Morphological Evolution and the Sustainability of Deltas in the 21st Century

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Situated at the dynamic interface between fluvial and coastal processes, deltas are major socioeconomic and ecological centres that are widely recognised as being highly vulnerable to the combined impacts of climate change and increasing levels of human activity. A review of recent literature shows that two dominant anthropogenic controls and two major climatic pressures influencing delta morphology can be identified as common to many systems around the world:

Bank erosion in the Mahanadi delta (Telegraph India, 2014)

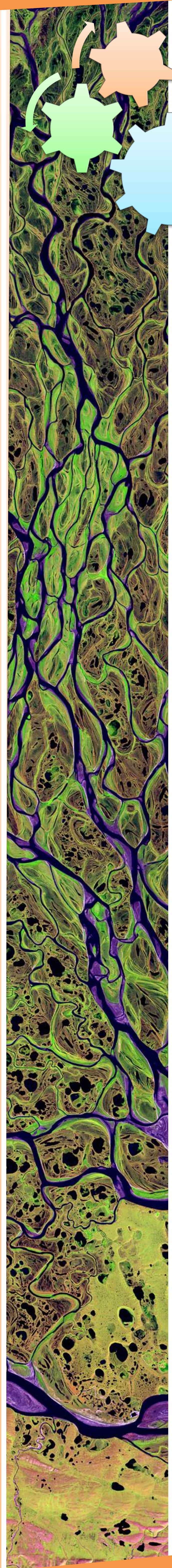
Sediment starvation, due to upstream damming and modifications to the distributary network (Syvitski *et al.*, 2009).
Accelerated subsidence, often due to groundwater and hydrocarbon extraction (Saito *et al.*,2007).
Accelerated eustatic sea-level rise, as a result of climate change (Zhang and Church, 2012).
Meteorological extremes , including shifts in large-scale climate indices such as the monsoon, and changes in the magnitude and frequency of short-term events such as tropical cyclones.(Jena *et al.*, 2014).

It is critical that morphological research focuses on developing a clearer understanding of **how these synergistic stressors, operating at a variety of temporal and spatial scales, influence the multidecadal evolution of deltaic environments** in order to develop feasible adaptation strategies that could enable their populations to thrive under conditions of increasing climatic stress.

Utilising the hydrodynamic modelling suite Delft3D, this study aims to provide multidecadal morphological projections for an idealised delta system under a range of synergistic climatic and environmental change scenarios. These scenarios are categorised within the four broad system stressors mentioned above. The idealised system is designed so as to represent conditions experienced in the **Mahanadi Delta,** India; a system that has regularly been highlighted in recent research as one at great risk from climate change and increased anthropogenic interventions within its distributary network (Jena *et al.*, 2014).

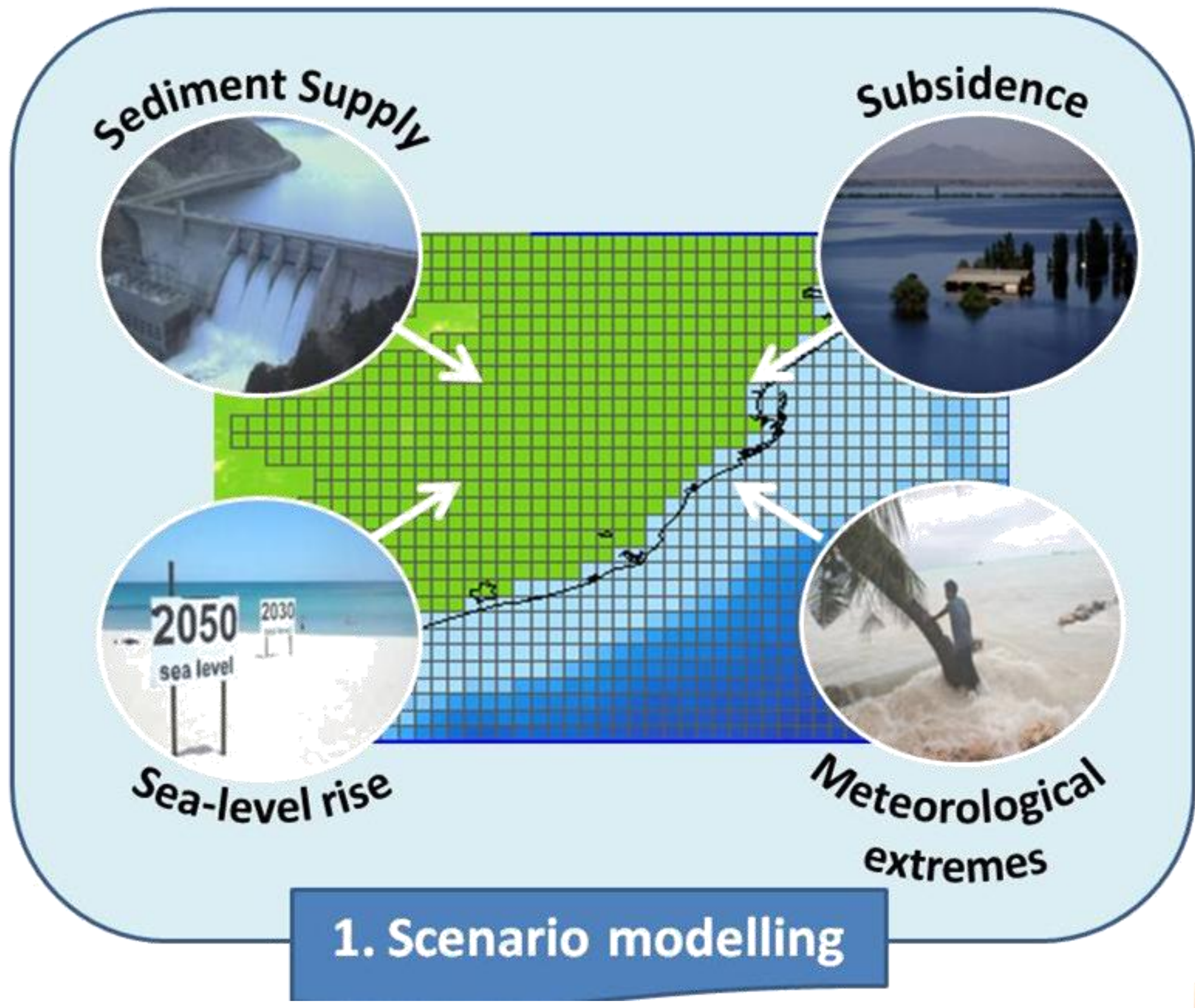
The Mahanadi River in flood (Source: Brian Brake, 1960)

This research aims to provide a route towards the development of a biophysical assessment tool. Whilst the primary aim of this research is to **explore the nature of volumetric changes to the terrestrial and subaqueous delta,** this study also aims **to identify important biophysical feedbacks between the morphological system and shifts in habitat cover.** As well as providing multidecadal biophysical projections, the tool may be used to test the viability of various management options, with the aim of developing achievable climate-resilient strategies for implementation in the Mahanadi region.

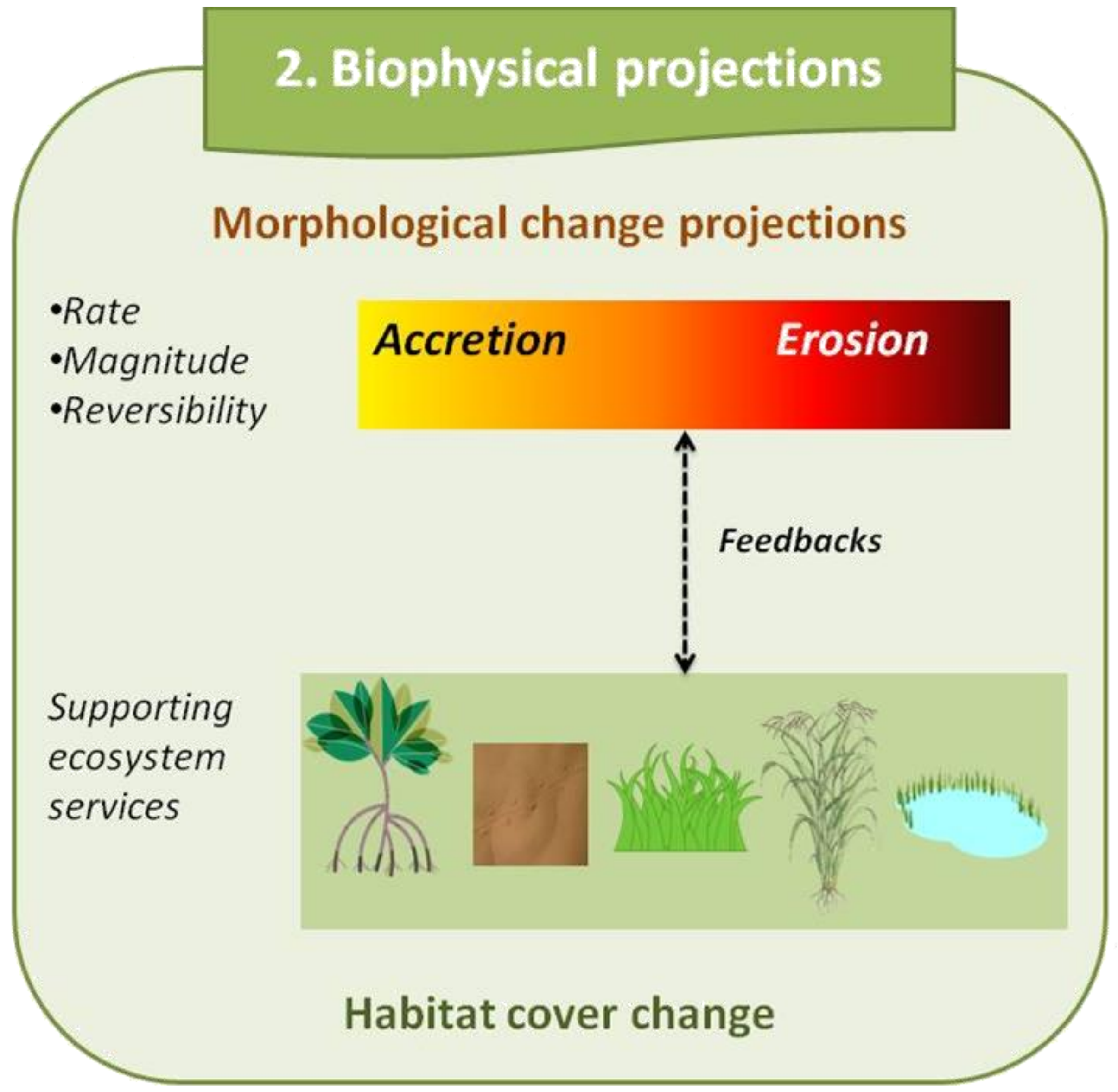


Biophysical Assessment Tool

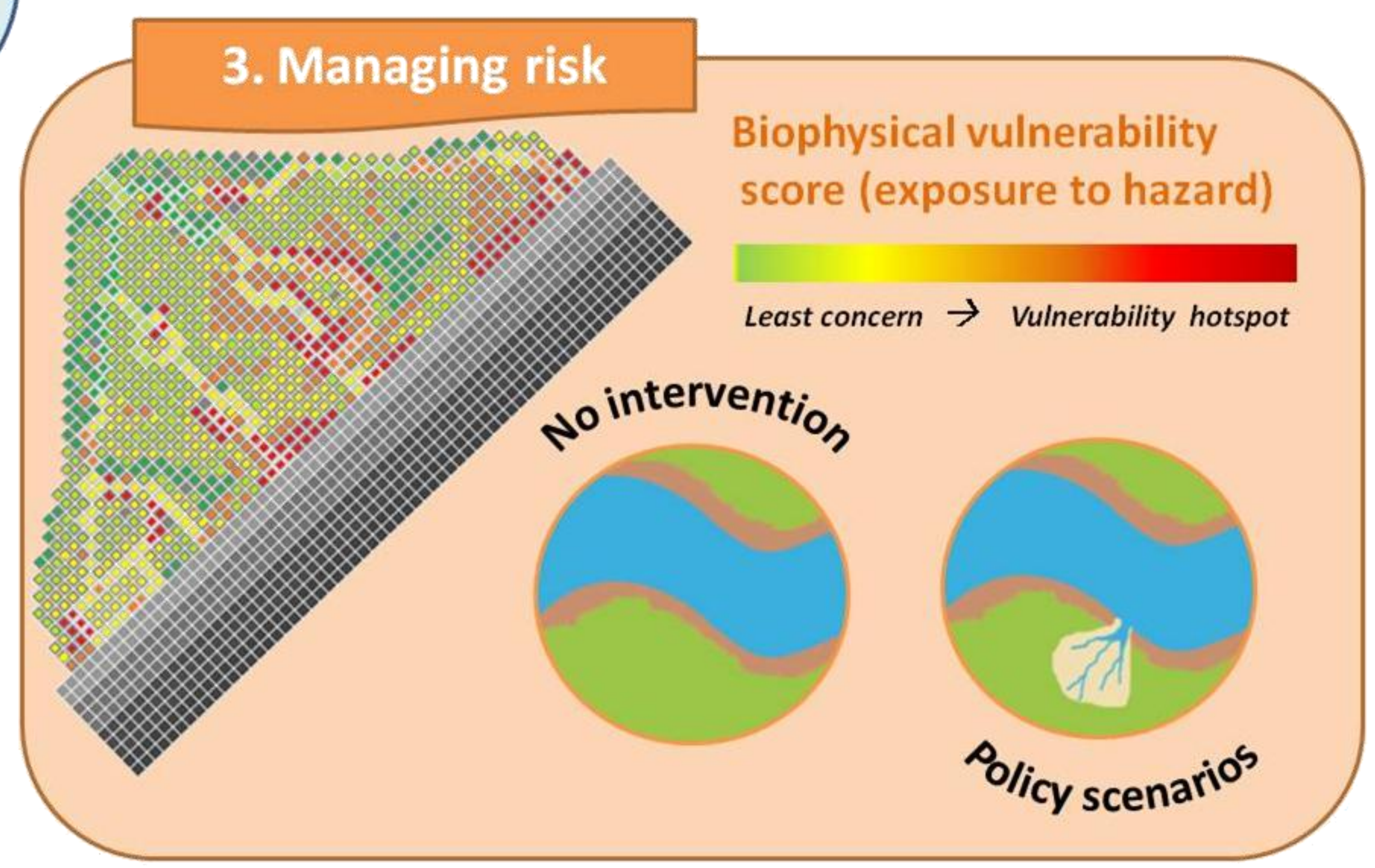
Conceptual framework



32 mechanistic scenarios – designed to explore the biophysical impacts of an individual stressor – and **53 synergistic scenarios** – designed to explore the combined impacts of multiple stressors – will be input into the idealised system model in **Delft3D-FLOW.** The scenarios have been designed to represent possible changes **to sediment supply, subsidence rates, sea-level and meteorological factors, under a range of climatic pathways**. The scenarios include both gradual, long-term changes and extreme short-term events. Two time periods are investigated: **2015-2045** and **2045-2075.**



The next stage of the research project, commencing in 2016, involves running these scenarios to **obtain projections of biophysical change.** The aim is to understand how the **rate, magnitude and potential reversibility of morphological change** will influence shifts in **large-scale habitat cover**, and how these changes to supporting ecosystem services then **feedback** into the morphological system. Utilising this approach provides a means to qualitatively assess how other types of service, such as crop yield, may be impacted under a particular scenario (Martin *et al.*,2002).



These projections shall then be transformed into maps showing **biophysical vulnerability** (defined here as exposure to detrimental biophysical change) for a given area over a given time period, under various environmental scenarios. This will provide a platform **to test the effectiveness of various management strategies** within the Mahanadi Delta, with a particular focus on options **that aim to restore natural deltaic processes.**

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References: Jena, P.P. *et al. (*2014) *Journal of Hydrology* 517:847-862; Martin, J.F. *et al., (*2002) *BioScience*, 52:357-365; Saito, Y. *et al. (*2007) *Land Ocean Interaction in the Coastal Zone* 2: 3–9; Syvitski , J.P.M. *et al., (*2009) *Nature Geoscience,* 2: 681-686 **;** Zhang, X. and Church, J.A. (2012) *Geophys. Res. Lett.,* 39

Images: *Centre banner* Landsat (2000); *Sediment starvation* MT Drought Advisory Committee (2012); *Subsidence* Bay Delta Conservation Plan (2011); *Sea-level rise*: Go_Greener_Oz (2007); *Meteorological Extremes* Jeremy Sutton-Hibbert/Alamy (2015)