KINGDOM OF THAILAND

MINISTRY OF AGRICULTURE AND COOPERATIVES

ROYAL IRRIGATION DEPARTMENT

THE EAST COAST WATER RESOURCES DEVELOPMENT PROJECT (PHASE II)

VOLUME 4

MAIN REPORT

FEASIBILITY STUDY ON KHLONG THAP MA DAM SCHEME

AUGUST 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

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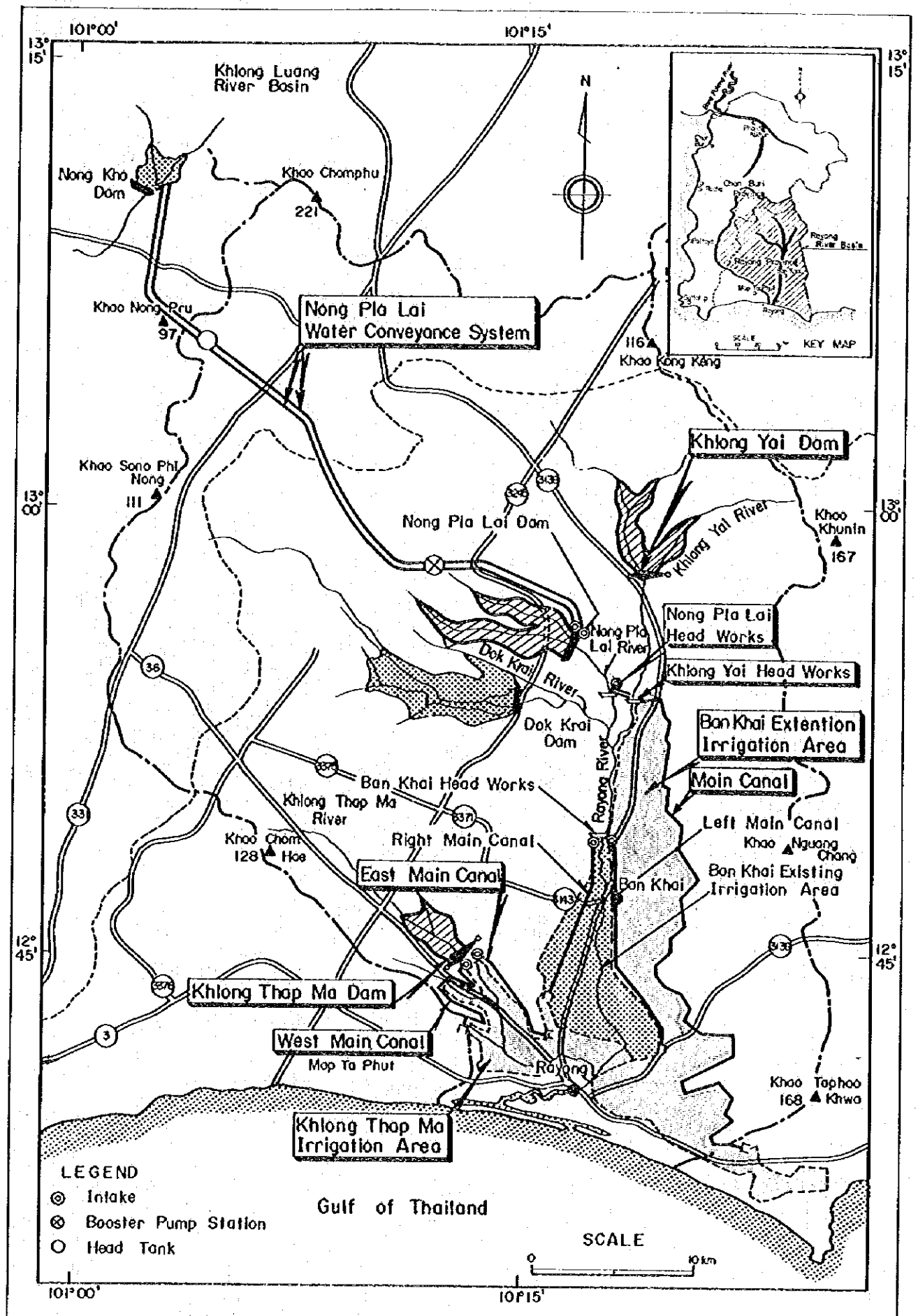


General Layout of Khlong Yai and Khlong Thap Ma Dam Schemes

SUMMARY OF CONCLUSION AND RECOMMENDATION

1. The Government of Kingdom of Thailand issued the Fifth National Economic and Social Development Plan (the Fifth National Plan), which covers a 5-year period from 1982 to 1986. The Fifth National Plan focuses to restore the nation's economic and financial stability, to improve the economic efficiency and to alleviate the poverty through the development of industry and increase of agricultural production.

2. The Eastern Seaboard Development is the spearhead of the nation's industrial development plan and aims at developing the basic industry based on natural gas. The development area extends over Chachoengsao, Chon Buri and Rayong Provinces. The majority of the development area are located along the coastal area in Chon Buri and Rayong Provinces.

3. The agricultural development is regarded to be promoted in the backward area of the industrial development area in order to create the balanced socio-economic situation throughout region and to increase the exportable quantity.

4. The East Coast Water Resources Development Project, Phase II (the Study) was launched by the Government to cope with increasing importance of land and water resources development for the industrial development and agricultural production.

   The objective area of the Study (the Study Area) covers Chon Buri and Rayong Provinces, except the Prasae river basin, and embraces the majority of the Eastern Seaboard Development Area.

5. The Study contains two subjects; (a) study for the long-term water demand and supply balance in the Study Area and (b) feasibility study for Khlong Luang, Khlong Yai and Khlong Thap Ma Dams.

6. The Scheme is located in the Khlong Thap Ma river basin, which has a drainage area of 158 km^2. The population in the basin is around 30,000 in 1981.

7. The lands and water resources of the basin remain almost untapped. Soils and land capability assessments revealed that the basin embraces 2,400 ha of irrigable land in the downstream from the proposed damsite. Although rice, cassava and sugarcane are being cultivated at present, their yields are low due to lack of irrigation water supply and agricultural input and to inundation.

8. The lower Khlong Thap Ma river basin is susceptible to inundation to a large extent, owing to flat topography and flooding of the Khlong Thap Ma river. It is estimated that about 21,000 ha of lands were inundated in the whole Rayong river basin in 1974.

9. The plan formulation study was conducted to ascertain the optimum development plan of the Scheme. It was performed in two steps each of which treats of various alternatives. The first step is directed to formulate the optimum land and water resources development plan. The second step is led to formulate the optimum flood mitigation measure in the basin. As the results, the optimum development plan of the Scheme is determined as follows:

Khlong Thap Ma Reservoir

Gross storage	:	74.3 x $10^6 m^3$
Surcharge	:	13.5 x $10^6 m^3$
Active storage	:	56.1 x $10^6 m^3$
Dead Storage	:	4.7 x $10^6 m^3$
Flood water level	:	El. 26.9 m
High water level	:	El. 25.7 m
Low water level	:	El. 16.2 m

Irrigation Development

Net irrigation area	:	2,400 ha

Agricultural Development

Crops	:	Rice, groundnuts, vegetables
Cropping intensity	:	170%

10. The flood mitigation plan evolved the most favourable basic flood control plan for standard project flood with a 50-year recurrence interval. The basic plan is made up of combination of dam and river improvement works. The river improvement works, however, are not recommendable positively for the present, because of less technical feasibility.

11. The proposed irrigation development area of 2,400 ha extends along the both banks of the Khlong Thap Ma river in the immediate down-stream from the dam. The area is divided into the East Area (1,250 ha) and the West Area (1,150 ha).

The recommended crops are rice, groundnuts and vegetables. The rice will be cultivated in the whole irrigation area during the wet season while the crops will be grown during the dry season. Cropping intensity is increased from 100 % at present to 170 %. The crop production will increase largely as shown below, resulting from the introduction of advanced farming practices and proper water management.

Crops	Without Project (t)	With Project (t)	Increase (t)
Rice			
- Local variety	2,120	1,760	-360
- High Yielding Variety	1,790	8,460 (Wet season) 4,150 (Dry season)	10,820
Groundnuts	30	1,750	1,720
Cassava	8,160	-	-8,160
Sugarcane	5,160	-	-5,160
Vegetables	-	1,500	1,500
Fruits	300	560	260

12. Preliminary designs were performed for the dam, and irrigation and drainage system, respectively.

Dam comprises a main dam and a saddle dam. The main dam is of homogeneous earth-fill type with the maximum height of 20.4 m above the river bed and the crest length of 810 m. The upstream and downstream slopes are 1 : 3.1 and 1 : 2.6 respectively. The total embankment volume is 1,345 x 10^6 m^3. The spillway is designed as a side-channel spillway with open channel chuteway based on inflow design flood with a peak discharge of 920 m^3/s (500-year recurrence interval). Its crest elevation and length are El. 28.9 m and 810 m, respectively.

Two irrigation intakes are constructed in the reservoir and are connected to the East and the West Main Canals respectively. The intake comprises an intake tower with 13.9 m in height and equipped with regulating gate, conduit pipe with inside diameter of 1.3 m and outlet associated with discharge measurement device. The East and the West Main Canals are designed with concrete lining and stretch for 5.3 km and 11.3 km, respectively. The total length of lateral canal is approximately 38 km.

13. Implementation period of the project extends over 5 years from fiscal year 1985 to 1989. The construction period of the dam and irrigation and drainage system will be 4 years from 1986 to 1989.

14. The total investment cost is estimated to be ฿ 1,591 x 10^6 comprising ฿ 1,200 x 10^6 of local currency component and ฿ 391 x 10^6 of foreign currency component as shown below:

(Unit: ฿ 10^6)

Project Components	Foreign Currency	Local Currency	Total
Multiple-purpose dam	294.5	981.5	1,276.0
Irrigation and Drainage System	97.0	218.4	315.4
Total	391.5	1,199.9	1,591.4

15. The benefit is accrued from the irrigation and drainage development and flood control. It is estimated as follows:

(Unit: ฿ 10^6)

Benefits	Annual Benefit
Irrigation and Drainage	81.7
Flood Control	19.5
Total	101.2

16. Economic evaluation was conducted and economic internal rate of return was found to be 12.1 %, indicating the high economic soundness of the Scheme.

17. Investment cost is allocated to the components by "Separable costs - remaining benefit method" and summarized as follows.

(Unit: ฿ 10^6)

Component	Foreign Currency	Local Currency	Total
Irrigation	326.6	983.9	1,310.5
Flood Control	64.9	216.0	280.9
Total	391.5	1,199.9	1,591.4

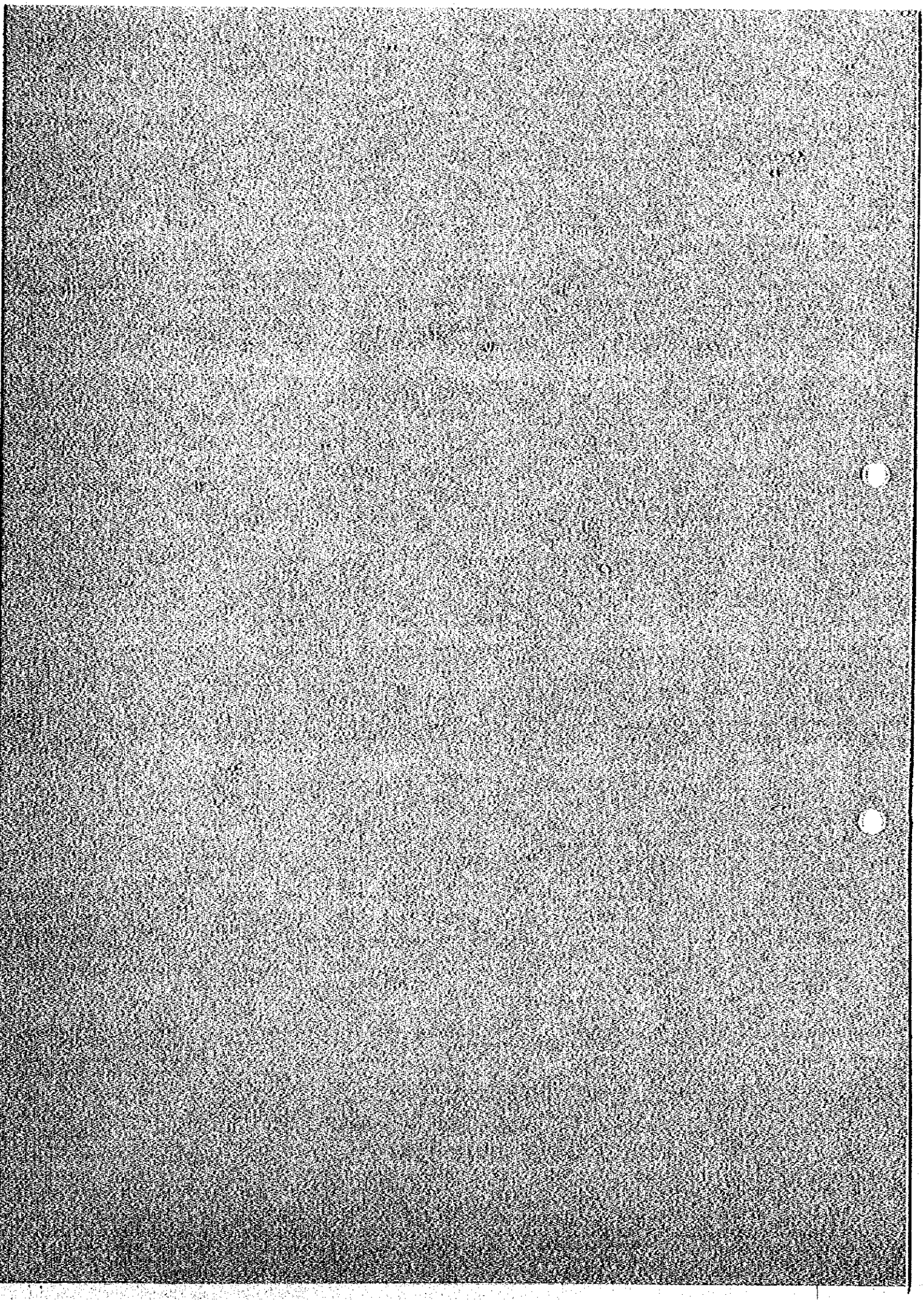
18. Financial aspect of the Scheme is evaluated by respective component paying particular attention to the repayability of the Scheme to the international loan. International loan will be financed with an interest rate of 3.5 % per annum and a term of 30 years including 10 years of grace period. Repayability is examined based on the project cost allocated to each component and revenue expected to be collected through water tariff. Water tariff on irrigation water is broadly estimated at ฿ 960/ha per annum to recover annual O&M cost. International loan will be repayed in due schedule with government subsidy given for the repayment of investment cost and replacement cost.

19. The Government agency related to the Scheme is the Royal Irrigation Department (RID). RID will be responsible for implementation, operation and maintenance of the dam and irrigation and drainage system.

PRINCIPAL FEATURES OF KHLONG THAP MA DAM SCHEME

1. MULTIPLE-PURPOSE DAM		
1.1 Hydrology		
(a)	Catchment area	158 km^2
(b)	Annual average inflow	1.75 m^3/s
(c)	Design flood for spillway (500-year flood)	920 m^3/s
(d)	Extra-ordinary flood (Probable maximum)	1,540 m^3/s
1.2 Reservoir		
(a)	High water level	El. 25.7 m
(b)	Low water level	El. 16.2 m
(c)	Flood water level	El. 26.9 m
(d)	Extra-ordinary flood water level	El. 27.5 m
(e)	Gross storage	74.3 x 106 m3
(f)	Surcharge	13.5 x 10^6 m3
(g)	Active storage	56.1 x 106 m3
(h)	Dead storage	4.7 x 10^6 m^3
(i)	Reservoir area at HWL	10.5 km^2
1.3 Main Dam		
(a)	Type	Homogeneous earthfill
(b)	Crest elevation	El. 28.9 m
(c)	Dam height above riverbed	20.4 m
(d)	Crest length	810 m
(e)	Crest width	8.0 m
(f)	Slope, upstream	1 : 3.1
	downstream	1 : 2.6
(g)	Embankment volume	
	Earthfill	1,182,000 m^3
	Filter	92,000 m^3
	Rock riprap	71,000 m^3
1.4 Saddle Dam		
(a)	Type	Homogeneous earthfill
(b)	Crest elevation	El. 28.9 m
(c)	Dam height above original ground surface	3.3 m
(d)	Crest length	420 m
(e)	Crest width	8.0 m
(f)	Slope, upstream	1 : 3.1
	downstream	1 : 2.6

	(g) Embankment volume		
	Earth fill		35,000 m^3
	Filter		9,000 m^3
	Rock Riprap		5,000 m^3
1.5	Spillway		
	(a) Type	Non-gated side-channel weir	
	(b) Overflow weir crest elevation	El. 25.7 m	
	(c) Overflow weir crest width	50.0 m	
	(d) Length of chuteway, including stilling basin	235 m	
2.	IRRIGATION AND DRAINAGE SYSTEM	East Area	West Area
2.1	Net Irrigation Area	1,250 ha	1,150 ha
2.2	Intake		
	(a) Location	Khlong Thap Ma Reservoir	
	(b) Discharge capacity	1.80 m^3/s	1.66 m^3/s
	(c) Diameter of outlet conduit	ø1,300 mm	ø1,300 mm
	(d) Length of outlet conduit	100 m	87 m
	(e) Intake gate (B x H)	1.3m x 1.3m	1.3m x 1.3m
2.3	Main Canals		
	(a) Type of canal	Trapezoidal, lined with concrete	
	(b) Side slope	1 : 1.5	
	(c) Effective width of inspection road	5.0 m	
	(d) Length	5.3 km	11.3 km
2.4	Lateral and Sub-lateral Canals		
	(a) Type of canal	Trapezoidal, unlined	
	(b) Side slope	1 : 1.5	
	(c) Effective width of inspection road	5.0 m	
	(d) Total length	17 km	21 km
2.5	Canal Structures	73 nos.	105 nos.
2.6	Drainage		
	(a) New drains	31 km	
	(b) Improved drains	8 km	
	(c) Structures	10 nos.	



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ABBREVIATIONS AND LOCAL TERMS

A. ABBREVIATION OF MEASURES

(1) Length
- mm = millimetre
- cm = centimetre
- m = metre
- km = kilometre

(2) Area
- m^2 = square metre
- ha = hectare = $10^4 m^2$
- km^2 = square kilometre = $10^6 m^2$
- rai = 0.16 ha

(3) Volume
- lit, l = litre = 1,000 cm3
- kl = kilolitre = 1 m3
- m^3 = cubic metres
- MCM = million cubic metres = 1,000,000 m3

(4) Weight
- mg = milligramme
- g = gramme
- kg = kilogramme
- t = ton = 1,000 kg
- qwt = quintal = 100 kg

(5) Time
- s = second
- min = minute
- h = hour
- d = day
- yr = year

(6) Money
- ฿ = Baht (unit of Thai currency US$ 1 = ฿ 23)
- $ = US dollar
- ¥ = Japanese Yen

(7) Electric Measures
- kV = kilovolt
- kW = kilowatt
- MW = megawatt = 1,000 kW
- kWh = kilowatt hour
- kVA = kilovolt Ampere

(8) Other Measures
- mmho = micromho = conductance
- ppm = parts per million
- ppb = parts per billion
- % = per cent
- LCD = litre per capita per day
- PS = 0.736 kW
- pH = scale for acidity
- ° = degree
- ' = minute
- " = second
- °C = degree centigrade
- 10^3 = thousand
- 10^6 = million
- 10^9 = billion (milliard)

(9) Derived Measures Based on the Same Symbols
- m^3/s = cubic metre per second
- ton/ha = ton per hectare
- $10^6 m^3/yr$, MCM/yr = million cubic meter per year

B. OTHER ABBREVIATIONS

- GDP = gross domestic product
- GRP = gross regional product
- El. = elevation
- HWS = high water surface
- SD = sanitary district
- DA = development area
- ESS = Eastern Seaboard Study
- FOB = free on board
- CIF = cost, insurance and freight
- WHO = World Health Organization

C. ABBREVIATION OF ORGANIZATIONS

MOAC	Ministry of Agriculture and Cooperatives
RID	Royal Irrigation Department
DOF	Department of Fisheries
LDD	Land Development Department
NESDB	National Economic and Social Development Board
NEB	National Environment Board
NSO	National Statistical Office
MOI	Ministry of Industry
DMR	Department of Mineral Resources
DIW	Department of Industrial Works
MOC	Ministry of Communications
HD	Harbor Department
DHW	Department of Highways
DOH	Department of Health
RTN	Royal Thai Navy
PWWA	Public Water Works Authority
MD	Meteorology Department
DOLA	Department of Local Administration
TAT	Tourism Authority of Thailand

D. LOCAL TERMS

Changwat	:	Province
Amphoe	:	District (Township)
Tambon	:	Township (Town)
Muban	:	Village
Muang	:	Administrative Center of Province
King Amphoe	:	Sub-district
Mae Nam	:	River
Khwae	:	Main tributary of a river
Huai	:	Stream, creek or small tributary
Khlong	:	Canal
Khao	:	Mountain

1. INTRODUCTION

1.1 Authority

The Feasibility Study on East Coast Water Resources Development Project, Phase II (the Study) was carried out in accordance with Implementation Arrangement, Technical Cooperation for Feasibility Study on East Coast Water Resources Development Project (Phase II), Khlong Luang, Khlong Yai and Khlong Thap Ma Dam (the Implementation Arrangement), which was concluded in the date of February 22, 1982 between Japan International Cooperation Agency (JICA), an executive agency of the Government of Japan and Royal Irrigation Department (RID), Ministry of Agriculture and Cooperatives, an executive agency of the Government of Kingdom of Thailand. The objective area of the Study (the Study Area) extends over Chon Buri and Rayong Provinces, excluding the Prasae river basin.

The JICA entrusted the Study to Nippon Koei Co., Ltd., associated with Nikken Consultant Inc. (the Study Team).

The Study Team conducted the field investigation and study during the period from July, 1982 to July, 1983 with the counterpart support provided by the Government of Kingdom of Thailand (the Government). This report is one of draft final report and presents the findings and recommendations on the Khlong Thap Ma Dam Scheme.

1.2 Historical Background

Thailand is embarking in a new era of industrialization with enforcement of the Fifth National Economic and Social Development Plan (the Fifth National Plan), which covers a 5-year period from 1982 to 1986. The Fifth National Plan places a great emphasis on Eastern Seaboard Development as the keystone of industrialization. It involves not only industrial development but also urban development and associated infrastructural development. The agricultural development is also given high priority in the Fifth National Plan. So far as the Study Area is concerned, the agricultural development deserves particular attention.

It must be promoted positively in the backward area of the industrial development areas so as to create the balanced socio-economic situation throughout the Study Area.

In order to cope with the rapidly increasing water demand due to the above-mentioned development activities, the Government launched the East Coast Water Resources Development Project (the Phase I Study), objective of which was to conduct the feasibility study of Nong Pla Lai and Ban Bung Dams. The Phase I Study was carried out by JICA in compliance with request made by the Government during the period from February, 1981 to March, 1982.

The NESDB conducted Eastern Seaboard Study (the ESS) and issued an Interim Report in July, 1982. The report contains a comprehensive study relevant to Eastern Seaboard Development, including economic, infra-structural, social and urban development programme, implementation, finance and impact of development.

The Government further requested the Government of Japan to extend the technical cooperation on the Study in September, 1981. The Government of Japan decided to provide the necessary technical cooperation and entrusted its execution to JICA. The JICA dispatched a Preliminary Survey Team to Thailand during the period from February 9 to 23, 1982 to finalize the technical cooperation and concluded the Implementation Arrangement with RID as aforementioned.

1.3 Scope of Study

The Study is to conduct the feasibility study on the water resources development of the Khlong Luang river and Rayong river, especially centering the construction of dams, namely Khlong Luang, Khlong Yai and Khlong Thap Ma dams. The Scope of Work contains two studying subjects as follows;

Part A: Study for the long-term water demand and supply balance in the Study Area.

Part B: Feasibility study for Khlong Luang, Khlong Yai and Khlong Thap Ma Dams.

For the purpose of the Study, target years have been set forth; 1991 as intermediate target year and 2001 as final target year.

The study for the long-term water demand and supply balance has been completed already during the field investigation period and "Study Report on Long-Term Water Supply Plan" was issued in January, 1983. The report points out clearly the significance of development of Khlong Thap Ma Dam Scheme (the Scheme). The Scheme is distinguished as multiple-purpose areal-development project, since it is designed as an element in regional plan. The feasibility study of the Scheme deals with;

(1) Khlong Thap Ma multiple-purpose dam development,

(2) Irrigation and agricultural development, and

(3) Flood mitigation plan

2. BACKGROUND

2.1 Socio-Economy of Thailand

2.1.1 Land and Population

The territory of Thailand is approximately 514 x 10^3 km^2, being located between 5°20' and 20°40' north in latitude and between 97°20' and 105°40' east in longitude. Administratively the country is divided into 72 provinces. Each province is further divided into more or less 10 districts. Each district is further subsegmented into several townships which are composed of a number of villages. Map of Thailand is shown in Fig. 1.

Thailand lies in tropical monsoon zone and is blessed with fairly rich land and water resources. Approximately 177 x 10^3 km^2, corresponding to 34 % of the nation's land, are used for agricultural purpose, of which about 118 km^2 are paddy fields.

The national population was 44.3 x 10^6 in 1980, of which 4.7 x 10^6 people reside in Bangkok Metoropolis. The population density in 1980 was 86.3 persons per km^2 on the average, ranging from 52.7 in North Region to 137.5 in Central Region. The population growth was 2.6 % per annum during a 10-year period from 1970 to 1980.

2.1.2 Economic Performance

The economy of Thailand has achieved a continuous expansion, through its five-year national development plans, of which the period is 1962 - 1966 for the first plan, 1967 - 1971 for the second plan, 1972 - 1976 for the third plan and 1977 - 1981 for the fourth plan, respectively. The GDP increased from ฿ 140 x 10^9 in 1971 to ฿ 315 x 10^9 in 1981 at 1972 constant price, or from ฿ 3,602 per capita to ฿ 6,636 per capita. The average growth rate was 9.5 % per annum in 1971 - 1976 and 7.4 % per annum in 1977 - 1981.

The 1981 GDP is composed of ฿ 151 x 10^9 in service sector, ฿ 88 x 10^9 in manufacturing sector and ฿ 76 x 10^9 in agricultural sector. The share of the manufacturing sector increased from 16 % in 1971 to 21 % in 1981, while that of the agricultural sector declined from 28 % to 24 %.

The export of goods and services increased sharply from ฿ 17 x 10^9 in 1971 to ฿ 153 x 10^9 in 1981, while the import of goods and services also increased from ฿ 27 x 10^9 in 1971 to ฿ 217 x 10^9 in 1981. The most dominant export and import commodities are rice and petroleum, respectively. Rice export was 3,036 x 10^3 tons in 1981 and earned ฿ 26 x 10^9, corresponding to 17 % of the total export value. The import of petroleum and lubricant amounted to ฿ 65 x 10^9 in 1981, which nearly coincides with the deficit in the foreign trade.

The socio-economy of Thailand is reported in more detail in Sectoral Report I, Socio-Economy.

2.2 The Fifth National Plan

The Government issued in October, 1981, the Fifth National Plan, which was established reflecting the performance in the preceding national plans during the last two decades. The Fifth National Plan contemplates to accomplish the following national policy objectives;

(1) To restore the nation's economic and financial stability by mobilizing more saving and building up the national and economic discipline in both the public and private sectors.

(2) To adjust the economic structure and to improve the economic efficiency in order to magnify the economic activities in the rural area, to earn more foreign exchange with expansion of export and to be consistent with the world's economic changes.

(3) To develop the social structure and to improve the social services such as education, health, justice and other basic needs in the rural area.

(4) To alleviate poverty in backward area.

(5) To coordinate consistently economic development activities with the national security management.

The economic target of the Fifth National Plan is presented in Table 1 in comparison with that of the Fourth National Plan.

More detailed explanation on the Fifth National Plan is presented in Sectoral Report I, Socio-Economy.

2.3 Eastern Seaboard Development

The Fifth National Plan sets forth the following policy measures with respect to industrial activity:

(1) To switch from import substitution to exports.
(2) To decentralize the industrial activities to the provincial areas.
(3) To develop the basic industry, practically based on natural gas.
(4) To develop labour intensive industry and technology in export industry.

The Fifth National Plan sets forth the following targets for industrial activities:

	Description	Average Growth Rate (%/yr)
(1)	Manufacturing output	7.6
	Export industry	15.0
	Domestic consumption	5 - 6
(2)	Employment increase	7.6
(3)	Consumption of petroleum product (max. level)	4.0

The Eastern Seaboard Development will make a great contribution to the national policy objectives. Firstly, it will spearhead to change the industrial structure from import substitution to exports, based on local resources, particularly on a natural gas. Secondly it will become a major employment generator in North and East Regions. Thirdly, in the long term, it will serve decentralization of economic and industrial activities from Central Region.

The ESS proposes seven strategic development areas in the eastern seaboard; Chon Buri, Si Racha-Laem Chabang, Pattaya, Sattahip, Map Ta Phut-Rayong, Chachoengsao and Ban Phe. Out of these, Chachoengsao and Ban Phe are located outside the Study Area. Fig. 2 shows the map of the Study Area, including the development areas.

Six industrial development zones have been designated by the ESS as tabulated hereunder together with development area and plan.

Proposed Zone	Area (ha)	Proposed Industrial Development
Chon Buri	160	Urban service industries
Laem Chabang	480	Export processing and light industry
Sattahip	40	Ship repairs and services and transhipment
Map Ta Phut	800	Heavy industry, polluting industry and construction materials
Rayong	80	Agro-industry
Chachoengsao	80	Agro-industry

The development of infrastructures is an integral part of industrialization. The infrastructure development plan has also been worked out by the ESS as presented in Table 2.

The Eastern Seaboard Development will certainly create additional employments and induce migrants from the outside of the Eastern Seaboard. The additional employments and induced population have been projected to be 130,200 and 201,550, respectively, by the ESS for a 20-year period from 1981 to 2001. The ESS predicts that approximately 71 % of the additional employment occurs in three development areas, Si Racha-Laem Chabang, Pattaya and Rayong-Map Ta Phut.

2.4 Agricultural Development

The agriculture still plays an important role in the economy of Thailand. It sustains the self-sufficiency of staple food and the employment absorption. It also makes a great contribution to foreign trade; share of agricultural products accounts for 52 % of the total export value in 1980. Major crops are rice, rubber, maize and cassava.

The agricultural development during the last two decades was characterized by diversification of crops and expansion of cultivation area. During a 10-year period from 1972 to 1981, planted areas were expanded year after year with a considerably high rate; 15.3 % per annum for upland crops, 40.0 % per annum for oil crops, 16.2 % per annum for perennial crops and 3.4 % per annum for paddy. The increase in production was mainly resulted from such rapid expansion of planted areas. However, an increase in crop yield remained as low as 2.0 % per annum on an overall average during the Fourth National Plan.

The Fifth National Plan puts forward the following targets and supporting policy measures, in order to achieve the short-run objectives of a rapid economic recovery and a greater degree of economic stability:

(1) To attain the target of about 7 % increase in GDP, the value in agricultural sector is projected as,

   (a) overall target: annual increase by 4.5%
   (b) crop production: annual increase by 4.7%
   (c) livestock production: annual increase by 4.2%
   (d) fisheries production: annual increase by 5.4%
   (e) forestry production : annual increase by 0.3%.