Japan International Cooperation Agency (JICA)
National Mapping and Resource Information Authority
Department of Environment and Natural Resources
Republic of The Philippines

No.

FINAL REPORT
OF
THE STUDY
ON
MAPPING AND LAND COVER ASSESSMENT
OF
MANGROVE AREAS
IN
THE REPUBLIC OF THE PHILIPPINES

July 1999

Japan Overseas Forestry Consultants Association (JOFCA)
Aero Asahi Corporation

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Introduction

This report presents the technical background, methodology and results of the Development Cooperation Survey Program entitled “Mapping and Land Cover Assessment of Mangrove Areas in the Philippines” (hereinafter referred to as “the Study”). This initiative was a joint effort of the Government of the Republic of the Philippines (GOP) and the Government of Japan (GOJ). The Study was based on an Implementation Arrangement signed between the preparatory study team dispatched by Japan International Cooperation Agency (JICA) and the Department of Environment and Natural Resources (DENR) of the GOP.

The Study began in November 1997 and was completed in June 1999. An Inception Report containing the detailed study plan was submitted on Dec. 3rd 1997. The Study was implemented in conformity with the plan. It was conducted in two Phases, the first phase covering the period from February to August 1998, and the second phase from November 1998 to July 1999.

The Study covered on three model areas located Aparri, Cagayan Province, Lamon Bay, Quezon Province, and Ulugan Bay, Puerto Princesa City. These model areas were selected within the mangrove forest distributed areas in the Philippines as representing different types of the Mangrove forest. The study was implemented to achieve the purpose of accumulating effective data on latest mangrove forest situation for Mangrove Forest Conservation Planning. The remaining areas will be covered following survey activities by NAMRIA and DENR.

Executive Summary

(1) Objectives and Process

This Study was designed to obtain data that will be useful in the formulation and future implementation of mangrove forest management plans in the Philippines. In this context the Study, *inter-alia,* examined and recorded detailed information on the current status of Mangrove forests in the three study areas, paying special attention to the following matters:

- Identification of ecological characteristics;
- Assessment of the effects of human activities;
- History of treatment of mangrove forests;
- Multiple functions of mangrove forests including benefits obtained by users and beneficiaries of these resources; and
- Identification of socio-economic conditions in areas adjacent to mangrove forests.

The First Phase of the Study consisted of two field surveys followed by compilation and interpretation of aerial photographs, along with preparatory work for the Second Phase. The field surveys were conducted from February to March 1998 (First study in the Philippines) and June to August 1998 (Second study in the Philippines). Compilation, interpretation, etc. comprised the Third Study. The following activities were carried out:

1) First Study
   a. Aerial Photography
   b. Preparation of Mosaic Photographs
   c. Natural Condition Study
   d. Transect Surveys in Mangrove forests
   e. General Survey of Socio-economic Conditions

f. Second study
   f. Preparation of Mosaic Photographs
   f. Preparation of a Base Map
   f. Survey of Socio-economic Conditions
   f. Preparation of Standards for the Interpretation of Aerial Photographs
   f. Survey of Mangrove Forest Resources
   f. Survey of Natural Conditions

3) Third study
   a. Interpretation of Aerial Photographs

b. Estimation of Mangrove Resources
c. Preparation of Thematic Maps
d. Preparation of Data Base for Geographic Information System (GIS)
e. Complementary Survey to supplement earlier Socio-economic Survey

The areas were Mangrove forests located in Aparri, Cagayan Province (Region II), Lamon Bay, Quezon Province (Region IV), and Ulugan Bay, Palawan (Region IV).

(2) The Study Results

The survey of natural conditions produced data which confirms the results obtained from studies in other parts of the world. Results of the survey shows that in the Philippines a strong correlation exists between the species composition of mangrove forests and the locational conditions. These findings validate observation on Mangrove species composition and distribution are strongly affected by inter-tidal position and estuarine location. The inter-tidal position relate to the ability of mangrove species to tolerate emergence under salt water. The estuarine location relates to the effects of fresh water on mangrove species.

The overall natural conditions of the areas were carefully examined and analyzed. Thereafter, mangrove habitats in each area were classified primarily on the basis of their fundamental formation processes, with the following results.

The Aparri study area is fundamentally an open-accreting coastal type. However, a large deposit of mud and sand provide limits on the mangrove habitat. The environment of mangroves in the Lamon Bay area may be classified as a combination of open-accreting coastal and estuary types. While the area is characterized by many bays and tidelands and a maze of creeks, it is also affected by supplies of soil and sand brought in by medium-sized rivers. Mangrove habitat at the Ulugan Bay area is of the estuary type but does not experience significant inflows of soil and sand. Mangroves grow in a narrow belt because the landward terrain is steep and no large flat lands extend behind them.

To examine the relationship between locational conditions and mangrove habitat, the Study Team observed three factors: (1) salinity, (2) duration of submergence and (3) soil matrix that may determine mangrove zonation. Results of the survey clearly showed a correlation between the three factors and mangrove species composition. In particular, duration of submergence is a major factor on mangrove zonation.

The Study Team found several ecological patterns in the Mangrove forests. The Team classified areas into various types based primarily on species composition and location. The classifications are listed below. Codes in the form of acronyms preceding each item on the list to identify types for reference in this report.

1) Aparri area

a. APN - Almost entirely occupied by *Nypa fruticans* (pure Nipa area).
b ANM - *N. fruticans* are dominant but sometimes mixed with high intertidal mangrove species.
c. AAN - *Avicennia officinalis* with rather big crowns within *N. fruticans* or in narrow belts along the riverbanks.
d. ASN - Shrubs mixed with *N. fruticans* and high intertidal mangrove species such as *Excoecaria agallocha*, *Acrostichum aureum* and *Acanthus ilicifolius*.
e. AMN - *A. officinalis*, *Sonneratia caseolaris*, and *Bruguiera sexangula* dominant but mixed in a few spots with *N. fruticans*.

2) Lamon Bay area

①Seaside flat area – comprising the Santa Cecilia Zone, Binactocan Zone, and the Calauag Bay coast of the Calauag Zone.

a. LRD - Dominated by small and low-height *Rhizophora apiculata*.
b. LRB - Small and low height *R. apiculata* mixed with *C. tagal* and *B. gymnorrhiza*.
c. LAS - Characterized by rather tall and recognizable crowns of *A. officinalis*, with *Scyphiphora hydrophyllacea* ccupying the lower canopy. Associated with *C. tagal* and *Xylocarpus granatum*.
d. LHS - Dominated by medium height *Heritiera littoralis*, mixed with high tidal mangrove species such as *S. hydrophyllacea* and *E. agallocha*. Large parts of this type are commonly covered by shrubs and vines. *A. ilicifolius* and *A. aureum* often comprise most of the forest floor.

② Tidal flat and contiguous riverside area - comprising the Tignigiban Zone, Santo Angel Bay Zone and Tinagan Dapat Bay in the Basiad Zone.

e. LSA - *Sonneratia alba* and/or *Avicennia marina* with *R. apiculata* on the outer edge of the shoreline. This type also includes:
  - parcels dominated by small and low height *R. apiculata* (same as ①-

a above) i.e. LRD and

- mixtures of small low height *R. apiculata, C. tagal, B. gymnorrhiza* (same as ①-b above), i.e. LRB

f. LAB - Medium height *A. officinalis* mixed with low height *A. lanata* and *B. sexangula.*

g. LLX - Mixed stands of low-height *Lumnitzera littorea, X. granatum, B. parviflora, B. sexangula, S. hydrophyllacea* and *H. littoralis.*

h. LAX - Mixed stands of low-height *Aegiceras floridum, Aegiceras corniculatum, Avicennia lanata, X. granatum, R. apiculata, B. sexangula, C. tagal* and *Camptostemon philippinensis.*

- Dominated by *H. littoralis* but mixed with high tidal mangrove species such as *S. hydrophyllacea* and *E. agallocha* (same as ①-d LHS above).

③ Kabibihan Zone and Makahadok Zone

i. LAA - Medium height *A. officinalis* mixed with *A. lanata, S. hydrophyllacea* and *A. corniculatum.*

j. LBE - Bushes growing together with *E. agallocha.*

k. LND - Dominated by *N. fruticans.*

l. LSA - *S. alba* and/or *A. marina* with *R. apiculata* stands at the outer fringe of the shoreline.

④ Lopez Zone (including riverside portion of the Calauag Zone)

(e. *S. alba* and/or *A. marina* and with *R. apiculata* stands at the outer fringe of the shoreline (same as ②-e LSA above).

(f. Medium height *A. officinalis* mixed with low height *A. lanata* and *B. sexangula* (same as ②-f LAB above).

(k Dominated by *N. fruticans* (same as ③-k LND above).

(3) Ulugan Bay area

a. URB - Medium height stands of *R. apiculata* or *R. mucronata* and *B. gymnorrhiza,* with the species mix continuously changing from seashore to the mid-tidal zone.

b. UTR - Dominated by tall *R. apiculata.*

c. UXH - High intertidal mangrove species such as *X. granatum*, *H. littoralis* and *E. agallocha*.

d. UMR - Dominated by medium height *R. apiculata*.

Large portions of two (2) areas (Lamon and Aparri) that were formerly mangroves have been converted to fishponds. The Study Team used aerial photography,

Table S-1 Results of the Natural Condition Study of Mangrove Species and Habitat

Species		Observation by The Study		
		Aparri Area Estarine-Tidal	Lamon Area Estarine-Tidal	Ulugan Area Estarine-Tidal
Aegiceras	corniculatum	M-H-M	M-H-M,U	–
Aegiceras	floridum	–	M-H-L	H-H-M
Avicennia	alba	–	L-H-L	–
Avicennia	lanata	–	M,H-H-M,U	–
Avicennia	marina	–	L,M,H-H-L,U	–
Avicennia	officinalis	M,H-H-M	M,H-H-L,M	–
Bruguiera	cylindrica	–	L,M-H-L,M	–
Bruguiera	gymnorrhiza	–	L,M-H-L,M	L,M-H-L,M
Bruguiera	parviflora	M-H-L	L,M-H-L,M	–
Bruguiera	sexangula	M-H-M	M,H-H-L,M,U	M-H-M
Ceriops	decandra	–	H-H-U	–
Ceriops	tagal	M-H-L,M	L,M-H-L,M,U	M-H-L
Excoecaria	agallocha	M,H-H-M,U	M,H-H-M,U	–
Heritiera	littoralis	M,H-H-M,U	M,H-H-M,U	–
Lumnitzera	littorea	–	M,H-H-L,M,U	–
Osbornia	octodonta	–	M-H-L	–
Rhizophora	apiculata	–	L,M-H-L,M	L,M,H-H-L,M
Rhizophora	mucronata	–	L-H-L	L,M-H-L,M
Scyphiphora	hydrophyllacea	–	M,H-H-L,M,U	–
Sonneratia	alba	–	L,M-H-L,M,U	–
Sonneratia	caseolaris	M-H-L	L-H-L	–
Thespesia	populnea	H-H-U	–	–
Xylocarpus	granatum	M,H-H-M	M,H-H-L,M,U	M,H-H-M

supplemented by field verification, to evaluate these fishponds. Based on this evaluation, one can safely assume that many of the ponds are not being intensively used. The Team identified nine (9) patterns or types of fishponds as shown on Table S-3 (Fishpond Categorization Patterns). Information on the breakdown into categories may be useful to the GOP in the formulation of plans and decisions to either rehabilitate the ponds or convert them back to mangrove forests in the near future under a new Mangrove Forest Conservation Plan.

Table S-2 Land Use of the Areas

Totaling Mangrove, Fishpond and Other Areas in Aparri Area (ha / %)

	Pamplona	Abulug	Linao	BugueyW	BugueyE	S.Teresita	Total
Mangrove area total (a)	466	373	822	133	154	285	2233
Fishpond total	0	2	69	876	309	180	1436
Other area total	21	9	5	11	7	18	71
Total (b)	487	384	896	1020	470	484	3740
Mang. within Fishpond (c)	0	0	30	252	104	81	468
Total Mangrove(a+c)	466	373	852	386	258	366	2701
T. Mang (%) (a+c)/b	96	97	95	38	55	76	72

Totaling Mangrove, Fishpond and other Areas in Lamon Bay Area (ha / %)

	Binactocan	S. Cecilia	S. Angel	Tiniguiban	Basiad	Makahadok	Kabibihan	Clauag	Lopez	Total
Mangrove area total (a)	170	412	915	746	436	245	264	55	132	3374
Fishpond total	33	26	51	95	518	729	701	137	209	2500
Other area total	0	2	6	4	16	9	24	0	1	63
Total (b)	203	440	972	845	970	984	989	192	341	5936
Mang. within Fishpond (c)	22	2	8	12	49	71	153	18	51	387
Total Mangrove(a+c)	192	414	923	758	485	316	417	73	182	3760
T. Mang (%) (a+c)/b	94	94	95	90	50	32	42	38	53	63

Totaling Mangrove, Fishpond and other Areas in Ulugan Bay Area (ha / %)

	Taronayan	Tagabi.	Macara.	Bahili	Total
Mangrove area total (a)	40	242	320	189	791
Fishpond total	0	16	0	0	16
Other area total	0	1	5	0	6
Total (b)	40	259	325	189	813
Mang. within Fishpond (c)	0	4	0	0	4
Total Mangrove(a+c)	40	247	320	189	795
T. Mang (%) (a+c)/b	100	95	99	100	98

Grand Total

Aparri	Lamon	Ulugan	Grand Total
2233	3374	791	6398
1436	2500	16	3951
71	63	6	140
3740	5936	813	10489
468	387	4	859
2701	3760	795	7257
72	63	98	69

Mangrove forests are recorded on the Mangrove Forest Type Maps prepared by the Study. The Study also calculated the extent of the mangrove areas including converted Fishpond areas and nipa zone as follows: Aparri area 3740ha; Lamon Bay area5936ha; and Ulugan Bay area 813 ha.

Table S-2 provides a detailed breakdown of mangrove forest and fishpond areas by the Study areas. The Ulugan Bay area has the highest percentage of remaining mangroves while the Lamon Bay area has the highest percentage of area converted to fishponds. The Aparri area is characterised principally by nipa vegetation. Only 9% of the original mangrove habitat (including nipa area) is covered by arboreal mangrove species (type AAN). At the Ulugan Bay area 75% of the mangrove area is similar or identical to a virgin mangrove forest. Tall stands of *R. apiculata* occupy large portions of this area. In the Lamon Bay area, low height stands of mangrove forests are widely-distributed. This area is essentially a secondary or residual forest, but it is rich in mangrove species and forest types. Almost all mangrove forest types recognized in the Philippines are found at this area.

As mentioned earlier, large areas of former mangrove habitats have been converted to fishponds, especially at Buguey in the Aparri area and at Makahadok, Kabibihan, Calauag and Lopez in the Lamon Bay area. These fishponds show different patterns on aerial photographs. The team recpgnized nine (9) types of aerial photo image patterns as shown on Table S-3 -"Fishpond categorization patterns".

Type 1 fishponds are those that are apparently active and productive. However, calculations by the Study Team indicate that these Type 1 ponds only comprise an estimated 31% of the total fishpond areas within the three areas. Fishponds categorized as Type 9 consist of what appears to be newly-constructed ponds or ponds that are still under construction. Study Team calculations indicate that these Type 9 ponds account for an estimated 127 ha of the total fishpond areas. Many of the fishponds should be more thoroughly evaluated as the basis for future planning and decision-making. However, the need for mangrove forest rehabilitation and conservation is already very clear at the Aparri and Lamon Bay study areas where rapid expansion of fishponds is an unquestionable fact.

Table S-3 Fishpond Categorization Patterns

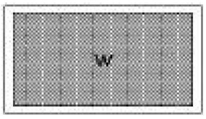
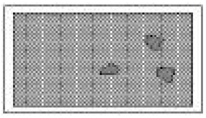
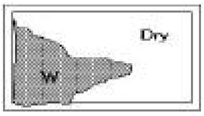
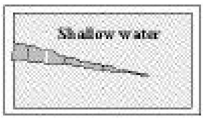
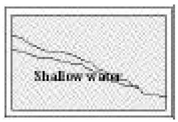
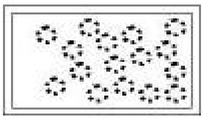
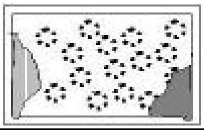
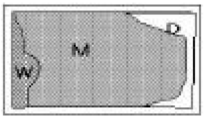
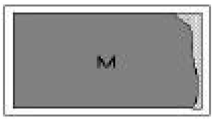
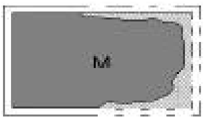
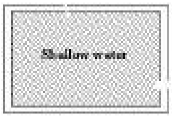
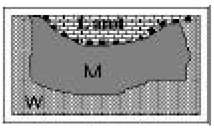
Type	Explanation	Image 1	Image 2	Image 3
F-1	Clear bank around the fishpond exists and filled with water.			
F-2	Clear bank around the fishpond exists but only less than 50% surface is covered by water.			
F-3	Clear bank around the fishpond exists and surface is covered by water but very shallow or mud mounds are developing.			
F-4	Clear bank around the fishpond exists but surface is covered with mud mounds and limited water and partly covered by vegetation.			
F-5	Clear bank around the fishpond exists but more than 50 % of surface covered by thin vegetation.			
F-6	Clear bank around the fishpond exists and water also observed but partly thick vegetation same as surrounding natural mangrove stands is developing.			
F-7	Clear bank around the fishpond exists, but surface is fully covered with vegetation, same as surrounding natural mangrove.			
F-8	Bank is not all around nor clears. Some ponds are dry, shallow water covered, and/or vegetation same condition as surrounding mangrove stands covered.			
F-9	Bank is not all around, but clear water exists in only some part. Vegetation covered is same as surrounding mangrove			

Table S-4　Total Fishpond Area of the Study Areas

Fishopond in Aparri Area

(ha)

	Pamplona	Abulug	Linao	BugueyW	BugueyE	S.Teresita	Total	Total(%)
F1	0	1	12	98	45	5	162	11
F2	0	0	6	419	45	13	482	34
F3	0	0	2	11	36	8	58	4
F4	0	0	2	4	39	76	120	8
F5	0	0	13	151	41	7	212	15
F6	0	0	17	113	45	9	184	13
F7	0	0	10	25	29	9	73	5
F8	0	0	8	51	15	29	103	7
F9	0	0	0	3	14	25	42	3
Tota	0	2	69	876	309	180	1436	100

Fishpond in Ulugan Bay Area

	Taronayan	Tagabi.	Macara.	Bahili	Total	Total(%)
F1	0	1	0	0	1	9
F2	0	0	0	0	0	0
F3	0	0	0	0	0	0
F4	0	0	0	0	0	0
F5	0	0	0	0	0	0
F6	0	0	0	0	0	0
F7	0	0	0	0	0	0
F8	0	14	0	0	14	91
F9	0	0	0	0	0	0
Total	0	16	0	0	16	100

Fshopond Total Lamon Bay Area

	Binactocan	S. Cecilia	S. Angel	Tiniguiban	Basiad	Makahadok	Kabibihan	Clauag	Lopez	Total	Total(%)	Grand Total	Gran.Total(%)
F1	0	0	11	13	246	400	272	40	72	1054	42	1217	31
F2	0	0	11	7	71	41	204	17	7	360	14	842	21
F3	0	0	3	0	87	107	21	26	43	287	11	344	9
F4	0	2	6	24	30	41	44	0	5	151	6	271	7
F5	0	0	0	1	2	2	42	0	23	70	3	283	7
F6	0	0	0	1	32	41	36	11	19	141	6	324	8
F7	3	0	0	3	2	7	28	2	17	62	2	135	3
F8	28	23	14	46	37	52	40	33	18	290	12	407	10
F9	3	0	6	0	10	37	15	8	6	85	3	127	3
Tota	33	26	51	95	518	729	701	137	209	2500	100	3951	100

The socio-economic objective of the Study was mandated to assess the condition of the human activities in the Mangrove areas, paticularly their actual use of Mangrove by the people, and also their intention toward the conservation of Mangrove forest. The Survey on this socio-economic aspect was conducted by two activities; 1) General Socio-economic Survey, by obtaining information from Barangay Captains and/or other Barangay Officials of all Barangays in the three Study Areas regarding general condition of the Barangay and use condition of Mangrove forest, 2) Socio-economic Survey, by interviewing 200 household heads sampled in each Study Area (total 600 household heads).

The summary of the Study results on the socio-economic aspect is as follows:

1) Aparri Area

The Barangays located within the Study Area consist of average three hundred (300) households, and these households have an average 5.4 family member per household. In most of Barangays surveyed, Nipa gathering is one of the biggest source of income. Various vegetables are planted which are limited in volume and are mainly for the purpose of domesic-consumption. As for the fishery products, shrimps, crabs and Tilapia are commonly observed in this Area. The labor force in this Area consists of 38.6 percent in fishery sector, and 11.3% in agricultural sector. The average monthly income in this area during the survey period was 4,917.50 Pesos.

In the Barangays within this Area, selling Nipa leaves is the major source of income source. Therefore, the land owners of these Nipa areas have permits (valid for one year, extendible) from DENR and employ people/laborer for collecting/cutting Nipa leaf. Many fishponds exist in this area which were converted or being converted from Mangrove/Nipa forests, however, most of them are registered as private land permit (Conversion Permit). There is only one (1) existing Fishpond Lease Agreement in the Barangays surveyed.

In this Area, both number of people entering Mangrove area and people presently using Mangrove are observed as the largest among three Study Areas, thus, it is considered that the use of Mangrove tree as the source of firewood is common practice in this Area. Since the remaining Mangrove trees are scattered within the Nipa forest, people may be cutting Mangrove trees when they enter and cut Nipa tree which is the major source of income. The existence of limited number of people who have negative sense on Mangrove cutting, and the fact that many people granting Mangrove cutting as the way to improve their income, may be also reflecting this practice. As for the reason, it is considered as the limited knowledge of legal prohibition on Mangrove cutting, less remembering discussions with government officials regarding Mangrove conservation. In spite of the much knowledge of people on the benefit of Mangrove as the prevention method against natural disaster (high tide and strong wind), it might be concluded that the present use condition of Mangrove will be continued in the future, in consideration of present situation above.

2) Lamon Bay Area

The Barangays located within the Study Area consist of an average of less than two-hundred (200) households, and these household have average 5.0 person of family member per household. Coconuts (copra) is one of the biggest source of income, followed by rice production, fishery, and Nipa gathering. The labor force consists of 33.8% percent in fishery sector, and 26.8 % in agricultural sector. An average monthly income in this area was 5,560.68 Pesos during the survey period.

Under the Coastal Environment Program (CEP), Mangrove Reforestation Projects have been implemented by contracting with local/outside NGO to plant Mangrove trees. Among eight (8) contracts, five (5) were completed (3 Projects by ADB finance) and the planted areas were transferred to DENR for the protection and maintenance (70 to 100 ha each). Many fishponds exist in the area which were converted from Mangrove forest, and the percentage of fishponds area occupying in total land area is relatively high compared with other two Study Areas. For example, total hectares of fishponds in the Municipality of Calauag is 2,690 ha which corresponds 6.35% of the total area of the Municipality. Many of these fishponds are not in use mainly due to the damage brought by Typhoon “Rosing” which brought huge damage to this area in November 1995, and also due to the shortage of fund for management. To determine whether these fishponds are just inactive or abandoned, it is necessary to survey on the use condition of fishpond, legal status, ownership, status of mortgage by bank, and absentee owners who are presently outside the Area or abroad.

In this Area, both the number of people observed as entering Mangrove area and presently using Mangroves were not so many as compared to other Areas, and also people have much knowledge on the legal prohibition on cutting Mangrove trees. These facts are supported by the fact that may people have negative sense on cutting Mangrove trees and not so many people are granting Mangrove cutting as the way to increase their income. However, many people showed intention to have their own fishponds in this Area. In consideration also with the fact that few people recognize the importance of Mangrove forest as protection against natural disaster, there will be a possibility of increase on the volume of Mangrove cutting in the future, in case present knowledge and recognition of people toward prohibition of Mangrove cutting decreases, or rapid increase of commercial value of fishery products from brackish water fishculture in the

Area.

3) Ulugan Bay Area

The Barangays located within the Study Area consist of an average of two-hundred thirty (230) households, and these household have average 5.3 person of family member per household. Fishery is one of the biggest source of income, followed by rice production. However, agricultural product is mainly for the self-consumption and they bring their products to the market only when they are able to have excess. Main fishery product is brakishwater fish such as Kalapato. The labor force consists of 32.4% in fishery sector, and 21.8 % in agricultural sector. The average monthly income was 4,946.90 Pesos during the survey period.

On June 1992, Republic Act 7611 was signed for the establishment of the Strategic Environment Plan (SEP) for Palawan. This Plan set up the policy on the conservation of Palawan's environment as a precondition to any development projects, by establishing Palawan Council for Sustainable Development (PCSD). Furthermore, the Provincial Government of Palawan has declared "Bantay Palawan" in March 1993, for the intensive control on illegal logging and illegal fishing in entire Palawan Province. Under such circumstance of environmental protection movement in the Province, Coastal Environment Program (CEP) is being implemented since 1993 in Ulugan Bay, and some cooperatives/corporation of beneficiaries has been organized and entitle into contract with DENR for planting tree, research, technical training and activities for environmental protection. There is only one (1) existing 50 ha fishpond for Prawn at Barangay Tagabinit in Ulugan Bay Area which is under Fishpond Lease Agreement (FLA), however, since new application for FLA was no longer accepted after 1989, there has been no legal conversion of Mangrove forest into fishpond. There is also existing one (1) Mangrove Stewardship Agreement in Barangay Bahile, and two (2) Mangrove Reforestation Projects, 100ha each in Barangay Bahile and Macarascas in this Area.

Environmental protection, which is the most emphasized policy in Palawan province, is desseminated to the community through information activities by the officials of the Agencies concerned. This is also supported by the frequent discussion between government officials and local people in this Area on the Mangrove conservation, and many people's understanding on the general environment protection movement. However, the people who are entering

Mangrove area and presently using Mangrove are not few. It may be considered that the present information drive can be more effective if the direction will be oriented on the viewpoint of community level to create more sound knowledge on the significance and background of legal prohibition on Mangrove use. In consideration of the factors, such as people commonly using the Mangrove in the past, with future intention of Mangrove use, as well as many people are granting Mangrove cutting as the way to increase their income, it is important to continue present efforts of the Agencies concerned on the information activities regarding protection and conservation of Mangrove resources in this Area.

The Philippine side shall continue to conduct surveys on mangrove forests in other areas in the Philippines using the survey methods used in the Study. Thus, the study team has prepared technical manuals for the interpretation of aerial photographs, field surveys of mangrove forests, and effective use of GIS.

(3) Recommendations

The Philippine side will formulate specific conservation and management plans for mangrove forests using the results of this Study, which was attained with the latest actual conditions of mangrove forests. In formulating such plans, the planners should consider following points:

1) Defining mangrove forests under land use plans

a. It is necessary to instil common understanding concerning the extent of mangrove forests covered by conservation plans. It is appropriate to define mangrove forests as areas covered by sea water at the time of spring high tide, not as areas covered by distinguishable mangrove species such as *Rhizophora*.

b. It is necessary to limit governmental support to facilitate fishpond rehabilitation or recovering except the fishpond located in upper middle to lower high inter-tidal zone. As for fishpond in low inter-tidal zones, land use plans should basically consider the possibility of restoring them to mangrove forests, except for those used for small holders of the seaside villagers.

2) Supply of mangrove woods

Under mangrove forest management plans, it is difficult to conceive supplying mangrove lumber on a commercial basis. However, supply for seaside villagers for fuel use should be considered. For the conservation of mangrove forests, the planners should consider how to supply substitute lumber/fuel wood with afforestation activities on other mangrove forest areas as well, so as to reduce the degree of dependence on mangrove forests.

3) Mangrove re-afforestation

Re-afforestation may be the key to Mangrove Management and Conservation plans. High percentages of the target areas for mangrove re-afforestation are located in high inter-tidal zones and abandoned or less used fishponds than in low inter-tidal zones along the coastline. In the former zones, direct seeding of *Rhizophora*, a commonly applied technique, is difficult to suceed. Thus, species diversification, and new planting techniques to be introduced and it's extension efforts are requested.

4) Who should take charge of conserving mangrove forests?

Seaside villagers should take charge of conservation activities for mangrove forests, and those who have been using mangrove forests need to be organized. To this end, it is necessary to identify the benefits these people will gain by participating in conservation activities. A swap system should be introduced in which participants in mangrove conservation activities will be given a guarantee of a certain concession for mangrove forests, or support for activities in land areas aimed at realizing cash income or alternative source of mangrove woods.

5) Institutional requirements for promoting re-afforestation activities

Various rules and agreements are required to assure seaside villagers' participation from the planning stage and to make it easier for villagers' organizations to work, so that seaside villagers will be able to join the conservation activities for mangrove forests. To support seaside villagers' group activities, institutionally as well as technically, a support committee should be established which will involve relevant administrative bodies and local governments.

I Objectives and Scope

1 Background

The Philippines is an island nation (an archipelago) with a total coastline of about 17,500 km. In the 1920s, mangrove forests covered an estimated 500,000 ha and were extensively distributed throughout the country. Mangroves played an important role in reducing damage by natural disasters and maintaining coastal ecosystems, while also making significant contributions to forestry and fisheries production.

Beginning in the 1950s, the Government of the Republic of the Philippines (GOP) adopted policies designed to accelerate the development of brackish-water fish and prawn farms. These policies led to the rapid conversion of mangrove forests into fishponds, in contrast with the modest pace of conversion that had been on-going for many decades. In the 1980s, an unprecedented boom in prawn exports accelerated such conversion and development. Additionally, rapid population growth increased the demand for firewood, charcoal and other forest products found in mangrove ecosystems. Clearing of coastal areas to make room for settlements and industry also contributed to the loss. As a result of these combined factors, there has been a drastic reduction in mangrove forest cover. Data from the Forest Management Bureau (FMB) of the Department of Environment and Natural Resources (DENR) reveal that by 1993 the area of mangrove forests had decreased to approximately 123,000 ha.

Because of this rapid decline, the GOP has promulgated new policies and regulations, and initiated new programs designed to conserve mangrove forests. One such initiative is the Coastal Environment Program (CEP), launched in the second half of the 1980s. Sustainable management, rehabilitation, protection and conservation of mangrove forest resources are important components of the CEP. However, the lack of adequate information necessary for effective reforestation and management is a major obstacle in CEP implementation and a constraint to the orderly development of other projects envisioned to pursue the same or similar goals. In October 1995, the GOP requested The Government of Japan (GOJ) to help address this problem by carrying out a development study intended to provide useful information for the protection/utilization of coastal resources and the management of mangrove forests.

In response to the GOP request, the GOJ, through the Japan International Cooperation Agency (JICA), dispatched a first preparatory study team in July 1996 and another preparatory study team in February 1997. On February 19, 1997, the JICA preparatory study team headed by Mr. Yasuyuki Yanagisawa and the DENR through its National Mapping and Resource Information Authority (NAMRIA) signed an Implementing Arrangement (I/A) on Technical Cooperation for "The Study on Mapping and Land Cover Assessment of Mangrove Areas in the Republic of the Philippines". This report documents the activities carried out by the JICA in response to the above-mentioned request.

1-1 Objectives of the Study

The principal component of the study is a survey of mangrove forest resources in the Philippines, with the intention of contributing to their proper management. Focusing on three (3) specific areas, the purposes of the study are to (a) identify mangrove areas and their structures, (b) prepare mangrove forest land use maps and (c) establish a Geographic Information System (GIS) database covering these areas. The Study also includes preparation of a manual on the use of aerial photography for the continuous survey of other mangrove areas in the Philippines by the technical staff of the concerned departments, agencies and other authorities of the GOP.

1-2 Study Areas

The Study covered approximately 10,000 ha of mangrove forests, located in Aparri, Cagayan Province (Region II), Lamon Bay, Quezon Province (Region IV) and Ulugan Bay, City of Puerto Princesa, Palawan Province (Region IV). These Study areas are specifically identified on the map attached to the I/A signed on February 19, 1997. The areas extend within the thick coastlines drawn on the map. They are identified as mangrove forests on the Land Use Forest Type Map that was an output of the "Information System Development Project for the Management of Tropical Forests", a collaborative effort of the Forestry Agency of Japan, the Japan Forest Technical Association and the DENR.

2 Overview of Activities

The Study was designed to obtain data that will be useful in the formulation and future implementation of mangrove forest management plans in the Philippines. In this context the Study, *inter-alia*, examined and recorded detailed information on the current status of Mangrove forests in the three (3) Study areas, paying special attention to the following matters :

- Identification of ecological characteristics;
- Assessment of the effects of human activities;
- History of treatment of mangrove forests;
- Multiple functions of mangrove forests including benefits obtained by users and beneficiaries of these resources; and
- Identification of socio-economic conditions in areas adjacent to mangrove forests, including traditional use of the resource.

The Study was implemented in two phases (Phases I and II). The main activities of each Phase are summarized below.

(1) Phase I: November 1997 to October 1998.

Activities in this Phase included (i) preparatory work in Japan, (ii) first study in the Philippines, (iii) first compilation/interpretation work in Japan, (iv) second study in the Philippines and (v) second compilation/interpretation work in Japan. The principal tasks were as follows:

a. Aerial photography with a small format camera (Panchromatic/photo-scale; 1:20,000)
b. Preparation of uncontrolled mosaic photographs (on a scale of 1:10,000)
c. Design and development of a GIS for data base management
d. Conduct of field surveys at the study areas
e. Preparation of standards for interpretation of the aerial photographs.

(2) Phase II: November 1st 1998 to July 1999

Activities in this Phase included (i) the third study in the Philippines, (ii) third compilation/interpretation work in Japan, (iv) fourth study in the Philippines, and (v) fourth compilation/interpretation work in Japan. The principal tasks were as follows:

a. Interpretation of the aerial photographs covering the study areas
b. Preparation of mangrove land use maps (on the scale of 1:10,000)
c. Preparation of a data base for GIS
d. Development of a manual for the survey of resources in mangrove areas.

The framework of the study consisted of four (4) inter-related sets of activities as shown on the left side of the Flow Chart presented in Figure 1-1. The first set included aerial photography covering the three Study areas, preparation of mosaic photographs for use in the preparation of the base map, and preparation of land use maps.

It is noted that the Flow Chart indicates a second set of activities (GIS) directly under the first set (aerial photography). This sequence of presentation on the Flow Chart reflects the close inter-action between work in aerial photography and preparation of a (GIS). However, the GIS work was actually an iterative process, dependent on production of data by the other sets. These data included Mangrove Forest Classification Maps, a Mangrove Forest Inventory Book, and a Data Book of Surveyed Barangays (i.e. socio-economic data), all of which were incorporated in the GIS. In other words, preparation of a GIS started early in the process, but was only completed after all data was compiled from the first set (aerial photography) and the third and fourth sets of activities described below.

The third set of activities dealt with pre-interpretation of the aerial photographs to identify typical distribution patterns of the mangrove vegetation from the seaward boundary of mangroves to the dry land above the high tide lines. Additionally, transect surveys were conducted to facilitate correlation between mangrove zonation patterns appearing on the photographs and inter-tidal locations. These surveys were also the methodology used to verify the different types of mangrove forest stand structure, including species, height, density of the stands (i.e. approximate number of trees) and crown density. The information derived from transect surveys, plot surveys and natural condition surveys was analyzed and then compared with results from pre-interpretation of the aerial photographs. Subsequently, a final interpretation of the aerial photographs was conducted and mangrove forest type maps were prepared.

The fourth set of activities indicated on the Flow Chart consisted of socio-economic surveys to study the relationship of local people with the mangrove forests, including the benefits they derive from mangrove ecosystems.

Each set of survey activities is explained briefly below. The detailed procedures and methods are described in Appendix-1, attached to this report.

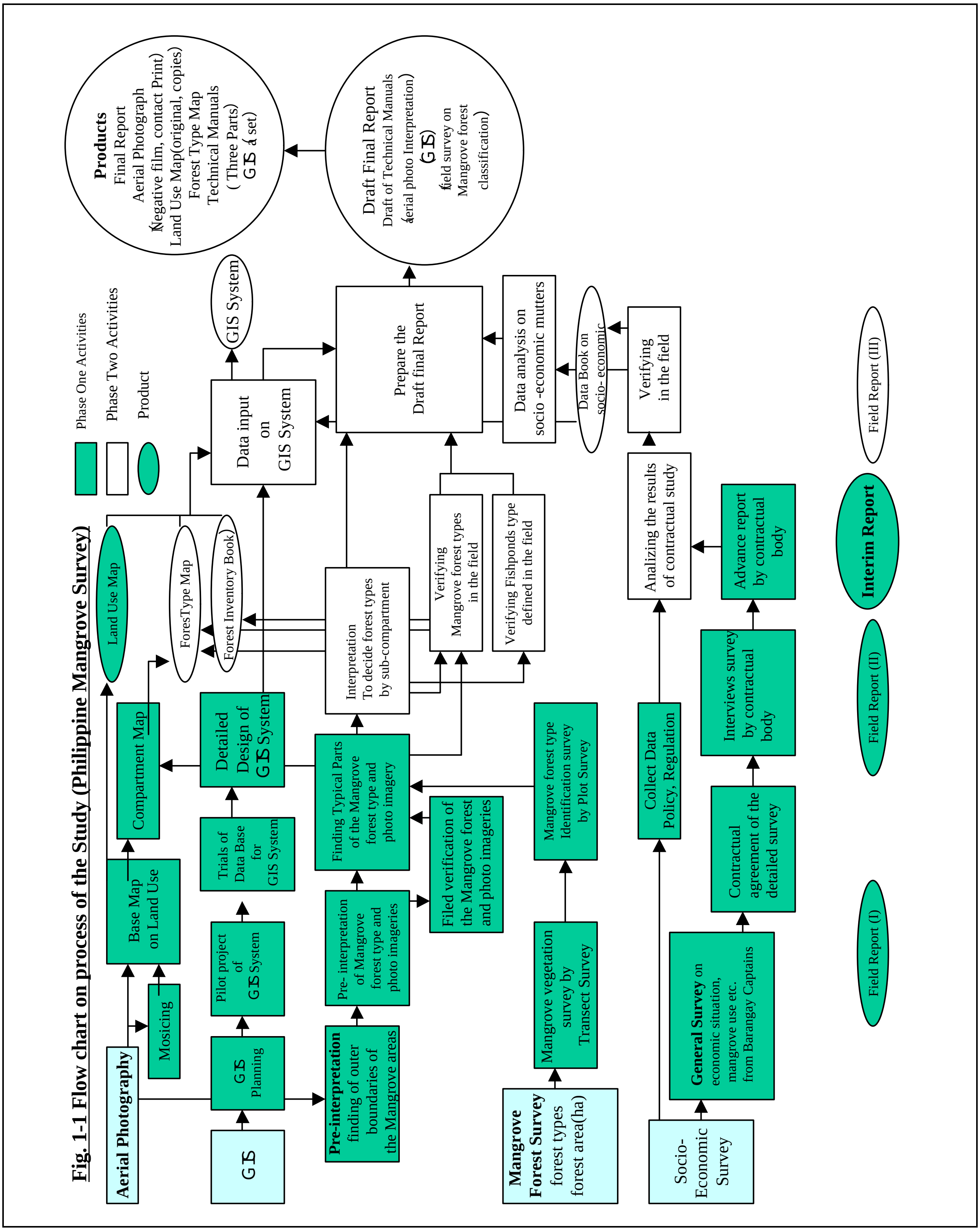


Fig. 1-1 Flow chart on process of the Study (Philippine Mangrove Survey)

2-1 Aerial Photography, Photo-mosaics, and Preparation of Land-use Maps

Aerial photographs were taken with a small-format camera (HIEI SE-II) with 120 mm focal length lens, mounted and flown in a Cessna U206 single engine aircraft.

Photographs were taken on a scale of 1:20,000 and the effective Screen Size was 115mm×115mm. Thus, the formulae for establishing the flight plan were as follows:

Altitude:	120mm×20,000	= 2,400m
Spacing:	115mm×20,000×0.3	= 920m (30% sidelap)
Exposure interval:	115mm×20,000×0.7	= 1,610m (60% overlap)

Aerial photography was carried out in 1998 from Feb. 11-14 at Lamon Bay, Feb.21-27 at Aparri, and Mar. 9-12 at Ulugan Bay. All-in-all, three hundred thirty-five (335) sheets of aerial photographs were produced; 169 covering the Lamon Bay area; 120 covering the Aparri area; and 46 covering the Ulugan Bay area.

Uncontrolled Mosaic Photographs were developed as the principal source of information for the preparation of Base Maps. NAMRIA's existing 1:50,000 scale topographic maps were enlarged to a scale of 1:10,000 to match the scale of the photo mosaic sheets.

Planimetric maps were prepared on a 1:10,000 scale as the Base Maps of respective thematic maps, such as forestry map and land use map. The Base map was drawn from a total of twenty-two (22) sheets; (Aparri area 7, Lamon Bay area 12, and Ulugan Bay area 3).

2-2 Identification of the Mangrove Forest Typology

Mangrove forests are distributed worldwide within the range of 20 ° C isotherms. The global mangrove distribution pattern is divided into two regions; (a), Indo-Pacific and (b) Africa to Latin America. Within the Indo-Pacific region, Southeast Asia is one of the richest areas in terms of mangrove species. Within Southeast Asia, the Philippines ranks as one of the highest in terms of mangrove species diversity.

In order to accurately identify mangrove forest types in the Study areas, it was necessary to examine mangrove vegetation types or associations in the Philippines, and to clarify where these types/associations are located *viz-a-viz* land conditions and inter-tidal levels. To gather this important data, the Study team, in collaboration with NAMRIA and DENR field offices, conducted transect surveys at each Study area. The transect survey lines started at the sea ward fringe to the border of the mangroves on the landward fringe. The lines ranged in length from 200 to 400 meters

(m) and in width from 1 to 2 m, adjusting to the different mangrove forest conditions. Four (4) transect survey lines were run at Ulugan Bay area, four (4) at Lamon Bay area and three (3) at Aparri area.

The transect surveys produced a wealth of basic information on (a) the correlation between the changing patterns of inter-tidal levels and the changing patterns of mangrove vegetation, (b) species composition and distribution on the land ward fringe, the intermediate inter- tidal zone, and the outer seaside fringe at each Study areas, and (c) other valuable data.

2-3 Pre-interpretation of Aerial Photographs

Among others, the purpose of pre-interpretation was to arrive at a tentative classification of mangrove forest types, tentatively delineate the outer boundaries of these forests, and tentatively determine land use conditions on the surrounding areas (i.e. the on-land borders) of the mangroves. Towards these ends, the aerial photographs were carefully examined and the areas covered by photographic sheets were roughly divided into groups or parts having similar color tones, shapes, sizes and patterns. In conducting this pre-interpretation work, the Study team concurrently utilized information obtained from the transect surveys, field observation and existing data from various reports. Figure 1-2 presents a sample of outputs from this process. The image on the left side of Figure 1-2 shows the appearance of the aerial photograph prior to pre-interpretation. The image on the

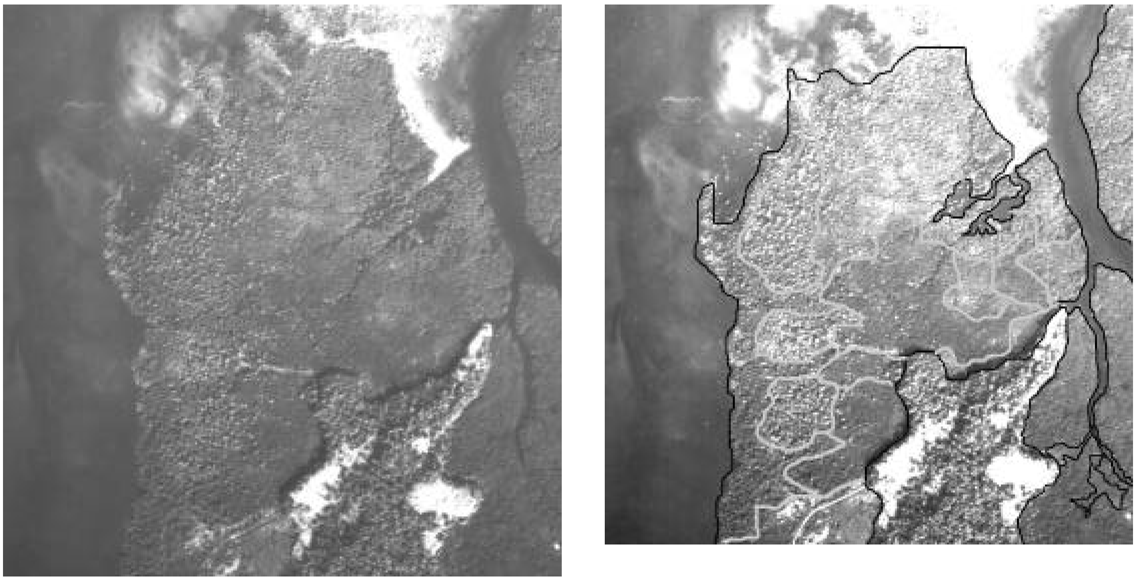


Fig. 1-2 Sample of Pre-interpretation Process

right side shows lines dividing the area into various groups or patterns.

2-4 Examining the Structure of Mangrove Forests and Other Factors

The results of pre-interpretation present a tentative overview of actual conditions. Where different patterns or groups are easily observed, this overview can be quite accurate. However, differences are not always apparent. For example, on the photographs of the Aparri area it was often difficult to delineate the borderline between mangroves growing in the high inter-tidal zone and other vegetation growing on the adjoining land above the high tide line. To deal with these types of uncertainties, supplementary work was essential. Therefore, after completing pre-interpretation, the Study team conducted extensive field verification including the establishment of forest survey inventory plots.

The forest survey inventory plots were established to examine the forest structure. Plots ranged in size from 200 m^2 to 800 m^2, depending on mean tree height. The plots were distributed throughout the study areas based on the results of pre-interpretation, taking into account the size (i.e. area coverage) of various groups, their locations, differences in tidal levels, and accessibility for efficient conduct of the inventories. Data obtained from the inventories records the number of trees in each plot, diameter at breast height (DBH) of all trees with DBH higher than four centimetres (4cm), dominant species and crown density by layer (high, middle, low). Five(5) plots were established and examined at Aparri area, twenty-five (25) at Lamon Bay area and twenty-one (21) at Ulugan Bay area. The Study team prepared tentative calculations of volume (i.e. cubic meters) for large-sized trees. However, this data was not used to estimate total standing volume. In this Study, volume estimation was not requested, nor was it particularly relevant, since the planning process focuses on conservation, protection and rehabilitation rather than timber production.

After completing this field work, the tentative lines previously drawn on the photographs (e.g. Figure. 1-2 above) were modified or amended as appropriate to reflect actual conditions. Then the lines were fixed.

2-5 Dividing into Compartments and Sub-compartments

Standard procedures in the preparation of a Forest Management Plan usually begin with division of the whole forest area into compartments and sub-compartments. This facilitates implementation by creating manageable size units. Each compartment is given a name. The location (address) of each compartment is indicated on a map. Generally, compartments range in size from eighty (80) to one hundred (100) hectares. However, this is not a fixed standard. The size of compartments will vary depending on forest conditions and management policies of the implementing agency.

Sub-compartments are basically smaller units within a compartment that will receive the same or very similar sets of silvicultural treatments pursuant to the management plan. Generally, sub-compartments are established on contiguous areas with more-or-less uniform stand structure such as dominant species, planted age (in the case of plantations), similar tree height, and similar biological conditions.

In the Study, the division into sub-compartments was based on the mangrove forest stand structure as observed on aerial photographs. In addition to dividing into basically similar units as discussed in the previous paragraph, two other criteria were used to set the size of sub-compartments: (a) they should be large enough to identify on a 1:10,000 scale map (at least 1 X 1 cm being the average lower limit of a small sub-compartment) and (b) there should not be too many sub-compartments except.

The different steps followed to divide into sub-compartment are summarized below.

a. First the Study areas were chosen (Aparri, Lamon bay, and Ulugan bay).
b. Each areas was divided into several Zones based on municipal boundary.
c. Each zone was divided into several compartments based on topographical lines such as a river or road, or other easily recognizable objects/ construction.
d. Each compartment was divided into sub-compartments.
e. Each sub-compartment was given a name or code; M-1 to M-n for Mangrove forests; F-1 to F-n for Fishponds, N-1 to N-n for Nipa areas, and O-1 to O-n for Other land uses.

2-6 Survey of Natural Conditions

Mangroves grow in areas affected by brackish water. Generally, these areas appear to be flat and more-or-less similar. In reality however, there are distinct differences in terms of soil, substrate, exposure to sea, inter-tidal factors, impacts of rivers and so on. As a result of these differences, more than forty (40) species of mangroves have evolved in the Philippines. These differences are usually reflected in the species composition and grouping of species. For instance, *Rhizophora apiculata* is usually found near the shoreline, *Avicennia officinalis* tends to be spread over wider areas and *Heritiera littoralis* is found on or near the land ward fringe.

The Study team conducted micro-level research surveys at each area to examine the relationship between mangrove species distribution and land or natural conditions (i.e. soil, substrate, etc.).

The examination of Natural conditions consisted of the following items:

a. Soil survey: - Chemical and physical analysis of the soil, soil depth, thickness and texture, organic matter including humus, mixture of gravel and/or pieces of shells and coral, and moisture.
b. Properties of the brackish water survey: - PH, salinity, and oxidation-reduction potential.
c. Tidal level: - Duration of submergence.

2-7 Socio-economic Conditions

The socio-economic aspect of the Study was tasked to grasp the condition of the human activities of the people in the Mangrove areas, especially on the condition of actual use of Mangrove by the people, and also their intention toward the conservation of Mangrove forest. The Survey on this socio-economic aspect was conducted by two activities; 1) General Socio-economic Survey, by obtaining information from Barangay Captains and/or other Barangay Officials of all Barangays in the three Study Areas regarding general condition of the Barangay and use of Mangrove forest, 2) Socio-economic Survey, by interviewing 200 household heads sampled in each Study Area (total 600 household heads) regarding detailed information on their living condition, Mangrove use and their intention on Mangrove conservation. The detailed methodology is described in Chapter 3 of this Report.

General Socio-economic Survey was conducted mainly during the First Study in the Philippines, and conducted in 77 Barangays located within the coverage area of aerial photographs.

For the Socio-economic Survey, questionnaire and draft tabulation sheet was made during the Second Study in Japan, and the actual interview survey was conducted on sub-contract basis during the Second Study in the Philippines, by using said questionnaire. During the Third Study in the Philippines, field verification work on the result of interview survey was conducted, at the same time analysis on the result was made during this period.

2-8 Geographic Information System (GIS)

Results from all the studies and activities discussed above were installed in a GIS database. These included the Base Maps, Compartment and Sub-compartment Maps, Mangrove Forest Inventory Book, Data Book of surveyed Barangays (socio-economic data), and Photographs of the mangrove stands and adjacent areas. Planners may now utilize the GIS to analyze and evaluate tentative management plans and conduct simulation exercises to assess possible impacts of various strategies.

ARC VIEW 3.0 by ESRI was the basic software selected for GIS development and application, using a PC operated on Windows NT 4.0 as the hardware. AVENUE was the computer language employed for use with ARC VIEW 3.0.

II Result and Discussions

1 General Observation

1-1 Natural and Socio-economic Condition of the Philippines

1-1-1 Natural Condition

(1) Location and Area

The Republic of the Philippines consists of more than 7,000 islands. The northernmost point of the archipelago is Y'ami Island in the Batan Islands Group. Y'ami is at latitude 21°25'N close to the southern tip of Taiwan. The southernmost point is Sitangkai Island in the Sibutu Islands Group situated at latitude 4°23'N off the northeast shore of Borneo. The distance between the northernmost and southernmost islands is approximately 1,800 km. The easternmost point of the Philippines is Baganga town in the Province of Davao Oriental located at longitude 126°35'E on Mindanao, the second-largest island of the country. The westernmost point is Balabac Island situated at longitude 116°53'E at the southern end of the Palawan Islands Group. The distance between the eastern and western extremes is approximately 1,100 km. The main islands are Luzon, Mindanao, Palawan, Samar, Leyte, Bohol, Cebu, Negros, Panay, Masbate and Mindoro.

The total land area of Philippines is approximately 300,000 square kilometers (km^2), or about thirty million hectares (30.0M ha). With a coastline longer than 13,000 km, the country has many inlets and small bays. Large bodies of territorial waters include the Davao Gulf, Moro Gulf, Babuyan Channel, Mindoro Strait, Surigao Strait and large inland seas such as the Visayan Sea, Sibuyan Sea and Sulu Sea. The territorial waters of the Philippines are much larger than the land area. These waters cover approximately 1,510,000 km^2 or about 151.0 million ha.

(2) Climate

With it's northernmost location at latitude 21°25'N, the Philippines is situated in the low latitudes of the Northern Hemisphere. Average monthly temperatures throughout the year do not drop below 20°C except at high elevations. Thus, the Philippines is included in the tropical climatic zone. The hottest month is May with an average temperature of 28.4°C. The coolest month is January with an average temperature of 25.5°C. The average annual temperature is 27.1°C.

Climatic divisions of the Philippines are described according to the types or amounts of rainfall that occur. The three main sources of rain are monsoon, tropical cyclones and the inter-tropical convergence zone.

There are two types of monsoon, rain, the southwest and the northeast. The southwest monsoon blows from May to October and the northeast monsoon from November to April. During each monsoon, the windward area in front of a mountain range experiences rainy weather while the downwind area tends to experience generally dry weather. Mountain ranges in the Philippines generally run in a north-south direction. Consequently, the west coast region experiences rainy season when the southwest monsoon is dominant. In contrast, most of the rainfall in the eastern coastal areas occurs during the northeast monsoon.

Tropical cyclones (typhoons) originate as low pressure areas in the seas near the Marianas Islands which lay far to the east of the Philippines. This area is sometimes referred to as the "birthplace of typhoons." On the average, approximately thirty (30) low pressure areas enter the Philippines each year, usually from June to November. As they move westward, some develop into typhoons. The typhoons bring heavy rainfall accompanied by strong winds usually affecting a broad swath of the country ranging from the northern Philippines to northern portions of the Visayan Islands. On the average, about 20 typhoons strike or pass near the Philippines annually, mostly during the three months from July to September, but sometimes as late as December or January.

The inter-tropical convergence zone is that point on the globe where tradewinds from the Northern Hemisphere meet and merge with tradewinds from the Southern Hemisphere. In the skies above this convergence zone, ascending air currents develop into cumulonimbus clouds during the heat of the day. Subsequently, a reversal of atmospheric currents takes place causing heavy rains to fall. The inter-tropical convergence zone moves southward as far as Java Island during the winter months and moves back northward toward summer. Around May, it emerges in the southern region of the Philippines, continues northward and reaches the skies over the East China Sea in July. Thereafter, it once again heads south and leaves the Philippine skies around October. Meanwhile, the inter-tropical convergence zone brings heavy daily rainfall over various parts of the country.

On a national scale, tropical cyclones (typhoons) account for about 47% of the total rainfall, while 39% is attributed to the inter-tropical convergence zone and 14% to the monsoons. Although the tropical cyclones are a major climatic factor, the winds associated with these events do not usually cause extensive damage on the island of Mindanao nor in the Sulu Islands group.

Climatic conditions in the Philippines are generally divided into four major types, each combining in varying degrees the impacts of monsoons, tropical cyclones and the inter-tropical convergence zone.

The first type has clearly-distinct wet and dry seasons. Heavy rainfall occurs from May to October owing to the overlapping effects of the monsoons, the period of tropical cyclone activity and the inter-tropical convergence zone. Beginning around November, the weather turns progressively more dry each month until April of the following year. Quite often, no rains occur from January to April. This type is referred to as the West coast climate and characterizes the climatic patterns on the western and southern sides of the mountain ranges.

The second type has frequent rainfall all year around with virtually no dry season. This climatic type is observed over the eastern region of the Philippines facing the Pacific Ocean and is referred to as the East coast climate. This region generally has the highest amount of rainfall in the country. Rains normally occur throughout the year becoming particularly strong in January and February. As a rule, there is minimal or no overlapping of monsoons, tropical cyclones and the inter-tropical convergence zone.

The third climatic type has a short dry season, lasting from one to three months. This is an Intermediate climatic type (I) between the West coast and the East coast types. However, it is more similar to the West coast type because it has a dry season. This type is observed in the Cagayan valley in Luzon Island and in some parts of the Visayan Islands.

The last type has year-round rainfall and little distinction between the dry and rainy seasons. This is also considered an Intermediate type (II) between the West coast and East coast climatic types. However, it is more similar to the East coast climate because it has no distinct dry season. This climatic type is distributed over the areas adjacent to the regions falling within the East coast climatic type.

The climatic divisions of the Philippines are shown on Figure 2-1-1.

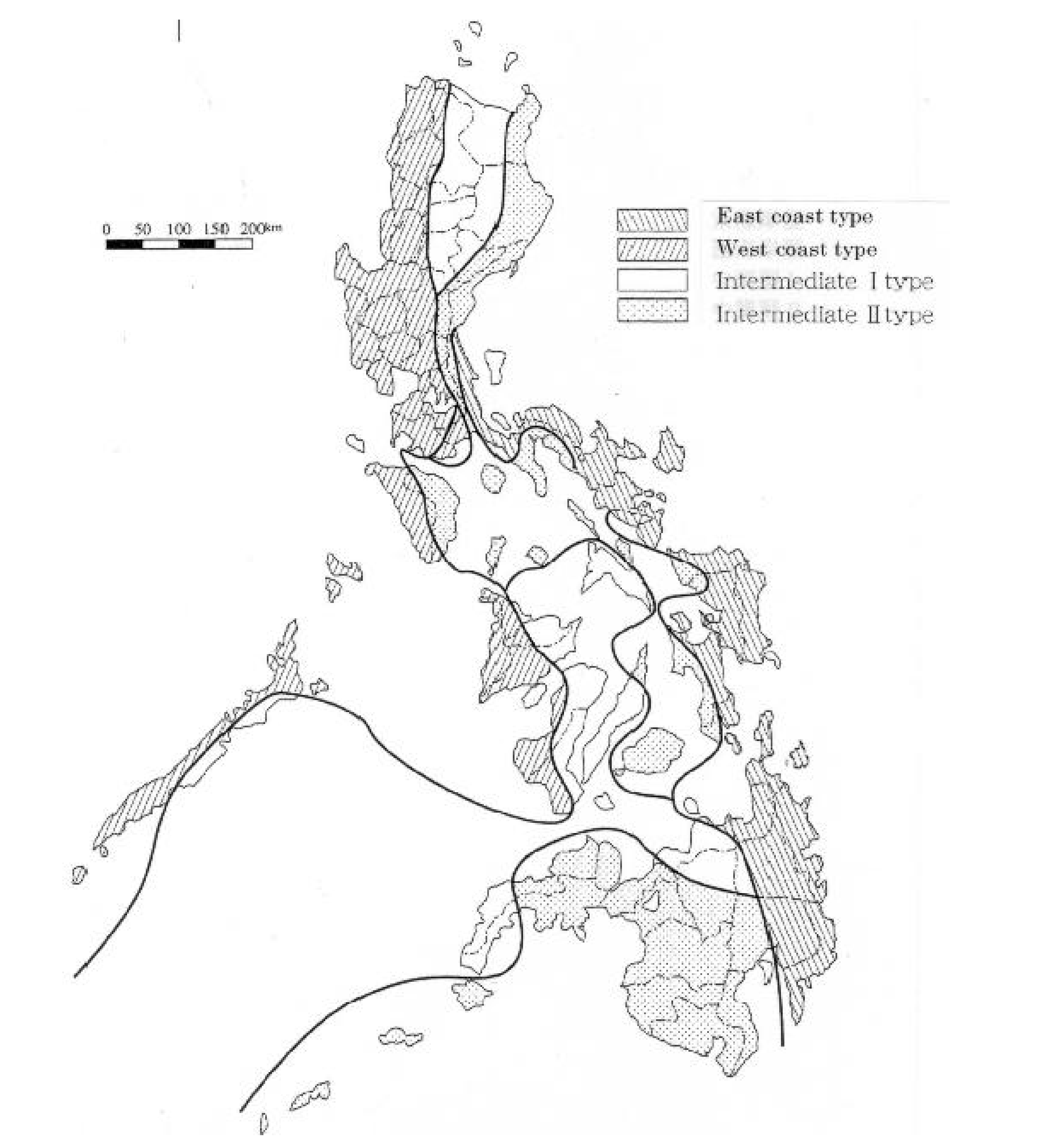


Fig. 2-1-1 Climatic Division in the Philippines 1_/

(3) Topography

The Philippines may be described as an island arc curving toward the east (Figure 2-1-2). Off the eastern side of the arc, an oceanic plate and a continental plate collide just as in the case of the Japanese Islands. Where the two plates collide, so-called subduction occurs with the oceanic plate thrusting its way under the continental plate. Consequently, a trench has developed along the subduction zone, creating a non-volcanic outer arc to the west, a volcanic inner arc and the sea further to the west. In this manner, the characteristic Philippine islands arc was created.

The collision between the Philippines sea plate and the Asian continental plate is the most significant subduction area in the seas near the Philippines. Along the collision boundary of the two plates, the Philippines Trench has been formed. The non-volcanic outer arc lies on the side of the continental plate and is referred to as

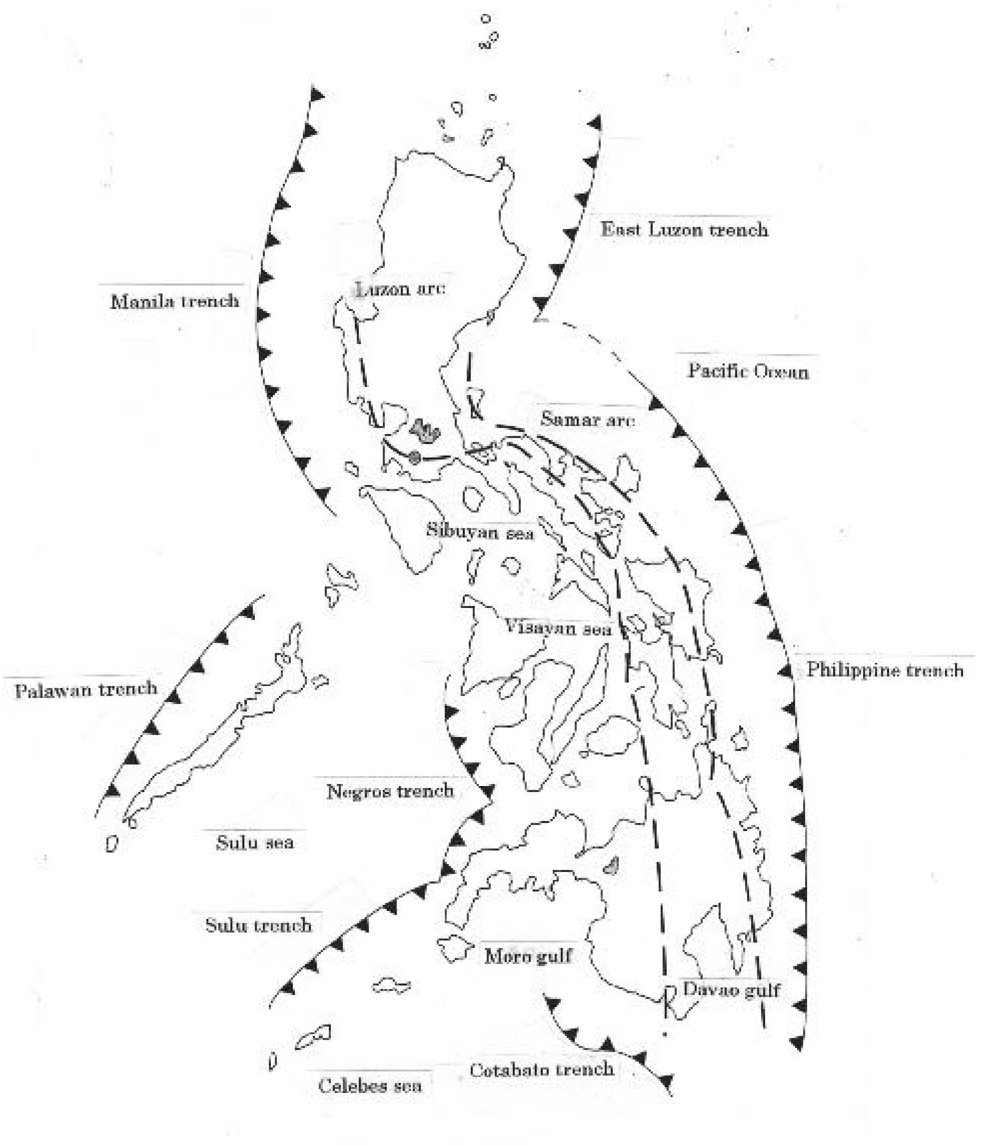


Fig. 2-1-2 Tectonics in the Philippines 2_/

the Samar arc. This arc runs from the Polillo Islands, through the Caramoan Peninsula, Catanduanes island and Samar island, to the Diwata Mountains in Mindanao. The volcanic inner arc runs along the inside of the outer arc and is referred to as the Luzon arc. This arc passes from the Zambales Mountains, through the Bataan Peninsula, the southern Tagalog region, the Bicol Peninsula, Camiguin island and the Mindanao Central Highlands to the Bukidnon plateau. To the west of arc are the Sibuyan Sea and the Visayan Sea.

From the central to the western regions of the Philippines, the islands are characterized by a very complex topography. This is primarily the result of westward subduction in the South China Sea basin located west of the Philippines, and southerly subduction in the Sulu Sea basin located in the southwest and the Celebes Sea basin located in the south. On a geologic timetable, the Philippine archipelago is still relatively young. Thus, its topography is steep and highly-dissected. There are more than seventeen (17) mountains with elevations exceeding 2,000 m.

Most rivers in the Philippines are relatively short and there are consequently few large alluvial plains. Two notable exceptions with comparatively large plains are the Cagayan Basin in northern Luzon and the Middle Luzon Basin. The Cagayan Basin is an alluvial plain formed by the Cagayan River while the Middle Luzon Basin is an alluvial plain formed by the Pampanga and Agno rivers. Medium-sized alluvial plains include the Iloilo Basin created by the Jalaud river, the Bicol River Basin, the Agusan River Basin and the Cotabato lowland in Mindanao created by alluvium carried down by the Cotabato river.

(4) Geology

The Philippines is situated in the Circum-Pacific orogenic belt. The islands comprising the archipelago were created by orogenic movements and volcanic activities such as folding, upheavals and fault activities since the Tertiary period of the Cenzoic Era. Even today, these processes are active. Notably, there are many volcanic eruptions and earthquakes. The Philippines has twenty (20) active volcanoes. In 1991 there was a cataclysmic eruption of Pinatubo volcano on Luzon island. At that time, approximately 900 million m^3 of pyroclastic materials were ejected. During and after the eruption, large volumes of pyroclastic materials were deposited on the sides and base of the volcano and adjacent mountains. Each rainy season since then, huge volumes of volcanic mud (lahar) flow into the adjacent eastern and the western flatlands. Similar volcanic events have occurred repeatedly in the past, accounting in large part for how the land has been molded and formed.

While volcanoes can be very destructive, they can also have beneficial results. Volcanic soil, meaning the soil washed down as alluvium, is often very fertile. To a large degree, this accounts for the high level of fertility in many areas of the South Tagalog and Bicol regions of Luzon Island, and the Bukidnon plateau and Koronadal valley on Mindanao. The volcanic front has spread widely in these areas carrying along valuable soil nutrients that nourish the rainfed crops grown there such as corn, pineapples, bananas, coconuts and many other tree crops and annual crops.

1-1-2 Socio-Economic Condition

(1) General Economic Condition

Growth rate of Gross National Production (GNP) of the Philippines in the year of 1997, as reported by the National Economic Development Authority (NEDA) on January 29th 1998, was 5.8 %, a decrease of 1.1 % of 6.9% from the 1996 figure of 6.9%. This was mainly due to the retreat of business caused by the stagnation of the stock market linked with the fall of the peso since its devaluation in July 1997. Similarly, growth rate of Gross Domestic Production (GDP) also decreased to 5.7 %, lower than the 5.1% of the previous year.

Growth rate of export remarkably increased from 9.6% to 15.2% due to the fall of value of the peso. However, that of importation severely decreased from 21.1 % to 8.7 % in 1997.

On the other hand, remittance from Overseas Contract Workers has increased from 1,112 billion Pesos of 1996 to 1,407 billion Pesos in 1997. However, the actual purchase power was weakened due to the devaluation of the peso.

The Philippines, which once seemed not to be seriously affected by the currency crisis that brought much damage to other Asian countries, is being gradually affected by the increase of interest rate and importation price. NEDA is expecting worst effects in the first half of the year 1998.

Though actual economic growth rate in 1997 showed a stable development (5.1%), foreign exchange market in early 1998 gave huge impact. Currency of peso, which was around 40 pesos against a dollar at the end of 1997, suddenly increased to 46 pesos due to the fall of other major Asian currencies. Though it seems stable, recently, at around 40 peso, business sectors are still on alert against further devaluation.

While the prolongation of high interest rate is affecting business sector, the effect of price increase of agricultural products caused by El Nino phenomenon, leads to the consumer price increase in 1998.

In view of this, the International Monetary Fund (IMF), as the support to economic recovery plan of the Philippine Government, approved Stand-by Credit in the amount of 1.37 billion dollars in March 1998. Upon this approval, the Philippine Government started to implement recovery plan, to 1) cope with the counteraction for short term problem such as decrease of the investment from foreign countries by the Asian currency crisis, 2) recover the economy to the sustainable development through such policy as reform of banking sector. According to this plan, though the actual growth rate of GNP will be programmed to be decreased from 5.8% in 1997 to 3.0% in 1998, it is projected to increase to 5.0% in 1999. Also, after increase of consumer price at 8.0% in 1998 (6.1% in 1997), it will be decreased to 6.0% in 1999. (On 17 Aug. 1997, Finance Secretary Edgardo Espiritu announced the approval of International Monetary Fund (IMF) on the partial reduction of the condition on the aforementioned Stand-by Credit. The approval is on the modification of the target of economic growth rate and trade balance in this year, in consideration of the stagnation of domestic economy and decrease of agriculture production by El Niño phenomenon. By this approval, target on the growth rate of Gross National Products (GNP) was modified from initial 3 ~ 4 % to 2 ~ 3 %, and trade balance of 5 billion Pesos was also modified to 40 billion Pesos deficit.)

The Central Bank of the Philippines announced in September 1998 the mutual agreement between IMF and the Philippine Government on the modification of the target GNP growth rate from initial 5-6% to 4.1%. The target growth rate of GDP for 1999 was also modified from initial 2.5% - 3.5% to 3.5%. Also, target average inflation rate was set to 8.5% in 1999 and 10.0% in 1998. The average inflation rate during the period of January – August 1998 was 9.3%. These major economic indicators were set as the condition on the 1.4 billion U.S.Dollar credit from IMF to the Philippines.

From July to September 1998, actual GDP had increased 0.8% as compared to that of 1997. On the other hand, GDP of same period had decreased 0.1%. In the period from January to September 1998, there were 0.8% increase in GNP and 0.2% increase in GDP.

NEDA once announced the forecast of positive growth rate for 1998, however, it was announced in November 1998 that the rate was decreased to 0.0% - 0.5%. Also, the growth rates in third and forth quarter of 1998 was modified as negative growth, thus, the economic growth of 1998 is foreseen as the lowest since 1992.

The IMF approved on 3 December 1998 the credit of 600 million U.S.Dollars. From this credit, $ 300 Million will be utilized for financial system reform, $ 150 Million each will be distributed to financial assistance to small enterprises, and Local Governments.

By such financial improvement and also forecast of the end of economic stagnation caused by Asian currency crisis, NEDA set the target 1999 growth rate of GDP as 1 – 3%.

(2) Administrative Systems

The Philippines consists of seventy eight (78) Provinces. These Provinces are divided into 81 Cities and 1,526 Municipalities, which are also divided into Barangay (village). The smallest political units (sub-division) which form Barangay, is called “Sitio” or ”Purok”, or ”Zone”.

The Government of the Philippines is govern by the Office of the President and 19 Departments under which there are total of 167 independent and attached agencies/authorities/administrations.

Among these Departments, the Department of Environment of Natural Resources (DENR) is the primary government agency responsible for the sustainable development of country’s natural resources and ecosystem. Regional offices of DENR (Provincial/Community Environmental and Natural Resources Office) are in charge of the various activities related to environment protection, in co-ordination with the Municipal Project Development Offices of the Local Government Units (LGUs).

On the other hand, National Mapping and Resource Information Authority (NAMRIA), as the attached agency of DENR, is responsible for mapping, remote sensing and other related activities pertaining of resource information for the proper development/management of the natural resources.

(3) Population, Gross Domestic Product and Income Resources Distribution

1) Population

The official statistics by National Statistical Co-ordination Board (NSCB) as of September 1995 shows that the total population of the Philippines was 68,614,162, which had been increased 13.0% from that of 1990. In five years, there was remarkable increase in National Capitol Region (NCR) and Region-4, followed by Region-12. Population density (nation-wide average) as of 1995 was 228.7 person/sq.km.

2) GDP

The Gross Domestic Production was 1,906,430 million pesos (at 1995 prices). The breakdowns of these figures are indicated in Table 2-1-1 below.

Table 2-1-1 GDP in the Philippines (Unit : Million P)

1.Agriculture/Fishery/Forestry	412,965	(21.7%)
a. Agriculture/Fishery	410,219	
b. Forestry	2,746	
2.Industry	612,540	(32.1%)
a. Mining	18,244	
b. Manufacturing	438,247	
c. Construction	106,639	
d. Electricity, Gas, Water	49,410	
3.Service Sector	880,925	(46.2%)
a. Transport/Communication	88,929	
b. Trade	261,862	
c. Finance	78,232	
d. Ownership of Dwellings	130,491	
e. Private Services	169,290	
f. Government Services	152,121	
TOTAL (GDP)	1,906,430	(100.0%)

(Source : 3_/ 1996 Philippine Statistical Handbook, NSCB)

3) Income Resources Distribution

Though the effort of the government for the industrialization of production structure, more than 40% of the total labor force of the Philippines are engaged in the agricultural sector. Thus, modernization and improvement of the production infrastructure are essential to the development of the society and poverty alleviation. The breakdown of the distribution of occupation are shown in Table 2-1-2 below (1996):

Table 2-1-2 Occupation Distribution (Unit : Million)

1. Agriculture/Fishery/Forestry	11,324	(44.0%)
2. Mining	95	(0.4%)
3. Manufacturing	2,571	(10.0%)
4. Electricity, Gas, Water	103	(0.4%)
5. Construction	1,238	(4.8%)
6. Wholesale/retail trade	3,745	(14.6%)
7. Transport./Communication	1,490	(5.8%)
8. Finance/insurance/real estate	551	(2.1%)
9. Community, services	4,559	(17.8%)
10.Others	21	(0.1%)
TOTAL (Employed persons)	25,698	(100.0%)

Source : 3_/ Philippine Statistical Handbook, NCSO 1996

(4) General Development Plan, Strategies

1) Medium-Term Philippine Development Plan 1993-1998 (MTPDP)

The MTPDP was formulated and updated to guide development efforts in both the public and private sectors from 1993 to 98. The long-term goal of the development plan is the alleviation of poverty, improvement of income and equal distribution of wealth while the major macro economics objectives are: 1) sustained and broad-based growth of output and employment; 2) price stability; and 3) a sound balance of payment positions.

In this MTPDP, the following are targeted as indicator:

1) to reduce the proportion of families below the poverty threshold, from 40.7% in 1991 to 30% by the end of 1998;

2) to attain 7.3% annual growth rate of GNP during the period;
3) to increase real per capita income from 11,298 pesos in 1993 to 14,874 pesos in 1998;
4) to raise annual growth rate of GDP from 3% to 10% in 1998;
5) to ensure an inflation rate of less than 5.8% per year;
6) to reduce unemployment ratio from 9.6% in 1993 to 6.3% in 1998.

2) The Philippine National Development Plan

At the end of the term of the Administration by President Fidel E. Ramos, "The Philippine National Development Plan, Directions for the 21st Century" was formulated by the Memorandum Circular No. 166 on 21 August, 1997. In response to this Memorandum, said Plan was issued on 1998 by the National Economic Development Authority (NEDA).

The Plan, emphasizing its challenge of modernization, consists of the following aspects:

1) Economic transfer to more productive economy through human resource development
2) Market developing by proper utilization of government resources to public goods and services
3) Establishment of monetary framework by independent monetary authority
4) Proper delivery of public goods/services by a) coordination of National Government and Local Government Units (LGUs), b)participation of community organizations/socio-civic organizations
5) Spreading development impact for the eradication of poverty
6) political stability for the business grow
7) Investment in social overhead for the integration of market
8) International or regional cooperation

The new national development plan to replace this Plan mentioned above, is now under consideration under the new Estrada administration.

3) Basic Policy of New Administration

By the result of national election held on 11 May 1998, President Joseph

Estrada, former Vice-President under Ramos Administration, assumed his post on 30 June, 1998.

Administration under former President Fidel V. Ramos, established the foundation of economic development by upgrading infrastructure to increase production efficiency, deregulation of finance, and active introduction of foreign investment. However, due to the stagnation of the Philippine economy caused by present currency crisis and decrease of foreign investment, the former Administration left serious economic problems such as high inflation rate (7%), unemployment, etc.

The tasks of the new Administration of President Joseph Estrada is summarized as how to maintain the economic growth and political stability established by the former Administration, and to overcome the effect of Asian currency crisis.

The Ramos Administration, which started in 1992, increased the growth rate of GNP from 1% at its start to 5.8% in 1997. However, economic stagnation by currency crisis caused 8% of high unemployment rate. If the new Administration will issue the policy against financial deregulation movement, more decrease on foreign investment can be expected. On the other hand, inspite of the economic development, there is no basic change of the social structure in the Philippines which consists of more than 60% of people in poverty. It is being criticized that the economic growth in the Ramos Administration widened the economic difference between the rich and the poor. Thus, the new Administration is strongly expected to have actual and effective reform plan to develop the rural areas and increase job opportunities.

Under such circumstance, President Joseph Estrada who assumed his post on 30 June, announced his basic policy as; 1) fair and equal development of society without violence, 2) government without corruption, 3) reflection of people's will to major policy. The initial action plan of his Government was also announced as follows:

a. Recovery of confidence for governmental offices, establishment of unity among the government, business sector and society
b. Achievement of effectiveness, minimization of unnecessary governmental inputs

c. Decrease of interest rate, control of inflation rate, maintain international competitive power of the peso, to stimulate new investment
d. Improvement of infrastructure such as power, transportation and communication
e. Increase of competitive power of agricultural products

(5) General Condition on the Forestry/Fishery/Agricultural Sectors

1) Forestry

The Total volume (amount) of log production has been reduced by 90% in the ten years period between 1985 to 1995 (3,434,000 cu.m to 605,000 cu.m). Other products such as veneer, plywood, lumber have also decreased during this period but not much significant as compared to the decrease of log production. While most of roundwood production shows decrease in this period, non-timber forest production (such as Bamboo, Almacig Resin, Rattan) has increased, especially the production of Nipa singles which has increased from 630,000 pieces in 1976 to 7,605,000 pieces in 1995.

The portion of total area of Alienable & Disposable land against the total land area of the Philippines has increased from 34.9% in 1955 to 47.06% in 1995, while that of Forest Land has decreased from 65.1% in 1955 to 52.9% in 1995.

By the effort of the Government, LGUs and private sectors, the total reforested land area have increased from 31,733 ha in 1976 to 49,551ha in 1994.

Forest destruction reaches 10,342 ha in 1994, 7,720 ha was by forest fire, 1,529 ha by kaingin (shifting cultivation) and 107 ha by illegal logging.

2) Fishery

Total quantity of fishery products has slightly increased from 2,052 thousand metric tons in 1985 to 2,740 thousand metric tons in 1995. However, the total value of the product changed from 31,297 million pesos in 1985 to 87,885 million pesos in 1995.

Likewise, total products of Aquaculture *_/, quantity (in metric tons) increased from 495 to 825 in this period, while value has increased from 8,724 million pesos to 37,560 million pesos.

*/ includes production from aquaculture activities as brackishwater fishponds, freshwater fishponds, culture of oysters, mussels and seaweeds in marine areas and fishpens/fishcages in lake, etc.

The total value of the products from brackishwater fishpond has been increased from 6,522 million pesos in 1985 to 28,733 million pesos in 1995, as indicated in Figure 2-1-3 below.

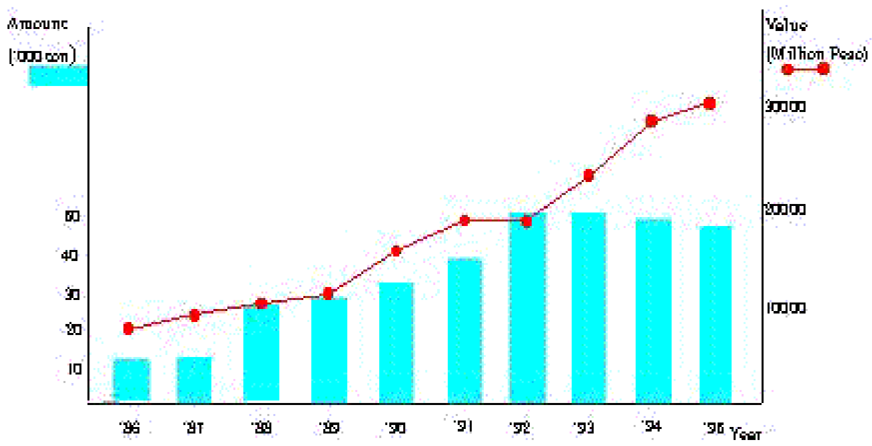


Fig. 2-1-3 Amount and Value of the Products from Brakishwater Fishpond (1986-1995)

3) Agriculture

Among all products, only rice and corn as cereals and coconuts as crops showed remarkable increase during the past ten years as compared with the increase in other crops. (See Table 2-1-3.)

Table 2-1-3 Major Agricultural Products

	Area ('000 ha)	Quantity ('000 ton)	Value (Million P)
1.Cereals	6,451	14,669	103,610
a. Rice	3,759	10,541	77,685
b. Corn	2,692	4,129	25,925
2.Major Crops	4,779	39,519	91,437
a. Coconut	3,079	12,183	21,321

b. Sugarcane	284	18,679	17,746
c. Banana	329	3,082	10,818
d. Pineapple	78	1,397	4,933
e. Coffee	141	124	6,817
f. Mango	68	432	7,263
g. Tobacco	55	64	1,567
h. Abaca	107	86	1,660
i. Rubber	90	181	4,473
j. Cacao	17	7	350
k. Cassava	213	1,907	4,958
l. Camote	146	690	2,663
m. Peanut	47	36	504
n. Mongo	35	27	453
o. Onion	9	88	995
p. Garlic	6	17	949
q. Tomato	18	156	712
r. Eggplant	18	131	980
s. Cabagge	8	85	624
t. Citrus	30	147	1,655
3. Other Crops	1,279	9,288	38,632
TOTAL	12,508	63,476	233,679

Source :3_/ Phil. Statistics Handbook, 1996 (NCSO)

Recently, the effect of El Niño phenomenon gradually affects in the agricultural products. Especially, decrease of rice production due to lack of irrigation waters has been often reported.

In 1995 exportation/importation of agricultural products, shows the following major items and its values:

Exportation - Coconuts Oil (475 million dollars)
Banana (215 million dollars)
Tuna (166 million dollars)

Importation - Cereal (394 million dollars)
Feeding Stuff for Animal (194 million dollars)
Tobacco (178 million dollars)

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1-2 Mangrove forests in the Philippines

1-2-1 Abstract of the Mangrove Forest

(1) Definition

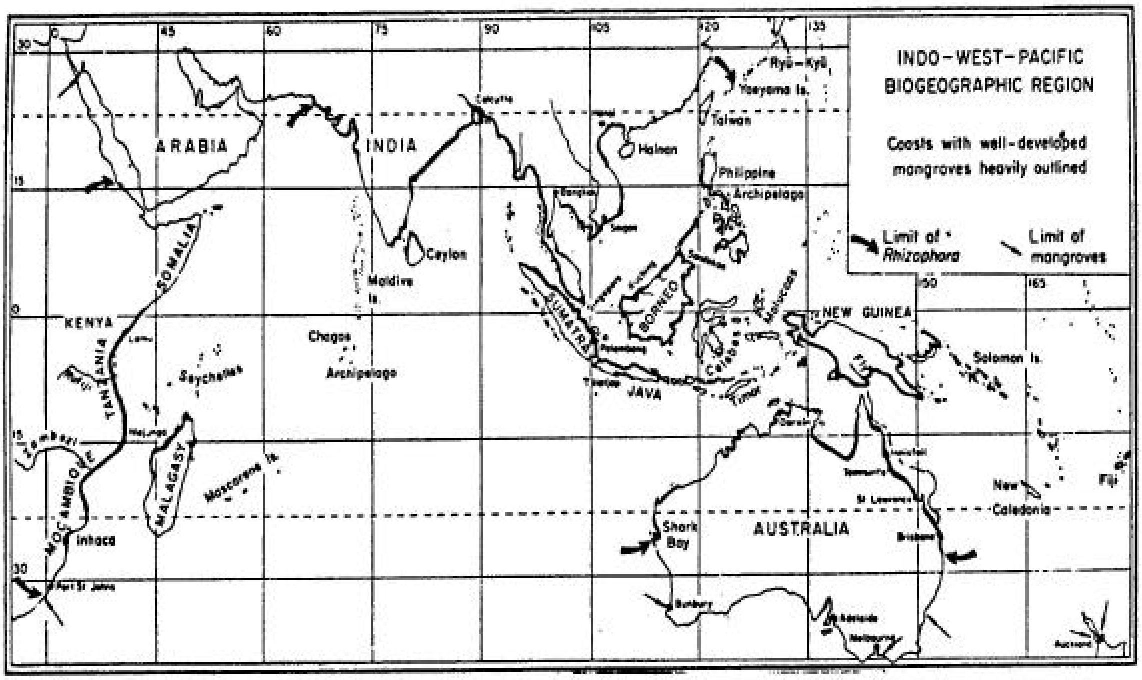
The term "Mangroves" generally refers to mixtures of trees, shrubs, palms or grand ferns exceeding one half meter in height, and normally growing above mean sea level in the inter-tidal zone of marine coastal environments or estuarine margins. When discussing mangroves, the terms "Mangrove forest" and "Tidal forest" are inter-changeable, both having the same meaning. However, the upper limits of the mangrove/tidal forests are not so clearly defined. For instance, at the interface between terrestial and mangrove vegetation, there is often disagreement on whether or not to classify such areas as mangrove forests.

The Working Group on Mangrove Ecosystems of the ICUN Commission on Ecology defines the mangrove forest as an area consisting of; (1) exclusive mangrove shrub and tree species, (2) non-exclusive species of plants, (3) the associated and/or correlated biota, i.e. the terrestrial and marine animals, lichens, fungi, bacteria and bryophytes, whether temporary, permanent, casual, incidental or exclusive in the area, and (4) the processes essential for its (resource) maintenance irrespective of whether or not these are within an area occupied by mangrove flora and fauna. 1_/

At present, there is no universally-accepted definition of the mangrove forest based on scientific standards. However, there is a reasonable degree of consensus that "Mangroves are trees and bushes growing below the high-water level of spring high tides. And their root systems are regularly submerged in saline water, even through the water may be diluted by flooding once or twice a year." 2_/ 3_/ Consistent with this consensus and general understanding, the Study covered by this report defines mangroves as the areas incorporating the seashore and the land ward fringe including Nipa areas.

(2) Worldwide Distribution of Mangrove Forests

Mangrove vegetation exists principally in the tropics, but also extends to part of the sub-tropics and in some cases even to warm temperate locations such as Kagoshima Japan, and the north islands of New Zealand. (Figure 2-1-4) 2_/ Geographically, mangroves are found in areas where January to July temperature is within the range of 20°C isotherms.3_/ Mangrove swamps are well-developed in the bio-geographical region of Malaysia, where the largest numbers of species exist. Mangroves normally favor a humid tropical climate, partly because the high rainfall ratio is usually accompanied by silt-laden rivers forming suitable mudflats. However, mangrove trees are also found growing in extremely arid coasts and coral or rocky islands. 3_/



Source: 2_/

Fig. 2-1-4 Mangrove Forest Distribution in Asia and Indo-Pacific

Table 2-1-4 shows the overall distribution and area (ha) of mangroves in the world. Figure 2-1-5 shows Asia and the Indo-Pacific mangrove areas. Indonesia has the most extensive mangrove forests, followed by Australia, Malaysia, Myanmar, Bangladesh and Thailand in that order. The Philippines ranks below these six (6) countries in terms of area, but mangroves are equally important to the Philippines in terms of their ecological and economical values.

Table 2-1-4 Mangrove Distribution in the World(1993)

Africa		Asia-Pacific		N-S America	
Country	area(1000ha	Country	area(1000ha)	Country	area(1000ha)
Angola	125	Australia	1150	Belitz	75
Cameroon	272	Bangradish	450	Brazil	2500
G. Bissau	230	Buruney	7	Colombia	440
Gabon	140	Fiji	39	Costa Rica	39
Gambia	60	India	96	Cuba	400
Guinea	260	Indonesia	2500	Dominica	9
Kenya	45	Kampuche	10	E. Guinea	20
Liberia	20	Malaysia	674	Ecuador	235
Madagascar	300	Myamer	812	El Salvado	45
Mozambique	455	Pakistan	345	G. France	55
Nigeria	970	Philippines	240	Guatemala	50
Tanzania	96	PNG	553	Guyana	150
Zaire	50	Sri Lanka	4	Haiti	18
		Thailand	287	Honduras	145
		Vietnam	320	Jamaica	7
				Mexico	660
				Nicaragua	60
				Panama	486
				Peru	28
				Senegal	169
				Sierra Leo	170
				Somalia	20
				Surinam	115
				Trinidad	4
				Venezuera	260
Total	3023	Total	7487	Total	6160

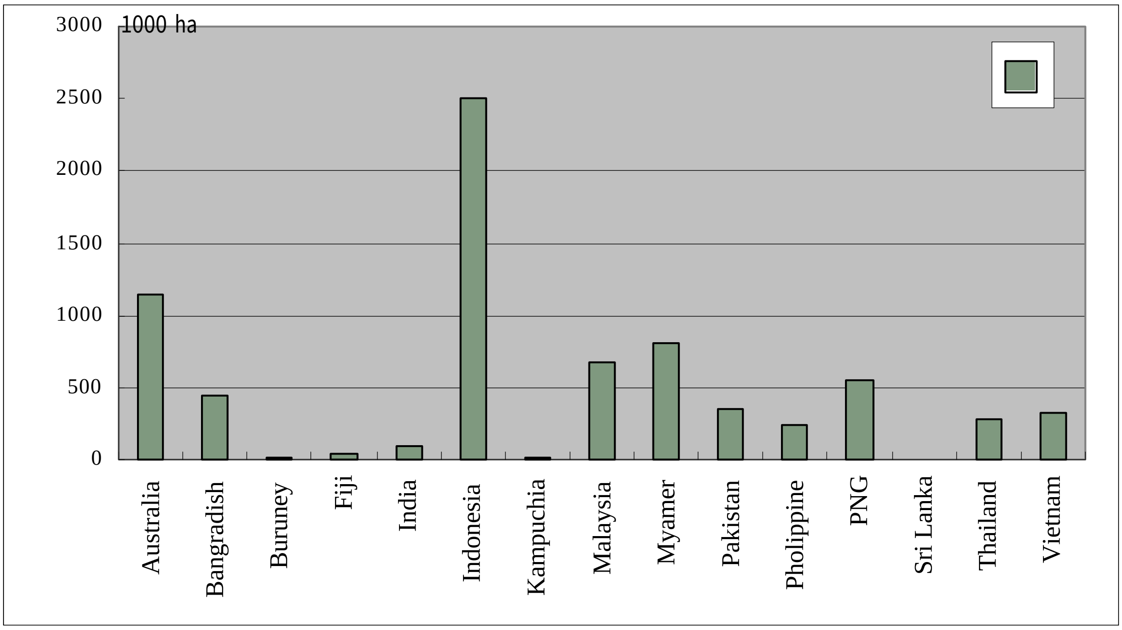


Fig. 2-1-5 Mangrove Distribution in the Asia-Pacific (1000ha) 4_/

On a global perspective, Walsh (1975) divided mangroves into two regions. One is the Indo-Pacific region extending from East Africa to Australia including the Pacific islands and New Zealand. The other region is West Africa to Latin America. 5_/

According to Nakamura (1992), the Southeast Asia and Pacific region is sub-divided into three areas as shown on Figure 2-1-6 and described hereunder. 4_/

← *Rhizophora mucronata* Area

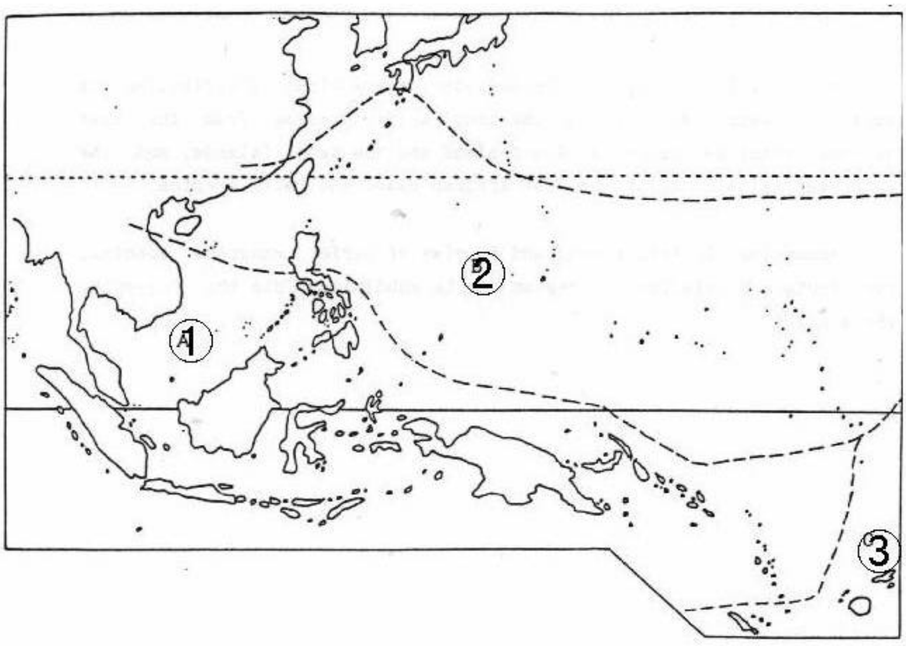
Including Myanmar, Thailand (Andaman, the Gulf of Thailand), the Malay Peninsula, Singapore, Sumatra, Java, Kalimantan, Brunei, Sabah, Sarawak, Sulawesi, Halmahera, Ball, Lombok, Timer, Papua New Guinea and the Philippines.

↑*Rhizophora stylosa* Area

Including Okinawa, Taiwan, Hainan island, the Philippines (Cebu), Guam, Yap, Palau, Truk, Pohnpei, Fiji (Viti Levu, Vanua Levu, Mango Island), Vanuatu, and New Caledonia.

→ *Rhizophora mangle and R. samoense* Area

Hawaii (Oahu, Kauai, Hawaii), Fiji (Viti Levu, Vanua Levu), Western Samoa, New Caledonia and Papua New Guinea (Lae).



Source: 5_/

Fig. 2-1-6 Geographical Distribution Areas of Mangrove in the Pacific

Nakamura also describes and recognizes the following twelve (12) types of mangrove communities in the Southeast Asia and Pacific Region. 5_/

(1) *Sonneratia alba* Community: - Thailand, Polynesia, the Philippines, Malaysia, Indonesia and Micronesia.

(2) *Rhizophora stylosa* community: - Okinawa, Micronesia and the Philippines.

(3) *Rhizophora apiculata-Bruguiera gymnorrhiza* Community: - Throughout the region.

(4) *Rhizophora apiculata* Community: - Southeast Asia, South Pacific (not beyond the Tropic of Cancer).

(5) *Rhizophora mangle* Community: - Polynesia,

(6) *Rhizophora mangle-Rhizophora stylosa* Community: - Polynesia,

(7) *Xylocarpus granatum* Community: - South of the Tropic of Cancer (see 4.).

(8) *Ceriops tagal Community*: - Hainan Island, Southeast Asia (rare in the Pacific Islands).

(9) *Lumnitzera littorea* Community: - Throughout Southeast Asia.

(10) *Scyphiphora hydrophyllacea* community: Throughout Southeast Asia and Micronesia (few in Polynesia).

(11) *Bruguiera gymnorrhiza* Community: Southeast Asia, Micronesia, Polynesia, Melanesia.

(12) *Avicennia alba* Community: - Southeast Asia, Micronesia, Polynesia, Melanesia.

Nakamura's 1992 report identifies the principle mangrove vegetation types in the Philippines as follows: the *Sonneratia alba* Community, *Rhizophora stylosa* Community, *Rhizophora apiculata* Community, *Xylocarpus granatum* Community, *Lumnitzera littorea* Community, *Bruguiera gymnorrhiza* Community, and *Avicennia alba* Community.

(3) Zonation in mangrove forests

Species composition in mangrove forests is primarily (but not exclusively) a function of location within an estuary, and position along the tidal profile. This function is usually referred to as "zonation". These zonings are generally summarised into six (6) categories based on two principal factors - estuarine location and inter-tidal position. Estuarine locations may be further divided into three (3) sub-categories; i.e. downstream, intermediate and upstream. Similarly, inter-tidal positions may be sub-divided into low, mid and high (Figure 2-1-7). Downstream also includes foreshore island communities, again sub-divided into three inter-tidal categories.

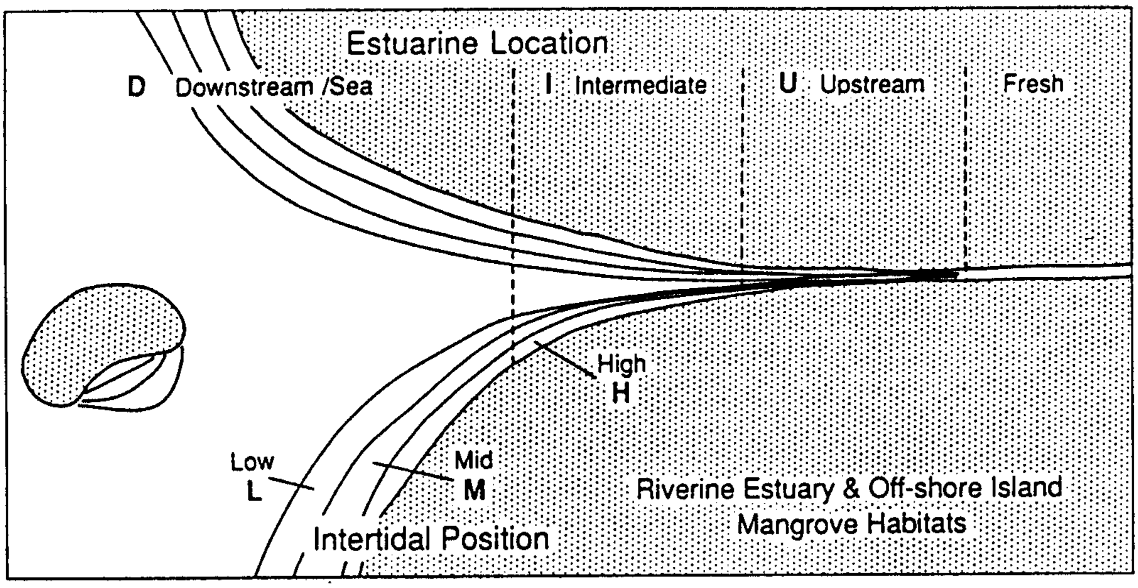


Fig. 2-1-7 A Sketch Map Delineating the Two Common Mangrove Habitats.
D: Downstream, I: Intermediate, U: Upstream, and H: High M: Medium L: Low 3_/

The tidal position of areas with mangrove vegetation determines the number of hours the mangrove root system can obtain oxygen or how many hours the mangrove roots stay under seawater. The estuarine location is significant in terms of the relative proportions of fresh water and saline (sea) water

.

The large body of literature dealing with mangroves provides various references on zonation and classification. For instance, classification work in Malaysia by Watson (1928) is typical of studies that focus basically on the inter-tidal level. On the other hand, studies by Mac Nae (1968) exemplify zonation based on the existence of typical or dominant species. Excerpts from these two classification/zonation studies are shown on Table 2-1-5 and Table 2-1-6. 2_/

Table 2-1-5 Zonation Pattern in Western Sea Board of P. Malaysia

class	condition	species	remarks
1	Inundated by all high tidal	Rhizophora mucronata	exceptionally
2	Inundated by medium-high tides	Sonneratia alba Avicennia alba Avicennia marina Rhizophora mucronata	
3	Inundated by normal-high tides	Rhizophora spp Ceriops Tagal Xylocarpus granatum Sonneratia alba Bruguiera parviflora	often dominant
4	Inundated by spring tide only	Rizophora spp Bruguiera spp Xylocarpus spp Lumnitzera littorea Excoecaria agallocha	little
5	Inundated by equinoctial	Burguiera gymnorrhiza Rhizophora apiculata Xylocarpus granatum Nypa fruticans	dominant little little

Source: 1_/

Table 2-1-6 MacNae's Zoning

1	landward fringe zone
2	Ceriops thickeds zone
3	Bruguiera forests zone
4	Rhizophora forest zone
5	seaward Avicennia zone
6	Sonneratia zone

Source 2_/

The above-mentioned studies document the results of field observation in various areas. Figure 2-1-8 presents a typical zonation pattern of mangrove forests in the deltaic areas of Western Peninsular Malaysia. *Avicennia* and/or *Sonneratia* are dominant in the seaward pioneer zone. As one moves closer to shore, *R. mucronata* and *R. apiculata* zones appear, and finally a *Nypa fruticans* zone. In most cases, *R. apiculata* comprises the upper level of the canopy and is associated with shorter, small-diameter trees such as *Ceriops tagal* and *Bruguiera parviflora* making up the middle and lower canopies.

Figure 2-1-9 illustrates the zonation pattern of a relatively small Mangrove forest in the western seaboard of the Malaysia Peninsula. *Bruguiera cylindrica* is dominant near the dry land, giving way to *Rhizophora* and then to *Avicennia* as one moves seaward.

Figure 2-1-10 illustrates a case where mixtures of *Heritiera littoralis* and

Excoecaria agallocha are found in a widespread *N. fruticans* zone at Sandakan, Sabah, Malaysia. *Rhizophora* is dominant in the seaward pioneer area of this zone.

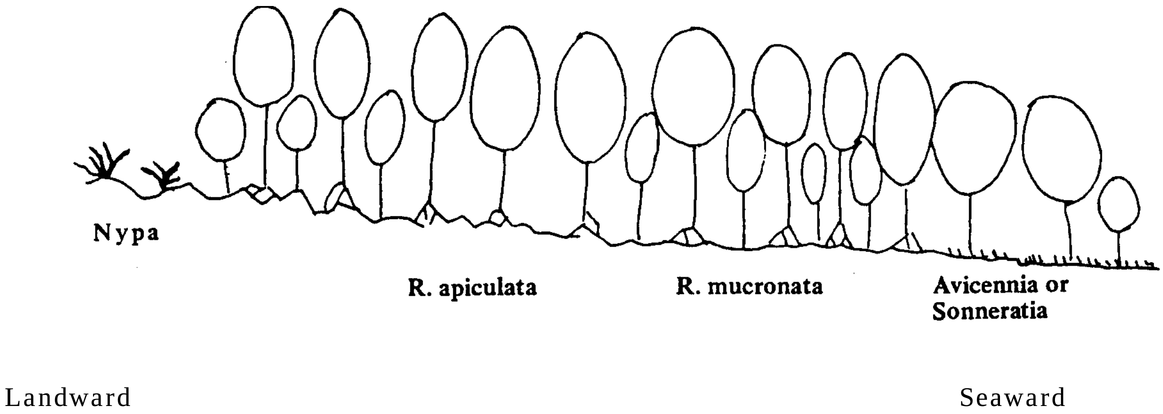


Fig. 2-1-8 Zonation Pattern in Deltatic Forest in Western Part of P. Malaysia

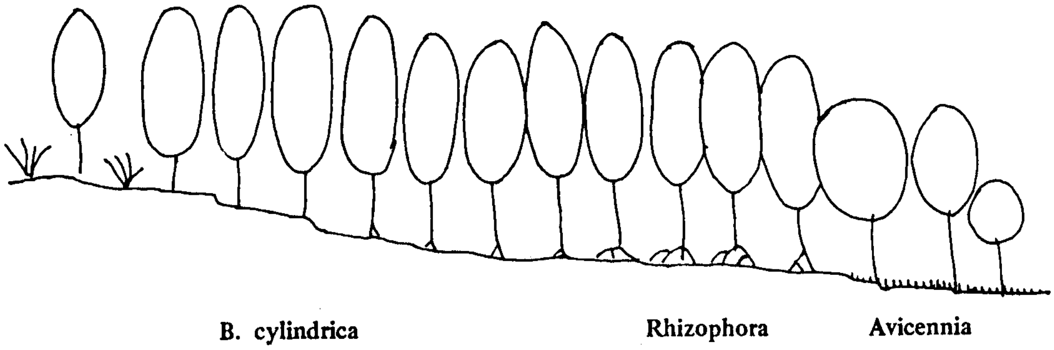


Fig. 2-1-9 Zonation Pattern in Western Sea Board of P. Malaysia

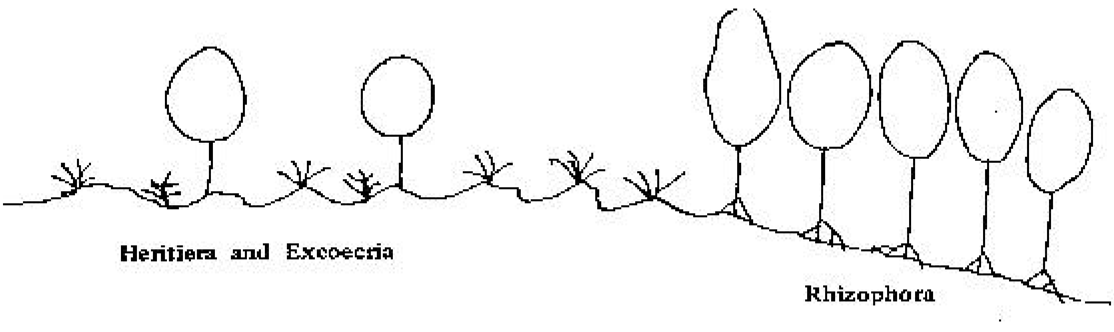


Fig. 2-1-10 Zonation Pattern at Sandakan, Saba, Malaysia

Figures 2-1-11 to 2-1-13 offer different examples of zonation on some Pacific islands. Figure 2-1-11 shows two (2) zonation patterns. At the mouth of a small river in Guam, *R. stylosa* is found at the outermost seaward location.

As topography of the seafloor rises towards the dry land, the vegetation changes to a *B. gymnorrhiza* zone, and then to a *N. fruticans* zone. 6_/ By comparison, the mangrove forest in a Lagoon area is characterized by *A. marina* along the coastline, continuing to a sand-hill forest on land. 6_/

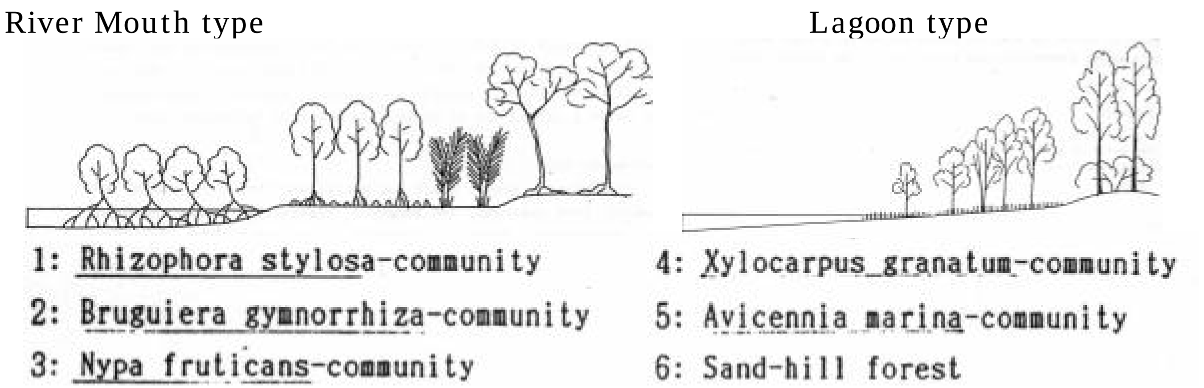


Fig. 2-1-11 Zonation Sample in Guam

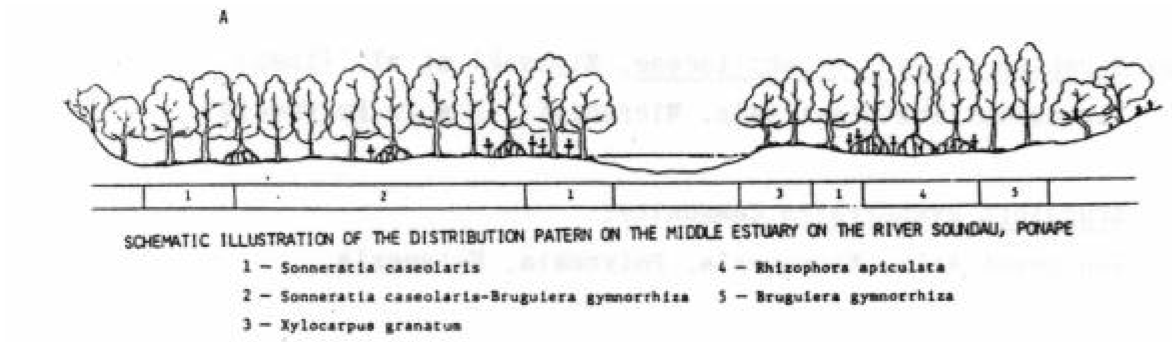


Fig 2-1-12 Zonation Sample in Pohnpei Island (Middle estuary area of a river)

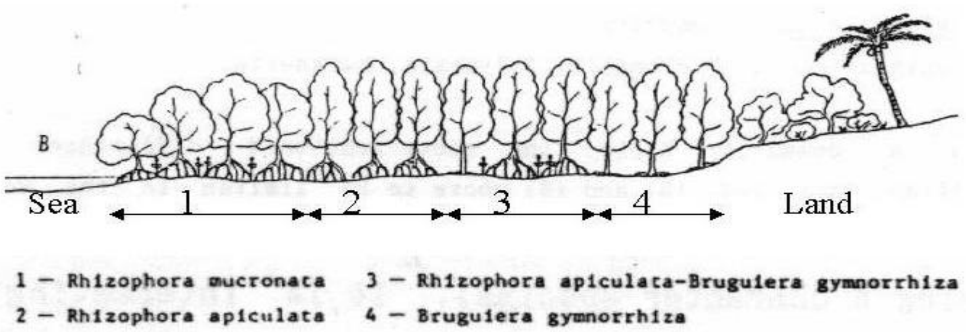


Fig 2-1-13 Zonation Sample in Pohnpei Island (River Mouth)

Figures 2-1-12 to 2-1-13 show three types of mangrove zonation in Pohnpei, Ragest Island, in the Eastern Caroline Islands of Micronesia. 6_/ Figure 2-1-12 illustrates zonation at an intermediate estuarine location. The land immediately adjoining the river (i.e. the riverfront) is characterized by *S. caseolaris.* Then as one moves inward, away from the riverfront, a zone dominated by *B. gymnorrhiza* or *R. apiculata* appears. In between, at slightly higher elevations (mounds) in the high intertidal area, *X. granatum* appears.

Figure 2-1-13 presents another river mouth zonation pattern at Pohnpei. Note the change from *R. mucronata* at the seaward extreme, giving way to *R. apiculata*, then to a mixed zone of *R. apiculata* and *B. gymnorrhiza*, and finally to *B. gymnorrhiza*. Figure 2-1-14 illustrates the zonation pattern at an outer shore area in Pohnpei. Facing the open sea, the vegetation consists of *R. mucronata* and *R. stylosa*. Moving towards the land, the vegetation changes to *R. apiculata* growing alone or mixed with *B. gymnorrhiza*. Continuing further inland, the vegetation gradually changes to an area dominated by *S. caseolaris*.

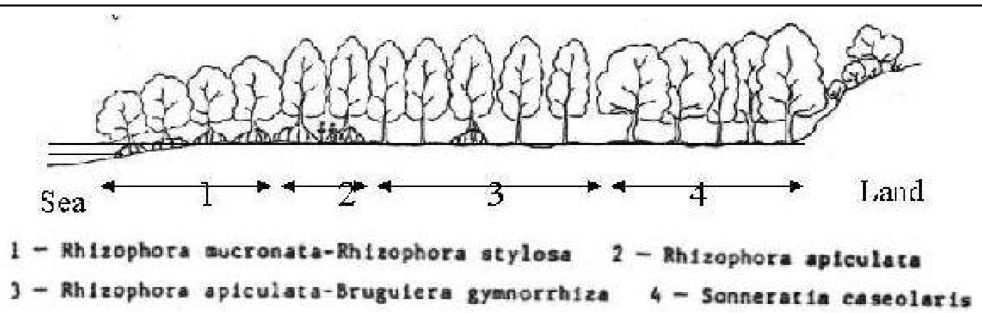


Fig 2-1-14 Zonation Sample in Pohnpei Island (Outer Shore)

Figure 2-1-15 shows a sample of zonation on the island of Samoa. The *R. samoensis* found at the seaside pioneer area is different from the *Rhizophora* species growing in Pohnpei. Moving landward, a *B. gymnorrhiza* zone is recognized, giving way next to *N. fruticans* and finally to *Hibisucus tillaceus* on the adjacent dry land. 7_/

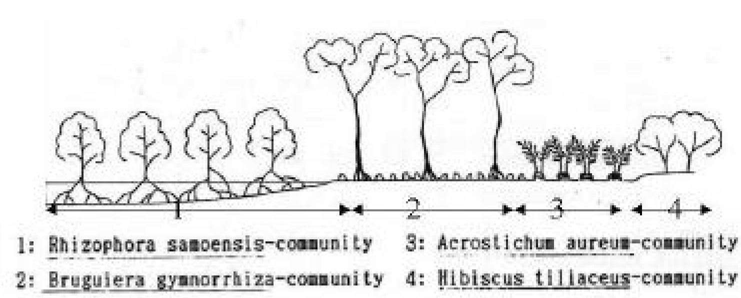


Fig 2-1-15 Zonation Sample in Samoa

The last sample on Figure 2-1-16 shows a zonation pattern at Iriomote, Okinawa in Japan. Moving from seaward to the land along a riverside, one can observe a change from *S. alba*, to *R. stylosa*, then to *Kandelia candel* and *B. gymnorrhiza* and finally to *Pandanus spp.* above the high tide line. 8_/

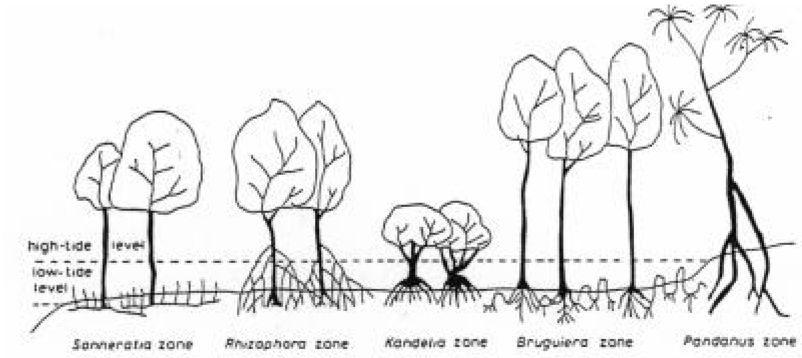


Fig 2-1-16　Zonation Sample in Iriomote Okinawa

As discussed in the next chapter of this report, the Study team observed zonation patterns in the Philippines that are similar to those just described. However, in the Philippines it is often difficult to pinpoint where one zonation pattern ends and another one begins. This is especially true in the case of upper inter-tidal areas which are frequently characterized by small channels and mud mounds. These ground conditions result in different tidal levels on small discrete portions of the mangrove ecosystem, thus creating micro-scale conditions favorable to species other than those which dominate the rest of the zone. While the existence of mangrove zonation patterns is a world-wide phenomenon, there are no universal patterns. Characteristics of the patterns in the Philippines are basically similar to examples elsewhere in the Pacific, but there are distinct differences in the species composition and structure.

The several types of mangrove vegetative structures are variously affected by coastal morphology, micro-level changes in the topography of the forest floor (i.e. height levels), and fresh water movements. During field studies, observers usually find it difficult to classify all parts of a mangrove into distinct zonation patterns. Therefore, to establish boundary lines between patterns on maps or aerial photographs, it is necessary to examine and determine the relationships between mangrove vegetation, mixtures of various species and land conditions.

1-2-2 Land and Locational Factors Influencing the Development of Mangrove Forests

(1) Formation Process

The formation process of mangrove habitats is well-summarized by Diemont and Wijingaarden (1974).9_/ They describe two different types of formation. One is an "Open accreting coast type" and the other is an "Estuary type". Differences between the two types stem from the process of soil sedimentation. In the former (coast type) marine sediment accumulates in front of and behind the coastline without being disturbed and the coastline gradually extends forward. The latter (estuary type) is characterized by the complexity of the estuary, including curvatures in the coastline along which sedimentary materials accumulate owing to dendritic tidal creeks which are subject to changes in the ebb and flow of water.(Figure 2-1-17). 10_/

When considering the correlation between development of mangroves and the process of sedimentation in these two types, the range of changes in tide level is very significant. Conditions favorable to formation of the open accreting type are present when a shallow muddy sea extends (several kilometers in some cases) from the high tide line. Inflows of soil and sand promote sedimentation and, depending largely on the degree of submergence, different species of mangrove vegetation take root.

As the mangroves develop, sedimentation accelerates and eventually the accumulation of sediment reaches a level higher than the sea. When this level is reached, the probability of submergence decreases and the pace of sedimentation slows down and eventually stops. On land that is no longer submerged at high tide, the vegetation gradually changes from mangrove to a terrestrial structure. Meanwhile, soil and sand will be continuously supplied by rivers and currents to the front of the mangroves. As a result, the coastline along with the mangrove zone will move forwards the sea.

In other words, an oxygen-reductive environment maintained by frequent submergence is not permanent. In fact, if large amounts of organic matter are supplied from mangroves, the oxygen-reductive environmental conditions may only last for a relatively short time. It is also obvious that a mangrove zone formed along the coast will be relatively narrow. A prerequisite for the forward movement of the coastline owing to rapid sedimentation is the volume of earth and sand supplied by rivers or currents.

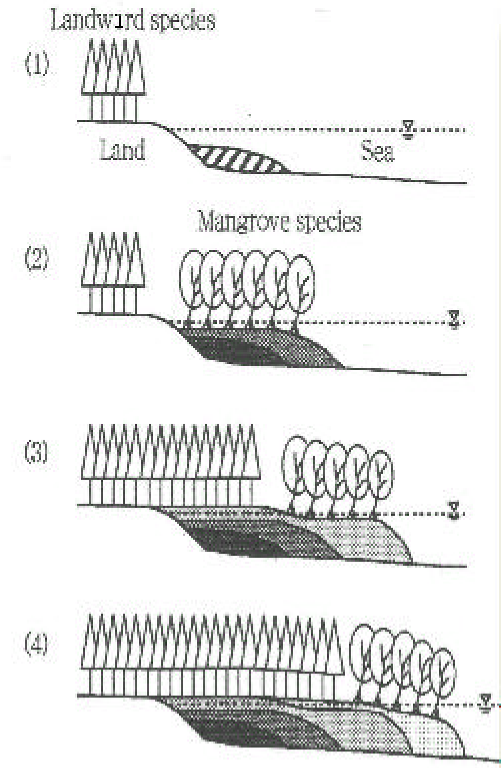
--- Open Accreting Coast Type--

(1) Soil and sand begin to accumulate under the influence of rivers and currents.

(2) Mangroves take root in the accumulated soil and sediment and accelerate sedimentation.

(3) As the first part of soil and sand sediment becomes land, mangroves are superseded by terrestrial plants.

(4)As soil and sand increasingly accumulate on the forefront of the coast, mangroves spread further forward.



--- Estuary Type ----

(1) Soil and sand accumulate at a slow pace without the influence of large rivers and currents.

(2) After soil and sand accumulate little-by-little over a long period of time, mangrove begin to take root.

(3) Since accumulation is slow, landward wet-lands are maintained for a long time as mangrove habitat. However, ebb and flow facilitate the development and increase in elevation (height) of natural banks.

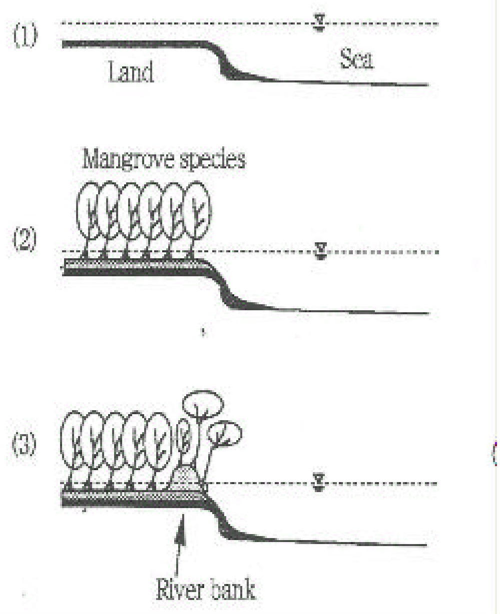


Fig. 2-1-17 Illustration of Fundamental Formation Process of Mangrove Habitats

By comparison (with the coast type), the estuary type generally develops under conditions characterized by less inflow of soil and sand. Sedimentation occurs at a slower pace. As in the former case, mangroves can generate root only when sediment rises to a certain level. But the mangroves do not significantly increase the speed of sedimentation because of the relatively lower supply (inflow) of soil and sand. However, since tidal creeks are backed up by the ocean tides, natural riverbanks develop near the estuaries. Thus, the elevations of these banks will increase over time. In back marsh, on the other hand, sedimentation hardly takes place and therefore a long and extensive mangrove habitant is maintained in stable condition. Peaty organic matter may partially accumulate in the back marsh. When a large amount of organic matter is supplied in this way, the influx of water will be reduced in spite of frequent submergence and therefore an oxygen-reductive environment can be maintained for a long time and a large amount of sulfides will be included in deposits. 11_/

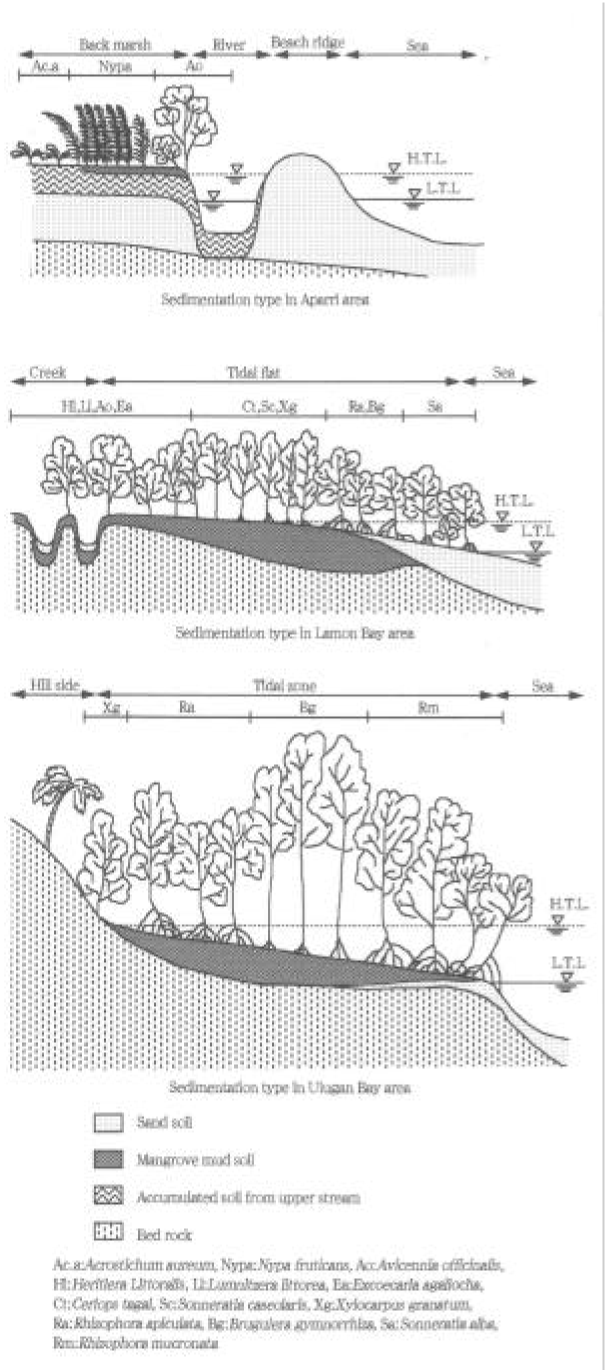


Fig. 2-1-18 Sedimentation Models

(2) Locational Conditions of the Mangrove Habitat

Differences in locational conditions of mangroves are reflected best in zonation. As verified by various case studies, the constituent species of mangrove forests are fundamentally arranged in a zonal distribution. However, the dynamics of zonation still need to be clarified. Factors which may affect zonation have been examined so far by Waiter & Steiner (1936)12_/, Macnae (1968)13_/, Baltzer (1969)14_/, Chapman (1976)15_/ and Snedaker (1982)16_/. Macnae attached importance to (a) frequency of submergence owing to ebb and flow, (b) tolerance to saline water, and (c) soil moisture - as dominant factors in zonation. He also stressed that creeks in and around mangrove forests and erosion of the mangrove coast would strongly affect these factors. Yamada (1986) referred to (a) salinity, (b) depth of water and (c) soil matrix, as factors which may determine the zonation of mangroves. Based on the results of these and other studies, the principal environmental conditions impacting on zonation in mangrove habitats are (a) soil sedimentation, (b) salinity, (c) duration of submergence, and (d) physical/chemical soil property. 10_/

The formation process of mangrove habitats is well-summarized by Diemont and Wijingaarden (1974). 9_/ They describe two different types of formation. One is an “Open accreting coast type” and the other is an “Estuary type”. Differences between the two types stem from the process of soil sedimentation. In the former (coast type) marine sediment accumulates in front of and behind the coastline without being disturbed and the coastline gradually extends forward. The latter (estuary type) is characterized by the complexity of the estuary, including curvatures in the coastline along which sedimentary materials accumulate owing to dendritic tidal creeks which are subject to changes in the ebb and flow of water. (Figure 2-1-18).

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By comparison (with the coast type), the estuary type generally develops under conditions characterized by less inflow of soil and sand. Sedimentation occurs at a slower pace. As in the former case, mangroves can take root only when sediment rises to a certain level. But the mangroves do not significantly increase the speed of sedimentation because of the relatively lower supply (inflow) of soil and sand. However, since tidal creeks are backed up by the ocean tides, natural riverbanks develop near the estuaries. Thus, the elevations of these banks will increase over time. In back marsh, on the other hand, sedimentation hardly takes place and therefore a long and extensive mangrove habitant is maintained in stable condition. Peaty organic matter may partially accumulate in the back marsh. When a large amount of organic matter is supplied in this way, the influx of water will be reduced in spite of frequent submergence and therefore an oxygen-reductive environment can be maintained for a long time and a large amount of sulfides will be included in deposits. 9_/

(3) Soil Condition

1) Soil Structure and Sediment

Soil surveys were conducted simultaneous with the transect and plot surveys. The soil survey points were selected in portions of a site where there were noticeable changes in the species distribution/composition, terrain and related features of the land as discussed above (6.2). The objective was to examine the correlation between soil conditions and species distribution/composition. The number of survey plots in each study site were as follows:

Study Site	Aparri	Lamon	Ulugan	Total
No. of Plots	10	17	15	42

The “Soil” referred to herein means principally the soil found in the mangrove areas. The properties of these soils are largely determined by the fact that they exist in mangrove eco-systems and their development is influenced by the mangrove vegetation. Additionally however, the Study also included a survey of soil carried in from the upper reaches of river basins and sandy soil washed in from the sea, even if this material was not an original component of soil within the study

Generally, soil depth and sedimentation are thin on the seaward boundary of the mangroves and gradually become thicker as one moves on a line pointing toward the land. The thickest soil depth is usually found at the middle of this line, after which depth gradually decreases near the shoreline. On land above the high tide line, where no mangrove vegetation is found, mangrove soil types no longer appear. Viewed on a horizontal plane, the structure of soil sediment looks like a convex lens with a thick center and thin rims. However, the depth of sedimentation varies from area-to-area probably under the strong influence of micro-topography.

Analyses of soil properties (color, depth, organic matter) document the variations in soil composition, and help demonstrate the link between these properties and species composition. For instance, at the condition of soil sedimentation in Aparri area, a dark-gray soil layer is observed where the soil depth is more than one meter (1.0 m) and the organic matter content is relatively low. On the other hand, in Lamon Bay area, there is a thick layer of dark-brown soil with a relatively high content of organic matter derived from mangrove forests. These soil properties indicate that in the Aparri area large volumes of sediment are washed in from the upper stream. By contrast, sediment inflows from the adjacent land are small at Lamon Bay and Ulugan Bay. In other words, the Buguey zone falls under the Open Accreting coast type in respect of sediment inflows, while the latter areas fall under the estuary type.

2) Soil/Species Correlation

As mentioned earlier, soil surveys were conducted simultaneously with transect and plot surveys that examined the vegetative structure. Combining the results of these concurrent surveys, the following can be observed:

(a) Where the soil texture is sandy, the outer seaward zone of the mangroves is dominated by *Sonneratia alba* and other species are limited.

(b) Where the soil has a higher mixture of silt and clay than the sandy-textured soils, several species are found with the most prominent being *Avicennia marina*. However, there are regional variations of this pattern.

(c)In muddy mangrove soils having a high content of silt and clay, various mangrove species appear and it is difficult to identify a correlation between soil properties and species composition.

(d) In areas with dark brown mangrove soil rich in humus and other organic matter, *Rhizophora* spp. thrive including *Rhizophora apiculata*, *Rhizophora mucronata* and *Bruguiera gymnorrhiza*.

(e)Further landward, submergence is rare, thus allowing time for the soil to partially dry out. Even though these soils are similar to mangrove soils in terms of silt and clay content, their bright color and low percentage of organic matter indicate that these soils are not derived from mangroves but rather originate from terrestrial sources. In such areas *Heritiera littoralis* and *Excoecaria agallocha* appear to be dominant.

Once colonies of *Rhizophora spp*. become well-established, the trees produce large amounts of litter. Decomposition of the litter leads to the development of a typical dark-colored mangrove soil with a high percent of organic matter. Conditions are then favorable for accelerated growth of mangroves and their dominance of the area. In other words, there is co-lateral development of the soil and the mangrove vegetation. The soil profiles in Lamon Bay area is good examples of this phenomenon. This co-lateral development process is generally observed in mangrove forests categorized as the estuary type.

(4) Soil Analysis

1) Aims of Soil Analysis

Soil analysis has the following two aims:
(i) To reveal the physical and chemical compositions of mangrove soils;
(ii) To show the correlation between soil composition and species selection.

The ultimate goal is to identify suitable mangrove species for planting in afforestation sites in the future, based on the soil analysis results.

2) Soil Sampling and Analysis Methods

Sampling was conducted in the Aparri, Lamon Bay, and Ulugan Bay areas using a soil auger. The sampling methods were different from one area to another. In the Aparri area, samples were taken from depths of 15 cm, 60 cm, 120 cm, and 180 cm to examine differences in soil layers. In the Ulugan Bay area, sampling was conducted in various mangrove species zones to learn the correlation between soil composition and each mangrove species. In the Lamon Bay area, sampling was carried out at several distances perpendicular to the coast line in order to compare with mangrove soil composition and further inland soil, and to examine the correlation between the micro topographical variations from inland areas to coastal fringes and change of mangrove soil.

The soil samples were carried in plastic bags back to the laboratory, air-dried, and analyzed. The analyzed items were divided into two categories, physical characteristics including particle size, and chemical properties including pH, electrical conductivity, organic matter content, disassociated phosphoric acid, and anion/cation content.

3) Result of Soil Analysis

1) Physical Composition

a. Depth/Physical Property Correlation

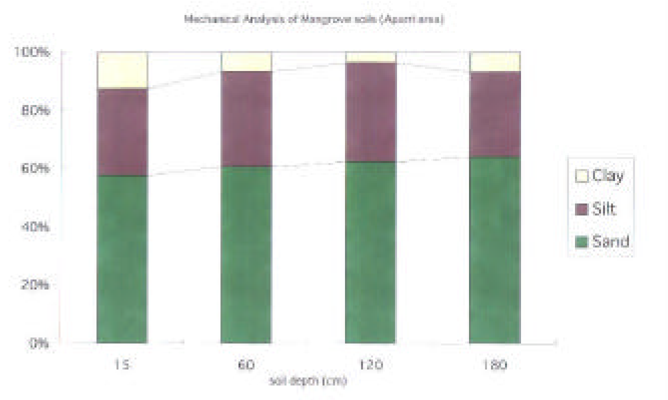


Fig. 2-1-19 Mechanical Analysis of Mangrove Soils (Aparri)

Figure. 2-1-19 indicates the physical composition of mangrove soils taken from different depths in the Aparri area. The samples were taken from depths of 15 cm, 60 cm, 120 cm, and 180 cm were found to resemble each other.

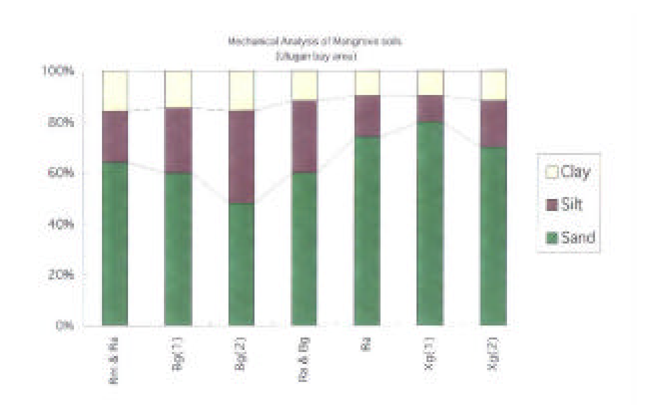


Fig. 2-1-20 Mechanical Analysis of Mangrove Soils (Ulugan)

Sand composed about 60% of the soil, silt about 25 to 30%, and clay about 10 to 15%. The fact that little difference exists across the depth means that the same sedimentation conditions have remained unchanged over long time. The soil in the Aparri area is thought to have been carried by big rivers, such as the Cagayan, and coastal sea currents.

b. Species/Physical Property Correlation

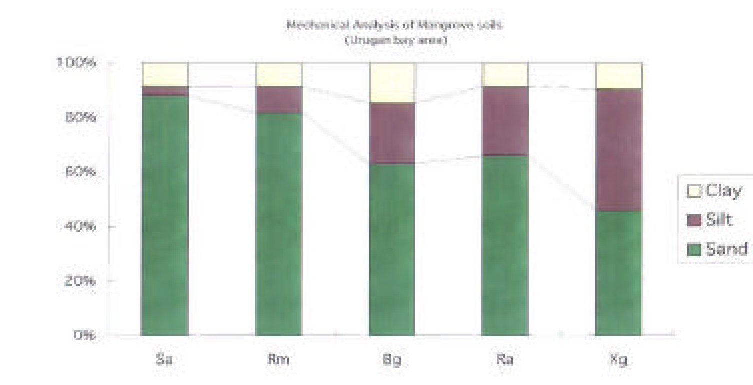


Fig. 2-1-21 Mechanical Analysis of Mangrove Soils (Ulugan)

Figures 2-1-20 to 2-1-22 indicate the composition of mangrove soil taken from species zones in the Ulugan Bay area. The compositions show that the ratio of sand is high in every zone. The ratios of silt and clay were found to increase from coastal fringes to inland areas. For example,

Figure 2-1-21 shows that the sand component is almost 90% in the Sa zone adjacent to the seashore. In the *Rhizophora mucronata* zone, located next inland area, the sand component drops to 80% and silt rises to 10%. In the *Bruguiera gymnorrhiza* and *R. apiculata* zones further inland, sand decreases to around 60% and the silt content increases further. In the *Xylocarpus granatum* zone, the furthest inland, sand falls to less than half and is replaced by silt.

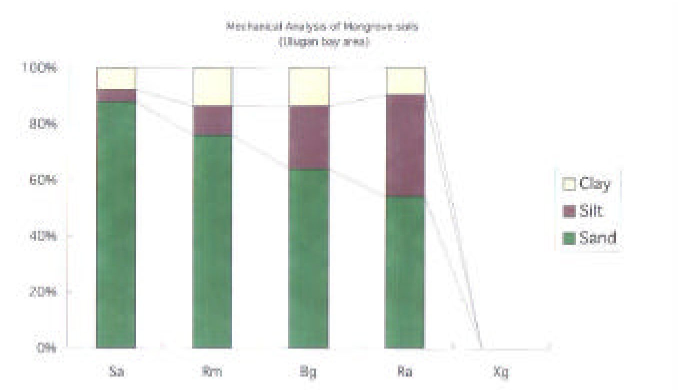


Fig. 2-1-22 Mechanical Analysis of Mangrove Soils (Ulugan)

Compared with the results from two other areas in the Ulugan Bay area, the result of one area (Figure 2-1-22) is much the same as that described above, but that of the other (Figure 2-1-20) shows that the ratio of sand decreases which proceed towards. However, the ratio of sand is higher again towards inland. This does not necessarily mean that *X. granatum* prefers silty soil. On the whole, some correlation is found between the variation of mangrove zones and the decrease in sand /increase in silt- contents. That is, the sand ratio is highest in *S. alba* areas, and decreases from *R. mucronata*, *B. gymnorrhiza* and *R. apiculata*, to *X. granatum* zones respectively. (In one area, *X. granatum* is not found.)

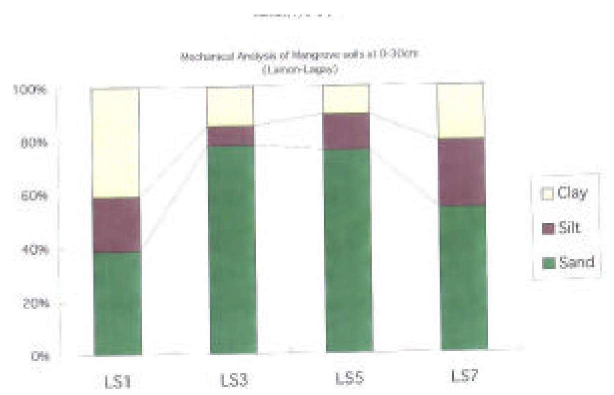


Fig. 2-1-23 Mechanical Analysis of Mangrove Soils (Lamon)

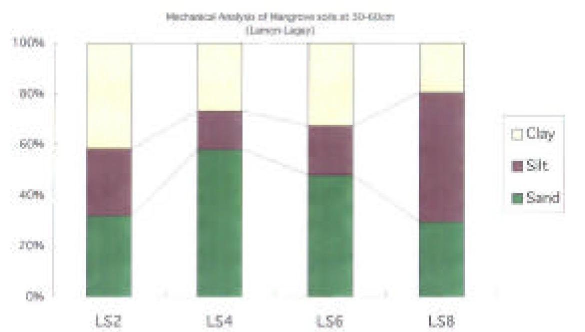


Fig. 2-1-24 Mecanical Analysis of Mangrove Soils (Lamon)

c. Micro Topography/Physical Property Correlation

Figures 2-1-23 and 2-1-24 show the physical composition of the mangrove soil samples taken according to the micro topographical variation from coastal fringes to the land zone of the Lamon Bay area.

Of the samples, LS1 and LS2 were taken on the inland zone, LS3 and LS4 along a boundary of inland and mangrove zones, LS5 and LS6 in an high inter-tidal zone, and LS7 and LS8 in an middle inter-tidal zone. LS1, LS3, LS5 and LS7 were taken from depths of 0 to 30 cm, and LS2, LS4, LS6 and LS8 from depths of 30 to 60 cm.

The results of analysis show that in the land zones, the clay ratios are high, where on the landward fringe and mangrove zones and in the high inter- tidal zone, the ratio of sand increases. In the inter-tidal zone, nearer to the seashore, the sand ratio drops again. And the clay ratio falls and the silt ratio rises through the high inter-tidal zone to the middle inter-tidal zone. As LS5 to LS8 were taken in the areas where mangroves grow, it is shown that the clay ratio tends to be high in soil sampled in land, while the silt ratio is high in mangrove soil.

2) Chemical Composition

Of all the chemical properties, the high organic matter content deserves special mention. Figure 2-1-25 indicate the organic matter contained in samples taken in the Lamon Bay area described above.

The results show that the organic matter content of LS1 and LS2, taken in the most inland zones, are less than 2% of the total weight, but those of LS3 and LS4, taken along the boundary of the inland and mangrove zones, increases to around 4%. The content increases further to around 5% through the high inter-tidal zone to the middle inter tidal zone. As described in the physical analysis, LS5

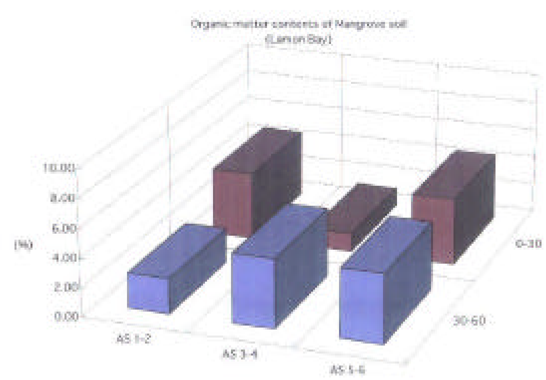


Fig. 2-1-25 Organic Matter Contents of Mangrove Soil (Lamon)

to LS8 were taken in the mangrove areas, and therefore, the mangrove soils contain more organic matter than the land soils.

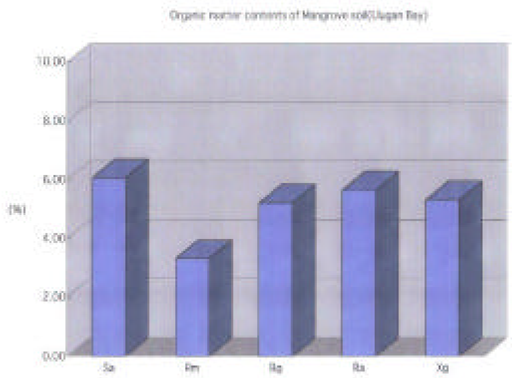


Fig. 2-1-26 Organic matter of Mangrove Soil (Ulugan)

In relation to the correlation between each mangrove species zone and its organic matter content. Figure 2-1-26 shows the organic matter content contained in soil samples taken in the Ulugan Bay area. This indicates that the soils where all the mangrove species except *R. mucronata* grow contain organic matter representing around 6% of the total weight. Only the soil where *R. mucronata* grows contains less than 4%.

The mangrove forests in the Ulugan Bay area are better conserved than those in other areas. And it is thought that, as a result, more organic matter is supplied by the mangroves to the soils, leading to the fact that the contents in the area are one more percent higher than those in other areas. However, large differences are not found in the organic matter contents of each mangrove species zones in the Ulugan Bay area. This is due to the fact that the environments where mangroves grow are affected by tides. Therefore, when the tide rises and falls, organic matter is distributed over some distance such that the levels contained in the soils of different zones have become almost the same level, even though the zones are not so small.

(5) Sedimentation Rate of Mangrove Soil

How long does it take for mangrove soil, described above, to accumulate? One possible mechanism is described below. There are relatively small and new plantation of *R. mucronata* in the Bahi1e and Macarascas zones, furthest inland of the Ulugan Bay area. A feature of *Rhizophora* spp. is the shape of its stilt-roots. Stilt-roots hold the soil, sand and organic matter, aiding soil sedimentation. It is thought that as *Rhizophora* spp. grows, the root system expands promoting further soil sedimentation.

In the Bahile and Macarascas zones, there is a plantation where *R. mucronata* trees were planted in lines over a different planted years. The mangrove soil sedimentation conditions were investigated in the *R. mucronata* planting zone at low tide by measuring the soil depths at regular intervals across the each plantation.

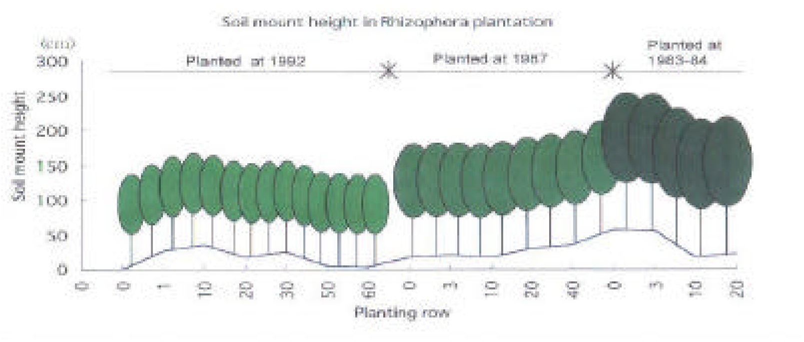


Fig. 2-1-27 Soil Mount Height in *R. mucronata* Plantation

In this plantation, mangroves planted between 1983 and 1984, in 1987, and in 1992 lie in a belt. The mangrove soil sedimentation condition was as follows: mangroves planted in 1992 shows a sedimentation depth of 15 to 20 cm, in 1987 between 25 and 30 cm, and between 1983 and 1984 more than 30 cm in which the largest depth was found to be 57 cm. Survey result is shown in Figure 2-1-27.

In the forest area planted in 1992, a rectangular plot 100 m by 60 m was marked out and divided into smaller 20 m by 10 m sections. The depth was measured at each node to uncover the soil sedimentation distribution of the forest ground. Results showed sedimentation depths between 10 and 40 cm, although some deviations were observed. The soil sedimentation distribution is shown in Figure 2-1-28.

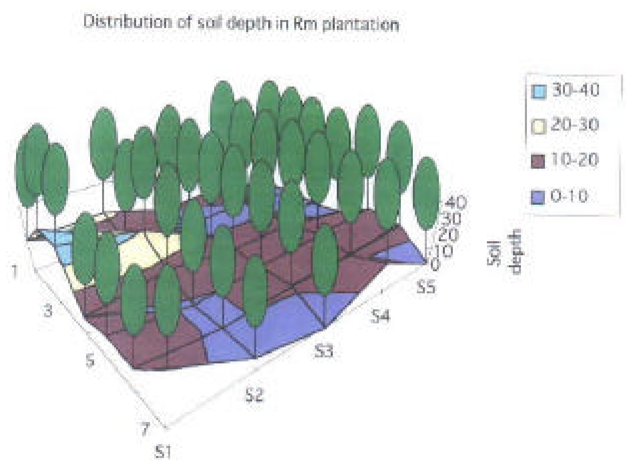


Fig. 2-1-28 Distribution of Soil Depth in *R. mucronata* Plantation

When the soil was analyzed, the composition was found to consist almost entirely of sand, with little silt or clay. The dark-color of a soil containing a large proportion of organic matter was not observed, which is peculiar for a mangrove soil. This shows that the soil contained in the zone was not created by mangroves, but was composed of the sandy soil from other places carried there by sea currents or tides and caught by the mangrove stilt-roots.

From this result, it is possible to infer that in the places where mangrove species like *R. mucronata* are planted, soil and sand transported by currents and tides are held by the stilt root structure, encouraging a rather high rate of accumulation. However, at this stage, organic soil typical to mangrove forests has not been accumulated. It is considered that it takes quite a long time for dark-color soil, which is found in mangrove forests at a later transition stage, to be created.

(6) Salinity

Mangrove forests develop extensively along rivers where fresh water turns brackish due to inflows of saline seawater. The degree of salinity may vary significantly in response to the rates of fresh water inflow from upstream, seawater incursion and gradient of the river channel. It is universally-recognized that salinity impacts on the growth of plants. Consequently, the Study team examined the correlation between salinity and species composition in mangroves. This was done by travelling upstream by boat on three (3) rivers at the Aparri and Lamon Bay study sites, gathering water samples, measuring salinity with a salinometer, and observing mangrove growth along the way. Tests and observations at the Aparri site were conducted on the Linao and Cabuyo rivers. These activities were carried out in Kabibihan River at the Lamon Bay site.

On the Linao River, mangrove species and salinity studies were conducted at 25 points along a distance of 28 km moving upstream from the river mouth. On the Cabuyo River, the same studies covered 17 points on an upstream trip of 17 km. from the river mouth. On the Kabibihan River, the studies were carried out at 19 points along a river route of 15 km upstream from the lowermost part covered by aerial photography. The composition of mangrove species and the salinity of the water at each of these points are shown in Figures 2-1-29, 2-1-32 and 2-1-35. Changes in the frequency of appearance by species from lower to upper most part are shown in Figures 2-1-30, 2-1-31, 2-1-33, 2-1-34 and 2-1-36, 2-1-37.

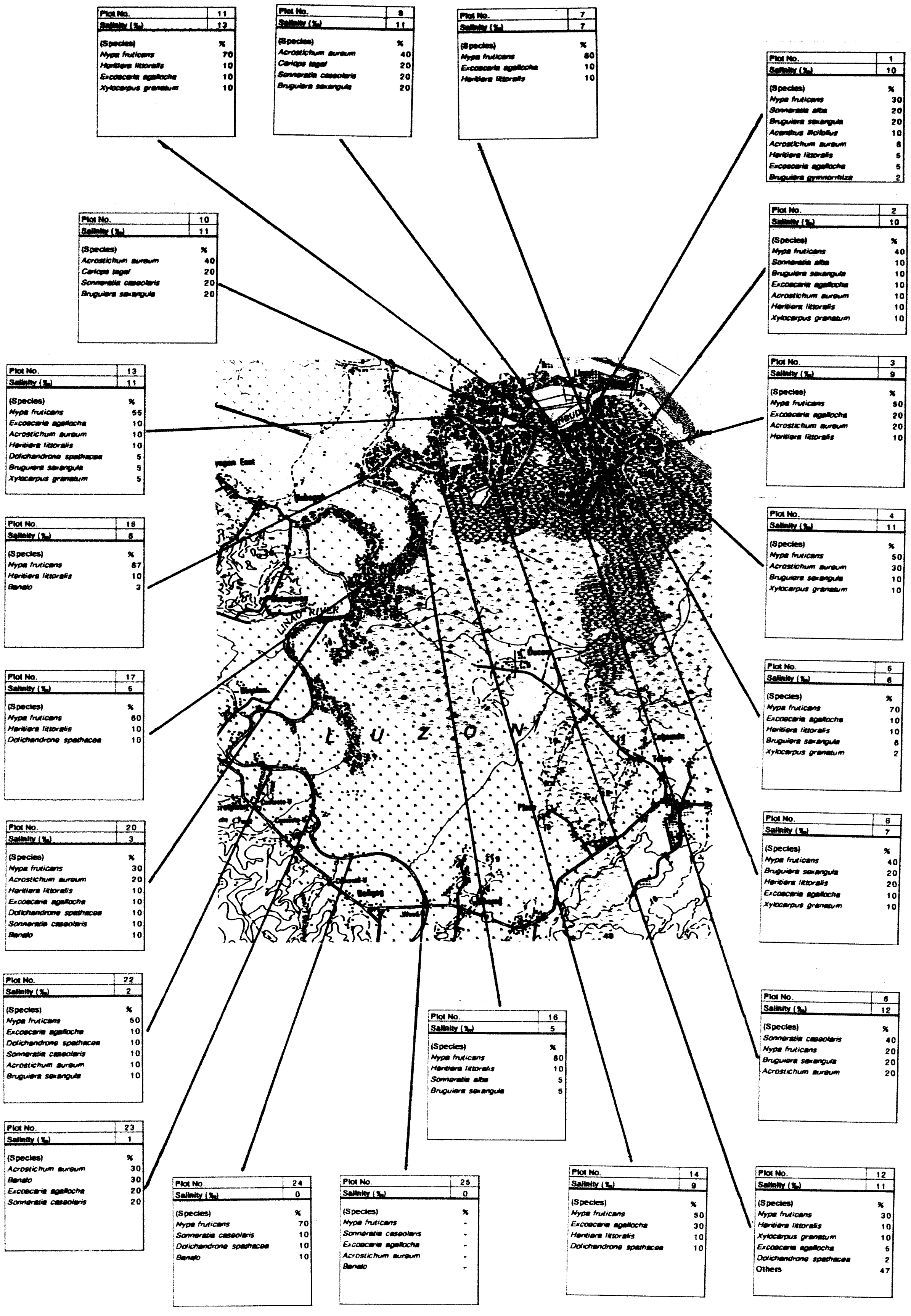


Fig 2-1-29 Survey Sites and Results on Linao River

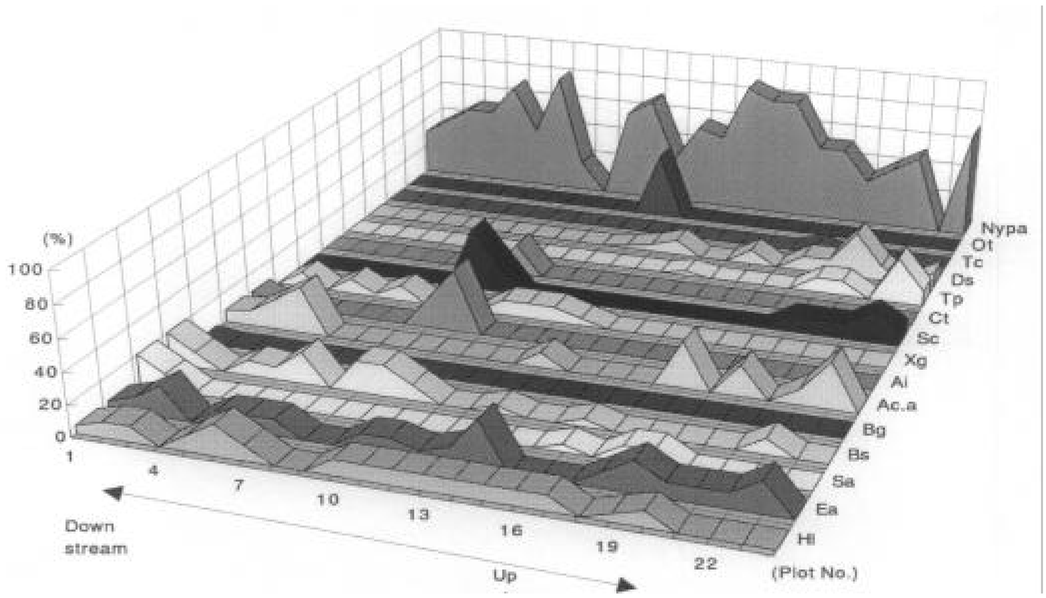


Fig 2-1-30　Distribution Range of Each Mangrove Species on Linao River

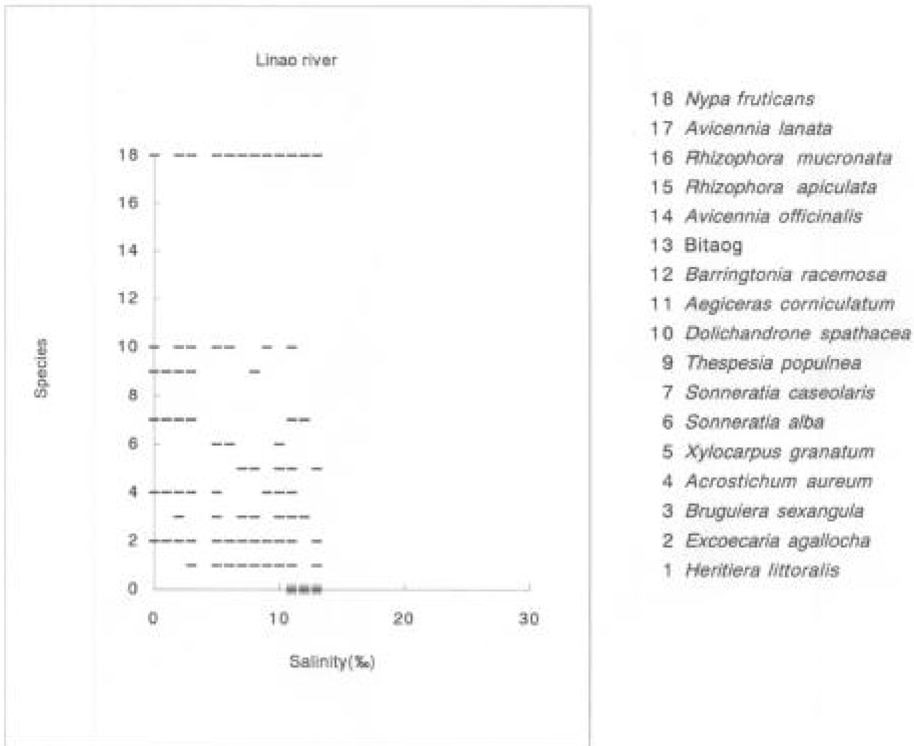


Fig. 2-1-31　Correlation Between Salinity and Mangrove Species

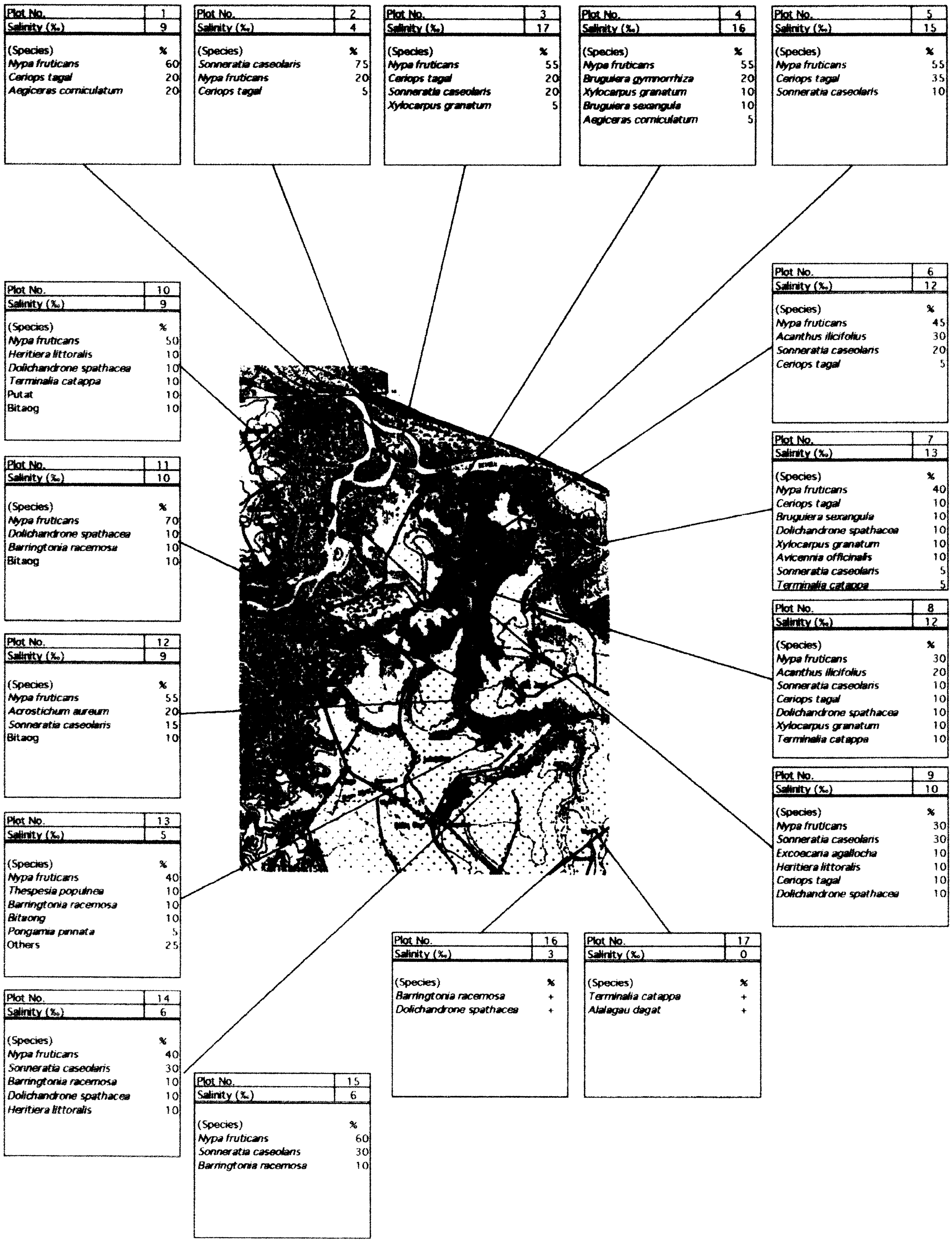


Fig. 2-1-32 Survey Site and Result in Cabuyo River

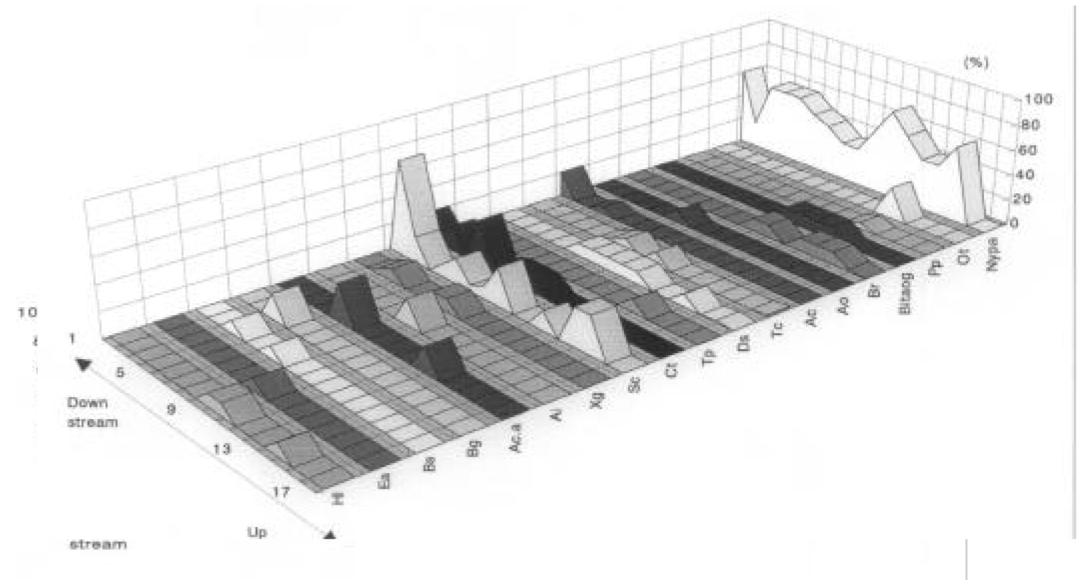


Fig. 2-1-33 Distribution Range of Mangrove Species on Cabuyo River

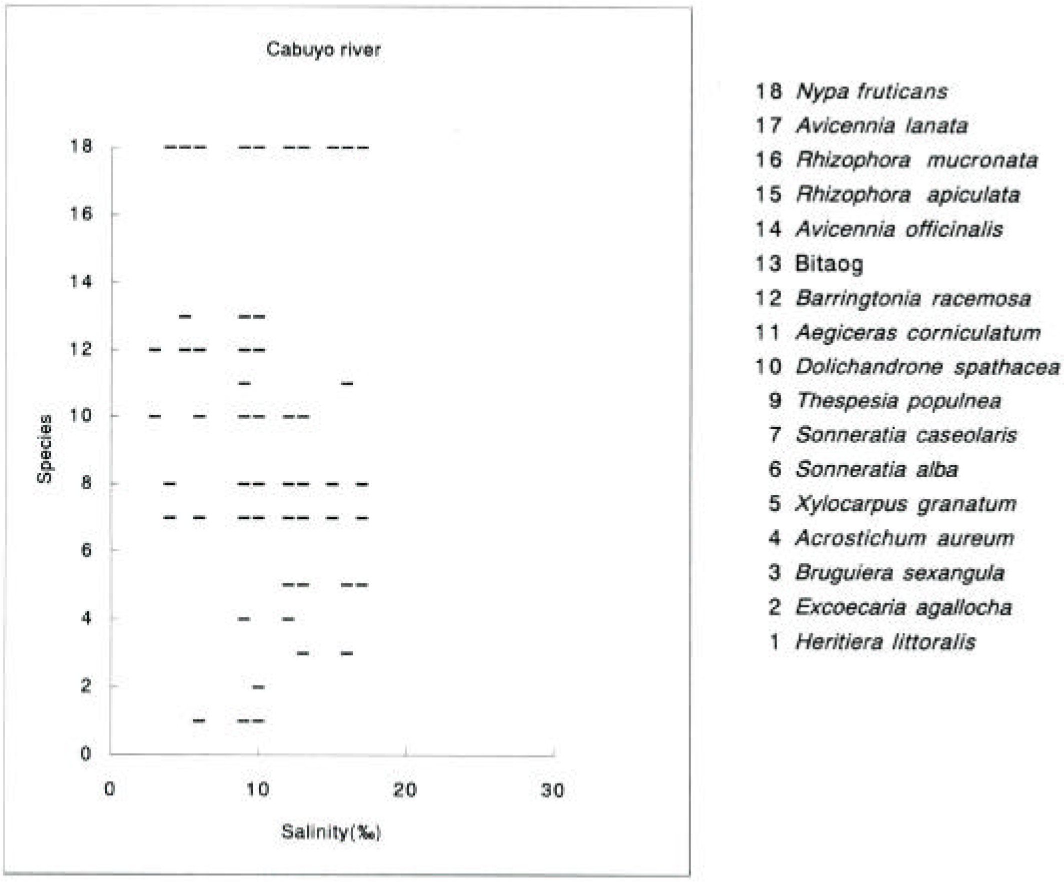


Fig. 2-1-34 Correlation Between Salinity and Mangrove Species on Cabuyo River

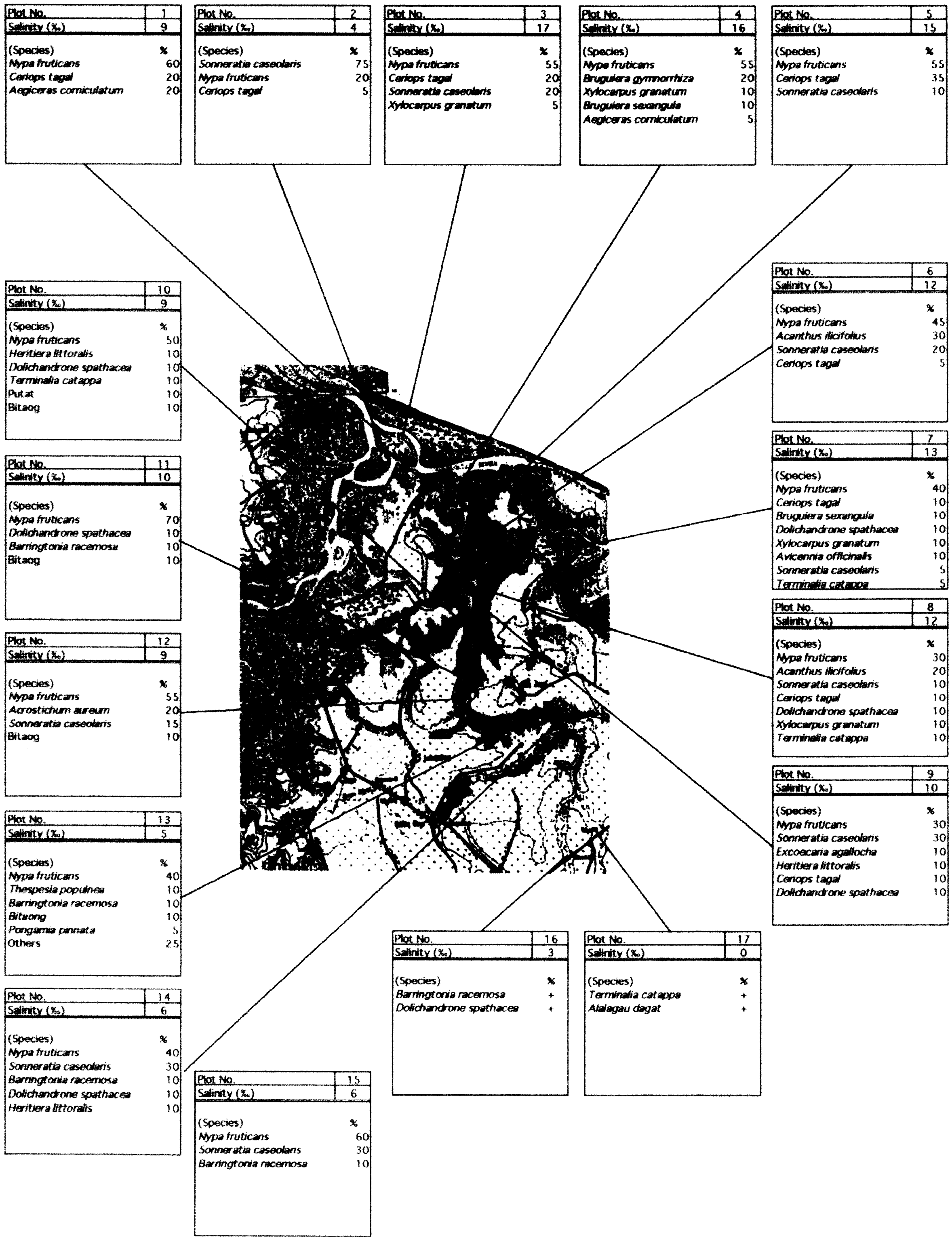


Fig. 2-1-35 Survey Site and Results on Kabibihan River

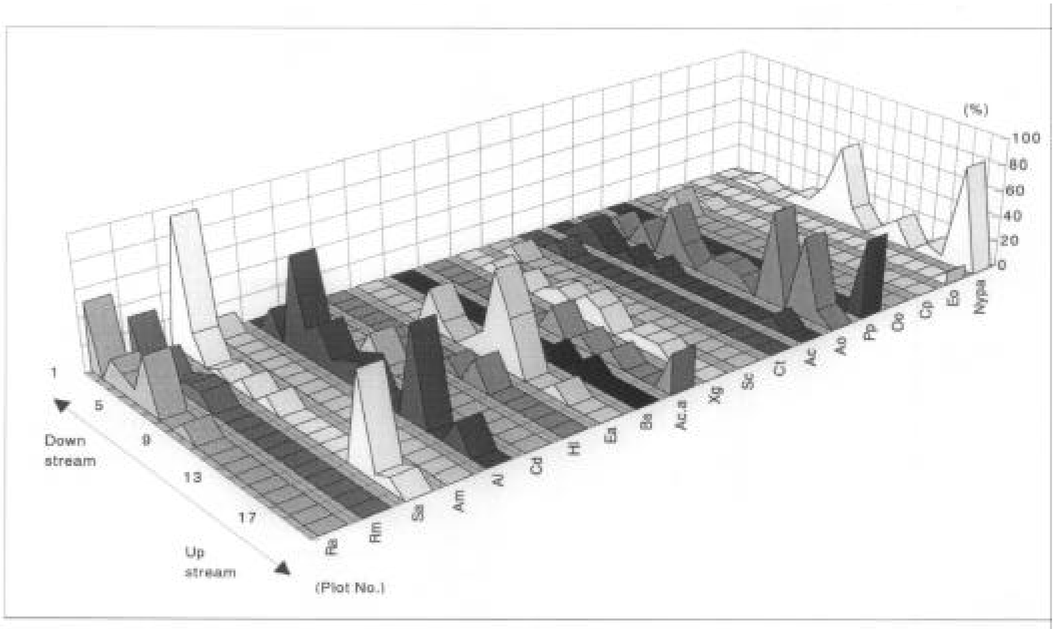


Fig. 2-1-36 Distribution Range of Mangrove Species of Kabibihan River

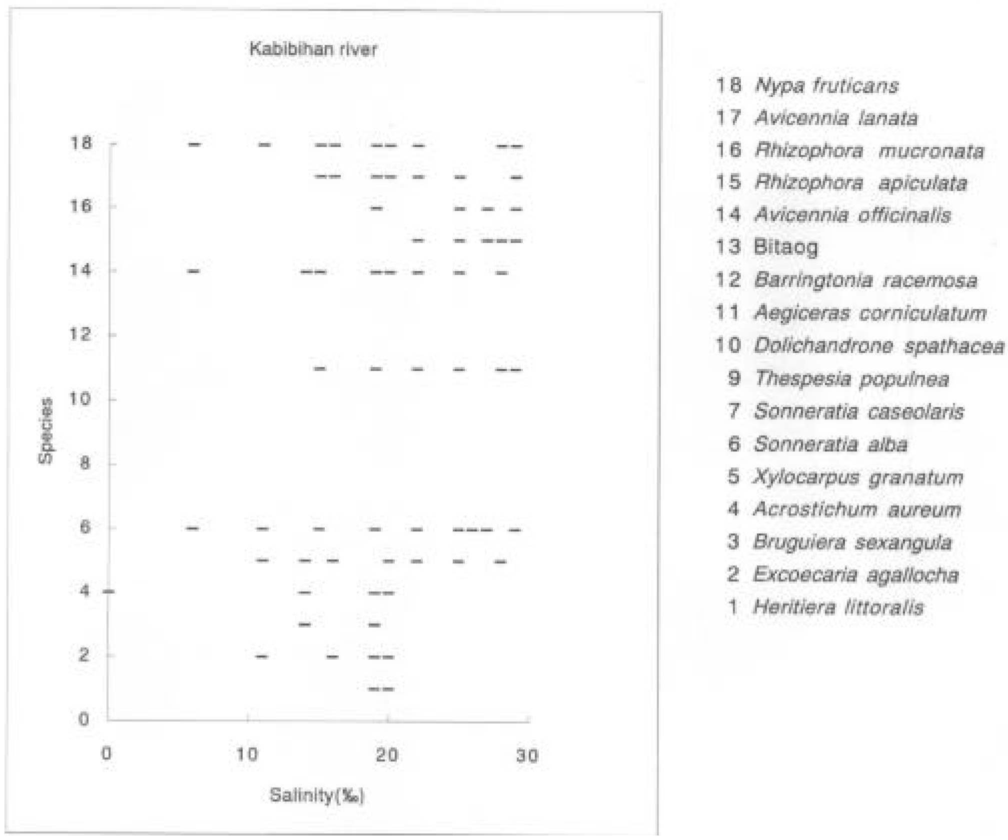


Fig 2-1-37 Correlation Between Salinity and Mangrove Species

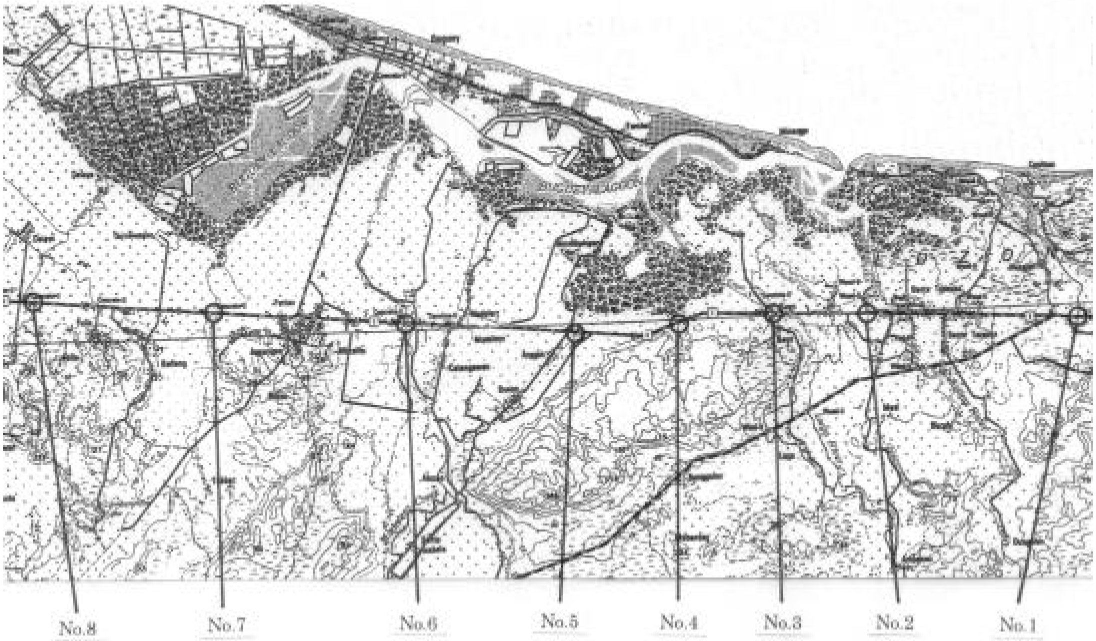
From the data appearing on Figures 2-1-29, 2-1-32 and 2-1-35, it is clear that *N. fruticans* grows at all the survey points on the Linao and Cabuyo rivers. However, this species was seen less frequently in the high-salinity lower reaches of the Kabibihan River. Based on these results, it is estimated that *N. fruticans* grows best in the lower salinity range (about 20% or less). .

Mangrove species along rivers may be roughly divided into three (3) groups: (i) those growing mainly in the lower reaches, (ii) species which appear frequently in the upper portion, and (iii) those found in both the lower and upper reaches. For example, in the Linao river *X. granatum* and *B. sexangul*a grow mainly in the lower portion while *Dolichandrone spathacea* and *Thespesia populnea* are plenty in the upper reaches. *H. littoralis* and *E. agallocha* are evenly distributed from the lower to the upper reaches, though at a low frequency.

As expected, results of the Study confirm that the distance from the river mouth to observation/test points is generally in inverse proportion to the salinity. However, the change is not always gradual. At some points midway along the river, there was an abrupt reduction of salinity due to inflow from a tributary. Figures 2-1-31, 2-1-34 and 2-1-37 show the distribution ranges of 18 main mangrove species in relation to salinity measurements. As seen in these Figures, the distribution range of mangroves viz-a-viz salinity varies slightly from species-to-species, probably indicating the salinity tolerance/preference level of each species.

In addition to salinity studies along rivers, the team also studied the creeks flowing into Buguey Lagoon. This exercise included (i) observations from a strategically-located bridge, (ii) estimating the flow rate of the creeks, (iii) calculating distances from observation sites to the uppermost streams, (iv) measurement of salinity and (v) listing of mangrove species growing on the riverside. The plots and results of this activity are shown in Figure. 2-1-38.

The several creeks surveyed are similar in width (10 m), but significantly different in salinity. At a salinity of 20%, mangrove vegetation was observed on the riverside. (Figure 2-1-39(A)) But where the salinity is at 0%, no mangrove vegetation could be found (Figure 2-1-39(B)). It may be inferred that the range of salinity accounts for the difference in vegetation.



	Salinity (‰)	Mangrove Species	Water flow	Distance of upper part of river
No.1	0	Nil	Strong	Very long, more than 20kms
No.2	20	*Nypa fruticans, Excoecaria agallocha*	Weak	Only 200m, like creek
No.3	0	*Excoecaria agallocha*	Average	Very long, more than 20kms
No.4	20	*Nypa fruticans, Excoecaria agallocha*	Weak	About 2kms
No.5	0	Nil	Very weak	Only 1km, like creek
No.6	0	Nil	Strong	Very long, more than 20kms
No.7	7	Nil	Weak	About 5kms
No.8	0	Nil	Weak	Only 1.5kms, like creek

Fig. 2-1-38 Location of Water Sampling Sites and Rivers Condition

Fig. 2-1-39(A) Landscape of Plot No2

Fig. 2-1-39(B) Landscape of Plot No6

Moreover, the variance in salinity undoubtedly relates to conditions of the upper stream, flow rate of each river and channel gradient. Rivers originating a