Mar. Res. Indonesia Vol.34, No.1, 2009: 47-61

Review:

MANGROVES FOR NATIONAL DEVELOPMENT AND CONSERVATION IN INDONESIA: CHALLENGES FOR THE FUTURE

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Received: 10 September 2008; Revised and Accepted: 3 March 2009

ABSTRACT

Indonesia's mangrove resources (soils and waters, flora and fauna, and as an ecosystem all are called as mangrove biodiversity) are growing in importance. As a consequence of past and present human utilization the mangrove resources have been depleted. Keen competition for use of the mangrove resources is apparent and is likely to intensify in the future. This policy document stresses the importance of mangroves for the Nation and the need for the Government to manage and protect them. A set of basic principles for the management and protection of mangroves is provided, together with an outline of some actions which local and central governments (Pemerintah Pusat dan Daerah) should take up in order to achieve a balance between the use of mangrove resources, their conservation and long term national development.

INTRODUCTION

With 17,504 islands of different sizes and land/water ratio of 1:3, Indonesia (6° N – 10° S and 95° E – 142° E) represents an important maritime country in the tropical zone and/or equatorial line. Indonesia's coastline is more than 956,181 km in length (DKP 2007). This coastal zone is a dynamic system in a state of continual adjustment as a result of natural processes and human activities. Coastal and marine ecosystems support complex social, cultural and economic human systems in Indonesia.

Coasts are home for many organisms and place for natural systems with specific water bodies, e.g. lagoons, estuaries. Humans have also been residents of coastal mangrove-estuarine wetlands for centuries (Sunier 1921-1922). Many of the estuaries are fringed with mangroves, which have a high nutrient potential for many marine organisms, e.g. in Apar Nature Reserve mangrove forests (Sukardjo 1995). However, both mangrove and estuarine (e.g. Hartoto and Sulastri 2004) resources are little understood, and very little information has been obtained which can be used as basic data for the management of the resources, e.g. new species of crabs and its diversity (Rahayu and Davie 2002). As a consequence of past and present human activities the resources have been depleted, especially those on the coastline of Java (Sukardjo 1980, 1982, 1990, 2007, Davie and Sumardja 1997). Furthermore, keen competition for the use of mangroves and estuarine resources is apparent, and is likely to intensify in the future. Owing to the importance of the mangroves and estuarine resources for human beings, it is urgent to document the basic principles for the management and protection of the mangroves and estuarine areas, to provide the Government of Indonesia (GOI) with the means of achieving a balance between the use of mangroves and estuarine resources and their conservation (Sukardjo 1994a). Based on information available on incidence of destructive activity in various types of mangrove ecosystems in Indonesia, more effective guidelines for their productive conservation and management can be developed.

The purpose of the paper is to stress the importance of mangroves and estuarine areas to the nation and the need for the GOI to manage and protect them. It is also to provide ideas for possible incorporation into the more comprehensive coastal resources use policy (see Law No.27/2007: Coastal Zone and Small Islands Management) which is anticipated for the next development plan (see: CRMP II. 2005, Darajati *et al.* 2004, Kusuma *et al.* 2004). This paper is yet another one of many already addressed to the goal of strengthening for

DOI: 10.14203/mri.v34i1.434

mangrove research, e.g. systematic research on flora and fauna.

THE MANGROVE ECOSYSTEM: ITS FUNCTION AND VALUES

Recent research has shown that mangrove ecosystems and estuarine wetlands are among the most productive natural ecosystems in Indonesia. For example, high amount of organic materials produced annually by certain mangrove forests, such as in East Kalimantan (Sukardjo 1995), Riau (Kusmana *et al.* 1997), exhibit high species diversity of commercial fish and shrimps (Genisa 2006, Sukardjo 2004). Although Indonesian mangrove and estuarine wetlands (e.g. Hartoto and Sulastri 2004) have not yet been fully studied and are not yet recognized as a productive ecosystem, they clearly perform essentially similar ecological functions to those in other parts of the world.

A bare coastal mudflat is made up of soil which has been washed from the land, carried by streams to the sea and worked by waves into deposits along the coast, e.g. east Sumatra. These deposits contain material (nutrients) which, had they remained within the soil on the land, could have been used for the growth of mangrove forests. The erosion of this soil is partly natural and is partly a result of man's activities, notably forest clearing, illicit felling, indiscriminate conversion and over-cutting. Mangroves grow on mudflats (mostly with pioneering species of *Avicennia* spp., *Sonneratia* spp.), and they can absorb the nutrients and process them into a form which can be used as food by a great variety and number of animals, e.g. east Sumatran mangroves (Sukardjo 2008). Mangroves are richer fishery areas than mudflats, particularly where they occur along a coast adjacent to reefs and lagoon, e.g. Segara Anakan lagoon. Mangrove plants are very important processors of the potential food supplies of mudflat into a form which can be used by various marine animals. Some of these animals, e.g. crabs, fish and shell-fish can be eaten by man. The foodstuffs processed by the mangrove plants are contained in the leaves, twigs and stems. Previously, the potential foodstuffs in the mud deposit have been processed by a chain of animals, ending sometimes in man. This is described as a food chain. An understanding of primary and secondary production is important for proper allocation of mangrove resources for different purposes, e.g. in Berau Marine Protected Area for nature reserve, nursery ground, fish sanctuary. So, a healthy growing mangrove forests has high primary production and is able to support a greater number of animals than can a thin forest of stunted *Rhizophora* or *Avicennia*. In other words, the secondary production of sea-food in and near a well-developed mangrove forest can also be expected to be high, e.g. shrimp production (Martosubroto and Naamin 1978).

Mangrove forests not only provide food for animals and assist in the rapid recycling of this food, so that much higher numbers of animals can be supported than on bare mudflats; they also create a more comfortable climate for animals. The harsh, hot conditions of mudflats exposed to the sun do not exist in a mangrove forest. Further, the tangle of mangrove stems and roots, coupled with variously shaped, sized and connected channels and pools provide protection for many animals, especially fishes (Sukardjo 2004). They are of particular importance in providing nurseries, as well as ready supplies of food, as protection from predatory fish and rough seas. The fish generally recognized mangroves as nurseries (e.g. Sheridam and Hays 2003). A number of fish which are regarded as resident in lagoons, around reefs (e.g. Dorenbosch 2006) or in the oceans do, in fact, depend on the mangroves for their development into the mature specimens which may be caught by fishermen long distance from mangrove areas. Wherever mangroves are destroyed, fish numbers, inshore and offshore, will decline (Sukardjo 2004), and the coastal zone will be open for tsunami attack (e.g. Forbes and Broadhead 2007, Mazda *et al.* 2007). Thus it is important to recognize that the value of mangrove forests extends beyond the areas they occupy (e.g. Beck *et al.* 2003); since they contribute also to the fish productivity of adjacent waters (Manson *et al.* 2005). For example, FAO (1994) has estimated that over 90% of the world marine fisheries catch (approximately 82 million ton, including aquaculture) is harvested from near-shore waters.

Mangroves can, therefore be valued in terms of their products, like fish and crabs, which have a market value in dollars (Hamilton and Snedaker 1984, Ronnback 1999). But there are also a number of intangible values which cannot be expressed in term of money, even though they

contribute greatly to national development, e.g. the role of mangrove forests in the mitigation of tsunami impacts (Kathiresan and Rajendran 2005, Mazda *et al.* 2007). In addition, many species of local and migratory birds rest and feed in mangrove ecosystem areas, e.g. the Pantai Timur Nature Reserve in Jambi. The biological importance of the mangrove ecosystems and estuarine wetlands necessitates their conservation and management, especially as man is now looking to the shallow coastal seas and the estuaries to augments the world's supply of protein. Careful planning and sound management are essential to the proper use of coastal and mangrove resources (e.g. See Law No.27/2007: Coastal Zone and Small Islands Management). Recently, GOI (Local and provincial or national) have paid much attention to the management of the mangrove ecosystems and estuarine wetlands (See: NSMEMI-National Strategy for the Mangrove Ecosystems Management in Indonesia). This means that coordination among and/or between leading GOI agencies (MOF, MOMAF, MOHA and SMOE) and appropriate development have taken place, to the detriment of the amenities provided by estuarine and coastal ecosystems.

The need for the conservation and management of mangrove and estuarine vegetation near large cities is particularly urgent, e.g. mangroves in Jakarta (Sukardjo 2007), as these mangrove estuaries are subject to the greatest stresses.

The main benefits from planning and sound management of Indonesian mangrove and estuarine areas will include (see also Sukardjo 1980, 1982, 1987, 1990, 1994a, 2007):

1) Prevention of coastal erosion.
2) Protection of land and human habitations from storm attacks.
3) Protection of juvenile fishes, crabs and prawns from rough weather and predatory animals.
4) Special characteristics of mangrove areas which render them particularly suitable as spawning and nursery areas for food species which may later mature and be captured in reef-lagoon areas.
5) Transfer of energy and nutrients through floating of mangrove leaves to adjacent water masses of river, lagoon and reef for use as food by animals in these areas.
6) Trapping of sediments resulting from soil erosion, thus protecting coral reefs from disruption by sedimentation and enabling the sediment nutrients to be repeatedly recycled in the mangrove ecosystem for use by marine animals, thus resulting, eventually, in the seaward extension of the land mass (natural land reclamation).
7) The cultural significance of an ecosystem alongside which some human communities have evolved and on which they continue to be dependent.
8) The reduction of problems of sedimentation and erosion, and consequently of the need for expensive corrective engineering works.
9) The maintenance of a range of natural ecosystems which are suitable for teaching and research purposes.
10) The continuing profitability of shellfish cultivation and of the inshore and estuarine prawn and fish industries.
11) The maintenance of attractive and readily accessible areas of high scenic and aesthetic value, suitable for both passive and active recreational pursuits by all members of the community.
12) The conservation of important coastal wetlands and estuarine habitats of mangrove ecosystems and of the breeding and nursery grounds of many marine organisms and birds.
13) Retention of a drought refuge habitat which can be used by inland birds and/or other wildlife species in dry years.

Land cover is also estimated to be the most important variable affecting mangroves biodiversity in particular islands. Thus, many other direct benefits from proper management of mangrove ecosystems could be added to this list. Local interests may be one of the direct elements to be evaluated for the benefit of mankind.

MANGROVE RESOURCES

Among those of the villagers who live in a mangrove environment, there is a wealth of knowledge and understanding of mangrove products, their uses and the value of those sea-food supplies dependent on the presence of mangroves. Most of this information, however, remains unrecorded (Heyne 1950, Sukardjo 1980, Lemmens and Wulijarni-Sutjipto 1991, Sosef *et*

*al.*1998). Information resulting from scientific research among Indonesia's mangrove (e.g. mangrove productivity) is very limited, e.g. National Seminar on Mangrove Ecosystems I-VI. However, the nature and functions of mangroves throughout Indonesia is similar. Most recorded information on Indonesia's mangroves is related to their management for fuel production, and comes mostly from Riau Province, Sumatra (Bodegom 1929, Jonker 1933, Boon 1936, Danhoff 1946, Steup 1946, Versteegh 1951, Rakoen 1955, Koo *et al.* 1956). Versteegh (1951) was prominent in this work, and worked out a system of mangrove forest management based on a 30-years cutting cycle.

The mangrove soils of Ujung Karawang and Cilacap were studied by Rielle (1923) and Soerianagara (1971) respectively. Other mangrove soils studies, especially in Cimanuk delta West Java (Sukardjo 1982), and in Apar Nature Reserve, East Kalimantan (Sukardjo 1994b), and in Batu Ampar, West Kalimantan have been made recently by Sukardjo (in preparation).

Taxonomic information on the Malesian (consisting of Indonesia, Singapore, Malaysia, Brunei Darussalam, Philippines and PNG) mangrove species, especially Rhizophoraceae has been fully described and published by Ding Hou (1958), and the distribution of their genera by Steenis (1962). Re-inventory of mangrove plant and its associated species in the mangrove ecosystems in Indonesia given by Sukardjo (2008), Giesen *et al* (2007) and Giesen and Wulffrat (1998). A partial regional inventory of mangrove floras in Bali and Lombok (Kitamura *et al.* 1997) estimated 30 true mangrove species and 19 associated mangrove species, and the new records and the rediscovery of *Bruguiera* species given by Sheue *et al* (2005). In Indonesia there are about 91 species diversity of principal and subsidiary mangrove plants, which includes ferns, herbs and shrubs, representing 24 families, and about 63 of marginal species (Sukardjo 2008).

Indonesia has an area of mangroves of about 3.9 million ha, and administratively belongs to State Forest Areas. Table 1 present the extent and loss of mangrove forests at the State Forest Areas and Non-State Forest Areas from 1982 to 2002, and this is probably conservative estimates and debatable. Table 1 shows also the approximate distribution of the area by province in the country. Amongst these, only about 11.94% have been exploited commercially for fuel-wood, charcoal, pulp and chip, and other wood products. Today,

Table 1. Mangroves (ha) in Indonesia (?: not surveyed yet/not available, SFA: State Forest Area, NFA: Non-State Forest Area)(Source: Department of Forestry 2005) .

Province	1982 (BIPRAN)			1993 (INTAG)			2002 (RLPS)		
	SFA	NFA	Total	SAF	NFA	Total	SFA	NFA	Total
Aceh	54,335	?	54,335	102,970	?	102,970	2,443	344,402	346,845
N.Sumatra	60,000	?	60,000	98,340	?	98,340	26,640	9,270	35,910
Riau	276,000	?	276,000	221,000	?	221,000	446,940	621,339	1,068,279
Jambi	65,000	?	65,000	13,450	?	13,450	36,654	226,647	263,301
W.Sumatra	?	?	?	4,850	?	4,850	6,062	13,255	19,317
Bengkulu	?	?	?	2,610	?	2,610	10,469	35,566	46,035
S.Sumatra	195,000	?	195,000	363,430	?	363,430	587,881	469,018	1,056,899
Lampung	17,000	?	17,000	49,440	?	49,440	10,763	7,609	18,372
W.Java	28,606	?	28,606	8,200	?	8,200	44,453	94,844	139,297
C.Java	13,576	?	13,576	18,700	?	18,700	18,933	76,407	95,340
E.Java	7,750	?	7,750	6,900	?	6,900	43	97,691	97,734
Bali	1,950	?	1,950	800	?	800	6,925	18,521	25,446
NTB	3,678	?	3,678	?	?	?	3,759	16,476	20,235
NTT	1,830	?	1,830	10,780	?	10,780	24,733	106,928	131,661
W.Kalimantan	40,000	?	40,000	194,300	?	194,300	86,919	252,908	339,827
C.Kalimantan	10,000	?	10,000	48,740	?	48,740	475,002	1,750,588	2,225,590
S.Kalimantan	66,650	?	66,650	120,780	?	120,780	76,006	132,454	208,460
E.Kalimantan	266,800	?	266,800	775,640	?	775,640	116,433	643,510	759,943
N.Sulawesi	4,833	?	4,933	38,150	?	28,150	21,848	26,734	48,582
C.Sulawesi	?	?	?	37,640	?	37,640	6,108	111,211	117,219
SE.Sulawesi	29,000	?	29,000	70,840	?	70,840	28,601	59,887	88,488
S.Sulawesi	66,000	?	66,000	104,030	?	104,030	64,603	443,602	508,205
Maluku	100,000	?	100,000	148,710	?	148,710	100,000	?	100,000
Irian Jaya	2,943,000	?	2,943,000	1,326,990	?	1,326,990	1,708,620	269,140	1,977,760
Indonesia	4,251,010			3,765,250			3,900,000	5,800,000	9,700,000

the commercial exploitation for wood products is limited to Bintuni, Irian Jaya (Sudarmadji pers. comm. 2008) and Riau (Mulia pers.comm. 2008).

The coastal belt of Indonesia is mostly characterized by the presence of mangrove forests and its swamp, where they are concentrated mainly along the coastline, estuaries of rivers and deltas. A recent study of the mangrove vegetational distribution in Sumatra, Kalimantan, Sulawesi and Irian Jaya showed a definite pattern of zonation and plant association from the sea and sheltered tidal rivers to the landward fringes. The 1978-1984 study in Banyuasin district, South Sumatra, showed that the average area covered by old growth of both *Rhizophora* spp. and *Bruguiera* spp. was 124.745 to 139.176 m^3 per hectare for trees of 10 cm diameter at breast height (DBH) and over (Sukardjo *et al.* 1984). Total volume up to 205 m^3 per hectare has been recorded for some older Sumatran mangrove forests, and reported by Sukardjo and Kartawinata (1979), Yamada and Sukardjo (1979), Kusmana and Watanabe (1992) and Kusmana *et al.* (1992), and 221.91 m^3ha^{-1} for Bintuni, Irian Jaya by Sudarmadji (Pers.Comm. 2007). Table 2 shows the stand density and volume of both *Rhizophora* spp. (186 trees ha^{-1}) and *Bruguiera* spp. (155 trees ha^{-1}), and its frequency in some of the Bintuni mangrove forests, Indonesia.

During the 1979-1982 several simple small studies of mangrove resources were undertaken and coordinate as part of the LON-LIPI Jakarta and UN-University Tokyo project on coastal resources management (see: Bird and Soegiarto1980, Bird *et al.* 1982). A number of GOI agencies and universities were involved. A valuation model is still in development as a basic for estimating the potential net economic value of mangrove food resources (Ronnback 1999), e.g. Bintuni bay mangroves (Ruitenbeck 1992). This model will be used in an assessment exercises on the potential of mangroves for food resources, particularly those of resident mangrove crabs (e.g. *Scylla serrata* Forskal) and other marine organisms dependent on mangrove forests in their life cycle, and for the implementation of Mangroves for the Future (MFF) programmes in Indonesia. Some studies were conducted also by LIPI (Indonesian Institute of Sciences) and LPPL (Marine Fisheries Research Institute) Jakarta on the socio-economics of small-scale commercial enterprises of fishermen operating in mangrove areas. Since the First Seminar on Mangrove Ecosystem in 1978 up to now, the Directorate General of Fisheries (renamed as Ministry of Marine Affair and Fisheries) has undertaken continuing studies of the marketing of mangrove food species, both through official markets and from unofficial roadside outlets. Also, the Cilacap monitoring project was set-up to monitor the long-term impact of petroleum discharge in the Segara Anakan lagoon and its tributaries rivers fisheries. The SMOE and Marine Fisheries Research Institute, Jakarta, has a program to carry out regular toxicity tests of hydrocarbons to marine organisms.

HISTORICAL USES OF MANGROVE RESOURCES

In Indonesia, mangrove forests have long been appreciated by people as the source of a variety of foods, construction materials, fuel, dyes and traditional drugs e.g. *Pemphis acidula* (Hardjito 2007). Also, mangroves have been extensively altered in Indonesia to permit commercial rearing of edible fish and prawns, e.g. in Java (Schuster 1949). However, during the 19th century, following the introduction of new ideas on natural resources

Table 2. Potential wood product (m^3 ha^{-1}) by species according to diameter classes in the mangrove forests of PT. BUMWI Irian Jaya. Values in parentheses mean number of trees ha^{-1}

Species	Diameter classes (cm)				Total
	10-20	20-30	30-40	>40	
Rhizophora	11.24 (112)	21.24 (42)	25.48 (21)	24.68 (11)	82.64 (186)
Bruguiera	13.29 (89)	20.14 (41)	23.01 (17)	17.27 (8)	73.71 (155)
Ceriops	3.52 (24)	2.13 (6)	-	-	5.65 (30)
Sonneratia	1.73 (19)	8.67 (18)	8.96 (9)	26.45 (9)	45.81 (55)
Xylocarpus	1.08 (9)	2.64 (3)	2.38 (3)	6.91 (3)	13.01 (18)
Avicennia	-	1.03 (2)	-	-	1.03 (2)
Heritiera littoralis	0.06 (2)	-	-	-	0.06 (2)
Total	30.92 (255)	55.85 (112)	59.83 (50)	75.31 (31)	221.91 (448)

development, these natural values have been relegated to a position of primary importance in terms of integrated fishery-forestry purposes, e.g. mangroves friendly aquaculture (Sukardjo 2000).

From information sources checked by Rollet (1981) it is clear that mangrove timbers have had a long history of use for many purposes. There are 28 species of mangrove timber (Becking *et al.* 1922), and two species of palms (*Nypa fruticans* and *Oncosperma tigilaria*) which are used for economic purposes traditionally since the colonial era, e.g. in South Sumatra and Jambi (Rooyen 1927). In some parts of Indonesia there is intensive utilization of mangrove forests for wood products, e.g. Riau province, Bintuni Irian Jaya.

Since 1930, when all mangrove areas in Sumatra were constituted a productive mangrove forests, the Department of Forestry has had the responsibility for controlling, by license, cutting for fuel and structural timber (Versteegh 1951). Ironically, having established Versteegh's working plans as bases for fuel harvests, production of fuel-wood began to decline markedly in the late of 1955s (Koo *et al.* 1956), but it is a still productive forests for charcoal materials until today, e.g. in Bengkalis district. Recently however, little is known about levels of fuel-wood production in Indonesia: Nurkin (1979) reports a total of 26,339 m^3 produced from South Sulawesi mangroves, and about 100 m^3 ha^{-1} was produced by the 586.10 ha mangrove plantation with seven years rotation in East Sinjai Sulawesi (Nurkin 1995), while from NW Muna Island fuel-wood production estimated to be about 8,954 m^3 in 1997. From Riau province between 7,000 and 15,000 m^3 of fuel-wood have been exported annually from 1973-1976 (Dinas Kehutanan Riau 1979), and recently in Bengkalis district Riau province fuel-wood production amounted to be 992.55 m^3 in 2002 and 391.95 m^3 by 2003 (Dinas Kehutanan Kabupaten Bengkalis 2004).

Charcoal production from mangrove forests reputedly began in the 1870's in Sumatra, and today the level of production there is high. From 1978-1980, the level of charcoal production was estimated to be about 52,000 tons $year^{-1}$. About 42,920.498 tones were exported in 1980, worth US$ 3,618,399 (Biro Pusat Statistik 1982). The 1985 Bina Program of the MOF estimated a potential production of 461,197 tons of mangrove charcoal a year from approximately 1 million ha of forest (excluding Irian Jaya). In 1993, 83,000 tons of mangrove charcoal was exported, generating revenue of US$13 million (Biro Pusat Statistik1993). Export from Indonesia rose to 177,833 tons in 1994. In 1998, approximately 330,000 tons of mangrove charcoal was produced, and from 1994-1998 charcoal export to Japan and Taiwan by the Riau province amounted to be 134,194 tones, worth US$106,863 (Pemerintah Daerah Tk.I Riau 1999) and for 2002-2003 the export to be about 4,718.565 to 6,911.735 tones with selling price of US$ 70/ton (Dinas Kehutanan Kabupaten Bengkalis 2004). The total charcoal productions are getting down due to kiln quality, e.g. charcoal export by community enterprise viz. Koperasi Silva, from 2001 amounted 3,117 tones and in 2004 it was down to 1,680 tones. Some government statistics on mangrove charcoal export and production are found in the reports given by Biro Pusat Statistik

Since the 1960's the use of mangrove forests as a source of chip-wood and pulp-wood has greatly increased, and from 1974 to 1982, 13 companies have been licensed to exploit 455,000 ha of mangroves forests for wood-chips, with an average production of about 250,000 m^3/annum. Indonesian Foresters hope to increase this production to 3 million m^3/annum (Wiroatmodjo and Judi 1979). As of 1979, the Directorate of Forest Planning estimated that the value of standing timber of both *Rhizophora* and *Bruguiera* of 10 cm diameter and over in the mangrove forests of Indonesia was 94.5 million m^3 (Wiroatmodjo and Judi 1979). In 1998, approximately 250,000 tones of mangrove chips were produced and exported mainly to Korea and Japan. Production areas are distributed in Riau, Aceh, Lampung, Kalimantan and Irian Jaya. Mangrove chip-wood export from Riau province by 1994-1998 was 703,568 tones, worth US$23,562,492 (Pemerintah Daerah Tk.I Riau 1999). The international market price in Japan is approximately US$40.00 per ton (JICA 1997). Recently, the total realization of mangrove wood-chip product for the 5 years period (2000: 70,558.53 m^3 to 2005: 94,103.06 m^3) by PT. Bintuni Utama Murni Wood Industries (PT-BUMWI) in Bintuni Irian Jaya was 471,431.67 m^3 or 78,555.28 m^3/annum (1m^3 chips equal to 1.2 ton).

As timber, mangrove-associated wood are generally poor, but according to Becking *et al.* (1922) they vary considerably in quality. The total production of mangrove logs in Indonesia by 1979 was 367,039 m^3, and its reported export increased

by 37.12% between 1977 and 1978 (Biro Pusat Statistik 1979). From 1978 to 1994 about 873,575 m^3 of mangrove logs have been produced by the PT. Bina Lestari, Riau province in the area of 11,310 ha of mangrove concession forests, and 1994-1998: about 760,036 m^3 logs from 7,980 ha mangrove forests. The remaining mangrove forests to be logged are about 12,250 ha with an estimated potential production of around 1,498,518 m^3 of logs (Mulia pers.comm. 2005). In other-hand, mangrove log production by PT-BUMWI increased from 67,014.82 m^3 in 2000, to 131,158.00 m^3 by 2005, or the total production for the period 2000-2005 was 539,947.32 m^3 (Sudarmadji pers.comm.2007).

Mangrove concessions of some 100 ha area dealt with by Local Government (Provincial and/ or District) offices, while larger areas are controlled by the Central Government (c/q Ministry of Forestry).

For those in the fish farming industry, the main concern is the utilization of the mangrove swamps for fish ponds (tambak) purposes. Not all of the site in the mangrove swamp will be appropriately suitable for, and be converted into tambak. Tambak in Indonesia is a centuries-old technique. The first uses of mangrove areas for conversion into fish-ponds are found in East Java during the reign of Hindu Kings (Sukardjo and Akhmad 1982). Because of their high productivity and no doubt also because of the physical structure which they provide in otherwise featureless terrain, mangroves are a valuable habitat for many species of organisms, and some of these are of commercial importance. The mangrove characteristic of swamps leads to the suitability of this ecosystem for aquaculture purposes. In 1949 fish pond (tambak) areas in Java and Madura was only about 80,000 ha (Schuster 1949). In 1979, the area of tambak in Aceh and North Sumatra increased to 38,100 ha (Duncan 1979), and to be 184,600 ha for the whole Indonesia (Biro Pusat Statistik 1979). From 1980 (185,000 ha) to 1985 (203,171 ha), the tambak area in Indonesia increased constantly. In 1986 (212,695 ha) to 1993 (309,247 ha) and 1998 (344,759 ha) (Biro Pusat Statistik 2000), the tambak areas increased considerably with many reasons and their hectarage be un-controlled administratively in Indonesia. Recently, the total area under tambak in Indonesia, however, has stabilized at about 550,000 ha by 2003. Unfortunately, at the local or district level the tambak areas growing vastly without any control from district government, e.g. in Pasir district East Kalimantan reported to be 39,000 ha in 2006, and in Mahakam delta only up to 85,000 ha in 2005, even official land-use permitted only up to 62,700 ha (59.32% of land-use) (Bapedalda Kabupaten Kutai Kartanagara 2005).

A new idea for mangrove area utilization was conversion into agricultural lands. During the First Five Years Development Plan (called as Pelita I: 1969-1974) almost 200,000 ha of the tidal forests were reclaimed in order to provide agricultural land. In the five years which followed an additional 500,000 ha was converted into rice fields, fish-ponds and other food production areas (Sukardjo *et al.* 1997). Moreover, with newly introduced technology and skill of the Indonesian scientists, some 4,927 ha of productive rice field was developed in the mangrove area of Segara Anakan, and in 2006 increased up to about 6,000 ha (BPKSA 2006). With regards to the Second Five Years Development Plan (Pelita II) of early 1979 up to 1984, GOI policies are likely to result in the reclamation of 1,000,000 ha of mangrove peat swamp areas for growing salt-tolerant rice varieties. Unfortunately, the results was unsatisfactory, and restoration to be done immediately right now, e.g. in Kalimantan.

Regarding fish-pond (tambak) development, the conflict between a need for expansion of agriculture and the importance of maintaining natural fisheries was expressed in various forms (See: Sukardjo 1980, 1982, 1987, 2000, 2007, Davie and Sumardja 1997). Nevertheless, differences of opinion over the most effective form of development of the country's mangrove resources continued to surface (Sukardjo 2008). However, the numerous small to large-scale activities, legal and illegal, in mangrove areas continue to diminish their potential as fisheries (cf: Martosubroto and Naamin 1978, Sukardjo 2000, 2004). These activities are cutting and waste disposal, the latter probably generating an as yet unrecognized health hazard to consumers of marine foods taken from areas adjacent to rubbish tips or industrial waste outlets.

In 1978, the Indonesian MAB Committee took an important initiative and convened a multi-disciplinary meeting of professionals from GOI, Research Institute and the Universities (called as First National Seminar on Mangrove Forest Ecosystem which was held in Jakarta) to discuss

this matter. Furthermore, Luytjes's report (1923), which was followed up in the resolution of this serial meeting (I-VII National Seminar on Mangrove Ecosystems), stipulates that an evaluation of the mangrove areas shall first be conducted before exploitation, utilization or occupation taken place.

PRINCIPLES AND OBJECTIVES OF MANGROVE MANAGEMENT

Many of the uses of mangrove forest outlined in many literatures, e.g. in Muna Island (Table 3) can with careful resources management, be viewed as renewable uses as they involve continuing harvests of mangrove produce for an indefinite period, with the mangrove ecosystem being allowed and assisted to recover between harvests. Moreover, if skillfully managed, the same of mangrove forest can be encouraged to produce several different products at the same time; an approach referred to as multiple uses, e.g. mangroves agro-forestry (Weinstock 1994).

A multiple use system would be one involving the clearance of carefully selected areas of mangroves for fish-pond construction while retaining appropriate areas of mangroves around these ponds, and as silvo-fisheries in the mangrove rehabilitation areas of abandoned tambaks (Sukardjo 1989, 2000). In the implementation of management strategies for mangroves the ecological concept of linkage is of special significance. Based on the earlier experiences conducted by Haan (1931), Versteegh (1951), Luytjes (1923), Steup (1946), Koo *et al.* (1956) has shown that no part of an ecosystem operates independently. Moreover, the results of these experiments have been generally unsuccessful due largely to lack of enforcement (Sukardjo 2006). Due to the highly productive nature of the estuarine and mangrove ecosystems, the water provides the essential linkage between the terrestrial and aquatic elements in the coastal ecosystem (cf. Hanson and Koesoebiono 1979, Muluk *et al.* 1980, Sukardjo 2002, 2004). This means that in planning the management of mangrove ecosystems it is important to recognize that activities in the catchment area can have far reaching effects on mangrove waters and their associated shore regions through the effect on the quality of the water in the catchment area. In this matter, management of the mangrove ecosystem must imply also control of all activities in the catchment areas which are likely to affect water quality and the young economically valuable marine organisms. As the devising of rules for catchment management called as DAS I-III (Kep.MenHutBun No.284/ Kpts-II/1999: Penetapan Urutan Prioritas DAS) is beyond the scope of these guidelines, a practical alternative is to provide protection for a buffer zone around the mangrove forests and its mudflats as well as estuaries (Sukardjo 2002, 2004)

At present, there are many agencies responsible for the management and development of mangrove ecosystems in Indonesia (with leads agencies being MOF, MOMAF, MOHA and SMOE) along with their legal, policy and planning instruments (Table 4). But no (up 2000) and/or little (today) coordinated efforts have been made to save the mangrove ecosystems. The following set of principles is basic to the management and conservation of mangrove ecosystems and should be accepted as the foundation of all future management policies. These principles represent a minimum requirement and need to be appropriately expanded as they are implemented

Table 3. Subsistence utilization of mangrove resources in NW Muna Island (Source: Kulp and Baruadi 1996 Rural sociology/Anthropology, MRMPS Technical Report 1996).

Species and Local Name	Principal Uses
Avicennia marina, Api-api	Firewood, medicines.
Bruguiera gymnorrhiza, Tongke	Household items, flooring, posts, kitchen implements.
Ceriops tagal, Tenger	Firewood, fish trap net posts, house posts, charcoal, gates, flooring, kaso, cotton strengthening, tanning, and alcoholic drinks.
Nya fruticans, Nipah	Roofing material (atap), food (fruits).
Rhizophora apiculata, Lara teji	Firewood, housing material, fish trap net posts, charcoal, boat poles.
R. mucronata, bakau	Firewood.
Sonneratia alba, Biroppa	Boast material, firewood, gates, food (fruits).
Xylocarpus granatum, Kontawu	House posts, firewood, komeko drink (bark), household tools.
X. moluccensis, Buli	Saw-timber boards, bagang flooring, spoons, face powder (fruits), kaso, house posts, gates.

Table 4. List of the most relevant legal, policy, and planning instrument.

Law/Government Regulations/Decree, etc.	Mangroves	Coral Reef	Sea grass	Other type of coastal wetlands
1. The Indonesian Constitution 1945 (UUD45, ps 33:3)	+	+	+	+
2. Law No. 12/1951 – Weapon and explosive Material	-	+	-	-
3. Law No.5/1960 – Land-use (Agraria)	+	+	+	+
4. Law No. 11/1967 – Mining	-	+	-	-
5. Law No. 5/1984 – Industry	-	+	-	-
6. Law No. 9/1985 – Fisheries	+	+	+	+
7. Law No. 17/1985 – Marine Law Convention of 1982	-	+	?	?
8. Law No. 5/1990 – Natural Resources Ecosystem and Conservation	+	+	+	+
9. Law No. 9/1990 - Tourism	+	+	-	-
10. Law No. 4/1992 – Housing and Settlement	-	+	-	-
10. Law No. 16/1992 – Quarantine	-	+	-	-
11. Law No. 21/1992 – Sail	-	+	?	?
12. Law No. 23/1992 – Chemicals, Health	-	+	-	-
13. Law No. 24/1992 – Spatial planning	+	+	+	+
14. Law No. 5/1994 – Biodiversity Convention of 1992	+	+	+	+
15. Law No. 6/1994 – Convention on Climate Changes	+	-	-	?
16. Law No. 6/1996 – Waters	-	+	-	?
17. Law No. 23/1997 – Environmental Management	+	+	+	+
18. Law No. 22/1999 – Local Government	+	+	?	?
19. Law No.25/1999 – Financial Balance between Central and Local Gov.	-	+	?	?
20. Law No. 36/1999 – Cable-Telecommunication	-	+	+	-
21. Law No. 41/1999 – Forestry	+	+	?	+
22. Law No. 25/2000 – PROPENAS	+	?	?	+
23. Law No. 7/2004 – Water Resource Management	+	-	-	+
24. Law No. 31/2004-Fisheries	+	+	+	+
25. Law No. 26/2007- Spatial Planning	+	+	+	+
26. Law No. 27/2007 – Coastal Zone and Small Islands Management	+	+	+	+
1. Government Regulation (GR) No. 28/1985 – Forest Protection	+	-	-	+
2. GR No. 15/1990 – Fisheries (See Also: GR No.60/2007-Fisheries)	+	+	?	?
3. GR No. 20/1990 – Water Pollution Monitoring	+	-	-	?
4. GR No. 27/1991 – Swamps	+	-	-	?
5. GR No. 35/1991 – Rivers	+	-	-	+
6. GR. No.18/1994 – Ecotourism Enterprise	+	-	-	?
7. GR No. 47/1997 – Spatial Planning for National Region	+	-	-	?
8. GR No. 68/1998 – Nature Reserve Area and Nature Conservation Area	+	-	-	+
9. GR No. 27/1999 – Environmental Impact Assessment	+	+	-	?
10. GR No. 29/1999 – Controlling and/or Marine Damage	-	+	-	-
11. GR No. 25/2000 – Province, District/City Authority as Autonomy Reg.	+	+	?	?
12. GR No. 34/2002 – Forest Zone, Forest Management and Utilization Plans, Forest Area Usage	+	-	-	?
1. President Decree (PD) No. 43/1978 – CITES Ratification dated 15/12/78	-	+	?	?
2. PD No. 32/1992 – List of Closed Business for Investing	-	+	-	-
3. Decree of Forestry Minister No. 687/Kpts-II/1989 dated 15/11/89 – Tourism Forest Business, National Parks, Forest Park & Marine Tourism Park	-	+	-	-
4. Decree of Forestry Minister No. 688/Kpts-II/1989 – Permit Approval on Tourism Forest Business, National Park, Forest Park & Marine Tourism Park	-	+	-	-
5. Decree of Forestry Minister No. 400/Kpts-II/1990 – Establishment of Steering Committee on Forest Boundary	-	+	-	-
6. Decree of Tourism, Post and Telecommunication Minister No. KM.13/PW.102/MPPT/93 – Tourism Infrastructure for Business	-			

by GOI both Central and Local (Provincial and District).

1) The mangrove ecosystem should be considered as a part of our national heritage and worthy of conservation, because of their high biological, hydrological and ecological, economic, aesthetics, scientific values and HANKAMNAS (National Defense Systems) (See: Law No.1/1973: Indonesia Continental Based, Law No.9/1990: Tourism, Law No.23/1997: Environmental Management, Law No.41/1999: Forestry,

Law No.31/2004: Fisheries, Law No.7/2004: Water Resources Management).

2) The mangrove ecosystems and its associated resources should be considered a valuable public amenity (See: Law No.5/1994: UN Convention on Biological Diversity).
3) When deciding between competing uses for mangrove resources or areas, priority should be given to those activities (e.g. fishing: offshore and inshore) which make use of renewable resources. This principle recognizes the high rate of organic production of which mangrove plants are capable and the fact that mangrove animals are a valuable and potential source of food for peoples (Law No.31/2004: Fisheries, Law No/41/1999: Forestry).
4) The management strategies developed for each mangrove forest should seek as far as possible to preserve it in a natural condition. Mangrove biota possesses adaptive abilities which fit them to their natural environment (See: Law No.5/1990: Conservation of Living Resources and their ecosystem, Law No.6/ 1994: Convention on Climate Changes).
5) The catchment area around mangrove forests should be considered as part of the mangrove ecosystem. Land-use planning and practice in the catchment area should be consistent with the protection of the mangrove forest (See: Law No. 41/1999: Forestry and, Kep.MenHutBun No.284/Kpts-II/1999: Penetapan Urutan Prioritas DAS).
6) Before the approval by GOI of any major development within mangrove areas or its wetland, a thorough multi-disciplinary study of the local and regional environmental, social-cultural and economic consequences of the proposed development should be conducted. A decision on the development proposal should not be made until all the relevant facts are publicly available and the community at large has had an opportunity to comment on the proposal (See: Law No.25/2000: PROPENAS, Law No.23/1997: Environmental Management).
7) All GOI ministries controlling mangrove ecosystems should prepare lists of such areas so that a complete inventory of Indonesian mangroves can be compiled. For each mangrove ecosystem the inventories should include data on location, geomorphology, hydrology, meteorology, water quality, biological and geological resources, major vegetation zones, dominant species present, area occupied by each vegetation type, estimate of species density and standing crops (e.g. for *Rhizophora* spp., and *Bruguiera* spp.) (See: Law No.26/2007: Spatial Land-use).
8) Until such a mangroves inventory referred to above is compiled and until the mechanism for conducting multi-disciplinary studies is established further development within the mangrove ecosystem or its wetlands, whether conducted by Perum Perhutani (The State Forestry Corporation) or other GOI agencies, should not be allowed (Law No.23/1997: Environmental Management, GR No.27/1999: Environmental Impacts Assessment).

CONCLUDING REMARKS

The mangroves of Indonesia are known to be extensive (Table 1) (Sukardjo 2006), floristically rich (Giesen and Wulffrat 1998, Sukardjo 2008), and diverse in characters (Sukardjo and Kartawinata 1979) and may be expected generally to be highly productive (Sukardjo 1995) and intrinsically valuable (Tables 2, 3). These mangroves of Indonesia's coast are exhilarating to view and exciting to explore e.g. Timika mangroves in Irian Jaya (Rahayu and Davie 2002). Mangrove ecosystems are also a conspicuous feature of the coastal zone in many islands of Indonesia. Both mudflat and mangrove ecosystems are climax communities which to a large extent are self maintaining. Of course they need management and monitoring against the inevitable impact of human activity, but they involve no major recurrent costs in the long term, e.g. the Mahakam delta in East Kalimantan.

Historically, mangroves management has been driven by the socio-economic needs of an area e.g. Bengkalis, Riau-Lingga (Bodegom 1929, Danhoff 1945, Koo *et al.* 1956, Dinas Kehutanan Riau 1979), and little attention have been paid to the scientific knowledge of mangrove systems. Also, both domestic and commercial uses of mangrove products have increased dramatically; there is very little control over these destructive practices in the country in the district level (Sukardjo 2006). The program of 123,800 ha tambak development in the 14 provinces has had

as tragedy of mangroves in Indonesia, including illegal expansion of tambak areas up to the nature reserve areas e.g. tambak constructions of 16,720.66 ha (December 2006) in Adang-Apar Nature Reserve in Pasir district, East Kalimantan. The mangrove forest cover in Indonesia has declined substantially during 1982-2002 (Table 1). Table 1 also indicated the needs for further evaluation of remaining status of the mangrove forest areas which is belonging to State and/or Non-State Forest Areas along with their damages. Indonesia has lost much of its mangrove forests to other uses.

Mangroves are common properties. Values concerning mangroves and specific institutions for dealing with mangroves use evolve in response to societal interests and pressures. It is therefore, political, social, and economic and culture sectors have different perception at all level of mangrove functions and services, and consequently produce a debate with no ending time, and finally a conflict come up as the result. This makes mangrove ecosystems are in the position of uncertain and the degradation going well and vast, e.g. degradation of mangrove forests in South Sulawesi (Nurkin 1994). Thus Indonesia has serious problems in managing the mangrove ecosystems.

In the aftermath of the recent tsunami that struck Indonesia, South Asia and East Africa, scientists have noted that destruction was far worse where protective mangrove swamps had been replaced by fish farms (e.g. tambak) and settlements (Pearson 2005). Increasing misuse and overuse of the mangrove ecosystems in recent years has prompted the nation-wide need for management and conservation plans, and the acquisition of the scientific data and knowledge required to draw up such plans e.g. *Rhizophora mucronata* plantation in Tritih, Cilacap (Sukardjo and Yamada 1992), agro-forestry with *Rhizophora* planting in South Sulawesi (Weinstock 1994), mangroves rehabilitation by silvo-fisheries (Sukardjo 2000), tsunami mitigation by mangrove planting (Mazda *et al.* 2007, Forbes and Broadhead 2007, Sukardjo 2005), green coasts programmes by SMOE, and National Parks (Table 5). Successful tests have been implemented in Sinjai South Sulawesi and in selected other communities. Thus, the paper is designed to stipulate public discussion of the problems attending the use of mangrove ecosystems, mudflats and its estuarine resources and to provide interested people, conservationists, civil engineers, town planner, local and provincial politicians, and GOI officials with an outline of a plan, information and philosophic

Table 5. National Parks (NP) with mangrove forest element in Indonesia (Source: Rais *et al.*, 2007)

Island/NP Name	Size (ha)	Mangrove Forest (ha)	Annual Rainfall (mm)	Remarks
Sumatra				
1. Siberut	190,500	7,500	3,320	Biosphere Reserve (UNESCO)
2. Berbak	150,982.27	8,500	2,300	International Wetland (RAMSAR)
3. Sembilang	202,896.31	77,500	3,120	17 true mangrove species was recorded
4. Way Kambas	130,000	11,000	2,500-3,000	-
Java				
1. Ujung Kulon	120,551	11,700	3,140	The Natural World Heritage Site (UNESCO)
2. Kep. Seribu	107,489	-	3,015	Mangrove assemblage associated with coral
3. Karimun Jawa	111,624.70	7,026	3,000	44 mangrove species was recorded
4. Baluran	25,000	-	900-1,600	-
5. Alas Purwo	43,420	-	1,000-1,500	13 mangrove species was recorded
Bali and Nusa Tenggara				
1. Bali Barat	19,002.89	634	1,400	-
2. Komodo	132,572	-	200-1,500	-
Kalimantan				
1. Gunung Palung	90,000	7,000	3,000	-
2. Tanjung Putting	415,040	-	2,400	7 ecosystems was identified: mangroves
3. Kutai	198,629	7,000	1,543-3,015	6 forest types was identified: mangroves
Sulawesi				
1. Wakatobi	1,390,000	-	1,500-2,000	7 vegetation types: mangroves
2. Rawa Aopa Watumphai	105,194	3,200	1,500-2,000	-
3. Kep. Togean	362,605	33	1,500-2,000	33 mangrove species was identified
4. Bunaken	89,065	-	2,500-3,000	Mangroves associated with coral reef
Maluku and Irian Jaya				
1. Manusela	189,000	-	1,500-2,000	-
2. Teluk Cendrawasih	1,453,500	-	1,295-3,708	-
3. Lorentz	2,505,600	301,500	3,700-10,000	The Natural World Heritage Site (UNESCO)
4. Wasur	413,810	6,180	1.780-3,312	-

for the management for mangrove ecosystems e.g. mangroves for the future (MFF) and, mangroves and climate change.

It is not the purpose of this paper to address all of the problems of coastal zone in all islands of the country (See: Law No.27/2007: Coastal Zones and Small Islands Management, GR No. 21/2007: Indonesian Maritime Council, Law No. 17/1985: UNCLOS, President Decree No. 178/1999: Agreement relating to the implementation of part XI of the UNCLOS of 10 December 1982). Other problems of coastal zone management must also be addressed by planners e.g. oil spill pollution in mangrove ecosystems of the northern coast of West Java (Sukardjo1980). Coastal zone management is a very complex area of planning with mangroves as a key element (Table 4), which at present neither is nor well developed in Indonesia (cf. Heileman 2006, Sukardjo 2002, Post and Lundin 1996, Birds and Soegiarto 1980, Birds *et al.* 1982, Hanson and Koesoebiono 1979). The emphasis on mangrove ecosystems in this paper stresses the vulnerability of these systems and the urgent need which exists to protect the remaining resources. Ideally, consideration of the use and management of mangrove resources should be part of a comprehensive analysis of all natural resources or at least all coastal resources in Indonesia. In the final analysis, for instance in such a land hungry island as over crowded Java, the justification for nature conservation must make both economic and political sense, e.g. the Cimanuk Nature Reserve, West Java (Sukardjo 1987).

Although a large base of general rehabilitation and/or reclamation of mangrove ecosystem and/or environment information is available from research findings abroad, local site-specific researches are needed considering the varying indigenous environmental conditions, their biota e.g. species *nova* and new record of crab species in mangrove forests (Rahayu and Davie 2002) and characteristics of surface layers of soils (e.g. Sukardjo 1994b) (as institutions: Mangroves Information Centre in Denpasar and in Medan). Research on this aspect must be expanded e.g. mangrove species matching, ethno-medicinal plant. The idea is to pursue economic development (e.g. livelihood species) while maintaining a reasonable environmental quality, e.g. mangroves green belt regulations, GNRHL (National Movement for Land and Forest Rehabilitation), man made mangrove forest by planting in Sinjai (Nurkin 1995, Roem 2003). The steps in planning and management of mangrove ecosystems are presented as flow chart by Sukardjo (1994a). Replanting the mangroves along the Indonesia's coasts after tsunami is needed badly (Sukardjo 2005) and, recently the strategy is formulated as a working document called as NSMEMI. It is therefore NSMEMI are important crucially at the moment, to stop conflicting interest between and/or among the GOI agencies (MOF, MOMAF, MOHA and SMOE) both in the field of TUPOKSI (Main tasks and functions) implementation and to bureaucratize it at the national and provincial levels. It is also important that national economic policies have to be improved to encourage enhanced management of mangroves.

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