areas and eventually forest will be recovered, the local people will receive income from the sales of logs at the cutting age. Good forests will also make a contribution to environmental conservation and improvement of land productivity.

1-3 Significance of Tree Farms

SAFODA has promoted the forestation of devastated or abandoned lands in Sabah. Through this activity, it has provided opportunities for local employment directly or indirectly, and consequently activated the local economy.

Tree farm is aimed at participation of farmers in planting and tending seedlings of *A. mangium*, which are distributed free by SAFODA, on a small scale. Labour required for these operations seems to be covered by surplus labour in each farm. However, it is not clear whether small tree farm households gain a surplus income or not. Although *A. mangium* is a fast-growing species, it will take about seven years to reach cutting age. At any rate, land will be effectively used during the period from planting to harvesting though farmers cannot earn any income from their plantations in that period. Developing a tree farm actually accumulates surplus labour in the form of standing trees, and the "deposits" can be withdrawn as cash incomes at the time of harvesting. These incomes are not negligible to the local economy.

The tree farm, which can be run by a family on a small scale, is an important means of utilizing small-size idle or abandoned land. It is also an extremely effective method for extending forestry activity to the local people.

Persons who will purchase logs produced by tree farms at a fair price are indispensable for making full use of the tree farm for the local economy. Moreover, if logs produced by tree farms is processed by local small-scale processing mills, its value added will be raised in the process and have a great effect on the development of the local economy. In other words, one complete cycle of operations is necessary from logs production by tree farms to processing and sales of products.

Tree farms will face difficulty in profitably selling standing trees which have reached their cutting age because such farms are scattered and run on a small scale. It would be advantageous for them if they could gather a small amount of logs from many farms to sell them together. A forest owners' cooperative would play such a role.

In Japan, forest owners' cooperatives are nonprofit cooperative associations of small forest owners, which directly serve members (Article 4 of the Forest Owners Cooperative Law). According to statistics of forest owners' cooperatives, there were about 1,600 cooperatives in Japan at the end of 1991, and the area of forests owned by the members was 11,521,000 ha, accounting for about 74% of the total area of private forests in the coverage areas of such cooperatives (Forestry Agency, 1991).

Forest owners' associations in Japan are organizations designed to improve the socioeconomic status of small forest owners as members, to foster sustainable management in forestry, and improve forest productivity in collaboration with each other. All projects will be carried out for the benefit of their respective members. Their main activities include:

(1) Guidance in forest management;
(2) Forest operations and management entrusted by their members;
(3) Prevention and control of diseases and insects;
(4) Loans for their members' forests and other projects or livelihoods;
(5) Supply of necessary items to their respective members for forestry and other projects; and
(6) Transportation, processing, storage and sales of forest products produced by their respective members and others.

Forest owners, common or juridical persons, who can afford to assume contribution are eligible for membership. The minimum unit and ceiling of contributions are determined by each of the associations.

As officers, directors and inspectors are responsible for the execution of the association's work. They are elected by a vote. The president of the association is elected from among officers and must deal with the association's work on its behalf and in accordance with the decisions made by the board of directors. Inspectors take charge of the association's property and inspect the execution of its work. The tenure of officers is usually three years.

The required personnel are employed to manage the association and many workers are employed to carry out forest operations, including routine tasks. In some cases, the whole of one district constitutes a large forest owners association and often takes the lead in managing private forests in that region.

Sales and log production activities are considered the most important in the coverage areas of this study and will be described in the following.

According to above mentioned statistics, about 1,113 cooperatives performed sales and log production in 1991, and 4,622,000 m^3 of logs were sold, of which about 61% or 2,820,000 m^3 was sold in an integrated process from logging to sale (Forestry Agency, 1991). These activities contribute to the increase in the incomes of their members, though the volume of logs sold by each cooperative was as small as approximately 4,000 m^3.

To give an example of forest owners cooperatives concerned with sales and log production in 1991, Hita Forest Owners Cooperative in Oita Prefecture was chosen from "Fifty Selected Forest Owners Cooperatives, Part II" (Federation of Forest Cooperatives, 1990). The total area of Hita City is 27,078 ha, of which 77% is occupied by forests, mostly private forests. At the end of 1988 (the same hereinafter), the area of man-made forests was 16,128 ha. The cooperative had 3,539 members, who owned 18,412 ha of forests, and the area of forest per member was no more than 5.20 ha. Hita City is located in the center of the Hita forestry area and is the center of sawing and processing industries. Log output in 1989 reached 64,000 m^3, of which about two-thirds was produced by contract. In addition, logs were sold on commission. A total of 77,689 m^3 was handled. This cooperative also undertakes forestation projects and have 30 full-time officials and 119 workers.

Hita Forest Owners' Cooperative is a successful case, but each felling area is not large. Even a small amount of logs from each will amount to 64,000 m^3 if they are combined. Logs are not usually purchased in small quantities, and their prices are beaten down. However, if they are combined through the cooperative, they can easily be sold at a profitable price.

Although it is unknown whether such a cooperative system will suit the study area or not, it is necessary to organize small forest owners to combine to market larger lots of logs.

1-4 Possibility of Activating the Local Economy by Wood Processing

It is expected that log output from natural forests in Sabah will be substantially lower than log demand in the state in 2020. Therefore, it is inevitable that the use of logs from man-made forests will be promoted (Rahim Sulaiman, 1993). Since small-diameter logs from man-made forests are not cost effective for long-distance transportation, it is advantageous to process them at places near the production area. Therefore, it is likely that a primary processing mills using small-diameter logs will be developed in northern Sabah as a production area of raw material. The primary processing of logs from man-made forests will be possible without huge investment, therefore some inhabitants can afford to invest funds in such activity. Moreover, if local primary processing is sophisticated, wood-related industries will take a higher share in the local economy of northern Sabah. Manufacturing industry in the 2020 Vision will be eventually achieved in the form of wood processing.

The above-mentioned development of wood processing industries is important to the development of the local economy where no favorable manufacturing industry exists except food processing. It is recommended that the government gives incentives for that purpose. The development of wood processing industries will activate the local economy and lead to more income of the inhabitants and improvement in infrastructure. In addition, degraded forests will be rehabilitated. On the whole, the state's economy will be substantially improved.

One of the incentives for timber processing is a subsidy for developing a timber industrial park. In Japan, a single timber industry or a group of relevant industries have intentionally gathered to construct a regional timber industrial park. There were 97 timber industrial parks completed or under construction throughout Japan as of February 1993. Besides these, there are some in the planning stage. There are 768 sawmills, 52 plywood mills and 622 other manufacturing factories in such parks, as well as 1,863 enterprises, including wholesalers, retailers and carriers (Forestry Agency, 1993).

Timber industrial parks are key facilities for bulk distribution and processing with high added value for the purpose of establishing centralizing timber related facilities, mainly including timber processing facilities, where upstream and downstream processing are integrated. Therefore, the members of such a park include log suppliers, sawmills, secondary processing industries, carriers, and machine repairers, all of whom usually organize a cooperative association together. The establishment of a timber industrial park will facilitate log producers to sell logs and for sawmills to collect logs. If facilities are shared, the quality of products could be improved, and more information could be collected through bulk sales. This will benefit both forest owners in upstream and timber processing industries and carriers on the downstream side.

The timber industrial park is to be managed by a cooperative association whose members come from different fields of business and management will comply with the principles of the cooperative association. In this respect, the clerical work and management system of the cooperative association of timber industries are similar to those of the forest owners association, though there are fewer members of the former compared with the latter.

According to the Timber Engineering Dictionary, the objectives of the development of timber industrial parks are to expand industrial sites for rationalizing production facilities into appropriate sizes, relocating such sites from urban areas to avoid fires, noise, traffic and other public nuisances, promote conglomeration, affiliation and cooperation, and facilitate the sharing of facilities, cooperation or projects.

In view of facilities, if such a park is developed, companies could reduce their investment in facilities for electric power supply, roads and log yards. Processing mills in the park could easily obtain logs, maintain machines, reduce transportation costs, obtain relevant information and use common facilities.

To give an example, Hitoyoshi Timber Industrial Park in Kumamoto Prefecture was completed in 1985 by parties engaged in log production, sawing, timber sales and transportation in Hitoyoshi and Kuma, Kumamoto Prefecture. It is a regional supply base of logs from man-made forests for general purposes such as the collecting of logs, the production and sale of sawn timber, the production of wood chips, and the shipment of products (Forestry Agency, 1989).

1-5 Public Benefits of Forest Improvement

It is reported that a big flood occurred in northern Sabah in December 1993 which took several lives. According to an interview with local inhabitants, floods like this have occurred every five or ten years. The above-mentioned flood destroyed many traffic routes in the areas. It washed out log bridges, collapsed roads, and destroyed cross conduits.

Although water retention capability is limited, the existence of forests will slow down coursing rainwater and ease the flooding of rivers. Forests work effectively in preventing hillside collapse and soil erosion from the forests.

On the other hand, without good forests, the efflux of earth and sand will raise the beds of lower streams and cause flood damage. When rainfall is small, river water will disappear due to the quick efflux of rainwater. For using river water and crossing rivers, the flow rate should not fluctuate siginificantly. In this respect, it is essential that the upper reaches of streams should be covered with forests as much as possible. Forests should be conserved immediately along with water retention capability of forest by foresting grasslands and shrubs resulting from forest fires.

In the coverage area of this study, there are few large rivers with big catchment areas and the large fluctuation of flow rate is unfavorable for using river water, and is likely to obstruct the development of the local economy in the future. If the Bengkoka River where forests are degraded in the upper reaches is compared with the Kadamaian River originating in Mt. Kinabalu, it is obvious that the state of forests in the upper reaches will affect the change of flow rate and the mud content of the flow.

1-6 Manpower

Although medium and large-scale forestation will take much manpower, it is preferable not to use fixed labour. However, as many as possible inhabitants should be employed to develop the local economy and raise their incomes. Accordingly, forestation should be done by contract and foster local contractors. Priority should be given to the employment of those who have stopped shifting cultivation.

1-7 Infrastructure

The network of traffic routes within this area is insufficient. Log transportation will require improvement in main roads as well as construction of bridges. If forestation is carried out according to the proposed project, a large amount of small-diameter logs must be transported at the cutting age. Good roads will be indispensable to smooth transportation. To carry a huge quantity of *A. mangium* logs produced in this area, bridges must be constructed across the Bengkoka and Kinaram rivers. Unless a bridge is constructed across the Bengkoka River, the use of *A. mangium* logs existing in the Pitas District will be impeded. Without a bridge across the Kinaram River, the upper reaches from that point will become difficult to develop. Especially in the case of the Bengkoka River, the absence of a bridge will affect on extensive development as well as transportation of plantation logs in the area.

The plantation of *A. mangium* in SAFODA's Bengkoka plantation now has an area of 13,000 ha. Assuming that the MAI of *A. mangium* produced there is 20 m^3, an increment of 260,000 m^3 could be expected from standing trees. If the yield is 80%, 208,000 m^3 of logs would be carried across the Bengkoka River. If transportation is year-round, about 693 m^3 of logs a day would be carried in 300 days a year. It is impossible to carry such a huge amount of logs by ferry across the Bengkoka River, and transportation cost will rise remarkably. Therefore, across the Bengkoka river, a major bottleneck to regional development, a bridge must be constructed for regional development, including forestry development in the eastward of the Bengkoka River.

A good transportation system is indispensable to the transporation of bulky small-diameter logs. The value of plantation logs will be reduced without it. Moreover, the economic effect of forestation will be remarkably reduced, and worse, forestation will no longer be economically viable.

2. Zoning

2-1 Necessity of Zoning

As this study covers an extensive area of 540,000 ha., the whole area cannot be uniformly treated when forestation plan is prepared. It needs to be divided into several zones based on the natural environment and socioeconomic conditions. Although it is convenient to divide this area according to existing districts, this method would be inappropriate for preparing a forestation plan because within the districts conditions are very much diversified. Moreover, forestation is mainly intended for shrub lands, grasslands and abandoned rubber and coconut palm plantation. However, there are many cases where local inhabitants have established or applied for the customary right to use shrub lands and grasslands. It cannot be easily determined from the present state whether a planting site is available or not.

Even if forest reserves, army area, state parks, SAFODA's Bengkoka plantation, and the proposed joint venture's project site for pulpwood production are excluded from this area, an area of 323,000 ha (result of land-use and vegetation survey) will remain. Needless to say, the natural environment and socioeconomic conditions will change. The availability of planting sites is a major prerequisite for preparing a forestation plan. The form of plantation management will depend on the size and ownership (or concession) of a planting site, the forestation entity, and the size of a consolidation. Moreover, the method of implementing the forestation plan will depend on natural conditions, including the gradient, soil and vegetation of the site, the local population density, and the form of agricultural management. If all these conditions are taken into account, the zoning of this area will be too complicated. Therefore, more weight was given to land use and vegetation as the most important factor in zoning.

2-2 Current Land-use Situation

As already stated, this area occupies a total area of 540,000 ha and has a population of about 181,000. This area is the least developed and least populated in Sabah. However, population density and land use vary from district to district. For example, in the northern part of Kudat, land is actively used. Inhabitants use the most of the land for agriculture, including paddies, coconut and oil palm plantation, except for a small forest reserve and SAFODA's plantation. In old coconut stands, *A. mangium* trees have been planted in some places, while natural trees have grown to form the lower layer of other places. In the latter case, the management of coconut palm plantation is now unattractive, and coconut palms to be regenerated are unattended. Some mix stands of coconut palms and *A. mangium* are also found in Pitas District, and more found in Kudat District. *A. mangium* plantations managed by tree farms are also scattered in the area covered by this study.

Much of the forest in Kota Belud were damaged by fire, and SAFODA's plantation also suffered such damage. Forests in Kota Marudu are mostly remote and steep. They are also significantly damaged by fire.

State-owned forests have been considerably damaged by fire after logging. If forests suffer from the frequent occurrence of fires in the few years after logging, useful medium- and small-diameter trees will wither only to be succeeded by intolerant species. If forest fires occur after several more years, standing trees in forests will diminish, soil will deteriorate, and forests will change into grassland. Forest lands which have changed or are now changing into grassland are found throughout this area.

In Sabah, land-use customs exist, and many inhabitants have applied to use land based on their customary right. In many cases, forest land is already subject to such rights. It cannot be judged easily at present whether or not a planting site is available. Specifically, state-owned lands which have already changed into grassland are extensive around Hobut in Kudat District. However, the use of these lands has already been applied for based on customary right. It is now impossible to consolidate them into a plantation area.

Even Kota Marudu District is covered mainly with forests, when a forest road is newly constructed, farmers in the neighborhood tend to encroach places near the road to start shifting cultivation and then settle there. Fire used for shifting cultivation often spreads to forests, obstructing forestation or recovery of natural forests.

2-3 Zoning According to Forestation Scale

The management of forestation was classified by scale into three categories, namely large-scale forestation (over 500 ha per consolidation), medium-scale forestation (50 - 500 ha), and small-scale forestation (less than 50 ha). The planting sites classified by management scale in northern Sabah are summarized in Table III-1 showing their areas according to land use and vegetation and the location of each respective consolidation is shown in Figure III-1.

In northern Sabah, three consolidations can be established for large-scale forestation: a consolidation (54,000 ha) in the middle reaches of the Kinaram River with its centre in Marak-Parak, a consolidation (35,000 ha) in the upper reaches of the Bengkoka River with its centre in Sonsogon Suyad; and, a consolidation (28,000 ha) in the eastern part of Tandek from the middle and lower reaches of the Bengkoka River to the coast. The hill area in the southern part of the Kudat Peninsula including Langkon is a promising site for medium-scale forestation, and can form a consolidation (64,000 ha). Other areas which are more actively used can be classified as sites for small-scale forestation.

Table III-1 Areas of Consolidations and Regions According to Vegetational Classification

Forestation Scale	Consolidation/ District	Area	Area by Land Use and Vegetation (ha)			Others
			G+F3 (2000 feet or more)	F2 (2000 feet or more)	F1 - D2 and Reserve	
Large	Marak-Parak	53,897	12,205 (163)	12,031 (744)	23,367	6,294
	Sonsogon	34,809	4,925 (0)	6,166 (504)	23,049	669
	Tandek	28,348	10,766 (0)	9,881 (0)	3,907	3,794
	Subtotal	117,054	27,896 (163)	28,078(1248)	50,323	10,757
Medium	Langkon	63,862	24,668 (0)	15,869 (0)	3,356	19,969
Toal of Large & Medium		180,916	52,564 (163)	43,947(1248)	53,679	30,726
Small	Pitas	31,713	7,131 (0)	881 (0)	0	23,700
	Kudat	16,939	8,088 (0)	3,169 (0)	444	5,238
	Kota Marudu	32,285	6,625 (0)	2,623 (0)	869	22,169
	Kota Belud	61,377	23,988(4313)	11,719(1763)	5,781	19,889
	Subtotal	142,314	45,832(4313)	18,392(1763)	7,094	70,996
Total		323,230	98,396(4476)	62,339(3011)	60,773	101,722

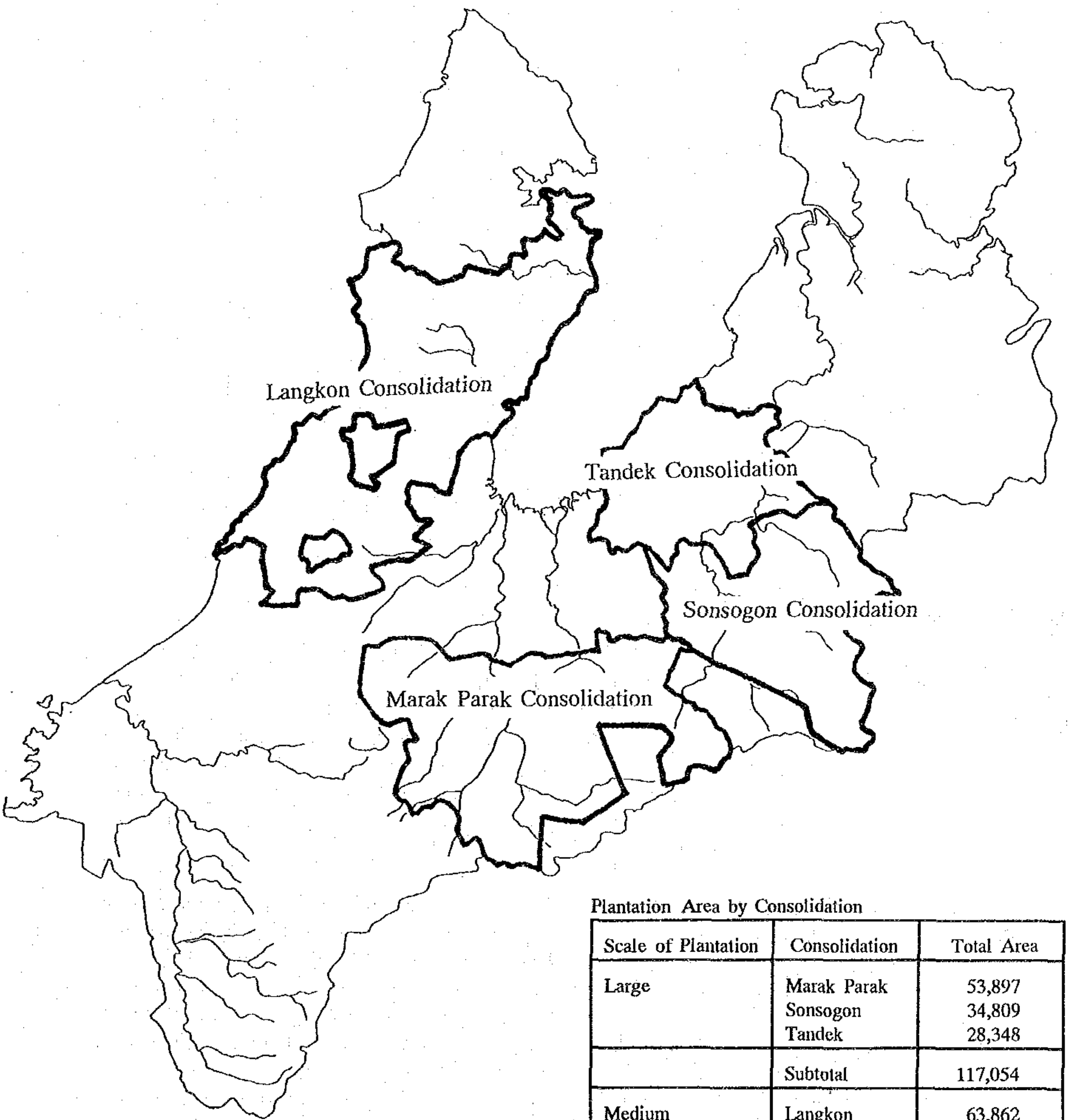
Note 1: Areas in right side of columns G+F3 and F2 include no. of hectares with elevation 2000 ft and more.

2: The alphabetic symbols stand for as follows:
D2: Medium density high forests
F1: Medium high forests, F2: Low forests, F3: Shrubs, G: Grassland

3: Some parts of "reserves" will be left as they are in the forestation process.

4: "Others" include arable lands, urban areas, and rubber and palm plantations.

Figure III-1 Location of Forestation Consolidation



Plantation Area by Consolidation

Scale of Plantation	Consolidation	Total Area
Large	Marak Parak Sonsogon Tandek	53,897 34,809 28,348
	Subtotal	117,054
Medium	Langkon	63,862
Small		142,314
Total		323,230

3. Forestation Plan

3-1 Proposed Site for Forestation

The basic principle of forestation is right tree on right site. In addition, natural and socioeconomic conditions must be taken into consideration in developing a forestation plan for proper and effective land-use. From this point of view, several sites for forestation were examined in the coverage of this study. The present conditions of these sites were verified by conducting an additional field survey again with the land-use and vegetation map drawn based on the interpretation of aerial photographs. The sites were then classified according to land-use and vegetation as follows:

Table III-2 Forest Management Systems According to Land-use Classification

Land Use/Vegetation Type	Code	Management	Areas
High Forest	D2 - D3	Conservation or natural regeneration treatment	5,150
Medium Forest	F1	Natural regeneration treatment	54,522
Low Forest	F2	Enrichment planting/Natural regeneration treatment	64,027
Shrub	F3	Reforestation	76,478
Grassland	G	Afforestation	24,650
Total			224,827

Areas falling under D1 to D3 are covered with secondary forests where dominant trees of 30 m or higher are dipterocarp species. Judging from the composition of species, they comprise stands close to the original vegetation including the climax. Accordingly, in view of the condition of such stands, silvicultural treatment to be applied for these areas is to tend and maintain the existing successors with the focus on conservation. A proper management system is intended to expedite timber restoration of forest while maintaining the original ecosystem of vegetation. This type of management would also on the whole contribute to the maintenance of the local natural environment.

Areas falling under F1 or medium forests are covered with secondary forests including the residual dipterocap species stands. Although pioneer species have partially invaded them, these forests are generally regarded as a transitional zone to D3. Therefore, they also need natural regeneration treatment to nurture useful successors including dipterocarp species. As a result, the diversity of species will be maintained, and commercially valuable forests will be revived. This type of treatment will also lead to the conservation of the local environment.

In areas falling under F2, species conversion has advanced further, i.e., successors to dipterocarp species do not exist, while pioneer species are dominant. Some stands will become commercially useful if the diameter class reaches a certain standard. In this sense, their economic value is quite significant. Effective forestry will make them more economically efficient by applying enrichment planting.

Areas falling under F3 are covered with shrubs consisting of poor quality stands degraded by the spread of fire from adjoining areas under shifting cultivation. These stands, containing no mother trees or successors, have already lost their natural recovery system and cannot be reproduced without human assistance. They need rehabilitation by means of reforestation treatment, which will eventually lead to the effective use of land and the conservation of the local environment.

Areas falling under G are covered with lalang grass, and have been abandoned after frequent shifting cultivation. They need immediate greening for water and soil conservation. Of the above-mentioned silvicultural treatments, afforestation should be carried out in these areas. To manage industrial forestation, clear cutting and uniform planting is a general method. Therefore, candidates for this management are areas falling under F3 and G in the land-use and vegetation classification.

3-2 Forestation System

The management of reforestation of logged-over and devastated forests can be roughly classified into four categories according to the level of stand status of the forest (ITTO, 1993).

Each management category is summarized as follows:

1) Afforestation

Originally this method referred to plantation on semi-dry land, but now this refers to plantation in devastated regions of rainforests, where plantation is conducted to reforest grassland or bare land with few woody plants. For quicker afforestation and improvement of the soil, generally fast growing species, such as from the Legume family, are introduced.

2) Reforestation

When primeval forests have undergone marked changes due to the intrusion of low value pioneer species, reforestation is conducted to change these forests into commercial forests, because economic value is extremely low if they are left as is. Usually after felling all trees, useful species (mainly fast growing species) are planted.

3) Artificial regeneration

Artificial supplementary plantation is used in areas where there are tall trees, but the density of useful trees with high economic value is low, and the growth of useful species through natural regeneration cannot be expected. This method is sometimes called enrichment planting and involves the introduction of useful species such as indigenous species that make up the climax. When line planting is done, adequate space should be left so that young trees in different stages of growth are able to obtain an adequate amount of light.

4) Natural regeneration

This kind of regeneration is conducted in forests where trees are generally in good condition and there are many useful succeeding trees. To accelerate the regeneration of useful trees, tending such as girdling of inferior trees which check the growth of useful trees, vine cutting are done.

In carrying out forest plantation, attention should be paid to slopes in forests. In areas appropriate for afforestation, trees should be artificially planted even if there are steep slopes, while in areas for reforestation, plantation should be decided after checking the conditions of the forests. For instance if a place needing reforestation has a steep slope and has growing trees, including pioneer species, it is better to refrain from the artificial plantation of trees from the viewpoint of forest conservation.

In the four districts in the northern part of Sabah State covered by this study, the secondary forest has been cultivated and left as it was to become lalang grassland covering a wide area. Around these areas, there are shrub groves which seem to have been damaged by forest fire, and the secondary forests in good condition have remained only around the innermost depths of forest reserves. Therefore, the management categories of the relevant areas are mainly afforestation and reforestation. Supplementary enrichment planting should, however, be done when appropriate.

In addition to forest plantation in medium and large spaces, it is thought necessary to introduce methods of agroforestry and to promote tree farm activities in small unused plots of private land.

3-3 Planned Plantation Area

The total coverage area of this study is about 323,000 ha, of which about 236,000 ha will be managed under this project, excluding farmland and villages. In the forestation plan, the plantation area was determined in light of land use and vegetation classification, soil conditions, grades, and socioeconomic conditions of the project sites. Proposed plantation sites are areas which fall under Categories G + F3 and F2 in the foregoing vegetational classification in Part II, Subsection 5-1, and have an average gradient of less than 25 degrees in viewpoint of forest conservation.

Accordingly, of the four consolidations, mentioned in Chapter 2 in this part, for large and medium forestation, a total area of 53,000 ha falls under G + F3, and a total area of 44,000 ha falls under F2.

According to the results of the field survey, the area actually available for large and medium forestation is estimated at about 80% of the above-mentioned area falling under G + F3. The remaining 20% is judged to be unsuitable for forestation and should be used for other purposes. Such areas comprise stands remaining along the valleys or on the ridges. Natural stands should be left intact for water and soil conservation. Rocky areas and swamps are unsuitable for forestation. Settlements and cemeteries within the coverage area of this study will also be excluded from planting sites. Thus, the residual area falling under G + F3 available for large and medium forestation in the whole northern Sabah is about 42,000 ha.

Areas falling under F2 will be subject to enrichment planting. Accessibility is the key to success in management. If accessibility and seedling availability are taken into account, the area available for forestation have limits. It is predicted that seedlings will not be easily supplied in large quantities, but limited to at most 500 ha of plantation per year. Therefore, the area of enrichment planting possible during the period of this project will be about 11,500 ha.

In areas where forestation will be carried out on a small scale, there are many inhabitants, and land is well used. Small plantations will be managed mainly by farmers, who will plant trees on sites with poor soil condition, including places where cultivation has been discontinued or abandoned due to low fertility. It is expected that small plantations will increase by 1,000 ha every year until 2020. Judging from soil conditions, *A. mangium* will be mainly chosen for these plantations.

3-4 Selection of Species to be Planted

A. Afforestation and Reforestation

The methodology of forestation was discussed by classifying several methods into four types of management. In comparison with the areas classified according to land use and vegetation, areas falling under G are suitable for afforestation, while areas falling under F3 are suitable for reforestation. In the areas falling under G and F3, the following species were judged to be the most favorable for the management of medium and large industrial forestation.

1) *Acacia mangium*: Taking into account of soil and climatic conditions as well as SAFODA's experiences in northern Sabah, this is judged to be the best species to be introduced first into the afforestation and reforestation in this study area. However, whether or not the species can be planted at high elevation over 600 m above sea level should be examined where more adaptable species may have to be selected.

   The provenance of seeds of *A. mangium* planted by SAFODA has not been fully examined, and its seeds were supplied from various sources. According to the results of the provenance test on seeds from eleven sources conducted in the SAFODA-JICA project, the provenance of seeds makes a large difference in timber volume. Against the base figure of 100 for the Sabah mix, timber volume exceeded 200 for seeds from three sources, and exceeded 150 for three source. These results cannot be immediately generalized, but it is true that volume varies with the provenance of seeds. It is possible to increase output per unit area by breeding, which may enable a 50% increase in volume to be achieved compared with the Sabah mix (Kawasaki H. and Kikuchi T., 1994).

2) *A. auriculiformis*: This species can complement *A. mangium*. If it is introduced into an area whose soil is poorer for afforestation, the species can grow and improve the land productivity of the area and partially prevent monocultural ecosystem resulting from uniform planting of *A. mangium*.

3) A hybrid clone of *A. mangium* and *A. auriculiformis*: This clone is being used by SSSB on a trial basis and achieving good results. This hybrid grows very vigorously, and some trees of this hybrid developed in the 1970s in the Ulu Kukut plantation of SAFODA reached 60 cm in DBH and 25 m in height. Good increment and quality can be expected from the plantation of clones of this hybrid (Kawasaki H. and Kikuchi T., 1994). *A. mangium* is apt to suffer from heart rot during growth which reduces chip production yield. Forestation with this clone is expected to offer the solution of this problem. According to the survey under the SAFODA–JICA project, five–year–old trees of *A. auriculiformis* and the hybrid clones of *A. mangium* and *A. auriculiformis* did not suffer from heart rot. Therefore, it is recommended that clones of this hybrid resistant to heart rot should be used for forestation (Ito S. and Nanis L., Hj., 1994). However, there are still some other problems to be solved before its application to any forestation project. It will take much time and experience to develop silvicultural techniques, including the nurturing of an elite clone and the establishment of a scion garden and high–yield seedling production techniques with scions. Therefore, the introduction of this clone should be examined as a method of replacing *A. mangium* gradually after the second rotation of planting. If the utilization of its timber is significantly changed by breeding technology, it could be eventually used for higher value–added. This means that the cost–benefit of mangium forestation could be upgraded in the future.

4) *Paraserianthes falcataria*: This is the most promising species after *A. mangium*. Since soil conditions substantially affect the volume increment of this species, great care should be taken to select the right planting site. In northern Sabah, natural regeneration of this species is often observed in the proposed Tandek and Langkon Consolidations. This indicates that suitable sites for this species are extensively distributed there. Therefore, this species needs to be actively introduced into the Tandek and Langkon Consolidations.

5) *Gmelina arborea*: This species is even more affected by soil conditions. Full care should be taken to select the right sites for this species. However, this species seems to be adaptable to the weather conditions of northern Sabah where the dry season is distinct. SSSB has obtained good experience of large–scale forestation as well as breeding practice in Sabah.

6) *Tectona grandis*: The climatical conditions of northern Sabah seem to be favorable for the growth of teak. In terms of soil conditions, however, soil suitable for teak is only limited. According to the results of the forest soil survey of this area, the soil is acid, lower than pH 6.5 optimum for the growth of teak. Laterite unsuitable for teak often appears. However, *Tectona grandis* is resistant to fire and fairly adaptable to regional characteristics. An experimental forest which remains in Kota Marudu proves that this species could be introduced if the right site is selected.

7) *Eucalyptus camaldulensis*: SFI has experienced in using this species in Sabah, and it seems that it can be introduced into high–altitude locations of over 600 m in northern Sabah. Forestation with *E. deglupta*, has been also attempted, along with SSSB, but has not yet obtained any good result in Sabah. It does not seem proper to introduce *E. deglupta* into northern Sabah with some length of dry season.

8) *Hevea spp.*: In Malaysia, *H. brasiliensis* is extensive in plantations for collecting latex. Recently, the use of its timber has also begun to attract attention. This species is a promising candidate for forestation, especially when agroforestry is introduced into the management of small-scale forestation. There is also a species intended only for timber production in the genus of Hevea. Although it has not had significant results in the forestation of Sabah, the species could be eventually introduced into small and medium scale forestation.

9) *Khaya ivorensis*: This species, native to West Africa, grows well below an altitude of 450 m above sea level. It grows even in places periodically flooded, but has a low tolerance to long dry periods. Accordingly, it grows well in wet valleys or riversides. Young trees do not need much light, and grow quickly. Since the trees planted in logged-over areas at one time are damaged by *Hypsiphyla robusla*, the damage can be decreased by underplanting or mixed planting. The MAI has been reported to be 7.74 m^3 (Appanah S. and Weinland G. 1993).

10) *Swietenia macrophylla*: This species, native to Central and South America, belongs to Meliaceae like *Khaya ivorensis*. These trees, which are capable of growing in a variety of soil conditions, prefer deep, rich and well-drained soil. The cutting period is 40 to 50 years and MAI is reported to be in the range of 15 to 20 m^3. Since this species is damaged by *H. robusta*, the underplanting method should be used to reduce damage. This species can also be used for enrichment planting.

11) *Araucaria hunsteinii*: This species should be also examined for introduction into the highlands.

B. Enrichment Plantating

Areas falling under F2 in the land-use and vegetation classification will be subject to artificial regeneration. This method is generally known as enrichment planting. Species to be introduced into these areas are mainly indigenous. They belong to Dipterocarpaceae. The species, which is faster-growing and easier to secure seeds and wilding, must be selected among them. Even individual trees of the same species have different growth characteristics, depending on their respective provenances or growth conditions. For successful enrichment planting, these aspects should be fully considered when selecting species to be introduced, and for obtaining seeds. Malaysia has much experience and a high level of know-how in enrichment planting. Species to be introduced are as follows:

12) *Dryobalanops lanceolata* (Kapur paji): Natural stands of this species are relatively widely distributed in the eastern part of Sabah. Owing to their extensive distribution, fruiting occurs almost every year compared with other dipterocarp species. Therefore, it is possible to establish a perennial production system of seedlings, including wildings.

13) *Shorea leprosula* (Seraya tembaga): This species is extensively distributed throughout Sabah. Like Kapur paji, it provides a very good possibility of collecting seeds and wilding.

14) *S. parvifolia* (Seraya punai): See 13) above.

The foregoing results are summarized in Table III-3.

Table III-3 Promising Species for Planting

Species/Scientific Name (Local name/English name)	Origin/Seed Supply	Suitable Planting Site
(1) *Acacia mangium* (Mangium)	Northeastern Australia, Papua New Guinea, and Eastern Indonesia. This appears usually at an altitude of 100 m or less. Selectively bred seeds are available from SSSB in Sabah.	Possible to extensively plant in the most area. In Sabah, planted in the low pH soil with pH 4.5. Symbiotic relationship with nitrogen-fixing bacteria of Rhizobium. A high-light place is favorable for growth.
(2) *Acacia aurcuriformis*	The north coast of Australia, Papua New Guinea, and Irian Jaya. Like mangium, selectively bred seeds are available from SSSB in Sabah.	Possible to grow in inferior soil. In Australia, this can grow in the soil with pH 3.
(3) Hybrid Clone of *A. mangium/A. auriculiformis*	In Sabah, naturally crossed trees grow in the SAFODA's Ulu Kukut Plantation. SSSB has a scion garden and can supply seedlings.	Similar to *A. mangium*.
(4) *Paraserianthes falcataria* (Batai)	Moluccas and Solomon Islands. Extensively planted in Sabah. Selectively bred seeds are available from SSSB.	Areas below 800 m above the sea are suitable. Very sandy and waterlogged area are unsuitable. The Tandek Consolidation and some parts of Langkon Consolidation seems suitable.
(5) *Gmelina arborea* (White teak)	Distributed in the lower part of the Himalayas in Pakistan, and in India, Nepal, Bangladesh, Sri Lanka, Myanmar, Thailand, Indochina and Southern China. Extensively planted in Southeast Asia. Seeds are available within Sabah.	Areas having a distinct dry season and annual rainfalls of 2000 mm at an altitude of 1000 m or less. Suitable soil is moderately moist, base-rich and well-drained alluvium.
(6) *Tectona grandis* (Jati/Teak)	Distributed in Myanmar, India, Indonesia, Thailand and Western Indochina. Favorable altitudes range from 0 to 1200 m. A very limited number of plantations exist in Sabah, which cannot supply seeds. Preferably, seeds obtained from Thailand.	This needs a regular dry season of three to five months. Deep and air-permeable alluvial soil is optimum. Laterite inhibits growth.
(7) *Eucalyptus camaldulensis* (River red gum)	Distributed throughout Australia except Tasmania in lowlands to 1200 m. Planted by SFI in Sabah, which can supply seeds and provide a model of management.	Alluvial flats with a high underground water table. Does well even in deep sandy loam or fairly heavy soil.

Species/Scientific Name (Local name/English name)	Origin/Seed Supply	Suitable Planting Site
(8) *Hevea brasiliensis* (Pokok getah para)	Amazon in South America. A representative primary product in Malaysia. Breeding is actively studied in peninsular Malaysia. Seeds are available.	Malaysia has accumulated a high level of know-how. Unsuitable for reforesting secondary forests or afforesting newly cleared areas.
(9) *Khaya ivorensis* (African mahogany)	Distributed from West Africa to areas 450 m above the sea. Plantations exist in Kedah State, peninsular Malaysia.	A candidate for agroforestry as well as enrichment planting.
(10) *Swietenia macrophylla* (Mahogany)	Mexico, Central America, Colombia, Venezuela, Ecuador, Peru and Bolivia. Up to 1500 m a.s.l.	Deep, fertile and well-drained soil is optimum.
(11) *Araucaria hunsteinii* (Klinki pine)	Distributed along valleys and in mountains 500 to 1500 m in New Guinea.	To be examined for use in highlands in northern Sabah.
(12) *Dryobalanops lanceolata* (Kapur paji)	Distributed in the whole Borneo Island except the south, and much on the east coast of northern Sabah. Up to 600 m above the sea. Easier to collect seeds and wild seedlings than other Dipterocarpaceae species.	A promising candidate for enrichment planting. *D. rappa* (Kapur paya) similar to this is optimum in low swamps.
(13) *Shorea leprosula* (Seraya tembaga)	Distributed from peninsular Thailand to peninsular Malaysia, Sumatra and the Borneo Island. Well known in Sabah. Collected from natural forests. The amount of seeds and the collecting time are always uncertain.	A promising candidate for enrichment planting.
(14) *Shorea parvifolia* (Seraya punai)	See above.	See above

Source: Ti Teow Chuan and Wilfred M. Tangau, Cultivated and Potential Forest Plantation Tree Species With Special Reference to Sabah, Institute for Development Studies (SABAH) 1991 Appanah S. & Weinland G., Plantating Quality Timber Trees in Peninsular Malaysia – a review –, Malaysian Forest Record No. 38, FRIM 1993

3-5 Plantation Area by Species

As already stated, of the coverage area of large and medium-scale plantation management of about 42,000 ha is available for forestation. It is estimated to be possible to plant *A. mangium* in two-thirds of the area or about 28,000 ha, *P. falcatoria* in about 7,500 ha, and some other suitable species in about 6,500 ha. *A. mangium* which constitutes almost all the existing plantations is expected for small-scale plantation management. Based on these results of the survey, targets for improvement of state-owned forests and plantation area by species in the coverage areas of this study in 2020 are summarized in Fig. III-2.

3-6 Management Systems by Treatment

3-6-1 Forestation by Clear Cutting

Treatment methods and cutting periods by species to be planted in the coverage areas of forestation by clear cutting are as follows:

1) *A. mangium*: Timber production system will be employed. The cutting period is seven years. The main utilization of this species include pulp and MDF chips. Uniform planting will be carried out after clear cutting and burning. The same operations will be repeated in the second and third rotations of planting instead of depending on natural regeneration. Because better varieties resulting from breeding will be planted in the second and following rotations. It is expected that the MAIs of planted trees will be 20 m^3/ha in the first rotation, 23 m^3/ha in the second, and 25 m^3/ha in the third. The spacing will be 4 m x 2 m (1250 seedlings/ha). After planting, trees will be tended three times over a period of two years. Thinning and weeding will not be carried out.

2) *A. auriculiformis*: This species will be planted in the poorest soil condition area in the area to be planted *A. mangium*. Since this species is free from heart rot, the sawlog production with selective breeding may be possible in the future.

3) Hybrid clone of *A. mangium* and *A. auriculiformis*: The area of planting the hybrid clone of *A. mangium* and *A. auriculiformis* will be gradually expanded in the second and following rotations. This clone will also become a promising candidate for the sawlog production in the future. A prerequisite for this is to secure a sufficient amount of scions, for which a scion garden will be needed. The scion garden will be described in Subsection 3-8-3.

4) *Paraserianthes falcataria*: Timber production system will be employed. The cutting period is ten years. The main applications of this species include blockboards, package panels, furniture and cabinets. Uniform planting will be carried out after clear cutting and burning. The same operations will be repeated in the second rotation of planting without dependence on natural regeneration by coppices. This is in order to breed better varieties in form and growth. If they are used as the second generation of planted trees under the proper management system, harvests will acquire better marketability in the future. The MAIs will be 30 m^3/ha in the first rotation and 33

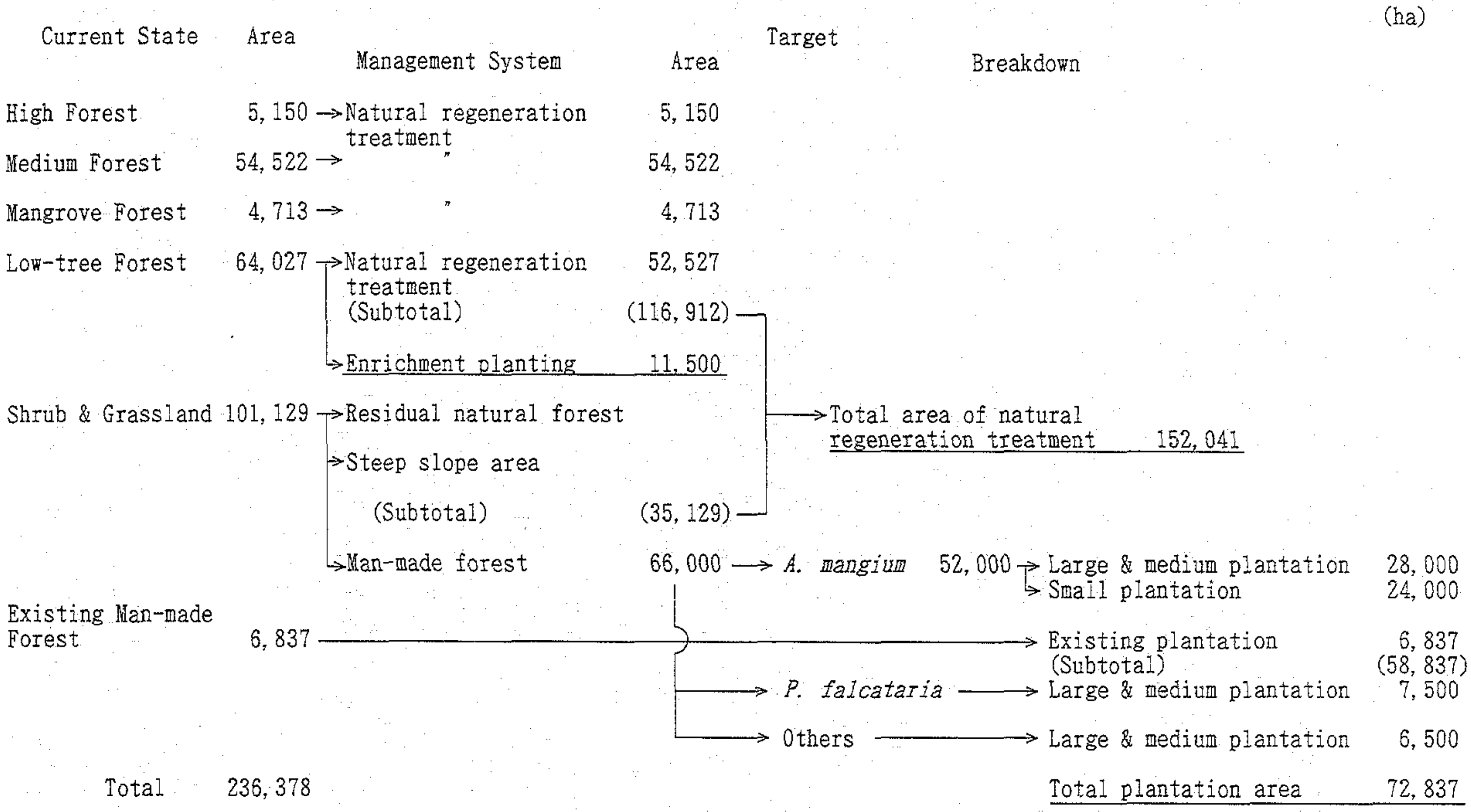


Fig. III-2 Targets for Improvement of State-owned Forests

Table III-4 Silvicultural Systems of Large and Medium-Scale Forestation for Major Species

Species	Local Name	System	Cutting Period (Years)	MAI	Spacing	Tending	Planting Site	Usage	Remarks
Acacia mangium		Timber production system	7	20–25m^3/ha	4m×2m	Three-time weeding No thinning	Areas under G & F3 600m or lower (1)(4)	Pulp, MDF chip	
		Timber production system	15					Frame, sliced veneer	
A. auriculiformis		Timber production system	10	17–20n^3/ha(2)	4m×2m	Three-time weeding No thinning	Low-site quality areas under G & F3 600m or lower (3)	Pulp	
		Timber production system	20					Heavy structural member, floor, panel	
A. mangium × *A. auriculiformis*		Timber production system	7	25m^3-/ha	4m×2m	Three-time weeding No thinning	Areas under G & F3 600m or lower	Pump	Establishment Scion garden
		Timber production system	15					Building material, floor, panel, furniture	
Paraserianthes falcataria	Batai	Timber production system	10	30–33m^3/ha	4m×3m	Three-time weeding No thinning	Areas under G & F3 600m or lower (4)	Plywood, cabinet, furniture, blockboard	Select suitable sites mainly in Tandek and some parts of Langkon.
Gmelina arborea		Timber production system	15	20–25m^3/ha	4m×3m	Three-time weeding No thinning	Areas under G & F3 1000m or lower (3)	Plywood, building material, furniture, box	Select suitable sites. Stump is favorable.
Tectona grandis	Jati	Timber production system	30	4–18m^3/ha(2)	4m×3m	Three-time line weeding Two full weeding Two thinnings	Areas under G & F3 300m or lower	High-grade furniture, cabinet, interiors	Select suitable sites. Plant stump.
Eucalyptus camaldulensis		Timber production system	30	20–25m^3/ha(2)	4m×3m	Three-time weeding No thinning	Possibly, areas under G & F3 600m or higher	Floor, ships, furniture, civil engineering, ornamental material	
Dryobalanops lanceolata	Kapur paji	Timber production system	40	8.3m^3/ha(8)	250sdls/ha	Three-time line weeding One light-control extraction No thinning	Areas under F2	Building material, plywood, floor, furniture, heavy structural timbers	

Species	Local Name	System	Cutting Period (Years)	MAI	Spacing	Tending	Planting Site	Usage	Remarks
Shorea parvifolia	Seraya punai	Timber production system	40	7.92m^3/ha(8)	250sdls/ha	Three-time line weeding One light-control extraction No thinning	Areas under F2	Buildin material, plywood, floor, furniture, heavy structural timbers	
Shorea leprosula	Seraya tembaga	Timber production system	40	7.7m^3/ha(8)	250sdls/ha	Three-time line weeding One light-control extraction No thinning	Areas under F2	Buildin material, plywood, floor, furniture, heavy structural timbers	

Source: (1) Advisary Committee on Technology Innovation, Mangium and Other Fast-Growing Acacia in the Humid Tropics, National Academy Press, Washington D.C. 1983
(2) Ti Tew Chuan and Wilfred M. Tangau, Cultivated and Potential Forest Plantation Tree Species, Institute for Development Studies (Sabah), 1991
(3) Edward S. Anyensu et al. Firewood Crops, National Academy of Sciences, Washington C.D. 1980
(4) Edward S. Anyensu et al. Firewood Crops, National Academy of Sciences, Vol. 1. 2. Washington C.D. 1980
(5) Awang Kamis and Taylor David A., Tropical Acacias in East Asia and Pacific, Winrock International Institute for Agriculture Research, 1992
(6) Burley J. and Nikles D.G., Tropical Provenance and Progeny Research and International Cooperation, Commonwelth Forestry Institute, Oxford, 1973
(7) Hillis W.E. and Brown A.G., Eucalyptus for Wood Production. Csiro/Academic Press, 1984
(8) Appanah S. and Weinland G., Planting Quality Timber Trees in Peninsular Malaysia, Malayan Forest Record No. 38 FRIM, 1993.

Note: MAI means mean annual increment.

m^3/ha in the second. Spacing will be 4 m x 3 m (833 seedlings/ha). Like *A. mangium*, this species will be tended three times over two years. Thinning and weeding will not be done.

5) *G. arborea*: Timber production system will be employed. The cutting period is fifteen years. The main utilizations of this species include plywood cores, light structural timbers and furniture. Uniform planting will be carried out after clear cutting and burning. If trees of this species are planted under good soil conditions, they could achieve a MAI of 20 m^3 to 25 m^3/ha at the time of harvesting. Spacing will be 4 m x 3 m (833 seedlings/ha). Like teak described in the following paragraph, it is reported that this species will survive better if stump is used. Like *A. mangium*, the tending of planted trees comprises line weeding three times over two years. Thinning or cleaning cutting will not be done.

6) *T. grandis*: Timber production system will be employed. The cutting period is thirty years. The main utilizations of this species include cabinets, and as building, flooring and shipbuilding materials. Uniform planting will be carried out after clear cutting and burning. Ranging widely from 4 to 18 m^3/ha, the MAI is expected to be 8 m^3/ha at the time of harvesting owing to natural conditions of this area. Spacing will be 4 m x 3 m (833 seedlings/ha). Stump will be used. This species needs intensive tending, and line and overall weeding will be carried out five times in the two years after planting. The first thinning will be carried out in the seventh year of planting to remove 50% of all the planted trees. The second thinning will be in the fifteenth year to remove 50% of the remaining trees. The final stands will have a density of 200 trees per ha.

7) *E. camaldulensis*: Timber production system will be employed. The cutting period is thirty years. The main utilizations of this species include posts, flooring panels, ships, furniture, civil engineering materials and pulp. Uniform planting will be carried out after clear cutting and burning. The MAI is estimated at 20 to 25 m^3/ha. The spacing will be 4 m x 3 m (833 seedlings/ha). For tending, see the description of *A. mangium*. Thinning or cleaning cutting will not be done.

3-6-2 Enrichment Planting

Enrichment planting requires proper methods to be chosen for specific stands. If a secondary forest is judged to generally have a poor stock of useful successors, the line planting method will be applied to artificially create a uniform commercial forest. When there are some gaps in the distribution of useful successors, the gap planting method is appropriate. The conventional method is line planting, which is carried out in a variety of ways, including single or cluster planting. However, the most important thing is to tend seedlings after planting. Dipterocarpaceae, in particular, needs proper light intensity control.

Seedlings of Dipterocarpaceae species generally grow on the forest floor in the shade. If the shade continues, they will not survive. Adequate light will be needed for their growth. Among other species in this family, relatively fast-growing species can grow well under strong-light conditions after the sapling stage. When introducing enrichment planting into secondary forests in northern Sabah, special attention should be paid to the dryness of forest soil. Compared with other areas in Sabah, this area has rather dry climatic conditions. Even stands falling under F2 according to land use and vegetation classification are expected to be in very dry soil, in contrast to those in the eastern part of Sabah. In addition to light control, enrichment planting needs soil moisture control as the most important factor which may have a direct effect on the survival and initial growth of introduced species. Therefore, the microclimate of the areas to be managed, including topographical conditions, needs to be fully examined. In particular, the Kudat Peninsula, among other areas, is very dry and judged to be unsuitable for enrichment planting, while the inland Sonsogon block is judged to be suitable.

A key to success in line planting is to secure a proper width of planting line. As a model, a proposed planting method is shown in Fig. 2. The extraction width of planting line will be 5 m, and two planting lines will be drawn with a space of 1 m in the center of the extraction width. Seedlings will be planted in a zigzag pattern. Conventionally, the extraction width has been generally 2 m. In some cases, however, light was deficient for relatively fast-growing species, as the remained crown became crowded and inhibited growth of planted seedlings when they started height growth. Tending schedule should be therefore designed taking into account of such condition. As a model, it is proposed that weeding will be done twice in the first year after planting and same operation will be done in the second year. Looping of remained trees on the margin of planting line will be done in the third year in order to avoid crown closure. Zigzag planting is intended to secure more equal light to be received and reduce competition for water absorption in the soil during the dry season.

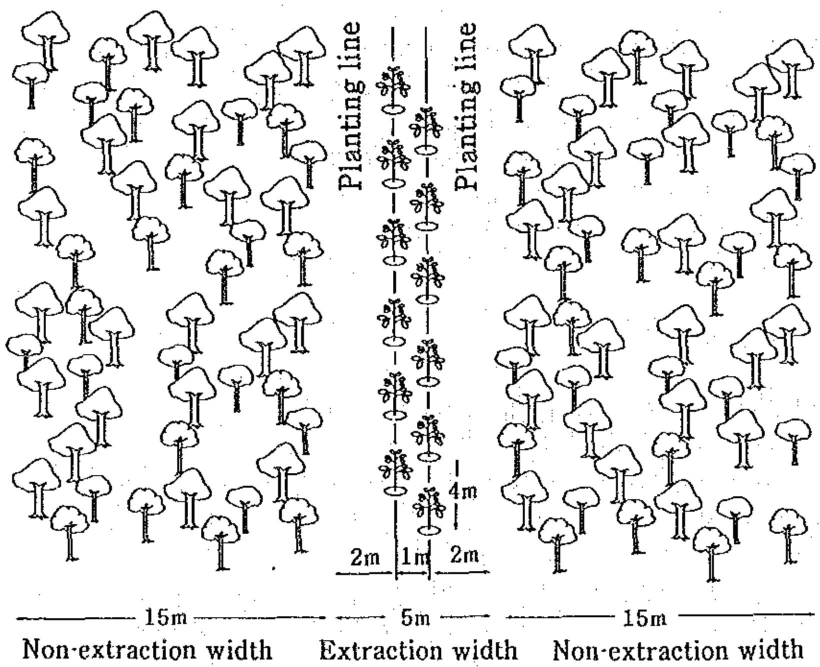


Fig. III-3 A Model of Line Planting

In the nursery, it is important to nurture sound seedlings which will survive at their outplanting. This requires seedling control (environmental adaptation) with light increased and less watering to produce seedlings through hardening before outplanting. A best method of producing sound seedlings is to use seeds or wildings collected from the nearest natural forest (of Classes D1 to D3) and raise their survival ratio. In this case, as many seeds as possible must be efficiently collected every year. In doing so, cooperation with district forestry offices is indispensable to obtain phenological information. When a certain quantity of trees are planted every year, seedling production must be stabilized. In fact, however, there are many uncertain factors in collecting an adequate quantity of seeds or wildings. To overcome this problem, propagation by cutting is a possible method of producing seedlings, for which an operational scale system needs to be established.

For these species to be planted by enrichment planting, it is possible to employ the timber production system with the cutting period of forty years. The main utilization of harvested timber include building materials, plywood, floor boards, furniture and heavy structural timbers. According to data, the MAIs are 8.3 m^3/ha for *Dryobalanops aromatica* (with reference to that of *D. lanceolata*), 7.92 m^3/ha for *Shorea parvifolia* (Seraya punai). and 7.7 m^3/ha for *S. leprosula* (Seraya tembaga) (Appanah S. and Weinland G., 1993).

3–7 Annual Plantation Plan for Large and Medium–scale Management

The plantation plan by year and species based on the foregoing results are shown in Table III–5. The first plantation in the large and medium–scale management blocks will be completed in the fourteenth year. Of the block area of 52,564 ha, 42,000 ha will be planted, and the ratio of plantation by clear cutting will be 79.9%. Besides this, small–scale plantation (24,000 ha) is planned and the already–planted area is about 6,800 ha. Currently, forests and grasslands excluding mangroves occupy an area of about 232,000 ha of the total area to be subjected to forest operations in the study areas. By contrast, the total area of the existing and planned plantations is no more than 84,300 ha, including those subject to enrichment planting (11,500 ha). Therefore, it can be said that the project for such a level of plantation involving forest operations takes into consideration the natural environment.

3–8 Annual Harvesting Plan for Large and Medium–scale Management

The harvesting plan for managing large and medium–scale plantations by year is shown in Table III–6. This is on the assumption that all planted trees of *A. mangium* will be supplied to pulpwood producers, and *P. falcataria* will be used to produce blockboards or sawn wood. *G. arborea* is excluded from the harvesting plan because its share of the total planting area is unknown and its harvesting area will not be so large, though it may be possible to harvest by 2020.

Table III-5 Plantation Plan of Large and Medium-Scale Plantation

Project Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13
A. mangium Planting area (4m × 2m)	0	2500	3000	3000	3500	3500	3500	3500	1500 2500	1000 3000	1000 3000	500 3500	500 3500	500 3500
Subtotal (ha)	0	2500	3000	3000	3500	3500	3500	3500	4000	4000	4000	4000	4000	4000
P. falcataria Planting area (4m × 3m)	0	500	600	800	800	800	800	800	800	800	800	500	600	800
Subtotal (ha)	0	500	600	800	800	800	800	800	800	800	800	500	600	800
Other spp. Planting area (4m × 3m)	0	0	400	700	700	700	700	700	700	700	700	500		
Subtotal (ha)	0	0	400	700	700	700	700	700	700	700	700	500	0	0
Dipterocarp spp. Planting area (250/ha)	0	0	500	500	500	500	500	500	500	500	500	500	500	500
Subtotal (ha)	0	0	500	500	500	500	500	500	500	500	500	500	500	500
Total planting area (ha)	0	3000	4500	5000	5500	5500	5500	5500	6000	6000	6000	5500	5100	5300

Table III-5 Plantation Plan of Large and Medium-Scale Plantation (continued)

Project Year	14	15	16	17	18	19	20	21	22	23	24	Total	
A. mangium													First rotation
Planting area	500											28000	planting area (ha)
(4m × 2m)	3500	1500	1000	1000	500	500	500	500				28000	Second rotation (ha)
		2500	3000	3000	3500	3500	3500	3500	1500	1000	1000	26000	Third rotation (ha)
									2500	3000	3000	8500	Fourth rotation (ha)
Subtotal (ha)	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	90500	Total area (ha)
P. falcataria													First rotation
Planting area												7500	planting area (ha)
(4m × 3m)	800	800	800	800	800	800	800					7500	Second rotation (ha)
								500	600	800	800	2700	Third rotation (ha)
Subtotal (ha)	800	800	800	800	800	800	800	500	600	800	800	17700	Total area (ha)
Other spp. Planting area (4m × 3m)												6500	First rotation planting area (ha)
Subtotal (ha)	0	0	0	0	0	0	0	0	0	0	0	6500	Total area (ha)
Dipterocarp spp. Planting area (250/ha)	500	500	500	500	500	500	500	500	500	500	500	11500	First rotation planting area (ha)
Subtotal (ha)	500	500	500	500	500	500	500	500	500	500	500	11500	Total area (ha)
Total planting area (ha)	5300	5300	5300	5300	5300	5300	5300	5000	5100	5300	5300	126200	

C+F3 52,564 Area of F2 43,947 ha

A. mangium 28,000
P. falcataria 7,500 Area of *Dipterocarp* spp. 11,500 ha
Other species 6,500

Total 42,000 (ha) (Rate of planting 79.7%) (Rate of enrichment planting 26.1%)

Table III–6 Harvesting Plan of Large and Medium–Scale Plantation

Project Year	0	1	2	3	4	5	6	7	8	9	10	11	12
A. mangium													
Planted areas (ha)	0	2500	3000	3500	3500	3500	3500	3500	4000	4000	4000	4000	4000
Harvesting areas (ha)	0	0	0	0	0	0	0	0	2500	3000	3000	3500	3500
Harvesting volume per ha MAI (m^3/ha)	0	0	0	0	0	0	0	0	140 (20m^3/ha)	140	140	140	140
Harvesting volume (m^3)	0	0	0	0	0	0	0	0	350000	420000	420000	490000	490000
P. falcataria													
Planted areas (ha)	0	500	600	800	800	800	800	800	800	800	800	500	600
Harvesting areas (ha)	0	0	0	0	0	0	0	0	0	0	0	500	600
Harvesting volume per ha MAI (m^3/ha)	0	0	0	0	0	0	0	0	0	0	0	300 (30m^3/ha)	300
Harvesting volume (m^3)	0	0	0	0	0	0	0	0	0	0	0	15000	18000
Total planted area (ha)	0	3000	1600	3800	4300	4300	4300	4300	4800	4800	4800	4500	4600
Total harvesting area (ha)	0	0	0	0	0	0	0	0	2500	3000	3000	4100	4300
Total harvesting volume (m^3)	0	0	0	0	0	0	0	0	350000	420000	420000	505000	508000

Table III-6 Harvesting Plan of Large and Medium-Scale Plantation (continued)

Project Year	13	14	15	16	17	18	19	20	21	22	23	24	Total
A. mangium													
Planted areas (ha)	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	90500 ha
Harvesting areas (ha)	3500	3500	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	
Harvesting volume per ha MAI (m^3/ha)	140	140	161 ($23m^3$/ha)	161	161	161	161	161	161	175 ($25m^3$/ha)	175	175	
Harvesting volume (m^3)	490000	490000	644000	644000	644000	644000	644000	644000	644000	700000	700000	700000	9758000m^3
P. falcataria													
Planted areas (ha)	800	800	800	800	800	800	800	800	500	600	800	800	17700 ha
Harvesting areas (ha)	800	800	800	800	800	800	800	800	500	600	800	800	
Harvesting volume per ha MAI (m^3/ha)	300	300	300	300	300	300	300	300	330 ($33m^3$/ha)	330	330	330	
Harvesting volume (m^3)	24000	24000	24000	24000	24000	24000	24000	24000	16500	19800	26400	26400	314100m^3
Total planted area (ha)	4800	4800	4800	4800	4800	4800	4800	4800	4500	4600	4800	4800	108200 ha
Total harvesting area (ha)	4300	4300	4800	4800	4800	4800	4800	4800	4500	4600	4800	4800	72700 ha
Total harvesting volume (m^3)	514000	514000	668000	668000	668000	668000	668000	668000	660500	715800	726400	726400	10072100m^3

3-9 Seedling Production Plan

3-9-1 Seedlings

Based on the annual forestation plan for large and medium-scale forestation by species as described in Subsection 3-6, an annual seedling production plan must be made for the nursery on a species basis. Table III-7 shows a seedling production plan which will correspond with the large and medium-scale forestation plan (Table III-5). The following is the assumptions on which the number of seedlings to be produced was calculated on a species basis. In the case of fast-growing species (*A. mangium, P. falcatalia, G. arborea,* etc.), the production yield (availability) in the nursery is 80% and the percentage of supplementary planting is 10%. The nursery seedling production per ha is as follows according to spacing.

4 m × 2 m: 1,250 × 1.1 ÷ 0.8 = 1,719 seedlings/ha
4 m × 3 m: 833 × 1.1 ÷ 0.8 = 1,145 seedlings/ha

In the case of dipterocarp species, assuming that the availability of seedlings is 70 %, the supplementary planting is 10%, and seedlings will be planted at a rate of 250 seedlings per ha, the seedling production will be as follows:

250 × 1.1 ÷ 0.7 = 393 seedlings/ha

The availability of seedlings varies from species to species, and the above-mentioned figures are an average. One problem in nursery management is how to stabilize seedling production at all times in pursuit of high availability of sound seedlings. The first step to the solution is to secure good quality seeds.

The standard operational procedure in the nursery will be described in the following.

(1) Compost Ripening

Since potted seedlings are used except for *G. arborea* and Teak, the operational procedure in the nursery will begin with the preparation of potting soil. It is ideal to mix compost into potting soil. As raw material for compost, straw, weeds and fallen leaves (excluding seeds) need to be secured. Domestic animal manure or nitrogenous fertilizer will be also mixed into compost to facilitate ripening. It takes about three months to make a compost heap. Fully ripened compost must be used.

(2) Seedbed Preparation

Sandy soil is usually used for seedbeds, and such soil needs burning treatment for eucalyptus susceptive to fungi. Sawdust is used for dipterocarp species whose roots are large and straight. The use of sawdust is effective in reducing the percentage of damaged radicles in the process of transplanting. Fungi control should be undertaken on the seedbed in any case. Covering seedbeds with a roof is effective in protecting seeds against raindrops.

Table III-7 Seedling Production Plan

Project Year	0	1	2	3	4	5	6	7	8	9	10	11	12
A. mangium Planting areas (4m × 2m)		2500	3000	3000	3500	3500	3500	3500	4000	4000	4000	4000	4000
Necessary seedlings 1719 /ha	4297500	5157000	5157000	6016500	6016500	6016500	6016500	6876000	6876000	6876000	6876000	6876000	6876000
P. falcataria Planting areas (4m × 3m)		500	800	800	800	800	800	800	800	800	800	500	600
Necessary seedlings 1145 /ha	572500	687000	916000	916000	916000	916000	916000	916000	916000	916000	572500	687000	916000
Other spp. Planting areas (4m × 3m)		400	700	700	700	700	700	700	700	700	700	500	
Necessary seedlings 1145 /ha	458000	801500	801500	801500	801500	801500	801500	801500	801500	801500	572500		
Dipterocarp spp. Planting areas		500	500	500	500	500	500	500	500	500	500	500	500
Necessary seedlings 393 /ha	196500	196500	196500	196500	196500	196500	196500	196500	196500	196500	196500	196500	196500
Total planting areas (ha)	0	3000	4000	5000	5500	5500	5500	5500	6000	6000	6000	5500	5100
Total necessary seedlings	5524500	6842000	7071000	7930500	7930500	7930500	7930500	8790000	8790000	8790000	8217500	7759500	7988500

Table III-7 Seedling Production Plan (continued)

Project Year	13	14	15	16	17	18	19	20	21	22	23	24	Total
A. mangium Planting areas (4m × 2m)	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	90500 ha
Necessary seedlings 1719 /ha	6876000	6876000	6876000	6876000	6876000	6876000	6876000	6876000	6876000	6876000	6876000	6876000	158143000
P. falcataria Planting areas (4m × 3m)	800	800	800	800	800	800	800	800	500	600	800	800	17700 ha
Necessary seedlings 1145 /ha	916000	916000	916000	916000	916000	916000	916000	572500	687000	916000	916000	916000	20610000
Other spp. Planting areas (4m × 3m)													
Necessary seedlings 1145 /ha													8244000
Dipterocarp spp. Planting areas	500	500	500	500	500	500	500	500	500	500	500	500	12000 ha
Necessary seedlings 393 /ha	196500	196500	196500	196500	196500	196500	196500	196500	196500	196500	196500	196500	4716000
Total planting areas (ha)	5300	5300	5300	5300	5300	5300	5300	5300	5000	5100	5300	5100	127400 ha
Total necessary seedlings	7988500	7988500	7988500	7988500	7988500	7988500	7988500	7615000	7759500	7989500	7988500	7989500	191723000

(3) Seed Procurement

Currently, SSSB is a supplier of high quality seeds of fast-growing species (*A. mangium, P. falcataria* and *G. arborea*) typical of Sabah. However, in the case of large-scale long-term forestation, the forestation entity should itself secure good quality seeds adaptable to the natural conditions of the site. The entity should strive to eventually establish a seed orchard and a scion garden. As for teak, it is recommended that seeds be obtained from the Lampang Seed Orchard in Thailand, which is the most advanced in research. For the procurement of dipterocarp species seeds, see Subsection 3-5-2 Enrichment Planting.

The number of seeds contained in 1kg is 80,000 to 110,000 for *A. mangium*, about 40,000 for *P. falcataria*, and about 2,000 for *G. arborea* in 1 kg in pyrene. The figure for teak is 1,000 to 3,500 pieces per kg.

(4) Seed Pretreatment

Seeds of *A. mangium* will be immersed in hot water for 30 seconds and then in room-temperature water overnight before sowing in order to facilitate germination. Seeds of *P. falcataria* will be treated in the same way as *A. mangium*. However, it is reported (Ti Teow Chuan and Wilfred M. Tangau, 1991) that it is better for germination to immerse seeds in warm water (38° C) for 12 hours first and then in room-temperature water. Seeds of *G. arborea* will be immersed in room-temperature water for 24 hours. Teak seeds will be immersed in water for 24 hours and then naturally dried for 24 hours. This treatment will be repeated for two weeks. Seeds of dipterocarp species can be collected immediately after falling onto the ground. However, they may be contaminated by various bacteria. It is recommended that after removing wings, seeds should be immersed in an antiseptic solution for several minutes before sowing.

(5) Sowing

Sowing will be started by reckoning back the period of seedling production until outplanting. In the case of fast-growing species except *G. arborea*, seeds will be sowed four to six months before the period. Seeds of *G. arborea* and teak will be sowed about one year before. Seeds of dipterocarp species should be sowed just after collection, if possible. Seeds of *G. arborea* and teak will be directly sowed, and covered with soil 2 or 3 cm thick after sowing.

(6) Soil Collection

As proved by the soil survey, the topsoil of the area to be forested in northern Sabah is very thin. Soil for the nursery must be collected from Horizons F and A that contain a high level of nutrient.

(7) Potting Soil Preparation

Soil collected for the nursery will be removed stones and roots of some plants and smashed by a pulverizer before sieving. Soil will be mixed with sand, compost and fertilizers to prepare potting soil. The ideal ratio of soil to sand and compost is 4 to 1 to 1. If compost is not available, fertilizers will be used.

(8) Potting of Prepared Soil

Unnecessary when stumps are to be planted.

(9) Pot Arrangement: See above.

(10) Transplanting after Germination:

Germinated seedlings are directly transplanted into pots. When stumps are produced, seedlings will be transplanted for density control.

(11) Watering

Seedlings will be watered twice during the dry season – in the morning and afternoon. Weather conditions should be taken into account because high humidity is likely to cause root rot.

(12) Shading

Seedlings of fast-growing species will be shaded about 50% only in the young stage, after which the shade will be removed for hardening. Although seedlings of dipterocarp species have conventionally been completely shaded, sound seedlings with a high survival ratio should be nurtured by hardening them gradually taken into consideration of species specific characteristics from one month or more before outplanting.

(13) Pesticide Spraying

Although diseases and damage by insects vary from species to species, pesticides should be sprayed weekly.

(14) Weeding and Removal of Damaged Seedlings

Any disease or damage by insects must be detected early and eliminated to prevent the spread to other seedlings.

(15) Selection and Loading of Seedlings:

Only sound seedlings will be selected and loaded for outplanting. Besides the height of every seedling, the thickness of its stem, and the colour, size and number of its leaves should be checked.

(16) Preparation of Supplementary Seedlings

The stock of seedlings for 10% supplementary planting will be secured in the nursery.

3-9-2 Rooted Cuttings

A large number of rooted cuttings will be needed for planting the hybrid of *A. mangium* and *A. auriculiformis*. When an experiment on hybrid cuttings was carried out under the SAFODA and JICA project, a relatively low rate of rooting was obtained except scions from some mother trees (Kikuchi T. and Tiasin S., 1994). It is necessary to tend mother trees by marcotting naturally-crossed individuals which have been discovered so far and produce seedlings from their scions. Moreover, it is necessary to obtain cuttings from these seedlings as mother trees and tend such mother trees (stock) which show a high rate of rooting by eliminating the conditions of scions. It is advisable to develop a scion garden by using seedlings produced in this way and raise a large amount of scions at the garden and then produce a large amount of good-quality rooted cutting.

However, improving the rooting of scions may be limited by individual differences, even if all requirements for scions are satisfied. It should be kept in mind that the choice of individuals must be based on whether or not they are expected to achieve a commercial level of rooting (60 - 70%).

In this plan, it is impossible to plant hybrids on a business basis until a large amount of hybrid rooted cuttings are made available. It is planned that a scion garden will be developed as soon as possible, and that hybrid rooted cuttings will be increasingly produced and used for forestation.

The development of a scion garden must begin with the raising of clones. Fortunately, a number of surveys and studies have been carried out under the SAFODA and JICA project which have produced useful results (Kikuchi T. and Tiasin S., 1994). To produce clones, good-quality hybrid standing trees of *A. mangium* and *A. auriculiformis* should be selected as mother trees in the 100 ha plantation in Ulu Kukut and layered. Subsequently, seedlings to be planted in the scion garden should be produced by marcotting or cutting. Individual clones expected to achieve a commercial level of rooting should be selected to plant in the scion garden.

Significant techniques for hybrid marcotting and cutting will be summarized by referring to the report of the SAFODA - JICA project (Kikuchi T. and Tiasin S., 1994).

In the experiment on marcotting of 18-year-old hybrid standing trees in Ule Kukut, a survival rate of about 60% was obtained. This is high rooted rate for marcotting of three mother trees. However, it is doubtful if a scion garden can be developed with clones from these three individuals only. More mother trees may be needed.

The development of a scion garden with mother trees will be accomplished in two steps. First of all, a large amount of scions will be obtained by marcotting, and then, the rooting rates of individual scions will be confirmed, and finally a scion garden will be developed with rooted cuttings. As for rooting, the younger the individual cuttings, the better their rooting rates. It is important to provide conditions for rejuvenating individuals by repeated cutting, and generate sprouting branches by truncation.

Unlike *G. arborea*, cuttings of *Acacia* spp. are difficult to root in an open or shaded space, but do well in a mist house where temperature and humidity are kept constant at all times. A mist house can be constructed only on a site which has electric power supplied.

The rooting rate of scions depends on the method of raising them, their position on the sprouting branch, their length, and the lapse of time after the occurrence of the sprouting branch. It is possible to improve the rate by employing the best rooting methods as well as an accelerant.

Techniques for raising hybrid seedlings of *A. mangium* and *A. auriculiformis* have not yet been completed and need more study for practical use in the future. It is necessary to construct a mist house for raising cuttings, develop a small scion garden and a test plot, and carry out experiments and studies. Expenses for these facilities and activities should be covered by administration and operation costs.

3-9-3 Development of a Scion Garden

(1) Significance of the Scion Garden

Scions can be collected in two ways, namely from a scion garden or a plantation. The former is more favorable. In Japan, when a large amount of cutting are planted, it is a common practice to develop a scion garden. The merits of the scion garden are that:

1) The species and strains of seedlings are clear.
2) Expenses for scion collection and outplanting are less.
3) Scions with a high rooting rate can be obtained from sprouting branches which have shifted from vegetative shoots.
4) Diseases and insects can be easily controlled, so that sound scions can be obtained.

At this moment, a scion garden is an essential condition for nurturing a large amount of clone rooted cutting especially from hybrid trees.

(2) Site for a Scion garden and Arrangement of Stocks

If its management and benefits are taken into account, a scion garden should be established in or near the nursery where cutting will be done. If it is in or near the nursery, weeding, disease and insect control, cultivating, fertilization and other operations can be performed in the combination with other works.

Stocks to collect scions can be classified by height into high, medium and low sizes. Generally, scions collected from the lower part of a stock show a higher rooting rate and are easy to obtain. Despite less scions per stock, low stocks are preferable. Therefore, it is advisable to make low stocks for a higher rooting rate under this project.

Stocks should be properly arranged to receive sufficient sunlight and produce good scions. Since the proposed site for developing a scion garden is located almost on the equator, no special care is needed for the horizontal arrangement of stocks. Instead, care should be taken to prevent soil erosion even on gentle slopes. Therefore, stocks should be planted along contours.

A distance of 1 m between stocks, and 2.5 m between the lines of stocks is sufficient to provide enough sunlight. In this case, the number of stocks will be 4,000 pieces per ha.

(3) Amount of Collected Scions

It is expected that sprouting branches from the hybrid clone of *Acacia mangium* and *A. auriculiformis* (hereinafter, the hybrid clone(s)) as a stock will continue to occur and grow throughout the year. Scions are cutting into beds which are placed in a mist house. After rooted, they are transplanted into pots. Tending will start when roots develop. The sizes of seedlings will be adjusted by trimming according to planting time. It is expected that scions can be collected about four times a year and at a rate of about ten scions a time from one mature stock. Thus, a maximum of 160,000 scions can be collected from a scion garden with an area of 1 ha.

Stocks will take at least three years to mature.

(4) Development of a Scion garden

1) Seedling

Select and plant as stocks in the scion garden seedlings of the hybrid clones which meet the following requirements:

i. Many hybrid clones must be collected
ii. They should grow well.
iii. The rooting rate is high.
iv. They are resistant to diseases and insects
v. They can produce good-quality timber.

Of course, it is difficult to meet all these requirements. However, they should be met as much as possible for the productivity and soundness of future plantations.

2) Site

A desired site for developing a scion garden must have good soil conditions and reasonably level for convenient operation and prevention of soil erosion. It must be also favorable for mechanized operations, including weeding, cultivating, fertilizing, and disease and insect control.

3) Land Preparation

For intensive operation and management throughout the year, shrubs and weeds over the ground should be carefully removed to prepare the site for planting stocks. The planting lines should be sufficiently spaced for tractor tillage.

4) Road

Roads should be provided to carry scions smoothly.

5) Facilities

Necessary facilities include a pool of running water to store scions after collecting, a workshop to prepare and cut scions into beds which are placed in the misthouse with shades and watering facilities. These facilities are best provided within the nursery.

6) Experimental Plantation

An experimental plantation attached to the scion garden in the neighbourhood should be developed to manage the plantation as an integral part of the scion garden.

(5) Management of the Scion Garden

1) Clone Control

The hybrid clone rooted cutting to be planted as stocks in the scion garden have not undergone examination for next generations. Therefore, as a first step, a growth test should be conducted on the hybrid clone seedlings produced in a particular part of the scion garden. Those which have undesirable properties will be culled and replaced with those with the desired properties for improvement.

Next, hybrid clones which seem to have the same properties will be excluded and replaced with those which have desired properties. In this way, the quality of the hybrid clones in the scion garden should be gradually upgraded.

In this process, many hybrid clones may be eliminated. It is recommended that as many kinds of hybrid clones as possible should be collected and planted as stocks in the scion garden in order to develop sound plantations.

2) Care of Stocks

The care of stocks is essential for collecting as many scions as possible from a limited-area of scion garden.

i. Nitrogen will probably be unnecessary because the stocks are leguminous trees. Potassium and phosphoric acid fertilizing will be necessary every year. If soil is composed of volcanic ashes, attention should be paid to the absorption of phosphoric acid.

ii. Collected scions will decrease and be susceptible to diseases and insects if weeds proliferate. The efficacy of fertilizers will also be reduced. Weeds must be removed.

iii. The scion garden should be patrolled periodically to detect stocks damaged by insects and diseases. Diseases and insects should be immediately eliminated and prevented from spreading if found.

3) Labour Administration

Workers for the nursery will also be employed in the scion garden. After training, fixed labour will be assigned to tests on the rooting and growth of scions from each stock as well as the care of stocks.

4) Management of the Experimental Plantation

Skilled workers will be assigned to the management of the plantation on a stock basis. Labels must be carefully kept.

(6) Making of Stocks

A complete stock will be 1 m or lower. Branches will be made to develop from the part near the root as far as possible. Sprouting branches from that part will be used as scions. To facilitate sprouting from that part, the planted seedlings of hybrid clones will be cut about 30 cm from the ground after their survival. Sprouting branches should be shortened to extend the branches of stocks outward.

As a large amount of hybrid clones cannot immediately be easily obtained, some of the seedlings produced in the scion garden may be used as stocks. Care should be taken not to plant only seedlings with well-developed roots as stocks in the scion garden.

"Scion gardens" was referred to this sub-section (Tanaka M., 1967).

3-10 Standard Process of Forestation

Although specific forestry operations vary with species and purpose of harvesting, the basic process is common. The most fundamental and important thing is tending after planting. Forestation will be unsuccessful unless tending is properly carried out. In the following, the standard process of forestation will be described in respect to medium- and large-scale management of forestation by clear cutting.

(1) Surveying

The proposed sites for forestation will be surveyed on a species basis in accordance with the annual forestation plan. In this case, the area of no plantation treatment or unplantable area within the coverage of this project must be estimated in advance. Since site preparation involves burning except in enrichment planting, new plantation sites must be zoned by assuming the direction of the wind at burning in order to avoid spread of fire to existing plantations.

(2) Clearance

To facilitate felling and subsequent operations, saplings and small-diameter trees on the forest floor will first be cut down with a bush knife. Sticks to show places of planting holes will be prepared for the next operation during this stage. These operation of clearance, felling and branch removal will be done in dry season.

(3) Preparation of Sticks for Planting

See above.

(4) Felling

Medium and large-diameter trees will be felled with a chain saw.

(5) Branch Removal

To remove obstacles against planting and facilitate burning, the branches of felled medium and large-diameter trees will be cut off with a chain saw or a bush knife.

(6) Firebreak Construction

Firebreaks will be constructed on the boundaries with adjoining plantations or other cultivated land to prevent spread of fire.

(7) Burning

For successful burning, the sites need to be dried for about two weeks after felling. Ideally, burning should be started just before the end of the dry season. This, however, is difficult to forecast. In northern Sabah, the dry season generally lasts five months from April to August. August is probably the best time for burning.

(8) Pre-planting Clearance (if required)

For stable employment and efficient nursery management, it is advisable to carry out planting throughout the rainy season. However, time is likely to be lost during the period from burning until planting, and weeds are apt to grow thick again. Weeds must be removed just before planting.

(9) Setting of Planting Lines

Planting lines will be set to secure the specified spaces (4 m x 2 m and 4 m x 3 m) for the chosen species and planting systems.

(10) Digging of Holes for Planting

This operation will be performed just before planting. If holes are left for a while, they may fill up again. The size of a hole will be a little larger than the pot.

(11) Seedling Transportation:

The seedlings selected in the nursery will be given enough water just before their transportation to avoid them drying out during the transfer. They should be carefully transported because the soil is likely to spill from the pots from vibration and damage seedlings. The distance between the nursery and the plantation should be limited to 20 km. Since they will be planted in the rainy season, a four-wheel-driven vehicle is necessary.

(12) Planting

Seedlings should not be planted if saplings of useful species already exist near the hole for planting, or the soil has been hardened by heavy machinery during felling, loading and other operations.

(13) First Weeding (fertilization)

Line weeding at 1 m wide will be carried out one month after planting. At the same time, fertilizer will be applied at a rate of about 50 g per seedling. During these operations, the survival of seedlings will be monitored.

(14) Supplementary Planting

Based on the results of the monitoring, supplementary seedlings will be planted usually at a rate of about 10%. The operations up to this stage are in the first year of planting in terms of forestation management.

(15) Second Weeding

Line weeding at 2 m wide will be carried out four months after the first. No fertilizer will be applied.

(16) Third Weeding

Full weeding will be carried out four months after the second. No fertilizer will be applied.

3-11 Harvesting Plan

With regard to harvesting under the large and medium-scale forestation plan, the annual harvest estimates of major species are shown in Table III-6. The mean annual increment (MAI) as a basis for estimating harvests have been described in Subsection 3-5-1 on a species basis.

When harvesting a plantation of *A. mangium*, it is necessary to set guidelines on the allowable extent of one harvesting area in light of water and soil conservation, environmental protection as well as logging efficiency. For instance, in the case of a seven-year-old plantation of *A. mangium*, the average stand volume is 140 m^3 (MAI 20 m^3/ha). If the harvesting area is calculated from the above-mentioned point of view, the required harvesting area will be about 90 ha on the assumption that log output from each harvesting area is 10,000 m^3, and logging yield is 80%.

10,000 / (7 x 20) / 0.8 = 89.3

A buffer zone needs to be constructed between the plantation (harvesting area) of the same year and its adjoining plantation in order to avoid developing a large plantation of a single species. If these are taken into account, it would be reasonable to set one harvesting area at around 100 ha. Fig.III-4 illustrates this case.

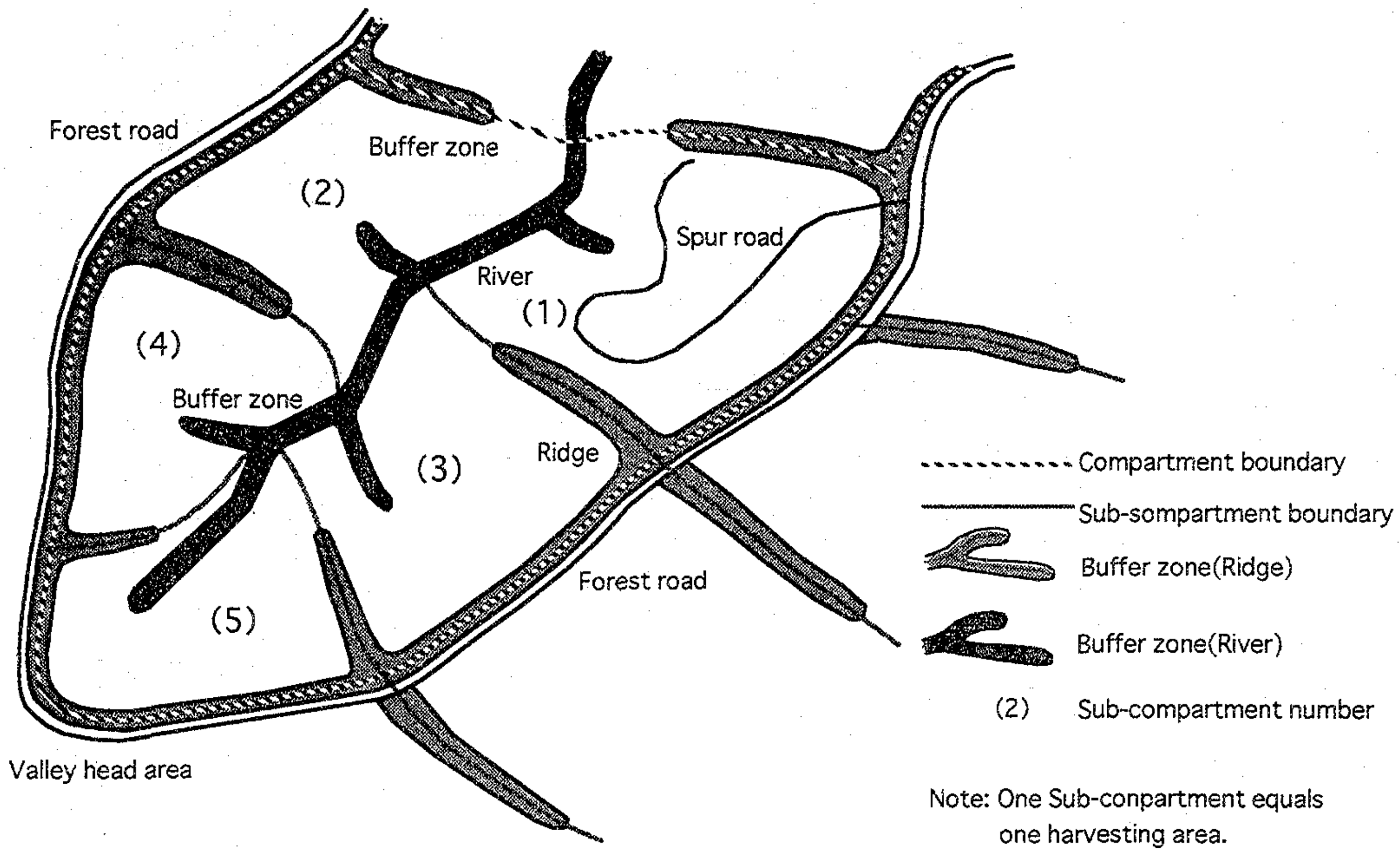


Fig.III-4 An Example of Subdivision of into Harvesting Areas

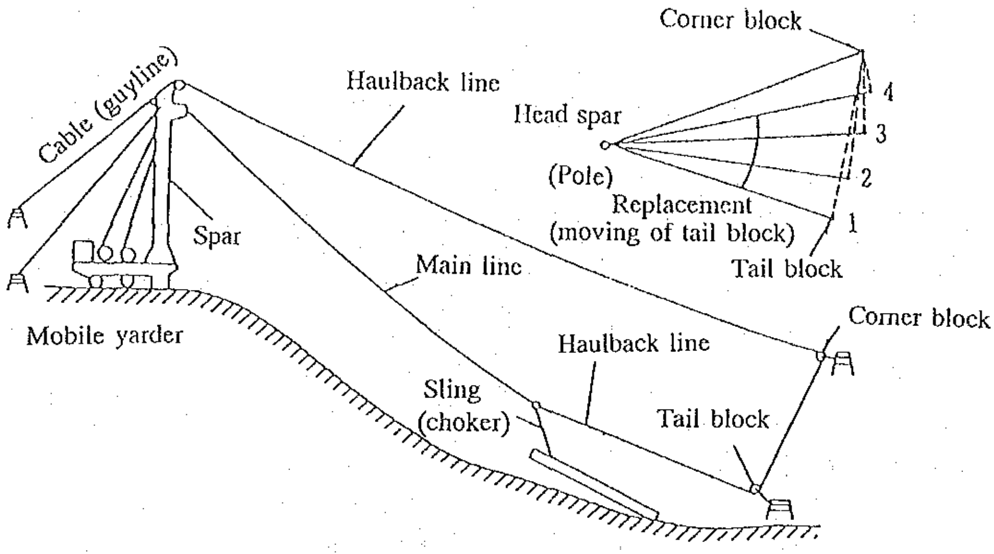


Fig. III-5 Highlead Skidding

Logs harvested from plantations are generally small in diameter, unlike large-diameter ones from natural forests. If the efficiency of yarding and the soil conservation of plantations are also taken into account, the cable logging system is judged to be proper for yarding from plantations. SSSB uses this system, for which leading wires must be laid in consideration of the topography of plantations. Unlike foresting operations, harvesting must be planned to the shipment schedule because it depends on trends in demand. Therefore, yarding will be carried out throughout the year independent of season.

Logs are generally carried by truck (10 t) from plantations to the timber-yard. Successful transportation depends substantially on road conditions. Improvement in roads, including bridges, is basic to any harvesting plan, and must be planned in line with harvesting.

3-12 Protection Plan

Large plantations tend to be simple and uniform in the same area in terms of species and age of planted trees. This will create a very susceptible environment to diseases or insects. Therefore, protective measures against damage must be determined in advance. One possible countermeasure is to avoid the large-area plantation of a single species. As the basic principle of forestation management is right tree on right site, protection should be also taken into account in planning forestation. Should any damage be found, damaged trees must be immediately removed, and the cause of the damage must be investigated to take effective measures for protection. Diseases and insects which may damage tree species to be planted are shown in Table III-8. Although damage by cattle is expected, no serious cases have occurred in northern Sabah. In this respect, measures need to be taken on a case-by-case basis.

Table III-8 Examples of Damage to Tree Species

Species/Scientific Name (Local name/English name)	Disease/Insect Damage, Defect, etc.
(1) *Acacia mangium* (Mangium)	Heart rot begins in the early growth stage. No solution found, but early pruning is effective in reducing damage.
(2) *Acacia auriculiformis*	It is reported that seedlings and planted trees were damaged by insects in the Philippines, but not in Indonesia. The damage is so slight as to be prevented by spraying insecticides.
(3) Hybrid Clone of *A. mangium/A. auriculiformis*	Heart rot as a demerit of mangium can be almost resolved.
(4) *Paraserianthes falcataria* (Batai)	In Sabah, it is reported that this is damaged by caterpillars of a yellow betterfly (*Eurema species*).
(5) *Gmelina arborea* (White teak)	Leaf-fall from insects, but can recover well. Slight damage by termites. Fire resistant.
(6) *Tectona grandis* (Jati/Teak)	Various diseases and damage by insects. Preventive methods have been studied and developed. Like Gmelina, resistant to fire.
(7) *Eucalyptus camaldulensis* (River red gum)	Damage by caterpillars of a moth (*Roeselia lugens*), termites and borers. Young trees weakened due to drought are susceptive to insects.
(8) *Hevea brasiliensis* (Pokok gatah para)	Damage by *Corticum salmonicolor*.
(9) *Khaya ivorensis* (African mahogany)	Damage by a borer (*Hypsipyla robusta*).
(10) *Swietenia macrophylla* (Mahogany)	Damage by borers (*Hypsipyla grandella* and *H. robsta*).
(11) *Araucaria hunsteinii* (Klinki pine)	Damage by termites.
(12) *Dryobalanops lanceolata* (Kapur paji)	Its timber contains camphor resistant to rot-fungi.
(13) *Shorea leprosula* (Seraya tembaga)	Successful in the Kepong Plantation.
(14) *Shorea parvifolia* (Seraya punai)	The highest increment recorded in Depterocarp plantations in Peninsular Malaysia.

Source; Ti Teow Chuan and Wilfred M. Tangau, Cultivated and Potential Forest Plantation Tree Species With Special Reference to Sabah, Institute for Development Studies (Sabah) 1991
Appanah S. & Weinland G., Plantating Quality Timber Trees in Peninsular Malaysia - a review -, Malaysian Forest Record No. 38, FRIM 1993

Forest fires may occur with a more significant impact and higher frequency than the above-mentioned threats. There are many cultivated areas owned by villagers near the proposed planting sites, and shifting cultivation is continuously carried out in most of them. Forestation also involves burning as part of site preparation. However, needless to say, forestation will be prudently managed by constructing firebreaks and studying the direction of burning to prevent the spread of fire. However, there is no guaranteed protection against fire used locally for shifting cultivation.

Preventive measures against forest fires include firebreaks, lookout towers, patrols, the distribution of water depots for fire and fire engines, and the education of inhabitants. Firebreaks need to be maintained and be 15 m or wider, which will be costly. If a very large fire occurs, they cannot be expected to be very effective. Therefore, their function should be supported and complemented with an improved network of forest roads. Patrols by watchmen as well as the installation of water depots for fire will be effective in preventing small fires from spreading if tackled soon after starting. Lookout towers should be constructed in locations favorable for watching as large plantations areas, and for neighbouring villagers to see them any time. They are also expected to draw inhabitants' attention to fire prevention.

These efforts for fire prevention cannot practically bear fruit without the local people understanding the forestation project. This is vitally important. To achieve good results, it is necessary to encourage more people to understand the project through stable employment and participation. A basis for them to enjoy the direct and indirect benefits of the project also needs to be established.

3-13 Tree Farm

In the previous sections, the forestation plan for medium- and large-scale management has been discussed. In the case of small-scale management, the total area falling under G and F3 in the land use and vegetation classification is about 46,000 ha in the whole of northern Sabah as shown in Table III-1. This is about 87% of the total area (about 53,000 ha) of the proposed four consolidations for large- and medium-scale forestation. Since these areas are occupied by many villages and more actively used, the introduction of forestation management of a certain size will be possible only to a limited extent. Where the forms of land-use are subdivided, and agriculture and stock raising are prevailing, a possible form of management is the small-scale forestation of abandoned or unused lands by individuals or their groups, or the introduction of agroforestry. These are methods for using land effectively. An important effect of their management is to attract more attention from the local people regarding forestation. If small-scale management of forestation spreads, it will also indirectly support large- and medium-scale management. In this sense, it is inadequate to leave small forestation to the initiative of individual farms. Instead, it is probably necessary to establish a supportive system of organizations like SAFODA for further extension and enlightenment activities.

In northern Sabah, tree farm as the small-scale management of forestation has been gradually expanded by SAFODA's cumulative effort. In pursuit of further extension, a proper method for meeting the needs of the local people should be developed by studying the diversification of introduced species and of management systems. Typical systems of tree farm are:

Small Plantation: Rubber plantations are widely managed throughout Malaysia. As its timber is also usable, rubber has begun to catch attention as a species for forestation as well as latex collection. The introduction of fruit trees (durian) whose timber is also usable will become an incentive for farms's forestation.

Agroforestry: This is to cultivate cash crops such as vegetables and fruits between the lines of planted trees. This system is designed to stabilize long-term incomes by earning income from cash crops until the harvesting of planted tees. There are a variety of combinations of species and crops and various planting methods. In Kudat, some farms plant mangium trees under coconut palms. This is one example of agroforestry.

Silvo Pasture: Stock raising has been traditionally managed throughout the district of Kota Belud. Much of the land used for this purpose were formerly covered with forests. This system is designed to promote the compound use of land by introducing forestry into such land. Pastures are burnt in the dry season to facilitate the sprouting of grass as fodder and eliminate insect pest. If this is taken into account, fire-resistant species must be selected for forestation. Planted trees will shade the cattle and serve as a windbreak.

Thus, management systems which reflect the various needs of the region must be employed to encourage inhabitants to participate in forestation. Prior to that, however, a survey of the local people needs to be conducted in order to properly understand their attitude and actual situation. Based on the results, the substance of the project should be studied in terms of workable operation and effectiveness.

3-14 Plantation Operator

The implementation of large- or medium-scale forestation needs a large area of land, much labour and a huge fund, which cannot be easily born and fixed by individuals for a long time until harvesting. Planting slow-growing species involves a great risk before cutting, which will make it difficult for private companies to undertake commercialized forestation. Therefore, the uniform planting of fast-growing species is appropriate for economic forestation, and slow-growing species are usually avoided. Enrichment planting, of which cutting period will be 40 years,.will bring more various effects of external economies called public functions of forests than that of fast-growing species forestation. It is preferable that public funds or grants will be provided for forestation in return of such effects. This will involve the problem of coordination between the effects of external economies on the public and those of internal economices on private companies. In this respect, it is significant for public agencies like SAFODA to implement a forestation project.

In this project, SAFODA as a public agency to undertake forestation activities in Sabah is expected to play a major role in (1) using know-how on plantation administration and management, (2) developing silvicultural techniques, and (3)extending small-scale forestation. To answer these expectations, necessary actions are (1) survey and research concerning plantation administration and management, (2) testing and research on forestry technology, (3) forestry extension activities, (4) personnel training, and (5) sufficient provision of facilities, equipment and materials. Budges should be appropriated for these actions.

Plantation operators will be described by scale of forestation in the following paragraphs.

1. Large-scale Forestation

As large-scale forestation will need proportionally a huge amount of money, an entity which will undertake such forestation must be strong enough to bear it. In this project, it is assumed that SAFODA alone or its joint venture with a private company (or companies) will serve as a large-scale plantation operator. In any case, no doubt, such forestation needs to get a great deal of fund mainly by way of public funding or low-interest loans.

In view of capital recovery, the operator cannot help depending on fast-growing species for the time being. Slow-growing species for producing saw timber should be introduced after soil fertility has been improved by planting two or three generations of fast-growing species. Enrichment planting should be also carried out at accessible sites as much as possible in pursuit of long-term forestry management and environmental conservation.

2. Medium-scale Forestation

In this project, it is assumed that SAFODA will undertake medium-scale forestation. The sporadic distribution of plantation areas will raise the administration and operation costs of medium plantations and make medium-scale forestation disadvantageous to corporate management. Even if a private company tries to carry out medium-scale forestation as an economic action, it would be difficult for the management to specialize in forestation. There remains an area of about 25,000 ha covered with grass or shrubs which needs forestation even in medium consolidations. No entity other than SAFODA is conceivable as the plantation operator. Currently, SAFODA possesses plantations in Ulu Kukut, etc., and medium plantations to be created under this project should be managed together with these existing ones.

3. Small-scale Forestation

In this project, it is planned that small-scale forestation will be mainly undertaken by farms in the form of tree farming. Tree farms have spread in the whole of the coverage area as a result of SAFODA's extension activities. The further development of tree farming will need more active extension activities in the future. Promoting tree farming will facilitate the utilization of underused or unused lands and surplus labour in farms, which, in turn, will provide a way to earn cash incomes and make a great contribution to the regional development.

4. Forestry Infrastructure

4-1 Forest Road

Forestry infrastructure includes roads, bridges, fire-fighting facilities, nurseries and timber-yards. Of them, forest roads are especially important for successful forest management. Planning the network and structure of roads depend on the size of plantations. Plantations produce small-diameter logs with low unit selling prices. Therefore, high cost in transportation after harvesting must be avoided in economical viewpoint. Transporting logs at a low cost is a matter to be concerned. One way of reducing the cost of log transportation from plantations is to raise the density of forest roads. In this sense, the density of forest roads is an important factor which will affect forestry management. General public roads are also important facilities for forestry management. In particular, bridges across rivers are essential. The present condition of public roads is not sufficient in the forest areas covered by this study. They also have various problems in structure, surface and cross culvert. Improvement is needed, particularly for log transportation in the rainy season.

Highways are also key facilities for forestry management. As part of forestry infrastructure in the coverage of this study, the situation of highways in northern Sabah is shown in Fig. III-6. All the roads in this area give access to these highways, which provide the main social and economic artery, including general traffic connection, industry, transportation.

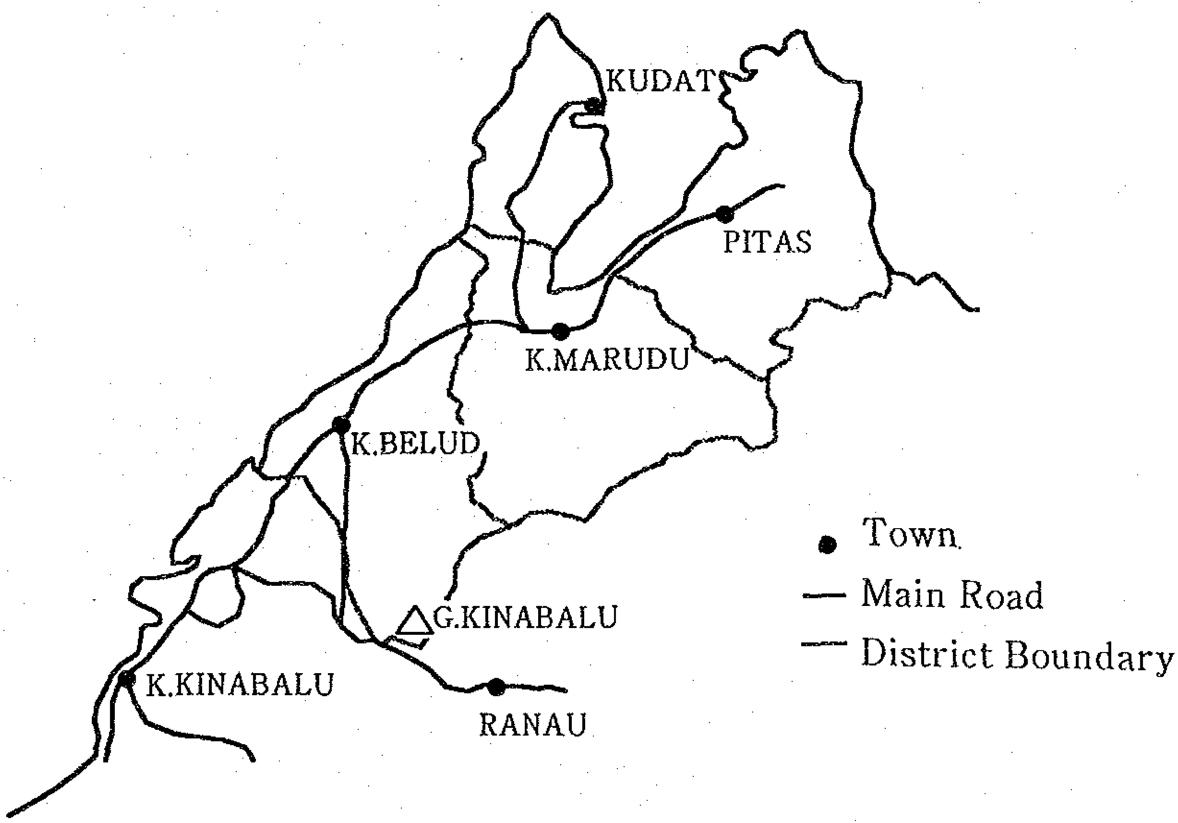


Figure III-6 Condition of Main Road Network

These highways are the most important roads because the planned roads for implementing this project will also be directly or indirectly connected to them in the future. Some public roads which branch from these highways and lead to villages could be used until December 1993, when heavy rain destroyed some sections of them, broke the surface, and washed out bridges and cross culverts. They are now under repair by JKR. According to local inhabitants, floods like this occur every five to ten years. The prevention of such damage requires proper drainage by installing side–ditches and increasing cross culverts, and correcting their cross section grades. Appropriate measures for preventing the bridges being washed out are to reinforce their abutments, select suitable sites for constructing bridges, and adjust spans. The broken part of road surfaces needs reinforcement and repairs. Whereas the properly gravelled sections of public roads were passable for vehicles during the survey in second phase, the ungravelled sections were impassable even for a four–wheel–drive vehicle after rain.

In the area covered by this study in northern Sabah, forest roads for log transportation as well as operating roads are very dense from ridge to valley. They were made completely impassable by the above–mentioned heavy rain, and are partially used after repairs with a grader and a bulldozer. Currently, unused roads was no longer usable without repairs in second phase survey. Vehicles could not pass through forest roads during the survey in second phase because they are not gravelled at all.

In the planning for forest roads in the future, it is suggested to construct new forest roads in some areas (5 m/ha), and consider the construction of operating roads whenever required. More weight should be given to improvement and repairs of the existing forest roads and spur roads so that they will be maintained at a rate of 25 m/ha in clear–cutting zones and 20 m/ha in enrichment planting zones.

When constructing a forest road, cutting earth should be ideally balanced with banking earth. In reality, many slips of banking earth resulted from the heavy rain of December 1993. It is recommended that forest roads should be constructed on ridges in order to reduce banking.

A width of 4 m is enough for forest roads except for main roads, as long as many sidings are installed. The surfaces and methods of cutting and banking vary with width, topography, longitudinal grade, cross sectional grade, and soil nature. These factors should be taken into account. An example of roadway diagraphs for civil engineering is shown in Fig.III–4.

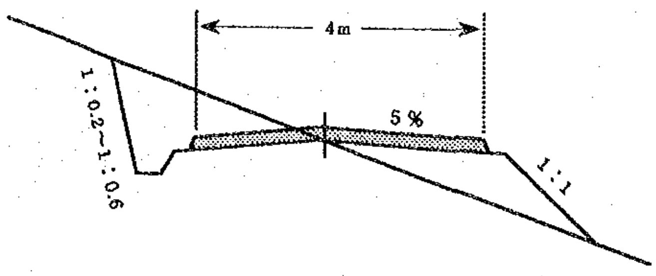


Fig. III-7 An Example of Roadway Diagraphs for Civil Engineering

Structures which will be needed include overflow bridges, side ditches and cross culverts. An example of overflow bridges is shown in Fig.III-5. The structure of an overflow bridge, and its execution of work and construction method depend on the width, flow rate, current, topography and bed of the river. A full survey should be carried out prior to execution of work.

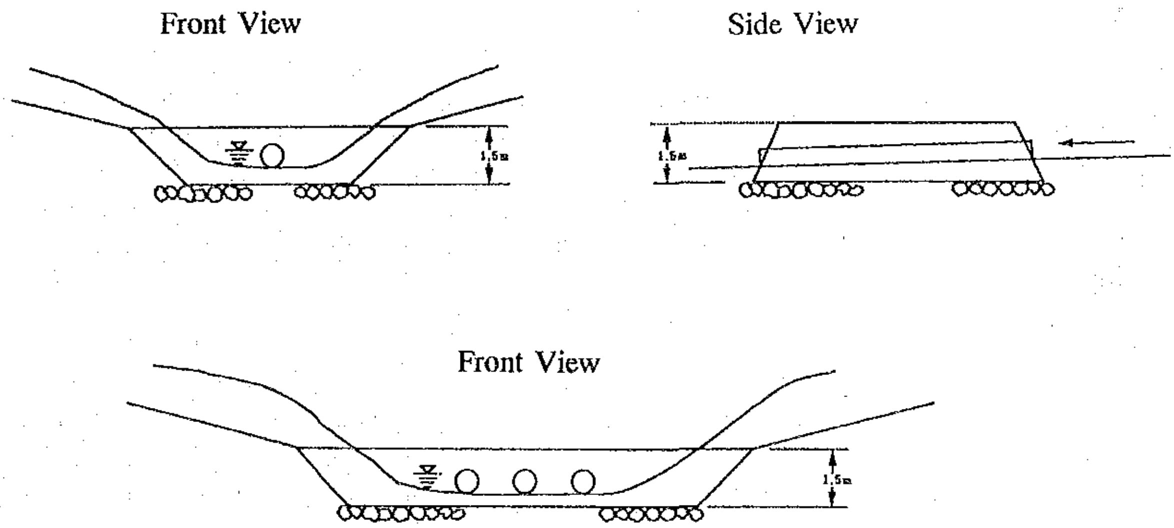


Fig. III-8 An Example of Overflow Bridges

4-2 Nursery

Currently, SAFODA has two nurseries in Ulu Kukut and Bongkol in northern Sabah and produce seedlings. In addition, individuals are entrusted by SAFODA with the production of *A. mangium* seedlings. Thus, there are a total of four nurseries which meet the demand for seedlings in northern Sabah. The number of seedlings available is 1.6 million seedlings per year in Ulu Kukut and 2.7 million per year in Bongkol. These nurseries altogether produce over 4 million of seedlings and can sufficiently meet the demand from the existing plantations. However, if medium- and large-scale forestation is carried out in the southern part of Kota Marudu, the current level of production will fall short of new demand. To ensure the supply system of seedlings, one or two new nurseries will be needed at a medium- and large-scale forestation site.

4-3 Countermeasures against Forest Fires

Forest fires are the greatest danger to forests. Once a fire occurs, previous forestation efforts will be reduced to ashes. Even regenerated natural forests will face difficulties in succession. The frequent occurrence of fires may degrade them and transform them into grassland.

At this stage countermeasure against forest fires taken in Northern Sabah is insufficient. There are only lookout towers constructed by SAFODA to watch man-made forests. The Forestry Department has not yet constructed such towers for natural forests. No firebreaks or buffer zones exist, and even fire-fighting equipment is not satisfactorily provided.

On the other hand, administrative agencies, including the Forestry Department are developing educational and extension activities for preventing forest fires. These however, are not sufficient and also need improvement. Specifically, they should organize brigades, enlighten and educate inhabitants, and educate children in fire prevention at schools. It would also a good idea to distribute pamphlets, notebooks and pencils as part of enlightenment on fire prevention.

4-4 Bridges

The Bengkoka River on the way from Pitas to Bongkol is currently crossed by ferry. When a large amount of logs are transported from man-made forests, it is obvious that crossing the river will become a bottleneck to regional development as well as forestry development. Moreover, bridges on the main local roads also have problems because most of them are made of wood.

If *A. mangium* logs produced in this area are exported, they will be processed into chips. However, at this moment, facilities for loading chips or even a chip mill do not exist in northern Sabah. Wood products are currently shipped by barge at Marasimsim.

Planted trees in small tree farms will reach the cutting age in the near future. Nevertheless, there are no facilities for gathering harvested logs in lots and selling them to processors at that time. Facilities here mean not only a timber-yard but also an organization like a forest owner's cooperative which will put several small lots together into a certain size of lot. If such an organization is established and serves tree-farm owners, it will enable the owners to play a major role as managers of small-scale forestry in raising incomes in northern Sabah.

4-5 Integration of Expenses

The extension cost of forest roads to the plantation area and the plan for nursery facilities and supplemental improvement of forest roads are shown in Tables III-9 and III-10 for each of the planned years, respectively. The details of facilities such as forest roads and nurseries are summarized in Tables III-11 and III-12, respectively.

Table III-9 Forest Road Extension Costs to Plantation Area

	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12
A. mangium	ha		2,500	3,000	3,000	3,500	3,500	3,500	3,500	1,500 2,500	1,000 3,000	1,000 3,000	500 3,500	500 3,500
P. falcataria	ha		500	600	800	800	800	800	800	800	800	800	500	600
Other spp.	ha			400	700	700	700	700	700	700	700	700	500	
Subtotal	ha		3,000	4,000	4,500	5,000	5,000	5,000	5,500	2,500 3,000	3,000 2,500	3,000 2,500	4,000 1,000	4,100 500
Dipterocarp spp.	ha			500	500	500	500	500	500	500	500	500	500	500
Total			3,000	4,500	5,000	5,500	5,500	5,500	5,500	6,000	6,000	6,000	5,500	5,100
Forest Road		(Extension)												
New construction	m	15,000	20,00	22,500	25,000	25,000	25,000	25,000	15,000	12,500	12,500	5,000	2,500	2,500
Improvement	m	12,000	18,000	20,000	22,000	22,000	22,000	22,000	24,000	24,000	24,000	22,000	20,400	21,200
Repair	m	48,000	72,000	80,000	88,000	88,000	88,000	88,000	96,000	96,000	96,000	88,000	81,600	84,800
Forest Road	RM1,000	(Cost)												
New construction	RM1,000	398	530	596	663	663	663	663	398	331	331	133	66	66
Improvement	RM1,000	159	239	265	292	292	292	292	318	318	318	292	270	281
Repair	RM1,000	200	300	334	367	367	367	367	400	400	400	367	340	354
Total	RM1,000	757	1,069	1,195	1,322	1,322	1,322	1,322	1,116	1,049	1,049	792	676	701

Table III-9 Forest Road Extension Costs to Plantation Area (continued)

	13	14	15	16	17	18	19	20	21	22	23	24	
A. mangium	500 3,500	500 3,500	2,500 1,500	3,000 1,000	3,000 1,000	3,500 500	3,500 500	3,500 500	3,500 500	1,500	1,000	1,000	
P. falcataria	800	800	800	800	800	800	800	800	500	600	800	800	
Other spp.													
Subtotal	4,300 500	4,300 500	4,800	4,800	4,800	4,800	4,800	4,800	4,500	4,600	4,800	4,800	
Dipterocarp spp.	500	500	500	500	500	500	500	500	500	500	500	500	Enrichment planting
Total	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,000	5,100	5,300	5,300	
Forest Road													Existing roads 20.0m/ha
New construction	2,500												Initial calculation 5.0m/ha
Improvement	21,200	21,200	21,200	21,200	21,200	21,200	21,200	20,000	20,400	21,200	21,200		Plantation area 4.0m/ha
Repair	84,800	84,800	84,800	84,800	84,800	84,800	84,800	80,000	81,600	84,800	84,800	84,800	See above 16.0m/ha
Forest Road													Unit RM1,000
New construction	66												26.5/m
Improvement	281	281	281	281	281	281	281	265	270	281	281		13.25/m
Repair	354	354	354	354	354	354	354	334	340	354	354	354	4.17/m
Total	701	635	635	635	635	635	635	599	610	635	635	354	

Table III-10 Costs of Nursery Facilities and Supplemental Improvement of Forest Roads

Year	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12
Forest Road	m	60,000	90,000	100,000	110,000	110,000	110,000	110,000	120,000	120,000	120,000	110,000	102,000	106,000
Concrete side-ditch	m MR1000	6,000 150	9,000 235	10,000 250	11,000 275	11,000 275	11,000 275	11,000 275	12,000 300	12,000 300	12,000 300	11,000 275	10,200 255	10,600 265
Gravelling	m MR1000	12,000 180	18,000 270	20,000 300	22,000 330	22,000 330	22,000 330	22,000 330	24,000 360	24,000 360	24,000 360	22,000 330	20,400 306	21,200 318
Subtotal	MR1000	330	495	550	605	605	605	605	660	660	660	605	561	583
Total	MR1000	1,087	1,564	1,745	1,927	1,927	1,927	1,927	1,776	1,709	1,709	1,397	1,237	1,284
		Nursery facilities												
Nursery	RM1,000	1,915	1,489											
Lookout tower	RM1,000		340	340	340	340	340							
Heavy machinery	RM1,000	805					805					805		
Vehicle	RM1,000	1,106					1,106					1,106		
Fuel	RM1,000	240	280	280	280	280	280	280	280	280	280	280	280	280
Repair	RM1,000	191	191	191	191	191	191	191	191	191	191	191	191	191
Power generator	RM1,000	130	130									130	130	
Total	RM1,000	4,387	2,430	811	811	811	2,722	471	471	471	471	2,512	601	471

Table III-10 Costs of Nursery Facilities and Supplemental Improvement of Forest Roads (continued)

Year	13	14	15	16	17	18	19	20	21	22	23	24	
Forest Road	106,000	106,000	106,000	106,000	106,000	106,000	106,000	100,000	102,000	106,000	106,000		
Concrete side-ditch	10,600 265	10,600 265	10,600 265	10,600 265	10,600 265	10,600 265	10,600 265	10,000 250	10,200 255	10,600 265	10,600 265		10% of improvement/repair/ extension costs RM25.0/m
Gravelling	21,200 318	21,200 318	21,200 318	21,200 318	21,200 318	21,200 318	21,200 318	20,000 300	20,400 306	21,200 318	21,200 318		20% of the same RM15.0/m
Subtotal	583	583	583	583	583	583	583	550	561	583	583		
Total	1,284	1,218	1,218	1,218	1,218	1,218	1,218	1,149	1,171	1,218	1,218	354	
Nursery													
Lookout tower													
Heavy machinery			805					805					
Vehicle			1,106					1,106					
Fuel	280	280	280	280	280	280	280	280	280	280	280		
Repair	191	191	191	191	191	191	191	191	191	191	191		
Power generator								130	130				
Total	471	471	2,382	471	471	471	471	2,512	601	471	471		

Table III-11 Details of the Forest Road Plan

Construction cost	RM	26.5/m
Improvement cost	RM	13.25/m
Repair cost	RM	4.17/m
Concrete side-ditch (0.45 m in internal width)	RM	25.0/m
Gravelling (incl. collecting, carrying and laying gravel)	RM	25.0/m^3 (3.0 m wide x 0.2 m thick) 25.0 x 0.6 = 15.0/m
Culvert (incl. concrete pipes, digging, leveling and construction)	RM	1,311/unit one unit per 500 m
Bridge (ford type 10.0 m long, 1.5 m high, 4.0 m wide)	RM	12,000/unit one unit per 5 km

The costs of culverts (RM2.62/m) and bridges (RM2.40/m) will be included in the construction and improvement work, while those of concrete side-ditches and gravelling will be separately calculated as supplemental improvement costs.

It is assumed that 10 % of improvement, repair and extension costs will be allocated to concrete side-ditches, and 20% to gravelling.

Table III-12 Details of Nursery and Other Facilities

Nursery bed 1.0 m (internal width) x 10.0 m (length)

	One bed	10.0 m^2
One block	60 beds per block	600.0 m^2
15 blocks		9,000.0 m^2

Required Water

0.003 m every time x twice per day = 0.006 m
9,000 m x 0,006 m = 54.0 t(m^3)

Water Tank

4.0 m x 2.5 m x 2.0 m = 20.0 t 3 units (60.0 t)

Reservoir

5.0 m x 5.0 m x 3.0 = 75.0 t

Seedling Production per bed

Acacia mangium: (*P. falcataria*)	(5 cm wide)	20 x 20 x 10 = 4,000 seedlings
Dipterocarp species and others:	(8 cm wide)	12 x 12.5 x 10 = 1,500 seedlings

Forestation (required trees) per ha

Acacia mangium:	(4m×2m)....1,250 + 125 = 1,375 seedlings If 80% yield: 1,719 seedlings
P. falcataria & others:	(4m×3m)....833 + 83 = 916 seedlings If 80% yield: 1,145 seedlings
Dipterocarp species	250 + 25 = 275 seedlings If 70% yield: 393 seedlings

Plantation Area and Required Seedlings

The First Nursery

A. mangium:	2,500 ha x 1,719 seedlings =	4,297,500 seedlings
P. falcataria:	500 ha x 1,145 seedlings =	572,500 seedlings
Dipterocarp species:	250 ha x 393 seedlings =	98,250 seedlings
Others:	400 ha x 1,145 seedlings =	458,000 seedlings

The Second Nursery

A. mangium:	1,500 ha x 1,719 seedlings =	2,578,500 seedlings
P. falcataria:	300 ha x 1,145 seedlings =	343,500 seedlings
Dipterocarp species:	250 ha x 393 seedlings =	98,250 seedlings
Others:	300 ha x 1,145 seedlings =	343,500 seedlings

Required Beds:
The First Nursery

A. mangium:	4,297,500 / 4,000 = 1,075 beds (18 blocks)
	(If produced twice a year, half, or 9 blocks, required.)
P. falcataria:	572,500 / 4,000 = 143 beds (2.5 blocks)
Dipterocarp species:	98,250 / 1,500 = 66 beds (1.1 blocks)
Others:	458,000 / 1,500 = 305 beds (5.1 blocks)

The Second Nursery

A. mangium:	2,578,500 / 4,000 = 645 beds (11 blocks)
	(If produced twice a year, the half or 6 blocks required.)
P. falcataria:	343,500 / 4,000 = 86 beds (1.5 blocks)
Dipterocarp species:	98,250 / 1,500 = 66 beds (1.1 blocks)
Others:	343,500 / 1,500 = 229 beds (4.0 blocks)

The second nursery will cover a deficit in the first nursery. This project will be carried out in both nurseries.

Nursery Area:	200 m x 200 m = 4.0 ha
Bed Area:	200 m x 140 m = 2.8 ha
Building Area:	200 m x 60 m = 1.2 ha

Nursery Construction Cost:

Total area:	200 x 200 = 40,000 m^2
Height differential (average):	1.0 m (cutting & banking)
Levelled earth:	40,000 m^3
Mechanical work:	RM 1.2/m^3
Cost:	RM 48,000

Costs of Beds and Shades

Number of beds: 1.0 m x 10.0 m 900 beds

Material costs:

Timber		
12 posts (0.1x0.1x3.0)	0.36 m^3	
2 frame members (0.025x0.1x1.05)	0.00525 m^3	
2 frame members (0.025x0.1x10.05)	0.05025 m^3	
3 beams (0.1x0.05x10.05)	0.1575 m^3	
6 cross-beams (0.1x0.05x1.05)	0.0315 m^3	
Total	0.6045 m^3	
Total (900 beds)	544.05 m^3	RM544,050
Shadecloth (145m x6x15) = 13,050 m^2		RM 26,100
Nails (2.0 kg per bed) 2x900 = 1,800 kg		RM 6,300
Labour cost (assembling & construction):		
6 persons per bed 6x900 = 5,400 persons		RM81,000
Total		RM657,450

Buildings

Center office :	(15.0 x 20.0 x 2)	600m^2 x 710 = 426,000
Nursery office:	(15.0 x 10.0)	150m^2 x 420 = 63,000
Garage:	(8.0 x 20.0)	160m^2 x 480 = 76,800
Workshop:	(10.0 x 20.0)	200m^2 x 340 = 68,000
Warehouse:	(10.0 x 10.0)	100m^2 x 340 = 34,000
Germination room:	(10.0 x 10.0)	100m^2 x 340 = 34,000
Compost storage:	(5.0 x 36.0)	180m^2 x 340 = 61,200
Power generator room:	(3.0 x 10.0)	30m^2 x 340 = 10,200
Fuel storage:	(5.0 x 5.0)	25m^2 x 450 = 11,250
Car washing lot (kit):	(4.0 x 6.0)	10,000
Toilet (kit):	(3.0 x 6.0)	10,000
Total		RM 804,450

Unit Costs of Buildings

Reinforced concrete building	RM 710/m^2
Wooden building	RM 420/m^2
Steel-framed garage	RM 480/m^2
Workshop	RM 340/m^2
Fuel storage	RM 450/m^2

Costs of Nursery Watering Facilities:

1.	Water-taking Facility		
	Concrete water measure (5.0m x 6.0m x 3.0m) (complete construction, including digging, gravelling, framing, steel & assembling, concrete placing)	RM	20,000
2.	Pumping Facilities		
	Suite (pump, piping, pump house, etc.)	RM	8,000
3.	Pipeline		
	Complete construction (digging, plumbing, burying)	RM	15,000
4.	Reservoir (settling tank)		
	Concrete (5.0x5.0x3.0) (Complete construction, including digging, levelling, framing and, placing reinforced concrete placing)	RM	7,000
5.	High-rise Water Tank (4.0x2.5x2.0) 3 units x 40,000 Foundation for steel tower, steel tower, tank, piping work	RM	120,000
6.	Rainwater Tank (for office) and High-rise Water Tank Concrete, steel tower, tank, piping work	RM	5,000
7.	Complete Plumbing of Nurseries, Yards and Buildings	RM	80,000
Others	(gate, fence, path, drain, etc.)	RM	150,000
	Total	RM	405,000

Costs of the First Nursery Facilities (at the outset)

Nursery site preparation cost (4.0 ha)	RM 48,000
Bed-shade cost (15 blocks)	RM 657,450
Building	RM 804,450
Watering cost (others)	RM 405,000
Total	RM 1,914,900

Costs of the Second Nursery Facilities (in the 1st year)

The cost of the first nursery facilities excluding the construction cost of the center office:

1,914,900 - 426,000 = RM 1,488,900

Lookout tower	one unit	RM 170,000
Power generator	(one set)	RM 130,000

Heavy Machinery

Wheel loader	KOMATSU	1 unit	RM 210,000
Grader	"	"	RM 325,000
Backhoe loader		"	RM 120,000
Tractor		2 units	RM 124,000
(attachments)		"	RM 26,000
Subtotal			RM 805,000

Vehicles

Dump truck	3 units	RM 480,000
Toyota Wagon (4WD)	1 unit	RM 114,500
Toyota Landcruiser (4WD)	2 units	RM 192,800
Toyota Pickup (4WD)	4 units	RM 268,800
Cost of radio installations, equipment and others		RM 50,000
Subtotal		RM 1,106,100
Total		RM 1,911,100

Fuel (including oil):

Wheel loader	200 l/day x 20 days =	4,000 l/month
Grader	"	"
Backhoe loader	150 l/day x 20 days =	3,000 l/month
Tractor (2 units)	100x20 = 200x2 =	4,000 l/month
Total		15,000 l/month
Dump truck (3 units)	60 l/day x20 days x 3 =	3,600 l/month
4WD vehicle	40 l/day x20 days x 7 =	5,600 l/month
Total		9,200 l/month
Power generator	200 l/day x 30 =	6,000 l/month
Subtotal		
Total		30,200 l/month
Cost (incl. 10% oil)	RM	20,000 l/month

Costs of Equipment Repair and Parts:

About 10% of purchase price from the purchasing year

RM 1,911,100 x 0.10 = RM 191,110

Price list of Machinery (as of February 1, 1994)

Heavy Machinery

Bulldozer	Komatsu	D70--class	RM	395,000
	Hitachi	DX75	RM	185,000
Excavator	Komatsu	PC120	RM	210,000
	Hitachi	EX120	RM	200,000
Wheel loader	Komatsu	WA180	RM	210,000
	Hitachi	LX70	RM	170,000
Grader	Komatsu	GD521A	RM	325,000
Tractor (for agriculture)	Kubota M8030		RM	62,000
	Attachments	Trailer	RM	13,000
		for agriculture	RM	9,500
		Roller	RM	8,500
Backhoe loader	John Deer E310D		RM	120,000

Vehicles

Dump truck (6 t)	RM	160,000
Toyota Land Cruiser Wagon (4WD)	RM	114,500
Toyota Land Cruiser (4WD)	RM	96,400
Toyota Land Pickup (4WD)	RM	67,200
Toyota Hilux Pickup (4WD)	RM	58,300

All of these prices include taxes

5. Cost–Benefit Analysis

Large– and medium–scale forestation is carried out differently from small–scale forestation: the former is industrial forestation, while the latter is mainly tree farm. A cost–benefit analysis cannot be carried out in the same way in both cases.

5–1 Cost–Benefit Analysis of Large and Medium–scale Plantation

5–1–1 Calculation of the Expenses and Revenues

Expenses were calculated based on the following conditions and assumptions in accordance with the project plan:

Prices are based on Malaysian Ringgit (RM) as of 1993. The unit cost of items was calculated based on the results of a survey in Sabah. Prices not locally available were estimated.

The project entity is SAFODA, a government agency for which no tax and no land rent will be imposed.

Total expenditure was calculated by adding price–fluctuation and physical reserves to the expenses calculated in the implementation plan.

The ratio of the price–fluctuation reserve is 4%, which was not applied at the outset but from the first year. The physical contingency is 10%.

A. Integration of Expenses

1) Workers and Expenses for Forestation

The number of workers and expenses for forestation were calculated according to annual foresting work and the standard processes of forestation (on a species basis) as shown in Tables III–13, III–14, III–15 and III–16.

The number of workers and expenses per year are shown in Table III–17.

2) Workers and Expenses for Seedling Production

An annual seedling production plan will be prepared on the basis of the annual foresting work. The number of seedlings produced per hectare of plantation area is shown in Table III–18. To attain the goal of the seedling production plan, the standard processes of seedling production (on a species basis) were tabulated on the seedling production standards after the social environment and labour circumstances of northern Sabah were comprehensively assessed. The standard processes are shown in Tables III–19, III–20 and III–21 on a species basis. The number of seedlings and workers and expenses for seedling production per year are shown in Table III–22 based on the planned forestation area.

3) Costs of Forest Roads and Vehicle Maintenance

Annual expenses for constructing new forest roads, and improving, maintaining and repairing the existing forest roads were also included along with expenses for supplemental improvement (concrete side-ditches and gravelling) according to the forest road plan as shown in Table III-23.

Annual repair cost of heavy duty machinery and vehicles and the cost of fuel and oil were also added as shown in Table III-23.

4) Costs of Facilities and Vehicles

Annual expenses for constructing nursery facilities for seedling production and lookout towers for fire prevention and fire fighting, and the costs of heavy duty machinery, vehicles and a power generator which will be required for seedling production, forestation and road construction/improvement, as well as administration, are shown in Table III-24.

Annual construction cost of houses and lodgings for the staff and daily-employed workers was also added to the annual cost of facilities and vehicles as shown in Table III-25. Houses for the staff will be one-storey wooden houses differentiated according to the job-ranking system as shown below. The annual construction cost was estimated according to the number of staff members.

Rank	Unit Cost (RM/m^2)	Area	Value (RM/unit)
Project Manager	650	120	78,000
Staff: Class A	650	100	65,000
Class B	625	80	50,000
Class C	600	60	36,000
Class D	580	55	32,000

Daily-employed workers include local commuters and the staff's families. Those who will occupy lodgings are estimated at 48 persons. The lodging price is RM20,000 per unit. It is planned to construct 14 units at the outset, 20 units in the first year, 6 units in the second year and 8 units in the eighth year.

5) Administration and Operation Costs

To facilitate the management and operation of plantations under this project, an organization with the staff reduced as far as possible was planned by referring to the organization of SAFODA as shown in Fig. III-9. The proposed organization should have a clear chain of command and responsibility and be operated in an organic and compound manner responsive to fluctuations in work to avoid rigidity.

The organization consists of the six divisions of Plantation, Planning and Mapping, Administration, Research, Roading and Fire Control, and Mechanical and Building under the project manager. From the eighth year when harvesing will begin, the Extraction Division will be added as the seventh division to the organization. The businesses, organizations and staffs of these divisions are as follows.

(1) The Plantation Division will be administered by the plantation manager and set up three plantation offices and two nurseries. One office will have two field assistants and two conductors under the assistant plantation manager and prepare and carry out an implementation plan for forestation in the assigned district. It will also promote the spread of tree farms and give them guidance in the district. The coverage of the forestation project will be divided into three areas, comprising the consolidations of Marak-Parak, Sonsogon and Tandek combined, and Langkon, in each of which one plantation office will be set up.

Two nurseries will be set up to produce seedlings. Each of them will have one assistant nursery manager and one field assistant under the nursery manager and prepare and carry out a seedling production plan for forestation and tree farming.

(2) The Planning and Mapping Division will survey and map the coverage areas of the forestation plan to provide basic material in cooperation with the Plantation and Roading and Fire Control Divisions prior to the implementation of the plan. It will also survey, map and compile the resource inventory of the areas after the implementation of the plan to prepare a drawing of execution of forestation and roadwork. The Planning and Mapping Division will have one assistant surveyor in each of the three coverage areas under the surveyor.

(3) The Administration Division will have the General Affairs and Accounts Sections under the administration manager. The General Affairs Section will have a secretary to the project manager, clerks and typists under the executive manager and take charge of public relations, discipline, recruitment, personnel, job rating, salaries, legal affairs, labour relations, organization, education and training, documentation, social insurance, general affairs, safety and health control, welfare and so on. The Accounts Section will have an accountant, clerks and typists under the section manager and deal with receipts and disbursements, booking and accounting.

(4) The Research Division will have two assistant research managers and two conductors under the research manager and take charge of the research and development of silvicultural, breeding and seedling techniques.

(5) The Roading and Fire Control Division will have one assistant manager and one field assistant for each of the coverage areas under the roading and fire control manager, who will be supported by several drivers, machine operators, lookout tower watchmen and patrolmen. The main businesses of the division will include the maintenance, administration and repair of forest roads, the prevention and extinguishment of forest fires, and the operation and administration of vehicles and machines.

(6) The Mechanical and Building Division will have mechanical and building engineers under the manager. Senior mechanics, assistant technicians, and persons responsible for parts will work under the direction of these engineers and be supported by mechanics, power generator operators, electricians and carpenters. The division will be mainly responsible for the repair of machines and vehicles, the operation, maintenance and administration of power generators, and the repair, maintenance and administration of wiring facilities and buildings.

(7) The Extraction Division will set up two extraction offices under the extraction manager. Each of these offices will have two field assistants under the assistant extraction manager as well as several scalers and conductors under the field assistant. The division will be mainly responsible for making and implementing an extraction plan.

To facilitate administration and management, the organization, management and staffing of this project were planned as shown in Table III-26. The positions and remuneration according to the job-ranking system are shown on an annual basis in Table III-27 Administration and Operation Costs.

Operation costs include the costs of welfare, maintenance and administration, clerical work, research and technical development. Annual costs were integrated as the same amount as administration and supervision costs.

Welfare costs include medical expenses incurred by the staff and day workers, various insurance premiums, and allowance in kind.

Maintenance and administration costs include expenses for maintaining, administering and repairing buildings and facilities. Clerical work costs include expenses for office supplies, communications including telephone and mail, and other miscellaneous expenses.

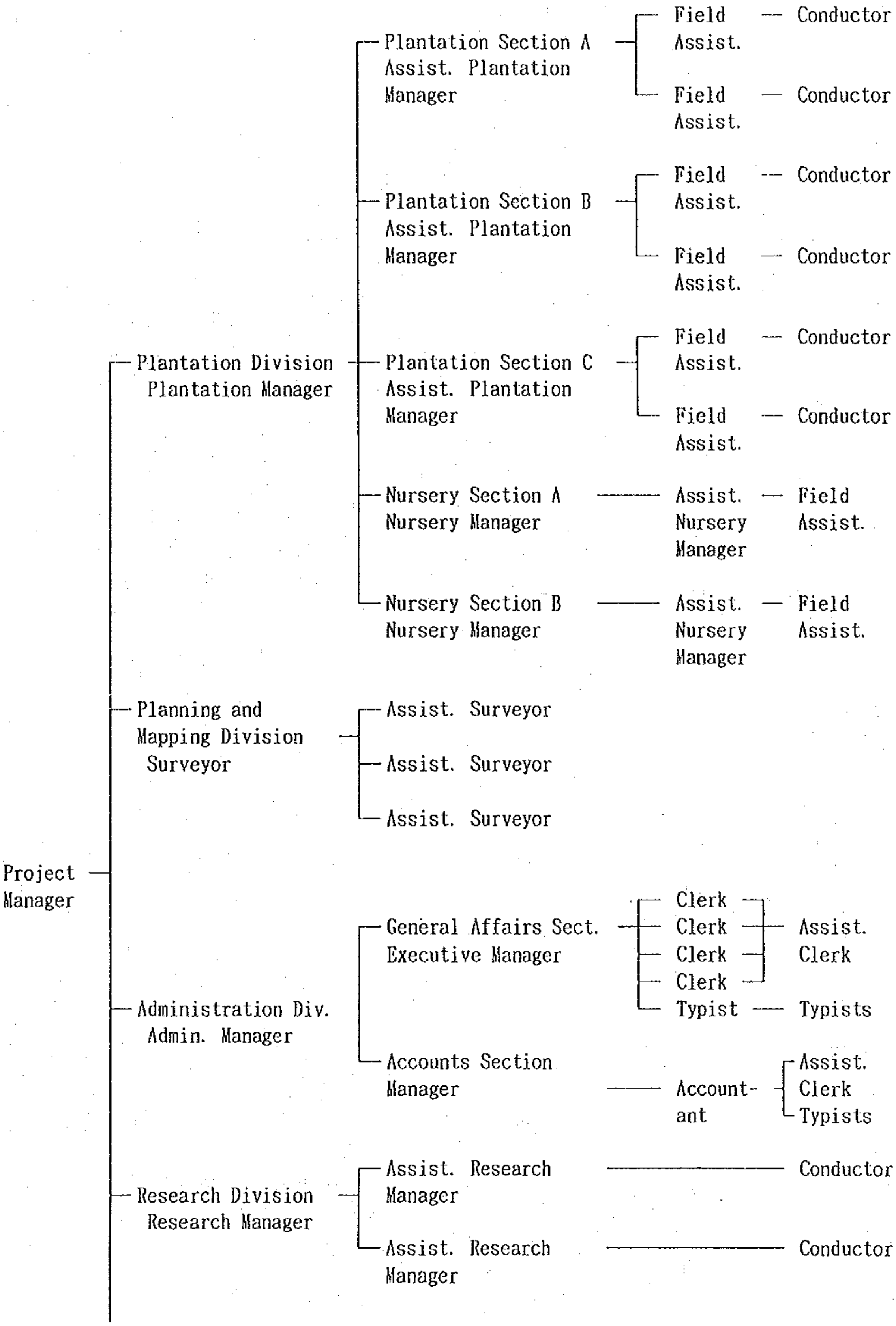
Research and technical development costs are expenses for research and development.

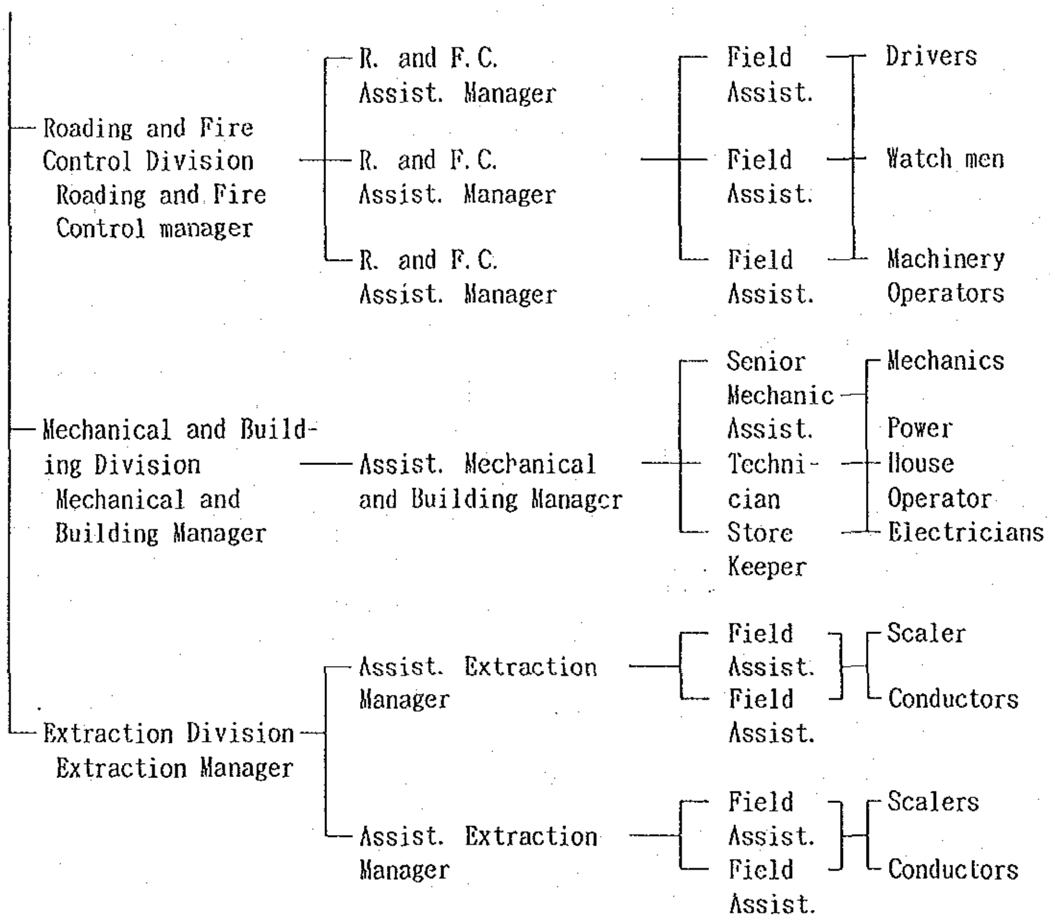
The summation of administration and supervision costs and operation costs is shown in Table III-28 Administration and Operation Costs.

6) Harvesting Costs

Acacia mangium will be harvested between the eighth and twenty-fourth years, and *Paraserianthes falcataria* between the eleventh and twenty-fourth years. Other species and Dipterocarp species will not be harvested until the twenty-fourth year. The volume of standing trees to be harvested and the volume of harvested trees were estimated on the following standards for *A. mangium* and *P. falcataria*.

Figure III-9 Implementation Organization Chart




Roading and Fire Control Division
Roading and Fire Control manager
R. and F.C. Assist. Manager
R. and F.C. Assist. Manager
R. and F.C. Assist. Manager
Field Assist.
Field Assist.
Field Assist.
Drivers
Watch men
Machinery Operators
Mechanical and Building Division
Mechanical and Building Manager
Assist. Mechanical and Building Manager
Senior Mechanic Assist.
Technician
Store Keeper
Mechanics
Power House Operator
Electricians
Extraction Division
Extraction Manager
Assist. Extraction Manager
Assist. Extraction Manager
Field Assist.
Field Assist.
Scaler
Conductors
Field Assist.
Field Assist.
Scalers
Conductors

7) Standards for Calculating the Volumes of Standing Trees and Harvested Trees

The volume of standing trees to be harvested was estimated based on the mean annual increment (MAI) according to the cutting period, as shown below. A yield of 80% was applied for the volume of harvested trees, excluding branches, top-ends and barks.

A. mangium:	MAI	Volume (standing)	Volume (harvested)
First planted trees (1st-7th Year)	20 m^3/ha	140 m^3/ha	112 m^3/ha
Second planted trees (8th-14th Year)	23 m^3/ha	161 m^3/ha	129 m^3/ha
Third planted trees (15th-21st Year)	25 m^3/ha	175 m^3/ha	140 m^3/ha

P. falcataria:	MAI (standing)	Volume (harvested)	Volume
First planted trees (1st-10th Year)	30 m^3/ha	300 m^3/ha	240 m^3/ha
Second planted trees (11th-20th Year)	33 m^3/ha	330 m^3/ha	264 m^3/ha

Harvesting costs were estimated in the light of the survey of harvesting and transportation from man-made forests in Sabah and other cases of harvesting. Expenses per m^3 of harvested tree volume are broken down in Table III-29 on a species basis.

Harvests and harvesting costs and incomes were calculated as shown in Table III-30 on a year and species basis.

8) Basic Data on Revenue Estimation

Incomes per m^3 of harvest were estimated on a species basis as follows:

1. Evaluation of *A. mangium* logs as Pulpwood

Wood chips of *A. mangium* have never before been produced or marketed, and no wood chip market for this species has been established. Therefore, the FOB price of *A. mangium* chips produced in Sabah will be calculated with reference to that of Australian eucalyptus chips which account for 33.4% of all non-conifer wood chips imported to Japan (on a BDT basis according to customs statistics from January to December 1993, provided by Japan's Ministry of Finance). Then the price ex the pulpwood yard of a chip mill in the shipping place in Sabah will be calculated.

With regard to the evaluation of *A. mangium* chips for export, there is a reference (A.F. Logan and V. Balodis, 1982). This report assessed *A. mangium* and compared it with other species in terms of chips exported to craft pulp mills and supplied to neutral sulphite semi-chemical pulp production (NSSCP). The report states as follows:

"The specific gravity in oven dry and screened yield of pulp are important economic factors of pulpwood. The former has indirect effects on chemical consumption, yield, and the nature of pulp, and direct effects on the freight rate of chips and the capacity of a digester. Whereas the transportation cost of chips is generally paid by the volume, the chip price is determined by the weight of oven dried chips. Accordingly, the higher is the specific gravity in oven dry, the lower is the freight and yet the higher is the FOB price. Table III-30 shows the specific gravity in oven dry and screened yields (unbleached and bleached chips) of three species and their effects on FOB prices on the basis of *A. auriculiformis* wood.

In terms of specific gravity in oven dry, the FOB price of *A. mangium* wood is 9% lower than *A. auriculiformis*, while that of eucalyptus is 10% higher than *A. auriculiformis*. In terms of unbleached yield, the FOB price of *A. auriculiformis* is 7% higher than *A. mangium*. Pulp output per m^3 of wood (DPE) and cooking and bleaching chemical consumption also affect the FOB price. The DPE of *A. mangium* (220 kg/m^3) is low compared with *A. auriculiformis* and eucalyptus (270 kg/m^3), but high compared with other plantation species such as *P. falcataria* (125 kg/m^3) and *Gmelina arborea* (179 kg/m^3). The amount of a chemical (Na_2O) to produce pulp with a Kappa number of 20 is 235 kg per ton of pulp for *A. auriculiformis*, 268 kg/t for *A. mangium*, and 416 kg/t for eucalyptus. Thus, eucalyptus wood requires a remarkably amount of chemicals compared with *Acacia* species. However, chemical costs substantially depend on whether the mill will produce or purchase or collect chemicals. In the light of freight, pulp yield and production cost, *A. auriculiformis* wood is the most excellent and followed by *A. mangium* and *Eucalyptus*."

According to the results of calculation based on Table III-30, the FOB price of *A. mangium* wood as a percentage to that of mixed eucalyptus is 83% in terms of specific gravity in oven dry, 131% in screened yield and 137% in bleached yield. Assuming that specific gravity in oven dry, screened yield and bleached yield affect the FOB price to the same extent, the FOB price of *A. mangium* is estimated at 117% of that of mixed eucalyptus. However, the processing of *A. mangium* chips into pulp was assessed just in the laboratory. A test report by a Japanese paper mill states that "on the whole, this species is evaluated to be good in cooking, bleaching and yield (screened and bleached) and provide good quality pulpwood compared with wood produced in Japan. Because of low volume weight, its chips in the digester will be lighter. When this wood is used on a full scale, its bleaching, resin content and vessel etc. should be examined."

Based on the above-mentioned reports, it is assumed that the FOB price of *A. mangium* chips is the same as that of Australian eucalyptus chips. Even if the distance of transportation is the same, ocean freight included in the CIF price at the unloading place varies with from vessel to vessel depending on the cargo tonnage and capacity, construction cost, and navigation and lay days of a chip-carrying vessel. Generally, ocean freight range from US$35 to US$45 per BDU (Bone Dry Unit: international transaction unit of wood chips, and equivalent to 2.400 pounds ≒ 1.089 metric tons in specific gravity in oven dry).

2. Calculation of the Price of *A. mangium* ex Chip Mill Yard

The price of Australian eucalyptus chips exported to Japan was A$154.50 per BDU between January 1994 and May 1994. The exchange rates of the relevant countries' currencies on the New York foreign exchange market (according to "Asian Wall Street Journal") as of May 1994 are as follows:

Malaysia	(Ringgit)	2.6105/US dollar
Australia	(Australian dollar)	1.3875/US dollar

Chip loading and chipping costs were calculated based on empirical figures in the United States and Australia. Chip loading costs range from US$5 ~ US$8 per BDU, and the figure of US$8 was chosen. Chipping costs range from US$20 ~ US$25/26 per BDU. In this calculation, the figure of US$26 was chosen.

FOB Price: A$154.50/BDU = US$ 111.35/BDU

Loading cost:	– US$	8.00/BDU	
Chipping cost:	– US$	26.00/BDU	
Balance	US$ 77.35/BDU		
Chipping loss:	– US$	6.19/BDU	(8% loss)
Balance	US$ 71.16/BDU		

Converted into price per BDT: US$ 65.32/BDT (BDT=0.918BDU)
Converted from per BDT into price per m^3:
As volumetric weight is 420 kg/m^3, volume per BDT is 1 ton / 0.42 ton/m^3 = 2.38 m^3

Therefore,	US$ 65.32/2.38 m^3
per m^3	US$ 27.45/m^3
in Malaysian Ringgit	RM 71.66/m^3 (US$1=RM2.6105)

As a result of the calculation, the price of *A. mangium* wood ex chip mill yard was estimated at RM71.66/m^3.

3. Selling Price of *P. falcataria*

In Sabah, *P. falcataria* logs are exported and supplied to the local market. According to the interview at SSSB, volume ratios of *P. falcataria* by diameter class are as follows:

Diameter Class (cm)	Volume Ratio (%)
10 – 14	6
15 – 19	15
20 – 39	70
40 – 59	7
60 or more	2
	100

On-barge prices from March to May, 1994 are as follows:

Diameter Class (cm)	Price
15 – 19	US$ 20.00/m^3
20 – 39	US$ 32.50/m^3
40 or more	US$ 36.00/m^3

Logs 10 to 14 cm in diameter are to be sold to local mills, and their price was estimated at 60% of logs 15 to 19 cm or US$12/$m^3$.

The average price per cubic meter calculated from the above volume ratios and prices is US$29.71/$m^3$. Converted into Malaysian Ringgit, the price is estimated at RM(US$1 = RM2.6105).

9) Reserves

(a) The wholesale price index in the country concerned is usually applied to the calculation of a price-fluctuation reserve. In this study, the index was not available and substituted with the consumer price index. In the January 1994 issue of "Monthly Report: The Bank of Japan", Malaysia's consumer price index was reported as an "interim average percentage to the previous year" as follows:

1990	1991	1992	1993 (Jan.-Oct.)	
3.1	4.4	4.7	3.6	(%)

The average increase rate in the recent four years is 3.95%. The figure was rounded to 4%, which was applied to the calculation.

(b) Physical Contingency

A physical contingency was estimated at 10%.

10) The foregoing expenses for seedling production, forestation, facilities and vehicles, forest roads, vehicle maintenance and administration were aggregated on an annual basis, and price-fluctuation and physical contingency were added to the total. The annual expenditure was then calculated as shown in Table III-32.