4.2. DEVELOPMENT PROGRAM

Three major constraints as described in previous sections should be overcome; 1) Land, 2) Finance and 3) Research and Development, and Extension.

1) Land

For large-scale estate, the land availability and acquisition are major constraint to development, while the security of land tenure is major constraint to the small holders. The followings are proposed development schemes for large-scale estate and small holders suffering from their own different constraints.

(1) Large Scale Estate Development

This type of development usually takes place in the forest reserve. Government incentives are to be given at the strategic locations for oil palm development, based on the development potential and availability of the land. Government owned land will be provided as concession area. Estate developers have been applying for concession areas. However, it is common in Thailand that there are some settlers in the concession areas. Each estate developer has been negotiating with the settlers so as for them either to sell over their lands when they are legal holders or to leave with a compensation for resettlement when they are illegal holders. It usually takes three to four years for an estate developer to get the concession area through these negotiations.

We propose a process of land development as follows:

i To designate strategic estate development areas

ii To provide the investors in estate development with the incentives under some specific guideline, including the following:

- Priority will be given to the concession areas
- Land will be provided for the existing settlers in the concession areas to be resettled.

iii To provide small holders in the designated areas with the following government support:

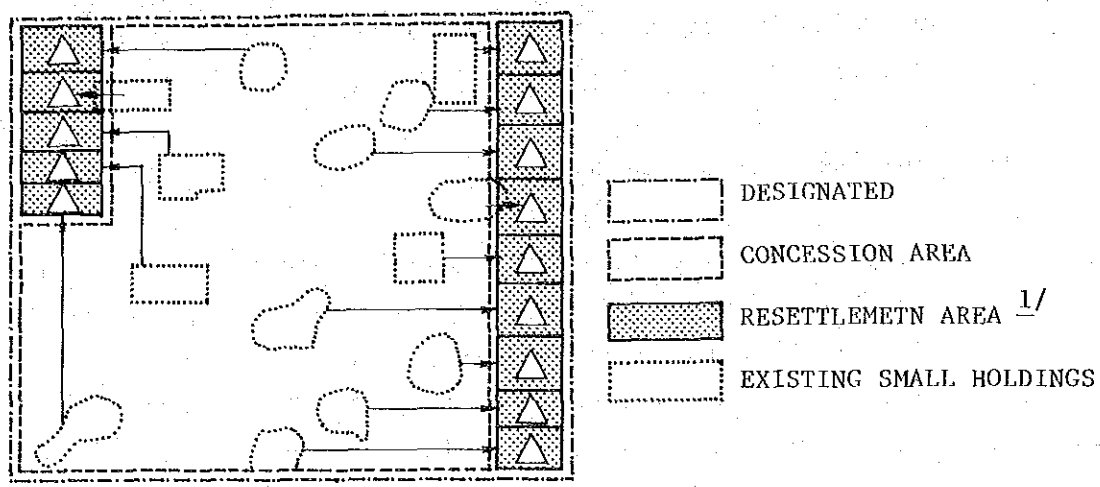
- The small holders to be resettled will be provided with the security of land title for

economically sufficient area.

- Priority of technical and financial assistance will be given to the small holders under this scheme.

The scheme described above are illustrated as below :

Land Resettlement Scheme



1/ Holders with secured land title

(2) Small holders' Plantation Development

Of the several land titles issued by both Royal Forestry Department and Department of Land, the only farmers that have Nor Sor Sam or Title deed can receive the financial support from BAAC at present. Through governmental or semigovernmental organization, security of land tenure should be given to the small holders or to the organizations of the small holders who are willing to develop plantation. In RFD land, the permanent right for cultivation without the right to sell land, and in private land, upgrading the land title or expenditions issue of certificate are required.

2) Finance

As a financial support the followings are recommended to be considered.

(1) To large-scale estate developers

- Incentives same as privilege by Board of Investments (BOI)

- Government support for social infrastructure development in the estate. (school, clinics, access roads to the estate, etc.)

(2) To small holders

- Agricultural extension service from the estate or government agencies.

- Financial support by BAAC or other government agencies.

BAAC is initiating the oil palm development project for small holders' including both resettlement type development in RFD land and agricultural cooperative type in private land. The Rubber Replanting Program executed by ORRAF is also a successful case of improving productivity of small farmers.

These experiences of plantation development by small holders' will be very helpful to consider the financial support for the small holders.

3) Research and Development, and Extension

The intensification of agriculture in Thailand has long been a matter of concern. Various projects have been undertaken and financed, including experiments with fertilizer and agricultural input, the use of high yield species, and the upgrading of species.

However, whether for the price or for the field and tree crops, none of these methods has greatly improved production. (The one exception is the improvement of rubber production.) For example, regardless of the fact that, for more than 20 years, a high yield of five to 10 tons per hectare of rice has become the standard for some countries, the yield per hectare in Thailand even now is no more than two tons per hectare. Of course, a very high yield is shown at the experimental farms. However, even though a high potentiality production has been demonstrated, this has not been a prevalent result according to production statistics.

The six constraints to extension commonly cited are as follows:

- Deficiencies in the extension system (a problem of organization)
- Insufficient affordability of farmers to adopt improved techno- logies (financing system/assistance system)
- Capability to absorb new technologies (education/training)
- Social and attitudinal characteristics of farmers
- Slow progress in research and development
- A number of problems related to the national economic policies are assumed to exist (problem associated with the export market)

Although a number of problems have yet to be solved, the rubber replanting project provides one example of success in extension and productivity increase. The difference between this project and other projects undertaken for agricultural improvement previously are as follows:

(1) A unified organizational system was established, the Office of Rubber Replanting Aid Fund and the Rubber Research Center, which had their own resources of revenue and employees.

(2) There was a channel of information between the research and development of the Rubber Research Institute and the farmers.

(3) Selected planting materials and other necessary materials for farm management were supplied directly to the farmers. There was no procedures or paperwork necessary between the farmers and the financing organization, and, therefore, small holders could make full use of these materials.

(4) A fixed development standard was set up. A system was established so that those who are qualified with the standard were paid a fixed subsidy, and in this way, the improvement in the quality of agricultural technology and education/training resulted.

(5) No funds were collected directly from the farmers. The project was financed by the "cess" collected from rubber exports.

This system provides an example where the Thai Government policy, the farmers' attitudes, and the organizational system were well coordinated. There are a number of points that could be learned from this system for the development of oil palm production. In addition, a number of oil palm development projects have adopted parts of this system, with the financial support of BAAC, in order to allow for the participation of small holders. (l), (3), and (4) above were employed by BAAC subcontractors. Through a long-term special loan, (5) was somehow introduced so that the loan could be paid back directly to BAAC. In other words, it can be said that BAAC-assisted projects were conducted by private enterprises in place of ORRAF for rubber.

However, one problem still remains. It is that technical assistance and extension services have not been undertaken sufficiently. The large-scale plantations, which have a long history and experience, can develop their technology through cooperation with foreign enterprises, and they are, therefore, in an extremely favourable position. However, for the small holders that support Thai agriculture, information regarding new agricultural methods is lacking, and they have little opportunity to get such information.

In order to increase the yield as we propose, it is important that extension activities and the improvement of the crop species are most suitable for the style of farm management and land conditions of small farms. In addition, the research and development of the use of palm oil and processing technology is important in order to broaden the market. Research and development and extension activities should be given particular emphasis in future.

4) Organizational Arrangement

For executing the proposed development program, the following government agencies will be involved:

Agencies*3	Major Responsibility
Royal Forestry Department	Establishment of designated area and concession area
Department of Land	Transfer/changes of land holding title
Bank for Agriculture and Agricultural Cooperatives	Financial support for the oil palm plantation development for small holders
Office of Rubber Replanting Aid Fund*1	Technical and financial support for small holders
Horticulture Research Institute*2	Technical assistance for the oilpalm development and extension

Notes: *1 ORRAF has been executing the rubber replanting program and succeeded in improving the productivity of the small holders' plantation.

*2 Horticulture Research Institute can expand its service to oil palm research to find the new high yielding clones and extension of technologies.

*3 One of the agencies or other relevant agency should take the function for coordinating these agencies.

4.3. PRODUCTION AND MARKET

4.3.1 Production

Based on the assumption and target to be achieved, production of fresh fruits bunch and palm oil are calculated and shown on the Table 4.4

4.3.2 Market and Other Consideration

Palm oil production has been increasing rapidly in recent years, mainly for the following reasons:

(1) Oil palm yields the highest oil and fats production among other oil producing vegetables in Thailand;

(2) With improved extraction and refining technique, the per unit output of palm oil is improved and price of oil is now competitive with soybeans; and

(3) Cost for producing the oil can be reduced because oil palm is tree crops which can produce oil for more than 20 years and, in addition, intercroping and cover croping maintain the ecosystem of the plantation to be in more stable conditions.

Table 4.4 PRODUCTION TARGET OF OIL PALM

	FFB(x1000ton)		Palm Oil(x1000ton)		Value Production[1/] (Mill. Bahts)	
	Upper South	Whole Kingdom	Upper South	Whole Kingdom	Upper South	Whole Kingdom
1985	444	629	77	108	1,001	1,404
	-	-	(8)	(12)	(110)	(154)
1990	1,061	1,520	202	274	2,626	3,562
	-	-	(22)	(30)	(2.89)	(392)
2000	2,570	3,350	533	695	6,929	9,035
	-	-	(58)	(76)	(762)	(993)
2005	3,300	4,190	681	867	8,853	11,271
	-	-	(75)	(95)	(973)	(1,239)

Source: The Team

Note: 1/ Based on assumed oil price of 13.0/kg.
2/ Figures in parentheses indicated kernel oil production.

Palm oil production planned in the year 2000 is 695,000 tons. This is approximately one tenth of the planned production of 6.9 million tons in Malaysea in the year 2000.

In the meantime, the domestic consumption of palm oil is expected to increase up to 200,000 tons in the year 2000, which is double of the present consumption volume in response to the increase in both population and consumption per capita. Thus, about 500,000 tons will be directed toward export market in the year 2000. Export of this volume is supposed possible because this 500,000 tons is only marginal even in the present world oil palm market and because it is hard to expect that other alternative vegetable oil will drive out the palm oil at very low cost. Thai palm oil can increase its competitiveness through the intensified research and development which we are proposing.

It can be presumed that the existing gap in technological and managerial skills for oilpalm development between Thailand and Malaysia is not something difficult to overcome. Oil palm development does not have long history in Malaysia itself and their skills are mostly imported from foreign countries. There is no difference between two countries in terms of the access to foreign technological and managerial skills for oil palm development. In addition, Thailand now has a successful experience of increasing productivity of rubber by the effort of the Office of Rubber Replanting Aid

Fund. It is not the start from scratch to improve efficiency of oil palm production but the start based on the similar experience already cumulated in the South. Possibility to secure labour is another strong advantage of Thailand.

4.4 DEVELOPMENT COST AND FINANCIAL RETURNS

Development cost for achieving the program and production described in the previous sections are calculated and summarized as shown in Table 4.5.

With this cost requirements, an attempt has been made to analyze the financial feasibility of the Central Lowland Development Program by illustrating a model project. The model project is assumed to cover a oil palm planted area of 60,000 rai comprising 30,000 rai to be developed and operated by the large-scale estate and another 30,000 rai to be newly cleared, cultivated and harvested by the small holders. The estate is assumed to own a plant to extract palm oil from the fresh fruits supplied from the plantations of both its own and small holders. An important planning assumption we have introduced is that the development of the small holders' plantation is financially assisted by relevant public funding agencies such as BAAC. The assistance is a credit of 5,000 baht per rai for the development period of four years. The credit is to be repaid within eleven years, including three years of grace period, by earmarking 12 percent of the gross revenue from selling the fresh fruits bunches to the estate-owned extraction plant.

The following assumptions are set for our analytical purpose:

1) Schedule

(1) Detailed feasibility is conducted in 1985.

(2) 50 percent of the plantation of both the estate and the small holders is developed in 1986 and the remaining 50 percent in 1987.

(3) Harvesting is possible in 1989 and the yield rises fairly rapidly to a peak in 2000-2001, and then is stable by the end of the whole project life, i.e. the year 2008.

(4) The oil extracting plant is built up in 1988 and 1989 so as to be ready for the yield of oil palm in 1989.

2) Investment Cost

(1) The costs of land development are 6,500 baht per rai for the estate-owned land and 5,000 baht per rai for the land owned by small holders.

(2) The cost of building the oil extraction plant is 60,000 baht.

(3) The basic infrastructure prepared by the public sector costs 1,000 baht per rai on average.

Table 4.5 DEVELOPMENT COST (INITIAL DIRECT COST)

Unit: million baht

	1985-1990 (5 years)	1991-2000 (10 years)	2001-2005 (5 years)
Whole Kingdom			
Total	3,099	4,275	1,390
Private	2,644	3,410	1,060
Public	455	865	330
Large-Scale Estate			
Total	1,500	800	0
Private	1,425	760	0
Public	380	40	0
Small holders			
Total	1,599	3,475	1,390
Private	1,219	2,650	1,060
Public	380	825	330
Research and Development	315	630	315
Extension Work	315	630	315
Upper South			
Total	2,143	3,689	1,390
Private	1,840	2,944	1,060
Public	303	745	330
Large-Scale Estate			
Total	1,100	700	0
Private	1,045	665	0
Public	55	35	0
Small holders			
Total	1,043	2,989	1,390
Private	795	2,279	1,060
Public	248	710	330
Research and Development Extension Work	Applicable to the Whole Kingdom being non-area-specific		

Source: The Team

3) Operating Cost

(1) 43 percent of the gross revenue of small holders are spent for the operating cost which consists of cost for cultivation, harvesting and transport of fruit to the oil extracting plant.

(2) The operating cost items of the estate are as follows:

- 25 percent of gross revenue from the oil palm grown in its own plantation are spent for the cost of cultivation and harvesting of oil palm.

- 15 percent of gross revenue from the oil palm grown in the estate-owned plantation and purchased from small holders are spent for the extraction of palm oil.

- 25 percent of gross revenue from the oil palm grown in its own plantation and 6.25 percent of gross revenue from the oil palm purchased from the small holders are spent for general charges, overhead costs and others.

4) Revenues

(1) Gross revenues are based on the data shown in the Table 4.4.

(2) To calculate the net revenue, the business tax and the income tax are subtracted from the gross revenue of the estate and of small holders, respectively.

- The unit price of fresh fruit bunch purchased from the small holders by the extraction plant is two baht per kilogram.

- The unit price of the extracted oil is assumed to be 13.0 baht per kilogram.

The Financial Internal Rate of Return (FIRR) for the period 1985 to 2008 is calculated at 17 percent for the large-scale estate with an extraction plant and 23 percent for the whole project, which covers not only the financial results of the estate and those of small holders but also the financial results of the government institutions which finance the small holders, receive repayments from them and invests in the basic infrastructures.

With these financial returns to the estate as well as the government institutions, the revenues of the small holders from this project will enable a standard of their living

being 4.6 times higher than the subsistence level of monthly 1,000 baht per household at constant prices, which is provided by BAAC as a subsidy for farmers at the initial stage of its resettlement scheme for small holder development.

If the net revenue streams of them are discounted by 15 percent per year for the whole project life, the standard of living of the small holders is still 3.5 times better off.

The above financial rates of return and the financial figures for the small holders can be regarded as a great possibility for the prospects of oil palm development at the Central Lowland particularly by small holders. Those results, however, should not be taken as the concrete ones but as the indicative and tentative ones since the calculation is based on its various assumptions and average unit figures for cost and revenue items, and does not take into account the specific locational conditions of the project site. Cost and revenue streams are easily affected by such factors as the degree of difficulty in the new clearings of the project site, the local soil conditions, the existence of infrastructure, the distance from the major traffic routes to the regional and national markets, etc.

Nevertheless, the above results certainly indicate that the oil palm development project at the Central Lowland should be taken as promising, the standard of living of the small holders will be better off by the implementation of the project, and the careful and detailed study reflecting the local conditions of the specific site is worthwhile to implement.

5. TAPI-PHUM DUANG RIVER BASIN MANAGEMENT

5.1 RATIONAL FOR RIVER BASIN PLANNING

A river basin is an appropriate geographical unit for planning the use and development of water and related land resources. Individual projects, whether single or multipurpose, cannot be undertaken with optimum benefit unless there is a broad plan for the entire drainage basin. Integrated river basin planning involves the coordinated and harmonious development of various resources, thus, realizes the advantage of multiple use of the resources and reconcile competitive uses or conflicting interests over the resources such as hydropower generation and flood control in operating a storage dam.

Such an integrated planning calls for a committee or an authority to oversee the manifold development of a basin. The success of basin development depends to a large extent on how effectively such a body can solve economic, institutional and political constraints and problems.

5.2 DEVELOPMENT PLANS

Tapi-Phum Duang River Basin is shown in Figure 5.1. The upstream of Phum Duang River will have large storage dams with such purposes as power generation, irrigation, flood mitigation, and fishery. The forest of the area requires some conservation and reforestation measures. The downstream area of Phum Duang River Basin can be developed for large-scale irrigation. Upstream area of Tapi River Basin requires forest conservation and reforestation. Small or medium-scale irrigation can be developed in this area and soil conservation measures will be necessary for development of upland crops, including rubber and oil plam trees. The downstream of Tapi-Phum Duang River requires a flood mitigation measure to protect expanding urban areas, existing agricultural lands and expected industrial areas including industrial estates. Future growth of urban and industry necessitates the expansion of water supply capacity in the downstream area. This downstream area including delta area and estuary requires a special attention to environmental protection particularly in terms of salt and water balance. In the following sections, the development plans are described in more detail for each objective.

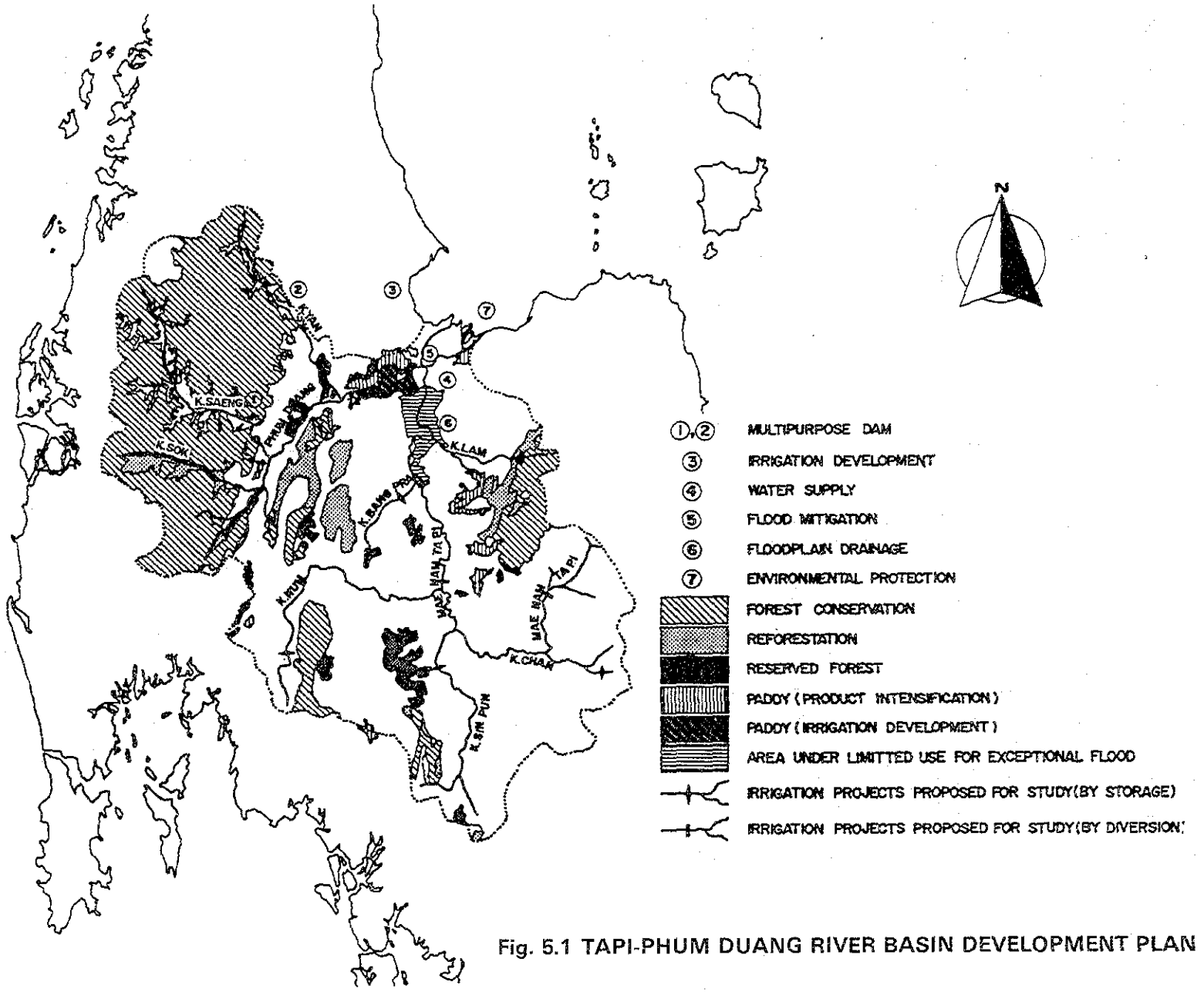


Fig. 5.1 TAPI-PHUM DUANG RIVER BASIN DEVELOPMENT PLAN

5.2.1 Hydropower Development

Chiew Larn Dam is being constructed by Electricity Generating Authority of Thailand (EGAT) and scheduled to be completed in July, 1987. The installed capacity and annual energy production will be 3 x 80 MW and 553.7 GWh, respectively. The dam has multipurpose such as power generation, irrigation development, flood control, environmental protection, fishery development, navigation improvement and recreation and tourism development ("Summary Report of Chiew Larn Project", EGAT, December, 1979) ; however, irrigation development is not scheduled to be implemented as yet.

Kaeng Krung Dam (formerly Klong Yan Dam) is planned to be constructed by EGAT and scheduled to be completed in June, 1991. Its installed capacity and annual energy production will be 2 x 34 MW and 165 Gwh, respectively. This is also a multipurpose project consisting of power generation, irrigation, fishery, flood mitigation, domestic water supply, salinity control at Ban Don Bay, navigation improvement and tourism ("Summary Report of Kaeng Krung Project", EGAT, September, 1983) ; however, irrigation development has not been scheduled to be implemented. The Kaeng Krung Power Development Project is proposed to be implemented as scheduled in this framework of Tapi-Phum Duang River Basin Planning since construction of the dam will meet many objectives of the river basin planning.

5.2.2 Flood Mitigation

1) Flood Problems

According to the study of Royal Irrigation Department (RID) (Electroconsult, 1973), the maximum area subjected to exceptional floods is estimated at about 400 square kilometers. Flooded area of Lower Tapi fulfills a valuable flood routing role for preventing heavy damages from population centers, particularly the Amphoe Phun Phin. In the downstream of Phum Duang River, floods are caused by overbank flows from Phum Duang River to cropped land of the left bank with the elevation of two to six meters above the mean sea level. The lands on the left bank of Phun Phin River which are very flat rice growing area are frequently inundated or water logged by the overflow from Phun Phin River and other streams draining from the high lands and also by the sea tide. In case of delta area, however, floods are significantly beneficial to waterway flushing and salt leaching. According to the observation of local people near the confluence of Tapi and Phum Duang Rivers, severity of floods have decreased in recent years as compared to more than 10 years ago. The annual runoff volumes

of Phum Duang Subbasins indicate downward trends at least in this 14 year period ("Chiew Larn Project, Environmental and Ecological Investigation", Volume II Main Report, EGAT, June 1980) ; however, it is uncertain that how long such trends should continue.

2) Effects of Chiew Larn and Kaeng Krung Dams

The reserved flood storage capacity of Chiew Larn Dam is 446 million cubic meters in all times. However, a reservoir operation study indicates that average reservoir capacity available for flood retention in August and September would be about 1,346 million cubic meters. The simulated flood hydrographs of various return periods were used to compute the regulated releases in those months with assumed conditions (Chiew Larn Project, 1980). The percentages of flood peak reduction at just above Phum Duang and Tapi Rivers confluence are 26 to 34 percent for the floods of two to 1,000 year return periods. The flood surcharge of Kaeng Krung Dam is only 121 million cubic meters and a simulation study indicates flood peak reduction of one to three percent at the confluence, which is almost negligible.

The combined annual benefit of flood mitigation from the two dam projects is 3.49 million baht for Amphoe Khiri Rattanikhom and Amphoe Ban Ta Khun and 7.83 million baht of which 0.25 million baht is the contribution by Kaeng Krung Dam for Amphoe Phun Phin ("Environmental and Resettlement Investigation of Klong Yan Multipurpose Project", EGAT, November 1983). The flood peak reduction below the confluence is less significant due to floods coming from Tapi River influenced by different seasonal monsoon, therefore, it is strongly recommended that additional flood mitigation measures be employed in the downstream area.

3) Additional Flood Mitigation Measures

At first two flood mitigation measures were considered: the expansion of Phun Phin River flow capacity and the construction of a retarding basin of Tapi Flood Plain. The advantages of the first measure include: (A) flood reduction of Phun Phin River Left Bank and resulting paddy field flood protection; (B) elimination of siltation along Tapi River Estuary Area; and (C) simplification of river water management by using mainly Phun Phin River only. The disadvantages are: (A) the environmental damages to the Tapi River Estuary Area, delta area and bay area caused by the considerable reduction in the amount of flow in the Tapi River downstream reach (damages to life of the people living along the river, coconut plantation, ecology, fishery, and salt and water balance); (B) the cost of project will be very high both in

the river works and many compensations for the damages. The approximate cost of this measure could be 360 million baht for the expansion of 18 kilometer long Phun Phin River.

The advantages of the second measure include: (A) reductions of flood peak at the confluence of Tapi and Phum Duang Rivers; (B) enhancement of fishery in the retarding basin; and (C) utilization of the storage as a source of water supply. The disadvantages are: (A) backwater effects to the upstream of Tapi River resulting from temporarily blocking the Tapi River may be significant considering extremely flat river bed slope (tidal effects propagate to the upstream as far as the south end of the Tapi Floodplain shown in Figure 5.1); (B) the impoundment will raise groundwater level and cause waterlogging at the surrounding area of retarding basin. The approximate cost of the second measure could be 520 million baht including the embankment, weir and gate.

Considering these advantages and disadvantages, the third measure has been first proposed in this report. The idea is based on the assumption that floodings at the downstream of Phum Duang and at the Tapi Flood Plain are to a large extent caused by the narrow portion of the reach at Amphoe Phun Phin just north of the Tapi - Phum Duang confluence and also based on the observation that floods do not flow to Tapi River but to Phun Phin River at the diversion point of Amphoe Phun Phin due to the stream lines of the rivers, which causes frequent floodings at the left bank of Phun Phin River.

This third measure consists of a new bypass waterway and a diversion dike as shown in Figure 5.2. The bypass waterway is designed to keep Phum Duang floods from flowing through the narrow portion of the river at Amphoe Phun Phin. This new waterway needs to be excavated and the existing reach to the confluence point can be filled with earth. In order to utilize flow capacity of Tapi River after diversion, the diversion dike can be constructed and extended approximately by 100 meters to guide flow to Tapi River. The bypass waterway and diversion dike should be designed through extensive data collection and experiments using a hydraulic model. At present, hydraulic conditions are not known and cannot even be estimated around this reach due to the dominent influence of sea tide. Precise effects of this measure may be found through a estuary flow mathematical model and a hydraulic experimental model. The constuction of diversion dike should be executed step by step by observing its effects.

The advantages of this measure include: (A) the flood reductions except delta area of

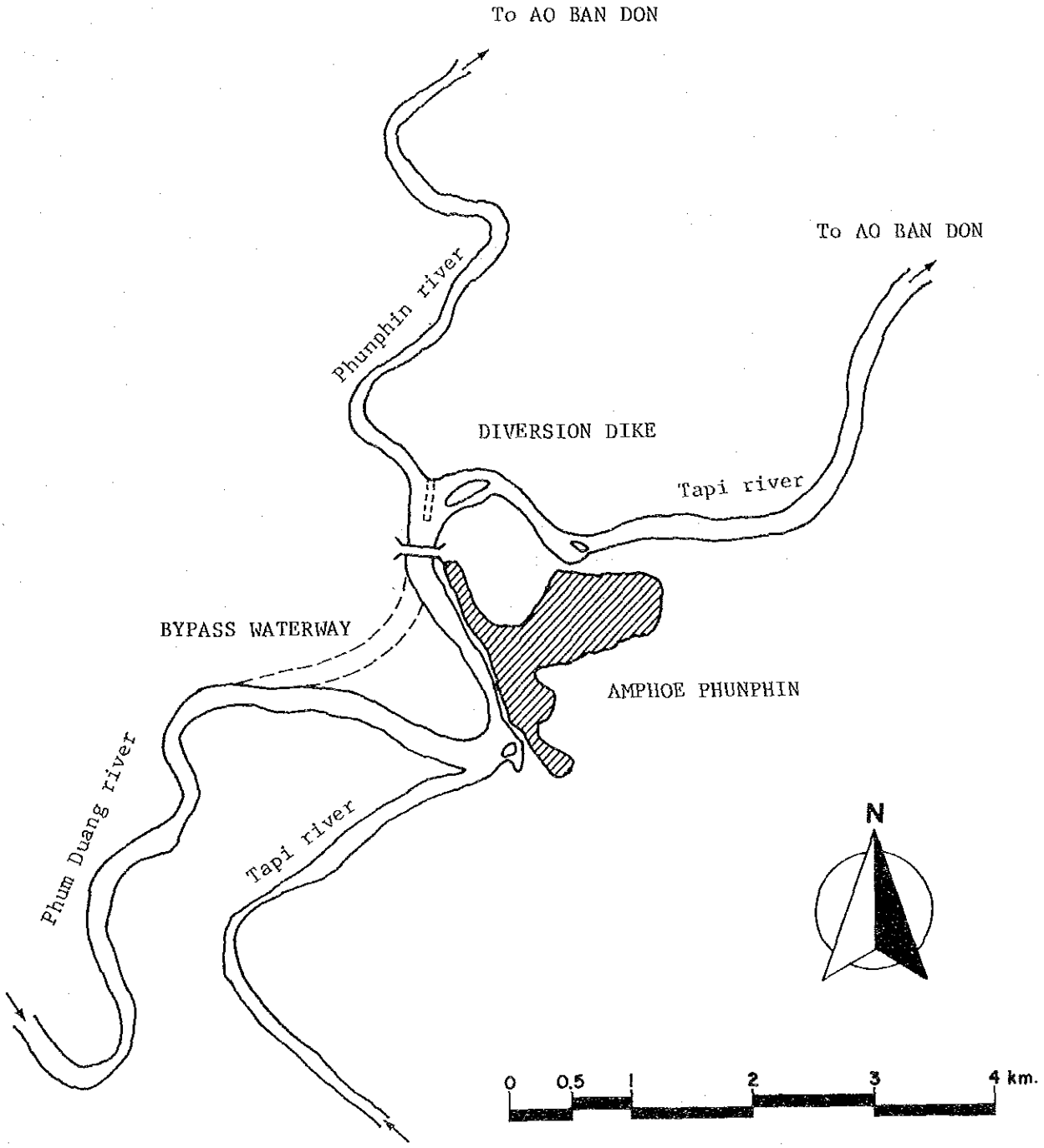


Fig. 5.2 BYPASS WATERWAY FOR FLOOD MITIGATION

the Tapi Flood Plain and Phum Duang and Phun Phin River left banks; (B) increased flood flows in the Tapi Downstream Reach will flush out siltation along the reach and contribute to improving navigation, particularly beneficial for fishery boats to Ban Don Fishery Wharfs; and (C) increased flood flows will improve salt and water balance in delta area and improve the environment.

The disadvantages are: (A) possible flooding at the upstream of new confluence point including Amphoe Phun Phin; (B) relocation of water supply intake station may possibly be necessary, (C) increased flood flows may be harmful to the existing settlement along the Tapi Downstream Reach; and (D) flood water management may become somewhat complicated due to diversion into two rivers.

Approximately, the new bypass waterway of two kilometer length and 200 meter width will cost 24 million baht and the diversion dike of 100 meter length and three meter width will cost 0.2 million baht. This incidates the third flood mitigation measure is the most economical alternative. There are some storage dam sites of Tapi River Upstreams proposed for irrigation as shown in Figure 5.1. These dams are not so large with capacities of more or less 100 million cubic meters and flood mitigation effects may not be significant, however, future planning of such dams should take into consideration the flood mitigation effects.

4) Drainage of Tapi Flood Plain

The flooding of Tapi Flood Plain has a valuable flood routing role as stated previously and do not cause significant damages because farmers have adapted their farming practice to conform with the flood characteristics of Tapi River. Drainage improvement has more practical importance than flood prevention to increase the productivity of the land. Drainage channels and ditches ease and fasten water movement to main river after floodings and thus help shorten the duration of flooding on the land.

If drainage works similar to those in paddy fields are applied to the flood plain of 170 square kilometers, it would cost approximately 100 million baht (0.6 million baht per square kilometer x 170 square kilometers). However, the land is not suitable for paddy but most for pasture use. The intensity of drainage works should not be as high as a paddy field. Therefore, the above drainage cost should be regarded as an upper limit. The implementation of such a drainage project should be preceeded by an environmental assessment and a study of possible adverse effects to the landuse.

5) Nonstructural Measure

With such structural measures as storage dams, bypass waterway and dikes, nonstructural measures will be necessary to control landuses. Nonstructural measures include landuse adjustment and zoning to regulate flood plain landuse. Urban and industrial expansion should take place in conformity with flood risks and the local government should impose zoning laws to regulate landuse expansion. Moreover, the local government should prepare the measures to mitigate the floods in foreseeable future, for example, by controling landuse where flood control structures would possibly be constructed.

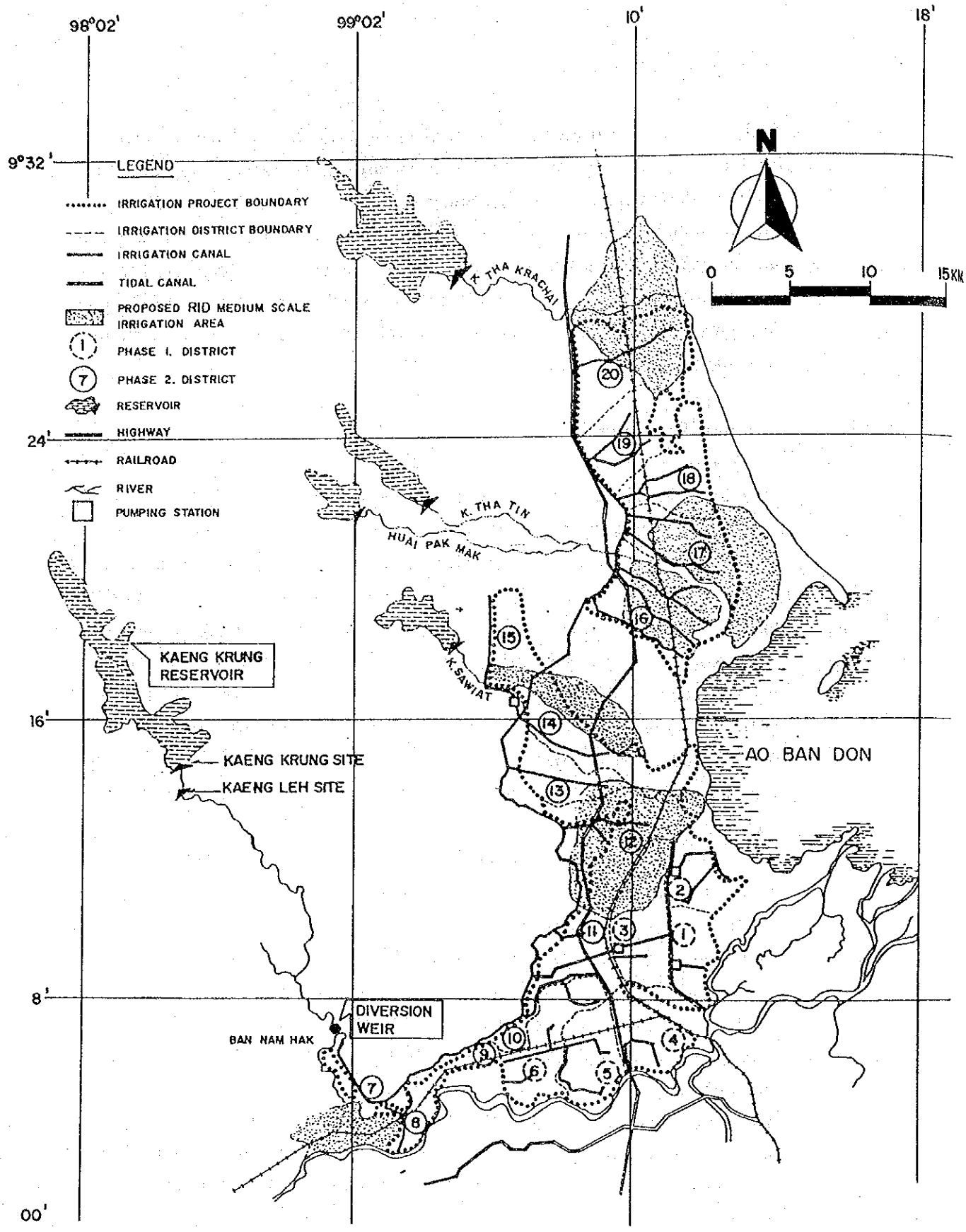
5.2.3 Irrigation Development

In order to attain self-sufficiency in rice production in the Upper South from the viewpoint of employment and rural economic stability and also to maintain rice export and control consumer prices of the country, it is important to increase the capability or rice production. Intensive irrigated rice production is preferable to scattered and extensive upland rice production by tree crop planters for their subsistence. According to a Surat Thani provincial officer, local farmers are eagar to increase their rice production by double cropping and irrigation. The Royal Irrigation Department (RID) completed a study of Tapi-Phum Duang River Basin Development in 1973 which includes irrigation developments in the Phum Duang Subbasin utilizing Chiew Larn and Klong Yan (now called Kaeng Krung) Dams; Chiew Larn Dam is now being constructed and Kaeng Krung Project is planned to be implemented, both by EGAT. The RID study also proposed various irrigation projects in the Tapi Subbasins, which have not been studied further or planned to be implemented.

1) Phum Duang Basin Irrigation Development Plan

As shown in Figure 5.3, the Phase I irrigation development utilizing Chiew Larn Dam consists of the irrigation districts of one to six which are located on the left bank of Phum Duang and Phun Phin Rivers extending downstream into the delta area, totaling the net irrigation area of 14,700 hectares or 91,875 rai. The Phase II irrigation area consists of portion of existing People's Irrigation Area presently classified by RID as a Medium Scale Irrigation Project, and 18 irrigation districts totaling 40,320 hectares or 252,000 rai.

The Phase I and II development include the areas which are north of the Phum Duang Basin Boundary. Of these, four districts are included in the Phase I. The



Source: "Environment and Resettlement Investigation of Khlong Yan Multipurpose Project EGAT, November 1983"

Fig. 5.3 IRRIGATION DEVELOPMENT PLAN OF PHUM DUANG BASIN

capital cost is 454 million baht in the Phase I development ("Summary Report of Chiew Larn Project", EGAT, December 1979) and 1,128 million baht in the Phase II development ("Summary Report of Kaeng Krung Project", EGAT, December 1983). For the implementation of the two projects, there should be close cooperation between EGAT and RID. The simulation study for reservior operation showed that there will be no conflict between power generation and use of irrigation water ("Chiew Larn Project", EGAT, June 1980, P.III -38).

2) Tapi River Basin Irrigation Development

The study by RID (1973) proposed several locations for irrigation developments. Those locations are shown in Figure 5.1 as irrigation projects proposed for further study. The capacity of storage dams of the projects varies from 30 to 150 million cubic meters and the cost of each project varies approximately 100 to 500 million baht. While those projects are located outside the downstream flood plain where paddy cultivation is relatively intensive and irrigation input is expected to be most effective, they need to be studied further.

5.2.4 Urban and Industrial Water Supply

There are three major urban waterworks within Tapi Phum Duang River Basin, i.e., Surat Thani, Phun Phin and Ban Na San, all of which are operated by the Provincial Waterworks Authority(PWA). The water supply for Surat Thani and Phun Phin will receive benefit from the Chiew Larn and Kaeng Krung Projects. The raw water intake station for Surat Thani - Phun Phin water supply is currently located on the Tapi River (200 cubic meters per hour) right bank just before the Phum Duang confluence and on the Phum Duang River (430 cubic meters per hour) left bank at Ban Tha Khum. At present, the Tapi Pumping Station is used only occasionally due to poor water quality. The present capacity of treatment plant is 10,800 cubic meters per day and the clear water is pumped to Surat Thani at the rate of 320 cubic meters per hour and to Phun Phin at the rate of 80 cubic meters per hour. The water supply is therefore, 1,800 cubic meters per day to Phun Phin and 7,700 cubic meters per day to Surat Thani on average during the period 1973 to 1981.

The demand projection of Surat Thani and Phun Phin is presented in Table 5.1. The development schedule to meet the demand is shown in Figure 5.4 for the three locations, i.e., Surat Thani Urban Area, Phun Phin Urban Area, and the Phun Phin Industrial Estate. The schedule consistis of three stages: the stage one is the completion of ongoing capacity expansion program, the stage two is to be completed by 1990

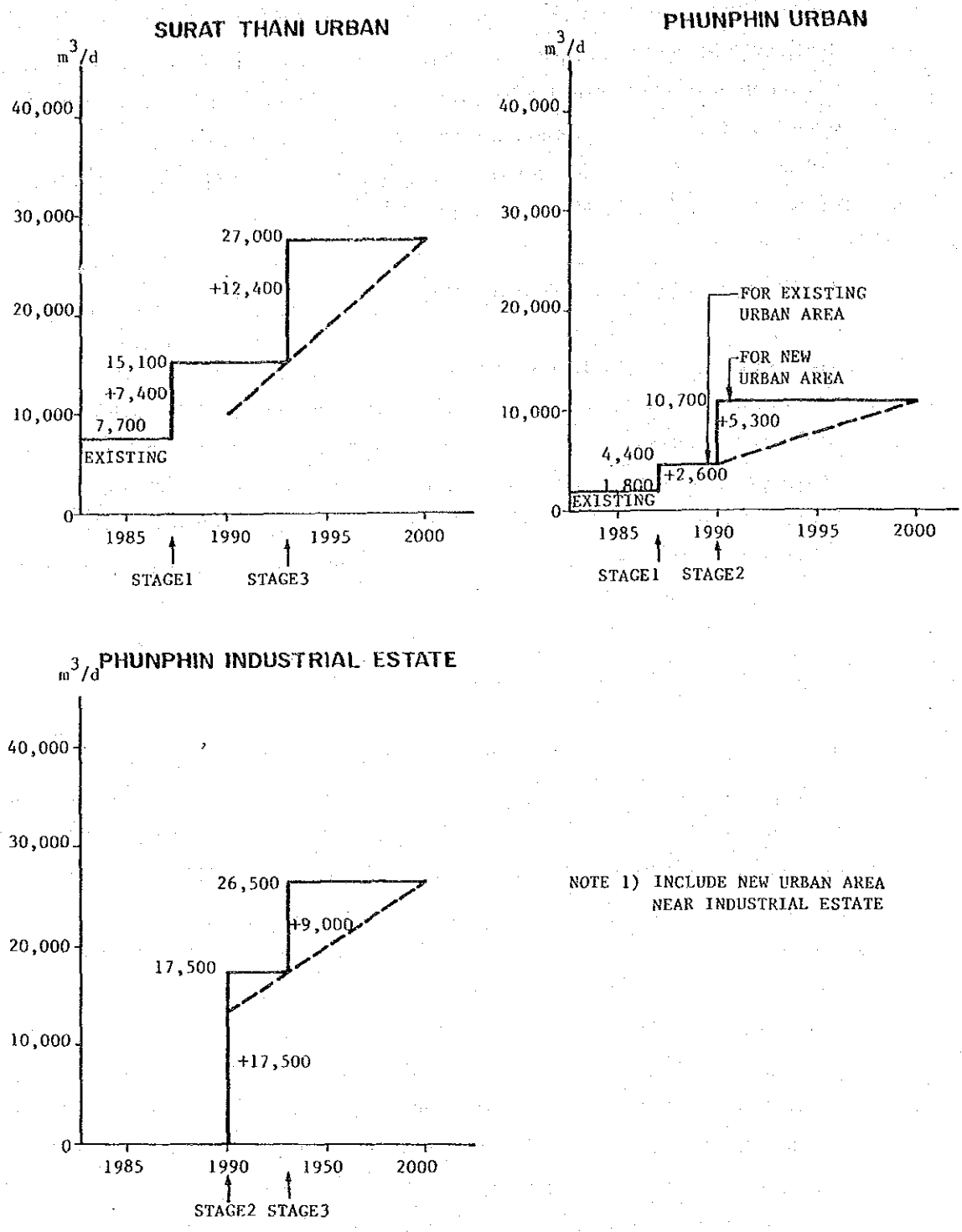


Fig. 5.4 DEVELOPMENT SCHEDULE OF SURAT THANI - PHUN PHIN WATER SUPPLY

to help start operation of Phun Phin Industrial Estate, the stage three is for the additional capacity expansion of the industrial estate and Surat Thani Urban Area. The investment cost of facilities are calculated using the cost functions (presented in "Udon Thani Water Supply Master Plan", PWA, April 1984) and shown in Table 5.2. The total investment cost will amount to 215.5 million baht during the period 1985 to 1992.

There is a serious concern over the quality of water at current water intake station. At present a whisky factory is being constructed near the proposed Phun Phin Industrial Estate and the water supply intake may be endangered by the effluent from the factory. Moreover, the effluent from the proposed Phun Phin Industrial Estate without sufficient treatment system would affect the water quality of Phum Duang and Tapi River. Such industrial effluent and, to some extent, urban sewage are expected to increase in the future near Tapi Phum Duang Downstream Reach. Considering a trade-off between the need for river water quality control and its cost which is a disincentive for industrial investment attraction, we propose a primary disposal system in the industrial estate and discharge of treated waste water to downstream of Phun Phin River.

Table 5.1 DEMAND PROJECTION OF SURAT THANI WATER SUPPLY

Unit : m^3/day

Location	1990	2000
Surat Thani		
Urban	8,870	24,670
Phun Phin		
Urban	4,440	10,730
Industry	13,250	26,500
Tourism 1/	1,400	2,810
Total	27,960	64,710

Source: The Team

Note : 1/ Tourism demand is included in the Surat Thani urban demand for a water transmission system.

Table 5.2 INVESTMENT COST OF SURAT THANI — PHUN PHIN WATER SUPPLY FACILITIES

Unit: million baht

Pipeline			Pumping Station			Treatment Plant			Ground Storage		
No.	Cost	(Year)	No.	Cost	(Year)	No.	Cost	(Year)	No.	Cost	(Year)
PL 1	58.1	(85-86)	PS1	1.5	(85)	T1	35.1	(86)	G1	1.2	(86)
			PS2	20.4	(86)	T2	22.1	(89)	G2	9.9	(86)
			PS3	2.5	(88)	T3	41.2	(91-92)	G3	3.0	(88)
			PS4	2.5	(92)				G3'	8.8	(88)
									G4	1.4	(92)
									G4'	4.9	(92)

Source: The Team

5.2.5 Fishery

Inland fishery can be enhanced by the ongoing Chiew Larn Project and the planned Kaeng Krung Project. The annual inland fishery output in the Chiew Larn Reservoir is about 133.4 square kilometers x 15 tons per square kilometer and in the Kaeng Krung Reservoir is about 37 square kilometers x 31 tons per square kilometer. The increased discharge from the Chiew Larn Dam in dry season increase the downstream of Chiew Larn Dam and the delta will enjoy about five percent increase (200 tons per year) of the present fresh water fish catches, and that of the Ban Don Bay is about one percent increase (500 tons per year) of the present sea water fish catches ("Summary Report of Chiew Larn and Kaeng Krung Project").

5.2.6 Environmental Protection

With regard to environmental protection, the following points will be important for the development of Tapi Phum Duang River Basin:

Deforestation will be unavoidable for the area of Chiew Larn and Kaeng Krung Reservoir Impoundment, therefore, conservation of the forest in their watersheds is essential;

Deforestation due to the expansion of rubber and oil palm plantations will take place in the basin. In such case, soil cover should be kept and terracing should be considered if necessary in order to minimize soil erosion and reduce flood runoff. This indicates the necessity of watershed management considerations;

As mentioned in the section of water supply, pollution control measures will be necessary particularly in industrial area development;

The salt and water balance at the delta and estuary area will be improved by the increased flows in Phum Duang River in dry season. Such enviromental effects should be studied for the future reservoir operations; and

The reservoir impoundments and possible dike constructions for flood control will decrease the fertility of watershed and delta by reducing siltation on the lands. These possible adverse effects are desired to be studied in advance of actual implementation.

5.2.7 Forestry

Three types of future plan for the forest area are identified. Figure 5.1 shows these, i.e., forest conservation, reforestation and forest reservation in the Tapi Phum Duang River Basin. In the Phum Duang Basin, the Sak River Subbasin particularly needs reforestation and conservation for all other Subbasins. In the Tapi River Basin the forest conservation is required particularly in the Num, Sin Pun and Lam Subbasins, and the reforestation particularly in the Lam and Bang Phra Subbasins. The referestation will not only increase forest resources but also help reduce flash floods and soil erosion.

5.3 PROPOSED PROJECTS AND THEIR COST/BENEFIT

Various development projects and possible measures for the Tapi - Phum Duang River Basin Planning are described in the previous section. Those projects which should be implemented toward the year 2000, are proposed in this section. However, the project which is already being implemented, such as the Chiew Larn Power Development will not be included here.

The following projects are proposed for implementation: (A) the Kaeng Krung Hydropower Development; (B) the bypass waterway at Phun Phin; (C) the Chiew Larn and Kaeng Krung Irrigation Development, i.e., Phase I and II of Lower Phum Duang Subbasin Irrigation; (D) Surat Thani - Phun Phin Urban and Industrial Water Supply; and (E) fishery development of Chiew Larn and Kaeng Krung Reservoirs and their downstreams. The Tapi Flood Plain Drainage should be implemented after the landuse in Tapi Subbasin becomes more intensive, i.e., probably after the year 2000. The bypass waterway project is selected because this is an inexpensive alternative.

The investment and the operation and maintenance cost streams are given in Table 5.3. The irrigation projects of Phase I and II and assumed to be implemented at the same time. The cost streams of water supply do not include distribution cost. The annual cost of fishery includes boat and equipment depreciation and then operation and maintenance costs.

The benefit streams are give in Table 5.4. The hydropower project benefit is assumed to be equal to the least cost alternative thermal power plant ("Summary Report of Kaeng Krung Project", EGAT, 1983). The flood mitigation benefit from Kaeng Krung Dam is for the Amphoe Phun Phin ("Environmental and Resettlement Investigation of Klong Yan Multipurpose Project", EGAT, 1983). The benefit of

Table 5.3 COST STREAMS OF TAPI - PHUM DUANG RIVER BASIN DEVELOPMENT

Unit: million baht

Year	(1) Kaeng Krung Power 1/ Project Investment	(1) Kaeng Krung Power 1/ O & M	(2) Bypass Waterway Investment	(3) Phase I and II 2/ Irrigation Investment	(3) Phase I and II 2/ O & M	(4) Water Supply Investment	(4) Water Supply O & M	(5) Fishery Annual Cost
1985	159.0					30.5		
1986	292.1					95.6		
1987	401.3						8.0	
1988	406.4			59.0		14.3	8.0	8.0
1989	452.4			206.0		22.1	8.0	8.0
1990	168.9	14.5	12.0	220.0			10.0	8.0
1991	0	19.3	12.2	215.0	5.6	25.0	10.0	14.0
1992			0	195.6	9.1	25.0	10.0	14.0
1993				181.6	13.9	0	13.0	
1994				257.0	18.4			
1995				244.5	25.3			
1996				0	35.4			
1997								
1998								
1999								
2000								
2012	73.8					0	13.0	
	335.5							
	48.3							
	0							
2027	12.4							
	29.7							
	7.4							
	0							
2039	0	19.3	0	0	35.4			14.0

1/ Source : Table 9-1 of "Summary Report of Keang Krung Project" by EGAT is adopted.

2/ Source : Table 8-2 of "Summary Report of Chew Larn Project" by EGAT and Table 9-2 of "Summary Report of Kaeng Krung Project" by EGAT are adopted.

Table 5.4 BENEFIT STREAMS OF TAPI - PHUM DUANG RIVER DEVELOPMENT

Unit: million baht

Year	(1) Kaeng Krung Power Project		(2) Bypass	(3) Irrigation	(4) Water Supply	(5) Fishery
	Power	Flood Mitigation				
1985			Unable to estimate			
1986	102.3				7.3	
1987	232.5					7.0
1988	258.8					14.0
1989	181.3			7.2	23.9	21.0
1990	119.6			71.8		32.2
1991	159.4	0.3		166.5		37.4
1992				282.6	39.6	47.8
1993				368.3		
1994				469.2		
1995				591.7		
1996				611.5		
1997				625.7		
1998				634.5		
1999						
2000						
⋮	↓	↓		↓	↓	↓
2007	238.3					
2008	264.6					
2009	238.3					
2010	159.4					
2011	261.7					
2012	312.9				39.6	
2013	312.9					
2014	261.7					
⋮	↓	↓		↓	↓	↓
2027	238.3					
2028	264.6					
2029	238.3					
2030	159.4					
⋮	↓	↓		↓	↓	↓
2039	159.4	0.3		634.5		47.8

Source: EGAT and The Team

bypass waterway is not possible to be estimated at present due to data unavailability. The irrigation benefit is annual gross production less annual production cost and the benefit of Phases I and II are combined. The benefit of water supply (before a distribution system) is computed assuming all produced water will be sold at the rate of two baht per cubic meter. The fishery benefit is annual gross production increase less annual production cost for the both reservoirs and downstreams (Summary Report of Chiew Larn Project and Kaeng Krung Project).

An attempt is made to calculate the Internal Rate of Return (IRR) from all the components in this proposed projects just for the sake of examining whether power and irrigation components together are beneficial enough to recover the costs for flood mitigation. IRR is estimated at 18.3 percent in the standard case, 15.2 percent if cost is 20 percent larger and 14.5 percent if benefit is 20 percent smaller.

Among many possible projects for the Tapi-Phum Duang River Basin Development Planning, five projects were proposed to be implemented; the priority of the five projects would be in the order of Kaeng Krung Hydropower Development, Surat Thani - Phun Phin Urban and Industrial Water Supply, Chiew Larn and Kaeng Krung Irrigation, Phum Duang Bypass Waterway, Chiew Larn and Kaeng Krung Fishery Development considering the extent of effects to the whole basin development plan and their productivities. The Tapi Flood Plain Drainage can be implemented after these five projects. In order to formulate an optimal development plan, it will be useful to model computer simulation programs. Such computer programs consist of subprograms representing each project and, therefore, make it possible to analyse overall performance in terms of water resources balance and regional economy. Moreover, the reservoir operation study for the Chiew Larn and Kaeng Krung Dams is essential to maximize the overall benefit of hydropower, water supply, irrigation, fishery, environmental improvement and flood mitigation. An on line system using flood stage telemeters is useful for real time control of the Chiew Larn and Kaeng Krung Dams.

6. PHUKET WATER SUPPLY PROJECT

6.1 GENERAL BACKGROUND

1) This study examines a method to supply water for the Phuket urban, industrial estates and tourism areas. At present, Phuket Municipality is unable to satisfy its water demand even for a domestic use only. Bulk water consumers such as hotels and industries have to carry water by themselves either by trucks or pipelines. People living outside of the existing pipeline water service area depend on brackish well water or rain water. Phuket water supply has been a responsibility of Phuket Municipality, however, it will be sponsored by the Provincial Waterworks Authority (PWA) in 1984. It is now in the process of a transfer from the municipality to the PWA.

We studied water demands and supply potentials as a whole, identified 12 potential dams in Phuket Island as well as 11 potential dams in the mainland in considering the possibility to intake water from Phangnga to Phuket. Based on this, we investigate ways to meet water demands of various locations by determing specific times and locations, estimate approximate costs of water supply facilities and propose a least cost alternative.

2) Existing Water Supply

The last capacity expansion of water supply took place in 1964 amounting to the total capacity of 330 cubic meters per hour and approximately 2,000 cubic meters per day by collecting water from seven mining ponds. Recently constructed Bang Wat Dam with a capacity of 8.5 million cubic meters is nearly filled up, however, a water transmission system does not exist yet. It is intended that the dam water will be used for the Phuket Urban Area through pipelines and a purification plant.

6.2 WATER DEMAND

Phuket Urban Water Demand Projection is presented in Chapter 3.2. A half of tourist water demand is allocated on the west coast area and remaining half in Phuket Urban Area. After some revision of urban and industrial water demands, the water demands at Phuket urban, near airport, at deep seaport and at west coast tourism area in 1990 and 2000 are finalized as shown in Table 6.1. The time span of up to 2000 is chosen for this study because 15 to 20 years period is considered to be appropriate for water supply planning.

Table 6.1 DEMAND PROJECTION FOR PHUKET WATER SUPPLY

Unit : m^3/day

Location	1990	2000
Phuket Urban		
Urban	8,950	30,950
Industry	2,300	4,600
Near Airport		
Urban	2,250	4,500
Industry	4,500	9,000
Deep Seaport		
Industry	1,050	2,100
Port & other facilities	530	1,050
Tourism	1,050	2,140
Total	20,630	54,340

Source: The Team
Note : Water use per capita is 350 litter per day, which includes domestic, commercial and office use.

6.3 ALTERNATIVES AND PROJECT COST

6.3.1 Alternative Schemes

Two alternative schemes are examined: the Alternative 1 utilizes sources of water within the Phuket Island and the Alternative 2 introduces water from the main land. Seven out of 12 dams including recently constructed Bang Wat Dam are identified as possible water sources for the Alternative 1 considering locations and demand growth of four demand centers and locations and capacities of supply sources. The possible twin dams in Phangnga (see Figure 6.2) have suitable capacities to use with Bang Wat Dam for the planning period of up to year 2000 and are selected as water sources of the Alternative 2. Figures 6.1 and 6.2 show the layout of pipeline systems connecting sources and demands.

Figures 6.3 and 6.4 show development schedule of the water sources for each alternative scheme. The Alternative 2 has a source capacity slightly more than the Alter-

native 1, however, the two alternatives are considered to have compatible source capacities.

There are some advantages and disadvantages in the two schemes: (1) the second scheme has a risk of overinvestment since the future water demand may not be realized as projected, however, the first scheme has the advantage in this regard because the supply capacity can be expanded step by step; (2) the land cost is more expensive in the Phuket Island, therefore some difficulties in land acquisitions are anticipated; (3) it is eventually necessary to import water from the mainland after year 2000 if water demands of the Phuket Island continue to grow; and (4) the first scheme needs strong administrative capability of local governments to monitor and coordinate the step by step progress while the second scheme could solve the long standing water shortage problem in a short time.

In order to design sizes and capacities of water supply facilities, the demand projection of Table 6.1 is used as the daily average demand.

6.3.2 Cost Comparison of Alternative Schemes

The costs of two alternative schemes are estimated using cost functions of each system component. A construction cost of dam varies in a wide range depending on site conditions and is difficult to estimate without detail studies. Several examples of small-scale dam construction in Thailand were analysed for this study and used for approximate cost estimation. The construction costs of pumping stations, pipelines, treatment plants, ground storages are estimated by cost functions ("Udon Thani Water Supply, Master Plan", Provincial Waterworks Authority, 1984). The investment cost and timing of construction completion of needed water supply facilities are presented in Table 6.2 and 6.3 for each alternative scheme.

The timing of investments is different for the two alternatives, therefore, it is necessary to compare the two system costs on the basis of present values. Assuming discount rate of 10 percent, the costs of two alternatives are discounted and computed as the present values oof 1984: 565 million baht for the Alternative 1 and 1,059 million baht for the Alternative 2. The large difference in the two costs are solely due to the high cost of a water transmission line from Phangnga to Phuket. The Alternative 1, which utilizes the sources of water in Phuket Island, is a least cost alternative.

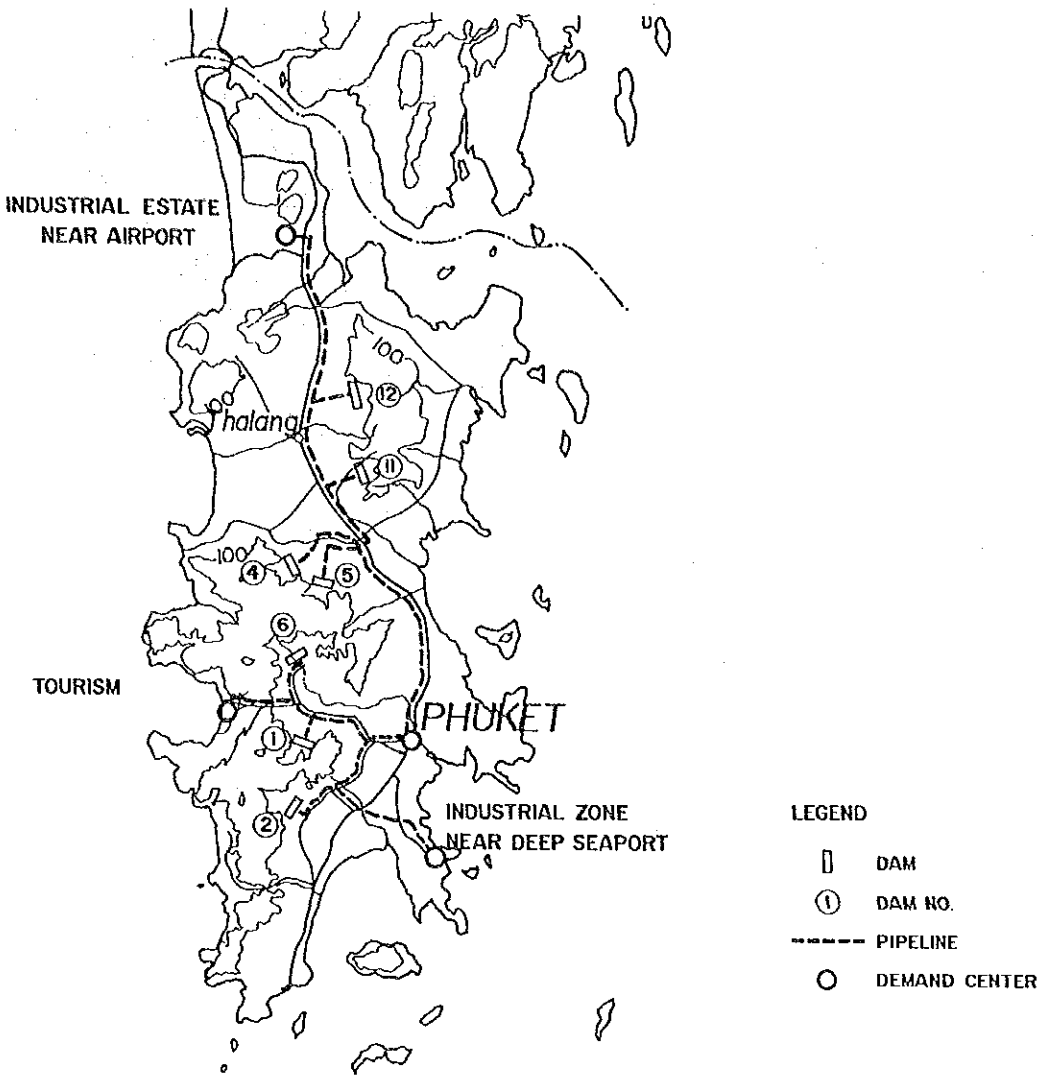


Fig. 6.1 LAYOUT OF PIPELINE SYSTEMS CONNECTING SOURCE AND DEMAND—ALTERNATIVE 1

6.4 PRPOPOSED SCHEME

The Alternative 1 is superior to the Alternative 2 and therefore is to be selected. It is useful to estimate water charges from the expected investment costs and to draw some implications for the water supply project. Assuming service life of 30 years for civil works, 15 years for electro-mechanical equipment and 30 years for pipelines, capital recovery factors are applied with 10 percent discount rate to the total investment cost of each system component such as the pipelines, pumping stations, treatment plants, ground storages and dam.

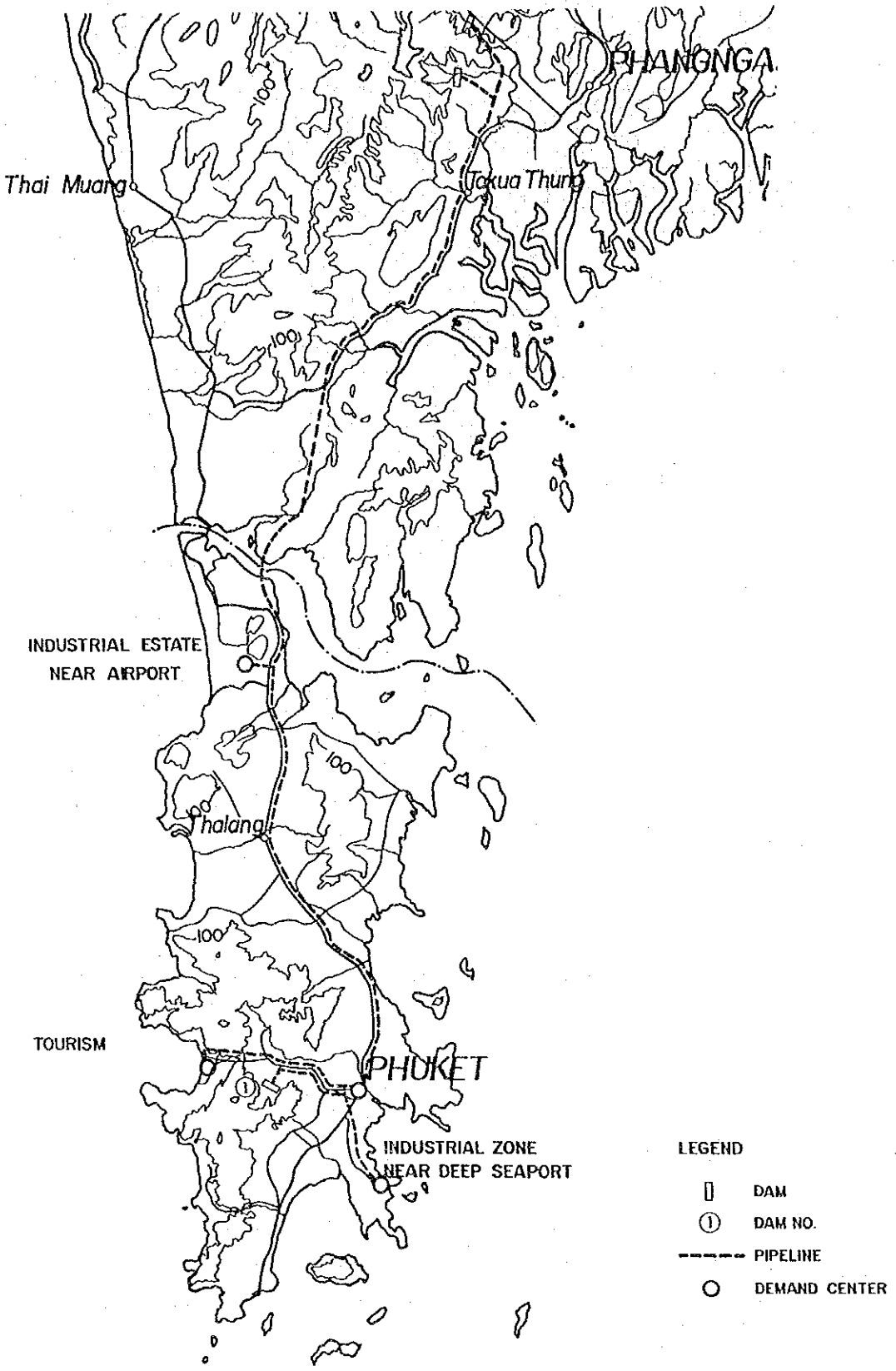


Fig. 6.2 LAYOUT OF PIPELINE SYSTEMS CONNECTING SOURCE AND DEMAND — ALTERNATIVE 2

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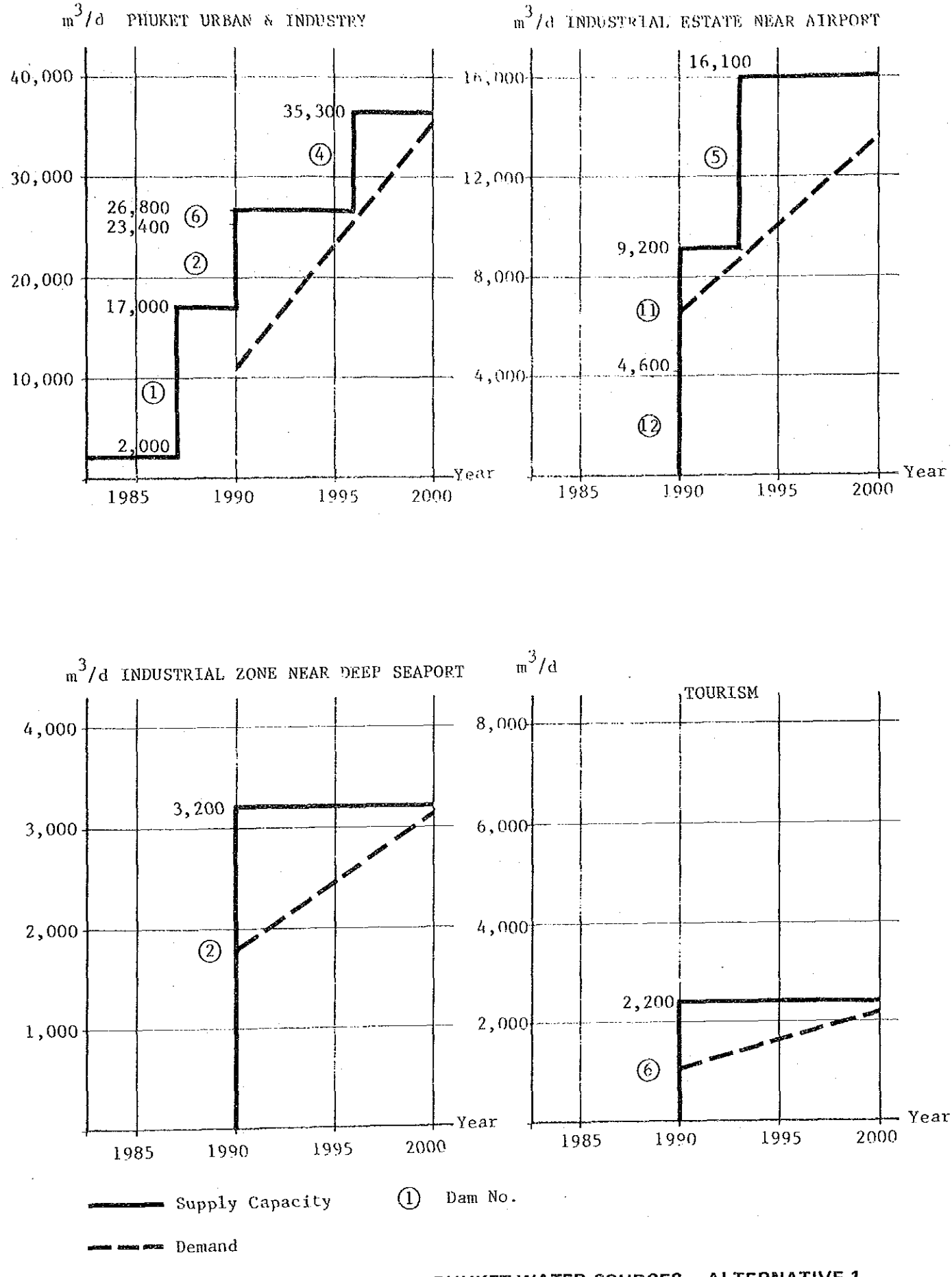

Fig. 6.3 DEVELOPMENT SCHEDULE OF PHUKET WATER SOURCES – ALTERNATIVE 1

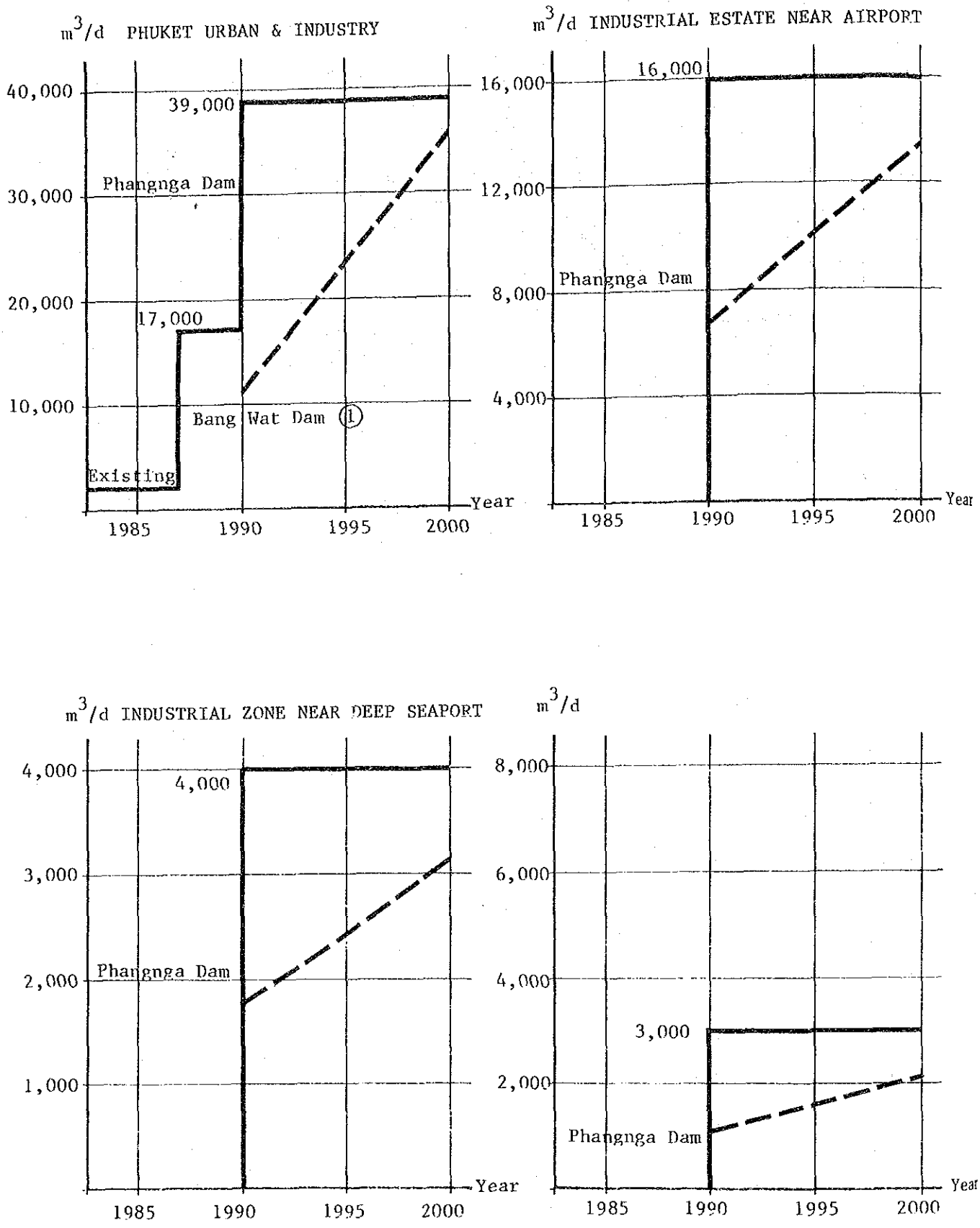

Fig. 6.4 DEVELOPMENT SCHEDULE FOR PHUKET WATER SOURCES – ALTERNATIVE 2

Table 6.2 INVESTMENT COST OF PHUKET WATER SUPPLY FACILITIES: ALTERNATIVE 1

Unit: million baht

Dam		Pipeline		Pumping Station		Treatment Plant		Ground Storage	
No.	Cost (year)	No.	Cost (year)	No.	Cost (year)	No.	Cost (year)	No.	Cost (year)
1	Existing	PL1	40.7(85-86)	PS1	6.2(89)	T1	47.5(86)	G1	7.7(86)
2	110 (87-89)	PL2	8.7(88)	PS2	7.0(89)	T2	21.0(89)	G2	2.8(89)
4	100 (94-95)	PL3	13.2(88-89)	PS3	5.3(89)	T3	12.9(89)	G2'	1.0(89)
5	80 (91-92)	PL4	14.6(88-89)	PS4	7.0(89)	T4	24.9(95)	G3	1.5(89)
6	70 (87-89)	PL5	13.2(88-89)	PS5	4.8(89)	T5	11.5(89)	G3'	0.6(89)
11	50 (87-89)	PL6	4.5(89)	PS6	5.3(95)	T6	6.9(89)	G4	3.4(95)
12	50 (87-89)	PL7	6.2(89)	PS7	4.3(92)	T7	19.2(89)	G4'	1.4(89)
		PL8	70.3(94-95)	PS8	8.3(89)			G5	1.4(89)
		PL9	20.6(91-92)	PS9	8.7(89)			G6	0.7(89)
		PL10	6.2(89)					G6	1.3(89)
		PL11	6.2(89)					G7	2.5(89)
		PL12	11.6(88-89)					G7	4.8(89)
		PL13	41.3(88-89)						

Source: The Team

Table 6.3 INVESTMENT COST OF PHUKET WATER SUPPLY FACILITIES: ALTERNATIVE 2

Unit: million baht

Dam		Pipeline		Pumping Station		Treatment Plant		Ground Storage	
No.	Cost (year)	No.	Cost (year)	No.	Cost (year)	No.	Cost (year)	No.	Cost (year)
1N	330(87-89)	PL1	40.7(85-86)	PS1	26.9(86)	T1	47.5(86)	G1	7.7(86)
1S	260(87-89)	PL2	17.5(87-89)	PS2	2.9(88)	T2	50.0(88)	G2	8.3(89)
		PL3	11.6(87-89)	PS3	18.3(88)	T3	19.2(88)	G2'	3.6(89)
		PL4	384.0(87-89)	PS4	6.2(89)	T4	6.9(89)	G3	2.5(89)
		PL5	4.2(87-89)	PS5	7.0(89)	T5	11.5(89)	G3'	4.8(89)
		PL6	213.2(87-89)					G4	0.7(89)
		PL7	21.3(87-89)					G4'	1.3(89)
		PL8	14.7(87-89)					G5	1.4(89)

Source: The Team

The unit cost of total investment cost for treated water and untreated water is 5.8 and 4.6 baht per cubic meter, respectively. If operation and maintenance cost is included, treated water and untreated water would approximately cost 7.3 and 5.1 baht per cubic meter at ground storages, i.e., before a distribution system. If a distribution cost is included, treated water may cost as much as nine baht per cubic meter, which will not be affordable to most of consumers. Since the average water charge in Thailand is 3.5 baht per cubic meter at present, subsidy of more than five baht per cubic meter would be necessary if the government is to keep the current low water charge. The charge of industrial water is prefered to be below three baht per cubic meter (the water charge at an industrial estate near Bangkok is currently 3.6 baht per cubic meter), therefore, subsidy of 1.5 to two baht would be desirable.

7. ENVIRONMENTAL ISSUES AND MEASURES

The rapid growth of population and economic development have been affecting valuable natural resources and have caused various environmental problems. Uncontroled deforestation, decrease of the mangrove forests, and prolification of uncontroled tin mining are the main problems in the Upper South.

Figure 7.1 reveals the siltation of seawater and destruction of lands after tin mining in Phuket and Figure 7.2 reveals the extended siltation of Tapi-Phum Duang River in Ban Don Day, Surat Thani.

7.1 DEFORESTATION

7.1.1 Present Situation

The fertile forest area decreased from 274,000 square kilometers (53 percent of the Kingdom) in 1961 to 132,000 square kilometers (25 percent) in 1977. The forest resource is used for housing material, firewood and charcoal as fuel, and the forest area is used for agriculture and development projects after felling the trees. Besides the economic value of wood, forest also contributes to absorbing rain and controlling floods, restraining soil erosion, alleviating effect of strong wind, and offering a living area for plants and animals.

Deforestation eventually leads to deterioration of the land, causes erosion and flood, and affects ecosystem of the area.

The forest area in the Upper South decreased significantly from 1973 to 1978 (see Table 7.1). The forest area of about 6,200 square kilometers in Changwat Surat Thani in 1973 decreased by 30 percent to 4,350 square kilometers in 1978, though the decreasing rate during 1978 and 1982 was smaller than this. The forest area of Phuket was very small, and decreased by 65 percent during 1973 and 1978. The forest decreasing rates during the same period in Surat Thani, Phuket and Krabi were higher than that of the Whole Kingdom.

7.1.2 Measure

The Fifth National Economic and Social Development Plan (1982-1986) has set a development measure as follows:

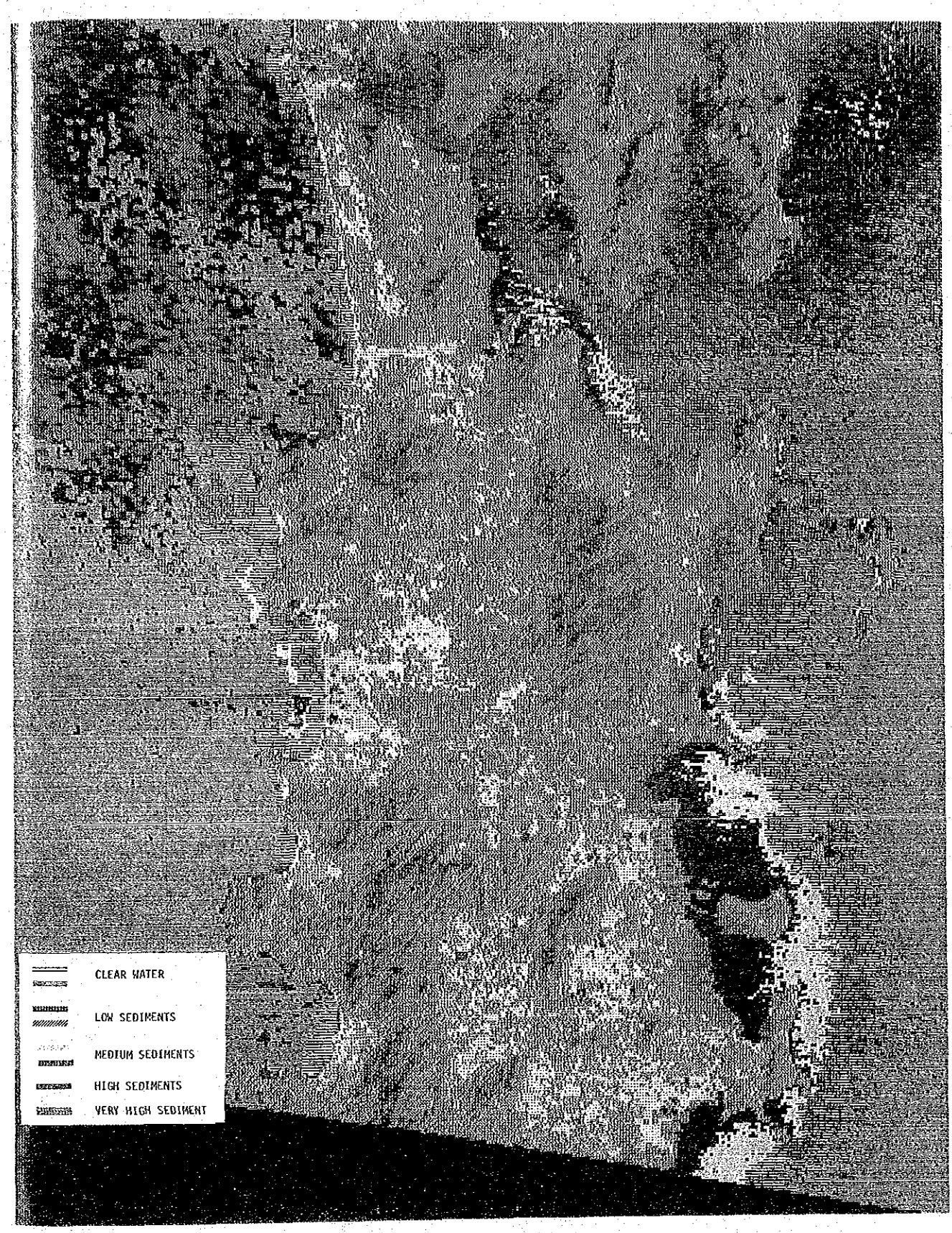

Fig. 7.1 LANDSAT IMAGE OF PHUKET COAST AND ISLAND

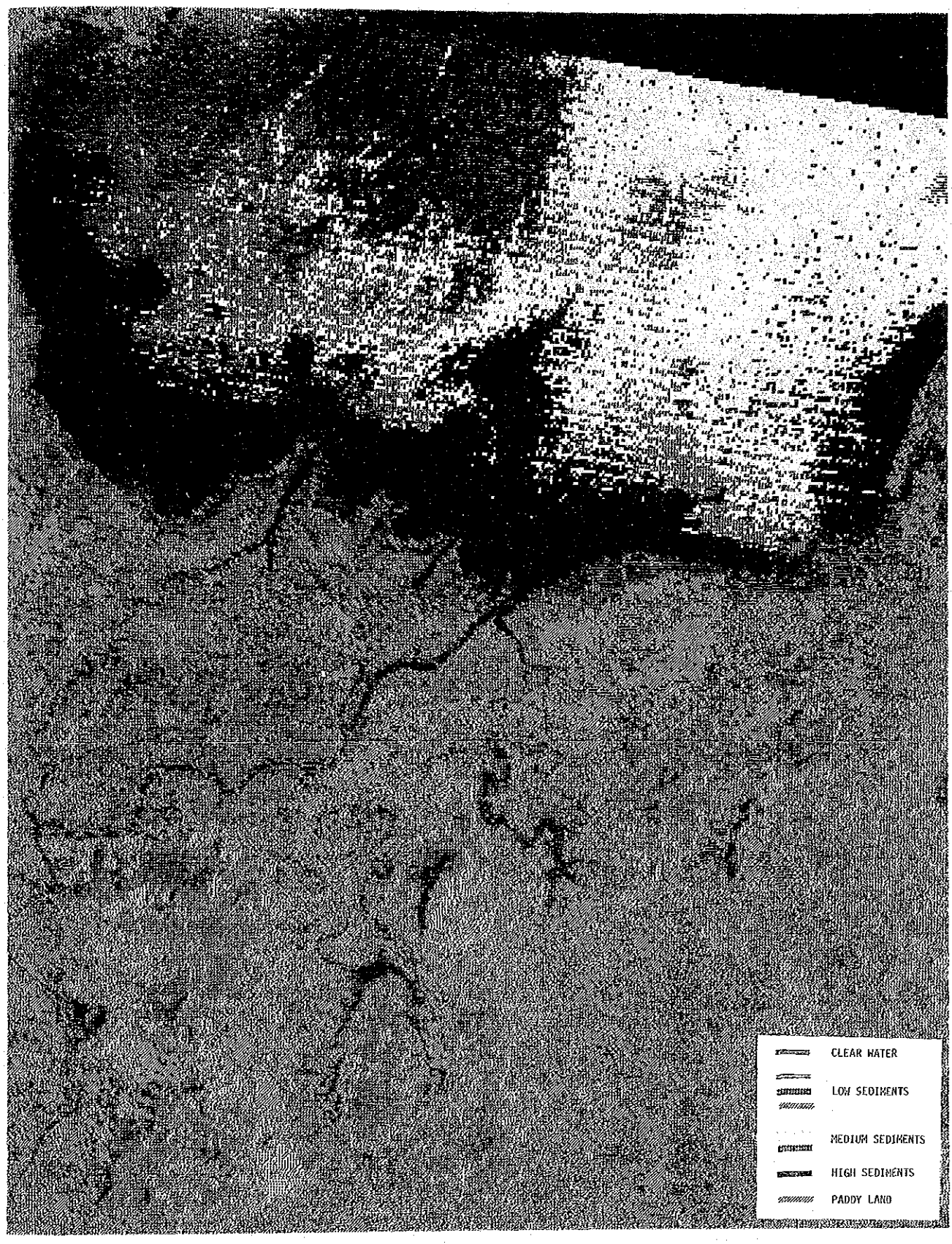

Fig. 7.2 LANDSAT IMAGE OF BAN DON BAY AREA

"Implement reforestation of 300,000 rai (480 square kilometers) per year by emphasizing private sector participation. The government will supervise the work according to correct technological methods in deteriorated forest areas, including the improvement and reforestation of swamps which have potential for coastal marine fishing."

In the Upper South, special attention should be paid to the reforestation programe for the deteriorated areas, and preservation of the fertile forest should be properly secured (see Landuse Guideline in Chapter 3.1).

Table 7.1 FOREST AREA TRANSITION (1973 - 1982)

Province	1973		1978			1982		
	Area(km2)	%	Area(km2)	%	Decrease rate(%)	Area(km2)	%	Decrease rate(%)
Surat Thani	6,202	48	4,346	34	30	4,138	32	5
Phangnga	1,650	40	1,605	39	3	1,467	35	9
Phuket	137	25	48	9	65	46	9	4
Krabi	921	20	522	11	43	492	11	6
Upper South	8,910	40	6,521	29	27	6,143	28	6
Whole Kingdom	221,707	43	175,224	34	21	156,600	31	11

Source : Year Book 1981 and Data in 1983, Royal Forest Department

Note 1. Percentage (%) shows the ratio of forest area to the provinical area

2. Decrease rates are for the periods between 1973 and 1978, and 1978 and 1982.

7.2 MANGROVE DESTRUCTION

7.2.1 Present Situation

Mangrove forests are important not only for economic use such as logging, firewood and charcoal, but also as natural marine habitat for shrimp, shellfish and other uses. A large mangrove area of 575 square kilometers, is found in Phangnga in 1977, when the total area was 1,182.4 square kilometers in the Upper South (see Table 7.2). The mangrove area has been decreasing mainly due to the following causes:

(1) Replaced by mining;

(2) Affected by sediments discharged from mining;

(3) Use the trees for building material, firewood and charcoal; and

(4) Coastal fish farming especially of shrimp.

Table 7.2 AREA OF MANGROVE FOREST (1977)

Province	Area (Km^2)
Surat Thani	145.0
Phangnga	575.0
Phuket	41.1
Krabi	421.3
Total	1,182.4
Total of South Region	3,468.2

Source : Department of Land Development

7.2.2 Measure

Measures have been formulated by the National Environment Board to preserve the mangrove forests as follows:

(1) Control the use and development of the mangrove forests;

(2) Promote replantation of the mangrove and a research to increase the production of the forests;

(3) Survey and analyse the present condition of the forests; and

(4) Promote studies on the environmental impact by the various development projects.

7.3 MINING POLLUTION

7.3.1 Present Situation

The mineral resources of Thailand are important for national economic development, but maximization of their profit should be gained by minimizing the environmental damage ensured by a long term program. The environmental problems are resulted from both land and offshore mining in the Upper South. Improper land mining causes erosion and loss of the surface soil, spoil river water and its ecosystem, raises river bed and causes floods, deteriorates natural scenery of the area, and sedimentation may damage marine resources.

Major mineral resources of Thailand are found in the South and North. Total concession area of the Upper South was 123 square kilometers, or 0.7 percent of the area in 1978 (see Table 7.3). Phuket had the largest proportion of concession area being 5.9 percent of the total area, while Phangnga had the largest area of 64 square kilometers.

Large proportion of the mining area in Phuket, together with its mountainous geographical characteristics, caused continuous annual floods in Phuket Municipality, according to the Report on Flood Preventation Project of Phuket Municipality.

Table 7.3 MINING CONCESSION AREA (1978)

Province	Area (km2)	Concession area	
		(km2)	%
Surat Thani	12,891	27	0.2
Phangnga	4,171	64	1.5
Phuket	543	32	5.9
Total	17,605	123	0.7
Whole Country	513,115	630	0.1

Source : NEB, The National Policy and Measure on Environmental Development

Offshore mining also affects the surrounding environment if operated improperly. Sludge from dredging and the muddy water used for ore cleaning cause turbidity of ocean water, and damage the aesthetic view of the coast. Considerable amount of sludge causes unfavourable change of marine ecosystem, such as destruction of the coral. The outflow of sludge also increases sedimentation and shallows the ship channel, then results in a serious damage on transportation and operation of harbour.

Almost entire stretch of the west coast of Phuket is covered by the concession areas (see Figure 7.3). Improper operation of offshore mining in these areas creates a serious problem on the ocean recreation and tourism of Phuket. The government issued a regulation to prohibit mining in Patong Bay within the distance of eight kilometers from the shore.

7.3.2 Measure

The Fifth Plan has set a development measure for conservation of natural resources as follow:

"Restore soil quality in areas previously used for mining activity in the South which caused environmental deterioration. Mine operators must bear the full costs for restoring the quality of the soils which have been disturbed during mining operations."

"Prevent and control onshore and offshore mining practices which are not in accordance with technical standards and are destructive to natural resources. Adopt a program to conserve the ecological system and control the utilization of resources in Songkhla Lake, the sea of Phuket, Phangnga and the Eastern Seaboard."

This guideline should be strictly followed and restration of the soil should be promoted.

Control of volume and quality of water is essential and important in managing the land mining. Following measures should be considered for proper operation of mining:

(1) Minimize volume of discharge by proper planning and control of water ingress;

(2) Maximize utilization of water mainly by recycling;

(3) Treatment of discharge as required; and

(4) Control of surface runoff and underground percolation.

The abandoned mine sites could be improved by revegetation with grass and legume covering the erodable surfaces. Certain crops and species are found to be adapted to different condition of soils as follows:

Sand/silt areas of the tailings;

Grass/legumes forage, root crops (cassava, groundnuts, onions, yams, carrots), melons, leaf vegetables, pepper, cloves, virginia tobacco, papaya, pomelo, citrus, cashew, star fruit and ipil-ipil;

Slime area with heavey colloidal clay;

Grass/legume forage, paddy and upland rice, maize, chillies, pineapple, banana, burley tobacco, pomelo, star fruit and ipil-ipil; and

Export-oriented tree crops such as rubber, oil palm and cocoa, are not recommended.

In offshore mining, direct physical distrubance of marine environment appears to be the most serious problem. Measures have been studied on different type of dredging methods, such as enclosure of the elevating side of the chain bucket ladder for the ladder type chain bucket dredges, and deliver of tailings back to the sea bed by a return pipe for the suction type dredges. The most effective measure is, however, to limit operation of mining especially near the tourism industry area to conserve the attractive natural resources.

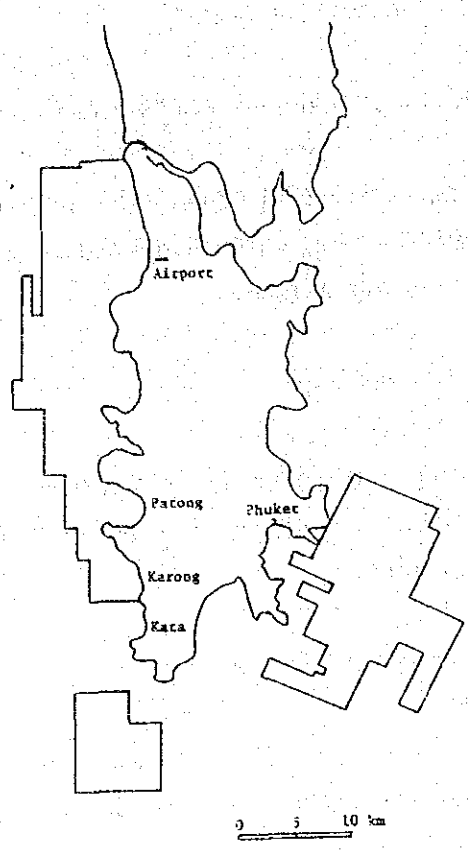

Fig. 7.3 CONCESSION AREA OF OFFSHORE MINING IN PHUKET

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ANNEX I TERMS OF REFERENCE FOR PROPOSED FEASIBILITY STUDIES

1. TERMS OF REFERENCE FOR FEASIBILITY STUDY ON CENTRAL LOWLANDS DEVELOPMENT PROGRAM (DRAFT)

A. BACKGROUND

In Thailand, the South is the only area that belongs to the tropical rain forest climatic zone and it still has a large potential of agricultural expansion. Particularly the Central Lowlands which extend over Changwat Surat Thani, Krabi and Nakhon Si Thammarat is one of the least developed parts in the South mainly due to the lack of accessibility. The potential of the Central Lowlands was identified by Hunting Technical Services, The South Thailand Regional Planning Study, 1973. Since then, agricultural development, particularly oil palm plantations expanded rapidly in the area by private effort thanks to the improvement of roads in and around the area.

In 1985, JICA, the Subregional Development Study of the Upper Southern Part of Thailand, prepared the prefeasibility study on the Central Lowlands Development Program with a stress on the small holder development for oil palm plantations. Whereas ongoing practice of oil palm plantation is based on the large-scale estate approach, the small holder approach will be equally important for its acceptability to Thai farming practice, effectiveness in securing lands and jobs for small farmers and complementarity to large-scale estate development in manpower, land and processing efficiency. It is also recognized that there are many experiences for the small holder approach to oil palm development to learn from ongoing programs of Office of Rubber Replanting Aid Fund and Bank for Agriculture and Agricultural Cooperatives.

B. OBJECTIVES

It is thus the objective of the Government of Thailand to conduct this study in order to determine the feasibility of the small holder oil palm system in the Central Lowlands.
Major study issues are:

(1) Method to secure land tenure for small holders/settlers with various land titles so as to encourage them to develop oil palm plantation,

(2) Most effective and feasible financial incentives or subsidies for small holders engaged in oil palm development, and

(3) Relevant organizational setup to organize and diffuse technical and managerial information for small holders.

C. SCOPE OF WORK

1) Assessment of Past Relevant Experiences

This section shall review and assess the past experiences of agricultural development programs from the viewpoint of their possible application to the small holder approach to oil palm plantation.

The study tasks are:

(1) Detailed assessment of the performance of Rubber Replanting Program carried out by ORRAF with special reference to extension system, financial incentives, economic return and small holders response, and

(2) Detailed assessment of the performance of Oil Palm Plantation Project carried out by BAAC as a resettlement scheme in the RFD owned forest reserve area, with special reference to land tenure and transfer, technical assistance, financial incentives, economic return, social impact and infrastructure conditions.

2) Identification of Organizational Setup, Financial Support System and Land Management System

This section shall examine possible alternatives regarding the above and identify the best combination to the extent necessary for determining the program feasibility. Based on the assessment of past relevant experiences, the following tasks shall be undertaken:

(1) Identification of useful results and problems of ongoing programs/projects of potential applicability to this program.

(2) Identification of the characteristics and bottlenecks peculiar to the operation and management of oil palm plantation.

(3) Identification of alternative organizational setups and their functions to promote small holder oil palm development. The alternatives shall include the modification and utilization of existing organizations.

(4) Identification of alternative systems of financial support to the small holders engaged in oil palm development, in correspondence to the alternative organizational setups above. The alternatives shall be examined particularly from the viewpoint of their effective relationships with technical assistance to the small holders.

(5) Identification of necessary arrangements for land management and the areas to which the arrangements need to be applied. Analysis shall be done particularly on the possible streamlining of organization, procedures and costs for the land tenure registration and transfer at the Amphoe level. Also, a possibility shall be examined as to the special ordinance for land title transfer to be used when existing national regulations are difficult to apply. It should be determined that what parts of the Central Lowlands are suitable to what types of land management system; cooperative type, resettlement type, concession type, etc.

(6) Identification of the best combination of organizational setup, financial support system and land management system, including administrative structure at respective levels, regulations and staff requirements.

3) Identification of the System of Research and Development, and Extension Services

R&D and extension services are vital to strengthen international competitiveness of Thai oil palm. In order to propose a feasible system of research and development, and extension services, the following tasks shall be undertaken:

(1) Assessment of the performance of research and development functions not only in ORRAF but other departments/agencies related to agricultural development.

(2) Identification of potentials and constraints of Thai research and development activities in the field of agricultural development.

(3) Preparation of alternatives of Research and Development (R&D) organizations and their functions, including the following alternatives:

i R&D organization for oil palm development only

ii R&D organization to cover oil palm and rubber development

iii R&D organization to cover not only oil palm and rubber but also other tropical rain forest species, possibly as a Tropical Agricultural Research Institute

(4) Preparation of proposals for possible funding system for the R&D organization.

(5) Preparation of proposals regarding functions and organizational setup (multi-level) for oil palm extension services.

(6) Examination of functional relationships and necessary coordination among R&D function, extension services, and administrative/financial support systems for oil palm development.

4) Economic and Financial Analyses of this program based on the study results of 1), 2) and 3)

Prior to this study, the following basic surveys will be completed in the Central Lowlands by the relevant government agencies both at central and local levels:

(1) Detailed Topographic Survey

(2) Detailed Soil Survey

(3) Survey of Land Tenure and Classification

(4) Meteorological and Hydrological Surveys.

D. STAFFING

The study team shall consists of experts at least in the following fields:

(1) Economic project planning/project management

(2) Agricultural economics especially in agricultural marketing and farm household economy

(3) Agronomics especially in R&D system and extension service program

(4) Regional and rural development planning especially in physical aspect

(5) Sociology especially in resettlement program, agricultural cooperative and community planning

(6) Land development and land management especially in estate development

(7) Financial analysis

(8) Public administration and legal aspect especially in coordination of different organizations at various levels.

2. TERMS OF REFERENCE FOR THE STUDY ON INTEGRATED TAPI-PHUM DUANG RIVER BASIN DEVELOPMENT (DRAFT)

A. BACKGROUND

The purpose of Integrated Tapi-Phum Duang River Basin Development is to achieve economic and social development of the basin in a coordinated and harmonious manner. The Royal Irrigation Department completed a master plan study of the Tapi-Phum Duang River Basin Development, which includes two major projects, i.e., Chew Larn and Kaeng Krung Dam Projects. A feasibility study of the Chew Larn Dam was also completed simultaneously with the master plan in 1973. After a decade of the study, the Chew Larn Dam is being constructed now and the implementation of Kaeng Krung Dam is under consideration both for power generation. The Integrated Tapi-Phum Duang River Basin Development, which includes various components such as hydropower development, flood mitigation,irrigation development, municipal water supply, and environmental protection, is proposed as one of projects in the Subregional Development Study of the Upper Southern Part of Thailand conducted by JICA. From a view point of the integrated river basin development and effective utilization of water resources, it is deemed necessary to prepare water use plan with a special attention to an optimal water use of the dams and to perform feasibility studies of irrigation development (partially, a revision of the past feasibility study), flood control, and municipal water supply.

B. OBJECTIVES

The objectives of this study are to prepare a master plan of multipurpose water use of Tapi and Phum Duang Rivers; and to perform feasibility studies of irrigation development, flood control, and municipal water supply projects. Here the irrigation project is to develop the left bank of Lower Phum Duang River; the flood protection project is to protect areas along lower reaches of Phum Duang River, Tapi River, and Phun Phin River; the municipal water supply project is to provide domestic and industrial water to Surat Thani and Phun Phin urban areas. The master plan study should proceed the feasibility studies and the feasibility studies should follow the water use frame work derived from the multipurpose water use master plan.

C. SCOPE OF WORK

The study of Multipurpose Water Use Master Plan aims at deriving a policy to use water of the Chew Larn and/or Kaeng Krung Dam. The water use policy will maximize the total benefit of power production, irrigation, flood control, municipal water supply, and environmental protection in esturine area. The master plan will also propose the role and structure of the committee which oversees the basin development activities operated by various agencies. The study of Multipurpose Water Use Master Plan needs to include the following components.

(1) Identify the role and function of the committee for Tapi-Phum Duang River Basin which is proposed to set up. The committee should consist of various government agencies and oversees the basin development and water use activities.

(2) Collect all the hydrologic data of Tapi and Phum Duang Rivers and examine hydrologic mechanism of the rivers with respect to water balance.

(3) Review the Tapi-Phum Duang River Basin Development Report (RID, 1973) and update necessary information for this and the following studies.

(4) Review the existing reservoir operation studies of the Chew Larn and Kaeng Krung Dams and also review the power generation requirement and flood control schemes associated with the reservoir operation.

(5) Review the past studies with regard to water requirements of the irrigation development, municipal water supply, and estuary environmental protection.

(6) Study the relationships between the power production benefit and the reservoir water release of the two dams, between the irrigation net benefits and the amount of irrigation water requirements, between the flood control benefits and the flood control schemes, between the net benefits and the amount of water supply requirements, and between the net benefits and the flow requirements for the estuary environmental protection.

(7) Prepare various criteria with different priorities on each water requirement of the power generation, irrigation, flood control, water supply, and environmental protection. Perform optimization study to obtain water allocation senarios under the various criteria. The optimization study should include water allocation patterns to water users and water balance along Tapi and Phum Duang River. The water allocation patterns and reservoir flow release schedules will result from the optimization study under the various criteria. This study should be performed assuming the existence of Chew Larn Dam only and the existence of both Chew Larn Dam and Kaen Krung Dam.

(8) Present the results of study performed in the Item (7), particularly water allocation patterns and benefits of each water user and associated criteria, to the Government of Thailand; and draw a decision from the government on the implementation of Kaeng Krung Dam and the allocation patterns. The decision shall be followed by the subsequent feasibility studies.

The second task for the study of Integrated Tapi-Phum Duang River Basin Development is the Irrigation Development Study. It is expected that the effective use of water resources being developed to irrigation development will contribute to the economic and social development in the Upper South in such aspects as to attain self-sufficiency in rice production by applying double cropping pattern, to increase opportunities in employment, to develop rural economics, to maintain rice exportation and to control consumer price of the country.

The objectives of the Irrigation Development Study are to formulate a irrigation project and to examine its feasibility. The area to be developed for irrigation is approximately 55,000 ha of the left bank of Lower Phum Duang River extending to the north of Surat Thani Province. The water availabilities derived from the preceding Multipurpose Water Use Master Plan Study should be adopted in the Irrigation Development Study as inherent information. The study should include the following components.

(1) The first stage of the study will focus on the review of the existing relevant reports and information. Collection of the existing data and information should cover the following items: national statistical data, national agricultural development plan, regional statistical data, regional agricultural development plan, topography, meteorology, hydrology and geohydrology, geology, soil, irrigation and drainage, agriculture, inundation, water quality and vegetation.

(2) Project area will be established and the following items will be studied: development strategy, project area partitions, water resource utilization plan and project priority.

(3) Determination of the basic items for the project planning includes: land use, agricultural production, farm management, farmer's association, supporting services, irrigation and drainage.

(4) Based on the first stage study of the Items (1), (2), and (3), the second stage study will be conducted for the following items: project formulation, preparation of the implementation schedule, estimation of the project cost and benefit, economic and financial evaluation of the project.

The third task for the study of Integrated Tapi-Phum Duang River Basin Development is the Flood Mitigation Study.
In the downstream of Phum Duang River, floods are caused by overbank flows from Phum Duang River to cropped land of the left bank. The lands on the left bank of Phun Phin River which are very flat rice growing area are frequently inundated. Even after the Chew Larn Dam, which include a flood mitigation purpose, is constructed, the effect of flood peak reduction by the dam may not be sufficient at the downstream of the confluence of the Tapi and Phum Duang Rivers. Therefore, an additional flood mitigation

measure, that is a bypass waterway, was proposed in the aforementioned JICA study. The objective of this feasibility study is mainly to examine its technical soundness with regard to the hydraulic performance. The secondary objective is to explore other possible measures through the analysis of hydraulic mechanism along the downstream of the confluence. The feasibility study should include the following components.

(1) Identify flood prone areas and estimate flood damages.

(2) Study hydraulic mechanism of the combined effects of Tapi and Phum Duang Rivers and high tides by field observations and measurements and hydraulic analyses.

(3) Investigate the effects of a bypass waterway by hydraulic analyses and hydraulic model experiments, under the flood control scheme drived from the preceding study of the Multipurpose Water Use Master Plan.

(4) Proceed to the estimation of cost and benefit analysis if the proposed flood mitigation measureof thebypass waterway is proved to be technically sound.

(5) Determine the feasibility of the measure and make propositions to implement it with regard to technical and social problems foreseen.

(6) Identify other possible flood mitigation measures if the proposed bypass water way is not assured to be technically sound.

The fourth task for the study of Integrated Tapi-Phum Duang River Basin Development is the Municipal Water Supply Study. It is deemed necessary to propose a water supply system to meet a present water demand of Surat Thani, and future demands including those of Surat Thani and Phun Phin Urban Areas and of Phun Phin Industrial Estate.

The study objectives are to revise existing water demand projections, to decide the supply schedule, to generate alternative water supply systems and choose a least cost alternative, and investigate the financial feasibility. The water availabilities derived from the preceding Multipurpose Water Use Master Plan should be adopted in the Municipal Water Supply Study. The study needsto include the following components.

(1) Study the existing water supply systems and review the existing water supply project study for the demand centers of Surat Thani and Phun Phin.

(2) Revise the water demand projections based on the new economic and social conditions of the present and future in and around the demand centers.

(3) Determine an appropriate planning period based on predicted future economic conditions and economy of a water supply system.

(4) Determine water supply schedules for the demand centers based on the amount of water abailable at the source, that is Phum Duang River.

(5) Generate water supply system alternatives, which include the components of timing and location of water supply activities, and identify the facilities required for each water supply system alternative.

(6) Determine the total costs for each alternative and select the least cost alternative.

(7) Perform cost and benefit analysis to determine financial feasibility and to draw implications to financial arangements.

D. STAFFING

The study shall be conducted by the four study teams for the four tasks. The first task of the Multipurpose Water Use Master Plan Study will require the following study members: hydrologist, hydropower economist, agricultural economist, water supply economist, environmental specialist, systems analyst and senior economist.

The second task of Irrigation Development Study will require the following study members: hydrologist, irrigation engineer, structural engineer, soil expert, agronomist, agricultural economist, engineering geologist, surveying engineer, planning engineer and river engineer.

The third task of Flood Mitigation Study will require the following study members: hydrologist, hydraulic engineer, experts of hydraulic model experiment, expert of hydraulic numerical analysis, river engineer, engineering geologist, surveyor, economist.

The fourth task of Municipal Water Supply Study will require the following study members: economist, hydrologist, engineering geologist, structural engineer, water supply engineer, and system analyst.

3. TERMS OF REFERENCE FOR FEASIBILITY STUDY ON PHUKET WATER SUPPLY PROJECT (DRAFT)

A. BACKGROUND

In the development of the Upper South, Phuket is expected to become a center of trade, tourism and export industries. Upon completion of Phuket Deep Seaport, distribution and productive activities will increasingly be attracted to Phuket. Tourism activities have been and will be expanding rapidly. These activities will stimulate the growth of Phuket City which at present is designated as a second generation urban growth center. Despite these growth potential of Phuket, it has a weakpoint that the water resources are limited in the coastal area of the Andaman Sea and in the Phuket Island particularly. Reliable water supply system is an essential need for the development of Phuket. Ban Wat Dam has been completed but it is not used yet for urban water supply purpose because of the delay in developing distribution system.

It has been proposed by JICA, the Subregional Development Study of the Upper Southern Part of Thailand, to develop a water supply network to connect by pipelines reservoirs and various water consumption centers including Phuket City , Phuket Deep Seaport and the intensive tourism development areas.

B. OBJECTIVES

While a treatment plant and a transmission system should be constructed immediately in order to utilize the Ban Wat Dam, it is the policy of the Government of Thailand to conduct a feasibility study for the long-term planning of water supply in the whole island. The following is the focus of the study:

(1) The availability of water sources and their amount of water should be studied with more detailed information of water balance. Site investigations of dams in those water sources should be made with respect to geological and topographical conditions. Utilization of existing mining ponds should be studied from the view points of economical water sources and flood mitigation effect.

(2) A complete system optimization with regard to combinations of water sources and demand centers, a layout and sizes of facilities will be useful to reduce investment and operation and maintenance costs.

(3) Necessary institutional arrangements among Provincial Waterworks Authority, Royal Irrigation Department, Phuket Municipality, sanitary districts, Phuket Changwat Administration Organization and other possibly relevant organizations should be made to maintain long-term implementation of water supply program and means of cost sharing among some of these agencies need to be studied in order to reduce the financial burden of the PWA and various consumers.

C. SCOPE OF WORK

In view of the objectives above, the Consultant shall undertake the following tasks:

1) Water Resources Investigation

In this section, the Consultant shall investigate availability of surface and groundwater in the whole Island based on the available gauging and rainfall records. Based on this, candidate sites of reservoirs shall be determined.

2) Preliminary Plans

In this section, the Consultant shall prepare preliminary plans to the extent necessary for estimating cost and water charges, determining division of works and cost sharing among agencies concerned and proceeding to engineering design.

(1) Review of existing reports

Any of existing reports relevant to the project, including the Subregional Development Study of the Upper Southern Part of Thailand, shall be reviewed as basic references for this preliminary plan making.

(2) Determination of supply area

The water supply service area shall include the municipal area of Phuket, Phuket Deep Seaport and intensive tourism development area (i.e., Patong, Karong and Kata Beaches and will not necessarily be constrained by administrative boundaries within the Changwat Phuket. Service to outlying and rural settlements shall be considered where this can be efficiently accomplished.).

(3) Review of existing water supply system

Existing public and private water supply systems in Phuket shall be reviewed and evaluated. This shall include preparation of an inventory of major system elements, comments on capacity and condition, an examination of existing water consumption, transportations and losses, and any consideration of the desirability of incorporating any existing facilities such as tin mining ponds into future planning.

(4) Water supply demand

Population, industries and other bulk consumers such as hotels shall be listed. In addition to the trend projection of the demand, regional development aspects as affecting water supply shall be investigated, in particular, urban area expansion and location of potential non-domestic consumers.

In estimating water requirements, realistic assessments shall be made of the rate at which new water supply facilities can be brought into operation, and of the likely cost of water in relation to the people's ability to pay.

(5) Evaluation of alternative means of intra-island transmission system

The consultant shall prepare alternative transmission systems, including the network system which allows intertransfer of water from different sources to cope with different fluctuation of demand in different consumption centers and the decentralized system which should be less costly. For respective alternatives, the Consultant shall prepare layout and size of facilities such as pipeline, pumping station, treatment plant and ground storage. (Distributions within the consumption center such as Phuket Municipality shall be planned by a separate study.)

(6) Cost estimation

Recommended works are to be a least cost solution considering both capital costs and operations, maintenance and replacement. For each major alternative, expenditures spread over a number of years are to be reduced to a discounted net present worth. A sensitivity analysis is also required.

(7) Recommendations

A least cost program of development in stages to meet water requirements up to the year 2000 shall be prepared. Recommendations shall also be made as to the possible method of water supply to meet a further increase of water demand, if anticipated, after the year 2000.

3) Organizational and Financial Analysis

The adjustment in division of responsibilities should be made especially between the Provincial Waterworks Authority and the municipality. The municipality can not fully develop the system within its capacity because the development of water resource should be planned and implemented keeping in mind the varying and extensive use of water and, at the same time, PWA will not be able to develop and maintain a feeder distribution system in the whole town areas because of a limit in personnel and funds. The Consultant shall prepare and discuss alternative divisions of responsibilities among agencies concerned, including PWA and Phuket Municipality. An alternative would be that the construction and maintenance cost of the water intake, transmission and purification systems to be born by PWA and those of the distribution to be born by the municipality. Financial recovery would be allocated in accordance with these cost sharing. The Consultant shall investigate into financial, technical and institutional feasibilities of these alternatives and provide information necessary for the government to make decisions from the long-term point of view.

D. STAFFING

The study term shall consist of experts at least in the following fields.

(1) Project management/Water supply planning

(2) Surface water hydrology

(3) Groundwater hydrology

(4) Engineering geology

(5) Water supply engineering

(6) Systems analysis

(7) Economic analysis

ANNEX II TECHNICAL PAPER

1. AGRICULTURE

1.1. EXISTING SITUATION

Farmland in the study area amounts to 3.2 million Rai (1 Rai = 0.16 ha), equal to 2% of the whole farmland in Thailand or 18% of that in the southern region. GPP of agricultural sector in the study area amounts to 2.9 billion baht (1980), which shares 4% of agricultural GPP of Thailand or 24% of that of the southern region. In 1975 agricultural GPP of the study area was 2.5 billion baht with a share of 40% of agricultural GPP of the southern region, since then the share was on a decreasing trend.

An average annual growth rate of agricultural GPP of the study area during the last five years was 3%. Although this growth rate is lower than that of the southern region by 2%, the study area still keeps up with the growth rate of the whole Thailand. Number of employees in the study area accounts for 510 thousand, 70% of which is engaged in agriculture. Agriculture is the leading industry in this area. Surat Thani is the most important province in the study area in terms of agriculture. It shares 59% of agricultural land and 50% of agricultural products of the study area. Of agricultural land in the study area, Phangnga, Krabi and Phuket shares 30%, 13% and 7% respectively. GPP in 1980 of two provinces of Surat Thani and Krabi was 10,374 million baht, of which 45% was produced by agricultural sector. The percentage is higher than that of the whole Thailand or that of the southern region, indicating their high dependence on agriculture. GPP of Phangnga in 1980 was 11,339 million baht, 30% of which was from agricultural sector. The percentage is higher than that of the whole Thailand but lower than that of the southern region. In Phuket, GPP in 1980 was 5,560 million baht, 12% from agricultural sector. Compared with other provinces in the study area, a share of agricultural sector in regional economy is extremely low in Phuket. In all provinces in the study area, however, agricultural sector's share in GPP is on a decreasing trend.

Gross Provincial Product of agricultural sector (agricultural GPP) in the study area in 1980 was 2.9 billion baht, 59% of which was of agricultural products, 18% was of forestry, 15% of fishery and 8% of livestock; thus share of agricultural products is very high. Composition ratios of each category (agriculture, livestock, fishery and forestry) sharing in agricultural GPP of the study area show similar percentage to those of the southern region but, compared with those of the whole Thailand, ratios of fishery and forestry are higher whereas those of agricultural products and livestock are lower.

Agricultural product of the study area in 1980 was 1.7 billion baht, which shares 3% of agricultural product of the whole Thailand, or 24% of that of the southern region. These figures indicate that agricultural land productivity of the study area is higher than that of the whole Thailand of 2% or that of the southern region of 18%. Of the agricultural product of the study area, Surat Thani shares 59%, Phangnga 19%, Krabi 18% and Phuket 4%. Gross Provincial Products of agriculture in 1980 were as follows; Surat Thani 1,033 million baht and Krabi 311 million baht. Percentages of these figures sharing in GPP of agricultural sector are 70% for the former and 80% for the latter, both exceeds the average percentage of 59% of the study area. Phangnga 323 million baht and Phuket 207 million baht. These share respective 37% and 34% in GPP of agricultural sector, which are comparatively low.

Main plant in the study area is natural rubber which occupies 60% of the total cultivated area of 3.2 million rai. Percentages of cultivated areas of other crops are 16% of rice, 12% of coconuts, 7% of fruits and 5% of oil palm. Main plant in the fruits cultivation area is rambutan but some other kinds are also common in the area, such as bananas, coffee, cashew-nuts and durian.

Rice production volume in the study area is 161 thousand tons as of 1980 which is equivalent to 1% of total production volume in Thailand, or 17% of that in the southern region. Surat Thani alone produces 66% of rice yielded in the study area but rice self-sustainance rate of the area is not more than 60% which is far from satisfying the areal demand. Natural rubber, the most important agricultural product in the study area, is cultivated everywhere in the study area. Its cultivation area reaches 1,943 thousand rai, of which 40% lies in Surat Thani, 30% in Krabi, 23% in Phangnga and 7% in Phuket.

Coconuts are chiefly cultivated along the coast. Coconut cultivation area amounts to 363 thousand rai in total, of which 78% lies in Surat Thani and 12% in Phangnga.

Oil palm was introduced from Malaysia in 1968 and has rapidly spread in Krabi and Surat Thani. In 1980, oil palm cultivation areas totalled to 173 thousand rai, of which 83% lies in Krabi.

Rambutan is cultivated mostly in Surat Thani which has now become one of the major rambutan producing area.

Pineapple is cultivated popularly in Phuket as intercrops of natural rubber.

Livestock product in the study area amounts to 224 million baht, which is equivalent to 2% of livestock product in the whole Thailand, or 20% of that in the southern region. Numbers of each kind of cattle in the study area in 1980 were 101,000 buffaloes, 38,000 cattles, and 74,000 swine. Among

them Surat Thani shares 50% of buffaloes, 68% of cattles, and 60% of swine whereas Krabi shares 20% each of buffaloes and cattles. During 5 years up to 1980 there was little change in heads of cattle except swine which decreased from a peak 216 thousand heads in 1975 down to 74 thousand heads in 1980.

Marine fish catch in the study area in 1980 recorded 157 thousand tons, which is equivalent to 10% of the catch in the whole Thailand, or 19% of that in the southern region. From this fact the study area can be regarded as a major fishery zone in Thailand. Marine fish catch in the study area showed a rise from 61 thousand tons in 1975 to 171 thousand tons in 1979 with 2.8 times increase but showed some drop in 1980. Main fishery ports in the study area are Surat Thani and Phuket, the former produces 52% and the latter 32% of marine fish catch in the study area.

Freshwater fish catch in the study area in 1980 was 4.7 thousand tons, accounting for only 3% of marine fish catch. Main places of freshwater fish catch lie in Surat Thani, where 80% of the catch is made.

Forestry product in the study area in 1980 was 541 million baht, sharing 3% of forestry product in the whole Thailand, or 30% of the same in the southern region. Timber production volume in the study area in 1980 was 231 thousand cubic meters, which corresponds to about 50% of forestry product in the study area. Surat Thani produces 78% of the timber production volume. Forest product in Phangnga in 1980 shares 74% of that in study area which was 470,000 cubic meters. Of that 90% was firewood and charcoal. Krabi was a main firewood producing province by 1978 but since then forest production in Krabi ceased. Phuket also ceased forest production. Forest production in study area showed a decreasing tendency from 732,200 cubic meter in 1978 to 470,400 cubic meter in 1980.

1.2 PROBLEMS

Agricultural sector has a great contribution to the economy of the southern region and the study area. GPP of the agriculture sector shared 41% of the total GPP in the southern region and 34% of that in the study area. The number of employees in the agriculture sector shared 70% of the total employees. Economy of these region relies more on agricultural sector than the whole Thailand. In agricultural GPP by subsector, the share of fishery and forestry is remarkably high. Topographically and climatically, this region resembles to neighbouring Malaysia than to the rest of Thailand. Rubber, produced for export, is the most representative crop of the southern region and the study area and dominates its farm economy. Economy of this region is unstable because it is much affected by international market price of rubber. Agriculture in the area is confronted with such various problems as described below.

Export of rubber shares 17% of the total agricultural exports in terms of money. In the world ranking of production and export volume of rubber products, Thailand is the third biggest country. Rubber production in the southern region shares 95% of the total production in Thailand in terms of money. In 1979, average yields of rubber per rai in Thailand was 60.3 kg, whereas Malaysia was 230.2 kg. The productivity of Thailand was just a quarter of that of Malaysia. Main causes of this low productivity can be attributed to the fact that the old rubber trees of more than 30 years are prevailing. Rubber Replanting Aid Fund Board was established in 1961 to accelerate rubber replanting. Since 1976, World Bank has been financing to promote the program. The amount of rubber production in Thailand has doubled since then, but on the other hand, rubber productivity per rai has been fluctuating in the range of 55 to 69 kg. A yield of high yield clone such as PR series , which is recommended by rubber station, has already attained the productivity of 300 kg per rai in the field station in the southern region. However, average yield of rubber in Thailand was 60.33 kg per rai in 1980. It would imply that rubber replanting has not been accelerated effectively. Further emphasis should be given to the increase of productivity and diffusion of nursery stock.

At present, waste rubber trees are only utlized as an energy source. They are of no value as goods. This can be one of the causes of the stagnation of rubber replanting project. Economic utilization of waste rubber trees could encourage rubber replanting. Research on such utilization as furniture production and mushroom cultivation should be promoted.

From a viewpoint of the quality of dust, air bubble and colour, quality of rubber sheet is classified into five grades. The quality of rubber sheet of Malaysia is high and most of them are graded as #1. But rubber sheet of Thailand contains dust when they are collected in the form of latex and are processed, so most of them are graded as #3. This fact will indicate that the processing technique after tapping is rather primitive. It is true that rubber produced in Thailand have developed a market for low grade of rubber at low price. For attaining further export of rubber, however, competition with Malaysia in the international market will be unavoidable in the future. Improvement of rubber processing technique would be indispensable for this competition.

Rubbers are cultivated in large scale plantation in Malaysia and Indonesia. In contrast, rubbers are cultivated primarily by smallholders of less than 20 rai in Thailand. That is characterized by poorly maintained holdings and primitive processing.

In the southern region, rubber planting farmers are forming groups by provinces. The main activity of those groups are joint collection of rubber sheets to sale at a better price.

At present, the farm gate price of rubber sheets per kg of organized farmers is about 1 baht higher than that of the others. But organized farmers are not so many. In order to promote agricultural development, it is indispensable to organize the farmers.

Agriculture of Thailand except the south region attained diversification of the crops. Agriculture in the south region has been mostly depending on rubber. Oil palm was introduced from Malaysia in 1968 and has rapidly spread. Oil palm is becoming one of the main agricultural products in the study area. The most promising area for further expansion is the Central Lowlands over North Krabi and South Surat Thani. There are two oil factories and in 1984 additional factories will be completed there. Oil palm should be extracted at the factory within 24 hours after harvest. Oil palm plantation area is expanding in study area where oil extraction within 24 hours is impossible, such as Phuket and the northern part of Surat Thani. In order to make oil palm one of the main agricultural products in study area, the arrangement of estates should be planned.

Oil palm cake is utilized mainly as an energy source. Palm oil price in the international market is rather stable than that of rubber and domestic and international market for palm oil is expected to be very bright. It is expected that oil palm plantation area will expand further. Research on the utilization of oil palm cake such as biomass and organic fertilizer is important.

At least 50 rai per household is needed to cultivate oil palm. In the study area, small holder of less than 20 rai are predominant. Without new land management, it is hard to consider that oil palm will contribute to the diversification of crops of small holders. Introduction of new crops for small holders is also urged in the region.

Tin mining has prospered around Phangnga area. At present, 190 thousand rai remains as unused area after tin mining. Appropriate landuse plan in the area is needed to conserve soil resource. Furthermore, silt blowing from tin mining is being deposited on the coral bed. It is feared that silt pollution will make bad effect on coastal fishery. An assessment of coastal pollution should be urged for protection of coastal fishery.

Agricultural production of Thailand has increased owing to the expansion of farmland. Expansion of farmland in Thailand except the region has already reached its limit and there seems little room for further expansion. But the farmland area of the southern region is 32% of the whole, smaller than that of other regions. So the region has rooms for further expansion of farmland. Especially in study area, farmland area is 23% of the whole, so rooms for expansion are considered greater

than the others. Appropriate landuse plan would be necessary to comply with this expansion.

The rate of irrigation (=irrigation area/paddy field area) of the southern region is 33.2%, higher than that of the whole kingdom of average 25.6%. But most of irrigation area is in the lower south such as Songkhla, Nakhon Si Thammarat, etc. In the study area, irrigation facilities are scarce. The rate of rice self-sufficiency in the study area is low, about 60%. The annual average rainfall is around 2000 mm in most parts of the study area, affected by monsoon. The region is abundant in water resources. And the expansion of paddy field by 1.4 times can be possible in Surat Thani. In the future, rice self-sufficiency in the study area will become possible by extending the irrigation area.

There are 85 agricultural experiment station in Thailand, with the following contents: rice 22, upland farming 20, horticulture 10, sericulture 14, rubber 19. All the rubber experiment stations are in the south region. As for the other 66 experiment stations, in the southern region, rice experiment station is in Nakhon Si Thammarat, Khuan Gut and Pattani, upland farming experiment station is in Phatthalung and horticulture experiment station is in Sawi. These stations except rubber station are in the Lower South. As the expansion of farmland in study area has high possibility, agricultural production can be greatly increased by intensification in research and extension. Some experiment stations should be introduced to the study area.

Coconut trees in the study area are old and coconut fields are not well maintained due to low saling price. Coconut planted area has a possibility of expansion by 2.6 times. To increase land productivity of coconut planted area, introduction of mixed crops such as pasture, mushroom cultivation, bee keeping, cacao and pepper will greatly contribute to cash income opportunities of small holders. Coconut-based industries such as copra, active carbon, coconut fiber and furnitures should be promoted at the same time to make full use of coconut.

Introduction of pasture under coconut tree could encourage cattle production of the study area.

Coastal and ocean fishing cannot be expected much due to recent overcatch and restriction of 200 seamiles. An emphasis will be given to increase per unit added of fish by expanding freezing facilities, reinforcing guard boats for limiting small and fry fish catch and regulating meshes of trawl for attaining this purpose. Also, fish culture is to be promoted in sea water.

It is feared that timber production in study area will cease to exist in the coming 5 to 10 years. However, forestry industry should be maintained at least at the present level for the purpose of maintaining basic resource of wood industries and environmental conservation.

1.3 DATA ON AGRICULTURE

Table 1.1. Agricultural Share of GPP in Study Area (%)

1975	1976	1977	1978	1979	1980
40.0	40.0	38.0	36.6	34.7	33.7

Source: NESDB

Table 1.2 Provincial Share in Agricultural GPP

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	51	54	49	50	54	50
Phangna	25	23	25	23	23	30
Phuket	6	8	8	7	9	7
Krabi	18	15	18	20	14	13
Total(million baht)	2507	2259	2496	2855	2847	2948

Source: NESDB

Table 1.3 Agricultural Share in GPP by Province

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	44.7	49.6	46.9	45.7	48.1	45.9
Phangna	48.0	36.4	33.0	28.7	26.2	29.9
Phuket	12.4	18.0	17.1	14.7	15.1	12.1
Krabi	51.1	46.7	50.4	54.9	46.1	43.6

Source: NESDB

Table 1.4 Subsector Share of Agricultural GPP in Study Area by Year

(Unit: %)

	1975	1976	1977	1978	1979	1980
Crops	54.3	64.5	66.7	54.3	62.4	58.9
Livestock	10.1	10.2	6.9	7.5	7.8	7.6
Fisheries	7.4	11.6	13.6	16.8	18.9	15.1
Forestry	28.2	13.7	12.7	21.4	10.9	18.4

Source: NESDB

Table 1.5 Crops Share of Agricultural GPP in Study Area by Province

(Unit: %)

	Surat Thani	Phangna	Phuket	Krabi
1975	68.5	18.2	4.4	8.5
1980	59.4	18.6	4.1	17.9

Source: NESDB

Table 1.6 Share of Crops in Agricultural GPP

(Unit: %)

	Surat Thani	Phangna	Phuket	Krabi
1975	72.7	39.3	39.2	54.3
1980	70.4	36.5	34.1	79.7

Source: NESDB

Table 1.7 Proportion of Main Crop Planted Area in Study Area (1977)

Paddy	Rubber	Coconut	Oil Palm[1)]	Fruit	Total (million Rai)
15.7	60.3	11.9	5.3	6.8	3.22

1) Oil Palm Planted Area in 1980 (Provincial Office)

Source: Department of Land Development

Table 1.8 Main Crop Production in Study Area

	Paddy	Rubber	Coconut[1)]	Oil Palm
Surat Thani	69.9	39.6	78.1	16.6
Phangna	8.0	23.0	11.6	-
Phuket	2.1	6.9	6.4	-
Krabi	20.0	30.5	3.9	83.4
Total (1,000xTon)	161	98	75	77

1) Copra Production

Estimated from Planted Area and Average Yield

Table 1.9 Provincial Share of Livestock GPP in Study Area

(Unit: %)

	Surat Thani	Phangna	Phuket	Krabi	Total (Million baht)
1975	52.5	17.8	9.7	20.0	252
1980	48.0	18.0	11.5	22.5	224

Source: NESDB

Table 1.10 Number of Buffaloes in Study Area by Year

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	43	42	46	50	50	51
Phangna	20	20	17	14	15	18
Phuket	4	5	3	4	3	3
Krabi	33	34	34	32	32	28
Total (1,000head)	99	104	117	116	121	101

Source: Agricultural Statistics of Thailand

Table 1.11 Number of Cattle in Study Area by Year

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	68	64	65	64	68	68
Phangna	3	3	2	3	2	2
Phuket	2	2	1	1	1	1
Krabi	27	31	32	32	29	29
Total (1,000head)	32	36	38	41	35	38

Source: Agricultural Statistics of Thailand

Table 1.12 Number of Swine in Study Area by Year

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	66	69	65	68	62	40
Phangna	12	12	15	13	19	29
Phuket	2	3	2	3	2	4
Krabi	20	16	18	16	17	26
Total (1,000head)	157	145	158	216	144	74

Source: Agricultural Statistics of Thailand

Table 1.13 Provincial Share of Fisheries GPP in Study Area

	Surat Thani	Phangna	Phuket	Krabi	Total(Million baht)
1975	58	3	34	5	787
1980	59	10	25	6	446

Source: NESDB

Table 1.14 Marine Fish Catch in Study Area by Year

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	53	46	44	62	57	52
Phangna	3	11	10	10	9	9
Phuket	38	38	36	20	27	32
Krabi	6	5	10	8	7	7
Total (1,000Ton)	61	84	115	162	171	157

Source: Fisheries Record of Thailand

Table 1.15 Fresh Water Catch in Study Area by Year

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	92	85	86	90	83	82
Phangna	3	4	5	6	12	16
Phuket	4	10	8	3	3	1
Krabi	1	1	1	1	2	1
Total (Ton)	2130	2512	2275	2951	3584	4871

Source: Fisheries Record of Thailand

Table 1.16 Provincial Share of Forestry GPP in Study Area

(Unit: %)

	Surat Thani	Phangna	Phuket	Krabi	Total (Million baht)
1975	16	46	1	37	707
1980	12	88	0	0	541

Source: NESDB

Table 1.17 Timber Production in Study Area by Year[1)]

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	75	80	73	85	85	78
Phangna	-	-	6	4	15	22
Phuket	-	-	-	-	-	-
Krabi	25	20	21	11	-	-
Total(1,000m^3)	313	262	304	397	281	231

1) Except Teak.

Source: Royal Forest Department

Table 1.18 Fire Wood Production in Study Area by Year

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	5	2	1	-	-	-
Phangna	56	53	57	50	98	100
Phuket	1	3	-	1	2	-
Krabi	38	42	42	49	-	-
Total (1,000m^3)	273	354	357	277	175	184

Source: Royal Forest Department

Table 1.19 Charcoal Production in Study Area by Year

(Unit: %)

	1975	1976	1977	1978	1979	1980
Surat Thani	-	100	-	-	-	-
Phangna	-	-	100	66	98	100
Phuket	-	-	-	1	2	-
Krabi	100	-	-	33	-	-
Total (1,000m^3)	1.3	0.01	2.0	58.2	37.2	55.4

Source: Royal Forest Department

Table 1.20 Rubber Yield in Thailand and Malaysia

(Unit: kg/rai)

	1965	1970	1975	1979
Thailand[1)]	59.1	56.6	56.2	60.3
Malaysia[2)]	155.2	190.2	203.5	230.2

Source: 1) Agricultural Statistics of Thailand
2) Rubber Statistics Handbook Malaysia

Table 1.21 Paddy Area and Irrigated Area in 1980

(Unit: Million Rai)

	North	NorthEast	Central	South	Whole Kingdom
Paddy Area (A)	16.78	35.89	16.05	4.84	73.56
Irrigated Area (B)	3.83	2.29	11.13	1.61	18.84
B/A %	22.8	6.4	19.3	33.2	25.6

Source: Agricultural Statistics of Thailand

1.4 WORLD SITUATIONS OF PALM OIL

1.4.1 Oilseeds and Oil Crops

Oilseeds are those seeds which are used as materials for the extraction of oil, and the crops which produce oilseeds are called oil crops as against food crops, fiber crops and other group of crops. All of the oilseeds obtained from these oilcrops are on the market, with the exception of oil palm. As palm oil is extracted from fresh palm fruit in or nearby the farm, the fruit are not marketed as oilseeds. However, palm kernels, which are the core of the palm fruit, are an internationally marketed commodity for the production of palm kernel oil. Palm kernel oil is an oil quite distinct from palm oil, and they are different in chemical composition and in their uses.

Oil crops can be classified into annual crops such as soybean, sunflower and peanut, and perennial plants such as oil palm and coconut. Annual crops account for the major share of both production and planted area. Most of the annual crops are widely cultivated throughout the temperate and tropical areas. Whereas the most important tree oil crops, i.e., oil palm and coconuts can be grown only in the tropics. Olive, camellia and other three oil crops are grown in temperate zone but they are of minor importance.

The production of annual crops undergoes large changes from year to year in comparison with perennial crops. One of the reasons for this is that annual crops are subject to the effects of nature, such as the climatic conditions. Another reason is that the farmers increase or decrease the planted area according to the fluctuations in price of the annual crops. Among tree crops, oil palm is planted mostly in large estate, in which cultivation of oil palm and oil extraction are done. Since 1960s, "nucleus estate system" has developed rapidly, originally in Malaysia but spread widely in other countries.

1.4.2 Usage of Oils

The oils obtained from oilseeds have a variety of types and contents of fatty acids, such as linoleic acid, oleic acid and palmitic acid, according to the type of oilseed. Consequently, their physical and chemical properties, such as their melting point and iodine value, also vary. The usage of these oils is therefore such that can make the best use of their respective characteristics. Fig. 1.1 shows the classification of oils and fats by materials and Fig. 1.2 shows the classification by the uses. Vegetable oils can be classified according to the property of drying or the physical state, i.e. liquid, semisolid or solid, at room temperature.

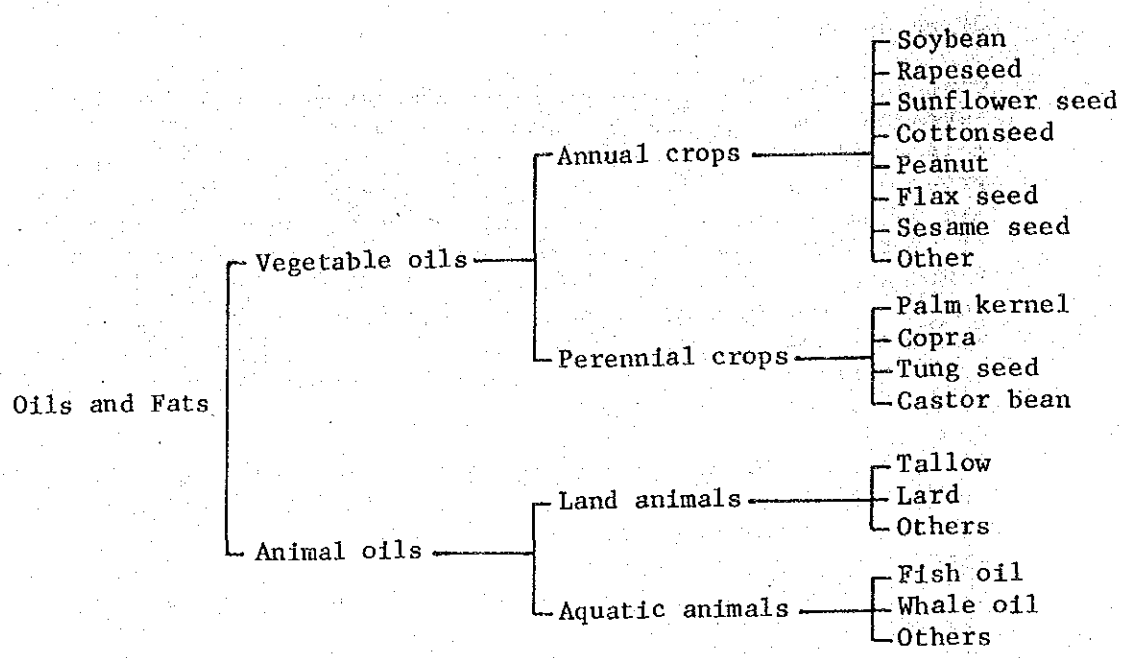

Fig. 1.1 CLASSIFICATION OF OILS AND FATS

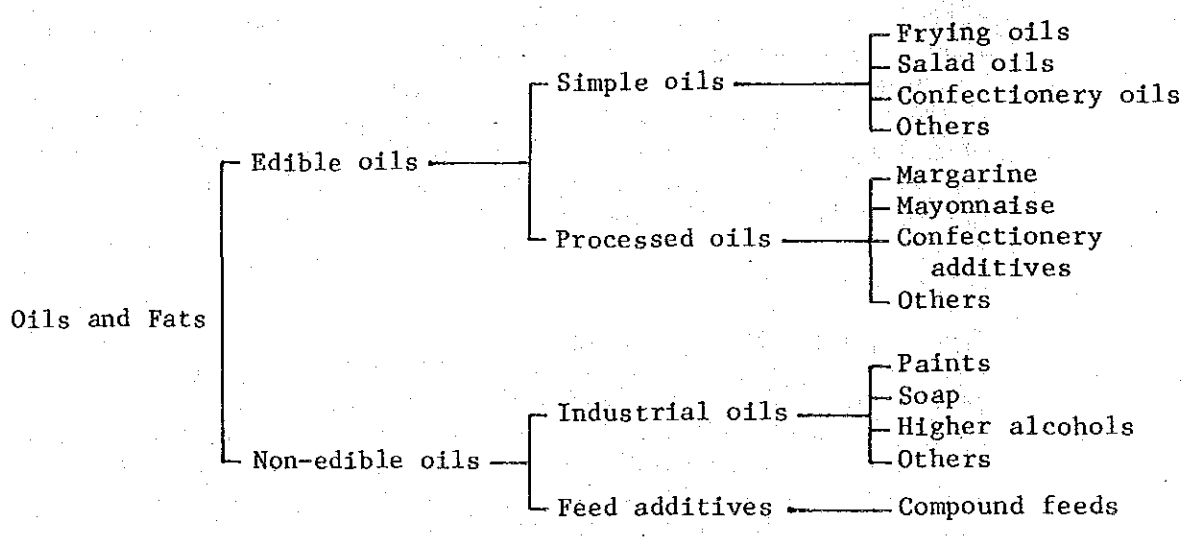

Fig. 1.2 USES OF OILS AND FATS

1.4.3 Production and Processing of Vegetable Oils

The processing of oilseeds consists of the steps of oil extraction, oil refining and fractionation. The oilseeds are pressed by a machine or extracted by means of a solvent, although some quantity is still pressed by primitive methods such as pressing by hand or by an animal-driven press in some countries. Mechanical pressing includes the hydraulic pressure method and the screw pressing method. The latter method is the most widely used. The oils which are extracted from oilseeds are known as crude oils in their unrefined form. The refining process includes the steps of degumming , deacidification, decoloration and deodorization.

A key feature of the oil industry is that the material cost, which accounts for the major portion of the overall costs, is subject to fluctuation. Furthermore, the formation of prices has two principal features. Firstly, both the materials and the products have international markets, so that their prices are subject to sharp fluctuations. Secondly, the domestic market prices of the oils and the oil cakes directly reflect the fluctuations of the international market price or exchange rates.

1.4.4 Production and Demand for Vegetable Oils

The most significant trend of vegetable oil production since the 1960s has been the rapid and market increase in soybean production due to an increase in the demand for soybean meal as a protein-rich feed, and the great increase in palm oil production due to the rapid expansion of oil palm planting in Malaysia. The increase in the supply of these two vegetable oils has depressed the prices of these oils, and consequently, the overall consumption of vegetable oils has increased. One of the most important aspects of the future outlook is the question as the whether or not soybean production will increase and retain its predominant influence on world oil economy. This will depend to a great extent on the future prospects of the world livestock industry. The per capita consumption of vegetable oils is comparatively large in the developed countries, but it has already reached or close to the saturation point. Accordingly, an increase in the demand for edible oils due to future increases in income or decreases in the prices of the oils is hardly expected in these countries. The increase in demand may be merely proportionate to the increase in population. To a certain extent, however, the consumption shift between oils may take place. Shift from animal oils to vegetable oils for health reason (cholesterol precaution) may also be expected.