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MANAGEMENT OF MANGROVE EXPLOITATION IN INDONESIA

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INTRODUCTION

In Indonesia the value of direct exploitation of mangrove resources in the form of wood products and the indirect value of mangroves in fisheries and coastal geomorphic processes are recognized by scientists and managers (Hardjosentono, 1978; Wiroatmodjo and Judi, 1978; Nurdin, 1978; Duncan, 1978). However, current mangrove resource development strategies have been based on extremely limited and incomplete information. The adaptive management of existing strategies is also hindered by the lack of monitoring of mangrove response to development pressures and by the lack of applied research on improving management practices. Apart from incomplete bio-physical data concerning the extent of mangrove areas and their response to development pressures, there is a shortage of data on the social and economic forces which affect the management of mangrove resources. This situation is not likely to improve until a more systematic view of the ecology of mangrove and related systems and the role of mangrove as a primary resource supporting a variety of sectoral interests are combined to define research priorities for improving the management of the resource.

In this paper we would like to present an overview covering (1) the area of mangrove vegetation, (2) the use and production of mangrove products, (3) current management arrangements, and (4) unresolved problems and conflicts in mangrove development. In conclusion we offer a series of suggestions for tackling the problem of information needs for improved mangrove development.

THE AREA IN MANGROVE VEGETATION

Wiroatmodjo and Judi (1978) estimated that in Indonesia mangrove vegetation covers an area of approximately 3.6 million hectares of which about 60% or 2.1 million hectares are considered as mangrove forests. Recent surveys have identified a further 205,000 ha of mangrove in Riau, Sumatra (± 20,000 ha), East Kalimantan (± 130,000) and South Kalimantan (± 55,000 ha) (Wiroatmodjo, 1980, personal communication). Table 1 shows the distribution of mangrove areas in

Table 1. Distribution of Mangrove Areas in Indonesia

Region	Hectares	% of total mangrove area
Sumatra	400,000	10.5
- Aceh	50,000	
- North Sumatra	60,000	
- Riau	95,000	
- South Sumatra	195,000	
Sulawesi	53,000	1.4
- South Sulawesi	24,000	
- Southeast Sulawesi	29,000	
Maluku	100,000	2.6
Irian	2,934,000	77.1
Kalimantan	275,000	7.2
- East Kalimantan	150,000	
- South Kalimantan	75,000	
- Central Kalimantan	10,000	
- West Kalimantan	40,000	
Java	40,441	1.1
- West Jaya	20,400	
- Central Java	14,041	
- East Java	6,000	
Nusa Tenggara	3,678	.10
TOTAL :	3,806,119	

Sources: Piran Wiroatmodjo dan Judi D.M. Pengelolaan Hutan Kayu di Indonesia (The Management of Timber Forests in Indonesia). Direktorat Bina Program Kehutanan, Februari 1978; Piran Wiroatmodjo, 1980. Personal communication.

Indonesia based on Wiroatmodjo and Judi's 1978 data updated to include Wiroatmodjo's 1980 data. Map 1 provides a general impression of the location of these mangrove areas.

Table 1 illustrates the large area of mangrove in Irian Jaya which represent 2.9 million hectares or 77% of the total mangroves in Indonesia. These mangroves are believed to be largely undeveloped. In contrast the most heavily populated island, Java, contains only 40,441 hectares or 1.1% of the total mangrove area. In Java the long history of land development and the pressures to extend coastal fish ponds and other land uses have led to the reduction of former mangrove area. However there is little information on the dynamics of past and present changes in both the area and condition of Indonesian mangrove.

The mapping of mangrove areas is carried out by the Directorate of Forest Planning of the Directorate General of Forestry, based on ground surveys and aerial photographs and maps are produced at a scale of 1:2,000,000. Monitoring of changes in the areal distribution of mangrove is attempted, however, a shortage of manpower and up to date photography limit the mangrove monitoring capability in Indonesia.

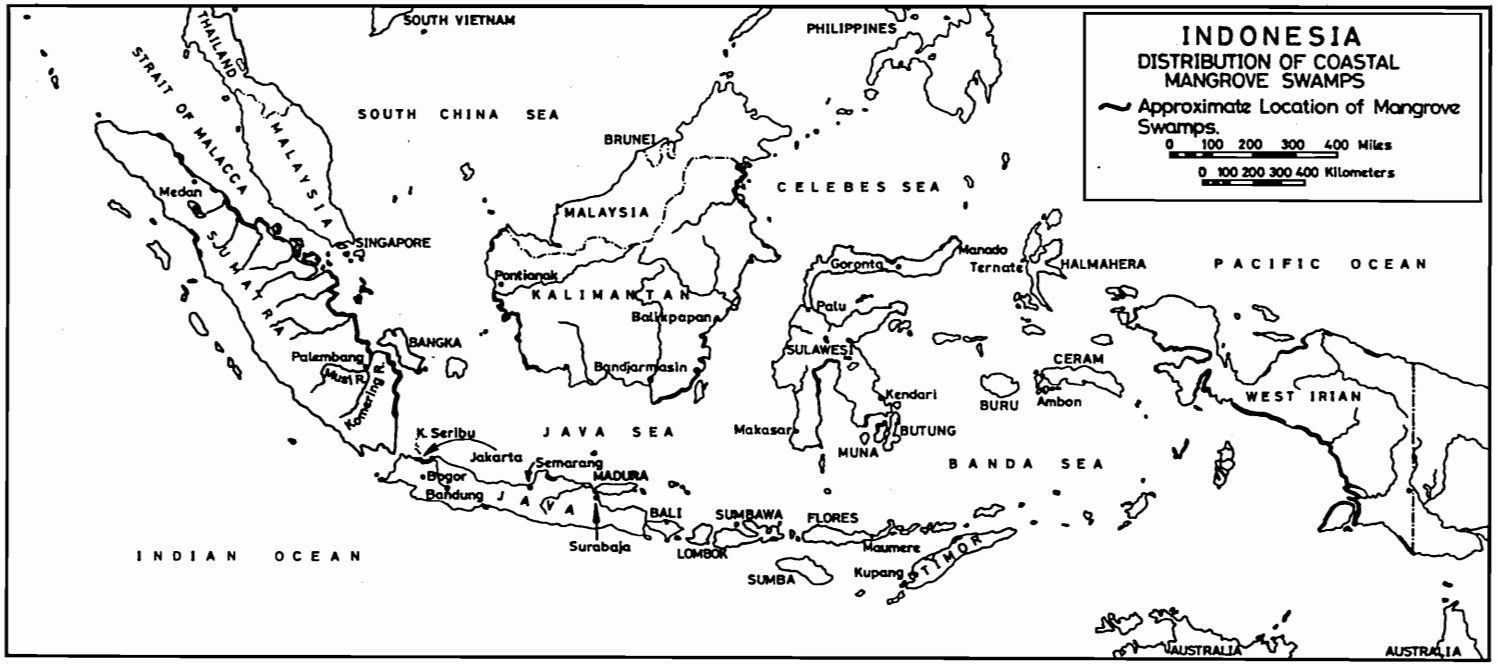
The Directorate of Forest Planning is currently attempting to estimate the species composition of the various mangrove stands on a provincial basis. In 1978 a report by this agency gave the following estimate of commercially valuable stands of mangrove dominated by *Rhizophora* spp. and *Bruguiera* spp. :

Table 2. Mangrove Area Dominated by *Rhizophora* spp. and *Bruguiera* spp.

Province	Forest Area	Standing Stock	Standing Stock per ha
A c e h	14,000 Ha	316,870 M^3	22.63 M^3
R i a u	197,000 Ha	4,846,230 M^3	24.60 M^3
J a m b i	65,000 Ha	7,800 M^3	0.12 M^3
South Sumatra	388,000 Ha	4,920,240 M^3	12.68 M^3
West Kalimantan	37,500 Ha	158,410 M^3	4.22 M^3
South Sulawesi	42,000 Ha	68,390 M^3	1.63 M^3
Irian Jaya	627,000 Ha	62,365,430 M^3	99.46 M^3
TOTAL	1,370,500 Ha	72,683,370 M^3	53.03 M^3

Source: Direktorat Bina Saraha Kehutanan, 1978. "Bakau" (*Rhizophora* spp.)

MAP 1.



Source: Coastal Zone Pollution in Indonesia with Emphasis on Oil: A Reconnaissance Survey, Institute of Oil and Natural Gas, Jakarta, 1974. Reproduced with the permission of the Institute of Oil and Natural Gas, Jakarta and UNESCO.

Table 3. Export of Mangrove Logs by Province

Province	1972		1977		1978	
	M^3	US$	M^3	US$	M^3	US$
Aceh	24,013	120,068	69,479	759,728	99,276	956,776
North Sumatera	-	-	2,904	18,000	-	-
Riau	39,546	82,265	178,765	916,735	226,589	1,142,450
Jambi	-	-	5,223	60,937	19,379	181,890
South Sumatera	196	4,874	-	-	13,404	106,391
West Kalimantan	-	-	12,073	52,798	-	-
Central Sulawesi	-	-	-	-	4,836	34,972
South Sulawesi	-	-	10,407	103,683	19,253	177,618
TOTAL	63,728	207,307	278,851	1,911,881	382,737	2,6000,097
(Value per cubic meter)		($3.25/$m^3$)		($6.86/$m^3$)		($6.79 m^3

Source: Direktorat Bina Sarana Usaha Kehutanan, Department of Agriculture.

Table 4. Export of Mangrove Logs by Country of Import

Country	1972		1977		1978	
	M^3	US$	M^3	US$	M^3	US$
Japan	24,013	120,068	48,465	242,089	34,089	310,912
Taiwan	169	4,974	230,250	1,668,949	348,226	2,289,145
Malausia	-	-	136	843	-	-
Not known	39,546	82,365	-	-	-	-
TOTAL	63,728	207,307	278,851	1,911,881	382,737	2,600,057*

Source: Direktorat Bina Sarana Usaha Kehutanan, Department of Agriculture.

* Note : There is discrepancy of $40 in the official figures. The total export value of logs is given as 2,600,057 or 2,600,097.

THE PRODUCTION OF MANGROVE PRODUCTS

Mangroves are harvested for a variety of purposes in Indonesia including charcoal, fuelwood, chipwood, tannin bark, and construction materials. The export of mangrove products is growing in importance. The combined exports of the two main mangrove products-charcoal and logs for chip-wood grew from $US671,628 in 1972 to $US3,971,016 in 1978. This represents an 83% growth in export revenues. Data concerning the domestic use of mangrove products is not collected on a systematic basis, we therefore have to rely on data collected by Central Government Offices, provincial reports and occasional papers to provide a guide to the production of mangrove products and their destination.

Mangrove log Production: The export of mangrove logs, primarily in the form of short lengths of wood less than 30 cm in diameter for conversion to wood chips, amounted to 382,737 cubic meters in 1978. Table 3 provides details of the regional export production of these materials. Aceh and Riau in Sumatra are the principle areas for log exports. The markets for mangrove logs are Taiwan and Japan (Table 4). A wood chip mill to convert mangrove logs into wood chips for export has recently been established in East Kalimantan and exports of chips were estimated at 70,000 cubic meters in 1979 (Sagala, 1980, pers. comm.).

The use of mangrove for pulp wood is not easy to identify in the current array of production statistics but 63,000 cubic meters of pulp wood were exported from Aceh in 1979. Riau is also a source of mangrove pulpwood and produced 164,530.15 cubic meters worth $US1,146.018 during 1977/78. This represented an increase in production of 49% over 1977/78 and an increase in value of 48%. The markets for the pulpwood from Riau were Taiwan (87.6% of the export) and Japan (12.3% of the export).

Mangrove poles are another form of export from Riau. In 1977/78 11,736.75 cubic meters of poles were exported to Singapore at a value of $US117,163.85. This level of production represented a 49% increase in production over 76/77 and a increase of 65% in value. Figures for 1972 placed the national export of mangrove poles at 17,500 poles worth $US3,724. These poles were produced in Riau.

Mangrove charcoal: Charcoal produced from mangrove formed exports worth $US1,370,919 in 1978 (see Table 5). The main markets were Japan, Singapore, Malaysia and Hongkong. These markets are closely related to regional sources of supply with Aceh supplying Hongkong and Malaysia, North Sumatra supplying Japan, and Riau exporting primarily to Singapore.

Table 5. Mangrove Charcoal Exports by Port and Destination 1978

Port Location	Net Weight Kg	F.O.B. US$
Aceh to Hongkong	3,310,000	46,788
Aceh to Malaysia	12,690,000	211,170
North Sumatra to Japan	6,902,350	826,045
Riau to Singapore	14,388,364	253,754
Riau to Malaysia	1,735,000	33,162
Total	39,025,714	1,370,919

Source: Statistik Perdagangan Luar Negeri. Biro Pusat Statistik, Jakarta, 1978.

The domestic consumption of mangrove charcoal is difficult to document. Wiroatmodjo and Judi (1978) suggest that charcoal production mainly using species such as *Rhizophora*, *Bruguiera* and *Xylocarpus* forms an important domestic energy source. Traditionally charcoal production has been a small scale form of development and is estimated to involve only several hundred hectares mainly in Sumatra near Riau and Jambi (Wiroatmodjo and Judi, 1978). Studies by Sudiono (1976) illustrate that the traditional forms of charcoal production using a harvesting cycle of 35 years have led to regeneration of mangrove where a sustainable production of 50-100 m^3/ha of wood is achieved. This would suggest that these small scale traditional forms of mangrove exploitation have been developed in balance with the mangrove's ability to support economic development. The trend in mangrove charcoal production for export shows a growth of approximately 33.8% from the 25,826,337 Kg reported in 1972 to the 39,025,714 Kg in 1978. Whether this rate of growth in production can be sustained is not clear and it should be born in mind that other competing forms of mangrove exploitation may reduce the effectiveness of traditional management techniques.

A 1973 estimate places the theoretical production of mangrove charcoal for the approximate one million hectares of mangrove excluding Irian Jaya at 461,197 tons per year. This estimate assumes that the areas of mangrove are basically undisturbed, however the mangrove in question is already under pressures of development about which we have little comprehensive information. The figures for pulp production and logs for chip wood suggest rapidly increasing demands on mangrove in regions of traditional charcoal activity. To this must be added domestic harvesting for construction materials, fuel-wood and tannin. To our knowledge data on small scale and informal mangrove harvesting has not been combined with the export related data to present an

overall estimate of demand on mangrove supplies or the regional implications of exploitation pressure.

New forms of demand on mangrove also pose questions for national and regional management. The production of wood chips rather than the export of logs for processing into chips is likely to form a major new form of mangrove exploitation. The first chip mill has been installed in East Kalimantan, an area which has not previously been developed for mangrove exports. Leases for a large area of mangrove have been given and trials are taking place to ascertain correct levels of harvesting and subsequent regeneration of mangrove using a clear cutting system.

Due to the high cost of establishing chip mills and the large areas of mangrove which will be required to form economic levels of production, it is likely that such mills will be located in areas previously undeveloped for large scale mangrove exploitation. With 81.1% of the available area of mangrove in Indonesia being located in Irian Jaya this region will logically form the major area for new chip mill locations.

THE MANAGEMENT OF MANGROVE EXPLOITATION

The management of mangrove resources in Indonesia is controlled by two major sets of regulations. The first controls silvicultural practices in mangrove harvesting and the second controls leasing arrangements for allocating mangrove areas.

The earliest attempt to regulate mangrove exploitation by law was through the Department of Public Health in 1933. The cutting of mangrove within three kilometers from a village was prohibited in order to control the mosquito population. The first mangrove management regulations incorporating silvicultural guidelines were passed to control the development of the Cilacap forest in Java. This regulation divided the forest into three management areas:

1. Mangrove production forest - where *Rhizophora* formed the main species and where clear cutting would be practiced leaving 60-100 seed trees (mother trees) with a minimum diameter of 20 cm to facilitate regeneration of the clear-cut areas.

2. Mangrove considered unsuitable for production.

3. Areas of protection forest along the coast and river edges where *Avicennia* and other mangroves formed the dominant vegetation.

The 1938 regulations introduced basic silgicultural concepts into Indonesian mangrove management. The wider application of these concepts to other mangrove areas in Indonesia was interrupted by World War II and the subsequent struggle for independence.

Though standardized management regulations for all mangroves in Indonesia were not put into law until 1978, research and experimentation continued after World War II. The effects of the clear-cutting system adopted in 1938 on regeneration of different species was studied by Versteegh. He drew attention to Watson's (1928) innundation classes and the methods of regeneration of the various commercial species which had largely been ignored in Indonesia. From experiments in the Bengkalis mangrove system he concluded that the clear felling system was suitable only for areas easily flooded by sea water. He also stressed the need to employ artificial as well as natural regeneration of the desired species and recommended an "area method" of regulating production. This method would divide the areas to be harvested into sub-areas of equal size based upon a period of rotation appropriate to both the regeneration of species and the use of harvested materials (Versteegh, 1951, 1952).

Versteegh's recommendations appear not to have had much impact until the late 1970's. Instead a follow up study of the Cilacap mangrove forest (Sagala, 1956) led to the adoption of the 1938 regulations and silvicultural system as the "Standard Clear-Cutting System" recommended by the Forest Research Institute in 1956. This system as applied to selected sites, with minor modifications to the number of seed trees required, formed the main thrust of mangrove management in Indonesia until 1978.

A modified clear-cutting system was recommended by the Forest Planning and Production division of the Directorate General of Forestry in 1972.

This system promoted the following practices:

a. No logging activity was to be allowed within 50 meters of the foremost (coastal) limit of mangrove vegetation or within 10 meters of a river.

b. Logging would be allowed in 50 meter wide strips at right angles to the coastline. An undisturbed strip of mangrove 20 meters wide would be left between the harvested areas to provide the seed for natural regeneration.

c. Only trees with a diameter of 7 cm and larger at breast height could be cut in the production strips.

d. Enrichment planting must be carried out on logged areas if natural regeneration is not adequate. The distance between planted mangrove should be 2 meters by 3 meters (based on research by the Forest Research Institute, 1971).

e. Logs should be removed by rafting using boats and artificial ditches/ canals.

f. A logging rotation cycle of 20 years should be observed.

These recommendations were given to large concession holders some of whom are believed to have implemented the "Strip Cutting System" on a voluntary basis. However the strip cutting system has never been adopted official silvicultural regulations. One concession, Chipdeco, in East Kalimantan is using a similar system in conjunction with a chip mill. The firm has had experience with the strip cutting technique and introduced it to East Kalimantan when they moved operations from Sabah, Malaysia.

The current regulations for mangrove management were put into law in 1978 and apply to all mangrove harvesting activities throughout Indonesia. These regulations are based upon Versteegh's 1951 recommendation for selective cutting leaving seed trees for natural regeneration and replanting. The main provisions of the law are as follows:

a. An inventory of the concession must be carried out by the concessionaire. Based on the inventory the forest must be divided to two zones: (1) the Production forest and (2) the protection zone. The zone of protection is defined as a strip of undisturbed mangrove of at least 50 meters depth inland of the seaward margin of mangrove and a minimum of 10 meters from river margins of mangrove.

b. Cutting can proceed only in those areas where 40 seed trees of a minimum diameter of 20 cm will be left per ha or 2.500 seedlings per ha are left with a spatial distribution of 2 m by 2 m.

c. Annual allowable cutting limits will be fixed by the Directorate General of Forestry.

d. Regeneration studies must be carried out to determine the effectiveness of the cutting and regeneration cycle.

These regulations place a great deal of responsibility for the inventory and subsequent regeneration studies on the concessionaire. The management of mangrove resources will therefore depend largely upon the goodwill of the concessionaires.

The Directorate General of Forestry is considering the effectiveness of these current regulations and realize that the new selective cutting procedures will be difficult to implement and control by forestry officials. To successfully monitor the effect of the new regulations there needs to be a forest inventory after logging has taken place. With a shortage of manpower and difficulties of access to sites such inventories may not be feasible.

The second major form of control over mangrove exploitation concerns the allocation and leasing of mangroves areas. In 1970 legislation was passed which radically altered the leasing process.

Table 6. Mangrove Area Allocated for Forestry Under Central Government Leasing Regulation

Province	Concession Holders	Mangrove Forest Area[x] (Hectares)	Maximum Annual Allowable Cut of Mangrove (m^3/ha)
Aceh	PT Bakau Selat Malaka	20,000	65,000
	PT Kabindi Langsa	12,000	19,000
Riau	PT Bina Lestari	42,000	127,000
	PT Sylva Saki	5,000	3,200
	PT Thai Rayvithi	40,000	41,000
South Sumatra	PT Bakau Indah Jaya	32,000	43,000
West Kalimantan	PT Bumi Indah Jaya	17,000	22,000
	PT Pelita K.A.	22,500	19,000
South Kalimantan	PN Perhutani (76)	67,500	77,000
East Kalimantan	PT Berau Timber	55,000	126,000
	PT Karyasa Kencana	56,000	57,000
	PT Bina Lestari	32,000	21,000*
Irian Jaya	PT Henrison	54,000	165,000*
		455,000	

* Permission has only been granted for a forest inventory no cutting is permitted at this time.

x The mangrove forest area refers to the area within a concession in which forestry operations may take place, the area of protection forest is not included within the area given.

Source: Direktorat Bina Program Kehutanan.

Prior to this date provincial authorities were responsible for the leasing of mangrove areas. After 1970 the Minister of Agriculture, acting on behalf of central government, became responsible for the allocation and leasing of mangrove resource for areas greater than 100 hectares. It is believed that this was done to facilitate and stimulate foreign investment in mangrove resources which were considered to be underdeveloped. This legislation permitted provincial authorities to grant two years leases for mangrove of less than 100 hectares and set time limits on harvesting activities by the lease. As a result major responsibility for control over the allocation and timing of mangrove exploitation was shifted from provincial to central government.

The area of mangrove and the annual allowable cut by concessionaires currently allocated through central government leasing arrangements is given in Table 6.

Table 6 illustrates a series of points. The first is that central government leases permitting logging approximately 12% of the total estimated mangrove area in Indonesia. Secondly, these leases tend to be held by a small number of concessionaires but constitute large areas of mangrove. The average area of mangrove leased by the thirteen concessionaires listed in Table 6 was 35,000 hectares. Thirdly, although the area of mangrove held under provincial lease (less than 100 ha per lease) is not given, central government leases form a major proportion of the total available mangrove area in the following provinces:

Aceh	64%
Riau	96.8%
West Kalimantan	97.5%
South Kalimantan	90%
East Kalimantan	95.3%

Fourthly, the large area of mangrove in Irian Jaya (2.9 million hectares) has only one central government concession of 54,000 hectares and no permit has yet been issued to cut mangrove. Unfortunately we can not draw any firm conclusions concerning the area of mangrove that is not under provincial or central government lease because we do not have figures on the area and location of provincial leases. However, it would appear reasonable to assum that the major areas of unallocated and undeveloped mangrove are to be found in Irian Jaya.

REGENERATION OF MANGROVE AREAS

In Indonesia studies of the regeneration of mangrove following different forms and intensity of exploitation are far from conclusive. Becking et al. (1922) reported that in Indonesia mangrove forests where the commercial species had been clear-cut succession was generally dominated by the commercially less valuable *Avicennia officinalis*.

However Becking *et al.* (1922) also reported that in certain areas the regeneration of the commercially valuable species was often surprisingly good. Unfortunately the reasons for the variation in regeneration between areas was not documented. Versteegh (1951) reporting on management trials in Bengkalis, Sumatra stated that in the case of *Rhizophora* spp., which is considered to be the most economically valuable species, clear-cutting quarantees a rich natural regeneration only on frequently inundated soils. Under average edaphic conditions and on places not so regularly inundated clear-cutting is considered by Versteegh to give wholly insufficient results. Riyanto and Tobing (1979) reported successful regeneration of *Rhizophora* in a series of trial plots using a strip clear-cutting system where a minimum of 70 seed trees were left per hectare. Though the species composition of the seed trees was not reported, regeneration was dominated by *Rhizophora apiculata* which comprised 82.9% to 92.4% of the vegetation followed by *Bruguiera gymnorrhiza* with between 7.6% and 17.1% (Riyanto and Tobing, 1979). In contrast field observations in South Sulawesi showed that regeneration in a cut over *Rhizophora* dominated forest was characterized by succession toward undergrowth consisting of *Acanthus* and *Acrostichum* (Nurdin, 1978). The succession observed in South Sulawesi may be related to differences in ecological conditions and felling methods. However, the reports do not make this clear.

In the formulation of guidelines and regulations concerning mangrove development great emphasis has been placed upon the "seed tree" method of regeneration based upon a small number of studies of isolated examples of mangrove habitat and methods of exploitation. Recommendations have been put forward concerning the number of seed trees or seedlings left per hectare of logged area (Versteegh, 1951; Sagala, 1956). However, a critical examination of the fundamental mechanisms of regeneration for different species has not been attempted. For example the part which water borne fruits from seed trees plays in regeneration of commercially valuable *Rhizophora* dominated forest is a subject of some debate amongst foresters. Dixon (1959, pp. 9-10) in his review of silvicultural and regeneration of the Matang mangrove forests in Malaysia argued that " ..... the regeneration of Bakau (primarily *Rhizophora*) areas after final felling depends primarily on the recovery of damaged advanced growth". He discounts the role of seeds trees and water borne fruit and suggest that researchers often overlook the inconspicuous advanced growth formed by coppice shoots which may be obscured by slash and forestry operations. Dixon subsequently altered the management practices in the Matang mangrove forest to safeguard the regeneration potential of advanced forms of growth (Dixon, personal communication, 1980).

Though the "seed tree" concept has been readily adopted in Indonesia the role of advanced growth in regeneration has not received much attention. If advanced growth plays a significant part in regeneration of Indonesian mangroves then current management practices may not safeguard that role.

The regeneration of mangrove will also be affected by land management outside the mangrove forest. Changes in seasonal water flows in rivers and rates of accretion of coastal areas will be conditioned by upland management. Ishemat (1968) attributed major changes in species composition and rates of regeneration of *Bruguiera* in the Cilacap mangrove to increase downstream flooding and deposition of soils resulting from the clearance of upland forests and increased soil erosion. From discussions with Indonesian foresters and silviculturists involved in mangrove management there appears to be a pattern of poor regeneration of mangrove stands near major rivers whose watersheds are being developed. In contrast mangrove areas in coastal bays and along shorelines with small rivers or undeveloped watersheds of major rivers show strong natural regeneration even under heavy harvesting pressures.

The trend toward allocating large areas of mangrove to new forms of mangrove exploitation would also suggest the need for a more broadly based enquiry into the mechanism of regeneraion and systems of silviculture appropriate to new forms of exploitation. These studies should also be related to a broader series of representative mangrove areas in which a range of external factors such as upland management are incorporated in adapting management guidelines for mangrove exploitation. If the linkages between mangrove and other resource system are shown to be strong then consideration should be given to incorporating guidelines to protect the integrity of mangrove areas when drafting management guidelines for areas such as watersheds.

CONFLICTS OF INTEREST

A series of conflicts of interest in mangrove development can be identified in Indonesia ranging from local demands for land for fish ponds and agriculture to conflicting regulations, guidelines and incentives from sectorally oriented government agencies. At the localized level of mangrove management in areas of acute population pressure such as Java, mangrove forests have been converted to agricultural fields and "tambak" fishponds. The desire for land for such activities has led, as in the case of parts of Krawang near Jakarta, to the total clearance of mangrove and the building of fish-ponds right to the edge of the sea. This has resulted in major changes in stream flow and siltation through diversion of stream channels, which in turn has altered coastal sedimentation processes. Altering the stream flow has also led to a reduction in the drainage of low lying lands and increased salt intrusion which has increased the problem of agricultural management. The most dramatic effect has been the erosion of the coast-line and "tambaks" as a result of removing the mangrove buffer to wind and wave action.

The reclamation of mangrove is also associated with the development of estate crop lands in Riau. Here government incentives to create estate crop plantations under the CESS program have under-

written the costs of clearing mangrove sites for coconut plantations (Dinas Kehutanan Propinsi, Riau, 1978).

During the period of Dutch Colonial Administration in Indonesia all forest lands, including mangrove, were deemed public lands. This remains true today and the clearance of these lands for other forms of use, even with the assistance of government incentives, is technically illegal. Following independence, a generally tolerant attitude has been taken toward people developing agricultural fields and fish-ponds in mangrove areas. However, clear title to these lands can not be established by the farmers or fish-pond operators.

A policy of reforesting all lands previously covered by forest and deemed public land has been instituted by the Directorate General of Forestry. This applies to all coastal land formerly covered by mangrove forest. A considerable part of these lands have been converted into fishponds and agricultural land, especially in Java, and conflicts between local people claiming rights of use over these lands and the Directorate General of Forestry have arisen. The resolution of these conflicts has been made more complex through a policy instruction within the Directorate General of Fisheries stating that a "Green Belt" of mangrove and swamp forest should be established along all coastlines.

This instruction conflicts with the 50 meter wide belt of "protection forest" set out in the mangrove silviculture regulations and impinges upon the authority of the Directorate General of Forestry. The Minister of Agriculture has instructed the Directorate General of Fisheries and Forestry to work together in defining the area of mangrove which is required to protect fish stocks. To date this has not been agreed upon and both the reforestation policy and the "green belt" instruction have continued to cause conflicts with fishpond operators (Akhmad, 1978).

The decision to establish a coastal green belt involves lands of all types of land ownership. It does not discriminate between privately owned coastal lands and lands under the authority of the Directorate General of Forestry or those owned by industrial crop estates which may be controlled by the government or by private companies.

In the case of tambak development there have been instances of conflicts between tambak operators who illegally opened tambaks on coastal lands owned by state owned industrial crop estates. In some cases these conflicts were solved by allowing the tambak operators to continue since the tambaks were located on unutilized coastal lands.

To reduce the conflicts between fishpond operators and the government a "tambak-forest" system where mangrove replanting and fishpond operations could be combined was introduced by the forest research institute (Alrasjid, 1971). Essentially this means planting *Rhisophora* spp. on a rectangular plantform surrounded by a 4-5 meter wide ditch where fish are to be cultured. Planting and maintenance of the

mangrove on the platform is assigned to the tambak operator. In addition to acting as fishponds the ditches can be used to transport mangrove logs. The system has not been a complete success and in areas such as Krawang the mangrove has been further depleted. Modest success with the "tambak forest" system has been reported in the Cilacap area where a 10 hectare pilot project was established in 1977. However local population pressures and pollution from neighbouring industrial sites are affecting regeneration of mangroves and fishpond production. Regeneration of the mangrove system has only been successful using artificial regeneration using nurseries (Hartono et al, 1978).

The main objections to the "tambak-forest" system from the aquaculturist's point of view are: (1) the difficulty of controlling pests such as snakes and birds which take refuge in the forest complex; (2) the effects of shading on the primary productivity of the tambak since the preferred fish to be cultured, i.e. milkfish (*Chanos chanos* Forskall), does not feed on detrital material from mangrove but on a variety of benthic algae (Akhmad, 1978); (3) the status of tambak ownership on the "tambak-forest" system, where the tambak operators have leased the tambak from the Forestry Office and cannot own it, prevents them from obtaining credit from banks to enable them to increase the productivity of the ponds through artificial fertilizer or other capital improvements.

In view of these objections two modifications to the "tambak-forest" system may be worthwhile. The first would be to allow the ditches surrounding the planted plantform to function simply as traps for marine organisms transported with the incoming tide which could later be harvested. The second would be to widen the channels to reduce shading.

Conflicts between the demand for fishponds and the effect upon coastal fish stocks should also be considered. The contribution to primary productivity in coastal water and the nursery and spawning areas provided by mangroves has prompted the recommendations for a coastal "green belt" However, due to the lack of any basic research on the contribution of mangrove to riverine and coastal fish stocks in Indonesia no one can define what mangrove areas are of critical importance and how broad a "green belt" would be required to support fishery development. Laying claim to too broad a zone where forestry operations would be prohibited would unnecessarily restrict forest production. On the other hand the existing controls specifying a minimum 50 meter belt of mangrove along shorelines and 10 meters from river banks may not be sufficient to ensure the maintenance of coastal fish stocks. A compromise will have to be reached in which forestry and fishery interests are satisfied. This may most sensibly be achieved by undertaking a series of studies to define mangroves of critical importance to fisheries and defining reserves in these areas where forestry must be strictly regulated. For areas of less importance to fisheries different management boundaries could be defined. Unfortunately all funds available for research on mangrove resources

in Indonesia are channeled by Bappenas, the National Planning Agency, into the Directorate General of Forestry. None of these funds is channeled to the Directorate General of Fisheries for fisheries research related to mangrove development.

The alteration in leasing arrangements for the allocation of mangrove resources may also lead to increasing conflicts between local traditional activities and new large scale operations such as mangrove chip mills. In Aceh large concession holders are suffering encroachment upon their mangrove areas from small concession holders who have over-exploited their concessions (Sagala, 1980, unpublished report). The problem of reserving sufficient mangrove areas to protect existing and projected demand from traditional mangrove activities has not been addressed by Central Government. The conflict in Aceh may have arisen due to insufficient control over the exploitation of the provincially allocated lands and the absence of sufficient reserves of mangrove to meet local demands. Such potential causes of conflicts will increase unless more attention is paid by Central Government to the allocation of provincial versus central government mangrove resource requirements.

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The development of a resource such as mangrove must remain a flexible process where the discovery of new forms of use should be met with creative research and adaptation of management procedures and regulations as a result of experience. With the current transition from traditional small-scale forms of mangrove development to centrally controlled large-scale leases for new forms of exploitation such as wood chips, increasing emphasis will be placed on economic efficiency in mangrove production. Similarly government emphasis on increased resource production and investment in new forms of economic activity will place increasing pressure on areas of long standing mangrove development as well as opening up undeveloped regions. The management of mangrove resources will therefore require a broader perspective than has characterized the development of leasing and silvicultural regulations to date. Specifically management solutions will be required which:

1. Protect and foster traditional resource development activities based on localized mangrove reserves.

2. Facilitate new and expanded forms of mangrove exploitation.

3. Safeguard the interests of economic activities such as coastal or riverine fisheries and inland agriculture which may be directly or indirectly dependent upon the maintenance of the ecological integrity of mangrove systems.

This will require a blend of social, economic, and bio-physical considerations in the formulation of mangrove management strategies.

To facilitate this broad approach to mangrove development we would suggest the following research themes be considered in Indonesia:

A. Social considerations

1. Traditional forms of mangrove use should be examined to understand perceptions of the utility of mangrove products, methods of allocation of resources through local institutions, past experience of the limits to exploitation, and the area and species of mangrove required to maintain traditional forms of use.

2. The role of traditional forms of mangrove use in coastal communities and the effect of changes in leasing arrangements and silvicultural and other procedures and regulations on communities.

3. Conflicts of use in mangrove development including traditional rights of use, claims on land ownership and local pressure on land.

B. Economic considerations

1. The role of traditional forms of mangrove use in the economy of different regions.

2. The role of land ownership and credit facilities in improving resource production in mangrove and fishpond systems.

3. The relationship between traditional and new forms of mangrove development.

4. The role of new forms of mangrove development in regional and national economic development.

5. The resource economics of the relationships between mangrove development and other forms of economic activity. In particular the value of mangrove in its undisturbed state to fisheries has never been clearly stated in Indonesia.

C. Bio-physical considerations

1. The effect on mangrove areas from the development of related ecological systems including upland watersheds, coastal swamplands, riverine and nearshore waters.

2. Mechanisms of regeneration in mangrove vegetation.

3. Factors affecting regeneration which may extend beyond the

mangrove zone including changes in salinity or siltation caused by upland management or tidal swampland reclamation.

4. The development of silvicultural systems which can respond to new forms of mangrove exploitation and the regeneration characteristics of the species involved.

5. The relationship between mangrove areas and fisheries production. Are there specific mangrove areas which are of great importance to fisheries? If such areas can be identified what should be done to protect their role in fisheries production? Is a "green belt" of mangrove required in all areas to protect fisheries or is this an unnecessary impediment to mangrove forest production?

6. Improvement of multiple use management systems. For example the fishpond cum mangrove system could be improved through the identification of species other than milk fish (*Chanos chanos)* which would be more resistant to predation. Fish production could also be improved by widening the fish channels around the mangrove stands to reduce the effects of shading.

7. Improvement in the survey and monitoring of mangrove areas and their response to management efforts.

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