Annex 3.

PRESENT CONDITIONS OF THE PROJECT AREA

ANNEX 3 PRESENT CONDITIONS OF THE PROJECT AREA

3-1 Natural Conditions

3-1-1 Geology and Topography

(1) Summary

Geological and topographical conditions of the Project Area are summarized below ;

1) Topographic characteristics can be roughly classified into 3 types, namely, flat plain, monadnocks and younger high terraces. Most of the candidate areas are situated in a flat but somewhat undulated zone with elevation ranging from 50 to 100 m.

2) The topographical characteristics are closely related to the geological structure. In the Eastern Region, tertiary members are lacking, so old rocks such as Mesozoic group have been exposed to the air for a very, very long time. This fact shows that various agents of weathering, erosion and deepening continued during this long geological period, so that the original high mountains were progressively destroyed, topographically dissected and flat plain was formed.

3) Rocks and deposits in the candidate areas are geologically classified into 3 types, every geological type has characteristics of erosion as shown below ;

Geology	Erosion
a) decomposed granite (very coarse sand)	very severe erosion
b) terrace deposits (sand, gravel, clay)	moderate --- severe
c) weathered soil (derived from bedrock)	severe

4) There are several shallow wells in the candidate areas situated near the top of streams. Their catchment areas are very small, therefore, streams and shallow wells occasionally dry up during the dry season. Although such water resources are very limited,

they are very important as they are the main source of domestic water supply in many places.

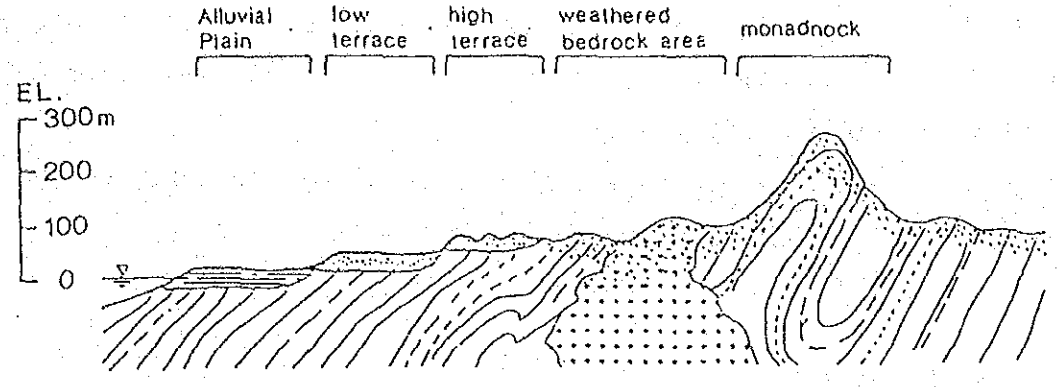
(2) Topographical condition

The Study Area is situated in eastern Thailand and includes 4 provinces. The topographic feature of this area is classified into 3 types as follows.

1) Central flat plain : The surface deposits of the central plain are made up of muddy marine facies and fresh water facies. These deposits are distributed along the main river in the north of Chonburi. The elevation of the alluvial plain ranges from 0 to 50 m.

2) Narrow coastal and low-high terrace : The majority of the flat plain are classified into 2 types by elevation. One is a low terrace and narrow coastal plain at an elevation of between 5-30 m and the other is a middle to high terrace at an elevation between 20-60 m.

3) Undulating high terrace and upland area with weathered bedrocks : The upland area consists mainly of monadnocks surrounded by undulating plain with high terrace. The elevation of monadnocks characterized by steep terrain falls between 250 and 300 m. The elevation of the flat high terrace and the area where weathered bedrock is exposed ranges from 50 to 100 m. Most of the pilot areas are included in this elevation level and severe soil erosion has developed in many places. Approximately 30% of the total Study Area is exposed to severe soil erosion.



The surface of the candidate areas are mostly flat or somewhat undulated with monadnocks sporadically distributed. Watersheds in each candidate pilot area are rather small being situated near the top of streams. When the watershed is very flat, the catchment area is occasionally difficult to define.

(3) Geological condition

1) Characteristics in pilot areas

Geology can be classified into the following 3 types ;

a) Older group (bedrocks)

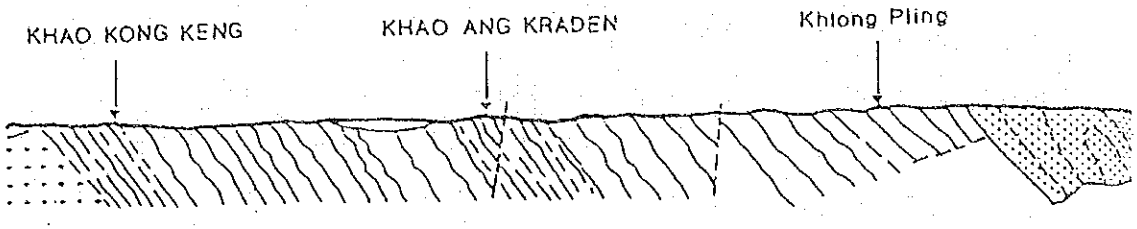
Older group consists of Precambrian complex and sedimentary rocks of the Palezoic and Mesozoic era. There are few outcrops occurring in the area, mainly bedrocks which are only covered with soil and decomposed material. Some part of the pilot areas consists of gneiss of schist which are metamorphic rocks. These areas are mainly situated in the central - eastern part of the Study Area.

The bedrock consists of various kinds of rocks and they exhibit many types of resistance against weathering. The highly resistant rocks such as chart and sandstone have remained as monadnocks.

Geological structure of the bedrock is complicated by various structural movements such as folding, or fault

movement. However, zonal arrangement of strata in a north - western direction is apparent with a tendency of N 20-3-W strike and 40-80 E dip.

Typical geological section in a N-E direction is shown in the following figure.



b) Granite batholith group

The bedrocks in most of the candidate areas which are located in Rayong and Chonburi are granitic batholith. A large granite mass which is exposed in the western part of the region extends over a NNW-SSE direction from Chonburi to the west of Rayong and small masses which are of the Triassic period are sporadically distributed in the northern part of Chachoengsao.The top soil which is composed of decomposed granite such as coarse sand has been exposed to severe erosion in these areas.

c) Unconsolidated thinly bedded younger terrace deposits

Some candidate areas are located in high terrace deposits. The terrace deposits range in thickness from 6 to 30m and contain such unconsolidated and bedded materials as laterite, rock fragments, sand, gravel, pebble and boulder. Matrix of most beds is clay and sandy clay.

2) Geology and erosion

Although soils in general tend to be similar in areas of similar climate, soil erosion is somewhat related to parent rocks. Characteristics of erosion can be classified into the 3 types as follows ;

a) Weathered bedrocks area

Soil in the old rocks area consists of material of schist, gneiss, sandstone and slate. As these areas are situated near the monadnocks with comparatively steep inclination, soil are soon removed downwards by severe erosion and weathered rocks are exposed.

b) Decomposed granite area

Soil material in the decomposed granite area mainly consists of coarse sand which has higher permeability and low resistance to erosion, therefore many gullies are formed on the slope of the weathered granite area by erosion.

c) Terrace deposit area

Soil material in the terrace deposit area consists of unconsolidated deposits such as clay, sand and gravel.This area is located in the high terrace at an elevation ranging from 50 to 100 m, and forms a comparatively flat plateau. Therefore, soil erosion in this area is more moderate than in the bedrock area.

3) Water resources

The bedrocks and granites in the Study Area have less productive aquifers and groundwater occurs only in the secondary openings such as joints, fractures, contact and decomposed zones and faults. In the terrace area, the aquifers are also less productive because deposits are very thin. Also, water catchment is very small as this area is situated near the upper part of streams. There are many shallow wells used for domestic water supply in the pilot areas, but streams and shallow wells occasionally dry up in the dry season. Thus water resources are very poor in these areas, therefore, investigation for groundwater development is eagerly recommended.

3-1-2 Meteorology and Hydrology

(1) Meteorological characteristics

Collection of general meteorological data at four sites, namely Chonburi and Sattahip in the Project Area and the neighboring area of Chanthaburi and Prachinburi which have been observed by the Meteorological Department (M.D), Ministry of Communications was made and summarized as general data (Refer to Vol. V Annex 5).

Meteorological data of Prachinburi and Sattahip are applied for Chachoengsao and Rayong province, since these provinces do not have M.D meteorological observation stations. According to the above mentioned data, the meteorological characteristics of the Project Area are as follows.

Rainfall data observed at Chanthaburi which is located at the southeastern part of the Project Area, belongs to the Tropical Rain-forest climate type and has a greater rainfall value than the other three sites which belong to the Tropical Savanna climate type. Monthly temperature observed at Prachinburi, which is located inland , is about 3 to 5° C higher than Chanthaburi which is located along the Gulf of Thailand. The fluctuation in monthly relative humidity observed at Prachinburi varies from the other three sites which are located along the Gulf of Thailand.

(2) Hydrological characteristics

There are 70 rainfall stations located in the Project Area from which data is collected by the Royal Irrigation Department (RID). Excluding the 21 stations with short observation periods or with misobservations the data of the remaining 49 stations was collected as shown in the following table. In Chanthaburi Province, rainfall data of 11 stations outside of the Study Area were collected as reference, as there is only one station located within the Study Area. The observation periods are different for each station with the longest period being 34 years (from 1952 to 1985) and the shortest period being 9 years (from 1977 to 1985).

	Chachoengsao	Chonburi	Rayong	Chanthaburi	Total
Total Number of stations	32	18	19	1 (12)	70 (81)
Number of stations at which data collected	20	13	15	1 (12)	49 (60)

( ): including reference data

There are 51 stream gauging stations on the two basins (East Coast-Gulf Basin and Prachinburi River Basin) in the Project Area established by RID, daily water level, daily discharge and rating curve between water level and discharge data on 21 stations that carry out water level conversions was collected.

1) Areal rainfall

Isohyetal map (scale 1/1,256,000), made by the Department of Land Development, was collected and areal rainfall for the Project Area and each province in the Study Area was estimated by isohyetal method.

The isoyetal map is shown in Vol.VII and the result of estimates for areal rainfall is shown in Vol.v Annex 5. According to the results, areal rainfall for Chachoengsao and Chonburi Provinces is 1,653.6 mm and 1,554.4 mm respectively which is not very high. Areal rainfall for Rayong Province is in the medium level at 2,041.0 mm and Western Chanthaburi Province has the most at 2,401.6 mm and areal rainfall for the whole Study Area is 1,811.0 mm.

2) Rainfall probability

Rainfall probability was estimated since it was deemed to be useful for establishing the irrigation and drainage plan. 5 rainfall stations which have about a 30 year observation period were selected from the stations of RID in the Project Area and rainfall probability at the 5 stations was estimated. Also, rainfall probability for Ban Tap Chum station in Chanthaburi which has a 14 year observation period was established, since this station is the only station in the Study Area of Chanthaburi Province.

i) Annual rainfall probability of unexceedance

Annual rainfall probability of unexceedance for the 6 rainfall stations mentioned above has been computed. Rainfall for a 5 day period has also been calculated from the daily rainfall probability for a return period of 2 years. The results of the calculation is used to calculate the water balance for the reservoir. (Refer to Table 3.1.2-1)

ii) Maximum daily rainfall probability of exceedance

Maximum daily rainfall, maximum 2-day continuous rainfall and maximum 3-day continuous rainfall probability of exceedance for the 6 rainfall stations has been computed. The results are shown in Figure 3.1.2-1.

3) Average rainfall intensity

Specific characteristics of rainfall for Chonburi and Chanthaburi are estimated by Rainfall Intensity-Duration-Frequency Curves at Chonburi and Chanthaburi which were published by M.D. Equations for average rainfall intensity in the Project Area are simulated by the specific characteristic of rainfall at the 2 sites. The results are shown in Vol.v Annex 5.

4) Run-off

A total of 5 run-off stations, in the watersheds covering each pilot area were selected from the run-off stations for which run-off data had been collected during the Phase 1 study. The selected run-off station's code, name of the river, location and pilot areas covered are shown in Table 3.1.2-2. Although the watershed for run-off station Z7 does not cover both CT-NO.2 and CT-NO.3, run-off data from Z7 was analyzed for the two pilot areas, because this station is the only station in the Study Area for Chanthaburi Province.

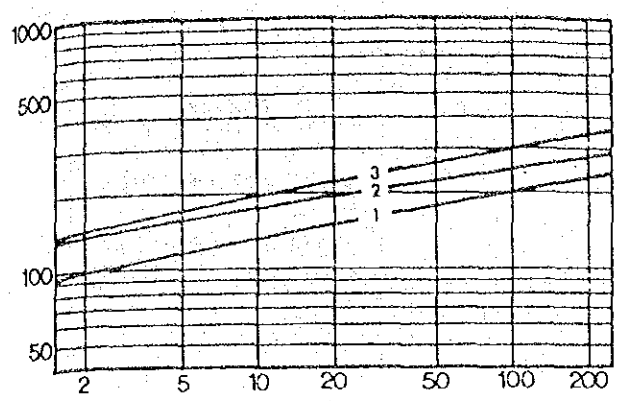
Probability annual run-off and the return period for the 5 stations runoff data were estimated by log normal probability paper. The plotting position was calculated according to the Thomas plot equation which is generally used when data is limited.

Probability run-off in the dry season (from Dec. to March) for the 5 stations was also estimated by the above-mentioned method.

Specific run-off probability both annual and in the dry season is shown in Table 3.1.2-3.

Table 3.1.2-1 Annual Rainfall Probability of Non-exceedance

RETURN PERIOD	A BANG KHLA CHACHOENGDAO (03052)		A SI RACHA CHANBURI (09042)		A SATTAHIP CHANBURI (09073)		A BAN KHAI RAYONG (48022)		A. KLAENG RAYONG (48032)		A BANG BUNG CHANBURI (06081)	
	RAINFALL	PERIODIC YEAR	RAINFALL	PERIODIC YEAR	RAINFALL	PERIODIC YEAR	RAINFALL	PERIODIC YEAR	RAINFALL	PERIODIC YEAR	RAINFALL	PERIODIC YEAR
2	1391.0	1967	11095.8	1961	1158.4	1958	1424.1	1982	1891.2	1965	2225.6	1967
3	1360.8	1977	1123.3	1972	1160.0	1964	1238.3	1959	1819.9	1971	2133.3	1976
5	1193.5	1974	984.2	1958	997.9	1963	1139.4	1960	1707.1	1975	1881.4	1985
8	1108.9	1959	-	-	926.0	1980	-	-	1613.0	1985	1759.4	1984
10	1069.0	1982	865.9	1962	873.3	1961	926.8	1979	1544.1	1984	-	-



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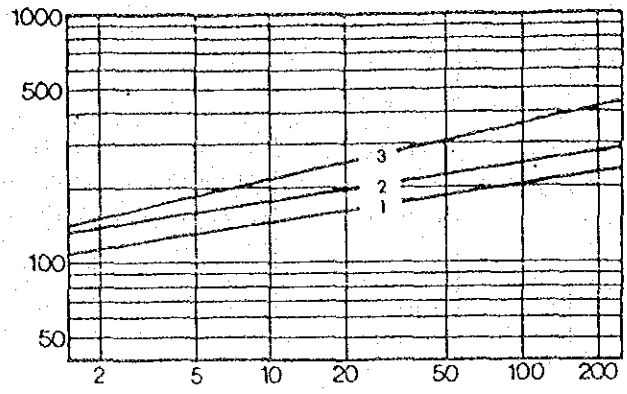
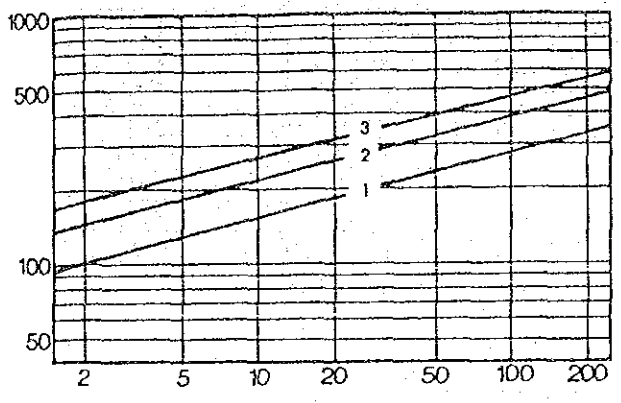


09042



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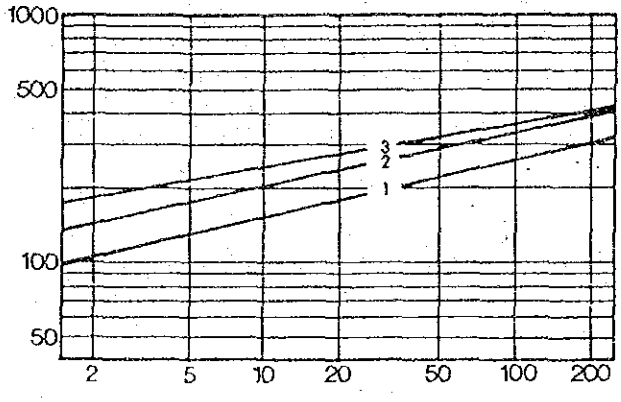

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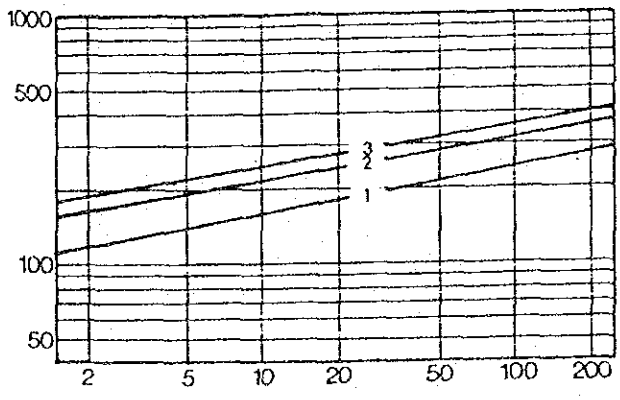

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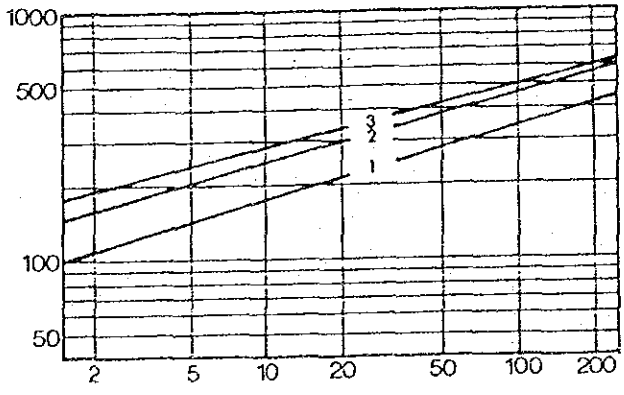


06081

Figure 3.1.2-1 Maximum Daily Rainfall Probability of Exceedance

Table 3.1.2-2 Selected Run-off Station

Code No.	River	Stream	Location		Pilot Area
			Amphoe	Province	
Kgt 18	Bang Pakong	Khlong Si yat	Sanom Chai Rhet	Chachoengsao	CS-NO.3, CS-NO.5, CS-NO.8
Kgt 19	Bang Pakong	Khlong Luang	Phanat Nikhom	Chonburi	CN-NO.1, CN-NO.8, CN-NO.9,
Z4	Khlong Yai	Khlong Nong Pla Lai	Ban Khai	Rayong	CS-NO.4 RY-NO.1, RY-NO.2, RY-NO.7,
Z5	Khlong Prasac	-	Klaeng	Rayong	CN-NO.2, CN-NO.4
Z7	Chanthaburi	-	Makham	Chanthaburi	RY-NO.3, RY-NO.5 CT-NO.2, CT-NO.3

Table 3.1.2-3 Specific Run-off in Annual and Dry Season

(ℓ/s/km²)

Return Period		(D.A = 951 km²) Kgt 18	(D.A = 951 km²) Kgt 19	(D.A = 429 km²) Z 4	(D.A = 41,164 km²) Z 5	(D.A = 41,2318 km²) Z 7
2	A	8.938	5.607	9.207	10.739	21.244
	D	0.158	0.355	3.520	0.842	0.759
3	A	7.045	4.299	7.576	8.591	18.361
	D	0.099	0.206	2.797	0.636	6.395
5	A	5.468	3.364	7.226	7.131	16.313
	D	0.063	0.123	2.284	6.481	0.212
10	A	4.206	2.523	6.294	5.756	14.112
	D	0.039	0.071	2.051	0.361	0.106

Note 1) A = Annual D = Dry season (Dec. -Apr.) D.A = Discharge Area

3-2 Soil Erosion

(1) Soil Erosion Map of the 4 provinces in the East

1) Methodology of establishment of Soil Erosion Map

Target and classification of Soil Erosion Map

Target of the Map is as follows;

i) 4-provinces (Chachoengsao, Chonburi, Rayong and Chanthaburi)

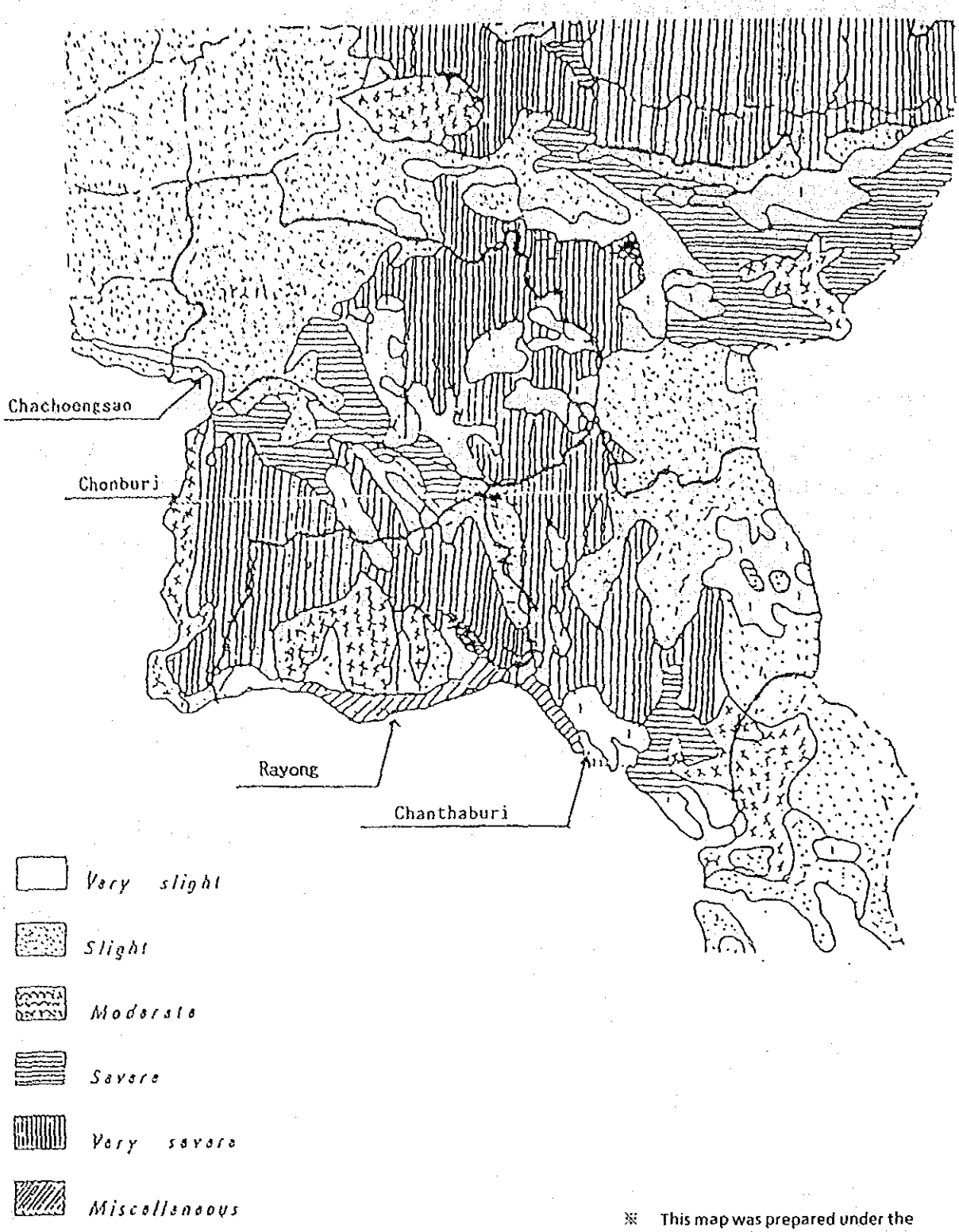
ii) Upland crops (not including forest, paddy field and abandoned area)

iii) Scale is 1:250,000

The Map shall contribute to the formulation of a basic plan and selection of pilot areas.

Classification of the Map for soil conservation is as follows;

	Classification	Soil Loss Volume
1	Top Urgent	more than 50 ton/ha/year
2	Urgent	50 ~ 30
3	Necessary	30 ~ 20
4	Normal	20 ~ 5
5	Not Necessary	less than 5



※ This map was prepared under the erosion investigation team comprised of technicians from various divisions of DLD, 1980.

Figure 3.2-1 General Soil Erosion Map, 1980

Table 3.2-1 Soil Erosion in the Eastern Region

Unit : 000 rai

Province	Total Area	Moderate	Severe	Very Severe	Total
Chachoengsao	3,344	–	323	1,283	1,606 (48.0%)
Chonburi	2,727	455	500	1,523	2,478 (90.9%)
Rayong	2,220	446	4	1,183	2,478 (73.6%)
Chanthaburi	3,961	251	313	–	564 (14.2%)
Total	12,252	1,152	1,140	3,989	6,281 (51.3%)

Source : Soil Erosion in Thailand, DLD in 1981

i) Basic formula

For calculation of soil loss volume, Universal Soil Loss Equation (USLE) was used.

Namely;

$$A = P \cdot K \cdot Ls \cdot C \cdot P$$

where A = Total Soil Loss Volume (ton/ha/year)

R = Rainfall Factor

K = Soil Erodibility Factor

C = Crop Management Factor

Ls = Soil Conservation Measures

P-value shall be omitted since it is required to find the value of A before adopting soil conservation measures.

Following data was used;

- Soil classification map (S = 1/250,000)
- Topographic map (")
- Land-use map (")
- Isohyetal map (")

These maps shall be overlapped and traced for calculation of soil loss volume using USLE.

ii) Soil classification map and soil erosion

a) Soil classification map

Soil classification map was published by DLD, 1985. Based on the map, the relation between soil and soil erosion was studied.

- Soil texture

  Soil classification is for soils 25 cm ~ 70 cm below the ground surface.

Soil texture		Contents
Sandy	;	Sand, loamy sand, Very fine sand less than 50%
Loamy	;	Loamy but finer than Very fine sand Very fine sand more than 50%, clay less than 35%
Clayey	;	Clay more than 35%
Skeletal	;	More than 2mm of junk rock, gravel more than 35%

- Soil particle

  Particle size is US system as shown in the following;

2.0	1.0	0.5	0.25	0.1	0.05	0.002	
V.Coarse	Coarse	Medium	Fine	V.fine	Silt	Clay	

b) Set up K - Value

K - Value of USLE was set up from both soil texture and soil particle size as in the following;

Soil Map	USLE	K - Value
Sand	Loamy sand	0.08
Loamy	Loam	0.33
Clayey	Clayloam	0.25
Skeletal	Sandy clay loam	0.23

The above relationship was obtained from the site survey. Namely, there is severe erosion of clayey

soil representing the soil existing around Dok Krai in Rayong Province, because the clay surface of the soil was already washed away.

Loamy soil existing widely in Chonburi Province is formed from weathered granite, therefore, there is severe soil erosion. Skeletal soil exists widely in the cleared forest area of Chonburi and Rayong Provinces. The surface of the soil contains a comparative amount of clay which exhibits rather slight soil erosion compared with Loamy and Clayey soils.

Sandy soil exists widely along the coastal area of Chonburi Province. In the area, topography is flat and erosion is slight. Therefore, the soil shall be omitted from the map.

e) Soil classification and candidate Pilot Project Areas

The relation between soil classification and candidate Pilot Project Areas in as follows;

Province	Soil Texture	Candidate Area	Pilot Area
Chachoengsao	Skeletal	1, 2, 3, 4, 5	3, 4, 5
	Loamy	6, 7, 8	8
Chonburi	Loamy	1, 2, 3, 5, 8, 9	1, 2, 8, 9
	Skeletal	7	
	Others	4, 6	4
Rayong	Clayey	1, 3, 5, 6, 7	1, 3, 5, 7
	Loamy	2, 8, 9	2,
	Skeletal	-	
	Others	4	
Chanthaburi	Skeletal	1	
	Clayey	2, 3	2, 3
	Loamy	4	

It is comparatively clear that each province has its own soil features, namely Chachoengsao has Skeletal soil, Chonburi has Loamy soil, Rayong has Clayey soil and Chanthaburi has skeletal soil.

Pilot areas have been selected considering the above conditions.

iii) Topography and Soil Erosion

It is impossible to extract slope gradient and slope length for USLE from the topo-map scaled 1 : 500,000.

Therefore, Ls - Value was set up from the relationship between above sea level (= contour) and topography observed during the site surveys.

a) Contour classification of each province

Contour classification of each province is as follows;

Province	0 ~ 50 m	50 ~ 100m	Above 100m	Total	Note
	km^2				
1. Chachoengsao	3,156	1,497	698	5,351	
	(59.0%)	(28.0)	(13.0)	(100.0)	
2. Chonburi	1,782	1,622	959	4,363	
	(40.8)	(37.1)	(22.1)	(100.0)	
3. Rayong	1,804	1,276	481	3,552	
	(50.8)	(34.5)	(13.5)	(100.0)	
4. Chanthaburi	888	560	533	1,981	Study area
	(44.8)	(28.3)	(26.9)	(100.0)	only
Total	7,630	4,946	2,671	15,247	
	(50.0)	(32.4)	(17.6)	(100.0)	

In general, topography of the East is com-paratively flat and rolling with a slope of 3 ~ 10%.

b) Contour range and land-use

The features of the relation between contour range and land-use of each province is as follows;

- Chachoengsao

  Above 100 m the contour is 13% and this area is

covered by forest. From 50 ~ 100 m, 80% of the area is cultivated for farming, mainly upland crops, it was also observed that rubber tree fields are concentrated in the same area. Most of this area belongs to the Royal Forestry Department (RFD).

In the range of 0 ~ 50 m, the lower area is covered by paddy and the upper area, above 20~30 m, is covered by upland crops. The ratio of paddy and upland crops is approximately 2:3. There is a mining area in the center of the Province and recently the area has been expanded.

- Chonburi

  Most of the province is covered by upland crops without any relation to contour range.

  Lower parts close to Chachoengsao are also covered by upland crops. RFD areas are mainly in the range of 50 ~ 100 m.

- Rayong

  There is a small area above 100 m, 19% only, the remaining 81% is from 0m ~ 100 m.

  From 0 m ~ 50 m, the main crop is paddy in the lower area and rubber trees in the upper area. The eastern area of the mountains in a North-South direction at the center of the province is mainly planted with rubber trees and the western area is mainly paddy.

  Places above 50 m are covered by upland crops and most of the area belongs to RFD.

- Chanthaburi

  In the Study Area of the province, the lower area is covered by rubber trees and the upper area is covered by upland crops.

  From 50 m ~ 100 m, most of the area is covered by

upland crops except forest areas in the upper part which belong to RFD.

c) Topography and soil erosion

It is obvious that there is a lot of severe erosion caused by upland crops such as cassava, pineapple, and sugarcane. The most severe erosion has occurred in the area of 50 m ~ 100 m. Moreover, the upland crop area of Chonburi above 100m has been seriously eroded. It is urgently required that soil conservation projects be carried out in these areas.

On the contrary, a lot of severe erosion has been observed in the encroached forest areas of the RFD. It is a principle that soil and water conservation countermeasures should be carried out from upstream. This means that existing farmland in RFD areas shall be considered as a top priority conservation area.

d) Ls-value

Ls-value shall be set up from the above studies as shown in the following.

ASL	Slope	Slope length	Ls - Value
0 ~ 50 m	2 ~ 4%	51 ~ 100 m	0.423
50 ~ 100 m	4 ~ 8	51 ~ 100 m	1.052
above 100	4 ~ 8	100 ~ 200 m	1.487

These values shall be used in USLE.

(iv) Land-use and soil erosion

Crop factor and C-value shall be obtained from the exsiting land-use map.

a) C-value

Land-use classification published by DLD in 1987 is as follows;

Symbol	Land-use
1	Community
12	Airport
13	Mine
2	Agriculture area
221	Mixed fruit tree
222	Para rubber
223	Coconut tree
23	Upland crops
24	Rice
3	Water farming
4	Unused area
5	Forest, mangroove forest
6	Water resources
61	Water-way
62	Reservoir

Associated unit: 70 - 30%

In the above, mainly 23, 221, 222, 223 are concerned with soil erosion.

Upland crops should be divided into more detail such as cassava, pineapple and sugarcane in original,

however, such data is insufficient so far. Therefore, upland crops shall be representated as cassava.

From the above, C-value shall be set up in the following.

Land-use classificaton	Symbol	Crop	C-Value
Upland Crops	23	Cassava	0.60
	23,4	"	"
	23,24	"	"
	23,221	"	"
	23,222	"	"
Para Rubber	222	Rubber	0.50
	222,24	"	"
	222,23	"	"
Mixed Fruit Tree	221	Orchard	0.35
Coconut Tree	223	"	"

(v) Annual rainfall and soil erosion

a) The feature of annual rainfall in each Province

- Maximum annual rainfall is 2,900 mm in Chanthaburi and minimum is 1,400 mm in Chanchoengsao and Chonburi.
- Rainfall range is 1,900 mm ~ 1,400 mm in Chachoengsao, average is 1,654 mm.
- 1,900 mm ~ 1,500 mm average 1,544 mm in Chonburi.
- 2,500 mm ~ 1,500 mm average 2,041 mm in Rayong.
- 2,900 mm ~ 2,000 mm average 2,300 mm in the Study Area part of Chathaburi.

b) R-value

The relation between average annual rainfall and R-value in USLE is as follows;

Province	Average of rainfall	X-value	R-value
Chanchoengsao	1,900 ~ 1,500	1,900	309.7
	1,500 ~ 1,400	1,500	244.5
Chonburi	1,900 ~ 1,500	1,900	309.7
	1,500 ~ 1,400	1,500	244.5
Rayong	2,500 ~ 2,100	2,500	407.5
	2,100 ~ 1,700	2,100	342.3
	1,700 ~ 1,500	1,700	277.1
Chanthaburi	2,900 ~ 2,500	2,900	555.0
	2,500 ~ 2,000	2,500	476.6

R-value was calculated from the following formulas;

Chachoengsao, Chonburi and Rayong

$R = 0.163 X$

Where, X : Average annual rainfall, mm/year

R : Soil loss volume : ton/ha/year

Chanthaburi

$R = 0.196 X - 13.4$

quoted from DLD FAO PROJECT, TCP/THA/4408(T), 1986

In the above, X value was assumed to be the maximum value from the range of each province. This is because the possibility of soil loss is an important subject in the study.

3) Result of Soil Erosion Map

The result of the Soil Erosion Map is shown in Table 3.2-2.

Study of Soil Erosion Map in 4 Provinces

Chachoengsao Province

1 Top-urgent (7.3%) Upland crop area higher than 100m above sea level

Soil texture: Loamy, Skeletal

Upland crop area between 50 m ~ 100 m above sea level

Soil texture: Loamy

2 Urgent (10.3%) Upland crop area betwen 50 m ~ 100 m above sea level
Soil texture: Skeletal

3 Necessary (9.7%) Upland crop area between 0 m ~ 50 m above sea level
Soil texture: Loamy

4 Normal (6.6%) Upland crop area between 0 m ~ 50 m above sea level
Soil texture: Skeletal

Rainfall factor is not a decisive factor in the Province.

Chonburi Province

1 Top-urgent (28.6%) Upland crop area (including coconut and rubber fields) higher than 100 m above sea level
Soil texture: Loamy and Skeletal

2 Urgent (11.9%) Upland crop area between 50 m ~ 10 m above sea level
Soil texture: Loamy, Skeletal and Clayey

3 Necessary (10.1%) Upland crop area between 0 m ~ 50 m above sea level
Soil texture: Loamy

4 Normal (0.5%) Upland crop area (including coconut field) between 0 m ~ 50 m above sea level
Soil texture: Skeletal, Loamy (coconut field)

Rainfall factor is not a decisive factor in the Province.

Table 3.2-2 Results of the Soil Erosion Map

Unit : km² (625 rai)

Province	Area	1	2	3	4	5	(1~4)	Note
Chachoengsao	5,351	388	553	523	351	—	1,815 (33.9%)	except for paddy, forest area
Chonburi	4,363	1,245	521	429	23	—	2,228 (51.1)	except for paddy field, sandy soil area
Rayong	3,552	923	170	864	223	—	2,180 (61.4)	except for paddy field
Chanthaburi	1,981	331	268	328	12	—	939 (47.4)	except for paddy field, forest area only one part of the province
Total	15,247 (100.0)	2,887 (18.9)	1,512 (9.9)	2,154 14.1)	609 (4.0)	—	7,162 (47.0)	

where;

Symbol	Classification	Soil loss volume ton/ha/year
1	Top-Urgent	more than 50
2	Urgent	50 ~ 30
3	Necessary	30 ~ 20
4	Normal	20 ~ 5
5	Unnecessary	less than 5

except for Soil: Sandy soil in the coastal area.
Land use: Urban area, paddy, forest mountainous area.
Mixed area of paddy and upland crop is included.

Rayong Province

1 Top-urgent (26.0%) Upland crop area higher than 50 m above sea level

Soil texture: Loamy, Skeletal and Clayey

Upland crop area is affected by rainfall.

2 Urgent (4.8%) Upland crop area between 50 m ~ 100 m above sea level, rainfall below 2,000 mm/year

Soil texture: Loamy, Skeletal and Clayey

Upland crop area between 0 m ~ 50 m above sea level, rainfall above 2,000 mm/year

Soil texture: Loamy

3 Necessary (24.3%) Upland crop area between 0 m ~ 50 m above sea level

Soil texture: Loamy, Skeletal and Clayey

In the case of upland crop area where soil texture is Skeletal and Clayey, rainfall is above 2,000 mm year

4 Normal (6.3%) Rubber field and orchard between 0 m ~ 50 m above sea level

Soil texture: Loamy, Skeletal and Clayey

In the above, rainfall factor does not exhibit much effect.

Chanthaburi Province

1 Top-urgent (18.9%) Upland crop area higher than 100 m above sea level

Soil texture: Loamy and Skeletal

Upland crop area, rubber field and orchard between 50 m ~ 100 m above sea level

Soil texture: Loamy, Skeletal and Clayey

2 Urgent (9.9%) Upland crop area, rubber field and orchard between 0 m ~ 50 m above sea level

Soil texture: Loamy, Skeletal and Clayey

3 Necessary (14.1%) Upland crop area, rubber field and orchard between 0 m ~ 50 m above sea level

Soil texture: Skeletal and Clayey

Table 3.2-3 shows the relation between the Soil Erosion Map and the Pilot Project Areas.

Most of the Pilot Project Areas were selected from Top-Urgent (more than 50 ton/ha/year in soil loss volume). However, in Chachoengsao, most of the Pilot Areas were selected from Urgent (50-30 ton/ha/year) because most of the Top-Urgent areas belong to reserved forest areas.

Table 3.2-3 Candidate, Pilot Area and Urgency of Soil Conservation

Province	Area	1 Top-Urgent	2 Urgent	3 Necessary	4 Normal
Chachoengsao	Candidate	7	2,3,4,8	5	1,6
	Pilot		3,4,8	5	
Chonburi	Candidate	1,2,3,6,8,9	4,7	5	-
	Pilot	1,2,8,9	4	-	-
Rayong	Candidate	1,2,3,7	5	-	4
	Pilot	2,3	5		
Chanthaburi	Candidate	2,3	-	1	4
	Pilot				

(2) Present Conditions of Soil and Water Conservation in the East

In order to establish soil and water conservation in the East, the programmes of DLD should be based on the following government policy, farmer's needs and the economic situation.

(i) Analysis of government policy

- The public service for the most people will be able to provide but not for individual farmer.
- Budget is relatively limited.
- Improve the efficiency of production as well as decrease the capital cost.
- Accelerate the private sector to participate.
- Increase the efficiency of natural resources utilization.
- Looking for more possibility of crop diversification.
- Transfer techinical know-how to farmer with more alternatives.
- Convince the farmer to help themseleves as much as possible.
- Strengthen the cooperation among local officials in the district and sub-district level.
- Accelerate a free economic system without competition between government and private sector.
- Cooperation between official government units.

(ii) Analysis of the farmer

The outcome from the socio-economic study in the Bo Win project area has shown the profile farmers as follows.

- An average of farmer age is 51 years old with their old opinion.
- The 50% of education level are recorded at the primary level, apart from those have non educated.
- Within the household, labor force consist of only 2.5 persons.
- Average land holding are 46 rais/family.
- Marketing problem for cassava and surgarcane have been gradually occured, while the declining of productivity made farmers obtaining lower benefit.
- Cost of crop cultivation is rather high especially from fertilizer and labor.
- Farmers have some experience in soil erosion and the recommended soil conservation measure which were previously introduced. Participation from the government and farmer are agreeable on the labor force from farmer.
- About 20% of farmers have the willingness to diversify crops.

Applicable measures which need to be introduced consist of:

- Implementation process should not be so complicated.
- Minimize the investment of construction.
- Require limited labor force.
- Crop diversification is preferable.
- Cultivate a specific crop in the specific area.

(iii) Evaluation of acceptability for farmer

Soil and water conservation technology has been introduced to farmers in the previous projects. The following conservation technologies are more acceptable to farmers.

a) Contour cultivation	33.0 %
b) Terracing (government provide the construction and farmer take care)	25.3 %
c) Crop rotation	13.2 %
d) Stripe cropping	9.2 %
e) Compost and green manure	6.0 %
f) Buffer of crop residue	3.3 %
g) Paddy terrace with drainage system	3.3 %
h) Cover crop	2.5 %
i) Drainage system	2.5 %
j) Bench terrace	0.5 %
k) Farm pond (constructed by farmer)	0.3 %
Total	100.0 %

Contour cultivation for soil conservation is most acceptable to farmers. Terracing measures could be acceptable to farmers if investment costs were reduced.

(iv) Basic soil conservation measures

Taking into consideration the matters mentioned above, the sequence of basic soil conservation measures for DLD is as follows.

Selection of these measures has been based on the physical conditions, government policy, and social and economic justification.

Priority	Measures
1	Grass cover crop
2	Crop rotation
3	Contour cultivation
4	Farm road
5	Orchard terrace

In addition to these soil conservation measures, the other activities of DLD are:

- Provide seed of cover crop
- Provide seedling of fast growing fruit crop species
- Construct farm ponds and farm roads with diversion ditch

Recommended soil conservation measures are shown in Table 3.2-4. The information on soil conservation was taken from FAO Project TCP/THA/4408 (T) Report V/4.

Table 3.2-4 Recommended Soil Conservation Measures

Slope range %	Texture of top soil	Land use		Soil conservation measure														
				Vegetative control							Mechanical control							
				1	2	3	4	5	6	7	8	9	10	11	12	13	14
3 – 6	Loam	Legume crop	a				2			2	2	2	+2				
		Upland crop	a		2		2			2	2	2	+2				
		Fruit tree	a	2		2		2					+2		2		
		Fast groving tree	b					2									
Justification																	
Analysis of physical		Government service								/		/	/				
characteristic:		Demonstrated by															
Possible measure		government and		/	/	/		/			/				/		
to be adopted		implemented by farmer															
Analysis of		Government service											/				
government policy:		Demonstrated by															
Possible measure		government and		/	/		/				/				/		
to be adopted		implemented by farmer															
Analysis of the		Government service											/				
farmer behavior:		Demonstrated by															
Possible measure		government and		/	/		/				/				/		
to be adopted		implemented by farmer															
Analysis of acceptability		Government service								/		/	/				
on the technology		Demonstrated by															
Possible measure		government and		/	/		/				/						
to be adopted		implemented by farmer															
Conclusion of		Government service											/				
overall analysis on		Demonstrated by															
Possible measure		government and		/	/		/	/			/				/		
to be adopted		implemented by farmer															

Soil conservation measure

1. Need
2. Necessary
– . Not necessary

Necessary soil conversation measure

/. Substituted measure
+ . Additional measure

Source: TCP/THA/4408 (T) Report V /4

Grass cover crop
Crop rotation
Soil mulching
Strip cropping
Buffer strip cropping
Contour strip cropping
Waterway
Contour cultivation

Contour terrace
Drainage
Broadbase terrace
Orchard terrace
Bench terrace
Hillside ditch

(3) Monetary Value of Soil Loss in the Study Area

1) Nutrient losses

Nutrient losses in sediment shall be exchanged to monetary value as follows ;

i) Price of fertilizer

Price of fertilizer is shown as follows ;

	W·B (Baht/ton)	BKK (Baht/ton)
N	6,563	7,609
P	7,911	16,596
K	2,967	6,717

Where, 1) Name of fertilizer

N : Urea (46%)

P : Super phosphate (P202, 45%)

K : Potasium choloride (K20, 60%)

2) W.B

Half-Yearly Revision of Commodity Price Forecast W.B, 1987

3) BKK

Bangkok retail current price, 1987

In the Report, BKK price shall be used for calculation.

ii) Unit price of sediment

Unit price of sediment (per ton) shall be calculated according to soil texture as follows;

Soil Texture	Nutrient	Contents %	Unit Price Baht/ton	Amount Baht
SL,LS	N	0.53	7,609	40.3
	P	0.034	16,596	5.6
	K	0.14	6,717	9.4
	total			55.3
SCL	N	1.37	7,609	104.2
	P	0.127	16,596	21.1
	K	0.29	6,717	19.5
	total			144.8

For calculation of nutrient lossed in sediment 55.3 Baht and 144.8 Baht shall be used against one ton predicted soil loss from cropland.

2) Dredging price of sediment

Dredging price shall be estimated in the following

Dredging unit cost = 50 Baht /ton

This figure is quoted from Vol.II 6-3-2 Project Benefit, (4) Conservation of Natural Resources and Environment Benefit .

3) Development Indicator

Above mentioned nutrient losses and dredging cost shall be used as development indicator's for the Basic Plan and Pilot Areas.

4) Monetary value of soil loss in the Study Area.

According to establishment of predicted soil loss in the study Area (A = 880,000 Ha) annual soil loss is calculated as follows ;

Province	Study Area Ha	Unit Soil loss ton/Ha/year	Total soil loss 10^6t/year
Chachoengsao	220,000	29.0	6.4
Chonburi	304,100	35.8	10.9
Rayong	263,400	33.3	8.8
Chanthaburi	96,500	40.4	3.9
Total	880,000	34.0	30.0

30 million ton of soil loss shall be predicted from the study area. This soil loss shall be equivalent to 4,260 million Baht.

Nutrient loss

Province	Soil Texture	%	Mt	Mt
CS	SL,LS	55	6.4	3.5
	SCL	45		2.9
		100		
CN	SL,LS	66	10.9	7.2
	SCL	34		3.7
		100		
RY	SL,LS	62	8.8	5.5
	SCL	38		3.3
		100		
CT	SL,LS	39	3.9	1.5
	SCL	61		2.4
		100		

± SL,LS =	17.7Mt	×	55.3Baht/t	= 978.8 million Baht
± SCL =	12.3Mt	×	144.8Baht/t	= 1,781.0 million Baht
total	30.0Mt			2,759.8 million Baht

Dredging	30.0Mt	×	50Baht/t	= 1,500.0
Total	2,759.8Mt	+	155.0Baht/t	= 4,259.8

3-3 Irrigation and Drainage

(1) Present conditions

1) Water Resources

a) Surface water

The total area of the four provinces (Chachoengsao, Chonburi, Rayong and Chanthaburi) is 19,361 km² and the average annual precipitation is about 1,820 mm.

The annual precipitation in the area increases toward the east. In the area, there are 10 large and medium scale irrigation projects and 104 small scale irrigation projects including 32 reservoir projects constructed under the RID as of 1986. The total reservoir capacity of the said projects including medium scale projects under the office of the coordinating committee for Royal Development Projects is 231.46 MCM as shown in Table 3.3-1.

Assuming that the run-off water is equivalent to 30% of the precipitation, the storage capacity of reservoirs in the area is only 2% of the assumed run-off water.

According to the survey data conducted by the Secretariat of the Prime Minister as of October 1987, there are 860 small water resources development projects in the area as shown in Table 3.3-2. About 75% of the total projects are well construction projects whose major purpose is domestic water supply.

Table 3.3-1 Reservoir Capacity in the Eastern Region (Four Provinces)
(completed to the end of 1985 and under construction in 1986)

Province	L/M Project	S.I. Project *	M.S. Project	Total (MCM)	%
Chachoengsao	4.20	2.73	3.31	10.24	5
	(1)	(12)			
Chonburi	148.88	1.96	4.97	155.81	67
	(7)	(9)			
Rayong	58.00	0.42	-	58.42	25
	(1)	(4)			
Chanthaburi	2.50	4.49	-	6.99	3
	(1)	(7)			
Total	213.58	9.60	8.28	231.46	100
	(10)	(32)			

Note: a) Source: RID, * Material obtained form RID October, 1987
b) Project definition
L/M project : Large and medium scale project (RID)
S.I. project : Small scale irrigation project (RID)
M.S. project : Medium scale project (Office of Coordinating Committee for Royal Development Project)
c) ( ) shows the number of projects.

Table 3.3-2 Number of Small Water Resources Development Projects of the Four Provinces in the Eastern Region

Province \ Project	Well	Pond	Dredging	Weir	Reservoir	Dike	Canal	Water supply	Pump	Total
Chachoengsao	200	5	3	7	10	-	2	-	-	227
Chonburi	78	12	7	5	5	-	-	-	-	107
Rayong	109	10	18	24	5	-	-	-	-	116
Chanthaburi	252	31	4	45	10	8	8	2	-	360
Total	639	58	32	81	30	8	10	2	-	860

Note a) Data source : the Secretariat of the Prime Minister, Office of the Prime Minister, October 1987
b) The projects were implemented under the following agencies : PWD, MASC, DLD, RID, DMR, DOH, ARDO, ALRO

b) Groundwater

The general conditions of groundwater resources in the Study Area based on the results of field reconnaissance and data collected were found as follows.

- There are 639 wells in the four provinces. 70% of the total wells are located in Chachoengsao and Chanthaburi provinces where the alluvial deposits are developed, particularly in Phanomsarakam and Tha Mai districts, respectively.
- More than 90% of the groundwater is used for domestic purposes in the rural area.
- The phreatic aquifers are mainly found in the alluvial deposits in the flood plains and the terrace deposits in the upland. The groundwater in the alluvial deposits is recharged by rivers and paddy fields and a remarkable decrease in the groundwater level takes place during the dry season.

  The groundwater in the terrace deposits is recharged by vertical infiltration of rainfall and has a small yield due to the comparatively low permeability and storage capacity of the terrace deposit.
- Regional groundwater flow hardly exists in the terrace deposits due to its low transmissibility ranging from 3 m/d to 10 m/d.

Consequently, since the surface water resources are situated under very poor conditions in comparison with the rest of Thailand, a survey for groundwater development potential will be required for domestic purposes.

2) Irrigation

The total cultivated area of both paddy and upland crops in the subject four provinces is about 729,200 ha (4,557,400 rai). About 175,400 ha or 24% of it is irrigated as of 1986.

The provincial characteristics of irrigation are understood as follows ;

Chachoengsao :

The province has the largest paddy land among the four provinces because of its comparatively flat topographical condition and large river basin (Bang Pakong river basin) and the most developed irrigation system under which 58% of the cultivated area is irrigated as of 1986 through construction of weirs in the said river.

Chonburi :

The province has an upland area about four times larger than that of paddy land because of its topographical characteristic. However, the water resources of the area are the most poorly developed with only 7% of the cultivated area being irrigated.

Rayong :

Rayong has similar characteristics to Chonburi in development of irrigation systems. Namely, the upland area occupies a larger area than the paddy land and only 9% of cultivated land is irrigated.

Chanthaburi :

30% of the total area (633,800 ha) of Chanthaburi is covered with forest and 13% of that, with tree crops. Therefore, land cultivated with paddy and upland crops is the smallest among the four provinces in spite of it having the largest amount of total land.

From the viewpoint of irrigation systems, the share of irrigated area has reached to about 14% of the cultivated areas.

Taking the conditions mentioned above into account, the upland areas especially in Chonburi and Rayong are expected to develop irrigation systems by providing small scale water resources because of their undulating area and small watershed.

3) Present water resources development plan

a) East coast water resources development plan

The Eastern seaboard will play the key role in the industrialization of Thailand in accordance with the National Economic and Social Development Plan. However, in order to accomplish the said development plan, the problem of domestic and industrial water supply for the industrial areas requires an urgent solution. In order to cope with the water demand mentioned above, the water supply plan in 2001 is proposed providing four new reservoirs in addition to the four existing reservoirs and Nong Plan Lai Dam (under construction).

b) RID, irrigation development plan

During the four years from 1988 to 1991, RID will implement the construction of Nong Pla Lai Dam in Rayong province as a multi-purpose project.

As a development plan after 1991, RID has scheduled the construction of large and medium scale projects, namely 11 projects in Rayong and 24 projects in Chanthaburi. The total irrigable area and reservoir capacity is about 195,800 ha and 1,800 MCM respectively.

Although the budget allocation for small scale irrigation projects in 1988 is approximately 1,050 MB, the detailed program has not been specified as yet in order to cope with any urgent projects.

After completion of all development plan projects including Nong Pla Lai Dam, the irrigation condition in the four provinces will become approximately as shown in Table 3.3-3.

As a result, almost the entire area of paddy field will be irrigated by the reservoirs but the upland area will still remain rainfed. Therefore, considering the topographic condition and benefits from production of fruit and vegetable crops, development of an irrigation system and water resources for the upland area will be required.

Table 3.3-3 Irrigation Development Plan of the Four Provinces in the Eastern Region (RID, Large and Medium Scale Project)

Implementation Schedule	Province	No. of Projects	Irrigable Area (1,000 rai)	Reservoir Capacity (MCM)	Remarks
I) 1988 ~1991	Rayong	1	21.875 (3,500 ha)	154.0	Nong Pla Lai Project
II) After 1991	Chachoengsao	11	493.020	813.39	
	Chonburi	24	123.600	341.68	
	Rayong	14	361.700	412.93	
	Chanthaburi	24	245.565	240.29	
	Total	73	1,233.885 (195,800 ha)	1,808.29	

Source : RID Region 9, October 1987

c) Small water resources development plan

Concerning small water resources development, there are 16 agencies involved as aforementioned. Although out of the 16, only nine (9) agencies are related to the construction of small scale ponds and reservoirs and four (4) agencies, namely RID, DLD, ARDO and ALRO are the major agencies among them.

They have their own master plan in line with the Sixth NESD Plan, however, some of the said plans do not specify a detailed program taking into account the financial schedule. The said plans are mostly comprised of well construction with the purpose of supplying domestic water and are not involved with upland crop irrigation or land conservation.

The implementation schedule of DLD water resources development in the four provinces is as follows ;

(unit : project)

Year	Pond	Reservior	Weir	Dike	Canal	Total
1986	1	2	3	2	-	8
1987	8	-	1	-	-	9
1988	1	1	2	-	1	5

4) Summary of present conditions and main problems

From the study results aforementioned, the present conditions of irrigation and drainage for the four provinces are summarized as follows (refer to Table 3.3-4).

The following major problems of irrigation and drainage development in the four provinces are findings of the field surveys and data analysis conducted.

- Almost all of the agricultural production in upland, vegetable and tree crop areas are only rainfed due to poor water resources development.
- The subject area has comparatively rich rainfall compared with other regions. However, 80% of the annual precipitation in the

Table 3.3-4 Summary of Irrigation and Drainage Conditions in the Project Area

Description	Chachoengsno	Chonburi	Rayong	Chanthaburi
1) Total Land (ha)	535,100	436,300	355,200	633,800
- Cultivated Land, Paddy	156,436	57,600	28,280	35,768
Upland crop	70,025	204,999	129,919	46,152
- Tree crops & vegetable land	22,829	30,789	39,578	83,358
- Forest land	135,192	25,857	24,042	193,463
- Other land	150,618	117,055	133,381	275,059
2) Total Population (persons)	525,717	806,396	418,814	390,348
- Number of farm (family)	45,762	38,232	34,673	37,944
- Farm size (rai)	39.4	50.1	37.1	32.6
3) Average Precipitation (mm/year)	1,310	1,310	1,330	2,930
4) Major Crops in Upland and Tree Crop land	Cassava Pineapple Sugarcane	Sugarcane Pineapple Cassava	Rubber Cassava Pineapple	Mangosteen Rambutan Durian
5) Reservoir Capacity (MCM)	10.2	155.8	58.4	7.0
- Storage rate (%)	0.5	9.0	4.0	0.1
6) Irrigated Area (ha)	131,900	17,100	14,800	11,600
- Irrigated rate (%)	58	7	9	14
7) Development Plan				
- Number of projects	11	24	15	24
- Irrigation area (ha)	78,900	19,800	61,400	39,300
- Reservoir capacity (MCM)	813.4	341.7	566.9	240.3

area occurs in the rainy season, therefore, even in Chanthaburi which has the greatest amount of rainfall, water shortage occurs in the dry season which affects growth of perennial crops.

- Depending mainly on rain water, the farmers may have little knowledge or experience in water resources development or irrigation systems.
- The existing water resources and the development of new water resources is the poorest among the whole Kingdom due to the lack of suitable dam sites, no large river basins except for Bang Pakong basin and the small area of paddy land.
- The function of existing reserviors and natural streams is decaying with the accumulation of sedimentation caused by land erosion particularly in the area planted with cassava in Rayong and Chonburi provinces.
- The present water resources development plans are established aiming to supply water for industrial, domestic and paddy irrigation water, and flood control, therefore, the development of water resources for upland and tree crop land will remain far behind other areas.
- As for irrigation facilities of the existing land and water conservation projects, the criteria for the water balance study, design and supervision does not appear to be firmly established.

(2) Basic plan for irrigation system

1) Development plan

a) Objective of development plan

Considering the background concerning irrigation and drainage development in the area as aforementioned, the development plan of irrigation for the project area (8,840 km^2) shall be introduced with the following objectives.

- To prevent destruction of natural resources, particularly land affected by disorderly development,

through introduction of land and water conservation projects.

- To supply food and raw material to the industrial area, especially the Eastern Seaboard, from the rural area which will also stabilize the farmers income and improve living standards.
- To reduce the disparity in income between the people living in the industrial and rural area.

b) Development plan

The development plan for irrigation in the area shall be formulated as follows ;

- Irrigation development project for upland and tree crops ;

  Recently, in order to cope with changing tastes in food, introduction of a diversity of crops is required. Considering the marketability of crops and the undulated ground condition of the area, an irrigation development project for upland and tree crops will be promoted with a high priority.

  Conduction of stable agriculture and introduction of perennial crops such as tree crops will play an important role in prevention of disorderly development and land erosion in the area.

  Concretely, an irrigation system consisting of several ponds within a small watershed area and a pipeline system which has a small amount of water loss shall be expanded over the project area.

2) Irrigation method for field crops

There are many irrigation methods for field crops such as surface irrigation (border, contour, furrow, perforated pipe, etc.), spray irrigation (sprinkler, drip, etc.) and subsurface irrigation (open canal, pipeline, etc.).

The characteristics of each type of irrigation method mentioned above is summarized in Table 3.3-5. Application of the said

Table 3.3-5 Method/Characteristic of Each Irrigation Type (1/2)

Type	Method/Characteristic
1) Sprinkler irrigation	Method; - Pressurized water is applied by sprinkler Characteristic; - Construction and operation cost are high but irrigation efficiency is good. - Available for multipurpose use and automatic system. - Less affect by topography and soil, but affected by wind. - Small amount of water applied. Frequent irrigation possible.
2) Perforated pipe irrigation	Method; - Water applied through perforated pipe on the ground. Characteristic; - Available for terrace field and/or small scale farm. - Available for tree crop irrigation. - Less effect by wind.
3) Furrow irrigation	Method; - Water is applied to the root zone of plants through furrow. Characteristic; - Suitable for impervious soil in the flat area. - Economical construction and operation costs but poor irrigation efficiency with comparative high maintenance cost.
4) Border irrigation	Method; - Water of shallow depth flows over the farm divided by small levee. Characteristic; - Almost same as that of furrow irrigation.

Table 3.3-5 Method/Characteristic of Each Irrigation Type (2/2)

Type	Method/Characteristic
5) Contour ditch irrigation	Method: - Arrangement of main and sub-ditch is made depending on the slope of land. In case of steep slope (1/100 - 1/200), the sub-ditches are constructed along the contour and the main ones, making a right angle with the contour. By damming the sub-ditch water is lead to the farm. However, in case of gentle slope the opposite way shall be taken. Characteristic; - Adaptable for sloped land by providing terrace. - Other characteristics are almost the same as for furrow irrigation.

irrigation methods will be conducted through a comparison study of each irrigation type as shown in Table 3.3-6.

Judging from the field condition in the project area, such such irrigation methods as border, contour ditch and furrow are not suitable due to the high amount of water consumption, but spot drip, sprinkler and perforated methods will be adoptable.

3) Irrigation water requirement

a) Basic concept for estimating diversion water requirements

The diversion water requirement will be estimated by the following formula ;

- Net Water Requirement = Crop consumptive use + Percolation + Water requirement for field preparation (land preparation, etc.)
- Field Water Requirements = Net water requirement - Effective rainfall + Field losses.
- Diversion Water Requirement = Field water requirement + Conveyance and operation losses.

b) Crop consumptive use (Cu)

Although the available data for upland crop consumptive use was collected from irrigation research stations such as Mae-tang station in Chiangmai, Samchuk station in Suphunburi, etc. through RID, the crop consumptive use is estimated by applying the modified Penman Method, arranging the said data for crop factor (Kc) to carry out the water balance analysis according to the proposed crop calendar. Therefore, the Cu can be obtained by multiplying the reference evapotranspiration (ETo) by the varying crop factor (Kc) for each kind and type of crop, their growing stage, etc.

Evapotranspiration (ETo) :

There are four meteorological stations located in/or near the Study Area, which have long term records ;

- Prachinburi station
- Chonburi station
- Sattahip station

Table 3.3-6 Comparison between Surface and Sprinkler Irrigation (1/2)

Method / Description	Sprinkler Irrigation	Surface Irrigation
1) Land slope	No objection	Border : < 3°, Furrow : <15° Contour ditch : <27°, Pipeline : No objection
2) Land leveling	Not required in most cases	Required
3) Soil classification	Any kind of soil is adaptable except clay	Sand with high rate of percolation water is not suitable except for pipeline method.
4) Irrigation efficiency	80 - 90%	Less than 70%
5) Irrigation technique	Makes even irrigation without skilled technique	Uneven irrigation depending on the technique
6) Wind factor	Affected by wind velocity Velocity (m/sec) / Equipment Pitch by sprinkler diameter 0 : 65% 0 - 2.5 : 60% 2.5 - 5.0 : 50% 5.0 - : 30%	No problem
7) Land erosion	Erosion will occur in the inclined area	Unconsolidated and/or uncompacted furrows will be eroded.
8) Water management	Management will be conducted through the farmer's group. There are less water losses.	Management is easily conducted by a person or family. Therefore, water losses are greater than that for sprinkler irrigation.

Table 3.3-6 Comparison between Surface and Sprinkler Irrigation (2/2)

Method / Description	Sprinkler Irrigation	Surface Irrigation
9) Labour Force for irrigation	For portable type sprinkler, 1 or 2 workers are required for 20 - 30 minutes to move the equipment.	Some labour required.
10) Construction cost	High	Low in flat plain, however, on the hill side, the construction cost might be higher than that of sprinkler irrigation owing to its lining and appurtenant structure costs.
11) Operation and maintenance cost	High (Operation cost for pump is required)	Low (Continuous maintenance is required for canal)

- Chanthaburi station

The ETo for each station mentioned above was estimated as shown in Table 3.3-7 by using the modified Penman Method. However, considering the provincial meteorological conditions, the estimated ETo's will be adopted as follows ;

- ETo at Chonburi station ; Chachoengsao province, Chonburi province,
- ETo at Sattahip station ; Rayong province
- ETo at Chanthaburi station ; Chanthaburi province

Crop factor (Kc) :

The crop factor for each crop is proposed as shown in Table 3.3-8, referring to the actual measurements of the irrigation research stations, RID.

c) Other requirements

Besides the crop consumptive use, water requirements for percolation, land preparation in paddy cropping and preparatory works in upland cropping shall be considered. Considering the soil characteristics in the subject area, the percolation value of 2.0 mm per day will be adopted for paddy land, this is a standard value in the Northeastern Region under the RID's Medium Scale Irrigation Project. Percolation in the upland area is regarded as an irrigation water loss. Such additional water requirement as land preparation water for paddy and pre-irrigation water for upland will be designed as below, referring to the data available from other similar projects in Thailand.

Crop	Additional Water Requirement (mm)	Required Period (days)
- Paddy	200	30
- Sugarcane	50	90
- Other upland crops	40	30

Table 3.3-7 Evapotranspiration (ETo)

(unit: mm)

Description	Prachinburi Station		Chonburi Station		Sattahip Station		Chanthaburi Station	
	Day	Month	Day	Month	Day	Month	Day	Month
Jan.	4.6	143	4.2	130	4.5	140	3.7	115
Feb.	4.4	123	4.7	132	5.0	140	3.6	101
Mar.	4.8	149	5.4	167	5.6	174	3.9	121
Apr.	4.6	138	5.4	162	5.7	171	4.1	123
May	3.9	121	4.5	140	4.9	152	3.3	102
Jun.	3.4	102	4.1	123	4.9	147	2.9	87
Jul.	3.3	102	4.0	124	4.6	143	2.8	87
Aug.	3.2	99	3.7	115	4.5	140	2.7	84
Sep.	3.2	96	3.4	102	3.7	111	2.7	81
Oct.	3.9	121	3.7	115	3.6	112	3.3	102
Nov.	4.2	126	4.2	126	4.3	129	3.7	111
Dec.	4.2	130	4.3	133	4.5	140	3.8	118
Total/Average	4.0	1,450	4.3	1,569	4.7	1,699	3.4	1,232

Note: a) From climatological data for the period 1956 - 1985 published by the Meteorological Department.

b) ETo's of Chachoengsao and Chonburi provinces are applied to that of Chonburi station, ETo of Rayong province, Sattahip station, and ETo of Chanthaburi province, Chanthaburi station, respectively.

Table 3.3-8 Crop Factors (Kc) for Representative Crops

Crop \ Month		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
1) Paddy													
- LV	1/	1.0	1.0	1.2	1.35	1.3	1.2	1.1					
- HYV	1/	1.0	1.25	1.35	1.3	1.1							
2) Upland Crop													
- Sugarcane	1/	0.6	0.8	1.0	1.2	1.25	1.2	1.15	1.0	0.85	0.65	0.6	0.50
- Cassava	2/	0.2	0.3	0.4	0.5	0.6	0.6	0.5	0.4	0.3	0.3	0.2	0.2
- Pineapple	2/	0.4	0.4	0.6	0.8	0.9	0.9	0.7	0.6	0.5	0.4	0.4	0.3
- Mungbean	2/	0.7	0.7										
- Soybean	2/	0.85	0.85	0.85	0.85								
- Groundnut	2/	0.8	0.8	0.8	0.8								
- Sweet corn	2/	0.8	0.8	0.8									
3) Tree Crop													
- Mango	3/	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
- Durian	3/	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Note: 1/: Based on the actual measurements by Irrigated Agricultural Section, RID in 1979
(Refer to the feasibility study report on the Mae Wang-Kew Lom Irrigated Agriculture Development Project, JICA 1980).

2/: Based on the actual measurements conducted from 1980-1983 by Irrigation Research Stations, RID.

3/: Based on the field investigation.

d) Effective rainfall

Effective rainfall for upland crop means rainfall which is effectively consumed fro crop growth out of all rainfall in the cultivation area. Namely, effective rainfall is water retained as the total readily available moisture (TRAM) of the effective road zone from which the crop consumes its required water. Rainfall beyond the effective rainfall will flow out from the field.

TRAM is estimated by applying the following equation.

$$TRAM = \frac{1}{100}(FC-Wp) \times D \times \frac{1}{Cp} \times K \quad (mm)$$

Where, FC ; Field capacity of moisture (%)

Wp ; Wilting point moisture (%)

D ; Important soil layer for growth (mm)

Cp ; Rate of available moisture in important soil layer

K ; Coefficiency 0.9

TRAM was assummed based on the previous effective data as follows :

Soil texture	Available Water Holding Capacity (FC-Wp)	Effective soil layer	D	Cp	TRAM
	(%)	(cm)	(mm)		(mm)
- Sandy loam	11	120	300	0.40	100
- Loamy sand ~ sandy loam	7~11	120	300	0.40	100
- Clay loam ~ silty clay	14~17	120	300	0.40	100

e) Losses

Field loss :

A part of the irrigation water to be supplied to the fields will be lost through horizontal and vertical percolation in the fields, or surface runoff. Therefore, the field water

requirement should be estimated by the following equation :

$$FWR = \frac{NWR - ER}{Ef}$$

Where,

FWR : Field water requirement
NWR : Net water requirement
ER : Effective rainfall
Ef : Field efficiency

The field efficiency varies with different irrigation methods and field conditions. Based on previous studies and research carried out in Thailand and/or Japan, the following factors described will be adopted in this study.

Field	Ef
- Paddy land	0.70
- Upland	
Surface irrigation	0.55
Spray irrigation	0.70
Spot irrigation	0.80

Conveyance and operation losses :

Some water losses take place while water is being conveyed through canals. The conveyance loss varies with the different structures of the canals concerned and the operational loss varies by operation method.

In taking these water losses into consideration, the diversion water requirements which will be required at the diversion site can be computed by the following equations :

$$DWR = \frac{FWR}{Ec \times Eo} = \frac{NWR - ER}{Ef \times Ec \times Eo}$$

Where,

DWR : Diversion water requirement
FWR : Field water requirement
NWR : Net water requirement
ER : Effective rainfall

Ef : Field efficiency

Ec : Conveyance efficiency

Eo : Operation efficiency

In this study, the following losses will be adopted.

Structure	EC	Eo
- Open canal		
- Lined canal	0.90	0.90
- Unlined canal	0.70	0.90
- Pipeline	0.95	1.00

(Since the Study Area is mostly covered with sandy soil, the canal shall be lined with concrete except for farm-ditch). From the above considerations, the overall efficiencies (Ef × Ec × Eo) are given as follows ;

Field	Ef	Ec	Eo	E
- Paddy land	0.70	0.90	0.90	0.57
- Upland				
Surface irrigation	0.55	0.90	0.90	0.45
Spray irrigation	0.70	0.95	1.00	0.67
Spot irrigation	0.80	0.95	1.00	0.76

3-4 Socio-Economy

(1) Overview

Of the four provinces located in the Study Area only Chachoengsao has not shown a decline in its per capita Gross Provincial Product (GPP) during the five year period from 1981-1985 (Figure 3.4-1). At current market prices the average annual percentage of increase in the GPP of each Province over the same period was ; Chachoengsao 14.77%, followed by Rayong at 10.29%, Chanthaburi at 3.67% and Chonburi at 3.14%. During the same period the Eastern Region's GRP grew at an average annual rate of 6.32%.

The total GPP of the four provinces was 82.0% of the Eastern Region's GRP in 1981 and 81.3% in 1985. Chonburi's GPP is of special interest since during the period it has continually produced 40-50% of the Eastern Region's GRP and has on average been 1.4 times that of the total GPP of the remaining three provinces in the Study Area (Figure 3.4-2). Chanthaburi's per capita GPP has been nearly 30% lower than the other 3 Provinces on the average over the period and less than half of that of Chonburi (Vol. Ⅳ, Annex 2 Table 2.2.1-1).

Looking at the GPP statistics for 1981-1985 of the four provinces in the Study Area, the following breakdown of characteristics can be made (refer to Tables 3.4-1 to 4) ;

1) Chachoengsao

In 1981, the agriculture sector produced 4,453 million Baht or 55.22% of total GPP, equivalent to 23.01% of the Eastern Region's total agricultural production of 19,329 million Baht. However, by 1985 this figure had fallen to 2,518 million Baht or 18.21% of GPP equivalent to 13.76% of the Eastern Region's total agricultural production of 18,298 million Baht. This means that production of the agricultural sector declined by 1,935 million Baht or 43.45%. At the same time the mining and quarrying sector increased from 243 million Baht or 3.01% of total GPP in 1981 to 6,277 million Baht or 45.39% of total GPP in 1985. This has more than made up for the decline in the agriculture sector. In 1985 the Eastern Region's mining and

quarrying sector produced 25.34% of the GDP in this sector and Chachoengsao produced 84.71% of the GRP in the sector.

2) Chonburi

From 1981 to 1985, Chonburi has produced more than 25% of the Eastern Region's GRP in the agriculture sector, which is more than any other province in the region. However, production of the agriculture sector has been second to the manufacturing sector during the same period and fell slightly behind the services sector for the first time in 1985. The manufacturing sector of Chonburi has continuously produced more than 45% of its total GPP and more than 92% of the total GRP in this sector. Regionally speaking, Chonburi is the agriculture and manufacturing sector leader. Also, production in the services sector since 1981 has been greater than 40% of GRP, reaching 5,060 million Baht or 59.68% of GRP in 1985.

3) Rayong

In the Study Area, Rayong ranks third to Chonburi and Chachoengsao in total GPP. Since 1983, when it surpassed Chachaengsao it has ranked second to Chonburi in agriculture sector production. There are two other sectors which play important but secondary roles in Rayong's economy. They are the transportation and communication sector (1,445 million Baht or 15.75% of GPP in 1985) which produced 26.88% of total GRP in this sector for 1985 which made it number one in the Eastern Region. The other sector is wholesale and retail trade which has steadily increased in value form 1,188 million Baht in 1981 to 1,447 million Baht in 1985, averaging 15.89% of total GPP for the period 1981-1985.

4) Chanthaburi

Economically, this is the poorest of the four provinces in the Study Area, it has never produced more than 8.55% (recorded in 1982) of the Eastern Region's GRP and even in the agriculture sector (2,483 million Baht or 13.57% of GRP) produced only half of Chonburi's 5,056 million baht or 27.63% of GRP in this sector in 1985. The only other sector of any significance is the wholesale and retail trade sector which increased from 1,120 million Baht or 20.42% of total GPP in 1981 to 1,355 million baht or 21.41% of total GPP in 1985. However,

in comparison with the percentage of GRP of this sector it still ranks fourth among the four provinces in the Study Area.

(2) Population

In 1985 approximately 65% of the Eastern Region's population lived in the four provinces of the Study Area with the largest population in Chonburi followed in order by Chachoengsao, Rayong and Chanthaburi (Figure3.4-3). Over the period 1981-1985 the population of the Eastern Region increased at a yearly average of 2.9% and only Chanthaburi experienced a higher rate of growth at 3.49%. Chanthaburi was also the only Province in the Study Area to record an average net migration of more than 1.0% (1.54%) during the same period.

In 1985, Chachoengsao, Chonburi and Chanthaburi received an influx of population which was greater than the natural (birth/death) population growth (Chachoengsao 8,604-6,805, Chonburi 13,924-12,381, Chanthaburi 9,134-6,654), and Chachoengsao and Chanthaburi had more new inhabitants than births. In the same year, Rayong's total population increase of 12,592 persons consisted of 6,143 new inhabitants or 47.4%. Of the 66,457 persons moving into the Eastern Region in 1985 a total of 37,805 persons or 56.9% settled in the four provinces of the Study Area (Vol. IV Annex 2 Table 2.2.1-2).

(3) Labor Force and Employment

According to the Population and Housing Census conducted by the National Statistical Office in 1980 the four provinces in the Study Area employed a labor force (economically active population 11 years of age and over) of 919,926 persons or 64.7% of the Eastern Region's total.

The total number of persons employed and the number and percentage of persons employed by the agriculture sector was as follows ;

	Employed Persons	Agri-sector (%)
Whole Kingdom	22,524,000	15,943,000 (71.0)
Eastern Region	1,421,133	959,569 (67.5)
Chachoengsao	232,398	165,599 (71.3)
Chonburi	334,961	172,246 (51.4)
Rayong	181,351	128,699 (71.0)
Chanthaburi	171,216	121,317 (70.9)

Although Chonburi had the lowest percentage of workers in the agriculture sector this was made up for by the 58,161 persons or 17.4% employed as factory workers.

(4) Income

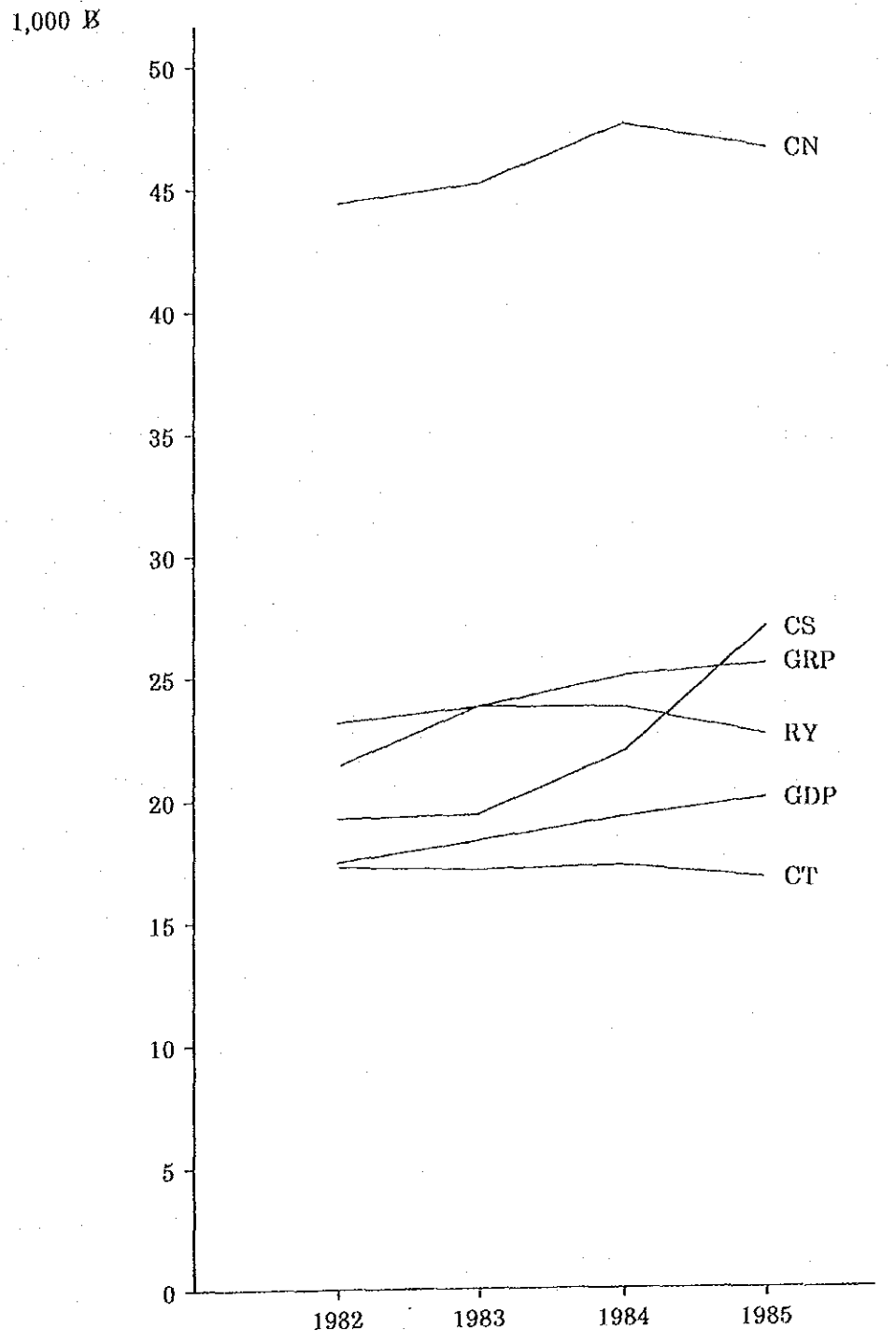
Average income per farm household in the four provinces of the Study Area was 1.65 to 1.82 times greater than the average for the whole Kingdom in crop year 1982/83 (see Figure 3.4-4). Off-farm income in monetary terms was greater than the average of 13,961.86 baht for the whole Kingdom by 3,524.52 Baht in Chachoengsao, 5,556.46 Baht in Chonburi, 1,956.71 Baht in Rayong and 559.93 Baht in Chanthaburi.

The main source of farm income for each of the four provinces was as follows ;

	Crop	Income (baht)
Chachoengsao	rice	20,345.94
Chonburi	cassava	19,005.66
	sugarcane	14,536.16
Rayong	cassava	28,110.99
Chanthaburi	fruit	16,678.05

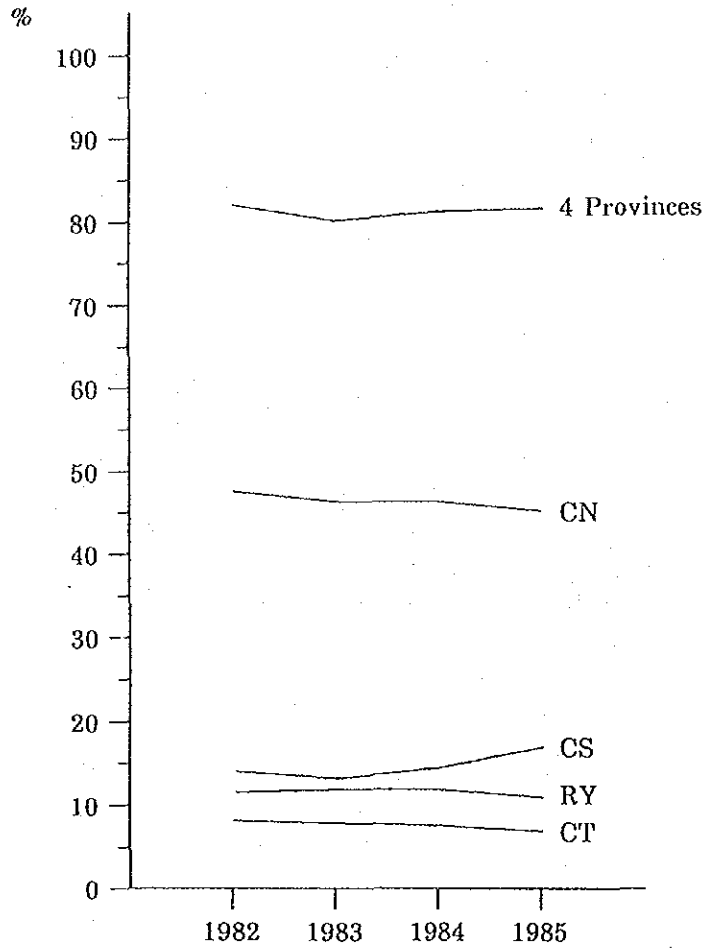
The main sources of off-farm income in Chachoengsao were salaries and compensation, and gifts ; in Chonburi hired farm work, and hired non-farm work, in Rayong hired farm work, hired non-farm work and middleman activity, and in Chanthaburi hired farm work, hired non-farm work and profit from business.

Farm input expense per farm in the four provinces of the Study Area was 2.19 to 2.90 times greater than the average for the whole Kingdom.



Source : NSO, 1958

Figure 3.4-1 *Per Capita GDP, GRP (Eastern), GPP (4 Provinces)*



Source : NESDB, 1986

Figure 3.4-2 4 Provinces % of Eastern Region GDP

Table 3.4-1 Comparison of GDP, Eastern Region GRP, 4 Province GPP

1982

Unit: million Baht (%)

Province	GDP	Eastern Reg. GRP [1]	GRP [2]			
			Chachoengsao	Chonburi	Rayong	Chanthaburi
1. Agriculture	188,742	20,222	3,679	5,617	3,632	2,677
		(10.71)	(18.19)	(27.78)	(17.96)	(13.24)
2. Mining & Quarrying	14,807	3,072	2,253	598	127	20
		(20.75)	(73.34)	(19.47)	(4.13)	(0.65)
3. Manufacturing	164,640	16,052	189	14,999	248	156
		(9.75)	(1.18)	(93.44)	(1.54)	(0.97)
4. Construction	43,040	1,729	143	819	200	164
		(4.02)	(8.27)	(47.37)	(11.57)	(9.49)
5. Electricity & Water Supply	14,454	808	100	411	116	77
		(5.59)	(12.38)	(50.87)	(14.36)	(9.53)
6. Transportation & Communication	63,133	4,973	541	1,403	1,493	469
		(7.88)	(10.88)	(28.21)	(30.02)	(9.43)
7. Wholesale & Retail Trade	159,849	10,614	1,510	3,390	1,254	1,236
		(6.64)	(14.23)	(31.94)	(11.81)	(11.64)
8. Banking, Insurance & Real Estate	61,021	2,435	339	1,004	298	335
		(3.99)	(13.92)	(41.23)	(12.24)	(13.76)
9. Ownership of Dwellings	9,912	664	113	157	88	78
		(6.70)	(17.02)	(23.64)	(13.25)	(11.75)
10. Public Administration & Defense	37,349	1,926	259	514	202	216
		(5.16)	(13.45)	(26.69)	(10.49)	(11.21)
11. Services	89,170	6,568	512	3,965	378	474
		(7.37)	(7.80)	(60.37)	(5.76)	(7.22)
Total	846,126	69,063	9,638	32,877	8,036	5,902
		(8.16)	(13.96)	(47.60)	(11.64)	(8.55)
Per Capita (baht)	17,450	23,284	19,354	44,368	21,546	17,258
		(1.33)	(0.83)	(1.91)	(0.93)	(0.74)

[1] : % of GDP

[2] : % of GRP

Note : At current market prices

Source : NESDB

Table 3.4-2 Comparison of GDP, Eastern Region GRP, 4 Province GPP

1983

Unit: million Baht (%)

Province	GDP	Eastern Reg. GRP [1]	GRP [2]			
			Chachoengsao	Chonburi	Rayong	Chanthaburi
1. Agriculture	204,443	21,296	3,015	5,839	4,344	2,841
		(10.42)	(14.16)	(27.42)	(20.40)	(13.34)
2. Mining & Quarrying	16,480	3,579	2,623	698	168	25
		(21.72)	(73.29)	(19.50)	(4.69)	(0.69)
3. Manufacturing	176,200	16,780	200	15,650	328	168
		(9.52)	(1.19)	(93.27)	(1.95)	(1.00)
4. Construction	47,129	2,272	272	975	408	241
		(4.82)	(11.97)	(42.91)	(17.95)	(10.61)
5. Electricity & Water Supply	16,319	1,007	143	478	188	89
		(6.17)	(14.20)	(47.47)	(18.67)	(8.84)
6. Transportation & Communication	73,708	3,945	490	992	912	244
		(5.35)	(12.42)	(25.15)	(23.12)	(6.19)
7. Wholesale & Retail Trade	165,812	10,930	1,612	3,259	1,395	1,175
		(6.59)	(14.75)	(29.82)	(12.76)	(10.75)
8. Banking, Insurance & Real Estate	72,381	3,308	411	1,284	409	400
		(4.20)	(13.53)	(42.26)	(13.46)	(13.17)
9. Ownership of Owellings	11,210	760	130	183	102	92
		(6.78)	(17.11)	(24.08)	(13.42)	(12.11)
10. Public Administration & Defense	42,551	2,282	295	599	228	249
		(5.36)	(12.93)	(26.25)	(9.99)	(10.91)
11. Services	98,680	7,259	556	4,308	468	565
		(7.36)	(7.66)	(59.35)	(6.45)	(7.78)
Total	924,913	73,148	9,747	34,265	9,418	6,089
		(7.91)	(13.33)	(46.84)	(12.88)	(8.32)
Per Capita (baht)	18,701	24,038	19,533	45,505	23,904	17,251
		(1.29)	(0.81)	(1.89)	(0.99)	(0.72)

[1] : % of GDP

[2] : % of GRP

Note : At current market prices

Source : NESDB

Table 3.4-3 Comparison of GDP, Eastern Region GRP, 4 Provoince GPP

1984

Unit: million Baht (%)

Province	GDP	Eastern Reg. GRP [1]	GRP [2]			
			Chachoengsao	Chonburi	Rayong	Chanthaburi
1. Agriculture	191,278	20,805	2,821	5,924	4,344	2,766
		(10.88)	(13.56)	(28.47)	(20.88)	(13.29)
2. Mining & Quarrying	21,291	4,713	3,626	792	168	28
		(22.14)	(76.94)	(16.80)	(3.56)	(0.59)
3. Manufacturing	196,257	18,254	237	16,904	328	183
		(9.30)	(1.30)	(92.60)	(1.80)	(1.00)
4. Construction	52,772	2,472	302	1,051	408	265
		(4.68)	(12.22)	(42.52)	16.50)	(10.72)
5. Electricity & Water Supply	18,884	1,296	334	529	188	99
		(6.86)	(25.77)	(40.82)	(14.51)	(7.64)
6. Transportation & Communication	83,588	4,810	604	1,109	1,380	270
		(5.75)	(12.56)	(23.06)	(28.69)	(5.61)
7. Wholesale & Retail Trade	181,993	11,922	1,737	3,358	1,395	1,291
		(6.55)	(14.57)	(28.17)	(11.70)	(10.83)
8. Banking, Insurance & Real Estate	80,577	3,339	449	1,419	409	437
		(4.14)	(13.45)	(42.50)	(12.25)	(13.09)
9. Ownership of Dwellings	12,377	810	139	195	102	98
		(6.57)	(17.16)	(24.07)	(12.59)	(12.10)
10. Public Administration & Defense	43,182	2,249	297	610	228	275
		(5.21)	(13.21)	(27.12)	(10.14)	(12.23)
11. Services	106,704	7,835	595	4,669	468	611
		(7.34)	(7.59)	(59.59)	(5.97)	(7.80)
Total	988,863	78,505	11,141	36,740	9,418	6,323
		(7.94)	(14.19)	(46.80)	(12.00)	(8.05)
Per Capita (baht)	19,622	25,210	22,283	47,963	23,904	17,323
		(1.28)	(0.88)	(1.90)	(0.95)	(0.69)

[1] : % of GDP

[2] : % of GRP

Note : At current market prices

Source : NESDB

Table 3.4-4 Comparison of GDP, Eastern Region GRP, 4 Province GPP

1985

Unit: million Baht (%)

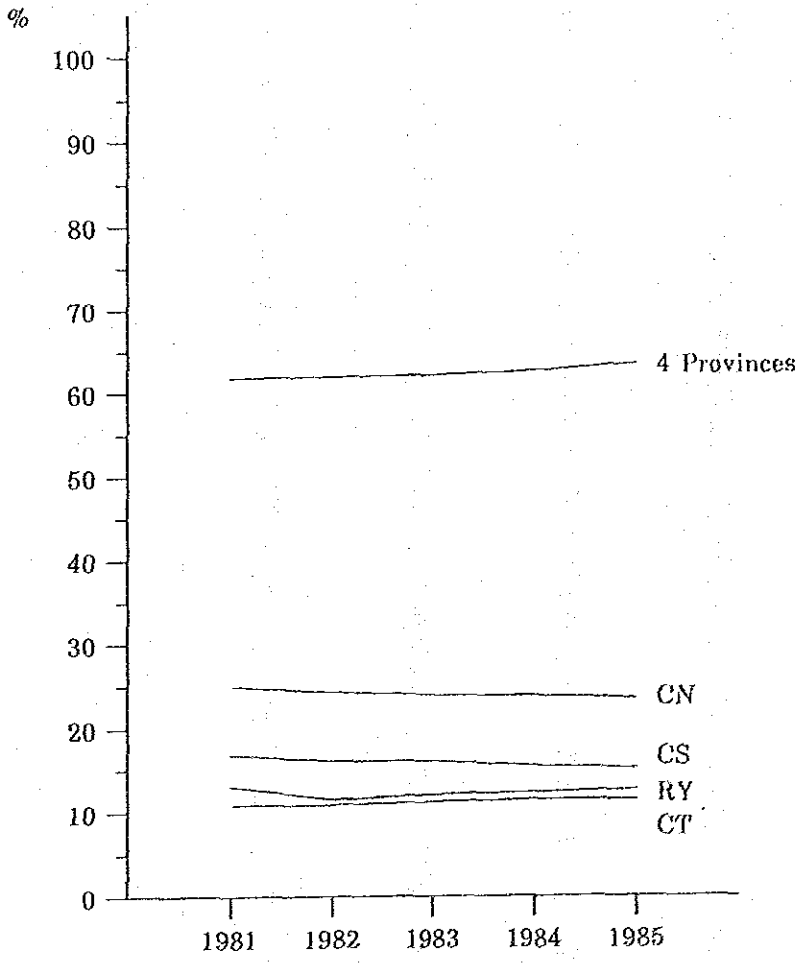
Province	GDP	Eastern Reg. GRP [1]	GRP [2]			
			Chachoengsao	Chonburi	Rayong	Chanthaburi
1. Agriculture	178,533	18,298	2,518	5,056	3,782	2,483
		(10.25)	(13.76)	(27.63)	(20.67)	(13.57)
2. Mining & Quarrying	29,240	7,410	6,277	805	197	34
		(25.34)	(84.71)	(10.86)	(2.66)	(0.59)
3. Manufacturing	209,014	18,056	221	16,692	340	186
		(8.64)	(1.22)	(92.45)	(1.88)	(1.03)
4. Construction	54,373	2,588	314	1,106	427	276
		(4.76)	(12.13)	(42.74)	(16.50)	(10.66)
5. Electricity & Water Supply	24,070	1,436	371	587	205	110
		(5.97)	(25.84)	(40.88)	(14.28)	(7.66)
6. Transportation & Communication	95,160	5,375	6785	1,268	1,445	309
		(5.65)	(12.56)	(23.59)	(26.88)	(5.75)
7. Wholesale & Retail Trade	189,736	12,450	1,831	3,669	1,447	1,355
		(6.56)	(14.71)	(29.47)	(11.62)	(10.88)
8. Banking, Insurance & Real Estate	84,922	3,739	500	1,584	460	493
		(4.40)	(13.37)	(42.36)	(12.30)	(13.19)
9. Ownership of Dwellings	13,608	887	152	214	112	107
		(6.52)	(17.14)	(24.13)	(12.63)	(12.06)
10. Public Administration & Defense	47,136	2,471	325	672	253	317
		(5.24)	(13.15)	(27.20)	(10.24)	(12.83)
11. Services	115,562	8,478	644	5,060	505	659
		(7.34)	(7.60)	(59.68)	(5.96)	(7.77)
Total	1,041,354	81,188	13,828	36,713	9,173	6,329
		(7.80)	(17.03)	(45.22)	(11.30)	(7.80)
Per Capita (baht)	20,299	25,603	27,168	47,068	22,875	17,014
		(1.26)	(1.06)	(1.84)	(0.89)	(0.66)

[1] : % of GDP

[2] : % of GRP

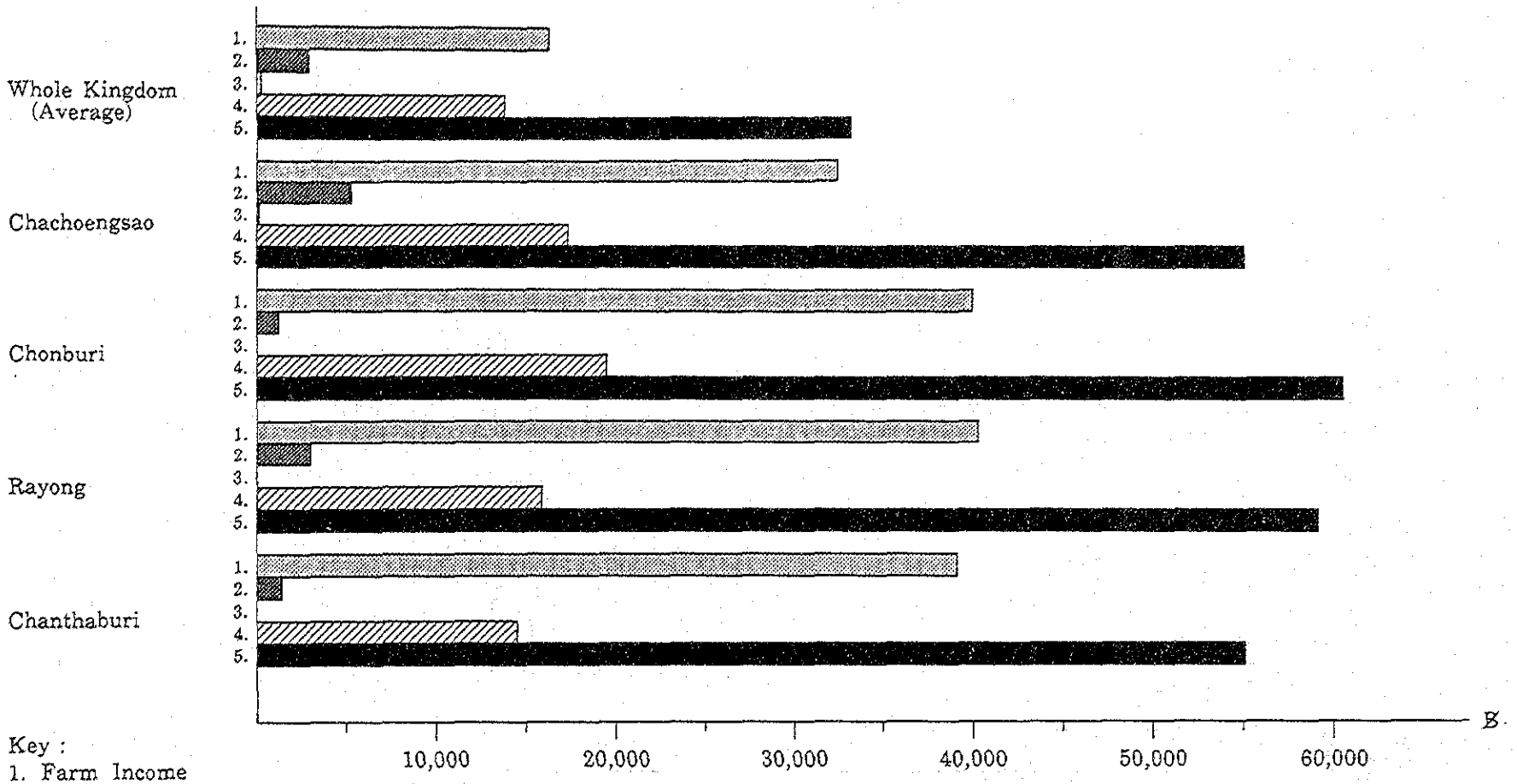
Note : At current market prices

Source : NESDB



Source : NSO, 1985

Figure 3.4-3 4 Provinces % of Eastern Region Population



Source : OAE, MOAC, 1987

Figure 3.4-4 Total Cash Income per Farm – All Sources Average Crop Year 1982/83

3-5 Cultivation and Farm Management

(1) Cultivation

Table 3.5-1 and Figure 3.5-1 ~ 3.5-3 show present condition of crop cultivation and production in the four provinces. Among the four provinces in the region, Chachoengsao is leading in the areal percentage of paddy and Chonburi and Rayong are two leading provinces in field crops. As far as fruit tree and tree are concerned Chanthaburi is leading followed by Rayong.

It is possible to say from those figures that the four provinces are the area of field crops and fruit tree and Para-rubber.

Its feature is as follows;

	Province			
Crop	Chachoengsao	Chonburi	Rayong	Chanthaburi
rice	○			
cassava	○	○	○	
pineapple		○	○	
sugarcane		○		
coconut		○		
rubber			○	○
mango	○	○		
rambutan				○
durian				○
jack fruit		○		
cashew nut	○	○	○	○
mangosteen				○

note: ○ shows main province

It is said that fertilizer application in crop production in Thailand remains at a very low level compared with other countries. This is also true in the four province of the region.

For instance, according to cost survey of cassava in 1986 by DOAE only 8.7 Baht/rai chemical fertilizer was applied as the average of whole country. In Agro-economic zone 13 (Chachoengsao and Prachinburi) no fertilizer was applied, in zone 15 (Chonburi, Rayong) 68.1 Baht/rai was invested.

The recommendation of fertilizer for cassava production is 50 ~ 80 kg/rai (313 ~ 500 kg/ha) of (15-15-15) fertilizer in sandy soil. This corresponds to 294 ~ 470 Baht/rai, on the basis of retail price at Chachoengsao (5.87 Baht/kg) in 1987. Even in zone 15, however, only one forth or one seventh of recommended amount of fertilizer is presently applied.

Table 3.5-2 shows the relationship between productivity and amount of fertilizer applied in cassava production in some pilot areas. These figures are from the economic survey and the amount of fertilizer applied are converted on the basis mentioned above. According to Figure 3.5-4, quite high correlation ($r = 0.81^{**}$) is observed between the two factors. Judging from these figures, it is possible to say that there is much room to improve yielding capacity of cassava and that one of immediate countermeasures for increasing the productivity is improvement of fertilization.

To the question made by the economic survey team "why do not use fertilizer?", there were several answers as follows though many farmers did not answer at all.

1) Not recommended
2) Do not know how to use
3) Fertilizer is too expensive
4) Fertilizer is not necessary because soil is good

It was surprising that some farmers think that soil of their fields is good for crop cultivation.

It is necessary to let them know the importance of fertilizer and it is also very obvious that the price of fertilizer is the main obstacle to its application.

Cassava has been found to be an erosion causing crop and efforts for diversification are being made. However, it is the most adaptable crop to the environment and without it, present economical standards could not have been reached. If extension of the new cassava variety "Rayong 60" release in 1986, is accelerated with more fertilizer application the future of the crop is rather bright as far as yield is concerned.

Increasing of soil fertility is the basic problem confronted in attaining high, stable and good quality agricultural products but it is very difficult in the pilot areas judging from the present conditions. This is the reason why fertilizer application has to be emphasized not only in cassava production but also in other crops.

(2) Farm management

Economical survey of selected farm households in the Project area was carried out by interview. The results related to soil erosion and substitute crop for cassava in the four representative sites are summarized as shown in Table 3.5-3.

Cassava is found to be the most affected by erosion and the majority of yield loss by erosion is 10% or below that. However, in Chachoengsao and Chonburi, some farms estimate as much as 20% ~ 40%.

Countermeasures against erosion adopted by farmers themselves are dike or terrace and many farmers are complaining of lack of technical know-how.

As for substitute crop of cassava, fruit trees and pineapple have the highest demand. Farmer's, requests for assistance in crop substitution are credit, technical know-how and water supply.

Table 3.5-1 Agricultural Land-use in the Four Provinces in the East

(1000 ha)

Province	Total Farm Land	Paddy	Field Crop	Fruit Tree and Tree	Vegetable	Others
Chachoengsao	267	156	70	22	0.6	18
	(100%)	(58.4)	(26.2)	(8.2)	(0.2)	(6.7)
Chonburi	306	58	205	30	0.5	12
	(100)	(19.0)	(67.0)	(9.8)	(0.2)	(3.9)
Rayong	206	28	130	39	0.5	9
	(100)	(13.6)	(63.1)	(18.9)	(0.2)	(4.3)
Chanthaburi	198	36	46	83	0.6	32
	(100)	(18.2)	(23.2)	(41.9)	(0.3)	(16.2)

Source: Agricultural Statistics of Thailand 1986/87 Crop Year, DOAE.

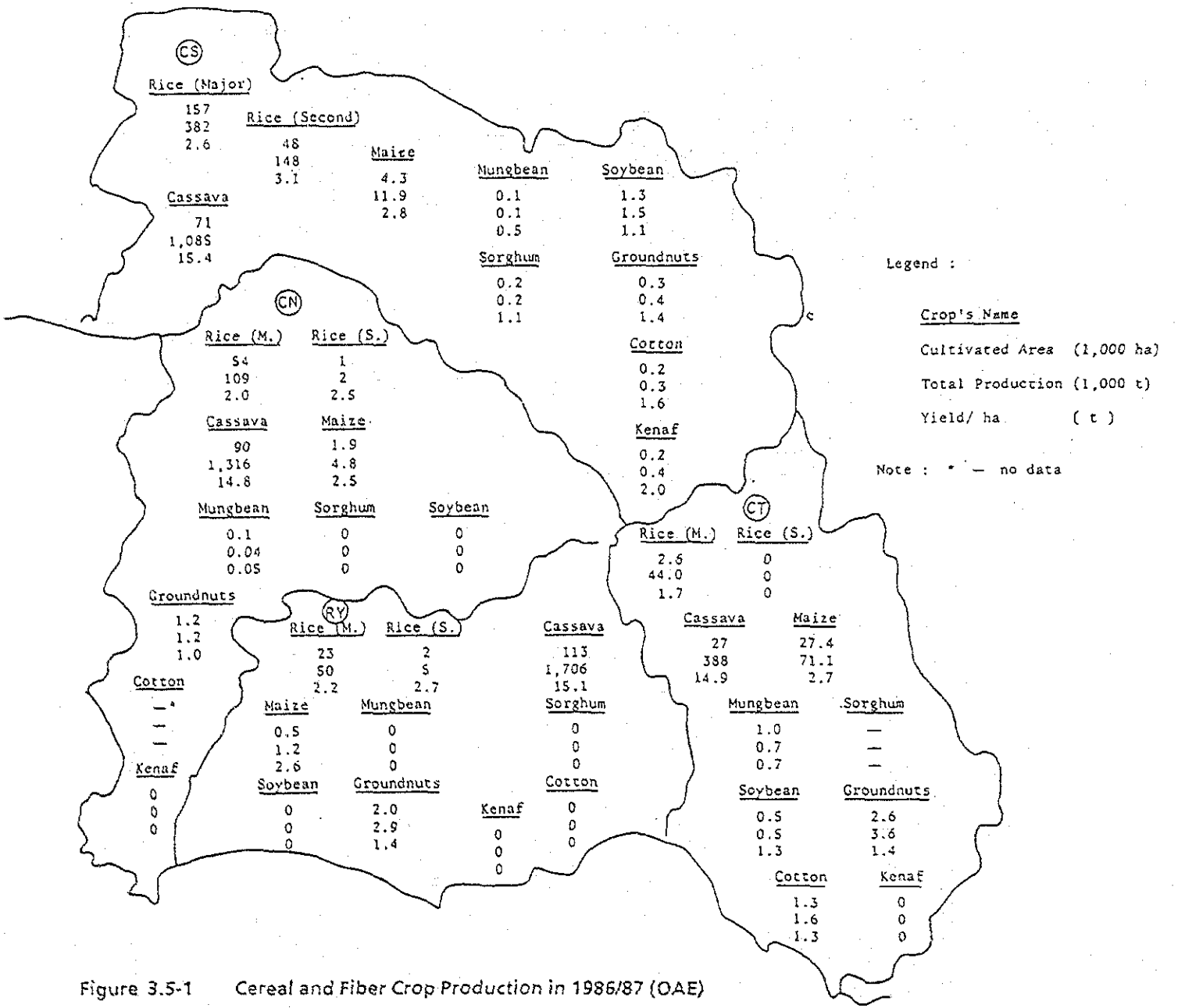


Figure 3.5-1 Cereal and Fiber Crop Production in 1986/87 (OAE)

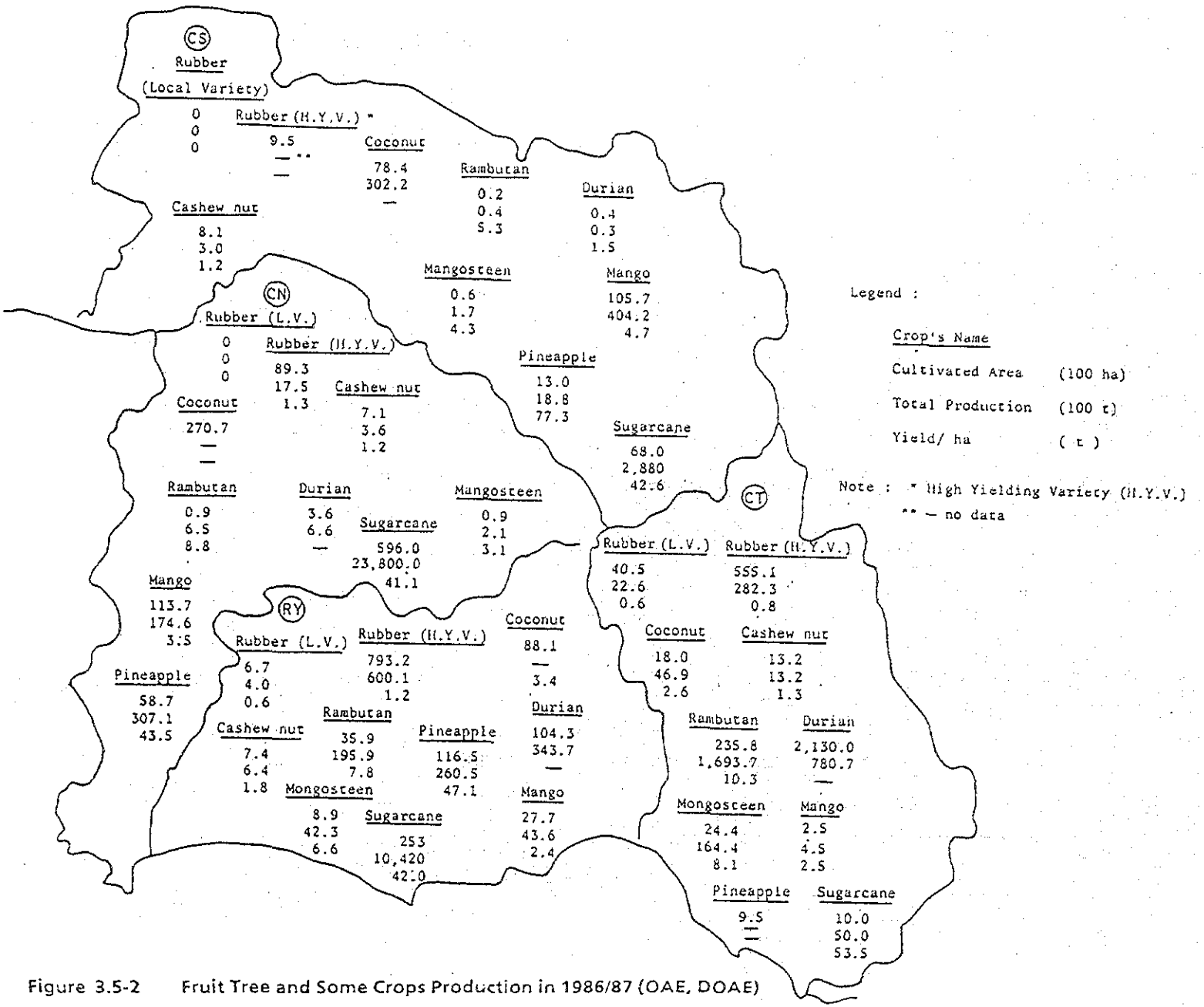


Figure 3.5-2 Fruit Tree and Some Crops Production in 1986/87 (OAE, DOAE)

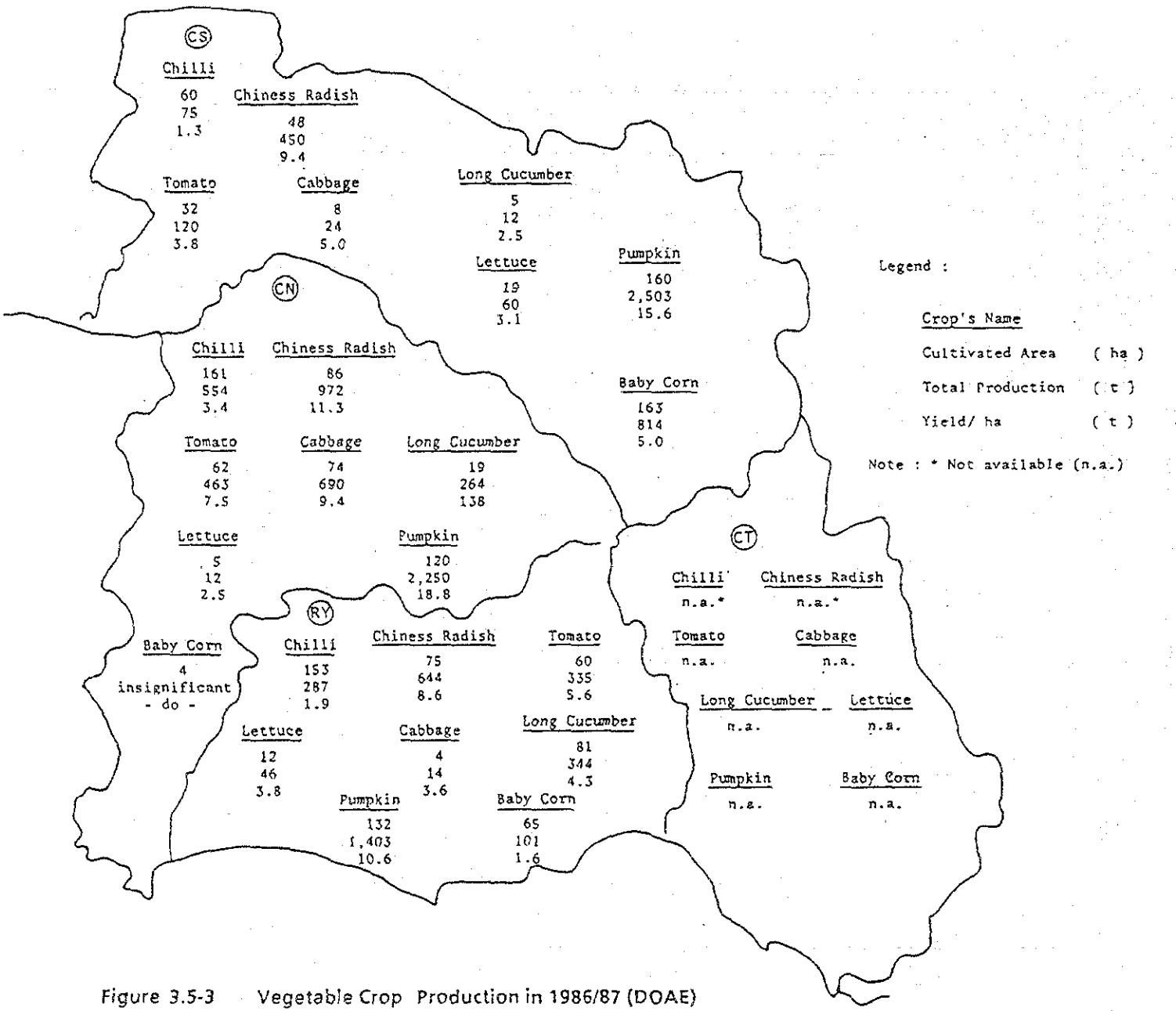


Figure 3.5-3 Vegetable Crop Production in 1986/87 (DOAE)

Table 3.5-2 Relationship between Productivity and Cost of Fertilizer Applied in Cassava Production in Some Pilot Areas (1988)

Pilot Area	Productivity (t/ha)	Fertilizer (15:15:15) (kg/ha) *
CS – No. 3	12.4	72
– 4	12.5	121
– 5	9.4	0
– 8	12.2	64
CN – No. 1	16.6	248
– 8	10.6	169
RY – No. 2	22.2	330
CT – No. 2	14.6	61
– 3	19.1	177

Note: * converted on the basis of 5.87 ฿/kg of 15:15:15 fertilizer

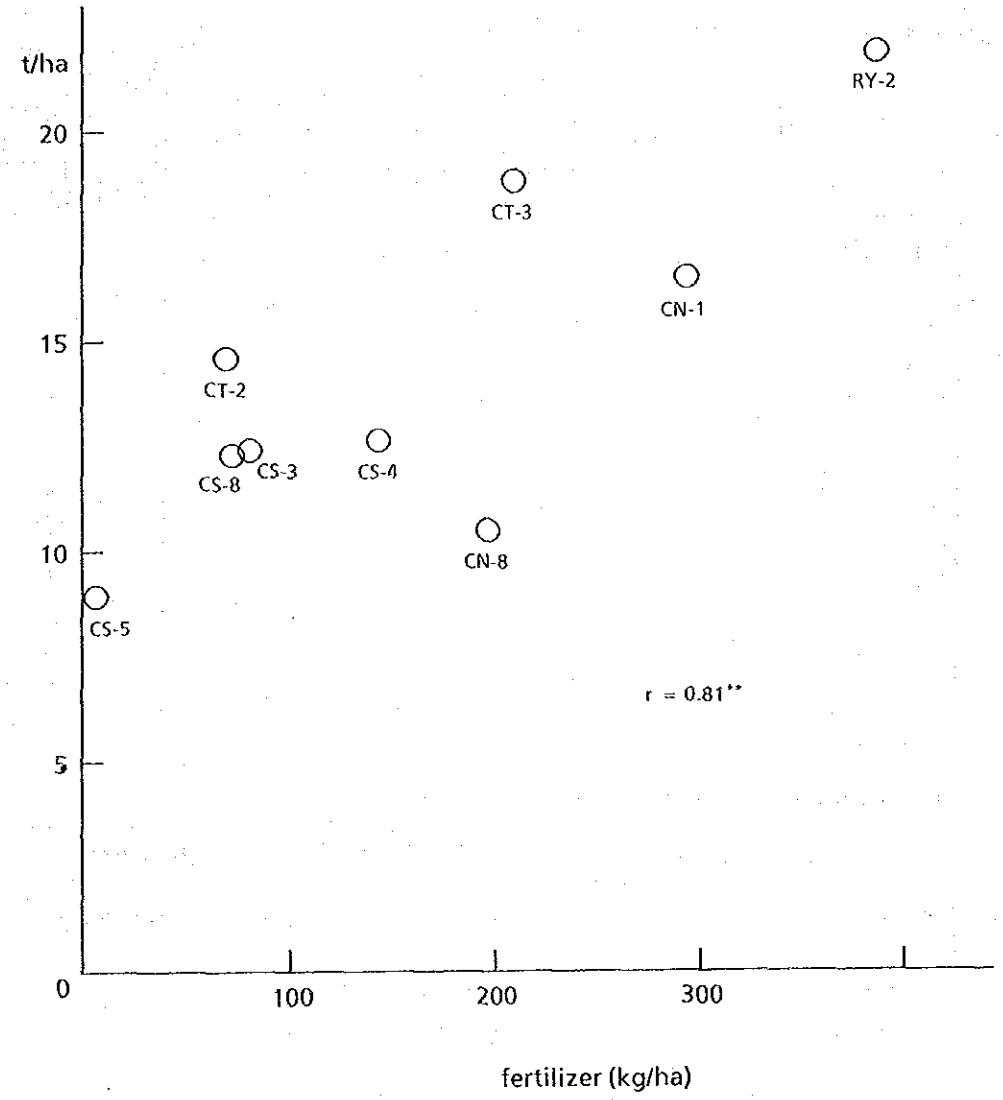


Figure 3.5-4 Relationship between Productivity and Fertilizer Applied (15:15:15) in Cassava Production in Some Pilot Areas (1988)

Table 3.5-3 Erosion Related Information Collected from Pilot Areas

1. Erosion

(1) Estimated yield loss by erosion by number of farm

Site	Crop	Estimated Yield Loss			Total No. of Farm
		~ 10%	10% ~ 20%	20% ~ 40%	
CS - No. 3	Cassava	1	1	4	13
	Para-rubber			1	3
CN - No. 8	Cassava		1	2	4
	Sugarcane	2			4
	Watermelon	1			1
RY - No. 2	Cassava	8	2	1	15
	Pineapple	2		1	7
	Cashew nut	1			1
	Coconut	1			1
CT - No. 2	Cassava	6	1	1	9
	Durian	1		1	2

(2) Countermeausres tried against erosion and the results

Site	Countermeasures	Results (No.)	Remarks
CS - No. 3	Dike	Fair (2)	Lack of knowledge
CN - No. 8	Terracing, Dike	Good (2)	
	Waterway improvement	Fair (1)	
RY - No. 2	Mulching with coconut leaves	Good (2)	
	Grass waterway	Fair (8)	
	Canopy making by cassava	Fail (1)	
	Terracing, sand bag		
	Fruit tree planting along contour		
CT - No. 2	Dike	Fair (6)	Lack of knowledge
		Fail (1)	

2. Substitute Crop of Cassava

Site	Crop	Request for Assistance
CS - No. 3	Sugarcane, Pineapple Soybean	Credit, marketing and irrigation
CN - No. 8	Durian	
RY - No. 2	Para-rubber, Fruit tree Cashew nut, Sweet bamboo Pineapple, Passion- fruit	Supplying seeds, credit, technical know-how
CT - No. 2	Rambutan Durian	Technical know-how, irrigation

3-6 Rural Development

(1) Existing condition of the Study Area

1) Local civil administrative set-up

According to the Directory of Local Administration by the Department of Local Administration (1986), the Study Area; Chachoengsao, Chonburi, Rayong and Chanthaburi provinces, is organized as follows;

4 Provinces	(Changwat)
28 Districts	(Amphoes)
3 Small Districts	(King Amphoes)
287 Sub-Districts	(Tambons)
2,334 Villages	

Each province is headed by a governor who is appointed by the Ministry of Interior. Each district is administered by a district officer (Nai Amphoe), who is under the direct authority of the provincial governor. Deputy district officers (Kamnans) supervise each sub-district. Each village is supervised by a headman (Puyai Ban). Both positions, Kamnan and Puyai Ban, are locally elected officers. In addition to these government units, there are also four forms of local self-government administration ; Provincial administrative organization, Municipality, Sanitary district and sub-district councils. There are 11 municipalities and 48 sanitary districts in the Study Area.

2) Rural population

As of 1985, total population in the Study Area was 2,441,275 and about 35% of the total population (745,105) live in towns/cities and the remaining 65% (1,396,170) live in rural areas, according to the NESDB's data.

3) Domestic/Drinking water

During the field surveys it was found that development of domestic/drinking water resources was urgently requested by rural people. As a result of the field survey, it was found that most of the households have their own or common shallow well but were suffering from a shortage of water in the dry season. Fundamental Data at the Village Level (hereafter referred to as Fundamental Data) shows the following :

Province	No. of Villages Having Water Shortage	No. of Villages Having Sufficient Water from Sources	
		at>1 km distance	Requiring>30 Min
Chachoengsao	498	22	2
Chonburi	285	40	3
Rayong	52	8	2
Chanthaburi	392	5	-
Total	1,227	75	7

Villages having a water shortage problem are :

Chachoengsao 64% (498 villages/782 villages)
Chonburi 44% (285 villages/653 villages)
Rayong 16% (52 villages/323 villages)
Chanthaburi 68% (392 villages/576 villages)

Therefore, domestic water development should be a core of rural development in the Study Area.

(2) Rural roads

Field investigation made the rural road condition clear by revealing that density of roads including farm roads is very low and roads without laterite pavement become muddy and impassable to vehicles during rainy weather. This matter also will be a core of rural development in the Study Area.

(3) Rural electrification

According to the fundamental data, it is recognized that rural electrification is progressing well. However, there are many villages which have little or no electrification as follows.

Unit : No. of villages

	Chachoengsao	Chonburi	Rayong	Chanthaburi	Total
More than half of households using public electricity	533 (73.5%)	388 (78.55)	202 (67.1%)	347 (66.2%)	1,470 (71.9%)
Half or less than half of households using public electricity	72 (9.9)	80 (16.2)	49 (16.3)	120 (22.9)	321 (15.7)
No. public electricity	120 (16.6)	26 (5.3)	50 (16.6)	57 (10.9)	253 (12.4)
Total	725 (100.0)	494 (100.0)	301 (100.0)	524 (100.0)	2,044 (100.0)

This item may also be a core for rural development in the Study Area.

(4) Public health

Rural people live in unfavorable health conditions typical of which is poor drinking water resources. Recently, public health care units have been established in most villages and this field has been improved very much.

Fundamental Data shows the existing rural public health condition as follows.

Unit : No. of villages

Criteria	Chachoengsao	Chonburi	Rayong	Chanthaburi	Total
1. There are no first-aid kits in the village. When the sickness is not serious, people buy simple medication at a drug store.	340 (47.4%)	236 (48.0%)	115 (38.5%)	163 (31.0%)	854 (42.1%)
2. There are first-aid kits, medical funds and supplies in the village. When the sickness is not serious, people go to the Health Center or clinic.	188 (26.4%)	133 (27.0%)	79 (26.4%)	215 (41.0%)	615 (30.3%)
3. There are first-aid kits, medical funds and supplies in the village. When the sickness is not serious, people buy medication at a drug store.	185 (25.9%)	123 (25.0%)	105 (35.1%)	147 (28.0%)	560 (27.6%)
Total	713 (100%)	492 (100%)	299 (100%)	525 (100%)	2,029 (100%)

(5) Education

Compulsory education has spread widely and more than 90% of children attend elementary school.

Educational facilities in the village

Unit : No. of villages

Criteria	Chachoengsao	Chonburi	Rayong	Chanthaburi	Total
1. No facilities	355 (48.9%)	288 (45.8%)	90 (30.9%)	250 (46.4%)	923 (44.9%)
2. No primary or secondary school except children's development center, children's nutrition center,village library or news distribution center.	59 (8.1%)	42 (8.4%)	16 (5.5%)	45 (8.3%)	162 (7.9%)
3. Primary or secondary school exists in the village	312 (43.0%)	228 (45.8%)	185 (63.6%)	244 (45.3%)	969 (47.2%)
Total	726 (100%)	498 (100%)	291 (100%)	539 (100%)	2,054 (100%)

Looking at the table above which is from the fundamental data of NESDB, it might be considered that there are many villages which have no schools. This is probably caused by the form of village structure of dispersed households.

(6) Facilities for agriculture

As soil and water conservation aims at agricultural development, this matter is also very important and in order to meet the main objective of this study the planning concerning this matter must be made. The fundamental data shows the existing condition of the facilities for agriculture in the Study Area as follows.

Unit : No. of villages

Criteria	Chachoengsao	Chonburi	Rayong	Chanthaburi	Total
No rice mills, shops, storehouse for crops, places for supplying agricultural materials. Even though there are such facilities, but only one.	222	101	37	122	482
There are rice mills, shops, places for supplying agricultural materials, but only 2-3 store-houses.	211	136	55	129	533
There are rice mills, shops, places for supplying agricultural materials, more than 3 storehouses.	284	260	209	276	1,029

Annex 4.

PROJECT EVALUATION

ANNEX 4 PROJECT EVALUATION

4-1 Analysis of Commodity Prices and Labor Cost

(1) Output price

For estimation of the financial prices of the internationally traded/tradable farm products, the world market prices have been quoted from December 1987 World Bank Commodity Forecast for 1995 prices expressed in 1985 constant US dollars. These have been adjusted by applying the MUV index at the relevant exchange rate to arrive at the 1988 price. As for crops which are major Thai exported commodities but of which prices are not projected by the World Bank, their projected prices have been assumed on the basis of the average export prices F.O.B. Bangkok during the 5 year period 1982-1986 and the future price trend of the same categories commodities forecasted by the World Bank. For example, cassava is obviously an internationally traded crop in Thailand, however, its world market price is not available from the World Bank publication. Therefore, the 1995 projected price of cassava was assumed in the following manner.

- According to the Thai foreign trade statistical data, the average export price of cassava pellets over the five year period (1982-1986) was US $ 98.7 per ton at 1985 constant prices. (see Table 4.1-14)
- The 1995 projected prices of maize and grain sorghum in terms of real value are expected to decline by 16% from their average prices during the 5 year period 1982-1986 according to World Bank publication. (see Table 4.1-13)
- Hence the 1995 price of cassava (1985 constant price) was estimated at US $82.9 per ton (= US $98.7 × 0.84).
- The 1995 price of cassava at 1988 constant prices was worked out at 2,970 baht per ton by applying the MUV index and the exchange rate of 25.52 Baht per US dollar.

The above estimation is based on the assumption that the cassava price is responsive to the price trends of maize and grain sorghum on the world market. Because cassava, maize and grain sorghum are mainly

consumed as livestock feed and they are considered mutually competitive on the world trade market.

The other crops of which prices are not available from the World Bank publication have been dealt with in the same manner as cassava. (see Table 4.1-14)

The financial farmgate prices of internationally traded/tradable crops were estimated by considering the various cost components between border (Bangkok) and the project area such as transport, handling and storage, processing, tax and margins. Economic farmgate prices have been derived by excluding various transfer payments and adjusting domestic financial costs by applying the conversion factors. Details of the estimation of the farmgate prices of internationally traded/tradable commodities have been given in Tables 4.1-2 to 4.1-9.

The financial farmgate prices of domestically traded items are determined on the basis of statistical data collected from the authorities concerned and the farm economic survey. Economic farmgate prices of these outputs are deduced by applying the distorted ratio between the financial and economic prices of internationally traded commodities.

(2) Input prices

Economic pricing of the input materials, both traded and non-traded, has been done basically on the same principle as the output prices. Financial price of seed commercially produced is estimated using the local retail market prices and has been converted by the economic/financial price ratio of its output to arrive at its economic price.

Fertilizers are all internationally traded/tradable inputs and thus are priced in the same manner as the internationally traded output. (see Table 4.1-10 - 4.1-12)

The economic price of agro-chemicals are estimated by applying the economic/financial price ratio of three fertilizers combined to the financial price from the local market.

(3) Economic cost of farm labor

Hired labor is reportedly required for farm work in and around most pilot areas throughout the year at a wage rate ranging from 35 to 50 Baht per man-day or about 40 Baht on an average.

It is presumed that the labor wage rates in the East are more responsive to locality than to seasonality. This means that the wage rates are almost stable year round within a certain area but different by about 10 Baht among the 4 provinces even during the same farming season. Since the agricultural and socio-economic situation differs by province, the wage rates reflect the difference in such a situation.

The Eastern Region is favored with an advantageous location due to its close proximity to the eastern coastal area and Bangkok. Also agro-industry has been developed by using local agricultural products. In view of the above conditions, off-farm employment opportunities are considered to be relatively large. The fact that a number of local farmers are working in Bangkok and/or at the local agricultural processing factories explains the labor market situation in the East. Meanwhile since main crops in the East are various kinds of upland crops, fruit trees, para-rubber, etc., farm labor demand is comparatively well balanced throughout the year, which is different from the monoculture areas.

The preceding suggests that the labor market in the East is almost competitive, which implies the present wage rate averaged at 40 Baht per man-day is considered to reflect opportunity cost of unskilled laborers. Thus the economic wage rate is estimated to be 37 Baht per man-day by adjusting the market price by the S.C.F.

(4) Economic oportunity cost of unskilled construction labor

The majority of unkilled construction labor for the project would be supplied by farm labor. The farmers are expected to serve as temporary laborers during the construction work period sacrificing the employment opportunities in agricultural activities. Thus, the economic opportunity cost of unskilled construction labor is considered to be equal to that of farm labor. The economic cost of the farm labor is estimated at 37 Baht per man-day as mentioned above, while the financial wage rate of unskilled construction labor is 75 Baht per man-day. Consequently, the conversion

factor for the unskilled construction labor is taken as Baht 37 / Baht 75 = 0.49.

Table 4.1-1 Summary of Input / Output Prices

Item	Unit	Financial	Economic
Input			
1. Seed			
a) Cassava	Baht/seedling	0.04	0.04
b) Pineapple	"	0.4	0.48
c) Sugarcane	"	0.5	0.55
d) Para-rubber	"	5.5	7.9
e) Durian	"	25	26.8
f) Mango	"	10	10.8
g) Rambutan	"	25	26.9
h) Cashew Nut	"	12	12.9
2. Fertilizer			
a) 15-15-15	Baht/kg	7.0	6.8
b) 14-14-21	"	7.2	6.9
c) 16- 8-16	"	6.0	5.8
d) 20-10-10	"	6.6	6.4
3. Labor	Baht/man-day	40	37
4. Land Preparation (Contract)	Baht/ha	1,000	920
Output			
a) Cassava	Baht/t	688	759
b) Pineapple	"	1,645	1,978
c) Sugarcane	"	375	415
d) Para-rubber	"	15,759	22,609
e) Durian	"	15,025	16,091
f) Mango	"	5,333	5,736
g) Rambutan	"	6,714	7,211
h) Cashew Nut	"	12,882	13,500
i) Fresh Fish	"	20.0	18.4

Table 4.1-2 Price Structure of Cassava

Cost Items		Unit	Constant 1988 Price		
			Financial	(CF)	Economic
Projected 1995 Export Price, F.O. B. Bangkok, Pellets	1)	Baht/t	2,970	-	2,970
Business and Municipal Taxes	2)	Baht/t	65	0	0
Exporter's Margin	3)	Baht/t	149	0.92	137
Wholesaler's Margin	4)	Baht/t	74	0.92	68
Transport & Handling to Bangkok		Baht/t	250	0.87	218
Ex-factory Price of Pellets		Baht/t	2,432	-	2,547
Pelletizing Cost and Pelleter's Margin	5)	Baht/t	170	0.92	156
Input Price of Chips at Pelletizing Factory	6)	Baht/t	2,262	-	2,391
Transport & Handling from Chipper's to Pelletizing Factory	7)	Baht/t	113	0.87	98
Chip's Price at Chipping Floor		Baht/t	2,149	-	2,293
Chipping Cost and Chipper's Margin	8)	Baht/t	236	0.92	217
Input Price of Cassava Roots at Chipping Floor	9)	Baht/t	765	-	830
Merchant's Margin	10)	Baht/t	77	0.92	71
Farm Gate Price of Roots		Baht/t	688	-	759

Note : 1) Based on the average Thai expot price during 1982 - 1986, the projected price is assumed taking into account the relationship between the world market prices of maize and grain sorghum over 1982 - 1986 and the World Bank 1995 projected prices for them (refer to Table 4.1-14).

2) Business Tax : two percent of F.O.B. Bangkok price
Municipal Tax: ten percent of Business Tax

3) five percent of F.O.B. Bangkok price

4) 2.5 percent of F.O.B. Bangkok price

5) Seven percent of Ex-factory price of pallets

6) 1.05 ton of cassava chips are equivalent to 1 ton of pellets.

7) five percent of input price of chips at pelletizing factory

8) eleven percent of chips price at chipping floor

9) 2.5 ton of cassava roots are equivalent to 1 ton of cassava chips.

10) ten percent of input price of roots at chipping floor including transport, handling and profit.

Table 4.1-3 Price Structure of Pineapple

Cost Items		Unit	Constant 1988 Price		
			Financial	(CF)	Economic
Projected 1995 Export Price, F.O.B. Bangkok, Canned (Net)	1)	Baht/t	14,300	–	14,300
Exporter's Margin	2)	Baht/t	2,860	0.92	2,631
Transport and Handling to Bangkok	3)	Baht/t	227	0.87	197
Ex-factory Price of Canned Pineapple		Baht/t	11,213	–	11,472
Processing Cost and Processor's Margin	4)	Baht/t	6,728	0.92	6,190
Input Price of Fresh Pineapple at Processing Factory	5)	Baht/t	1,794	–	2,113
Value of By-Product		Baht/t	30	–	30
Merchant's Margin	6)	Baht/t	179	0.92	165
Farm Gate Price		Baht/t	1,645	–	1,978

1) Current price, quoted from 'Agricultural Ecomomic News No.34, Jan. 2531' by OAE, MOAC

2) 20 percent of F.O.B. Bangkok price, including storing and handling charges

3) 1,500 Baht by container (11 ton), the transportation ratio (net) ; 60%

4) 60 percent of Ex-factory price

5) 2.5 ton of fresh pineapple is equivalent to 1 ton of pineapple canned

6) ten percent of input price at processing factory

Table 4.1-4 Price Structure of Rubber

Cost Items		Unit	Constant 1988		
			Financial	(CF)	Economic
Projected 1995 World Market Price					
RSS No.1, in bales, Spot New York	1)	US$/t	1,300	–	1,300
Ocean Freight and Insurance		US$/t	200	–	200
Grade Differential	2)	%	98	–	98
Projected 1995 Export Price		US$/t	1,078	–	1,078
F.O.B. Bangkok, RSS 3	3)	Baht/t	27,511	–	27,511
Custom Gate Duty		Baht/t	20	0	0
Estimated Cess	4)	Baht/t	1,801	0	0
Estimated Export Tax	5)	Baht/t	5,784	0	0
Exporter's Margin	6)	Baht/t	275	0.92	253
Transport and Handling to Bangkok		Baht/t	200	0.87	174
Ex-factory Price, Smoked Sheet		Baht/t	19,431	–	27,084
Processing Cost and Processor's Margin	7)	Baht/t	1,360	0.92	1,251
Input Price at Processing Factory, RSS Dry Rubber Content (DRC)		Baht/t	18,071	–	25,833
Merchant's Margin	8)	Baht/t	181	0.92	167
Farm Gate Price, RSS DRC		Baht/t	17,890	–	25,666
Farm Gate Price,DRC	9)	Baht/t	17,318	–	24,845
Farm Gate Price, Weight Sold	10)	Baht/t	15,759	–	22,609

Note : 1) December 1987 World Bank Forecast for 1995 Price in 1985 constant US dollar adjuysted to 1988 constant US dollar using MUV index of 140.3

2) Based on ratio of RSS 3 to RSS 1 prices averaged over the period 1974-1982 (Songkhla Lake Basin Planning Study, NESDB)

3) 1US$ = 25.52 Baht

4) 50 Bath per ton for assumed gazetted price less than 10,000 Baht per ton plus 10 percent of prices above 10,000 Baht per ton

5) Using RRC formula (gazetted price- 5,800 Baht) × 0.4-2,900 Baht

6) One percent of F.O.B Bangkok price, including port charge

7) Seven percent of Ex-factory price

8) One percent of input price at processing factory, including transport, handling and profit

9) Eight percent scrap sells at a discount of 40 percent from sheet

10) Adjusted for moisture content assumed to be 9 percent

Table 4.1-5 Price Structure of Sugarcane

Cost Items	Unit	Constant 1988 Price		
		Financial	(CF)	Economic
Projected 1995 Export Price, F.O.B Carribean Port, raw sugar 1)	US$ /t	340	–	340
Corresponding F.O.B. Price Bangkok 2)	Baht / t	7,809	–	7,809
Bussiness Tax 3)	Baht / t	156	–	–
Exporter's Margin 4)	Baht / t	781	0.92	719
Transport & Handling to Bangkok	Baht / t	250	0.87	218
Ex-factory Price of Sugar	Baht / t	6,622	–	6,872
Processing Cost and Processor's Margin 5)	Baht / t	1,987	0.92	1,828
Input Price of Sugarcane at 6) Processing Factory	Baht / t	417	–	454
Merchant's Margin 7)	Baht / t	42	0.92	39
Farm Gate Price	Baht / t	375		415

1) December 1987 World Bank Commodity Price Forecast for 1995 Price in1985 constant US dollar adjusted to 1988 constant dollar using MUV index of 140.3 at 1US$ = 25.52 Baht

2) Ten percent below the projected 1995 Export Price which is considered to reflect the long-term relationship berween F.O.B Bangkok and F.O.B Carribean Ports prices

3) Two percent of F.O.B. Bangkok price

4) Ten percent of F.O.B. Bangkok price

5) 30 percent of Ex-factory price, considering value of By-product

6) 90 kg of sugar is equivalent to 1 ton of sugarcane

7) Ten percent of input price of sugarcane at processing factory, including transport, handling, service charge by leaders under 'Quota Leader System' charges, etc.

Table 4.1-6 Price Structure of Durian

Cost Items		Unit	Constant 1988 Price		
			Financial	(CF)	Economic
Projected 1995 Export Price, F.O.B. Bangkok, Fresh	1)	Baht/t	28,200	-	28,200
Exproter's Margin	2)	Baht/t	3,666	0.92	3,373
Wholesaler's Margin	3)	Baht/t	2,820	0.92	2,594
Transport & Handling to Bangkok		Baht/t	250	0.87	218
Local Price, Fresh		Baht/t	21,464	-	22,015
Merchant's Margin	4)	Baht/t	6,439	0.92	5,924
Farm Gate Price		Baht/t	15,025	-	16,091

1) Based on the average Thai export price over 1982-1986, the projected price is assumed taking into account the relationship between the world market prices of orange and banana for 1982-1986 and the World Bank 1995 projected prices for them (refer to Table 4.1-14).
2) 13 percent of F.O.B, Bangkok price, including storage and handling charges, etc.
3) Ten percent of F.O.B. Bangkok price
4) 30 percent of the local price, including local transportation, handling charges and profit

Table 4.1-7 Price Structure of Mango

Cost Items		Unit	Constant 1988 Price		
			Financial	(CF)	Economic
Projected 1995 Extort Price, F.O.B. Bangkok, Fresh	1)	Baht/t	10,220	-	10,220
Exporter's Margin	2)	Baht/t	1,329	0.92	1,223
Wholesaler's Margin	3)	Baht/t	1,022	0.92	940
Transport & Handling to Bangkok		Baht/t	250	0.87	218
Local Price, Fresh		Baht/t	7,619	-	7,839
Merchant's Margin	4)	Baht/t	2,286	0.92	2,103
Fatm Gate Price		Baht/t	5,333	-	5,736

1) Based on the average Thai export price over 1982-1986, the projected price is assumed taking into account the relationship between the world market prices of orange and banana for 1982-1986 and the World Bank 1995 projected prices for them (refer to Table 4.1-14).
2) 13 percent of F.O.B, Bangkok price, including storage and handling charges, etc.
3) Ten percent of F.O.B. Bangkok price
4) 30 percent of the local price, including local transportation, handling charges and profit

Table 4.1-8 Price Structure of Rambutan

Cost Items		Unit	Constant 1988 Price		
			Financial	(CF)	Economic
Projected 1995 Export Price, F.O.B. Bangkok, Fresh	1)	Baht/t	12,780	-	12,780
Exporter's Margin	2)	Baht/t	1,661	0.92	1,528
Wholesaler's Margin	3)	Baht/t	1,278	0.92	1,176
Transport & Handling to Bangkok		Baht/t	250	0.87	218
Local Price, Fresh		Baht/t	9,591	-	9,858
Merchant's Margin	4)	Baht/t	2,877	0.92	2,647
Fatm Gate Price		Baht/t	6,714	-	7,211

1) Based on the average Thai export price over 1982-1986, the projected price is assumed taking into account the relationship between the world market prices of orange and banana for 1982-1986 and the World Bank 1995 projected prices for them (refer to Table 4.1-14).
2) 13 percent of F.O.B. Bangkok price, including storage and handling charges, etc.
3) Ten percent of F.O.B. Bangkok price
4) 30 percent of the local price, including local transportation, handling charges and profit

Table 4.1-9 Price Structure of Cashew nut

Cost Items		Unit	Constant 1988 Price		
			Financial	(CF)	Economic
Projected 1995 Extort Price, F.O.B. Bangkok, unshelled	1)	Baht/t	20,440	-	20,440
Exporter's Margin	2)	Baht/t	2,044	0.92	1,880
Wholesaler's Margin	3)	Baht/t	2,044	0.92	1,880
Transport & Handling to Bangkok		Baht/t	250	0.87	218
Local Price, Fresh		Baht/t	16,102	-	16,462
Merchant's Margin	4)	Baht/t	3,220	0.92	2,962
Fatm Gate Price		Baht/t	12,882	-	13,500

1) Based on the average Thai export price over 1982-1986, the projected price is assumed taking into account the relationship between the world market prices of soybeen over 1982-86 and its World Bank 1995 projected price. (refer to Table 4.1-14).
2) Ten percent of F.O.B. Bangkok price, including storage and handling charges, etc.
3) Ten percent of F.O.B. Bangkok price
4) 20 percent of the local price, including local transportation, handling, drying charges and profit

Table 4.1-10 Price Structure of Urea, 46 percent N

Cost Items		Unit	Constant 1988 Price		
			Financial	(CF)	Economic
Projected 1995 World Market Price, F.O.B. Europe	1)	US$/t	229	-	229
Ocean, Freight and Insurance		US$/t	50	-	50
Import Price, C.I.F. Bangkok		US$/t	279	-	279
		Baht/t	7,120	-	7,120
Tax	2)	Baht/t	142	0	0
Importer's / Wholesaler's Margin	3)	Baht/t	712	0.92	655
Transportation from Bangkok to Project Area		Baht/t	260	0.87	226
Wholesaler's Price		Baht/t	8,234	-	8,001
Retailer's Margin	4)	Baht/t	823	0.92	757
Farm Gate Price		Baht/t	9,057	-	8,758
Farm Gate Price of Nutrient (N)		Baht/t	19,689	-	19,039

Note : 1) December 1987 World Bank Price Forecast for 1995 Price in 1985 constant US dollar adjusted to 1988 constant dollar using MUV index of 140.3 at 1US$ = 25.52 Baht

2) Two percent of C.I.F. Bangkok price for business and municipal tax

3) Ten percent of C.I.F. Bangkok price including handling charge and profit

4) Ten percent of wholesaler's price including local transportation, handling charges and profit

Table 4.1-11 Price Structure of TSP, 45 percent P_2O_5

Cost Items		Unit	Constant 1988 Price		
			Financial	(CF)	Economic
Projected 1995 World Market Price, F.O.B. Europe	1)	US$/t	199	–	199
Ocean, Freight and Insurance		US$/t	50	–	50
Import Price, C.I.F. Bangkok		US$/t	249	–	249
		Baht/t	6,354	–	6,354
Tax	2)	Baht/t	127	0	0
Importer's/Wholesaler's Margin	3)	Baht/t	635	0.92	584
Transportation from Bangkok to Project Area		Baht/t	260	0.87	226
Wholesaler's Price		Baht/t	7,376	–	7,164
Retailer's Margin	4)	Baht/t	738	0.92	679
Farm Gate Price		Baht/t	8,114	–	7,843
Farm Gate Price of Nutrient (P_2O_5)		Baht/t	18,031	–	17,429

Note:
1) December 1987 World Bank Price Forecast for 1995 Price in 1985 constant US dollar adjusted to 1988 constant dollar using MUV index of 140.3 at 1US$ = 25.52 Baht
2) Two percent of C.I.F. Bangkok price for business and municipal tax
3) Ten percent of C.I.F. Bangkok price including handling charge and profit
4) Ten percent of wholesaler's price including local transportation, handling charges and profit

Table 4.1-12 Price Structure of Potassium Chloride, 60 percent K_2O_5

Cost Items		Unit	Constant 1988 Price		
			Financial	(CF)	Economic
Projected 1995 World Market Price, F.O.B. Europe	1)	US$/t	114	–	114
Ocean, Freight and Insurance		US$/t	50	–	50
Import Price, C.I.F. Bangkok		US$/t	164	–	164
		Baht/t	4,185	–	4,185
Tax	2)	Baht/t	84	0	0
Importer's/Wholesaler's Margin	3)	Baht/t	419	0.92	385
Transportation from Bangkok to Project Area		Baht/t	260	0.87	226
Wholesaler's Price		Baht/t	4,948	–	4,796
Retailer's Margin	4)	Baht/t	495	0.92	455
Farm Gate Price		Baht/t	5,443	–	5,251
Farm Gate Price of Nutrient (K_2O_5)		Baht/t	9,072	–	8,752

Note: 1) December 1987 World Bank Price Forecast for 1995 Price in 1985 constant US dollar adjusted to 1988 constant dollar using MUV index of 140.3 at 1US$ = 25.52 Baht

2) Two percent of C.I.F. Bangkok price for business and municipal tax

3) Ten percent of C.I.F. Bangkok price including handling charge and profit

4) Ten percent of wholesaler's price including local transportation, handling charges and profit

Table 4.1-13 Trend of International Prices of Major Commodities

(unit : US$ / ton, (1985 Constant dollars))

year	Maize	Grain Sorghum	Banana	Orange	Sugar	Rubber	Soybean
1982	106	105	362	372	180	970	237
1983	135	128	426	371	185	1,230	280
1984	137	120	374	356	116	1,110	285
1985	112	103	378	398	90	920	224
1986	74	70	323	333	113	800	176
Total	564	526	1,863	1,830	684	5,030	1,202
Ave.(A)	113	105	373	366	137	1,006	240
1995(B)	93	89	335	338	242	930	205
(B) / (A)	0.82	0.85	0.90	0.92	1.77	0.92	0.85

Source : Half-Yearly Revision of Commodity Price Forecast IBRD, December 1987

Table 4.1-14 Trend of Bangkok Export Prices of Major Commodities (1/3)

1) Cassava pellets

year	Quantity (10^3 ton)	Value (Baht x 10^6)	Unit Price (Baht/ton)	Exchang Rate (Baht/US$)	Unit Price (US$/ton)	MUV Index (1985 = 100)	1985 Constant Price (US$/ton)
1982	6,893	16,676	2,419	21.7	111.5	103.3	107.9
1983	4,554	12,650	2,778	23.0	120.8	100.7	120.0
1984	5,975	14,221	2,380	23.6	100.8	99.0	101.8
1985	6,475	12,723	1,965	27.1	72.5	100.0	72.5
1986	5,842	16,632	2,847	26.3	108.2	118.3	91.4
Total	29,739	72,902					493.6
Ave.	5,948	14,580	2,451				98.7

1995 Projected Price

- 1985 Constant Price (US$ / ton) 98.7 × 0.84 *1 = 82.9
- 1988 Constant Price (US$ / ton) 82.9 × 1.403 *2 = 116.3
- Equivalent Baht (Baht / ton) 116.3 × 25.52 *3 = 2,968 (≈ 2,970)

Note: *1; The ratio of the 1995 world prices of maize and grain sorghum to the average world market prices over 1982 - 1986 (refer to Table 4.1-13)

*2; 1988 MUV index (1985 = 1.00)

*3; Exchange rate as of early 1988 (1US$ = 25.52 Baht)

Source : Agricultural Statistics of Thailand 1986/1987 Crop Year, DOAE

Table 4.1-14 Trend of Bangkok Export Prices of Major Commodities (2/3)

2) Durian fresh

year	Quantity (ton)	Value (Baht x 10^3)	Unit Price (Baht/ton)	Exchange Rate (Baht/US$)	Unit Price (US$/ton)	MUV Index (1985 = 100)	1985 Constant Price (US$/ton)
1982	2,346	58,381	24,885	21.7	1,146.8	103.3	1,100.2
1983	2,819	64,443	22,860	23.0	993.9	100.7	933.4
1984	3,470	67,685	19,506	23.6	826.5	99.0	834.8
1985	9,784	171,851	17,564	27.1	648.1	100.0	648.1
1986	6,964	173,480	24,911	26.3	947.1	118.3	800.6
Total	25,383	535,840					4,327.1
Ave.	5,077	107,168	21,109				865.4

1995 Projected Price

- 1985 Constant Price (US$ / ton) 865.4 x 0.91* = 787.5
- 1988 Constant Price (US$ / ton) 787.5 x 1.403 = 1,104.9
- Equivalent Baht (Baht / ton) 1,104.9 x 25.52 = 28,197 (= 28,200)

Note: * The future trend of the world prices of orange and banana (refer to Table 4.1-13)

Source: Agricultural Statistics of Thailand 1987/86 Crop Year, DOAE

3) Mango fresh

year	Quantity (ton)	Value (Baht x 10^3)	Unit Price (Baht/ton)	Exchang Rate (Baht/US$)	Unit Price (US$/ton)	MUV Index (1985 = 100)	1985 Constant Price (US$/ton)
1982	4,118	32,541	7,902	21.7	364.1	103.3	352.5
1983	2,538	20,876	8,225	23.0	357.6	100.7	355.1
1984	3,175	31,256	9,844	23.6	417.1	99.0	421.3
1985	8,311	57,170	6,879	27.1	253.8	100.0	253.8
1986	9,400	54,287	5,775	26.3	219.6	118.3	185.6
Total	27,542	196,130					1,568.3
Ave.	5,508	39,226	7,122				313.7

1995 Projected Price

- 1985 Constant Price (US$ / ton) 313.7 x 0.91* = 285.5
- 1988 Constant Price (US$ / ton) 285.5 x 1.403 = 400.6
- Equivalent Baht (Baht / ton) 400.6 x 25.52 = 10,223 (= 10,220)

Note: * The future trend of the world prices of orange and banana (refer to Table 4.1-13)

Source : Same as above

Table 4.1-14 Trend of Bangkok Export Prices of Major Commodities (3/3)

4) Rambutan fresh

year	Quantity (ton)	Value (Baht x 10^3)	Unit Price (Baht/ton)	Exchang Rate (Baht/US$)	Unit Price (US$/ton)	MUV Index (1985 = 100)	1985 Constant Price (US$/ton)
1982	523	3,979	7,608	21.7	350.6	103.3	339.4
1983	273	3,554	13,018	23.0	566.0	100.7	526.1
1984	341	3,951	11,587	23.6	491.0	99.0	496.0
1985	1,169	11,382	9,737	27.1	359.3	100.0	359.3
1986	1,865	13,973	7,492	26.3	284.9	118.3	240.8
Total	4,171	36,839					1,961.6
Ave.	834	7,368	8,835				392.3

1995 Projected Price

- 1985 Constant Price (US$ / ton) 392.3 x 0.91* = 357.0
- 1988 Constant Price (US$ / ton) 357.0 x 1.403 = 500.9
- Equivalent Baht (Baht / ton) 500.9 x 25.52 = 12,782 (= 12,780)

Note: * The future trend of the world prices of orange and banana (refer to Table 4.1-13)

Source: Agricultural statistics of Thailand 1986/1987 Crop Year, DOAE

5) Cashew nut unshelled

year	Quantity (ton)	Value (Baht x 10^3)	Unit Price (Baht/ton)	Exchang Rate (Baht/US$)	Unit Price (US$/ton)	MUV Index (1985 = 100)	1985 Constant Price (US$/ton)
1982	3,026	49,643	16,405	21.7	756.0	103.3	731.8
1983	331	4,583	13,846	23.0	602.0	100.7	597.8
1984	2,305	39,600	17,180	23.6	728.0	99.0	735.4
1985	802	14,146	17,638	27.1	650.8	100.0	650.8
1986	4,135	82,779	20,019	26.3	761.2	118.3	643.4
Total	10,599	190,751					3,359.2
Ave.	2,120	38,150	17,995				671.8

1995 Projected Price

- 1985 Constant Price (US$ / ton) 671.8 x 0.85* = 571.0
- 1988 Constant Price (US$ / ton) 571.0 x 1.403 = 801.1
- Equivalent Baht (Baht / ton) 801.1 x 25.52 = 20,444 (= 20,440)

Note: * The future trend of the world price of soybeen (refer to Table 4.1-13)

Source : Same as above

4-2 Crop Budget

A crop budget provides the basis for an estimation of crop production benefit and an analysis of farm economy, relative to the implementation of the project.

The crop budget for the without-project condition is estimated on the basis of the present yield and production cost obtained from the agro-economic survey. The results are shown in Table 4.2-1.

Crop budget for the with-project condition (target yield level = 100%) is estimated on the basis of the target yield, requirement of input materials and labor as well as available data and information provided by OAE and DLD. The results are summarized in Table 4.2-2.

For the above estimation, the following assumptions have been made.

- Crop yields in the without project condition have been assumed to decline even though the farmers may attempt to prevent soil degradation by undertaking some measures such as contour cropping and mulching, which can be introduced under the present condition. The rate of decreased yield is assumed to be two to four percent per year taking into consideration the rates of decrease that have been reported so far and farmers' efforts in future. The crop yields in the without-project condition would continue to decrease for at least 15 years. After 15 years from the completion of project construction work, the crop yields are assumed to be sustained at the same yield level owing to other factors. As a result, the net return of the presently cultivated crop for the without-project condition would be reduced to about 50 ~ 70 percent of the net return presently earned in project year 15. The annual rate of decrease to net return of crop relative to the present soil erosion is assumed as follows:

Annual Rate of Decrease to Net Return of Crop
by Soil Erosion Condition for the With-Project Condition

Predicted soil loss for the without-Project Condition (t/ha/year)	≦40	40<, ≧80	80≦
Annual decrease rate of yield (%/year)	2	3	4
Applied Province for B/P		CS, CN RY, CT	
Applied Pilot Area for F/S	CS-No.4 CS-No.5 CS-No.8 CN-No.8* CN-No.9	CS-No.3* CN-No.1 CN-No.2 RY-No.2* RY-No.5 RY-No.7	CN-No.4 RY-No.1 RY-No.3 CT-No.2* CT-No.3

Note : * Representative pilot area

- It is considered that the net return of crop for the with-project condition would differ according to the future soil erosion condition. Soil erosion apparently causes a decrease in crop output and an increase in production cost, resulting in a reduction of the net return of crop. In this study, the net return of each crop for the with-project condition by predicted soil loss is set up as follows:

Target Level of Net Return of Crop
by Soil Erosion Condition for the With-Project Condition

Predicted soil loss for the with-Project Condition (t/ha/year)	≦10	10<, ≧20	20≦
Target level of net return of crop (%)	100	95	90
Applied Province for B/P	CS, CN RY, CT		
Applied Province for F/S	CS-No.4 CS-No.5 CS-No.8 CN-No.1 CN-No.8* CN-No.9 RY-No.2* CT-No.3	CS-No.3* CN-No.2 CN-No.4 RY-No.1 RY-No.5 RY-No.7	RY-No.3 CT-No.2*

Note : * Representative pilot area

- Fruit trees and para-rubber newly cultivated under the project require large investment for land preparation and provision of

necessary facilities and equipment and they must be managed during their early growing stages in spite of not generating any profit. These initial costs are valued as depreciation costs which are included in the production cost for the trees after the commencement of harvest.

For fruit trees and para-rubber, fixed costs such as depreciation costs for orchard development and equipment, occupy a considerable portion of total production costs. In this study, these depreciation costs have been estimated on the basis of not only desirable materials and equipment to be provided but the results of the survey conducted by OAE and DLD as well. The latter was duly considered because there is a large difference in facilities and equipment provided among farmers when farmers actually attempt orchard management due to the large investment required for farm preparation. Thus, it seems appropriate to refer to the data available which indicate the average farm management's performance.

- The average yields of perennial crops during their economic fruit-bearing lives are assumed to be 80% of their peak yields.
- The marketability rate for perishable products such as fruits is assumed at 85% of the total production.
- 80 percent of the labor requirement for each crop which will be cultivated under the with-project condition is deduced to be offset by hired labor, taking into account the present farm labor situation reported by the farm-economic survey and the predicted trend in future of the labor situation in the East. As a result, labor costs for each crop in financial analysis includes the cost equivalent to 80 percent of the total labor requirement.

Table 4.2-1 Crop Budget Per Hectare (Without Project, Project Year 0)

Item	CS-No.3		CN-No.8				RY-No.2				CT-No.2	
	Cassava		Cassava		Sugarcane		Cassava		Pineapple		Cassava	
	Fin.	Eco.	Fin.	Eco.	Fin.	Eco.	Fin.	Eco.	Fin.	Eco.	Fin.	Eco.
1. Yield (t/ha)	12.3	12.3	13.2	13.2	38.7	38.7	22.2	22.2	38.8	38.8	14.5	14.5
2. Farm Gate Price (Baht/t)	688	759	688	759	375	415	688	759	1,645	1,978	688	759
3. GPV	8,462	9,336	9,082	10,019	14,513	16,061	15,274	16,850	63,826	76,746	9,976	11,006
4. PC (Baht/ha)												
a) Land Preparation	1,000	920	1,000	920	333	307	1,000	920	333	307	1,000	920
b) Seed	–	360	–	360	2,100	2,324	–	400	8,000	9,600	–	360
c) Fertilizer	564	550	1,318	1,285	2,582	2,517	2,392	2,332	9,631	9,388	427	416
d) Agro-Chemical	187	183	182	177	–	–	1,160	1,131	4,927	4,803	1,031	1,005
e) Labor	2,220	3,030	1,890	2,190	3,690	4,060	3,250	3,885	6,068	6,742	2,060	3,610
f) Others	397	365	439	404	871	801	780	718	2,896	2,664	452	416
Total	4,368	5,408	4,829	5,336	9.576	10,009	8,582	9,386	31,855	33,504	4,970	6,727
5. NPV (Baht/ha)	4,094	3,928	4,253	4,683	4,937	6,052	6,692	7,464	31,971	43,242	5,006	4,279
6. NPV Ratio (%)	48.4	42.1	46.8	46.7	34.0	37.7	43.8	44.3	50.0	56.3	50.2	38.9

Note : GPV ..... Gross Production Value
PC ..... Production Cost
NPV ..... Net Production Value

Table 4.2-2 Crop Budget per Hectare (With Project) (1/3)

Item	Unit Price		Cassava			Pineappie			Sugarcane		
	Fin.	Eco.	Qty.	Fin.	Eco.	Qty.	Fin.	Eco.	Qty.	Fin.	Eco.
1. Yield (t/ha)			24.0			48.0			64.0		
2. Farm Gate Price (Baht/t)				688	759		1,645	1,978		375	415
3. GPV (Baht/ha)				16,512	18,216		78,960	94,944		24,000	26,560
4. PC (Baht/ha)											
a) Land Preparation (Baht/ha)	1,000	920		1,000	920		333	307		333	307
b) Seed (Baht/seedling)											
– Cassava	–	0.04	10,000	–	400						
– Pineapple	0.4	0.48				20,000	8,000	9,600			
– Sugarcane	0.5	0.55							6,000	3,000	3,300
c) Fertilizer (Baht/kg)											
– 15-15-15	7.0	6.8	400	2,800	2,720				500	3,500	3,400
– 14-14-21	7.2	6.9				2,500	18,000	17,250			
– 16- 8-16	6.0	5.8									
d) Agro-chemical (per ha)				1,160	1,131		4,100	3,977		200	194
e) Labor (man-day)	40	37	110	3,520	4,070	230	7,360	8,510	180	5,760	6,660
Sub-total				8,480	9,241		37,793	39,644		12,793	13,861
f) Miscellaneous (depreciation, tax, interest, repair, fuel, rent, etc.)				848	780		3,779	3,477		1,279	1,177
Total (Baht/ha)				9,328	10,021		41,572	43,121		14,072	15,038
5. NPV (Baht/ha)				7,184	8,195		37,388	51,823		9,928	11,522
6. NPV Ratio (%)				43.5	45.0		47.4	54.6		41.4	43.4

Table 4.2-2 Crop Budget per Hectare (With Project) (2/3)

Item	Unit Price		Rubber			Durian			Mango		
	Fin.	Eco.	Qty.	Fin.	Eco.	Qty.	Fin.	Eco.	Qty.	Fin.	Eco.
1. Yield (t/ha)			1.6			8.2			5.4		
2. Farm Gate Price (Baht/t)				15,759	22,609		15,025	16,091		5,333	5,736
3. GPV (Baht/ha)				25,214	36,174		123,205	131,946		28,798	30,974
4. PC (Baht/ha)											
a) Orchard (Farm) Development (Baht/ha)				2,100	1,932		5,450	5,014		6,550	6,026
b) Fertilizer (Baht/kg)											
-15-15-15	7.0	6.8				750	5,250	5,100	615	4,305	4,182
-14-14-21	7.2	6.9									
-16- 8-16	6.0	5.8	375	2,250	2,175						
c) Agro-chemical (per ha)				400	388		8,000	7,760		2,500	2,425
d) Labor (man-day)	40.0	37.0	215	6,880	7,955	440	14,080	16,280	210	6,720	7,700
Sub-total				11,630	12,450		32,780	34,154		20,075	20,333
f) Miscellaneous (depreciation, tax, interest, repair, fuel, rent, etc.)				1,163	1,070		3,278	3,016		2,008	1,847
Total (Baht/ha)				12,793	13,520		36,058	37,170		22,083	22,180
5. NPV (Baht/ha)				12,421	22,654		87,147	94,776		6,715	8,794
6. NPV Ratio (%)				49.3	62.6		70.7	71.8		23.3	28.4

Table 4.2-2 Crop Budget per Hectare (With Project) (3/3)

Item	Unit Price		Rambutan			Cashew Nuts					
	Fin.	Eco.	Qty.	Fin.	Eco.	Qty.	Fin.	Eco.	Qty.	Fin.	Eco.
1. Yield (t/ha)			10.2			2.2					
2. Farm Gate Price (Baht/t)				6,714	7,211		12,882	13,500			
3. GPV (Baht/ha)				68,483	73,552		28,340	29,700			
4. PC (Baht/ha)											
a) Orchard (Farm) Development (Baht/ha)				4,700	4,324		1,150	1,058			
b) Fertilizer (Baht/kg)											
-15-15-15	7.0	6.8	750	5,250	5,100	1,400	9,800	9,520			
-14-14-21	7.2	6.9									
-16- 8-16	6.0	5.8									
c) Agro-chemical (per ha)				5,000	4,850		2,200	2,134			
d) Labor (man-day)	40.0	37.0	420	13,440	15,540	160	5,120	5,920			
Sub-total				28,390	29,814		18,270	18,632			
f) Miscellaneous (depreciation, tax, interest, repair, fuel, rent, etc.)				2,839	2,612		1,827	1,681			
Total (Baht/ha)				31,229	32,426		20,097	20,313			
5. NPV (Baht/ha)				37,254	41,126		8,243	9,387			
6. NPV Ratio (%)				54.4	55.9		29.1	31.6			

4-3 Aquaculture Benefit

(1) Production cost

Cost Item	Qty	Unit Price (Baht)			Cost (Baht/rai)	
		Fin.	(C.F.)	Eco.	Fin.	Eco.
(1) Fish Fry per year	3,000	0.25	0.92	0.23	750	690
(2) Lime	160kg	3.0	0.92	2.76	480	442
(3) Food	–	–	0.92	–	2,220	2,042
(4) Manue	2,000kg	0.5	0.92	0.46	1,000	920
(5) Labor *1	50 man-day	40	0.92	37	2,000	1,850
(6) Fuel and Other Goods			0.92		375	345
(7) Others (depreciation for boat, net etc.) *2			–		341	314
Total					7,166	6,603

Note : *1 – Labor requirement (man-day)

° Receiving fly 1 (1 person × 1 day)

° Nursing fly 6 (0.2 person × 30 days)

° Transplant 1 (1 person × 1 day)

° Fertilizing & feeding 36 (0.2 person × 180 days)

° Harvesting 6 (0.15 person × 4 times)

*2 $((1)+(2)+(3)+(4)+(5)+(6)) \times 0.05$

(2) Gross production value

1) Financial ; Yield 600kg/rai × Unit Price 20 Baht/rai = 12,000 Baht/rai

2) Economic ; Yield 600kg/rai × Unit Price 18.4 Baht/rai = 11,040 Baht/rai

(3) Net production value

1) Financial ; (12,000 - 7,166) Baht/rai = 4,834 Baht/rai

2) Economic ; (11,040 - 6,603) Baht/rai = 4,437 Baht/rai

Reference : "Inland Fishery Promotion Plan, Roiet Province" by BAAC, 1988

"Cost and Benefit of Inland Fishery in Thailand" by OAE, 1987

4-4 Development of Benefit Accrual

(1) Crop benefit

1) Without project (adverse development)

It is assumed that until project year 15 the net production value of all annual crops presently cultivated for the without-project condition would decrease by two to four percent per annum from the net production value earned at present (see 4-2).

2) With project

The gestation period between the completion of construction work and full development accrual is estimated at five years for both the presently cultivated crops of which yields are expected to increase through proper land conservation measures and the annual crops to be newly introduced in the with-project condition. As for perennial crops such as fruit trees and para-rubber to be newly planted under the project, the gestation period to the full development stage is assumed to be 8-13 years. The incremental benefit for each crop is assumed to develop in the following proportion. Out of the 16 pilot areas, in some areas, e.g. RY-NO.2 the crop yield level presently attained is quite high. As for these advanced areas, the build-up of NPV for an annual crop is set up differently from that in common areas.

Crop \ Year	1	2	3	4	5	6	7	8	9	10	11	12	13
◦ Annual crops* (Common area)	0.6	0.8	0.9	0.95	1.0								
◦ Annual crops* (Advanced area)	0.90	0.92	0.95	0.98	1.0								
◦ Rubber (Rainfed)	–	–	–	–	–	0.2	0.4	0.5	0.6	0.7	0.8	0.9	1.0
◦ Cashew nut (Rainfed)	–	–	–	0.1	0.4	0.6	0.8	1.0					
◦ Durian (Irrigated)	–	–	–	–	0.1	0.4	0.6	0.9	1.0				
◦ Mango and Rambutan (Irrigated)	–	–	–	0.1	0.3	0.5	0.8	0.9	1.0				

Note : * Cassava, Pineapple, Sugarcane, etc.

(2) Inland fishery benefit

The gestation period to the full development stage is assumed to be five years. The benefit is assumed to build up in the same proportion as the annual crop benefit in the common areas as shown above.

(3) Natural resources and environmental benefit

This benefit is expected to accrue immediately after the completion of the civil works for the project.