Transactions National Academy of Science & Technology Philippines
ISSN 0115-8848 (print)
ISSN 2815-2042 (online)
Vol. 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

Climate Change Resilience with Focus on Coastal Ecosystems: Mangroves and Beach Forests

Jurgenne H. Primavera

SEAFDEC Aquaculture Department, Iloilo, Philippines
Zoological Society of London
National Academy of Science and Technology Philippines

ABSTRACT

The coastal ecosystems of mangroves and beach forests are key to Climate Change adaptation and mitigation (CCAM) through their services of coastal protection, carbon sequestration, and provision of seedlings of pioneering (beach forest) species for lowland reforestation. The paper discusses science-based CCAM interventions that combine my formal training in marine biology and the need for coastal protection in the local communities where my environmental NGO operates. These initiatives include mangrove ecoparks, ecologically sound mangrove rehabilitation, coastal greenbelts of mangroves and beach forests, reversion of abandoned fishponds to mangroves, and beach forest nursery. It gives recommendations to government agencies and non-government organizations alike to protect mangroves as ecoparks, establish protective coastal greenbelts, and revert abandoned fishponds to mangroves.

Keywords:
mangroves, beach forests, ecoparks, coastal greenbelts, reversion of abandoned ponds

Citation:
Primavera JH. 2018. Climate change resilience with focus on coastal ecosystems: Mangroves and beach forests. Transactions NAST PHL 40 (2): doi.org/10.57043/transnastphl.2018.1090

Email: georginehp@yahoo.com

Plenary paper presented during the 40th Annual Scientific Meeting (July 2018) of the National Academy of Science and Technology Philippines.

INTRODUCTION

Among the many negative impacts associated with Climate Change (CC) are sea level rise, increasing storm intensity, if not frequency, and associated floods and droughts. Key to the mitigation of, and adaptation to, these impacts are the services of storm protection, carbon sequestration, and resources for reforestation (Table 1) provided by coastal ecosystems, in particular mangroves and beach forests. This paper discusses these services as enhanced by the R&D-based initiatives of an environmental NGO (which has focused on mangrove conservation and rehabilitation since 2009) – mangrove ecoparks, coastal greenbelts, and abandoned pond reversion to mangroves.

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

Table 1. Ecosystem services of coastal habitats key to mitigation of and adaptation to Climate Change impacts (+ reflects degree of importance).

	Storm Protection	Carbon Sequestration	Lowland Reforestation
Mangroves	+++	+++	+
Beach Forests	++	+	+++

CLIMATE CHANGE MITIGATION: MANGROVE ECOPARKS

Mangroves capture carbon at rates 4–5 times higher than terrestrial forests (Donato et al. 2011), therefore their conservation will ensure the permanent storage of C stocks. This approach has great potential for the Philippines considering that globally we rank No. 10 in terms of both mangrove area (206,400 ha) and amount of mangrove captured carbon (104.5 million tonnes) (Table 2).

Establishing protected areas and mangrove ecoparks would be the best way of sequestering such carbon, as illustrated by the *Katunggan it Ibajay* (KII) Mangrove Ecopark in Ibajay, Aklan. Part of the ~100-ha basin mangrove was to be converted to fishponds in the 1980s when local townspeople blockaded the bulldozers. The timeline in Table 3 traces its 1998 "discovery" by aquaculture researchers to the present protection provided by a 2009 municipal ordinance and its official launching as an ecopark in 2010. The 44-ha KII Ecopark features 27 (of 35-40) true mangrove species in the country, including its crown jewel of a magnificent *Avicennia rumphiana* (measuring more than 3 m diameter and 9 m circumference, arguably the biggest mangrove tree in the country), a 1.8-km boardwalk, and is managed by local cooperatives. This case study combines scientific research (on mangrove-friendly aquaculture, but also mangrove species and zonation) by the SEAFDEC Aquaculture Department (Primavera et al. 2004); community

Table 2. National estimates of mangrove carbon holdings, 2012 (Hamilton and Friess 2018).

Country Name	Mangrove area (2012) (km²)	Mangrove Rank	Tonnes of carbon			Percentage of global total	C rank	Change
Indonesia	23,324.29	1	1,275,115,175	±	19,597,086	30.41	1	0
Brazil	7,674.94	2	389,760,564	±	9,556,539	9.30	2	0
Malaysia	4,725.84	3	258,882,085	±	4,002,528	6.17	3	0
Papua New Guinea	4,172.29	4	223,096,105	±	3,836,601	5.32	4	0
Australia	3,316.21	5	152,539,573	±	2,104,454	3.64	5	0
Mexico	2,991.83	6	149,261,592	±	1,203,826	3.56	6	0
Nigeria	2,653.99	7	127,914,456	±	2,559,377	3.05	7	0
Myanmar	2,557.45	8	118,883,668	±	1,409,261	2.84	8	0
Venezuela	2,403.83	9	112,537,865	±	1,851,142	2.68	9	0
Philippines	2,064.24	10	104,470,697	±	1,341,367	2.49	10	0
Thailand	1,886.33	11	91,793,396	±	1,414,284	2.19	11	0
Colombia	1,671.86	13	84,108,157	±	1,831,402	2.01	12	1
Cuba	1,633.46	14	81,223,503	±	651,189	1.94	13	1
USA	1,568.60	15	75,453,694	±	622,606	1.80	14	1
Bangladesh	1,772.98	12	74,049,402	±	653,854	1.77	15	–3
Panama	1,323.94	16	72,929,978	±	1,222,387	1.74	16	0
Gabon	1,082.11	19	58,592,889	±	1,979,216	1.40	17	2
Mozambique	1,223.67	17	55,803,315	±	723,403	1.33	18	–1
Ecuador	935.74	20	55,566,461	±	1,660,042	1.33	19	1
Cameroon	1,112.76	18	53,980,215	±	1,138,012	1.29	20	–2

Hamilton and Freiss 2018. Global carbon stocks and potential emissions due to mangrove deforestation from 2000 to 2012. Nature Climate Change. Vol 8; pp 24-244

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

Table 3. Timeline of events in the establishment of the *Katunggan it Ibajay* (KII) Mangrove Ecopark in Ibajay, Aklan, 1980s-2000.

TIMELINE OF EVENTS	
1980s	Some 30 villagers and local officials organized People Power to prevent chainsaws from cutting mangroves for fishpond construction
1996	Pristine mangroves of Bugtongbato-Naisud 'discovered' by Southeast Asian Fisheries Development Center – Aquaculture Department (SEAFDEC AQD) researchers
1998	SEAFDEC AQD Seminar-Workshop in August with participants from Local Government Units (LGUs), NGOs, and other stakeholders to assess Ibajay socio-economic resources; 1st mapping of Bugtongbato-Naisud mangroves by SEAFDEC AQD
1999	Signing of SEAFDEC AQD-Ibajay LGU Memorandum of Agreement (MOA) on Mangrove-Friendly Aquaculture projects (J.H. Primavera study leader; results published in 2007)
2000	Aklan Province creates Provincial Technical Working Group (PTWG) through Exec. Order 25 to formulate and implement Integrated Coastal Resource Management and Area Development Program (including Ibajay mangroves) in consultation with stakeholders Aklan Provincial LGU and SEAFDEC AQD sign MOA on research studies and other projects in Ibajay; Joint construction of mangrove treehouse, concrete stairs
2001	Publication of *An Assessment of the Mangrove Resources of Ibajay and Tangalan, Aklan: Implications for Management* by SEAFDEC AQD
2002 – 2005	Initial discussion with LGU on mangrove footwalk and eco-tourism in Ibajay; Mangrove mud crabs *Scylla* research by University of Wales graduate students (MJH Lebata, K Hutchinson, M Langdown); Continued mapping of Bugtongbato-Naisud mangroves
2004	Publication of the UNESCO-funded *Handbook of Mangroves in the Philippines - Panay* by JH Primavera, RB Sabada, MJH Lebata, and JP Altamirano
2006 – 2007	Signing of LGU Ibajay–Pew Fellows (JH Primavera) MOA on Mangrove Conservation, including construction plans and GPS mapping of Bugtongbato-Naisud mangrove footwalk; Case Study on Mangrove Eco-Tourism Project by JM Estolloso, other staff
2008	Construction of 30 meters footwalk by LGU Ibajay with Pew Fellowship support; DENR survey of total mangrove area within timberland – 44.22 hectares Start of Community-Based Mangrove Rehabilitation Project in the Philippines (CMRP) supported by Zoological Society of London (ZSL), including gathering of socio-economic data in Bugtongbato-Naisud Creation of Katunggan It Ibajay Technical Working Group (KII TWG)
2009	MOA signed between LGU Ibajay and ZSL regarding the implementation of the CMRP Organizational formation and strengthening of the POs Bugtongbato Fisherfolk Association (BFA) and Naisud Mangrove and Aquatic Organization (NAMAO) Regular team meetings and planning of KII TWG of Mangrove Ecopark activities 20 May: Passage of Municipal Ord. No. 092 "... Declaring 44.22 Hectares of Mangroves in Barangays Bugtongbato and Naisud, Ibajay, Aklan as Mangrove Eco-tourism Park" Processing of CBFMA application of BFA and NAMAO for 25-yr management of Bugtongbato-Naisud mangroves LGU Ibajay, ZSL, and ASU-CHARRM sign MOA for conduct of training on eco-tourism and value adding food products for Mangrove Eco-tourism Project Construction of Welcome Center, 120 meters footwalk (to the century-old trees area) by POs, 670 meters footwalk (continuation from main road) by LGU + 80 meters footwalk (near century-old trees) by ZSL Training of local officials, PO members on tour guiding; tagging of mangrove trees
2010	Launching of *Katunggan It Ibajay* Eco-tourism Park
2000 – present	Visits of Swedish, Japanese, British, American, and other foreign scientists; Conduct of mangrove training courses for researchers, NGOs, POs, etc.

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

organizing by the Zoological Society of London, an environmental NGO (Primavera et al. 2012b); and infrastructure development funded by a Pew Fellowship grant, ZSL, the municipal government, TIEZA, BFAR, and other government agencies.

CC ADAPTATION: COASTAL GREENBELTS

The Philippines is an archipelago of around 7,100 islands bordered by 36,300 km of coastline which provide the setting for a variety of coastal aquatic events. Assuming that the average Filipino will experience 1,400 storms in his/her lifetime (average of 20 storms/yr x 70 yr average lifespan), the information in Table 4 should be taught to schoolchildren from the primary grades upwards. Knowledge of tides, waves, storms, and tsunamis including their causative mechanisms will better prepare them to cope when these natural phenomena turn into disasters.

Focusing on storms (locally called typhoons), the Philippines has the dubious distinction of being visited by the greatest number (more than 20 yearly) that also are the most intense (Category 5 on the Saffir-Simpson Scale). By the turn of the century, super typhoons had become stronger based on resulting damage and casualties — from a yearly average of only 100 dead + missing as of 2003 and US$380 million in damage as of 2008, to a per typhoon record of ~3,000 dead + missing from 2011 Typhoon Washi (Philippine name Sendong) and US$22 million (or PhP1 billion) from 2012 Typhoon Bopha (Pablo). The strongest storm on record to make landfall, the November 2013 Super Typhoon Haiyan (Yolanda) sent gusts up to 315-375 kph, storm surges more than 7 m high, affected 14 million persons, and resulted in 6,300 deaths (although on the ground reports gave estimates of ~15,000 as of June 2015), and damage of US$12-15 billion including one million homes destroyed (Primavera 2013).

Table 4. Different types of waves and their characteristics (data from McIvor et al. 2012; collage by J.H. Primavera).

Different types of waves and their characteristics (adapted from MacIvor et al. 2012; collage by J.H. Primavera)				
	Tides	***Wind-wave/ swell wave***	***Storm Surge***	***Tsunami***
Wave period	12-24 hr	<15 sec <30 sec	1 hr to 4 days	20 mins to several days
Wave length *Wave height*		100 to 200 m 20 to 50 cm	2.5 km (Nargis) 2.4 to 8.5 (US) 5 to 12 m (Indian Ocean)	200 to 350 km 2 to 40 m
Physical mechanism	**Gravity,** earth's rotation	**Wind shear**	**Wind stress +** atmospheric pressure variation	**Earthquakes,** volcanic eruptions, landslides

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

In a review of hundreds of mangrove and other related papers, McIvor et al. (2012) enumerated the factors that affect attenuation of wave energy (Fig. 1), namely, physical (e.g., slope, bathymetry) and biological (e.g., species, density of trees). Collating estimates of reduction of wave energy and coastal vegetation, they projected that a 100-m and 500-m band of mangroves would reduce energy in wind and swell waves by 13-60% and 50-99%, respectively. However, most of the mangrove band fringing the Philippine coastline has disappeared or is degraded due to overexploitation by coastal communities and conversion to settlements, tourist resorts, agriculture, salt beds, industry, and brackish water aquaculture (Primavera 2000).

There is therefore urgent need to rehabilitate mangroves along the coastline, given the importance of coastal protection in typhoon-prone Philippines, and especially with Climate Change. With increasing environmental awareness, there has come huge funding from international development agencies for mangrove rehabilitation starting in the 1980s (Primavera and Esteban 2008). This was followed by more recent international and national financial support of which the most significant is the multiyear, multitrillion peso National Greening Program of the Philippine government. Unfortunately, such massive funding has focused on target area (hectares) and numbers (of propagules), that is, % targets achieved <u>in the beginning</u> rather than new mangrove forest area created <u>at the end</u>.

The focus on expedient, rather than science-based, protocols can be seen in the common

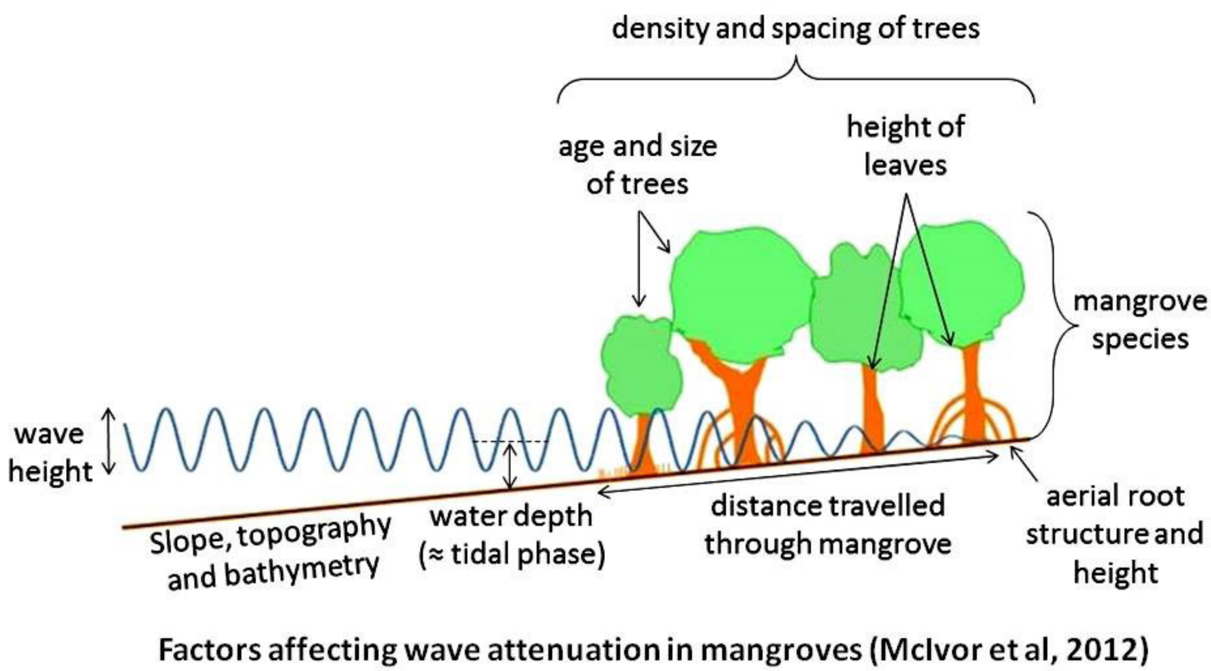


Figure 1. Factors affecting wave attenuation in mangroves (McIvor et al. 2012).

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

practice of planting mangroves in the open access lower intertidal zone which has no tenurial conflicts, despite problems of barnacle infestation, strong wave action and too frequent inundation. Hence, the low mangrove survival rates in this zone (Primavera et al. 2016b) compared to healthy mangrove growth in the middle to upper intertidal elevation where they are naturally found (Fig. 2). Moreover, in these *Avicennia*- and *Sonneratia*-dominated sites, *Rhizophora* are the favored planting species because the big-sized propagules of the genus are easy to source and to plant. This is best described as planting by convenience rather than by ecology (Primavera and Esteban 2008; Primavera et al. 2012a). *Rhizophora mucronata* and *R. apiculata* are more ecologically suited to muddy tidal creeks and rivers because they can tolerate brackish water salinity levels. The classic example of one million *Rhizophora* propagules planted by 7,000 volunteers in one hour in Camarines Sur, Philippines in 2012 was targeted more for the Guinness Book of Records than for environmental rehabilitation. Not surprisingly, the survival rate of one million mangroves after four years was only 1.9% (D. Wodehouse, pers. communication).

Therefore, mangroves of the right species — *A. marina* and *S. alba* instead of *Rhizophora* spp. — should be planted in the right sites, the middle to upper intertidal instead of the lower intertidal. In extreme, yet all too common cases, mangroves have been planted on seagrass beds (Primavera 2015) because of the shortage of plantable areas (i.e., seafront sites are narrow) and the oversupply of multimillion-dollar funding (e.g., from World Bank, Asian Development Bank). Between 1984 and 2006, external funding for mangrove rehabilitation in ~26,000 ha (Primavera and Esteban 2008) may explain the sudden doubling of Philippine mangrove area to ~240,000 ha by around 2000, ending a decline that started in the 1950s. This increase baffled Filipino scientists, until satellite images showed dark green mangrove plantations regularly appearing in the middle of light green seagrasses in open but shallow waters (Fig. 3).

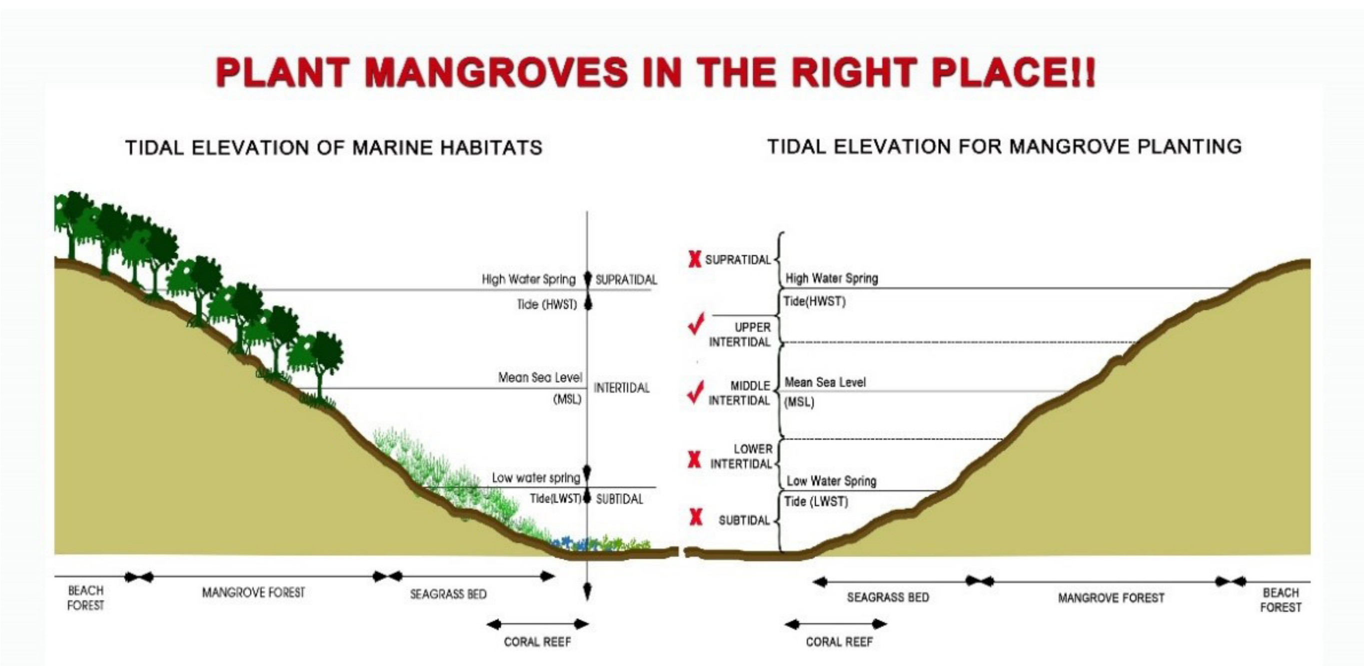
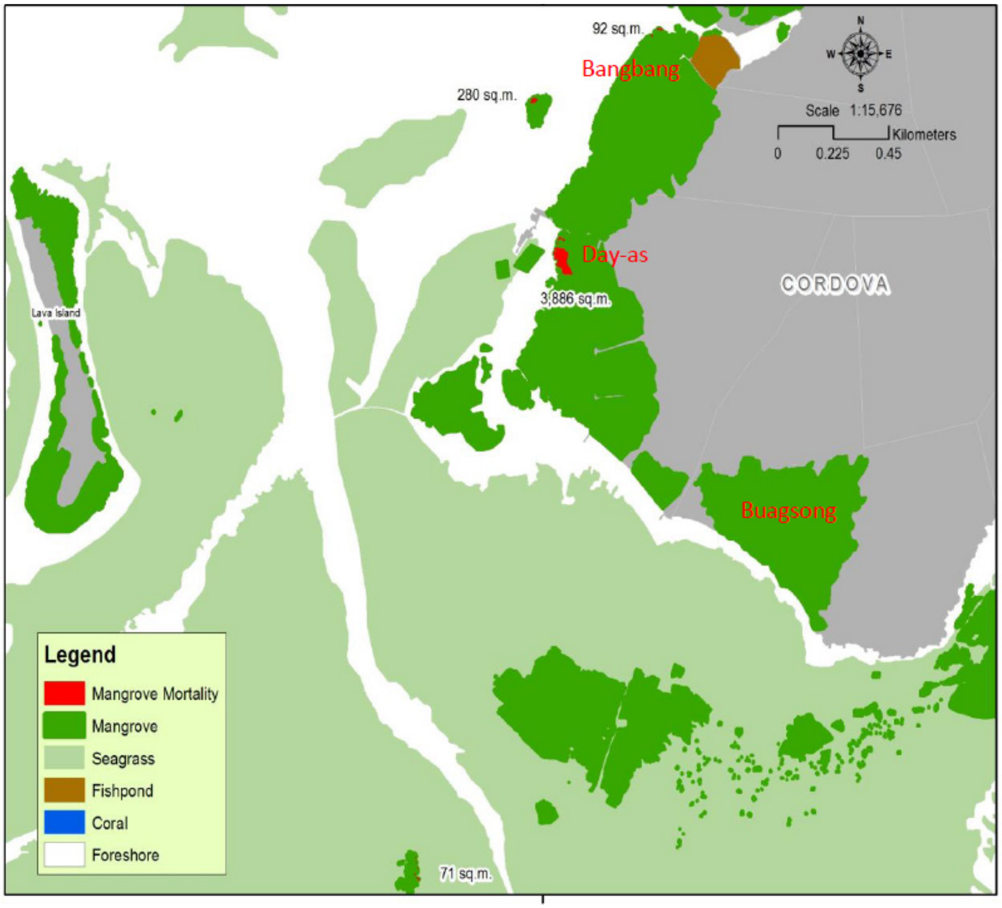


Figure 2. Tidal elevation of marine habitats and for mangrove planting (ZSL-Philippines).

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090



Areas with dead mangroves in oil spill affected areas in Cordova, Cebu. (April 10-16, 2014). Map prepared by A. Moscoso.

Figure 3. Map of Cordova, Cebu showing natural mangroves near the mainland (dark green) and planted on seagrass beds (light green). Prepared by Alan Moscoso, U.P. Visayas.

CC ADAPTATION: MANGROVE REVERSION OF ABANDONED PONDS

The narrow coastal band from the lower intertidal down to the subtidal zone that includes tidal flats and seagrass habitats is preferred for mangrove reforestation programs because this band comprises open access public lands that pose little ownership conflicts. But this area is located below the Mean Sea Level or MSL (Fig. 2) and therefore is not optimal for mangroves, hence their generally low mangrove survival rates of 10-20% (Primavera and Esteban 2008; Samson and Rollon 2008). Rather than these suboptimal areas, rehabilitation projects should focus on the middle to upper intertidal sites occupied by (abandoned) ponds (Fig. 4). Reverting hundreds to thousands of hectares of such ponds holds better promise for increasing mangrove area as they were formerly mangrove forests (Primavera et al. 2013). However, the tenurial status of a pond which can be complicated where overlapping government agencies and levels claim jurisdiction must first be established, whether privately owned or public. Various laws (e.g., DENR Admin. Order 15 of 1990, DA-DENR Memo. Order 3 of 1991, and Republic Act 8550) mandate the cancellation of leases of abandoned, underutilized and unutilized ponds (AUU), and reversion to the Forestry Bureau of the Department of Environment (DENR) for mangrove rehabilitation. Few of such ponds have been reverted so far (Ferrer et al. 2011),

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

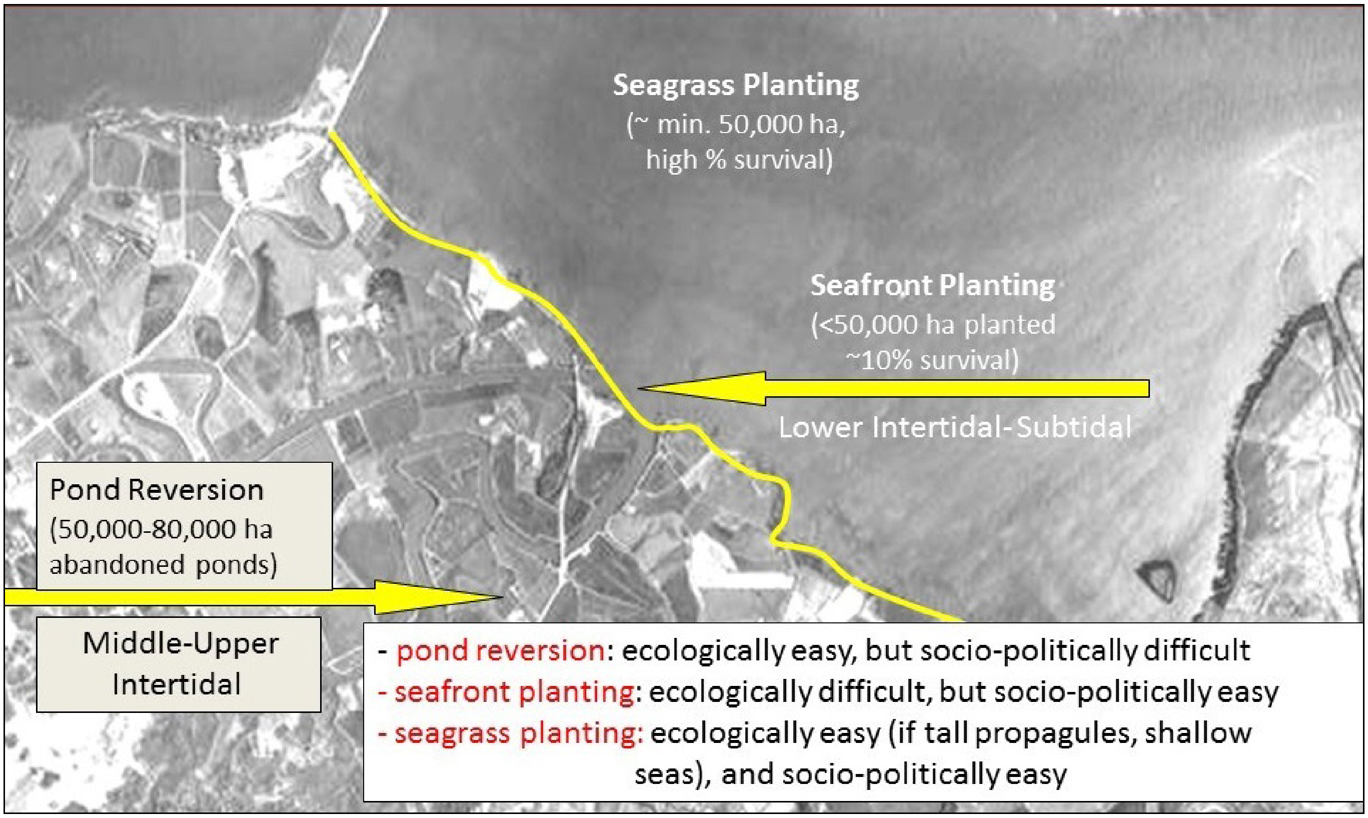


Figure 4. Mangrove rehabilitation – seafront planting vs seagrass planting vs abandoned pond reversion (collage by J.H. Primavera).

because of problems and the generally poor level of law enforcement in the country. Moreover, many ponds with cancelled leases are declared open and available to new applicants, rather than reverted to the DENR.

The low earthen dikes of shallow extensive fishponds are easily breached by strong waves and tidal hydrology is subsequently restored. In contrast, canals and depressions have to be filled in deeply excavated, intensively stocked fish/shrimp ponds, and higher dikes broken down before mangroves can be restored (Primavera et al. 2013). Once natural hydrology is restored and if propagule sources are present, such shallow, extensive ponds will return to their mangrove state in 15-20 yr by natural regeneration (NR) or in 3-5 yr by assisted natural regeneration (ANR) which includes planting (Fig. 5). High regeneration rates in such extensive ponds are illustrated by the 15-ha *Katunggan* Mangrove Ecopark in Iloilo, Central Philippines. Pond rehabilitation started in 2009 under the Community-based Mangrove Rehabilitation Program of the Zoological Society of London in collaboration with the municipal government of Leganes, Iloilo.

Over the 4-year project, 80,000 wildings (out of 90,000 collected) were bagged for nursery conditioning, then outplanted by students, government employees, local communities, and other volunteers to achieve complete mangrove cover by 2010 (Primavera et al. 2012b). In volunteer planting, the contribution of labor from planters such as local folk gives them *de facto* mangrove ownership and commits them to ensuring survival of the plants to maturity. In contrast, paid planting often becomes a mere business transaction which ends when planters are paid for their efforts, and plant survival becomes of minor concern.

This project was greatly facilitated by the creation of a Municipal Environment and Natural Resources Office and passage of a municipal ordinance protecting the mangroves, which

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

Figure 5. Pond-mangrove reversion: assisted natural regeneration (left) which achieved complete cover in 3 yr (2009-2012: by ZSL with LGU support), in contrast to natural regeneration (right) which takes 15-20 yr on the average (photo taken in 2009). (Nabitasan, Leganes, Iloilo, Philippines).

led to the declaration of the 15-ha area as a protected Mangrove Ecopark in 2014 (Fig. 6). Recent developments include the formation of the Mangrove Seedling Growers Association by local fishers who share profits with the LGU, and the awarding of the Disney Conservation Hero Award to a local champion in the LGU who headed the project from the start.

The Ecopark has given the local community pride of place, and more significantly, a 200-meter-wide greenbelt to protect adjacent fishponds and community households from future storms. This success story of pioneering pond-to-mangrove reversion is underpinned by social and biological success factors: (a) science-based protocols, (b) assisted natural regeneration, (c) volunteer planting, and (d) political will (Primavera et al. 2013).

CC ADAPTATION: BEACH FORESTS

In the McIvor et al. (2012) review, a 100-m wide band of coastal vegetation can reduce energy of wind and swell waves by 13-60%. This coincides with a 1986 government regulation which requires a 100-m mangrove width along shorelines in storm surge areas. Most of the Philippine coastline has narrow fringing mangroves that cover a width of only 20-50 m. The remaining balance of 50-80 m needed to complete the required 100-m band can be provided by supratidal beach forests. These forests comprise some ~160 species of trees, shrubs and other plants found above the high tide line (Primavera and Sadaba 2012; Primavera et al. 2016a). Some common beach forest tree species are found in Table 5. (In areas where the slope is steep and the coastline too unprotected to allow mangrove growth, beach forests completely take over the role of coastal protection.)

Beach flora start at or near the beach, but many tree species can grow inland up to 200 masl (meters above sea level), transitioning into lowland forests. The ecotonal location of beach

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

Figure 6. Collage of Leganes, Iloilo Katunggan Ecopark (clockwise): ZSL trainees on footwalk in 200-meter greenbelt, Multipurpose Center, 2014 Ecopark launching by Mayor A. Jaen, and Ecopark sign along the highway.

forest species gives them adaptable "eury" features of colonizers (e.g., tolerance to strong sunlight and salt spray, inadequate water, low nutrients), in contrast to the limiting "steno" characteristics of climax species such as dipterocarps (Primavera et al. 2016a). These pioneering characteristics make beach flora ideal for lowland reforestation. Native tree species planted 2008-2011 in a former ricefield in Oton, Iloilo showed interesting survival patterns through the El Nino years of 2010 and 2016 – 87% of 31 beach forest species survived as of 2016, compared to only 7% survivors from 27 dipterocarp and other non-beach species (J.H. Primavera, personal observation). Foremost among these beach trees is *Millettia pinnata*, locally called **bani** or **balukbaluk**, whose seeds were collected from a coastal tree (P generation), then germinated and produced seedlings (F_1) in 2007. Outplanted in 2008, these seedlings matured and bore flowers, fruits and wildings (F_2) in 2011 – 3 generations from P to F_2, all in 4 years (Primavera et al. 2016a).

The early reproduction and fast growth of beach trees, in addition to their colonizing features make such species suitable for reforestation under the National Greening Program. Germination has been achieved for ~50 beach species, including *M. pinnata*, and the F_1 and F_2 generations have been produced for 30 and 15 species, respectively, by outplanting the germinated seedlings/saplings (Primavera et al. 2016). Other beach trees may be used for urban landscaping – big-crowned trees like **bitaog/dangcalan** *Calophyllum inophyllum* and

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

Table 5. Some common beach forest tree species in the Philippines (Primavera et al. 2016a).

Scientific Name	Common Name	Scientific Name	Common Name
Alstonia macrophylla	batino, itang-itang	*Macaranga tanarius*	binunga
Alstonia scholaris	dita, itang-itang	*Melia azedarach*	magalnga, bagalunga
Barringtonia asiatica	bitoon, bulubitoon	*Millettia pinnata*	baluk-baluk, bani
Barringtonia racemosa	putat, sako	*Morinda citrifolia*	noni, nino, apatot
Buchanania arborescens	an-an, balinghasai	*Pandanus polycephalus*	pandan
Calophyllum inophyllum	dangkalan, bitaog,	*Pandanus tectorius*	pandan
Cerbera manghas	baraibai, buta-buta	*Planchonella obovata*	banasi
Cerbera odollam	baraibai, buta-buta	*Premna odorata*	agdaw, alagaw
Cocos nucifera	niyog, lubi	*Premna serratifolia*	agdaw, argaw
Cordia subcordata	banalo, agut-ut	*Scaevola taccada*	panabolong
Cycas edentata	pitogo	*Sterculia ceramica*	banilad, malakalumpang
Dendrolobium umbellatum	miyagos, malapigas	*Sterculia foetida*	bubog, kalumpang
Diospyros ferrea	bantolinao	*Syzygium confertum*	tamo
Diospyros maritima	kanomai, malatinta	*Syzygium leucoxyloon*	putian, ngaret
Ficus microcarpa	lunok, baleteng-ibong	*Talipariti tiliaceum*	malabago, balibago
Ficus septica	labnog, hawili	*Terminalia catappa*	talisay
Guettarda speciosa	bagaolan, lambon	*Thespesia populnea*	banago
Heliotropium foertherianum	trompa-elepante	*Vitex parviflora*	tugas, molave
Heritiera littoralis	dungon, dungon-late	*Vitex trifolia* var. *trifolia*	lagunding-dagat
Hernandia nymphaeifolia	koron-koron	*Wrightia pubescens*	laniti
Intsia bijuga	ipil	*Xylocarpus rumphii*	pigau

bitoon *Barringtonia asiatica* for shade, and trees with attractive flowers like **uringon/salingogon** *Cratoxylum formosum*, **limboaya** *Utania volubilis* and *Villaria philippinensis* for ornamental purposes.

CONCLUSIONS AND RECOMMENDATIONS

1. The coastal ecosystems of mangroves and beach forests are key to resilience to a changing climate.
2. Their services of storm protection, carbon sequestration, and resources for reforestation are critical to the mitigation of, and adaptation to, increasing storm frequency and intensity, rising sea level, and other negative impacts of Climate Change.
3. Therefore national government institutions, international development agencies, NGOs, academe, industry and other stakeholders are urged to:
    a. protect remaining mangrove forests, e.g., as ecoparks;

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

b. *establish coastal greenbelts comprising mangrove and/or beach forest vegetation 100 meters wide, especially for typhoon-vulnerable coastlines;*

c. *prioritize reversion of abandoned ponds to mangroves as this is more ecologically sound than seafront planting;*

d. *where seafront planting of mangroves is necessary, plant the dominant* Avicennia marina ***piapi/bungalon*** *and* Sonneratia alba **pagatpat** *rather than* Rhizophora spp. **bakhaw***, at middle to upper intertidal levels rather than lower intertidal to subtidal elevation;*

e. *stop planting on seagrass beds (and mudflats, coral reefs) as they are ecosystems that also contribute to Climate Change resilience in their own right;*

f. *shift the paradigm of defining mangrove reforestation success from % quotas (of number of planted propagules or hectares) and target budgets achieved (by national agencies and international development banks) to % survival rate and new mangrove area created; and*

g. *establish R&D programs for beach forests to enhance their role in storm protection (complementary to mangroves) and as suitable species for coastal-lowland reforestation.*

REFERENCES

Donato DC, Kauffman JB, Murdiyarso D, Kurnianto S, Stidham M, Kanninen M. 2011. Mangroves among the most carbon-rich forests in the tropics. *Nature Geosci* 4:293-297.

Ferrer AJG, Hopanda J, Orquejo M, Moscoso AD, Sadaba R. 2011. Reversion of disused Fishpond Lease Agreement areas to mangrove forests in Region VI, Philippines. EEPSEA Research Report No. 2011-RR9. Singapore: Economy and Environment Program for Southeast Asia (EEPSEA)

Hamilton SE, Friess DA. 2018. Global carbon stocks and potential emissions due to mangrove deforestation from 2000 to 2012. *Nature Clim.* Chang. 8:240-44

McIvor AL, Möller I, Spencer T, Spalding M. 2012. Reduction of wind and swell waves by mangroves. Natural Coastal Protection Series: Report 1. Cambridge Coastal Research Unit Working Paper 40. The Nature Conservancy and Wetlands International. 27 pages.

Primavera JH. 2000. Development and conservation of Philippine mangroves: institutional issues. Ecol. Econ. 35:91-106

Primavera JH, Sadaba RB, Lebata MJHL, Altamirano JP. 2004. Handbook of Mangroves in the Philippines – Panay. SEAFDEC Aquaculture Department (Philippines) and UNESCO Man and the Biosphere ASPACO Project, 106 pp.

Primavera JH, Esteban JMA. 2008. A review of mangrove rehabilitation in the Philippines: successes, failures and future prospects. Wetlands Ecol. Mngmnt. 16 (3): 173-253

Primavera JH, Sadaba RB. 2012. Beach Forest Species and Mangrove Associates in the Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines and UNESCO Office, Jakarta. 157 p.

Primavera JH, Rollon RN, Samson MS. 2012a. The pressing challenges of mangrove rehabilitation: pond reversion and coastal protection. Chapter 10 in Volume 10: Ecohydrology and restoration, (eds., L. Chicharo and M. Zalewski) in the Treatise on Estuarine and Coastal Science (Series eds., E. Wolanski, and D. McLusky), Elsevier, Amsterdam, pp. 217-244

Primavera JH, Savaris JD, Bajoyo B, Coching JD, Curnick DJ, Golbeque R, Guzman AT, Henderin JQ,

Transactions NAST PHL 40 No. 2 (2018)
doi.org/10.57043/transnastphl.2018.1090

Joven RV, Loma RA, Koldewey HJ. 2012b. Manual for Community-Based Mangrove Rehabilitation. London, UK: Zoological Society of London, viii + 240 p.

Primavera JH, Yap WG, Savaris JD, Loma RJA, Moscoso ADE, Coching JD, Montilijao CL, Poingan RP, Tayo ID. 2013. Manual on Mangrove Reversion of Abandoned and Illegal Brackishwater Fishponds - Mangrove Manual Series No. 2. London, UK: ZSL, xi + 106 p.

Primavera, JH. 2013. Shelter from the storm: Coastal greenbelts of mangroves and beach forests, *The Philippine Star*, 9 Dec. 2013

Primavera, JH. 2015. Stop planting bakhaw on seagrass beds. *The Philippine Daily Inquirer*, 28 Feb. 2015

Primavera JH, Sadaba RB, Lebata MJHL, Altamirano JP. 2016a. Mangroves and Beach Forest Species in the Philippines. Ecosystems Research and Development Bureau, Department of Environment and Natural Resources, College, Laguna, Philippines

Primavera JH, dela Cruz M, Montilijao C, Consunji H, dela Paz M, Rollon RN, Maranan K, Samson MS, Blanco A. 2016b. Preliminary assessment of post-Haiyan mangrove damage and short-term recovery in Eastern Samar, Central Philippines. Mar. Poll. Bull. 109: 744–750

Samson MS, Rollon RN. 2008. Growth performance of mangroves at the enhancement sites: need to revisit forest management strategies. Ambio 37 (4), 234–240.