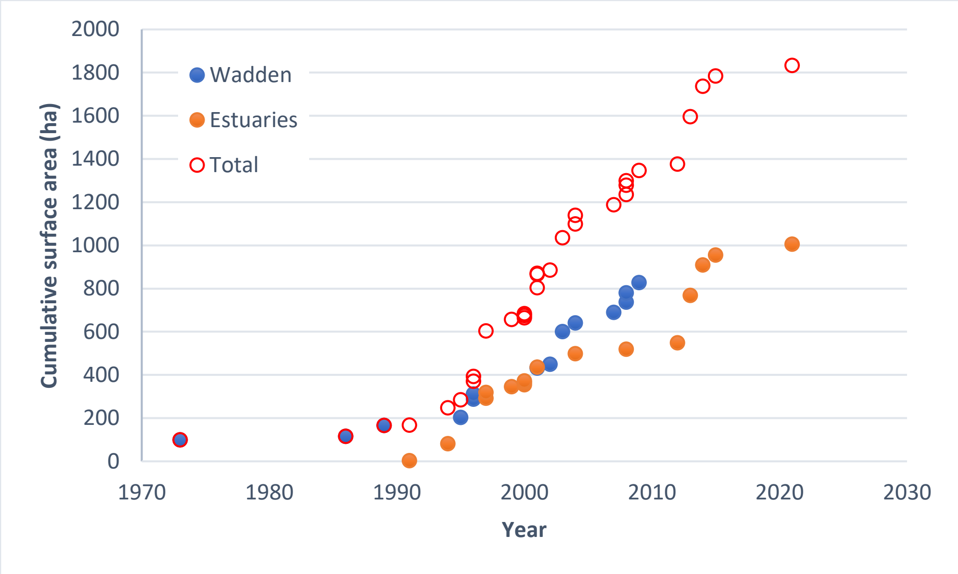
Landward Solutions Managed Realignment

Along the Wadden Sea mainland coastline, the main estuaries and on some barrier islands managed realignment has occurred. Part of it was accidental due to dike breaches; another part was planned. Plans on large-scale realignment are currently be considered.

An important estuarine and tidal habitat restoration measure is opening areas up and forming new sedimentation space via managed realignment. In the past, such realignments were often accidental when dikes were breached and had to be given up (e.g. Paesummer lannen). Nowadays, with the increased quality of the dikes, realignment is a choice. An important way to address these issues is by managed realignment (or de-embankment): the reintroduction of tidal (storm surge) influence to polders by breaching or removing dikes.

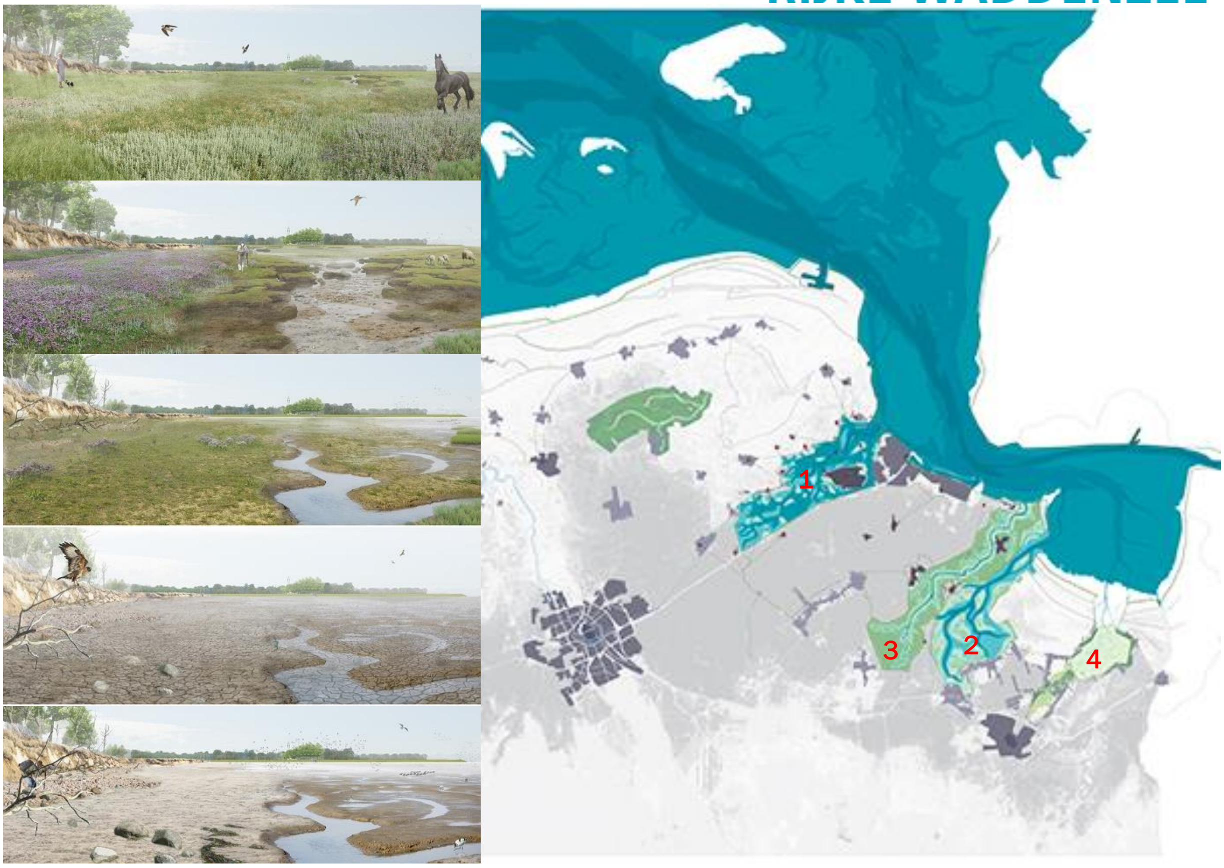


Realignment projects and cumulative area in the estuaries (Ems + Weser + Elbe) and the Wadden Sea outside the estuaries (data mainly Esselink et al., 2016, APA, 2013 and several other sources).

Since 1973 over 30 realignment projects have been implemented in the Wadden Sea Area and the estuaries, totaling to a surface area of more than 1800 ha. In areas which have been embanked during decades to centuries tides are once more introduced. A large part are summer polders previously reclaimed from artificial salt marshes. Next to that former beach plains and dune slacks have been depoldered on the islands and former dredging dump sites and polder along the estuaries. In some cases, the whole dike was removed. In other cases, only a part of the dike was opened and sometimes (storm-surge) sluices, culverts or dams were installed. Sites with regulated tidal access (Polder Breebaart and Lütetsburger Sommerpolder) have a low success rate, due to high sedimentation rates. The Polder Breebaart must be dug out from time to time to maintain nature values.

For the Ems where turbidity is high which is considered to have detrimental effects on fish migration and primary production. The reason for the high concentration is primarily sought in the ever-smaller dimensions of the estuary, so that fine-grained sediment cannot settle anymore. Thus, there is a desire to de-polder large areas. It is hoped that in that manner sediment deposition of fines will take place on a large scale. The following benefits are expected:

- Reducing the concentration of suspended matter within the estuary;
- Heightening the de-poldered low lying areas so that vulnerability for flooding is reduced;
- Providing chances for large-scale ecological gradients between the present estuary up to the new inland dikes or beyond when streams are restored (a.o. fish migration);
- Providing opportunities for salty agriculture and fish farming;
- Providing opportunities for ecotourism;
- Reducing oxidation of local peat & storing CO_2;
- Refurbishing the water management structure: rerouting canals, heightening the land.



Sketch of subsequent depoldering of low-lying areas and re-poldering after sedimentation. Artist impression of sedimentation at left side http://www.lamaland.eu/projects/rijzend-land/

Presently, there are several possibilities are being considered: from a totally open landscape without dikes to strongly regulated tidal basins. The most comprehensive and futuristic plan is "Rijzend Land" of Bureau Lamaland. It envisages to open polders surrounded by inland dikes which function as sedimentation systems. When the area has become high enough it can be reclaimed, or if sea level rise is high: left to nature. At the same time other realignment projects are still silting up. For comparison: the silting up of a basin of 10 km^2 with 1 cm/yr, would require 0.1*10^6 m^3/yr of mainly mud. Variants of the plan with even more futuristic approach have been brought forward by the bureau later.

More to the west also plans for double dike construction are being considered. Although reaching less inland than the Lamaland polders, they form a series of managed realignment areas. Flood safety, agriculture, tourism and nature are major drivers for these plans.

Sediment storage

Mostly the areas which have become connected to the tides of the Wadden Sea will silt up. Mostly the areas are still quite sheltered, due to the land-near location and the (partial) presence of dikes. Where storm surge barriers are present the natural erosion is largely halted. Often sedimentation rates in these areas are slightly higher or comparable to averages found in the near tidal marshes (Spadenländer Spitze: 8.8 mm/yr; Holwerder summerpolder: 10 mm/yr) However sometimes sedimentation rates are very high, especially in estuaries. An example is the Kleinsieler Plate in the Weser with a sedimentation rate of 500 mm/yr. To lower sedimentation rates an adaptation of the sill in the entrance was made. Occasionally, sedimentation rates may be very low (e.g. Bildtpollen: 1.2 mm/yr), resulting in a lag relative to mean high water level rise, but that is rare. Nowadays modelling and monitoring can prevent such effects.

The reasons for differences in sedimentation rates are the following:

- Inner dike or outer dike realignment

Whereas outer dike realignment allows full tidal action and relatively natural sediment transports and inner dike situation is often connected via a sill or smaller entrance leading to a smaller tidal range with less transport. Due to heightening of the terrain an open connection can be reduced over time, also reducing sedimentation rates.

- Suspended Particulate Matter concentrations

In general, sedimentation rates are higher at sites with a high SPM concentration. Basically, most realigned areas form a basin where all mud entering the area deposits in the high-water turn of the tides.

- Hydrodynamics of the area

Sedimentation and erosion are partially determined by the exposure of the area. For instance, if a large tidal channel is oriented towards the area, waves can be stronger leading to more erosion. Also, waves generated by ships can lead to very strong erosion. Such effects can be dampened by the design of the realignment measure.

- Elevation and inundation of the site

Differences in elevation will influence the spatial patterns of accretion and salt marsh vegetation development. There is an inverse relation between elevation and vertical accretion. Vegetation may only develop if the area is or has accreted to a few decimeters below mean high water. The vegetation will enhance the sedimentation rates during the pioneer stage and the low and middle marsh stage.

- Slope of the terrain

It has been observed that a shift from sedimentation to erosion occurs once the slope grade becomes higher than 2.5%.

- The number of breaches

If one breach is present, the area functions as a basin in which all the sediment which enters will be deposited. If several openings are present water may flow through and sedimentation rates are reduced or even erosion may occur. This was for instance the case in the Wrauster Bogen in the Elbe, where one site of a creek was closed to stop erosion and enhance habitat development.

In general, it is advised to aim at a development of the site which takes the conditions of the surrounding area into account and use, where possible, the hydrodynamic conditions to optimize the functioning of the area.

Natural values

Over many centuries, and continuing far into the 20th Century, poldering has resulted in the loss of extensive areas of salt marshes. Often, poldering proceeded in a two-step fashion by first building summer dikes resulting in summer polders which are occasionally flooded, after which they were diked more definitely to form polders. Especially along the mainland, poldering rates exceeded the development of new salt marsh, despite the artificial enhancement. Consequently, the size of the current mainland salt marshes is much smaller than the historic reference and salt marsh restoration was called for, especially now nature conservation and coastal defense issues have become increasingly important. Nowadays, the complete hydrodynamic gradient of natural wide salt marshes is only present in a limited number of cases. Thus, de-embankment of summer polders or inland polders will specifically contribute to the restoration of wide marshes. Along the estuaries many of the realignment projects are meant as compensation for the loss of values in the estuary due to shipping lane adaptations, enlarging harbors and expansion of industries. Often such plans are very local in nature and do not consider the relation with the surrounding system. An example where this has been done is the Luneburger Plate, where connectivity to inland streams is restored (see factsheet). Unrestricted tidal access and a moderate grazing regime will help to maintain high species diversity.

With realignment, sub-tidal creeks or ponds, intertidal flats, or supratidal salt marshes are added as extra habitats to the Wadden area and the estuaries. Due to the, often engineered, approach many of these projects have “extra” features which are beneficial to plant life and insects (tidal marshes), fish (connectivity, sheltered kindergarten areas), invertebrates (a.o. shell fish, spiders), specialized birds (breeding without predation). A beneficial by-product is that these areas can then be used to promote recreation and ecotourism, although this is up to now rather limited in the Wadden Sea (e.g. Noarderleeg, Wangeroog) and estuaries (e.g. Luneplate). Modelling can be used to determine if alterations to the site such as creek excavation/filling or elevation raising, can encourage formation of beneficial features. Additionally, modelling will provide information on environmental changes, such as changes to estuarine ebb/flood dominance or heights.

However, the existence of important or protected habitats behind or in front of existing coastal defenses may pose a barrier. Managed realignment can bring about detrimental impacts to many plants, animals and endangered aquatic invertebrates, which are unable to deal with tidal flooding.

Safety against flooding

In the Wadden Sea and in the estuaries managed realignment is mainly targeted at natural values. However, (when outer dikes) it may significantly reduce the cost of providing protection against coastal flooding and erosion. This goal is partially reached due to the formation of a new foreland, shortening the dike, or damping of waves by the newly established foreland. Furthermore, the it is a highly robust measure against climate change futures and generally enhances resilience to unexpected changes. Furthermore, it may locally help to reduce storm surge levels. A bonus is that it helps to mitigate carbon dioxide and methane emissions due to storage in the sediments. because the gases are stored within the sediment deposits. All these factors could be taken into consideration for future planning of new managed realignments. Preferably, managed realignment should be part of a ‘strategic’ shoreline management plan, which typically consider tens of kilometers of coastline in a holistic way. In this manner a variety of needs within the targeted area is addressed and can maximize benefits and overcome potential constraints.

Stakeholder processes

It requires land to be yielded to the sea, which may require the relocation of important infrastructure or buildings and giving up former functionalities. Thus, often the need of land leads to sharp political and social controversy. A lack of public acceptance is the main barrier for implementation of plans as it is often perceived as a loss of land. Furthermore, it is difficult for the general public to understand how the technology mitigates coastal flooding and erosion and furthers natural values.

The second most important barrier relates to farming communities as managed realignment is mainly implemented on agricultural land, which thus will be lost. If enough compensation is available, many farmers are willing to sell their land. Alternatively, the land may be used in other ways, such as for recreation, (shell)fish farming or salty agriculture, but also then extra investments are needed. It is interesting to notice that the higher-value future crops take up much less land and deliver the same amount of income (see table).

Overview for an area in Groningen, the Netherlands: the present-day areal extent of the crop production compared to a situation after realignment with a mix of present-day crops, shellfish farming and salty crops delivering the same income as in the current situation, leaving some 80% of the area for new nature (data Roggema, 2020). With less natural area the income can increase.

Crops	*Present day situation (ha)*	New nature (ha)	After transition present-day crop (30%)	Shellfish (20%)	Salty crops (50%)
Potatoes	*6,875*	2,750	1,203	859	2,063
Sugar beet	*2,475*	1,980	186	62	248
Wheat	*7,500*	6,750	225	150	375
Dairy cows	*9,975*	8,978	299	200	499
Grass	*9,975*	8,978	299	200	499
Carrots	*1,200*	480	210	150	360
Mais	*1,860*	1,674	56	37	91
Barley	*2,060*	1,854	62	41	103
Total	*41,920*	33,444	2,540	1,700	4,238
%	*100%*	80%	6%	4%	10%

Legal and financial difficulties, for instance concerning the responsibilities and liabilities of certain land owners or authorities, can also be a barrier to implementation for managed realignment schemes.

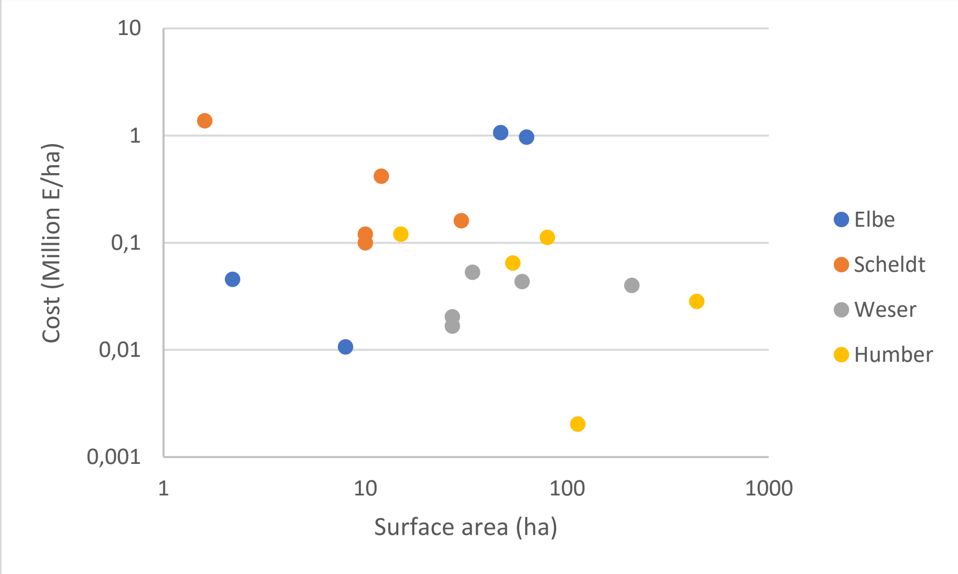
For all these reasons, it is essential that coastal managers fully engage stakeholders and the local community in the process of managed realignment for successful implementation of the schemes. Participation can help to understand legitimate concerns and interests; explain and convince stakeholders of a scheme's merits; manage expectations and develop (a feel of) ownership among stakeholders. Furthermore, care should be taken to plan strategically to avoid problems and detrimental local impacts. Better yet, planning should see to it that it improves the local situation for the surrounding area.

Financial requirements and costs

As can be observed from the 19 examples of realignment projects in estuaries the costs of vary strongly; in this case between 2000 to 1.4 million Euro per hectare. The differences are due to:

- Cost of purchasing land (mostly high)
- Compensation to occupiers
- Dismantling human-made structures to prevent marine pollution (buildings, roads, pipes, wires)
- Building/reinforcing new sea defenses to protect the hinterland
- Optional: storm surge barriers
- Optional: (restoring) connectivity to fresh water flows
- Availability and cost of human resources including expertise
- Landscaping
- Scale and frequency of monitoring

Sometimes local values lead to steep cost increases. In Germany, the cost of realignment is seen as a major barrier, since most of the North Sea defenses are in excellent condition. Monitoring and modelling in the preparation phase will help to maximize the benefits and lower the costs.



19 examples of managed realignment projects in several estuaries: x-axis: area; y-axis cost per ha; both on log scale (data from TIDE, 2013).

Relevant conditions

Managed realignment is possible when:

- Coastal defenses are present (preferably with extra already existing defenses landward of the sea dike)
- Low-lying land is available
- Flood or coastal defense systems need to be improved
- A sustainability-oriented coastal management attitude is present
- There is a desire or need to create sub-tidal creeks or ponds, intertidal flats, or supratidal salt marshes
- There is societal awareness about the benefits of managed realignment
- Realignment brings advantages

Lessons learned

- Identify requirements for salt marsh restoration: be realistic in formulating dynamic goals with a time trajectory
- Management plan for salt marsh restoration (incl. priorities)/ Feasibility study
- Discuss with stakeholders and adapt plans
- Detailed planning: do consider terrain level heights with reference to MHW) at an early stage.
- Choose the right measures for the site (consider tides, natural hydrology, preexisting top soils and plants, terrain levels and likely sedimentation rates)
- Discuss with stakeholders and adapt plans
- Make cost calculation
- Check functionality via hydrological models in combination with local gauge data.
- Find money and sponsors
- Realize the work
- Organize long-term monitoring & evaluation
- Ensure scientific analysis
- Share results

Discussion points

- The costs of managed realignment are often high. What is a sound approach to lower the costs?

- Large-scale realignment programs which are part of a comprehensive coastal development plan may serve several goals at once, consider the regional context (and add to that) and provide more possibilities to solve local problems due to realignment. Should that be the future way forward?
- Large amounts of mud are being deposited in these newly opened areas: should such muds be primarily/temporarily used for nature development, or primarily to heighten the area and to make it more resilient to sea-level rise or both?
- Should realignment be based on a life-cycle approach or is this useless given the unknown future velocity of sea-level rise?
- Should clean mud be kept in the Wadden Sea system and estuaries or is it better to take it out and use it on land?

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