

Assessing vulnerability of fisheries in the Philippines to Climate Change Impacts

Tool for Understanding Resilience of Fisheries (VA-TURF)

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OUTLINE

- **Introduction**
  - Climate Change
  - Impacts of Climate Change to Fisheries
- **Significance of the study**
  - Philippines as a vulnerable country
  - Status of Coral Reefs and Fisheries
- **Tool for Understanding Resilience of Fisheries (VA-TURF)**
- **Case study**
- **Summary**

INTRODUCTION

Storm Surge

Acidification

CLIMATE CHANGE

Typhoons

Global Warming

Image credits: www.stormsurge.noaa.gov| www.pmel.noaa.gov| www.nasa.gov| www.scienceblogs.com

INTRODUCTION

CLIMATE CHANGE

-any **significant change** in the measures of climate lasting for an extended period of time

- -temperature
- -precipitation
- -wind patterns

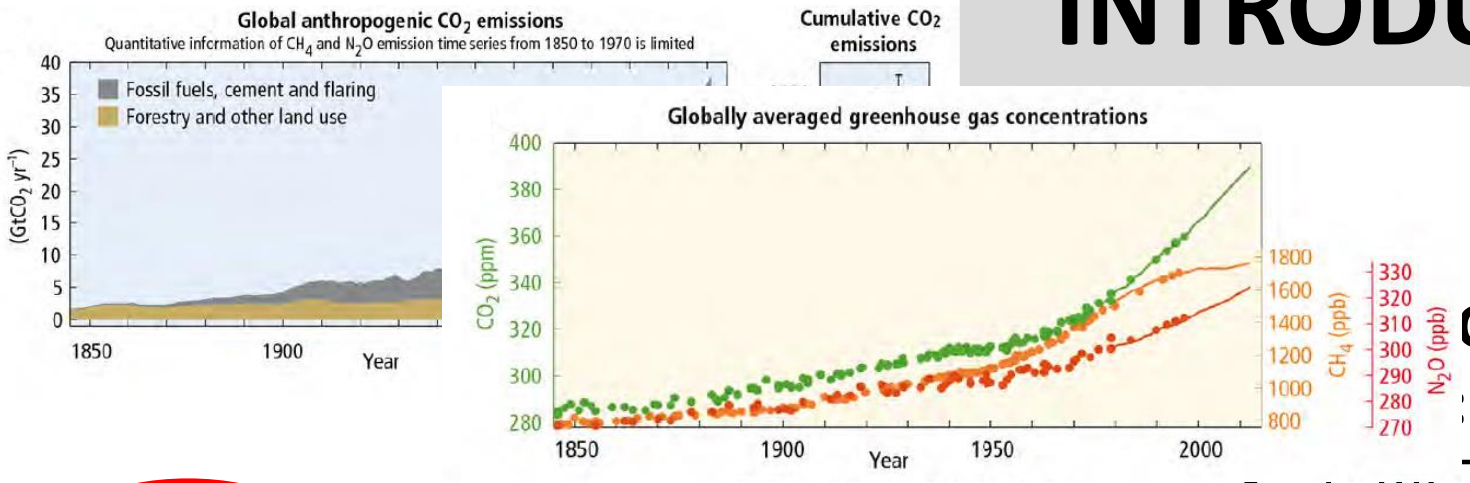
Global Warming

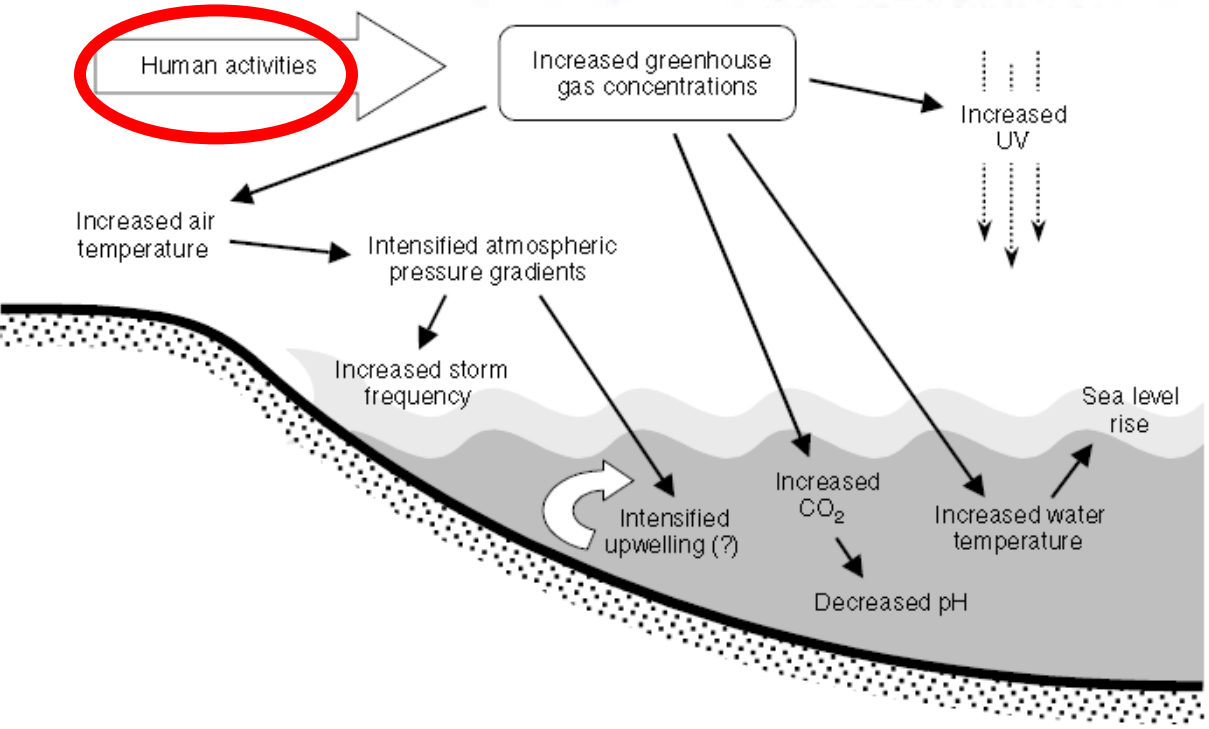
-recent and ongoing **rise in global average temperature** caused mostly by increase in concentration of **greenhouse gases** in the atmosphere

-only represents one aspect of climate change

Source: US Environmental Protection Agency

INTRODUCTION





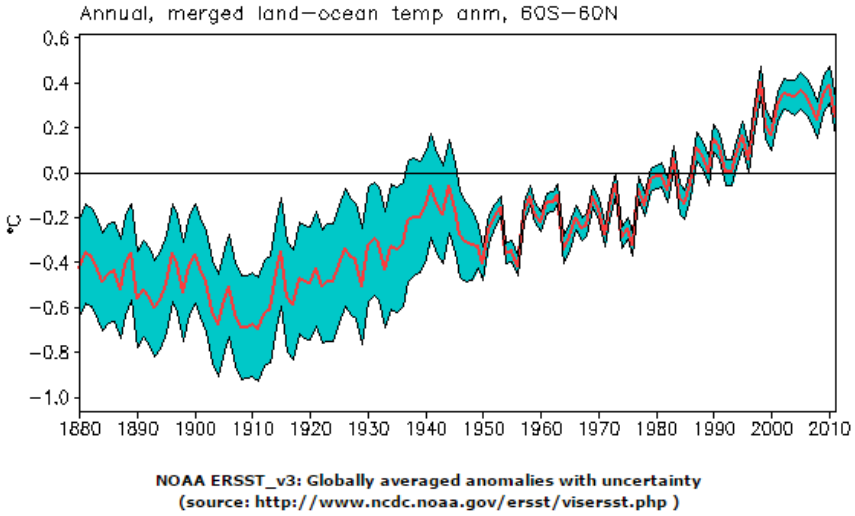
Change

- ↑ Air Temperature
- ↑ Sea Surface Temperature
- Sea Level Rise
- Change in amount and pattern of rainfall
- Wave energy

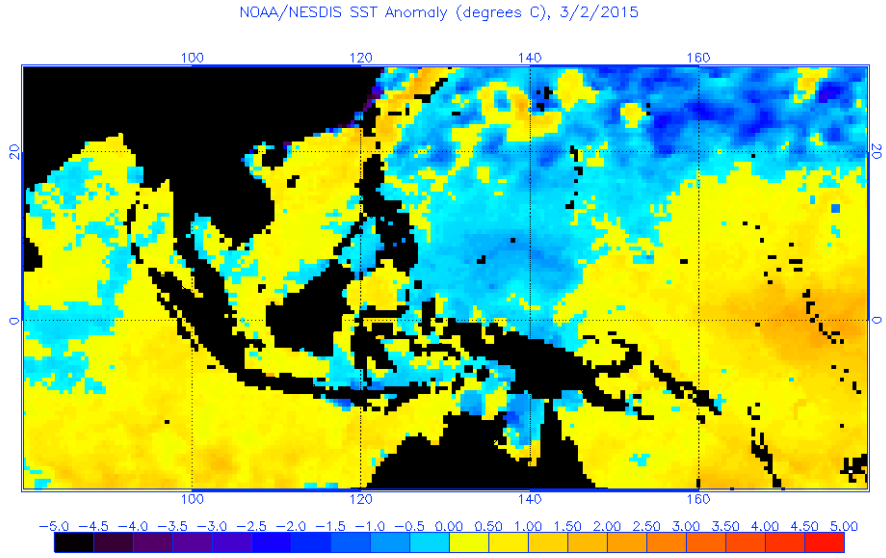
Source: Harley CDG et al.,(2006). The impacts of climate change in coastal marine systems. Ecology Letters 9:228-241 | IPCC Climate Change 2014 Synthesis Report

INTRODUCTION

Sea Surface Temperature (SST)



NOAA ERSST_v3: Globally averaged anomalies with uncertainty
(source: http://www.ncdc.noaa.gov/ersst/visersst.php)



- Global average SST increased
  - Pacific Ocean increased by 0.31°C from 1950-2009[a]
  - Philippines increased by 0.64°C from 1951-2010[b]

Source: Huang et al (2014). The Climate Data Guide: SST data: NOAA Extended Reconstruction SSTs, Version 3 (ERSSTv3&3b)| www.coralreefwatch.noaa.gov |[a] Hoegh-Guldberg et el., 2014. The Ocean| [b] www.pagasa.dost.gov.ph

IMPACTS OF CLIMATE CHANGE TO FISHERIES

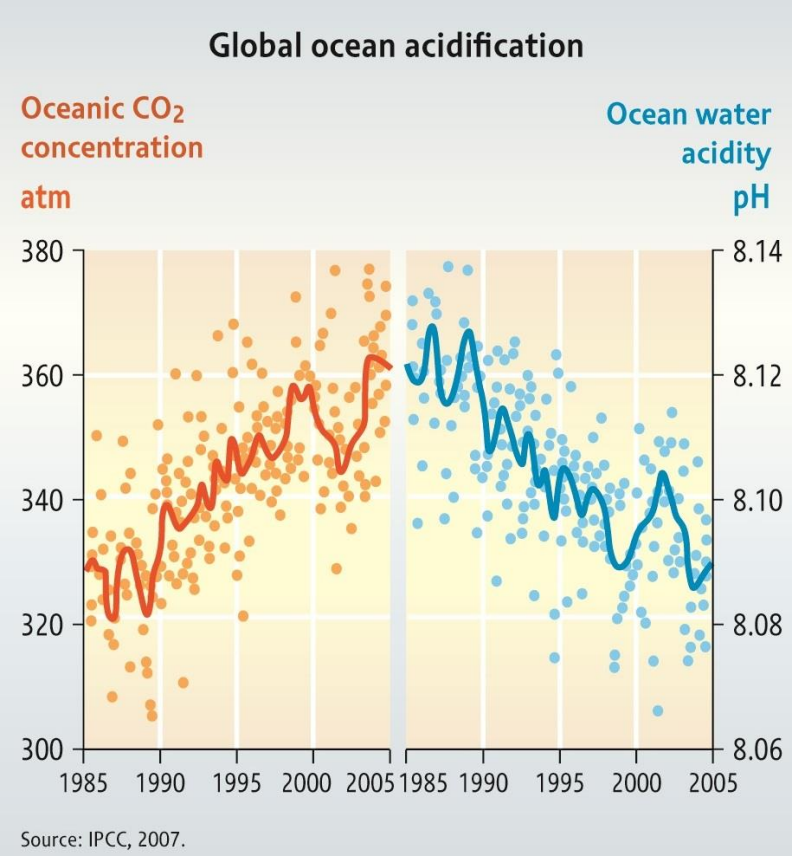
Type of change	Climatic variable	Impacts	Potential Impacts to Fisheries
Fish stocks	High SST	Change in physiology and sex ratios of fished species Altered timing of spawning, migrations, and/or peak abundance Increased invasive species, diseases and algal blooms	Changes in timing and levels of productivity across marine and freshwater systems Reduced production of target species

Source: Allison,EH et al. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries DOI: 10.1111/j.1467-2979.2008.00310.x

INTRODUCTION

Ocean Acidification/ Decrease in ocean pH

- CO_2 uptake has decreased ocean pH
  - Implications on biology of organisms (reproduction, growth, neural functions, etc.) and ecosystem processes (reef building, primary productivity, etc.)



Source: IPCC 4th Assessment Report: Climate Change 2007| Hoegh-Guldberg et al (2014).

INTRODUCTION

Ocean Acidification/ Decrease in ocean pH

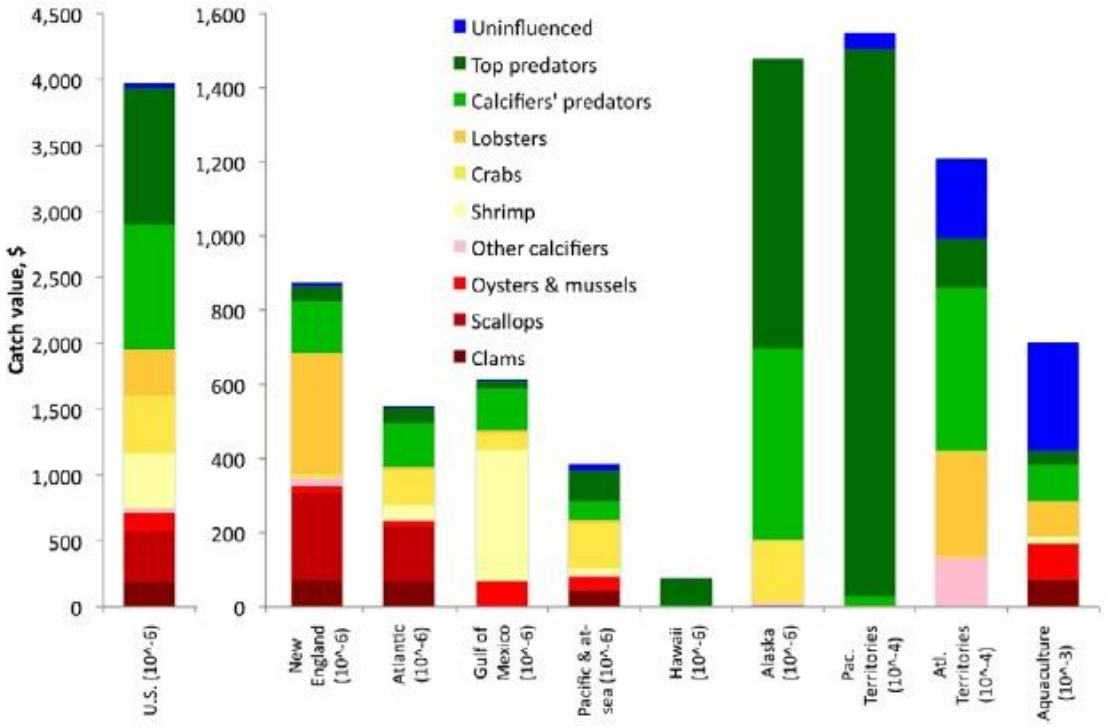


Figure 2. US commercial fishing ex-vessel revenue for 2007 (NMFS statistics, accessed October 2008). Reds indicate organisms containing primarily aragonite, yellows indicate those using primarily calcite, greens indicate predators, and blue indicates species not directly influenced by ocean acidification. (NMFS statistics and Andrews *et al* 2008.)

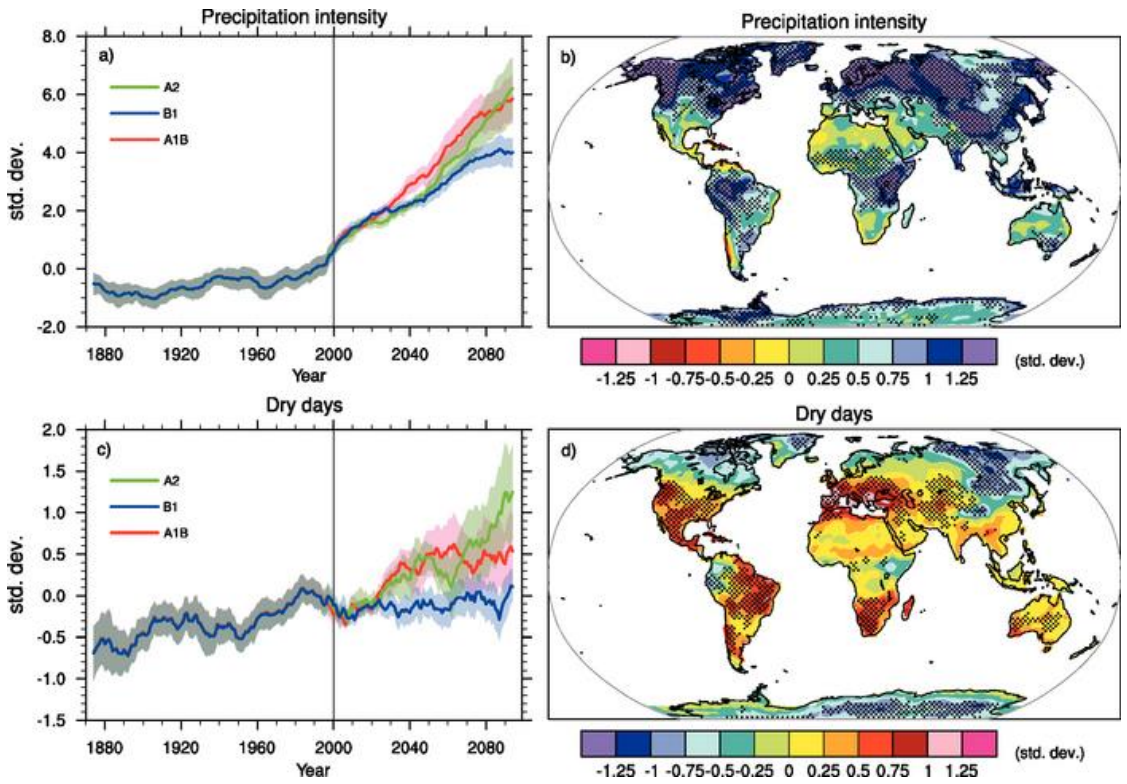
Source: IPCC 4th Assessment Report: Climate Change 2007| Hoegh-Guldberg et al (2014).

INTRODUCTION

Change in frequency and intensity of rainfall

- Global annual land mean precipitation showed small but upward trend over the century,
  ~ 1.1 mm per decade [a]

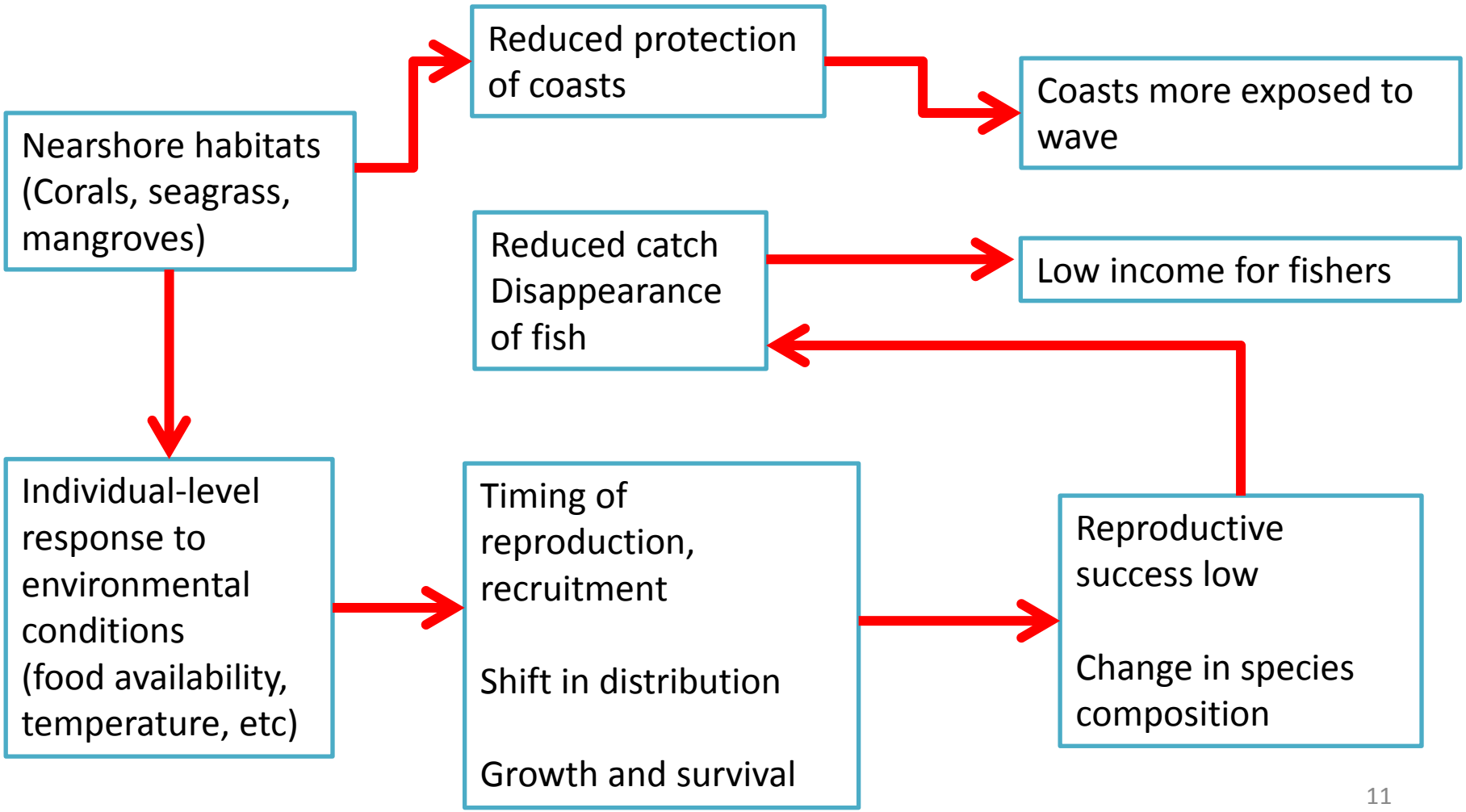
- In Philippines, increasing trend in frequency and intensity of extreme rainfall observed [b]



Source: [a] IPCC 4th Assessment Report: Climate Change 2007| [b] www.pagasa.dost.gov.ph
Image credit: IPCC 4th Assessment Report, 2007

INTRODUCTION

IMPACTS OF CLIMATE CHANGE TO FISHERIES



SIGNIFICANCE OF THE STUDY

Temperature change

Ocean acidification

Storms/cyclones

CLIMATE CHANGE

PEOPLE

MARINE ECOSYSTEM

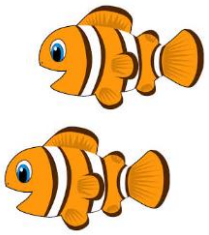


Image credits: www.komusin.com |www.motor-kid.com |www.foundmyself.com

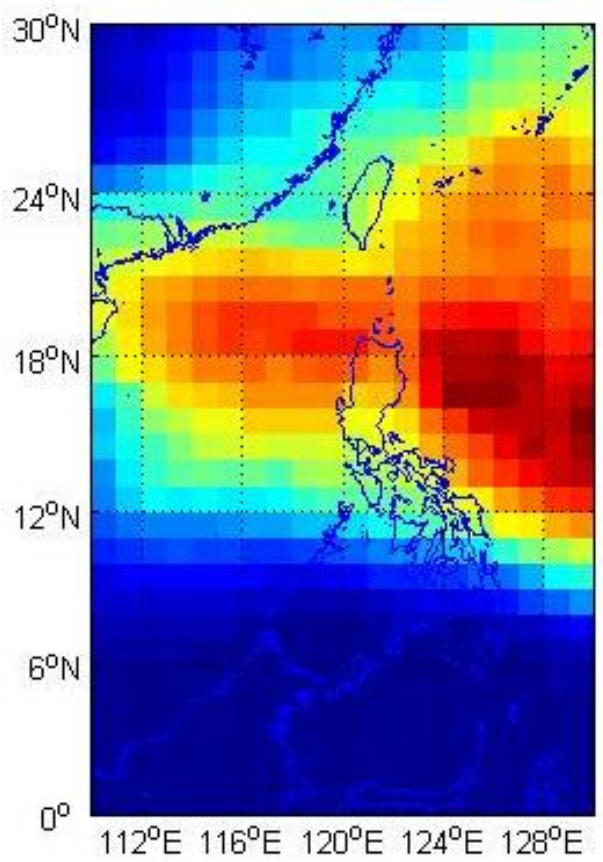
SIGNIFICANCE OF THE STUDY

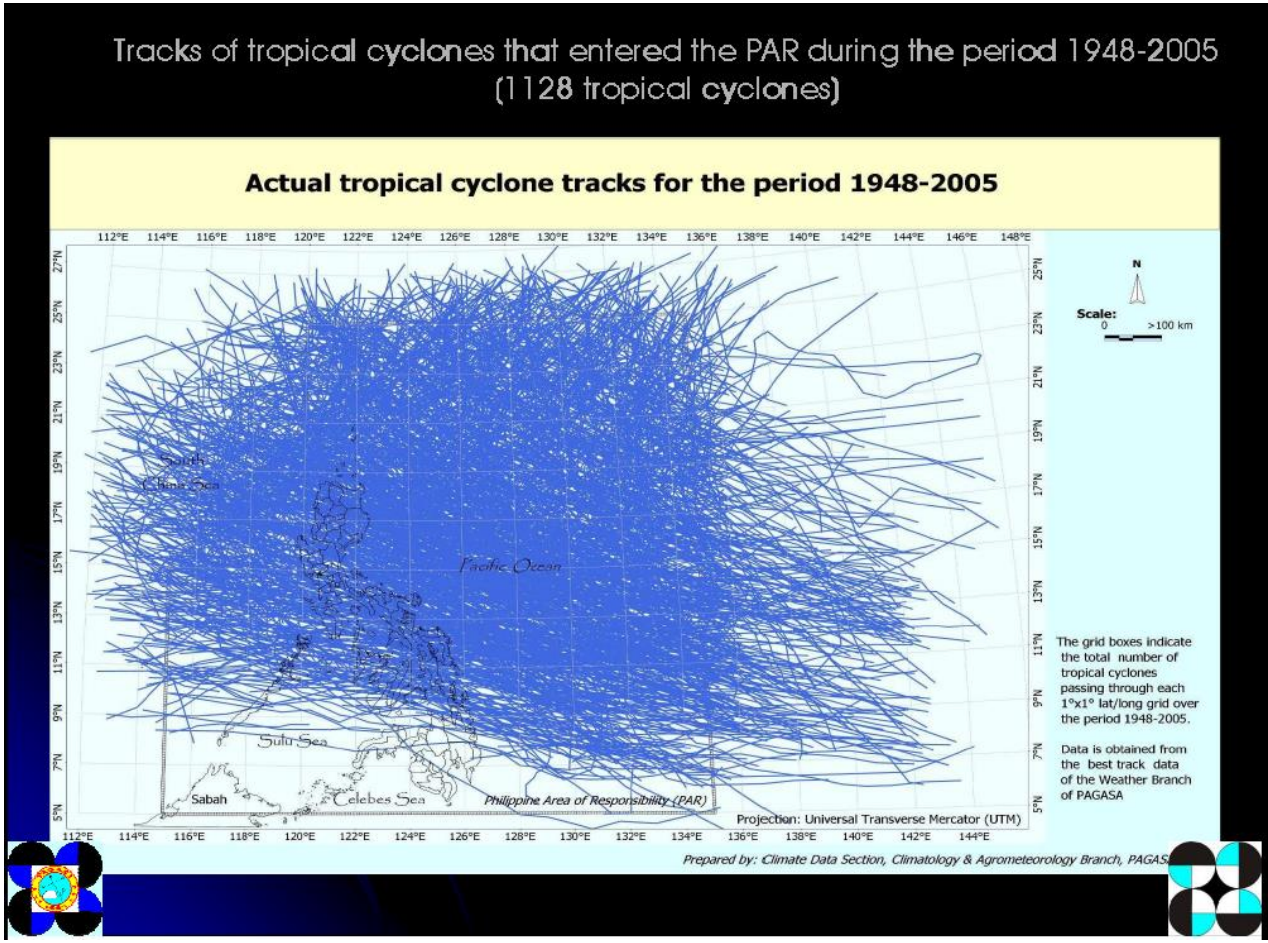
PHILIPPINES: A VERY VULNERABLE COUNTRY

CRI 1993–2012 (1992–2011)	Country	CRI score	Death toll	Deaths per 100,000 inhabitants	Total losses in million US$ PPP	Losses per unit GDP in %	Number of Events (total 1993–2012)
1 (1)	Honduras	10.17	329.80	4.86	667.26	2.62	65
2 (2)	Myanmar	11.83	7135.90	13.51	617.79	1.20	38
3 (5)	Haiti	16.83	307.50	3.45	212.01	1.73	60
4 (3)	Nicaragua	17.17	160.45	2.81	224.61	1.74	44
5 (4)	Bangladesh	19.67	816.35	0.56	1832.70	1.16	242
6 (6)	Vietnam	24.00	419.70	0.52	1637.50	0.91	213
7 (14)	Philippines	31.17	643.35	0.79	736.31	0.29	311
8 (10)	Dominican Republic	31.33	212.00	2.43	182.01	0.32	54
8 (12)	Mongolia	31.33	12.85	0.52	327.38	3.68	25
10 (9)	Thailand	31.50	160.35	0.26	5410.06	1.29	193
10 (11)	Guatemala	31.50	82.35	0.69	312.23	0.58	72

Image credit: Kreft,S. and Eckstein,D. (2014). Global Climate Risk Index 2014: Who Suffers Most from Extreme Weather Events? Weather- Related Loss Events in 2012 and 1993 to 2012.

SIGNIFICANCE OF THE STUDY





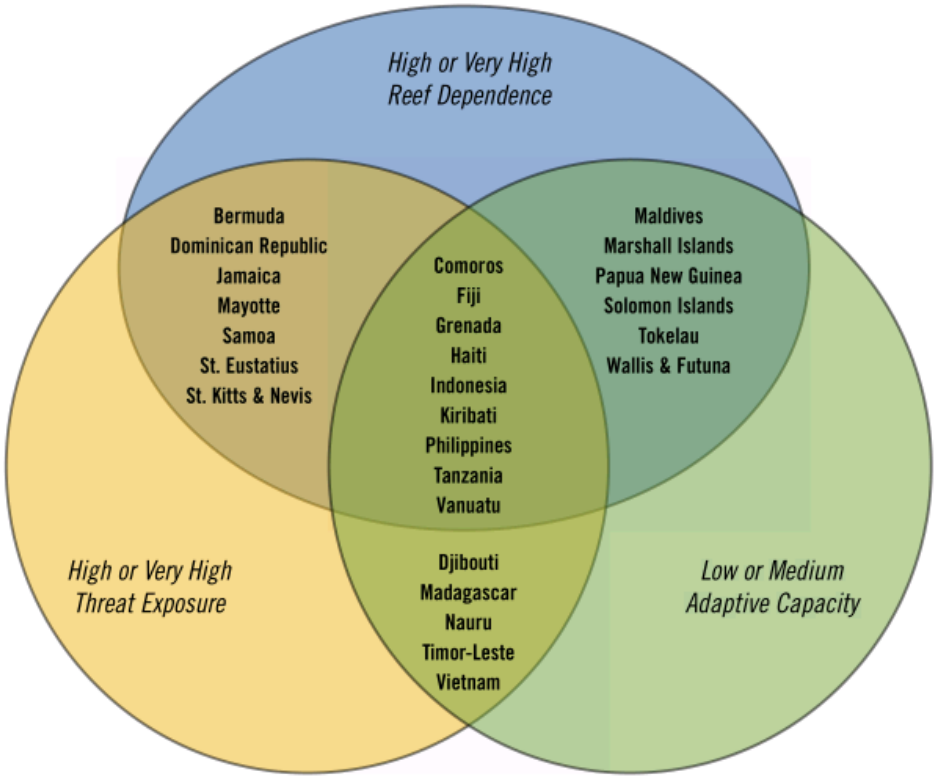
Map of typhoon frequency in the Philippines

Photo credit: C. Villanoy| Slide courtesy of HOA

SIGNIFICANCE OF THE STUDY

PHILIPPINES: A VERY VULNERABLE COUNTRY

FIGURE ES-5. DRIVERS OF VULNERABILITY IN HIGHLY VULNERABLE NATIONS AND TERRITORIES

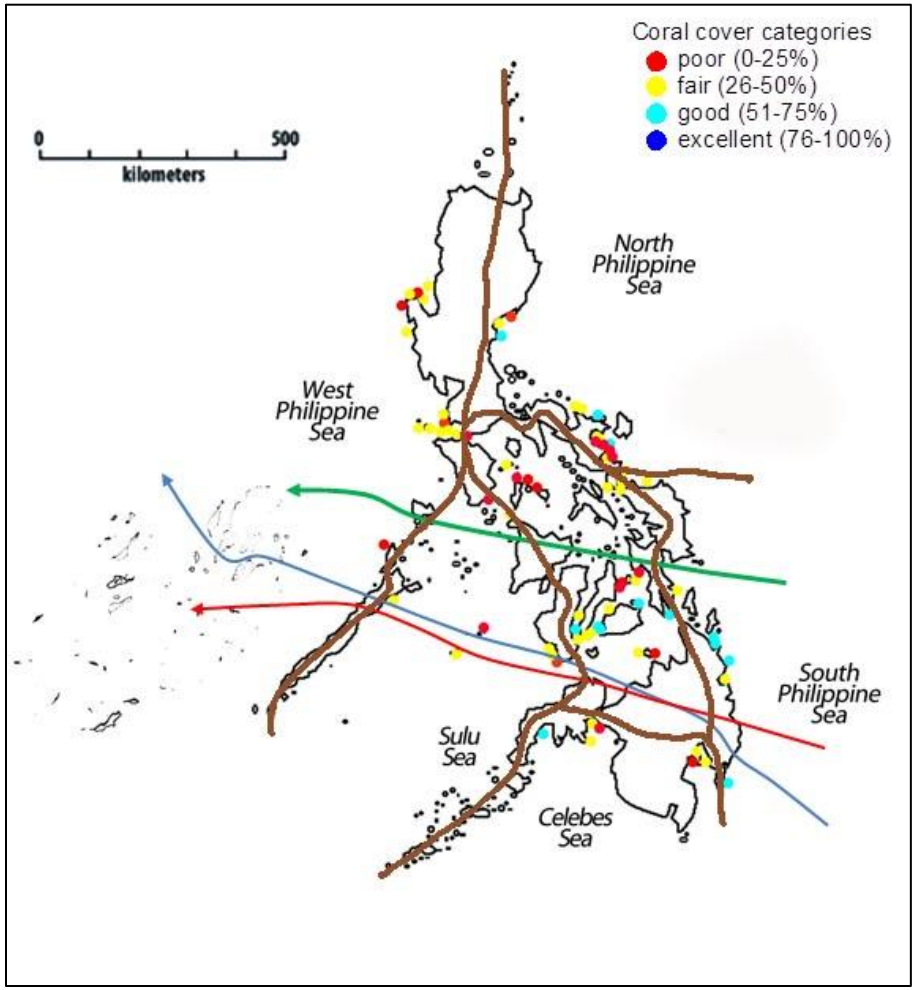


Note: Countries or territories within the yellow circle are highly or very highly exposed to reef threat; those within the blue circle are highly or very highly reef-dependent; and those within the green circle have low or medium adaptive capacity. Only the 27 very highly vulnerable countries and territories are shown.

Source: Burke LK et al. (2011). Reefs at Risk Revisited. Washington DC, USA: World Resources Institute

SIGNIFICANCE OF THE STUDY

STATUS OF PHILIPPINE CORAL REEFS



Threats to Coral Reefs:

- Overfishing
- Destructive Fishing
- Pollution
- Sedimentation
- Coastal Development

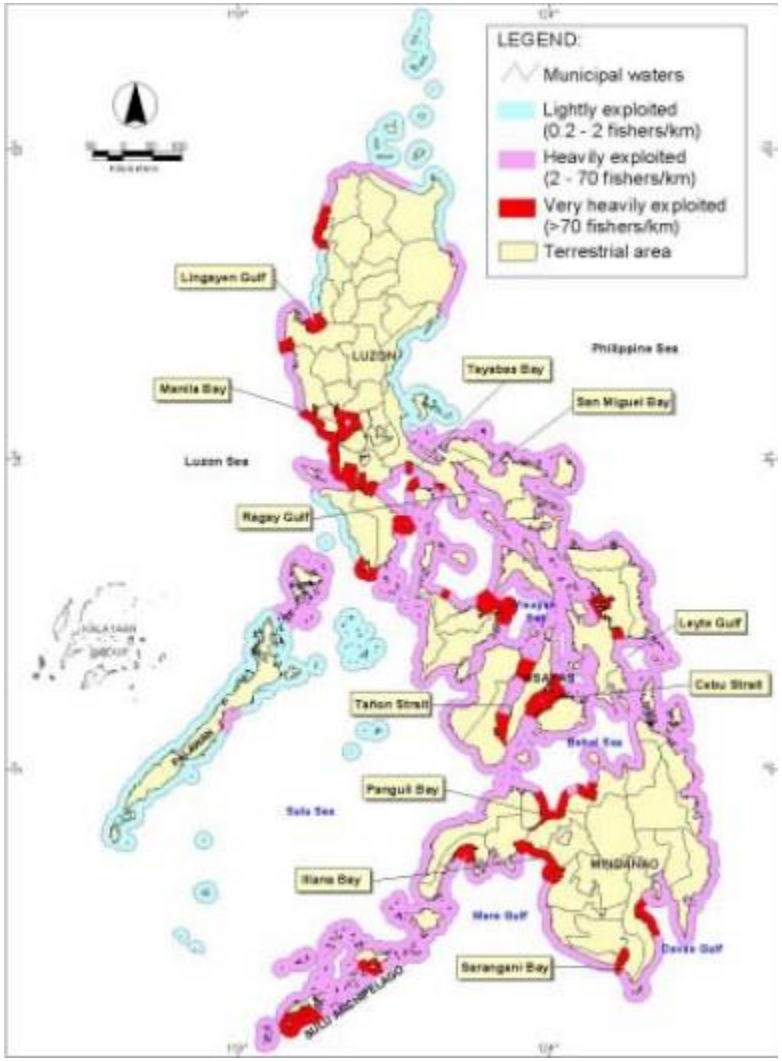
Figure 3. Philippine map and its biogeographic regions (brown lines; Aliño and Gomez 1994) showing the color coded hard coral cover data that were surveyed from 2008 to 2014 in 73 municipalities. Typhoon paths: Blue arrow for Typhoon Washi (*Sendong*), Red arrow for Typhoon Bopha (*Pablo*) and Green arrow for Typhoon Haiyan (*Yolanda*).

Source: Aliño PM et al., (2014)Status of Philippine Coral Reefs 2014 (in press)| Burke et al.,(2011). Reefs at Risk Revisited

SIGNIFICANCE OF THE STUDY

STATUS OF PHILIPPINE FISHERIES

- Nearly 60% of the population is dependent on fisheries
- Fishers are the poorest of the poor sector [a]
- Fish stocks in major fishing grounds in the Philippines have been reduced to less than 10% of 1950s level [b]
- Average catch rate of Filipino fisherfolks is less than ½ of what they catch in 1970s[c]



Sources: [a]Castro,LV (2006). Poverty Statistics for the Basic Sector; [b]Green, SJ et al., (2003): Philippine Fisheries in Crisis: A Framework for Management; [c]Muallil et al., (2014)

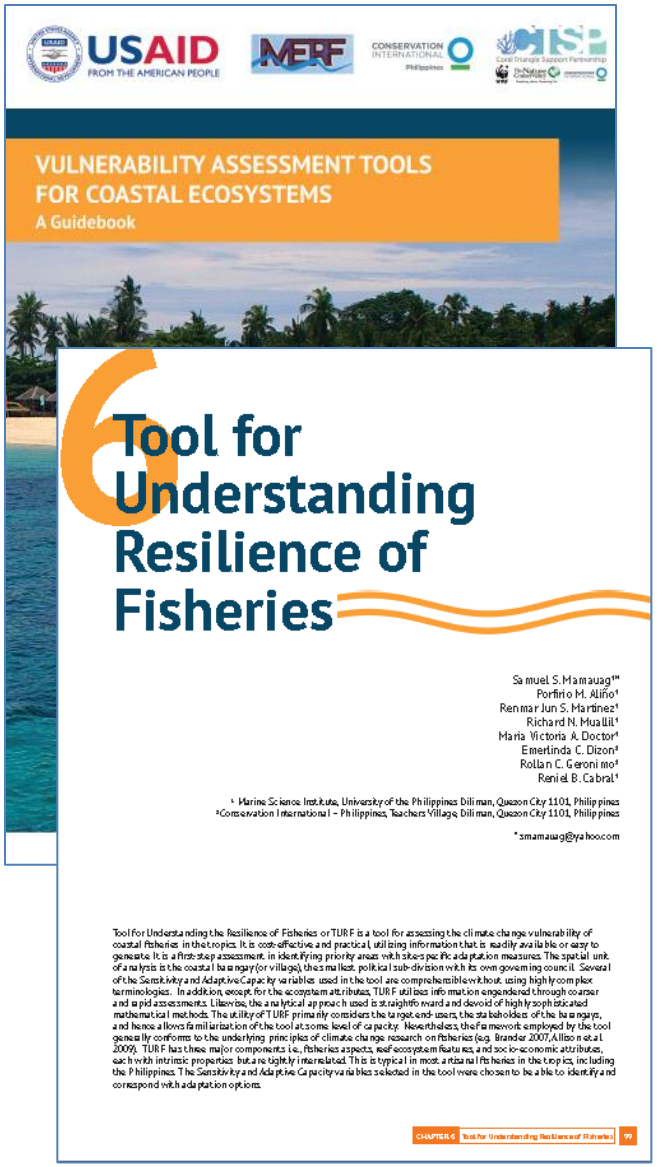
TOOL FOR UNDERSTANDING RESILIENCE OF FISHERIES (VA-TURF)

VA-TURF

OBJECTIVES

- To identify vulnerable fishing communities
- To demonstrate how to link vulnerability assessment results to climate change adaptation
- To draft action plans towards reducing vulnerability

VA-TURF



Fisheries Research 147 (2013) 381–393

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journal homepage: www.elsevier.com/locate/fishres

A framework for vulnerability assessment of coastal fisheries ecosystems to climate change—Tool for understanding resilience of fisheries (VA–TURF)

Samuel S. Mamauag[a,b,*], Porfirio M. Aliño[a,b], Renmar Jun S. Martinez[a,b], Richard N. Muallil[a,b,c], Maria Victoria A. Doctor[b], Emerlinda C. Dizon[d], Rollan C. Geronimo[d], Fleurdeliz M. Panga[a,b], Reniel B. Cabral[a,b,e]

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VA-TURF

FEATURES

- Target end-users: Local stakeholders
- Spatial scale: Fishing village or barangay
- Climate Change hazards considered: Waves and storm surge, SST

✓ Required data is accessible or easily generated

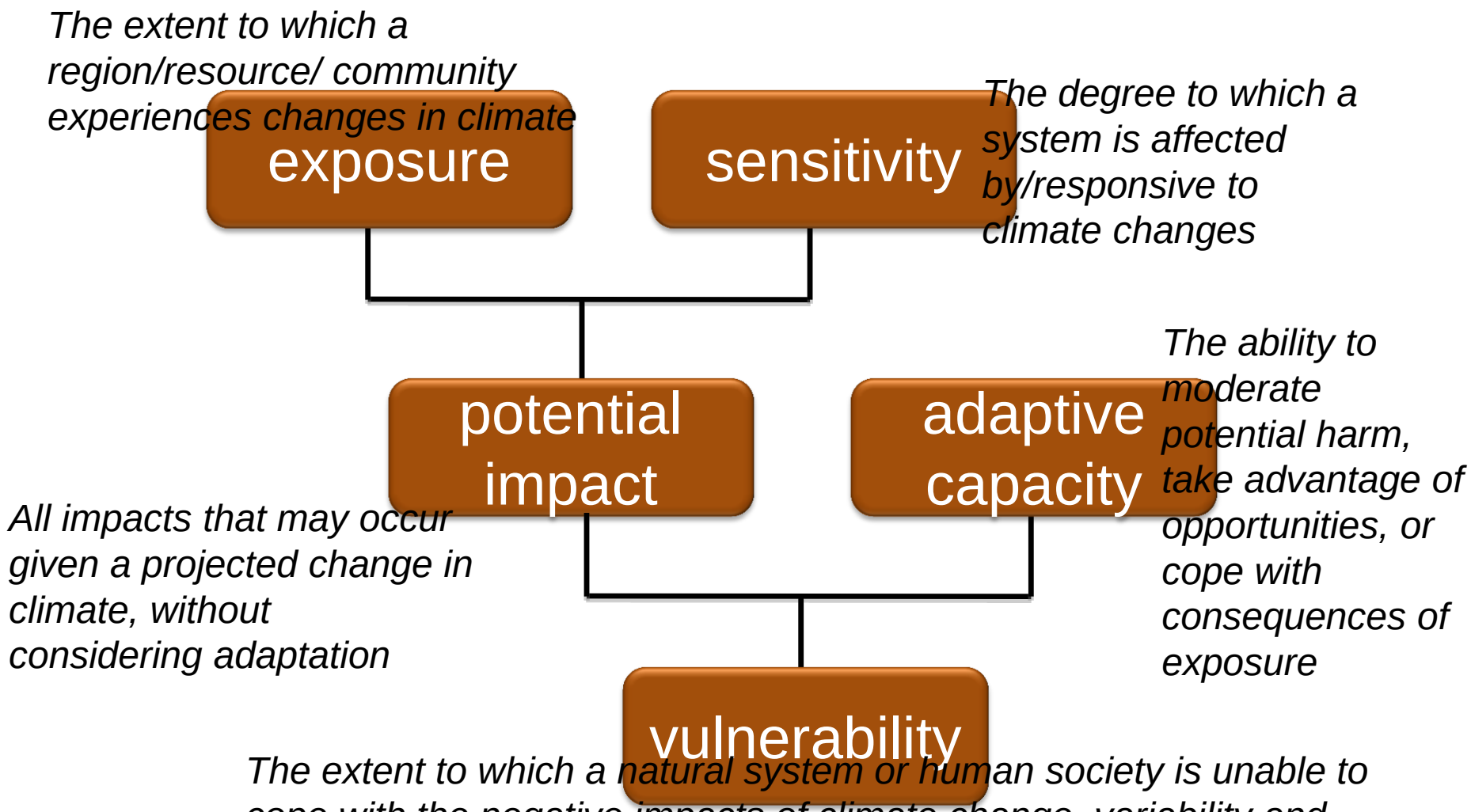
✓ Analysis (Scoring and ranking) is simple; devoid of complicated mathematical equations

✓ Assessment is participatory

✓ Assists in decision-making for the local adaptation strategies

FRAMEWORK

VA-TURF



Slide courtesy of P. Marshall GRMPA

Sources in OECD 2006

Sources in OECD 2006

FRAMEWORK

VA-TURF

Fisheries

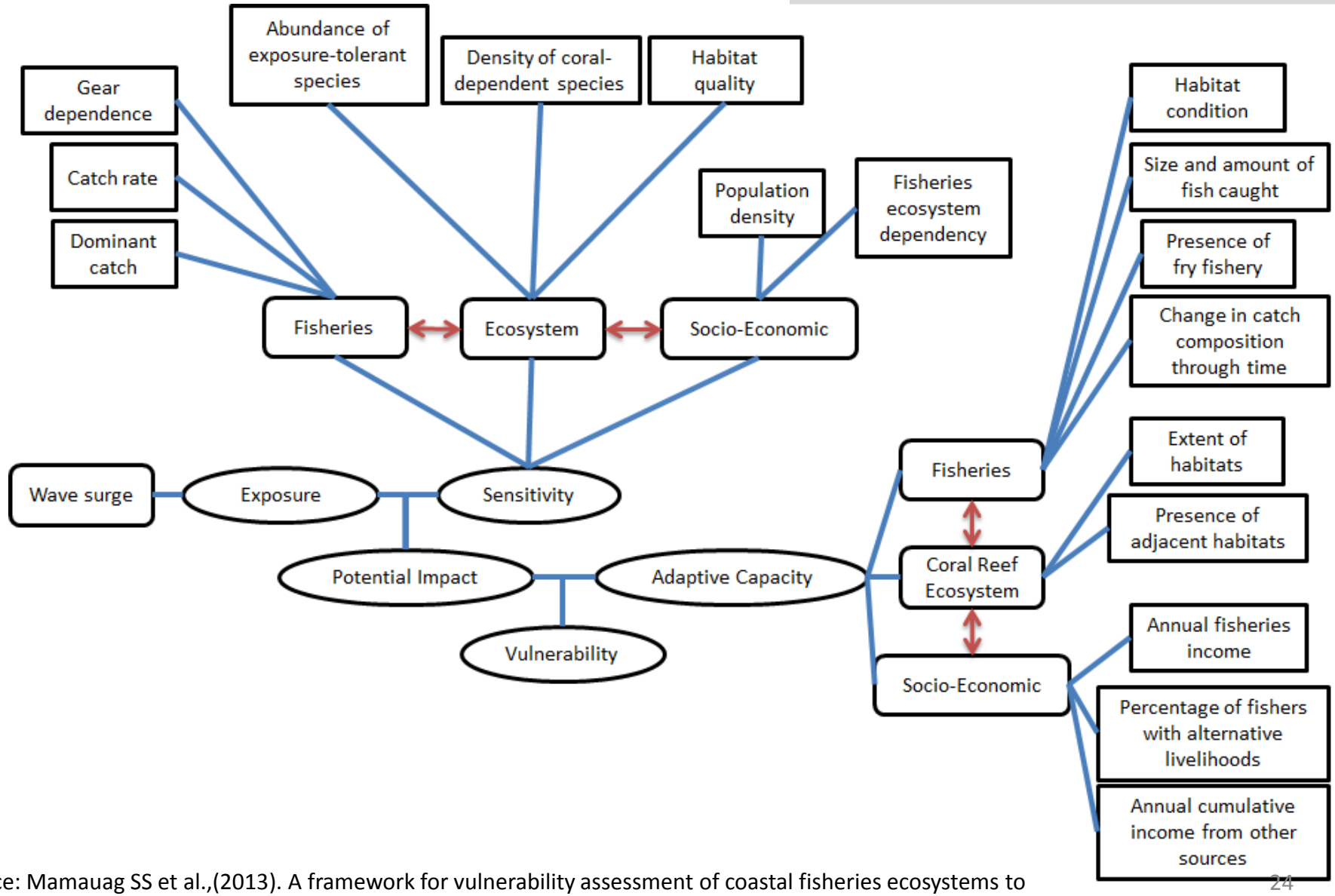
Reef Ecosystem

Socioeconomic

Source: Mamauag, SS et al.,(2013). A framework for vulnerability assessment of coastal fisheries ecosystems to climate change—Tool for understanding resilience of fisheries (VA-TURF). Fisheries Research 147; 381-393.

FRAMEWORK

VA-TURF



Source: Mamauag SS et al.,(2013). A framework for vulnerability assessment of coastal fisheries ecosystems to climate change—Tool for understanding resilience of fisheries (VA-TURF). Fisheries Research 147; 381-393.

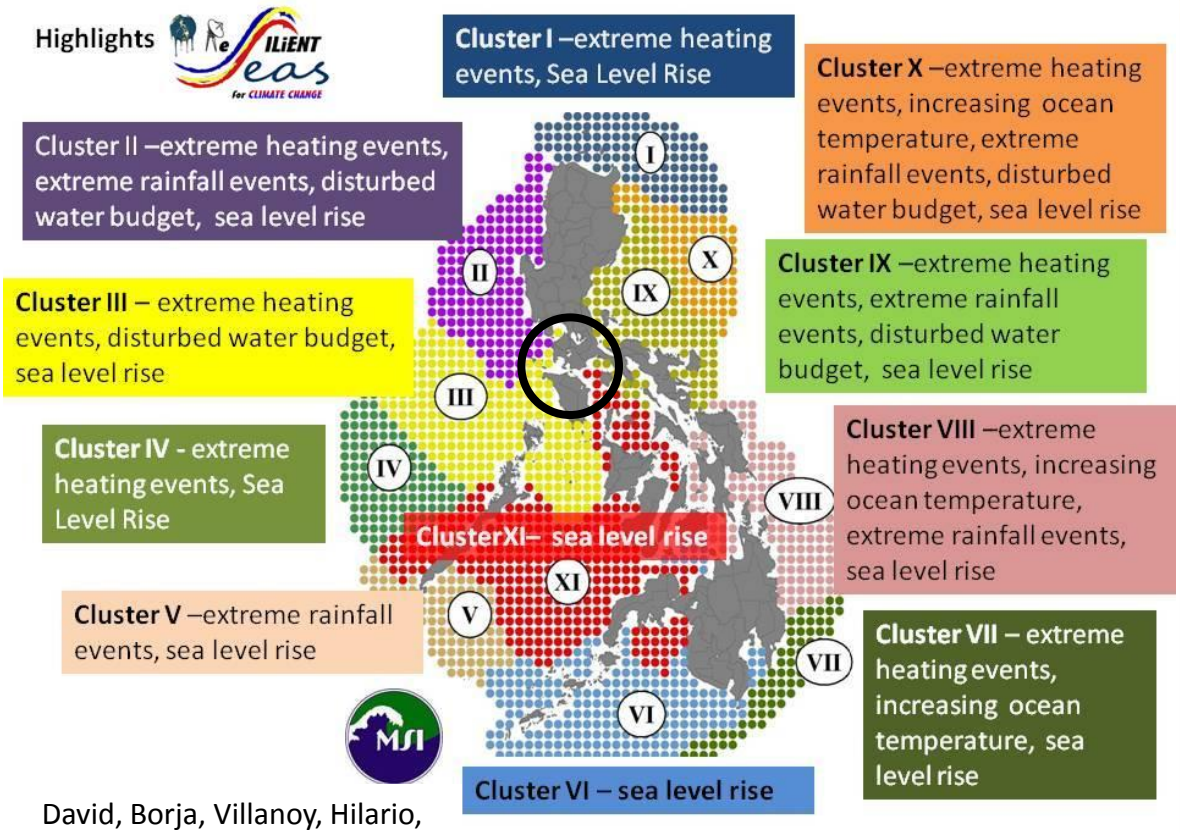
VA-TURF

			Components		
			Fisheries	Reef Ecosystem	Socio economic
Vulnerability	Potential Impact	Exposure	Wave	Wave	Wave
		Sensitivity	Gear dependence	Abundance of exposure-tolerant species	Population density
			Catch Rate	Density of coral-dependent species	Fisheries ecosystem dependency
			Dominant Catch	Habitat quality	
	Adaptive Capacity		Habitat condition	Extent of habitats	Annual fisheries income
			Size and amount of fish caught	Presence of adjacent habitats	Percentage of fishers with alternative livelihood
			Presence of fry fishery		Annual cumulative income from other sources of livelihood
			Change in catch composition through time		

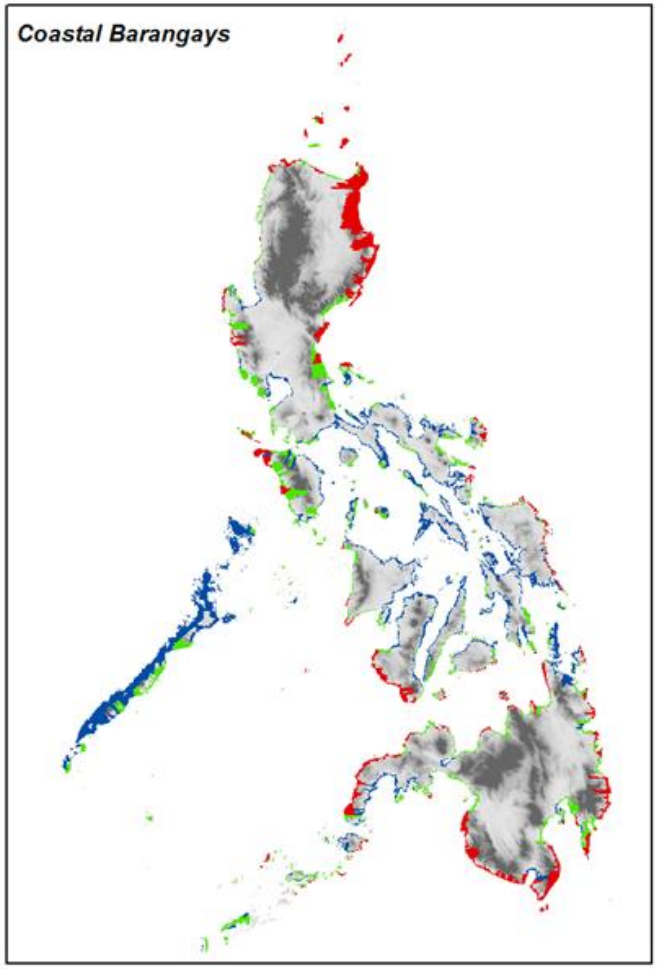
Secondary data	Municipal profile, literature, government websites, etc
Primary data	Focused group discussions with key informants
Primary data	One-on-one interview with fishers
Primary data	Habitat assessment methods such as LIT, FVC

EXPOSURE

VA-TURF



David, Borja, Villanoy, Hilario, Alino. 2012 for submission Climatic Change



Wave (Relative Exposure Index)

VA-TURF

EXPOSURE

- Input data:
  - Gridded bathymetry
  - Digital coastline
  - Wind data

- Calculated using WEMo (Wave Exposure Model) (http://www.ccfhr.noaa.gov/stressors/wemo/)

$$\mathrm{REI} = \left(\sum_{i=1}^{8} EffF_i \; V_i \; D_i \} \right) / 8$$

$Eff\,F_i$ = Effective fetch for the i^{th} direction

V_i = Wind speed for the i^{th} direction

D_i = Wind duration for the i^{th} direction

VA-TURF

EXPOSURE

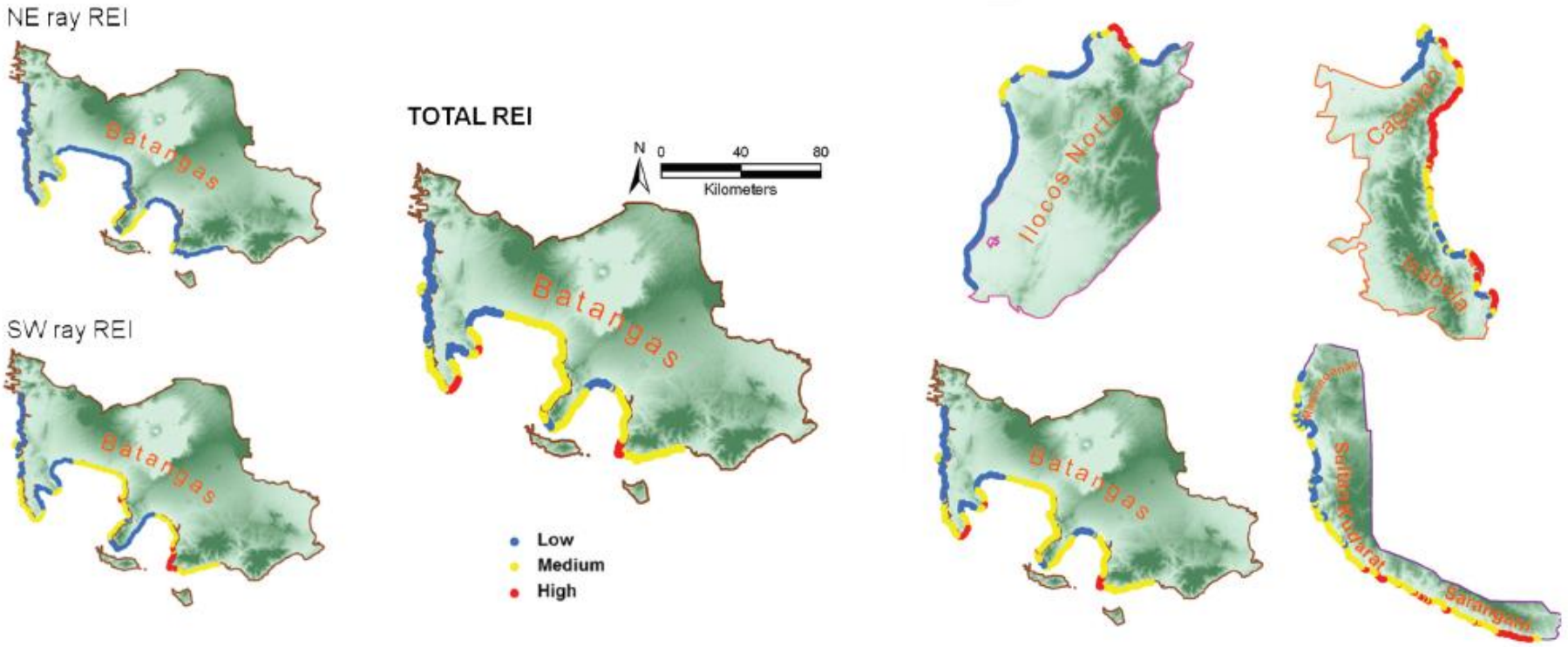


Figure 8: Wave exposure maps based on WEMo-derived Relative Exposure Index for the northeast or NE ray (upper left panel), southwest or SW ray (lower left panel) and the sum of all rays or TOTAL (right panel)

Source: Villanoy CL et al. (2013). Chapter 3 Exposure: Waves and storm surges. In Vulnerability Assessment Tools for Coastal Ecosystem: A Guidebook. MERF Quezon City

SENSITIVITY

VA-TURF

FISHERIES

CRITERIA	LOW 1 to 2 points	MEDIUM 3 to 4 points	HIGH 5 points
Dominant catches	Pelagics (tuna, mackerel, etc)	Mix of demersal and pelagic species	Demersal species (e.g. grouper)
Catch rate	>8 kg/fisher/day	3 to 8 kg/fisher/day	<3 kg/fisher/day
Gear habitat dependence	Mostly mobile gears (e.g. drift gill nets)	Presence of both types	Habitat-associated gears (e.g. fixed on seagrass beds)

VA-TURF

REEF ECOSYSTEM

CRITERIA	LOW 1 to 2 points	MEDIUM 3 to 4 points	HIGH 5 points
Wave-tolerant species relative to total abundance	Pectoral-swimming fishes (labrids, scarids, acanthurids) greater than 50%	Mix of site-attached and mobile fish species; 15-50% pectoral swimming fish	Abundant site-attached butteflyfish, angelfish, damselfish; <15% pectoral swimming fish
Density of coral dependent fish species (Butterflyfish)	<5% of the total density	5 to 10 % of the total density	>10% of the total density
Coral cover	>50% coral cover	25 to 50% coral cover	<25% coral cover

VA-TURF

SOCIO-ECONOMIC

CRITERIA	LOW 1 to 2 points	MEDIUM 3 to 4 points	HIGH 5 points
Population density	<200 individuals/km^2 (not crowded; sparsely distributed)	200 to 400 individuals/km^2 (moderately crowded)	>400 individuals/km^2 (very crowded)
Fisheries ecosystem dependency	<15% of total population are fishers	15 to 30% of total population are fishers	>30% of total population are fishers

ADAPTIVE CAPACITY

VA-TURF

FISHERIES

CRITERIA	LOW 1 to 2 points	MEDIUM 3 to 4 points	HIGH 5 points
Habitat size(fishing grounds)	Small (relative to the waters)	Intermediate size	Large
Average size/amount of catch	Mostly small, immature fishes	Abundance of small but with few large fishes	Abundant large fishes (most likely include spawners)
Occurrences of juveniles/fry fisheries	Absence to minimal occurrence (no known peak occurrence)	Few to medium level abundance during peak occurrence	Abundant juvenile during peak occurrence
Change in catch composition	Considerable changes in the last two decades	Few changes in the last two decades	No change in catch composition

VA-TURF

REEF ECOSYSTEM

CRITERIA	LOW 1 to 2 points	MEDIUM 3 to 4 points	HIGH 5 points
Extent of habitats (coral reef areas)	Small reef areas; fragmented	Intermediate size of areas	Large reef areas
Presence and condition of adjacent habitats (corals, seagrass, mangroves)	Poor adjacent habitat quality/ No adjacent habitats	One habitat is of poor quality or very far	Presence of adjacent habitats with good conditions

SOCIO ECONOMIC

CRITERIA	LOW 1 to 2 points	MEDIUM 3 to 4 points	HIGH 5 points
Annual per capita income from fisheries	Below the provincial poverty threshold	Income is higher than the provincial poverty threshold up to 60%	Income is higher than 60% of the provincial poverty threshold
Fishers with other sources of income	<40% of fishers have other sources of livelihood	40 to 60% of fishers have other sources of income	>60% of fishers have other sources of income
Total amount of all income	Total cumulative income is below provincial poverty threshold	Total cumulative income is higher than provincial poverty threshold up to 60%	Total cumulative income is greater than 60% of the provincial poverty threshold

VA-TURF

Computation for Potential Impact (PI):

1 Add the scores of the components of "Sensitivity". (S) Put it in "Total" cell.

From exposure (E) model 3

Barangay	Fisheries Sensitivity Attributes				Sensitivity (S)	Exposure (E)	Potential Impact (ExS)
	Dominant catch	Catch rate	Gear-habitat association	Total			
Bangkerohan	3	1	3	7	Low	High	Medium
Buluan							
Caparan							
Magdaup							
Makilas							
Tiayon							

2 Convert scores into L, M and H categories "Rank"

4 Use S and E to derive "Potential Impact"

VA-TURF

Computation for VULNERABILITY (V):

Add the scores of the components of "Adaptive Capacity" **(AC)**. Put it in

1 **"Total"** cell.

3 **P.I.** score (from previous slide)

Barangay	Fisheries Adaptive Capacity Attributes					Adaptive Capacity (AC)	Potential Impact (ExS)	Vulnerability (ACxPI)
	Habitat condition	Size/amount of adults	Peak of juvenile occurrence	Change in catch composition	Total			
Bangkerohan	1	1	1	1	4	Low	Medium	High
Buluan								
Caparan								
Magdaup								
Makilas								
Tiayon								

2 Convert scores into L, M and H categories **"Rank"**

4 Use **AC** and **PI** to derive **"Potential Impact"**

VA-TURF

1 Reference to convert scores into L, M and H categories ("**Rank**")

Table 2. Point class interval and corresponding rank classifications for the sensitivity and adaptive capacity components of fisheries ecosystem.

Fisheries Ecosystem	Number of variables	Minimum total score possible	Maximum total score possible	Point class interval (score to rank system conversion)
Fisheries				
Sensitivity	3	3	15	3-7 → Low (L) 8-11 → Medium (M) 12-15 → High (H)
Adaptive Capacity	4	4	20	4-9 → Low (L) 10-15 → Medium (M) 16-20 → High (H)
Reef ecosystem				
Sensitivity	3	3	15	3-7 → Low (L) 8-11 → Medium (M) 12-15 → High (H)
Adaptive Capacity	2	2	10	2-4 → Low (L) 5-7 → Medium (M) 8-10 → High (H)
Socio-economic				
Sensitivity	2	2	10	2-4 → Low (L) 5-7 → Medium (M) 8-10 → High (H)
Adaptive Capacity	3	3	15	3-7 → Low (L) 8-11 → Medium (M) 12-15 → High (H)

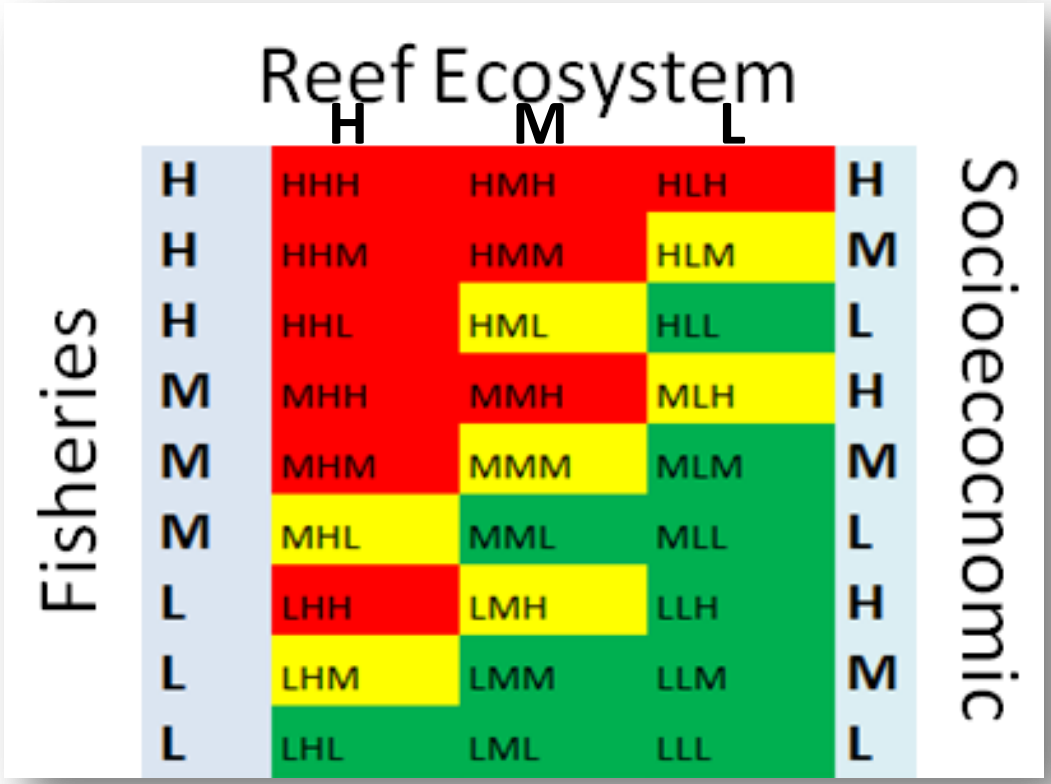
2 Reference to derive "**Potential Impact**"

Exposure \ Sensitivity	L	M	H
L	L	L	M
M	L	M	H
H	M	H	H

3 Reference to derive "**VULNERABILITY**"

Potential Impact \ Adaptive Capacity	L	M	H
L	M	L	L
M	H	M	L
H	H	H	M

Computation for Overall Vulnerability



Legend:
- High
- Medium
- Low

Tip:
1st Letter: Fisheries vulnerability
2nd Letter: Reef ecosystem vulnerability
3rd Letter: Socioeconomic vulnerability

NEXT STEPS

ADAPTATION

- **adjustment in natural or human systems** in response to actual or expected climate change and associated impacts in **order to reduce harm** or take advantage of beneficial opportunities (IPCC, 2001; USAID, 2009)

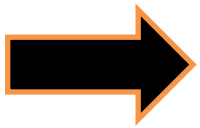
-a process that results in **a reduction in harm** or risk of harm, and the attainment of benefits relating to climate variability and climate change (UK CIP, 2003)

NEXT STEPS

VA-TURF

REDUCE
Sensitivity & Exposure (POTENTIAL IMPACT)

INCREASE
Adaptive Capacity



REDUCE
Vulnerability

- **High → Medium**
- **Medium → Low**
- **Low → Not Vulnerable**

INCREASE Resilience

NEXT STEPS

VA-TURF

ADAPTATION STRATEGIES FOR SUSTAINABLE FISHERIES

- **R**educing fishing mortality
- **E**nhancing stock recovery
- **S**ustainable fisheries use
- **T**hreat reduction on ecosystems
- **O**rganizing fisher communities
- **R**estoring resiliency & connectivity
- **E**AFM development with equitability
- **D**iversifying livelihood options

Aliño et al. 2012

NEXT STEPS

VA-TURF

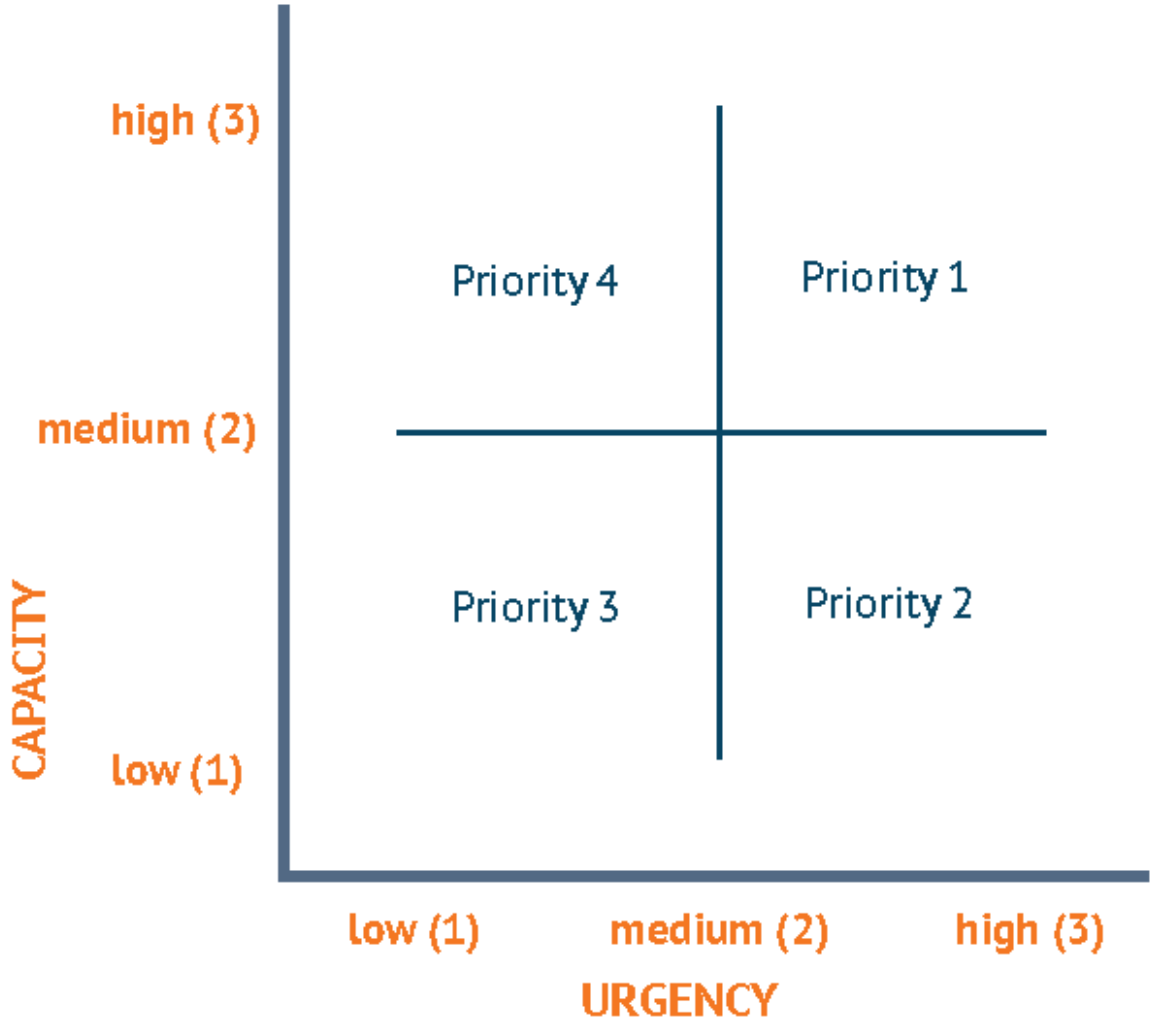
Table 37: Scoring for Urgency (Importance) and Capacity

Each action is scored based on whether they are important and/ or address an urgent need, and if there is capacity for implementation.

ADAPTATION ACTION	URGENCY	CAPACITY
1) 2) 3) **(1)** *List of top three actions most relevant to the highest vulnerabilities of each barangay, as guided by the VA*	**(2)** *Does the action address an URGENT need?* High: **3** Medium: **2** Low: **1**	**(3)** *Is there operational CAPACITY to implement activities?*

NEXT STEPS

VA-TURF



CASE STUDY

Map of municipalities assessed with VA-TURF

CASE STUDY

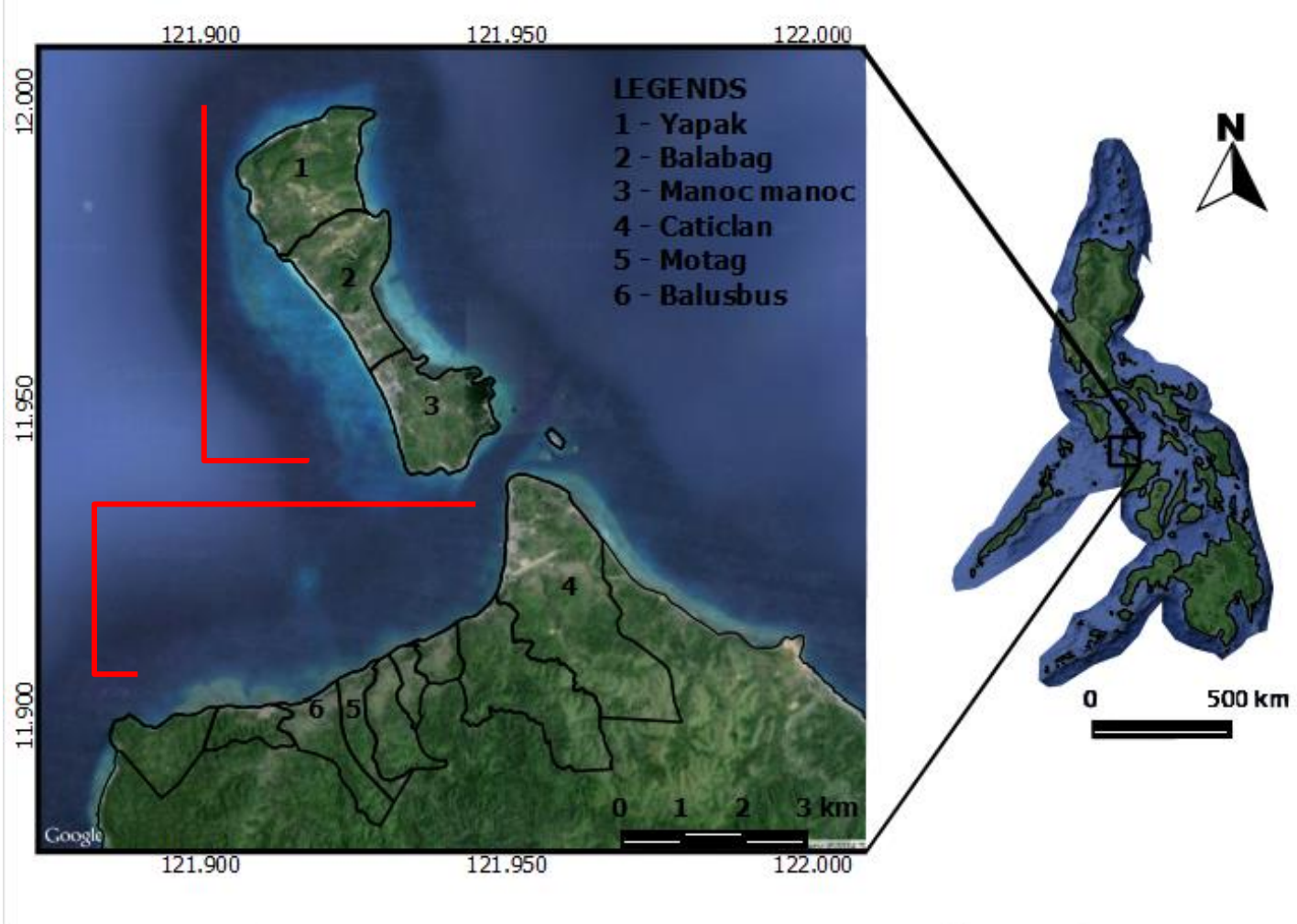
- First class municipality
- 17 villages; 12 are coastal
- Estimated 1.3 million visitors (2013)
- Population: 45, 811 (2010)
- No. of fishers: 870 (2012)

Boracay Island

- 62% of the total municipal population (28, 369)
- urban villages
- marine parks located around the island
- 573 registered fishers
-Main Source of Income: Tourism

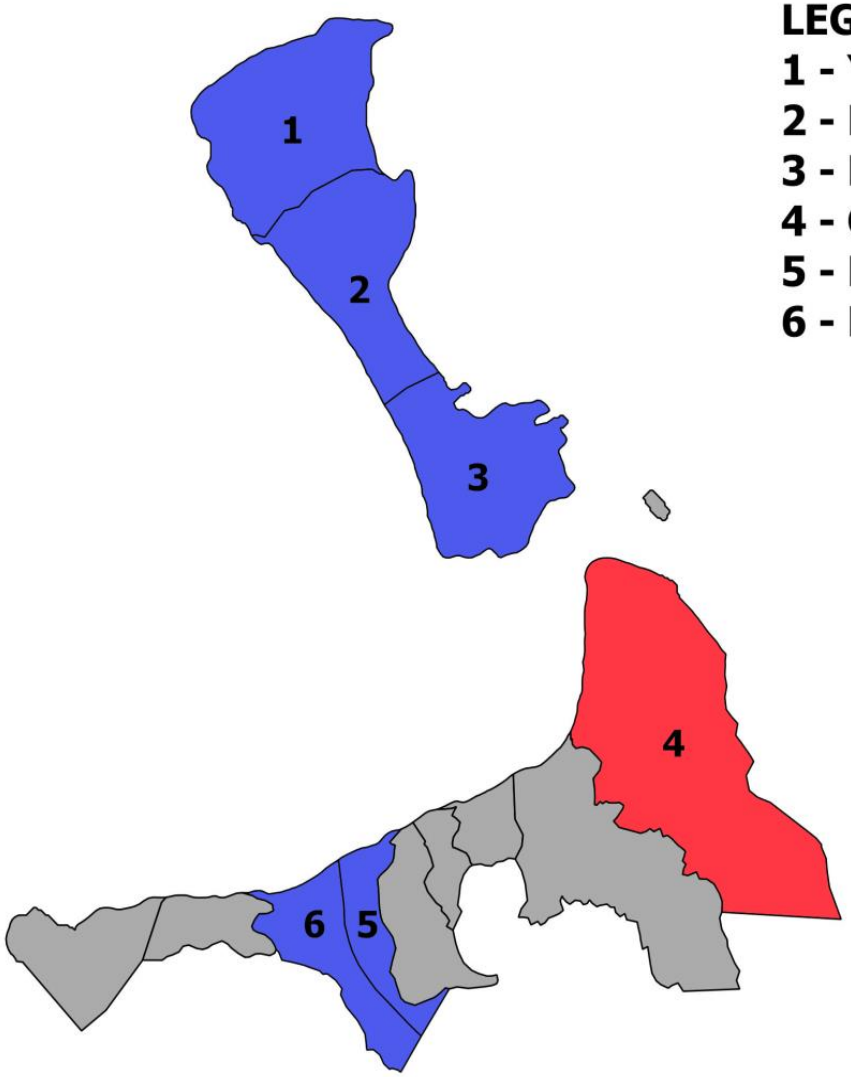
Mainland Malay

- 38% of the total municipal population (17,442)
-2 urban villages; the rest are rural
-297 registered fishers
-Main Source of Income: Fishing and Farming



CASE STUDY

WAVE EXPOSURE

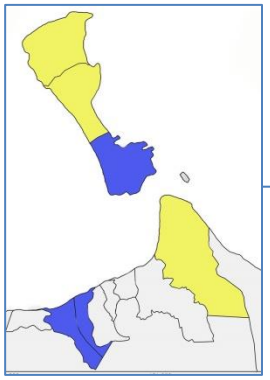


LEGENDS
1 - Yapak
2 - Balabag
3 - Manoc manoc
4 - Caticlan
5 - Motag
6 - Balusbus

Low
Medium
High

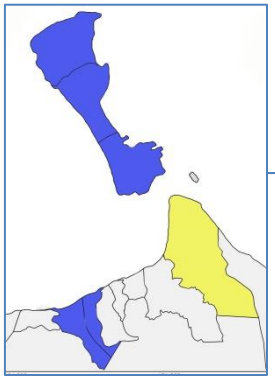
CASE STUDY

Fisheries



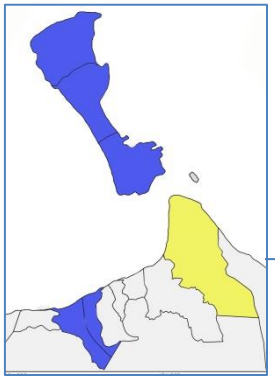
Demersal catch
Average catch <3 kg/fisher/day
Habitat-associated gears
Significant change in catch composition
Few occurrence of fry fisheries

Reef ecosystem

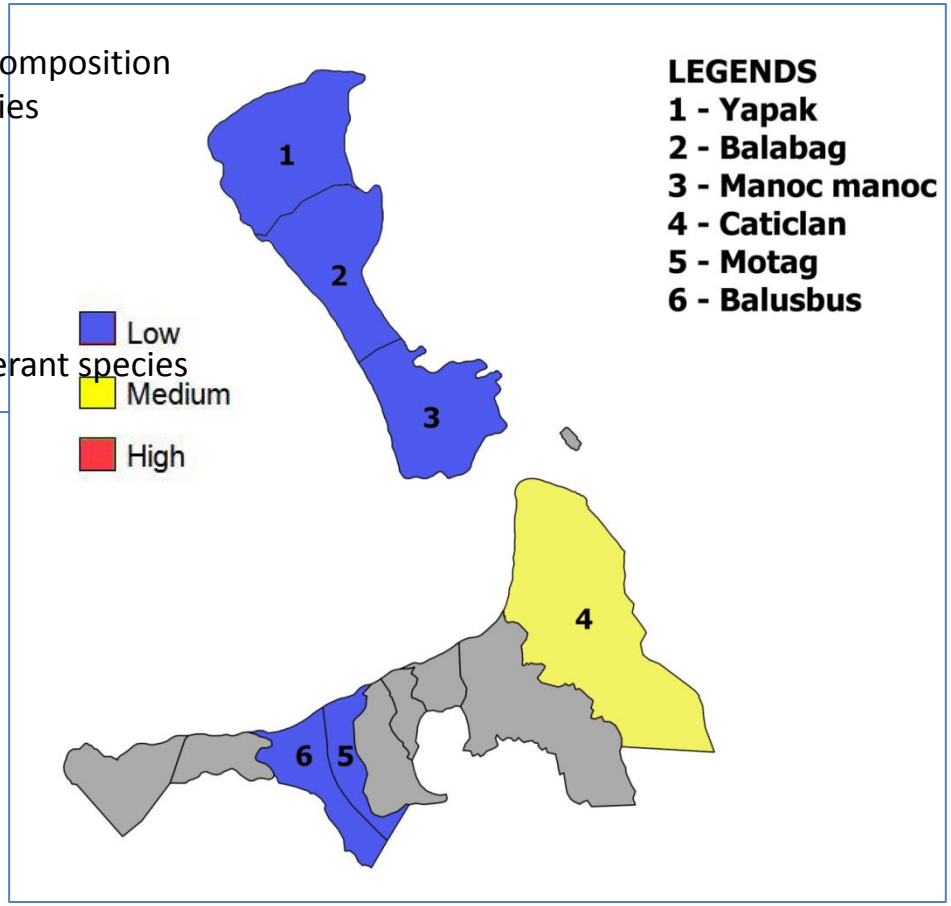


Low proportion of wave-tolerant species
Low coral cover
Few adjacent habitats

Socio-economic

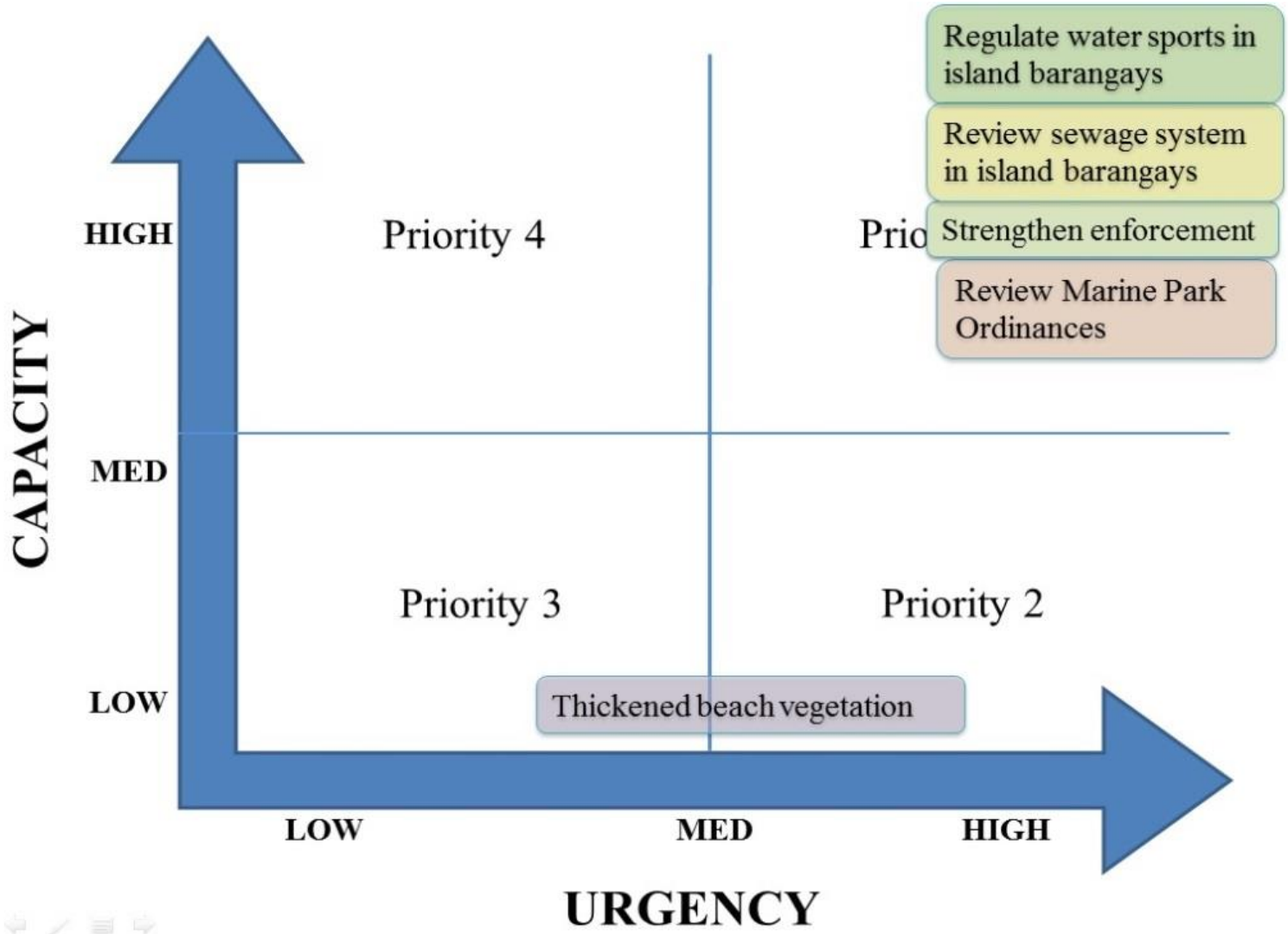


High population density



ACTIONS	How does the action reduce vulnerability? (↓PI↑AC)	URGENCY	What is needed for implementation?			CAPACITY	Are there potential negative impacts? (Y/N)	What is the value added to address CC concerns?	List benefits e.g. ecological, socio-economic
			Socio-economic	Ecological	Governance				
Review Marine Park ordinances (island, mainland)	↑AC	3		Establish Marine Park coordinates	Establish Marine Park coordinates	3	Y	Expand marine park to other habitats	Socio-economic, ecological
Review sewage system (Yapak, Balabag, Manoc-manoc)	↓PI	3	IEC to residents and establishments	Assessment of potential groundwater seepage; Review water circulation on the east side	Coordination with BIWC ; Enforcement of ordinance	3	N	Reduction of habitat threats	Health benefits (Habitat; Human)
Regulate water sports (island)	↓PI	3		Assess areas where water sports exist	Review for legal basis for zonation	3	Y	Reduction of habitat threats	Health benefits (Habitat; Human); Proper Zoning
Strengthen enforcement in fisheries (mainland, island)	↑AC, ↓PI	3	IEC to fisherfolks and Bantay Dagat		Review updated ordinance; Capacity building for Bantay Dagat	3	Y	Reduction of habitat threats	Sustainable fisheries
Stricter implementation	↑AC, ↓PI	3	IEC to residents and establishments	Study variability	"Kamay na Bakal"	3	Y	Adjustment of easement standards	Protect lives; livelihood
Thicken beach vegetation (island, mainland)	↑AC, ↓PI	2		Assess beach vegetation (existence, identification or profiling)		2	Y	Natural buffers to erosion	Protection against erosion

CASE STUDY


Regulate water sports in island barangays
Review sewage system in island barangays
Strengthen enforcement
Review Marine Park Ordinances
HIGH
Priority 4
Prio
MED
Priority 3
Priority 2
LOW
Thickened beach vegetation
CAPACITY
LOW
MED
HIGH
URGENCY

POST VA ACTIVITIES

CASE STUDY

Mangrove rehabilitation
Photo: MAO-Malay

Seaweed farming at Mainland Malay
Photo: FJBalquin

Other Projects:

Underwater Clean Up
Beach Clean Up
Adopt a Marine Sanctuary Program
Coral refurbishment project
Demolition of establishments on the 25+5 easement zone

Ridge to Reef IEC for barangay organizations, primary and secondary schools Photo: AAKLumagod

Refresher for Bantay Dagat on ordinances
Photo: MAO-Malay

SUMMARY

- Climate change has direct and indirect impact to fisheries.
- Identification of vulnerable areas is a first step towards climate change adaptation.
- Site-specific attributes contribute to the overall vulnerability of an area.

SUMMARY

- VA-TURF is a simple tool for non-scientists to use and apply in their community to identify vulnerable fishing communities.

- The results from the assessment allows identification of adaptation strategies to alleviate potential climate change impacts on fisheries.

- Vulnerability differences and adaptation measures can significantly shift the outcome of any climate change impact.


CLIMATE CHANGE
will
We can do something about it!

Thank you!

community ecology laboratory

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