No. 2

THE KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
DEPARTMENT OF LAND DEVELOPMENT

THE STUDY ON AGRICULTURAL LAND CONSERVATION FOR INTEGRATED RURAL DEVELOPMENT IN THE EAST

Vol. III FEASIBILITY STUDY OF 16 PILOT AREAS

SEPTEMBER 1988

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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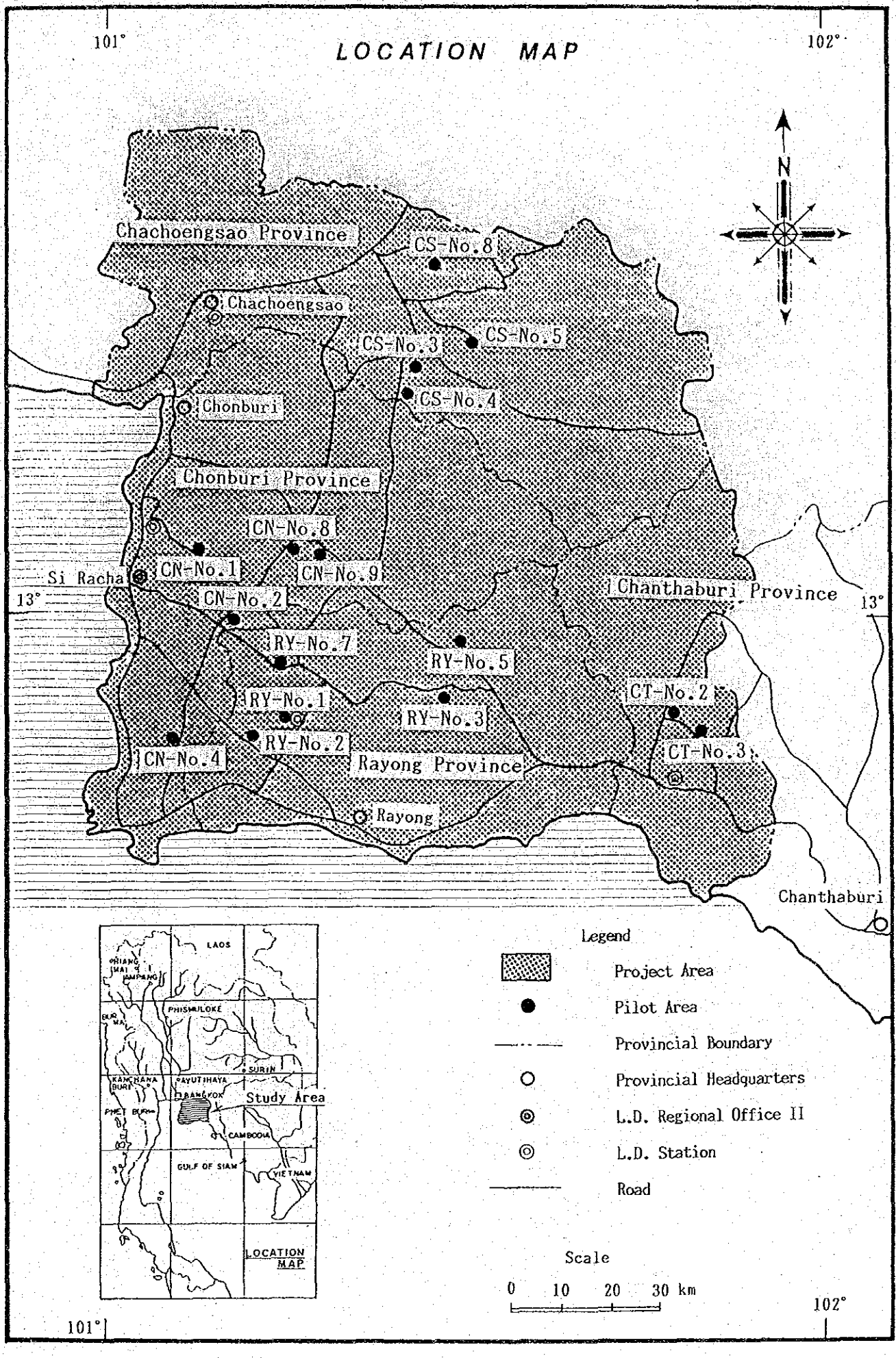
LOCATION MAP
101°
102°
13°
N
Chachoengsao Province
Chachoengsao
Chonburi
Chonburi Province
Si Racha
Chanthaburi Province
Chanthaburi
Rayong Province
Rayong
CS-No.8
CS-No.3
CS-No.5
CS-No.4
CN-No.8
CN-No.1
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LAOS
PHISNULOKE
SURIN
PAYUTHAYA
BANGKOK
Study Area
CAMBODIA
GULF OF SIAM
VIETNAM
LOCATION MAP
Legend
Project Area
Pilot Area
Provincial Boundary
Provincial Headquarters
L.D. Regional Office II
L.D. Station
Road
Scale
0 10 20 30 km

SUMMARY

Volume Ⅲ, Feasibility Study of 16 Pilot Areas, is composed of 6 chapters. The outline of each chapter is summarized as follows.

Chapter 1 Introduction

The process of "the Study on Agricultural Land Conservation for Integrated Rural Development in the East" and plan of activity of the JICA team was briefly explained. It was clearly mentioned that the policy of development should follow the objective of the Sixth NESD Plan.

The outlines of agriculture, the soil erosion problem and its importance in agricultural production were expressed.

The socio-economic and environmental impacts of the proposed project were expected in the fields of employment, regional disparity, etc.

16 pilot areas were selected from 30 candidate areas and data was collected for the whole planning area.

The feasibility of all 16 pilot areas was examined from technical and economical viewpoints.

Chapter 2 Selection of Pilot Areas

For the feasibility study, 16 pilot areas, CS 4 areas, CN 5 areas, RY 5 areas and CT 2 areas, were selected. The total acreage of the area was 2,062 ha.

The selection criteria of 16 pilot areas included 8 items such as, landowner should be multiple, consent of people on land conservation works under DLD was expected, etc.

Present conditions of these areas from the aspects of agriculture, physical environment and sociology were listed. Among these, factors related to soil erosion were especially discussed and causes of soil loss were summarized. Eventually, predicted soil loss in each pilot area was shown in a table.

Chapter 3 Project Formulation

Three kinds of alternative plans, grade I (high), II (medium) and III (common), were proposed and applied depending on the general conditions in each pilot area. Their costs are 16,800, 12,800 and 7,500 Baht/rai, respectively.

The grades to be applied to each pilot area were suggested judging from farmers' economical conditions, land tenure, farmer's age, etc.

As for soil conservation measures, agricultural measures, mechanical measures, irrigation facilities, supporting measures, and organization and management were mentioned.

Basic idea for agricultural measures was expressed in Vol. II and suggested crops and cropping patterns in each area are listed in the tables.

Mechanical measures were explained in principle in Vol. II and in Vol. III mechanical measures to be applied to each pilot area were proposed and the effects of soil conservation in each area were estimated.

The proposals regarding irrigation facilities for each pilot area were mentioned in detail with special emphasis on the selected four pilot project areas.

As back data for such proposals, run-off, water losses in reservoir, frequency of design flood and design sediment etc. were calculated.

As supporting measures, infrastructural approaches to rural development was mentioned with existing infrastructural conditions of the pilot areas and villager's needs. Some recommendation related to this issue was made such as small scale water resources development, etc.

Chapter 4 Cost Estimation

The unit cost for the construction works was estimated taking into account the costs such as efficiency of the construction equipment, labour, materials and operation cost of construction equipment.

The project cost of the 16 pilot areas, estimated on the contract basis by using the above-mentioned unit costs, is shown in the tables.

The total project cost was 169.7 million Baht, of which 39% is foreign currency and 61% is local currency.

Chapter 5 Construction works

Two items, construction schedule and construction equipment, were discussed in this chapter.

As for construction schedule, construction method such as farm pond, sub-soiling, contour terrace, farm road, check dam and fish pond were discussed. Workable days in each province in both wet and dry season were also suggested. Based on the result of the construction plan for the pilot area, RY-NO.2, construction schedules for all pilot areas were estimated. In case that all pilot areas should be completed in two years as described in Vol. II, mobilization of four crews would be necessary.

As for construction equipment, necessary equipment for RY-NO.2 (Plan I) was estimated as 33.8 million Baht on C.I.F. basis.

Considering the merits and demerits of force-account and contract basis in case of implementation of all 16 pilot areas, it was recommended that half would be directly under DLD, force-account, and the other half would be under contract basis. The equipment for two crews under the idea mentioned above is estimated to cost 70 million Baht.

Chapter 6 Project Evaluation

The project evaluation was carried out for all 16 pilot areas and for the representative 4 pilot areas in detail, in view of economic and financial aspects.

The economic analysis of all pilot areas by means of EIRR is shown in the tables. According to the table, the range of EIRR's was 8.1%-18.6% and the average was 10.1%. For the 4 representative pilot areas, sensitivity analysis was applied as shown in the tables.

It is obvious that the economic viability of the project depends on the physical and agricultural conditions of the area, especially availability of water resources by constructing a small reservoir.

Financial analysis was carried out for the representative pilot areas from the aspect of farm economy, employing two criteria, farm budget and cost recovery index. The latter is derived from cost-recovery charges and farmer's ability to pay. They are shown in the tables.

The financial analysis of the farm budget indicates that the implementation of the project would ensure increase of farm income but the farmers will not be able to recover the total cost.

Judging from the aforementioned analysis, the key for the success of the project is governmental assistance, such as subsidy, post-project technical service, agricultural extension service and provision of institutional loans with low interest.

Table of Major Figures

Province and Pilot Area NO.		Area	Soil Loss Volume	Class	Project Cost	EIRR
		(ha)	(ton/ha/yr.)		(000 Baht)	(%)
Chachoengsao						
CS	NO.3	186.9	63.8	Top urgent	7,473	8.5
	NO.4	79.0	16.8	Necessary	8,097	8.3
	NO.5	92.0	34.7	Urgent	4,184	8.1
	NO.8	115.5	34.7	"	6,318	8.2
Chonburi						
CN	NO.1	94.4	41.1	Urgent	12,741	8.3
	NO.2	116.8	75.3	Top urgent	9,075	18.6
	NO.4	94.1	86.9	"	6,311	9.4
	NO.8	130.6	33.2	Urgent	16,104	9.3
	NO.9	127.2	34.7	"	11,415	8.6
Rayong						
RY	NO.1	173.7	83.2	Top urgent	8,638	9.8
	NO.2	219.5	62.8	"	23,108	11.6
	NO.3	96.7	167.6	"	9,638	8.5
	NO.5	155.8	68.6	"	12,953	8.5
	NO.7	89.9	64.0	"	7,392	8.1
Chanthaburi						
CT	NO.2	143.1	142.6	Top urgent	11,789	10.8
	NO.3	146.8	99.2	"	14,456	9.3
Total		2,062.0			169,692	10.1

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ABBREVIATIONS AND UNIT

Agencies

AC	Agricultural Cooperative
ADB	Asian Development Bank
ALRO	Agricultural Land Reform Office, MOAC
ARDO	Accelerated Rural Development Office, MOI
BMA	Bangkok Metropolitan Administration, MOI
DA	Department of Agriculture, MOAC
DH	Department of Health, MPH
DLD	Department of Land Development, MOAC
DMR	Department of Mineral Resources, MI
DOAE	Department of Agricultural Extension, MOAC
DTEC	Department of Technical and Economic Cooperation
EGAT	Electricity Generating Authority of Thailand
FAO	Food and Agriculture Organization of the United Nation
JICA	Japan International Cooperation Agency
LWCB	Land and Water Conservation Board
MD	Meteorology Department
MI	Ministry of Industry
MOAC	Ministry of Agriculture and Cooperative
MOI	Ministry of Interior
MPH	Ministry of Public Health
MWWA	Metropolitan Water Works Authority
NESDB	National Economic and Social Development Board, PMO
PMO	Prime Minister's Office
PWD	Public Welfare Department, MOI
RFD	Royal Forestry Department, MOAC
RID	Royal Irrigation Department, MOAC

Other abbreviations

CS	Chachoengsao
CN	Chonburi
RY	Rayong
CT	Chanthaburi
B/P	Basic Plan
F/S	Feasibility Study
GDP	Gross Domestic Product
GRP	Gross Regional Product
GPP	Gross Provincial Product
HYV	High Yield Varieties
LV	Local Varieties
EIRR	Economic Internal Rate of Return
NPV	Net Present Value / Net Production Value
B/C	Benefit Cost Ratio
GPV	Gross Production Value
F. C	Foreign Currency
L. C	Local Currency
C. I. F	Cost, Insurance and Freight
F. O. B	Free on Board
O & M	Operation and Maintenance
H. W. S	High Water Surface
N. W. S	Normal Water Surface
L. W. S	Low Water Surface

Glossary

Park	Region
Changwat	Province
Muang	Capital of Province
Amphoe	District
Tambon	Sub-district
Muban	Village
Mae Nam	Large river
Nam	A medium-size river
Lam	A small river
Kwae	A tributary of a river
Huai	A rivulet

Unit

Rai	Unit of land measurement
Baht	Unit of Thai Currency
mm	Millimeter
cm	Centimeter
m	Meter
cu. m	Cubic meter
MCM	Million Cubic Meter
cu. m/s	Cubic meter per second
km	Kilometer
sq. km	Square kilometer
g	Gram
kg	Kilogram
ton	Metric ton
ha	Hectare
El	Elevation above mean sea level
MSL	Mean Sea Level
°C	Degree Centigrade
mmho/cm	Millimho per centimeter
HP	Horsepower
ppm	Parts per million

Units of Measurement

Rai	=	0.16 hectares = 1,600 sq.m
Hectare	=	6.25 rais = 10,000 sq.m

Currency Equivalents (Average of March, 1988)

US Dollar	US$ 1.00 = 25.52 Baht = ¥ 128.92

Definition of Words

The Sixth Plan or the Sixth NESD Plan	The Sixth National Economic and Social Development Plan (1987~1991) published by NESDB
Survey area or Study area	19,604 km^2 (12,252,500 rais) covering the whole area of 4 provinces (Chachoengsao, Chonburi, Rayong and Chanthaburi)
Project area	15,248 km^2 (9,530,000 rais) covering 3 whole provinces (Chachoengasao, Chonburi and Rayong) and a part of Chanthaburi province (approximately one third of the western side of the province)
Planning area	The net area of 8,840 km^2 (5,525,000 rais) out of the Project area excluding paddy and forest land, residential and industrial area, etc.

Chapter 1.

INTRODUCTION

CHAPTER 1 INTRODUCTION

1-1 General

The agreement for the Study on Agricultural Land Conservation for Integrated Rural Development in the East was concluded between the Japan International Cooperation Agency (JICA) and the Department of Land Development (DLD), Ministry of Agriculture and Cooperatives (MOAC) of Thailand on February 17, 1987. The Study was divided into two phases, Phase I and II, with each respective phase consisting of field survey works and home analysis works.

The Phase I field survey and home analysis works were carried out from September 24 to November 23, 1987 and from December 18 to January 13, 1988 respectively. The Phase II field survey and home analysis works were carried out from December 24, 1987 to March 28, 1988 and from May 14 to July 12, 1988 respectively.

For the survey and study JICA assigned and dispatched a study team composed of twelve (12) experts.

The purpose of the study was to formulate the Basic Plan for the 4 provinces in the Eastern Region and to carry out a Feasibility Study on the 16 pilot areas for agricultural land and water conservation.

As for the basic plan, the policy of rural development in the East is understood to be as follows;

- 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 sector, 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.
- To protect national security particularly in the area near the border between Cambodia and Thailand.

The development policy mentioned above follows the objectives of "the Sixth National Economic and Social Development Plan (1987-1991)" established by NESDB.

The Report on the Study consists of seven volumes as follows;

Vol. I. Main Report (As the Project Summary)

Vol. II. Basic Plan for Land and Water Conservation in the 4 Provinces of the East

Vol. III. Feasibility Study of 16 Pilot Areas

Vol. IV. Appendix for B/P

Vol. V. Appendix for F/S

Vol. VI. Guideline for Planning, Design and Construction of Land and Water Conservation

Vol. VII. Drawings

Vol. I is a summary of the Basic Plan (Vol. II) and the Feasibility Study (Vol. III).

Both Vol. II and Vol. III shall be independent and complete in itself.

1-2 Necessity and Importance of Soil Conservation Works

(1) Position and weight of agriculture in Thailand

The share of Agricultural Production in the GDP of Thailand was 22.3% in 1982 and 16.6% in 1986.

As for exports, the share of Agricultural Production was 67.5% in 1982 and 57.1% in 1986, maintaining the most important position in the Thai economy.

(2) Country and area

The total area of Thailand is 51,300 thousand hectares (513,000 km^2). Of this total farm land accounted for 18,098 thousand hectares (35.3%) in 1976 increasing to 20,576 thousand hectares (40.1%) in 1985.

On the contrary, the forest area was 19,842 thousand hectares (38.7%) in 1976 and since then has been extremely reduced to 14,905 thousand hectares (29.1%) by 1985.

The farm land is divided into two categories; paddy field and, upland field and orchard such as fruit trees, para-rubber and trees for manufactured timber products. The area of paddy was 11,411 thousand hectares in 1976 and 11,824 thousand hectares in 1985. This figure has not changed much during the last ten years.

On the other hand, the area of upland crops and tree crops was 5,064 thousand hectares in 1976 increasing to 7,211 thousand hectares in 1985. The ratio of increase is 142 percent during the last ten years. This means that most of the encroached forest area has been converted to upland crops and tree crops.

(3) Position and weight of agricultural production in the East

The share of Agricultural production in the GRP of the East was 30.4% in 1981 and became 22.55% in 1985 and still ranked as number one among other sectors such as manufacturing (22.2% in 1985) and whole-sale and retail trade.

Forest encroachment has accelerated so rapidly reducing the forest area from 2,116 thousand hectares (58.0%) in 1961 to 799 thousand hectares (21.9%) in 1985. (Figure 1.2-1)

This means that 62.2% or 1,317 thousand hectares of forest were encroached and converted to farm land during the last 25 years.

As for the study area in the East in 1985, the total area is 1,960 thousand hectares, the forest area is 378.6 thousand hectares (19.3%) and farm land is 976.4 thousand hectares (49.8%).

Farm land consists of 278.1 thousand hectares (14.2%) of paddy field and 451.1 thousand hectares (23.0%) of upland crops. This means that upland crops such as cassava, sugarcane and maize are the main crops in the area.

(4) Soil erosion in the East

Soil erosion in the East is very severe due to the 62.2% of forest area which has been encroached during the last 25 years.

The predicted soil loss in the planning area (880,000 ha) is estimated as 34 ton/ha/year (1.8 mm) and approximately 30 million tons in total.

The value of such soil loss is estimated to be equivalent to 4,260 million baht consisting of 2,760 million baht of nutrient loss and 1,500 million baht of dredging costs.

Agricultural production is 13,839 million baht (GPP in 1985) in the Study Area. Therefore, the estimated damage from soil loss is 30.7% of the total agricultural product.

Moreover, the number of farms in the Area is 171,159. Therefore, monetary loss can be estimated at 24.9 thousand baht per farm and 4.5 thousand baht per capita (one farm family is 5.5 persons on average).

(5) Relationship between soil degradation and decrease in the unit yield of crops

The rapid encroachment of the forest area has accelerated soil degradation.

The predicted soil loss can be calculated from the five factors of the Universal Soil Loss Equation (USLE);

- Rainfall factor
- Soil factor
- Crop management factor

- Land slope and slope length factor
- Soil conservation practice factor

Under present farm land conditions every factor mentioned is relevant in the East particularly for sandy soil, extensive crop farming represented by cassava and more then 300 meters of slope length. In spite of the fact that the average slope of farm land is not very steep, 2~5% , soil erosion occurs because of its length caused by no farm road, no terrace, no drainage system, etc.

Soil erosion causes the removal of surface soil from the farm land, this causes nutrient loss consisting mainly of nitrogen (N), phosphorous (P) and potassium (K).

Therefore, without fertilizing the unit yield of crops shall decrease year by year.

In the case of cassava, unit yield has decreased from 29 tons per hectare to 16 tons per hectare during the 16 years from 1955 to 1971. The average ratio of declining yield is estimated to be 3.85%. This trend is almost the same for all areas and soil conditions in the East.

If it is supposed that cassava is planted on all farm land, annual income shall be reduced 3,431 Baht per farm on average in the Study Area based on the following figures:

Average farm size = 6.24 ha

Price of cassava = 950 baht/ton in 1987

Unit yield of cassava = 15 ton/ha in 1987

Data : Agricultural Statistics 1986/1987

In the coastal area of the East, there are many scenic places along the Gulf of Thailand represented by Pattaya in Chonburi. It was reported that more than one million people visited Pattaya in 1987.

On the contrary, a huge volume of eroded soil is flowing into the Gulf of Thailand. It was reported that approximately 48 million tons per year was estimated as annual sediment yield in the Gulf of Thailand (Natural Resources Profile 1987).

This soil shall be suspended and then accumulated as bedload at the bottom of the sea. This phenomenon pollutes the sea and changes its ecology. This destruction is progressing rapidly in a steady and invisible manner.

Furthermore, the estimated sediment volume is equivalent to a loss of 13,500 ha/year of farm land when the top soil of the farm land is presumed to be 20 cm.

(6) Necessity and importance of soil conservation in the East

From the above mentioned matters, it is strongly recognized that soil conservation work is indispensable and the most fundamental work for protecting natural resources such as farm land, water, sea products and the human environment.

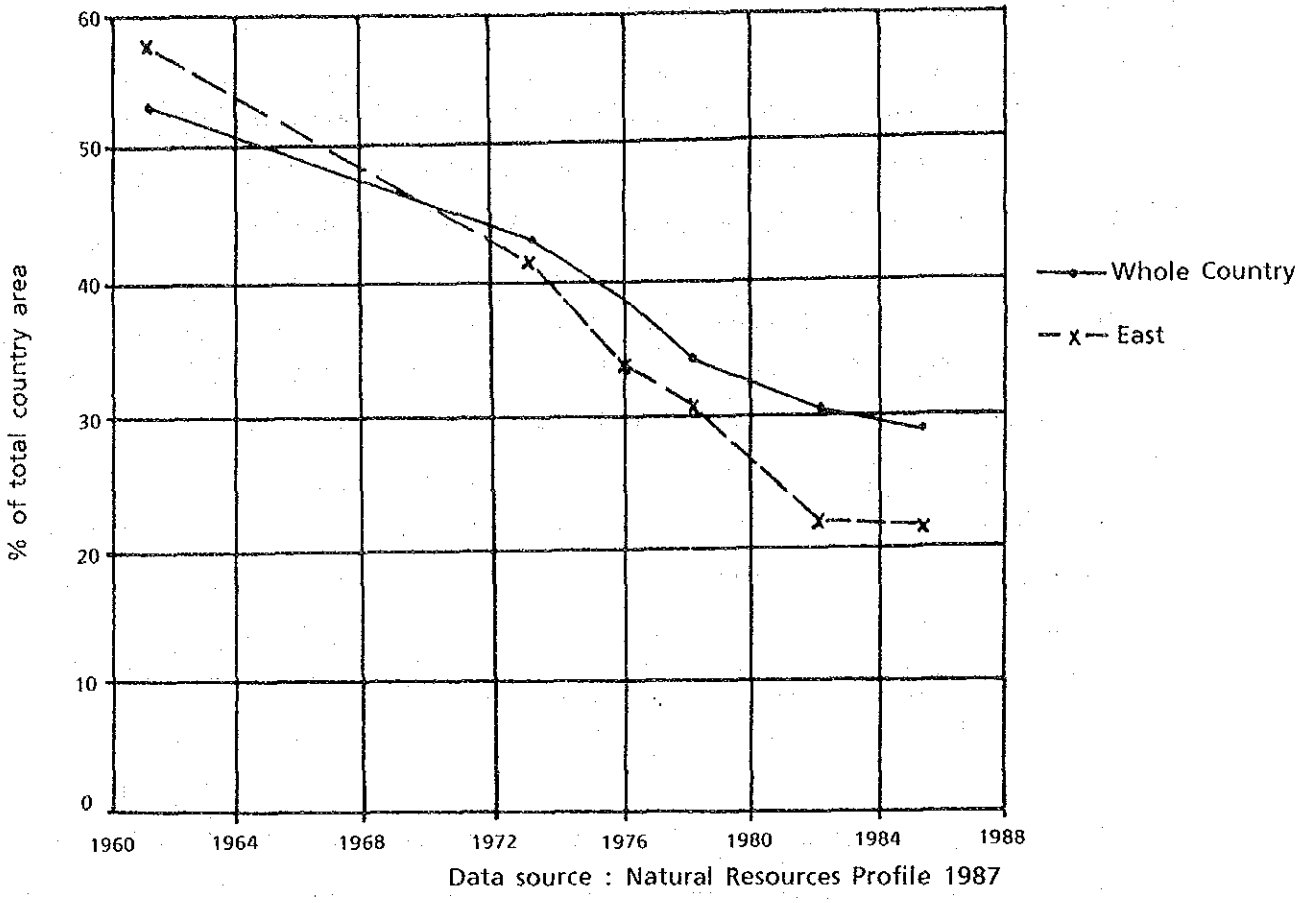

Figure 1.2-1 Forest Area in Thailand, 1961-1985

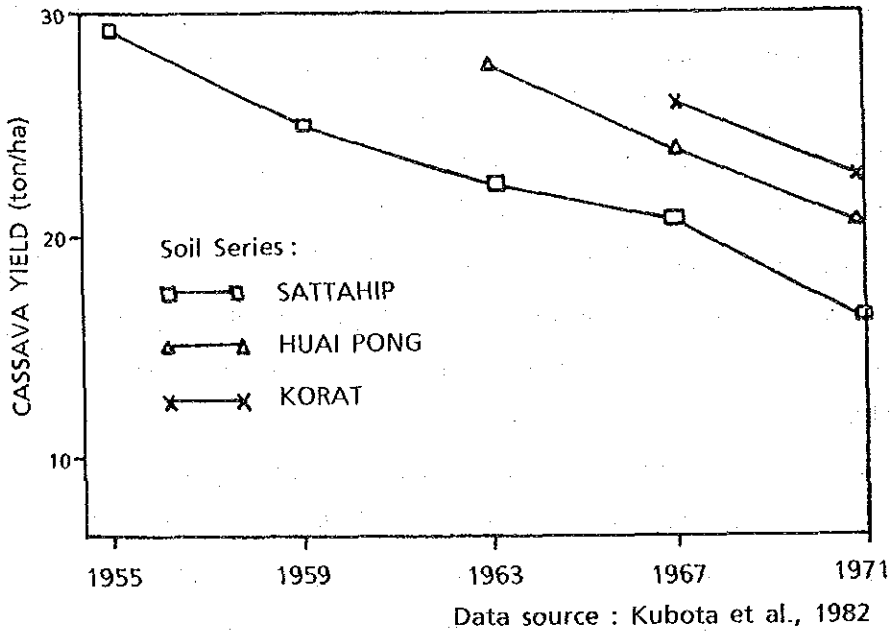

Figure 1.2-2 Tendency of Cassava Yield

1-3 Socio-economic and Environmental Impacts

In addition to the quantitative benefits expected, this Project would entail large socio-economic and environmental impacts which are intangible. the major impacts expected are discussed below.

(1) Creation of employment opportunities

The Project's implementation would give rise to employment opportunities for the unskilled labor force.

The unskilled labors required for the construction works under the first ten (10) years plan of the B/P is estimated at 7 million man-days. This estimation is based upon the assumption that unskilled labor costs would account for 3% of the total construction cost and that unskilled construction labor would be hired at a wage of 75 Baht per day.

The demand for farm labor would increase by 18 million man-days per annum through introduction of intensive agriculture under the first en years of the B/P. Promotion of inland fishery will also help to enlarge employment opportunities in the rural area.

Furthermore, development of secondary and tertiary industries associated with increased agricultural production is expected to offer employment opportunities to the rural population.

(2) Reduction of regional disparity

Improvement of living conditions among the rural farmers in the Eastern Region through an increase in farm income as well as provision of supporting facilities, e.g. wells and meeting halls would have a significant socio-economic impact not only in the East but in the neighboring regions as well.

A more settled down style of agricultural life and increased farm income would encourage farmers to invest more in education and other social services which would improve communication and thus accelerate the integration of the local population. This would greatly help in rectifying regional disparity which is the current concern of Government.

Improvement of rural living conditions is also expected to prevent the younger generation from migrating to Bangkok where the Thai economy is now greatly concentrated and there are lots of socio-economic problems in the wake of the population expansion.

Furthermore, the settlement of the rural population would contribute to the maintenance of national security especially in the sensitive border area with Cambodia.

(3) Saving and earning of foreign exchange

Large amounts of nutrients available for crop growing which are contained in soil have been washed away due to lack of proper land conservation measures. The implementation of the Project is expected to reduce these nutrient losses.

The amount of major elements to be saved annually in an area of 225,700 ha is estimated at 89,000 t for N, 7,400 t for k_2O and at 20,600 t for P_2O_5. This corresponds to 640 million Baht, 60 million Baht, and 70 million Baht, respectively when expressed in monetary terms using the current international prices of chemical fertilizers. The project's implementation would indirectly reduce the quantity of fertilizer imports, resulting in the saving of foreign exchange.

The increase in agricultural production is expected to earn foreign exchange. In response to the Government's policy and the current domestic market, the emphasis of this project is on expansion of production of commercial or exportable crops such as para-rubber, pineapple, durian, etc. Exportation of one-tenth of the incremental crop production expected from an area of 225,700 ha would earn 1,200 million Baht (equivalent to US $ 47 million) per year (at 1988 constant prices).

(4) Enhancement of cooperation among farmers

It is necessary to establish a farmer's group for success of the proposed land conservation measures and irrigated agriculture. Also, establishment of client groups consisting of at least five farmers is prerequisite for farmers without collateral to utilize agricultural loans under the BAAC which are indispensable for the promotion of the

proposed crop diversification. These organization activities would enhance the cooperative spirit among the farmers and help improve their technical and management skill.

(5) Environmental impact

The Project's implementation would contribute to conservation of the environment as stated above. The major environmental impacts considered are summarized below.

- to prevent disorderly deforestation, and thereby to retain existing ecosystems (e.g. to retard the occurrence of erratic rainfall and extinction of wildlife)
- to conserve surface run-off and groundwater
- to alleviate flooding and drainage damage in lower reaches

1-4 16 Pilot Areas

(1) Purpose of pilot areas

It was clarified in the study of B/P that there are 884 thousand ha of erodible upland farm areas in the 4 provinces of the Eastern Region.

For the implementation of land and water conservation works of 884 thousand ha, the total project is planned over a period of 30 years divided into six 5-year plans. This means that an average of 35,000 ha is planned to be implemented annually.

The purpose of the 16 pilot areas, therefore, is to supply technical data for the scheduled projects covering the 884 thousand ha area.

The 16 pilot areas are widely distributed within the 4 provinces, namely 4 sites in Chachoengsao, 5 sites in Chonburi and Rayong respectively and 2 sites in Chanthaburi to collect comprehensive data concerning land and water conservation.

The civil works of the 16 pilot areas are recommended to be completed on both the force account and contract basis. Force account is recommended for DLD to gain experience and data by itself. On the other hand the contract basis applying competitive bidding is also recommended since recently it has become a common method due to the number of experienced contractors in Thailand and other factors stated hereafter.

(2) Selection of 16 pilot areas

Based on the selection criteria thirty (30) sites were preliminary nominated (eight (8) sites in Chachoengsao, nine (9) sites in Chonburi, nine (9) sites in Rayong and four (4) sites in Chanthaburi).

Among them, sixteen (16) sites were selected for the feasibility study taking into account the following conditions.

1) The area should not belong or be under administration of another agency's project particularly the reserve forest and wildlife sanctuary under RFD.
2) The areas shall not be concentrated in the same place to maximize the demonstration effect.
3) The areas shall have representative characteristics of soil, topography, crop, water resources and socio-economy.

(3) Role of pilot areas

The planning area of 884,000 ha shall be improved through conservation works including irrigation works, etc. according to the long term plan. For improvement of the 884,000 ha a technical standard should be prepared and tested in the 16 pilot and other areas.

The 16 pilot areas were selected with parameters of topography, soil, crop and climate based on the soil erosion classification of the B/P. One pilot area is approximately 50 - 250 ha in size.

The 16 pilot areas are considered to play the role of testing and as a model farm of the land conservation works. That is the pilot areas shall be utilized by DLD to collect data on farming, technical and civil works.

(4) Feasibility of pilot areas

Feasibility of the pilot projects is judged mainly from economical and financial viewpoints.

For the former, economic analysis was carried out on all 16 pilot areas based on the proposed agricultural development plan. For the latter, financial analysis, based on farm economy, was carried out on the 4 representative pilot areas, one in each province.

As the basic figures for the above analysis, unit cost for the construction works is estimated and the total cost of each of the 16 pilot areas calculated according to the grade proposed.

Construction schedule and equipment necessary for the implementation of the project are proposed as well.

Chapter 2.

SELECTION OF PILOT AREAS

CHAPTER 2 SELECTION OF PILOT AREAS

2-1 General

The planning area of 8,840 km² for the Basic Plan covering the four provinces is upland crop area which has recently been shifted from the forest area mainly utilized for planting cassava under rainfed farming. The people living there suffer from land erosion problems due to poor natural conditions of soil and water, and lack of irrigation knowledge.

Therefore, the Thai government through DLD intends to rehabilitate the land resources and improve the living standard of farmers by introducing the land and water conservation project to the area.

From the above background, thirty (30) candidate pilot areas were selected by DLD during the Phase I stage. Among them, sixteen (16) pilot areas were finally selected for making the feasibility study taking into account farmers' needs, land right conditions, efficiency of demonstration and other factors, at the initial part of the Phase II stage.

The total acreage of the 16 pilot areas was found to be 2,062 ha.

2-2 Selection Criteria

The main purpose for the implementation of the pilot areas is to instruct the necessity of land and water conservation to the farmers in the Eastern Region in order to prevent the further degradation of land and water resources and to improve the living standard of villagers. Moreover, the implementation of the pilot areas is expected to establish the most appropriate method and measures in DLD through the monitoring of pilot areas.

Based on the policy mentioned above, the selection criteria for pilot areas was established as follows ;

1) Number of farmer's family who shall be land owner and/or have government permission for living and cultivation in the area such as under SPK shall be multiple.
2) The farmers and/or land owners of the area shall understand and expect implementation of land conservation works under DLD.

3) The area shall exhibit erosion and/or be considered to be erodible due to such poor soil conditions as sandy soil, sandy loam and sloping topography.

4) The area shall be undulating with a small watershed and/or potentiality of water resources development.

5) The major crops in the area shall be upland crops such as cassava, sugarcane, pineapple, etc.

6) The area shall be located nearby DLD station and a main road and/or be accessible to a main road for demonstration and monitoring effect.

7) The area shall be such that the farmer's income and living conditions will increase and improve due to the land conservation project.

8) The acreage of the area will be 50 to 250 ha (300 ~ 1,500 rai)

2-3 Selection of 16 Pilot Areas

Refer to sub-section 1-3,(2). The 16 sites selected for the F/S are shown in the following table.

List of Pilot Area

Province	Pilot Area
Chachoengsao	CS-NO 3, 4, 5, 8
Chonburi	CN-NO 1, 2, 4, 8, 9
Rayong	RY-NO 1, 2, 3, 5, 7
Chanthaburi	CT-NO 2, 3

2-4 Present Conditions of Pilot Areas

(1) General Conditions

The present conditions of selected 16 pilot areas from the view of agricultural, physical and social conditions are summarized as shown in Table 2.4-1 (1/4) to (4/4) and Table 2.4-2 (1/2) to (2/2). Detailed information is presented in Vol. V "Appendix for F/S".

Table 2.4-1 General Present Conditions of Pilot Areas (1/4)

Description \ Province / Pilot Area	CHACHOENGSAO				
	CS-NO 3	CS-NO 4	CS-NO 5	CS-NO 8	
I. General					
1) Location	Sanamchaikhate Lat Kra Ting B.Khun Klang,B.Lum Tone	Plang Yao Nong Mai Kaen B.Nongpladuk	Sanamchaikhate Khu Yai Mo B.Pai Tan, B.Klong Ta Phung	Phanomsarakham Kao Hin Sorn B.Nong Langnar, B.Muang Phlong	
2) Area (ha)	186.9	79.0	92.0	115.5	
3) Watershed (Km^2)	3.2	26.6	7.3	38.6	
4) Average annual rainfall (mm.)	1,650	1,650	1,650	1,650	
II. Agricultural condition Major crops	Cassava, Para-rubber Sugarcane.	Cassava, Sugarcane, Pineapple, Eucalyptus Fruit tree	Cassava, Mango, Coconut	Cassava, Eucalyptus, Pineapple, Fruit tree	
III. Physical condition					
1) Topography	EL 80 - 100 m Undulating-Rolling (2 - 10 %)	EL 60 - 80 m Undulating (2 - 6 %)	EL 30 - 45 m Undulating (2 - 6 %)	EL 25 - 45 m Undulating (2 - 6 %)	
2) Geology	Qt deposit/Bedrock (Schist)	Qt deposit	Qt deposit	Granite deposit	
3) Eroded condition	Top.U (63.8 t/ha/y)	Nec (16.8)	Urg (34.7)	Urg (34.7)	
4) Soil	Hat Yai (SCL/V.G.C)	Sattahip (LS/LS)	Ko Khanum (SL/GSCL)	Warin (SL/SCL)	
5) Transportation means	V.R (Earth road)	ARD.R (Earth road, Good)	V.R (Earth road, Poor)	V.R (Earth road)	
6) Water resources	Two small streams (very poor) / shallow well	Huai Muang (Poor) / Shallow well (1.5 m)	Huai Kom (poor) / Deep well (8.5 m)	Lower Huai Nam (Comparative rich) / shallow well	
IV. Social condition					
1) Land right condition	Sor Por Kor	Sor Por Kor	Sor Por Kor	Sor Por Kor	
2) Number of landowners	48	29	36	29	
3) Average land holding (rai) inside pilot area	23.4	15.7	15.3	23.2	
4) Major problem	Water shortage Land erosion	Water shortage Land erosion	Water shortage	Land erosion	
V. Other			There is one RID reservoir.	There is one RID reservoir and some irrigation system.	

Table 2.4-1 General Present Conditions of Pilot Areas (2/4)

Description \ Province / Pilot Area	CHONBURI				
	CN-NO 1	CN-NO 2	CN-NO 4	CN-NO 8	CN-NO 9
I. General					
1) Location	Si Racha Bang Phra B.Wan Kaung	Si Racha Bo Win B. Huai Prap	Bang Lamung Huai Yai B. Ban Nok	Ban Bung Klong Kew B. Sohm	Ban Bung, Nong Yai Nong I Run B. Chai Wat
2) Area (ha)	94.4	116.8	94.1	130.6	127.2
3) Watershed (Km^2)	13.1	20.9	2.4	1.9	62.3
4) Average annual rainfall (mm.)	1,540	1,540	1,540	1, 540	1,540
II. Agricultural condition					
1) Major crops	Cassava, Asparagus Para-rubber, Pineapple	Cassava, Sugarcane, Para-rubber, Coconut	Cassava, Coconut, Pineapple	Pineapple, Cassava Fruit tree (Durian)	Sugarcane, Cassava
III. Physical condition					
1) Topography	EL 65 - 90 m Undulating-Rolling (3 - 10 %)	EL 105 - 145 m Undulating (2 - 6 %)	EL 60 - 125 m Hill side (5 - 10 %) Plain side (2 - 5 %)	EL 80 -110 m Undulating (3 - 8 %)	Undulating (2 - 5 % rather flat)
2) Geology	Granite	Granite	Granite/Ad.	Granite	Granite
3) Eroded condition	Urg (41.1t/ha/y)	Top (75.3)	Top (86.9)	Urg (33.2)	Urg (34.7)
4) Soil	Sattahip (SL/LS)	Sattahip (LS/LS)	Map Bon (SL/SCL)	Sattahip (LS/SL)	Satuk (SL/SCL)
5) Transportation means	V.R (Earth road, poor)	N.R (Route 331)	V.R (Earth road)	N.R (Route 331)	National highway (Route 331)
6) Water resources	Khlong Huai Kruat / Pon Din Dam reservoir	Huai Prap (rich)	one small stream (poor)	Huai Map Khla (poor)	Huai Nong Nai / Huai Chai Wat (poor)
IV. Social condition					
1) Land right condition	Sor Kor 1, Bai-chong	Nor Sor 3	Nor Sor 3, Chanode	Nor Sor 3, Chanode	Chanode, Nor Sor 3
2) Number of landowners	9	18	14	8	8
3) Average land holding (rai) inside pilot area	64.0	36.2	40.3	98.7	92.5
4) Major problem	Land erosion Water shortage	Land erosion	Water shortage Land erosion	Land erosion Water shortage	Water shortage
V. Other	Down-stream of RID reservoir There are some RID irrigation facilities.				

Table 2.4-1 General Present Conditions of Pilot Areas (3/4)

Description \ Province / Pilot Area	RAYONG				
	RY-NO 1	RY-NO 2	RY-NO 4	RY-NO 8	RY-NO 9
I. General					
1) Location	Pluak Daeng Maenam Ku B.Map Kha, B.Patamapank 2	Ban Khai Pana Nikhom B.Chark Char Deao	King A. Wang Chan Chum Saeng B.Dao Ta Inn	King A. Wang Chan Payup Wai B. Payuipnai	Pluak Daeng Mapyangporn B. Chakauay
2) Area (ha)	173.7	219.5	96.7	155.8	89.9
3) Watershed (Km^2)	3.4	8.1	1.4	4.0	3.9
4) Average annual rainfall (mm.)	2,040	2,040	2,040	2,040	2,040
II. Agricultural condition					
1) Major crops	Pineapple, Cassava, Eucalyptus	Cassava, Pineapple Fruit tree	Casaava, Sugarcane, Para-rubber, Fruit tree	Cassava, Sugarcane Para-rubber, Pineapple	Cassava, Fruit tree
III. Physical condition					
1) Topography	EL 65 - 90 m Undulating-Rolling (3 - 10 %)	EL 105 - 145 m Undulating-Rolling (3 - 10 %)	EL 55 - 100 m Undulating-Rolling (3 - 10 %)	EL 50 - 60 m Undulating (3 - 8 %)	EL 60 - 80 m Undulating (2 - 6 %)
2) Geology	Granite	Granite	Granite small mass/Qt	Bedrocks (Gniss schist)	Granite
3) Eroded condition	Top (83.2 t/ha/y)	Top (62.8)	Top (167.6)	Top (68.6)	Top (64.0)
4) Soil	Map Bon (SL/SCL)	Map Bon (SL/SL-VGSL)	Phangnga (SL/SCL)	Phangnga (SL/SCL)	Map Bon (LS/SL)
5) Transportation means	V.R (Earth road poor)	N.R (Route 36)	V.R (Earth road)	V.R (Earth road)	V.R (Earth road)
6) Water resources	Klong Map Kahmin (poor)	Klong Chakch (poor)	Khlang Klie (poor)	Khlong Sip Paed (poor) / High ground table	Khlong Rawang (very poor) / Shallow well
IV. Social condition					
1) Land right condition	P.W.D Nor Khor	P.W.D Nor Sor 3	C.P.D	C.P.D	Nor Sor 3
2) Number of landowners	75	44	16	21	25
3) Average land holding (rai) inside pilot area	12.8	27.6	36.4	43.9	21.4
4) Major problem	Land erosion Water shortage	Land erosion Water shortage	Water shortage Land erosion	Water shortage	Water shortage Land erosion
V. Other	Up-stream of Dok Krai reservoir (RID)				

Table 2.4-1 General Present Conditions of Pilot Areas (4/4)

Description \ Province / Pilot Area	CHANTHABURI		Remarks
	CT-NO 2	CT-NO 3	
I. General			
1) Location	Tha Mai Thung Benja B.Wangpla Pattana	Tha Mai Thung Benja B.Tapong	
2) Area (ha)	143.1	146.8	
3) Watershed (Km^2)	2.2	8.1	
4) Average annual rainfall (mm.)	2,400	2,400	
II. Agricultural condition			
1) Major crops	Cassava, Para-rubber, Mango	Pineapple, Para-rubber Pepper, Cassava	
III. Physical condition			
1) Topography	EL 20 - 60 m Undulating (3 - 8 %)	EL 20 - 80 m Undulating (2 - 8 %)	
2) Geology	Bedrocks (SL, SS), Qt	Bedrocks (SL, SS)	
3) Eroded condition	Top (142.6 t/ha/y)	Top (99.2)	
4) Soil	Chumpon (CL/VGCL)	Chumpon (CU/VGCW)	
5) Transportation means	Earth road (8 - 5.0 m)	Earth road (8-5.0m)	
6) Water resources	Small stream (very poor) / some spring	Two streams (poor)	
IV. Social condition			
1) Land right condition	Nor Sor 3 Kor	Nor Sor 3 Kor	
2) Number of landowners	34	34	
3) Average land holding (rai) inside pilot area	23.8	25.6	
4) Major problem	Water shortage		
V. Other	Some existing irrigation facilities	East side : Rather developed area West side : Rainfed area	

V.R ; Village road
ARD.R ; ARD road
N.R ; National road
Qt ; Quaternary
Top ; Top urgent
Urg ; Urgent
Nec ; Necessary

Table 2.4-2 Characteristics of 16 Pilot Areas (1/2)

Pilot Area	Project Area (ha)	(1) Agricaltural Income			(2) Land Ownership			(3) Soil Classification					(4) Vegetation			(5) Rainfall (mm/y)					
		High	Medium	Low	High	Medium	Low	Sh	Hb	Pga	Cp	K-km /Hy	I	II	III	1,200 ~ 1,400	1,400 ~ 1,600	1,600 ~ 1,800	1,800 ~ 2,000	2,000 ~ 2,400	2,400 ~ 2,600
Chachoengsao																					
CS – NO.3	186.9			○′			○					○	○′		○			○			
CS – NO.4	79.0		○′				○					○			○			○			
CS – NO.5	92.0			○′			○					○	○′					○			
CS – NO.8	115.5		○′				○					○	○′					○			
Chonburi																					
CN – NO.1	94.4	○′			○			○					○			○					
CN – NO.2	116.8		○			○		○					○′			○					
CN – NO.4	94.1			○		○			○				○′			○					
CN – NO.8	130.6	○′			○			○									○				
CN – NO.9	127.2	○			○			○						○			○				
Rayong																					
RY – NO.1	173.7		○				○		○					○			○				
RY – NO.2	219.5	○′					○		○	○			○		○		○				
RY – NO.3	96.7		○							○					○			○			
RY – NO.5	155.8		○															○			
RY – NO.7	89.9			○			○		○				○				○				
Chanthaburi																					
CT – NO.2	143.1		○′				○				○				○						○
CT – NO.3	146.8	○′					○				○				○						○
Total	2,062.0	5	7	4	3	4	9	5	4	2	2	3	9	2	5	3	5	6	–	–	2

(6) Water Resources			(7) Urgency of Soil Conservation			(8) Topogaphy (Undulation)			(9) Land Right Condition	Remarks
Rich	Medium	Poor	I	II	III	I	II	III		
		○′		○					Sor Por Kor	
	○′			○		○		○	Sor Por Kor	
					○		○		Sor Por Kor	
○′		○′		○			○		Sor Por Kor	
			○			○			Sor Kor 1	
○′			○				○		Nor Sor 3	
		○′	○			○			Nor Sor 3	
		○′	○			○			Nor Sor 3	
	○′		○					○	Nor Sor 3	
		○′	○			○			Nor Khor (P.W.D)	
		○′	○			○			Nor Sor 3 (P.W.D)	
		○′	○			○			C.P.D	
		○′		○			○		C.P.D	
		○′	○			○			Nor Sor 3	
		○′	○			○			Nor Sor 3 Kor	
		○′	○			○			Nor Sor 3 Kor	
2	3	11	11	4	1	10	4	2		

(2) Predicting soil loss in the pilot area

The present conditions of the pilot areas are stated herein based on the soil erosion situation which is the main item to be dealt with in this study.

From the detailed field survey of the pilot areas predicted soil loss of each pilot area was calculated.

Universal Soil Loss Equation (USLE) was adopted for calculation and the result is shown in the Table 2.4-3. Detailed calculation is stated in Vol.V Annex 5, 5-5.

Causes of soil loss in the pilot areas is summarized in the following;

1) Slope length is more than 300 m in cultivated area. This makes LS-value Large. The relation between LS-value and slope length in the same slope is shown below;

Slope	Slope length	LS-value
4%	50 m	0.49
	70	0.55
	100	0.65
	200	1.00

Average slope of the 16 pilot areas is 4.3% which is not so steep. Therefore, slope length should be shortened for soil conservation.

2) It is obvious that clayey soil is less erodible compared with sandy soil. Soil-Factor (K-value) differs greatly between clayey soil and sandy soil as shown below;

Soil Texture	K-value
Sandy Loam	0.34
Loamy Sand	0.08

Table 2.4-2 Characteristics of 16 Pilot Areas (2/2)

Note;

Definition of each classification is as follows;

Category	Classification	Definition
(1) Agricultural income (average)	High	More than 150,000 Baht/year, gross
	Medium	50,000 – 150,000 Baht/year, gross
	Low	Less than 50,000 Baht/year, gross
(2) Land holding (average)	Large	More than 50.1 rai
	Medium	50 – 30.1 rai
	Small	Less than 30.1 rai
(3) Soil Classification	Sh	Sattahip (LF-FL/LS – SL)
	Mb	Map Bon (SL-LS/CoSCL – GrSCL)
	Pga	Phangna (SL/SCL)
	Cp	Chumpon (CL/V GrCL)
	Kkn	Ko Khanum (SL/GrSCL)
	/Hy	Hat Yai (SC.-CL/V GrC)
(4) Vegetation	I	Cassava
	II	Cassava and sugarcane/Sugarcone/
	III	Cassava and Pineapple
		Cassava, Sugarcane, Fruit-tree, Para-rubber, etc.
(6) Water Resources	Rich	More than 20km^2 of watershed with water flow in dry-season.
	Medium	More than 10km^2 of watershed with some water flow in dry season.
	Poor	Less than 10km^2 of watershed without water flow in dry season.
(7) Urgency of Soil conversation	I	Top-urgent
	II	Urgent
	III	Necessary
(8) Topography (Undulated area of more than 3% slope)	I	More than 80.1% of project area
	II	80 – 60.1% of project
	III	Less than 60% of project area

Most of the pilot areas are Sandy Loam (SL) and Clay Loam (CL). Therefore, from the surface soil texture soil loss is not so different among areas.

3) As for Rainfall-Factor (R-value)
Chanthaburi has the largest about 2 times that of Chachoengsao so that eastern Rayong and Chanthaburi are more erodible among the Planning Area.

4) As for crop management factor (c-value), the major crop is cassava, covering 60~80% of cultivated land in almost all pilot areas. Therefore, soil loss is not so different due to crops.

5) The most erodible area is RY-NO.3, estimated at 167.6 ton/ha of soil loss per year due to a farmland slope of 6.4%. The lowest is CS-NO.4, estimated at 16.8 ton/ha/year due to a slope of 2.7% and less annual rainfall.

6) In general, rill erosion was observed on 5~8% slope range and sheet erosion was observed in lower farmland

7) Gully erosion was observed beside roads where run off discharges are collected, a good example of this is RY-NO.2.

Based on the aforementioned conditions, predicted soil loss for each pilot area is estimated as shown in Table 2.4-3.

Table 2.4-3 Predicting Soil Loss of Pilot Areas

Name	Plan	Project Area ha	Urgency	Elevation EL	S (%)	SL m	Rainfall mm/year	Soil Texture Surface/Sub	Crop	P.R	R	K	LS	C	A (t/ha/year)
CS – 3	III *	187	1	70 ~ 101	5.4	More than 300	1,500	CL / C-CL	C : 82% R, Others : 18%	O / T	244.5	0.25	1.8	0.58	63.8
4	II	79	3	60 ~ 80	2.7	"	1,440	CL / CL	C : 48% S, Others : 52%	T	244.5	0.25	0.5	0.55	16.8
5	III	92	2	30 ~ 45	3.1	"	1,520	SL / SCL	C : 60% Others : 40%	T	309.7	0.34	0.6	0.55	34.7
8	II	116	2	25 ~ 45	3.1	"	1,750	SL / SCL	C : 70% R, Others : 30%	G	309.7	0.34	0.6	0.55	34.7
CN – 1	I	94	2	65 ~ 90	3.7	"	1,440	SL / LS	C : 76% S, Others : 24%	G	244.5	0.34	0.9	0.55	41.1
2	II	117	1	105 ~ 145	4.5	"	1,600	SL / LS	C : 66% Others : 34%	G	309.7	0.34	1.3	0.55	75.3
4	III	94	1	60 ~ 125	5.7	"	1,500	SL / SCL	C : 68% Others : 32%	G / T	244.5	0.34	1.9	0.55	86.9
8	I *	131	2	80 ~ 110	3.4	"	1,490	SL / LS	C : 81% S, Others : 19%	G	244.5	0.34	0.7	0.57	33.2
9	I	127	2		3.1	"	1,540	SL / LS	S : 93% Others : 7%	G / T	309.7	0.34	0.6	0.55	34.7
RY – 1	II	174	1	65 ~ 90	4.6	"	1,800	SL / LS	C : 55% P, Others : 45%	G	342.3	0.34	1.3	0.55	83.2
2	I *	220	1	105 ~ 145	4.1	"	1,720	SL / LS	C : 63% S, Others : 37%	G	342.3	0.34	1.0	0.54	62.8
3	II	97	1	55 ~ 100	6.4	"	2,150	SL / SCL	C : 34% S, Others : 66%	G / T	407.5	0.34	2.2	0.55	167.6
5	II	156	1	50 ~ 60	3.7	"	2,000	SL / LS	C : 53% R, Others : 47%	O	407.5	0.34	0.9	0.55	68.6
7	III	90	1	60 ~ 80	4.1	"	1,780	SL / LS	C : 65% P, Others : 35%	G	342.3	0.34	1.0	0.55	64.0
CT – 2	II *	143	1	20 ~ 60	5.9	"	2,480	CL / GCL	C : 61% P, Others : 39%	O / T	476.6	0.25	2.1	0.57	142.6
3	I	147	1	20 ~ 80	4.6	"	2,570	CL / GCL	C : 34% P, Others : 66%	O / T	555.0	0.25	1.3	0.55	99.2
Total		2,062		Average	4.3										

Note : P.R : Parent Rock
O : old basement
T : terrace
g : granite

S : slope
SL : slope length
R : R-value (rainfall) in USLE
LS : LS-Value in USLE

K : K-value (soil) in USLE
C : C-value (crop) in USLE
P : Predicting soil loss

* Representatives of each plan

Table 2.4-4 Present Land-use in the Pilot Areas

Unit : ha & (%)

Crop	* CS-3	CS-4	CS-5	CS-8	CN-1	CN-2	CN-4	* CN-8	CN-9	RY-1	* RY-2	RY-3	RY-5	RY-7	* CT-2	CT-3
Cassava	153.5 (82)	38.1 (48)	55.6 (60)	80.9 (70)	72.0 (76)	77.2 (66)	64.3 (68)	105.1 (81)		96.4 (55)	138.1 (63)	32.6 (34)	6.6 (4)	57.8 (65)	88.0 (61)	50.8 (34)
Sugarcane		18.5 (23)			16.2 (17)	3.1 (3)		12.1 (9)	118.4 (93)			52.9 (55)	82.7 (53)			
Pineapple		9.0 (11)			4.0 (5)					30.4 (18)	15.4 (7)		15.2 (10)	12.3 (14)	4.0 (3)	22.0 (15)
Rubber	15.8 (3)					4.7 (4)				17.4 (10)	9.3 (4)	6.0 (6)	42.1 (27)			16.9 (12)
Bamboo											7.0 (3)					
Other trees	5.2 (3)					0.9 (1)	5.8 (6)				8.6 (4)			1.2 (1)		
Various fruit trees	1.6 (1)	1.0 (1)		14.7 (13)				5.8 (5)		0.5 (-)	11.6 (5)	1.8 (2)	0.5 (-)	5.6 (6)	14.8 (10)	17.0 (12)
Durian															10.3 (7)	10.0 (7)
Coconut		2.0 (3)				3.5 (3)	20.2 (21)	1.4 (1)		3.8 (2)						
Mango	2.4 (1)	3.0 (4)		6.9 (6)						5.2 (3)						
Paddy rice	1.4 (1)	1.3 (2)	16.4 (18)	5.3 (4)									0.5 (-)			1.8 (1)
Other crops								1.9 (2)			4.0 (2)				12.3 (9)	2.5 (2)
Unclassified **	7.0 (4)	6.1 (8)	20.0 (22)	7.7 (7)	2.2 (2)	27.4 (23)	3.8 (4)	4.3 (3)	8.8 (7)	20.0 (12)	25.4 (12)	3.4 (3)	8.2 (5)	13.0 (14)	13.7 (10)	25.8 (17)
Total	186.9 (100)	79.0 (100)	92.0 (100)	115.5 (100)	94.4 (100)	116.8 (100)	94.1 (100)	130.6 (100)	127.2 (100)	173.7 (100)	219.4 (100)	96.7 (100)	155.8 (100)	89.9 (100)	143.1 (100)	146.8 (100)

Note : * Representatives of each plan
** Residence, Water body, Road, Abandoned, etc.
Data source : Cadastral Map and Site Survey in Jan. 1988

Table 2.4-5 Present Conditions of the Slope in the Pilot Area

Unit : ha

Slope (%)	Chachoengsao				Chonburi					Rayong					Chanthaburi	
	CS-3	CS-4	CS-5	CS-8	CN-1	CN-2	CN-4	CN-8	CN-9	RY-1	RY-2	RY-3	RY-5	RY-7	CT-2	CT-3
A_1																
0 ~ 2	39.8	41.7	25.5	33.8	12.4	9.9	5.8	19.4	61.2	-	53.8	8.5	66.9	3.4	3.4	12.6
A_2																
2 ~ 5	66.3	34.3	66.5	81.7	75.7	76.6	63.7	111.2	49.9	130.0	113.7	14.7	51.5	76.5	76.3	76.2
A_3																
5 ~ 8	63.4	3.0	-	-	6.3	30.3	8.1	-	16.1	43.7	49.3	70.9	37.1	10.0	10.2	34.0
A_4																
8 ~ 16	16.4	-	-	-	-	-	16.5	-	-	-	2.7	2.6	0.3	-	-	20.3
16 <	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	186.9	79.0	92.0	115.5	94.4	116.8	94.1	150.6	127.2	173.7	219.5	96.7	155.8	89.9	89.9	143.1
WM (%)	5.4	2.7	3.1	3.1	3.1	4.5	5.7	3.4	3.1	4.6	4.1	6.4	3.7	4.1	4.1	5.9

where WM = Weighted Mean Slope (%), Formula = $1.5A_1 + 3.75A_2 + 7.25A_3 + 14A_4 / 2A_{1\sim4}$
Data Source : Topo-Map (1/2,000) surveyed in Jan. 1988

Chapter 3.

PROJECT FORMULATION

CHAPTER 3 PROJECT FORMULATION

3-1 Classification of Pilot Area

(1) Alternative plan

As mentioned in the B/P, alternative plan of the study area development shall be formulated in the following depending on the grade of soil conservation measures.

Project grade shall be classified into three levels such as High grade, Medium grade and Common grade, each grade is explained below:

a) High grade (Plan I)
   - Target : prevention of soil loss by 90%
   - Selected mechanical measures shall be applied at a full scale
   - Irrigation facilities shall be applied with one large Farm Pond (Tameike), Pump Station, fixed pipeline and tank.
   - Supporting measures shall be considered on a suitable scale.

b) Medium Grade (Plan II)
   - Target : prevention of soil loss by 85%
   - Selected mechanical measures shall be applied at a medium scale
   - Irrigation facilities shall be applied with some small scale Farm Ponds, portable pumps and portable hose.
   - Supporting Measures shall be considered on a medium scale.

c) Common Grade (Plan III)
   - Target : prevention of soil loss by 80%
   - Selected mechanical measures shall be applied on a certain scale.
   - Irrigation facilities shall be applied by small scale Farm Pond, portable pump and portable hose.
   - Supporting measures shall include only shallow well for drinking water.

Table 3.1-1 shows the summary of the contents of each case, and Figure 3.1-1 shows the illustration of farm road, drainage and terrace arrangement of each case.

Table 3.1-1 Alternatives of Soil Conservation Plan

Measures	Plan I	Plan II	Plan III
Target (soil loss)	90 % (50 → 5 t / ha / y)	85 % (50 → 7.5)	80 % (50 → 10)
1. Mechancisl measures			
a. Sub Soiling	50 % of the Area	25 %	0
b. Graded Terrace	Interval 40m (40m / rai)	50m (32m / rai)	60m (26.7m / rai)
c. Collecting ditch	Masonry ditch + drops Interval 200m (= 8.0m / rai)	Grass water-way + drops 300m (= 5.3m /rai)	Grass water-way 400m (= 4.0m /rai)
d. Sediment trap	1 pl / 25 rai	1 pl / 50 rai	1 pl / 100 rai
e. Draining ditch	Masonry water-way (3.2m / rai)	Grass water-way (3.2m / rai)	Grass water-way (3.2m / rai)
f. Road			
– lateral	8.0m / rai	5.3m / rai	4.0m / rai
– trunk	1.6m / rai	1.6m / rai	1.6m / rai
g. Check dam	1 pl / 250 rai (masonry)	1 pl / 250 rai (masonry)	1 pl / 250 rai (earth dam)
h. Slope protection	6.4m² / rai (sodding)	3.2m² / rai (sodding)	–
2. Irrigation facilities			
i. Farm Pond	one large scale	1 pl / 300 rai small scale	1 pl / 500 rai small scale
j. Irrigation Facilities	Pump station, Pipeline, Tank } package	Portable pump Portable hose	Portable pump Portable hose
3. Supporting measures			
k. Fish pond	1 pl / 250 rai	1 pl / 500 rai	–
l. Shallow well	1 pl / 150 rai	1 pl / 250 rai	1 pl / 350 rai
m. Meeting house	200m²	100m²	–
n. Warehouse	500m²	300m²	–

Unit : m

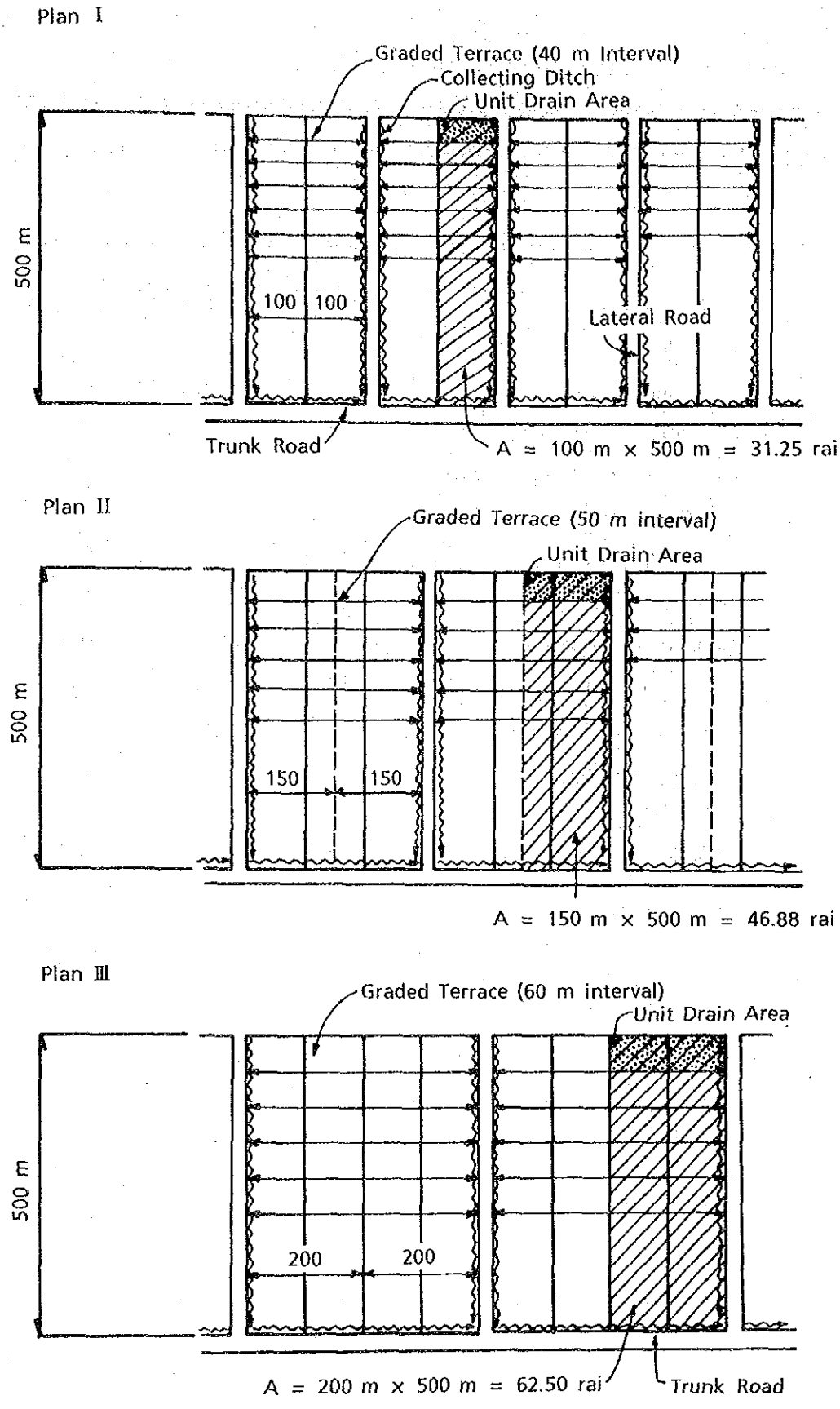

Figure 3.1-1 *Farm Road, Drainage and Terrace Arrangement*

(2) Project cost of alternative plan

Case study of each alternative plan was carried out on RY-No.2 for setting down project cost and is summarized as follows.

Unit : 1,000 Baht/rai

Description	Plan I	Plan II	Plan III
1. Civil Works			
1.1 Preparatory Works	0.6	0.4	0.2
1.2 Mechanical Measures	4.3	3.5	3.1
1.3 Irrigation Facilities	4.4	3.7	1.6
1.4 Supporting Measures	2.4	1.2	0.2
Sub-total (1)	11.6	8.8	5.1
2. Project Administration	0.6	0.5	0.4
3. Engineering Service	1.2	0.9	0.5
Sub-total (1 to 3)	13.4	10.2	6.0
4. Physical Contingency	1.3	1.2	0.6
Total (1 to 4)	14.8	11.3	6.6
5. Price Contingency	2.0	1.6	0.9
Total (1 to 5)	16.8	12.8	7.5

where : 3 = 1×10%
4 = (1~3)×10%
5 = (1~4)×15% in FC, (1~4)×10% in LC

Note : Detailed estimation is shown in Vol. V Annex 5, 5-10

(3) Classification of pilot area

Pilot areas were classified by development grade considering the following factors.

Category	Class	Grade
a. Land tenure	Private	H
	National land	M~L
b. Farmers age	40>	H
(Years old)	41~45	M
	46<	L
c. Land holding area	11<	H
(Ha)	10~4	M
	3>	L
d. Gross farm income	101<	H
(10^3 bahts/year)	51~100	M
	50>	L
e. Planted crop	80<	H
(percentage of cassava)	79~50	M
	49>	L
f. Land suitability	A	H
(total judgement)	B	M
	C	L
g. Potential of water	Rich	H
resources	Medium	M
	Low	L

where H : high potential
M : medium potential
L : Low potential

In the pilot area, the most important factor is assumed to be farm gross income due to the capability for paying operation and maintenance cost after completion of the Project.

The result of classification is shown below:

Plan	CS	CN	RY	CT	Total
I		No.1, *No.8 No.9	* No.2	No.3	5
II	No.4, No.8	No.2	No.3, No.5	* No.2	6
III	*No.3, No.5	No.4	No.1, No.7		5
Total (Places)	4	5	5	2	16

* Representative of each plan and province, detailed condition of each pilot area is shown in Table 3.1-2.

Table 3.1-2 Classification of Pilot Areas

Province	Project	1) Acreage (ha)	Land Tenure		Farm		Persons/farm	2) Ave. Age year	G.F.I 3) 000 Baht/yr.	O.F.I 4) 000 Baht/yr	Cassava Baht/Rai	M. crop 5) I : > 35% II : Others	Land 6) suitability (Total Rank)	7) W. R (Potential)	Plan
			Type	Agency	No.	ha/farm									
CS	CS - 3	187 (180)	SPK, 4-01	ALRO	48	3.7	5.0	40.0	20	10	539	I . C II . R	C	L	Plan - III
	CS - 4	79 (73)	"	"	29	2.5	4.6	39.4	92	5	762	I . C II . S.P.F	B	M	II
	CS - 5	92 (88)	"	"	36	2.4	6.8	49.5	37	7	660	I . C II . Pa	B	L	III
	CS - 8	116 (108)	"	"	29	3.7	6.3	47.4	79	16	660	I . C II . F.P	A	H	II
CN	CN - 1	94 (92)	SK.1	Private	9	10.2	4.3	40.5	237	9	1,298	I . C II . S.P	B	M	I
	CN - 2	117 (104)	NS.3	"	18	5.8	not available	not available	not available	not available	not available	I . C II . R	A	H	II
	CN - 4	94 (90)	"	"	14	6.4	"	"	"	"	"	I . C II . Co. F	B	L	III
	CN - 8	131 (126)	"	"	8	15.8	5.6	38.2	153	36	847	I . C II . S	B	L	I
	CN - 9	127 (118)	"	"	8	14.8	not available	not available	not available	not available	not available	I . S II . -	A	M	I
RY	RY - 1	174 (154)	NK.1	PWD	75	2.0	5.6	46.9	71	15	1,057	I . C II . P. R	A	L	III
	RY - 2	220 (194)	NK.3	"	44	4.4	5.4	42.5	167	31	1,791	I . C II . F. R	B	"	I
	RY - 3	97 (93)	KSN	CPD	16	5.8	not available	not available	not available	not available	not available	I . S II . C. R	B	"	II
	RY - 5	156 (148)	KSN	"	21	7.0	"	"	"	"	"	I . S II . R. P. C	B	"	II
	RY - 7	90 (77)	NS.3	Private	25	3.4	"	"	"	"	"	I . C II . P. F	A	"	III
CT	CT - 2	143 (129)	NS.3 (K)	Private	34	3.8	4.8	43.8	121	20	1,212	I . C II . F	C	L	II
	CT - 3	147 (139)	"	"	34	4.1	4.9	47.6	395	15	1,233	I . - II . C. R. F	C	"	I
Total		2,062			44.8	4.3									

Note : 1) Figure enclossed by parenthesis means the present cultivated area
2) Average age of farmers
3) Gross farm income
4) Off farm income
5) Major crop C (Cassava), R (Rubber), S (Sugar cane), P (Pineapple), F (Fruit tree), Pa (Paddy), Co (Coconut)
6) A : high, B : medium, C : low
7) Water resources H : high, M : medium, L : low

3-2 Soil Conservation Plan

Soil conservation measures consist of the following items;

1. Agricultural Measures
2. Mechanical Measures
3. Irrigation Facilities
4. Supporting Measures

The countermeasures consist of two main categories, namely software and hardware. Software covers agricultural measures including biological measures, crop cultivation and farm management system, and organization and management system. Hardware covers mechanical measures including civil engineering, land preparation and operation system, and irrigation facilities and supporting measures.

As to cost estimation of the Project, only hardware shall be counted. Software shall be included in the production cost of crops, and the operation and maintenance cost of the Project.

3-2-1 Agricultural Measures

Basic concept of agricultural measures against erosion and cropping pattern for that purpose are mentioned and suggested in Vol.II, 4-1.

This section deals with what crops should be planted in each pilot area based on those principles.

Selection of crops should be in line with the Sixth Plan and the targets of production, planting area and productivity of each crop in the Plan are shown in Table 3.2.1-1.

Judging from Table 3.2.1-1, production of some industrial and fruit crops is encouraged and major crops at present, such as rice or maize, are going to be kept at present levels or lower. It is planned to decrease the planting area of cassava but production will be maintained by increasing yields.

Table 3.2.1-2 shows the production tendency of same selected crops in the plan in the Eastern Region and the four provinces. As mentioned earlier, instead of the existing major crops such as rice, maize, pineapple or sugarcane, tree crops or fruit trees are being emphasized.

Under such circumstances and the local situation of the 16 pilot areas, the crops to be suggested are listed in Table 3.2.1-3.

In the irrigable area, mango and durian are the main fruit trees and pineapple or cassava will be intercropped for a few years.

In the non-irrigable area, Para-rubber and cashew nut are the main crops with the same intercrops as mentioned above.

The precise cropping patterns in the four representative pilot areas are suggested in Table 3.2.1-4.

Table 3.2.1-1 The Target of Agricultural Extension by Production Percentage (1991 / 1987) in the Sixth Plan and Percentage of Production by Region in 1991

Crop	Production	Area	Yield (kg/rai)	Production by Region in 1991 (%)					
				North	Noth East	Central	East	West	South
Rice	106 %	100 %	106 %	27.7	36.8	12.2	7.4	9.2	6.6
Major	107	100	105	29.0	39.8	9.9	7.2	7.2	6.8
Second	94	100	103	14.2	5.1	35.6	9.7	30.5	4.8
Maize	110	103	118	47.4	25.5	15.8	6.3	4.3	0.3
Sorghum	124	106	118	38.5	8.2	48.4	1.1	3.4	–
Mungbean	113	101	111	73.6	9.3	9.9	0.8	2.5	3.9
Cassava	102	97	105	4.4	57.3	1.3	31.8	5.2	–
Pineapple	121	96	126	3.7	–	–	25.0	71.2	–
Soybean	130	121	107	74.3	11.1	6.4	4.1	2.7	–
Groundnut	109	101	108	46.0	30.6	3.1	10.1	2.9	7.4
Castorbean	157	138	114	39.0	29.9	6.1	7.5	17.5	–
Sesame	159	141	113	50.1	25.1	7.3	3.8	11.5	2.2
Coconut	116	104	106	6.6	2.7	3.5	10.4	22.1	54.0
Oil Palm	170	115	114	–	–	–	–	1.7	98.3
Cotton	127	116	110	42.1	15.1	13.1	13.1	16.4	–
Hemp	101	91	112	–	94.1	–	6.0	–	–
Kapok	149	126	119	30.6	51.6	2.9	2.9	10.3	1.7
Para-rubber	124	102	121	–	–	–	12.2	0.1	87.7
Mango	158	116	121	23.8	15.1	14.1	30.0	13.8	8.7
Rambutan	130	107	117	0.1	–	–	48.0	–	52.0
Durian	128	110	113	7.0	–	2.3	60.5	–	30.0
Tamarind	124	161	104	17.4	39.3	14.1	8.6	4.5	16.2
Longan	140	112	114	93.0	6.3	–	0.7	–	–
Cahew Nut	162	122	103	1.2	9.7	–	10.1	1.1	77.9
Mangosteen	116	109	105	0.3	–	0.5	36.6	–	62.5
Lichi	141	121	101	74.2	0.9	4.4	0.1	20.4	–
Pomelo	160	120	124	30.9	3.7	9.8	7.4	31.9	16.4
Grape	124	113	108	–	–	–	–	100	–
Sweet Orange	134	116	110	11.8	–	64.5	13.3	5.2	5.1
Banana	129	112	113	17.6	16.4	22.5	22.4	21.1	–
Pepper	166	123	103	–	–	–	82.2	–	17.6
Coffee	170	102	117	0.2	–	–	0.8	1.0	98.0
Cocoa	783	24.7	133	–	–	–	1.7	22.6	75.7
Sweet Potato	140	132	107	15.0	16.5	8.8	15.2	27.0	17.3
Potato	123	112	110	97.3	2.7	–	–	–	–
Red Onion	100	100	100	48.4	50.4	–	–	–	1.2
Big Onion	100	100	100	83.3	–	–	–	–	16.7
Garlic	100	101	100	97.0	2.9	–	–	–	–

Source : The Taget of Agricultural Extension 1987 - 1991, DOAE

Table 3.2.1-2 The Target of Production of Main Crops in the Sixth Plan in the Four Provinces

Crop	East	Chachoengsao	Chonburi	Rayong	Chanthaburi
Rice Major	−	−	±	±	− −
Second	− −	− −	±	±	
Marge	+		+ +		±
Sorghum	+ +	±			
Mungbean	±				±
Cassava	−	±	−	− −	− −
Pineapple	±	±	±	±	
Soybean	+ + +	+ + +			+ + +
Groundnut	±	±	±	±	±
Castor bean	+ + +	+ + +		+ + +	+ + +
Sesame	+ +	+	+ + +	+ + +	+ + +
Coconut	+	±	±	+ +	+
Para-rubber	+ + +	+ +	+ +	+ + +	+
Mango	+ +	+ + +	+	+ +	+ + +
Rambutan	+		+	±	+
Durian	+	+ + +	+ +	+ +	+
Cashew nut	+ + +	+ + +	+ +		+ +
Mangosteen	+ +		±	+ +	+ +
Pomelo	+	+	±		
Sugarcane	− −	− −	− −	− −	±

Source : The Target of Agricultural Extension 1987 - 1991, DOAE

Note : − − Productionis less than 90% in 1991/1987
− Production is 91% ~ 99% in 1991/1987
± Production is 100% in 1991/1987
+ Production is 101% ~ 109% in 1991/1987
+ + Production is 110% ~ 119% in 1991/1987
+ + + Production is more than 120% in 1991/1987

Table 3.2.1-3 Suggested Crops for the Pilot Areas

Site No.	Area (ha)		Plan	Irrigable Area		Non-Irrigable Area		Remarks
	Total	Cultivable		ha	Main Crop (Inter Crop)	ha	Main Crop (Inter Crop)	
CS – NO.3 1)	187	165	III	1.5	Mango (Pineapple or Cassava)	138.1	Para-rubber (Pineapple or Cassava or Cover Crop) and Cassava or Pineapple	1) Existing perennial crop such as Para-rubber or fruit tree are being cultivated as follows;
– 4	79	66	II	2.3	-do-	63.7	-do-	
– 5	92	67	III	4.0	Durian (Kolapogonium, Pineapple or Cassava)	63.0	-do-	CS - NO. 3 25.0 ha CN - NO. 8 9.1 RY - No. 2 40.5 CT - No. 2 30.4 These are excluded from cultivable areas in this table.
– 8	116	97	II	0		97.0	Bamboo, Pineapple, Cassava	
CN – NO.1	94	78	I	10.8	Asparagus, Durian	67.2	Cashew nut (Cassava) and Cassava or Pineapple	
– 2	117	81	II	46.8	Mango or Durian (Pineapple or Cassava)	34.2	Same as CS – NO.3	
– 4	94	84	III	5.7	Vegetable, Durian	78.3	Same as CN - NO.1	
– 8 1)	131	104	I	19.0	Same as CS – NO.5	77.1	Cashew nut (Cassava) and Sugarcane or Cassava	
– 9	127	100	I	7.5	-do-	92.5	-do-	
RY – NO.1	174	143	III	9.0	Durian or Mango or Mangosteen (Cover Crop, Pineapple, Cassava)	134.0	Same as CS - NO. 3	2) Irrigable areas are determined on the basis of Mango cultivation in CS and Durian in other Pilot Areas.
– 2 1)	220	161	I	45.0	Same as CS - NO. 5	82.1	-do-	
– 3	97	85	II	5.8	Mango or Rambutan or Durian (Pineapple or Cassava)	79.2	-do-	
– 5	156	133	II	9.6	-do-	123.4	-do- and Sugarcane	
– 7	90	72	III	1.1	Same as RY - NO.1	70.9	-do-	
CT – NO.2 1)	143	112	II	9.8	Durian (Pineapple)	102.2	Para-rubber (pineapple) and Cassava	
– 3	147	103	II	9.2	Pepper or Durian	93.8	-do-	

Table 3.2.1-4 Cropping Patterns Suggested for the Selected Pilot Areas

Site No.	Irrigable Area			Non - Irrigable Area			
	ha	Main Crop	Inter Crop	ha *	Main Crop		Inter Crop
CS - NO.3	1.5	Mango (1.9 ha)	• Pineapple (1.5 ha × 7/10 = 1.1 ha) for two seasons (in three years). Then cover crops to prevent erosion.	138.1	1) Para-rubber (80 ha) 2) Cassava (58.1 ha)		• Cassava (80 ha × 7/10 = 56 ha) for five years. After that cover crops.
CN - NO.8	19.0	Durian (19.0 ha)	• Pineapple (19.0 ha × 7/10 = 13.3 ha) for two seasons (in three years). Then cover crops to prevent erosion.	77.1	1) Cashew nut (30 ha) 2) Sugarcane (30 ha) 3) Cassava (17.1 ha)		• Cassava (30 ha × 7/10 = 21 ha) for four years
RY - NO. 2	45.0	Durian (45.0 ha)	• Pineapple (45.0 ha × 7/10 = 31.5 ha) for two seasons (in three years). Then cover crops to prevent erosion.	82.1	1) Para-rubber (40 ha) 2) Pineapple (20 ha) 3) Cassava (22.1 ha)		• Cassava (40 ha × 7/10 = 28 ha) for five years Then cover crops
CT - NO.2	9.8	Durian (9.8 ha)	• Pineapple (9.8 × 7/10 = 6.9 ha) for two seasons (in three years). Then, cover crops to prevent erosion.	75.9	1) Para-rubber (50 ha) 2) Cassava (25.9 ha)		• Pineapple (50 ha × 7/10 = 35 ha) for five years (four seasons) Then cover crops

Note : * excluding existing perennial crops' areas

3-2-2 Mechanical Measures

Appropriate mechanical measures were applied to each pilot area based on the development grade.

The results are shown below;

1) Major applied measures are summarized in Table 3.2.2-1.
2) Gross cultivable areas after completion of Project are shown in Table 3.2.2-2.
3) Soil conservation effects are shown in Table 3.2.2-3.

To minimize project cost and non-cultivable area the following matters were considered;

1) Bench terrace was not applied.
2) Horizontal interval of graded terrace has been decided depending on the development grade.
3) Total width of water-way and terrace were minimized as much as possible due to detailed hydraulic calculation.

Table 3.2.2-1 Major Mechanical Measures Applied to Pilot Areas

Name	Plan		Water-way			Water-way			Farm P	C-A	Terrace			Note
			G.W.W	M.W.W	A_1	M. R	L. R	A_2	A_3	a/o T	Intensity	Total L.	A_4	
			B = 2.7 m	B = 2.9 m		B = 6.0 m	B = 4.0 m		ha	ha	m/ha	km	B = 3.0 m	
CS – 3	III	L (m)	4,405	2,605	7,010	1,750	4,800			173.5	166.9	29.0		
		A (ha)	1.2	0.8	2.0	1.1	1.9	3.0	1.4				8.7	
CN – 8	I	L (m)	9,095	2,325	11,420	2,030	5,800			112.0	250.0	28.0		
		A (ha)	2.5	0.7	3.2	1.2	2.3	3.5	7.6				8.4	
RY – 2	I	L (m)	11,550	3,950	15,500	3,100	8,830			173.8	250.0	43.5		
		A (ha)	3.1	1.1	4.2	1.9	3.5	5.4	10.8				13.0	
	II	L (m)	7,950	4,440	12,410	2,800	6,300			184.1	200.0	36.8		
		A (ha)	2.1	1.3	3.4	1.7	2.5	4.2	2.5				11.0	
	III	L (m)	3,825	5,290	9,115	2,800	4,700			187.4	166.9	31.3		
		A (ha)	1.0	1.5	2.5	1.7	1.9	3.6	0.7				9.4	
CT – 2	II	L (m)	4,730	4,220	8,950	950	5,050			119.1	200.0	23.8		
		A (ha)	1.3	1.2	2.5	0.6	2.0	2.6	5.5				7.1	

where G.W.W = Grass Water-way
M.W.W = Masonry Water-way
M. R = Main Road
L. R = Lateral Road
B = Total Width of Structures
CA w/o T = Cultivable Area without Terrace

Table 3.2.2-2 Gross Cultivable Area of Pilot Areas

Unit : Ha

Name		Total A	Cultivable A	Non-cultivable Area										Increased non. C.A * (%)
				Stream	Exist. R	New R.	Water-way	Terrace	Farm R.	Green Belt	Resident	Others	Total	
CS – 3	Present	186.9	179.9	3.3	3.1	–	–	–	–	–	0.6	–	7.0	
		(100)	(96.3%)											
	Plan - III	"	164.8	3.3	"	3.0	2.0	8.7	1.4	–	"	–	22.1	△ 8.1
			(88.2)											
CN – 8	Present	130.6	126.3	2.9	1.3	–	–	–	–	–	0.1	–	4.3	
		(100)	(96.7)											
	Plan - I	"	103.6	"	"	3.5	3.2	8.4	7.6	–	"	–	27.0	△17.4
			(79.3)											
RY – 2	Present	219.5	194.1	7.2	17.4	–	–	–	–	–	0.8	–	25.4	
		(100)	(88.4%)											
	Plan - I	"	160.7	"	"	5.4	4.2	13.0	10.8	–	"	–	58.8	△15.2
			(73.2)											
	Plan - II	"	173.0	"	"	4.2	3.4	11.0	2.5	–	"	–	46.5	△ 9.6
			(78.8)											
	Plan - III	"	177.9	"	"	3.6	2.5	9.4	0.7	–	"	–	41.6	△ 7.4
			(81.0)											
CT – 2	Present	143.1	129.4	8.4	4.9	–	–	–	–	–	0.1	–	13.7	
		(100)	(90.4)											
	Plan - II	"	112.0	"	"	2.6	2.5	7.1	5.5	–	"	–	31.1	△12.1
			(78.3)											
								* Increased non cultivable area compared with without Project.						

Table 3.2.2-3 Effects of Soil Conservation

Name	Plan	Project Area ha	Crop Land ha	Non Crop Area ha	Soil Loss t/ha/y	S. Texture	Monetary Loss (10^3 Baht)			Saving (10^3 Baht)	Mechanical Measures				Soil Depth Infiltration
							Nutrient	Dredging	Total		Terracing	C. Ridging	C. Ploughing	Sub-Soiling	
CS – 3	Present	186.9	179.9	7.0	63.8	CL	1,662	574	2,236		–	–	–	–	<25 cm
					×20%										Low
	Plan - III	〃	164.8	22.1	12.8	〃	305	105	410	△1,826	ctc 60 m				
											(A = 16.5 ha)			Dep. 0.6 m	
														168.3 ha	
CN – 8	Present	130.6	126.3	4.3	33.2	SL	232	210	442						50 ~ 100
					×10%										Low
	Plan - I	〃	103.6	27.0	3.3	〃	19	17	36	△ 406	ctc 40 m			–	
											(A = 104 ha)				
RY – 2	Present	219.5	194.1	25.4	62.8	SL	674	609	1,286						50 ~ 100
					×10%										High
	Plan - I	〃	160.7	58.8	6.3	〃	56	51	107	△1,179	ctc 40 m			–	
					×15%						(A = 161 ha)				
	Plan - II	〃	173.0	46.5	9.4	〃	90	81	171	△1,115	ctc 50 m			–	
					×20%						(A = 173 ha)				
	Plan - III	〃	177.9	41.6	12.6	〃	124	112	236	△1,050	ctc 60 m			–	
											(A = 178 ha)				
CT – 2	Present	143.1	129.4	13.7	142.6	CL	2,672	923	3,595						25 ~ 50
					×15%						ctc 50 m			Dep. 0.6 m	High
	Plan - II	〃	112.0	31.1	21.4	〃	347	120	467	△3,128	(A = 112 ha)			56.0 ha	
														(50%)	

where ; Nutrient Cost CL = 144.8 Baht/ton
SL = 55.3 Baht/ton
Dredging Cost = 50.0 Baht/ton

3-2-3 Irrigation Facilities

(1) General

As mentioned in the Basic Plan (Vol. II), irrigation facilities shall be introduced to the pilot areas as one of the effective soil conservation measures;

- To obtain stable agricultural production.
- To diversify from cassava to other upland crops including tree crops.

The irrigation facilities of each pilot area are planned as follows;

Plan	General ideas	Pilot area
I	One large pond (maximum dam height, 6.0 m) with a pump station	CN-NO1, CN-NO8, CN-NO9, RY-NO2, CT-NO3
II	Three small ponds (maximum dam height, 6.0 m) utilizing portable pumps	CS-NO4, CS-NO8, CN-NO2, RY-NO3, RY-NO5, CT-NO2
III	One small pond utilizing portable pumps	CS-NO3, CS-NO5, CN-NO4, RY-NO1, RY-NO7

Note : The criteria for planning the reservoirs mentioned above is only shown in principle, therefore, the final plan is adjusted taking into account the actual conditions of topography, watershed, land tenure, etc. in each pilot area.

(2) Irrigable area

Irrigable area of a pond and/or weir will be estimated through the water balance study taking into account inflow (run-off) from watershed, such water losses in the reservoir as evaporation and seepage , and outflow (water requirement) to the irrigation area.

1) Run-off water

Since there are no effective run-off data for small watersheds, the run-off water is estimated applying the following formula.

$$V = Ci \cdot Pi \cdot A$$

Where, V ; Run-off volume

Ci ; Run-off coefficient (RID method)

Pi ; Rainfall

Rainfall data is 1/2 year minimum probability rainfall the same as in the estimation of irrigation water requirement

A ; Watershed

In addition to the run-off water from rainfall, some base water flows are considered as a result of the field investigation conducted.

2) Water losses in reservoir

Evaporation ;

Open water evaporation from the reservoir is estimated at 70% of pan evaporation value.

Seepage ;

Although less than 0.05% of total storage water per day is normally applied for seepage water, considering the characteristic of soil in the project area, approximately 0.10% shall be adopted.

3) Irrigable area

From the water balance study, applying a 5 day interval based on the conditions mentioned above, the irrigable area for each pilot area is obtained as shown in Table 3.2.3-1. As a result, the total irrigable area is 187 ha equivalent to about 9% of the total project area (2,062 ha). The table indicates that about 4,000 m^3 of total reservoir capacity is required for one ha of irrigable area.

(3) Design discharge

1) Frequency of design flood

Frequency of design flood for facilities shall be determined by the importance of facilities and economic aspects.

Judging from other similar projects in Thailand and the results

Table 3.2.3-1 Irrigable Area of 16 Pilot Areas

Province	Pilot Area	Project Area (ha)	Pond Total Capacity (1,000 m³)	Irrigable Area (ha)	Plan	Remarks
Chachoengsao	CS - No.3	186.9	11.2	1.5	III	One pond
	〃 - No.4	79.0	13.8	2.3	II	One pond
	〃 - No.5	92.0	11.5	4.0	III	One weir
	〃 - No.8	115.5	-	-	II	No farm pond
	Sub-Total	473.4	36.5	7.8		
Chonburi	CN - No.1	94.4	79.4	10.8	I	One pond
	〃 - No.2	116.8	11.0	46.8	II	One weir / large watershed
	〃 - No.4	94.1	5.0	5.7	III	One pond
	〃 - No.8	130.6	123.5	19.0	I	One pond
	〃 - No.9	127.2	4.5	7.5	I	One weir
	Sub-Total	563.1	223.4	89.8		
Rayong	RY - No.1	173.7	12.5	9.0	III	One pond
	〃 - No.2	219.5	122.5	45.0	I	One pond
	〃 - No.3	96.5	32.6	5.8	II	Two pond
	〃 - No.5	155.8	24.1	9.6	II	One pond
	〃 - No.7	89.9	12.1	1.1	III	One pond
	Sub-Total	735.6	203.8	70.5		
Chanthaburi	CT - No.2	143.1	48.1	9.8	II	Two pond
	〃 - No.3	146.8	39.3	9.2	I	Three pond
	Sub-Total	289.9	89.4	19.0		
Total		2,062.0	553.1	187.1		

Note ;

(1) Irrigation rate

		(In case of excluding CN-No.2 and CS-No.8)
Total average	; 9.1%	(7.7%)
Plan I	; 12.7%	(12.7%)
Plan II	; 10.5%	(5.8%)
Plan III	; 3.3%	(3.3%)

(2) Required pond capacity for irrigable area

Average ; 3,000m³/ha (4,000m³/ha)

(3) The irrigable areas excluding CS-No.3, CN-No.8, RY-No.2 and CT-No.2 were assumed based on the results of detailed water balance study for said four pilot areas.

of the field investigation, the following criteria shall be adopted as the design flood for facilities.

Frequency	Application
1/50 year	Spill-way for reservoir and weir
1/10 year	Main drainage, crossing structure of road
1/5 year	Lateral drainage (grass water-way, terrace, ditch)

2) Design flood

Design flood analysis was made by applying the Rational Formula in the study because of lack of run-off data in the small watershed.

Equation of the Rational Formula is ;

$$Q = 0.2778 \cdot C \cdot I \cdot A$$

Where,

Q ; Flood discharge (cu.m/sec)

C ; Run-off coefficient (applying ARDO method)

I ; Rainfall intensity for duration of time of concentration (Tc) (mm/hr).

The rainfall intensity of the project area is estimated by applying "Talbot Equation" which is well fitted to the area as shown in Table 3.2.3-2.

A ; Watershed area (km^2)

Based on the analysis method mentioned above, the specific flood discharge for each province was calculated as shown in Table 3.2.3-3.

3) Design sedimention

Since almost all of the coarse sand will be stored in the sediment trap and/or pond to be provided upstream of each farm pond, its design sediment volume shall be estimated by the suspended load of the stream. Judging from the study report for the East Coast Water Resources Development Project conducted by JICA, the specific yield of sedimentation in the project area is

Table 3.2.3-2 Talbot Equation

Province	Coefficient	Return Period (Year) 1/5	1/10	1/50	Equation
Chachoengsao /Chonburi/Rayong	A	69.119	71.209	77.918	$I = \frac{A}{Tc + B} \times R_N$ (mm/hr)
	B	39.358	42.247	44.348	
Chanthaburi	A	61.430	63.660	71.497	
	B	56.401	54.103	67.519	

Table 3.2.3-3 Specific Flood Discharge (cu.m/sec/km^2)

Province	Gaging Station	Return Period (Year) 1/5	1/10	1/50	Application of Pilot Area
Chachoengsao	03052	7.7	9.0	12.9	CS-NO3, CS-NO4, CS-NO5, CS-NO8
Chonberri	09042	8.6	9.9	13.4	CN-NO1, CN-NO2, CN-NO8, CN-NO9
"	09073	8.7	10.7	17.0	CN-NO4
Rayong	48022	9.1	10.9	16.3	RY-NO1, RY-NO2, RY-NO7
"	48032	9.4	10.9	15.3	RY-NO3, RY-NO5
Chanthaburi	06081	7.2	9.5	14.8	CT-NO2, CT-NO3

Note; C = 0.35 (silty sand, cultivated land - wood land, undulation)
Tc = 60 min, A = 1.00 km^2
R_N = Probable rainfall (mm/day)

presumed to be 300 $m^3/km^2/year$.

On the assumption that maintenance for ponds will be conducted once every five years, the design sediment volume for the pond is as follows.

$$V = 300\ m^3/km^2/year \times 5\ year \times A = 1,500 \times A\ (m^3)$$

Where, A ; Watershed (km^2)

(4) Irrigation facilities

Basic ideas for the irrigation facilities are as follows;

1) Location of facilities

Facilities should be located in places which shall satisfy their functions completely, however, places such as uncultivated land, land of existing facilities and boundaries of land tenure shall be selected as much as possible in order to minimize the land loss of farmers.

2) Farm pond

i) Pond capacity

Pond capacity shall be determined taking into account the following factors;

a) Run-off volume from watershed

b) Water requirement for proposed cropping pattern

c) Land loss area

d) Dam height (Maximum 6.0 m from the original ground surface) 1/

e) Geological and topographic conditions in the field

f) Availability of construction materials, etc.

1/ ; In case of less than 2.0 m dam height, the dam shall be designed as a weir (CS-NO5, CN-NO2 and CN-NO9).

ii) Dam-body

a) Dam type - Considering availability of impervious material in the project area, inclined type earth dam shall be selected in principle. Moreover, in such high permiability foundation as CS-NO4, CN-NO4, CN-

NO8, RY-NO2 and RY-NO7, earth blanket shall be provided to take a long path length of seepage.

b) Maximum height - 6.0 m

c) Width of dam crest - 5.0 m

d) Free board - 1.0m from high water level

e) Dam slope - Upstream 1: 3.0/downstream 1: 2.5 in principle with riprap protection for erosion.

f) Foundation treatment - 0.5 m thickness for stripping/loose soils (less than 15 N-value) and high permeability soils (more than 1×10^{-3} cm/sec K-value) shall be removed.

iii) Spillway

a) Design flood - 1/50 years frequency flood but design discharge from spillway can be reduced from the flood discharge taking reservoir storage effect above normal water level into account

b) Location - Shall be placed on the original ground

3) Intake facilities

Irrigation will be made in principle by pumping up except some area downstream of pond.

i) Pump station

a) In case of more than 100,000 m^3 of reservoir capacity, fixed pump station shall be planned and in other case, portable pump shall be procured for easy operation.

b) Minimizing the pump capacity, rotation block method for irrigation shall be employed.

Pump	Operation Hour (hr/day)	Max Block Size (ha)
ϕ150 m/m	8.0	10.0
ϕ100 m/m	8.0	5.0

ii) Water tank

Water pumped up from a pond is stored in a water tank for distribution to the irrigable area by gravity. Storage

capacity of the water tank is planned at about one day water demand.

4) Farm road

- Effective width ; Main road 5.0 m
  Lateral road 3.0 m
- Pavement ; at least laterite pavement
  (t = 0.20 m)
- Longitudinal slope ; Maximum 5% (1/20)

5) Feature of irrigation facilities

As the results of the study, the feature of irrigation facilities for the selected four pilot areas are shown in Table 3.2.3-4 and those for whole 16 pilot areas are shown in Vol. V Annex 5, 5-7.

Table 3.2.3-4 Major Component & Dimension of Irrigation Facilities

Description	CS-NO3	CN-NO8	RY-NO2	RY-NO2			CT-NO2	
1) Plan	III	I	I	II/III			II	
2) Irrigation method[1/]	Type B	Type A	Type A	Type B			Type B	
3) Irrigation facilities				Plan II (3 places)				
a) Farm pond	1 place	1 place	1 place	Plan III (1 place)			2 places	
– Pond name	NO1	NO1	NO1	NO1	NO2	NO3	NO1	NO2
– Irrigable area (ha)	1.5	19.0	45.0	1.7	4.8	1.5	7.0	2.8
– Watershed (ha)	49	69	810	23	131	26	91	21
– Total storage (m^3)	11,200	123,500	122,500	6,300	5,500	4,600	35,300	12,800
– Effective storage (m^3)	10,400	122,400	110,300	5,900	3,500	4,200	33,900	12,400
– Dam-body H (m) [2/]	4.0	6.0	6.0	4.0	4.0	3.5	4.0	3.0
– Dam-body V (m) [3/]	3,500	32,300	26,900	8,400	5,000	6,200	5,200	2,500
– Design flood (m^3/sec)	7.6	10.8	81.1	5.2	23.8	5.8	15.0	4.0
– Design discharge (m^3/sec)	4.9	1.9	71.4	3.2	21.8	2.5	6.4	1.3
b) Pump station	–	1 place (Ø100m/m)	1 place (Ø100m/m)	–	–	–	–	–
c) Irrigation pipe fixed (m)	–	2,500	3,900	–	–	–	–	–

(Note) 1/; Type A; Fixed and movable pipe line/spot drip irrigation
Type B; Movable pipe line/spot drip irrigation

3-2-4 Supporting Measures

(1) Strategy for supporting the soil conservation project

In order to support the soil conservation project the following should be considered as being a countermeasure of rural development;

1) soil conservation project should embrace the villagers' needs concerning rural development as much as possible.
2) soil conservation projects should be managed on the basis of the rural development committees which have been set up at the national, provincial, district and sub-district level.
3) soil conservation must contribute to alleviate the problems against rural development taking into account the existing conditions of the project area.

(2) Existing condition of the pilot area

1) Classification of the villages concerned

As mentioned in the basic plan, target areas are determined in accordance with the particular problems and needs such as backward area, middle-level area and progressive area for rural development in the Sixth NESD Plan.

They can be classified as follows:

i) Backward area :

CS-NO1, CS-NO4, CS-NO5, CS-NO8, RY-NO2, RY-NO3, RY-NO5

ii) Middle-level area :

CN-NO1, CN-NO2, CN-NO4, CN-NO8, CN-NO9, RY-NO1, RY-NO7, CT-NO2, CT-NO3

2) Existing number of scattered farmers' houses located in the pilot project area

Pilot Area	No. of farmers' houses	Area of the project (ha)	Housing density (ha/house)
CS-NO. 3	59	187	3.2
CS-NO. 4	11	79	7.2
CS-NO. 5	13	92	7.1
CS-NO. 8	42	116	2.8
CN-NO. 1	11	94	8.5
CN-NO. 2	13	117	9.0
CN-NO. 4	0	94	-
CN-NO. 8	11	131	11.9
CN-NO. 9	6	127	21.2
RY-NO. 1	20	174	8.7
RY-NO. 2	20	220	11.0
RY-NO. 3	7	97	13.9
RY-NO. 5	18	156	8.7
RY-NO. 7	30	90	3.0
CT-NO. 2	26	143	5.5
CT-NO. 3	36	147	4.1

3) Existing condition of the villages in which the pilot projects are located as of 1987

i) Number of households and population of the villages concerned

Number of households per one village ranges from 80 to 700.

Population per one village ranges from 392 to 2,250.

ii) Rural electrification

Five villages among 16 have no electricity.

Average rate of electrified households is 34.6%.

iii) Villagers' occupation

There are 3,205 households in the villages concerned excluding CN-NO. 4, among them :

326 households (10%) are engaged in employment only.

1,633 households (51%) are engaged in agriculture only.

33 households (1%) are entrepreneurs.

iv) Annual income per household

Annual income per household ranges from 7,200 to 16,000 Baht.

v) Public health service

Nine villages among the 16 have first aid kits or medical fund.

There is, however, only one village which has a children's development center or a nutrition center among them.

All of the Tambons to which the villages concerned belong have a hospital or a public health center.

vi) Water source

Concerning potable water, 1,316 households (41%) are suffering from shortages.

There are 1,422 shallow wells in all and the average number of shallow wells per household is 0.44.

On the other hand the number of deep wells is only 19.

Most of the villagers have a serious problem about water for agriculture as well.

vii) Education

Primary schools have been established at 12 villages and there is one village that has a secondary school. Both primary and secondary schools have been established in all Tambons concerned.

viii) Rural road

Result of the interview survey of the village heads concerning this matter are as follows;

CS-NO.3 : Satisfied with the existing number of rural roads.

CS-NO.4 : ditto

CS-NO.5 : ditto

CS-NO.8 : Requested to construct a new road to connect the houses in the village (50 km).

CN-NO.1 : Satisfied with the existing number of rural roads.

RY-NO.1 : Requested to construct a new road to connect Moo 8 to Moo 9 (7 km).

RY-NO.2 : Satisfied with the existing number of rural roads.

CT-NO.2 : Requested to construct a new road to connect village to amphoe market (12 km)

CT-NO.3 : Requested to construct a new road to connect Moo 6 to Moo 16 (4 km)

As far as maintenance and paving the existing roads are concerned, all of the village heads strongly requested such measures. However, paving was only requested for specific sections of roads which are not passable during the rainy season.

(3) Villagers' needs

As a case study, previously mentioned villages were selected to grasp villagers' needs in connection with the soil conservation project.

The following were strongly requested by the village heads.

1) Developing water sources for drinking, domestic and agricultural use.
2) Maintaining and paving the existing rural roads in order to ensure the availability of all-weather roads.
3) Promotion of rural electrification.
4) Creating employment opportunities by introducing agro-industry and/or other industries.
5) Warehouses were also requested by several villages.

(4) Recommendation

Firstly, the following must be considered.

1) What kind of rural development program is related to the soil conservation project?
2) How can the soil conservation project help other rural development projects?

As to the above two items, recommendations are;

i) Small scale water resources development

The top priority of selection for the project site will be whether there is a stream which can be developed or not.

ii) Rural road development

Farm road net-work will be developed by the project and in

that case the net-work should be considered to develop not only the agricultural aspects but also convenience of villagers' daily life.

iii) Changing the existing dispersed households to the ideal style of the settlement for rural development.

By using this useful measure, a residential area should be established in the area. Of course, immediate reorganization of the settlement will not be expected from the viewpoint of economic and social conditions, however, when the opportunity comes this measure will be very useful.

It is obvious that the existing style of settlement has been preventing rural development.

iv) Village fish-pond development

Most of the villagers seek employment and infant malnutrition can still be seen in 11 of the villages concerned.

From the viewpoint of location, marketing and investment, it is not so easy to introduce cottage industry to the area.

Fortunately, small reservoirs will be developed by the project and therefore, small scale inland fishery using the reservoirs should be created, so it will meet with the villagers' request.

v) Developing a forest for firewood and charcoal by allocating a part of the project area to be for common use.

Villagers living in 14 of the 16 villages in which the proposed pilot project areas are located have been using firewood and/or charcoal for fuel.

Most of the villagers said that they collect wood at the outside of the forest reserve area, in order to protect valuable natural resources firewood should be produced in project areas expressly for such purposes and using the material produced a cottage industry for charcoal could be introduced.

Chapter 4.

COST ESTIMATION

CHAPTER 4 COST ESTIMATION

4-1 Unit Cost

(1) Unit cost

The unit cost for the construction works is estimated taking into account the costs such as efficiency of the construction equipment, labour, materials, and operation cost of the construction equipment. The estimated unit costs for each major work are shown in Vol. V, Annex 5,5-10, of which details are given in Vol. VII Chapter 4.

(2) Labour efficiency per unit cost

The labour cost is mainly based upon the data obtained in Thailand. However, those not available are obtained from the standard figures used in Japan.

In this estimation of labour efficiency, some allowance is made in consideration of the working capability of local labour and quality/capacity of the construction materials and equipment to be supplied for the project implementation.

(3) Equipment efficiency per unit work

The basic data for estimation of unit cost consists of purchase price, life time, depreciation rate, repair rate, maintenance rate, operation rate and fuel/oil consumption for the construction equipment.

The purchase price of the construction equipment is estimated making reference to data collected in Thailand and Japan. The life time and operation rate are obtained considering the prevailing situation of construction works in Thailand. The depreciation rate, repair rate, maintenance rate and fuel/oil consumption are from standard data used in Japan.

The portion of foreign and local currency are decided as follows;

- Depreciation cost : 100 percent of foreign portion assuming the construction equipment will be imported.

- Repair cost : 80 percent of foreign portion and 20 percent of local portion, for spare parts and labour costs, respectively.
- Maintenance cost : 50 percent of foreign and 50 percent of local portion, for tools and equipment and labour costs, respectively.

The operation costs for major construction equipment are shown in Vol. V, Annex 5, 5-10.

4-2 Project Cost

The project cost of the 16 pilot areas are estimated on the contract basis by using the above-mentioned unit costs as shown in Table 4.2-1.

The total project cost for 16 pilot areas was 169.7 million Baht, and the portion of foreign currency and local currency is 66.0 million Baht (39.0%) and 103.7 million Baht (61%) respectively. The unit project cost by each development grade was as follows;

Plan	Unit Project Cost	
	(Baht/ha)	(Baht/rai)
I	108,300	17,300
II	81,700	13,000
III	53,400	8,500
Average	82,300	12,900

Table 4.2-1 Project Cost for 16 Pilot Areas

(,000 Baht)

Pilot Area	Plan	Acreage	Total	Foreign Currency	Local Currency
Chachoengsao		ha			
CS-NO.3	III	186.0	7,473	2,332	5,141
CS-NO.4	II	79.0	8,097	3,274	4,823
CS-NO.5	III	92.0	4,184	1,166	3,018
CS-NO.8	II	115.5	6,318	2,142	4,176
Chonburi					
CN-NO.1	I	94.4	12,741	5,672	7,069
CN-NO.2	II	116.8	9,075	2,972	6,103
CN-NO.4	III	94.1	6,311	2,343	3,968
CN-NO.8	I	130.6	16,104	7,301	8,803
CN-NO.9	I	127.2	11,415	4,048	7,367
Rayong					
RY-NO.1	III	173.7	8,638	2,864	5,774
RY-NO.2	I	219.5	23,108	9,926	13,182
RY-NO.3	II	96.7	9,638	3,896	5,742
RY-NO.5	II	155.8	12,953	5,095	7,858
RY-NO.7	III	89.9	7,392	2,946	4,446
Chanthaburi					
CT-NO.2	II	143.1	11,789	4,263	7,526
CT-NO.3	I	146.8	14,456	5,776	8,680
Total		2,062.0	169,692	66,016	103,676
			(100%)	(39%)	(61%)

Chapter 5.

CONSTRUCTION WORKS

5. CONSTRUCTION WORKS

5-1 Construction Schedule

(1) Construction method

1) Farm pond

There are some streams in the pilot areas which have frequent flood in the rainy season. Therefore, construction of dam-bodies shall be carried out in the dry season as much as possible.

Concerning the soil condition, the distribution of sandy soil or sandy loam is observed in the pilot areas. In general, soil is available for construction of farm ponds. However, in some pilot areas such as CN-NO.2, CN-NO.4, RY-NO.1, RY-NO.2 and RY-NO.7, soil is not available for use as construction material for embarkments. Therefore, embankment materials at these sites have to be carried in from other places.

In particular, testing of embankment materials should be executed before starting construction.

The major equipment of the dam body construction per one pilot area are as follows;

Equipment			Unit	Remark
Bulldozer	21ton	211ps	2	Excavation, Spreading & Compaction
Front loader	1.4m	110ps	2	Loading
Dump truck	8ton	240ps	5~6	Hauling
Backhoe	0.7m	140ps	1	Excavation

2) Sub-soiling and contour terrace

Farm tractors (6 ton, 67 ps) are available for small scale civil works such as sub-soiling and graded terrace.

In particular, construction of the graded terrace during the early stages of implementation is useful for soil conservation during the construction of the pilot area.

3) Farm road

The road construction is executed by cutting and filling the existing soil along the planned road line.

Bulldozers (11 ton, 108 ps) are used for the excavation, filling, spreading and compaction of the farm roads.

4) Check dam and fish pond

The major equipment for the construction of the check dam and the fish pond are the same as for the farm pond. They will be removed immediately to the site of the check dam and fish pond after completion of the farm pond construction.

5) Supply of construction materials

There are many factories and dealers of construction materials in the cities and towns, nearby the pilot areas. Upon implementation of construction, the major materials for construction are to be supplied from these cities and towns.

There are two crushing plants one in Chonburi located nearby DLD Chonburi Station and one in Chanthaburi along National Highway Route 3 in Chanthaburi Province, respectively.

There are many borrow-pits for laterite around the pilot areas. Therefore, construction material should be obtained easily.

(2) Workable days

Earth works are mostly affected by rainfall. Thereby, monthly mean workable days during the construction period are estimated by using the daily rainfall records of the recent ten years (1976-1985) at representative observation stations in the 4 provinces.

The criteria for estimation of workable days is shown in Vol.VI Chapter 4.

Based on the said criteria, the workable days for four provinces were estimated as shown in the table.

In principal, the construction works mentioned above shall be implemented in the dry season due to good working conditions such as number of workable days and easy mobilization of labour.

Province	Workable days per month	
	Wet Season (May to Oct.)	Dry Season (Nov. to Apr.)
Chachoengsao	22	25
Chonburi/Rayong	22	24
Chanthaburi	18	24

(3) Construction schedule

1) Pilot area RY-NO.2

The detailed construction schedule for the representative pilot area, RY-NO.2 (219.5 ha) was made as shown in Figure 5.5-1. The total construction period is nine (9) months.

2) All pilot areas

Based on the result of the construction plan for RY-NO.2 mentioned above, the construction schedule for all pilot areas is estimated as follows ;

- Average acreage of one pilot area : 130 ha
- Average output of construction per month : 219.5 ha/9 months = 24 ha/month
- Average construction period per one site : 130 ha/24 ha/month 5.4 ≒ 6.0 month (0.5 year)
- Total construction period : 16 sites ×0.5 year = 8 years per crew

In case that all pilot areas are completed within two years as described in Vol.II Chapter 5, mobilization of four (4) construction crews will be required.

Figure 5.1-2 shows the construction schedule for 16 pilot areas.

Figure 5.1-1 Construction Schedule for RY-NO. 2 (Plan I)

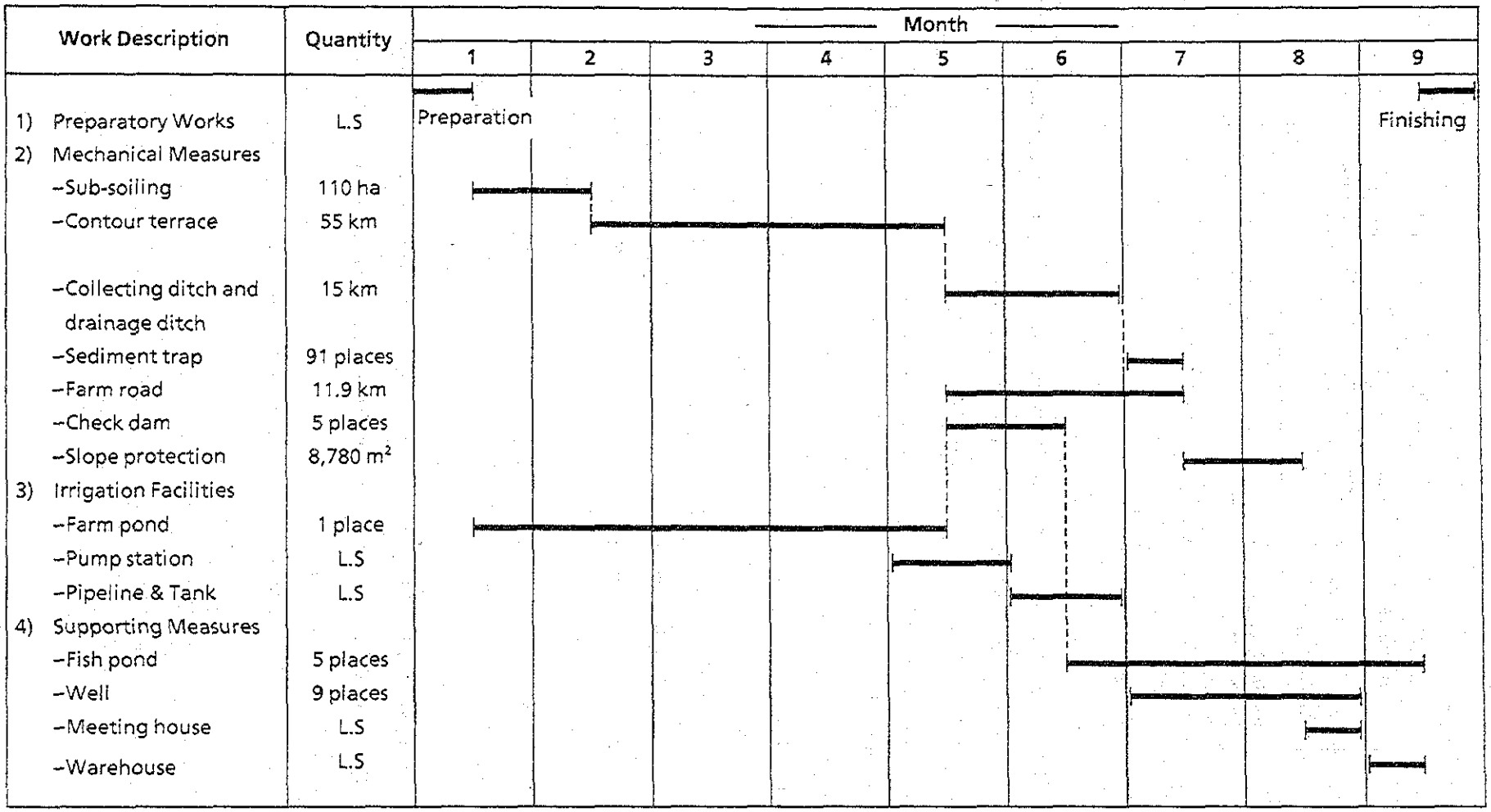

Figure 5.1-2 Construction Schedule for 16 Pilot Areas

Pilot Area	Acreage (ha)	1st year	2nd year
Chachoengsao			
CS-NO. 3	186.9		
CS-NO. 4	79.0		
CS-NO. 5	92.0		1st crew
CS-NO. 8	115.5		
Chonburi			
CN-NO. 1	94.4		
CN-NO. 2	116.8		
CN-NO. 4	94.1	2nd crew	
CN-NO. 8	130.6		
CN-NO. 9	127.2		
Rayong			
RY-NO. 1	173.7		
RY-NO. 2	219.5	3rd crew	
RY-NO. 3	96.7		
RY-NO. 5	155.8		
RY-NO. 7	89.9		4th crew
Chanthaburi			
CT-NO. 2	143.1		
CT-NO. 3	146.8		
Total	2,062.0		

5-2 Construction Equipment

(1) Equipment for construction of one pilot area

Required construction equipment for one pilot area was estimated based on the construction schedule as shown in Table 5.2-1. Total procurement cost C.I.F. basis is 33.8 million Baht.

(2) Required construction equipment

Construction for the total project area of 8,840 km² was recommended to be implemented under contract basis through international competitive bidding taking into account economy and work volume as described in Vol.II (B/P) Chapter 5. However, for the construction of the pilot areas, the following consideration shall be taken into account.

- In order to extend the land and water conservation project throughout the country, DLD is required to have more experience in implementation of projects through direct execution of the works.
- After completion of the pilot projects, DLD will have responsibility for maintenance of the pilot areas using the construction equipment procured during the construction stage.
- The pilot areas are mostly cultivated ones, therefore, negotiations between the farmers and construction personnel may require suspending the construction works. In those cases, the construction works under DLD force-account basis are more convenient and progressive than that of contract basis because of easy arrangement.
- On the other hand, the construction by contract basic has several merits as mentioned in Vol. II (B/P) Chapter 5.

Consequently, considering the comparatively huge amount of work volume and the time schedule for pilot projects, half of the pilot projects are recommended to be executed under DLD and the other half under contract basis.

Based on the results mentioned above, the list of construction equipment to be procured for implementation of pilot areas under DLD is proposed as shown in Table 5.2-2.

Table 5.2-1 List of Construction Equipment for RY-NO. 2 (Plan I)

Equipment	Specification	Unit	Unit *1 Price	Amount	Applications
			(1,000 Baht)	(1,000 Baht)	
– Bulldozer	11 t 108PS	2	2,350	4,700	excavation, spreading
– Bulldozer	21t 211PS	2	3,500	7,000	excavation, compaction
– Backhoe	0.7m³ 140PS	1	2,300	2,300	excavation for trench
– Front loader	1.4m³ 110PS	2	1,800	3,600	loading
– Dump truck	8t 240PS	6	920	5,520	hauling
– Portable concrete mixer	0.6m³ 7.5KW	1	330	330	concrete mixing
– Truck crane	2t 86PS	1	430	430	pipe laying
– Motor grader	3.1m 113PS	1	2,400	2,400	road grading
– Grass spreader	1,300L 10PS	1	530	530	soil protection
– Soil compacter	80-100kg 4PS	2	40	80	soil compaction
– Water tank truck	6,000L 180PS	1	880	880	moisture control, concrete mixing, etc.
– Drainage pump	Φ 100mm	2	30	60	drainage
– Pick up truck	4 wheel drive	1	500	500	communication
– Pick up	light truck	2	200	400	– – ditto – –
– Motorcycle	125cc	2	30	60	– – ditto – –
– Farm tractor	67PS	2	980	1,960	sub – soiling, contour terracing
– Spare parts	(10%)	L.S		3,050	
Total				33,800	

*1 : C.I.F Prince as of March 1988 excluding tax

Table 5.2-2 List of Construction Equipment for Pilot Project (2 crews)

Equipment	Specification	Unit	Unit *1 Price	Amount	Remarks
			(1,000 Baht)	(1,000 Baht)	
– Buildozer	11 t 108PS	4	2,350	9,400	2 units × 2 sites
– Buildozer	21 t 211PS	4	3,500	14,000	2 × 2
– Backhoe	0.7m³ 140PS	2	2,300	4,600	1 × 2
– Front loader	1.4m³ 110PS	4	1,800	7,200	2 × 2
– Dump truck	8t 240PS	10	920	9,200	6 + 4 (considered by diversion)
– Portable concrete mixer	0.6m³ 7.5KW	2	330	660	1 × 2
– Truck crane	2t 86PS	1	430	430	considered by diversion
– Motor grader	3.1m 113PS	3	2,400	7,200	1 × 2 + 1 (maintenance)
– Grass spreader	1,300L 10PS	1	530	530	considered by diversion
– Soil compacter	80-100kg 4PS	4	40	160	2 × 2
– Water tank truck	6,000L 180PS	1	880	880	considered by diversion
– Drainage pump	φ 100m/m	4	30	120	2 × 2
– Pick up truck	4 wheel drive	4	500	2,000	1 × 2 + 2 (maintenance)
– Pick up	light truck	6	200	1,200	1 × 2 + 2 (maintenance)
– Motorcycle	125cc	6	30	180	1 × 2 + 2 (maintenance)
– Farm tractor	67PS	6	980	5,880	1 × 2 + 2 (maintenance)
– Spare parts	(10%)	L.S		6,360	
Total				70,000	

*1 : C. I .F. price as of March 1988 excluding tax

Chapter 6.

PROJECT EVALUATION

CHAPTER 6 PROJECT EVALUATION

The project evaluation has been carried out for all 16 pilot areas and in detail on the four (4) representative pilot areas; CS-NO.3, CN-NO.8, RY-NO.2 and CT-NO.2 to ascertain the feasibility of each project in view of economic and financial aspects. The basic concepts and procedures of the evaluation for the F/S are the same as for the B/P (refer to Vol.II, Chapter 6).

6-1 Economic Analysis for the Representative Pilot Areas

The economic feasibility of the project is judged from the viewpoint of national economy mainly by computing the economic internal rate of return (EIRR).

The economic benefit from crop production for each representative pilot area is estimated on the basis of the proposed agricultural development plan. Benefits from inland fishery and conservation of natural resources and the environment are worked out in the same manner as in the B/P.

The results of the analysis are summarized in Table 6.1-1.

6-2 Financial Analysis for the Representative Pilot Areas

Financial feasibility of the project is investigated from the viewpoint of farm economy. The analysis is carried out employing two (2) criteria, namely farm budget and cost recovery index (at 1988 price levels).

Farm budget analysis has been made for the typical farm type under both the with and without project conditions. The size and land-use pattern of the typical farm is determined for each representative pilot area on the basis of the results of the farm-economic survey.

The results of the farm budget analysis for the representative pilot areas are shown in Table 6.2-1.

Recovery of the project cost including recurrent O&M and replacement costs has been analyzed by comparing farmer's willingness and ability-to-

pay (farm economic surplus for the with-project condition) to the cost-recovery charge for the total project cost. The maximum willingness-to-pay of beneficial farmers is presumed to be half of the incremental agricultural net income. Cost-recovery charges for the capital and replacement costs are estimated at an interest rate of 12 percent per annum for a repayment period of 30 years including a grace period of 10 years.

Table 6.2-2 shows the results of the cost recovery analysis.

6-3 Project Evaluation for the Representative Pilot Areas

The results of the economic analysis for the representative pilot areas reveal that the proposed three (3) alternative plans should be selected taking into account the physical and agricultural conditions of each pilot area as well as the socio-economic status of the beneficial farmers. Because the economic viability of the Project would be different mainly according to the physical and agricultural conditions of the project areas and not to the grade of development plan (Plan-Ⅰ, Plan-Ⅱ, and Plan-Ⅲ). In case that a larger irrigated area could be provided under the Project, the implementation of the Project would be economically feasible as indicated by the economic analysis of RY-NO.2 and CT-NO.2. On the contrary, when expansion of the irrigated area is limited due to natural conditions, even selecting a higher grade plan does not necessarily mean that the Project will become economically feasible. The result of the economic analysis of CN-NO.8 reveals this prospect. Pilot areas with smaller watersheds such as CS-NO.3 and CN-NO.8 should be implemented applying the common grade development plan. However, the EIRR estimated for CS-NO.3 shows that even lower grade development plans for small watershed areas can not give sufficient economic returns to the investment costs in spite of the lower amount of costs required.

The results of the financial analysis of the farm budget indicates that the implementation of the Project would ensure significant increase in farm income leading to improvement of living standard. As for the beneficial farmer's cost recovery ability, they should be able to pay O & M and replacement costs, however, they can not recover the total cost.

Thus, a governmental subsidy will be required in undertaking the Project. It is recommended that the subsidy ratio of the government to be set up would be different according to the site because the economic viability of the pilot areas are largely different depending on the localities as mentioned above.

In view of the nature of the land and water conservation project, some allowance should be made in judging the project's feasibility as a whole.

According to the aforementioned analysis, it is appraised that the most important key for success of the Project is governmental assistance in both financial and technical aspects. It is considered that the following governmental assistance is prerequisite for successful implementation of the Project.

- Provision of governmental subsidy for the Project investment cost.
- Establishment of post-project technical services, especially relating to land conservation management.
- Strengthening of agricultural extension services for crop diversification.
- Provision of institutional loans with low interest rates to reduce the burden of the project cost on the farmers as well as encourage crop diversification.

6-4 Economic Analysis for the 16 Pilot Areas

The economic analysis for the 12 pilot areas (excluding the four representative pilot areas) has been carried out based on the cropping patterns and the net returns of crops for the representative areas. Table 6.4-1 summarizes the results of this analysis including the representative areas.

Table 6.1-1 Summary of Economic Analysis for the Representative Pilot Areas

	CS-NO. 3	CN-NO. 8	RY-NO. 2	CT-NO. 2	Overall
Grade of Plan	III	I	I	II	
1. Area, with Project (ha)					
a) Cultivated Area *	139.6	96.1	127.1	85.7	448.5
b) Irrigated Area	1.5	19.0	45.0	9.8	75.3
2. Annual Benefit (10^3 Baht)					
a) Without Project	379	418	1,074	230	2,101
b) With Project	2,406	3,297	6,673	2,433	14,809
3. Incremental Annual Benefit (10^3 Baht)					
a) Crop Production	1,807	2,766	5,314	1,817	11,704
b) Inland Fishery	–	22	22	9	53
c) Natural Resources & Environment	220	91	263	377	951
d) Total	2,027	2,879	5,599	2,203	12,708
e) Total per ha	10.8	22.0	25.5	15.4	18.7
4. Economic Project Cost (10^3 Baht)					
a) Investment Cost	5,988	13,120	18,774	9,500	47,392
b) Investment per ha	32.0	100.5	85.6	66.4	69.7
c) O & M per annum	493	493	493	493	1,972
d) Replacement (every 5 or 10 years)	117	509	509	117	1,252
5. Economic Indicators					
a) EIRR (%)	8.5	9.3	11.6	10.8	10.4
b) B/C (discount rate 8%)	1.05	1.13	1.48	1.23	1.26
c) B/C (discount rate 10%)	0.87	0.94	1.18	1.06	1.04
d) B/C (discount rate 12%)	0.72	0.78	0.95	0.92	0.86
e) NPV (discount rate 8%, 10^3 Baht)	553	2,494	11,671	3,519	18,236
f) NPV (discount rate 10%, 10^3 Baht)	−1,402	−1,125	4,252	875	2,600
g) NPV (discount rate 12%, 10^3 Baht)	−2,766	−3,736	−1,049	−1,055	−8,606
6. Sensitivity Analysis, EIRR (%)					
a) 10% increase in construction cost	8.0	8.6	10.8	10.0	9.7
b) 20% increase in construction cost	7.5	7.9	10.2	9.2	9.0
c) 10% decrease in benefit	7.4	8.2	10.6	9.4	9.2
d) 20% decrease in benefit	6.1	7.0	9.4	7.8	8.0
e) Combination of a) and c)	6.9	7.5	9.8	8.6	8.5
f) Combination of a) and d)	5.6	6.3	8.8	7.0	7.4
g) Combination of b) and c)	6.4	6.9	9.2	7.8	7.9
h) Combination of b) and d)	5.2	5.8	8.2	6.4	6.8

Note : * Excluding the existing perennial crops and paddy rice area

Table 6.2-1 Summary of Farm Budget Analysis for the Representative Pilot Areas

Item \ Pilot Area	CS-NO. 3 (Plan III)		CN-NO. 8 (Plan I)		RY-NO. 2 (Plan I)		CT-NO. 2 (Plan II)	
	W.O.P	W.P	W.O.P	W.P	W.O.P	W.P	W.O.P	W.P
1. Farm Size (ha)	3.3	3.0	12.5	10.2	4.5	3.7	8.0	7.1
2. Cropped Area (ha)								
a) Cassava	3.3	1.2	11.2	1.8	3.5	0.6	8.0	2.3
b) Pineapple	–	–	–	–	1.0	0.6	–	–
c) Sugarcane	–	–	1.3	3.2	–	–	–	–
d) Para-rubber	–	1.7	–	–	–	1.2	–	4.0
e) Cashew nut	–	–	–	3.2	–	–	–	–
f) Durian (Irrigated)	–	–	–	2.0	–	1.3	–	0.8
g) Mango (Irrigated)	–	0.1	–	–	–	–	–	–
3. Farm Budget (Baht)								
a) Agricultural income	8,560	28,390	39,920	290,150	35,080	154,930	21,710	122,330
b) Off-farm income	9,980	9,980	36,290	36,290	31,270	31,270	20,400	20,400
c) Farm Household income	18,540	38,870	76,210	326,440	66,350	186,200	42,110	142,730
d) Increase in net income		(20,330)		(250,230)		(119,850)		(96,020)
e) Household expenditure *	29,910	37,390	62,080	77,610	64,530	80,680	38,710	48,400
f) Farm economic surplus	– 11,370	1,480	14,130	248,830	1,820	105,520	3,400	94,330

Note : W.O.P ····· Without Project
W.P ····· With Project

* including texes, levies, etc.
It is assumed that household expenditure for the with-project condition would increase by an average annual growth rate of 1.5% until the target year (the project year 15) with an aim of improving the living standards of the beneficiaries of the Project.

Table 6.2-2 Summary of Cost Recovery Analysis for Representative Pilot Areas

	CS-NO. 3	CN-NO.8	RY-NO. 2	CT-NO. 2
Grade of Plan	III	I	I	II
1. Farm Size (ha) *1	3.0	10.2	3.7	7.1
2. Cost-recovery Charge (Baht/year)				
a) Investment Cost	18,200	212,300	71,200	100,100
b) O & M Cost	9,500	51,200	12,000	33,000
c) Replacement Cost	500	5,200	1,200	1,600
d) Total	28,200	268,700	84,400	134,700
3. Farmers' ability-to-pay (Baht/year)				
a) Farm economic surplus	1,500	248,800	105,500	94,300
b) Willingness-to-pay *2	10,200	125,100	59,900	50,300
4. Recovery Index (%)				
a) 2. a) / 3. a)	1,213	85	67	106
b) 2. b) / 3. a)	633	21	11	35
c) 2. c) / 3. a)	33	2	1	2
d) 2. d) / 3. a)	1,880	108	80	143
e) 2. a) / 3. b)	178	170	119	199
f) 2. b) / 3. b)	93	41	20	66
g) 2. c) / 3. b)	5	4	2	3
h) 2. d) / 3. b)	276	215	141	268

Note : *1 cultivated area under with-project condition
*2 50% of the incremental net farm income derived from the implementation of the Project

Table 6.4-1 Summary of Economic Analysis for the 16 Pilot Areas

Pilot Area	CS				CN					RY					CT		Over-all
	NO.3*1	NO.4	NO.5	NO.8	NO.1	NO.2	NO.4	NO.8*1	NO.9	NO.1	NO.2*1	NO.3	NO.5	NO.7	NO.2*1	NO.3	
Grade of Plan	III	II	III	II	I	II	III	I	I	III	I	II	II	III	II	I	
I. Area (ha)																	
a) Project Area (Gross)	187	79	92	116	94	117	94	131	127	174	220	97	156	90	143	147	2,062
b) Cultivated Area (w.o.p)*2	153	66	56	81	92	81	64	117	118	127	153	86	105	70	99	73	1,541
c) Cultivated Area (w.p)*2	140	59	52	73	78	73	60	96	100	118	127	77	95	65	86	62	1,361
d) Irrigated Area	1.5	2.3	4.0	-	10.8	46.8	5.7	19.0	7.5	9.0	45.0	5.8	9.6	1.1	9.8	9.2	187.1
II. Incremental Annual Benefit (10^3 Baht)																	
a) Crop Production	1,808	1,418	1,277	1,393	2,020	4,414	1,300	2,766	1,905	2,391	5,314	1,520	2,312	1,430	1,817	2,142	35,226
b) Inland Fishery	-	9	-	9	22	9	-	22	22	-	22	9	9	-	9	22	164
c) Natural Resources & Environment	220	25	48	76	81	138	149	90	88	259	263	320	206	94	377	258	2,692
d) Total	2,028	1,452	1,325	1,478	2,123	4,561	1,449	2,878	2,015	2,650	5,599	1,849	2,527	1,524	2,203	2,422	38,082
e) Total per ha	10.8	18.4	14.4	12.7	22.6	39.0	15.4	22.0	15.9	15.2	25.5	19.1	16.2	16.9	15.4	16.5	18.5
III. Economic Project Cost (10^3 Baht)																	
a) Investment	5,998	6,534	3,360	5,099	10,358	7,324	5,068	13,120	9,280	6,936	18,774	7,778	10,453	5,936	9,500	11,793	137,271
b) Investment per ha	32.1	82.7	36.5	44.0	110.2	62.6	53.9	100.2	73.1	39.9	85.3	80.2	67.0	66.0	66.4	80.0	66.6
c) O & M per annum	493	493	493	493	493	493	493	493	493	493	493	493	493	493	493	493	7,888
d) Replacement (every 5 or 10 years)	117	117	117	117	509	117	117	509	509	117	509	117	117	117	117	509	3,832
IV. Economic Indicators																	
a) EIRR (%)	8.5	8.3	8.1	8.2	8.3	18.6	9.4	9.3	8.6	9.8	11.6	8.5	8.5	8.1	10.8	9.3	10.1
b) B/C (discount rate 8%)	1.05	1.02	1.01	1.02	1.02	2.42	1.10	1.13	1.05	1.21	1.48	1.04	1.05	1.01	1.23	1.12	1.20
c) B/C (discount rate 10%)	0.87	0.89	0.87	0.88	0.86	2.02	0.96	0.94	0.89	0.98	1.18	0.88	0.86	0.86	1.06	0.94	1.01
d) B/C (discount rate 12%)	0.72	0.77	0.76	0.76	0.73	1.69	0.84	0.78	0.76	0.79	0.95	0.75	0.71	0.74	0.92	0.80	0.85
e) NPV (10^3 Baht, discount rate 8%)	552	229	72	175	361	18,201	1,079	2,494	785	2,659	11,671	574	735	71	3,519	2,044	45,220
f) NPV (10^3 Baht, discount rate 10%)	-1,402	-1,264	-996	-1,195	-2,114	12,131	-378	-1,125	-1,549	-218	4,252	-1,425	-2,164	-1,430	875	938	1,061
g) NPV (10^3 Baht, discount rate 12%)	-2,766	-2,351	-1,742	-2,170	-3,905	7,779	-1,431	-3,736	-3,241	-2,239	-1,049	-2,864	-4,232	-2,510	-1,055	-3,109	-30,623

Note : *1 Representative Pilot Areas
*2 Excluding the existing perennial crops area, and paddy area, w.o.p ..... without project, w.p ..... with project