BLUE CARBON & CLIMATE CHANGE IN INDONESIA

SEAGRASS FUNCTION AND ITS RESOURCE VALUATION

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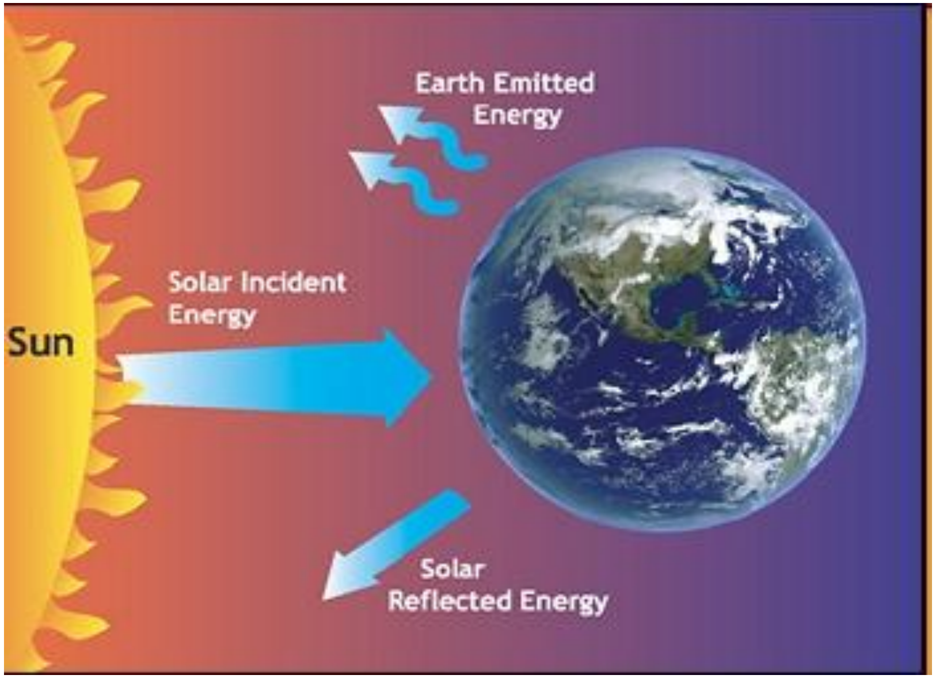
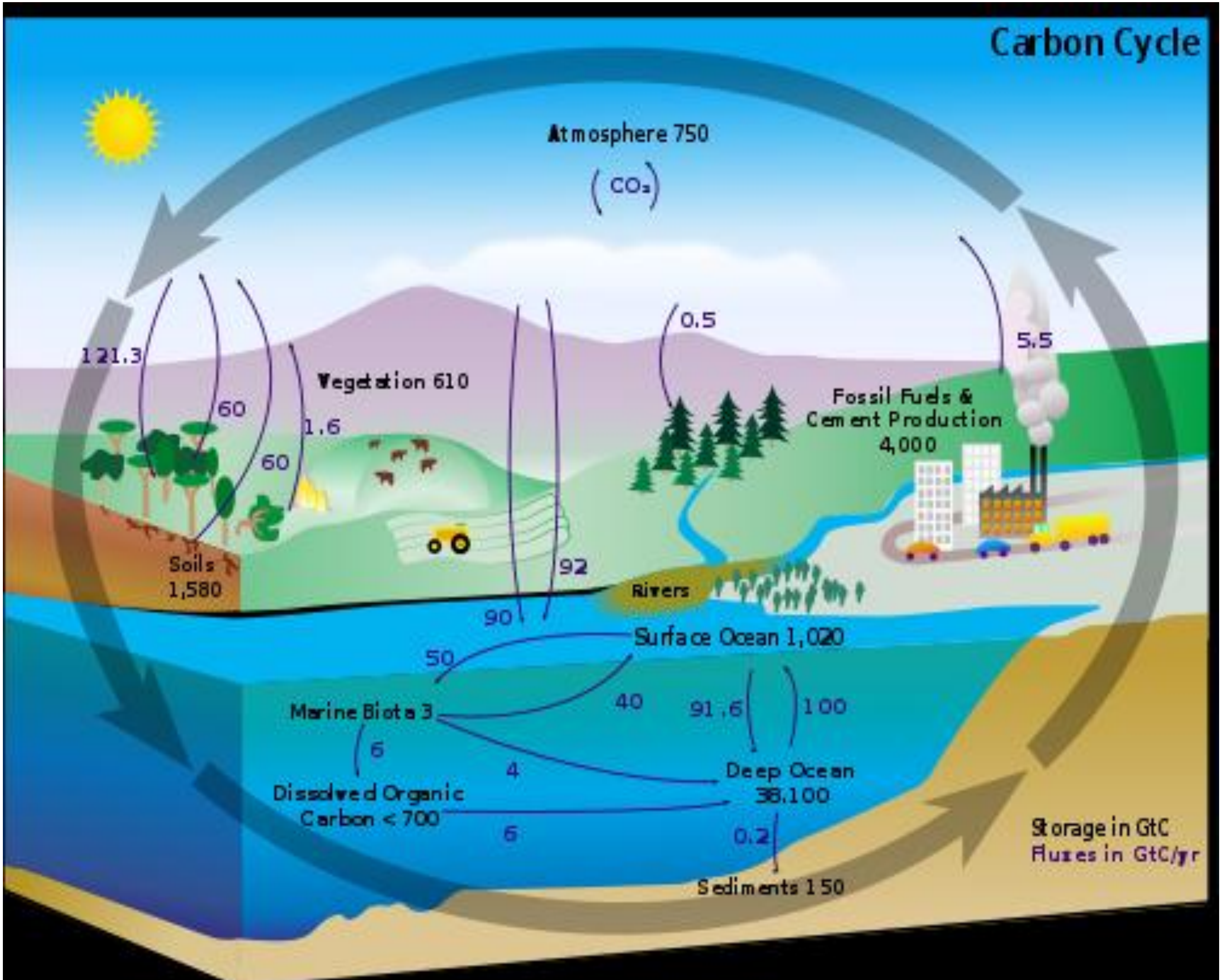
Jakarta, 2013

Oceans are warming: various ways of putting it

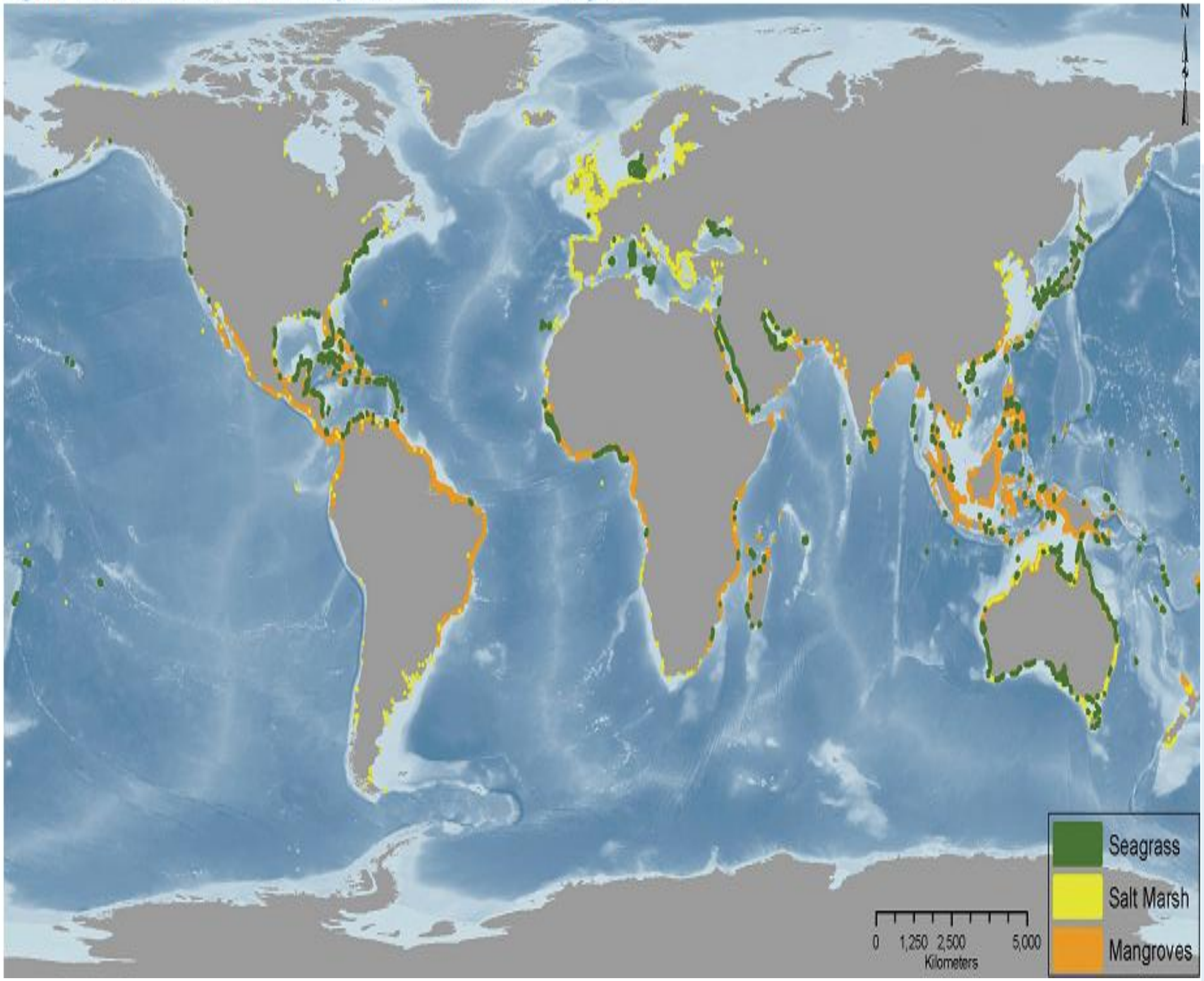
- Earth is burning!
- Human hand is involved in this fire.
- Smoke (CO_2) is all around us.
- C-footprint is strong.




Carbon Cycle
Atmosphere 750
CO₂
121.3
60
60
1.6
Vegetation 610
0.5
5.5
Fossil Fuels &
Cement Production
4,000
92
90
Soils
1,580
Rivers
Surface Ocean 1,020
50
40
Marine Biota 3
91.6
100
6
4
Deep Ocean
38,100
Dissolved Organic
Carbon < 700
6
0.2
Sediments 150
Storage in GtC
Fluxes in GtC/yr

What and Where is Blue Carbon?

Figure 1. Global distribution of seagrass, salt marsh, and mangroves.



Seagrass meadows are communities of underwater flowering plants found in coastal waters of all continents except the Antarctic. There are more than 60 known seagrass species and up to 10 to 13 of them may co-occur in tropical sites.

Tidal salt marshes are intertidal ecosystems occurring on sheltered coastlines ranging from the sub-arctic to the tropics, though most extensively in temperate zones. They are dominated by vascular flowering plants, such as perennial grasses, but are also vegetated by primary producers such as macroalgae, diatoms, and cyanobacteria.

Mangroves are salt-tolerant flowering plants, predominantly arboreal, that grow in the intertidal zone of tropical and subtropical shores. They are estimated to occupy almost 40% of tropical coasts worldwide, down substantially from 75% in the recent past.

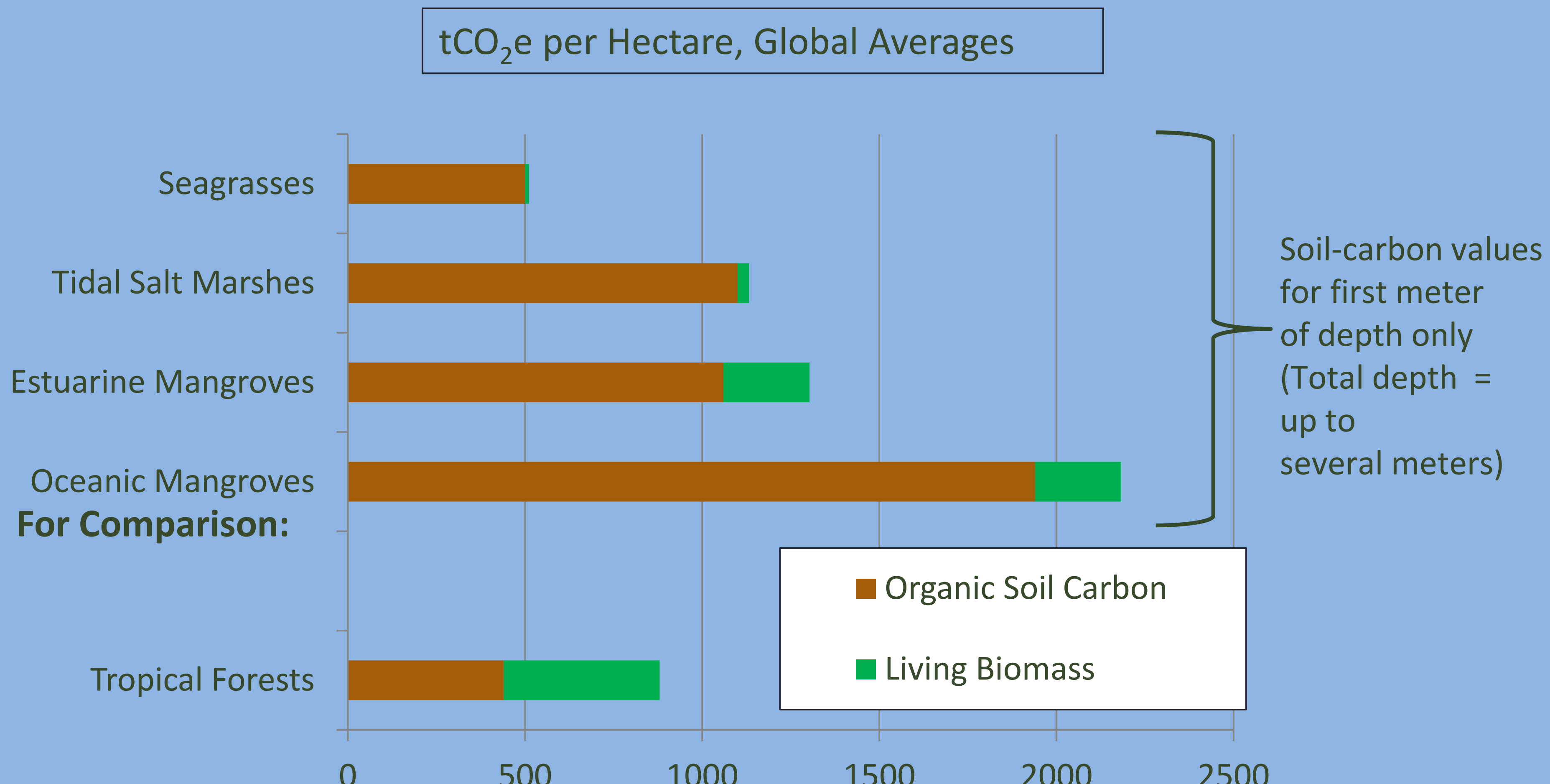
Source : Nicholas Institute for Env. Policy Solution

The Blue Carbon Story

- Coastal ecosystems are at great risk
  - Significant store of “blue carbon”
  - Many other ecosystem services
- Risks are driven by economic pressures to convert (aquaculture, agriculture, development,…)
- Global climate mitigation efforts could change economic incentives for protection
  - Payments for reducing conversion and restoration
  - Similar to forests (REDD+)
  - Not yet in UNFCCC system
- Initial test of concept
  - Science: how much carbon can be lost/restored over time
  - Economics: at what cost
  - Policy: can current policy frameworks adapt? New ones needed?

(source: modification from UNEP, 2012)

…Yield High Soil-Carbon Stocks



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Loss rates are high

Habitat Type	Global extent (km^2)	Annual Loss Rate (~1980–2000)	Total Historical Loss (%)
Seagrass	300,000–600,000[a]	1.2%–2%[b]	29[c]
Tidal Marsh	400,000[d]	1%–2%[e]	Centuries of conversion[f]
Mangroves	152,000–170,000[g]	0.8%–2.1%[h]	35[i]

Source : Nicholas Institute for Env. Policy Solution

What May Be Eligible for Crediting?

Potential Credit Source	**Time Period**	**Ecosystems**
Avoided Loss of Sequestration Flux	Perpetuity	Seagrasses Tidal Salt Marshes Mangroves
Avoided Emissions from Soil Carbon	Several Years to Decades	Seagrasses Tidal Salt Marshes Mangroves
Avoided Emissions from Biomass (REDD)	Immediate	Mangroves

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We need to lighten the C-footprint:

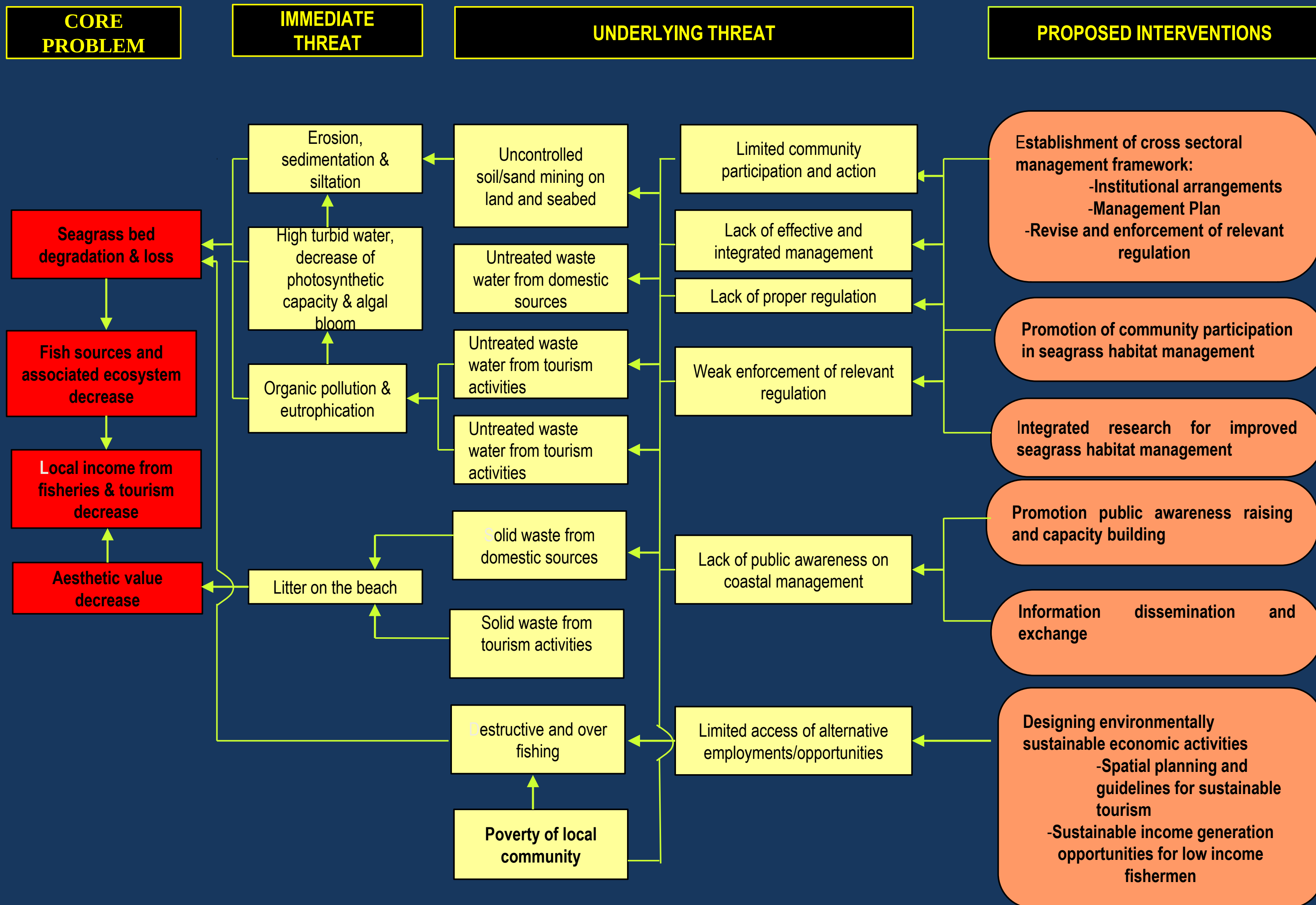
To save Oceans as a habitable environment & functioning ecosystem.

Projected scenarios: Reviews

1. Acidification
2. Warmer ocean (Ocean has absorbed 80% of heat added to Earth’s system by climate change).
3. Altered chemistry of seawater
4. Shift in key nutrients
5. Changes in key biogeochemical cycles
6. Reduced calcification (corals & shells)

One of Solution: Sequestration of CO_2

- Ocean sink
    - CO_2 ocean uptake
    - Ocean fertilization (uptake by marine plants)
    - Uptake by microalgae for biofuel
    - Storage below seabed



CAUSAL ANALYSIS OF THREATS

What are seagrasses?

Submerged marine flowering plants

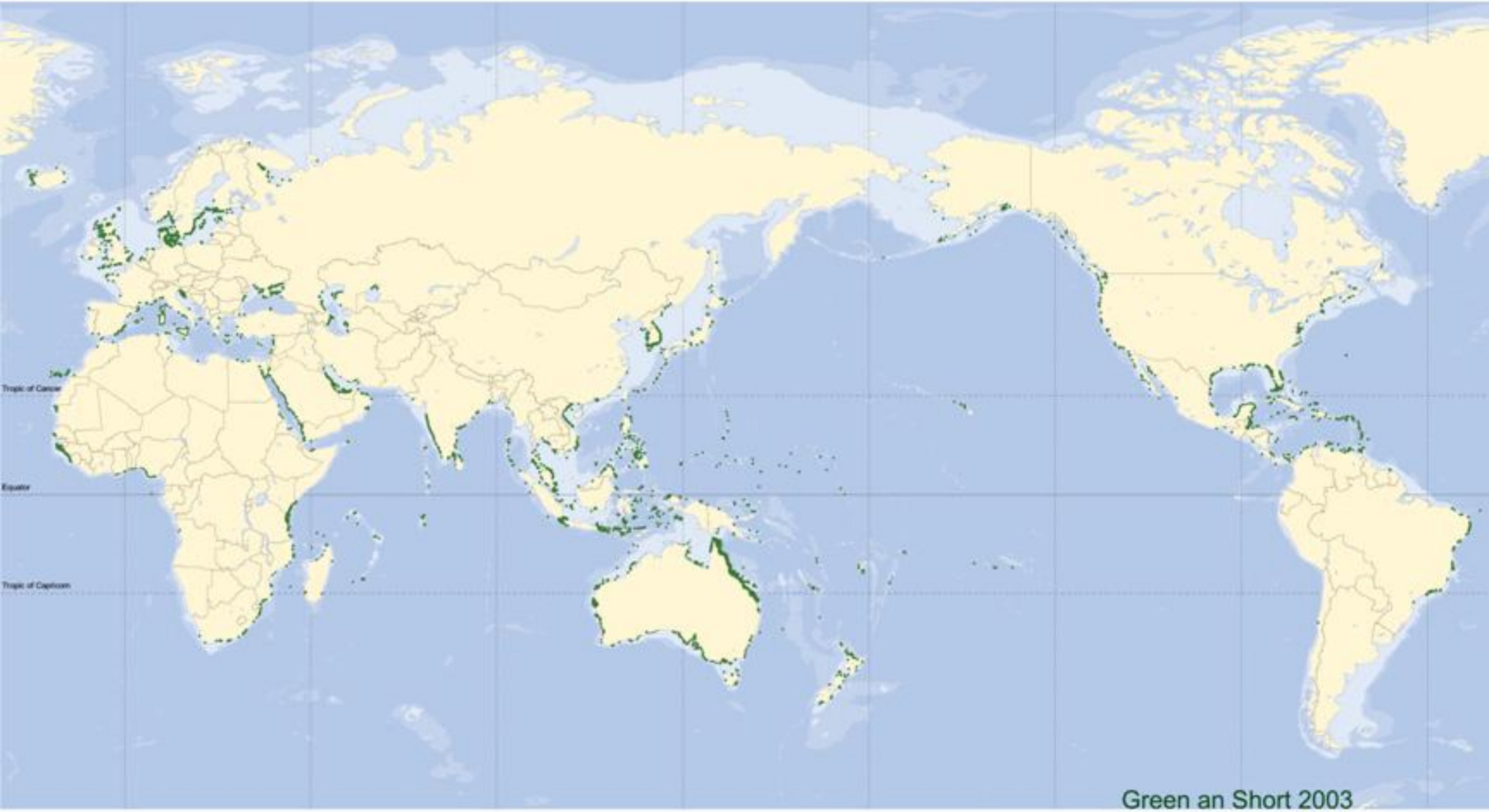
Belonging to Class Liliopsida within the Division Magnoliophyta

Structurally, seagrasses are similar to terrestrial grasses. All seagrasses are typically rhizomatous, they have prostrate underground stems (or rhizomes), with developed air channels

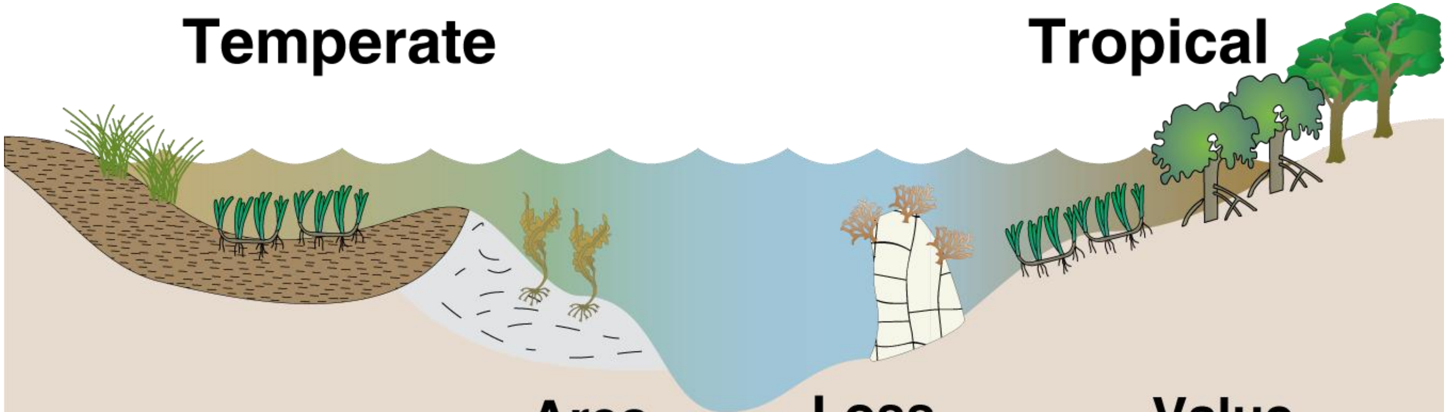
Seagrass plants have two flowering forms

1. **Monoecious : male and female flowers borne on the same plant**
2. **Dioecious : male and female flowers occur on separate plants**

Seagrasses have a broad global distribution



Seagrasses are valuable and threatened compared to other major marine habitats



Ecosystem	Area (10^6 ha)	Loss (% $year^{-1}$)	Value (US$ ha^{-1} $year^{-1}$)
Seagrass	18	2–5	19 004
Salt marsh	140	1–2	9 990
Mangrove	15	1–3	9 990
Coral	62	4–9	6 075
Tropical forest	1 900	0.5	2 007

Source : PEMPSEA, 2012)

But what about the value of the Blue Carbon stored in the system?

Research Location

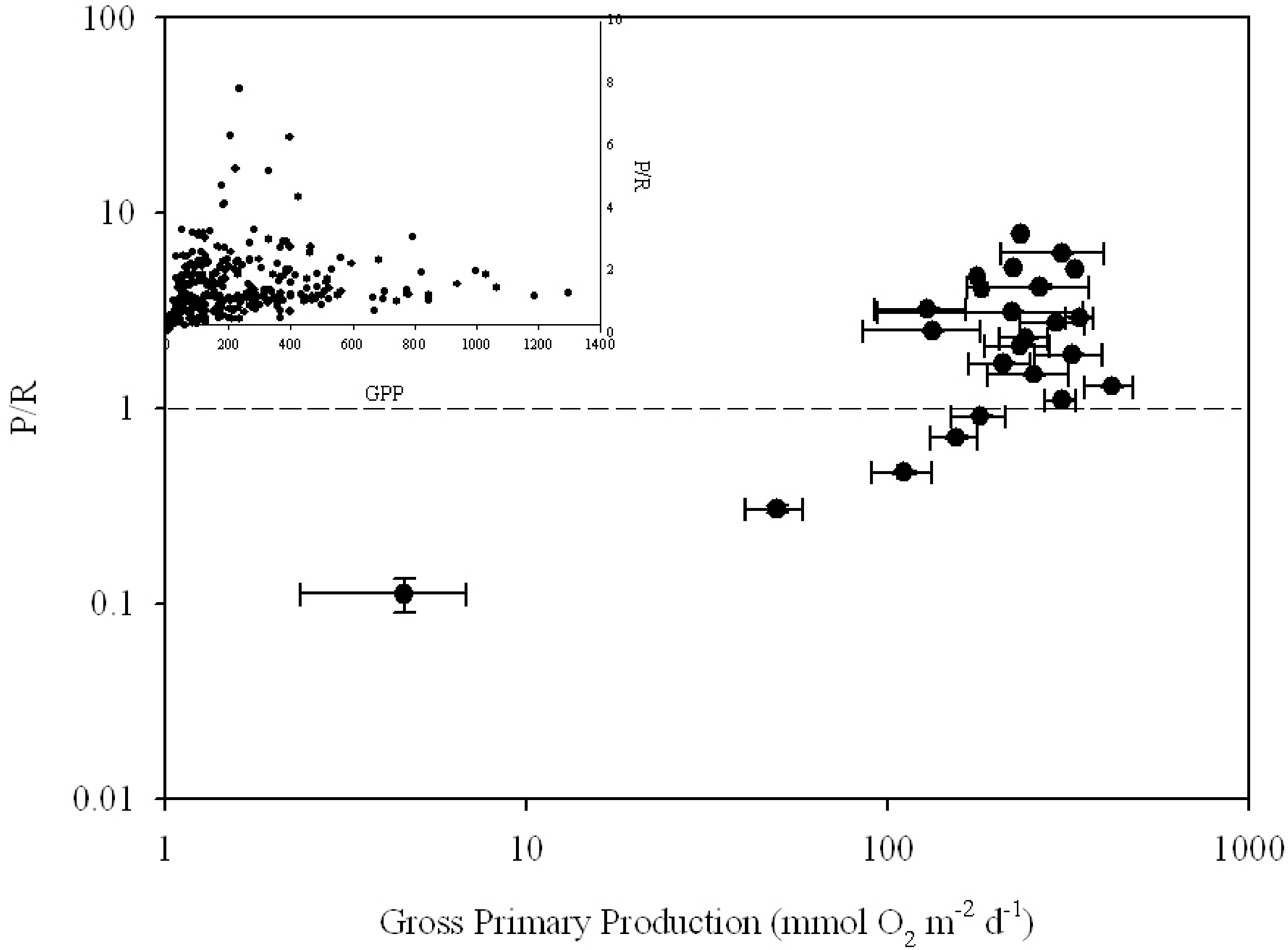
TRIKORA BEACH

- **BENEFITS**:
  - ECOSYSTEM BENEFITS
  - BENEFITS FOR FISHES AND OTHER MARINE ANIMALS
  - LOCAL BENEFITS

- **EXPECTED OUTCOMES:**
  - MANAGEMENT OF THE AREA IMPROVED
  - AWARENESS IS IMPROVED
  - ENVIRONMENTALLY SUSTAINABLE OF LOCAL ECONOMIC ACTIVITIES INCREASED

- **MAJOR COMPONENTS OF ACTIVITIES:**
  - **IMPROVING THE MANAGEMENT OF SEAGRASS AND ASSOCIATED HABITATS**
  - **AWARENESS RAISING AND CAPACITY BUILDING**
  - **PROMOTING ENVIRONMENTALLY SUSTAINABLE ECONOMIC ACTIVITIES**

A new realization: seagrasses are important in the global carbon balance - Dense seagrass beds fix more CO_2 than they consume



Estimates of global CO_2 flux in seagrass beds

	NCP	low estimate of global extent	Integrated NCP	high estimate of global extent	Integrated NCP
	tons $CO_2e\ ha^{-1}y^{-1}$	km^2	Tg $CO_2e\ y^{-1}$	km^2	Tg $CO_2e\ y^{-1}$
Mean	4.4	300000	130.7	600000	261.4
Upper 95th cl of mean	6.2	300000	185.5	600000	371.1
Lower 95th cl of mean	2.5	300000	75.9	600000	151.8
maximum	85.4	300000	739.2	600000	1478.3

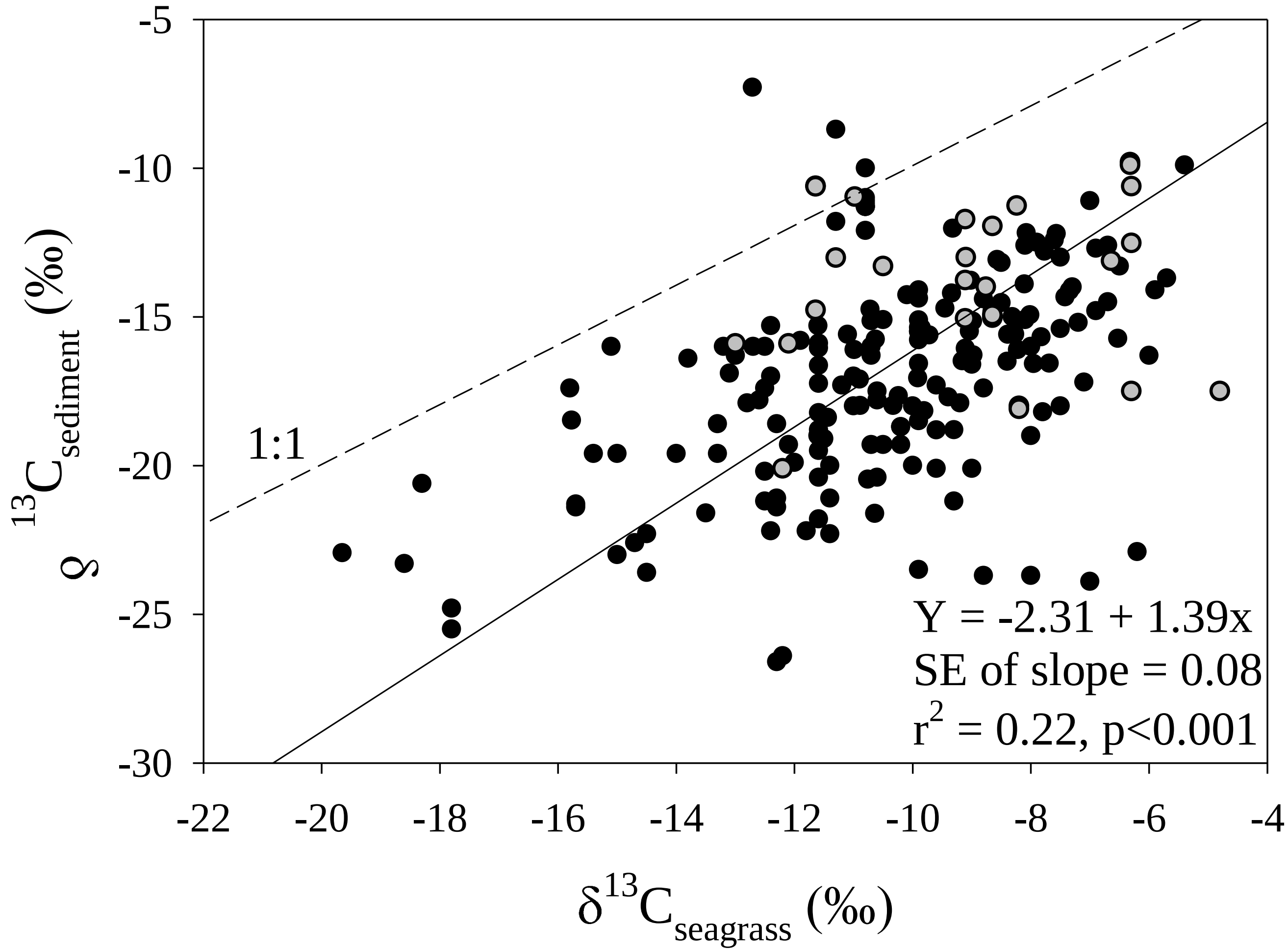
At $20/ton, the NCP value of seagrasses is about $88 $ha^{-1}y^{-1}$, small compared to the $19k for nutrient processing or $3k of fisheries yield

For comparison, mean NCP for:

wetlands = 0.6 tons $CO_2e\ ha^{-1}y^{-1}$

Amazon rainforest: 3.7 tons $CO_2e\ ha^{-1}y^{-1}$

Only about half of the C buried in seagrass beds is derived from seagrass



Source Kennedy et al 2010 GBC

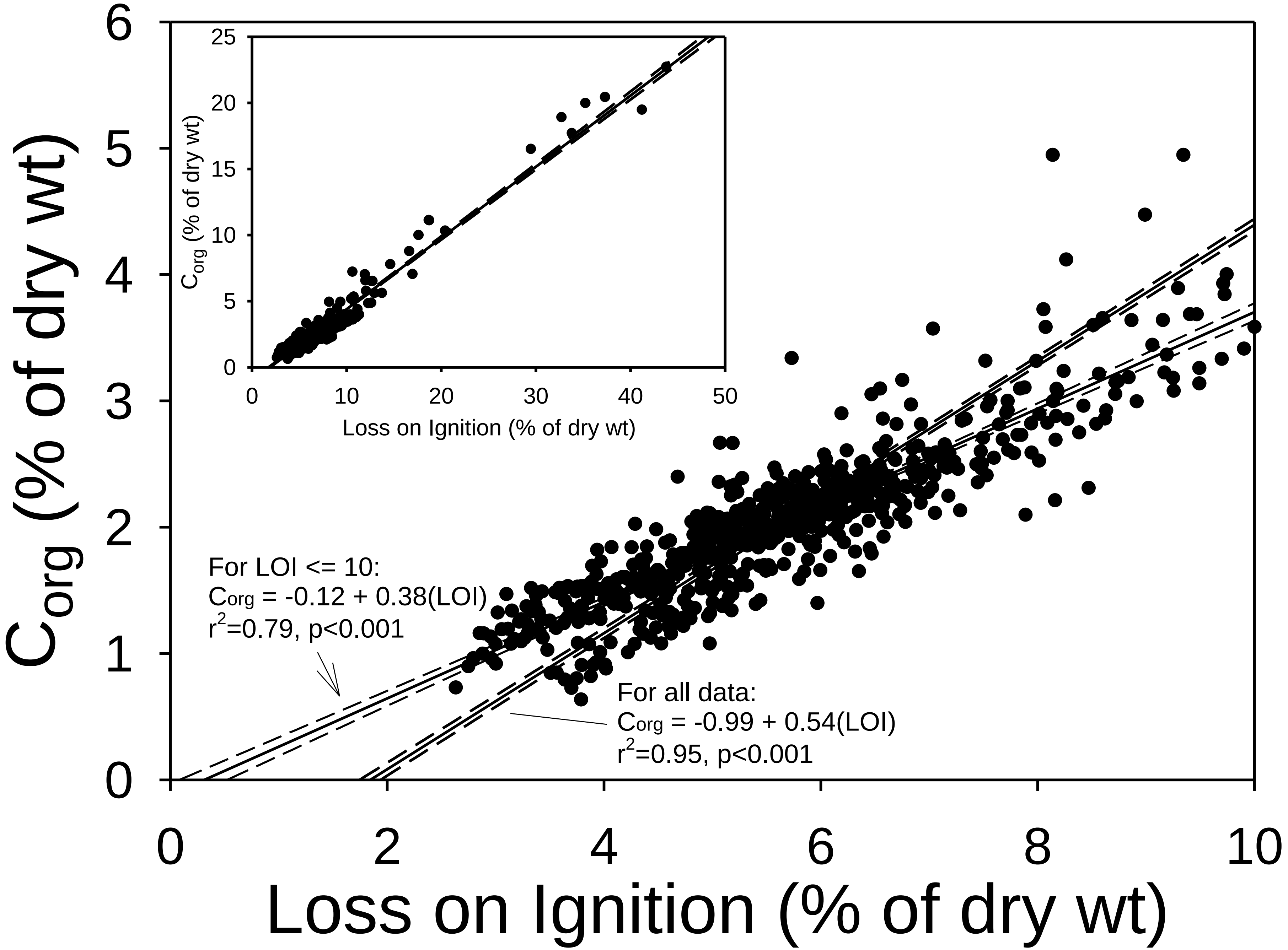
So, how much C is stored in seagrass ecosystems?

- **Measuring C storage in some Seagrass ecosystems:**
  - **Bintan waters**
- **Literature review of C stores in seagrasses**
- **Back-of-the-envelope estimates of the sizes of stocks and potential value of those stocks in a global CO_2 market**

Measuring C stored in living biomass

Need:

- **volumetric measures of Dry Bulk Density (mass of soil per volume)**
- **Carbon content of soil (as a fraction of mass)**
  - **Organic matter, or Loss on Ignition (LOI)**
  - **C_{org}**



6
5
4
3
2
1
0
0
2
4
6
8
10
C_{org} (% of dry wt)
Loss on Ignition (% of dry wt)
For LOI <= 10:
C_{org} = -0.12 + 0.38(LOI)
r^2=0.79, p<0.001
For all data:
C_{org} = -0.99 + 0.54(LOI)
r^2=0.95, p<0.001
25
20
15
10
5
0
0
10
20
30
40
50
C_{org} (% of dry wt)
Loss on Ignition (% of dry wt)

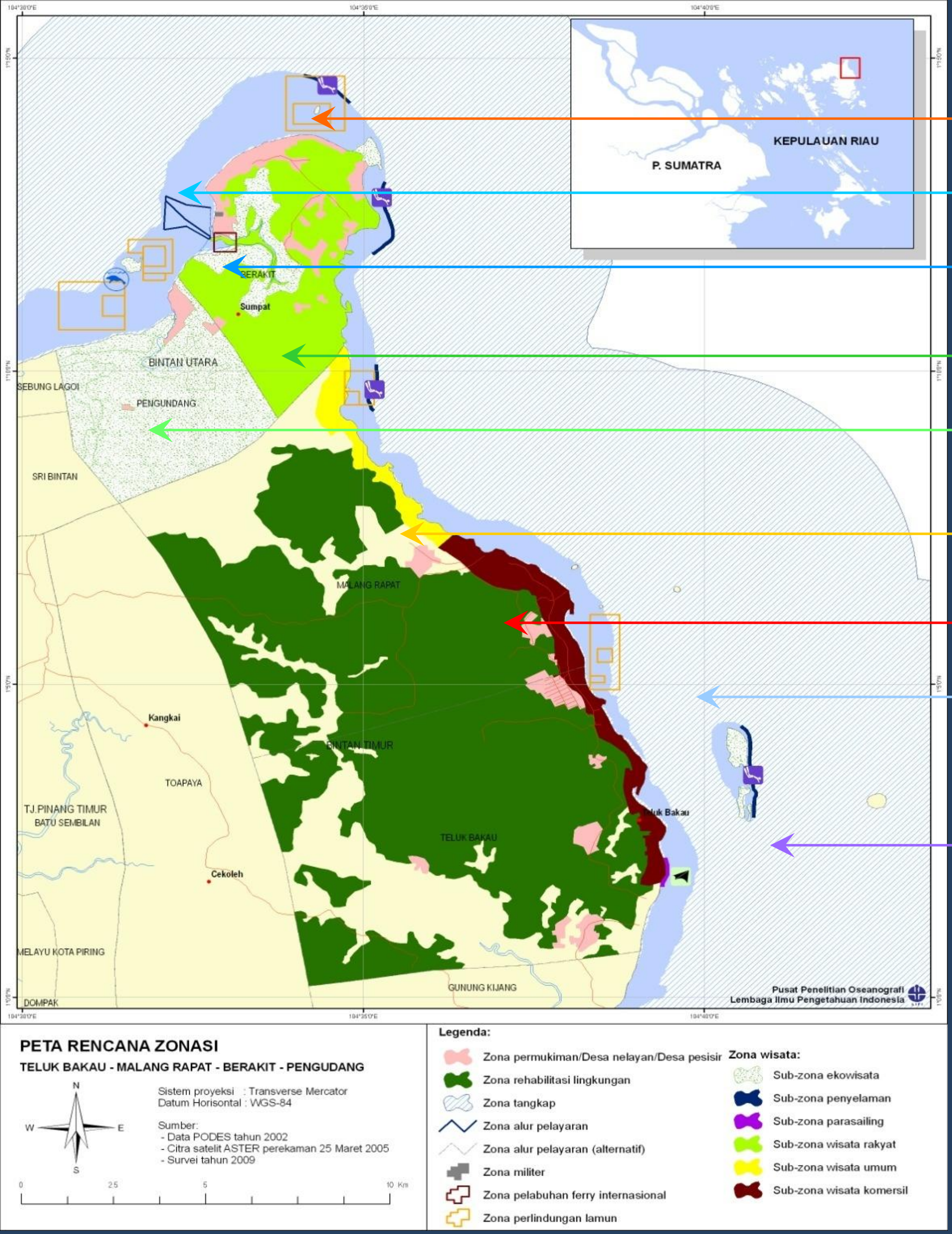
A very rough estimate of carbon stored in the top meter of seagrass soils in Bintan Water

18,000 km^2 of seagrasses
594 tons CO_2e ha^{-1}

1 x 10^9 tons CO_2e stored in the soils!

Anthropogenic CO_2e flux is about 29 x 10^9 tons y^{-1}

Zonation of Bintan Coastal



Seagrass Protection Zone)

Limited Utilization Zone

Ship traffic Line Zone

Tourism Village Sub- Zone

Ecotourism Sub-Zone

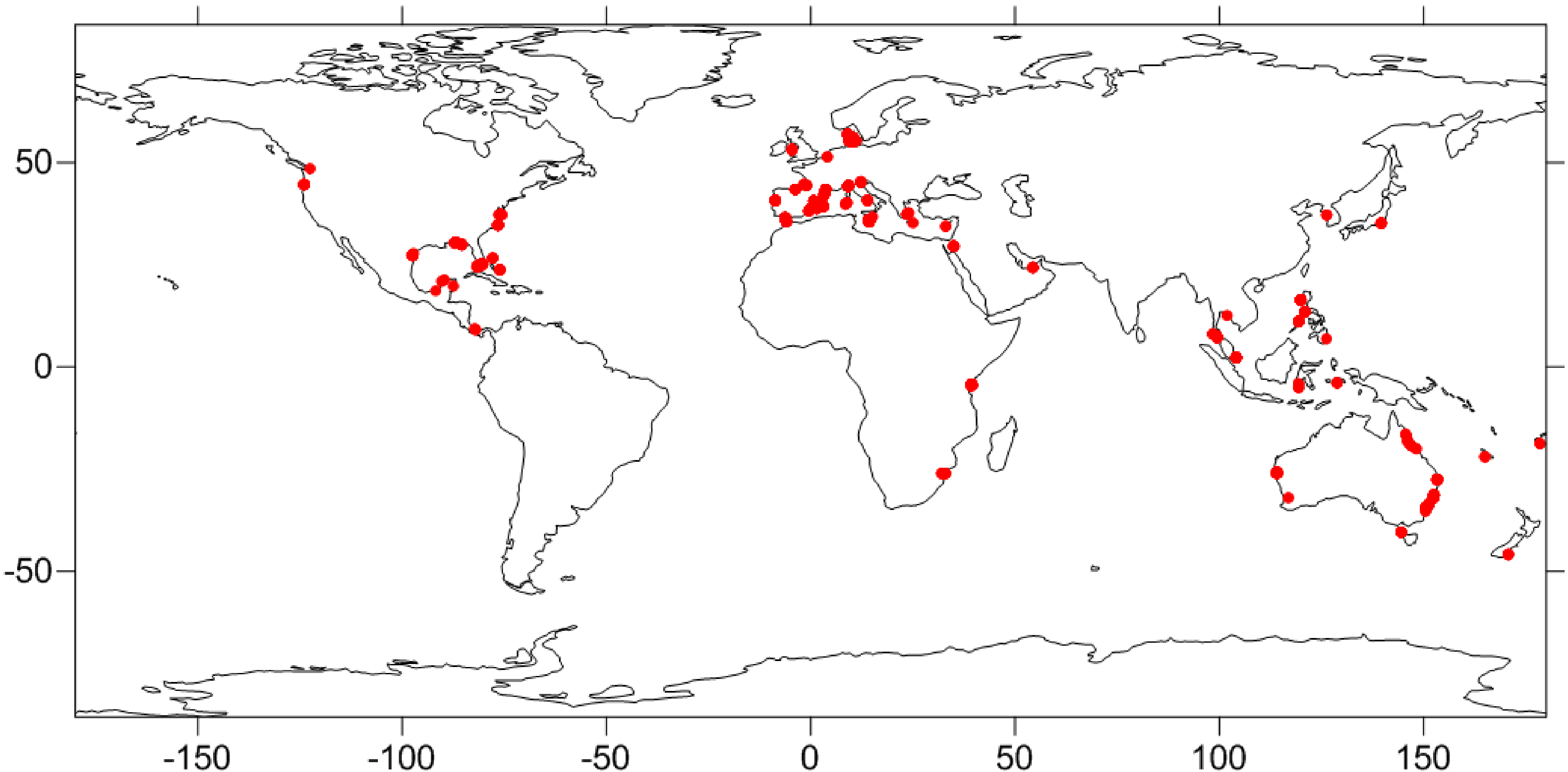
Common Tourism Sub Zone

Comercial Tourism Sub Zone

Capture Fisheries Sub Zone

Diving Activity Sub Zone

Towards an estimate of global Seagrass Blue carbon stocks



3576 data points from 882 discrete sample locations

Global averages carbon sequestration rates and global ranges for the main carbon pools, by habitat type

Habitat Type	Annual Carbon Sequestration Rate ($tCO_2e/ha/yr$)	Living biomass (tCO_2e/ha)	Soil organic carbon (tCO_2e/ha)
Seagrass	4.4 ± 0.95[a]	0.4–100[b]	66–3040[c]
Tidal Marsh	7.97 ± 8.52[d]	12–60[e]	330–1,980[f]
Estuarine Mangroves	6.32 ± 4.8[g]	237–563[h]	1,060[h]
Oceanic Mangroves	6.32 ± 4.8[g]	237–563[h]	1,690–2,020[h]

Table 1. Estimates of total carbon (C) at risk of release, including biomass carbon and soil organic carbon in the top meter of soil beneath coastal habitats.

Habitats	Soil Organic Carbon at risk (top meter, $tCO_2e\ ha^{-1}$)	Total Carbon at risk including biomass ($tCO_2e\ ha^{-1}$)	Current Habitat Extent (Mha)	Total Carbon in Habitat (BtCO2e)	C loss from annual habitat conversion - 0.7% rate ($BtCO_2e\ yr^{-1}$)	C loss from annual habitat conversion - 2% rate ($BtCO_2e\ yr^{-1}$)	Economic costs of habitat loss - 0.7% rate (Billion US\$ yr^{-1})	Economic costs of habitat loss - 2% rate (Billion US\$ yr^{-1})
Salt Marsh	917	949	5.1	4.8	0.03	0.10	1.4	4.0
Mangroves	1298	1762	13.8	24.3	0.17	0.49	7.0	19.9
Seagrass	500	511	30	15.3	0.11	0.31	4.4	12.6
Total			48.9	44.5	0.31	0.89	12.8	36.5

Note: Carbon loss estimates with conversion assume complete loss of carbon in biomass and the top meter of soil; these estimates are nevertheless conservative since most areas contain deeper soils up to several meters which may also be affected by habitat conversion, though there is less scientific certainty on the fate of deeper soil layers.

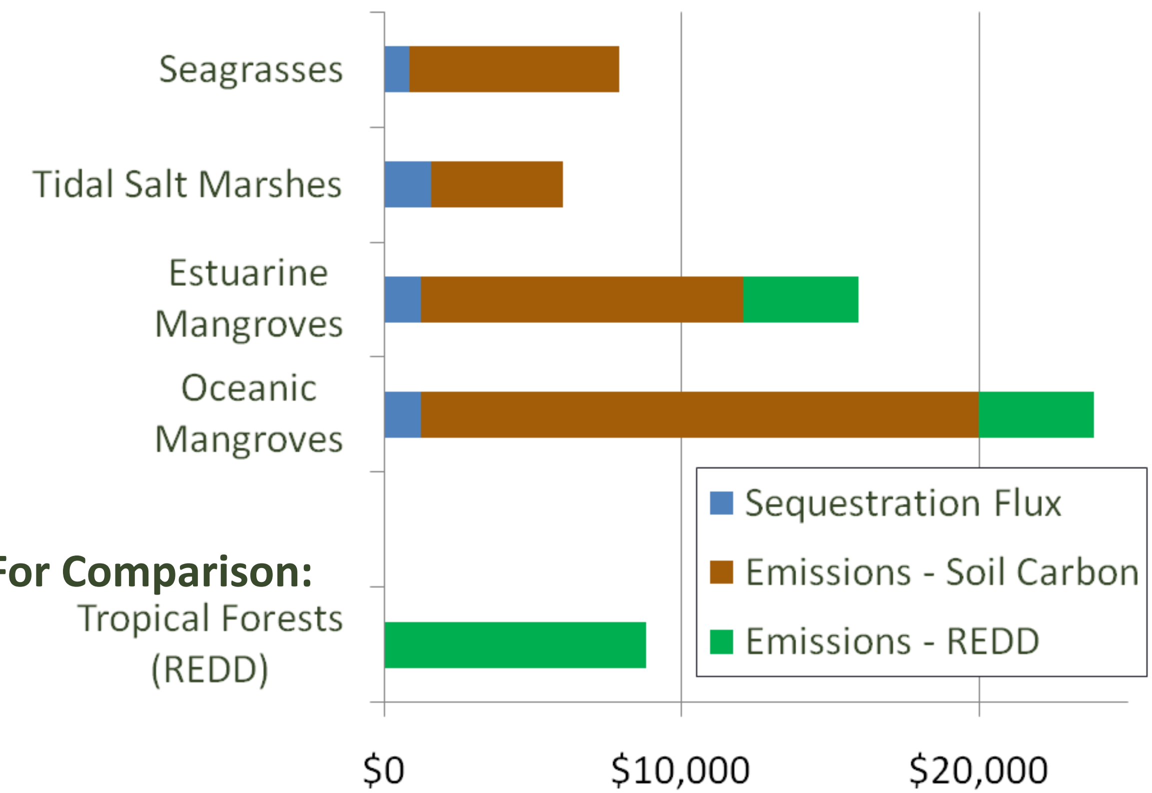
Pendelton et al. in review

Points to remember:

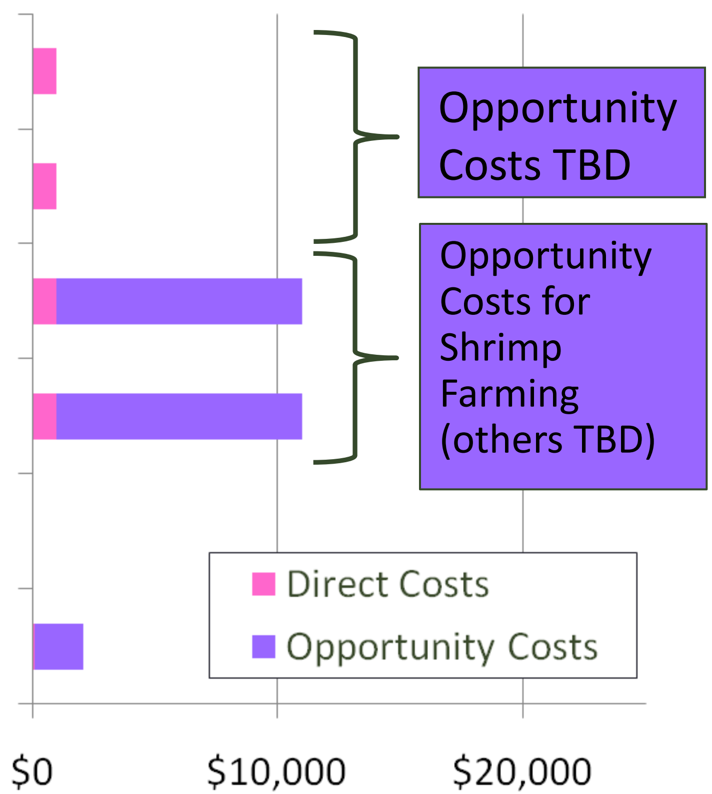
1. **Seagrasses play a significant part in the global C cycle**
2. **Bintan Waters have huge C stocks**
3. **Globally, seagrasses are as important as forests in storing CO_2 (on an areal basis)**
4. **The value of the C stored in seagrasses is around \$12,000 ha^{-1}, on par with the annual value of other ecosystem services provided by seagrasses**
5. **Seagrasses are declining at a fast rate, potentially releasing 0.1 – 0.3 Gton CO_2e y^{-1} (worth ca. \$4-12 B y^{-1} at current market values)**
6. **Can seagrasses be included in a REDD+-like scheme? Who would get the payments?**
7. **Big job ahead: predicting the fate of stored C when seagrasses are destroyed**

The Economics May Work in Some Cases

Potential Carbon-Credit Values



Cost of Protection



Values Vary by Location, Destruction Method and Economic Activity

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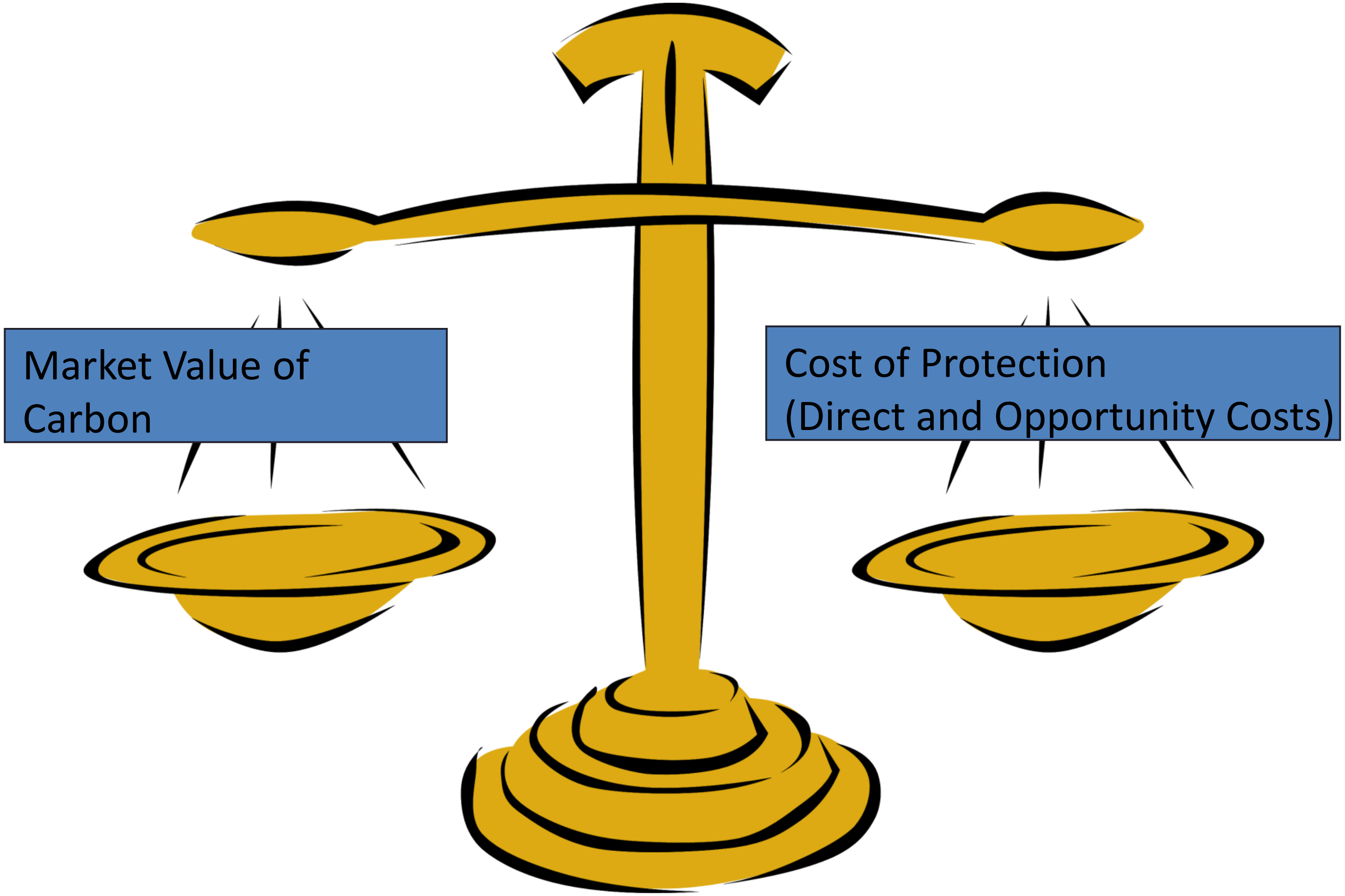
Can the Economics Work?



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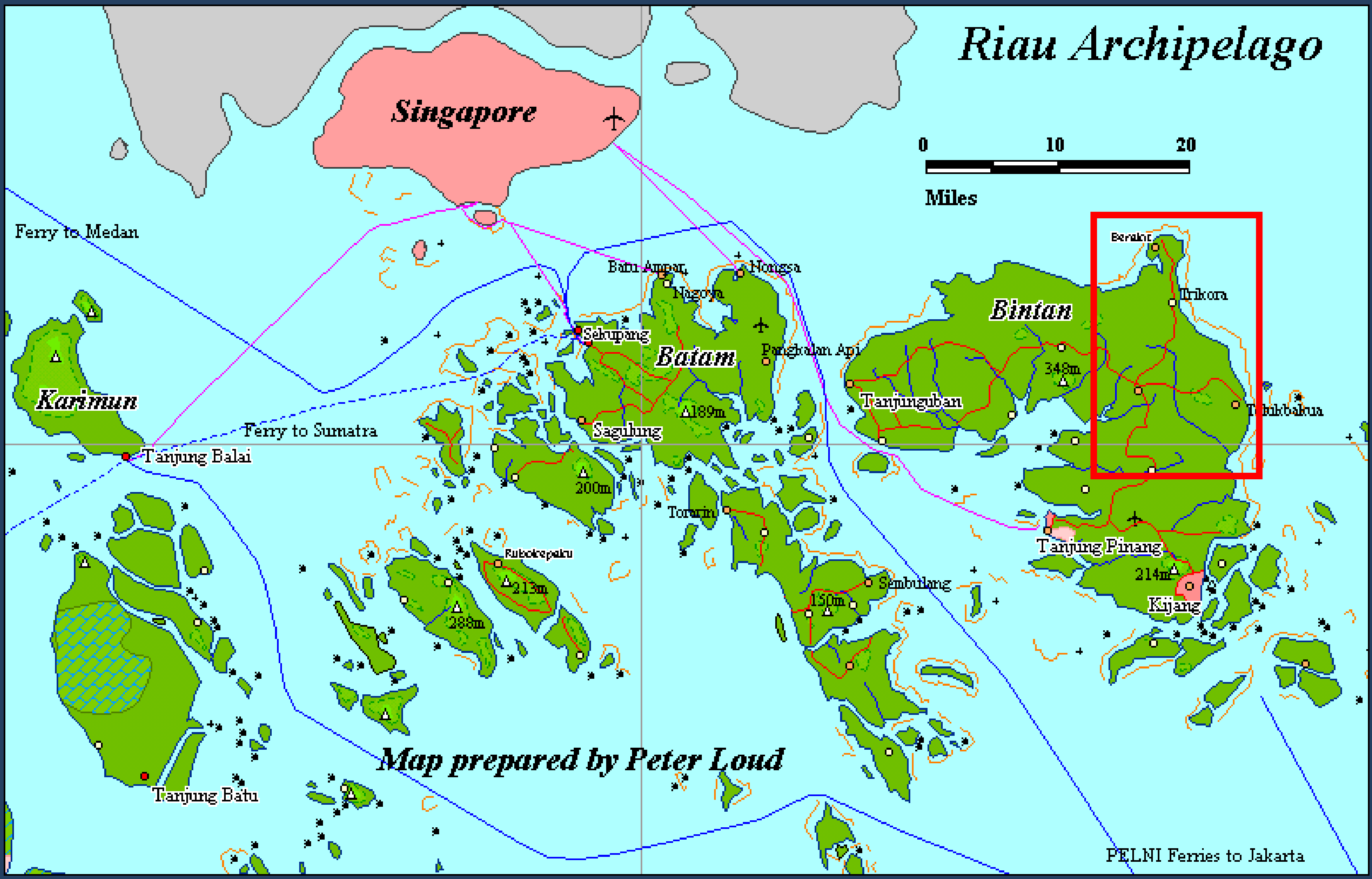
ECONOMIC VALUATION OF EAST BINTAN SEAGRASS ECOSYSTEM

STUDY SITE



Riau Archipelago
Singapore
0
10
20
Miles
Ferry to Medan
Batu Ampar
Nongsa
Nagoya
Sekupang
Batam
Pangkalan Api
Bintan
Trikora
348m
Tanjunguban
Telukbakau
189m
Sagulung
Karimun
Ferry to Sumatra
Tanjung Balai
200m
Torurin
Tanjung Pinang
214m
Kijang
Sembulang
150m
213m
288m
Map prepared by Peter Loud
Tanjung Batu
PELNI Ferries to Jakarta

EAST BINTAN SEAGRASS BEDS

- **TOTAL AREA : 2,093.66 HA**
  - TANJUNG BERAKIT : 847.29 HA
  - MALANG RAPAT : 595.32 HA
  - TELUK BAKAU : 147.02 HA

- **SPECIES DIVERSITY :11 SPECIES i.e.**

  H.u., H.p., C. r., C.s., S.i., Th.c., E.a., Th.h., H.o., H.d., H.s. (ISC 2005)

ECONOMIC VALUATION
EAST BINTAN SEAGRASS AND ITS ASSOCIATED HABITAT

- ***Direct use value*: Fisheries Production**
  - ***Type of gears:***
    - **Kelong**
    - **Net**
    - **Sampan (dinghy)**
    - **Crab trap**
    - **FAD**
    - **Kelong darat**

VALUATION METHODS

- Combination of market value
- Based on in-depth interview and questionnaire

Table 1: Total Economic Value of Seagrass from Fisheries Sector

No	Location	Type of Gear	Total Type of gear	Total involvement of: Households	Total involvement of: Residents *)	Total Income Household per year (Rp.)	Total Revenue per year (Rp.)
1	Teluk Bakau	Kelong	28	56	280	18,000,000	1,008,000,000
		Net	10	20	100	11,700,000	234,000,000
		Dinghy	3	3	15	4,800,000	14,400,000
		Crab trap	20	20	100	6,660,000	133,200,000
		Kelong Darat	3	3	15	8,400,000	25,200,000
			64	**102**	**510**		**1,414,800,000 (US$157,200)**
2	Malang Rapat	Kelong	40	80	400	18,000,000	1,440,000,000
		Net	42	84	420	11,700,000	982,800,000
		Dinghy	7	7	35	4,800,000	33,600,000
		FAD.	4	16	80	37,500,000	600,000,000
			93	**187**	**935**		**3,056,400,000 (US$339,600)**
3	Tanjung Berakit	Kelong	38	76	380	18,000,000	1,368,000,000
		Net	50	100	500	11,700,000	1,170,000,000
		Dinghy	19	19	95	4,800,000	91,200,000
		Artificial Dev.	20	80	400	37,500,000	3,000,000,000
		Kelong Darat	10	10	50	8,400,000	84,000,000
			137	**285**	**1425**		**5,713,200,000 (US$634,800)**
Total Economic Value			**294**	**574**	**2,870**		**10,184,400,000 (US$1,131,600)**

Note:
*) It is measured based on the estimation that one household consists one fisher, one wife and three Children
Source:
Based on data analysis from study sites

CAPTURE FISHERIES

- 2870 fishers (65% of total East Bintan residents)
- Valuation based on actual income gained from actual works of fishers (6-7 month/year):
  - Tg. Berakit : Rp. 5,713,200,000 or US$ 634,800 per year
  - Malang Rapat: Rp. 3,056,400,000 or US$339,600 per year
  - Teluk Bakau : Rp. 1,414,800,000 or US$157,200 per year

- Total value from capture fisheries:
  - Rp. 10,184,400,000 or US$ 1,131,600 per year

ECONOMIC VALUATION

- ***Indirect Use Value:***
  - **Tourism activities (Foreign and local tourists)**
  - **Valuation using travel cost method**

NUMBER OF TOURISTS AND THEIR SPENDING-TRAVEL COST METHOD

- **13,832 Singaporean and foreign visitors annually and average spend two nights**
  - **Conservative estimate of expenditure US$185 or Rp 1,530,000)**
  - **Total expenditure US$ 2,352,440 or**
  - **Rp 21,162,960,000)**
- **9,620 local tourists annually, their expenditures US$10,00 or Rp. 90.000/visit**
  - **Total expenditure per year US$ 96,200 or Rp. 865,800,00**
- Total economic value of tourism sector:

US$2,447,640 or Rp 22,028,760,000 per year

ECONOMIC VALUATION

- *Indirect Use Value:*
  - *Education value as research object*
  - *Valuation technique developed by White & Cruze-Trinidad (1998)→ calculation of project cost of research output → using data recorded by RCO-LIPI and some research project by local students*

PROJECT COST OF RESEARCH OUTPUT (White & Cruz-Trinidad 1998)

- Using data recorded by Research Centre for Oceanography-Indonesian Institute of Sciences and some research project of students

- **Total cost of seagrass project:**
  - **US$55,556 or Rp.500,000,000**

Table 2: Total Economic Value of Seagrass

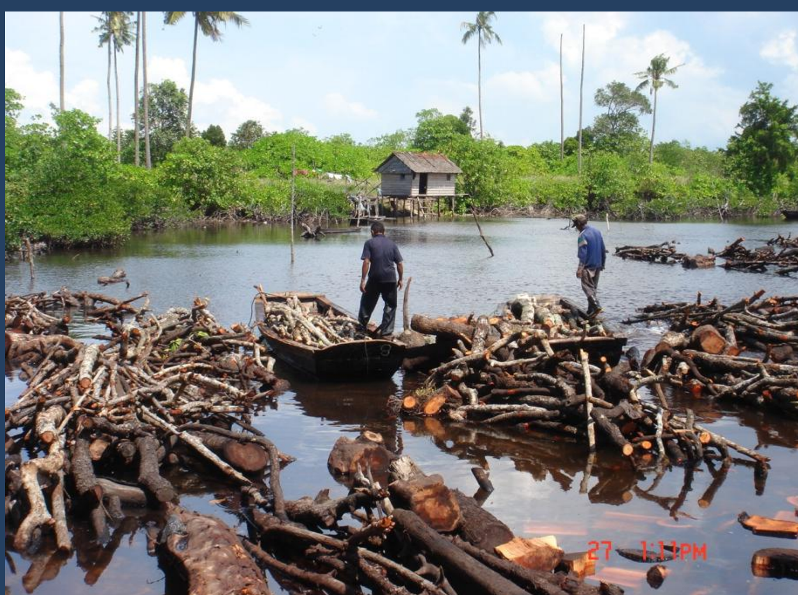
No	Activity	Value	Total Economic Value	
			Rp	US$
A	Use Value			
	Direct Use Value			
1	Fisheries	Direct Use Value	10,184,400,000	1,131,600
2	Food	Direct Use Value	*Not accounted*	
3	Medicinal	Direct Use Value	*Not accounted*	
4	Fertilizer	Direct Use Value	*Not accounted*	
5	Handy craft	Direct Use Value	*Not accounted*	
	Sub Total		10,184,400,000	1,131,600
	Indirect Use Value			
1	Marine Tourism	Indirect Use Value	22,028,760,000	2,447,640
2	Research Object	Indirect Use Value	500,000,000	55,556
	Sub Total		22,528,760,000	2,503,196
B	Non Use Value			
1	Existence Value	Direct / Indirect Value	*Not accounted*	
2	Option Value	Direct / Indirect Value	*Not accounted*	
3	Bequest Value	Direct / Indirect Value	*Not accounted*	
	Total Economic Value		32,713,160,000	3,634,796
	Total Seagrass Area (ha)		1,590	
	Total Economic Value per ha per year		20,579,103	2,287

HUMAN INDUCED THREATS

- Sand mining →sedimentation→ impact on water clarity and cover seagrass→ decrease → photosynthesis
- Blast and poison fishing → degrade coral and seagrass
- Mangrove cutting →sedimentation → degrade other neighboring ecosystems → decrease fisheries production and disturb coastal amenities


24 9:08AM


27 1:14PM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CONCLUDING REMARKS

- Economic gain of East Bintan seagrass bed is estimated: US$3,634,796 or US$2,287/ha/year
- Marine tourism contributed highest US$2,447,640/year
- Capture fisheries absorb highest labor force: 574 households or 2870 peoples and contributed US $ 1,131,600/year
- Tourisms absorb 150 households or 750 peoples
- Integrated and sustainable management is needed

What Next?

Estimate stocks, emission rates and protection costs under a wider range of conditions

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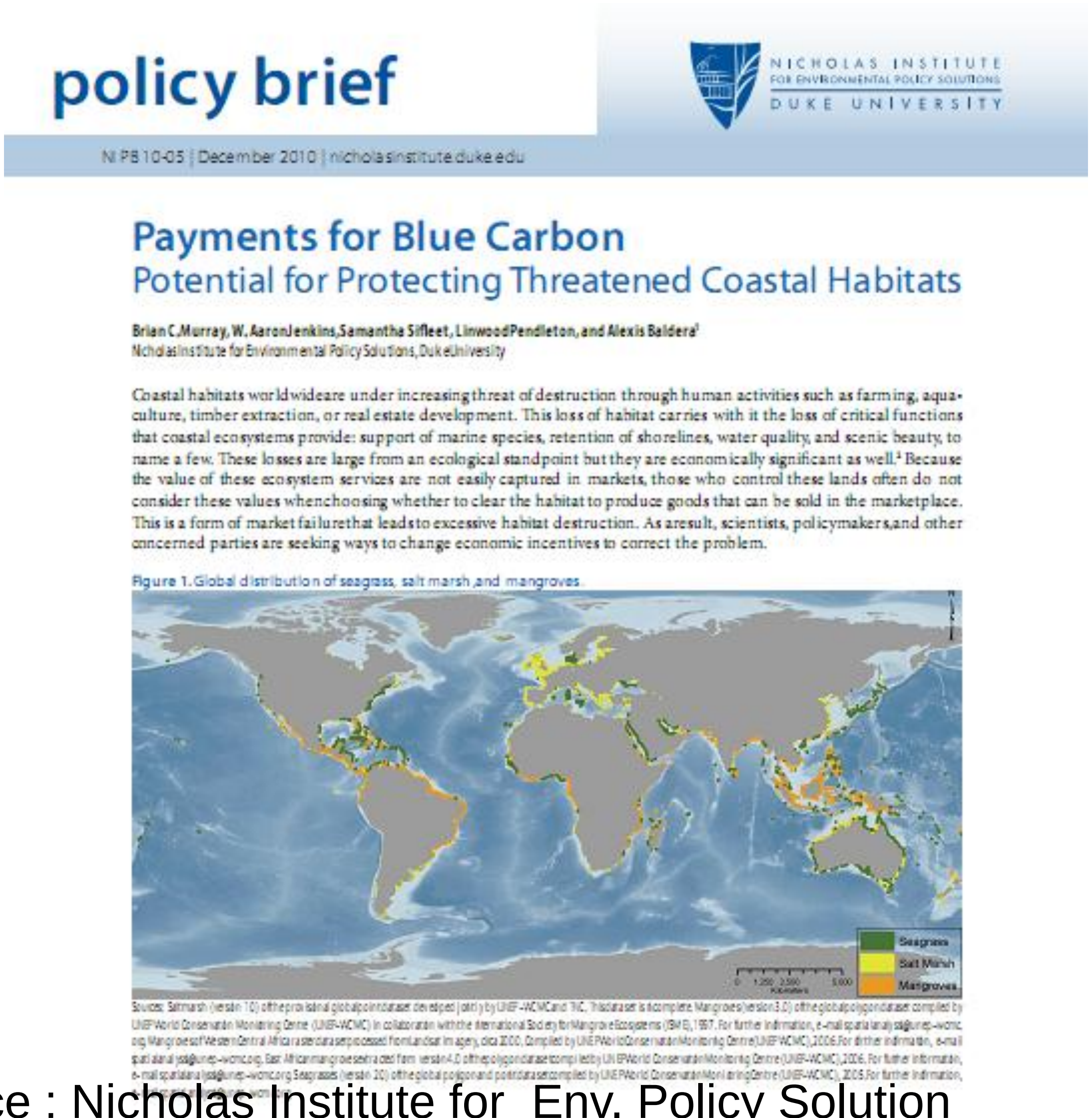
Pick up a Copy



policy brief

NICHOLAS INSTITUTE
FOR ENVIRONMENTAL POLICY SOLUTIONS
DUKE UNIVERSITY

NI PB 10-05 | December 2010 | nicholasinstitute.duke.edu

Payments for Blue Carbon
Potential for Protecting Threatened Coastal Habitats

Brian C. Murray, W. Aaron Jenkins, Samantha Sifleet, Linwood Pendleton, and Alexis Baldera[1]
Nicholas Institute for Environmental Policy Solutions, Duke University

Coastal habitats worldwide are under increasing threat of destruction through human activities such as farming, aquaculture, timber extraction, or real estate development. This loss of habitat carries with it the loss of critical functions that coastal ecosystems provide: support of marine species, retention of shorelines, water quality, and scenic beauty, to name a few. These losses are large from an ecological standpoint but they are economically significant as well.[2] Because the value of these ecosystem services are not easily captured in markets, those who control these lands often do not consider these values when choosing whether to clear the habitat to produce goods that can be sold in the marketplace. This is a form of market failure that leads to excessive habitat destruction. As a result, scientists, policymakers, and other concerned parties are seeking ways to change economic incentives to correct the problem.

Figure 1. Global distribution of seagrass, salt marsh, and mangroves

Source : Nicholas Institute for Env. Policy Solution

Thank You