BF-DELTAS

"Catalyzing Action Towards Sustainability of Deltaic Systems with an Integrated Modeling Framework for Risk Assessment"

Rotterdam. September 23, 2014

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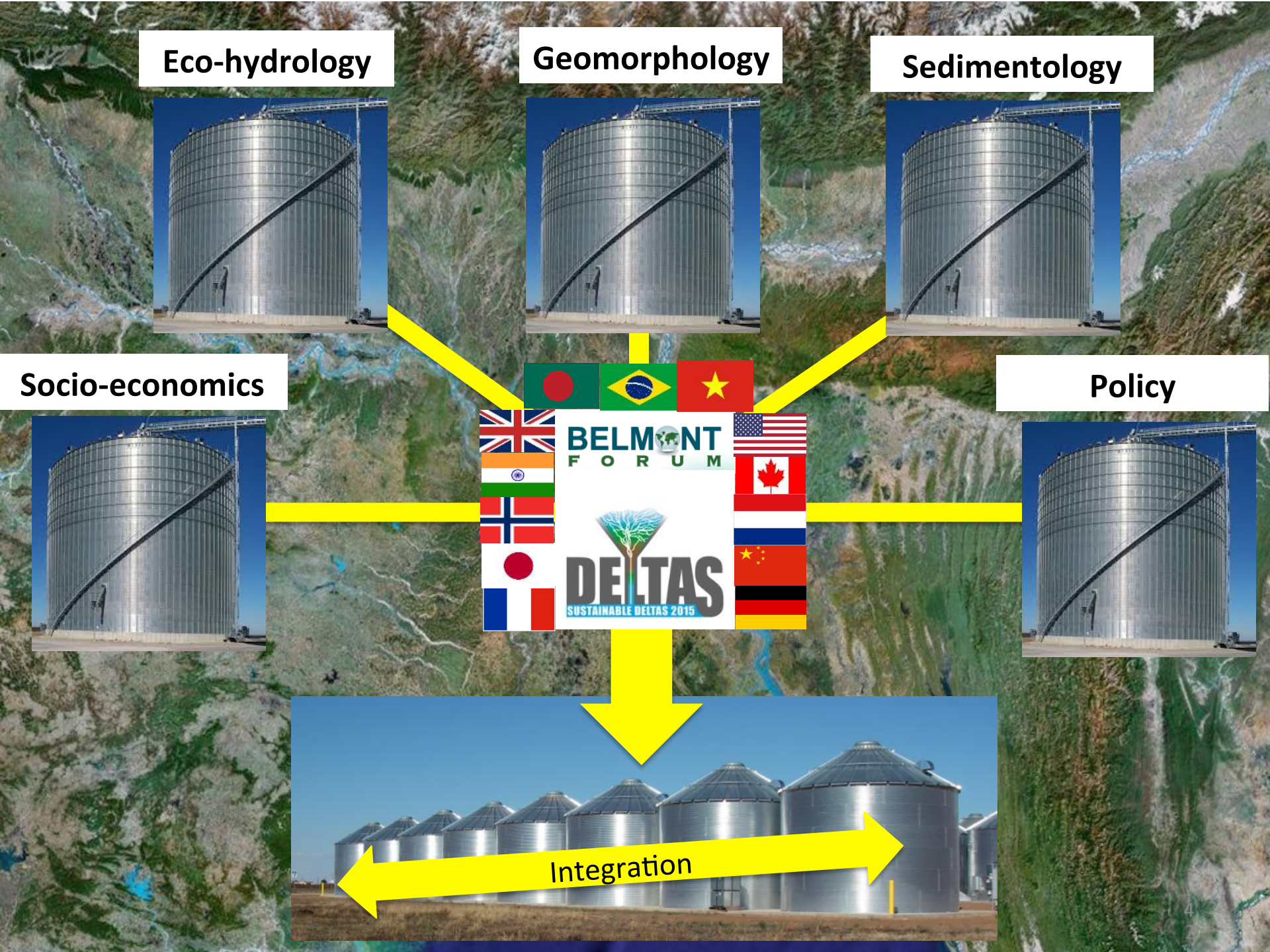
Department of Civil, Environmental and Geo- Engineering


Discharge / Sediment
Local
Activities
Ocean waves/tides


Discharge / Sediment
Local activities
Sea level / Subsidence

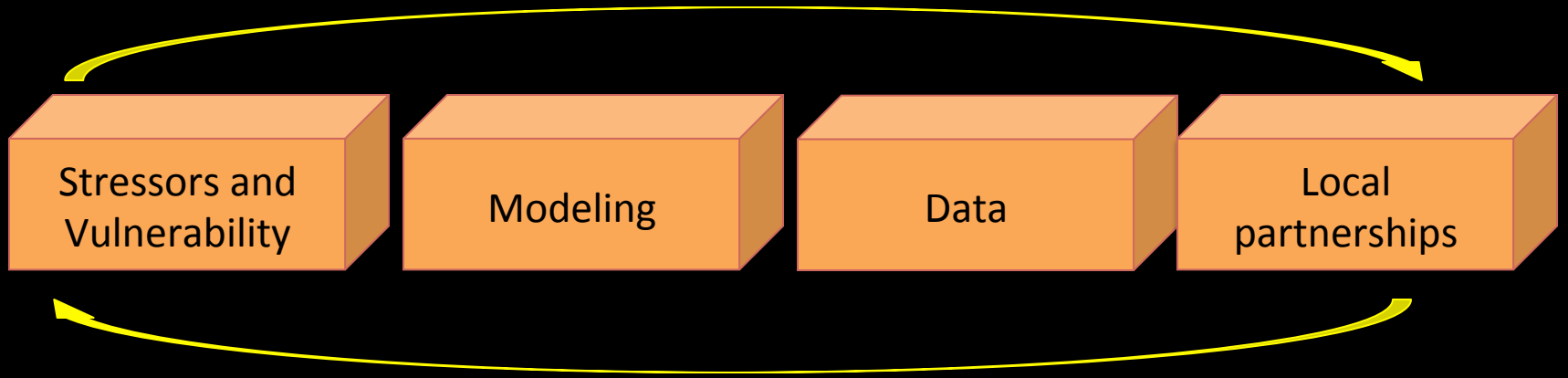

Eco-hydrology
Geomorphology
Sedimentology
Socio-economics
Policy
BELMONT FORUM
DELTAS
SUSTAINABLE DELTAS 2015
Integration

The “DELTAS Team”

USA: E. Foufoula-Georgiou and V. Voller (*Univ. of MN*); I. Overeem (*Univ. of Colorado*); S. Goodbred (*Vanderbilt University*); I. Harrison (*Int. Union for Conservation of Nature*); C. Vorosmarty and Z. Tessler (*City College of New York*); E. Brondizio (*Indiana University*)
Japan: Y. Saito (Geological Survey of Japan, Japan);
Germany: S. Dech and C. Kuenzer (University of Wuerzburg); F. Renaud (United Nations Univ.);
France: E. Anthony (Aix-Marseille University);
U.K: Z. Matthews, R. Nicholls, J. Dearing, A. Lazar, and A. Baschieri (Univ. of Southampton); J. Hutton (UNEP - World Conservation Monitoring Centre);
India: R. Ramachandran (Anna Univ.)
Netherlands: M. Marchand and T. Bucx (Deltares)
Bangladesh: K.M. Ahmed (Univ. of Dhaka); M.M. Rahman (Bangladesh Univ. of Engineering and Technology);
Vietnam: V. L. Ngugen (Vietnam Academy of Science and Technology); M. Goichot (World Wide Fund for Nature – Greater Mekong)
Norway: A. Newton (Norwegian Inst. for Air Research, Norway);
Brazil: S. Costa (University of Vale do Paraíba),
Canada: G. Lintern (Natural Resources Canada); P. Van Cappellen and H. Durr (University of Waterloo),
China: S. Gao (Nanjing Univ.)

The Vision:

- Pull together interdisciplinary expertise, global human capital and resources, modeling frameworks, data, and local partnerships to understand the workings of these complex coupled socio-ecological systems and inform sustainable management and policy decisions



Major science questions

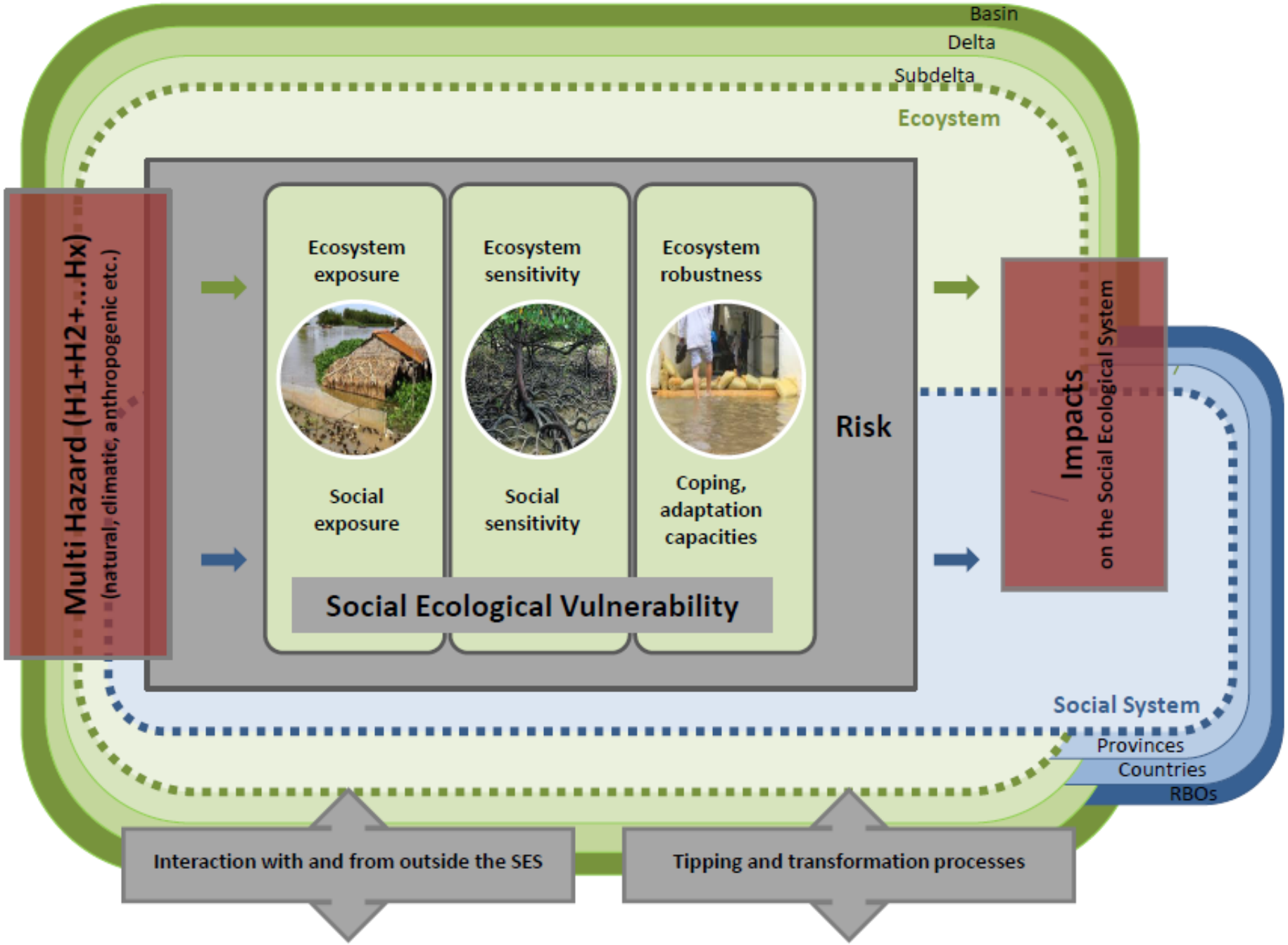
(1) How do climate change, pressure on resources, and engineering/ infrastructure development make people, biodiversity, and delta ecosystems vulnerable? -- cascade of stressors

(2) How is delta vulnerability to be measured? -- metrics of change

(3) How do delta areas absorb extreme events? What are the hydrological and ecological thresholds underlying the integrity of a delta region? -- threshold behavior

(4) What are the relevant local and regional hydrological, biophysical and social stressors for a particular delta system, how do these interact, and how do they vary spatially and over time? – local to regional scales

(5) How can one reduce future risk while attaining sustainable development? – actionable scenario building



Sebesvari & Renaud 2014, after Turner et al. 2009, Garschagen 2014, Kloos et al. forthcoming

Work Packages (WPs)

1. Advance *science on resilience and sustainability* of deltas as critical coupled socio-ecological systems undergoing change (Delta-SRES)

2. Develop and deliver a science-based delta sustainability framework for risk assessment and *decision support* (Delta-RADS)

3. Build an international *repository of data* sets including physical, social, and economic data (Delta-DAT)

4. Develop *Global Delta Vulnerability Indices* that capture the current and projected physical-social-economic status of deltas around the world (Delta-GDVI)

5. Implement and demonstrate the developed modeling and decision support framework in selected deltas *in partnership with local stakeholders,* and open to door for global use and adoption (Delta-ACT)

Delta-DAT

Socio-Political

Biogeophysical

- Data storage
- Visualisation
- Spatial (GIS) analyses

Delta-GDVI

Delta Vulnerability & Resilience Analysis

Delta-SRES

- Process understanding
- Coupled socio-ecologic system
- Feedbacks
- Thresholds
- Scenario development

Governance

Economical

Social

Bio-Physical

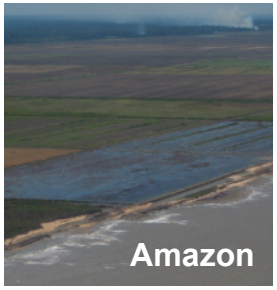
Delta-RADS

- Integrated model development
- Scenario testing

Iterative Learning

Delta-ACT

- Prototyping in 3 deltas:



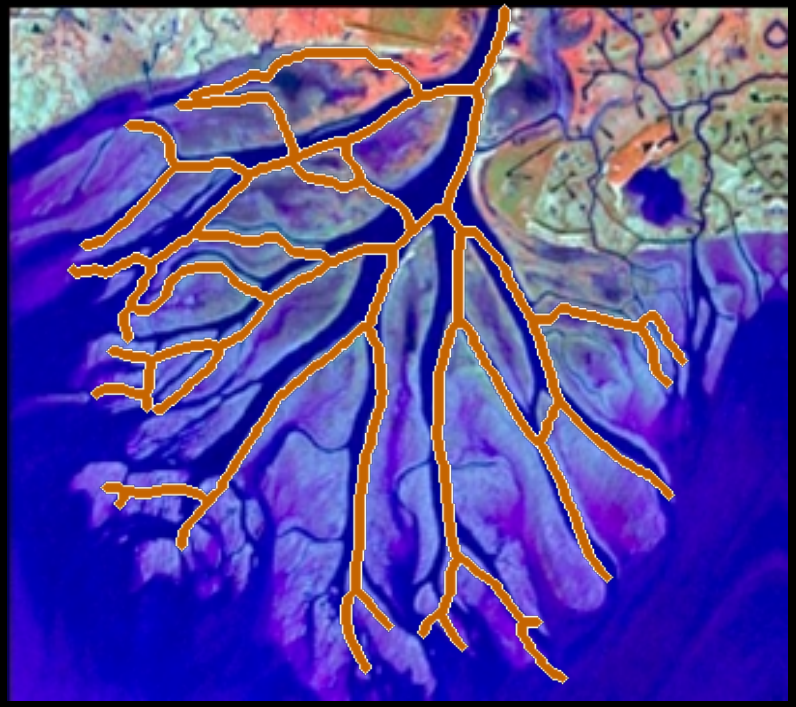
- Extend to other deltas

Stakeholder participation & consultation

A Few Highlights

1. Delta network analysis and vulnerability to change (Delta-SRES)
2. Models: from physics to decision support tools (Delta-RADS)
3. Historical trends in demographic and bio-physical parameters (Delta-DAT/ACT)
4. Climate-human-landscape coupling (Delta-SRES/RADS)
5. Global Vulnerability indices (Delta-GDVI)
6. Stakeholder Partnership (Delta-ACT)

1- Delta Networks and Vulnerability



Wax Lake delta, Louisiana Coast, USA

Overall Question: How does delta connectivity (in process and/or structure) control the overall system robustness to change?

Approach:

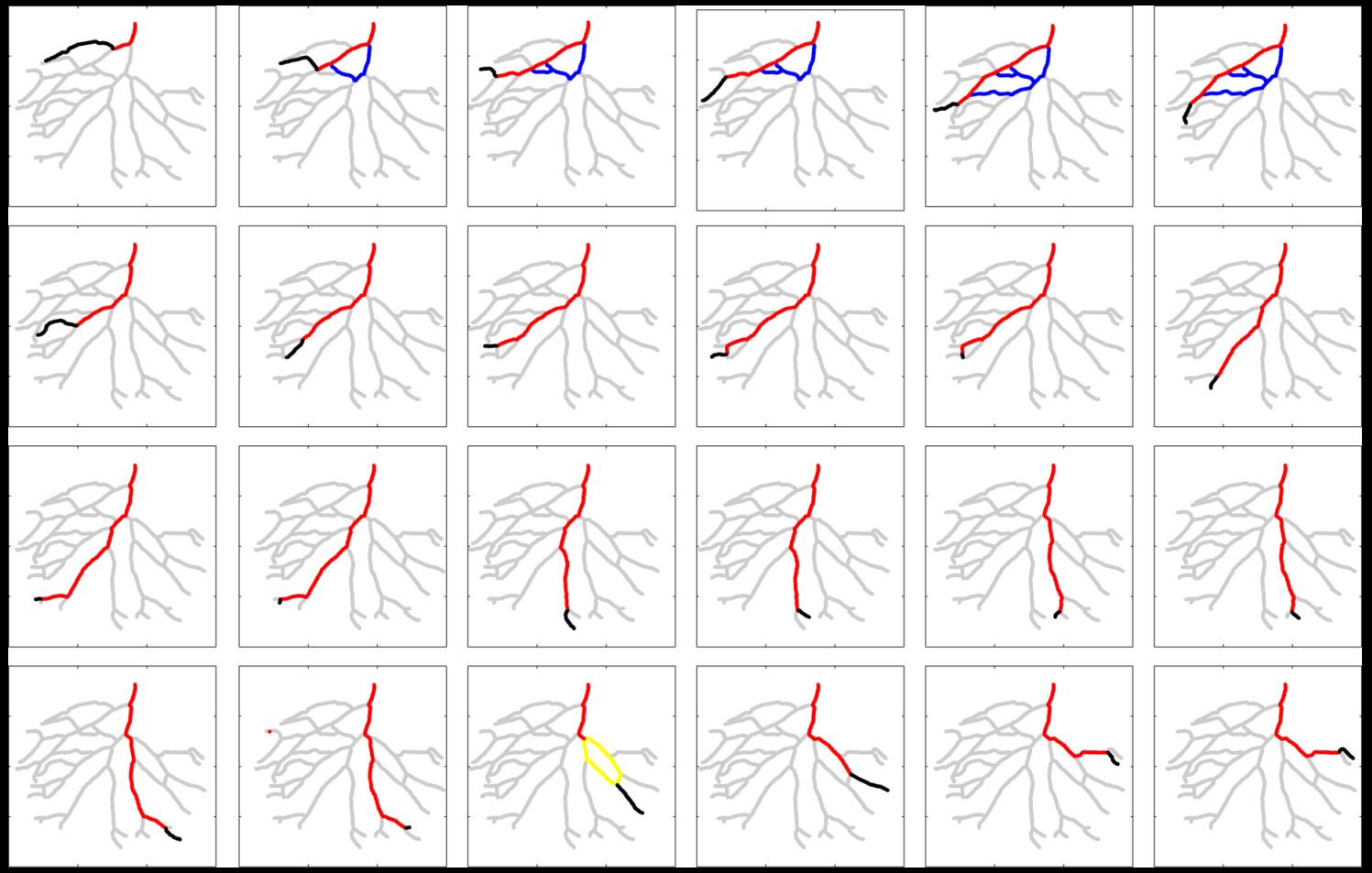
Develop a framework that can allow probing into the delta system connectivity in a systematic way and evaluating system changes in view of changes in one or more of its connected components (vulnerability analysis)

Have developed:

1. A rigorous framework for delta network analysis of topology and dynamics: Extracting subnetworks, Nourishment Areas, Upstream Areas.
2. Use this framework for building vulnerability maps
3. Define comparison metrics and relate those metrics with measures of robustness

1- Delta Networks and Vulnerability

Vulnerability Maps



H

M

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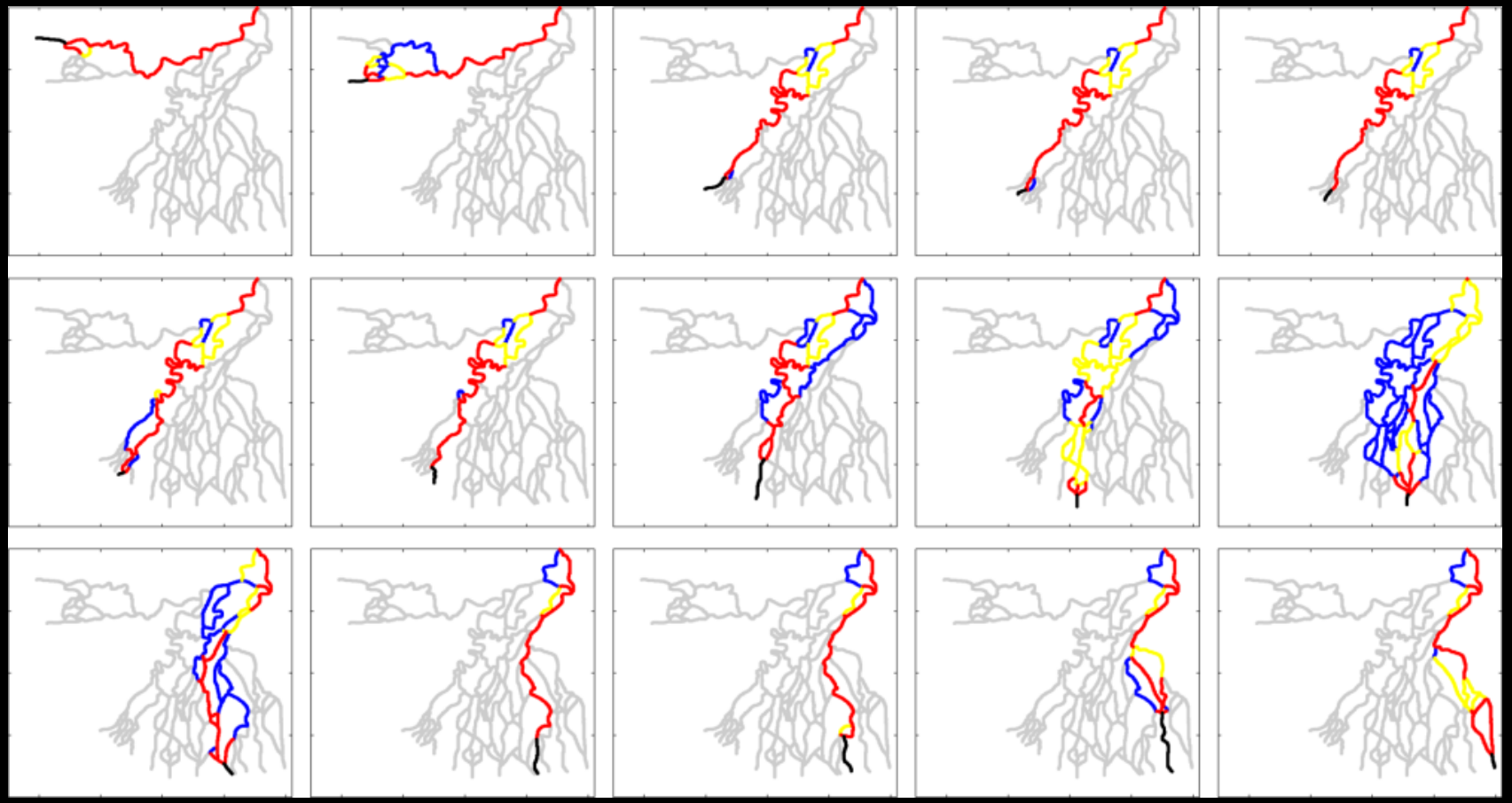
Wax Lake Delta

1- Delta Networks and Vulnerability

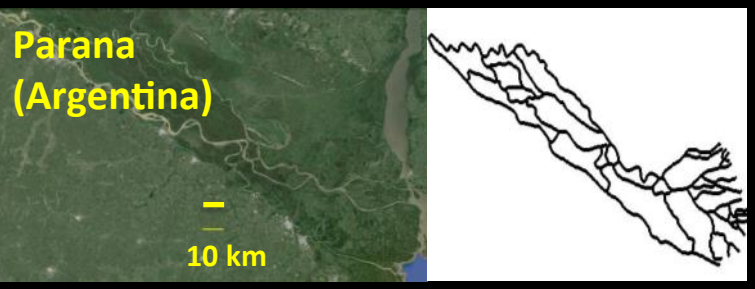
Vulnerability Maps

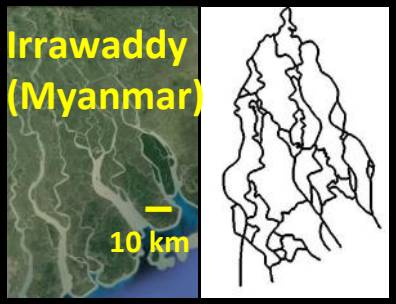


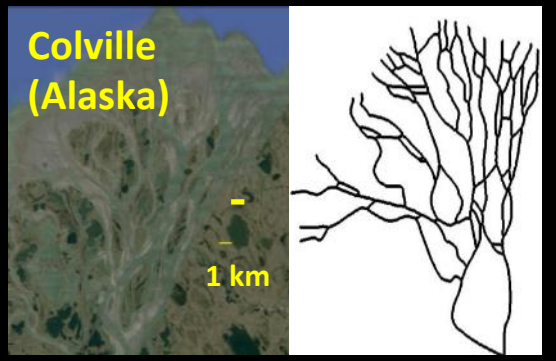
Niger Delta

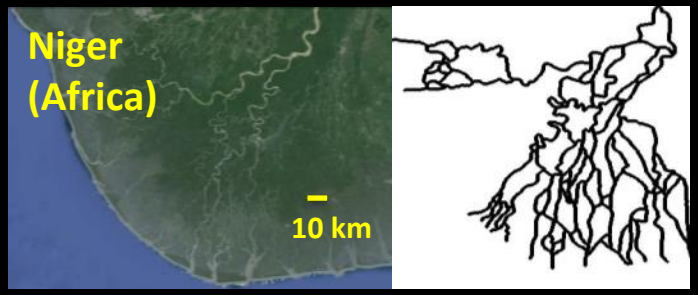
1- Delta Networks and Vulnerability

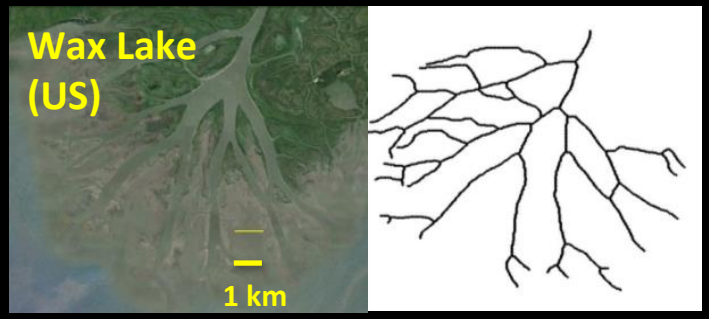
Can delta network topology and dynamics differentiate among underlying physical process and vulnerability to change?

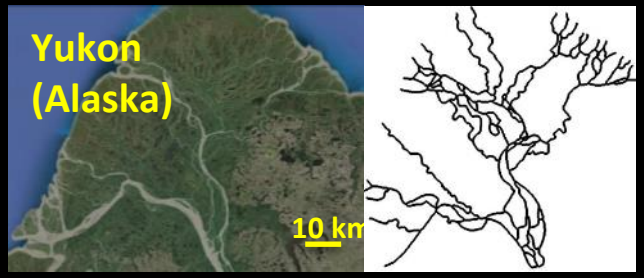


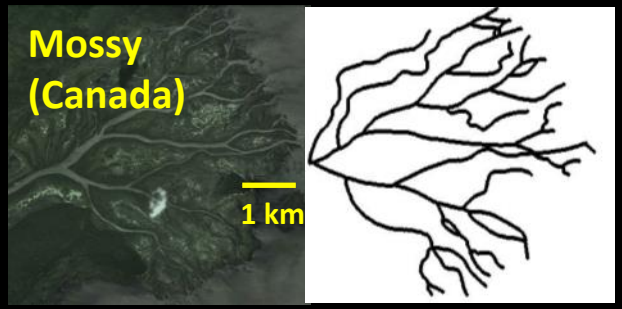






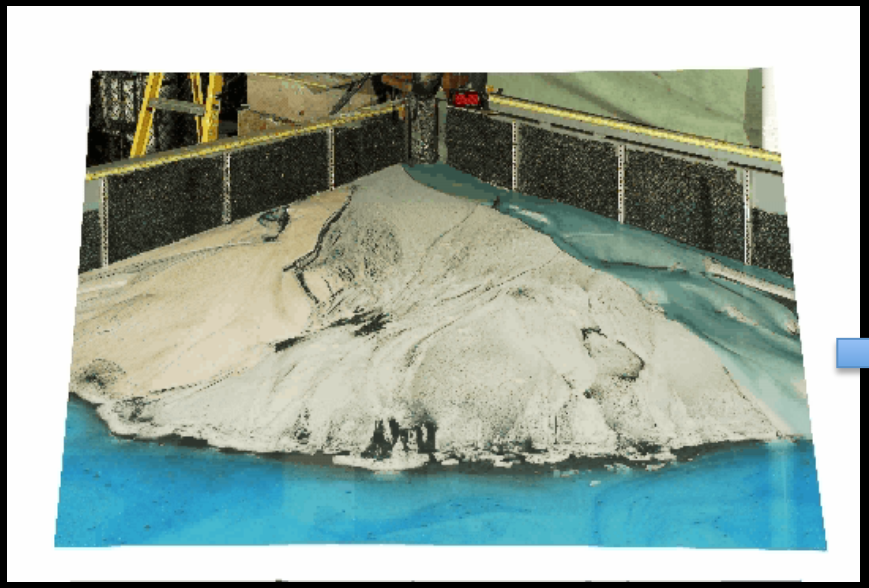


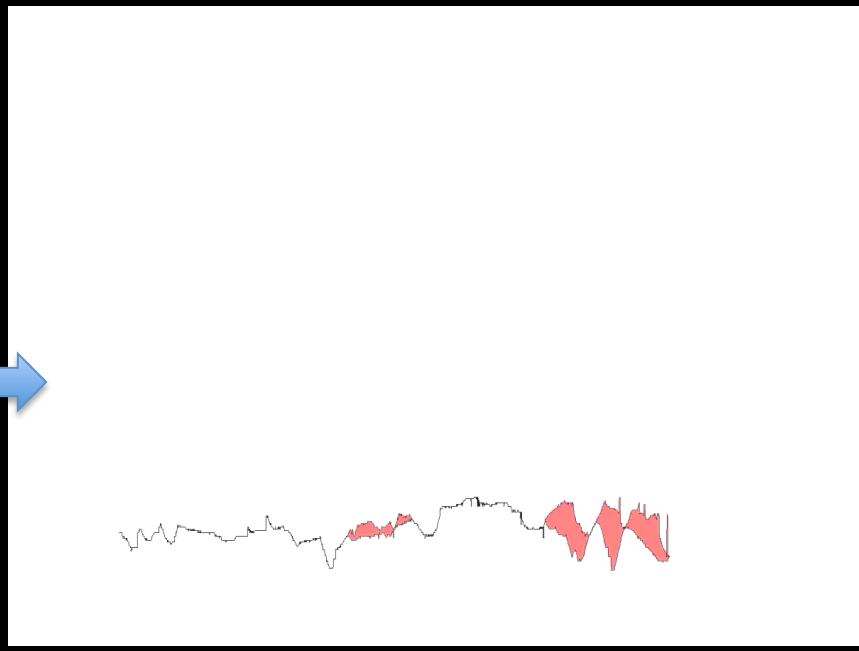




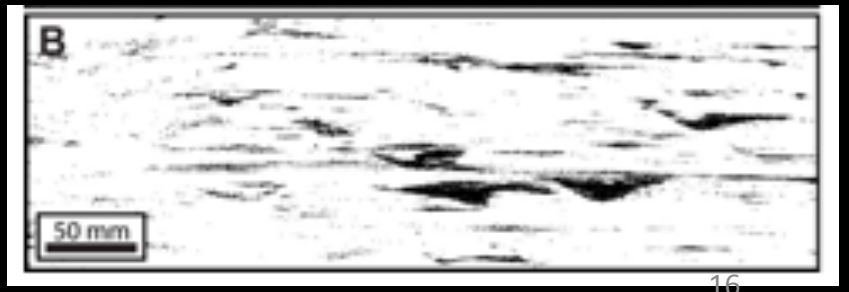
2- Modeling : Laboratory Deltas

Controlled Laboratory experiments: Form Deltaic Surface Evolution & Stratigraphy





St. Anthony Falls Laboratory
University of Minnesota



Experiment DB03, SAFL – see Sheets et al., 2007
Ganti et al., JGR-ES, 2011, 2013

2- Modeling : Integrated Models

Developing of Online Resources Modeling Examples focused on 3 DELTAS case-studies

CSDMS
COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

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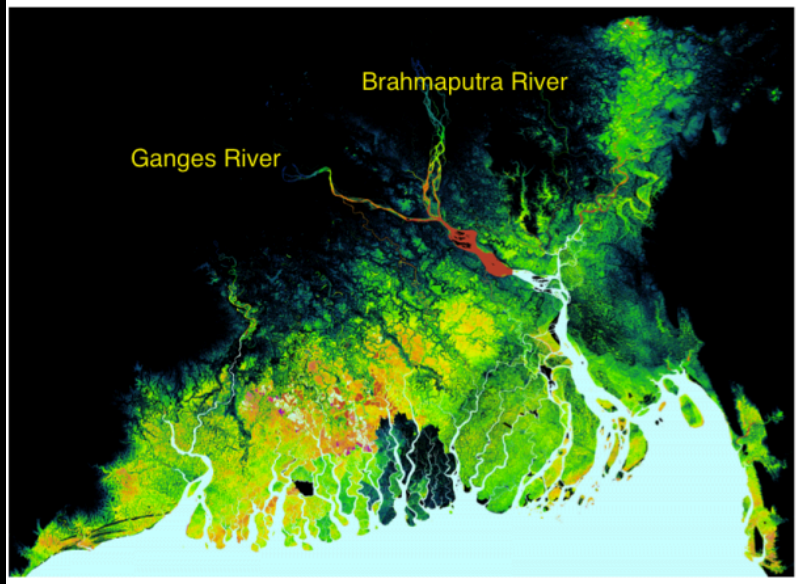
Modeling the Future Sediment Flux of the Ganges River with HydroTrend

If you have never used the Web Modeling Tool, learn how to use it here. The WMT allows you to set up simulations, but once you are ready to run them, you
HPCC Access

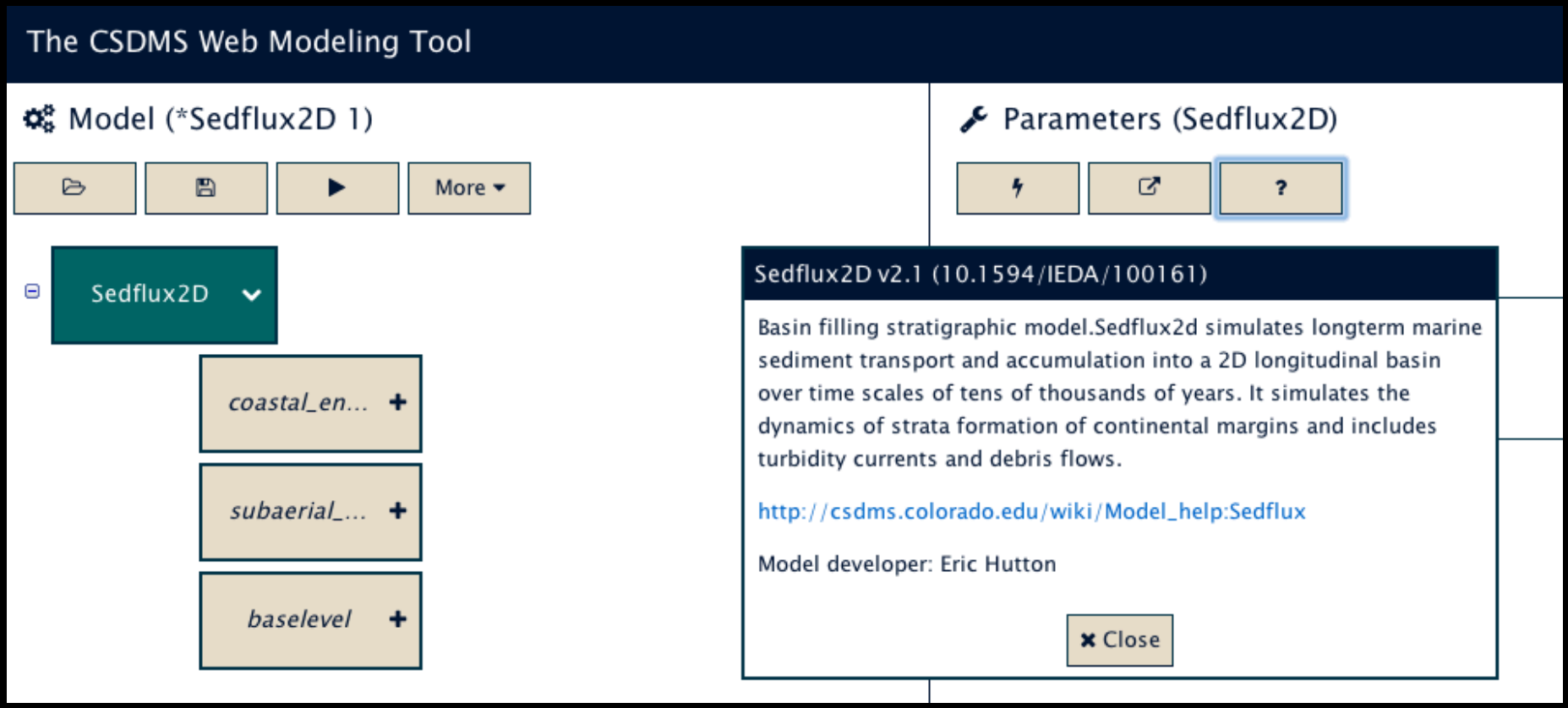
The Ganges-Brahmaputra Delta is one of the largest deltas in the world. In Bangladesh alone, 160 million people live in the floodplains. The Ganges and Brah
rainfall: flooding, river erosion and channel switches. The people of Bangladesh have adapted to this dynamic delta system, they have raised villages above t
Still, the lowlands of the Ganges-Brahmaputra Delta are considered one of the regions most at risk from climate change, and particularly from sea level rise.
change will be profound in Bangladesh where 32% of the country is already affected by tides, salinization, and cyclones/storm surges. At the same time, the
ask: how does this amount of sediment change with a changing monsoonal climate? Does this sediment aggrade fast enough to help counteract rapid sea-lev



http://csdms.colorado.edu/wiki/Labs_WMT_Ganges_Sediment_Supply

2- Modeling : Integrated Models

Developing of Online Resources Modeling Examples focused on 3 DELTAS case-studies



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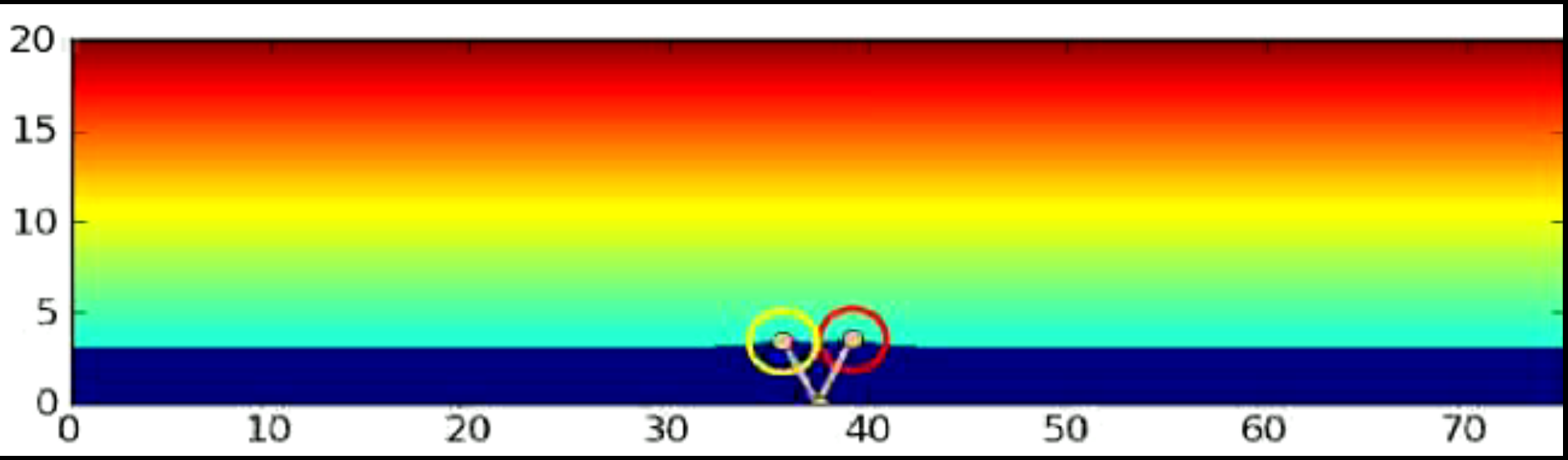
2- Modeling : Integrated Models

A coupled model run of WAVES, CEM (coastline evolution model), Avulsion, and HydroTrend. The wave model drives longshore sediment transport. Two small rivers enter the coastal zone and deliver sediment. The river mouths of the two river prograde over the 100's of years. The avulsion is dynamic, and happens more easily when the pathway to the coast becomes longer.



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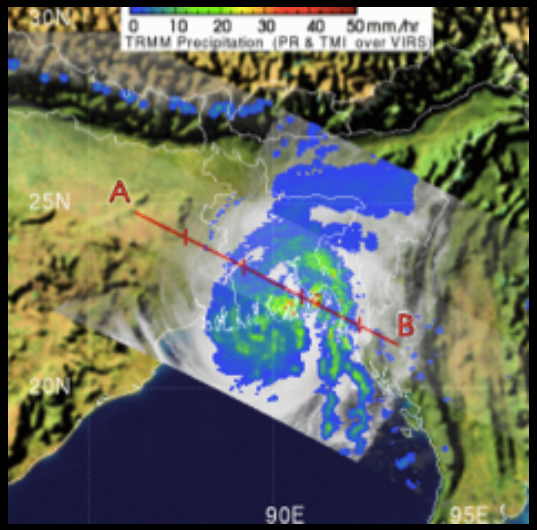
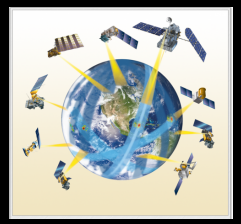
2- Modeling: Precipitation/ Inundation

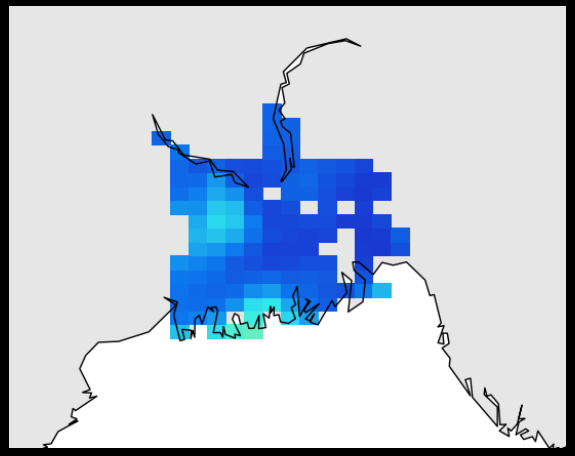


Retrieval of precipitation from space (TRMM/GPM)

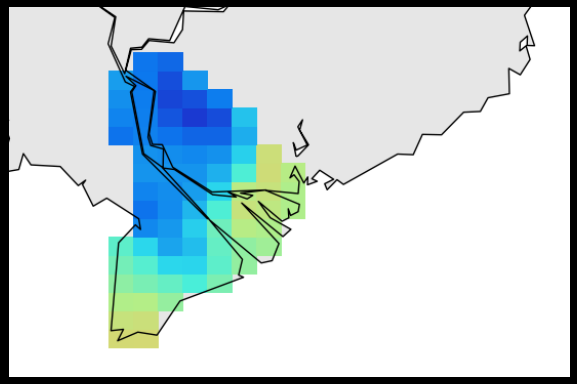


GPM: Global Precipitation Measuring Mission

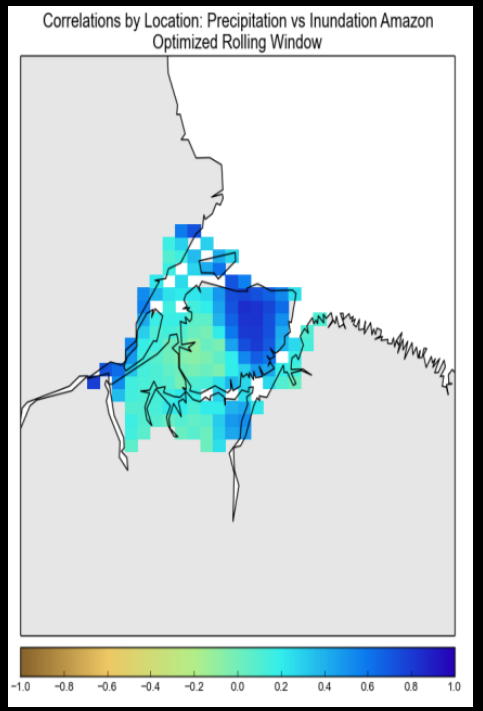
Spatial correlations between inundation and precipitation over a per-delta optimized rolling window



(Ganges)



(Mekong)



(Amazon)

3- Trends: Demographic data

Data Collection

- Bangladeshi Household Income and Expenditure Survey
- Censuses, demographic and health surveys (DHS), and maternal mortality surveys (BMMS)
- Demographic Analysis: Population Projections
- Analysis of budget surveys: (Food, Mitigation, Inequalities)

Analysis

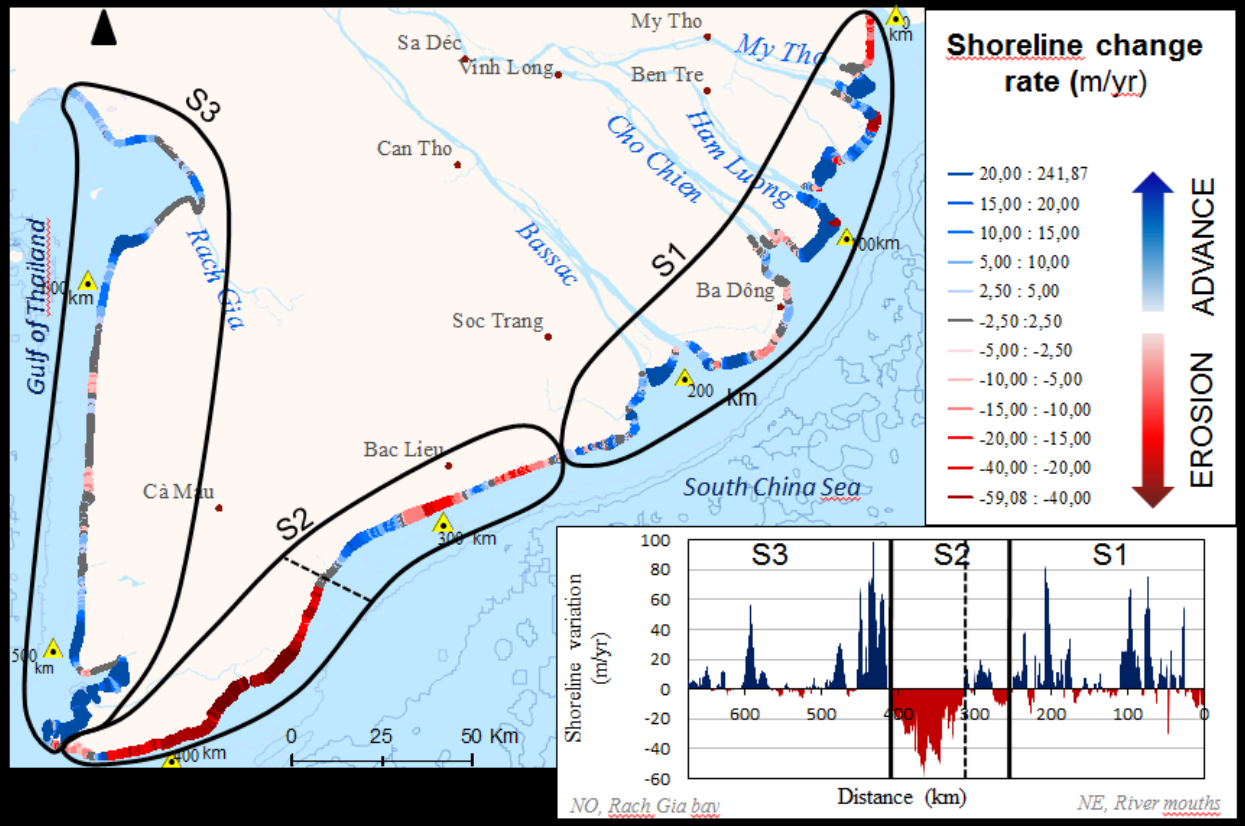
- Vietnamese Household Living Standards Survey (HLSS)
- Historical trends in selected social and environmental indicators from the Mekong River Commission (MRC)
- Analysis of budget surveys

- Consumer Expenditure Surveys have been obtained from the Brazilian Statistical Office (IBGE).

3- Trends: Shoreline Erosion

Mekong Delta shoreline variations (1965 – 2014)

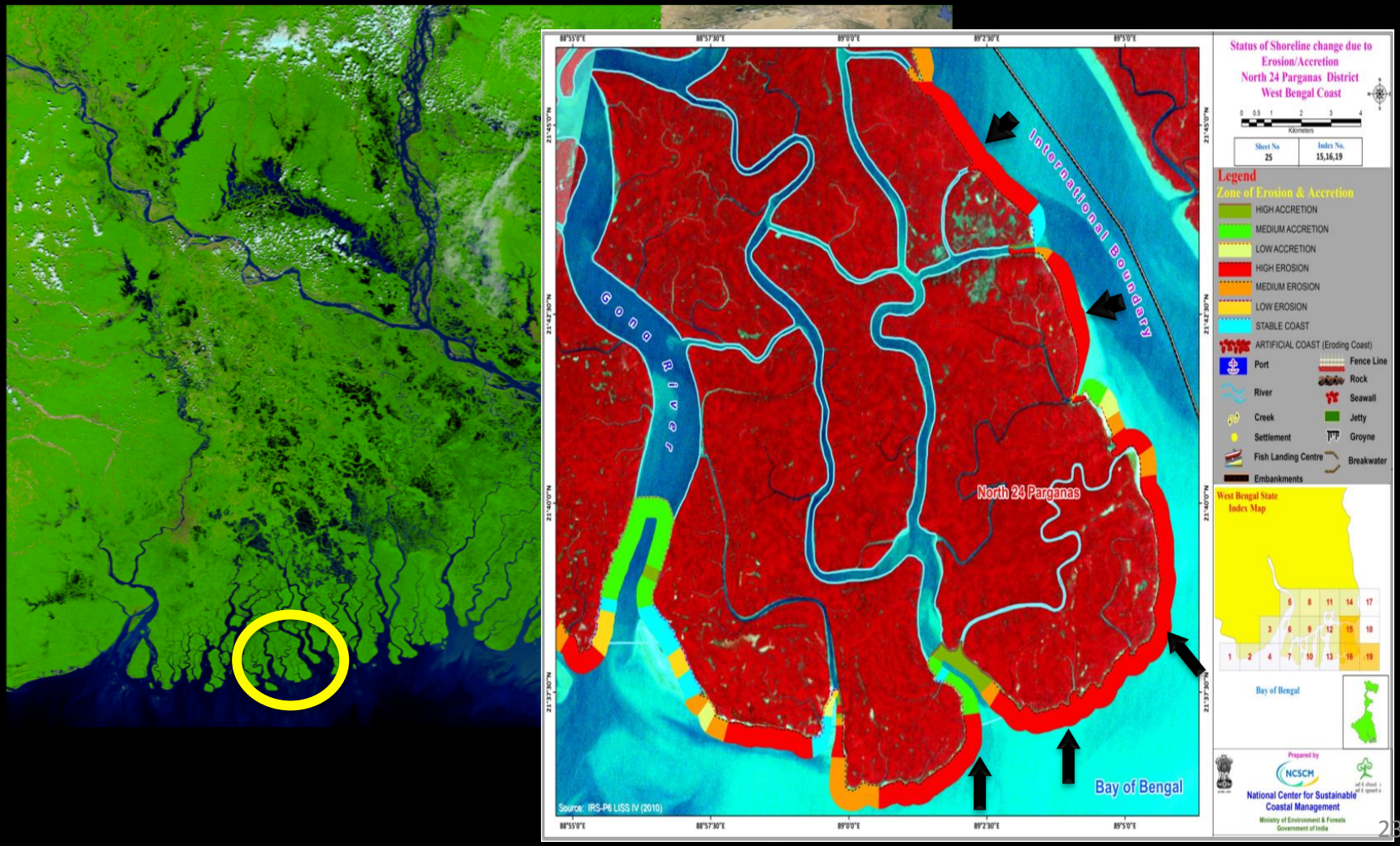
ANALYSIS OF 6000 shoreline transects (100 m spacing) using Landsat and very high-resolution SPOT 5 images



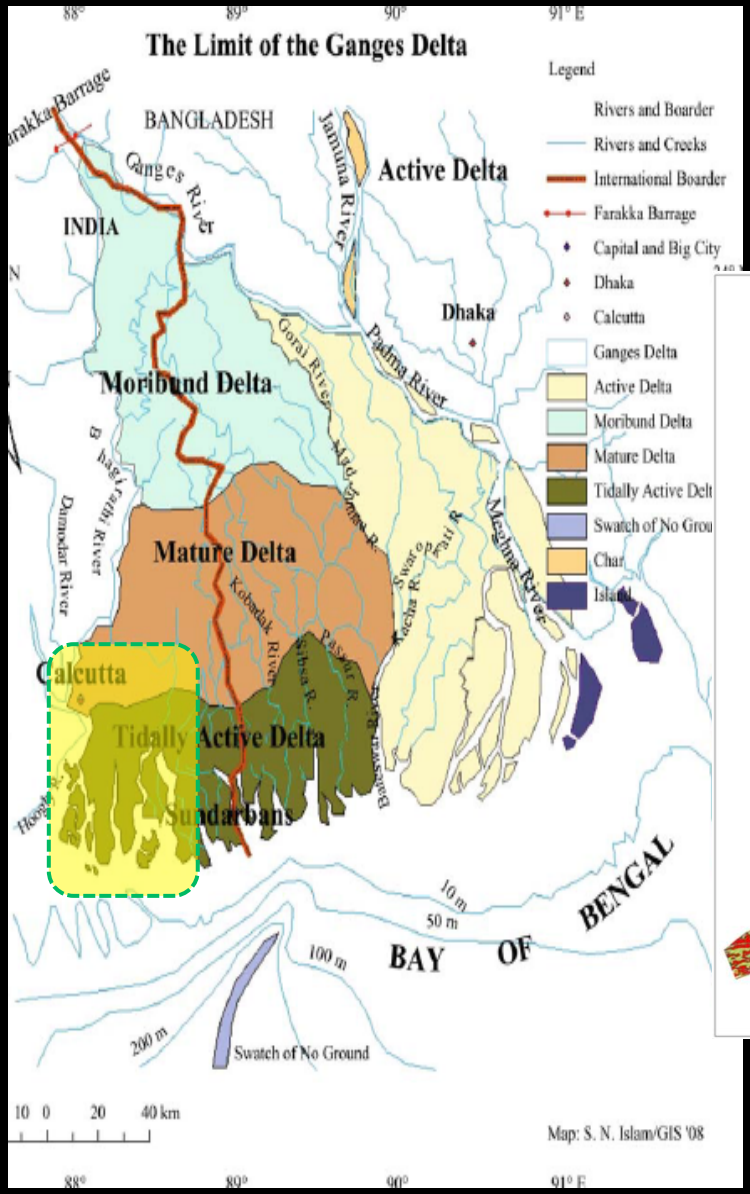
TRENDS INFORMING DECISIONS

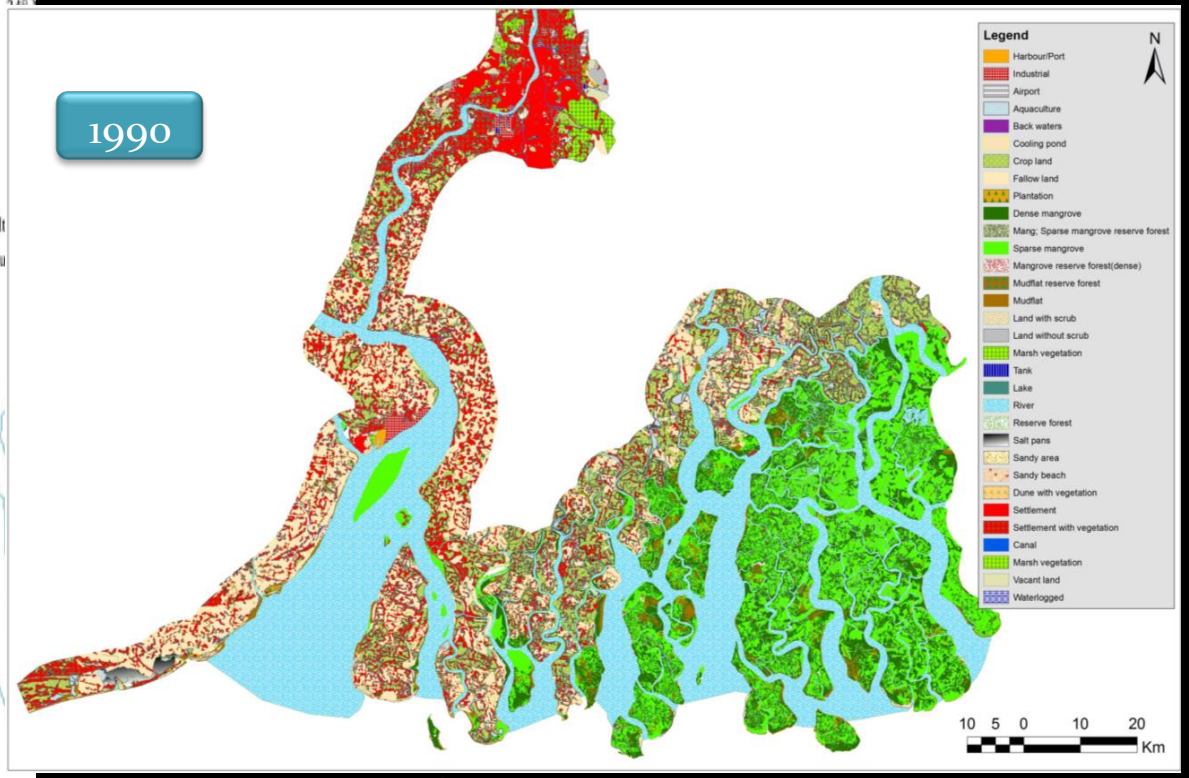
1. Disentangle the role of human vs. natural processes in shoreline vulnerability (mangrove clearance, modification of sediment supply, modification of delta plain).
2. Sustainable shoreline management cells, and options for the future. Recommendations regarding river sediment husbandry (channel-bed mining, future dams).

3- Trends: Sundarban Erosion/Accretion



3- Trends:
Land Use / Population Expansion





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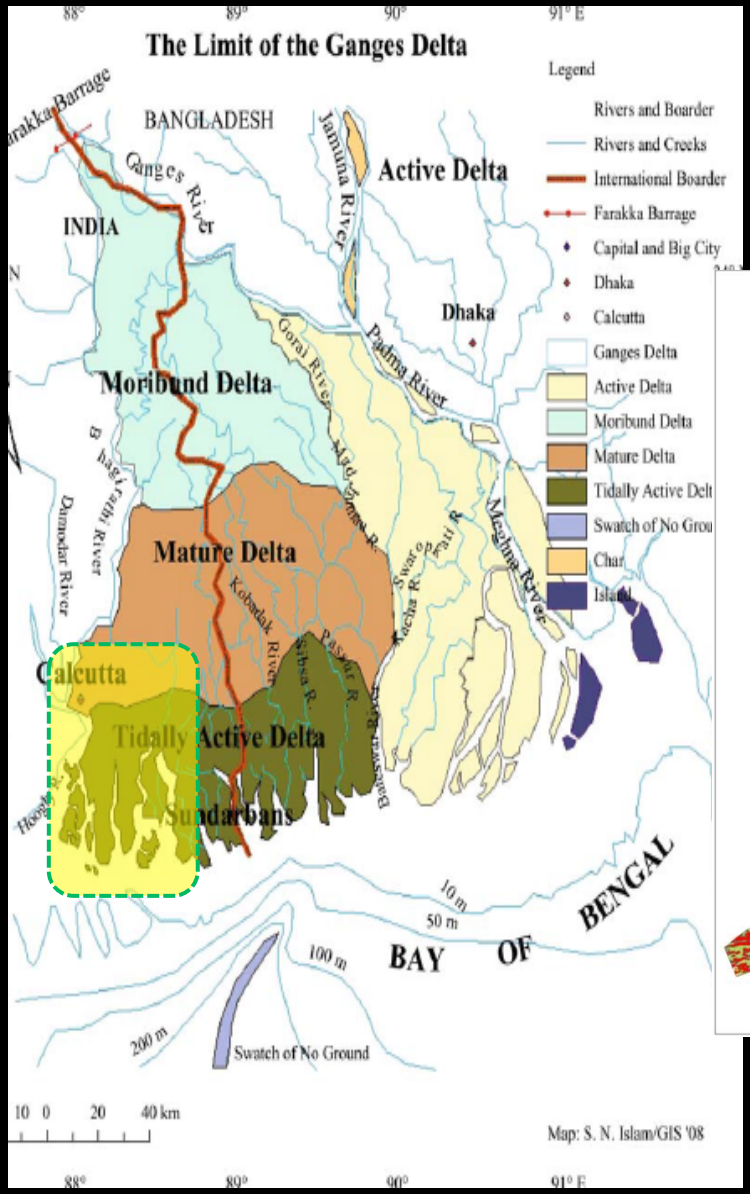

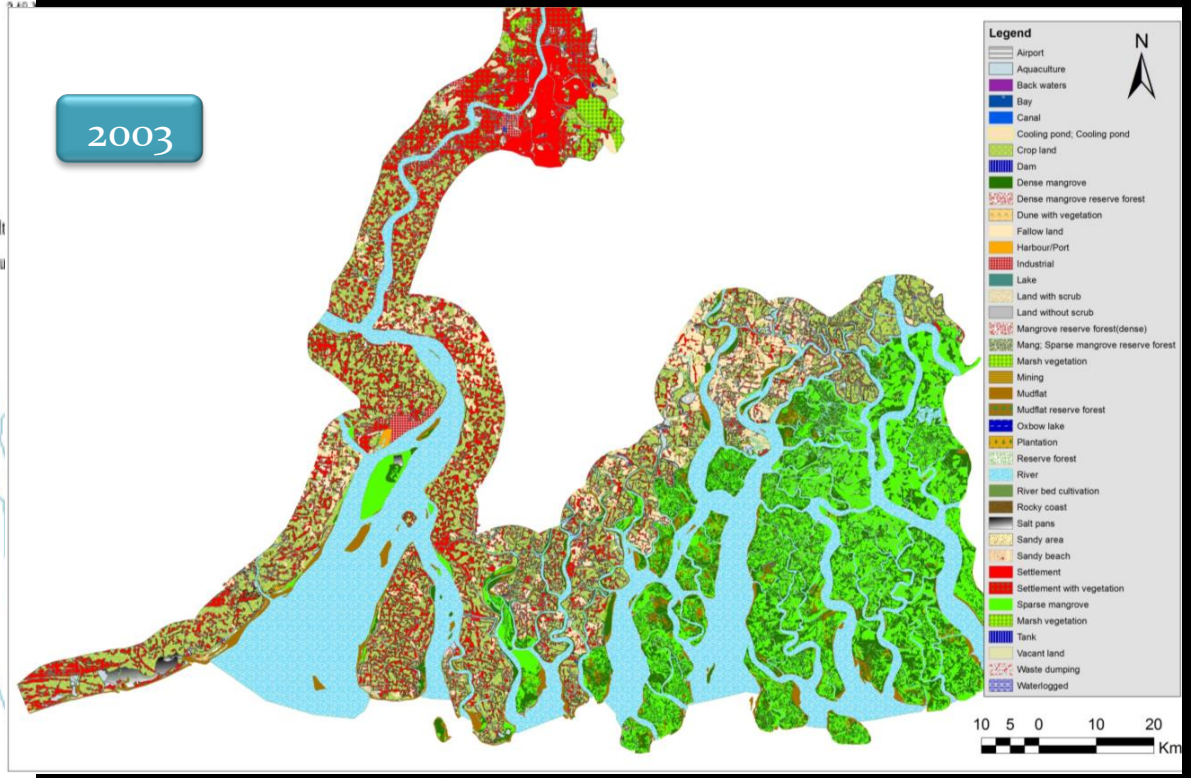

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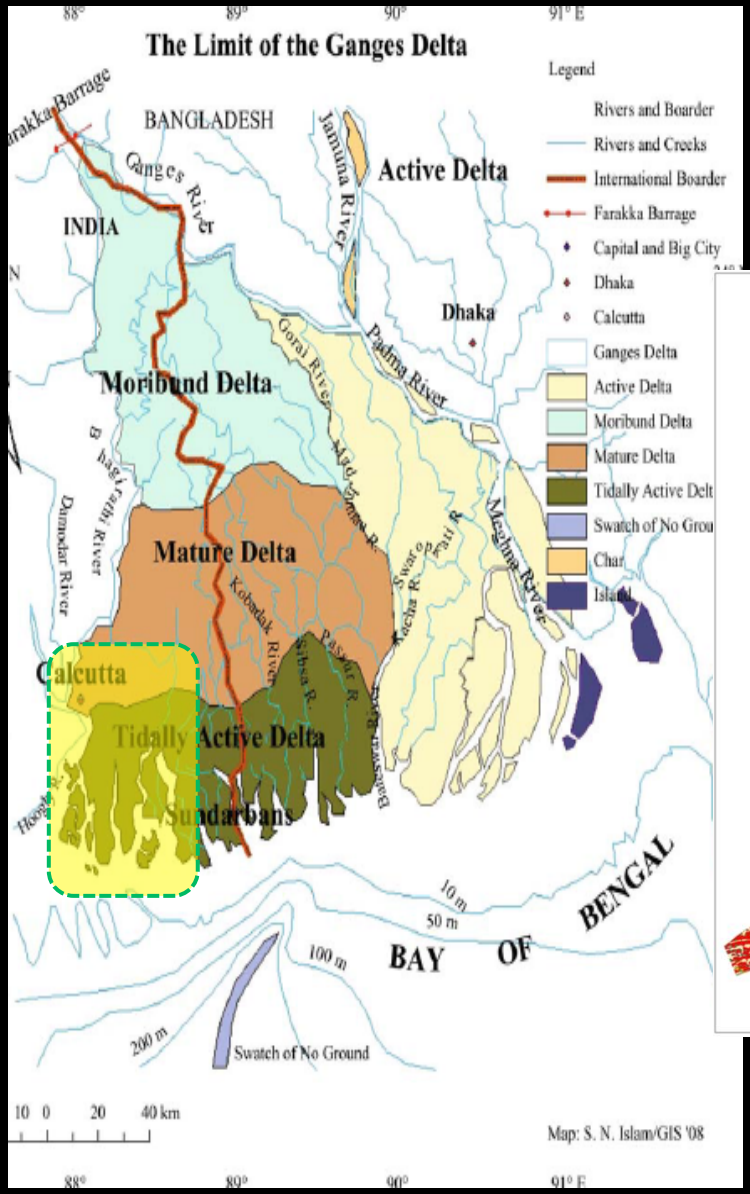
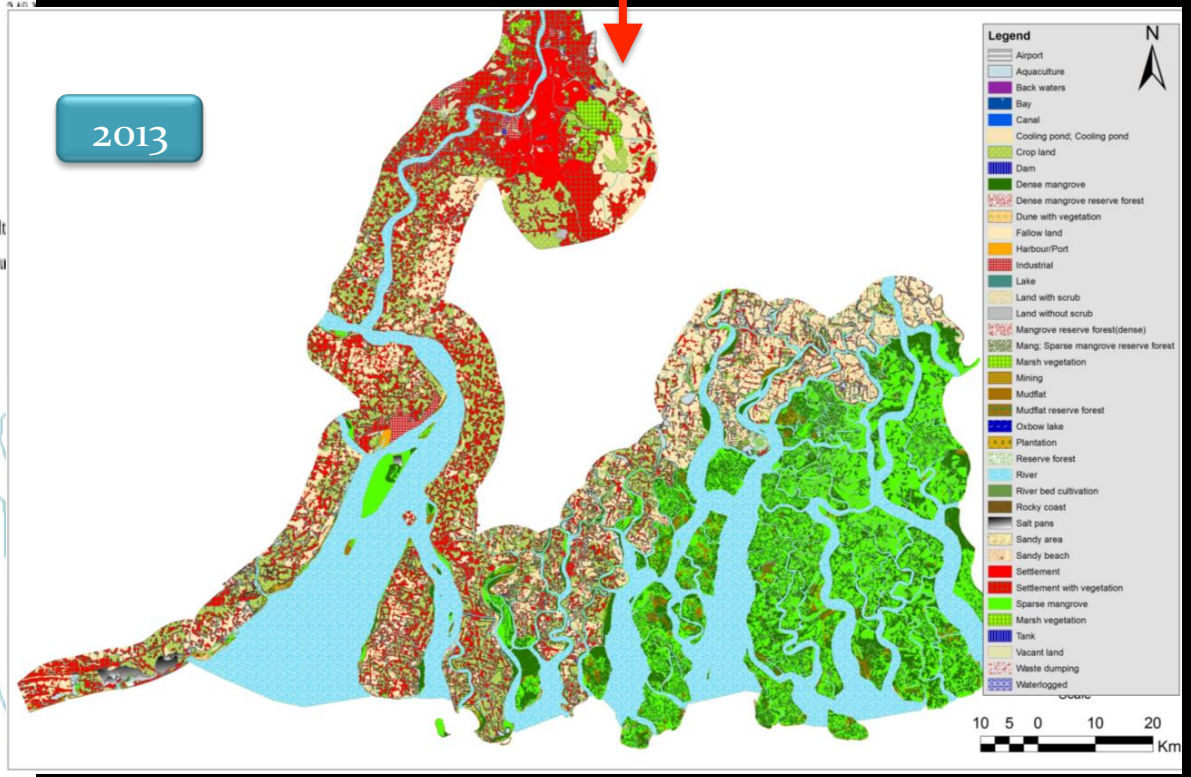
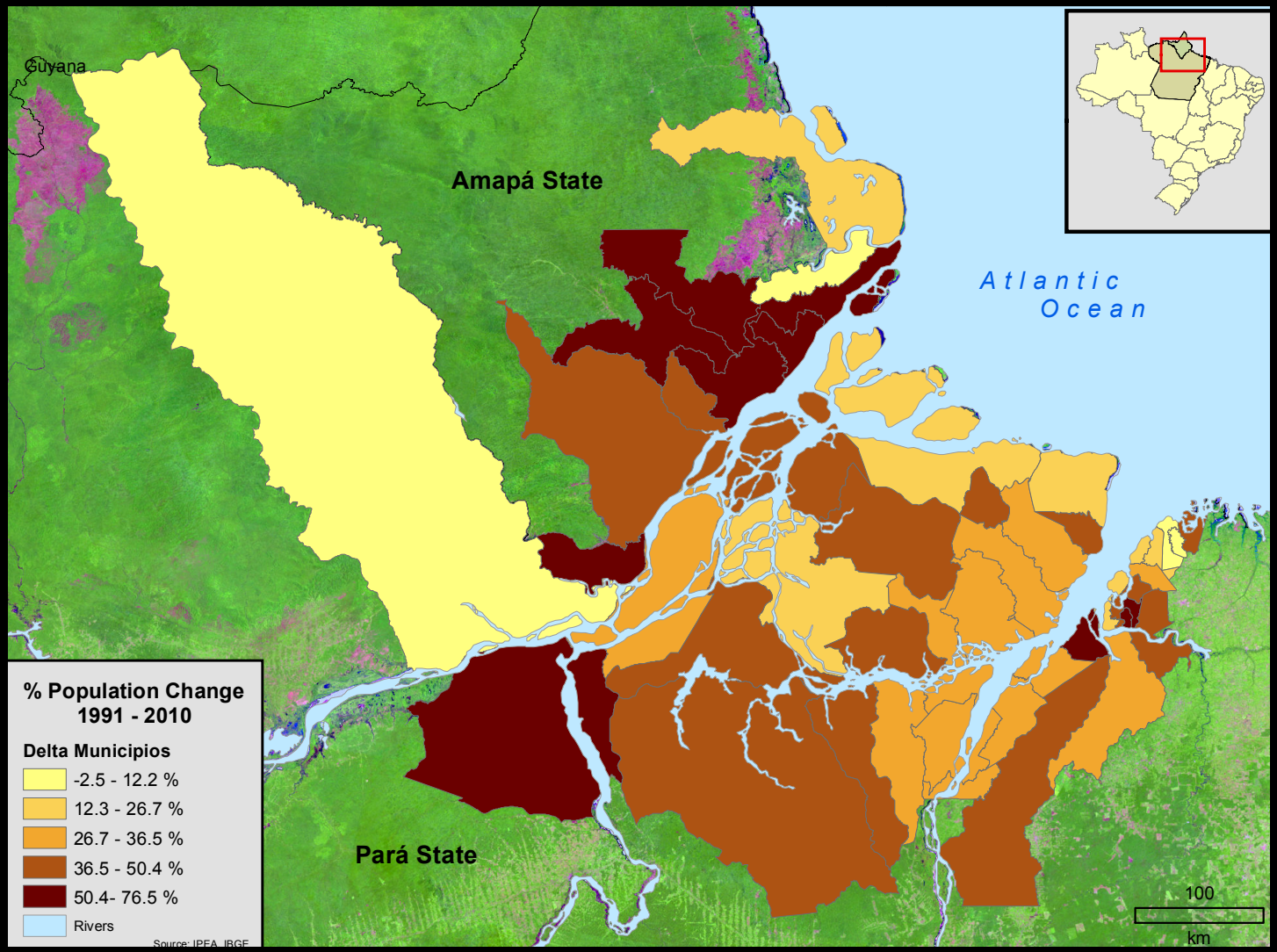


Kolkata's urban agglomerate accounted for an increase of over a million people in the last decade alone



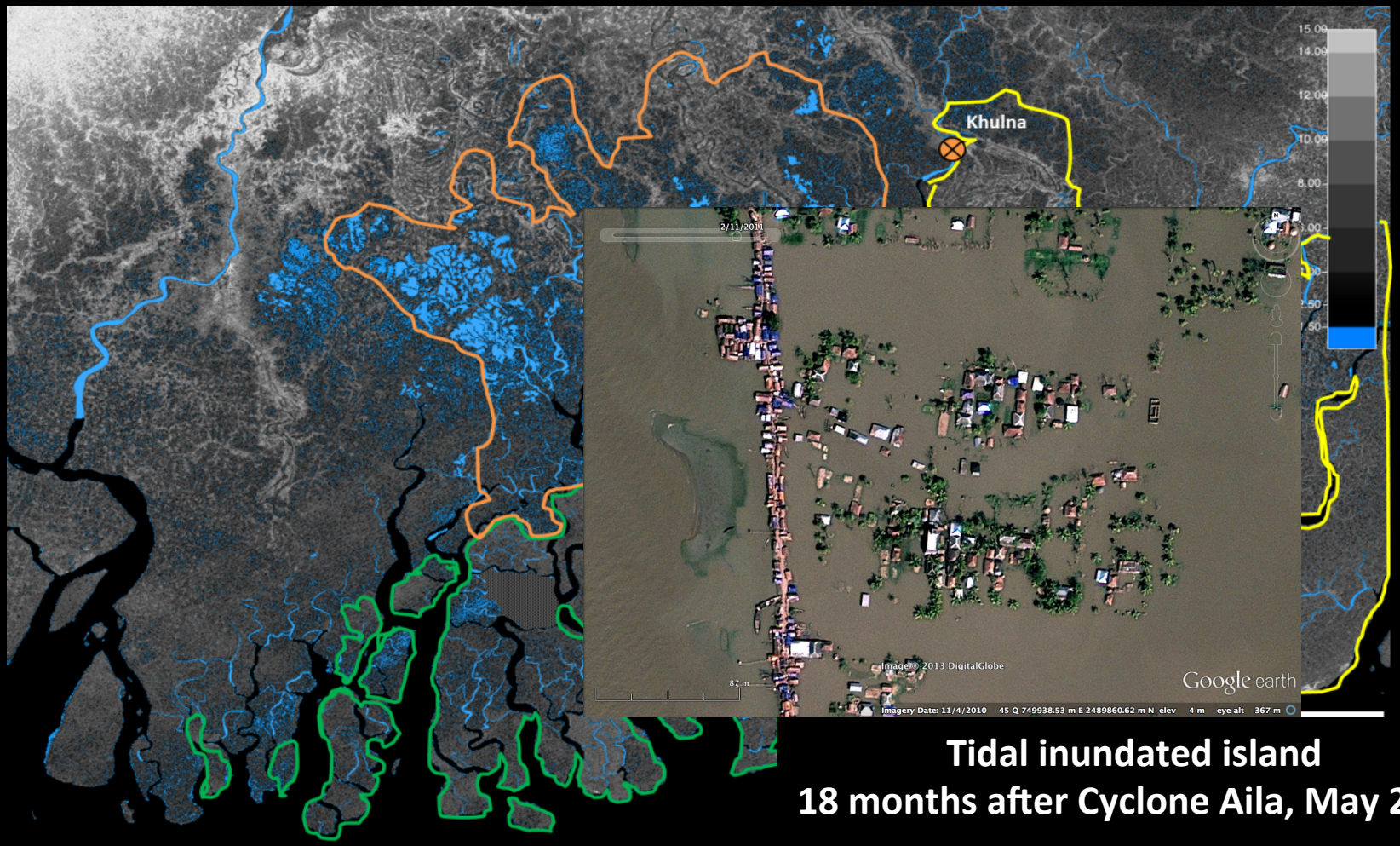
3- Trends:
Land Use / Population Expansion

POPULATION CHANGE – MUNICIPALITIES (1991-2010)



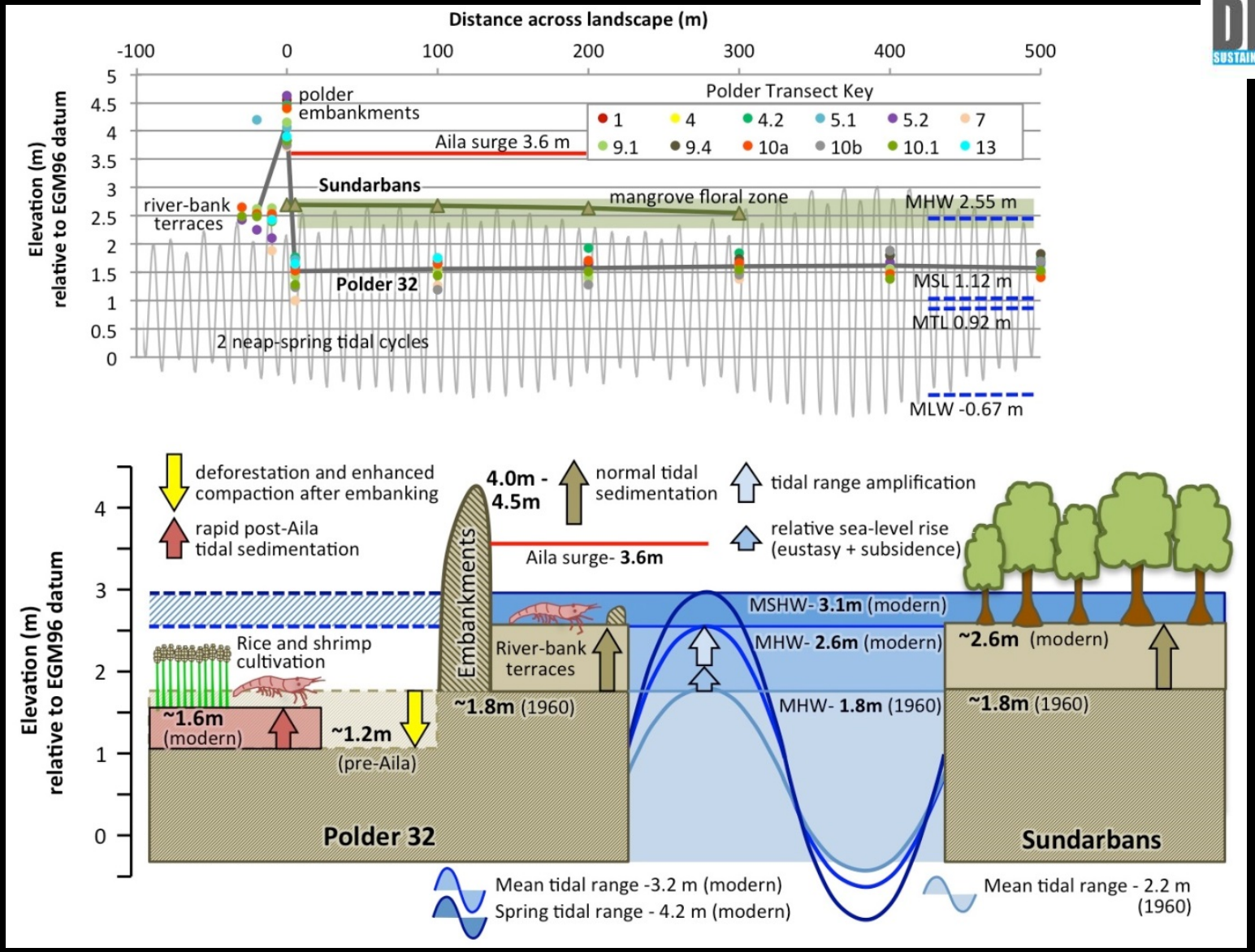
4- Climate-human-landscape Coupling

- *Climate-human-landscape interactions increase flood potential*



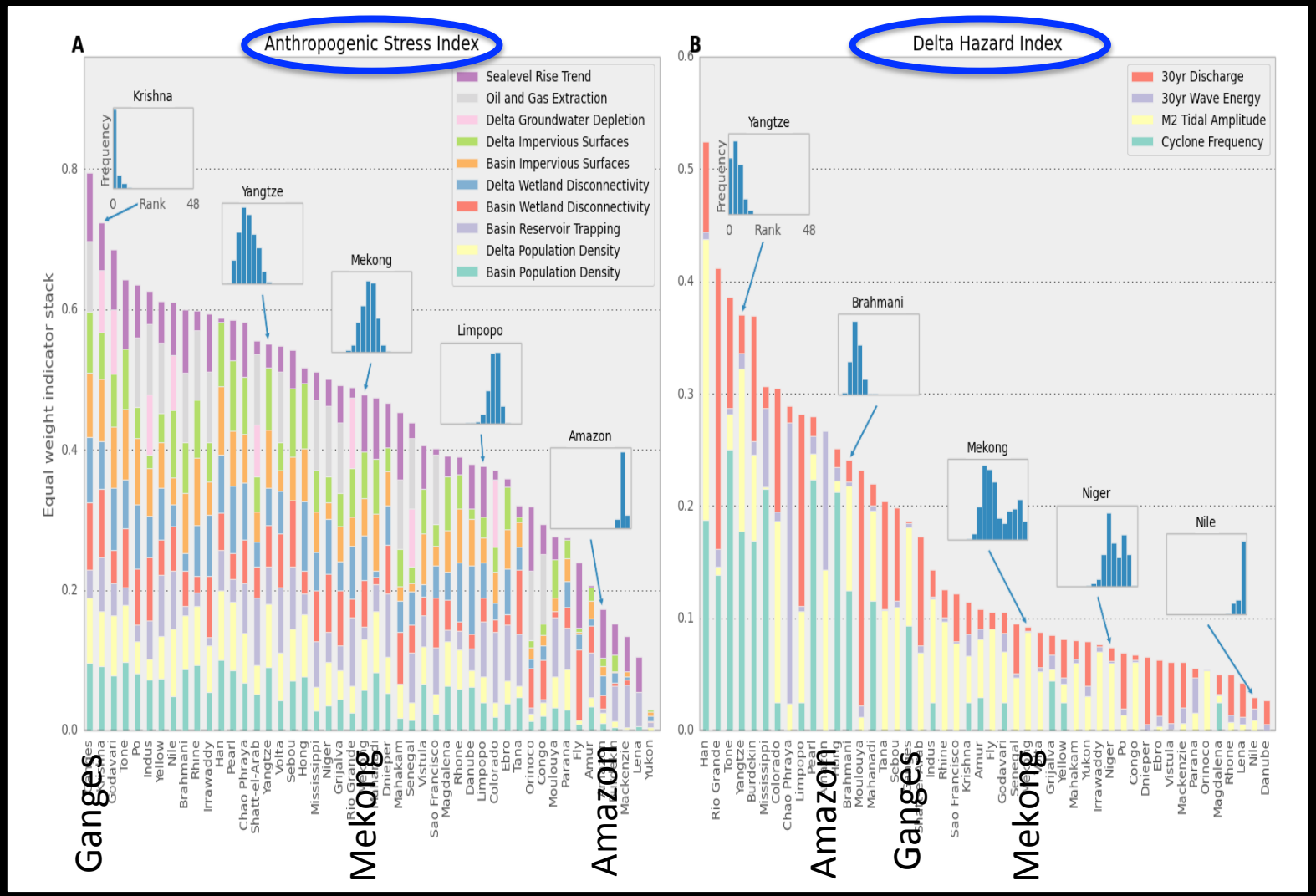
Tidal inundated island
18 months after Cyclone Aila, May 2009

4- Climate-human-landscape Coupling



5- Global Indices of Vulnerability

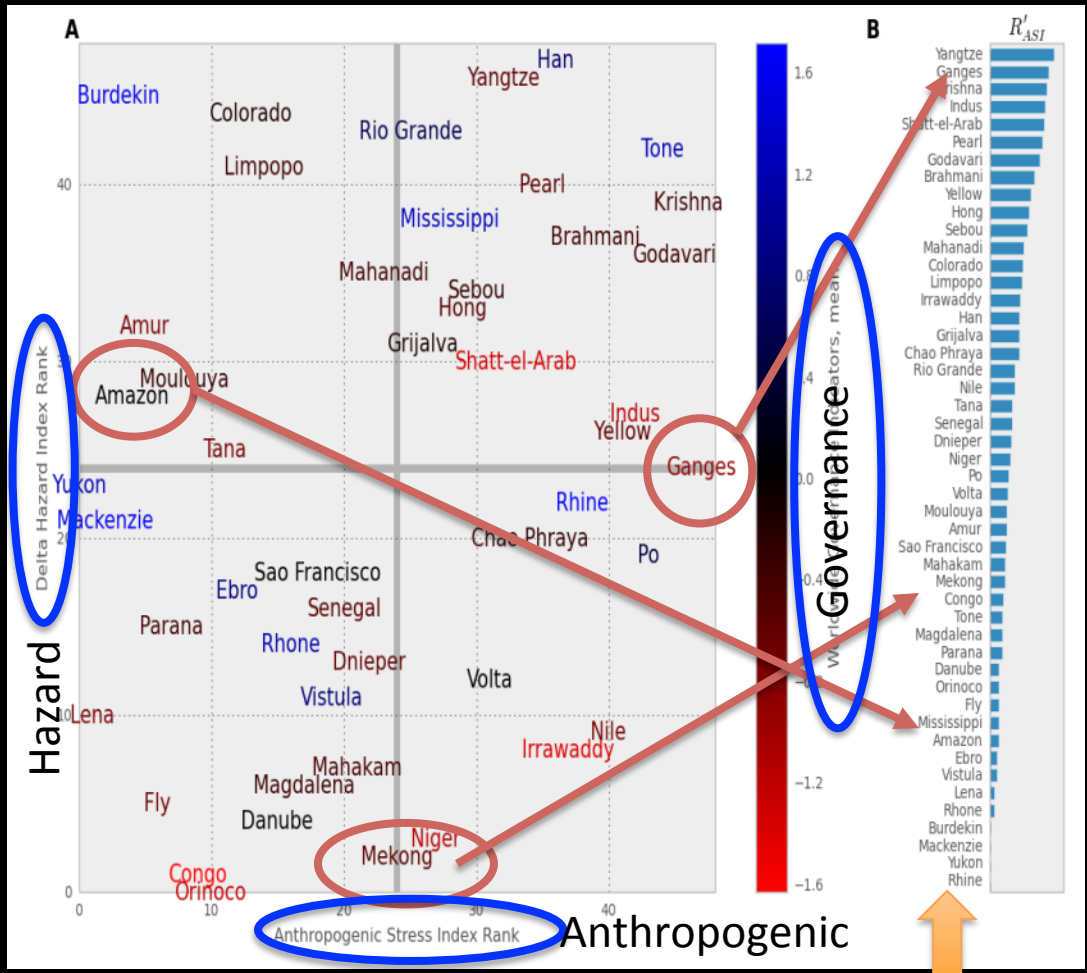
Anthropogenic Stress and Coastal hazard intensity indices



5- Global Indices of Vulnerability

Anthropogenic Stress and Coastal hazard intensity indices

- **Amazon**, **Mekong**, and **Ganges** occupy very different places in the *risk space*.
  - **Amazon** – low anthropogenic stress, moderate hazard frequency/intensity, moderate governance score. **Low rate of change of risk due to anthropogenic stress**
  - **Mekong** – moderate anthropogenic stress, low hazard frequency/ intensity, moderate/low governance score. **Moderate/low risk rate of change**
  - **Ganges** – very high anthropogenic stress, moderate hazard frequency/ intensity, low governance score. **Very high risk rate of change.**



Estimated rate of change of risk due to anthropogenic stress (land subsidence, wetland loss…)

6- Stakeholder Partnership

Local consultations in the three demonstration deltas at the sub-delta scale (Mekong: 2-3 April 2014, Ganges: 3-4 September 2014, Amazon: early 2015)

(Stakeholder meetings)

6- Stakeholder Partnership

Approach and progress

Local consultations in the three demonstration deltas at the sub-delta scale (Mekong: 2-3 April 2014, Ganges: 3-4 September 2014, Amazon: early 2015)

Identification of a **set of indicators as a joint outcome** of the desk-based studies and the 3 local consultations

Collection of **secondary and spatial data -> assessment**

Feedback to the delta model

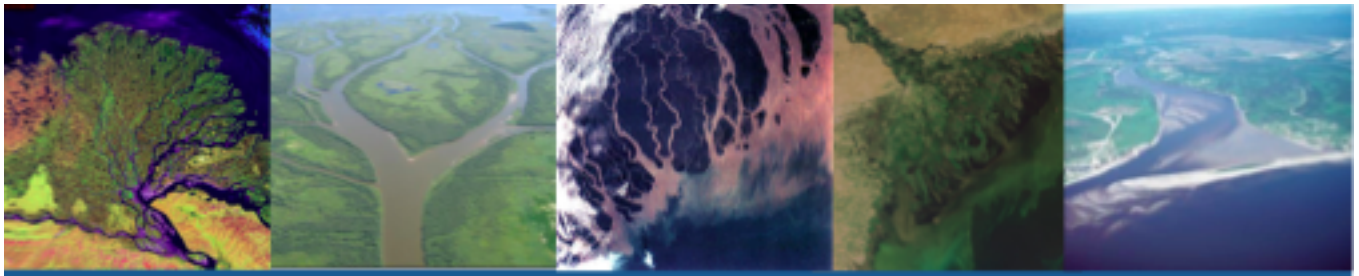
6- Stakeholder Partnership

Join us!

Deltas-in-Practice Workshop:

"Science-to-Action: Aligning science with stakeholder community needs in the Mekong and other delta systems"

Deltas in Practice 6: DP 6.3 (Friday 9 am – 12 noon)



INTERNATIONAL YEAR OF DELTAS 2013 : A PROPOSAL

We propose that 2013-2014 be designated the *International Year of Deltas* to: (1) increase awareness and attention to the value and vulnerability of deltas worldwide, (2) promote and enhance international and regional cooperation at the scientific, policy, and stakeholder level, and (3) focus and accelerate a comprehensive research agenda towards understanding and modeling these complex socio-ecological systems as the cornerstone of ensuring preparedness in protecting or restoring them in a rapidly changing environment.

FORUM

Foufoula-Georgiou et al., ***Oct., 2011***

International Year of Deltas 2013: A Proposal

PAGES 340–341

Marine and lacustrine deltas around the world are economic and environmental hot spots. They occupy approximately 1% of the Earth's land area but are home to more than 500 million people—a population density more than 10 times the world average [*Ericson et al.*, 2006]—all within 5 meters of

There is an urgent need to rally the international community for a focused effort toward a holistic physical-socioeconomic understanding of deltas as critically delicate and vulnerable systems undergoing change. Such understanding is a basic requirement for their management, protection, and restoration.

We propose that 2013–2014 be designated as the International Year of Deltas (IYD) to

geomorphology, ecology, sediment engineering, hydrology, coastal oceanography, stratigraphy, geography, history, anthropology, sociology, political sciences, and economics.

Basic research questions across these disciplines include the following:

1. What are the system dynamics of a delta, its main processes and reservoirs, feedback loops, system gains, and relevant parameters that govern dynamic equilibrium states? How strong is the two-way coupling between the ecological communities of the delta top and the geomorphic (physical) template?

2. How does the delta system (distributaries, wetlands, lakes, lagoons, and coastlines) self-organize into a dynamic structure capable of maintaining the subaerial delta over different time scales?

3. How do perturbations in the incoming

IYD Sponsors

International Union of Geodesy and Geophysics

International Association of Hydrological Sciences

Land-Ocean Interactions in the Coastal Zone

International Geographical Union

“Sustainable Deltas 2015 Initiative”

1. SD2015 is a statement of urgency for global cooperation, a call-to-arms to the global community of citizens, scientists, policy makers, funders

2. SD2015 is a mechanism to bring countries together at all levels of science, policy, decision makers, and public

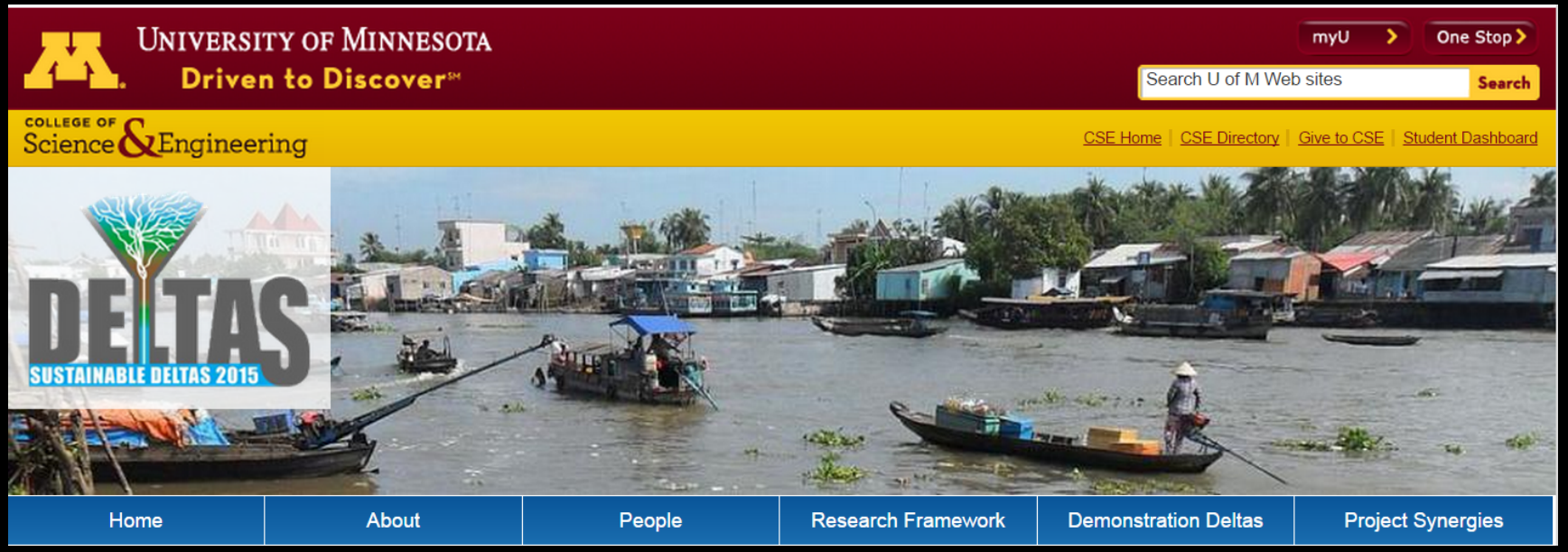
3. SD2015 is an opportunity to integrate and leverage disparate efforts for accelerating progress

“Sustainable Deltas 2015 Initiative”

DELTAS
SUSTAINABLE DELTAS 2015
ICSU
International Council for Science

Join us for the launch of SD2015!

Thursday, 09.00-10.45 Penn Room II



Affiliated Projects

DELIGHT
Delta Information System for Geoenvironmental and Human Habitat Transition

WISDOM
A GERMAN - VIETNAMESE INITIATIVE

life
Linked Institutions for Future Earth

BanglaPIRE

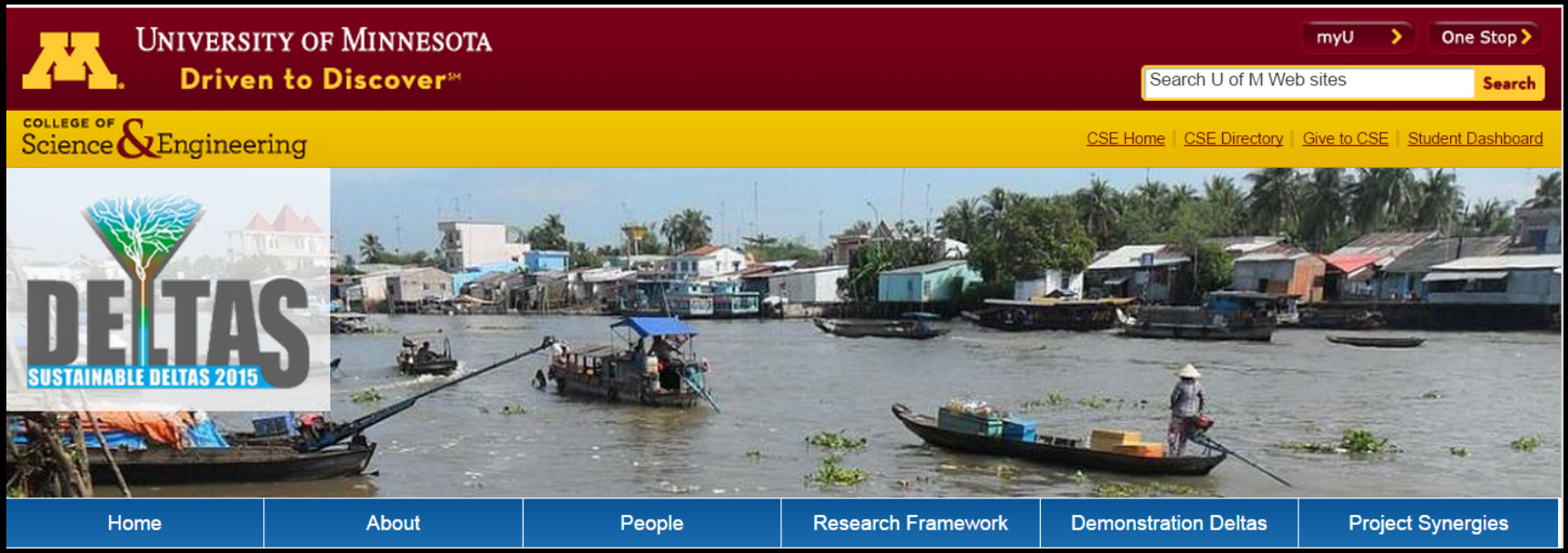
NCSCM
NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT
Ministry of Environment and Forests, Government of India

espa
ecosystem services for poverty alleviation

NCED
Earth · Water · Life

FESD
Delta Dynamic Collaboratory

www.delta.umn.edu



delta.umn.edu

Why Deltas?

1. Deltas are home to over half a billion people (occupy only 1% of the world's land)
2. They are home to biodiverse and rich ecosystems, such as mangroves, reedlands and marshes
3. They are economic hotspots, food baskets for many nations, supporting much of the world's fisheries, forest products, and extensive agriculture
4. They are ports of entry supporting significant growing cities and harbors

YET … they are disappearing at an alarming rate

1. Human actions from upstream deplete them from water and sediment : on a global scale >40% of river discharge and 26% of sediment are being intercepted by large reservoirs
2. Local exploration contributes to subsidence, loss of wetlands, and accelerated erosion
3. Sea level rise increases salinity and accelerates land loss
4. Tropical storms and cyclones cause devastating flooding