CHALLENGES IN DELTAS UNDER PRESSURE

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&
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CSDMS

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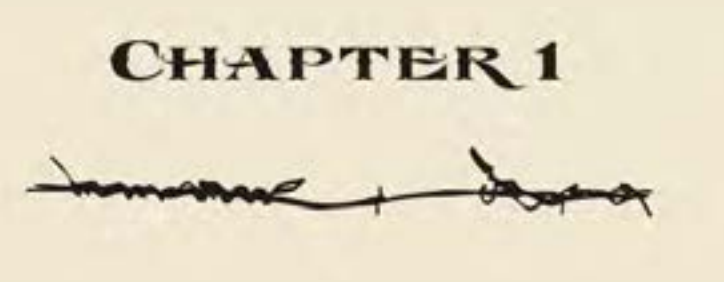

On Deltas and Humans

My Love of Deltas

Delta Blues

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I was grew up on the Kam delta
It became my first (1975) thesis.
My ‘78 doctoral thesis was on another delta.
Over my career I visited and researched another 50 deltas.
I know and love deltas. They are like snowflakes, similar yet different.
Thunder Bay
Fort William First Nation
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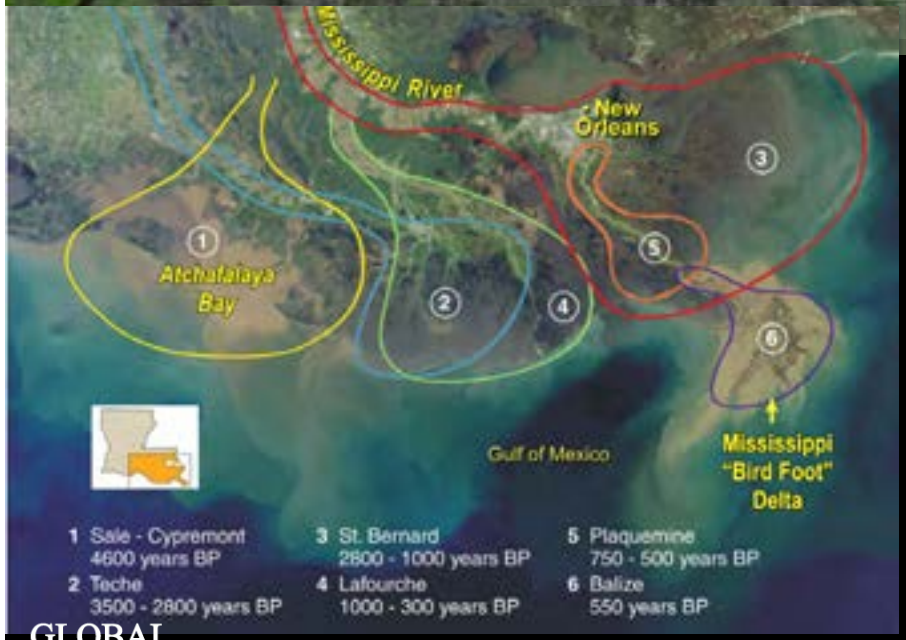

Pristine deltas are dynamic wetlands, with lobe & channel switching, and shorelines shifting under the influence of rivers, tides and waves.

They offer lush vegetation, diverse forests, wildlife, fisheries, & rich organic muddy soils. Movement through these ultra-flat environments was mostly aquatic.

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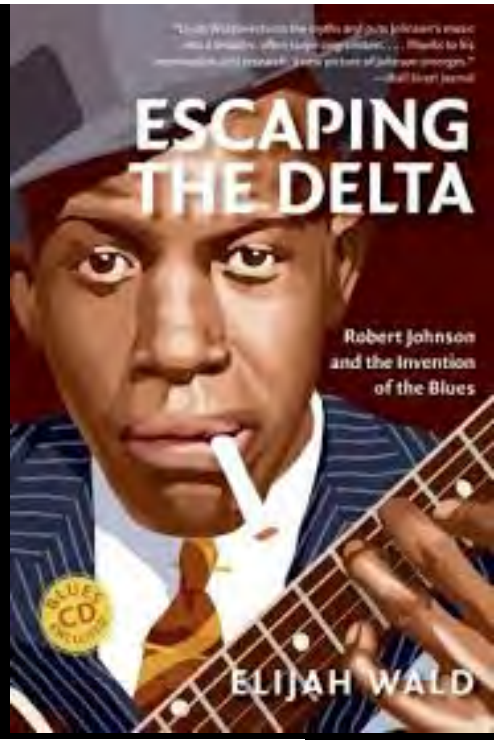
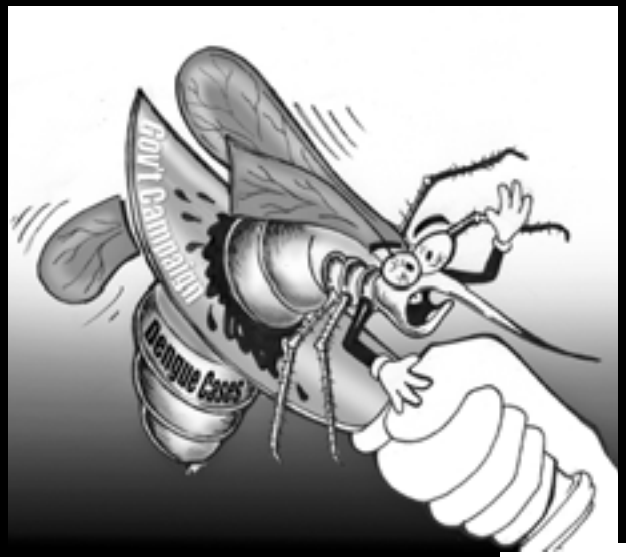


Delta wetlands were also host to many (sub) tropical infections, from disease-carrying insects to parasites and wildlife that kept human populations low.



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Most deltas formed ~7000 y ago when sea level was stable. But human-causes also contributed to the generation of modern deltas (e.g. Po, Ebro, Rhone, Yellow). For example deforestation in Madagascar let to many new deltas (MOVIE).

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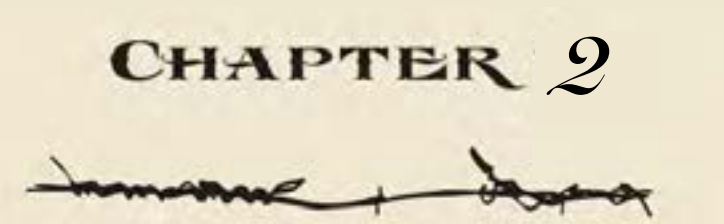

20th Century Transformation

Population & Migration

Engineered Water

Damn Dams - Missing Water & Sediment

Changes in Land Use

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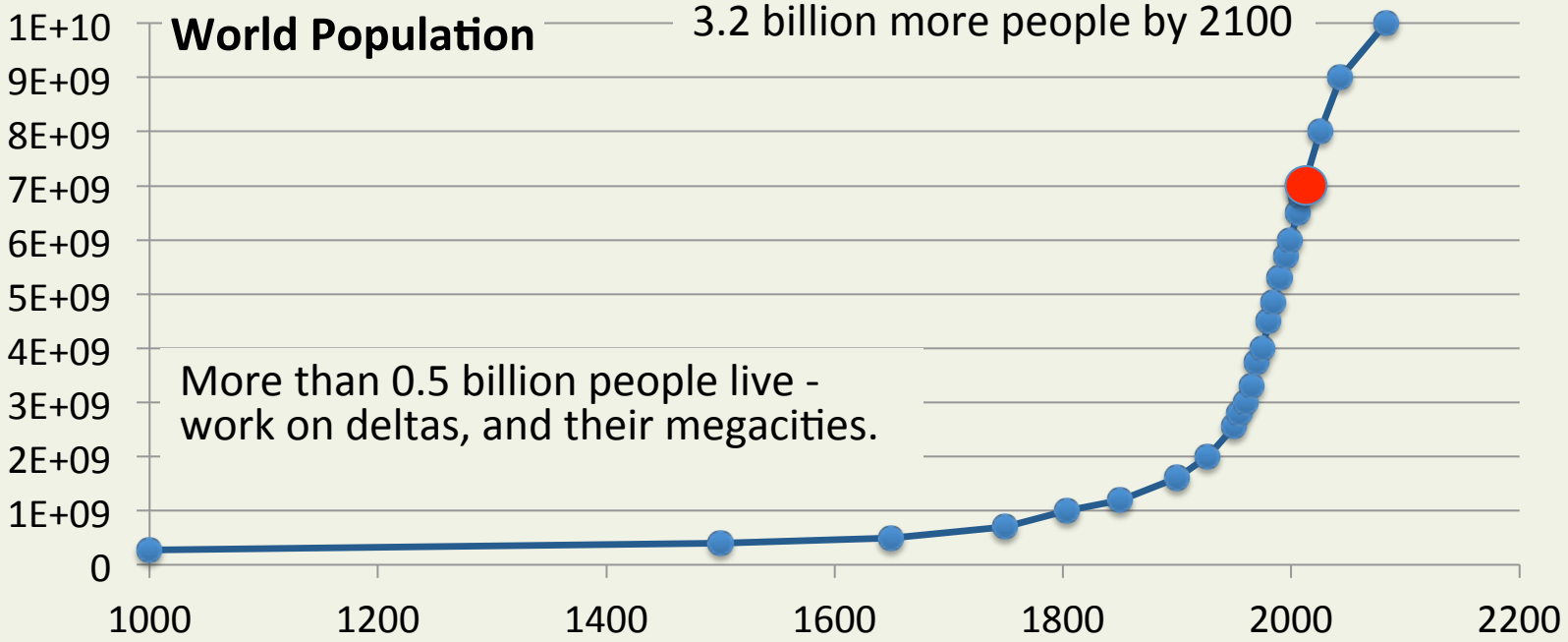

City	Delta	1975	2000	2010
Karachi	Indus	4.0	10.0	12.0
Kolkata	Ganga	7.9	13.1	15.1
Dhaka	Brahmaputra	2.2	9.5	13.0
Rangoon	Irrawaddy	1.8	4.4	6.3
Bangkok	Chao Phraya	3.8	7.4	11.9
Ho Chi Minh	Mekong	2.8	6.6	10.0
Hanoi	Red	1.9	7.8	14.5
Guanzhou	Pearl	3.1	8.9	12.8
Shanghai	Changjiang	11.4	12.9	20.0
Tianjin	Old Huanghe	6.2	9.2	10.3
Cairo	Nile	6.0	10.5	14.5
Buenos Aires	Parana	10.9	11.8	12.8

Migration

12 delta cities have gone from

62 M people in 1975 to

153 M people in 2010

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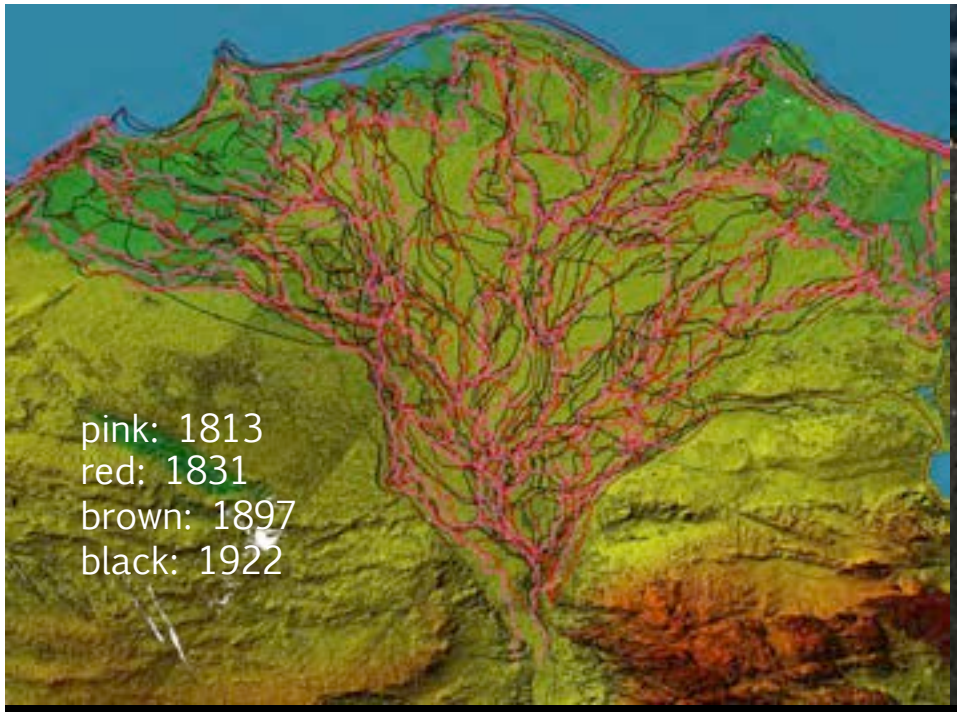

When you add 50 million people to a delta (Nile), you do not want channel avulsions and shifting, particularly when valuable infrastructure is at risk (e.g. Vancouver Intl Airport). So you reduce the number of channels, and engineer the flow of water.

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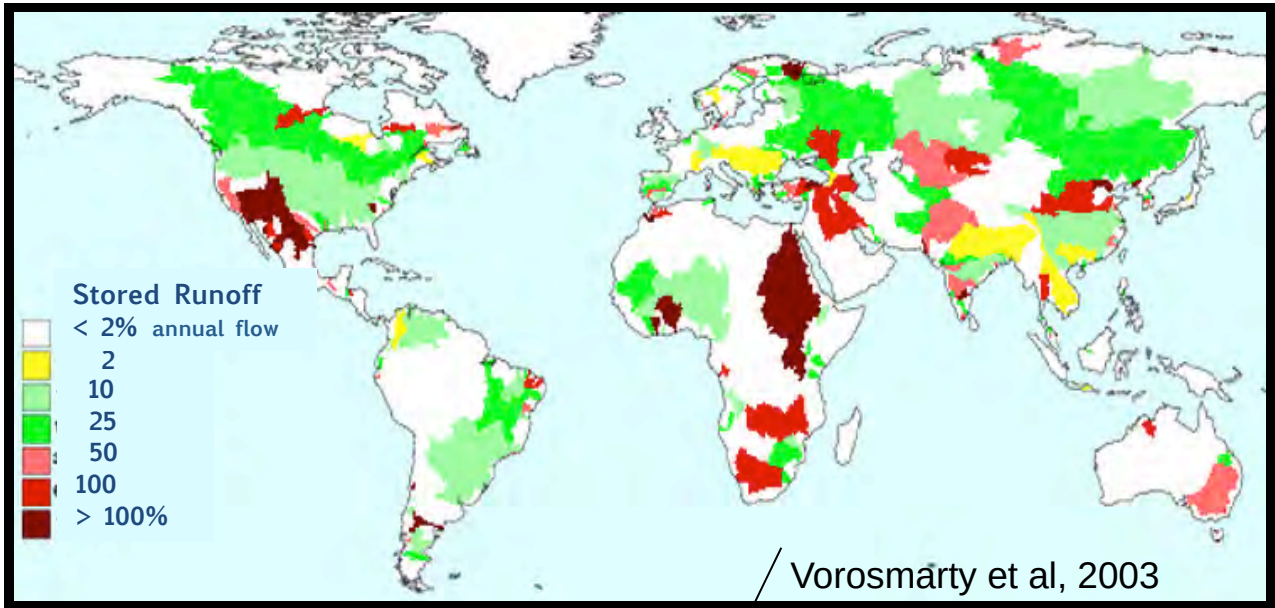
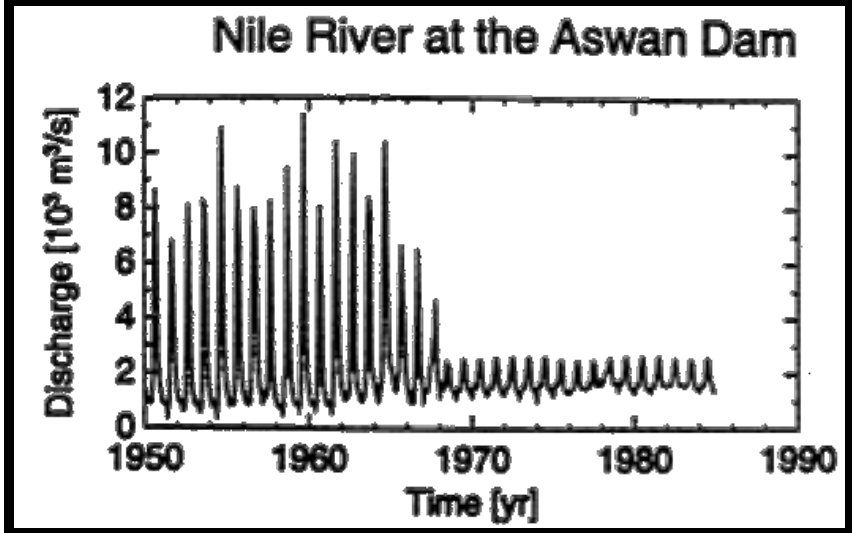


Vorosmarty et al, 2003



Water engineering distorts a river's flow and timing, with delays, diversions, storage — providing for unusual hydrographs & sediment sequestration

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The global location of very large dams.
Note 1952 and China's Great Leap forward.

Movie credit: CSDMS

On average we build one large dam every day
And for the last 130y !

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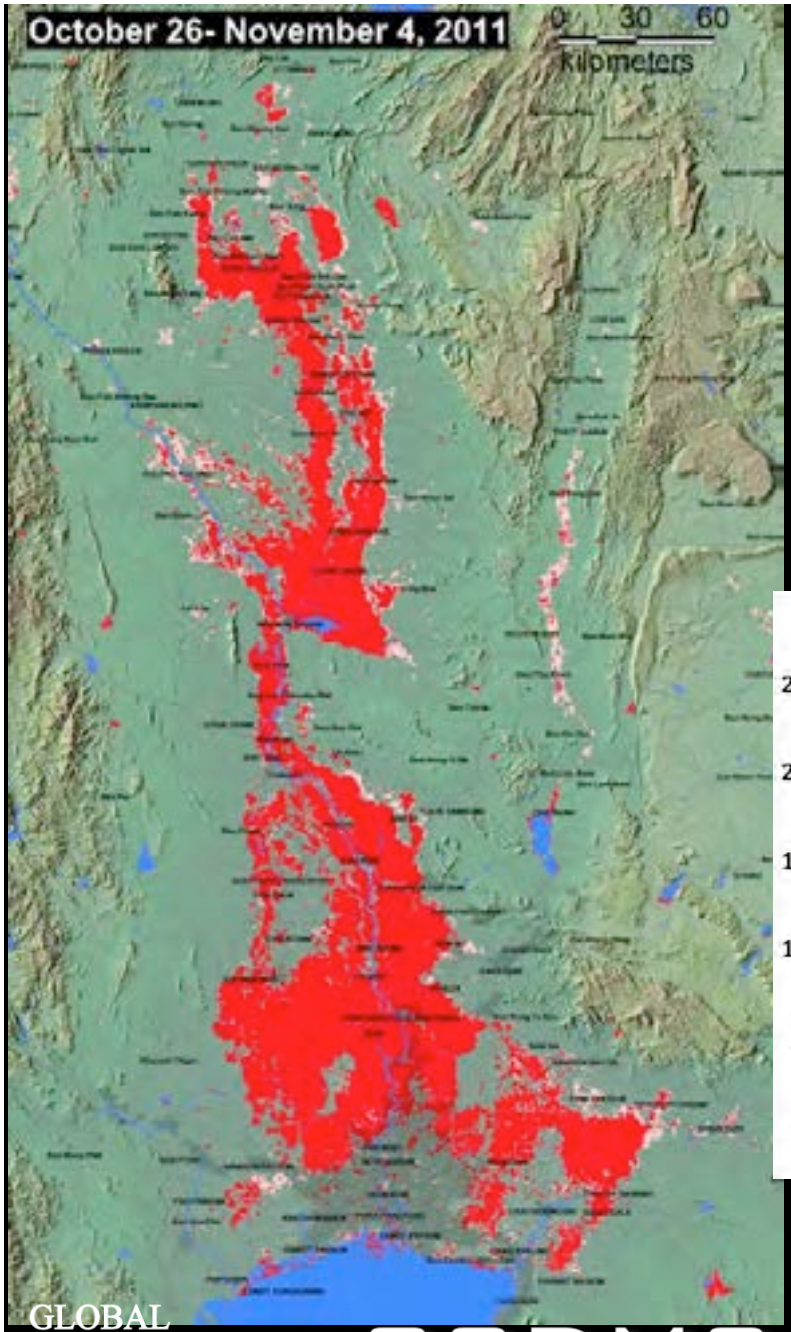
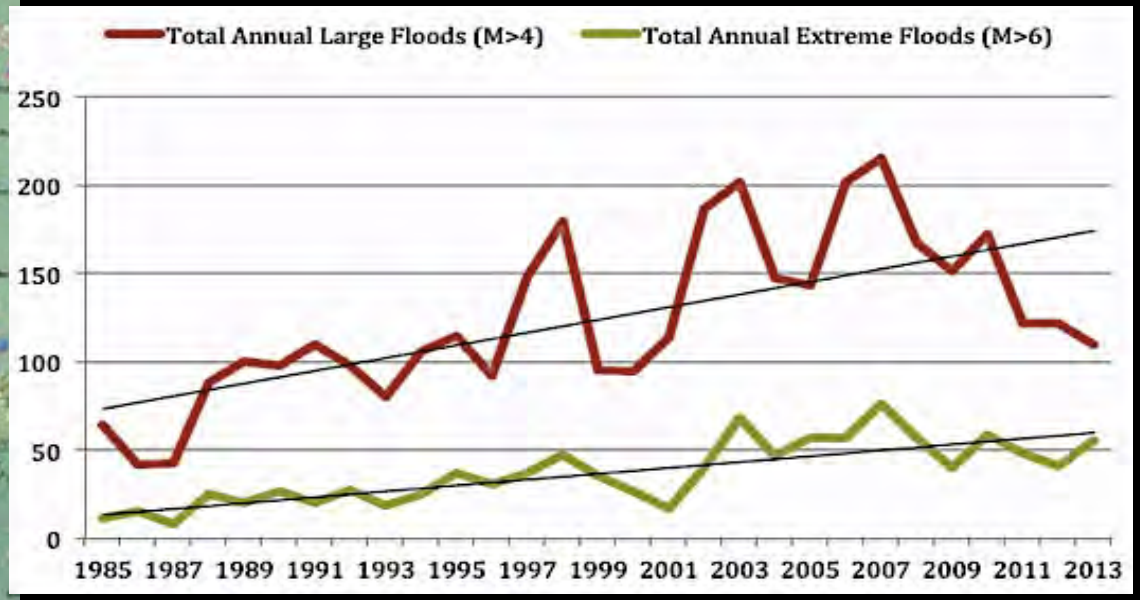


Modification of the world's hydrological system continues to accelerate, and thus so do floods due to engineering failure



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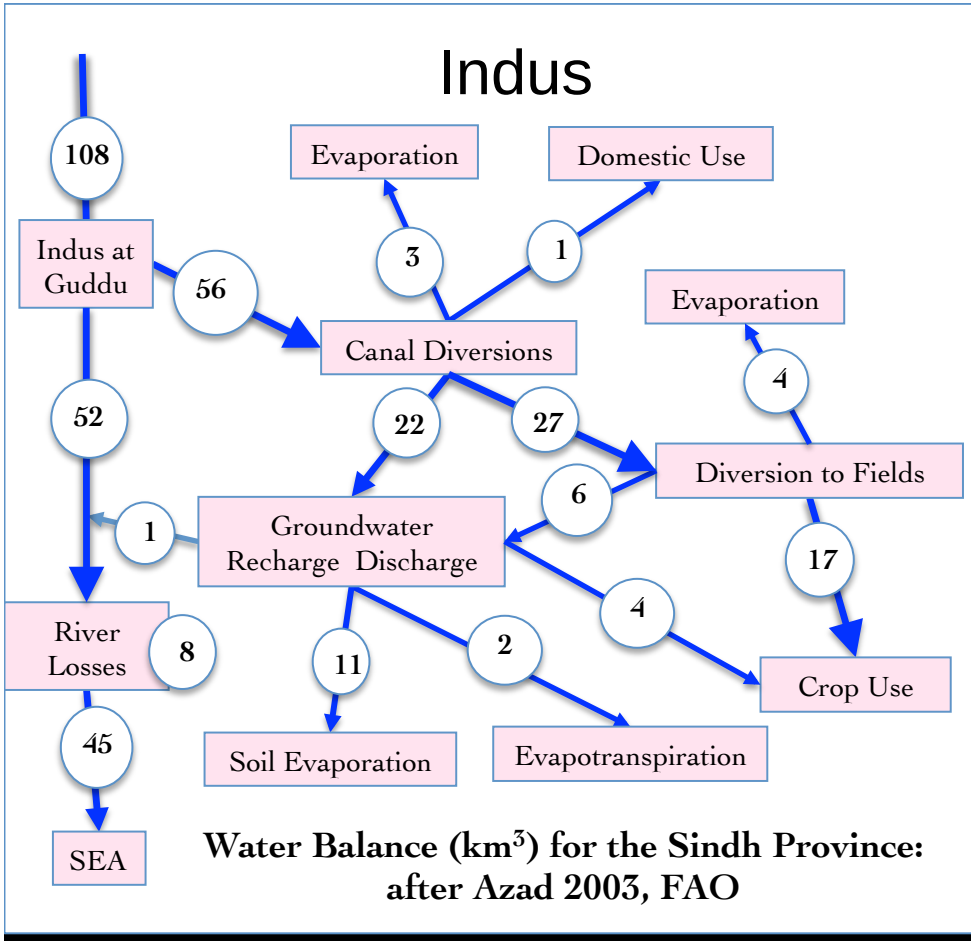
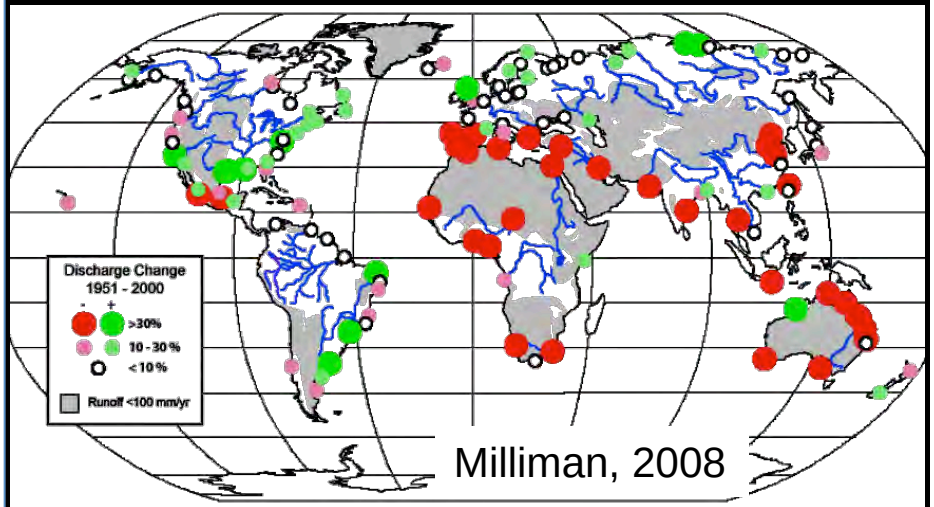


Water Balance (km^3) for the Sindh Province: after Azad 2003, FAO

Engineering has reduced the amount of freshwater entering our delta systems



Milliman, 2008

Leading to: reduced biodiversity; saltwater intrusion, salinization of soils; and increased coastal salinity & temperature.

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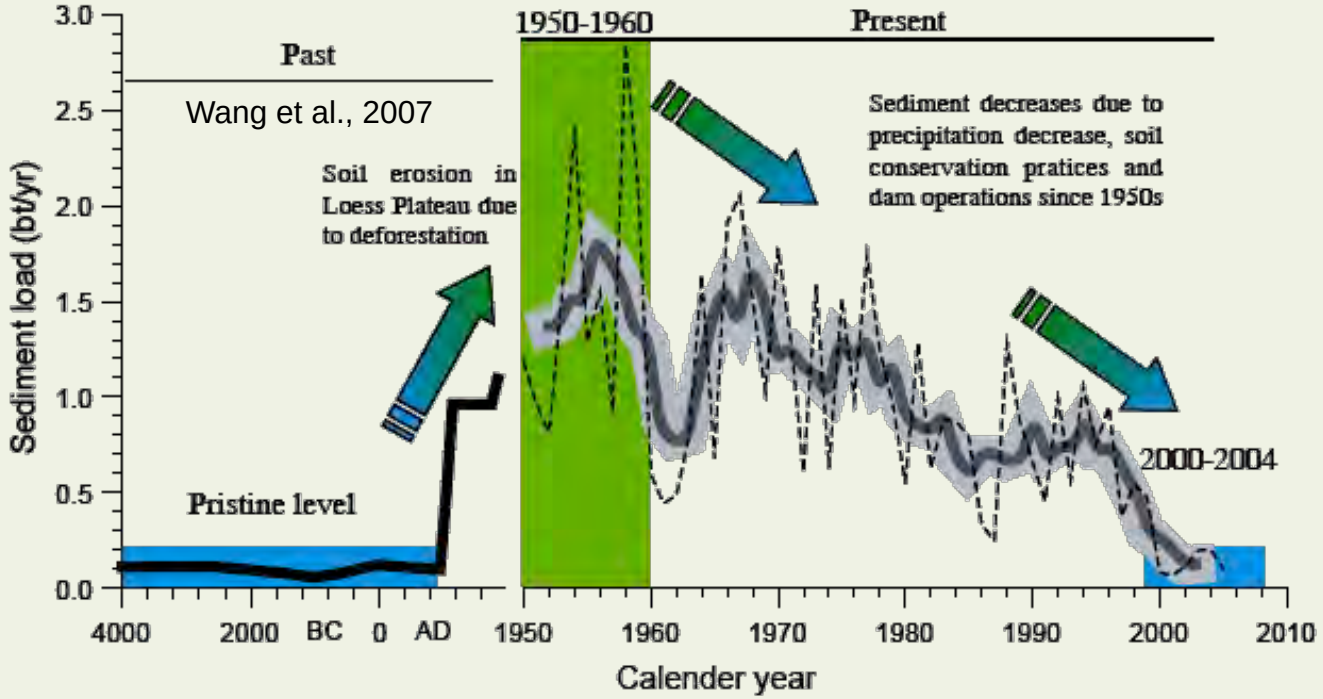
Engineering has also reduced the amount of sediment entering our delta systems



Huanghe is an example of its sediment load returning to pristine levels through engineering

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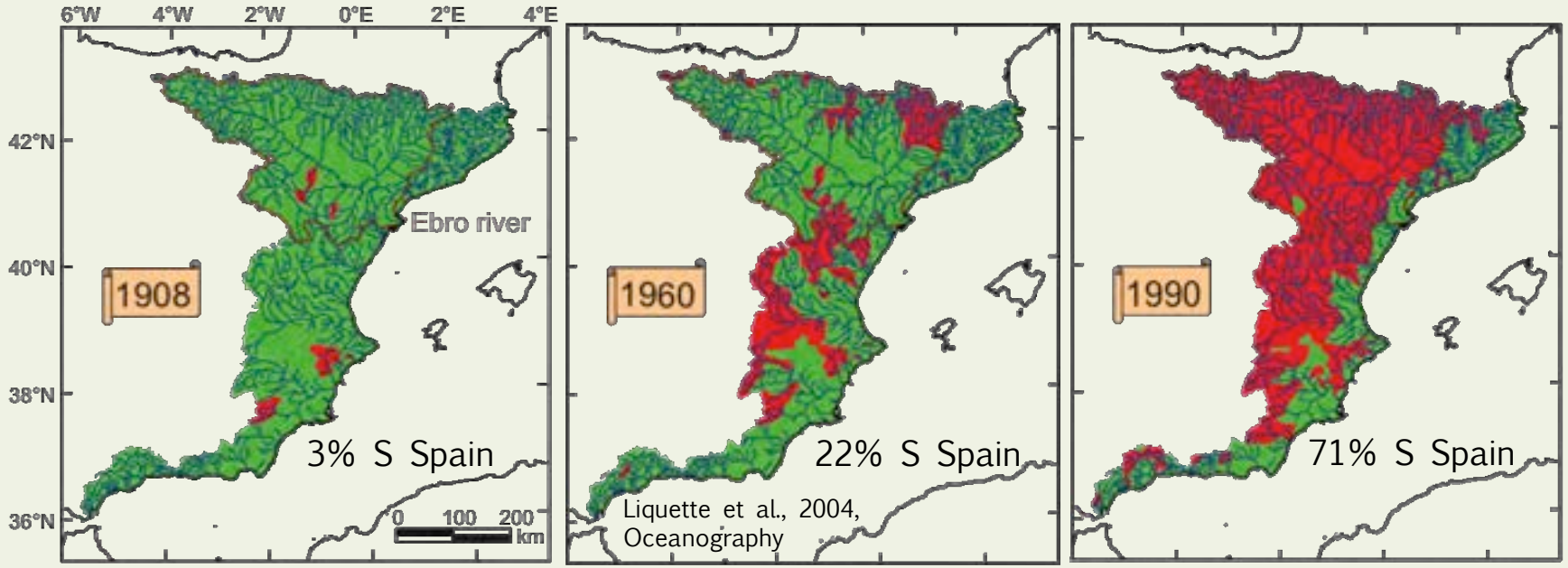
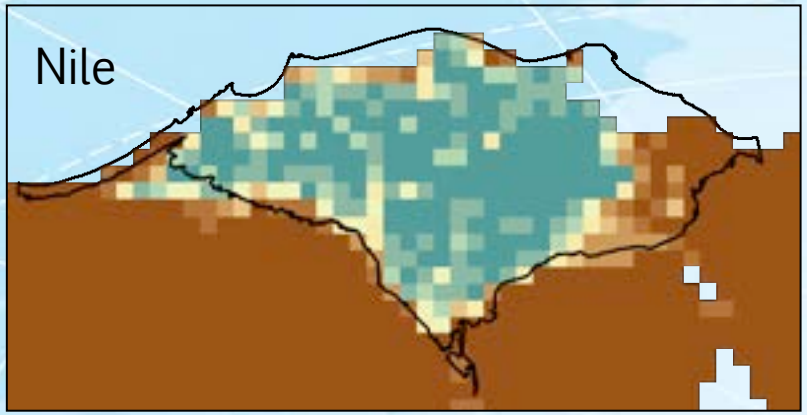


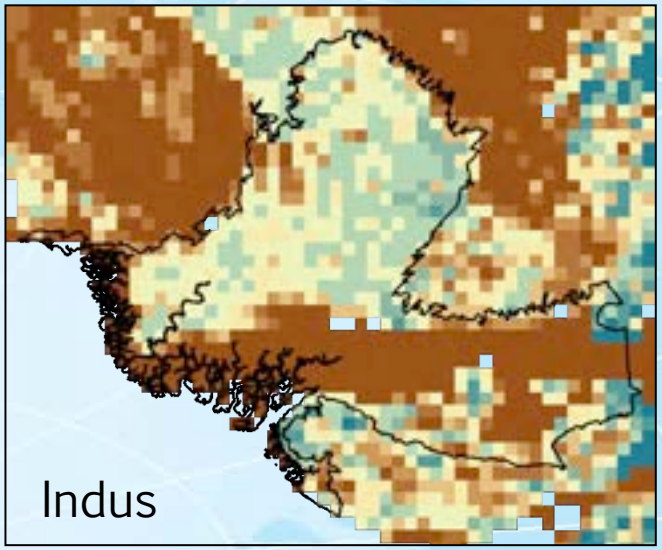
Ebro R.	Water m^3/s	Sediment MT/y
1913-62:	1732	18
1965-85:	429	2
1988-90:	300	0.2

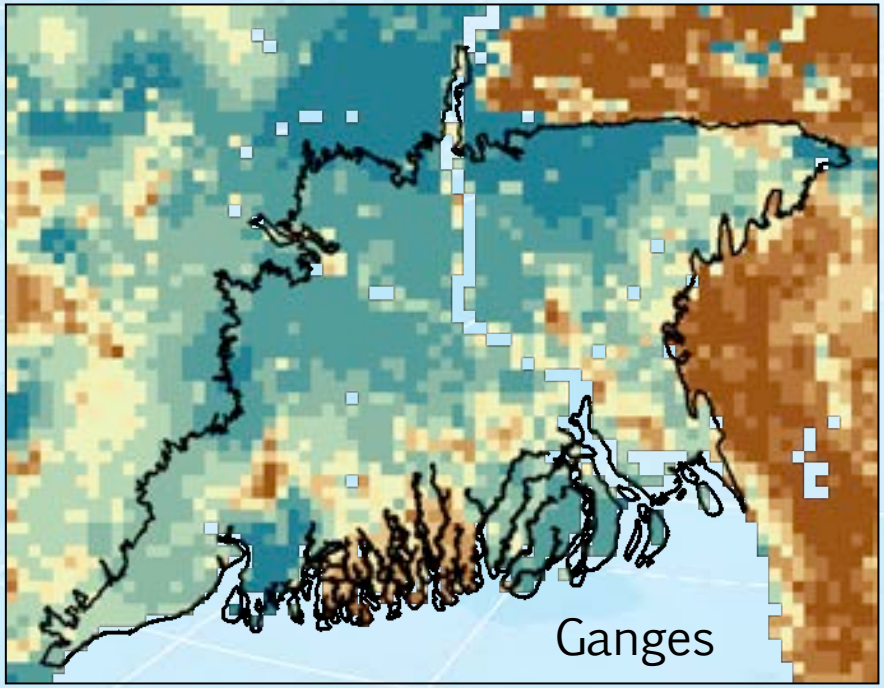
Since 1983, 110 MT of sand have been delivered by trucks to the Spanish shores to ease the rate of coastal retreat.

Once the World's Rice Bowls

Ramankutty et al.

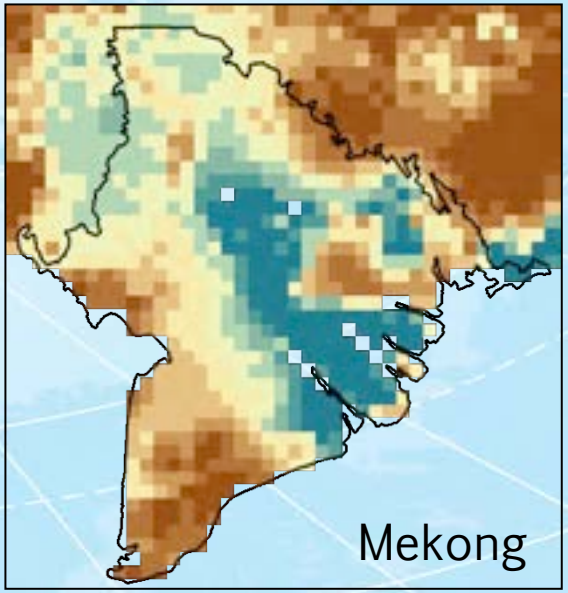






Proportion Land in Crops

- 0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1



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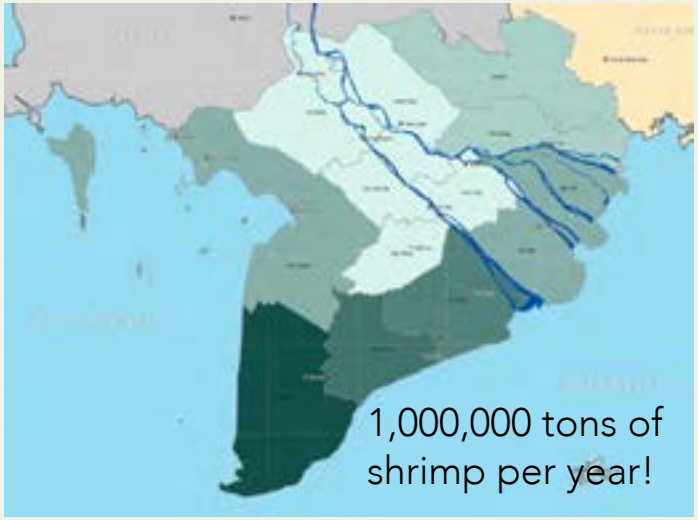
Deltas have transformed to become our Protein Bowls

Pearl River delta, China
Courtesy of Mark Bender

Mekong delta, Vietnam
Wisdom Project/DLR (2009)



Destruction of mangrove forests for shrimp farms hastens shoreline retreat

CHAPTER 3

To Sink or Not to Sink

The Balance

Shrimp & Fish Farms

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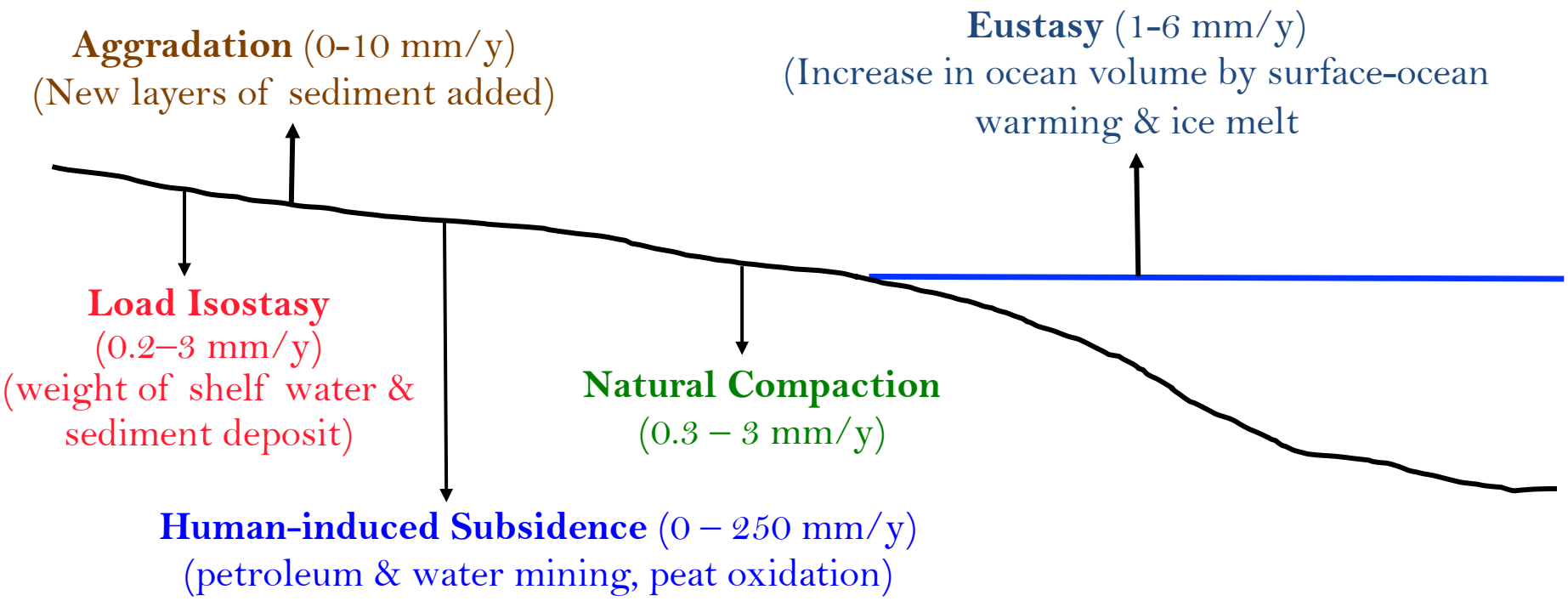
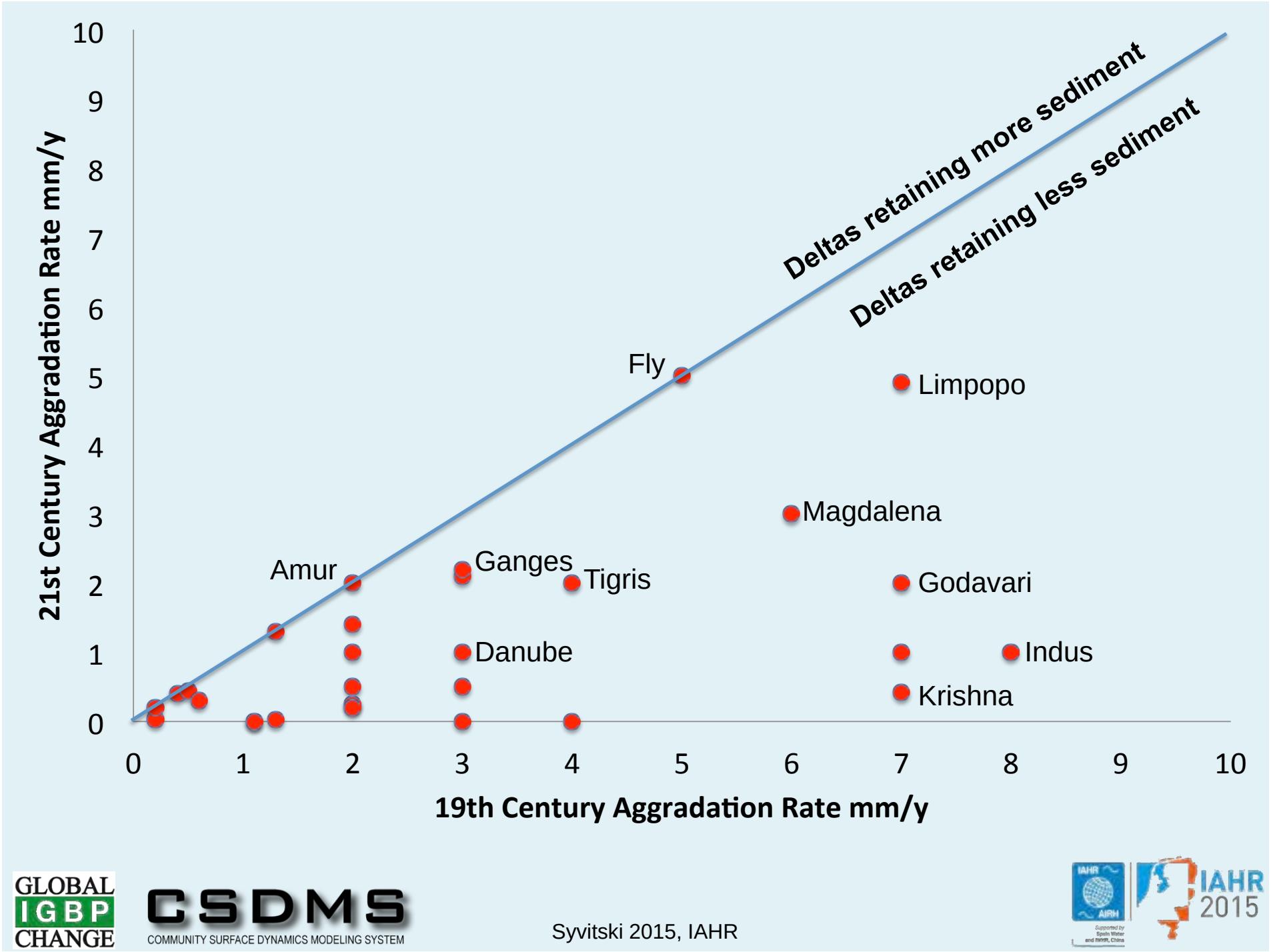
Delta Surface Elevation Processes & Rates

(Syvitski et al, 2009 Nature Geoscience)



Delta Surface Elevation $\Delta_{RSL} = A - \Delta E - C_n - C_A \pm M$

Each term is spatially and temporally variable, between deltas and within a delta.



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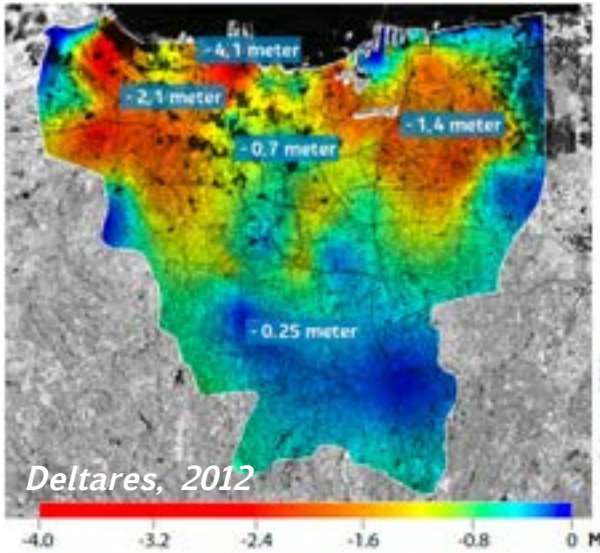

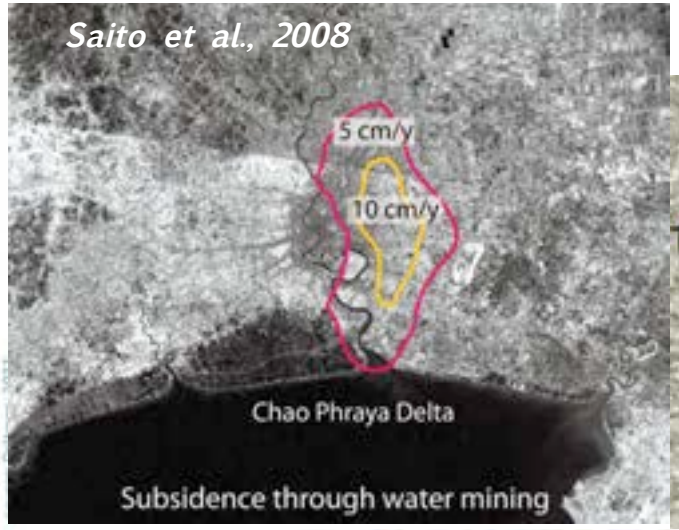

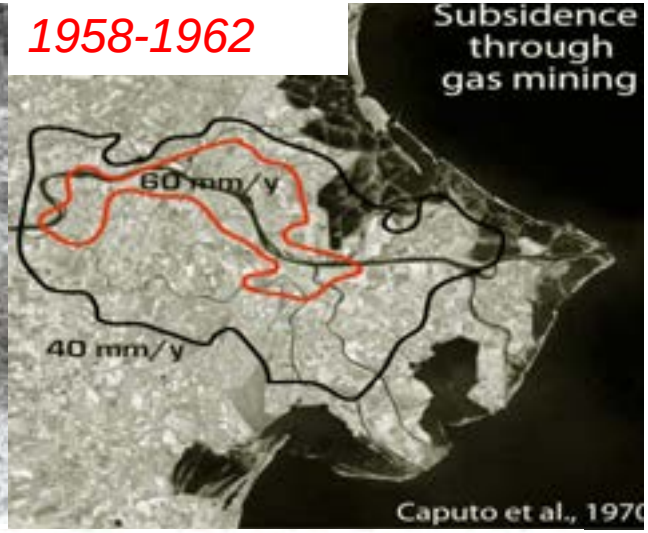

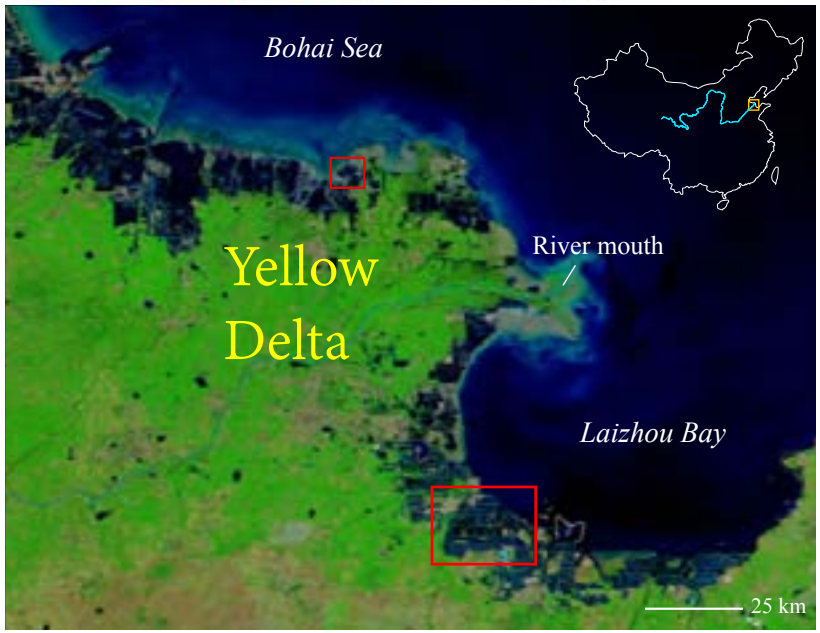

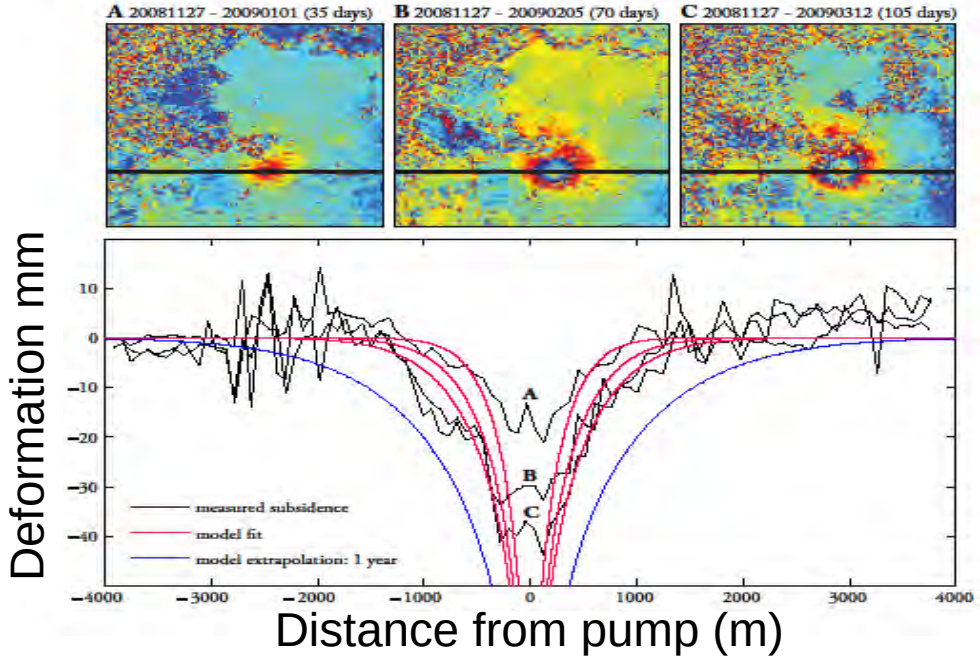

Subsidence at fish farms is up to 250 mm/y due to groundwater extraction

Higgins et al., 2013, GRL & Higgins, S. (2014)

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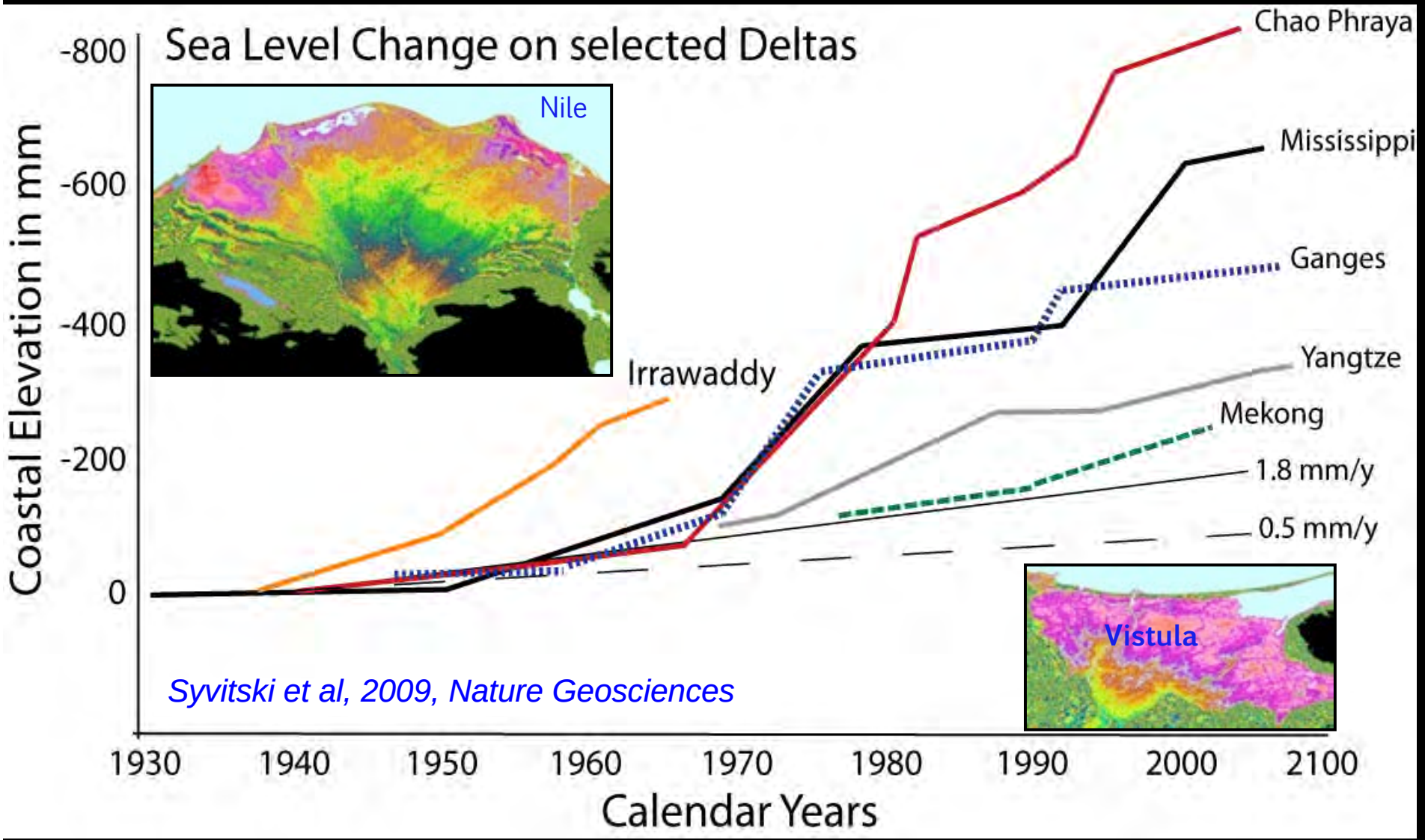
Humans are sinking deltas 4x faster than sea level is rising



CHAPTER 4

Consequences & Adaptation

Public Alarm

Inundation & Shoreline Erosion

Coastal Barriers & Failures

Adaptation

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Sinking Deltas in the Press

U.S. News & WORLD REPORT

Saturday, September 26, 2009

Sinking River Deltas Threaten Millions

A new report suggests that humans may be causing river deltas to sink.

Nile Delta: 'We are going underwater. The sea will conquer our lands'

The Nile Delta is under threat from rising sea levels. Without the food it produces, Egypt faces catastrophe

A farmer ploughs his rice paddy in the Delta. Photograph: Jason Larkin

Science

AAAS Magazine News Signaling Ca

All Free Articles Top 10 Last Month

Home > News > Daily News Archive > 2009 > September > 22 S

In Race With the Sea, River Deltas Falling Behind

UPI.com

100 YEARS OF JOURNALISTIC EXCELLENCE

River deltas sinking due to human activity

Published: Sept. 21, 2009 at 2:06 PM

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Sinking Deltas in the Press

BBC

News Front Page

Africa

Page last updated at 12:25 GMT, Monday, 21 September 2009 13:25 UK

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'Millions at risk' as deltas sink

DECCAN HERALD

Govt to vet seven key areas of DTC

You are here: Home » Special Features » River deltas and that sinking feeling threaten e

Kalyan Ray in New Delhi

River deltas and that sinking feeling threaten environment

The Krishna River Delta in Karnataka is listed in the 'Greater Peril' category of high-risk rivers that threaten to flood.

The world faces a heightening risk of floods because major river deltas are sinking into the ground while the sea level is rising thanks to global warming.
India is no exception. The threat of flooding is the highest in the Krishna River Delta which flows through Karnataka.

Three river delta areas sinking, report claims

By Wang Qian (China Daily)
Updated: 2009-09-23 07:40

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Three river deltas in China are sinking due to global warming and excessive extraction of underground water, leaving millions of people with an increasing risk of floods, a recent scientific report showed.

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Sinking Deltas in the Press

BREAKING NEWS: Iran nuclear chief says U.N. will be allowed to inspect newly revealed site

U.S. news Environment

Categories
U.S. news

Most major river deltas are sinking, study finds

Dams, other barriers upstream and drilling in deltas cited as key factors

The Vancouver Sun

World's deltas in danger

Study finds two-thirds on planet shrinking

Sinking river delta could mean trouble along Fraser

with 6 comments

Peace Arch News

Mississippi Delta, 1984-2012, LandSat

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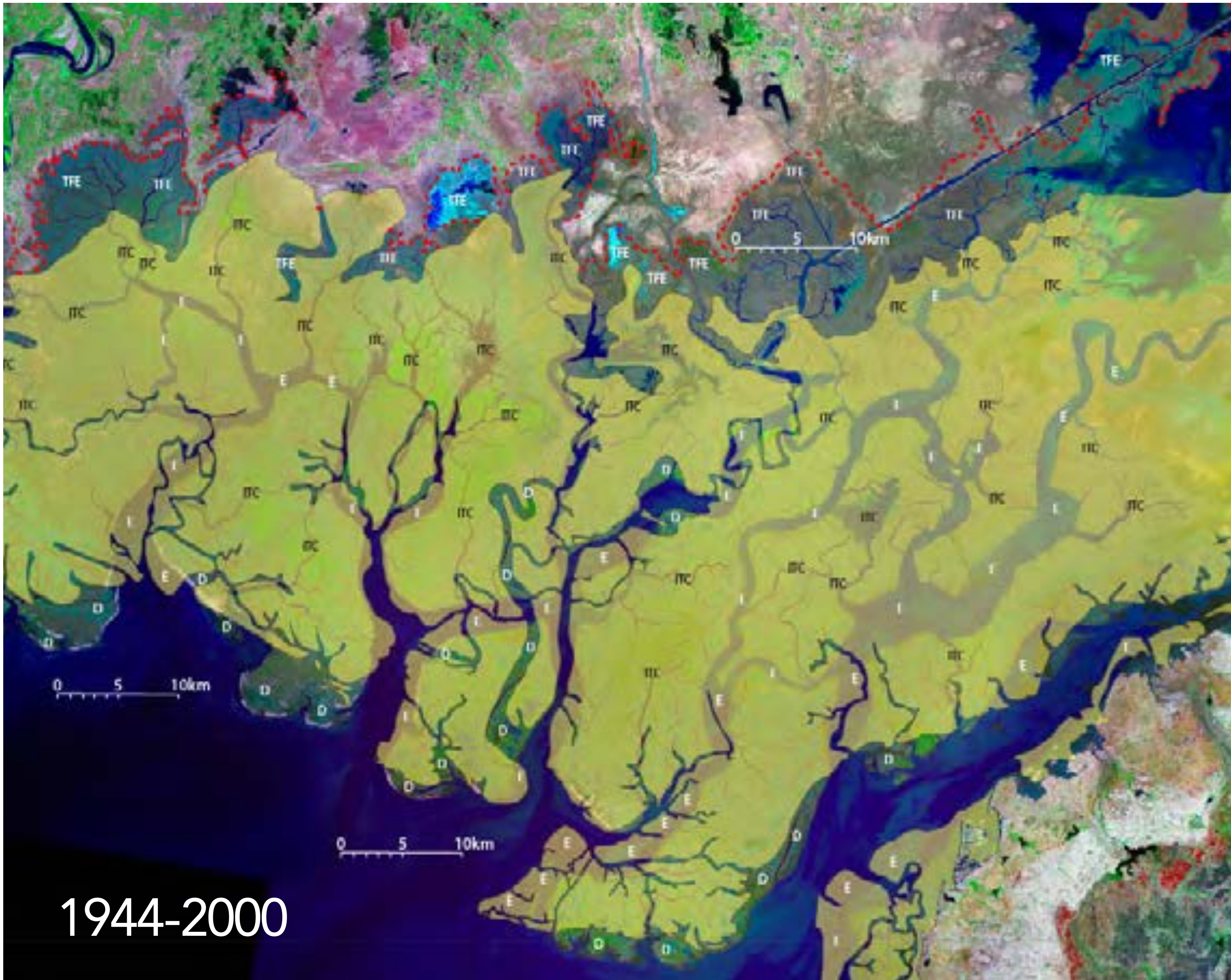

Starved of sediment, erosion dominates the modern Indus Delta. New estuaries and tidal channels have formed, and tidal flats have extended landward.

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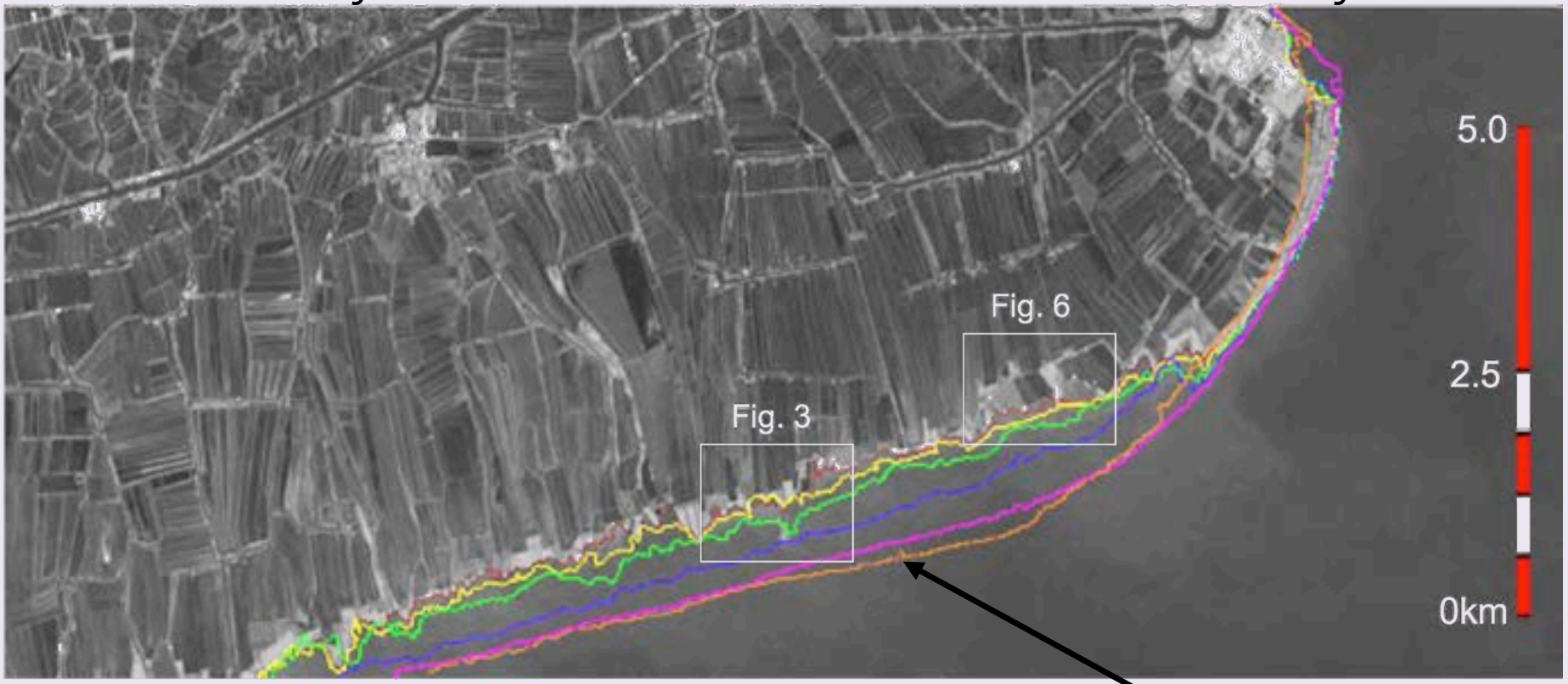
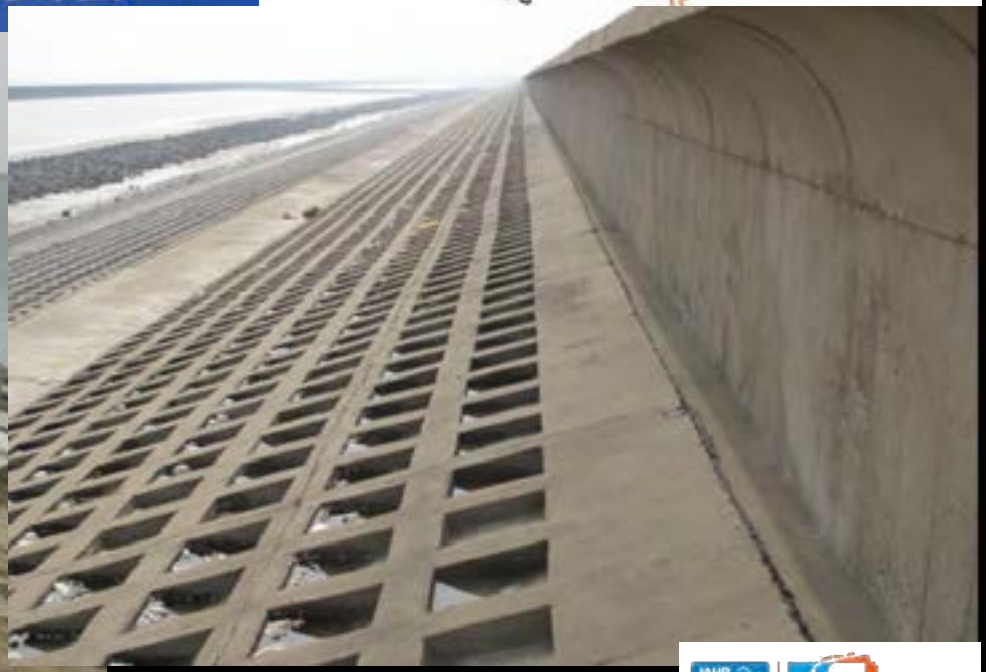
The Chao Phraya Delta shoreline has retreated 1 km in 50 years.



Rokugawa et al., 2006; Saito et al., 2007



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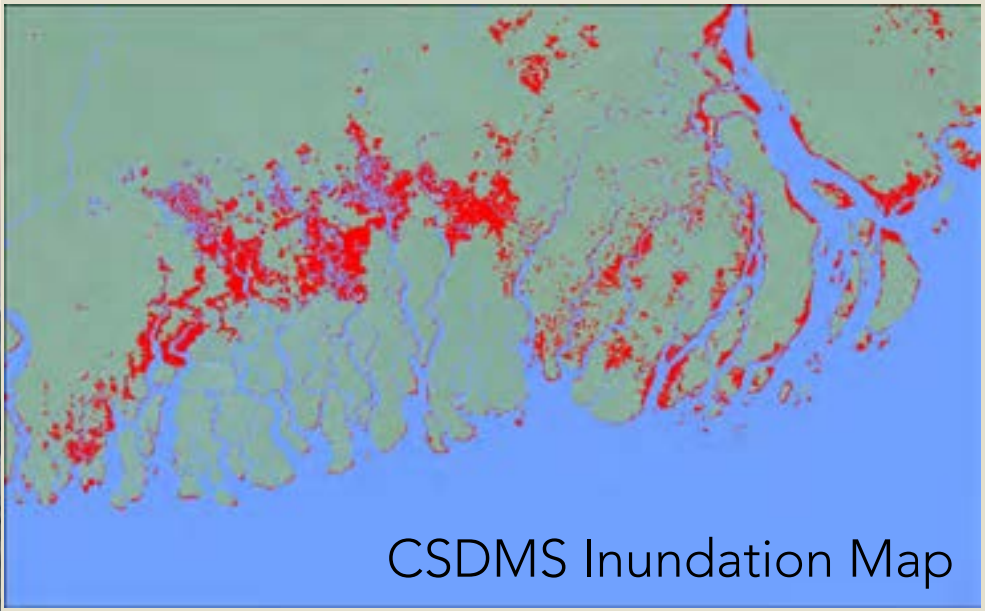
Storms, Storm Surges and Floods are killers.

Every year levees in the GBM delta need of repair, as the dynamic channels churn up the landscape. *Photo credit. Irina Overeem*

Ganges-Brahmaputra Delta



CSDMS Inundation Map

Cyclone Aila, May 2009, caused extensive GBM flooding, as the storm surge reached 6-7m

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San Joaquin Delta
Mississippi Delta
Even in rich countries,
infrastructure failures are common
New Orleans
Rapid Drawdown
induced failures
(Mississippi Delta)
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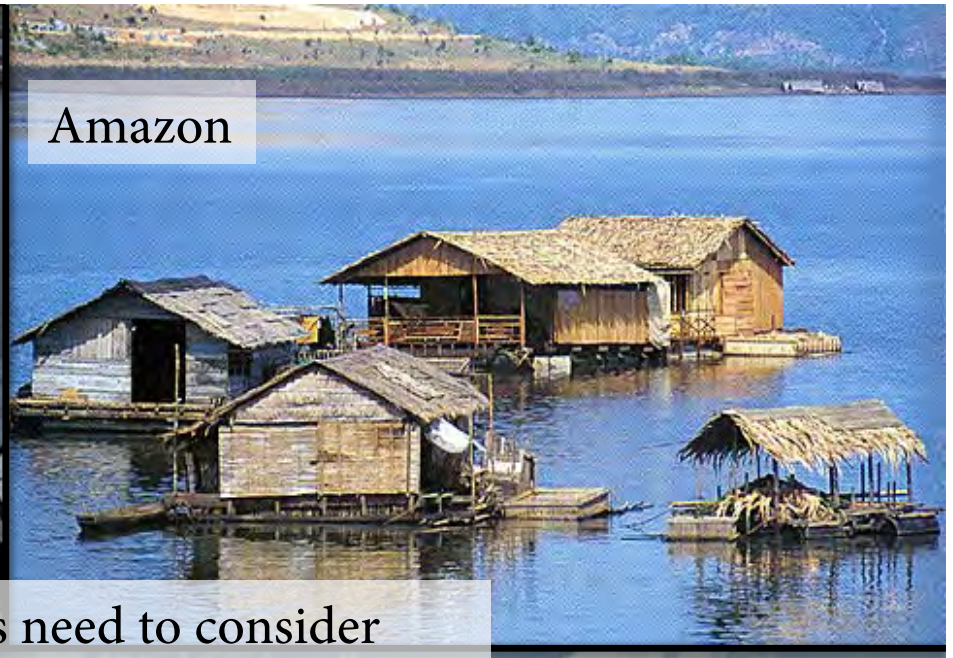

Countries need to consider methods of adaptation

Fight or Flight = Protect or Get out of the Way

Deltas hold 500+M people, are highly productive, biodiversity hotspots, filters, repositories & reactors for water, sediment, carbon, nutrients, pollutants. They are megacity hubs, and ports, and offer waterway transport. Ecosystem services include forestry, fisheries and agriculture. Human interventions put deltas in peril through flooding, shoreline retreat, land subsidence, saltwater intrusion, and saline soils. Food security is threatened, infrastructure repairs need ever increasing resources for coastal protection.