Southeast Asian Studies, Vol. 29, No. 4, March 1992

The Management Problems and Research Needs of the Mangrove Forest in the Cimanuk Delta Complex, Ujung Indramayu, West Java

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Abstract

The mangrove forest of the Cimanuk delta complex, Ujung Indramayu, is estimated to cover about 1,500 ha and represents an important natural resource in West Java. The mangrove forest area is managed by the Perum Perhutani Unit III (The State Forestry Corporation), West Java. This area is described together with the various problems arising from the present exploitation at the traditional level, for fuelwood, edible vegetables, animal fodder, green manure and other uses. Since the mangrove forest ecosystem supports many commercially valuable marine species, stabilizes the delta area and provides important raw materials for many purposes, its destruction will mean a long-term loss far exceeding any immediate gain. It is important, but it suffers from a lack of management and is threatened by pollutants and expansion of tambak (fish pond) areas. The purpose of this paper is to deal with the issues and research programs on management, conservation and utilization. A series of recommendations is presented which allow for optimum long-term development and preservation while encouraging further research and understanding of the complexity of the factors influencing the future of the mangroves.

Introduction

The latest estimate indicates that the mangrove forest area in the Cimanuk delta complex, Ujung Indramayu, amounts to almost 1,500 ha, or 4.64% of the total mangrove forests of West Java. The forest areas belong to and are managed by the Perum Perhutani Unit III, KPH Indramayu West Java [Perum Perhutani Unit III KPH Indramayu 1984]. This forest type constitutes an important natural resource. Therefore, its principal role is for the economic benefit of its inhabitants [Sukardjo 1986; 1987a; 1989].

The mangrove forest of Cimanuk delta complex, Ujung Indramayu, serves various functions. With proper management, we believe the economic benefit derived from this forest can be optimized. Moreover, tambak (fish ponds) constructed on the tidal flat of the delta have contributed to national fish production [Badan Penelitian dan Pengembangan Pertanian 1986]. On the other hand, it is also necessary to conserve the mangrove forest area for breeding of parental stock and ecological stabilization of the region [Sukardjo 1989]. These seemingly competing demands for mangrove resources call for rational utili-

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zation, management and conservation [Sukardjo 1989]. Among the environmental problems on the northern coast of West Java are overcutting through the haphazard felling of trees, severe modification through conversion of natural mangrove forest into fish ponds, garbage discharge and localized pollution [Sukardjo 1980]. All of these processes have the effect of destroying more of the remaining mangrove forest areas, and the need for action to control the situation has now become pressing. However, it must be borne in mind that natural mangrove forest resources in the Cimanuk delta complex, Ujung Indramayu, should be used to best advantage. The best return to the community does not necessarily result from complete protection. A level-headed approach to conservation is needed in which controlled use is the kenynote and in which some sacrifices have to be accepted for the greater good.

The present paper reports the actual condition of the mangrove forest in the Cimanuk delta complex, Ujung Indramayu, for better management through conservation strategy.

The Study Area

Location

The study area covers a lower part of the Cimanuk river basin, which has three tributaries in the delta, namely, Pancar Song, Pancar Payang and Pancar Balok. The mangrove forest ecosystem of the delta in Ujung Indramayu is shown in Fig. 1. The delta is fast grown and can be classified as a dynamic delta [Hehannusa 1979; 1980]. The distance from Indramayu (108°18.9′ longitude and 6° 15.1′ latitude) to the study area is about 15 km in a generally northerly direction. The shoreline length of Ujung Indramayu at high water level is approximately 55 km.

Physiography

The Cimanuk delta complex has generally shallow estuaries, vegetated with mangroves and marsh sedges. The bottom of the estuaries is mainly sand and the remainder of the area comprises extensive mudflats, areas of silty clay and large tracts of mangroves with clay [Effendi *et al.* 1981; Sukardjo 1980].

Inland is a series of coastal plains with scattered wasteland which are mostly wetland areas. The elevation rarely exceed 3m above sea level. In the northern part of the lower coastal plain of the Cimanuk river basin the soil is entirely composed of alluvium [Dent *et al.* 1977]. Soils within the delta complex comprise mud and seasonally hardsetting surface soils, usually sandy loams. The soils in the mangrove forests can be classified as clay, clay loam and loam, and have an acid reaction (wet pH 5.2-6.1) [Sukardjo 1982; 1987b; 1987c]. The poorly drained coastal plain, which is subject to flooding, consists of hardsetting sandy loams which have a similar acid reaction. The fringe mangroves and tidal mudflats are composed of saline clay with uniform soil texture [Sukardjo 1982].

Climate

The climate is humid tropical. According to Schmidt and Ferguson [1951], the region belongs to the climate type D, and annual rainfall is about 1,621mm [The Institute of Meteorology and Geophysics, Department of Communication, Indonesia 1975-1985]. Most of the precipitation falls during the rainy

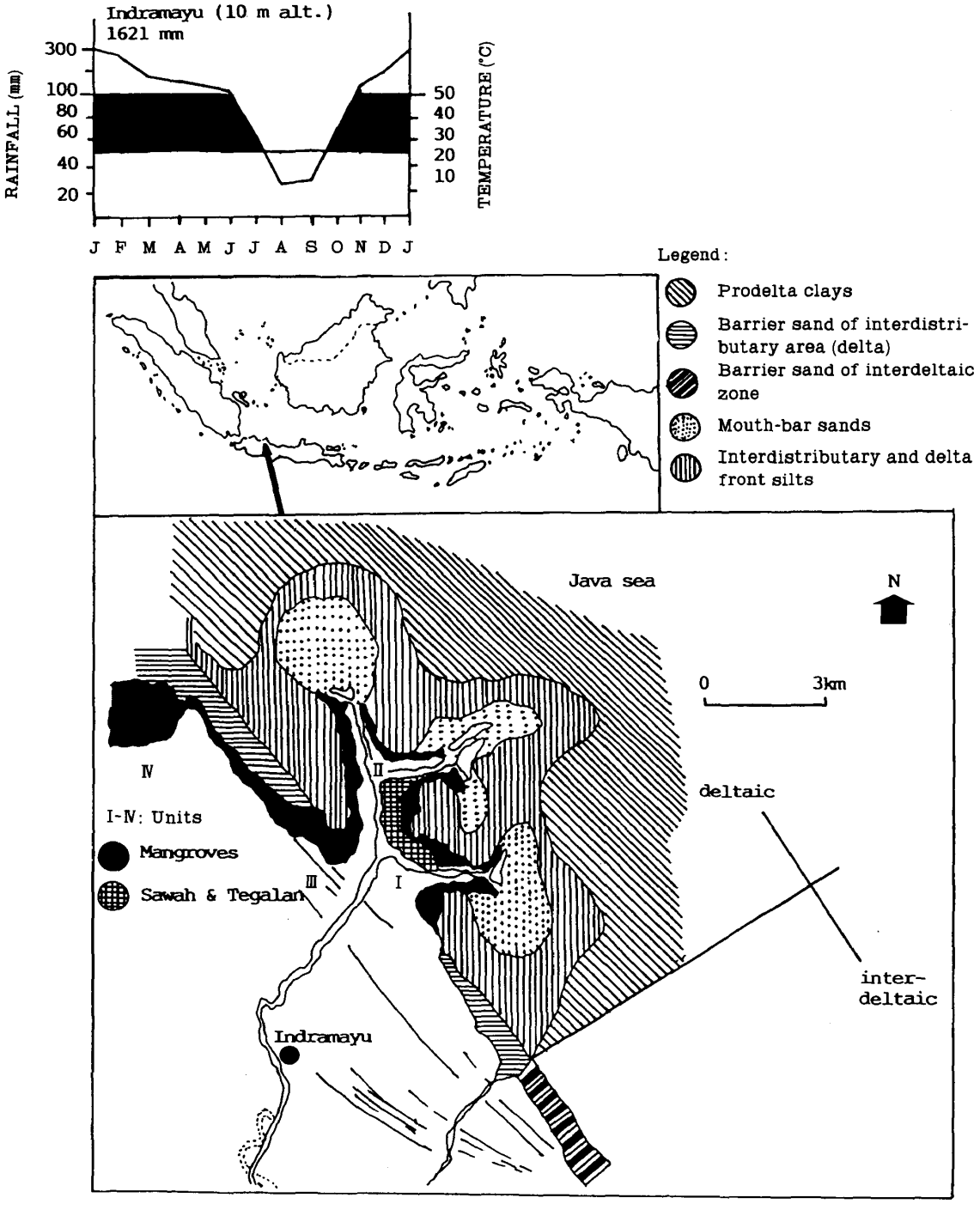

Fig. 1 Mangrove Forest Area in the Cimanuk Delta Complex, Ujung Indramayu, in 1981, Its Depositional Environment [after Hehannusa 1980] , and a Climate Diagram for the Meteorological Station at Indramayu(10 m ait.)

season, from November to April. There is little variation in mean monthly temperature, which ranges between 29.2° and 29.9°C. The climate diagram for the meteorological station at Indramayu is presented in Fig. 1.

Tides

The tides of the Ujung Indramayu waters are of a mixed type, mainly semi-diurnal. According to Arief [1980], the difference in tide characteristics between the east and west side of the Pancar Balok river, a branch of the Cimanuk river, is relatively small. Generally, the average range of diurnal and semidiurnal types is 44 cm for both during the spring tide and 36 cm and 16 cm, respectively, during the neap tide. The tidal influence appears to be responsible for the widening of the inlet by bank washing, and also responsible for fluctuating discharge. The leveling and steady silting have made the river shallow in places, the depth varying from 2 to 6 m. The tidal range on the river bank indicates between 40 and 100 cm.

Population and Land Use

The lower part of the Cimanuk river basin has 13 villages located around the mangrove forests in the delta. The total population of the 13 villages is reported to be 12,172 persons in 5,494 households, of whom only 5,752 or 47.26% are males [Susilowaty 1980]. The present land use within the watershed of the Cimanuk study area is predominantly rural. Of the inhabitants of the Cimanuk delta complex, Ujung Indramayu, 69.68% are engaged in fishery [*ibid.*]. The coastal plain is used mostly for rice fields and 'tegalan' (dry land agriculture system). Fish ponds have been set aside over part of the mangrove forest. Land use of the Cimanuk delta complex, Ujung Indramayu, represents cyclic human intervention to satisfy human needs.

Materials and Methods

Survey work began in April 1979 as part of the Cimanuk delta project conducted by the Center for Geotechnological and Mining Research and Development, Indonesian Institute of Sciences, Bandung, and was completed in August 1984.

Using 38 transect lines supplemented by aerial photo maps, an ecological study of mangrove forests was carried out in the delta system which was covered by mudflats, mangrove forest, sedges and abandoned wetland areas. Trees (diameter at breast height more than 10 cm), saplings (trees with diameter 2–9.99 cm) and seedlings present were assessed in 20 m × 10 m plots for trees, 5 m × 5 m and 1 m × 1 m subplots at 10 m intervals for saplings and seedlings, respectively. Practices of tree cutting, harvesting of vegetable ('lalab' in Sundanese), grazing of livestock and gathering of other raw materials in each 20 m × 10 m plot were also noted.

Botanical exploration was conducted to discover the extent of mangroves and other plants in the Cimanuk delta complex, Ujung Indramayu. The topography of the mangrove forest ecosystem and its interactions with adjacent ecosystems were noted. Because of the length of time spent in the field it was possible to develop close personal contact with many of the local inhabitants, particularly in the villages around the mangrove forest. This in turn made it possible to gather a great deal of information relating to traditional uses and exploitation of mangroves, and conversion of mangrove environment into fish ponds. Interviews were always done informally without use of a set question-

naire.

Results

1. *Mangrove Vegetation and Its Species Composition*

Data from 38 transect lines show that the mangrove forest of the Cimanuk delta complex occurs in varying degree of development due to the fast growth of the delta, and represents a young mangrove vegetation (Table 1). The best development of mangrove forest, typically consisting of *Rhizophora apiculata*, is found in unit IV (Tiris), about 9 km from the estuary of the Cimanuk river.

The young mangrove vegetation in the Cimanuk delta complex, Ujung Indramayu, is in the sapling stage and characterized by the dominance of *Avicennia* spp. As a pioneer species, its seedlings rapidly and readily colonized newly deposited mud. Based on the dominant and co-dominant species, the mangrove forest communities can be identified as *A. alba-A. marina* (units I-III) and *R. apiculata-A. marina* (units IV) (Table 2). There are 38 species recorded from that community types (Table 3), representing 20 families. Only 19 species are principal mangrove species. The presence of sedges, grasses and other marginal species in the mangrove forest habitat is due to freshwater influx and flooding from the Cimanuk river, especially during the rainy season. The extent and distribution of mangrove forests are given in Fig. 1.

From the forestry standpoint, mangrove forest is low thicket with tree diameter of less than 10 cm and an average height of 3.50-10.50 m (Tables 1, 4). Potentially, the forest has standing stock with a density of 30 to 2,438 saplings/ha/diameter class (Table 4). Species of Rhizophoraceae represent 0-73.72% of the total sapling population per diameter class. In unit IV (Tiris) the *Rhizophora* spp. represent 0.29-73.72% of the total density/ha/diameter class.

2. *Value of the Mangrove Forest Ecosystem*

Based on the geomorphological characters of the delta, the mangrove forests of the Cimanuk delta complex, Ujung Indramayu have provided natural resources supporting the survival of man since time immemorial. It serves as a stable source of income and livelihood for people living in nearby villages and communities. The various uses and amenities of the mangrove ecosystem cannot be underestimated.

2.1. *Value at the Traditional Level*

The value at the traditional level relates to present human activities in the coastal zone. Among the villagers who live in the mangrove environment at Ujung Indramayu, there is a wealth of knowledge and understanding of the function and uses of mangrove and the value of seafood supplies that are dependent on the presence of mangroves.

2.1.1. *Edible Vegetable ('lalab') and Leaf Fodder*

Two genera, *Avicennia* and *Sonneratia*, are the most important source of edible mangrove species, and can be harvested at any time. The useful parts of the plants are young leaves, shoots and fruits. During the dry season, the frequency and intensity of food harvesting from mangroves increases rapidly from 3 to 5 bakul of edible vegetable per day per family (1 bakul = ±5 kg fresh weight).

There are no pastures or fields available for

Table 1 Structural and Geomorphological Characteristics of Mangrove Forest in Ujung Indramayu in 1982

Attribute	Unit I	Unit II	Unit III	Unit IV
1. Average height of tree (m)	3.50	3.75	4.25	10.50
2. Average diameter of tree (cm)	4.15	4.35	5.85	7.15
3. Basal Area of tree (m^2/ha)	1.754	3.868	5.375	7.163
4. Complexity Index*	0.082	1.975	9.903	13.109
5. Number of species (diameter>2cm)	4	8	11	7
6. Height of forest floor (Above mean low water (m))	0.35	0.30	0.30	0.40
7. Height of salt flat floor (Above mean low water (m))	0.30	0.25	0.27	0.45
8. Maximum tidal amplitude (m)	0.55	0.55	0.55	1.00
9. Height of highest annual tide (Above mean low water (m))	0.53	0.53	0.53	0.53
10. Height of pneumatophores (cm)	5—10	5—10	10—15	5—10
11. Height of obstruction to tidal inundation (m)	none	none	none	1.8

* : Complexity Index is the product of d(density/ha), h(height of tree), n(number of species), b(basal area/ha) divided by 10^5 [Pool *et al.* 1977] .

Table 2 The Basal Area (BA=m^2/ha) and Importance Value(IV=%)of Sapling (trees with diameter 2—9.99 cm) in the Mangrove Forest in Ujung Indramayu in 1982

Species	Unit I		Unit II		Unit III		Unit IV	
	BA	IV	BA	IV	BA	IV	BA	IV
1. *Aegiceras corniculatum*	—	—	0.163	11.14	0.381	16.51	—	—
2. *Avicennia alba*	0.775	123.05*	1.864	136.58*	2.614	120.23*	0.048	6.14
3. *A. marina*	0.684	99.56+	1.548	107.03+	1.548	83.36+	1.358	62.85+
4. *A. officinalis*	0.259	69.67	—	—	0.511	33.00	—	—
5. *Bruguiera parviflora*	—	—	—	—	0.005	1.93	0.019	1.68
6. *B. sexangula*	—	—	—	—	0.009	3.11	0.138	12.86
7. *Ceriops decandra*	—	—	—	—	0.128	8.90	0.098	6.84
8. *Excoecaria agallocha*	—	—	0.011	6.25	0.005	0.98	—	—
9. *Lumnitzera racemosa*	—	—	0.005	1.73	0.008	1.99	—	—
10. *Rhizophora apiculata*	—	—	0.019	6.69	0.064	16.98	5.427	203.12*
11. *R. mucronata*	—	—	—	—	—	—	0.075	6.51
12. *Sonneratia alba*	0.036	7.72	0.254	27.36	0.049	13.01	—	—
13. *S. caseolaris*	—	—	0.004	3.21	—	—	—	—
Total	1.754		3.868		5.375		7.163	

Importance Value is the sum of the relative frequency, relative density and relative dominance.

* : Dominant species

\+ : Co-dominant species

Table 3 List of Species Occurring in the Cimanuk Delta Complex, Ujung Indramayu

1. *Aegiceras corniculatum**
2. *Acanthus ilicifolius**
3. *Acrostichum aureum**
4. *Allophyllus cobbe*
5. *Avicennia alba**
6. *A. marina**
7. *A. officinalis**
8. *Bruguiera parviflora**
9. *B. sexangula**
10. *Calophyllum inophyllum*
11. *Ceriops decandra**
12. *Cyperus malaccensis*
13. *Derris trifoliata**
14. *Eleocharis dulcis*
15. *Erythrina orientalis*
16. *Excoecaria agallocha**
17. *Glochidion littorale*
18. *Heritiera littoralis**
19. *Ipomoea fistulosa*
20. *Lumnitzera racemosa**
21. *Nypa fruticans**
22. *Panicum repens*
23. *Paspalum commersonii*
24. *P. vaginatum*
25. *Phragmites karka*
26. *Pluchea indica*
27. *Rhizophora apiculata**
28. *R. mucronata**
29. *Sonneratia alba**
30. *S. caseolaris**
31. *Sesuvium portulacastrum*
32. *Scirpus littoralis*
33. *Sporobulus sp.*
34. *S.* cf *humilis*
35. *Terminalia catappa*
36. *Thespesia populnea*
37. *Wedelia biflora*
38. *Xylocarpus moluccensis**

The nomenclature follows Backer & Bakhuizen van den Brink Jr. (1963-1968) and Ding Hou (1958).

*: Principal mangrove species

grazing, and inhabitants therefore use the mangrove forest environment for grazing their livestock (cattle, buffalo, goats and sheep). The animals mainly graze on *Avicennia* spp. *Bruguiera* spp., *Derris trifoliata, Rhizophora* spp. While livestock is kept in 'kandang' (stock pen) people feed it with mangrove leaves and grasses or other plants, locally known as 'rambanan' (ration). The production of fodder from the mangrove forest is estimated to be about 35 kg fresh weight/ha/day, which is enough to feed 5 cattle or 9 goats.

2.1.2. Home Industry

Traditionally, fishermen used mangrove species (*Avicennia* spp., *Excoecaria agallocha* and *Sonneratia* spp.) as the best raw material for floating equipment and sail boats. *Bruguiera* spp., *Ceriops* spp. and *Rhizophora* spp. are used as source of tannin for 'batik' dyes. These valuable species represent an important source of income for many inhabitants of Ujung Indramayu. It is common for fishermen in Ujung Indramayu to extract a reddish liquid from mangrove barks and use it to protect their fishing nets. Tannins of *Bruguiera* and *Rhizophora* barks are used for coloring the sails and roofs of boat and handicrafts. Carved wooden products made from mangrove species include kitchenware, such as 'uleg-uleg' (crushers), 'kelom' (wooden slippers), 'telenan' (wooden sheets) and kitchen utensilholder. These products are made from wood of *Avicennia, E. agallocha, Heritiera littoralis, Lumnitzera racemosa* and *Sonneratia. H. littoralis* provides the best mangrove wood for carving and has been heavily exploited without regard for its survival. The framework of huts is made only from *Aegi-*

Table 4 Diameter Class Distribution of Species in Terms of the Number of Individuals per ha in the Young Mangrove Forest, Ujung Indramayu, 1982

Diameter class (cm): Species	Unit I				Unit II				Unit III				Unit IV			
	2-4	4.01-6	6.01-8	8.01-9.99	2-4	4.01-6	6.01-8	8.01-9.99	2-4	4.01-6	6.01-8	8.01-9.99	2-4	4.01-6	6.01-8	8.01-9.99
1. *Aegiceras corniculatum*	–	–	–	–	32	20	1	–	55	65	45	–	–	–	–	–
2. *Avicennia alba*	10	2	8	80	391	301	99	100	1,558	358	242	73	27	10	3	–
3. *A. marina*	8	2	8	81	89	148	249	95	548	338	100	21	150	112	38	20
4. *A. officinalis*	10	90	13	10	–	–	–	–	227	103	71	2	–	–	–	–
5. *Bruguiera parviflora*	–	–	–	–	–	–	–	–	–	2	1	1	4	5	–	1
6. *B. sexangula*	–	–	–	–	–	–	–	–	1	4	–	1	55	20	–	5
7. *Ceriops decandra*	–	–	–	–	–	–	–	–	30	18	2	9	17	15	5	3
8. *Excoecaria agallocha*	–	–	–	–	–	–	3	1	–	1	–	1	–	–	–	–
9. *Lumnitzera racemosa*	–	–	–	–	–	–	–	2	–	2	1	1	–	–	–	–
10. *Rhizophora apiculata*	–	–	–	–	–	–	5	3	9	8	15	2	780	610	300	260
11. *R. mucronata*	–	–	–	–	–	–	–	–	–	–	–	–	25	9	1	5
12. *Sonneratia alba*	2	1	6	4	59	68	32	–	10	7	7	2	–	–	–	–
13. *S. caseolaris*	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–
Total	30	95	35	175	575	537	389	201	2,438	906	484	113	1,058	781	347	294

Table 5 Forestry Value by Family in Terms of Their Density of Sapling per ha (Sp.) and Seedling per ha (S.) in the Mangrove Forest of Cimanuk Delta Complex, Ujung Indramayu

Family	Unit I		Unit II		Unit III		Unit IV	
	Sp	S	Sp	S	Sp	S	Sp	S
Combretaceae	–	–	2(0.12)	–	4(0.10)	–	–	–
Euphorbiaceae	–	4(0.15)	4(0.23)	20(0.84)	2(0.06)	9(0.92)	–	–
Myrsinaceae	–	–	53(3.12)	68(2.85)	165(4.18)	9(0.92)	–	960(17.56)
Rhizophoraceae	–	18(0.66)	8(0.47)	33(1.38)	103(2.61)	303(31.08)	2,130(85.54)	3,356(61.40)
Sonneratiaceae	13(3.77)	4(0.14)	163(9.56)	46(1.93)	26(0.66)	3(0.31)	–	–
Sterculiaceae	–	–	2(0.12)	–	4(0.10)	–	–	–
Verbenaceae	322(96.23)	2,697(99.05)	1,472(86.38)	2,220(93)	3,641(92.29)	651(66.77)	360(14.46)	1,150(21.04)
Total	345	2,723	1,704	2,387	3,945	975	2,490	5,466

Note : Sapling=tree with diameter 2–9.99 cm.
Value in parentheses mean percentage value from total.

ceras corniculatum.

Bruguiera and *Rhizophora* woods yield excellent charcoal and poles which are extensively used for making houses, huts and construction materials such as 'usuk' (rafters). Usuk measuring 5 cm in diameter and 5 m in length are very expensive, costing about Rp 500 to Rp 550 each in 1981, rising to Rp 750 to Rp 950 each in 1984. The demand for both species for usuk is high. Traditional tools such as digging sticks, coconut peeler and spears are also made of mangrove wood.

Nipa (*Nypa fruticans*) is a very common palm in rural areas of the Ujung Indramayu. As a versatile palm of the mangrove forest, it has varied and innumerable uses. It provides inexpensive construction materials that are within the reach of the masses and employment opportunities for fishermen. The leaves of nipa are quite costly since they are highly valued for use in roofing, walling, handicrafts and 'sapu lidi' (brush of palm leaf ribs), while the freshly gathered juice can be fermented to a good beverage, locally known as 'legen'. Young nipa leaves used for 'hiasan janur' (palm leaf decoration)in traditional ceremonies such as 'sunatan' (circumcision), 'mintoni' (Javanese sense of belonging)and wedding parties are very expensive, costing about Rp 10, 000 to Rp 15, 000 (equal to US $10 to 15) in 1982. In markets, cigarette wrappings made from nipa leaves cost Rp 50 to Rp 150 per 'pak' (Javanese traditional pack of 20 wrappings measuring 4.5 cm × 5.5 cm) in 1982.

2.1.3. Green Manure

Fish ponds and 'tambak tumpang sari' are the most common forms of mangrove environment in the Cimanuk delta complex, Ujung Indramayu, used for fishery purposes. To improve and maintain the soil fertility of these ponds, farmers use mangroves as green manure. To maximize the yield of fish or shrimp, the application of green manure is usually involved fish pond management. The first period of green manure application is at the time of pond construction. The system of green manuring is known locally as 'pembenaman'. After completion of construction of the pond (about 2 months), the green manure has completely decomposed and supports the growth of 'kelekap' as a source of food for fish and shrimp. Usually farmers use 75 kg of green manure to fertilize a pond measuring 50 m × 50 m size in the first period. To maintain the productivity of canals in the ponds, farmer periodically use green manure.

2.2. Forestry Value

The most important product of the mangrove forest in the Cimanuk delta complex, Ujung Indramayu, is firewood. This is provided mainly by trees of the families Verbenaceae, Rhizophoraceae and Sonneratiaceae, of which the standing stock is esti-

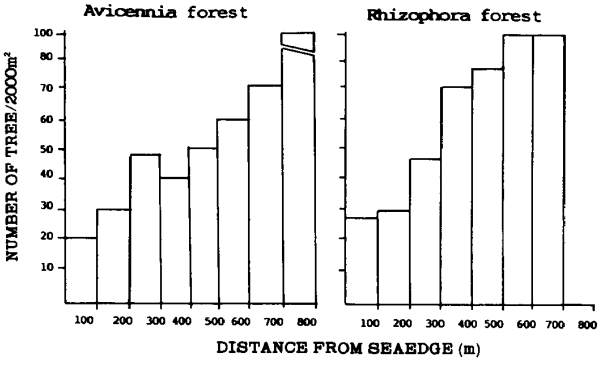

Fig. 2 Number of Mangrove Trees (diameter 5–9.99 cm) Collected by Inhabitant for Fuelwood from the Young Mangrove Forest in Cimanuk Delta Complex, Ujung Indramayu during the Period 1979–1984

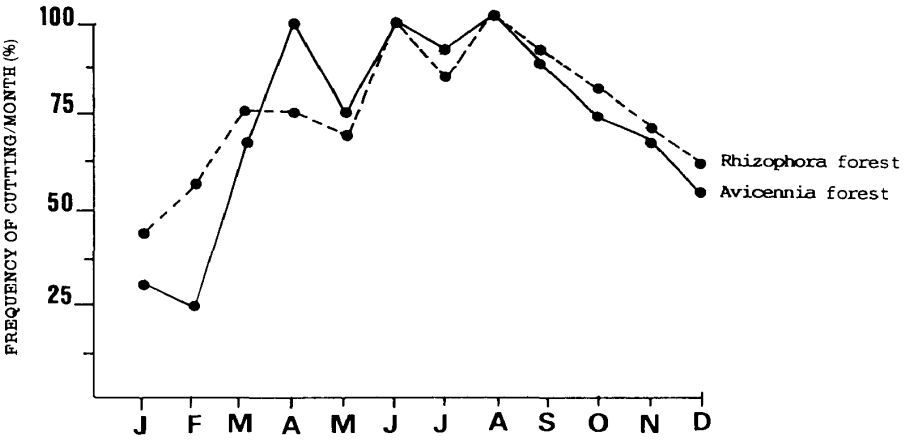

Fig. 3 Frequency of Tree Cutting (5–9.99 cm diameter) by Inhabitant in 1320 20 m x 10 m Plots in the Young Mangrove Forest in Cimanuk Delta Complex, Ujung Indramayu during the Period 1979–1984

mated to be 8–3,641 saplings/ha (Table 5). The exploitation of mangrove forest for firewood increases during the dry season. Among the forest types (Table 2), the *Avicennia* forest communities have the greatest economic value for many inhabitants. About 3–5 pikul/ha/day of wet wood is harvested (1 pikul = ±40kg, and 1 pikul cost Rp 500 in 1982 and Rp 2,500 in 1984). This is the main biomass utilization of mangroves at the local level (Fig. 2, 3).

2.3. Fishery Value

Information about the faunal community in the Cimanuk mangrove ecosystem is scanty [Sukardjo 1987a], and not as comprehensive as that on the flora. Fish and shrimps are the most populous mangrove dwellers. More than 45 families of fish have been recorded by the Dinas Perikanan Daerah Indramayu. Manuputy [1980; 1984] reported 13 species of crustaceans commonly found in the Pancar Balok waters, of which 6 species have high commercial value.

Fishery is the main livelihood for 66.82% of the population living in the mangrove environment. The fisherman use traditional fishing gill nets, traps etc. and the common catch is fish, shrimp and prawn, and crab. These species depend on the existence of healthy mangrove forest in Ujung Indramayu for their life cycle. Moreover, Sukardjo (in preparation) reported that the *Avicennia* forest communities produce litter fall amounting to 8.145 g/m²/day of dry wt. as a source of organic matter to support the fishery potential in the region. The litter supplies valuable organic nutrients to the waters which serve as a rich food source for many coastal and offshore fish, shrimp and prawns. There are 12,172 fishermen living in the Cimanuk delta complex, Ujung Indramayu, and the mangrove ecosystem of the region contributes significantly to their total catch per day.

The tidal character of Ujung Indramayu has led to the suitability of this area for fish ponds. Susilowaty [1980] reported that fish pond area in the Cimanuk delta complex increased from 18.75 % (1966) to 41.58 % (1974) of the land use in the delta area.

2.4. *Ecological Value*

Aside from the direct benefits mentioned above, the mangrove forest ecosystem at Ujung Indramayu offers indirect but beneficial ecological services. As a land-building and land-protective agent, the dense and extensive pneumatophore system of *Avicennia* and *Sonneratia* in the delta traps eroded soil, sediments and pollutants. It is instrumental in the reclamation of a considerable area of land through the gradual deposition and accumulation of eroded soil as permanent land area. This is reflected in the enlarging of the delta and the natural birth of new lands, locally known as 'tanah timbul' [Hehannusa 1979; 1980; Hehhannusa *et al.* 1975; Purbohadiwidjojo 1964; Tjia 1964; 1965]. Moreover, the succession of species seems to be similar in general character in all 'tanah timbul'. Although the resulting complex and changing micro-environment in all 'tanah timbul' is not yet well understood, being reflected in varying growth patterns of pioneer species, the net effect of the peculiar habitat in which mangrove seedlings occurs is very clear.

For most areas, the mangrove forest at Ujung Indramayu is probably more important from an ecological standpoint than the other values listed above, since it provides suitable and fertile areas for breeding and spawning grounds of many commercially valuable marine species. The final component playing a role in maintaining an ecological balance in the mangrove forest of Ujung Indramayu includes land crabs and the thalasinid mud lobster (*Thalassina anomala*). The extension of mangrove forest and their habitat is critical in the maintenance of ecological stability in Ujung Indramayu. Man's growing and increasing use of the delta has subjected the fragile mangrove areas to enormous stresses. Our continued multiplicity of demands upon the estuarine and coastal environment of Ujung Indramayu makes it imperative for us to fully understand the exact ecological function of the mangrove forest in the Cimanuk delta complex, Ujung Indramayu.

3. *Problems*

3.1. *Forestry Problems*

The mangrove forest of the Cimanuk delta complex, Ujung Indramayu has been heavily disturbed by persistent cutting for firewood. This activity has intensified since 1950 (Oldest people, pers. comm. 1979-1984). The poor condition of most people living around the mangrove forests also contributed significantly to its degradation. They used illegal and haphazard felling in collecting fuelwood from the mangrove forest.

At present, the forest consists mostly tree mangrove species with diameters of less than 10 cm and lower stand density for the commercial mangrove species (*Bruguiera, Ceriops, Rhizophora*) (Table 4). Moreover, due to haphazard felling and unregulated exploitation, rhizophoras are scarce in units I , II and III areas with only 0-103 saplings/ha (Table 5). No commercial-size (DBH more than 10cm) trees were found in the Cimanuk delta complex, Ujung Indramayu. This indicates that the forest has been overcut and is in a degraded state. All mangrove forest areas had suffered from a lack of forest management. Mangrove trees are highly favored by people , and the threat of their elimination is accordingly great.

3.2. Land Tenure and Human Population Problems

Communities in the mangrove environment of the Cimanuk delta complex, Ujung Indramayu, are densely populated and represent an important problem for land use and forest management. They are always looking land and food in the mangrove environment for supporting their life. This crucial problem is generally known in Java as 'lapar lahan' (hungry for land).

Illegal occupation of the 'tanah timbul' by people constitutes a part of the land use problem for regional development. According to Perum Perhutani Unit III [Perum Perhutani Unit III Jawa Barat 1984], the 'tanah timbul' should belong to the government, being known administratively as 'tanah negara' (state land). At the national and regional level, the conflict of interests over 'tanah timbul' between people and Perum Perhutani is the main and most sensitive problem.

3.3. Pollution Problems

In the Cimanuk delta complex, Ujung Indramayu, the mangrove environment is constantly subjected unsystematic use for garbage disposal. Increasing demand for new land for habitation coupled with other human uses of the mangrove environment produces various pollutants. The degradation of quality of the mangrove environment is proceeding rapidly in Ujung Indramayu, parallel to economic development in the region (e. g., oil drilling, pumping and shipping).

Pesticide residues and domestic rubbish are among the most abundant pollutants threatening the mangrove ecosystem. All of these contaminants end up in waterways and may adversely affect the living organisms of the mangrove ecosystem. Sumatra [1982] reported that leaves of standing mangrove trees, soils and some marine organisms have been contaminated by pesticides (Tables 6, 7). Accumulation of pollutants in any component of the food chain or the physical destruction of a component by widespread salt will disturb the nutrient cycle and might even be dangerous to the health of fish and shrimp consumers. Data show that the mortality of *R. apiculata* and *R. mucronata* seedlings in the polluted habitat was 10 to 17.5 % per year and for *Avicennia* spp. was 5 to 12.5 % per year.

Discussion and Conclusion

Cimanuk delta complex and its estuaries, which are subject to variable rates and types of geomorphological change, provide a network of habitats which are colonized by mangroves. Physiognomically, the mangrove at Cimanuk delta complex, is low thicket in the stage of prime development into commercial size (DBH more than 10 cm). It is of considerable economic and ecological importance not only indirectly because of its contribution to the stability of otherwise relatively fragile brackish water habitats, but also directly as a source of firewood, vegetables, leaf fodder and grazing for livestock, and fishing stakes. There is no question that the mangrove forest in the Cimanuk delta complex, Ujung Indramayu, should be made more productive. Unfortunately as yet no coordinated effort has been made to tap the renewable resources of this extensive forest type on a sustained yield basis. If we want to

Table 6 Insecticide Residues in Marine Organisms Taken from the Mangrove Ecosystem of Cimanuk Delta Complex during March and April 1980

Localities	Type of Organisms	Type of Organophosphate (in ppb)											
		Diazinon		Thiodan		DDE		O.pDDT		p.pDDT		Total DDT	
		March	April	March	April	March	April	March	April	March	April	March	April
Pancar Song :													
Adjacent water	Shrimp	–	–	–	187	–	–	–	–	–	265	–	265
Adjacent water	Mugil	–	36	–	–	–	–	–	–	–	118	–	118
Adjacent water	Squid	–	–	–	734	–	–	–	–	–	132	–	132
Mouth	Mudskipper	–	–	–	–	–	–	–	47	–	147	–	194
Mouth	Shrimp	–	–	–	–	–	–	–	–	625	–	625	–
Mouth	Shrimp	–	–	–	–	–	–	–	–	250	–	250	–
Mouth	Shrimp	–	–	–	–	–	–	–	–	1,525	–	1,525	–
Fish pond	Milkfish	–	–	–	–	88	–	225	–	750	–	1,063	–
Pancar Payang:													
Mouth	Crab	–	–	–	–	–	–	–	–	375	–	375	–
Mouth	Crab	–	–	–	–	–	–	–	–	506	–	506	–
Pancar Balok:													
Mouth	Mudskipper	–	–	–	–	87	–	200	–	1,125	–	1,412	–
Mouth	Mudskipper	–	–	–	–	–	–	–	–	625	–	625	–
Balongan:													
Adjacent water	'Loang'	–	53.3	–	15	–	–	–	–	–	132	–	132
Adjacent water	Crab	–	753	–	–	–	–	–	–	–	59	–	59
Adjacent water	'Koro'	–	–	–	–	–	–	–	–	–	148	–	148
Fish pond	Milkfish	–	–	–	–	–	–	–	–	813	–	813	
Tiris:													
Area 1	Shrimp	–	–	–	–	–	–	–	–	250	–	250	–
Area 2	Shrimp	–	–	–	–	–	–	419	–	569	–	986	–

Source:Sumatra [1982]

Table 7 Insecticide Residues in the Sediments Taken from Cimanuk Delta Complex during March and April 1979

Localities	Type of Sediment	Type of Organophosphate (in ppb)											
		Diazinon		Thiodan		DDE		O.pDDT		p.pDDT		Total DDT	
		March	April	March	April	March	April	March	April	March	April	March	April
Pancar Song:													
Mouth	Mud	–	1.9	–	–	–	43.4	–	–	–	–	–	43.4
Fish pond	Mud	843.8	–	3.5	23.7	–	–	9.8	–	43.3	34.6	53.1	34.6
Midle land	Compact	–	–	–	74.8	–	16.1	–	–	–	6.6	–	22.7
Coastline	Mud	–	3.8	–	127.0	–	–	–	–	–	–	–	–
Pancar Balok:													
Mouth	Mud	124.5	14.9	17.0	87.0	3.8	3.2	–	51.6	100.5	128.5	104.3	183.3
Fish pond	Mud	23.2	–	24.9	–	–	–	35.1	–	167.0	–	–	–
Cimanuk river	Sand	37.4	6.2	17.0	59.2	–	4.0	–	–	19.8	36.5	32.4	40.5
Balongan:													
Fish pond	Mud	12.2	–	–	–	–	–	–	–	54.1	–	54.1	–

Source: Sumatra [1982]

have the best mangrove forest resources for people, the first step must be to save the existing mangrove forest through conservation measures. Conservation of the mangrove forest of the region is difficult but important for any long-term program of regional development. Attention has been paid so far to the conservation and rehabilitation of this forest type by intensive reforestation and/or afforestation. The creation of the Cimanuk nature reserve with an area of 7,100 ha is a conservation effort which should contribute significantly to the development of the mangrove vegetation and its associated resident animal population [Sukardjo 1987a]. It should also act as an effective buffer against the destructive effects of the present cutting and exploitation policy of fuelwood dealers.

The system of shallow waters and creeks in the mangrove forest provides shelter and valuable breeding grounds for coastal fisheries and other useful wildlife (e. g., birds). Therefore, fishery potentials and associated factors are included in the management system of the mangrove vegetation in the Cimanuk nature reserve. To ensure that the ecological functions of the mangrove forest in the nature reserve are maintained, four steps of management should be drawn up as follows.

1. Need for Mapping and Demarcation : A serious and sensitive problem related to the management of the mangrove forest is the illegal occupation of 'tanah timbul' accompanying the rapid increase of population in the region. Therefore, the existing mangrove forest should be mapped and delineated on the topographic map. Delineation should be carried out not only to mark the existing mangrove forest but also to demarcate the areas which are potentially suitable for the extension of mangrove forest areas. This will allow determination of the area of surviving mangrove forest and the total suitable area that could be afforested to bear and sustain this valuable resource.

2. Proper Conservation, Development and Management of the Mangrove Forest : In Ujung Indramayu, mangrove forest growth is changed and threatened by illegal and haphazard felling, pollutants, the expansion of fish ponds and the catastrophe of 'lapar lahan'. The management plans will deal with the demarcation of boundaries, and the tending and scientific exploitation of the *Avicennia* spp., which would need to be determined. They will also provide natural and artificial regeneration of the wooded areas and those bank areas which are considered fit for raising the forest management.

3. Maintenance of More Valuable Mangrove Species : Floristically, the mangrove forest at the Cimanuk delta complex, Ujung Inframayu, contains 19 mangrove species and 19 non-mangrove species (Table 3), dominated by two genera, *Avicennia* and *Rhizophora* (Table 2). *Avicennia* is able to colonize the new land (tanah timbul) and form new areas suitable for sustaining mangrove vegetation. Other species, such as *Bruguiera* spp., *Ceriops decandra* and *Rhizophora mucronata* have the lowest stand density (Tables 2, 4). A planting program for these valuable species will be of benefit. These mangrove species, though more demanding and delicate, are economically much more valuable for the

Perum Perhutani.

4. Need for a Forest Conservancy and Management Law : For introducing and applying proper conservancy and scientific management to the mangrove forest of the Cimanuk delta complex, Ujung Indramayu, it would be worthwhile to enact a comprehensive forest law. This proposal also envisages a technically trained and suitably constituted forest service [e. g., Perum Perhutani 1984] to apply and enforce the provisions of the proposed law.

The success of the above steps will ensure that the mangrove forest in the Cimanuk nature reserve will optimally fulfil its ecological function and support the inhabitants with more valuable trees. The abundance of seedlings in units I to IV (Table 5) indicates that natural regeneration may be successful if the above 4 steps are applied in the field. The competition by less desirable mangrove species (*Acrostichum aureum, Acanthus ilicifolius, Derris trifoliata*), smothering regeneration by abundant growth of *Panicum repens, Paspalum commersonii, P. vaginatum, Cyperus malaccensis, Scirpus littoralis*, and possible crab damage to mangrove seedlings are likely also to pose problems. Therefore, these grasses, sedges and less desirable mangrove species should be evaluated as plant competitors. Research priority should be set based on urgency and demand for information to support the desired developmental activities. Research thus managed is expected to result in action, application or adoption. Topics include :

1. Protection and maintenance of mangrove forests in Cimanuk nature reserve.
2. Reforestration/afforestation of mangrove areas in the Cimanuk nature reserve, and in all areas of Ujung Indramayu.
3. A zone of mangrove areas in Ujung Indramayu for various uses.
4. Fish pond and 'tambak tumpang sari' development in inland mangrove areas in Ujung Indramayu.

Mangrove forest in the Cimanuk delta complex, Ujung Indramayu, may be a simple ecological community in terms of species diversity (Tables 1, 2), but it is an exceedingly complex ecosystem to evaluate. The biological basis for sustained use and management is still deficient, and the safest policy is to minimize direct utilization and especially disturbance. The woodcutter puttering through the mangrove creeks with a load of firewood in a shallow-draft boat may not be a very dramatic figure in interpreneurial terms, but this is probably the best image that can be associated with a mangrove forest treated as a resource to be sustained in perpetuity. Nevertheles, pollution (Tables 6, 7) has been reported to be a major problem in the fishery sector. In connection with the health of biological resources, the following investigations must be undertaken immediately.

1. Effects of pollutants on the mangrove flora and fauna at Ujung Indramayu.
2. Erosion, sedimentation and fresh water influx rates in mangrove areas of Ujung Indramayu.
3. Habitat alteration effects on mangroves and hydrodynamics in the mangrove ecosystem of Ujung Indramayu.
4. Biological impact of fish ponds and 'tambak tumpang sari' and other land use in

Ujung Indramayu.

Taking the fundamental approach, including all interacting steps and action to be taken for conserving the mangrove forest in Cimanuk delta complex, Ujung Indramayu, and in view of the fact that the forests are beneficial economically [Sukardjo 1987a; 1990], we strongly recommended a field research program reflecting the need to investigate the following in depth.

1. Multiple use management of the coastal zone of the northern coast of West Java.
2. Analysis of fish pond and 'tambak tumpang sari' leases, sizes of leased areas and performance in the coastal zone of the northern coast of West Java.
3. Economics of mangrove areas utilized for forest products (e. g., firewood) and fisheries versus developed fish ponds and 'tambak tumpang sari' in the coastal zone of the northern coast of West Java.
4. Socio-economic conditions of mangrove-dependent populations in the coastal zone of the northern coast of West Java.
5. Marketing system of the biological products from the coastal zone of the northern coast of West Java.

Acknowledgments

We are very thankful to Miss. Hiroko Muguchi for typing this manuscript. This work was prepared during the tenure of the first author as Visiting Research Scholar of the Center for Southeast Asian Studies, Kyoto University, Kyoto.

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