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Effect of environmental change on the morphology of tidally influenced deltas over multi-decadal timescale

Balaji Angamuthu (1), Stephen Darby (2), and Robert Nicholls (3)

(1) Geography and Environment,University of Southampton, Southampton, United Kingdom (B.Angamuthu@soton.ac.uk), (2) Geography and Environment,University of Southampton, Southampton, United Kingdom , (3) Engineering and the Environment,University of Southampton, Southampton, United Kingdom

An understanding of the geomorphological processes affecting deltas is essential to improve our understanding of the risks that deltas face, especially as human impacts are likely to intensify in the future. Unfortunately, there is limited reliable data on river deltas, meaning that the task of demonstrating the links between morphodynamic and environmental change is challenging. This presentation aims to answer the questions of how delta morphology evolves over multi-decadal timescales under multiple drivers, focussing on tidally-influenced deltas, as some of these, such as the Ganges-Brahmaputra-Meghna (GBM) delta are heavily populated. A series of idealised model simulations over 10^2 years were used to explore the influence of three key drivers on delta morphodynamics, both individually and together: (i) varying combinations of water and sediment discharges from the upstream catchment, (ii) varying rates of relative sea-level rise (RSLR), and (iii) selected human interventions within the delta, such as polders, cross-dams and changing land cover. Model simulations revealed that delta progradation rates are more sensitive to variations in water discharge than variations in fluvial sediment supply. Unlike mere aggradation during RSLR, the delta front experienced aggradational progradation due to tides. As expected, the area of the simulated sub-aerial delta increases with increasing sediment discharge, but decreases with increasing water discharge. But, human modifications are important. For example, the sub-aerial delta shrinks with increasing RSLR, but it does not when the sub-aerial delta is polderised, provided the polders are restricted from erosion. However, the polders are vulnerable to flooding as they lose relative elevation and can make the delta building process unsustainable. Cross-dams built to steer zones of land accretion within the delta accomplish their local goal, but may not result in net land gain at the scale of the delta. Applying these results to the contemporary GBM delta implies that cross-dams and polders have been a key control on the morphodynamic evolution of the GBM delta over the last 60 years. However, with increased fluvial water discharge and rates of RSLR likely under greenhouse gas (GHG) -driven warming, the continuing use of sediment starved polders will only increase the vulnerability of poldered areas from regular flooding, and eventually may lead to catastrophic, permanent, inundation of the land. Hence, the future trend of morphological evolution of the GBM delta depends on local human intervention, including measures to raise the elevation of the land to cope with the continuing trend of RSLR and varying fluvial discharges. The model findings provide a basis to establish guidelines for planned future management interventions to prevent the delta from destruction.