The Coastal Protection Services of Mangroves in the Philippines: Preliminary Workshop, July 2016: Day 2

Siddharth Narayan
Michael W. Beck, Pelayo Menendez, Iñigo J. Losada & Borja G. Reguero
The Coastal Protection Services of Mangroves in the Philippines: Preliminary Workshop – Agenda

1. Risk and Hazard Assessment - How do engineers approach coastal risk assessment (30 min)

2. Assessing Coastal Protection Value of coastal habitats – Methods and Models – Part 1 (45 min)
   1. Methods for physical (engineering) assessments of natural coastal protection values
   2. Methods for Cost-Effectiveness Analyses
   3. Special considerations when dealing with coastal habitats – bio-physical, economic, etc.
Risk reduction cascade

Initial risk

Residual risk

Cumulative interventions

Wetlands

Levees/ Flood walls

Building codes/ zoning

Early warning/ Evacuation plans

Spalding et al. 2014
Combinations of structural and non-structural measures

- **Soft solutions**: more space, no dike, flexible and cost-effective
- **Hybrid solutions**: less space, dike, less flexible, extra investment
- **Hard solutions**

Van Wesenbeeck, 2015. *IAHR 2015 Keynote*
Typhoon Haiyan (2013)

Typhoon Haiyan: Philippines to plant more mangroves

Mangrove swamps along the the Poyay Poyay River in Sabang, on the island of Palawan in the Philippines. The Philippines said it will plant more mangrove area to prevent a repeat of the deadly storm surge that claimed hundreds of lives during Typhoon Haiyan earlier this month. — ST FILE PHOTO; LEE SIEW HUA

Mangroves, nature’s shield against typhoons and tsunami

Van Wesenbeeck, 2015. IAHR 2015 Keynote
Engineering Ecosystems for Coastal Protection

ECOLOGY

MANGROVE ENGINEERING

Various species of mangroves to be planted at 1.65km stretch on Pulau Tekong to stop erosion

1. Existing mangroves. About 1,300 trees are already growing organically. In the future, they are likely to fail.
2. Biodegradable sacks filled with suitable material and placed beneath the bank.
3. Nourishment including floating rafts, formed to secure the shoreline.
4. Mangroves that naturally grow in the area will be planted.
5. Bakau wood poles to dissipate wave energy.

ENGINEERING (CEM)

- Problem
- Status quo
- Alternatives
- Evaluation of effectiveness
- Comparison of alternatives
- Selection of best alternative

Reguero, et al. in prep.
Valuing Ecosystems for Coastal Protection

**ECOLOGY**

- Mangrove Engineering

**ENGINEERING (CEM)**

- Problem
- Status quo
- Alternatives
- Evaluation of effectiveness
- Comparison of alternatives
- Selection of best alternative

**ECONOMICS (SEEA – EEA)**

- 1. Land Cover Accounting
- 2. Land Use Accounting
- 3. Framing the Measurement of Ecosystem Conditions
- 4. Carbon Stock Accounting
- 5. Biodiversity Stock Accounting
- 6. Water Stock Accounting
- 7. Accounting for Ecosystem Services
- 8. Integrating Ecosystem Accounting with National Accounts

*Adapted from Reguero, et al. in prep. and Fulleros, 2016.*
## Engineering Requirements for Different Coastal Defense Options

<table>
<thead>
<tr>
<th></th>
<th>Artificial Reefs</th>
<th>Mangroves and Marshes</th>
<th>Beach &amp; Dunes</th>
<th>Low-crested and submerged structures</th>
<th>Floodwalls</th>
<th>Leves</th>
<th>Storm Surge Barriers</th>
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<tbody>
<tr>
<td>Space requirement</td>
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<td>Probability of functional failure</td>
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<td>Probability of structural failure</td>
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<td>Restriction by development</td>
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<td>Influence in development</td>
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<td>Construction cost</td>
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<td>Maintenance costs</td>
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<td>** **</td>
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<tr>
<td>Sustainability / Adaptation to SLR</td>
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<tr>
<td>Sustainability / other threats from CC</td>
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<td>Fragility / reliability / Design threshold</td>
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<td>Wave Attenuation/Protection</td>
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<td>Surge Attenuation/Protection</td>
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Table 1. Qualitative ranking of importance of different design factors for several green and gray coastal defenses. *** = High; * = Low. Reguero, et al. in prep.
Framework for Estimating Coastal Protection Values

1. Offshore waves
2,3. Near-shore waves and effects of habitat
4,5. Flooding Level; Damages and Coastal Protection Benefits

From WB WAVES 2016, Chapter 4
Ocean Waves → Reef front

\( \frac{c_1}{\sin \alpha_1} = \frac{c_2}{\sin \alpha_2} \)

\[ \frac{\partial E_w}{\partial x} = D_b + D_f + D_{\text{veg}} \]

\[ D_b = \frac{3\sqrt{\pi}}{16} \rho g \frac{B^3 f_k^2}{\gamma h^5} H^7 \]

\[ D_f = \frac{C_f}{16\sqrt{\pi}} \left( \frac{a}{\sinh kh} \right)^3 H^3 \]

\[ D_{\text{veg}} = \frac{1}{2\sqrt{\pi}} \rho C_d \left( \frac{k g}{2\sigma} \right)^3 \left( D_r + D_i + D_i \right) \frac{1}{3k \cosh kh} H^3 \]

\[ N_{\text{b}r}(\sinh^2 k \alpha_p h + 3 \sinh k \alpha_p h) \]

Thornton and Guza 1983

Thornton and Guza 1983

Dalyrymple et al. 1984, Mendez and Losada 2004

Beck et al., 2016 (In Review)
Coastal Protection Model – Setup for Global Model

Adapted from Beck et al. 2016 (In Review)
**Global Coastal Protection Model – Expected Benefits from Reefs**

Reef benefits for flood protection from **100-year event** in terms of exposure of built capital to flooding with reef loss ($US billions) and relative to total national built capital.

<table>
<thead>
<tr>
<th>Built capital flooded (100-yr)</th>
<th>% of the national built capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Indonesia</td>
<td>Cayman Islands 6.81</td>
</tr>
<tr>
<td>2 Philippines</td>
<td>Belize 4.28</td>
</tr>
<tr>
<td>3 Malaysia</td>
<td>Grenada 3.76</td>
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<tr>
<td>4 Cuba</td>
<td>Bahamas 3.70</td>
</tr>
<tr>
<td>5 Mexico</td>
<td>Jamaica 2.67</td>
</tr>
<tr>
<td>6 United Arab Emirates</td>
<td>Cuba 2.61</td>
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<tr>
<td>7 Saudi Arabia</td>
<td>Philippines 2.37</td>
</tr>
<tr>
<td>8 United States</td>
<td>Dominican Republic 2.19</td>
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<tr>
<td>9 Dominican Republic</td>
<td>Malaysia 1.54</td>
</tr>
<tr>
<td>10 Thailand</td>
<td>Antigua and Barbuda 1.50</td>
</tr>
<tr>
<td>11 Jamaica</td>
<td>Seychelles 1.14</td>
</tr>
<tr>
<td>12 Vietnam</td>
<td>Turks and Caicos Islands 0.88</td>
</tr>
<tr>
<td>13 Taiwan</td>
<td>New Caledonia 0.83</td>
</tr>
<tr>
<td>14 Myanmar</td>
<td>Pitcairn Islands 0.74</td>
</tr>
<tr>
<td>15 Bahamas</td>
<td>Indonesia 0.72</td>
</tr>
</tbody>
</table>

Beck et al. 2016 (In Review)
Global Coastal Protection Model – Expected Benefits from Reefs

Annual expected benefit of reefs for flood protection in terms of annual averted damages to built capital ($ millions per year) and relative to Gross Domestic Product (GDP).

<table>
<thead>
<tr>
<th>Annual Averted Damages ($ millions)</th>
<th>Annual Averted Damages/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Indonesia</td>
<td>Cayman Islands 0.98</td>
</tr>
<tr>
<td>2 Philippines</td>
<td>Belize 0.37</td>
</tr>
<tr>
<td>3 Malaysia</td>
<td>Grenada 0.30</td>
</tr>
<tr>
<td>4 Mexico</td>
<td>Cuba 0.25</td>
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<tr>
<td>5 Cuba</td>
<td>Bahamas 0.16</td>
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<tr>
<td>6 Saudi Arabia</td>
<td>Jamaica 0.14</td>
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<tr>
<td>7 Dominican Republic</td>
<td>Philippines 0.13</td>
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<tr>
<td>8 United States</td>
<td>Antigua and Barbuda 0.13</td>
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<tr>
<td>9 Taiwan</td>
<td>Dominican Republic 0.11</td>
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<tr>
<td>10 Jamaica</td>
<td>Malaysia 0.09</td>
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<tr>
<td>11 Vietnam</td>
<td>Seychelles 0.06</td>
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<tr>
<td>12 Myanmar</td>
<td>Turks and Caicos 0.06</td>
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<tr>
<td>13 Thailand</td>
<td>Guadeloupe 0.05</td>
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<tr>
<td>14 Bahamas</td>
<td>Indonesia 0.04</td>
</tr>
<tr>
<td>15 Belize</td>
<td>Solomon Islands 0.04</td>
</tr>
</tbody>
</table>

Beck et al. 2016 (In Review)
Mapping Ocean Wealth – Country Snapshot

**Flood Protection Provided by Coral Reefs**

This analysis combines ecology, engineering, and economics to estimate the global role of coral reefs in flood protection.

- Annual Expected Benefit
- Region: Philippines
- Storm Return Period: 25 yrs, 100 yrs
- View Coral Reef Habitats

These values represent the predicted losses avoided to people, built capital, and land by keeping coral reefs intact.

- **395,551** People Protected
- **$5,102M** Built Capital Protected
- **762km²** Area Protected

![Map Legend](https://www.maps.oceanwealth.org)

![Map of Philippines](https://www.maps.oceanwealth.org)

[www.maps.oceanwealth.org](http://www.maps.oceanwealth.org)
MODELLING EXAMPLE – KANIKA SANDS MANGROVE ISLAND, INDIA
Wave Reduction by Mangroves Case-Study: Study Site

- Mangrove inhabited island
- Cyclone – affected region
- In front of upcoming Dhamra Port

Narayan, 2009
Case-Study: Numerical Model Setup

• Offshore wave parameters from cyclones
• Transformation of offshore waves to near-shore
• Near-shore water levels

• Near-shore bathymetries
• Grid setup

• Vegetation parameters
• Shape of mangrove vegetation patch
• Spatial vegetation density

\[ \text{Step 1: Offshore Hydrodynamics} \]
\[ \text{Step 2: Nearshore Hydrodynamics} \]
\[ \text{Step 3: Vegetation Parameters} \]

Narayan, 2009
Step 1: Offshore Hydrodynamics *Data* – Waves and Water Levels

- Offshore wave heights and time periods – from cyclones
- Used as input in SWAN 1-D with simplified offshore bathymetry
- Near-shore surge levels from previous studies

Narayan, 2009
Step 1: Offshore Hydrodynamics Results – Waves and Water Levels

• Wave heights at -11 m and +3 m depths obtained using SWAN 1-D

• Extreme Water Levels (EWLs) as sum of surge, tide, SLR
Step 2: Nearshore Hydrodynamics *Data* – Bathymetry

<table>
<thead>
<tr>
<th>Distance from port (x 100 m)</th>
<th>Distance Alongshore (x 100 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0</td>
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<tr>
<td>100</td>
<td>0</td>
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<tr>
<td>200</td>
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<td>400</td>
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<td>500</td>
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<td>600</td>
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<tr>
<td>700</td>
<td>0</td>
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</table>

Narayan, 2009
Step 2: Nearshore Hydrodynamics Results – Wave Propagation

Narayan, 2009
Step 3: Mangrove Vegetation *Data* – Vegetation Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value Range</th>
<th>Control Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Stem Diameter (DBH)</td>
<td>0.2 – 0.5 m</td>
<td>0.3 m</td>
</tr>
<tr>
<td>2. Pneumatophore Diameter</td>
<td>0 – 0.04 m</td>
<td>0.02 m</td>
</tr>
<tr>
<td>3. Canopy Diameter</td>
<td>0.02 – 1 m</td>
<td>0.5 m</td>
</tr>
<tr>
<td>4. Stem Density</td>
<td>0.5 – 1.7 m²</td>
<td>0.7 m²</td>
</tr>
<tr>
<td>5. Pneumatophore Density</td>
<td>4 – 100 m²</td>
<td>50 m²</td>
</tr>
<tr>
<td>6. Canopy Density</td>
<td>1 – 100 m²</td>
<td>100 m²</td>
</tr>
<tr>
<td>7. Stem Height</td>
<td>3 – 15 m</td>
<td>6 m</td>
</tr>
<tr>
<td>8. Pneumatophore Height</td>
<td>0.3 – 0.8 m</td>
<td>0.5 m</td>
</tr>
<tr>
<td>9. Canopy Height</td>
<td>0.2 – 3 m</td>
<td>2 m</td>
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</tbody>
</table>

Narayan, 2009
Case-Study Step 3: Mangrove – Wave Interaction *Results* – Wave Reduction

- 60% wave reduction by mangroves
- Vegetation Removal
  - 60 year event $\rightarrow$ 20 year event
  - 7 year event $\rightarrow$ 1 year event
- Optimum width cross-shore – 300 to 800 m
MODELLING EXAMPLE – HURRICANE SANDY AND COASTAL WETLANDS, U.S.A
RMS Case-Study Step 1: Offshore Hydrodynamics

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RMS Case-Study Step 3/4: Surge Interaction with Ecosystems

RMS Case-Study Step 3/4: Flooding by Sandy Surge
RMS Case-Study Step 5: Damage Estimation

Attributes:
- Occupancy
- Number of Floors
- Square Footage
- Valuation
- Basement
- Year of Built
- Construction

Copyright © 2015, Risk Management Solutions, Inc.
RMS Case-Study Step 6: Coastal Protection Value of Ecosystems

MODELLING EXAMPLE – INVEST COASTAL PROTECTION TOOLBOX
INVEST Step 1: Profile Generator Model

Options to generate a cross-shore profile:

1. Use a bathymetric DEM
2. Manually enter cross-shore profile
3. Assume a profile using INVEST empirical guidance

http://www.naturalcapitalproject.org/invest/

INVEST Step 2: Nearshore Waves and Erosion

• Wave Propagation Estimated Using:

\[
\frac{1}{8} \rho g \frac{dCgH^2}{dx} = -D
\]

• \(D = D_{\text{break}} + D_{\text{veg}} + D_{\text{bot}}\)

• \(D_{\text{break}}\) is depth-induced wave breaking (e.g. wave breaking at shallow depths)

• \(D_{\text{veg}}\) is vegetation induced wave-drag (e.g. drag through mangrove trees) - after Mendez and Losada 2004

• \(D_{\text{bot}}\) is bed friction (or roughness) (e.g. reef cover)

http://www.naturalcapitalproject.org/invest/

INVEST Steps 3/4: Erosion Reduction and Avoided Damages

• Erosion reduction estimated using wave height profiles and wave run-up value sets, calculated for with and without vegetation

• Avoided erosion damages using market values; tax estimates; replacement cost values

http://www.naturalcapitalproject.org/invest/

MANGROVE COASTAL PROTECTION MODEL: REQUIREMENTS, CONSIDERATIONS AND KEY OUTPUTS
Coastal Protection Model: Critical Data Requirements

- Study Domain/Extent
- Bathymetry
  - Offshore
  - Nearshore
- Hydrodynamics
  - Offshore wave heights and water levels – *may be computed using global metocean datasets*
  - Storm tracks, intensities – *available from global datasets*
  - Wind speeds, fetch distance – *for every-day waves, e.g. INVEST*
  - Nearshore wave heights and water levels – *may be computed using offshore and bathy data*
- Ecosystem Characteristics
  - Extent
  - Width
  - Density and Fragmentation
  - Species (Primary or Distribution)
  - Age
- Inland Floodplain
  - Topography (i.e. for elevation, slope, distance to coast)
  - Land-use/Land-cover
  - Known coastal defenses – *may be assumed as captured in Topo*
- Flood Damages
  - Population
  - Built Capital (Assets)
Coastal Protection Model: Special Considerations for Ecosystems

- **Study Domain/Extent**
  - Ecosystem extent may be difficult to define/relate to modelling or accounting unit

- **Bathymetry**
  - Crucial for all ecosystems; may be difficult to measure within inter-tidal habitats

- **Hydrodynamics**
  - Storm properties (duration, forward speed, ...) will influence variations in ecosystem impacts

- **Ecosystem Characteristics**
  - Should assess/measure parameters like relative height, relative width, standing biomass, etc.
  - Should assess uncertainties in ecosystem health (relevant to coastal protection)

- **Inland Floodplain**
  - Ecosystem presence (esp inter-tidal) can help reduce overall exposure to flood risk

- **Flood Damages**
  - Ecosystems can occasionally increase flood damages depending on relative location of hazard and assets
Coastal Protection Model: Key Outputs

1. Storm Surge Inundation Heights and Extents
   a) With mangroves
   b) Without mangroves
   c) For multiple sea-level scenarios

2. Storm – surge Induced Damages
   a) With mangroves
   b) Without mangroves
   c) For multiple sea-level scenarios

3. National Map of Spatial Variation
   a) In mangrove effect on flooding extents
   b) In mangrove effect on flood damages
   c) For multiple sea-level scenarios

4. Case-Study Results
   a) High resolution estimates of mangrove effects
   b) Sensitivity analyses for different sea-level and mangrove scenarios
THOUGHTS ON INTEGRATION OF CP MODEL OUTPUTS INTO SEEA – EEA FRAMEWORK
Model of flows related to ecosystem services

From Fulleros, 2016 (PSA).
Bio-physical Environment

Ecosystem Assets

- Ecology
  - Structure
  - Composition
  - Processes
  - Functions
- Location
  - Extent
  - Configuration
  - Landscape form
  - Climate & seasonal patterns
- Biodiversity

Abiotic resources
- e.g. Mineral and energy resources

Inter – & Intra Ecosystem flows Supporting services

Ecosystem services (CICES)

- **Provisioning services**
  - e.g. Water, natural plants and animals, nutrient resources for crops, fibres from plants and animals
- **Regulating services**
  - e.g. Atmosphere regulation, bioremediation, water flow regulation, lifecycle maintenance
- **Cultural services**
  - e.g. Opportunities for non-extractive reaction, information and knowledge, religious functions, meaning of place

Abiotic services
- e.g. Flows of mineral resources, Flows of renewable and non-renewable energy resources, Space for human habitat and infrastructure

Benefits

- **SNA benefits (goods & services)**
  - e.g. Agricultural products (vegetables)
  - Live animal & animal products
  - Forestry and logging products
  - Water
  - Tourism & recreational services
  - Mineral & energy products

- **Non-SNA benefits**
  - e.g. Clean air
  - Protection from flooding and soil erosion
  - Reduction in greenhouse gases in the atmosphere

Input to production of SNA benefits (goods and services) & Inputs to non-SNA benefits

From Fulleros, 2016 (PSA).
Example Accounting for Ecosystem Condition Characteristics

<table>
<thead>
<tr>
<th>Ecosystem extent (proportion of EAU)</th>
<th>Characteristics of ecosystem condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Vegetation indicators (e.g. Leaf area index, biomass index)</td>
</tr>
<tr>
<td></td>
<td>Biodiversity indicators (e.g. species richness, relative abundance)</td>
</tr>
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<td></td>
<td>Soil indicators (e.g. soil fertility, soil carbon, soil moisture)</td>
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<td></td>
<td>Water indicators (e.g. river flow, water quality, fish species)</td>
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<td></td>
<td>Carbon indicators (e.g. net carbon balance, primary productivity)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of LCEU</th>
<th>Vegetation</th>
<th>Biodiversity</th>
<th>Soil</th>
<th>Water</th>
<th>Carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forests</td>
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<tr>
<td>Agricultural land</td>
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<td>Urban areas</td>
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<td>Inland water bodies</td>
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</tbody>
</table>

Note: key interest with these tables is particularly with evaluating the trends over time.

From Fulleros, 2016 (PSA).
Example Accounting for Ecosystem Condition Characteristics

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<tr>
<td>Indicators (e.g. Leaf area index, biomass index)</td>
<td>Indicators (e.g. species richness)</td>
</tr>
</tbody>
</table>

Type of LCEU

- Forests
- Agricultural land
- Urban areas
- Inland water bodies

For Coastal Protection, additional indicators can include soil retention rates, land elevation, age, etc.

Note: key interest with these tables is particularly with evaluating the trends over time.

From Fulleros, 2016 (PSA).
Mangrove Ecosystem Extent / Mangrove Area Asset Account

Mangrove Ecosystem Extent Account
- Refers to the size of the mangrove ecosystem asset.
- Generally measured in terms of surface area, e.g. hectares of land cover type.
- It can be reflected in the proportion of different types of mangrove forest.

Mangrove Area Asset Account
- A unique environmental asset that delineates the "space" covered by a mangrove forest.
- It can be reflected in the proportion of different classifications of mangrove forest e.g. land cover (fringe, riverine, basin, overwash, scrub and hammock) and land use (e.g. recreational, strictly protected area, fishpond – production mangrove forest). – "coastal protection/buffer mangrove forest"?

From Fulleros, 2016 (PSA).
<table>
<thead>
<tr>
<th>Parameter / Data</th>
<th>Disaggregation</th>
<th>Period</th>
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<tr>
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<td>2 Thematic Map of Pagbilao Land Cover, Elevation Map and Storm Surge Inundation (without mangrove) including map interpretation</td>
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<tr>
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Addition of Expected Damage
Function Approach, for national scale?

From Fulleros, 2016 (PSA).
DAY 2 PARTNER PRESENTATIONS
DAY 2 DISCUSSION
## Data Sources, Types and Availability

<table>
<thead>
<tr>
<th>No</th>
<th>Bathymetry</th>
<th>Mangrove Characteristics</th>
<th>Topography</th>
<th>Asset/Socio-Economic Data</th>
<th>Validation Data</th>
</tr>
</thead>
</table>
| 1  | **Data:** Bathymetry/ Habitat Maps  
Agency: CoRVA  
Extent/ Resolution: ??  
Availability: ?? | Agency: PHIL-LIDAR (UP C-Eng)  
Funding: CCC  
Extent: National **(Samar, Leyte Completed)** | Data: LiDAR (1 m)  
Agency: PHIL-LIDAR (UP C-Eng)  
Extent: **Samar, Leyte**  
Availability: ?? | Data: Household Census Info  
Agency: Gem/ PHIL-LIDAR (UP C-Eng)  
Funding: CCC  
Extent: **Samar, Leyte**  
*El Nido*  
Availability: Now  
Resolution: Per Barangay | Data: Storm Surge Heights from survey  
Agency: PAGASA  
Extent: **Davao Oriental**  
*Baganga, Cateel, Boston*  
Availability: ?? |
| 2  | **Data:** Bathymetry/ Reef Maps  
Agency: MSI  
Extent: **El Nido**  
Availability: Now | Data: Habitat Maps  
Agency: CoRVA  
Extent/ Resolution: ??  
Availability: ?? | Data: DEM (5 m)  
Agency: NAMRIA  
Extent: **National**  
Availability: Now | Data: Database of fish ponds  
Agency: BFAR (FRMD)  
Extent: **Infanta, Quezon**  
Availability: Now | Data: Storm Surge Heights  
Agency: Project Noah  
Extent: **National**  
Availability: Now, may have to pay for processing |
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</thead>
</table>
| 3  | Data: Bathymetry  
Agency: PAGASA  
Extent: **Davao Oriental**  
Availability: Dec 2016 | Data: **Mangrove Community Structure/Sedimentation Rates**  
Agency: Dr. Samson(De LaSalle)/ Dr Rollon (UP)  
Extent: ?? *(Haiyan – Samar/Leyte)*  
Availability: ?? | Data: **LiDAR Imagery**  
Agency: Dream Project (UP)/ Project NOAH  
Extent: Selected Areas  
Availability: ?? | Data: Fish sanctuary database  
Agency: BFAR  
Extent: **National**  
Availability: Now | Data: Storm Surge Heights  
Agency: MGB  
Availability: ?? |
| 4  | Data: Bathymetry  
Agency: NAMRIA  
Extent/ Resolution: **National, Variable resolution**  
Availability: Now | Data: **National Data on Mangrove Cover as of 2010**  
Agency: NAMRIA  
Extent: **National**  
Availability: NOW – Shapefiles ?? | Data: Shore/ Beach Profiles and Coastal Structure Info  
Agency: MGB  
Extent: 150+ profiles (typhoon belt)  
Availability: Now (??) | Data: Survey Data on Household info, Yolanda Deaths, Damage Estimates  
Agency: EEPROM Project Data  
Extent: **Yolanda Track**  
Availability: August 15, 2016 | Data: SS Heights  
Agency: USAID  
Extent: Yolanda  
Available: Now |
| 5  | Data: Bathymetry  
Agency: CORVA (CIMERP)  
Extent: Biri, El Nido, Guiuan, Siargao  
Availability: Now ?? | Data: **Mangrove Mapping for Verde Island Passage**  
Agency: BMB  
Extent: **Oriental Mindoro, Occidental Mindoro and Batangas**  
Availability: Now | ------ | Data: Socio-Economic Data  
Agency: ERDB  
Extent: 42 provinces  
Availability: On-going | ------ |
<table>
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<tbody>
<tr>
<td>7</td>
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<td>Data: ACCCoast Mangrove and FLA Mapping Agency: BMB Extent: <strong>CALABARZON, MIMAROPA, Bicol, Eastern Visayas, CARAGA, Zamboanga Peninsula</strong> Availability: NOW – via GIZ</td>
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<td>8</td>
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<td>Data: Mangrove Baseline Data Agency: ERDB Extent: ?? Availability: Not Available (On-going) – viz GIZ</td>
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</tbody>
</table>
| 9  | --------   | Data: *Coastal Resource Assessment*  
Agency: BFAR  
Extent: **National**  
Availability: *Now* | -------- | -------- | -------- |
| 10 | --------   | Data: *Inventory of Mangroves*  
Agency: Zoological Society of London  
Extent: **Panay Island**  
Availability: ?? | -------- | -------- | -------- |
| 11 | --------   | Data: 1945 Mangrove map (digitized) (from U. Texas)  
Agency: EEPSEA  
Extent: Yolanda Track  
Availability: August 15  
Letter: to EEPSEA | -------- | -------- | -------- |
| 12 | --------   | Data: Mangrove Baseline Mapping  
Agency: ERDB  
Extent: 42 provinces  
Availability: On-going | -------- | -------- | -------- |
<table>
<thead>
<tr>
<th>Study Region</th>
<th>Coastal Risk</th>
<th>Coastal Mangroves</th>
<th>Data Availability: Bathymetry and Topography</th>
<th>Data Availability: Mangroves</th>
<th>Data Availability: Socio-Economic and Validation</th>
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<tbody>
<tr>
<td>NATIONAL</td>
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<td>Present</td>
<td>Bathymetry – Depth Soundings (NAMRIA)</td>
<td>2010 Mangrove Cover (NAMRIA)</td>
<td>Household Info per Barangay (Gem)</td>
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<td>Topo: IFSAR DEM 5m (NAMRIA)</td>
<td>1945 Mangrove Cover Digitized (EEPSEA)</td>
<td>BFAR Fish Sanctuary Database (BFAR)</td>
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<td>SAMAR</td>
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<td>Coastal Features: Beach Profile data (MGB)</td>
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<td>PHIL_LIDAR Data (CCC – UP Ceng) ??</td>
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<td>Yolanda SS Heights (USAID/Uni Tokyo/Project Noah)</td>
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<tr>
<td>LEYTE</td>
<td>• Tacloban</td>
<td>Present</td>
<td>Coastal Features: Beach Profile data (MGB) – Northern Leyte (31 municipalities)</td>
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<td>EEPSEA Death/Damage Surveys</td>
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<tr>
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<td>• El Nido</td>
<td>Absent</td>
<td>PHIL_LIDAR Data (CCC – UP Ceng) ??</td>
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<td></td>
<td>• Coron</td>
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<td>• …</td>
<td>Present</td>
<td>MSI/ CORVA data ??</td>
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## Data Sources and Types – Exercise to Identify Study Sites

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Potential Study Sites: Northern Leyte, Guiuan (mg+CORVAdata), Siargao (mg + CORVAdata), Northern Bohol (mg+MGBdata on subsidence and flooding), Busuanga (Palauan), Coron has damage data
Potential Study Sites

- Tacloban (N. Leyte) – high risk; has mangrove presence; overlap of good topography, socio-economic and shore profile data; complex coastline with channel

- Guiuan – point of first land-fall of Typhoon Haiyan (/Yolanda); has mangrove presence; open coast; overlap of mangrove data and potential CORVA data on reef bathymetry

- Siargao – popular tourist site; high risk; overlap of mangrove data and potential CORVA data on reef bathymetry

- Northern Bohol – substantial mangrove presence; overlap of mangrove data and MGB data on land subsidence and flooding

- Busuanga (Palauan) – only location in Palauan with damages data; point of last landfall of Typhoon Haiyan in Philippines

- Coron (Palauan) – data on damages
1. Model Advantages and Disadvantages
   a) Advantages
      • Open Access
      • Can be used for DRM/Policy
      • Easy reference, input to PAGASA National Inundation maps

   b) Disadvantages
      • Data Availability/Jurisdiction
      • Technical capacity needed to use/operate model, and maybe for interpreting some results
      • Transferability of site-specific results
      • Model not yet incorporated into a cost model (i.e. not comparing to structural alternatives for cost, avoided damages, etc.)
Group Discussion: Model Expectations, Outputs and Alignment with other efforts

2. Desired/ Expected Model Outputs
   a) Identification of specific flood risk zonations or no-build zones
   b) Preparation of Coastal Risk Maps
   c) Data on Inundation per return period
   d) Use of information for Early Warning Systems, Monetary Evaluations, Vulnerability Indices
   e) Preparation of guide for deciding/ choosing appropriate coastal protection measures
   f) Transformation of model outputs to environmental statistics and environmental accounts
Group Discussion: Model Expectations, Outputs and Alignment with other efforts

3. How do we align with on-going analyses in the Philippines?
   a) Adopt PSA study site
   b) Create up-datable data bank of mangrove characteristics relevant for various ecosystem services
   c) Standardise methods for data processing on ecosystem characteristics to complement with SEEA-EEA work in the Philippines
   d) Complement post-hazard analyses by EEPSEA
   e) Align with ongoing Geo-hazard Assessment program of MGB
   f) Help fill data gaps for storm surge damage extents, for PSA’s impact evaluation studies
SALAMAT PO.

- Links to some natural defense databases
  - http://www.maps.coastalresilience.org/global/# - SNAPP Coastal Defenses, USA
  - http://www.naturalcapitalproject.org/ - Natural Capital Project, USA
  - http://mycopri.org/ - Living shorelines Database, USA
  - http://www.omreg.net/ - Managed Realignment Database, UK
EXTRA SLIDES
Sources of data on offshore hydrodynamics

• A comprehensive list of global datasets on sea surface conditions can be found in: http://www.aviso.altimetry.fr/en/data.html.

• Sources of wave data include wave buoys: for example, http://www.ndbc.noaa.gov/; and satellite measurements: example, http://www.oceanor.com/Services/wwa_info/

• Examples of precomputed wave atlases include Global Ocean Waves (Reguero et al. 2012, 2013), NOAA’s operational hindcast (http://polar.ncep.noaa.gov/waves/index2.shtml); ERA-20C (http://www.ecmwf.int/en/research/climate-reanalysis/era-20c) and WW3 CFSRR Reanalysis (http://polar.ncep.noaa.gov/waves/CFSR_hindcast.shtml).

• Information on tide levels can be found at http://www.oco.noaa.gov/tideGauges.html.


• Data on past storm events can be found at https://www.ncdc.noaa.gov/stormevents/ and https://climatedataguide.ucar.edu/climate-data/ibtracs-tropical-cyclone-best-track-data.

Info from WB WAVES Chapter 4.
Sources of wave data beyond numerical simulation include wave buoys (for example, http://www.ndbc.noaa.gov/) and satellite measurements, (for example, http://www.oceanor.com/Services/wwa_info/).


There are also some databases that provide measurements of storm surge for several locations, such as Surgedat: http://surge.srcc.lsu.edu/data.html.

Surge attenuation depends strongly on the forest width and other factors, such as vegetation density and relative submergence or the storm velocity.

Main parameters: structure geometry (crest width, slopes, freeboard) and porosity, incident wave parameters (height, period), and depth.

Info from WB WAVES Chapter 4.