Seagrasses:
See How They Protect Us!

A Guide to Community Appreciation of Seagrasses in the Philippines

M.D. Fortes[1], E.G. Fortes[1], M.B. Sarceda[1],
L.A. Jimenez[2], R.S. Lucero[3]

[1]Marine Science Institute CS, University of the Philippines, Diliman, Quezon City;
[2]Davao Oriental State College of Science and Technology, Mati, Davao Oriental;
[3]Southern Philippines Agri-business and Marine and Aquatic School of Technology, Malita, Davao Occidental

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Disclaimer

This guidebook provides easily understandable information about seagrasses in the Philippines. It aims primarily to enhance appreciation of the least known of our coastal ecosystems –seagrass, especially on the part of local communities who are highly dependent upon the services the ecosystem provides. Hence, it addresses one of the biggest gaps in conserving and managing this untapped resource –the lack of a deeper understanding of what it is, how it responds to disturbances, and how it is linked to our daily lives. Information collected in this guidebook should be used simply to identify the important components of the beds, changes to the beds and provide information that may be used as a tool for management decisions. The knowledge and information are primarily outcomes of research projects undertaken from 2000-2016, in seven sites in the country, hence, far from being exhaustive. Accurately quantifying the species and the changes, and determining their exact causes, will require greater depth of analysis of data and consultation with relevant experts and potentially further investigation.

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Introduction

In 1930, the first true scientific work on seagrass was undertaken. But it took 53 years after that to initiate the first ecological work on seagrasses as a distinct ecosystem in the Philippines. To date, about a hundred scientific works have been published, augmented by more than that number but in the form of informal accounts in newsletters, bulletins, posters, brochures, and news clippings. The knowledge we have on seagrasses remain depauperate, in contrast to the abundance of the resource itself, which thrives in practically all parts of the shallow coastal fringes of the Philippines. Here, they are a readily available space for fishing, gleaning, recreation -source or food and income for coastal dwellers. As such, however, seagrass beds are used as waste dumps, dredged and filled to give way to resorts and domiciles, or completely removed in favor of resorts and shopping malls. Here, too, we see that the lack of appreciation of the true value of the habitat is a major driving force of people's unsustainable actions. There remains a paucity of information needed to understand fully the basic nature of the plants and the ecosystem as basis of their conservation and sound use.

Ironically, seagrass is comparatively the least studied among the coastal habitats in Southeast Asia. This is largely due to the fact that the interests of marine scientists focus mainly on coastal resources with immediate economic value or impacts (e.g. coral reefs, seaweeds, animals, or fish, tourism, coastal development). Suggesting a shift in national conservation focus, this guidebook gives simple, common but compelling reasons for promoting more research and a stronger and more vigorous advocacy on seagrass conservation in the Philippines.

Seagrass is remarkable!

What is a seagrass?

Seagrasses are flowering plants that grow and complete their life histories fully submerged in marine and brackish waters. They have two methods of propagation or reproduction: they can reproduce asexually or sexually. When they reproduce asexually, or clonally, rhizomes (underground stems) elongate beneath the sediment and new, genetically identical shoots are produced as exemplified by *Cymodocea rotundata* (Figure 1). This method of reproduction is important in the expansion of meadows, but it is relatively small in scale, since all shoots must be connected.

Figure 1. *Cymodocea rotundata* grows by elongation of its tips

Seagrasses can also reproduce sexually by means of flowers (Figure 2). Some species of seagrasses have distinct male and female flowers (like *Enhalus acoroides*), while others have both male and female parts within the same flower. When the male pollen fertilizes the female ovary of the flower, new genetically unique seagrass shoots are produced. In addition, flowers or their fruits can break off and travel long distances through the water. This is essential in the creation of new beds or meadows. In time, they become a complete seagrass ecosystem.

Figure 2. Sexual reproductive parts in two seagrass species

Marine algae or seaweeds are often confused with seagrasses. The two, however, are vastly different. Often confused with the seagrasses, seaweeds are more primitive plants, with no true roots ('holdfasts' used in attachment only, not for absorption), stems (or 'thalli') and no conductive tissues (e.g. xylem, phloem), leaves (or 'fronds'). More importantly, and unlike seagrasses, they produce no flowers nor fruits. They are also short-lived, or ephemeral, with short life histories. Seagrasses have a true root system, enabling them to successfully colonize otherwise unstable surfaces, such as sand and mud, whereas most algae cannot. Some seaweeds, however, can grow in sandy to muddy-sandy substrates: *Caulerpa lentillifera,* (the common edible "lato" or "ar-arocep"), *Udotea, Halimeda, Cyathiformis.*

What is a seagrass ecosystem? Why is it important?

A seagrass ecosystem is a space in the shallow coastal region dominated by seagrasses, which interact with each other, with all other plants and animals in it, and with the physical environment to produce a unique energy flow, trophic structure and functions. It is the latter which makes seagrasses important especially to the coastal inhabitants. The high biodiversity and sensitivity to changes inherent in seagrass communities make seagrasses an important component of the sea to help determine the overall health of coastal ecosystems. Seagrasses perform numerous functions:

1. Maintaining high biodiversity – Fishes, invertebrates, seaweeds and other species associated with them grow, forage, derive nutrients, and reside in seagrass beds. The high diversity of animals is shown in Figure 3. Overall, these organisms interact to form a complex food web which contributes to the stability and integrity of the coast.

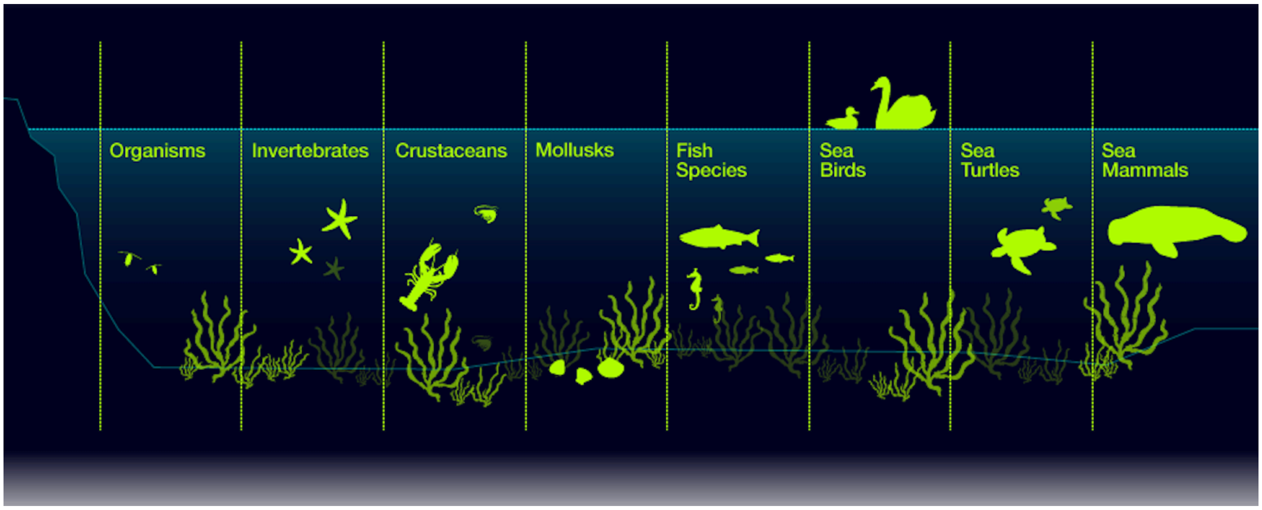


Figure 3. Animal diversity in seagrass beds (www.oceanhealthindex.org)

2. Providing food and habitat for many marine organisms - These beds provide nursery and feeding grounds especially for the young of marine organisms, protecting them from predators and providing the food necessary for the survival of plants and animals. See a school of the striped eel catfish (*Plotosus lineatus*), actively grazing on the epiphytes of *E. acoroides* (Figure 4).

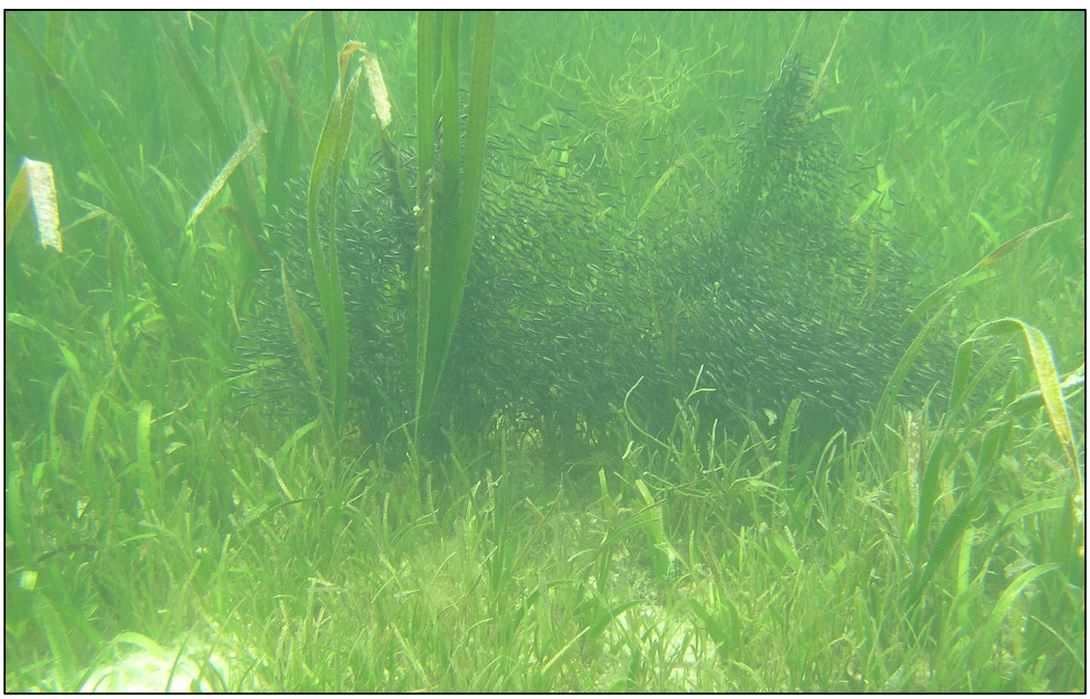


Figure 4. A school of the striped eel catfish (*Plotosus lineatus*) grazing on the epiphytes attached to the leaves of *E. acoroides*

3. Maintaining high water quality – In silted or turbid areas, seagrasses help trap fine sediments and particles that are suspended in the water column,

increasing water clarity. Without seagrass communities, the sediments are more frequently stirred up by passing boats, wind and waves, decreasing water clarity, affecting marine plant and animal behavior, and generally decreasing the recreational quality of coastal resorts. Seagrasses also help filter nutrients coming from land-based industrial discharge and storm water runoff before these nutrients are washed out to sea and to other sensitive habitats such as coral reefs.

4. Stabilizing the sea bottom - Sea bottom without seagrass are vulnerable to strong wave action from currents and storms. The extensive root system in seagrasses, which extends both vertically and horizontally, helps stabilize the bottom in the same way land grasses prevent soil erosion. Seagrasses help reduce the force of the currents along the bottom, making beaches, businesses, and homes safer from greater damage from pollution and storms.
5. Sequestering carbon dioxide from the air – Recently seagrass meadows are called 'blue carbon ecosystems", primarily because of their exceptional ability to capture carbon from the atmosphere and store this carbon in their tissues and sediments (for thousands of years, in the latter). Hence, they reduce the amount of toxic carbon dioxide we breathe, the temperature which heats up the sea, and acidification of the coastal waters upon whose components many coastal dwellers depend for food and survival.
6. Interacting with other coastal ecosystems – Seagrass beds are interconnected with mangroves and coral reefs (and with forests) in terms of, among others, nutrients, physical events, plant propagule dispersal, and animal migrations (Figure 5). Human impacts are recently recognized as a major linking factor. This 'interlinking' helps maintain the stability and integrity of the coast, so that if you destroy one, you destroy the other.

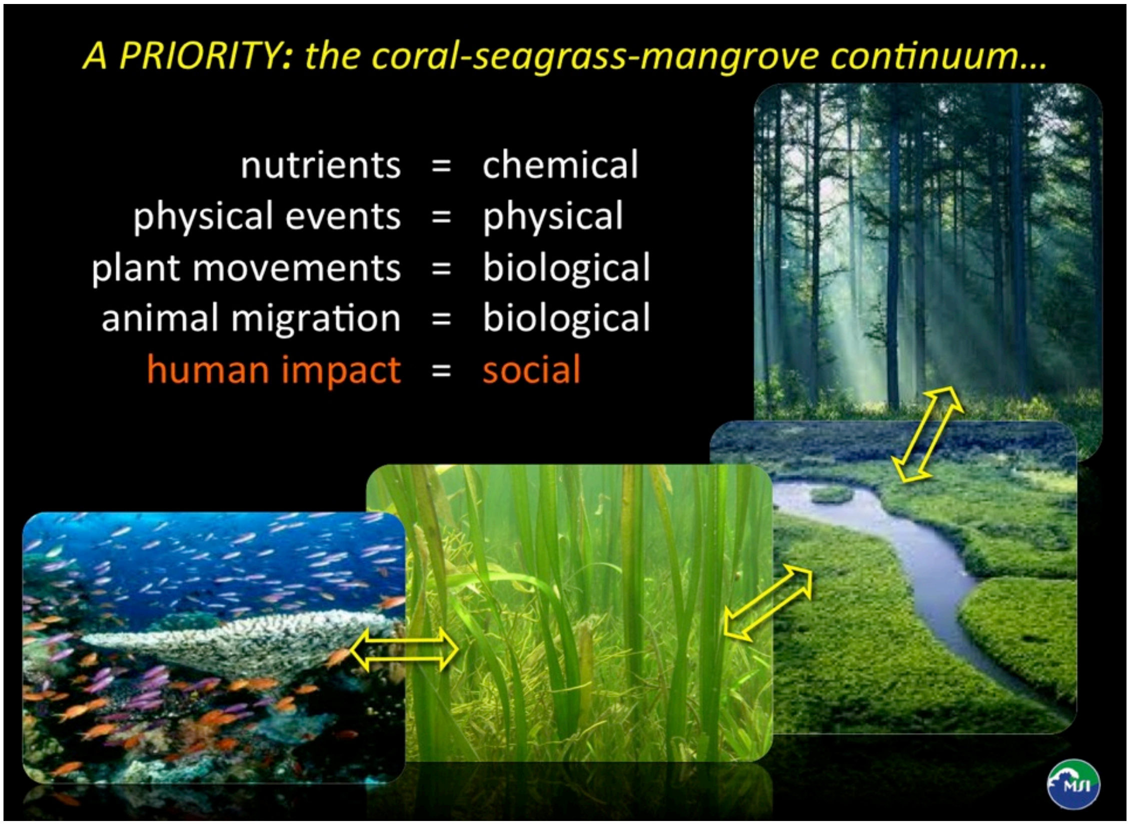


Figure 5. Inter-habitat connectivity, emphasizing its study as a research priority

7. Supporting local economies – The functions of seagrasses which are mentioned above sustain artisanal, commercial and recreational fisheries which would otherwise be lost if seagrasses are removed or destroyed. Although seagrass is not a commodity that is directly cultivated in the Philippines, its economic value can be measured through other industries, such as commercial and recreational fisheries and nature and wildlife tourism, which rely on this habitat to survive. Most of the country's fishery species (approximately 70%) spend at least part of their life cycle within seagrass communities; hence, seagrasses are vital to the survival of these fishing industries. The pictures below show a common scene along Philippine coasts, showing the degree of dependency of people on the ecosystem. Gleaning (Figure 6A) and fish traps on seagrass (Figure 6B) are cheap and ready sources of support for the local economy.

Figure 6. Gleaning on seagrass (A) fish pens on seagrass beds (B).
They are a common means to improve the local economies

From the ordinary to the extraordinary

The above functions of seagrasses make this 'ordinary' ecosystem 'extraordinary'. It is true, among the coastal ecosystems in the Philippines, coral reefs are the most popular, mangroves the most disturbed, and seagrass beds the least studied. This is largely due to the fact that the interests of marine scientists and the general public focus mainly on coastal resources with immediate economic value or impacts (e.g. coral reefs, seaweeds, animals, or fish, tourism, coastal development). However, when the functions of seagrasses are translated into the actual day-to-day needs of coastal inhabitants, they become the services which the ecosystem provides, making seagrasses rival coral reefs and mangroves in importance to people.

In summary, seagrasses are remarkable because they are functionally unique. Globally, they act as bioshields by:

- Storing about 15% of the carbon in the ocean
- Exporting 24.3% of their net production to adjacent systems
- Providing oxygen to waters and sediments
- Sequestering carbon from the atmosphere
- Trapping and cycling nutrients
- Stabilizing (and preventing resuspension of) sediments
- Improving water transparency and quality
- Lessening wave action and protecting the shoreline

- Providing food and habitat for microbes and other flora and fauna
- Interacting ecologically with coral reefs and mangroves

Recently, seagrasses have been considered 'a new engineering material'. This is because, according to Dr. Carlos Duarte:

> "*Seagrass, unlike other coastal engineering materials, have production that leads to CO_2 removal, not CO_2 emission; they can grow; repair themselves; can adapt to changing boundary conditions. In polluted areas, they provide oxygen to animals & plants & offer refuge to organisms from nearby reefs when these habitats are destroyed, hence, sustaining biodiversity & enhancing their resilience. When intact, seagrass & mangroves form sediments & raise the seafloor with organic-rich materials, achieving equal efficiency for coastal protection as cement-based solutions."*

So, how much are seagrasses worth?

The need to give money values to something that is obviously useful and essential is unnecessary, this view is limited only to those who regard them as such. To some administrators and policy makers who need immediate answers to questions of legal and economic in nature, they need to translate the goods and services of seagrass beds into money, since the latter is the currency or common denominator in economic, legal and oftentimes political circle discussions. In court cases where seagrass destruction is a question, practically nobody listens when scientists and practitioners anchor their arguments only on the scientific, cultural, and moral merits of the ecosystem. Indeed, when money talks, everybody listens! In large measure, this is the argument that has lead to the concept of economic valuation of natural resources.

For examples of the monetary values that came out of the economic valuation exercise on seagrass are given below. Obviously, all of them are gross underestimates and the readers are warned that the values are not only not true values but are useful only as indicators and at the administrative levels only:

- US$ 18,385 per ha per yr (some fisheries items only) (China)
- US$ 16,640 per ha per yr (coastal protection, adopting the cost of materials only) (China)
- US$ 1.2 M per ha per yr (some items of fisheries and recreation) (Thailand)
- US$ 20,000 per ha per yr (some fisheries items and organic matter only) (Philippines)
- US$ 37,000 per 1 football field per yr (Nitrogen and carbon absorption only) (U.S.A.)

According to Waycott *et al.* (2009), the net result of global seagrass loss is equal to one football field per 30 minutes. The ecological services of one football field of seagrass include: it absorbs 5.8 kg N per yr (or it absorbs treated sewage from 780 people); and translated into carbon absorption, the area absorbs 166 g C per sq. m per yr (which is equivalent to the emission of a car travelling 12,000 km).

Hence, in the absence of sound and truly reliable methods in giving money equivalents to ecosystem goods and services that have no direct market value, nobody has as yet come up with a satisfactory valuation of a natural resource that can be considered truly reliable. How much more if we consider giving peso or dollar value to the interrelationships among the system components that are the most valuable and key to ecosystem integrity!

Seagrass species in the Philippines

How many species of seagrass are there in the Philippines?

In the Philippines, 19 seagrass species have been found from the 529 sites visited (Figure 8). The species so far recorded are:

Cymodocea rotundata (1)
Cymodocea serrulata
Enhalus acoroides (2)
Halodule uninervis (3)
Halodule pinifolia
Halophila beccarii
Halophila decipiens
Halophila gaudichaudii
Halophila major
Halophila minor
Halophila ovalis (4)
Halophila ovata
Halophila spinulosa (5)
Halophila species 1
Halophila species 2
Ruppia maritima (6)
Syringodium isoetifolium (7)
Thalassia hemprichii (8)
Thalassodendron ciliatum

Numbers in parentheses correspond to the photographs of the species in Figure 7.

Nine of the 19 species of seagrasses recorded in the Philippines are shown in Figure 7 below. In general, these are the most commonly found in the sites studied in the country.

In general, the three species that dominate most seagrass beds in the Philippines are *Enhalus acoroides, Thalassia hemprichii, and Cymodocea rotundata. Cymodocea serrulata* is currently locally dominant, having disappeared from sites, which have been disturbed especially by pollution. In the case of *Ruppia maritima*, it is found only in highly disturbed areas (e.g. in polluted and where coastal development is concentrated as in coastal Parañaque) and where salinity is very high (e.g. salt pans). On the other hand, *Halodule pinifolia, H. uninervis*, and *C. rotundata* are very quick to colonize areas, which have previously been disturbed. They are called, pioneering seagrasses.

Figure 7. Common species of seagrasses in the Philippines

Where are the seagrass beds in the Philippines?

Seagrasses in the Philippines are found practically in all parts of the coasts where the bottom is favorable for their growth (i.e., plenty of sand mixed with mud, slightly acidic), with sufficient light, and subjected to low-to-moderate wave action. Of the 529 sites surveyed, both the western and eastern seaboard of the country yield lush meadows, although the shallow coasts of northwestern Luzon, of the entire Palawan, and the northern and western coasts of Mindanao also have healthy beds (Figure 8, indicative).

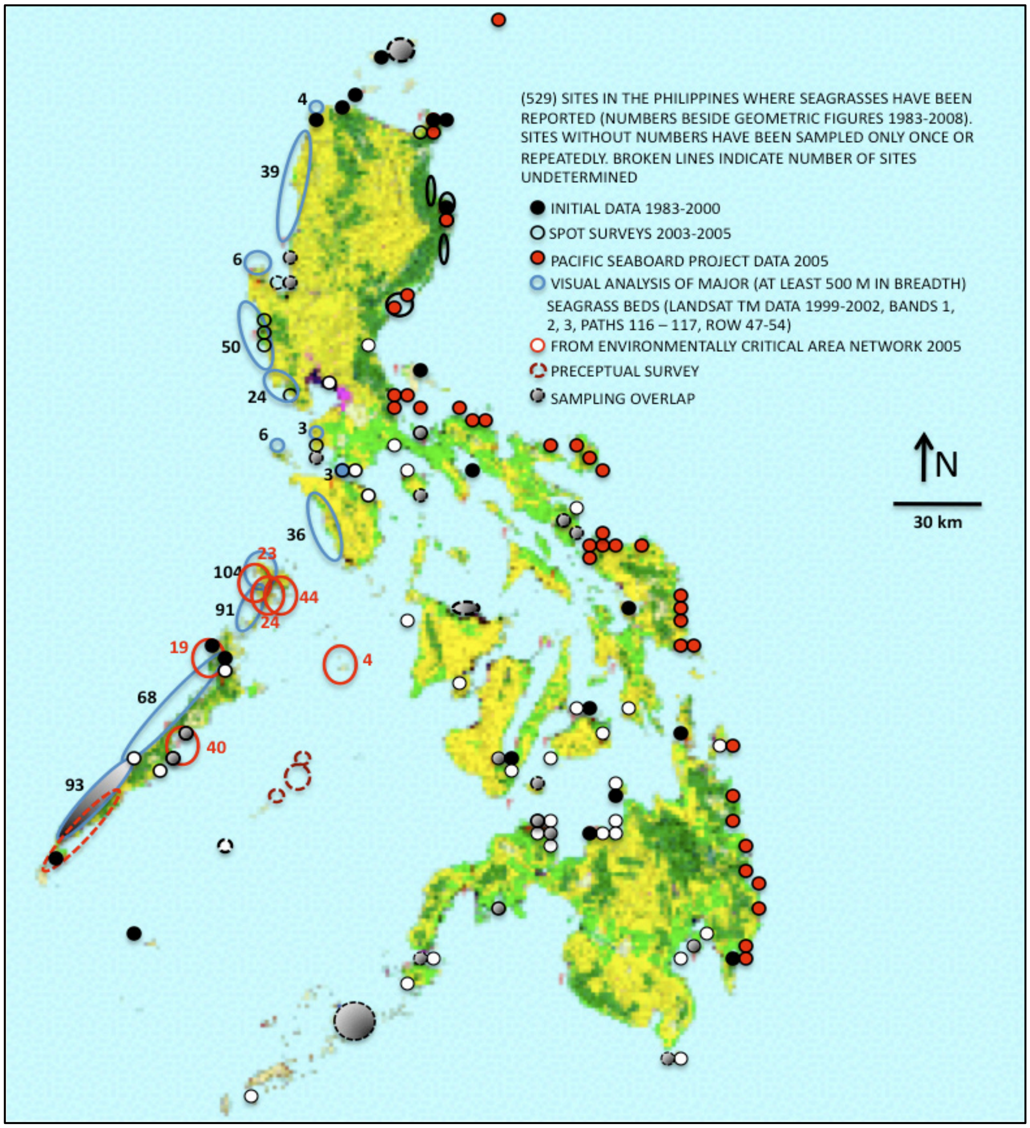


Figure 8. Distribution of seagrass beds in the Philippines

More assessment studies of the distribution and abundance of seagrass in the Philippines are needed in order to fully understand and sustainably utilize their potentials as a resource –both as food source and one in need of protection.

Seagrass beds are bioshields

What is a 'bioshield'?

Literally, a 'bioshield' is a biological protector. Hence, when we speak of seagrass as a bioshield, we refer to the ecosystem's inherent functions to protect the coastal environment and its dependent populations by counteracting or mitigating the threats and negative impacts of both human-induced and natural forcing factors. This way, the seagrass bioshield enhances the productivity of plant and animal communities, enabling them to adapt to stresses and be able to bounce back to its original or close to its original healthy state. This concept is shown in Figure 9, emphasizing the role of projects and programs which study and assist the system in the process:

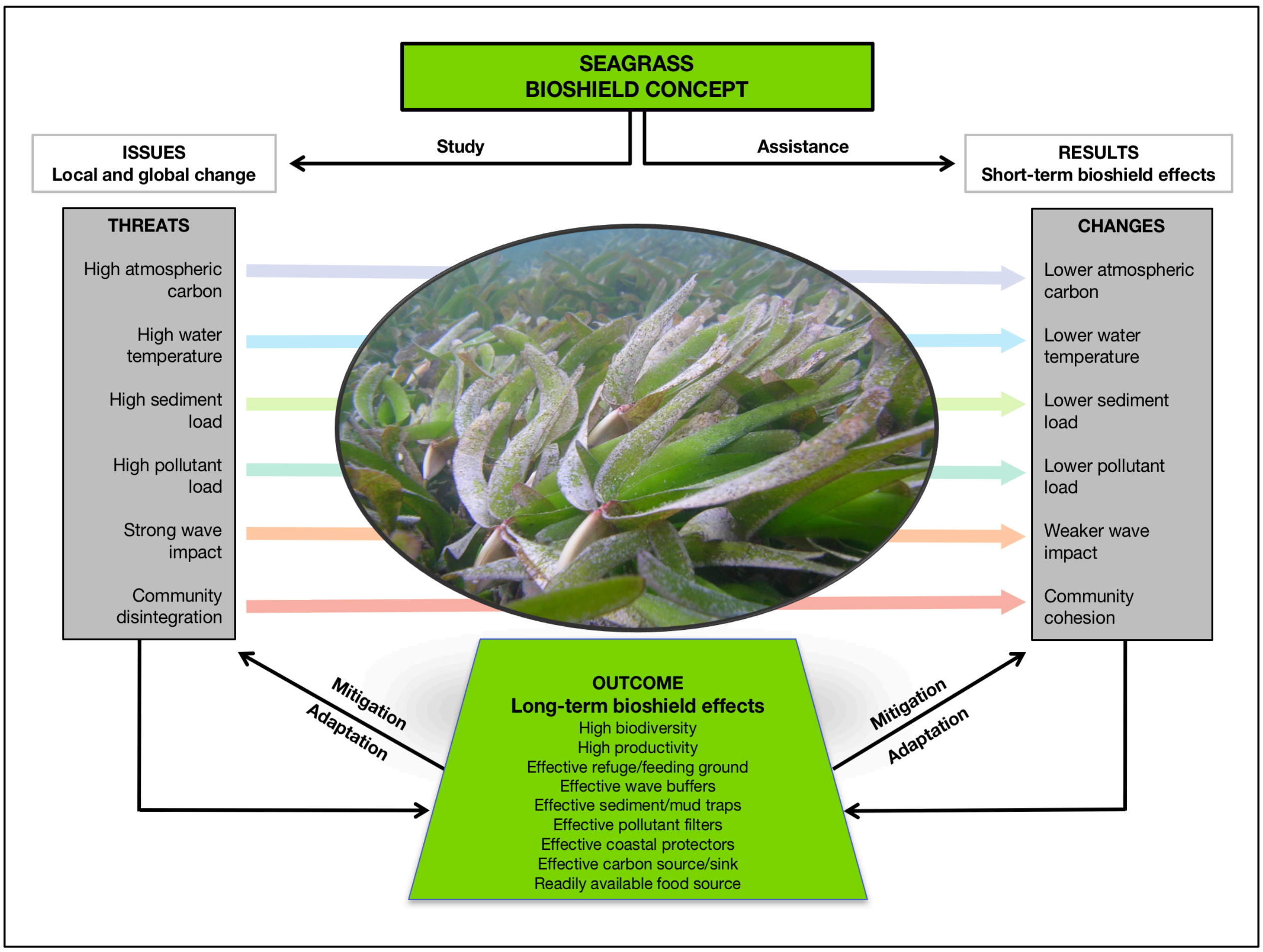


Figure 9. The concept of 'bioshield' emphasizing the role of research in the process

How does a seagrass bed protect us from biodiversity loss?

Seagrass meadows provide a three-dimensional structure wherein other smaller organisms can avoid predators, nutrients especially for the juvenile stages of countless invertebrates and vertebrates, and providing additional substrates where organisms could establish and colonize. This way the meadows protect people from the loss of biodiversity -the ready source of food, medicine, income, hence, livelihood for most coastal populations in the Philippines.

How does it protect us from the impacts of climate change?

Seagrass ecosystems reduce the impacts of threats like high atmospheric =carbon, high water temperatures, and strong wave impacts which, emanate from the current climate variability. Directly or indirectly, these threats result into the disintegration of communities. Once these threats are reduced, with the support of external initiatives like projects and programs of government, the inherent ability of the ecosystem to counteract stress and disturbances is restored. The buffering effects of intact seagrass bed is able to prevent erosion or accretion of the sea floor and coastal fringes.

Seagrass beds in the Philippines are diverse

What are the other plants found in seagrass beds?

At the 529 sites surveyed throughout the country, the most common macrobenthic plants besides the seagrasses are the seaweeds. Figure 10 shows some of the commonly encountered seaweeds in seagrass beds in the country. Depending on the season and substrate types, seaweed species may vary even in the same locality.

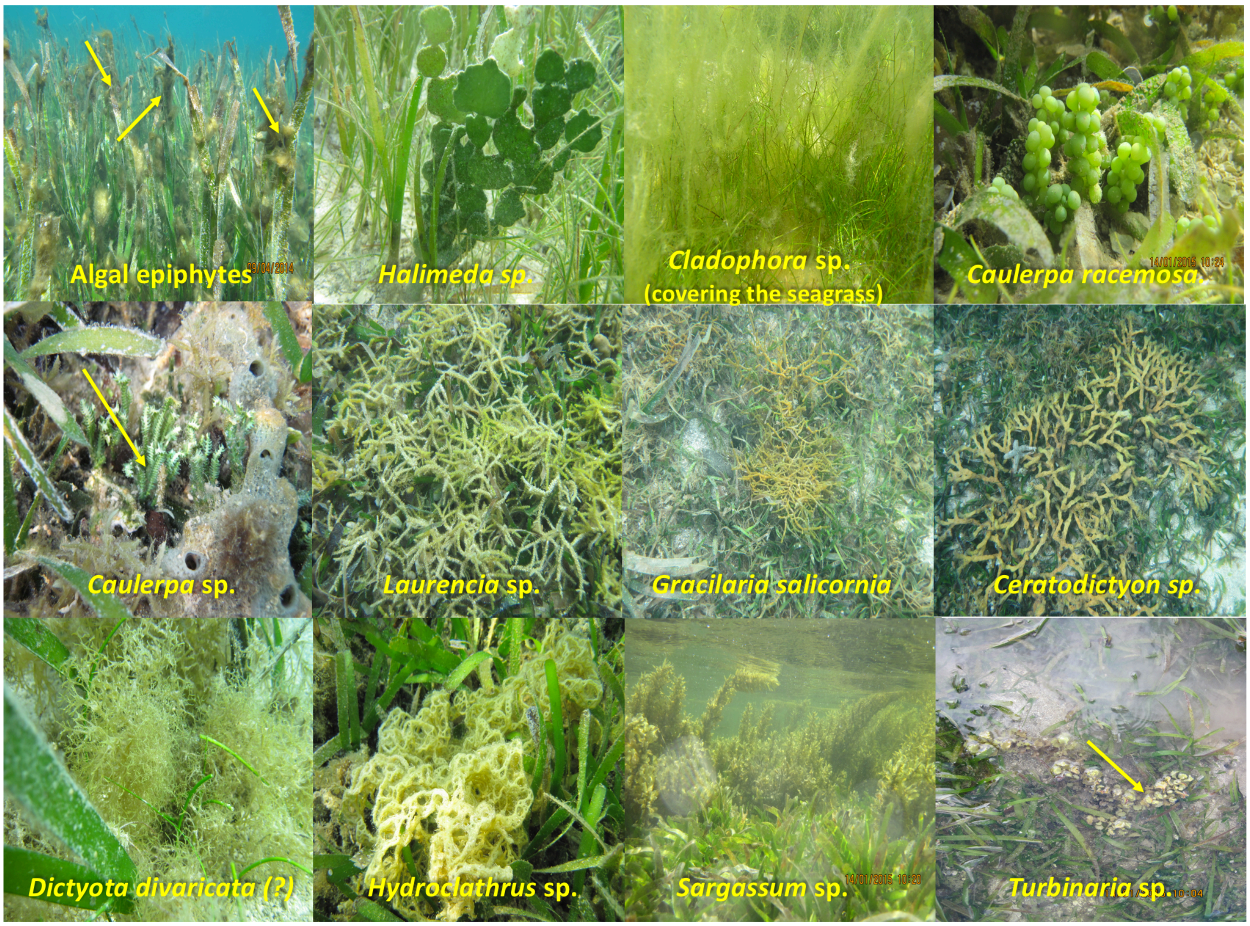


Figure 10. Some seaweeds commonly found in seagrass beds

Interestingly, some seaweed farms are located on seagrass beds, because some physical (e.g. moderate water movement, shallow depth) and nutritional requirements for growth of farmed seaweeds are often found in seagrass beds. Unfortunately, seaweed farmers remove the seagrasses to prevent sea urchins from climbing up to reach and graze the 'planted' seaweeds, which are tied to the farm lines above. In Guimaras, the seagrasses are considered a hindrance in the harvest of the seaweeds. Fishes (e.g. siganids), common grazers of seagrass beds, also graze on the farmed seaweeds.

What are the animals found in seagrass beds?

The animals that are found in seagrass beds are highly diverse –from the minute protozoans, to the epizoans, i.e., tunicates; also gastropods, bivalves, sea urchins, star fishes, sea cucumbers, synaptids, polychaetes, shrimps, sea anemones, sponges, other invertebrates, fishes, to reptiles and mammals. Many of them are herbivores, grazing on the plants (e.g. sea turtles, dugong). Since the beds are nurseries for the juvenile stages of many organisms, they visit the beds as carnivores, preying on the smaller fishes and invertebrates. Some species are omnivores, subsisting on both plants and animals for their food. A few of the animals commonly encountered in seagrass beds in the Philippines are shown in Figure 11:

Figure 11. Animals commonly found in seagrass beds in the Philippines. *Dugong* is locally common

Disturbances, Impacts and Natural Variation

The health of seagrass beds in the Philippines constantly changes. This is because of dynamic nature of the environment, which likewise constantly changes over time and space. Any temporary change in environmental conditions that causes a pronounced change in the seagrass ecosystem is a ‘disturbance’. It often occurs quickly, with high intensity but with a relatively short duration. Its impact takes the form of extensive damage to lives and property.

Climate change is a natural event. It is currently well documented that it is increasingly affecting the direction and intensity of occurrence of typhoons, temperatures, subjecting coastal areas to massive erosion and accretion (deposition), and in a lesser degree, acidification of coastal waters.

Climate change: Typhoons and storm surges

In typhoon-prone areas as in Quezon and Bicol provinces, storm surge after strong typhoons sometimes uproots and removes tons of seagrass biomass, dumping them along the shores. The response of seagrasses to typhoons and their recovery rates vary largely according to the dominant species making up the bed. *Cymodocea rotundata, Halodule uninervis,* and *Halophila ovalis* are opportunistic species and, although frequently disturbed by wave action from typhoons, they recover quickly primarily through rhizome growth. *Enhalus acoroides* and *Thalassia hemprichii*, on the other hand, resist wave action as they have deep, dense root mats within the mud or sediment. Almost bimonthly flower and fruit formation, and seed dispersal and germination facilitate recovery in *E. acoroides*. In *T. hemprichii,* seed production is less frequent. The more intense the storm is, the more likely that seagrasses in deeper waters will be affected.

In the short-term, typhoon events may reduce the size of seagrass beds, particularly in the shallower margins. Long-term disturbances may be manifested in one species displacing others, as in the case of *E. acoroides*, taking over the bed almost completely after. In some instances, this is also true when the water is polluted.

Climatic Change: Increase in water temperatures

Climate variability is affecting world temperatures and currents. In 2002 seagrass bleaching occurred over a number of seagrass beds in the Bicol region, and in other shallow areas with seagrass (Figure 12). This event led to damage and loss of the beds. This happens when the rhizomes are uprooted. In many areas in the country, full recovery from severe bleaching events over seagrass beds take about four to six months, but in others, it takes years. Where viable seed banks are present for the recruitment of seedlings to occur, recovery is facilitated.

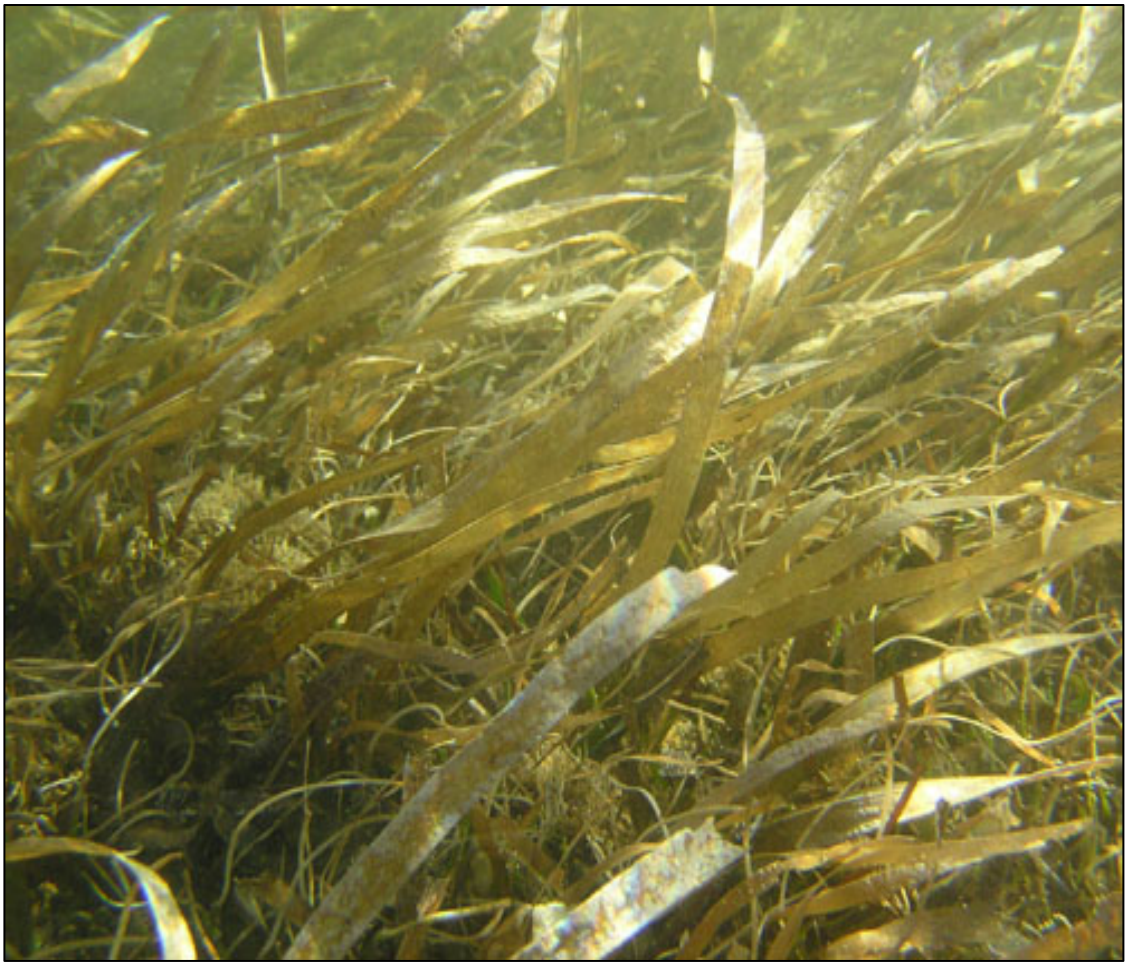


Figure 12. The 45^{O}C air temperature lasting more than 3 hours completely 'burned' this exposed seagrass bed in Bacon, Sorsogon in 2002. It, however, recovered after 2 months

In relation to climate change, seagrass is a winner! This is because, as Figure 13 shows, seagrasses have inherent capacities to adjust to the impacts wrought by climate variability (e.g. temperature and sea level rise, acidification, erosion/accretion). They utilize carbon dioxide from the atmosphere and water and convert this to energy which fuel these capacities to counterbalance negative impacts. For example, increase in sea level may erode the lower portions of the beds (submarine erosion), reducing seagrass area. However, this loss is counterbalanced by an increase in area at the upper parts (new habitat), making the net effect to the bed zero. This is a demonstration of the high resilience of seagrasses.

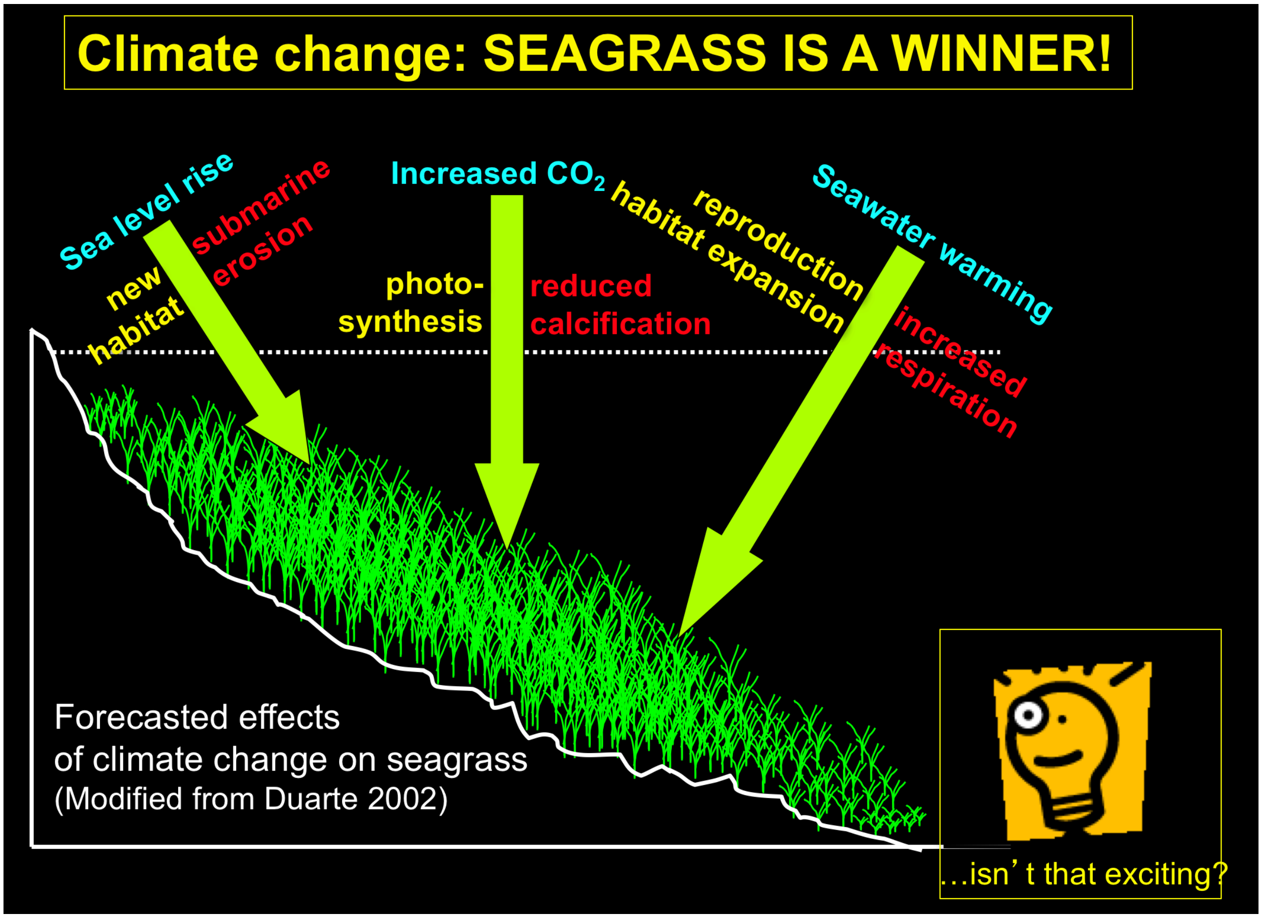


Figure 13. Why seagrass is a winner in relation to climate change impacts

Human impacts

Development through industrialization is a major thrust of the Philippines. This process, however, is replete with human activities that impact the environment, and when seagrasses are present, disturb their health and accelerate degradation of the ecosystem. The following are some of these activities that affect seagrass ecosystem health.

Coastal Constructions

In many parts of the country, structures such as coastal resorts, fish cages, fish pens, marinas, breakwaters, jetties, wharves, bridges, and pontoons, are commonly encountered. The construction of these structures alters and restricts water flow, causes physical changes, and shading of the waterways, affecting seagrass beds. Construction of such structures within an estuary can dramatically change the water movement or hydrology of a water body. This is aggravated with dredging and dumping dredge spoil, which changes water circulation or currents. There is a reduction in water movement resulting in less oxygen, and increased nutrients (causing eutrophication), algal bloom and seagrass degradation. In cases where the resulting water velocity is high, water movement physically damage seagrass beds by ripping out sediment and damaging root structures.

Reclamation and dredging

Filling in of shallow coastal areas by reclamation has brought about a significant loss of seagrass areas. In Coron, Palawan, draining, infilling or clearing of land for foreshore development, in many cases, completely destroyed portions of the shallow coastal ecosystems. Reclamation has reduced the tidal range of rivers leading to alteration of water inputs, and affecting water quantity through increased turbidity.

In some cases, dredging operations in areas where seagrass growth occurs "…is generally conducted in order to aid navigation, modify water flow, obtain supplies of natural materials such as sand and gravel or to lay pipes and cables". Dredging physically removes and destroys seagrass beds, degrades and alters the substrates, and decreases the recreational and economic quality of the coastal waters by increasing turbidity and sedimentation. Sometimes, seagrass beds may never recover under these conditions.

Excess nutrients (eutrophication) and sediments

In Bolinao, northwestern Philippines, the ecological integrity of the seagrass beds is affected greatly by excess nutrients and increased sediments as these enter the channel. This occurs as a result of a combination of the construction of a great number of fish cages and fish pens, plus discharges from the rivers upstream, entering the narrow waterways, shown in Figures 14 and 15 below. Excess sediment or silt in the waterway clouds the water and can settle on the blades of seagrass, which, together with the epiphytes, deprives the seagrass of light required in photosynthesis or food manufacture.

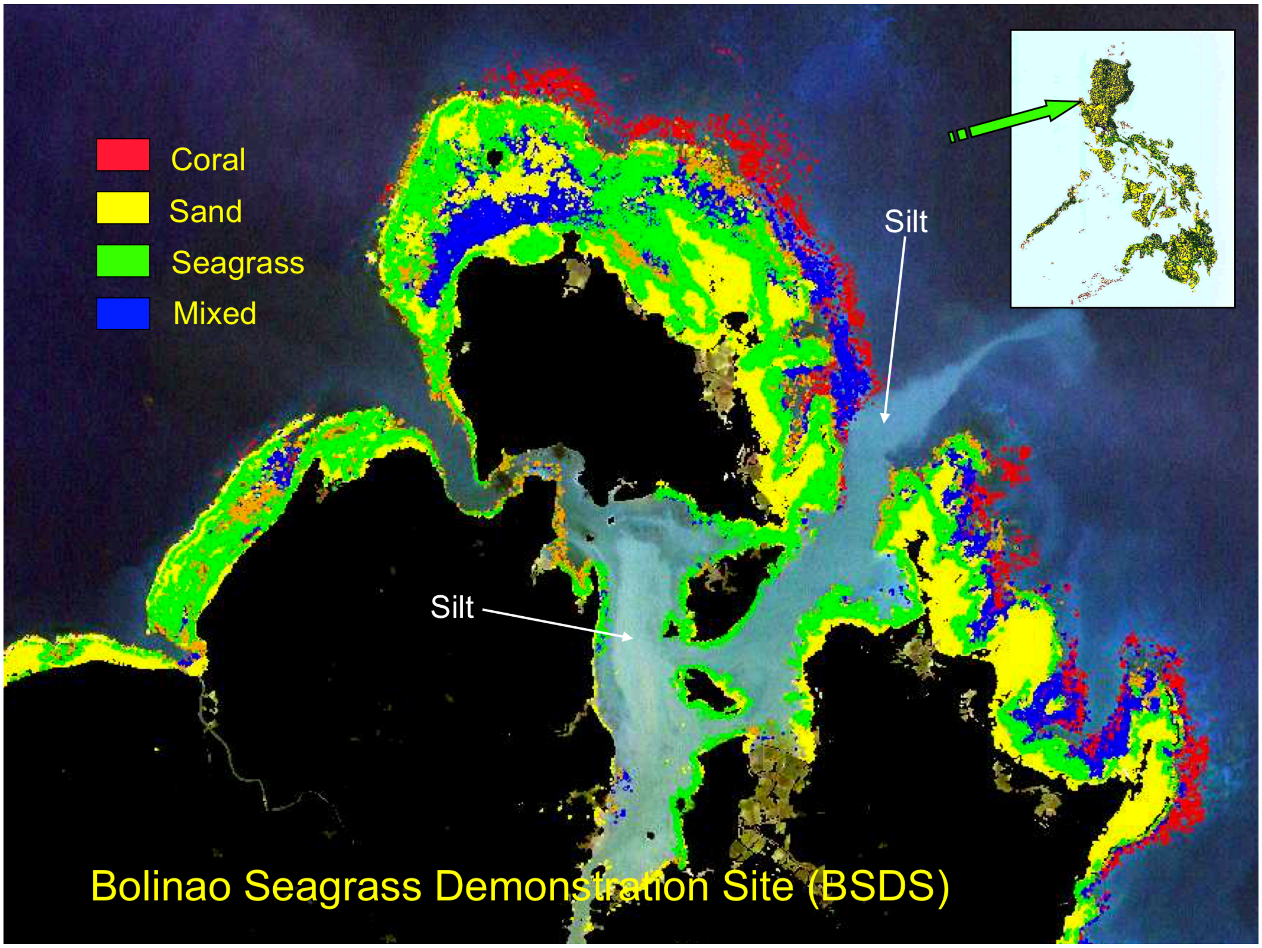


Figure 14. Silt or sediments are carried by the rivers upstream (below in the figure) and out (up) into seagrass beds (green), smothering them, especially during the wet season.

In the case of Bolinao, the flow of the nutrients and sediments is impeded by the thick growth of seagrasses. This 'bioshield' function of the seagrass bed reduces significantly the amount of substances deleterious to seagrass and other organisms (e.g. excess nitrates, potassium, phosphates) at the same time aerating the waters made anoxic by the bloom algae. In a separate study, this bioshield function of seagrass was demonstrated when the acidity of the waters flowing out and away from the fish cages and fish pens was reduced and reached normal levels at the seagrass reserve five km away from the fish structures. After 17 years, the loss of seagrass species from, seven to 0, in four study sites, coincided strongly with the temporal nutrient load from fish cages/pens and sediment discharges from rivers upstream.

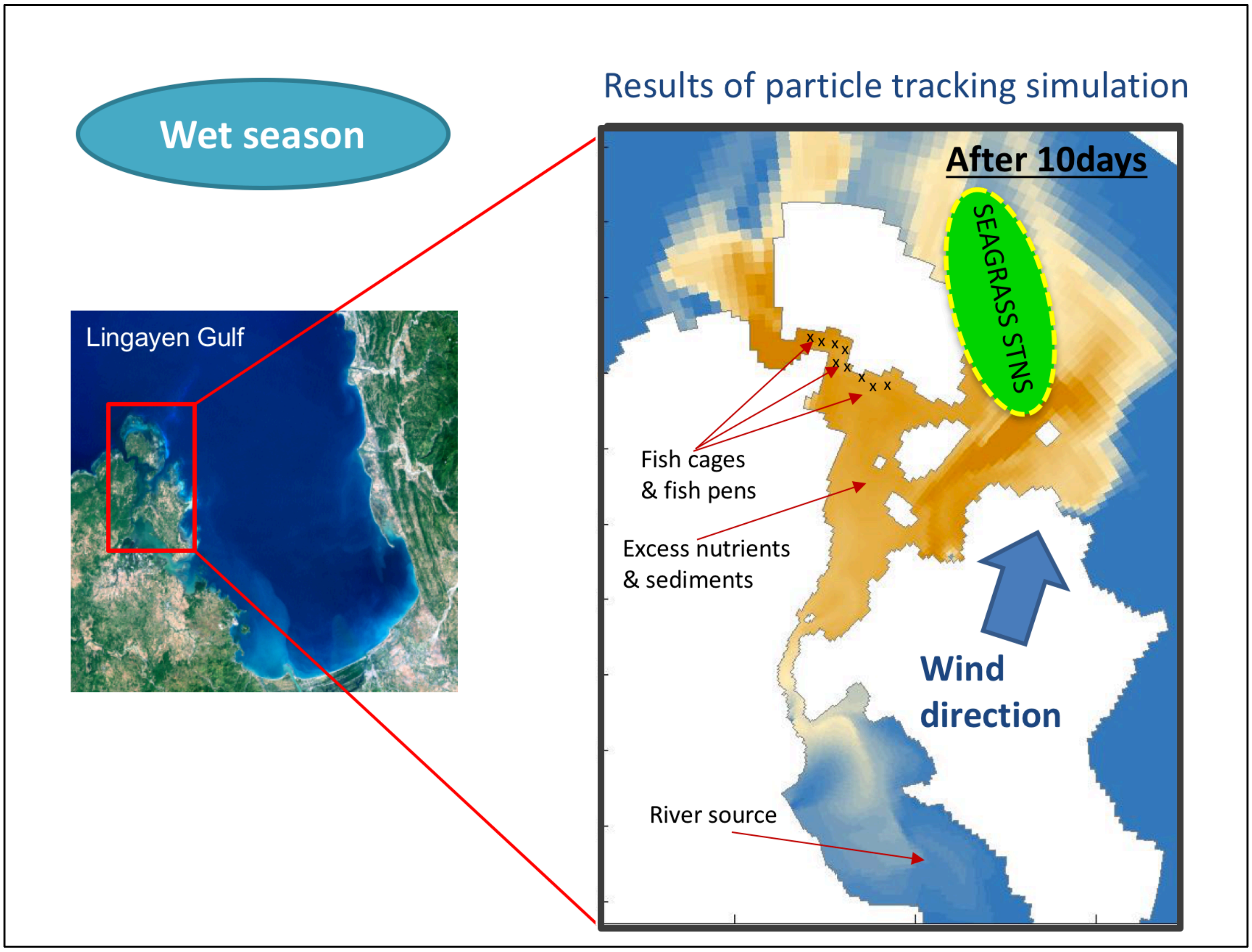


Figure 15. After 10 days, nutrients and sediments almost completely covered the seagrass beds (Tsuchiya *et al.* 2013)

The minute algae (dinoflagellates) present in the system respond quickly to a substantial increase in nutrients by multiplying and growing faster than when the nutrient levels are normal for the system. The resulting thick layers of bloom algae out-compete seagrass for space, blanketing the substrate, depriving seagrass of light they require for photosynthesis. The blooms, now occurring almost regularly, are a major concern as they imperil the lives of people and their local economies.

Under bloom conditions, minute (but bigger than the dinoflagellates that cause algal blooms) algae may grow on the surfaces of seagrasses. This algal population or epiphytic algal growth is another indicator of nutrients in the water body. When there is an excess nutrient present in the waterway there may be excess epiphytes covering seagrass, which may smother and restrict photosynthesis (Figure 16).

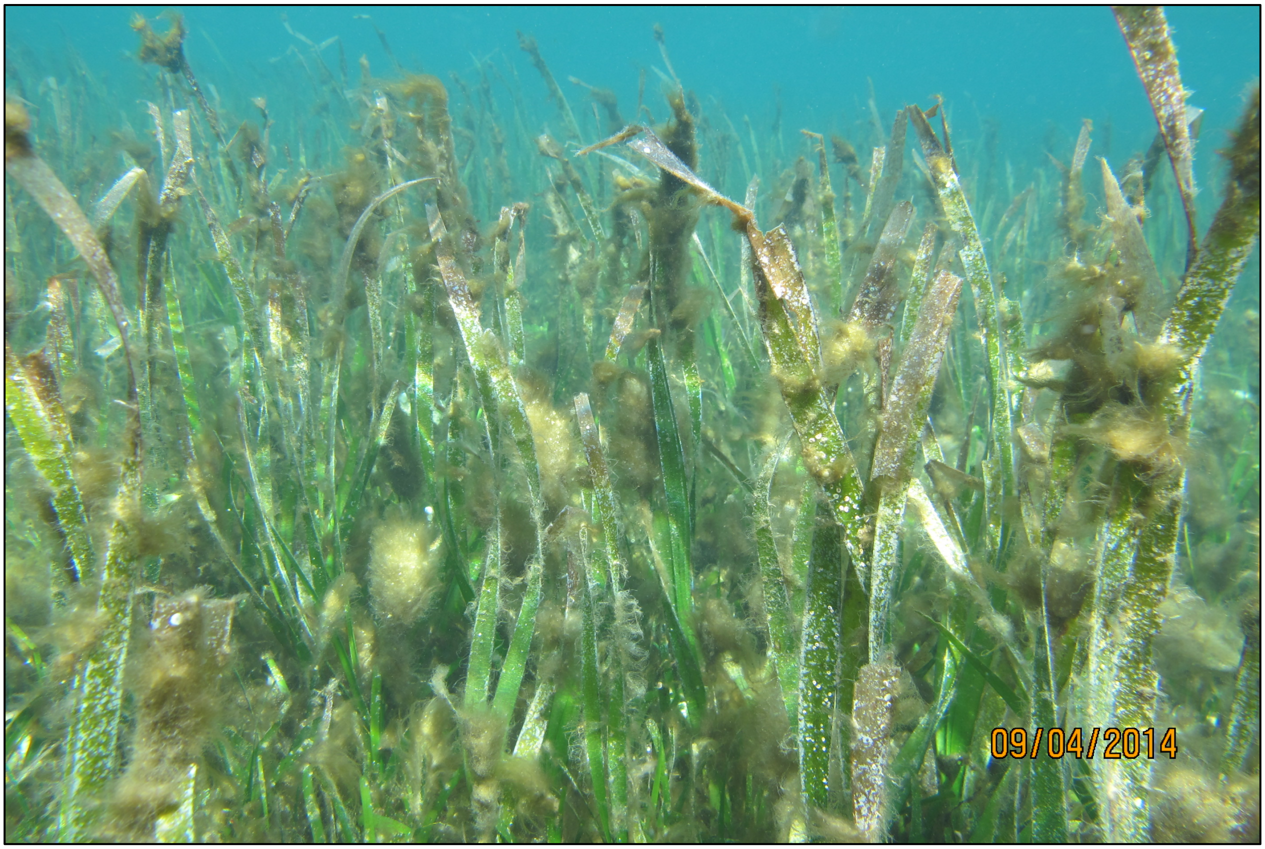


Figure 16. Algal epiphytes, almost completely covering the leaves of *E. acoroides*, depriving these of light needed for food production

In Boracay, the 'green tide' has become a regular almost year-round occurrence, blanketing seagrasses where they occur (Figure 17). It is caused by the heavy concentrations of nitrogen and phosphates from resorts, which discharge their washings and sewage into the waters either directly or through pipes. The occurrence is aggravated by the destruction of seagrass beds and coral reefs. It should be emphasized, however, that the causal organisms (the small filamentous green seaweeds, *Enteromorpha*, *Ulva*, *Chaetomorpha*) are often present even in healthy habitats. Their populations, however, are checked or balanced by nutrients just sufficient to maintain their normal developmental processes. In addition, grazing by fish, urchins, etc. do a similar check in these habitats. In areas with high concentrations of the nutrients like at the site shown in Figure 17, the amounts of nutrients exceeded even the maximum allowable. Under this condition, no grazers or herbivores could be seen because there were no more plants to graze on. Hence, the seaweeds are given the best conditions for their growth and reproduction and 'green tide' results.

Figure 17. At the deeper parts, “green tides” smother seagrasses and corals when the tide recedes. They result from heavy loads of nitrogen and phosphorus from sewage and washings discharged largely from resorts.

Boat propellers, traffic, and anchors

In resorts where boat traffic near seagrass is high, seagrass beds can suffer damage from propellers or hulls gouging into and up-rooting seagrass. When boat propellers hit seagrass they physically remove plants and cause damage to roots. As one seagrass plant often has extensive root structures connecting them, damage from propellers often means significant damage or death of seagrass in most cases.

In addition, heavy boat traffic increases turbidity, particularly in muddy areas as fine mud or silt is constantly re-suspended in the water column, and/or increasing water pollutants such as oil and grease. In area where such impacts occur over time seagrass beds can become patchy or otherwise reduced in extent, density and condition.

Patchiness in seagrass areas adjacent boat docks are often the result of anchors which create holes within beds. This event reduces the area density and increasing “patchiness” or discontinuity of seagrass distribution. Without the mats of roots, which stabilize sediment, the area is more susceptible to erosion from wave and tide action.

Emerging threats to seagrass

The threats to seagrass ecosystems in the future are not too different from those of today. Hence, the following are expected to accelerate the degradation or demise of the habitats in the Philippines:

- Rapidly increasing coastal populations
- Depletion of natural fish populations
- Expanding neighboring coastal aquaculture
- Widespread eutrophication
- Increasing threats to reefs (natural)
- Giant clam gardening and mangrove 'afforestation' in seagrass areas

Present seagrass losses are expected to accelerate, as human pressure on the coastal environment around most cities and barangays grows. This is especially true in areas where the capacity to implement conservation policies is limited. But seagrass conditions may somewhat improve in some parts, because active and well meaning organizations, backed by new and practical means to conserve the resource plus legislation, help in rapidly implementing protection of seagrass meadows.

What can we do to conserve seagrasses?

As Figure 18 below points out, loss of seagrass habitats has many repercussions affecting the totality of the environment. Worse, is that once disturbed, it is exceedingly difficult and expensive to restore the system to (or even close to) its original condition. This is in stark contrast when the system is left intact, it is able to sustain its ecological integrity in a dynamic stability condition. This illustrates the need for resolving natural resource issues adopting the Ecosystem-Based Management approach. So, what drives humans to destroy the habitats which sustain their everyday lives?

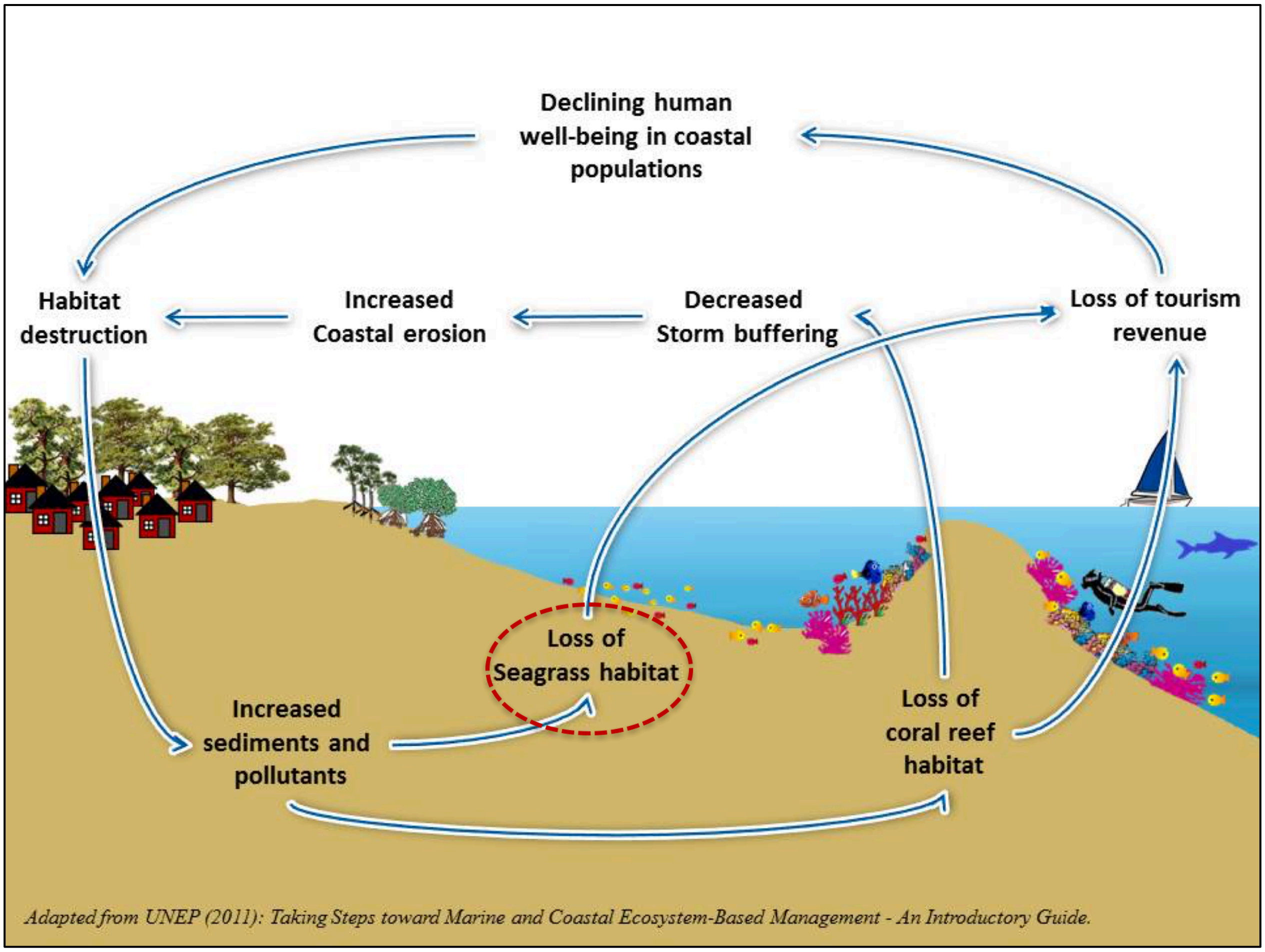


Figure 18. The importance of leaving habitats intact; the principle of Ecosystem-Based Management

In the Philippines, the root causes of the persistent coastal environmental issues boil down to seven (last column, to the right, Figure 19). These are demographic (rapidly increasing human population), economic (high prices of goods leading to greater pressure on the resources), technological (improper use of technology), knowledge (lack of the essential and proper knowledge), socioeconomic (difficulty in meeting the basic needs, especially on the part of coastal dwellers), institutional weaknesses (weak law enforcement), and governance (difficulty in implementing integrated, multi-sectoral management plans). Why practically similar issues and concerns arise persistently through the years is due primarily to the programs of government as well as other institutions and agencies which tackle not the root causes but the peripheral ones.

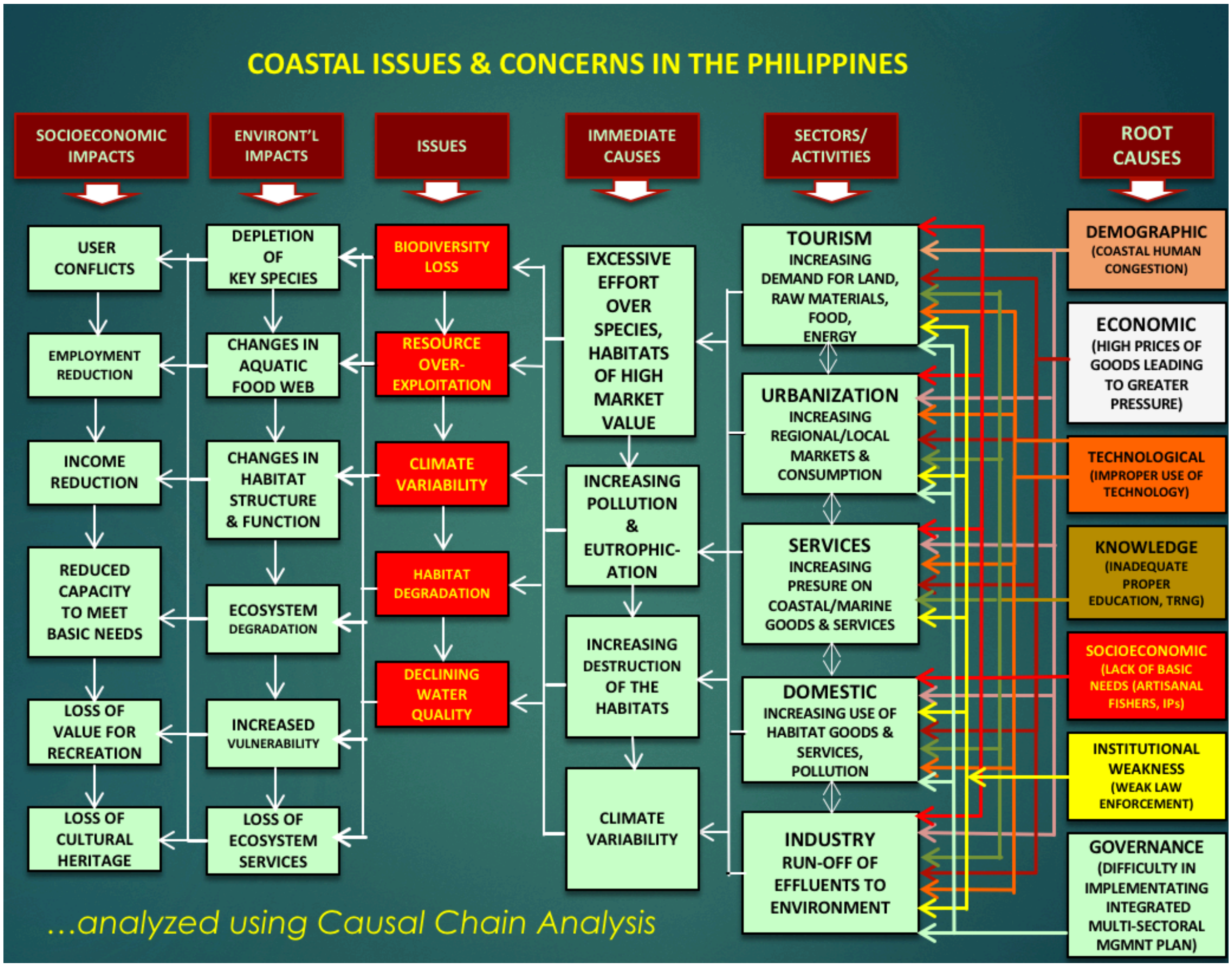


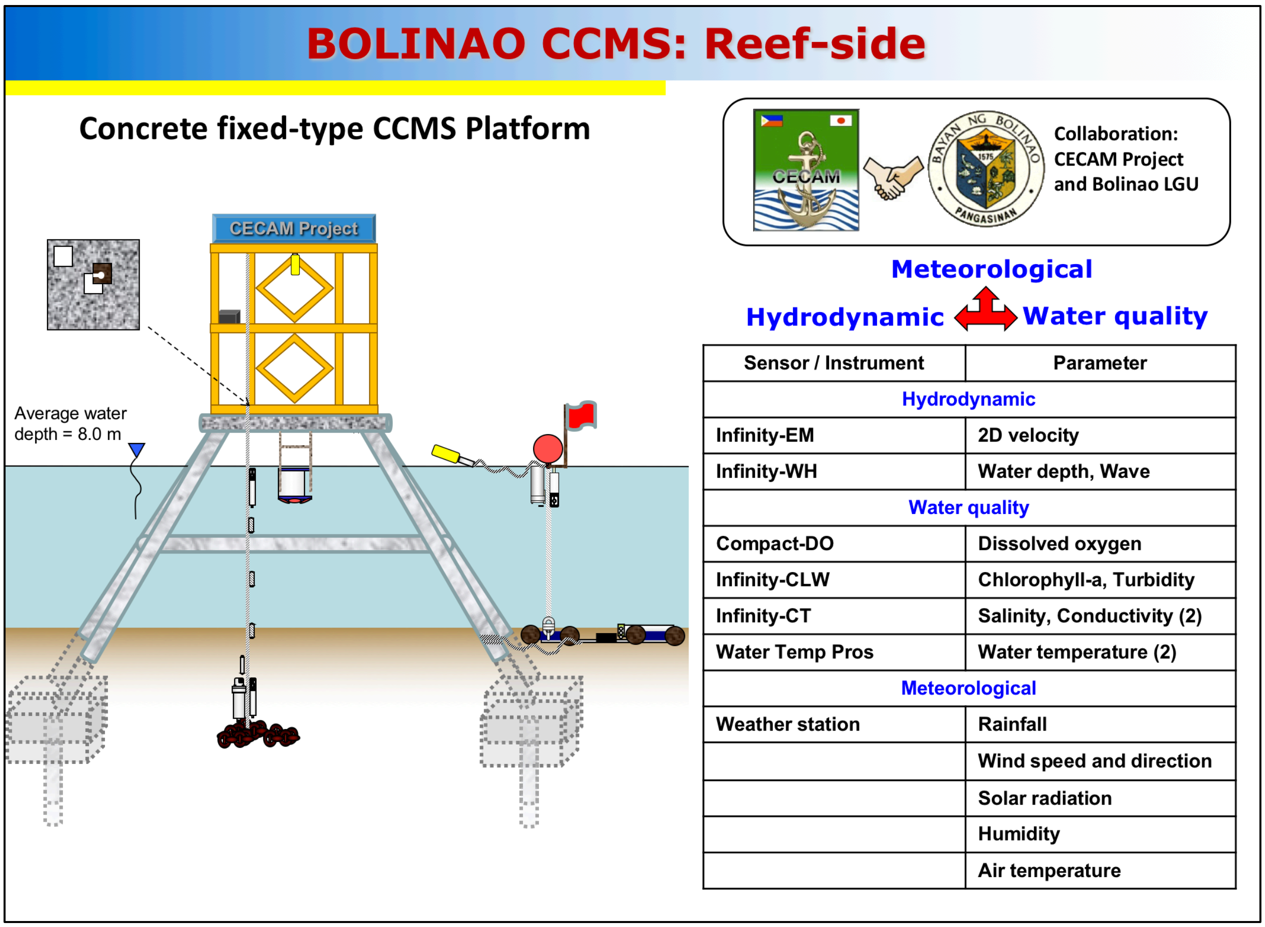
Figure 19. The root causes (last column) should be the focus of management effort, not the peripheral ones, if it wants to effectively address the issues.

Below are some insights on why humans do and act the way they do. However, the gaps in knowledge and in management which we emphasize and recommend to address below are just manifestations of deeper driving forces which are the true causes of the ills we see and experience in society and in relation to the conservation of our coastal environment. We are referring to the 'true' causes, which Mahatma Gandhi openly stated as the **'seven blunders'** humans committed and are committing. These are: *knowledge without character, science without humanity, wealth without work, politics without principles, worship without sacrifice, commerce without morality,* and *pleasure without conscience*. This guidebook is, however, not the proper venue where these blunders should be elucidated.

In order to sustain the efficient flow of services seagrass ecosystems provide especially to coastal inhabitants and economies, we should help address the following issues –*NOW*:

Help address the gaps in knowledge

1. Pursue a thorough assessment of the distribution and areal cover of seagrass beds in your own locality and report your findings;
2. Focus resources on priority scientific research that is management-oriented e.g. blue carbon, seagrass bioshield functions, habitat interconnections;
3. Pursue research on responses of seagrass beds at thresholds or under stress conditions, but with predictive values on their recovery and resilience. It is recommendable to invest on a Continuous and Comprehensive Monitoring System (CCMS, Figure 20);



Sensor / Instrument	Parameter
Hydrodynamic	
Infinity-EM	2D velocity
Infinity-WH	Water depth, Wave
Water quality	
Compact-DO	Dissolved oxygen
Infinity-CLW	Chlorophyll-a, Turbidity
Infinity-CT	Salinity, Conductivity (2)
Water Temp Pros	Water temperature (2)
Meteorological	
Weather station	Rainfall
	Wind speed and direction
	Solar radiation
	Humidity
	Air temperature

Figure 20. CCMS gives the hydrodynamic, meteorological and water quality conditions of the specific locality in real time.

4. Support a coherent national monitoring program for seagrass;
5. Utilize the products of research in advocacy and in localizing school subjects and curricula by means of teaching aids adopting the local language (see Figure 21).

6. In pursuing all these recommendations, the participation of the stakeholders from Day 1 to the last day is essential (see Figure 22).

Figure 21. 'Localizing' school subjects and curricula using research results translated into the vernacular is more effective than knowledge and practices adopted from outside the country and rendered in foreign languages.

Figure 22. Training in field monitoring of seagrass, with the aid of a waterproof field guide

Years of research to develop a sound seagrass science in the Philippines has produced some scientific findings now useful in conservation and management of the coastal resources and environment. These include:

1. Detrimental siltation level: 10 – 15 % of sediment dry weight
2. As distance from fish cages/pens decreases, species richness and biological production also decreases;
3. Prolonged exposure (17 years) of seagrass to excessive nutrients result in the complete disappearance of the more sensitive species;
4. The number of kinds of animal species is reduced along a pollution gradient by approximately 19% from the least polluted to the most polluted station;
5. Ranking of seagrass species in terms of sensitivity to siltation: *Enhalus* most resistant; *Syringodium* most sensitive;
6. Seagrasses are indicators of siltation loads detrimental to coastal ecosystems;
7. A 25% - 30% reduction in light availability determines community heterotrophy or the area becomes dominated by non-food producers;
8. Organic matter enrichment of sediment by a factor 4 is detrimental to seagrasses;

9. Sediment conditions deteriorate fast and recover slowly (in years)
10. Seagrass recovery is distinct and not continuous, slow (years), and mostly dependent on sexual reproduction;
11. Seagrass sexual reproduction is negatively affected by siltation and spatial fragmentation;
12. Cover threshold for successful fruit production: 40 % (or fruiting occurs only when cover of seagrass is 40% and above)

Help address the gaps in management

1. Establish a functional network of concerned agencies and institutions doing R and D on seagrass communities;
2. Undertake an assessment of the social, cultural and economic benefits of seagrass systems;
3. Work harder to secure funds for support functions e.g., compensation, incentives;
4. Support a nationally integrated seagrass ecosystem network anchored on common objectives to ensure its resilience and sustainability.
5. Strengthen advocacy in favor of seagrass, involving the youth (Figure 23).

Figure 23. The streamer says: "*Ang lusay ay buhay*", meaning "*Seagrass is life*". Note the headgears of the children; they are designed to mimic seagrass. "BSDS" is Bolinao Seagrass Demonstration Site.

The key to the success of these endeavors in addressing the gaps in knowledge and in management resides in working together toward a common goal, guided by common principles. In other words, actions at three levels which are mutually supportive and interactive are needed to effectively conserve seagrass habitats. This is shown in Figure 24 below:

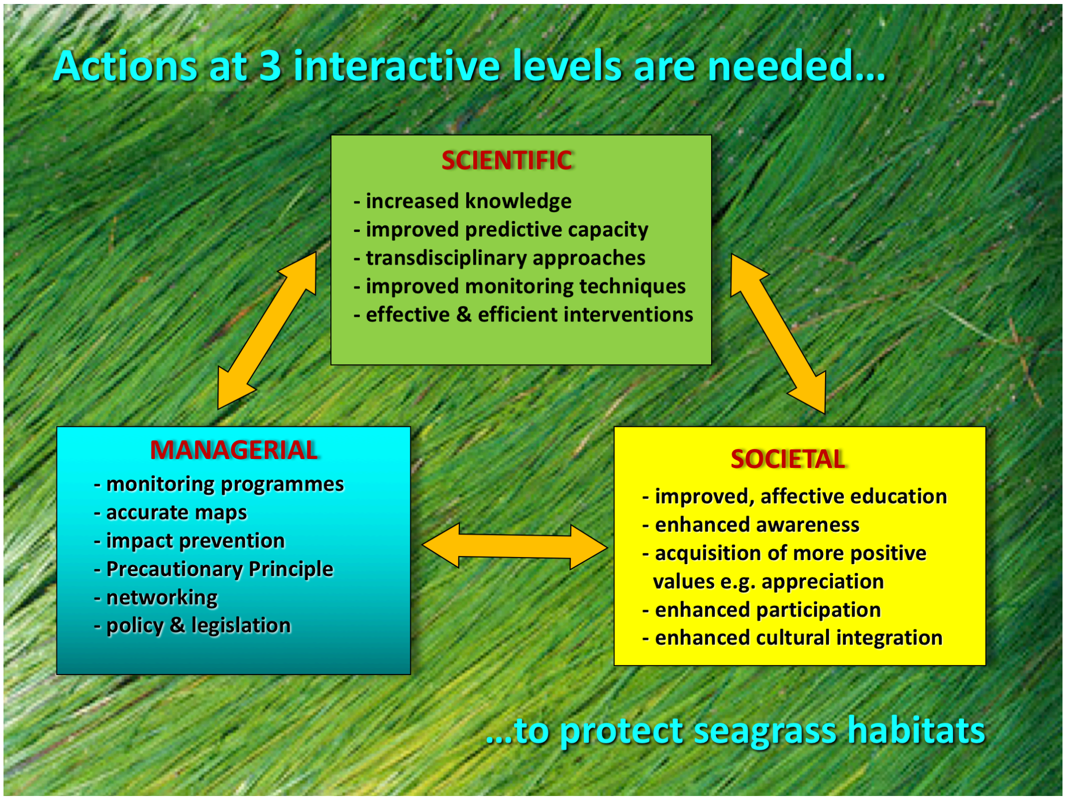


Figure 24. The needed interaction among scientists, managers, and society in order to protect seagrass habitats

In addition, Figure 25 shows why scientists and decision makers should work together in coming up with well-informed decisions pertaining to the protection of the environment.

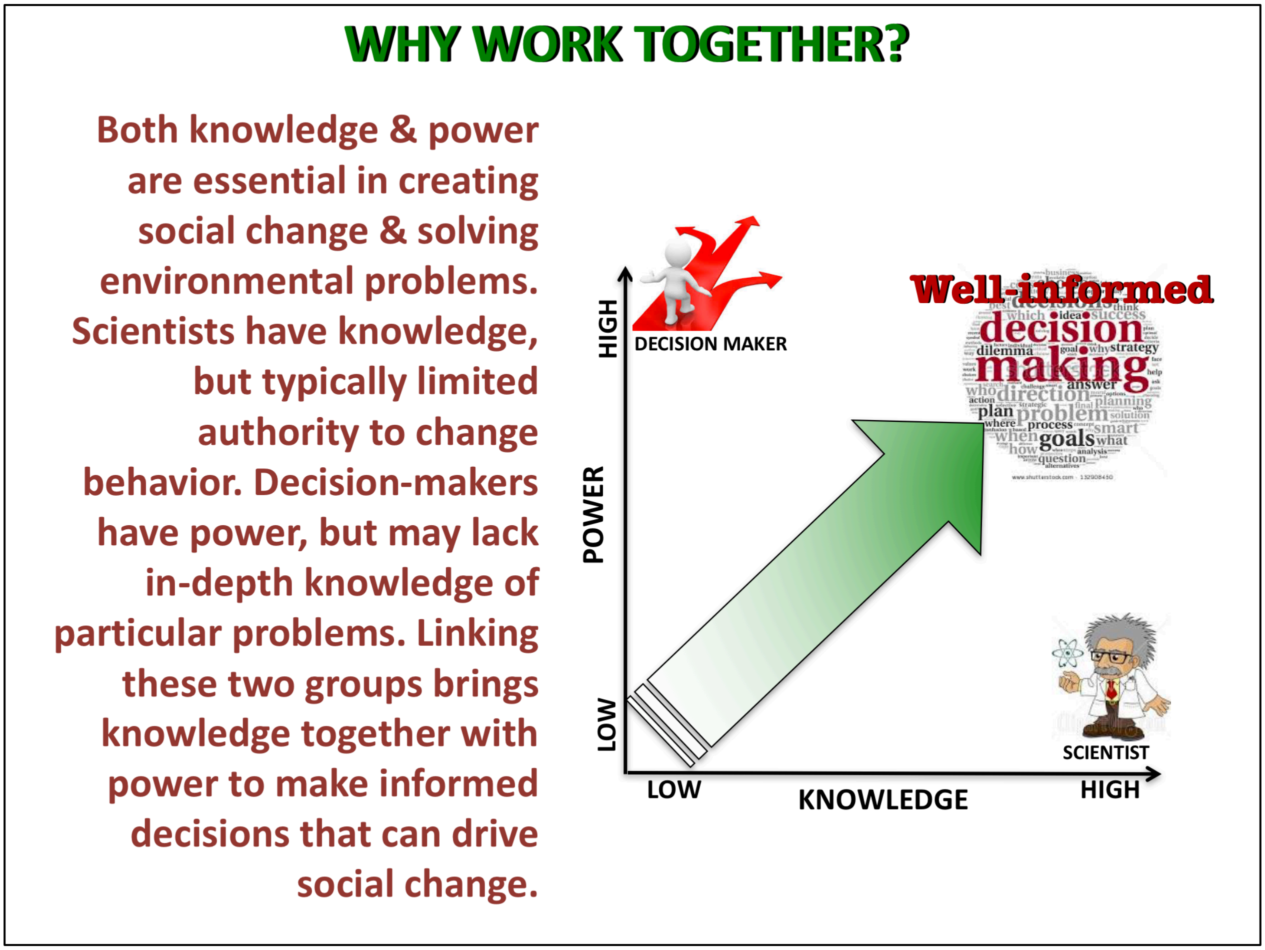


Figure 25. The need to bring together science and policy to make well-informed decisions

The goal of science-policy linkage is to come up with well-informed decisions. But there is still a long way to go before these decisions reach the communities which need them most. The issues are resolved when the communities are sufficiently informed so that they accept them and they themselves act to resolve the issues with finality. One big stumbling block to this proper consultation is the lack of serious interaction and communication among the stakeholders. This is shown in Figure 26. Even if the decision is sound, if this is not communicated well to the communities concerned, the issues will not be effectively resolved.

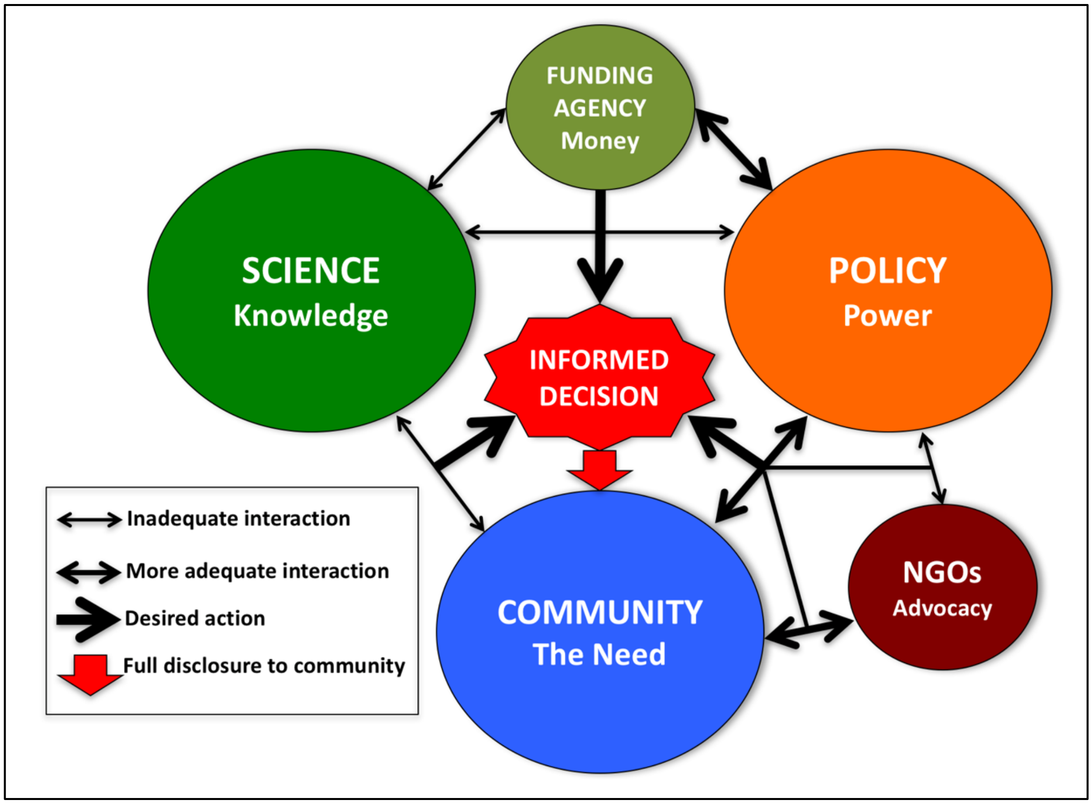


Figure 26. The 'well-informed' decisions should trickle down to the communities for their understanding, acceptance and action

Conclusion

Seagrasses are only very recently recognized as important primarily because of the services they offer to coastal dwellers. But do we have to wait for hazards and disasters to cause their demise and realize how they are closely linked to us as a people? And only then to act as we should? Do we have to know first that they are useful before we conserve them? If people realize that seagrasses are important simply because they are seagrasses, a product of millions of years of evolution, then and only then would we seriously regard them as an essential component of our lives and our environment. As a result, their conservation becomes a necessity and a way of life, doing so would not be for economic gain, but for sustaining their ecosystem services. The latter, in turn, are linked intricately to our well being (e.g. security, basic needs, health, good social relations, freedom of choice and action). This connection between their services and human well being empowers us to become true stewards of the natural bounty we have around us, making us truly human and one with the environment.

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Glossary of Key Terms

Accretion The increase, typically by the gradual accumulation of additional layers or matter, as the accretion of sediments in seagrass beds.

Algal bloom An increase or accumulation in the population of algae (typically microscopic Cyanobacteria (blue-green algae) or dinoflagellates.

Anoxic Condition of the water body as when there is an algal bloom characterized by the absence or presence of a very small amount of oxygen.

Biodiversity It is a measure of the variety of organisms present in an ecosystem. This can refer to genetic, ecosystem, or species variation (number of species) within an area.

Bioshield Literally, a 'bioshield' is a biological protector. Hence, when we speak of seagrass as a bioshield, we refer to the ecosystem's inherent functions to protect the coastal environment and its dependent populations by counteracting or mitigating the threats and negative impacts of both human-induced and natural forcing factors

CCMS or Continuous and Comprehensive Monitoring System, is a platform consisting of sensors that detect and record hydrological, meteorological and water quality parameters in real time. It is left in the field for extended periods.

Climate change Long term change in the climate patterns brought about by global warming.

Community A community is a social unit of any size that shares common values, or that is situated in a given geographical area.

Dinoflagellates "Single-celled organisms with two flagella, occurring in large numbers in marine and freshwater plankton. Some produce toxins that can accumulate in fish, shellfish, resulting in poisoning when eaten".

Disturbance The interruption of a settled and peaceful condition by an event which occurs with a high intensity but short duration. Typhoon is a disturbance.

Ecological integrity "The structure, composition, and function of an ecosystem operating within the bounds of natural or historic range of variation."

Economic valuation Assigning monetary value to environmental factors (such as the services of an ecosystem, quality of air and water and damage caused by pollution). It provides a means for measuring and comparing the various benefits of natural resources and their ecosystems.

Ecosystem Based Management Ecosystem-based management is an environmental management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation (Christensen et al. 1996, McLeod et al. 2005).

Erosion The process of eroding or being removed or diminished by wind, water, or other natural agents, as "…the problem of coastal erosion."

Eutrophication Excessive amount of nutrients in a body of water, frequently due to overfeeding in fish culture, or runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen.

Global warming It refers to the recent and ongoing rise in global average temperature near the Earth's surface. It is caused mostly by increasing concentrations of greenhouse gases in the atmosphere. Global warming is causing the climate to change.

Habitat interconnectivity The perceived linkage among adjacent coastal habitats necessary for preserving population and community resistance and resilience. The connections are in the form of physical, nutrient, animal migrations, plant propagule movement, and human impacts.

Heterotrophy A condition that results wherein organisms that are dependent on complex organic substances for nutrition (because they cannot synthesize their own food) dominate. This is common in highly eutrophic waters.

Network The organization produced by the interaction among people or institutions to exchange information and develop contacts, especially to further and meet an agreed objective.

Recruitment The increase in a natural population as members grow and additional members arrive.

Seagrass A seagrass is a flowering plant that grows and completes its life history fully submerged in marine and brackish waters.

Seagrass ecosystem A unit of biological organization comprised of interacting biotic and abiotic components. The structural components are shelter and food and feeding pathways and biodiversity.

Seaweeds A group of 'primitive plants', composed of large algae, growing in the sea without true roots, stems, or leaves, and with simple reproductive structures. They do not produce flowers nor fruits.

Stakeholder 'an individual, group, or organization, who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project'.

Storm surge “A rising of the sea as a result of atmospheric pressure changes and wind associated with a storm” (Wikipedia)

Stress The interruption of a settled and peaceful condition by an event, which occurs with a low intensity but prolonged duration. While typhoon is a disturbance, the impact of pollution or eutrophication is a stress.