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Land Reclamation Controls on an Estuarine Regime Shift from a Multichannel to Single Channel Configuration

R.A. Schrijvershof^{1,2}, D.S. van Maren^{3,2,4}, M. Van der Wegen^{4,2}, and A.J.F. Hoitink¹

¹Wageningen University and Research, Wageningen, The Netherlands; ²Deltares, Delft, The Netherlands; ³State Key Lab of Estuarine and Coastal Research, East China Normal University, Shanghai, China; ⁴Delft University of Technology, Delft, The Netherlands; ⁴IHE-Delft Institute for Water Education, Delft, The Netherlands; reinier.schrijvershof@wur.nl; reinier.schrijvershof@deltares.nl

1. Introduction

Deltaic intertidal areas disappear worldwide. This impacts delta morphology, because the extent and physiological character of the tidal floodplains control the tidal regime and, as a result, residual sediment transport patterns. Extensive reclamation of former tidal flats, effectively changing the ratio of channel volume to intertidal storage volume (V_s/V_c), drastically changes the functioning of the estuarine system. This might result in morphodynamic feedback loops that reach a tipping point towards an alternative stable regime (Van Maren et al., 2023). Our capacity to predict the consequences of future land reclamation or depoldering methods, a measure frequently suggested to cope with the effects of sea level rise, is limited, because the conceptual framework describing estuarine response to tidal flat reclamation fails to predict such regime transitions.

2. Study site, methods, and results

The Ems estuary (bordering The Netherlands and Germany) provides a well-documented study site where an extensive storm surge-formed basin was gradually reclaimed over a period of 500 years (Figure 1). A unique bathymetric dataset, spanning nearly the same period, shows that channel configuration evolved from a multichannel system to an alternative stable state consisting of a single channel. Land reclamations appear to be the primary driving force behind these altered channel dynamics, but realignment of the main channel as a result of dredging works over the past century is probably accelerating this process. Channel dynamics are further constrained by the presence of erosion resistant layers of pleistocene origin (Pierik et al., 2022).

For this study, we developed and applied a process-based morphodynamic model (Delft3D-FM), forced with a newly constructed synthetic spring-neap tidal cycle (Schrijvershof et al., 2023), to study the estuarine channel evolution over the past centuries. Simulation results demonstrate that the evolution from the initially flat-bed bathymetry evolves to a system with multiple channels and tidal flats when former storm surge basins are included as intertidal areas. Reclaiming the basins in the simulations results in a single channel configuration, suggesting that the system shift is indeed driven by land reclamations. The ongoing efforts aim to quantify the contribution of natural versus human-driven controls on the century-scale channel evolution.

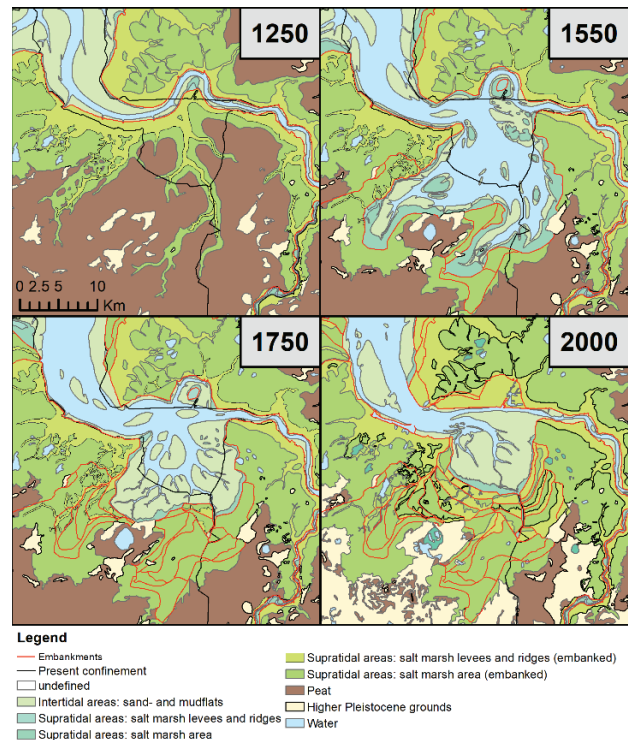


Figure 1. Formation and reclamation of storm surge basins in the Ems estuary (adapted from Vos et al., 2020).

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