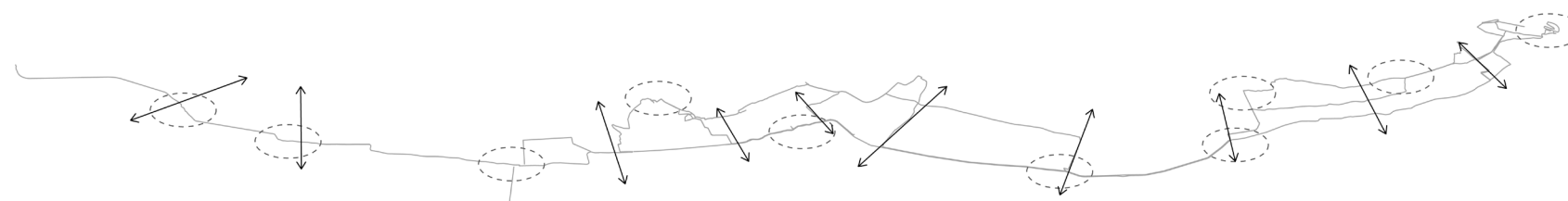


Regression & Progression

Towards a Regenerative Water Landscape in Wadden Coast

Heather Yin Wah Wong
June 2022





Wadden Sea World Heritage Site.
Photo: Wadden Sea World Heritage Site, 2021.



Wadden Coast.
Photo: Author, 2022



Coastal salt marshes as flood fighters.
Photo: NIOZ/Edwin Parée, 2021.



Cycling along sea dike.
Photo: Author, 2022..



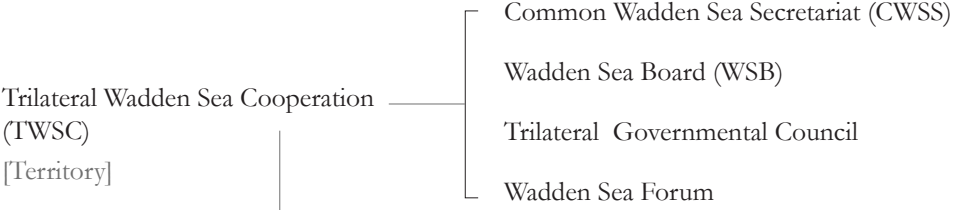
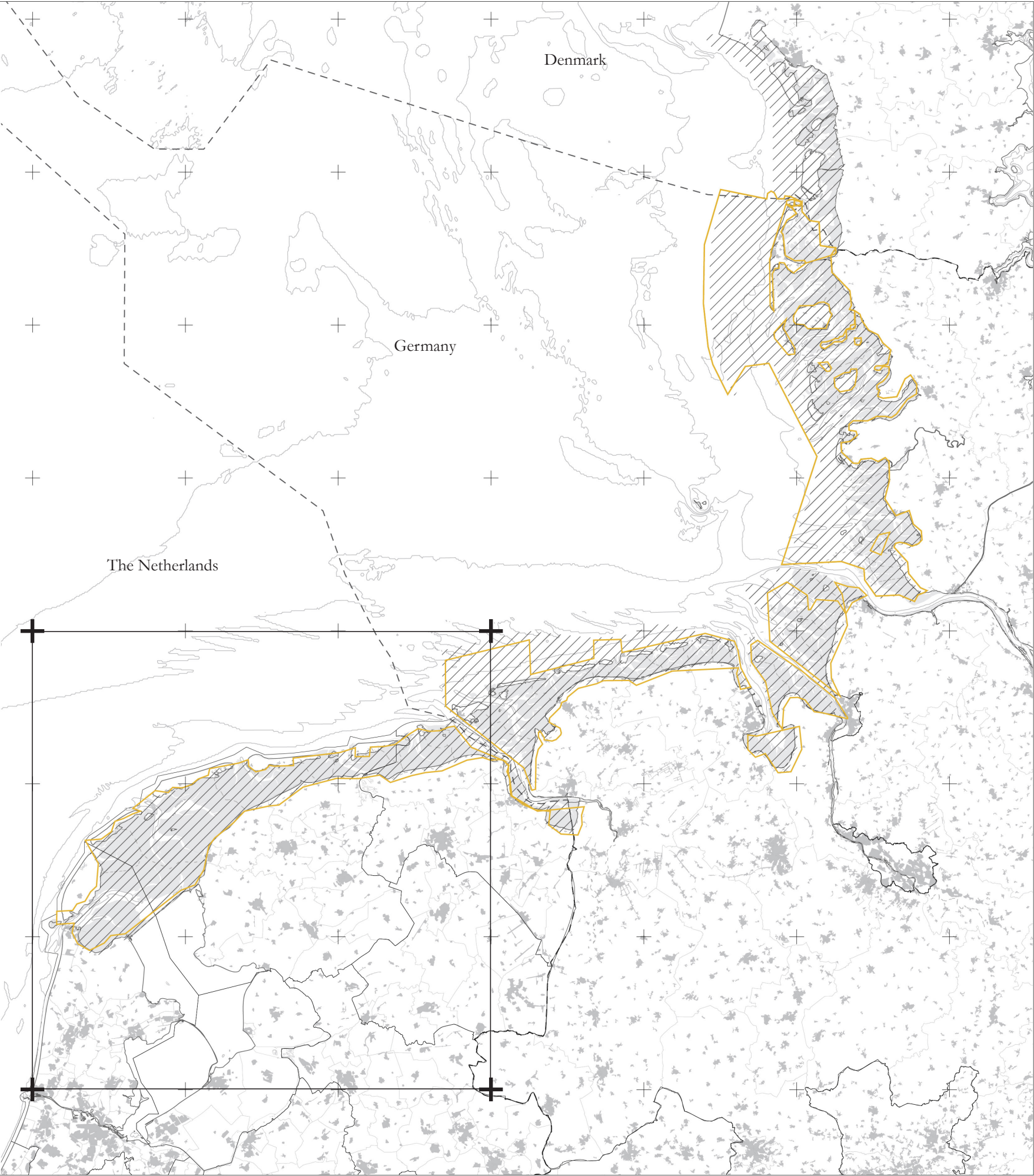
View of sea dike from the farmland.
Photo: Author, 2022.



Sea dike segregation
Photo: Author, 2022.

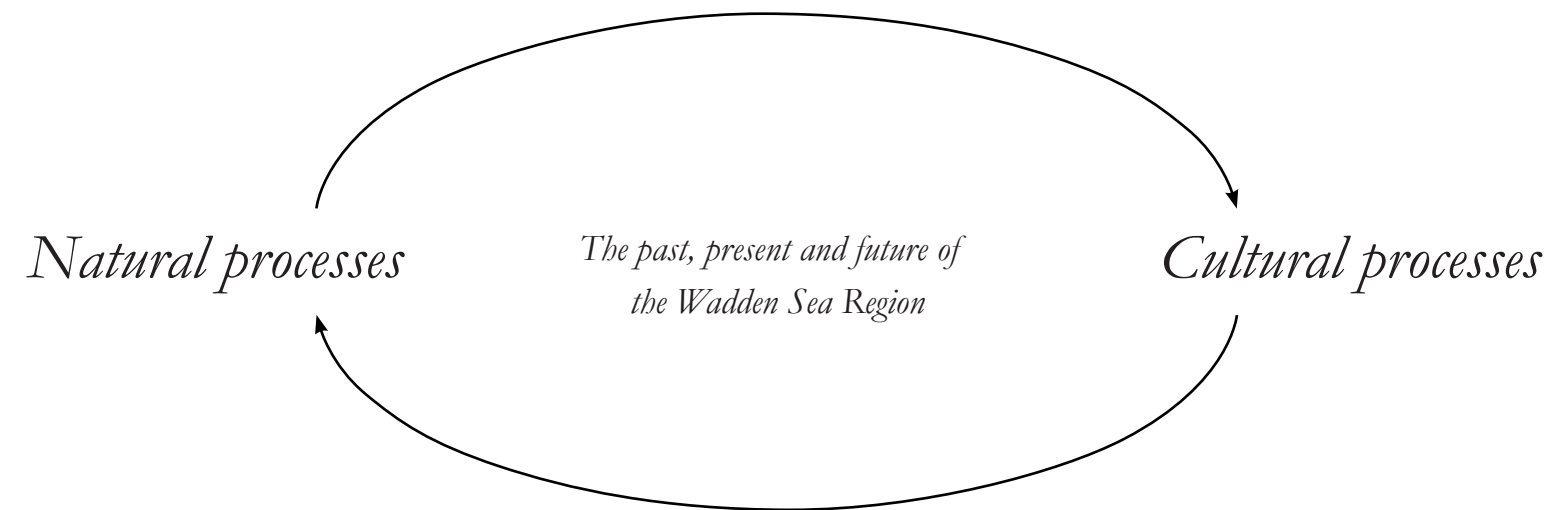
Site Complexity

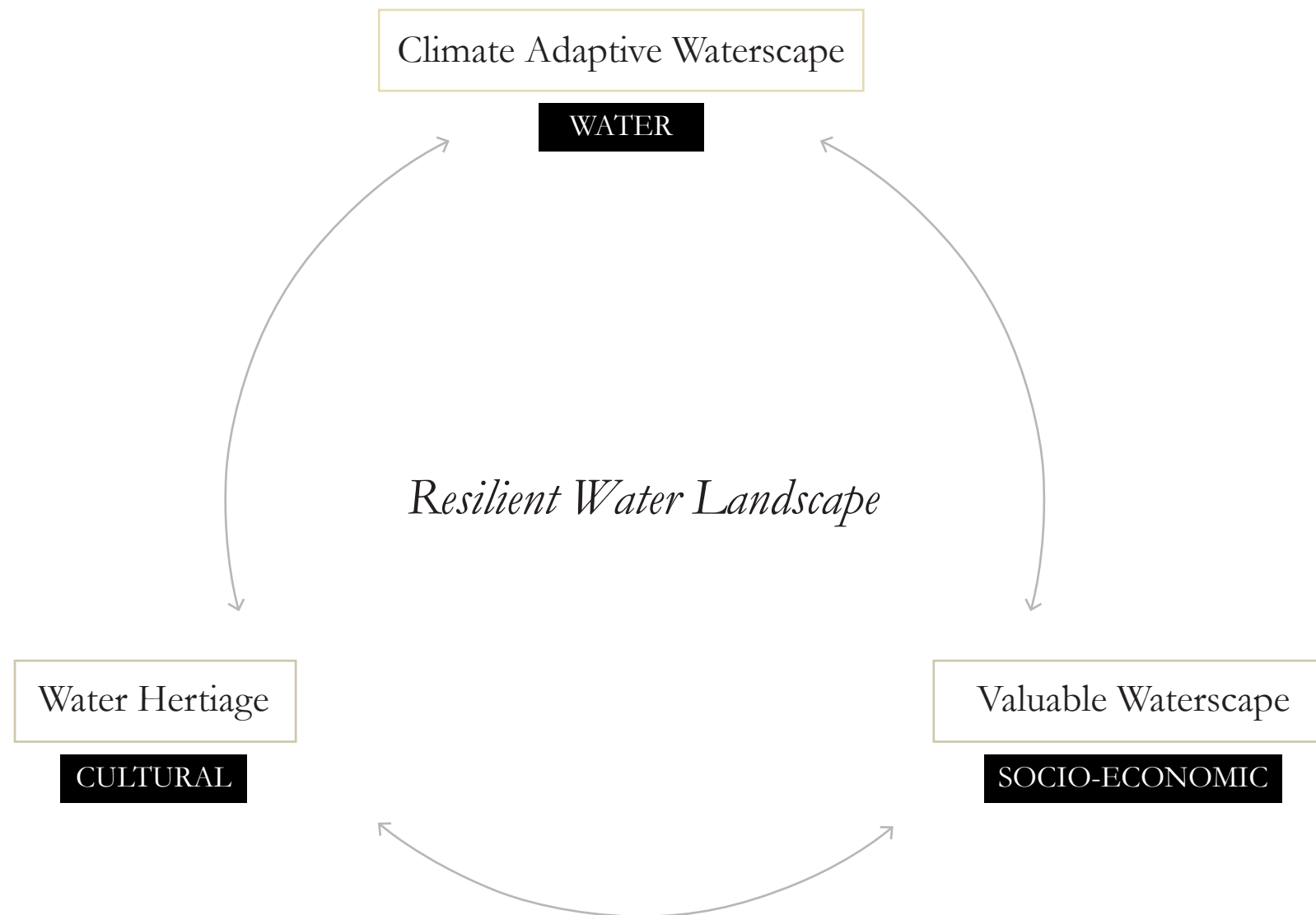




Denmark	Germany	The Netherlands
1 Region	4 Federal States	3 Provinces
3 Municipalities	14 Municipalities	14 Municipalities
		[Regional]

- National border
- Province border
- Municipality border
- UNESCO border
- Trilateral Conservation area
- Bathymetry
- Tidal basin
- Urban area

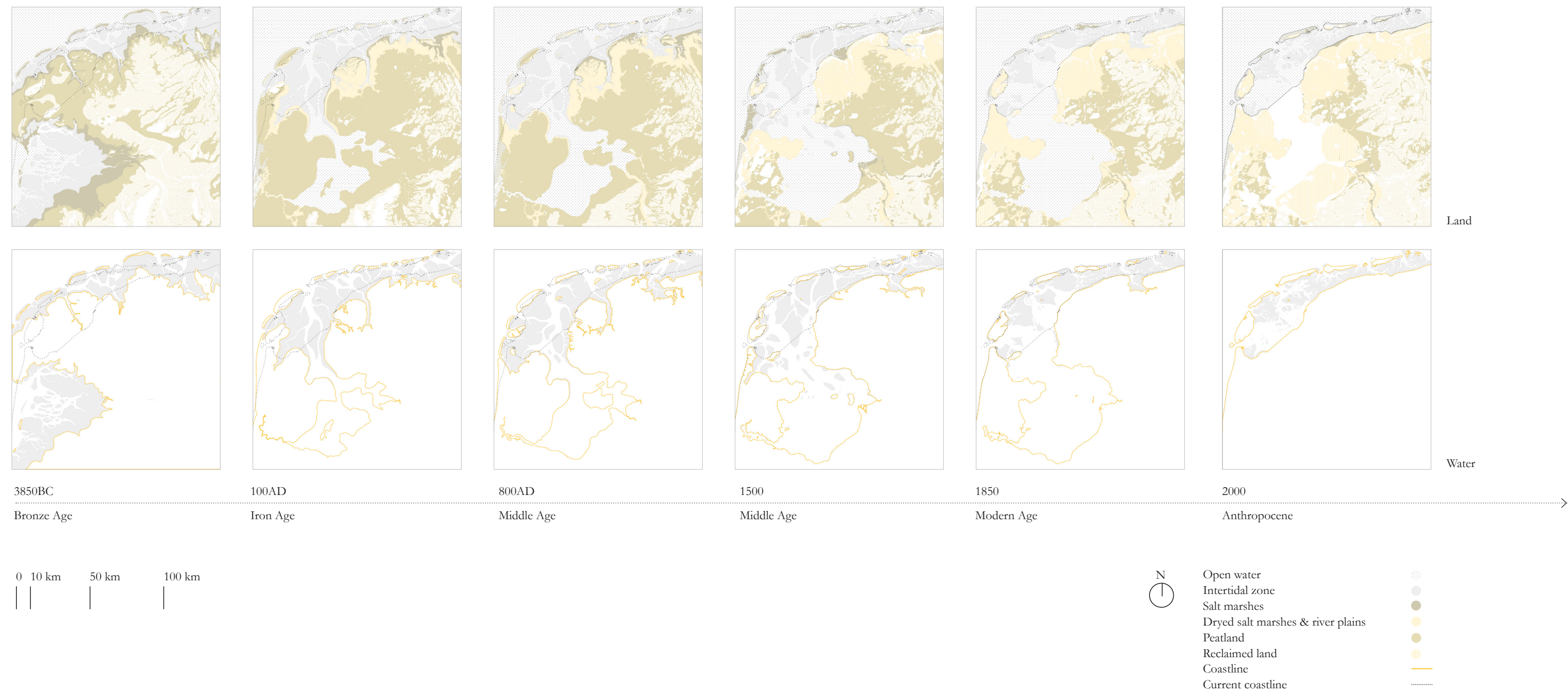




the Past
the cultural water landscape

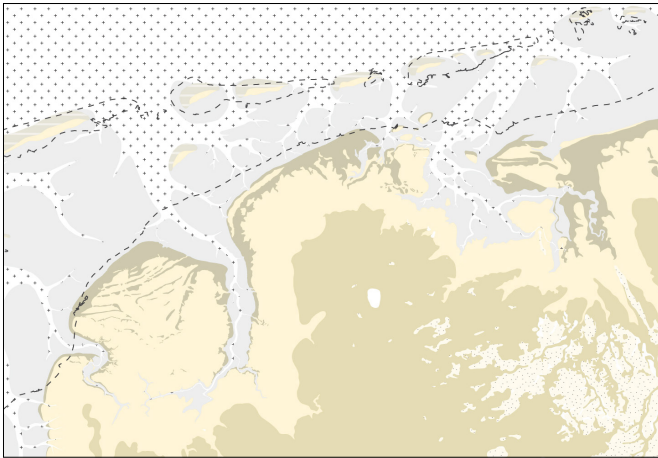
Geomorphological Development

Data: Vos, P., M. van der Meulen, H. Weerts and J. Bazelmans 2020 ,Dutch Dikes 2015



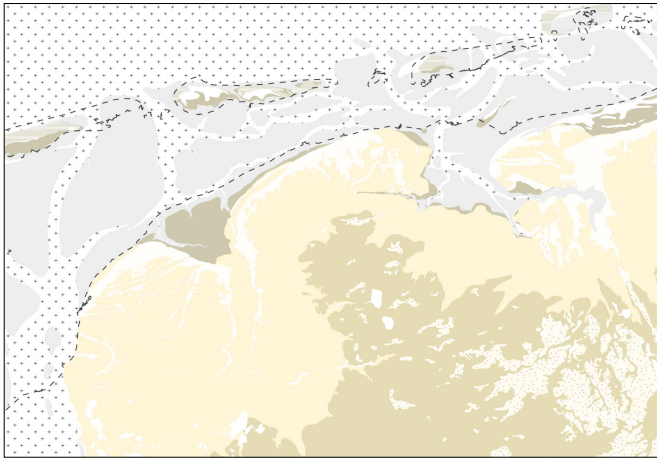
Geomorphological Development

Data: Vos, P., M. van der Meulen, H. Weerts and J. Bazelmans 2020 ,Dutch Dikes 2015



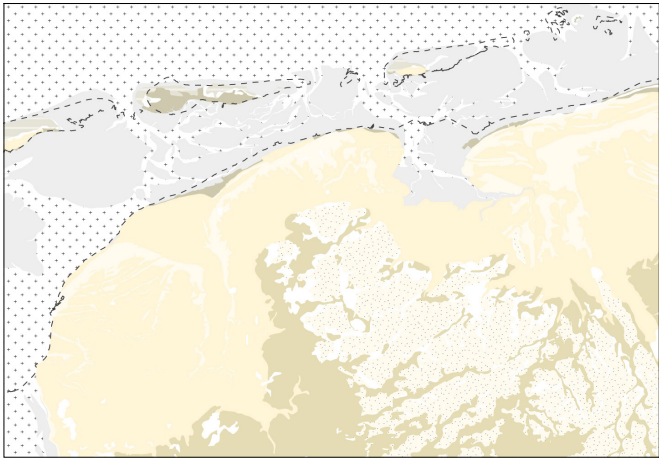
800AD

Middle Age



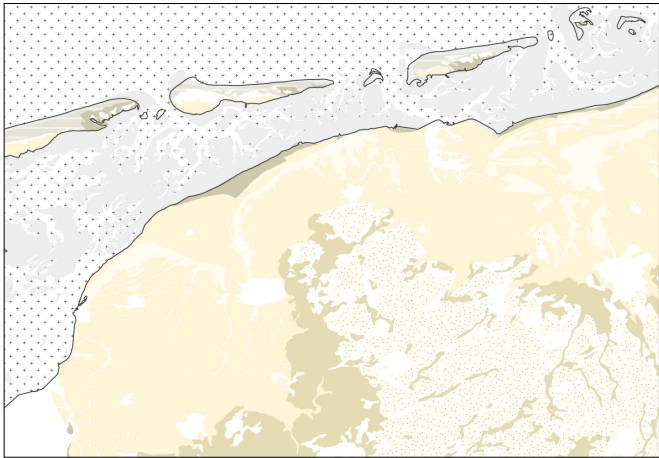
1500

Middle Age



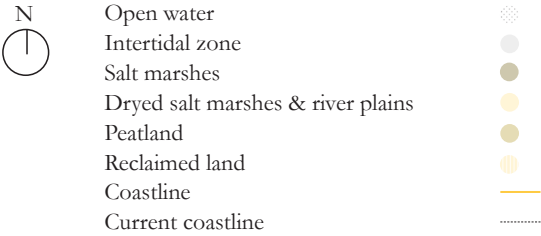
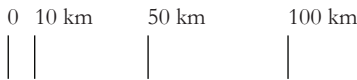
1850

Modern Age

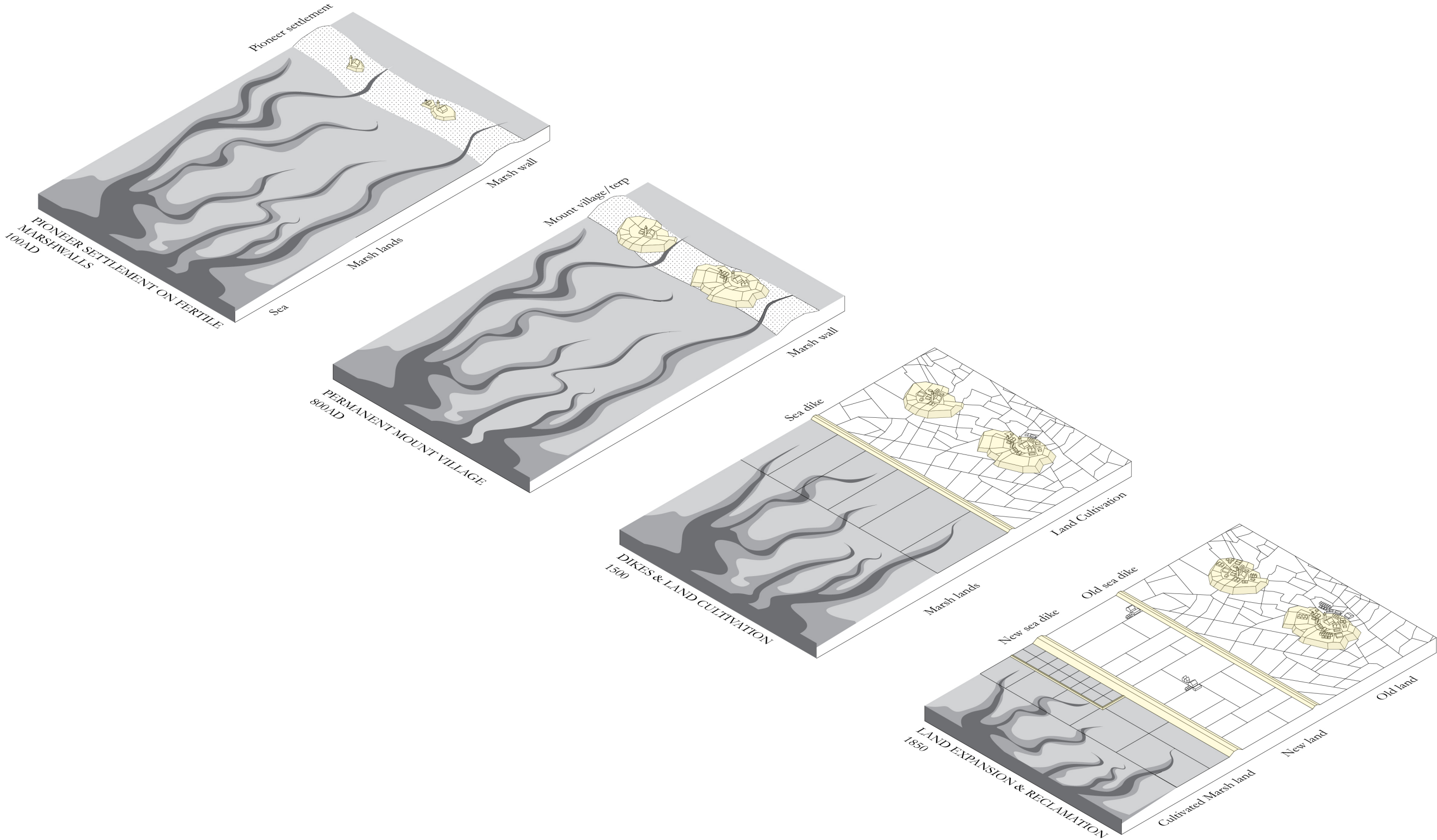


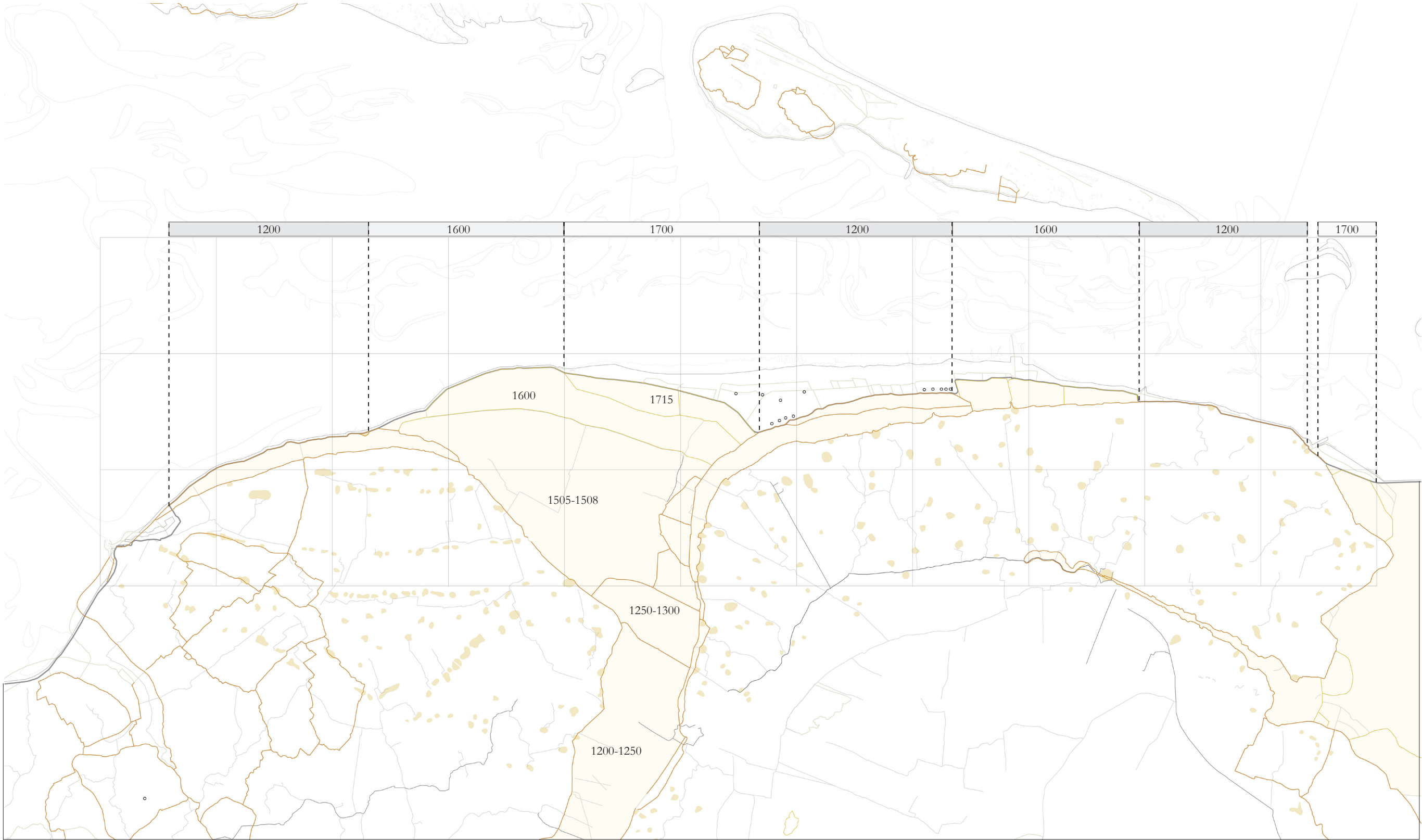
2000

Anthropocene



Fighting Against The Water





0

5 km

15 km

N

Dikes built before 1500
Dikes built from 1500-1850
Pumping stations
Sluices & Locks
Dobbens
Terps
Young polders





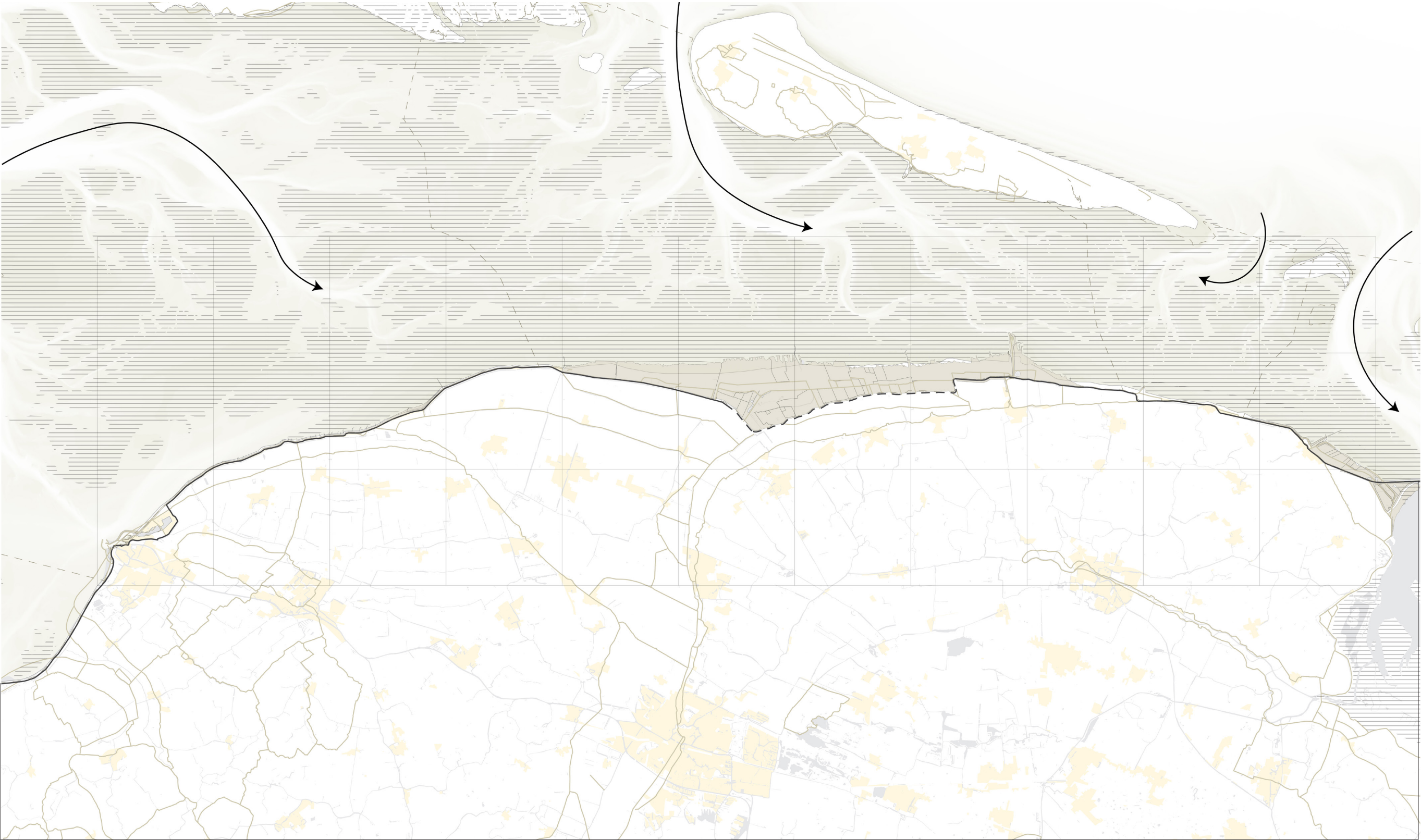
Dikes as water heritage.
Photo: Author, 2022.



Terp.
Photo: Author, 2022.

the Present
the dynamic landscape

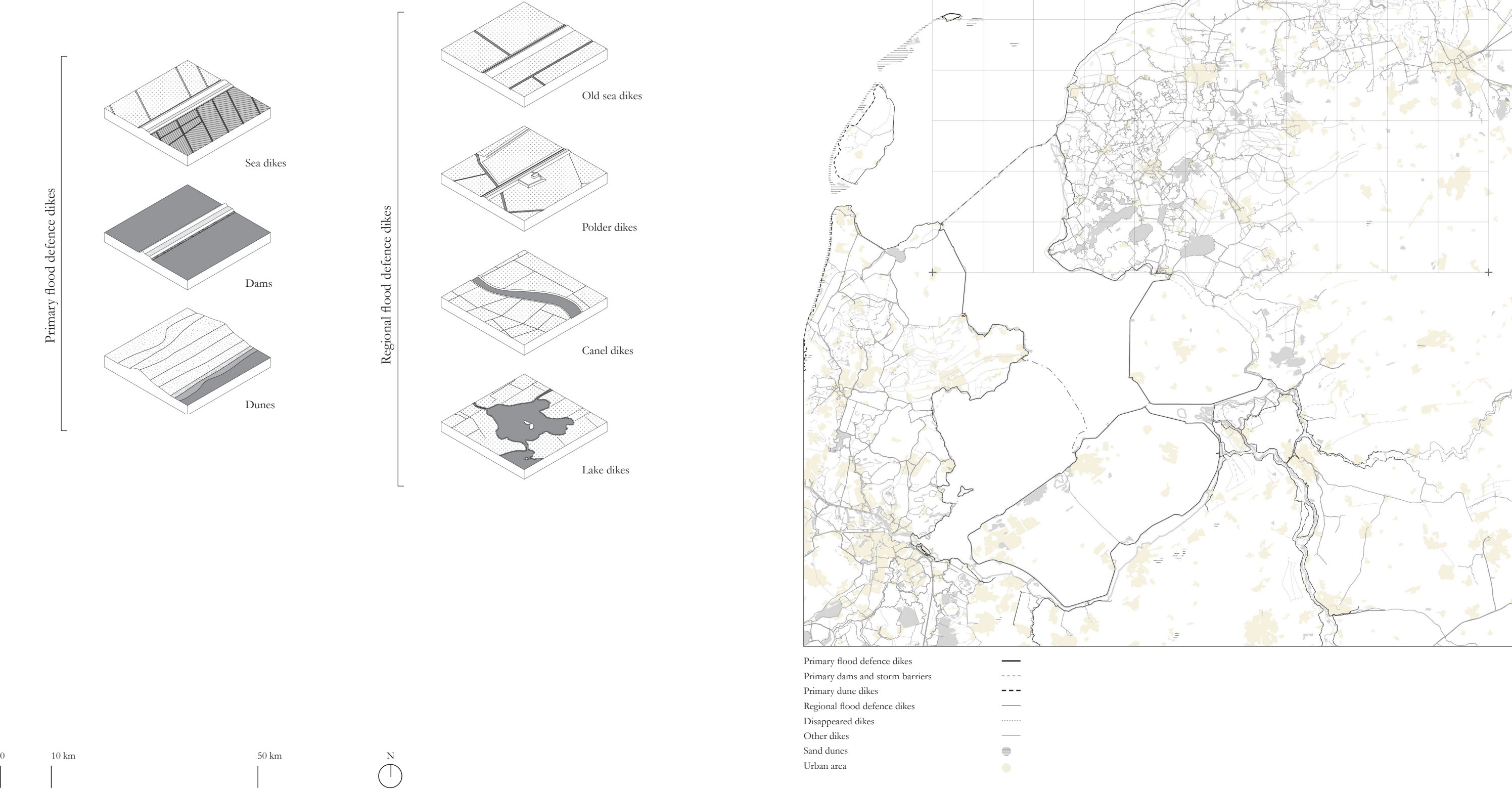
Tidal System & Flood Defense System



- Sea dike with asphalt
- Wide green dike
- Regional dike
- Salt marsh
- Tidal flat
- Tidal basin
- Water current
- Urban

Flood Defense Systems

Data: RCE-Dijkenkaart, 2021.



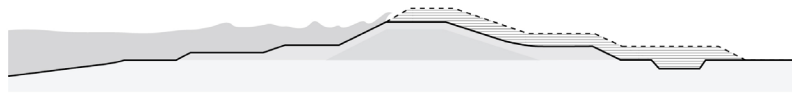
Dike Reinforcement

Data: Witteveen+Bos, 2021.

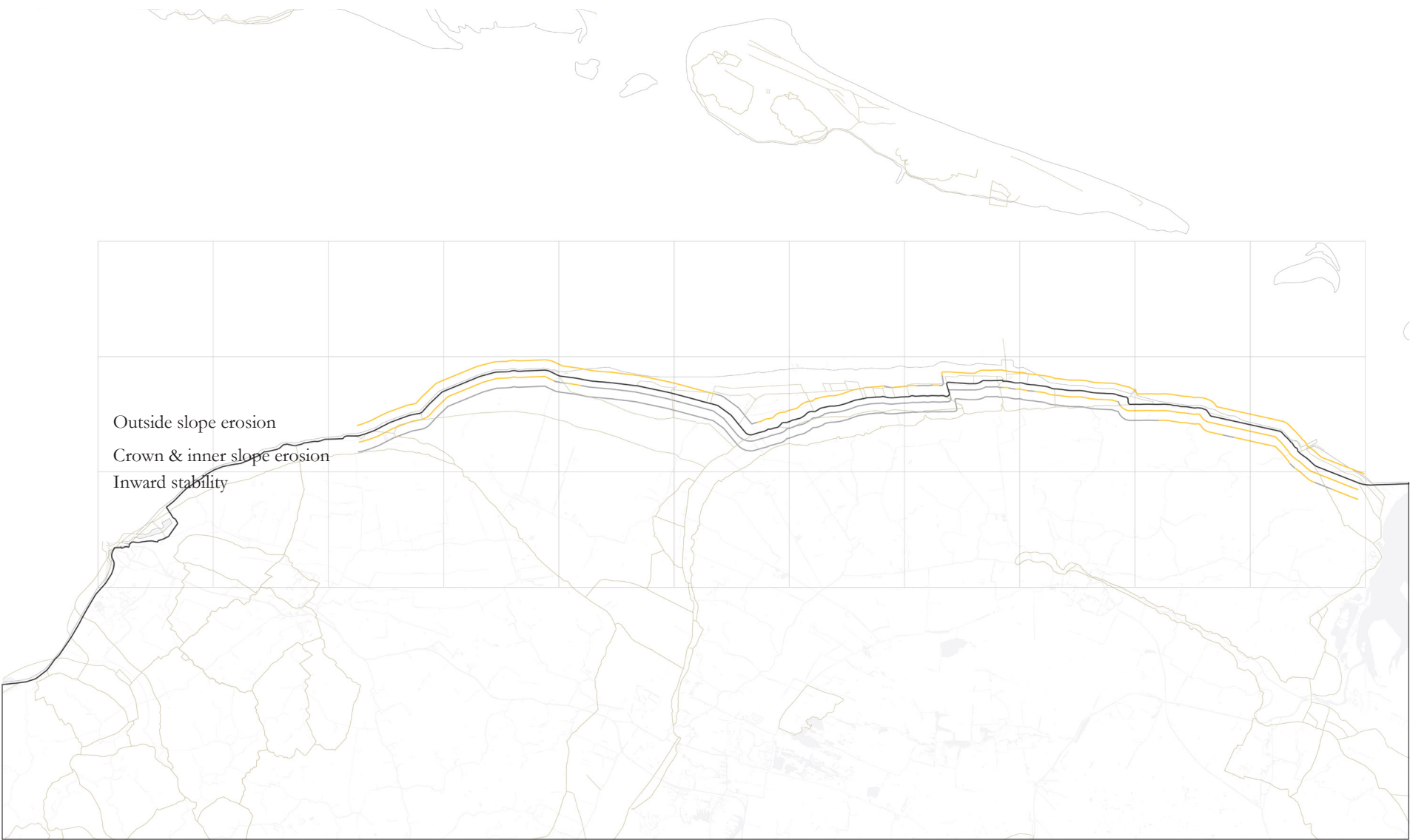
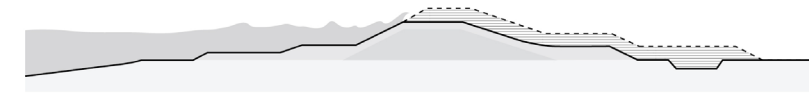
1. Increasing the outer slope



2. Increasing the height/making the inner berm wider



3. Reinforcing revetment (roughness or resistance to wave overtopping)



FAILURE MECHANISMS



Outside slope erosion



Crown & inner slope erosion

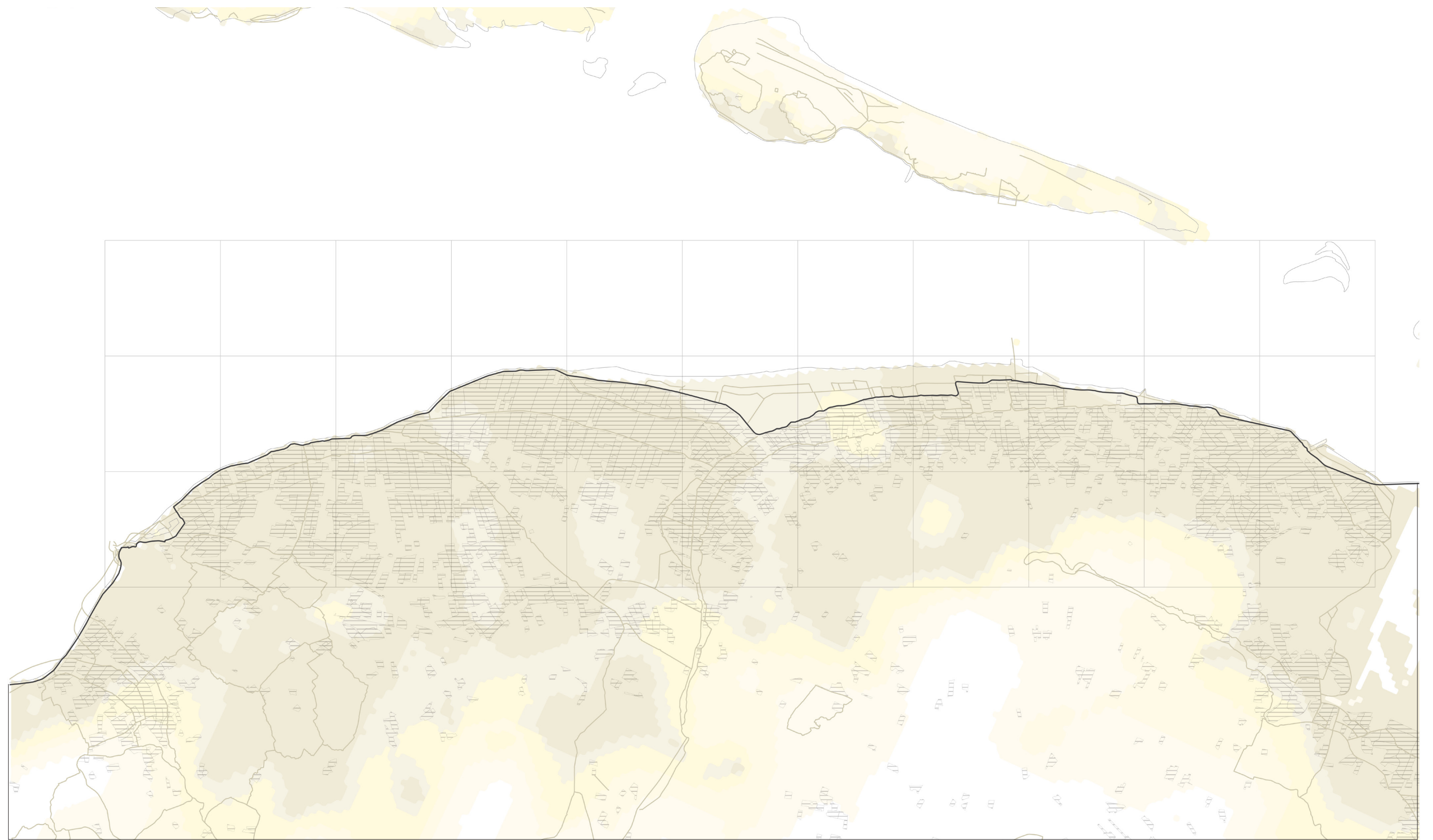


Inward stability



Approved for failure mechanisms
Rejected by failure mechanisms

Salinization



0

5 km

15 km

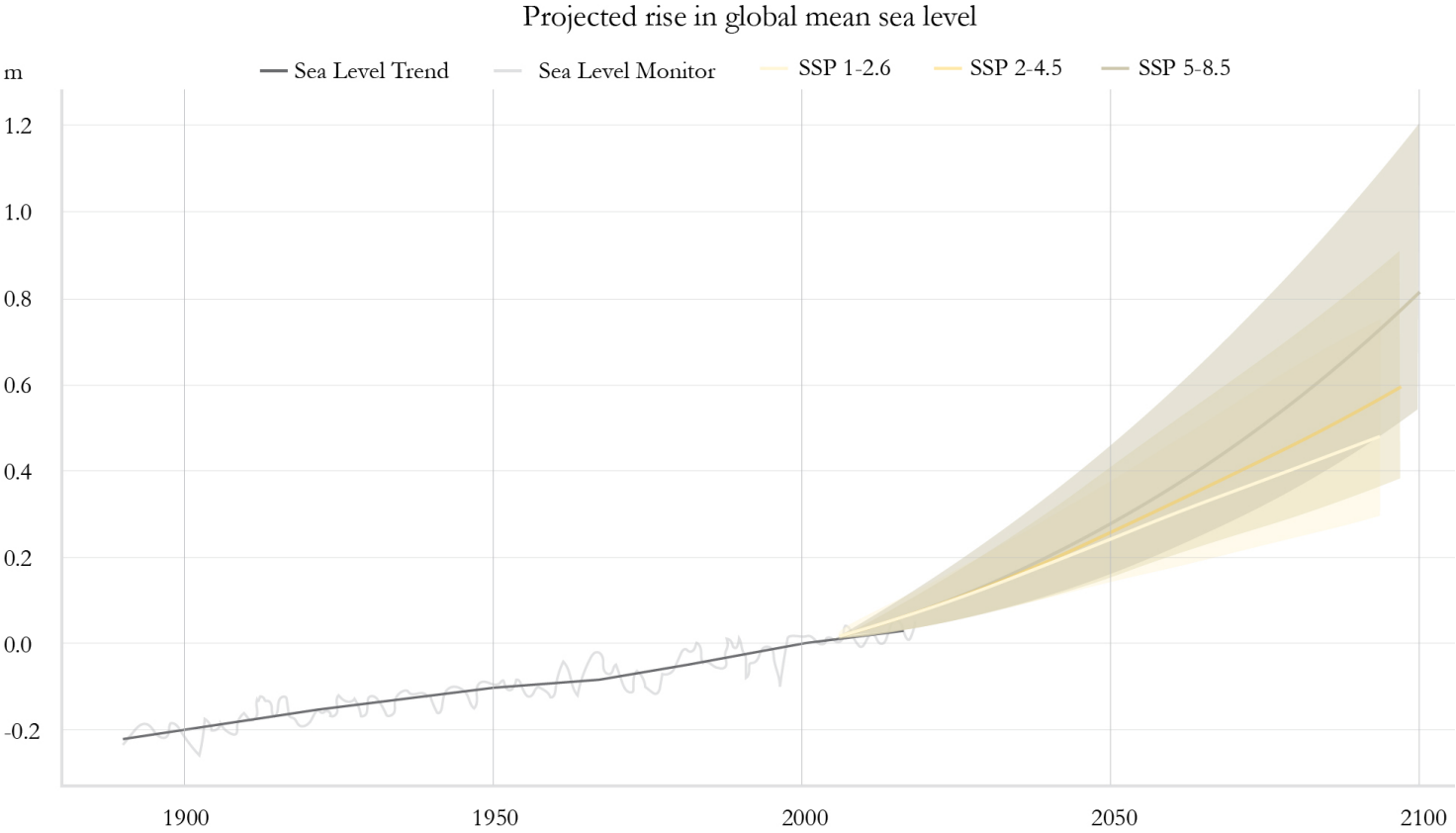
N

Salinization of groundwater
0-5m below ground level
5-10m
10-25m
25-50m
50-100m
Cropland

the Future
the vulnerable landscape

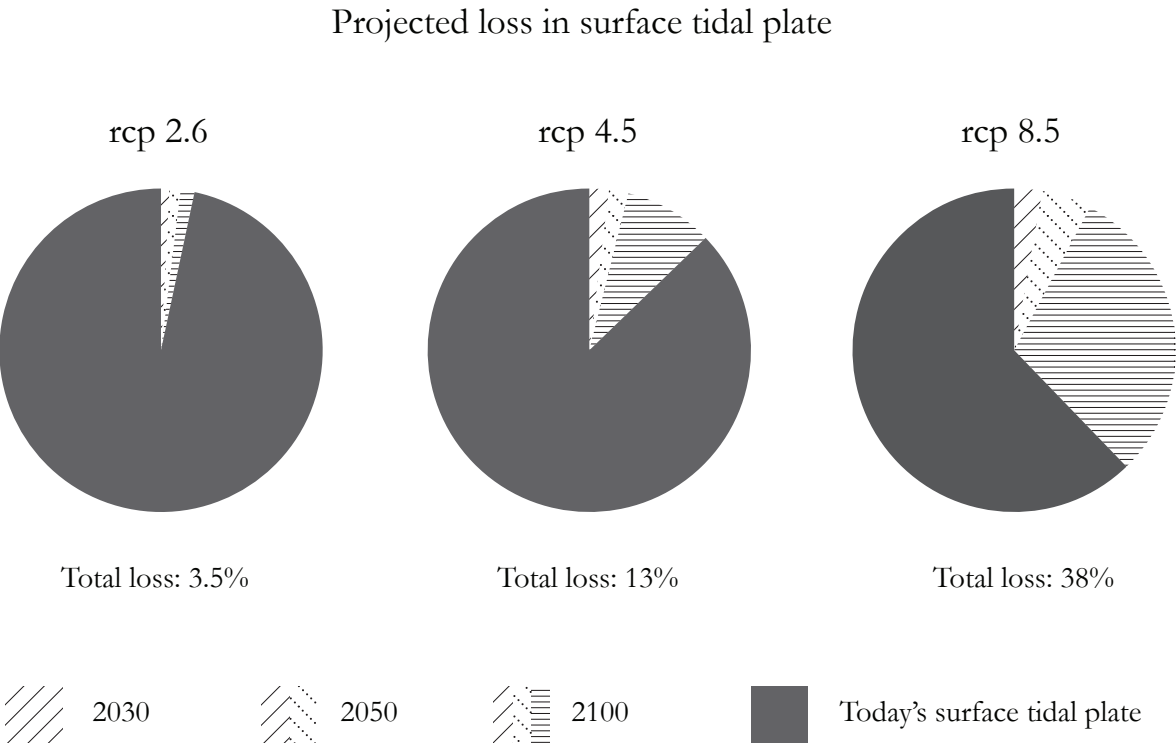
Sea Level Rise In The Future

Data: Climate Signal' 21, 2021.



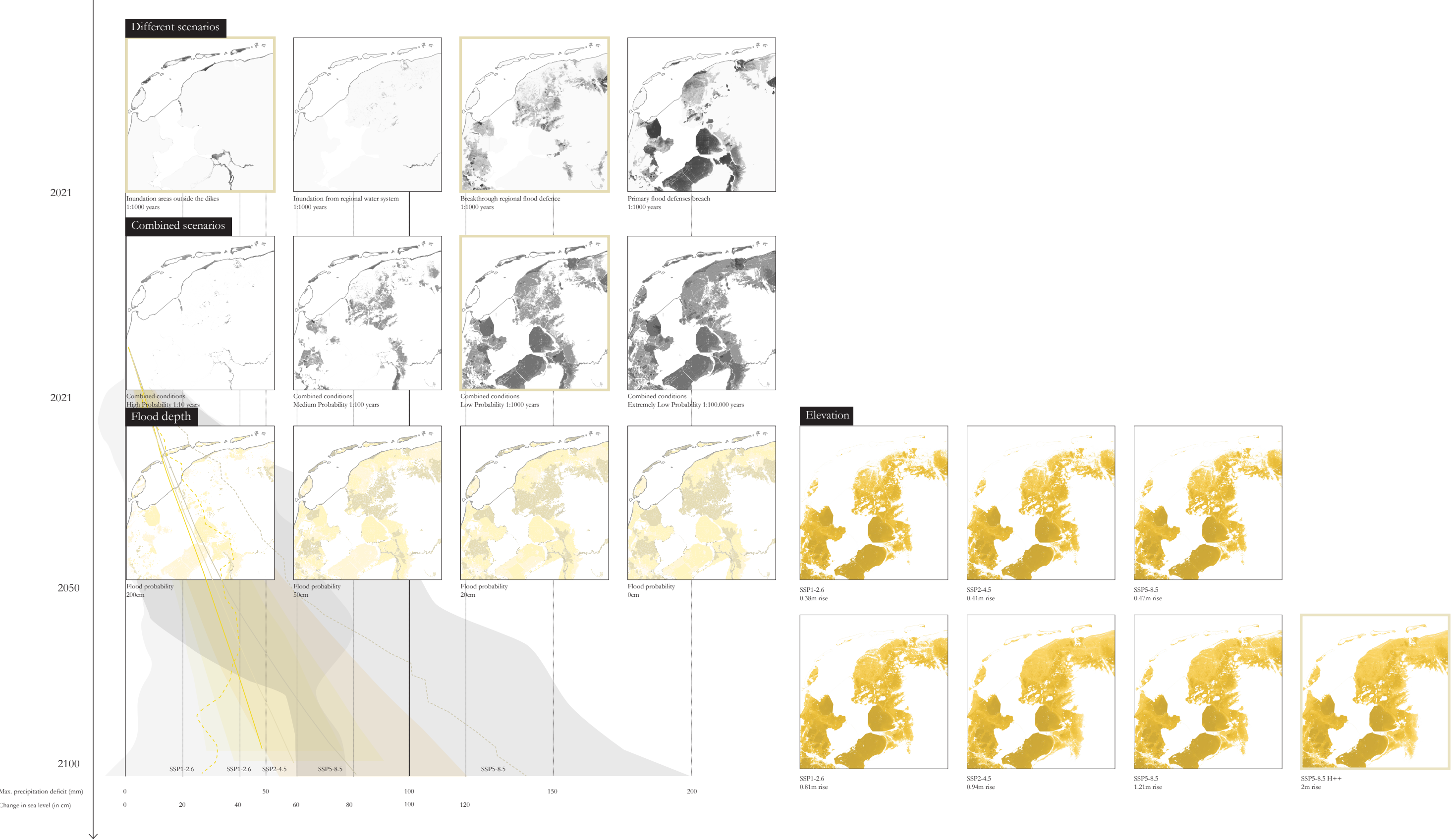
Loss Of Tidal Plains

Data: Van der Spek, 2018



Future Uncertainties

Data: Climate Impact Atlas, 2021.



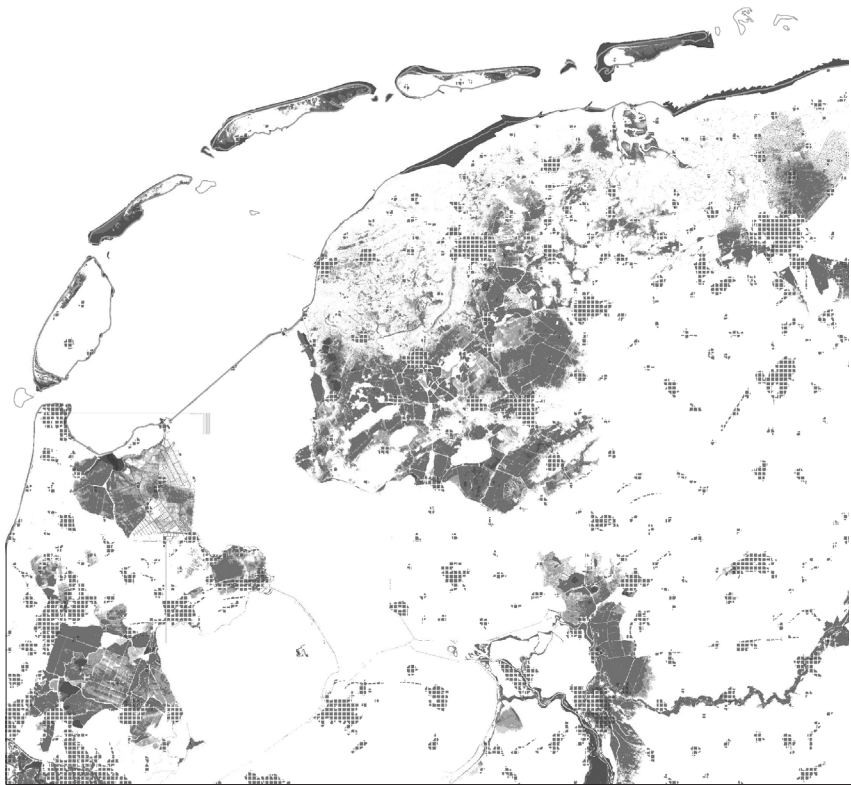
Future Uncertainties

Data: Climate Impact Atlas, 2021.



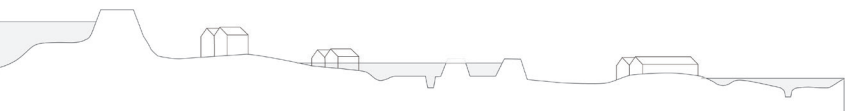
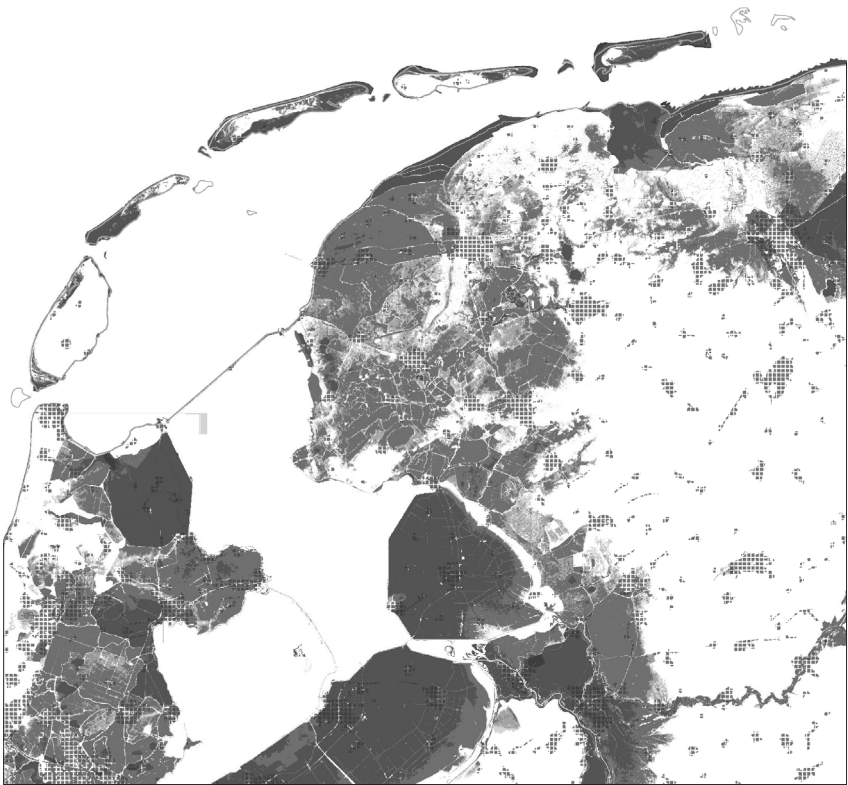
Scenarios In 2100

Data: KNMI Klimaatsignaal'21



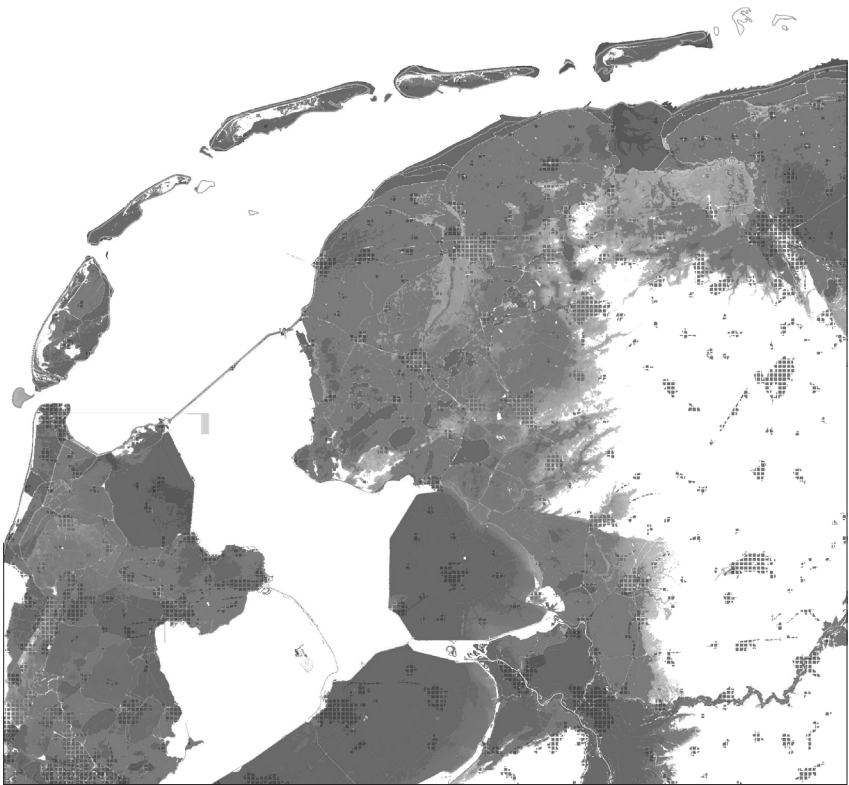
SCENARIO 1
+0.8m sea level rise

SSP1-2.6
High precipitation deficit
Regional dike breach



SCENARIO 2
+1.2m sea level rise

SSP5-8.5
Very high precipitation deficit
Regional dike breach & failure of part of primary dike



SCENARIO3
+2.0m sea level rise

SSP5-8.5 H++
Extremely high precipitation deficit
Primary & regional dike breach

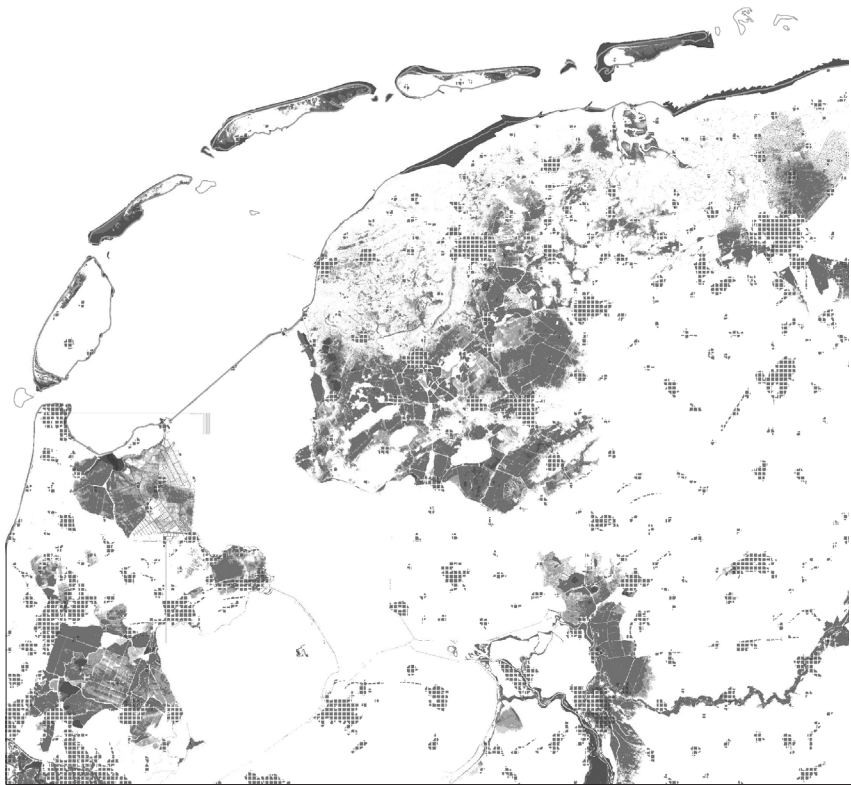
Moderate sea level rise

Extreme sea level rise

“The higher the degree
of uncertainty concerning the future the
more appropriate is the application of the
scenario approach”
(Ahern, 1999)

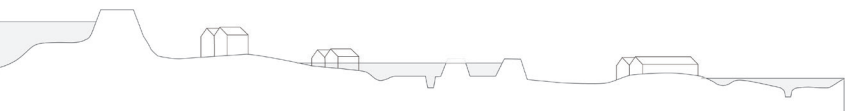
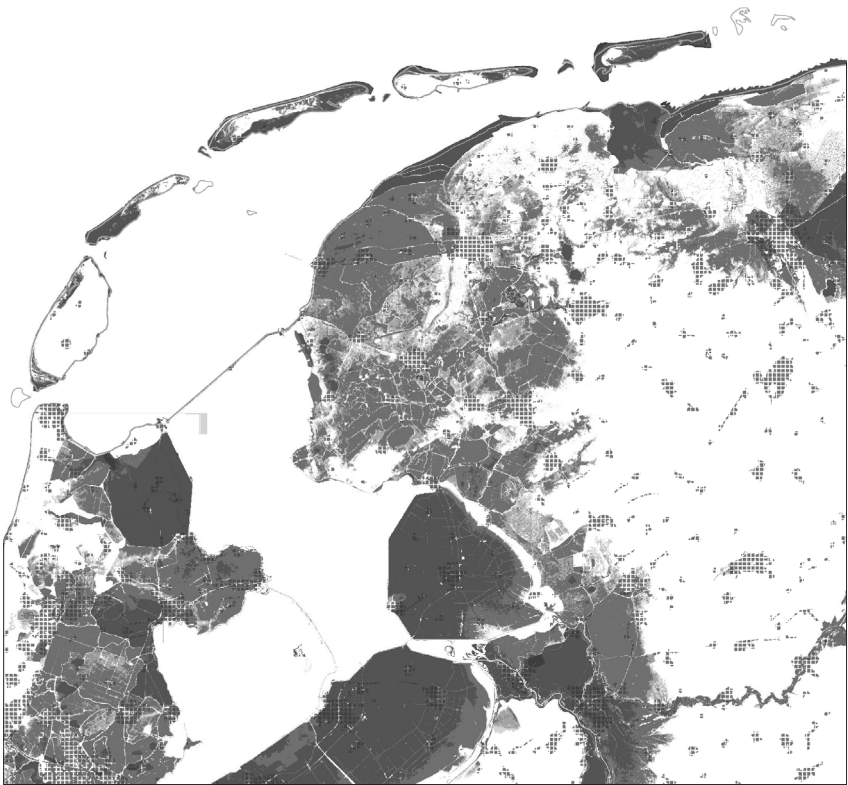
Scenarios In 2100

Data: KNMI Klimaatsignaal'21



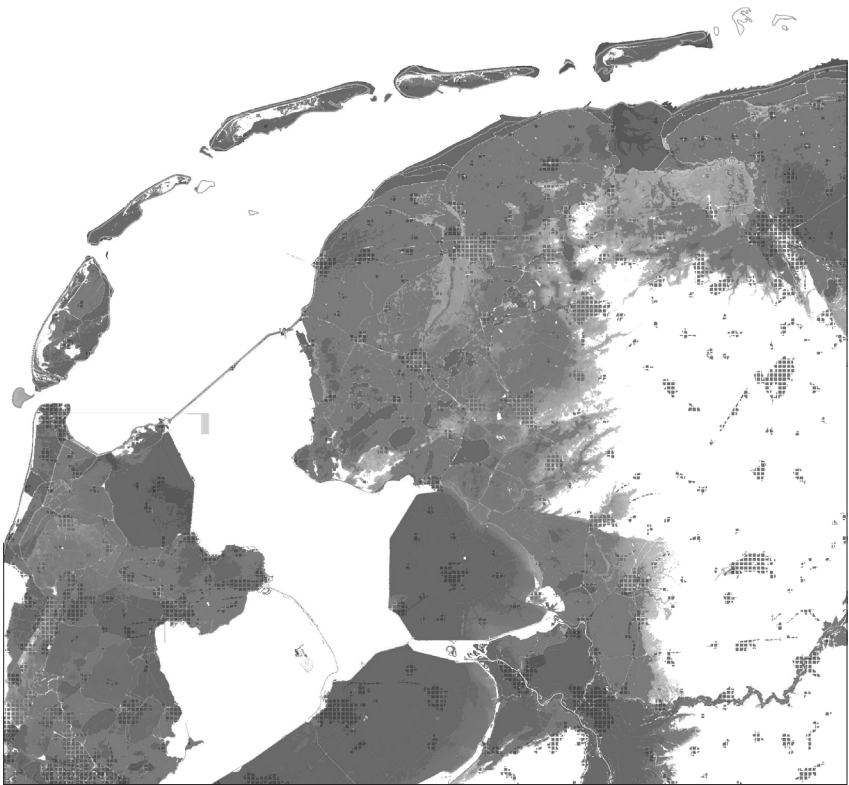
SCENARIO 1
+0.8m sea level rise

SSP1-2.6
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Regional dike breach



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+1.2m sea level rise

SSP5-8.5
Very high precipitation deficit
Regional dike breach & failure of part of primary dike



SCENARIO3
+2.0m sea level rise

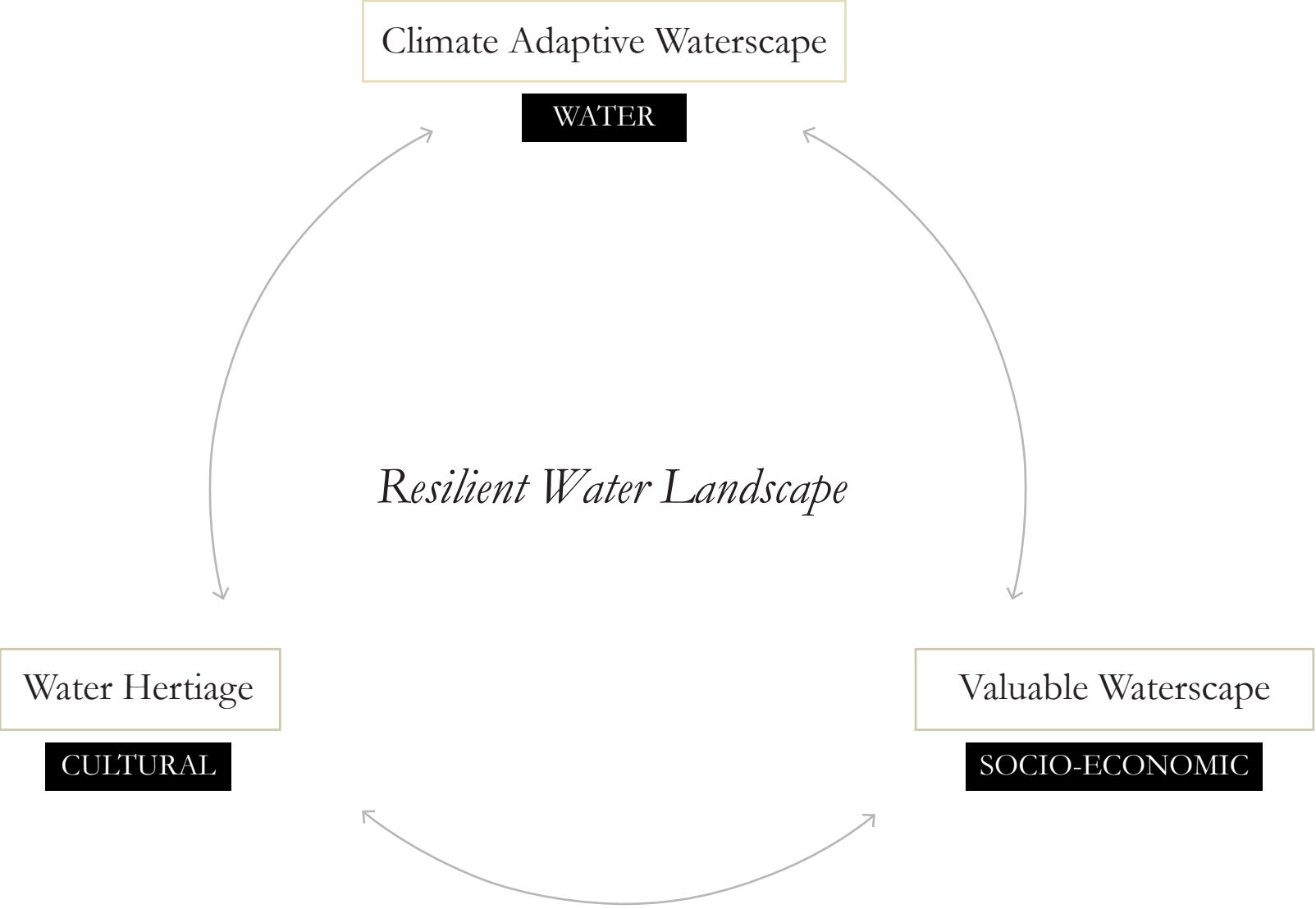
SSP5-8.5 H++
Extremely high precipitation deficit
Primary & regional dike breach

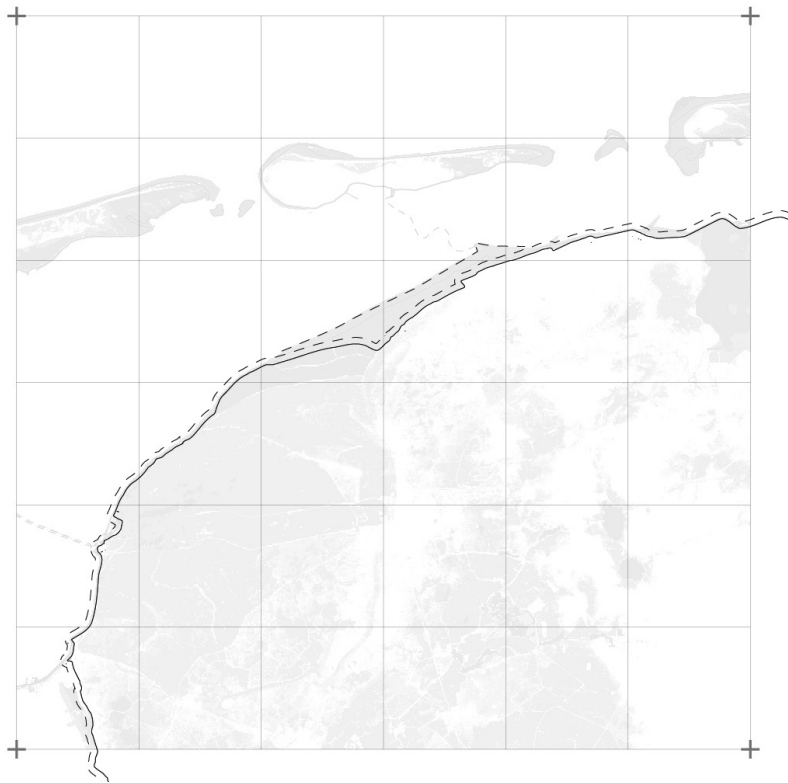
Moderate sea level rise

Extreme sea level rise

Design

An adaptive & resilient landscape





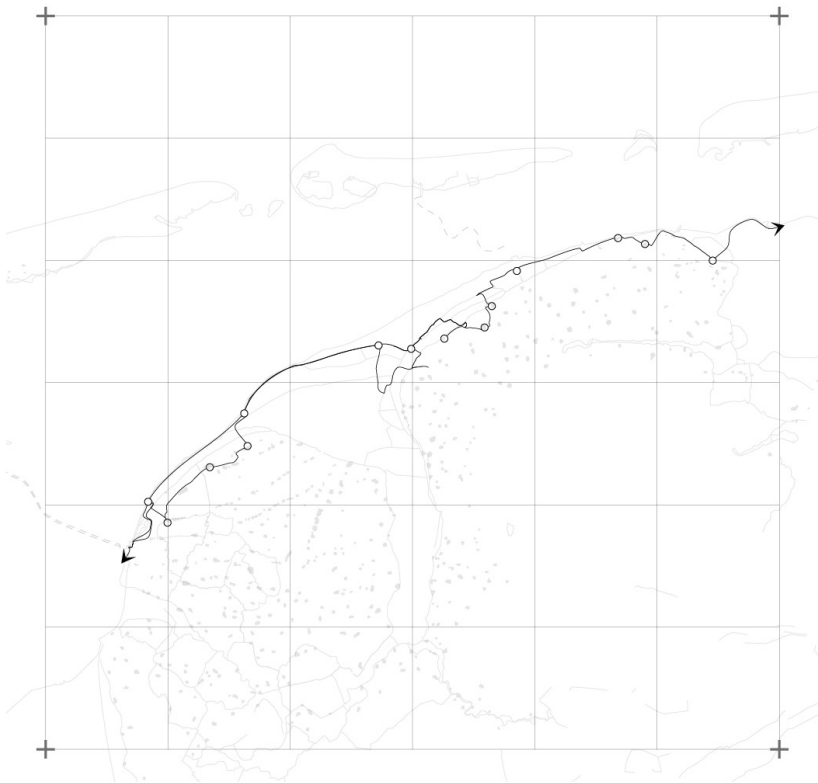
Climate Adaptive Waterscape

WATER

STRATEGY 1.

Develop a landscape-integrated approach along the coastline for climate adaptation

- Expansion of salt marshes for coastal defence
 - Double dike system
- Multifunctional flood protection zone
- Saline agriculture to adapt salinization



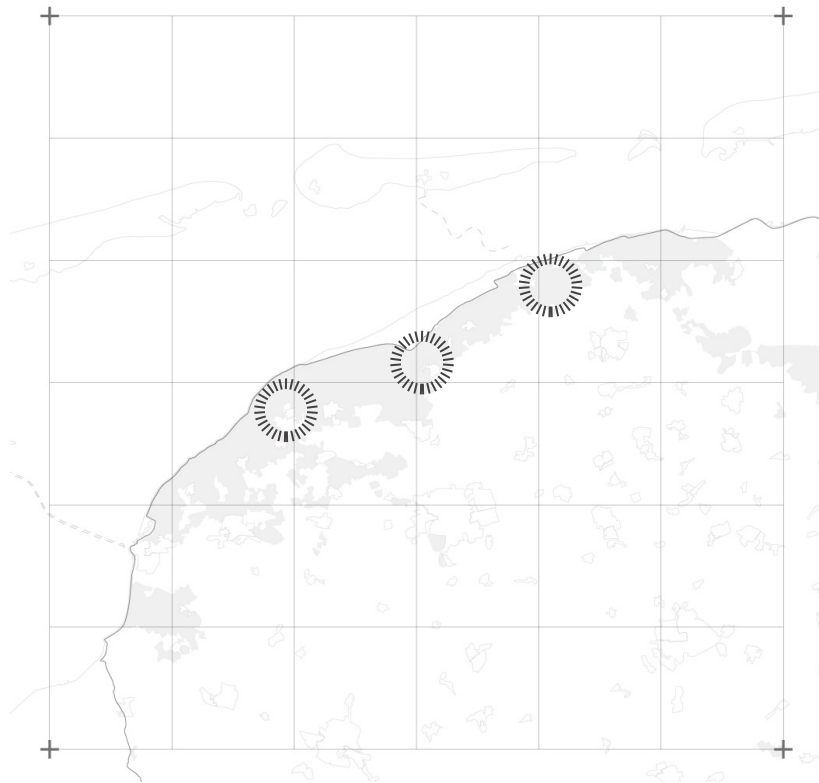
Water Hertiage

CULTURAL

STRATEGY 2.

Strengthen landscape identity and the value of the cultural water heritage

- Routing design connecting to the water heritage
 - Restoring the role of the old sea dike



Valuable Waterscape

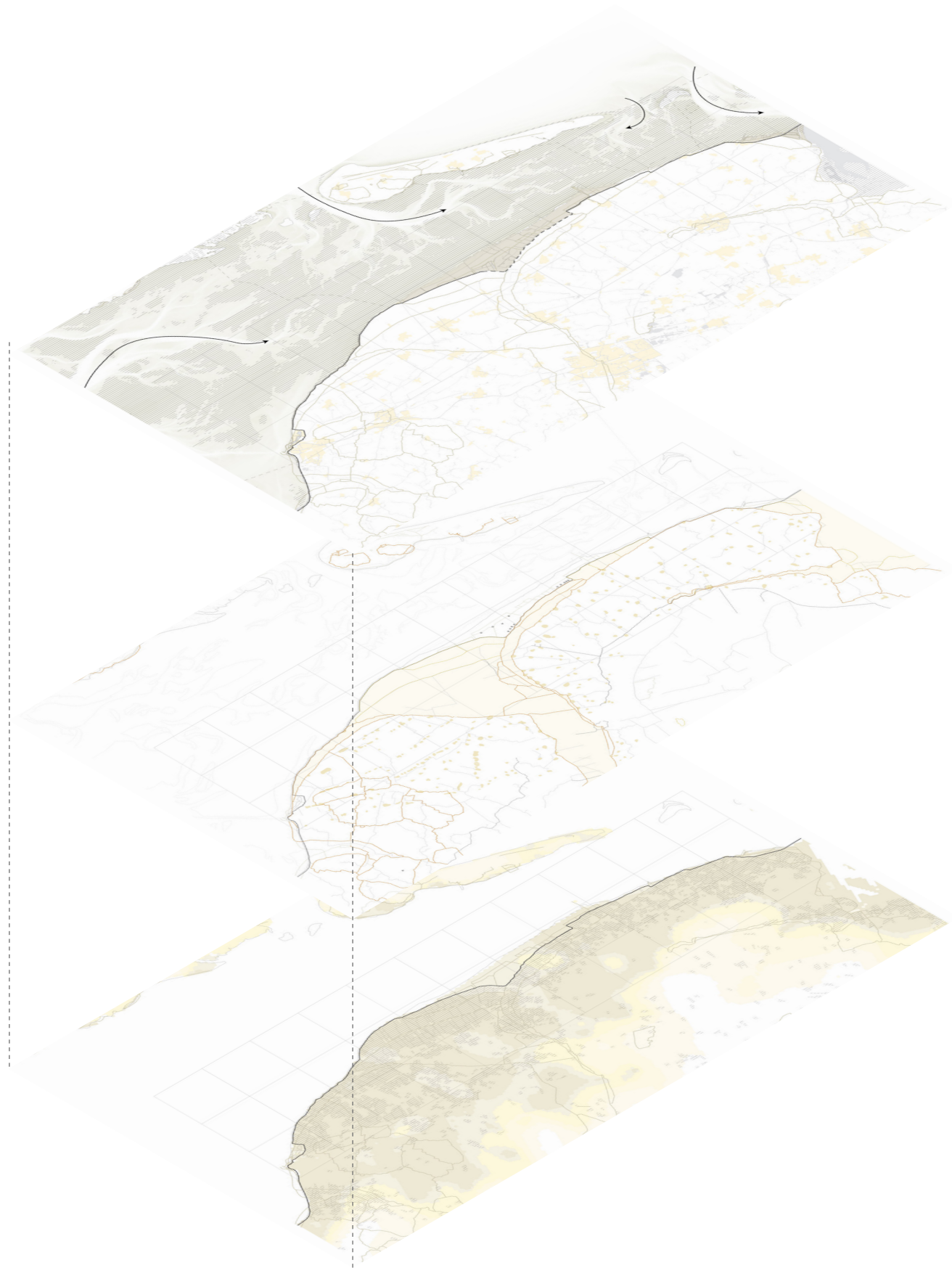
SOCIO-ECONOMIC

STRATEGY 3.

Enhance the regional economy and livability to make the coast an attractive living and working place

- Bring new socio-economic & ecological opportunities
 - Enhance connections to the Wadden Islands
- Introduce saline agriculture as a new type of productive landscape

Design Diagnosis

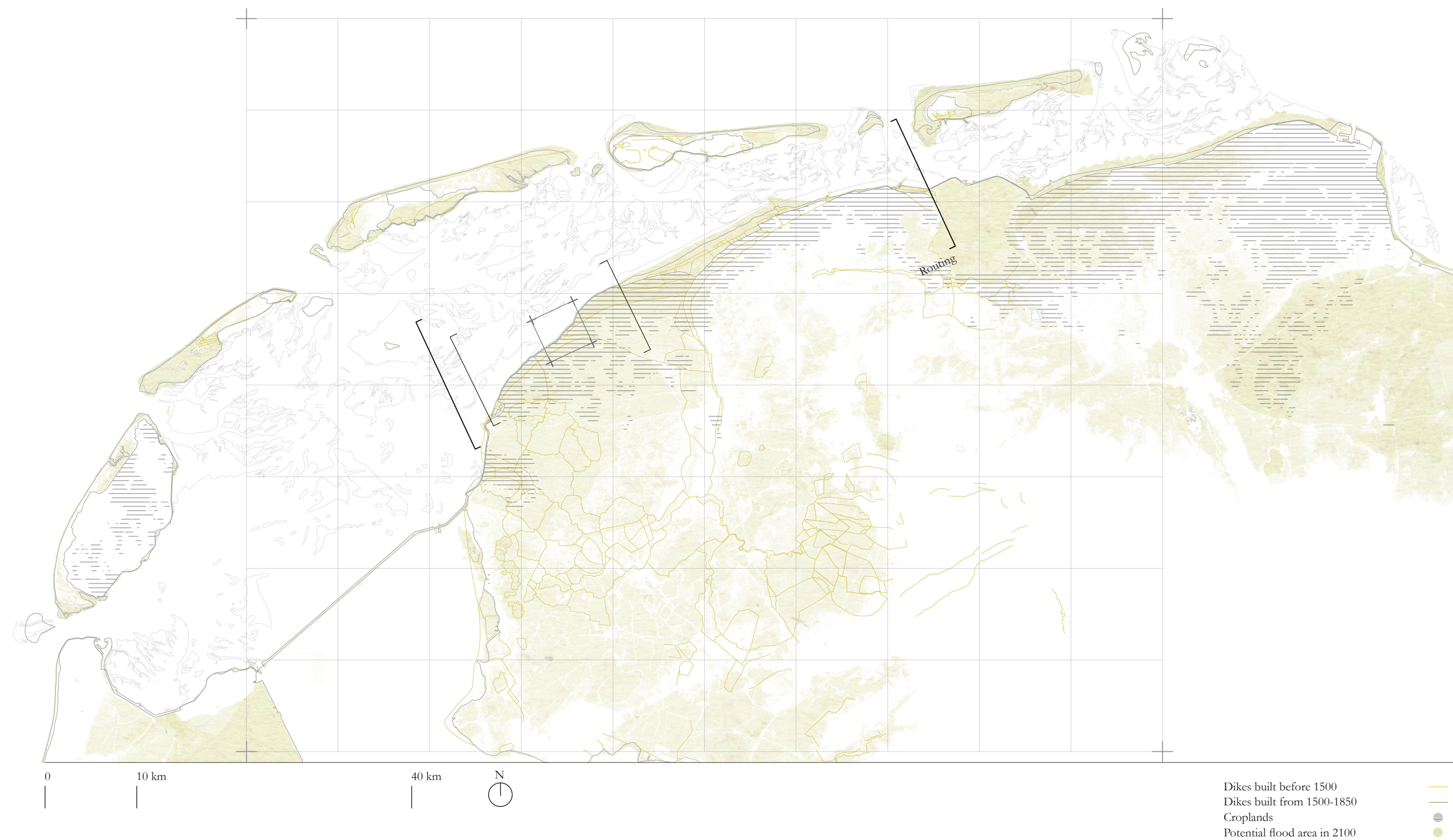


CLIMATE ADAPTIVE WATERSCAPE
Water defense system

WATER HERITAGE
Cultural system

VALUABLE WATERSCAPE
Socio-economic system

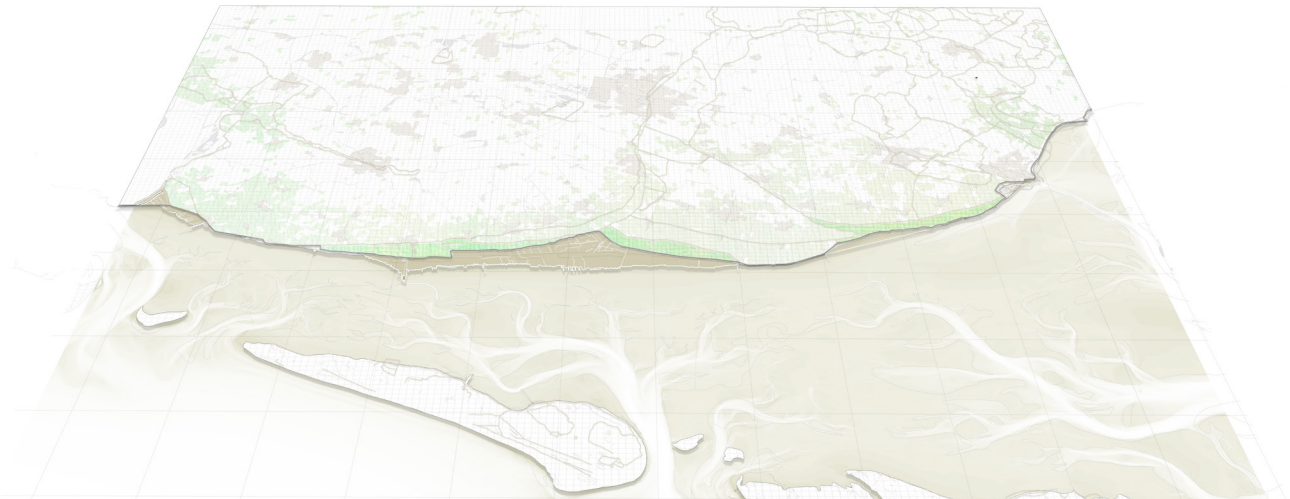
Water As Opportunities



Regional strategic plans



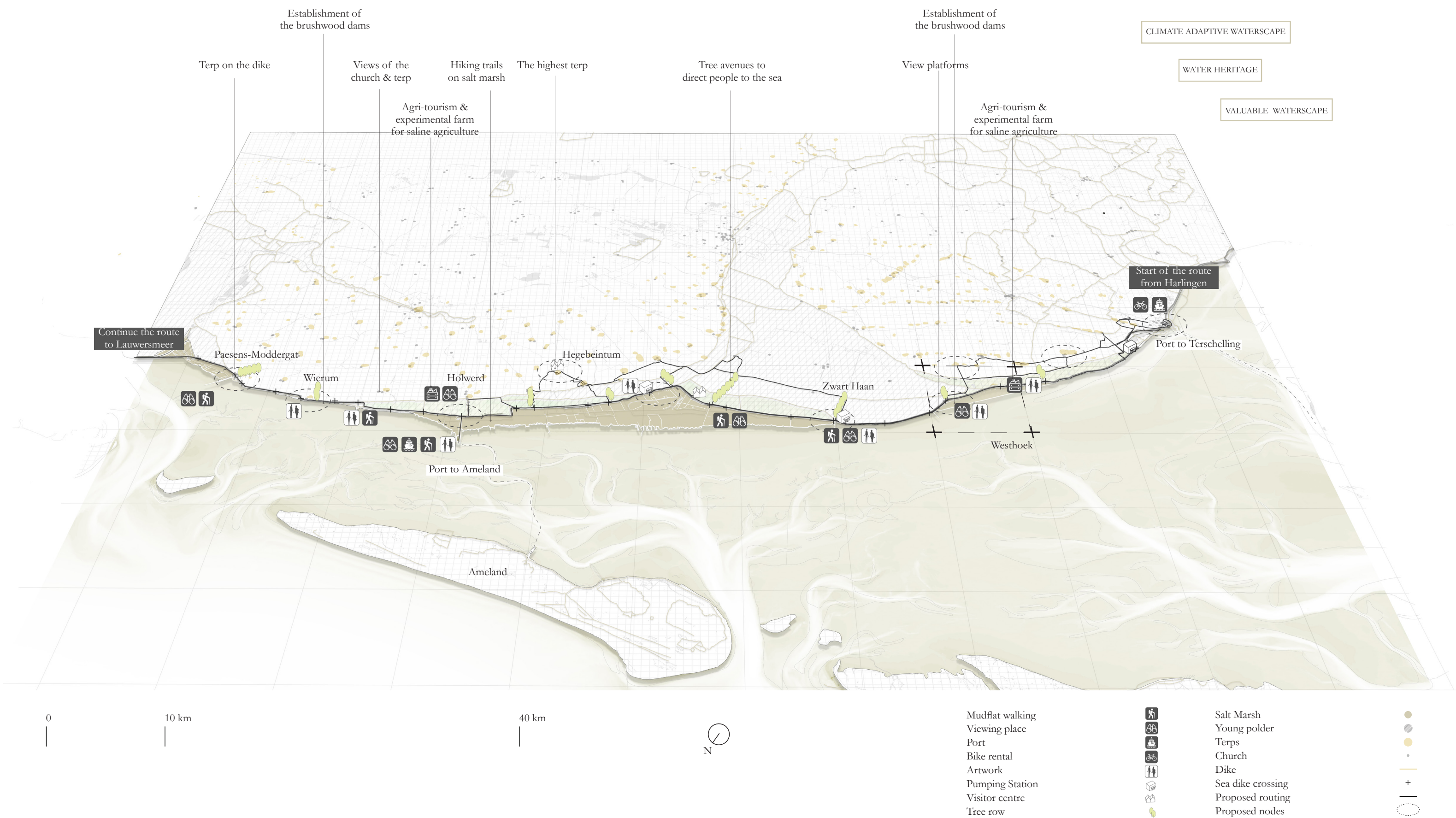
2030



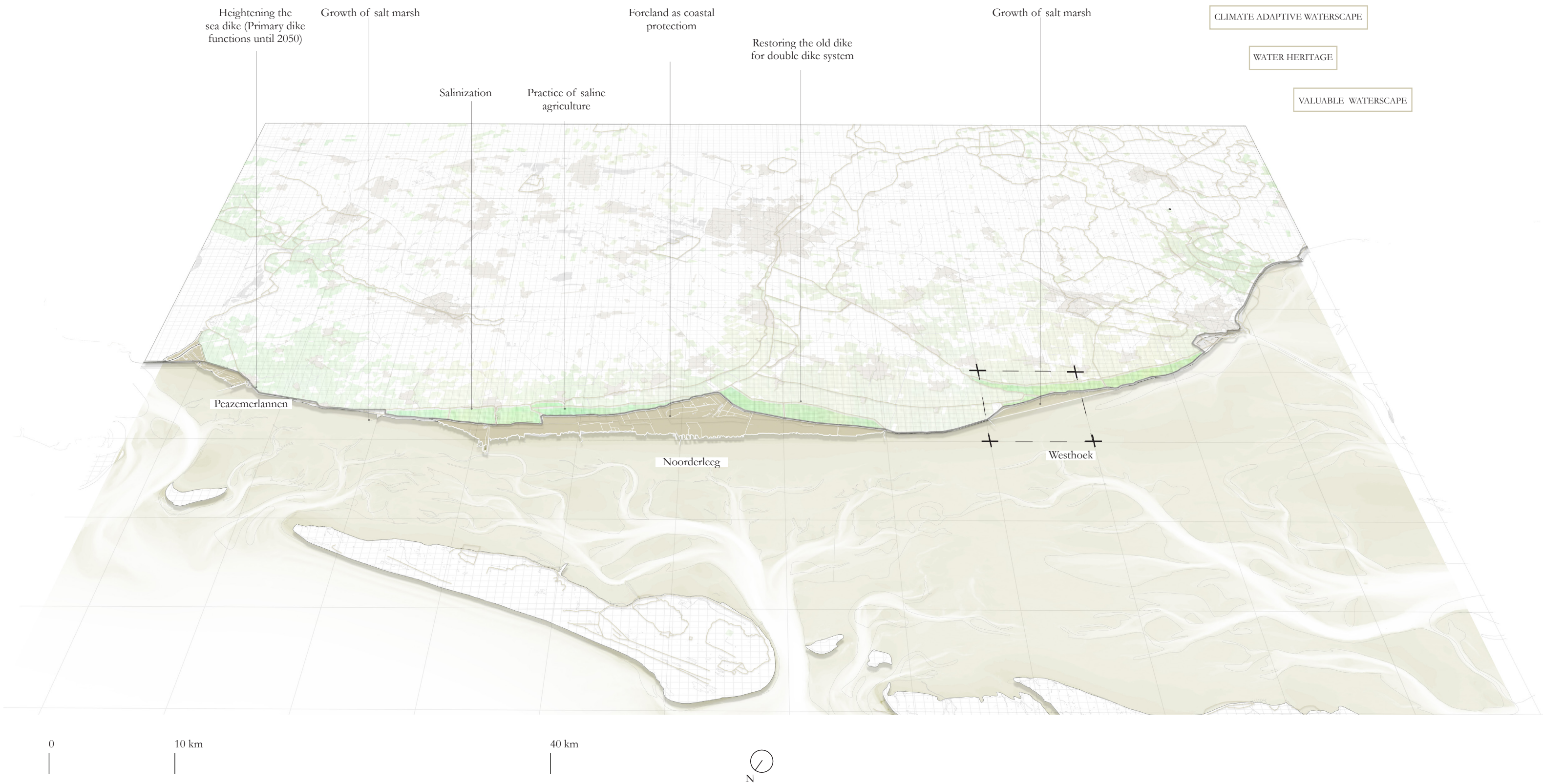
2050



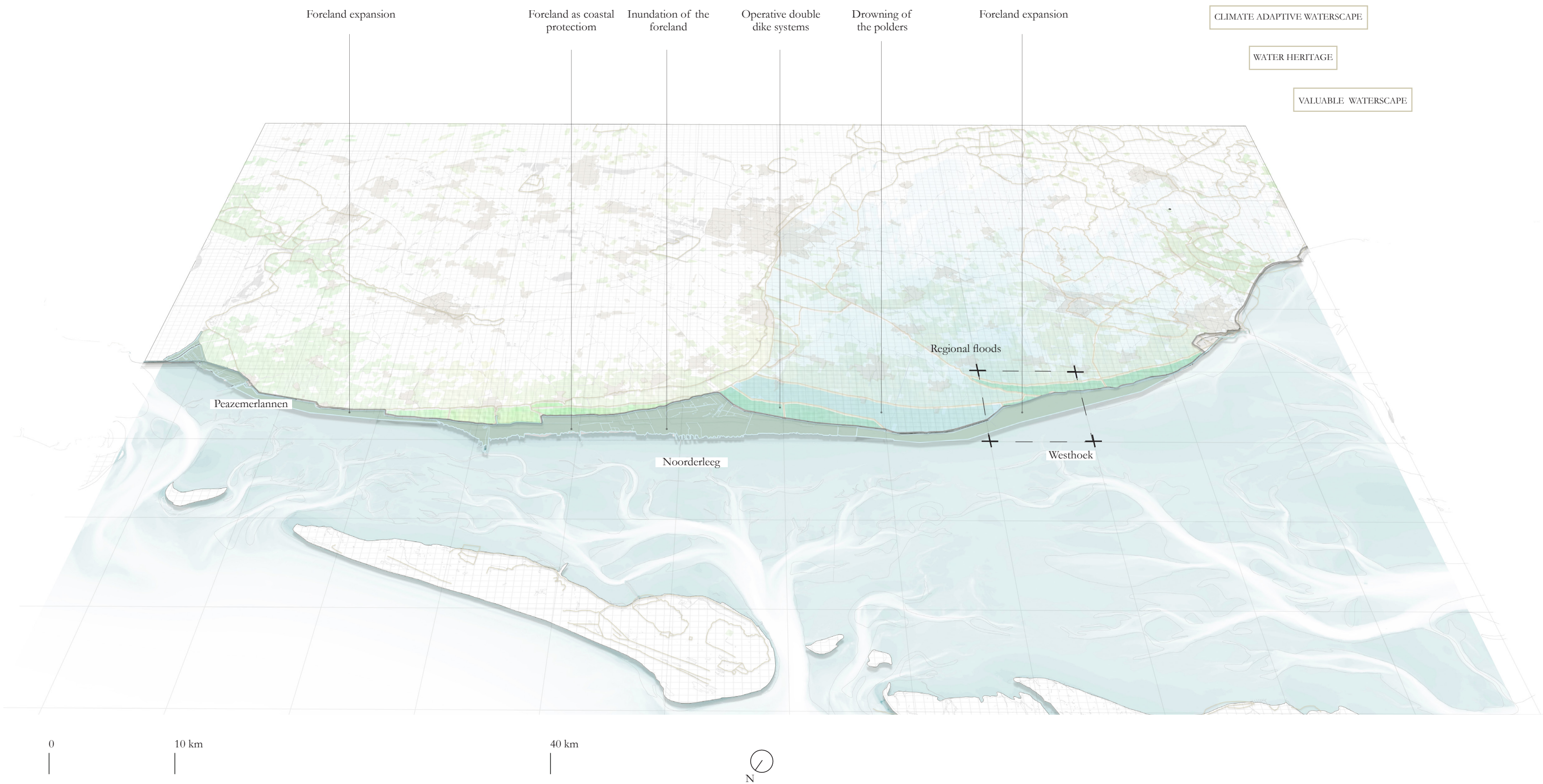
2070



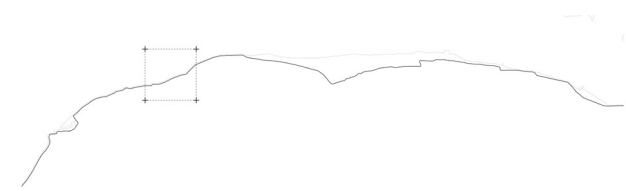
2050



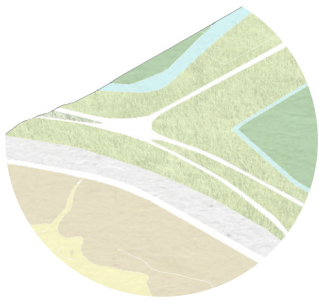
2070



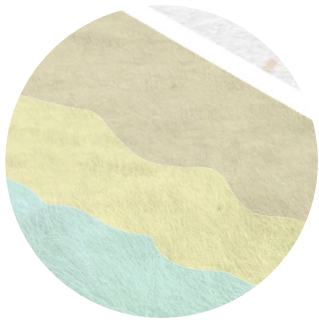
Design Location



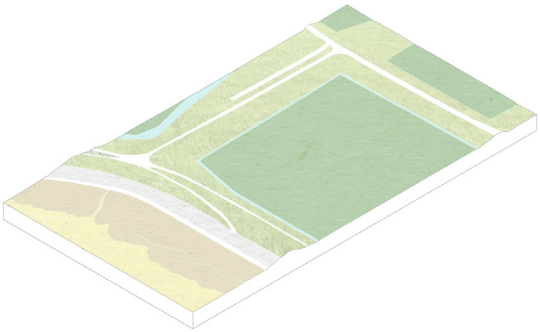
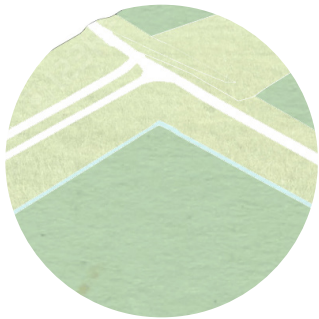
Interesting nodes



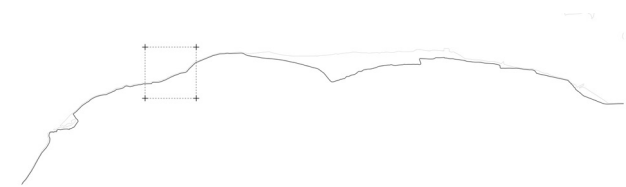
Salt Marsh



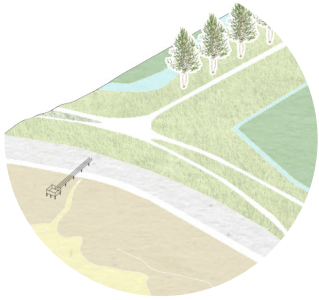
Old sea dike



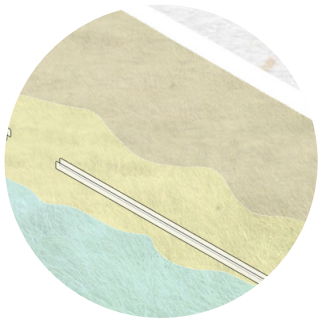
Design Location



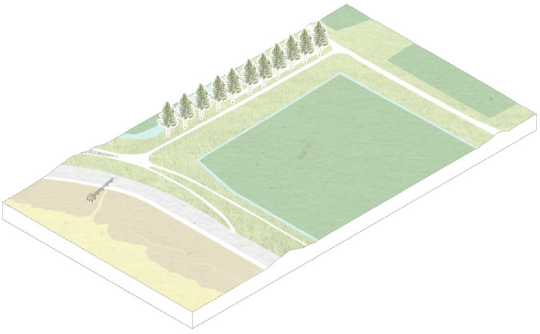
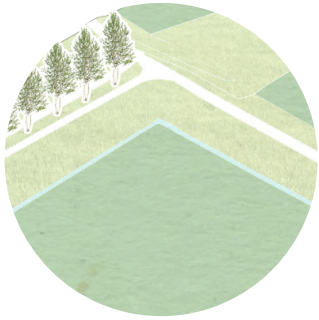
Routing & Node



Salt Marsh Flood Defense

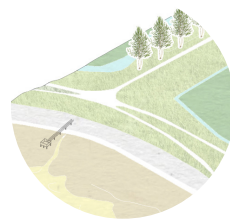


Double Dike System & Saline agriculture

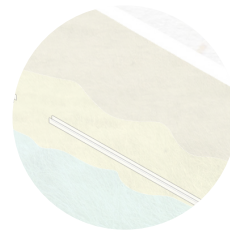


2030

Routing Design



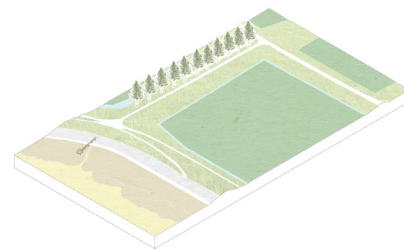
Routing & Node



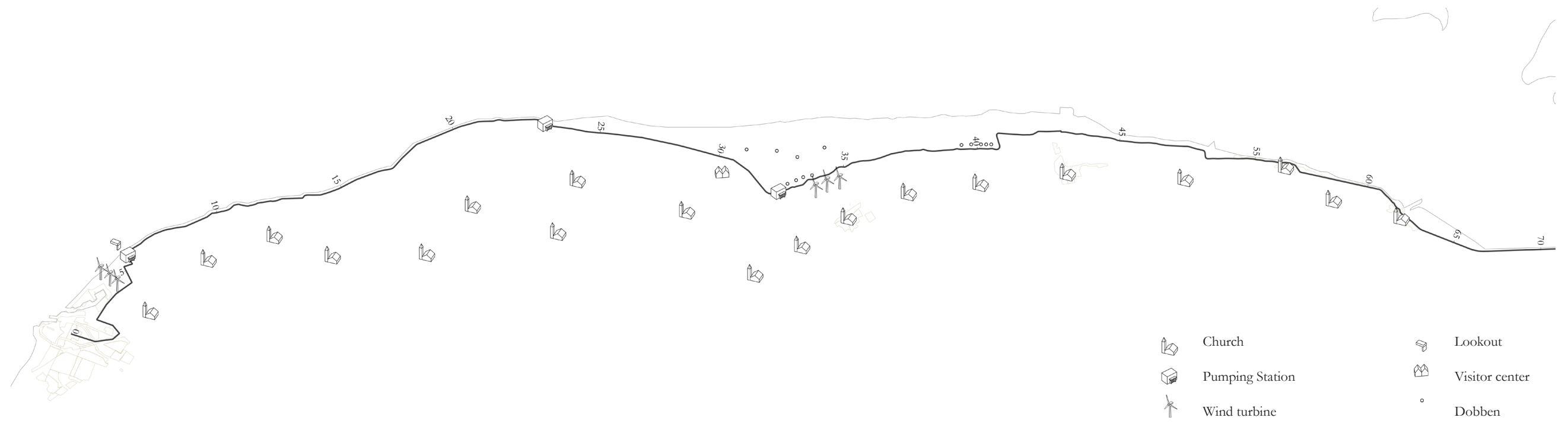
Salt Marsh Flood Defense



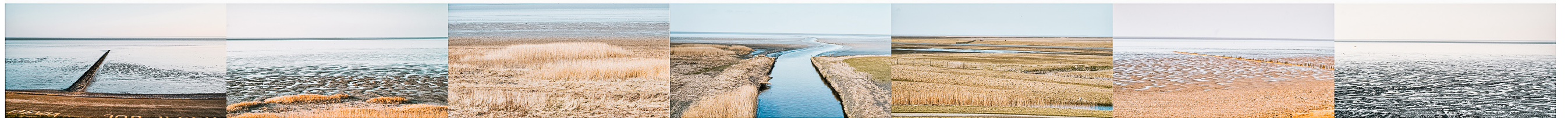
Double Dike System &
Saline agriculture



Routing Experience

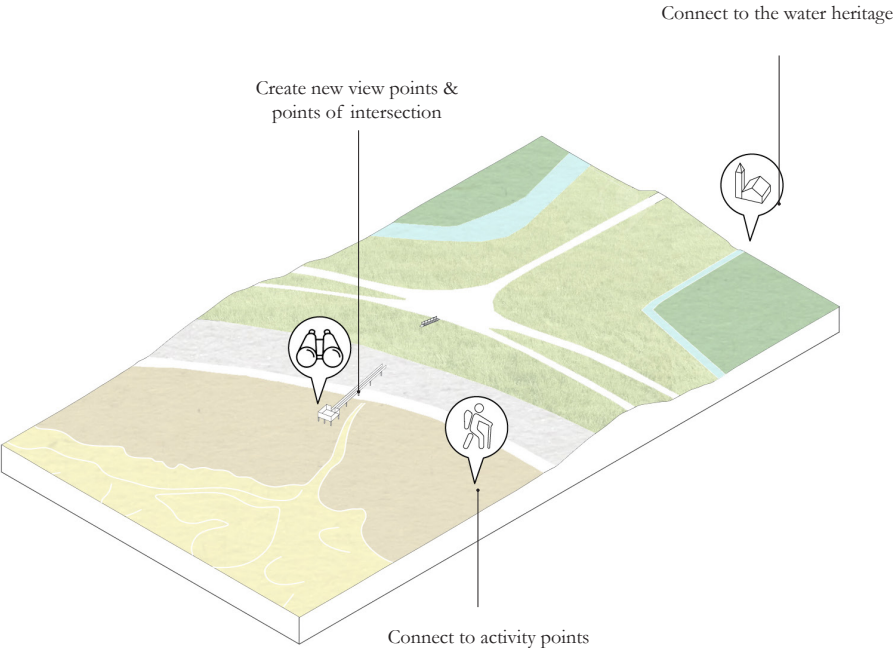
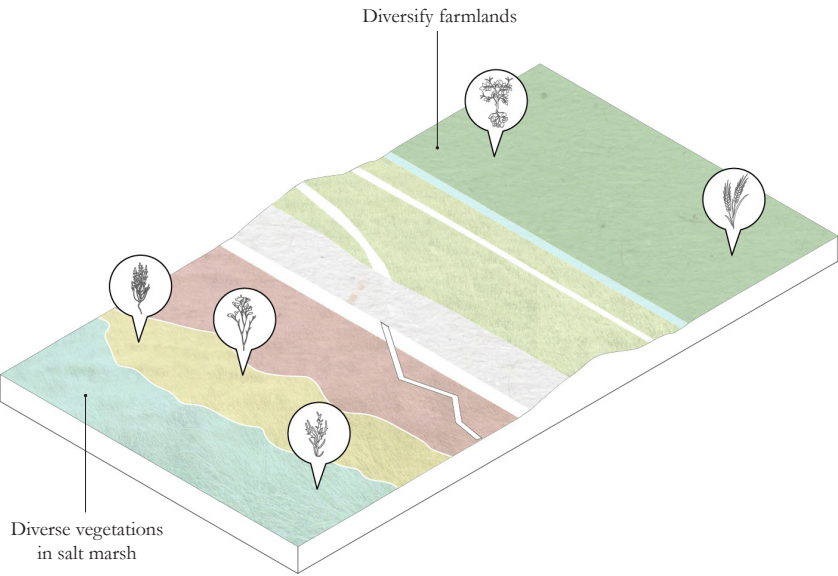
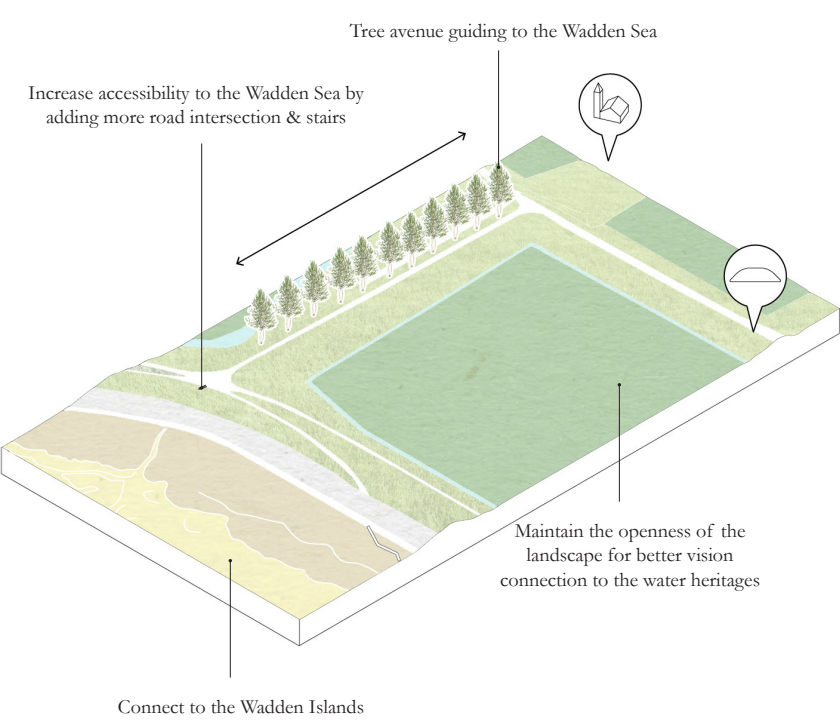


Land

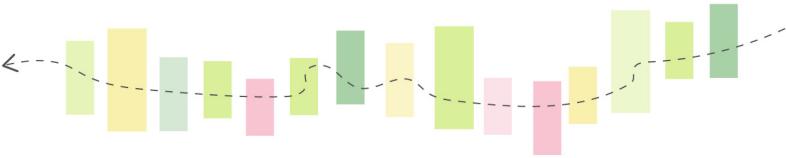


Wadden Water

Routing Design Principles



1. CONNECTIVITY

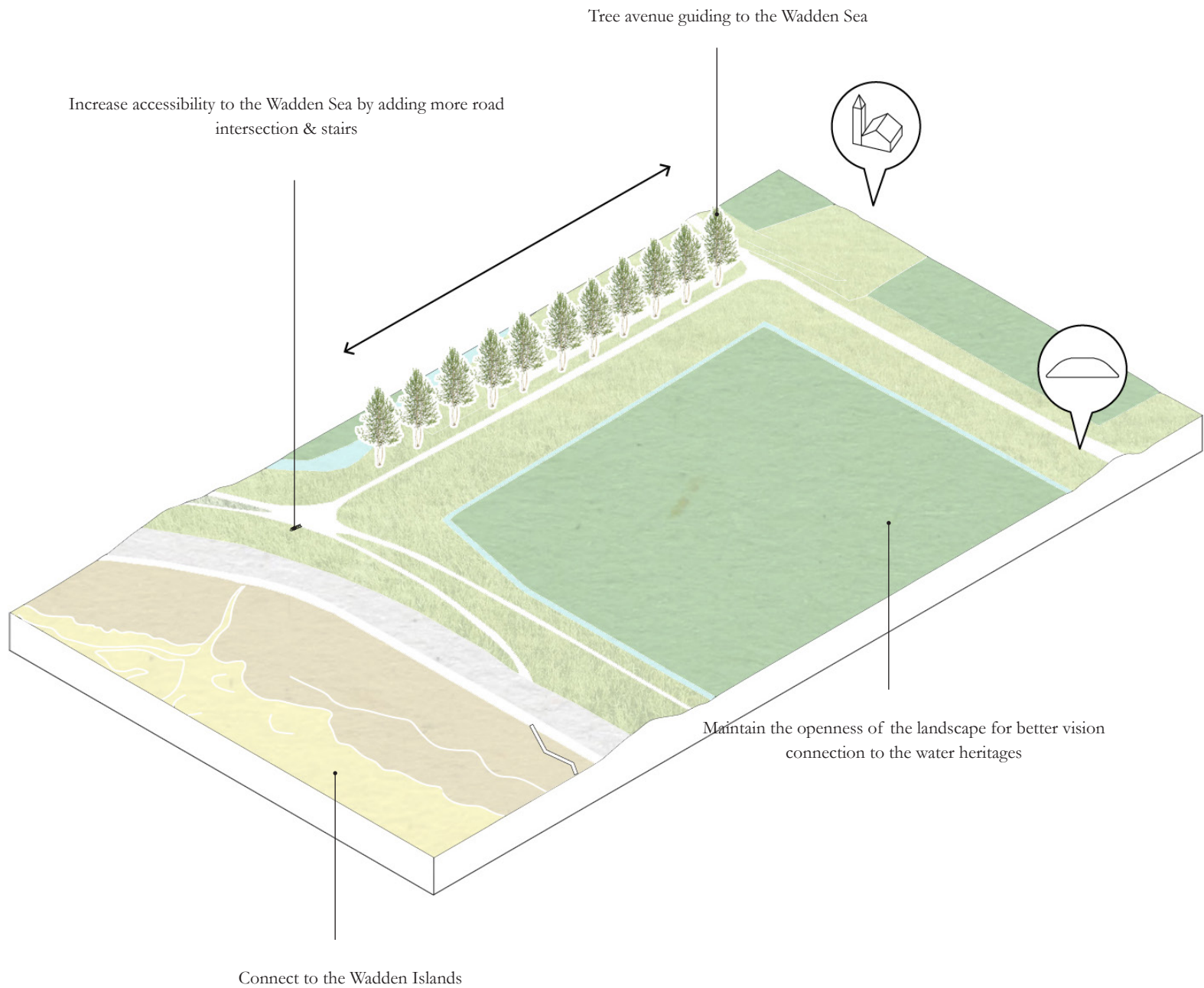
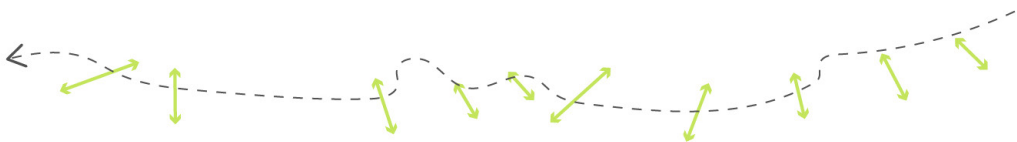


2. SENSORY EXPERIENCE

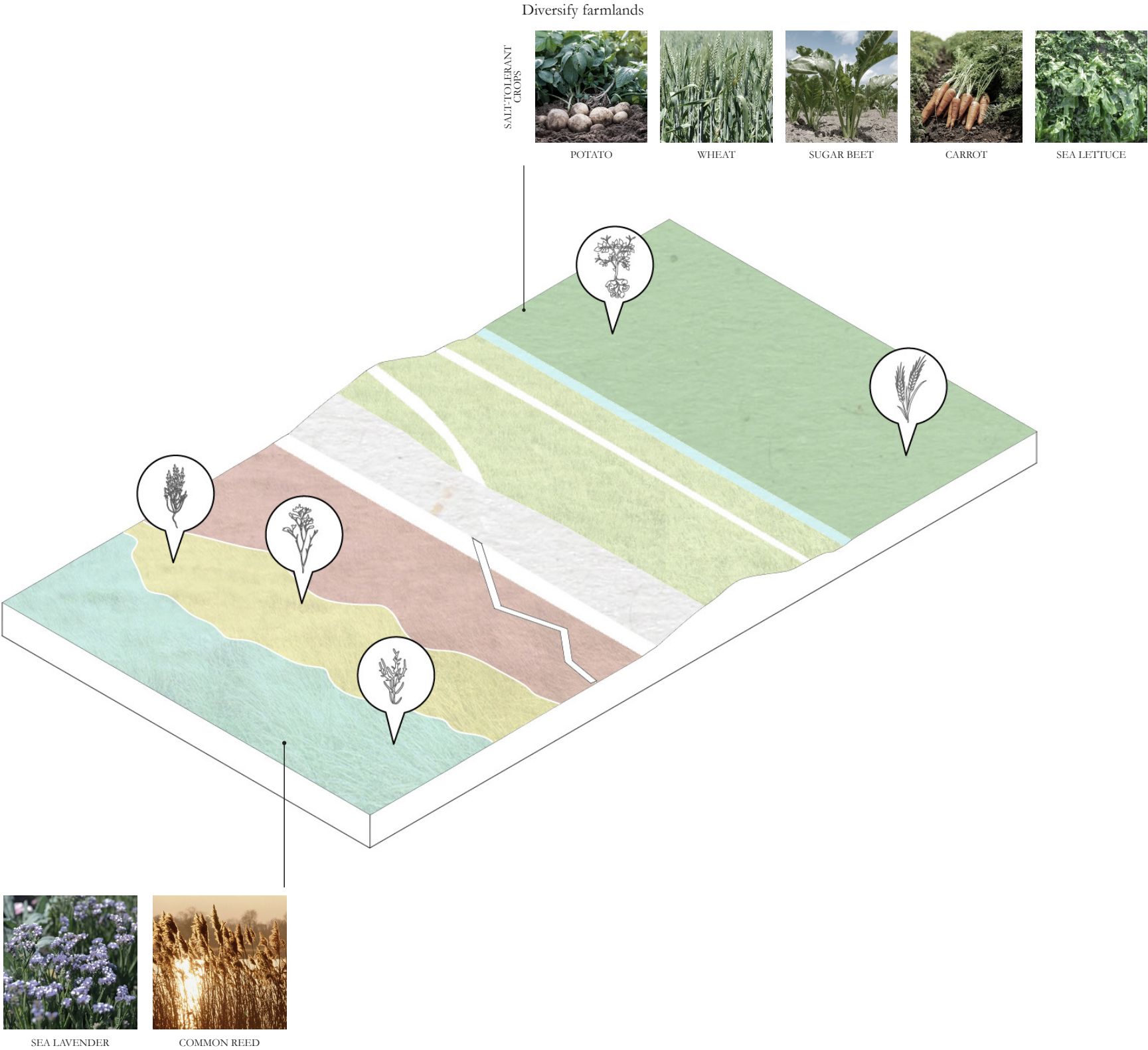
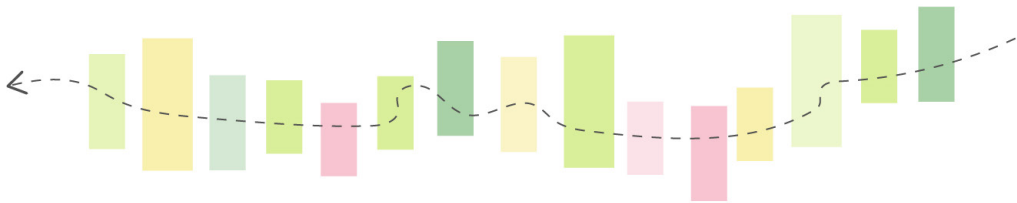


3. NODES

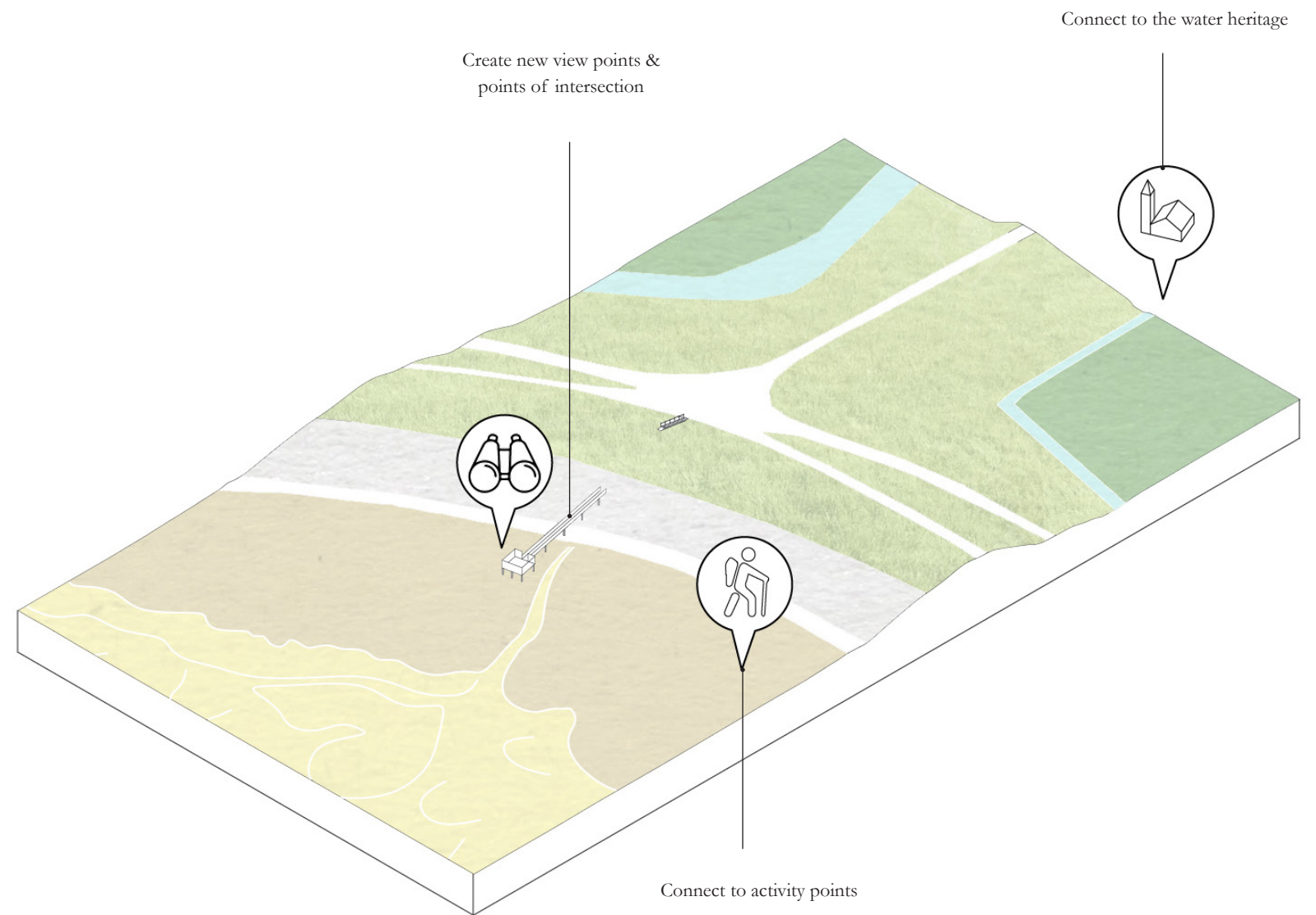
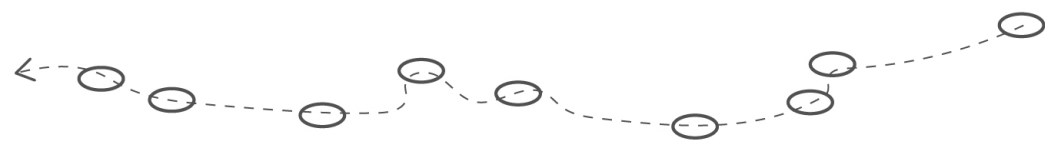
Routing Design Concept 1: Connectivity



Routing Design Concept 2 : Sensory Experience



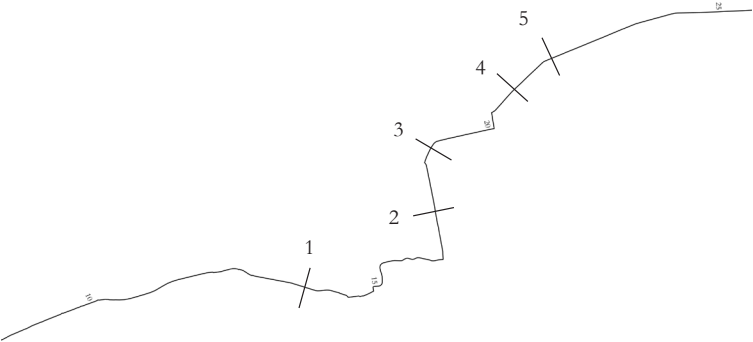
Routing Design Concept 1: Nodes



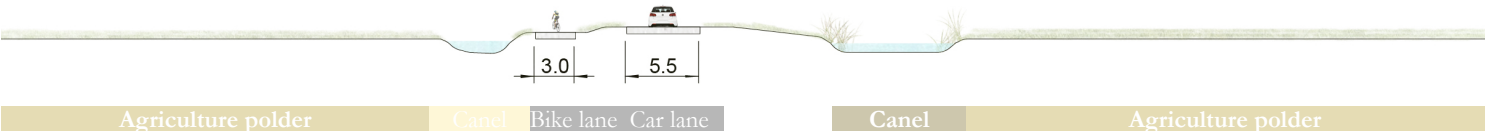
Routing Design



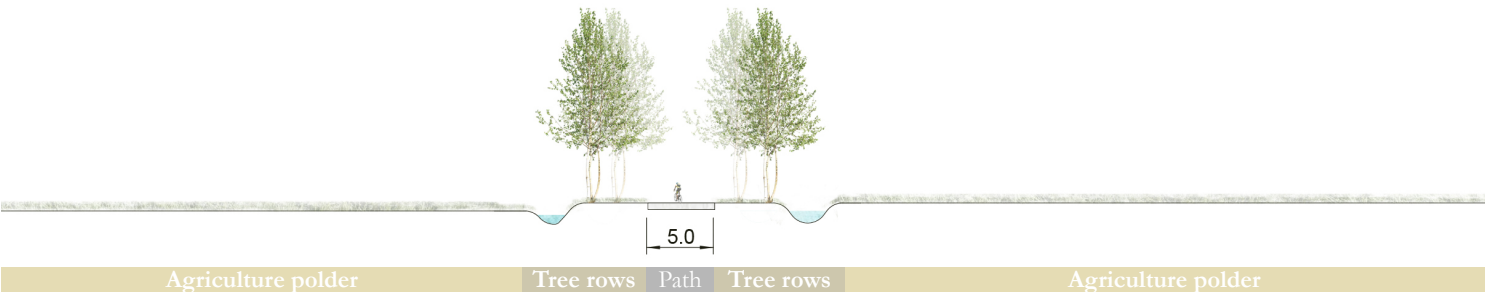
Routing Design



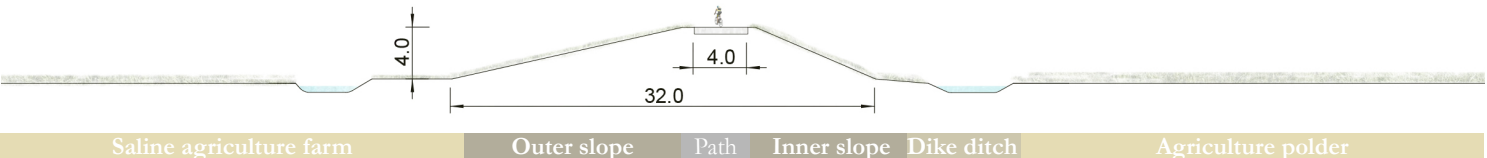
Section 1 Bike path along the canal to the terp village



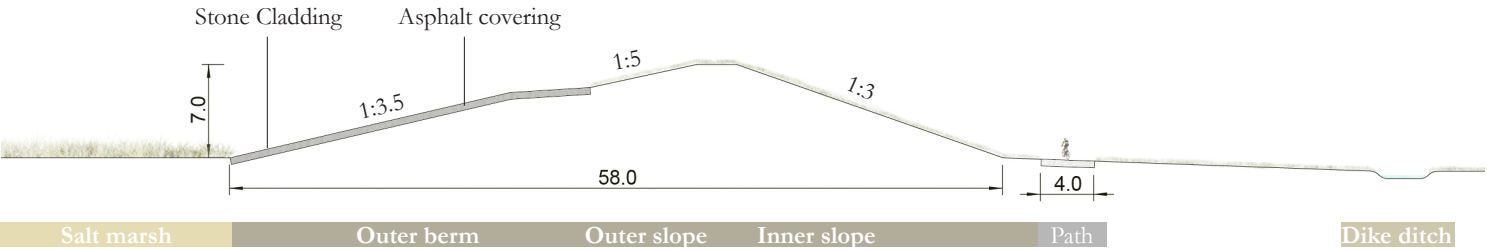
Section 2 Tree avenue leading towards the Wadden coast



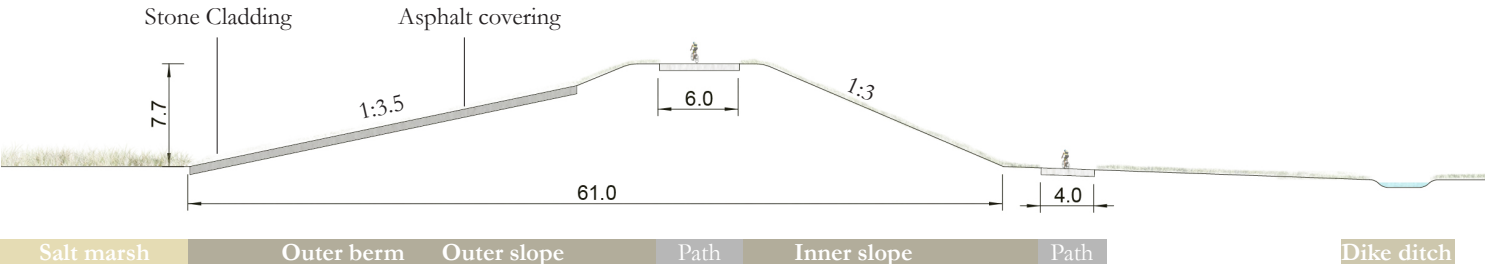
Section 3 Route on the old dike



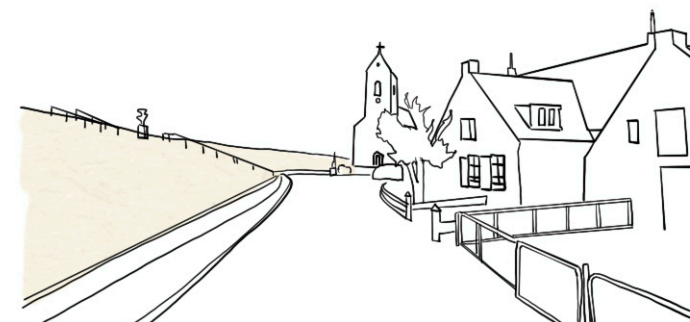
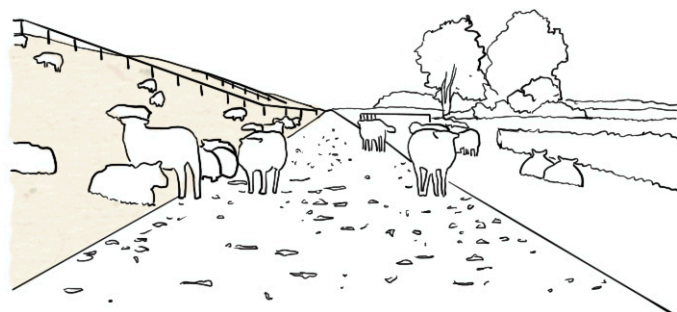
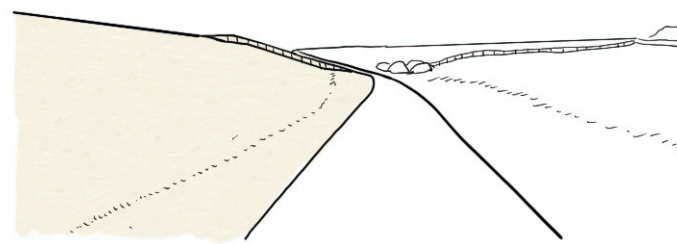
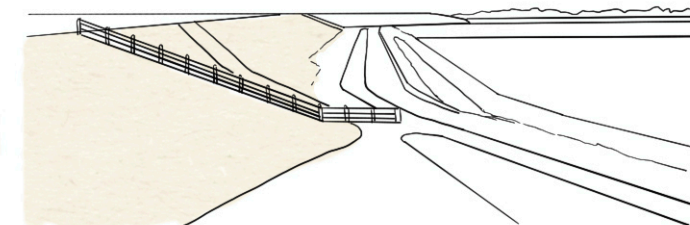
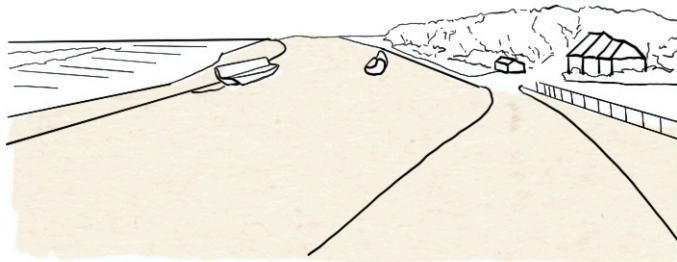
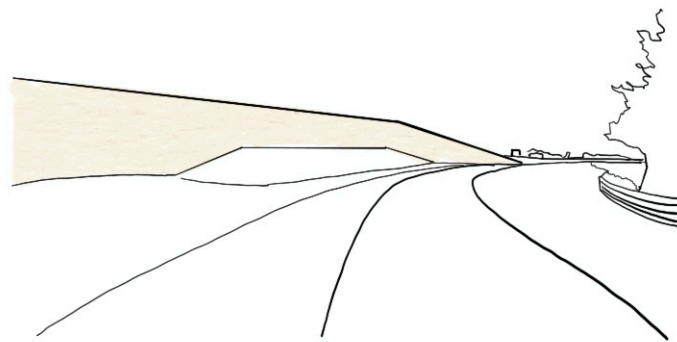
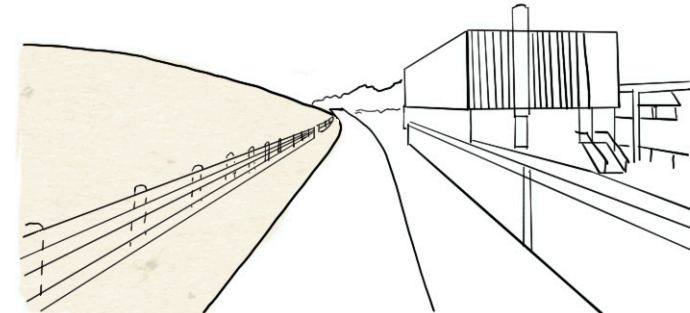
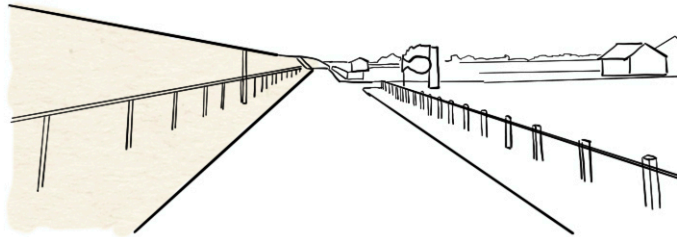
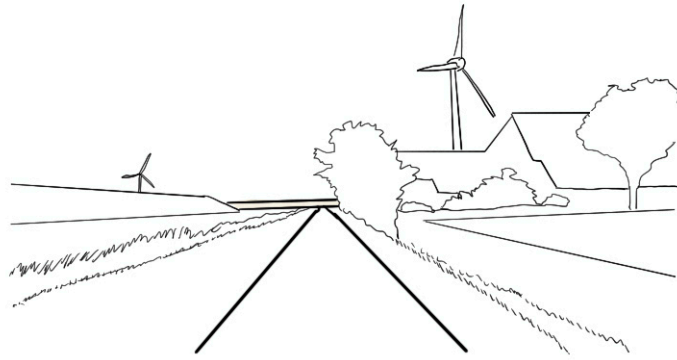
Section 4 Route along the sea dike



Section 5 Route on top of the sea dike



Routing Design



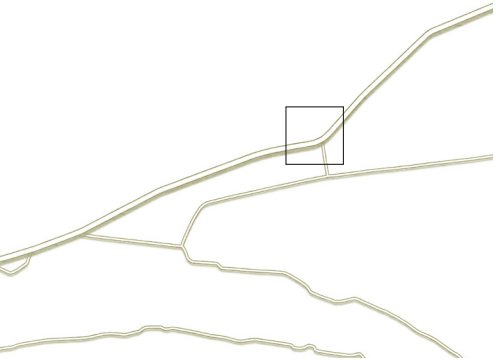


Westhoek.
Photo: Google Earth, 2022.



Westhoek.
Photo: Google Earth, 2022.

Design Interventions



0 10m 50m

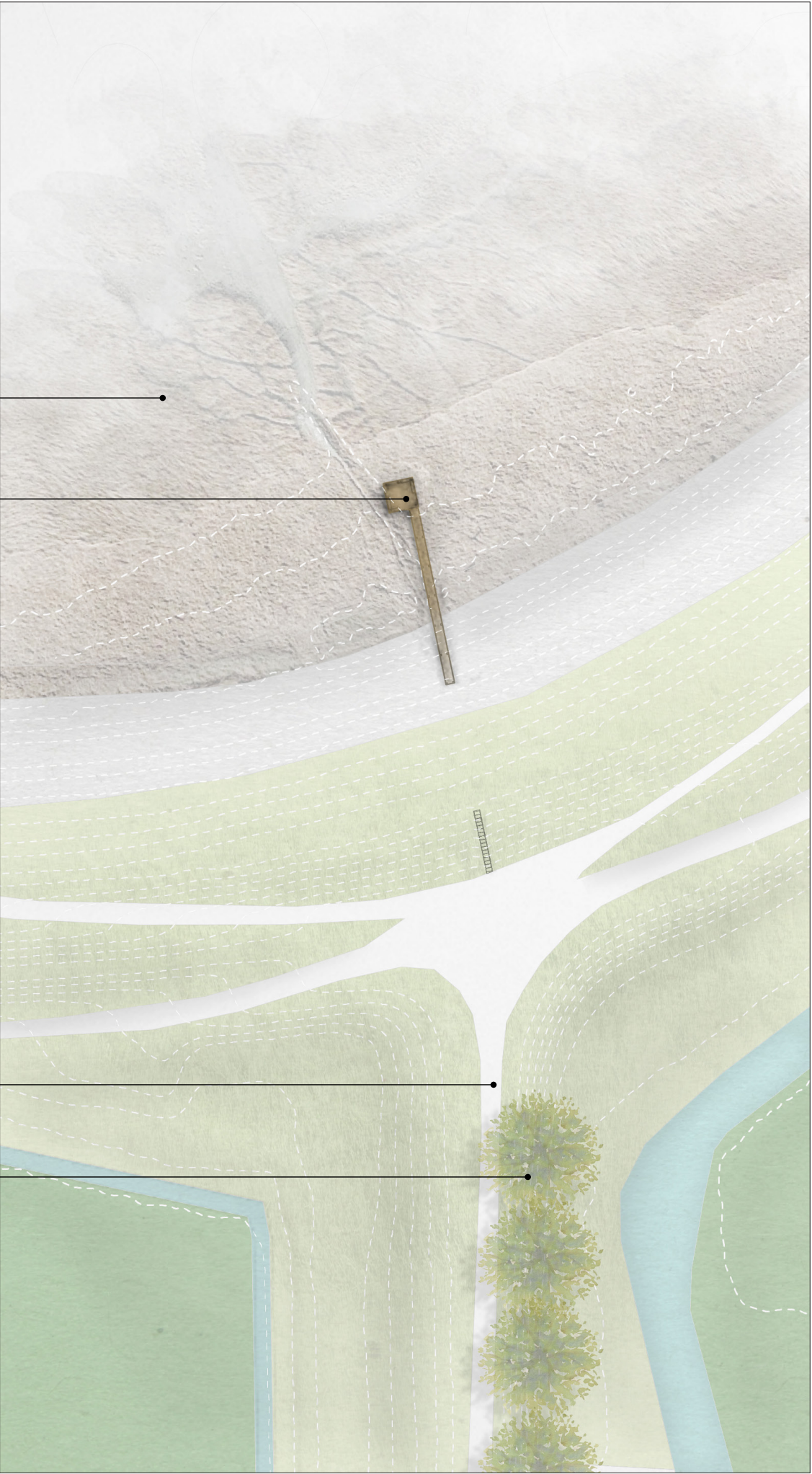


Salt marsh naturally developed

Bird watching platform

Routing

Tree avenue



Design Interventions



Wooden panel

Wooden beam



High tide

Low tide

Design Interventions



View tower



Platform



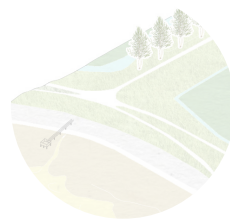
Seat



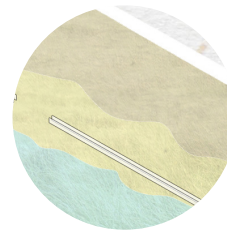
Wind shelter

2050 & 2070

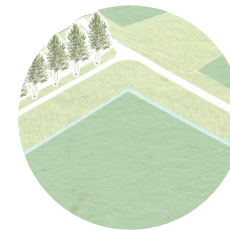
Two flood defense systems



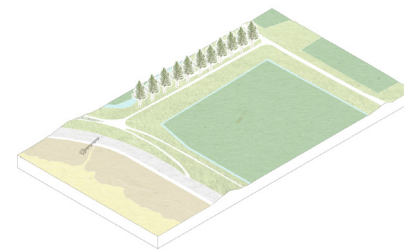
Routing & Node



Salt Marsh Flood Defense

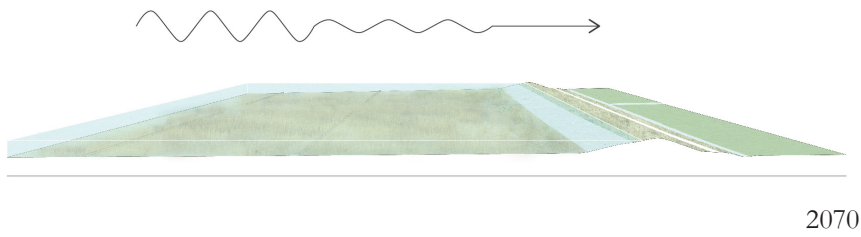
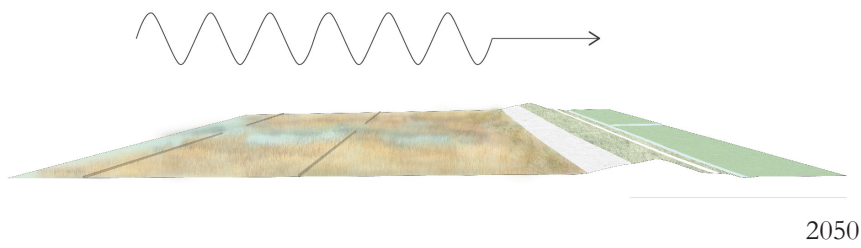
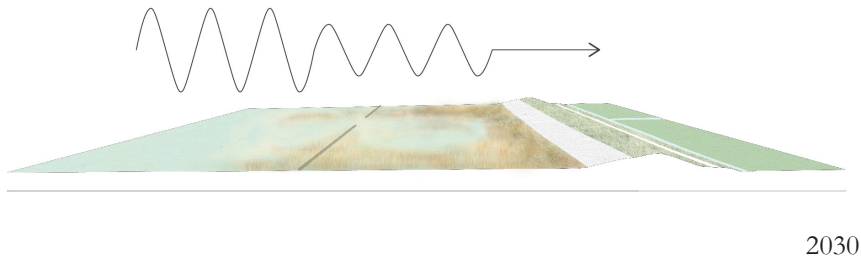
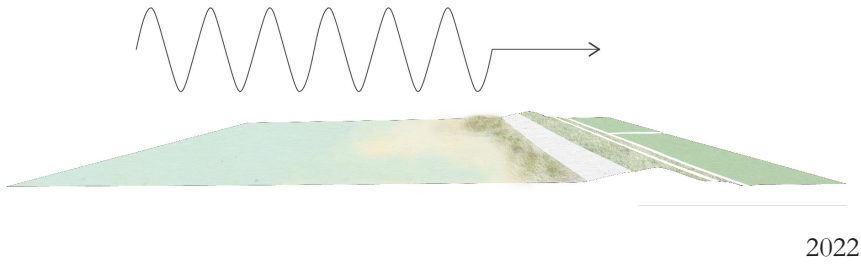


Double Dike System &
Saline agriculture

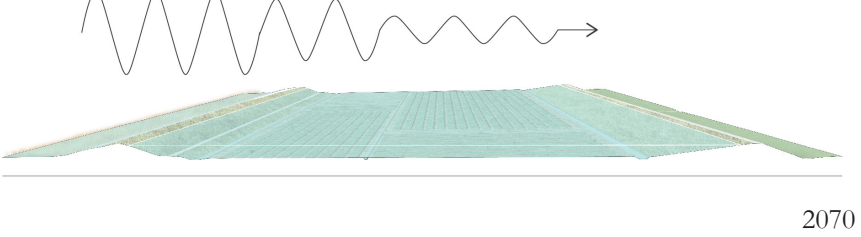
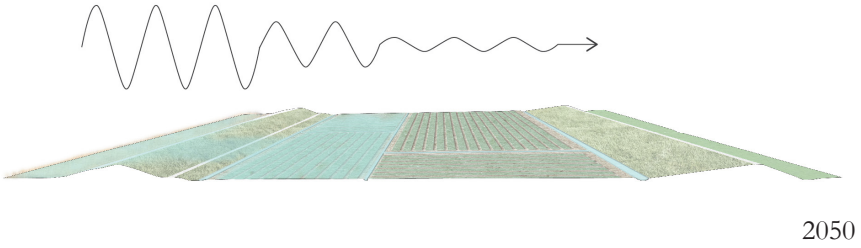
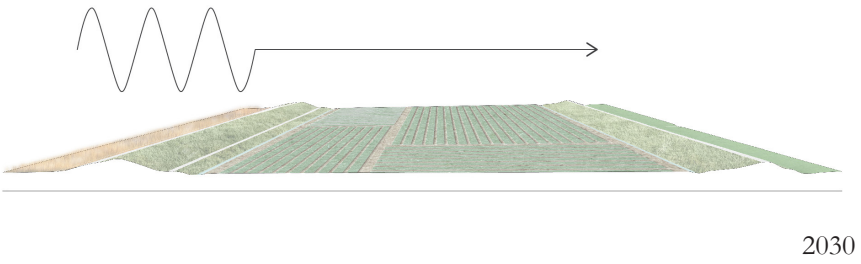
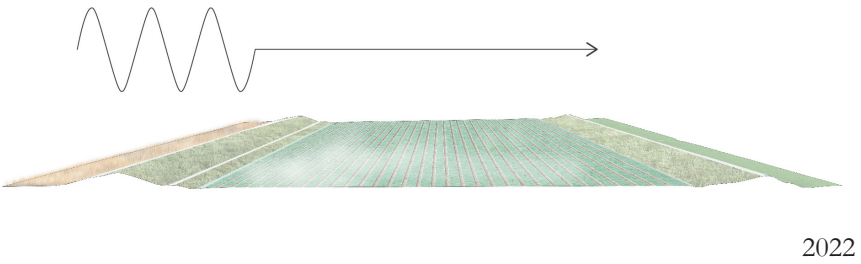


Two Defense Systems For Climate Adaptation

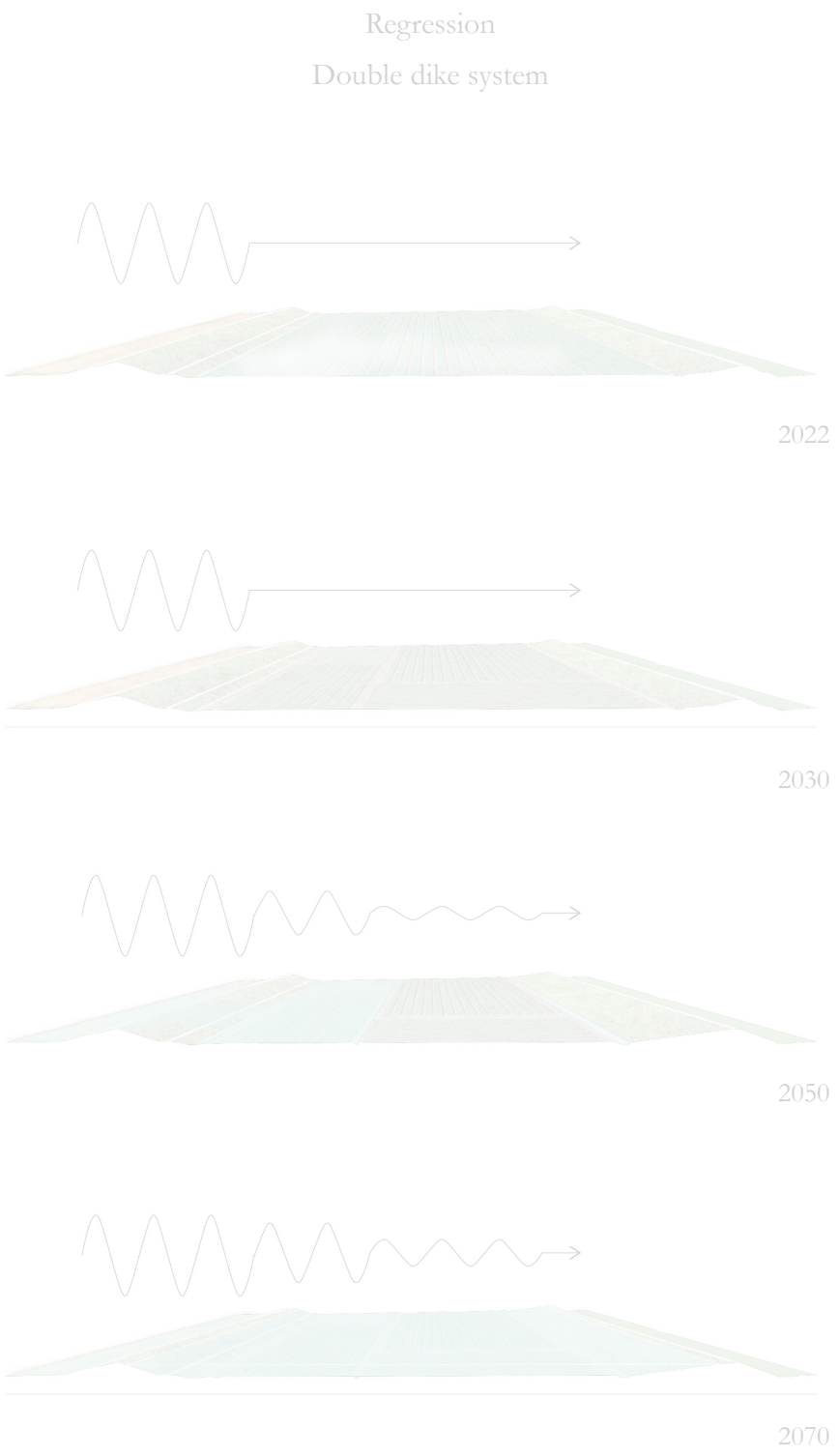
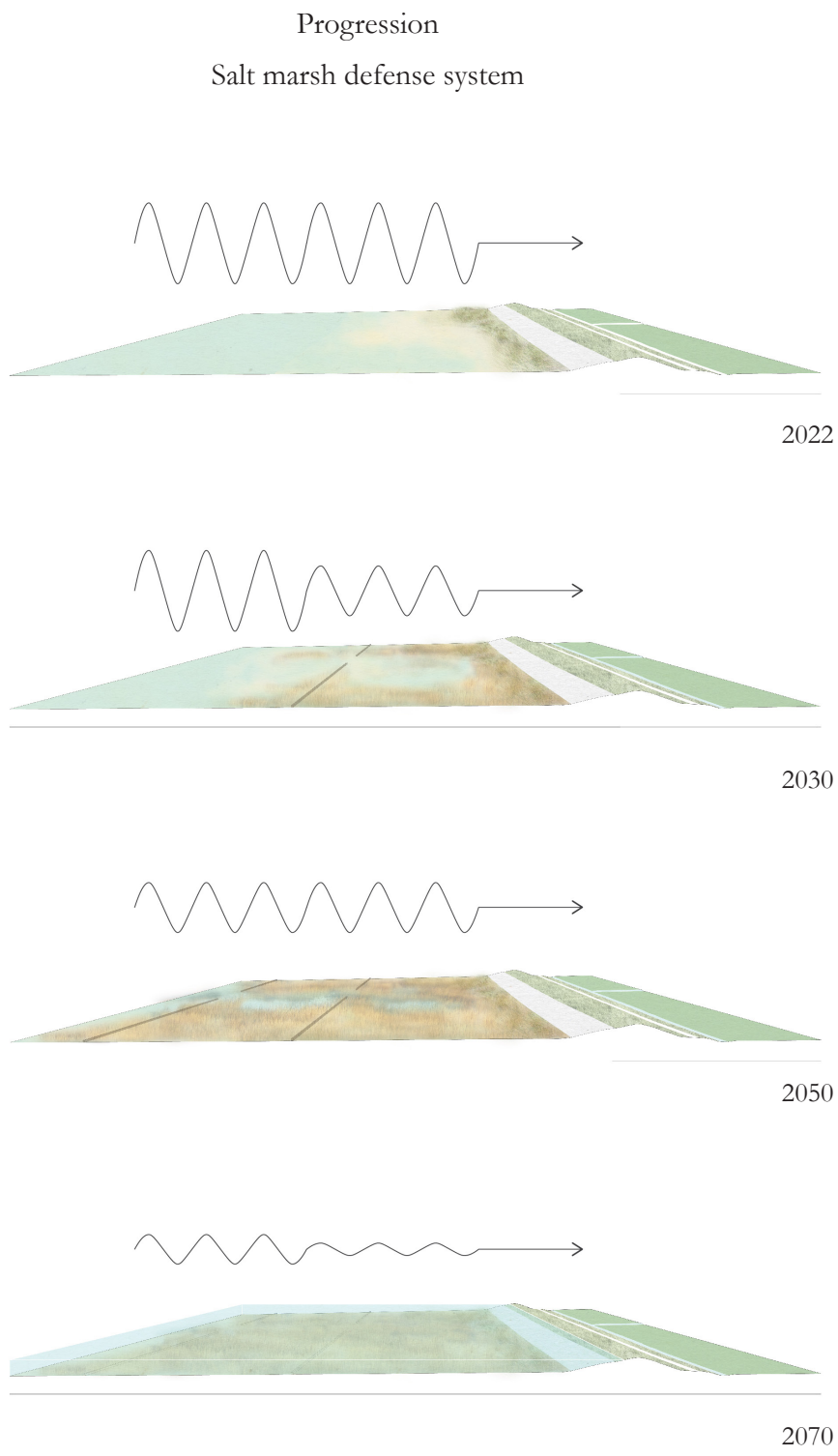
Progression
Salt marsh defense system



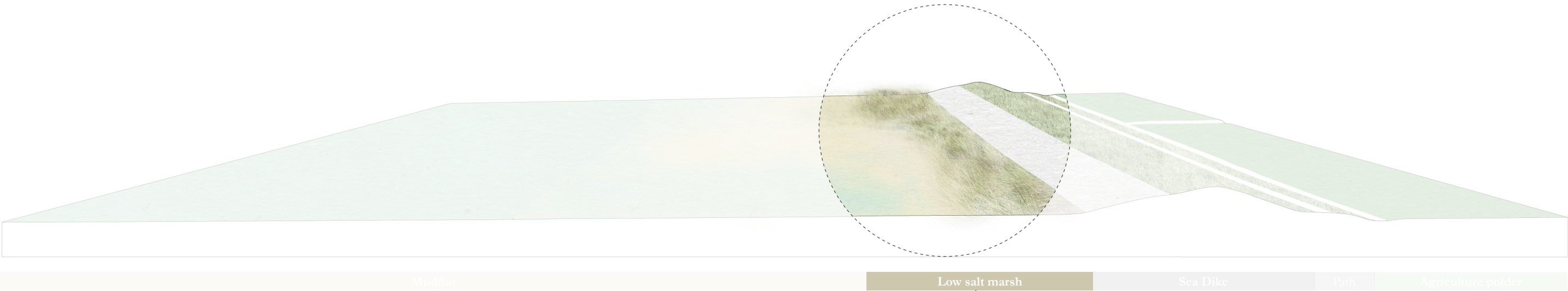
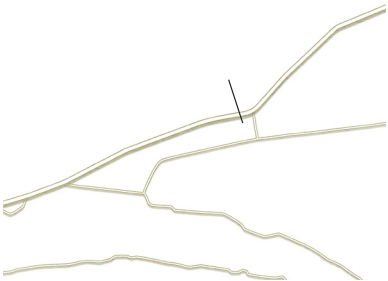
Regression
Double dike system



Two Defense Systems For Climate Adaptation







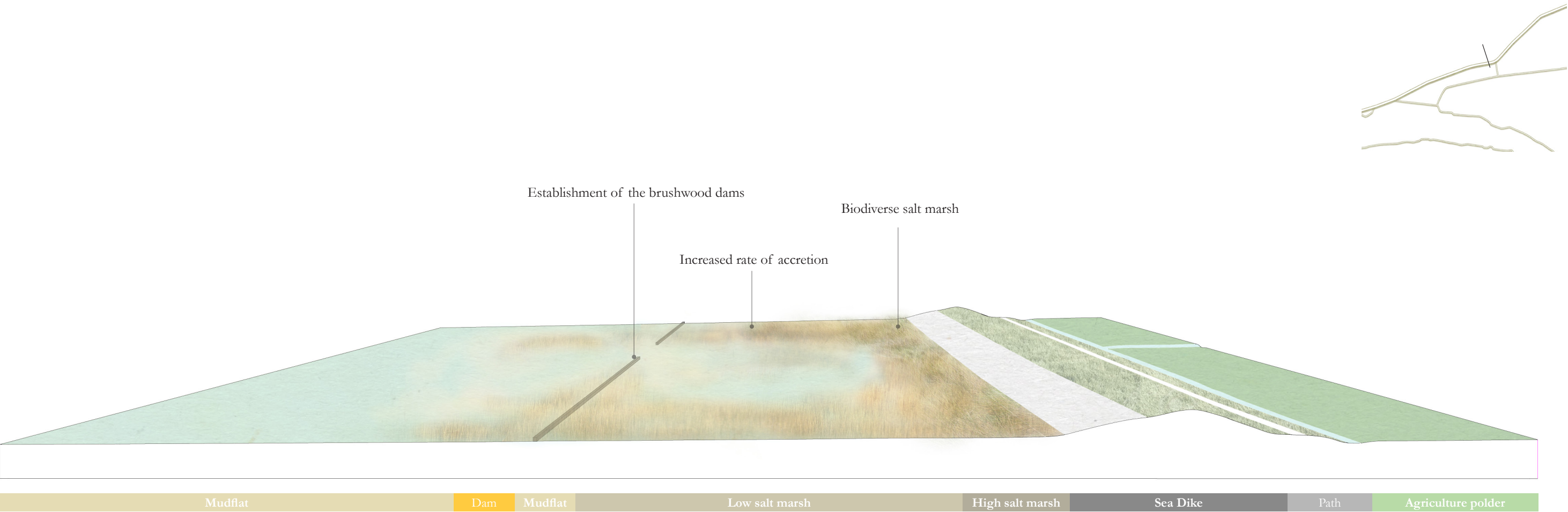
Low salt marsh sometimes inundated in high tide

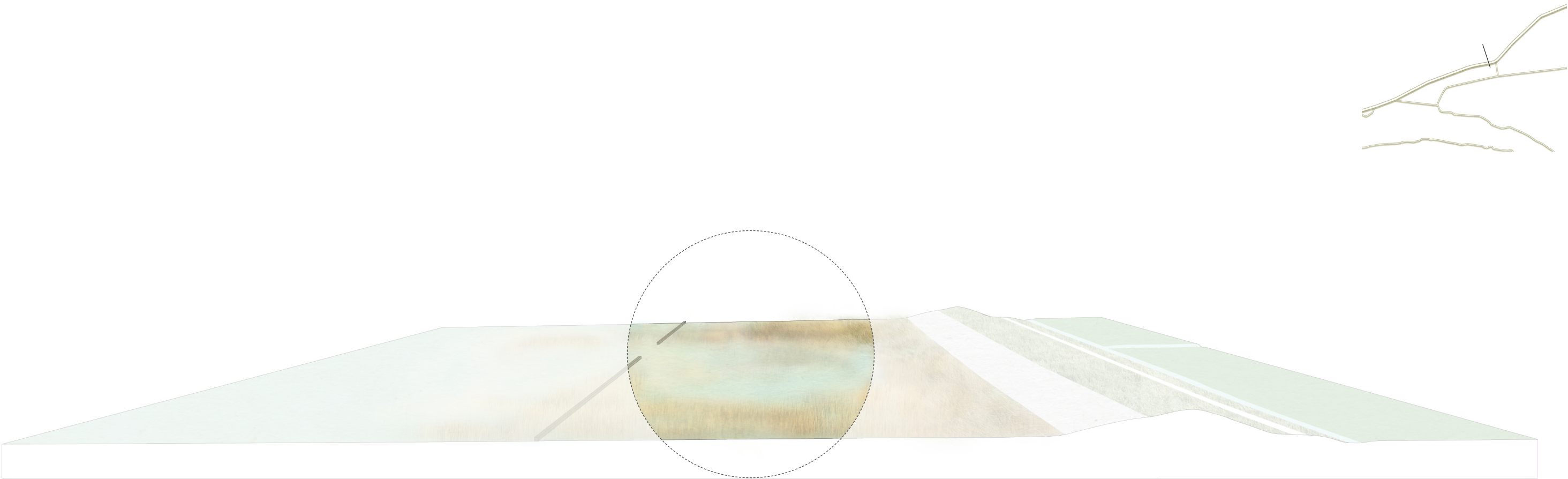
Little vegetation



Sea grass

2030





Mudflat Dam Mudflat Low salt marsh High salt marsh Sea Dike Path Agriculture polder

Low salt marsh sometimes inundated in high tide

Birds foraging for small shellfish

Pioneer plant species



Kluut



Scholekster



Lepelaar



Herring gull



Small crustaceans & shellfish



Glasswort



Common cord grass

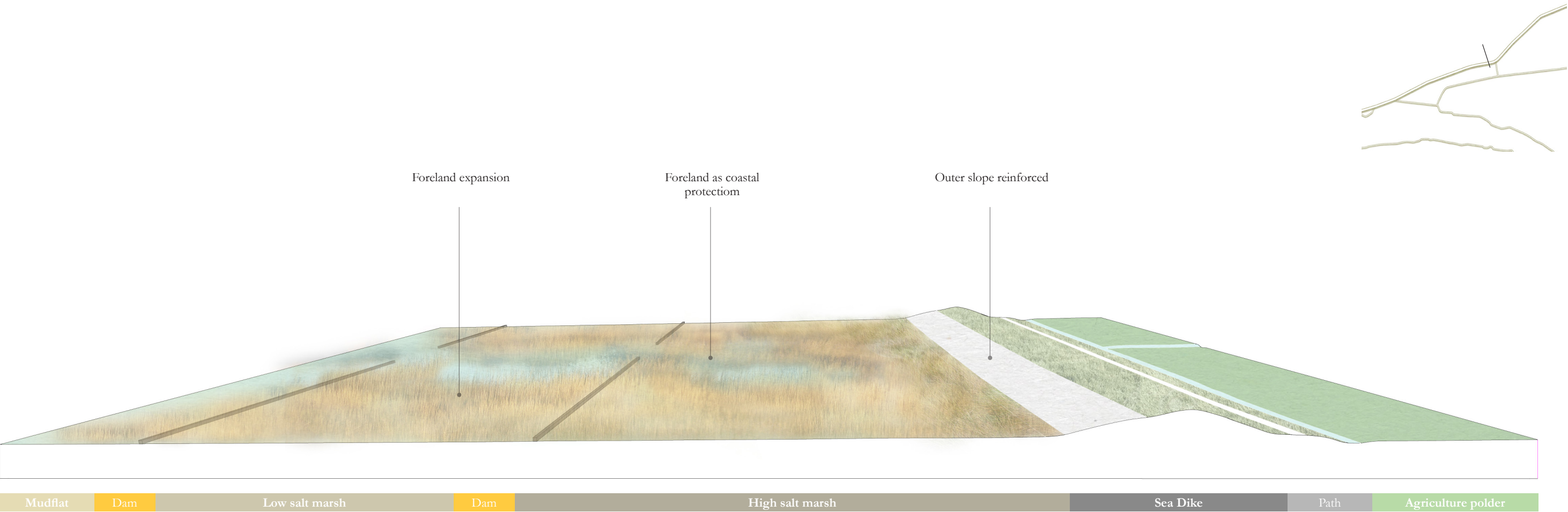


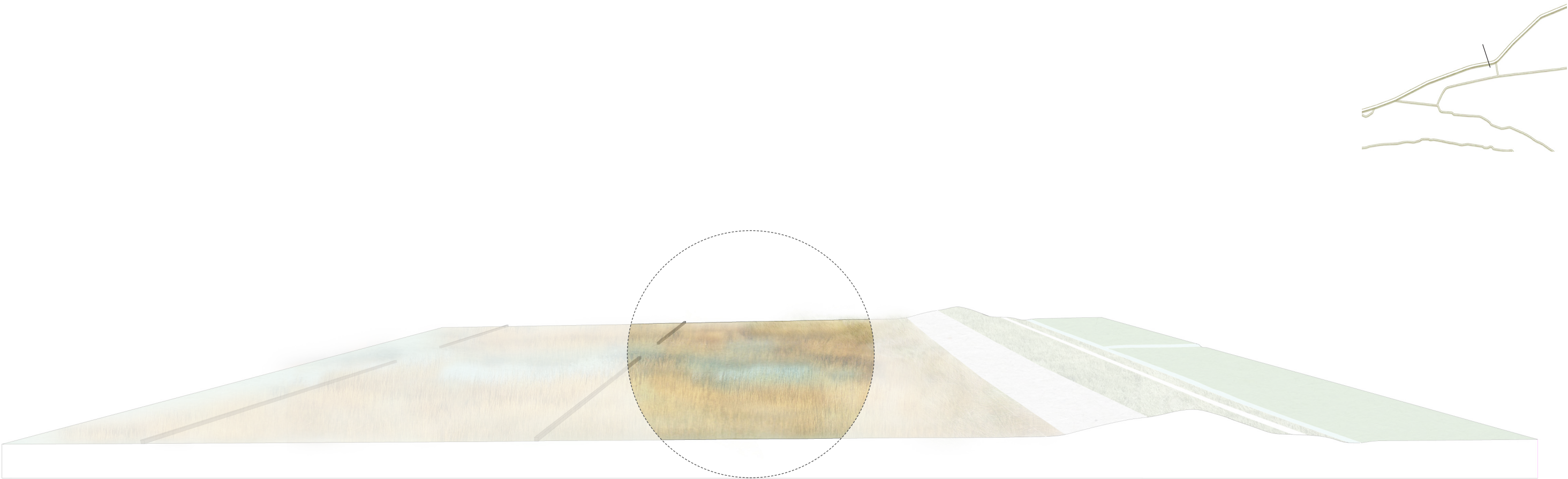
Sea lavender



Samphire

2050





Modiflat Dam Low salt marsh Dam High salt marsh Sea Dike Path Agriculture polder

High salt marsh inundated a few times each year at spring tides

Birds recuperate & breed in spring

More pioneer plant species



Kluut



Scholekster



Lepelaar



Herring gull



Insects



Annual seablite



Sea purslane

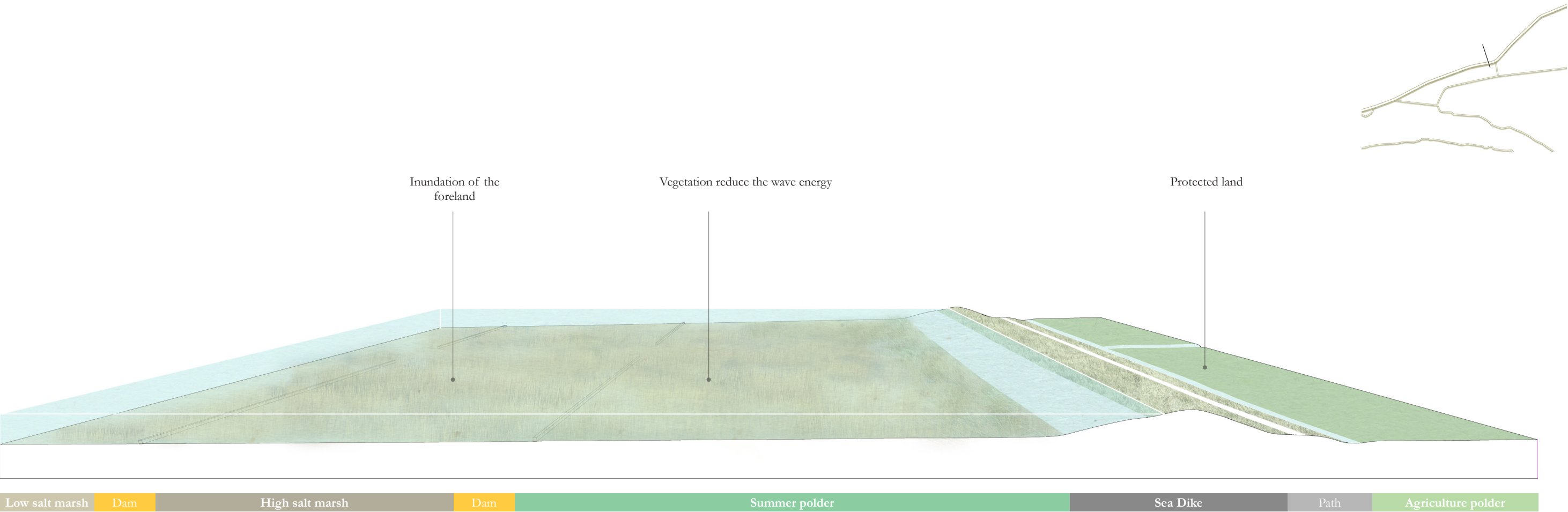


Red fescue

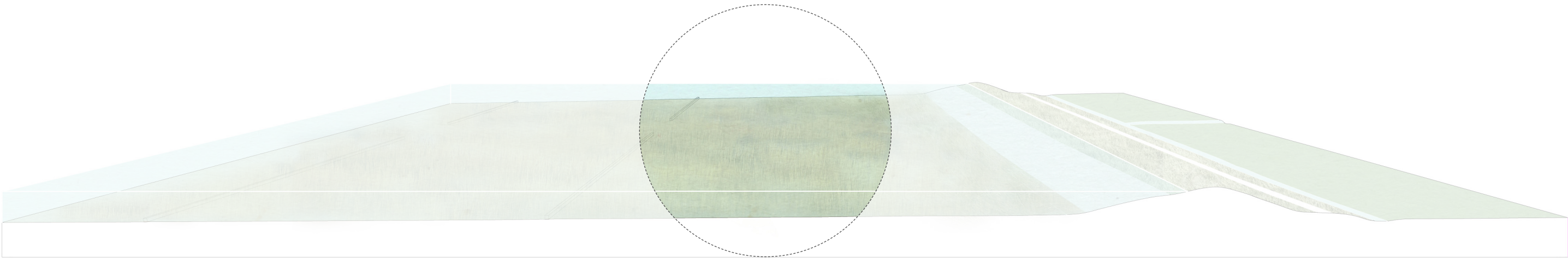
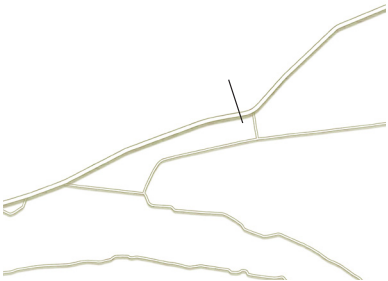


Weed

2070



2070



Low salt marsh Dam High salt marsh Dam Summer polder Sea Dike Path Agriculture polder

Inundated only in exceptionally high tides

Nesting grounds for birds

Grazing in summer



Kluut

Scholekster

Lepelaar

Herring gull

Insects

Cattle

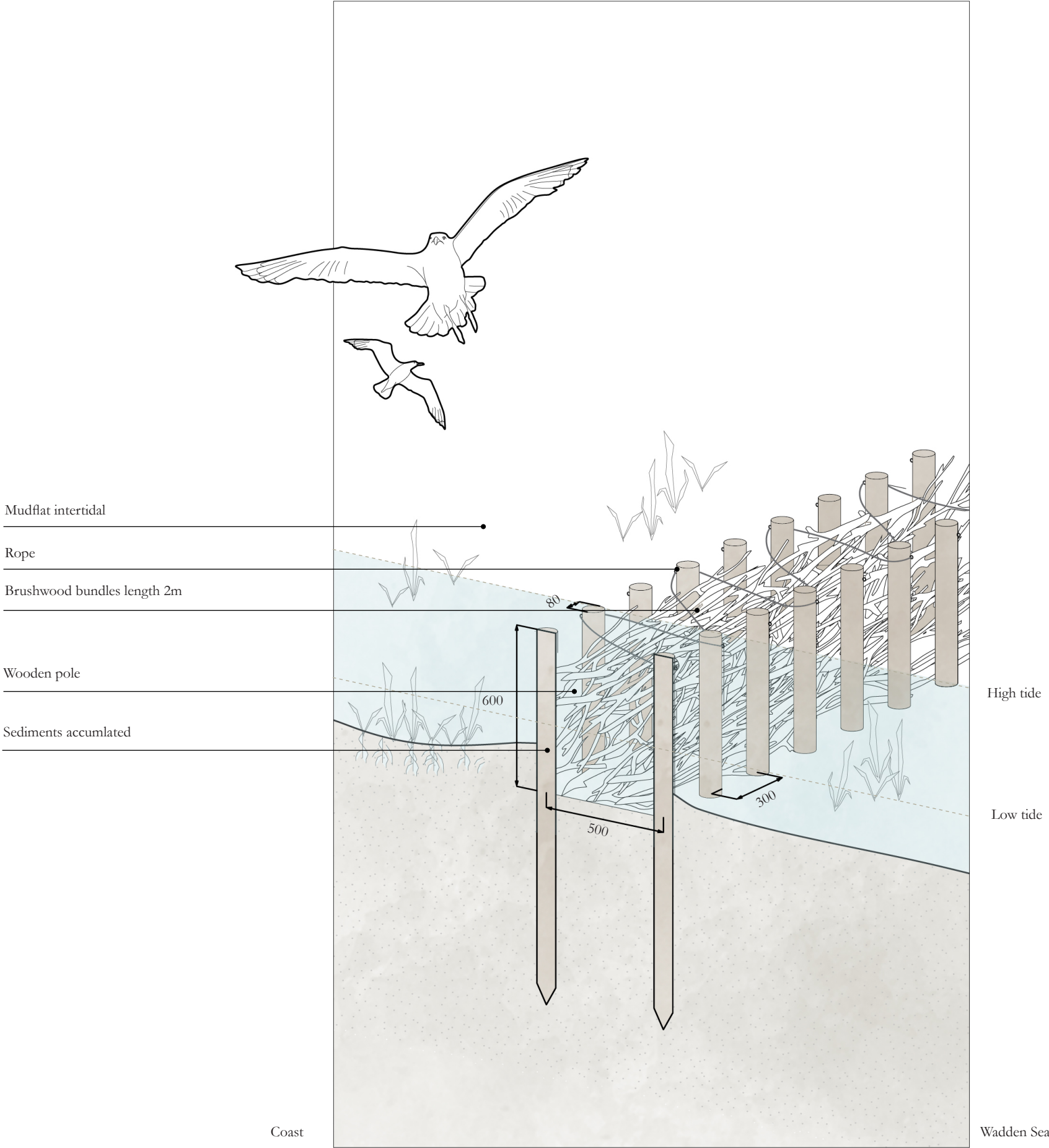
Sheep

Horse

Brushwood Dams



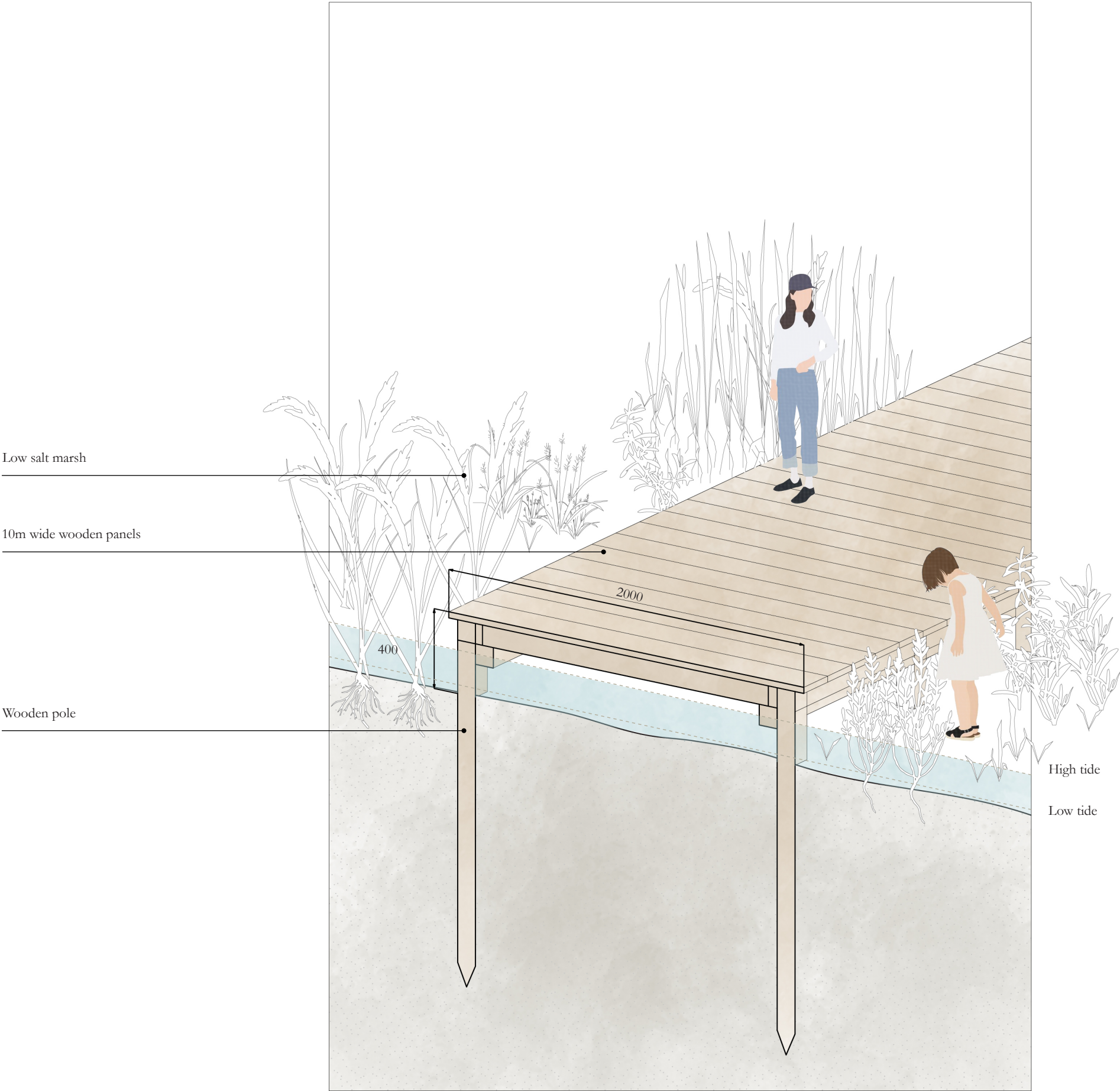
(Brushwood dams in Wadden Sea, 2021)



Walkway



(Marker Wadden, 2022)



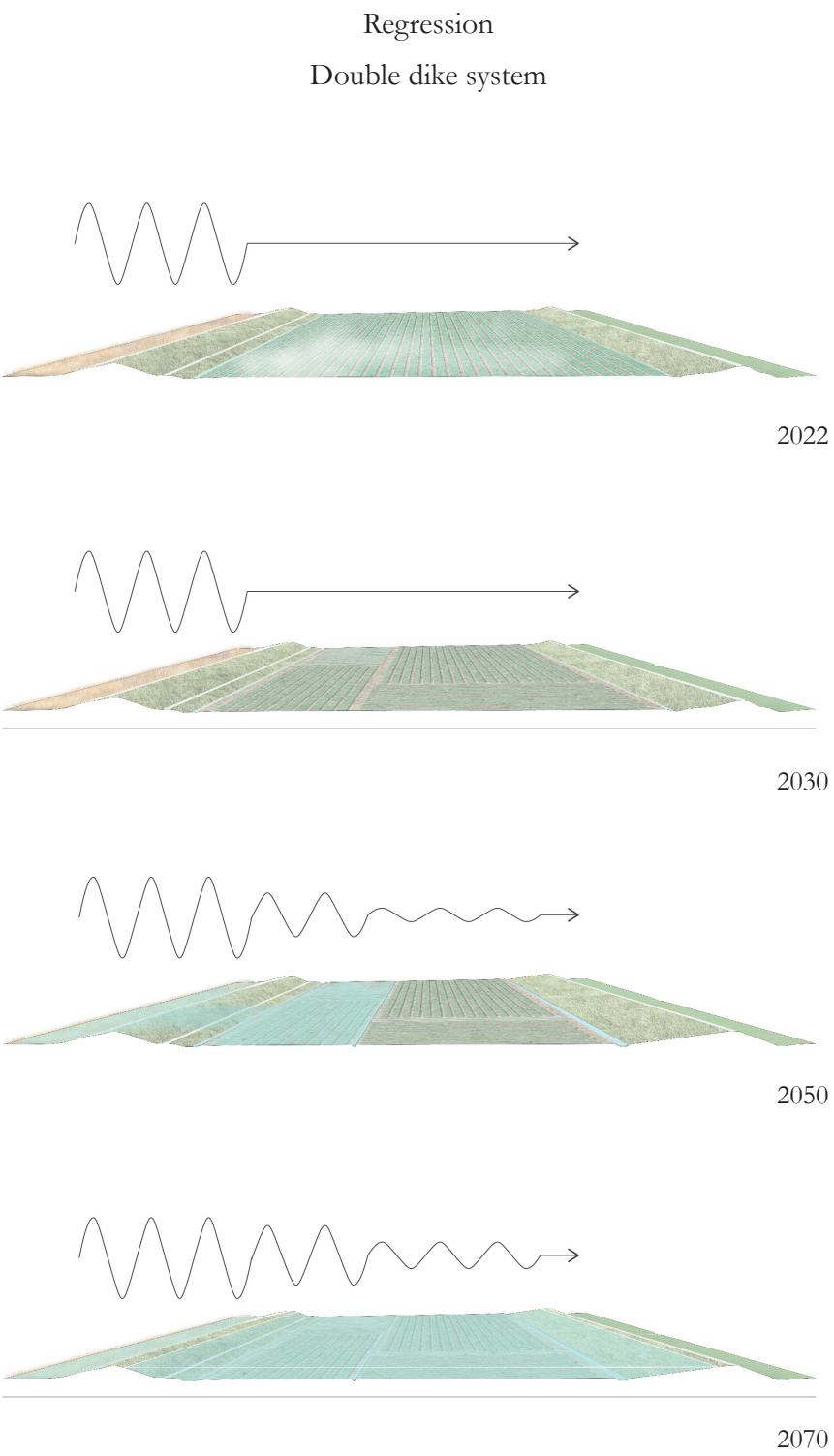
Low Tide

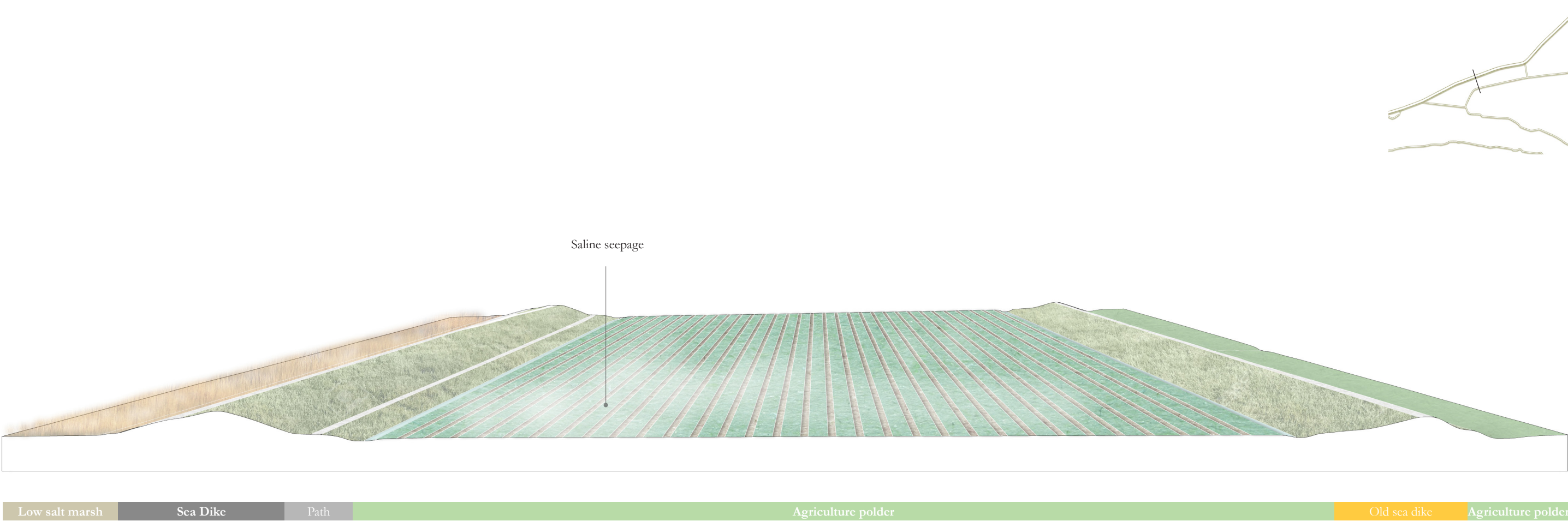


High Tide

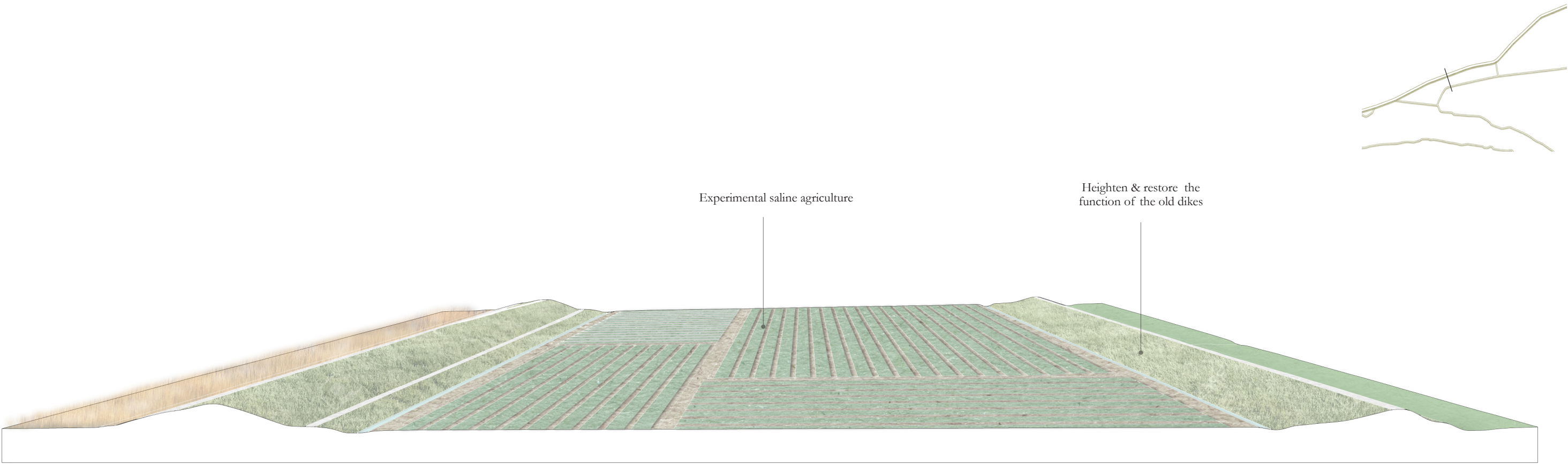


Two Defense Systems For Climate Adaptation





2030



Low salt marsh Sea Dike Path Saline agriculture farm Old sea dike Agriculture polder

Salt-tolerant crops



Potato



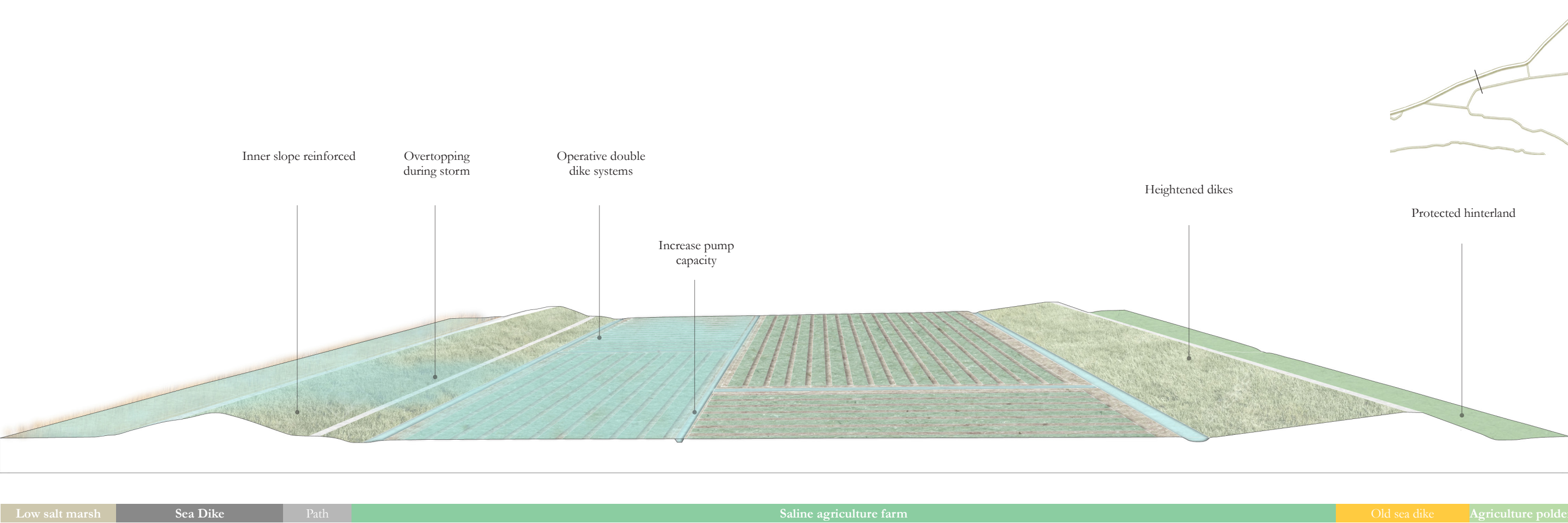
Wheat

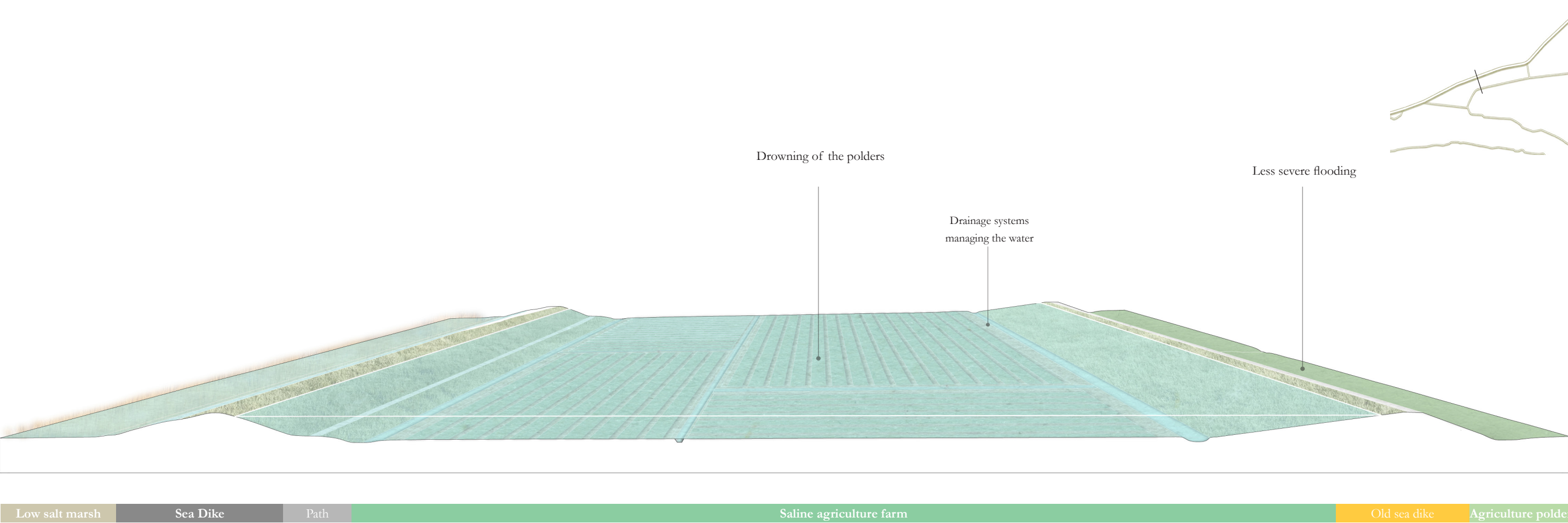


Sugar beet



Carrot





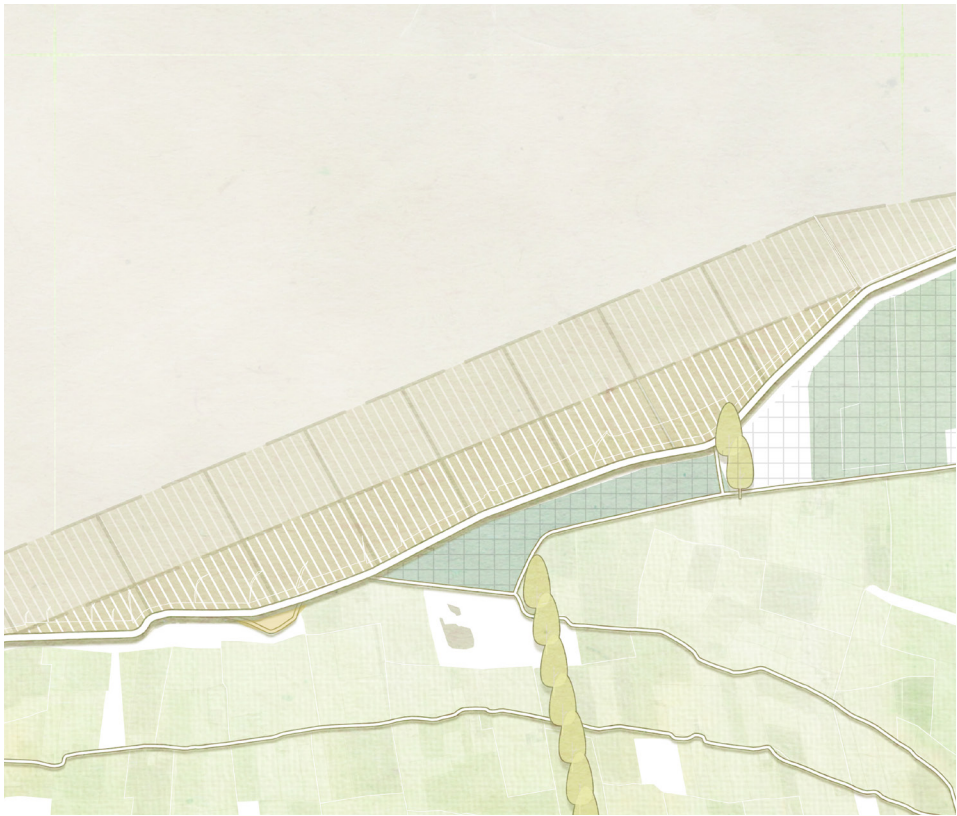
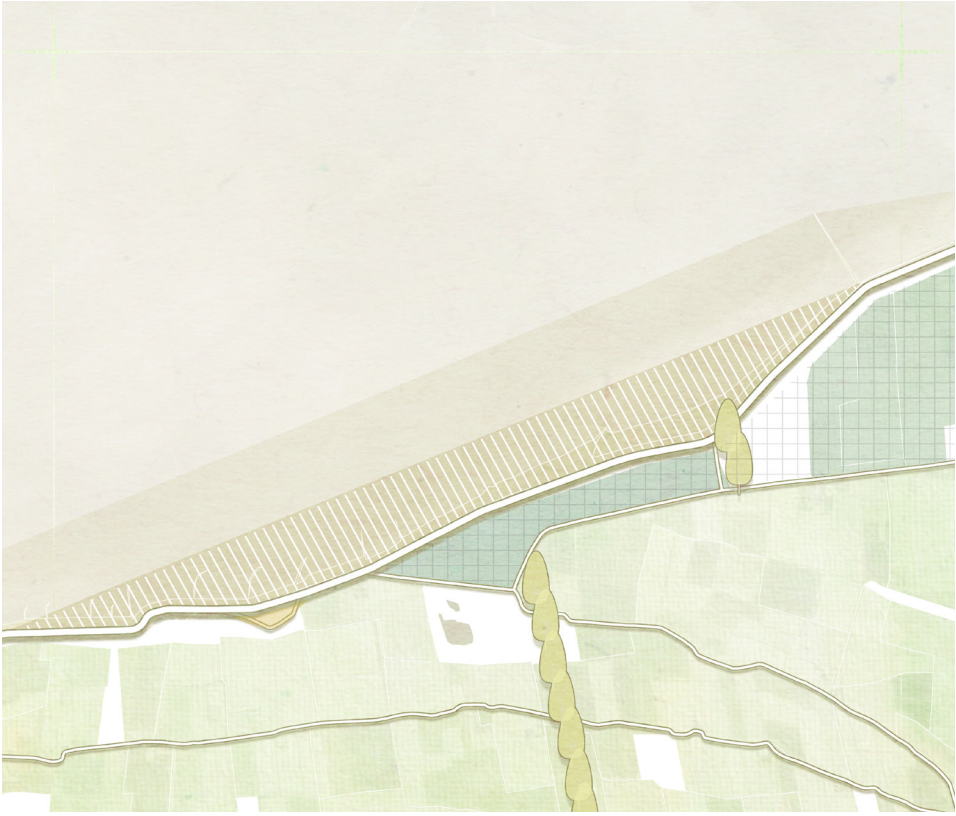
Low Water



High Water



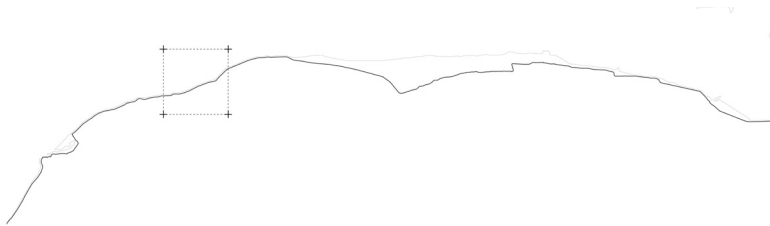
Design Time Phase



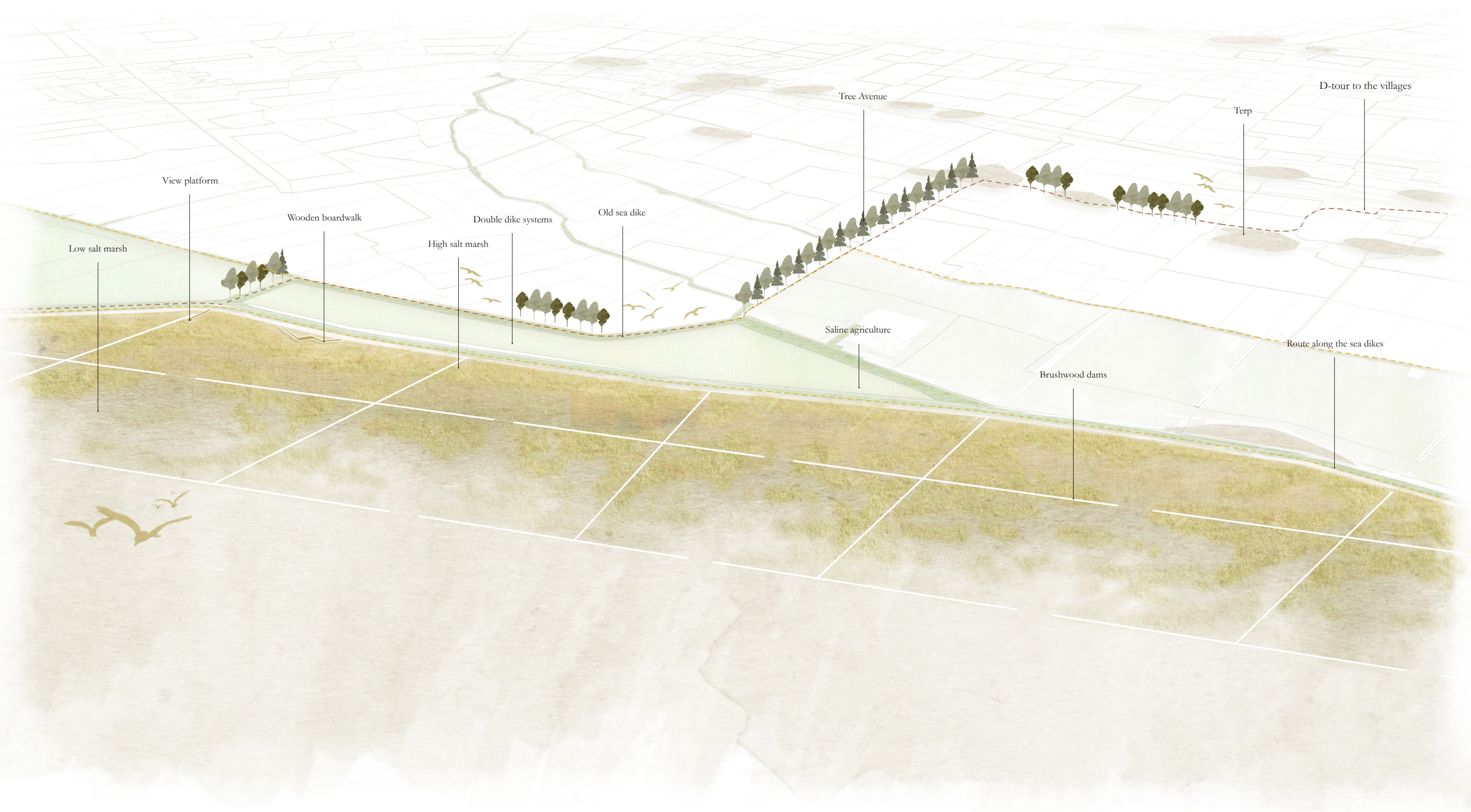
Routing Design
Establishment Of The Brushwood Dam
Saline Agriculture

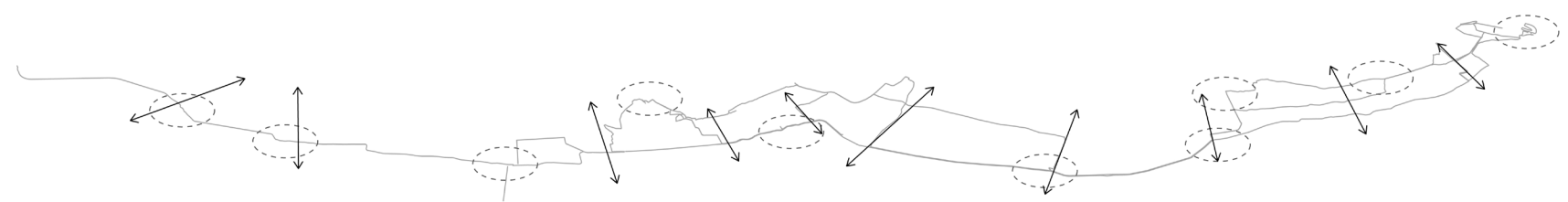
Old Dike Restoration
Productive Saline Agriculture

Salt Marsh Expansion
Functional Double Dike Systems



Bird's Eye View





thank you!