Philippines: Mangrove-friendly aquaculture

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Abstract

Mangrove areas in the Philippines were once considered vast tracts of wasteland that can be developed into other land uses. The economic "advantages" associated with such exploitation were considered socially "valuable" to human communities. Such advantages and exploitation, however, are now questioned, with the cost to society reevaluated. This paper discusses the factors causing mangrove deforestation with emphasis on aquaculture. Existing and future programs like the government's Coastal Resource Management project for the implementation of mangrove-friendly aquaculture are presented. Research needs and problems affecting mangrove management are likewise discussed.

Brief overview of aquaculture

Aquaculture is a major contributor to overall fish production. It is the only sector where continuous growth has been attained when compared to the municipal and commercial fisheries sectors. Aquaculture production of 392,348 tons in 1982 rose to 957,390 tons in 1997. This is about 35% of total fish production (2,766,507 tons) in 1997, a big contribution inspite of the many problems confronting the industry.

In 1996, there were 239,323 ha of brackishwater ponds although production varied according to fishpond management. Milkfish and tiger shrimp are still the major commodities reared and produced through aquaculture.

Table 1. **Estimates of mangrove forest area and depletion rates, 1920-1988**

Year	Estimated mangrove forest (ha)	Average depletion (ha/yr)
1920	450,000[a]	
1950	375,020[b]	2,499
1972	227,947[c]	6,685
1988	139,100[d]	5,553
1988	149,400[e]	4,572*
1988	141,713[f]	

[a] Brown and Fisher. 1920. Minor forest products of the Philippines. Bureau of Printing, Manila
[b] Aerial photographs taken in late 1940s and early 1950s by NAMRIA
[c] Digital analysis of 1972 LANDSAT data (NRMC)
[d] DENR. 1988. Philippine-German Forest Resources Inventory Project
[e] Swedish Space Corporation. 1988. Final report on mapping of the natural conditions in the Philippines (SPOT satellite images)
[f] NAMRIA's manual interpretation of 1987 SPOT satellite data
*1920-1988

Table 2. **Remaining mangrove areas in the Philippines in 1988,** by region and province (NAMRIA 1990)

Region	Province (area in ha)	Area (ha)	% of total
1	Pangasinan (200)	200	0.14
II	Cagayan (3,000), Isabela (400)	3,400	2.43
III	Pampanga (300), Zambales (200)	500	0.36
IV	Aurora (300), Marinduque (1,100), Occ. Mindoro (900) Or. Mindoro (1,500), Palawan (42,300), Quezon (4,000) Romblon (700)	51,000	36.50
V	Albay (400), Camarines Norte (2,500), Camarines Sur (2,500), Catanduanes (1,200), Masbate (1,500)	9,900	7.09
VI	Aklan (0), Antique (100), Capiz (1,700), Iloilo (300) Negros Occ. (725)	2,825	2.02
VII	Cebu (400), Bohol (8,700), Negros Or. (550)	9,650	6.91
VIII	Eastern Samar (6,000), Northern Samar (5,500), Western Samar (10,450), Leyte (2,900)	24,850	17.79
IX	Basilan (3,600), Sulu (*), Tawi-Tawi (*), Zamboanga Norte (300), Zamboanga Sur (15,400)	19,300	13.81
X	Agusan Norte (1,100), Agusan Sur (*), Misamis Occ. (1,200), Misamis Or. (*), Surigao Norte (6,300)	8,600	6.15
XI	Davao Norte (*), Davao Sur (*), Davao Or. (800), South Cotabato (*), Surigao Sur (6,300)	7,100	5.08
XII	Lanao Norte (1,300), Maguindanao (300) Sultan Kudarat (800)	2,400	1.72
Total		139,725	100.00

*not available

Table 3. **Mangrove area converted to fishponds** (ha)

Year	BFAR[1]	Change In area	BFAR[2]	NAMRIA[3]
1970	168,118	3,704		
1971	171,446	3,328		
1972	174,101	2,655		
1973	176,032	1,931	530	
1974	176,032	0	3,401	
1975	176,032	0	3,913	
1976	176,032	0	5,391	
1977	176,032	0	5,847	
1978	176,230	198	3,818	2,764
1979	176,230	0	5,717	3,348
1980	176,230	0	6,727	29,805
1981	195,831	19,601	5,932	12,992
1982	195,831	0	3,850	13,516
1983	196,269	438	3,985	9,676
1984	206,252	10,256	3,700	17,396
1985	205,000	(1,525)	3,159	1,891
1986	210,319	5,319	2,580	8,653
1987	210,458	139	3,213	27,598
1988	210,681	223	1,977	860
1989	210,681	0	514	70

[1]Data from the Philippine Fishery Statistics, 1970-1985, and NEDA Statistics Yearbook, 1986-1989. The annual area reported is cumulative
[2]Data from the list FLAs issued by BFAR Licensing Division as of 1973
[3]Data from the list released by DENR to BFAR on suitable areas for fishponds

Aquaculture development and mangrove area conservation

For many years, mangrove areas were considered vast tracts of wasteland that can be developed into other land uses. Vegetations were cleared to give way to development or when its presence was considered unsightly. The then Bureau of Forest Development (BFD) reported in 1967 that mangrove areas covered 418,990 ha; 15 years later, only 239,387 ha existed (Table 1); and to date, only 139,735 ha remained (NAMRIA 1990). Table 2 presents the distribution of remaining mangroves in the country. NAMRIA noted that 95% of presently existing ponds are former mangrove areas developed between 1952 to 1987. In 1952, there were 89,000 ha of fishponds which expanded to 210,681 ha in 1989 (Table 3).

Causes of mangrove destruction

There are many. On top of the list is utilization for charcoal/firewood. Other factors are expansion of agricultural areas including fishponds, urban and industrial development, harbor and channel construction, mining, and community housing projects.

Policies, legislation and regulations

The depletion of mangrove resources prompted the Philippine government to formulate policies and legislation for its protection. Some of these legislations were general in nature, some are more specific laws. In 1989, the government adopted the Philippine Strategy for Sustainable Development (PSSD) to resolve and reconcile the conflicting issues from different sectors. Among the PSSD implementing policies are:

Administrative jurisdiction: DENR is authorized to control and administer mangrove resources (Executive Order 192); protect and maintain buffer zones (DENR Administrative Order 76); protect, develop and manage mangrove areas (AO 15). DA-BFAR, on the other hand, is authorized to manage fishponds.

Legislation: Presidential Decree 159 provided for silvicultural and harvesting scheme for mangroves; PD 704 (1975) provided for buffer zones along shorelines facing seas and lakes and the general protection of mangrove areas; and PD 2151 and 2152 (1981) declared 74,268 ha of mangroves as wilderness areas and forests reservoirs. Letter of Intent 917 provided for the protection of mangrove forests; Memorandum Circulars (s. 1989, 1992, 1993) declared *Oplan Sagip-Gubat* as a banner program of DENR and provided for the participation of local people in reforestation. Lastly, the Fisheries Code of 1998 promotes conservation and management of mangrove resources.

Existing programs on appropriate utilization of mangrove areas

Programs for the preservation, development and rehabilitation of mangroves are being implemented jointly by DENR and DA through the National Mangrove Committee (NMC), and concerned non-government organizations. NMC was created in 1976, and was tasked to formulate a comprehensive national mangrove plan and to review fishpond and timber license applications. The result of NMC's inventory was used in PD 2151 and 2152.

Another approach was the reforestation of degraded areas. Mangrove rehabilitation started as small scale community-based projects in the provinces of Bohol, Cebu and Negros Oriental. In recent years, however, contract reforestration, agreement or stewardship or 25-year leases were undertaken. As of 1990, there were 8,705 ha planted to mangroves (Table 4).

The programs undertaken by DENR and NGOs include: (1) Central Visayas Regional Project I (CVRP-1), Rural Rainfed and Development Program (RRDP), Palawan Integrated Area Development Program (PIADP), Organization for Industrial, Spiritual and Cultural Advancement (OISCA), National Reforestation Program (NFP), Fisheries Sector Program (FSP), and Coastal Environment Program (CEP).

On fishpond development, the existing Joint DA-DENR General Memorandum Order No. 3 s. 1991 promotes the rational utilization of mangrove forest lands, previously released for fishpond development. Some provisions:

- Undeveloped ponds (no dikes and no water control structures; water in pond can not be changed by tidal action), and abandoned or unproductive ponds shall be reverted to mangrove forests

Table 4. **Mangrove areas reforested**
(as of December 1990)

Region	Area (ha)
I	575
II	252
m	1,292
IV	1293
V	741
VI	519
VII	820
VIII	939
IX	1,280
X	598
XI	396
XII	-
Total	8,705

Source: Planning Division, DENR, Quezon City

- Areas no longer covered by fishpond leases or found vegetated with mangroves shall revert to DENR

The Fisheries Code of 1998 strengthened the above Order, having pro-environment provisions such as: (1) reforestation of river banks, bays, streams and seashore fronting reservoirs, settling ponds, and other pond facilities; (2) granting of incentives and non-incentives for sustainable aquaculture practices; (3) reversion of all abandoned, undeveloped, or underutilized fishponds to mangrove state; and (4) provision for a *Code of Practice for Aquaculture* based on FAO's Responsible Fisheries Code.

The Fisheries Resource Management Project, a component of the Coastal Resource Management Program (CRMP) which supports mariculture development and generation of non-fishing employment for municipal fisherfolk is probably one of the most important programs of DA-BFAR. FRMP will diversify the source of income of fisherfolk, and reduce their reliance on fishing, thus facilitating implementation of mangrove resource conservation and protection.

Lastly, the promotion of the technology on marine cage culture can divert the attention from fishpond to mariculture.

Model areas of mangrove-friendly aquaculture

Under BFAR's CRMP, the culture of mudcrab, some fishes and molluscs are considered for aquaculture in the mangroves. But since the participation of local communities is very much required, community organization and training is first implemented. In the process, pilot testing of the technologies known to be successful in other countries will follow.

Aquasilviculture in Ubay, Bohol

In 1987, DA started aquasilviculture in its Ubay Brackishwater Research Station in Bohol. The idea came from a cross-country visit to Indonesia by one of DA's regional directors. The station's farm area is divided into 4.94 ha of aquasilvi pond, 4.22 ha of open ponds, 1.0 ha of experimental ponds, and 0.08 ha infrastructure (Figure 1).

The developmental scheme of this project is something to reckon with. In 1987, mangrove propagules were planted in rows inside the 2.63 ha (MP#4) and 2.32 ha (RP2 and MP2) fishponds, taking into consideration that sufficient spaces between the dikes and the newly planted trees is left. About 20% of the pond area was utilized for fish culture, while 80% was planted to mangrove.

During the first five years of the project (1987-1993), the area was stocked with milkfish fingerlings at the rate of 1,000-3,000/hectare. There was no feed given, but production was observed to be good, producing as much as 1 ton/ha/yr. To date, the trees are on its 15th year, but no harvest of mangrove trees is done. There are as many as 20,000 fully grown trees at the center of the pond. There are still spaces between the dikes and trees where aquaculture is undertaken, but the area is no longer stocked with milkfish fingerlings. It is used as a free entry area for various marine fish species coming from the sea through the main supply canal.

To maintain ample spaces between trees, regular thinning or removal of small old branches is undertaken every 3 months. This further avoids total shading of the pond which can lead to anaerobic condition in the bottom.

Mangrove trees are also planted inside the milkfish ponds, along the periphery of the main dike, and outside the pond along the water supply canal. The trees not only protect dike from erosion, but also make the soil compact and firm. The litter or fallen leaves that decay outside or in the pond provides organic fertilizer which enhances the growth of natural food. The fully grown mangrove trees are now luxuriantly growing.

After the beneficial impact of mangrove trees was noted, another pond compartment (1.6 ha) was planted with mangrove trees in 1995 with 20:80 ratio of pond space to mangrove. The trees are now five years old, but the area is still used for growing milkfish fingerlings to marketable sizes.

Fish production

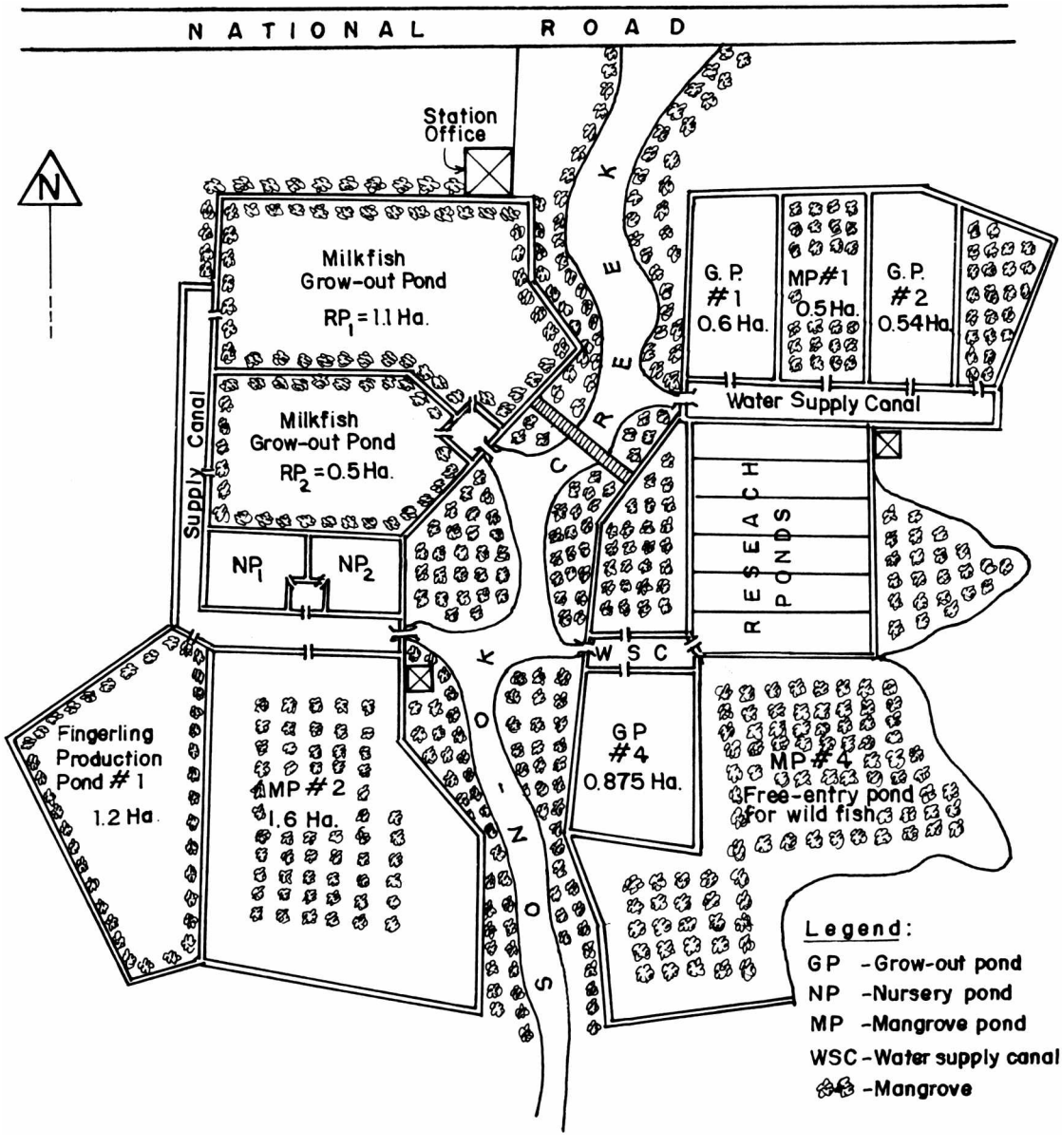
Fish production in the mangrove-aquaculture ponds may not be too high, but it consisted of several species of high commercial value. Although there was no recording made by the station staff, they reported that about 500 kg of several fish species were recovered in 1998 from the 2.27 ha pond. The fishes were caught at the entrance of the pond, including: siganids, tilapia, groupers, shrimps, mullets, barracudas, caravalle, slipmouth, whiting, milkfish, ten pounder, tarpons, scats, goby, snappers and sea bass. Crustaceans (blue crabs, shrimps) and molluscs (oysters, clams, snails) were also collected.

It was noticeable that big-sized carnivorous species like groupers, snappers and barracudas were collected. Few planktonic and herbivorous feeders were caught. Fishes collected were big, some were over 1 kg each (grouper barracuda, snapper, others).

Other observations and problems encountered

Wild birds. The area serves as a refuge/sanctuary for wild birds and ducks, too. These are commonly

Figure 1. **Layout of Ubay Brackishwater Demonstration Farm** (not drawn to scale)



observed in the morning. Birds usually found only in the forests are seen among the trees.

Fish monitoring and harvest. The presence of mangrove roots and watered depressions in the mangrove forests posed a problem in assessing the fish stocks. Total fish harvest was also a problem particularly when the stock was grouper. They took refuge in tree roots or got buried in mud when water receded. The fish were found weak and some died when recovered. This affected marketing since live groupers are preferred.

Death of mangroves. Some species of mangroves are not resistant to prolonged submersion of its aerial roots, leading to their death.

Thick growth of filamentous algae. Mangrove-aquaculture ponds were observed to have an overgrowth of filamentous green algae, covering the entire pond surface. Such condition is not very favorable to fish stock as it could lead to oxygen depletion at night and may result in fish kills.

Agri-nipa-aquaculture farm in Puerto Galera, Mindoro

The agri-nipa-aquaculture (ANA) project in Tabinay, Puerto Galera started in March 1989. Productivity of the area prior to ANA establishment was very low since the site was mostly covered with tall reed grass. An area measuring 1,400 m^2, located in the central part was already planted to nipa while rice (5,000 m^2) was planted in the southern part. Rice production was very poor according to the farmer because of its proximity to the sea and salt sprays carried by winds.

Protection of existing mangrove stands
At the start of the project, the second growth mangrove stand fringing the site was protected from wood gatherers. The mangrove area is about 3.68 ha consisting of six species. The mangrove stand protect the site from strong waves, typhoons and strong winds. Some open areas and skips were planted to *Rhizophora* species.

Fishponds
It took three months to plan and construct the nipa-aquaculture ponds. Two fishponds were constructed (Figures 2 and 3). One was around the newly established nipa plantation (Pond I), and the other was around the established mature nipa stands (>2 years) (Pond II). Tilapia and milkfish fry were stocked in each pond. Mixed stocking was also done.

Nipa plantation
Nipa accounted for 80% of the central portion of ponds I and II. Nipa seedlings about 4-5 months old were used to plant Pond I. The seedlings were spaced either 1 or 2 m apart Nipa was used instead of mangrove trees because of its higher economic potential in the area. It can be compared with coconut in terms of economic value. Its ecological role includes erosion control, coastal protection and stabilization, and provision of sanctuaries for some marine species. Its leaves are used in making nipa shingles, native bags, coarse baskets, hats, mats, brooms and raincoats. Nipa sap can also be extracted and processed into alcohol, wine, sugar and vinegar.

Fruit and vegetable crops
Agricultural crops were planted on the dikes and available open spaces within the site to maximize use of the area. This is to provide immediate and added source of food and income since it takes 3-4 years before nipa can be utilized for income generation. Crops found to adapt to saline conditions

Figure 2.
Layout of the agri-nipa-aquaculture scheme

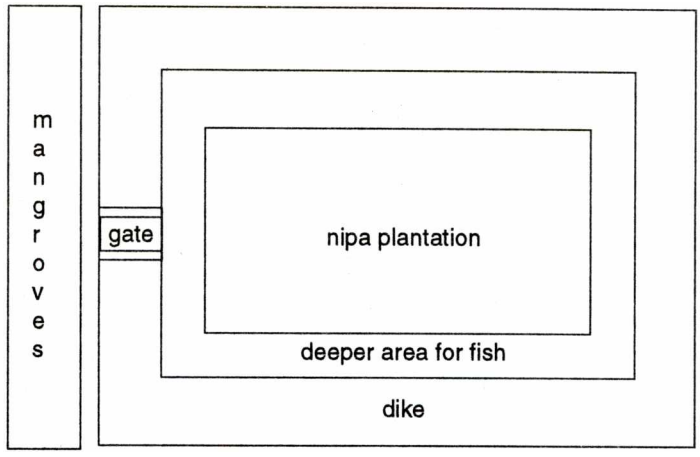
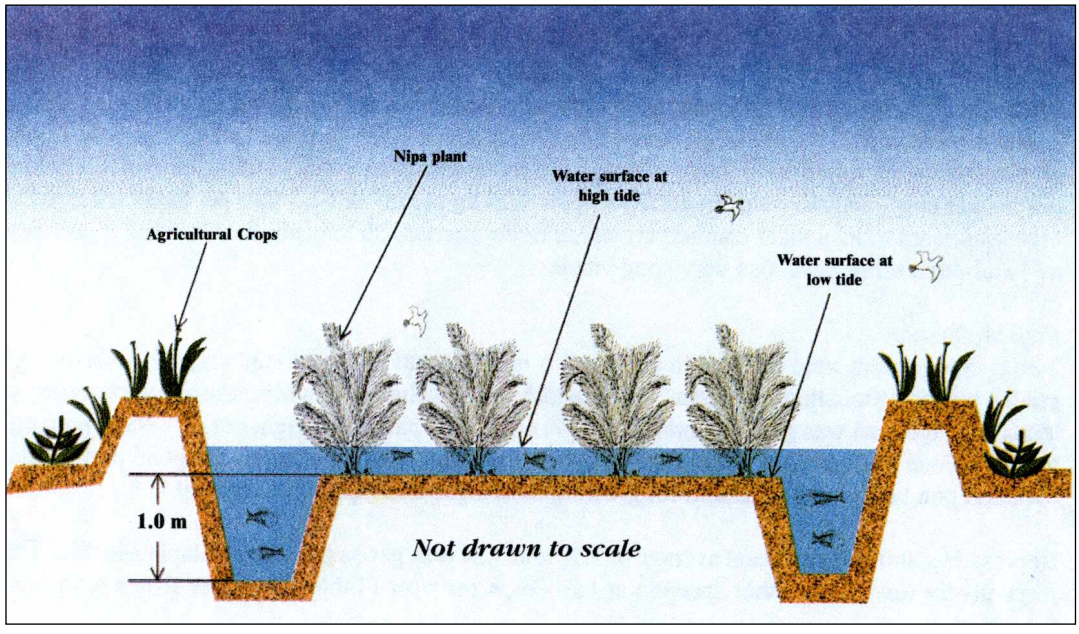


Figure 3. **Cross section of agri-nipa-aquaculture pond** (water level during low and high tides indicated)



of the pilot site were banana, tomato (*marikit* variety), pole *sitao*, bush *sitao*, eggplant, *upo*, *okra*, pineapple, passion-fruit, peanuts, corn, *patola*, and jackfruit.

Mangrove litter and other coastal debris that were washed ashore were collected and used as organic fertilizer and soil conditioner. Laboratory analysis showed that mangrove litter has adequate nutrient contents to support good crop production, as follows: pH, 6.2; organic matter, 15.27%; nitrogen, 0.76%; phosphorus, 10.35%; potassium, 0.81%; calcium, 43.91%; magnesium, 24.21%; sodium, 7.74%; cation exchange capacity, 55.51 meq/100 mg soil.

Table 5. **Fish production in the agri-nipa-aquaculture system, Mindoro** (tons/ha/crop)

Cropping cycle	Pond I (newly established nipa)			Pond II (w/ mature nipa stand)		
	Tilapia	Shrimps[1]	Others[2]	Milkfish	Shrimps[1]	Others[2]
1st crop	1.62[a]	0.05	0.17	d	d	d
2nd crop	1.58[b]	0.10	0.06	1.71[e]	0.08	0.03
3rd crop	1.55[c]	0.07	0.06	1.40[f]	0.06	0.05
4th crop	1.57[b]	0.02	0.03	1.68	0.07	0.01
5th crop	1.60[b]	0.03	0.10	1.66	0.06	0.04
6th crop	1.65[a]	0.01	0.03	1.70	0.03	0.03
7th crop	1.54[b]	0.01	0.05	1.58	0.02	0.01
Average	1.59*	0.04	0.07	1.62**	0.05	0.03

[1]majority are freshwater shrimps; [2]mullet, mudfish, tarpon, sea bass, etc.
[a]sex reversed tilapia; [b]mixed sex tilapia; [c]golden hybrid tilapia; [d]construction stage; [e]milkfish only; [f]mixed milkfish and tilapia
*approx. 3.18 tons per ha per year; **approx. 3.24 tons per ha per year

From the data generated, the best variety of bush *sitao* under the prevailing condition is UPLB-3 with a yield of 2.77 kg per m^2 per crop. There were seven other varieties tested. For pole *sitao*, all three varieties tested were high yielding. On top is *sandigan* variety with a yield of 11.29 kg per m^2 per crop. Tomato (*marikit* variety) yields 9.75 kg per m^2 or 97.5 tons per ha which is very high compared to its upland counterpart which rarely exceeds 30 tons per ha. Com (32 pieces per m^2) and other crops have also very good yields.

Fish production

Two species of fish were cultured in the ponds -- milkfish and tilapia (mixed sex, sex-reversed and golden hybrid). Stocking rates were 2-3 fingerlings per m^2. Supplemental feeding with commercial feeds and rice bran was given amounting to 5% of the fish biomass weight per day. Pond preparation was done prior to each crop. Two crops were stocked yearly. Activities for pond preparation included pond drying, fertilization for growing food algae and water management.

Harvest data showed an annual average of 3.18 and 3.24 tons per ha per year of tilapia and milkfish, respectively (excluding other species) at two crops per year (Table 5). Other fishes were also harvested.

Nipa production

The first harvest of fronds from the newly established nipa at 3 years old (Pond I) is shown below:

Spacing of nipa	*Production (no. of fronds)	*Length (cm)
1 m apart	125.67	155.01
2 m apart	234.00	180.05

Note:
**Average of three replicates. Area for each replicate is 120 m^2. Each replicate has either 99 plants (for nipa spaced 1 m apart) or 20 plants (nipa spaced 2 m apart)*

For nipa planted 1 m apart, it took 2.75 fronds to produce one shingle; while two fronds from nipa planted 2 m apart were needed. Harvest from Pond II was about 4 fronds per nipa palm (now >5 years old). About 1.5 fronds made up a shingle. Harvesting was done every 4 months.

At the project's end in December 1996, the cooperator-farmer had a net income of ₱81.00 from nipa planted 1 m apart in a 120 m^2 plot or about ₱20,250 per ha per year. From nipa planted 2 m apart, the annual net income is ₱52,500 per ha per year.

Soil quality
There was soil degradation at the site. The new nipa plantation had loam type of soil, becoming sandy loam three years later. The mature existing nipa area was sandy loam, later becoming silt loam.

Costs-and-returns
Tables 6 and 7 show the projected income of a backyard nipa-aquaculture farm in the first few years of operation.

Other projects

BFAR has started last August 1998 a small-scale mudcrab project in one of the mangrove areas adjacent to its research center in Pagbilao, Quezon. The project consists of 6 units of 10 x 20 m net pens.

DENR's Ecosystem Research and Development Bureau, on the other hand, had a 0.8 ha project started in 1994. The project utilized a 60:40 combination of mangrove plantation and fishpond as pilot areas in Catanauan, Quezon and a 0.25 ha area in Sta. Elena, Camarines Norte. Projects had been completed and turned over to the local mangrove association.

Also, SEAFDEC/AQD has a model area of mudcrab culture in pens in mangroves since June 1997 in Palawan province. It is a joint project with the Puerto Princesa City government and the Manalo Multi-Purpose Cooperative Inc. The cooperative provided the area and technician that manages the project; the City government acted as coordinator and provided crablets and feeds for one cropping; AQD provided the design, technical assistance and technology packaging.

There are may other similar projects operated by academe, NGOs and other interested private individuals but these have not been reported.

Recommendations

Establishing a national plan
With BFAR becoming a line bureau effective January 1999, a national plan for the improvement of mangrove areas integrating aquasilviculture will be prepared. Consultative meetings with DENR, DA Regional Offices, NGOs, other agencies and community organizations will be conducted to determine issues and problems that need to be addressed. Implementation will be a joint undertaking by the government and these organizations. The plan will be in consonance with the provisions of the Fisheries Code of 1998 and other related laws.

Table 6 **Projected income from fish and nipa of a 1,000 m² backyard nipa aquaculture farm for the first three years of operation (pesos)**

Activities	Unit cost	Year I	Year II	Year III
Aquaculture				
Digging 20% of the area (20 man-days)	120.00	2,400.00	-	-
Tilapia fingerlings, sex-reversed	0.30	450.00	450.00	450.00
Feeds, manure, fertilizers		2,000.00	2,000.00	2,000.00
Repair and maintenance		-	400.00	400.00
Nipa plantation				
Clearing for nipa planting (1 man-day)		80.00	-	-
Hole digging (2 man-days)		160.00	-	-
Planting (1 man-day)		80.00		
4-5 month old nipa seedlings	5.00	1,250.00	-	-
Maintenance (4 man-days per year)		320.00	320.00	320.00
Nipa harvest				
Tie	0.10	-	-	280.00
Bamboo sticks, 1.5 m	0.10	-	-	260.00
Labor, per 50 shingles	50.00	-	-	2,808.00
Shingle assembling and sewing		-	-	2,808.00
Gross income / sales				
2 harvests with 80% survival, (5 pcs fish per kilo)	30.00	14,000.00	14,000.00	14,000.00
Nipa shingles, 1.5 m long / double		-	-	11,232.00
Net income (before tax)		7,660.00	11,230.00	16,284.40

Table 7 **Projected income from banana and vegetables of a 1,000 m² backyard agri-nipa-aquaculture farm for the first five years of operation (pesos)**

	No. of plants	*Price per bundle*	*Year I*	*Year II*	*Year III*	*Year IV*	*Year V*
Banana							
Saba	100	60	-	6,000	6,900	7,935	9,125
Lakatan	20	85	-	1,700	1,955	2,248	2,585
Poot	50	42	-	2,100	2,415	2,777	3,194
Total			**-**	**9,800**	**11,270**	**12,960**	**14,904**

Basic assumptions: (1) yearly increase of 15% on price of bananas and (2) yearly production of banana is 1 bundle per plant

	Harvest	*Price*	*Year I*	*Year II*	*Year III*	*Year IV*	*Year V*
Vegetables							
Pole *sitao*	188 kg	12/kg	2,256	2,594	2,983	3,430	3,945
Bush *sitao*	100 kg	12/kg	1,200	1,380	1,587	1,825	2,099
Tomato (*marikit*)	100 kg	5/kg	500	575	661	760	874
Corn	375 pc	2/pc	750	862	991	1,140	1,311
Upo (cooking variety)	200 pc	3/pc	600	690	794	913	1,050
Total			**5,306**	**6,101**	**7,016**	**8,068**	**9,279**

The rational and sustainable management of the mangrove resource would not be an easy task since many government forestry programs (mangrove included) in the region are polarized with two or three agencies having opposing mandates. Activities must be balanced, otherwise, irreversible damage will occur. Sustainable management should ensure that the ecological integrity of the ecosystem and its closely associated resources are intact.

Population and economic development pressures must be minimized. As much as possible, conversion should be restricted to areas that will not adversely affect other resources. Traditional rights of the coastal communities must be given due consideration (e.g., provide a tenurial system to make use of mangrove areas on a sustainable basis).

Information, education and training

The private sector and other stakeholders will be kept informed of the status of aquaculture in the mangrove areas and the plans of the government. Information campaigns through meetings, printed media, among others, is necessary.

Education campaigns will be an integral part of the national program. Likewise, training of local fisherfolk in resource management and development will be conducted.

The need for baseline information

Since important data on mangrove and other resources would be needed in the national plan, the research and academic community may be invited to undertake studies on some critical areas.

Baseline information on mangrove ecosystems is still insufficient, especially its relationship with other ecosystems and resources within the coastal zone. There is a need to assess the extent of mangrove use, and quantify their socio-economic benefits. Creating multi-disciplinary research committees on various aspects of the mangrove ecosystem may be necessary. There are, however, many tools that can provide better baseline information today like remote sensing, geographic information system (GIS), and environmental impact assessment techniques (Umali *et al.* 1986; Untawale 1986).

Applied research needs

Economic valuation of mangroves is not easy. On the whole, there is a need for researchers to determine the impact of mangrove conversion on fisheries resources, its socio-economic repercussions and the other resources associated with mangroves (Untawale 1986).

The impact of mangrove conversion varies, depending on prevailing local conditions. In typhoon prone areas, the destruction of the mangroves increases the risk of coastal erosion from storm surges and winds. Along estuaries, denudation accelerates the erosion of riverbanks. When large areas of mangroves have been converted to shrimp ponds, it results in the exposure of acid sulfate soils, leading to poor production, mass mortality of stocks, and the discharge of toxic substances into nearby waters (Paw & Chua 1991). Conversion to salt ponds also alters soil structure and increases salt content, making the area difficult to reclaim especially for agriculture or silviculture. These conditions are sometimes irreversible or costly to mitigate. Hence, an economic analysis of mangrove conversion should take all these into consideration.

Intensive aquaculture production systems are likely to have greater impact in terms of pollution and employment potential. The cost of waste treatment can be considered and its damage to the aquatic

environment valued. Semi-intensive culture system is recommended for adoption.

The present rate of wood cutting appears to be unsustainable and degradation of mangrove is apparent in many areas. With the degradation of mangrove areas, fisheries areas are showing signs of overexploitation or diminishing population (Aquaculture Asia 1996).

Socioeconomic studies

It is generally accepted that for sustainable management to succeed, local communities must be involved in the planning, implementing and monitoring stages. Without this early involvement, such programs can not work. Along with the anticipated involvement of local communities, new and rather experimental technology on aquasilviculture should be introduced as livelihood. Aquasilviculture involves traditional non-destructive aquaculture techniques combined with sustainable forestry techniques, including limited harvest of mangrove products.

Socio-economic studies which could be replicated have been piloted with success by DA, SEAFDEC/AQD and DENR in some areas. Culture of other fishery resources like mollusc and seaweeds should also be piloted to give additional income to fisherfolk.

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