JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MALAYSIA
GOVERNMENT OF MALAYSIA

THE FINAL REPORT
OF
THE MASTER PLAN STUDY FOR THE FOREST PLANTATION DEVELOPMENT IN NORTHERN SABAH
IN
MALAYSIA

November 1994

Japan Overseas Forestry Consultants Association

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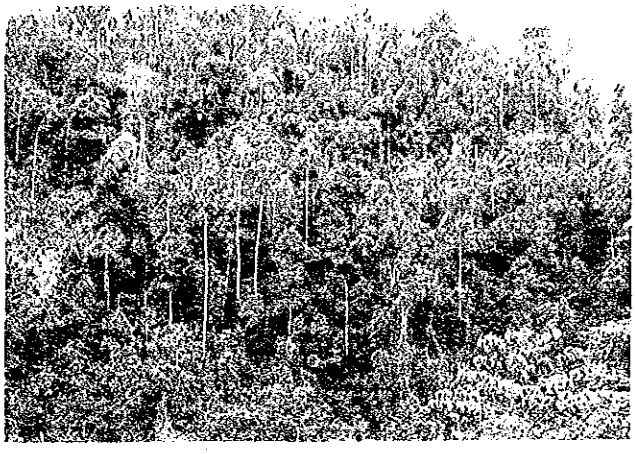
High Forest

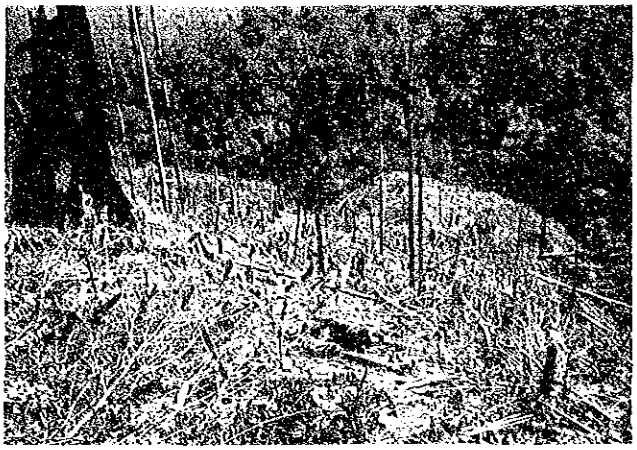


Medium High Forest

Shrubs

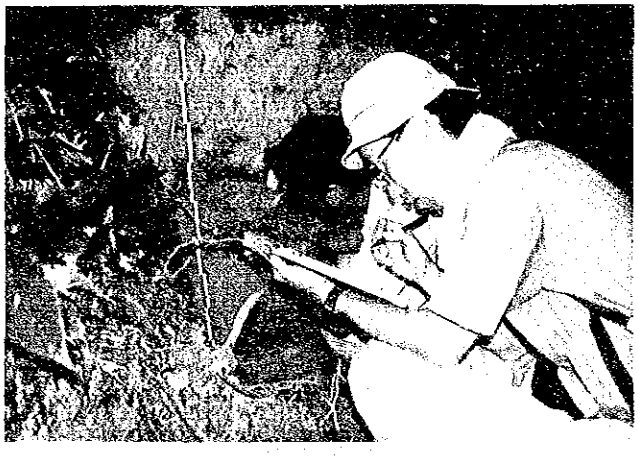
Natural Forest of *Paraserianthes falcataria*

Grassland



Prepared Land for Shifting Cultivation

Man-made Forest of *Acacia mangium*

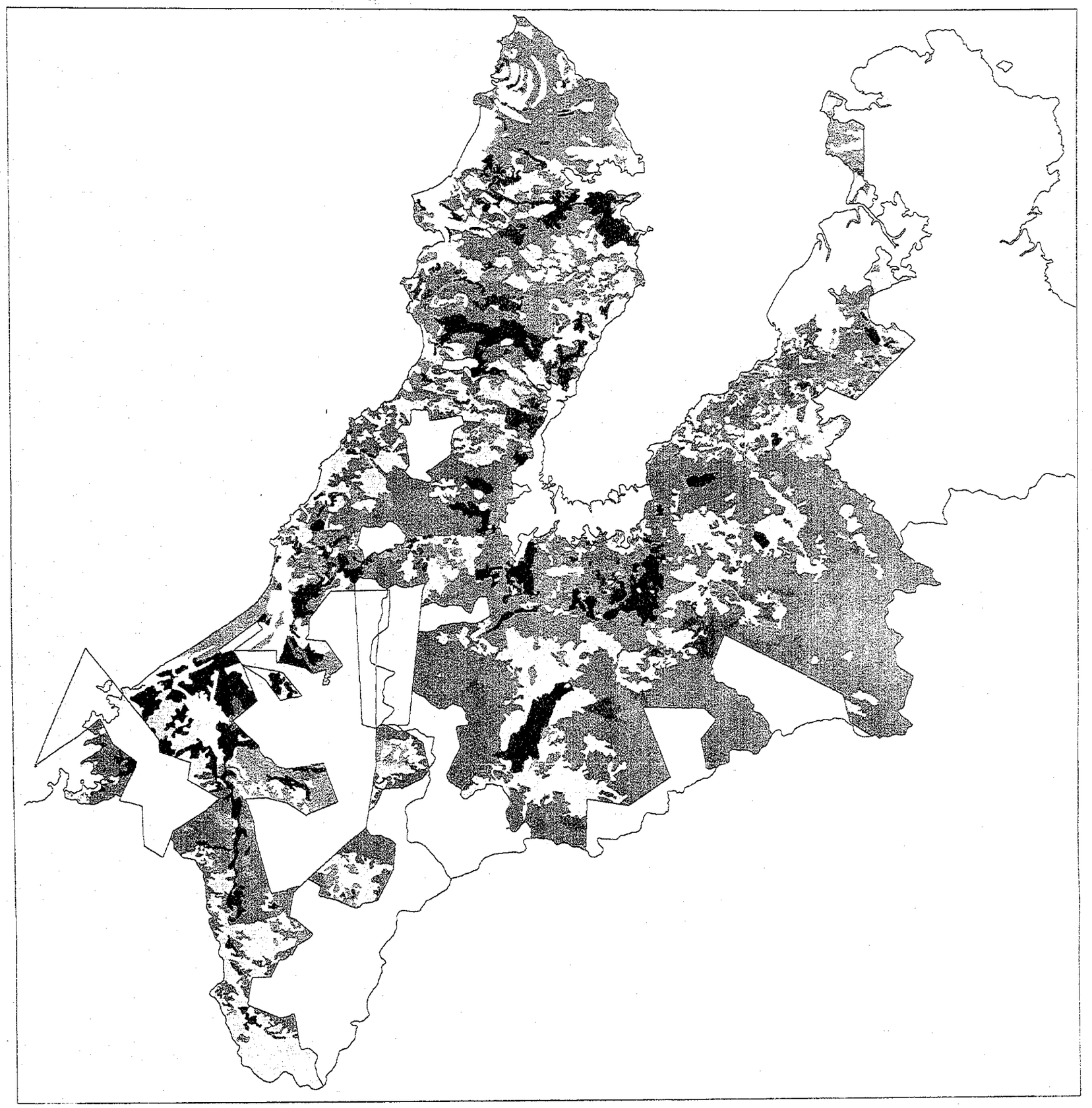


Soil Survey

Discussion in the Field

Measurement

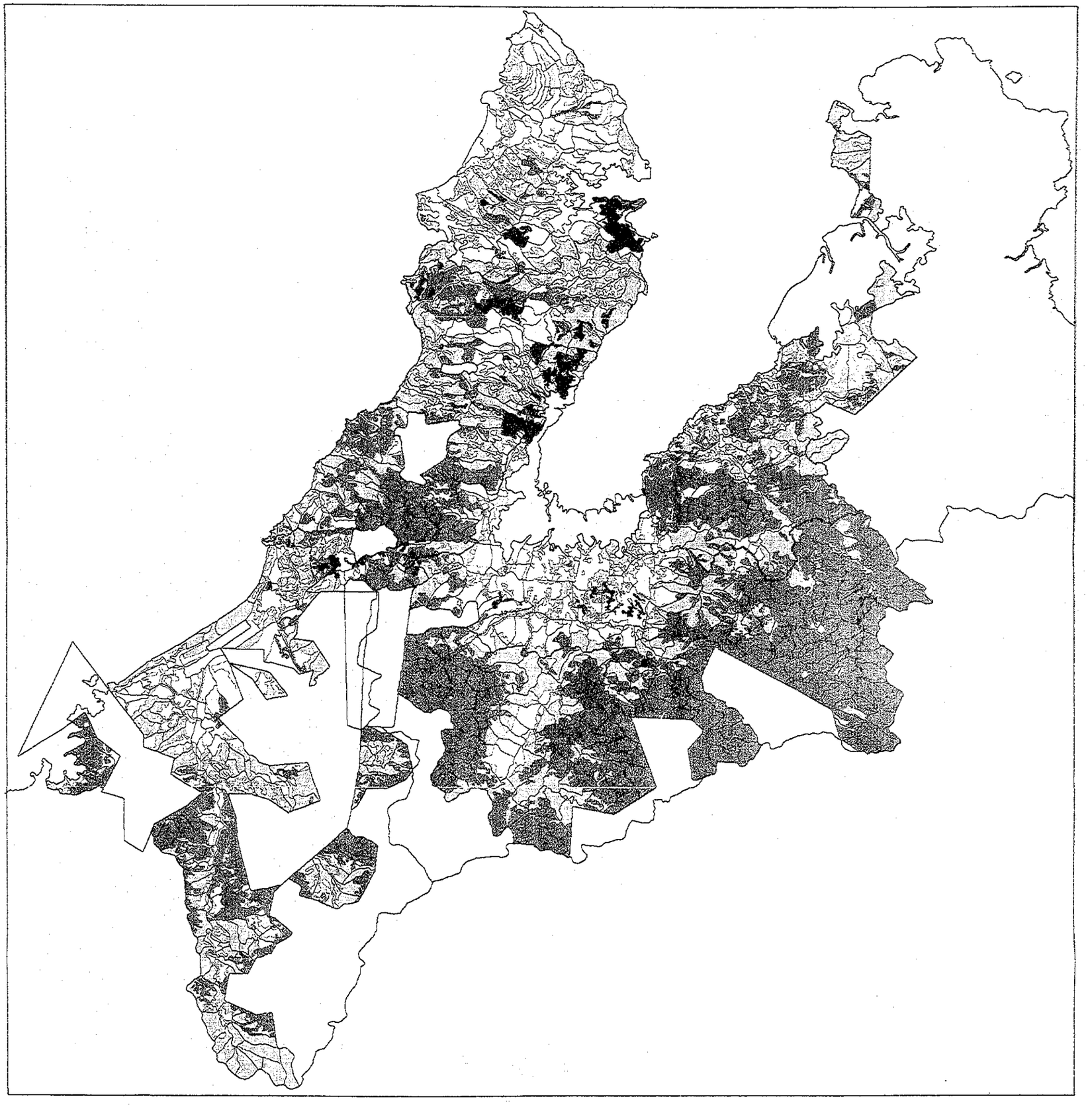
Interviewing with Residents



1／420，000

MAP OF LAND USE IN NORTHERN SABAH

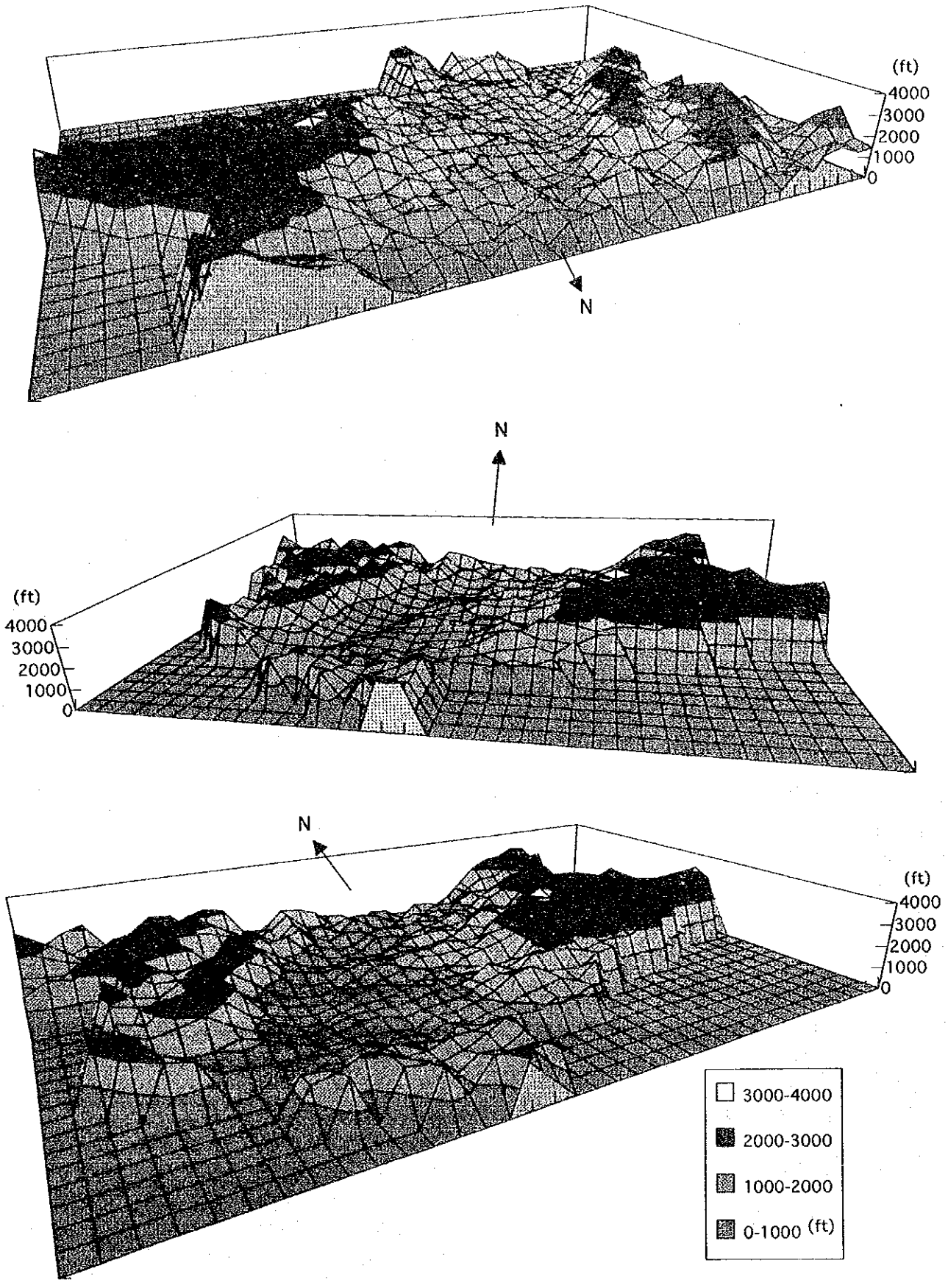
High Forest
Medium High Forest
Low Forest
Shrub Forest
Grassland
Plantation
Cropland
Man-made Forest



1／420，000

MAP OF PLANTATION PLAN

- Afforestation/Reforestation Area
- Enrichment Planting/ Natural Regeneration Treatment Area
- Conservation Forest Area
- Plantation Forest Area
- Boundary of Block
- Boundary of Sub-Block
- Langkon Compartment
- Sonsogon Compartment
- Tandek Compartment
- Marak Parak Compartment



Bird's-eye View of Marak-Parak Consolidation

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ABBREVIATIONS

B.D.T.	Bone Dry Ton
B.D.U.	Bond Dry Unit
CIF	Cost, Insurance and Freight
CMD	Chief Minister's Department
CSIRO	Commonwealth Scientific and Industrial Research Organization
D.B.H.	Diameter at Breast Height
DPE	Digester Production Efficiency
FA	Forestry Agency, Ministry of Agriculture, Forestry and Fisheries
FIRR	Financial Internal Rate of Return
FLM	Federal Manufacturing License
FOB	Free On Board
GDP	Gross Domestic Product
GNP	Gross National Product
HTI	Hutan Tomaman Industri (Industrial Afforestation/Reforestation)
IEE	Initial Environmental Evaluation
MAI	Mean Annual Increment
MDF	Medium Density Fiberboard
MITI	Ministry of International Trade and Industry
MTIB	Malaysian Timber Industry Board
MUS	Malayan Uniform System
NBT Corp.	North Borneo Timber Corporation
NDP	National Development Policy
NEP	New Economic Policy
NSSCP	Neutral Sulphite Semi-Chemical Pulp
NVP	Net Present Value
OPP	Outline Perspective Plan
OPP2	Second Outline Perspective Plan
SAFODA	Sabah Forestry Development Authority
SBLC	Stettin Bay Lumber Co., PTY., LTD.
SDD	State Department of Development
SFD	Sabah Forestry Department
SFI	Sabah Forest Industries Sdn. Bhd.
SGA	State Government Approval
SLDB	Sabah Land Development Board
SMIs	Small- and Medium-Sized Industries
SMP	Sixth Malaysia Plan
SSIA	Sabah Sawmilling Industri Association
SSSB	Sabah Softwood Sdn. Bhd.
S/W	Scope of Work

Summary

I. Introduction

Sabah State economy depends on forestry. However, forest exploitation has caused a visible depletion of timber resources and a rapid decline in timber production. In 1976, the Sabah State government established the Sabah Forestry Development Authority (SAFODA) and has made efforts to rehabilitate forest resources by planting fast-growing species. Among other areas, the northern part of the state is less fertile and not so arable. There are lots of abandoned land areas covered with grass resulting from shifting cultivation in this area. In this situation, the Government of Malaysia decided to promote regional development based on forestry in view of the poor soil conditions and deficient infrastructure in the northern Sabah and requested the government of Japan to prepare a master plan for such development.

In December 1991, a contact team was sent to Northern Sabah in Malaysia for the purpose of a survey and conferring with their Malaysian counterparts.

In October 1992, another contact team was sent to Northern Sabah for a field survey and meetings with their Malaysian counterparts, and the S/W and relevant minutes were signed.

In light of the natural and socioeconomic conditions and backgrounds of northern Sabah, it is necessary to increase forest resources and improve the socioeconomic condition of the local people through regional development based on forestry. Therefore, this study is intended to prepare a master plan for sustainable forest management in order to achieve:

(i) Forestry activities on a sustainable basis giving consideration to the environment;

(ii) Improvement of the social and economic conditions in view of the residents' life through forestry activities; and

(iii) Recovery and improvement of devastated natural environment through forestry activities.

As basic materials for such a plan, aerial photographs were taken, and a forest base map was drawn.

This study covers an area of about 323,000 ha out of the total area of about 540,000 ha of Kudat (excluding islands), Pitas, Kota Marudu and Kota Belud Districts, excluding lands of army areas, state parks, the Bengkoka plantation area which a feasibility study was completed by SAFODA, forest reserves managed by the Forestry Department.

This study has been carried out in three phases over two years as follows:

(i) Aerial photography and the preparation of a forest base map

(ii) Collection of existing materials and information on policies concerning forests, environments and regional development, natural, social and economic conditions, the existing state of land use, vegetation and soil, etc.;

(iii) Preparation of Land-use and Vegetation Map, Implementation Scheme Map, Forest Inventory Book, etc.; and

(iv) Preparation of Master Plan aiming to develop forestation by the year 2020.

Aerial photography and the preparation of Forest Base Map were subcontracted in Phase I.

II. Details of the Results of Basic Study

1. Natural Environment

This study covers an area of about 323,000 ha consisting of the four districts of Kudat (excluding islands), Pitas, Kota Marudu, and Kota Belud, but excluding the military areas, state parks and SAFODA's Bengkoka Project sites.

This area falls under the tropical rainy climate as classified by Köppen's system, and features high temperatures and high humidity. The West Coast Division and the two peninsulas of Bengkoka and Kudat are, however, strongly affected by the southwest monsoon and the northeast monsoon, respectively. The average annual rainfall is 2,352 mm (measured over a period of ten years) in Bongkol. The average high temperature is 30.9° C, and the average low is 22.3° C in the low-altitude coastal area.

This area consists of the two peninsulas of Bengkoka and Kudat, the long and narrow west coastline, the alluvial plain in Kota Marudu, and hill areas and mountains around Mt. Kinabalu. On the whole, the topography of this area is strongly affected by the geological structure.

This area is extensively covered mainly with sedimentary rocks originating in the Tertiary to the Quaternary periods, except for the area around Mt. Kinabalu which consists of granodiorite and adamellite. The base rock of hill areas covered by this study consists of hydrogenous sandstone, shale, mudstone and limestone. Alluvium is found along the rivers. The soil is composed mainly of sandstone, shale and mudstone. Weakly acid acrisols, luvisols and cambisols are extensively distributed.

This area falls under the tropical rain forest zone and is characterized by forests comprising a variety of species. The Sabah State has been endowed with an abundance of trees of the dipterocarp species, and 90% of the total log output in the state comes from this family. Mangrove forests have developed around river-mouths, and oak and chinguapin trees can be found in the mountains at altitudes higher than 900 m above sea level. Highlands over 2,200 m are covered with mossy forests, including lichens and rhododendron. Lowland forests are secondary forests partially occupied by grass (*Imperata cylindrica*) due to the frequent occurrence of fires.

2. Socioeconomic Environment

Sabah State has a one-chamber legislative assembly. The governor is the head of the state and is appointed by the King of Malaysia. The actual administrative management of the state is performed by the Chief Minister. The state administration is divided into eight ministries, including Industry and Development, Agriculture and Fisheries, and Finance as well as the Chief Minister's Department (CMD).

Sabah State consists of five divisions, each of which is subdivided into several districts. The area covered by this project consists of four districts, namely Kudat, Pitas and Kota Marudu Districts, all of which belong to Kudat Division, and Kota Belud District which belongs to West Coast Division.

The Forestry Department in the CMD is responsible for the administration of forests and forestry in Sabah. Government agencies which support the Forestry Department include the Sabah Forestry Development Authority (SAFODA), the Sabah Foundation, and Sabah Forest Industries Sdn Bhd (SFI). The Forestry Department Headquarters is in Sandakan, and the department has a staff of about 1,100 under the director. Forestry offices and regional forestry offices are affiliated to the department. This area is under the jurisdiction of the Kudat Regional Forestry Office, to which four regional forestry offices are affiliated. SAFODA was established in 1976 and has its head office in Kota Kinabalu. It is aimed at promoting the use of wasteland and agriculturally marginal areas for forestry, the shift of timber production from natural forests to plantations, the expanding employment of the local people by means of forestation, and the improvement of their living standard under the forest-settlement plan.

The Malaysian government has achieved remarkable economic development through its economic policies over the two decades from 1971 to 1990. Since 1991, the government has been making efforts for further economic development under the Second Long Perspective Plan which covers the period from 1991 to 2000. Based on such stable economic development, Malaysia intends to join advanced countries by 2020.

The Sixth Malaysia Plan corresponds to the first half of the Second Long-term Perspective Plan which has set targets such as an economic growth rate of 7.5% or more on an average, a manufacturing sector share of 32.4% of the GDP, and an employed population of 7.5 million.

Sabah State's goals of economic development as specified in the Sixth Malaysia Plan are to achieve an economic growth rate of 6% on average, improve the living standards, reduce the relatively poor, eradicate absolute poverty, and promote the development of infrastructure and public facilities. The strategies for attaining these goals are to reduce the percentage of the poor in the total population by 1 percentage point every year, modernize and commercialize agriculture, and make forest resources sustainable through excellent forest management and operation, reforestation and afforestation.

Hills in the area under study have conventionally been used for shifting cultivation. A relatively large number of people are concentrated in the peninsular part of Kudat since it was the former capital of Sabah State. Lowlands have been used for agriculture. Hills are covered with only secondary forests as a result of shifting cultivation. In Kota Marudu and Kota Belud, flat areas are used for paddy cultivation where water is available. Coconut palm and rubber plantation are distributed in hill areas. In Pitas, a comparatively large proportion of land is covered with forests.

There are about 180,000 people in this area, about 75% of whom are rural.

Major industries in the study area include agriculture, livestock industry, forestry, fisheries and commerce. Forestry is described in Chapter III.

The main agricultural crops are rice, rubber and coconut palm, which together account for about 80% of the total cropped area in this area. This area accounts for about 29% of the total area of Sabah State devoted to rice, 50% of the area devoted to coconut palm and

16% of the area used for rubber plantation. Thus, the study area has a large proportion of areas of the state growing rice and coconut palm. On a district basis, Kota Belud has a high share in the total rice-cropped area. Rice occupies 50% of the total cultivated area in the district and 21% of the total cultivated area in Sabah. In terms of coconut palm-cropped area, Kudat has as a remarkably high share as 34%. There is, however, a tendency to abandon coconut palm estates and to shift from coconut palm to other crops as the price of coconut palm falls every year. The cultivation of oil palm instead of coconut palm has also been expanding rapidly in this area. Plantations of this crop are concentrated in Kota Marudu and Pitas.

Between 1985 and 1990, domestic animals, such as cattle, goats and pigs increased, and the production of broilers and eggs also increased. However, their consumption exceeds their production, and all of them but broilers are currently imported. Whereas the number of raised buffaloes slightly increases, that of slaughtered ones decreases.

The coastline of Sabah extends for 900 miles (approximately 1,400 km), supplies a wide variety of fish. Despite being abundant in this area, marine resources have not be fully utilized due to a shortage of storage and processing facilities, lack of fishing technology and investment in this sector. Coastal fishing is prevalent. The mouth of the Telaga River on the Bengkoka Peninsula is a suitable site for prawn culture, and its future development is expected.

There is no significant commercial activity, except for small retailers, in this area. The mining industry is also not significant.

3. Forestry and Forest Industries in Sabah

Sabah State granted its first concession (contract) in 1879. A commercial sawmill started operation as early as 1888. The Forest Department was set up in 1914 to manage the felling of forests, but log exports had remained at a low level until the 1950s. Sawmills were mechanized in the second half of the 1950s, and a plywood mill was constructed for the first time in 1960.

A survey of forest resources was conducted in 1969. The designation of forest reserves was continued, and the permanent conservation of forests covering an area of 4.2 million ha was legislated in 1985 in order to ensure the existence of forestry activities.

Although forestry in Sabah depends mainly on the felling of natural forests, forestation was launched in the 1970s. Terminology of "forestation" comprised criteria of Afforestation, Reforestation and Artificial Regeneration. Large-scale forestation was carried out in Sabah by Sabah Softwood Sdn. Bhd. (SSSB), SAFODA and Sabah Forest Industries Sdn. Bhd (SFI). Of these organizations, SSSB has made the most progress in forestation, and a large amount of timber is already produced from man-made forests in the Brumas Consolidation.

Despite being low at present, the volume of timber exports from man-made forests is increasing steadily and will continue to do so in the future.

Four species, *Acacia mangium, Paraserianthes falcataria, Gmelina arborea* and *Eucalyputus deglupta*, were selected as the most suitable species for forestation in Sabah based on the results of previous experimental plantation and commercialized plantation. In addition to these main species, eleven other species were also selected, including *A. auriculiformis* and *Tectona grandis*.

Based on the results of the survey, the study team designated *A. mangium* as the most promising candidate for industrial forestation, and also selected *G. arborea, P. falcataria* and *T. grandis* as introducible species.

The output of logs from natural forests in Sabah was stable at around 10 million m^3 per year from 1970 to the first half of the 1980s. It, however, began to fall after the peak in 1987. As wood processing was promoted as a policy, logs for the domestic market began to increase in 1987, and exported logs decreased to below 50% in 1990. The Sabah State government laid an embargo on log export from natural forests in January, 1993.

The output of timber products has been increasing rapidly since 1990. This has been accompanied by an increase in their exports. The output and exports of plywood are also rapidly increasing.

Raw-material logs for wood processing industries in the state have recently showed a tendency to fall short. The Zero-Waste Campaign is being performed under the guidance of the Forestry Department. Processing mills for blockboard and glued lamination board have also been constructed and brighten the prospects for wood processing industries.

There is, however, a global fear of the depletion of natural resources. Sabah State has also been faced with the problem of decreasing natural resources. Meanwhile, however, industrial forestation has been promoted steadily, and the processing of logs from man-made forests has already begun. It is expected that an increasing amount of logs supplied from large man-made forests will be processed and exported in the future.

4. Aerial Photograph and Preparation of Forest Base Map

Aerial photography and the preparation of a forest base map were performed by contract. The contents of the contract were explained to several surveying companies in Malaysia. A series of hearing was held to confirm their operational capabilities, technical skills and willingness to present a quotation.

After specifications were approved by the Japan International Cooperation Agency, the presented quotations were compared. As a result, Jurukur Perintis became the successful bidder in both the assignments. A contract was officially concluded with the company.

Photographs of the planned area could fortunately be taken, even though it was expected that weather conditions caused by the tropical rainy climate might obstruct aerial photography. Therefore about 5% of these photographs, were, however, rendered unusable due to the cloudy conditions. Aerial photographs taken in 1986 were used in preparing a land use and vegetation map and an inventory book.

A forest base map was prepared in compliance with the specifications.

5. Results of the Inventory

The main purpose of the second field survey in Phase I was to gain a first hand knowledge of the actual conditions of forests, analyzed aerial photographs, prepare a forest inventory book and collect basic material for the development of a forestation plan. For this purpose, study plots were chosen in natural and man-made forests and surveyed with the focus on standing trees. The number of natural forest plots was 27 and man-made forests plots was 32. Twenty-one of these plots were covered in the soil survey.

Forests in the state land in this area have been felled to a considerable extent even in the hinterland. High dipterocarp forests unexpectedly occupy only a small portion of the forests and the major portion consists of secondary forests. The survey of natural forests was conducted mainly in the southern part of Kota Marudu District. This is because the stands to be surveyed may not have been found if the coverage of the survey had not been extended to such an inland area. Shifting cultivation prevails even in the inland area. The results of this survey are reflected in the inventory book.

Man-made forests covered by this survey consisted mostly of *A. mangium*. The average D.B.H., average height and basal area of trees in every plot were calculated, and the tree volume of the sample plot was determined by sectional measurement.

According to these results, the highest mean annual increment (MAI) of *A. mangium* was 25.95 m^3 and the lowest was 8.40 m^3, and the variation was significant from plot to plot.

A soil survey was conducted at 15 spots in natural forests and 6 spots in man-made forests. The results showed that the soil of the planting sites was weakly acidic and would pose no problems to the planting of *A. mangium*.

6. Current Land-use and Vegetation Conditions

Prior to the interpretation of aerial photographs, forest reserves, army area, state parks and the Bengkoka area were demarcated from the area covered by this study. Subsequently, land-use and vegetation analysis items were listed, and preliminary interpretation was performed. Based on the preliminary interpretation and the results of the forest survey, criteria for analyzing aerial photographs were determined with respect to stand type, forest type and vegetation.

The results of the interpretation were traced on to the forest base map, and a land-use and vegetation map was prepared using this. As a result, it was found that the total area of low and medium forests, shrubs and grasslands reached about 210,000 ha.

A forest inventory book which describes the zoning of forests, the current land-use situation, and the actual conditions of land and forests was prepared.

7. Forestry Infrastructure

Forest roads, bridges and fire-fighting facilities constitute the major part of forestry infrastructure. Of these, forest roads are an especially important factor in forest management, and their distribution substantially affects the cost of log transportation from forests. General public roads and bridges are also an important element of infrastructure and are indispensable, especially for crossing rivers. The existing forest roads which were previously constructed for felling natural forests along with the bridges need improvement and repairs before they can be used for forestation and log transportation from man-made forests.

There are two nurseries in Ulu Kukut and Bongkol. A new nursery will be needed for large-scale forestation in the future.

Countermeasures against forest fires are indispensable for forestation. The existing measures do not seem sufficient. Lookout towers should be constructed and fire-fighting equipment should be installed. In addition, extension and enlightenment activities are also needed.

8. Environmental Assessment

This study is intended to develop a plan for the creation of man-made forests and is not subject to the obligation of environmental assessment. Should the implementation of this project, however, have negative effects on the environment, measures to counter these effects will be needed. Therefore, the objective of the environmental impact assessment is to propose appropriate improvement measures by means of the initial environmental examination and scoping.

To confirm that the location of this project is appropriate, a survey was conducted to evaluate the socioeconomic conditions of the area. Data gathered included villages, population, land use, economic activity, labour force, practices and institutions as well as natural conditions, including climate, forest vegetation and the present topography of forests. Subsequently, the screening method was employed to check environmental items, including inhabitants' livelihoods, population problems, economic activity, valuable organisms, soil, the sustainability of forest resources and functions, specially designated areas, locational conditions and requirements to be considered in terms of natural and social environments.

9. Survey of Farmers in the Coverage Areas of Forestation

To understand the intentions of farmers who live in the coverage areas of forestation, a survey was conducted by distributing questionnaires to them. Forty-two families gave replies. The survey was carried out from January through February in 1994 with support from SAFODA's staff.

Most of the farmers living in mountain areas have long been making a living by shifting cultivation. Arable land has become very scarce as the population has increased. Those who cannot inherit land go deep into the mountains, where they cut natural forests to cultivate land. Some places have become sterile and been abandoned. This is shown by the result of a survey in which many farmers have idle land.

Farmers intend to work if any opportunity for employment is available, such as forestation, in order to stabilize and raise their incomes. They are not reluctant to give a second priority to agriculture. With limited land available, they have no choice but to seek a source of income other than agriculture in order to escape from poverty. They are willing to work if the opportunity is available, including, but not limited to, forestation work.

Eighty percent of the respondents are willing to participate in a settlement project. This suggests that they want to stabilize their livelihood. They also expect various types of assistance from the government.

Thus, regional development through the implementation of this project is an important measure for improvement in farmers' life, forest protection and environmental conservation.

III. Proposed Plan for Forestation

1. Forestation and Its Effects

The Malaysian economy has been developing steadily and has achieved a basic shift from primary to manufacturing industries. Malaysia aims at achieving the goal of the 2020 Vision to reach the level of the advanced countries by 2020. Sabah State is striving to develop its economy and society in compliance with the 2020 Vision.

Forests are important resources in Sabah, and their utilization has great significance for the development of the state. If the productivity of forests is improved by forestation and wood processing industries develop under proposed project, this area will be able to make solid progress in economic development.

Grassland or shrubs have low productivity. In the worst case, soil erosion will occur and cause land productivity to fall further. However, if such land is afforested, its fertility will rise and enable timber to be produced. Tree farms are a kind of forestation by small farmers. They are significant for using the surplus labour and idle land of farms. They will also contribute to the development of wood processing industries which will use logs produced from plantations. The development of wood processing industries is important for economic development in northern Sabah where manufacturing industries are limited.

If good forests are created by forestation, soil erosion in mountains will be reduced and the flow rate of rivers stabilized. They will also reduce the risk of damage by flooding.

It is recommended that large- and medium-scale forestation entities not employ fixed labour as little as possible but use contractors as much as possible for the sake of securing of efficiency of project management.

The current level of infrastructure in this area is insufficient. If a large amount of logs are transported, improvement will be needed in roads and, especially bridges. For example, unless a bridge is constructed across the Bengkoka River, the economic value of logs produced in Pitas District will be remarkably low, and industrial forestation will not be viable.

2. Zoning

This study covers a vast area extending in four districts, which cannot be uniformly treated in terms of natural and socioeconomic environments. Therefore, this area was divided into several zones with the focus on planting sites.

This area is the least developed and least populated in Sabah. The current state of land-use varies in areas, i.e., some areas are well developed, while others are covered with forests or dominated by paddies. In every area, however, hillside slopes with good soil conditions are used for shifting cultivation. In many cases, places which look like forests from a distance are previously the sites of shifting cultivation.

Forests in the state land are degraded by forest fires after felling. Frequent fires will cause useful species to be replaced with intolerant secondary forests. If these secondary

forests are burnt again, the vegetation of forest land will regress to grassland. Grasslands of this type are found throughout this area. Although grasslands should be forested, the possibility of foresting them is difficult to judge. Customary rights to them also must be taken into account.

The forms of forestation were classified by management size into three categories: large (over 500 ha of consolidation), medium (50 – 500 ha), and small (under 50 ha). In this study area, Marak-Parak, Sonsogon and Tandek consolidations are possible sites for large-scale forestation. A medium consolidation can be established in Langkon in the southern hills area of the Kudat Peninsula. Consolidations other than these are available for small-scale forestation.

3. Forestation Plan

Whereas forestation will cover shrubs and grasslands in state-owned forests, enrichment planting will cover low forests. High and medium forests will be managed as natural regeneration system to maintain the diversity of species. In this way, the reproduction of exploitation forests will be made compatible with environmental conservation.

In the case of large and medium-scale plantation management, methods for treating the covered stands are classified into (1) afforestation, (2) reforestation, (3) enrichment planting, and (4) natural regeneration. Judging from the current state of the coverage areas, afforestation and reforestation will mainly be employed. Enrichment planting appears to be suitable for low forests. As well as large and medium-scale management, individuals or small enterprises may be engaged in planting trees in small unused areas.

The total area covered by this study is about 323,000 ha, of which about 236,000 ha will be subject to forest management. Large and medium-scale management will cover about 54,000 ha of grassland and shrubs and about 44,000 ha of low forests. Large-scale management will entail forestation, and about 80% of the area, or 42,000 ha, will be forested. The latter will be treated by enrichment planting at a rate of 500 ha per year in light of seedling supply and access. Accordingly, a total area of 11,500 ha will be covered by enrichment planting in the period of this project. In the case of small-scale forestation, it is planned that plantations will be newly created at a rate of 1,000 ha per year, and reach 24,000 ha by the end of this project. Thus, about 72,800 ha of forestation consists of 66,000 ha of newly planted clear cutting plantations and 6,800 ha of existing plantations, and about 11,500 ha of enrichment planting, will be completed in 2020.

For industrial forestation in this area, favorable species in terms of management are:

Acacia mangium
A. auriculifolmis
Hybrid clone of *A. mangium* and *A. auriculifolmis*
Paraserianthes falcataria
Gmelina arborea
Tectona grandis
Eucalyptus camaldulensis
Hevea spp.

Khaya ivolensis
Swietenia macrophylla

For enrichment planting in low forests, favorable-growing species whose seedlings are comparatively easy to grow up will be selected from indigenous dipterocarp species. For example:

Dryobalanops lanceolata (Kapur paji)
Shorea leprosula (Seraya tembaga)
S. parvifolia (Seraya punai)

Looking at 42,000 ha of plantation area above mentioned by tree species, *A. mangium* trees will be newly planted in an area of 28,000 ha, and *P. falcataria* in 7,500 ha, and other species in 6,500 ha. Stands classified as low forests will undergo enrichment planting. The area of enrichment planting may be limited by the availability of seeds and accessibility.

The cutting period of *A. mangium* trees is seven years, and they will mainly be used as pulpwood and chips for medium density fiberboard (MDF). They will be planted in a space of 4 m x 2 m each, a rate of 1,250 seedlings per ha. MAI is estimated at 20 m^3/ha on average in the first planting, and 25 m^3/ha as a result of effective breeding in the third planting. The plantation area of the hybrid clone of *A. mangium* and *A. auriculifolmis* will be gradually increased in the second and subsequent planting. *A. auriculifolmis* will be planted in poorly fertile areas in *A. mangium* plantations.

The cutting period of *P. falcataria* trees is ten years. Their main applications include blockboard, packaging box panel, furniture and cabinet materials. They will be planted in a space of 4 m x 3 m each, a rate of 833 seedlings per ha. MAI is estimated at 30 m^3/ha on average in the first planting, and 33 m^3/ha as a result of effective breeding in the second planting. Trees of other species will be planted in the same way as *P. falcataria*.

As part of tending, weeding will be carried out for all forestation species. Thinning will be carried out only for *T. grandis*.

Enrichment planting will be line planting with an extraction width of 5 m. Two planting lines will be drawn within the width, and seedlings will be planted every 4 meters in a zigzag pattern. The number of seedlings planted will be 250 seedlings per ha. The cutting period is forty years. Main applications include building materials, plywood, flooring, furniture and heavy structural members. Sunshine control is important in the case of enrichment planting.

It is assumed that the yield of seedlings is 80% for fast-growing species and 70% for dipterocarp species. The number of seedlings required was determined on the assumption that the supplementary planting rate is 10% for all species.

When using the hybrid clone of *A. mangium* and *A. auriculifolmis*, seedlings must be produced from cuttings, and a large amount of scions must be secured. For this purpose, a scion garden needs to be established. If scions are available from the scion garden, rooted cutting can be produced with full care for breeding. Technical instructions for developing a

scion garden are given in this report. The development of a scion garden will take several years from start to completion. The number of scions available from the garden is estimated at about 160,000 pieces per ha. Raising low stocks would be preferable.

In the case of large and medium-plantation, the annual harvesting area of *A. mangium* trees will reach 4,000 ha annually at the completion of this project. The standing tree volume will be estimated 700,000 m^3 at harvesting. The harvesting area of *P. falcataria* trees will be about 800 ha a year, and the standing tree volume will be about 260,000 m^3. Thus, these species will produce about one million m^3 of standing trees at harvesting. It is best to carry logs from man-made forests by the cable logging system.

When the same species constitutes a large plantation, countermeasures against diseases and insects are essential. If any damage occurs, damaged trees must be immediately removed, and simultaneously the cause of the damage should be investigated to take effective countermeasures.

The most serious threat in forest management is fire. When shifting cultivation is carried out in the area, plantations will face a high risk of destruction by the spread of fire caused by such cultivation.

As countermeasures, the establishment of firebreaks, the construction of lookout towers, patrols, the distribution of water depots, and the enlightenment of inhabitants are needed. Among other things, it is important that inhabitants understand the significance of forestation and actually receive benefits from forestation.

Tree farms in small-scale forestation are carried out by farmers. This is a kind of farmer's forestry, which SAFODA has tried to promote. To extend this type of forestation more widely, the needs of local people should be met by reviewing the diversification of introduced species as well as management forms. The management system of tree farms is represented by agroforestry, silvo pasture, and small plantations.

With respect to plantation operators by scale, it is assumed that SAFODA alone or its joint venture with a private company (or companies) will undertake (1)large-scale forestation which needs a huge fund in the form of public funding or low-interest financing, while SAFODA will undertake (2) medium-scale forestation. There remain grasslands and shrubs which need afforestation even in medium consolidations. No entity other than SAFODA is conceivable as the operator of such afforestation. The Sabah State Government is required to appropriate a budget for the afforestation. It is planned that (3) small-scale forestation will be mainly undertaken by individuals in the form of private tree farms. In this case, a budget should be appropriated for the extension activities of SAFODA.

4. Forestry Infrastructure

Forestry infrastructure includes forest roads, nurseries, fire prevention and fighting facilities, and bridges.

It is planned that the density of forest roads will be 25 m/ha for plantation and 20 m/ha for enrichment planting. These requirements will be almost satisfied by the existing

forest roads constructed for logging of natural forests. New roads will be constructed only at a rate of 5 m/ha. Bridges on the way to forests should be made as ford type if possible.

Two new nurseries will be added to the existing ones, and a total of about 8.7 million seedlings will be produced. A management office and other buildings will be constructed in each nursery. Assuming that one entity will execute the forestation of three consolidations, a headquarters will be needed.

To prevent and fight fires, lookout towers and fire-fighting equipment are needed. In addition, appropriate measures should be taken, including the organization of brigades, the enlightenment of inhabitants, and school education in forest fire prevention.

A bridge to cross the Bengkoka River is indispensable to the management of plantations in Pitas District and also as infrastructure necessary for the local development. Besides this, bridges need to be constructed in some sections of public roads. To export chips, chipping and loading facilities will be needed.

5. Cost-Benefit Analysis

As the first step in financial analysis, costs and revenues were calculated. Costs were integrated on the following conditions and assumptions under the project plan.

(1) Prices are in the Malaysian Ringgit as of 1993. The unit cost of each item was based on the results of the survey in Sabah. Prices not locally available were estimated.

(2) The proposed project entity is SAFODA as a government agency, on which no tax or land rent will be imposed.

(3) The total expenditure was calculated by adding price-fluctuation and physical contingency to the expenses calculated in the implementation plan.

(4) The ratio of the price-fluctuation reserve is 4%. The reserve was not included at the outset, and this percentage was applied from the first year. The physical contingency is 10%.

Revenues were calculated on the following conditions and assumptions.

(1) *A. mangium* was assessed as pulpwood. *A. mangium* chips have not yet been produced or sold, and no chip market for this species has been established. Therefore, the FOB price of *A. mangium* chips was calculated converting from that of Australian eucalyptus chips. The price ex the timber-yard of a chip mill in the shipping place in Sabah was calculated. The result of the calculation is a price of RM71.66 per m^3.

(2) Logs of *P. falcataria* are already exported and locally sold, and markets exist. The average price of all diameter classes was estimated at RM77.56 per m^3 on barge in the light of the results of the field survey.

Assuming that this project will start in 1997 and continue until 2020 on the above-mentioned conditions, net present value (NPV) calculated at a discount rate of 10% is negative, the financial internal rate of return (FIRR) based on the integration of all expenses and incomes is 9.25%. This figure reflects the inclusion of planting cost for *T. grandis* and dipterocarp species from which no income will accrue and *A. mangium* and *P. falcataria* some part of which will not be harvested within the period of this project. Therefore, the financial analysis of this project will be made by calculating expenses only for planted trees of *A. mangium* and *P. falcataria* which will be harvested within the period of this project.

According to the analysis, a surplus will begin to occur in the eighth year. The cumulative deficit will reach a peak in the eighth year and be resolved in the fifteenth year. Calculated at a discount rate of 10%, NPV is M$38,419,000. FIRR is 13.66%. Judging from this figure, profitability is high to be acceptable. If untangible effects are taken into account, this project is judged to be feasible.

Untangible Significant Effects:

(1) Creation of forest resources by forestation
(2) Conservation of forest land and riverheads
(3) Improvement of land productivity
(4) Creation of employment opportunities.

The cost and benefit of small-scale plantation were analyzed with reference to the materials used in the analysis of large and medium-scale forestation. As a result, small-scale plantation under this project was judged to be feasible.

6. Market Research

The prices of logs from man-made forests of newly introduced species are still low until a sufficient stable supply of logs is available to wood processing mills. If the supply is stabilized in both quantity and quality, their value as timber will rise and an adequate market will be established.

Not enough time has elapsed since the start of the supply of logs from man-made forests in Sabah, so it is still at a trial-and-error stage. Logs of *A. mangium, G. arborea* and *P. falcataria* are traded in small quantities. However, logs of *P. falcataria* are produced by SSSB at a rate of 12,000 m^3 per month, and roughly 60% of them are locally processed into blockboard. The sales of *A. mangium* are still small. Nevertheless, the processing of these species has already been launched even on a small scale. It is expected for the future of such processing industries.

The global movement for the protection of tropical forests is strengthening. Markets for logs from man-made forests are very responsive to trends in the supply of logs from natural forests. It is predicted that the supply of logs from natural forests in Sabah will fall short of demand within the state. According to a report by Rahim Sulaiman, great hope is placed on logs from man-made forests.

Malaysia is the largest timber exporter in Asia, and has a particularly dominant share

of industrial logs. On the other hand, the largest timber importer is Japan, which imports large quantities of logs from not only Asia but also North America and Russia. China and South Korea are also large timber importers. In particular, China is expected to increase its imports in parallel with its economic development in the future.

With respect to projections for the Japanese timber market at the turn of the century, (1) demand for sawn timber will remain at the current level, (2) demand for plywood and other wood panels will increase slightly, and (3) demand for wood chips will increase. It is expected that imports of sawn timber will increase on the whole, while domestic output of the same will decrease. Sawn timber imports from North America are expected to increase substantially, and plywood and other wood panels are also expected to increase. Imports of wood chips, especially of hardwood trees, are expected to increase.

A. mangium is evaluated as good pulpwood. Demand for hardwood chips has been increasing in along with the consumption of printing paper. With growing concern about the natural environment in recent years, demand for pulpwood as raw material has shifted from logs from natural forests to hardwood logs from man-made forests which are renewable and homogeneous.

Over 90% of imports of wood chips and particles within Asia is shared by Japan. The volume of these imports has fallen due to the influence of the recession in Japan. Nevertheless, imports of hardwood pulpwood reached 13.8 million m^3 in 1993. Due to the decrease in the domestic supply of pulpwood in Japan, and the international movement to protect natural forests, users will be forced to depend on man-made forests for the long-term stable supply of hardwood pulpwood. Therefore, *A. mangium* in Sabah will also be targeted as a source of hardwood logs to be imported to Japan in the future.

7. Environmental Assessment

In Phase I, the outline and locational conditions of this project were confirmed as the subject matter of the initial environmental evaluation. Subsequently, environmental factors drawn from these conditions were verified by screening to focus on what effects they might have on man-made forests. Based on the results of the screening, each environmental factor was checked by scoping. Then, negative effects were identified, and appropriate measures for their improvement were proposed.

The scoping is focused on the evaluation of the following relationship at each of the proposed planting sites:

(1) Relationship between man-made forests and the natural environment
(2) Relationship between man-made forests and the social environment
(3) Relationship between man-made forests and customary systems.

Possible measures were proposed to improve the negative impact of shifting cultivation, the loss of forest diversity, diseases and insects, and soil deterioration.

8. Conclusion

Natural forests in Sabah have been extensively felled. If this trend continues, the land will deteriorate into low-productive farmland or grassland. Some part of them need large-scale forestation or enrichment planting. The effective use of land in this way will effectively contribute to the development of Sabah's economy and society. Large-scale forestation will benefit the local community by providing employment opportunities for local people, developing wood processing industries, and improving infrastructure.

As fast-growing species, *A. mangium* and *P. falcataria* are prime candidate species for plantation. If this project is implemented, logs of these species will be supplied in adequate quantities to stimulate the development of wood processing industries. Although there is now no major market for *A. mangium*, SSSB has plans to export chips of this species to Japan. *P. falcataria* wood is currently exported in the form of primary processed products or logs.

By 2020, it is expected that about 1.4 million m^3 of *A. mangium* logs will be produced annually from plantations planned in this project and the Bengkoka plantation of SAFODA and existing small tree farms. With such a large output, these plantations will serve as significant pulpwood production areas.

Farmers dependent on shifting cultivation are living in the proposed sites for large- and medium-scale forestation. To carry out such forestation, the resettlement of these farmers will be needed. The implementation of this project will provide more opportunities for earning incomes to the local people. Tree farming is necessary to improve the welfare of farmers who live in the coverage areas of large and medium-scale forestation.

The concerned area has been an underdeveloped and economically marginal part of Sabah. If the creation of man-made forests under this project facilitates the development of wood processing industries and activates the regional economy, the welfare of inhabitants will be improved, underused or unused land will be used more economically, and moreover, the natural environment will be well conserved. These effects will not be limited to northern Sabah, but will have a significant impact to the development of whole of Sabah State and Malaysia supporting the achievement of the year 2020.

I. Introduction

1. Outline of This Study

1-1 Background

The state of Sabah, having a population of about 1.75 million in an area of 7,362,000 ha, is located in the north of the Borneo Island within the tropical rainforest zone with annual rainfalls between 1,700 mm and 5,100 mm.

The study has been conducted in 540,000 ha of the northern-most, the least developed area of Sabah, where the population of about 181,000 is very thinly scattered except for urban zones at which most of the population is concentrated.

Natural forest resources in Sabah has been decreased due to a drastic increase of logging. National forests in northern Sabah has the most devastated forests compared with other jurisdictions. The Kudat District located in the northern Sabah, a jurisdiction of Regional Forestry Office, has a forest of which stocking per unit area has been reduced by felling, and forest fires resulted in secondary forests and many forests were degraded into shrubs. There are many cases where repeated shifting cultivation has transformed forests into grassland.

In order to improve these conditions, the Government started its projects to establish man-made forests in devastated or logged-over areas with the object of improving natural environment and developing local economy. To execute the projects, the Sabah Forestry Development Authority (SAFODA) was established in 1976 under the state law. SAFODA selected *Acacia mangium* as a fast growing species for forestation which has so far been carried out in an area. Nevertheless, a large area is still covered with shrubs and grasses. Upgrading land use by forestation and promoting regional development by forestry is urgently required.

Under these conditions, the Malaysian Government asked Japan to prepare master plans as a part of efforts to develop by promoting forestry. At the request, Japan sent a survey team to investigate forestation programmes in the northern Sabah, Malaysia in December 1991. The survey team held a conference to confirm the details of the request and the scope of cooperation.

On October, 1992, a mission (for S/W conference) was sent again in order to conduct field study and to confer with the Malaysia party on S/W of the master plan study of the programmes. As a result, the S/W and associated minutes (M/M) were concluded.

1-2 Purpose

In view of the natural and social conditions and the state of affairs of the state, it has been planned to develop the northern Sabah, where natural environments are increasingly devastated, by means of forestry promotion. In such programmes, the goal should be set at the increase of forest resources and the improvement of economical conditions of the regional society on a sustainable basis.

For this reason, the purpose of the study is to prepare master plans, especially those of forestation programmes for 540,000 ha of the northern Sabah which can contribute to the forestry management in a sustainable manner, aiming at:

(i) Forestry activities on sustainable basis with consideration in environment;
(ii) Improvement social, economical conditions in view of residents' life through forestry activities; and
(iii) Recovery and improvement of devastated natural environment through forestry activities.

In addition, aerial photographs and forest base maps were prepared to provide basic materials required for preparing master plans.

1-3 Study Area

The study will be conducted for the area within about 540,000 ha of the northern Sabah, which was selected as an area to be forested on the basis of the result of a status survey of the forest. However, army areas, state parks, the Bengkoka plantation area where feasibility study of forestation has been completed by SAFODA, and forest reserves managed by Forestry Department are excluded from the study as a rule. Thus an area to be examined by field surveys, analysis or investigation is about 323,000 ha (Fig. I-1).

1-4 Scope of the Study

The study works include:

(i) Aerial photography and preparation of Forest Base Map

(ii) Collection of existing materials and information on policies concerning forests, environments and regional development, conditions of nature and social economy, the existing state of land use, vegetation and soil, etc.;

(iii) Preparation of Land-use and Vegetation Map, Implementation Scheme Map, Forest Inventory Book, etc.; and

(iv) Preparation of Master Plan aiming to develop forestation by the year 2020.

The above works are to be conducted in three phases over two years.

Aerial photographing and Preparation of Forest Base Map, which are to be assigned to contractors in Phase I, are detailed in Part II Chapter 4.

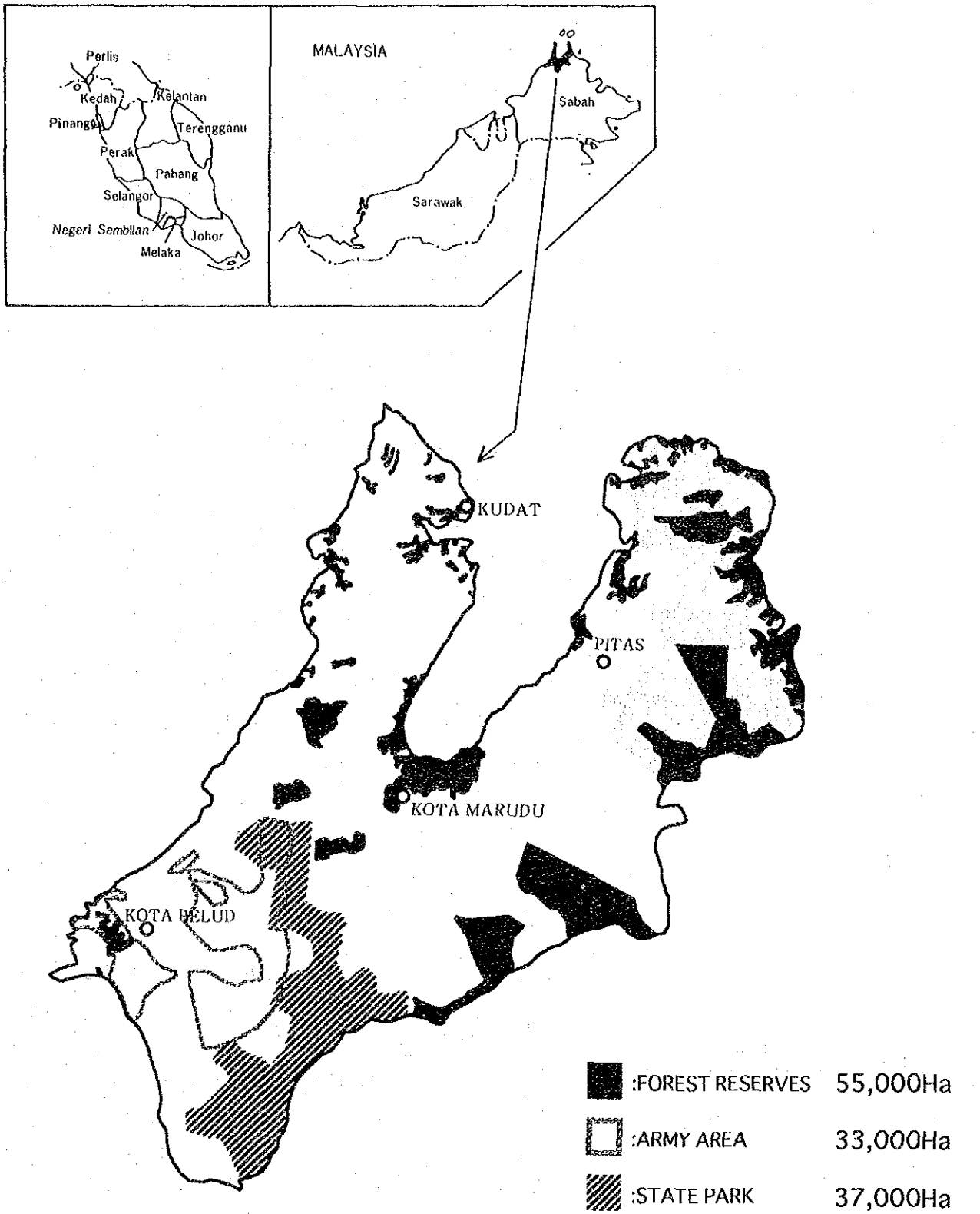


Fig. 1-1 Coverage Areas of This Study

The scope of each study phase is as follows:

1) Phase I

Phase I study, including the following works, has been conducted laying stress on basic study of the first field study and subsequent works in Japan include:

(i) Preliminary study for collecting and reviewing materials and for preparing general plans prior to the start of the study;

(ii) Preparation of an inception report;

(iii) Field study with main objects of collecting materials concerning natural conditions, social and economical conditions, initial environmental assessment, etc. and of study area sectioning;

(iv) Conclusion of subcontracts concerning the execution of aerial photography and preparation of Forest Base Map; and

(v) Analysis and arrangement of the results of the field study, and preparation of a progress report.

The second field study and subsequent works in Japan include:

(i) Inspection of Aerial Photographs and Forest Base Map

(ii) Forest and soil survey;

(iii) Investigation of silviculture techniques;

(iv) Investigation of initial environment effect;

(v) Preparation of Land-use and Vegetation Map and Forest Inventory Book;

(vi) Review of forestation programmes; and

(vii) Analysis and compilation of the results of the field study and preparation of a progress report.

2) Phase II

Basic study for preparing forestation and logging programmes are to be done. These include:

(i) Planning study of work standards of forestation and logging programmes;

(ii) Planning study of forestry base improvement programmes;

(iii) Planning study of project implementation programmes;

(iv) Market research;

(v) Inspection of initial environmental assessment;

(vi) Financial analysis of the implementation of forestation programmes;

(vii) Arrangement and analysis of collected materials;

(viii) Preparation of Master Plan (draft proposal) and Implementation Scheme Map (proposal); and

(ix) Preparation and submission of an interim report.

3) Phase III (1994)

The following works are to be done to complete the study :

(i) Explanation of and conference on the interim report;

(ii) On-the-spot examination of the draft Master Plan;

(iii) Arrangement and analysis of collected materials;

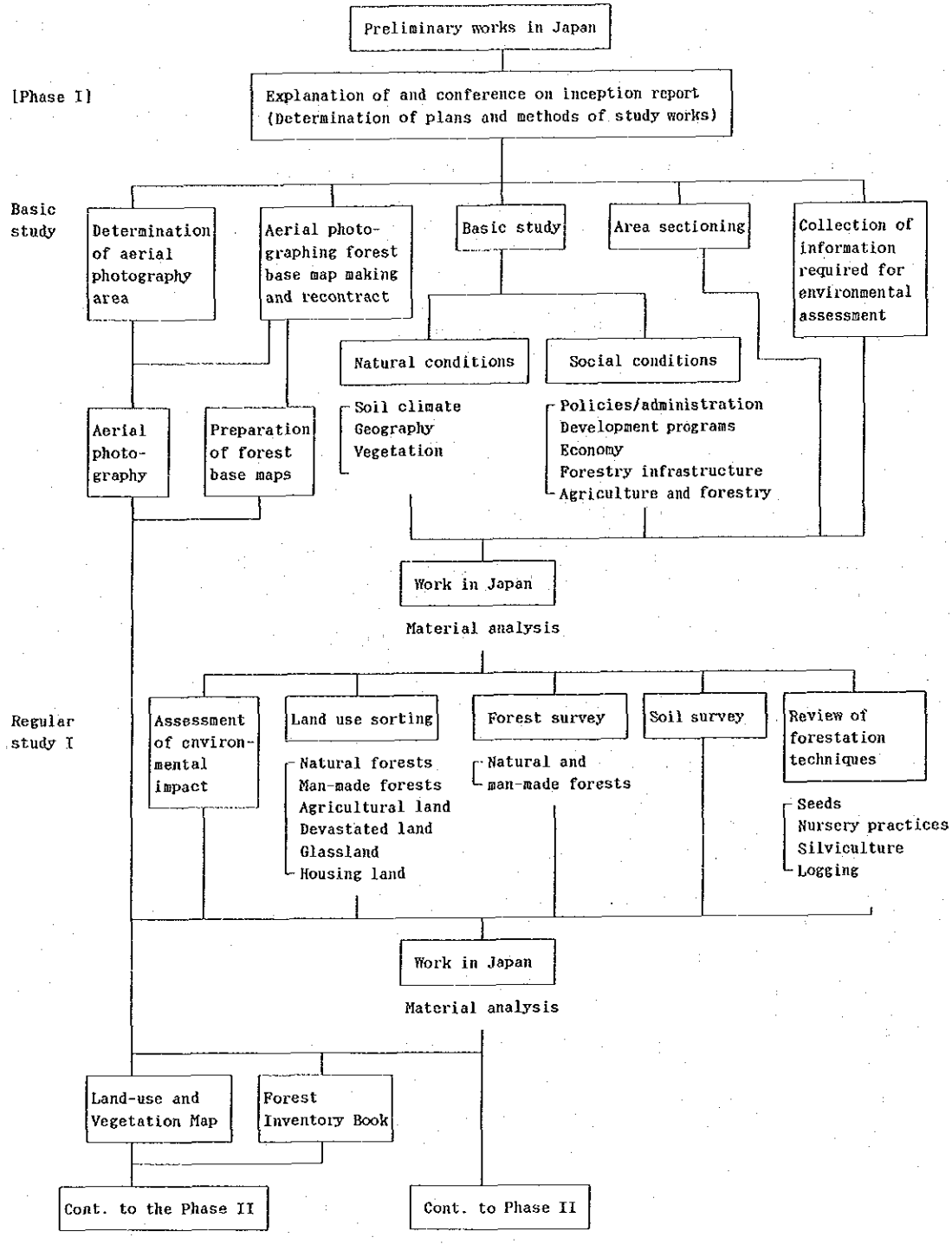
(iv) Preparation and explanation of a draft final report;

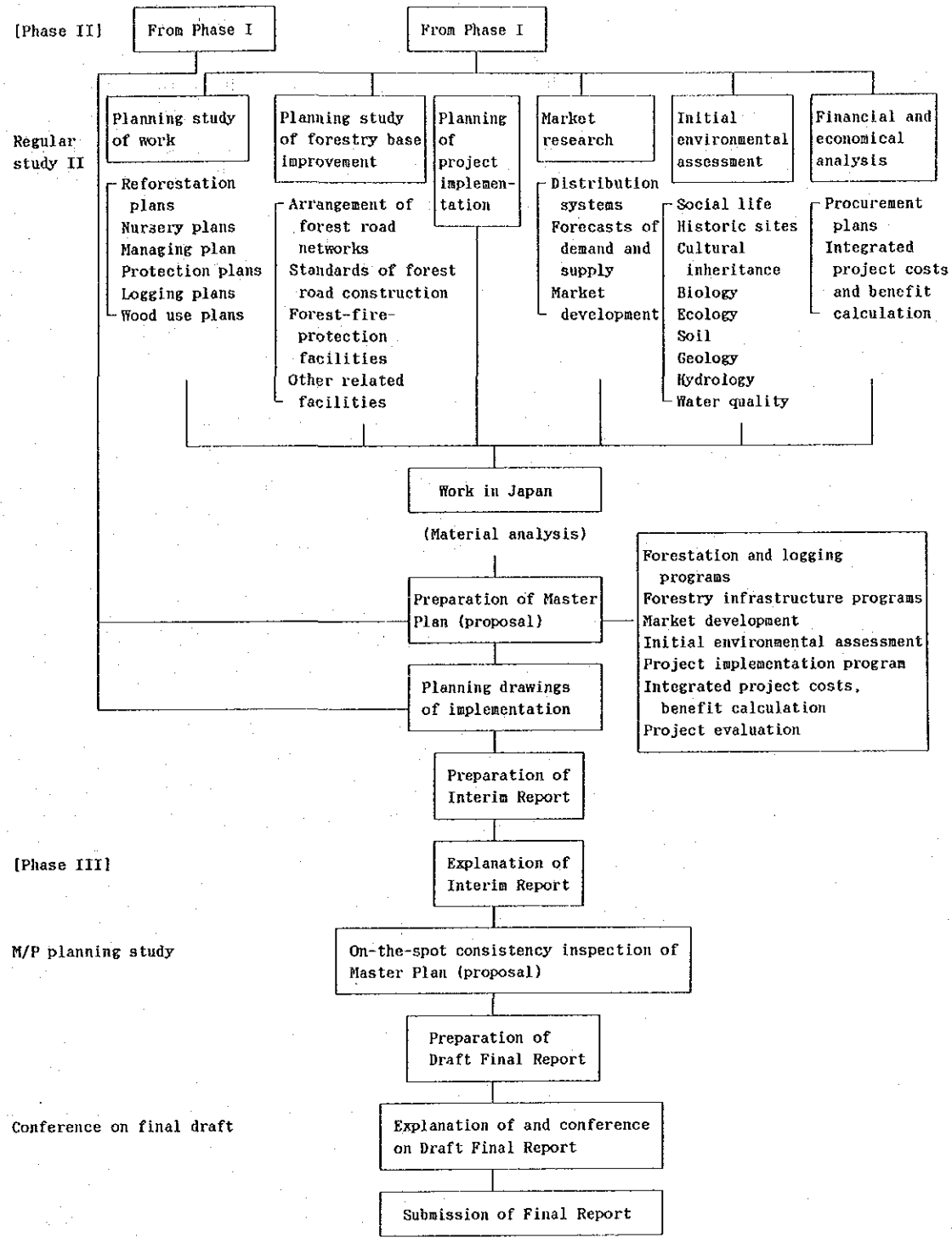
(v) Modification of the draft final report;
and

(vi) Preparation and submission of a final report.

An overall plan and a flow chart are shown in Fig. 1-2.

Figure I-2 Flow Chart of Proposed Work




[Phase II]
From Phase I
From Phase I
Regular study II
Planning study of work
Planning study of forestry base improvement
Planning of project implemen-tation
Market research
Initial environmental assessment
Financial and economical analysis
Reforestation plans
Nursery plans
Managing plan
Protection plans
Logging plans
Wood use plans
Arrangement of forest road networks
Standards of forest road construction
Forest-fire-protection facilities
Other related facilities
Distribution systems
Forecasts of demand and supply
Market development
Social life
Historic sites
Cultural inheritance
Biology
Ecology
Soil
Geology
Hydrology
Water quality
Procurement plans
Integrated project costs and benefit calculation
Work in Japan
(Material analysis)
Preparation of Master Plan (proposal)
Forestation and logging programs
Forestry infrastructure programs
Market development
Initial environmental assessment
Project implementation program
Integrated project costs, benefit calculation
Project evaluation
Planning drawings of implementation
Preparation of Interim Report
[Phase III]
Explanation of Interim Report
M/P planning study
On-the-spot consistency inspection of Master Plan (proposal)
Preparation of Draft Final Report
Conference on final draft
Explanation of and conference on Draft Final Report
Submission of Final Report

1–5 Fundamental Policies

Fundamental policies for implementing this study are as follows:

(1) A master plan will be developed in light of the present situation of northern Sabah, and the opinions and intentions of the Malaysian people concerned and local people so that the plan will comply with the current situation of Malaysia, northern Sabah and the study area. It is intended that implementing the master plan will promote the regional development of this area.

(2) The fauna and flora covered by the Convention on International Trade in Endangered Species of Wild Fauna and Flora do not exist in this area. Although this project is not subject to environmental impact assessment under the Environmental Quality Act (1974) enacted by Malaysia, an environmental survey is to be conducted to give full consideration to environmental conservation.

(3) When the Malaysian counterparts carry out a similar survey, technical methodology should be effectively transferred by study team to them by full use of the experience in this study. A seminar on the transfer of technology is to be held so that the Malaysian people concerned is understand the content of the master plan as well as its methodology of developing of plan.

(4) In order to facilitate the effective implementation of this study, a proper survey will be carried out in cooperation with the Malaysian counterparts and the people concerned in forestry.

(5) In order to facilitate the effective implementation of this study, a socioeconomic survey is to be carried out in cooperation with local relevant organizations and experts having experience in and knowledge of Sabah State and Malaysia.

2. Members of the Study Team and Malaysian Government Agencies and Officers

2-1 Members of the Study Team

The members of the study team and the period of the study are shown by phase in the following.

(1) Phase I (1993)

i) Study Team: Basic and forest surveys, aerial photography, and preparation of a forest base map, and etc.

Assignment	Member	Period			
Leader	Hiroji Okabe	20 days	Mar. 2	–	Mar.21,'93
		30 days	Jul.27	–	Aug.25,'93
Assistant Leader	Susumu Miyatake	20 days	Mar. 7	–	Mar.26,'93
Forestation planning		40 days	Jul.21	–	Aug.29,'93
Forestry infrastructure	Toshio Saito	20 days	Mar. 7	–	Mar.26,'93
		30 days	Jul.28	–	Aug.26,'93
Socioeconomic analysis	Kiyoshi Fujii	20 days	Mar. 2	–	Mar.21,'93
		30 days	Jul.28	–	Aug.26,'93
Land use and vegetation	Takaki Toyoda	20 days	Mar. 7	–	Mar.26,'93
		40 days	Jul.21	–	Aug.29,'93
Environmental assessment	Kenzo Tajima	20 days	Mar. 7	–	Mar.26,'93
		30 days	Jul.28	–	Aug.26,'93
Forest inventory & soil (I)	Hirotsugu Nishizawa	20 days	Mar. 7	–	Mar.26,'93
		40 days	Jul.21	–	Aug.29,'93
Forest inventory & soil (II)	Kouta Shimokawa	20 days	Mar. 7	–	Mar.26,'93
		40 days	Jul.21	–	Aug.29,'93
Aerial photography	Takehiko Hirano	105 days	Mar. 7	–	Jun.19,'93
		30 days	Jul.12	–	Aug.10,'93
Aerial photo analysis (I)	Seishiro Shojiguchi	31 days	Jul.28	–	Aug.27,'93
Aerial photo analysis (II)	Hiroki Toomiya	31 days	Jul.28	–	Aug.27,'93

ii) Advisory Team

Assignment	Member	Period			
Leader	Kazuhiko Shigeta	10 days	Mar. 2	–	Mar.11,'93
Forestation	Katsusuke Okada	10 days	Mar. 2	–	Mar.11,'93
Coordination	Akio Kagawa	10 days	Mar. 2	–	Mar.11,'93

(2) Phase II (1993/1994)

i) Study Team: Forestation planning, market research and financial analysis, and etc.

Assignment	Member	Period
Leader	Hiroji Okabe	30 days Jan.12 – Feb.10,'94
Assistant Leader	Susumu Miyatake	30 days Jan.12 – Feb.10,'94
Forestation planning		
Forestry infrastructure	Toshio Saito	15 days Jan.19 – Feb. 2,'94
Socioeconomic analysis	Kiyoshi Fujii	30 days Jan.12 – Feb.10,'94
Land use and vegetation	Takaki Toyoda	30 days Jan.12 – Feb.10,'94
Environmental assessment	Kenzo Tajima	30 days Jan.12 – Feb.10,'94
Forest inventory & soil (I)	Hirotsugu Nishizawa	30 days Jan.12 – Feb.10,'94
Forest inventory & soil (II)	Kouta Shimokawa	30 days Jan.12 – Feb.10,'94

ii) Advisory Team

Assignment	Member	Period
Leader	Kazuhiko Shigeta	10 days Jan.12, – Jan.21,'94
Coordination	Akio Kagawa	10 days Jan.12 – Jan.21,'94

(3) Phase III (1994)

i) Study Team: Survey and final discussion to develop a master plan, and etc.

Assignment		Member	Period
M/P Survey	Leader	Hiroji Okabe	20 days May30 – Jun.18,'94
	Assistant Leader Forestation planning	Susumu Miyatake	20 days May30 – Jun.18,'94
	Land use and vegetation	Takaki Toyoda	20 days May30 – Jun.18,'94
	Forest inventory & soil	Hirotsugu Nishizawa	20 days May30 – Jun.18,'94
M/P Draft Report	Leader Presenting a draft	Hiroji Okabe	10 days Sep.19 – Sep.28,'94
	Assistant Leader Presenting a draft	Susumu Miyatake	10 days Sep.19 – Sep.28,'94
	Presenting a draft	Takaki Toyoda	10 days Sep.19 – Sep.28,'94
	Presenting a draft	Kiyoshi Fujii	10 days Sep.19 – Sep.28,'94
	Presenting a draft	Kenzo Tajima	10 days Sep.19 – Sep.28,'94

ii) Advisory Team

Assignment		Member	Period			
M/P Survey	Leader	Katsusuke Okada	10 days	May30	–	Jun.8,'94
	Coordination	Akio Kagawa	10 days	May30	–	Jun.8,'94
M/P Draft	Leader	Kazuhiko Shigeta	10 days	Sep.19	–	Sep.28,'94
	Forestry civil engineering	Naoya Ikeda	10 days	Sep.19	–	Sep.28,'94
	Coordination	Hiroyuki Abe	10 days	Sep.19	–	Sep.28,'94

2-2 Malaysian Government Agencies and Officers

- [EPU] Economic Planning Unit

Mr. Mohd. Rosnan bin Sulaiman	Director, Agriculture Section
Mr. Kassim bin Sarbani	Director, Agriculture Section (former)
Mr. Mohd. Sani bin Mistam	Assistant Director, Extended Assistant Sector
Mr. Mohd. Fadzil bin Akram	Principal Assistant Director, Agriculture Section
Mr. Alias bin Simin	Assistant Director, Agriculture Section
Mr. Ramli bin Hj. Hasan	Assistant Director, Agriculture Section

- [MPI] Ministry of Primary Industries

Mr. Jusoh bin Salleh	Assistant Director
Ms. Molly Koe	Assistant Director

- [FDD] Federal Development Department, Sabah

Mr. Jihek Hj. Basanu	Assistant Director

- [SDD] State Development Department, Sabah

Ms. Monica Yee	Principal Assistant Director
Mr. Maisuri Besri	Assistant Director

- [ONR] Office of Natural Resources

Datuk William Shim	Secretary of the Natural Resources Office
Mr. Chin Wui Kee	Principal Assistant Secretary

- [MAF] Ministry of Agriculture and Fisheries

Mr. Felix Madan	Permanent Secretary
Mr. Juif bin Adzim	Chief Assistant Secretary
Mr. Deratil bin Boaklan	Research Officer

- [LSD] Lands and Survey Department

Mr. Kuleong C. Mopilin	Director
Mr. Anthony C. Linggian	Survey Superintendent
Ms. Justina Jais	Drawing Office Supervisor, Map Revision Section
Mr. Phillip Anacletus	District Surveyor, Photographic Section
Mr. Dahlan Hj. A. H. Tangah	Land Superintendent
Ms. Doria Tai	District Surveyor, West Coast (North)
Mr. Jessel bin Quintin	Land Office Surveyor, Kota Marudu

- [WIL] Wildlife Department

Mr. Augustine Tuga	Wildlife Officer

- [FD] Forestry Department

Datuk Miller Munang	Director
Mr. Daniel K.S. Khiong	Deputy Director
Mr. Richard Tay	Principal Senior Assistant Director
Mr. Herman Anjin	Senior Assistant Director

Mr. Eric Juin	Senior Assistant Director
Mr. Yahya Awang	Assistant Director
Mr. Frederick Kugan	Assistant Director
Ms. Masniah bintc Hj. Othman	Assistant Director
Ms. Ellen Empau	Assistant Director
Mr. Rahim Sulaiman	Assistnat Director
Mr. Domingo Chai	Assistant Director
Mr. Hj. Ag. Tengah Ag. Amin	Assistant Director
Mr. M.P. Udarbe	National Project Director
Mr. Robert C. Ong	Act. Head of Research Division
Dr. Wong Koon Meng	Botanist
Mr. Jaffrin Lapongan	Research Officer
Mr. Joseph Ahlan	Kudat Regional Forest Officer
Mr. Yusof bin Awang	Kudat District Forest Officer
Mr. Valerian J. Anthonius	Kota Marudu District Forest Office
Mr. Bacho Pendrongi	Kota Bulud District Forest Officer
Mr. Abdul Salam Akup	Pitas District Forest Officer
Mr. Sapin bin Kasim	Forester, Kota Marudu District Forest Office

- [FRIM] Forest Research Institute of Malaysia

Dr. Wan Razali W.M.	Director, Forestry Division
Dr. Darus Ahmad	Director, Forest Plantation Division
Dr. Atsushi Maruyama	Visiting Scientist

- [SAFODA] Sabah Forestry Development Authority

Mr. Blaise Yapp	General Manager
Mr. Francis G. Otigil	Deputy General Manager
Mr. Nobert Bolong	Regional Forest Manager, Kota Marudu
Mr. William Ahlan	Regional Forest Manager, Bengkoka
Mr. Freddy Lee	Surveyor
Mr. Soguli Olid	Public Relation Officer
Mr. Gimson Stanley	Forest Economist
Mr. Shim Phyau Soon	Principal Research Officer
Mr. Suhaimi Ahmad	Assistant Surveyor

II. Details of the Results of Basic Study

1. Natural Environment

1-1 Location and Area

The area covered by this study is located from the north to the northwest of Sabah State, and comprises the four administrative districts of Kudat, Pitas, Kota Marudu and Kota Belud. The total area of these districts is 540,000 ha, of which 323,000 ha is the area for the Master Plan concerns. The relatively large towns in this area are Kudat, Kota Belud and Kota Marudu. There are also other small and large communities variously surrounded by farmland, and rubber, coconut palm and oil palm plantations. There is also a state park centred around Mt. Kinabalu, and land for military use in the region.

The following descriptions in this chapter are based on The Land Capability Classification of the West Coast Residency, Sabah, Malaysia (Ministry of Overseas Development, England, 1974).

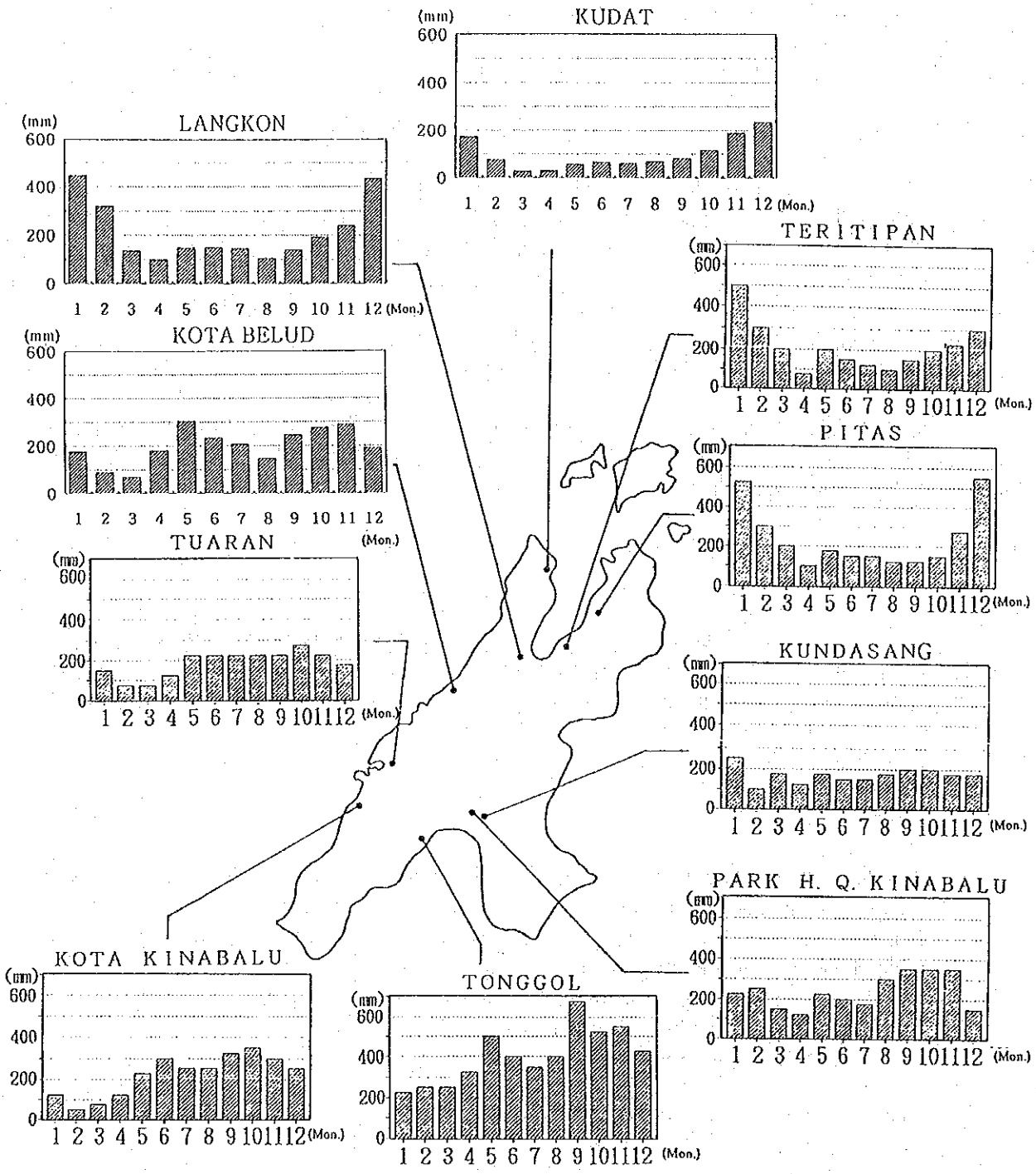
1-2 Climate

This area is classified as having a tropical rain forest climate (Af) according to Köppen's system. Although generally described as hot and humid, there are some climatic variation in the study area. Temperature variations are attributable to altitude, while rainfall variations are attributable to monsoonal influence and topography.

(1) Rainfall

The West Coast Division is strongly influenced by the southwest monsoon. As a result, it is generally dry from the beginning of the year, and the driest month is February as observed at nearly half the meteorological stations in the region. The west coast area of the study area also seems to be influenced by the same monsoon. Rainfall due to the southwest monsoon increases from April, and maximum average humidity is reached from September to November. The maximum rainfall is generally recorded at Tonggol, southwest of Mr. Kinabalu.

The precipitation pattern of the Bengkoka and Kudat peninsulas is different from that of the west coast and the southwestern part of this area, and usually under the strong influence of the northeast monsoon. On these peninsulas, much rainfall is recorded from November to February, while less rainfall is recorded in other seasons. Monthly rainfall by district is shown in Figure II-1.



Source: The Land Capability Classification of the West Coast Residency, Sabah, Malaysia, and Perkhidatan Kajicuaca Malaysia (Cawangan Sabah)

Figure II-1 Monthly Average Rainfall in West Coast and Kudat Divisions

(2) Temperature

There are five meteorological stations in the West Coast Division. According to their records, the mean annual maximum temperature in the low-altitude coastal area is about 30.9° C with a low of 22.3° C. Fluctuations from high to low range among the stations are from 7° C to 11° C. Monthly fluctuations are small. The temperature in the study area shows the same tendency. In the northern part, whose records are not included in the data, changes in temperature are probably similar to those in the coastal area. As shown in the data for Kundasang and Kambarangan, the temperature falls as the altitude rises. The temperature in Kambarangan is lower than that in other locations of similar altitude. The data shows a maximum temperature decrease per 100 m of between 0.5 - 0.6° C, and minimum temperature decrease of between 0.5 - 1.0° C. Regional variation in temperature is shown in Table II-1.

Table II-1 Mean Monthly and Annual Maximum and Minimum Temperatures (° C)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.	Var.
KOTA KINABALU	Max	29.6	29.7	30.4	31.1	31.3	31.0	30.8	30.7	30.6	30.4	30.1	29.9	30.5	1.7
	Min	22.5	22.6	22.9	23.6	23.9	23.6	23.3	23.4	23.3	23.2	23.1	22.9	23.2	1.4
KAIDUAN	Max	30.5	30.7	31.5	31.9	31.7	32.0	31.7	31.8	31.7	31.5	31.2	31.1	31.4	1.5
	Min	20.1	19.9	20.3	20.8	21.2	21.1	20.6	20.6	20.8	20.8	20.8	20.3	20.6	1.3
TUARAN	Max	30.6	30.8	31.4	31.4	31.1	31.3	30.8	30.8	30.8	30.7	30.4	30.3	30.9	1.1
	Min	22.5	22.8	22.6	23.5	23.9	23.5	23.2	23.0	23.4	23.1	23.0	22.8	23.1	1.4
KUNDASANG	Max	22.5	22.8	24.0	24.8	25.7	25.1	24.7	24.5	24.5	24.3	24.0	23.3	24.2	3.2
	Min	15.1	14.6	15.2	15.5	16.2	16.6	16.5	16.1	16.3	16.2	15.9	15.2	15.8	2.0
KAMBARANGAN	Max	16.9	17.2	17.5	17.6	17.4	17.4	17.0	17.1	16.6	16.7	16.9	17.3	17.1	1.0
	Min	10.9	11.0	11.1	11.3	11.7	11.6	11.5	11.4	11.3	11.4	11.3	11.5	11.3	0.8

Source: The Land Capability Classification of the West Coast Residency, Sabah, Malaysia

1-3 Topography

Topographical features of this area are represented by the Kudat and Bengkoka peninsulas at the northern end with their long coastlines, a long and narrow coastal plain along the west coast, a subsequent hill zone, and a range of high mountains in the southeast. On the whole, the topography of this area is strongly influenced by its structure.

The western coastline continues from the mouth of the Kadamaian River to the tip of the Kudat Peninsula. Marudu Bay is located between the Kudat and Bengkoka peninsulas. The coastline is generally simple, though it is partially complicated by the influence of the Crocker Formation mentioned below. Fringing reefs exist in such indented parts.

There is a long and narrow coastal plain, called the Crocker Plain, along the west coast. This plain is extended around Kota Belud and near the mouth of the Kadamaian River.

This part is considered to be an alluvial plain formed by the Kadamaian River. Another alluvial plain extends near Kota Marudu behind Marudu Bay. This plain was formed by the Kinaram River and other small and medium streams which flow into Marudu Bay.

There are no high ridges on the Kudat and Bengkoka peninsulas. On the Bengkoka Peninsula, in particular, no hills or mountains exist north of Pitas at 6° 45' North Latitude. Most of the area is occupied by plains and coastal swamps and is called the Bengkoka Lowlands. Southward from Pitas through Taritipan to the base of the Bengkoka Peninsula, altitude gradually rises to about 450 m. There is an area called the Kaindangan Peneplain on the southern side, where a strike ridge is outstanding from northwest to southeast. A subsequent valley develops along the ridge. The Kudat Peninsula is hillier than the Bengkoka Peninsula. It begins to rise from the northeastern part of the Crocker Plains into relatively low ridges which were formed by the northeasterly continuation of the Sir James Brooke Range, which extends through the three districts of Kudat, Kota Marudu and Kota Belud. In this area, as on the Kaindangan Peneplain, the strike ridge is outstanding from northwest to southeast, and the area is dissected by rivers deepening the ridges in the same direction.

A long and narrow range of hills called the Crocker Foothills at an altitude of about 300 m lies further up the Crocker Plains along the west coast. These hills are strike ridges outstanding from northeast to southwest, and look like plural ridges in the south. The Crocker Range, the backbone of North Borneo, is further up the Crocker Foothills. This area is deeply dissected and rugged. Summits usually range from 1,200 to 1,800 m, but Mt. Kinabalu reaches 4,101 m at the far southern end of the study area, the highest peak not only in Borneo, but in Southeast Asia.

The topographical division of this area is shown in Figure II-2.

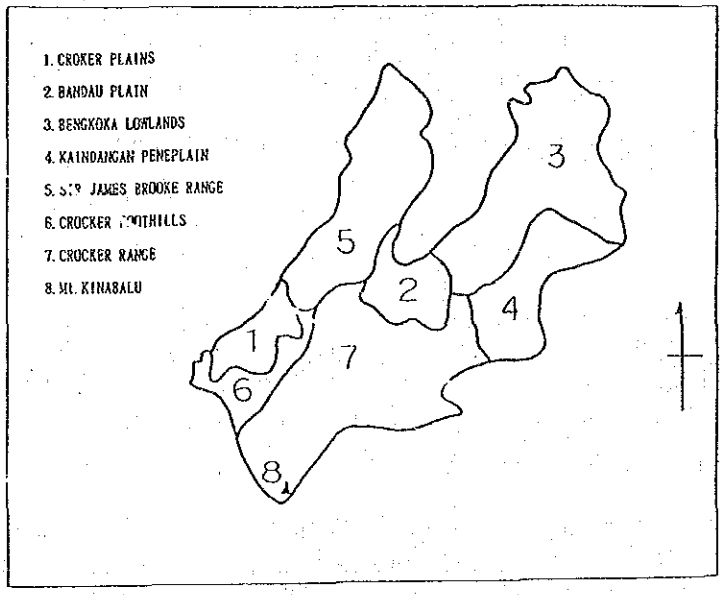


Figure II-2 Physiography of Study Area

Source: The Land Capability Classification of the West Coast Residency, Sabah, Malaysia

1-4 Geology

This area is extensively covered with sedimentary rocks originating from the Tertiary to the Quaternary Periods. The sedimentary Crocker Formation, originating in the Eocene to the Oligocene, occupies the largest area. This sediment comprises calcareous sandstone and shale. It is distributed in the Sir James Brooke Range forming the base of the Kudat Peninsula, the Kaindangan Peneplain forming the base of the Bengkoka Peninsula, the Crocker Foothills and the Crocker Range. In all these areas, folds are observed with the axis running from northwest to southeast, and followed by the development of valleys. As already stated, however, the axis of the folding structure runs from northeast to southwest in the southern part of the Crocker Foothills.

The two peninsulas of Kudat and Bengkoka are composed of Oligocene sedimentary rocks called the Kudat Formation. This sediment comprises sandstone, shale, mudstone, breccia and limestone. In this area, folds are also seen with the axis running from northwest to southeast. A middle Miocene sediment, called the Bongaya Formation, is partially distributed on the west side of the Bengkoka Peninsula. This sediment mainly consists of sandstone, mudstone, shale, breccia and limestone. Its formation is a mixture of neptunian and continental deposits.

Sedimentary rocks called the Chert-spilite Formation, formed in the Cretaceous to the Eocene, are distributed in the west base of the Bengkoka Peninsula and some part of the Kudat Peninsula. This formation is mainly composed of sandstone, chert, breccia and tuff. It is the oldest formation in this area.

The alluvium originating in the Holocene epoch (late Quaternary) is distributed in the Bandau Plains behind Marudu Bay and Crocker Plains along the west coast, and the delta formed by the Bengkoka River. All these deposits consist of earth and sand carried by rivers.

Sedimentary rocks called the Wariu Formation originating in the period from the Oligocene to middle Miocene are distributed along the fault on the west side of Mt. Kinabalu. This sediment is mainly composed of coarse rock debris from the Kinabalu Massif.

Unlike most of this area, which consists of sedimentary rocks, granodiorite and adamellite are distributed around Mt. Kinabalu. Mt. Kinabalu was formed by the batholith of these plutonic rocks penetrating through the Crocker Formation.

1-5 Soil

As already mentioned, the study area falls under the topical rain forest climate (Af) according to Köppen's system. Therefore, soils generally found in wet tropical zones are also distributed in this area. Acrisols and cambisols are distributed in mountain and hill areas, including the Crocker Range, the Crocker Foothills, the Sir James Brooke Range and the Kaindangan Peneplain. Aquatic gleyic acrisols and gleyic luvisols, and highly saturated eutric gleysols are also distributed in plains and low and swampy areas, including the Bandau Plain and the Bengkoka Lowlands.

Siliceous sand from which Fe, Al and basic minerals have leached is also partially distributed. It was a kind of podzol because its formation resembled temperate-zone podzols (Ministry of Overseas Development, 1976). Such areas are called "kerangas" meaning "barren soil", where the growth of plants is generally dull, and shrubs like heath and poor forests develop.

1-6 Vegetation

According to "Forestry in Sabah", the total area of Sabah is 7,371,000 ha. Of the total, about 64% or 4,732,000 ha is covered by forests. Falling under a tropical rain forest climate, if it is a virgin forest, constituent species of forest in the area are very abundant. It is well known that even in small plots, forests in this area constitute of the largest number of species in the world.

The northern part of Sabah covered in the survey in this study is sparsely populated and underdeveloped. The long-term continuation of shifting cultivation has deforested an extensive area, and virgin forests no longer remain near coastal plains, villages and roads. Mangrove forests of *Rhizophora* spp., *Bruguiera* spp. and *Nipa fruticans* have developed along tidal rivers and shorelines. Moreover, small freshwater swamp forests are distributed in swampy zones.

The original vegetation of lowlands and hills was tropical rain forests represented by Dipterocarpaceae including *Dipterocarpus* spp., *Shorea* spp. Now, however, lowland vegetation has been replaced by rubber, coconut and oil palm plantations and other types of farmland, while the hill vegetation has been replaced by secondary forests as a result of logging and regenerated forests after shifting cultivation. There are many grasslands covered with *Imperata cylindrica* following the frequent occurrence of forest fires every year.

Table II-2 Forest Areas

Category		Area ('000 ha)
a.	Mangrove	361
b.	Transitional, beach and swamp forests	194
c.	Lowland dipterocarp forests and hill dipterocarp forests	1,348
d.	Montane forests	722
e.	Other forests (disturbed regenerating forests)	1,857
f.	State Parks	245
Total		4,732

Source: Forestry in Sabah, 1989

The vegetation changes to tropical submontane rain forests at an altitude of over 1,200 m. They include evergreen broad-leaved trees such as *Castanopsis* spp., *Quercus* spp. and *Trigonobalanus* spp., and conifers such as *Agathis* spp., *Dacrydium* spp. and *Podocarpus* spp. The vegetation changes to tropical uppermontane rain forests in the range of 1,800 m to 3,000

m. They are mainly occupied by mossy forests. There are many plants like *Eugenia* spp., *Leptospermum* spp., *Phyllocladus* spp., *Podocarpus* spp. and *Tristania* spp., and the surface, stems and branches are covered with moss. *Nepenthes lowii* (a kind of pitcher plant) is often found on the forest floor. Over 3,000 m, tropical subalpine forests appear, and shrubs like *Leptospermum–Rhododendron* are dominant. Only Mt. Kinabalu exceeds that altitude. Near the summit of Mt. Kinabalu (over 3,700 m), tropical alpine shrub forests are dominant, and only dwarfed plants of the aforementioned *Leptospermum–Rhododendron* and Gramineae are found. The vertical distribution on Mt. Kinabalu is illustrated in Figure II–3.

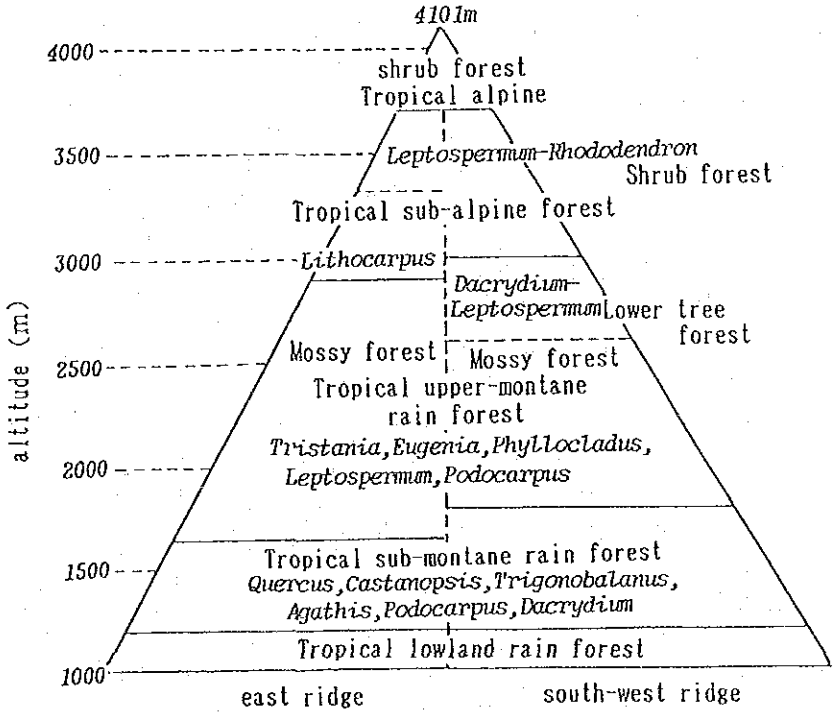


Figure II–3 An Illustration of the Vertical Distribution of Vegetation in Mt. Kinabalu

Source: The Land Capability Classification of the West Coast Residency, Sabah, Malaysia (1971)