Climate adaptation for the Wadden Sea coast in the 21st century

PROGRAMMA NAAR EEN RIJKE WADDENZEE

WADDENZEE
WERELDERFGOED

STROOTMAN
LANDSCHAPSARCHITECTEN

Visualising tasks and future courses

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Content

1. Introduction

Average annual temperature in the Netherlands 1850-2019, each vertical stripe = 1 year. Data: Institute for Environmental Analytics

Introduction

Motivation and purpose

The climate is changing: the earth is warming up and the sea level is rising, with an increasing impact on our ecosystems, the way we grow our food, and the way we live. The chart on the previous page is a clear indication of what the danger is: the rapid increase in the average annual temperature in the Netherlands is an alarming trend with all that it entails. We need to adjust to solve the problems arising from climate change. A large number of challenges combine to form a threat to the Wadden Sea coast, a unique intertidal area that is one of the largest of its kind in the world, but they also offer plenty of opportunities for adaptation to the climate – reason enough to get down to tackling them.

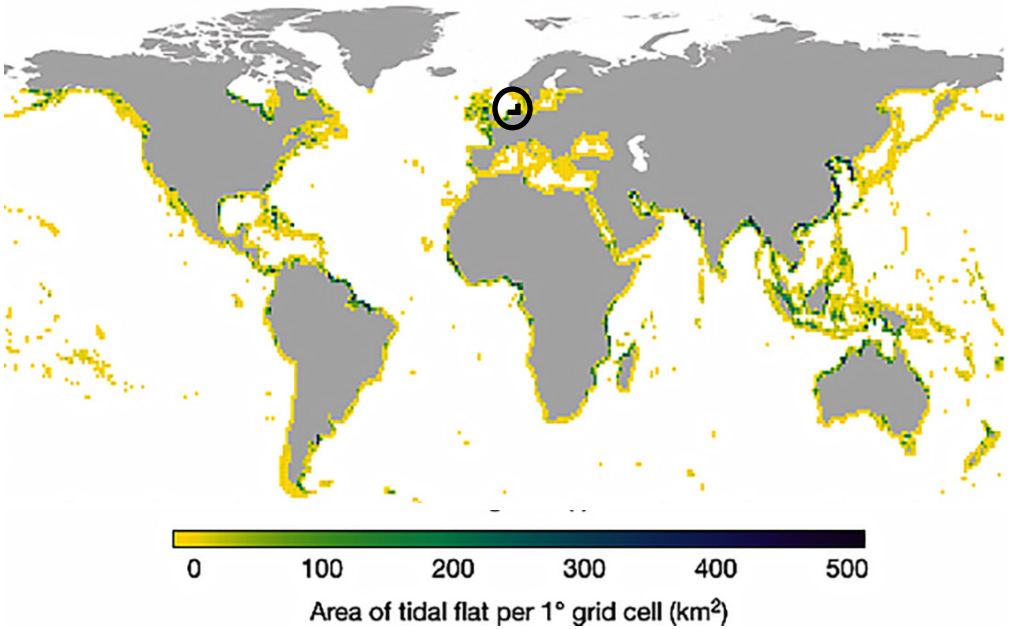
The direct motivation for this report is the Climate Adaptation Summit (CAS) to be held in the Netherlands in January 2021 within the framework of the Global Center on Adaptation (GCA). This worldwide summit is designed to harmonise the accelerated action that has been launched by the GCA and to obtain even more support for the climate adaptation movement. The Groningen municipality and various other partners in collaboration with the GCA are holding a Climate Adaptation Week to offer a platform where the latest insights and ideas on climate adaptation can be shared with one another: examples of adaptive solutions to the consequences of climate change. They will be related to current issues such as health and the quality of life, not only in cities but also in the countryside: urban and rural. The Programme towards a Rich Wadden Sea (PRW) is a partner in this with a focus on the entire Wadden Sea coast of the Northern Netherlands. The issues presented by PRW are operative in comparable delta regions with a soft coast all over the world: coastal security, land use, water management and nature.

This is a strategy for climate adaptation on the Wadden coast that sets priorities, inspires and looks forward towards an attractive, integrated, climate-resistant future in the 21st century. We here offer a perspective on the future of the Wadden coast in the form of an adaptation strategy. In other words, what are the problem spots, and what can we do about them? We want to look ahead and focus on the opportunities that are present and offer inspiration for similar regions and processes that will operate in the area. While there is a strong focus at the moment on climate mitigation (including energy transition), our focus is on climate adaptation with measures that will enable us to adapt to the changed climate.

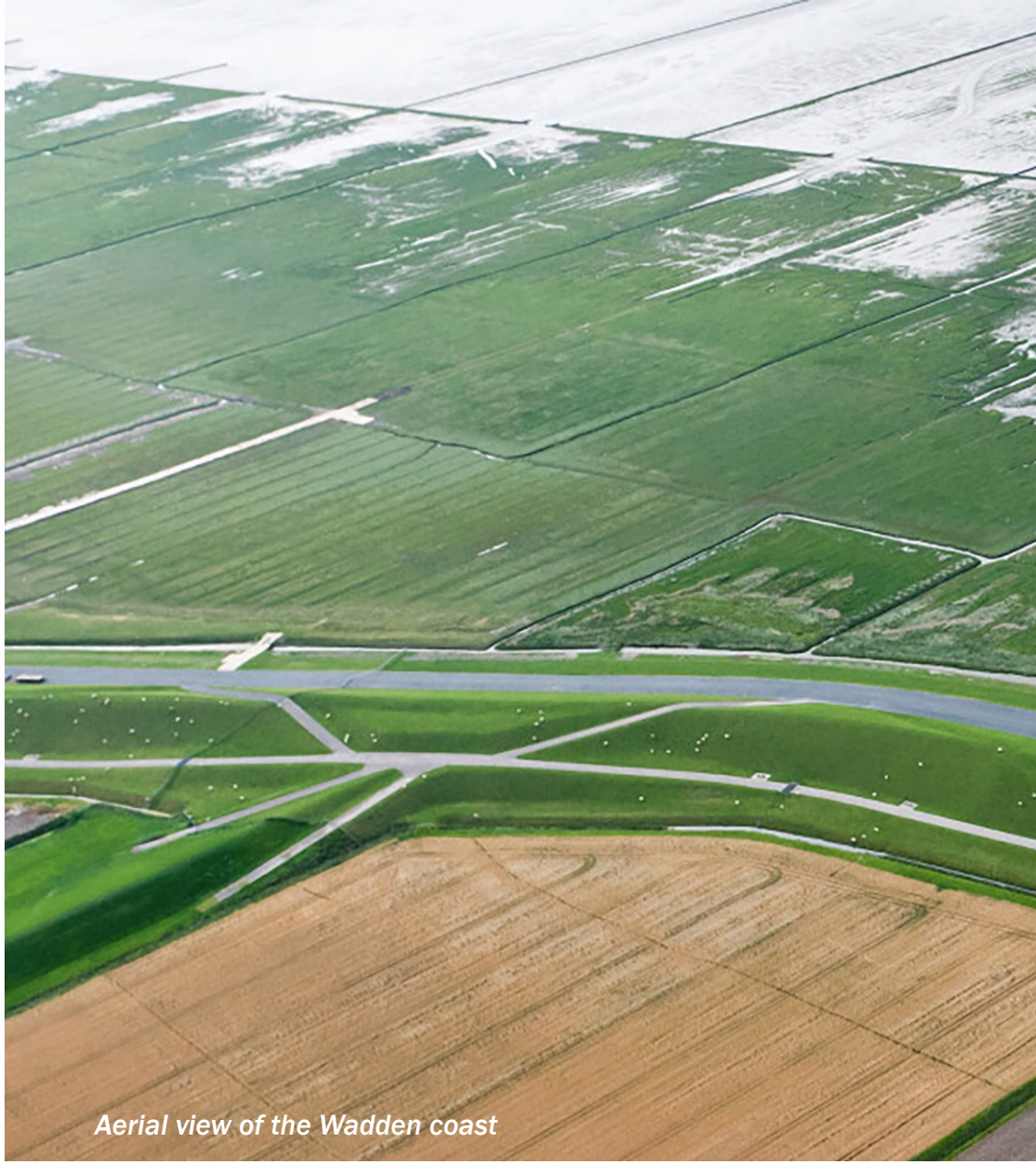
This adaptation strategy is not intended as a clearly defined policy, but it aims to inspire and fix priorities. To make well-considered choices now and to anticipate future developments, we look far into the future, towards 2100. This goes beyond the horizon set, for example, in the Delta Programme and the Wadden 2050 Regional Agenda. There are many uncertainties in the longer-term expectations of climate effects, but the choices we make now determine the field of operations in which future activities will take place. Hence it is important not to limit the range of choices available in the future. That is why we are deliberately looking beyond 2050 and are proposing adaptive solutions on which we can already start working now. In doing so, we aim to align ourselves with existing, positive developments that are currently taking place.

The area under review is the Wadden coast, from the salt marshes beyond the dikes in the north to the peatlands and creeks in the south, and from Den Helder in the west to the German border in the east. The report is thus an overarching Wadden coast perspective in which we focus on the interaction between mud flats and land. The Wadden Sea itself, including its shallows and islands, is left out of account here – there are already many regional processes under way there, and it is particularly the interaction between salt marshes and land that interests us. Finally, the multi-stage perspective that we offer here is still not present in some quarters: we offer solutions that not only contribute to climate adaptation but also have positive effects on agriculture, biodiversity and the quality of life.

PRW is supported in this project by Strootman Landschapsarchitecten. Several working sessions with sounding board groups and experts have provided valuable input and lively discussion.This report is the result.



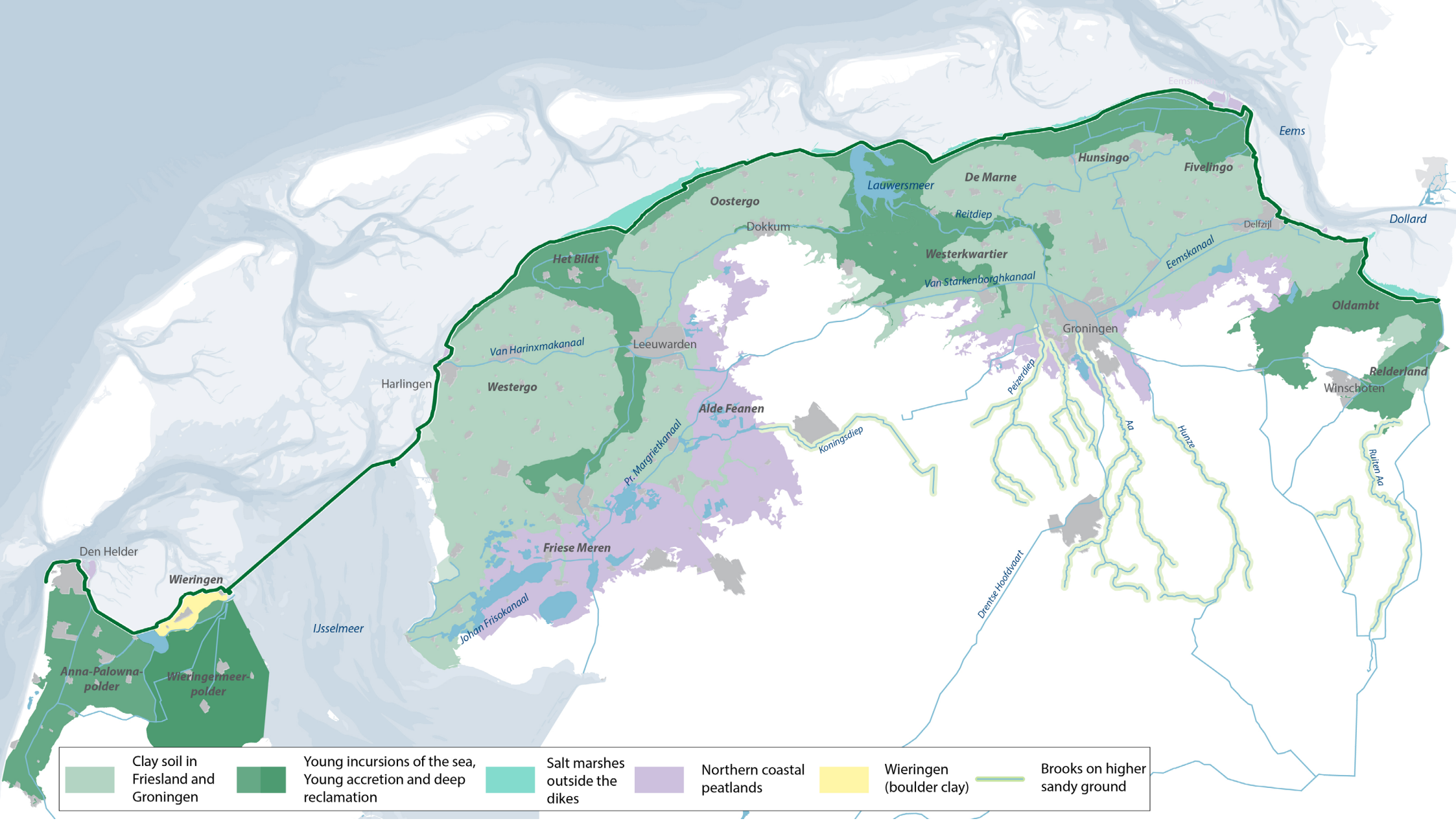
Intertidal areas in the world, Murray et al. 2019



Aerial view of the Wadden coast

The project within a larger context

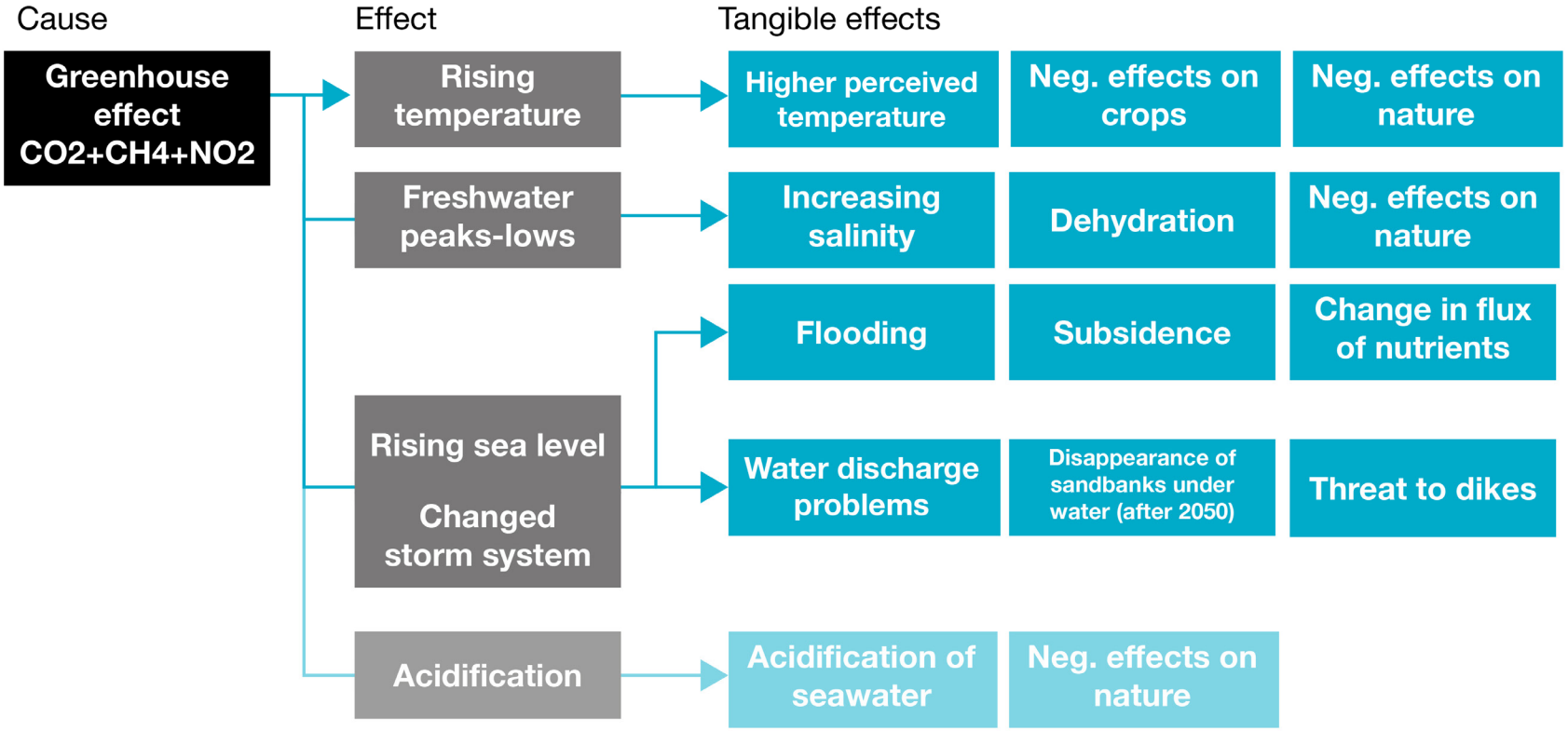
The Wadden region extends from Den Helder in the Netherlands to Esbjerg in Denmark over a length of some 500 km. As one of the largest intertidal areas in the world, the Wadden coast has an enormous natural value, which is why it has been placed on the UNESCO World Heritage list. Large tracts are zoned as National Park and as Natura 2000 zones. It is an important habitat for numerous (migratory) birds, fish species and seals. Many of these are mobile, making the Wadden area part of a large meta-ecosystem of similar regions in Europe and Africa (the swimway and flyway) (Council for the Wadden Sea, 2011).
In addition, the Wadden coast is important for fisheries, recreation and mineral extraction, as well as for excellent agricultural land.

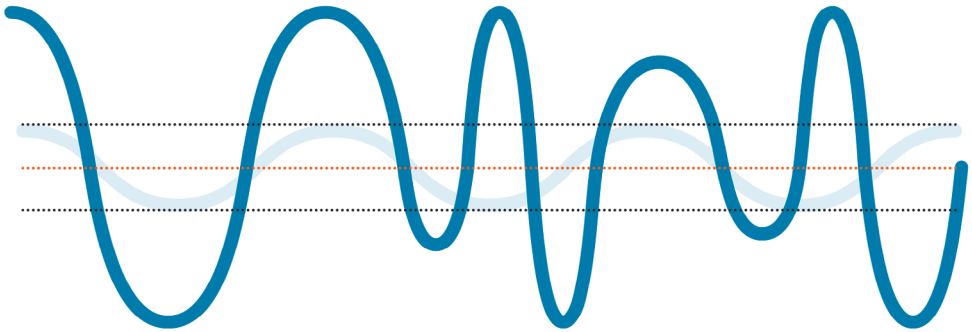


Area

The area covered by this report is the land that borders on the Wadden Sea (to about 60 km inland), including the salt marshes. In this study we look beyond the dike, but particularly inland as well, so this perspective excludes the sea and the islands. The project area contains landscape types of cultural-historical value, such as the peatlands on the transition from Holocene to Pleistocene, the old sea clay areas, the inlets that have been incorporated in a polder, the new clay areas that have been reclaimed and turned into polders over the centuries, and the former Wieringen island with the Wieringermeerpolder. The salt marshes beyond the dike also belong to the planning area. From an international perspective, this results in a recognisable delta system with a soft coast, historic towns, rich agricultural land, exuberant vegetation and fishing. It can thus also serve as an example for other countries too, for instance as a Knowledge Hub.

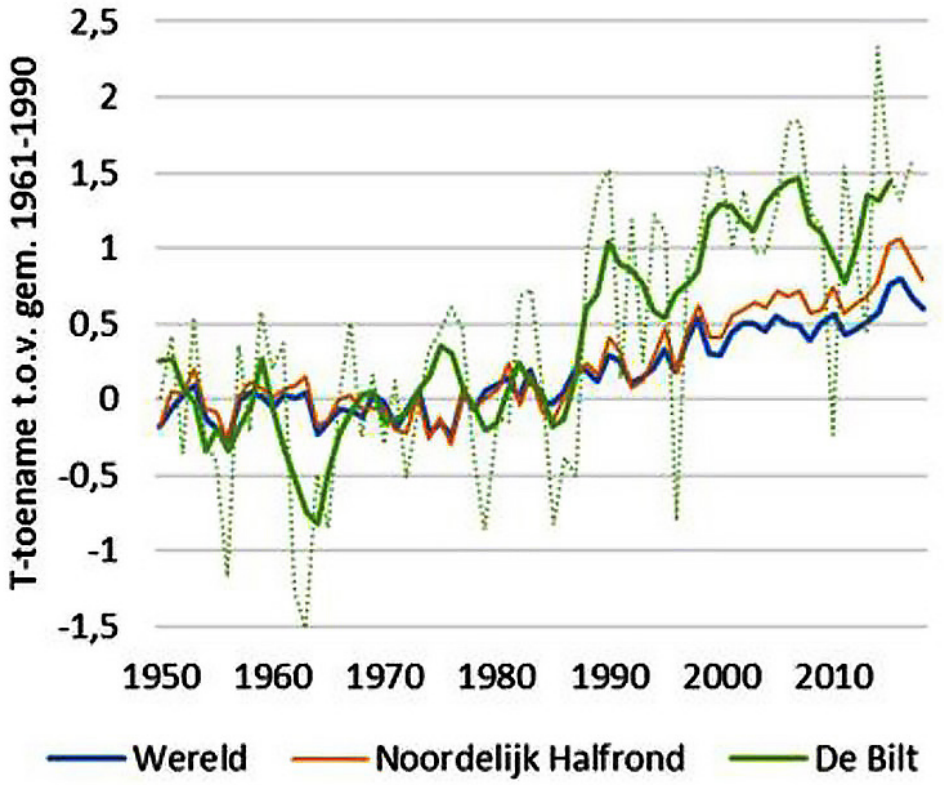
2. Charting the challenges



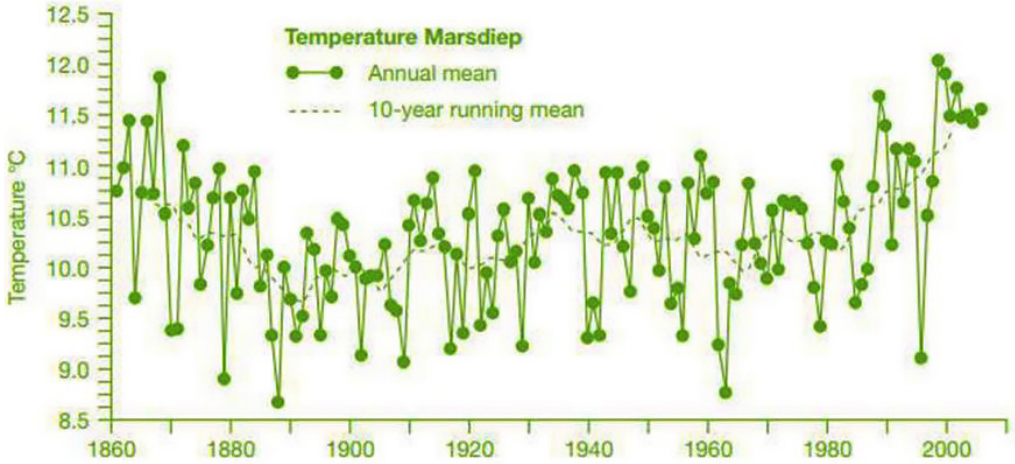


Climate change: cause, consequence and effect

The greenhouse effect causes the temperature to rise, changing precipitation patterns, a rising sea level, increased salinity, other storm systems and acidification of the ocean. The first three of these in particular have tangible effects on the Wadden coast area. The rise in temperature produces negative effects on nature and agriculture and the warmer climate becomes noticeable. Changing precipitation patterns lead to more drought and flooding with the concomitant negative effects. The rise in the sea level affects water safety, increasing salinity, freshwater drainage and marine life in the Wadden Sea. These effects are becoming not only greater but also more unpredictable.



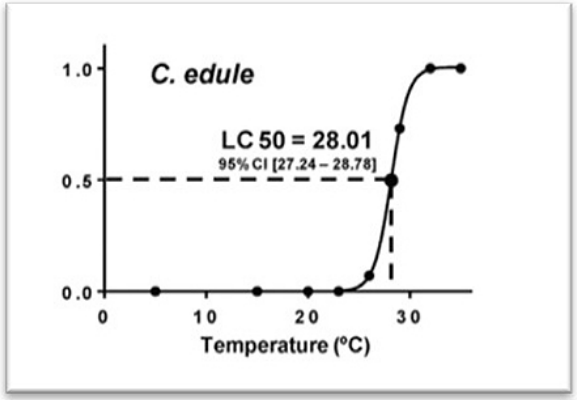
Rise in average temperature in De Bilt from 1950

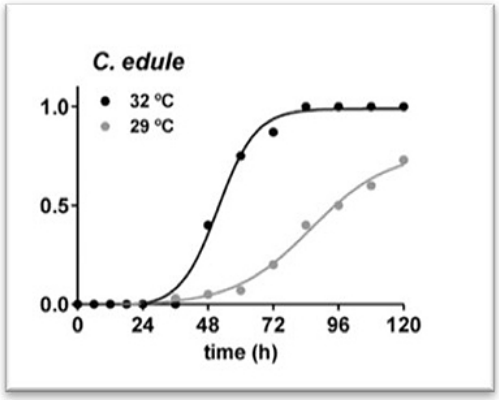


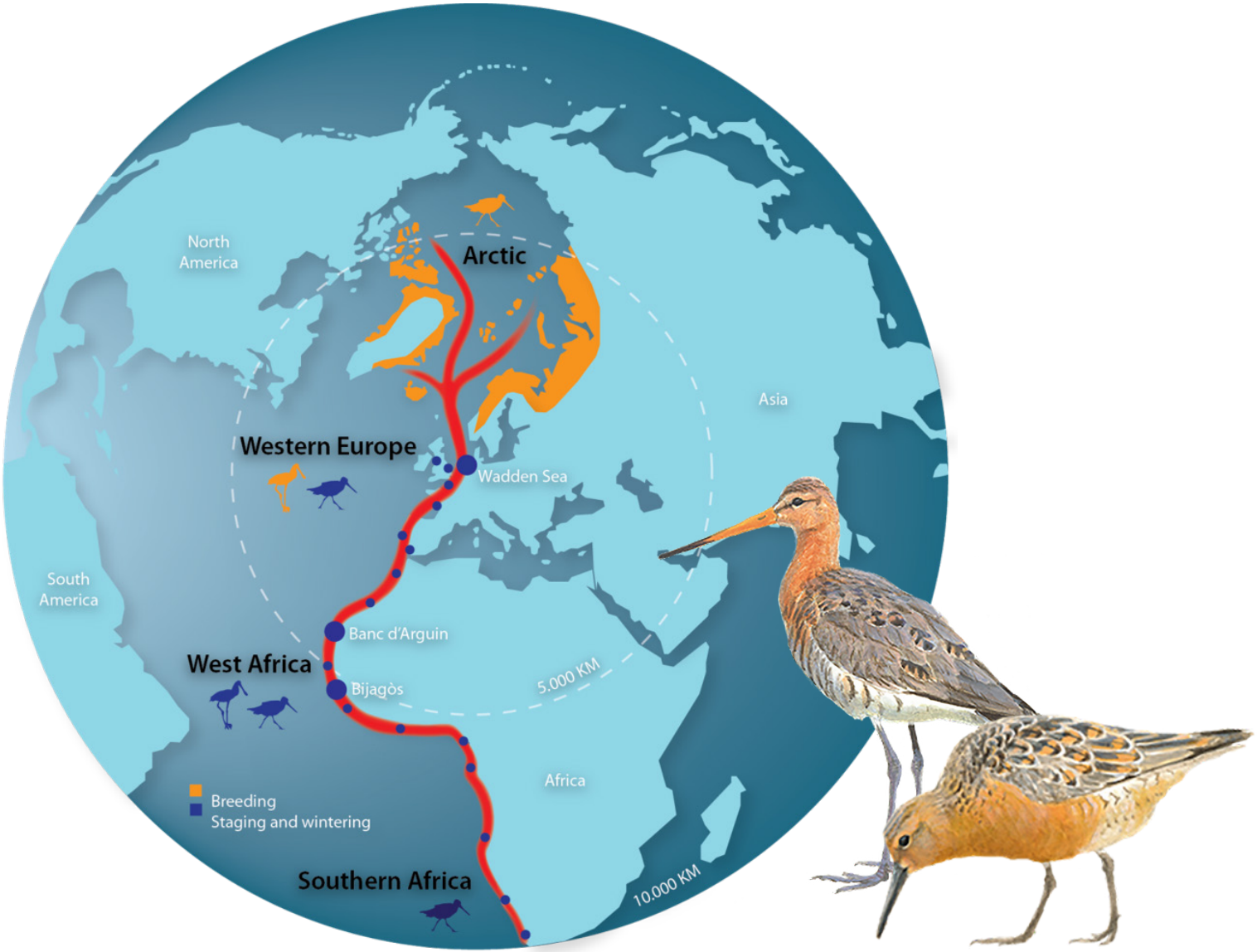
Rise in average temperature of Marsdiep from 1860

Effect 1 – Rise in temperature

The temperature on land went up in the last few decades, and this trend is likely to continue. Measurements show that the temperature is rising more rapidly in the northern hemisphere, but even faster in the Netherlands. The water is heating up the sea as well as the land. The 10-year average temperature of the Marsdiep has gone up around 1.5°C since the beginning of the 20th century, with an accelerated rise in the last thirty years (Noordhuis et al., 2019). Besides these averages, the number of heatwaves per annum in the Netherlands is increasing too (KNMI, 2018), resulting in increasingly long periods of high temperatures and high evaporation in the summer.



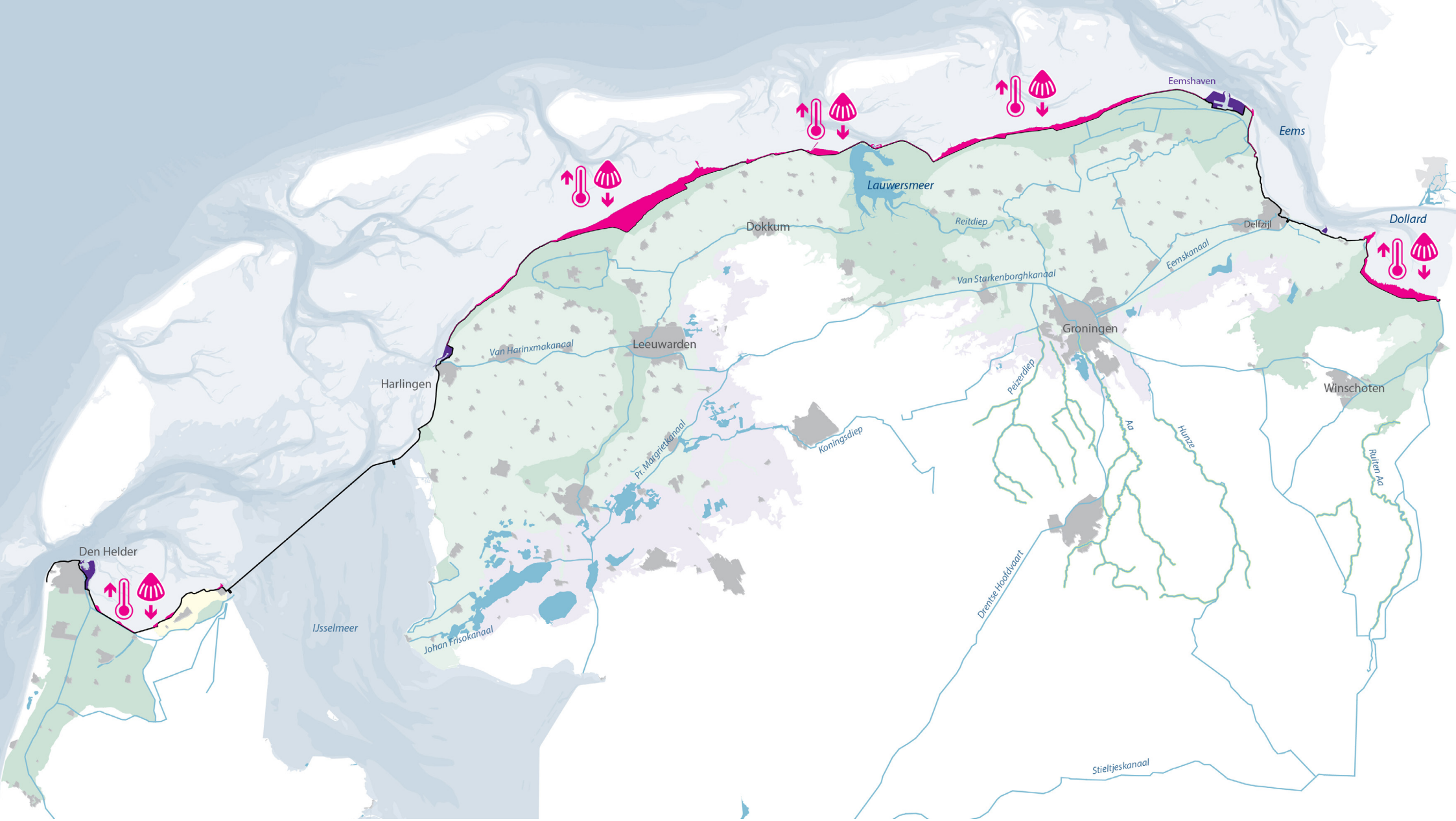




Decline of cockles (C. edule) with warmer temperature (for a longer period)

Already consequences for shellfish and birds

On their long journey, birds like the black-tailed godwit and the red knot look for food, which consists mainly of molluscs such as cockles, in the shallows or on the sandbanks. The rise in temperature of land and water is detrimental to the shellfish population, as the above graphs on the common cockle (C. edule) show. The food supply for shorebirds is thus decreasing in this crucial link in the North Atlantic flyway. As a result, the birds have to stay longer to build up strength. And as a result of the rising temperatures in Siberia, mosquitoes, for example, fly away earlier and the birds arrive too late for them (Reneerkens, 2020).



Rise in the temperature of the seawater leads to less cockles and less food for shorebirds

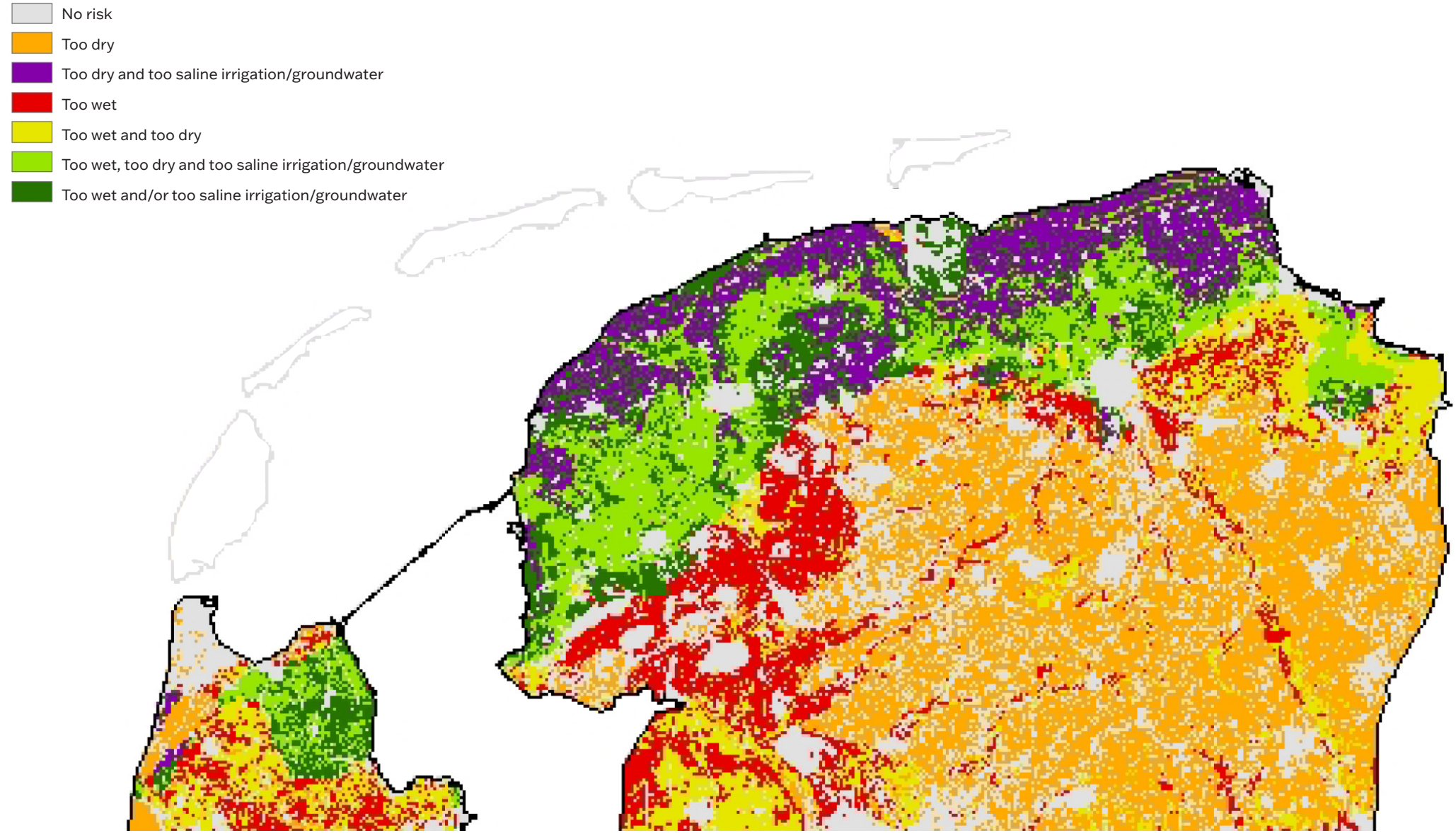
The effects of the rise in temperature on the food network on the Wadden coast is especially noticeable in the areas outside the dikes: the sand banks (outside the planning zone), the borders of the salt marshes, and the salt marshes themselves. The ecological diversity and quality of these areas is in danger of declining at a faster rate than, for example, other kinds from more southern climate zones that come to settle here. If we want the Netherlands Wadden Sea to remain an important link in the swimway and flyway, it is crucial for the food network to remain intact with an adequate supply of food. That calls too (outside this study) for a different approach to the management of channels and sandbanks, sometimes with a demand for space and adaptation in the study area.

Dehydration of grasslands

Secondary growth of potatoes

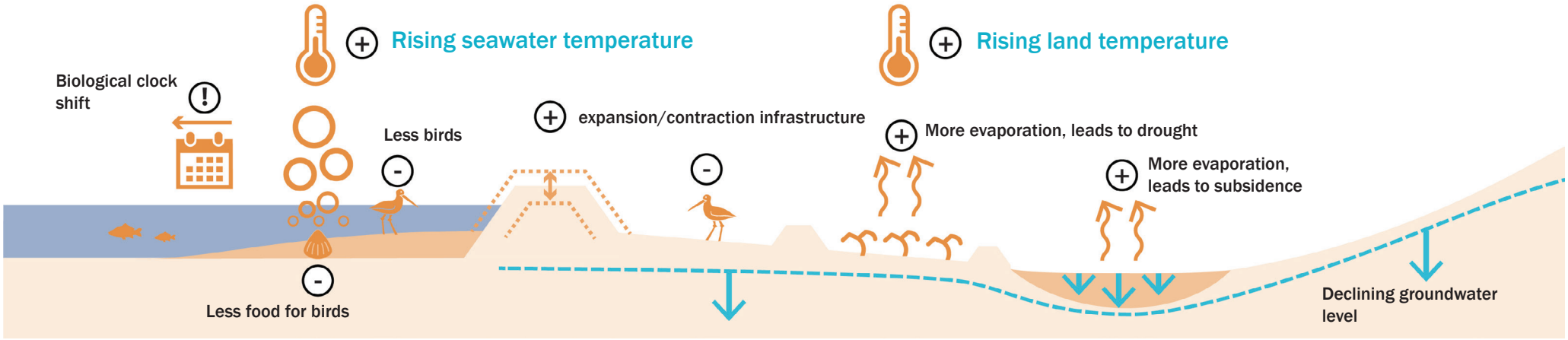
Already consequences for agriculture: more evaporation, lower crop yields

The (prolonged) higher temperatures on land also influence agriculture. English rye grass, for example, has a 10% lower yield per heatwave because the grass dries up and the sods die; potatoes are affected by saline groundwater, secondary growth and die off, resulting in a strong decrease in crop yield of between 25 and 100%. Wheel sprinklers are hardly feasible any more, and farmers have to irrigate intensively by hand (RTV noord, 2020). On the other hand, some crop yields are higher with higher temperatures and it becomes possible to cultivate crops from more southern climates (Geijzendorffer et al., 2011). It is evident that, to adapt to climate change, agriculture – an important sector of the regional economy – will have to set its sights on crops that are resistant to drought and high temperatures and that the regional water system will be in need of adjustment too.



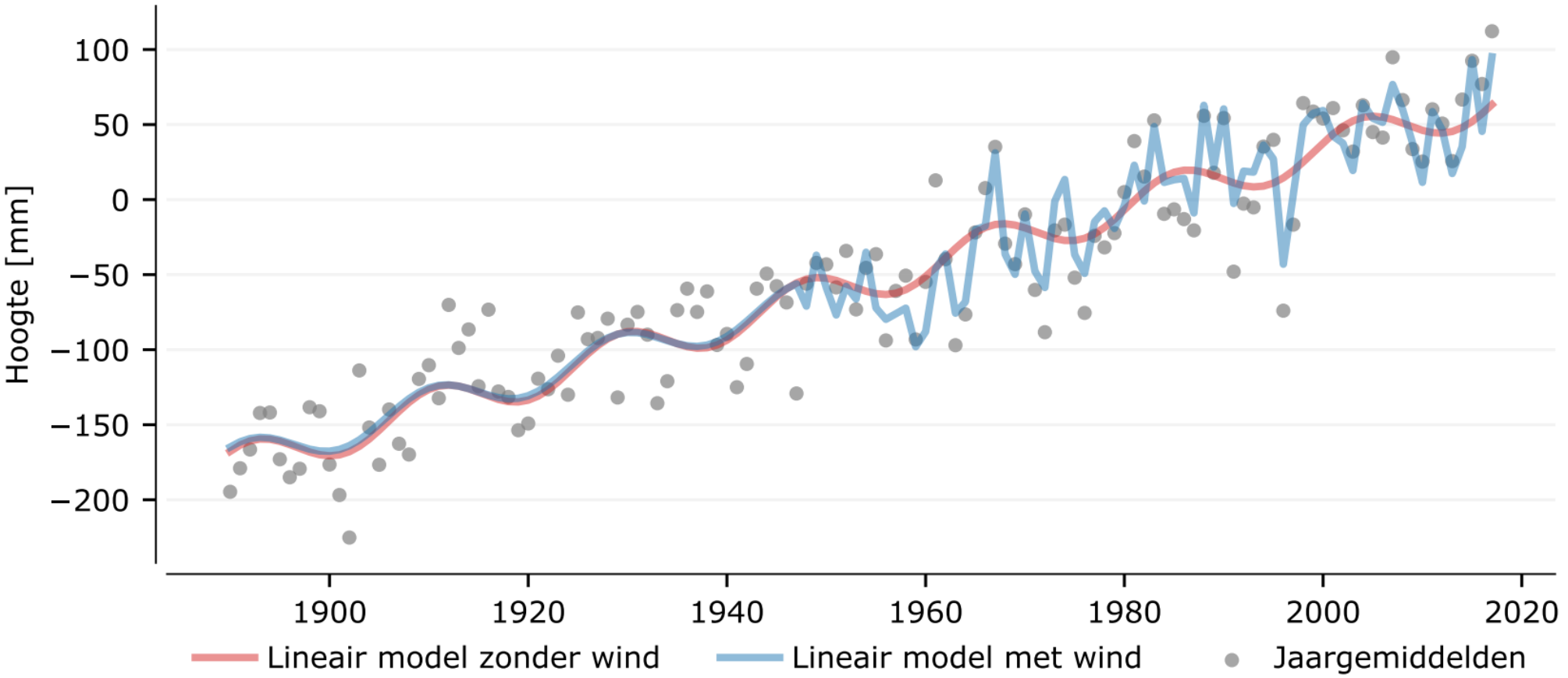
And the trend continues

In 2011 Alterra produced a map indicating the consequences of extremes in climate for agriculture in the Netherlands in the future. The Wadden coastal strip is at risk of conditions that are too dry and too saline. Further inland, flooding is an additional problem, while the only problem really facing the peatlands is flooding (Geijzendorffer et al., 2011). There are places that will eventually only have to face a few problems, but the map shows the need for Dutch agriculture to adapt. Even on locations where everything is supposed to be in order at the moment, it is likely that extremes of climate will result in lower crop yields.



Consequences of the rise in temperature for the Wadden coast

The warming up of the seawater and the temperature on land have major consequences for the ecosystem and agriculture of the Wadden coast. In particular, the shift of biorhythms and the reduced food supply pose a danger to the natural environment, both now and in the future. Agriculture is threatened above all by drought, flash floods and more protracted warm periods. The consequences for the infrastructure have not yet been mentioned. Heatwaves can cause crucial infrastructure, such as bridges and sluices, to expand and contract, which may affect the durability of these objects.

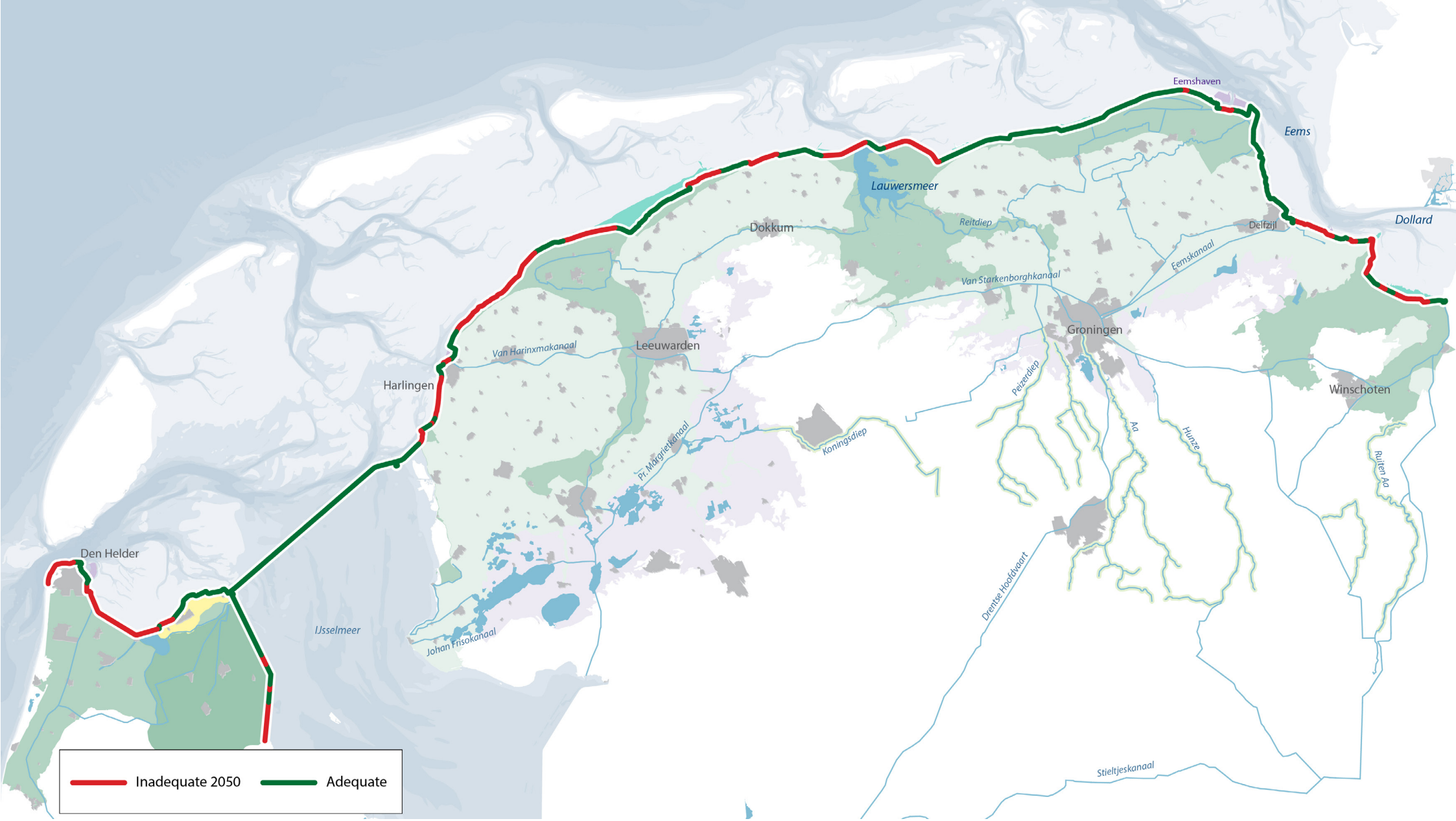


Sea level monitor 2018. F. Baart et al., Deltares, 2019

Trend rising sea level from 1890 = + 2 mm per annum

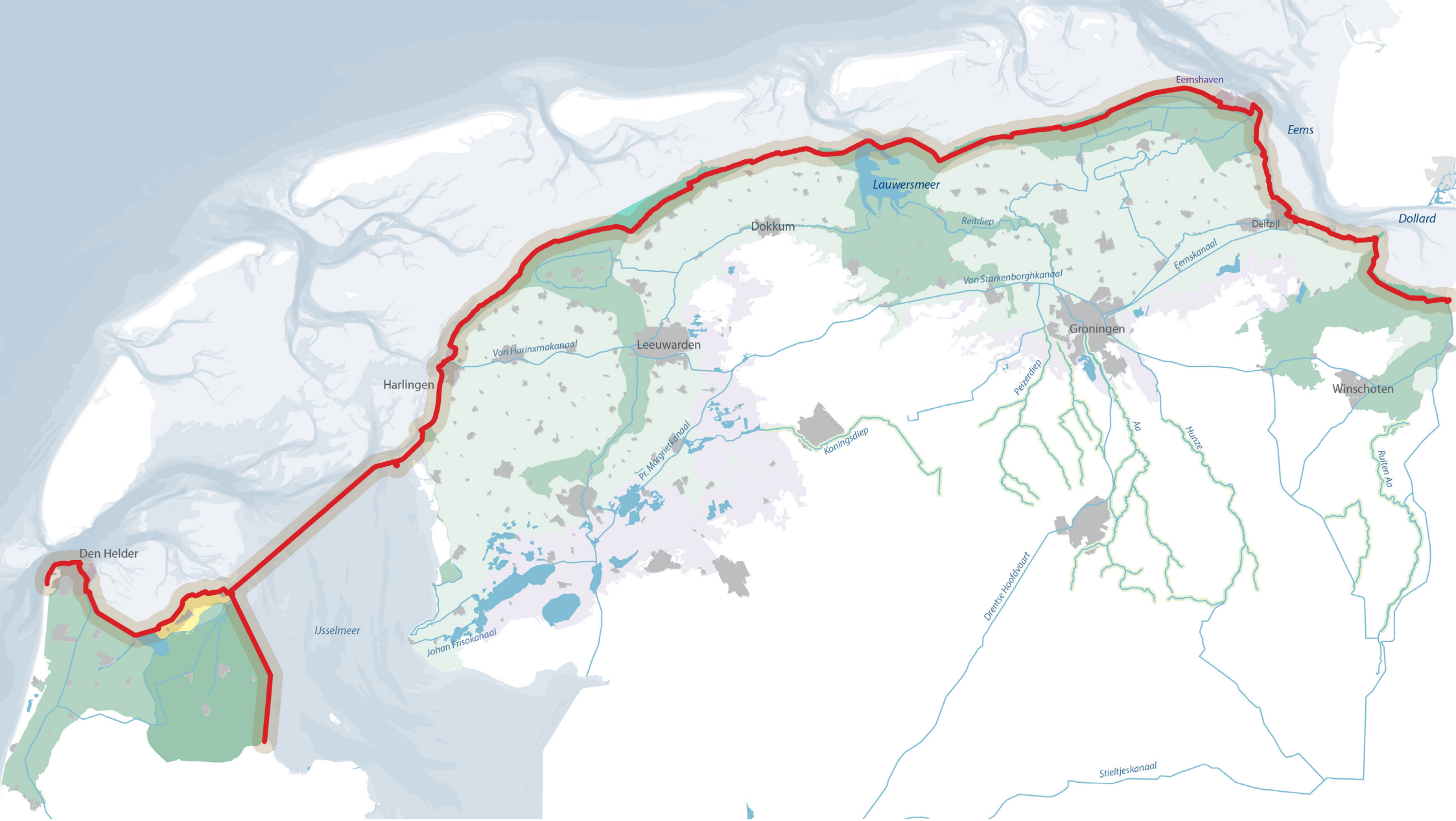
Effect 2 – The sea level rises, barely noticeable in the Wadden Sea until 2050

Since 1890 the sea level has been rising by about 2 mm a year. There is no evidence of a major change to this picture, except the disturbance caused by storms, for example. Besides the rising sea level, the Wadden Sea is also affected by land subsidence leading to sedimentation. The sedimentation of the Wadden Sea has proceeded at a much faster rate since the construction of the Afsluitdijk in 1932, and this process is expected to outpace the rate of the rise of the sea level until 2050. So for the time being the Wadden Sea will become drier unless sufficient refills of sand are done to maintain the sandbanks. (Baart et al., 2019). However, the sea level may rise at a faster rate after 2050 and it is possible that the western Wadden Sea will slowly drown (Haasnoot et al., 2018).



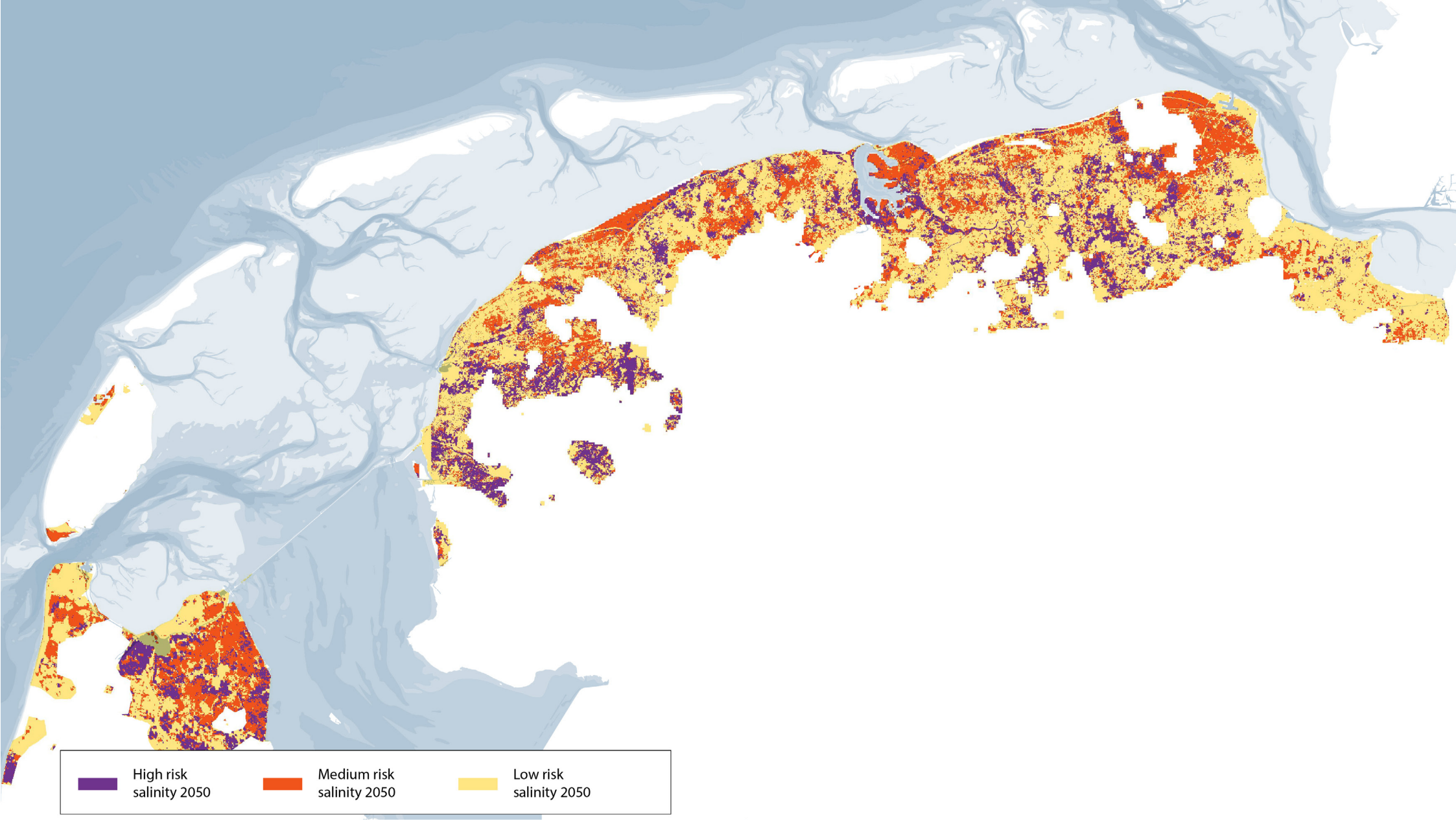
Already a major coastal safety task

Dykes protect the land from the sea on the Wadden coast. An inspection of their quality was recently held with a view to the expected rise in the sea level until 2050. Large sections of the dikes have been declared inadequate and in need of reinforcement (POV Waddenzeedijken, 2016; HHNK, 2016). Plans have already been made for a large part of this, while part is under development. For the Wadden Sea dikes in Friesland and Groningen, the Project Overstijgende Verkenning (POV) has resulted in innovative dike concepts to ensure that reinforcements are carried out less expensively, faster and with greater integration. Tests are being conducted with such concepts as double, rich and surge-resistant dikes.



With a rise in the sea level of + 1.5 m, it is highly unlikely that all the dikes meet the requirements

The explorations that have been conducted so far consider the rise in sea level until 2050. However, as mentioned above, the rate of that rise in the Wadden Sea will accelerate from 2050 onwards (Haasnoot et al., 2018). This has serious implications for the dikes until 2100. With a rise in the sea level of 1.5 m, an average scenario for 2100, it is likely that all the dikes will have to be reinforced again. The expense and the space they will take up increase exponentially. Current solutions for water security could already take further reinforcement into account, and it would be good to adopt no-regret measures as far as possible now that can be expanded or easily adapted to the situation in fifty years' time



Increased risk of salination along the coast

One effect of the rise in sea level along the Wadden coast is that the land is becoming more and more brackish. This is caused not only by increasing saline seepage from the sea, but also to changes in the supply of freshwater and increased evaporation. The increasingly saline surface is already a problem on several locations at the level of individual plots of land and it is expected to continue to rise in the future. Unless action is taken, by 2050 it will no longer be possible to grow certain (lucrative) crops on land at a high risk of becoming brackish. Moreover, with the accelerated rise in sea level after 2050, and thus more seawater pressure, the risk may increase exponentially. On the other hand, large tracts of the Wadden Sea coast will remain good freshwater farming land, at least until 2050 (Acacia Water, 2018).

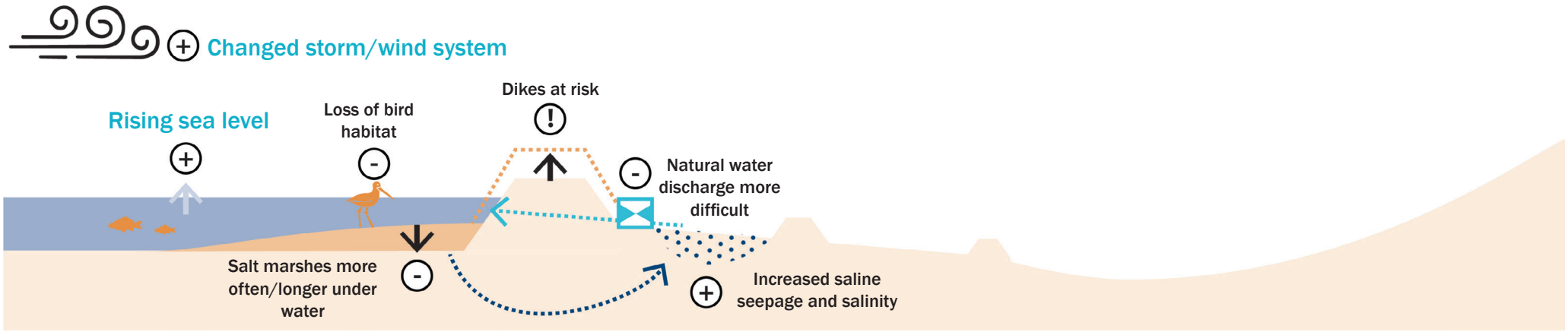
R.J. Cleveringssluizen

Varde Å
Sneum Å
Kongeå
Ribe Å
Resjby Å
Brøns Å
Brede Å
Vidå / Sønder Å
Alter Sielzug
Lecker Au
Arlau
Husumer Au
Tummlauerbucht
Eider
Nartstrom
Süderstrom / Südermiele
Miele
Barlter
Elbe
Medem
Oste
Benser Tief
Dornummer Tief
Neuharlinger tief
Weser
Ley/Norder Tief
Jade
Lauwers
Hunze
Fivel
Zuider Ee
Marne
Tjariet
Knockerster Tief
Middelzee
Reitdiep
Damsterdiep
Drentsche Aa
Zype
Eems
Tjamme
Westerwoldse Aa
Brone
Tjonger
Linde
Kromme Leek
IJssel/Rijn

It becomes more difficult to discharge water naturally into the sea and to restore historic links

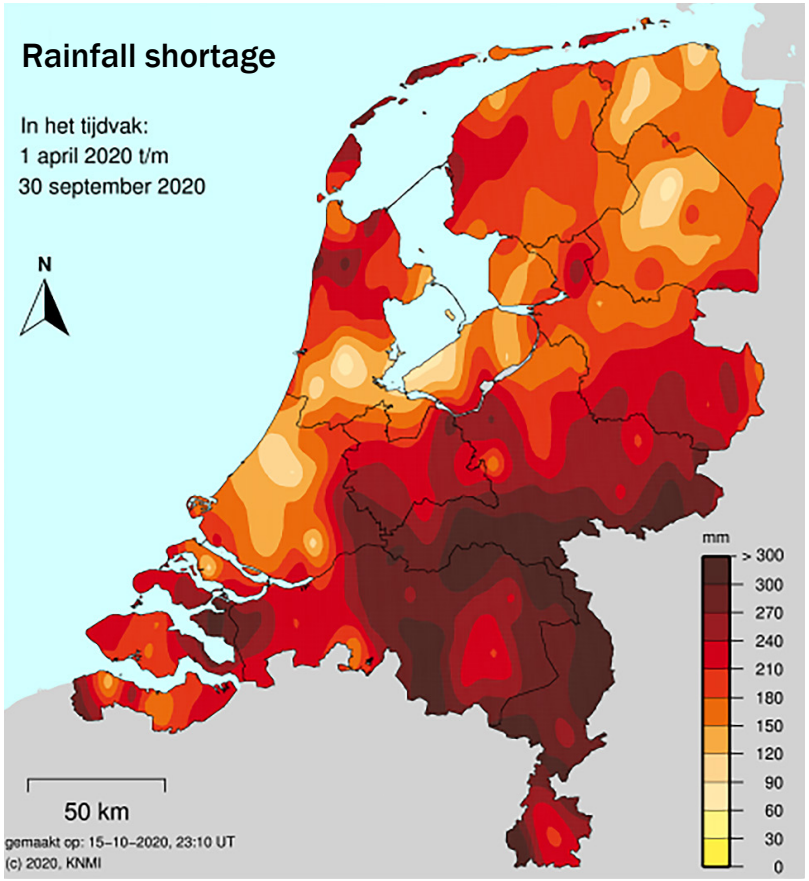
In the past many streams discharged into the Wadden Sea and inlets ran deep inland. Fish could migrate from upstream to the sea and villages and towns enjoyed an open connection with the sea. The Hunze, Fivel, Zype – all these streams have become cut off from the sea over the centuries. Villages and towns are further from the sea than ever because of land reclamation and polder expansion (Vos et al., 2018). Besides, as a result of later land rise by accretion, the coastal zone is now higher than inland, so that freshwater has to be pumped into the sea or discharged at low tide, as for example through the drainage sluices in the Lauwersmeer. The rising sea level increases the counter-pressure from the sea, rendering natural discharge even more difficult.

Every open connection with the brook and river systems is needed for a resilient nature in the Wadden. Sustainable drainage and more open connections both call for creative, systemic and possibly less technical solutions. As a side-effect, fish passages and saltwater/freshwater gradients will become increasingly difficult to achieve.

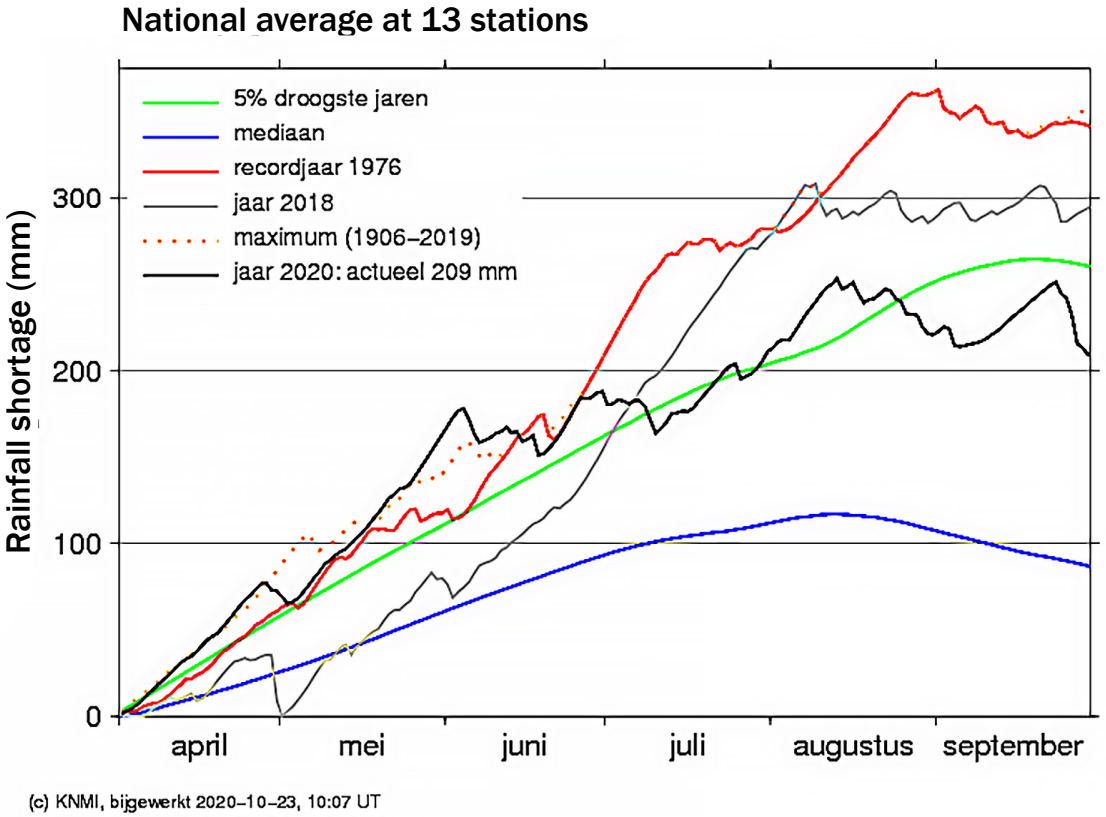


The consequences of the rise in the sea level for the Wadden coast

To sum up, the rise in the sea level and a changing storm and wind system lead to increasing pressure on the defence of the coast. It is still manageable at the moment, but in the long term this pressure and thus the scale of the measures required will increase exponentially. In the longer term sandbanks and salt marshes may be flooded more often and for longer periods, entailing a considerable reduction in the size of these special habitats. The risk of salinity is increasing as a result of the rising sea level and that process will probably intensify after 2050. Finally, it will become more difficult to discharge water naturally into the current border strip between sea and inland, whereas open connections with the sea offer the most options, as well as a concomitant increase in coastal security. There is as yet not enough support for this line of thought.



Rainfall shortage April-September 2020, KNMI



Rainfall shortage NL in the growing season, KNMI

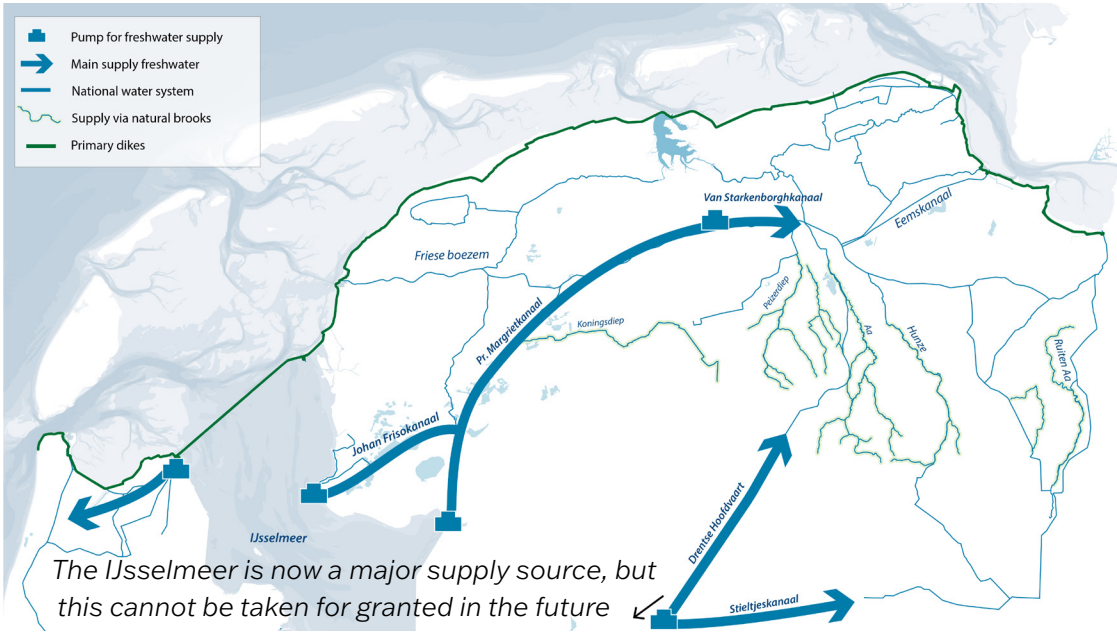
Effect 3 – Bigger fluctuations in the freshwater supply: greater frequency of extreme drought and heavier flash floods

For the last three summers the shortage of rainfall has been much larger than average (Droogtemonitor KNMI, 2020). This is due above all to prolonged drought in combination with higher evaporation because of the rise in temperature. This dry summer trend is expected to continue in the future. This increases the demand for water for all kinds of purposes in the summer, all the more as, without structural adjustment of the regional water system, the water there will no longer be filled naturally from the higher land.

On average, the Netherlands still has a precipitation surplus over the year, and this situation is expected to continue in the future. This means wetter winters and downpours in the summer.

Dehydration of wetlands

Drought causes dust on arable land

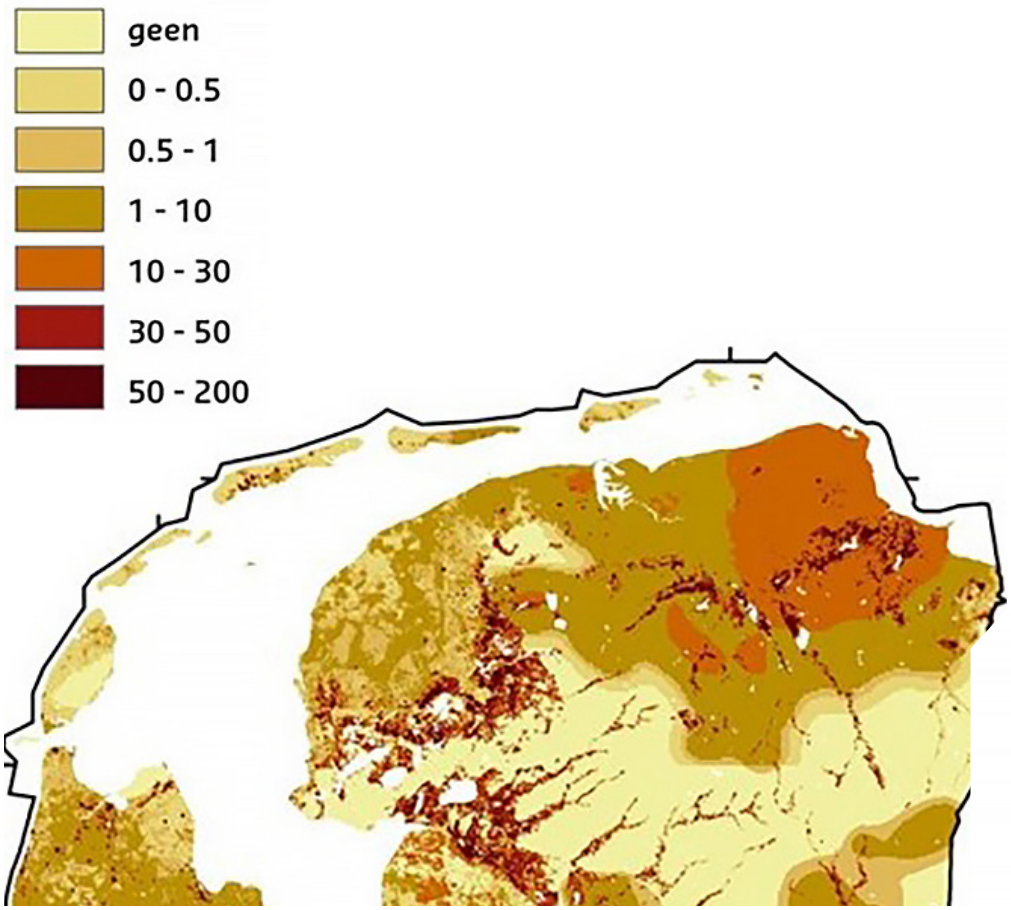


The IJsselmeer is now a major supply source, but this cannot be taken for granted in the future

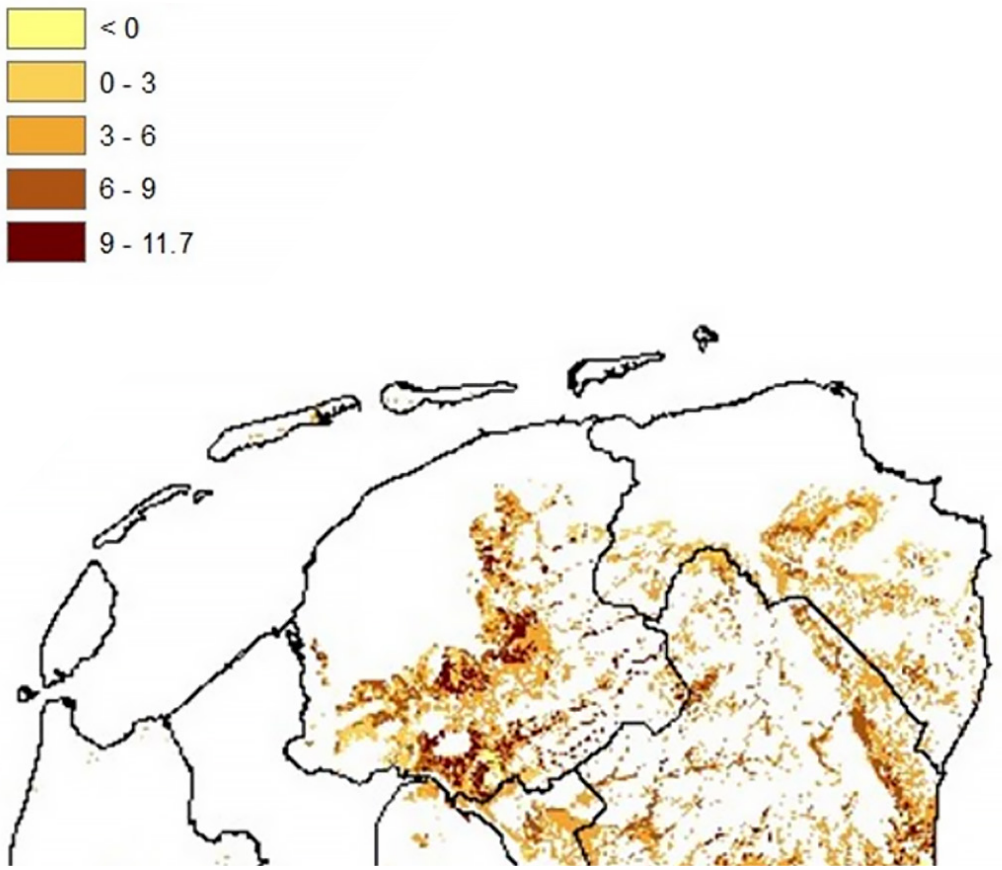
Present system is geared to rapid drainage with major consequences for the environment and agriculture

The present water system is a technically sophisticated one in which the groundwater level is precisely adjusted to the agricultural use. During rainy periods we keep the groundwater level artificially low and discharge excess water in the sea; in the summer water is supplied from the IJsselmeer. This system has been showing signs of strain in the last few years: there was a shortage of freshwater, conservation areas dried up, and a ban on sprinklers was introduced. Arable land turned to dust, crop yields fell and the soil became brackish. The supply from the IJsselmeer is not an unlimited supply of freshwater that can continue to be used for all kinds of purposes in the future. Nevertheless, from a European perspective this is still a relatively wet region with good agricultural land. If we want to keep the best agricultural land, big and small interventions are called for to retain the water better.

Expected subsidence
2002-2050 in cm

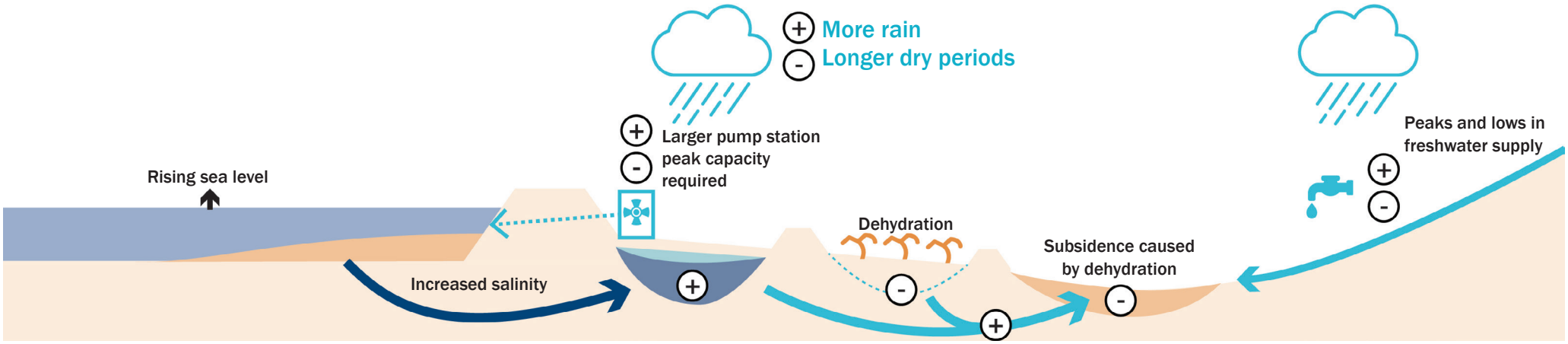


Carbon emission from peat in
tonnes C per ha per year



Artificially keeping the groundwater level low leads to subsidence and higher CO2 emissions in the peatlands

A lot of water is extracted from the peatlands in Friesland and Groningen for intensive dairy farming, and from a relatively deep level compared with fens in the rest of the country. This leads to peat oxidation, resulting in subsidence and the release of CO2, For the Netherlands as a whole, fen oxidation contributes 5% of the national CO2 emissions each year, the equivalent to the annual emissions from two million cars. If we continue with the present system of water extraction, the maintenance costs will rise for water boards and road managements. Farming will run up against restrictions, with lower profits and less bright prospects for the future. In addition, the extraction of water from deep levels has negative effects on wetlands and biodiversity (Van den Born et al., 2016).

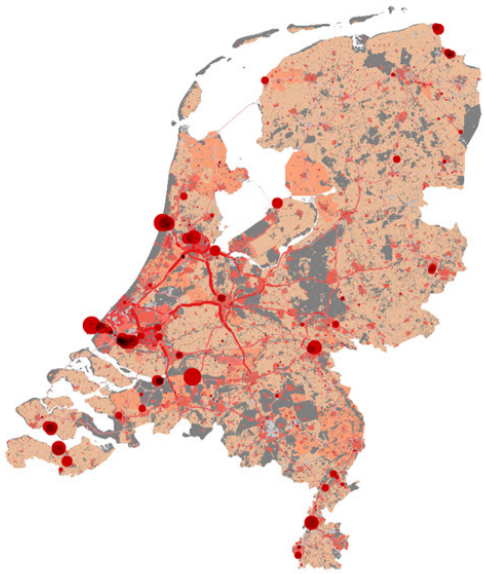


The consequences of greater freshwater fluctuations for the Wadden coast

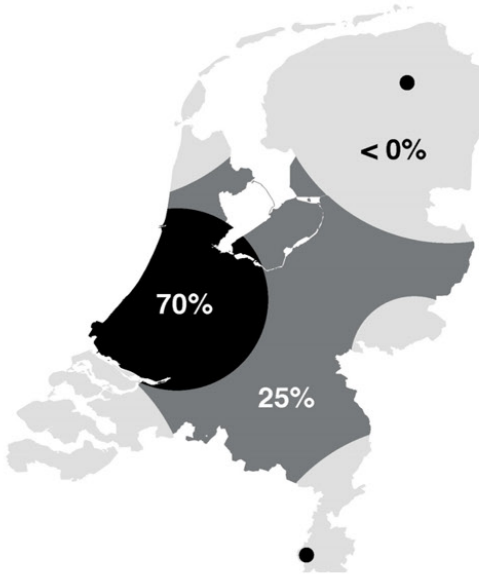
When all this is taken into account, the changing precipitation system calls for changes in the water system of the Wadden coast. Drying up leads to subsidence and crop damage; heavy downpours and prolonged rainy periods can cause local flooding. If we stick to the present water system, we will have to deploy bigger and bigger pumping stations to remove the excess water. In addition, it will still be necessary to pump freshwater from the IJsselmeer, among other things to apply pressure to counteract the increasing salinity caused by the rise in sea level, while the supply of water from the IJsselmeer will come increasingly under pressure.

3. Course for the 21st century

A climate adaptation action perspective



Achieving Paris targets
Energy transition



1 million homes
Housing shortage

Dry feet & cool head
Climate adaptation

Sustainable agriculture
Agricultural transition

Choose quality and the long term

The Netherlands is confronted by major challenges: not only climate adaptation, but also the transition to sustainable agriculture, compliance with the Paris agreements, and the housing shortage are hot issues. Panorama Nederland (CRa, 2018) can serve as an example of how to approach climate adaptation on the Wadden coast: 'We must […] take advantage of transitions as an opportunity to make the Netherlands richer, more cohesive and cleaner. We do not have the space, the money nor the time to address issues independently of one another'. We must therefore be 'steward and merchant at the same time, and ensure the maximal social benefit from the euros we invest'.

The tasks

1. Ensure a safe coastal landscape
2. Maximal freshwater use
3. Act against decline in biodiversity

Linking opportunities

Strengthen landscape identity, e.g.

- Make cultural history visible

Resilient ecosystem as basis for agriculture, nature and healthy surroundings, e.g.

- New sustainable agriculture opportunities

Strengthen regional economy, e.g.

- New recreation and tourism opportunities
- Promote agricultural and knowledge economy

Mitigate climate change

- Reduce and fix CO2 emissions
- Actively reduce temperature

We see three major climate adaptation issues

Looking towards the future, we see three major climate adaptation issues for the Wadden coast: 1) ensure a safe coastal landscape, 2) maximal utilisation of freshwater, and 3) countering the decline of biodiversity. These challenges ensue from the effects of climate change as described in the previous section. By choosing the right measures, we can create an added value and at the same time satisfy other ambitions to make the region richer and more robust. For instance, we can strengthen the landscape identity by making its cultural history visible, explore new possibilities for (circular) agriculture, recreation and tourism, as well as more mitigating targets such as the reduction and fixing of CO2 emissions.

Plan	Andere oplossingsrichtingen waar een plan bij past
1.1.0.1. De mooiste en Veiligste Delta 2010-2100	Beschermen (open), meebewegen, zeewaarts
1.1.0.2. Naar zee! (scenario Holland op zijn Langst)	Beschermen (open), meebewegen, zeewaarts
1.1.0.6 Nova Delta	Beschermen (open), zeewaarts
1.1.0.7 Plan New Netherlands	Beschermen (open), meebewegen
1.1.1.08. Eiland voor één seizoen	Beschermen (open)
1.1.1.12 Plan Emergo	Beschermen (open)
1.2.1.0. Zandmotor Delfland	Beschermen (open)
1.2.1.3. Segmentatie Hollandse Kust	Beschermen (open)
1.3.2.2. Plan Waterlely	Meebewegen
1.3.2.3. Schetsplan Waterlely	-

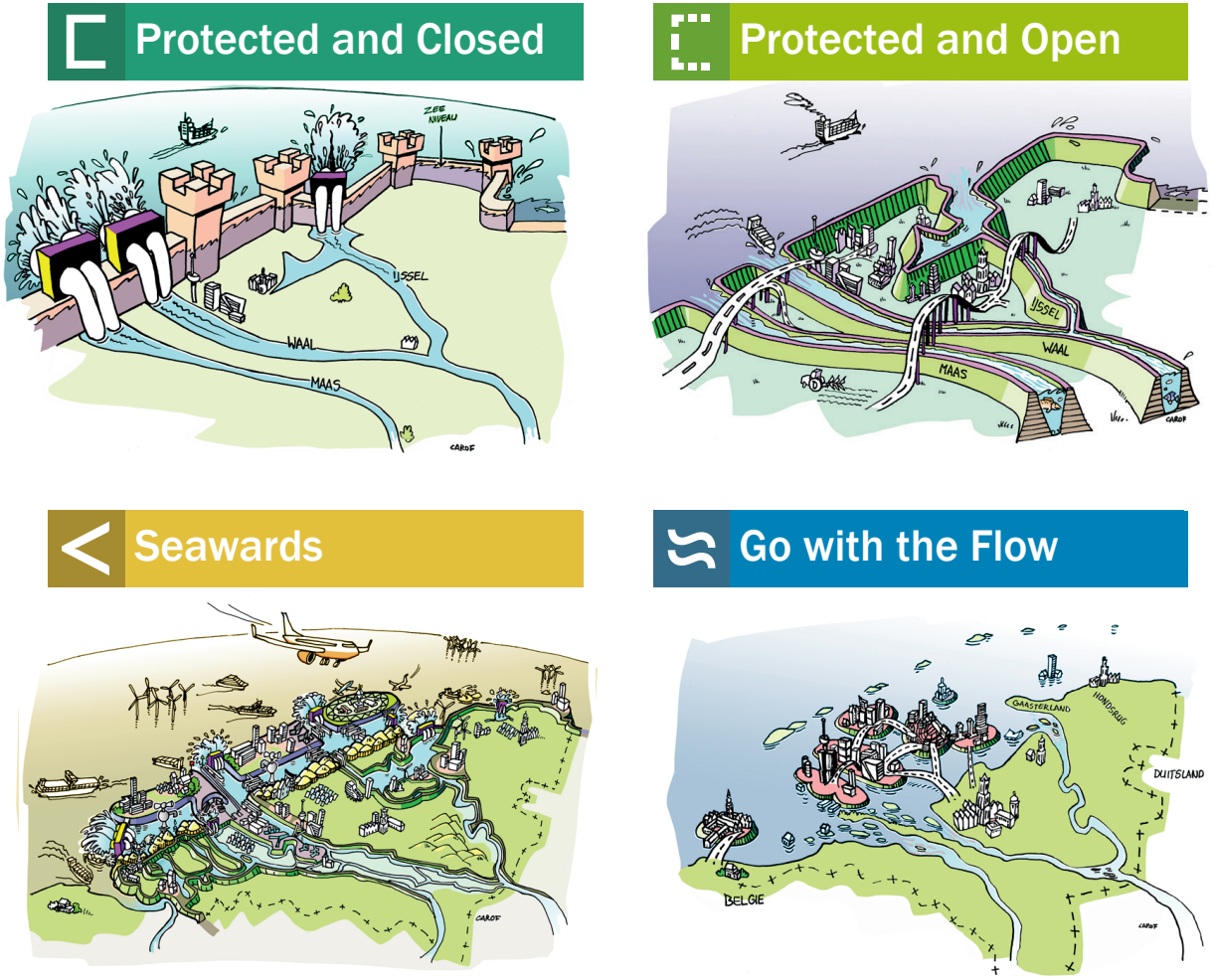
Plans adaptation to rising sea level, Haasnoot, M. 2019

There are 100+ adaptation possibilities, choose the solutions that serve more than one purpose

The Deltares website contains a list of 185 adaptation plans for the rising sea level alone (Haasnoot, 2019). This number is an indication not only of the quantity of different plans in existence, but also of the impossibility of implementing them all. Choices will have to be made: which solutions serve the greatest number of purposes? In other words, how do you maximise the social benefits? Take traditional dike reinforcement, consisting of a soil embankment. This may serve one purpose - making the coast safe - whereas creating a salt marsh instead of just a higher dike might serve the same purpose, but it also fixes CO2 and creates potential new agricultural land and countryside.

Task 1. Ensure a safe coastal landscape

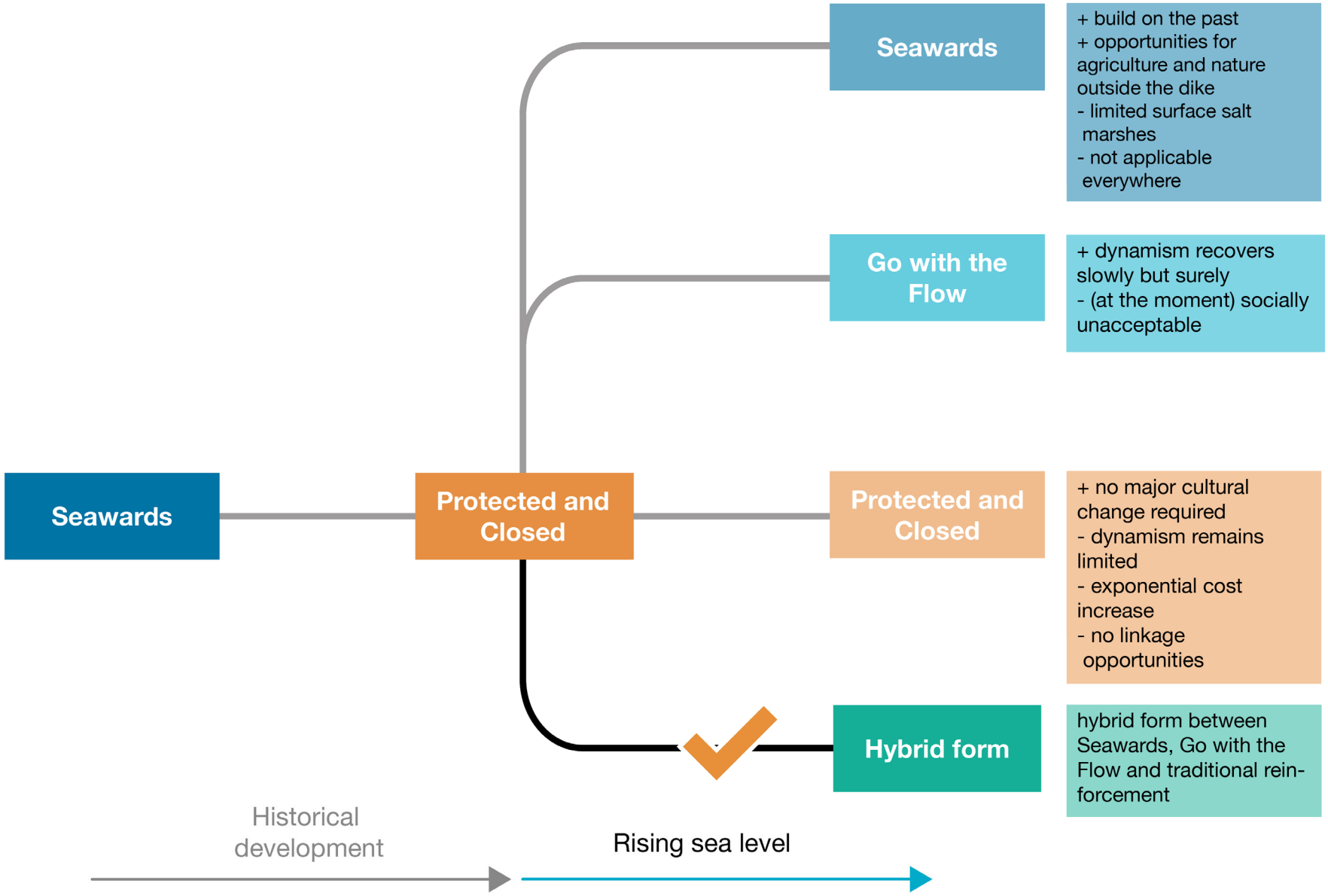
Defend the hinterland with sea-restraining landscapes that are safe, ecologically interesting and offer economic possibilities



Carof beeldleveranciers in: Strategieën voor adaptatie aan hoge en versnelde zeespiegelstijging, Deltares, 2019

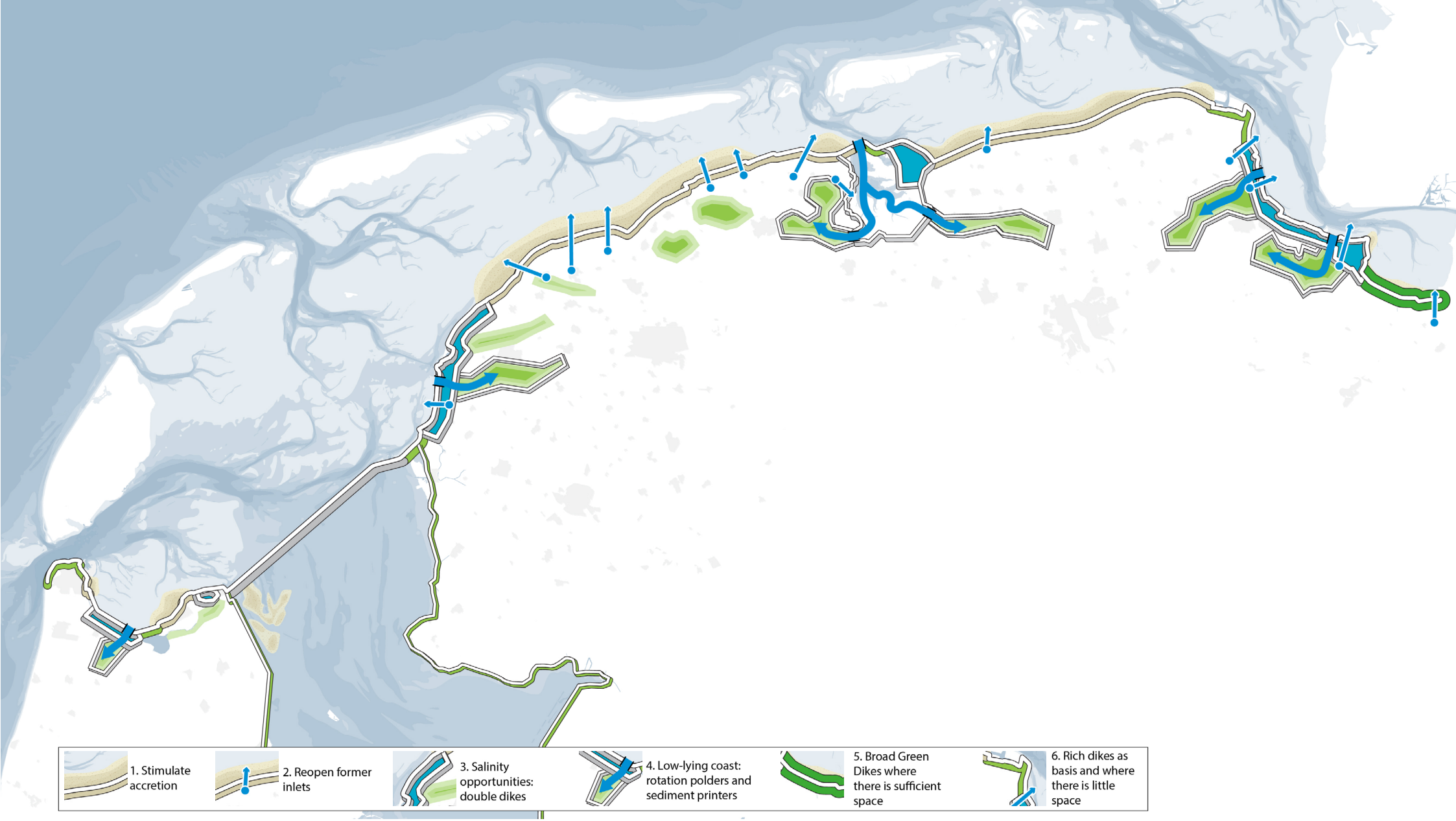
Scenarios for the coast of the Netherlands

In 2018 Deltares published a report on 'Strategies for adaptation to a high and accelerated rise in the sea level' (Haasnoot et al., 2018). It contains four guidelines for adaptation to the rising sea level: Go with the Flow, Open and Protected, Closed and Protected, and Seawards. They can also be combined or take place in succession. You can see this, for example, in the Northern Netherlands, where the strategy down to 1900 was Seawards before gradually shifting towards Closed and Protected. It is worthwhile to explore the consequences of these strategies for the Wadden coast and to choose measures that are a good idea in all acceptable scenarios.



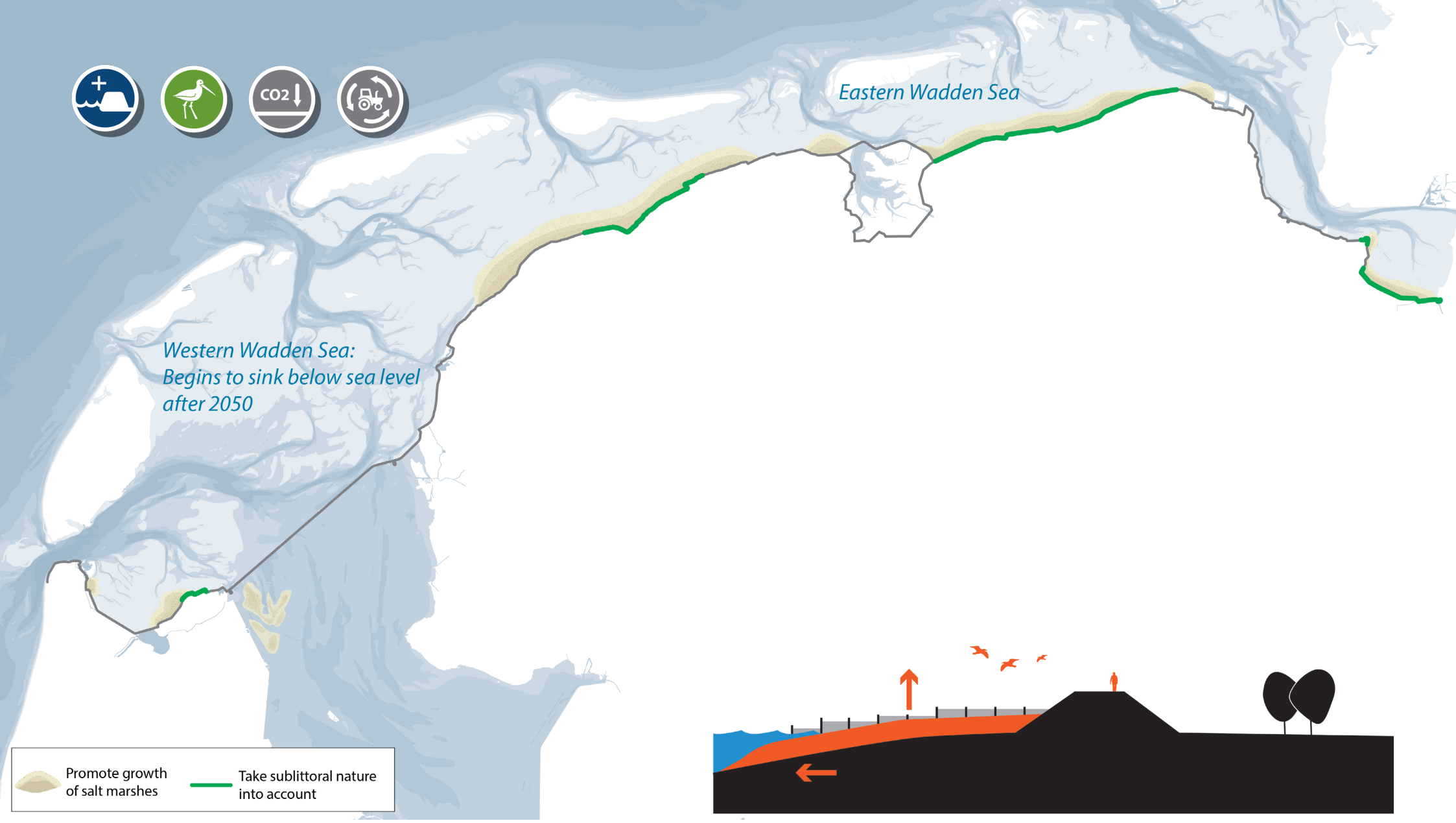
Choosing a course with the most opportunities for linkage

In the past the course in the Wadden region was Seawards, with the creation of polders and the control of inlets. Today the course is primarily Closed and Protected, with a fairly narrow, hard coastline. The disadvantages of this option are that the typical dynamism of the Wadden is restricted, and that the costs of traditional dike reinforcement become exorbitant at a certain moment. Choosing now to Go with the Flow completely is unnecessary for the next fifty years and socially unacceptable: there is excellent agricultural land at many points behind the dike and tens of thousands of people live there. It is more logical at the moment to opt for a combination of Go with the Flow and Seawards where possible, and Closed and Protected where necessary. This is a hybrid form as the specific location determines the course to be followed.



Course: a varied coast, therefore varied solutions

Given the varied nature of the Wadden coast, it is logical to opt for a variety of solutions, based on the premise: from a narrow, monofunctional coastline to sea-restraining landscapes that are ecologically interesting and offer economic possibilities. This means not only widening the salt marshes where possible (Seawards), but also restoring former connections with the sea for ecological links and recreation (Go with the Flow). In addition, in the shorter term Go with the Flow can be chosen in the form of double dikes and polder rotation to allow the coast to silt up again naturally in order to secure the safety of the coast in the long term. The Broad Green Dike is an example of a robust barrier made of local material that can be rapidly adjusted in the event of an accelerated rate of the rise in sea level. Rich dikes are the basis for the remaining coastal security (POV Waddenzeedijken, 2018).



1. Salt marshes coast: seize the opportunities to grow now

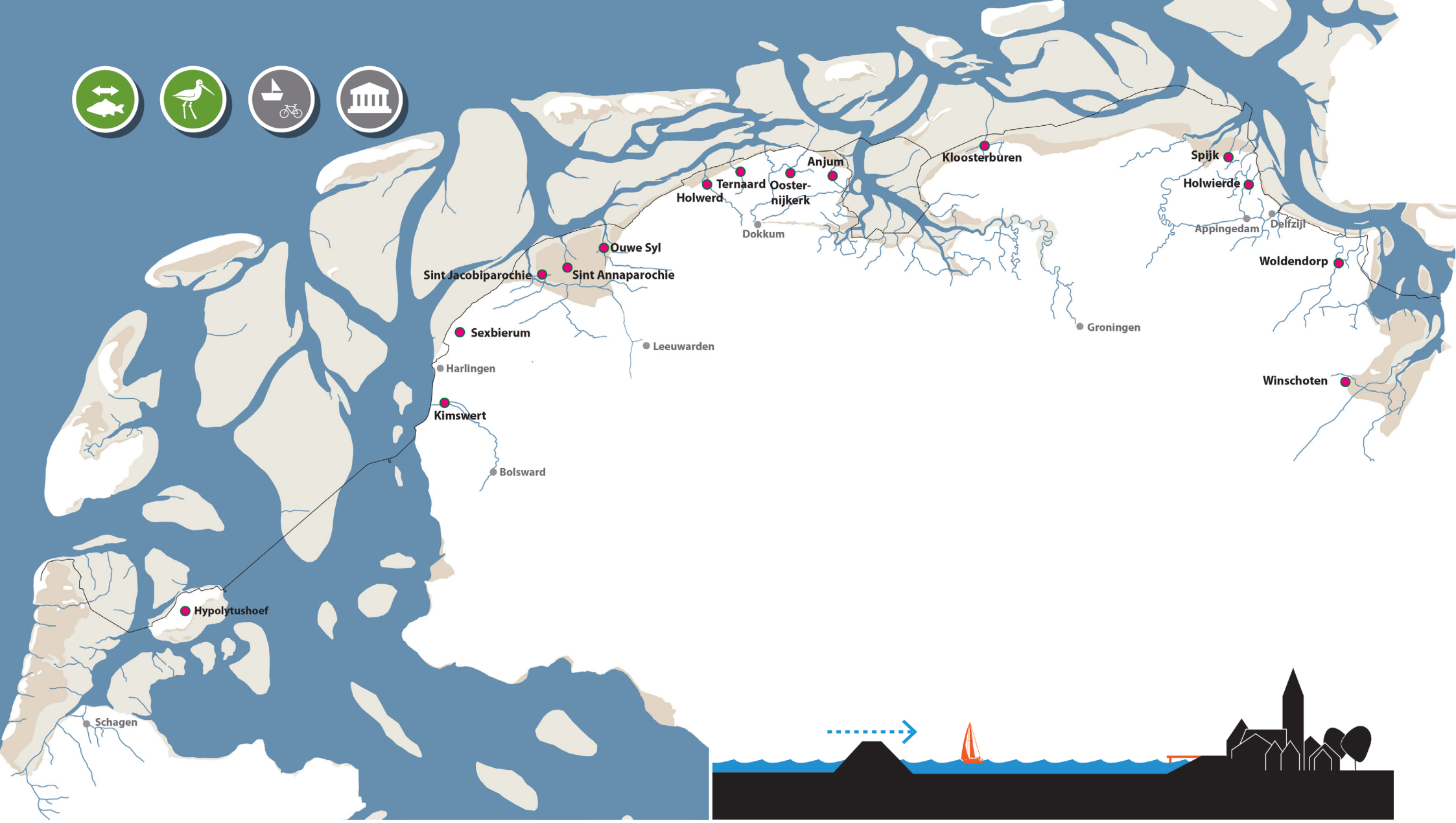
Salt marshes offer enormous opportunities for coastal reinforcement, as well as for the fixing of CO2. They have been shown to have a strong wave-braking capacity. It is the type of land use that fixes the most CO2 in the Netherlands (Teunis, 2018). This is five to ten times as much as a forest. There will be a surplus sedimentation in the whole of the Dutch Wadden Sea until 2050. This opportunity can be used to stimulate the growth of salt marshes, considerably enlarge the salt marshes habitat, and thereby improve water safety and expand the number of catchment points for high levels of water in the future. It may also afford opportunities for agriculture. However, it will be necessary to examine whether this is in conflict with the important natural values that are present in the transition between salt marshes and sea (Van Loon-Steensma et al., 2012).

Moordgat, Fryslân Butendyks

Delfzijl, Marconi Buitendijks, here under construction, 2020

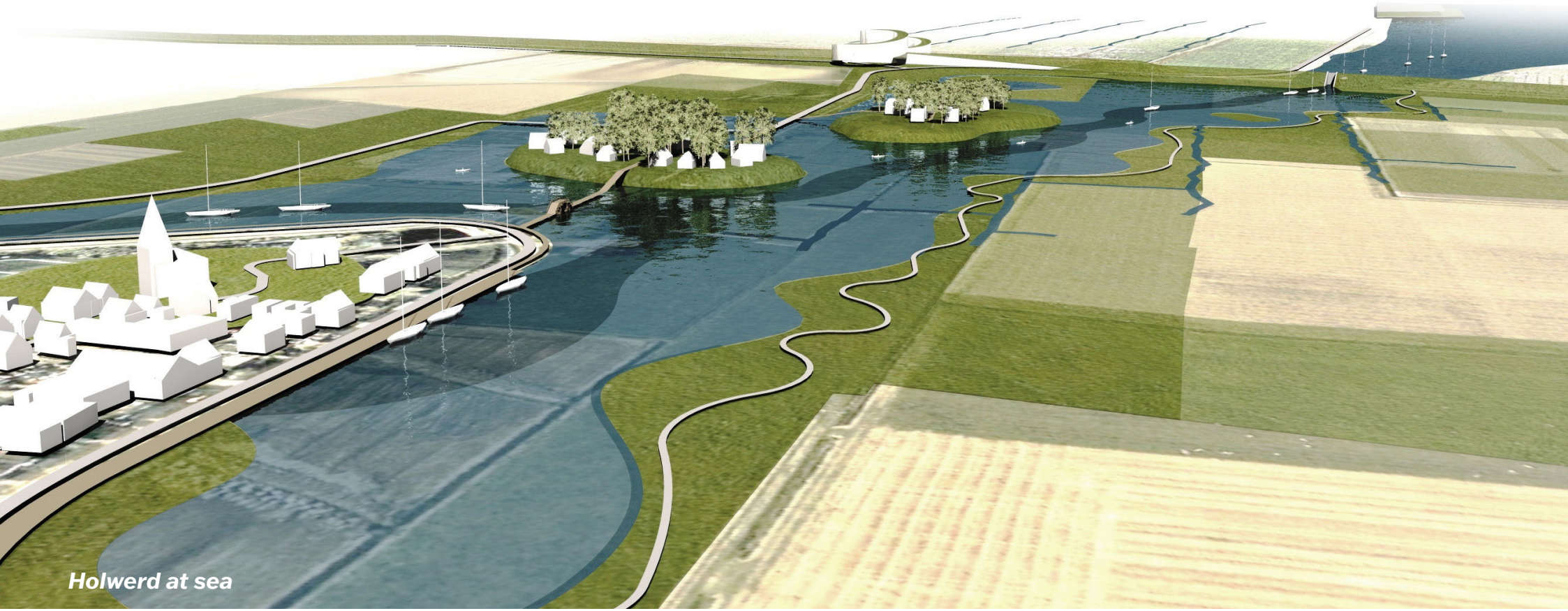
It is already being done, but there are opportunities for its large-scale application

Experiments have been carried out in the last few years with the use of salt marshesfor CO2 fixing on the tidal marshes on the coast of Friesland and the Uithuizerwad. Thickets have been used as dams here to encourage the formation of salt marshes. It is calculated that a strip of salt marshes 5 km long and 800 m wide can fix around 4,050 tonnes of CO2 a year (Teunis, 2018), and can silt up 7 cm in ten years (It Fryske Gea, 2014). This is thus a great opportunity for linking salt marshes expansion with the defence of the coast and climate targets. Recreation can also be accommodated here provided it is properly harmonised with the natural values. As part of the Marconi project, in 2020 a new strip of salt marshes was created beside the Eems-Dollard in Delfzijl and designed with a footpath through the natural environment for visitors.



2. Strengthening landscape identity and biodiversity by restoring former connections with the sea

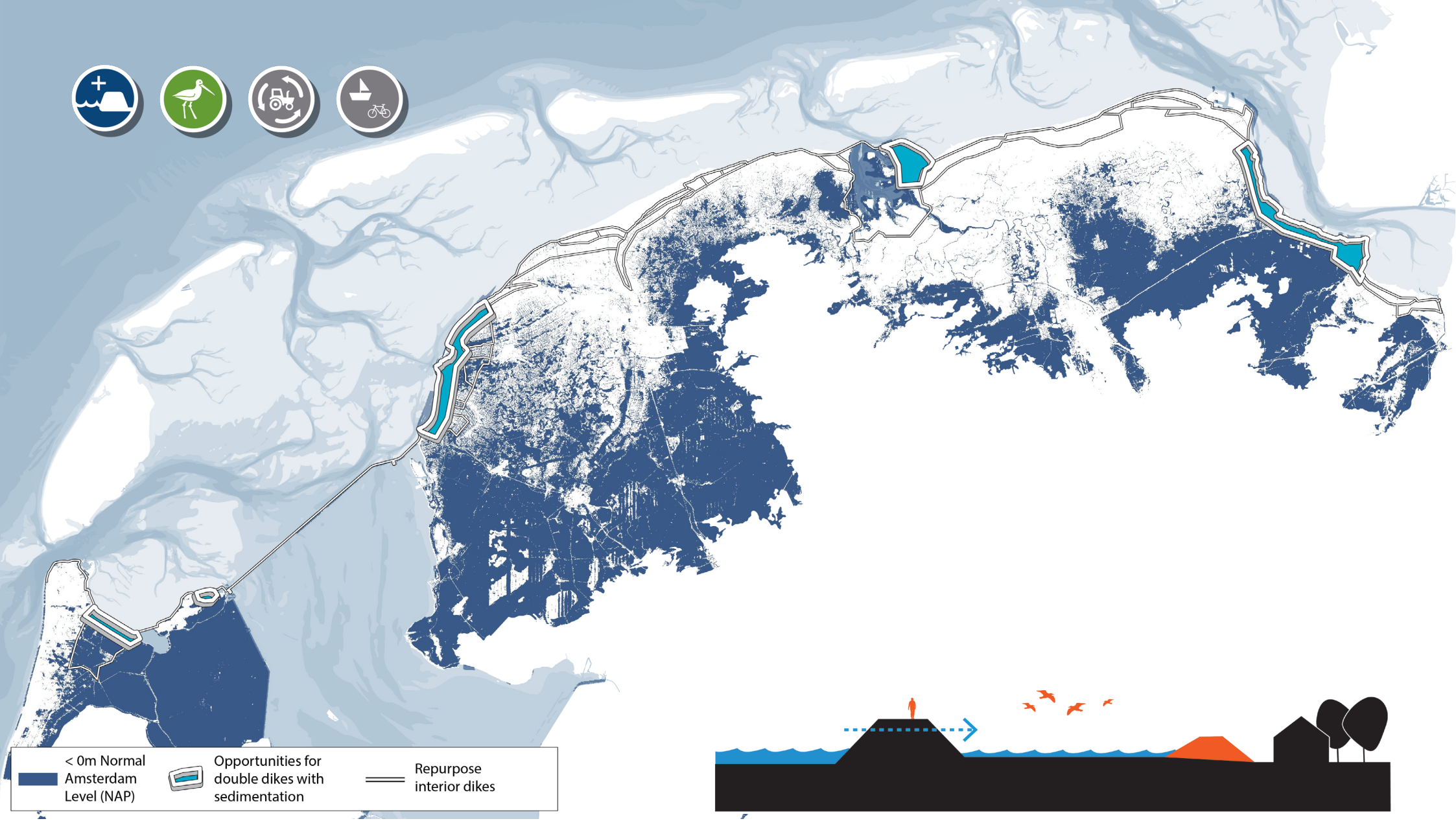
A brief glance at the palaeographic map of the Netherlands around 1500 shows that the sea advanced much further inland in the past, and that towns and villages were on the coast and were flooded from time to time. The erection of dikes and land reclamation have gradually cut these former coastal locations off from contact with the sea. Fish can no longer migrate through open channels from the sea and are thus prevented from breeding in the upper reaches of inland creeks. Restoring the contact with the sea and the freshwater-saltwater gradients for fish offers a great opportunity to give the locations on the Wadden coast back their coastal identity. Furthermore, it promotes fish migration and offers opportunities for fish tourism, as in Jutland, Denmark. Still, it will be necessary to take a good look at the precise locations and to pay attention to the present height above sea level, the risk of becoming more saline locally, and the presence of enough counter-pressure from the freshwater.



Holwerd at sea

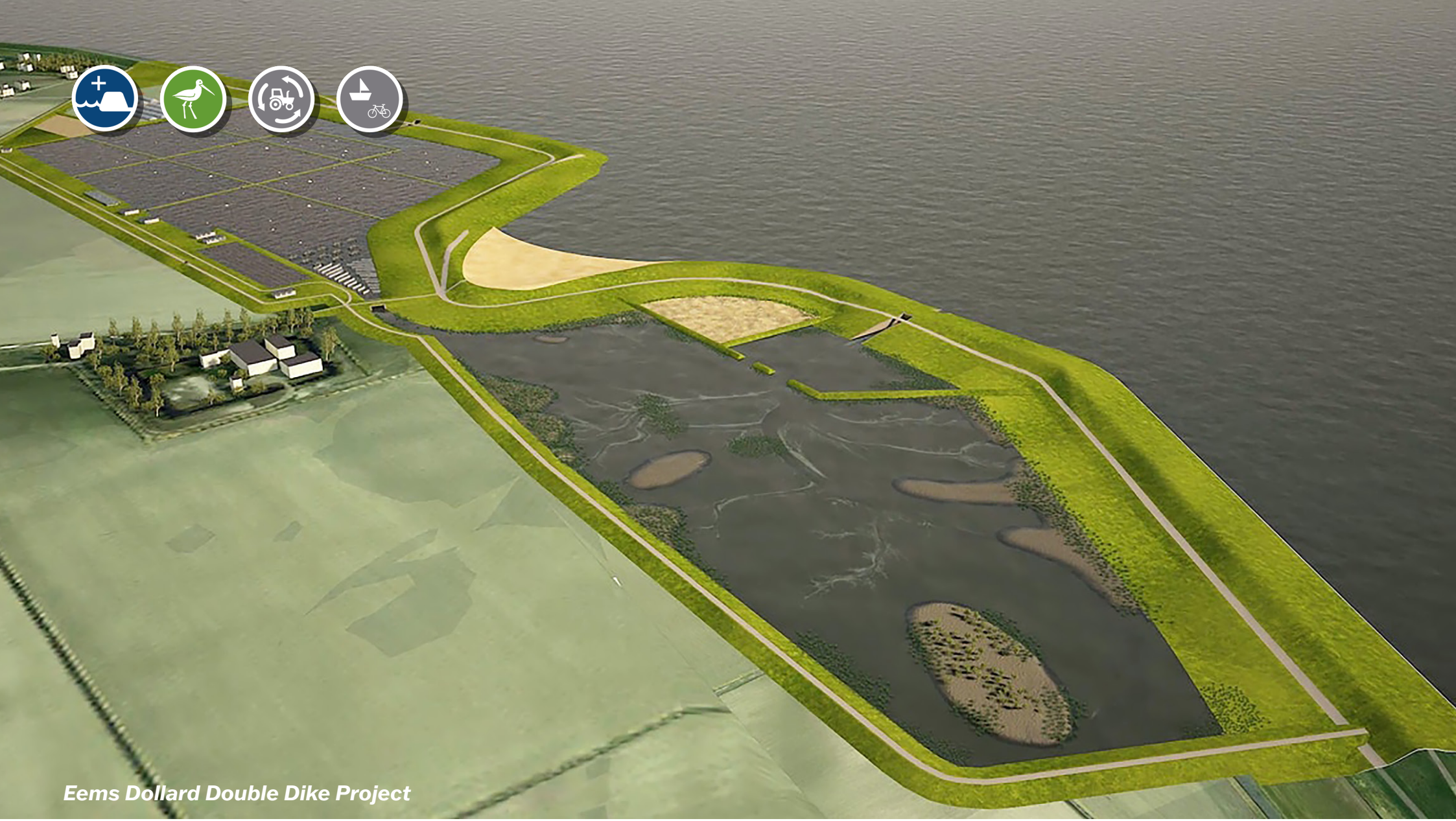
Strengthen landscape identity and biodiversity by restoring former contacts with the sea

A very well-known precedent for the restoration of a former connection with the sea is Holwerd aan zee. The coastal village is some 2 km from the spot where hordes of tourists take the ferry to Ameland, but hardly benefits from that at all at the moment. Initiatives have been taken to give the village its identity again by making a connection with the sea by water. This brings the water back to the village centre and recreational craft coming from the sea can moor in the village. The ecological quality of the coast can be promoted by this kind of smart combination of recreation, agriculture and attractive natural setting.



3. Opportunities for double dikes and rotation polders on low-lying land along the coast

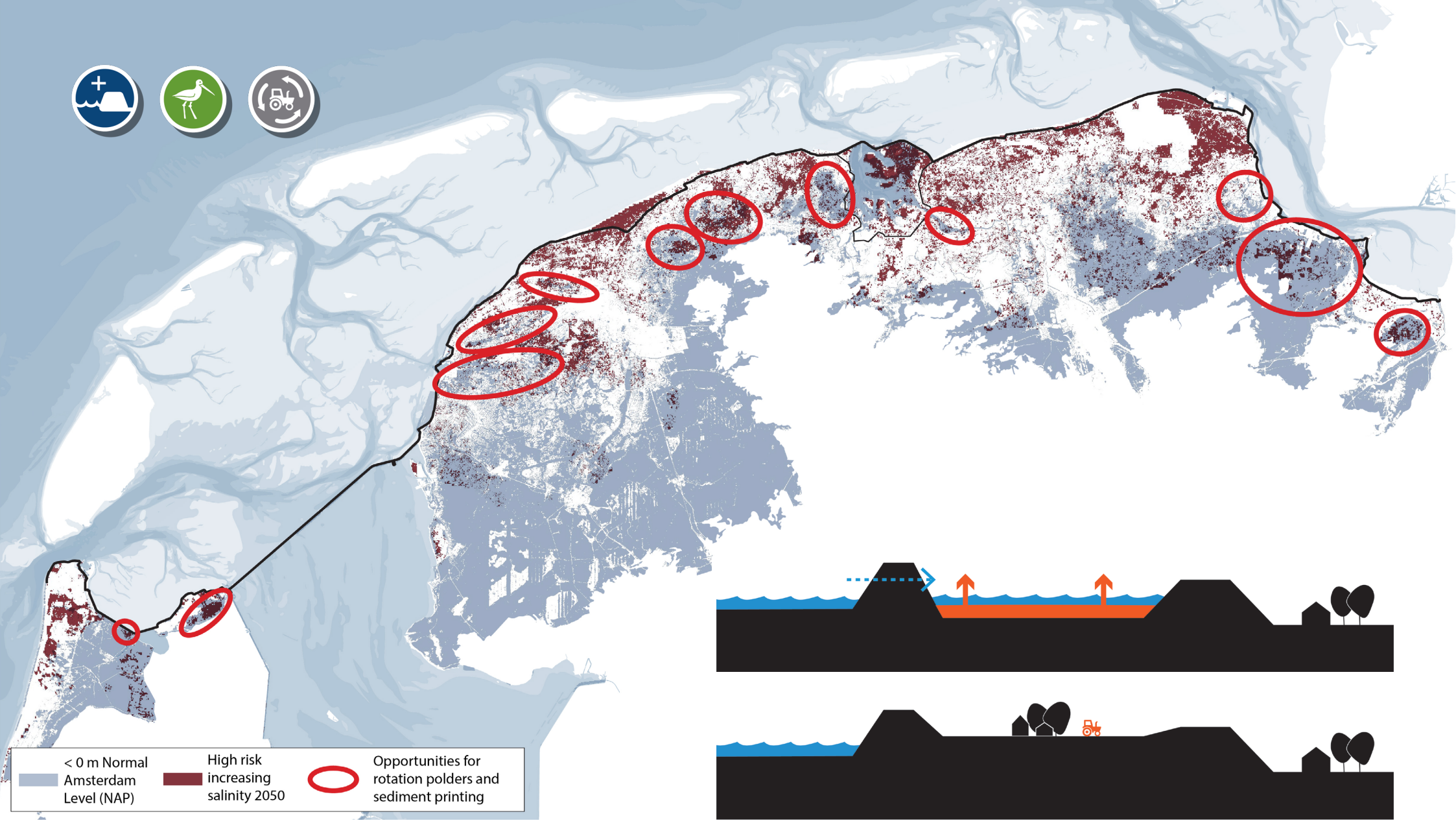
At a number of points on the Wadden coast there are tracts of low-lying, poor agricultural land that is not so sedimented as elsewhere on the coast. The construction of a high, heavy dike here would only put extra pressure on the soggy ground. If a lot of silting sedimentation is still happening here and there are clay dikes (Goedhart, 2017), there are opportunities to apply the double dike concept: a system in which not one but two dikes guarantee protection (POV Waddenzeedijken, 2017). The intermediate zone can be used as a catchment area for sedimentation, an aquaculture zone and/or a wetland to which seawater with sediment is admitted. In the course of time the zone silts up and offers good soil for agriculture. In the meantime, it thus offers opportunities for new natural zones along the Wadden coast and stimulates innovative aquaculture.



Eems Dollard Double Dike Project

Opportunities for double dikes and rotation polders on low-lying coastlands

A double dike pilot project has been launched along the coast between Eemshaven and Delfzijl to investigate how the system of sediment catchment, aquaculture and wetlands works. It is an interesting example of a sea-restraining coastal landscape that we hope can be applied on more locations. The advantages of a double dike in combination with rotation polders are: the silt catchment reduces the amount of silt in the Eems-Dollard, provides better agricultural land and a new freshwater bubble, and counteracts increasing salinity. It also offers a robust water management with fewer fixed water level areas, making it easier for water boards to manage. In the meantime coalitions are being formed to apply this idea on a large scale in the region.



4. Rotation polders and 'sediment printing' as an opportunity to raise large contiguous areas

Silt sedimentation has for centuries been a formative force in shaping the landscapes of the Wadden coast. LAMA (2019) sees this application of sediment as an opportunity to raise areas that suffer greatly from silting up or their low location. It makes it possible to compensate the subsidence that has taken place here and to improve the structure of its soil. There is more than one way to raise land with sediment. It can be left to nature with inlets (this can be done in large contiguous low-lying areas on the coast) and opportunities for the growth of (temporary) natural zones. Another method is with 'sediment printers' (further inland), or the two methods can be combined. Afterwards (some of) the land can be utilised as agricultural land again.

Rotation polders, LAMA Landscape Manifesto

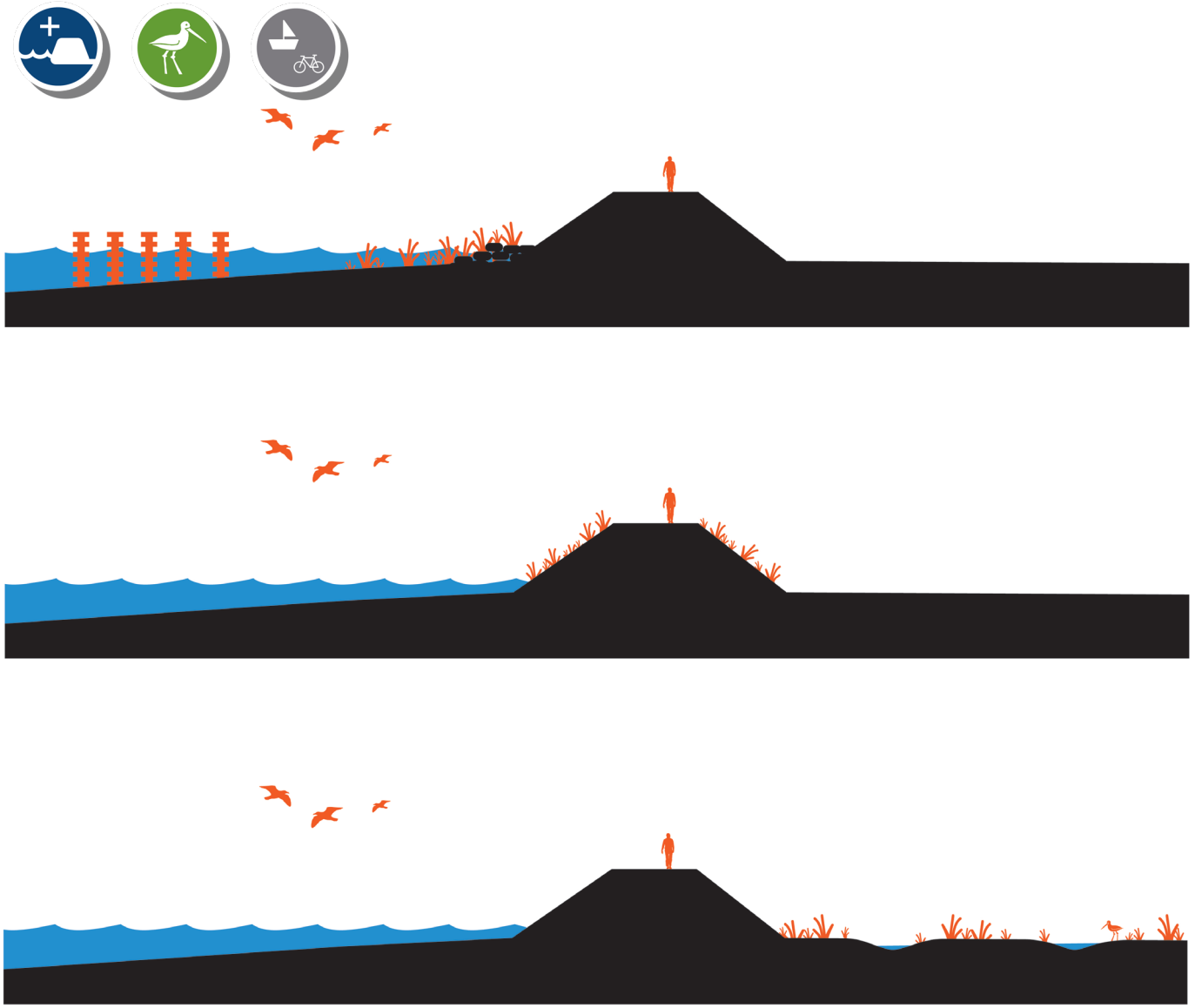
Rotation polders and ‘sediment printers’ as an opportunity to raise large contiguous areas

In ‘Sediment, the Grey Gold’, LAMA (2019) explains how rotation polders and sediment printing could work. Low-lying polders on the coast can first be prepared for flooding by constructing dikes on higher ground. The next step is to admit the seawater and allow the sediment to settle (estimate: 1.66 m in 10 years), before covering it with a layer of sediment with a spreader or a printer. A further advantage of polder rotation is that it creates a natural environment of (temporary) extra tidal marshes and considerably softens the saltwater-freshwater gradient again. A number of strategies are possible, involving a greater or lesser degree of state involvement.

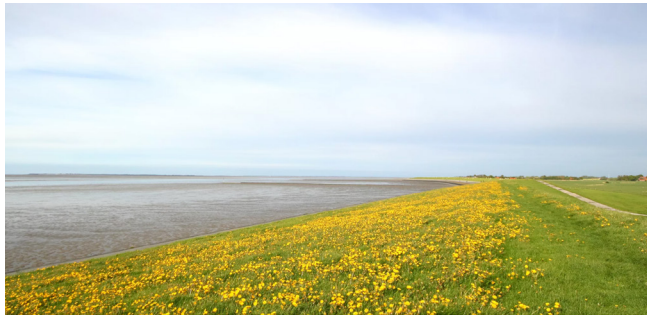
Pilot project Brede Groene Dijk Eems-Dollard

5. Broad green dikes as an adaptive solution where there is sufficient space

A good example of an adaptive solution is the Broad Green Dike, a clay dike that can be rapidly adjusted in the event of an accelerated rate of the rise in sea level. Allowing local material (sediment from the Eems-Dollard) to harden as clay provides material to broaden the dike considerably with a gently sloping embankment on the side facing the sea. This reduces the energy of battering waves. In combination with an avocet lake, it also makes a substantial contribution to nature in this area.



Rows of poles



Rich dike in Jutland, Denmark

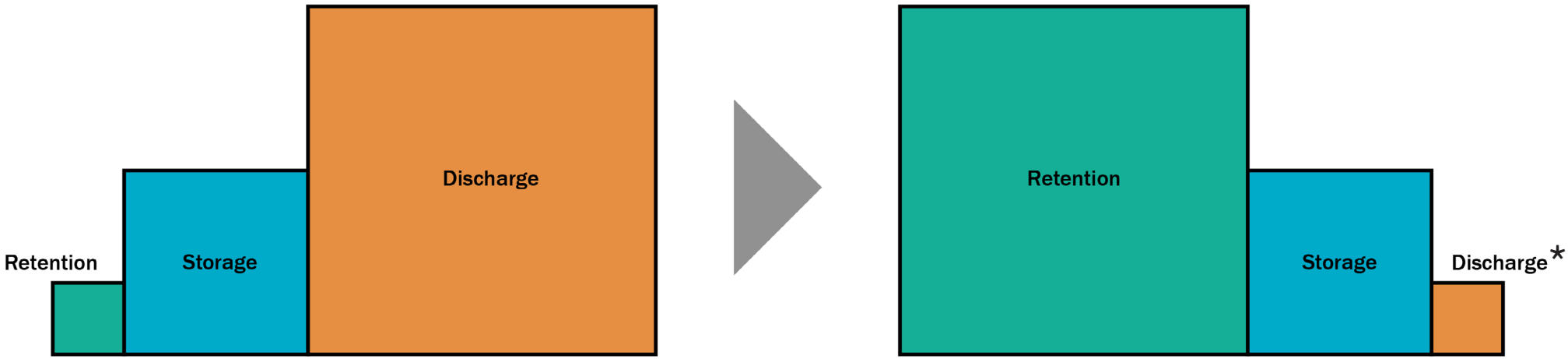
Wet rear banks beside the Eems-Dollard dike

6. Rich dikes as the basis, and where there is not much space

Large stretches of the Wadden coast are taken up by dikes whose only function is that of coastal defence. In the case of these dikes, as well as dikes on locations where there is little space, it is worth focusing on the opportunities to turn them into rich dikes (POV Waddenzeedijken, 2018). Taking the surroundings and their opportunities and needs into account results in a rich dike with added value that can suddenly come to mean much more in ecological and social terms. For instance, a scenic route can be created on the dike at the same time, like the recent example of Kiek over Diek, where a new 90 km cycle track has been constructed that runs (partly) over the Waddendijk. The addition of natural values can also help to protect the coast by improving its wave-braking capacity, such as rows of poles, a coarse foreshore, or embankments planted with herb-rich grasslands. Finally, there are also opportunities to give flexible water storage facilities connected to the main water system, which are sometimes low-lying and saline, an ecological function to soften the transition between sea and land.

Task 2. Maximal use of freshwater

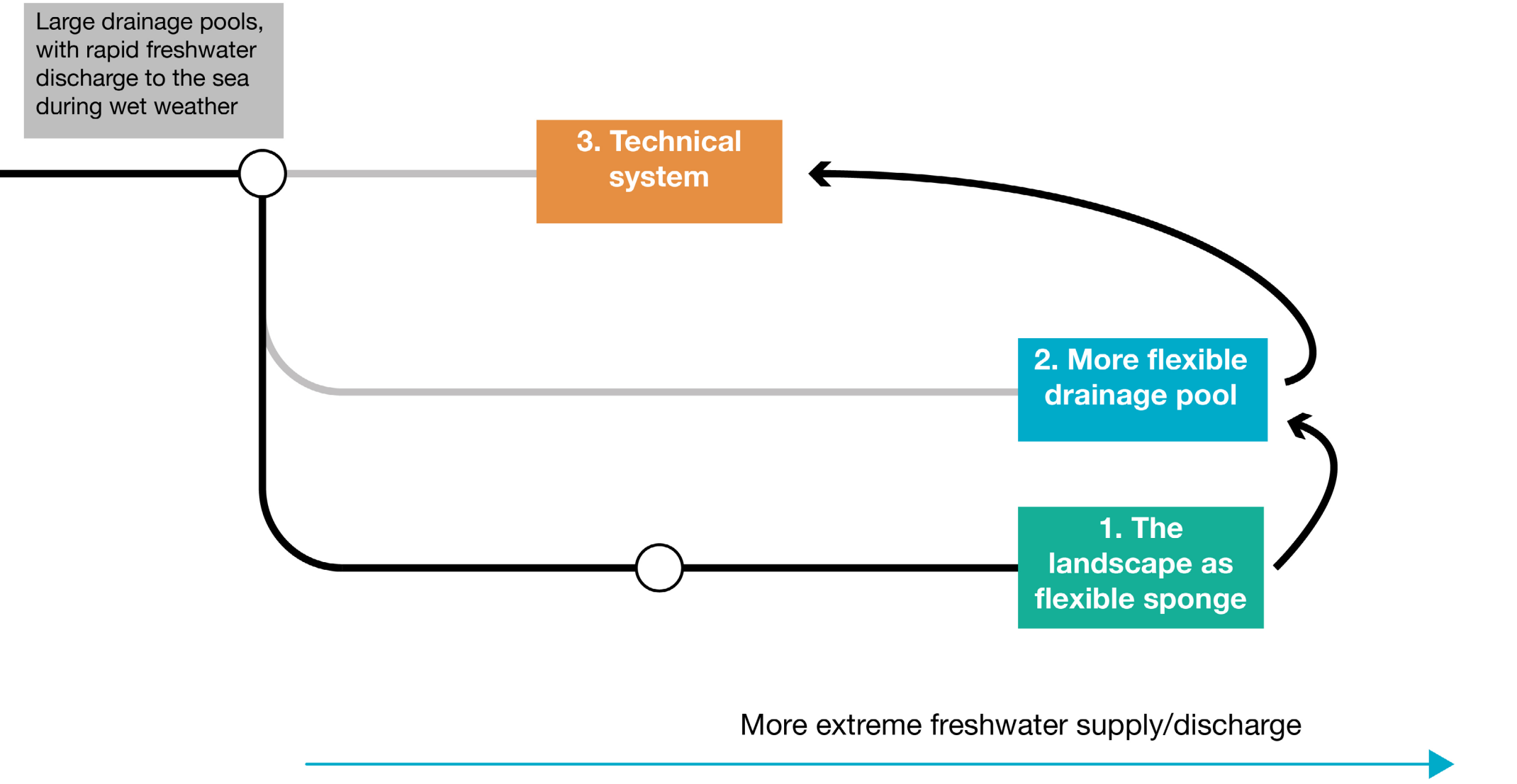
Not a drop of freshwater discharged into the sea without being used: catch, store and link



*Because there is still surplus rainfall and otherwise a disaster for nature, estuaries and shallow coastal waters

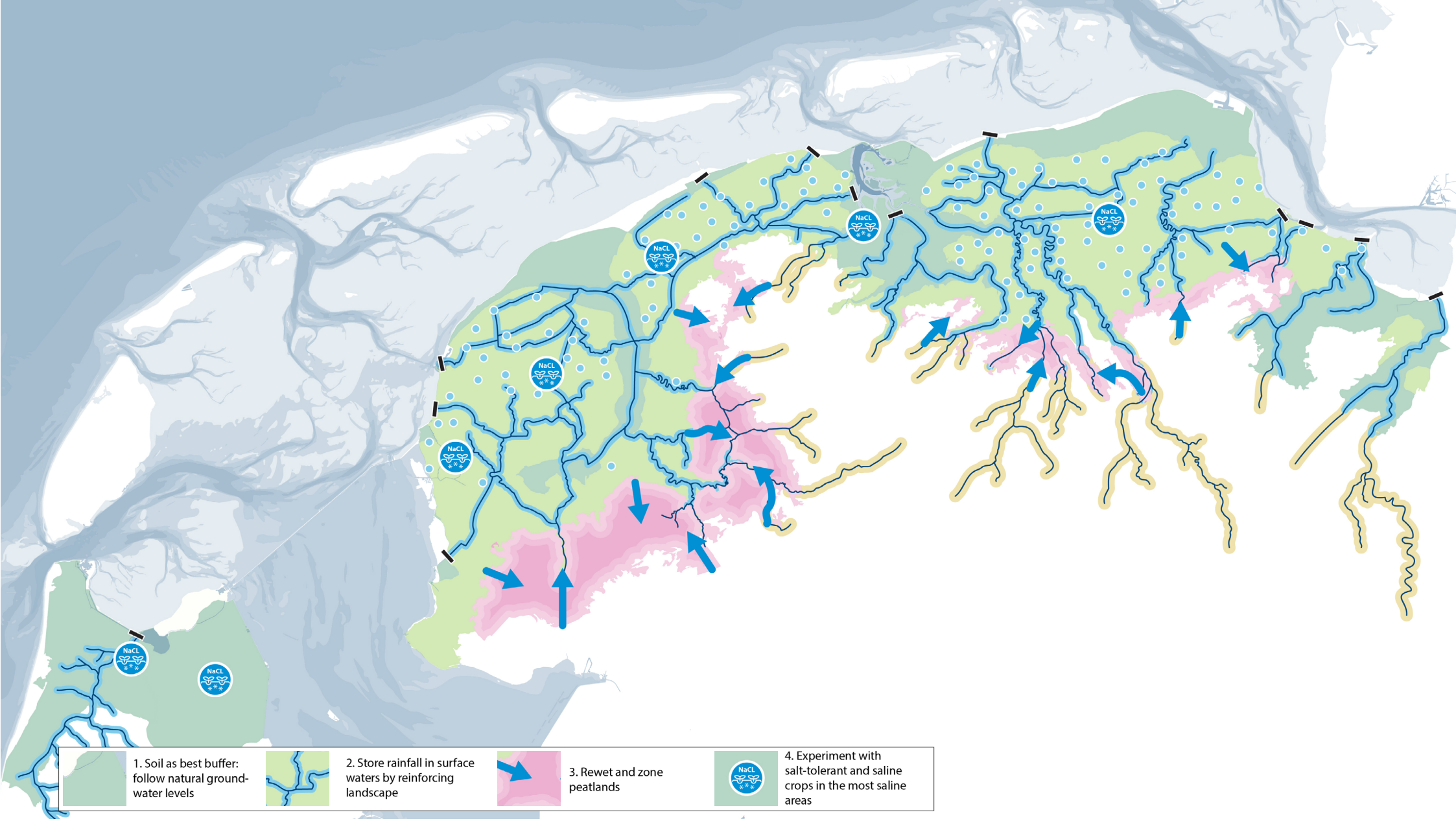
Not a drop of freshwater discharged into the sea without being used: catch, store and link

Subsidence and CO2 emissions are already urgent problems in the peatlands. Furthermore, it is expected that shortage of precipitation as a result of prolonged drought and higher evaporation will become increasingly common. Increased salinity requires more flushing with freshwater. Part of this demand can be met with water from the IJsselmeer, but by no means all. What is needed is a water system that can resist both extreme drought and extreme precipitation, a system that can also solve this problem within the region. So there are opportunities to reverse the situation of little catchment, a bit of storage and a lot of discharge: large catchment, more storage and discharge only when there is no alternative, under the motto 'not a drop of freshwater discharged into the sea without being used'. It is important not to forget the nature outside the dike: nutrients from inland are crucial for the Wadden Sea and the inflow of freshwater contributes to the seawater-freshwater gradient (a stream to direct fish) and the particular character of the shallow reaches of the sea that is the Wadden Sea, so the freshwater sponge should be allowed to leak a little through a number of apertures.



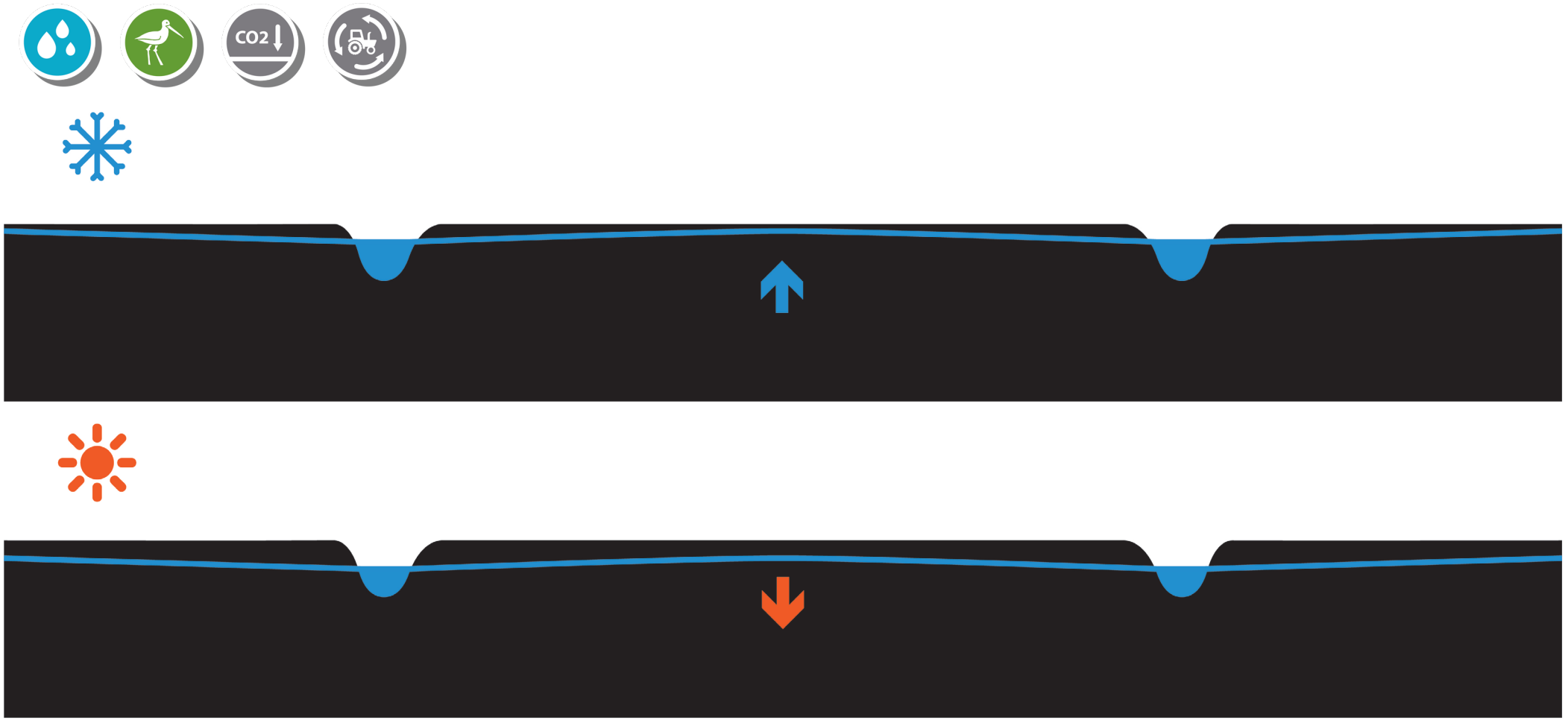
Multi-stage system based on the landscape as a sponge, then storage in a drainage pool or discharge by pumping

The present reflex of water boards is to drain the water away rapidly during rainy periods through a system of drainage pools into the sea. In a system of increasing downpours or prolonged drought and a rising sea level, at a certain point it is longer enough to build even bigger pumping stations. An alternative can be to make the drainage pools more flexible, leading to an enormous task of drainage pool expansion and dike reinforcement. It is more logical to deploy the landscape far more as a flexible sponge: in the soil, the capillaries of the system and the former landscape structures that have disappeared. Only after that sponge is saturated can a more flexible drainage pool be used, and finally the pumps to discharge the water into the sea. These measures can palliate the shortage of freshwater during dry periods and enable the region to become less dependent on the supply from the IJsselmeer.



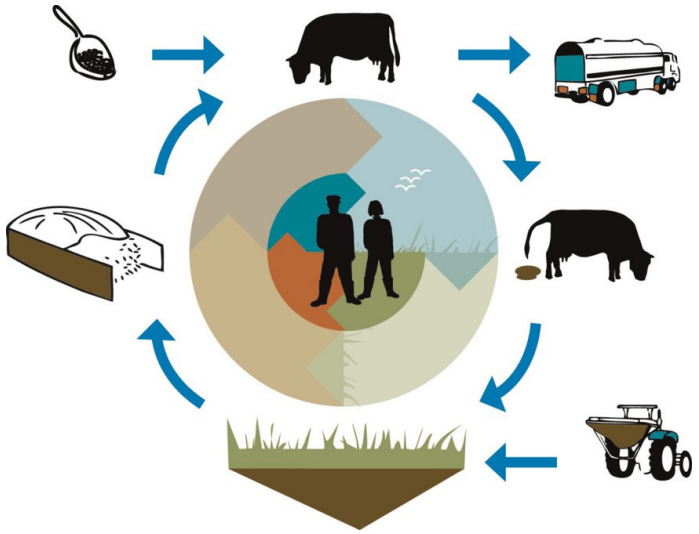
Course: retention, storage and drainage on the scale of the landscape

This multi-stage system can also be deployed on the scale of the landscape. Healthy soils play an important role everywhere as the basis in the water system, for example through more nature-inclusive agriculture and following natural groundwater levels. The peatlands at the Holocene-Pleistocene transition can begin to play a much larger role than at present as water buffers for the entire Wadden coast. At the same time they can counteract local subsidence and CO2 emissions: a genuine water battery. Former streams, brooks and creeks then carry the water further northwards, and if they are expanded and allowed to become overgrown they can store the water better. Finally, in very saline areas there are opportunities for large-scale experimentation with salt-tolerant crops that can grow on saline soil.



1. The soil is the best buffer: retain water by following natural groundwater levels

The natural buffer capacity of the soil has decreased in the last few decades because of soil cultivation, the reduced content of organic material, and accelerated drainage (Stowa, 2015). In order to be prepared for dry periods, it would be advisable to be able to store the water in the soil during periods of surplus precipitation. Measures to improve the buffer capacity of the soil include: increasing the content of organic material (1% more organic material retains 4-6 mm extra water), providing nutrients for life in the soil, ensuring a good soil structure and promoting healthy and deep rooting. Besides the improved buffer capacity, this also requires less external supply of nutrients and pesticides.

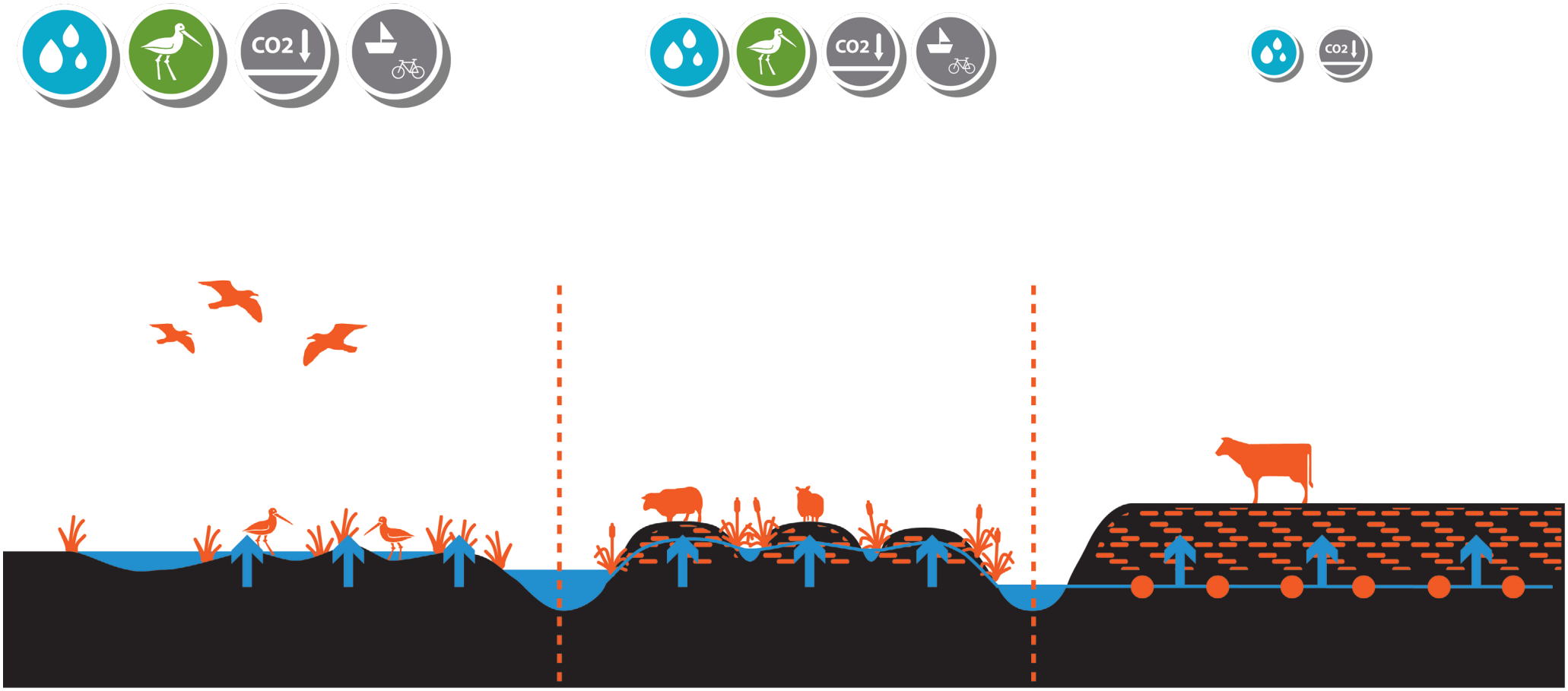


Circular farming in dairy farming

Chickpea farmer in Zeeland

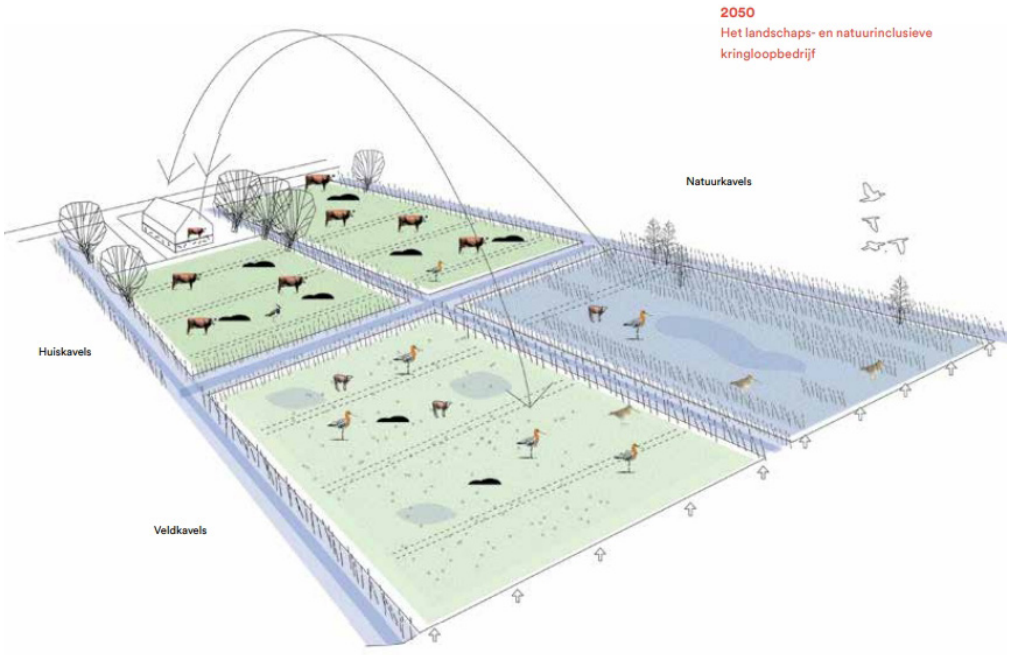
Make the soil healthy again and encourage circular farming and other crops

Circular farming and new crops can contribute to improving the capacity of agricultural soils to supply water. One of the most crucial aspects of circular farming is the use of flows of waste such as plant waste and manure to improve the quality of agricultural soil. The application of crops in the crop rotation that can fix nitrogen can also contribute to this (WUR, 2020). Besides circular farming, the protein transition towards vegetable proteins can play a role in soil improvement. Chickpeas, for example, are very good for fixing nitrogen in the soil and replacing animal proteins with their high nitrogen and CO2 emissions (Pyett et al., 2019).

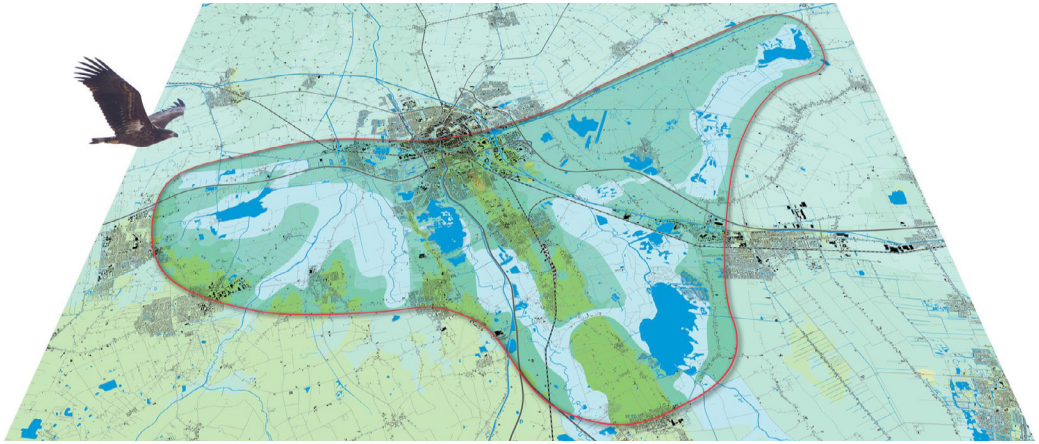


2. Rewetting and zoned land use in the peatlands

There is a lot of variation in the peatlands. In some places there is high peat oxidation, while in others there is virtually none. It is clear that it is necessary to keep the area wet to counteract the peat oxidation, with as its principal target the creation of that water battery for other agricultural soils with better growth potential. The current level of production can be maintained in large parts of the peatlands by means of technical measures such as water infiltration and raising with clay or sediment. At the same time subsidence and CO2 emissions are considerably reduced. In other parts the conditions for agriculture are worse. There are opportunities in them for wetter and more extensive farming, combined with natural grasslands and (temporary) water storage.



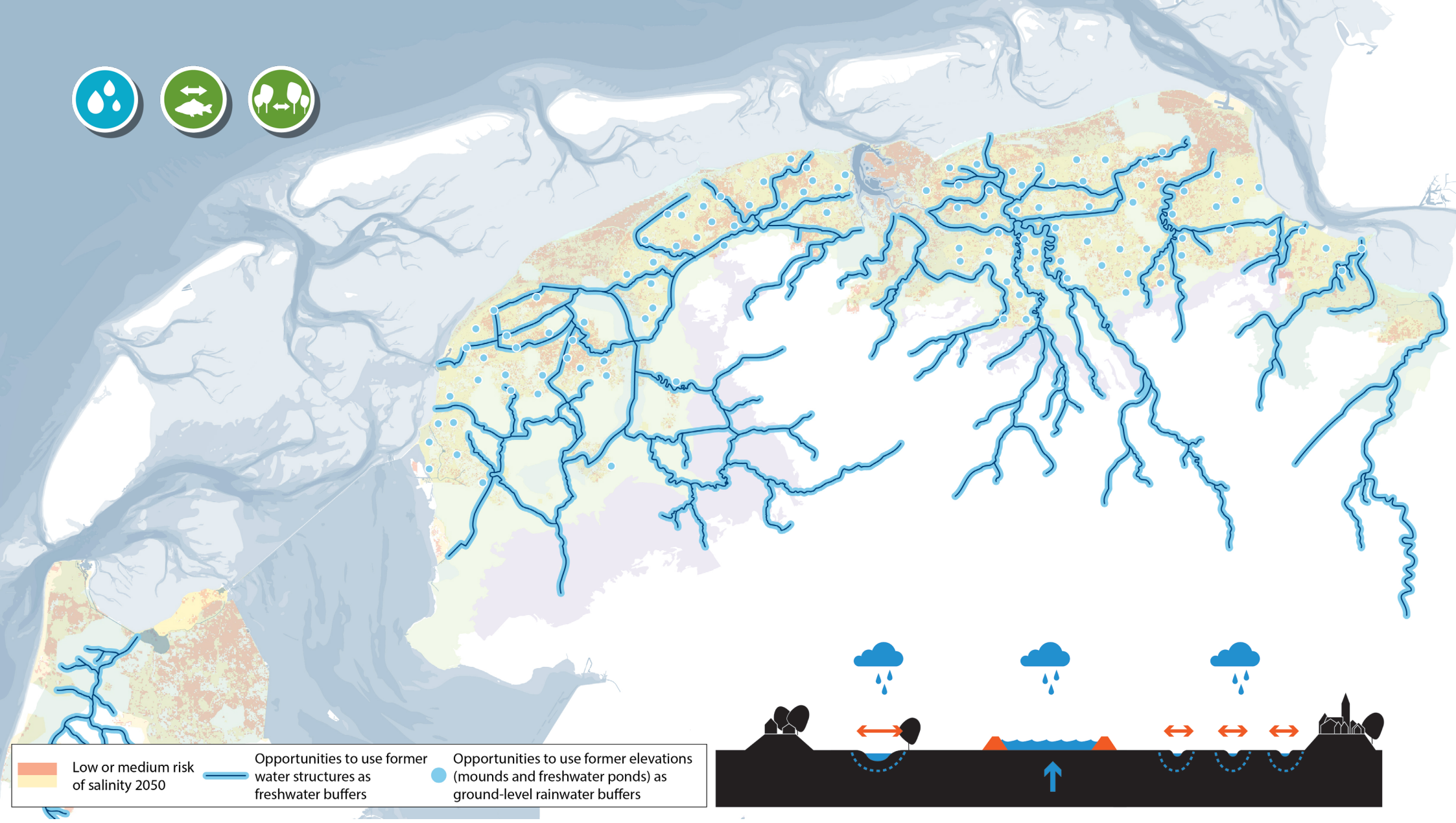
Agricultural pilot Krimpenerwaard, Van Paridon x de Groot, commissioned by CRa



Groningen low peat belt, Elzinga & Oterdoom & Zuidema

Rewetting and zoned land use in the peatlands, for example in contiguous water storage and uncultivated areas

Rewetting peatlands can go hand in hand with the continuation of agriculture and water storage. Together with Van Parison x De Groot, the Cra has outlined a future perspective for 2050 for the Krimpenerwaard that can serve as inspiration for the peatlands in the north (CRa, 2020). Here the grassland is zoned in intensive plots with technical wetting, extensive plots and (almost) uncultivated plots. Farmers make a living not only from agriculture, but also by broadening their activities. Wetting can also be deployed in combination with new opportunities for nature and recreation near the cities, as the study for the low peatland belt around Groningen shows (Elzinga, Oterdoom & Zuidema, 2013).



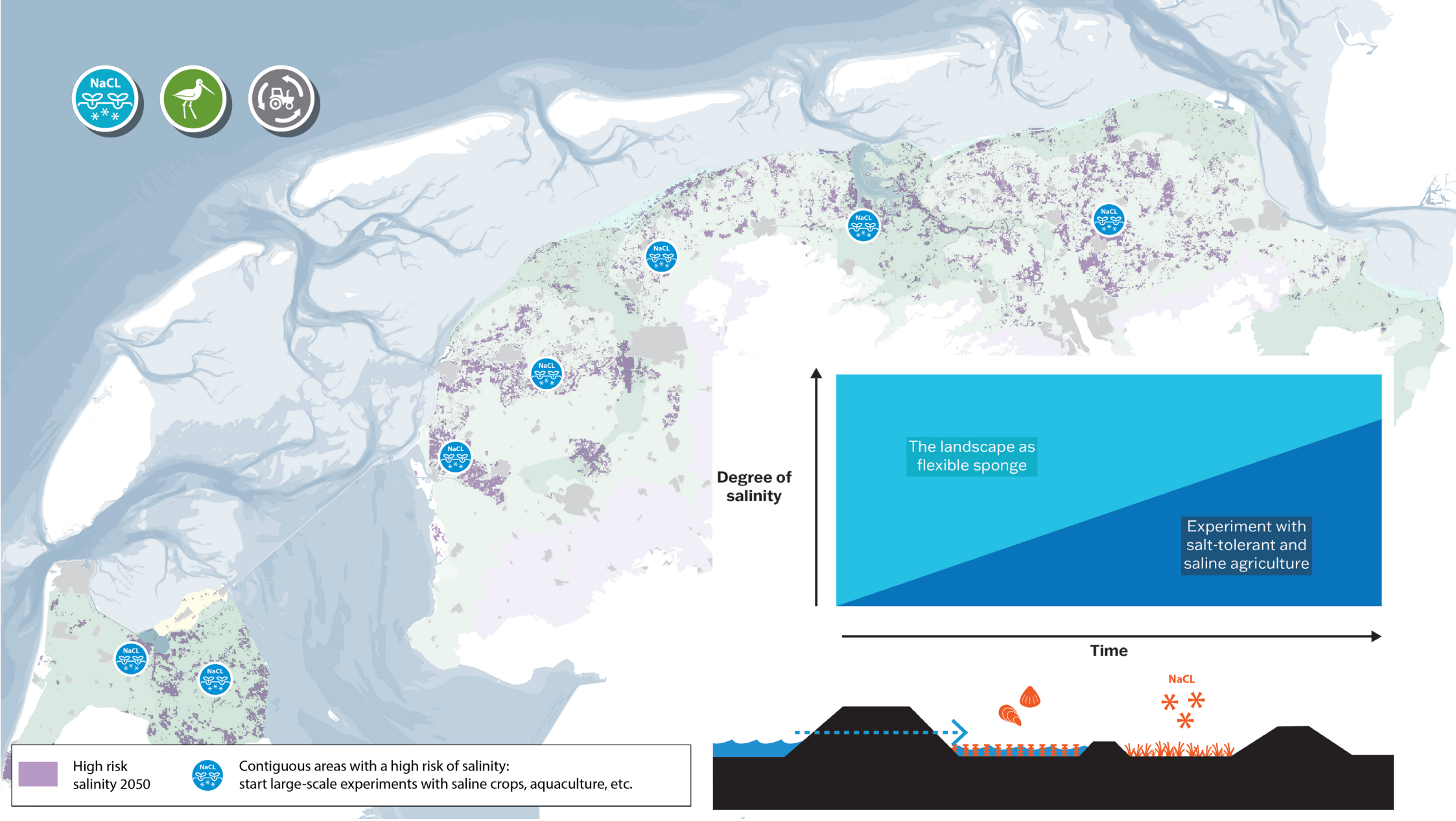
3. Rainwater storage in surface waters by reinforcing the landscape: upgrade and enlarge old creeks, brooks, waterways and streams

It is precisely in the capillaries of the system that there lies a great opportunity to upgrade and enlarge old landscape structures. The pilot for landscape-inclusive agriculture in the Marne (CRa, 2020) offers a good example. In areas that are already intersected with waterways, these can be widened. In this way they provide water catchment during downpours, retain it, and purify the drainage water. This also offers opportunities to link recreational routes and ecological green-blue veining. The areas that lie further away from the water supply can retain the freshwater in surface or subterranean basins. The ground-level storage can thus harmonise with former landscape elements such as freshwater ponds and duck decoys.

Agriculture pilot De Marne, Flux, commissioned by the CRa

Upgrade and enlarge old creeks, brooks, waterways and streams

Upgrading landscape structures to form a freshwater buffer has a good many advantages. In areas with potential increasing salinity, it can apply pressure to counteract that process. Green-blue veining can also help natural pest regulation and the use of mowings as a source of compost (CRa, 2020). This is in line with the transition to sustainable agriculture encouraged by the Minister of Agriculture Schouten (Hakkenes, 2019). Finally, some of the water discharged can be purified by a natural buffer, which can improve water quality.



4. Experimenting with salt-tolerant and saline crops: shift in place and time

While many areas will not be affected by increasing salinity in the short term, others are in deep trouble (see map on p. 23). The risk of increasing salinity is expected to rise and spread very gradually. In a number of areas freshwater farming is still thriving thanks to drainage to counteract saline water and other measures. In other areas where freshwater farming is no longer feasible, it is natural to turn to experiments with salt tolerant and other crops, all the more in view of the likely risk of increasing salinity. It would be advisable to upscale from pilot plots to larger experiments in which salinity and salt-tolerant agriculture are seen as an integral part of the local sustainable agriculture (Acacia Water, 2020).

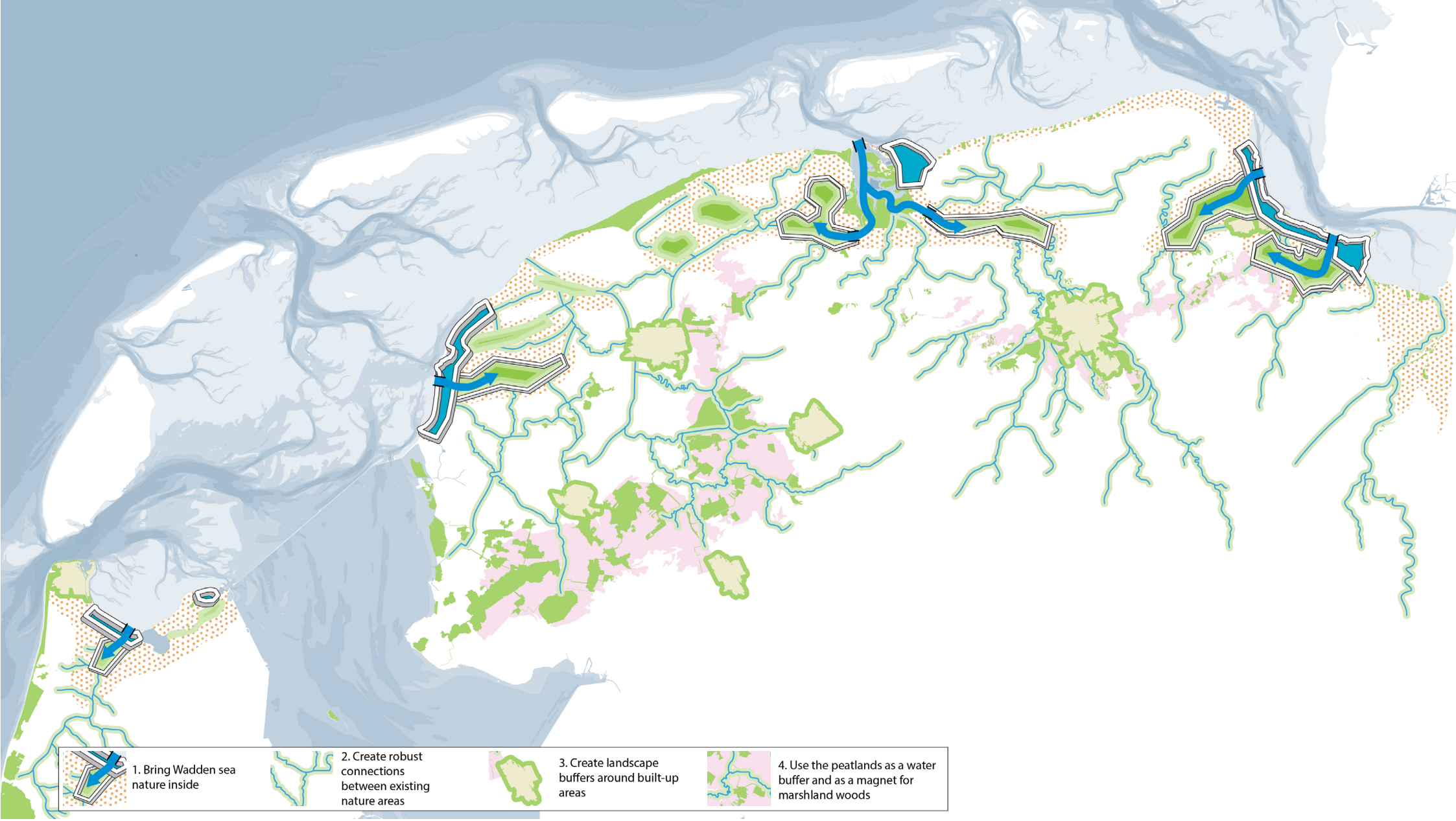
Pilot plantation saline cultivation, Texel

Experimenting with salt-tolerant and saline crops

There are already successful enterprises in Zeeland that work with salt-tolerant crops. A number of pilots have been started in the north too in recent years, such as the Salt Foundation on Texel and 'Fresh on Saline' on the SPNA experimental farm. Crops can be further developed and upscaled, enterprises suffering from saline soil can be approached for pilots, and salinity and salt-tolerant crops can be integrated in local sustainable farming. For example, the development of cockle and seaweed farming inside the dikes can be linked to the development of double dikes. Crops like sea lavender and glasswort have a limited share in the market at present, but common sugar beet, for instance, is relatively salt-tolerant. There are also opportunities to develop potatoes as a salt-tolerant crop (Acacia Water, 2020).

Task 3. Counteracting the loss of biodiversity

Make nature more robust by linking and expanding deteriorating habitats



Course: Make nature more robust by linking and expanding deteriorating habitats

As a result of the rise in temperature and sea level combined with drought, habitats both outside and inside the dike are under pressure, and this trend is expected to continue. Strengthening of the natural environment on the edge of the Wadden Sea is therefore necessary, and the best way to do this is when habitats are in order – such as the transitions from freshwater to seawater – and uncultivated areas are connected. Improving conditions locally has an immediate effect, but they can be made more robust by expanding and connecting them with one another. The conservation of nature is an end in itself, but it can also be combined with the achievement of other ends. The introduction of double dikes and (temporary) rotation polders increases the sandbank area, but within the dike. Making better use of the water network of creeks and channels for water storage has a direct added value for ecological green-blue veining. Recreation areas around the built-up zone bring the countryside closer. And using the peatlands as a water buffer offers opportunities for natural wetlands and marshland forests.

Plan Tureluur, Schouwen-Duiveland

1. Enhance the ecological value of the coastal zone by softening the edge and bringing the Wadden sea nature inside the dikes

Bringing in Wadden sea nature inside the dikes means that at some points space is needed for brackish, wetter and more extensive conditions. Fortunately there are many places where this can be combined with other targets, such as salt-tolerant agriculture and coastal reinforcement. It is only natural to suppose that a good, integral weighing up has to be done when it comes to making room for a salt marsh environment. While on the one hand it will still be possible to continue farming for a very long time without much difficulty, there are also very brackish, wet soils that, from a broader perspective, are more suited to the transition to a natural environment or experimental crops. There are also areas where the conditions for farming will not deteriorate for the next fifty years, but where it is still advisable to think about a different use of the land.

Leyre delta, south of Bordeaux

Natural brooks in southwest Jutland, Denmark

Examples from abroad

The Wadden coast is unique, but the challenges facing it are not, so there are many opportunities and solutions from other deltas that also have a chance of succeeding here, or at least can offer inspiration. The Leyre delta near Bordeaux, for example, is still open to the sea. Nature and food production are integrated here, and there is also a lot of recreational use thanks to the fine-meshed network. The natural brooks in Jutland are an inspiration for how to deal with the fine-meshed water network that is potentially feasible on the Wadden coast too. A renewal of the brooks led there to improvement in water quality and an increase in the fish population, resulting in a fish recreational economy.

Link recreation with connections between nature areas

2. Make robust connections between existing natural surroundings: draw on the northern identity and link it with other tasks

The identity of the northern landscape varies per area, but they all share a couple of characteristics: sweeping panoramas and water everywhere. We can build on these very characteristics in making new connections between natural surroundings. We should see whether the Northern Wet Axis can appear on the map again as a robust ecological link that binds the Wadden region together. These new waterway connections can also be deployed for recreation and water storage.

Link recreation with nature areas along the Reitdiep

Hunze axis as example for waterway connections

Long lines through the open landscape

Residents of the northern provinces love the open landscape, the vistas and the open fields. Even a small village like Appelscha makes them feel claustrophobic, as it was put during one of the expert sessions. Focusing on the long (historical) lines of the landscape can preserve this specific identity while at the same time building up a more robust ecological network. In Groningen, for example, there are opportunities for a wide river valley from Lauwers to Reitdiep, passing through the city of Groningen and on towards Drentsche Aa and Hunzedal. Wide avenues, lanes or sturdy vegetation beside the open fields on estates can also strengthen the structure and make it more attractive for recreation in areas like the Breezand or the Bildt.

Village woodlands and landscape elements around Middelstum

3. Create landscape buffers around the built-up area: in the northern way

A perfect opportunity for the creation of new natural zones is offered on the outskirts of cities, towns and villages. It is known that greenery helps against heat stress, contributes to the quality of life of the urban residents, and increases the value of real estate (CRa, 2020). There are already beautiful examples of village woods, recreational green and city parks in the northern landscape. Provided densification on the spot is applied, trees are well suited to the open northern landscape (Provincie Fryslân, 2014). It is precisely on the outskirts of towns and villages that there is more space for the broadening of agriculture with secondary activities and the sale of local products. These can readily be combined with (partial) extension of agriculture in the interests of nature conservation.

Hegewiersterfjild near Harlingen

Leeuwarder Bos

Bringing the countryside closer

There is a major task in and around the cities. Cities like Groningen and Leeuwarden want to grow, but they have said themselves that they no longer want to build in the meadows but to expand inside the city. The importance of public greenery and the pressure on it grows (Gemeente Groningen, 2020). That is particularly noticeable at the moment now that we are spending more time at home. In the surrounding countryside there are all kinds of opportunities to allow greenery to take on more significance for society. We should take advantage of these opportunities, such as linking drinking water storage, nature and recreation as in the low peatland ring of Groningen (Elzinga, Oterdoom & Zuidema, 2013), or food production in combination with an attractive landscape as in the example of the Herenboeren (a collective of small local, ecological farmers).

Agricultural pilot Krimpenerwaard, Van Paridon x De Groot in collaboration with CRa

Waterlands Woud. Patrick Ruijzenaars

4. Use the peatlands as a water buffer and as a magnet for marshland woods

There is an urgent need of more water buffering in the peat bogs. This means a partial extension of the marshy land, with more room for natural grassland and wet nature. A number of local birds, such as the black-tailed godwit, can also forage without difficulty in meadow areas. Wetting the peatland area offers them the opportunity of a new habitat. In addition, there are opportunities on the outskirts of towns and villages and on the Pleistocene-Holocene transition for conversion into marshy woodland with recreational secondary functions. The advantage of natural peatlands is that they can regenerate after a while as long as the water level stays high enough, and they can fix CO2 instead of emitting it.

Responsive land, Sander Hermens

Places of hope, Peter de Ruyter

Continue along the present courses, but start now!

The peatlands are the subject of a lot of discussion, full of all kinds of trajectories and ideas that can be further developed. But the time to act is now, because if the peatlands continue to disappear at this speed, there will be hardly any left in the north by 2100. This means not only the loss of extraordinary natural quality, but also consequences for infrastructure, dwellings and agriculture that we cannot foresee yet. This calls for measures now that may be painful and will lead to different landscapes, but they will still be productive and above all beautiful landscapes!

4. Follow-up

Hotspots for further developments

It will be clear that we are facing a big task, as all of the experts consulted agree. At the same time anticipating the challenges also provides an opportunity to make the region more interesting, richer and more attractive. The questions facing us are: How do we tackle the challenges and which choices do we make? What do we do now, what will the landscape look like in eighty years' time, and how do we get there? We can discuss these questions with one another with the information and lines leading to solutions. The seven hotspots that we have indicated in the map can help us in this task. They are locations where many tasks are combined and where there are already projects under way, but where the horizon of 2100 is not taken into account. We invite everyone, on the basis of this report and with the help of the hotspots, to think about the questions of how residents, entrepreneurs and visitors to the Wadden Sea coast will be able to live comfortably, earn a decent living and enjoy their rich surroundings in eighty years' time.

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Colophon

Colophon

December 2020

This report and the presentation during CAS 2020 are an initiative of the Programme for a Rich Wadden Sea. Many experts and managers joined in the various sessions with experts and focus groups. Strootman Landschapsarchitecten supervised the process and compiled the report.

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(This group consisted of representatives of municipalities, provinces, the national government, water boards and agricultural en nature organisations. In these sessions, we spoke about opportunities, threats and points of attention in a political-administrative context. This does not mean that everyone endorses the content of this report)

The climate is changing: the earth is warming up and the sea level is rising, with an increasing impact on our ecosystems, the way we grow our food, and the way we live. A large number of challenges combine to pose a threat to the Wadden Sea coast, a unique intertidal area that is one of the largest of its kind in the world and a highly productive agricultural area, but they also offer plenty of opportunities for adaptation to the climate – reason enough to get down to tackling them.

The direct motivation for this report is the Climate Adaptation Summit (CAS) to be held in the Netherlands in January 2021. In cooperation with the Groningen municipality, the Programme towards a Rich Wadden Sea (PRW) and other partners, the Global Center on Adaptation (GCA) is organising a Climate Adaptation Week to discuss climate adaptation and adaptive solutions. The issues presented here by PRW for the Wadden coast in the Netherlands are faced by comparable regions all over the world: coastal safety, food production, water management and nature conservation.

This report presents a strategy for climate adaptation that sets priorities and is inspiring. To make well-considered choices now, we look far into the future, towards 2100. We offer an overarching perspective on the Wadden coast with a focus on the entire stretch of the Wadden coast region in the Netherlands: from the salt marshes beyond the dikes in the north to the peatlands and creeks in the south, and from Den Helder in the west to the German border in the east,

Yes, the climate is changing. A lot needs to be done. But if we make the right choices now, we can ensure that we do not only work on the conservation of the Wadden coast region. Wecan also create added value by opting for solutions that not only contribute to climate adaptation but also have a positive impact on agriculture, biodiversity and the quality of life.