

Seaward/Landward Solutions Development of clay pits in front of and behind the dike



Clay mining pits have been must have been in use from Roman times onwards, given the clear marsh characteristics of the sods observed in dike profiles of the Roman, medieval and postmedieval times. The system of taking sods from either inner dike areas or outer dike salt marshes to repair or built dikes has been in operation up to the 21st century.

Clay mining pits in outer dike salt marshes will fill up with new clay in due time and salt marshes can become re-established. This may result in a rejuvenation of the tidal marsh if the right conditions are met. Currently outer dike clay mining pits are no longer in use in Schleswig Holstein. The argument is that mud is part of the Wadden Sea area. There it is needed to balance sea-level rise and for the nature development of the system. In Lower Saxony the locations and the exact dimensions of outer dike clay mining are strongly determined by the interests of the National Park.

In the Netherlands clay mining has largely been stopped, because the quality constraints for sediments allowed in dike building mostly forbid the use of tidal marsh deposits. Recently, a new experiment in the Dutch part of the Eems is presently under way where clay mining in the tidal marshes of the Dollard area was combined with a bird breeding island in the center: the Nieuwe Klutenplas. At the moment monitoring is carried out.

Clay mining is as old as the earliest dikes in the Wadden area. A part of the sods visible in old dike profiles can be shown to have been taken from the tidal marshes. However, at many locations clay rich sods have also been taken from the inner dike areas as can be concluded from the many inner dike clay mining areas. Dike strengthening agreements often are written down as adding one or several sods annually on the dike profile. The inland clays were not only mined for dike building, but also to produce bricks. Large areas near the Oste river in Lower Saxony were mined for that purpose.



Cross section dike remnants at Peins 1 Cent BC given by red line. Dike built by sods in disarray taken from the middle tidal marsh various phases. Ditch visible of which clay was taken seaward of dike. (Compilation of RWS Photo's by R. Juncurt)

Where clay mining pits have been made behind the dike, they are semi-permanent although they may fill up with plant material over a prolonged time. These historic inner dike clay mining pits often provide reserves for bird life (e.g. Feddema's-plas in Groningen). At the moment it is proposed to locally allow the formation of new fresh to brackish lakes in combination with breeding areas at the landside of the Wadden Sea area to stimulate the nature functions of the Wadden Sea (Ontwerp Agenda Waddengebied 2050). These proposals have been criticized by the Nederlandse Akkerbouw Vakbond (the Dutch Agricultural Union) They state that the new approach integrates a large part of the inner dike area to manage the Natura 2000 and World Heritage area of the Wadden Sea and lead to strongly negative consequences for agriculture. One of the main objections is against proposed measures which will increase the salinity of inner dike areas, by such measures as the formation of clay pits and managed retreat.



Feddema's plas near the Ommelander Sea Dike. This inner dike lake was formed in 1924 to build dike the Julianapolder. The Waterboard Hunsingo bought the area to mine clay. Thereafter it filled with brackish water. As a result, plants are present around the lake which are characteristic for brackish to saline conditions. The lake is used by Wadden Sea birds. In 1994 the area was given to the Groninger Landschap, a provincial nature organization. (Source: <https://www.groningerlandschap.nl/natuur/waddenkust/feddemas-plas/>)

Where clay mining pits are formed outer dikes, it is often in the tidal marshes where clay rich sods are easily available. The strong roots in the sods made them easy to work and to use in dike building. After mining such areas might fill up relatively quickly if drainage is sufficient. Maintenance of outer dike drainage channels can be observed on maps as early as the first half of the sixteenth century. However, there are indications that drainage networks to enhance mud sedimentation on the tidal marsh may have been established much earlier, perhaps already in Roman period, as lower dikes have been observed on the lower tidal marshes and higher dikes with channels in front of them on the middle tidal marsh.

Recently, Schleswig Holstein ruled that clay mining outer dikes should be stopped as the sediments are needed for the natural functioning of the system and to keep up with sea-level rise. One question in this approach is if the present-day rather static situation with dike lines can mimic the natural rejuvenation which was originally existing. Before dikes were a dominant factor, land areas might be flooded/eroded so that new mud sedimentation or generation areas were formed¹. This land-scape rejuvenation has largely disappeared, the only exemption being managed retreat areas and clay pits, which in scale are generally much smaller than natural formation of new embayments.

In contrast, in Holland and Lower Saxony clay mining is still allowed. On the tidal marsh of the Lower Saxony coast many clay pits have been dug. Experience learned that pits may exist for 10 to 40 years depending on the infill rates. Thus, tidal marsh area is locally lost and with it an area where insects and other organisms can live. Also, breeding area for tidal marsh birds is lost for a period of 15 to 40 years, as well as roosting space. On the positive side the large-scale clay pits generate a more natural dynamics with natural creeks and it possibly improves the quality of bird breeding, roosting and feeding area. By law, clay mining on tidal marshes is allowed when inland clay cannot be mined. However, in the National Park clay mining is in practice only by exemption allowed for individual cases, if:

- the removal does not significantly affect the protective values of the Park.
- a sustained improvement is expected of the ecological value of these areas in the sense of Natura 2000 conservation targets
- the clay removal is carried out according to nature conservation requirements.
- in the area the value-determining bird species remain in a favorable conservation status or at least their conservation status does not deteriorate.

This restricts the choice of areas where clay pits can be dug and how their form should be and makes these choices important to nature preservation. Furthermore, it was learned that large rectangular clay mining fields with only a limited connection to tidal flow need a very long regeneration time. Nowadays the clay mining takes into account the generation of extra values for nature by:

- Beveling the embankments, flat banks;
- Creating height differences;
- Undulating borders with the tidal marshes;
- Dismantling of existing anthropogenic structures;
- Connection of the creeks of the area to existing creeks;
- Initiation of the development of a creek system;
- Creation of predation-poor spaces and islands.

¹ In that period (mainly Middle Ages and direct post-medieval period) mud availability was huge due to the intense erosion of land due to deforestation. Nowadays much of the mud which is transported by rivers is trapped in artificial lakes, thus reducing mud transport to open sea. The present-day availability of mud might be considerably lower than in the past, thus reducing the possibilities for rejuvenation of the landscape via new mud deposition.



Jadebusen embayment, Lower Saxony: At the left side and between the two new restorations: old-fashioned clay pits of the 60-ies and 70-ies, which were water-logged until 15 years ago, when they were reconnected. In between and to the right side modern clay pits with irregular borders, connectivity with creeks and height differences resulting in islands and, seaward of them, tidal marsh areas which are surrounded by water and creeks (Google Earth; pers. Information: A. Groeneveld, Nationalparkverwaltung Niedersächsisches Wattenmeer).

In Holland currently clay mining pits for dike building have become rare as the clay has to meet very strict specifications to be used for dike building. However, bird breeding islands are formed surrounded by ponds by digging out tidal marshes. Up to now the dug-out material was often used for infrastructure on the tidal marshes or the closure of ditches. In 2018 the so-called Nieuwe Klutenplas in the Dollart area, in the province of Groningen was established. This is an experiment. The clay has been used to build a containment dike for mud which should ripen to clay to be used for dike building (see Broad Dike Factsheet).

Piping

An important restriction is that the sedimentation of fine material on the tidal marsh and the older clay deposits landward of the dike results in an impermeable layer. This has an inhibiting effect on the groundwater flow. The effect is beneficial to failure mechanisms such as piping and macro-instability due to pushing up. The effect already occurs at widths >100 m. It is important that the 'impermeable layer' is not disturbed by clay pits, so that dike stability is ensured.

Research

Piping

Many dikes in the Netherlands nowadays do not meet the required safety standards; in a large part due to the perceived danger for piping. Sedimentation of thick clay layers in the front of the dike might prevent the piping process from happening, but in most cases such clay layers are not taken into account for safety calculation (one exception are the muddy deposits in the Mok-bay Texel). As far as known no research is at present carried out to evaluate the possible role of such layers or the influence of establishing outer dike clay pits.

Netherlands, Nieuwe Klutenplas

In 2018, the construction of the Nieuwe Klutenplas, an area of 3.5 ha of open water with 0.5 ha breeding island for Pied Avocets (*Recurvirostra avosetta*) created an area of open water which is much larger than those in natural tidal marshes in which pools have a maximum dimension of 0.125 ha. The Dollart tidal marshes are artificial and have an unnatural dewatering system. It is hoped that upon infill a more natural creek system will develop. However, waterboard Hunze en Aa's considers the possibility to use the mud which is deposited from time to time to let it ripen to clay which can be used for dikes. The island in the open water reduces predation by foxes and it is hoped that the breeding success of the Avocets will increase.

For the development of the Klutenplas area which is a pilot for sustainable mud production, monitoring is carried out of the development of the

- 1) drainage network;
- 2) tidal marsh erosion;
- 3) the sedimentary infill in the Klutenplas
- 4) vegetation on the breeding island.

Lower Saxony

For each potential clay pit questions which are studied on beforehand in Lower Saxony are:

- Is the mining of clay in the tidal marsh a good management action for nature conservation to further the targets in the National Park?
- Does the clay mining increase the quality of the various protected values in the National Park (tidal marshes, breeding and roosting birds)?
- To what extent does nature protection require special measures to the mining operation?

Results

In spring 2018, during the digging of the Nieuwe Klutenplas avocets were present. The first results show that the drainage channel from the Nieuwe Klutenplas towards the tidal flats initially deepened with 0.3-0.5 m. Tidal marsh erosion along the edges with the tidal flats is an autonomous process which already existed before the Klutenplas was created. The first measurement over the period 2017-2018 (-0,08 ha due to a landward retreat of 0.9 m) indicate a reduction with reference to the period 2009-2017 (resp. 0.14 ha and 1.1 m/yr). The infill of the Klutenplas is rather rapid with an initial sedimentation in the first 5 months of on average 13 cm. Vegetation on the island initially mainly consisted of annual plants and *Tripolium pannonicum*.

The findings at the Nieuwe Klutenplas are in line with the findings of Lower Saxony. The rapid sedimentation in the Klutenplas may well result from: 1) the good connectivity of the pit with the creeks so that tide water can flow in allowing for the repeated deliverance of mud; 2) the observed deepening of the drainage channel at the Nieuwe Klutenplas clearly points to the fact that the amount of tidal water is too large for the channel leading to high current velocities and hence erosion: this sediment is partially deposited in the Klutenplas. Like in the Lower Saxon case a more natural approach was followed for the formation of the clay pit. As a result, in early vegetation at some places. Like in Lower Saxony the island has proven to be a safe haven for breeding birds.

Lessons learned

From the above considerations several lessons can be learned:

- 1) For outer dike clay mining it is important to first have insight in the amount of mud which is needed for the nature functions of the Wadden Sea system, at present and in the future under conditions of accelerated sea-level rise. Schleswig Holstein concluded that on that basis clay mining cannot be allowed. As far as known such studies have not been carried out in other parts of the system. At the moment an appraisal study for the trilateral Wadden Sea is being conducted, aiming at getting an overview of the available knowledge.
- 2) If outer dike clay mining is allowed, the approach developed by Lower Saxony seems a very sensible one: nature values should increase due to the effects of the clay pit formation.
- 3) Allowing inland clay mining may be profitable if the sediment is meeting the requirements for use of the clays. The areas which are thus formed can provide a rich habitat for bird life and other organisms which are depending on fresh to brackish conditions.

4) In all cases, seaward and landward of the dike it is important to consider the possibility of piping and macro instability when new clay pits are made for whatever reason.

Stakeholder processes

Stakeholder processes for clay mining is mainly between dike managers such as waterboards, land owners, dike builders and nature conservationists. In Germany the state regulated management groups to a large extent determine the possibilities for clay mining. This is also true for the Netherlands, but here a growing tendency can be observed to join forces in the search of more optimal solutions for the various problems. For instance, the Nieuwe Klutenplas is the result of the experimental project which involves the following parties: Waterboard Hunze en Aa's, POV Waddenzeedijken, Eems-Dollard 2050, Province of Groningen, Groningen Seaports, Het Groninger Landschap, Ecoshape, Waddenfonds, Rijkswaterstaat, Maatschappij Onverdeelde Munnikeveen, E.H. Huisman.

Discussion points

It is clear that there are relatively large differences in the approach of formation of clay mining pits in the various countries. As such, much can be learned from each other. A main question is: is there sufficient mud available to mine clay from the tidal marshes, without negative consequences for the functioning of the trilateral Wadden Sea at large? If that is the case, the local mud availability must be considered with a similar question. Thirdly the approach of Lower Saxony seems to be an optimal choice between clay mining and nature values. But is this really the case or is the scale of clay mining too small or too large to restore natural values that were once present in a natural landscape? Or is the shift from an artificial tidal marsh towards a more natural tidal marsh so valuable that it is a justification for such measures?

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