



Robert J. Nicholls¹, W. Neil Adger², Craig W. Hutton³, Susan E. Hanson³, Attila N. Lázár³, Katharine Vincent⁴, Andrew Allan⁵, Emma L. Tompkins³, Iñaki Arto⁶, Md. Munsur Rahman⁷, Sugata Hazra⁸, Samuel Nii Ardey Codjoe⁹ and Steve Darby³

¹Tyndall Centre for Climate Change Research, UK; ²University of Exeter, UK; ³University of Southampton, UK; ⁴Kulima, South Africa; ⁵University of Southampton, UK; ⁴Kulima, South Africa; ⁵University of Ghana, Ghana.

Human actions and choices, including adaptation, control what the future will be for populous deltas in the Anthropocene. The diverse social and environmental changes reflect the challenges and trade-offs that are emerging across the planet.

Pressures and Change

Loss of relative elevation due to relative sea-level rise (combining climate and subsidence effects) is a major threat to dynamic delta systems, but there are others such as catchment changes (e.g., water extraction and dam construction) which reduce water and sediment inputs. Rapid socio-economic changes within the delta (e.g., migration, urbanisation, economic transition and land use change) are also a widespread feature, increasing wealth and aspects of adaptive capacity. To understand populated deltas in the Anthropocene we need to consider the multiple and interacting pressures that are shaping deltas.



Sustainable Deltas in the Anthropocene

Adaptation: Buying time

People in deltas have adapted to changing conditions through history. Today, many deltas cope with 'lost elevation' via defences and now "Delta Plans": the Netherlands is most advanced in this approach reflecting its high wealth, access to technology and good governance indicating wealthy societies in deltas can buy time and adapt with technology — at least in the 21st Century. Other countries may take a more bottom-up approach, using a combination of physical, social and economic adaptation methods. Importantly, any implemented adaptation will feedback on future delta evolution



For further information contact: Robert J Nicholls robert.nicholls@uea.ac.uk See: Nicholls et al (2020) Deltas in the Anthropocene Palgrave Macmillan https://doi.org/10.1007/978-3-030-23517-8

Large scale engineered adaptation The Netherlands

Long term choices

In the long-term (i.e. 2100 and beyond), there are three distinct policy choices for deltas each of which will involve trade-offs, compromises, and strategic development pathways:

(i) retreat (planned or unplanned (disaster response)) and progressive abandonment and landward migration; (ii) **protection** with ever-higher defences, growing pumping needs, requiring a vibrant economy generating a continuous stream of finance, good governance and recognition of residual risk (the potential for occasional catastrophic failure); or (iii) **raise land elevation** by working with nature and controlled sedimentation (assuming controlled flooding is acceptable and sufficient sediment is available — only really suitable in rural areas).

It also depends on the magnitude of sea-level rise (global-scale), subsidence (delta-scale) and the availability of sediment (deltascale). The future of deltas is highly uncertain and will almost certainly follow diverse trajectories. Maximising the application of land raising would be prudent. Protection also has the scope to buy time, but what are the limits? Retreat is unlikely to be proactively planned.



Combined adaptation options Ganges-Brahmaputra Delta, Bangladesh

DECCMA



Land cover change Demographic change Economic change Groundwater and fluid extraction