BLUE CARBON & CLIMATE CHANGE IN INDONESIA
SEAGRASS FUNCTION AND ITS RESOURCE VALUATION

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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)

Vegetation 610

Soils 1,580

Rivers

Surface Ocean 1,020

Marine Biota 3

Dissolved Organic Carbon < 700

Deep Ocean 38,100

Sediments 150

Fossil Fuels & Cement Production 4,000

Storage in GtC Fluxes in GtC/yr
What and Where is Blue Carbon?

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, although 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 microalgae, diatoms, and cyanobacteria.

Mangroves are salt-tolerant flowering plants, predominantly deciduous, that grow in the intertidal zone of tropical and subtropical shores. They are estimated to occupy almost 40% of tropical coastlines, 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

For Comparison:

- Seagrasses
- Tidal Salt Marshes
- Estuarine Mangroves
- Oceanic Mangroves
- Tropical Forests

Soil-carbon values for first meter of depth only (Total depth = up to several meters)

- **Organic Soil Carbon**
- **Living Biomass**

tCO₂e per Hectare, Global Averages
Loss rates are high

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Global extent (km²)</th>
<th>Annual Loss Rate (~1980–2000)</th>
<th>Total Historical Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seagrass</td>
<td>300,000–600,000⁹</td>
<td>1.2%–2%⁸</td>
<td>29⁹</td>
</tr>
<tr>
<td>Tidal Marsh</td>
<td>400,000⁴</td>
<td>1%–2%⁸</td>
<td>Centuries of conversion⁷</td>
</tr>
<tr>
<td>Mangroves</td>
<td>152,000–170,000⁸</td>
<td>0.8%–2.1%⁹</td>
<td>35¹</td>
</tr>
</tbody>
</table>

Source: Nicholas Institute for Env. Policy Solution
What May Be Eligible for Crediting?

<table>
<thead>
<tr>
<th>Potential Credit Source</th>
<th>Time Period</th>
<th>Ecosystems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided Loss of Sequestration Flux</td>
<td>Perpetuity</td>
<td>Seagrasses Tidal Salt Marshes Mangroves</td>
</tr>
<tr>
<td>Avoided Emissions from Soil Carbon</td>
<td>Several Years to Decades</td>
<td>Seagrasses Tidal Salt Marshes Mangroves</td>
</tr>
<tr>
<td>Avoided Emissions from Biomass (REDD)</td>
<td>Immediate</td>
<td>Mangroves</td>
</tr>
</tbody>
</table>
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

**CORE PROBLEM**
- Seagrass bed degradation & loss
- Fish sources and associated ecosystem decrease
- Local income from fisheries & tourism decrease
- Aesthetic value decrease

**IMMEDIATE THREAT**
- Erosion, sedimentation & siltation
- High turbid water, decrease of photosynthetic capacity & algal bloom
- Organic pollution & eutrophication
- Uncontrolled soil/sand mining on land and seabed
- Untreated waste water from domestic sources
- Untreated waste water from tourism activities
- Solid waste from domestic sources
- Solid waste from tourism activities
- Litter on the beach
- Erosion, sedimentation & siltation
- Limited community participation and action
- Lack of effective and integrated management
- Lack of proper regulation
- Weak enforcement of relevant regulation
- Lack of public awareness on coastal management
- Limited access of alternative employments/opportunities

**UNDERLYING THREAT**
- Limited community participation and action
- Lack of effective and integrated management
- Lack of proper regulation
- Weak enforcement of relevant regulation
- Lack of public awareness on coastal management
- Limited access of alternative employments/opportunities

**PROPOSED INTERVENTIONS**
- Establishment of cross sectoral management framework:
  - Institutional arrangements
  - Management Plan
- Revise and enforcement of relevant regulation
- Promotion of community participation in seagrass habitat management
- Integrated research for improved seagrass habitat management
- Promotion public awareness raising and capacity building
- Information dissemination and exchange
- Designing environmentally sustainable economic activities
  - Spatial planning and guidelines for sustainable tourism
  - Sustainable income generation opportunities for low income fishermen
- Poverty of local community
- High turbid water, decrease of photosynthetic capacity & algal bloom
- Untreated waste water from tourism activities
- Solid waste from tourism activities
- Erosive and over fishing
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.

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

Source: PEMPSEA, 2012
But what about the value of the Blue Carbon stored in the system?
Research Location
**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

<table>
<thead>
<tr>
<th></th>
<th>NCP</th>
<th>low estimate of global extent</th>
<th>Integrated NCP</th>
<th>high estimate of global extent</th>
<th>Integrated NCP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons CO$_2$e ha$^{-1}$y$^{-1}$</td>
<td>km$^2$</td>
<td>Tg CO$_2$e y$^{-1}$</td>
<td>km$^2$</td>
<td>Tg CO$_2$e y$^{-1}$</td>
</tr>
<tr>
<td>Mean</td>
<td>4.4</td>
<td>300000</td>
<td>130.7</td>
<td>600000</td>
<td>261.4</td>
</tr>
<tr>
<td>Upper 95th cl of mean</td>
<td>6.2</td>
<td>300000</td>
<td>185.5</td>
<td>600000</td>
<td>371.1</td>
</tr>
<tr>
<td>Lower 95th cl of mean</td>
<td>2.5</td>
<td>300000</td>
<td>75.9</td>
<td>600000</td>
<td>151.8</td>
</tr>
<tr>
<td>maximum</td>
<td>85.4</td>
<td>300000</td>
<td>739.2</td>
<td>600000</td>
<td>1478.3</td>
</tr>
</tbody>
</table>

For comparison, mean NCP for:
- wetlands = 0.6 tons CO$_2$e ha$^{-1}$y$^{-1$
- Amazon rainforest: 3.7 tons CO$_2$e ha$^{-1}$y$^{-1$

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

\[
Y = -2.31 + 1.39x \\
SE of slope = 0.08 \\
r^2 = 0.22, \ p<0.001
\]

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)
  - $C_{\text{org}}$
For LOI $\leq 10$:

$$C_{\text{org}} = -0.12 + 0.38(\text{LOI})$$

$$r^2=0.79, \ p<0.001$$

For all data:

$$C_{\text{org}} = -0.99 + 0.54(\text{LOI})$$

$$r^2=0.95, \ p<0.001$$
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$_2$e ha$^{-1}$

1 x $10^9$ tons CO$_2$e stored in the soils!

Anthropogenic CO$_2$e 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
- Commercial 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

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Annual Carbon Sequestration Rate (tCO$_2$e/ha/yr)</th>
<th>Living biomass (tCO$_2$e/ha)</th>
<th>Soil organic carbon (tCO$_2$e/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seagrass</td>
<td>4.4 ± 0.95$^a$</td>
<td>0.4–100$^b$</td>
<td>66–3040$^c$</td>
</tr>
<tr>
<td>Tidal Marsh</td>
<td>7.97 ± 8.52$^d$</td>
<td>12–60$^e$</td>
<td>330–1,980$^f$</td>
</tr>
<tr>
<td>Estuarine Mangroves</td>
<td>6.32 ± 4.8$^g$</td>
<td>237–563$^h$</td>
<td>1,060$^h$</td>
</tr>
<tr>
<td>Oceanic Mangroves</td>
<td>6.32 ± 4.8$^g$</td>
<td>237–563$^h$</td>
<td>1,690–2,020$^h$</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Habitats</th>
<th>Soil Organic Carbon at risk (top meter, tCO₂e ha⁻¹)</th>
<th>Total Carbon at risk including biomass (tCO₂e ha⁻¹)</th>
<th>Current Habitat Extent (Mha)</th>
<th>Total Carbon in Habitat (BtCO₂e)</th>
<th>C loss from annual habitat conversion - 0.7% rate (BtCO₂e yr⁻¹)</th>
<th>C loss from annual habitat conversion - 2% rate (BtCO₂e yr⁻¹)</th>
<th>Economic costs of habitat loss - 0.7% rate (Billion US$ yr⁻¹)</th>
<th>Economic costs of habitat loss - 2% rate (Billion US$ yr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Marsh</td>
<td>917</td>
<td>949</td>
<td>5.1</td>
<td>4.8</td>
<td>0.03</td>
<td>0.10</td>
<td>1.4</td>
<td>4.0</td>
</tr>
<tr>
<td>Mangroves</td>
<td>1298</td>
<td>1762</td>
<td>13.8</td>
<td>24.3</td>
<td>0.17</td>
<td>0.49</td>
<td>7.0</td>
<td>19.9</td>
</tr>
<tr>
<td>Seagrass</td>
<td>500</td>
<td>511</td>
<td>30</td>
<td>15.3</td>
<td>0.11</td>
<td>0.31</td>
<td>4.4</td>
<td>12.6</td>
</tr>
<tr>
<td>Total</td>
<td>48.9</td>
<td>44.5</td>
<td></td>
<td></td>
<td>0.31</td>
<td>0.89</td>
<td>12.8</td>
<td>36.5</td>
</tr>
</tbody>
</table>

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.
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$_2$e 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

- Seagrasses
- Tidal Salt Marshes
- Estuarine Mangroves
- Oceanic Mangroves

Cost of Protection

- Opportunity Costs TBD
- Opportunity Costs for Shrimp Farming (others TBD)

For Comparison:
- Tropical Forests (REDD)

Values Vary by Location, Destruction Method and Economic Activity
Can the Economics Work?

Market Value of Carbon

Cost of Protection (Direct and Opportunity Costs)
ECONOMIC VALUATION OF EAST BINTAN SEAGRASS ECOSYSTEM
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.
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

<table>
<thead>
<tr>
<th>No</th>
<th>Location</th>
<th>Type of Gear</th>
<th>Total Type of gear</th>
<th>Total involvement of:</th>
<th>Total Income Household per year (Rp.)</th>
<th>Total Revenue per year (Rp.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Households</td>
<td>Residents *)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Teluk Bakau</td>
<td>Kelong</td>
<td>28</td>
<td>56</td>
<td>280</td>
<td>18,000,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Net</td>
<td>10</td>
<td>20</td>
<td>100</td>
<td>11,700,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dinghy</td>
<td>3</td>
<td>3</td>
<td>15</td>
<td>4,800,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crab trap</td>
<td>20</td>
<td>20</td>
<td>100</td>
<td>6,660,000</td>
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<tr>
<td></td>
<td></td>
<td>Kelong Darat</td>
<td>3</td>
<td>3</td>
<td>15</td>
<td>8,400,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>64</td>
<td>102</td>
<td>510</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Malang Rapat</td>
<td>Kelong</td>
<td>40</td>
<td>80</td>
<td>400</td>
<td>18,000,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Net</td>
<td>42</td>
<td>84</td>
<td>420</td>
<td>11,700,000</td>
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<tr>
<td></td>
<td></td>
<td>Dinghy</td>
<td>7</td>
<td>7</td>
<td>35</td>
<td>4,800,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FAD.</td>
<td>4</td>
<td>16</td>
<td>80</td>
<td>37,500,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>93</td>
<td>187</td>
<td>935</td>
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<tr>
<td>3</td>
<td>Tanjung Berakit</td>
<td>Kelong</td>
<td>38</td>
<td>76</td>
<td>380</td>
<td>18,000,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Net</td>
<td>50</td>
<td>100</td>
<td>500</td>
<td>11,700,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dinghy</td>
<td>19</td>
<td>19</td>
<td>95</td>
<td>4,800,000</td>
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<tr>
<td></td>
<td></td>
<td>Artificial Dev.</td>
<td>20</td>
<td>80</td>
<td>400</td>
<td>37,500,000</td>
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<tr>
<td></td>
<td></td>
<td>Kelong Darat</td>
<td>10</td>
<td>10</td>
<td>50</td>
<td>8,400,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>137</td>
<td>285</td>
<td>1425</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Economic Value</td>
<td>294</td>
<td>574</td>
<td>2,870</td>
<td></td>
</tr>
</tbody>
</table>

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
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

<table>
<thead>
<tr>
<th>No</th>
<th>Activity</th>
<th>Value</th>
<th>Total Economic Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rp</td>
</tr>
<tr>
<td>A</td>
<td>Use Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Use Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Fisheries</td>
<td>Direct Use Value</td>
<td>10,184,400,000</td>
</tr>
<tr>
<td>2</td>
<td>Food</td>
<td>Direct Use Value</td>
<td>Not accounted</td>
</tr>
<tr>
<td>3</td>
<td>Medicinal</td>
<td>Direct Use Value</td>
<td>Not accounted</td>
</tr>
<tr>
<td>4</td>
<td>Fertilizer</td>
<td>Direct Use Value</td>
<td>Not accounted</td>
</tr>
<tr>
<td>5</td>
<td>Handy craft</td>
<td>Direct Use Value</td>
<td>Not accounted</td>
</tr>
<tr>
<td>Sub Total</td>
<td></td>
<td></td>
<td>10,184,400,000</td>
</tr>
<tr>
<td>B</td>
<td>Non Use Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Existence Value</td>
<td>Direct / Indirect Value</td>
<td>Not accounted</td>
</tr>
<tr>
<td>2</td>
<td>Option Value</td>
<td>Direct / Indirect Value</td>
<td>Not accounted</td>
</tr>
<tr>
<td>3</td>
<td>Bequest Value</td>
<td>Direct / Indirect Value</td>
<td>Not accounted</td>
</tr>
<tr>
<td>Total Economic Value</td>
<td></td>
<td></td>
<td>32,713,160,000</td>
</tr>
<tr>
<td>Total Seagrass Area (ha)</td>
<td></td>
<td></td>
<td>1,590</td>
</tr>
<tr>
<td>Total Economic Value per ha per year</td>
<td></td>
<td></td>
<td>20,579,103</td>
</tr>
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HUMAN INDUCED THREATS

- Sand mining $\rightarrow$ sedimentation $\rightarrow$ impact on water clarity and cover seagrass $\rightarrow$ decrease $\rightarrow$ photosynthesis

- Blast and poison fishing $\rightarrow$ degrade coral and seagrass

- Mangrove cutting $\rightarrow$ sedimentation $\rightarrow$ degrade other neighboring ecosystems $\rightarrow$ decrease fisheries production and disturb coastal amenities
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
Payments for Blue Carbon
Potential for Protecting Threatened Coastal Habitats

Brian C. Murray, W. Aarond Jenkins, Samantha Siffleet, Limwood Pendleton, and Alexis Balders
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. 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