Blue Carbon and Ecosystem Services: small-scale fisheries in mangroves and seagrasses Busuanga Island, Philippines

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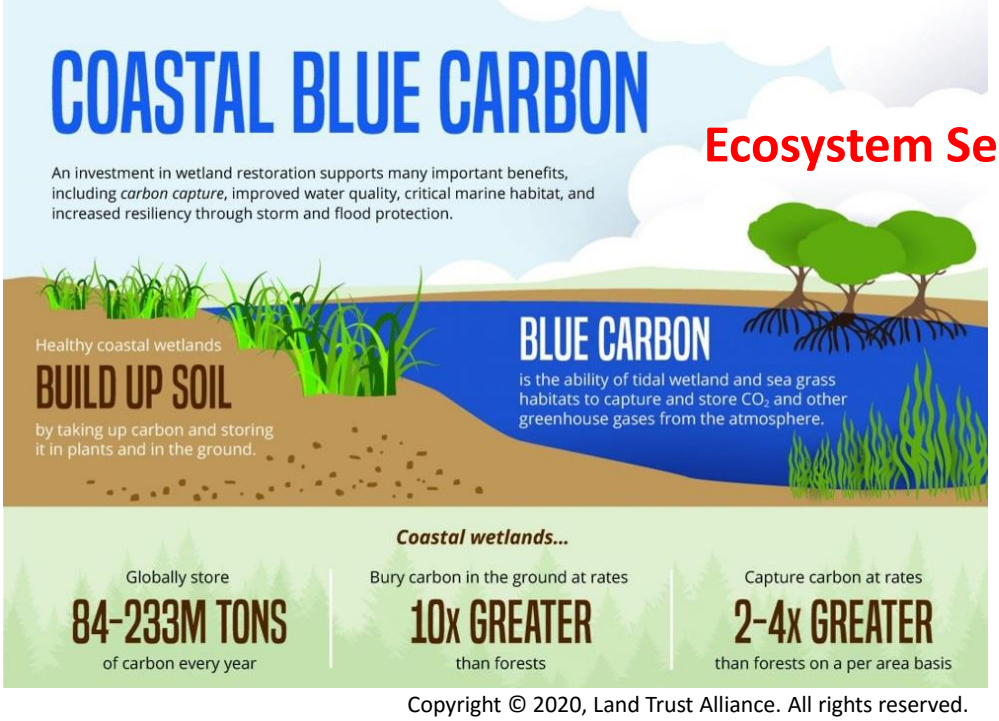
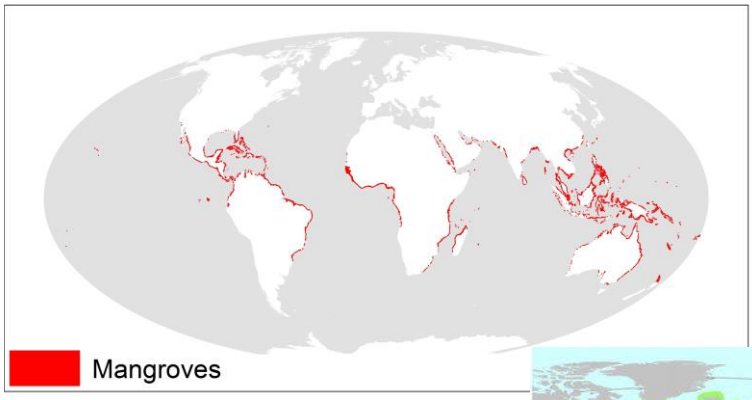


Ecosystem Services

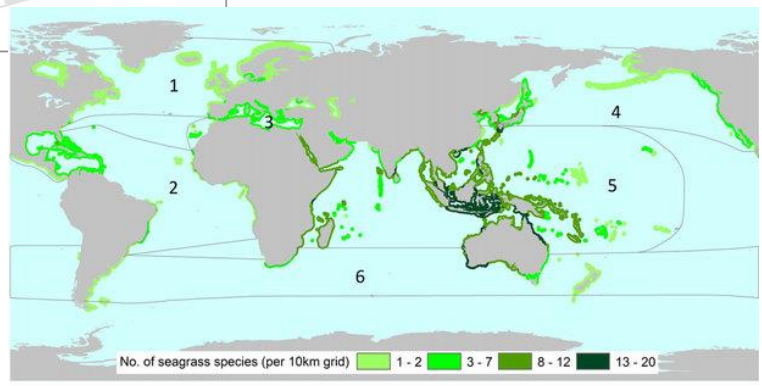
2



Mangroves

Spalding, Kainuma, Collins, 2010

Seagrass



Short, et al. 2011

Small-scale fisheries: 200 million people, 90% developing world

Allison & Ellis, 2001; Bene, Hersoug, Allison, 2010

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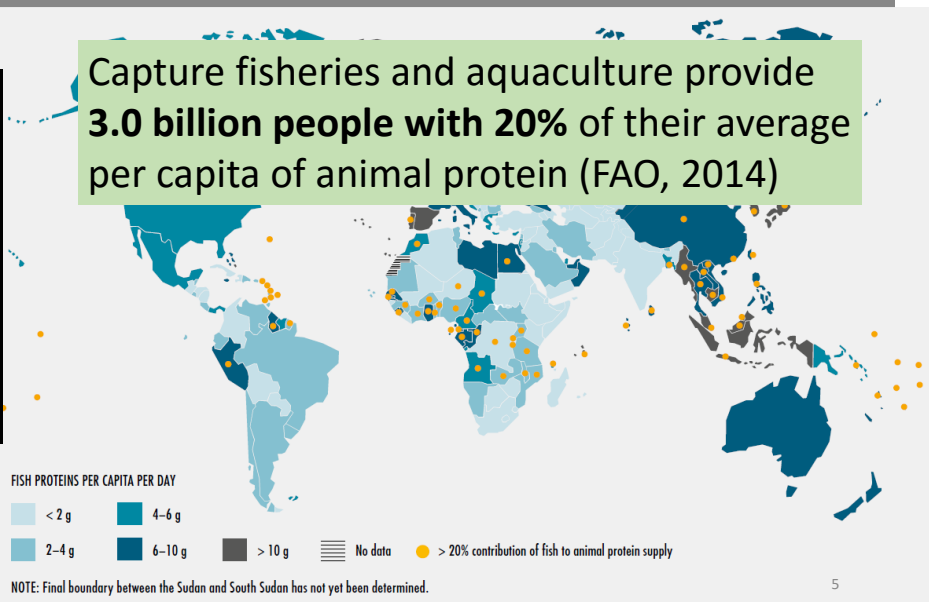
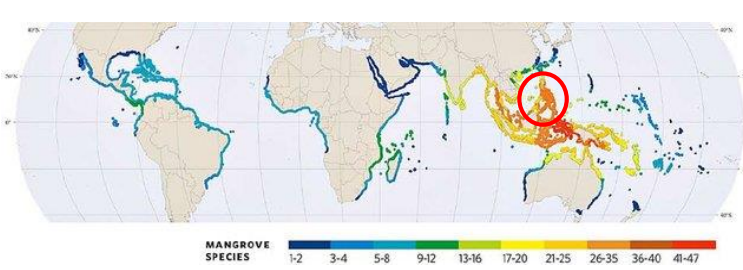
FIGURE 29
CONTRIBUTION OF FISH TO ANIMAL PROTEIN SUPPLY, AVERAGE 2013–2015

Capture fisheries and aquaculture provide **3.0 billion people with 20%** of their average per capita of animal protein (FAO, 2014)

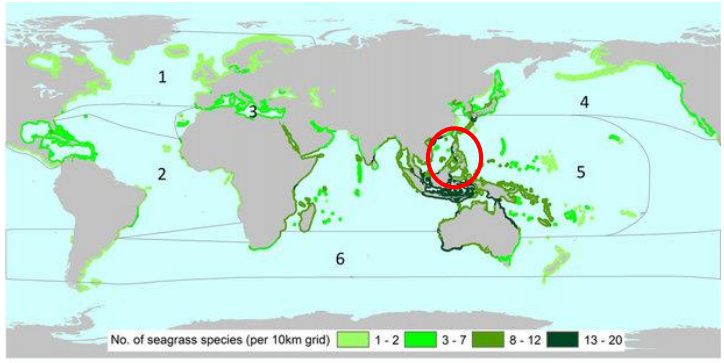


Questions

- Can we assess differences in coastal communities' **vulnerability** to the loss of blue carbon habitat?
- How **prevalent** is the **provisioning service** of blue carbon habitat for coastal communities?
- Can we use **socio-ecological** data to improve management of blue carbon ecosystems?



Deltares, 2014



Short, et al. 2011

Philippines context

- 78% of provinces and 56% of cities and municipalities along the coastline, making up 60% of population
- Fish gives 70% of total animal protein
- Philippines has 16 seagrass species and 42 mangrove species

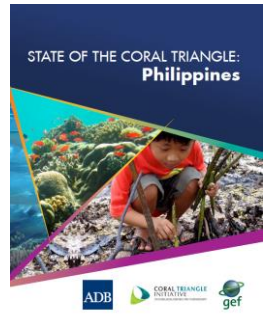
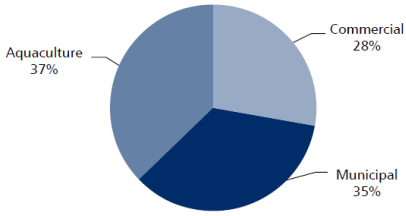
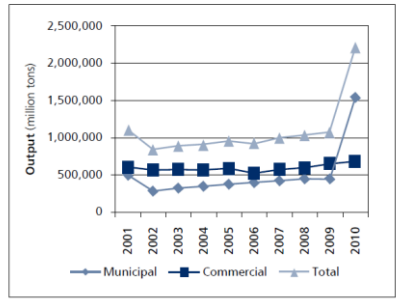


Figure 3 **Subsector Percentage Shares in Total Value of Catch, 2010**



Source: BAS (2010).

Figure 2 **Output of Philippine Capture Fisheries by Subsector, 2001–2010** (million tons)



Source: BFAR (2010).

Busuanga

- 14 barangays
- High mangrove, seagrass, coral cover, but low biomass of target reef fish
- Dugong, sea turtle
- 87% of people in poverty
- High number of recreation, tourism areas
- Problems: coral harvesting, conflicting knowledge on MPAs, need for food livelihood & access to tourism

Coron

- 23 barangays (30% urban barangays)
- High mangrove, seagrass, coral cover
- Tourism leading livelihood source
- Problems: illegal mangrove cutting

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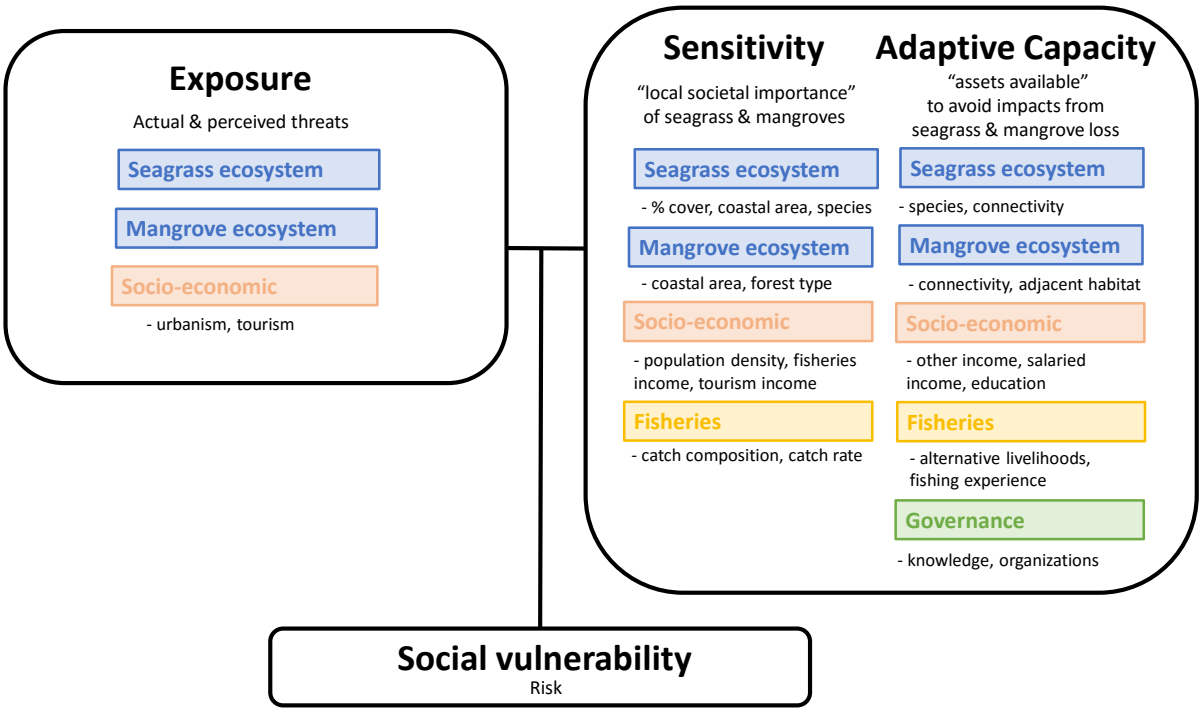
Source: Busuanga and Coron ECAN Resource Management Plans, 2017-2022



Data sources using multiple methods

Ecological surveys & spatial analyses
(n=10)

Landing surveys
(n=601)

Key informant interviews
(n=10)

Household surveys
(n=310)

Participant observation
(120 days)

Indo-Pacific Seagrass Network

Field collections between February 2019 - October 2020

15

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Some communities specialize in seagrass fisheries, others in mangrove fisheries, or both

Municipality	Barangay	Mangrove landings	Mean CPUE (kg/hr) (SD)	Seagrass landings	Mean CPUE (kg/hr) (SD)	
Busuanga	Concepcion	n=19	1.58 (1.11)	n=117	1.37 (1.76)	SG
	New Busuanga	n=0		n=32	0.83 (0.55)	SG
	Quezon	n=17	6.12 (3.70)	n=4	0.86 (0.32)	MG
	Salvacion	n=8	0.31 (0.21)	n=60	1.73 (1.62)	SG
Coron	Borac	n=92	2.02 (1.21)	n=0		MG
	Brgy. 5	n=10	0.78 (0.38)	n=49	0.93 (0.99)	SG
	Decalachao	n=19	1.87 (1.91)	n=9	0.64 (0.15)	MG
	San Jose	n=18	1.63 (1.11)	n=50	1.02 (1.31)	SG
	Turda	n=15	0.97 (1.35)	n=21	1.17 (0.91)	SG/MG
Totals		**n=198**	**2.24 (2.39)**	**n=342**	**1.23 (1.42)**	

Mangrove catch

clam

crab

MG

Landing surveys

snail

shrimp

Seagrass catch

clam

SG

snail

fish

Spatial analyses

- Limited analysis to 10 barangays within Busuanga Island
- **Exposure**: Urbanism
  Weighted average distance, human population, with Coron Town weighted heaviest (population 19,000) and Salvacion town (population 4,000)
- Coron had a weight of 0.84 (a/(a + b))

Salvacion had a weight of 0.16 (b/(a + b))

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Spatial analyses

- **Sensitivity:** Coastline covered by seagrass and mangroves
  Remotely sensed data ground-truthed in the field or by expert opinion
- **Mangrove Vegetation Index (MVI)**: Baloloy et al, 2020
  Using a 100-m buffer distance (ArcGIS), calculated the length of mangrove forest by total length of each barangay coastline
- **Landsat 8 linear spectral unmixing method for seagrass**
  Overlaid validated seagrass map on UNEP coral reef base layer (reef flat) to show the proportion of reef flat covered by seagrass in each barangay

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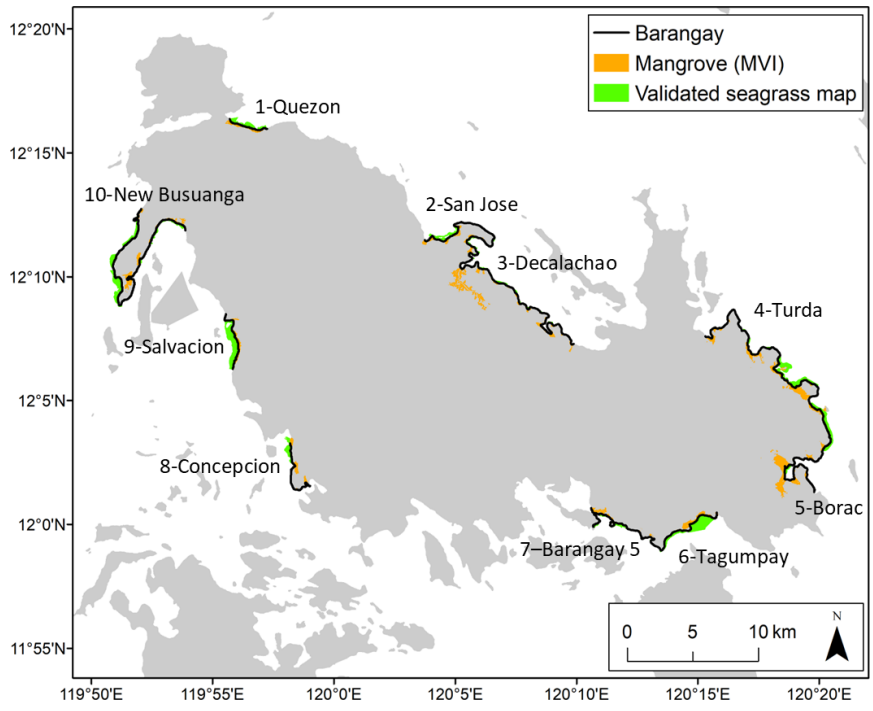

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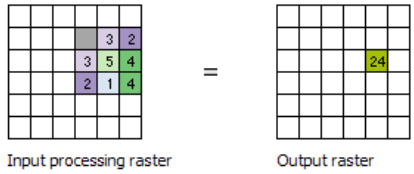
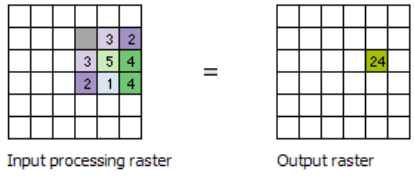
Spatial analyses



- **<u>Adaptive capacity:</u>** Habitat patchiness
- Continuous grid of 500-m cells in the mangrove & seagrass layers
- Focal statistics function (ArcGIS) to calculate the contiguous area of 3 cells with seagrass or mangroves, separately
- Focal analysis score divided by number of 500-m cells within that barangay for a connectivity ratio
- Focal analysis ratio <25% small, fragmented habitats
  25-60% medium patchiness
  >60% contiguous

https://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/how-focal-statistics-works.htm 24

Spatial analyses



- **<u>Adaptive capacity:</u>** Adjacent habitat
- Same grid of 500-m cells in the mangrove & seagrass layers
- Connectivity score between 0 and 2
  Score = 0 : 1 habitat (seagrass, mangrove or coral)

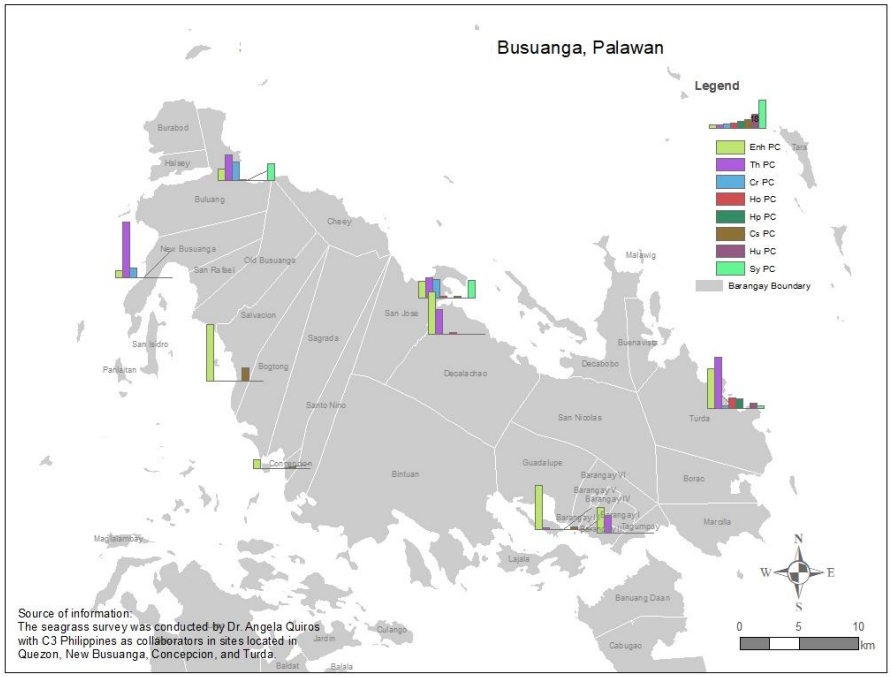
Score = 1: 2 habitats (seagrass/mangrove, seagrass/coral or coral/ mangrove)
Score = 2: 3 habitats present

Divide total cells in barangay grid by cumulative connectivity score
Low connectivity score <1; Medium score between 1 to 1.5;

High score > 1.5

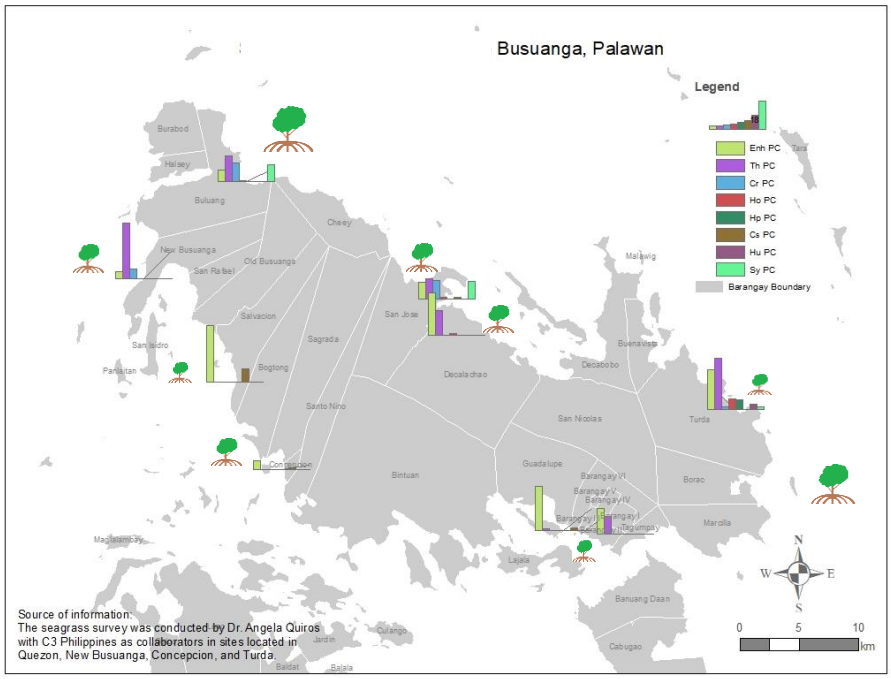
https://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/how-focal-statistics-works.htm 25

Seagrass abundance by species,



Map created by Ayin Tamondong with superimposed data from the BlueCARES Ecology Group

Seagrass abundance by species,
Mangrove forest type,



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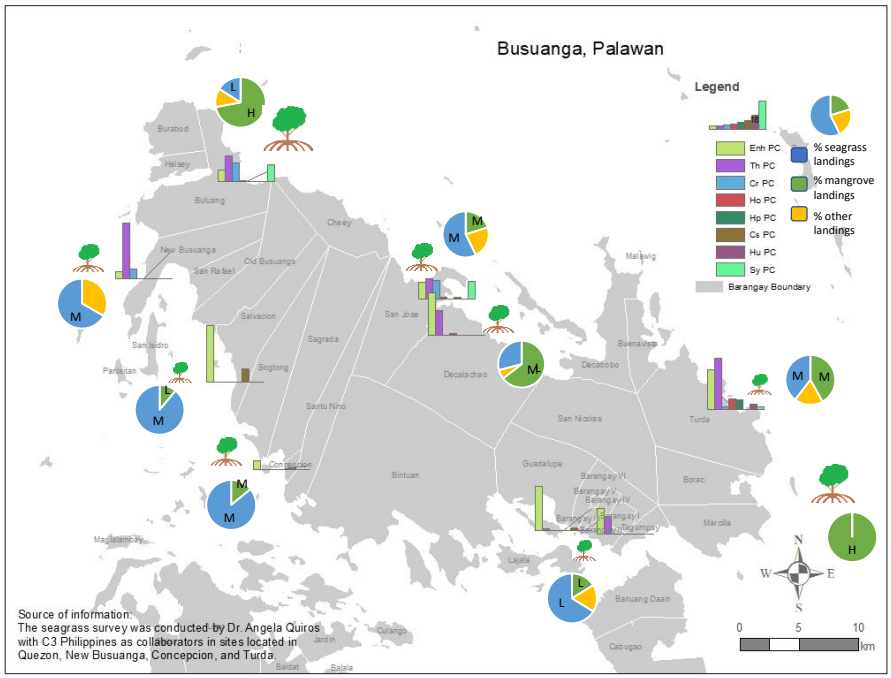
Riverine-basin-fringing

Riverine-fringing

Scrub-fringing

Seagrass abundance by species, Mangrove forest type, **Proportion seagrass & mangrove landings coded by Catch Per Unit Effort (CPUE) across 9 barangays Busuanga Island, Philippines**



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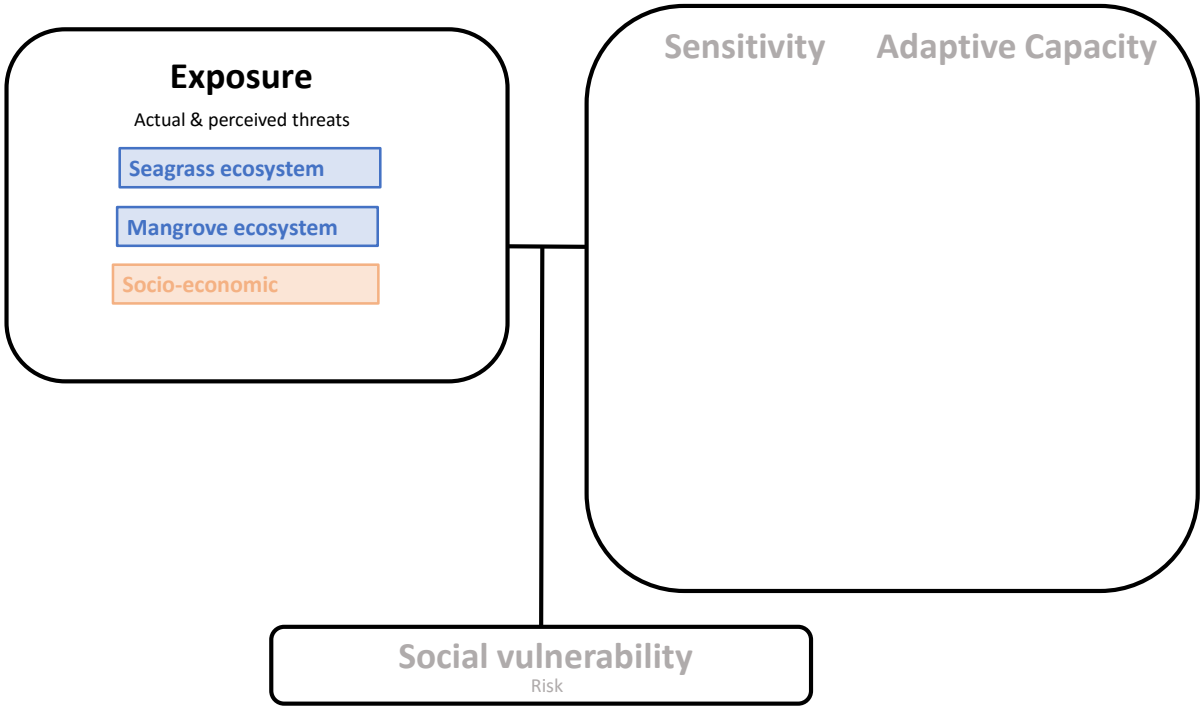

Exposure Indicators for fisheries systems

Mamauag et al, 2013;
Jacinto et al, 2015;
Licuanan et al, 2015

	Criteria	Low, Medium, High
Seagrass ecosystem	Perception to changes in seagrass cover	**Low exposure**: widespread, dense **Medium exposure**: patchy, decreasing **High exposure**: sparse
Mangrove ecosystem	Perception to changes in mangrove cover	**Low exposure**: widespread, dense **Medium exposure**: patchy, decreasing **High exposure**: sparse
Socio-economic	Urban gradient*	**Low exposure**: Weighted distance > 40 km **Medium exposure**: Weighted distance 20-40 km **High exposure**: Weighted distance < 20 km
	Tourism gradient*	**Low exposure**: low **Medium exposure**: medium **High exposure**: high

*additional variable created for this study

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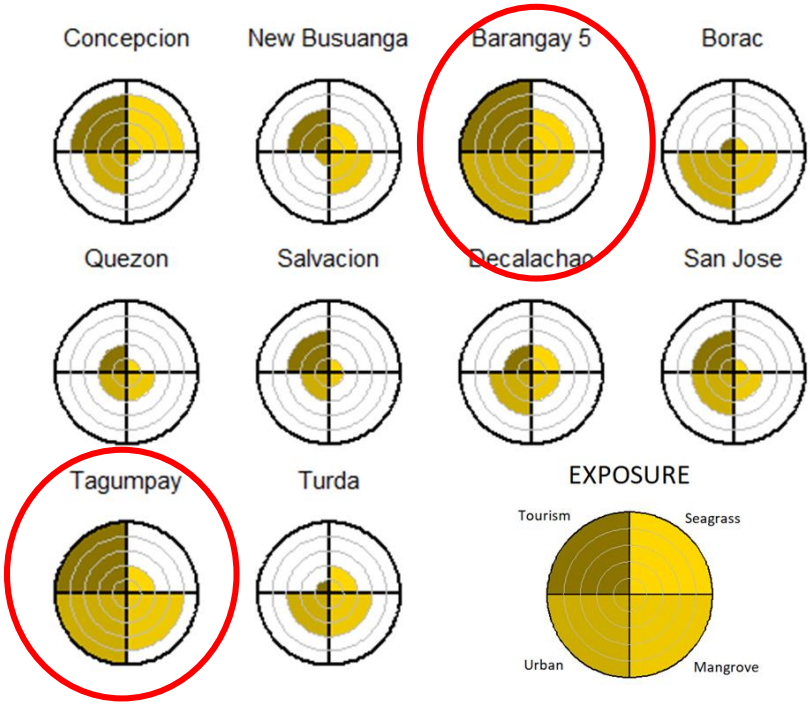

Urban barangays have higher Exposure

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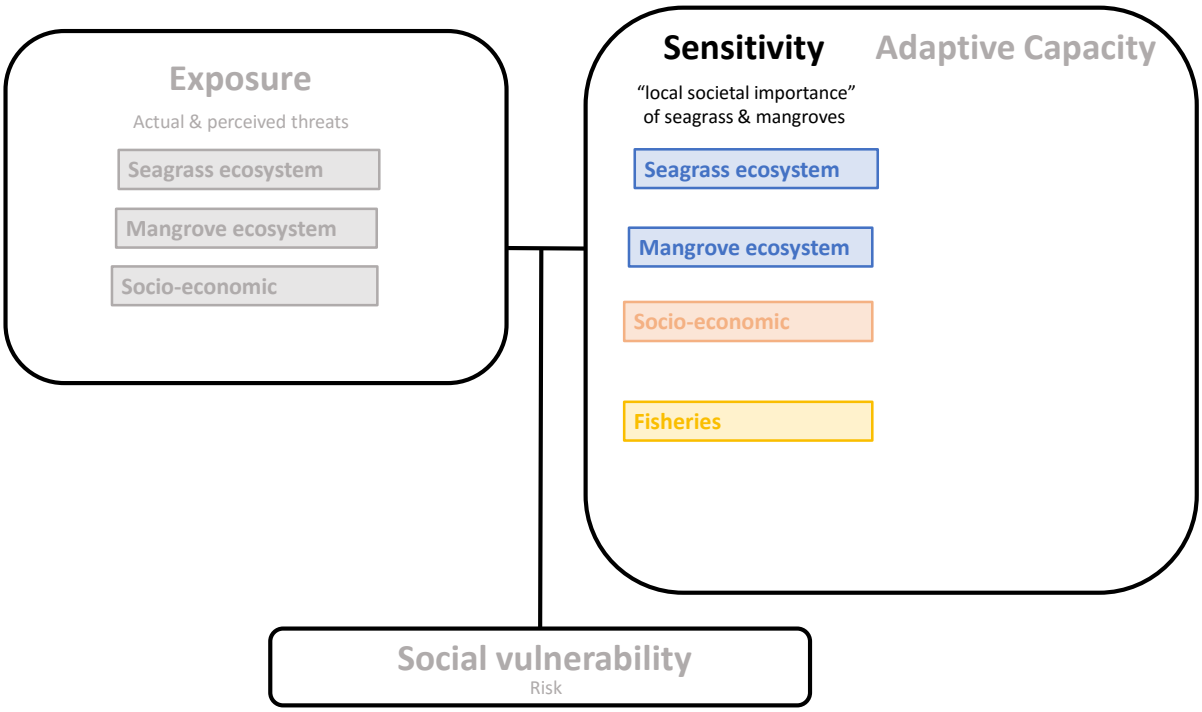

What makes up a healthy seagrass bed?

- **Methods**
- Seagrass habitat (Seagrass Watch, Indo-Pacific Seagrass Network (IPSN))

Sensitivity Indicator	Low sensitivity (1-2 pts)	Medium sensitivity (3-4 pts)	High sensitivity (5 pts)
Seagrass % cover	> 51%	21-50%	<20%
Seagrass species number	> 5 species seagrass	2 – 4 species	Monospecific seagrass bed

Ecological surveys

Sensitivity Indicators for fisheries systems

Mamauag et al, 2013; Jacinto et al, 2015; Licuanan et al, 2015

	Criteria	Low, Medium, High
Ecosystem SG	Seagrass % cover	**Low sensitivity**: seagrass % cover > 51% **Medium sensitivity**: seagrass % cover 21-50% **High sensitivity**: seagrass % cover <20%
	Coastal area covered by seagrasses	**Low sensitivity**: > ½ reef flat **Medium sensitivity**: 1/8 to ½ reef flat **High sensitivity**: < ½ reef flat
	Seagrass species number	**Low sensitivity**: > 5 species **Medium sensitivity**: 2-4 species **High sensitivity**: monoculture
MG	Coastal area covered by mangroves	**Low sensitivity**: > ½ coastline **Medium sensitivity**: 1/8 to ½ coastline **High sensitivity**: < ½ coastline
	Kind of mangrove forest	**Low sensitivity**: riverine-basin-fringing **Medium sensitivity**: riverine-fringing **High sensitivity**: scrub-fringing

*additional variable created for this study

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What makes up a less sensitive catch?

Methods

- Fishery variables (Quiros et al, 2018, Indo-Pacific Seagrass Network (IPSN))

Sensitivity Indicator	Low sensitivity (1-2 pts)	Medium sensitivity (3-4 pts)	High sensitivity (5 pts)
Dominant catch	pelagics	mix of pelagic, demersal	demersal, nearshore
Seagrass CPUE (catch per unit effort)	> 8 kg / fisher/ day	3 kg / fisher/ day	< 3 kg / fisher/ day

Landing surveys

Sensitivity Indicators for fisheries systems

Mamauag et al, 2013; Jacinto et al, 2015; Licuanan et al, 2015

	Criteria	Low, Medium, High
Fisheries	Dominant catch composition	**Low sensitivity**: pelagics **Medium sensitivity**: mix of pelagic, demersal **High sensitivity**: demersal, nearshore
	Catch rate	**Low sensitivity**: > 8 kg / fisher/ day **Medium sensitivity**: 3 kg / fisher/ day **High sensitivity**: < 3 kg / fisher/ day
Socio-economic	Population density	**Low sensitivity**: < 200 /km2 **Medium sensitivity**: 200-400 /km2 **High sensitivity**: > 500 / km2
	Fisheries ecosystem dependency	**Low sensitivity**: < 25% full time fishers **Medium sensitivity**: 25-50% full time fishers **High sensitivity**: > 50% full time fishers
	Tourism income	**Low sensitivity**: <7 % tourism workers **Medium sensitivity**: 7-15% tourism workers **High sensitivity**: >15% tourism workers

*additional variable created for this study

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How reliant are households on seagrass resources?

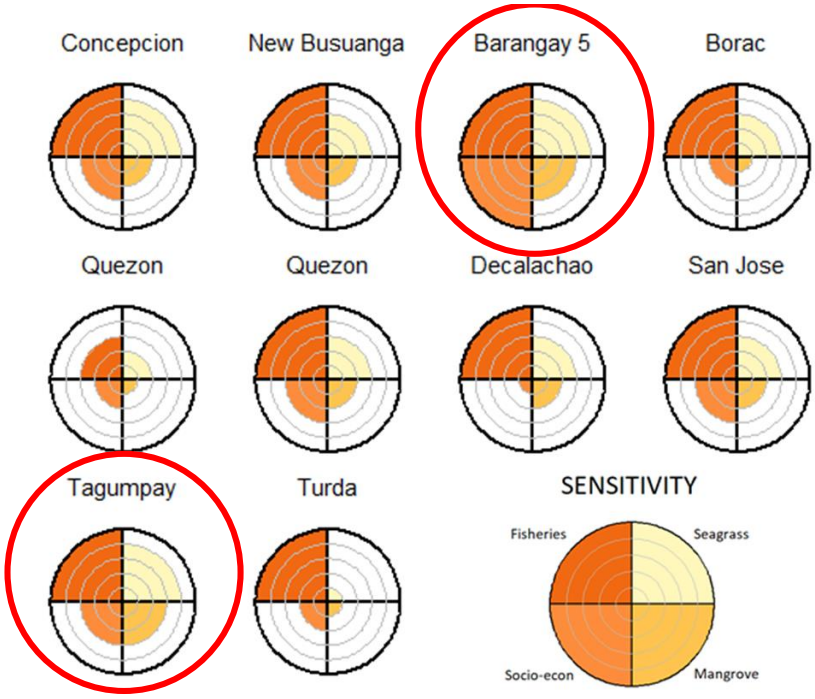
Socio-economic

- Non-fishing employment
- Household reliance on seagrass

Household surveys

Quiros et al, 2018

Sensitivity Indicator	Low sensitivity (1-2 pts)	Medium sensitivity (3-4 pts)	High sensitivity (5 pts)
Human population density	< 200 /km2	200-400 /km2	> 500 / km2
Fisheries income	< 25% full time fishers	25-50% full time fishers	> 50% full time fishers



Urban barangays have higher Sensitivity

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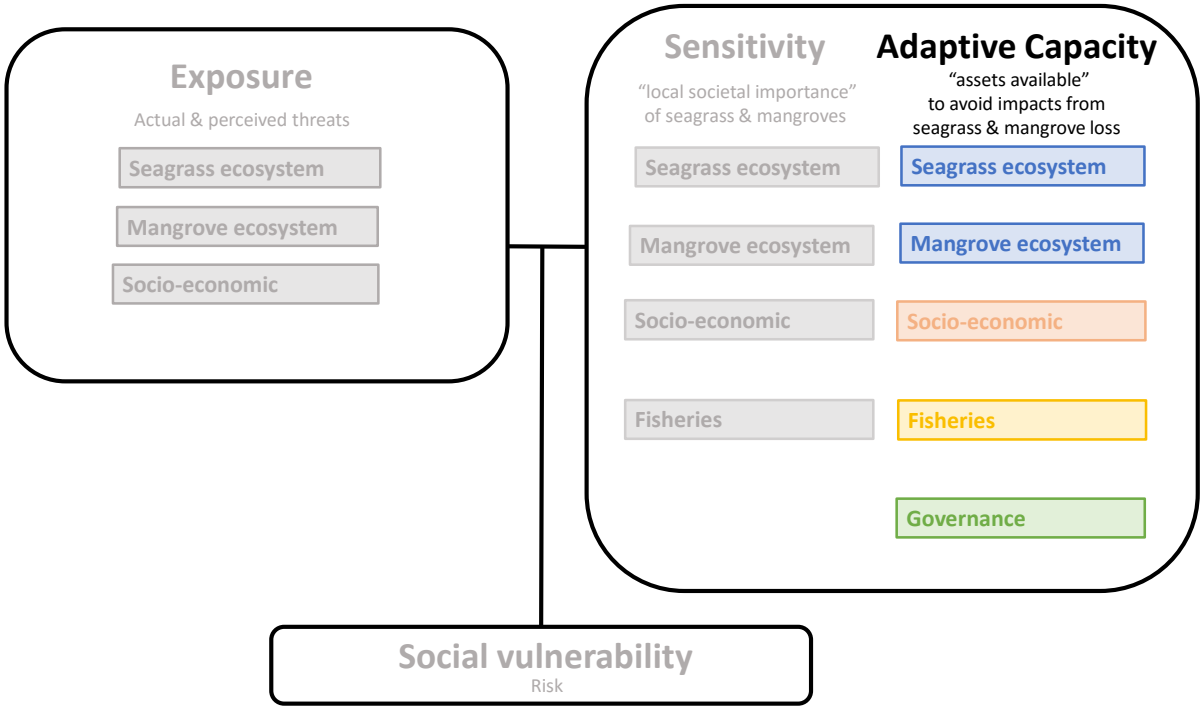

Adaptive Capacity Indicators for fisheries systems

Mamauag et al, 2013; Jacinto et al, 2015; Licuanan et al, 2015

	Criteria	Low, Medium, High
Ecosystem SG 	Seagrass species composition	**Low adaptive capacity**: *Enhalus* or no seagrass **Med adaptive capacity**: *Enhalus, Thalassia, Cymodocea, Halodule* **High adaptive capacity**: *Halophila, Halodule*
	Seagrass habitat extent	**Low adaptive capacity**: Small, fragmented **Med adaptive capacity**: Patchy, but large area **High adaptive capacity**: Large, contiguous area
	Presence of adjacent habitat (seagrass or mangroves or corals)	**Low adaptive capacity**: Absent **Med adaptive capacity**: Presence of 1 adjacent habitat in good condition **High adaptive capacity**: Presence of 2 adjacent habitats
MG 	Mangrove habitat extent	**Low adaptive capacity**: Small, fragmented **Med adaptive capacity**: Patchy, but large area **High adaptive capacity**: Large, contiguous area

*additional variable created for this study

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Adaptive Capacity Indicators for fisheries systems

Mamauag et al, 2013; Jacinto et al, 2015; Licuanan et al, 2015

	Criteria	Low, Medium, High
Socio-economic	Fishers with other sources of income	**Low adaptive capacity**: < 40% fishers **Med adaptive capacity**: 40-60% fishers **High adaptive capacity**: > 60% fishers
	Households with Salaried income	**Low adaptive capacity**: < 10% salaried **Med adaptive capacity**: 10-15% salaried **High adaptive capacity**: > 15% salaried
Fisheries	Alternative livelihoods to fishing	**Low adaptive capacity**: Only fishing **Med adaptive capacity**: 1-2 other livelihoods **High adaptive capacity**: > 3 other livelihoods
	Fishing experience	**Low adaptive capacity**: > 20 years **Med adaptive capacity**: 5-10 or 10-20 years **High adaptive capacity**: < 5 years

*additional variable created for this study

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Adaptive Capacity Indicators for fisheries systems

Mamauag et al, 2013; Jacinto et al, 2015; Licuanan et al, 2015

	Criteria	Low, Medium, High
Governance	Access to knowledge, information	**Low adaptive capacity**: No NGOs, 1 past NGO **Med adaptive capacity**: 1 current NGOs **High adaptive capacity**: 2 current NGOs
	People's Organizations	**Low adaptive capacity**: No presence, 1 PO **Med adaptive capacity**: 2-5 POs **High adaptive capacity**: > 5 Pos
	Education	**Low adaptive capacity**: > 60% less than 10 years schooling (high school) **Med adaptive capacity**: 20-40% or 40-60% less than 10 years schooling **High adaptive capacity**: < 10 % with less than 10 years schooling

*additional variable created for this study

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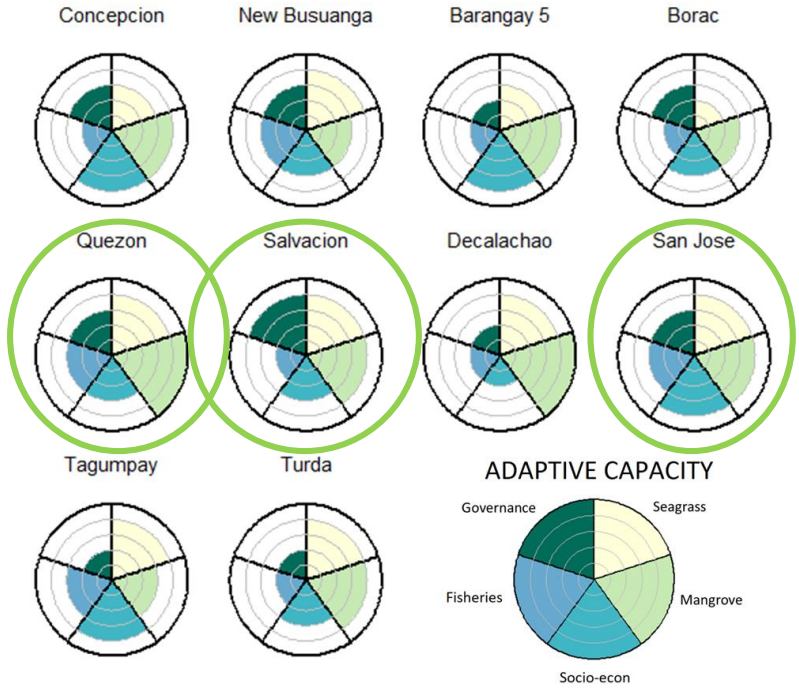

Rural & Peri-urban barangays have higher Adaptive Capacity

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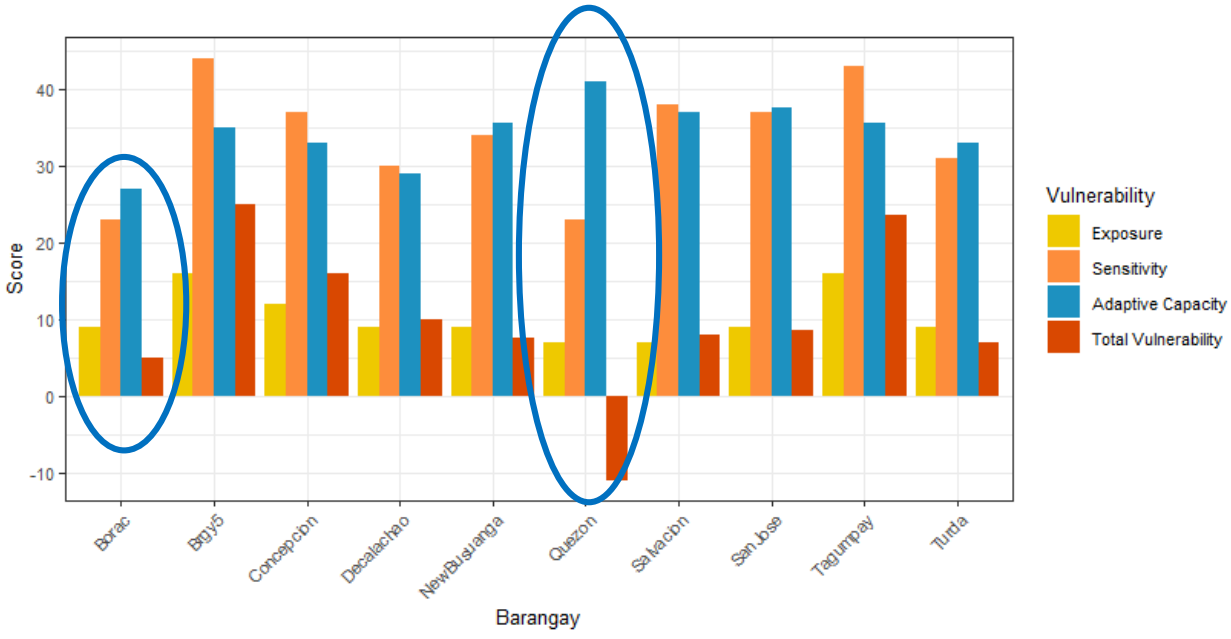
Simple ranking of vulnerability scores

Categories	Number of variables	Minimum score	Maximum score	LOW score	MEDIUM score	HIGH score
Blue Carbon fisheries	3	3	15	3-7	8-11	12-15
Socio-economic	4	4	20	4-9	10-15	16-20
Seagrass ecosystem	2	2	10	2-4	5-7	8-10

Scores were used to rank variables using a point class interval

Mamauag et al, 2013



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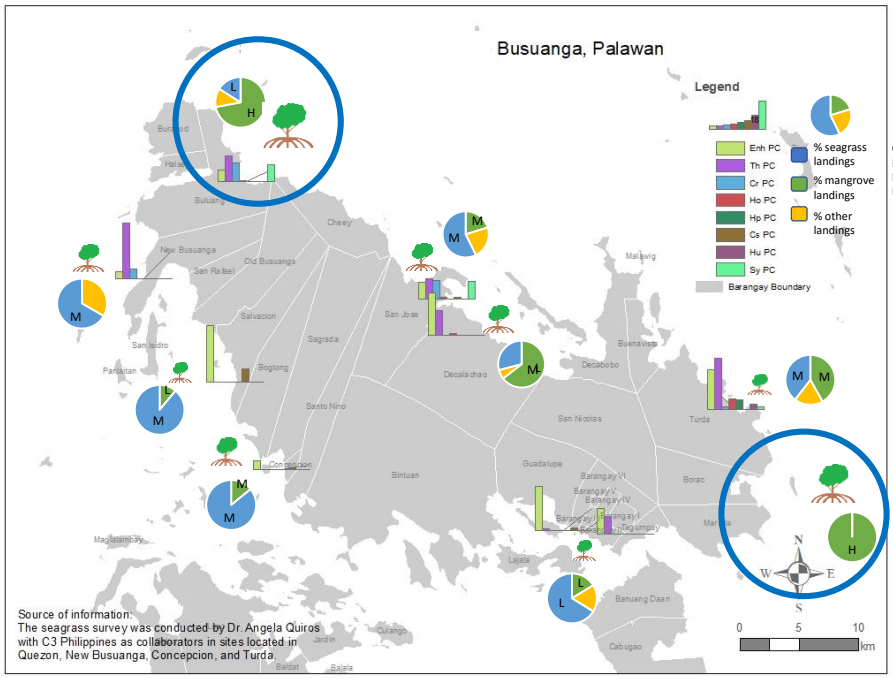

Map created by Ayin Tamondong with superimposed data from the BlueCARES Ecology Group

Conclusions

- Vulnerability criteria can help address multiple SDGs at once (poverty, hunger), while tackling natural resource management issues
- Policy prescriptions for Busuanga Island:

1) Improve access to education

2) Increase information and organization opportunities

3) Equitable fisheries management

4) Establish protected areas and limit tourism development in sensitive habitat

Less vulnerable communities

Low population density

Low fisheries dependency

Good governance

Healthy blue carbon habitat

Many thanks to-
University of the Philippines, Dilliman – Gay Go, Joy Jamilla, Mikko Garcia
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Palawan Council for Sustainable Development
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