

BF-DELTAS

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



Deltas in Times of Climate Change II
Rotterdam. September 25, 2014

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Department of Civil, Environmental and Geo- Engineering





Discharge / Sediment

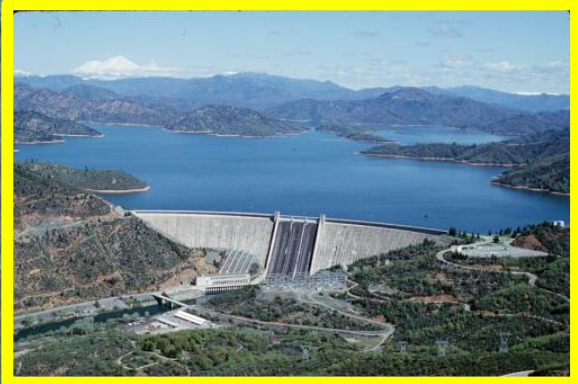


Local activities



Ocean waves/tides





Discharge / Sediment



Local activities



Sea level / Subsidence



Eco-hydrology



Geomorphology



Sedimentology



Socio-economics



Policy





***A key International Network of Funders
of Environmental Research***

Slides courtesy of Dr. Patrick Monfray

IGFA/Belmont Forum co-chair

Future Earth Governing Council member

- The Belmont Forum gathers the world's **major and emerging funders of global environmental change research**, and international science councils
- **Acting as Council of Principals for IGFA**, a larger group of funding agencies
 - Australia/CSIRO
 - Brazil/FAPESP
 - Canada/NSERC
 - China/NSFC
 - European Commission/DG R&I
 - France/CNRS&ANR, co-chair
 - Germany/DFG&BMBF
 - India/MoES
 - Italy/CNR
 - Japan/MEXT&JST
 - South Africa/NRF, co-chair
 - Sweden/SSEESS
 - United Kingdom/NERC
 - United States/NSF
 - *International Council for Science (ICSU)*
 - *International Social Sciences Council (ISSC)*

BELMONT
FORUM



ICSU

International Council for Science

Funders

Academics

S & T Alliance for Global Sustainability



UN bodies



UNITED NATIONS
UNIVERSITY



WMO
as observer

>>> A critical mass with strong international visibility

The “BF-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),

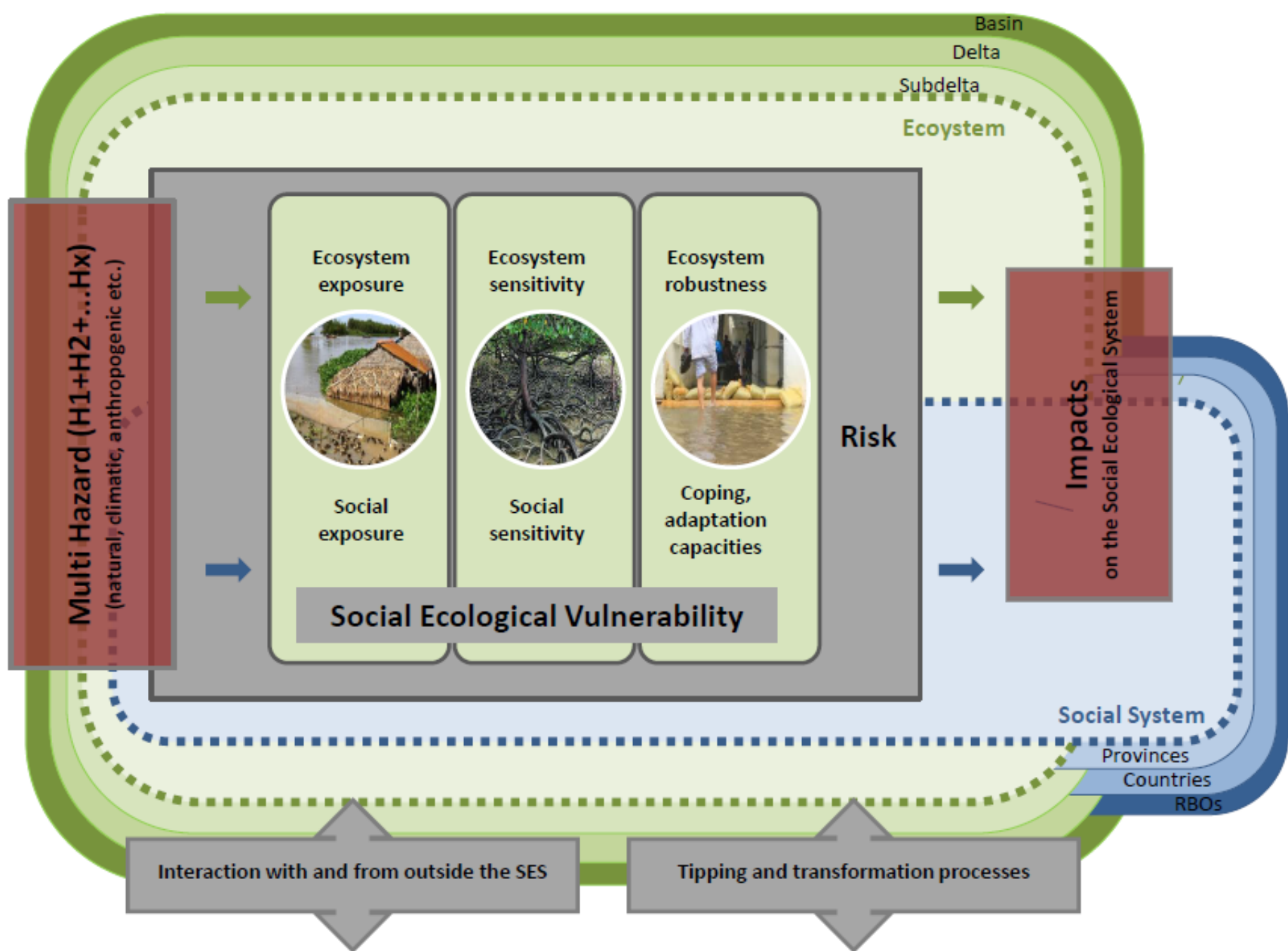
Canada: G. Lintern (Natural Resources Canada); P. Van Cappellen and H. Durr (University of Waterloo),

China: S. Gao (Nanjing Univ.)

Major science questions



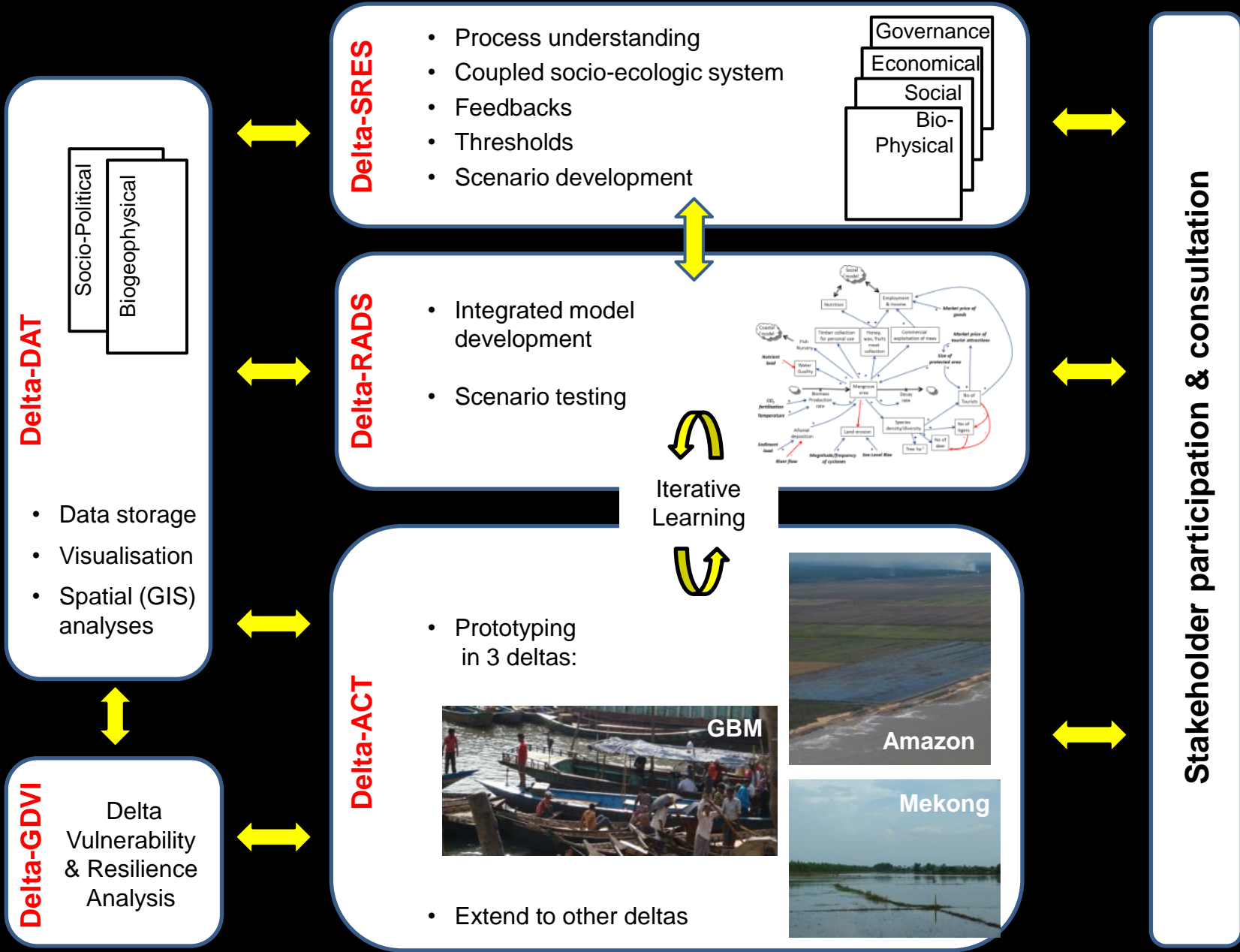
- (1) How do climate change, pressure on resources, and engineering/infrastructure development make people, biodiversity, and delta ecosystems vulnerable? -- **cascade of stressors**
- (2) How is delta vulnerability to be measured? -- **metrics of change**
- (3) How do delta areas absorb extreme events? 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**



Work Packages (WPs)



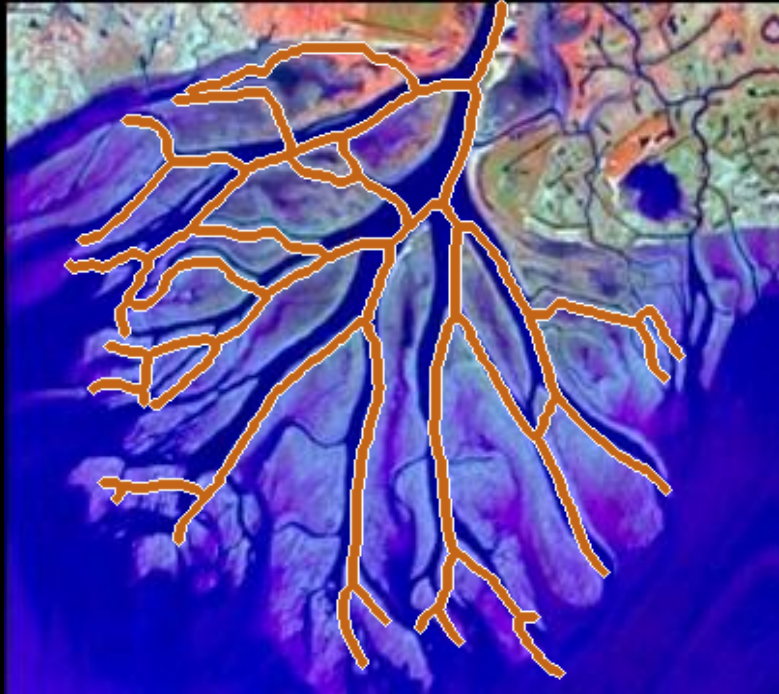
1. Advance *science on resilience and sustainability* of deltas as critical coupled socio-ecological systems undergoing change (**Delta-SRES**)
2. Develop and deliver a science-based delta sustainability framework for risk assessment and *decision support* (**Delta-RADS**)
3. Build an international *repository 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**)



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?

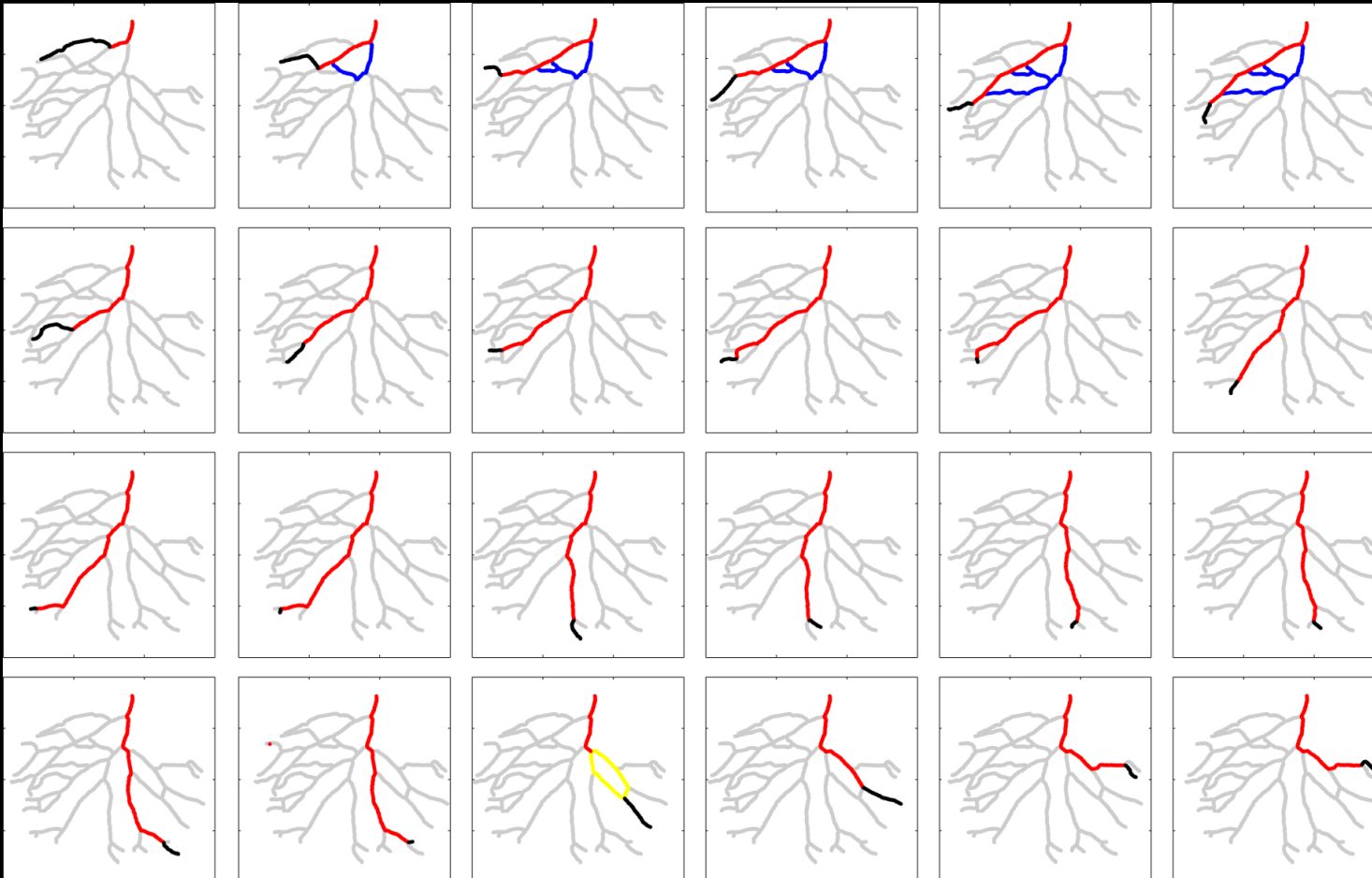
Approach:

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

Vulnerability Maps

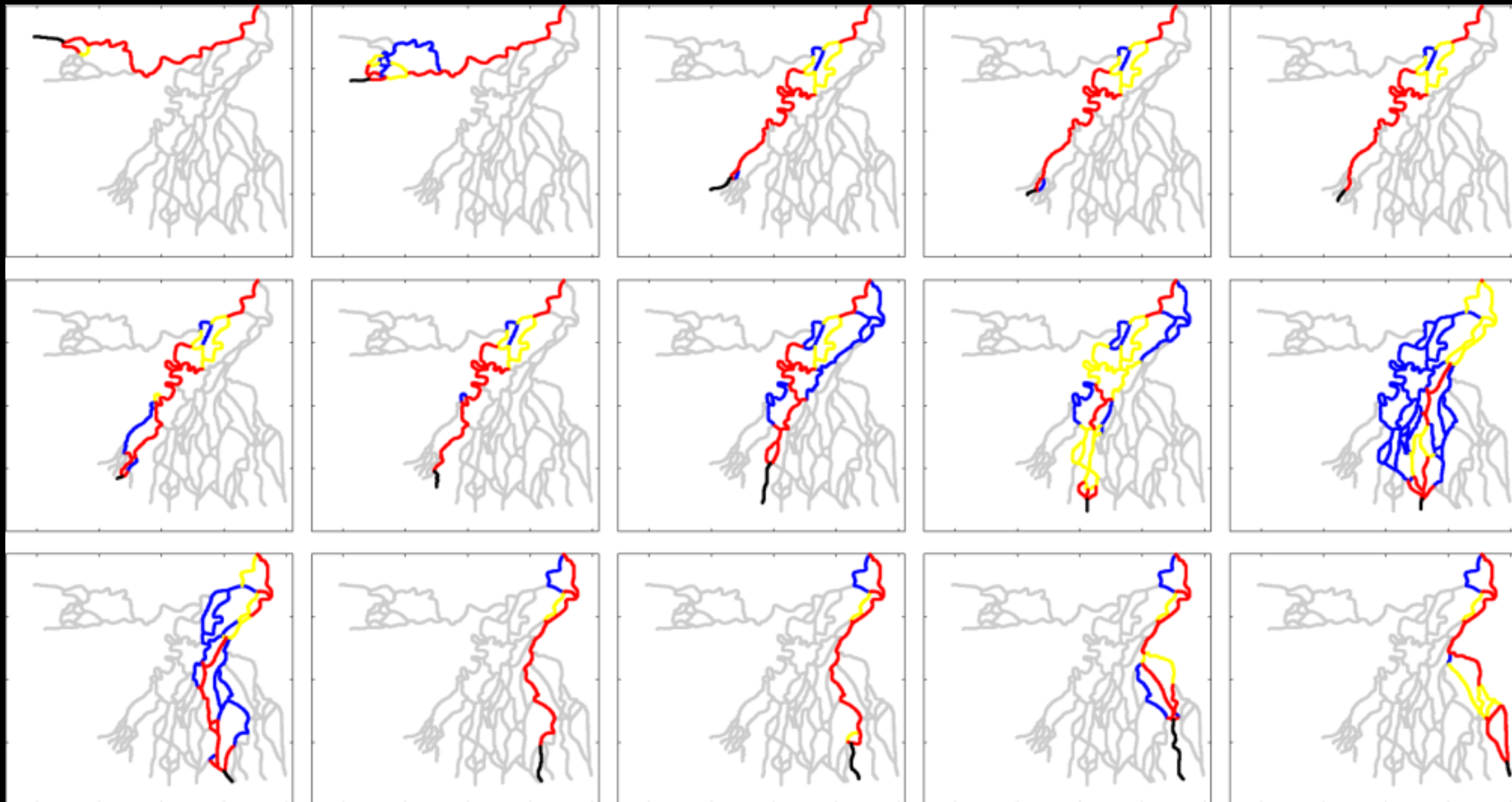


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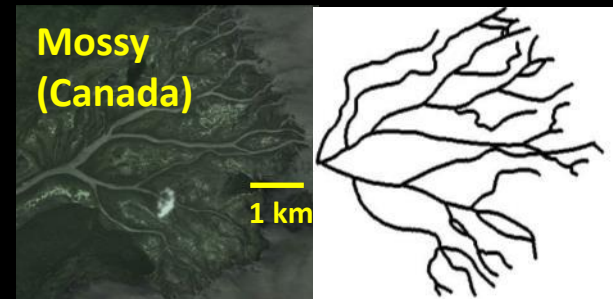
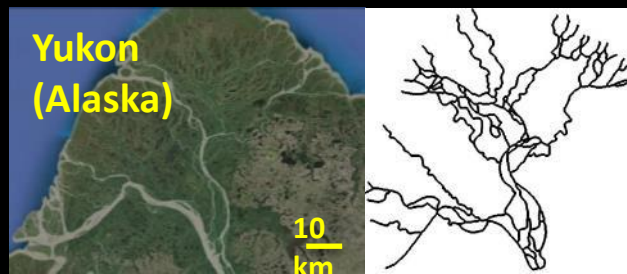
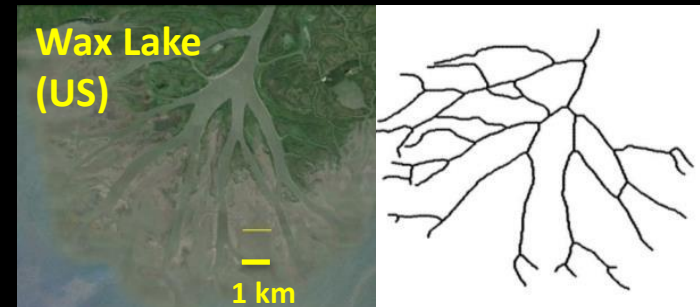
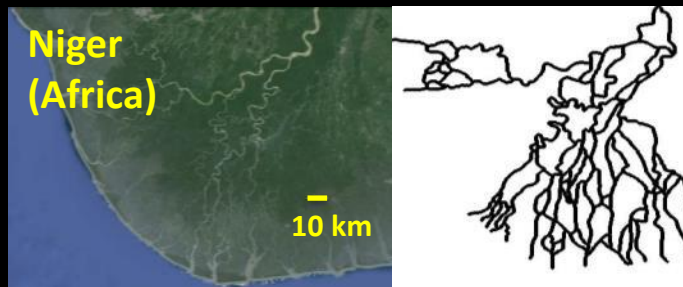
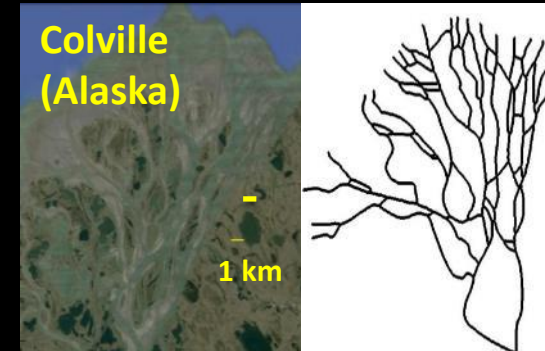
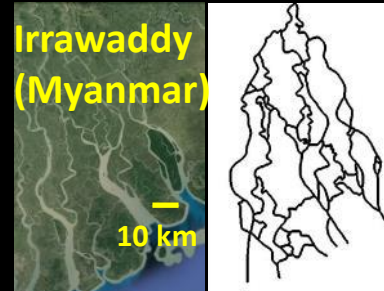
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Vulnerability Maps



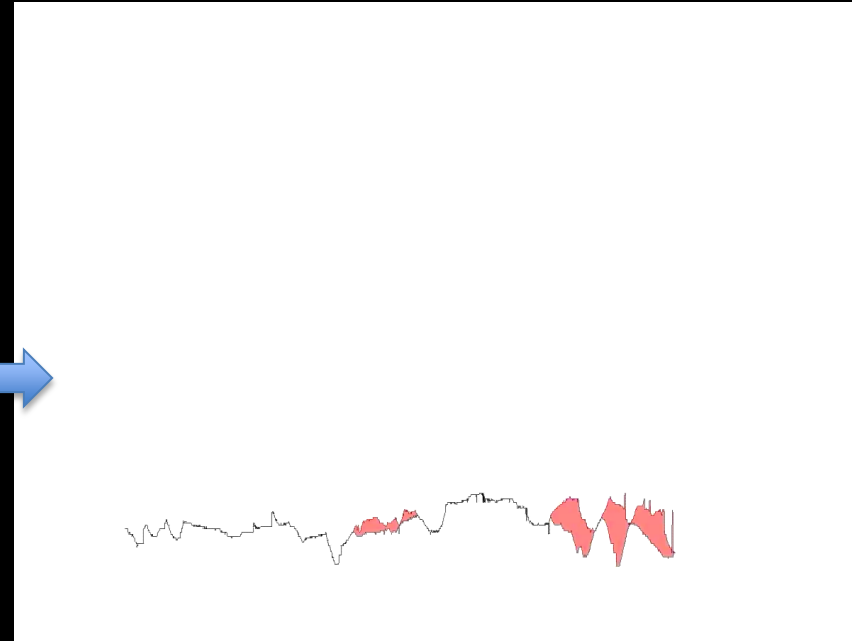
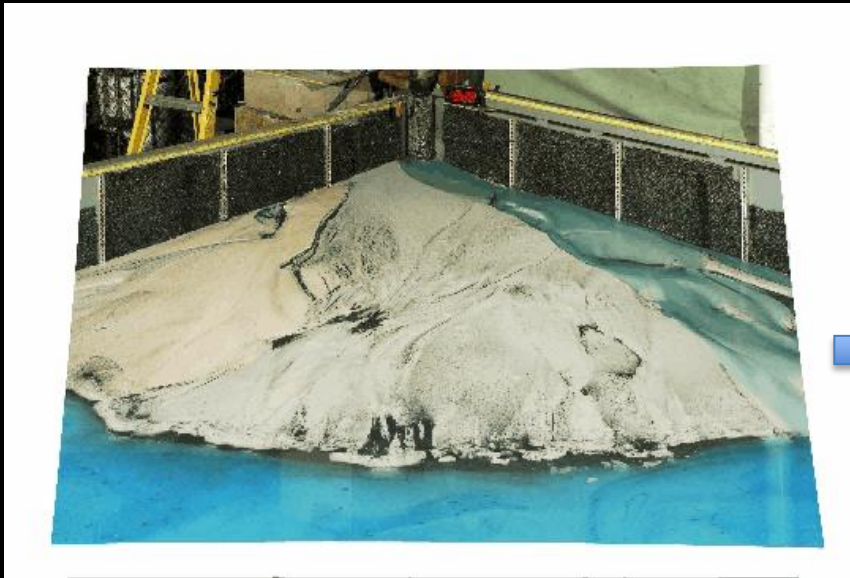
1- Delta Networks and Vulnerability

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 need [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 Brahmaputra rainfall: flooding, river erosion and channel switches. The people of Bangladesh have adapted to this dynamic delta system, they have raised villages above the floodplains. 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. The 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 question is: how does this amount of sediment change with a changing monsoonal climate? Does this sediment aggrade fast enough to help counteract rapid sea-level rise?

2- Modeling : Integrated Models

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

The CSDMS Web Modeling Tool

Model (*Sedflux2D 1)

Sedflux2D ▾

- coastal_en... +
- subaerial... +
- baselevel +

Parameters (Sedflux2D)

Sedflux2D v2.1 (10.1594/IEDA/100161)

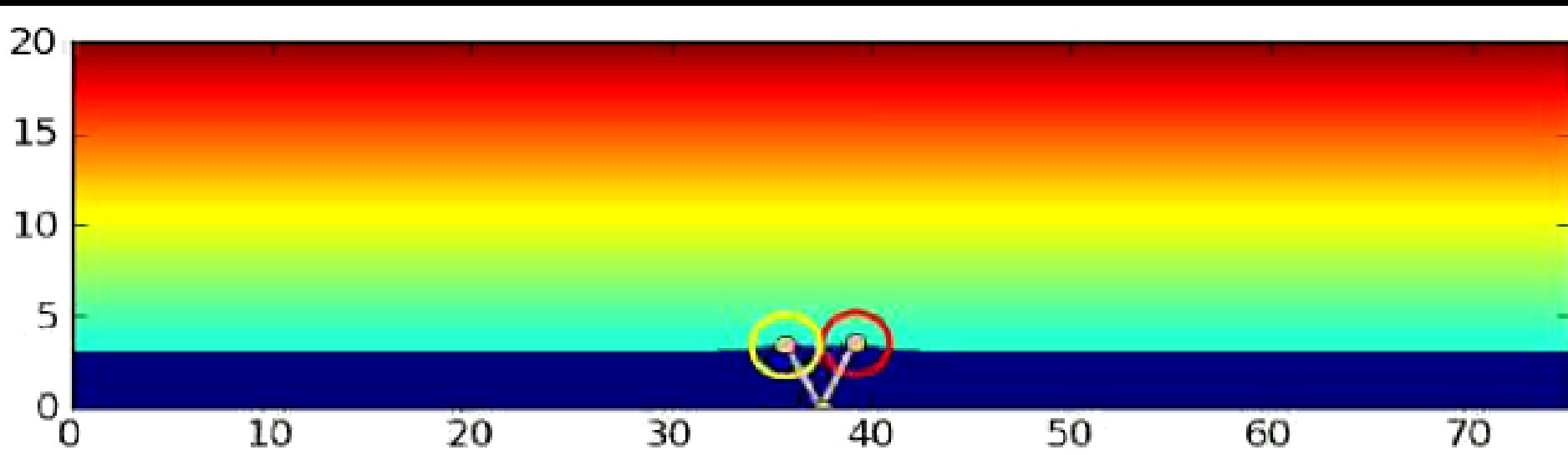
Basin filling stratigraphic model. Sedflux2d simulates longterm marine sediment transport and accumulation into a 2D longitudinal basin over time scales of tens of thousands of years. It simulates the dynamics of strata formation of continental margins and includes turbidity currents and debris flows.

http://csdms.colorado.edu/wiki/Model_help:Sedflux

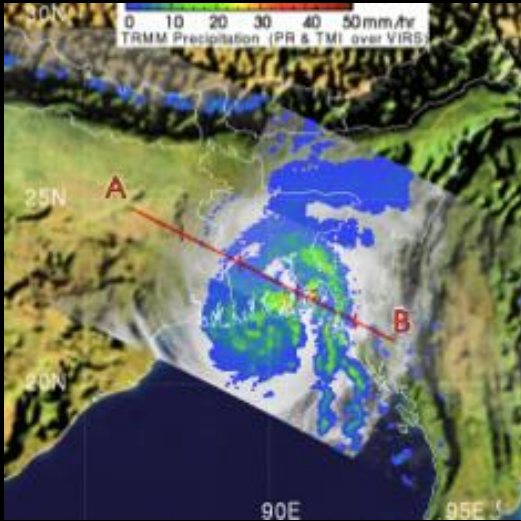
Model developer: Eric Hutton

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.



2- Modeling: Precipitation/ Inundation

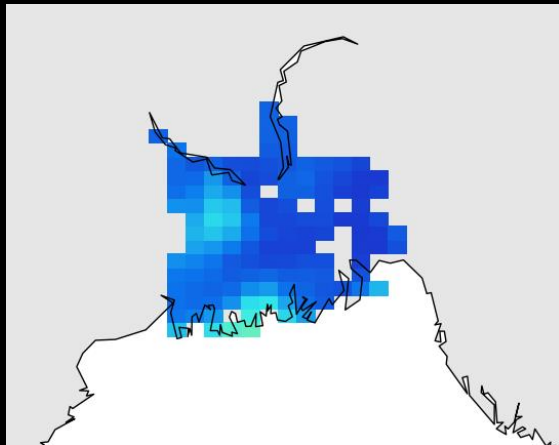


Retrieval of precipitation from space (TRMM/GPM)

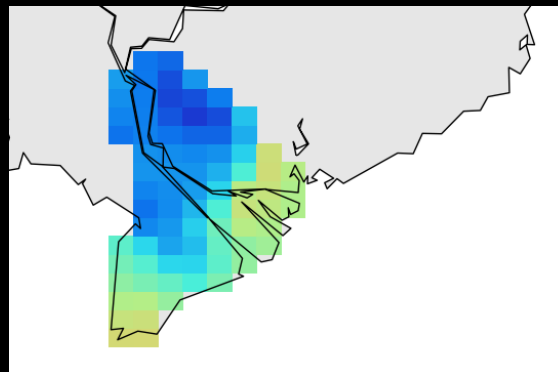


GPM: Global Precipitation Measuring Mission

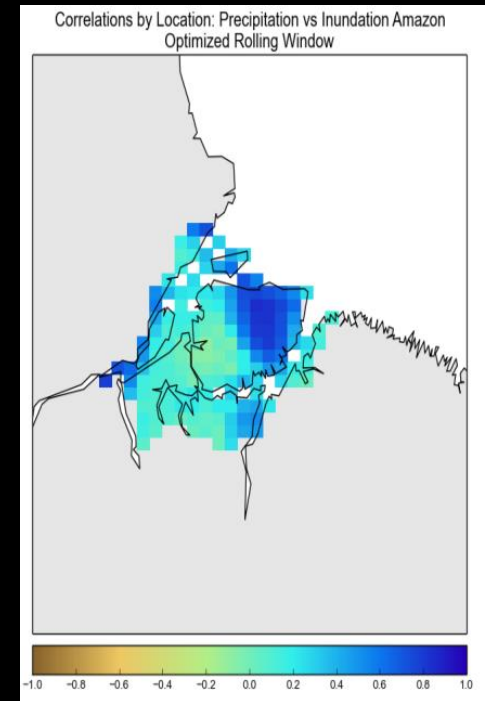
Spatial correlations between inundation and precipitation over a per-delta optimized rolling window



(Ganges)



(Mekong)



(Amazon)

3- Trends: Demographic data



**Data
Collection**



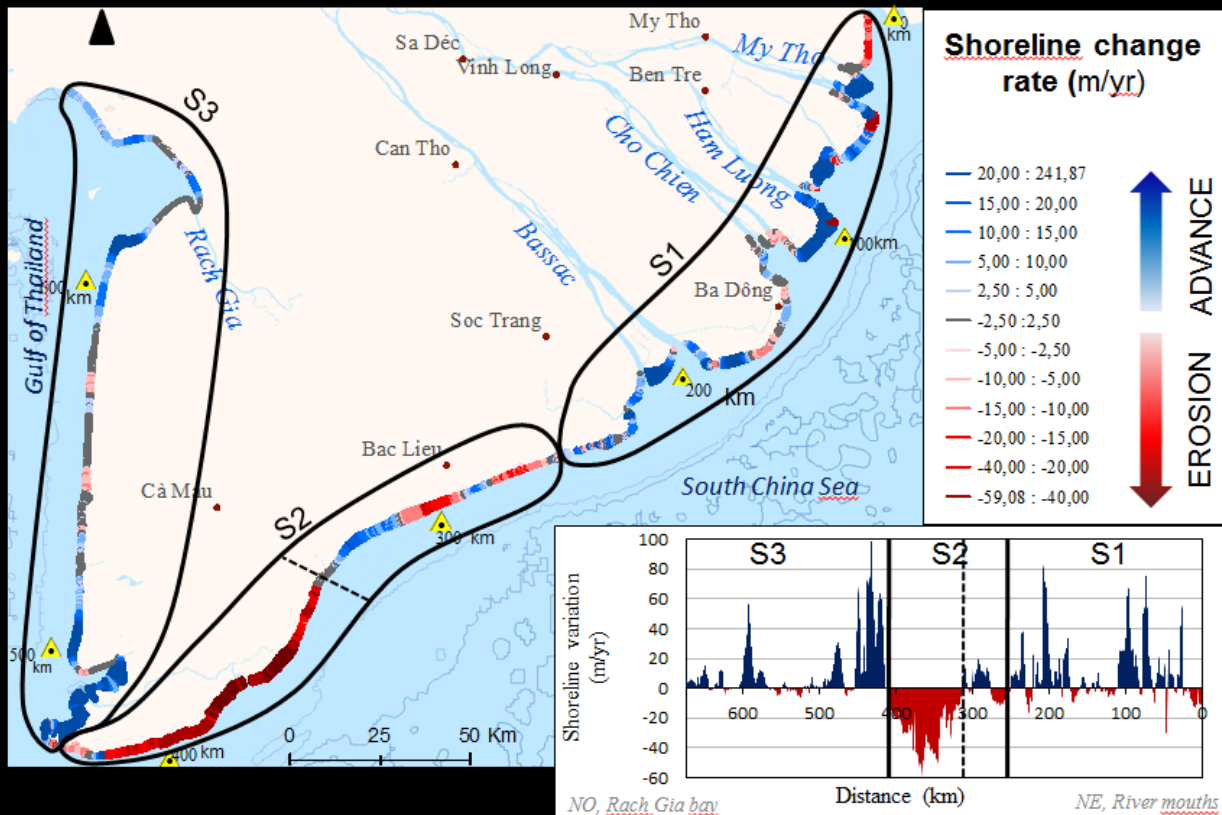
Analysis

- 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)
- 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)

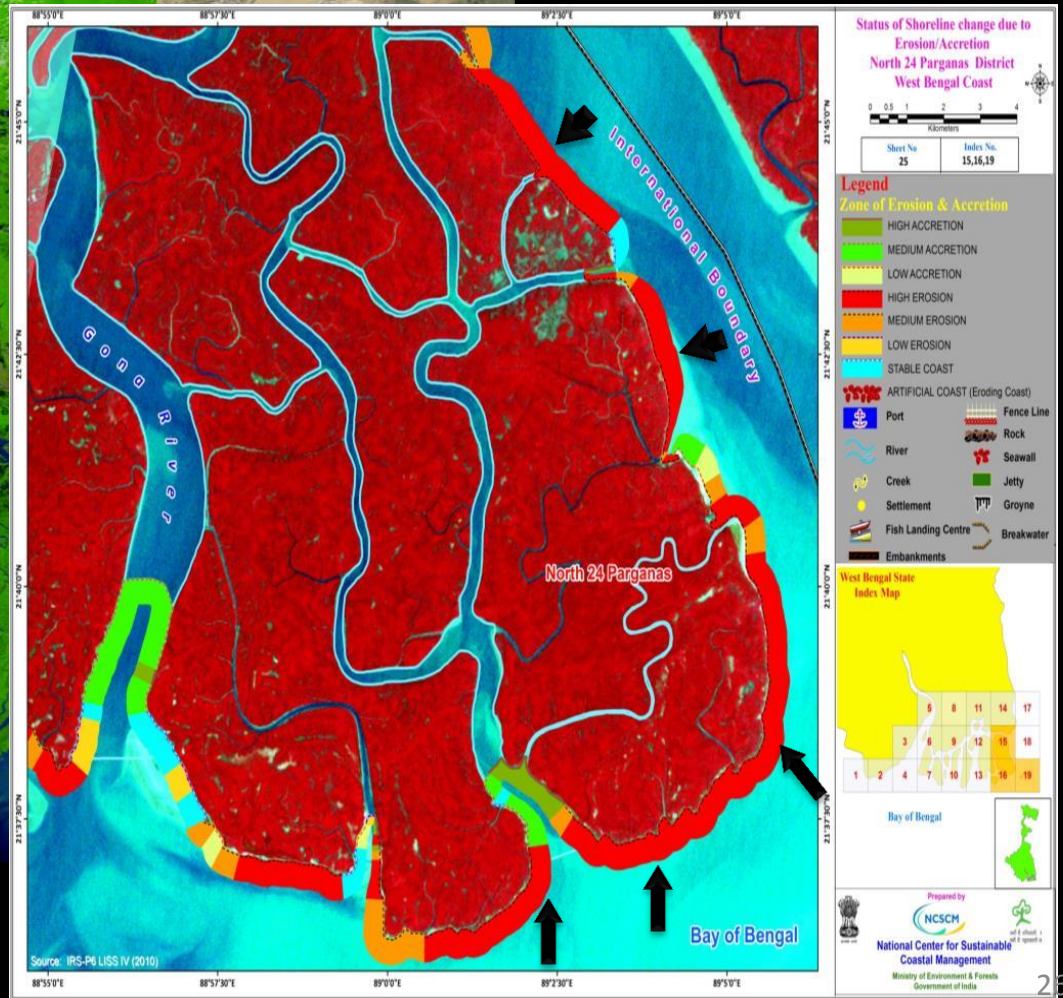
ANALYSIS OF 6000 shoreline transects (100 m spacing) using Landsat and very high-resolution SPOT 5 images



TRENDS INFORMING DECISIONS

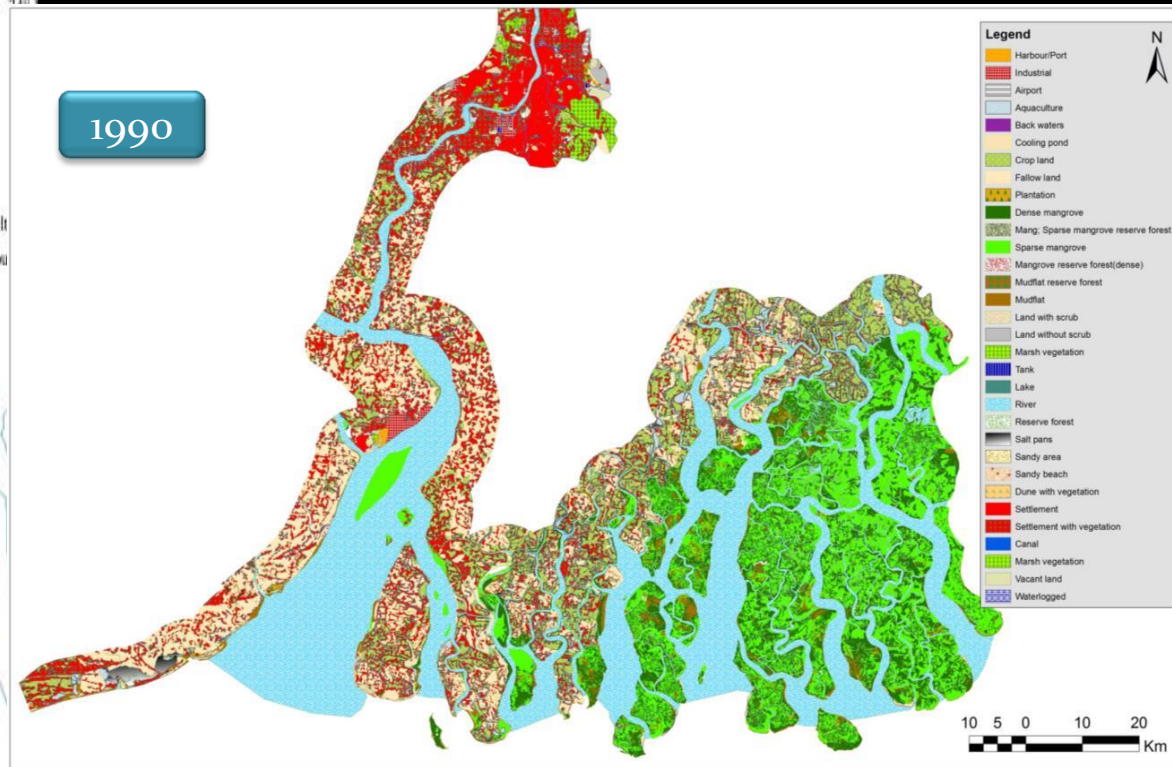
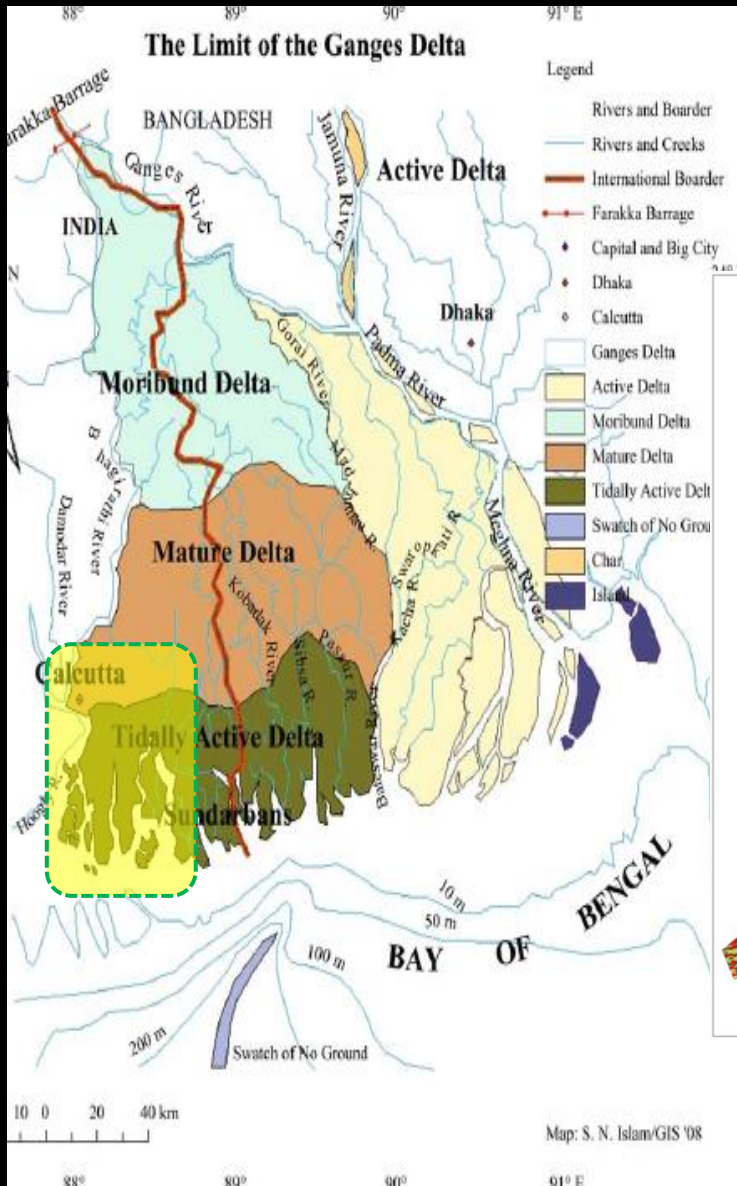
1. Disentangle the role of human vs. natural processes in shoreline vulnerability (mangrove clearance, modification of sediment supply, modification of delta plain).
2. Sustainable shoreline management cells, and options for the future. Recommendations regarding river sediment husbandry (channel-bed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

3- Trends: Sundarban Erosion/Accretion



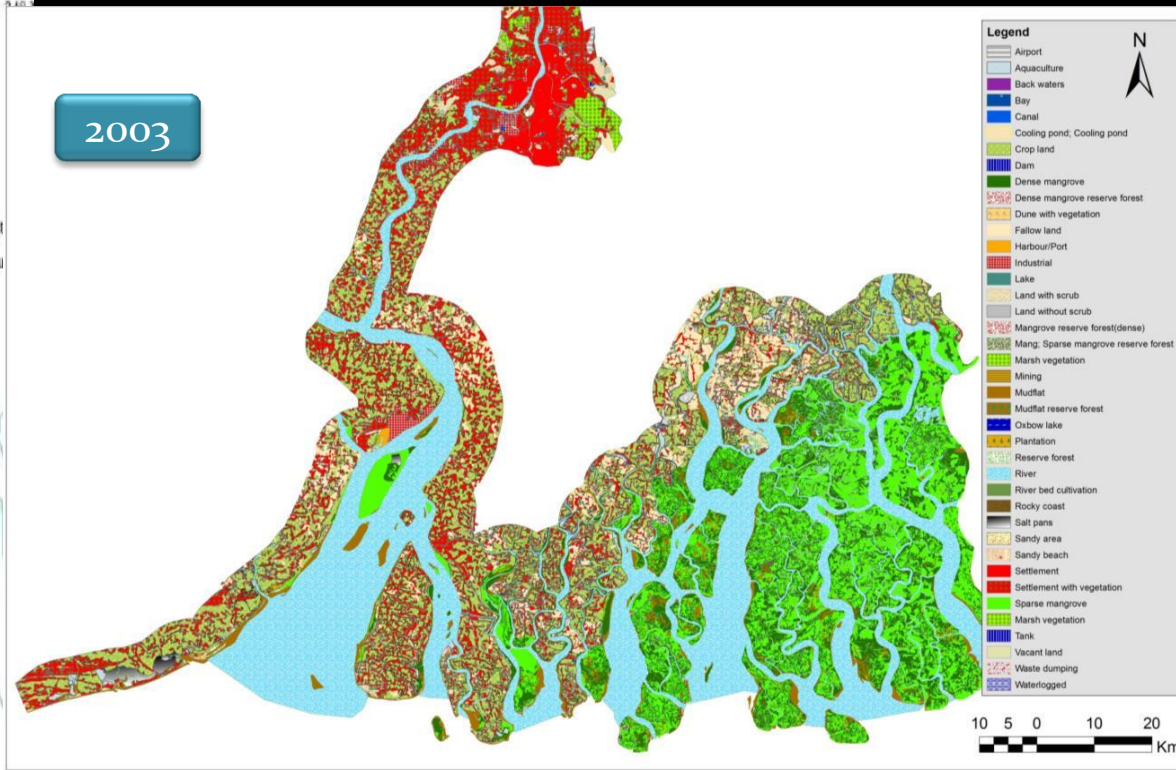
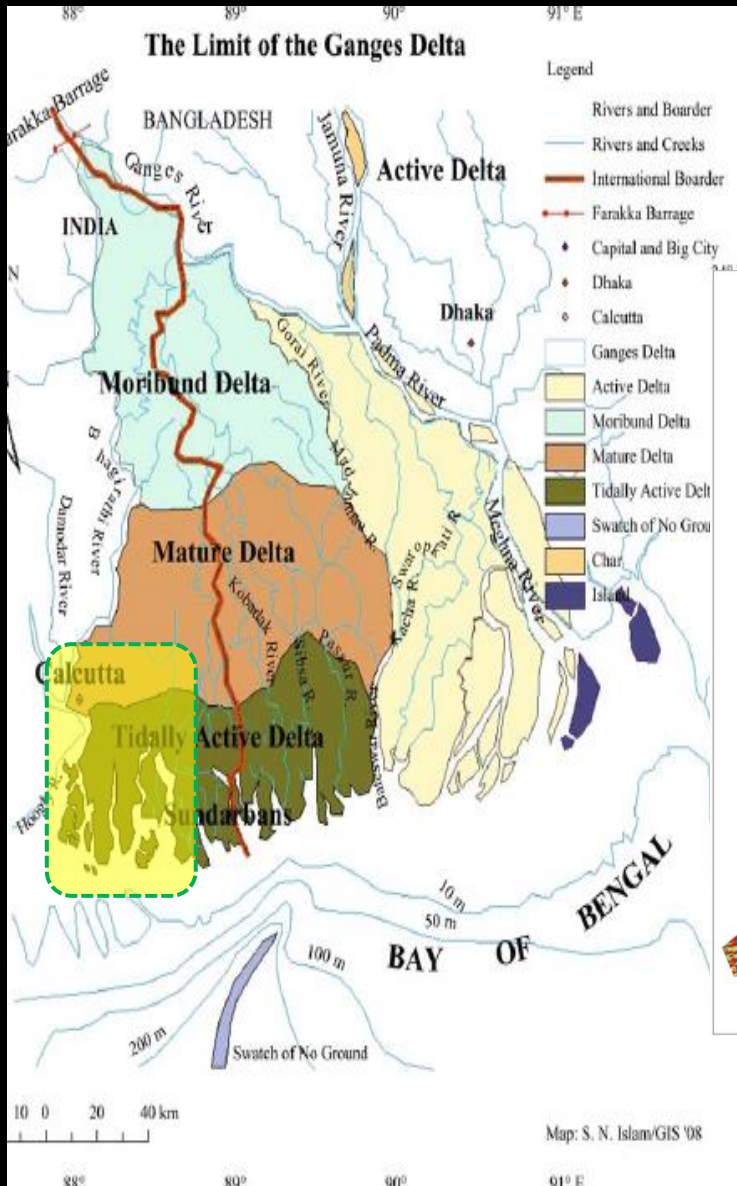
3- Trends:

Land Use / Population Expansion



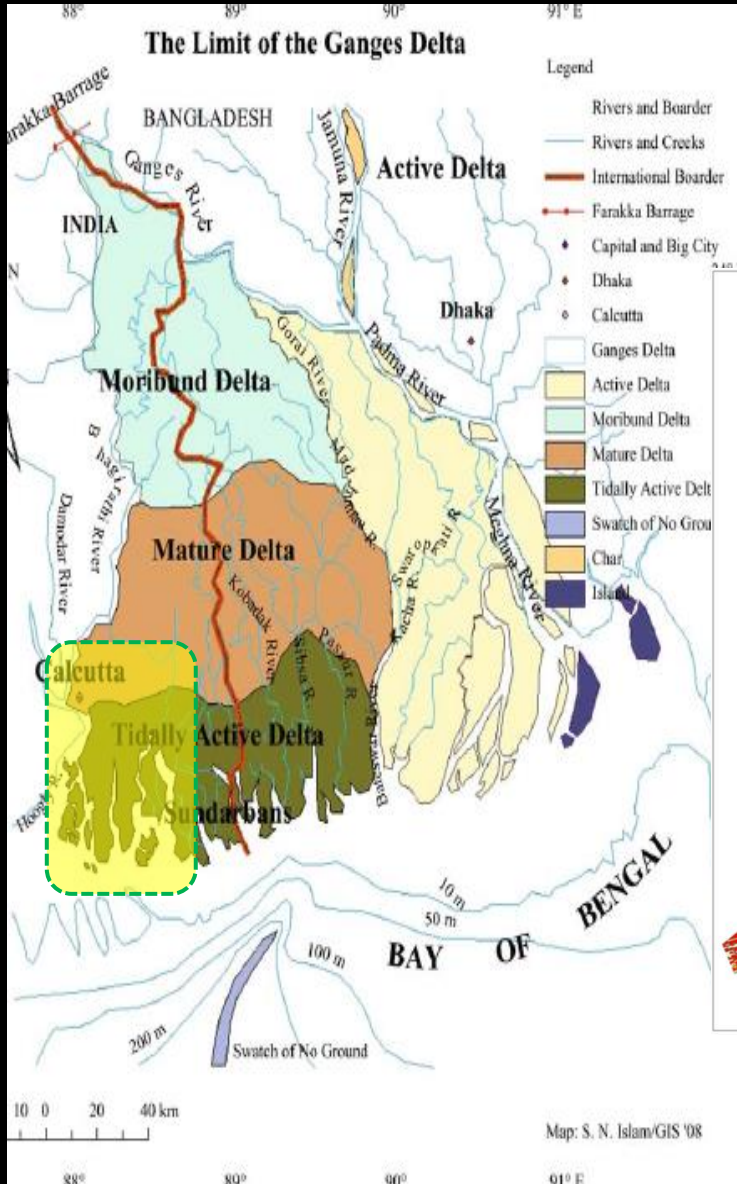
3- Trends:

Land Use / Population Expansion

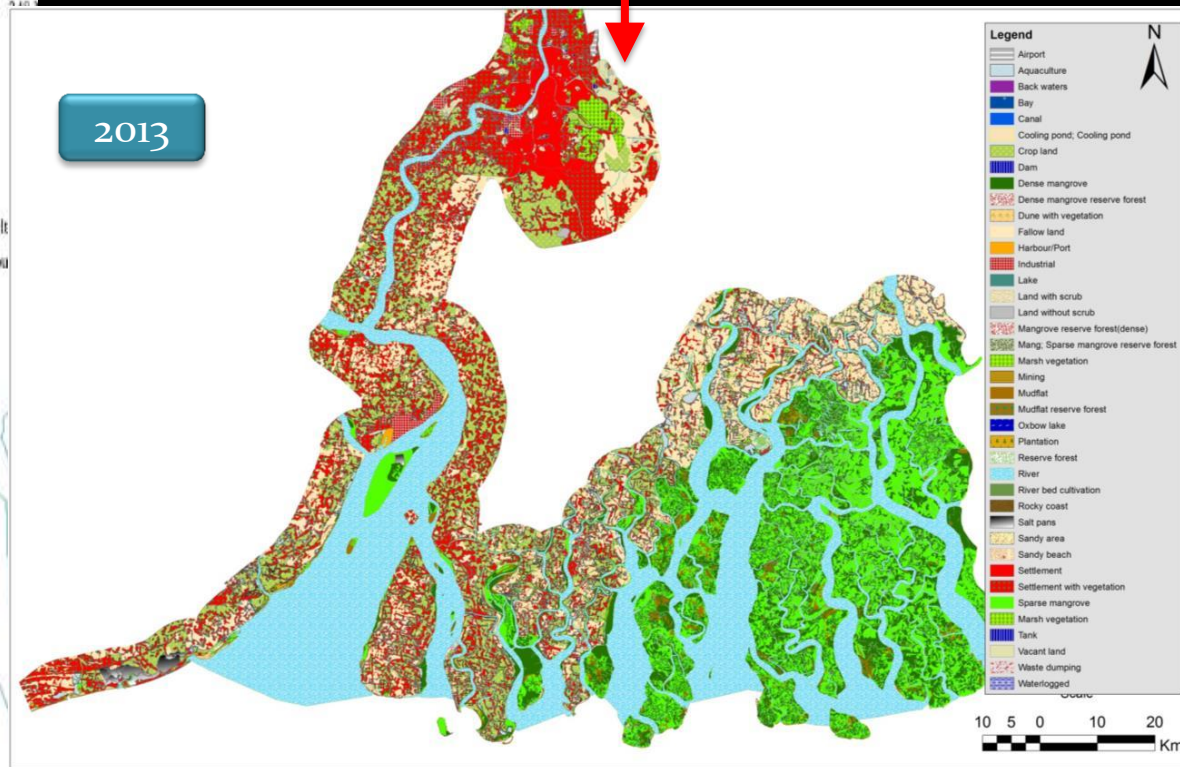


3- Trends:

Land Use / Population Expansion



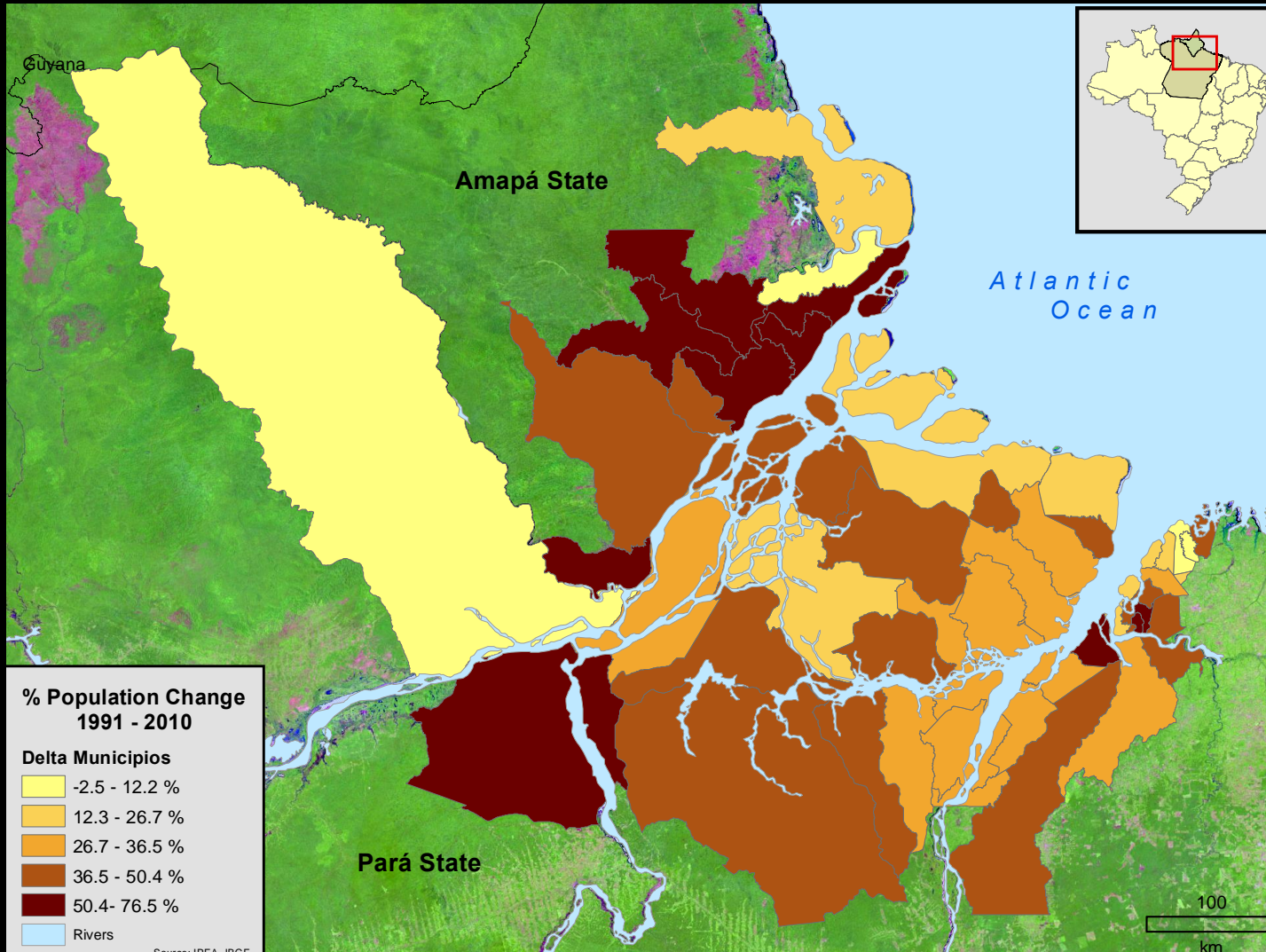
Kolkata's urban agglomerate accounted for an increase of over a million people in the last decade alone



3- Trends:

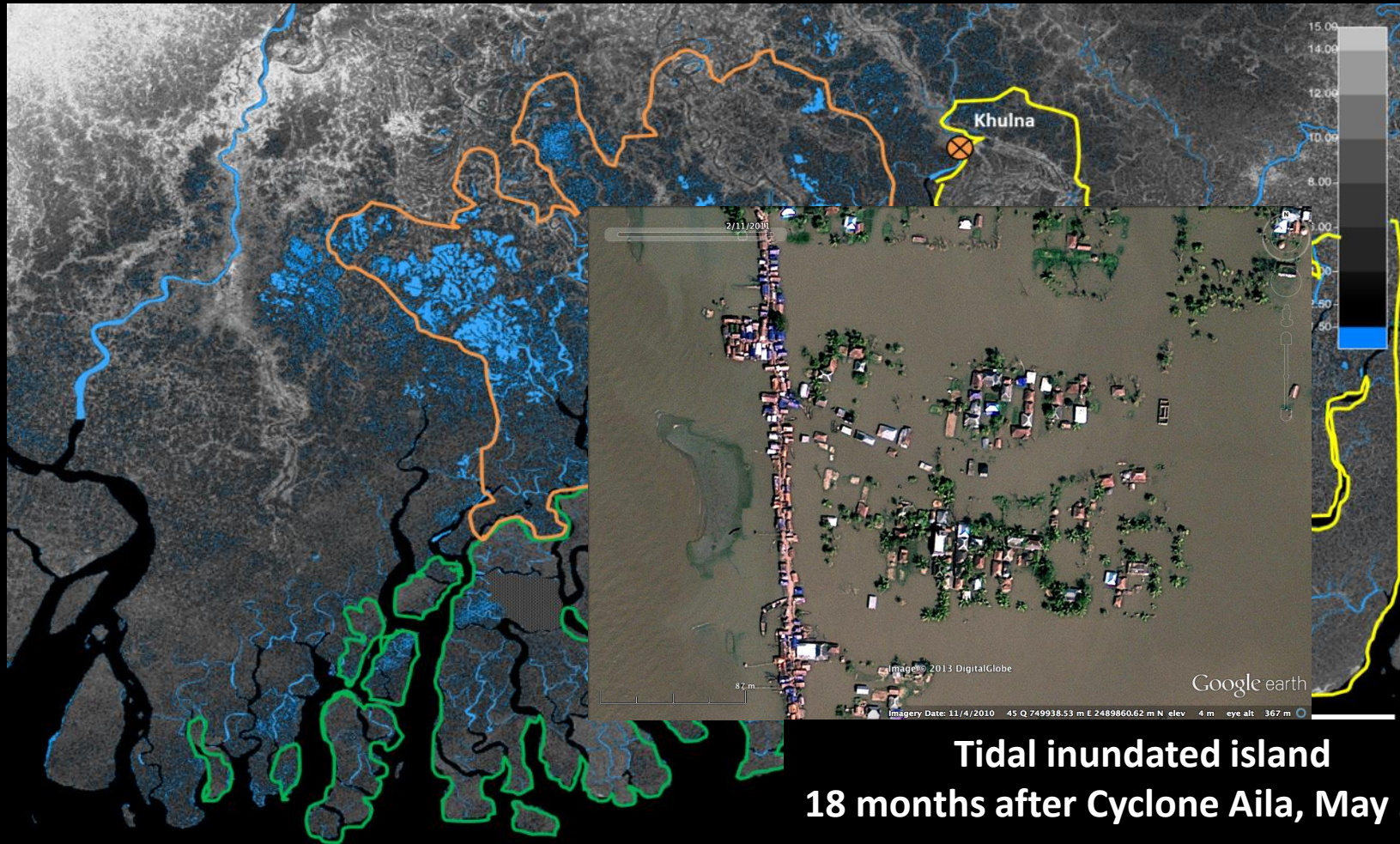
Land Use / Population Expansion

POPULATION CHANGE – MUNICIPALITIES (1991-2010)

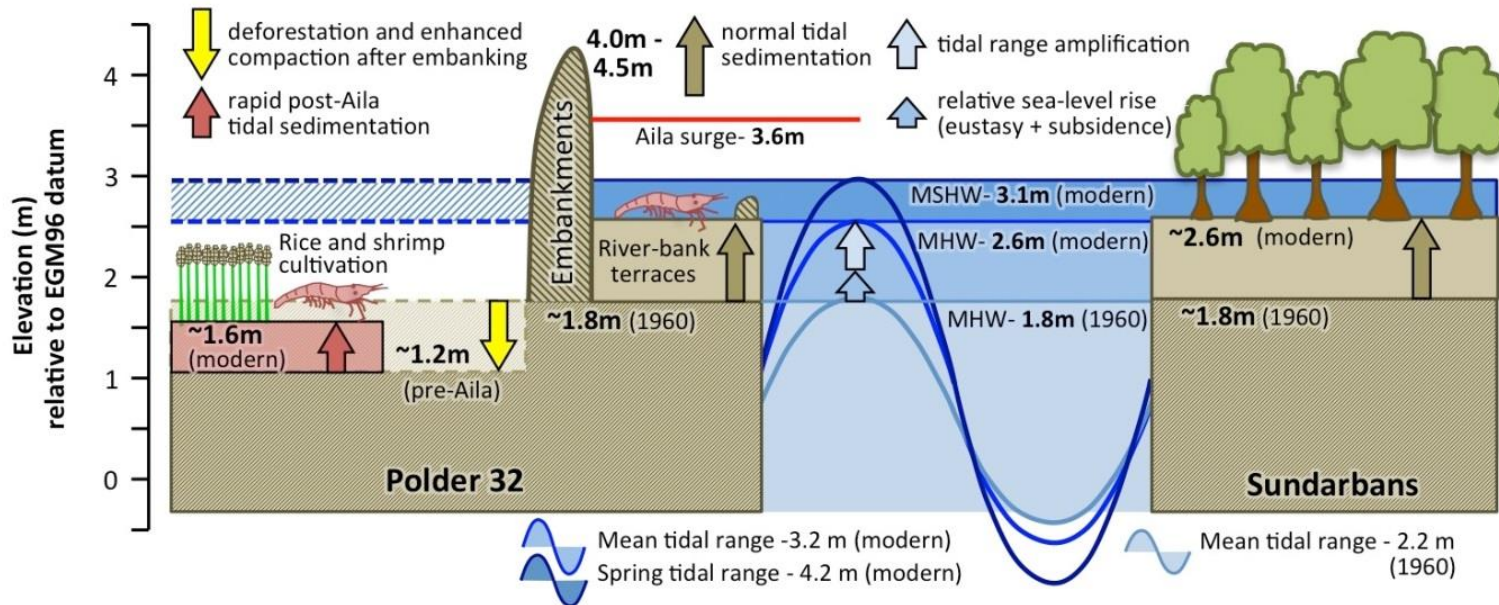
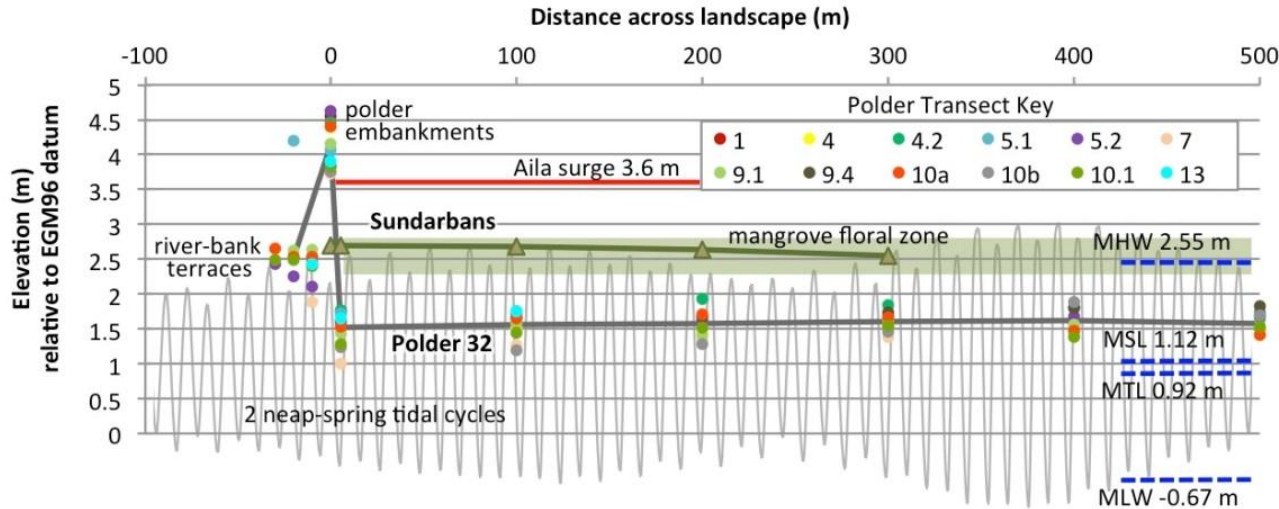


4- Climate-human-landscape Coupling

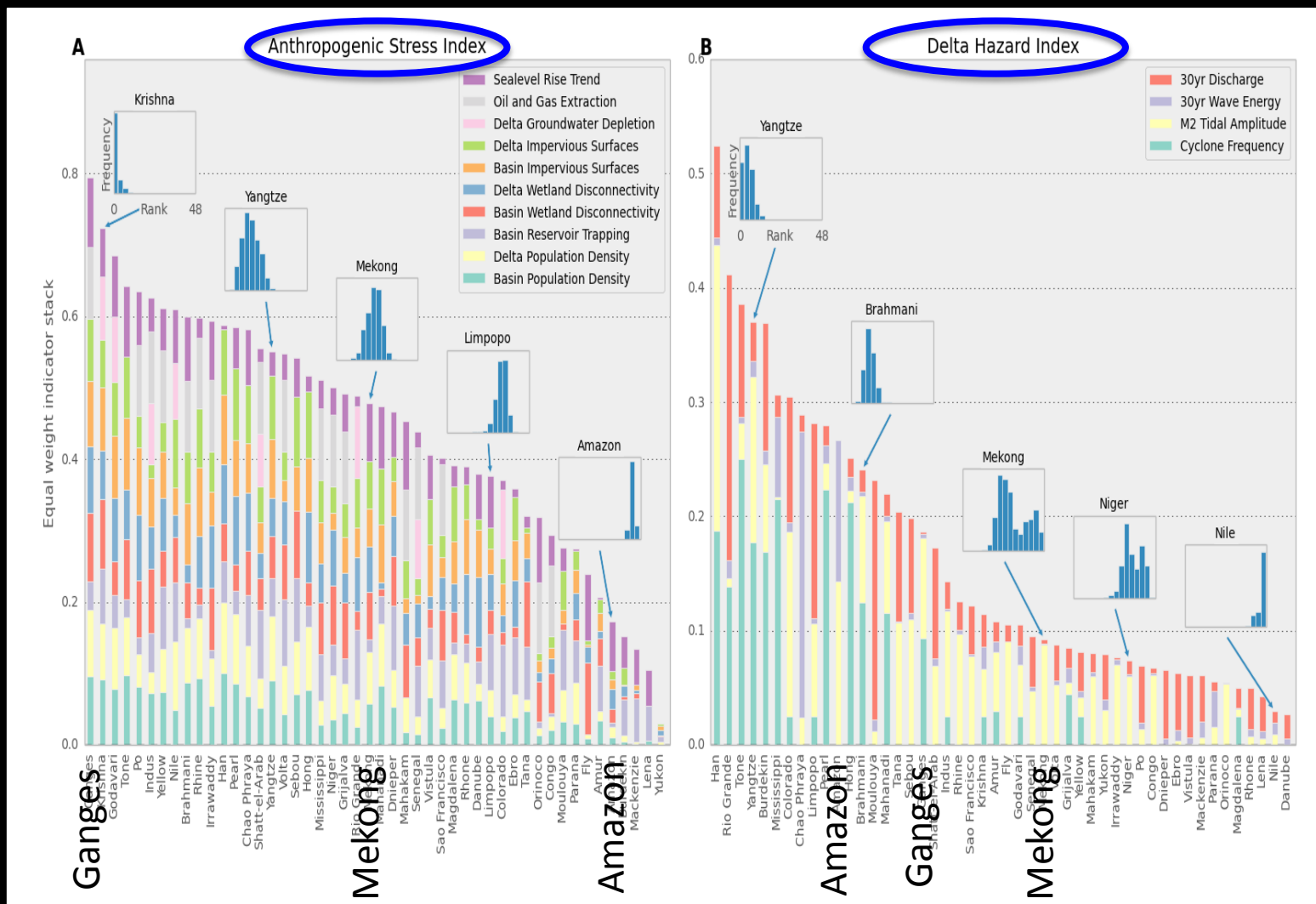
- *Climate-human-landscape interactions increase flood potential*



4- Climate-human-landscape Coupling

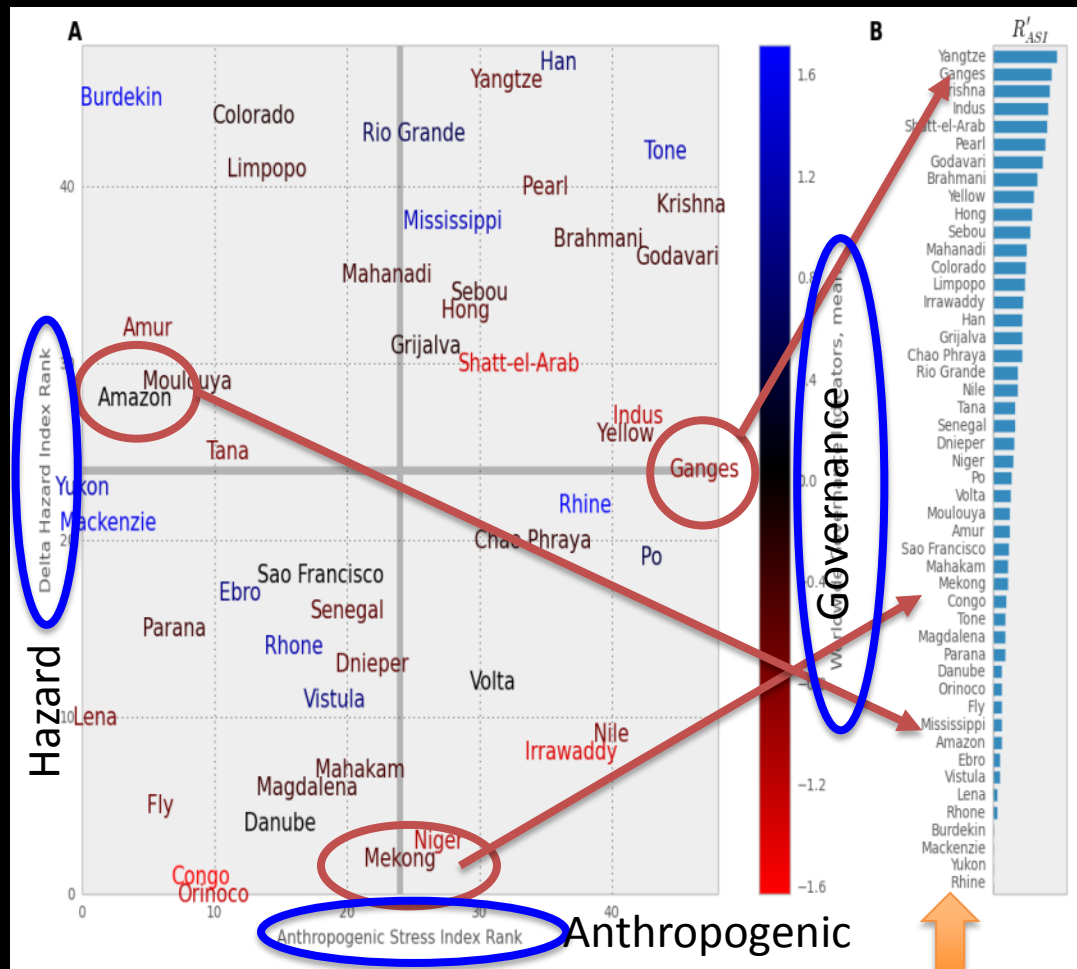


Anthropogenic Stress and Coastal hazard intensity indices



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 Partnerships

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)

Join us tomorrow !

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)



**DELTA S IN TIMES OF
CLIMATE CHANGE II**

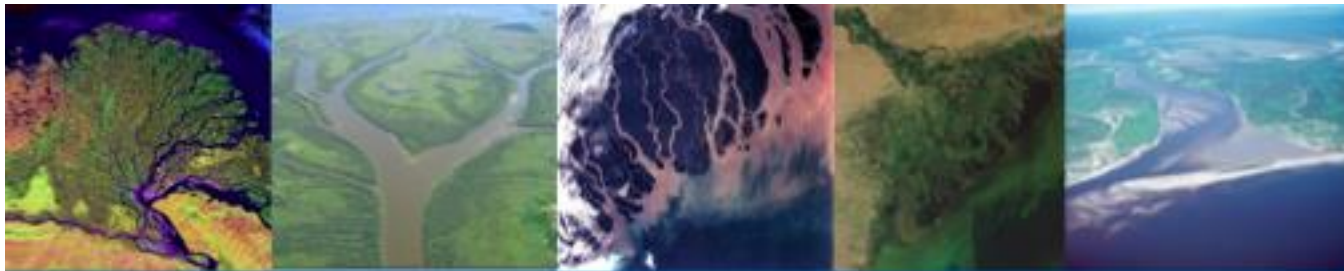
OPPORTUNITIES FOR PEOPLE, SCIENCE, CITIES AND BUSINESS

INTERNATIONAL CONFERENCE

ROTTERDAM, THE NETHERLANDS 24 – 26 SEPTEMBER 2014

The BIG Question

How to bring together disparate efforts on deltas, facilitate **preservation of data**, **share** models and research, **build trust** with stakeholders and **truly affect management** and policies for **delta sustainability**?



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?

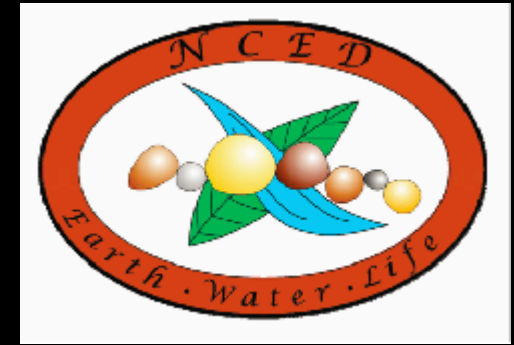
3. How do perturbations in the incoming

IYD Sponsors



International Union of Geodesy and Geophysics

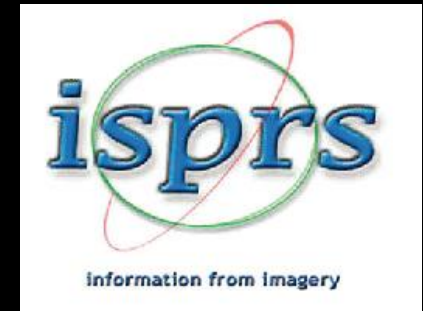
International Association of Hydrological Sciences



Land-Ocean Interactions in the Coastal Zone



International Geographical Union



“Sustainable Deltas 2015 Initiative”



1. SD2015 is a **statement of urgency** for global awareness and cooperation, a call-to-arms to the global community of citizens, scientists, policy makers, funders
1. SD2015 is a **mechanism to bring countries together** at all levels of science, policy, decision makers, and public
2. SD2015 is an **opportunity to integrate and leverage** disparate efforts for accelerating progress towards delta sustainability
3. SD2015 is the **beginning** (not the end) **of a bigger effort** and the springboard for a coordinated path forwards

“Sustainable Deltas 2015 Initiative”



Need your leadership and ideas to make
SD2015 a success

1. Make your organization part of the SD2015 initiative effort – use the logo in your web site
2. Carry the message around and ask others to join
3. Share your data and models – **NEED A CENTRAL REPOSITORY**
4. Sponsor at least one lecture in your institution under the SD2015 umbrella
5. Summer institutes and training courses – connect them to SD2015
6. Science museum exhibits and public meetings -- increase awareness of deltas at risk
7. Think BIG – influence funding resources for SD2015+
8.