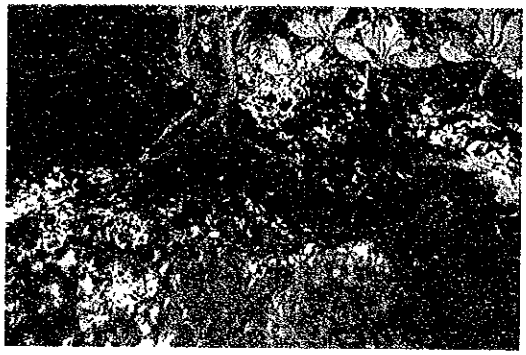
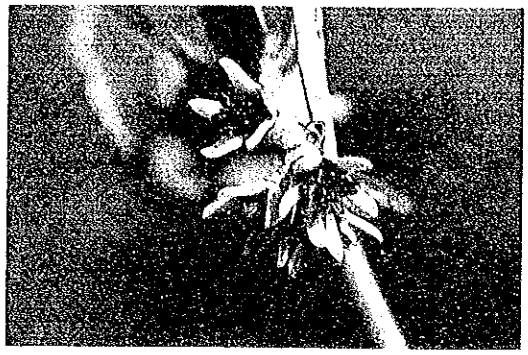
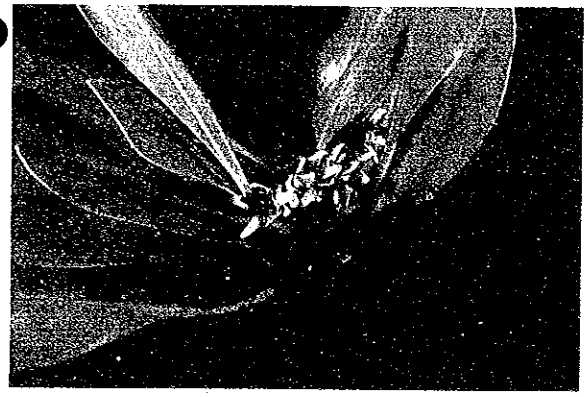


T3 : root system



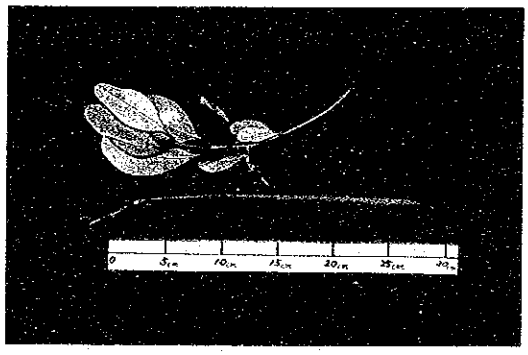
T4 : flowers.



T5 : flowers

T6 : shoot with seedling.

T7 : seedling.



T8 : leaves and seedling.

4. Rhizophora apiculata
Rhizophoraceae

One of the dominant species on BALI and LOMBOK islands, this species grows at any depth of tidal area, in good habitat up to 30m, but usually up to 20m on BALI and LOMBOK islands. Used for fuelwood by local people and very important raw material for charcoal in SUMATERA.

Characteristic aerial stilt roots develop well. The number of stiltroots are influenced by location of the tree. In suitable habitat the roots are a few, when isolated, the roots numerous. Bark is gray, smooth when juvenile, slightly lenticellate when mature.

Leaves opposite, upper surface coriaceus green to greenish yellow, under surface greenish yellow, midrib on lower part sometimes reddish, 10 to 20cm long, 5 to 8cm wide, elliptic oblong, apex pointed.

Leaves are very similar to B.gymnorrhiza, but evident differences are the black dots on the under surface of older leaves and apex with an erectmucro 2 to 3mm long.

Flowers always twins, calyx 12 to 14mm long, 9 to 10mm wide, yellowish orange, slightly brown lenticellate on the surface.

Seedlings development takes 22 months, beginning when peduncle is 7 mm until mature seedling drops. Seedling up to 35cm long, apex not pointed, somewhat round, not warty.

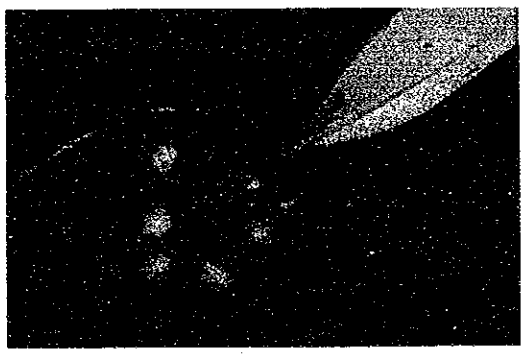
Seedling always maturing well bellow oldest leaf of shoot.

Fruits 25 to 30mm long, 15 to 17mm wide, brown and rough-skinned.

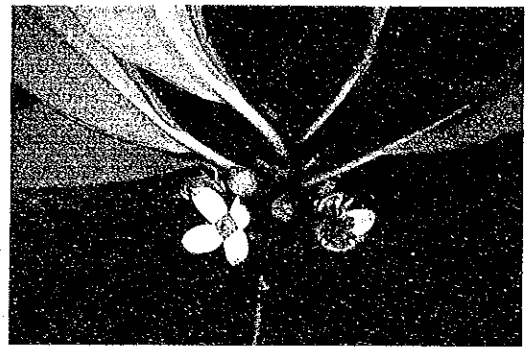
A1 : isolated tree.

A2 : trees in good habitat.

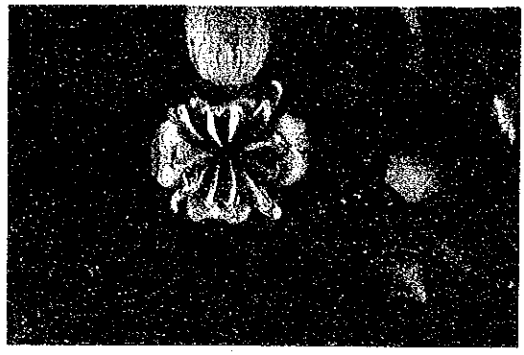
A3 : shoot.



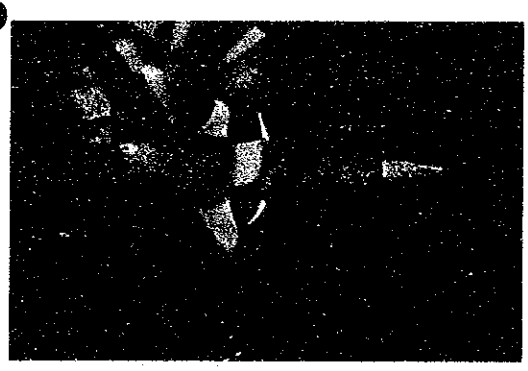
A4 : inflorescence.



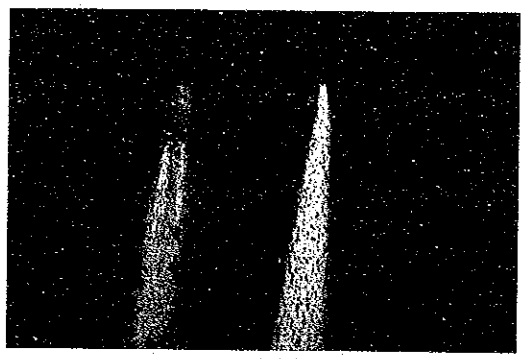
A5 : flowers at anthesis.



A6 : flower at anthesis.

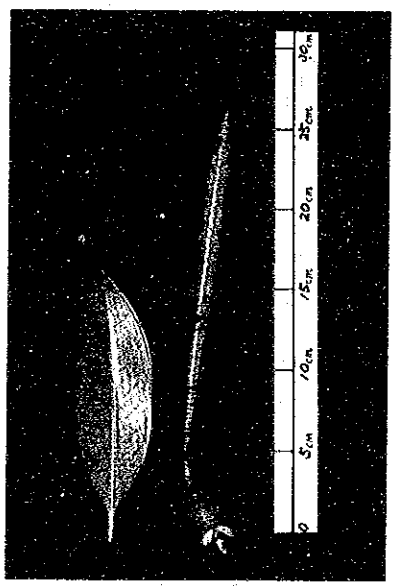


A7 : juvenile fruits and hypocotyle.

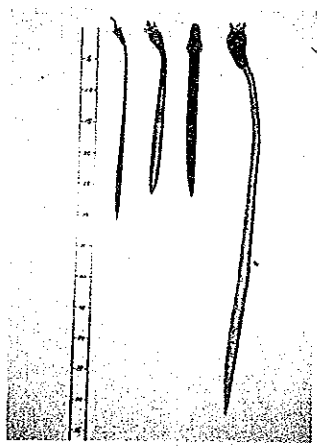


A11 : seedling apex R.apiculata (left)
R.mucronata (right).

A8 : shoot with seedling.



A9 : seedling and leaf



A10 :
seedling of Rhizophoraceae
C.tagal (left)
R.apiculata (middle left)
B.gymnorrhiza (middle right)
R. mucronata (right)

5. Rhizophora mucronata Rhizophoraceae

One of the dominant species in WEST BALI and on LOMBOK island, this species grows at any depth of tidal area, usually not face to shoreline, though sometimes grows on sand beaches.

In good habitat this tree can grow up to 30m, but usually up to 20m on BALI and LOMBOK islands. Used it for fuelwood by local people and very important raw material for charcoal in SUMATERA.

Characteristic aerial stilt roots develop well. The number of stiltroots are influenced by location of the tree.

Bark gray when juvenile, slightly lenticellate. Rough, flaky and with peeling patches at maturity.

Leaves largest in Rhizophora species, opposite, upper surface coriaceus green to light greenish yellow, under surface light greenish yellow, 13 to 23cm long, 8 to 12cm wide, broadly elliptic, ovata to oval, apex with a short persistent and erect mucro 5 to 7mm long. Obvious black dots on the under surface of older leaves.

Flowers 4 to 16, calyx 14 to 16mm long, 7 to 9mm wide, yellowish green at juvenile, ivoryish white at athensis, 4 hairly petals, style short as 1 to 2mm, ovary 3 to 4mm at base.

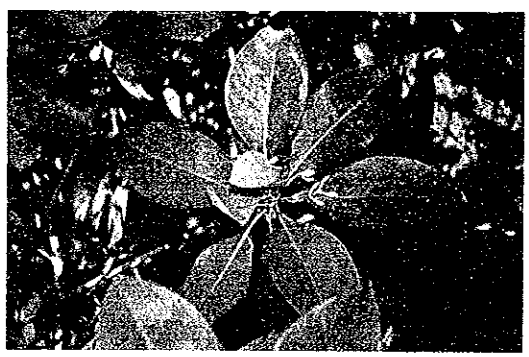
Fruits is largest in Rhizophora, 6 to 8cm long, 2 to 3cm wide.

Seedlings also largest in Rhizophora, up to 90cm long, apex acuminate, warty throughout.

Seedlings rarely stick in the ground when they drop.

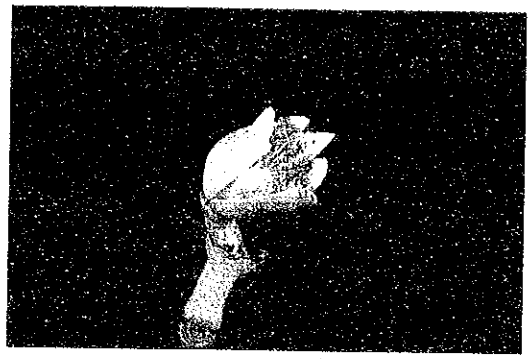
M1,2 : R.mucronata stand

M3 : aerial stilt root.

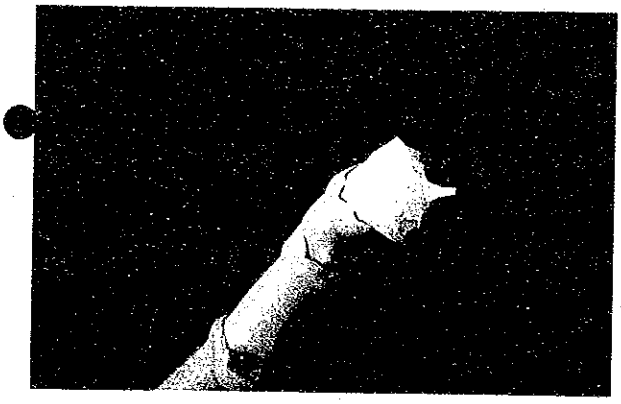


M4 : flowering shoot

M5 : inflorecence.

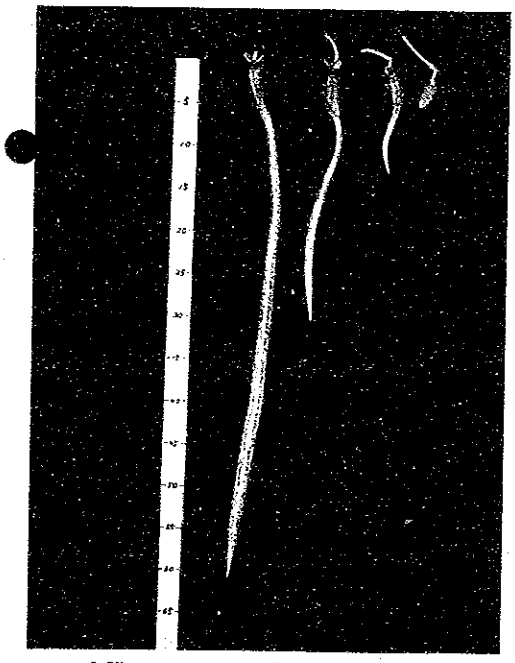


M6 : flower.

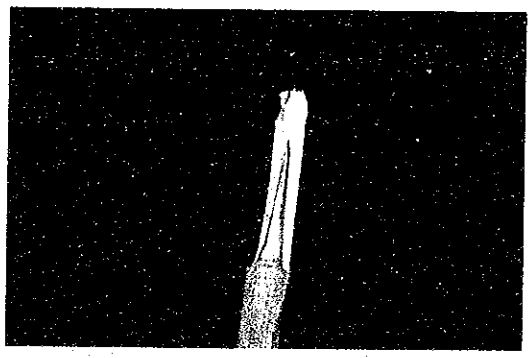


M7 : short style and fat oval.

M8 : seedling.



M9 : sequence of developmental stages of fruit and hypocotyl.



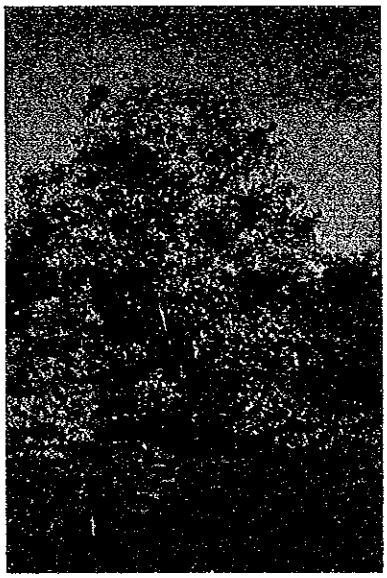
M10 : first leaves (red) in the tubular collar.

6. Sonneratia alba
Sonneratiaceae

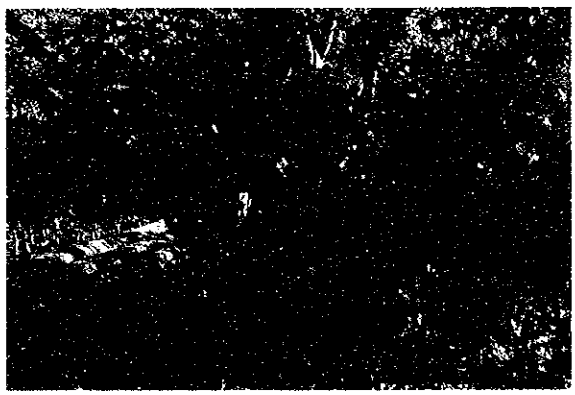
Very common species on BALI and LOMBOK islands. Grows any place in tidal area, usually dominantes as pioneer species. In good habitat this tree grows up to 25m, but near villages often grows "bonsai" -like, trunk base enlarged, multi-branched cause by local people cutting the stems and branches for fuel wood or forage.
Large numbers of extensive erect pneumatophores (aerial root) develope, 40 to 100cm tall, 3 to 15cm in diameter, not hard when juvenile, hard when mature.
Bark gray, tiny warts throughout, at maturity bark fissured and peeling in narrow strips.
Leaves opposite, ovata, obovate to obocordate, surface of the both surface look same.
Calyx tube 40mm long, 20mm wide, outside light green, inner surface vivid red or thin red, petal white, stamen white and numerous, style light green and long.
Fruit green, 35 to 45mm in diameter, hard when mature.
Development from flower bud to anthesis about 7 weeks and from anthesis to mature fruit dropping about 10 weeks, total development about 4 months.

S1 : S.alba stand.

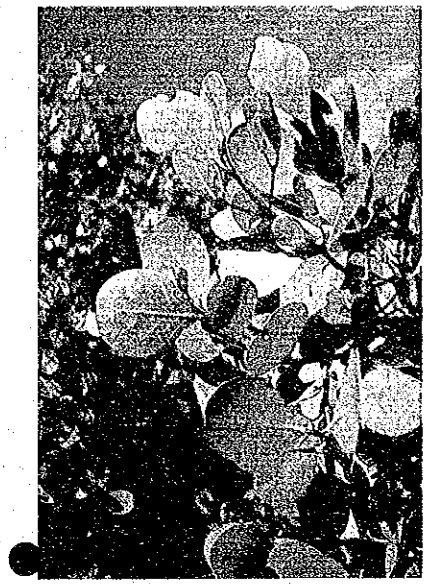
S3 : root system (pneumatophores).



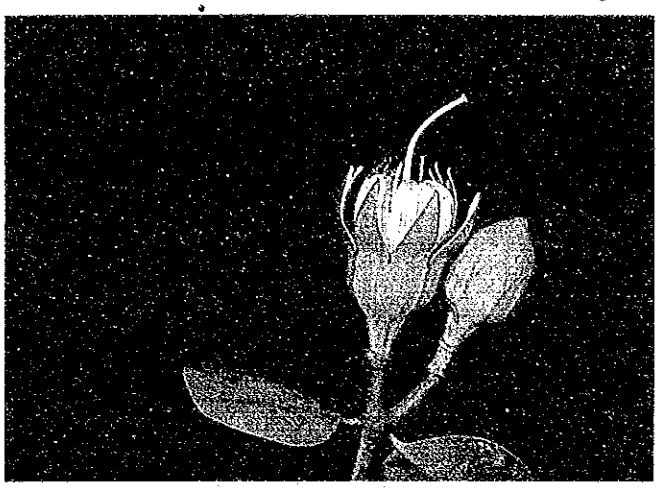
S2 : S.alba.



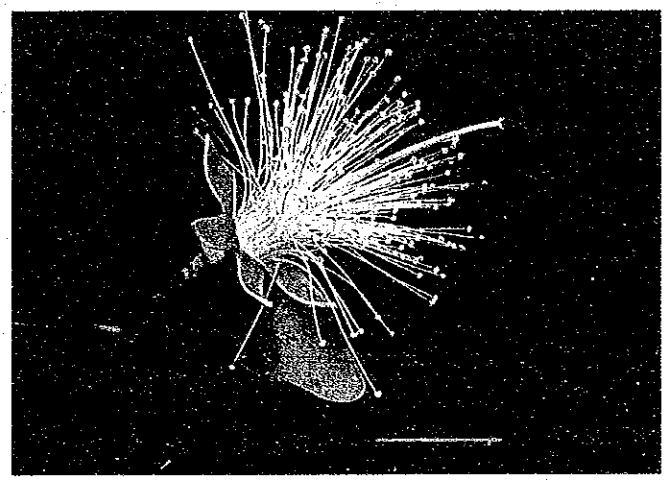
S4 : trunk shape caused by human activity.



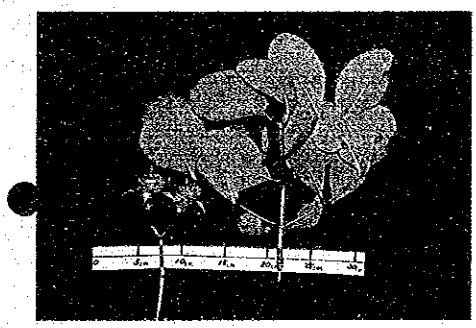
S5 : leaves on distal shoot.



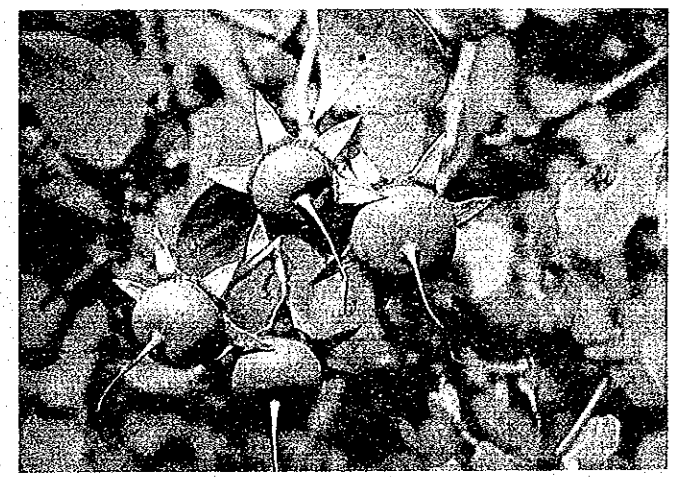
S6 : flower and calyx tube.



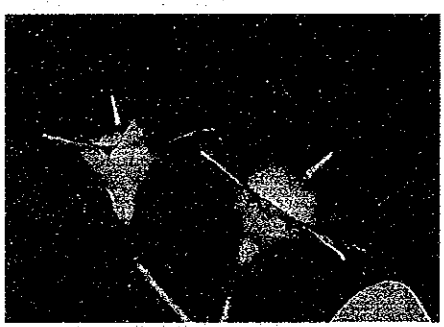
S7 : flower and calyx.



S9 : leaves and fruits



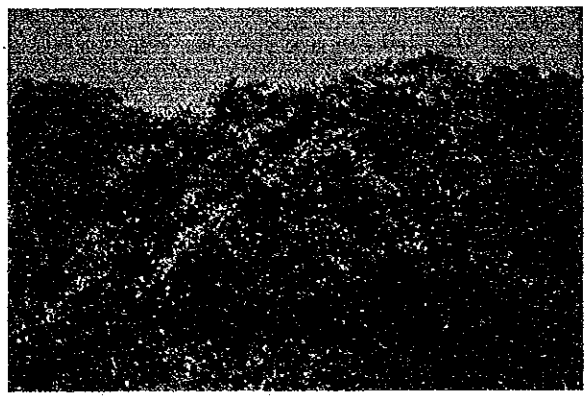
S8 : mature fruits



S10 : fruits

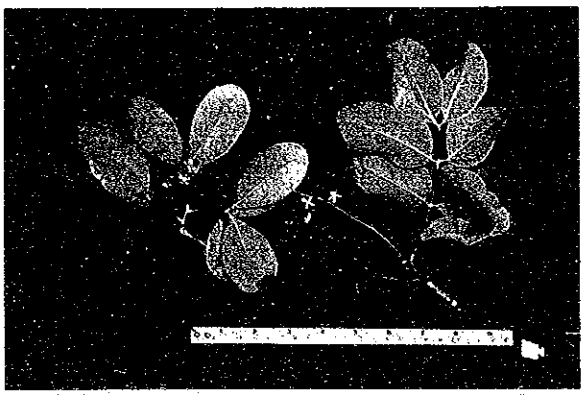
7. Xylocarpus granatum
Meliaceae

This species is common on BALI and LOMBOK islands, prefers to grow in higher tidal muddy area or on the banks of shrimp pond canals.
In good habitat this tree grows up to 18m, but usually only up to 8m on BALI and LOMBOK islands.
Root system developes buttresses, plank roots.
Bark is smooth, pale green, peeling mottled.
Leaves alternate, parippinate, rachis 7 to 20cm long. Leaflets 2 to 3 pairs each, 5 to 12cm long, 3 to 7cm wide, apex obtuse or emarginate.
Flowers ivory white, 6 to 8mm in diameter, inflorescence up to 10cm long.
Fruits up to 20cm in diameter, yellowish brown, 10 to 15 seeds in each fruit.

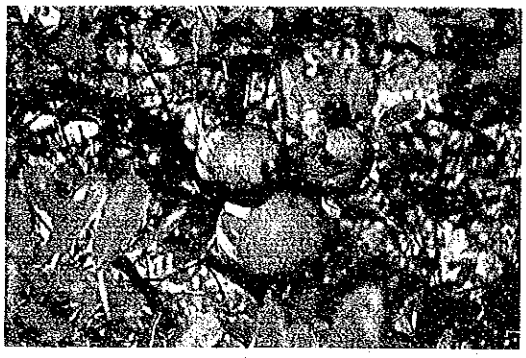


X1 : isolated tree.

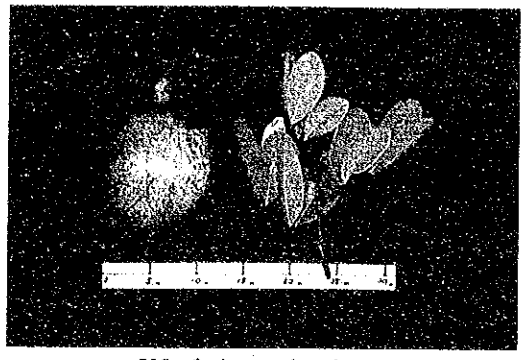
X3 : fruit on the shoot.



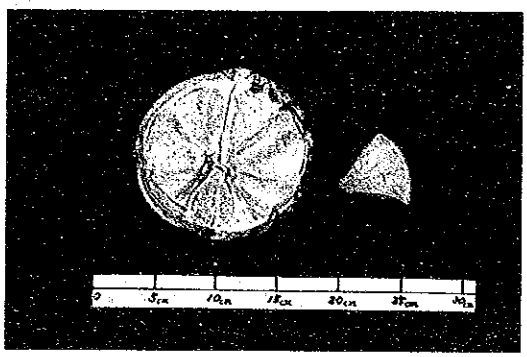
X2 : shoot with inflorescence
left ; X.granatum right ; X.moluccensis.



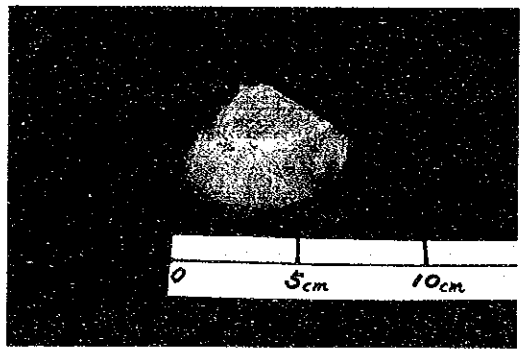
X4 : fruits on the shoot.



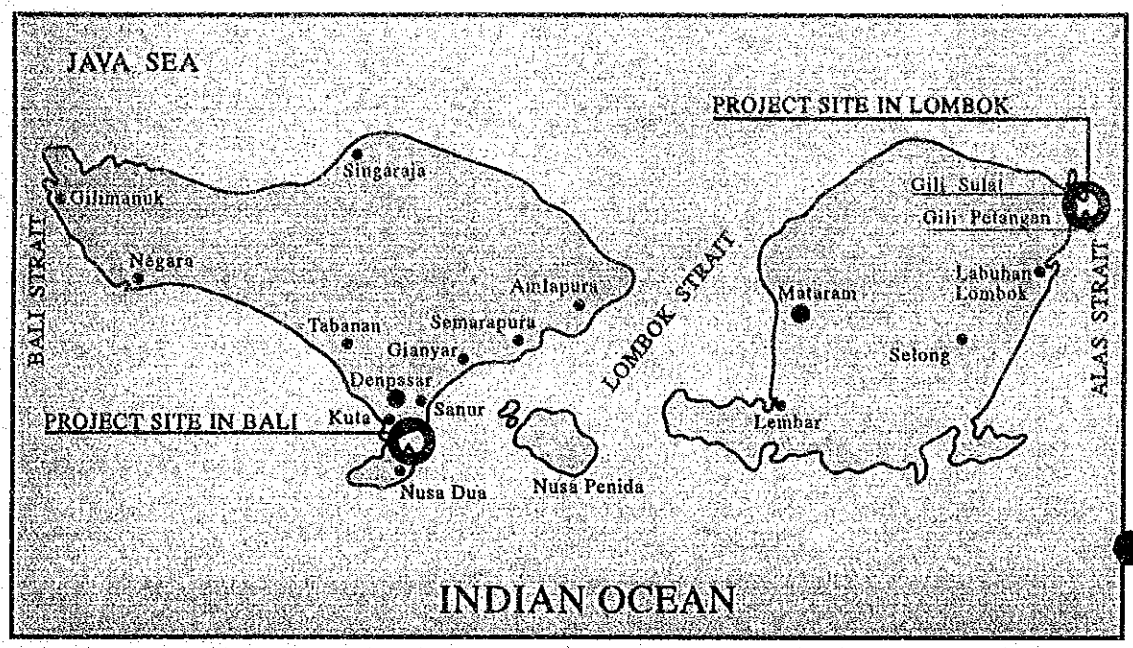
X5 : fruits on the shoot.



X6 : longitudinal section.



X7 : seed.



THE DEVELOPMENT OF SUSTAINABLE MANGROVE MANAGEMENT PROJECT

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: Regional Forestry Office, Nusa Tenggara Barat Province.

Shinji HAYASHI
: JICA Mangrove Project, Bali.

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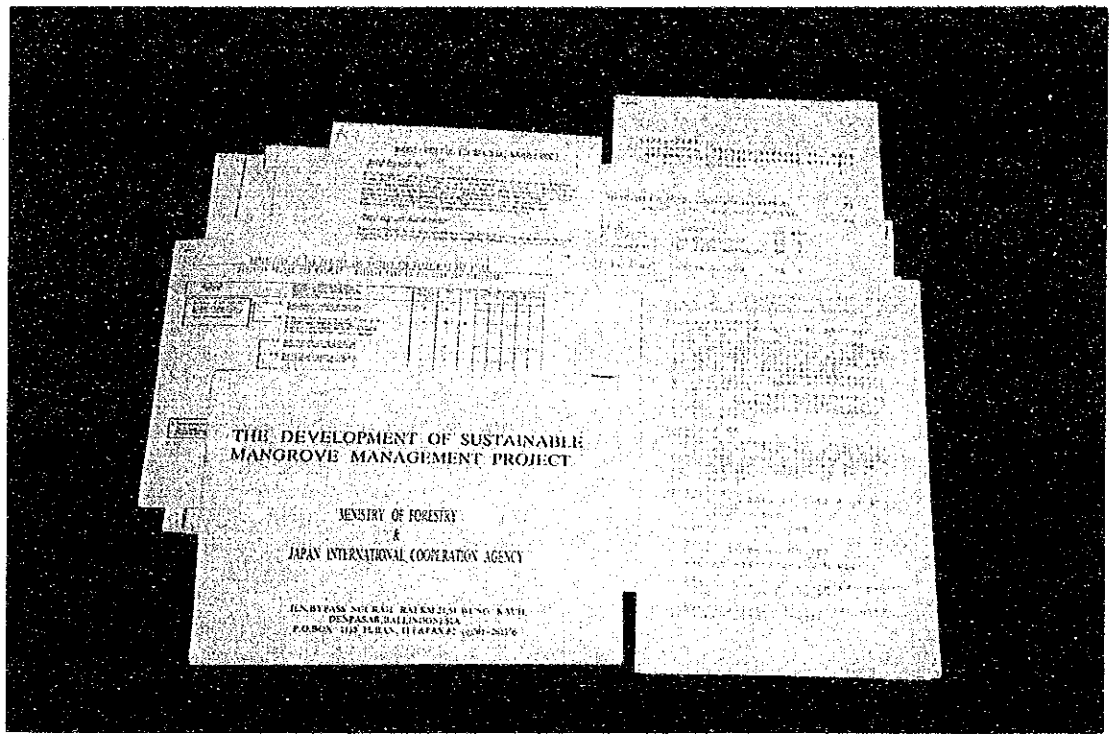
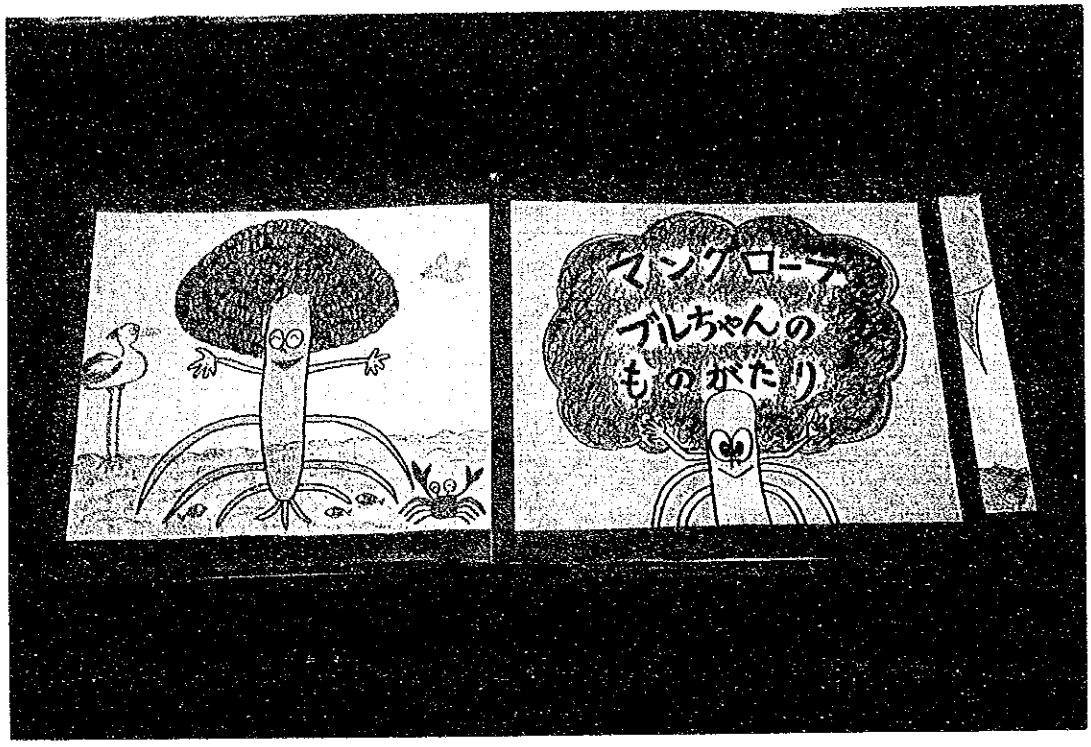
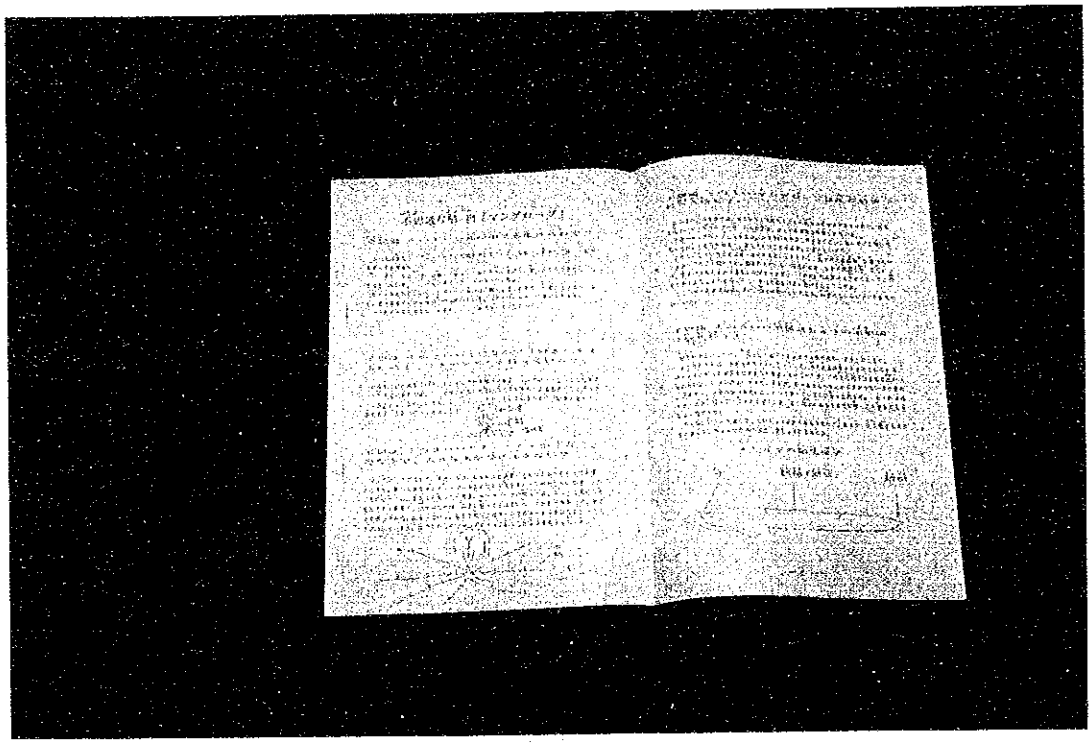


プロジェクト概要

マングローブ樹種図鑑、プロジェクトパンフレット

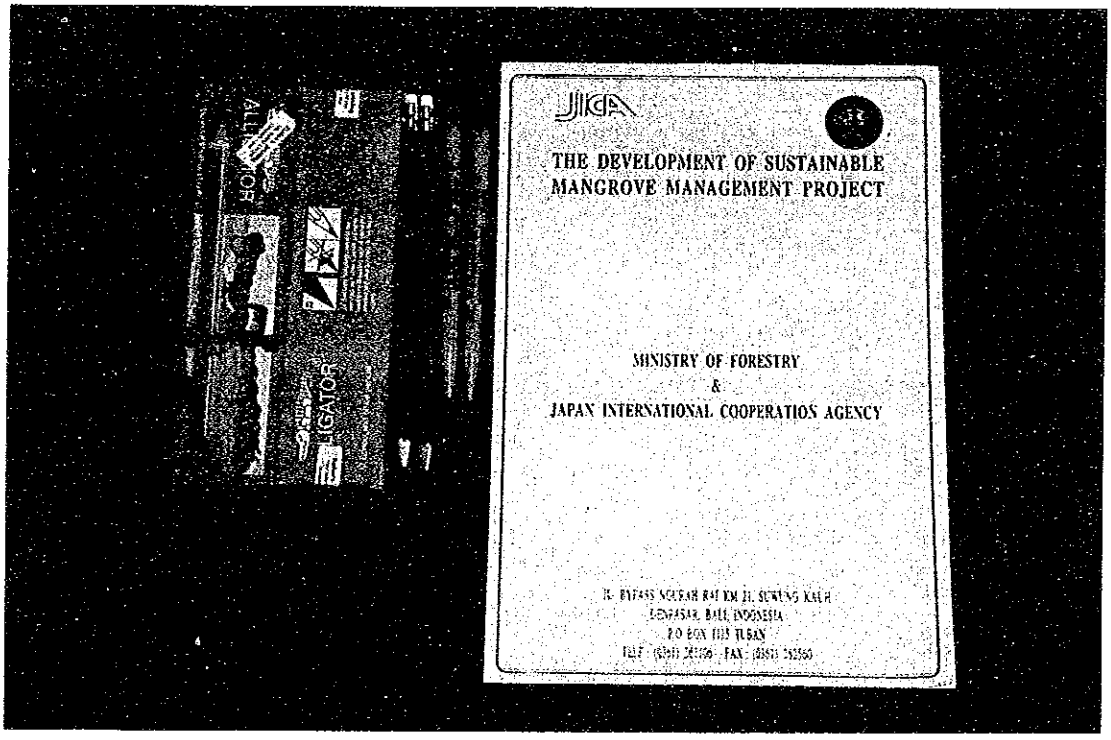


子供向けマングローブ紙芝居

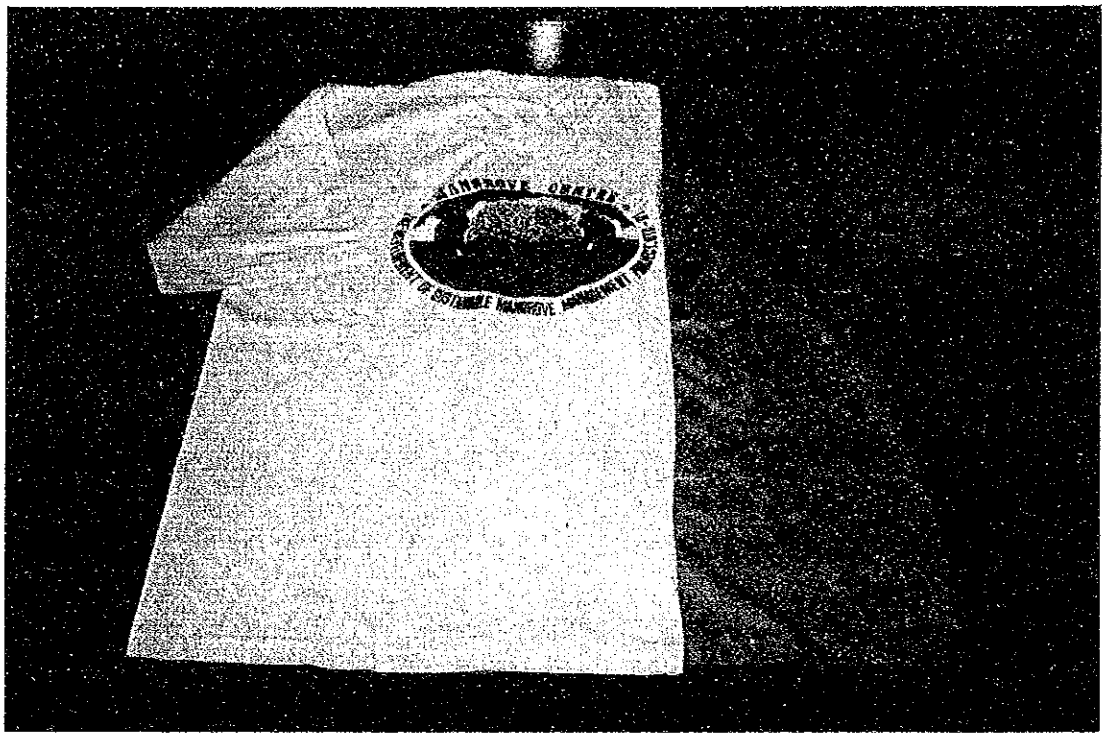


子供向けマングローブ紹介本
不思議な植物マングローブ

写真パネル



ロゴ入り鉛筆、ボールペン、リポート用紙



プロジェクトロゴ入りTシャーツ

プロジェクト名屋根塗装

1．日本水産学会編：海洋の生態系と微生物　10，119．　恒星社厚生閣　(1983)
2．日本水産学会編：海の生態学と測定　17，130．　恒星社厚生閣　(1980)
3．日本水産学会編：海洋の生化学資源　27，155．　恒星社厚生閣　(1979)
4．日本水産学会編：水域の自浄作用と浄化　30，142．　恒星社厚生閣　(1987)
5．日本水産学会編：沿岸海域の富栄養化と生物指標　43，155．　恒星社厚生閣　(1982)
6．吉田多摩尾夫編：環境化学物質と沿岸生態系　58，133.恒星社厚生閣　(1986)
7．Anthony J.Whitten, Muslimin Mustafa, Gregoryhenderso : The Ecology of Sulawesi, 777.　Gadjah Mada University Press (1987)
8．Anthony J.Whitten, Sengli J.Damanik, Jazanul Anwar, Nazaruddin Hisyam : The Ecology of Sumatera, 583. Gadjah Mada University Press　(1987)
9．A.Kadir Rachman, Yudo Sudart : Nipah as a source of a new decoration, 43.　Penerbit Kanisus　(1992)
10．熱帯植物研究会編：熱帯植物要覧，734.　養賢堂　(1986)
11．FAO : Indo-Pacific Fishery Commission, Country Status Reports on Inland Fisheries　FAO Fisheries Report No.370 Supplement　248. (1986)
12．S.Das, N.A.Siddiqi : The Mangroves and Mangrove Forests of Bangladesh, 142.　Bangladesh Forest Research Institute　(1985)
13．東京農業大学総合研究所：マングローブ研究，297, Tokyo University of Agriculture　(1985)
14．FAO : Mangrove Management in Thailand, Malaysia and Indonesia, 60. (1985)
15．NRCT-JSPS : Rattanakosin Bicennial Joint Seminar on Science and Mangrove Recources Abstracts, 30.　(1982)
16．Malaysian Forest Research : Mangrove Forests In Malaysia, 275. (　)
17．West Africa Rice Development Association : A Guide to Better Mangrove Swamp Rice Cultivation in the Warda Region, 28. Warda Regional Mangrove Station, Rokupr, Siera Leone　(1986)
18．B.Roller : Bibliography on Mangrove Research 1600-1975, 479. UNESCO (1981)
19．Japan Society for The Promotion of Science : Proceedings of a Seminar on Southeast Asian Mangrove, Nodai Research Institute, 147. Tokyo University of Agriculture　(1980)
20．Panitia Program Mab Indonesia-Lipi : Prosidings Seminar : IV Ekosistem Mangrove, 30. Proyek Penelitian Lingkungan Hidup　(1990)
21．Panitia Program Mab Indonesia-LIPI : Prosidings Seminar III Ekosistem Mangrove, 208. Proyek Penelitian Lingkungan Hidup (1987)
22．Panitia Program MAB Indonesia-LIPI : Prosidings Seminar II Ekosistem Mangrove, 394. Proyek Penelitian Lingkungan Hidup (1986)

23. Panitia Program MAB Indonesia-LIPI : Diskusi Panel Daya Guna dan Batas Jalur Hijau Hutah Mangrove, 154. Proyek Penelitian Lingkungan Hidup (1986)
24. Mangrove Management its Ecological and Economic Consideration, 35. SEAMEO- BIOTROP (1989)
25. Symposium on Mangrove & Estuarine Vegetation in Southeast asia, 227. SEAMEO-BIOTROP (1979)
26. Coral reef management on Southeast Asia, 184. SEAMEO-BIOTROP (1987)
27. Recent Research Activities on Coral Reefs in Southeast Asia, 83. SEAMEO-BIOTROP (1984)
28. Coral Zone Management, 164. SEAMEO-BIOTROP (1992)
29. C.L.MING : A Guide to the Coral Reef Life of Singapore, 128. Singapore Sience Centre (1992)
30. L.W.H.Tan : A guide to Seashore , 159. Singapore Sience Centre (1992)
31. Dr.Ir.Adnan Kasri : Crub Culture of Mangrove and Biology, 105. Penerbit Bhatara
32. Examination on the method of mangrove ecosystem in north coast of west Java, 76. Team of Mangrove ecosystem MAB-LIPI and perum perhutani (1984)
33. Proceeding of a Seminar on Mangrove Forest Ecosystem (1978)
34. Training Course on Management of Mangrove Forest, Vol II Part A 85. Part B 192. SEAMEO-BIOTROP (1988)
35. Training Course on Management of Mangrove Forest, VOL III 129. SEAMEO-BIOTROP (1989)
36. Romashi R Vakatora : From The Mangrove Swamps, 98 University of South Pacific (1988)
37. John Mackinnon : Burung-burung di Jawa dan Bali , 421. Gadjah Mada University Press (1984)
38. John Mackinnon : Birds of Java and Bali, 391. Gadjah Mada University Press (1984)
39. M.T.Oureshi: Mangrove Ecosystems Occasional Papers No.4 Experimental Plantation for Rehabilitation of Mangrove Forest in Pakistan, 37 UNDP/ Unesco Regional Mangrove Project Ras/86/120 (1990)
40. N. Paphavasit, S. Dechaprompun, E. Aumnuch : Mangrove Ecosystems Occasional Papers No.5 Physiological Ecology of Selected Mangrove Crabs, 39 ' UNDP/ UNESCO Regional Mangrove Project RAS/86/120 (1990)
41. Murphy, Wijarn Meepol : Mangrove Ecosystems Occasional Papers No.7 Four Papers on Insects and Ground , Meso Fauna at Ranong, UNDP/UNESCO Regional Mangrove at Ranong Project RAS/86/120 (1990)

42. N.A.SIDDIQI, M.A.S.KHAN : Mangrove Ecosystems Occasional Papers No.8 TwO Papers on Mangrove Plantation in Bangladesh, UNDP/UNESCO Regional Project RAS/86/120 (1990)
43. B.Kjerfve : Manual for Investigation of Hydrological Processes in Mangrove Ecosystems, 78 UNDP/UNESCO Regional Mangrove Project RAS/86/120 (1990)
44. B.F.Clough; ISME Mangrove Ecosystems Technical Reports the Economic and Environmental Values of Mangrove Forests and their Present State of Conservation in the South-East/Pacific Region, 202. International Society Mangrove Ecosystems (1993)
45. Beng King, WoodcocK, E.C.Dickinson : Birds of South East Asia, 480 Collins (1987)
46. Proceedings of Mab-Comar Regional Workshop on Coral Reef Ecosystems, Their Management Practices and Research /Training Needs 97, 151. LIPI (Indonesian Instituted Science) (1986) p.151
47. Proceedings of The Second Thai National Seminar on Mangrove Ecology 99, 73. National Research Council of Thailand (1977)
48. Mangrove Swamp Rice Research Project in Nigeria, 35. West Africa Rice Development Association (1981)
49. The Coastal Ecosystems of West Africa : Coastal Lagoons, Estuaries and Mangroves, A Workshop Report Dakar, 11-15 June 1979, 60. UNESCO (1981)
50. Coral Reefs, Seagrass Beds and Mangroves, Their Interaction in Thecoastal Zones of the Caribbean 102, Report of a Workshop at West Indies, Lab., 133 UNESCO (1983)
51. The Mangrove Ecosystem: Human Uses and Management Implications, Report of a UNESCO Regional Seminar in Dacca Bangladesh, 19. UNESCO (1979)
52. Prosiding Seminar Ekosistem Mangrove III, 208 LIPI (Indonesian Institute Science), Departemen Kehutanan RI, Perum Perhutani (1986)
53. Ong Jin-Eong, Gong Wool-Khoon Ong : Mangrove (MALAYSIA) (Final Report 105 School of Biological Sciences
PENANG MALAYSIA), 51 (1988)
54. The Mangrove Ecosystem, Scientific Aspects and Human Impact 、Report of The seminar at Call Colombie, 46. UNESCO (1979)
55. Geoffrey A. Kent Assessment of Mangrove regeneration after logging for Woodchips in Sabah、44. Forest Research Centre, Sandakan, Sabah, Malaysia (1986)
56. Prosiding Seminar Ekosistem Mangrove II, 394. LIPI (INDONESIAN Institute Science), Departemen Kehutanan RI, Perum Perhutani (1984)

５７．Identification of Potensial Research as a Last report, 43. Pusat Penelitian Pengembangan Geoteknologi LIPI (1993)
５８．イラン沿岸地域における緑化推進実態調査，第二回中東マングローブ植生調査報告書，96. 財団法人 中東協力センター (1980)
５９．イラン沿岸地域における緑化推進実態調査，第三回中東マングローブ調査報告書126. 財団法人 中東協力センター (1982)
６０．オマーンにおける緑化推進実態調査，第四回中東マングローブ調査報告書，105 財団法人 中東協力センター (1986)
６１．Research Report 117. (1977)，82. (1979) West Africa Rice Development Association Mangrove Swamp Rice , Research Project Rice Research Station Rokupr Sierra Leone
６２．NRCT-JSPS : Rattnakoshin Bicentennial Joint Seminar on Science and Mangrove Resources , 16. Phuket, Thailand (1982)
６３．A Guide to Better Mangrove Swamp Rice Cultivation in the Werda Region West Africa Rice Development Association, 29. Wardaregional Mangrove Swamp Rice Research Station Rokupr Sierra Leone
６４．太平洋島嶼地域におけるマングローブ生態系に関する総合研究，413. 日本国際マングローブ協会 (1992)
６５．荻野和彦：マングローブ林の生態系と保全、創造の世界学７９巻，48-67.小学館 (1991)
７０．吉見 光治 :西表島マングローブの生き物たち，127. 新日本教育図書 (1990)
７１．鶴見良行：マングローブの沼地で， 333. 朝日新聞社 (1985)
７２ Papers for the Simposium Nasional Rehabilitasi dan Konservasi kawasan Mangrove di Institute Pertanian Stiper Yogyakarta , (1993)
７３．宮脇昭編：タイ国マングローブ林の植生生態学的研究，152.横浜国大環境科学研究センター植生学研究室 (1985)
７４．Margaret Percival, John S. Womersley : Floristics and Ecological of The Mangrove Vegetation of Papua New Guinea. Botany Bulletin No.8 Departement of Forests, Division of Botany, Papua New Gguinea
７５．Indo-Facific Fishery Commission : Country Status Reforests on Inland Fisheries, The Workshop on Strategies for the Management of Fisheries and Aquaculture in Mangrove Ecosystems, 248. FAO Bangkok (1986)
７６．S. DAS, M. A. SIDDIQI : The Mangrove and Mangrove Forests of Bangladesh Mangrove Silviculture Division, Bulletin No. 2, 142. Bangladesh Forest Research Institute (1985)
７７．日本国際マングローブ協会：世界におけるマングローブの開発と環境保全に関する調査，124. (1993)
７８．日本国際マングローブ協会：東南アジアにおけるマングローブ林の保全の現状と今後の問題点， (1990)

７９．日本国際マングローブ協会：アメリカ地域におけるマングローブ生態系の分布と保全の現状，156 (1992)
８０．Clifford, Dawn Frith : Australian Tropical Reef Lige 70. FRITH & FRITH Books (1992)
８１．S. Akoornkoae, G. S. Maxwell, S. Havanond, S. Panichsuko : Plants in Mangroves Chalongrat Co., Ltd. Bangkok (1992) 204
８２．Leonard Pinto : Mangrove of Sri Langka Natural Resources, 53. Energy & Science Authority of Srilanka (1986)
８３．Don Hadden : New Zealand Birds, 112. The Caxtpn Press Christchurch New Zealand (1990)
８４．Gordon Ell, Geoff Moon; Seashore Birds of the New Zealand, 96. The Bush Press Auckland (1984)
８５．Geoff Moon : New Zealand Birds, 251. Reed Books Auckland (1992)
８６．R. A. Falla, R. B. Sibson, E. G. Turbott : Collins Field Guide Birds of New Zealand 212 (1991) po. 247 Harper Collins Publishers
８７．Chloe Talbot Kelly : Collins Birds of New Zealand , 127 Harper Collins Publishers (1993)
８９．Management of Cilacap Mangrove Forest, 22. イ語，英語 28. Perum Perhutani Unit I Java Tengah
９０．Operation Guideline of Evaluation on Mangrove Forest Rehabilitation in Bali, 5. BRLKTI VII (1993)
９１．月刊マンダイビング編集：サンゴ礁の仲間，145 水中造形センター (1994)
９２．小田部 家邦：プランクトンウオッチング、140 研成社 (1992)
９３．益田一、ジェラルドＲアレン：世界の海水魚（太平洋・インド洋編，527. 山と渓谷社 (1992)
９４．ＦＡＯ：Management and Utilization of Mangrove in Asia and the Pacific
９５．Phan Nguyen Hoang, Hoangthi San : Mangroves of Vietnam, 173 IUCN (1993)
９６．S. Aksornkoae : Ecology and Management of Mangroves, 176. IUCN (1993)
９７．P. Thanasukarn, S. Chaturongakul, K. Thirarongnarong , K. Vongvanavoravit : Review and Research Activities of Mangrove Ecology in Thailand 143. Funny Publishing Limited Partnership (1986)
９８．Proceedings of the Second Thai National Seminar on Mangrove Ecology Workshop at Phuket Marine Biological Centre, 73. National Research Council of Thailand Bangkok, (1977)
９９．N. A. Siddiqi, M. R. Islam, M. A. S. Khan, M. Shahidullah : Mangrove Nurseries in Bangladesh, 14 ISME (1993)
１００．Kiatkong Pitpreecha, Shozo Nakamura : Research Activities and Achievements of the Forest Ecology Section, Royal Forest Departement in the Research and Training in Re-afforestation Project (Phase 2), 146

Re-afforestation Project (Phase 2)RFD-JICA (1991)
101. S.Sukardjo: Conservation of Mangrove Formations in Java, The Plant Diversity of Malesia, 329-340. Kluwer Academic Publishers Netherlands (1990)
102. Baharuddin Nurkin : Degradation of Mangrove Forests in South Sulawesi Hydrobiologia 1-6, Kluwer Academic Publishers Belgium (1993)
103. S.Sukardjo; Natural Regeneration Status of CommercialMangrove Species in South Sumatra, Forest Ecology and Management 20, 233-252 Elsevier Science Publishers B.V. (1987)
104. A.B.Cribb, J.W.Cribb : Plant Life of the great Barrier Reef and Adjacent Shores 291. University of Queensland Press (1985)
105. Jamus W.Nybakken : Biology of Ocean as Ecological Approach Gramedia 307
106. 環境省、林業省、科学省、内務省 : Proposal of National Strategy for Mangrove Forest Management, 49. マングローブ協会 (1993)
107. PHPA/AWB Sumatra Wetlant Project : East Coast Natural Reserve Mangrove 1 Forest in Jambi, Survey Report No.17, 34. (1991)
108. P.Erftemeijer, G, Allen, Zuwendra : Preliminary Resource Inventory of Bintuni Bay and Recommendations for Conservation and Management, 150 PHPA/AWB-Indonesia (1989)
109. Glemm M.Wightman : Mangroves of the northern Terrotorynorthern Territory Botanical Bulletin No.7, Conservation Commission of The Northern Territory
110. V.J.Chapman J.Cramer : Mangrove Vegetation, 447. (1976)
111. J.G.Watson : Mangrove Forests of The Malay Peninsula, Malayan Forest Records No.6, 275 (1928)
112. Marcel J.Silvius : Survey of coastal Wetlands in Sumatra Selatan and Jambi, 101 PHPA-Interwader Report No.1 (1986)
113. Wim Giesen : Indonesia's Mangroves:an Update on Remaining Area & Main Management Issues, 10.Asian Wetland Bureau (1993)
114. Prescilano M.Zamora : Mangrove Plants;Their Structural Characteristics and Methodologies of Collection them in the Field, 95.UNDP/UNESCO Regional Mangrove Project (1988)
115. N.C.Duke : A Systematic Revision of the Mangrove Genus Avicennic (Avicenniaceae) In Austraia, Australian Sys.Bot., 4, 299-324 (1991)
116. Kazuhiko Ogino, Mitsuo Chihara : Biological System of Mangroves, 181 愛媛大学 (1988)
117. Harold N. Moldenke : Avicenniaceae, Flora of Trinidad and Tobago, Vol. II Part VI 418-420. Trinidad, Government Printing Office (1955)

１１８．R.C.Bakhuizen Van Den Brink ：Bulletin Du Jardin Botanique Troisime Serie Vol.iii,fasc.2 199-493 Archipel Drukkerij-Buitenzorg (1921)
１１９．Cecep Kusmana,S.Sabiham,K.Babe,H.Watamabe ：An Estimation of above Ground Tree Biomass of a Mangrove Forest in East Sumatra,Indonesia Tropics Vol.1 (4), 243-257 (1992)
１２０．日本学術振興会：東南アジアの植物と農林業, 492. (1989)
１２１．David Burnie:Seri Eyewitness Burung, 63.Dorling Kindersley ・London (1992)
１２２．R.F.Symes :Seri Eyewitness Batu & Mineral, 63. Dorling Kindersley, London (1992)
１２３．Steve Parker:Seri Eyewitness Kerangka, 63. Dorling Kindersley,London (1992)
１２４．Michele Byam:Seri Eyewitness senjata & baju zirah, 63. Dorling Kindersley,London (1992)
１２５．David Burnie:Seri Eyewitness Pohon, 63.Dorling Kindersley・London (1992)
１２６．David Burnie:Seri Eyewitness kolam & Sungai, 63.Dorling Kindersley ・London (1992)
１２７．Lecture for Practice Cutting,Grafting,14. Overseas Cooperation Division National Forest Tree Breeding Centre Forestry Agency (1994)
１２８．D.J.Boland,M.I.H.Brooker,G.M.Chippendale,N.Hall,B.P.M.Hyland, R.D.Johnstone,D.A.Kleining,J.D.Tutner:Forest Trees of Australia, 687. Csiro Australia (1992)
１２９．小林安雅：ミクロネシアの海水魚、 157. 東海出版会 (1994)
１３０．Leonard Cronin: The Concise Australian Flora, 320. Reed Books PTY. LTD. (1989)
１３１．Wilhelm Lotschert,Gerhard Beese:Collins Guide to Tropical Plants, 256. William Collins Sons & CO.LTD. (1992)
１３２．Setijati Sastrapradja,Kuswata Kartawinata,Roemantyo,Usep Soetisna, Hari Wiriadinata,Soedarsono Riswan:Jenis-Jenis Kayu Indonesia, 117. PN Balai Pustaka (1980)
１３３．S. Sastrapradja,J.Palar Mogea,H.Murni Sangat,J.Jumiati Afriastini: Palem Indonesia, 120. PN Balai Pustaka (1980)
１３４．ペドロジスト編：土壌調査ハンドブック，156.博友社 (1990)

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RE-AFFORESTATTION OF MANGROVE FOREST IN INDONESIA

by

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Introduction

It has been widely publisized that Indonesia possesses the largest mangrove land in the world. Official figures state that it covers more than four million hectares (Darsidi, 1984). However, it should be noted that not all this mangrove lands are covered with forest. According to Soemodihardjo et al. (1993), as of 1992 the forested mangrove land is estimated to cover 1,537,000 hectares, or around 32% of the total mangrove land. Fig.1 shows the distribution of the mangrove forests in Indonesia.

Several decades back, mangrove land was considered waste land which should be "reclaimed" or converted into other uses. Fortunately, this misleading perception has since been gradually remedied and hopefully will eventually be abandoned. Thus there is now noticeable increase in awareness of the importance of this resources, whether it is ecological, physical or economical function.

Mangrove resources in Indonesia have various functions. Apart from biological and ecological functions, it serves as wood producers for fuel, charcoal, housing material, industrial raw material, etc. Over the past several years the utilization of mangrove forests as tourist attraction has become evident. Mangrove based industries include wood chips, pulp, brown sugars and alcohol.

Many human activities have negative impacts on mangrove communities. The most extensive form of mangrove land conversion is the brackish water fish ponds. In 1980 covered an area of approximately 155,000 ha distributed mainly in Java, Sulawesi and Sumatra (Soewito, 1982). Conversion of mangrove land into other land uses is undoubtedly the most damaging, since the end result is a completely transformed environment. The demand to convert mangrove land for other uses has increased over time. Aware of the growing pressures on the resource, the Indonesian Government has taken steps to set aside sufficient mangrove forests as conservation areas. It is envisaged that these conservation areas will amount to 20% of the total mangrove areas. Presently over 700,000 hectares of mangrove forests have been gazetted as conservation forests.

The most extensive degradation of mangroves in Indonesia occured during the World War II. Shortage of oil and coal at that time, increased the use of wood for energy. Because of that, forest destruction, including mangroves, took place indiscriminately. On top of that people also opened up mangrove forest for agriculture and settlement. In Java most mangrove lands are under the jurisdiction of Perum Perhutani (State Forest Corporation).

After the war the Department of Forestry, in this case Perhutani, took the illegally occupied lands back under its full control. The first thing Perhutani had to do was to rehabilitate and reforest the degraded land. This report is an attempt to collate and analyse all available information on the activities and progress of mangrove rehabilitation carried out in Indonesia to date. However, it should be emphasized here that it is prepared on the basis of information that the author managed to collect. There is always the possibility that some information may have been missed.

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Plantation Areas

The need to develop mangrove plantations was felt many years back, quite likely some years prior to the World War II, during the Dutch administration. For example, in 1932 De Yong had carried out mangrove rehabilitation experiments. It was on the planting of *Rhizophora* spp using three different methods, namely (1) planting mangrove propagules freshly picked from mother trees, (2) keeping the propagules in a damp place before sowing, and (3) transplanting seedlings that already have two up to four leaves.

Despite the early planting experiments, proper re-afforestation activity was not started until 1964, when Perhutani made the first attempt to replant degraded mangrove lands in Indramayu on the north coast of West Java (Tim Ekosistem mangrove MAB-LIPI 1984). This was soon followed by similar activities in other locations along the north coast of West Java.

All these activities were under the responsibility of Perhutani and were carried out on degraded coastal land under its jurisdiction.

It should be pointed out here that mangrove rehabilitation activities were mostly done in Java. The main reason is the fact that mangrove resources in Java have suffered the most human disturbance as compared to those on the other islands. The fact is quite understandable taking into account that around 70% of the Indonesian population live in Java and that the coastal region is the most densely populated area in the country. At the same time, a significant proportion of the coastal villages are poor, consisting of farmers, labourers and fishermen. Poor living condition forced them to make use of common resources available nearby to supplement their meagre earnings, damaging and degrading these resources.

Outside Java, the mangrove resources are in much better condition as human pressures are much less. However, with the advent of woodchip industry, the demand on mangrove timbers from outside Java has increased.The chipwood industry has been and is being developed in Sumatra, Kalimantan and Irian Jaya. One condition attached to industrial mangrove exploitation is that the concessionnaires must re-afforest the logged over areas. It is in this light that some re-afforestation activities are underway in Riau and Palembang (Sumatra).

Table 1 and Fig.2 show the distribution and extent of mangrove rehabilitation activities that have been reported up to 1992. It is apparent from the table that private corporations share the burden of rehabilitating exploited land with Perhutani, particulary in Sumatra. In the case of Probolinggo (East Java), mangrove rehabilitation was carried out by the coastal population themselves. This action is a strong indication of the increasing awareness of coastal populations of the importance of mangrove forests for coastal environments and coastal communities.

In most cases, rehabilitation programmes have been carried out on degraded and logged-over forest lands including abandoned fishpond sites. Afforestation on newly formed land has never been attempted. This was due, among other things to the fact that it is customary for coastal inhabitants to claim ownership or land use right on land that is still in the process of emerging above sea surface in accretion areas (Soemodihardjo, 1986). This newly formed land will later on be transformed into brackish water fishpond.

Data on the annual planting areas and budget are currently rather scanty. Simbolon (1984) stated that according to the official plan of the Department of Forestry at the end of the 5th Five Year Development Programme, i.e. March 1994, the reforested mangrove land would cover 41,500 ha. And if everything goes as planned, in the year 2000 the rehabilitated mangrove land area will reach 85,000 ha. At the moment there is still the need to know to what extent the aforementioned target has been accomplished.

With respect to Cilacap mangrove forest, the local Perhutani office has a definite annual plan for rehabilitation and budget covering several years (Table 2). The species planted are *Bruguiera gymnorrhiza* and *Rhizophora mucronata.*

Nursery Practices

Mangrove forest rehabilitation in Indonesia is intended to serve two main objectives. The first aimed at restoring the ecological functions of degraded mangrove lands to their original level. The second is to grow mangrove trees to meet commercial as well as industrial needs. For the first objective, theoretically any mangrove species can be used. But the most common trees

Table 1 Distribution and extent of mangrove re-afforestation in Indonesia in 1992

Provinces	Locality/Company	Area (ha)
West Java	1. Bogor	9,047
	2. Purwakarta	10,531
	3. Indramayu	5,422
Central Java	4. Cilacap	10,000
East Java	5. Madura	427
	6. Bamyuwangi	236
	7. Probolinggo	60
Riau	8. P.T. Bina Lestari	200
South Sumatra (Palembang)	9. P.T. Ciptamas Bumi Subur	3,000
	Total	38,923

Sources : State Forest Corporation Unit III, West Java (1993), Haditenoyo and Abas (1984); Djojomihardjo (1989); Soeroso and Hadipurnomo (1984); P.T. Bina Lestari (1984); Sumardjani and F. Mulia (in press).

planted for this purpose in Indonesia are those belonging to the genera *Rhizophora, Avicennia* and *Sonneratia*; whereas for the second, it is limited to the genus *Rhizophora* and *Bruguiera gymnorrhiza* (Sumardjani and Fairus Mulia, 1993 in press).

Mature propagules of *Rhizophora* are collected from mother trees that are at least 5 years old (Wirjodarmodjo and Zufri Hamzah, 1984). In the case of *Bruguiera gymnorrhiza*, the best mother trees are those that are 8-10 years old (Mulia, 1993). According to this author old mother trees of *Bruguiera gymnorrhiza* do not produce adequate quantities of propagules. Besides, the propagules from old trees are often damaged due to attack by insects. Not rarely seeds of *Rhizophora* spp may be collected under the mother trees or may also be retrieved from those transported by water movement. Field experience indicated that fruiting season occured from September to March (Mulia, 1992). Fig.3 and 4 show the propagules of *Rhizophora apiculata* and *Bruguiera gymnorrhiza*.

Eventhough ripe propagules of Rhizophoraceae can be planted directly in the rehabilitation site there remains a strong indication that they may do better if they are first grown into rooted seedling in the nursery. In other words the percentage survival of seedlings from the nursery is higher than that from direct planting.

Nursery bed is prepared commonly in the landward portion of the intertidal area which is less inundated by tides. An embankment is made around the nursery bed to reduce the impact of tidal inundation and water currents. Channels to regulate the inflow and outflow of tidal water are constructed within the nursery area. To avoid direct sunlight the nursery bed is mostly established under the shade of big trees or alternatively, some sort of shading using nipa leaves or *Acrostichum* fronds is built (Fig.5).

Mangrove propagules are grown in polybags (15 x 20 cm) that have been filled with mud. These polybags are then arranged side by side and half burried in the mud of the nursery bed. After 3 to 4 months, *Bruguiera* seedling will produce around 4 leaves and are ready for transplantation. For *Rhizophora*, seedling growth in the nursery requires shorter time period, i.e. between 2 to 3 months (Haditenoyo and Abas, 1984). Fig.6 and 7 show *Bruguiera gymnorrhiza* and *Rhizophora apiculata* grown in polybags in nursery.

Table 2 **Planned annual acreage of mangrove rehabilitation in Cilacap, Central Java (1980-1989) (Haditenoyo and Abas, 1984)**

Year	Area (ha)	Budget (in million rupiah)
1980	200	15.400
1981	500	47.926
1982	1,000	113.498
1983	1,000	147.525
1984	1,000	175.501
1985	1,000	146.483
1986	1,000	219.981
1987	1,300	282.929
1988	1,500	368.283
1989	1,500	434.181
Total	10,000	2,001.507

For *Avicennia* and *Sonneratia*, direct planting of the seeds in the field is rather difficult due to the small propagules and seeds. Therefore, for these two genera of mangrove it is best to go through nursery step before field planting. Nursery stage is done by way of polybag technique as well as direct seed sowing on the nursery bed. In places where great numbers of natural seedlings occur, wilding (using of wild seedlings) technique is also carried out. Fig.8 and 9 show *Avicennia* seeds grown in nursery.

Direct seed sowing in the nursery bed is commonly undertaken during the neap tide period. The water in the nursery is regulated so that is level with the mud surface. This condition is to be maintained for 10 - 15 days, after which time most of the seeds will have germinated. At the same time they would have developed an adequate root system which provides strong anchorage for the newly developed seedlings (Perum Perhutani Unit III, Jawab Barat 1984). Only then will inundation by tidal water be allowed.

Planting Technique

As mentioned in the preceding section, mangrove rehabilitation in Indonesia has been carried out on logger-over forests and degraded coastal lands, including abandoned fishponds. Selection of sites to be rehabilitated was made on the basis of suitability of existing environmental factors for mangrove growth such as frequency of inundation, extent of muddy substrate, stability of substrate and fresh water supply. Sumardjani and Mulia (1993) asserted the importance of the existence of muddy bottom that is flooded by high tides at least several times a month and should be dry during neap tides.

Preparation of Planting Sites

The land selected for rehabilitation is then cleared of plant debris left over from the previous logging. This cleaning operation is absolutely necessary otherwise the debris will shift back and forth with tide to the detriment of the planted seedlings. In South Sumatra most of the rehabilitation activities have been done on former nipa forests and on degraded land infested with the fern *Acrostichum aureum* (Sumardjani and Mulia, 1993). The same is true in Cilacap. While in the north coast of Java it is mostly on degraded lands and abandoned fishponds over grown by *Acrostichum, Acanthus* and *Cyperus*.

Another important step taken at the commencement of the rehabilitation process is the construction of access passages across the area to be rehabilitated. These access passages are 2 to 3 meters wide, parallel to one another and perpendicular to the coast line or river bank. The spacing between successive passages is 100 m. Past experience has demonstrated that these passages are extremely useful in the transportation of seeds prior to planting, in and facilitating subsequent maintenance activity (Mulia 1993).

The next step is to prepare the land

between the access passages for mangrove transplants. In Cilacap, parallel strips of cleared land are made by cutting away all vegetation existing along the strips. The width of each strip is one meter while the spacing between strips is 3 m. In these cleared strips mangrove seeds or seedlings are planted by dibbling technique (taking the form of a pointed wooden stick, used for making holes in the ground for seeds) at a distance of 2 m. between plants. Thus the spacing of the planted seedlings is 3 x 2 m. In Sumatra the spacing is mostly 2 x 2 m. Two other spacings have also been tried, namely 1 x 3 m and 2 x 1 m (Mulia 1993; Wirjodarmodjo and Zufri Hamzah 1984).

Planting

Two planting techniques have been employed, 1) direct planting and 2) indirect planting. In the former, ripe propagules are directly planted in the field without going through nursery stage. In the later, the propagules or seeds are grown into seedlings prior to planting in the field. Sumardjani and Mulia (1993) reported that direct planting on open land required some sort of shading to reduce prolonged direct scorching by sunlight. Nypa and *Acrostichum* fronds are good shading material in South Sumatra. Shading is not needed in direct planting on former Nypa stands provided that the lower portions of the Nypa, up to about one meter high above ground, are left standing in the field to provide shade.

For direct planting, mangrove propagules are stuck into the mud up in an upright position to a depth of between 3 to 7 cm. In indirect planting, the plastic bag should first be removed before seedlings are planted in the mud by dibbling technique.

One year after planting, overall field inspections are made to see how the seedlings have fared. Supplementary planting to replace dead seedlings are then carried out. This schedule must be strictly observed, since individual plants of more or less the same age are expected from industrial forest plantations.

All activities were carried out manually, without use of any machinery.

Tending Practices

Successful mangrove rehabilitation and afforestation require proper care and tending. These activities are particulary needed in the early years of the plantation. Current tending practices in Indonesia include weeding, thinning and replacement planting. Pest and disease controls have so far not been attempted.

In Cilacap, south coast of Central Java, weeding activities are carried out twice a year (Haditenoyo and Abas, 1984). According to Wirjodarmodjo and Zufri Hamzah (1984) weeding is no longer necessary after the young mangrove plants reach two meters tall. At this stage the mangrove plants are tall and strong enough to compete for space and sunshine.

Locations that are of somewhat higher elevation, in other words less inundated by tides, usually require more intensive attention compared to those that undergo daily tidal flooding. This is because the less frequently inundated locations are more susceptible to invasion by *Acrostichum* ferns. Therefore, as soon as the growth of the ferns begins to interfere with the young mangrove plants, a clean up operation has to be immediately carried out.

Sites that have high natural regeneration capacity approximately 5,000 seedlings per hectare have to be thinned out. This process is meant to provide adequate space for the remaining seedlings to enable them to grow faster.

According to forestry regulation (Decree No. 60, 1978) the first thinning has to be carried out after the plants are 15 to 20 years of age or the plant density is over 1,100 trees per hectare. And the trees to be cut down must be the less healthy or abnormal ones. Mulia (1993) studying the mangrove plantations in South Sumatra reported that the annual increment of the planted mangroves decreased after the plants were seven years old. He therefore, suggested that first thinning should be conducted when the plants are 7 to 10 years old.

In the 1950s, mangrove forest production was still available in Java, namely in Cilacap, on the south coast of Central Java. This covered an area of more than 5,000 hectares. In those days the rotational age for logging was 50 years (Wirjodarmodjo and Zufri Hamzah, 1984). For charcoal production in Bengkalis, Sumatra, the cutting cycle was 10 years. While for woodchips production in East Kalimantan, Chipdeco Ltd adopted on 20 year-cycle (Kartawinata et.al. 1979).

Plantation Costs

Two main factors determine the budget for establishing mangrove plantation. The first factor is the location of the land to be rehabilitated or reforested, and the second is the physical condition of the habitat. Rehabilitation areas in remote places invariably will be more costly due to shortage of labour as well as high transportation costs. Likewise, a densely *Acrostichum* infested land will require higher development cost compared with the less densely infested area, let alone bare mud flats.

In view of the above point, direct comparison between differing rehabilitation sites on the basis of expenses per unit area alone may be misleading, since each has each own specific characteristics.

Table 3 shows a summary of expenses borne by P.T. Ciptamas Bumi Subur, a private company, in its activity to establish a mangrove forest industrial plantation in South Sumatra. From this table, it is apparent that indirect planting method appears to be preferable, due to lower labour requirement, high survival rate and moderate plantation costs.

In the north coast of West Java around 25,000 ha of coastal land was eventually reforested by the end of 1984. The total of over 1,076 million rupiah or about 42,000 rupiah per hectare was spent. As for the mangrove rehabilitation in Cilacap, over two billion rupiah was allocated for rehabilitation of 10,000 ha (200,000 rupiah per ha) of degraded mangrove land from 1980 to 1989. In the case of mangrove rehabilitation through silvofishery system the cost of preparing one hectare of silvofishery pond is about Rp. 1,200,000 in 1978 (approximately US$ 3,000 in 1984) or 4,000 man days (Soekartiko 1978).

Growth and Productivity

To date there are very few studies on the growth of cultivated mangrove, particularly in terms of time series data. A number of incidental measurements were available derived from measuring mangrove plant of known ages. For instance Wirjodarmodjo (1984) reported that four year-old planted mangroves measured 4 m high, with an average stem diameter at 10 cm above root collar of 4.5 cm. Seven year-old *Rhizophora apiculata* grown in Riau, South Sumatra with spacing of 2 x 1 m and 3 x 1 m attained an average diameter of over 6 cm (Effendi and Bachtiar 1991).

In this respect it is encouraging to state here that in the middle of the scanty information there are a couple of researches that have produced time series data. Fig.10 and 11 show the average diameter and average annual increment in diameter resulted from the research activities done in Riau by Mulia (1993) respectively.

It should be stressed here that Fig.11 is derived from Fig.10 by the Figures, Mulia (1993) indicated that the annual increment of diameter increased until the plants reached 7 years (in year 1990). Since then it started to decline.

In Indramayu, north coast of West Java, Effendi (1989) measured the stem diameter and the hieght of *Rhizophora mucronata* of different ages, i.e. 6,11,14 and 18 years planted in the tumpang sari tambak (Table 4). The calculated annual increments for the four age-classes were 0.7, 0.5, 0.6 and 0.6 cm respectively. These data are comparable with those obtained for *Rhizophora apiculata* from Riau plantations. At the age of 18 years the *Rizhophora mucronata* from tumpang sari tambaks in Indramayu were estimated to reach diameter of 10 cm. From height data however, the growth appeared rather slow.

In term of timber production and annual timber volume increment, Mulia (1993) estimated a standing stock of 89.99 m^3/ha/year or 11.25 m^3/ha /year for planted 8 year-old *Rhizophora apiculata*.

Re-afforestation and Fisheries

The vital role played by mangrove ecosystem is currently well recognized by all concerned in Indonesia (Soemodihardjo, 1986). Nonetheless, due to population and development pressures the resource keeps on declining. Various measures have been introduced to halt or slow down the decline, and some show encouraging result. Rehabilitation of degraded mangrove land is one of them. Silvicultural guidline on mangrove constitutes another.

The followings are some salient points of Indonesian mangrove silviculture (Soemodihardjo, 1986).

(1) Logging is to be carried out following the seed trees method, whereby 40 mature trees per hectare are left to function as seed producers.

These trees should have diameter of at least 20 cm and are 17 m apart from one another.

(2) Clear felling is allowable on the condition that 2,500 evenly distributed seedling per hectare are available. Only species of *Rhizophora*, *Bruguiera* and *Ceriops* are acceptable as seed trees.

(3) Felling rotation is 30 years with thinning when the plants reaches 15 years of age. Trees to be extracted must have a minimum DBH of 20 cm. Only machetes, axes and saws are to be used for felling the trees.

(4) Slash must be removed from the felling areas and the logs transported by raft or boat through rivers or man-made canals. The space between successive man-made canals must not be less than 200 m.

(5) A 50 m wide buffer zone is to be maintained along the coast and 10 m wide buffer zone along the river. These zones are designated as protection forest, hence should be left undisturbed.

Depending on the amount of available seedlings on the felling sites, regeneration may take place naturally, supplemented by enrichment planting, or by means of artificial regeneration through transplantation.

Table 3 Working performance, survival and cost of various planting methods of mangrove plantation in South Sumatra.

Planting methods	Labour (mandays)	Survival (%)	Cost per hectare (Rupiah)
Indirect	25	85	200,000.-
Direct with shade	50	70	275,000.-
Direct without shade	10	55	75,000.-

Source : Sumardjani and Mulia 1993 (in press).

Table 4 Mean diameter and height of four age-classes *Rhizophora mucronata* in the tumpang sari tambak in Indramayu, on the north coast of West Java.

Plots	Age (years)	Mean diameter (cm)	Height range (m)
1	6	4.04	3-5
2	6	3.76	3-5
3	11	3.56	3-5
4	11	4.91	3-5
5	14	6.75	10-12
6	14	8.94	8-10
7	18	10.00	10-12
8	18	9.61	10-12

Source : Effendi (1989)

Fig.12 and 13 show *Bruguiera gymnorrhiza* and *Rhizophora apiculata* plantations in South Sumatra. Fig.14 shows two month-old *Rhizophora apiculata* planted in abandoned shrimp farm at Bali island.

Another technique of mangrove re-afforestation is through silvo-fishery system, which locally is called "tambak tumpang sari" or the taungya fishpond. As a matter of fact, this system is a compromise between two somewhat conflicting interests, namely to develop proper mangrove forest versus to gain as much fish production as possible. Therefore the end result depends much on the attitude and honesty of the fish farmers who manage the fishponds. In the cases where they play their part according to the rules of the game, the system works well. The problem is many among the fishfarmers which are biased toward the increase in fish production at the expense of proper maintenance of mangrove plantations.

Presently there are three models of the tambak tumpang sari method in Indonesia (Fig.15). The second and third models are progressive improvements of the first model. Currently Model I is widely used, while Model II and Model III are still in the experimental stages or as demonstration plots.

Model I was the first to be introduced and it has the simplest design, consisting of a shallow platform with mangroves plants, encircled by man-made canals of 3 to 5 m wide and 0.5 m deep. The ratio between canal and platform is approximately 1:4. The canal is used to rear milkfish, *Tilapia* or shrimps. The model is considered sufficiently profitable, but is not free of short-comings. The followings are two of them:

(1) Only one watergate to regulate the water flow to and from the pond. In many cases waters regulation by the fish farmers takes more attention to meet the need of the cultured fish and shrimps e.g. maintaining high water level during ebb tide, hence over flooding the mangrove platform. Continuous submergence of the substrate is not very favourable for good mangrove growth.

(2) As mangrove plants grow bigger and higher, they hamper substantially the penetration of light into the water of the pond. This in turn will result in the decrease of the production of natural food upon which the reared fish or shrimps depend, thereby preventing normal fish growth.

The second model (Fig.1-15) was designed to overcome the shortcomings associated with Model I. In this Model II, the planted mangrove species and the pond are quite independent of one another. These models higher light intensity can be able to penetrate the water of the pond due to the less shading of the pond by the trees. During neap tide water gates a and b remains open to let the water flow in and out the pond freely with the movement of tide.

Model III is of a more intricate design, but the underlying principle is no different with that of Model II. Despite the improvements made, Model II and III still have some minor disadvantages, namely the need for higher investment and maintenance costs due to their having longer dikes and to the three watergates instead of one.

In financial terms, tambak tumpang sari is reported to increase the income of the fish farmer by more than Rp. 100,000 per month. Income contribution from tambak tumpang sari was estimated to range from 44.7% to 53.8% of the total income (Widiarti and Effendi, 1989).

Fig.16 and 17 show the tambak tumpang sari (Model I) and the fish farmers collected fishes in the pond.

Re-afforestation Policy

The utilization of renewable resources on a sustainable basis has been globally accepted as the basic principle in the management of natural resources. Indonesia, whose economic development depends a great deal on her natural resources, fully agree with the said proposition. This acceptance is reflected by the introduction of many regulations and laws concerning the above matter. In this respect, re-afforestation programmes constitute one of the activities that is aimed to achieve that effect. For this reason, re-afforestation is considered a top priority programme.

Past experience has demonstrated that without cooperation and active participation of the community at grassroot levels re-afforestation efforts would commonly fail. Therefore, in order to get some success, re-afforestation activities should seek the cooperation and involvement of the local population living near the target area. This has been the re-afforestation policy of the Indonesian government for the past two decades or so.

The main obstacle confronting the afore mentioned policy is the poor socio-economic situation of the population surrounding the area to be reforested. This condition has been identified to be the most pronounced stress factor affecting the health of the natural environment and the sustainability of the resources it contains. Therefore, to overcome the constraints the socio-economic condition of these people have to be uplifted.

In view of the above point, the Department of Forestry, in this case the State Forest Corporation of Perhutani, is now introducing a special programme called the "Social Forestry Programme" which is also referred to as the "prosperity approach forestry programme". The idea is to assist the surrounding populations to increase their incomes invarious ways. As a matter of fact silvo-fishery system is one form of the Social Forestry Programme.

Perhaps it should be pointed out here that re-afforestation policy in Indonesia is aimed not only to mitigate degraded coastal lands but also to increase the economic condition of the local population, to meet the needs of industry and to sustain available resources.

For the rehabilitation and regeneration of mangrove lands in Java, the State Forest Corporation serves as the executing agency. Outside Java it is carried out by some logging companies. It is policy of the Government that every logging company is responsible for re-afforesting the logged over areas under its concession.

Socio-Economic Aspects

Mangrove lands in Indonesia include those lands covered by mangrove vegetation as well as non-vegetated mud flat (Soemodihardjo et al., 1993). The latter may take the form of degraded mangrove land, abandoned fishpond or bare mud flat adjacent to mangrove forest. Not rarely, the bare mud flat is a newly formed land resulting from a continuous sedimentation process.

The largest proportion of mangrove forests fall under the jurisdiction of the Department of Forestry and its sub-ordinate agencies, like Perum Perhutani, Inhutani, Directorate General of Forest Protection and Nature Conservation. Smaller portions are under the jurisdiction of the Department of Home Affairs and Local Governments.

Soemodihardjo (1993) described the land use pattern of mangrove lands under the jurisdiction of the Department of Forestry according to their designated function,i.e.(1) production forest, which is designated to provide harvestable production such as timber, poles, chipwood, fuelwood, charcoal, etc; (2) protection forest, which functions to protect the surrounding environment from destruction by natural forces; (3) conservation forest, with the function to preserve the forest and its contents, e.g. nature reserves, national parks, wildlife sanctuary, etc.

Some portion of the forest within the Protection Forest and forest land under the jurisdiction of the Department of Home Affairs are set aside for conversion uses as appropriate. The important thing to note is that the type of conversion must be in compliance with the general guidelines and national as well as regional land use planning as stipulated in the "Spatial Planning Act of 1992".

Traditional uses of mangrove resources refer to small scale extraction of mangrove forest products for home consumption. Not rarely people collect mangrove products also for sale to get some additional income for their meagre earnings. From that point of view mangrove forests are economically important assets for the surrounding populations. In the years long gone, the practice of haphazardly collecting mangrove products did not do much damage to the resources, since the amount taken was relatively insignificant compared with the available resources at that time. With the ever increasing coastal population, coupled with the poor living conditions, the negative impact of this anthropogenic interference on mangrove forests have grown uncontrolably to such a level as to endanger the existence of the resources themselves.

Fisheries is also another important asset of mangrove forest or the coastal population, al-

though the fish caught is not a direct mangrove product. It is widely known that extensive mangrove forests are commonly associated with lucrative fisheries. Capture fisheries as well as mariculture will find mangrove environment a suitable place for their activities.

Thanks to the untiring efforts of the Department of Forestry and its sub-ordinate institutions, the distressing process of ever degrading mangrove forests in Indonesia have gradually been brought more or less under control. It is accomplished not only through exercising tight controls and supervision but more fruitfully through persuasion and encouragement of community participation in managing the resources, e.g. by way of silvo-fishery system. On top of that, other means are sought to improve the socio-economic conditions of the coastal villagers viz by creating work opportunity where possible, provision of fuelwood by plantation of fast growing trees etc.

The concerns of the Department of Forestry and of other relevant institutions as to the fate of mangrove resources have shown encouraging progress. Awareness on the part of coastal villagers on the importance of mangrove forests as economic and ecological assets has markedly improved. The case of Curah Sawo village, where, by their own free will the people rehabilitated and afforested the coastal lands of their villages, serves to illustrate the above assertion. Presently there is an NGO in Indonesia, called Indonesian Mangrove Foundation, which specialises in serving the mangrove cause. Hopefully there will be the day when the Indonesian people can look at their mangrove forests with a lot of pride.

References

Anonymous. 1993. Implementation of social forestry program on Forest State Corporation mangrove forest through silvo-fishery practices. Perum Perhutani Unit III, Jawa Barat.

Bina Lestari, P.T.1984. Beberapa aspek pengelolaan hutan mangrove pada areal HPH P.T. Bina Lestari di Propinsi Riau. Prosiding Seminar II Ekosistem Mangrove. MAB-LIPI

Darsidi, A. 1984. Pengelolaan hutan mangrove Indonesia. Prosidings Seminar II Ekosistem Mangrove. MAB-LIPI, pp. 19-28.

Djojomihardjo, S. 1984. Sekelumit tentang pengelolaan hutan mangrove di Jawa Timur. Prosidings Seminar II Ekosistem Mangrove. MAB-LIPI.

Effendi, R. 1989. The growth of *Rhizophora mucronata* in the "tambak forest" system at the mangrove forest complex of Indramayu, West Java. Biotrop Special Publication, *37*:271-274.

Effendi, R. and A. Bachtiar 1991. Pengaruh jarak tanam terhadap pertumbuhan diameter dan tinggi pohon bakau (*Rhizophora apiculata*) di Tembilahan, Riau. Bul. Pen. Hutan, *540*:35-44.

Haditenojo, P.S. dan Ts Abas 1984. Pengalaman pengelolaan hutan payau di Cilacap. Prosidings Seminar II Ekosistem Mangrove MAB-LIPI, pp. 65-73.

Mulia. F. 1993. Saran penyempurnaan pedoman sistem silvikultur hutan mangrove. A recommendation to the Indonesia Government (unpublished).

Simbolon, M. 1991. Sumberdaya hutan mangrove menjelang tahun 2000. Prosidings Seminar III Ekosistem Mangrove. MAB-LIPI.

Soemodihardjo, S. 1986. Country report. Indonesia. In. Umali; Zamora; Gotera, Jara, Camacho and Vannucci (Eds), Mangrove of Asia and the Pecific : Status and Management. Technical report UNDP/UNESCO RAS/79/002.

Soemodihardjo, S.,P. Wiroatmodjo; A. Abdullah, I.G.M. Tantra and A. Soegiarto 1993. Condition, Socio-economic values and environmental significance of mangrove areas in Indonesia. In B.F. Clough (Project Coordinater). The Economic and Environmental Values of Mangrove Forest and their present state of conservation in the South-East Asia/Pacific Region. ITTO/ISME/JIAM Project PD 71/89 Rev 1(F), *1*:17-40.

Soeroso, S.D. and Hadipurnomo 1982. Rehabilitasi hutan mangrove di pantai Probolinggo, Jawa Timur. Kasus Desa Curah Sawo. Prosidings Seminar II Ekosistem Mangrove MAB-LIPI.

Soewito, 1982. Status ekosistem hutan mangrove dalam kaitannya dengan kepentingen perikanan di Indonesia dan kemungkinan pengembangannya. *Dalam* : Soemo-dihardjo, S; I. Soeria-negara; M. Soetisna; K. Kartawinata; Supardi; N. Naamin dan H. Al Rasyid, (Eds.). Prosidings Seminar II Ekosistem Mangrove, Indonesian National MAB Programme-LIPI,pp. 124-129.

Sukartiko, B. 1978. Intensifikasi tumpang sari tambak di hutan payau Cilacap. Duta Rimba 4(26):40-54.

Sumardjani, L. and F. Mulia 1993. Some experience on the rehabilitation of mangrove forest in Palembang. Paper presented in the Seminar on Ecosystem Rehabilitation/ Ecotone II, Jakarta 29-31 March 1993.

Tim Ekosistem Mangrove MAB-LIPI. 1984. Laporan telaah tataguna ekosistem mangrove pantai utara Jawa Barat. MAB-LIPI Perum Perhutani, Jakarta.

Widiarti, A. and R. Effendi 1989. Socio-economic aspects of tambak forest in mangrove forest complex. Biotrop Special Publication, 37:275-280.

Wirjodarmodjo, H. and Z. Hamzah 1984. Beberapa pengalaman Perum Perhutani dalam pengelolaan hutan mangrove. Prosidings Seminar II Ekosistem Mangrove. MAB-LIPI, Jakarta.

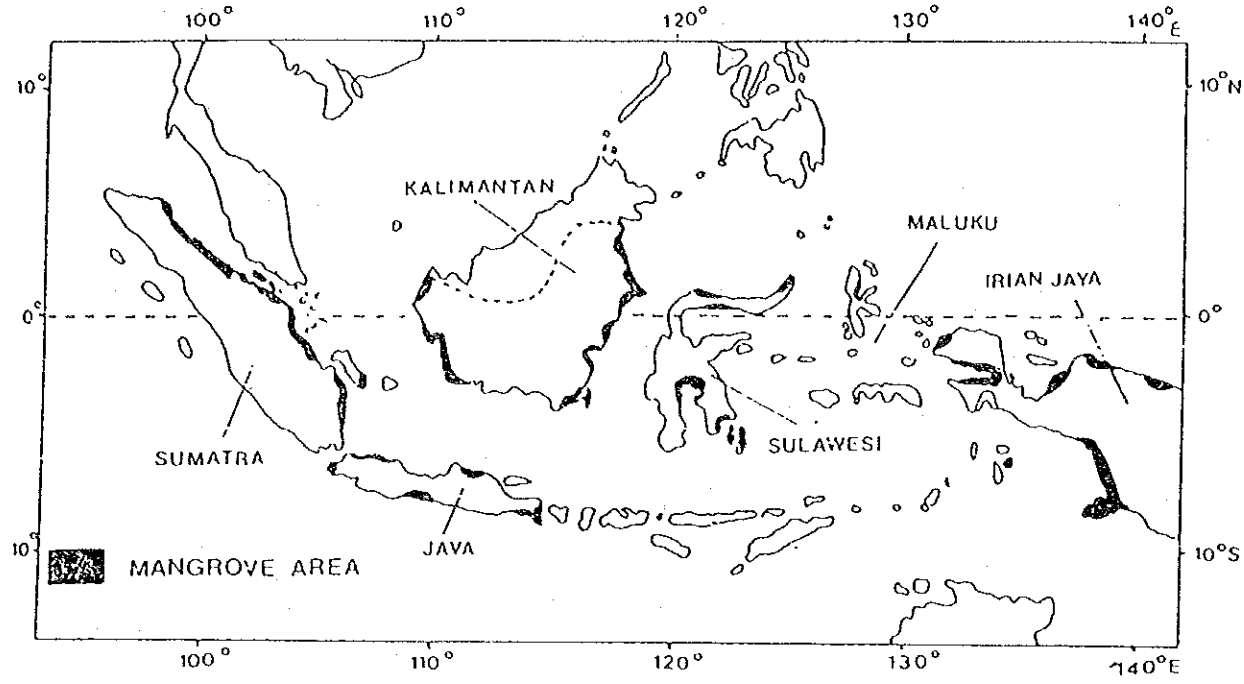


Figure 1 Distribution of mangrove forests in Indonesia (not to scale; Soemodihardjo et al. 1993)

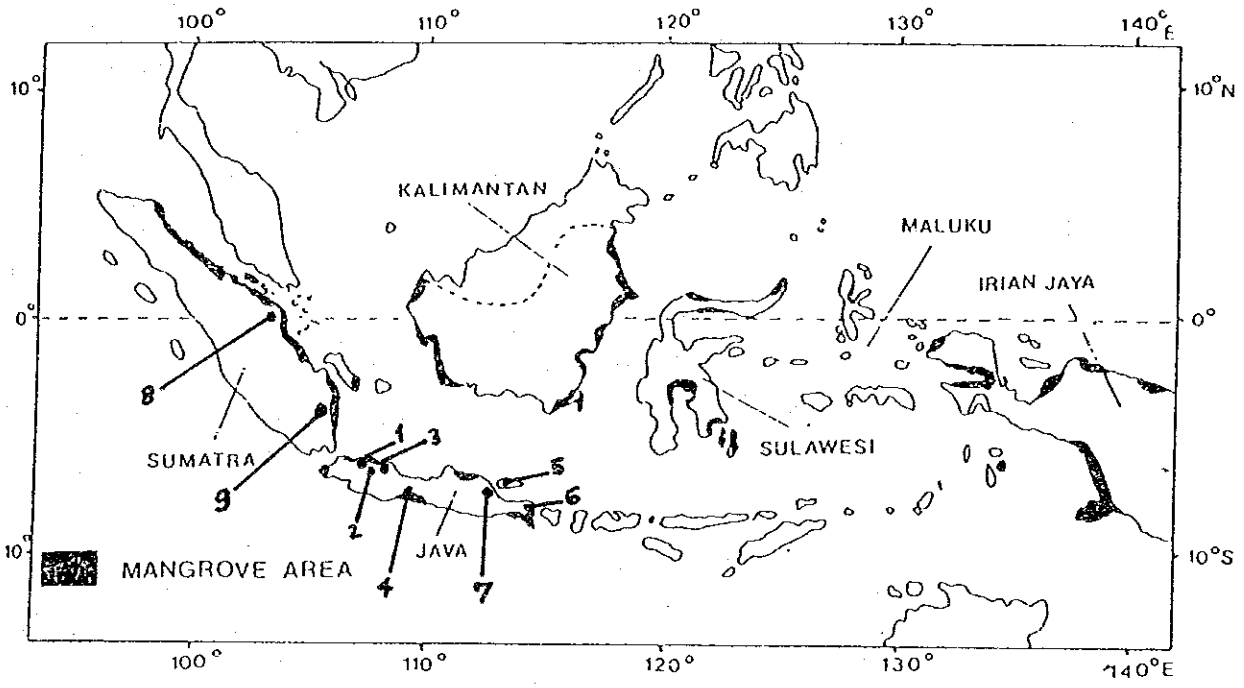


Figure 2 Distribution of mangrove re-afforestation in Indonesia in 1992.

観 察 歩 道 設 置 の 手 引 き

（観察歩道のルート踏査、部材組立加工、現場据付の作業歩掛り）

NOV 1994
JICA MANGROVE PROJECT, BALI, INDONESIA

1　部材の材質

木材は海水に強い材質のBINKRAI または BALAUを使用するが、場所によっては他の樹種もあると思われるので現場で確認すること。

釘は亜鉛メッキされた造船用船釘(paku laut) を使用する。BINKRAI や BALAUは硬質であり釘打ちのときに割れが生じやすいため部材の組立てには前もって釘の先導穴をドリルで開ける必要がある。

2　作業歩掛の基礎条件

(1) 作業環境

①据付現場

据付現場はマングローブ林の泥沼の中であるのでかなりの重労働となる。また地盤が低い場所では大潮の時期は水に漬かりながらの作業となり効率が落ちるので避けるべきである。

②作業の効率化のための施設

内陸側から部材搬入ができる場合以外は、作業の効率化を図るためにマングローブ林の林縁に船が横付けでき、部材などの仮置ができるよう桟橋などを作る。

③木材の加工

据付現場での木材加工作業は避け、設置現場と離れた作業条件の良い安全な場所で木材の加工を行い、人力で運搬できる程度の重さ以下の半加工品を作る。今回は長さ4mの梯子状の上部構造、橋脚の杭、踏み板、落橋防止板の部品を半加工品として作成した。

(2) 部材の運搬

現場への運搬は安定の良いアウトリガー付きの漁船で行う。一般的には漁船を借り上げる方法をとる。必要な船数は次の数値を参考に決定すること。

①乗船可能人数を確認し一人50kg換算で積載可能量を求めること。

一般的に船体長4.2mで250kg 、船体長6mで600kg 程度の積載が可能である。

②各部材の重量は一セット（４ｍ）の上部構造（踏板を除いた梯子部分）55kg、踏み板２枚48kg、橋脚６本と落橋防止板３枚のセットで55kgであった。使用した木材は比重が大きく水に沈む場合が多いので1m3=1000kgと換算した。

③荷物満載時のアウトリガー付きの漁船の船の速力は、

・零細漁業者用の簡易船外エンジン(5ps) 付き船体長4.2m：　時速10km、

・ヤマハ製専用船外機付き(25ps)船体長6m：　時速15km

④運搬船は据付作業、踏み板設置作業、準備・据付調整・片付作業の間借り上げる。

⑤運搬船の数は現場までの距離に応じて一日の使用船数が異なるが一般に２隻を一組で使うほうが効率的である。

(3) 作業時間

現場条件により異なるが、現場での実作業時間は一日 6時間を基本とする。この作業時間であれば一週間連続作業しても作業は安全に行われまた誤りも少ない。

今回のGili Sulatでの作業時間を例示すると下記のとおりであった。

7:30集合、積込み
8:00出発
8:40桟橋到着、荷降ろし
9:00桟橋出発、材料運搬開始
休息１時間
} 実運搬作業時間は 6時間
15:30作業終了、片付け、現場出発
16:00桟橋到着
16:10帰路出発
16:40到着
17:00片付け終了

3　各作業の説明と作業歩掛り

各作業の歩掛は最初に200m程設置した時に木材加工現場と据付現場で歩掛を調査したうえで作成した。

なお作業歩掛は作業員が連日作業しても労働の質が低下、安全などへの注意力低下を招かない程度に設定した。

(1) 歩道ルート踏査

天然林内ルート踏査は、一チーム四人編成で一人が耐水性磁石を用い方位を指示、二人が巻尺で距離測定、一人が30m 毎に赤色蛍光テープを幹に巻き付け、必要に応じ30mの補助点として黄色蛍光テープを幹に巻き付ける。 30m毎の赤色蛍光テープには起点からの通加距離を記入する。測定間隔は30m を越えると林内で目印を見失う可能性が高くなり危険であるためそれ以上の間隔にしないこと。

林の状況をみて歩道据付作業の難易度を考慮しながらルートを決定すること。

調査時の歩行速度はヒルギ属の支持根や膝根に覆われている林内では100 ～150m/ 時間、距離測定などの調査が終えて引上げ時の歩行速度は250 ～300m/ 時間である。一回のルート設定は調査員の不慮の事故がある場合、その作業員の搬出を行うこと考慮し上限を300 ～400mの範囲とする。

(2) 木材加工、組立

作業内容：木材を指定寸法に切断、上部構造組立、杭に打ち付け易くするための釘の先導穴開け、杭の先端拵え、整列保管。

歩掛人工：0.8 人／１セット　（１セット４ｍ、図－１の部材一式）

(3) 現場での据付

現場での据付とは、3-(1) で踏査し目印をつけたルートを伐開し伐採木の除去片付けなどの準備を行い、部品の搬入、組立て据付、片付けを行い撤収する一連の作業をいう。

据付作業　：６人一組で１日10セット（歩掛は運搬距離に関係なく一定）

人力運搬作業（現場内運搬）　：平均運搬距離　0 ～ 500m は２人一組で１日10セット
平均運搬距離 501m～1000m は４人一組で１日10セット
平均運搬距離 1001m～1500m は６人一組で１日10セット

踏み板設置　：100 セットに付き２日間。

踏み板設置作業の一組の人数は、据付作業の６人に平均運搬距離に応じた一組の人数との合計とする。

（例）平均運搬距離0 ～ 500m の場合は据付作業の６人に運搬の２人を合わせた８人が２日間踏み板設置作業に携わるものとする。

準備、据付調整、片付：100 セットに付き２日間。

なお設置するセット数が少なくても１日を計上する。ただし非常に少ない場合は踏み板設置の１日に含めることができる。

作業の一組の人数は、据付作業の６人に平均運搬距離に応じた一組の人数との合計とする。

（例）平均運搬距離0 ～ 500m の場合は据付作業の６人に運搬の２人を合わせた８人が準備・据付調整・片付作業に携わるものとする。

（例）平均運搬距離が1500m 、100 セット（400m分）の場合下記のとおりであった。

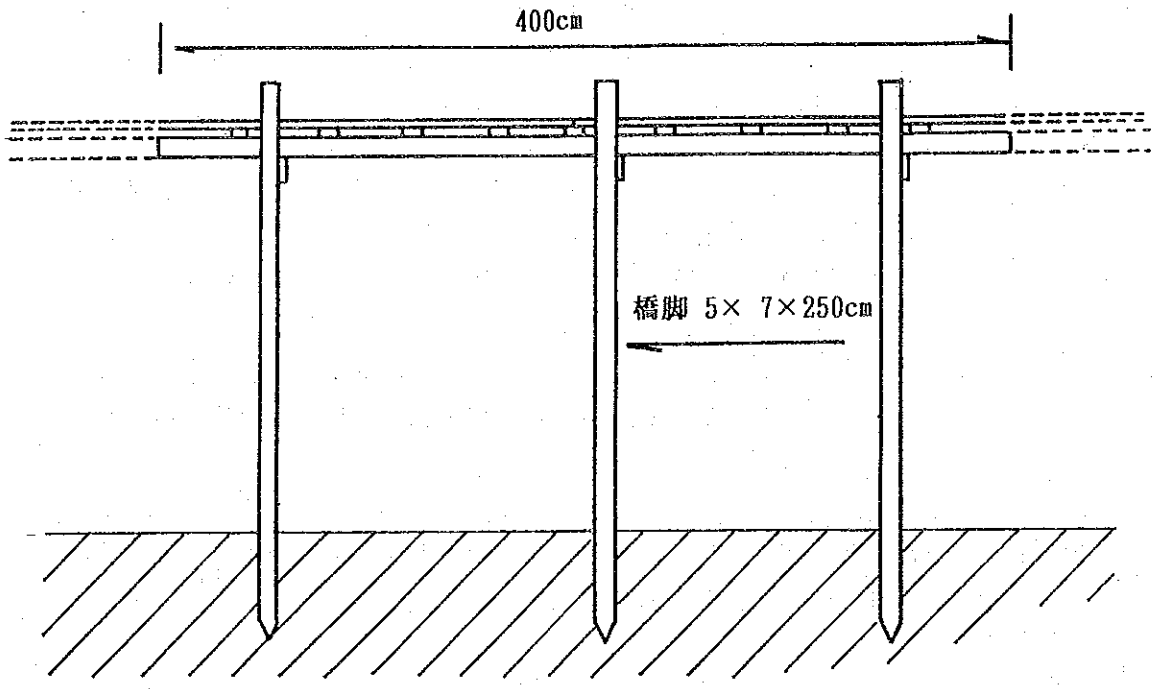
木材加工、組立	：0.8 人×100set	＝80人
据付作業	： 6人/10set× 100set	＝60人　10日間
運搬作業	： 6人/10set× 100set	＝60人
	（他の作業と作業日が重なる。）	
踏み板設置	：12人× 2日間	＝24人
準備・据付調整・片付	：12人× 2日間	＝24人

据付現場での作業日数は14日間(10+2+2)　作業員合計 248人

船借り上げ　：船（大）14日間×１往復＝14回（作業員＋部材運搬）

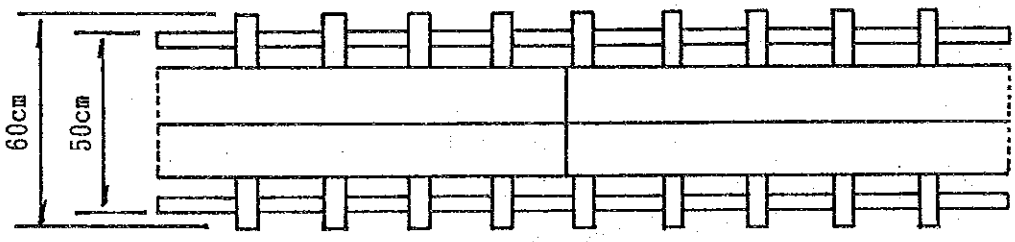
船（小）14日間×２往復＝28回（部材運搬）

（注）船の大１隻は作業員の運搬と少量の部材運搬、小１隻は部材運搬専用で１日２回往復とした。１隻は必ず現場に待たせ緊急時の連絡用とすること。

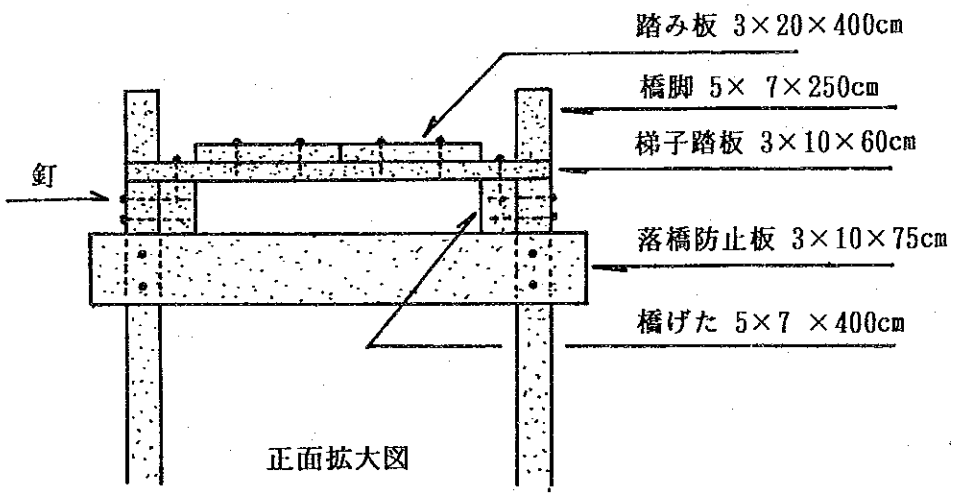


側面図

（注）踏み板は二つの梯子を連結するように据え付ける。



投影図



正面拡大図

図－　観察歩道の構造

ヘリウムガス気球を利用した写真撮影の手引

NOV 1994

JICA MANGROVE PROJECT, BALI, INDONESIA

1　必要機材

A. 気球（カラビナを付けた気球保持用ロープ含む）

B. カメラ（35㎜レンズ、フラッシュ付き）

C. カメラ取付台（無線受信機内蔵、吊下げ用４点支持ロープ含む）

D. 送信機

E. 牽引ロープ（牽引荷重300kg 直径5㎜ の登山ロープ500m）

F. 牽引ロープ巻取機（700m巻取可能、ステンレス製）

G. 繋留用ロープ（牽引ロープと同等品、7m×　4本）

H. 気球注入口封緘用ロープ（牽引ロープと同等品、2m×　1本）

I. 麻布シート（草などの棘が通らない程度の厚さ、5m×5m）

J. 繋留用ネット（7m×7m程度）

K. ヘリウムガスボンベ

L. ヘリウムガス専用ガスディストリビューター（3mのゴムホース付き）

M. 測量用簡易トランシットコンパスと巻き尺

N. 工具セット

O. カメラ、フラッシュ用交換電池とフィルム。

P. 地上標識板（白く塗装した合板６枚、大きさは高度300m程度で撮影するならば50cm×50cm程度、高度500mならば1m×1m程度）

Q. トランシーバー４台

R. 双眼鏡１台

S. 関数付き電卓

2　気球操作と写真撮影の手順

1)準備

A. ヘリウムガスの購入はジャカルタ、スラバヤで行う。

B. 地上で三脚にカメラを据え、図－１のように対象物までの距離測定後、撮影現像し対象物までの距離と対象物の大きさを比較しレンズ特性を確認する。

C. 牽引ロープの「ほつれ」、張力検査を行う。牽引ロープ100m毎に2mの長さの赤色蛍光テープを目印として取り付け、100mの目印間に 50m毎に短い黄色蛍光テープを取り付ける、さらに 10m毎にマジックインキなどで目印を付ける。

D. 撮影目的地近辺で 20m×20m 程度の広さの平坦地に気球停泊用アンカー杭と３本の予備アンカーを設置する。（図－２、写真－５　）

E. アンカー脇にシートを広げ機材を並べ確認する。

F. カメラ取付台、吊下げ用４点支持ロープ、カメラを組み合わせる。

G. 気球をシート上に広げ牽引ロープと結び、さらに牽引ロープをアンカーに結ぶ。

H. アンカーに結んだ気球繋留用ロープ４本を気球保持ロープのカラビナに結ぶ。

I. 気球脇に置いたガスボンベにガスディストリビューターを取り付ける。

J. 気球の注入口にゴムホースを差し入れ徐々にガスディストリビューターの弁を緩め、ガスを注入する。注入中は気球の注入口からガスが漏れないようホースを注入口の

気球のナイロン布で包むようにして手で締める。

K. 気球が浮かび多少の風でも気球が凹まない程度までガスを注入したらガスディストリビューターの弁を締め、ガスホースを気球から抜く。注入口の気球のナイロン布をねじり固結びに結ぶ。さらに注入口を三重に折り気球注入口封緘用ロープで固く縛る。　浮力は直径3mの気球で15kg程度である。

L. E で組合わせたセットを気球の保持ロープのカラビナに結ぶ。カメラが必ず真下を向くように吊下げ用４点支持ロープの長さを調整する。

M. カメラとフラッシュの電源を入れ、カメラの焦点を無限大で固定しさらにレンズの焦点が動かないように接着テープで固定する。5mほど気球を揚げ送信機で二三度試験撮影を行い、シャッター作動とフラッシュ点灯を確認する。

このフラッシュは地上からの送信を受けカメラが撮影しているかどうかの確認のためのものであり、光量不足を補うためのものではないのでフラッシュの光量は問題ではない。

N. 標識板を撮影予定地に簡易トランシットコンパスと巻き尺を用い50m 間隔の格子状に並べる。格子の各線分は正確に東西南北を向くようにする。

O. 調査員を気球牽引班（調査員１人、作業員４人）、測量班（調査員１人、作業員１人）気球位置判定班（二班編成で各班調査員１人、作業員１人）に分け予定高度に応じて散開し待機する（図－３）。

2)撮影の手順

A. 風向を見ながら地上から徐々に気球を上空に向け上げていき、目的地の上に気球が到達するよう操作する。目的地の上空に達したかどうかは各々距離をおいて待機している気球牽引班、測量班、気球位置判定班が互いにトランシーバーで連絡し確認する。

B. 目的地の上空に届いたら気球の高度を測定し、目的の高度まで上げ下げし調整する。高度調整は牽引ロープを伸縮する方法によるが、その度 Aの作業を行う。

気球高度の測定方法は以下の二つの方法がある。

a 簡易トランシットコンパスによるスタジア測量

気球の直径は3mであることを利用し、簡易トランシットコンパスでスタジア測量を行い斜距離を測り、同時に高低角を測り高度を計算する。

計算式は以下の通り。

$h = \sin\theta \times L$　　h ＝気球の高度

θ ＝高低角

L ＝斜距離

b 牽引ロープの距離目印を利用した高度計算

風により牽引ロープが大きくたわんでいない場合、牽引ロープの距離目印を斜線距離の近似値とし簡易トランシットコンパスで高低角を測り高度を計算する。

C. 地上から上空に揚げた気球に取り付けたカメラに無線送信機に信号を送り写真を撮る。撮影の注意点は以下の通り。

a 撮影がなされたかどうかはフラッシュの点灯を双眼鏡で確認する。

b 風によりカメラが揺れる場合があるので双眼鏡により揺れていないのを確認し送信するか、揺れるカメラが真下に来るときを狙い送信する。

c bの事態を避けるためには一般に早朝か朝の風が止まる時間帯を狙い撮影することが望ましい。

D 撮影枚数を控えておき、所定の枚数ごとに気球を降ろしフィルムを交換する。
交換する毎に2)-(1)-L、2-(2)-A,B,C を繰り返す。
フラッシュの発光間隔が長くなってきたら早めに電池を交換すること。

3)繋留方法

A 2-1)で準備したアンカーと予備アンカーに繋留ロープで固定する。牽引ロープもアンカーに結ぶ、さらに繋留ネットで気球を覆い予備アンカーに結び風により揺れ動かないように固定する。
ガスは一度充填すると約4日間は浮力が維持できる。浮力が不足すればガスを補充する。

4)片付け

A 繋留したうえで気球の脇に麻布シートを広げ、注入口を開きガスを放出する。ヘリウムガス自体は毒性はないが大量に吸い込むと酸素欠乏で失神、死亡する場合があるので注意すること。

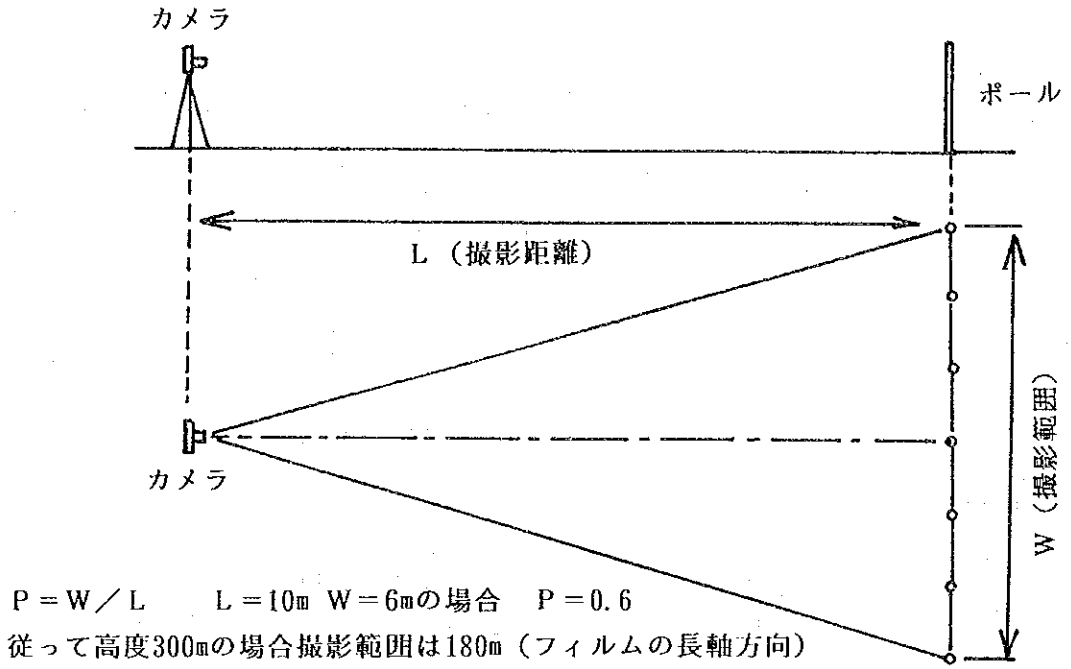
B ガスを抜いた気球は石や木の枝などが入らないように畳む。事務所にて真水で洗浄し乾燥した後に保管すること。その他の物品も真水で洗浄した後乾燥させて保管すること。

3　その他の注意事項

A カメラ本体に遠隔操作の機能が着いている場合は送信機や受信機も特別に制作する必要がないので購入時に機能を確認すること。
レンズの焦点距離は35㎜程度が写真の歪みと撮影範囲のバランスが比較的良い。

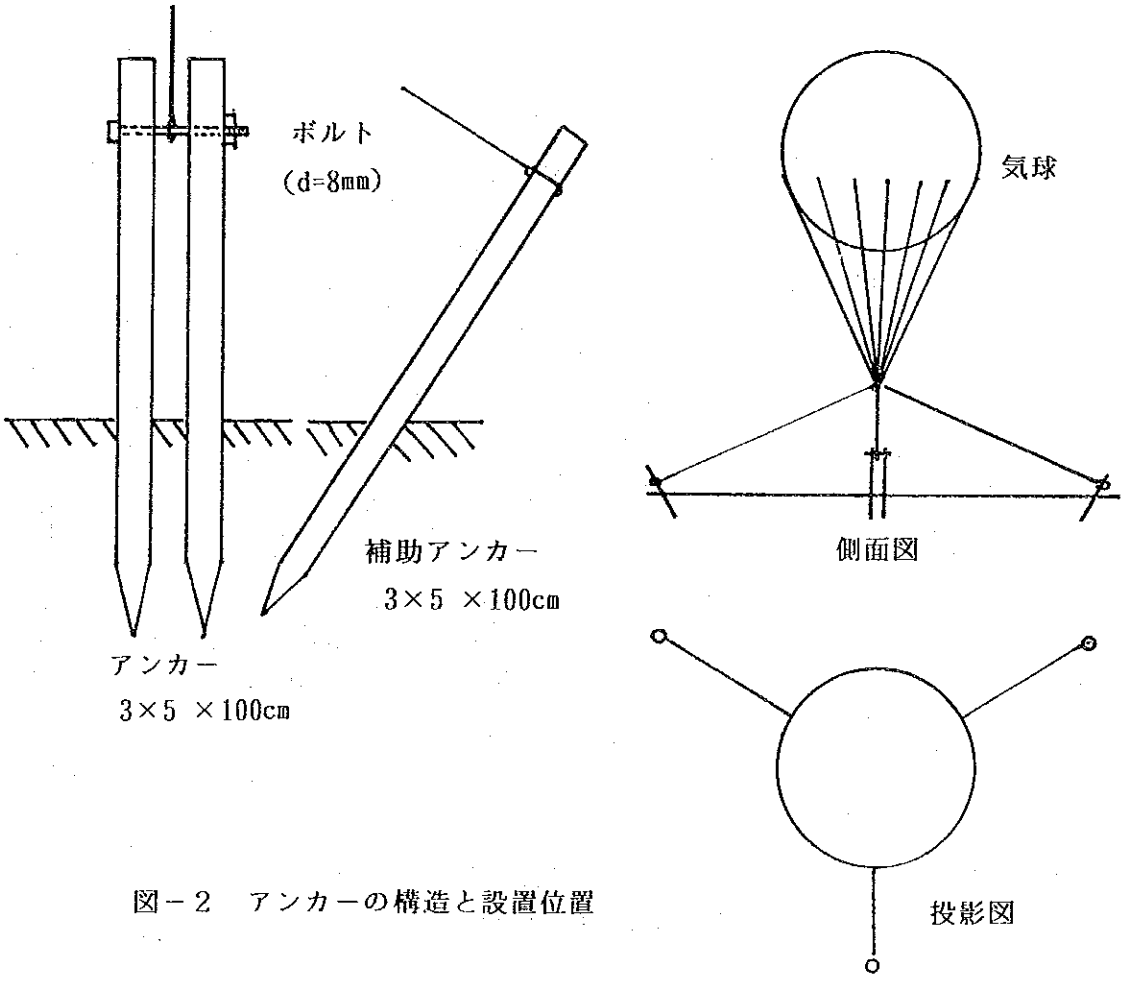
B 真下だけの撮影は行わず、場合によっては斜め方向の鳥瞰図を撮影すること。

c 双眼鏡でフラッシュの点灯を確認する場合に太陽を視野に決して入れないこと。網膜が焼けて失明の恐れがある。

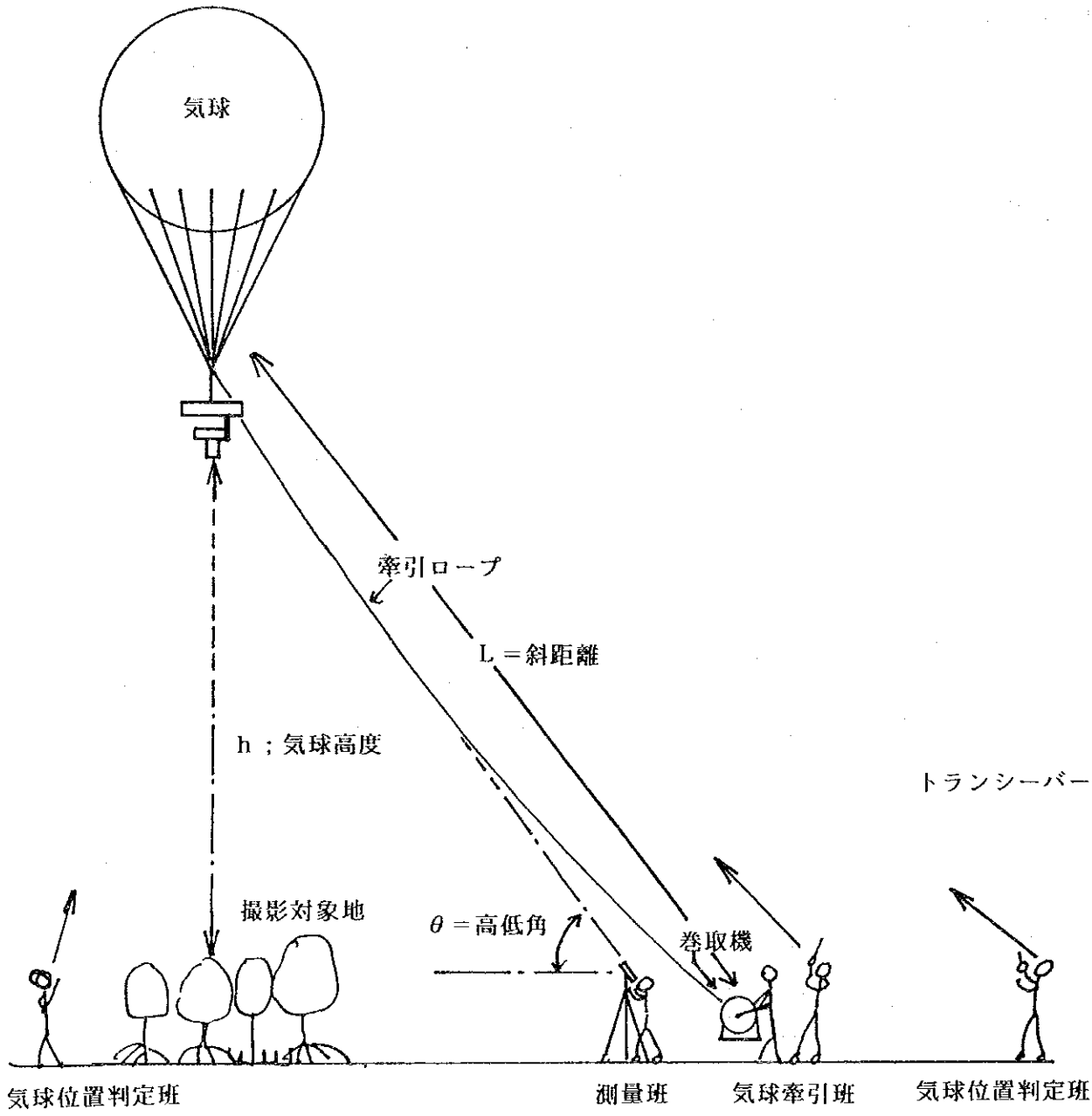


P＝W／L　　L＝10m　W＝6mの場合　P＝0.6
従って高度300mの場合撮影範囲は180m（フィルムの長軸方向）

図－1　レンズ特性の確認方法



図－2　アンカーの構造と設置位置



簡易トランシットコンパス

図－３　撮影時の調査員配置

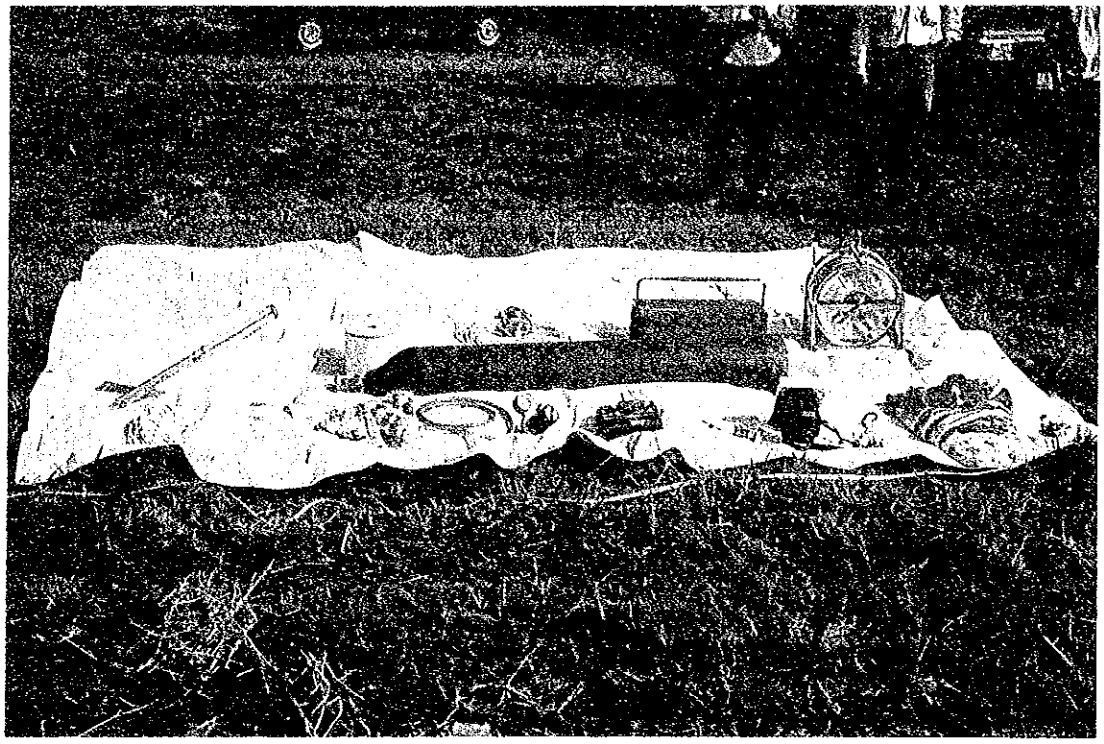


写真-1　機材一式の確認
部品の紛失を避けるため麻布シートの上で確認すること。

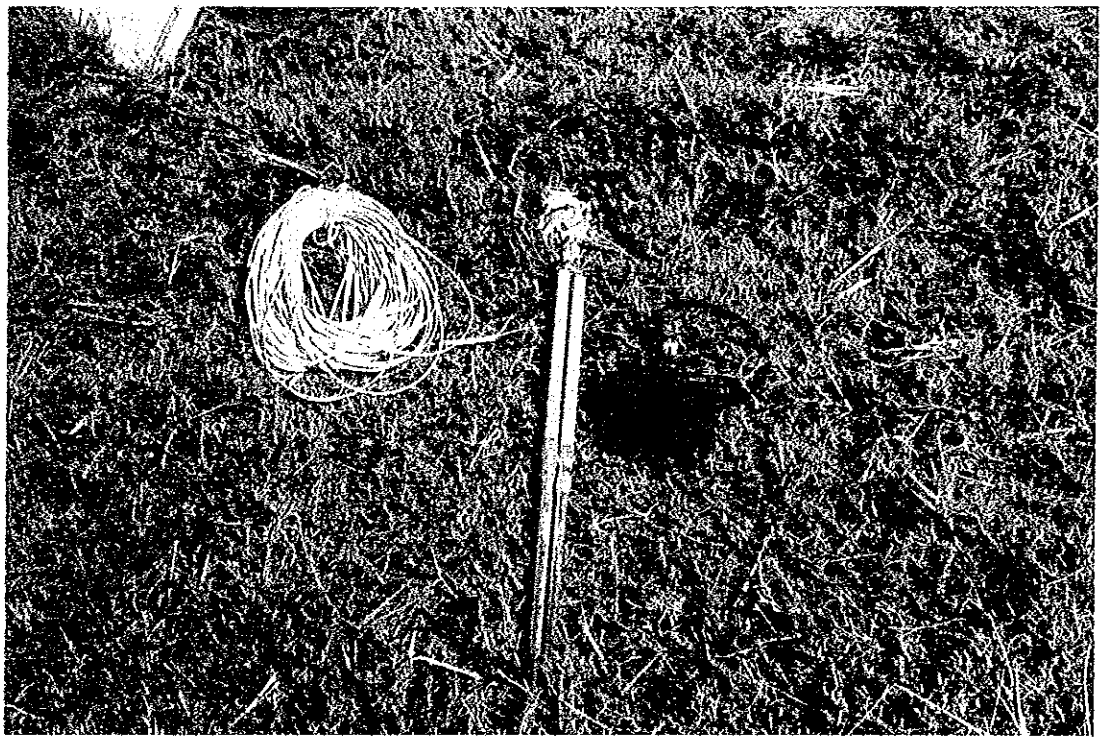


写真-2　測量機材一式
簡易トランシットコンパス、テープ

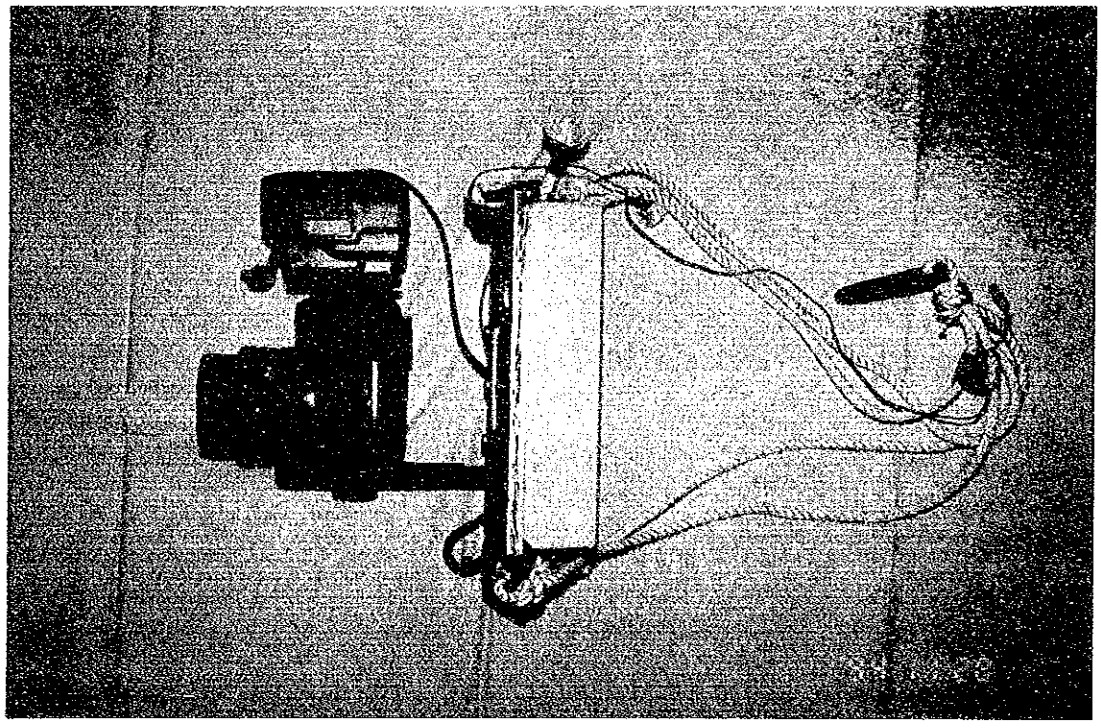


写真-3　撮影機材
カメラ取り付け台にセットしたカメラとフラッシュ

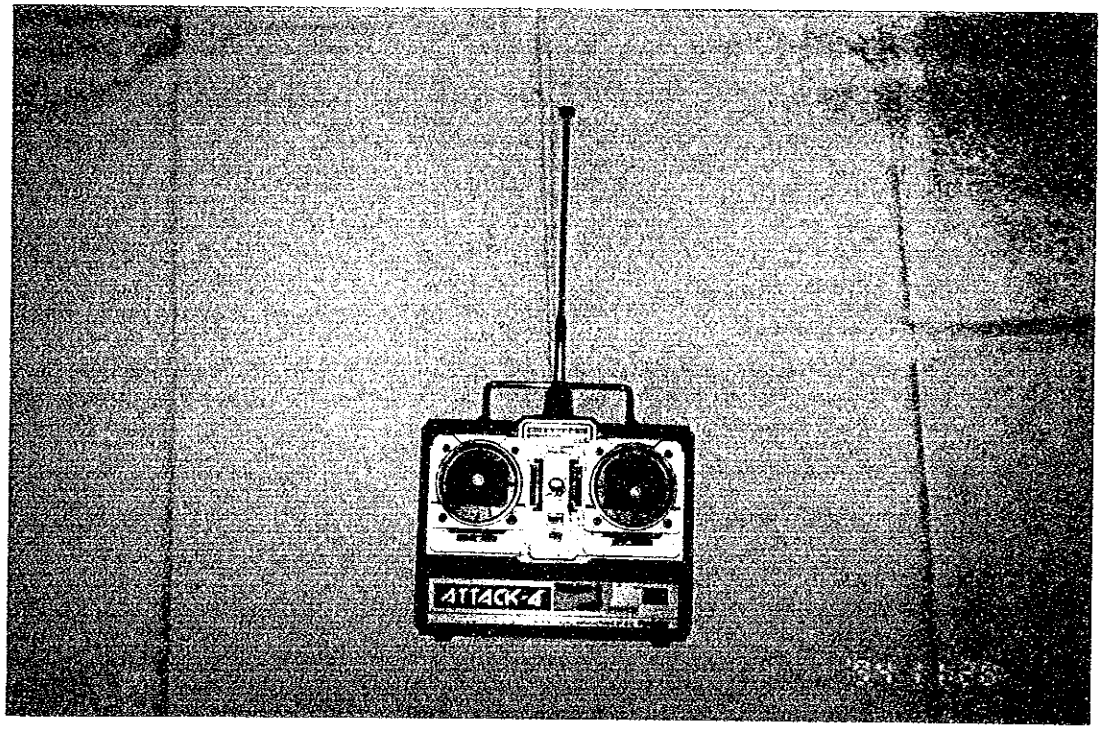


写真-4　送信機

写真-5　アンカー、補助アンカーの設置

写真-6
アンカーとボルト

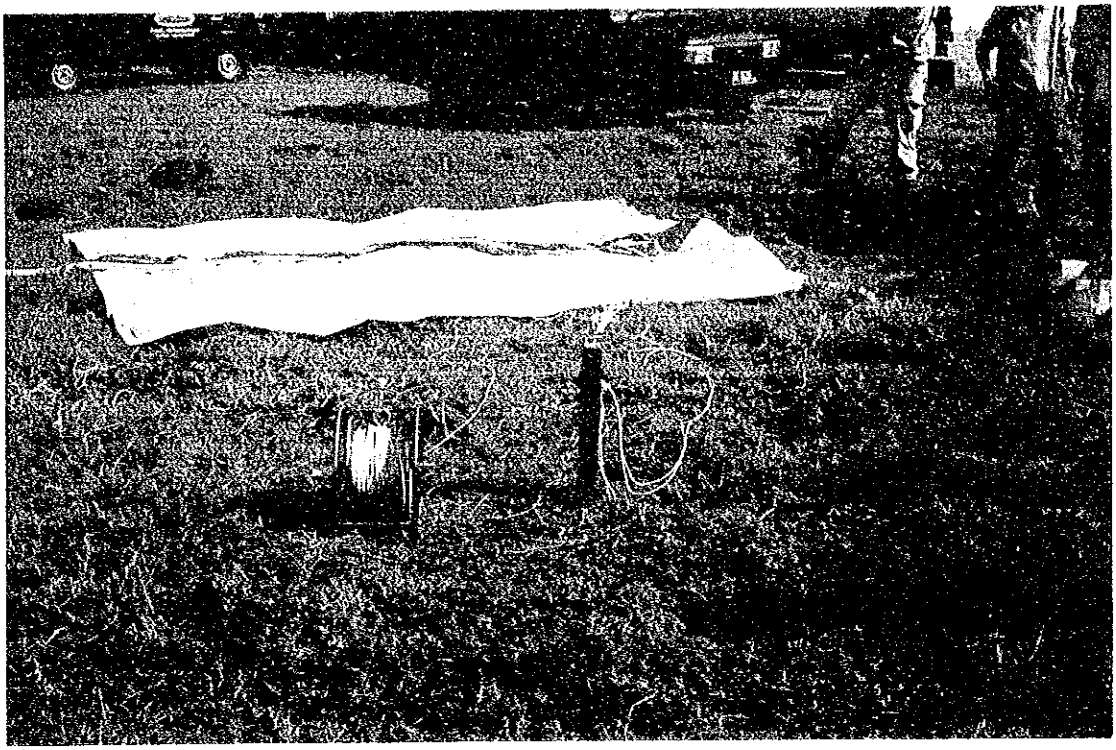


写真-7　気球、牽引ロープ　　ガス注入前にアンカーに結ぶこと。

写真-8　ガスディストリビューターの取付