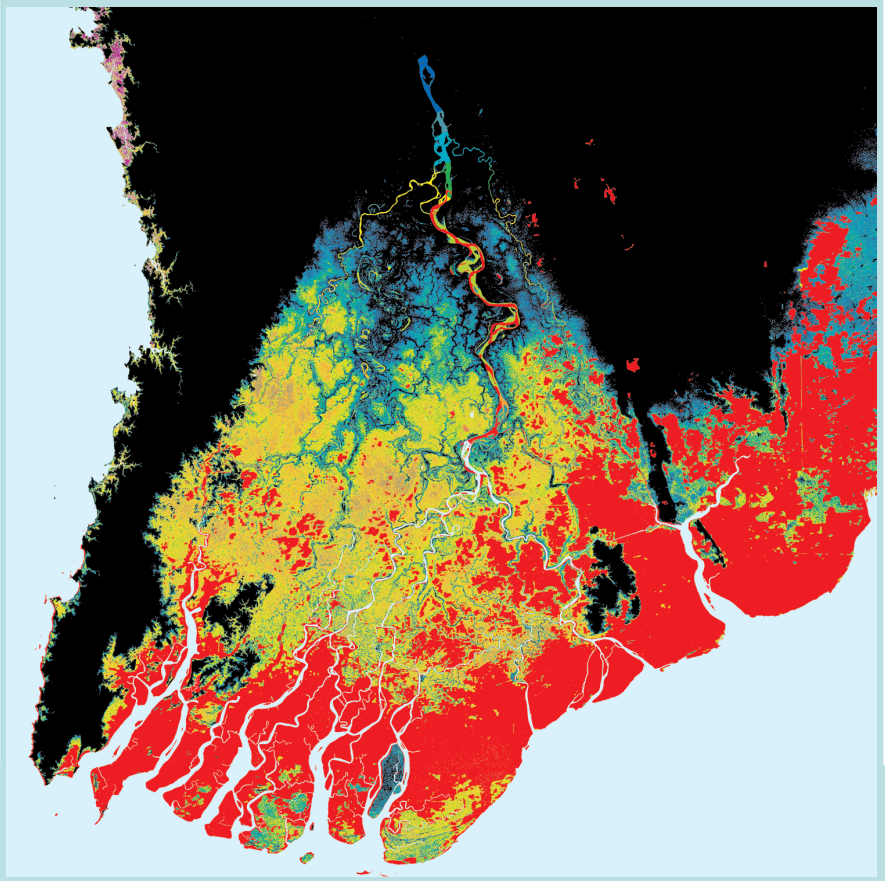
LAND-OCEAN INTERACTIONS IN THE COASTAL ZONE (LOICZ)

Core Project of the International Geosphere-Biosphere Programme (IGBP) and
the International Human Dimensions Programme on Global Environmental Change (IHDP)



Dynamics and Vulnerability of Delta Systems

Irina Overeem and James P. M. Syvitski

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Dynamics and Vulnerability of Delta Systems

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Cover: The cover photograph shows a Shuttle Radar Topography Mission (SRTM) data for the Irrawaddy delta overlain with the flood extend at time of Cyclone Nargis in April 2008 (in red), mapped by the Darthmouth Flood Observatory (courtesy CSDMS).

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The LOICZ Reports and Studies Series is published and distributed free of charge to scientists involved in global change research in coastal areas.

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Executive Summary

Deltas form where rivers meet the ocean. They are then naturally shaped by the forces of rivers, waves and tides. Intricate mazes of river channels, wetlands and coastal features, that ever-change host a wide variety of unique ecosystems. Deltas are recognized as critically important habitats for threatened terrestrial and marine species. Deltas act as filters, repositories, and reactors for a suite of continental materials, including carbon, on their way to the coastal ocean.

Due to their low topography, high productivity, rich biodiversity, and easy transport along abundant waterways, deltas are preferred locales of human habitation as well. Deltas may only comprise 5% of the land area, but over 500 million people live on them, including many heavily populated megadeltas in Asia. The Ganges-Brahmaputra, Yangtze and Nile deltas alone are extremely densely populated with 230 million people in 2000. It is expected that there will be a 35% increase of population in the major world deltas by 2015.

Deltas are unfortunately also fragile geomorphic features, and can change dramatically with modest modifications in the controlling environmental conditions. Already, thirty-three major deltas collectively include significant area (~26,000 km^2) below local mean sea level and another ~70,000 km^2 of vulnerable area below 2 m. This vulnerable area may increase by 50% under projected 21st century eustatic sea level rise. Intensive human development, population growth, as well as recent human-induced global changes are degrading deltas and often transforming them into increasingly hazardous coastal regions. Given current trends including shifts in climate, upstream changes in water quantity and quality, and population pressure, many deltas are in danger of collapse within the 21st century.

What would a collapse look like? A collapse may include complete loss of wetlands and concomitant biodiversity, cities and villages and the associated infrastructure flooded, permanent loss of fishing areas, farming lands, and valuable forests, and rapid shoreline retreat. Future preservation of deltas will become increasingly difficult and costly. Restoration or maintenance will require developing integrated management strategies that incorporate extensive monitoring, focused research and complex numerical modeling as well as detailed consultation with people affecting and affected by deltas.

To assess the state-of-the-art understanding of the changes in and vulnerability of delta systems, the following report was commissioned jointly by: 1) LOICZ, the joint IGBP (International Geosphere-Biosphere Programme) and IHDP (International Human Dimensions Programme on Global Environmental Change) Core Project entitled Land-Ocean Interactions in the Coastal Zone, 2) GWSP, an Earth System Science Partnership project of DIVERSITAS, IGBP, IHDP and WCRP (World Climate Research Program), entitled Global Water Systems Project, and 3) CSDMS, the Community Surface Dynamics Modeling System.

The report discusses the changes and vulnerabilities of world deltas resulting from anthropogenic alteration of upstream freshwater and sediment inflows, anthropogenic alteration of sediment and water routing through deltas, hydrocarbon and groundwater extraction from deltas, sea-level change, and the increased frequency of extreme climate events. A conceptual framework highlights the importance of temporal and spatial scaling in deltas, and the complex interlinkages between constructive and destructive forces of pulsed energy coming from the feeding rivers and the attacking ocean, and the role of extreme climate events.

These concepts lead the authors to target their research strategies and questions to enhance understanding of change and vulnerability of world deltas, and include research agendas for a linked technology for socio-economical, ecological, and morphological process modeling. Along with thoughts on implementation strategies, a series of case study vignettes are included to document the uniqueness of world deltas and the challenges before us. A multidisciplinary community effort is sought to bring intellectual resources to address the urgent challenge of stewardship and sustainable management of delta systems.

Acknowledgements

We acknowledge the scoping meeting sponsored by LOICZ, GWSP and CSDMS entitled "Dynamics and Vulnerability of River Delta Systems", details of which can be found at http://csdms.colorado.edu/wiki/index.php/Deltas_2007. The list of authors and workshop participants and their contact information can be found at the end of the report.