1. PROTECTING AND RESTORING MANGROVE FORESTS TO SUPPORT COASTAL RESILIENCE IN ASIAN MEGA DELTAS

The Living Deltas Hub is using interdisciplinary research excellence to combine a new, accessible hydrodynamics sensor (the 'Mini Buoy') with state-of-the-art social-ecological knowledge on coastal tipping points to protect and restore mangroves forests, combating climate change and biodiversity loss.

Foreign, Commonwealth & Development Office

Climate change & biodiversity

Science, research, technology

SUSTAINABLE DEVELOPMENT GOALS

13 CLIMATE ACTION

14 LIFE BELOW WATER

15 LIFE ON LAND

17 PARTNERSHIPS FOR THE GOALS

Achievements

Over 90% of all mangrove restoration projects fail, typically due to poor planning. Living Deltas is developing accessible hydrological sensors and interdisciplinary knowledge of mangrove resilience to enable local stakeholders to plan and improve delta-wide success of mangrove restoration, promoting the UK government's goals on climate change mitigation and biodiversity.

Hydrodynamic monitoring is essential in coastal planning, yet conventional hydrographic equipment is expensive, difficult to transport, and complicated to use. This is especially problematic in the Global South, where managers often rely on measurements at a single location to represent hydrodynamics over tens of kilometres, or more often forgo field monitoring entirely and rely on qualitative expert judgement. This leaves coastal management and mangrove conservation strategies weakened across Vietnam, India, and Bangladesh river deltas in a changing climate.

The Hub-developed Mini Buoy is a novel, easy-to-use modular sensor for mangrove conservation research. The materials to assemble Mini Buoys are globally available, adaptable, relatively affordable and easy to transport. We have already published the development, testing, and application of Mini Buoys in identifying the suitability of abandoned aquaculture ponds for restoration as a case study[1].

A self-build guide and online application to analyse the data has been published alongside the paper[1], and through the Hub we will further tailor the data analysis to the needs of each delta region. In January 2020, a Hub team led by An Giang University, in collaboration with Ca Mau Forest Protection Department, identified sites and trialled the roll-out of a large-scale Mini Buoy survey in the Mekong Delta, Vietnam (Fig. 1). Sites in the Indian Ganges-Brahmaputra-Meghna Delta have also been identified by Hub colleagues at Jadavpur University and BUET, and 50 loggers will soon be sent to each delta for deployments along mangrove forests. This survey is the largest of its kind, and has been able to continue with the support of partners

[1] Balke et al. (2021) Hydrol. Earth Sys. Sci. https://doi.org/10.5194/hess-25-1229-2021; https://www.downtoearth.org.in/news/forests/plant-50-million-mangroves-in-the-sundarbans-improbable-say-experts-71977).

in the delta regions despite the Covid-19 pandemic. The work will identify threshold tides, waves, and currents that drive either mangrove expansion or erosion.

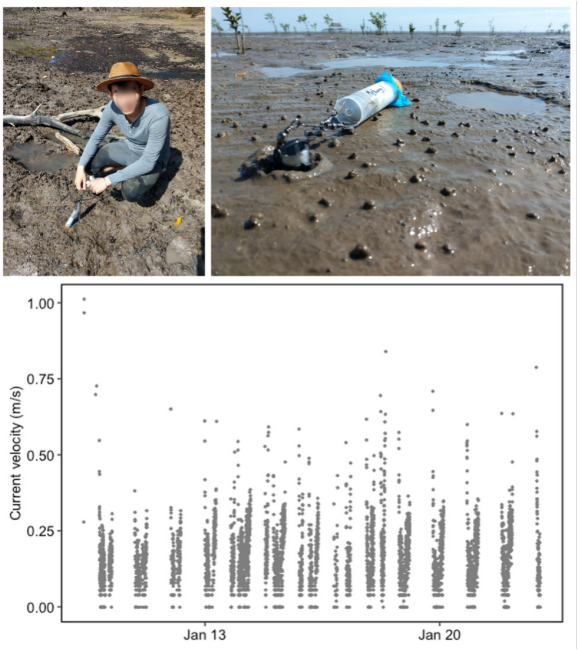

Figure 1: *1 Mini Buoy deployment and the measured current velocities on a developing mangrove in Ca Mau, Mekong Delta, Vietnam.*

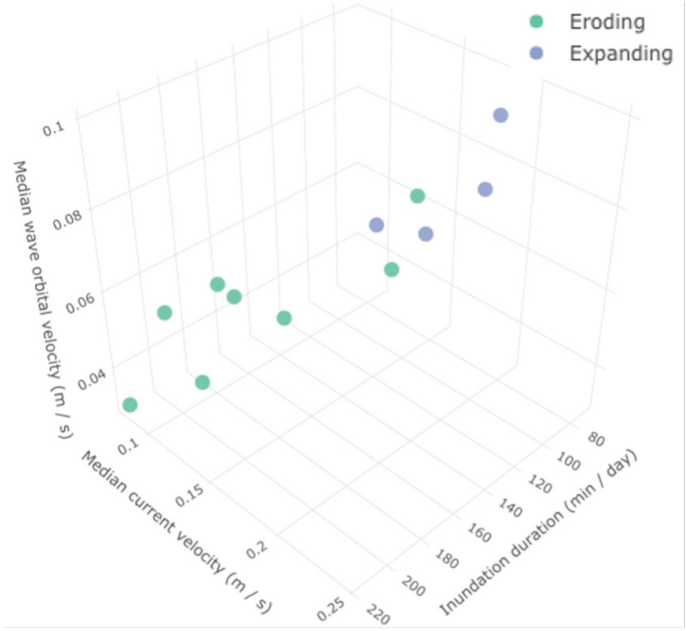

Figure 2: *Threshold shift in erosion (green) to expansion (blue) patterns at critical inundation duration, wave orbital velocity and current velocity values for along a saltmarsh test-case in Scotland, UK. The same thresholds will be identified along mangrove forests.*

Interdisciplinary approaches

Taking an interdisciplinary approach to understanding mangrove dynamics allows us to not only provide quantitative information on drivers of mangrove loss and hydrological bottlenecks for their restoration, but also place those findings into larger scale modelling and socio-ecological and policy contexts aimed at increasing protection and restoration success of mangrove forests along the coastal fringes of Asian mega deltas.

Living Deltas is achieving this by mobilising and integrating scholarship across disciplines to create new knowledge that supports mangrove restoration:

- Using Mini Buoys to identify thresholds in waves, currents, and tides that drive mangrove propagation or erosion (Fig. 2).
- Collating spatial data on coastal hydrodynamics, which will be used to upscale findings from the Mini Buoys and map the likelihood of long-term mangrove establishment at the delta scale.
- Documenting community use and values of mangrove resources, to understand anthropogenic drivers of mangrove deforestation and conservation.
- Examining land use change in each delta, to provide an historical perspective of where mangroves are being lost and replanted.
- Assessing the effectiveness of forest management policy in delivering a range of ecosystem services.

Working with policy makers and communities the evidence from our research will be used to generate practical management advice on where best to restore mangroves as Nature-based Solutions for supporting flood mitigation, food security and biodiversity protection. Hub links with national and global policymakers and local communities engaged with mangrove restoration, mean we are well placed to communicate our findings to those who will benefit from it most. Our interdisciplinary approach will directly contribute to building sustainable deltas by:

- Identifying areas of mangrove forest that are particularly valuable local resources and are also at risk of erosion, to build anticipatory capacity (through providing long- and short-term delta risk information, and capacity for improved planning and preparedness).

- Detailing social and ecological status of mangroves, to communicate the coping capacity of delta coasts to policymakers (highlighting mangrove forests as natural infrastructure that provides a safety net or 'bioshield' for coastal populations).

- Sharing research findings, to enable transformation and adaptive capacity (by informing strategic policy and planning, enabling the provision of natural assets for generating income, food security, adaptation with climate change, and improving delta health through boosting biodiversity).

Innovation

The Mini Buoys identify where mangrove bio-physical tipping points lie. The deployment of Mini Buoys across a potential restoration site can provide quick and low-cost information on whether mangrove saplings will likely survive and thrive. This will avoid the substantial costs of mangrove plantation failures. The low cost, easy assembly, and simple analysis of Mini Buoy data2 empowers coastal managers to survey a potential restoration site themselves, without needing additional expertise.

Our work is therefore making an innovative contribution to the field of coastal ecosystem resilience. The work has wide-reaching implications for boosting globally important ecosystem services provided by mangroves, including carbon sequestration, storm surge protection and the provision of food, fuel, and culture.

The reach and influence of Living Deltas with state officials in Vietnam, Indian and Bangladesh has the potential to facilitate the large-scale uptake of Mini Buoys in mangrove restoration practice. Mangrove protection in the Sundarban is recognised as a major policy objective by Rob Elsworth (Regional Climate Change Policy & Programme Manager - Indo Pacific Regional Team, FCDO) and Nick Low (Deputy High Commissioner to Kolkata), and the Government of West Bengal has recently committed to a large-scale mangrove plantation project to restore forests after Cyclone Amphan. Research by Living Deltas could help improve the success of this plan3. It also has scope for replication and global scaling in other resource poor settings.

Summary of key achievements, interdisciplinarity and innovation

Achievement	Why it is timely	Why it is innovative	Those who benefit
Developed new sensors to improve mangrove restoration success	Nations are investing in mangrove restoration schemes that often fail due to lack of data	Providing an alternative to expensive and cumbersome hydrographic equipment	Mangrove conservation and restoration practitioners
Identifying potential mangrove restoration sites at delta scales	Limited ground-truthing is hampering mangrove restora-tion schemes	Integrating ecology, hydrology, and sociology disciplines to assess mangrove resilience	Multiple communities living and working in coastal deltas
Formulating interdisciplinary knowledge on delta risk	Deltas are being increasingly exposed to saline intrusion, biodiversity loss, and livelihood insecurity	Combining traditional knowledge and new technolo-gy to understand delta envi-ronments	Increased 'buy-in' and potential for sustainable outcomes (economic, cultural, social) for delta dwellers

People involved in this work

Name	Gender	Discipline	Work Package	Institution	Country
Thorsten Balke	M	Coastal biogeomorphology	Delta-level interventions	University of Glasgow	UK
Sumana Banarjee	F	Coastal socioecology	Delta-level interventions Delta SDGs	Jadavpur University	IN
Tjeerd Bouma	M	Coastal engineering	External research partner	NIOZ	NL
Abhra Chanda	M	Coastal biogeochemistry	Delta-level intervetions	Jadavpur University	IN
Ishtiaque Chowdhury	M	Environmental engineer; water pollution	Delta baselines Delta-level interventions	BUET	BN
Emilie Cremin	F	Coastal socioecology	Delta-level interventions	University of Glasgow	UK
Laura Ebeler	F	Coastal socioecology	Delta-level interventions	University of Glasgow	UK
Efi Foufoula	F	Coastal engineering	Delta-level interventions	University of California	USA
Tuhin Ghosh	M	Coastal geomorphology & disaster management	Delta baselines Delta-level interventions	Jadavpur University	IN
Zhan Hu	M	Coastal biogeomorphology	External research partner	Sun Yat-Sen University	CH
Md. Shah Alam Khan	M	Water resource engineering	Delta Social Ecological Systems Delta Baselines Delta-level interventions	BUET	BN
Cai Ladd	M	Coastal biogeomorphology	Delta-level interventions	University of Glasgow	UK
Qiuhua Liang	M	Computation hydraulics	Delta Social Ecological Systems Delta Baselines Delta-level interventions	Loughborough University	UK
Lan Nguyen	F	Water resources planning	Delta-level interventions	An Giang University	VN
Tanh Nguyen	M	Water resources planning	Delta-level interventions	An Giang University	VN
Fabrice Renaud	M	Coastal socioecology	Delta-level interventions	University of Glasgow	UK
Chau Tran	F	Hydrology	Delta-level interventions	An Giang University	VN