Aquaculture, Forestry and Conservation in Malaysian Mangroves

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ABSTRACT. *Malaysia's 650,000 ha of mangroves are under the jurisdiction of the various State Forest Departments. Some 20% of mangroves have been lost through "reclamation" by the woodchip industry in the past twenty years. Another 20% has been earmarked for possible aquaculture development in Peninsular Malaysia. A comparison between sustained-yield management for forestry and conversion to aquaculture shows that aquaculture development is economically precarious. A conservation plan involving sustained-yield management and the establishment of mangrove protected areas is suggested. Seed materials from the protected areas will ensure genetic vigour for sustained-yield management.*

1. INTRODUCTION

Mangroves comprise some 650,000 ha (about 2%) of the total land area of Malaysia; about 110,000 ha occur in Peninsular Malaysia, while the rest are in Sabah and Sarawak. In Peninsular Malaysia, some 20% of the mangroves have been reclaimed in the last 20 years (Ong, 1978). The major mangrove forests in Peninsular Malaysia are under some form of sustained yield management by the different State Forest Departments. In recent years the loss of mangrove areas is due mainly to excision for port and airport facilities, industrial estates and, to a lesser extent, agriculture. In Sabah and Sarawak, another 20% has been licensed for woodchip production (estimated from figures of annual coupes given by Chai, 1977 and Liew, 1977). It appears that no new licenses are being issued in Sabah and Sarawak for the production of woodchips (the socio-economic returns being poor and the degradation to the mangrove being a problem—Nair, 1977, and Ong, 1978).

The Ministry of Agriculture has estimated that about 27,000 ha of land in Peninsular Malaysia is suitable for brackish water fish culture (in Gedney, *et al.*, 1982). This presumably is mostly mangrove land, which means some 20 to 25% of the mangroves in Peninsular Malaysia has been earmarked for aquaculture use. Indeed, the Fisheries Development Authority (Lembaga Kemajuan Ikan Malaysia or Majuikan), has started the initial phase of a giant aquaculture scheme by acquiring some 300 ha of forest in the Sungai Merbok Mangrove Forest Reserve, Kedah. It would thus appear that aquaculture presents the greatest threat to Malaysian mangroves in the near future.

The aim of this study is to examine the various implications of developing aquaculture schemes in mangrove forests as compared with sustained yield management for timber production and suggest the most rational use of this so often misunderstood ecosystem.

2. TWO MANGROVE SYSTEMS

This will be done by examining two mangrove areas in Peninsular Malaysia:

i) The Matang Mangrove Forest Reserve, which is under sustained yield management for charcoal, poles and firewood by the Perak Forest Department; and
ii) The Sungai Merbok Mangrove Forest Reserve, which is being developed into a major aquaculture scheme by Majuikan.

2.1. The Matang Mangrove

Sustained yield use of mangrove forest is seen at its best in the Matang Mangrove Forest Reserve, which contains about 40,000 ha of forests dominated by almost pure stands of *Rhizophora apiculata*. It is situated in the state of Perak and is under the jurisdiction and management of the Perak Forest Department. The forest has been under sustained yield management since the early part of this century.

2.1.1. Management plan. The forest has been worked under a 30- to 40- year rotation plan is now in its third rotation; the annual coupe for clear-felling is about 1,000 ha, with trees clear-felled in patches of a few hectares in an area. Clear-felled timber is used mainly for the manufacture of charcoal, the rest being for firewood. After clear-felling, the slash (i.e. small branches, twigs, leaves, fruits and stumps) is left to decompose naturally. This slash usually becomes neglible after about two years. In certain areas natural regeneration of young plants is good so no planting is necessary but in areas where regeneration is poor, the area is planted with *Rhizophora apiculata* propagules, at about 1.2 m intervals. In some areas it is necessary to manually remove weeds like the mangrove fern *Acrostichum* before replanting can be carried out. It is estimated that some 50% of the clear-felled areas need artificial replanting.

The seedlings are allowed to grow unattended for 15 years, at which time the first thinning is carried out. A 1.2 m stick is used during this process. Any tree within a radius of 1.2 m (the stick) of the central tree is removed. The aim of the thinning is to obtain poles which have a diameter at breast height of about 15 cm. Poles are used for scaffolding by the local building industry, pilings and fishing stakes. Apparently this is not intended as a silvicultural treatment although an unpublished (Gong, Ong & Wong) study indicated "natural thinnings" occur to a very significant extent between 10 and 15 years. A second thinning is carried out between 20 and 25 years with a 1.9 m stick and the trees are finally clear-felled at about 30 years, ending the rotation. This rule-of-thumb system (Watson, 1928) appears to have worked remarkably well although there has been a drop in yield between the second and third rotations (the first rotation figures cannot be used for comparison because the first fellings were of larger trees more than 30-40 years old); the reason for the decrease in yield is not known (Tang *et al.*, 1980).

2.1.2. Socio-economic factors. A number of villages are located within mangrove forests. The population is either involved with forestry or the fishing industry. It has been estimated that the forest industry provides employment for a direct work force of about 1,400 and an indirect work force of another 1,000 (Ong, 1978). The estimated annual total value of mangrove forest products in the area is about US$ 9 million (Haron, 1980).

The fishing industry in the same area provides employment for an estimated direct work force of about 2,500 and an estimated indirect work force of another 7,500 (Ong, 1978). Based on the value of prawns and cockles landed in 1979 of US$ 32 million for the whole State of Perak (Tang *et al.*, 1980), it is estimated the total annual value of the Matang mangrove fisheries to be at least on the order of US$ 30 million.

Thus, it can be seen that the fishing industry in Matang provides employment (directly or indirectly) for 4 times as many people as the forest industry and the value from fishing is at least 3 times that derived from forestry. Matang is the best mangrove forest in Malaysia (and possibly in the world). The returns from the forest industry will probably be less in lesser managed forests. This vividly illustrates the value of the fishing industry in the mangrove environment.

2.1.3. Ecological implications. Since the pioneering works of Heald (1971) and W.E. Odum (1971) there is now ample circumstantial evidence to demonstrate the dependance of coastal fisheries on mangroves. Certain species of penaeid prawns, including *Penaeus indicus*, *P. merguiensis*, *P. monodon* and most species of *Metapenaeus*, are dependant on mangrove forests for shelter during their juvenile stages (Macnae, 1974). While in some areas the correlation between prawn landings and mangrove area is good the relationship does not hold in other areas; it is not possible to generalize and say "no mangroves: no prawns." In Peninsular Malaysia there is also a good correlation between prawn landings and mangroves (Gedney *et al.*, 1982) and a number of studies (T.L. Ong, 1978); Sasekumar and Thong, 1980; Thong and Sasekumar, 1980; Leh and Sasekumar, 1980) have shown the presence of significant amounts of mangrove detritus in the guts of many important commercial fishes in coastal waters.

Unfortunately, direct or quantitative evidence to link mangroves and coastal fisheries appear lacking. The vital question, "How much mangroves can be removed in any particular area without adversely affecting the adjacent coastal fisheries?" as yet cannot be answered. There is an urgent need for concerted research efforts in this area.

In the Matang Mangroves some 10 tonof mangrove litter is produced per hectare per year (Gong *et al.*, 1980; Ong *et al.*, 1980a). Slash produced by thinnings and clear-felling adds significantly to this amount (Wong *et al.*, 1982). Thus the practice of sustained yield production of timber in Matang can coexist in harmony with coastal capture fisheries. Efforts should be made to have fisheries input to the present management plan since any alternate use or change in management plan may have an adverse effect on the fisheries.

Until more information becomes available it appears that the system of management as practiced in Matang should be maintained and encouraged, though this management results in almost a monoculture of *Rhizophora apiculata*. Conservation is essentially rational use, and I have previously suggested a pragmatic approach

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(for Peninsular Malaysia) of preserving about 1% of mangroves for posterity and maintaining most of the rest as practiced at Matang until such time as we have a better understanding of the ecosystem (Ong, 1982). The close association between man and mangroves has made it such that there is no truly virgin stand of mangroves in Peninsular Malaysia.

2.2. The Sungai Merbok Mangrove

The Sungai Merbok Mangrove Forest Reserve is used here to illustrate the use of mangroves for aquaculture. The reserve is made up of 18 forest compartments with a total area of 4176 ha. The vegetation is dominated by *Rhizophora apiculata* and *Bruguiera parviflora*. Some 1,500 ha on the north bank of the Sungai Merbok (known as the Ban Merbok area) had been previously reclaimed for rice cultivation but the development of acid sulphate conditions has resulted in the land lying idle. Compartment 15, comprising 307 ha, has recently been excised for aquaculture by Majuikan. The reserve is under the jurisdiction of the Kedah Forest Department.

2.2.1. Forest Management Plan. The forests are thinned and clear-felled under a plan similar to that at Matang but there is no silvicultural treatment like weed extermination and planting. Regeneration is completely left to nature, yet the forests are surprisingly good (Ong *et al.*, 1980a). The lack of selective planting has resulted in a forest of mixed species, some of the Compartments in this forest are specifically set aside for the use of fishermen in the area.

2.2.2. Aquaculture Development Plan. Majuikan and the State Government of Kedah are developing an aquaculture scheme here. Already some 50 ha have been converted into ponds and its associated infrastructure. The rest of the mangrove is being studied for further conversion. A master plan for the development of the whole mangrove estuary into a major aquaculture scheme is being undertaken. The objectives of the scheme are to provide gainful employment to the farmers and fishermen in the area and to raise their living standards. The overall development plan will "include aquaculture installations and regional and local settlement centres with communication systems, infrastructure, and utilities (water supply, electricity, sewage, roads, etc.) and amenities (schools, hospitals, recreational centres, etc.), conducive to creating an attractive living and working environment" (Majuikan, 1979). The plan includes a socio-economic evaluation as well as an environmental impact assessment. A baseline ecological survey has already been completed (Ong, *et al.*, 1980b). It is expected that the scheme will involve the economically depressed population of about 15,000 in the area.

2.2.3. Economics of pond aquaculture. A recent assessment (Gedney *et al.*, 1982), showed that, in the Malaysian context, culture of the tiger prawn, *Penaeus monodon* in ponds provides the best returns. A net income of between US$-4,200 (i.e. net loss) to US$16,800 per ha of pond per annum was estimated, depending on the survival rate of the prawns. Majuikan has started culturing tiger prawns in their new ponds. Input/output calculations have shown that, unless seed and feed costs can be reduced, the project will face serious economic problems unless a remarkably high survival rate of 60% can be achieved. With better technology, it is possible to reduce the cost of seeds but it is unlikely that the cost of trash fish for feeding will go down since with more ponds, demand will become greater. Already Malaysia is a net importer of trash fish (Gedney *et al.*, 1982). Only under ideal conditions will it be possible to approach the net income of over US$12,000 estimated by Gedney *et al.* It is evident that the risks are great as an economic venture, which may account for the paucity of private enterprise in brackish water pond aquaculture.

2.2.4. Ecological implications. The high organic content in mangrove soils, iron in the soil and the ever-present sulphate from tidal seawater makes practically all mangrove soils susceptible to acid sulphate conditions should oxidation of the soil occur. This often happens during pond construction, when the soil is exposed to air and oxidized. When this happens the pH of the ponds often drops to 3 or less—a condition not conducive to pond culture. It is sometimes possible to control this condition with the use of lime and careful control of water levels, but this can prove uneconomical. It is not known if mangroves will recolonize ponds abandoned as a result of acid sulphate conditions. If recolonization can take place, it may be possible to restore the mangroves.

The aquaculture system used by Majuikan involves feeding the prawns with trash fish (with plans for the use of pellitized food at a later stage); it is not known if this is more efficient than the natural system in the mangrove waterways.

Since the aquaculture ponds rely on a supply of water from the adjacent mangrove waterways, it is vital that the water is of good quality and unpolluted. It is thus important that steps are taken to ensure that pollution upstream from the mangroves is well controlled; any laxity could result in catastrophe for the ponds. Pond operators will automatically put great pressure on the relevant authorities to enforce strict control, and the surrounding mangrove areas will benefit from this control.

The main problem now for Majuikan is to decide how much of the mangroves can be converted to aquaculture ponds and the associated infrastructure without adversely affecting the adjacent coastal fisheries. There is no ready answer to this; it will take some years of concerted research effort to solve the problem. Unless the aquaculture scheme within the mangrove ecosystem can improve on the productivity (in terms of either quality or quantity), then such use of the mangrove eco-

system is a wasteful one. This is a vital consideration for resource managers. The mangrove is nature's own aquaculture system with a number of advantages. An artificial system has the advantage of relatively easier harvest and selection of particular species but nature's system is vastly more stable and less susceptible to diseases and epidemics. Unless the artificial ponds can very significantly surpass the natural system, the establishment of aquaculture ponds may be a case of robbing Peter to pay Paul with the possible added cost of having to compensate Peter after.

3. CONSERVATION

One concept of conservation is that of total preservation for the sake of posterity. While such a concept may have its proponents in the developed nations (where conflict between prosperity and posterity is sometimes thought to be minimal), a more pragmatic concept may have to be applied in the less developed countries (where rapid growth in prosperity is often a primary target of national development). The concept that would be generally acceptable is one that regards conservation as the rational use and mangement of resources. Indeed, this concept does not necessarily exclude the narrower concept of total preservation for posterity.

Since most of the world's mangroves occur in the less developed countries, conservation plans are more likely to succeed if based on the concept of rational use and development rather than one based on preservation for posterity (if a certain amount of prosperity is not achieved, there may be no posterity left to preserve for).

Conservation of mangroves in Malaysia would thus involve a plan or strategy for its rational use and management. As a background to this, it would be necessary to demonstrate the usefulness of mangroves. This can then be followed by a national strategy for rational use and management.

3.1. The value of mangroves

The mangrove ecosystem is in all likelihood the most productive (in terms of net productivity) of all natural ecosystems; its timber yield alone is greater than those of land forests (Tang *et al.*, 1980) and its very considerable contribution to adjacent coastal fisheries (especially the prawn fishery) makes this ecosystem too valuable to be neglected or callously ravaged (as has sometimes been the case in the past).

Ecologically these forests appear to be involved in stabilizing soil and checking erosion in the riparian and littoral zones as well as providing nourishment (from mangrove litter) to aquatic organisms in the mangrove and adjacent coastal ecosystems.

3.2. Major uses of mangroves

At present there are three major uses of mangroves: sustained yield management for the production of charcoal, poles and fuelwood (as seen at its best at Matang); harvesting of woodchips with little serious attempt at regeneration (as seen in Sabah and Sarawak) and the conversion of mangroves into aquaculture ponds (as at Sungai Merbok).

The use of mangroves as now practiced by the woodchip industry can do irreparable damage to the mangrove ecosystem as well as affect the adjacent coastal fisheries. It is possible, however, with proper planning and good management, for the woodchip industry to use the mangrove ecosystem on a sustained yield basis similar to that seen at Matang.

The conversion of mangroves for aquaculture ponds is not a use of mangrove but a replacement of the ecosystem with ponds. As practiced now, it is extremely wasteful—especially when less productive coastal land can be used for the same purpose. Add to this the acid sulphate potential of mangrove land and the precarious economic returns and the balance tilts against this wasteful use. However, a breakthrough in the state of art of prawn culture in the foreseeable future is a good possibility (e.g., the drastic reduction in the production cost of seeds). If this happens, prawn culture becomes economically very attractive, and mangroves, because of their coastal location will no doubt be the main targets for conversion to ponds.

One advantage of having aquaculture ponds (as well as other aquaculture activities like cockle and floating cage culture) is that deterioration of water quality caused by pollution will have a dramatic effect in terms of fish kills, ensuring that the relevant authorities keep a close check on pollution of the ecosystem.

3.3. Mangrove National Parks

The first National Park in Malaysia that includes the mangrove ecosystem is the Bako National Park in Sarawak. The Klias National Park in Sabah consists of mainly mangroves. There is, however, no mangrove national park in Peninsular Malaysia, only two almost insignificant areas of Virgin Jungle Reserve (VJR). It is suggested that a mangrove national park be established in Peninsular Malaysia, preferably in the state of Johore, where more natural mangroves can still be found. The number of mangrove Virgin Jungle Reserves should be appreciably increased.

Apart from the usual arguments for the establishment of national parks (and VJRs) there is an additional strong argument here. The management system in Matang (in its third rotation) has seen a drop in yield. Although the actual reason for this reduction in yield is not known, the use of selected (e.g. high yield) seeds could have prevented this. Also, the current practice may have resulted in the reduction of genetic vigour.

Availability of seeds (propagules) has also been a problem. Mangrove national parks and VJRs would certainly be excellent sources for seeds and genetic material. The proposed mangrove national park for Peninsular Malaysia should include a complete ecosystem (from the freshwater to seawater) and it is not unreasonable to suggest that the area should be not less than 1 percent of the total mangrove area on the Peninsula. The area of Mangrove VJRs should also be increased to at least 1 or 2 percent of the total mangrove forest reserves.

4. CONCLUSION: A STRATEGY FOR RATIONAL USE AND MANAGEMENT

It is evident that at present the most rational use of mangroves in Malaysia is the sustained yield system as practised in Matang. It is also possible to manage mangroves on a sustained yield basis for the woodchip industry (although this is not done at the present). Certain mangrove areas may be suitable for conversion to aquaculture ponds

The strategy for rational use and management of Malaysia's mangroves should follow a national mangrove management plan based on the following guidelines:

- for the time being mangroves should be used on a sustained yield basis and managed along the lines used in Matang;
- the management plan used in Matang should be improved with greater research input. There should also be a significant input from fisheries research;
- the use of mangroves for aquaculture should be further researched and explored before major efforts at implementation;
- the conversion of mangroves to aquaculture ponds should proceed with extreme caution and carefully evaluated both ecologically and socio-economically;
- the use of *hutan darat* or land forests of the mangroves for conversion to aquaculture ponds should be thoroughly investigated before productive mangrove forests are used for this purpose;
- a number of mangrove national parks and Virgin Jungle Reserves (each covering at least 1 percent of the mangrove area in Peninsular Malaysia, Sabah and Sarawak) should be established; and
- funding should be obtained for much-needed scientific and socio-economic research on the mangrove ecosystem; the establishment of a National Mangrove Research Institute is opportune.

A National Mangrove Committee has already been established in Malaysia. It is hoped that this Committee will show its effectiveness by drawing up a national mangrove management strategy for the Government's consideration. This is a matter of ugency. Unless such a strategy is adopted soon, Malaysia's unique and rich mangroves will disappear, leaving the country poorer for the loss.

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