Philippines' Mangrove Ecosystem: Status, Threats and Conservation

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Abstract The Philippines has very rich biodiversity in terms of number and percentage. It is regarded as one of 17 mega biodiversity countries due to its geographical isolation, diverse habitats and high rates of endemism. It ranks fifth globally in terms of the number of plant species and maintains 5 % of the world's flora. In mangroves alone, the country holds at least 50 % mangrove species of the world's approximately 65 species. However, due to anthropogenic activities as well as natural disturbances, the country continues to lose its rich biodiversity resources including mangroves. This chapter revisits the status of Philippines' mangroves, its current and future threats and analyzes the mechanisms on how various stakeholders put efforts to address those threats. We found out that while a number of successful conservation and restoration efforts have been made, there are still clear gaps on how different stakeholders can turn their commitments and initiatives into actions to conserve and rehabilitate Philippines' mangrove for human well-being and sustainable development.

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1 Mangrove Distribution in the Philippines

As an archipelagic country made up of more than 7,000 islands, the Philippines has one of the longest coastlines in the world extending up to 36,289 km. It is located at 13 °00 °N, 122 °00 °E, along the tropical band where mangroves thrive. Hence, the diversity of mangroves is relatively high due to its geographical location. The country holds at least 50 % (Primavera et al. 2004) of the world's approximately 65 mangrove species (Kathiresan and Bingham 2001). It is also considered as one of the top 15 most mangrove-rich countries in the world according to Long and Giri (2011).

The Philippine Government adopts the Food and Agriculture Organization (FAO) definition of forest as "an area of more than 0.5 ha and tree crown cover (or equivalent stocking level) of more than 10 % which includes natural and plantation and production forests" (Lasco et al. 2012). Based on this definition, the Department of Environment and Natural Resources (DENR) estimates that 7.2 million ha comprise the forest ecosystem, which is approximately 24 % of the total land area as of 2003 (FMB 2007). Three percent of the remaining forest cover in the country is considered as mangrove forests. Generally, mangrove area is declared by the Philippine government under Presidential Decree (PD) 705 as forest land. Mangrove forest is defined as a type of forest on tidal mudflats along the sea coast extending along the streams where the water is brackish. Mature mangrove areas do not exceed 20,000 ha, of which approximately two-thirds are in Palawan. Consequently, around 80,000 ha of mangroves left in the country were declared as wilderness and forest reserves in 1981, including all the 40,000 ha of pristine mangroves in Palawan (Primavera 2002).

The Philippines used to be covered by 400,000–500,000 ha of mangroves in 1920 but it declined to around 120,000 ha in 1994 (Chapman 1976; Brown and Fischer 1918; Primavera 2000). The decline may be attributed to overexploitation by coastal dwellers, and conversion to agriculture, salt ponds, industry and settlements (Primavera 2000). Recent estimates suggest that the mangrove area has increased to 247,362 ha (FMB 2007); however, it still fell short by almost half of its original area. This loss resulted in a significant decrease in mangrove ecosystem services including fish production and carbon sequestration. Primavera (1997) demonstrated the correlation in comparable decline in Philippine mangrove areas and production from near-shore municipal fisheries that contrasts with the increase in brackish water pond area and aquaculture contribution to total fish production (Fig. 1).

According to the estimate of Long and Giri (2011), using remotely sensed satellite observations for the year 2000, 66 out of the 82 provinces in the country contain mangroves with a total covered area of 256,185 ha. The estimate of Long and Giri (2011) from 2000 is slightly higher than that of DENR's estimate in 2003 (Fig. 2). In the same paper, they estimated that 19 % (49,363 ha) of the Philippines' total mangrove area is located within existing protected area networks (International Union for Conservation of Nature (IUCN) protected areas categories, I–VI), with the greatest area of protected mangroves located on Palawan.

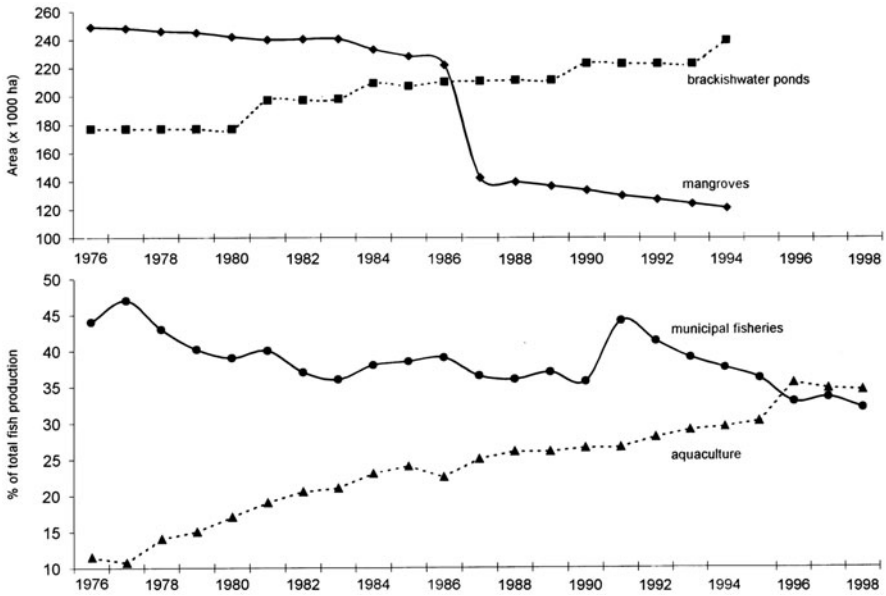

Fig. 1 Changes in mangrove and brackish water pond area (**a**) and contribution of municipal fisheries and aquaculture (**b**) to total fisheries production in the Philippines, 1976–1990. (Primavera 1997)

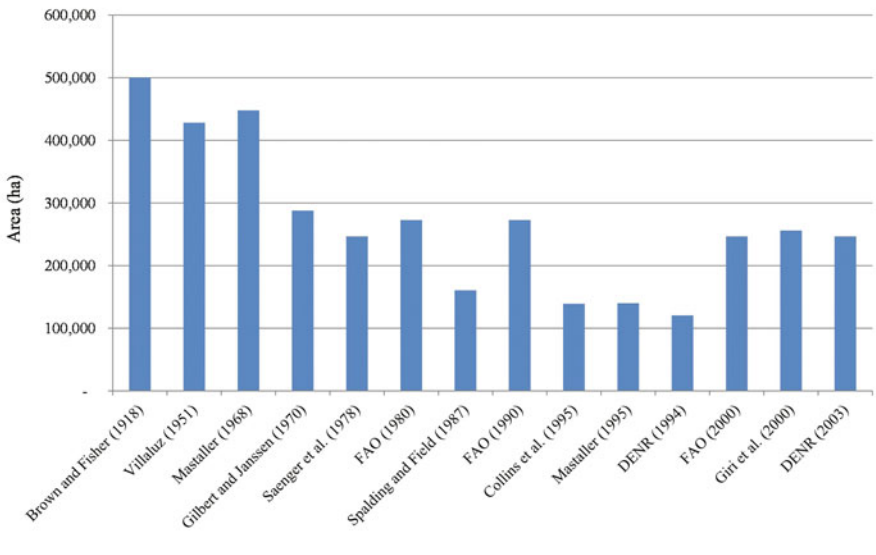

Fig. 2 Comparison of areal estimates of mangrove forest for the Philippines. Dates indicate year of estimate. (Long and Giri 2011)

Table 1 Number of subgeneric taxa in each true mangrove genera

Family	Genus	Number of species	Number of subspecies	Number of hybrids
ACANTHACEAE	*Acanthus*	2 (2)		
	Avicennia	8 (2)	4 (3)	
BIGNONIACEAE	*Dolichandrone*	1 (1)		
COMBRETACEAE	*Conocarpus*	1		
	Laguncularia	1		
	Lumnitzera	2 (2)		1
EUPHORBIACEAE	*Excoecaria*	3 (1)		
FABACEAE	*Cynometra*	1		
LYTHRACEAE	*Pemphis*	2 (1)		
	Sonneratia	6 (3)		2
MALVACEAE	*Camptostemon*	2 (1)		
	Heritiera	2		
MELIACEAE	*Aglaia*	1		
	Xylocarpus	2 (2)		
MYRSINACEAE	*Aegiceras*	2 (2)		
MYRTACEAE	*Osbornia*	1 (1)		
PELLICIERACEAE	*Pelliciera*	1		
PLUMBAGINACEAE	*Aegialitis*	2		
RHIZOPHORACEAE	*Bruguiera*	6 (4)		
	Ceriops	5 (2)		
	Kandelia	2 (1)		
	Rhizophora	6 (3)		4
RUBIACEAE	*Scyphiphora*	1 (1)		
Total 14 (11)	*23 (16)*	60 (29)	4 (3)	7 (0)

Note: Numbers inside the parenthesis are number of taxa present in the Philippines

2 Mangrove Taxonomy in the Philippines

Diversity of mangroves is extremely low as compared to that of tropical rainforests. However, mangroves can be considered one of the most taxonomically complex plant groups. Different mangrove species share a lot of common morphological characters that makes identification a very confusing task. Mangrove biologists generally classify mangrove plants into two: the true mangroves—species that are limited to the mangrove habitat; and the mangrove associates—mainly distributed in a terrestrial or aquatic habitat but also occur in the mangrove ecosystem (FAO 2007; Macintosh and Ashton 2002; Jayatissa et al. 2002; Duke et al. 1998). The true mangroves are further distinguished as major mangroves, which are tree species capable of forming dense pure stands, and minor mangroves, denoted by their inability to form a conspicuous element of the mangrove vegetation (Polidoro et al. 2010; Tomlinson 1986). There has been a long outstanding debate on these classifications, but during recent years, the increasing number of molecular works in mangroves has somehow developed a taxonomic consensus among mangrove biologists. Table 1 presents the most updated global mangroves' taxonomic list, which is a modification of the works of Kathiresan and Bingham (2001), to include the recent taxonomic revisions resulting

Table 2 Major and minor mangroves in the Philippines. (Primavera 2000)

I. ACANTHACEAE	*1. Acanthus ebracteatus*
	2. Acanthus ilicifolius
II. AVICENNIACEAE	*3. Avicennia alba*
	4. Avicennia officinalis
	5. Avicennia marina
	6. Avicennia rumphiana
III. BOMBACACEAE	*7. Camptostemon philippinensis*
	8. Captostemon schultzii
IV. COMBRETACEAE	*9. Lumnitzera littorea*
	10. Lumnitzera racemosa
	11. Lumnitzera rosea
V. EUPHORBIACEAE	*12. Excoecaria agallocha*
VI. LYTHRACEAE	*13. Pemphis acidula*
VII. MELIACEAE	*14. Xylocarpus granatum*
	15. Xylocarpus mekongensis
VIII. MYRSINACEAE	*16. Aegiceras corniculatum*
	17. Aegiceras floridum
IX. MYRTACEAE	*18. Osbornia octodonta*
X. PALMAE	*19. Nypa fruticans*
XI. PLUMBAGINACEAE	*20. Aegialitis annulata*
XII. RHIZOPHORACEAE	*21. Bruguiera cylindrica*
	22. Bruguiera exaristata
	23. Bruguiera hainesii
	24. Bruguiera gymnorrhiza
	25. Bruguiera parviflora
	26. Bruguiera sexangula
	27. Ceriops decandra
	28. Ceriops tagal
	29. Kandelia candel
	30. Rhizophora apiculata
	31. Rhizophora lamarckii
	32. Rhizophora mucronata
	33. Rhizophora stylosa
XIII. RUBIACEAE	*34. Scyphiphora hydrophyllacea*
XIV. SONNERATIACEAE	*35. Sonneratia alba*
	36. Sonneratia caseolaris
	37. Sonneratia gulngai
	38. Sonneratia lanceolata
	39. Sonneratia ovata

from various molecular works. Primavera (2000) also presented a list totaling some 35–44 major and minor mangrove species belonging to 14 families that can be found in the Philippines (Table 2).

3 Importance of Mangrove in the Philippines

Mangroves provide tremendous values and benefits to mankind and other marine organisms. They are a source of valuable plant products used as food, traditional herbal medicine and other wood and forest products. Mangrove forests serve as nesting grounds for hundreds of bird species, as well as nurseries, and are home to a wide variety of reptile, amphibian, mammals, fish, crabs, shrimps, mollusks and many other invertebrates (Nagelkerken et al. 2008). Being archipelagic in nature, a large part of the population of the Philippines depend on the mangroves for food, livelihood, and shelter derived from the mangrove ecosystem. In fact, more than half of the country's 1,500 towns and 42,000 villages depend on these marine habitats for food and other goods and services (Primavera 2000).

Recognizing the vulnerability of the country to storm surges and strong winds due to typhoons, planting of mangroves has been identified as one of the adaptation strategies to such climatic events. For instance, on the eastern coast of the Samar Island, the mangrove forest plays an important role in the protection of the coastline for coconut plantations. Mendoza and Alura (2001) noted that in areas without mangroves, the coconut trees were uprooted due to wave action during stormy weather. The event did not occur in coastal areas where a strip of mangroves was easily eroded compared to those with mangrove trees. In coastal areas directly exposed to the strong wave action of the Pacific Ocean, coastal erosion was reduced either by mangrove trees or cliffs. Mangroves also act synergistically with adjacent ecosystems such as seagrass and coral reef communities for coastal protection.

In the face of climate change, many of the regulating services of mangroves are actually becoming more necessary and valuable, especially their buffering capacity against storms and flooding. Mangroves can hold back the sea waves and reduce wave forces with their extensive and dense above-ground roots by an estimated 70–90 % on average (Macintosh 2010). Furthermore, in a study conducted by Harada et al. (2002) they demonstrated that mangroves are as effective as concrete seawall structures for reduction of tsunami-hit house damage behind the forest. Moreso, a six-year old mangrove forests of 1.5 km width reduce the sea waves by 20-fold, from 1 m high waves in the open sea to 0.05 m at the coast (Mazda et al. 1997).

Mangroves are also potential sources of livelihood for the community in the Philippines through the development of policies and programs that can help provide incentives to local people who are largely dependent on mangroves (Camacho et al. 2011). For instance, Camacho et al. (2011) wrote that Banacon Island in the Province of Bohol is perhaps one of the best when it comes to illustrating the carbon sink potential of mangroves in the Philippines. Banacon mangroves are in a vigorous condition and capable of storing vast amounts of carbon. They estimated that the 40-year-old plantation has the largest carbon density with 370.7 tons per ha, followed by the 15-year-old plantation with 208.5 tons per ha, 20-year-old plantation with 149.5 ton ha per ha, and lastly by natural stand with 145.6 tons per ha. They recommended that adopting incentive-based conservation programs such as payment for environmental services (PES) and Reducing Emissions from Deforestation and Forest Degradation projects (REDD) should also be explored in order to stimulate protection and enhance biodiversity, carbon stocks, water, aesthetics and local livelihoods.

Table 3 List of Mangrove Species Included in IUCN Red List. (after Polidoro et al. 2010)

Family	Species	Red List category
ACANTHACEAE	*Avicennia bicolor* Standley	VU
	Avicennia integra Duke	VU
	Avicennia rumphiana Hallier f.	VU
BIGNONIACEAE	*Tabebuia palustris* Hemsley	VU
FABACEAE	*Mora oleifera* (Hemsl.) Duke	VU
LYTHRACEAE	*Sonneratia griffithii* Kurz	CR
MALVACEAE	*Camptostemon philippinense* (Vidal) Becc.	EN
	Heritiera fomes Buch.-Ham.	EN
	Heritiera globosa Kostermans	EN
RHIZOPHORACEAE	*Bruguiera hainesii* C. G. Rogers	CR
PELLICIERACEAE	*Pelliciera rhizophorae* Triana and Planchon	VU

4 Conservation Efforts Addressing Threats

4.1 Current and Potential Threats to Mangrove Ecosystem Rehabilitation and Conservation

It is no doubt that mangrove forests are one of the world's most threatened tropical ecosystems. In fact, 11 true mangrove species (Table 3) qualified for the IUCN Red List categories of threat including two critically endangered, three endangered, and six vulnerable species (Polidoro et al. 2010). For these reasons, many tropical countries have considered the sustainable management of mangroves as major priorities in biodiversity conservation (Macintosh and Ashton 2002). In addition, several countries have already come up with their local mangroves Red List of threatened species. For instance, 12 species of true mangroves in India are considered to be 'critically endangered' and a total of 57 mangrove and mangrove-associated species are considered threatened (Kathiresan and Bingham 2001). Sri Lanka categorized eight mangrove species as locally threatened (Bambaradeniya et al. 2002). Ironically, in the Philippines, not a single mangrove species is included in the National Red List crafted by the Philippine Plant Conservation Committee and issued as a DENR Administrative Order (DAO) 2007–01.

Many reports have identified major causes of mangrove deforestation in the country including practices that pose potential threats to the diversity of mangrove species. While aquaculture development was identified as the most significant cause of mangrove degradation since the early years until present, there are also a number of serious threats including urbanization, conversion to agriculture, overharvesting for industrial uses such as timber and charcoal, and climate change, among others (Agaloos 1994; Alongi 2002; Primavera 2000; Boquiren et al. 2010).

4.1.1 Aquaculture Development

Aquaculture development, wherein ponds were built up into cultured ponds for production of shrimp, fish, and other aquatic resources, is known to be the leading cause of mangrove loss in the country. For instance, between 1968 and 1983, 237,000 ha of mangroves were lost for pond construction. This was almost half of the total national mangrove area (Fernandez 1978) at that time. Similarly, Agaloos (1994) and Primavera (2000) estimated that around half of the 279,000 ha of mangroves lost from 1951 to 1988 were developed into culture ponds (Agaloos 1994; Primavera 2000). Not only does aquaculture decrease the mangrove area, it also pollutes the mangrove ecosystem with effluents which in turn affect the services that a healthy ecosystem can provide. Shrimp aquaculture operates extensively normally for three to ten years after which the production decreases, and then abandonment occurs. Pollution and problems are often left behind (de la Torre and Barnhizer 2003). Once the operation is halted, aquaculture operators find another new location containing a healthy mangrove ecosystem and again deplete the resources (Ellison 2008). If this trend continues, mangrove areas in the country will be in serious threat. Although greater conservation and rehabilitation efforts have been in place (Samson and Rollon 2008), it is expected that the mangrove ecosystem in the country will continue to face degradation (Fortes 2004).

The municipal fishing sector comprises 68 % of the one million people engaged in the fishing industry in the Philippines, but it contributes only about 30 % of the total fish catch, while the 28 % engaged in aquaculture and only 4 % in commercial fishing contribute 60 % of the national fish catch (BFAR 1997). However, these figures do not reflect the negative impact of aquaculture to the mangrove ecosystem and to other marine ecosystems nearby such as the sea grass and coral reef.

4.1.2 Conversion to Agriculture

As opposed to aquaculture development, there were no significant accounts on mangrove area conversion to agriculture purposes in the country. However, it does not mean that this threat is far from beyond happening. Due to continued urbanization, some of the prime agricultural lands in the country are now being converted to settlements, hence the decrease in the available land for agriculture. As mangrove areas are rich in organic soils, they are prime locations for conversion into agricultural land, especially rice paddies and palm oil plantations to sustain the growing need for food. The possible greater threat from this happening is the drying and rapid and irreversible acidification of soils which can result in unusable land. In addition, as farmers often use fertilizers and chemicals, runoff containing these pollutants makes its way into water supplies. Despite their resilience, mangroves can tolerate only a limited amount of industrial and agricultural pollution without dying (American Museum of Natural History, n.d.).

4.1.3 Urbanization, Industry and Settlement

Extensive mangrove plantations found in Manila Bay in the early 1900s were subsequently replaced by fish ponds, settlements and port infrastructure (Brown and

Fischer 1920; Cabahug et al. 1986). In Bais Bay and Banacon Island, Philippines, cutting to make space for residential settlements has dramatically reduced the distribution on mangroves in the area (Walters 2003). The building of a causeway on Daco Island in 1950 and perimeter roads hastened further in-migration which caused local population to dramatically increase. The concentration of homes along the shore prompted mangrove cutting there. Backyard planting became widespread in the 1970s, but plantation expansion was later offset by the further cutting of mangroves from the landward side (Walters 2003).

Recently, the Philippine Reclamation Administration allowed the implementation of a 635-hectare reclamation project in Manila Bay beside the 175-hectare protected mangroves, lagoons and ponds known as the Las Pinas-Paranaque Critical Habitat and Ecotourism Area. While there has been a huge opposition to the project, the Court of Appeals approved the reclamation. Opposing parties which include politicians, socio-civic organizations and non-government organizations, proclaimed that reclamation is a passport for the destruction of Manila Bay and will allow imminent threats to livelihood and local fisheries (Punay 2013). It has also been raised that in pursuit of continued growth and economic development, the government failed to consider the ecological aspect of approved projects.

4.1.4 Cutting of Timber, Fuel and Charcoal

Due to an increase in the prices and access to commodities such as fuel and construction materials, people are forced to look for cheaper and alternative resources. Because of its physical characteristics, mangroves are often chosen as a primary option. Mangrove wood burns exceptionally hot and evenly and so has long been preferred as both a domestic cooking fuel and a fuel for commercial bakeries in the Philippines. In Bais Bay, for the past century people living along the coast have been relying heavily on cutting mangroves for domestic fuel and construction wood, especially for use as posts in fish weirs, called *Bunsod*, which are abundant in the shallow waters of North and South Bais Bay (Walters 2004).

4.2 Conservation and Rehabilitation Efforts: Failures and Future Directions

A number of efforts on mangrove conservation and rehabilitation have been completed in the country. Some were successful, some were not. Primavera and Esteban (2008) reviewed eight mangrove rehabilitation projects in the Philippines and found out that despite heavy funding in the hundreds of millions of dollars to rehabilitate thousands of hectares of mangroves over the last two decades, the long-term survival rates of mangroves are generally low at 10–20 %. Two of the main reasons cited are inappropriate species and sites because the ideal sites have been converted to brackish water fishponds. The favoured but unsuitable *Rhizophora* are planted in sandy substrates of exposed coastlines instead of the natural colonizers *Avicennia* and *Sonneratia*. Mangroves should be planted where fishponds are, not on seagrass beds and tidal flats where they never existed.

In addition, among the issues that were identified that impede success of mangrove rehabilitation and conservation efforts include lack of awareness, complexity of interactions between natural systems, social systems, and human values across temporal and spatial scales, weak and inadequate manpower, and lack of political will to enforce the laws (Primavera and Esteban 2008; Farley et al. 2009).

Among the reforestation projects that were implemented, community involvement is identified as they key factor for success (Alcala 1998; Primavera and Esteban 2008; Farley et al. 2009; Camacho et al. 2011). Involving the community is a more sustainable approach to reforestation and maintenance of existing resources because participatory approaches empower local communities to contribute more effectively to forest management (Contreras 2003). A popular success story involving a community that manages its natural resources is that of Banacon in Bohol Island. Recognizing the dire local needs for fuel wood and construction materials for building boats and houses due to mangrove scarcity after decades of continued exploitation, residents on Banacon have come to appreciate the benefits of owning their own mangrove plantations, and have so continued to plant vigorously even after the island was designated a protected area (Walters 2003; Camacho et al. 2011). Mangrove reforestation in Banacon is a community-initiated effort that started in 1957. Currently, mangrove plantations of Banacon are being managed by the local community with assistance from the DENR (Camacho et al. 2011).

Lasco et al. (2012) calculated the rate of change of each forest type based on official government data on forest cover as of 2003 and from the latest FAO Forest Resource Assessment (FRA) report for the Philippines (FAO 2010). They found that there has been a positive change for mangrove forests of about 0.008 % per year. This positive change in mangrove area may be attributed to some successes in mangrove reforestation and rehabilitation projects in the country. However, this positive change is still far from bringing back the mangrove area to its original extent, hence more is needed to be done.

In a recently concluded study by Calumpong and Cadiz (2012), it was recommended that to shore up its fish population and sustain its food supply, the Philippines must pursue a program to expand its mangrove forests from the current 140,000 hectares to approximately their 1920 level of 500,000 hectares. The researchers encouraged multi-species mangrove reforestation instead of dependence on monospecies stands of *Rhizophora* spp. or bakawan, which can be risky, since it is prone to pest attacks.

Another promising approach that is being developed in the country to encourage mangrove rehabilitation and conservation is the establishment of ecotourism in mangrove areas. The Philippines defined its ecotourism goal and described ecotourism as a form of sustainable tourism within a natural and cultural heritage area where community participation, protection, and management of natural resources, culture and indigenous knowledge and practices, environmental education and ethics as well as economic benefits are fostered and pursued for the enrichment of host communities and satisfaction of visitors (NESC 2002).

Currently, there are only a handful of mangrove-based ecotourism sites in the country. One is the Pagbilao Mangrove Experimental Forest in Quezon province which has the largest number of mangrove species of any stand in the Philippines (Bennagen and Cabahug 1992). The administration constructed a boardwalk wherein visitors can see clearly different mangrove and faunal species in the area. Another example is Banacon Island, which is the oldest of mangrove-based ecotourism sites. Likewise, Olango Island in Cebu province serves as recreational grounds for bird watching and observation of other wildlife. The development of ecotourism in mangrove areas provides cultural benefits. People from urban areas desire to experience the atmosphere of the mangrove ecosystem. The diverse mangrove plants and animals and their adaptations make the mangrove ecosystem an ideal ecological destination and field laboratories for biology and ecology students and researchers.

However, concerns are also being raised on ecotourism as it may also bring potential threats to the mangrove ecosystem. Among those are establishment of commercial areas, indirect costs of the damages to the services of the mangrove ecosystem, pollution, and waste. For instance, population density of tourists and frequency of visits for ecotourism activities might affect the natural vegetation and fauna in the mangrove areas. The noise and presence of people affects sensitive species of wildlife unlike tolerant species.

5 Conclusion and Future Perspectives

Mangroves are unique ecosystems which offer tremendous values and benefits. Philippine mangroves are very much diverse but facing tremendous threat. While previous major mangrove reforestation/rehabilitation in the Philippines is a big failure, there are also success stories that encourage continuing implementation of reforestation and conservation programs. We encourage those future programs to take into consideration the following recommendations:

a. Strengthening the information, education and communication program for the protection and conservation of mangrove areas.
b. Successful projects always start with proper awareness. There is a need for a more effective awareness campaign on the ecological and socio-economic importance of mangrove forests and other ecosystems. The government should implement new mangrove planting guidelines to enhance the survival rate of the mangrove species. The scientific community needs to provide the decision-makers with relevant information.
c. We should also continue to closely engage the local community in the management of resources as it is a more sustainable approach. They must be given technical assistance, training, education and diverse livelihood programs to enhance their capability. There is also a greater need for conservation that integrates research, training, advocacy and action including all sectors of the society at all levels.

d. If ecotourism is to be developed in a mangrove area, sustainable development and a holistic approach must be strengthened in the management, conservation, protection and utilization of the services provided by a mangrove ecosystem. The area must have management zonation with a strict protection zone and multiple use zones which includes ecotourism designated area. Each local government unit, DENR, people's organizations, private organizations and non-government organizations must cooperate in the management. The revenues gained from the collection of fees must be for the conservation and maintenance of the area.

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