Mud Motor in Port of Harlingen

Young salt marshes are important for the Wadden Sea ecosystem, an intertidal zone with tidal flats and wetlands in the southeastern part of the North Sea. Salt marshes are present north of the harbour city Harlingen (The Netherlands) but their size is limited, either due to limited mud supply or hydrodynamic conditions being too energetic. To ensure sustainability of the ecosystem, the sediment supply to the area had to be increased. The BwN project Mud Motor proposed to deposit dredged sediment north of Harlingen and let natural processes spread the sediment to the nearby salt marshes. The underlying hypothesis of the Mud Motor concept was that the deposited sediments would be picked up by a tidal current. As a result the currents that feed a salt marsh have higher mud concentrations, which then probably accelerates marsh-development processes.

Here, we highlight key uncertainties in the natural, technical and social aspects of this particular BwN case and discuss how these uncertainties were addressed throughout the different phases of the project.

Natural uncertainties

The key uncertainty of the Mud Motor project from the natural system lay within the effects of temporal variability in wind direction and strength on erosion and accretion of sediments on the salt marshes. What would be the effect of wind direction and strength on the transport of fine sediments onto the mudflat? How does the wind interact with tidal flow? Those uncertainties were monitored in the operation and maintenance phase. Field measurements showed that the tidal flood flow direction (and thus the sediment fluxes toward the study area) can be reversed by a wind with opposite direction when the wind speed is about 10-12 m/s. Wind direction and strength are thus a key factor of influence, implying large seasonal and yearly variation in transport of fine sediments onto the mudflat. It was found that layers of fluidised mud up to a thickness of 10 cm were deposited at some locations of the salt marsh, but also disappeared quickly. Also here, wind conditions play a role, as it was found that specific storm conditions induced sedimentary and/or erosive event. Furthermore, during the monitoring campaigns, no increased pioneer vegetation cover at the salt marshes was measured over the first two years. Future monitoring should provide more insight whether acceleration in salt marsh development will take place in the long-term.

Technical uncertainties

The key technical uncertainty concerned the effectiveness by which the deposited sediment would end up at the desired location, the salt marches. Model simulations were made to predict the tidal flow conditions and to determine the best disposal location where dredged sediment would be disposed of, relative to tidal flows to choose an appropriate location for the Mud Motor. Based on the model simulations a preliminary disposal locations was chosen in shallow water. Subsequently, a pilot study was set up to assess whether the efficiency of the Mud Motor in the field corresponded with the model computations. In the pilot, a fluorescent tracer was used and fully mixed trough the dredged sediment. The tracer had a similar particle size distribution and comparable behaviour to the dredged sediment. Tracers in the deposit sediments were used to identify the destination of the disposed sediment and to determine what percentage of the disposed sediment reaches the salt marshes. The efficiency of the Mud Motor was found to be higher than predicted. Another finding from the tracer study was that the sediment deposits occur in relatively shallower areas than indicated by the model. This is assumed to be the result of wave-induced resuspension, which was not included in the modelling. In order to further reduce the modeling uncertainty concerning the depositing sediment, it would be necessary to also model wave-induced resuspension.

Social uncertainties

Although the Mud Motor at Harlingen itself is a pilot project, the concept could potentially be applied wider as a strategy to combine harbour and nature development for harbour cities. This strategy would have potential both from an economic and ecologic perspective. In the case of the four medium sized harbours located in the Dutch Wadden sea, for example, all harbours deal with large siltation rates. Additionally, these harbours need to develop their economic activities to survive in the long run, but expansion is hampered because of their location at the Wadden Sea, which is protected as a UNESCO and Natura2000 site. The ecological value of the Wadden Sea is already affected in and around the harbour locations (Van Eekelen et al., 2016). Key social uncertainties in further application of the MudMotor concept are therefore related to, amongst others: whether regulations and the protected status of the Wadden Sea will allow for such combined approaches to nature and harbour development, and whether such a combined approach is also economically feasible.

Lessons are learnt through pilots such as the Mud Motor, which reduce the level of uncertainty and give insight into how to address these uncertainties in the future. For example, during the initiation phase of the Mud Motor pilot, project permits had to be obtained. Therefore, an assessment had to be completed that detailed the natural values that potentially could be harmed and that illustrated possible mitigation measures. The required permits were obtained, but disposal of the dredged sediments was only allowed in autumn to minimize the potential impact on other flora and fauna. Hence, this taught that the strategy for mud disposal is strongly affected by these permits. This in turn, can affect the economic feasibility of the solution. A broader cost-benefit analysis for salt marsh enlargement, in turn, may yield other financial benefits. Wider marshes can, for example, reduce dike maintenance costs as a result of the reduced wave energy. The extent to which dike maintenance can be reduced is however uncertain, as this depends on the effectiveness of the salt march growth. An additional complicating factor is that the port authority is not the beneficial recipient of this cost reduction. Therefore, complex financial agreements would be required for such future developments.

Sources:

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- Van Eekelen E, Baptist MJ, Dankers PJT, Grasmeijer B, van Kessel T & van Maren DS (2016) Muddy waters and the Wadden Sea harbours