REGIONAL FLYWAY INITIATIVE TRAINING SERIES:

Workshop on Wetland Ecosystem Services and Nature-based Solutions

BANGLADESH

27–29 May 2024

East Asian-Australasian Flyway - Regional Flyway Initiative

Carbon Biomass Estimates using Remote Sensing

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Research Fellow | National University of Singapore
2021 National Geographic Explorer

Hao Tang
Asst. Proof, NUS Geography

Dan Friess
Professor, Tulane University

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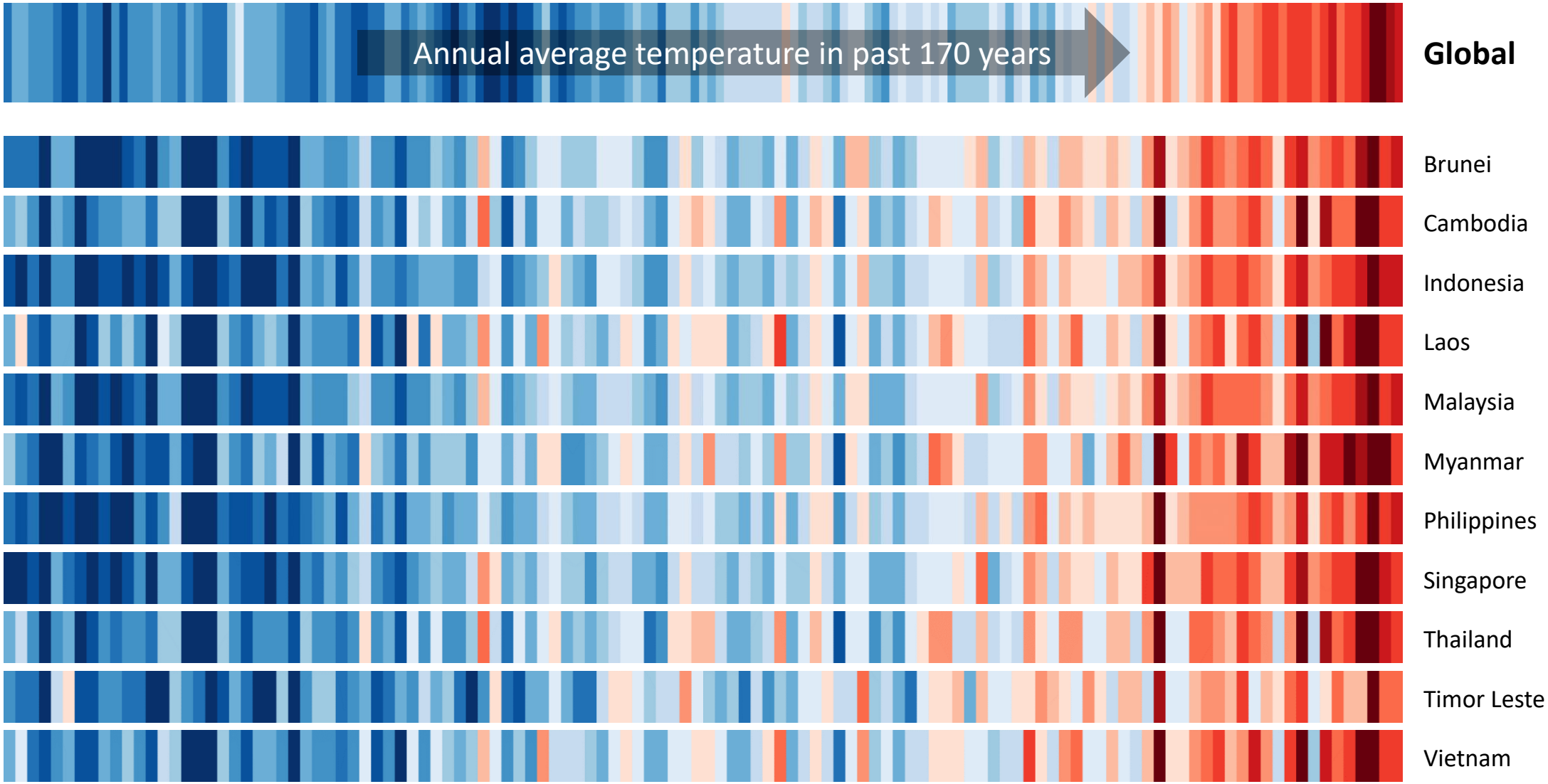
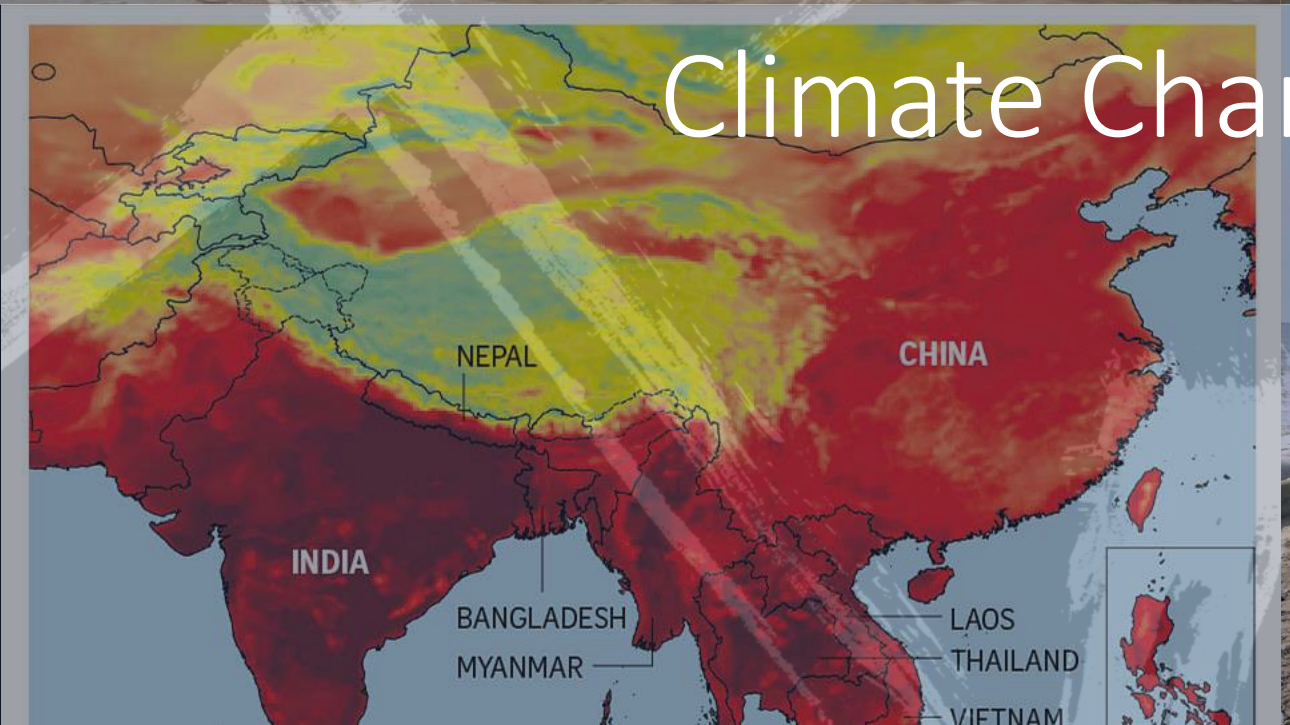
NUS National University of Singapore | Centre for Nature-based Climate Solutions Faculty of Science

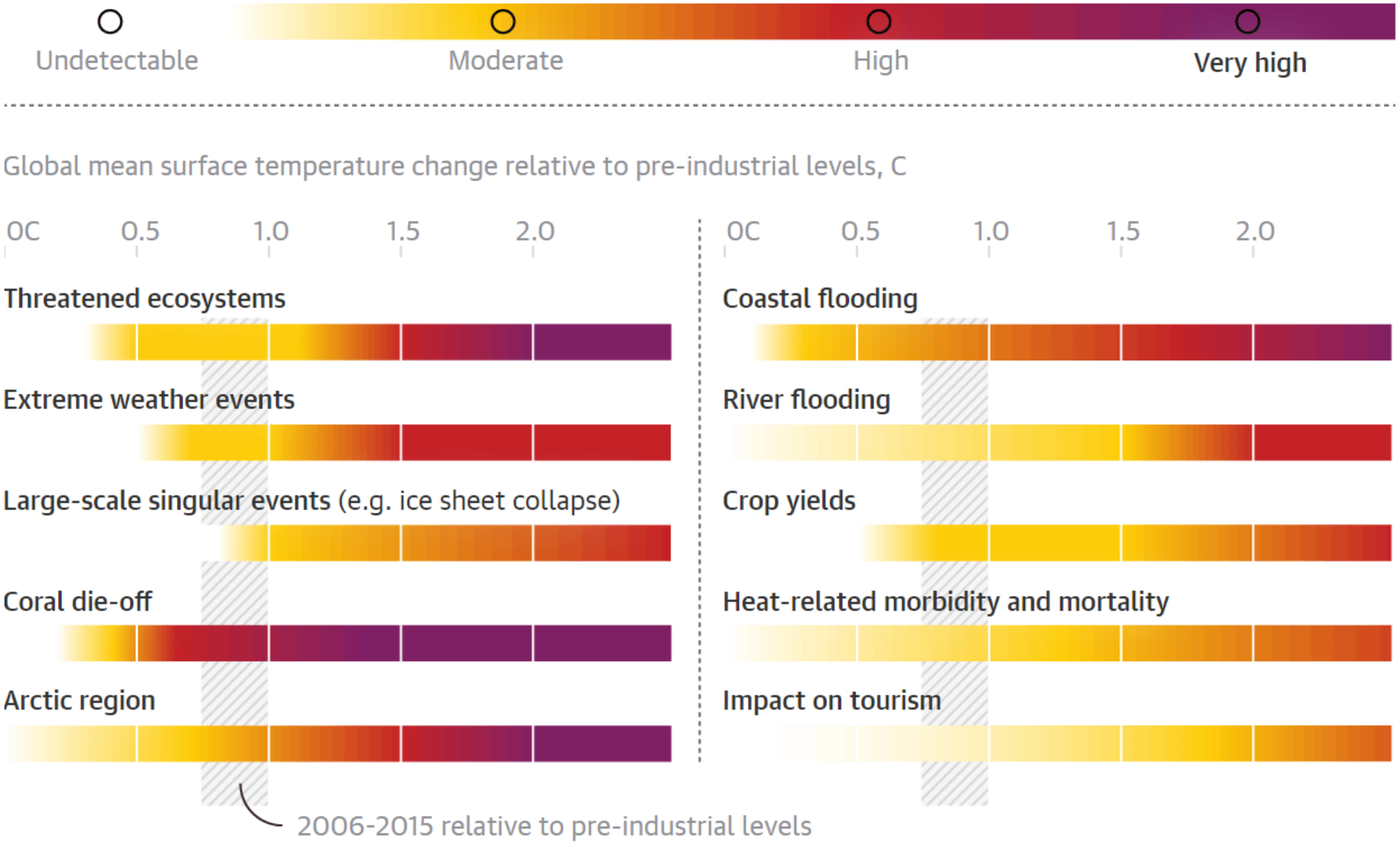
Climate Change





Climate Change Impacts

Future Climate Change Impacts



The Guardian; IPCC Special Report 2018

Carbon Storage in Earth's Ecosystems

Achieving net-zero by 2050 depends on the Earth's natural carbon sinks.

Forests play a critical role in regulating the global climate. They absorb carbon from the atmosphere and then store it, acting as natural carbon sinks.

Where is Carbon Stored?

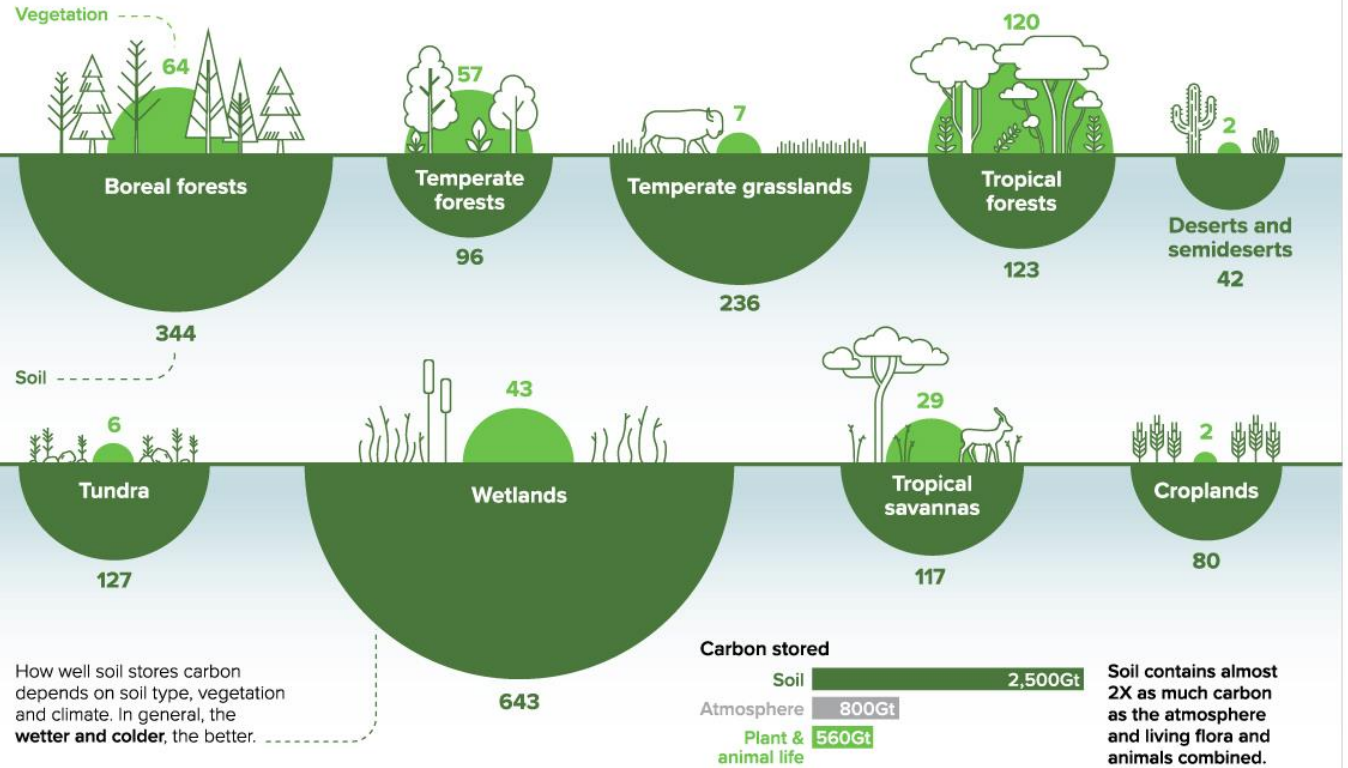
There are various carbon pools in a forest ecosystem.

Carbon Storage

Tonnes of Carbon

The world's forests absorb around **15.6 gigatonnes** of CO_2 each year. That's around 3X the annual CO_2 emissions of the United States.

However, around **8.1 gigatonnes of CO_2 leaks back into the atmosphere** due to deforestation, fires and other disturbances.



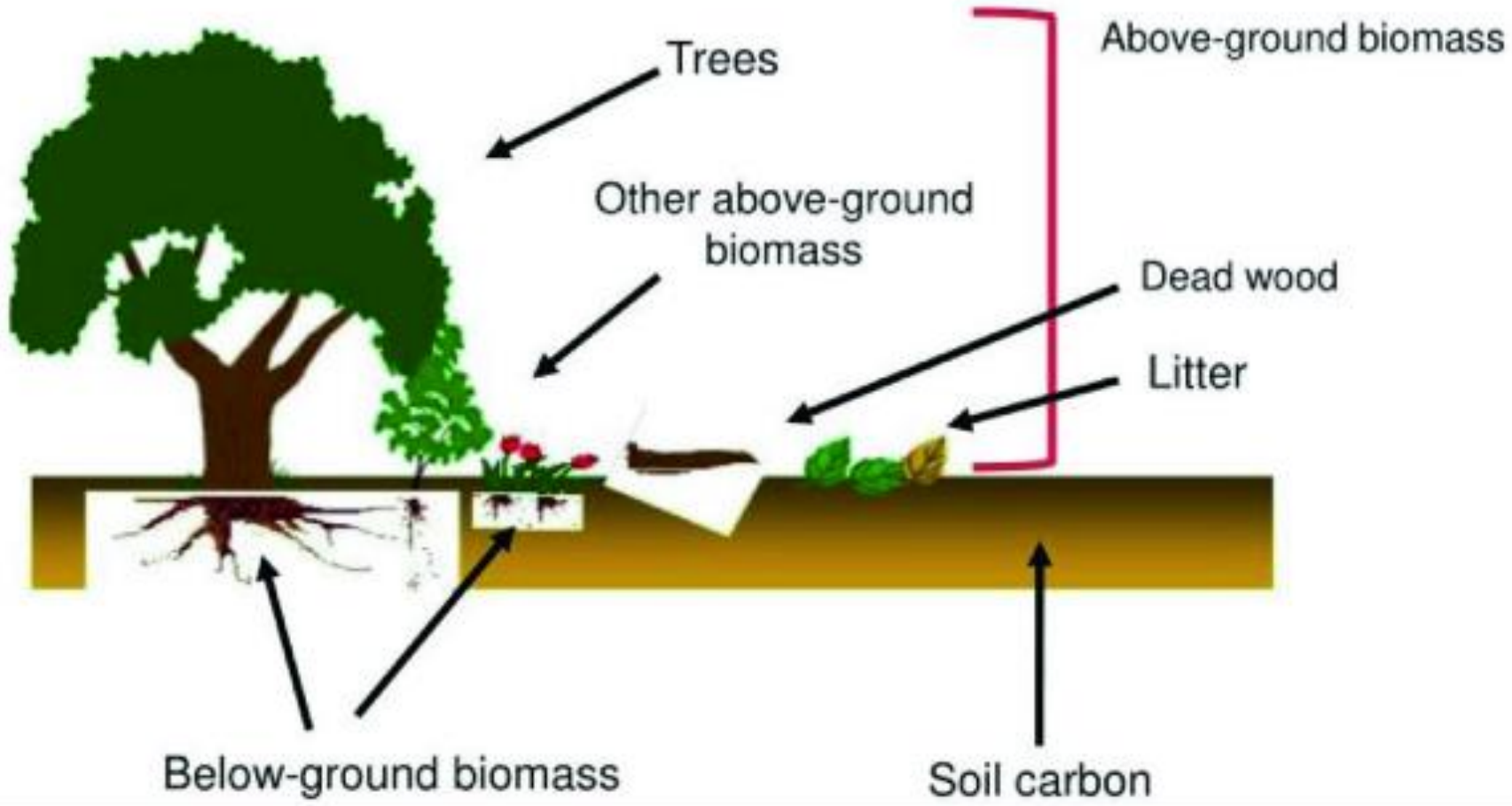
How well soil stores carbon depends on soil type, vegetation and climate. In general, the **wetter and colder**, the better.

Soil contains almost 2X as much carbon as the atmosphere and living flora and animals combined.

Average stored carbon in tonnes per hectare at a ground depth of one meter

Sources: IPCC; NASA

- The IPCC GPG (2003) - five carbon pools:
  aboveground biomass, belowground biomass, litter, dead wood, and soil organic carbon

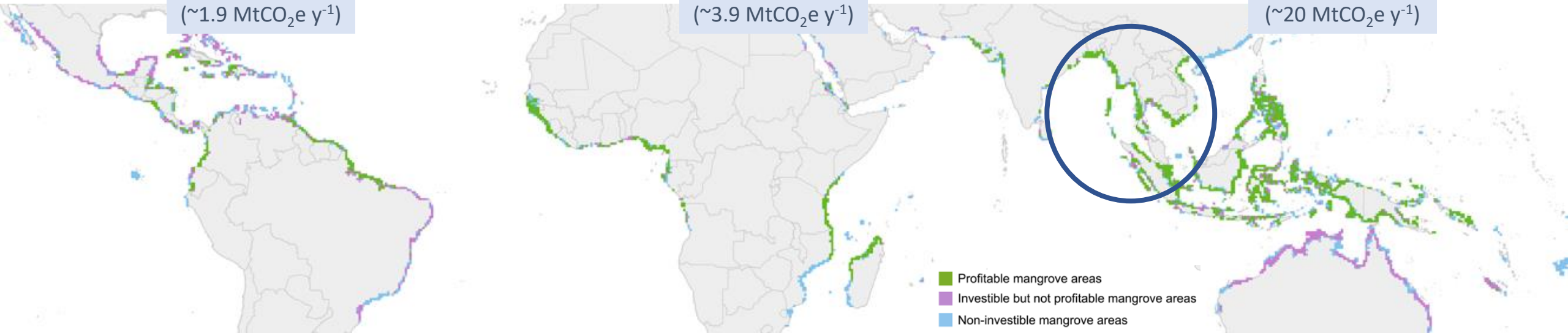


Where are the Opportunities for NCS?

Americas
(~1.9 $MtCO_2e\ y^{-1}$)

Africa
(~3.9 $MtCO_2e\ y^{-1}$)

Asia Pacific
(~20 $MtCO_2e\ y^{-1}$)



Blue Carbon Prospecting

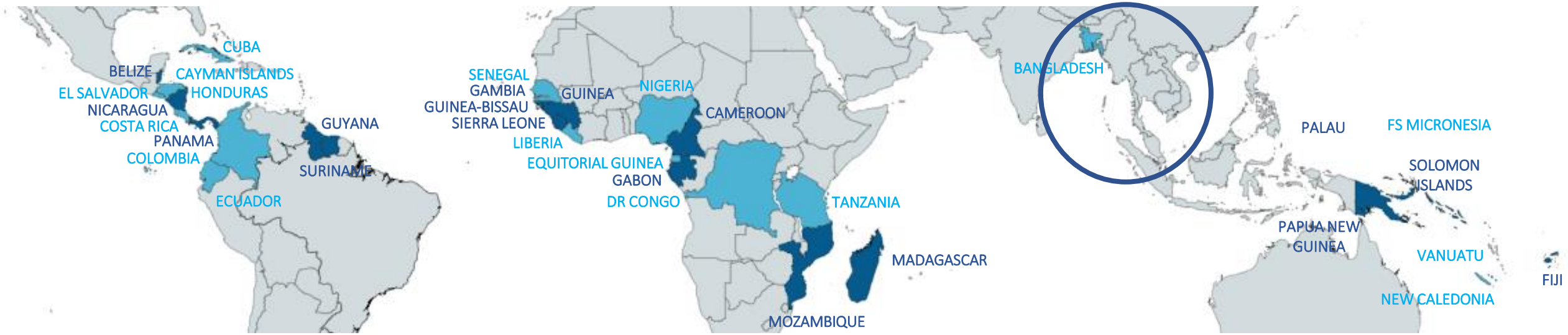
(Protecting Threatened Mangroves)

Zeng et al., *Current Biology*(2021)

United Nations
Framework Convention on
Climate Change

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

- 17 countries where **mangrove** carbon sequestration offsets >5% of national greenhouse gas emissions
- 17 countries where **mangrove** carbon sequestration offsets 1-5% of national greenhouse gas emissions

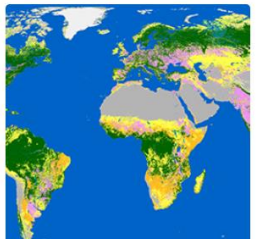


Bangladesh NDC and Wetlands

- Carbon source and sink accounting does not include Soil Carbon or Carbon Sequestration potential of wetlands
  - Unsure if AGB and BGB wetland specific methods are used
  - Currently might be using Tier 1 methods?
- Currently only includes reforestation and afforestation programs
  - Carbon sequestration potential is yet to be tapped in for NDCs

Datasets

ESA WorldCover 10m v200

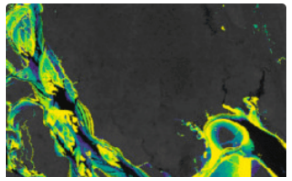


DESCRIPTION | BANDS | TERMS OF USE | CITATIONS

The European Space Agency (ESA) WorldCover 10 m 2021 product provides a global land cover map for 2021 at 10 m resolution based on Sentinel-1 and Sentinel-2 data. The WorldCover product comes with 11 land cover classes and has been generated in the framework of the ESA WorldCover project, part of the 5th Earth Observation Envelope Programme (EOEP-5) of the European Space Agency.

See also:

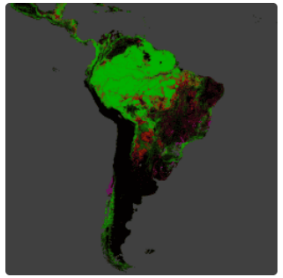
Murray Global Intertidal Change Classification



DESCRIPTION | BANDS | TERMS OF USE | CITATIONS | DOIS

The Murray Global Intertidal Change Dataset contains global maps of tidal flat ecosystems produced via a supervised classification of 707,528 Landsat Archive images. Each pixel was classified into tidal flat, permanent water or other with reference to a globally distributed set of training data.

Hansen Global Forest Change v1.10 (2000-2022)



DESCRIPTION | BANDS | TERMS OF USE | CITATIONS | DOIS

Results from time-series analysis of Landsat images in characterizing global forest extent and change.

The 'first' and 'last' bands are reference multispectral imagery from the first and last available years for Landsat spectral bands corresponding to red, NIR, SWIR1, and SWIR2. Reference composite imagery represents median observations from a set of quality-assessed growing-season observations for each of these bands.

Please see the User Notes for this Version 1.10 update, as well as the associated journal article: Hansen, Potapov, Moore, Hancher et al. "High-resolution global maps of 21st-century forest cover change." Science 342.6160 (2013): 850-853.

Dataset Availability

2000-01-01T00:00:00 - 2022-01-01T00:00:00

Dataset Provider

Hansen/UMD/Google/USGS/NASA

Collection Snippet

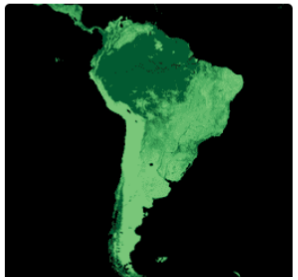
```
ee.Image("UMD/hansen/global_forest_change_2022_v1_10")
```

See example

Tags

CLOSE | IMPORT

Global Aboveground and Belowground Biomass Carbon Density Maps



DESCRIPTION | BANDS | TERMS OF USE | CITATIONS | DOIS

This dataset provides temporally consistent and harmonized global maps of aboveground and belowground biomass carbon density for the year 2010 at a 300-m spatial resolution. The aboveground biomass map integrates land-cover specific, remotely sensed maps of woody, grassland, cropland, and tundra biomass. Input maps were amassed from the published literature and, where necessary, updated to cover the focal extent or time period. The belowground biomass map similarly integrates matching maps derived from each aboveground biomass map and land-cover specific empirical models. Aboveground and

OpenLandMap Soil Organic Carbon Content

DESCRIPTION | BANDS | TERMS OF USE | CITATIONS | DOIS

Soil organic carbon content in x 5 g / kg at 6 standard depths (0, 10, 30, 60, 100 and 200 cm) at 250 m resolution

Predicted from a global compilation of soil points. Processing steps are described in detail here. Antarctica is not included.

To access and visualize maps outside of Earth Engine, use this page.

If you discover a bug, artifact or inconsistency in the LandGIS maps or if you have a question please use the following channels:

- Technical issues and questions about the code
- General questions and comments

Dataset Availability

1950-01-01T00:00:00 - 2018-01-01T00:00:00

Dataset Provider

EnvirometriX Ltd

Collection Snippet

```
ee.Image("OpenLandMap/SOL/SOL_ORGANIC-CARBON_USDA-6A1C_M/v02")
```

See example

Tags

CLOSE | IMPORT

Carbon Assessment for the RFI Wetland Sites in Bangladesh

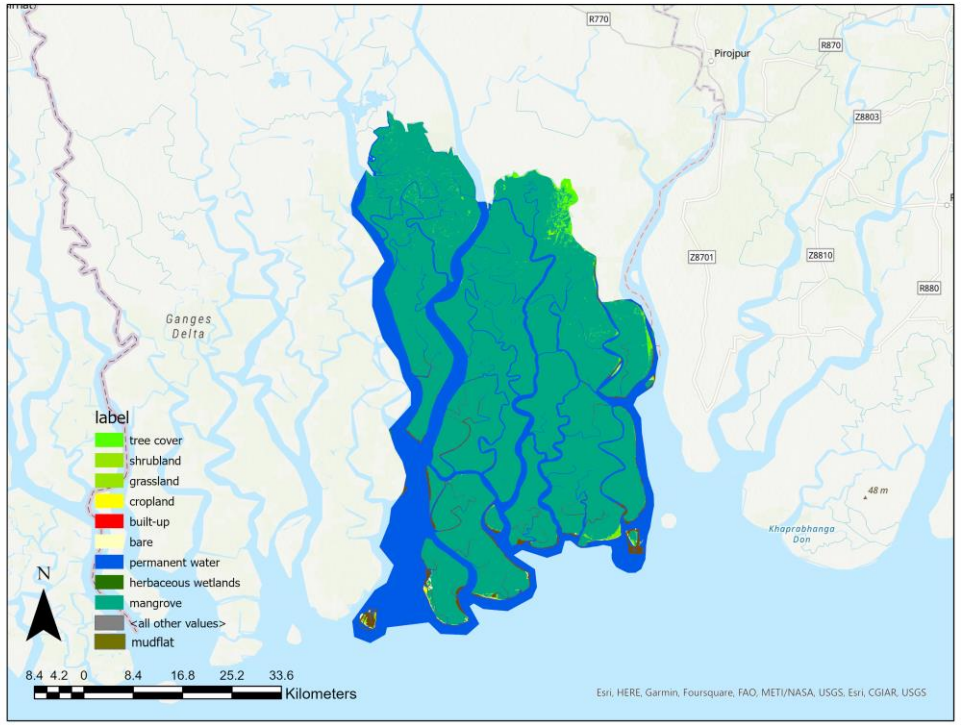
Above Ground Biomass (MgC)	Uncertainty	Below Ground Biomass (MgC)	Uncertainty	Soil Organic Carbon (MgC)	Carbon Sequestration (MgC/yr)
213.15	77.18	76.27	46.06	**381,343,478.65** 381 million tonnes ~ 1% of global annual carbon emission ~ **200%** of Bangladesh's carbon emissions (2021)	377378.73

Ecosystem	Above Ground Biomass (MgC)	Uncertainty	Below Ground Biomass (MgC)	Uncertainty	Soil Organic Carbon (MgC)	Carbon Sequestration
Tree cover (5/5 sites)	**54.43**	17.59	**19.38**	15.95	3586934.74	1150.9
Grassland (5/5)	20.3	5.8	8.19	7.27	1293952.1	1176.9
Cropland (5/5)	21.23	6.37	9.27	8.39	26977.97	813
Tidal Flat (4/5)	30.85	10.64	7.83	5.87	**137142314.3**	**143361.1**
Herbaceous Wetlands (5/5)	26.74	9.68	11.59	8.58	163499.14	3266.11
Mangroves (3/5)	**59.5**	27.1	**20.01**	13.35	**239129800.4**	**227610.72**

Eastern Sundarbans
ID003

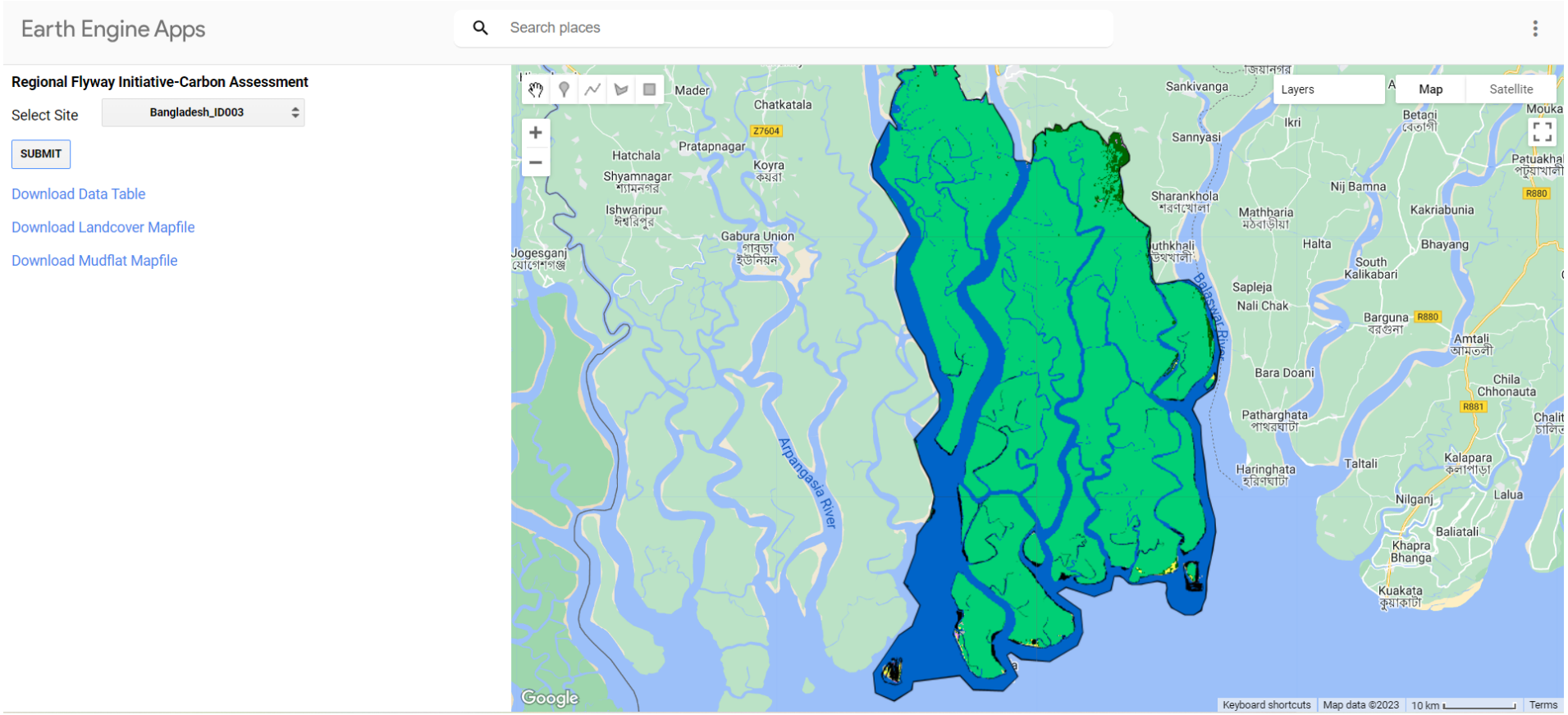
Total Area: 28310 ha

Total C: 747365838 MgC
Vegetative C: 240.66 +- 119.5 MgC
Soil C: 747365598.59 MgC



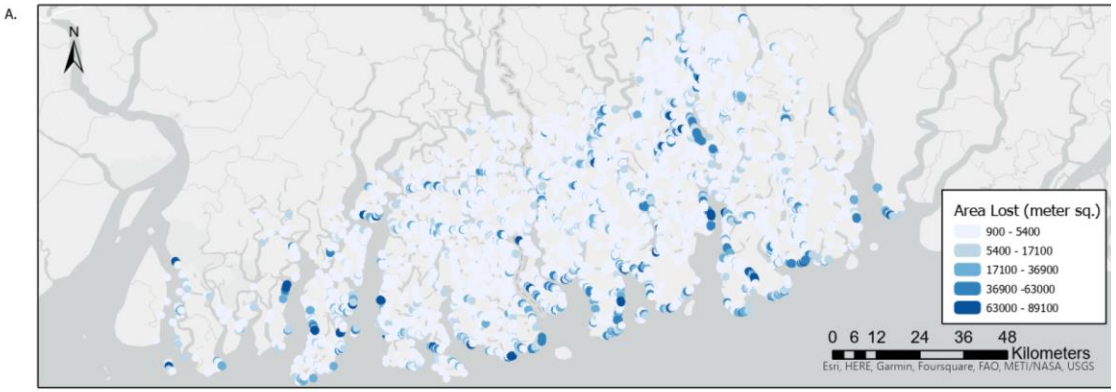
Landcover Dynamics*#				Vegetative Carbon				Soil Carbon	Carbon sequestration Rate		
Landcover type	Area (ha)	Gain (ha)	Loss (20-75% tree cover) (ha)	AGB (MgC)	Uncertainty (MgC)	BGB (MgC)	Uncertainty (MgC)	SOC (MgC)	Total C seq MgC/ y	Min C seq rate (MgC y-1)	Max C seq rate (MgC y-1)
Tree cover	2826.20	0.2	0	30.70	10.83	9.53	6.75	3571069.73	0	0	0
Shrubland	0	0	0	0	0	0	0	0	0	0	0
Grassland	533.9	0	0	8.30	3.16	3.09	2.63	1275424.30	92.10	26.82	192.05
Herbaceous wetlands	47.50	0	0	17.10	6.81	5.63	3.59	132354.73	17.01	7.89	40.43
Mangroves	**200640.00**	0.6	0	**44.06**	**19.00**	**11.71**	**8.18**	**239122359 63% of all**	**223932.22**	**163454.18**	**523053.36**
Tidal flat	54336	0	0	20.63	10.04	6.66	4.92	137131970.21	70528.13	54336.00	85850.88

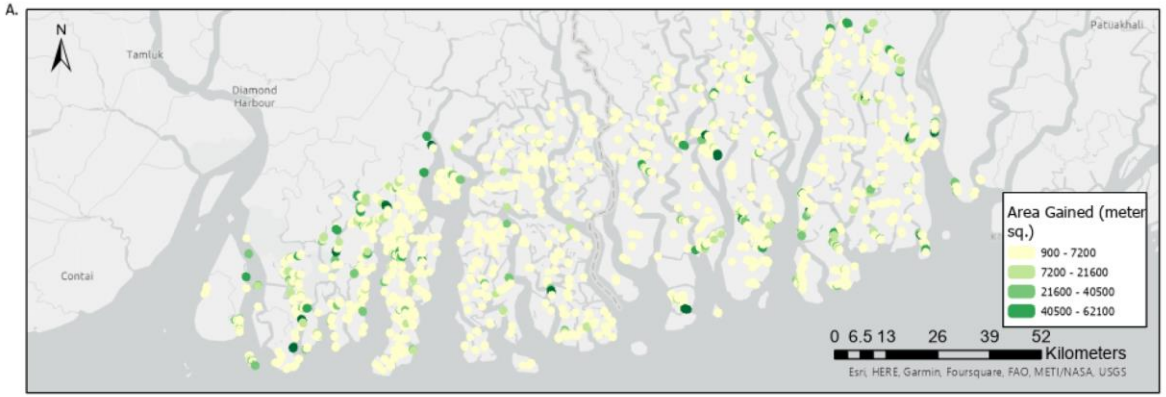
https://ee-radb06.projects.earthengine.app/view/rfi

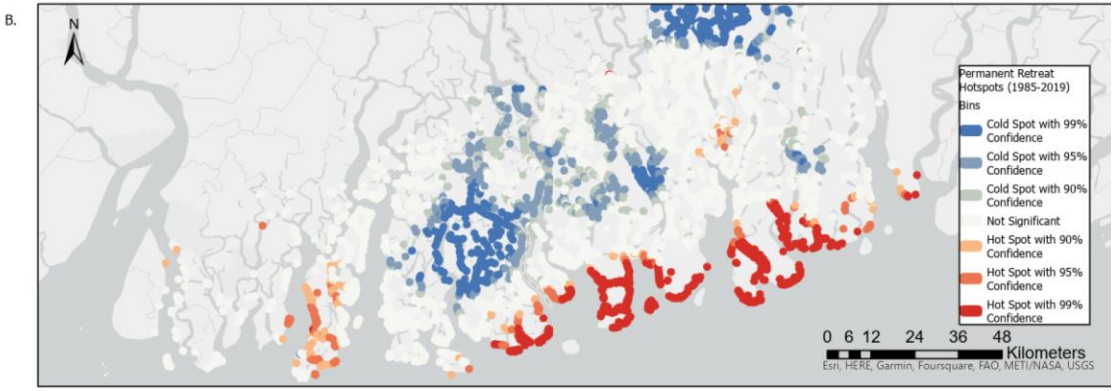


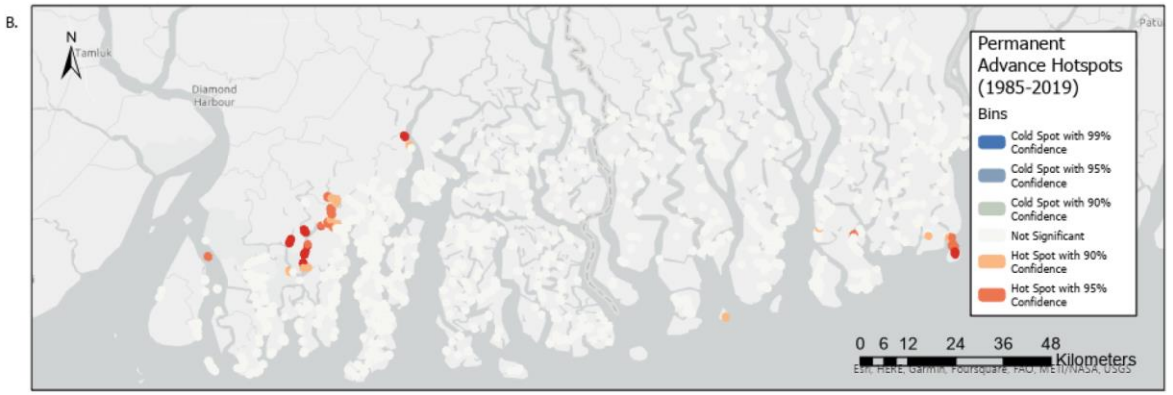
Shoreline retreat is a cause of mangrove loss in the Sundarbans

24.5 % loss vs 12.5% gain





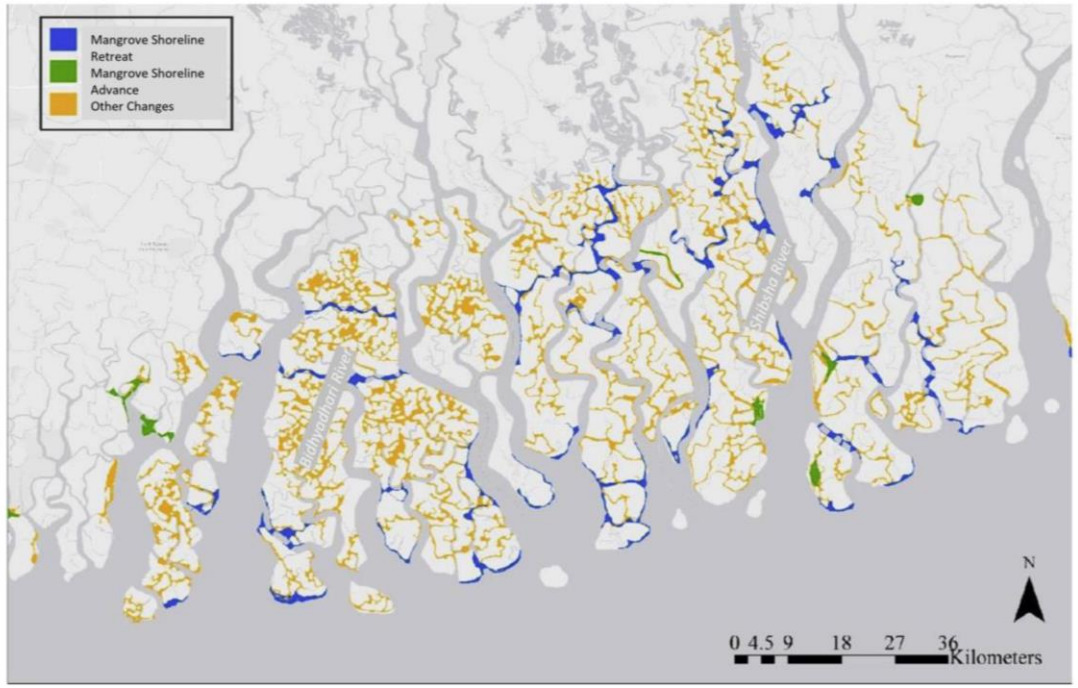


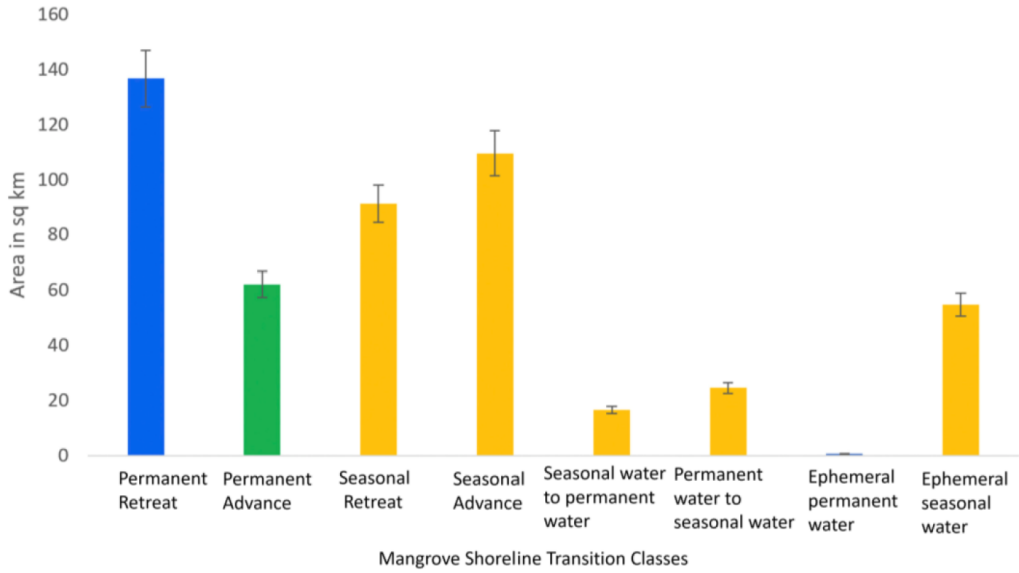


1985-2019

Bhargava et al. 2020

Non-permanent shoreline changes are also significant causes of change

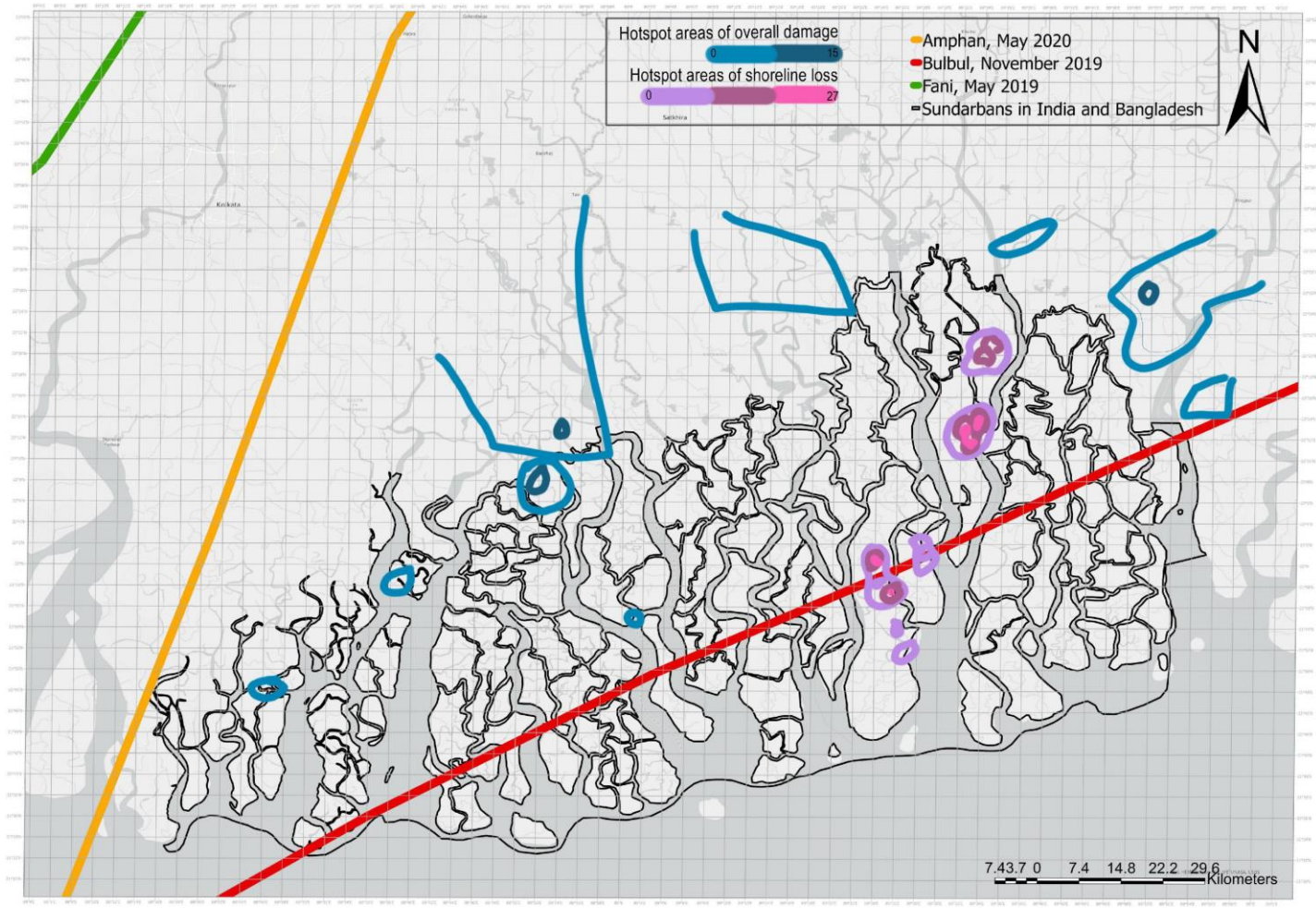




1985-2019

Bhargava et al. Estuary Coastal & Shelf Science 2020

Different cyclone paths but impacts are on same shoreline area



Classification
Accuracy > 97.2%
Kappa > 92%

Bhargava and Friess Frontiers on Marine Science 2022

Social impacts of mangrove shoreline retreat

Kalabogi, Bangladesh, November 2021

Kumirmari, India, September 2021

Images by the author

% of respondents who suffered from social impacts of shoreline retreat

94%	72%	31%	96%	45%	88%
Loss/damage to land	Loss/damage to houses	Water-borne diseases	Flooding	Transport disruption	Salt-water contamination

Multiple cycles of shoreline retreat and embankment reconstruction

Map by the author

Economic stress due to land loss and pre-existing vulnerabilities reduces the resilience of the community and increases the demand for embankments

Pre-existing Vulnerabilities

Lack of government support – **63%** of respondents

Lack of livelihood opportunities - **100%**

Mangrove degradation – **87%**

"We have to load and borrow as well. We have to work much harder to make ends meet. Somehow, we are managing. We are going through a difficult phase indeed"

Management Strategies

15% of the respondents have the means to migrate to inland areas

25% to migrate within the island

60% are or will become landless

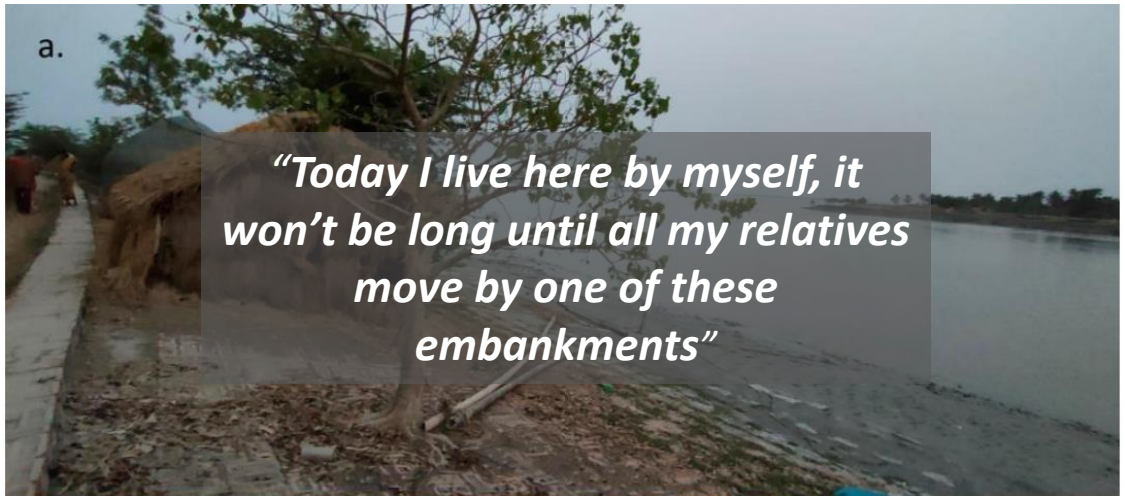
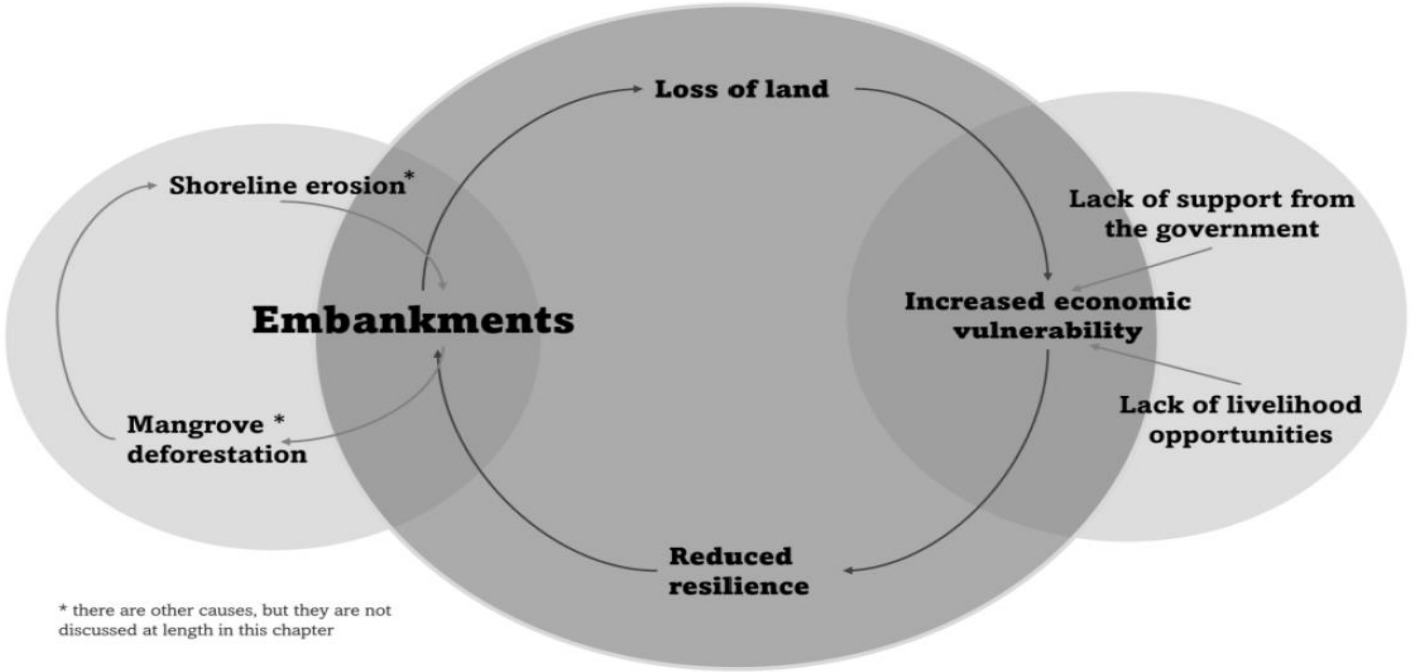


Image by the author

Failure of embankments in the presence of pre-existing vulnerabilities triggers a cycle of reduced resilience to shoreline retreat

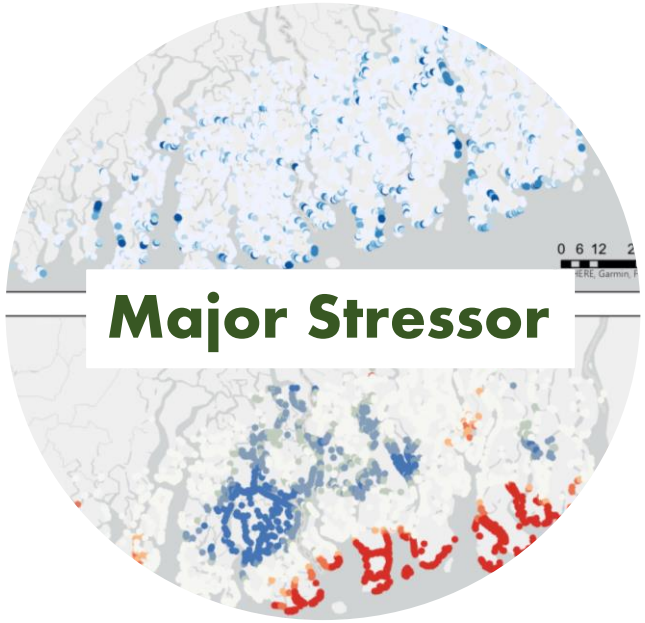
"We were better off. It is only after the land loss that things turned out this way. With passing generations, we are losing prosperity. We do not have much left."

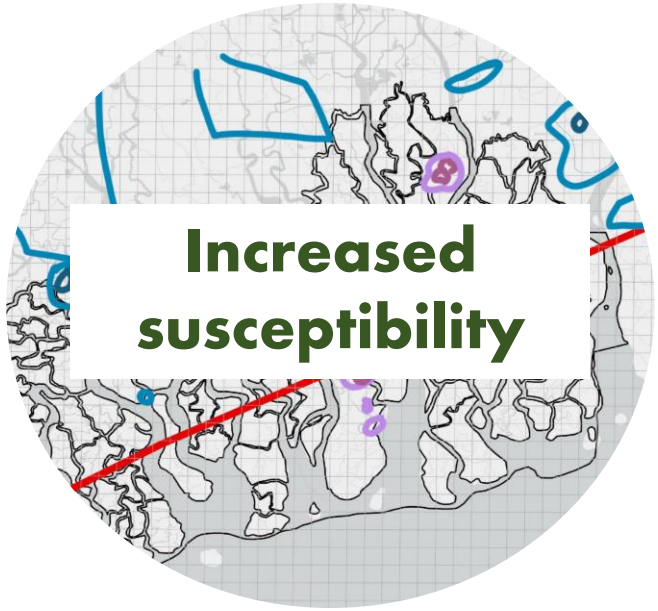


Bhargava et al. *In Prep*

Response of mangroves and shoreline-dwelling communities to coastal erosion

Increased vulnerability leads to broad biophysical and socio-economic characteristics **reinforcing** mangrove loss and mangrove shoreline retreat





One solution does not fit all shorelines!

Mangrove dominant shoreline

Potential restoration sites

Embanked Sites

Managing retreating and vulnerable mangrove shorelines

Supporting communities to enhance preparedness

Upstream Dams

Maritime Transportation

Image from Creative Commons

Managing causes of shoreline retreat

Images by the author

Carbon Biomass Estimates using Remote Sensing
Thank you!

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2021 National Geographic Explorer

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Asst. Proof, NUS Geography

Dan Friess

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