Valuation and Evaluation of Management Alternatives for the Pagbilao Mangrove Forest

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Abstract

Mangrove forests and swamps are rapidly declining in many parts of the world. This has resulted in the loss of important environmental and economic functions and products, including forest products, tidal wave control, breeding ground for fish etc. One of the major threats to mangroves in the Philippines is the rapidly increasing aquaculture industry. In order to understand the importance of mangroves, insight into the total economic value of mangroves is important. Comparisons are made with the total value generated by alternative uses such as aquaculture and forestry. In addition to economic value, equity and sustainability objectives are taken into account and analyzed according to the perspective of different types of decision makers involved..

The aim of this paper is to demonstrate the use of results obtained from valuation of mangroves to support an evaluation of management alternatives for the Pagbilao mangrove forest. The structure of this paper is as follows: first the study site is introduced; this is followed by a review of management alternatives for the Pagbilao mangrove forest, and an assessment of the values of the goods and services linked to these management alternatives. Next, the results from the valuation are used to support the selection of the preferred management alternative, first in a cost-benefit approach, then combined with other types of information in a multi-criteria approach. This paper concludes that if economic efficiency is maximized, conversion to aquaculture is the preferred alternative. However, if equity and sustainability objectives are included commercial forestry is the preferred alternative.

Abrégé

Les forêts et marais en mangroves subissent un déclin rapide en de nombreux endroits du monde, avec pour conséquence la perte d'importants produits et fonctions écologiques et économiques: produits forestiers, contrôle des courants de marées, lieux de reproduction halieutique, etc. Aux Philippines, l'une des principales menaces pesant sur les mangroves tient à la rapide croissance de la filière aquacole. Pour comprendre l'importance des mangroves, il faut en discerner la valeur économique totale. On procède à des comparaisons entre valeurs totales engendrées par deux modes alternatifs d'exploitation des mangroves: aquaculture et foresterie. Outre la valeur économique, on tient compte d'objectifs relevant de l'équité et de la durabilité, qu'on analyse du point de vue des différents décideurs intervenant dans la gestion des mangroves.

Le but de ce texte est de montrer quel usage on peut faire des résultats d'une estimation de la valeur des mangroves pour appuyer l'évaluation des options de gestion de la mangrove forestière de Pagbilao. Ce texte emprunte le plan suivant: en premier lieu, on présente le site d'étude; puis on présente les options alternatives de gestion de la mangrove forestière de Pagbilao ainsi qu'une estimation de la valeur des biens et services afférents à ces alternatives. On utilise ensuite les résultats de l'estimation pour appuyer la sélection de l'option de gestion préférée, d'abord dans le cadre d'une approche coût-bénéfice, puis, combinés à d'autres types d'informations, au sein d'une approche à critères multiples. Le texte aboutit à la conclusion que pour maximiser l'efficacité économique de la mangrove, il faut préférer la conversion à l'aquaculture. Mais si on se fixe aussi pour objectifs l'équité et la durabilité, c'est la foresterie commerciale qui devient l'option préférable.

Resumen

Los bosques y pantanos de mangle se deterioran rápidamente en muchos lugares del mundo. El resultado de este proceso de deterioro tiene una repercusión importante en la pérdida de funciones y de productos económicos y ambientales, incluyendo productos forestales, control de mareas, criaderos de peces, etc. En Filipinas, una de las mayores amenazas a los manglares es el rápido crecimiento en la industria de la acuicultura. Para entender la importancia de los manglares, es importante tener una idea general acerca de su valor económico. Con este propósito, en este trabajo se hacen comparaciones con el valor total que se genera por usos alternativos como son la acuicultura y la silvicultura. Además de su valor económico, se toman en cuenta objetivos de equidad y sustentabilidad los cuales se analizan de acuerdo a la perspectiva de los distintos actores que tienen poder decisorio en el manejo de los manglares.

El objetivo de esta monografía es demostrar el uso de los resultados obtenidos en el avalúo de manglares para sustentar una evaluación de alternativas de gestión para el manglar de Pagbilao. La estructura de esta monografía es la siguiente: primero se describe el lugar de estudio; a ésto le sigue un examen de las alternativas de gestión del manglar de Pagbilao y una evaluación del valor de los bienes y servicios relacionados con estas alternativas de gestión. A continuación, los resultados del avalúo se utilizan como base para justificar la selección de la alternativa de gestión escogida, primero, desde una perspectiva de vista costo-beneficio, y luego en combinación con otros tipos de información dentro de un enfoque de criterios múltiples. La monografía concluye que, si se desea maximizar la eficiencia económica, la alternativa preferida es la conversión a la acuicultura. Sin embargo, si se incluyen en el análisis objetivos de equidad y sustentabilidad, entonces la alternativa preferida sería la silvicultura comercial.

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Introduction

Mangrove forests can be found in the brackish water margin between land and sea in tropical and subtropical areas. They are part of rich ecosystems providing a variety of economic and environmental functions and products. In traditional subsistence economies the exploitation of mangrove resources is usually not intensive and settlement is quite sparse. In South East Asia this has been attributed to the scarcity of freshwater for domestic use and the unsuitability of mangrove soils for long-term agricultural exploitation. However, in recent years, as traditional economies have become increasingly market-integrated and modernised, the building of access roads, the provision of amenities in these areas, and the improvements in technology have intensified the exploitation and settlement of mangrove forests. In the Philippines, these changes in mangrove forest use have resulted in a loss of forest cover from approximately 288,035 ha. in 1970 to 23,400 ha. in 1993.

One of the major threats to mangroves in the Philippines is the rapidly increasing aquaculture industry. In 1993 261,402 ha. of mangrove area were used for brackish water fishponds (Table 1). Although a moratorium has been placed on harvesting of mangroves for timber, the process of conversion is still taking place. In order to understand the importance of mangroves, insight into the total economic value of mangroves is important. Comparisons can then be made with the total value generated by alternative uses such as aquaculture and forestry. Several studies which have analysed and valued the environmental functions of mangroves indicate the importance of internalising these externalities in environmental management (Opschoor 1987, Ruitenbeek 1992, Barbier 1991, Dixon and Lal 1994, Gren et al. 1994).

Besides estimating the total value of mangrove forests, it is also important to focus on the decision makers involved in mangrove forest management. Decision makers exist at different levels, from fishpond owners at the local level, to the Global Environmental Facility at the international level, and each has specific objectives which are not always included in the economic valuation of the management alternatives. These may include improvement of local employment and income (equity objectives), and the conservation of intrinsic qualities of the environment (sustainability objectives).

The objective of this paper is to demonstrate the use of results from valuation to support the evaluation of management alternatives for the Pagbilao mangrove forest in the Philippines. This paper presents results from the project "Economic Valuation of Mangrove-Fishpond Interactions", part of the programme for Collaborative Research in the Economics of Environment and Development (CREED).

Table 1. Area of mangroves and brackish water fishponds (ha)

year	mangroves	brackish water fishponds
1970	288,035	168,118
1971	286,650	171,446
1972	284,211	174,101
1973	258,895	176,184
1974	256,156	176,032
1975	254,016	176,032
1976	251,577	176,231
1977	249,138	176,231
1978	246,699	176,231
1979	245,000	176,231
1980	241,801	176,231
1981	239,382	195,832
1982	239,382	195,832
1983	234,504	196,269
1984	232,065	206,525
1985	226,673	205,001
1986	221,280	210,319
1987	143,522	210,458
1988	139,100	210,681
1989	135,700	210,681
1990	132,500	210,681
1991	129,200	225,002
1992	126,300	239,323
1993	123,400	261,402

Source: Forest Management Bureau, Bureau of Fisheries and Aquatic Resources.

The structure of the paper is as follows: first the study site is introduced; this is followed by a review of management alternatives for the Pagbilao mangrove forest, and an assessment of the values of the goods and services linked to these management alternatives. The decision problem is then formulated. Next the results from the valuation are used to support the selection of the preferred management alternatives, first in a cost-benefit approach then combined with other types of information in a multi-criteria approach. Conclusions and recommendations are presented in the final section.

The Pagbilao Experimental Mangrove Forest

The municipality of Pagbilao is situated in the foothills of Mount Banahaw in the southern part of Quezon Province in Luzon Island. It is bounded on the north-west by the municipality of Tayabas, north-east by Atimonan, south-east by Padre Burgos and south-west by the City of Lucena (Figure 1). It has a total land area of 15,820 ha. covering 27 barangays[1] of which 21 are rural and 6 are urban. Pagbilao has 9 coastal barangays of which 6 are fringed with mangroves. Pagbilao has a volcanic terrain with slope of up to 15%.

The population of Pagbilao stood at 41,635 in 1990 (National Statistics Office) with an annual growth rate of 2.77% from 1980-1990. The total number of households is 8,450. It is estimated that by the year 2000 the municipal population and the number of households will reach 56,730 and 11,818 respectively. Over 50% of the population of Pagbilao is of working age and about 97% is literate. Half of Pagbilao's population depends on agriculture for its livelihood: 77% of the land area is devoted to agriculture with coconut and palay being the dominant crops with respectively 65% and 12% of the total land area planted. Coffee, corn, bananas, root crops, citrus fruits and vegetables are also grown, while copra is the main agricultural product in Pagbilao. In addition, agro-livestock and cottage industries provide considerable employment. Pagbilao is a fourth class municipality[2] in terms of municipal income. Since municipal income is derived from municipal taxes, which in turn is a function of the income of households and business establishments, it may be inferred that the municipality is relatively poor. Information of the average household income is not available but observations of the type of dwellings in the coastal villages show that these are similar to the rest of the Philippines. Poverty is widespread, and emigration in search of more stable sources of income is common. Education is seen as the key to finding employment elsewhere.

Pagbilao has a total of 1,440 ha of forest lands scattered in several barangays. The northern and western sides are parts of the Quezon National Forest Park with 983 ha of old-growth tropical dipterocarp forest. Surrounded by mangrove forest and coral reefs, Pagbilao Bay is one of the richest natural marine areas in Southern Luzon. There are about 2,048 fishermen with 247 motorised and 282 non-motorised bancas. There are 56 fishpond operators covering 1,146 has. The collection of tropical aquarium fishes is an important alternative to capture fishing. and currently involves about 300 collectors.

Coral reef diversity is average with 33 genera recorded. There are 60 species belonging to 18 families of coral reef fish. With live coral cover ranging from only 27% - 73%, the coral resources are categorised poor to good. There are 10 species of seaweed and 4 species of seagrasses but these resources are disturbed (Fortes 1993). In the mangroves, there are 128 fish

[1] The barangay is the smallest political unit in the Philippines.

[2] Municipalities are classified based on the following income ranges during the last three years (1990-1992): First class (P15 million or more), second class (P10 M or more but less than P15 M), third class(P7 M or more but less than P10 M), fourth class (P4 M or more but less than P7 M), fifth class (P2 M or more but less than P4 M) and sixth class (below P2 M). (Source: Department of Finance Order No. 35-95)

Map of municipality

Figure 1 here

belonging to 54 families (Pinto 1987). *Ambassis kopsi* (*Ambassidae*) was the most abundant species. Gobies (*Glossoqobius sp*.), mullets (*Mugil sp*.), snappers (*Lutjanus sp*.), milk fish (*chanos*), scads (*Scathophagus sp*.) and groupers (*Serranids*) were also found in the area. Crustaceans such as shrimps (Peneaus sp), macrobrachium sp. and crabs (*Grapsidae*) also dwell in the mangroves.

Some rare and endangered species can be found in the Quezon National Forest Park. Endangered species include the Rufous hornbill, the Philippine deer (*Cervus rusa philippinensis*) and the Philippine monkey (Table A1). Classified as rare birds are the Philippine forest kingfisher, spotted wood kingfisher and Luzon little crow. Rare mammals in the park include the Philippine rind rat. In the mangroves, shore birds are the most apparent wildlife species. There are 20 species observed in drained or disused fishponds and inter tidal areas at low tide. Common species include the wood sandpiper, red-necked stint, common sandpiper and wimbrel. Also observed in Tayabas Bay are herons, egrets and bitterns. Nankeen night herons breed in the seaward mangrove fringe and are hunted by the local community. Cattle egrets can be found in the rice fields and some portions of the landward parts of the fishponds and coastal area. An endangered species, the Chinese egret was found foraging in the inter tidal areas of Pagbilao. Terns (*Laridae*) were also observed wherein the most common is the whiskered tern and an endemic duck, the Philippine mallard. Bats are identified as locally important through the collection of guano (bat manure) as a source of income.

A recent estimate (Bina 1988) of remaining mangrove areas in the Philippines shows that, of the original 400,000 - 500,000 ha. thought to have existed in 1918 (Brown and Fischer 1920), about 139,725 ha. remain. The distribution of this area is as follows: 16% Luzon, 30% in Palawan, 27% in the Visayas and also 27% in Mindanao (excluding Sulu and Tawi-Tawi). The figure should be smaller now, considering the continued clearing of mangroves for aquaculture and the decimation brought about by pollution. Of the remaining mangroves only 10,000 has. are old growth and the rest are mainly second growth. While around 68% of the denuded mangrove areas are now devoted to brackish water aquaculture (Zamora 1990), mangrove areas are not usually directly converted to fishponds. Conversion to fishponds follows construction of dikes in unproductive mangal areas. The latter results from unsustainable harvesting of mangrove forest resources. Table 1 suggests that most of the mangrove areas lost have been converted to fishponds.

The original area of mangroves in Pagbilao is not known but can be deduced from the existing area of mangroves and brackish water fishponds. In 1984 the total area of Pagbilao mangrove forest was around 693 ha. Of this, 396 ha were within public forest lands while 297 ha were owned privately (RP-German FRI Project, 1987). Today, what remains of the public forest land is the experimental forest under the jurisdiction of the Department of Environment and Natural Resources. The legal basis of the experimental forest is Presidential proclamations 2151 and 2152, in 1981, which declared certain islands and/or parts of the country as wilderness areas. These laws withdrew from entry, sale, settlement and other forms of disposition a large portion of mangrove areas in the country. The primary purpose of these proclamations was to preserve whatever was left of the mangrove forest in the country.

The second growth mangrove forest in Pagbilao was further designated as a Genetic Resource Area and National Training Centre for Mangroves. The specific objectives of a genetic resource area include: a) conservation of the genetic diversity of the mangrove ecosystem; b) demonstration of practical management for perpetuating mangrove species; c) establishment of sources of documented seeds and seedlings for mangrove reforestation; d) provision of livelihood and recreational amenities to communities and visitors; and e) to serve as a laboratory for students, scientists, environmentalists, researchers, and other interested parties. Since its declaration, the mangrove area has generated scientific interest and has attracted numerous scientists, both local and foreign.

Forest zones and mangrove tree species

The experimental forest has three evident zones. The landward portion borders towards the ecotone[3]. Among the landward tree species are *nilad*, *buta-buta*, *api-api*, *pi-api*, *tinduk-tindukan*, etc. (Table A2). Except for *api-api* and *pi-api*, most species in this portion are small in diameter with plenty of thickets underneath. Vines such as *bagnit* and *gatasan* also abound. The middleward portion is the part immediately after the landward and constitutes the central portion of the forest. This portion has big trees of *api-api* and *pi-api* together with *busain*, *pototan*, *tangal*, and *malatangal*. The forest floor is relatively clear, with vines such as *bagnit* and *gatasan* occurring sparsely. The seaward portion begins from the shore towards the middleward portion (Figure 2). Tree species in this portion are *bakawan lalaki*, *bakawan babae*, *bagatpat*, etc. although they are stunted due to heavy exploitation in the past. Regeneration underneath is also observed. In the riverine portions, *tabigi, pagatpat, nipa, lagolo, pedada, bagnit*, and *galivario* (thorny vine) exist in association with the species as observed in the previously described zones wherever the riverine portion is located.

Compared to other mangrove areas in the Philippines, Pagbilao Bay has the highest number (19) of true mangrove species, comprising 56% of the total true mangrove species. It also appears to be the most botanically diverse in terms of number of tree species, associates and variations in the nature of topography and substrate (NRMC 1980). The most important of the true mangrove families observed in Pagbilao are the *Rhizophoraceae* and *Aviceniaceae* where the *bakawans* and *api-api* species belong, respectively.

Mangrove fishery resources

The fisheries surveys for this project were conducted to extend and verify the results of previous studies on fishery resources of the Pagbilao mangrove forest. The most abundant species of fish were the glass fishes *Ambassis kopsi* and *A. urotaenia*, the halfbeak *Zenarchopterus buffonis* and the juveniles of the ponyfish *Leiognathus spp* (Appendix table A3). Several species appear to be residents of Sukol creek and the waterways of Pagbilao Bay based on: (1) high abundance in the pocket seine catches; (2) wide size range including adult sizes; and (3) low abundance or non-occurrence outside the mangroves. Such residents include *Ambassis kopsi, A. urotaenia, Zenarchopterus buffonis, Butis butis, Prosposodasys gogorzae,*

[3] An ecotone is a transition area between two adjacent ecological communities usually exhibiting competition between organisms common to both.

Figure 2 Seaward section of the Pagbilao mangrove forest

Figure 3 Pagbilao fishing harbour

Gullaphalus mirabilis, Yongeichthys criniger, Oxyurichthys opthamonema, Acentrogobius spp, *Leiognathus* spp., and *Valamugil cunnesius*. The other gobies in the catch were probably also residents but not in high population densities. The *Ambassis* and *Leiognathus* spp. are found all over Pagbilao Bay, even outside the mangrove areas. Snakes are common in the mangroves and in Pagbilao Bay in general. Two colubrid snakes were caught during the study: the dog-faced *Cerberus rhychops* and sea snake *Acrochordous granulatus*. Both species are known to feed on fish (Table A4). The coastal villages of Pagbilao are dependent on the mangrove fishery resources, the most important of which are the mud crabs and marine crabs. Mostly local artisanal fishers based in the coastal villages of Pagbilao exploit the mangrove fishery resources in Pagbilao Bay (Figure 3). The fisheries of Tayabas Bay, to which Pagbilao Bay opens, is exploited by both local municipal and commercial fishers. Commercial fishers based elsewhere may also exploit Tayabas Bay fisheries.

Mangrove Resource Management Alternatives

Past and current uses

Through the years mangroves have provided a livelihood for Pagbilao coastal residents such as the gathering of minor mangrove products like vines for handicraft, shells and crabs for food, nipa leaves for home construction, and bark for tannins. Wide scale conversion into fishponds contributed to the loss of mangrove areas while excessive harvesting of timber for charcoal and fuel wood degraded the quality of the forest. It is estimated that the total area of fishponds in Pagbilao town with legitimate fishpond lease agreements (FLAs) is 604.57 ha. This area excludes the area in private lands and those which were illegally established.

Although extraction of mangrove forest resources is now prohibited, harvesting still persists on a limited scale. Field visits and interviews have verified the cutting of mangrove branches for fuel wood and poles (but not for timber) and nipa fronds for shingles even after Proclamations 2151 and 2152. These low-impact forms of extraction are tolerated but not the wide-scale cutting or clearing of a mangrove patch. An illegal attempt to convert part of the area into fishpond is now under court litigation. Trapping of resident fish species is not prohibited and is undertaken by local fishers.

The continuing exploitation of mangrove resources may be attributed to their accessibility. The experimental forest is very close to inhabited areas and is easily accessible by boat, by land transport and on foot. From the nearest village of Palsabangon, access time on foot is about 30 minutes, while tricycles can negotiate the same route in about 10 minutes. Work animals such as carabaos and horses may be used more effectively to transport forest resources such as poles and timber. Boats are more commonly used in gathering nipa products. Because the Pagbilao mangrove forest is the only in-tact forest remaining close to Manila, it has been the site of frequent mangrove-related studies conducted by the government, university and other research communities, both local and foreign. This is evident in studies cited in the fisheries and forestry reports and from our own study period.

Management alternatives

In this study eight management alternatives are considered and are described below. The allocation of the area in each management alternative is shown in Table 2. The likely institutional arrangement for each management alternative is also described as this is an important consideration in resource valuation. Sustainability is the overriding consideration in the exploitation of mangrove fishery and forestry resources as well as in aquaculture alternatives. This consideration is imbedded in the specification of the recommended silvicultural and aquaculture technologies. Therefore all alternatives listed below can be considered sustainable.

Table 2. Area allocation by management alternative

Management alternative	Fishponds		Forest: Production forest		Forest: buffer		Total
	ha	%	ha	%	ha	%	ha
Preservation	0	0	110.7	100	0	0	110.7
Subsistence forestry	0	0	0	0	110.7	100	110.7
Commercial forestry	0	0	110.7	100	0	0	110.7
Aqua-silviculture	28.6	26	66.6	60	15.5	14	110.7
Semi-intensive aquaculture	95.2	86	0	0	15.5	14	110.7
Intensive aquaculture	95.2	86	0	0	15.5	14	110.7
Commercial forestry & intensive aquaculture	35	32	60.2	54	15.5	14	110.7
Subsistence forestry and intensive aquaculture	35	32	60.2	54	15.5	14	110.7

1. Preservation (PR). Extraction of forest products is not allowed but the gathering of fish and shellfish, such as molluscs and crabs, is permitted. The current institutional arrangement for the exploitation of fishery resources is open access although a community-based management of mangrove and bay fishery resources may be arranged. Most dependent on mangrove fishery resources are the poor artisanal fishers from the coastal villages of Pagbilao.

2. Subsistence forestry (SF). Coastal communities are allowed to obtain wholly or partly their forest products needs from the forest. The communities themselves manage the forest in accordance with existing policies on community-based forest management. To sustain the benefits, a maximum allowable harvest not to exceed the capacity of the forest to regenerate and develop naturally, is imposed. This implies that some sort of limited entry into the forest resources will be instituted. Mangrove stewardship agreements may be signed between the government and the communities in alternatives involving extraction of forest products. Thus, the benefits from this alternative would accrue to the local residents who are generally poor.

3. Commercial forestry (CF). A specified commercial volume of forest products is to be harvested. The required silvicultural system for this is the seed tree method with planting; seed trees (mother trees) are selected to be left to provide propagules for the harvested areas. Similarly, a mangrove stewardship agreement between the government and communities may be put in place for this management alternative. Thus, revenues from commercial mangrove forestry may accrue to the local community acting as a co-operative.

4. Aqua-silviculture (AS). Portions of the mangrove area are converted to fishponds while some portions will remain forested. Buffer zones are allocated based on legal requirements of 50 meters for areas facing the sea and 20 meters along river channels. The remaining area is devoted to aqua-silviculture assuming a 30 to 70 ratio for fishpond and forest. This is a combined use alternative whereby silviculture and aquaculture are simultaneously practised in one pond compartment. Considering the high investment costs in the construction of pond compartments, coastal dwellers may not be able to participate in this management alternative. The most likely beneficiaries are those who are able to shoulder the investment costs which are the rich, either from Pagbilao but more likely from elsewhere.

5. Semi-intensive aquaculture (SI). The mangrove forest is converted to fishponds for semi-intensive aquaculture while observing the required buffer zone. The remaining area will be covered by a system of ponds and water distribution systems. The recommended semi-intensive aquaculture technology is an average four crops of milk fish per year with stocking density of about 0.3 fingerling per m^2. The low stocking density and the limited use of chemicals in semi-intensive pond culture are likely to contribute to sustainability. For the management alternatives involving aquaculture, fishpond lease agreements may be auctioned off. These are likely to go to the wealthy who are able to put up the high costs of pond development.

6. Intensive aquaculture (IA). This alternative is similar to semi-intensive aquaculture in terms of allocation of area between the required buffer zone and fishponds. The same tenure structure as in semi-intensive aquaculture may emerge with this management alternative. The only difference is that the aquaculture technology employed is intensive. The intensive part of the recommended aquaculture technology applies to the one crop of prawn per year whereby relatively high rates of stocking (up to 15 fry per m2) and artificial feeding are practised. A second crop of milk fish is immediately grown with zero input to feed on the remaining fish food in the pond. The rotation of prawn and milk fish is considered sustainable given the high mortality experienced when growing two prawn crops in one year in some parts of the Philippines (Padilla and Tanael 1996).

7. Commercial forestry and intensive aquaculture (CF/IA). This alternative divides the area into commercial forestry and fishponds for intensive aquaculture. It is intended to satisfy competing demands on the mangroves. Mangrove stewardship agreements may be signed with the communities for the commercial forestry alternative while fishpond leases may be auctioned. The silvicultural practice in commercial forestry and the intensive aquaculture technology are as described above.

8. Subsistence forestry and intensive aquaculture (SF/IA). This is similar to the previous alternative except that the remaining forest is used for subsistence purposes. Tenure arrangements would be similar to the subsistence forestry alternative and the aquaculture alternatives. The silvicultural practice in commercial forestry and the intensive aquaculture technology are as described above.

The institutional arrangement for each management alternative is briefly described above. Alternatives including subsistence forestry or commercial forestry require mechanisms for controlling access and limiting cutting rates to sustainable levels. The costs of enforcement of such mechanisms are assumed to be lowest in community-based management. Regulations may become self-enforcing if these are formulated and enforced by the community itself.

Quantification and Valuation of Goods and Services from the Mangrove Forest

The management alternatives range from preservation to combined uses of mangroves in Pagbilao. Some alternatives permit the use of the entire mangrove forest by an interest group (community or fishpond operators) while the combined use alternatives involve shared use by competing users. Environmental considerations are satisfied in all alternatives, for instance, the rate of timber harvesting is limited to sustainable levels. The prescribed technology for aquaculture allows for long-term use of the fishponds and can therefore be considered sustainable.

Forest products

The quantification and valuation of goods and services proceeded from field surveys of the mangrove reserve in 1995. For the forest resources, the results are summarised in Carandang and Padilla (1996). The mangroves of Pagbilao are all second growth with an average age of 20 years. Three zones or ecotones were identified, ie, landward, middleward and seaward. Sample plots were established in each ecotone and tree density, tree dimensions and subsequently wood volume were measured or computed. Projected timber yield was estimated over time using an empirical equation for the Philippines with stand age and site index as explanatory variables. For 1995, the average timber yield in m^3 per ha ranges from 2.18 to 3.08 for the various zones. Over 100 years, the computed mean annual increments in m^3 per ha are respectively, 1.18, 1.67 and 1.49 for the seaward, middleward and landward zones. Litter traps were also set within the same plots to estimate litter fall which were then dried in an oven to determine nutrient content.

Fuel wood, timber and nipa shingles are the primary forest products that may be derived from the Pagbilao mangrove reserve. In estimating the quantity of forest products, a sustainable cutting regime is recommended based on sound silvicultural practices. The specified breakdown of forest products, particularly timber, takes into account the forest management regime which is either subsistence or commercial exploitation. In subsistence forestry the breakdown of forest products follows the requirements of the coastal communities which are mostly fuel wood, charcoal and poles (timber) for fences and posts. In commercial forestry, high value products to be produced are primarily timber with incidental fuel wood from tree branches (Table A5). In subsistence forestry about 262 m^3 of wood products may be harvested compared to 272 m^3 per year in commercial forestry.

Valuation for subsistence use is different from valuation for commercial use. Computations are described in Table A6. In subsistence forestry, the use value of the forest products derived from the mangroves should be net of the gathering cost. When households are denied access to mangrove forest resources, the value attached to the forest products is equivalent to the cost they incur in obtaining alternative products. Such cost is equal to the market price of the alternative product plus the transport cost from the market to the point of use. Thus, the shadow price of forest products is the market price of the alternative product plus the transport cost less gathering costs. In a commercial forestry regime, it is assumed that the co-operative's objective is to maximise the value of net benefits to be derived from the forest. Net benefit is the stumpage value which is equal to the market price of the good less the costs of transport, extraction and related costs incurred in managing the forest. Thus, in forest product valuation, shadow prices were computed for non-traded products. For simplicity, the alternative product is the same regardless of whether it is used for subsistence or commercial purposes. For traded forest products such as nipa, actual market price is used which is then adjusted by transport and gathering costs.

For the five alternatives which permit harvesting of forest products, the highest value for such products may be derived in commercial forestry at over 400,000 pesos/year followed by subsistence forestry at about 350,000 pesos/year. On the other hand, the combination of subsistence forestry with intensive aquaculture yields only 187,000 pesos/year. In terms of production value per unit area, ie, economic efficiency, commercial forestry is superior to subsistence forestry.

Capture fisheries

A taxonomic identification of resident and transient fish species was conducted to assess fisheries productivity of the mangrove reserve. The fisheries component of this study (Ong and Padilla 1996) updated some information generated in more thorough studies in previous years (eg., de la Paz and Aragones 1985; Pinto 1985 and 1988; Fortes 1984). The experimental forest supports both on-site (resident species) and off-site (transient species) fisheries. Only the top 6 resident and 6 transient species groups are presented in the paper although about 45 species in 25 families were identified in the fisheries component of this study. The most abundant resident species are glass fishes and crabs while mullets and juvenile shrimps are the major transient species.

The estimation of a sustainable harvest of fishery resources presents difficulties as the fisheries surveys for this study, as well as in previous studies, did not cover stock assessment. Simplified assumptions were made to arrive at some measure of abundance based on the number of each species caught by the sampling gears. Moreover, the results of the survey of one creek were raised to arrive at an estimate for the entire mangrove forest. Sustainable harvests are then estimated for each species group using simple rule-of-thumb such as Gulland's 50% exploitation rate, which sets fishing mortality equal to natural mortality.

Most fish are found in the mangrove reserve as juveniles, hence, the equivalent weight in terms of adult fish is first estimated. It is computed by multiplying sustainable harvest by the percentage deviation from market sizes of the fish found in the creek. This is assumed to account for losses from natural mortality and predation as the fish grow to market size. The results show that the experimental forest supports a small on-site fishery and contributes minimally to off-site fisheries (upper part of Table A7). The estimates of sustainable yields would be a very small fraction of Pagbilao Bay fisheries even in the absence of data on total catches for the entire Bay. For the other management alternatives, fisheries productivity is linked primarily to nutrient production. The ratio between the quantity of nutrient production in each management alternative and in the preservation alternative is used to adjust fisheries production. Likewise, the impact of chemical discharges in the aquaculture alternatives are also factored in by assuming zero production of vertebrate species for both residents and transients.

The valuation of market-size fish found in the forest uses market prices of adult fish observed during the field surveys. The following are the steps in the valuation. First is the computation of the in-situ value of the fish which is the relevant figure in valuation. It is estimated that 87.75% of the landed price of fish covers the costs of harvesting, the remainder is the value of the fish in-situ (NSCB 1996). Next, the estimates of the value of fisheries production for the waterways are first converted to the entire forest. It is assumed that the relevant production area is three times the area of the waterways (Sukol Creek, Palsabangon and Nahalinhan Rivers) which comes to about 30.75 ha. This is used to multiply the gross value of the contribution to fisheries which are then divided by the total area of the mangrove forest (110.7 ha) to arrive at the average value of the production for the entire forest. The value figures in lower part Table A7 may be interpreted as conservative estimates of the value of fisheries production. The preservation of the mangrove forest contributes about 1,490 pesos per ha per year to capture fisheries in the area.

Aquaculture

The performance of aquaculture ponds converted from mangroves was also assessed as part of this study (refer to Padilla and Tanael 1996a; 1996b). Due to the changing productivity of aquaculture in the Philippines, several studies are compared to assess the long-term prospects of aquaculture operations in the mangrove reserve. The primary objective of the aquaculture studies is to identify the appropriate (sustainable) aquaculture technology and the corresponding production levels. The type recommended for aquaculture technology - both semi-intensive and intensive - are described in Section 3.

Conversion of the mangrove forest into fishponds is an attractive alternative when equity considerations are not considered. Under controlled conditions in aquaculture systems higher fish production levels are achieved at over 6270 kg./ha/year in semi-intensive culture of milk fish or 2530 kg./ha/year when rotating intensive prawn culture with extensive milk fish culture (Table A8). Albeit requiring high capital investments and operating expenses, the present value of net profits from aquaculture ranges from 13.2 million pesos/year to 112.4 million pesos/year. Semi-intensive culture of milk fish turned out to be superior to intensive prawn culture on several counts: a) the recommended technology for the latter -- crop rotation -- while more sustainable gives lower profits; b) low prices of prawn in the international market; and c) higher development costs for intensive ponds. Intensive prawn culture may become more profitable than semi-intensive milk fish if more sustainable prawn culture technology is developed and if prawn prices improve. Profits from aquaculture are much higher compared to the value of forest products and capture fisheries. A summary of all values estimated can be found in Table A9.

The Decision Problem

A decision problem is characterised by alternatives, effects, decision makers and their objectives. The effects table including the management alternatives for the Pagbilao mangrove forest is shown in Table 3. The management alternatives and technical studies conducted to quantify the effects were presented in the previous sections. The effects on shore protection, biodiversity and eco-tourism linked to the different alternatives could not be predicted within these technical studies. Experts in forestry, marine biology zoology were invited to provide judgement on the relative performance of the alternatives on these three effects (Carandang, Guarin, Ong 1996). To obtain expert judgement an assessment procedure was used that asked each expert to compare for each effect all pairs of alternatives on a nine point scale (Janssen 1992). The results are included in Table 3. Note that Subsistence Forestry performs best on eco-tourism. This alternative performs well because it preserves not only the ecosystem but also the socio-economic structure linked to subsistence forestry. The low score of Aqua-Silviculture for biodiversity may be the result of uncertainties associated with this experimental type of aquaculture.

Each type of decision maker has his/her own objectives. Decision makers and their objectives are listed in Table 4. The fish pond owner will be concerned with the profits generated; local government protects local interests, through income to local government to provide local services, or income to the local population; the social planner focuses on a national level, finding a balance between efficiency and equity objectives. In addition to efficiency and equity objectives, a sustainable planner also aims to maintain a minimum level of environmental stocks. This can be expressed as minimum levels of environmental quality but also as minimum sizes of certain ecosystems. Finally, the sustainable world planner - institutionalised as the Global Environmental Facility (GEF) - will try to maximise total environmental benefits from the mangrove forests to the world as a whole. Because each type of decision maker has his own objectives, each decision maker will evaluate the information on the alternatives in a different way. In the last section, results from valuation and evaluation will be used to select the best alternative for each type of decision maker.

Table 3. Effects table of management alternatives for the Pagbilao Mangrove forest

	unit	PR	SF	CF	AS	SA	IA	CF/IA	SF/IA
forest	ha	110.70	110.70	110.70	82.10	15.50	15.50	75.70	75.70
fishponds	ha				28.60	95.20	95.20	35.00	35.00
Fuel wood subsistence	m^3/year		184.40						99.40
Fuel wood commercial	m^3/year			65.20	42.30			35.00	
Timber subsistence	m^3/year		46.40						25.10
Timber commercial	m^3/year			206.70	134.10			110.80	
Charcoal subsistence	m^3/year		31.20						22.30
Charcoal commercial	m^3/year								
Nipa subsistence	1000/year		45.00						22.50
Nipa commercial	1000/year			45.00				22.50	
Soil accretion	cm/year	1.00	0.34	0.42	0.22	0.10	0.05	0.13	0.15
Milk fish production	tons/year				179.32	596.90	65.69	24.15	24.15
Prawn production	tons/year						175.17	64.40	64.40
Variable costs	1000 pesos				-2748.00	-9148.00	-15000.00	-5460.00	-5460.00
Capital costs	1000 pesos				-1287.00	-4284.00	-4284.00	-1575.00	-1575.00
Emissions	tons/year				-20.00	-40.00	-100.00	-50.00	-50.00
On site fish	1000 pesos	163.05	158.63	158.63	122.58	8.14	8.14	40.00	40.00
Off site fish	1000 pesos	1.94	1.88	1.88	1.46	0.09	0.09	0.28	0.28
Shore protection	index	1.00	0.37	0.15	0.15	0.13	0.07	0.15	0.15
Biodiversity	index	1.00	0.72	0.52	0.16	0.22	0.09	0.24	0.44
Ecotourism	index	0.80	1.00	0.38	0.18	0.14	0.08	0.21	0.30

Alternatives: PR: Preservation, SF: Subsistence Forestry, CF: Commercial Forestry, AS: Aqua-Silviculture, IA: Intensive Aquaculture, CF/IA: combination of Commercial Forestry and Intensive Aquaculture, SF/IA: Combination of Subsistence Forestry and Intensive Aquaculture

Table 4. Decision makers and their objectives

- Fishpond owner
  - Maximise profit
- Local government
  - Maximise net income to local government and/or to local population.
- Social planner (national government)
  - Maximise total benefits to the Philippines (efficiency)
  - AND
  - More equal income distribution (equity)
- Sustainable planner (national government)
  - Maximise total benefits (efficiency)
  - AND
  - More equal income distribution (equity)
  - AND
  - Maintain minimum level of relevant environmental stocks.
- Sustainable world planner (UNEP/GEF)
  - Maximise global environmental benefits from mangrove forests .

Valuation: a Benefit-Cost Approach

Valued effects

Using the prices derived in the technical studies, the effects table can be transformed to the valued effects table shown in Table 5. This table includes valued effects and effects that were not valued for reasons described below. Valued effects include effects representing direct and indirect use values, such as benefits to forestry and fisheries. Values shown are annual values for the entire area. Alternatives are assumed to be sustainable. This implies that the time horizon can be assumed to be indefinite. The life time of existing fishponds supports this assumption. Development costs and other capital costs are valued according to the borrowing rate for capital in real terms. It is assumed that, due to cyclones, once in every five years one of the two yearly fishpond harvests is lost entirely, and is therefore included as a 10 percent reduction of the annual harvest.

From the totals of the valued effects it is clear that the aquaculture alternatives perform better than the forestry alternatives and preservation. It is interesting to note that Semi-intensive Aquaculture (SA) performs better than Intensive Aquaculture (IA). This is due to high development costs linked to intensive aquaculture and to the constraints set by the sustainable management of the ponds. The performance of both alternatives is very sensitive, however, to changes in prices of milk fish and prawns. Milk fish are produced for the local market and the price level is relatively stable. The price of prawns, however, is determined on the world market and fluctuates strongly. In this study a price of 185 pesos/kg is used to value prawns. If this price increases above 214 pesos/kg the total value of intensive aquaculture will be higher than the total value of semi-intensive aquaculture. Note also the bad performance of aqua-silviculture (See also Padilla and Tanael 1996a 1996b).

Other effects

Effects of the alternatives on emissions, soil accretion, shore protection, eco-tourism and biodiversity were not valued for the following reasons:

- No cost is attributed to emissions because with the production technique selected for aquaculture, emissions are not expected to create any water quality problems. Also there are no current problems with water quality.

- Shore protection is not valued because this is provided under all alternatives, ie, by the mangrove forest under preservation and forestry alternatives, or by the buffer zones in the aquaculture alternatives. The value is therefore not relevant to the decision.

- Soil accretion may result in the expansion of the forest to the sea. This could be valued according to the total value of the mangrove forest. Since this is very uncertain and, due to cyclones, may even be non existent, no value is attributed.

Eco-tourism is, at present, non existent. Facilities offered in the past, such as walkways, have not resulted in a substantial influx of tourists. A considerable amount of both local and

Table 5. Annual values of management alternatives for the Pagbilao mangrove forest.

	unit	PR	SF	CF	AS	SA	IA	CF/IA	SF/IA
Valued effects									
Subsistence forestry	1000 pesos		349.73						189.34
Commercial forestry	1000 pesos			415.84	217.77			229.00	
Fishponds	1000 pesos				6724.20	22000.00	17000.00	6328.00	6328.00
Fish on site	1000 pesos	163.05	158.63	158.63	122.58	8.14	8.14	40.00	40.00
Fish off site	1000 pesos	1.94	1.88	1.88	1.46	0.09	0.09	0.28	0.28
Total value	1000 pesos	164.99	510.24	576.35	7066.01	22008.23	17008.23	6597.28	6557.62
Other effects									
Emissions	tons/year				20.00	40.00	100.00	50.00	50.00
Soil accretion	cm/year	1.00	0.34	0.42	0.22	0.10	0.05	0.13	0.15
Biodiversity	index	1.00	0.72	0.52	0.16	0.22	0.09	0.24	0.44
Shore protection	index	1.00	0.37	0.15	0.15	0.13	0.07	0.15	0.15
Eco tourism	index	0.80	1.00	0.38	0.18	0.14	0.08	0.21	0.30

Alternatives: PR: Preservation, SF: Subsistence Forestry, CF: Commercial Forestry, AS: Aqua-Silviculture, IA: Intensive Aquaculture, CF/IA: combination of Commercial Forestry and Intensive Aquaculture, SF/IA: Combination of Subsistence Forestry and Intensive Aquaculture.

foreign visitors, however, visit the site for educational or research purposes. Since no alternatives exist on the island of Luzon, no easy accessible alternatives for this function exist. The value of the forest for research is also reflected by the nearby research station. For practical reasons values attached to education and research are not included.

- If all effects listed above represent the direct and indirect use values of the ecosystem the value of biodiversity can only be linked to non use values such as the existence , option or even the intrinsic value of the ecosystem. Due to the importance of mangrove ecosystems the value of biodiversity is expected to be high. Valuation, however, would involve a contingent valuation approach, which raises the question about whose values should be included - local, national or world populations. In addition, it is questionable whether intrinsic values linked to biodiversity can be captured using valuation techniques, especially where the loss of an ecosystem is irreversible (see, for example, Dixon 1994).

Comparison with other studies

A literature survey was conducted in order to compare results from the Pagbilao studies with other mangrove studies (Spaninks and Beukering, in prep). In Table 6 results from studies in Thailand, Fiji and Indonesia are compared with the Pagbilao study. The values for forestry and fisheries are comparable for all studies with a relatively high value for forestry products and a relatively low value for fisheries products in Pagbilao. The value of aquaculture is listed as a negative value since this value represents the foregone benefits of not converting the forest to fishponds and can therefore be considered as an opportunity cost of preservation. The value found by Ruitenbeek for biodiversity is based on a contingent valuation approach. The value used by Lal for purification involves construction of a sewage treatment plant. Since water pollution is not a problem in Pagbilao this value can not be attributed to prevention of emissions in Pagbilao.

Table 6. A comparison of net annual benefits of mangrove products and functions.

	Thailand Christensen (1982)		**Fiji** Lal (1990)		**Indonesia** Ruitenbeek (1992)		**Pagbilao**	
	US$/ha.	*Pesos/ha.*	*US$/ha.*	*Pesos/ha.*	*US$/ha.*	*Pesos/ha.*	*US$/ha.*	*Pesos/ha.*
Forestry	30	750	6	150	67	1675	151	3775
Fisheries	130	3250	100	2500	117	2925	60	1490
Agriculture	165	4125	52	1300				
Aquaculture	-2106	-52650					-7124	-178100
Erosion					3	75		
Biodiversity					15	375		
Local uses	230	5750			33	825		
Purification			5820	145500				

The cost of biodiversity

As indicated above it is very difficult or even impossible to value biodiversity. It is, however, possible to calculate the benefits lost if an alternative is selected that preserves biodiversity but results in a total value lower than the maximum. In this study the value of aquaculture can be considered as an opportunity cost for alternatives that preserve the mangrove forest. Aquaculture generates 7,124 US$/ha compared to 211 US$/ha for the commercial forestry alternative. This leaves a deficit of 6,913 US$/ha. Under the rules of the Global Environmental Facility (GEF) this deficit can be considered to be the incremental costs to keep the forest. The issue is not how much is this forest worth in terms of biodiversity, but how much should be paid to balance the foregone benefits of a more profitable alternative without the forest. The deficit is substantial and far removed from the value of 15US$/ha as listed by Ruitenbeek. The values for erosion control and local as found by Ruitenbeek do not bridge this gap. The value found by Lal for purification is not relevant as explained above.

Figure 4 here

Evaluation: a Multi Criteria Approach

The starting point of the multi criteria analysis is the valued effects table introduced in the previous section (Table 5). A graphic presentation of this table is presented in Figure 5. In this presentation each effect is standardised between 1 (the best alternative) and 0 (the worst alternative). Each row represents an effect. For each effect the highest bar represents the best alternative. For emissions, as an example, Preservation (PR), Subsistence Forestry (SF) and Commercial Forestry (CF) are the best alternatives. All three do not produce emissions and receive a score of 1. Intensive Aquaculture (IA) produces the most emissions and receives a score of 0. All other alternatives are scaled relatively to these two extremes. Figure 5 clearly shows the trade-off between revenues from fishponds and all other criteria.

Figure 5 A graphic representation of the valued effects table

This graphic representation can be used to rank the alternatives according to policy priorities. The effect that is considered most important is moved to the top row, the second most important effect to the second row etc. In Figure 6 priority is given to environmental effects: biodiversity is moved to the top row, followed by emissions etc.. By exchanging the columns the alternatives can be ranked visually. Given the priorities assigned to the effects, Figure 6 shows that Preservation (PR) is the best alternative because it is the best alternative for the four effects that are considered the most important, second best for eco-tourism and best for fisheries. Looking at the lower end of the ranking it can also be seen that Semi-intensive Aquaculture (SA) will always be preferred over Intensive Aquaculture (IA) because it performs worse for five of the included effects and equal on the remaining five[4].

Figure 6 A graphical ranking of the valued effects table

The previous section dealt with the economic efficiency objective. As was shown in Table 4, decision makers also consider equity and environmental objectives. In the previous section effects were not differentiated according to income groups. Also effects on the environment were not included because these effects could not be valued. Therefore equity and environmental objectives were not included. Therefore the decision problem is now redefined into a multi objective decision problem with the following three objectives:

- Maximise efficiency: maximise monetary benefits over costs.

[4] The ranking shown in Figure 5 was derived using the expected value method to transform the priority order of effects to quantitative weights and the weighted sum of weights x standardised effects to derive a performance index for the alternatives.

- Maximise equity: maximise income to local population.
- Maximise environmental quality: maximise the balance of positive effects and negative effects to the environment

It is assumed that the country-city income distribution parallels the poor-rich income distribution. This is reflected in the ownership of existing fishponds. Equity is defined as the benefits that go to the local poor. Environmental quality is linked to preservation of environmental functions (Gilbert and Janssen in prep). The performance of the alternatives on these three objectives is shown in Table 7. The first two objectives are measured in monetary terms: all effects are aggregated according to their prices or shadow prices. Environment is defined as an index combining effects on soil accretion, emissions, shore protection, biodiversity and eco-tourism. The relative weight of biodiversity within this index is ten times the relative weight of each of the other effects.

Table 7 Performance of the alternatives on three objectives

	unit	PR	SF	CF	AS	SA	IA	CF/IA	SF/IA
Efficiency	1000 pesos/year	165	510	576	7065	22000	17000	6588	6558
Equity	1000 pesos/year	165	510	576	3418	8	8	260	230
Environment	index	12.8	9.0	6.2	-17.9	-37.4	-98.9	-47.1	-45.0

Three scatter diagrams are used to analyse the trade-offs and level of conflict between efficiency and equity (Figure 7), efficiency and environment (Figure 8) and equity and environment and equity (Figure 9). Figure 7 shows the performance of the alternatives on the objectives efficiency and equity. The horizontal axis represents the performance on efficiency and the vertical axis the performance on equity. Scores are standardised between 0 (the worst alternative) and 100 (the best alternative). Therefore the most efficient alternative, Semi-intensive Aquaculture (SA), can be found on the far right of the diagram and the most equitable alternative, Commercial Forestry (CF) can be found at the top of the diagram. The ideal alternative for these two objectives would combine optimal performance on efficiency with optimal performance on equity. This ideal alternative would have a score of 100, 100 and would be found in the upper right corner of the diagram. It is clear from Figure 7 that in this case this ideal alternative does not exist. Also compromise alternatives, combining good or moderate performance on both objectives, do not exist. The level of conflict between both objectives is also reflected by the correlation coefficient. A value close to one indicates minimal conflict, a value close to minus one indicates extreme conflict. The value of -0.79 indicates high conflict between efficiency and equity. Addition or removal of alternatives may influence the relative position of the remaining alternatives and will also influence the correlation coefficient. It is therefore important that only alternatives that are relevant to the decision are included in the evaluation

The line shown in this diagram can be used to rank the alternatives visually. In this diagram equal weight is given to efficiency and equity. This is reflected in the angle of the line. All points on this line have the same distance from the ideal alternative[5]. The alternatives can now be ranked by moving this line from top right to bottom left. The first to cross the line and therefore the best alternative is Commercial Forestry (CF) almost immediately followed at the other extreme of the diagram by Semi-intensive Aquaculture (SA). A change in relative weight of the two objectives is reflected by a change in angle of the line. The ranking shown in Figure 7 is extremely sensitive to variations in the relative weights of efficiency and equity.

Figure 7. Trade-off between efficiency and equity

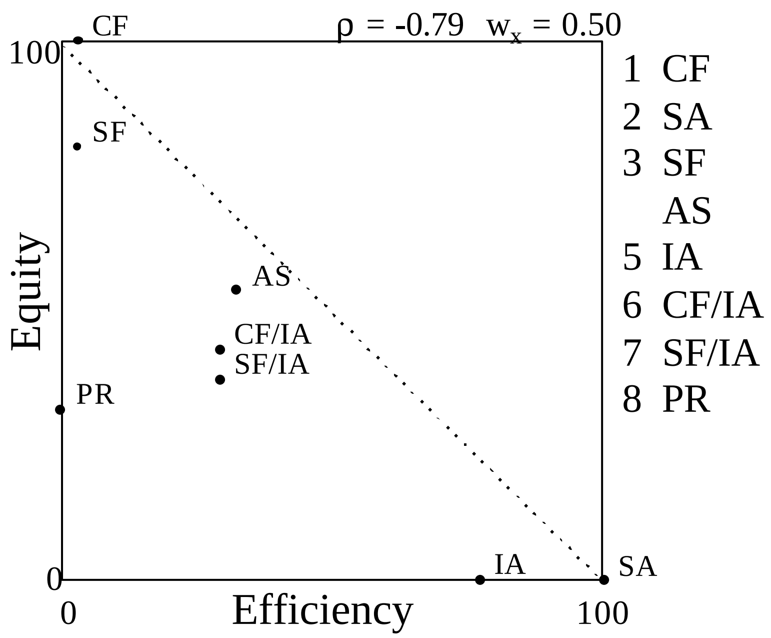
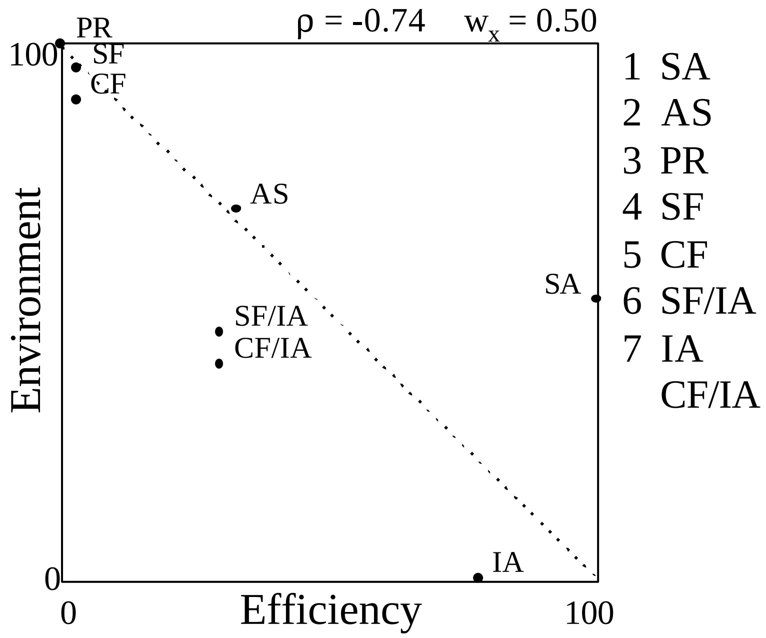


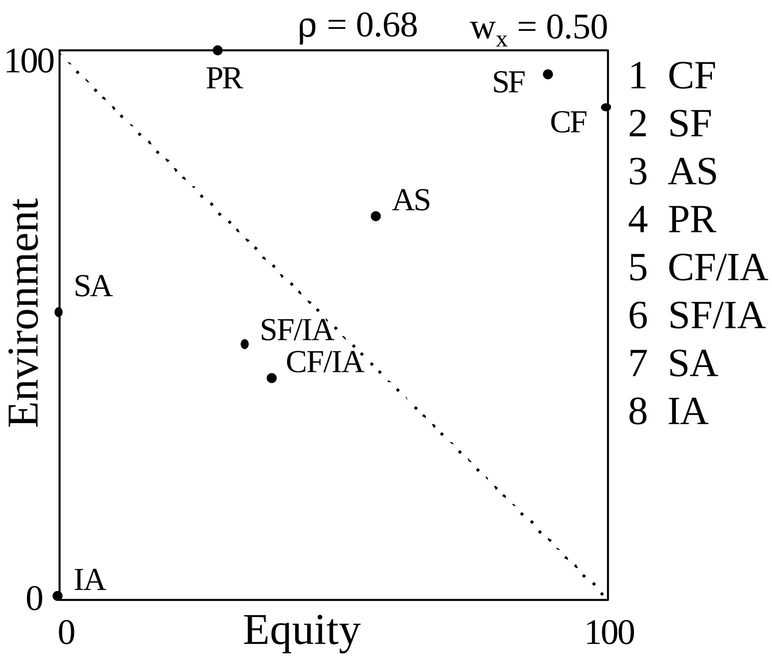
Figure 8. Trade-off between efficiency and environment

[5] Distance is defined here as the sum of the distance along the x axis and the distance along the y axis. Since the line intersects the x axis and the y axis at the same distance form the ideal alternative, all points on the line share the same distance to the ideal point.



The trade-off between efficiency and environment is shown in Figure 8. Conflict is less than between efficiency and equity, but still fairly high at -0.74. Semi-intensive Aquaculture (SA) now ranks as the best alternative. If the relative weight of environment is substantially increased, Preservation (PR) will move to the first position. The most interesting of the three diagrams is shown in Figure 9. In this diagram the trade-off between equity and environment is shown. The correlation coefficient of 0.68 indicates minimal conflict. Two alternatives can be found near the ideal alternative with Commercial Forestry (CF) as the best alternative. Note also the extreme bad performance of Intensive Aquaculture (IA) at the lower left corner of the diagram. The ranking shown to the right of the diagram is fairly insensitive to changes in the relative weights of both objectives.

Figure 9. Trade-off between equity and environment



In Figures 7,8 and 9 the trade-offs between pairs of objectives were analysed. As a last evaluation step the ranking according to all three objectives simultaneously is shown in Figures 10, 11 and 12. In Figure 10 all three objectives are considered equally important. This results in Commercial Forestry (CF) as the most preferred alternative[6]. In Figure 11 efficiency is the most important objective followed by equity. In Figure 11 environment is the least important objective. This results in Semi-intensive Aquaculture (SA) as the most preferred alternative. In Figure 12 priority is given to environment followed by equity and efficiency. In this case Commercial Forestry (CF) ranks as the best alternative. Note that Preservation (PR) never ranks within the two most preferred alternatives.

Figure 10. Efficiency, equity and environment are equally important.

[6] The ranking shown in Figure 5 was derived using the expected value method to transform the priority order of effects to quantitative weights and the weighted sum of weights x standardised effects to derive a performance index for the alternatives

Figure 11. Efficiency is more important than equity; equity is more important than environment

Figure 12. Environment is more important than equity, equity is more important than efficiency.

The trade-off between efficiency and equity could be accommodated by policies that reallocate income from the distant fish pond owners to the local community or by policies that would channel government revenues from the auction of fishpond lease agreements to the local poor. It could also be accommodated by new types of ownership arrangements of the fishponds. In practice, attempts to achieve a more equitable distribution of income from fishponds have failed for political and legal reasons. Change in ownership arrangements has also failed because of limited access to capital by the local poor.

Conclusions and Recommendations

This study evaluated the conversion of the 110.7-hectare strip of protected mangrove forest in Pagbilao, Philippines, into aquaculture, forestry and combined uses. Two points are emphasised in the specification of alternative uses of the mangrove forest. The first is that the overriding consideration is sustainability. For instance, the recommended harvesting rates in forestry options are based on sound silvicultural practice. Likewise, the specified aquaculture technology is based on the recommendations of studies on Philippine milk fish and prawn farming. The second point is community-based management of forest and fishery resources which is now the natural resource strategy in the Philippines.

The previous sections have shown that if efficiency is maximised, semi-intensive aquaculture is the preferred alternative; if equity and environment are also considered important policy objectives commercial forestry is the best alternative. Policy objectives differ according to the role of the decision maker involved. Table 8 lists the preferred alternatives according to type of decision maker and their objectives. A short explanation of the position of each decision maker is included below.

Table 8 Decision makers, their objectives and their preferred alternatives.

- Fishpond owner
  Maximise profit
  => Conversion to semi-intensive aquaculture

- Local government
  Maximise net income to local government and to the local population from the forest
  => Increase the licence fees for fishponds and convert to fish ponds
  OR
  => Forestry and fisheries

- Social planner
  Maximise total benefits to the Philippines (efficiency)
  AND
  More equal income distribution (equity)
  => Conversion to fishponds if efficiency is emphasised.
  OR
  => Forestry and fisheries if equity is emphasised.

- Sustainable planner
  Maximise total benefits (equity)
  AND
  More equal income distribution (equity)
  AND
  Maintain minimum level of relevant environmental stocks.
  => Preservation to maintain a minimum level of mangrove ecosystems.
  (minimum stock of habitat, biological and genetic diversity)

- Sustainable world planner (UNEP/GEF)
  Maximise global environmental benefits from mangrove forests
  => Pay a maximum of US$ 614748 per year to the Philippines
  OR
  => Accept the loss of the Pagbilao forest

- Under the assumption of sustainable management the individual fish pond owner will prefer semi-intensive aquaculture since this alternative generates the largest profits. This preference can also be observed at existing fish ponds in the Pagbilao region. Many of the existing fish ponds date from the 1950s which suggests that the management of these ponds is sustainable.

- If local government finds a way to increase the licence fees linked to the various activities to a level that equals the producer's surplus, conversion to fish ponds would generate the highest revenues. If these revenues are ploughed back into the community this would also generate the largest improvement to equity. However, recent attempts to substantially increase the licence fees have failed due to political resistance. Therefore, in the current situation commercial forestry should be the choice of local government.

- A social planner should take both efficiency and equity objectives into consideration. In the absence of mechanisms to transfer income from fishponds to the local poor the choice of the social planner is dependent on the priority given to both objectives.

- In addition to a social planner, a sustainable planner will try to maintain a minimal level of mangroves. It can be argued that on a world and national scale this minimum level is already reached; certainly for the island of Luzon this is the case. The preservation of the forest despite the potential revenues from fish ponds, suggests that the Philippine government operates as a sustainable planner in this case

- If it is accepted that preservation of the mangrove forest is primarily in the interest of the world community, it is not reasonable to make the Philippines pay the price of preservation. Under this assumption, the sustainable world planner, institutionalised in the Global Environmental Facility, should be prepared to pay the incremental costs of 614748 US$/ year if he considers preservation of the forest worthwhile.

For this study much effort has been invested in data collection and modelling. However, results have to be used with care. This holds particularly for the results linked to off-site fisheries. It proved to be very difficult to establish a clear link between the size of the mangrove forest and the value of off site fisheries. A production function approach proved to be unfeasible. Given these limitations the following can be concluded:

- For the Pagbilao mangrove forest, aquaculture is the policy alternative with the highest economic value. If equity and environmental considerations are included subsistence forestry is the preferred alternative.

- Environmental services, such as biodiversity, shore protection and flood mitigation, need to be priced very highly to make preservation the alternative with the highest value.

This study used a combination of cost-benefit analysis and multi criteria analysis. Although biodiversity is considered crucial to the decision to preserve the forest, it proved impossible to put a monetary value on changes in biodiversity. This raises the question of the limitations of valuation - whether it is possible to value irreversible effects such as the loss of life, the loss of ecosystems, the loss of species, the loss of works of arts etc.

Another crucial issue in the case of Pagbilao is the distribution of wealth. The income from the fish ponds goes to distant investors. Also the conversion to fish ponds creates areas that cannot be accessed by the local population. The equity issue cannot be addressed adequately using cost-benefit analysis. Multi criteria analysis was used to supplement cost-benefit analysis, and proved to be useful for including equity and environmental objectives. From a methodological point of view the following can be concluded:

- It is questionable whether it is possible to value non use values linked to irreversible effects such as loss of biodiversity.

- It is recommended to use a combination of cost-benefit analysis and multi criteria analysis if effects on biodiversity or other important irreversible effects are important to the decision or if major changes in income distribution are expected.

Additional research is required including the following topics:

- the ecological linkages both within mangrove ecosystems and between mangrove and other coastal ecosystems is essential.

- an assessment of production functions between mangroves and mangrove related products, such as fisheries, can be seen as an extension of these efforts. It is questionable, however, whether an assessment of production is feasible in applications such as Pagbilao.

- approaches for valuing environmental values such as biodiversity is necessary. This should include an appraisal of the appropriateness of valuation to support decisions including this type of environmental values.

- The conflict between efficiency and equity could be reduced by changes in ownership arrangements or adequate mechanisms to transfer costs and benefits between income groups. Research on the potential and limitations of existing transfer mechanisms and research on the development of new mechanisms is therefore important.

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Appendix

Table A1. Wildlife of the mangrove areas of Pagbilao, Quezon, Philippines

I. Fauna specifically reported from the mangrove areas, fishponds and mudflats at Pagbilao Bay		
	Scientific Name (Family)	Common Name
A. Birds	Anas luzonica	Philippine Malard/Duck
	Bubulcus ibis	Cattles Egrets
	Butorides striatus	Green-backed Heron
	Calidris tenuirostris	Red-necked Stint
	Chilodonia hybrida	Whiskered Terns
	Egretta alba	Great White Egret
	Egretta eulophotes	Chinese Egret
	Egretta garzetta	Little Egret
	Gorsachius goisagi	Night Herons
	Numenius phaeopus	Whimbler
	Nycticorax caledonicus	Rufous Night Heron
	Sterna hirundo	Terns
	Tringa brevipes	Grey-tailed Sandpiper
	Tringa glareola	Wood Sandpiper
	Tringa hypoleucos	Common Sandpiper
	Tringa nebularia	Greenshank
	Tringa stagnatilis	Marsh Sandpiper
	Tringa Totanus	Red Shank
		Long-toed stint
		Sharp-tailed sandpiper
B. Mammals	Balaenoptera edeni	Dolphin spp.
	Macaca fascicularis	Philippine Monkey
	Small cetaceans	Marine mammals
	(Pteropodidae)	Bats
II. Fauna specifically reported from the forest part of Pagbilao (Quezon National Forest Park)		
A. Birds	Buceros hydrocorax	Rufous Hornbill
	Ceyx melanurus	Philippine Forest Kingfisher
	Corvus enca sierramadrensis	Luzon Little Crow
	(Alcenidae)	Spotted Wood Kingfisher
B. Mammals	Batomys grantii	Philippine Rind Rat
	Cervus rusa philippinensis	Philippine Deer
III. Birds typical of the Philippine mangrove forest (expected to occur in the Pagbilao mangrove forests)		
	Aegithia tiphia	Commonm Iora
	Cyornis rufigastras	Mangrove Blue Flycatcher
	Halcyon capensis	Stork-billed Kingfisher
	Halcyon chloris	White-collared Kingfisher
	Lalage nigra	Pied triller
	Nectarina calcostetha	copper-throated Sunbird
	Nectarina sperata	Purple-throated Sunbird
	Orthotomus sericeus	Rufous-talied Tailorbird
	Pachycephala grisola	Mangrove Whistler
	Streptopelia bitoquata	Island Collared Dove

Sources: Protected Areas and Wildlife Bureau, DENR, Davies et al., 1990

Table A2 Major Plant Species of the Pagbilao Mangrove Reserve, By Zone

A. Seaward Portions
Nipa (Nypa fruticans)
Bakauan lalaki (Rhizophora apiculata Bl.)
Bakauan babae (R. mucronata Lamk)
Api-api (Avicennia officinalis L.)
Pagatpat (Sonneratia alba J. Smith)

B. Middleward
Tangal (Ceriops tagal (Perr.) C.B. Robins
Pototan (Brugiera sexangula (Lour.) Poir)
Api-api (Avicennia officinalis L.)
Buta-buta (Excoecaria agallocha L.)
Saging-saging (Aegiceras corniculatum (L.) Blco.)
Tinduk-tindukan (A. floridum Roem. & Schult.)
Piagau (Xylocarpus moluccensis (Lamk.) Roem.)
Gapas-gapas (Camptostemon philippinense (Vid.) Becc.)
Pototan lalaki (Bruguiera cylindrica (L.) Bl.)
Malatangal (Ceriops decandra (Griff) Ding Hou)
Tabau (Lumnitzera littorea (Jack.) Voigt.)
Taualis (Osbornia octodonta F. Mueller)

C. Landward
Api-api (A. officinalis L.)
Pi-api (A. marina (Forsk.)Vierh. var rumphiana(Hallier) Bakh.)
Dungon-late (Herritiera littoralis Dryand. ex. W. ait.)
Lagolo (Acrostichum aureum)
Buta-buta (Excoecaria agallocha L.)
Acanthus sp.

D. Riverines
Lagolo (A. aureum)
Nipa (N. fruticans)
Pagatpat (Sonneratia alba J. Smith)
Pedada (S. caseolaris (L.) Engl.)
Busain (Bruguiera gymnorhiza (L.) Lamk.)
Bakauan lalaki (R. apiculata Bl.)
Bakauan babae (R. mucronata Lamk)
Api-api (A. officinalis L.)
Pi-api (A. marina(Forsk.)Vierh. var rumphiana (Hallier)Bakh.)
Bungalon (A. marina (Forsk.) Vierh)
Nilad (S. hydrophyllaceae Gaertn.)
Tabigi (Xylocarpus granatum Koen.)

Table A3. Taxonomic identification of fish species found in the Pagbilao mangrove reserve

Species	Family	NMC 1982	de la Paz Aragones 1985	Pinto (1985, 1988)	Fortes 1994
Total species		26	110	128	37
Total genera		25	73	82	
Total families		21	47	54	26
Total orders		6	13		
Chanos chanos	Chanidae	x	x	x	x
Epinephelus malabaricus	Serranidae		x	x	x
Epinephelus suillus	Serranidae			?	x
Epinephelus sexfasciatus	Serranidae				
Epinephelus quoyanus	Serranidae				
Lutjanus johni	Lutjanidae		x	x	
Lutjanus argentimaculatus	Lutjanidae	x	x	x	
Lutjanus russelli	Lutjanidae		x	x	
Lutjanus fulviflamma	Lutjanidae		?	?	
Siganus guttatus	Siganidae	x	x	x	x
Siganus javus	Siganidae	x	x	x	
Siganus fuscescens	Siganidae	x	?	x	x
Scatophagus argus	Scatophagidae	?	x	x	x
Valamugil cunnesius	Mugilidae	?	?	?	
Lisa tade	Mugilidae		?	?	x
Leiognathus equulus	Leiognathidae		x	x	?
Leiognathus splendens	Leiognathidae		x	x	
Leiognathus brevirostris	Leiognathidae	x	x	x	
Gazza minuta	Leiognathidae		x	x	
Cynoglossus abbreviatus	Cynoglossidae		?	?	
Pseudeorhombus arsius	Bothidae		x	x	
Apogon amboinensis	Apogonidae	x	?	?	x
Gerres filamentosus	Gerreidae	x	x	?	x
Sillago sihama	Sillaginidae	x	x	x	x
Sillago aeolus	Sillaginidae		?	?	
Lethrinus miniatus	Lethrinidae		?	?	?
Scolopsis taeniopterus	Nemipteridae				
Scolopsis affinis	Nemipteridae				
Nemipterus nematophorus	Nemipteridae				x
Upeneus tragula	Mullidae		x	x	x
Upeneus sulphureus	Mullidae		x	x	x
Sphyraena forsteri	Sphyraenidae		?	?	x
Strongylura incisa	Belonidae		?	?	
Tylosurus indicus	Belonidae		?	?	?
Scomberiodes tol	Carangidae		x	x	?
Alepes melanoptera	Carangidae				x

Table A3 Continued.

Species	Family	NMC 1982	de la Paz Aragones 1985	Pinto (1985, 1988)	Fortes 1994
Therapon jarbua	Therapontidae	x	x	x	x
Pelates quadrilineatus	Therapontidae		x	x	?
Platycephalus indicus	Platycephalidae	x	x	x	
Cymbacephalus nematophthalmus	Platycephalidae			?	
Inegocia japonica	Platycephalidae			?	
Stolephorus commersonii	Engraulidae		?	?	x
Sardinella hualiensis	Clupeidae		?	?	?
Megalops cyprinoides	Megalopidae	x	x	x	
Elops machnata	Elopidae	x	x	x	x
Yongeichthys criniger	Gobiidae			x	
Glossogobius sp.	Gobiidae	x	?	?	
Bathygobius sp.	Gobiidae				
Exyrias puntang	Gobiidae		?	?	
Acentrogobius janthinopterus	Gobiidae				?
Acentrogobius suluensis	Gobiidae				
Acentrogobius viganensis	Gobiidae				
Acentrogobius sp.	Gobiidae				
Oxyurichthys opthalmonema	Gobiidae		x	x	
Redigobius bikolanus	Gobiidae		x	x	
Cristagobius nonatoae	Gobiidae				
Favonigobius reichei	Gobiidae				
Brachyamblyopus anotus	Gobiidae				
Ophiocara porocephala	Eleotridae				
Butis butis	Eleotridae		x	x	
Ambassis kopsi	Ambassidae	x	x	x	
Ambassis urotaenia	Ambassidae		?	?	
Ambassis interruptus	Ambassidae		?	?	
Toxotes jaculator	Toxotidae				
Zenarchopterus buffonis	Hemiramphidae	?	x	x	
Gullaphallus mirabilis	Phallosthetidae				
Atherinomorus lacunosus	Atherinidae		?	?	
Hippichthys spicifer	Syngnathidae			?	
Prosopsdasys gogorzae	Scorpaenidae		x	x	
Arothron reticularis	Tetraodontidae		?	x	
Chelonodon patoca	Tetraodontidae		x	x	
Lagocephalus lunaris	Tetraodontidae		x	x	
Triacanthus indicus	Triacanthidae		?	?	
Paramonacanthus japonicus	Monacanthidae		?	?	
Lactoria cornuta	Ostraciontidae				
Parachaetodon ocellatus	Chaetodontidae		?		
Halichoeres miniatus	Labridae		?	?	

Table A4. Habits and other characteristics of selected fish species found in the Pagbilao mangrove reserve

Species	Habitat	Habit	Social Groupings	Trophic Level	Food Items
Chanos chanos	E	S, B	Pg, Gr	H	algae, invertebrates
Epinephelus malabaricus	M	BP	So	C	fishes, crustaceans
Lutjanus spp.	M	BP	So, Pg	C	shrimps, fish
Siganus spp.	M	BP	Pg	H	algae, diatoms
Liza tade, Valamugil cunnesius	E	BP	So	H	algae, diatoms, plant detritus
Leiognathus spp.,Gazza sp.	M	BP	Gr	C	copepods, polychaetes, plant detritus
Apogon amboinensis	M	BP	Gr, Pg	C	shrimps, fish, plant detritus
Gobiidae	R, E	B	So, Pg	C	amphipods, isopods, nematode, plant detritus
Ambassis spp.	E	BP	Gr	C	zooplankton. shrimp, plant detritus
Cynoglossus abbreviatus	M	B	So,Pg	C	crustaceans, forams,diatoms, plant detritus
Pseudorhombus arsius	M	B	So	C	crustaceans, fishes
Gerres filamentosus	M	B	Pg	C	invertebrates, plant detritus
Sillago sihama	M,E	BP	Pg	C	annelids, crustaceans
Stolephorus commersonii	M	S	Gr	C	copepods, other crustaceans, plant detritus
Megalops cyprinoides	E,M	P	So,Pg	C	small fishes
Elops machnata	M	P	So	C	amphipods, isopods, nematodes, plant detritus

Source: Pinto (1985)

Legend: E= estuarine, M= marine, R= riverine; B= benthic, P= pelagic, BP= benthopelagic, S=surface;
So= Solitary, Pg= pair, Gr= gregarious; H= herbivorous, C= carnivorous

Table A5. Estimates of sustainable production of forest products for various management alternatives

Forest Product	Management alternatives							
	PR	SF	CF	AS	SA	IA	CF/IA	SF/IA
I. Potentially Marketable								
A. Fuel wood (m^3/year)	0	184	65	42	0	0	35	99
1. Subsistence	0	184.4	0	0	0	0	0	99.4
2. Commercial	0	0	65.2	42.3	0	0	35.0	0.0
B. Timber (m^3/year)	0	46	207	134	0	0	111	25
1. Subsistence	0	46.4	0	0	0	0	0	25.1
2. Commercial	0	0	206.7	134.1	0	0	110.8	0
C. Charcoal (m^3/year)	0	31	0	0	0	0	0	22
1. Subsistence	0	31.2	0	0	0	0	0	22.3
2. Commercial	0	0	0	0	0	0	0	0
Sub-Total (Timber)	0	262	272	176	0	0	146	147
D. Nipa shingle (1000/year)	0	45.0	45.0	0	0	0	22.5	22.5
II. Ecological contribution								
Nutrient prod. (1000kg./year)								
Nitrogen	70.1	28.6	28.6	22.1	4.2	4.2	20.4	20.4
Phosphorus	23.7	23.0	23.0	17.8	3.4	3.4	16.4	16.4
Potassium	5.7	5.6	5.6	4.3	0.8	0.8	4.0	4.0

Alternatives: PR: Preservation, SF: Subsistence Forestry, CF: Commercial Forestry, AS: Aqua-Silviculture, IA: Intensive Aquaculture, CF/IA: combination of Commercial Forestry and Intensive Aquaculture, SF/IA: Combination of Subsistence Forestry and Intensive Aquaculture.

Notes

- Charcoal is zero in commercial forestry as production is not in commercial quantity.

Source: Carandang and Padilla. 1996. Assessment of forest resources of the Pagbilao mangrove Forest. Resources, Environment and Economics Center for Studies, Philippines, and Institute for Environmental Studies, Free University, The Netherlands.

Table A6. Valuation of Forest Products

	Subsistence Forestry	Commercial Forestry	Unit (pesos)
A. Nipa Shingles			
Market price per shingle	2.9	2.9	per piece
Transport cost	0.2	0.2	
Gathering costs	0.9	0.9	
Shadow price	2.2	1.8	
B. Timber Products			
i) Timber alternative: coconut lumber			
Market price (4.50 pesos/bd.ft)	1,907	1,907	per m^3
Transport cost	40	40	
Gathering costs	303	303	
Shadow price	1,644	1,564	
ii) Fuel wood alternative: upland fuel wood			
Market price (5 pesos/bundle of 0.010 m^3)	500	500	per m^3
Transport cost	310	310	
Gathering cost	0	0	
Shadow price	810	190	
iii) Charcoal: Valuation is similar to fuel wood	810	190	per m^3

Source: Carandang and Padilla. 1996. Assessment of forest resource of the Pagbilao mangrove forest. Resources, Environment and Economics Center for Studies, Philippines, and Institute for Environmental Studies, Free University, The Netherlands.

Notes:

- Gathering of nipa shingles. One person can fill up one boat-load of nipa shingles over 3 hours of work. One boat-load is equivalent to about 40 shingles. Total harvest in a 6-hour-day work is 80 shingles. Imputed cost is the income to be earned from a 6-hour fishing trip where average catch is 2-3 kg equivalent to 75 pesos/day if price of fish is 30 pesos/kg. This brings the gathering cost at 0.9 pesos per shingle.

- Timber harvesting. Volume of wood harvested in 5-6 hours of work (including travel time) is about 0.577 m^3, all of which can be loaded to a carabao-drawn cart. Imputed cost is also based on income from fishing which is estimated at approximately 130 pesos per m^3. The cost of transporting timber from the forest at forest at 100 pesos (173 pesos/) per m^3 trip. Total gathering cost is the sum of the two. Cooking with liquefied petroleum gas (LPG) is not considered as the appropriate substitute considering high costs from: a) capital investment in gas stove and the gas tank; and b) uncertainty in availability of refills particularly in areas like Pagbilao.

- Fuel wood harvesting. Four bundles (0.04 m^3) may be gathered in about 6 hours traveling to a site 200 meters away. It is assumed that non-working family members do this task and hence the opportunity cost is close to zero and is assumed to be zero in this case.

- In subsistence forestry, the use value of the forest products derived from the mangroves should be net of the gathering cost. When households are denied access to mangrove forest resources, the value attached to the forest products is equivalent to the cost they incur in obtaining alternative products. Such cost is equal to the market price of the alternative product plus the transport cost from the market to the point of use. Thus, the shadow price of forest products is the market price of the alternative product plus the transport cost less gathering costs.

- In a commercial forestry regime, it is assumed that the co-operative’s objective is to maximise the value of net benefits to be derived from the forest. Net benefit is the stumpage value which is equal to the market price of the good less the costs of transport, extraction and related costs incurred in managing the forest..

Table A7. Estimates of annual production and value of market-size fishes taking into account natural mortality of various fish species (kg/ha/year)

	Alternatives					Fish Prices
	PR	SF CF	AS	SI IA	CF/IA SF/IA	(pesos/unit)
A. Quantity of Production (kg/ha/yr)						
Mangrove Residents						
Slipmouths (3 spp.)	50.9	49.5	38.2	0.0	12.7	20
Cardinal fish (1 sp.)	2.2	2.1	1.6	0.0	0.5	20
Glass fishes (2 spp.)	360.9	351.2	271.4	0.0	90.2	20
Gobies (4 spp.)	4.4	4.2	3.3	0.0	1.1	20
Crabs (1) in #	297.2	289.2	223.4	29.7	74.3	2.7
Mud crabs (1) in #	416.7	405.4	313.3	41.7	104.2	12.5
Mangrove Transients						
Milk fish (1 sp.)	0.4	0.4	0.3	0.0	0.0	50
Rabbit fishes (2 spp.)	0.2	0.2	0.2	0.0	0.0	20
Mullets (2 spp.)	2.3	2.2	1.7	0.0	0.2	20
Groupers (1 sp.)	0.0	0.0	0.0	0.0	0.0	90
Snappers (3 spp.)	0.0	0.0	0.0	0.0	0.0	80
Shrimps (4 spp.) in #	1261.1	1226.9	948.1	63.1	189.2	1
B. Value of Production						
Mangrove Residents						
Slipmouths	72.1	70.2	54.2	00.0	18.0	
Cardinal fish	01.9	01.8	01.4	00.0	00.5	
Glass fishes	658.9	641.0	495.3	00.0	164.7	
Gobies	05.0	04.8	03.7	00.0	01.2	
Crabs	97.1	94.5	73.0	09.7	24.3	
Mud crabs	638.0	620.7	479.7	63.8	159.5	
Sub-total	1,472.9	1,433.0	1,107.3	73.5	368.2	
Mangrove Transients						
Milk fish	00.7	00.7	00.5	00.0	00.0	
Rabbit fishes	00.0	00.0	00.0	00.0	00.0	
Mullets	00.6	00.6	00.4	00.0	00.1	
Groupers	00.0	00.0	00.0	00.0	00.0	
Snappers	00.0	00.0	00.0	00.0	00.0	
Shrimps	16.2	15.8	12.2	00.8	02.4	
Sub-total	17.5	17.0	13.2	00.8	02.5	
Total	1,490.4	1,450.0	1,120.5	74.3	370.7	

Alternatives: PR: Preservation, SF: Subsistence Forestry, CF: Commercial Forestry, AS: Aqua-Silviculture, IA: Intensive Aquaculture, CF/IA: combination of Commercial Forestry and Intensive Aquaculture, SF/IA: Combination of Subsistence Forestry and Intensive Aquaculture.

Source: Ong and Padilla. 1996. Assessment of fisheries functions of the Pagbilao mangrove forest. Resources, Environment and Economics Center for Studies and Institute for Environmental Studies, Free University, The Netherlands.

Notes

- Production estimates are adjusted by the percentage deviation of fish sizes caught in Sukol Creek from market sizes. Length measures are first converted to weight. These are then adjusted for adjusted downwards to reflect production of the entire forest. For simplicity, this is assumed to represent losses from natural mortality as the fish grows to market sizes.

- Fish prices listed on the rightmost column are adjusted by the percentage deviation of fish found in the creek to market sizes. This adjustment represents level of dependence of fish on the mangroves. Further, the value of fish in-situ is equivalent to 12.25% of market prices.

Table A8. Aquaculture production and computation of present value of net Profits for each management alternative over 25 Years

	Management alternative				
	Semi-intensive aquaculture: Milk fish	Intensive aquaculture: Crop Rotation	Intensive aquaculture. and commercial Forestry	Intensive aquaculture and Subsistence Forestry	Aqua-silvi-culture
Production (1000kg)	596.90	240.86	88.55	88.55	179.32
Average Prices (pesos/kg)					
Milk fish	60	60	60	60	60
Prawn		185	185	185	
Gross Revenue (1000 pesos)	35,814	36,347	13,363	13,363	10,759
Variable Costs (1000 pesos)	9,148	14,851	5,460	5,460	2,748
Gross Profit (1000 pesos)	26,666	21,496	7,903	7,903	8,011
Development Costs (1000 pesos)	42,840	42,840	15,750	15,750	12,870

Notes:

- Development costs for intensive aquaculture are estimated at P400,000 per ha when exchange rate is P11/US$.
- It is assumed that development costs moved with the exchange rate, hence, it is estimated now at P900,000 per ha. when exchange rate is at P25/US$.
- Development cost for semi-intensive ponds is assumed 50% of the amount.

Table A9. Value of annual production of different marketable products for each management alternative (1000 pesos/year)

	Alternatives							
	PR	SF	CF	AS	SA	IA	CF/IA	SF/IA
I. Forest Products								
Fuel wood	0	149.364	12.388	8.037	0	0	6.650	80.514
Subsistence	0	149.364	0	0	0	0	0	80.514
Commercial	0	0	12.388	8.037	0	0	6.650	0
Timber	0	76.282	323.279	209.732	0	0	173.291	41.264
Subsistence	0	76.282	0	0	0	0	0	41.264
Commercial	0	0	323.279	209.732	0	0	173.291	0
Charcoal	0	25.272	0	0	0	0	0	18.063
Subsistence	0	25.272	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	18.063
Nipa shingle	0	99.000	81.000	0	0	0	40.500	47.250
Sub-Total	0	349.918	416.667	217.769	0	0	220.441	187.091
II. Aquaculture	0	0	0	6724	22000	17000	6328	6328
III. Capture Fisheries	164.987	160.515	160.515	124.039	8.225	8.225	41.036	41.036
Residents	163.050	158.633	158.633	122.578	8.136	8.136	40.760	40.760
Transients	1.937	1.882	1.882	1.461	0.089	0.089	0.277	0.277

Alternatives: PR: Preservation, SF: Subsistence Forestry, CF: Commercial Forestry, AS: Aqua-Silviculture, IA: Intensive Aquaculture, CF/IA: combination of Commercial Forestry and Intensive Aquaculture, SF/IA: Combination of Subsistence Forestry and Intensive Aquaculture.

Notes:

- The value of forest products is derived from Tables A5 and A6;
- The value for fisheries is computed by multiplying total value in Table A8 by 110.7 ha.