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Reframing Deltaic Salinisation

Why offshore controls are primary drivers – and anthropogenic factors are accelerants.

Mo Hoque

mo.hoque@port.ac.uk

Sean Feist[1] · ChiSan Tsai[2,3] · Muntaha Aurthy[1] · Kristine Belesova[4] · Ashraf Dewan[5] · Adrian Butler[2]

[1] University of Portsmouth, UK · [2] Imperial College London, UK · [3] University of Tokyo, Japan · [4] Imperial College London (Public Health), UK · [5] Curtin University, Australia

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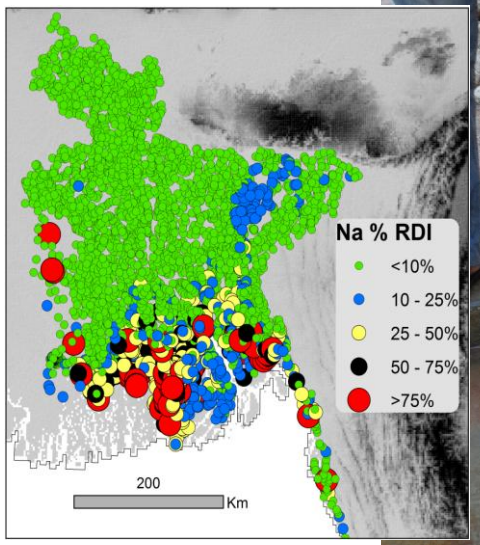
This matters for 30 million coastal people



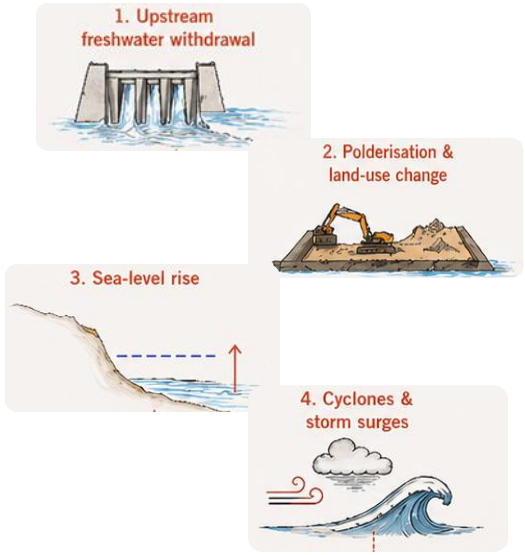
The reframing

Salinisation in deltas is not what we usually say it is.

THE CONVENTIONAL VIEW

Salinisation is driven by recent human and climatic forcing.

- ✓ Upstream freshwater withdrawal
- ✓ Polderisation & land-use change
- ✓ Sea-level rise
- ✓ Cyclones & storm surges



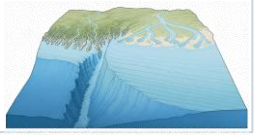
OUR REFRAMING

Offshore geometry sets the structural floor.

Anthropogenic factors are accelerants on a system already predisposed to salinity.

STRUCTURAL

Continental shelf geometry · submarine canyons · tidal range

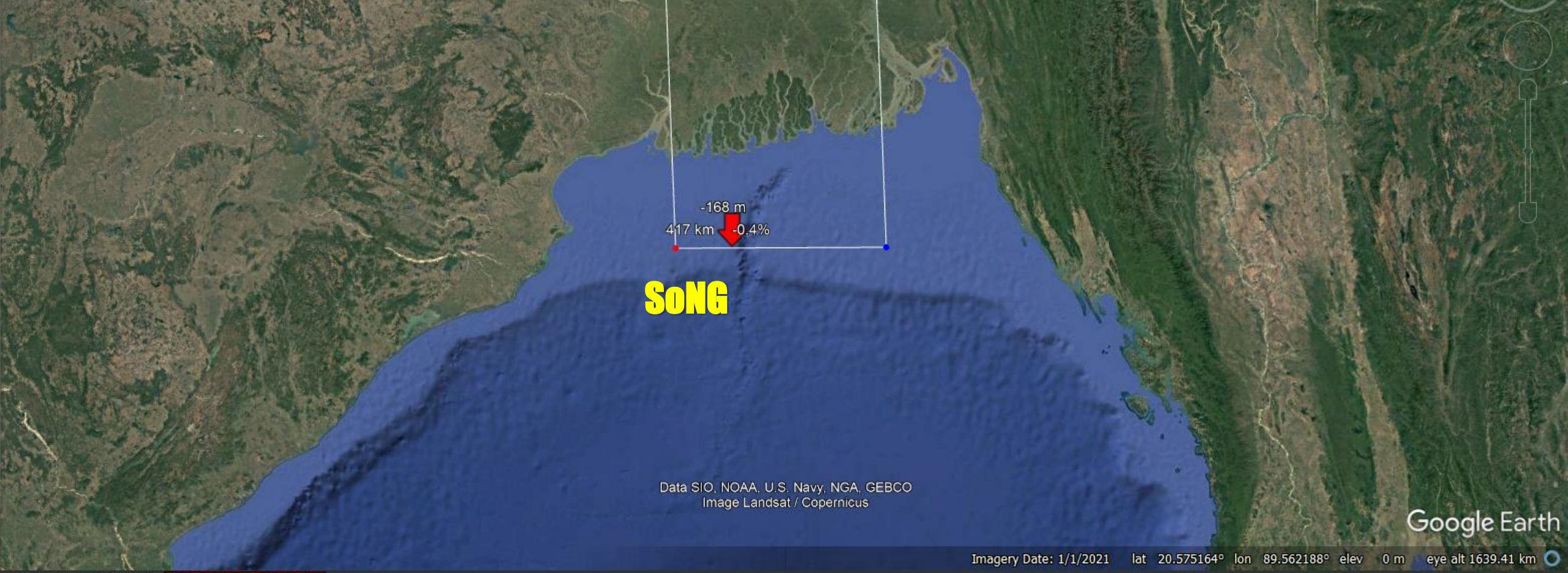


ACCELERATING

Withdrawal · polderisation · SLR · storm surges

Google Earth

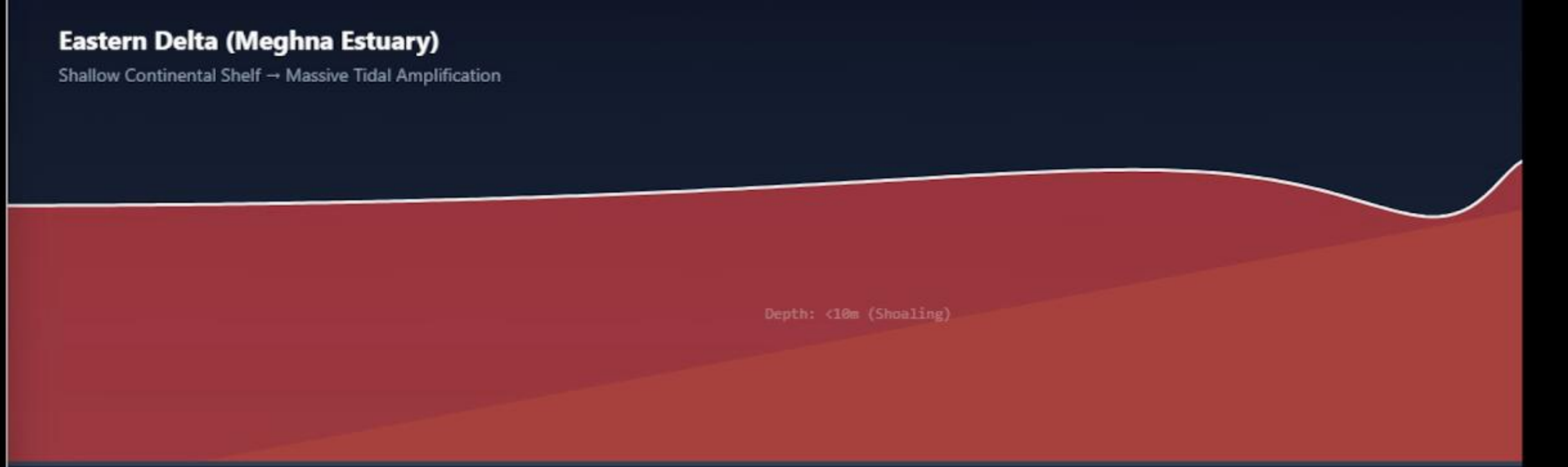
Data SIO, NOAA, U.S. Navy


-168 m
417 km -0.4%
SoNG
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Google Earth
Imagery Date: 1/1/2021 lat 20.575164° lon 89.562188° elev 0 m eye alt 1639.41 km


Graph: Min, Avg, Max Elevation: -1157, -52, 48 m
Range Totals: Distance: 946 km
Elev Gain/Loss: 1864 m, -1891 m
Max Slope: 8.5%, -12.1%
Avg Slope: 0.3%, -0.3%
48 m
-250 m
-500 m
-750 m
-1157 m
-168 m
-0.4%
75 km
150 km
225 km
300 km
375 km
417 km
450 km
525 km
600 km
675 km
750 km
825 km
946 km

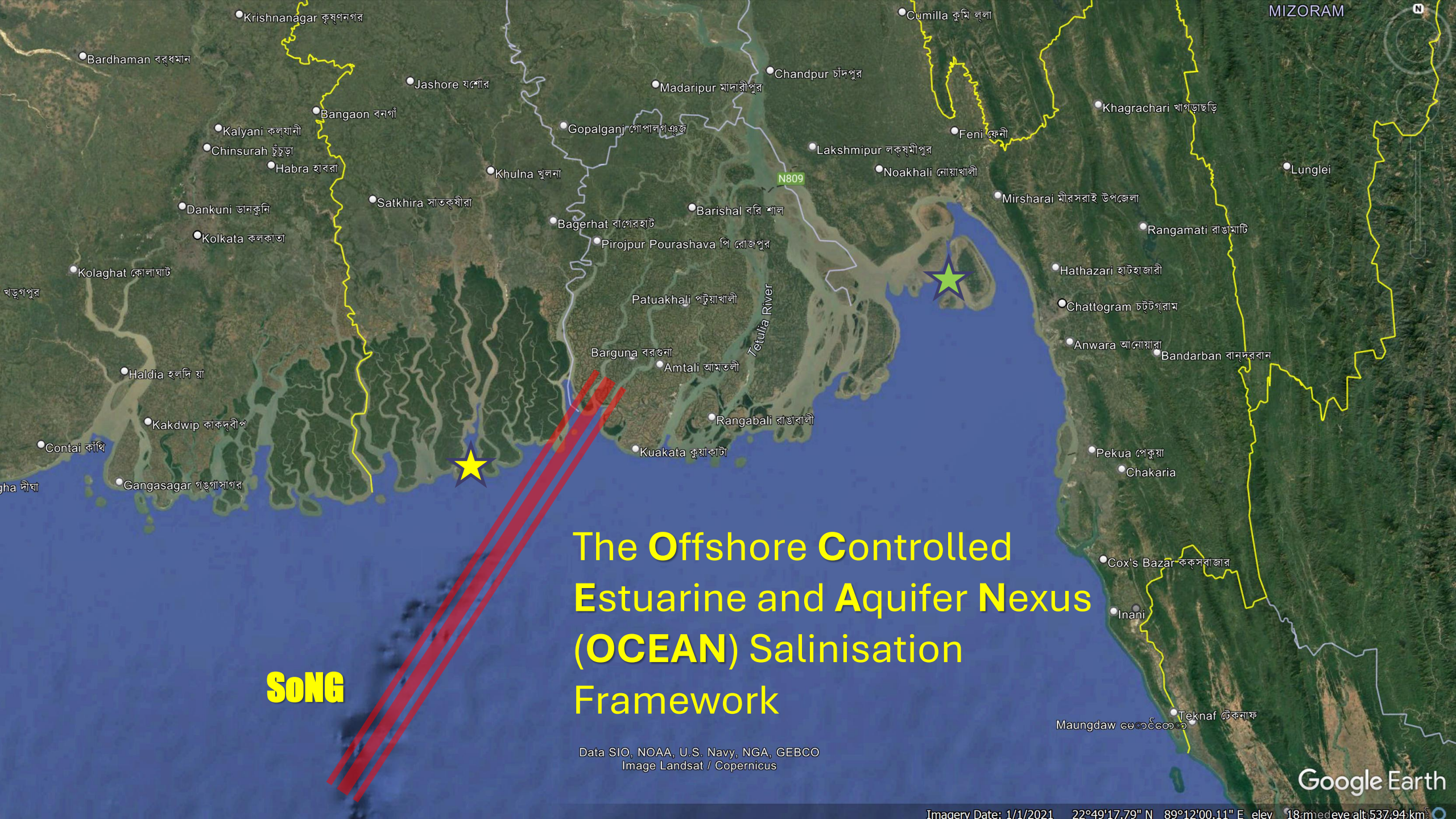
Eastern Delta (Meghna Estuary)

Shallow Continental Shelf → Massive Tidal Amplification

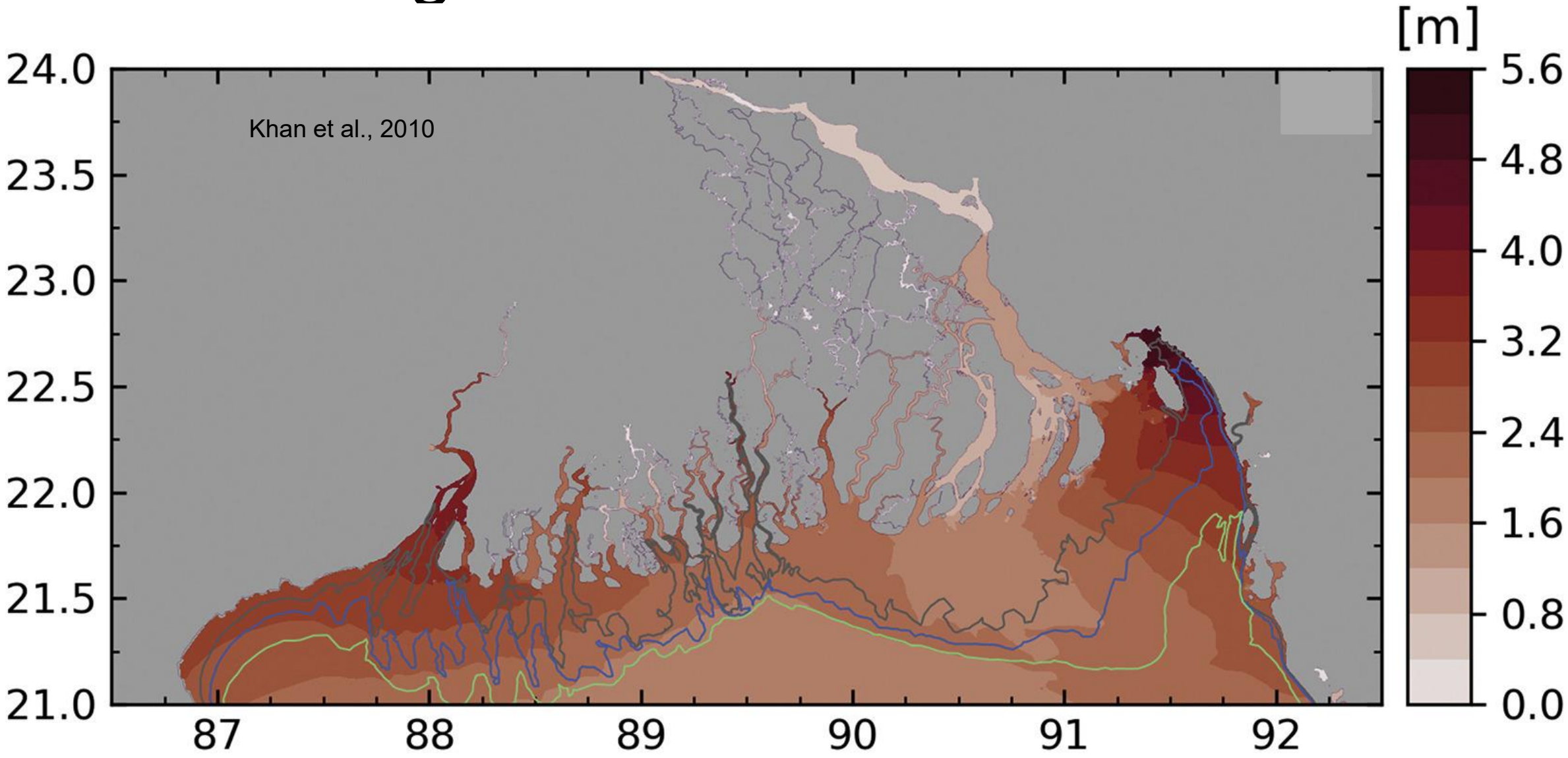


Western Delta (Sundarbans)

Deep Submarine Canyon → Energy Absorbed (No Shaling)


Krishnanagar কৃষ্ণনগর
Bardhaman বর্ধমান
Jashore যশোর
Bangaon বনগাঁ
Kalyani কল্যানী
Chinsurah চুঁচুড়া
Habra হাবরা
Dankuni ডানকুনি
Kolkata কলকাতা
Kolaghat কোলাঘাট
খড়্গপুর
Haldia হলদি য়া
Kakdwip কাকদ্বীপ
Contai কাঁথি
Gangasagar গঙ্গাসাগর
gha দীঘা
Satkhira সাতক্ষীরা
Khulna খুলনা
Gopalganj গোপালগঞ্জ
Madaripur মাদারীপুর
Barishal বরি শাল
Bagerhat বাগেরহাট
Pirojpur Pourashava পি রোজপুর
Patuakhali পটুয়াখালী
Barguna বরগুনা
Amtali আমতলী
Rangabali রাঙাবালী
Kuakata কুয়াকাটা
Tetulia River
N809
Chandpur চাঁদপুর
Lakshmipur লক্ষ্মীপুর
Noakhali নোয়াখালী
Cumilla কুমি ল্লা
Feni ফেনী
Khagrachari খাগড়াছড়ি
MIZORAM
Lunglei
Mirsharai মীরসরাই উপজেলা
Rangamati রাঙামাটি
Hathazari হাটহাজারী
Chattogram চট্টগ্রাম
Anwara আনোয়ারা
Bandarban বান্দরবান
Pekua পেকুয়া
Chakaria
Cox's Bazar কক্সবাজার
Inani
Teknaf টেকনাফ
Maungdaw ေမာင်ေတာ
SoNG
The Offshore Controlled Estuarine and Aquifer Nexus (OCEAN) Salinisation Framework
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Google Earth
Imagery Date: 1/1/2021 22°49'17.79" N 89°12'00.11" E elev 18 m eye alt 537.94 km

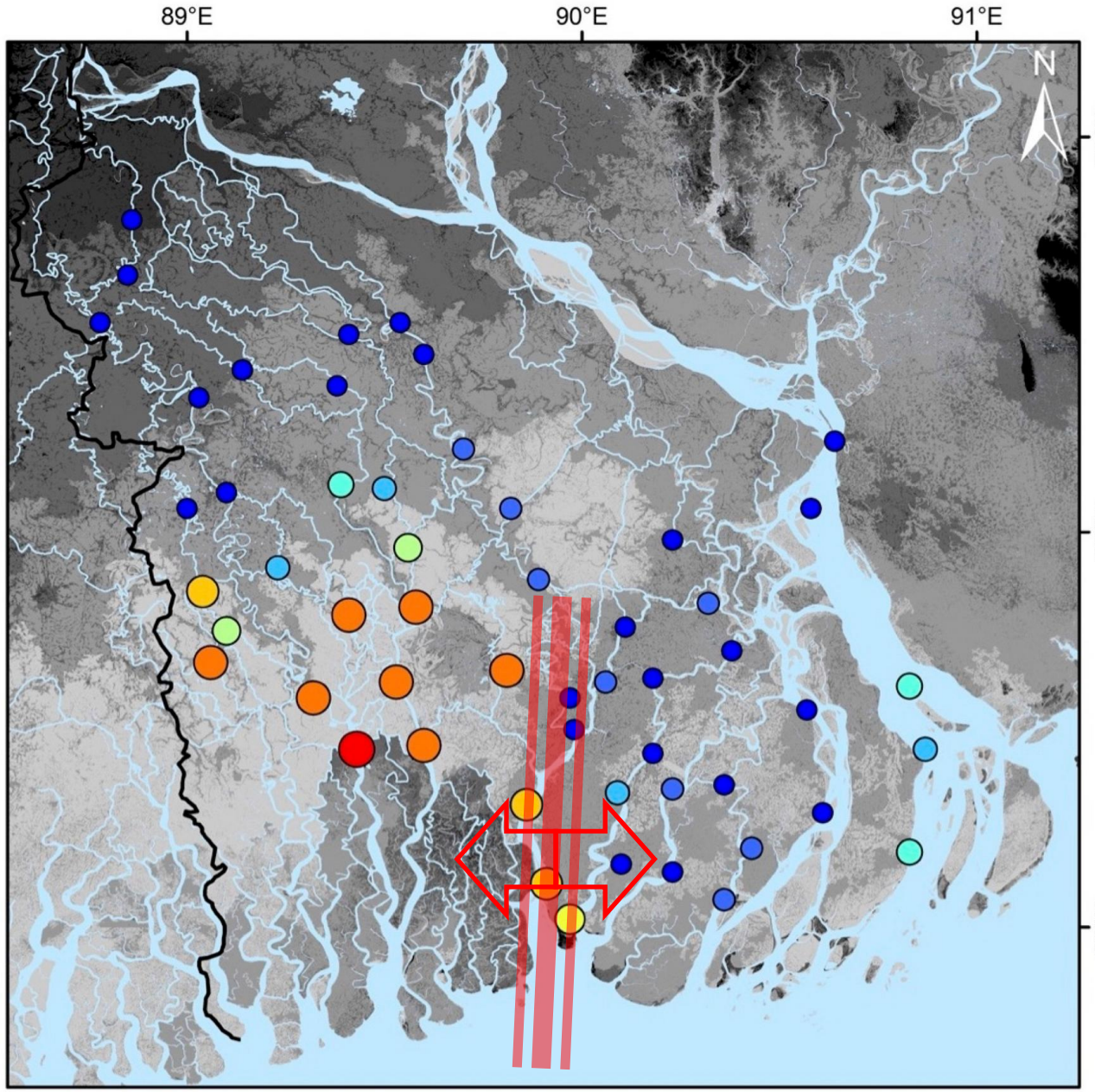
Tidal Range West vs East




Paradoxical…

Salinity Divide

- Salinity maxima in the river system of Bangladesh during the period 2000 to 2017

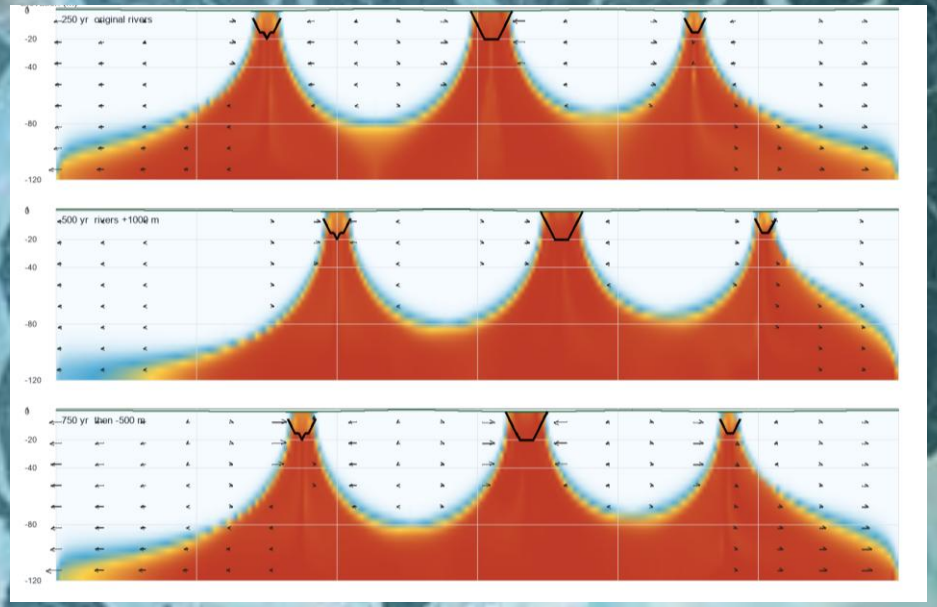


EC (µS/cm)	Water Quality
>25000	Highly Saline
10000 - 25000	Saline
8000 - 10000	Moderately Saline
6000 - 8000	
4000 - 6000	Impacts on biodiversity

EC (µS/cm)	Water Quality
3000 - 4000	
2000 - 3000	Irrigation Guideline
1000 - 2000	Fresh/Poor DW limit
0 - 1000	Drinking Water

Feist et al., 2023

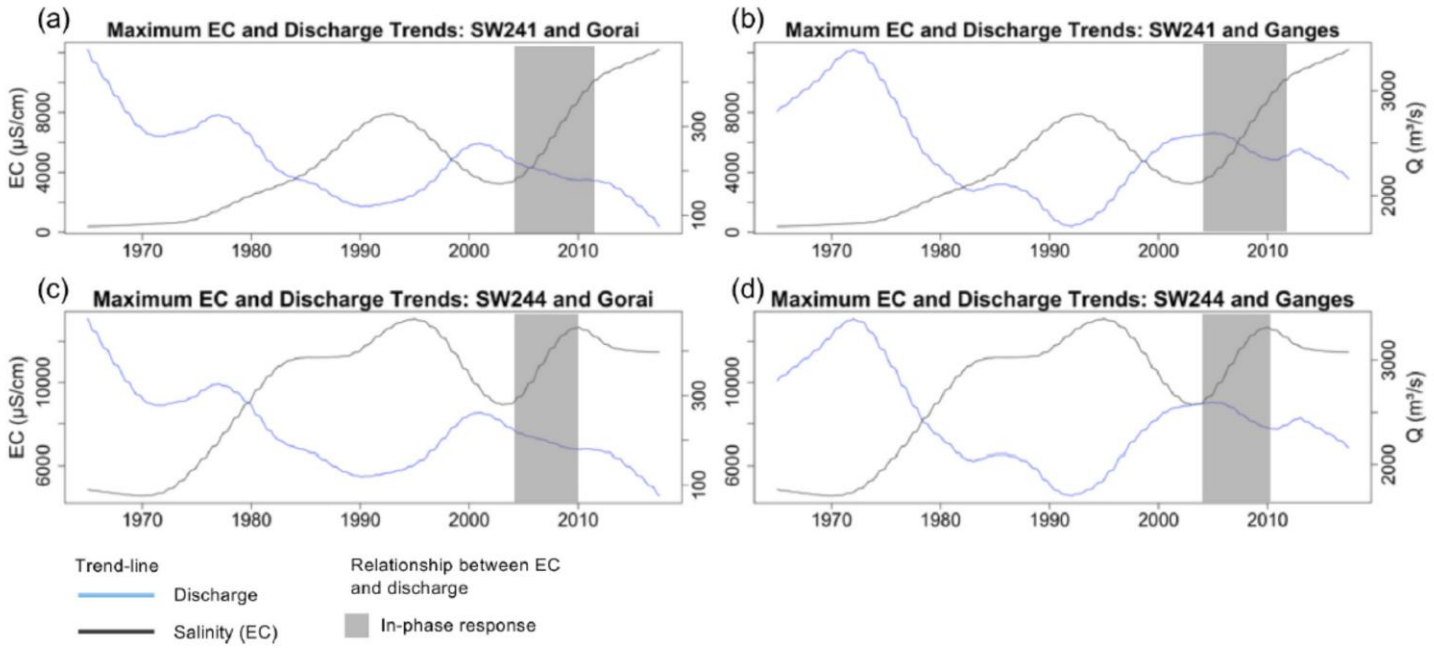
Dense tidal creeks and low-lying floodplains sustain lateral salinity in groundwater. Former tidal channels leave widespread saline pockets that freshen only over decades

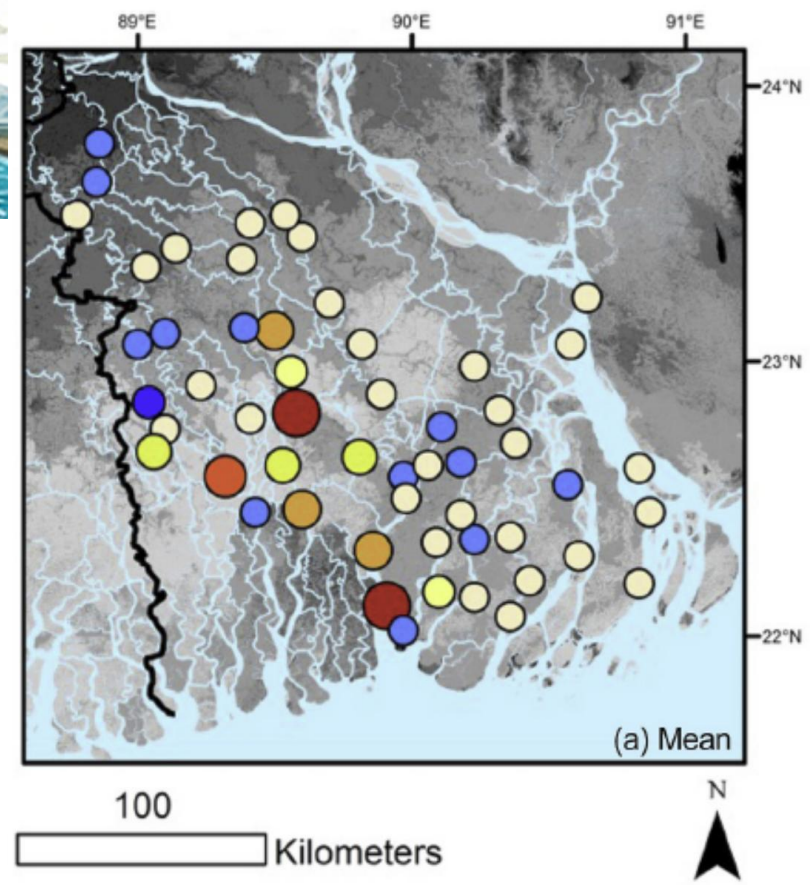


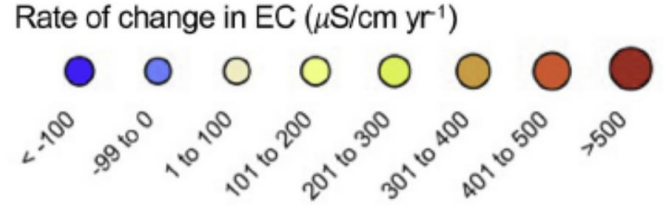
SUTRASET staged migration with land-only recharge and abandoned-channel imprint

Stage 1 starts from hydrostatic freshwater conditions; stages 2 and 3 inherit the previous final state. Freshwater recharge at 30 percent of 2000 mm/yr is applied only outside active saline rivers, and each

Upstream Abstraction





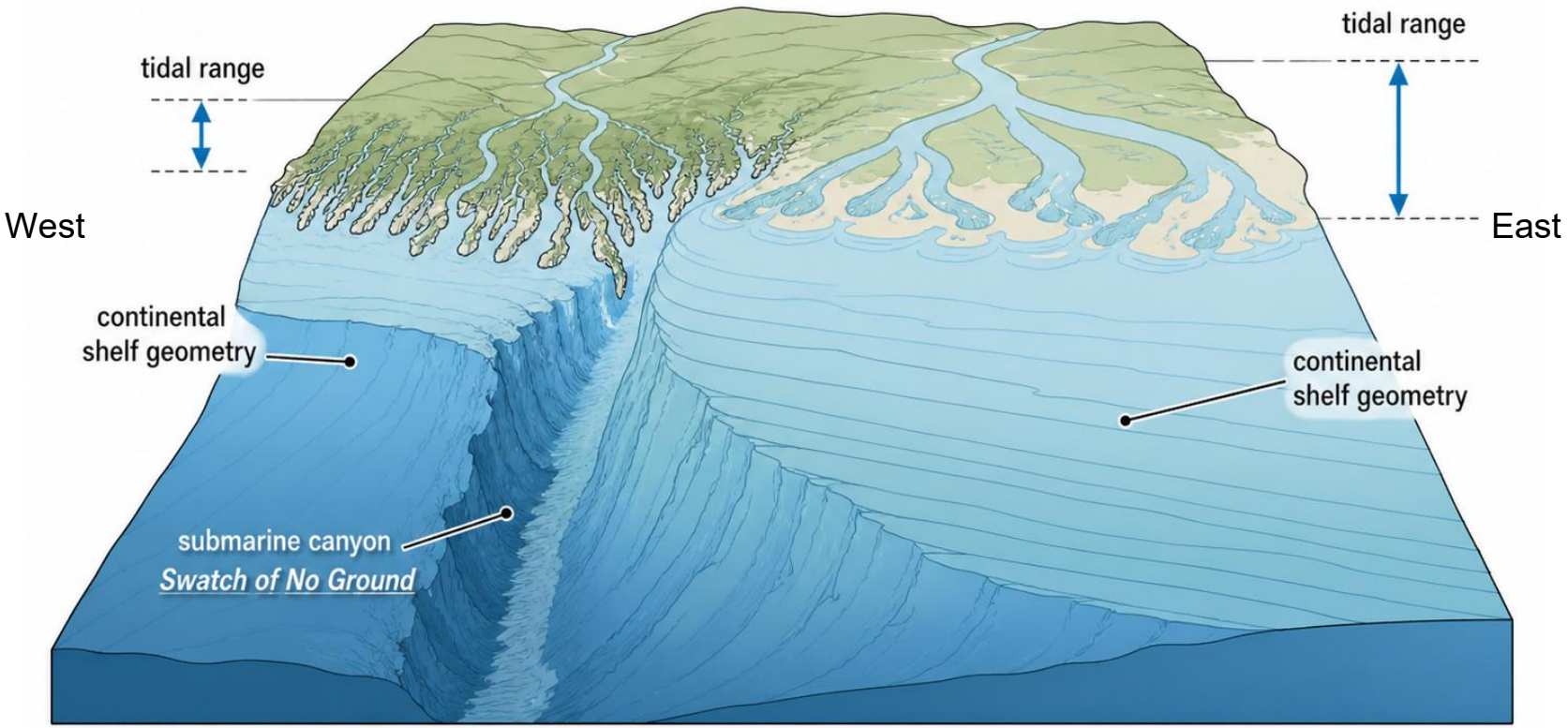


- Downstream from Khulna: Salinity rises during low river discharge, with a post-2007 increase indicating compounding controls.
- Western Estuarine System experiencing rapid increases averaging 111 ± 28 µS/cm yr^{-1}

Feist et al., 2025

Annual rates of change in electrical conductivity (EC µS/cm) between 2000 and 2017 at 54 monitoring stations in Bangladesh.

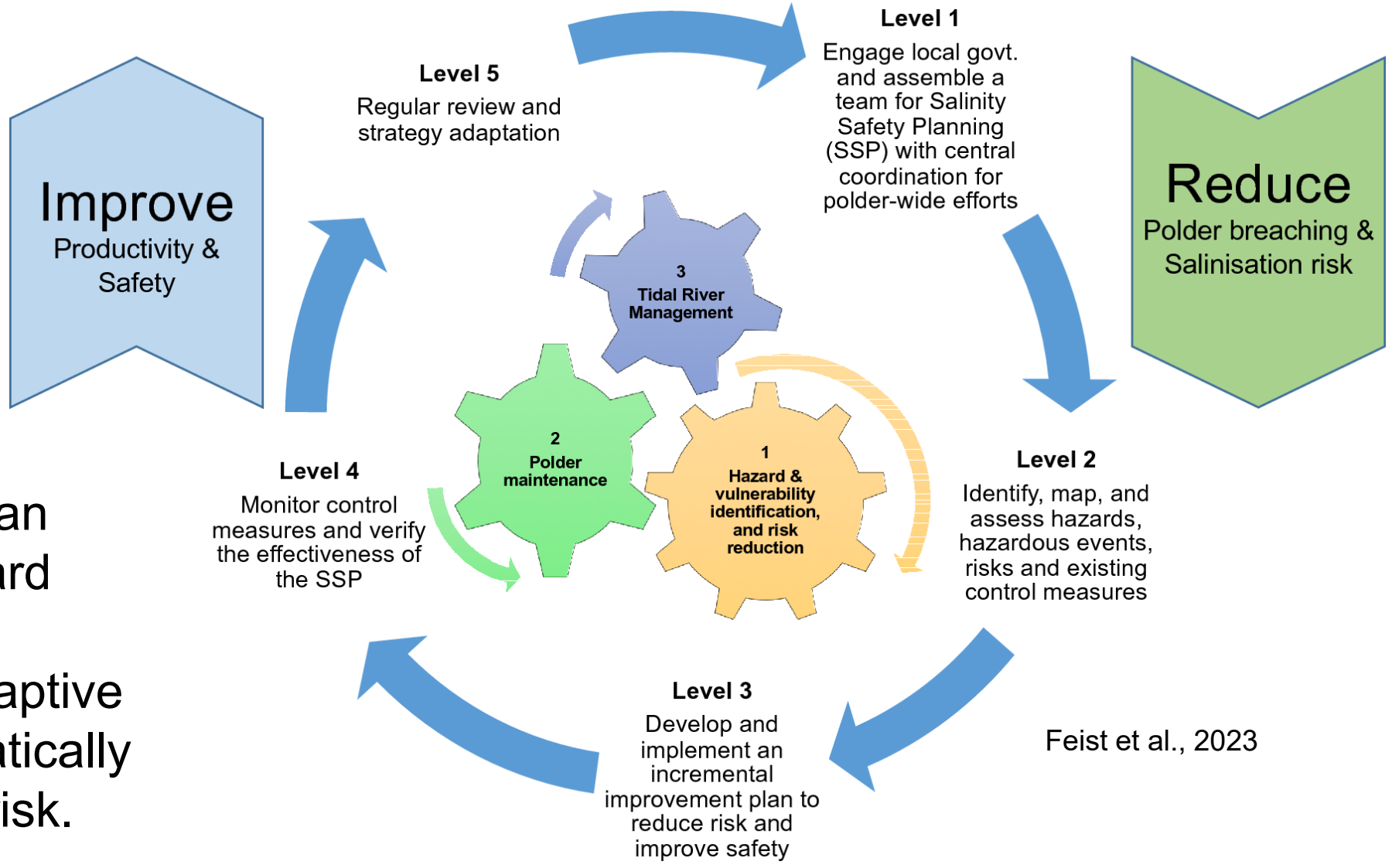
Combining Everything Together



Structural vulnerability sets the stage, while human activity and climate change accelerate salinisation, locking salt into surface water and groundwater systems.

What Can We Do

- The Salinity Safety Plan (SSP) integrates hazard identification, polder management, and adaptive monitoring to systematically **manage** salinisation risk.



Feist et al., 2023

Key Takeaway

- Bengal Delta east–west asymmetry – and the 111 ± 28 μS/cm yr^{-1} western trend – is the empirical signature of that control.
- The OCEAN framework links offshore controls with estuarine and aquifer persistence, amplified by human modification
- Anthropogenic and climatic drivers are real, but they accelerate a structurally predisposed system – adaptation must be calibrated accordingly.

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