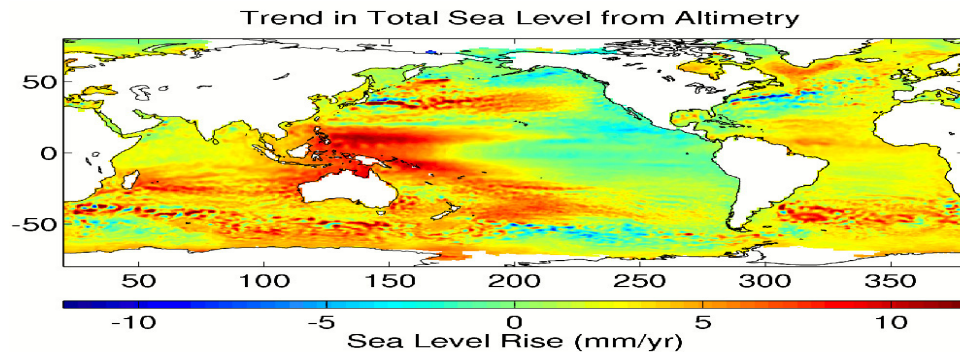


Mangrove Research & Management as Adaptive Strategy Against Rising Sea Level



OUTLINE

- Mangrove Ecology & Importance
 - Status & Threats
- Sea Level Rise: Implications
 - Mangrove Adaptation
 - Conservation & Restoration
- Summary: Lessons & Challenges



Severino G. Salmo III

Department of Environmental Science

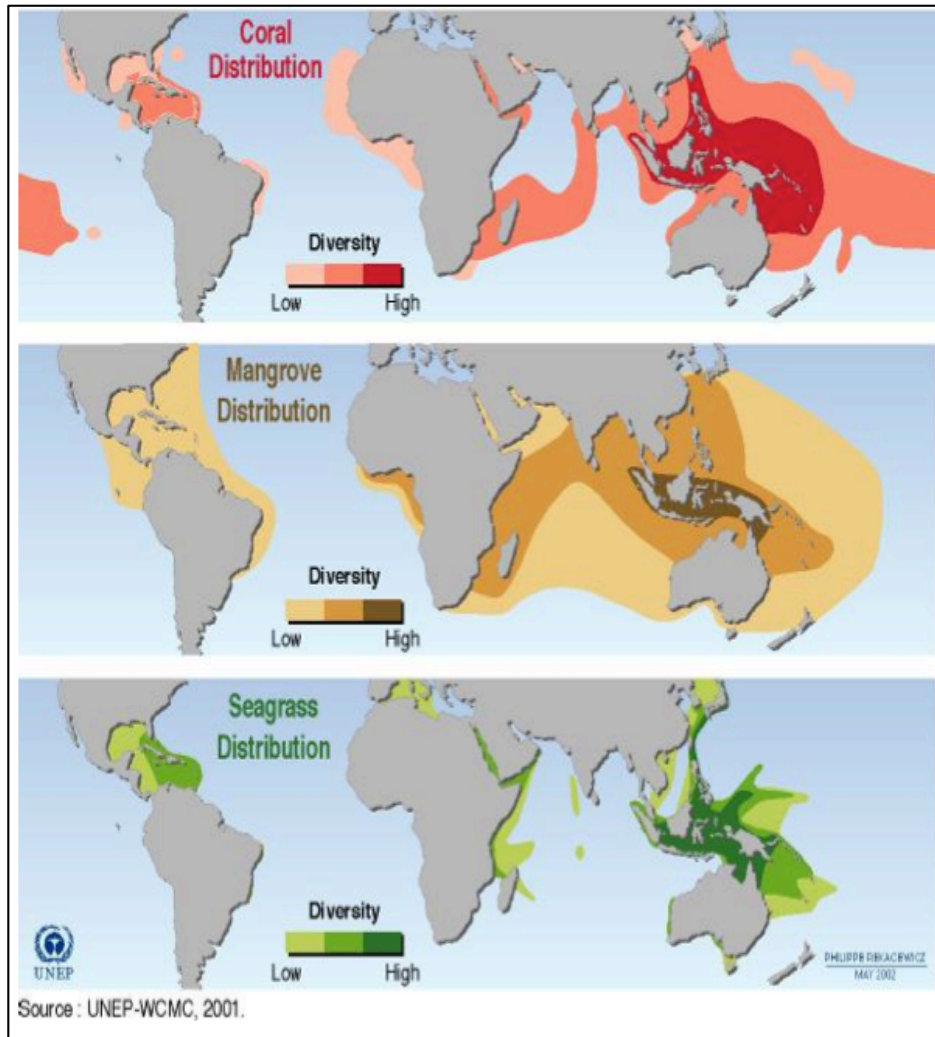
Ateneo de Manila University

1108 Quezon City, Philippines

ssalmo@ateneo.edu



Mangrove Ecology & Coastal Interconnectivity

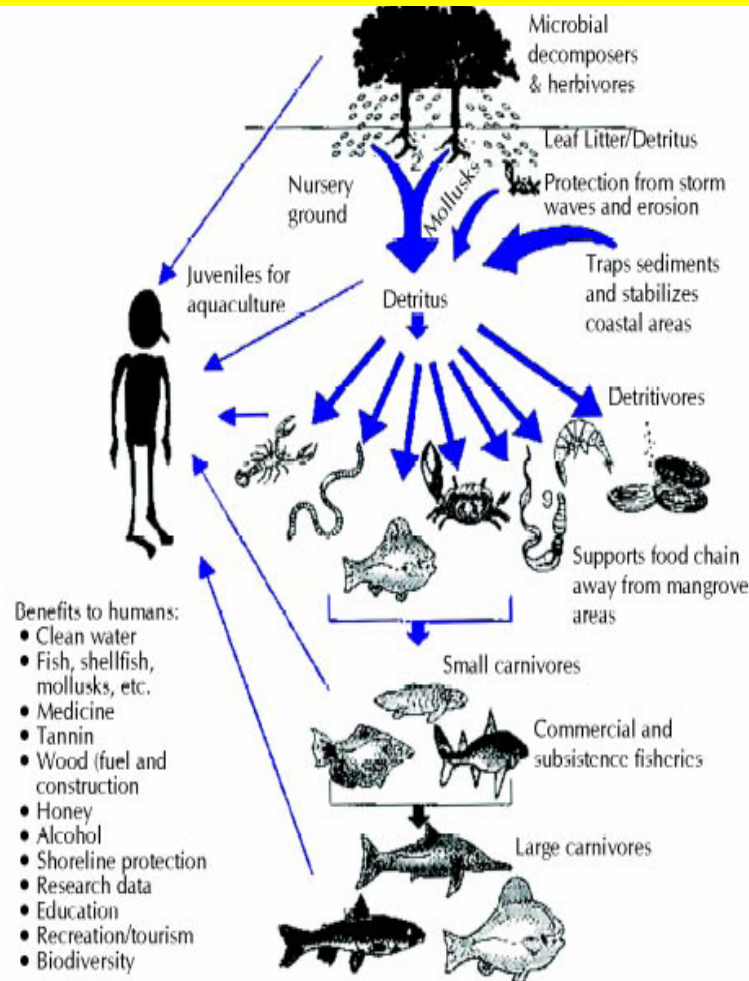


Busuanga, Palawan

- Coastal stabilization
- Species exchanges
- Nutrient retention and transfer
- Socio-economic importance

Mangrove Importance and Status

US\$ 4,000 – 12,000/ha
(Brander et al., 2012; Barbier, 2016)



CRMP, 2000

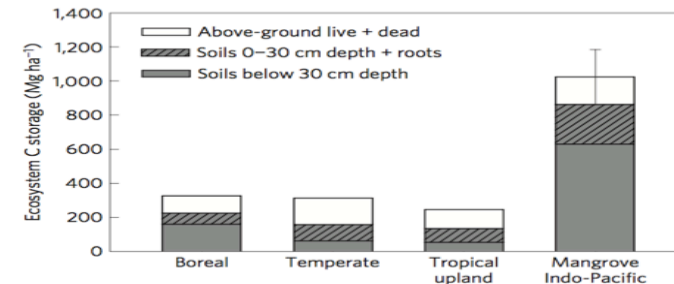
nature
geoscience

LETTERS

PUBLISHED ONLINE: 3 APRIL 2011 | DOI: 10.1038/NGE01123

Mangroves among the most carbon-rich forests in the tropics

Daniel C. Donato^{1*}, J. Boone Kauffman², Daniel Murdiyarso³, Sofyan Kurnianto³, Melanie Stidham⁴ and Markku Kanninen⁵



nature
climate change

LETTERS

PUBLISHED ONLINE: 27 JULY 2015 | DOI: 10.1038/NCLIMATE2734

The potential of Indonesian mangrove forests for global climate change mitigation

Daniel Murdiyarso^{1,2*}, Joko Purbopuspito^{1,3}, J. Boone Kauffman⁴, Matthew W. Warren⁵, Sigit D. Sasmito¹, Daniel C. Donato⁶, Solichin Manuri⁷, Haruni Krisnawati⁸, Sartji Taberima⁹ and Sofyan Kurnianto^{1,4}

Table 1 | Ecosystem C stocks, area, deforestation rate, and total C stocks in mangroves of ten selected countries.

Country	n	Ecosystem C stocks		Area (ha)		Annual deforestation rate*		Total C stocks (Pg)
		(MgC ha ⁻¹)	Reference	1980	2005	(ha)	(%)	
Indonesia	39	1,082.55 ± 377.85	This study	4,200,000	2,900,000	52,000	1.24	3.14
Mexico	7	621.85 ± 336.79	19	1,124,000	820,000	12,160	1.08	0.51
Malaysia	3	1,267.00 ± 872.72	28	674,000	565,000	4,360	0.65	0.72
Bangladesh	2	565.60 ± 26.16	2	428,000	476,000	(1,920)	(0.45)	0.27
Thailand	3	662.33 ± 126.59	28	280,000	240,000	1,600	0.57	0.16
Philippines	3	441.76 ± 120.76	29	295,000	240,000	2,200	0.75	0.11
Vietnam	15	862.95 ± 210.09	†	269,150	157,000	4,486	1.67	0.13
Dominican Republic	9	922.11 ± 274.56	7	34,400	16,800	704	2.05	0.02
Micronesia	3	1,063.88 ± 283.68	20	8,500	8,500	0	0	0.01
Palau	3	719.73 ± 309.38	20	4,700	4,700	0	0	0.003

n = number of plots. Numbers in brackets indicate afforestation. *Area and deforestation rates are from ref. 3. †Nam, V. N. et al., manuscript in preparation.

Status of Philippine Mangroves

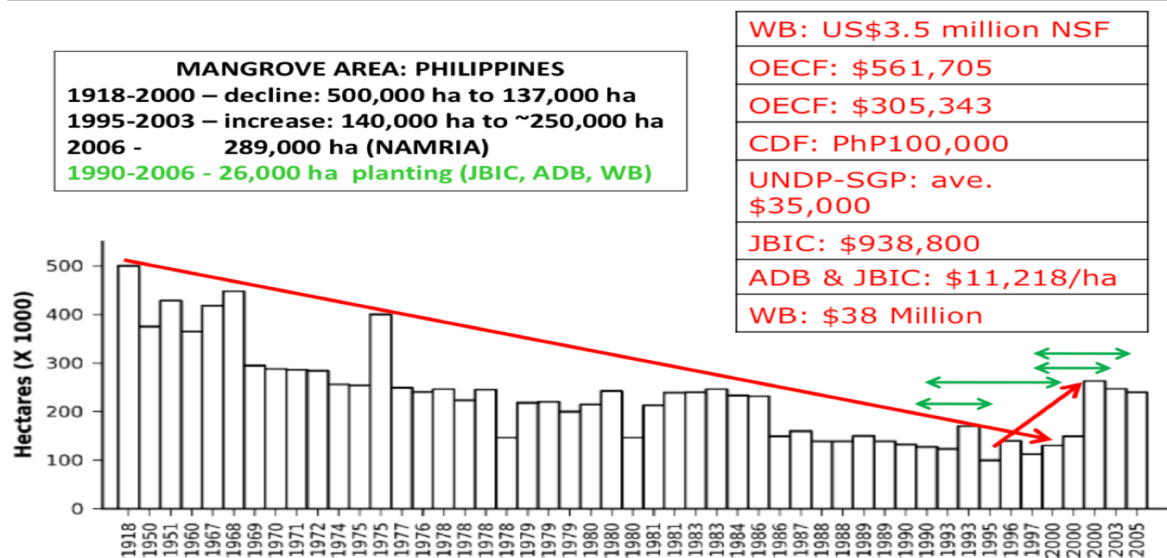
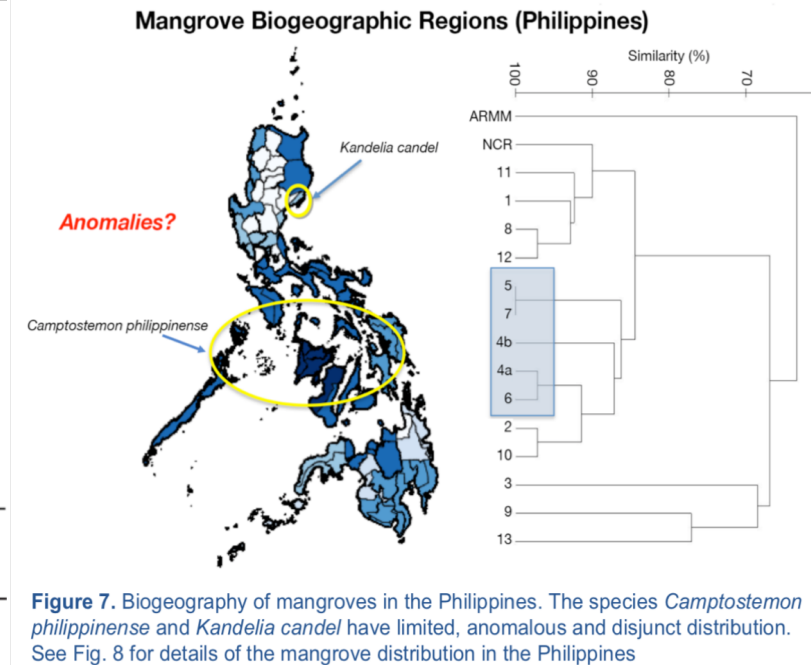


Figure 2. Historical mangrove areal estimates for the Philippines (FAO, 2007; Long and Giri, 2011; Wilkie and Fortuna, 2003). Long et al, 2013

Long J, Napton D, Giri C and J Graesser. 2013. A mapping and monitoring assessment of the Philippines' mangrove forests from 1990 to 2010. J. Coastal Research. DOI. 10.112/JCOASTRES-D-13.00057.1

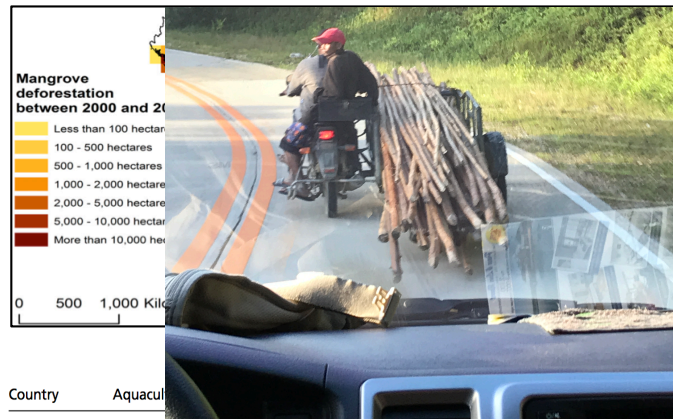
Degradation:

- world: 250,000 ha/yr in the last 20 yrs
 - SE Asia: 29-84% loss of original cover
 - Philippines: ~80%
- (Spalding 1997; Adeel & Pomeroy 2002)



Bohol: -1,400 ha 1990 to 2010
 (Long et al. 2014)

Threats to Mangrove Survival

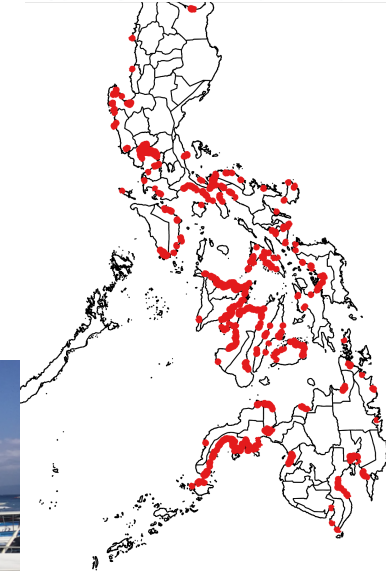


Country	Aquaculture					
Indonesia	48.6	0.1	15.7	22.6	1.9	11.2
Myanmar	1.6	87.6	1.1	0.5	1.6	7.6
Malaysia	14.7	0.1	38.2	17.6	12.8	16.7
Thailand	10.8	5.6	40.0	5.1	14.4	11.1
Philippines	36.7	0.9	11.1	7.3	2.7	
Cambodia	27.7	1.5	8.9	9.8	4.6	
Vietnam	21.0	10.4	0.5	0.6	62.5	
Brunei	29.2	0	27.7	12.5	15.9	
Timor-Leste	0	26.1	0	0	0	
Singapore	0	0	0	0	0	
Total	29.9	21.7	16.3	15.4	4.2	

Richards & Friess 2016

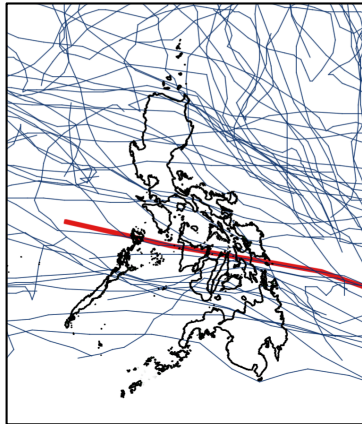


Figure 38. Huge tracts of mangroves have given way to fishponds in Dagupan, Pangasinan (Photo-courtesy: GS Jacinto).

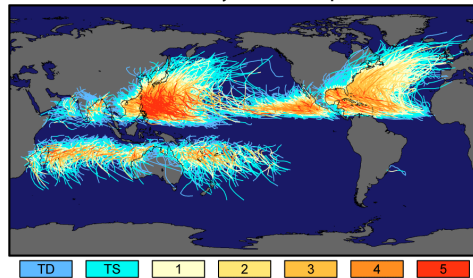


- aquaculture ponds

Threats to Mangrove Survival



Tracks and Intensity of All Tropical Storms



TD TS 1 2 3 4 5

Saffir-Simpson Hurricane Intensity Scale

- 20 typhoons/yr



Kalibo; Typhoon Frank; June 2008

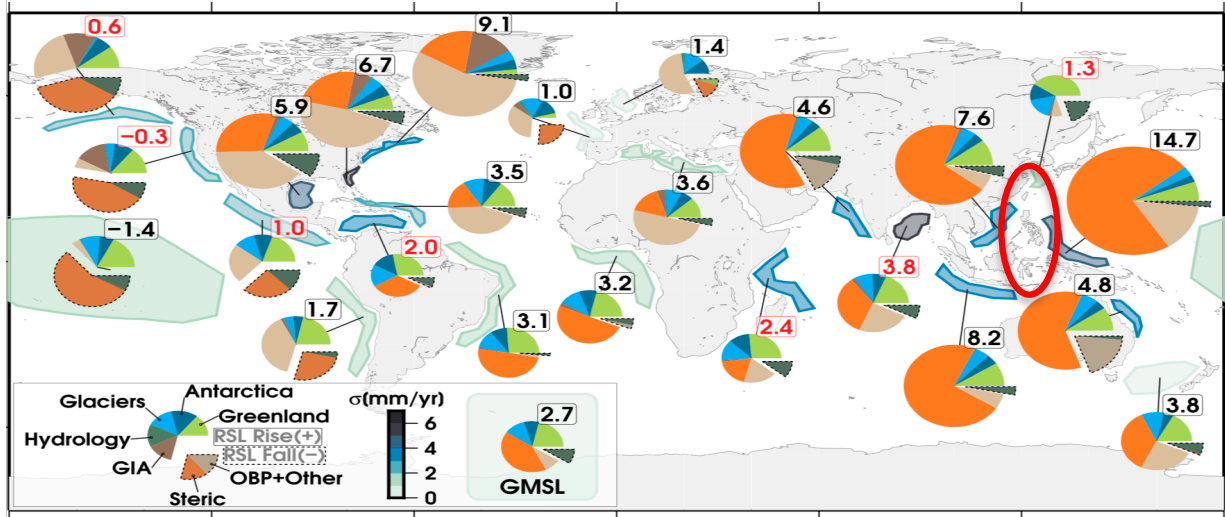
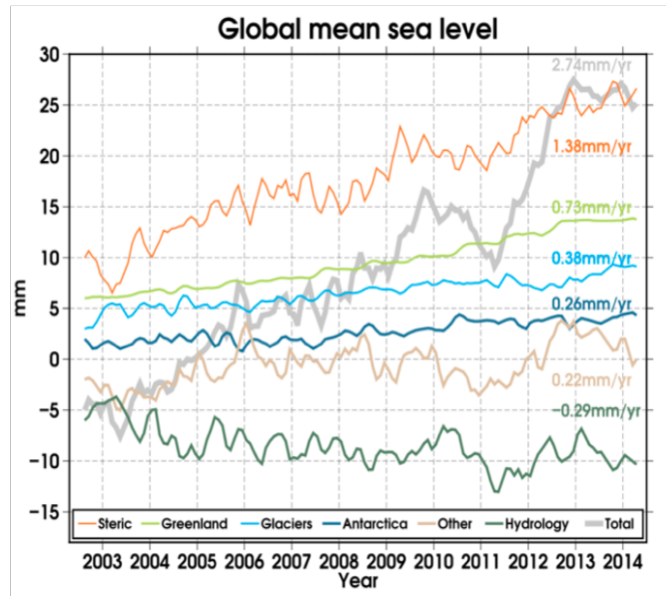


Bani; Typhoon Emong; May 2009

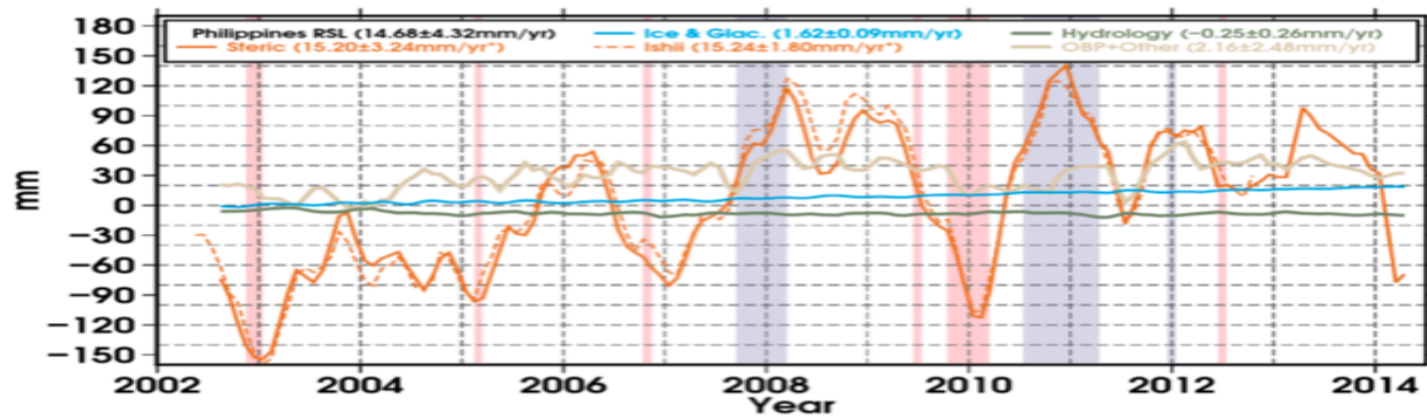


Ormoc; Super Typhoon Yolanda; November 2013

Sea Level Rise: Global

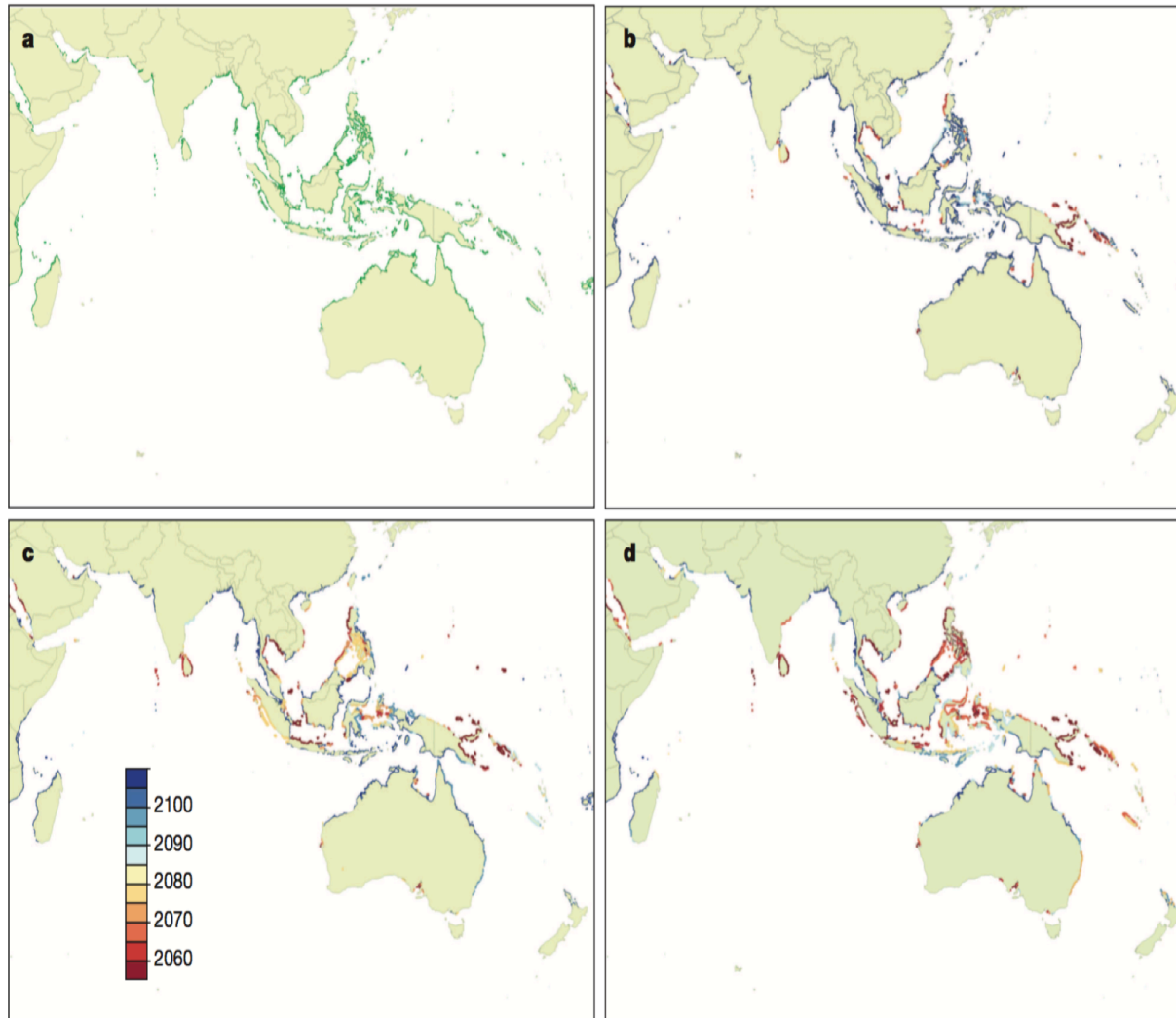


Rietbroek et al. 2016



Eastern Philippines

Sea Level Rise: Asia-Pacific



- 4-5x higher rate of SLR
- 51% wetland loss
- 11 million individuals
- US\$ B 6.5/yr

Lovelock et al. 2015

Sea Level Rise: SE Asia

Sustain Sci (2010) 5: 207-222

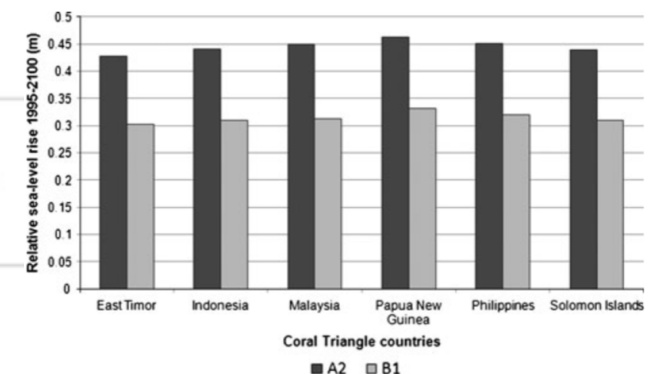
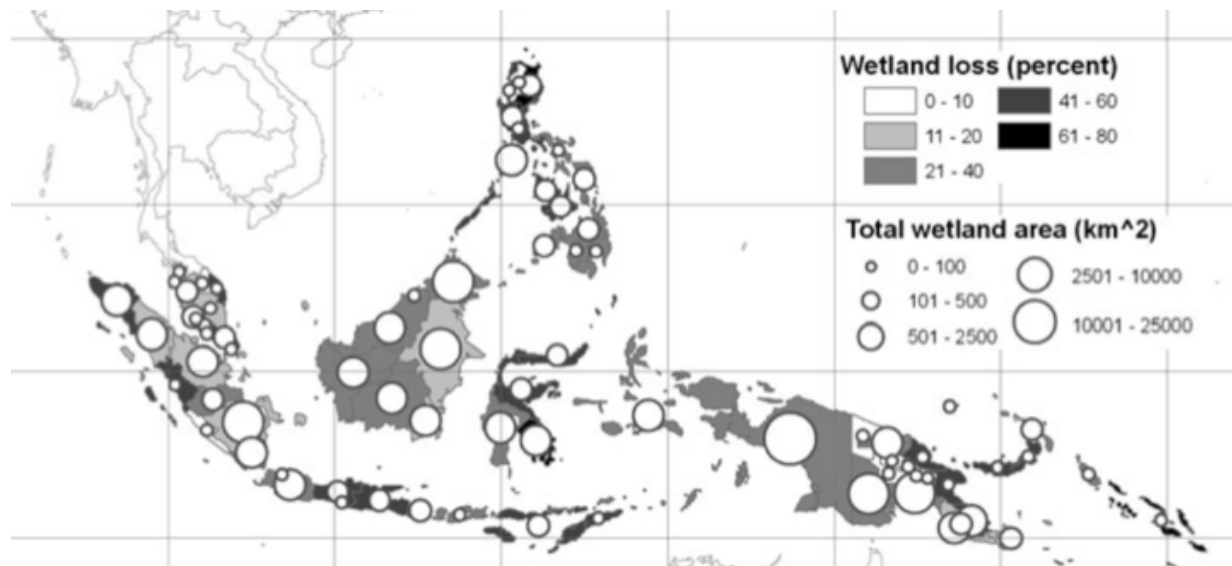
Sea-level rise vulnerability in the countries of the Coral Triangle

Elizabeth Mcleod · Jochen Hinkel · Athanasios T. Vafeidis ·
Robert J. Nicholls · Nick Harvey · Rodney Salm

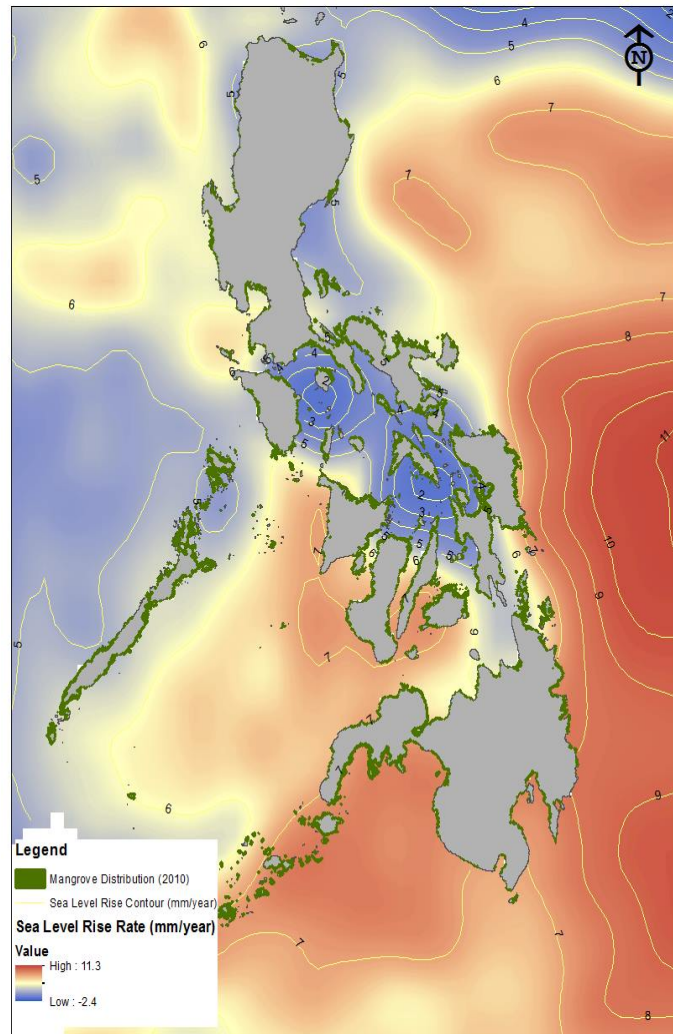
Global: 1.7 ± 0.5 mm/yr

Asia: 1-3 mm/yr

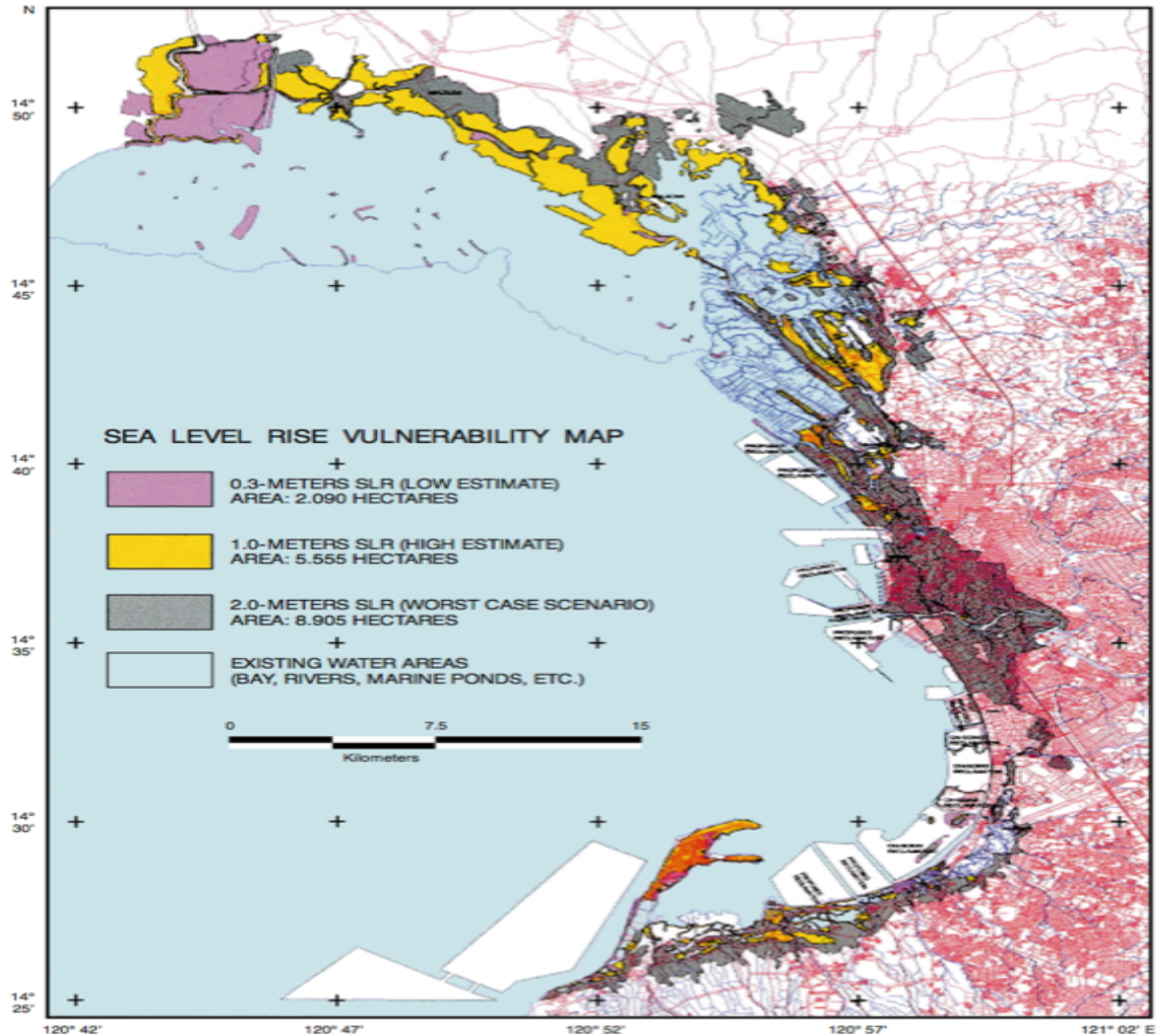
E. Philippines: 4.5-5.9 mm/yr



Sea Level Rise: Philippines




Torio 2017



Perez et al. 1999

ORIGINAL PAPER

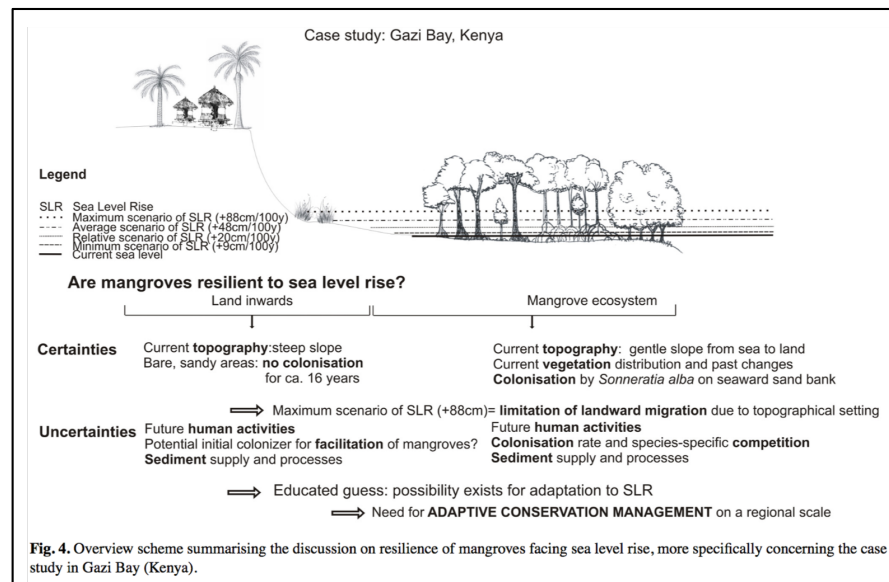
Can mangroves keep pace with contemporary sea level rise? A global data review

Sigit D. Sasmito  · Daniel Murdiyarso · - 23.05 +/- 9.05 mm/yr (cleared)
Daniel A. Friess · Sofyan Kurnianto + 0.70 +/- 0.40 mm/yr

Yes, and No!

Mangroves facing climate change: landward migration potential in response to projected scenarios of sea level rise

D. Di Nitto¹, G. Neukermans¹, N. Koedam¹, H. Defever¹, F. Pattyn^{3,4}, J. G. Kairo⁵, and F. Dahdouh-Guebas^{1,2}



Sea Level Rise: Mangrove Adaptation and Response



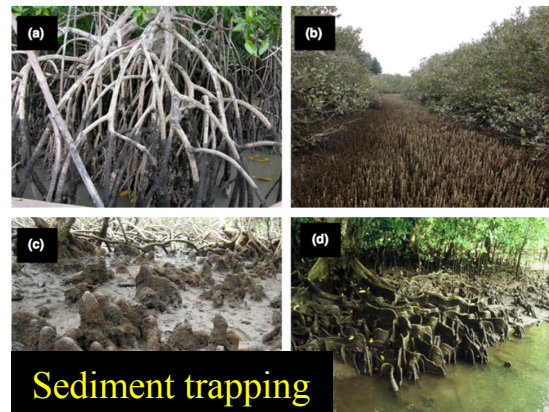
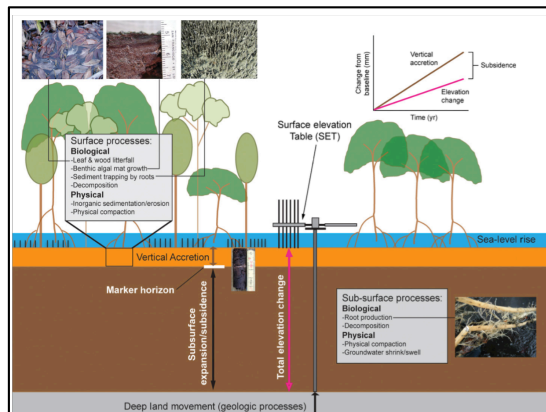
- IPCC Projection: 0.5 to 1.0m
- Colonization or retreat?



High tidal level

Mean tidal level

Low tidal level



Sea Level Rise: Mangrove Adaptation and Response

McIvor et al 2013.

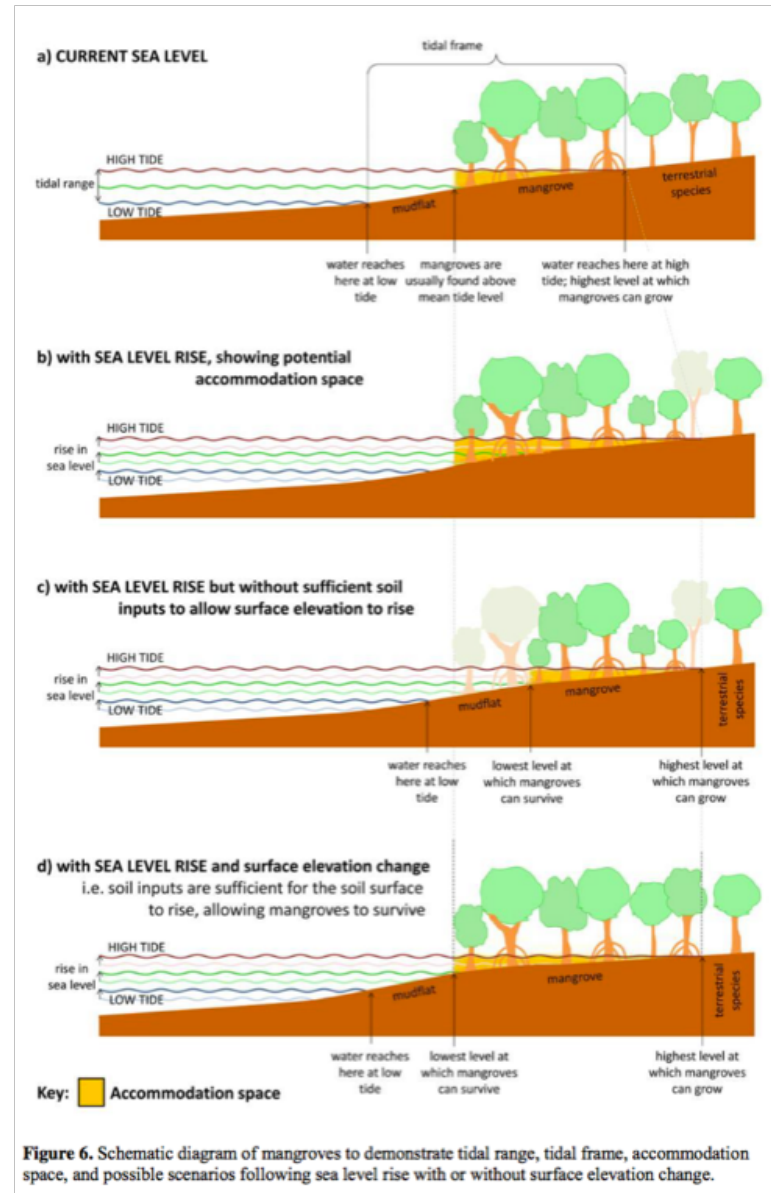
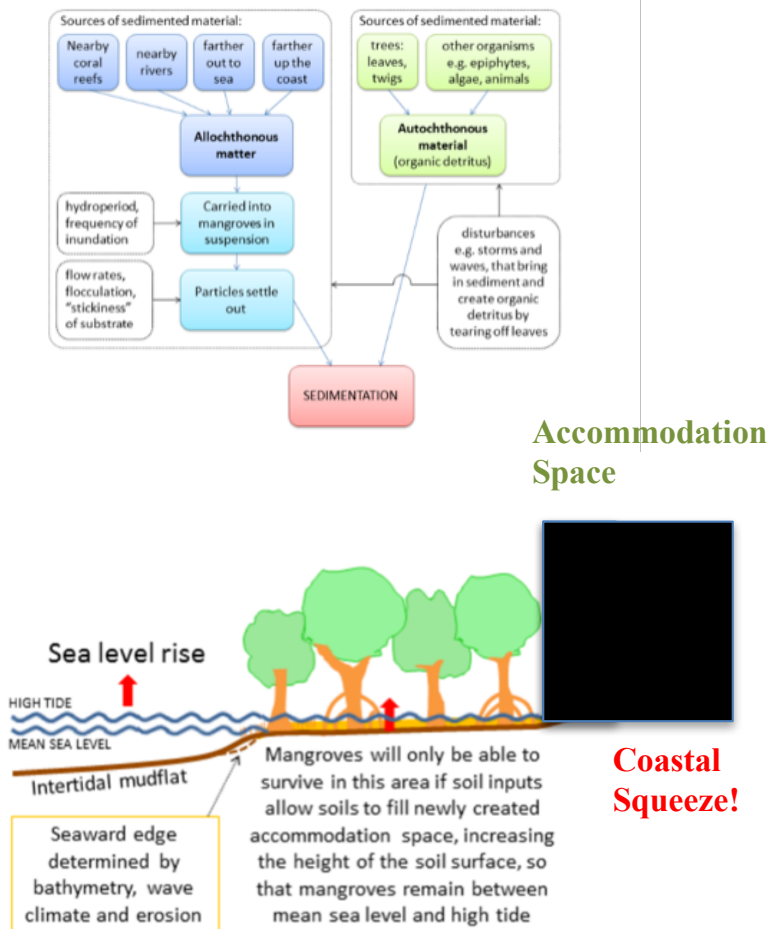
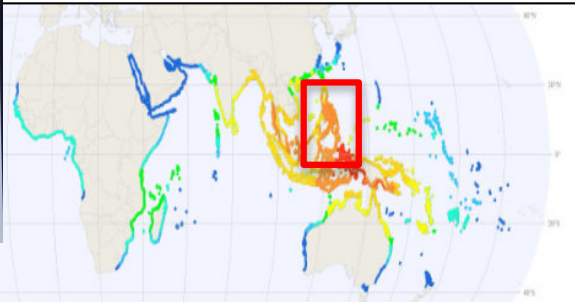


Figure 6. Schematic diagram of mangroves to demonstrate tidal range, tidal frame, accommodation space, and possible scenarios following sea level rise with or without surface elevation change.

Mangrove Conservation/Restoration Program



UNEP-WCMC 2014



Mangrove Protected Area; Subic



CI 2000



Restoration program; Cebu; > 80% mortality; ineffective Salmo et al 2013. Hydrobiologia 720(1): 1-18

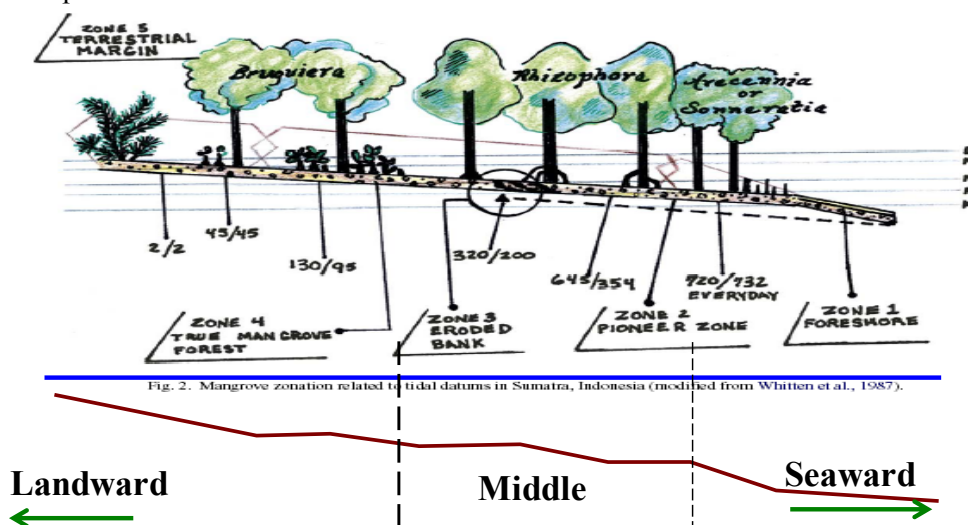


Summary and Management Implications: Why? What now? Where to Restore or Plant?



Consider Species Zonation

- results from combination of tidal inundation, exposure to wind, waves and water currents, soil properties, morphology of species, salinity, light and species association.



Summary and Management Implications: Why? What now? Where to Restore or Plant?

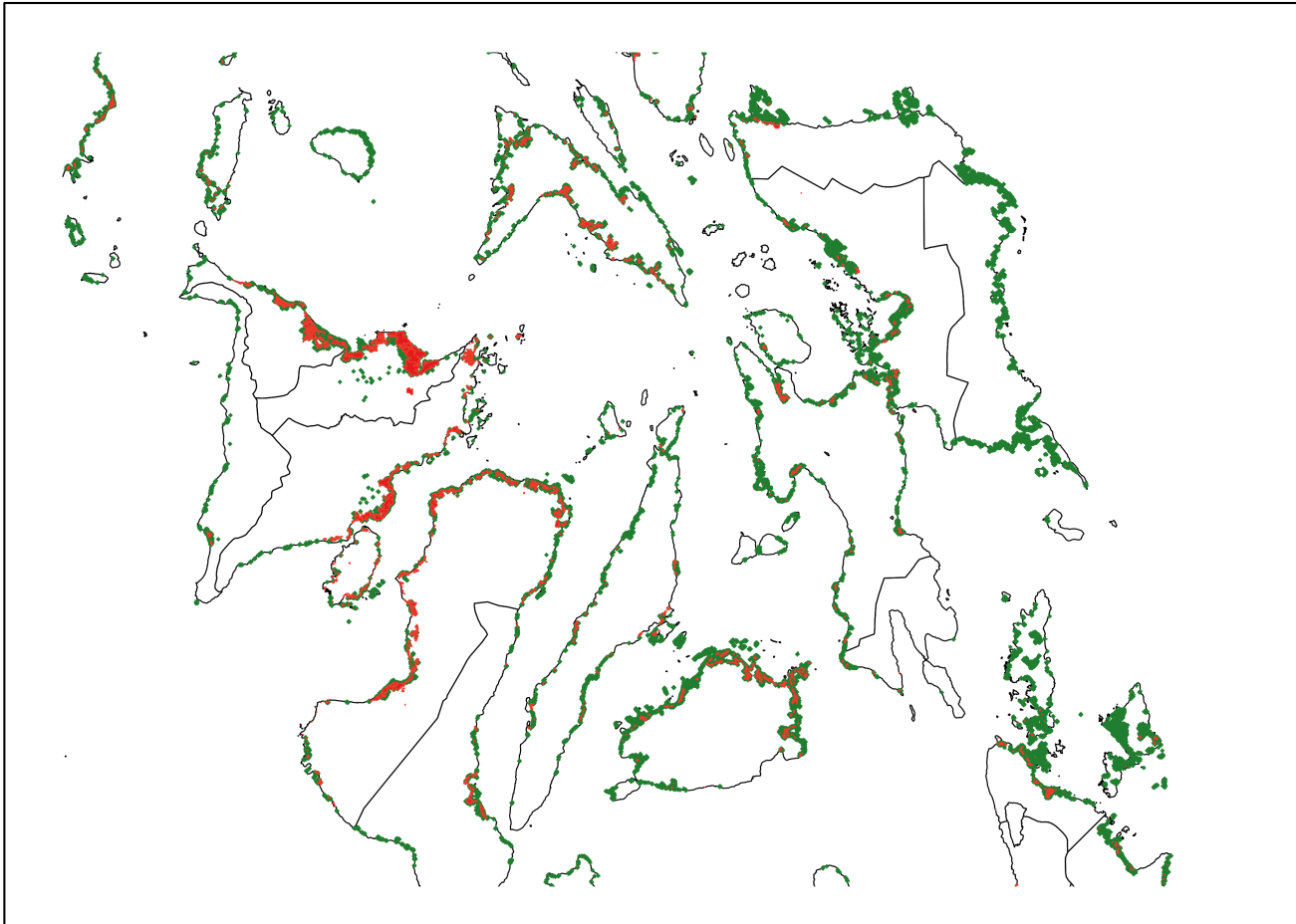
2017 Para El Mar Finalist



Sinandigan Marine Sanctuary
Ubay, Bohol

Summary and Management Implications

- Know your mangroves, but know your sea-level as well
- Prioritize conservation
- Restoration is needed, but prioritize sites to restore



Maraming Salamat !!!



<http://mangroveecology.com>

Philippines' Research Initiative on Mangrove Management and Enhancement Against Natural Disasters



**Partnerships for Enhanced
Engagement in Research
(PEER)**

ATENEODERMANILA UNIVERSITY
PHILIPPINES

