Article

Maricar S. Samson and Rene N. Rollon

Growth Performance of Planted Mangroves in the Philippines: Revisiting Forest Management Strategies

The effort toward restoring lost mangroves in the Philippines has been commendably immense, specifically during the past two decades. In light of such, it is important to evaluate outcomes and, where appropriate, apply the lessons learned to the current strategies in mangrove forest management. This article synthesizes the results from several research projects assessing the performance of planted mangroves across the country. Overall, there is a widespread tendency to plant mangroves in areas that are not the natural habitat of mangroves, converting mudflats, sandflats, and seagrass meadows into often monospecific *Rhizophora* mangrove forests. In these nonmangrove areas, the *Rhizophora* seedlings experienced high mortality. Of the few that survived (often through persistent and redundant replanting), the young *Rhizophora* individuals planted in these nonmangrove and often low intertidal zones had dismally stunted growth relative to the corresponding growth performance of individuals thriving at the high intertidal position and natural mangrove sites. From this evidence, this article argues that a more rational focus of the restoration effort should be the replanting of mangroves in the brackish-water aquaculture pond environments, the original habitat of mangroves. For such, a number of management options can be explored, the implementation of which will ultimately depend on the political will of local and national governments.

INTRODUCTION

During the past three quarters of the century, the deforestation of Philippine mangroves has been massive (1–8). Some 337 000 hectares (75%) of mangrove habitats have been lost, the bulk (278 657 ha; 66%) of which occurred between 1950–1990 (2, 3). Such forest loss has been largely attributed to its conversion into brackish-water fishponds (230 000 ha; ~60%) (2), as well as timber harvesting for building materials, firewood, charcoal, and coastal development. Realizing this immense decline in mangrove habitats, several mitigating efforts were implemented, the earliest (e.g., in Bais Bay in the 1930s and Banacon, Bohol, in the 1950s; 2–4; Table 1) of which were intended primarily for wood supply and coastal protection against winds and typhoons (2–4). However, these and most subsequent actions have been mainly vast afforestation (i.e., establishing mangroves on areas not previously forested) (4–7), although some of the more ideal reforestation and enhancement of existing forests can be mentioned (e.g., 8, 9).

During the past 2 decades, more than 44 000 hectares (10) (see also Table 1), mostly nonmangrove mudflats, sandflats, and seagrass beds had been planted with mangroves, using almost exclusively the genus *Rhizophora* (4–7, 11, 12). Relative to other mangrove genera, the large and long propagules of *Rhizophora* can be handled much more conveniently and may not require nursery culture before planting in frequently flooded (i.e., mid to low intertidal) areas. The estimated cost of such planting effort is at least PhP 880 million (USD 17.6 million), assuming a conservative cost estimate of PhP 20 000 (USD 400) per hectare (17) using 440 million *Rhizophora* propagules at a planting density of 1 per square meter (18). Given this seemingly immense effort, it is important to evaluate the outcomes and, where appropriate, apply what we learn to ongoing forest management (10).

In this study, we synthesize the findings of a number of research projects (11, 12, 16, 19–21), aimed at assessing a number of mangrove forest management locations in the Philippines (Pangasinan, Calauag and Tayabas Bays, Palawan, Bohol, Surigao, and Tawi-Tawi; Fig. 1) several years after the initiation of such efforts. Aside from determining mangrove community structure in these areas using the transect-plot method (i.e., species composition, stem density, size class, height, crown, etc.) (22), we focus our observations on those factors affecting the survival and growth performance of developing trees. More specifically, we assessed the differences in the vertical growth of young *Rhizophora* (the most commonly

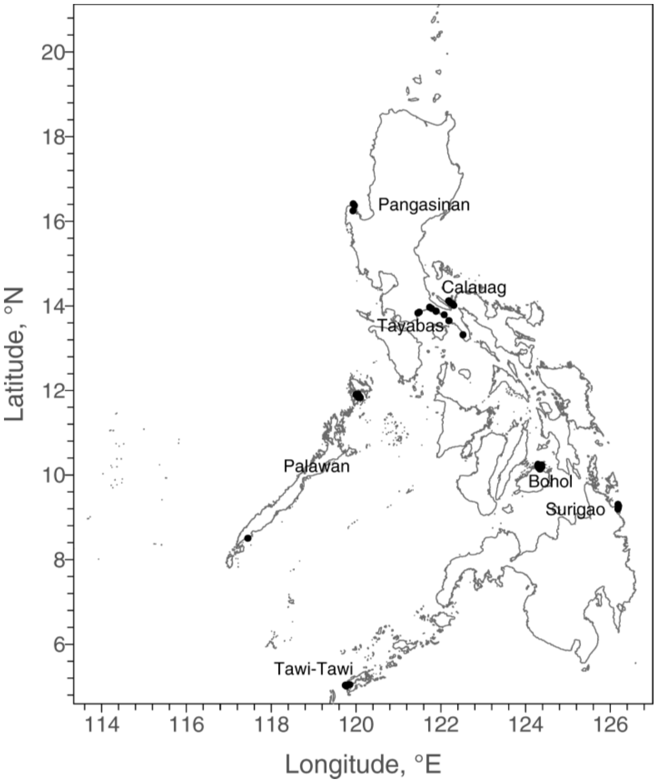

Figure 1. Mangrove locations surveyed (•) in a number of intensive field campaigns, covering >70 sites across the Philippines. These areas, particularly Tayabas and Calauag Bays, Palawan and Bohol, are among those where considerable amounts of mangrove forests still exist and where substantial planting efforts had been carried out.

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Table 1. Some of the better-documented mangrove management initiatives in the Philippines over several decades now. Several other similar initiatives elsewhere (e.g., Calauag, Sorsogon, Samar, Eastern Mindanao, etc.) had not been formally reported in accessible forms.

Location	Area (ha)	Year	Notes
Daco Is., Bais, Negros Oriental		1930s–1940s	Backyard planting (4, 6)
Bais Bay, Negros Oriental		1940s–1950s	"Hacienda" (along edges) planting (3, 4, 6)
Banacon Is., Jetafe, Bohol	400	1957–1958, 1964–1970	Community participation; included harvesting and selling of propagules, partial thinning operations for firewood, charcoal, piles, posts, and deployment of fish aggregating device within mangrove forests (3, 4, 6, 13)
Pagangan Is., Calape, Bohol	along a 4.8 km causeway	1968	School initiated (3)
Marungas, Sulu	150	1981	First large-scale government-initiated project (3)
Basilan, Sulu	50	1985	Bureau of Forestry Development (3)
5 sites in Bohol, Cebu, Negros Oriental	650	1984	Central Visayas Regional Project; World Bank-funded, USD 3.5 million; stewardship contracts (3)
Negros Oriental	14	As of 1986	Community-based (57 planters, two towns) (3)
Cebu	365	As of 1986	Community-based (384 planters, five towns) (3)
Bohol	562	As of 1986	Community-based (870 planters, 10 towns) (3)
Hunan, Buenavista, Bohol	4	1990–1995	Aquasilvipasture in an abandoned fishpond (13)
Catanauan, Quezon	0.8	—	Aquasilviculture (13)
11 regions under the Fisheries Resource Management Project	~1900	As of 2003	Project implemented by the Department of Agriculture–Bureau of Fisheries and Aquatic Resources with loan funding from Asian Development Bank and Japan Bank for International Cooperation (15)
Lucena City, Quezon	160 000 propagules planted	As of 2005	Local government unit (LGU) initiated project (16)
Pagbilao, Quezon	35	As of 2005	Partnership of LGU and Mirant–Pagbilao (16)
Unisan, Quezon	2	As of 2005	LGU-initiated (16)
Macalelon, Quezon	10	As of 2005	LGU-initiated (16)
Catanauan, Quezon	20	As of 2005	LGU-initiated (16)
Mulanay, Quezon	2	As of 2005	LGU-initiated (16)

Main sources: Primavera (3), Melana et al. (13, 14), Roldan (15), and MERF (11).

planted genus) at these sites, comparing, as much as possible, natural, reforested, and afforested vegetations. Vertical growth was derived by applying mainly age-reconstruction techniques (23, 24), corrected appropriately for plastochron intervals determined at selected sites (25).

PLANTING *RHIZOPHORA* IN NONMANGROVE AREAS

In the Philippines, the operations of brackish-water fishponds are governed by foreshore lease agreements ([FLAs] 25-year duration and renewable) between the operators and the state. Such FLAs helped facilitate the massive mangrove forest clearing in the mid- to late-1900s, although now such clearing for fishponds is completely outlawed (26). Ideally, mangrove reforestation should take back some of the 230 000 hectares of cleared mangrove areas. In recent years, the pressure from various sectors (nongovernmental organizations, scientific community, etc.) to revert some of the idle and/or abandoned aquaculture ponds into mangrove forests again has been mounting, but the legal process and mechanics to realize such advocacy have been extremely difficult until now (e.g., 27). Virtually no FLA certificate holders are willing to yield some of these areas for revegetation. Most want to hold on to their active FLAs and have those expiring and/or expired certificates renewed. Meanwhile, the clamor and financial support from both national and international sources for various mangrove restoration projects is increasing. As a consequence, the planting of mangroves has become a standard practice in coastal resource management (CRM) in recent years. The design and implementation of CRM plans often involves lengthy consultation, planning, and political consensus building on which certain zones of the coastal environment are delineated for mangrove planting. Typically, these zones were located in areas least likely to conflict with existing resource uses and interests (i.e., available intertidal sandflats mudflats, and/or seagrass beds) instead of the more desirable aquaculture ponds. Furthermore, the handy, large, and long propagules of *Rhizophora* were widely used as planting materials irrespective of where these zones were positioned in relation to the range where *Rhizophora* occurs in a natural zonation of mangroves (4, 6, 16).

Although this may seem sound from the perspective of coastal management, the practice has two major ecological problems: *i)* mangrove species-site incompatibility and *ii)* the conversion of other habitats (particularly mudflat, sandflats, and seagrass beds) into mono-specific *Rhizophora* plantations. These mudflat, sandflats, and seagrass beds are usually located at seafronts (and thus exposed to stronger mechanical wind stress and wave action) and are frequently within the low intertidal zone. *Rhizophora* species are broad-leafed and occur naturally in the mid-forest, middle intertidal zone, so being planted at the seafronts may pose serious survival problems (28, 29). Wind and wave stress damage planted seedlings directly and carry debris (macroalgae, trash, logs; Fig. 2b,e). In many cases, the anchoring architecture of young *Rhizophora* (in contrast to those of *Sonneratia* and/or *Avicennia* occurring more commonly at the seafronts) cannot withstand the eroding power of direct wave action (Fig. 2d, h). In cases where such plantations are already at the low intertidal zone, drowning of the seedlings may occur during periods of the year when the mean tide level is high and young plants are submerged over an extended period (Fig. 2a) (see also 30, 31). Adding to this stress of prolonged immersion, the stems of seedlings have also been found to serve as desirable substrates for colonizing oysters and barnacles (Fig. 2f), hastening the mass mortalities of *Rhizophora* seedlings in some sites (16, pers. obs.).

Even granting that some mangroves planted in these apparently inappropriate environments survive and flourish (e.g., NE Bohol mangrove plantations), the habitat gains may be offset by the corresponding loss of mudflats and sandflats (which, at low and high tides, may be used as feeding grounds for shorebirds and some species of fish, respectively) and productive seagrass meadows may just offset whatever modest gains we may have in converting these zones into mangrove habitats (see also 7).

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Figure 2. Some examples of the less successful mangrove enhancement initiatives in the Philippines, mainly planting *Rhizophora* at the seafronts: (a) under a prolonged period of immersion, *Rhizophora* seedlings planted at the lower intertidal zone may "drown," causing massive mortalities in Tayabas Bay (16, pers. obs.); (b and e) macroalgae and other debris may cause defoliation of the broad-leafed *Rhizophora*; (c and g) planting between pneumatophores (c) of *Sonneratia* and aided by bamboo stakes (g) did not prevent many *Rhizophora* seedlings from dying (g; i.e., <50 of the ~1000 seedlings planted survived; Agdangan, Quezon); (d and h) part of 10-ha mangrove plantation (carbon-sink) effort in which *Rhizophora* seedlings mostly (i.e., >95% of the seedlings within sampling plots) died after only about 9 months, apparently because of the mechanical stress of wave action and substrate erosion; and (f) seedling stems serving as substrates for oyster colonization.

GROWTH PERFORMANCE OF THE SURVIVING TREES

Although the stem density and canopy cover of reforested and/or afforested mangroves did not significantly differ from those of existing natural stands (Table 2), these mainly afforestation efforts (if able to overcome high seedling mortalities through redundancies [18] and persistent replanting [pers. obs.]) drastically altered the natural species assemblage pattern, transforming the *Avicennia–Sonneratia* dominated seafronts into monospecific *Rhizophora* zones (Fig. 3). Inferring from the growth patterns of young individuals, the surviving *Rhizophora* trees at the seafronts performed dismally relative to their counterparts at the high intertidal zones. For example, the internodal lengths along the main stem of *Rhizophora* surviving in the coarse, sandy, low intertidal zone in NE Bohol were <5 cm during 12 years of existence (1992–2004) and were <3 cm during the initial 10-y period (Fig. 4). This was in strong contrast to the growth performance of the same species growing in the corresponding high intertidal area, showing much longer internodes (average length: ca. 10 cm) and reflecting much clearer seasonal and interannual variability (range: 3–14 cm). One internode is equivalent to a vertical elongation over about 40 days (23–25, 32). In a broader perspective, such poorer growth performance of young *Rhizophora* at the seafronts in NE Bohol (Fig. 4) was also shown clearly in all of the other mangrove study areas across the country (Fig. 5), demonstrating that *Rhizophora* individuals surviving at the low intertidal zone (seafronts) would barely attain 3 m in height during the first 10 years, whereas the corresponding vertical growth of *Rhizophora* trees at the high intertidal zone would be 2–3 times as much.

Furthermore, the prop-root architecture of *Rhizophora* trees at the seafront, although also able to trap sediments, would be likely less efficient in maintaining sediment elevation as compared with the complex pneumatophore system of the

Table 2. Canopy index (i.e., total crown area relative to the area of substrate surveyed) and stem density (i.e., number of trees per 100 m^2) of various mangrove forest types (natural, reforested, and afforested) across different locations in the Philippines. Reforested and afforested types were mostly situated at the low intertidal positions. Numbers in parenthesis indicate the number of sites sampled within locations (Fig. 1). Error terms are standard deviations.

Location	Parameter	Natural	Reforested	Afforested	Overall
Calauag	Canopy	2.432 ± 2.275 (5)	2.785 ± 1.431 (10)	3.220 ± 2.616 (2)	2.732 ± 1.713 (17)
	Stem density	30.2 ± 18.2 (5)	40.7 ± 15.2 (10)	43.0 ± 19.8 (2)	37.9 ± 16.3 (17)
Tayabas	Canopy	3.506 ± 3.098 (22)	3.288 ± 1.155 (5)	—	3.465 ± 2.822 (27)
	Stem density	42.0 ± 26.3 (22)	67.2 ± 39.8 (6)	100.0 ± 0.0 (3)	52.5 ± 33.1 (31)
Palawan	Canopy	2.384 ± 1.389 (10)	4.950 ± 0.000 (1)	1.570 ± 0.919 (2)	2.456 ± 1.473 (13)
	Stem density	21.7 ± 14.6 (10)	36.0 ± 0.0 (1)	66.5 ± 41.7 (2)	29.7 ± 24.2 (13)
Bohol	Canopy	2.215 ± 1.435 (2)	1.410 ± 0.000 (1)	2.270 ± 0.000 (1)	1.129 ± 1.029 (7)
	Stem density	26.0 ± 9.9 (2)	27.0 ± 0.0 (1)	92.5 ± 60.8 (4)	64.1 ± 55.8 (7)
Surigao	Canopy	3.925 ± 1.096 (2)	—	2.270 ± 0.000 (1)	3.373 ± 1.230 (3)
	Stem density	53.5 ± 29.0 (2)	—	55.0 ± 0.0 (1)	54.0 ± 20.5 (3)
Tawi—Tawi	Canopy	1.286 ± 0.191 (2)	1.640 ± 0.000 (1)	—	1.403 ± 0.245 (3)
	Stem density	30.0 ± 22.6 (2)	16.0 ± 0.0 (1)	—	25.3 ± 17.9 (3)

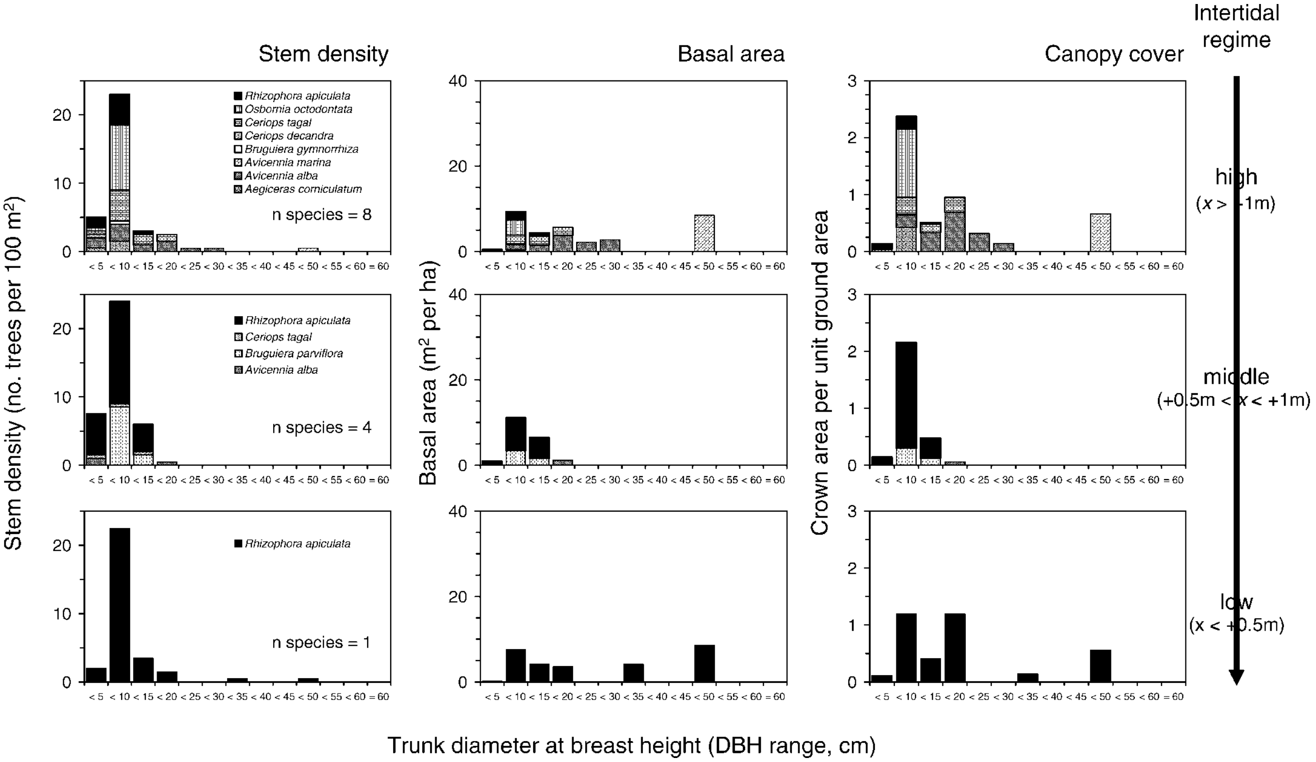

Figure 3. Afforesting the seafront: tree density, basal area, and canopy cover of mangrove trees in Lagay (Calauag), traversing across an intertidal regime (i.e., high, mid, and low intertidal; *x* range indicates elevation relative to the mean low tide level [zero datum]). Values for different tree classes (DBH range) are also shown.

naturally-seafront taxa *Avicennia* and/or *Sonneratia* (33, 34). If one of the objectives of mangrove forest enhancement is the mitigation of upland-derived sedimentation on more seaward habitats (e.g., seagrass beds and coral communities), such sediment trapping and retention capacity of various mangrove species should be seriously considered as well.

ACTION POINT: REVISIT CURRENT PRACTICES AND REVERT SOME AQUACULTURE PONDS INTO MANGROVE FORESTS

The circumstances (ecological, socio-institutional, and economic; see also Table 3) surrounding the management of a particular coastal area can be very complex. However, the widespread practice of converting the "available" mudflats, sandflats, and seagrass beds into often monospecific *Rhizophora* forests should be reconsidered. Such expensive and labor-intensive efforts offer little ecological gains. It would be far more appropriate to reforest some of the former (natural) mangrove areas, which are

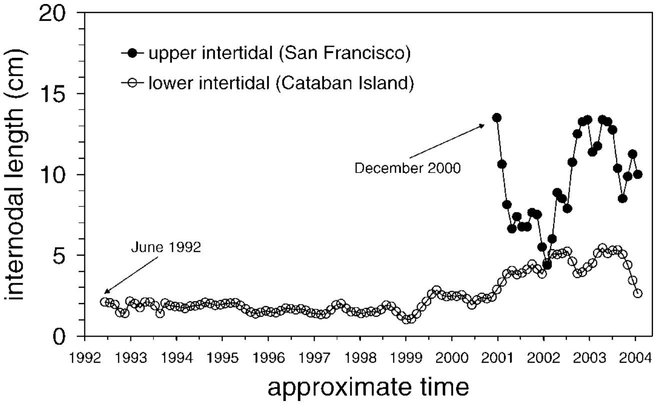

Figure 4. Temporal variation in the length of internodes along the main stem of young planted *Rhizophora apiculata* growing in Cataban (coarse sand, low intertidal zone) and San Francisco (muddy, high intertidal zone) in Talibon NE Bohol. For clarity, error bars were omitted.

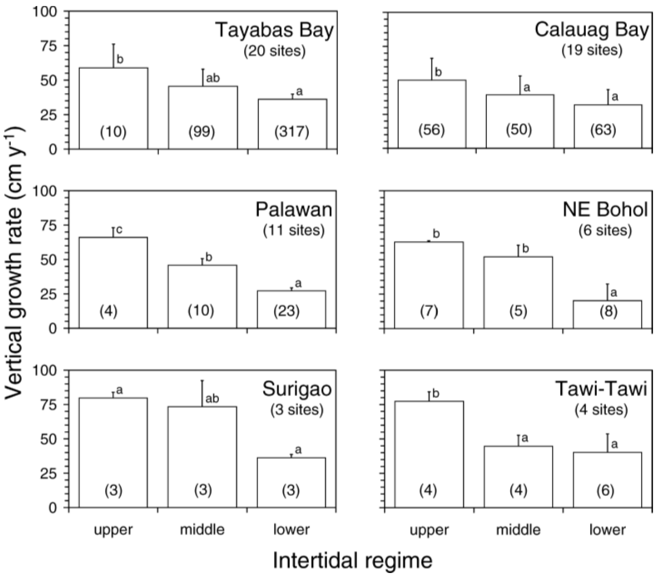

Figure 5. Estimated mean annual rates of vertical growth (i.e., internodal increments along the main stem) of young *Rhizophora* spp. trees growing in different intertidal regime (i.e, high, mid, and low intertidal zones) in six mangrove locations in the Philippines, with various number of sites per location. Numbers in parentheses inside bars indicate the total number of young mostly-planted trees sampled corresponding to the tidal regime. Different letters attached to bars indicate significant differences ($p < 0.05$; Tukey test) across tidal regime within sites.

Table 3. Ecological, social/institutional, and economic circumstances surrounding mangrove management initiatives in the Philippines.

Ecological	Social/ institutional	Economic
Lack of baseline ecological assessment of the target areas prior to mangrove rehabilitation (11) Site and species unsuitability (11, 13) Monospecific forest (*Rhizophora* spp.) (11) Poor growth performance (11) Infestations by barnacles and other pests (11, 13) Natural calamities (11, 13) Domestic and agricultural pollution (13) Animal grazing (11, 13) Sand accretion (11)	Lack of clearly defined goals of mangrove management (10) Lack of sustainability mechanisms such as monitoring and evaluation system, maintenance, and financing support (11) Aquaculture as a development strategy (3) Lack of coordination among concerned agencies (3) Weak law enforcement, especially on the moratorium on fishpond development and cutting of mangroves (3) Lack of interest by the local community (13) Conflicting interests of various users (3) Reforestation contracts benefited only a few (13)	Food security Low perceived economic values of mangrove habitats and hence aquaculture development was favored (3) Lack of funding for sustainability of projects (11) Long waiting time for economic returns (3) Mismanagement of funds (3)

currently utilized as brackish-water fishponds. The legal, institutional, and economic challenges of doing so are overwhelming. The issue of food security also merits consideration. By producing fish and fishery products through aquaculture rather than harvesting from overexploited wild stocks, an important protein source for the booming human population is provided. But as has long been argued, a balance between aquaculture food production and the conservation of mangrove habitats must be achieved given the many and diverse values offered by mangroves, including diverse seafood, wood products, storm protection, etc. (4, 8, 9, 36–38). Often, when taken together, such values may far exceed the benefit of producing fish in the ponds.

Preliminary Questions

In the Philippine context, determining the management options for idle and active brackish-water aquaculture ponds might be pursued by first addressing some prejudicial questions on whether *i)* the ponds are covered with existing and valid FLAs; *ii)* the fish production from these ponds would be necessary in a broader fisheries perspective, perhaps as evaluated using bioeconomic analysis tools that compare costs and benefits of various management actions (e.g., Grasso [39] and other broader-scale models [40–42]); *iii)* these ponds are operating at optimal levels (e.g., various systems of prawn culture [1]), and *iv)* these ponds, if indeed reverted, could be revegetated by natural recruitment of mangrove propagules. Depending on the answers to these questions, a decision tree might be constructed (Fig. 6), leading to a number of management options.

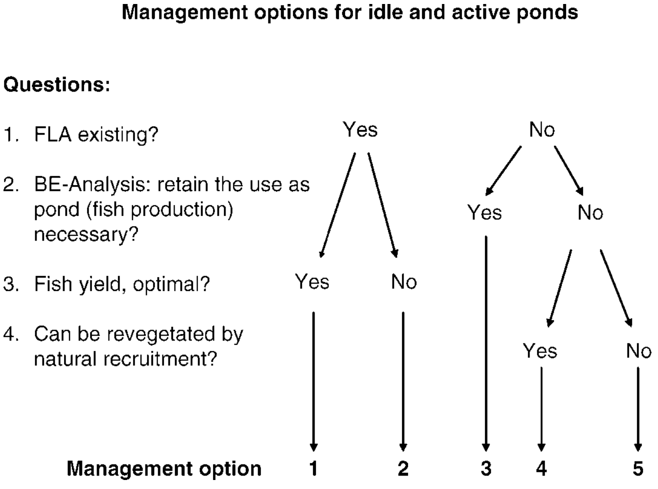

Figure 6. A possible decision-tree of options for idle and active brackish-water fishponds in the Philippines: (1) Status quo; (2) Optimize fish yield and reduce pond size as small as possible; (3) If pond existence is necessary based on a bioeconomic analysis, reapply for FLA; go to Question 3; (4) Restore the natural tidal flooding regime by removing pond dikes to enable natural revegetation, and (5) Determine physico-chemical conditions, may need to restore substrate elevation (7, 41), study species appropriateness, reforest applying species suitability and community succession principles.

Management Options

Option 1. For ponds with valid FLAs and optimal operation, the only option would be to leave those ponds as they are now. These legal rights make questions 2 and 4 irrelevant.

Option 2. For ponds with valid FLAs but operating at a suboptimal level, measures to increase fish yield per unit pond area should be pursued (for instance, see Primavera [1]). By doing so, some portions of the existing pond area may no longer be necessary. For such excess area, FLA holders should then be encouraged to terminate the FLA covering the portion of the existing ponds, and revegetation must be pursued following either Option 4 or 5. To make this option more amenable to FLA holders, economic incentives (e.g., tax holidays, ecolabeling, technical support to optimizing operation, disease control, etc. [43]) may be explored.

Option 3. For ponds without valid FLAs (i.e., terminated, expired, or otherwise illegal ever since), question 2 should be asked to evaluate whether retaining the use of the area (either in its entirety or just some part thereof) as aquaculture ponds would still be desirable. If that is the case, an FLA may be sought. Among others, the bioeconomic analysis (39–42) may consider the supply (including wild stocks) and demand of fish in both a local and a much broader fisheries perspective.

Option 4. For ponds without valid FLAs and where existing conditions (mainly physico-chemical characteristics and the dispersal possibilities of propagules from nearby areas) permit natural revegetation, the pond dikes may be removed. The resulting reinstallation of the natural tidal flooding regime should permit natural recolonization of mangroves (see also 7).

Option 5. In many cases, aquaculture operations will have significantly altered the sediment conditions of sites. The possibility of natural colonization may be low as well in cases where nearby mangroves have been cleared or highly fragmented. Taking site-specific conditions into account, a full-scale restoration may then proceed carefully, with consideration of the suitability of species and the principles of community succession.

Indeed, focusing our effort on reverting brackish-water ponds into mangrove forests again will yield much more substantial results. To illustrate, there are 230 and 480 hectares

Table 4. Estimated extent of mangrove areas in Tayabas Bay; historical potential (derived from topographic maps from National Mapping and Resources Information Authority) and 2000 satellite image (classified to distinguish mangrove areas).

	Extent of mangrove area, hectares					
Town/city	Historical potential	% of total	2000 satellite image	% of total	Forest loss	% reduction
Lucena	830.11	14.15	190.32	10.58	639.79	77.07
Sariaya	276.13	4.71	85.60*	4.76	190.53	69.00
Pagbilao	1222.59	20.83	549.33	30.54	673.26	55.07
Padre Burgos	782.95	13.34	287.56	15.99	495.39	63.27
Agdangan	157.62	2.69	52.79	2.93	104.83	66.51
Unisan	365.55	6.23	186.58	10.37	178.97	47.67
Pitogo	554.46	9.45	69.02	3.84	485.44	87.55
Gumaca	57.04	0.97	17.68*	0.98	39.36	69.00
Macalelon	389.04	6.63	73.39	4.08	315.65	81.14
General Luna	281.24	4.79	30.80	1.71	250.44	89.05
Catanauan	527.25	8.99	101.65	5.65	425.60	80.72
Mulanay	88.52	1.51	51.90	2.89	36.62	41.37
San Francisco	335.59	5.72	102.26	5.68	233.33	69.53
Total for Tayabas Bay	5868.09		1798.88		4069.21	69.53

*Absent in classified image, assumed 69% loss (average for all sites).

of idle and active aquaculture ponds, respectively, in Calauag (44). Revegetating most of these existing idle ponds (see also 7, 45) will have far greater impact than converting a number of inappropriate sites (i.e., 1–2 hectares of sandflats, mudflats, and seagrass beds) as commonly practiced over the last decade. This will increase the present mangrove cover (930 ha [44]) by 25%. A parallel argument could be put forward for Tayabas Bay, which lost about 70% of its historical mangrove cover (Table 4) to mostly aquaculture development.

Other essential pursuits: lessons learned from field observations. Synthesizing the findings from our research activities (11, 12, 19–21), management efforts need not be limited to revegetating former mangrove areas and/or creating new mangrove plantations. Enhancing the productivity of existing degraded and fragmented forests should also be pursued by filling-in forest openings. It may be desirable to pursue mangrove planting along the seaward edge because of competing land uses. In such case, it would be better if pneumatophore-producing taxa and those better adapted to seafront conditions (e.g., *Avicennia*, *Sonneratia*, etc.) were planted before other species. With the pneumatophores, sediment trapping and substrate conditions modification are facilitated, which may enhance natural recruitment by trapping more mangrove propagules. To increase the success rate in such areas, seedlings should be protected against strong waves, wastes, and debris (e.g. stakes, fence, protective nets, etc.). In any case, mangrove nurseries may need to be established.

To further increase the collaboration of local communities, the current honorarium-based incentive system might be strengthened by, for example, *i)* granting permits and licenses for aquasilviculture; *ii)* enhancing a market system for permissible harvests (i.e., oysters, crabs); and *iii)* granting tenurial instruments (i.e., community based forest management agreement) (see also 4, 5). In an increasing number of successful cases, ecotourism in mangrove areas (i.e., bird watching and other nature-appreciation board walks with local guides) has brought a supplemental livelihood to the local community and thus may be pursued. Excellent models (also the more ideal reforestation efforts) would include the Pagbilao Mangrove Demonstration Site (Tayabas Bay), the Pangasinan Mangrove Reserve (Bani, Pangasinan), Buswang Mangroves (Aklan), and the Talabong Mangrove Forest Reserve (Bais Bay, Negros Oriental).

Finally, the stronger role of the local government units (LGUs) in coordination with the Department of Environment and Natural Resources and the Bureau of Fisheries and Natural Resources is crucial in the design, implementation, monitoring, and evaluation of any mangrove enhancement project. Of critical importance is the stronger involvement of the LGUs in defining clearly the goals (coastal protection, fisheries and productivity, ecotourism, etc.) and thus also formulating the indicators of success. In making the role of LGUs stronger, the sustainability of these efforts would be, to a large extent, enhanced through appropriate local legislations, competent management bodies, and corresponding local budget allocations rather than relying as they have on initiatives driven from the national and international levels.

CONCLUSIONS

The massive deforestation of Philippine mangroves over the past three quarters of the century has, in recent years, prompted various efforts to increase mangrove coverage. These efforts have mainly included afforestation of *Rhizophora* spp., converting mudflats, sandflats, and seagrass meadows into often monospecific mangrove forests, making the ecological gains of such efforts highly uncertain. Worse, in these nonmangrove areas, seedlings experienced high levels of mortality and, in the few that survived (apparently through stubborn, expensive replanting), have displayed dismally stunted growth relative to the corresponding growth performance of individuals thriving at the high intertidal position and natural mangrove sites.

Our evidence suggests that the current practices and strategies on mangrove forest management in the Philippines need to be reviewed. This article stresses that a more rational focus of such efforts should be on the recovery of some of the former mangrove areas that were lost to brackish-water aquaculture. A number of prejudicial questions could be evaluated that may lead us to constructing a decision tree and hence aid in identifying a number of highly workable options. In the end, however, implementation of these options may depend on the political will of local and national governments.

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17. Roughly, the further breakdown would include: PhP 5000 (USD 100) for propagules; PhP 10 000 (USD 200) for labor; PhP 3500 (USD 70) for transportation, and PhP 1500 (USD 30) for fence and other materials. This estimate does not include expenses for redundancies (18), subsequent monitoring, maintenance, and/or replanting activities.
18. A spacing of 1 m apart between seedlings has been recommended by the Department of Environment and Natural Resources (DENR), Philippines (14). This spacing recommendation has been strictly followed across the country, although in many cases (11, 12, 19–21), 2–5 seedlings were planted together on the same spot at the same time (redundancy), apparently hoping that at least 1 would survive.
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Maricar S. Samson works on various aspects of mangrove restoration leading toward her PhD degree in environmental science and management. She has also worked in several projects dealing with the management of coastal zones including policy reviews. Her address: The Marine Science Institute, College of Science, University of the Philippines, Diliman, Quezon City 1001 Philippines.
E-mail: msamson@upmsi.ph

Rene N. Rollon is an associate professor at the Institute of Environmental Science and Meteorology, University of the Philippines, Diliman, where he studies various aspects of the biology and ecology of seagrasses and mangroves. His address: Institute of Environmental Science and Meteorology, College of Science, University of the Philippines, Diliman, Quezon City 1101 Philippines.
E-mail: rnrollon@up.edu.ph