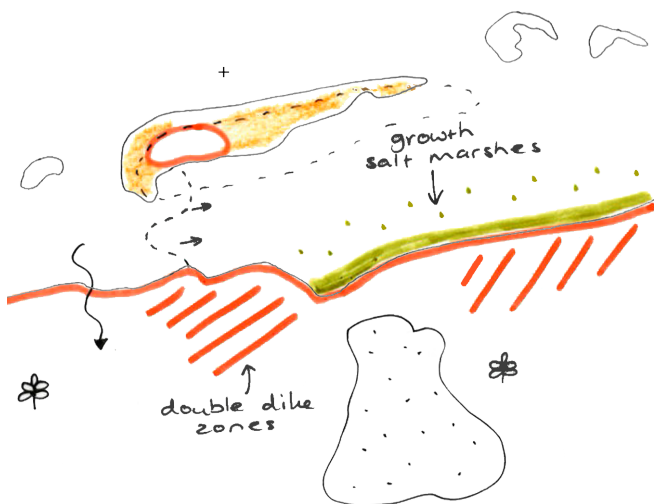
Move

Netherlands

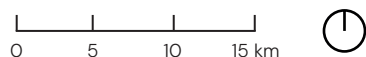


Use of the land has to adapt and water- and natural systems lead.

The last solution direction of Deltares is called Move. Following this solution direction means being adaptable to the consequences of an accelerated sea level rise. A key characteristic of this solution direction is that the land-use will have to adapt and the water- and natural systems lead, increasing the need to live with water. This solution direction emphasises the forces of nature and the importance not to oppose. Here people will move along with the effects of nature, some might even need to live on higher grounds, some areas outside the protection of dikes will have to adapt to more frequent floodings and land-use needs to be more water- and salt tolerant. This way vulnerable coastal areas can still be used in the developing sea level rise.

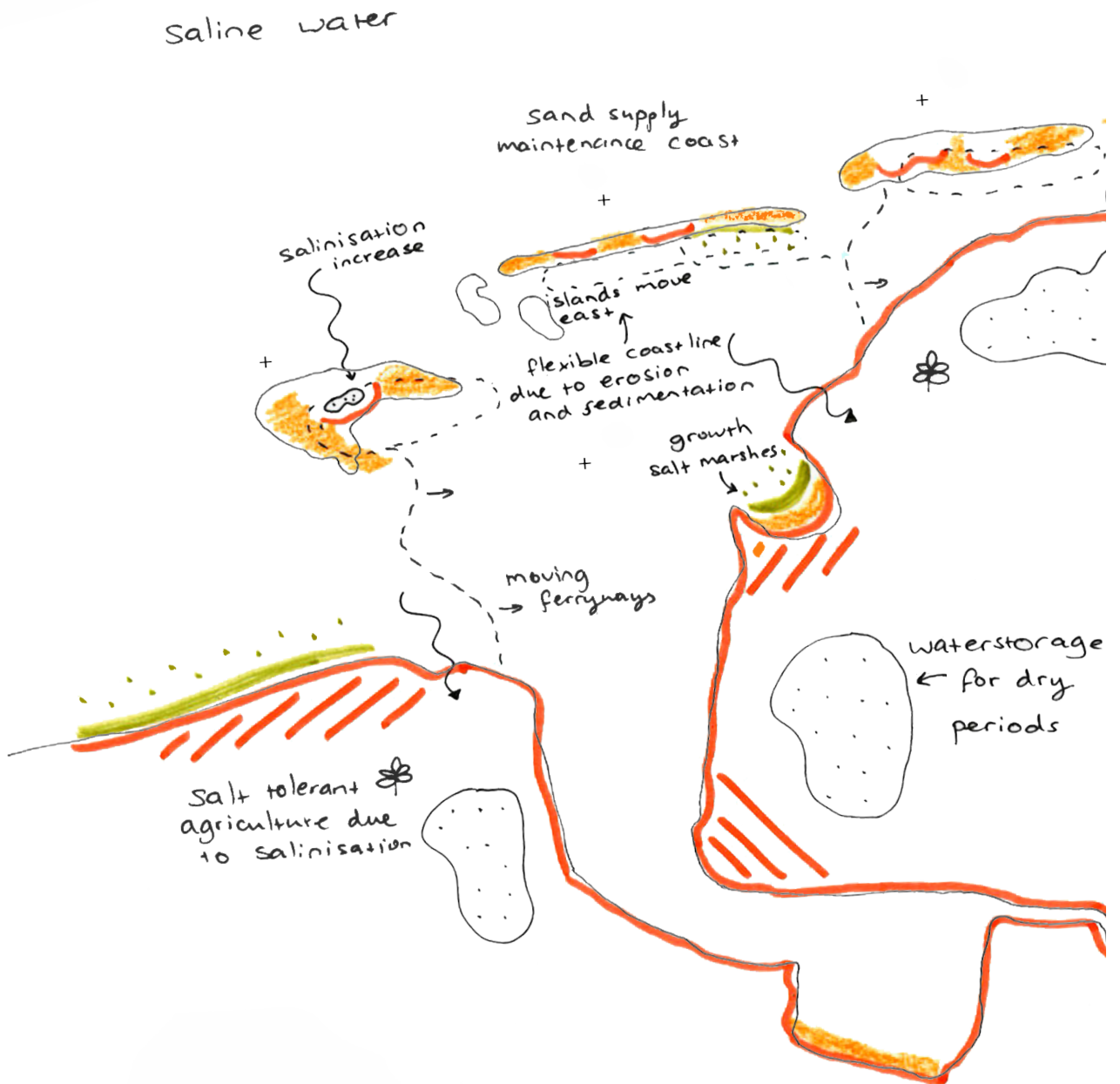


In this project Move encompasses a strategy in which we move along with the forces of nature and emphasised is the movement of the Wadden islands in the tidal system. Double dike zones will be implemented to reduce the pressure of the current sea dike, creating zones which will occasionally flood. The islands will move quicker along the littoral drift, as measures to maintain its form are executed less. This causes the coastline to be more flexible due to erosion and sedimentation. This is a natural process that has happened for centuries, but without intervention this process will accelerate.



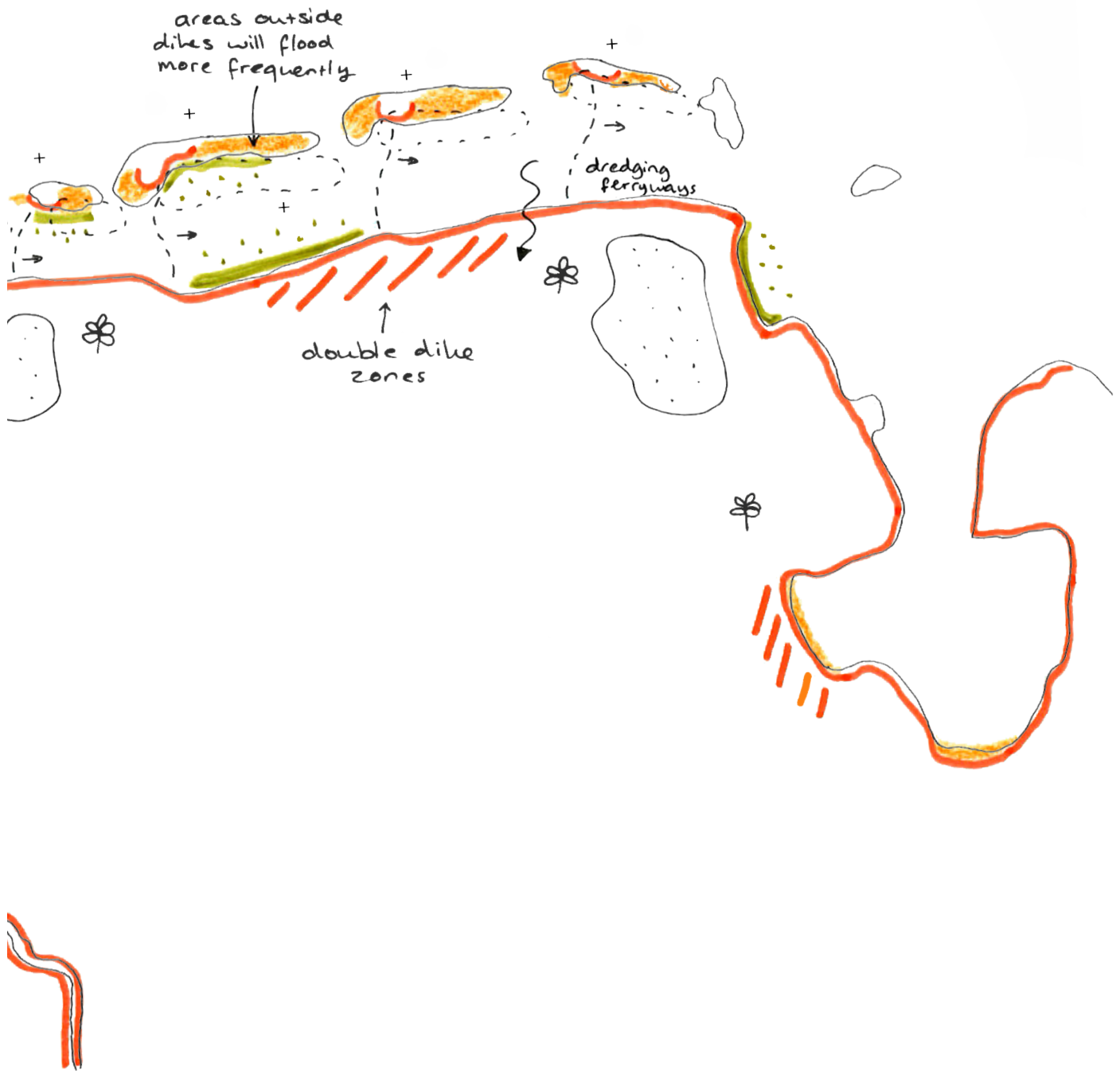
Move

Niedersachsen



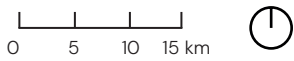
0 5 10 km





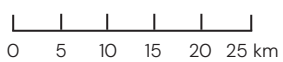
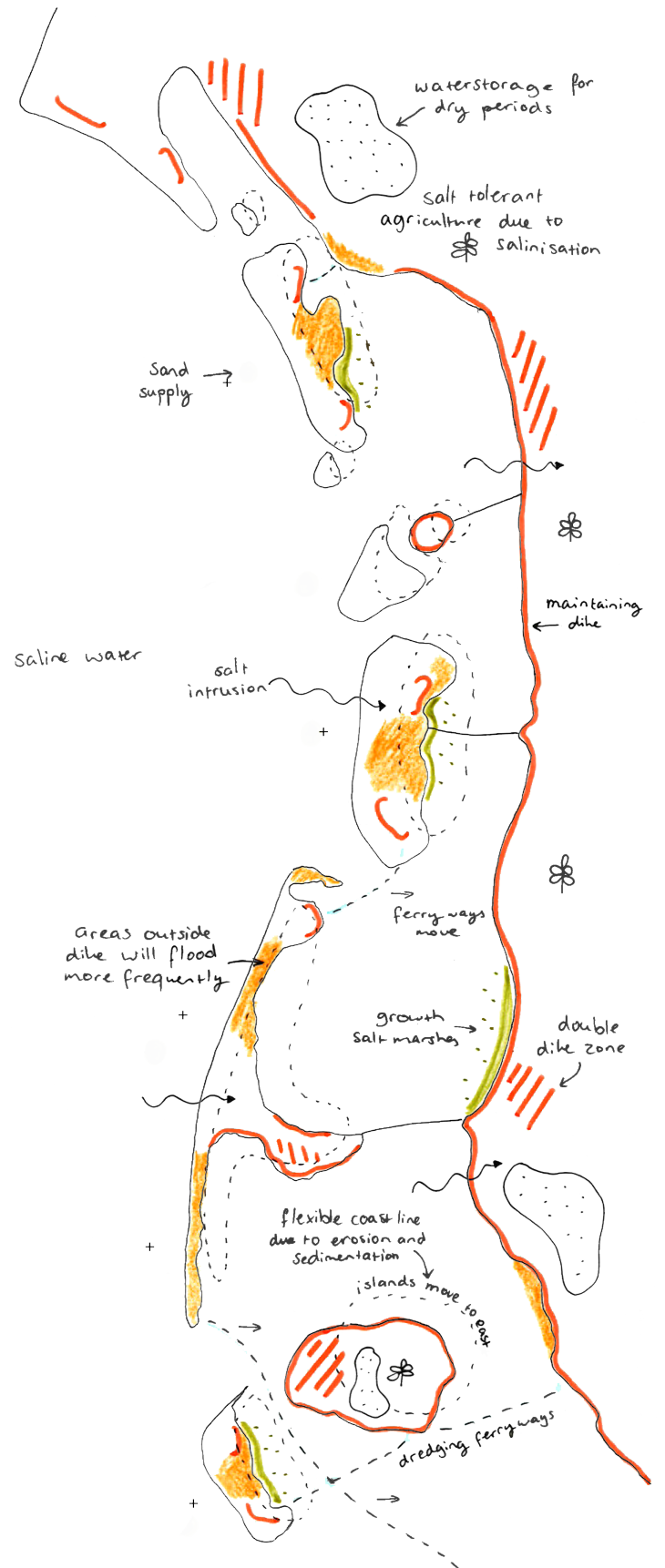
Move

Schleswig-Holstein



Move

Denmark



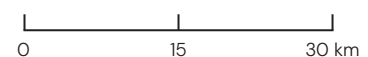
Island typology

The Wadden Sea islands can be distinguished in four main types: three inhabited and one uninhabited type. The inhabited islands can be identified as a dune island, polder island, and salt marsh island. To make this distinction, the land types were studied. Large concentrations of arable land indicate the presence of polders and therefore the identification as polder island. The dune islands have a significant presence of strips of dunes and beaches. The salt marsh islands have been identified through satellite data. The fourth island type are uninhabited islets. These are mostly in the form of sand





banks. In the following section these types will be defined. The types are explained through base maps that are based on existing islands (Salt marsh - Hooe (DE), Polder - Pellworm (DE), Dune - Spiekeroog (DE)), but are not identical to them. Noted must be that some inhabited islands have characteristics of more than one typology.



- Arable land
- Dunes and beach
- Salt marsh landscape
- Sandbank





-  Islets
-  Salt marsh islands
-  Polder islands
-  Dune islands

Island type

Islet

Next to the three main island types, there are also uninhabited islets. Before humans started to colonise some islands permanently in the 8th century (De Vries, n.d.), all Wadden islands, in whatever form they were back then, were uninhabited. Nowadays the remaining uninhabited islands are in the form of sandbanks of different sizes. Some consist of only sand, while others contain vegetation and in some cases even posts for researchers of nature. However, many of these islands are prohibited for people to access, as to not bother species in their natural habitat. According to Oost et al. (2017), there are more than 65 uninhabited islands in the trilateral Wadden Sea, ranging from 0,01 to 17 km². Some are bird sanctuary, some are just sandy shoals. The islands are under constant change. Because especially here, the forces of the wind and sea have free reign. The island Razende Bol (NL), or Noorderhaaks, is a shoal of around four km², situated between the most western Wadden Island, Texel, and the Dutch mainland. On this island even high dunes can emerge because of these forces and time will tell whether or not the shoal will someday be connected to the island Texel (Prins, 2020). The uninhabited islands have a less prominent role in this project, as the connection between people and nature is explored. However, they are important in the system of the Wadden Sea. They are part of the barrier island chain that form protection for the mainland coast and many islands are resting places for birds and other species, such as seals.



Uninhabited islands in Wadden Sea ▲

	area (km ²)	(Prins, 2020)
Razende Bol (NL)	4	
Richel (NL)	1	
Griend (NL)	1	
Rif (NL)	0,9	
Engelsmanplaat (NL)	0,83	
Rottumerplaat (NL)	7,82	
Rottumeroog (NL)	2,5	
Zuiderduintjes (NL)	0,4	
Lütje Hörn (DE)	0,31	
Kachelotplate (DE)	1,7	
Memmert (DE)	6	
Minseneroog (DE)	3,7	
Mellum (DE)	4,5	
Hoher Knechtsand (DE)	2,6	
Nigehörn (DE)	0,5	
Scharhörn (DE)	5	
Trischen (DE)	1,8	
Süderoogsand (DE)	15	
Norderoogsand (DE)	9,4	
Japsand (DE)	2,9	
Koresand (DK)	25	
Langli (DK)	0,8	



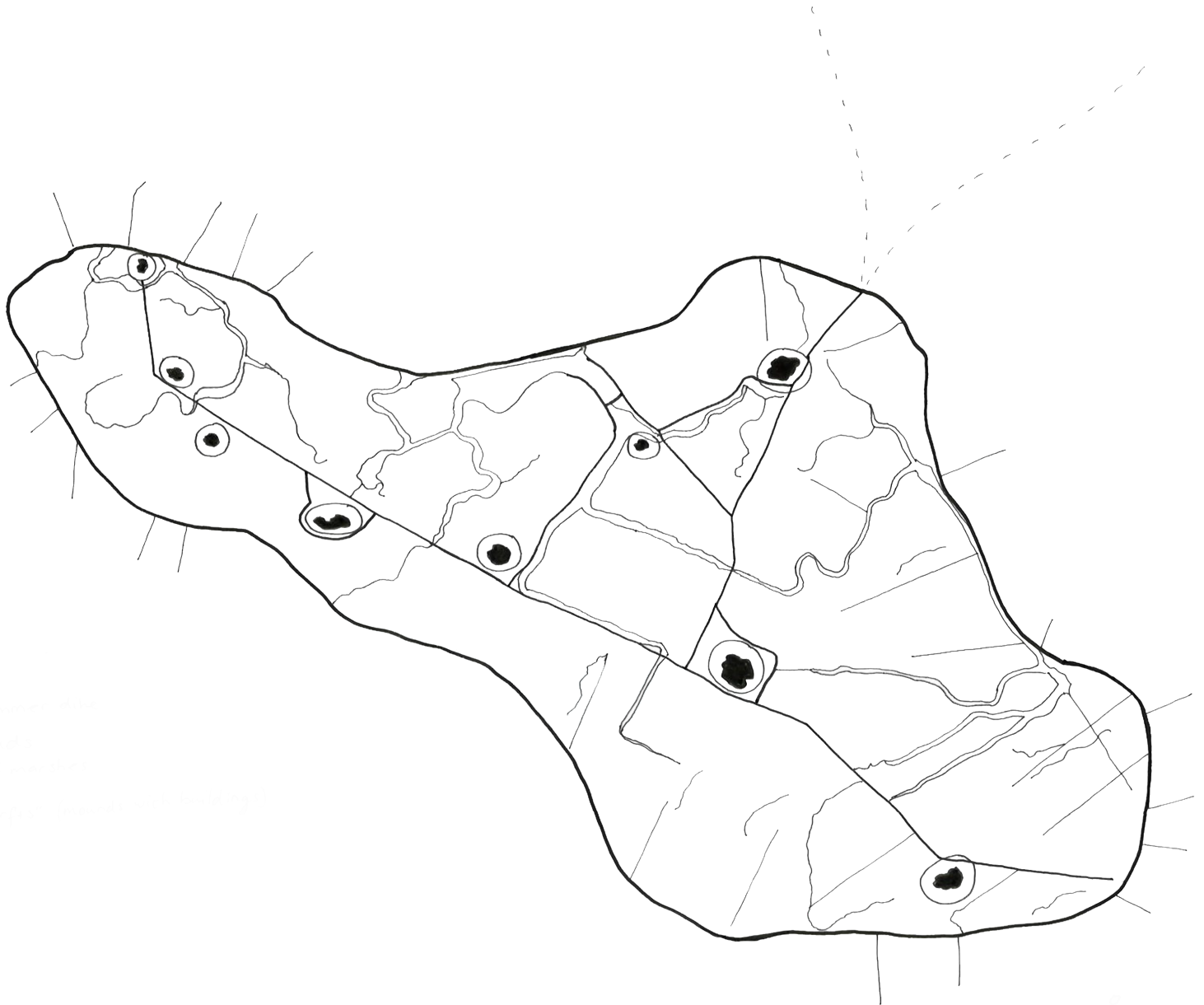
▲ Aerial photo of Zuiderduintjes (NL)
Rijkswaterstaat, Joop van Houdt, beeldbank.rws.nl (2011)



▲ Aerial photo of Süderoogsand (DE)
Walter Rademacher (2012)

Island type

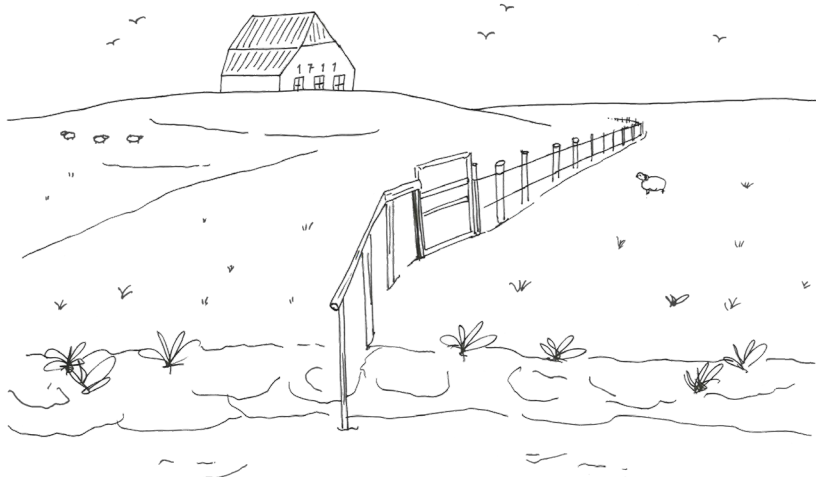
Salt marsh island



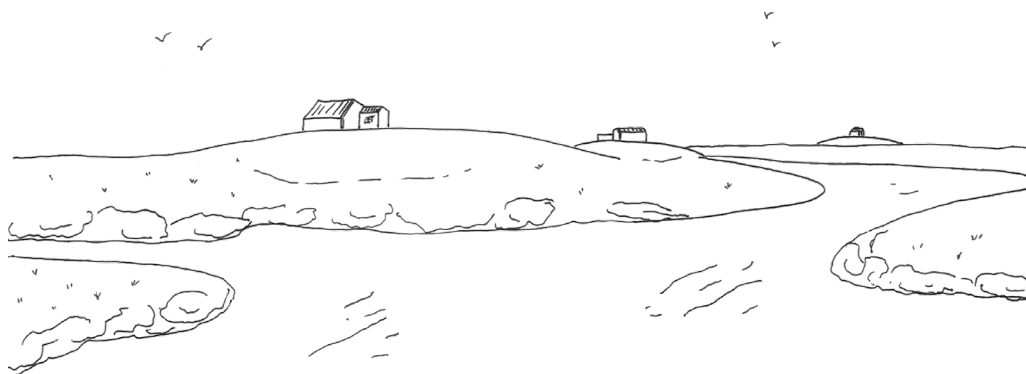
- Summer dike
- Roads
- ~ Salt marshes
- Warft (mound)

0 0,5 1km

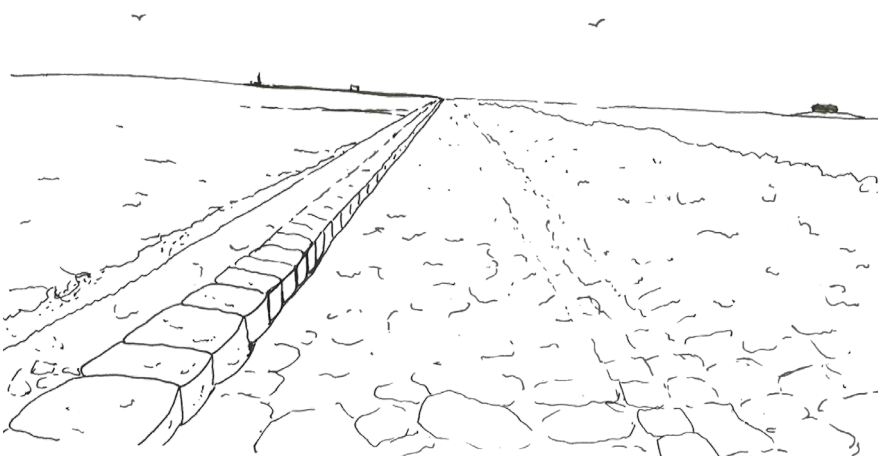




Salt marsh landscape with mound



Mound (Warft) with sheep farming



Summer dike

Salt marsh island

In the Wadden Sea area of Schleswig-Holstein a group of salt marsh islands are located, which barely rise above the sea level (Jank-Humann, 2024). Most of these islands have been formed through siltation on the old subsoil (Ecomare, n.d.-a). However, around 1900 on some islands the coastal protection was improved and low summer dikes were built. Now only during winter storms these are overflowed with water. A negative consequence of this is that because of the addition of these dikes, there is not enough inflow of sediment to make these island grow upward with siltation (Ecomare, n.d.-a).

The salt marsh lands are occasionally flooded (Prins, 2020). Because the salt marsh islands lack significant coastal defences, storm tides frequently flood the islands in winter, submerging nearly everything except the artificial mounds (Walker, 2020). This is called *Landunter*. During this period, the life on the Halligen comes to a halt. The islands are flooded around 20 times each year between November and March (*Landunter*, n.d.), with some without dikes even up to 50 times annually (Walker, 2020). To be able to live on these islands *Warften*, man-made dwelling mounds, are made, on which farms and houses are built. Living permanently on these islands is not without sacrifices (Jank-Humann, 2024), but the residents are used to living with the tidal changes of nature (Walker, 2020). After the flood of 1962, the mounds have been raised again and at least every mound was equipped with a shelter room to provide security in the case of severe storm surges (Jank-Humann, 2024). If needed, people raise the crown of the mounds around the houses.

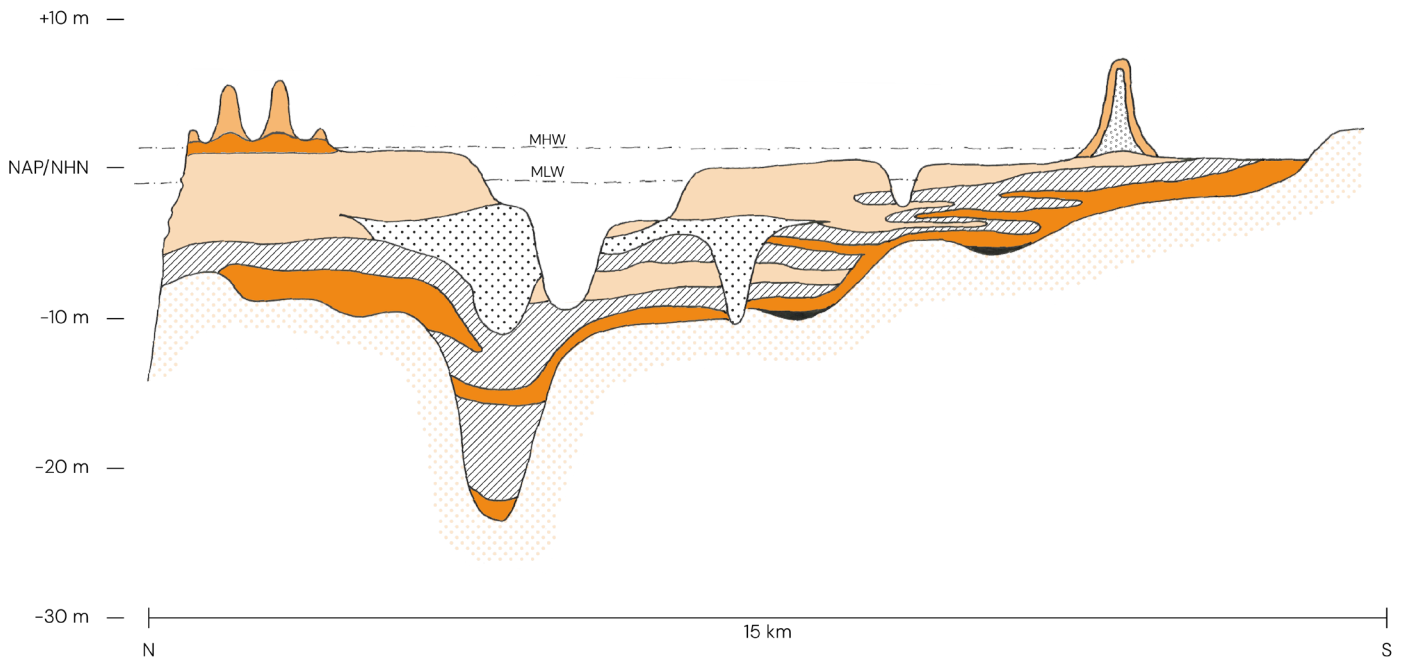


Islands in Wadden Sea distinguished as salt marsh island ▲

Section of salt marsh island ▲









	area (km ²)	inhab.
Südfall (DE)	0,56	2 (summer)
Süderoog (DE)	0,62	3
Nordstrandischmoor (DE)	1,9	22
Oland (DE)	2,01	29
Gröde (DE)	2,77	9
Hooge (DE)	5,78	133
Langeneß (DE)	9,56	113

(Prins, 2020)



Since the sixties tourism became a significant economic driver on the salt marsh islands and because of *Landunter* agricultural cultivation is limited. Agricultural practices are adapted to the regular winter flooding, with the meadows serving mainly as seasonal summer grazing lands for livestock owned by farmers from the mainland (Jank-Humann, 2024). The islands are connected to the mainland by ferries and sometimes even small wagons, that move along the rail dams.

Geomorphology section
Salt marsh island and Wadden Sea

-  Tidal channel deposits
-  Tidal flat deposits
-  Brackish to lagoonal deposits
-  Fen peat
-  Gyttja
-  Pleistocene
-  Sand
-  Clay layer

Langeneß

Island example (DE)

Langeneß is an island in the Halligen, and an example of a salt marsh island. People used to make a living on this island through fishing, keeping cattle, hunting seabirds and salt extraction from peat, but also much economic prosperity was generated by whaling. The island used to consist of three parts, however, with building summer dikes and dams made of brushwood, accretion occurred more and the parts became one. There are 18 mounds (*Warften*) on the island and the green space in between is habitat for birds, and space for cows and sheeps to graze. The image shows the event of *Landunter*. Inhabitants are quite used to this and one of the islanders even said: 'during the holidays, we have *Landunter* more often than a white Christmas' (Prins, 2020, p. 294). Even though, both electricity (*History of the Halligen Langeness and Oland*, n.d.) and drinking water (*Lighthouse Oland*, n.d.) is provided through cables and pipes from the mainland, the islanders are prepared for emergencies. One of the *Warften* is equipped with an emergency provision for electricity. The little wagons that go to Oland and Dagebüll on the mainland, are privately owned and are used to move goods and people to the other islands or the mainland (*Informationen Zu Hallig Langeneß*, n.d.).

Fieldtrip notes:

Taking a stroll on the small and only hardened road, a constant sound of birdsong can be heard. Here and there, I see flagpoles proudly display the flag of Langeness, fluttering in the wind that whistles past your ears. Surrounding the Warften stretches a vast, green landscape of salt marshes, primarily inhabited by many different species of birds and small herds of cows. Trees are only found on top of the Warften, which, on a clear day, visibly rise from the flat terrain. On one Warft, a few houses stand, with some even dating back to the 18th Century, while on another, a small church and little school can be seen. Beyond the landscape of this island, you see water, but also wind turbines, forests, beaches, and the buildings of the other islands on the horizon, as the Halligen are not far apart. Between them, there are many ferries, transporting residents and, at the start of the high season, just a handful of visitors between the islands. In that same space in between the island, just a few hours ago, a sailing boat rested on the mudflats as low tide might have surprised them. But here on the Warft, the atmosphere is peaceful. People know their neighbours well and seem to be prepared for when the first Landunter of the winter season will arrive, just wait and see nature be nature.



Lorenbahn on Langeneß
Brouwer (2026) ▲



▲ Kirchhofswarf on Langeneß
Brouwer (2026)



▲ *Land unter* during a storm surge on Hallig Langeneß in the Wadden Sea
Martin Stock (n.d.)

Langeneß

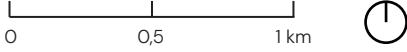
Island example (DE)





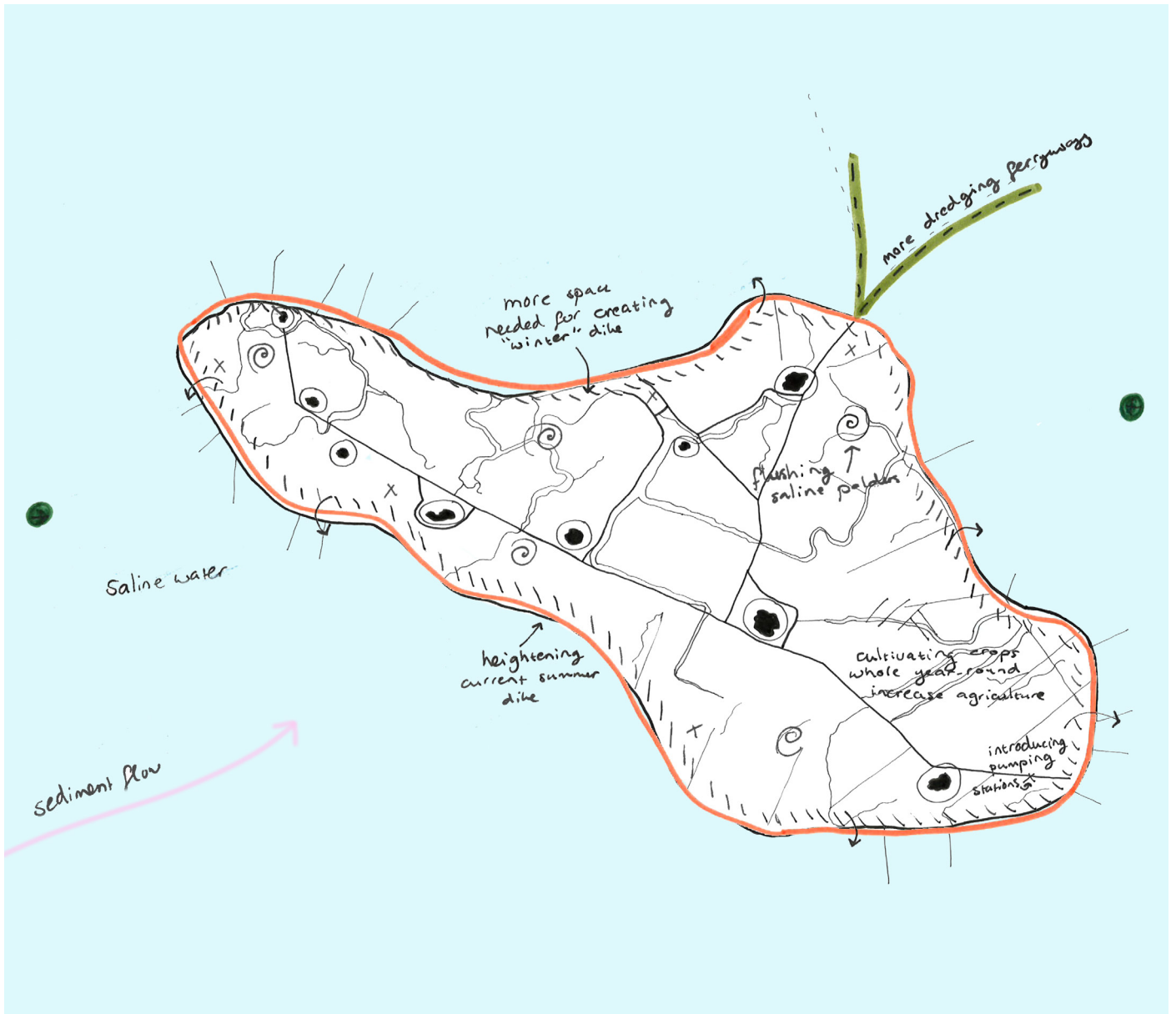
Palimpsest map of Langeneß
1900 - now

- Outline 1900
- Current outline
- Mound
- Lost mound
- Mud flats
- Human-made salt marshes
- Historical pathway
- - - Current roads
- ⋯ Lorenbahn
- ⊕ Church
- ✱ Lighthouse
- ⊃ Boat activity (1900 - now)



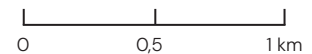
Protect

Salt marsh island



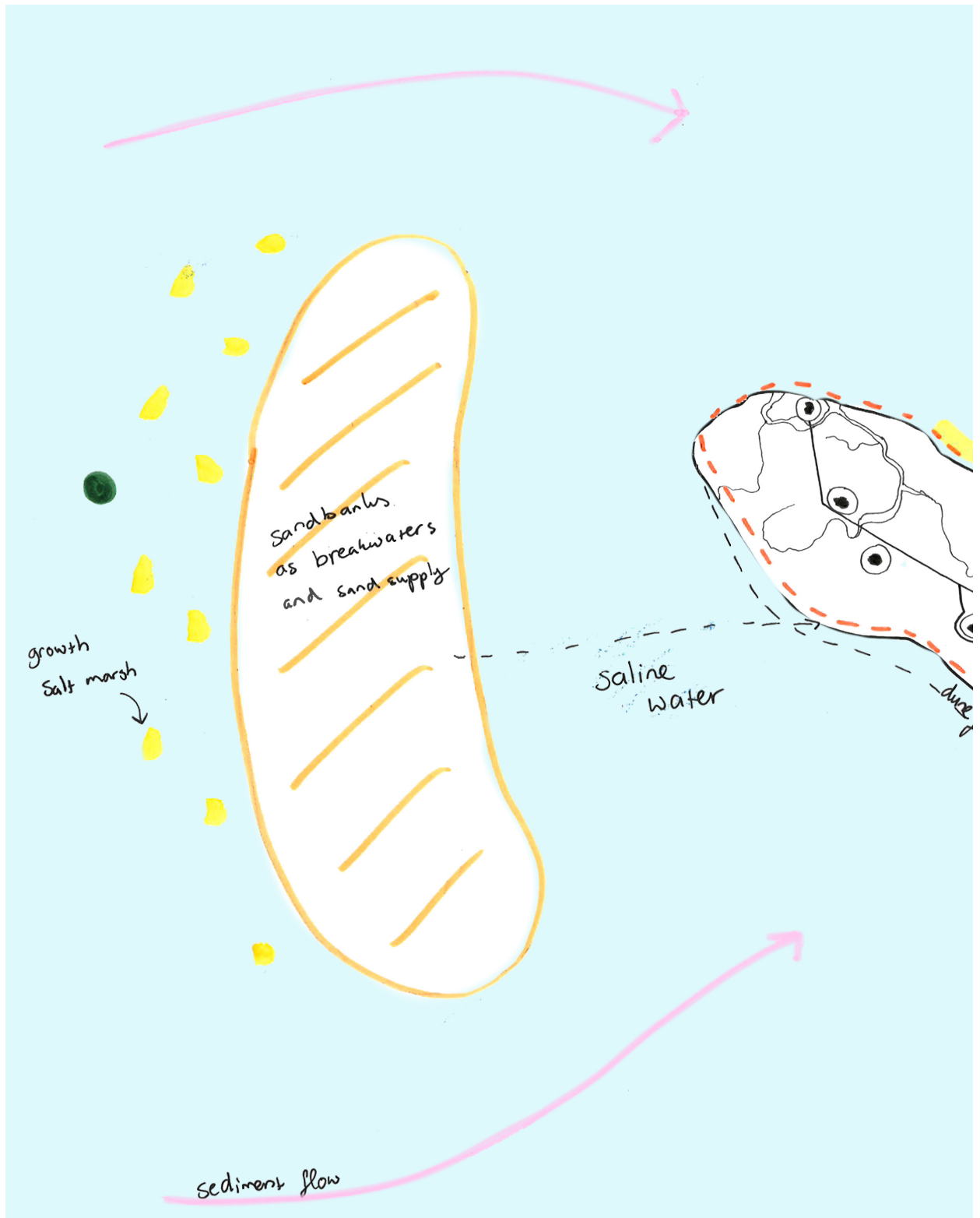
Move

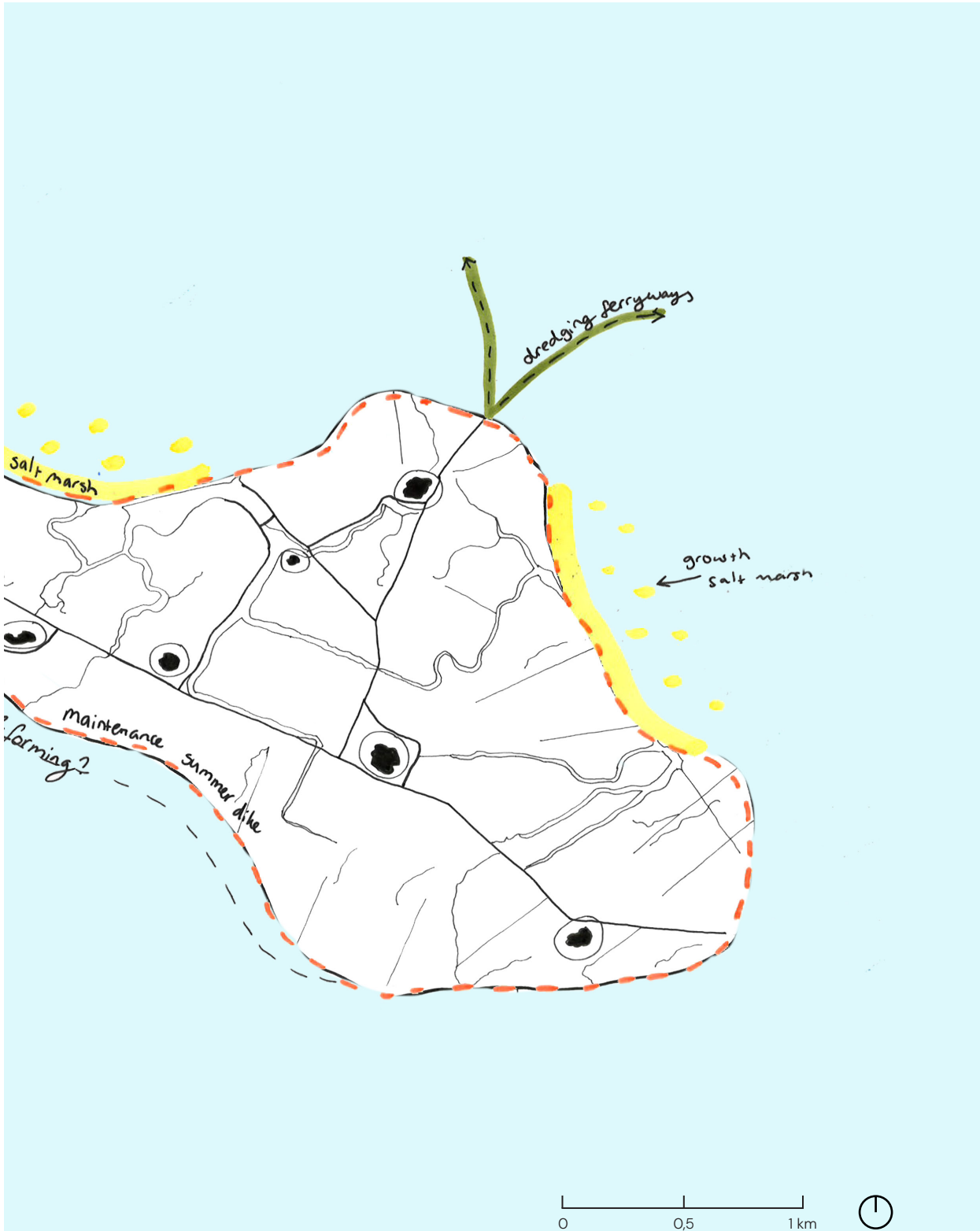
Salt marsh island



Seaward

Salt marsh island





Island type

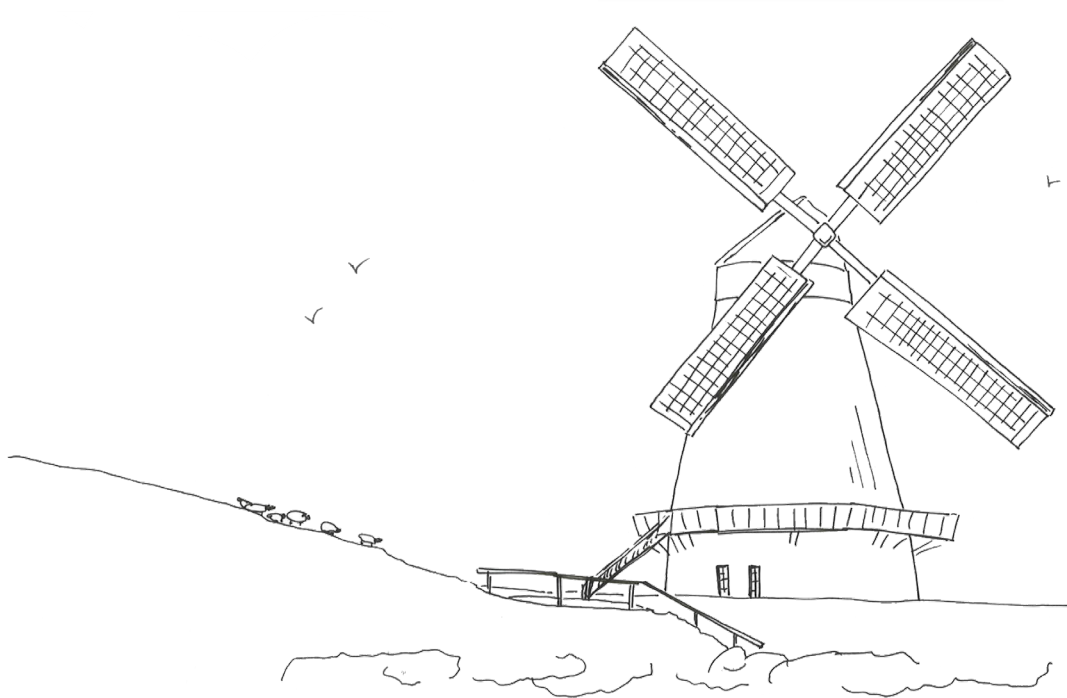
Polder island



- Dike and road
- Roads
- Urbanisation
- ## Polder

0 0,5 1 1,5 km





Windmills were used to pump the polder dry



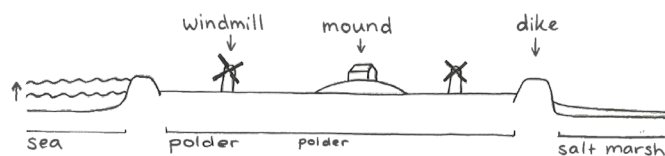
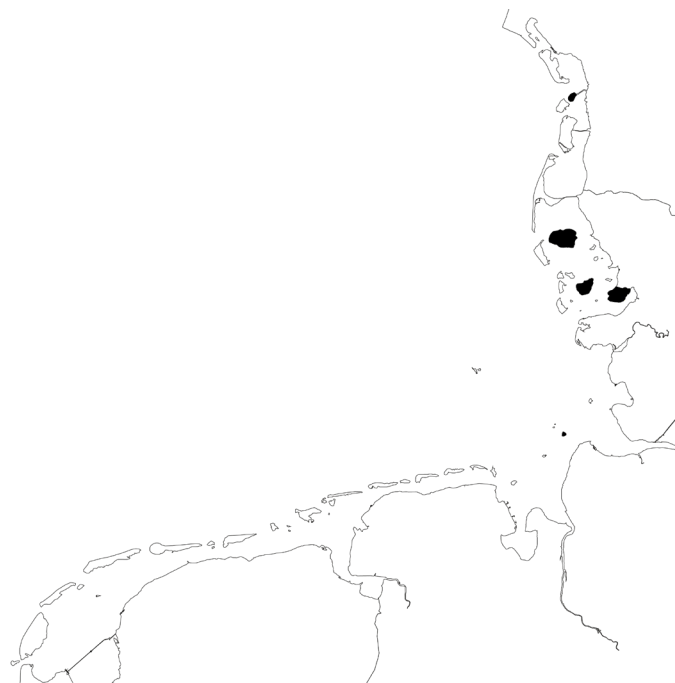
Mounds on arable land

Polder island

The polder islands are completely surrounded by a dike ring and consists of polders, allowing for the cultivation of arable pastures and settlement in areas that would otherwise be under water. The old windmills that can be found on these island indicate that farming has played an important role on these polder islands. However, at the moment tourism is one of the most important source of income (Ecomare, n.d.-b).

Many farms are built on mounds (also *Warften*), just like on the salt marsh islands. When the sea level rises also the groundwater level in the polder rises, which is mechanically pumped out, but then still the houses are dry on the *Warften* (Prins, 2020).

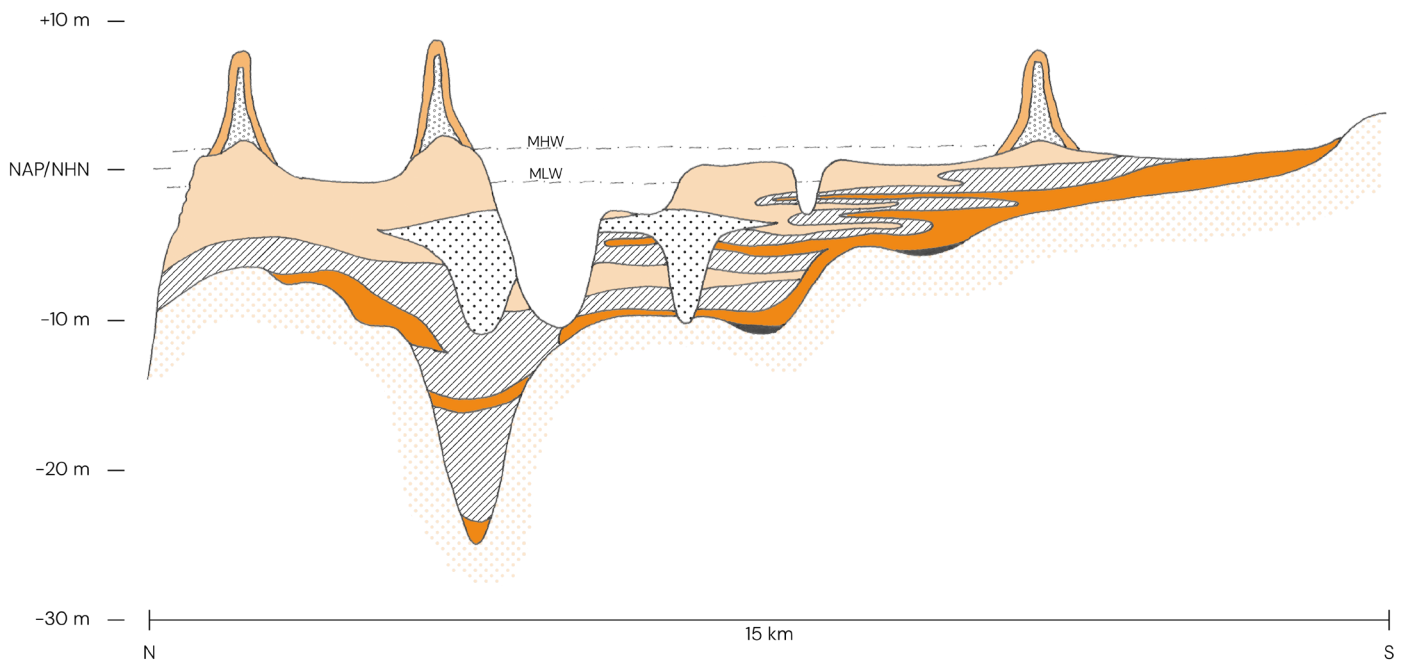
The islands are mainly connected to the mainland by ferry, but Mandø (DK) is for instance connected to the mainland by a tidal road. This road is raised half a metre above the seabed. At low tide this road is accessible, but during low tide the road is completely flooded (National Park Vadehavet, n.d.).











Islands in Wadden Sea distinguished as polder island ▲

Section of polder island ▲

	area (km ²)	inhab. (Prins, 2020)
Mandø (DK)	8,63	42
Pellworm (DE)	37,44	1136
Nordstrand (DE)	49	2218
Föhr (DE)	82,82	8259



Geomorphology section
Polder island and Wadden Sea

-  Tidal channel deposits
-  Tidal flat deposits
-  Brackish to lagoonal deposits
-  Fen peat
-  Gyttja
-  Pleistocene
-  Sand
-  Clay layer

Nordstrand

Island example (DE)

Even though the island of Nordstrand is since 1987 officially a peninsula, it can still be viewed as an island, since the only main connection to the mainland of Schleswig-Holstein is a dam with a stretch of 3 kilometres, which has been constructed in 1935. Long before it was an island, facing many storm surges. In 1652 Dutch enterprises got assigned carte blanche by the duke of that time to embank the island of Nordstrand. This happened despite dissatisfaction among local residents, whose concerns were largely disregarded. Since then, even the French have contributed their share, and 7 polders have been created. The island is characterised by these polder landscapes and the old houses that are located on the dikes (Prins, 2020).

Fieldtrip notes:

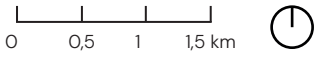
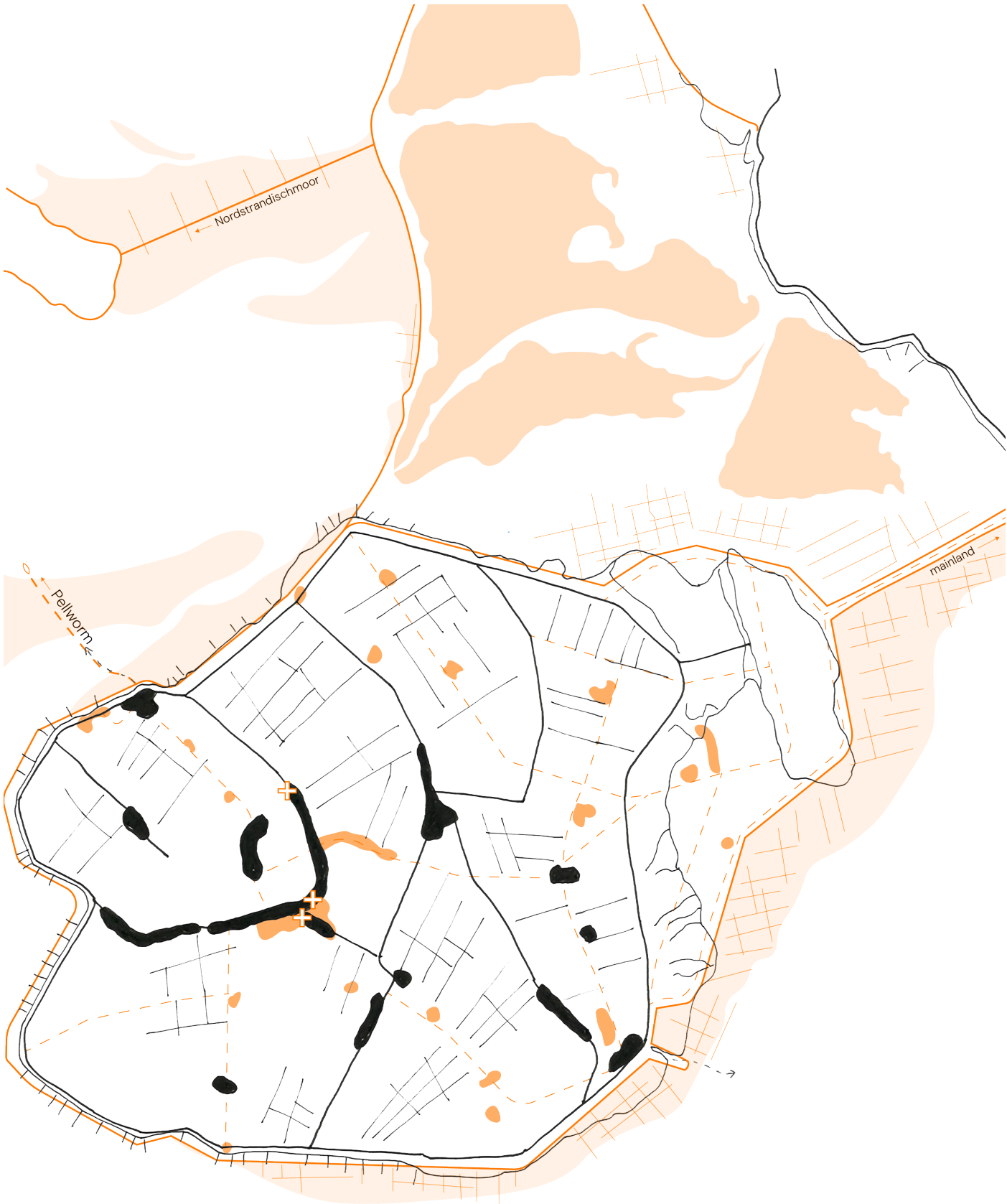
When driving onto the peninsula of Nordstrand, you get greeted immediately by a view of many sheep and their little ones. They graze on the dikes and the salt marshes. The island consists of a flat and extensive polder landscape, divided by high dikes. In between the landscape is coloured by large fields of yellow rapeseed. Some villages, like Süden, rise up from this landscape. Here the road is raised and the houses are located on higher grounds. Some farms are built on low mounds, dating back to the time there were no polders yet and the water came up to the farms. I imagine how it would have been here before the Dutch started to make polders of this landscape. Standing on the sea dike, the Halligen appear on the horizon. Closer, in the foreground lie the stretch dams, constructed for extra protection of the polder island. Currently, it is low tide. The mudflats are exposed, and in the small harbor, sailboats lie in the mud. From here many fishermen went on their way to sea, providing for the families back on the island. Now people live seem to live from the many cultivated arable land.



▲ Higher situated houses of village Süden
Brouwer (2026)

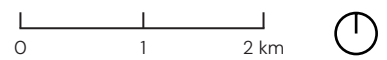
Palimpsest map of Nordstrand 1900 - now

- Outline 1900
- Current outline
- Lake
- Mud flats
- Human-made salt marshes
- Arable polder landscape
- - - Current roads
- Roads 1900
- ⊕ Church
- - - Current ferry route
- - - Ferry route 1900
- Urbanisation 1900
- Current urbanisation



Protect

Polder island



Move

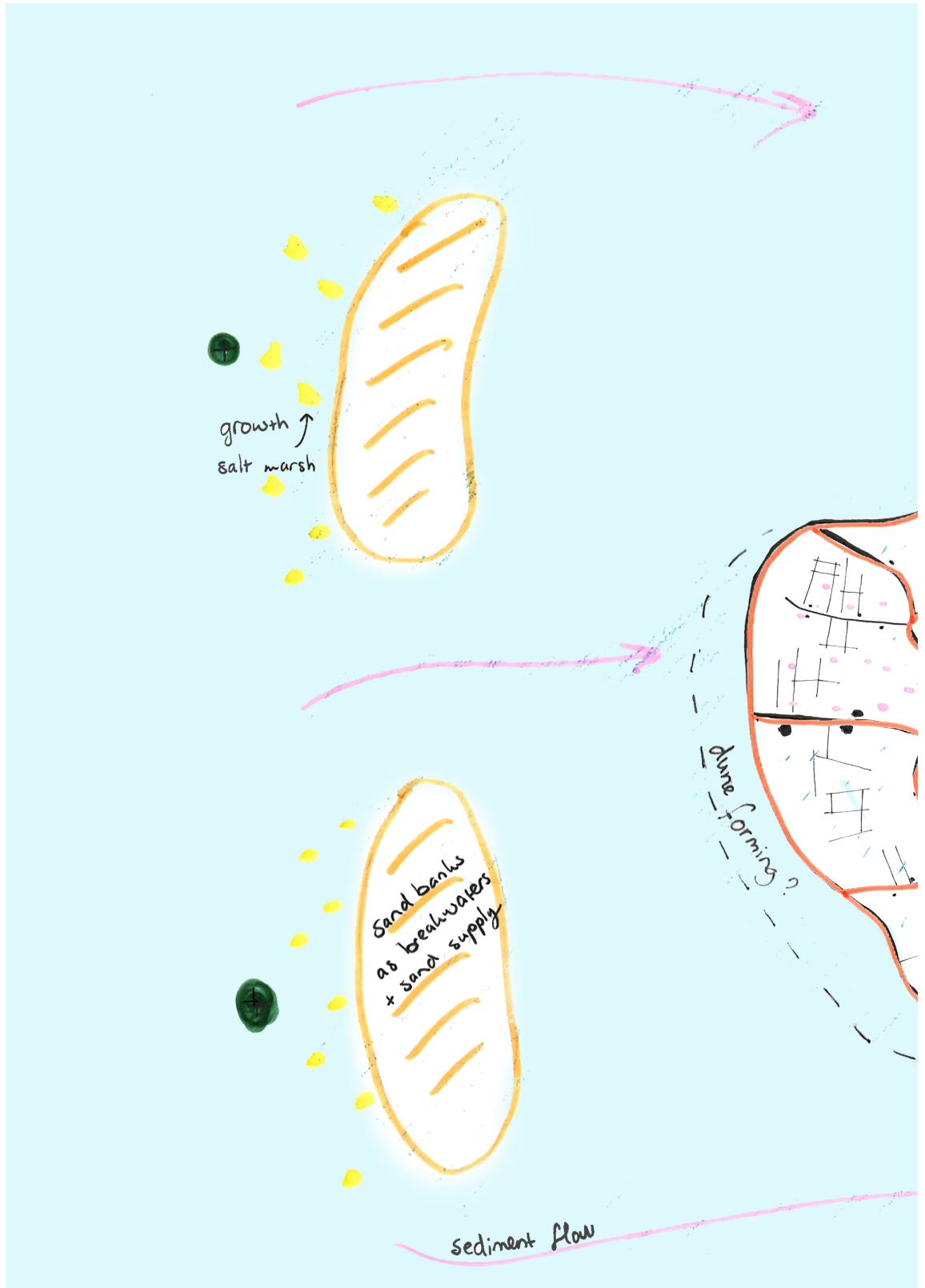
Polder island

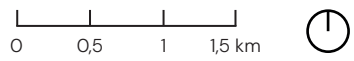


0 1 2 km



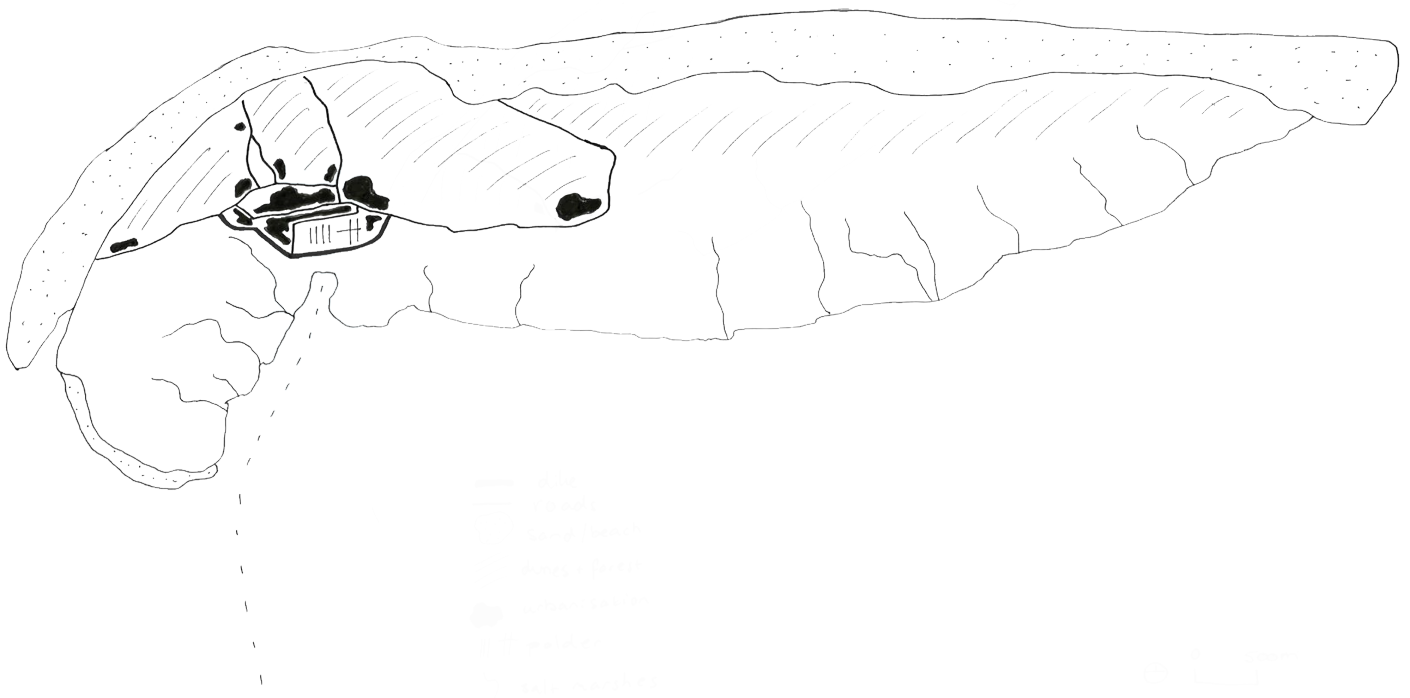
Seaward Polder island





Island type

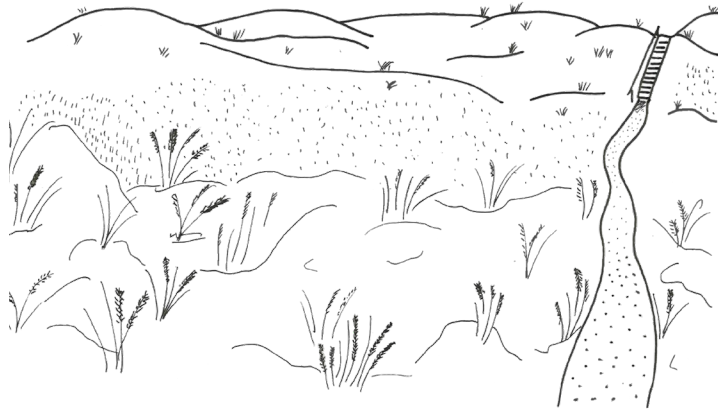
Dune island



- Dike
- Roads
- ☉ Sand, beach
- ▨ Dunes, forest
- Urbanisation
- ▤ Polder
- ~ Salt marshes

0 0,5 1 1,5 km

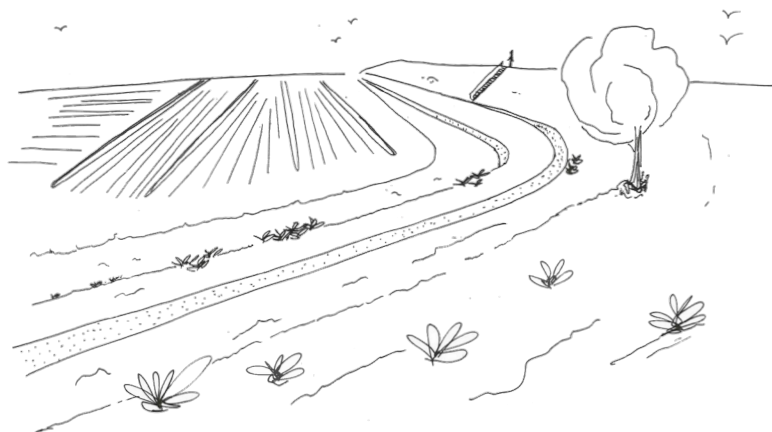




Dune landscape



Dune landscape with lighthouse



Polder land and protective dike

Dune island

Many of the Dutch islands and those in the tidal waters of Niedersachsen can be distinguished as a dune island. On these islands the dunes play a crucial role in the coastal defence system. The white dunes are actively preserved and shielded from erosion. Although these externalities form them, dunes are vulnerable to the waves of the sea and wind. However, marram grass is the silent hero here. Their roots provide stability of the dunes and keep the sand in place (McHarg, 1969). In these areas, the natural processes shaping the beaches are sometimes altered by coastal protection efforts, such as constructing stone groins or replenishing sand on the beach or foreshore. Additionally, the beaches tend to serve as popular locations for recreation (CWSS, 2012).

The islands also consist of salt marshes, some of which are naturally formed and some are artificial, recognisable by their rectangular shapes from above. The urbanised areas are in some cases located in the polders, that is mostly adjacent to the inner Wadden Sea, bordered by a dike. It is on this side of the islands where the ferry ports are situated. With the exception of some islands with small airports and the occasional possibility to go mudflat hiking, the ferries are the one mobility connection to the mainland and other islands.

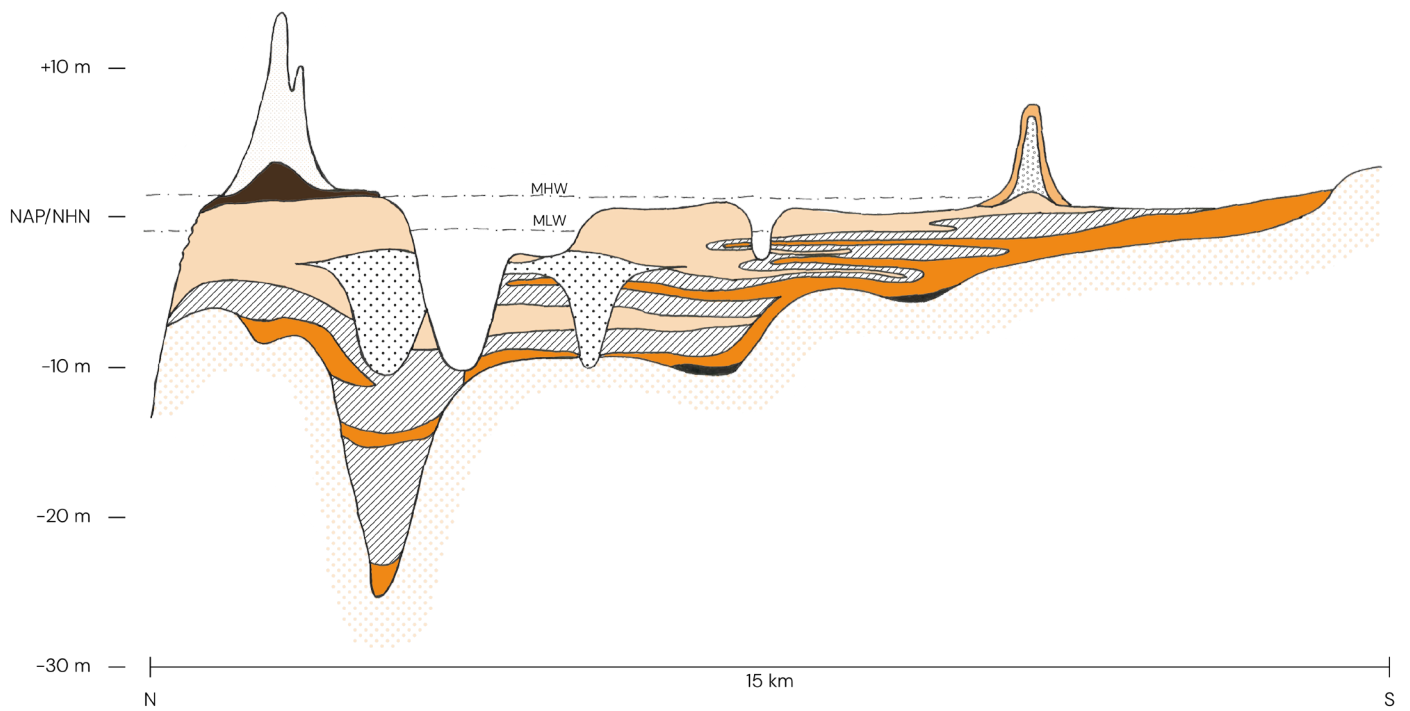
As these islands are formed through sand and the geomorphological processes, they could be expected to “walk” more to the east and main land coast, as erosion and sedimentation is a constant process.












Islands in Wadden Sea distinguished as dune island ▲

Section of the dune island ▲

	area (km ²)	inhab. (Prins, 2020)
Wangerooge (DE)	7,94	1355
Spielerooog (DE)	18,25	800
Langeoog (DE)	19,6	2000
Norderney (DE)	26,3	6000
Schiermonnikoog (NL)	40,8	950
Ameland (NL)	59	3630
Terschelling (NL)	68,16	4859
Texel (NL)	162	13.545



Geomorphology section
Dune island and Wadden Sea

-  Dunes and exposed beach
-  Tidal channel deposits
-  Tidal flat deposits
-  Brackish to lagoonal deposits
-  Fen peat
-  Gyttja
-  Pleistocene
-  Sand
-  Clay layer

Schiermonnikoog

Island example (NL)

The island of Schiermonnikoog is an example of the dune island typology. Along the western and northern part, it consists of beaches, dunes and forest. Walking along the two lighthouses, several dune tops are crossed and lead you to the vast beach plain. Most inhabitants are centred in the village, which is next to the polder. The village is constructed according to a street pattern. The oldest, main streets are horizontally located from west to east. Together with the specific way of building the roofs of the houses, people used to be better protected from the wind, that raged over the island. Along the south and east salt marshes are creating an interesting natural landscape, that is a habitat for many ecological species. Going even further to the east you will enter the sandbank of Balg (Prins, 2020). It is connected to the island, however, some say, here, due to the forces of wind and water, the island might be splitting in two (reference).

Fieldtrip notes:

The wind cuts sharply across the island, and if it wasn't for the sun shining, I would have stayed indoors to keep warm. However, bundled up well, I dare to go out for a walk from the polder in the south to the beach on the north side of the island. From the dike, the Wadden Sea is visible on one side, and the polder landscape on the other. Cows, horses, sheep, they all are kept here, along with the many birds that inhabit the landscape. The walk continues towards the village, hoping the urbanised are will provide some shelter from the wind. Between the authentic houses lined up from west to east, residents and tourists around by bike or on foot, and even the bus makes its rounds. A large gate made of whale bones in the middle of the village, serves as a reminder of a time when, alongside fishing, whaling was also an important economic factor. Beyond the village, paths lead toward the beach, guiding you past dunes with marram grass. Once over the very last dune, an expansive stretch of beach awaits you. It's low tide, so the beach appears especially big at the moment. The wind sends sand swirling across the sand flats, and the patterns in the sand reveal the dynamic power of nature.



▲ Characteristic streets and houses of village Schiermonnikoog, built according to the wind.



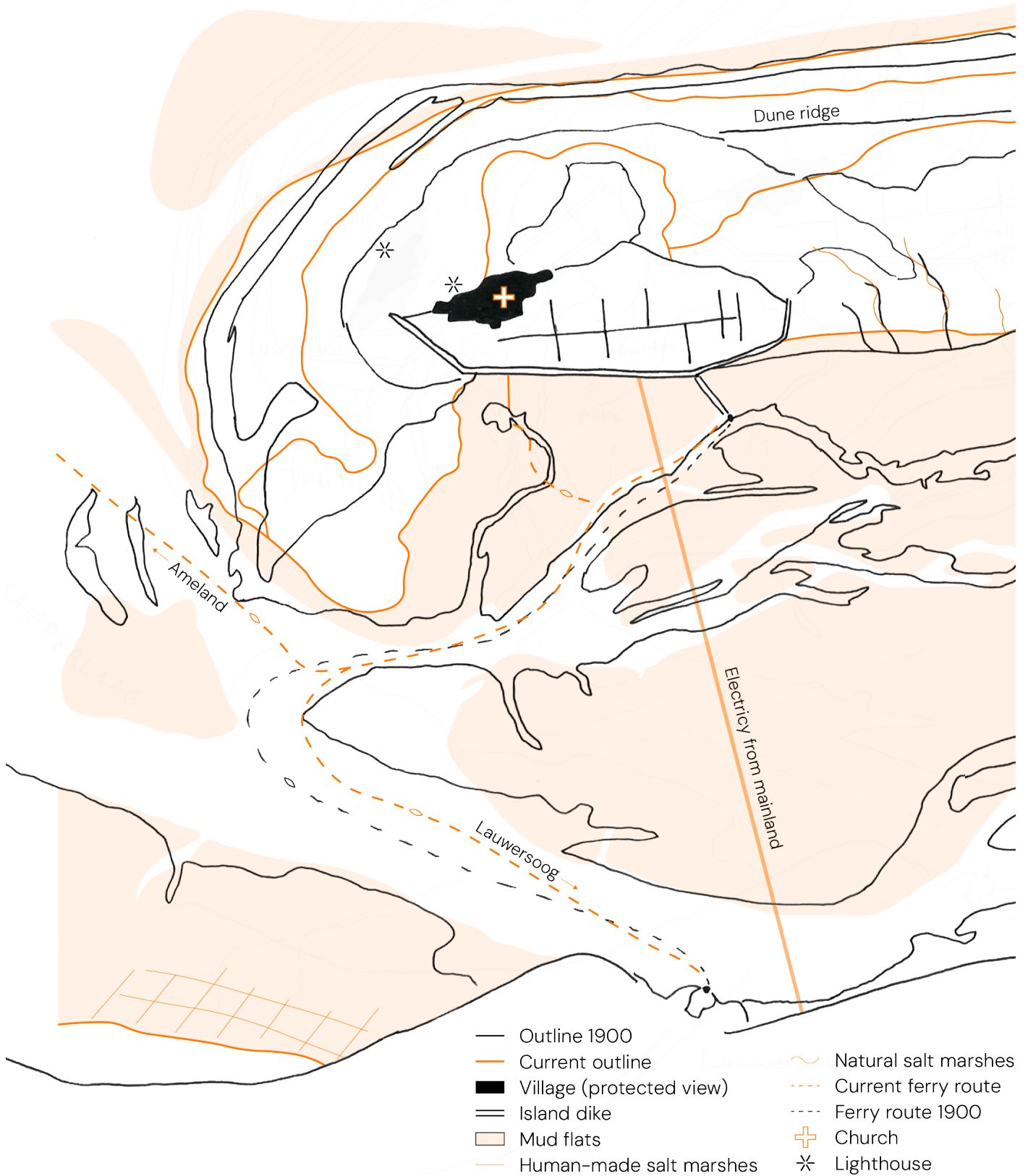
▲ Marram grass on the beach, Schiermonnikoog
Brouwer (2026)



▲ Beach, Schiermonnikoog
Brouwer (2026)

Schiermonnikoog

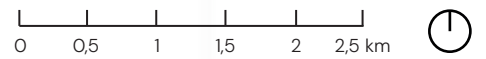
Island example (NL)



Breaking in half?

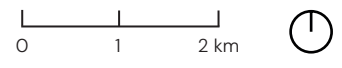
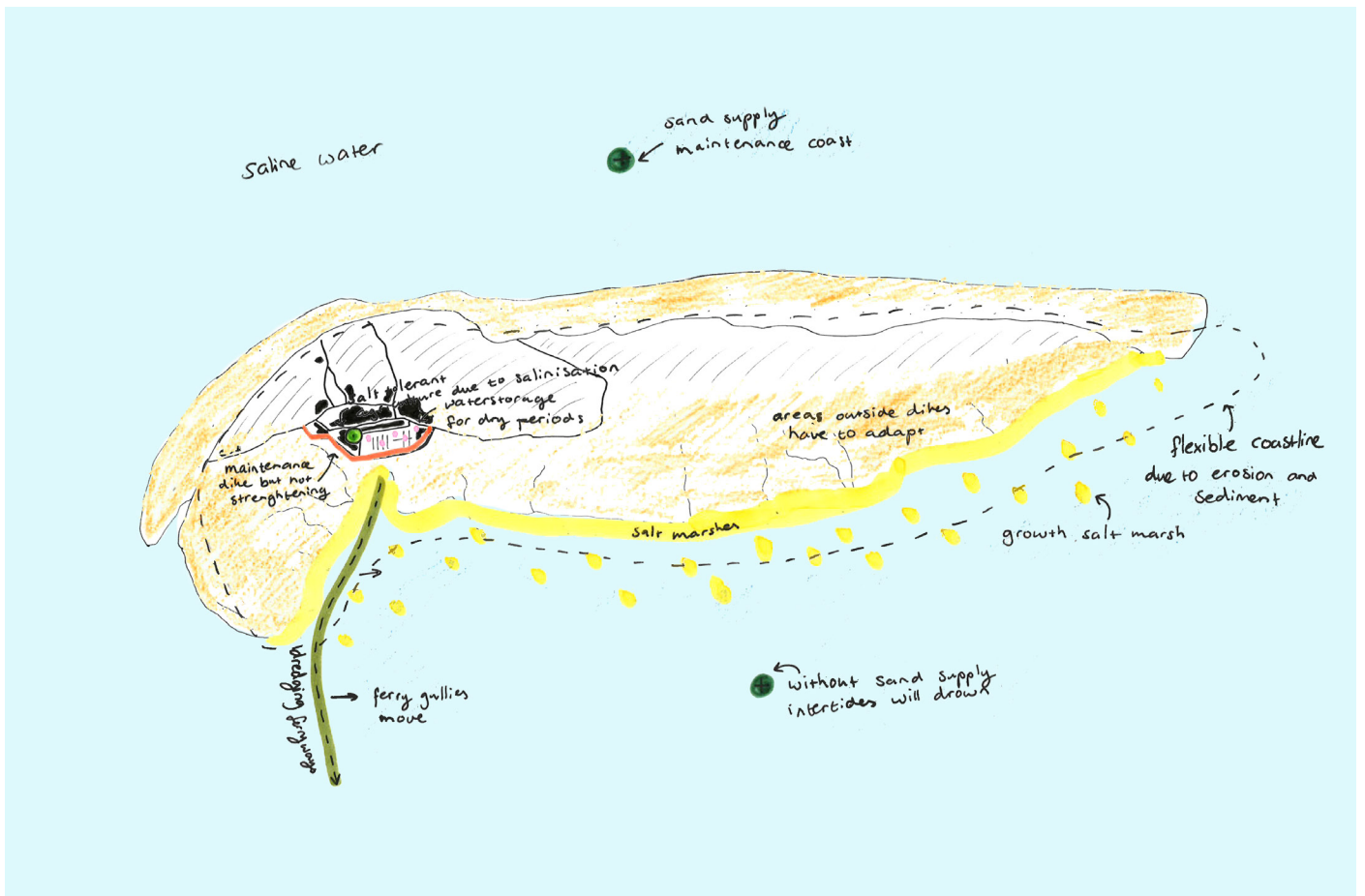


Palimpsest map of Schiermonnikoog
1900 - now



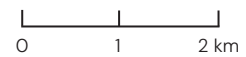
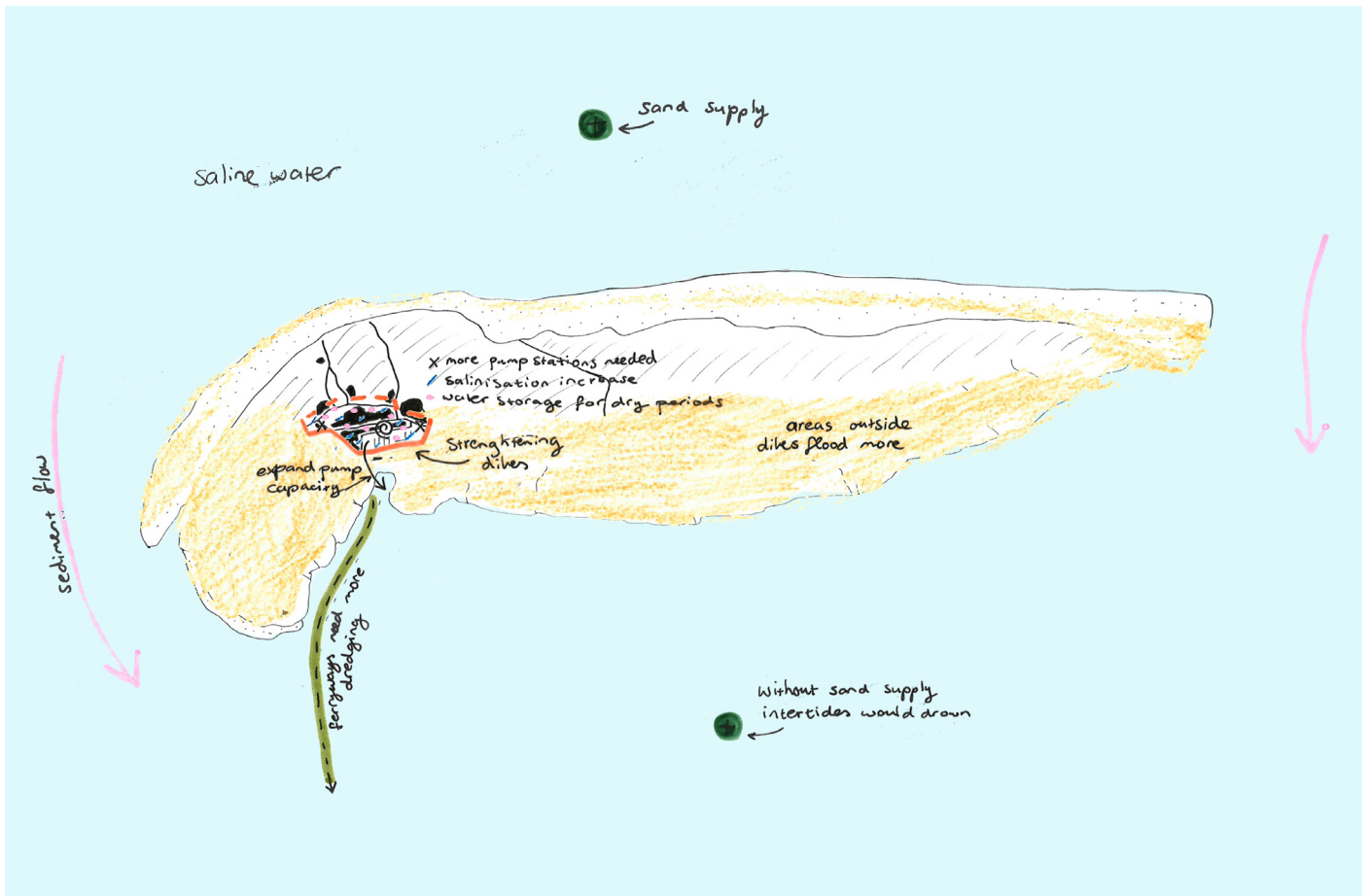
Protect

Dune island



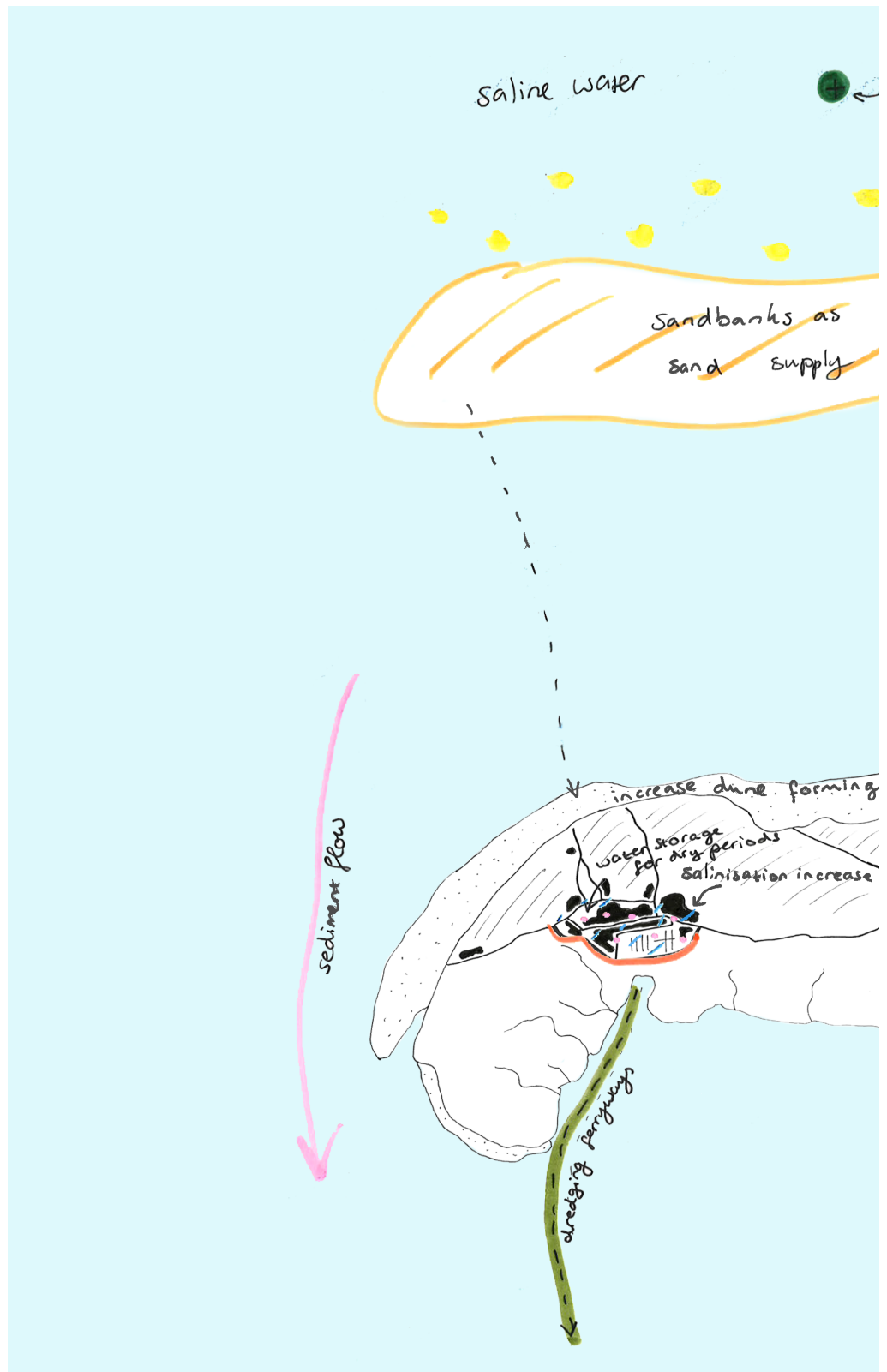
Move

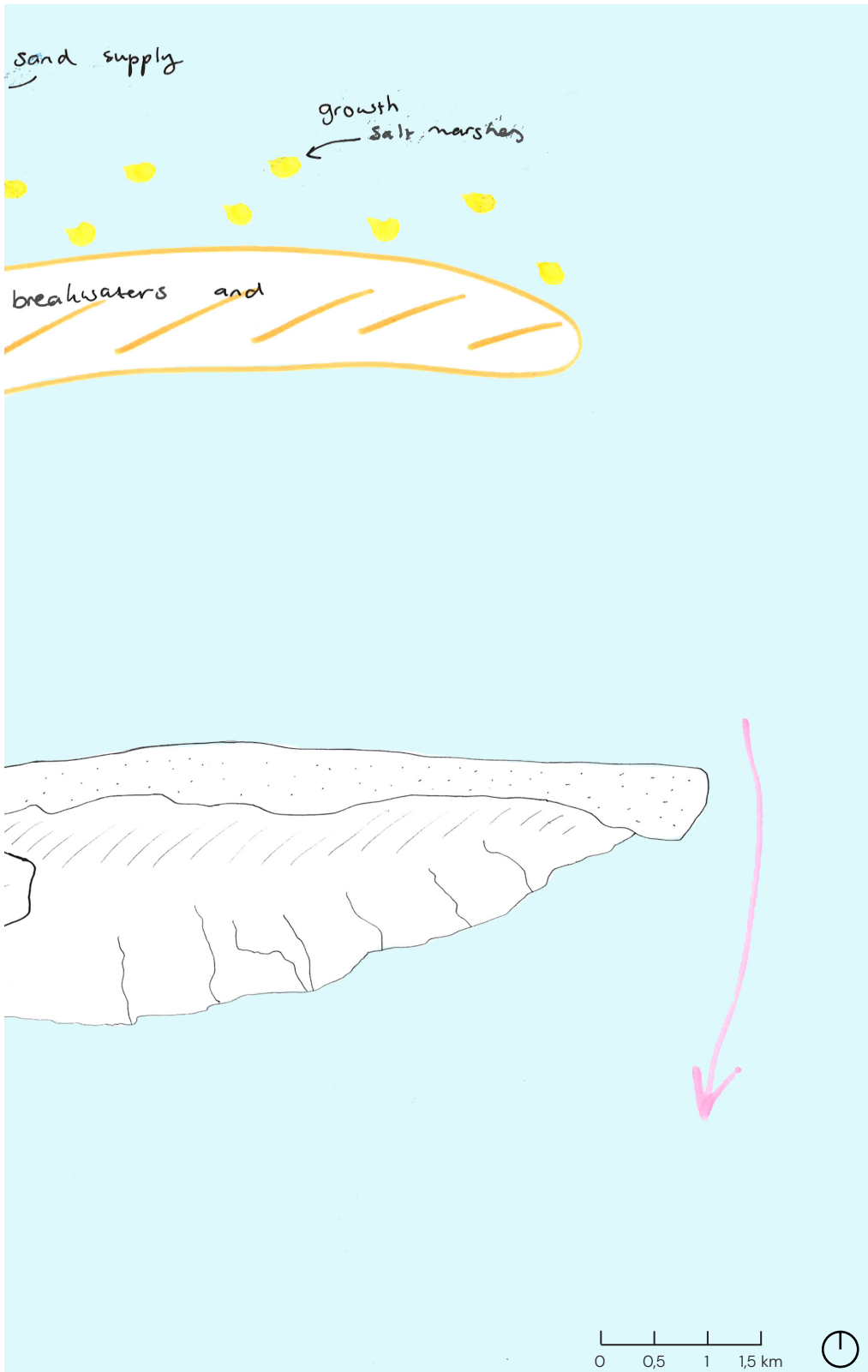
Dune island



Seaward

Dune island





Islands in motion

Design phase

Islands in motion

Wadden Sea

Vision

The exploration of the Deltares solution directions, projecting onto the Wadden Sea and its islands have given insight into their spatial implications on the islands. The first two solution directions, protect and seaward, rely on manipulating the land or new land to maintain current land-use. In both cases the aim is to keep the current land-use the same. The Dutch have been famous for it. A common saying even goes: 'God created the world, but the Dutch created the Netherlands'. The Dutch have been manipulating land and water for centuries as we had the feeling that we were entitled to do so, while nature species have been adapting to changes due to climate change and human interventions. This manipulation can be traced back to the long tradition of making polders, and since then, the view of the Dutch that the land can be manipulated and used to own will, is visible in many land reclamation. This view on land-use has not changed much. Even this year some political parties in the Netherlands have requested more research to expand land reclamation (Motie van het lid Grinwis c.s. (314), 2026), despite the growing challenge of simply keeping existing polders dry and to keep on maintaining and improving the current hard water defence.

The analysis has shown that the Wadden Sea and its islands are under constant movements. Dynamics have shaped the landscape and influenced how people have adapted over time. The Move solution direction aligns most closely with this historical perspective, acknowledging the *longue durée*, the long-term processes that have shaped the region. When designing for the future this dynamic nature must be considered, as the current landscape is both a product of the past and a foundation for the future.

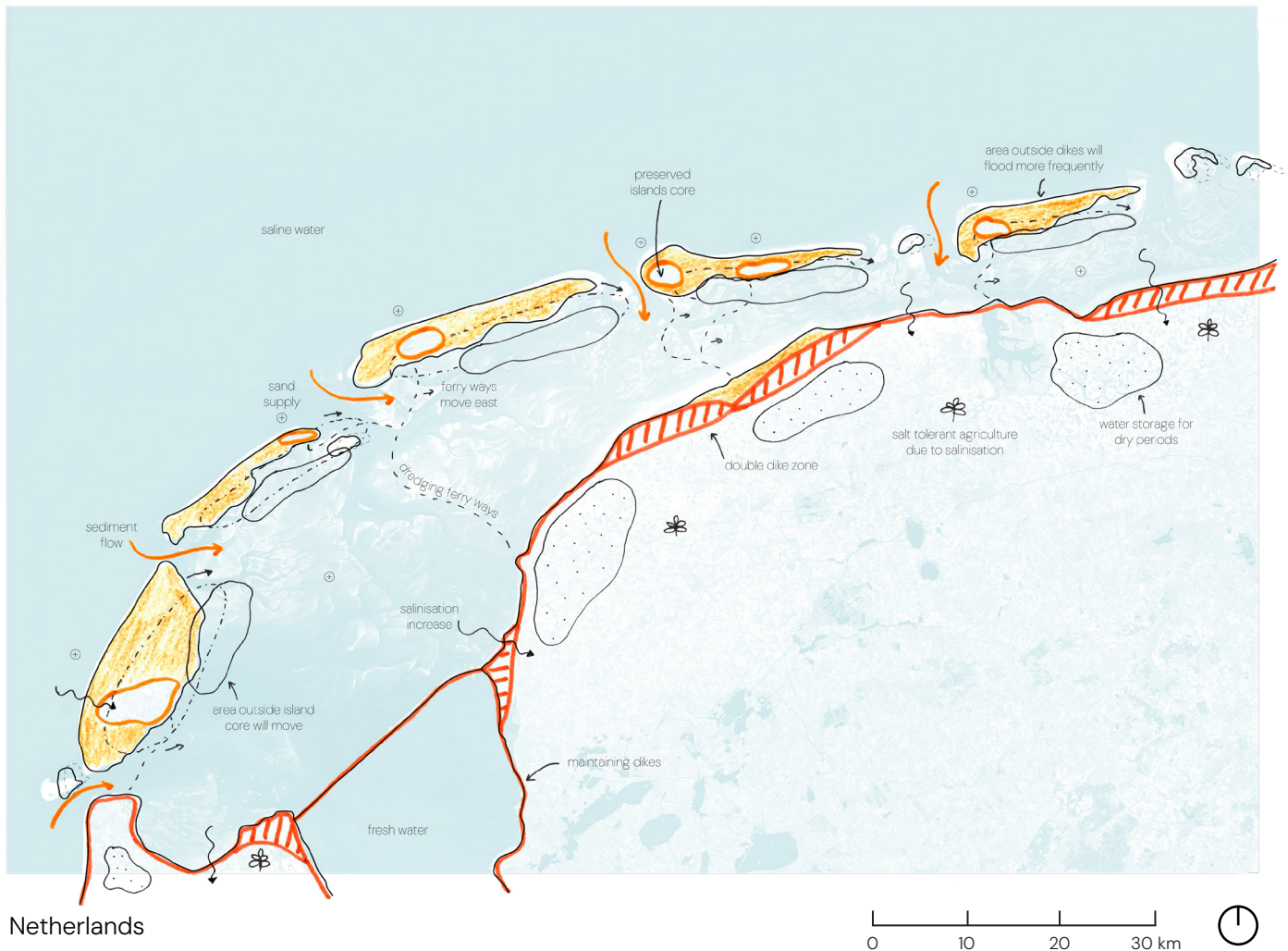
It is time for people to also adapt. The Wadden Sea, an area in which dynamics are a great part of the identity and its values, is a promising location to do so. Together with the design brief that has been concluded from the analysis, this forms the base for the preferred solution direction.

Design brief

Develop a future-proof plan for the islands of the Wadden Sea which prepares the island residents for rising sea levels, while not only honour the natural heritage of the Wadden Sea, that has been appointed by UNESCO, but also the cultural heritage. Many buildings of monumental value embody the stories of the people of the islands and their connection to the *longue durée* of the islands. This heritage should be acknowledged, celebrated, and taken into consideration in a new plan. Tourism is, next to agriculture, an important economic driver. Balance them, but embrace adaptivity. Past generations have proved to be adaptive when it comes to the economy. Embrace this adaptivity, as it is needed when imagining the future of the islands. The Wadden Sea islands are under influence of many dynamics, both short and long-term; the tides, the littoral drift.

Islands in motion

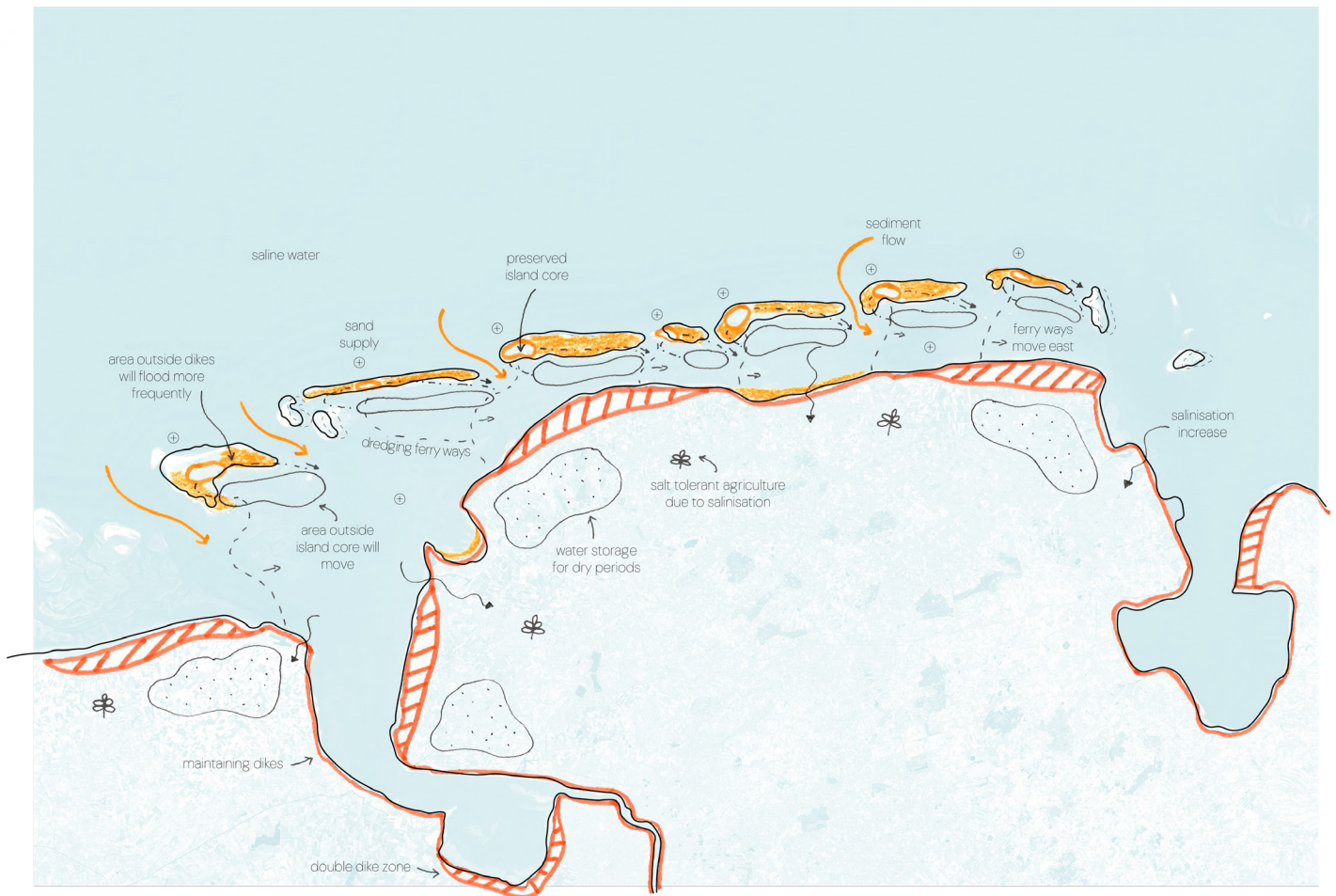
Wadden Sea



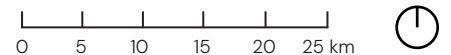
The preferred solution direction Islands in Motion embraces the dynamic nature of the Wadden Sea as a core principle. The urbanised centres of the islands, which house a lot of historical valuable buildings, will be protected, while the forces of nature change the form of the islands. This way we adapt to nature, while still providing a protected places for people to live.

Dynamics are one of the most important characteristics of the heritage of the Wadden and can be seen in both the nature and culture through long changes in history and everyday movements. This solution direction emphasises that identity of the area.

Every effort will be made to protect the most densely populated areas. The not stabilised island parts will move along with the littoral drift and the areas outside the preserved centres, which are outside the dikes or other protection will flood more frequently. Due to salinisation the whole area must reimagine the type of cultivation and adaptation is necessary. As salinization intensifies, the entire region will need to rethink agricultural practices and adapt to new conditions. Additionally, climate change demands better water storage solutions to prepare for droughts and ensure a reliable supply of fresh drinking water.



Niedersachsen

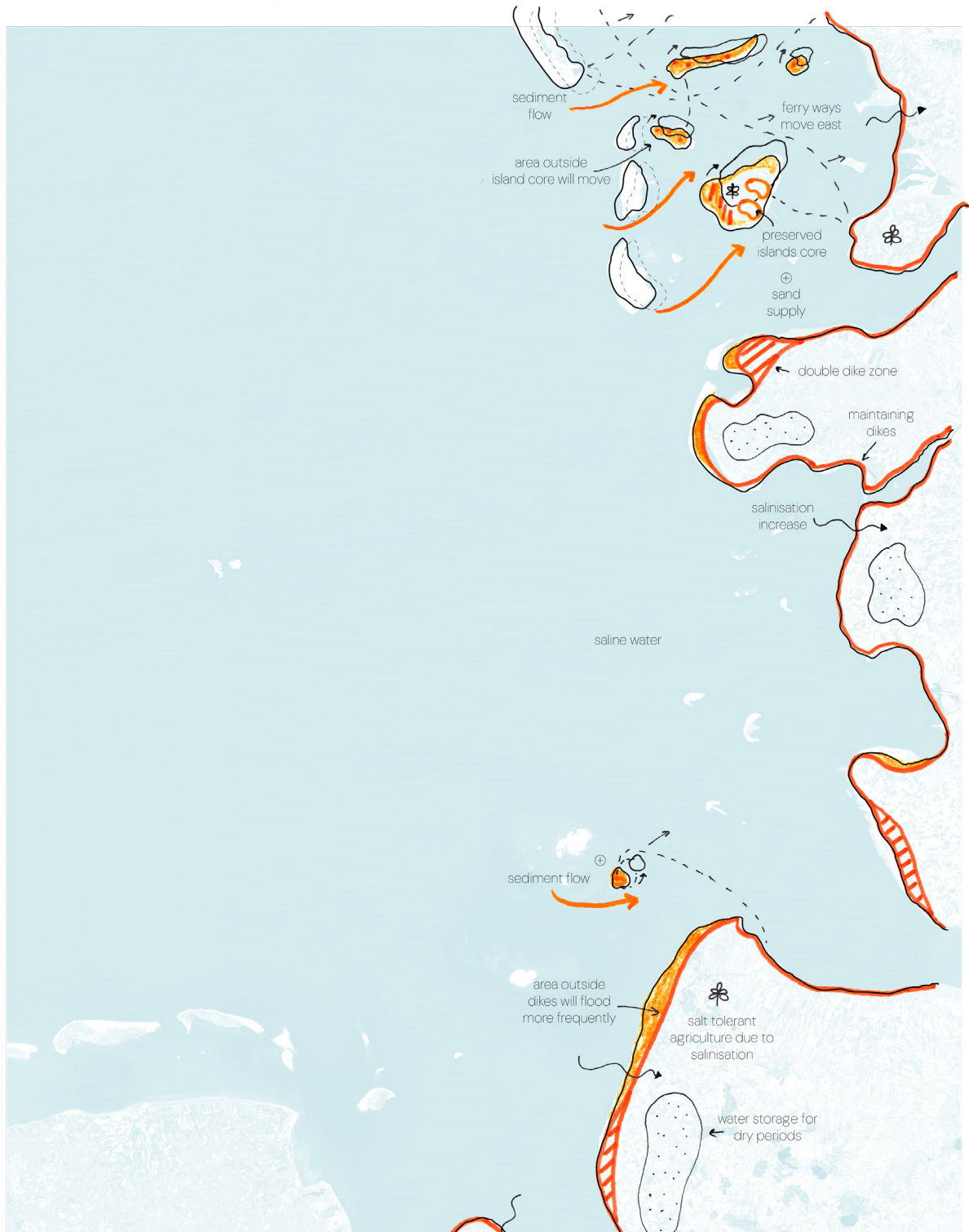


To maintain connections between the islands and the mainland, ferry routes will continue to be dredged, though their paths may need to adapt as the landscape evolves.

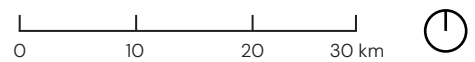
However, research has shown what conditions we work with on the islands and what is already happening protection/adaption wise. The three types of inhabited islands are assessed on adaptiveness and the amount of needed interventions. The aim is to allow some areas to move with nature while ensuring that others remain protected, so that the islands remain liveable for future generations.

Islands in motion

Wadden Sea

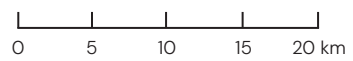


Schleswig-Holstein





Denmark



Islands in motion

Salt marsh island

The salt marsh islands, such as the Halligen, demonstrate the highest adaptability to rising water levels, especially when protection standards are minimal (Schindler et al., 2014). The frequent occasion of *Landunter*, a frequent flooding, is simply part of life. The local population has long adapted to the rhythms of the tides and the dynamic forces of nature, fostering a harmonious relationship between people and their environment.

For these islands, Islands in Motion means embracing movement while providing localized protection for the mounds where homes and heritage are concentrated. This approach allows the landscape to evolve naturally, while ensuring that the most vital areas remain secure.

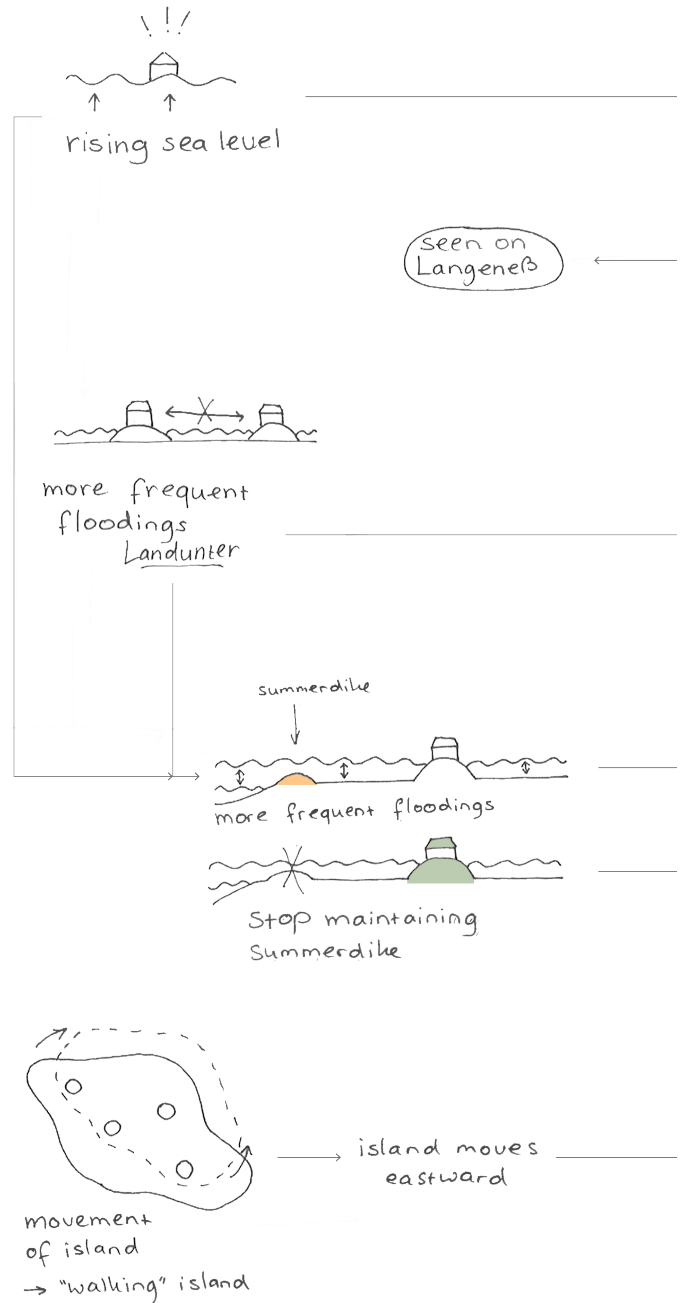
Mounds

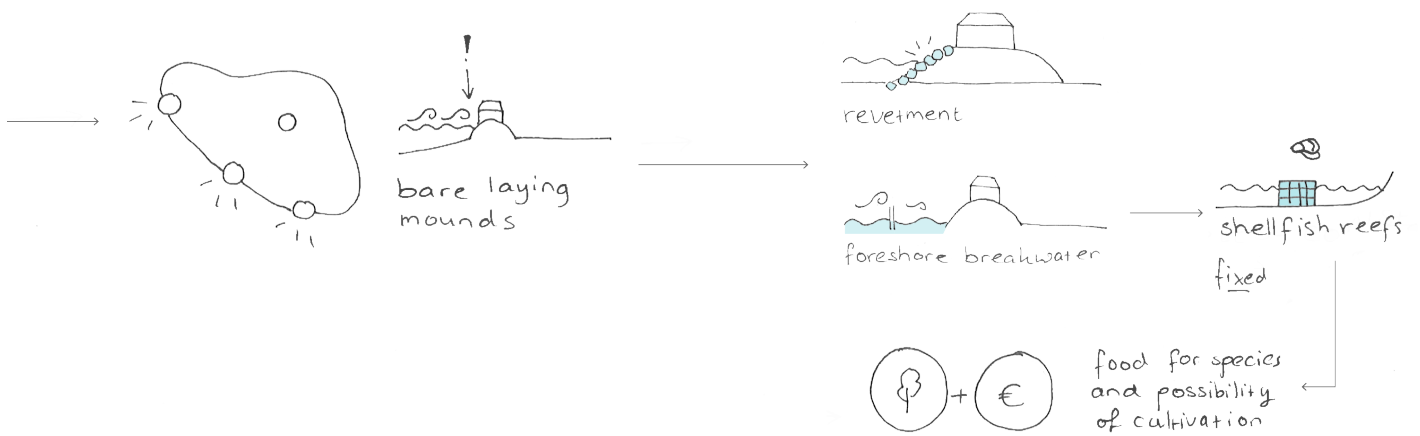
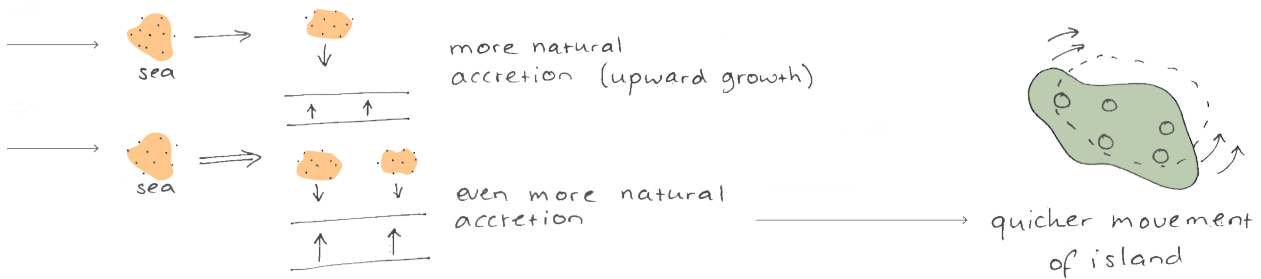
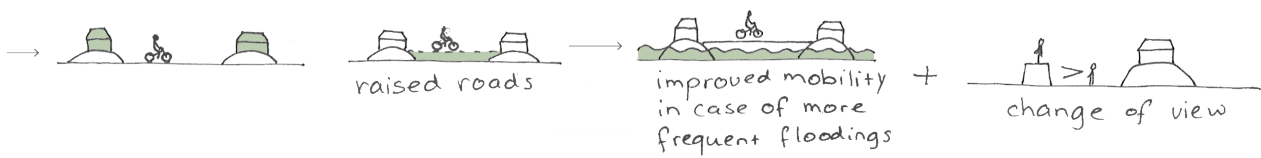
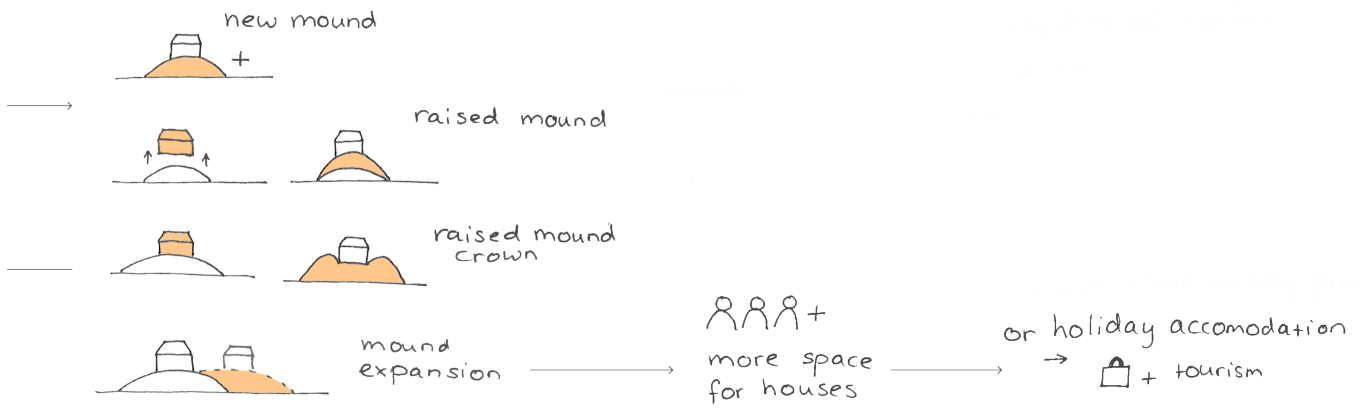
All the mounds must adapt to rising sea levels. That is why some mounds are raised with local subsoil. To stay above sea level, meeting the prognosis up to the year 2300. Working with ground elevation on this small-scale, the possibility of raising the houses together with the mounds is bigger. This way buildings of historical and cultural value, dating back to in some cases even the 18th century, can remain. In other cases, there is always the option to raise only the crown of the mound, causing the buildings to disappear behind a green hill.

New mounds will be constructed to provide more houses for people to live, but they will be used probably more to house tourists. Adding to the economic drive of the salt marsh islands. Next to that new mounds or the extension of existing mounds can also be dedicated to cattle. When the arable land in between the mounds will be flooded more frequently and for longer periods, cattle need to be able to graze on higher grounds.

Mobility

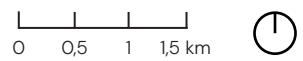
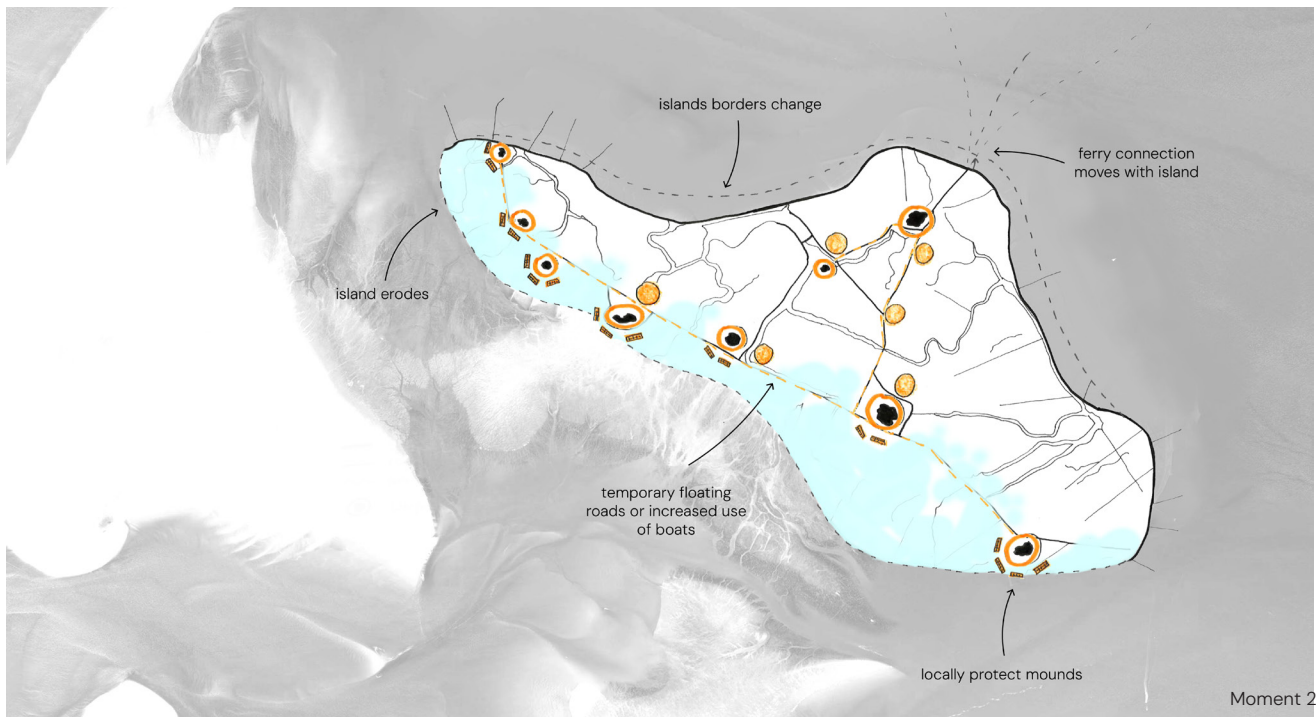
Due to more frequent floodings and higher water levels, boats should be used more again, like it was used to when wider creeks made up the salt marsh islands and fishing was one of the most important





Islands in motion

Salt marsh island



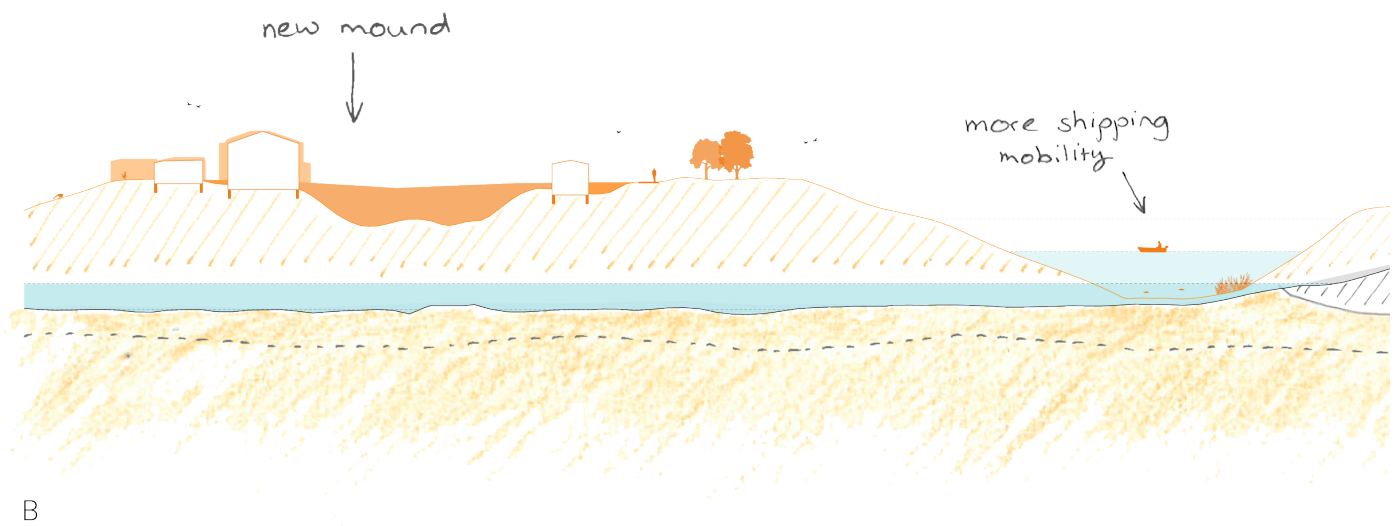
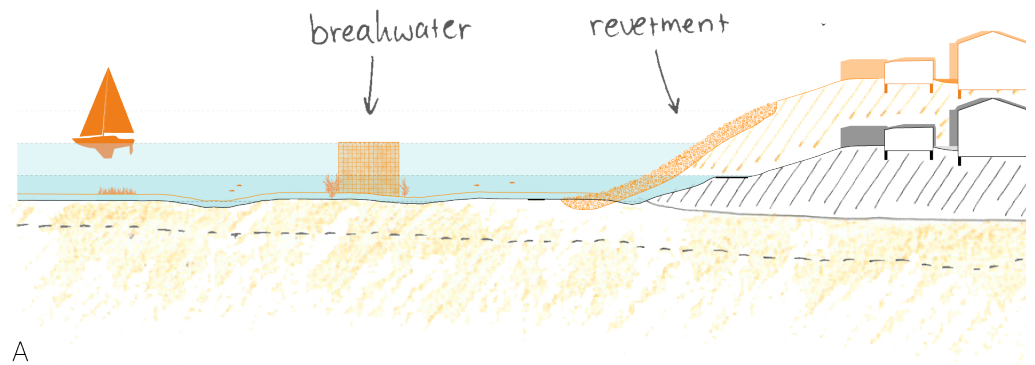
economic drivers. In case mounds are closely situated from each other, floating roads might be an option to keep the mobility something intact.

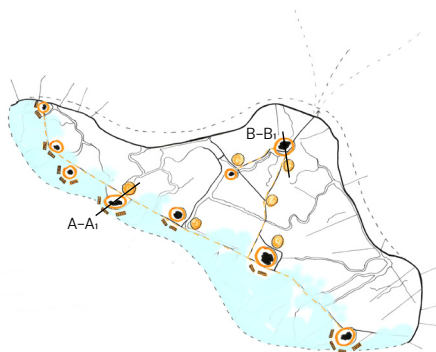
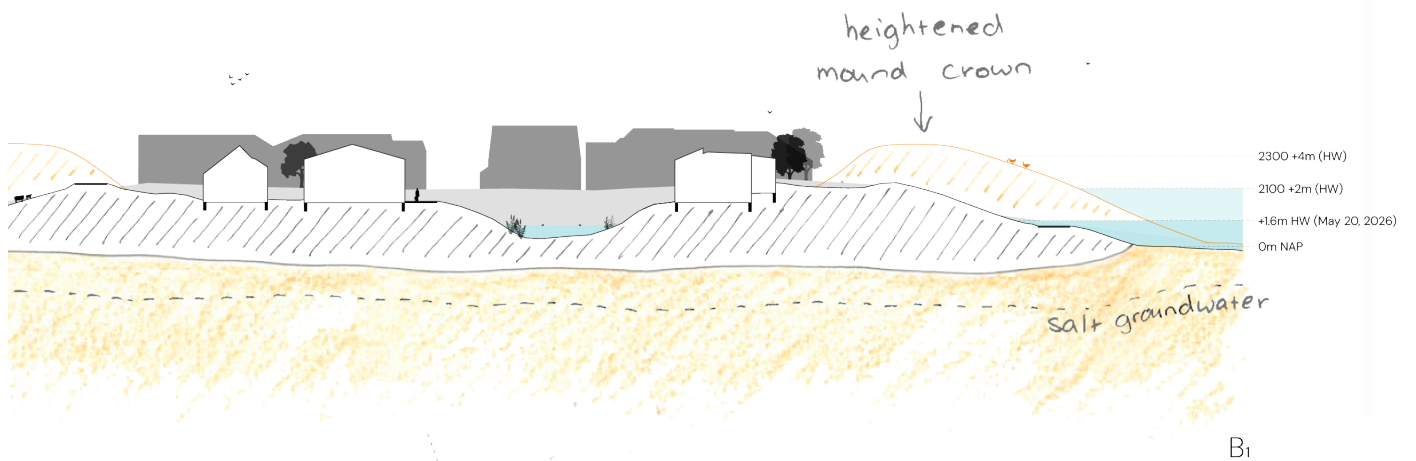
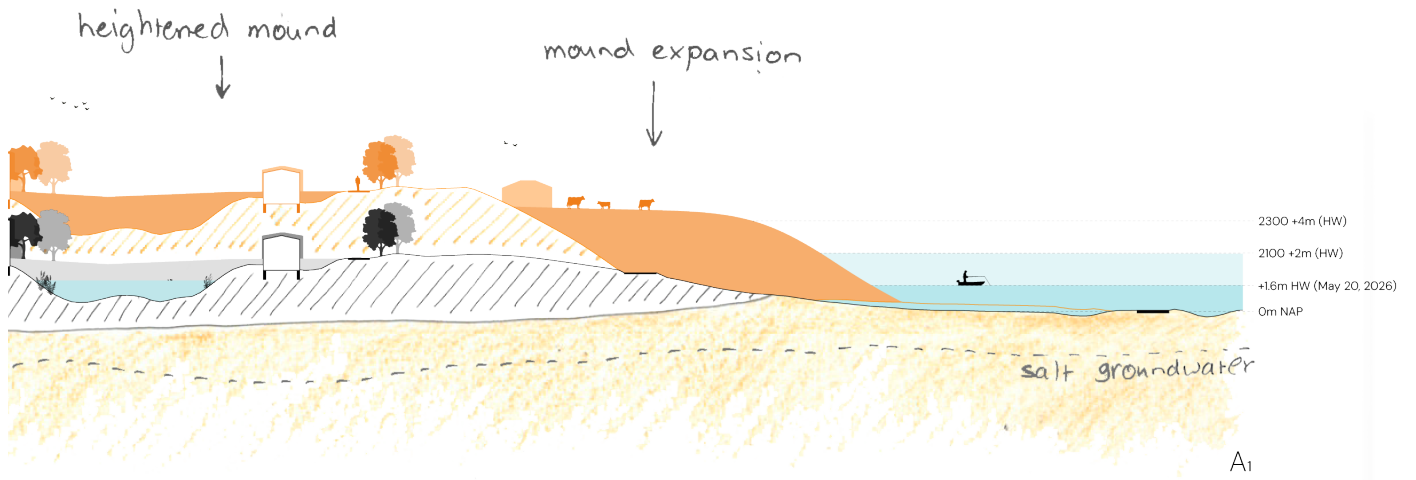
Protection

As the boundaries between land and water might shift in the direction of the littoral drift, some mounds become laying more bare into the open water. A combination of breakwaters on the foreshore and revetments on the mounds might decrease the impact of water and protect the mounds from erosion. The summer dikes will not be improved to allow for increased natural accretion of the land.

Islands in motion

Salt marsh island





Sections salt marsh island
 2x vertically stretched
 A - A₁ 290m
 B - B₁ 330m

Islands in motion

Polder island

The strategy for the polder islands for a climate resilient future shifts from full protection towards adaptation. With the preferred solution direction the inhabitants of the island will gradually be prepared for the changes that the future will bring. This approach ensures that people not only adapt to new conditions but also engage with a transformed natural landscape, strengthening the connection between humans and nature.

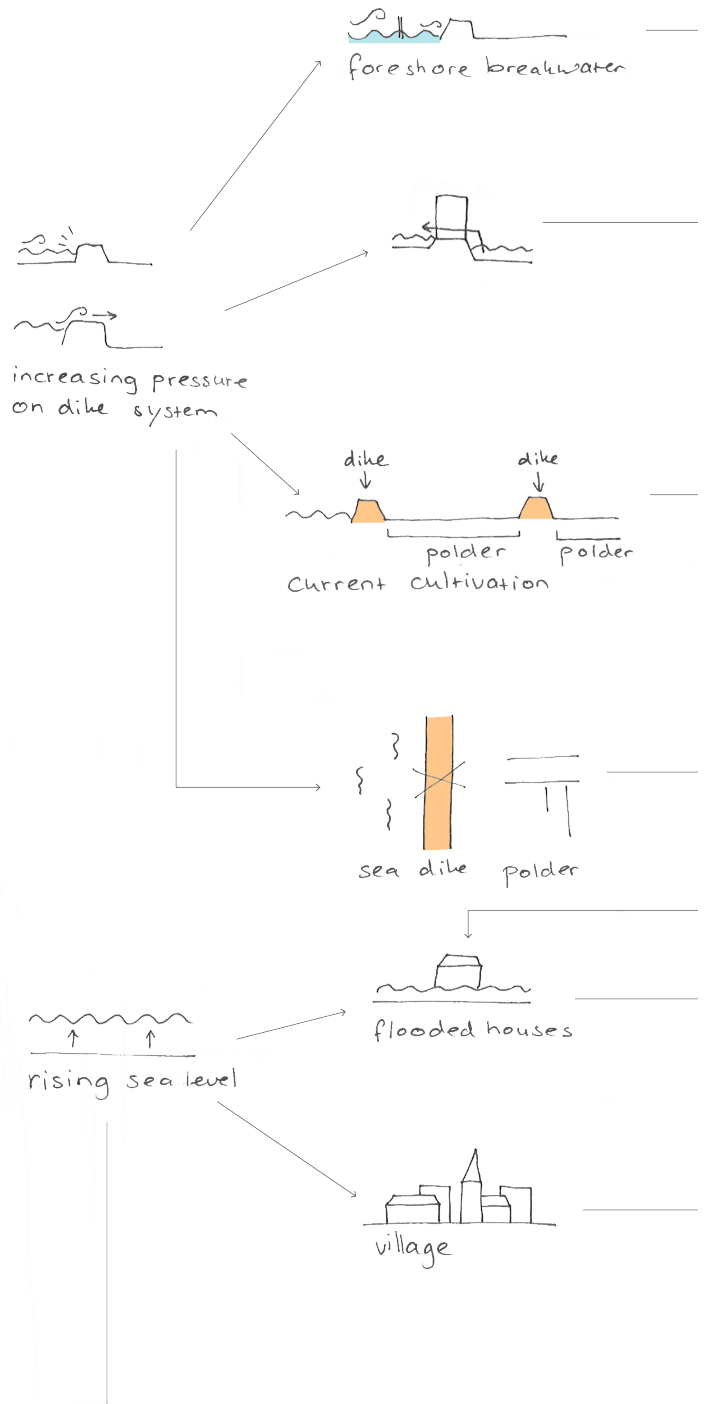
Breakwaters

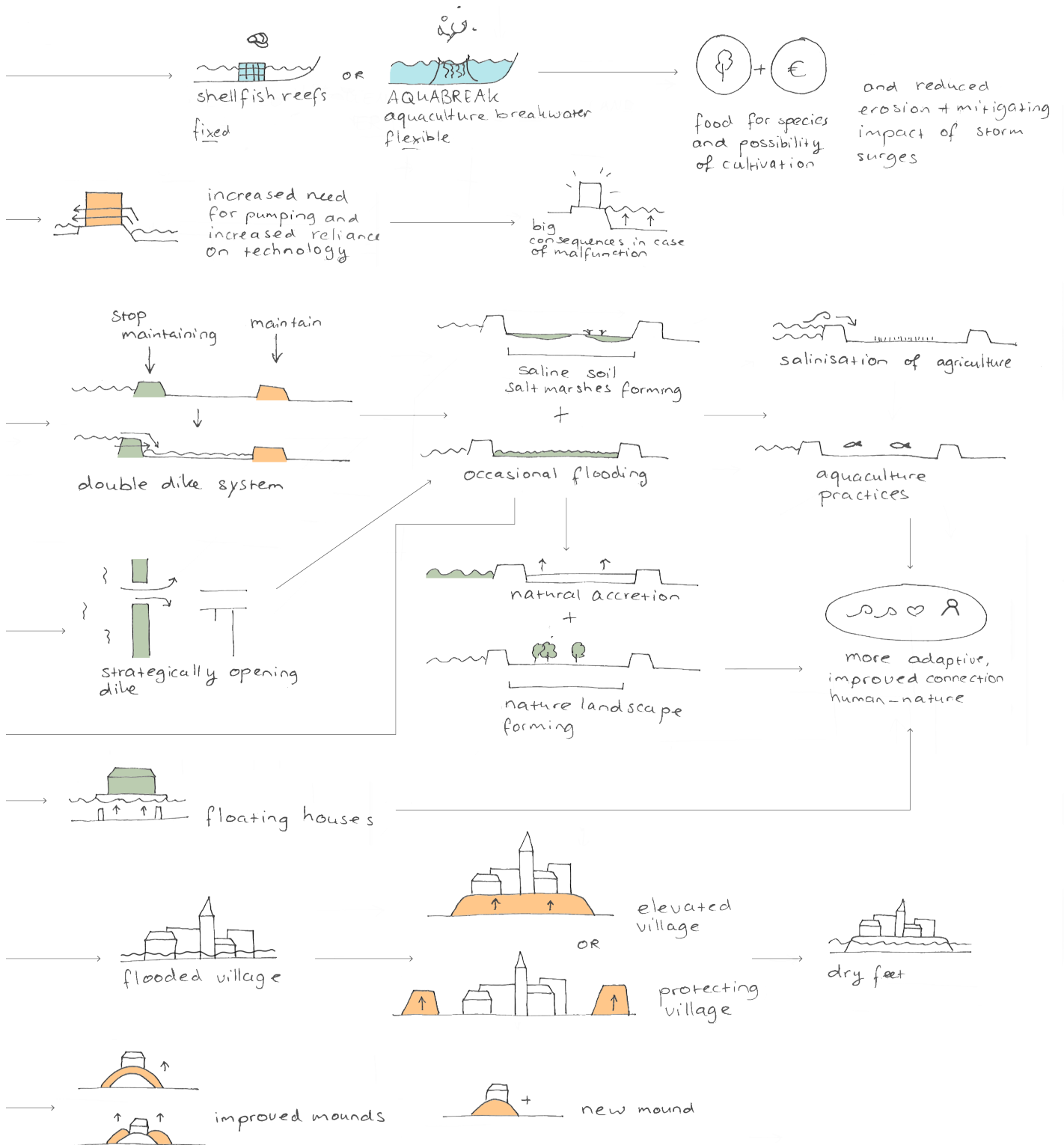
To mitigate the growing pressure on dikes, the first implementations will involve foreshore breakwaters, which could take the form of fixed shellfish reefs (Bouw & van Eekelen, 2020) or aquaculture breakwaters (Kazakis et al., 2025). Both options reduce wave impact and erosion, and create habitats for species. However, the latter are flexible, floating structures that enable aquatic cultivation as well.

Double dike system

The increasing pressure on the dikes and an growing reliance on pumping and technology calls for a double dike system. In parts of the polder islands double dike zones will be created with two existing dikes. The secondary dike will be maintained and upgraded, while the primary dike presents two adaptive approaches:

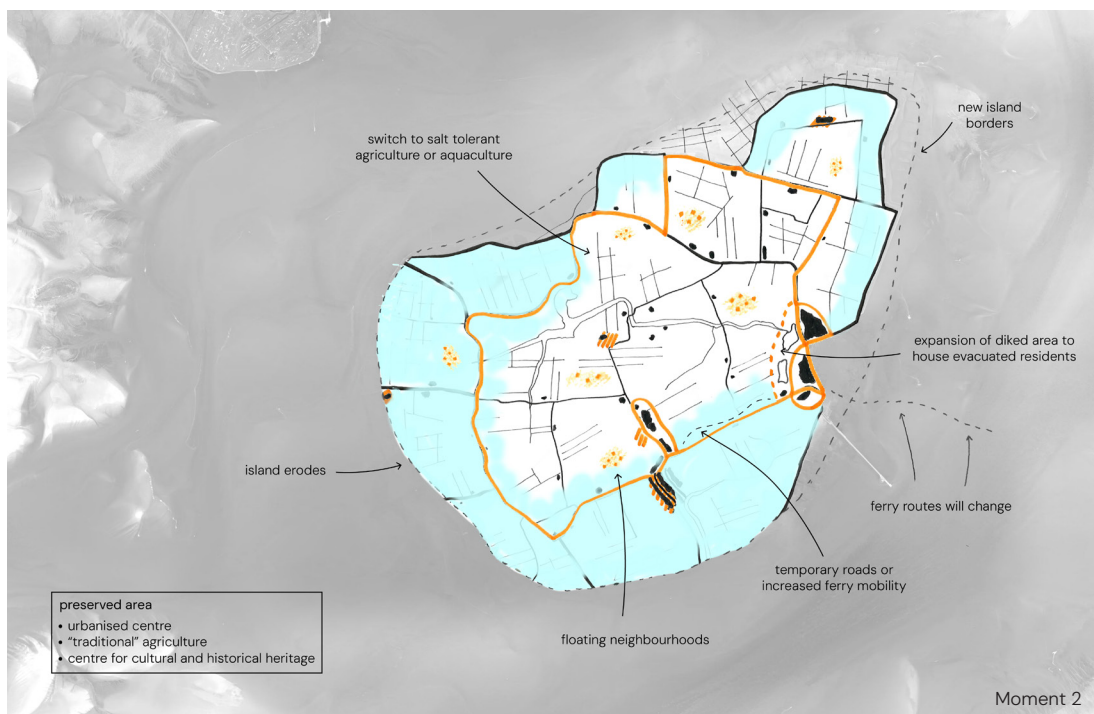
1. Inspired by projects like the Wisselpolders by Defacto Urbanism (n.d.) and Double dike zone Eemsmonding by BoschSlabbers (n.d.), the approach of strategically opening the primary dike allows tides to enter the polder between the two dikes. The resulting tidal flow deposits sediment, enabling natural accretion and occasional flooding. Over time, this fosters the formation of saline soils and salt marshes, creating a dynamic natural landscape. The intertidal zone between the dikes can be leveraged for aquaculture, saline crop cultivation, recreation, and ecological strengthening.



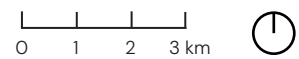


Islands in motion

Polder island



- preserved area
- urbanised centre
 - "traditional" agriculture
 - centre for cultural and historical heritage



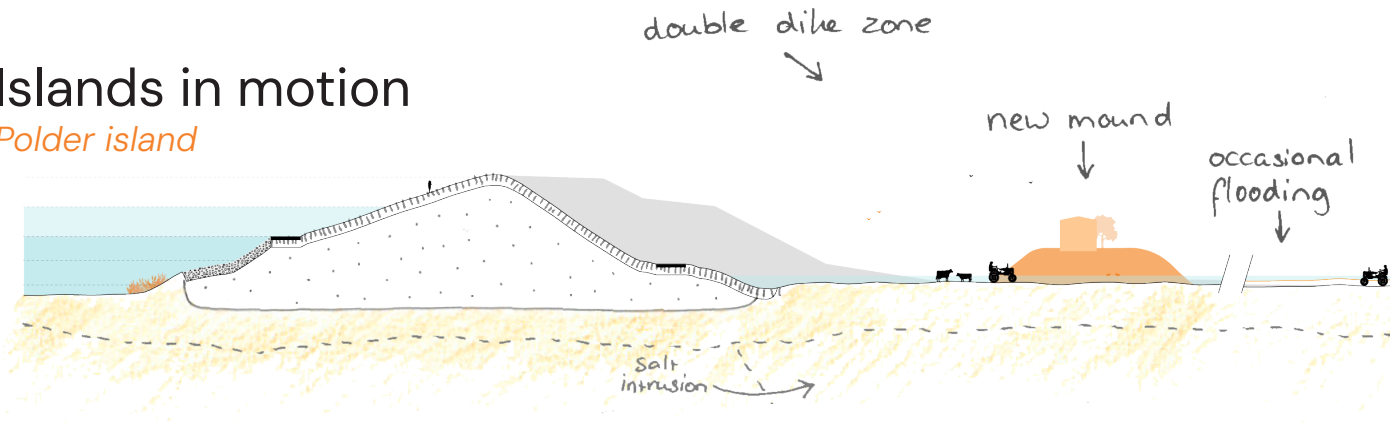
2. The other option is to make the secondary dike serve as the strongest line of defence, while the primary dike is designed to allow controlled overflow.

Protected centres

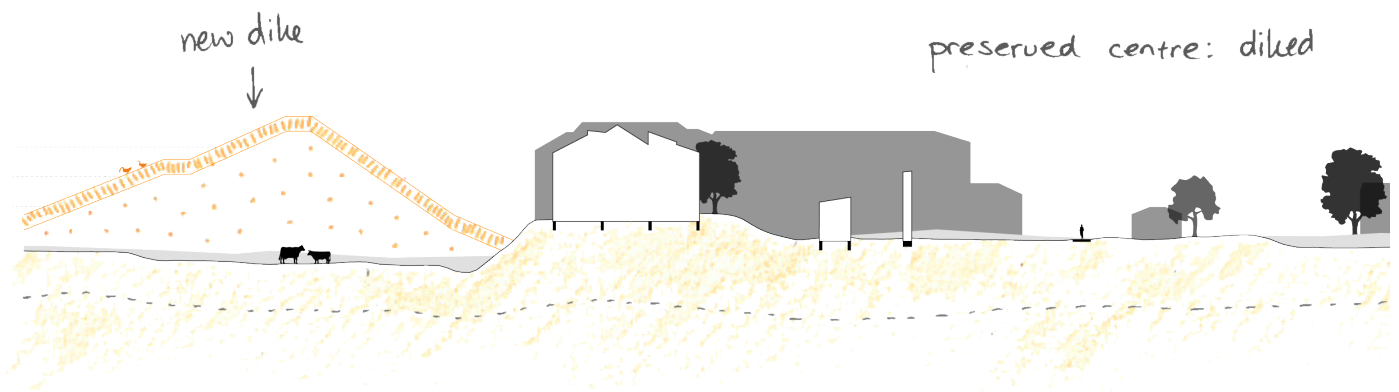
In densely urbanized centres, protection is prioritized by partially raising ground levels, particularly in new constructions or smaller areas. For larger areas, protection is achieved through surrounding dikes, either newly built or adapted from existing ones. The surrounding areas must adapt to potential future flooding or salinization, much like the space between the two parallel dikes. This adaptation includes the introduction of floating housing, a transition from traditional agriculture toward saline tolerant cultivation and improving existing mounds or creating new ones. This way, even in flood-prone areas, buildings of historical and cultural value will be preserved by carefully elevating the ground beneath them.

Islands in motion

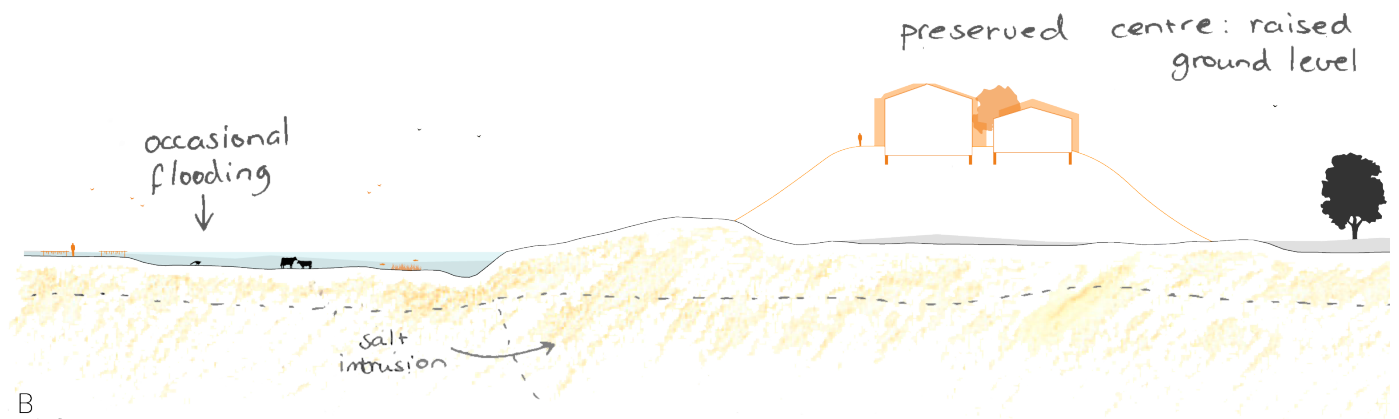
Polder island



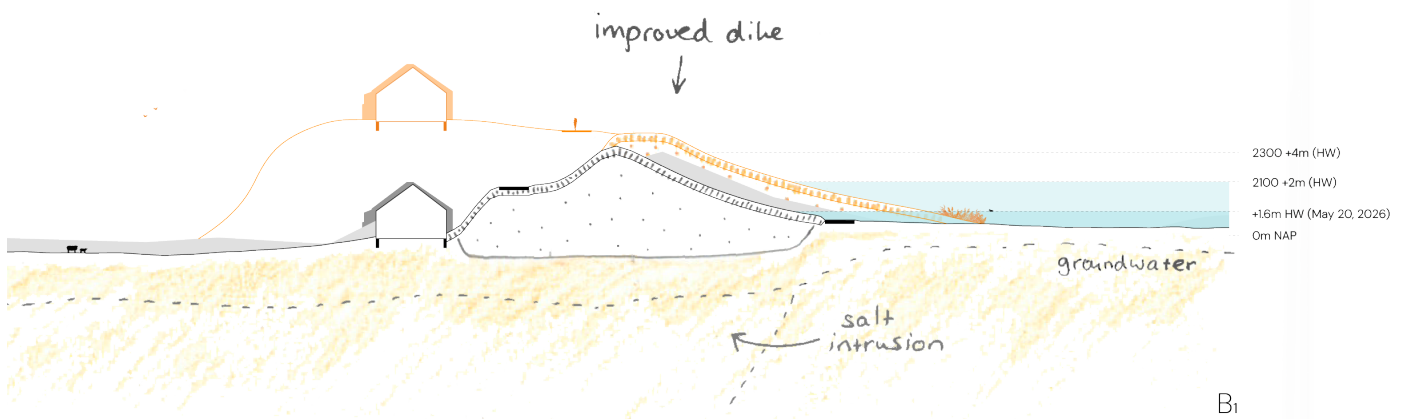
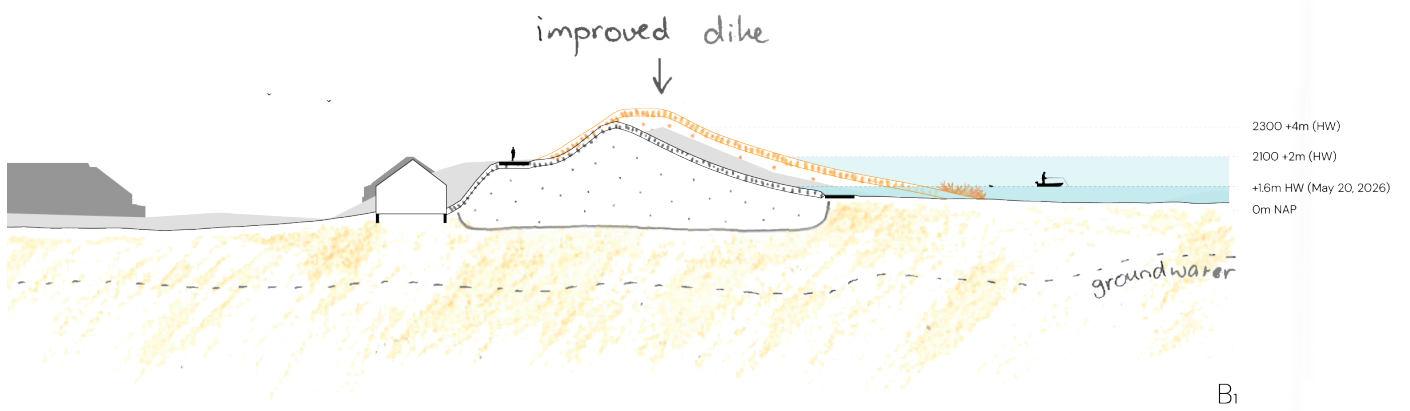
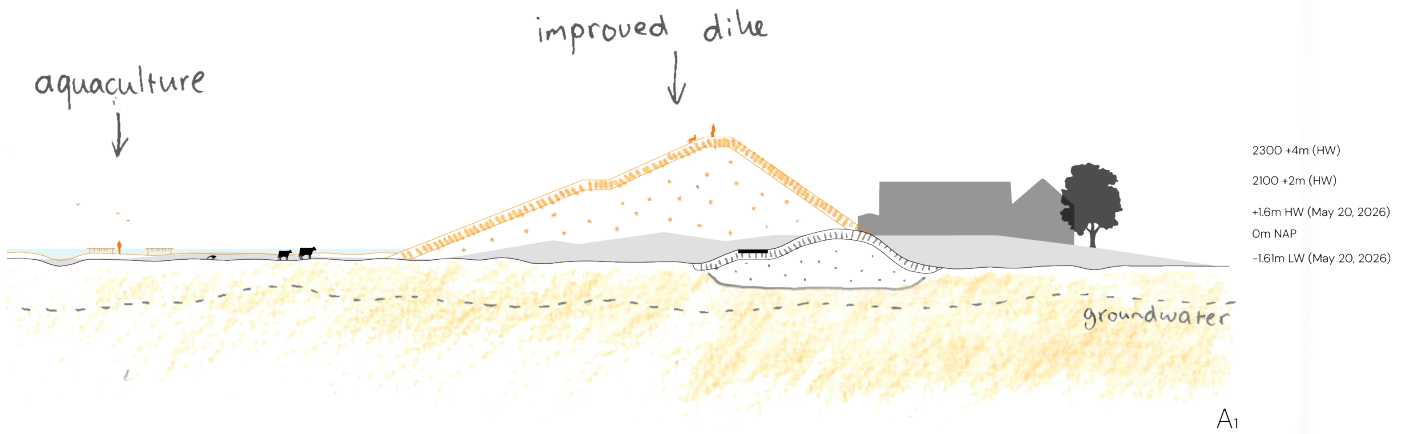
A



B
option 1



B
option 2



Sections polder island
 2x vertically stretched
 A - A₁ 350m
 B - B₁ 350m

Islands in motion

Dune island

For the dune islands, the strategy is to protect the most densely urbanised areas. All else follows the dynamics of nature; the rest of the island “walks” (page 46).

South side

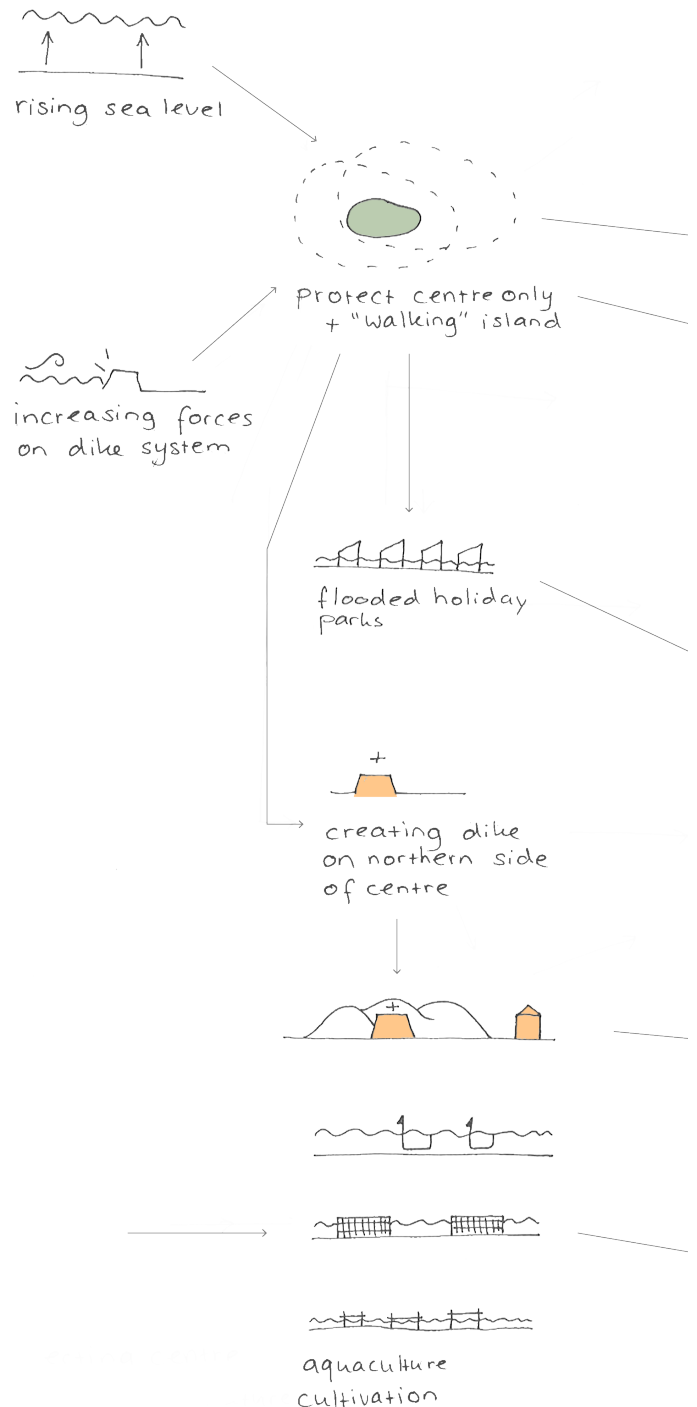
On the south side, the side of the Wadden Sea, the existing dikes will be improved and heightened, according to the prognosed future sea levels. To enhance the connectivity between human and nature, and to increase the ability of experiencing the Wadden Sea, when living in the preserved centre, people are able to spend time on the dike. Improved cycling and walking networks will increase the connection between the village and the dike. The dike is the perfect location for an informative centre about the Wadden and the heritage of the island, in which people get to learn about the *longue durée* that shaped the environment in which they live, and which will continue to shape the landscape.

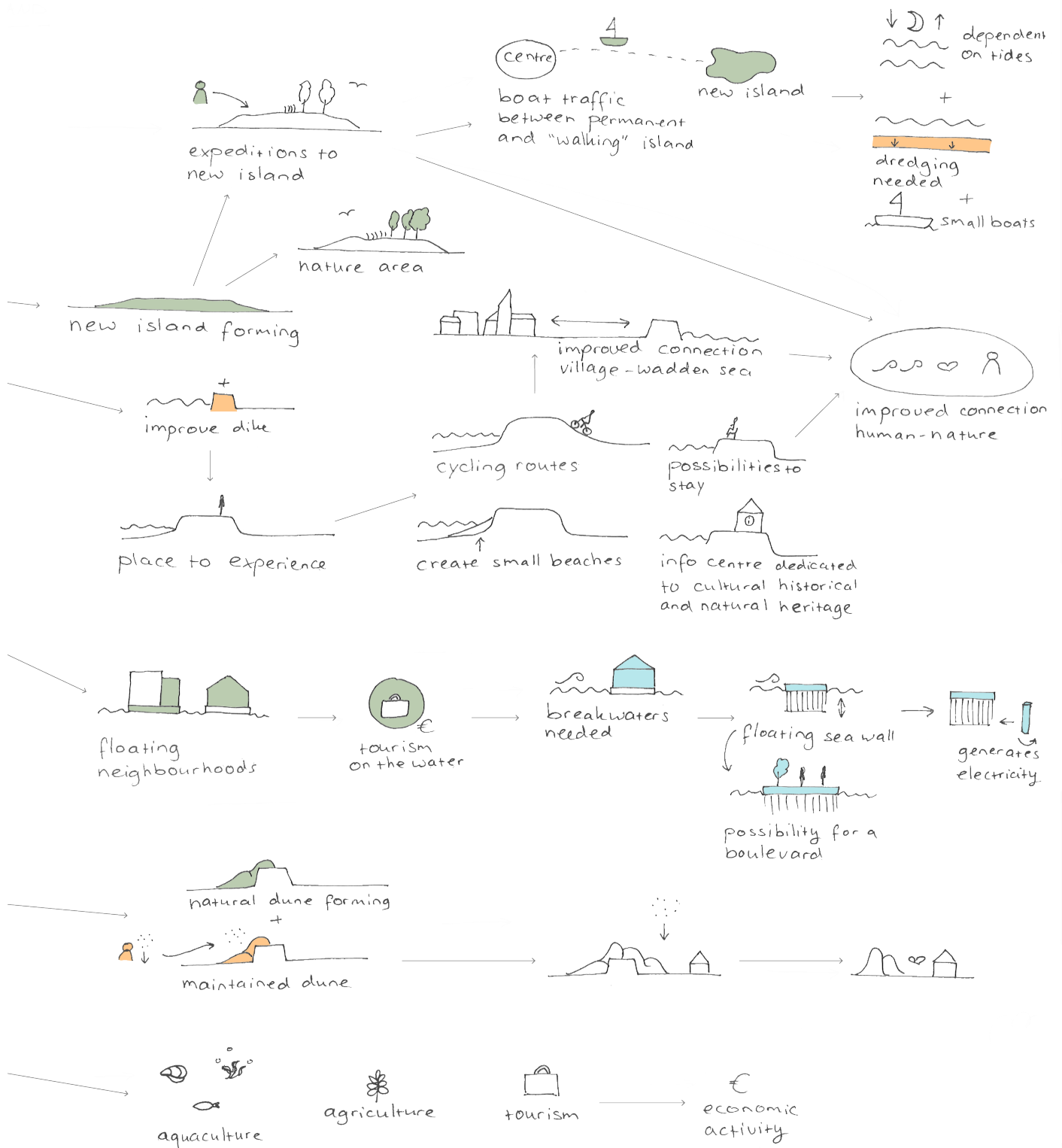
As being left outside of the water defence, some houses and holiday homes might eventually, in the far future have to relocate. Floating neighbourhoods will be introduced as holiday homes, feeding the need of tourism. Breakwaters, such as a floating boulevard (conform the idea of Parthenon by Waterstudio (n.d.)), are needed to protect them, while being in the open sea.

North side

On the northern side, the island’s dune identity will be preserved. A protective dike will be constructed beneath the dunes, ensuring their continuity. The landscape will feature a combination of newly formed dunes and existing natural dunes, both of which must be sustained. To strengthen the current dunes, natural stabilization methods should be employed. An example is planting marram grass, as it traps sand and enhances dune stability (Mangor et al., 2017).

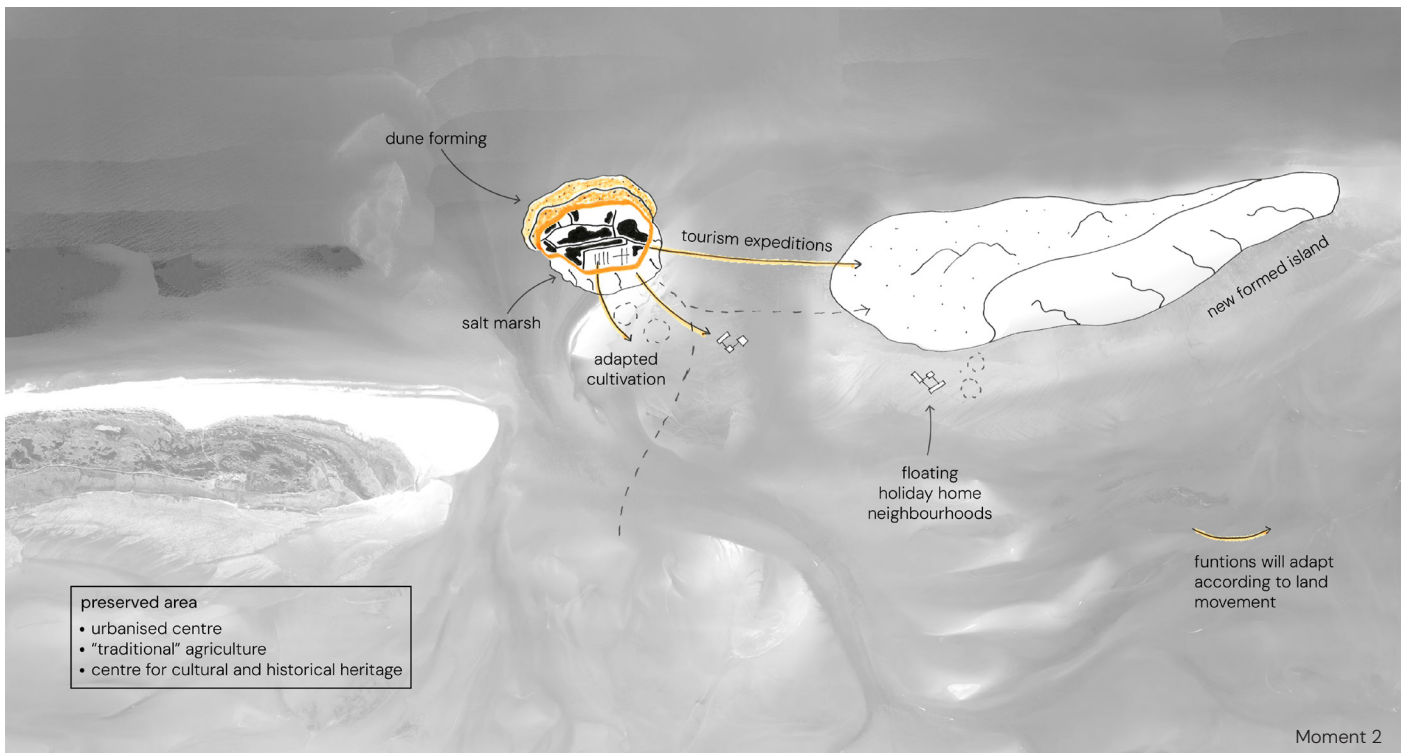
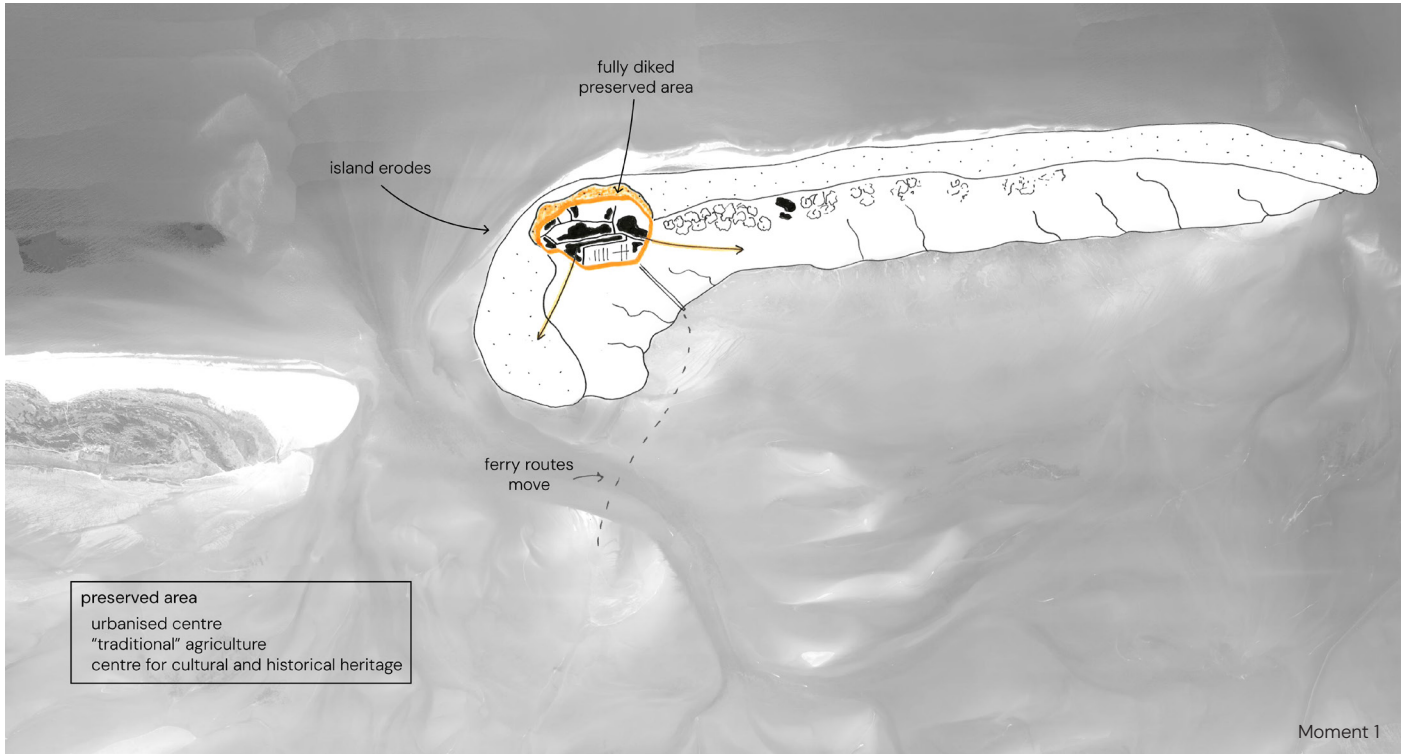
To best protect the dunes, no passage or construction should be allowed in these areas. Walking on dune grasses must be avoided, as it





Islands on the move

Dune island

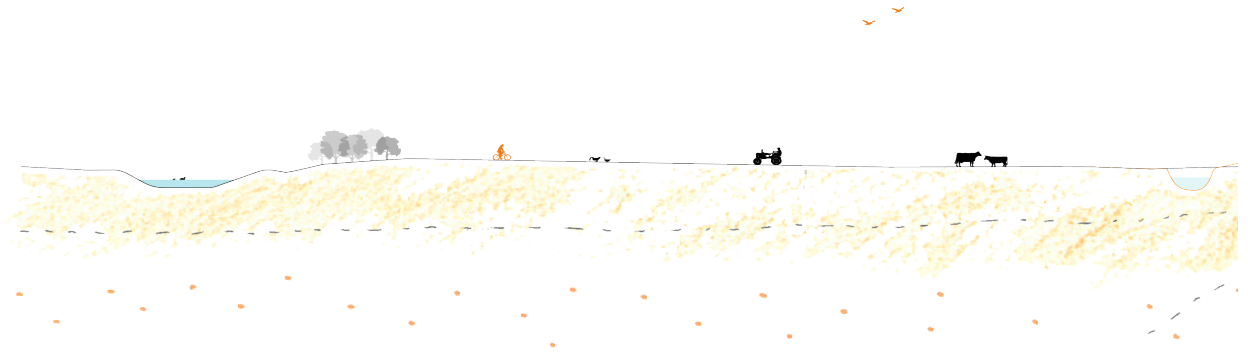


can trample and damage them. Instead, the beach can serve as the primary space for recreational use (McHarg, 1969).

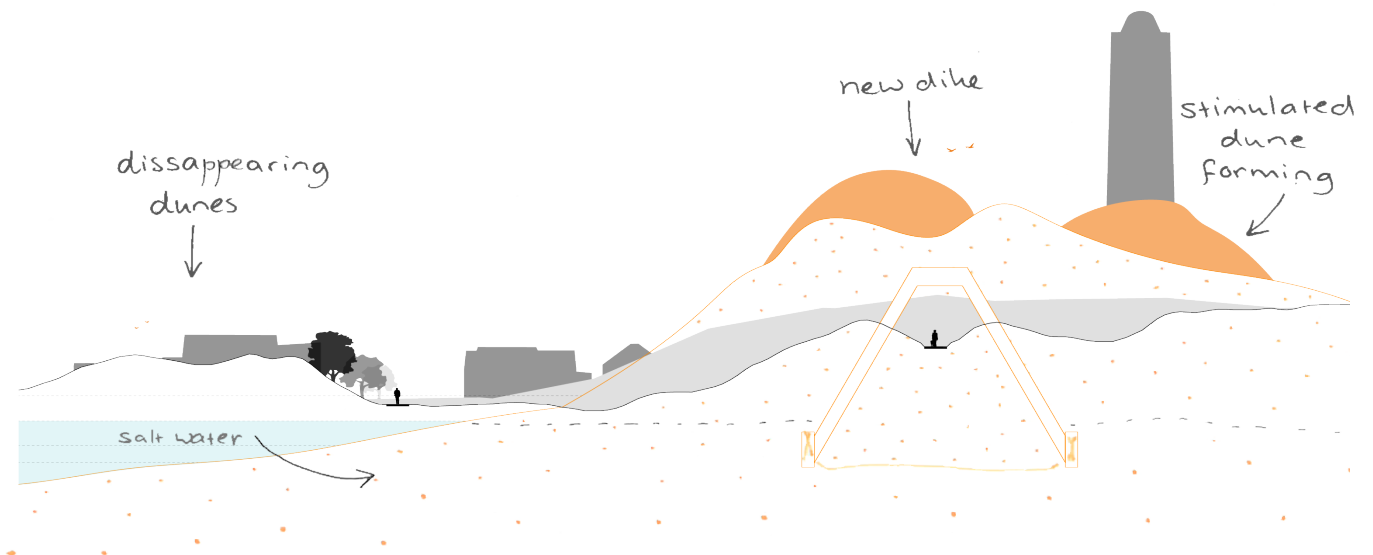
Beyond the preserved centre, life will continue to thrive. As traditional agriculture shifts or expands, aquaculture will develop outside the dikes. Together with agriculture and tourism, these activities will drive the island's economy. Over time, as the unfixed parts of the islands drift eastward with the littoral current, a new island, moving away, may eventually form in the distant future. This could lead to increased boat traffic between the fixed and "walking" islands, facilitating visitor trips to these natural landscapes.

Islands in motion

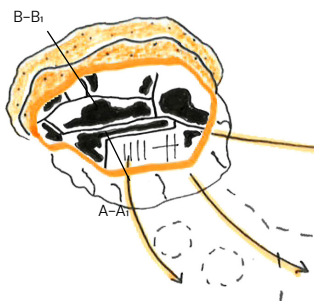
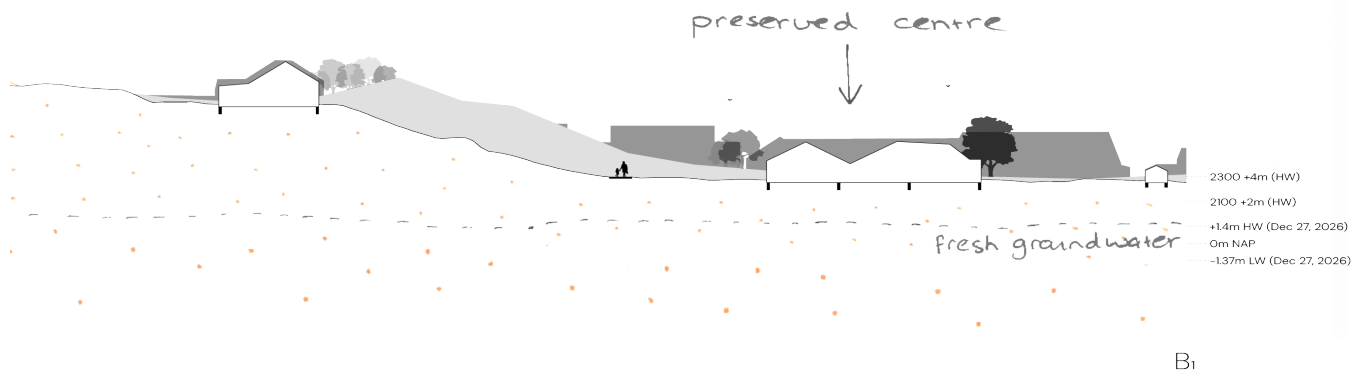
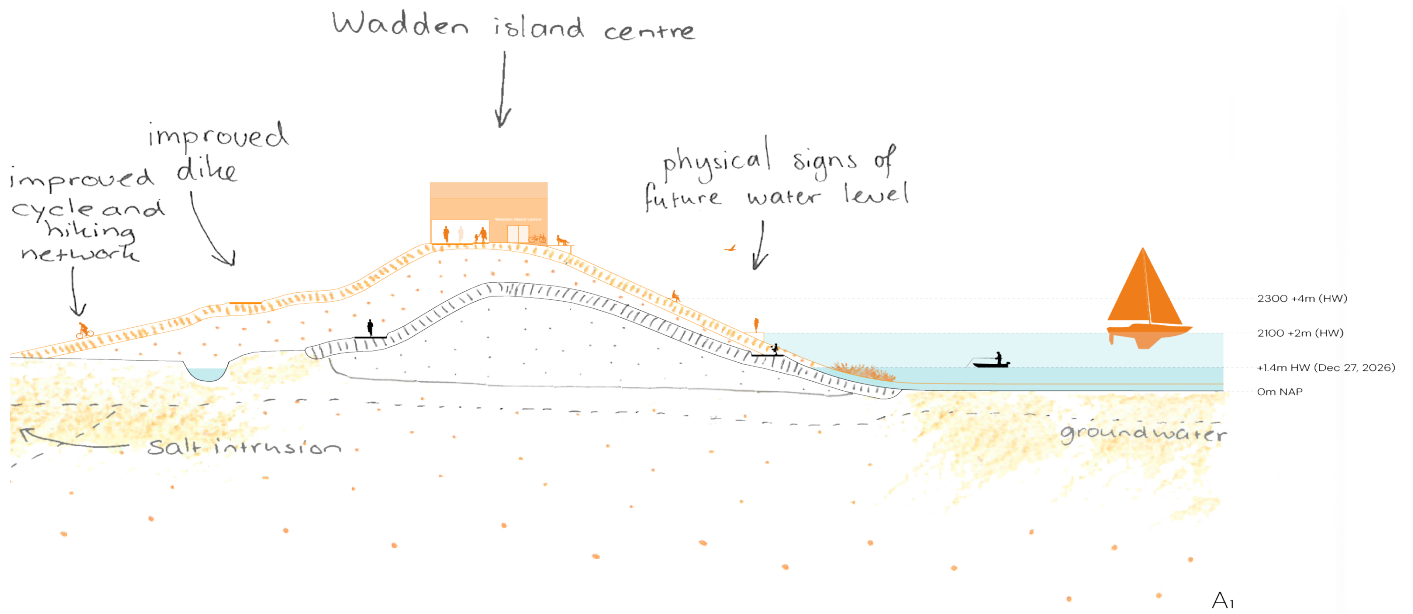
Dune island



A



B



Sections dune island
 2x vertically stretched
 A - A₁ 240m
 B - B₁ 260m

Conclusion

Post-design phase

Conclusion

The aim of this project was to investigate how spatial design can contribute to the challenges in the Wadden Sea and what the characteristics of a *research by design* methodology are to support the role of spatial design in making the Wadden islands future proof. *Research by design* merges research and design to generate new knowledge. It is an iterative process, that uses design to test spatial potential, clarify research questions, and envision future possibilities (see page 26).

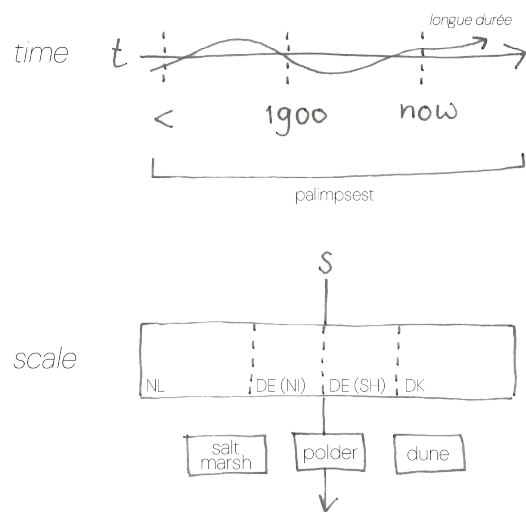
The analysis shows how the Wadden Sea is a dynamic, UNESCO-recognized landscape shaped by natural processes and human adaptation. Its ecosystem and islands are resilient, constantly shifting, and rich in biodiversity, though threatened by climate change. Human history reflects centuries of coexistence with the environment and the ability to adapt. Climate change pose future challenges, but the region's natural and cultural resilience offers inspiration for sustainable, adaptive design.

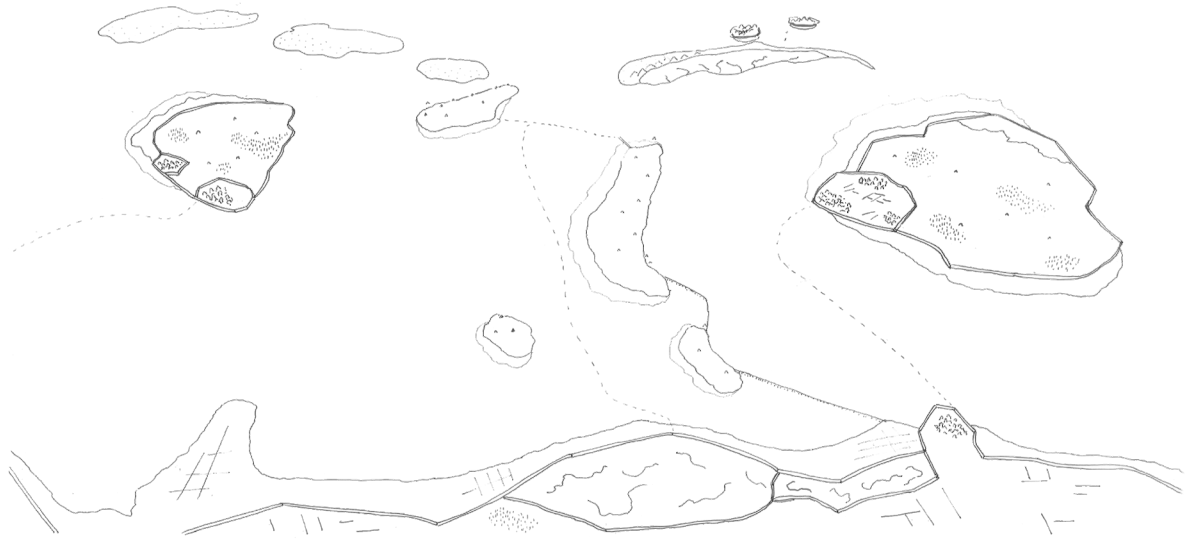
As climate change and rising sea levels accelerate, the uncertainty of flood safety on the Wadden islands increases. Because climate change will continue and is part of an longer history, the concept of *longue durée* is often used in design, expressing the relationship between human practices and the landscapes over a long time. This is why the main research question in this project stated: **What are the characteristics of a spatial design methodology in which the *longue durée* is at the base of projecting a climate resilient future for islands in the Wadden Sea?**

The *longue durée* (see page 34) reveals how cultures have developed in response to gradual changes of climate and geography. Furthermore, it offers insights into how human cultivation has transformed the landscape. By examining the *longue durée*, an understanding can be formed on the exchange between humans and the dynamics of nature.

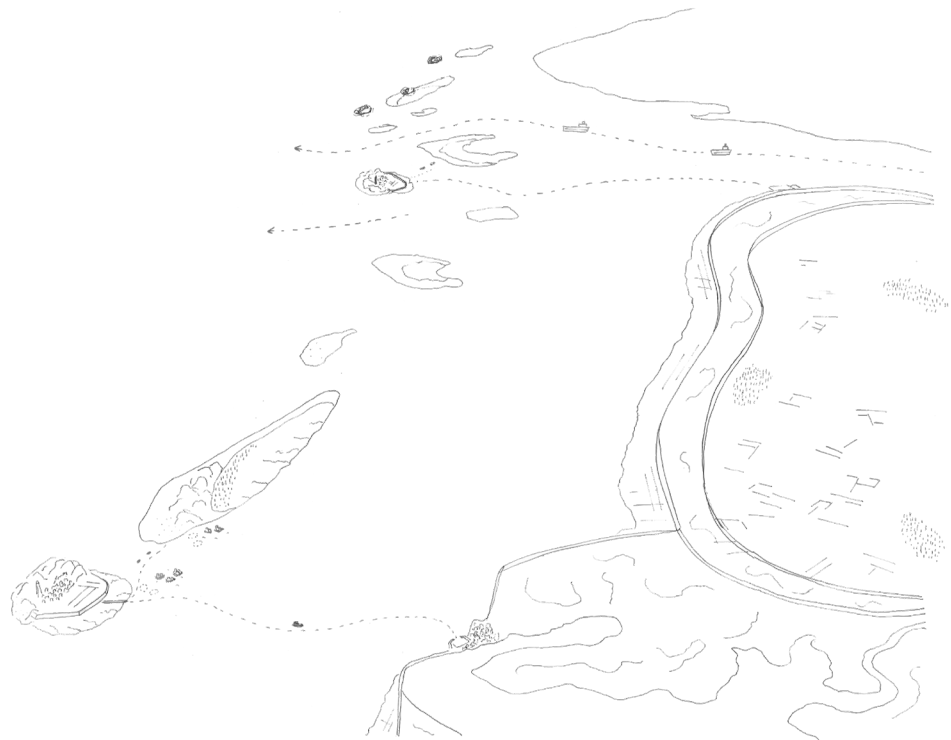
To fully grasp the *longue durée* of the Wadden islands, it is important to recognise that all islands must be approached differently. The islands in the Wadden Sea are not uniform, each island possesses unique conditions, histories, and responses to long-term environmental changes. Therefore, distinguishing between island typologies is essential.

Based on the spatial conditions, like coastal dune formation, flooded lands and cultivated polders, the inhabited islands in the Wadden Sea are divided in three typologies: salt marsh islands, polder islands, and dune islands. As research showed, the salt marsh islands, being the most adaptable island typology of the Wadden Sea yet, have incorporated mounds on which they live and house their farms or businesses, which are above the water level when experiencing frequent floodings during *Landunter*, a moment when they accept the fact that they have to wait until the water has receded. These islands have adapted the most, while intervening the least in the dynamics of nature. On the polder islands people have adapted the least to nature, but have manipulated the land and the water the most. Also on the dune islands humans have started cultivating and fixing the borders between water and land. However, as an island consisting for a great part of sand, this island subjected a lot to





Birds eye view of the polder and salt marsh islands in the future



Birds eye view of the dune islands in the future

the littoral drift and the movement of sediment.

Differences in typology give direction to spatial interventions. This can be of importance during analysing, to understand the spatial context and applied interventions, but also in the process of design. Even with an integrated plan for the scale of the Wadden Sea region, the specific characteristics and historical adaptations of individual islands must be carefully analysed to ensure a spatial design that fits within the context. This has resulted in a gradient of interventions. The salt marsh islands can already be identified as adaptive and could therefore do with less interventions.

When envisioning a climate resilient future of small islands in the Wadden Sea, the Deltares-solution directions are a great methodology for spatial design. The three solution directions proposed by Deltares are valuable because they illustrate a range of extreme scenarios, this is intended to learn from. The most applicable solutions likely lie somewhere in the middle or as a combination of aspects of all three.

In this project the solution directions, that were originally made with the Dutch coasts in mind, are expanded to the trilateral Wadden Sea and are projected with a focus onto the Wadden islands. This expansion strategy is a different approach because it shifts the focus from the protection of the mainland coasts, like Deltares does, to the islands. Incorporating the method of solution directions, spatial design is not fixed and can make space for strategies that are adaptable to the uncertainty of the future. This design-driven method initiates the exploration of somewhat extreme alternatives, to start a dialogue about climate resilience in the future and to obtain new insights.

So to answer the main research question: **What are the characteristics of a spatial design methodology in which the *longue durée* is at the base of projecting a climate resilient future for islands in the Wadden Sea?** The methodology

should combine an exploration of solution directions and a typology study.

It should emphasise the lessons learned from the *longue durée*. Studying the *longue durée* gives insight into the future geomorphological dynamics, but also into the behaviour of people and their reaction to dynamics of nature. Research should include learning from historical protective measures considering sea level rise and must, therefore, include a study of the palimpsest.

The methodology should be acknowledged that in an area with many islands, there are different typologies, which all have different conditions and on which people have adapted to the *longue durée* differently.

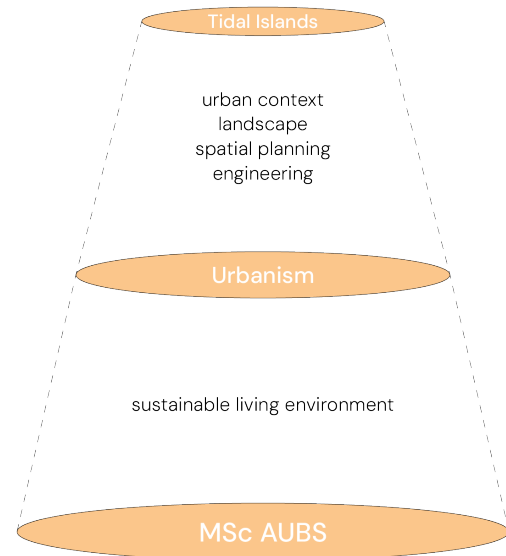
An exploration of different solution directions should be executed to test the different possible futures. Eventually the plan should not be a fixed solution on a Wadden Sea wide scale as it depends on island typology and the uncertainty of climate change. However, the extreme long-term future should be taken into consideration, as the changes of the *longue durée* have shaped the spatial for centuries and will remain to do so in the future.

Reflection and evaluation

Sea level rise presents a highly complex challenge. This project set out to explore multiple solution directions while honouring the values of the Wadden Sea and its islands. The exploratory approach effectively investigated various potential futures. Reflecting on the process, the analysis might have benefited from a more clear structure. Incorporating Meyer & Nijhuis's 3x3x3 layer method (2010) alongside the four key subjects that I investigated (heritage value, state of nature, economic value, and challenges) would have provided a clearer analytical framework. Their approach is based on the Layer Approach (page 26) and focuses on three scales, three periods of time and three layers of information. In this project the amount of layers, scales and time are approached a little bit differently. Two scales (the Wadden Sea, consisting of four areas, and the island scale) were used, but the amount of time and layers have not been consistently. The importance was to map the changes throughout time. Standardizing time frames across all components would have made it easier to compare and use the four subjects together. It would further enhance the overview and strengthen the palimpsest. However, the organic approach, tailored to available data and emerging insights, ultimately proved adequate for the project's needs, and supported informed design decisions, drawing on analytical experience developed throughout my studies.

The project incorporates the theory of *longue durée* as a foundational layer for decision-making. Building on this, the method of Deltares of exploring solution directions (page 26) was applied and extended across the entire Wadden Sea to create an integrated design approach for the region as a whole, with a focused zoom on the island typologies.

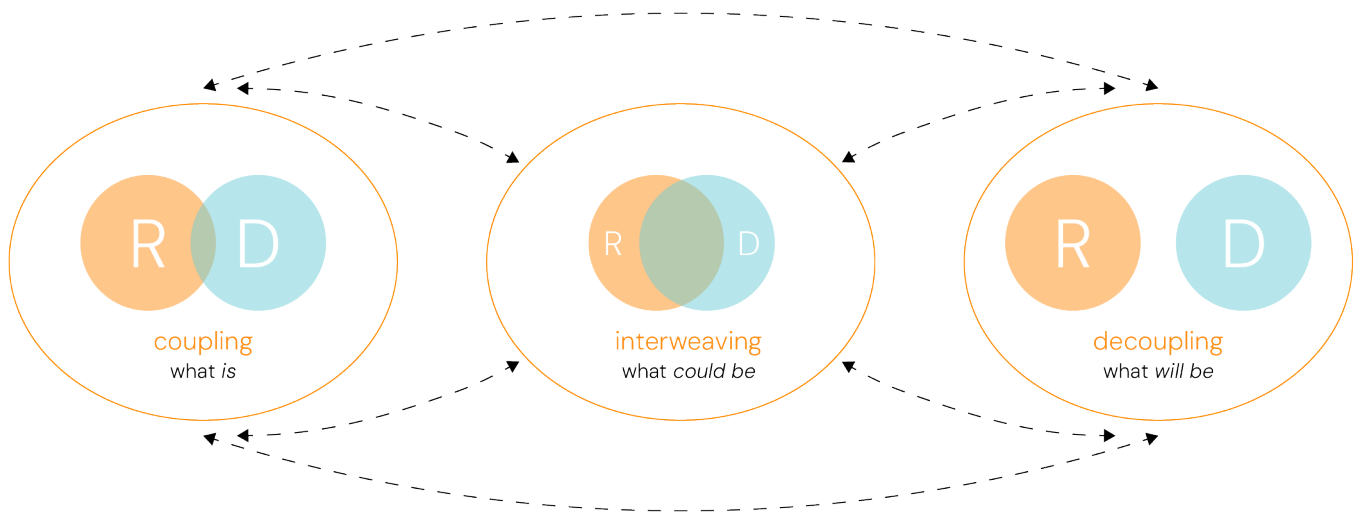
This project does not create a direct and fixed solution. As stated before, it focuses on studying possible futures and adopting a shifted perspective on water defence management. This project emphasises the fact that a solution direction has different effects and consequences for different



Relation between Master programme, track and project ▲

type of islands in the Wadden Sea. This project aims to open a dialogue about different spatial futures, but also about our role as humans in the landscape. Do we have the right to manipulate the landscape according to our preferred land-use, or should we aim to co-exist with the forces of nature?

In this *research by design* project, research and design continuously influenced each other throughout the process. The methodology describes this relationship as a process of coupling, interweaving, and decoupling of both research and design. In practice, however, the process was more organic: even in the final phase, specific interventions were still being researched, such as how to improve a dike or create a stable dune. The results from the research directly informed the design interventions and the research itself influenced the design in such a way that its insights could be applied later in the design process. Through researching how geomorphology works in the Wadden Sea, I learned key principles that I then applied in designing for the future.



Research by design

▲ Re-evaluated from Nelson & Stolterman (2012), Jonas (2007) and Roggema (2016)

This *research by design* method, which uses exploratory solution directions, can be applied to various projects. A project's scope must be understood through research and by exploring different alternative futures, plans for a new future can be created. However, the final solution direction of Islands in Motion is more specialized and tailored specifically to the Wadden Sea's unique conditions as a socio-ecological system with dynamic processes. To transfer the plan onto another location, the new site should share similar conditions, such as tidal dynamics in combination with mud flats and inhabited barrier islands that are subject to movement, which gives the Wadden Sea its unique character.

Examples of such locations include the coast of Georgia, United States of America, and Morecambe Bay, United Kingdom. Either way, the local conditions should be studied thoroughly and unique island typologies should be defined.

Discussion

It could have been considered to incorporate different estimations of global warming in the design. Now this study worked with an estimation of 2m sea level rise by 2100. However, using the high and moderate levels of global warming could emphasise the uncertainty of the future.

The proposed plan affects local inhabitants on the islands and their economic activities. A drastic approach like this requires adaptability and a different perspective on the area and water defence management. The methodology is recommended for both transborder and local policy makers and planners. However, for further research, it would be beneficial to collaborate with local people and explore a climate resilient future for their habitat through the execution of the workshop. Since local inhabitants and authorities were not involved in this research and design project, the analysis relied primarily on maps, data, publications, field trips, and stories from previously published books, images, and audiovisual materials. As a result, the design is quite top-down. This raises questions about the unstable balance between planning on a larger, cross-border scale while making decisions that directly affect local actors. Being a *research by design* project, the primary intention was to learn from it, creating a methodology to explore alternative futures which is accessible enough for those living in the project area. Incorporating interviews with island inhabitants would provide valuable insights into their experience with flood threats and their existing efforts or willingness to adapt. This together with the co-explore workshops, would allow a more bottom-up influence.

Touching upon the preferred solution direction, economic activities crossing the Wadden Sea, such as shipping routes from mainland ports to

the North Sea, will need periodic reassessment. In a hundred years, some routes may have to shift along with island movement and sedimentation patterns to maintain their activity.

Personal reflection

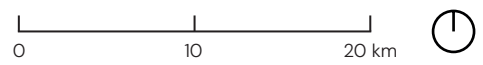
My graduation project embodies the Urbanism master track, addressing complex spatial challenges where urban context, landscape, spatial planning, and engineering come together. The project's integration of design with physical and social sciences demonstrates Urbanism's interdisciplinary character. This work builds upon the MSc programme Architecture, Urbanism and Building Sciences (AUBS), which provided the framework to contextualize spatial problems within political, social, cultural, and economic dimensions, aiming to achieve a sustainable living environment.

Working on my graduation project made clear how interconnected research and design were. Research and design were often crossing paths and my curiosity sometimes made me take a detour. While it often felt chaotic, navigating that complexity was both challenging and rewarding. One of the biggest hurdles was knowing when to stop researching, some things just fell outside the project's scope. Balancing exploration with focus was key, as progress had to be made.

Another challenge was working independently on a long-term project. Though I had the support of peers for feedback, the responsibility ultimately rested on me. While this does not perfectly mirror professional collaboration, it was a valuable opportunity to discover and develop my own strengths and makes me excited for what the future brings.



- ▲ Jekyll Island, Georgia, United States of America
Bing Satellite
- ▲ Morecambe Bay, United Kingdom
Bing Satellite



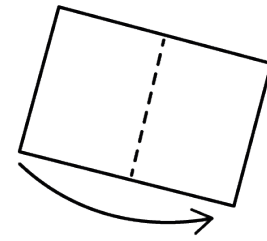
Appendix

Design workshop trial

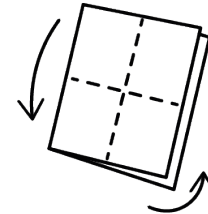
The workshop was held with peer students from the fields of Urbanism and Watermanagement and the minizine (see right page) was shown to explain the process.. It's challenging to actually get people to actively draw and sketch together. They felt the instructions were clear, but perhaps due to my inexperience the expectations did not align with reality. To adapt, I shifted the approach, opening a dialogue to discuss solution directions and the island typologies. I asked them what they think will happen when applying a solution direction on a specific island typology.

With their input, questions were raised about the timeline of the "walking" islands, the drive of people to use new land when implementing a seaward approach and the current adaptibility of the islands was discussed.

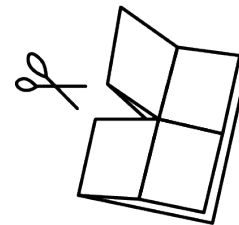
Implementing a co-explore workshop, like this one, could be valuable to the design process, especially when combining actors of different scales: local island inhabitants, planners of bigger scale and governing actors.



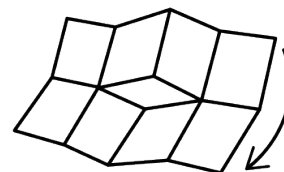
1 Fold in half



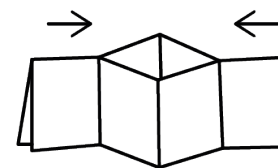
2 Crease in all ways



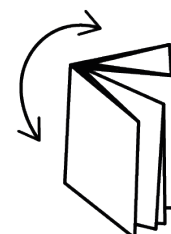
3 Cut halfway



4 Open and fold along edge



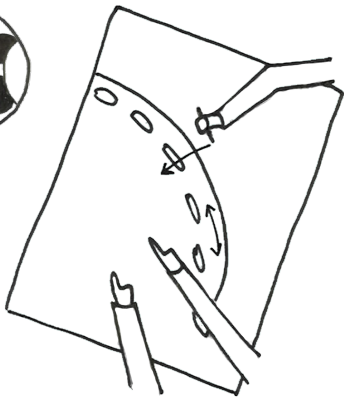
5 Put both sides inwards



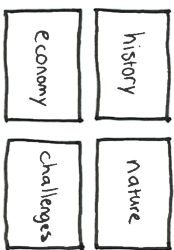
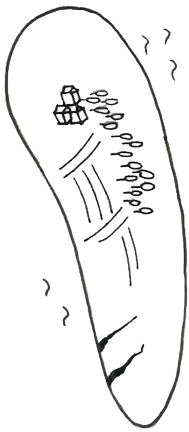
6 Close and form pages

Steps to making the minizine
Adapted from Huang (2022)

discussing and sketching together



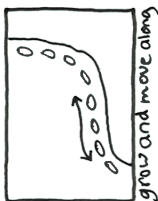
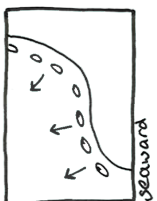
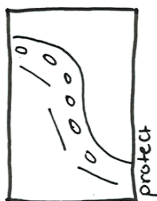
What do you think?



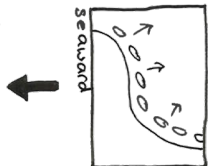
This is the island I'll be redesigning. Welcome to



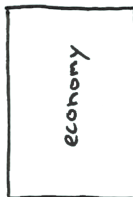
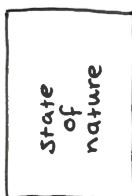
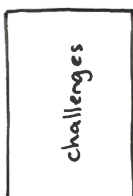
I created 3 solution directions



Let's imagine one solution direction for the island of



sketching and brainstorming together

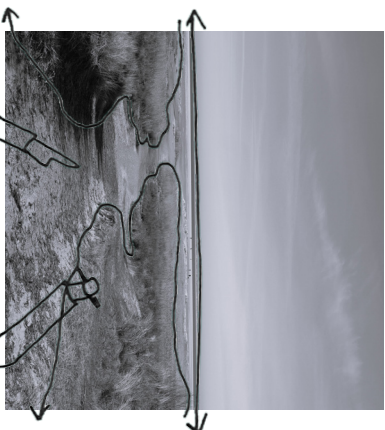


This is what we're working with in the Wadden Sea.

TANNE



For my graduation project I am researching the use of the *longue durée* in designing a more resilient future for islands in the Wadden Sea that are increasingly being threatened by rising sea levels. The *longue durée* is the theory of the long lines in history, such as slow changes in soil and water, that influence human interventions in the landscape. This workshop is intended to incorporate your valuable feedback on my project on the future of the Wadden Sea. Together we'll explore an alternative future for the Wadden Sea and its islands!



WORKSHOP

designing with the *longue durée* for a resilient future of Wadden islands

THANK YOU!

Data management list

Section A. General considerations	yes	no
<p>1. Is the graduation project conducted as part of an internship (at a company), or as part of a research project at TU Delft?</p> <p>If a student's graduation project is conducted at a company or as part of a research project at the university, questions of data ownership and intellectual property rights need to be addressed in a written graduation or internship agreement before the project begins. Students and their supervisor should consult the Intellectual Property Rights of Students webpage. Additional information can also be found in the Extended Personal Research Data Workflow.</p>		x
<p>2. Does the project involve conducting (part of) the research outside the Netherlands?</p> <p>Students who intend to travel abroad (even to other EU countries) for study, exchange, research, internship, or graduation project purposes need to follow the Travel Safety Protocol. This includes attending a mandatory Travel Safety Training Session: see the Disclaimer.</p>		x
<p>3. Will the research involve processing data from humans, such as running a survey, conducting interviews or workshops, collecting data through social media or internet forums, or re-using existing datasets about humans provided by a third party? (If 'yes', see follow-up questions 4 to 13 in Checklist B.)</p> <p>Students who work with data from human participants must complete the next section and apply for and receive ethical approval from the Human Research Ethics Committee (HREC) before conducting the research.</p>		x

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