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THE STUDY ON THE DEVELOPMENT OF RAJANG PORT IN MALAYSIA

VOLUME II MASTER PLAN

FEBRUARY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

Final Report

THE STUDY ON THE DEVELOPMENT OF RAJANG PORT

IN MALAYSIA

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1. BACKGROUND OF THE DEVELOPMENT

1.1 Economic Development in Sarawak

As stated in VOLUME I, 1. Introduction, Sarawak State is moving vigorously toward economic growth mainly as a result of industrial development in five industries, that is, timber processing industry, petrochemical industry, agriculture, tourism industry and electronic industry. These industries require mass transportation modes to supply materials, export finished products and transport tourists; in other words, the development depends upon transportation to great extent.

Although Sarawak State has made great efforts to develop a transportation infrastructure, roads are still not adequate due to natural conditions such as widely spreading forests, swampy land and many rivers. Sarawak State has proposed plans for improvement of the existing arterial road connecting Kuching, Sri Aman, Sibu, Bintulu, Miri and other major towns and construction of bridges on the road. However, it is expected to take a long time to implement the plans due to length of the roads and difficulty in construction caused by natural conditions. Moreover, development in air transportation is also ongoing such as the new Sibu international airport development. However, while air transportation is efficient for haulage of electronic products, it is not suitable as a mass transportation mode. On the other hand, Sarawak State has four major ports, Kuching, Rajang, Bintulu and Miri Ports, and an inland waterway network that connects these respective ports. Urban areas in Sarawak were originally developed using these waterways and water transportation is still the best mode for mass and economical transportation. Consequently, water transportation is extremely important and its development is needed to encourage industrial development.

1.2 Development Relating to Rajang Port Hinterland

Rajang River region and its adjoining areas, which occupies the central area of Sarawak, are rich in timber and coal resources and suitable for agricultural activities. Rajang Port is defined as port facilities under control of the RPA (Rajang Port Authority) at Sibu, Sarikei, Bintangor, Sungei Merah and Tg. Manis area. Rajang Port can accommodate ocean-going vessels and play a role as a gateway for not only major towns in the Lower Rajang River area such as Sibu, Sarikei and Bintangor but also the other major towns in the Rajang River region, Belaga, Kapit, Song, Kanowit, Daro, Mukah, etc.

On going or proposed development relating to this hinterland are as follows:

a) the Timber Processing Zone (TPZ) development by STIDC in Tg. Manis area which consists of STIDC sawmills, timber-related industry estate for private enterprise, business center, residential estate, recreational facilities, etc,
b) private sawmills development on Rajang River and its branches,
c) ongoing agricultural development in the Rajang Port hinterland such as palm tree plantation project in Saratok and Betong Districts, sago and pineapple plantation project in the Rajang Port hinterland, and cocoa and coconut plantation project in Tg. Manis area
d) coal thermal power plant development in the Sibu area proposed by SESCO
e) improvement of the arterial road from Kuching to Bintulu and construction of a bridge over Rajang River
f) installation of the water supply pipeline between Sarikei and the TPZ (expected to complete until 1994)
g) other economic development in the hinterland

Consequently, Rajang Port should be developed based on the State's economic development policy and the status of the Rajang Port and its hinterland. And the above developments should be taken into consideration when a development plan of Rajang Port is formulated.

1.3 Rajang Port Development

1.3.1 General Demand

Rajang Port has been constructed as a terminal for imports of consumer goods and exports of agricultural products on a small scale, although about 4 million tons of timber logs, the main cargo at this port, are being exported using no port facilities. However, population has grown at a steady rate and will increase by about 50% from 1990 to 2010 according to our demand forecast. In addition, Sarawak State is promoting further agricultural development such as palm tree plantation in Saratok and Betong districts. These factors will result in a growth of demand for consumer goods imports and the agricultural products exports as well as coastal and riverine cargo transportation. This will generate demand for cargo transportation through Rajang Port, as transportation in the Rajang River Region depends greatly on water transportation.

1.3.2 Rationalization of the Cargo Handling System at the Port

Rajang Port is currently behind in modernization in areas such as containerization. The present yard/shed area at Sibu Center is not large enough for smooth container marshaling and vanning/devanning in future. Reinforcement of cargo handling equipment will be also required.

Moreover, a couple of facilities cannot be used due to structural problems. The reinforced concrete piles supporting the apron is worn-out and the width of the apron is not wide enough for handling containers and other large cargoes. However these piers are currently undergoing renovation, and are expected to be completed no later than 1993.

1.3.3 Timber Industry Development

Almost all of the timber logs produced in the Rajang River Region are being exported unprocessed and only 10-15% of those are processed into swan timber, plywood, moulding, dowels, etc. Sarawak State is promoting more and more timber processing factories within the state to shift Sarawak's timber industry from logging to down-stream and value-added industries. This shift is extremely important if the state is to obtain more income because timber log production will not increase as a result of the need to protect timber resources in Borneo. The timber processing zone (TPZ) being considered by Sarawak Timber Industry Development Corporation (STIDC) in the Tanjung Manis area is the largest and only government-based development for the timber processing industry. The TPZ will generate a lot of timber products for export and require port facilities close at hand for quick and economical exports. On the other hand, the advantage of saving in transportation cost by using port facilities in front would attract entrepreneurs, who are considering establishing timber mills in the Rajang River Region, to the TPZ area.

1.3.4 Coal Development

The Merit Pila coal mine, which is located near Kapit, has produced coal since 1988. The measured deposit, the largest in Malaysia, is about 88 million tons. The present average capacity of mining is 10,000 tons per month and the present maximum capacity is 30,000 - 40,000 tons per month, but increasing the mining capacity to 1 - 1.5 million tons per year is possible. The quality is "high volatile bituminous C or subbituminous A with low sulfur and the gross calorific value is 6,000 kcal/kg. Export of this coal from Rajang Port started in 1989.

Moreover, Sarawak Electricity Supply Corporation (SESCO) is preparing a plan for three coal thermal power plants, one of which would be established in the Sibu area using coal from the Merit Pila mine, another plant in the Kuching area would be partly supplied by the Merit Pila mine.

As further coal development is likely to be undertaken, more coal exports and construction of power plants can be expected. A Coal terminal would then be required as a transfer point from rive barges to ocean-going ships and for a coal supply deposit to the plants.

1.3.5 Constraints on Development of Rajang Port

Rajang Port, facilities under control of RPA at Sibu, Sarikei, Bintangor, Sungei Merah and Tg. Manis, is located in the Rajang Delta and has two long and winding waterways called the Rajang Route and the Paloh Route. As the depths of the estuaries are shallow, these depths determine the largest size of ship that can enter Rajang Port, that is, ships of up to 9m draught on the Rajang Route and 6.0m draught on the Paloh Route are able to enter. Littoral sand drift is so active at these estuaries that dredging is not recommended.

Moreover, the erosion and sedimentation caused by river current, ocean currents, tidal current, shore current, etc., currently offset each other, leaving the river bottom in a settled state. Large-scale dredging, reclamation or other changes would break the balance, resulting in erosion and/or sedimentation in currently stable areas.

Consequently, the development of Rajang Port should have the following constraints:

- *the maximum ship size is determined by the current depth of the estuaries*
- the development must not include large-scale dredging and reclamation
- the port facilities should not significantly disturb river current

2. DEVELOPMENT POSSIBILITY AT RAJANG PORT

In this Chapter, we evaluate the possibility of further port development at Rajang Port from the viewpoint of natural and socioeconomic conditions. This will provide us with a general idea of the possibilities and limitations to development of the Rajang Port.

2.1 Evaluation of Natural Conditions

2.1.1 Conditions of the waterway and basin

(1) General

The river bottom of the Rajang River is kept stable by a balance between the flowing in and out of soil. However, if any large scale changes such as dredging or reclamation are mode, the balance will be broken. Then, sedimentation and erosion will take place, which will result in shore erosion and a refilling of the dredged area. Consequently, the port development should be planned on the basis of native navigable depth of the estuary and river as much as possible so that no large-scale dredging or reclamation in the water area is required.

Figure-2.1.1.1 shows the navigable depth from chart datum of the Rajang Port from the estuaries to Sibu along the Rajang Route and the Paloh Route. Both routes have bottlenecks such as shallow areas and sharp curves, and therefore only small ships can enter Sarikei and Bintangor through the Rajang Route.

(2) Estuaries of the Rajang River and Paloh River

Hydrodynamics at a estuary is complicated. The bottom is affected by a tidal current, an ocean current and shore current generated by waves as well as the river current. Bottom materials are transported by these currents and the bottom is settled in the balance between erosion and sedimentation caused by these currents. Ocean and shore currents cause littoral sand drift in the shore area and estuary. The volume of silt and sand which is transported in littoral drift is so large that the drift tends to refill a waterway made by a flash of river current at estuary. This is one of the reasons why the depth at the estuary of the Rajang River (6 to 7m from CD) is shallower than that inside the estuary (10m or more

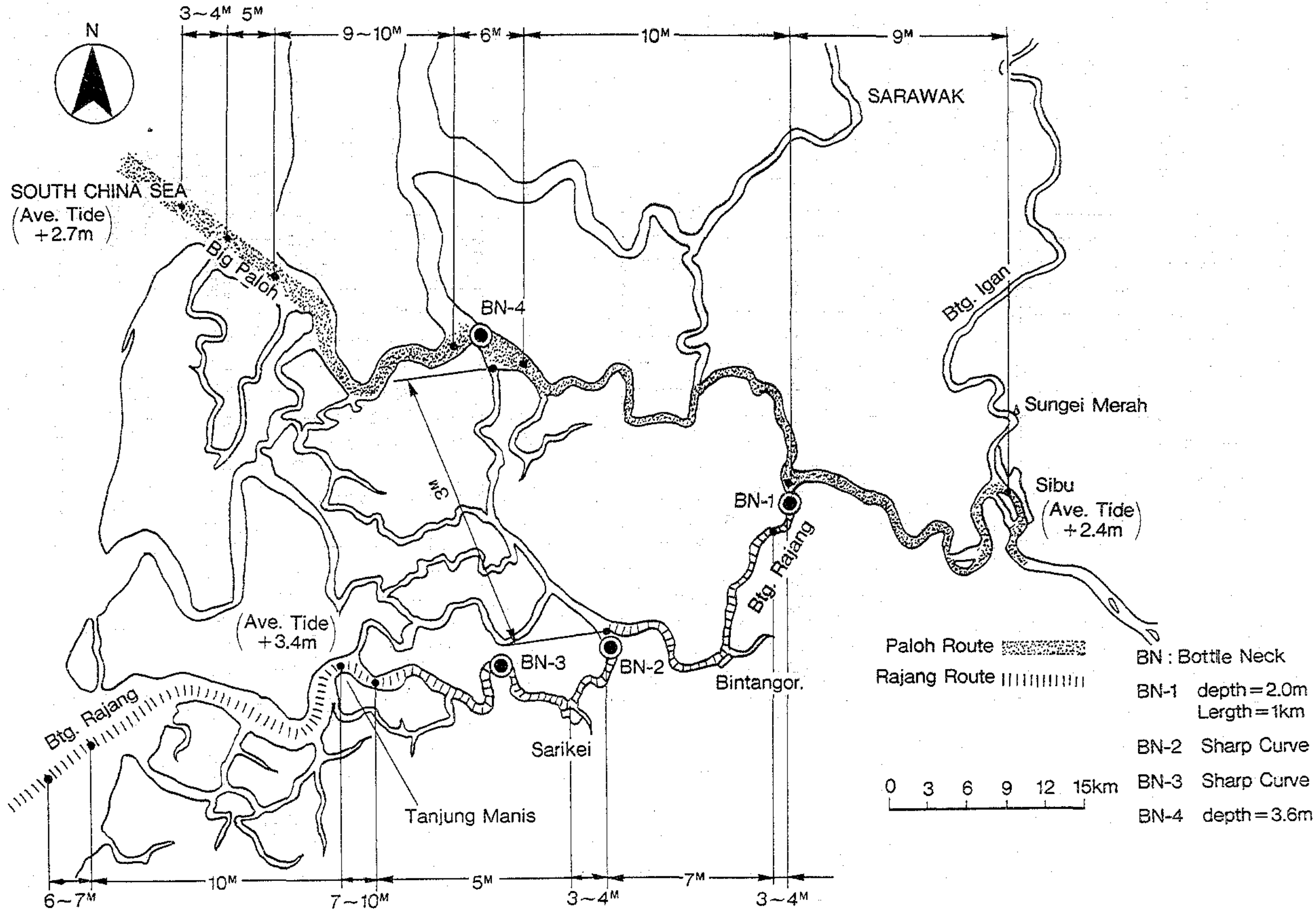
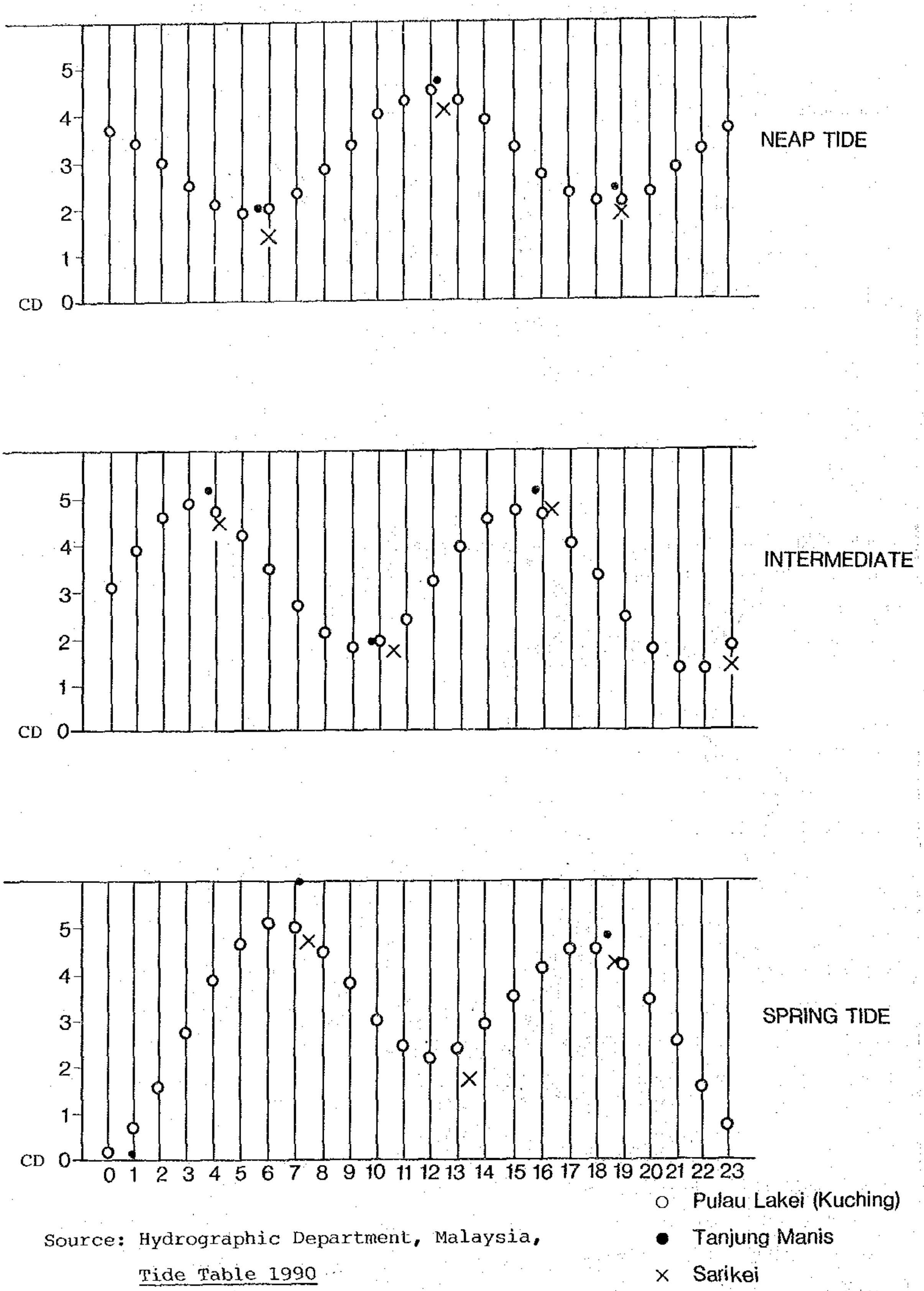


Figure-2.1.1.1 NAVIGABLE DEPTH OF RAJANG AND PALOH ROUTES
(depth from chart datum)



Source: Hydrographic Department, Malaysia,
Tide Table 1990

Figure-2.1.1.2 Tidal Level Changes from Chart Datum at Rajang Port from CD), another is soil sedimentation due to speed down of the flash flow. This means also that if we dredge the estuary and prepare a deep waterway, it will easily shoal; the cost of maintaining the depth will be high.

Consequently, the native depth at estuaries of the Rajang River and Paloh River determine the maximum draught of the Rajang Route up to Tg. Mains and Paloh Route up to Sibu.

Figure-2.1.1.2, which depicts tidal level changes at the estuary of the Rajang River and other points in and around the study area, shows that the depth becomes deeper by 3 to 5m for several hours a day and that even ships with a deep draught can pass through the estuaries during this time. In this context, as the minimum depth from chart datum at the estuary of the Rajang River is about 6m, ships can use 10m-deep water. Similarly, ships can use about 7m-deep water on the Paloh Route because the minimum minimum depth from chart datum of the estuary of Paloh River in addition to a 3m increase during high tide through the Paloh Route can be expected.

(3) Rajang Route

Once passed the estuary, ships can sail through the waterway with a depth of 10m or more and a width of not less than 300m until Tg. Sebubal East. From Tg. Sebubal East to Tg. Manis East, the depth is 7m at least. After that, bottlenecks, such as "Sarikei Rock" and shallow banks block entry of large ships. Consequently, the maximum ship size which can call at Sarikei and Bintangor wharves is 61m in length or about 1,000DWT.

(4) Paloh Route

On the route to Sibu there are bottlenecks both at Tg. Bungai and at the estuary . Both bottlenecks can be cleared during high tide. Depth at high tide is 6 to 7m, consequently, the maximum ship size is 5,000DWT.

(5) Conclusion

Consequently, the following depth conditions are prerequisites for port development at Rajang Port.

Table-2.1.1.1 Depth Condition of Rajang Port

Area	Depth from CD	Tide	Hours during which Tide occurs each day	Depth for Development
THE RAJANG PORT				
Estuary	5.8m	4.2m	8 hrs	10.0m
Estuary to Tg. Sebubal East	10.0m+	-	-	10.0m+
Tg. Sebubal East to Tg. Manis East	7.5m	-	-	7.5m
Tg. Manis East to Sarikei	5.0m	-	-	5.0m
Sarikei to Bintangor	3.5m	-	Whole day	5.0m
THE PALOH ROUTE				
Estuary	3.5m	3.5m	8 hrs	7.0m
Estuary to Sibu	3.6m(Min) - 10.0m	3.5m	8 hrs	7.1m
Sibu to Sibu South	6.0m	-	-	6.0m

2.1.2 Condition of the waterfront line and land area

Development in the river area should be made without large-scale dredging because the river bottom is unstable due to continuous erosion and accumulation. Therefore, sites where development can be done without large-scale reclamation or dredging, that is, water areas deep and broad enough for ship maneuvering and close to land, shall be selected. So, an area with a broad lagoon in front such as the north bank of Kuala Rajang should not be considered. **Figure-2.1.2.1** illustrates a possible waterfront for the development.

The entire back area of the possible waterfront lines except A (a private sawmill company has already developed this area) has land with only very small populations and an area large enough for both a port terminal and industrial development.

Present situation of the possible areas are as follows.

A: dry land and swampy land, private timber company
B: dry land and swampy land
C: swampy land
D: dry land, cultivated land, partially urbanized
E: dry land, cultivated land
F: swampy land
G: swampy land
H: swampy land

2.1.3 Condition of geology

According to our survey and the existing data, soil system of this area consists of soft silt, sandy clayey silt, clayey silty sand, etc. Hard strata which could sustain structures appear at a level of about -20m from chart datum. From a civil engineering point of view, a structure could be kept stable with piles driven into the hard strata, and this condition must be met for almost the entire study area.

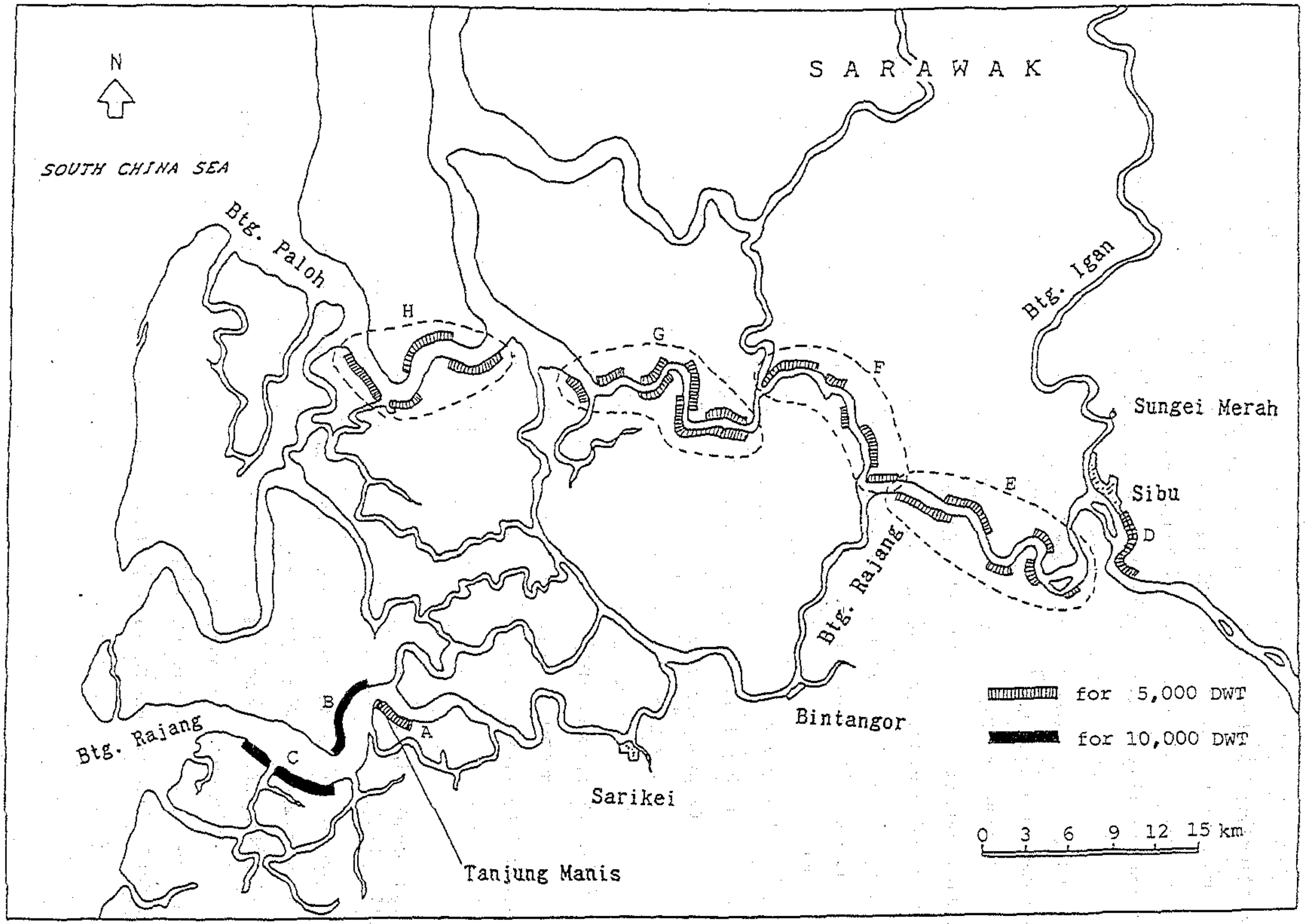


Figure-2.1.2.1 Possible waterfront for the New Development

2.2 Evaluation of Socioeconomic Conditions

2.2.1 Urban area

(1) Urbanization up to the present in the Study Area

Urbanization in the Rajang River Region started when the white Raja (King) promoted migration to this region to produce jungle and agricultural products such as pepper and rubber for exports in 19th Century. Sibu, Sarikei, Bintangor, Kapit and other towns were established as trading points for these products and imported goods brought from outside of the region. The jungle and agricultural products were produced in mountain or hill areas and transported by water to towns. Sibu, Sarikei, Bintangor, Kapit and so on were developed in relatively dry areas facing a deep basin near subsidiaries of the Rajang River (these river branches were used for transportation of the products) and also in the outskirts of hill areas where agricultural and jungle products yielded. Since Sibu town has the deepest basin and a deep waterway which extends to the ocean, it has been developed as the trading center of this region.

(2) Future Urbanization in the Study Area

In the next couple of decades, urbanization is likely to continue primarily at existing towns and their outskirts because the present industrial structure composed of timber industry and agriculture will be maintained in the future and there will be no impact on regional urban structure. This means that main urbanization will take place in the southern area of the Rajang River (which included Sarikei, Bintangor and Tg. Manis) and Sibu and its surrounding areas. However, there will be a small impact on the urban structure from timber industry development and its related development.

The development of a timber processing zone (TPZ) complex by Sarawak Timber Industry Development Corporation (STIDC), which will consist of an industrial and recreational estate, commercial center and recreational facilities, etc. at Tg. Sebubal, will form a new town with a population of about 21,000 - 27,000.

Moreover, urbanization at Sibu will move eastward. Development of a new airport has already begun about 20km east of the town; a connection road with the town is already under construction. Moreover, the civic hospital will move from the central area (next to Rajang Port Authority) to the eastern area in a few years. These projects will stimulate urban development in the eastern area of Sibu.

2.2.2 Infrastructure

(1) Transportation

Port terminal plays a role as a transfer point between water transportation and land transportation or as a transshipment point between ships. Therefore, a port terminal should be connected with consumption areas and production areas such as cities and industry estates through road and waterways (although railroad is another option, it is not necessary to be considered at Rajang Port).

i) Road

Figure-2.2.2.1 shows the existing and proposed road network. The areas south of Rajang River from Tg. Manis to Bintangor will be connected together by road and if a bridge over the Rajang River of the trunk road from Kuching to Miri, passing through Sibu and Bintulu, is constructed, Tg. Manis - Bintangor will be connected with Sibu. Construction of the road connecting Belawai village, Rajang village and Tg. Sebubal where the TPZ development is going on is under construction and the Belawai-Rajang section has already been completed. On the other hand, a road network has not been established in the north area of the Rajang River and will not be developed because swampy land and river branches make the construction difficult and costly; nor is there enough demand to justify construction.

Road connection of port and neighboring towns and villages is preferable for container and general cargo transportation because secondary water transportation tends to take a longer time and because cargoes still need to be transferred to land transportation to arrive at the final destination. However, if port terminals handle cargoes, such as logs or coal, which prefer water transportation to land transportation, or if factories are located next to the terminal, road connection is not required.

ii) Waterway

All towns, factories and other facilities on the river bank can be connected with each other by water. The main water area allows traffic of large ships and all towns up to Kapit are connected with passenger boats or small cargo vessels.

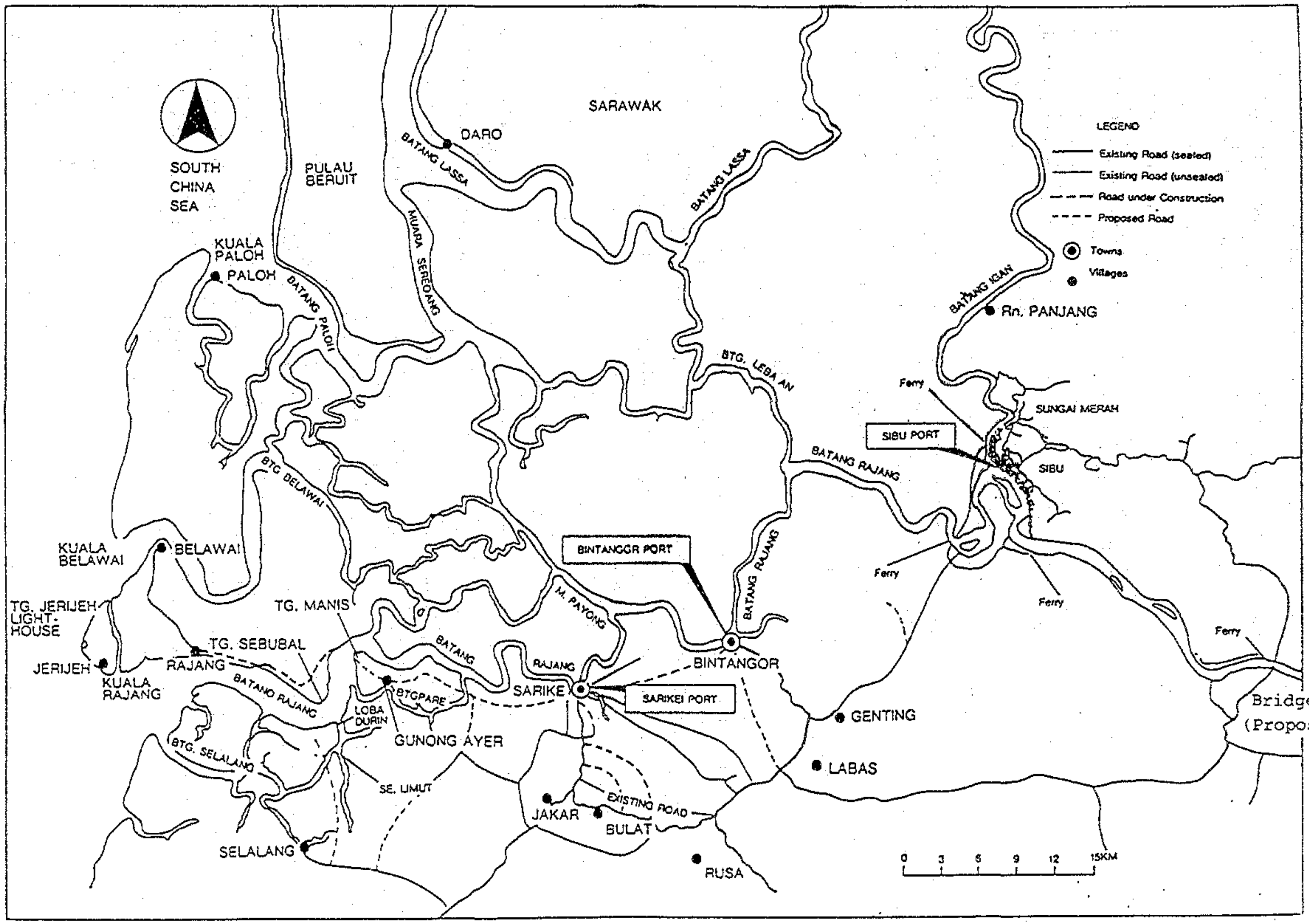


Figure-2.2.2.1 Road network in the lower Rajang River area

Currently, we can find the following cargo movement by waterway other than international trade; logs from the upstream areas to Tg. Manis Anchorage or mills located on the bank of Rajang River and its branches, coal from the loading point near Kapit to Tg. Mains Anchorage, timber products from the mills to Tg. Manis Anchorage, coastal/reverine transportation between towns in the study area and the other parts of Sarawak, and consumption goods redistributed from wharves of Sibu, Sarikei, etc.

Although waterway transportation can be used for an access and an egress transportation mode from/to the ocean-going ship terminal in the Rajang River Region if the terminal is located for from Sibu or Sarikei Towns, we should only decide the access or egress transportation mode considering the availability and construction possibility of road and comparing the land and water transportation infrastructure cost and operating cost.

(2) Utility

Ports supply water to vessels and need water for container van/equipment washing facilities and administrative facilities. In addition, the coal yard needs water to cool coal and prevent it from catching fire and flying in the wind.

Cargo handling equipment does not consume electricity but fuel oil. Main consumers of electricity are lights installed in the cargo storage/sorting facility and administration building. The required capacities of water and electricity supply are not large. If existing supply lines are installed nearby, the terminal will be sufficiently supplied by installing branch lines from the main lines. Electricity can be also supplied by private generators. However, it is advisable to locate terminals near the existing lines.

Water supply lines have been installed along almost all roads. In addition, Sarawak Electricity Supply Corporation (SESCO) plans to construct a 14MW power plan inside the TPZ. And the Ministry of Works in Sarawak (Sarawak JKR) has a plan to install a water supply line from Sarikei to Tg. Sebubal Area.

2.2.3 Land use

Figure-2.2.3.1, which illustrates population density as well as

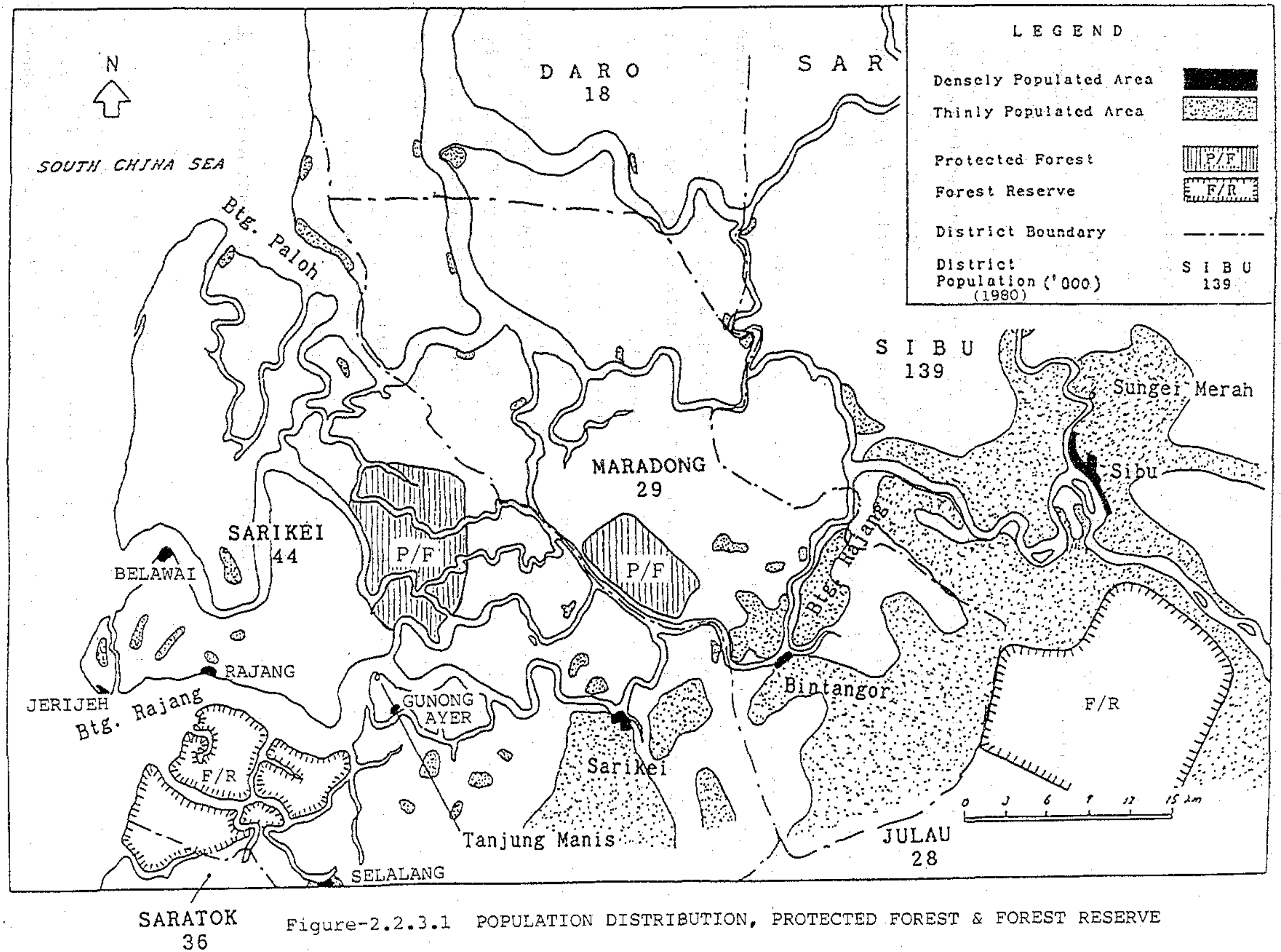


Figure-2.2.3.1 POPULATION DISTRIBUTION, PROTECTED FOREST & FOREST RESERVE permanent forests, shows that almost all the area between Sibu and Sarikei on the Rajang River is inhabited or cultivated for rubber and rice. Moreover, at Tg. Manis East, large-scale sawmill development has been undertaken by a private company.

Factories would emit some smoke into the atmosphere and thereby be a nuisance to their neighbours. Therefore, factories should not be located upwind of and adjacent to residential or commercial areas.

As port terminal would generate traffic of heavy vehicles, residential and commercial areas should be far enough away to avoid noise and danger. However, this is not so crucial.

A coal terminal would generate coal dust instead of heavy vehicle traffic. Although water spray on a coal yard will mitigate the effect of coal dust spreading, a coal terminal should not be located upwind of residential and commercial areas.

2.2.4 Labour

Population is distributed mostly in Sibu, Sarikei, Bintangor and villages spread in the southern area of Sarikei and Maradong districts and in the area north of Kuala Rajang. Therefore, the Lower Rajang River Area (between Sibu and Kuala Rajang) is suitable for industrial development from the viewpoint of labour procurement.

On the other hand, port terminals for general cargo, container and coal does not require many workers. Thus the proximity of a densely populated area is not a priority. But, as these terminals would handled products and consumer goods to/from the neighbouring cities, towns and villages, they are likely to be located near a densely populated area.

2.3 The Possible Sites for Port Development at Rajang Port

2.3.1 Target of development

When we consider future development at Rajang Port, we should know what Rajang Port will need or what potential Rajang Port has. The latter is evaluated in 2.1 and 2.2.

Currently, Rajang Port is an international trading center with terminals of coastal/riverine cargo and passenger transportation that sustains the economic and daily life of this region. This will not change in future; moreover, Rajang Port will be required to contribute to the enhancement of the local economy by mating room for industrial development, especially the development of a timber processing industry which is a major industry in this region as well as acting as an effective export mode for agricultural products, another major enterprise in this region. Also, the Rajang River region has a coal mine with the largest deposit in Malaysia, and therefore a coal terminal for export and/or coastal transportation base is required.

Consequently, the following targets can be set:

- Timber Industry Development
- Terminal Development for International Trade (timber products, coal and general cargoes)
- Terminal Development for Coastal/Riverine Cargo and Passenger Transportation

And the timber industry development will need a terminal to export the products; moreover, the terminal should be located next to the timber factories for easy transportation of large amounts of products.

2.3.2 Long list selection by natural conditions

Timber industry development and terminal development for international trade requires a basin deep enough for ocean-going vessels and land facing the deep basin. The deeper the basin, the larger the ships that can be accommodated and the less transportation cost is required. And the waterfront line should not have a lagoon in front but should have a wide basin for a mooring facility and waterway. The possible development sites (A, B, C, ..., H) can be selected by considering navigable depths and waterfront conditions of each part of the Rajang and Paloh Routes shown in Figure-2.1.2.1.

2.3.3 Short list selection by socioeconomic conditions

(1) Timber industry and timber products terminal development

Road and waterway connections with neighbouring towns and villages are needed for employees' commuting, material (logs) supplies and transfer of timber products from private factories spread out through the Rajang River system. If a road is not available, the existing waterway network can be used. The installation of a water supply pipe is proposed at Tg. Sebubal area and an electricity supply can be established in the TPZ area. However, at the northern part of the Rajang River Delta, water and electricity are currently not supplied well and the new installation will be costly due to natural conditions. Therefore, sites, F, G and H should be rejected.

Another important point is vessel size. Sites B and C can accommodate 10,000 DWT class vessels in full load although sites A, E, F, G and H can accept 5,000 DWT calls vessels at most and site D can accept 3,000 DWT class vessels at most. For timber products exports, 5,000-10,000 DWT class vessels are required taking into consideration the trading lot size (about 5,000 - 10,000 tons). So, site D is not suitable for the timber terminal development.

Timber industry development needs a vast amount of land, so, sites A and D are rejected due to shortage of land. And to prepare the land, a large volume of predominantly silt free soil is required, and sites F and G are disadvantageous due to the narrow sedimentation area in the river where soil could be dredged. Also, site E is covered with mature rubber trees. Considering that rubber is one of main agricultural products in this area, site E is not suitable.

Timber industry requires many workers. So, sites F, G and H are not suitable for the timber industry development from the labour procurement point of view.

Consequently, the possible development sites for timber industry and timber products terminal development are B and C.

(2) Terminal development for international trade (coal)

The price of bulk cargo such as coal depends largely on transportation costs. Therefore, the terminal should be able to handle large ships. Sites B and C can accommodate 10,000 class vessels (using 4m or more tide) and at the highest tide (4.5 - 5m above chart datum) or in case of partial load (loading factor: 0.9 or 0.8), 20,000 to 30,000 DWT class vessels can be accommodated. At other sites, this is impossible.

Moreover, sites B and C can be kept apart from the urban area and are rich in land.

Consequently, the possible development sites of coal terminal are B and C.

(3) Terminal development for international trade
(general cargo/container)

Terminals at site B and C can accommodate 10,000 DWT class vessels at most. Although transportation costs using this class of vessel are cheaper than those using smaller vessels, the distance from B or C to Sibu is so far (100 km) that these sites are not suitable for a container terminal. However, sites B and C could handle containers staffed with timber products from a timber processing zone located next to the terminal.

Sites A, E (north bank), F, G and H have only 7.5-m navigable depth and at most can accommodate 5,000 DWT class vessels. As well, road connections between Sibu and sites E (north bank), F and G are so poor that secondary containers or general cargo transportation depends on barges. etc.

Site A will be connected with Sarikei, Bintangor and Sibu by the proposed road between Sarikei and Tg. Manis and proposed bridge over Rajang River. However, the distance to Sibu is too far for it to play a role as the supply terminal of Sibu.

Sites E (south bank) and D are located near Sibu. Site D is in the best position, next to the Upper Lanang Industrial Estate and connected by the existing paved road with Sibu town. However, Site D has a basin with a depth of only 6m. So, site D would be a supplementary terminal of Sibu Center wharf. Construction of the bridge over Rajang River is under consideration and improvement of the arterial road from Kuching to Miri has been initiated. If construction is completed, site E (south bank) will be connected with Sibu by land. But, it is likely to take a long time to complete construction and by that time Sibu Center wharf will be overflowing with cargoes. So, site E (south bank) is a possible development site in very long term.

Consequently, A, B, C, D and E (south bank) are possible sites for general cargo/container terminal development for international trade.

However, these sites have the following conditions:

Table-2.3.3.1 Possible Sites for General Cargo/Container Terminal Development and the Conditions

Site	Situation	Utilization
A	- most areas have been already developed by a private company, area for new terminal development is limited - depends on completion of the road to Sarikei - too far to Sibu (about 100km by road) - supplementary terminal of Sarikei wharf	- agricultural products exports - timber products exports
B, C	- timber products terminal - handling general cargo generated in TPZ development	- timber products exports - general cargo imports - part of cargo is handled in containers
D	- vessel limit is 3,000 DWT - supplementary terminal of Sibu Center wharf	- general cargo imports - agricultural products exports
E	- depends on completion of bridge over Rajang River - supplementary terminal of Sibu Center wharf	- general cargo imports - agricultural products exports

(4) Terminal development for coastal/riverine cargo and passenger transportation

These terminals should be developed at each town. The required area for development is relatively small because vessel size in charge and cargo volume is small.

2.4 Ship Size for the Development

2.4.1 Stock of vessels

(1) Carriers for timber products

Currently, timber products are carried by conventional cargo ships from Rajang Port because long sawn timber and standardized plywood (3' x 6' or 4' x 8') do not match the size of containers and because the purchase lots of end users are much smaller than a full container lot. However, containers will be used for transportation of timber products from now on to avoid damage to them, to save on package costs (and their disposal cost) and efficiently use empty containers, which otherwise would be exported without cargo. Only some timber products will be containerized, while others will be carried by conventional cargo ships or possibly by RO/RO ships.

Trading lots of timber logs and timber products are not so big, about 5,000-10,000 tons according to Japanese trading companies, and the average ship size being currently used for export of timber logs and products from Tg. Manis is about 5,000 DWT. Moreover, the maximum navigable depth of Rajang Port is 10-11m up to Tg. Manis or 6-7m up to Sibu. Therefore, it can be assumed that 5,000-10,000 DWT class ships will be used, according to the standard dimensions of general cargo ships (**Table-2.4.1.1**).

Table-2.4.1.1 Standard Dimensions of Conventional Cargo Ships (75% Envelop)

Ship Size (DWT)	Length (M)	Beam (M)	Molded Depth (M)	Full Draught (M)
2,000	81	12.7	6.8	4.9
3,000	92	14.2	7.7	5.7
5,000	109	16.4	9.0	6.8
8,000	126	18.7	10.3	8.0
10,000	137	19.9	11.1	8.5
15,000	153	22.3	12.5	9.3
20,000	164	23.9	13.4	9.9
25,000	175	25.5	14.3	10.4
30,000	186	27.1	15.2	10.9

Source : Lloyd's Register

Ships of less than 5,000 DWT and 10,000 DWT occupy 66% and 81% of all general cargo ships, and standard full draught of these class vessels are 6.8m and 8.5m (**Appendix-II.2.4.1**). Generally, RO/RO ships have relatively shallower draughts than other types of ships. For instance, the average draught of Ro/Ro ships of 10,000 GRT is about 6.5m (**Table-2.4.1.2**). Therefore, RO/RO ships of more than 10,000 GRT can be accommodated at Tg. Manis.

Table-2.4.1.2 Standard Dimensions of RO/RO Ship

(75% Envelop)

Ship Size (GRT)	Length (M)	Beam (M)	Full Draught (M)
2,500	110	17.5	5.2
5,000	140	22.0	6.7
7,500	160	24.0	7.4
10,000	175	26.0	8.0
15,000	200	29.0	8.8
20,000	220	31.0	9.2

Source : Lloyd's Register

(2) Container Ships

Although the main types of ships carrying containers in and out of Rajang Port will still be containerized ships and conventional ship, which are currently operated for container transportation at the port, cellular container ships will possibly also be used. Recently, the share of cellular container ships of more than 40,000DWT has grown, but shares of the ships of less than 5,000DWT and 10,000DWT are 12% and 30%, respectively. Similarly, shares of the ships with draught of less than 6.5m and 9.0m are about 15% and 40%, respectively (**Appendix-II.2.4.1**). The standard dimensions of container ship are shown in **Table-2.4.1.3.**

Table-2.4.1.3 Standard Dimensions of Container Ships

(75% Envelop)

Ship Size (DWT)	Capacity (TEU)	Length (M)	Beam (M)	Full Draught (M)
5,000	200	120	18.0	6.7
8,000	400	140	21.0	7.9
10,000	500	155	22.5	8.3
15,000	800	180	25.5	9.6
20,000	1,200	201	27.1	10.6
30,000	2,000	237	30.7	11.6

Source : Lloyd's Register

Therefore, container ships of 10,000 - 15,000 DWT can be accommodated at Tg. Manis.

(3) Coal Carriers

The shares of dry bulk carriers of less than 30,000DWT, 20,000DWT and 10,000DWT are 47%, 17% and 2%, respectively. And the shares of ships with draught of less than 9.0m, 10.0m and 11.0m are 8%, 30% and 61%, respectively **(Appendix-II.2.4.1)**. The standard dimensions of dry bulk carriers are shown in **Table-2.4.1.4.**

Table-2.4.1.4 Standard Dimensions of Dry bulk Carriers

(75% Envelop)

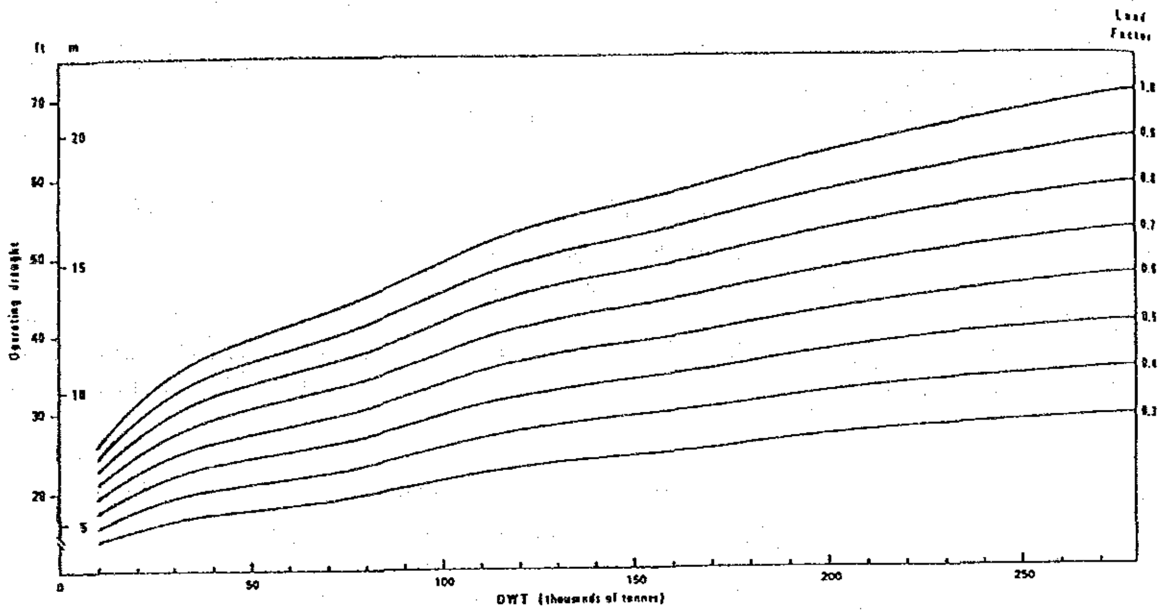
Ship Size (DWT)	Length (M)	Beam (M)	Full Draught (M)
5,000	100	15	6.5
10,000	140	21	8.2
15,000	155	23	9.2
20,000	165	25	10.0
25,000	185	27	10.8
30,000	200	28	11.2

Source : Lloyd's Register

Therefore, dry bulk carriers of 15,000 DWT can be accommodated at Tg. Manis.

(4) Partial Load

Draughts of ships would be shallower by 1-2 m with 90% to 80% load (load factor) of full capacity. **Figure-2.4.1.1** depicts the relationship between ship size and draught for several load factor values. From this figure, **Table-2.4.1.5**, which shows draughts of general cargo ships, container ships and dry bulk carriers by load factor, can be made.



Source: University of Liverpool, Marine Transport Centre. *The Principal Dimensions and Operating Draughts of Bulk Carriers.*

Figure-2.4.1.1 Operating draughts for different load factors against dwt for dry bulk cargo carries

Table-2.4.1.5 Draughts of Partial Load Ships by Load Factor

(unit:m)

Ship Type	Ship Size (DWT)	Load Factor			
		1.0	0.95	0.9	0.8
General Cargo	5,000	6.8	6.6	6.4	6.1
	10,000	8.5	8.2	7.9	7.4
	20,000	9.9	9.4	9.2	8.6
Container	5,000	6.7	7.1	6.9	6.6
	10,000	8.3	8.0	7.7	7.3
	20,000	10.6	10.0	9.8	9.2
Dry Bulk	10,000	8.2	7.9	7.6	7.2
	20,000	10.0	9.5	9.3	8.6
	30,000	11.2	10.8	10.4	9.4

2.4.2 Conclusion (Ship sizes for the development)

Depths of the estuaries decide maximum vessel size on Rajang and Paloh Routes. The allowable draught can be decided as follows:

$$D = W + T - Ss - St$$

where,

D : Allowable Draught

W : Depth at the Estuary from Chart Datum

T : Tide

Ss: Squat of ship (about 0.5m)

St: trim of ship (about half of wave height)

If wave height is assumed to be 1m, D can be calculated to be as follows:

$D = 6 + 4 - 0.5 - 0.5 = 9.0m$ (Estuary of Rajang River)

$D = 3.5 + 3.5 - 0.5 - 0.5 = 6.0m$ (Estuary of Paloh River)

Moreover, required clearance between ship keel and river bottom in front of site is 0.5m.

Consequently, ship size for the each possible site for development can be set as shown in **Table-2.4.2.1.**

Considering the results of the site investigation at the Rajang River, there are no navigational hazards for the proposed ship (10,000DWT class) to pass the estuary all year round for the following reasons:

According to the analysis of tide table year 1990, the proposed ship of 10,000DWT, whose full draught is 9m, is able to negotiate the estuary almost all year round using the tide. Current channel depth at the shallowest point is -5.8m from CD, and percentage of days when tide becomes +4.2m or more for two hours or more daily is 91 (in case of +2.2m -- ships of 5,000DWT-- the percentage is 100).

A distance of the shallowest section in the waterway where careful maneuvering is required is about three miles and the ships can pass the section about 15 minutes at a cruising speed of 12 knots. Consequently, a few ships are able to pass the shallowest section safely in one hour.

Dredging the channel at the estuary is not necessary to accommodate 10,000DWT class vessels. And dredging is not recommended because a dredged area would be easily refilled by littoral sand drift and siltation of river for cost reason.

Table-2.4.2.1 Maximum Ship Size at Each Possible Site for Development at Rajang Port

Site	Route	Allowable Draught (m)		Maximum Ship Size & Draught (DWT, m)			
		Estuary	Site Front	Conventional Ship	Container Ship	RO/RO Ship	Bulk Cargo Ship
A	Rajang	9.0	7.0	5,000 (6.8)	5,000 (6.7)	5,000 (6.7)	5,000 (6.5)
B	Rajang	9.0	9.5	10,000 (8.5)	10,000 (8.3)	15,000 (8.8)	15,000 (9.2) -25,000* (9.0)
C	Rajang	9.0	9.5	10,000 (8.5)	10,000 (8.3)	15,000 (8.8)	15,000 (9.2) -25,000* (9.0)
D	Paloh	6.5	5.5	3,000 (5.7)	-	2,500 (5.2)	-
E	Paloh	6.5	7.0	5,000 (6.8)	5,000 (6.7)	5,000 (6.7)	5,000 (6.5)

* partial load condition (loading factor = 0.8)

3. PORT DEVELOPMENT POLICY

3.1 Federal and State Policy surrounding Rajang Port

3.1.1 Federal Port Policy

Malaysia buys and sells commodities and manufactured products in markets throughout the world. The vast majority of this trade is seaborne. Domestically, prior to the development of inland roads and a rail system, water transport was also crucial for communication in the country. Therefore, in Malaysia, ports form the economic and social development of the nation.

The Sixth Malaysia Plan (1991 - 1995) states that an increase in cargo volume handled at ports in Malaysia is expected from 80 million tons in 1990 to 130 million tons in 1995 and that a sufficient handling capacity will be required to meet the expected increase in throughput. The Plan also states that a greater containerization is expected and that development of intermodal services, ports and inland services associated with containerization, will be required, including the upgrading of organizational facilities to meet the demands of intermodalism.

The "National Port Plan", formulated by the Economic Planning Unit with the participation of the Ministry of Transport, Malaysia, gives us the long term perspective for the roles of ports in Malaysia; namely, to sustain national economic growth by providing rational, economic and reliable water transportation services. The plan calls for a transport network for the following main commodities; containers, timber products, palm oil and other commodities.

Container Network

Deep sea container vessels are costly ships to operate; therefore, for reasons of speed and economy, they call at fewer ports than conventional break bulk vessels. The tendency is therefore to concentrate on a few load center ports (normally situated at the hub of a trading area) and feed the out ports in that region. This pattern, combined with a network of feeder links, has continued to develop and reflects the current situation worldwide, including the Far East. In South East Asia, with Singapore occupying a central position within the region, a number of shipping lines choose to load or discharge containers at Singapore for relaying to and from the neighbouring countries of Malaysia, Thailand and Indonesia.

Functional allocation among main container handling ports in Malaysia and Singapore is as follows:

Port Klang: Principal Container Load Center for most trading routes
International Trading Center for the other hinterland

Penang Port: Direct Liner Connection with Far East
Feeder Port via Klang Port or Port of Singapore

Johore Port: Direct Liner Connection with Far East
Domestic Shipment to Sabah/Sarawak

Sabah/Sarawak Ports: Some International Direct Connection
Feeder Port via Klang Port or Port of Singapore
Domestic Container from Klang and Johore Ports

Port of Singapore: Transshipping International Containers

Sawn Timber

Timber is a major export commodity in Malaysia. The center of log production in Malaysia has moved to Sarawak and the logs are being exported unprocessed. However, from the forest preservation point of view, shifting the timber industry from logging to down-stream and value-added industries and reducing the log production are a part of national target.

Port Klang: Export Outlet (will decline)
Gateway for inward timber products bound for Capital area from Sabah/Sarawak

Johore Port: Export Outlet (will decline)
Accepting inbound timber products bound for the Southern Peninsular from Sabah/Sarawak

Kuantan Port: Export Outlet (will decline)

Accepting inbound timber products bound for the Peninsular from Sabah/Sarawak

Sabah/Sarawak Ports (Rajang, Bintulu and Sandakan): Export Gateway for Malaysia's timber products bound for international market and the Peninsular

Palm Oil

Relies on all ports but concentrates on Johore Port.

Other Commodities

The market shares of other commodities continue to be allocated to ports in the same pattern as the market place has already defined. That is, growth in traffic results only from growth in demand for a commodity, not due to any rerouting or diversion of cargo.

Malaysia's major ports combine a number of multi-purpose functions; for example, they should play the roles of gateway for regional seaborne transportation and for industrial development, as well as other specialized roles. "National Port Plan" recommends the following roles for the major ports of Malaysia:

Multi-purpose and Concentration Center

Port Klang	containers
Johore Port	dry and liquid bulk
Kuantan Port	timber from Sabah/Sarawak to the Peninsular

Multi-purpose and Regional Gateway

- Penang Port
- Kuching Port
- Rajang Port
- Kota Kinabalu Port

Multi-purpose and Industrial Port and Regional Gateway
Bintulu Port

3.1.2 Port Development Policy of Sarawak State

The roles of the ports should be to sustain state's economic growth through providing rational, economic and reliable water transportation services. Ports in Sarawak should be a gateway for growing regional seaborne transportation and should promote industrial development.

In Sarawak, the absence of significant inland road or rail links represent formidable barriers to any long distance overland consolidation/movement of cargoes. Lack of bridges and weight limitations on existing roadways are the current obstacles. Although an improvement plan for the existing arterial road from Kuching to Bintulu and a construction plan for bridges on the road are proposed, it is not economical or appropriate to concentrate seaborne cargo to and from Sarawak at a single port because the state spreads widely from east to west and because the each region can be directly connected with the Peninsular and foreign countries through its port. Therefore, the state's seaborne cargo should be mainly handled at Kuching, Rajang and Bintulu ports.

Kuching Port should become the gateway port for the Sarawak River basin, Rajang Port for the Rajang River Basin and Bintulu for the eastern Sarawak, respectively. Bintulu Port also plays a role of the gateway port for the offshore oil and gas industry and for onshore industrial development. The timber industry is one of leading industries in Sarawak and STIDC (Sarawak Timber Industry Development Corporation) has timber processing zone development plans at the three ports. Therefore, Kuching, Rajang and Bintulu Ports should have a role as the gateway for timber product exports from Sarawak. Miri Port, a principal minor port, plays the role of the gateway for those area which Rajang and Bintulu Ports do not cover.

Roles of these ports are as follows:

Rajang Port:

- Regional gateway port for Rajang River basin
- Multi-purpose port to handle full range of cargo classifications
- Container handling port for geared vessels, most transshipped via Port Klang
- Gateway for timber product exports

Kuching Port:

- Regional gateway port for Sarawak River basin
- Multi-purpose port to handle full range of cargo classifications
- Container handling port for geared vessels, most transshipped via Port Klang
- Gateway for timber product exports

Bintulu Port:

- Regional gateway port for the eastern Sarawak
- Multi-purpose port to handle full range of cargo classifications
- Gateway for offshore oil and gas industry
- Gateway for onshore industrial development
- Container handling port for geared vessels, most transshipped via Port Klang
- Gateway for timber product exports

Miri Port:

- Gateway for the area which Rajang and Bintulu Ports do not cover

3.2 Development Policy for Rajang Port

On the basis of the federal port policy, in the relationship between Rajang Port and other major ports in Sarawak, that is Kuching, Bintulu and Miri Ports, and development mentioned above, the following roles are ascribed to Rajang Port.

- Regional gateway port for Rajang River basin

- Multi-purpose port to handle full range of cargo classifications
- Container handling port for geared vessels, most transshipped via Port Klang
- Gateway for timber product exports

Rajang Port should play a role as a gateway for general cargo imports, agricultural product exports, timber product exports and coal exports. The following is required if Rajang Port is to play its role efficiently:

- full utilization of the existing facilities
- renovation and expansion of the existing facilities
- new wharf development on the current water depth conditions (no large-scale dredging)
- rational allocation of roles among wharves
- rational container handling
- safe ship maneuvering and port operation

3.3 Needs for Development

3.3.1 Ongoing renovation of the existing facilities

Existing port facilities of Rajang Port were evaluated from the points of view of structural condition, handling capacity and harmony with neighbouring land use. The following points have been examined for development.

- deterioration of the structure
- shortage of capacity

These two points should be imposed on Sibu, Sarikei and Bintangor.

On the other hand, several port facility renovations have been planned and are under construction or about to start as follows;

Table-3.1.1.1 Renovation Plans at Rajang Port

District	Facility	Status
Sibu	Old Wharf (148m)	will be completed in 1992
	Transit Shed	ditto
Sarikei	RPA Wharf (88.5m)	will be completed in 1992
	Transit Shed	ditto
Bintangor	RPA Wharf (48.2m)	partially completed
	Transit Shed	ditto

Therefore, the existing renovation plans are examined in their capacity and new renovation and expansion plans are formulated, if necessary.

3.3.2 Evaluation of the existing wharves

The existing facilities are evaluated in the light of the port demand as follows:

- The future cargo volume is expected to exceed the handling capacity at Sibu Center wharf even if the ongoing renovation is taken into consideration. A supplementary terminal is required.

- Even after the ongoing renovation is completed, the future cargo volume is expected to exceed the handling capacity at Sarikei. However, Sarikei has room for one more berth expansion.

- The existing facility at Bintangor is capable of handling the future demand.

- Although the existing oil jetty at Sungei Merah has the capacity to handle the future demand, oil tankers are at risk in case of fast currents.

- Although at Tg. Manis anchorage, cargoes (logs, timber products, coal, etc.) are currently transferred from barge to ocean-going vessels without a port facility, future mooring facilities will be required to handle timber products rapidly, safely and economically, and handle coal rapidly and economically.

3.3.3 Rationalization of container handling

(1) Terminal capacity

In order to handle containers smoothly, quickly and safely, enough terminal capacity, berth length, apron and container yard areas, are required. The capacity of Sibu Center wharf should be expanded.

At present, containers are handled only at Sibu Center. Cargoes imported by containers are consumption goods such as food and daily necessities and cargoes exported by containers are agricultural products. In future, these cargoes will be transported by containers as it is today. Although present annual handling volume is about 12,000 TEU, the number of containers handled at Rajang Port will grow rapidly due to the growth of population and economic activities in the hinterland as well as to the progress of containerization.

Containers would overflow the present capacity at Sibu Center without construction of more berths, yards and CFS.

Although a renovation project for the terminal is proceeding (reconstruction of wharf [same length, same depth], construction of new transit shed [removal of old shed included], expansion of container yard), the project will increase capacity only for the short-term scheme. As Sibu Center does not have enough room for expansion of the terminal unless the RPA can use the site where the hospital is located (the hospital will move at some time, but even if it is available, there is still no room for berth expansion), a new terminal area will be required.

On the other hand, some part of high grade timber products such as high grade sawn timber, plywood, dowel/moulding and furniture will be vanned in containers. However, as the timber products terminal can handle containers stuffed with timber products, other wharves will not have to handle them.

(2) Terminal location and functional allocation

As capacity expansion of Sibu Center is limited due to land availability, Sibu South wharf and the timber products terminal should share the role as a container terminal or supplement for Sibu Center.

Main container cargo will be consumption goods (import), timber products and agricultural products (export). The consumption and production areas will be Sibu and other major towns (as it is today) and Tg. Manis area where STIDC's TPZ is located and the Rajang River Delta where private sawmills lie. TPZ needs a port facility in front of the industrial development area for exporting timber products while a consumption goods import terminal should be located as near the center of the consumption area as possible to minimize the secondary transportation costs.

On the other hand, it is possible to construct one large-scale container terminal for handling both consumption goods and timber products. However, it would require locating the terminal in front of the TPZ, the most important project in this area, and the terminal at the TPZ would then not have the advantage of terminal consolidation because it can accommodate only up to 10,000 DWT container ships due to the water depth of the estuary, and the entrance to Tg. Manis area, which is too small for a mother container port. Moreover, the terminal would have to compete with Johor Port and the Port of Singapore which have large-scale container handling facilities and are so near Rajang Port that Rajang Port would play a role as a feeder port. Consequently, the container terminal to be constructed will be for feeder container ships.

Moreover, if containers of consumer goods are discharged at the terminal in front of the TPZ, almost all cargoes should be forwarded to Sibu, the center of consumption (100 km upstream by water). This system will not be economical.

Consequently, the handling of containers should be done at the TPZ terminal for timber products export and, at Sibu Center and its supplementary terminal near Sibu, containers should be handled for consumption goods imports and agricultural products exports.

The site at Sibu South is suitable for the supplementary terminal. The site is very near Sibu town and connected through a paved road and is located next to a new industrial development, Upper Lanang Industrial Estate. Although it has the disadvantage of shallow water depth, 6m, Sibu South will be able to accommodate up to 3,000 DWT ships. As many vessels of less than 3,000 DWT currently call at Sibu Center, this situation will not change to a large degree. The disadvantage can be removed by functional allocation; Sibu Center mainly accepts large vessels and Sibu

South accepts small ships up to 3,000 DWT.

Moreover, as the amount of TEUs handled at each wharf of Rajang Port will not be great, the terminal should have a multipurpose function able to handle container and general cargo.

(3) Handling equipment

Rajang Port Authority (RPA) is using the following equipment for container handling currently:

- Load on ship/discharge from ship : Ship crane
- Transportation between apron and yard : Tractor+ Chassis
- Handling in yard : Large forklift
- Vanning/devanning : Small forklift

Taking into consideration the number of container handled (Sibu, 22,000 in 1997 and 61,000 in 2010; TPZ, 21,000 in 1997 and 115,000 in 2010), this combination of equipment is suitable.

However, a large capacity mobile crane will be required to assist the ship crane for quick handling and to handle containers from/on gearless ships, because Rajang Port will play a role as a feeder container port and ships with handling gears are expected to call.

Additional tractors, chassis, large and small forklifts will also be needed for handling the increasing number of containers. Moreover, the handling of a large number of container by only large forklifts may be inconvenient, so we recommend that the introduction of straddle carriers should be examined to evaluate the productivity of a large forklift.

3.3.4 New port development

(1) Terminal for timber products export

More timber logs will be processed into products such as swan timber, plywood, etc., and a terminal for export of these products will be required. The products not only from the STIDC's timber processing zone but also from some of private sawmills scattered through the Rajang River system will be stocked temporarily and loaded on ocean-going ships at the new terminal. Products from private sawmills will be transported by barges or trucks to the transit sheds behind the terminal.

(2) Coal terminal

Coal is the most likely mineral resource to be developed at the Merit Pila mine in the Rajang River Region. The deposit is the biggest in Malaysia and the quality is suitable for fuel for thermal power plants. Moreover, on the basis of the energy diversification strategy of the Malaysian Government, SESCO (Sarawak Electricity Supply Corporation) is interested in utilization of the coal as fuel for three proposed thermal power plants, whose most possible location are at the Tanjung Manis Area, near Kuching and Bintulu. We assume that the SESCO will install a coal thermal power plant in Tg. Manis area.

Coal from the Merit Pila mine will be transported by barges from the loading point near Kaipt to a coal terminal in Tanjung Manis area and stocked in the coal stockyard of the coal terminal. Coal will be fed from this stockyard to a thermal power plant which might be established next to the terminal.

Rajang Port does not have a facility for cola export, although coal is currently exported. Bintulu Port is another possible port for coal export. But Rajang Port is deemed more suitable for coal export port based on the following comparison.

Possible export routes of coal from Merit Pila mine are as follows:

- Merit Pila -(truck)->
  Kapit loading point (existing) -(barge)->
  Rajang Port (Tg. Manis) ->
  ocean-going ship

- Merit Pila -(truck or railway)->
  Bintulu Port ->
  ocean-going ship

The first route has been already established although coal is transferred directly from barges to ocean-going ship in the anchorage. The second route needs the construction of a new road or railway over the mountainous area from Merit Pila mine to Bintulu Port, which is a costly endeavour. Moreover, the operation cost of coal haulage by road (truck) or railway is far higher than that by barge. Therefore, coal should be exported through Rajang Port since it can provide a deep basin to accommodate large coal carriers and reduce freight cost. Moreover, the coal yard, which is proposed to be constructed next to the thermal power plant, could supply the plant with coal as well as serving as a base for exports, thereby reducing costs. Coal could be also carried to another proposed thermal power plant at kuching.

Consequently, the first route is better and Rajang Port is the more suitable port for export of coal from Merit Pila.

(3) Location

i) Locational alternatives

The south bank of Rajang River from the estuary to Sibu is preferable for Port Development from the socioeconomic point of view, that is, urban development (accessibility to consumption and production area), utility such as water and electricity supply and labour procurement.

Taking into consideration natural and socioeconomic conditions, possible sites for new port development and their respective navigable depth from the estuaries of Rajang and Paloh Rivers to the site are as follows:

a) Tg. Manis East (-7.5m)

b) Tg. Sebubal East (-10m)

c) the opposite side of Tg. Sebubal (-10m)

d) Sibu South (Tg. Kumpel East) (-6m)

e) South bank between Tg. Leba-an and Tg. Binjei (-7.5m)

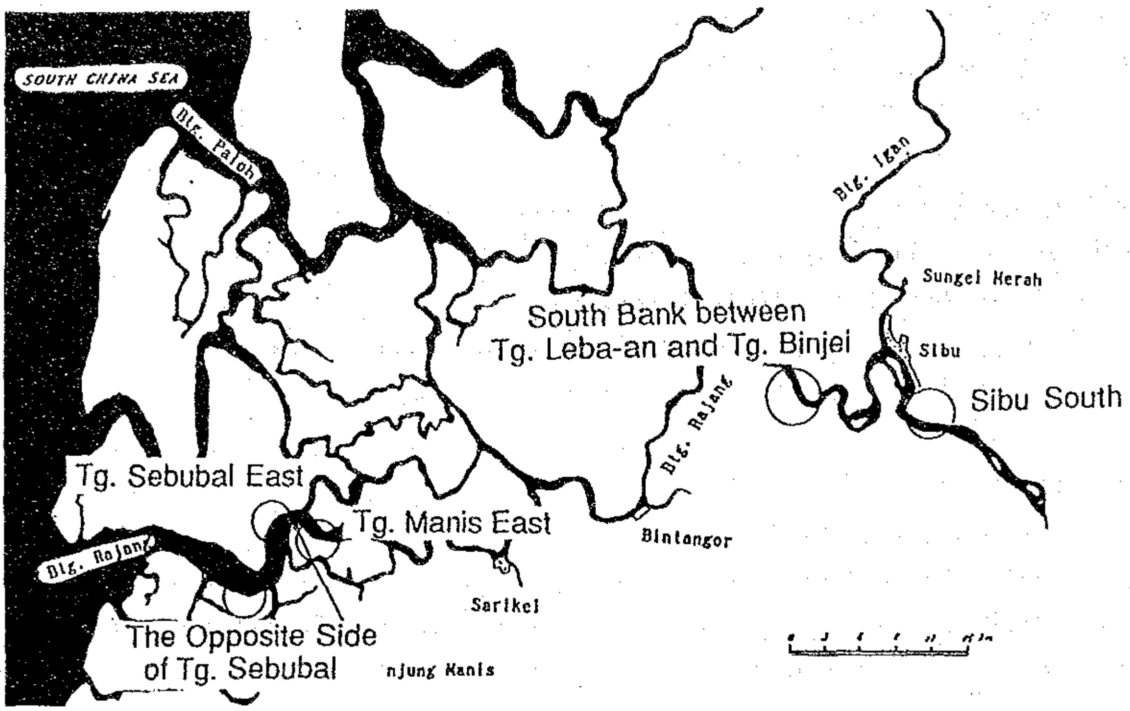


Figure-3.3.4.1 Possible Port Development Sites

Tg. Sebubal East and the opposite side of Tg. Sebubal are possible sites for the timber products and coal terminals (please see **II.2.3.3**).

A coal terminal tends to emit coal dust during handling coal at wharves and coal yards. So, the coal and timber products terminals should be maintained separately (coal dust generally travels about 1,000m). Sites B and C have such huge areas that the two terminals can be located with an appropriate distance between them.

Consequently, the timber products and coal terminals can be located at both sites B and C, which means that there are a few locational alternatives. The alternative locational plans for the timber and coal terminals are as shown in **Figure-3.3.4.2** to **3.3.4.5**.

ii) Comparison and the optimum plan

The four alternative plans were compared from the following points of view.

- distance from urban area:
  industry area, especially coal terminal should be kept separate from urban areas,

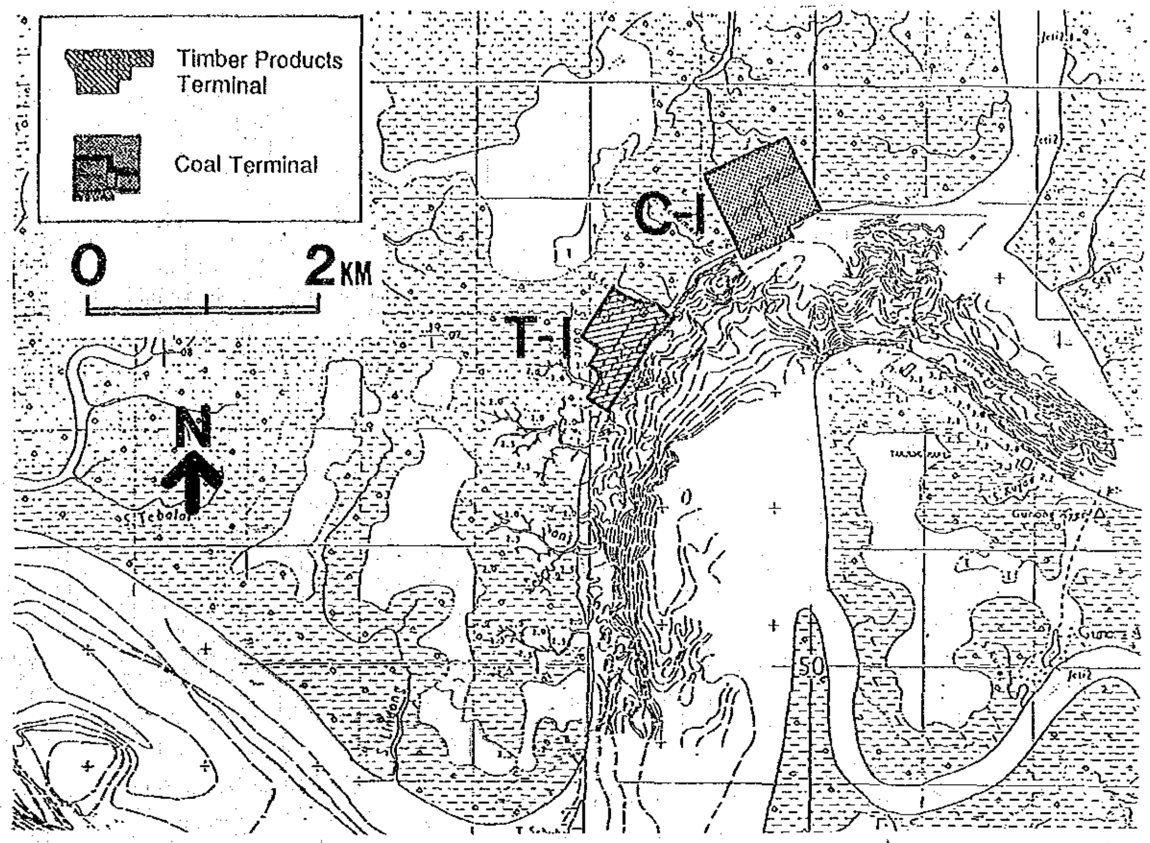


Figure-3.3.4.2 Locational Alternative (1) for Timber Products and Coal Terminals

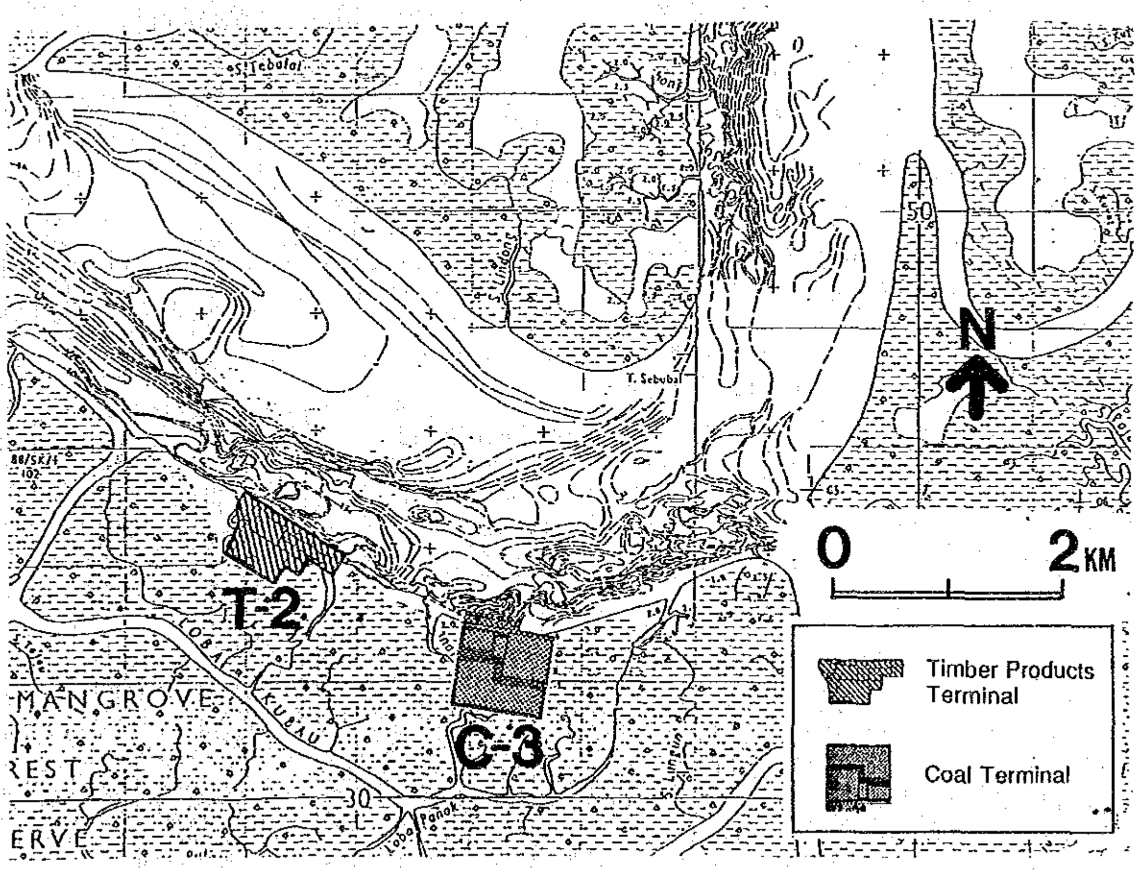


Figure-3.3.4.3 Locational Alternative (2) for Timber products and Coal Terminals

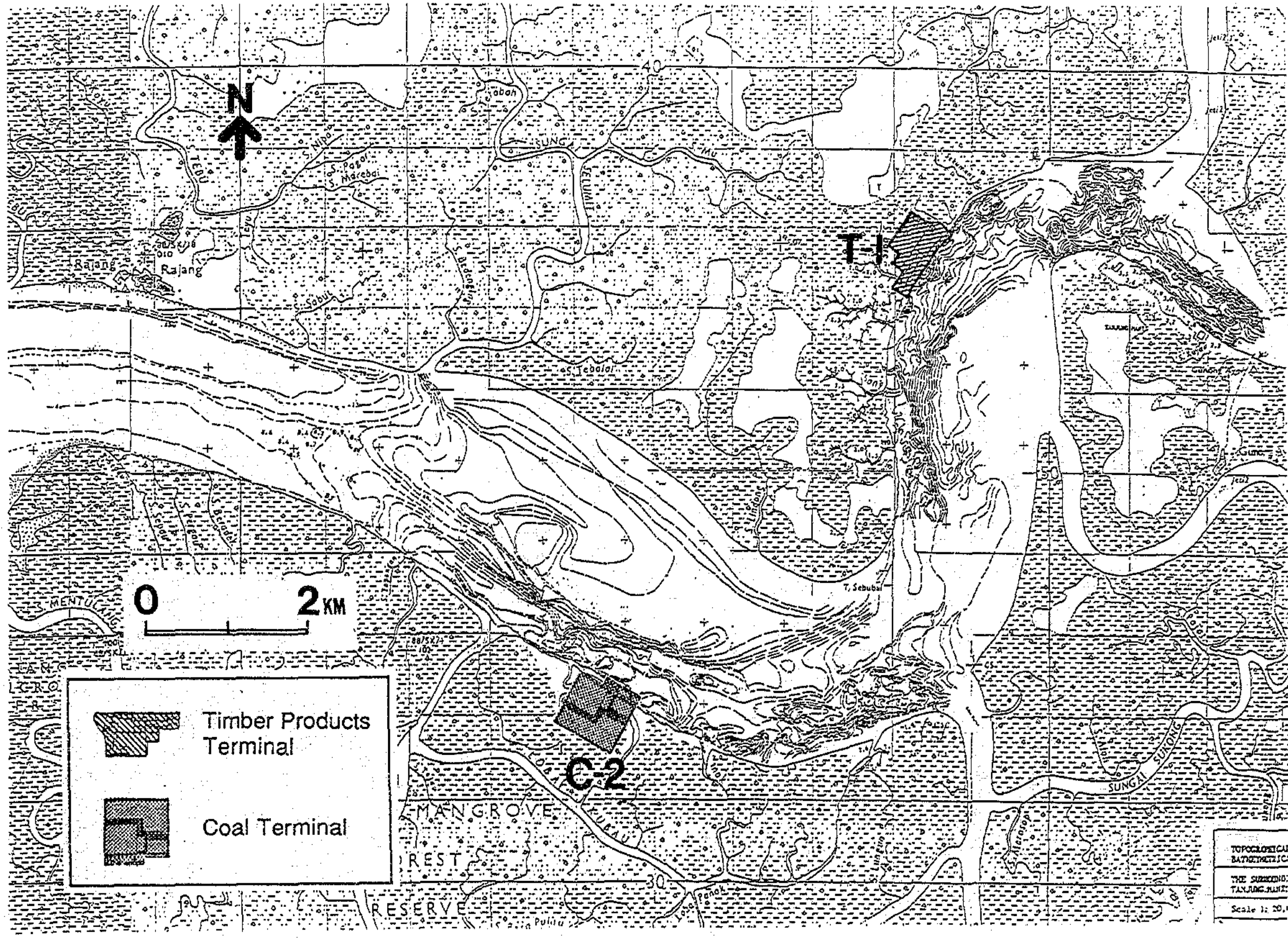


Figure-3.3.4.4 Locational Alternative (3)
for Timber Products and Coal Terminals

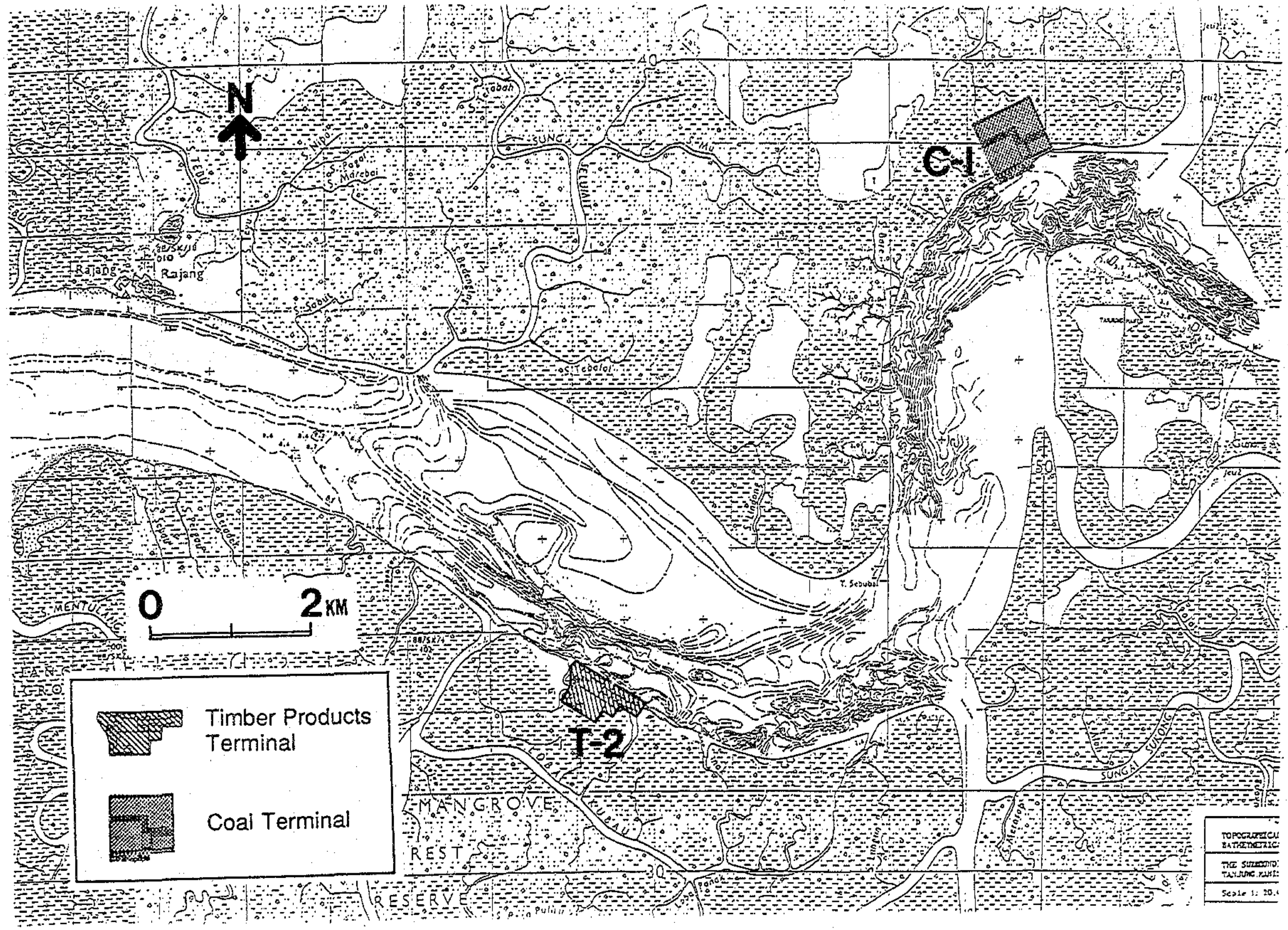


Figure-3.3.4.5 Locational Alternative (4) for Timber Products and Coal Terminals

- distance between the timber products terminal and the coal terminal:
  timber products will deteriorate if coal dust sticks to the surface,
- labour commuting:
  although the industrial zone includes residential areas, some workers will commute from outlying areas,
- natural conditions:
  hard stratum, topography, waterfront stability (erosion and sedimentation) and wave conditions,
- capital costs,
- impacts on environment.

i) Distance from urban area

Figure-3.3.4.6 shows the locational relationship of alternative coal terminals and urban areas. This figure shows all alternative terminals have a distance of more than 1km to the nearest urban area (See **Appendix-II.3.3.1.** Flying Distance of Coal Dust).

ii) Distance between the timber products terminal and the coal terminal

Similarly, the timber products terminal preferably need to have a distance of more than 1km to the coal terminal.

iii) Labour commuting

Figure-3.3.4.7 shows a possible commuting route of workers. This shows that site B can be reached via the road under construction that will conect Belawai, Rajang and the site B, and that this situation makes the site B more convenient than site C from the commuting point of view.

vi) Natural conditions

Figure-3.3.4.8 to **3.3.4.10** show natural conditions such as hard stratum, topograpy, waterfront stability and wave. These show:

- hard stratum: no significant difference,
- topography: land level of site C is lower than that of site B by 0.5-1.0m, site C has more creaks than site B,
- waterfront stability: almost no difference, sites for timber products terminal (T-1) and Coal terminal (C-1 and C-3) are located in a slightly erosive area which needs shore revetment,

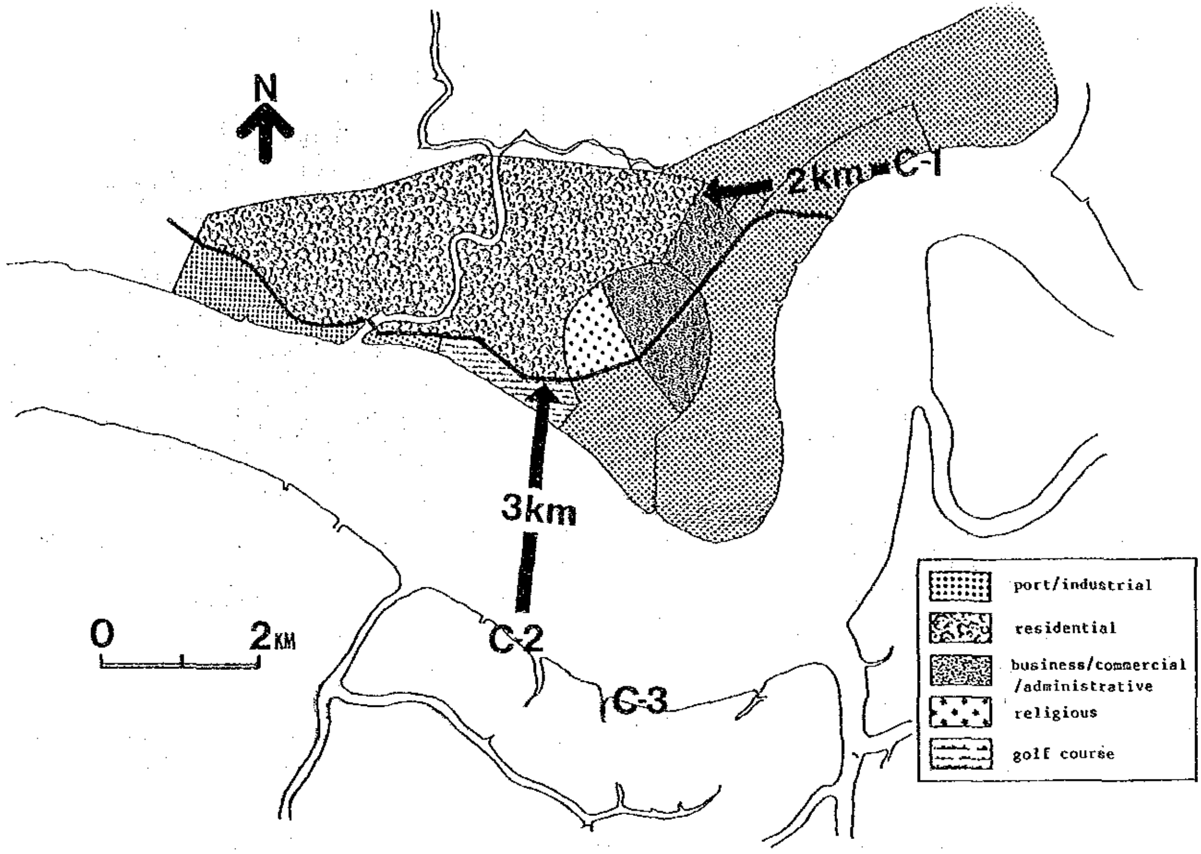


Figure-3.3.4.6 Distances for Alternative Coal Terminals to the Proposed Urban Area in TPZ

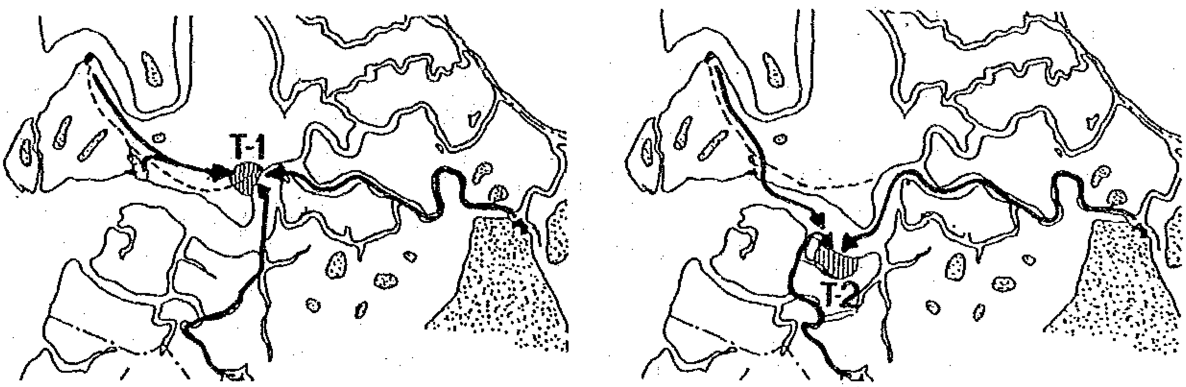


Figure-3.3.4.7 Comparison of Commuting Routes

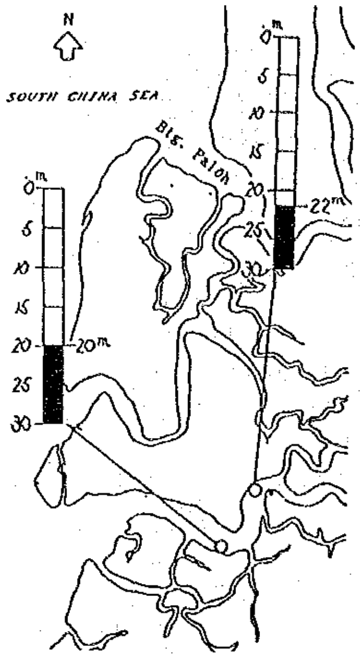


Figure-3.3.4.8 Comparison of Hard Strata

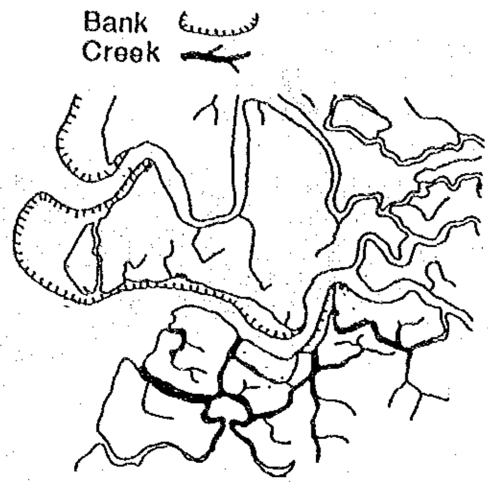


Figure-3.3.4.9 Comparison of Topography

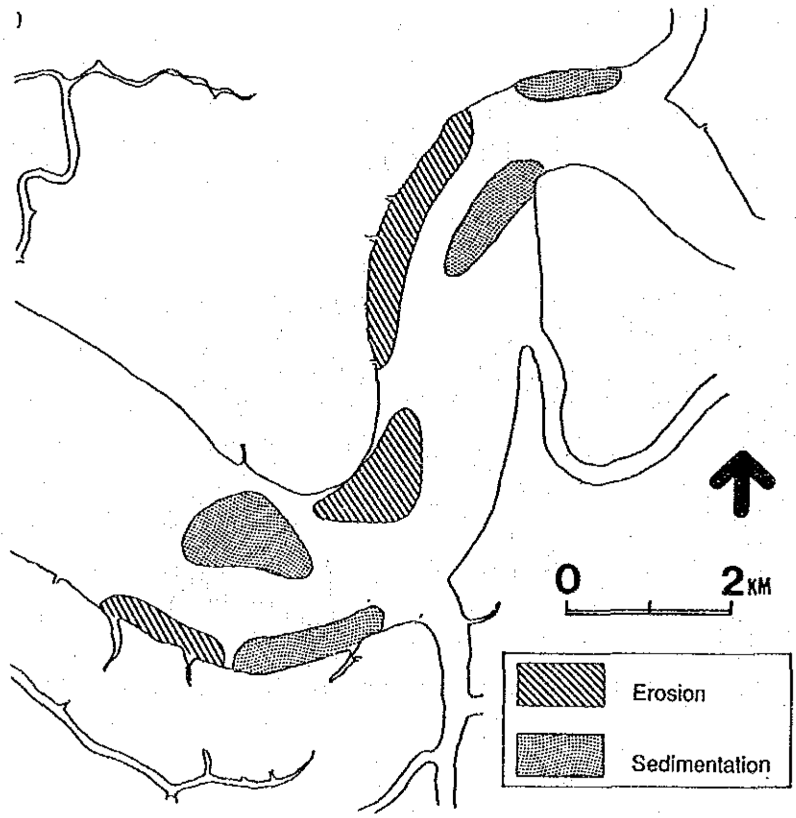


Figure-3.3.4.10 Waterfront Stability in Tg. Manis Area

- waves:

waves coming from the estuary make the basin in front of site C turbulent a little, while Tg. Sebubal shelters the basin in front of site B, so, site B is better than site C from the viewpoint of wave condition.

v) Capital costs

To operate the terminals, road and water/electricity supply are required for development at B and C as shown in **Figure-3.3.4.11.**

Table-3.3.4.1 show capital costs for terminal infrastructure and the related facilities such as road and water supply (electricity can be generated in the development area).

Table-3.3.4.1 Comparison of Capital Costs (million Ringgit)

Alternative	Timber products terminal	Coal terminal	Capital costs			
			terminal *infra-structure*	road	water supply	Total
1	T-1	C-1	212	0	20	232
2	T-2	C-3	218	21	10	249
3	T-1	C-2	213	0	30	243
4	T-2	C-1	217	21	10	248

vi) Impacts on environment

There is probably no rare or protected species in either site B or C. If the sites are developed, the mangrove forest will be affected. However the impact on the mangrove forest will be limited, and there will be no significant difference between the impact on site B and C.

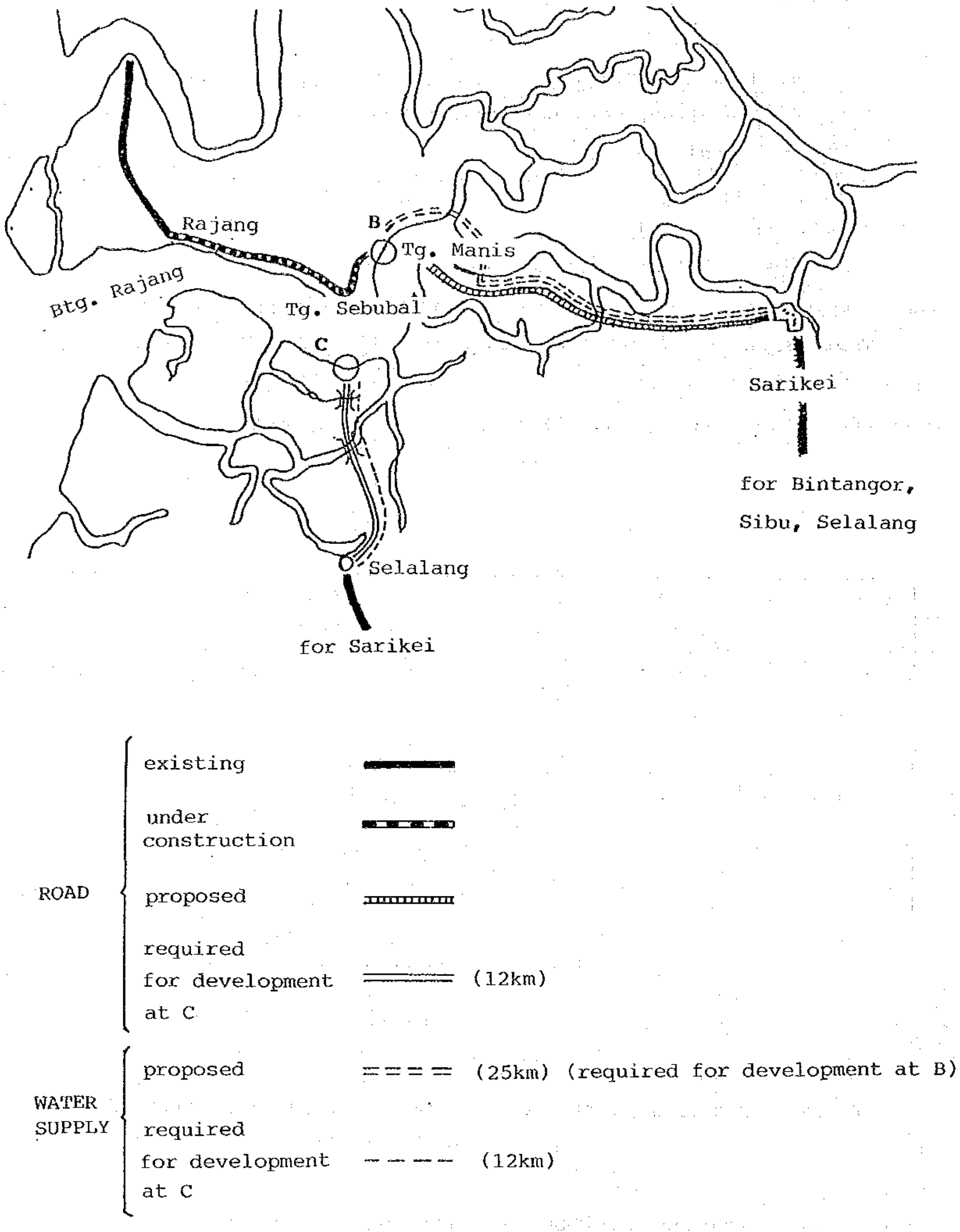


Figure-3.3.4.11 Required Related Infrastructure for Development at B and C

vii) Conclusion

Table-3.3.4.2 shows overall comparison among four alternatives. This shows that Alternative-1 have the best evaluation and Alternative-3 is evaluated as the second best.

Table-3.3.4.2 Overall Comparison

Evaluation Points	ALTERNATIVES 1	2	3	4
Distance from Urban Areas	A	A	A	A
Distance between the timber products and coal terminals	B	B	A	A
Labour Commuting	A	B	A	B
Natural Conditions				
Hardpan	A	A	A	A
Topography	A	B	B'	B
Waterfront Stability	B	B	B	B
Wave	A	B	A	B
Capital Costs	A	B	B	B
Impacts on environment	B'	B	B	B
OVERALL EVALUATION	**A**	**B**	**B'**	**B**

* A > B' > B

3.4 General Concepts on Allocation of Roles for Sibu, Sarikei, Bintangor, Sungei Merah and Tanjung Manis Area

The allocation of roles for Sibu, Sarikei, Bintangor, Sungei Merah and Tanjung Manis area are determined by the natural and socioeconomic conditions.

3.4.1 Sibu

Sibu is the center of the Rajang River Region and is the site of the most vital urban and economic activities. Moreover, Sibu has played a role as trade center for consumption goods and some agricultural products in the region, especially in Sibu, and Kapit divisions. This situation will probably not change because the basic urban and industrial structure of the two divisions will not change. Therefore, Sibu should keep the same role.

3.4.2 Sarikei

Sarikei plays a role as an export center of agricultural products such as pepper, rubber and palm products as well as being an import terminal for consumption goods for Sarikei town and the vicinity. Large-scale palm tree plantation projects are on-going or proposed in Saratok and Betong districts and crude palm oil and palm kernel will be shipped out through Sarikei Wharf. Consequently, the role of Sarikei as an agricultural products export center will not change. Moreover, Sarikei will handle more consumption goods due to population growth in the Sarikei town and the vicinity.

3.4.3 Bintangor

Bintangor imports fertilizers mainly and acts as a supplementary wharf to Sarikei. Bintangor also handles imported consumption goods. This situation will be maintained in the future.

3.4.4 Sungei Merah

Sungei Merah is the petroleum products distribution center of the Rajang River Region. Esso and Shell have oil tanks behind the existing jetty and accept petroleum products from Port Dickson, West Malaysia, etc. and deliver to almost all areas in Sarawak. Moreover, Petronas plans to construct a new oil terminal which consists of a private jetty and oil tanks about 1 km downstream of the Igan River. The RPA wharf will not handle other cargo because of its proximity to Sibu Center wharf, the trading center of the region. Therefore, Sungei Merah wharf will continue to be the oil distribution center.

3.4.5 Tanjung Mains Area

Tanjung Manis area has no port facility except anchorage where export cargoes are transferred from barges to ocean-going ships. This area has the deepest basin in the region and is suitable for terminal development at which large ships can call. The TPZ will be located here and need port facilities for timber products export. Moreover, this area seems suitable for coal terminal development because the basin is deep and because the area is not heavily populated. Conversely, this area is not suitable for general cargo terminal for the same reason. Consequently, this area should play a role as a timber products exports center and a coal terminal.

3.5 Perspective of Rajang Port

Improvement of Rajang Port will progress according to the several demands stated in 3.1 and functional allocation among wharves stated in 3.2. Here, we show the perspective of Rajang Port in **Table-3.5.1.1** for three periods, that is, up to 1997 (target year for the short-term plan), between 1997 and 2010 (target year for the master plan), and beyond 2010 (detailed discussion about possible development site beyond 2010 is shown in **Appendix-II.3.5.1**).

Table-3.5.1.1 Perspective of Rajang Port

Wharf	- 1997	1997 - 2010	beyond 2010
Sibu	Center: Renovation 148m wharf transit shed open yard	South: New Terminal wharf transit shed open yard	South: Expansion wharf transit shed open yard Center: Expansion open yard (hospital area)
Sarikei	Expansion 88.5m wharf open yard Renovation transit shed	Expansion wharf open yard	
Bintangor	Renovation (completed) 48.2m wharf transit shed open yard		
Sungei Merah	New terminal one jetty		

Table-3.5.1.1 Perspective of Rajang Port (continued)

Wharf	- 1997	1997 - 2010	beyond 2010
T.Manis Area	Timber Products Terminal deep wharf shallow wharf transit shed open yard	Expansion of Timber Products Terminal	Expansion of Timber Products Terminal
	Coal Terminal deep wharf shallow wharf coal yard	Expansion of Coal Terminal	Expansion of Coal Terminal
			New Wharf Development at Tg. Manis East
Other Areas			New Wharf Development at South Bank between T.Leba-an & T.Binjei

4. DEMAND FORECAST

4.1 Forecast of Population

4.1.1 Forecast method

(1) Selection of Forecast Method

Population is a basic piece of information for forecasting other socio-economic indices such as traffic volume and consumption. Population is often forecast by time-series analysis and sometimes is projected by using so-called "cohort survival analysis." Cohort survival analysis is a demographic forecast method which employs population, birth rate, death rate and social increase/decrease of population (migration) by age group at one point in time and projects age-grouped population after one time step.

The time-series method is simple but cannot reflect population distribution by age group or changes in birth and death rates. On the other hand, the cohort survival analysis can reflect them rationally although the migration factor is still uncertain. In this study, cohort survival analysis is used for forecasting population of each community whose birth and death rates differ from community to community.

(2) Cohort Survival Analysis

The population of each age group (the age step should be same as the time step) one time step ahead can be calculated from the present population of each age group, present birth/death rate of each age group and migration during one time step from the present. This process can be expressed in the following formula:

$$_1P_{t+1} = \sum_j ({_jP_t} * {_jb_t}) + {_1M_{t+1}} \qquad (4.1.1.1)$$

$$_{i+1}P_{t+1} = {_iP_t} * (1- {_id_t}) + {_{i+1}M_{t+1}} \qquad (4.1.1.2)$$

where,

$_iP_t$: Population of Age Group i in Period t

$_ib_t$: Birth Rate of Age Group i in Period t

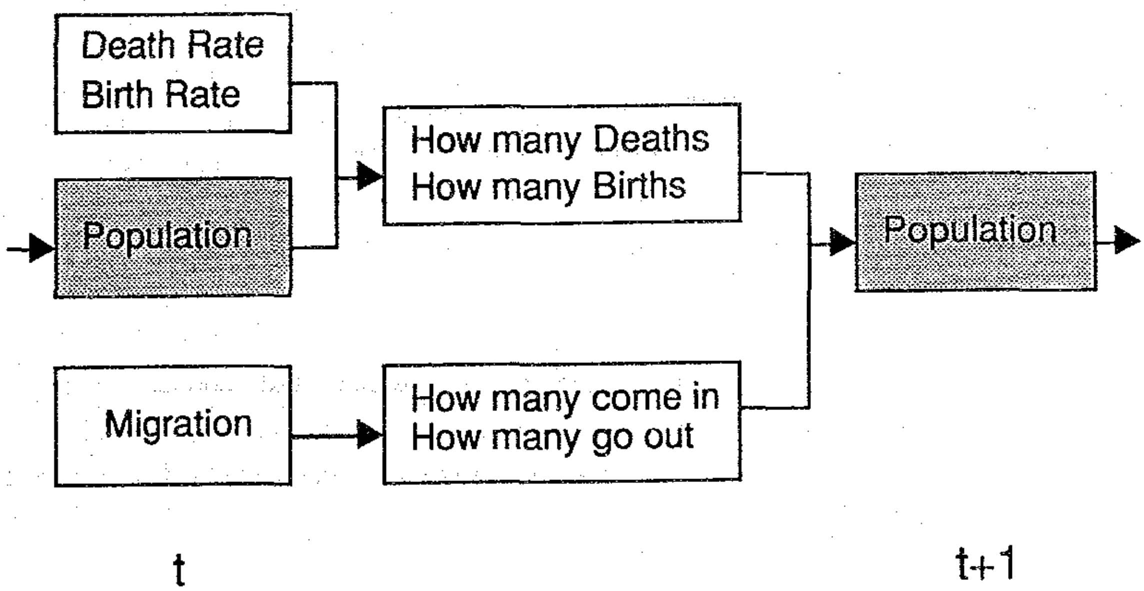
$_id_t$: Death Rate of Age Group i in Period t

$_iM_t$: Migråtion of Age Group i in Period t or, $$P_{t+1} = B_t * P_t + M_{t+1} \qquad (4.1.1.3)$$

$$P_{t+1} = \begin{bmatrix} {}_1P_{t+1} \\ {}_2P_{t+1} \\ \cdot \\ \cdot \\ \cdot \\ {}_nP_{t+1} \end{bmatrix} \qquad (4.1.1.4)$$

$$B_t = \begin{bmatrix} {}_1b_t, & {}_2b_t, & \cdots\cdots, & {}_{n-1}b_t, & {}_nb_t \\ (1-{}_1d_t), & 0, & \cdots\cdots, & 0, & 0 \\ 0, & (1-{}_2d_t), & \cdots\cdots, & 0, & 0 \\ \cdot, & 0, & \cdots\cdots, & 0, & 0 \\ \cdot & \cdot & \cdots\cdots, & 0, & 0 \\ 0, & 0, & \cdots\cdots, & (1-{}_{n-1}d_t), & (1-{}_nd_t) \end{bmatrix} \qquad (4.1.1.5)$$

$$M_{t+1} = \begin{bmatrix} {}_1M_{t+1} \\ {}_2M_{t+1} \\ \cdot \\ \cdot \\ \cdot \\ {}_nM_{t+1} \end{bmatrix} \qquad (4.1.1.6)$$



Usually, calculation time step and age group pitch is five or ten years.

Future birth and death rates should be forecast by time-series regression or other methods. However, future migration depends on the migration policies of the state and federal government. Therefore, we first forecast population every five years up to the present by this method, without accounting for the migration factor. Second, we analyze a trend on forecast error, the difference between actual and forecast population and assume the future correction rate.

4.1.2 Forecast process

(1) Goal of forecast

Through the forecasting, the following population data should be obtained.

- birth and death rate by age group and community in Sarawak from 1990 to 2010

- population of each district in the hinterland in 1997 and 2010

Although, using the forecast process, population by age group, community and district is calculated, this detailed figure is not used for further demand forecast of cargo and passenger volume. Populations in 1995, 2000 and 2005 are also forecast because the cohort survival analysis forecasts for each period, which is five years in this case.

(2) Data necessary for forecasting

For forecasting, the following data are needed.

- time series population data of each district by age group and community in the hinterland

The populations of each district by age group and community in the hinterland are shown in **Appendix-II.4.1.1.** Here, populations by district and community from 1960 through 1990 are shown in **Table-4.1.2.1.**

- time-series birth and death rate data by age group and community in Sarawak

As these data could not be obtained, but can be estimated from the data by age group and community in latest year **(Table-4.1.2.2)** and the time-series data by community **(Table-4.1.2.3)**.

Table-4.1.2.1(1) Population of the Hinterland by District and Community (1960)

COMMUNITY / DISTRICT	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other	TOTAL
Betong	11604	48	13782	11	1	2832	14	28292
Saratok	7331	31	14926	49	5	2234	36	24612
Sibu	6804	2816	15009	96	183	52047	327	77282
Mukah	241	8249	12783	28	34	2660	100	24095
Kanowit	266	101	15958	8	13	5015	12	21373
Dalat	134	7643	5080	7	38	1688	39	14629
Sarikei	1823	4436	6850	39	124	14780	102	28154
Maradong	2344	1116	6189	18	6	11632	50	21355
Daro	252	11862	312	3	1	889	20	13339
Julau	54	85	18729	21	23	1289	14	20215
Kapit	316	1010	20841	12	606	1954	21	24760
Song	194	249	9669	5	20	536	8	10681
Belage	118	356	312	4	4579	222	13	5604
TOTAL	31481	38002	140440	301	5633	97778	756	314391

Source: Statistic Department, Sarawak, Census of Population

Table-4.1.2.1(2) Population of the Hinterland by District and Community (1970)

COMMUNITY / DISTRICT	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other	TOTAL
Betong	15695	64	16127	28	13	3050	19	34996
Saratok	9440	53	17667	63	11	2739	29	30002
Sibu	9538	5813	18901	278	414	62680	372	97996
Mukah	419	10047	15530	48	48	2844	69	29005
Kanowit	550	188	19969	25	27	5223	16	25998
Dalat	239	9517	6312	12	53	1847	27	18007
Sarikei	2800	5599	8422	100	99	16898	88	34006
Maradong	2981	1297	8054	44	26	12565	36	25003
Daro	292	12432	372	9	2	875	17	13999
Julau	103	139	20486	45	38	1178	17	22006
Kapit	489	612	25597	46	769	2437	55	30005
Song	322	161	12717	22	30	719	24	13995
Belage	186	219	391	18	5871	285	36	7006
TOTAL	43054	46141	170545	738	7401	113340	805	382024

Source: ditto

Table-4.1.2.1(3) Population of the Hinterland by District and Community (1980)

COMMUNITY / DISTRICT	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other	TOTAL
Betong	18531	71	17175	35	16	3016	20	38864
Saratok	11762	68	20813	69	14	3303	15	36044
Sibu	14265	10023	26750	512	725	86447	487	139209
Mukah	613	12466	19247	61	56	3196	26	35665
Kanowit	787	255	22485	28	30	5040	8	28633
Dalat	339	11549	7649	14	62	2028	10	21651
Sarikei	4113	7436	11020	168	74	21071	75	43957
Maradong	3637	1479	9989	61	38	13613	15	28832
Daro	392	15643	503	11	3	1046	6	17604
Julau	161	215	26390	72	53	1295	10	28196
Kapit	700	264	32778	69	1401	3141	76	38429
Song	430	65	15207	32	46	862	28	16670
Belage	262	93	490	23	10592	357	49	11866
TOTAL	55992	59627	210496	1155	13110	144415	825	485620

Source: ditto

Table-4.1.2.1(4) Population of the Hinterland by District and Community (1990, estimate)

COMMUNITY / DISTRICT	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other	TOTAL
Betong	24097	82	20512	44	23	3696	23	48477
Saratok	14869	89	24960	101	23	3940	20	44002
Sibu	19432	12540	31992	623	1086	104908	562	171143
Mukah	687	14703	23309	81	96	3746	30	42652
Kanowit	1041	374	29484	38	28	6531	15	37511
Dalat	384	13738	9340	20	107	2399	12	26000
Sarikei	5215	9433	11571	214	151	25324	77	51985
Maradong	4590	1905	10729	82	60	16623	14	34003
Daro	478	19408	521	15	5	1231	7	21665
Julau	207	304	32987	89	44	1591	17	35239
Kapit	919	683	39878	90	1739	3979	94	47382
Song	577	174	18962	42	60	1118	37	20970
Belage	346	243	601	32	13181	456	61	14920
TOTAL	72842	73676	254846	1471	16603	175542	969	595949

Table-4.1.2.2 Birth and Death Rates by Age Group and Community 1988, Sarawak

(Birth Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other	TOTAL
0- 4	0	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0	0
15-19	23.70	14.99	39.40	25.59	29.60	10.19	1.70	24.96
20-24	101.20	71.73	81.45	82.55	100.14	63.90	44.43	80.21
25-29	134.42	105.61	81.64	106.40	117.51	118.60	48.87	108.39
30-34	91.81	92.88	64.27	80.27	97.01	92.74	22.37	83.24
35-39	58.59	64.66	37.57	47.20	51.06	38.37	9.61	44.52
40-44	23.62	23.52	14.24	20.47	18.66	5.40	3.77	14.41
45-49	2.76	3.42	3.21	2.43	4.84	0.71	0	2.36
50-54	0	0	0	0	0	0	0	0
55-59	0	0	0	0	0	0	0	0
60-64	0	0	0	0	0	0	0	0
65-	0	0	0	0	0	0	0	0
TOTAL	34.22	28.62	26.79	29.73	32.79	28.46	11.54	29.31

Source: Statistic Department, Sarawak, Vital Statistics

(Death Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other	TOTAL
0- 4	3.23	3.30	2.60	3.52	3.08	1.91	0	2.71
5- 9	0.23	0.27	0.30	0.25	0.11	0.20	0	0.24
10-14	0.21	0.97	0.21	0.24	0.27	0.49	0	0.33
15-19	0.53	0.29	0.47	0.30	0.57	0.68	0	0.51
20-24	0.58	0.63	0.69	0.33	0.91	0.83	0.66	0.68
25-29	0.90	1.03	1.17	0.97	1.41	1.05	1.22	1.07
30-34	0.88	2.22	1.31	1.25	1.74	0.87	0.56	1.12
35-39	0.98	1.97	1.82	1.88	1.47	1.65	0.53	1.56
40-44	2.47	3.44	2.20	3.53	1.55	1.63	0.75	2.20
45-49	3.47	3.70	2.29	5.52	3.63	3.81	0.89	3.32
50-54	7.23	6.53	5.25	8.62	6.11	5.68	6.00	6.18
55-59	11.38	8.03	9.00	12.63	6.03	8.73	9.00	9.36
60-64	19.55	19.86	13.97	16.49	13.79	13.40	13.00	15.13
65-	50.52	53.73	28.59	43.54	18.52	46.37	30.00	38.70
TOTAL	3.43	4.53	3.26	3.56	2.69	3.66	-	3.45

Source: ditto

Table-4.1.2.3 Birth and Death Rates by Community 1960-1988, Sarawak (per 1000)

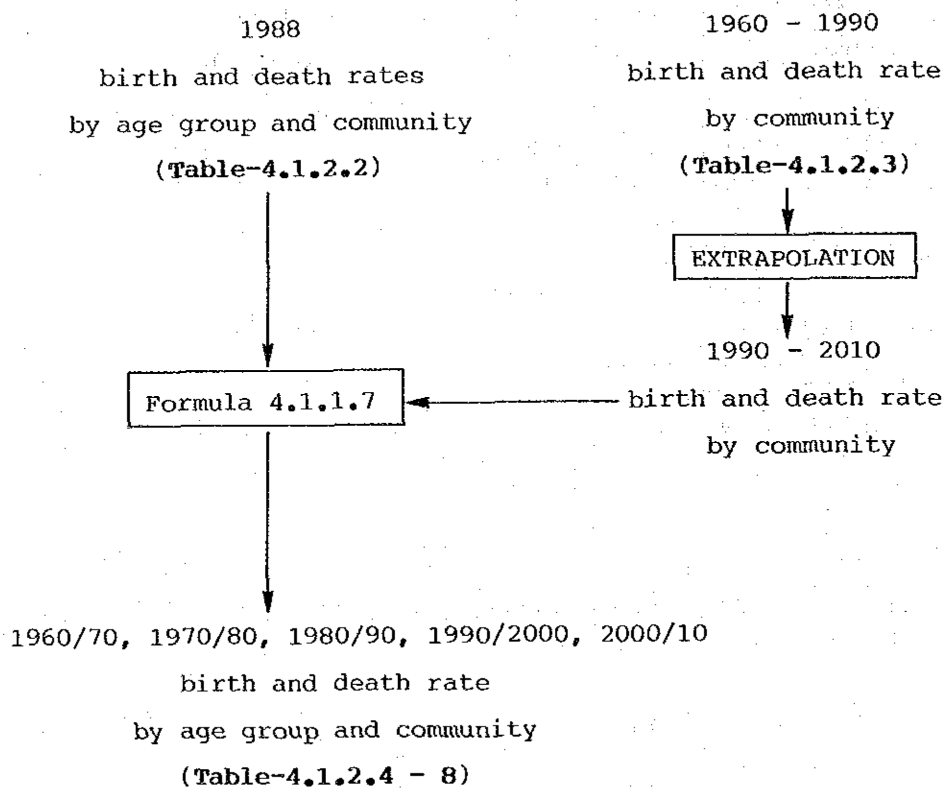
	1960	1965	1970	1975	1980	1985	1988
Malay	34.2 10.6	38.2 8.9	42.2 7.3	37.7 6.5	36.2 4.4	35.4 3.9	34.2 3.4
Melanau	17.5 6.8	22.0 6.9	26.5 6.9	31.0 7.0	32.0 5.4	35.4 5.1	28.6 4.5
Iban	10.7 3.3	13.5 3.5	16.3 3.7	20.8 3.9	22.4 3.5	25.7 3.7	26.8 3.3
Bidayuh	36.7 9.1	39.9 7.6	43.2 6.1	36.0 5.7	30.4 3.9	30.0 3.5	29.7 3.6
Other B.	23.1 3.8	25.2 3.9	27.4 3.9	29.0 3.2	26.2 2.4	32.4 3.1	32.8 2.7
Chinese	38.1 5.1	38.0 5.1	38.0 5.1	32.5 4.8	30.6 4.5	26.7 3.9	28.5 3.7
Other	23.1 3.8	25.2 3.9	27.4 3.9	27.8 6.2	23.5 3.5	9.3 1.6	11.5 1.2

Upper: birth rate
Lower: death rate
Source: Statictic Department, Sarawak, Vital Statistics

(3) Forecasting procedure

Forecasting is carried out according to the following flow chart.

i) forecasting future birth and death rates.



- forecasting formula

Birth (death) rate in period p are estimated by multiplying the birth (death) rate in 1988 by changing the ratio of all age birth rate (period p/1988).

Projection is made as follows.

$$ {}_{i}b_{p}{}^{c} = {}_{i}b_{88}{}^{c} * ({}_{T}b_{p}{}^{c} / {}_{T}b_{88}{}^{c}) $$

$$ {}_{i}d_{p}{}^{c} = {}_{i}d_{88}{}^{c} * ({}_{T}d_{p}{}^{c} / {}_{T}d_{88}{}^{c}) \qquad (4.1.1.7) $$

where,

${}_{i}b_{p}{}^{c}$: average annual birth rate of age group i in period p for community c

${}_{i}b_{88}{}^{c}$: annual birth rate of age group i in 1988 for community c

${}_{T}b_{p}{}^{c}$: average annual birth rate of all ages in period p for community c

${}_{T}b_{88}{}^{c}$: annual birth rate of all ages in 1988 for community c

${}_{i}d_{p}{}^{c}$: average annual death rate of age group i in period p for community c

${}_{i}d_{88}{}^{c}$: annual death rate of age group i in 1988 for community c

${}_{T}d_{p}{}^{c}$: average annual death rate of all ages in period p for community c

${}_{T}d_{88}{}^{c}$: annual death rate of all ages in 1988 for community c

- results

The results are shown in Tables-4.1.2.4 - 8.

Table-4.1.2.4 Annual Birth and Death Rates by Age Group and Community 1960/70, Sarawak

(Birth Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0
15-19	26.47	11.53	19.85	34.42	22.79	13.60	3.73
20-24	113.04	55.18	41.03	111.04	77.09	85.31	97.55
25-29	150.14	81.24	41.12	143.12	90.46	158.34	107.30
30-34	102.55	71.45	32.37	107.97	74.68	123.82	49.12
35-39	65.44	49.74	18.93	63.49	39.31	51.23	21.10
40-44	26.38	18.09	7.17	27.53	14.36	7.21	8.28
45-49	3.08	2.63	1.62	3.27	3.73	0.95	0
50-54	0	0	0	0	0	0	0
55-59	0	0	0	0	0	0	0
60-64	0	0	0	0	0	0	0
65-	0	0	0	0	0	0	0
TOTAL	38.22	22.02	13.49	39.99	25.24	38.00	25.34

(Death Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	8.46	5.02	2.76	7.43	4.39	2.63	0
5- 9	0.60	0.41	0.32	0.53	0.16	0.28	0
10-14	0.55	1.48	0.22	0.51	0.39	0.68	0
15-19	1.39	0.44	0.50	0.63	0.81	0.94	0
20-24	1.52	0.96	0.73	0.70	1.30	1.14	2.12
25-29	2.36	1.57	1.24	2.05	2.01	1.45	3.91
30-34	2.31	3.38	1.39	2.64	2.48	1.20	1.80
35-39	2.57	3.00	1.93	3.97	2.10	2.27	1.70
40-44	6.47	5.24	2.33	7.45	2.21	2.25	2.41
45-49	9.09	5.63	2.43	11.65	5.18	5.25	2.86
50-54	18.94	9.94	5.57	18.20	8.71	7.83	10.00
55-59	29.82	12.22	9.55	26.66	8.60	12.03	16.00
60-64	51.23	30.23	14.82	34.81	19.66	18.47	15.00
65-	132.38	81.79	30.32	91.92	26.41	63.92	40.00
TOTAL	8.99	6.90	3.46	7.52	3.84	5.04	-

Table-4.1.2.5 Annual Birth and Death Rates
by Age Group and Community
1970/80, Sarawak

(Birth Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0
15-19	26.42	15.81	29.51	30.84	25.09	11.88	4.05
20-24	112.82	75.66	61.00	99.48	84.89	74.47	105.74
25-29	149.86	111.40	61.15	128.22	99.61	138.22	116.30
30-34	102.35	97.97	48.14	96.73	82.24	108.08	53.24
35-39	65.32	68.21	28.14	56.88	43.28	44.72	22.87
40-44	26.33	24.81	10.67	24.67	15.82	6.29	8.97
45-49	3.08	3.61	2.40	2.93	4.10	0.83	0
50-54	0	0	0	0	0	0	0
55-59	0	0	0	0	0	0	0
60-64	0	0	0	0	0	0	0
65-	0	0	0	0	0	0	0
TOTAL	38.15	30.19	20.07	35.83	27.80	33.17	27.46

(Death Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	5.59	4.81	2.79	5.28	3.27	2.40	0
5- 9	0.40	0.39	0.32	0.38	0.12	0.25	0
10-14	0.36	1.41	0.23	0.36	0.29	0.61	0
15-19	0.92	0.42	0.50	0.45	0.61	0.85	0
20-24	1.00	0.92	0.74	0.50	0.97	1.04	2.61
25-29	1.56	1.50	1.25	1.46	1.50	1.32	4.83
30-34	1.52	3.24	1.40	1.88	1.85	1.09	2.22
35-39	1.70	2.87	1.95	2.82	1.56	2.07	2.10
40-44	4.28	5.01	2.36	5.30	1.65	2.04	2.97
45-49	6.01	5.39	2.45	8.29	3.86	4.78	3.52
50-54	12.52	9.52	5.63	12.94	6.49	7.12	10.00
55-59	19.7	11.70	9.64	18.96	6.41	10.95	11.84
60-64	33.85	28.95	14.97	24.76	14.65	16.81	15.00
65-	87.46	78.32	30.64	65.36	19.67	58.16	40.00
TOTAL	5.94	6.6	3.49	5.34	2.86	4.59	-

Table-4.1.2.6 Annual Birth and Death Rates by Age Group and Community 1980/90, Sarawak

(Birth Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0
15-19	23.81	15.46	37.22	25.63	27.27	9.67	2.03
20-24	101.68	74.00	76.95	82.68	92.27	60.63	53.09
25-29	135.06	108.95	77.13	106.56	108.28	112.53	58.39
30-34	92.25	95.82	60.72	80.39	89.39	87.99	26.73
35-39	58.87	66.71	35.49	47.27	47.05	36.41	11.48
40-44	23.73	24.26	13.45	20.50	17.19	5.12	4.50
45-49	2.77	3.53	3.03	2.43	4.46	0.67	0
50-54	0	0	0	0	0	0	0
55-59	0	0	0	0	0	0	0
60-64	0	0	0	0	0	0	0
65-	0	0	0	0	0	0	0
TOTAL	34.38	29.53	25.31	29.78	30.21	27.00	13.79

(Death Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	3.61	3.40	2.59	3.57	3.04	2.01	0
5- 9	0.26	0.28	0.30	0.25	0.11	0.21	0
10-14	0.23	1.00	0.21	0.24	0.27	0.52	0
15-19	0.59	0.30	0.47	0.30	0.56	0.72	0
20-24	0.65	0.65	0.69	0.33	0.90	0.87	0.89
25-29	1.00	1.06	1.17	0.98	1.39	1.11	1.64
30-34	0.98	2.29	1.31	1.27	1.72	0.92	0.75
35-39	1.09	2.03	1.81	1.91	1.45	1.74	0.71
40-44	2.76	3.55	2.19	3.58	1.53	1.72	1.01
45-49	3.87	3.82	2.28	5.60	3.59	4.01	1.20
50-54	8.07	6.73	5.24	8.74	6.04	5.98	8.00
55-59	12.70	8.28	8.98	12.81	5.96	9.19	9.00
60-64	21.82	20.48	13.93	16.72	13.63	14.11	13.00
65-	56.40	55.41	28.51	44.14	18.30	48.82	30.00
TOTAL	3.83	4.67	3.25	3.61	2.66	3.85	1.60

Table-4.1.2.7 Annual Birth and Death Rates by Age Group and Community 1990/2000, Sarawak

(Birth Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0
15-19	23.13	14.99	41.5	22.79	29.7	8.10	1.63
20-24	98.75	71.73	85.7	73.50	100.5	50.79	42.50
25-29	131.17	105.61	85.9	94.74	117.9	94.27	46.75
30-34	89.59	92.88	67.7	71.47	97.3	73.72	21.40
35-39	57.17	64.66	39.5	42.03	51.2	30.50	9.19
40-44	23.05	23.52	15.0	18.23	18.7	4.29	3.61
45-49	2.69	3.42	3.4	2.16	4.9	0.56	0
50-54	0	0	0	0	0	0	0
55-59	0	0	0	0	0	0	0
60-64	0	0	0	0	0	0	0
65-	0	0	0	0	0	0	0
TOTAL	33.39	28.62	28.2	26.47	32.9	22.62	11.04

(Death Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	3.23	3.30	2.60	3.52	3.19	1.91	0
5- 9	0.23	0.27	0.30	0.25	0.11	0.20	0
10-14	0.21	0.97	0.21	0.24	0.28	0.49	0
15-19	0.53	0.29	0.47	0.30	0.59	0.68	0
20-24	0.58	0.63	0.69	0.33	0.94	0.83	0.66
25-29	0.90	1.03	1.17	0.97	1.46	1.05	1.22
30-34	0.88	2.22	1.31	1.25	1.80	0.87	0.56
35-39	0.98	1.97	1.82	1.88	1.52	1.65	0.53
40-44	2.47	3.44	2.20	3.53	1.61	1.63	0.75
45-49	3.47	3.70	2.29	5.52	3.76	3.81	0.89
50-54	7.23	6.53	5.25	8.62	6.34	5.68	6.00
55-59	11.38	8.03	9.00	12.63	6.25	8.73	9.00
60-64	19.55	19.86	13.97	16.49	14.30	13.40	13.00
65+	50.52	53.73	28.59	43.54	19.21	46.37	30.00
TOTAL	3.43	4.53	3.26	3.56	2.79	3.66	1.19

Table-4.1.2.8 Annual Birth and Death Rates
by Age Group and Community
2000/10, Sarawak

(Birth Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0
15-19	21.92	14.99	43.5	24.95	29.9	8.24	1.63
20-24	93.61	71.73	90.0	80.51	101.1	51.65	42.50
25-29	124.34	105.61	90.2	103.77	118.6	95.85	46.75
30-34	84.93	92.88	71.0	78.29	97.9	74.95	21.40
35-39	54.20	64.66	41.5	46.03	51.5	31.01	9.19
40-44	21.85	23.52	15.7	19.96	18.8	4.37	3.61
45-49	2.55	3.42	3.5	2.37	4.9	0.57	0
50-54	0	0	0	0	0	0	0
55-59	0	0	0	0	0	0	0
60-64	0	0	0	0	0	0	0
65-	0	0	0	0	0	0	0
TOTAL	31.65	28.62	29.6	29.00	33.1	23.00	11.04

(Death Rate, per 1000)

COMMUNITY / AGE GROUP	Malays	Melanau	Iban	Bidayuh	Other B.	Chinese	Other
0- 4	3.23	3.30	2.60	3.52	3.19	1.91	0
5- 9	0.23	0.27	0.30	0.25	0.11	0.20	0
10-14	0.21	0.97	0.21	0.24	0.28	0.49	0
15-19	0.53	0.29	0.47	0.30	0.59	0.68	0
20-24	0.58	0.63	0.69	0.33	0.94	0.83	0.66
25-29	0.90	1.03	1.17	0.97	1.46	1.05	1.22
30-34	0.88	2.22	1.31	1.25	1.80	0.87	0.56
35-39	0.98	1.97	1.82	1.88	1.52	1.65	0.53
40-44	2.47	3.44	2.20	3.53	1.61	1.63	0.75
45-49	3.47	3.70	2.29	5.52	3.76	3.81	0.89
50-54	7.23	6.53	5.25	8.62	6.34	5.68	6.00
55-59	11.38	8.03	9.00	12.63	6.25	8.73	9.00
60-64	19.55	19.86	13.97	16.49	14.30	13.40	13.00
65-	50.52	53.73	28.59	43.54	19.21	46.37	30.00
TOTAL	3.43	4.53	3.26	3.56	2.79	3.66	1.19

ii) estimation of forecast error

1960, 1965, 1970, 1975, 1980, 1985
population of each district
by age group and community
(**Appendix-II.4.1.1**)

↓

$P_{t+1} = B_t * P_t$ ← 1960/70, 1970/80, 1980/90, average annual birth and death rate by age group and community (**Table-4.1.2.4 - 6**)

↓

1965, 1970, 1975, 1980, 1985, 1990
forecast population of hinterland

↓

COMPARISON WITH ACTUAL DATA

↓

1965, 1970, 1975, 1980, 1985, 1990
forecast error for hinterland population

↓

EXTRAPOLATION

↓

1995, 2000, 2005, 2010
forecast error for hinterland population

By using the cohort survival analysis method, the population of the hinterland in 1965,..., 1985 and 1990 can be forecast from the actual populations in 1960,..., 1980 and 1985 and the birth and death rates of the periods 1960/70, 1970/80 and 1980/90 if the immigration factor can be neglected. **Table-4.1.2.9** shows actual population and error ratio ((forcast-actual)/actual).

Table-4.1.2.9 Forecast Error

unit: 1000, %

YEAR	1965	1970	1975	1980	1985	1990
ACTUAL POPULATION	349	382	434	486	541	596
FORECAST POPULATION	360	388	449	494	545	591
ERROR(Forecast-Actual)	11	6	15	8	4	-5
ERROR RATIO	3.1	1.5	3.4	1.6	0.7	-0.9

Figure-4.1.2.1 shows a time-series regression of the forecast error ratio, and the forecast error ratios for the years 1995 to 2010 are as shown in **Table-4.1.2.10.**

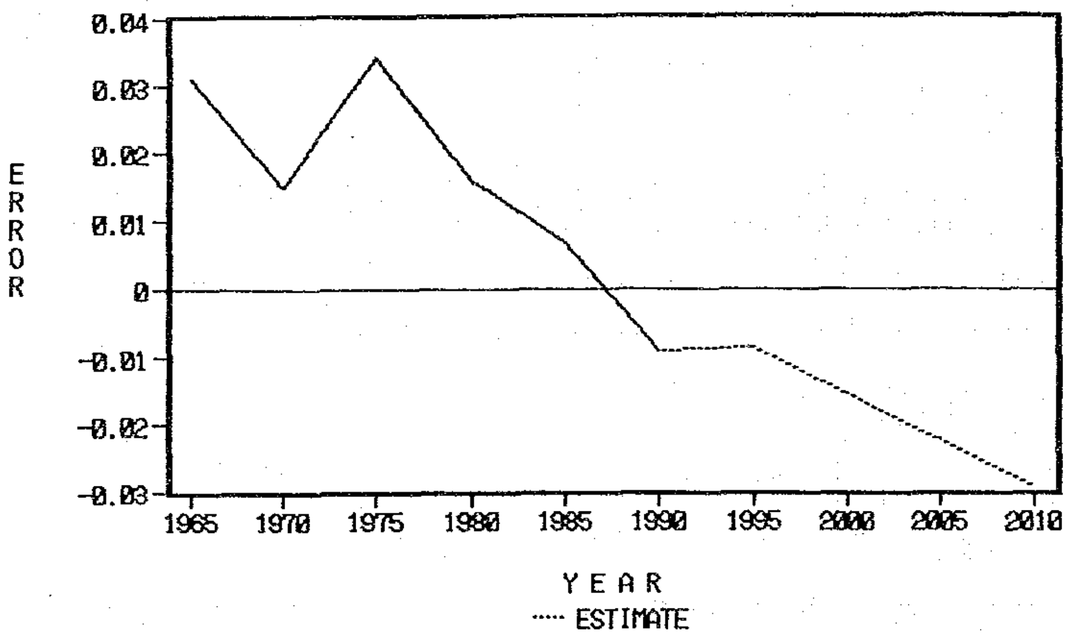


Figure-4.1.2.1 Regression of Population Forecast Error

Table-4.1.2.10 Forecast Error Ratio for year 1995 to 2010

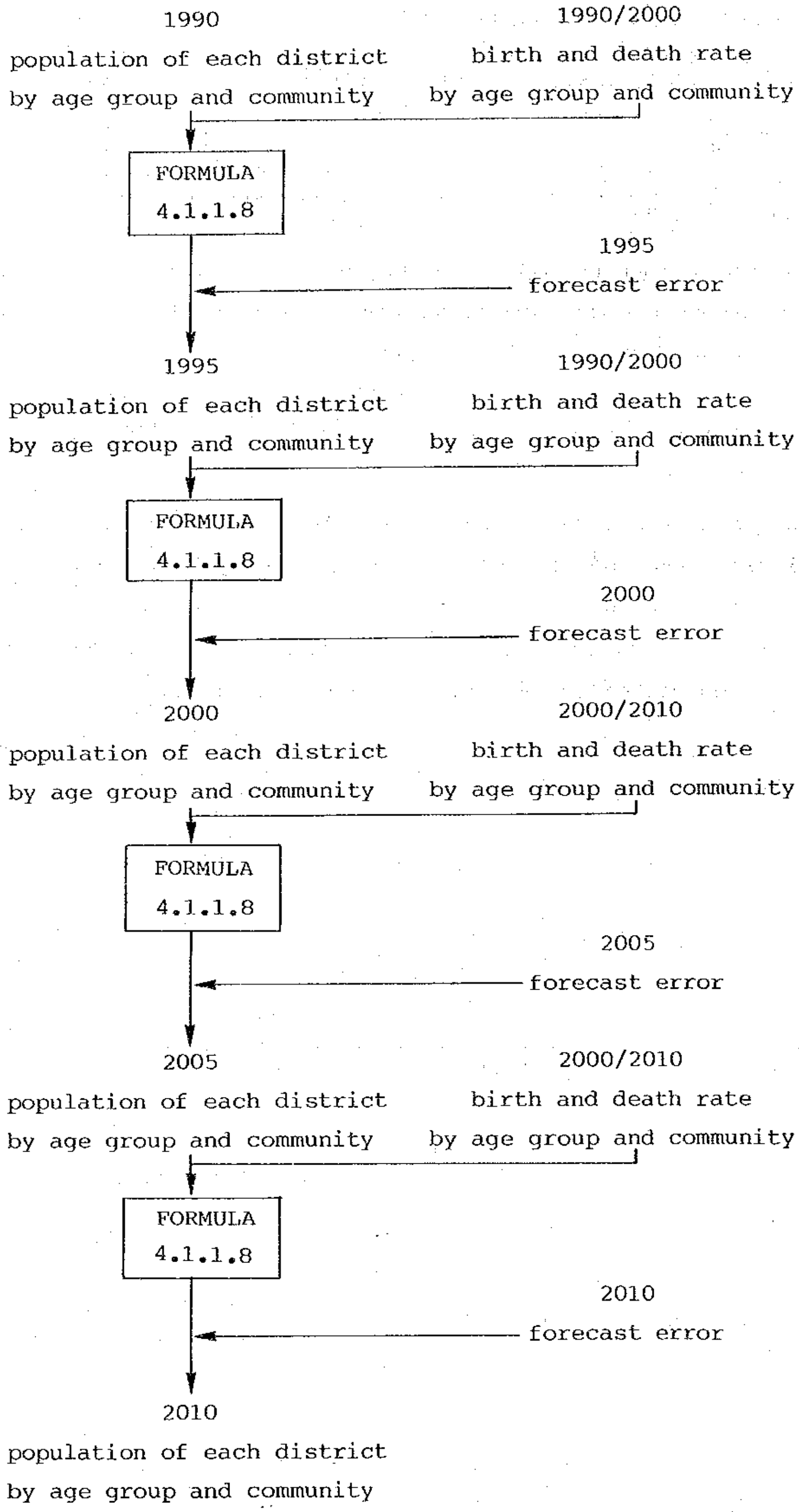
YEAR	1995	2000	2005	2010
ERROR RATIO(%)	-0.9	-1.5	-2.2	-2.9

Also, from this result, the migration factor can be neglected. Therefore, the population can be forecast by using the following formula because the error which includes migration is so small.

$$P_{t+1} = B_t * P_t \qquad (4.1.1.8)$$

iii) forecasting of future population in 1995, 2000, 2005 and 2010

Population can be forecast according to the following procedure. First, crude population is forecast by the cohort survival analysis method without the immigration factor (Equation 4.1.1.8). Then, the crude population is corrected by the forecast error ratio.


1990
population of each district
by age group and community
1990/2000
birth and death rate
by age group and community
FORMULA
4.1.1.8
1995
forecast error
1995
population of each district
by age group and community
1990/2000
birth and death rate
by age group and community
FORMULA
4.1.1.8
2000
forecast error
2000
population of each district
by age group and community
2000/2010
birth and death rate
by age group and community
FORMULA
4.1.1.8
2005
forecast error
2005
population of each district
by age group and community
2000/2010
birth and death rate
by age group and community
FORMULA
4.1.1.8
2010
forecast error
2010
population of each district
by age group and community