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Tidal Response to Land Reclamation in Single- and Multichannel Estuarine Systems

J.G.W. Beemster¹, D.S. van Maren² and A.J.F. Hoitink¹

¹ Department of Environmental Sciences, Wageningen University and Research, Wageningen, The Netherlands, joris.beemster@wur.nl, ton.hoitink@wur.nl

² State Key Lab of Estuarine and Coastal Research, East China Normal University, Shanghai, China; Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands; Deltares, Marine and Coastal Systems Unit, Delft, The Netherlands, bas.vanmaren@deltares.nl

1. Introduction

Intertidal areas play a crucial role in controlling tidal hydrodynamics and morphodynamics in estuaries and tidal inlets. As a consequence, widespread land reclamation of the intertidal zone has led to alterations in tidal dynamics and the associated morphodynamics of estuaries worldwide. Comparatively little research has focussed on the impact of width changes on tidal hydrodynamics, and results that do exist are highly ambiguous (Talke and Jay, 2020). Tie channels in between parallel inlets complicate the tidal motion, as multichannel systems exhibit a hydrodynamic response that differs significantly from the response observed in single channel systems. In this study, we combine idealized process-based modelling and historical data analysis to investigate the effects of intertidal land reclamation on the tidal dynamics of single- and multichannel systems. Specifically, we focus on the Scheldt and Pasur-Shibsa estuaries, which represent a single- and multichannel system, respectively.

2. Main Findings

For single-channel systems, our Scheldt findings indicate that the reclamation of parts of the intertidal area results in increased tidal amplitudes within and landward of these areas. Embankment of the intertidal areas causes a significant loss of intertidal storage. However, the amplified tidal range results in an increase in intertidal storage within the main channel. This increase is due to two factors: a local increase in the tidal range and a stronger landward intrusion of the tidal wave. Consequently, the tidal prism is partially maintained, and the loss of storage within the intertidal zone is partially compensated for by an increase of storage within the channel. Moreover, the removal of the intertidal area enhances wave propagation in the channel, leading to reduced travel times and alterations of the resonance properties.

Multi-channel systems exhibit a similar initial response to widespread land reclamation. However, cross-basin feedbacks can lead to a reorganization of discharge pathways and drastic morphologic changes. Such feedbacks can be instigated through asymmetric or asynchronous land reclamation. In the Pasur-Shibsa estuary, the Shibsa was subjected to earlier and more widespread land reclamation, leading to severe tidal amplification (van Maren et al., 2023). This has led to partial capture of the intertidal storage of the Pasur, and the river discharge it receives. These changes caused severe bank erosion in both the Shibsa and

the channels connecting it to the Pasur, while widespread sedimentation caused the Pasur to degenerate.

3. Conclusions

Our study sheds light on the unexpected morphodynamics that can result from widespread land reclamation and how the hydrodynamic response differs between single- and multichannel systems. Our findings emphasize the need for a comprehensive understanding of the role of the intertidal zone on estuarine tidal dynamics.

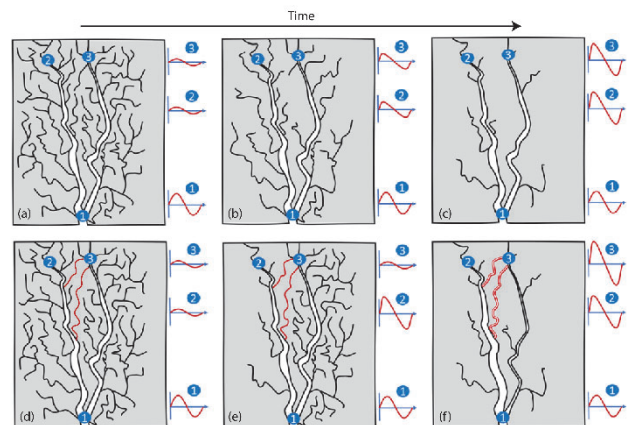


Figure 1. Positive feedback mechanisms leading to tidal deformation and channel network reorganization. Top and bottom rows illustrate the response to land reclamation for two connected and disconnected estuaries, respectively.

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