On the other hand, in many developing countries, per capita oil consumption is less than the minimum required level for the maintenance of health. Accordingly, any increase in demand for oils will depend on an increase in personal income in each country as well as an increase in population. Already, an increase in oil consumption in the petroleum producing countries in the Middle and Near East due to increased income levels is in evidence. These countries have been importing edible oils, but many developing countries which are short of foreign exchange will have to increase their domestic production of oils, rather than increasing their level of imports, in order to accommodate the prospective increase in demand for oils.

From these trends in the production of and demand for oils, it can be considered that both the supply and demand of the vegetable oils overall will increase at a moderate rate, although this rate of increase will slightly lower than that during the 1970s.

1.4.5 International Trade of Palm Oil

Palm oil exports went up rapidly at the beginning of the 1970s, reflecting Malaysia's production growth. During the 9 years from 1970 to 1979, world palm oil exports rose from 1.16 million tons to 2.29 million tons, a high average rate of 7.8% a year.

In Malaysia, refined palm oil (RBD palm oil, palm olein, palm stearin, etc.) accounted for 17.5% of the country's palm oil exports in 1975, but due to the policy of raising added value, the proportion rose to 93.9%, or 2.35 million tons, in 1981. Only a little of crude palm oil are now exported from Malaysia, including that from East Malaysia. Thus the exports from the Peninsular Malaysia are mostly refined, but the greater part of palm crude oil is exported to EC nations such as the United Kingdom and the Netherlands. In these countries palm oil refining and processing industries have long been established, and there exists a strong demand for crude oil. The governments of these countries impose duties on processed oil products in favor of crude oil imports.

Palm oil imports are increasing chiefly in the South Asian and Middle Eastern developing countries. India and Pakistan, in particular, increased their imports from 140,000 tons in 1975 to 600,000 tons in 1979. This is closely related to the production of oilseeds such as peanut, rapeseed, etc., in the region, and to the foreign currency situation.

With the growing population and income, oil consumption in the developing countries is expected to increase from now on, and their trade in palm oil is likely to become vigorous. In African nations which are traditional palm oil producers, the surpluses available for export are shrinking, and the volume of exports is likely to dwindle. The oil trade will therefore expand with even more dependence on Malaysia.

A major characteristic of the palm oil and palm kernel oil trade is the large volume of re-exportation from countries like Singapore and the Netherlands. Exports of crude and kernels from Malaysia, which produces about half of the world total, have come to account for only a fraction of the total due to the country's export taxation system intended to raise added value. Furthermore, the processing industry in the producing countries has been developing.

Consequently, the volume of trade of re-exporting nations has been unchanged in the last few years. As for palm oil, however, West Germany re-exports about 20,000 tons, or 15% of the amount imported; the Netherlands 60,000 to 70,000 tons (one-third to half); and Singapore 400,000 to 700,000 tons (nearly all). West Germany re-exports to France, Australia, Switzerland and African countries; and the Netherlands to West Germany, France, Belgium, the Middle East and African countries. Singapore exports to a large number of countries, virtually the whole world, so that it acts as a major distribution center, and there are many European and American dealers handling palm oil and palm kernel oil in Singapore.

Although a succession of palm oil producing countries is becoming independent traders, Singapore is at the center of a network, making the most of its status as a free port. Massive transactions will probably be carried out directly between producing and consuming countries as a matter of policy, but with Malaysia's production on the rise, the role played by Singapore in opening up new markets and creating new demand should be noted. Among the countries to which Singapore exports over 50,000 tons a year are the USSR, Bangladesh, India, Pakistan and Saudi Arabia.

The prices of palm oil, like those of other products, are determined basically by the balance of supply and demand. However, since each vegetable oil can be used as a substitute for others, the price of each is affected by the prices of substitutes for it; and palm oil is no exception to this. At the same time, the price of palm oil affects the prices of other oils. The oils interrelated with palm oil in relation to price are such animal fats as tallow, and vegetable oils like soybean and rapeseed oils.

Generally, the processing costs of palm oil, such as for hydrogenation, are lower than the other oils.

The factors which determine the price trends of palm oil are : a. Malaysia's palm oil production; b. Indonesia's domestic consumption; c. Refiners' response to the decreased cost efficiency brought about by surplus refining capacity; d. Importation by new markets such as South Asian, Middle Eastern and African nations; e. World supply and demand situation, particularly movement of the production of soybean in the United States and South America, sunflower seed in the USSR and oilseeds in India, is also an important factor.

Since it is highly probable that the increased output of palm oil will be devoted to domestic consumption in all producing countries except Malaysia, the only country which will continue to have a substantial effect on the international palm oil market in the foreseeable future will be Malaysia.

With regard to the palm oil consumption, annual per capita consumption of oil is as much as 25 to 30 kg in Europe, and a large increase cannot be expected there. On the other hand, in developing countries, where per capita consumption is low (5 to 6 kg), consumption is continually growing.

1.5 WORLD SITUATIONS OF NATURAL RUBBER

1.5.1 Outline

1) Types and Grades of Natural Rubber

Natural rubber is roughly classified into two types: The conventional type and the technically specified type. In addition, the former is classified into sheets (the major type comprising RSS-Ribbed Smoked Sheets - with the subordinate type being Air Dried Sheets) and Crepes. These classifications depend on differences in grading methods, manufacturing methods and raw materials. Gradings of RSS, Crepes and TSR are mainly based on the following criteria:

1. RSS : Foreign matter and color
2. Crepes : Raw materials, foreign matter and color
3. TSR : Foreign matter, viscosity, vulcanization properties and color

The international criteria for grading natural rubber are defined in the International Standards for Quality and Packing for Grades of Natural Rubber, commonly known as the "Green Book", which has been prepared by the International Rubber Quality and Packing Conference. According to these criteria, natural rubber is classified into 35 standard grades. These classifications are however, applicable only to the conventional type, while TSR grading depends on the standards of each producing country.

2) Structure of the Industry

Producers of natural rubber are classified into estates and smallholders. In general, estates are producers who maintain plantations for the cultivation of rubber trees of 100 acres (40 hectares) or more, while smallholders cultivate areas of less than 100 acres. However, the usual size of a smallholder is actually four hectares or less. Figure 1.3 shows the comparison of three major producing countries. The point most worthy of note in comparing estates with smallholders is the yield. As an exmaple, in Malaysia the average annual yield per hectare is 1,200 kg for estates, while it is some

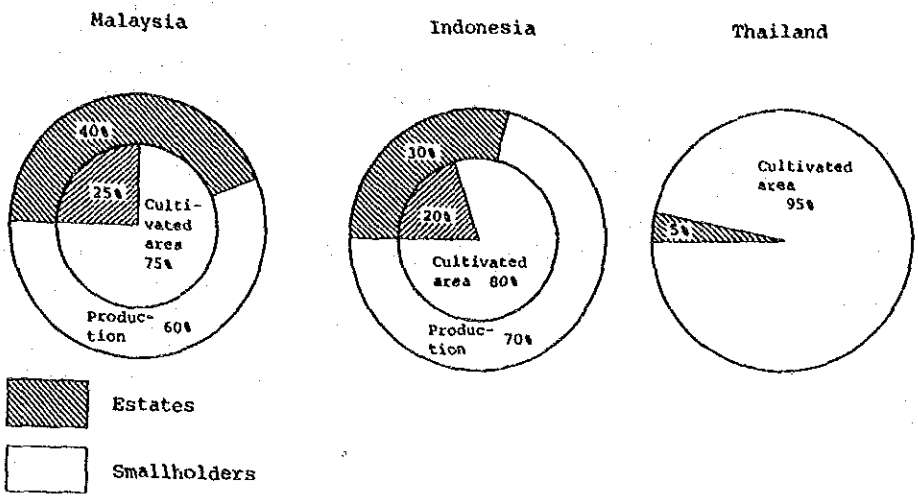


Fig. 1.3 STRUCTURE OF RUBBER INDUSTRY

700 to 750 kg for small-holders, and this latter figure is about double the figure for Thailand. The focus for the production development plans of each of the major countries lies in the development of high-yielding clones and in re-planting, especially with regard to smallholders.

3) Relationship between Natural and Synthetic Rubber

Natural rubber and synthetic rubber compete with each other in cost and end-use performance, but also complement each other in the development of the desired properties for various products, due to the advantages of their respective features. A comparison in terms of costs must include not only the comparison of purchase prices but also those of expenditures for storage and material handling and processing.

Synthetic rubber, being produced in the various consuming countries themselves, is consequently available within a short procurement term and production can be immediately adjusted against fluctuation in demand, which results in lower storage costs. The packaging of synthetic rubber is palletized for easy handling, whereas the emergence of TSR has brought about improvements in material handling methods for natural rubber.

The most important factor with regard to the prices of natural and synthetic rubber is that natural rubber is traded on the open market and the price is therefore unstable, depending on fluctuations in short-term supply-demand forecasts and various speculative factors. In contrast, however, the price of synthetic rubber is stable, because it is fixed on the basis of agreements between producers and users.

A large quantity of natural rubber is used in the tire manufacturing sector, and the consumption ratio of natural rubber is greater in that sector than in the non-tire manufacturing sector. This indicates that many technical requirements of the tire industry are met by the superior properties of natural rubber. For example, natural rubber is used for the tread of truck and bus tires because of its low heat build-up characteristics, and for the belt and ply of steel radial tires due to its superior adhesion to steel.

1.5.2 Rubber Production

1) Worldwide Production of Natural Rubber

The worldwide production of natural rubber was 2,353,000 tons in 1965 and peaked at 3,860,000 tons in 1979, with an increase of 1.6 times over a period of about two decades. Thereafter, production declined in 1980 and 1981 to a level of 3,665,000 tons in 1981, a 5% decrease over 1979. This reflected the global fall in demand for natural rubber caused by the decreased production of automobiles and tires in the United States, and other factors. As a reference, the total volume of production in 1981 for synthetic rubber was 8,490,000 tons, and the share held by natural rubber of the total supply of new rubber (including both natural and synthetic rubber) was about 30%.

The production of natural rubber is principally centered in Southeast Asia, with additional production in Asian countries including India, Sri Lanka and Vietnam, and in Africa and South America. The three major producing countries in Southeast Asia are Malaysia (42% production share), Indonesia (24%) and Thailand (14%), and the total share of these three countries amounts to 80% of world-wide production. Changes in production levels for these three countries and for the world are shown in Table 1.22

Table 1.22 Production of Natural Rubber

(1,000 MT, %)

Year	Malaysia		Indonesia		Thailand		World Total	
	Production	Share	Production	Share	Production	Share	Production	Index*
1965	917	39.0	716	30.5	216	9.2	2,354	100
1970	1,269	40.9	815	26.3	287	9.3	3,103	132
1975	1,459	44.0	823	24.8	355	10.7	3,315	141
1979	1,570	40.7	905	23.4	531	13.8	3,860	164
1980	1,530	39.9	1,020	26.6	501	13.1	3,830	163
1981	1,529	41.7	868	23.7	504	13.8	3,665	156

* Index based on 1965 = 100.

Source: IRSG, Rubber Statistical Bulletin

2) Malaysia

In Malaysia a production increase program called the "Dynamic Production Policy" is currently in progress, based on new planting and replanting.

The share held by rubber tree plantations of the total planted area is now 45%, which is planned to be reduced to a level of some 30% in the future to raise the share of other agricultual products. Overall natural rubber production will, however, be increased by the development of high-yielding varieties of trees and replanting. The five-year program for 1981 through 1985 provides for 50,000 ha. of new planting and 25,000 to 30,000 ha. of replanting every year.

High-yielding trees of the RRI 600/700/800 series have been planted on a trial basis. In particular, the yield from the RRI 700/800 series averages 3,500 to 4,000 kg/ha/year, which represents some 2,500 kg/ha/year on a commercial basis, and the unit yield is expected to grow in the future by increased planting of trees of the RRI 700/800 and PB (another high-yielding variety) series. Expected yields are:

	Present	The year 2000
Estates	1,400 kg/ha/year	2,000 kh/ha/year
Smallholders	1,000 " or less	1,500 "

The yield is calculated on the basis of areas where tapping is currently performed, without the inclusion of immature areas.

As a link in the chain of policies for the promotion of exports, the government adjusts and revises the export duty. The trading price of natural rubber is decided on the basis of the international market price, so that the net receipts of an exporter are the trading price minus the export tax. When the market price is low, therefore, the net receipts of the exporter fall, resulting in a decrease of the net receipts of the farmer as well. Accordingly, the government practices a policy to offset declines in the net incomes of the exporter and the farmer by providing an exemption of export duty or by adjusting and revising the export duty and the base price, with the aim of lightening the tax burden.

3) Indonesia

The Third Five-Year Program (FYDP III) which began in 1979 pays great attention to increasing production levels and to raising the unit yield, especially for smallholders. The program is being carried out by means of two development systems: PMU, Project Management Units (UPP in Indonesian), and NES, Nuclear Estates for Smallholders (PIR in Indonesian).

The main activity of PMU is to guide smallholders in the replanting and rejuvenation of plantations where cultivation is being performed. There are two types of such plantations, the Major Unit (10,000 ha/unit) and the Minor Unit (2,500 ha/unit), and 136 units have been completed, which are planned to be increased to 321 units by the end of the Fourth Five-Year Program.

NES is a system in which core estates provide guidance regarding new planting in virgin areas and provide a variety of other technical guidance to improve the level of production of the smallholders. Latex and cup-lump from the smallholders are processed by the central estates and sold through the Joint Marketing Organization (JMO). Under the NES system, the net receipts of the smallholders are expected to increase to some 70% of the FOB price. (The present net receipts of smallholders stand at only around 40% of the FOB price, because of the exploitation of intermediary margins due to the intervention of cargo collectors and traders, and because of relatively high processing costs arising from widely dispersed and obsolete facilities.)

The main product handled by the NES system is RSS (60-70%), and the seven NES systems currently existing will be increased to ten in the future.

For replanting and new planting, there is a system through which a long-term (17-year) loan can be obtained from the Government, for which the interest rate is 6% per year for the first three years and 10.5% per year for the remaining years.

The yield of smallholders is 300 to 350 kg/ha/year, and that of estates is 650 to 700 kg/ha/year at present, which will be raised to 1,200 and 1,500 to 2,000 kg/ha/year respectively within 15 years.

4) Production of Synthetic Rubber

The amount of production grew from 3,795,000 tons in 1965 to a peak of 9,330,000 tons in 1979, about 2.5 times the former level over a 15-year period, while natural rubber showed a growth of 1.6 times in the same period. The share of synthetic rubber of total consumption of new rubber rose from 60% in 1965 to 70% in 1979. Unlike natural rubber, the major consuming countries of synthetic rubber are also the major producing countries, and the shares held by these countries of world production in 1981 were 26% for the United States, 19% for the EC countries and 12% for Japan, the combined share of these three regions accounting for a little less than 60% of the world total.

1.5.3 Rubber Consumption

The world consumption of natural rubber in 1981 was 3.7 million tons. This is 4.4% less than the previous peak of consumption, 3.87 million tons in 1979. The consumption of synthetic rubber in 1981 was 8.435 million tons, 7.6% less than the peak of consumption in the past, which was 9.125 million tons in 1979.

The world consumption of new rubber including natural and synthetic rubber was 12.135 million tons in 1981, 6.6% less than in 1979.

Both synthetic rubber and new rubber were consumed less in 1981 than in 1977, and only the consumption of natural rubber was slightly higher (1%) in 1981 than in 1977.

A remarkable decrease in rubber consumption was seen in the United States, where new rubber consumption was 2.657 million tons in 1981, a large drop of 23% from 3.447 million tons in 1977, although it exceeded the figure for consumption in 1980, which registered 2.565 million tons.

This was caused by the decrease in automobile production, longer tire life achieved by adoption of the radial tire, shorter traveling distances caused by higher gasoline prices, smaller tire sizes due to downsizing of cars, etc. This is illustrated by the fact that the number of replaced tires per passenger car decreased from 1.28/car in 1977 to 0.98/car in 1980, and this trend is likely to continue.

The consumption of natural rubber has gradually decreased as the consumption of synthetic rubber has increased. For example, in 1965, natural rubber accounted for about 40% of new rubber consumption, but in 1979, the share decreased to less than 30%. Since 1976, however, it has been rather steady at about 30%.

Table 1.23 Trends in New Rubber Consumption

(1,000 MT)

		1965	1970	1975	1979	1980	1981
USA	Natural	523	568	666	740	585	635
	Synthetic	1,565	1,949	1,964	2,501	1,980	2,022
	Total	2,088	2,517	2,630	3,241	2,565	2,657
Canada	Natural	43	51	72	94	80	82
	Synthetic	98	135	180	232	200	210
	Total	141	186	252	326	280	292
UK	Natural	187	188	171	138	131	120
	Synthetic	183	274	266	301	248	220
	Total	370	462	437	439	379	340
France	Natural	123	158	156	177	188	167
	Synthetic	154	261	278	318	322	293
	Total	277	419	434	495	510	460
W. Germany	Natural	158	201	197	185	180	169
	Synthetic	209	358	360	447	421	396
	Total	367	559	557	632	601	565
Italy	Natural	87	113	118	128	132	123
	Synthetic	113	197	220	285	288	265
	Total	200	310	338	413	420	388
Australia	Natural	39	40	50	45	42	42
	Synthetic	41	54	50	51	59	58
	Total	80	94	100	96	101	100
Japan	Natural	202	283	285	390	427	436
	Synthetic	176	496	585	830	885	851
	Total	378	779	870	1,220	1,312	1,287
Brazil	Natural	27	37	59	76	81	74
	Synthetic	38	85	176	225	244	202
	Total	65	122	235	301	325	276
Others	Natural	1,059	1,354	1,594	1,897	1,914	1,852
	Synthetic	1,163	1,816	2,948	3,935	4,038	3,918
	Total	2,222	3,170	4,542	5,832	5,952	5,770
World total	Natural	2,448	2,993	3,368	3,870	3,760	3,700
	Synthetic	3,740	5,625	7,027	9,125	8,685	8,435
	Total	6,188	8,618	10,395	12,995	12,445	12,135
	(Ratio of synthetic to total)	(60.4)	(65.3)	(67.6)	(70.2)	(69.8)	(69.5)
Index	Natural	100	122	138	158	154	151
	Synthetic	100	150	188	244	232	226
	Total	100	139	168	210	201	196

Table 1.24 Consumption of Natural Rubber by Use (Major Countries)

(1,000 MT)

	1971	1973	1975	1977	1979	1981
USA						
Tire	425	515	497	623	578	470
Non-tire	162	197	169	179	162	165
Total	587	712	666	802	740	635
Share held by Tire	(72.5)	(72.4)	(74.7)	(77.7)	(78.0)	(74.0)
UK						
Tire	102	90	96	96	79	78
Non-tire	83	97	75	67	59	42
Total	185	187	171	163	138	120
Share held by Tire	(55.0)	(48.0)	(56.2)	(58.8)	(57.5)	(65.0)
France						
Tire	116	120	118	130	146	138
Non-tire	43	42	38	34	31	29
Total	159	162	156	164	177	167
Share held by Tire	(73.2)	(73.7)	(75.8)	(79.5)	(82.4)	(82.8)
W. Germany						
Tire	106	107	106	121	122	110
Non-tire	92	99	91	56	63	59
Total	198	206	197	177	185	169
Share held by Tire	(53.6)	(52.0)	(53.9)	(68.5)	(65.9)	(64.9)
Japan						
Tire	166	217	197	223	290	336
Non-tire	129	118	88	97	100	100
Total	295	335	285	320	390	436
Share held by Tire	(56.2)	(64.8)	(69.1)	(69.7)	(74.4)	(77.1)

Of the technological innovations in the tire industry over the past 20 years, the main items which have affected the state of rubber technology are as follows: The development of radial tires, low profile tires, durability, wear resistance, high speed durability, driving performance at high speed, higher performance on wet road, all-weatherability, studless technology, fuel efficiency, etc.

The factors affecting the ratio of use of the natural and synthetic rubber and the factors restricting changes in this ratio are as follows:

i An increase in the use of natural rubber will occur due to increased use of the radial tire.

ii The trend towards fuel efficiency and all-weatherability will increase the use of natural rubber.

iii Higher-speed and low profile and studless tires will result in a decrease in the use of natural rubber.

iv The use of the natural rubber will increase or decrease depending on price competitiveness with synthetic rubber.

v The development of a synthetic rubber possessing such properties as to completely replace natural rubber is unlikely.

vi From the performance viewpoint, there is a limit to the increased use of natural rubber. (Examples: Wet skid performance, wear resistance, air permeability resistance, thermal deterioration resistance)

If tire construction changes from bias to radial types, the use of natural rubber will increase by 19% for truck/bus tires and by 29% for passenger car tires.

1.5.4 International Trade

The principal characteristic of the international trade in natural rubber is that the main producing countries and consuming countries are distinctly divided. The main producing countries are developing countries mainly situated in Southeast Asia, whereas the main consuming countries are advanced industrial countries such as the United States, Europe and Japan. These consuming countries do not produce natural rubber, a very important material for them, and must depend entirely on imports, the only exception to this being China, which produces about 45% of the quantity required for domestic consumption.

Natural rubber can be said to be a typical "export commodity", since about 85 to 90% of production is exported.

Imports of natural rubber by the main consuming countries have remained in the same pattern for several years; e.g., the United States imports most of its requirements, about 50%, from Indonesia; the EC countries import mainly from Malaysia and also from Africa; and Japan predominantly imports from Thailand, about 70 to 80% of its requirements.

Exchanges influencing the price of natural rubber are located in Singapore and Malaysia, which are the collecting and distribution centers as well as the shipping centers for Southeast Asia, the main producing region.

The selling price is determined for each type, grade, shipping date and destination, considering the supply-demand trend, financial situation and shipping conditions, using as a barometer the quoted price at the rubber exchanges in Singapore and Malaysia.

As to the determining factors for the market price, the price of primary products is determined on the basis of the balance of supply and demand, and natural rubber price is no exception to this. However, natural rubber has the following characteristics:

a. Tapping is possible throughout the year. Although there is a temporary decrease in the harvest during the defoliation (wintering) period, a relatively constant harvest can be expected. Therefore, natural rubber is not much affected by price fluctuations due to good or bad harvests, unlike the grains or coffee.

b. The rubber tree requires 6 to 7 years after planting before it can be tapped, and it is impossible to increase production immediately when the price has become high. Furthermore, since the industry depends on many smallholders, it is also difficult to decrease production immediately, from the viewpoint of their income levels, when the price has become low. Therefore, price elasticity can be said to be low.

For the above reasons, it can be said that the supply of natural rubber will not fluctuate much in the short term, and therefore it is expected that factors on the supply side will not play a very important role in determining the price.

Actually, price fluctuations for natural rubber are caused largely by factors on the demand side rather than the supply side, and prices are particularly affected by the trend of demand in the tire industry, accompanying that of the automobile industry.

1.5.5 Demand and Supply Projection

To estimate the demand for natural rubber, firstly the total new rubber consumption (total consumption of natural and synthetic rubber) is estimated and then the result is multiplied by the percentage share held by natural rubber.

The decreasing trend in the ratio of use of natural rubber has bottomed out and as the use of radial tires increases, the use of natural rubber is expected to increase again. The long-term supply of natural rubber is determined by the government policy of each producing country regarding the expansion of new planting, increase of yield by replanting of high-yielding trees and production increases through the use of stimulants.

Table 1.25 shows the projected demand and supply of natural rubber. If a comparison is made between the supply and demand projections for 1990 and 2000, it can be said that a slight excess of supply is to be expected overall. For 1990, demand is projected at 5.64 million tons, 5.5 million tons and 5.35 million tons for the high, medium and low cases respectively, while supply is projected at 6.39 million tons, 5.75 million tons and 5.2 million tons respectively. The rate of over-supply is 13.3% for the high and medium cases, and only in the case of low does the demand exceed supply by 2.8%. For the year 2000, demand is projected at 7.28 million tons, 6.85 million tons and 6.45 million tons for the high, medium and low cases respectively, while supply is projected at 8.63 million, 7.45 million and 6.45 million tons respectively, and in the case of the high and medium cases, an excess of supply is projected, as is the case for 1990. The proportion of over-supply in the year 2000 registers 18.5% and 8.8% respectively, whereas in the case of the low estimate, supply and demand are balanced.

Table 1.25 Projected Demand and Supply of Natural Rubber

(1,000 MT, %)

Estimating Cases		1980	1985	1990	2000
Demand	High			5,640	7,280
	Medium	3,760	4,670	5,500	6,850
	Low			5,350	6,450
Supply	High		4,792	6,390	8,630
	Medium	3,830	4,550	5,750	7,450
	Low		4,290	5,200	6,450
Balance	High		+122 (2.6)	+750 (13.3)	+1,350 (18.5)
	Medium	+70 (1.9)	-120 (-2.6)	+250 (4.5)	+600 (8.8)
	Low		-380 (8.1)	-150 (-2.8)	±0 (-)

Source : "The Study Related to the Regional Development Plan of the Great Carajas Program" by JICA, March 1983

2. FISHERIES DEVELOPMENT

2.1 POTENTIAL AND PROBLEM AREAS

The marine fisheries in Thailand expanded their production in the 1960's and 1970's due to timely introduction of trawling method. Marine fish catch volume increased sharply from 150,000 tons in 1960 to 2,068,000 tons in 1977. At the same time, however, on the other hand, as catch per unit effort (C.P.U.E.) of fishing fleets, especially for trawlers rapidly decreased in response to increase of fishing intensities, economic operation of fishing fleets became difficult. Therefore, they had to employ more advanced technologies and to expand their fishing grounds to further area or sometimes up to the territorial waters of other countries. In spite of these efforts to improve their catch rate, resource conditions especially for demersal resources in Siam Bay as well as the coastal area in Andaman Sea is still decreasing.

Under these circumstances, the responsible agency in Thai Government, Department of Fisheries (DOF), Ministry of Agriculture and Cooperatives has been encouraging fishermen to convert their fishing intensities from demersal resources to pelagic resources development. The number of purse seiners especially equipped with advanced fishing gear has been gradually increasing in accordance with scarcity of demersal resources. However, most of fishermen still stick to trawling method, as the method can catch shrimp, an internationally valued species and even pelagic species with advanced technologies.

Coastal areas of Thailand are originally good fishing grounds for small-scale and subsistence level fishermen, but their activities are seriously affected by the depletion of fish resources. Coastal areas which consist mainly of mangrove area and sandy or muddy beaches are known as productive area for aquatic resources. Especially, the mangrove area is important in terms of nursery function for juveniles and fry of useful species. However, these important coastal areas for marine resources have been decreasing or environmentally deteriorating due to urbanization and industrialization. Shrimp cultures which construct their ponds right in the mangrove areas and illegal operation of push netters along the beach are also counted as factors of these environmental deterioration. Since these coastal areas have large potential for aquaculture and propagation of aquatic resources, fuller consideration for preservation and utilization of these areas should be taken for further development.

These general characteristics of fisheries in Thailand and resource condition are naturally reflected on the fisheries conditions in Upper South.

Various external sources have provided loan and grant for fisheries development in Thailand (see Table 2.1). In marine fisheries sector, most of the projects have focused on the development of small-scale fisheries or development of pelagic fisheries reflecting the current situation of marine resources in Thailand. Recently, there is no large-scale marine fisheries project even for pelagic fisheries. On the other hand, various kind of coastal and inland aquaculture, inland fisheries projects have been possitively undertaken in many coastal areas, including those of Upper South.

2.2 NOTES ON STRATEGIES

Fisheries sector in Thailand has largely contributed to the national economy, especially in terms of foreign exchange earnings and supply of protein source to the people, in spite of a relatively small number of the people who are engaged in the fisheries. However, marine resource condition become worse due to overexploitation and overinvestment by means of advanced technologies.

In this connection, approaches for fisheries development in Thailand would be different from the ones which are usually taken in another developing countries. As a matter of fact appropriate measures for resource management program for marine fisheries would have to be taken. However, as the existing fishing activities and system, although they are rather in disorder, have established in a long history of fisheries development, drastic change of the system is not supposed to be possible. Accordingly, these approaches as the national strategy would have to be planned and executed in a pragmatic and step by step manner under a long-term perspective.

Although products of coastal aquaculture will not be able to substitute the volume of fish to decrease in marine fisheries from now on, they will very much contribute the national economy in terms of value.

Coastal aquaculture would certainly increase some biomass in semi artificial or natural environment. However, it has no effects on the increase of aquatic resource.

At the first stage, the potential areas for coastal aquaculture would be firstly selected. The areas would have to be reserved for coastal aquaculture and small scale fishermen as "Aquaculture Zone" to exclude operation of push netters and trawlers from the zone accordingly necessary legal actions would also have to be taken. Based on surveys, appropriate sites for aquaculture in each species are to be selected in the zone. The related agency would encourage small scale fishermen to join the aquaculture business. For this purposes, appropriate governmental assistance, both technical and financial, would be needed.

Table 2.1 LIST OF FISHERIES DEVELOPMENT PROJECT

Name of Project	Year Start End	Executing Agency	Assisting Agency	Brief Description
A. MARINE FISHERIES				
1. Fisheries Development Project	1976 1982	CSO/FMO	ADB	Five Cold Storages and Purse Seiners
2. Tuna Fishing	1978 1980	DOF	UNDP	Pole & Line Fishing Test in Southern Thailand
3. Acoustic Survey	1979	DOF	TCP	Pelagic Resource Assessment
4. Small Scale Coastal Fisheries Development	1984 on going	DOF	UNDP	Development of Small Scale Fisheries
5. Regional Cities Dev. Project	1985	Harbour Dept. Public Work	IBRD	Songkhla Fishing Port
6. Demersal Seminar	1979	DOF	DANIDA	Demersal Fisheries Management
7. Small Scale Fisheries Development	1983 on going	DOF	CIDA	Small Scale Fisheries Dev. Rayong
8. Improvement of Fisheries Station	1984 on going	DOF	JICA	Artificial Reef
9. Small scale Fisheries Dev. Project	1977 1985	DOF	FAO BOBP	Phangnga Bay Fisheries Development
B. COASTAL AQUACULTURE				
1. Aquaculture Development Project	1979 on going	DOF DCP BAAC	ADB	Shrimp Culture and Other 5 Sub Project
2. Second Aquaculture Development Project	1982	-	ADB	F/S Coastal Aquaculture
3. Shell Fish Economics	1984 1985	DOF	ICLARM GTZ	Shell Fish Culture

Name of Project	Year Start End	Executing Agency	Assisting Agency	Brief Description
4. Shell Fish Demonstration Farm	1983 on going	DOF	ICLARM GTZ	Shell Fish Culture
5. Phangnga Project	1983 on going	DOF	SIDA BOBP	Brackish Water Culture
6. Coastal Aquaculture	1979	DOF	JICA	Coastal Aquaculture Research Center (NICA)
7. Agricultural Credit	1980 1982	BAAC	IBRD	Shrimp Culture Credit
C. FRESH WATER				
1. Songkhla Lake Study	1984 1985	DOF	ADB	Environmental Study
2. Freshwater Prawn Program	1978 1980	DOF	UNDP	Development of Freshwater Prawn
3. Pond Management	1978 1982	DOF	UNDP	Freshwater Fish Culture
4. Agricultural Support	1984 on going	DOF	IBRD CIDA	Inland Fisheries in NE Thailand
5. Irrigation	1977	BAAC	IDA	Inland Fish Farming
6. Inland Fisheries Institute	1973 1979	DOF	CIDA	Freshwater Fisheries Institute (NIFI)
7. Aquatic Weed Utilization	1981 1984		IDRC	Fish Farming in Songkhla Lake
8. Small Scale Inland Fishing	1979 1981	AIT	ODA	Aquaculture Pond Construction
9. Inland Center Development	1983 1984	DOF	JICA	Freshwater Center Ayutthaya-Trang-Surat Thani
10. Fish Culture	1982 1984	AIT	JICA	Freshwater Fish Feeding
11. Small Swamp Fisheries	1982 on going	DOF	OECF	Improvement of Fish Production
12. Large Swamp Fisheries	1983 on going	DOF	OECF	F/S
13. Water Hyacinth Utilization	1982 1984	AIT	GTZ	Fish Pond Fertilizer
14. Pilot Fish Farm	1979	DOF	NEDECO	
15. Inland Fisheries Center	1984	DOF	NEDECO	Center Nakhon Ratchasima

Name of Project	Year Start End	Executing Agency	Assisting Agency	Brief Description
D. OTHERS				
1. Fishery Sector Study	1984		ADB	
2. Marine Science Education	1979 1984		UNDP UNESCO	
3. Marine Biological Center	1979 1983	DOF	DANIDA	Scientific Equipment
4. Food Storage and Handling	1984 on going	DOF	CIDA	Fish Processing
5. Fish Genetics	1984	DOF	IDRC	Freshwater Fish
6. Fish Processing	1980	DOF	IDRC	Low Cost Fish Processing

Establishment of artificial reefs in coastal water in Thailand, would be justified for its following functions expected:

- Spawning and propagation of aquatic resources on and around the reefs,
- Fish aggregation on and around reefs,
- Function as barrier to protect outflow of shellfish larvae from coastal to offshore area, and
- Function as obstacles to prevent trawlers from intrusion into coastal area.

The existing governmental hatcheries in the area would expand their facilities and activities in order to meet the requirement of seeds to be used at enlarged aquaculture farms. The hatcheries would also initiate artificial propagation of selected species to be released around artificial reefs.

At the second stage, the stage would be tentatively planned to start at the year 2000. Up to the end of the first stage, "Aquaculture Zone" would be appropriately developed as aquaculture farms. Some of the facilities for aquaculture like oysterculture have the same effects as artificial reefs for aquatic resources. Number and scale of aquaculture farms would not be increased but aquaculture technologies would be improved, especially for shrimp culture; from semi-intensive method to intensive mono-culture system. Accordingly private hatcheries for seeds production would be developed at this stage.

Development of large-scale artificial reefs would substantially started at this stage based on the result of evaluation for experimental reefs and surveys. The governmental hatcheries would change their scope of activities from the production of seeds for aquaculture to mass production of juveniles and fry to be released around artificial reefs. In accordance with recovery of resource condition of the areas small scale fishermen would start coastal fishing using selected fishing gear like handlining or traps.

Surat Thani faces to one of the good fishing grounds in Siam Bay. However, this area is currently utilized by large-scale fishermen with their base in the northern coast such as Samut Sakon and Samut Prakarn. All fish catch are, therefore, transported long way to the northern coast and unloaded at their stations except some unloading at Chumpon. However, in case the good port facilities are once provided in Surat Thani , it is expected that some bigger fishing vessels would unload their catch at Surat Thani for economic reason.

2.3 NOTES OF PROJECT

2.3.1 Coastal Aquaculture and Fisheries Development

1) Shrimp Culture

In Ban Don Bay Aquaculture Zone, there are some potential area for shrimp culture especialy in Kanchanadit and Tha Chang area. Shrimp culture is important for Thailand because its international value will significantly contribute to earning foreign exchange. Presently they have cultured mainly White shrimp, Penaeus merguiensis and Metapenaeus spp. The size of cultured shrimp is usually smaller than 10 grams in weight. Accordingly, it is not suitable to export. However, with improvement of their technologies and increase in the capacity of seeds supply of governmental hatcheries, they would be able to culture more internationally valuable species at larger size; P. monodon and P. merguiensis.

Development of shrimp culture usually conflicts with the preservation scheme of mangrove areas which are ecologically important. Therefore, it would be necessary to undertake scientific surveys for the usage of mangrove areas. Based on the result of surveys, some guidelines for the usage of mangrove areas would have to be issued, ex. the mangrove areas within 0.5 km from shoreline should be strictly preserved in order to avoid the destruction of natural environment as nursery and the erosion of coastal area. In this connection, there are little area being able to be developed for shrimp farms in Phangnga and Krabi area. However, shrimp culture using pen or cage would have to be developed in order to avoid the conflict with preservation scheme of mangrove area.

The shrimp farmers currently employ a semi-intensive method to intake water with seeds and feeds by means of push pump. However, this method would not be effective considering the decline of natural resources. Accordingly, culturing methods should be changed to intensive-mono culture system before cultivating fisheries start.

2) Shellfish Culture

Shellfish is a cheaper protein source because of their food habit. Since shellfish situate at a lower level in ecological food chain, big production rate is possible theoretically. If big production is achieved, cheaper protein source can be supplied to the people.

In Upper South, shellfish culture could be undertaken for cockle Anadara granosa, Oyster Crassastrea commercialis, C. lugubris, C. belcheri, green mussel Mytilus smaragdinus and horse mussel Modialus senhausenii. Cockle culture would be undertaken at shallow area. However, to secure cockle seeds is a problem because Malaysian Government recently banned the export of cockle seeds.

3) Cage Culture

As for institutional aspect, it is supposed rather easy to organize cooperative societies in aquaculture farmers compared with marine fisheries project. Since most of member of aquaculture farmers are newly immigrated to aquaculture area, there have little relationship with middlemen in the area. Therefore, incase the governmental assistance for farmers are appropriate from start, cooperative societies can be easily established without any disturbunces by middlemen.

Environmental pollution is a serious problem for the operation of aquaculture. Therefore, appropriate standards for water pollution control would have to be elaborated. In addition, some devices for industrial drainage treatment would have to be equipped in each industrial estate. Dredging of navigation canal to Tha Thong Port is currently going on. However, dredging in such shallow area is worried to cause the problem of finding the place to throw away excavated soil. In care these soil would piled along the navigation canal, long dike would have consequently been constructed along canal. In this connection, a careful hydrographical study on the effect of dike to environmental condition for aquaculture would have to be taken place in advance. Artificial Reef Research Center mentioned later would be responsible for three kinds of research work.

4) Artificial Reef Research Center

Hydrographical research section is responsible for the execution of hydrographic research work in Aquaculture Zone especially for water circulation and siltation. Environmental and ecological research section would be responsible for the periodical check of environmental condition in Aquaculture Zone in close collaboration with the staff of Phuket Marine Bioligical center. Above two section would also collaborately undertake study on deposit mechanisms of cockle larvae to substratum and research work to identify the appropriate natural sea bed for seeds production of cockle. Structure and design section would develop the shape, material and scale of artificial reef suitable to local condition. Artificial reef workshop would construct experimental reef based on the research and studies. ARRC would execute experimental artificial reef project in collaboration with each provincial government. ARRC would also investigate artificial reefs and analyze their effects to ecosystem so as to be able to satisfactory start large scale development which is tentatively planned in the year 2000.

5) Improvement of Capacities of Governmental Hatcheries

Existing government hatcheries would expand their capacities to produce seeds, especially for shrimp sea bass and grouper, in order to meet growing demands of seeds in accordance with development of aquaculture in Aquaculture Zone. However, shrimp culture system would be changed from semi-intensive method to

intensive method upon certainty of seeds supply. At this stage, the private hatcheries business would start as the case in the Philippines of providing seeds based on growing demands. Accordingly, some part of responsibilities of governmental hatcheries to provide seeds to farmer would be handed over to private hatcheries. Therefore, governmental hatcheries would have to change their scope of services from seed production to "cultivating fisheries". For this purposes, governmental hatchery would start a basic study on the artificial propagation program for release of juveniles to artificial reefs area, keeping pace with activities of ARRC.

2.3.2 Marine Fisheries Development

1) Development of Surat Thani Fishing Port

In accordance with the development of Tha Thong Port for distribution and industrial purposes, navigation canal would be dredged and maintained. Under this condition, fishing port near Tha Thong port can economically be functioned. As existing FMO facilities are too close to the town area, Tha Thong area would be more appropriate for further development of fish-related activities including fish processing industries.

2) Development of Phuket Fishing Port

Considering future development of deep sea fishing, Phuket is a good location for fishing base in terms of availability of various facilities and services for maintenance, repair and procurement or necessary goods. In additon, good road connection to market is also attractive conditions for fishing base.

In this regard, existing FMO's wharf is currently occupied by big mother boats (500 G/T) transporting fish catch in Bangladesh. Smaller fishing boats can not consequently utilize facilities.

3) Development of Kantang Fishing Port

Although Phuket would become the fishing center for deep sea fishing and coastal pelagic fishing in terms of facilities available and location, fish processing industries can not be developed in Phuket. Because these industry may spoil the images of Phuket as tourist spot. In this context, Kantang is the only one place to develop the fishing base for deep sea fishing and fish processing industries. In addition, as Kantang has already been established as a fishing port and industrial base, fisheries development in the area is appropriate and easy from the technical point of view. Although local fish marketing is presently transacted by so called middlemen, they are closely connected with major fishing companies located at large fishing centers like Samut Sakon and Samut Prakarn. In view of this, the cooperation of big fishing companies would be necessary, to ensure successful operation of proposed fish processing industries areas in Surat Thani and Kantang. Therefore, government would have to encourage these fishing companies to expand their business to Upper South.

3. LANDUSE AND LAND DEVELOPMENT

3.1 PLANNING FRAME

Land Development Potential of the Study Area was estimated based on the existing landuse and land capability maps. The estimated land development potential was then used as a basic information to formulate the future framework of land development of the Area. Fig. 3.1 shows the procedure adopted in this landuse study.

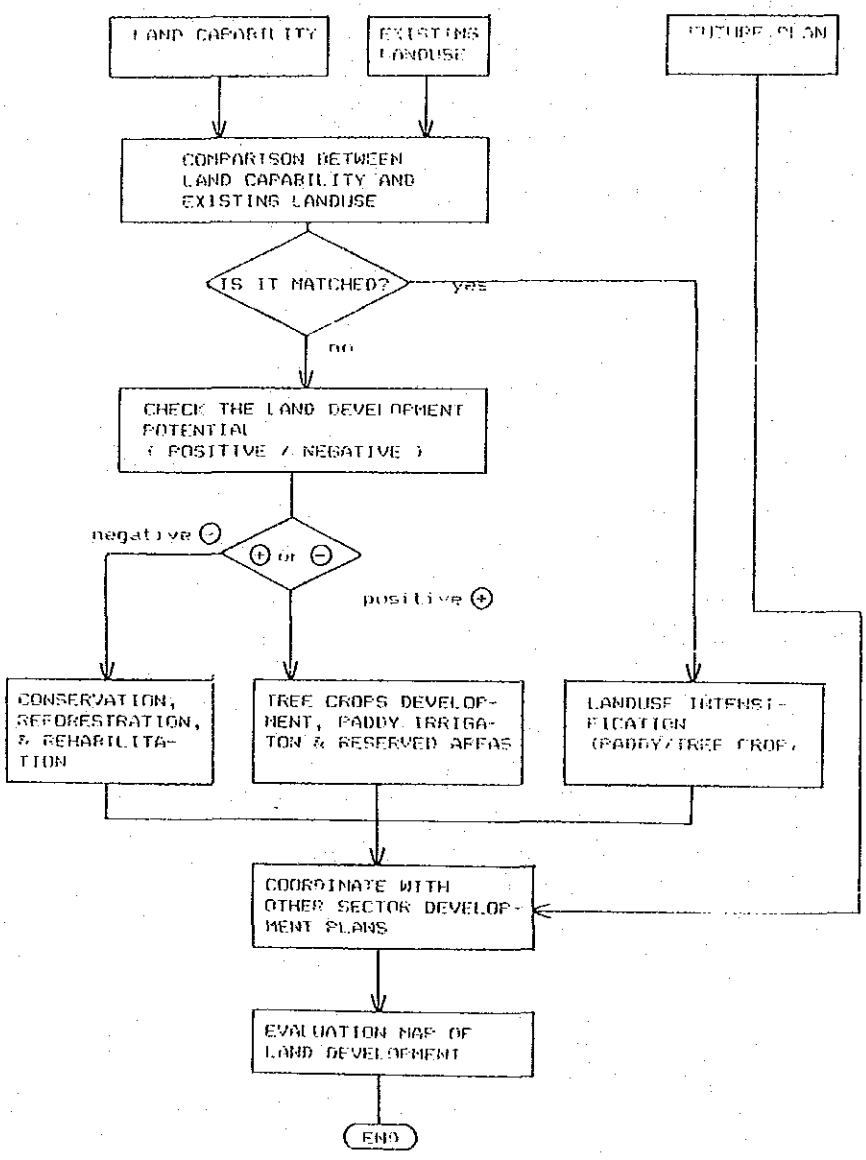


Fig. 3.1 PROCEDURE OF LANDUSE STUDY

3.2 EXISTING LANDUSE IN 1982

The information on the existing landuse was obtained from the landuse maps published by the Department of Land Development (DLD) in scale 1:100,000 for the years of 1973 and 1977. The change of landuse was revealed to be great from 1973 to 1977

In order to make clear the latest change of landuse in the Study Area, a landuse map in scale 1:250,000 was prepared based on the imaginary of Landsat-2 as of January 1982. The mapping was performed by the National Research Council with an effort to keep relevancy with the landuse map of 1977. Compared with the landuse map of 1977 which was made based on the information of aerophotography, the new landuse map contains some unclear points due to the difference in scale and lack of field information to identify the objects:

- Distinction of idle land and coconut area from paddy field is unclear in some portions.
- It is rather difficult to distinguish oil palm field with 1-2 year plant with idle or grass lands.
- Young rubber fields with intercropping are sometimes expressed as idle land with fruit crops.

In spite of these points, the new landuse map is very useful to get the information on general landuse as a whole. It is most useful to know the stretch of low intensive landuse area typical to the Study Area, which is shown in Fig. 3.2 Table 3.1 shows the existing landuse of the four changwats in the Area in 1982. Low intensive landuse area accounts for approximately 41 percent, comprising 17 percent of Secondary Forest, 7 percent of Secondary Forest mixed with Crops, 15 percent of Idle Land and 2 percent of Mining & Others. Low intensive landuse area in the Study Area accounts for 70 percent of its cultivable land which are to be explained in the section of Land Capability.

The existing conditions of the low intensive landuse area are briefly explained as follows:

Secondary Forest This area is usually situated at locations of unfavorable accessibility. Most of the area became secondary forest after cutting or shifting cultivation.

Secondary Forest mixed with Crops This area is characterized by its extensive landuse of low productivity though legal as well as illegal small holders cultivate rubber trees on scattered cutovers.

Idle Land This area, generally, belongs to suitable land for agricultural cultivation. However, owing to such reasons as no availability of labor/capital, this area seems to have been abandoned or forced to stop farming.

Mining and Others This area covers exhausted/operating mining sites and urban landuse area.

Table 3.1 EXISTING LANDUSE IN 1982

Unit: Km^2

Landuse \ Changwat	Surat Thani Area	(%)	Phangnga Area	(%)	Phuket Area	(%)	Krabi Area	(%)	Total Area	(%)
Primary Forest	4,178	(32.4)	2,083	(49.9)	71	(13.1)	732	(15.6)	7,064	(31.7)
Mangrove Forest	65	(0.5)	411	(9.9)	27	(5.0)	378	(8.0)	881	(3.9)
Low Intensive Landuse	5,861	(45.5)	853	(20.5)	225	(41.4)	2,274	(48.3)	9,213	(41.3)
Secondary Forest	2,732		223		211		728		3,894	
ditto with Crops	947 1/		177		-		454 2/		1,578	
Idle Land	2,157		166		-		1,089		3,412	
Mining & Others	25		287		14		3		329	
Tree Crops	2,183	(16.9)	719	(17.2)	194	(35.7)	1,146	(24.3)	4,242	(19.0)
Paddy Land	605	(4.7)	105	(2.5)	26	(4.8)	179	(3.8)	915	(4.1)
TOTAL	12,892	(100.0)	4,171	(100.0)	543	(100.0)	4,709	(100.0)	22,315	(100.0)

Note 1/ : Includes some paddy area.

2/ : Rubber and oil palm plantation area with scattering would be included.

Source : 1) Prepared by TUSP in cooperation with National Research Council using LANDSAT-2 imagineries of January 1982.

2) Landuse 1977, Department of Land Development.

The information of this map was interpreted from LANDSAT-2
imagery by enlarging from diapchrome 1:1,000,000
to 1:250,000 scale PATH 131 ROW 54
JAN 23 1982
PREPARED BY REMOTE SENSING DIVISION
NATIONAL RESEARCH COUNCIL THAILAND

KO SAMUI

CHAIYA

SURAT THANI

TAKUA PA

PHANGNGA

KRABI

PHUKET

KANTANG

LEGEND :

FI	PRIMARY FOREST
M	MANGROVE
OP	OIL PALM
R	RUBBER
CO	COCONUT
FC	FIELD CROPS
OC	ORCHARD
P	PADDY
	LOW INTENSIVE LAND

FIG. 3.2 EXISTING LANDUSE IN 1982

3.3 POTENTIALITY OF LAND DEVELOPMENT

Potentiality of land development was then estimated by comparing the actual landuse map of 1982 with the landuse capability map just explained.

The potentiality is classified in accordance with the following five grades:

Excellent

This is the area of highest potentiality, land capability being best suited for tree crops or suitable for paddy and the actual landuse being primary forest or low intensive landuse.

Good

This is the area of second highest potentiality, while land capability being well suited for tree crops, the actual landuse being low intensive landuse.

Moderate

Here, the actual landuse corresponds with land capability. Agricultural productivity can be further improved by introducing such methods of intensification as fertilization, new cropping and farm management.

Poor

The area belongs to this grade is not suitable for agriculture as a rule due to the conditions of soil and or water resource. Although agriculture is prevailing in this area, more input will be required to raise the productivity. Potentiality of land development is concluded very low.

Hazardous

Characteristics of this area is that though the development of the area should be prohibited from such viewpoint as prevention of natural disasters and preservation of water resources, development activities have penetrated there. This is the area to be designated as conservation area for erosion control and watershed protection.

Fig. 3.3 shows potentiality of land development in the Study Area.

LAND CAPABILITY \ EXISTING LANDUSE		PRIMARY FOREST	MANGROVE FOREST	LOW INTENSIVE LANDUSE				TREE CROPS	PADDY LAND
				SECONDARY FOREST		IDLE LAND	MINING & OTHERS		
				FOREST	MIX WITH CROPS				
CONSERVATION & LIMITED SUITABILITY	FOREST CONSERVATION		NA						
	FISH POND OR MANGROVE	NA			NA			NA	
	WOOD LAND AND PASTURE		NA						
	COCONUTS OR VEGETABLE WITH IRRIGATION		NA						
TREE CROPS	WELL SUITED FOR TREE CROPS		NA						
	BEST SUITED FOR TREE CROPS		NA						
PADDY LAND	MULTIPLE CROPS & PADDY WITH IRRIGATION		NA						
	WELL SUITED FOR PADDY		NA						
	BEST SUITED FOR PADDY		NA						

LEGEND :

: HAZARD

: POOR

: MODERATE

: GOOD

: EXCELLENT

NA : NOT APPLICABLE

Fig. 3.3 POTENTIALITY OF LAND DEVELOPMENT

3.4 TAKUA PA TIN MINING AREA REHABILITATION

As described in this main volume , land rehabilitation is very important especially in Takua Pa Area. The rehabilitation of land turns the waste land into the positive productive land. There is an appriciative case study which aims to indicate a "Development Guide Line for Abandoned Mineland" focusing on Amphoe Takua Pa. This study was carried out by Miss Oratai Aunskul as her Master's Thesis in Chulalongkorn University, Department of Urban Planning in 1982. In accordance with this study, the development guide lines are divided into two parts of land forms in correspondance with physical features of the abandoned Mine Land: One is the tailing areas where high mound of earth sand and gravels, and another is mining ponds. For the tailing areas, the Guide Line suggests following development approach/measures :

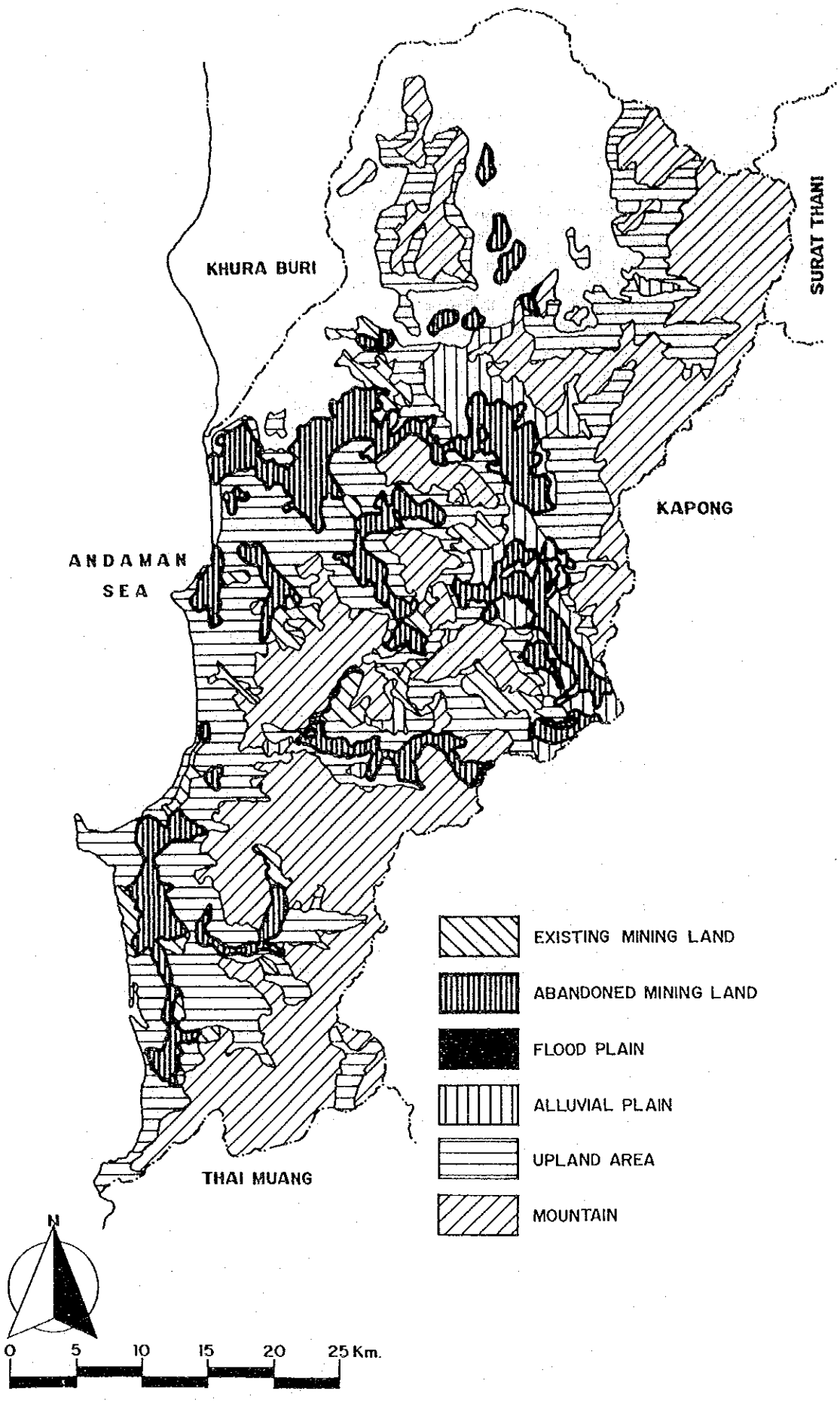
1. Reafforestation area: In environmentally critical areas like mangrove forests and hilly terrains of water-shed areas should be reserved and restored its original conditions as much as possible.
2. Area suitable for agriculture: Alluvial plains which are more fertile than other areas should be developed for agriculture.
3. Area suitable for grazing area: The upland zone which is free from floods should be developed to be grazing area.
4. Area suited for community expansion: The areas connected with Takuapa Municipality in which infrastructures are available should be developed for built-up area.

The latter approach for mining ponds development guidelines are summed up as follows:

1. Fresh water fishery should be developed in mining ponds which are not affected by the sea water.
2. Saline water fishery could be developed in mining ponds with the sea water access.
3. The mining ponds in community expansion area can be reserved for water resources of fire fighting or pipe water purposes, in case of their water quality are fully examined.

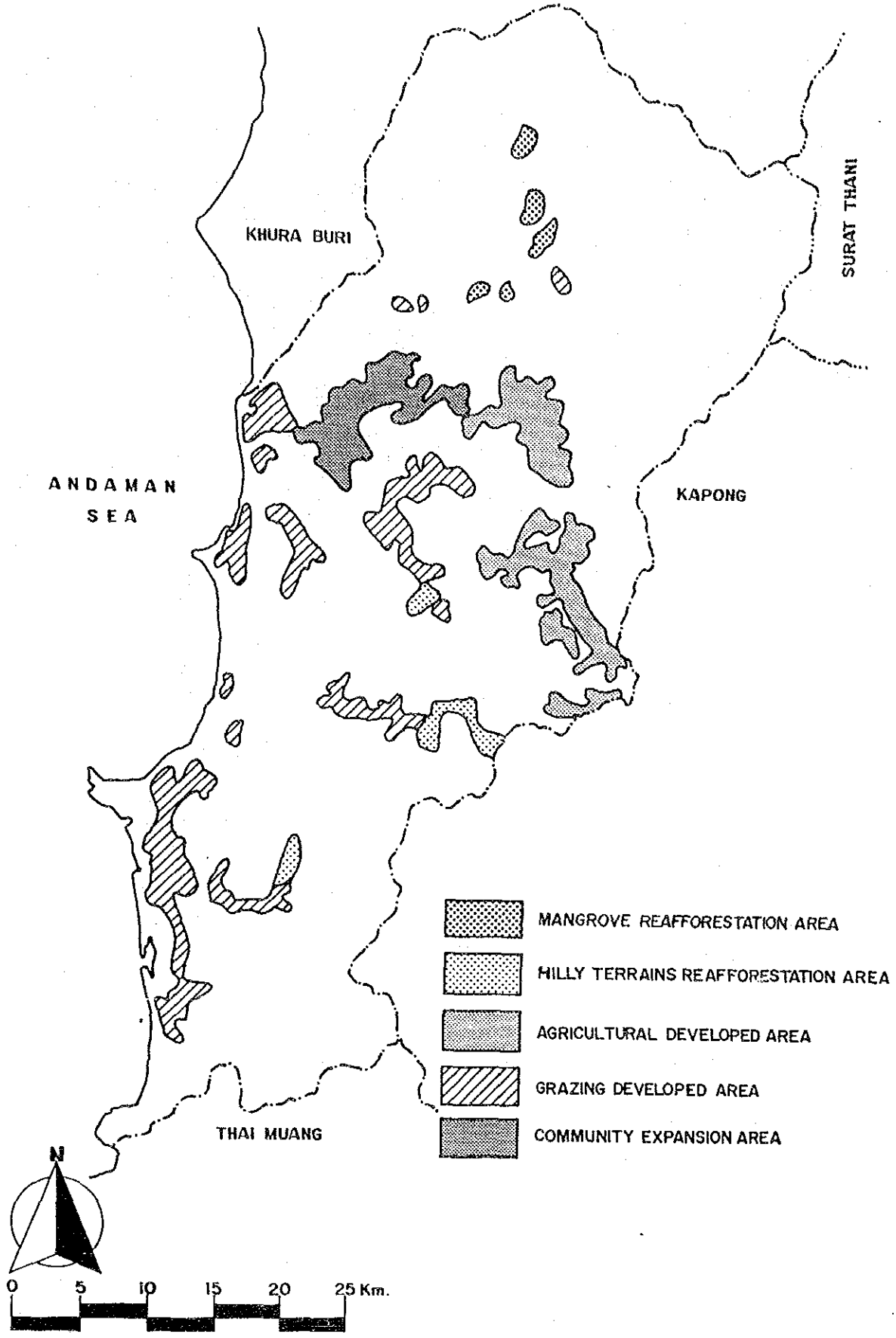
The applications based on the above guide lines are mapped out as shown in Figure 3.5.

The Study Team appriciates the above measures for land rehabilitation policies and aggressive implementation should be carried out in line with the guide lines proposed. The report, furthermore, said that the necessity of governmental coordination and help entails establishing a budgeting system of the "Special Maintenance Fund" which is collected from the mining concessionaires for implementation of land rehabilitation. The Study Team fully agrees with this idea recommended by this report. Implementation of land rehabilitation in accordance with this Development Guide Lines is expected to improve the erosion problems especially in the hilly watershed area. As it will reduce the occasions of siltation at the river mouth of Takua Pa, simultaneously flood problems in the town area of Takua Pa will be somewhat alleviated.



SOURCE: DEVELOPMENT GUIDELINE FOR ABANDONED MINE LAND
CASE STUDY : AMPHOE TAKUAPA, CHANGWAT PHANGNGA 1982 (by Miss Oratai Aunskul)

Fig. 3.4 LANDUSE IN AMPHOE TAKUA PA IN 1981



SOURCE: DEVELOPMENT GUIDELINE FOR ABANDONED MINE LAND
CASE STUDY : AMPHOE TAKUAPA, CHANGWAT PHANGNGA 1982. (by Miss Oratai Aunskul)

Fig. 3.5 DEVELOPMENT GUIDE-LINE FOR ABANDONED MINE LAND IN AMPHOE TAKUA PA

3.5 CENTRAL LOWLAND DEVELOPMENT: TECHNICAL NOTES

3.5.1 Potential Area of Oil Palm Estate Development

The locations of potential area of oil palm estate development are shown in Figure 3.6. This was derived from over-lay of both the overall evaluation of development potential mentioned in Chapter 4.2, Vol. 1 Master Plan, and the existing landuse analysis. The former is composed of the following four (4) zones in consideration of natural factors such as water, topography and land capability, and infrastructure/urban service factors such as transportation, electricity supply and convenience of urban services :

Zone A-a : In this zone, it will be possible to promote agricultural and/or urban developments in an accelerated and intensive manner and a substantial benefit can be expected soon.

Zone B-a : This zone is most likely to have the highest development potential next to Zone A-a, while development is limited by water resource constraint.

Zone AB-b: In this zone it will be necessary to intensively develop the appropriate infrastructure in accordance with future needs for agricultural development. Therefore, this area strongly requires a comprehensive planning to make best use of this area/land in a proper manner.

Zone D-ab: This zone should be preserved or reserved up to at least the year 2000 because of some physical constraints. However, a partial development for settlement area will be possible if a proper programme is established.

As to the latter, the areas involved in two categories of "Second Forest and Idle Land" and "Secondary Forest and Mixed with Crops" were picked up from the existing landuse map, because they are desired to be developed so as to utilize their potential by some measures.

Table 3.3 shows the characteristics of development potential for oil palm estate in relation with the above classifications of land.

Based on a general identification of locations of potential areas in accordance with the above examination, seven (7) potential sites shown in Fig. 3.6 of this main volume were identified, considering the following prerequisites :

- Possibility of land preparation with a proper scale : As already mentioned, the oil extracting factory should be simultaneously located. It is generally said that the area with 20,000 to 30,000 rai is necessary to make the factory feasible and that less than 12 to 15 km is a desirable distance between plantation areas and the oil extraction plant.
- Possibility of good accessibility : The location of the oil extracting factory needs a convenience of transport and good accessibility to service center.

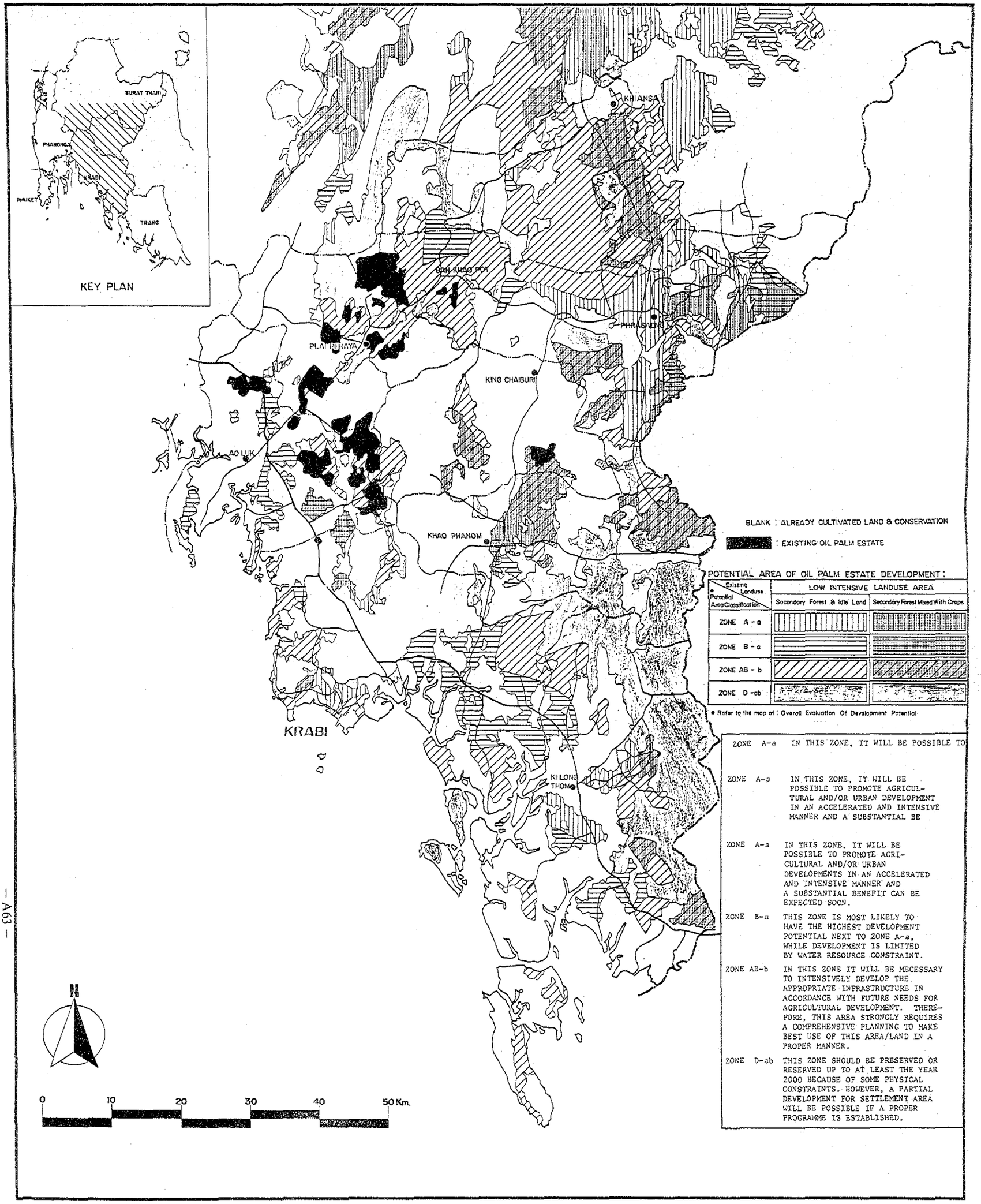


Fig. 3.6 POTENTIAL AREA OF OIL PALM ESTATE DEVELOPMENT

- Appropriate distance between oneand another sites.

The total area of these 7 sites accounts for about 2,740 sq.km, and Table 3.2 shows the compositon of area by site and category classified into four (4) ranks explained in Table 3.3. Among these areas all are not suitable for oil palm plantation estate. Judging from the examples, the area with rank of II seems to be suitable for the estate development. The sites with large area of rank II are KIANSA, PLAI PRAYA, PRA SAENG and AO LUK.

Table 3.2 AREA OF OILPALM PLANTATION DEVELOPMENT POTENTIAL CLASSIFICATION

Unit : Sq.Km.

Name of Site	I	II[1/]	III	IV	Total
KIANSA	95	260	180	30	565
PLAI PRAYA	55	275	0	140	470
PRA SAENG	175	155	140	40	510
AO LUK	50	160	0	40	250
KHAO PHANOM	25	25	120	100	270
KRABI	185	125	0	30	340
KHLONG THOM	120	85	25	105	335

Note : 1/ Existing Oil Palm Estate included in this Classification.

Considering the characteristics and composition of land in accordance with Tables 3.2 and 3.3 it can consequently be said that the most suitable site for estate development with possibility of proper location of extracting plant factories are KIAN SA, PLAI PRAYA and PRASAENG. The sites of KRABI and KHLONG THOM possess a large potential and will enable several locations of estates and extracting plants. The good accessibility in these two sites might retail a contract plantation system centering on small-medium investors of extracting plan factories.

Furthermore, as the site of KHAO PHANOM has large area of rank III, if a system to collect the raw materials from small holders' harvests is accomplished, extracting plant factories can be developed in this site. But rubber plantation has been already advanced in the adjacent area of this site, so it can be evaluated that this site is rather suitable for encouragement of rubber plantation than oilpalm.

Above all, it is recommended that five sites excluding two sites of AO LUK and KHLONG THOM are taken note for oil palm plantation development and a few estates as nuclear estates are established there up to the year 1991, with a prospect of expanding or enlargement toward the year 2000 in consideration of market and other conditions.

Table 3.3 CLASSIFICATION OF OIL PALM ESTATE DEVELOPMENT POTENTIAL

Rank	Potential Area Classification (from Overall Evaluation)	Existing Landuse	Characteristics of Development Potential for Oil Palm Estate
I	Zone A-a, and Zone B-a	Secondary Forest & Idle Land	The highest potential land with a possibility of minimum development cost, on the other hand, because of this, easy to utilized for other use. In some areas rubber or oil palm is already planted.
II	Zone AB-b	Secondary Forest & Idle Land	The most suitable land for oil palm estate despite that some infrastructure is necessary to be developed and settlements seems to be few.
III	Zone A-a Zone B-a Zone AB-b	Secondary Forest mixed with crops	The land with remarkable potentiality and where many settlements and cultivations have proceeded. Accordingly, a large scale estate is not necessarily fitting, however, if this land is located aside the large estate, the farmer in this land can plant some contract oil palm for the factory. As this is worthy of notice from diffusion of oil palm plantation point of view, this should be taken into account the estate development.
IV	Zone D-ab	Secondary Forest and Idle Land, & Secondary Forest mixed with crops	The reserved land for development after the year 2000, because of lack of infrastructure at all. Especially acquisition of useful water will be costly in this area. But a sufficient possibility toward the year 2000 can be found out.

3.5.2 Oil Palm Estate Location Study

A location study was carried out in order to actually identify the possibility and problems of development. The estate with the plantation area of 30 thousand rai was assumed for the study. The criteria of site selection for this model study are :

- Topographic condition suitable for oil palm plantation;
- Physical shape with possibility of easy development of collector and sub-trunk roads;
- Unnecessity of a lot of investment for drainage facilities development;
- The area with rank I or II in accordance with Table 4.1.8
- The area without existing settlement; and
- The area with access to the regional/national highways.

Based on the above criteria, the site for location study was selected by using the map of 1/50,000. The structure of development was drawn up as shown in Figure 3.7. As the map was issued in 1974, some information might be subject to change, the areas along Provinical Highway No. 4035 in particular.

The outline of oil palm estate studied herewith are as follows :

- Location : Approximately 5 km east of the inter-section of Provincial Highways of 4133 and 4035.
- Total Area of Oil Palm Estate : About 30 thousand rai including about 1,000 rai of community facilities and extracting plant site.
- Road Development : 43 km, of which 15 km is provincial highway and 28 km is collector roads in the site.
- Rough Estimation of Projects Cost : 600 million Baht (1980 price)
  - . Plantation Farm Development Cost including the costs of resettlement, road, public and relevant facilities.
  - . Extracting Plant Factory Development : roughly 300 million Baht

Concerning the implementation, the following issues should be solved in proper manner.

- Land acquisition/compensation;
- Coordination with relevant authorities for infrastructure and social facilities developments;
- Consideration of local employments and of the farmers living in its vicinity.

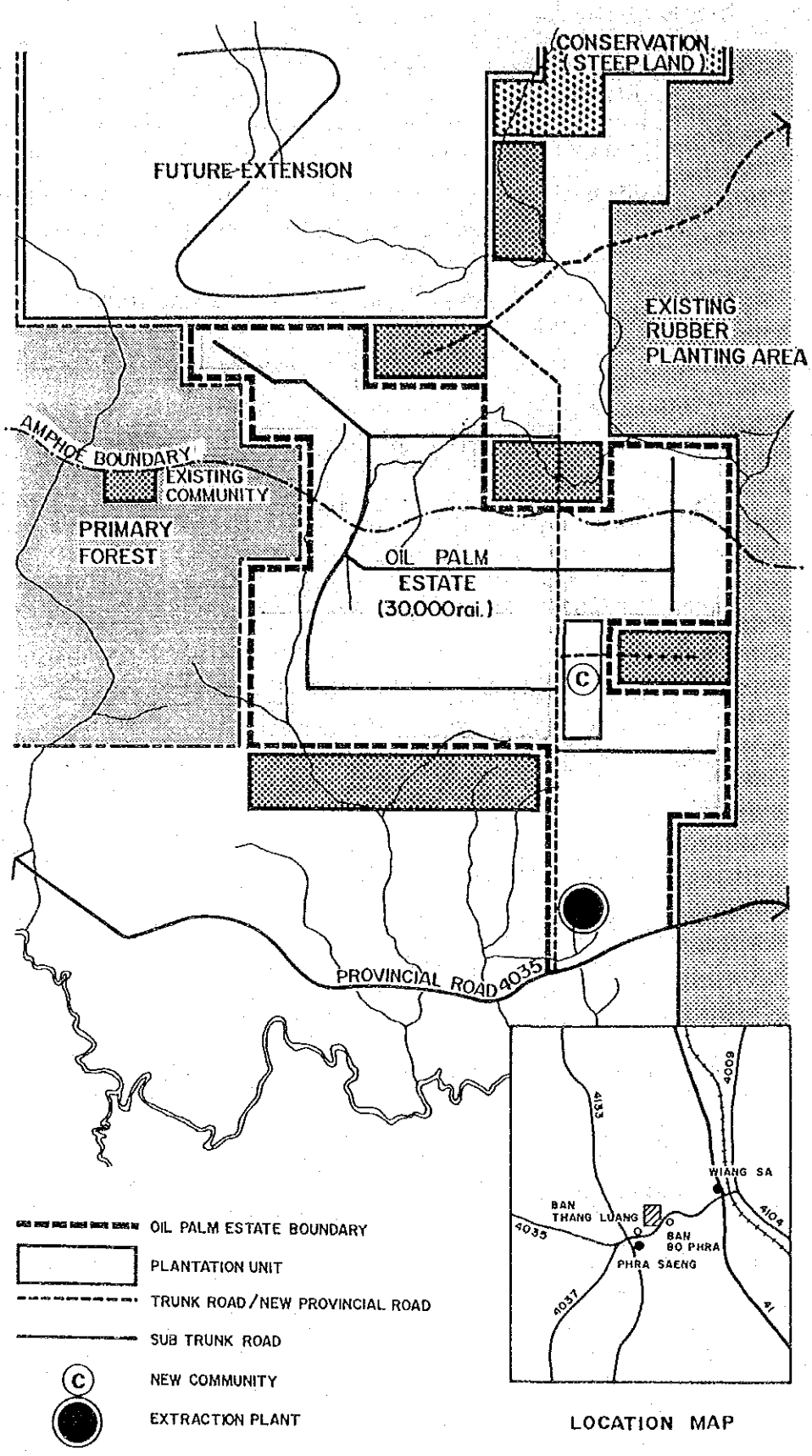


Fig. 3.7 MODEL PLAN OF OIL PALM ESTATE DEVELOPMENT

3.5.3 Cost Estimates

1) Largescale Plantation with Extraction Plant

Plantation : ฿ 5,000/rai
Extraction Plant : ฿ 3,000/rai
Community facilities, office and others ฿ 1,500/rai
Public facilities developed by the Government ฿ 500/rai

Total ฿ 10,000/rai — Private : ฿ 9,500; Public : ฿ 500

2) Resettlement Scheme Development on Public Owned Land

Plantation : ฿ 5,000/rai
Public facilities developed by the Government ฿ 500/rai
Addministrative & Technical ฿ 2,500/rai
Assistance Cost (Direct) — Private ฿ 1,000/rai; Public ฿ 1,500/rai

Total ฿ 8,000/rai — Private : ฿ 6,000/rai; Public : ฿ 2,000/rai

This type of development will be performed in RFD owned land.

3) Small Holders' Development and Agricultural Cooperative

Plantation : ฿ 5,000/rai
Public Assistance (direct) : ฿ 1,500/rai

Total ฿ 6,500/rai — Private : ฿ 5,000; Public : ฿ 1,500

This type of development will be performed in the area other than forest land.

4) Administration and Research & Development Cost for Governmental/ Semi-governmental Agencies

It is proposed that administration cost and R & D cost, respectively, are one percent of the total oil production value during the period 1985 to 2000 on the assumption that price of crude palm oil is 13.0 baht per kilogram.

With regard to the R & D expenditures necessary for this program, we have used the gross production estimated for the 15 year period between now and the year 2000 and the actual expenditure of the Rubber Research Center as references. In order to achieve a production increase for this 15 year period, it is estimated that 1% of the estimated gross production or 63 million baht per year will be necessary. A positive effort is necessary to maintain production amount so that one percent of it is equivalent to 63 million baht rather than cutting R & D funds when the production amount does not increase.

Of course, no matter how good the results of the experimental farms are, production will not increase if breeding and management technology and the replanting of sprouts to other locations is not correctly implemented. The method considered most appropriate for these extension services must be recommended based on the ORRAF system and the experience of BAAC. As the necessary expenses for the extension services, we consider the target of 1% of the gross production for the next 15 years to be appropriate as experienced in the ORRAF program.

Each changwat and amphoe extension center will assume an important role in providing careful and considerate services. Because of this, it is presumed necessary that more than 90% of the extension fund be directed to the local centers. In addition, private research and development activities should be positively mobilized and encouraged in the form of commissioned research and development and/or public-private joint research.

4. WATER RESOURCE DEVELOPMENT

4.1 PRESENT CONDITIONS OF WATER RESOURCE

4.1.1 Topography and Geology

Topography of the southern Thailand is divided into eastern and western parts.

The Phuket Range begins at the Kra Buri River, running southward along the peninsular, close to the west coast and south to the island of Phuket. It finally dives into the Andaman Sea. The total length is roughly 400Km and the width ranges from 25 to 75 Km. The mountains are generally smoothly shaped and reach heights of 600 to 900 m.

Nearly parallel to the Phuket Range, but about 100Km to the east, runs the Nakhon Range. The northern origin of this mountain chains lies under water in the Gulf of Siam, marked by a few islands such as Samui Island and Phangnga Island. It stretches southward towards the south-westernmost changwat of Satun. The mountains reach heights of 1,300 to 1,400m between Surat Thani and Nakhon Si Thammarat, but the range hardly surpasses 500m and never reaches to 800m between Thung Song and Trang.

Between the Phuket and the Nakhon Ranges, an area with rather flat land spreads. This area is called the Central Low Land which forms the watershed of the Tapi River System.

Topography of the Study Area is schematically shown in Fig. 4.1 and the typical geology of the Area is presented in Table 4.1.

4.1.2 Rainfall

South East Asia is fully under the influence of both summer winds from the south-west which brings the heavy and economically important summer monsoon rains and winter winds from the north-east. While the inland area of the Kingdom experiences this twofold rainfall, often modified through mountain ranges, the peninsular is exposed fully and without hindrance to both currents. However, since there are mountain chains along the peninsular, both the west and the east coast experience the summer and the winter monsoon differently.

Table 4.2 and Fig. 4.2 show the monthly and annual normals of rainfall as averages of a ten years' period from 1969 to 1978. (1) indicates the average rainfall of Surat Thani and Nakhon Si Thammarat on the east coast and (2) indicates that of Ranong and Phangnga on the west coast.

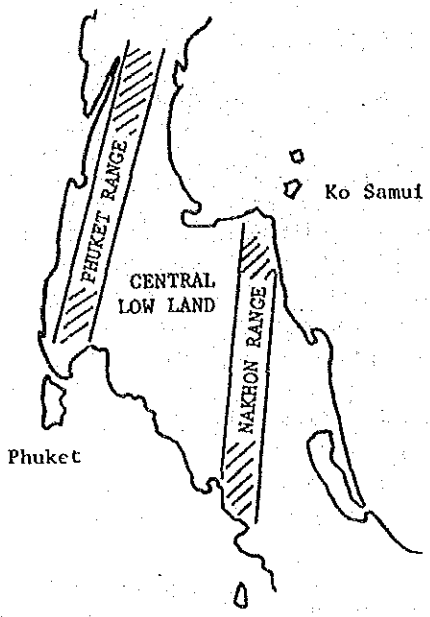


Fig. 4.1 TOPOGRAPHIC CHARACTERISTICS

Table 4.1 GEOLOGY OF THE REGION

Name of Area	Typical Geology
Surat Thani Area	Chiang Mai loams
40Km west of Surat Thani	Swampy stretches with Malaleua leucodendron
Central Low Land	Mountainous soils derived from granitic and metamorphic rocks (Khuntan sandy loams) and soils from shales, conglomerates and lime-stone (Pak Chong loams)
Phangnga coastal strip	Recent alluvial soils
Krabi coastal strip	Same with Central Hilly Area
Phuket Island	Recent alluvial soils and those from granites, silicidus snadstone, etc.

Table 4.2 ANNUAL RAINFALL (1969-1978)

Month	(1) East	(2) West	(3) Krabi	(4) Phuket
(1)	153	50	51	32
(2)	26	29	47	31
(3)	37	90	68	62
(4)	75	154	128	118
(5)	174	342	222	320
(6)	111	643	325	351
(7)	120	527	249	318
(8)	117	550	193	265
(9)	167	548	320	414
(10)	302	365	231	305
(11)	512	164	183	152
(12)	296	37	47	48

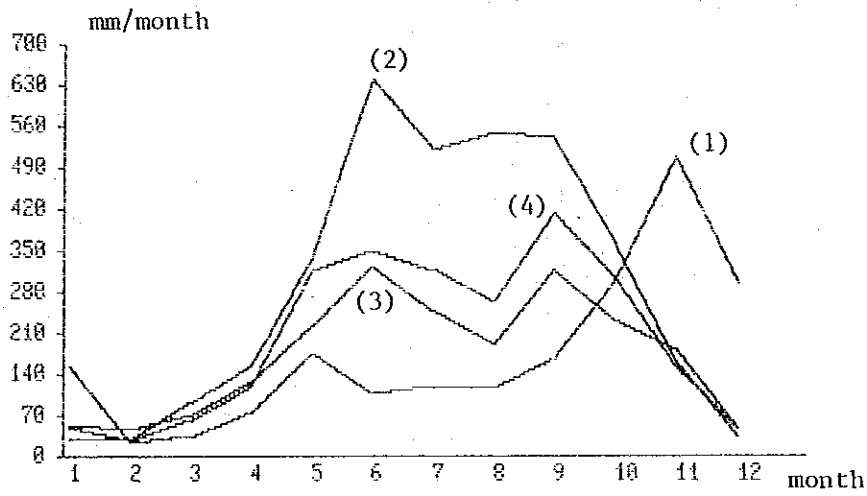


Fig. 4.2 ANNUAL RAINFALL

Note : 1) Rainfall of the East is the average of Surat Thani and Nakhon Si Thammarat

2) Rainfall of the West is the average of Ranong and Phangnga

Source : Changwat Statistics

Fig. 4.2 shows that there is a generally dry season in February and March on both coasts. Then, from April on, as the south-west monsoon makes its appearance, the rainfall on the west coast begins to cumulate and reaches its plateau from June to September, after which month the precipitation abruptly stops; the dry season then becomes more and more pronounced up to December. In contrast, the rainfall on the east coast remains moderate at around 100mm per month until September, when north-eastern wind brings moist air and the precipitation jumps up to 500mm in November; after a relatively dry summer, the east coast receives its rain mainly in early winter. Although the rainfall patterns of Phuket and Krabi belong to that of the west coast, their precipitation is considerably lower than the average of Ranong and Phangnga.

4.1.3 River Water

1) Catchment Area

Fig. 4.3 shows the distribution of catchment area of the rivers in the Study Area. There are a number of small catchment areas in both zones between the Phuket Range and the western coastal line and between the Nakhon Range and the eastern coastal line. The Phum Duang River basin constitutes the largest catchment area of the Region, amounting to 6,125Km^2, or 41 percent of total catchment area. The Tapi River basin is the second largest, amounting to 5,457Km^2, or 37 percent of total catchment area. The Phum Duang River comes from the west and drains mainly the eastern slopes of the Phuket Range with several substantial tributaries such as the Saeng River, the Sok River and the Yan River, whereas the Tapi River comes from the south and drains an extended part of the Central Low Land and the western slopes of the Nakhon Range. The two main rivers join in the coastal plain about 10Km west of Surat Thani and from here they start forming quite an extended delta towards the Gulf of Siam.

2) Annual Runoff of Rivers

The hydrological characteristics of the rivers are summarized in Table 4.3 and Fig. 4.4 . The number given to each river corresponds with the river gating site number in Fig. 4.3 The most significant characteristics is that the max/min ratios of water discharge are extremely high in most of the rivers, implying that the monthly discharge fluctuates very much in correspondence to the seasonal precipitation pattern. Table 4.4 and Fig. 4.5 show monthly fluctuation of runoff of the Tapi and Phum Duang Rivers. The Tapi River shows typical eastern regime due to the fact that the upper courses remain in eastern and central part of the region. On the other hand, the Phum Duang River shows typical western regime owing to the fact that the upper courses reach close to the western shores.

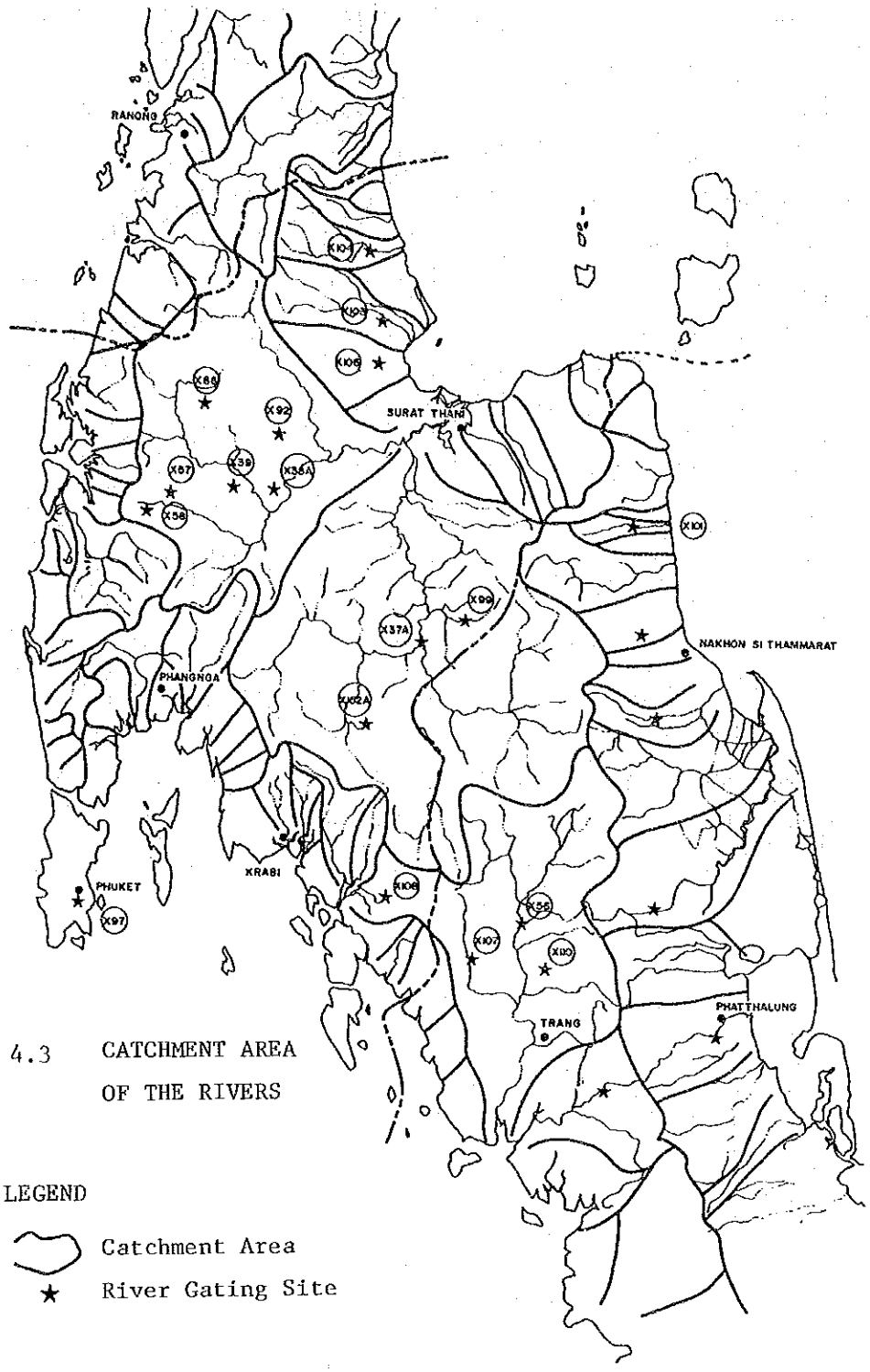


Fig. 4.3 CATCHMENT AREA OF THE RIVERS

LEGEND

Catchment Area

★ River Gating Site

Table 4.3 HYDROLOGICAL CHARACTERISTICS OF SELECTED RIVERS

No.	Name of River	Catchment Area(km^3)	Discharge(m^3/sec)			Ratio Max/Min	Annual Runoff (million m^3)
			Mean	Min.	Max.		
X104	Khlong Tha Krachai	354	10.99	0.30	203.20	677	347.6
X103	Khlong Takhian	180	3.91	0.00	140.68	-	123.8
X106	Khlong Chaiya	309	5.03	0.00	41.42	-	159.1
X38A	Khlong Phum Duang	2,706	179.60	5.70	1686.60	296	5,679.3
X39	Khlong Saeng	1,437	116.60	4.70	1437.60	306	3,886.2
X57	Khlong Chong Lom	8	1.31	0.11	22.66	206	41.3
X58	Khlong Sok	312	26.36	2.00	250.05	125	833.7
X66	Khlong Yan	661	36.00	1.80	561.00	312	1,138.3
X92	Khlong Yan	1,001	44.24	5.00	473.00	95	1,399.0
X37A	Mae Nam Ta Pi	5,200	131.92	16.50	421.60	26	4,171.5
X99	Khlong Tan	105	1.78	0.28	14.08	51	56.4
X102A	Khlong Sang	152	2.76	0.04	21.88	547	87.4
X97	Khlong Ao Yan	2	0.02	0.00	1.64	-	0.5
X101	Khlong Tha Thong	95	3.49	0.41	226.90	553	110.4
X56	Mae Nam Trang	1,801	31.34	3.28	214.60	65	990.9
X107	Khlong Chi	248	4.68	0.23	48.61	211	147.9
X108	Khlong Kalase Yai	57	0.70	0.13	5.08	39	22.0
X110	Khlong Lamphu La	229	3.82	0.13	28.83	222	120.8

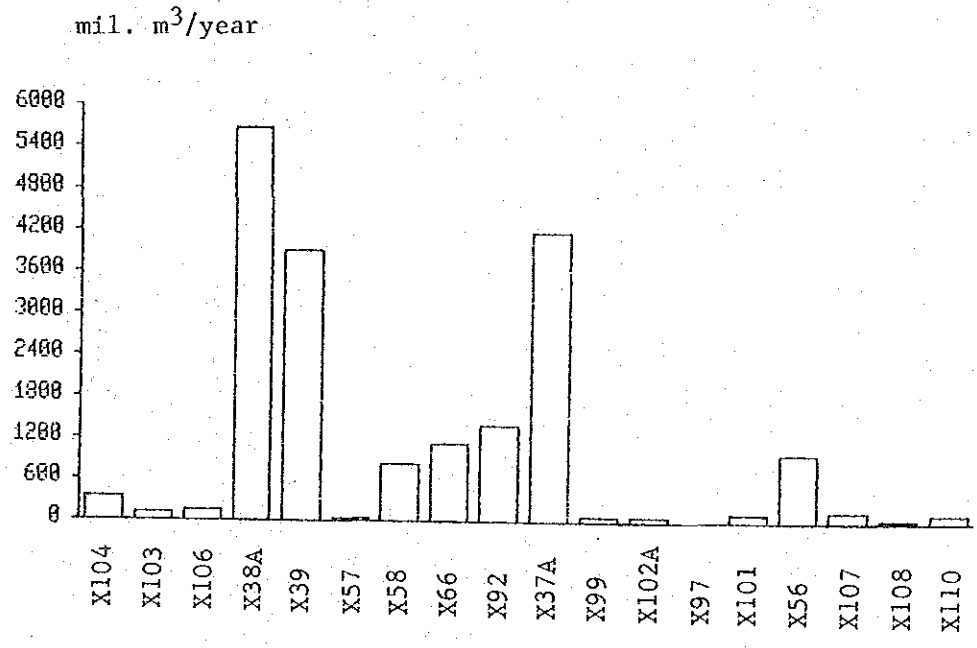


Fig. 4.4 ANNUAL RUNOFF

Table 4.4 MONTHLY DISCHARGE

Unit : m^3/sec

Month	(1) TaPi	(2) Phum Duang
(1)	91.10	47.60
(2)	36.10	27.00
(3)	31.90	19.70
(4)	23.30	24.50
(5)	29.80	100.70
(6)	55.50	213.60
(7)	129.70	364.00
(8)	132.30	446.30
(9)	264.60	378.30
(10)	291.60	272.10
(11)	314.70	163.50
(12)	183.70	98.50

Source : RID

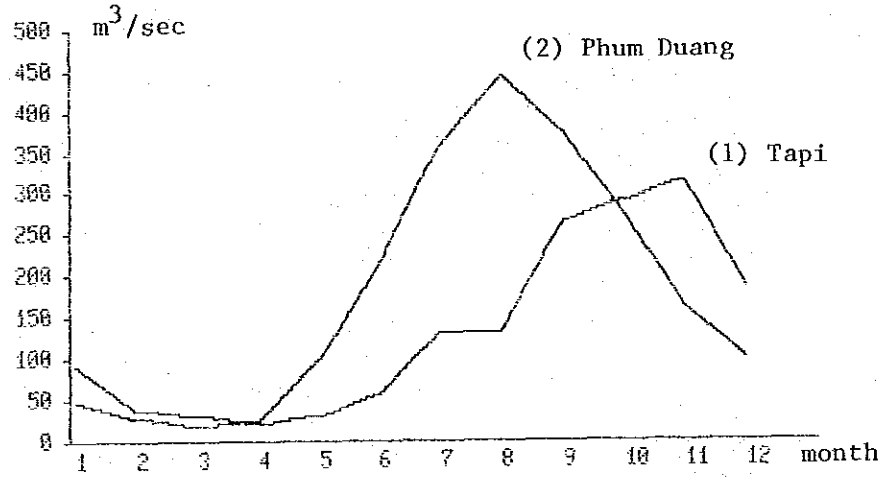


Fig. 4.5 MONTHLY DISCHARGE

3) River Water Utilization

(1) Irrigation

Geographical and climatological conditions in the peninsula has restricted its cultivation to very clearly defined areas where suitable soils and rainfall exist, together with irrigation possibilities. Irrigation activities are largely bound to the rainy season and result in fostering traditional cropping pattern rather than in permitting the introduction of additional cultures.

In 1980, the irrigated area of the whole kingdom amounted to 3,015 thousand ha, where the South Thailand shared 8.5 percent, or 256 thousand ha. The irrigated area in the Study Area amounted to 27 thousand ha, that is to say, 0.9 of the total irrigated area in the whole kingdom and 10.5 percent in the South Thailand.

The location of irrigation sites already implemented in the Study Area is shown in Fig. 4.6 and that of on foot ones is shown in Fig. 4.7 . Their contents are summarized in Table 4.5 and 4.6 respectively. The number of irrigation sites accounted for 17 locations, of which total area amounted to 27,010 ha. Major irrigation sites, ⑥, ⑦ and ⑧ are concentrated in the area from Kanchanadit to Don Sak in Changwat Surat Thani. The total area of these three amounts to 13,540 ha, or 50 percent of the whole irrigated area in the Study Area. The irrigation site of Chaiya follows them, amounting to 4,800 ha. There are two irrigation projects scheduled; expansion of the existing irrigation site in the Khram River basin and new development in the Takhian River basin.

Most of the irrigation projects already implemented were confined to diversion facilities and not to storage of water. These irrigated areas, however, could have another possibility to introduce such additional cultures as double cropping by developing reservoirs for the dry season. Table 4.5 and 4.6 show the water balance between demand for irrigation water and water discharge of the rivers in the dry season, too. All the irrigation sites other than the ones in the Tapi and Phum Duang basins are estimated to suffer shortage of water at the minimum level of discharge. The irrigation sites in the ① Takhian, ⑥ Kradae and ⑧ Khao Lak River basins are the ones that irrigation water demand exceed the respective mean level of discharge. It would be concluded that Chaiya and the area between Kanchanadit to Don Sak are the most probable water deficit area in the region.

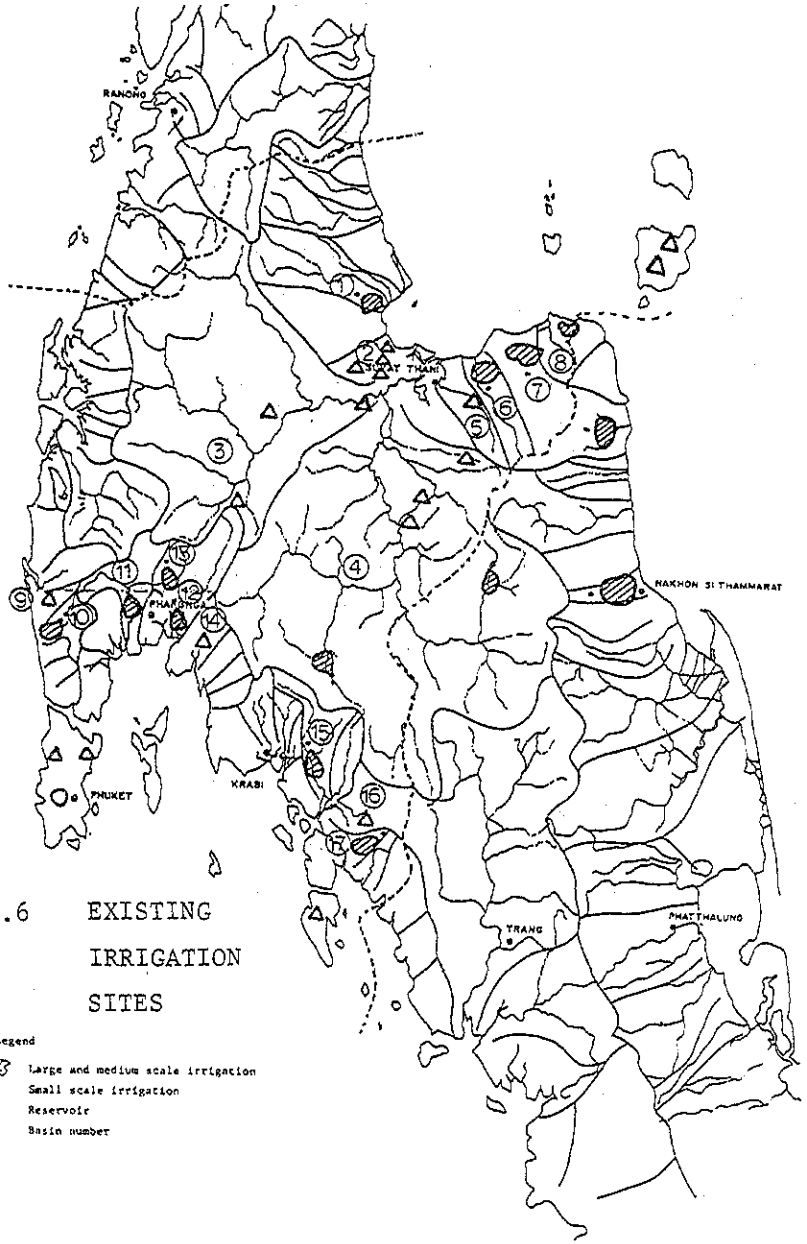


Fig. 4.6 EXISTING IRRIGATION SITES

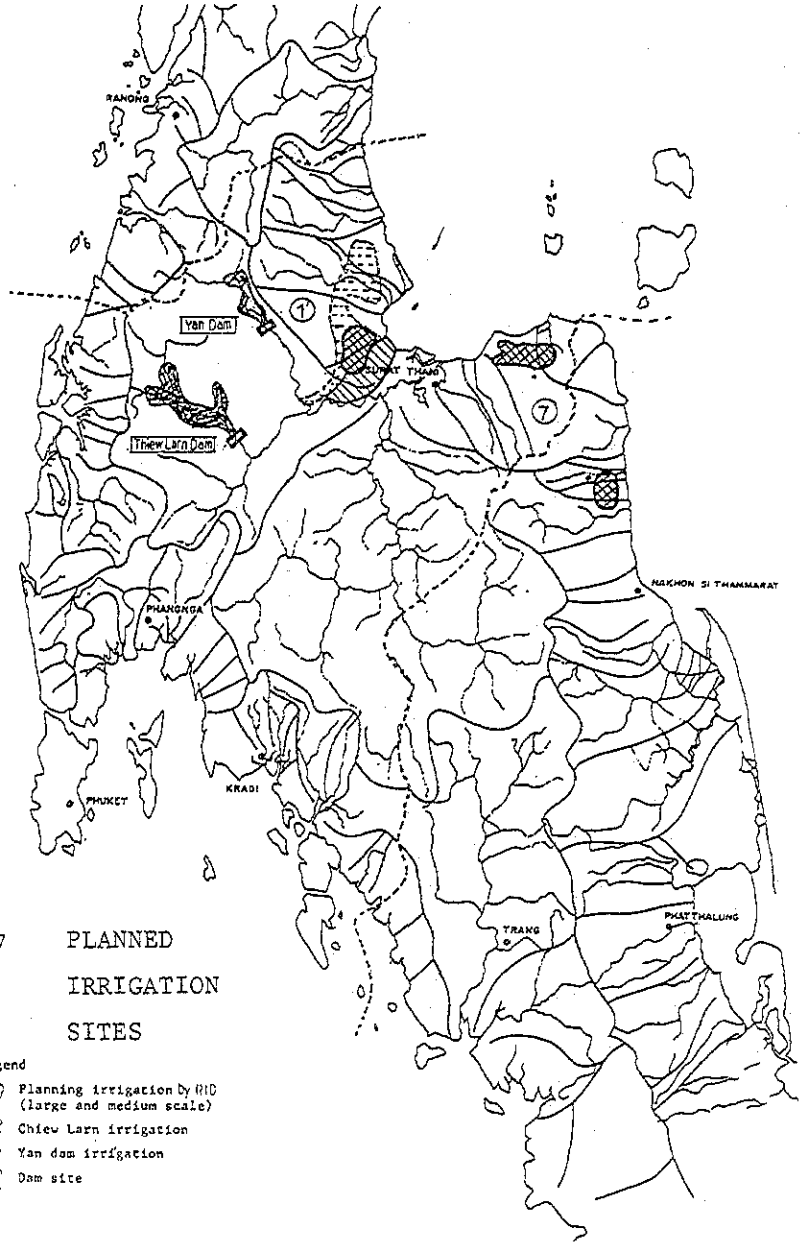


Fig. 4.7 PLANNED IRRIGATION SITES

Table 4.5 WATER UTILIZATION BY EXISTING IRRIGATION SITES

Catchment Area No.	River	Catchment Area	Discharge Mean	Discharge Min.	Existing Irrigation Area Covered	Existing Irrigation Water Distributed	Balance with Mean Discharge	Balance with Min. Discharge
		Km^2	m^3/sec	m^3/sec	Ha	m^3/sec		
1	Takhian	180	3.91	0	4,800	4.8	△	△
2	Maruan	52	(1.32)	(0)	480	0.5	+	△
3	Phum Duang	2,706	179.6	5.7	1,120	1.1	+	+
4	Tapi	5,200	131.9	16.5	1,760	1.8	+	+
5	Thap Sathon	64	(1.62)	0	960	1.0	+	△
6	Kradae	100	(2.54)	(0)	2,880	2.9	△	△
7	Khram	320	(8.11)	(0.2)	6,400	6.4	+	△
8	Khao Lak (Tentative)	50	(1.27)	(0.1)	4,260	4.3	△	△
9	Hia Noi	18	(0.80)	(0)	240	0.3	+	△
10	Yai Nin	100	(3.80)	(0.1)	640	0.6	+	△
11	Suan Phrik (Tentative)	14	(0.44)	(0)	190	0.2	+	△
12	Bo Saen	21	(0.66)	(0)	480	0.5	+	△
13	Suan Phlu (Tentative)	21	(0.66)	(0)	640	0.6	+	△
14	Rong Luai (Tentative)	48	(1.20)	(0)	320	0.3	+	△
15	Huai Khram (Tentative)	90	(1.50)	(0.1)	1,200	1.2	+	△
16	Thom	210	(6.65)	(0.1)	160	0.2	+	△
17	Raet	30	(0.95)	(0)	480	0.5	+	△

Note: 1. Discharges are estimated based on the pattern of rainfall runoff and the runoff data at selected points.

2. Water consumption in the irrigated area is assumed to be the national average or one litre per sec. ha.

3. Mark"△" means minus

Table 4.6 ESTIMATED WATER UTILIZATION BY PLANNED IRRIGATION SITES

Catchment Area No.	River	Catchment Area	Discharge Mean	Discharge Min.	Irrigated Area Existing	Irrigated Area Planned	Irrigated Area Total	Water Distributed for Existing and Planned Area	Balance with Mean Discharge	Balance with Min. Discharge
			m^3/sec	m^3/sec	Ha	Ha	Ha	m^3/sec		
1	Khlong Takhian	260	4.09	0	0	5,000	5,000	5.0	△	△
7	Khram	320	(8.11)	(0.2)	6,400	10,340	16,740	16.7	△	△

Note: 1. Discharges are estimated based on the pattern of rainfall runoff and the runoff data at selected points.

2. Water consumption in the irrigated area is assumed to be the national average on one litre per sec. ha.

(2) Potable Water

Rain water and ground water are major sources of potable water in the Study Area. River water is seldom used for that purpose with the exception of waterworks implemented in municipalities of Surat Thani and Krabi and amphoes of Tha Chang, Yan Din Daeng and Tha Chana in Changwat Surat Thani. The total number of population who are supplied potable water by these waterworks amounts to only 80 thousand persons. This fact shows that intakes of river water remains very little at present.

(3) Hydro Power Plant

There are two dam construction projects in the Study Area; Chiew Larn Dam, now under construction, is scheduled to be completed in 1987 and Khlong Yan Dam is now under study. Their contents are shown in Table 4.7 but irrigation schemes are disregarded due to the budgetary restrictions.

Table 4.7 HYDRO POWER PROJECT

Basin	Project Name	Province	Capacity (KW)	Irrigation (Rai)
Tapi-Phum Duang	Chiew Larn	Surat Thani	240,000	92,000
Khlong Yan	Khlong Yan	Surat Thani	106,000	252,000

4.1.4 Ground Water

Drilling of ground water in the peninsula is done efficiently. Ground water is usually obtainable from alluvium, diluvium, talus sediment, limestone cave and weathering zone in low flat land excluding mountainous high land. A fairly large supply, as high as 4,000 litres per minute, can be obtained from sand and gravels of the eastern coastal plain, and moderate quantities can also be obtainable from river flood plains and valleys. Ground water is generally contaminated with sea water along the muddy coastline in the west. Ground water is not normally used for irrigation but for the supply of potable water to the population.

4.2 NEEDS AND PROBLEMS

4.2.1 General

Water use is roughly divided into utilization of its energy (hydro-electricity) and consumption of itself (agricultural,urban and industrial uses). The consumption of water is steadily increasing due to population growth, upgrading of standard of living, the expansions of urban, industrial and agricultural activities. Water supply must be considered in relation to the water resource based on the condition that most of water stably flowing and easily taken, is utilized for agricultural use.

In order to ensure the water for urban and industrial uses, it is necessary to prepare the water development facilities such as storage reservoir. Taking much groundwater is sometimes subject to ground subsidence and salt water intrusion especially in large urban area. A careful attention must be given to the use of groundwater.

4.2.2 Urban And Industrial Water Development

Urban and industrial areas that needs plenty of water generally are located on the alluvious plain near coast. The water used by these areas depends on the resource development facilities to ensure the water intake in the large portion, because river has generally the variation by season. As mentioned above, although groundwater is utilized positively , because of a low price and good quality, this is in danger of land subsidence and salt water intrusion. These phenomena are difficult to recover if they once occure.Basically, the dependance of large volume on groundwater is not suitable. In the water quality, as urban use requires the strictness of it, generally its purification and sterilization is necessary to supply for service water. Industry use is common to be supplied after a simple treatment.

General notices have to be considered, i.e., groundwater is possible in the volume of about 1,000 m^3/d, but river water use or development of water reservoirs must be considered to the requirement of more than 5,000 m^3/d.

4.2.3 Inland Water Development

Generally, the upperstream of rivers is surrounded by mountain and valley, and clean stream is flowing continuously. The water of river flowing through mountain area enter into flat plain, and sometimes percolates into underground and occasionally forms wadi. Usually small volume of use may be obtained in the upper part of the stream.

According to the analysis of natural conditions, water use of about 1,000-2,000 m^3/d in inland area will be obtained easily from river or groundwater and especially piedmont area seems to be good. But it will be necessary to develop the intake facility as reservoir and dam if the water of more than 10,000m^3/d is required.

4.2.4 Critical Factor

1) Forest Conservation

A forest enables to average the discharge volume, to increase the retaining capacity of water, and to decrease erosion of soil. As a trend of whole Thailand including the study area, forest resource is being subject to random cutting. The portion of forest area decreased to 25 percent from 55 percent in the former times. In the study area, the uncovered land can be seen in many areas, and also waste land or grass field is remarkable. It is conceivable that this is dependent on poor management of river basin. A difference of water flow between rainy and dry seasons will become larger because of this. This will originate a pollution of sediment caused by runoff with soil and entail erosion and worse water quality. Anyway the conservation of forest resource seems to be a important policy because it is strongly related with preservation of water resource.

2) River Management

River management focuses on debris barrier, bank and retarding basin, etc. for flood prevention. The debris barrier and the river bank are popular in Japan but generally can not seen in Thailand yet. The debris barrier is essential for prevention of the mud flow and the water quality protection. The justification of the river bank is still controversial because a flood gives an occasion to transport nutriment from the upperstream and give natural fertilizer for agriculture. If so, we must think of how to utilize flooding or other idea of the flood adjustment. On the other hand, a dam and reservoir will inestimably contribute not only to hydro-electricity generation and irrigation but also to flood control and averaging of the discharge volume. The solution of this simultaneous contradiction will come to be an issue in terms of river management. Chiew Larn dam, recently being constructed for the purpose of hydro-electricity in the upperstream of Phum Duang River, therefore, will give a large meanings but simultaneously some problems for the regional development.

3) Port Burying

Because of lack of forest conservation and poor river management in the study area, Tapi-Phum Duang River, the largest in the southern region, is carrying muddy water and pouring into Ban Don Bay. Therefor, Tha Thong Port, the entrance to sea in Surat Thani

province, is being buried by sediment. The cost of dredging is said to need 120 Mill. Baht and this port is continuously in danger of burying. An effective management seems to be one of the urgent ploicies. The idea that a retarding basin should be prepared in the downstream of Tapi river will be one counter-measure against this problem.

4) Flooding

Generally, some countries in tropical area do not have river bank based on a thinking that it is common to company with flood in rain season. However it seems that a flood problem is getting more severe than the former times. In order not to expand flood, a perfect execution of forest conservation and river management is desirable. Surat Thani lowland usually suffers from flood. Phun Phin area located on 20 km inland from coast, is the lower land of m.s.l. 1-4 m , and is located at a junction of Tapi-Phum Duang river, moreover the width of rivers is narrow. This area is usually flooding between July and December in rain season and the flooding duration often amounts to 2-3 months. If recovery time after flood is considered, the damage period will continue for a long term. The Chiew Larn dam is said to have 500 Mill. m^3 of retention storage, however, this dam seems to be difficult to completely stop flooding in the routing area.

Accordingly, some countermeasures against flooding such as formation of a flood retarding area will be necessary. The retention storage of the retarding basin which the Study Team proposes, attains 100 Mill. m^3 and can decrease by 10 percent, 1,000 m^3/sec of Tapi River's water discharge. Besides this, there are reports of flood damage in minor rivers. For example, Takua Pa area in Phangnga province suffers from a large injuly. This area is high rainy zone, amounting to 4,000 mm of mean annual rainfall. This area is in a circumstance generating instantly large discharge. If a proper forest and river management is neglected, this phenomenon seems to be more severe. A protection of forest, debris barrier construction and elimination of waste land seems to be essential policy. Any land destruction must be controlled.

5) Comprehensive River Use Planning

The study area is expected to make a rapid development toward the year 2000 in agricultural, industrial and urban developments. To encourage this water use planning effectively and efficiently, an integrated planning should be required.

4.3 A WATER BALANCE ANALYSIS

4.3.1 Urban use

Urban use is divided into residents use and business use in offices, shops and public institutions etc. The present condition of urban use in the sutdy area is not active however rapid expansion of urban water demand will be anticipated in the year 2000 because of increasing of population, urban area's extension by introduction of large scale industry, and activation of commercial business.

Assumed conditions for the analysis are as follows:

- Supply raio targeted to the urban area in the year 2010 is 80 - 90 percent of households, from 30 - 45 percent of the year 1980.
- Water supply in the rural area is regarded as another system.
- Urban use (family and business) rate generally rises accompanying with living level improvement but its upper limit is 300 l/d/person.
- Outside element of tourism can be absorbed into urban use in Krabi and Phangnga area but is counted additionally in Phuket and Surat Thani area.

The assumed urban use demand is as the following Table 4.8.

Table 4.8 ESTIMATION OF URBAN WATER DEMAND

unit : m^3/d

area \ year	1990	2000	2010
Surat Thani	8,870	24,670	52,160
Phunphin	4,440	10,730	22,460
For tourists	1,400	2,810	4,010
Sub-total	14,710	38,210	78,630
Ban Na San	1,210	4,060	13,230
Phangnga	1,210	3,180	6,720
Ta kua pa	1,270	3,300	7,640
Krabi	3,900	9,240	17,680
Phuket	8,430	29,860	65,660
For tourists	2,100	4,280	6,150
Sub-total	10,530	34,140	71,810
Grand total	32,830	92,130	195,710

In the above table, Surat Thani and Phuket urban area are presumed to expand rapidly in water supply demand. Surat Thani area can directly take the water from Tapi river.

The water demands in Ban Na San, Phangnga, and Takua Pa area are under 5,000 m^3/d so that, surface and groundwater will be available. However, Phangnga and Takua Pa areas will need dams toward the year 2000. As Krabi area faces to the coast, surface water may be available for the demand under 5,000 m^3/d but dams will be required in the demand of more than 5,000 m^3/d.

In Phuket area, a remarkable river does not exist, and also groundwater is in a difficult condition to obtain. Accordingly its water use cannot help depending on ponds and now planning dams. As the water use potential seems to be 50,000 - 75,000 m^3/d, Phuket area's water supply will be able to meet the demand up to the middle of the 1990s, but an alternative supply plan from the mainland will be necessary. These are summarized as Table 4.9 .

Table 4.9 WATER USE BALANCE

Urban name	Water kind 1990	2000	2010	Balance	Remarks
Surat Thani				+	
Ban Na Sah				+	Together use of groundwater and river water
Phangnga				+	"
Takua Pa				+	"
Krabi				+	Dam water
Phuket				Δ	Supply from mainland also need to considered

Note: Legend ——— River water
- - - - - Ground water
— · — · — Dam water

4.3.2 Industrial Use

Industrial use is water offered for service of industrial activity relating to manufacturing industry etc. and is utilized for various purposes of material, product treatment, washing, boiler, cooling and temperature adjustment, etc. The use volume increases in proportion to expansion of industrial activity.

Table 4.10 INDUSTRIAL USE DEMAND

Unit : m^3/day

	to 1990	1990-2000	after 2000
Surat Thani	11,000	20,000	28,000
Chaiya	-	1,000	1,000
Wiang Sa	-	1,000	1,000
Phanom	-	1,000	1,000
Phuket	2,500	13,750	15,000
Krabi	1,000	2,000	2,000
Phangnga	-	1,000	1,000
Takua Pa	1,250	2,500	5,000
Total	15,750	42,250	54,000
		(49,250)	(61,000)

Note : The figure in parenthesis shows the demand when an oil refinery is developed.

The supply for this demand is anticipated as the following in the same manner as urban.

- Surat Thani area can be taken from the downriver of Tapi River.
- The water demands in Chaiya, Wiang Sa, and Phanom areas will be possible to meet be utilization of groundwater.
- Phuket area cannot help furnishing dam construction.
- Krabi area will be suitable to be supplied from river because of the location near coast.
- Phangnga and Takua Pa areas can depend on groundwater and surface water up to the supply of 2000-3000 m^3/d but it will necessary to provide dams to meet the demand of more than 5,000 m^3/d.

4.3.3 Agricultural Use

Agricultural use is mainly divided into paddy irrigation, upland irrigation, and livestock water. Namely it is utilized for production of crops and livestock. The water for agricultural use also generally forms natural environment of its region and functions as conservation of groundwater. Major portion of agricultural use is for irrigation of rice crop. Rice crop is cultivated in submerged condition and water is consumed for evapo-transpiration necessary for rice growth, evaporation from water surface, and percolation to underground. Accordingly during the cultivation period the water must be supplied with the volume subtracted a direct rainfall on paddy field from the water requirement as mentioned above. The requirement depends on weather, soil, underground water level, and growth condition of rice crop. Generally Thailand paddy fields are fewer in water requirement because of the clay soil condition, however, its net duty is regarded as about 1.0 l/sec per a hectare. In comparison with this paddy irrigation water, upland irrigation use and livestock use is very small. Agricultural use contents and the balance are shown in Figure 4.8 and Table 4.11.

Fig. 4.8 IRRIGATION CATCHMENT AREA

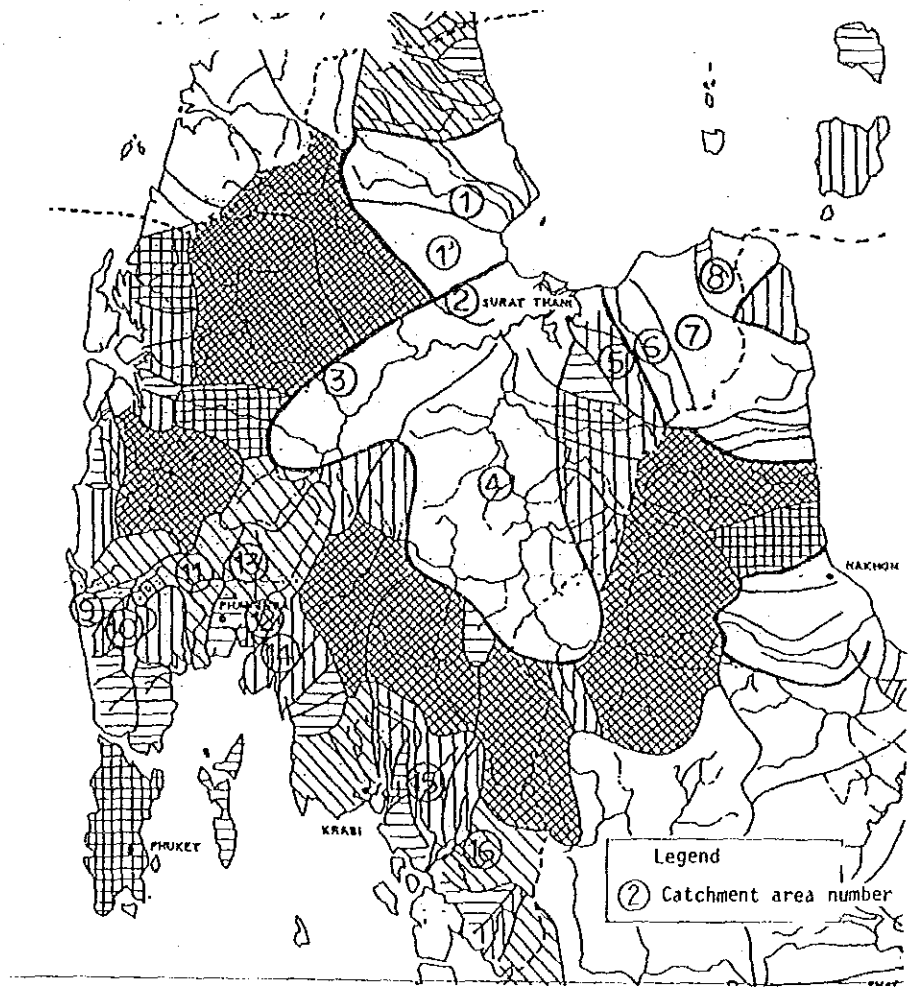


Table 4.11 AGRICULTURAL BALANCE

	yearly available water	present irrigation need volume	balance	Remarks
	$x10^3m^3$	$x10^3m^3$		
①	31,000	49,000	△	
②	54,000	51,000	○	
③	1,480,000 *	11,000	+	much surplus
④	430,000	18,000	+	much surplus
⑤	25,000	10,000	+	
⑥	14,000	30,000	△	
⑦	23,000	66,000	△	
⑧	11,000	44,000	△	
⑨	3,000	3,000	○	
⑩	8,000	6,000	+	
⑪	8,000	2,000	+	surplus
⑫	16,000	11,000	+	
⑬				
⑭	5,000	3,000	+	
⑮	12,000	12,000	○	
⑯	16,000	2,000	+	surplus
⑰	5,000	5,000	○	

Note: ① Calculated from expected river available volume
② Irrigation period regard as 120 days
③ Phuket is excluded by conservation
④ * Due to average increase of 47 m^3/sec in Chiew Larn dam

In this figure, Phum Duang and Tapi river of No. 3 and No. 4 have much surplus. Besides these, No. 11 and No. 16 in the western region are in slight surplus, but the others don't afford to reserve. Phum Duang river of No. 3 also has the following projects in the future irrigation plan.

Table 4.12 FUTURE IRRIGATION PLAN

	yearly available water	Future irrigation need volume	balance	Remarks
	$x10^3m^3$	$x10^3m^3$		
⑰	20,000	51,000	△	
⑦	23,000	151,000	△	
③	1,480,000	* 272,000	+	Chiew Larn, yan dam project

Note: * by RID data

4.3.4 Total Balance

The total demand of water use is summarized in Table 4.13 .

Table 4.13 ESTIMATION OF WATER DEMAND

area \ year	Composite demand to 1990	1990 - 2000	after 2000	Remarks
Surat Thani	urban 14,710 } 25,710 m³/d industry 11,000 } agriculture 250,000	38,210 } 58,210 m³/d 20,000 } 850,000	78,630 } 106,630 m³/d 28,000 } 1,100,000	Intake from Phum Duang and Ta pi River
Sub-total	275,710	908,210	1,206,630	
Ban Na San	1,210	4,060	13,230	
Chaiya	(industry - agriculture 410,000	(1,000 410,000	(1,000 410,000	
Sub-total	410,000	411,000	411,000	
Wiang Sa	-	1,000	1,000	
Phanom	-	1,000	1,000	
Phangnga	urban 1,210 } 1,210 industry - }	3,180 } 4,180 1,000 }	6,720 } 7,720 1,000 }	
Takna Pa	urban 1,270 } 2,520 industry 1,250 }	3,300 } 5,800 2,500 }	7,640 } 12,640 5,000 }	
Krabi	urban 3,900 } 4,900 industry 1,000 }	9,240 } 11,240 2,000 (16,240) (7,000)	17,680 } 19,680 2,000 }	
Phuket	urban 10,530 } 13,030 industry 2,500 }	34,140 } 47,890 13,750 (42,890) (8,750)	71,810 } 86,810 15,000 }	
Total	708,580	1,394,380	1,759,710	

Table 4.14 SUPPLY AND BALANCE

Area	demand (after 2000)	Available supply	balance	water source
	m³/d	① m³/d		
Surat Thani	1,206,630	4,000,000	+	Phum Duang - Ta pi river
Ban Na San	13,230	② 1,000,000	+	Ta pi river
Chaiya	411,000	③ 84,000	Δ	Takkian river, ground water
Wiang Sa	1,000	② 5,000-10,000	+	Ground water
Phanom	1,000	④ > 10,000	+	Ground water
Phangnga	7,720	② 30,000 - 50,000	+	Phangnga river, ground water
Takua Pa	12,640	④ > 75,000	+	Takuapa river
Krabi	19,680 (24,680)	② 30,000 - 50,000	+	Khao Din river
Phuket	86,810 (81,810)	② 50,000 - 75,000	Δ	Reservoir, supply from main land

Note : ① By average flow increasing (47m³/sec) of Chiew Larn dam.
② Expected usable volume.
③ Calculated by possible discharge of rainfall.
④ Expected usable groundwater.

Table 4.14 shows a summary of water balance between supply and demand. As shown in the table, the water supply in present development plan is in surplus as a whole but Chaiya and Phuket area are in deficit. However, as the industrial use of Chaiya area can be met by groundwater, the dificit is only in Phuket province finally. Concerning Phuket province, the water supply must be furnished from not only the inside of Phuket but also the outside mainland in future.

Figure 4.9 shows an intentional or desirable scheme for water balances in Surat Thani and Phuket areas.

Fig. 4.9 URBAN AND INDUSTRY USE BALANCE PLAN