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Urban Sustainability and Wetland Reservation with Nature-based Solutions

Coastal green infrastructures in European cities

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Dunes, salt marsh and hybrid infrastructures BENEFITS

Dunes

Are a protective feature that **provide sand buffer and protect the land from waves and flooding**. Therefore they represent a **buffer between sea and land, in a similar way to a seawall** but are usually of natural origin.

Salt marsh

Can **protect coastal zones from currents and waves by stabilizing sediments and reducing wave action**. The structures associated with the plants also induce deposition of sediment and organic material from the water column (this organic material is a source of food for fauna). Salt marshes also provide economic benefits and contribute to a healthier ecosystem functioning. Furthermore, **salt marshes mitigate the effects of subsidence and sea level rise.**

Hybrid infrastructures

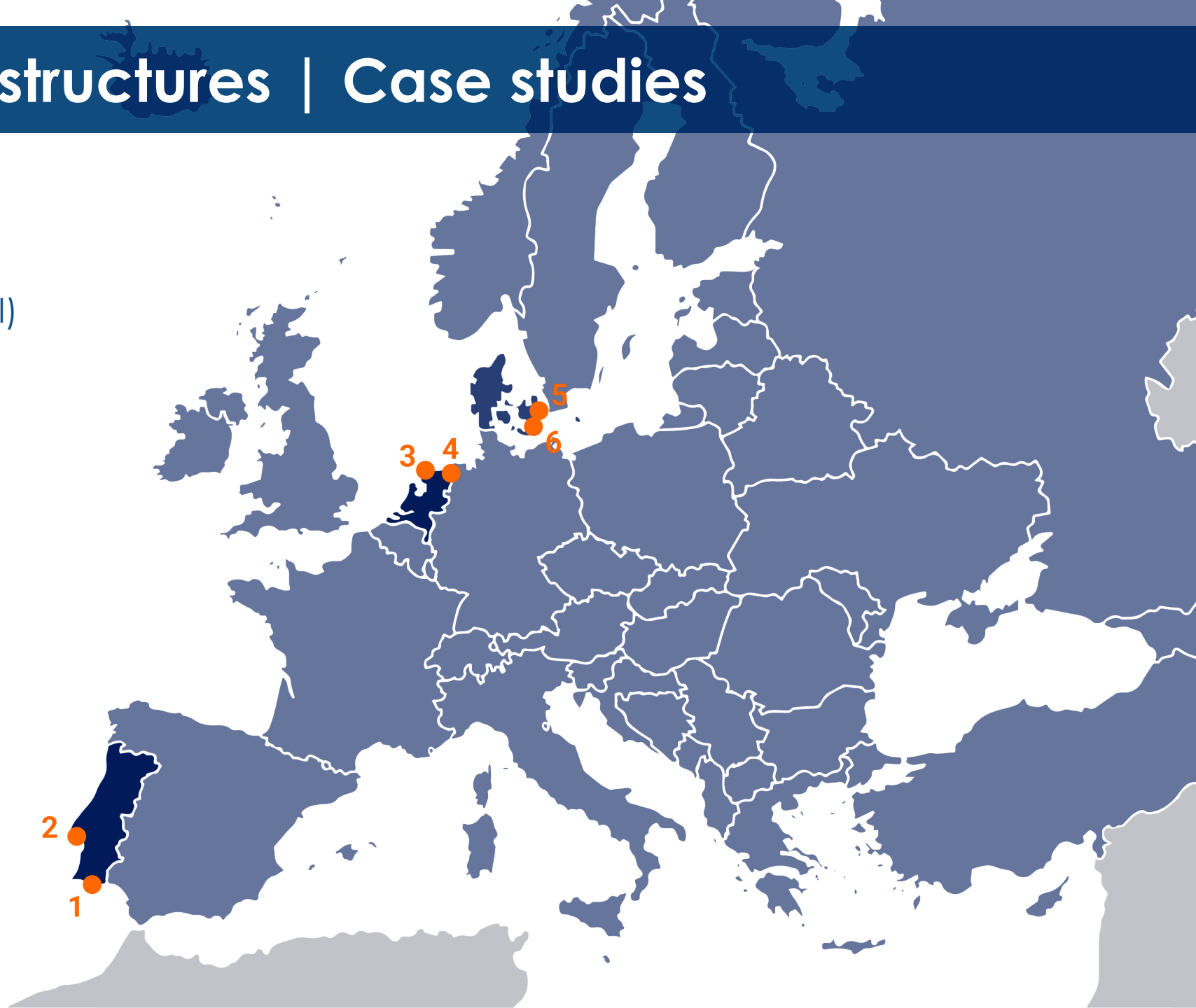
Combines green and gray management options in an effort to optimize community resilience to a range of environmental and community hazards. **It increase the resilience to sea level rise, coastal erosion, flooding, storm surge and changes to coastal habitats.**

Coastal green infrastructures | Case studies

Dunes
1. Praia de Faro (Portugal)
2. S. João da Caparica (Portugal)
3. Terschelling (Netherlands)

Salt marshes
4. Delfzijl (Netherlands)

Hybrid infrastructure
5. Copenhagen (Denmark)
6. Køge (Denmark)

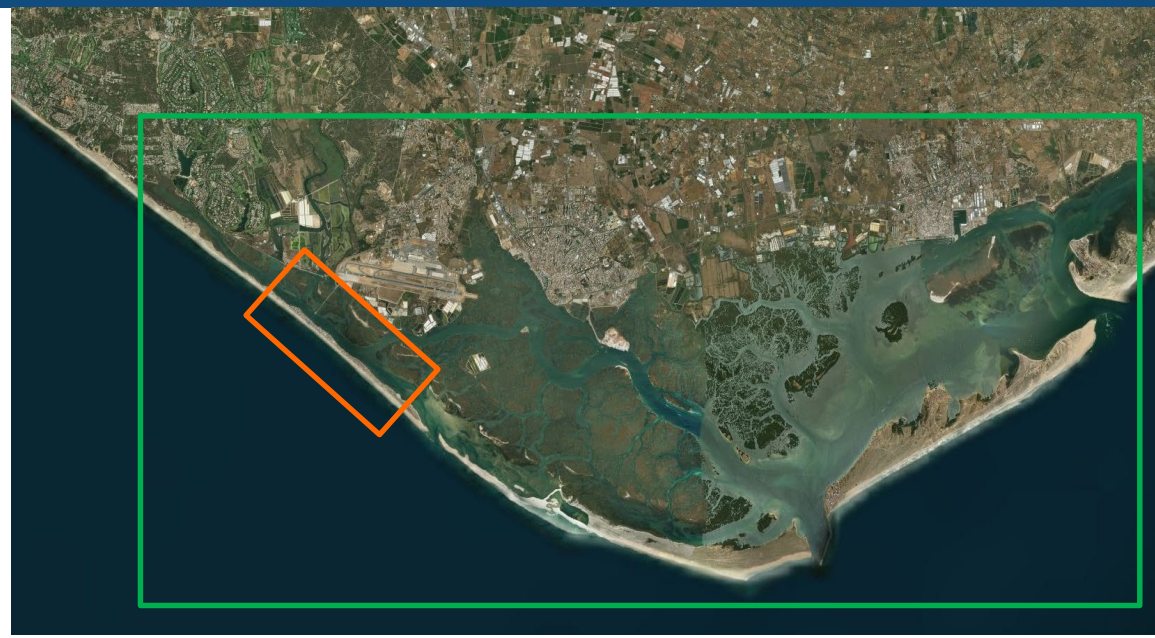


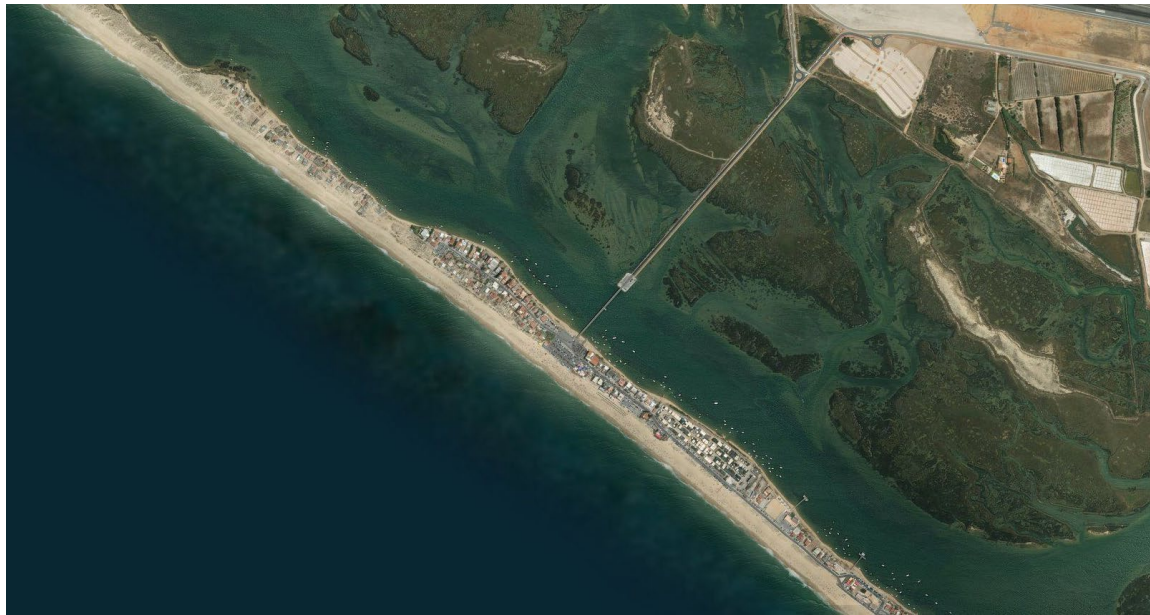
DUNES | 1. Praia de Faro (Portugal)

Dune rehabilitation

The coastal town of Praia de Faro is located partly on a natural dune area separating a lagoon from the open sea.

The Ria Formosa lagoon is a Ramsar site That aim to conserve and have a sustainable development of the wetlands





DUNES | 1. Praia de Faro (Portugal)

Threats

- **coastal erosion from storms**
- **human interventions** that alter the natural behavior of the area, e.g. the use of (summer) houses and trampling paths, crossing the dune.

Consequences

The human interventions had reduced vegetative cover increasing the sand loss with notable dune destruction due to trampling.

DUNES | 1. Praia de Faro (Portugal) - PROJECT

1. Construction of a dune fences
2. Construction of an elevated wooden pathway alongshore and cross-shore

A row of fences was placed along the ocean and additionally fences were built as a reticulate (continuous rectangles or about 7x5.5 m).

The **fences helped to trap sand in the dune areas** leading to **a growth of the dune system**.
Over the past 15 years the dunes grew around 10 meters in width and about 1.3 meters in height, leading to an almost natural ecological state.

The **wooden path** played **an important role in the dune recovery**, because it led **to reduction of wild paths through the dunes**. The fences were also an additional obstacle which minimized the usage of wild paths through the dunes.

DUNES | 2. S. João da Caparica (Portugal)

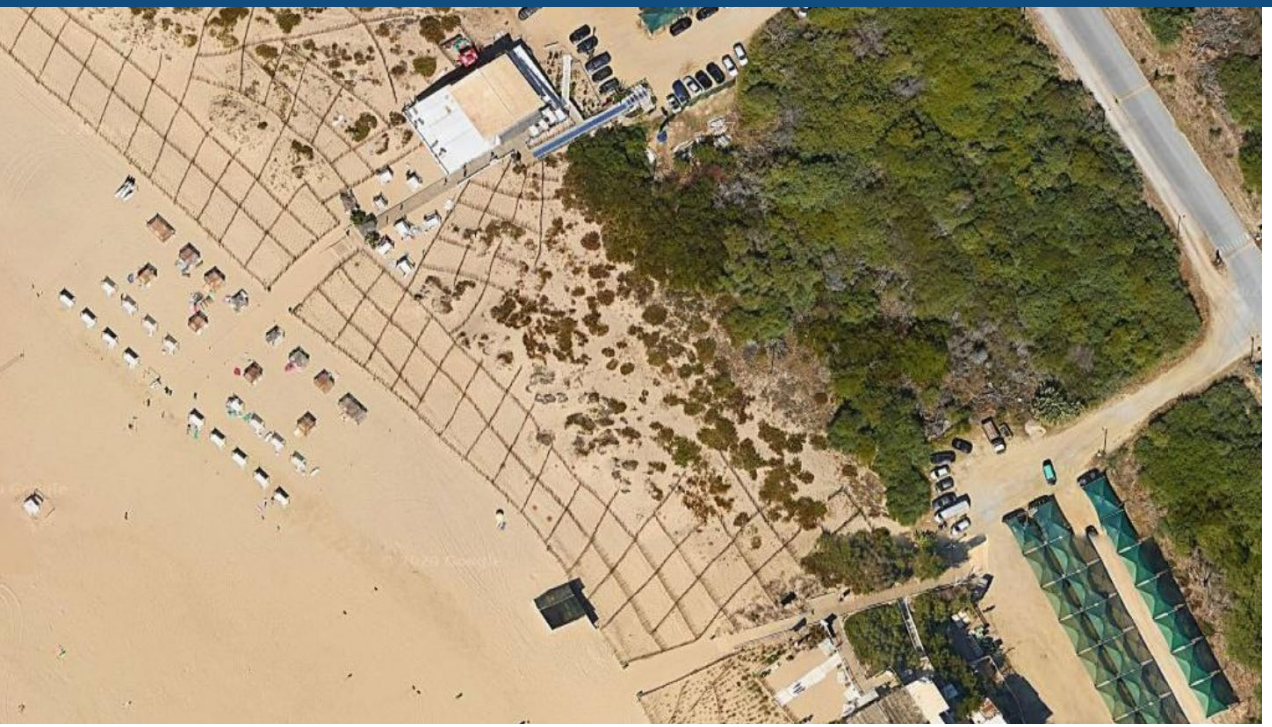
ReDuna: Recovery and Ecological Restoration of S. João da Caparica Dune System.

Threats

- Long-term **shore retreat** of the coastline
- Extreme weather conditions (2014 **storm** and **overwash**)
- **Human pressure**

Dune erosion and vegetation degradation

DUNES | 2. S. João da Caparica (Portugal) - PROJECT



Construction of reticulate fences

Construction of elevated wooden pathway alongshore and cross-shore

After 2014, major storm and overwash, the dune was artificially restructured, the beach was sand nourished, including willow sand fences, plantation of dune species, and the mitigation of human pressure with fences, pathways and strong communication.

DUNES | 3. Terschelling (Netherlands)

The case study is about enhancing the natural dynamics of the dunes and the sand transport on the Wadden Sea island of Terschelling.

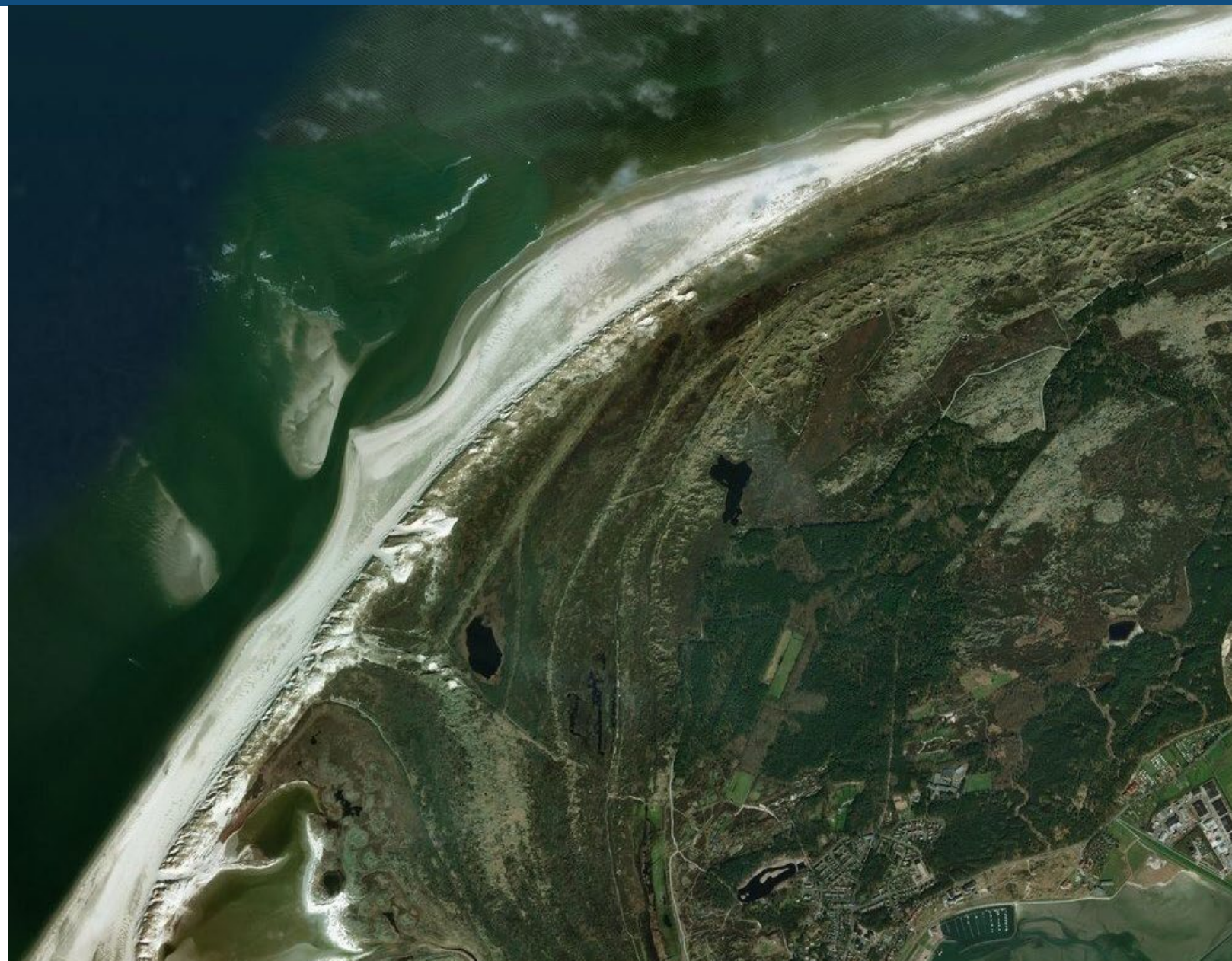
The Wadden Sea is the largest tidal flats system in the world and is geologically and ecologically unique.

DUNES | 3. Terschelling (Netherlands)

Threats

- The natural processes have been disrupted in the past by **planting or measures with the aim of fixing the coastline**.
- Introduction of **drainage systems** > the **groundwater level has been lowered and wetlands in the dune system declined.**

Overall, natural dynamics at the dunes were hindered and because of the limiting of the sediment transport, **the adaptive capacity to sea level rise** (and resulting higher floods) **are also limited.**



DUNES | 3. Terschelling (Netherlands) - PROJECT

The dynamic dune management approach

5 km of the northern coastline, the outer dunes were **mechanically opened to start a rejuvenation process of the dune system**.
With the help of **reed fences along the cuts**, **wind** regimes were **channeled** so over the years a considerable amount of **sand was blown** from the beach through the dunes into the inland.

Additionally an artificial wetland was created (called 'Eldorado') by the removal of pine forest and other vegetation.

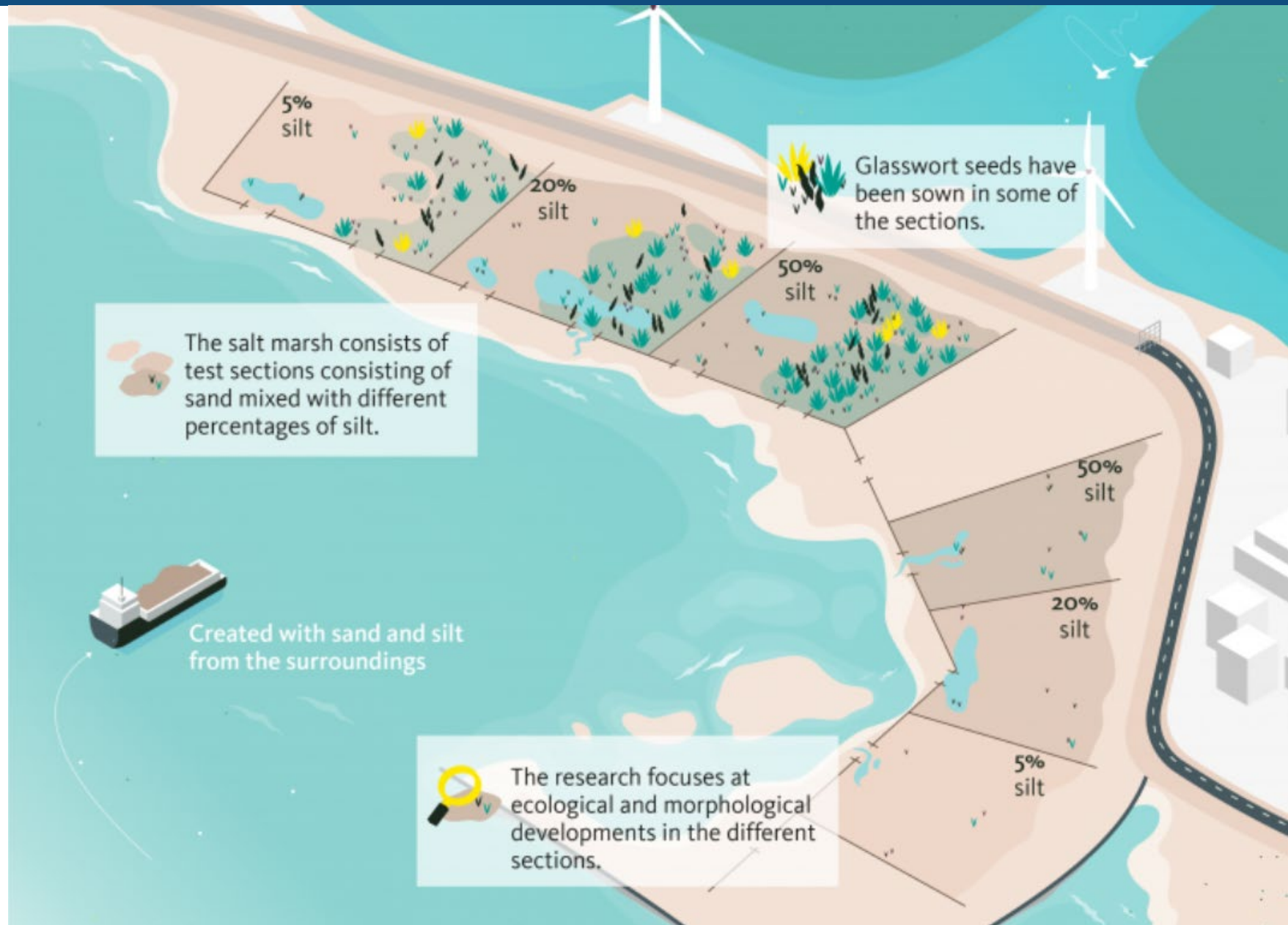
The dynamic dune management approach has no negative impact on the safety of the people during storm floods.

The natural sand transport from the beach has the effect that the dune system is 'growing' with the sea level rise.

SALT MARSH | 4. Delfzijl (Netherlands)

EcoShape research project.

Aim to investigate the best way to restore salt marshes by reusing sediment, while developing nature that contributes to the water quality, ecology, coastal defenses and the attractiveness of the coast.



SALT MARSH | 4. Delfzijl (Netherlands)

The salt marshes are developed with **sediment from the port**.

The experiments use different percentages of sand and fine sediments as base-layer for the salt marshes.

The creation of salt marsh **will decrease the power of waves on the concrete dikes** (It will need less maintenance and less tall).

The salt marshes are planted of Salicornia and other autochthone plants.
These will **increase the fauna** of the area and its **biodiversity**.

SALT MARSH | 4. Delfzijl (Netherlands)

Before

After

HYBRID INFASTRUCTURES | 5. COPENHAGEN (Denmark)

Amager strandpark project

is a constructed island.
Built between 2004-2005. It not only **serves recreational purposes** for the local population but is also a **coastal defense** structure to protect the main coastline.

It was built from 1.5 million cubic meters of raw material, mainly because the old beach had **"required almost annual additions of sand to keep it from disappearing into the shallow waters of the Baltic channel"** (Cohen 2010).

HYBRID INFASTRUCTURES | 5. COPENHAGEN (Denmark)

The project created a recreational spot for swimming, sailing, walking and running

This is an example of **combination of ecosystem-based approaches with engineering solutions**

Green Infrastructure

Grey Infrastructure

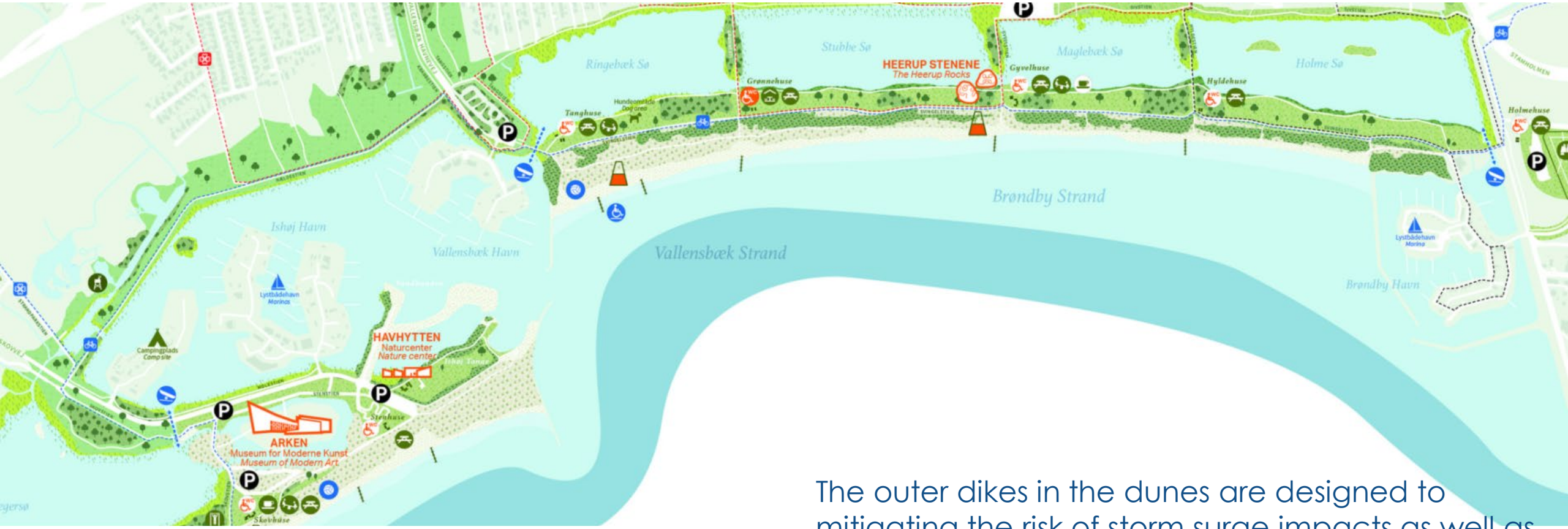
HYBRID INFASTRUCTURES | 6. KØGE (Denmark)

Køge Bugt Strandpark project

The coastline is a curved bay area with a wide flat and low-lying hinterland and a number of streams discharge into the bay area

It is an areas at risk of **flooding** and **storm surge**.
A key issue is the **flat hinterland** which put **larger urbanized areas at risk of inundated** as a result of storm surges.

HYBRID INFASTRUCTURES | 6. KØGE (Denmark)



The barrier island and sluice gate system along the streams and lakes in Køge Bugt Strandpark serve as a flood protection system and is designed to manage storm surges from the sea up to a level of approximately 3 meters above mean sea level
(COWI/Hvidovre Municipality, 2015)

The outer dikes in the dunes are designed to mitigating the risk of storm surge impacts as well as reducing coastal erosion caused by waves.
The gates mitigate the risk of storm surges entering the three streams and catchments discharging into the lagoon, and hence they aim to reduce the risk of backwash flooding of inland settlements.
(Faragò, M., et al, 2018)

HYBRID INFASTRUCTURES | 6. KØGE (Denmark)

The sandbanks and lagoon environment is a wildlife habitat protected by Natura 2000.

The Køge Bugt Strandpark provides a **wide range of habitats** including 'bird islands', **lakes, sand dunes, coastal meadows, grasslands, forests and the open sea**. Consequently, the beach park accommodates a diverse group of flora and fauna species.

The artificial beach park Køge Bugt Strandpark has **created a recreational spot for swimming, sailing, walking and running.**

The Køge Bugt Strandpark project shows how **offshore coastal protection** can be well **integrated with the development of new recreational landscapes that serve multiple functions**.

Remarks

> Wetland and salt marsh not only work like a horizontal levee, but if used in front existing dikes will decrease their maintenance and future changes.

> Building coastal defense with nature increase biodiversity.

> Building hybrid coastal infrastructure enhance not only biodiversity but also has a social impact.

> Dune belt work as a buffer between land and sea.

Thank you

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