DEVELOPMENT OF A GIS-BASED COASTAL RESOURCES VULNERABILITY ASSESSMENT FRAMEWORK FOR COASTAL RESOURCES IN THE PHILIPPINES

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ABSTRACT: Vulnerability assessment (VA) is a concept recently being developed and widely used in various fields. The complexity and diversity of VA allows us to tailor fit frameworks according to specific targets, range, data availability and stakeholder capacity. This study developed a GIS-based framework for vulnerability assessment of coastal resources (i.e. mangroves, seagrass and corals) in the Philippines using remotely sensed data. The VA framework utilized inputs from previously established vulnerability assessment tools for coastal areas in the Philippines to complement with the object-based VA approach using LiDAR data set. Exposure values for the whole country derived from a separate study were merged with the sensitivity layers produced to determine the potential impacts of climate change for each coastal resource. Adaptive capacity layers generated by combining both spatial and social factors were also generated to compute for the final vulnerability for each coastal resource. The results of the initial framework demonstration on various pilot sites showed how spatial information from GIS and remote sensing can be effectively utilized in the vulnerability assessment of coastal resources. The object-based coastal resource VA framework developed can provide useful information for developing strategic management and conservation plan for mangroves, seagrass and coral reefs in the Philippines.

VULNERABILITY ASSESSMENT

Vulnerability, as defined by the International Panel on Climate Change (IPCC), is the degree to which a system is susceptible to adverse effects of climate change, including climate variability and extremes. The figure below illustrates Vulnerability as a function of the Potential Impact of a particular climate hazard to a system, derived by factoring together the degree of Exposure of a system to climate hazard and those that contribute to its Sensitivity, and the system's Adaptive Capacity (IPCC, 2001).

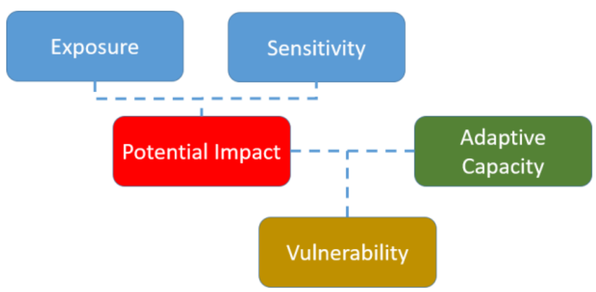

Figure 1. Vulnerability as a function of Potential Impact and Adaptive Capacity.

The primary goal of climate change vulnerability assessments is to provide insights and recommendations that would aid in the development of policies and management practices that would help mitigate and reduce the risk of climate change hazards. Vulnerability assessment studies define each vulnerability component (i.e. exposure, sensitivity and adaptive capacity) differently following an operational definition. This complexity and diversity allows us to design vulnerability frameworks according to specific targets, data availability and stakeholder capacity.

Coastal habitat resources and Climate change in the Philippines

Philippines is an archipelagic country with coastline of approximately 36, 290 kilometers. The country's coastal area is rich in coastal and marine resources such as coral reefs, seagrass and mangroves, and is home to more than 60% of the population that rely on these resources for sustenance and livelihood (NSCB 2012). According to the study conducted by Long et al. (2013), mangrove cover for the whole country is estimated to be 240,824 ha in 2010. On the other hand, baseline information on the current extent for seagrass and corals is still lacking.

Philippines is considered to be the center of the center of marine biodiversity in the world (Carpenter and Singer, 2005). The presence of these coastal habitats across the country greatly contribute to its high species biodiversity. It is home to at least 2,000 species of fish, 5,000 species of clams and other mollusks and crustaceans, 900 species of seaweed, and more than 400 species of corals (Greenpeace, 2013). However, despite the prestigious title the Philippines hold when it comes to biodiversity, threats to marine ecosystems still remains. Both anthropogenic and natural disturbances endanger not only coastal habitat resources but also those depending on it (Burke et al. 2012, Roberts 1993). Anthropogenic disturbances include but is not limited to destructive fishing practices, overfishing, sedimentation from runoffs, pollution and coastal development whereas natural disturbances include typhoons, increasing sea surface temperature, sea level rise and extreme rainfall, or most commonly known as impacts of climate change.

Climate change has been a hot topic not only in the Philippines but in other countries as well (Songcuan and Santos, 2013). As defined by the United Nations Convention on Climate Change, it is the rapid change of climate of which can be attributed directly or indirectly to anthropogenic causes. The continuous increase in sea surface temperature, sea level rise, and other climatic effects evidently caused serious damage to coastal habitats in different parts of the world such as coral bleaching, decline and change in species composition, landward migration of mangroves and hypoxia and anoxia on seagrass beds. In order to adapt to the current and worsening situation, researchers began conducting vulnerability assessments on different fields of science. Methods to assess climate change vulnerability have been established since 1991 by the IPCC but is continuing to improve alongside with new knowledge in climate change impacts and adaptive strategies (Aliño et al. 2013). Efforts to study climate change impacts have also helped us understand that impacts of climate variability vary greatly from location to location thus, a considering localized approach in assessing vulnerability would be ideal.

Vulnerability Assessment studies in the Philippines

Several vulnerability assessment studies have been conducted in the Philippines each designed to address issues of a particular system. The Integrated Coastal Sensitivity, Exposure, and Adaptive Capacity to Climate Change (ICSEA-C-Change) tool developed by Licuanan et al. (2013) measures integrated vulnerability of coastal system (i.e. fisheries, coastal integrity and biodiversity) at the Barangay level using sea-level rise, waves and storm surge, SST, and rainfall as exposure parameters.

Another tool that targets a different sector is the Coastal Integrity Vulnerability Assessment Tool (CIVAT) by Siringan et al. (2013). The CIVAT tool focuses primarily on coastal integrity per Barangay unit. It considers sea-level rise and waves as exposure factors. Unlike ICSEA-C-Change, which tackles both ecological and socio-economic domains, CIVAT predominantly uses environmental parameters such as coastline characteristics and habitat condition.

Tools for Understanding Resilience of Fisheries (TURF) by Mamauag et al. (2013) employs a fisheries specific approach to vulnerability assessment. It uses wave and storm surge and increased sea surface temperature as exposure values for fisheries sector per Barangay unit. TURF uses three variables, i.e. fisheries, ecosystem, and socio-economic. The framework uses a general exposure value for the three components and a set of unique sensitivity and adaptive capacity criteria for each variable. Similar to CIVAT, which interprets vulnerability in relation to coastline itself, TURF results are relevant for prioritization of fisheries vulnerability per barangay unit. TURF also developed a more complex matrix in computing for the vulnerability index using exposure, sensitivity and adaptive capacity scores.

Another sector-based vulnerability assessment approach is the Fisheries Vulnerability Assessment Tool (Fish Vool) for tuna and sardine sectors in the Philippines by Jacinto et al. (2014). Similar to TURF, it is more focused on the vulnerability of the fisheries sector. The tool uses three variables, Fish (commodity/ sector), Human (fishermen and stakeholders) and Community (community and locals). Unlike previously mentioned VA tools that measure vulnerability per Barangay level, Fish Vool describes the vulnerability of a particular fisheries sector. Also, the matrix used for computing the vulnerability index is similar to that of CIVAT.

DEVELOPMENT OF GIS-CoRe VULNERABILITY ASSESMENT TOOL

GIS-CoRe VA Framework

Based on the VA framework established by the IPCC as well as existing vulnerability assessments conducted in the Philippines, we formulated a framework for a GIS-based Coastal Resources Vulnerability Assessment Tool (GIS-CoRe) to determine the vulnerability of each coastal habitat (i.e. mangroves, seagrass, and coral reefs). The tool enables us to utilize remotely sensed data (e.g. satellite images, LiDAR data) as well as field data and incorporate them into a GIS platform for better illustration and interpretation. Moreover, the tool employs an object-based approach vulnerability assessment. The figure bellow show the general framework used in this study to compute for vulnerability.

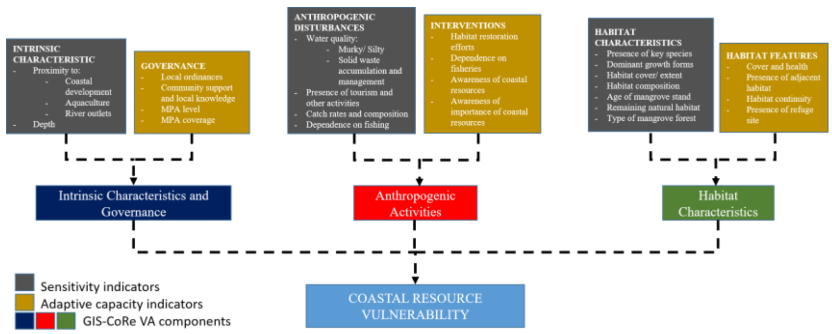

Figure 2. GIS-CoRe Vulnerability Assessment Framework

Exposure to climate change and impacts to coral reefs, seagrass and mangroves

Exposure, as defined by Alino et al. (2013), is the measure that quantify the intensity or severity of physical environmental conditions that drive changes in the state of the biophysical system, which may also include future state and projections, historical, or long-term trends. Most climate vulnerability assessment studies use various or combinations of climatic change impacts such as increased ocean temperature, wave and storm surge exposure. For the study, we used the Philippine climate-ocean typology developed by David et al. In their study, they used long-term satellite-derived data sets for sea surface temperature (SST), sea surface height (SSH), wind data and precipitation. Using these parameters, they were able to develop clusters of different typologies by modeling trends and anomalies.

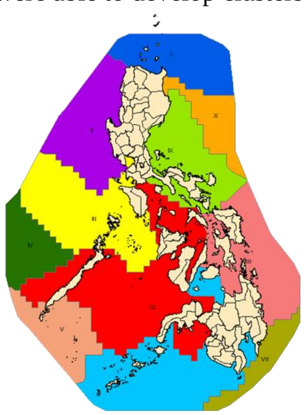

Figure 3. Philippine Climate-Typology relative exposure

Table 1. Typology values for the Philippine Climate-Typology

Exposure Type	Increased Ocean Temperature	Extreme Heating Event	Extreme Rainfall	Disturbed Water Budget	Sea Level Rise
I	3	5	2	3	4
II	3	5	5	5	5
III	2	4	1	5	5
IV	3	4	1	1	4
V	2	2	4	3	5
VI	3	3	1	3	5
VII	5	4	3	1	5
VIII	5	4	4	3	4
IX	3	4	4	4	4
X	5	4	4	4	4
XI	3	3	1	3	5

Sensitivity Variables: Intrinsic Characteristics, Anthropogenic and Habitat

Sensitivity, as used in this study, is the measure that describe the system's present state that contribute or respond to exposure factors from climate change. We formulated criteria for each vulnerability component: 1) Intrinsic Properties, 2) Anthropogenic Activities, 3) Habitat Characteristics.

Intrinsic Characteristics: Intrinsic properties as used in this study are object-based criteria that contribute to the sensitivity of each coastal resource that can be derived using GIS and LiDAR datasets such as proximity values to coastal development, aquaculture, depth, and river outlets. Proximity values were derived from the pilot study conducted prior to the development of framework. These criteria give sensitivity values to each object/ resource based on its geographic characteristic.

Table 2. Sensitivity criteria for intrinsic characteristic component

SENSITIVITY CRITERIA		DESCRIPTION	COASTAL RESOURCE
INTRINSIC PROPERTIES	**Proximity to Coastal Development**	Coastal Development is a possible source of pollution and other disturbances, thus increasing the resource's sensitivity to climate change.	Corals, seagrass, mangroves
	Proximity to Aquaculture	Aquaculture ponds can contribute to increased nutrient content in coastal areas. Chemicals and waste products released from aquaculture ponds are harmful to seagrass and coral reefs.	Corals, seagrass, Mangroves
	Proximity to river outlets	Rivers are one of the primary link between the terrestrial environment and the marine ecosystem. Unfortunately, they are also source or transfer mechanism for waste from the terrestrial environment.	Corals, Seagrass
	Depth	Deeper reefs are less susceptible to drastic change in temperature and other threats such as sedimentation and anthropogenic disturbances.	Corals, Seagrass

Antrhopogenic disturbances: Some human activities such as tourism and fishing increases coastal habitat sensitivity by putting additional pressure to the habitat on top of climate change impacts. Moreover, other anthropogenic activities can degrade water quality, which greatly affects sensitivity of coastal resources primarily seagrass and corals.

Table 3. Sensitivity criteria for anthropogenic activities component

SENSITIVITY CRITERIA		DESCRIPTION	COASTAL RESOURCE
ANTHROPOGENIC DISTURBANCES	**Murky/ silty water**	Water turbidity is an important indicator of water quality. It suggests high sedimentation rates as well as high nutrient content which can lead to hypoxic/ anoxic environment	Corals, Seagress
	Solid waste accumulation and management	Solid waste from human activities are harmful to coastal resources. Presence of effective solid waste management can decrease sensitivity to climate change impacts.	Corals, Seagress, Mangroves
	Presence of tourism activities and other activities	Tourism activities, such as snorkeling, jetski, boat anchoring, and other activities, can potentially damage coastal resources if not properly managed or stirct zonation is not implemented.	Corals, Seagrass

	Catch rates	Catch rates reflect fish abundance, which also indicates the condition of the habitat. Higher catch rates of demersal or habitat dependent species reflects good habitat condition.	Corals, Seagrass
	Catch composition	Similar to catch rates, catch composition also reflect habitat quality. Dominance of demersal catch can indicate a good habitat quality.	Corals, Seagrass
	Dependence on fishing	High dependence on fishing translates to high sensitivity of coastal habitats.	Corals, Seagrass

Habitat characteristics: Habitat characteristics affect its sensitivity to climate impacts. Healthier habitats are less susceptible to impacts of climate change than degraded habitats. This variable also includes habitat specific criteria.

Table 4. Sensitivity criteria for habitat component

SENSITIVITY CRITERIA		DESCRIPTION	COASTAL RESOURCE
HABITAT CHARACTERISTIC	**Presence of key species**	For mangroves and seagrass, presence or abundance of habitat associated fish species and key indicator species correlates with habitat quality	Corals, Seagrass
	Dominant growth forms	Diversity not only in species but also in growth forms is important. Different coral growth forms are sensitive to different climatic threats thus, high growth form diversity of corals can reduce sensitivity of the coral reef.	Corals
	Seagrass cover/ extent	Extensive seagrass beds are less sensitive to impacts of climate change.	Seagrass
	Seagrass bed composition	Monospecific beds are more sensitive to impacts of climate change such as species specific threats and diseases.	Seagrass
	Age of the mangrove stand	Older mangrove stands are more resilient to impacts of climate change as compared to younger plantation.	Mangroves
	How much of the natural forest are left?	Natural stands are more resilient to impacts of climate change.	Mangroves
	What kind of mangrove forest is left?	Different types of mangrove forests based on location have different sensitivities to climate change	Mangroves
	What kind of species are present?	Mangrove forests dominated by fast growing species have higher recovery potential	Mangroves

Adaptive capacity variables – Governance, Human Interventions, Habitat Features

Adaptive capacity is the ability of the system to cope with impacts associated with changes in climate. In the study, not only the intrinsic characteristic of the system but also external processes that contribute to its adaptive capacity were included. Here we assigned adaptive capacity criteria for each resources and categorized it into three variables: 1) Governance, 2) Human Interventions, and 3) Habitat Features.

Governance: Governance includes the presence of laws and ordinances that protect and conserve coastal resources. These ordinances play a vital role on the recovery potential of each resource. Moreover, strict implementation and other strategies also increase the adaptive capacity of coastal resources.

Table 5. Adaptive capacity criteria for governance component

ADAPTIVE CAPACITY CRITERIA		DESCRIPTION	COASTAL RESOURCE
GOVERNANCE	**Local Ordinances**	Local ordinances to protect and conserve coastal resources and strict implementation of such increases the adaptive potential of coastal resources.	Corals, seagrass, mangroves
	Community Support and Local Knowledge	Community support and awareness that these ordinances exist and how they respond to it is important to the success of any management and conservation effort.	Corals, seagrass, mangroves
	MPA level	Level of MPA in accordance to the MPA MEAT guidelines and Horigue et al. (2014) (http://mpasupportnetwork.org/meat/)	Corals, seagrass, mangroves
	MPA coverage (extent of focus)	Marine Protected Areas are not limited to coral reefs. Integrated MPA which include more than 1 habitat can provide more benefit to the coastal resources increasing their recovery potential	Corals, seagrass, mangroves

Human Adaptive Capacity: Human adaptive capacity is the measure of how human intervention influence the coastal resource's adaptive potential. This include habitat restoration efforts, dependence on fisheries resources, and awareness of coastal resources.

Table 6. Adaptive capacity criteria for anthropogenic activities component

ADAPTIVE CAPACITY CRITERIA		DESCRIPTION	COASTAL RESOURCE
HUMAN INTERVENTION	**Habitat restoration efforts**	Human intervention such as restoration efforts can reduce the impact on the whole coastal resources by increasing their recovery potential	Corals, seagrass, mangroves
	Dependence on fisheries resource	Higher dependence on fisheries resources equates to higher pressure on coastal resources.	Corals, Seagrass
	Awareness of coastal resources	Awareness on the available coastal resources in the area as well as where they are located is essential in effective management.	Corals, seagrass, mangroves
	Awareness of importance of each coastal resource	similar to awareness of the location and extent of each resources available in the area, knowing their importance also contribute to effective management through community support.	Corals, seagrass, mangroves

Habitat Features: Habitat adaptive capacity describes the inherent characteristic of each habitat or the ecosystem that increases recovery potential. This includes habitat extent/ cover, presence of adjacent habitats, and presence of recruitment zones.

Table 7. Adaptive capacity criteria for habitat component

ADAPTIVE CAPACITY CRITERIA		DESCRIPTION	COASTAL RESOURCE
HABITAT ADAPTIVE CAPACITY	**Coral cover/ Health**	Coral cover is proportionate to the adaptive capacity of coral reefs. Higher coral cover provide higher recruitment potential.	Corals
	Presence of Adjacent Habitat	Recovery potential of each habitat is enhanced by presence of adjacent coastal habitat and its condition.	Corals, seagrass, mangroves
	Is the Seagrass bed continuous?	Higher seagrass cover correspond to higher recovery potential	Seagrass
	Presence of refuge site (buffer zone)	Presence of available areas for mangroves to migrate landward increases their adaptive capacity.	Mangroves

VULNERABILITY SCORING MATRIX

Exposure, Sensitivity and Adaptive Capacity Rescaling

This study adapts the rescaling method used in previously developed VA tools (TURF and CIVAT). Total scores were rescaled using the formula (Figure 4) to assign Low, Medium and High scores. Rescaling was done to normalize the values and eliminate the effect of the differences in the number of criteria for each variable. After rescaling, vulnerability values for each component were derived using cross-tabulation table in figure 5. Overall vulnerability was computed using cross-tabulation table in figure 6.

[(No. of criteria) x (maximum category)] = Maximum Score

[(No. of criteria) x (minimum category)] = Minimum Score

(Maximum Score) – (Minimum Score) = Class Range

(Class Range) / (No. of Classes) = Class Intervals

Figure 4. Rescaling equation for exposure, sensitivity and adaptive capacity components

If the no. of criteria = 2

Maximum score	(2 x 5) = 10
Minimum score	(2 x 1) = 2
Total range	[max - min] = 8
Intervals	8 ÷ 3 = 2.7 or 3
Interval	8/3
	2.7

Rating	Range
Low	2-4
Medium	5-7
High	8-10

Figure 4. Sample values after rescaling on different numbers of criteria based on TURF VA Tool.

	Sensitivity			
Exposure	*PI*	L	M	H
	L	L	L	M
	M	L	M	H
	H	M	H	H

	Adaptive Capacity			
PI	*V*	L	M	H
	L	M	L	L
	M	H	M	L
	H	H	H	M

Figure 5. Cross-tabulation table for each component

Intrinsic Properties and Governance	Anthropogenic Characteristics				Habitat Characteristics
		H	M	L	
	H	HHH	HMH	HLH	H
	H	HHM	HMM	HLM	M
	H	HHL	HML	HLL	L
	M	MHH	MMH	MLH	H
	M	MHM	MMM	MLM	M
	M	MHL	MML	MLL	L
	L	LHH	LMH	LLH	H
	L	LHM	LMM	LLM	M
	L	LHL	LML	LLL	L

Figure 6. Cross-tabulation table for overall vulnerability

Scoring Matrix for Sensitivity and Adaptive Capacity Variables

Table 8. Sensitivity score matrix for GIS-based CoRe VA Tool.

Coastal Resource	SENSITIVITY CRITERIA		Very High (5)	High (4)	Medium (3)	Low (2)	Very Low (1)
Corals	INTRINSIC CHARACTERISTICS	**Proximity to Coastal Development**	<1000m to nearest built-up region	1001m to 2000m to nearest built-up region	2001m to 3000m to nearest built-up region	3001m to 4000m to nearest built-up region	>4000m to nearest built-up region
		Proximity to Aquaculture	<1250m to nearest aquaculture	1251m to 2500m to nearest aquaculture	2501m to 3750m to nearest aquaculture	3750m to 5000m to nearest aquaculture	>5000m to nearest aquaculture
		Proximity to river outlets	<750 to nearest river outlets	751m to 1500m to nearest river outlets	1501m to 2250m to nearest river outlets	2251m to 3000m to nearest river outlets	>3000m to nearest river outlets
Corals and Seagrass		**Depth**	0-5m	5-10m	10-30m	30-60m	>60m
Seagrass		**Proximity to Coastal Development**	<300m to nearest built-up region	301m to 600m to nearest built-up region	601m to 900m to nearest built-up region	901m to 1200m to nearest built-up region	>1200m to nearest built-up region
		Proximity to Aquaculture	<300m to nearest built-up region	301m to 600m to nearest built-up region	601m to 900m to nearest built-up region	901m to 1200m to nearest built-up region	>1200m to nearest built-up region
		Proximity to river outlets	<500 to nearest river outlets	501m to 1000m to nearest river outlets	1001m to 1500m to nearest river outlets	1501m to 2000m to nearest river outlets	>2000m to nearest river outlets
Mangroves		**Proximity to Coastal Development**	<500m to nearest built-up region	501m to 1000m to nearest built-up region	1001m to 1500m to nearest built-up region	1501m to 2000m to nearest built-up region	>2000m to nearest built-up region
		Proximity to Aquaculture	<750m to nearest aquaculture	751m to 1500m to nearest aquaculture	1501m to 2250m to nearest aquaculture	2251m to 3000m to nearest aquaculture	>3000m to nearest aquaculture
Corals and Seagrass	ANTHROPOGENIC DISTURBANCES	**Murky/ silty water**	water is murky all year round	Water is murky for 3 quarters a year	Water is murky for 2 quarters a year	Water is murky for 1 quarters a year	Water is clear all year round
		Solid waste accumulation and management	solid waste accumulates in the coastal area all year round, ineffective solid waste management	solid waste are observed around 7 to 9 months per year	solid waste are observed around 4 to 6 months per year	solid waste are observed around 1 to 3 months per year	no solid waste in coastal area, effective solid waste management
		Presence of tourism activities and other activities	High tourism activities with poor zonation and regulation	Moderate tourism activities with poor zonation and regulation	Low tourism activities with poor zonation and regulation	High tourism activities with strict zonation and regulation	Low to moderate tourism activities with strict zonation and regulation
		Catch rates	Average catch is less than 3kg/ fisher/ day	Average catch is between 3 to 8 kg per fisher per day		Average catch is greater than 8kg per fisher per day	
		Catch composition	Catch is largely comprised of demersal fishes associated with nearshore habitats	Catch composition is a mixture of pelagic and demersal fishes		Catch is predominantly pelagic fishes	
		Dependence on fishing	More than 50% of the total population are fishers and majority are full-time	More than 50% of the total population are fishers and majority	Fishers population is between 30-50% and majority are full time	Fishers population is between 30-50% and majority have alternative livelihood	Fisher population is below 30% of total population

				have alternative livelihood			
Corals	HABITAT CHARACTERISTIC	**Dominant growth forms**	Single growth form is more than 80% dominant	Single growth forms dominant more than 50%	Two dominant growth forms	Mixed growth forms	
Corals and Seagrass		**Presence of key species**	Desnsity of coral-dependent/ associated species is less than 5% of total fish density		Desnsity of coral-dependent/ associated species is between 5% and 10% total fish density		Desnsity of coral-dependent/ associated species is greater than 10% total fish density
Seagrass		**Seagrass cover/ extent**	seagrass cover less than 1/8 of the reef flat	seagrass cover more than 1/8 to 1/2 of the reef flat		Seagrass cover more than half of the reef flat	
		Seagrass bed composition	Monospecific bed	2 to 4 species		mixed bed with over 5 species	
Mangroves		**Age of the mangrove stand**	<5 years	5 to 10 years	10 to 15 years	15 to 20 years	more than 20 years
		How much of the natural forest are left?	<20% of natural mangroves are left	20-40% of natural mangroves are left	40-60% of natural mangroves are left	60-80% of natural mangroves are left	<80% of natural mangroves are left
		What kind of mangrove forest is left?	scrub-fringing type	riverine-fringing type		riverine-basin-fringing type	
		What kind of species are present?	All species are slow growing	presence of 1-2 fast growing species	presence of 3-4 fast growing species	presence of 5-6 fast growing species	All species present is fast growing

Table 9. Adaptive capacity score matrix for GIS-CoRe VA Tool.

Coastal Resource	ADAPTIVE CAPACITY		Very High (5)	High (4)	Medium (3)	Low (2)	Very Low (1)
Corals, Seagrass and Mangroves	GOVERNANCE	**Local Ordinances**	There are laws and ordinances and properly enforced	No written laws and ordinances but protection is strictly observed	Laws and ordinances exist but not well enforced	Few laws and ordinances exist and not well enforced	Laws and ordinances are absent
		Community Support and Local Knowledge	Community widely accept and aid in the impelementation		Community knows about the ordinances but leaves it to the officials to do		Community does not know such ordinances exist
		MPA	4	3	2	1	0 to no MPA
		MPA coverage (extent of focus)	all habitats are represented in MPAs	Only 2 habitats are represented in MPA	Only 1 habitat is included but with more than 50% coverage	Only 1 habitat is included but with less than 50% coverage	no MPA
Corals and Seagrass	HUMAN INTERVENTION	**Dependence on fisheries resource**	less than 20%	21 to 40%	41 to 60%	61 to 80%	above 80%
Corals, Seagrass and Mangroves		**Habitat restoration efforts**	More than 90% of the degraded habitats have been rehabilitated	Between 70 to 90% of the degraded habitats	Between 50 to 70% of the degraded habitats	Less than 50% of the degraded habitats	No rehabilitation efforts being done

		Awareness of coastal resources	Knows all coastal resources very well	Knows all coastal resources but not very well	Knows atleast 2 coastal resources very well	Knows atleast 2 coastal resources but not very well	Not familiar
		Awareness of importance of each coastal resource	Knows the importance of all coastal resources	Knows the importance of all coastal resources but not very well	Knows the importance of atleast 2 coastal resource very well	Knows the importance of at least 2 coastal resources but not very well	does not know the importance of the coastal resources
Corals	**HABITAT MORPHOLOGY**	**Coral cover/ Health**	>50% coral cover	25-50% coral cover		<25% coral cover	
Seagrass		**Is the seagress bed continuous?**	Barren area is less than 20%	Barren area is 20-40%	Barren area is 40-60%	Barren area is 60-80%	Barren area is more than 80% of the meadow
Mangroves		**Presence of refuge site (buffer zone)**	80 to 100% of buffer	60 to 80% of buffer	40 to 60% of the buffer	20 to 40% of the buffer	0 to 20% of the buffer
Corals, Seagrass and Mangroves		**Presence of Adjacent Habitat**	2 adjacent habitats, 2 good condition	2 adjacent habitat, atleast 1 good condition	1 adjacent habitat, in good condition	1 adjacent habitat not good condition	no adj habitat

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