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CONSERVATION STRATEGIES FOR ENDANGERED MANGROVE SWAMP FORESTS IN MALAYSIA

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Abstract

Ecosystem diversity in Malaysia is represented by various terrestrial and aquatic ecosystems from deep seas to montane forests. Species diversity is represented by about 15,000 plant species and more than 6000 animal species, excluding insects, the largest and most diverse group which is inadequately known. As the country is pursuing for industrialization conflicts may necessarily occur for biodiversity conservation and socio-economic development, unless strict sustainable development is adopted. Currently 1.39 million ha (about 7.6%) area under forests of all types has been set aside for biodiversity conservation including mangrove swamp forests. However, a framework for managing biodiversity in protected areas especially that of mangrove ecosystem is inadequate. The country is yet to define priorities for conservation and sustainable use of ecosystem diversity. The impacts of eco-tourism, agriculture and urbanization on mangrove forests are yet to be ascertained. In the absence of concrete data of mangrove biodiversity loss it is difficult to assess the vulnerability of this fragile ecosystem in the light of looming socio-economic development. Many factors contributing to mangrove loss include rapid socio-economic development of the country that has transformed vast mangrove forests for agriculture and resettlement and subsequently created semi-urban and industrial areas which are relatively poor in mangroves. These changing land-use patterns are affecting not only mangrove ecosystems but also the environment *per se*. Other factor such as pollution had also contributed in small part. These activities had led to significant mangrove loss, degradation and fragmentation. The strategies needed for mangrove biodiversity include assessment of land-use patterns, benefit sharing mechanism and some legal measures for sustainable use and protection of mangrove biodiversity.

Introduction

In Malaysia the mangrove ecosystem is an important natural resource for the coastal communities. The mangrove aquatic ecosystems provide resources like fishes, shells and other gastropods for the fishermen while productive forests provide fuel-wood, poles and other building materials for local constructions. In particular, poles of *bakau* (*Rhizophora apiculata*, *R. mucronata*) have been used widely to protect river banks, ponds, lake margin from erosion; the multiple-use *nipah* palms (*Nypa fruticans*) have been providing free services of its parts to those communities all over. Accordingly, such forms of social forestry and fishery have been coexisting harmoniously for generations and incurred minimal impact on the ecosystem.

As the Forestry Departments realized the importance of mangroves to the communities, they took steps to conserve some mangrove swamp forests as forest reserves and effectively managed them based on good forestry management practices. The total extent of the mangrove forests reserves has been estimated to be about 105,537 ha of which 77.8% is considered productive. About 90% of these occur on the more sheltered west coast while only 4% occur on the more exposed east coast of Peninsular Malaysia (Table 1).

Biological characteristics (vegetation and flora): The mangrove vegetation is evergreen and simple in structure varying from 5-25 m in height, depending on age. The canopy is comparatively even and closed, except where there had been gaps caused by lightning and cuttings. The understorey layer is poorly defined while the ground layer is devoid of herbs. The principal mangrove species are characterized by special roots such as stilt roots and pneumatophores and also by their viviparous propagules habit. Several authors such as Wyatt-Smith (1960), Liew (1980), Chai (1982) reported about 31 plant species which are exclusively found in the mangrove swamp forest, while a total of 51 species are considered non-exclusive or associate species. Early in the last century, Watson (1928) had classified the mangroves in Peninsular Malaysia into five vegetation types based on species composition and dominance. They are *Avicennia-sonneratia* type, *Bruguiera cylindrica* type, *Bruguiera parviflora* type, *Rhizophora type* and *Bruguiera gymnorhiza* type. A better and more comprehensive classification is given by Chai (1982) which included the inland mangroves.

World-wide, Tomlinson (1986) reported a total of 114 species of mangrove species, while in Malaysia a total of 104 species has been recorded (Japar, 1994) with only 38 species being exclusive. As stated above the vegetation of the mangrove forest is simple in structure and the floristic composition is also low compared to other forest types. The mangrove flora, structure, above ground biomass and net productivity in the west coasts does not differ very much but when compared with that of the east coasts, some differences are observed. It is found that the flora of the east coast mangroves is poorer and zonation is not obvious as they are not sheltered. This is probably due to the east coast mangroves are exposed to larger waves of South China Sea.

Fauna: Berry (1972) broadly categorized the animal communities in the mangroves into two components, namely the aquatic and the terrestrial. The former consists of fishes, crabs, snails, worms and the bivalves, whilst the latter consists of insects (including the fireflies), birds (including the migratory species), lizards and monkeys.

The mangroves of Pulau Langkawi, Matang, Port Kelang and Kukup are known for fishery, and those of Kg. Kuantan, Kg. Belimbing (Selangor) and Sungai Dew, Matang and Sungai Kerian (Perak) harbour fireflies which attracted good number of ecotourists. The mangroves of Kuala Merbuk (Kedah), Kukup (Johor) and Kuala Gula (Perak) are equally known for supporting migratory birds.

Table 1. Extent of mangrove forest reserves (in ha) in Peninsular Malaysia in 2005.

State	Total area	Note
Johor	17,185	In 1994, 16,659 ha were left. Lately more mangroves were felled in Kukup, Sungai Pulai, Sungai Santi areas for development
Kedah	8,118	In 1994, only 8,034 ha existed, noew some have been converted to prawn and shrimps ponds; while that at Malut in Langkawi has been totally lost. In other parts of Langkawi they habe been protected
Perlis	13	There are patches of mangrove forest in the area of Kuala Perlis but not economical
Negeri Sembilan	204	In 1994, only 879 ha existed along the Sungai Linggi; much of the mangroves in the vicinity of Port Dickson have been developed
Pahang	2,416	The mangroves are found in the sheltered estuaries and also along the rivers, especially Sungai Kuantan and Sungai Rompin
Perak	41,617	Most are quite intact especially in Matang but those in Majong district and Setiawan had been degraded
Pulau Pinang	279	Both the mangroves in Penang Island and Seberang Prai are affected by water pollution
Selangor	14,897	In 1994, it was reported that only 15,090 ha is left; that of Jugra and Pulau Ketam have been badly affected by development
Kelantan	744	There are patches of mangrove forests at estuaries and their river banks in Tumpat and Bachok districts
Terengganu	1,295	There are mangrove forests at estuaries and their river banks, especially Sungai Kemaman
Melaka	80	There are patches of mangrove forests at estuaries and their river banks especially Sungai Linggi
Total	99,767	Whilst in 1994 it was 105,537
Sabah	340,689	23,266 ha are state lands
Sarawak	126,400	93,200 ha are state lands
Grand total	**566,856**	

Microorganisms: There are very few studies on the microorganisms in the mangroves except that of Kuthubutheen (1984) who reported on the diversity of the phylloplane fungi. The microscopic fungi and lichens are quite well represented in the mangrove forests. The authors were also informed of other studies especially the degradation of mangrove leaf litter by microbes. One of the most noticeable macroscopic fungi in the mangroves is the species of *Ganoderma*.

Exploitation of mangrove forests-Timber extraction: Even though mangrove forests are not known for their timber as their lowland dipterocarp forests counterparts, pole extraction is well known. They are either used as poles or in charcoal making. As mangrove forests are species poor, only small-scale logging could be carried out.

Thinning: In Matang, Perak traditional method of stick thinning is employed. However, it has been observed that self-thinning occurs in the mangrove forests. Two schedules of thinning is practiced, the first after 15 years and the second after 20 years. This procedure needs to be assessed for its economic implications.

Harvesting: In the east coast states and Penang harvesting for *nipah* leaves to make *nipah* cigarettes and the edible fruits is being practiced. Furthermore, the inflorescences are tapped for its sweet juice that can be made into vinegar and also direct consumption.

Mangrove forest conversion-agriculture: Much of the inland mangrove forest lands have been converted to oil palm estates. This could be observed in Jugra, Selangor, in particular, as well as though certain areas in Perak and Johor. It is without doubts that oil palm is more economical than mangroves.

Aquaculture: Certain areas in Johor, Selangor, Perak and Kedah, the mangrove swamp forests had been converted into aquaculture pods, in particular prawn ponds. The mangroves in Pulau Langkawi had been converted to fish landing port and in some other areas cage-fish culture has been introduced.

Resettlement: The inland mangrove mixed forests suffered from their conversion to settlement areas, especially for the rural poor.

Impacts on mangroves-pollution: One of the crucial factors that make mangrove forest deteriorate is water pollution. It is well-known that rivers have been the sinks for all kind of sludges and sullages either from domestic sources or factories that are built near the rivers in the inland areas. The pollutants that flow with the water has greatly affected the mangrove resources of the inland mangroves as well as those in the sheltered estuaries. One case of point is the water pollution that had affected the snails and the *beremban* trees (*Sonneratia caseolaris*) that affect the life cycle of fireflies at Kg. Kuantan and Kg.

Belimbing, Kuala Selangor. The sediments from the inland activities had also caused siltation and sedimentation in many mangrove forests.

A few case studies in Pulau Langkawi (Kedah), Kuala Selangor (Selangor) and the east coasts are discussed to show the impacts on the mangroves. All these impacts are serious concerns for conservation efforts and subsequent sustainable management.

Mangroves of Langkawi archipelago-taxonomic composition: Pulau Langkawi has an exceptional natural settings and beautiful landscapes that attract both natural scientists and tourists alike. The mangrove forests of Kilim-Kisap areas in particular are testimony to the above statement. In addition, the mangrove forests there are found on the shallow limestone substratum, making them one of the most outstanding features in Peninsular Malaysia. Mangrove ecosystem is both dynamic and fragile that is very sensitive to either the natural stochastic events and human activities. Though they provide many essential services such as storm protection, erosion control, waste-water clean-up, forest products, they are consistently subjected to conversion to other land-use for more economic returns.

In 1980, the total mangrove area was 3657.67 ha and about 11 years later, the extent of mangroves area was reduced by 10.6% to 3270 ha. Some of the mangrove areas had been earmarked for aquaculture ponds, resorts, chalets and other uses. In1988 much of the mangroves at Kisap, Malut, Pasir Tengkorak, and Pulau Dayang Bunting were quite intact and pristine (Figs. 1-3). But by the year 1993, the forests at Malut had been clear-felled to make way for a fishing landing facility and subsequently abandoned. The consideration made was that there are much more mangrove forests elsewhere that sacrificing those of Malut was not going to make an impact on the whole mangrove ecosystem of Pulau Langkawi.

But by the year 1999, those of other areas especially at Pasir Tengkorak, and Kisap Forest Reserve had also being developed as ecotourism resorts. Channeling of waterways to ease the plying boats had been extensive and there were proposals also to further excise the mangroves in the vicinity.

Norhayati & Latiff (2001) had estimated the density of mangroves in a 1-ha plot as being 849 per ha, belonging to nine species and four families. The most dominant species is *Rhizophora apiculata* with an important value of 50.2 and tree density of 557/ha. While, the total above ground biomass was estimated at 115.07 t/ha. In the subsequent studies, Norhayati *et al*., (2005) estimated the above ground biomass at different compartments as being quite comparable.

The details of losses and gains of the mangrove forest in all localities in Pulau Langkawi are given in Table 2. In some cases no change is detected and it is assumed no exploitation of mangrove forests had taken place. Elsewhere there had been changes of area as they are been converted to other more economical land-use. The only locality that had registered 100% loss was Malut as being discussed earlier.

Table 2. The extent of mangrove areas in Pulau Langkawi.

Locality	1980 (ha)	1990 (ha)	% loss/gain
Ayer Hangat	730	402	44.9
Dayang Bunting	684	684	0
Gua Cherita	131	208	58.7
Kisap Forest Reserve	1463	1463	0
Kubang Badak	419	419	0
Pulau Langgun	14	14	0
Pulau Singa Besar	16	16	0
Pulau Timun	26	26	0
Selat Panchor	9	9	0
Tanjung Dagu	27	27	0
Bukit Malut	137	0	100
Total	**3657**	**3270**	

Threats and conservation: It is estimated that in 1988 there were a total of 4,165.29 ha of mangroves in Pulau Langkawi and in the year 1993 there were 3,902.85 ha and by the year 1999 there were a total of 3,764.97 ha. This means that between 1988 and 1999, a total of 400.32 ha or 36.39 ha per year were lost to other land-uses and development. From a study, in a period of five years interval (1988-1993) 6.3% of the total mangrove areas were deforested, and in the next interval (1993-1999), a further 3.53% were deforested. These activities coincided with the fact that Pulau Langkawi was declared as a free-trade zone in 1985 and subsequently there had been great pressure to convert the so-called unproductive forests of mangroves to other more economic enterprises. Notable among them were the conversion of Malut Forest Reserve to fishing landing port, the development of eco-tourism facilities at Kisap and Kilim areas, the conversion of mangrove areas at Tanjung Rhu for hotels and also that of Pasir Tengkorak for some tourism facilities too.

Acknowledging all those recent activities above and the possible threats to the mangrove forests on Pulau Langkawi, may be it is timely and appropriate to propose that a certain area of mangroves be set aside for conservation. Some times ago there were talks of proposing the Kisap-Kilim areas be proposed as a State Park. This proposal is an excellent idea as the area stated above represents mangrove vegetation on shallow limestone substratum, a unique feature in Malaysia, and perhaps in South-East Asia.

As it could be seen from the above figure, some areas of mangrove forests had been converted to either aquaculture ponds and also some mixed agricultural orchards (Fig. 4). However after 1993 there was a patch in the Kisap-Kilim area, where the mangrove was clear-felled for unknown use.

As stated by Norhayati & Latiff (2001), the estimated above ground biomass of mangroves in Pulau Langkawi is 115.07 t/ha. This figure represents a high productivity value for the mangroves, very comparable, if not better than those elsewhere in the world. Using this figure it could be estimated that the total amount of biomass lost in the last 11 years (1988-1999) was 46,064.82 tonnes. Beginning in 1988 to 1993 a total of 129.69 ha were lost and only s mall area to agriculture (33.09 ha) and between 1993 to 1999, a total of 128.54 ha were lost, 23.94 ha to agriculture and 15.75 ha to aquaculture. In Pulau Langkawi a total of 76 species in 58 genera and 35 families of mangrove species was reported, consisting of 34 species of trees, 16 shrubs, seven ferns, six climbers, four herbs and three mosses representing 73% of Malaysia's mangrove taxa (Wan Juliana *et al*., 2010).

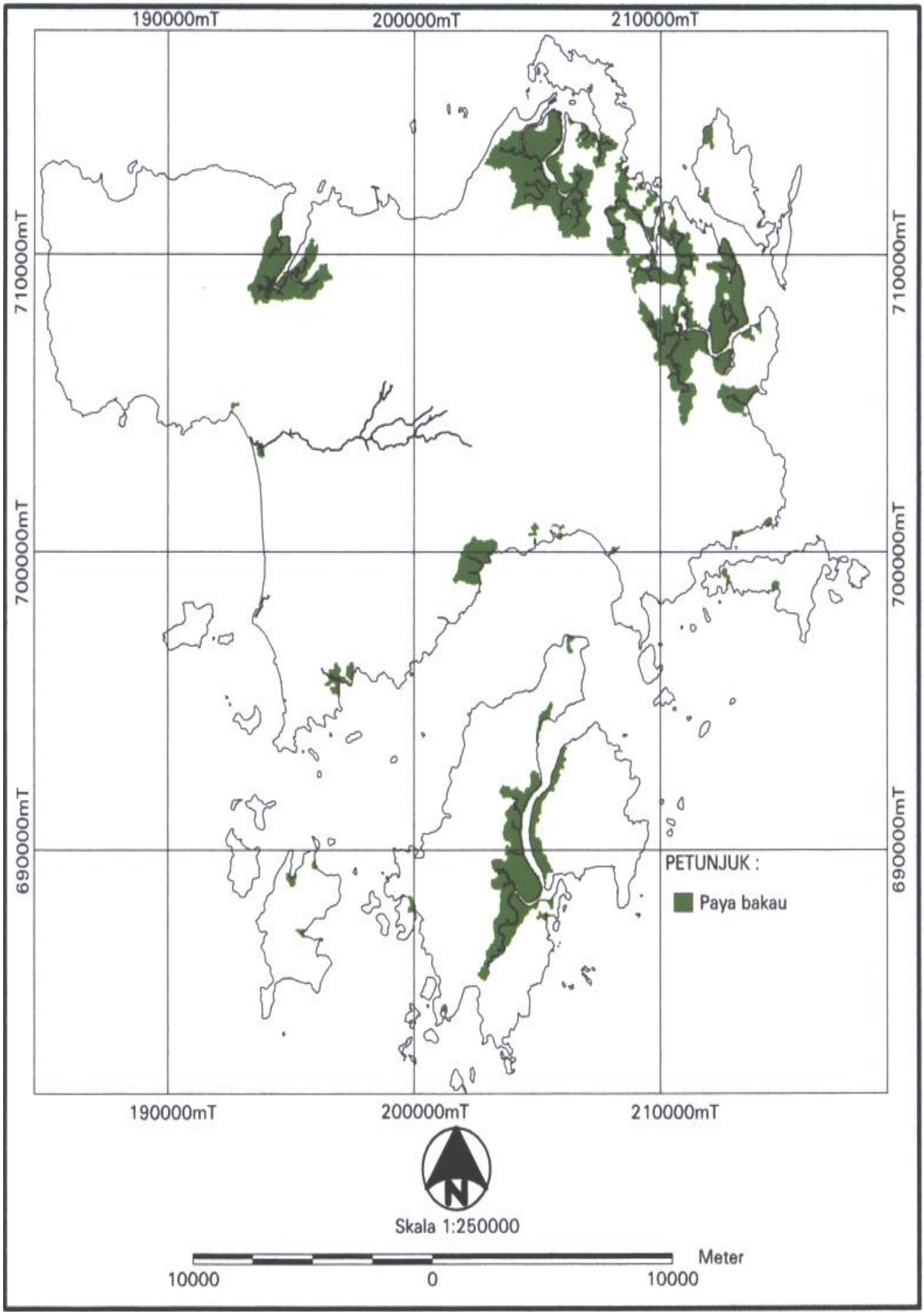

Fig. 1. Distribution of mangrove swamp forests in Pulau Langkawi in 1988.

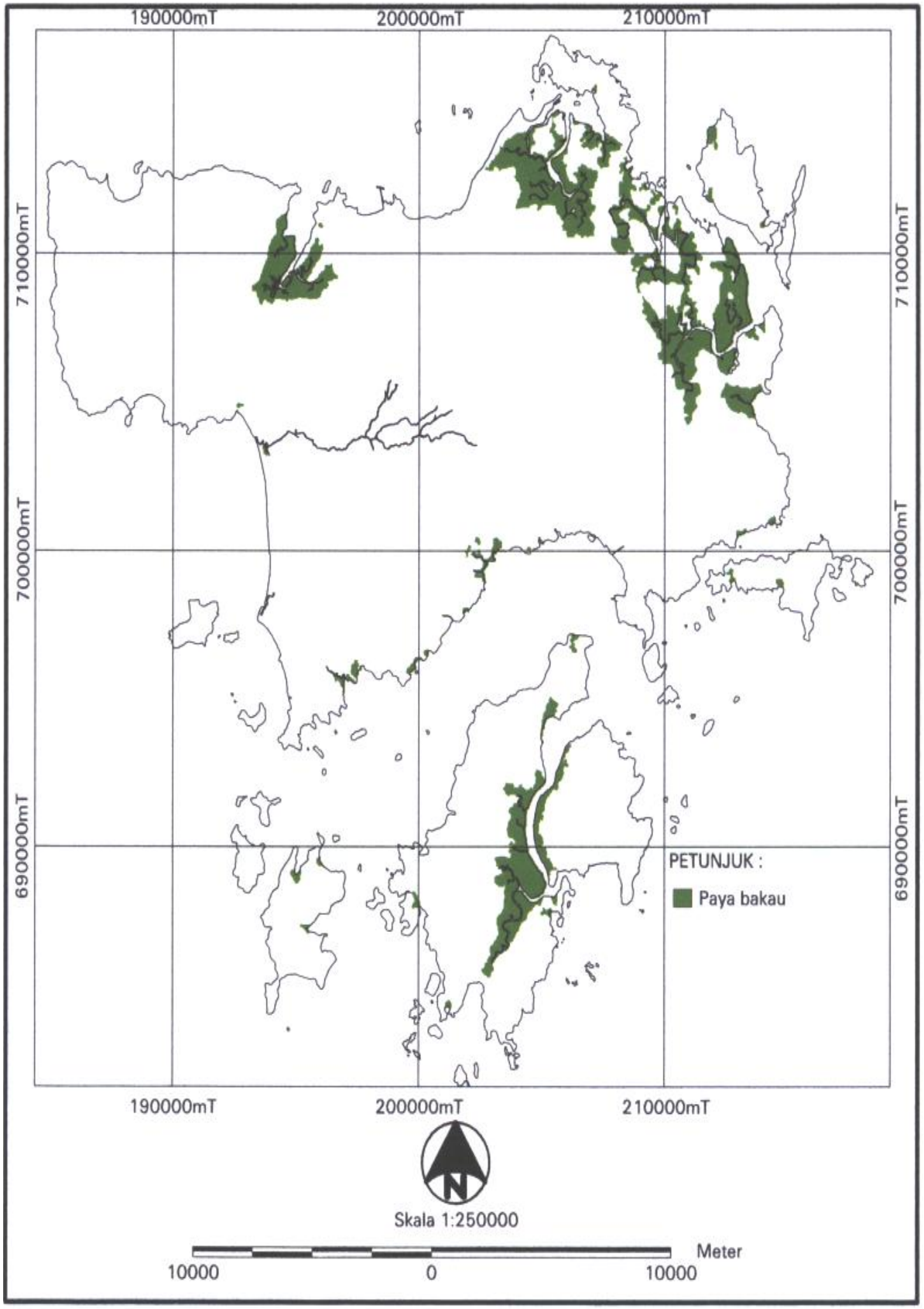

Fig. 2. Distribution of mangrove swamp forests in Pulau Langkawi in 1993.

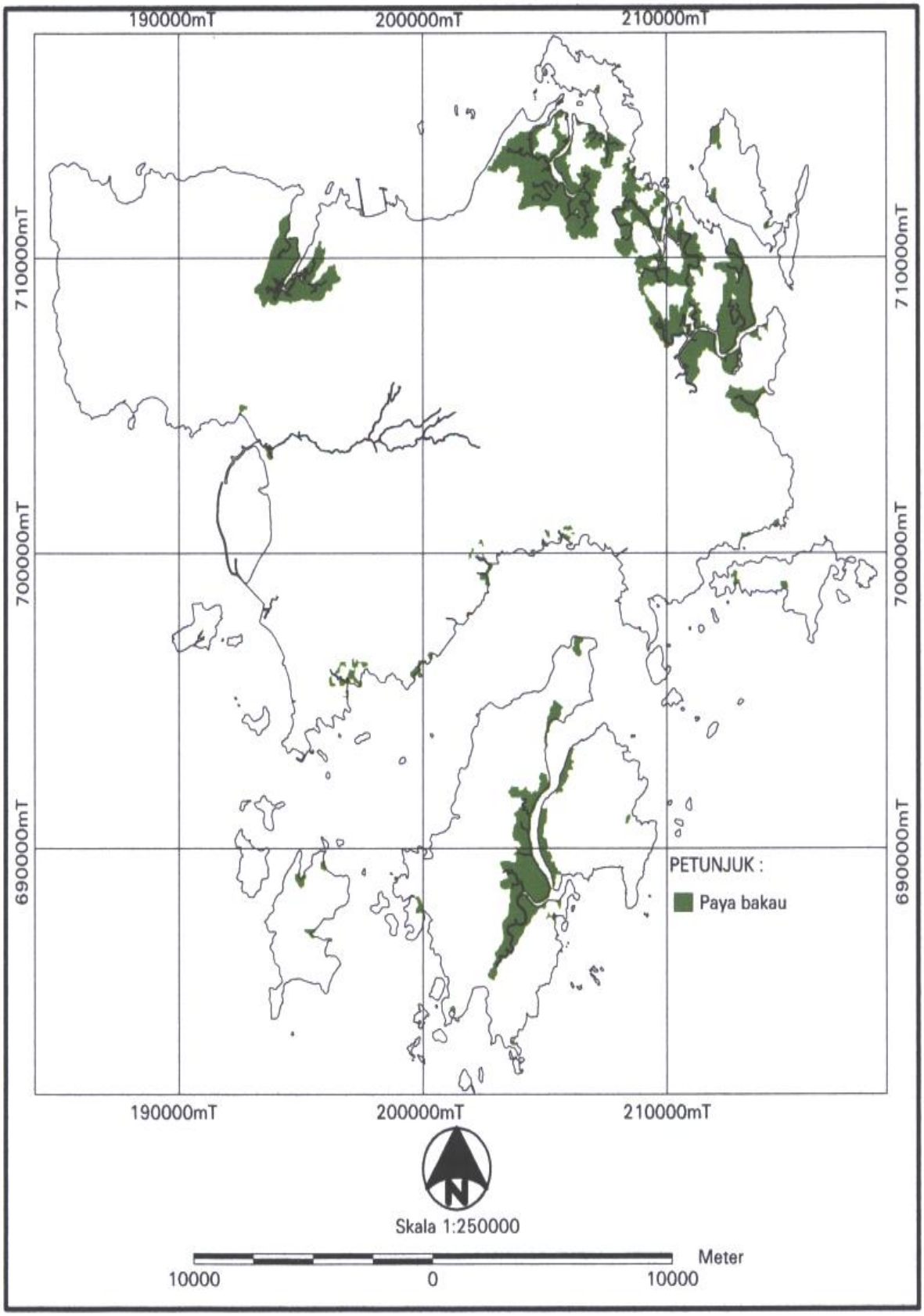

Fig. 3. Distribution of mangrove swamp forests in Pulau Langkawi in 1999.

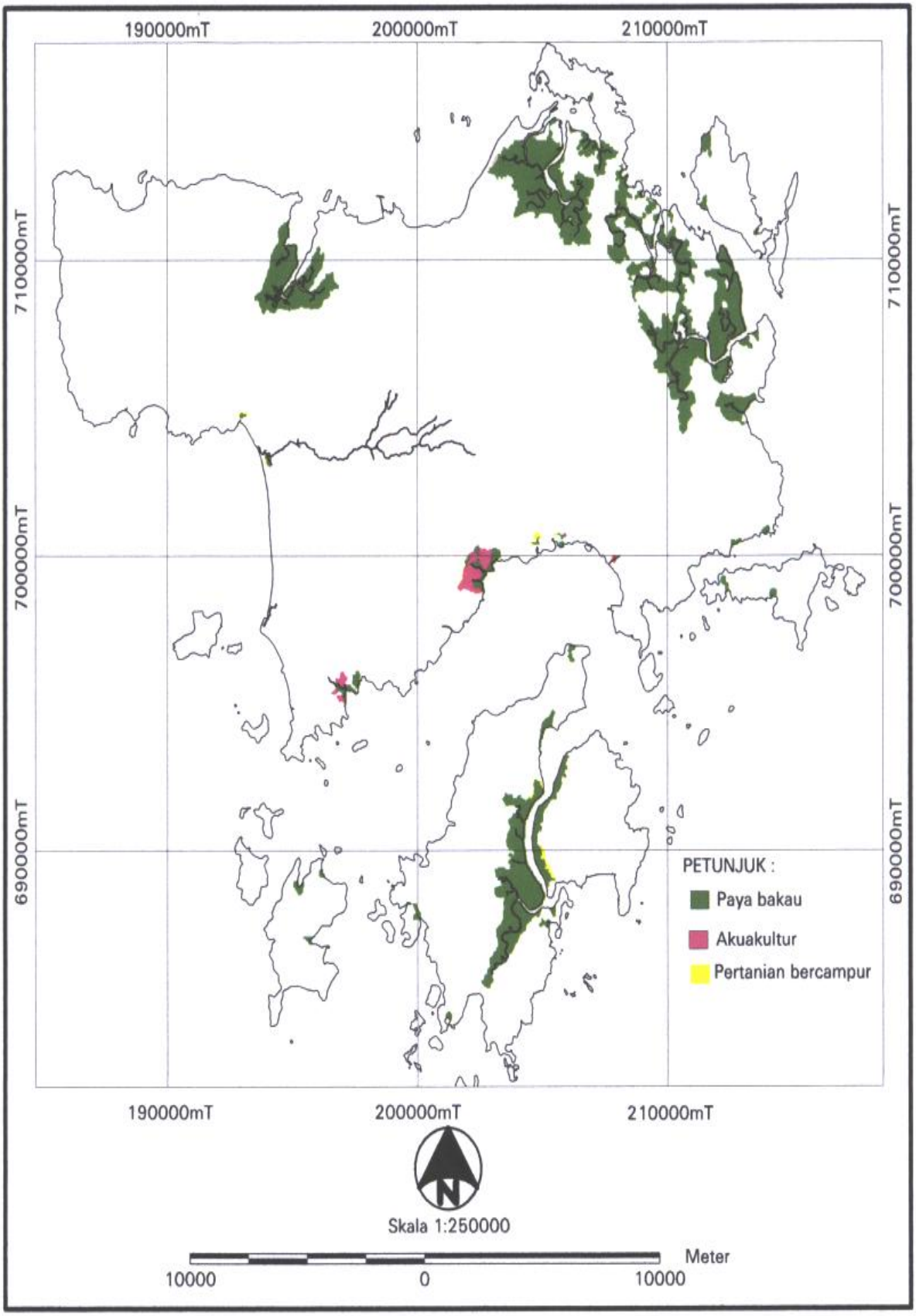

Fig. 4. The appearance of aquaculture activities between 1888 and 1993.

Mangroves of Selangor-taxonomic composition and biomass: Soepadmo and Pandi Mat Zain (1989) surveyed the mangroves of Sementa, Selangor and reported a total of 32 species of plants were found. The dominant species were *Avicennia alba* and *Sonneratia alba* in the *Avicennia* zone. In the mixed *Rhizophora* zone, the dominant species are *Rhizophora mucronata* and *R. apiculata*, and in the *Bruguiera* zone, the dominant species are *Bruguiera cylindrica* and *B. parvifolia*. The total number of stems differs from zone to zone, ranging from 4189/ha in *Avicennia* zone to 13,290/ha in the *Bruguiera* zone and the above ground biomass ranges from 124.53 t/ha in the former zone and 150.78 t/ha in the latter zone.

Threats and conservation: In Selangor, especially Kuala Selangor and Port Kelang areas including the off-shore islands adjacent to it, represent a case where conservation efforts over the years lost to socio-economic pressures. The mangroves on those islands, especially Pulau Ketam, Pulau Carey had paved ways to either agriculture, aquaculture or infrastructural facilities. There is no more hope for recovery–what are lost are lost. However, there were hopes for the mangrove in the Kuala Selangor area especially the area under the Kuala Selangor Nature Park. Attempts to rehabilitate the degraded mangroves receive mixed results, some efforts proved to succeed while some failed due to both natural enemies and also management flaws.

Mangroves of Matang, Perak - taxonomic composition and biomass: Norhayati *et al*., (2004) and Mohd. Nizam & Wan Juliana (2004) discussed both the taxonomic composition and comparative biomass value of Matang. As for the species composition, Azahar Muda and Nik Mustafa (2003 had compiled an extensive list of Matang mangroves flora and fauna.

Threats and conservation: The author is of the opinion that there is not an immediate threat to the mangroves of Matang as the forest reserve is very well management in a sustainable manner. In fact the working plan for the Matang mangroves is a show-case for the world. If there were to be threats, it could be from water pollution that is coming from the interior areas feeding via the rivers to the estuary and ultimately to the mangrove belts.

Mangroves of east coast

Taxonomic composition and biomass: Soepadmo & Pandi Mat Zain (1989) surveyed the mangroves of Kuala Kemaman and Kg. Pantai Tinggi, Kemaman where only 24 species of plants are found. The dominant species were *Rhizophora apiculata* and *Bruguiera gymnorrhiza*. The total number of stems at Kuala Kemaman was 5,340/ha and the above ground biomass was 199.13 t/ha, whereas those of Kg. Pantai Tinggi were 3,281/ha and 163.10 t/ha, respectively. Mohd. Lokman Hussain & Sulong Ibrahim (2001) had provided an excellent overview of the mangroves in Terengganu. They listed a total of 29 species of mangroves which are classified as exclusive species. Some for example, *Nypa fruticans, Intsia bijuga, Heritiera littoralis*, in fact are not termed as exclusive.

Threats and conservation: Mohd. Lokman Hussain & Sulong Ibrahim (2001) discussed the threats and possible conservation efforts in Terengganu. However, in two other states, Pahang and Kelantan, the situation might be similar. There was an effort to set aside a mangrove area in Tumpat, Kelantan and the author is not sure about the situation in Pahang.

Management and conservation

Sustainable forest management: As stated above the working plan for Matang mangroves (Azahar Muda & Nik Mustafa, 2003) is an excellent example for the management of other mangroves in Malaysia to follow. For the last 100 years, Matang mangroves were managed in a sustainable manner and they could facilitate all functions of mangrove ecosystem.

Minimizing impacts and promoting wise use of resources: Azahar Muda & Nik Mustafa (2003) clearly proposed ways and means of minimizing the impacts from activities up-streams of the mangrove areas, as well as ways to optimally use the resources. As stated above the possible threats is water pollution as also being witnessed at Kuala Juru, Penang and elsewhere.

Enhancing biodiversity management: As Malaysia is a signatory to the Convention on biodiversity, it is imperative for the country and also all states to enhance mangrove biodiversity in the mangrove areas. It has been observed that Matang mangroves including Kuala Gula, the Kukup mangroves and others are rich in flora and wildlife, especially migratory birds.

Strengthening mangrove Virgin Jungle Reserve: In Matang mangrove forest reserve, there are several compartments of Virgin Jungle Reserves (VJR). Efforts to propose and gazette a few more VJR within the mangrove forest in Pulau Langkawi, Kuala Merbuk (Kedah), Kukup (Johor) and Kuala Kemaman (Terengganu) and possibly in other east coast mangroves augur very well with sustainable forestry development.

Enhancing public awareness: Of course public participation in conservation efforts is extremely important. Without greater public awareness of our natural heritage such as mangroves, normally conservation efforts would fail. The efforts taken by Matang and Pulau Langkawi authorities in creating public awareness and participation is laudable.

Mangrove forest management: In Malaysia, the basis and concept that underlines the practice of sustainable forestry is to set aside adequate natural forest lands, including mangrove forests as Permanent Forest Estate (PFE) that are strategically located throughout the country. There are two types of PFEs, namely the production and protection forests. While the cutting cycle for hill mixed dipterocarp forest is 25 years, that for peat swamp forest is 45 years and for the mangroves it is between 20 to 30 years.

Functions of mangroves as sinks for waste-water borne pollutants: It has been shown that mangrove soils could trap and immobilize heavy metals and nutrients from waste water. Hence it is believed that mangroves could function as purifier of pollutants (Conley *et al*., 1991; Ambus & Lowrance, 1991). Those mangrove forests in Peninsular Malaysia are no exceptions to this function especially those situated in industrialized states.

As sediments removal system: As water flows slower in streams and rivers of mangrove areas than that of non-mangrove rivers, sediments tend to settle down to the bottom and that that flows outwards towards the sea is sediment-free (Wolanski, 1995).

Coastal erosion prevention: The strong roots and buttress systems of the mangrove plants form a natural buffer between the land and sea. They also tend to break strong wind and wave actions. In addition, mangroves also contribute to land-building through accretion (Othman, 1994).

Recreational areas: To-day mangrove areas are capable of generating some economic returns through boating, bird watching, jungle trekking, and other recreational activities. Kg. Kuantan and Kg. Belimbing in Kuala Selangor are known to attract eco-tourists as fireflies become the attraction.

Education: As mangrove forests contain salt-tolerant plants and animals, they could play an important role in educating the public, especially school children. An excellent example, is the Kuala Selangor Nature park that has conducted many education programmes for the school children and the public at large. The area is about 95 ha and a total of 157 species of birds and 13 species of plants are present in the park.

Development of management plan: Mangrove swamp forests are always under serious threats of various forms notably from conversion to other land-uses especially aquaculture and agriculture. Razani Ujang (1982) had stated that between 1955 to 1980, a total of 10,500 ha of mangrove swamp forests have been converted and Selangor alone had lost about 7,500 ha or about 30% of the total mangrove areas in the state. The state of Kedah including Pulau Langkawi is no exception. About 1,500 ha of Sungai Merbok mangrove area had been converted to rice fields but those areas remained idle because of the acid sulphate soils.

The problem lies in the difficulty in recognizing the indirect and direct benefits of the mangrove swamp forests. Since, mangrove ecosystem is an inter-phase between terrestrial and marine environment, there exist competition for various economic interests. Major industries in sectors such as forestry, fisheries and agriculture could claim mangroves as their administrative domain, and the policy that is best for one is detrimental for another. This is observed as happening in many states. Hence, trade-offs between alternative development and resource use must be examined more carefully and comprehensively. Current economic analysis can assist to identify the problem of using the cost-benefit approach to solve problems associated with a decision on coastal resource use, such as mangroves.

Research and development: Though research on the mangroves of Matang and Pulau Langkawi have been quite extensive, similar efforts must be considered for those in Sungai Merbuk, Kuala Selangor, Kukup and the east coasts. Without a real understanding of the biology of the species of plants and animals, ecology and the physical aspects of the mangroves, survival of the species would be in jeopardy.

Ecotourism: Lately, some values were accrued to the pristine forest of the mangroves in Pulau Langkawi that efforts to bring in eco-tourists were employed. This is one of the ways of informing the public that mangroves are beautiful too and have tourist attraction. The tourists were not only attracted by the rich flora but also the fauna that are unique to this fragile ecosystem.

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