THE LOWER NORTHEAST MEDIUM SCALE IRRIGATION PACKAGE PROJECT

IN

THE KINGDOM OF THAILAND

Recommendation on Criteria and Guideline for Preparation of Feasibility Study on Small-Medium Scale Irrigation Project in Northeast Thailand

July 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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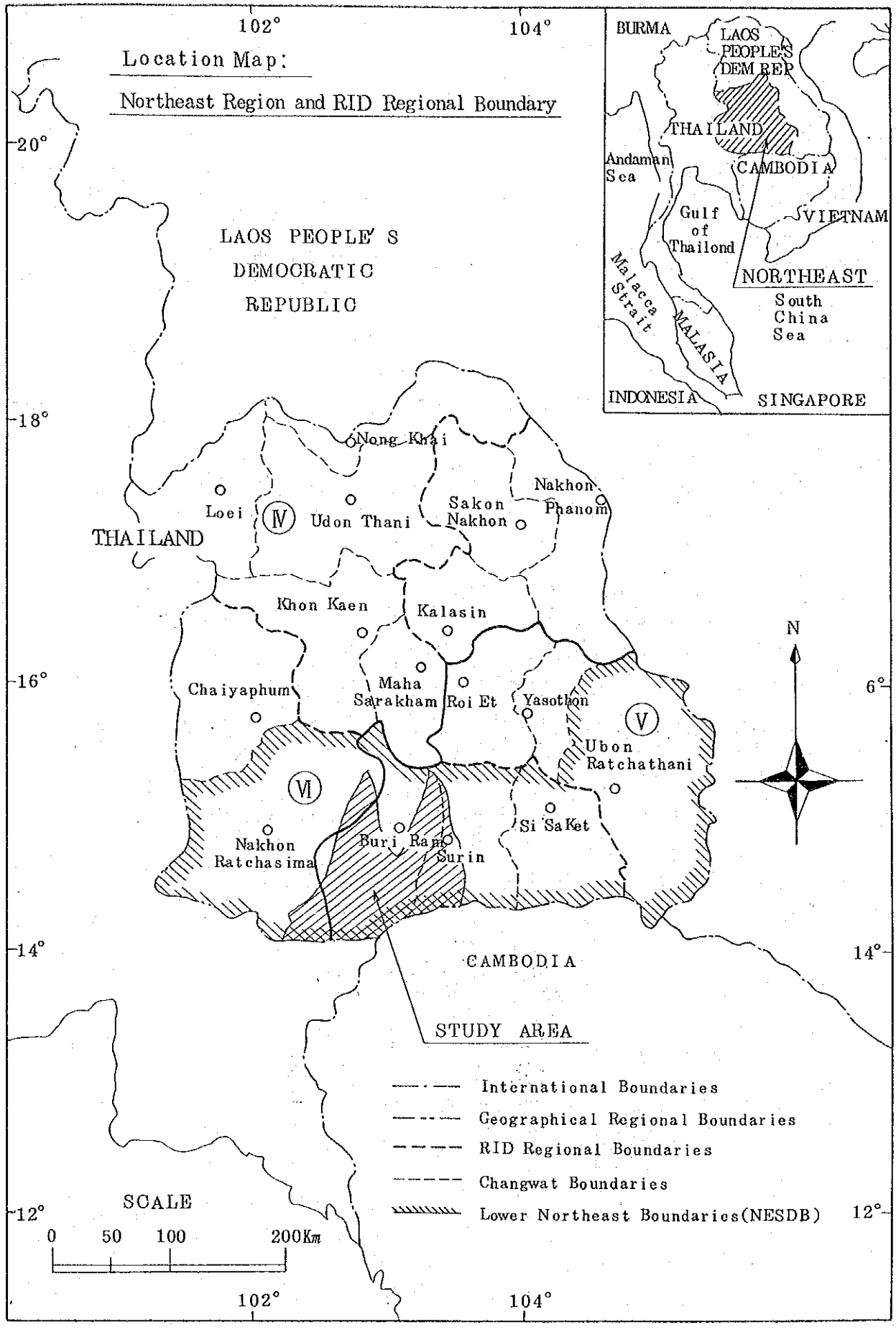

Location Map:
Northeast Region and RID Regional Boundary
102°
104°
20°
18°
16°
14°
12°
LAOS PEOPLE'S DEMOCRATIC REPUBLIC
THAILAND
CAMBODIA
Nong Khai
Loei
Udon Thani
Sakon Nakhon
Nakhon Phanom
Khon Kaen
Kalasin
Chaiyaphum
Maha Sarakham
Roi Et
Yasothon
Ubon Ratchathani
Si Saket
Nakhon Ratchasima
Buri Ram
Surin
STUDY AREA
BURMA
LAOS PEOPLE'S DEM.REP
THAILAND
CAMBODIA
VIETNAM
Andaman Sea
Gulf of Thailond
Malacca Strait
MALASIA
INDONESIA
SINGAPORE
South China Sea
NORTHEAST
N
6°
International Boundaries
Geographical Regional Boundaries
RID Regional Boundaries
Changwat Boundaries
Lower Northeast Boundaries(NESDB)
SCALE
0 50 100 200Km

CONTENTS

CHAPTER 1 INTRODUCTION

CHAPTER 1. INTRODUCTION

1.1. Development Policy of Northeast Thailand

Northeast Thailand has been regarded as the most backward and undeveloped region with poverty problems caused by insufficient water resources, poor soils, severe climate, high density population, limited transportation, etc.

The Thai Government intends to develop the rural area of Northeast Thailand in accordance with one of the national development policies set forth in the Fifth National Plan (1982-86) which consists of poverty alleviation in the rural area and income redistribution between the rural and urban areas.

Among several kinds of governmental investment for the development in the Northeast region, the most important and urgent subject is to promote development for the more efficient utilization and rehabilitation of lands, water resources and forestries in order to increase agriculture output, stabilize the farmer's life and alleviate poverty problems, especially the development of water resources to supply water for irrigated agriculture and domestic needs in the rural area.

1.2. Water Resources Development of the Lower Northeast Region

The rural area of the Lower Northeast region is located along the common border with the Democratic Republic of Kampuchea and is nominated as one of the urgent development areas in the Fifth National Plan.

Water resources such as rainfall and river runoff in the rural area of the Lower Northeast are considerably scarce as compared with the human and land resources. Most farmers in the rural area have been engaged in the unstable wet season rainfed paddy cultivation

and suffered from water shortages. The unstable agricultural productivity by water shortage has brought the low income and poverty problems in the rural area.

This poverty condition in the rural area brings also the social problem that many people migrate from the rural area to urban area in order to work as seasonal workers.

Water resources development with a storage reservoir is essential to stabilize the irrigated agriculture and farmer's life and to alleviate poverty in the rural area.

In Lower Northeast Thailand, RID has made a preliminary study of the water resources development project to find a possible site of the approximate scale since 1979, and proposed 98 projects as shown in Table 2-1.

1.3. Small Scale Irrigation Program

The Thai Government has strongly promoted small scale water resources development on the village level in the rural area of Thailand and aims to supply water urgently and effectively to farmers suffering from water shortage.

Eighteen Thai Governmental agencies concerned have been engaged in small scale water resources development. RID is the largest and most important agency to carry out this development and has started the "Small Scale Irrigation Program (SSIP)" in October 1976. RID has a share of 60% against the total budget of SSIP and allocates a share of 50% against RID's total budget of SSIP to the Northeast Thailand.

Construction cost of SSIP is restricted to the cost of less than ฿4.0 million per project, so that the construction of SSIP is also limited to village unit as a spot-type development. SSIP has really brought a contribution to farmers in the rural area within a short

implementation period and was evaluated as a successful project in the rural development. There are still many SSIP projects requested by the rural area, which will be implemented continuously by the Thai Government. However, SSIP, with a restriction of construction costs of less than ฿4.0 million, cannot develop the rural area on a large scale consisting of several villages.

1.4. Medium Scale Irrigation Project

RID has also carried out the Medium Scale Irrigation Project (MSIP) in parallel with SSIP in order to expand the development of the rural area which is not covered by SSIP. However, MSIP consists of the medium scale project with construction cost of ฿200 million per project at the maximum, so that the implementation of MSIP, including the plan formulation, detail design and construction, will require a long period and cannot meet the urgent development requirement or have early effect on the rural area.

1.5. Small Medium Scale Irrigation Project

RID has intended recently to formulate a plan of Small Medium Scale Irrigation Project (SMSIP), which is considered as a project on the extension line of SSIP, in order to expand irrigated agriculture in the rural area by the water resources development within the shortest possible period.

SMSIP aims to develop the water resources of small medium scale tributaries in the basin and to supply stable water for irrigation and domestic needs in several villages of the rural area and consists of the small-medium scale dam and canal system (SSIP contributes to only one or two villages and consists of only a small reservoir without a canal system in the service area).

SMSIP will be formed by a package project consisting of a number of sub-projects and requires a feasibility study for each sub-project before its implementation because of its project scale. (SSIP does not require a feasibility study). A feasibility study of SMSIP will consist of many subjects such as water resources, agriculture and socio-economy in the project area as well as a dam and canal system for the project facilities. In addition, the overall basin study will be required prior to the feasibility study in order to grasp the present condition of the rural area with poverty problems and to select a number of projects with the first priority to carry out the feasibility study.

1.6. Objective of the Criteria and Guideline for SMSIP

The objective of the criteria and guideline for SMSIP is to clarify the concept of SMSIP and to find a rationalized and simplified method to formulate a feasibility study of SMSIP.

This Report has been prepared on the basis of the Feasibility Study in "Lower Northeast Medium Scale Irrigation Package Project", which has been made by the Japan International Cooperation Agency in response to the request from the Government of Thailand.

The Report presents the recommendations on basic and processed data obtained through the Study with a view to formulating the criteria and guidelines for the preparation of a feasibility study for the "Medium Scale Irrigation Package Project", especially "Small Medium" in Northeast Thailand. The content and recommendations have been prepared based on the overall basin study for the Lam Plai Mat and Lam Chi Noi basin and the Feasibility Study of the three sub-projects, large-medium scale Lam Plai Mat and two small-medium sub-projects of Nong Lum Puk and Huai Phlu.

The planning, concept and approach to planning for SMSIP will be applicable to other projects. However, the figures and values

described in the report are presented only as a reference for easy understanding of the project planning and survey, and summary of basic and processed data are shown.

The study of the criteria and guideline has been carried out in parallel with the Overall Basin Study and the Feasibility Study during a short period of about one year, so that the content of the report, including figures and values, will be reviewed by supplemental and additional study in SMSIP of the other basin.

CHAPTER 2 CONCEPT OF SMALL MEDIUM SCALE IRRIGATION PROJECT

CHAPTER 2. CONCEPT OF SMALL MEDIUM SCALE IRRIGATION PROJECT

RID Regional Office VI located at Nakhon Ratchasima has carried out the preliminary study for 98 medium scale irrigation projects consisting of storage reservoir in five changwat of Nakhon Ratchasima, Buriram, Surin, Sisaket, and Chaiyaphum. The scale of 98 projects has been approximately reviewed as shown in Table 2-1 and Figure 2-1 based on the result of the Feasibility Study for three sub-projects of Lam Plai Mat, Nong Lum Puk and Huai Phlu.

The following concept of the medium scale irrigation project (MSIP), especially the small medium scale irrigation project (SMSIP) will be recommendable in accordance with the result of the Feasibility Study and the review of 98 projects.

2.1. Project Objective

The project objective for MSIP and SMSIP in Northeast Thailand is to develop water resources in the medium and small medium basin by providing storage reservoirs and to supply water for irrigation and for Basic Human Needs (BHN) in the rural area suffering from water shortage. The project aims also to stabilize cultivation of wet season paddy, increase farmer's income and improve farmer's life by introducing stable water, and to alleviate poverty in the rural area.

2.2. Definition

The construction cost of SSIP and MSIP per project is defined as follows by RID internal criteria but the cost for SMSIP is not specified yet.

75 to 80 sub-projects which are considered as SMSIP with dam height of lower than 20m and with the construction cost of less than ฿100 million are distributed in the Lower Northeast region as shown in Table 2-1 and Figure 2-1.

Table 2-1 Medium Scale Irrigation Project Proposed by RID Region VI

No.	CHANG-WAT	AMPHOE	PROJECT	RTSD MAP NO. (1: 50,000)	Drainage Area	Ave. Annual Rainfall	Ave. Annual Runoff	Regulatable Runoff	Reservoir Capacity	DAM			Service Area	CONSTRUCTION COST			Cost per Rai
										Height	Length	Embank. Volume		Dam	Irrig. & Drain.	Total	
					Sq.Km.	MM	MCM	MCM	MCM	M	M	CUM x10³	Rai	($x10⁶)	($x10⁶)	($x10⁶)	($x10³)
1	CHAIPHM	BANNET NARONG	HUAI SAI	5340 III	22.0	1,148	13.3	10.4	17.1	14.0	1,260	288	8,940	40.3	40.2	80.5	9.0
2	"	"	LAM KAN CHU	5339 IV	212.0	1,148	39.2	30.5	50.0	8.9	1,160	116	23,130	16.2	104.1	120.3	5.2
3	"	"	WANG TALAT	5339 IV	116.0	1,148	21.5	16.7	27.4	12.1	650	113	12,660	15.8	57.0	72.8	5.8
4	NAKORN RACHA-SIMA	SIKIEW	HUAI SAI	5339 III	162.0	1,059	26.9	17.8	29.2	21.0	1,300	284	17,510	141.1	78.8	219.9	12.6
5	"	"	SUB-TABUO	5338 IV	23.0	1,059	3.8	2.5	4.1	10.0	895	110	1,900	15.4	8.6	24.0	12.6
6	"	DARN KHUN TOD	HUAI WANG RONG	5339 III	56.0	1,157	10.5	8.3	13.6	11.3	600	92	6,300	12.9	28.4	41.3	6.6
7	"	"	HUAI PRASAT	5339 III	20.0	1,157	3.7	3.0	2.3	8.2	1,200	103	1,350	14.4	6.1	20.5	15.2
8	"	"	HUAI PRASAT	5339 III	67.0	1,157	12.5	9.9	16.2	15.5	1,180	321	8,730	44.9	39.3	84.2	9.6
9	"	"	LAM CHIANG KRAI	5339 III	49.0	1,157	9.1	7.3	12.0	13.0	608	121	5,980	16.9	26.9	43.8	7.3
10	"	"	HUAI PRONG	5339 III	41.0	1,157	7.7	6.1	10.0	13.2	1,150	236	5,000	33.0	22.5	55.5	11.1
11	"	"	HUAI PRONG YAI CHI	5339 IV	30.0	1,157	5.6	4.4	7.2	11.8	665	74	3,340	10.4	15.0	25.4	7.6
12	"	"	UPPER HUAI JAB PONG	5339 IV	20.0	1,157	3.7	3.0	1.4	5.5	325	14	825	2.0	3.7	5.7	6.9
13	"	PAK, CHONG	HUAI KROK TE	5337 IV	23.0	1,134	4.2	3.2	5.2	22.0	450	296	3,160	53.3	14.2	67.5	21.4
14	"	"	BAN, KLONG KRATHON	5337 IV	112.0	1,134	20.4	15.6	25.6	15.1	950	250	13,420	35.0	60.4	95.4	7.1
15	"	"	HUAI LAMCHANEE	5238 II	8.0	1,130	1.4	1.1	1.8	13.0	300	60	900	8.4	4.1	12.5	13.9
16	"	"	HUAI KLONG DEOK	5238 II	32.0	1,130	5.8	4.4	7.2	16.0	500	147	5,720	20.6	25.7	46.3	8.1
17	"	"	KLONG DIN DAM	5238 II	10.0	1,130	1.8	1.4	2.3	11.0	800	117	1,060	16.4	4.8	21.2	20.0
18	"	"	HUAI KLONG POON	5337 IV	7.0	1,130	1.3	1.0	1.64	15.0	300	78	1,360	10.9	6.1	17.0	12.5
19	"	"	HUAI KLOK TAE	5337 IV	23.0	1,130	4.2	3.2	5.2	16.0	300	88	2,900	12.3	13.1	25.4	8.8
20	"	"	HUAI SUB	5337 IV	14.0	1,130	2.5	1.9	3.1	10.0	700	86	1,445	12.0	6.5	18.5	12.8
21	"	PAK THONG CHAI	HUAI HU	5337 I	20.0	1,133	3.6	2.8	4.6	15.5	750	208	2,470	29.1	11.1	40.2	16.3
22	"	"	HUAI TAPRON	5338 III	24.0	1,133	4.4	3.3	5.4	6.3	1,010	54	2,510	7.8	11.3	18.9	7.5
23	"	"	NGAO TAI	5337 IV	9.0	1,130	1.6	1.2	2.0	17.0	300	99	1,100	13.9	5.0	18.9	17.2
24	"	"	LAM CHIANG SA	5337 I	96.0	1,133	17.5	13.3	21.8	52.0	390	1,332	13,900	240.2	62.6	303.3	21.8
25	"	"	LAM PRA-PERNG (1)	5337 IV	51.1	1,130	9.2	7.0	11.5	16.0	700	206	6,310	28.8	28.4	57.2	9.1
26	"	"	LAM PRA-PERNG (2)	"	130.0	1,130	23.5	17.8	29.1	23.0	400	286	17,390	51.5	80.5	132.0	7.4
27	"	"	HUAI KAM-SI-HA (1)	5337 I	6.6	1,130	1.2	1.0	1.64	11.0	400	59	760	8.3	3.4	11.7	15.4
28	"	"	HUAI KAM-SI-HA (2)	"	6.0	1,130	1.1	0.8	1.3	14.0	200	46	690	6.4	3.1	9.5	13.8
29	"	"	HUAI KAM-SI-HA (3)	"	23.1	1,130	4.2	3.2	5.2	10.0	400	49	2,440	6.9	11.0	17.9	7.3

No.	CHANG-WAT	AMPHOE	PROJECT	RTSD MAP NO. (1: 50,000)	Drain-age Area	Ave. Annual Rainfall	Ave. Annual Runoff	Regula-table Runoff	Reser-voir Capacity	DAM			Ser-vice Area	CONSTRUCTION COST			Cost per Rai
										Height	Length	Embank. Volume		Dam	Irrig. & Drain.	Total	
					Sq.Km.	MM	MCM	MCM	MCM	M	M	CUM x10³	Rai	($x10⁴)	($x10⁴)	($x10⁴)	($x10³)
30	NAKORN RACHA-SIMA	PAK THONG CHAI	KLONG BONG (1)	5337 I	21.8	1,130	3.9	3.0	4.9	25.0	200	168	3,080	30.2	13.9	44.1	14.3
31	"	"	KLONG PAI (2)	"	29.3	1,130	5.3	4.0	6.6	11.0	300	44	3,020	6.2	13.6	19.8	6.6
32	"	"	KLONG PAI (3)	"	27.3	1,130	4.9	3.7	6.1	11.0	600	88	2,800	12.3	12.6	24.9	8.9
33	"	"	KLONG PONG HAN	"	14.0	1,130	2.5	1.9	3.1	16.0	400	118	1,720	16.5	7.7	24.2	14.1
34	"	PAK THONG CHAI	BA-E-TAN	5438 III	14.0	1,130	2.5	1.9	3.1	9.0	500	51	1,450	7.1	6.5	13.6	9.4
35	"	KORN BURI	HUAI SAKAE	5438 II	91.0	1,056	15.1	10.0	16.4	13.5	1,060	227	8,400	31.8	37.8	69.6	8.3
36	"	"	NONG LUMPUK	5437 I	25.0	1,065	4.4	2.9	4.4	12.0	1,160	190	1,870	24.3	7.8	32.1	17.2
37	"	"	MOON BON		446.0	1,056	74.0	49.1	80.5	33.0	880	1,252	51,310	225.4	230.9	456.3	8.9
38	"	"	LAM SAE		601.0	1,056	99.8	66.1	108.4	29.5	2,370	2,720	69,080	489.6	310.9	800.5	11.6
39	"	"	HUAI TAP KOUR	5437 IV	33.5	1,130	6.1	4.6	7.5	23.0	650	465	4,630	83.7	20.8	104.5	22.6
40	"	"	HUAI PONG RU	5437 I	13.0	1,200	2.5	2.1	3.4	20.0	350	193	2,030	34.7	9.1	43.8	21.6
41	"	CHOKE CHAI	HUAI SANPHET	5438 II	66.0	1,056	11.0	7.3	12.0	11.4	1,320	206	5,530	28.8	24.9	53.7	9.7
42	"	SOENG SANG	HUAI HIN	5437 I	31.0	1,056	5.1	4.2	1.9	16.0	460	135	1,250	18.9	5.6	24.5	19.6
43	"	"	HUAI TOEY	5337 IV	37.0	1,056	6.1	5.1	6.6	14.0	1,890	432	2,080	60.5	9.3	69.8	33.9
44	"	"	HUAI SADAO	"	32.0	1,056	5.3	4.4	5.5	13.6	950	206	1,875	28.8	8.4	37.2	19.8
45	"	"	KLONG LAN LARK	5437 I	91.0	1,200	17.8	14.9	7.5	11.0	1,100	161	2,500	22.5	11.3	33.8	13.5
46	"	"	HUAI PRIAK	5437 I	112.0	1,056	18.6	15.3	19.7	31.0	680	858	8,440	154.4	38.0	192.4	22.8
47	"	"	LAM PRAI MAT	"	485.0	1,065	77.4	57.0	97.3	44.6	1,160	1,656	56,870	2,862	238.1	524.3	9.2
48	BURI RUM	LA NAN SAI	LAM NANG RONG	5537 I	450.0	1,200	88.2	73.8	121.0	23.5	1,500	1,118	74,100	201.2	333.5	534.7	7.2
49	"	"	LAM CHANG HAN	"	150.0	1,200	29.4	25.8	34.3	21.0	1,780	1,073	11,880	193.1	53.5	246.6	20.8
50	"	"	LAM PATHIA	"	100.0	1,200	19.6	16.4	26.9	19.0	1,030	419	15,790	58.7	71.1	129.8	8.2
51	"	BAN KRUAD	UPPER HUAI SIEW	"	45.0	1,466	11.3	10.5	5.2	15.0	1,880	489	5,000	68.5	22.5	91.0	18.2
52	"	"	HUAI PLUE	5637 IV	21.0	1,312	4.6	3.7	6.4	20.0	840	275	4,380	42.4	16.8	59.2	13.5
53	"	"	HUAI TAKIEW	"	12.0	1,466	3.0	3.2	5.2	17.0	240	79	2,960	11.1	13.3	24.4	8.2
54	"	"	HUAI SIEW	"	179.0	1,346	40.6	39.2	64.3	15.0	1,500	390	33,730	54.6	151.8	206.4	6.1
55	"	"	HUAI MAEKA	"	21.0	1,466	5.3	5.6	9.2	17.0	530	175	5,160	24.5	23.2	47.7	9.2
56	"	"	HUAI KA KO	"	23.0	1,466	5.8	6.1	10.0	15.0	1,100	286	5,250	40.0	23.6	63.6	12.1
57	"	"	HUAI TAKAO	"	12.5	1,466	3.2	3.3	5.4	11.0	1,250	183	2,510	25.6	11.3	36.9	14.7
58	"	"	HUAI O-PRING CHANROM	"	25.0	1,466	6.3	6.6	10.8	16.0	1,500	441	5,960	61.7	26.8	88.5	14.8
59	"	"	BAN KOK KRA CHEONG	5638 III	77.0	1,346	17.5	16.9	27.7	7.0	1,200	78	12,820	10.9	57.7	68.6	5.4

No.	CHANG-WAT	AMPHOE	PROJECT	RTSD MAP NO. (1: 50,000)	Drain-age Area	Ave. Annual Rainfall	Ave. Annual Runoff	Regula-table Runoff	Reser-voir Capacity	DAM			Ser-vice Area	CONSTRUCTION COST			Cost per Rai
										Height	Length	Embank. Volume		Dam	Irrig. & Drain.	Total	
					Sq.Km.	MM	MCM	MCM	MCM	M	M	CUM x10³	Rai	($x10⁴)	($x10⁴)	($x10⁴)	($x10³)
60	BURI RAM	BAN KRUAD	DON ARANG	5438 II	98.0	1,256	20.3	18.1	29.7	12.5	1,290	239	13,720	33.5	61.7	95.2	6.9
61	"	"	HUAI SAKAT NAK	5538 III	75.0	1,256	15.5	13.9	22.8	12.7	1,160	221	11,390	30.9	51.3	82.2	7.2
62	"	"	HUAI LOT WAT	5438 II	30.0	1,256	6.2	5.6	2.3	7.9	970	78	1,300	10.9	5.9	16.8	12.9
63	"	"	HUAI KROK AI WAN	5538 III	24.0	1,256	5.0	4.4	2.5	10.0	1,240	153	1,500	21.4	6.8	27.3	18.2
64	"	PRA KAM	NONG WA	5537 IV	23.0	1,230	4.6	3.1	2.9	13.0	1,710	341	1,250	47.7	5.6	53.3	42.6
65	"	KRA SUNG	BAN KRANUNG	5638 I	2,764.0	1,238	563.9	445.4	241.5	13.0	7,540	1,503	15,560	210.4	70.0	280.4	18.0
66	SURIN	PRASART	HUAI KRA-BAN-RIEW	5637 I	36.0	1,176	6.9	6.1	7.8	13.0	2,110	421	3,125	58.9	14.1	73.0	23.4
67	"	"	HUAI O-CHIEW	"	19.0	1,176	3.6	2.9	4.8	7.0	900	58	2,190	8.1	9.9	18.0	8.2
68	"	"	HUAI RUNE	5638 II	70.0	1,176	13.3	10.9	1.0	5.0	1,000	36	500	5.0	2.3	7.3	14.6
69	"	"	HUAI DON MEK	5637 I	21.0	1,176	4.0	3.3	1.0	5.0	500	18	500	2.5	2.3	4.8	9.6
70	"	"	O-DAI-KRAHORM	5637 I	29.0	1,176	5.5	4.5	7.4	13.0	500	100	3,680	14.0	16.6	30.6	8.3
71	"	"	HUAI TA CHIEW	5638 II	44.0	1,176	8.4	6.8	11.2	6.0	2,200	109	5,140	15.3	23.1	38.4	7.5
72	"	"	HUAI LAE NGAO	5638 II	235.0	1,318	51.9	49.1	20.0	8.0	2,000	164	12,000	23.0	54	77.0	6.4
73	"	"	HUAI SANENG (UPPER)	5638 II	108.0	1,176	20.6	16.7	12.5	11.0	2,000	293	4,300	41.0	19.4	60.4	14.0
74	"	KARP CHERNG	HUAI RA-KA	5737 IV	35.0	1,225	7.0	6.1	10.0	11.0	1,300	190	4,630	26.6	20.8	47.4	10.2
75	"	SANG-KHA	HUAI TA-PAO	5737 IV	33.0	1,225	6.6	5.7	9.3	15.0	600	156	4,920	21.8	22.1	43.9	8.9
76	"	"	KAH POAK	5738 III	70.0	1,225	14.1	12.2	10.4	11.0	2,200	322	3,500	45.1	15.8	60.9	17.4
77	"	"	HUAI DAN	5737 IV	28.0	1,225	5.6	4.9	8.0	12.0	800	137	3,730	19.2	16.8	36.0	9.7
78	"	"	HUAI CHERNG	"	31.0	1,225	6.2	5.4	8.9	15.0	1,300	338	4,640	47.3	20.9	68.2	14.7
79	"	"	HUAI KHA-NARD NOEN	5737 I	50.0	1,225	10.1	8.7	14.3	15.0	600	156	7,480	21.8	33.7	55.5	7.4
80	"	"	HUAI CARENGVAKE	"	49.0	1,225	9.8	8.5	13.9	15.0	2,000	521	7,320	72.9	32.9	105.8	14.5
81	"	"	HUAI JARUS	"	69.0	1,225	13.9	12.0	19.7	28.0	1,000	1,039	12,290	187.0	55.3	242.3	19.7
82	"	"	HUAI SIED JERNG	"	45.0	1,225	9.0	7.8	12.8	19.0	700	284	7,510	39.8	33.8	73.6	9.8
83	"	"	HUAI SUM RUN	5837 IV	130.0	1,225	26.1	22.6	37.1	22.0	1,000	658	22,690	118.4	102.1	220.5	9.7
84	"	SRIKORN-PHUM	KRA DEON	5738 IV	180.0	1,329	40.1	38.3	27.0	8.0	3,100	645	9,300	90.3	41.9	132.2	14.2
85	"	"	KAH POK	5738 I	403.0	1,329	89.9	85.8	10.4	7.0	2,000	130	3,600	18.2	16.2	34.4	9.6
86	SRISA-KET	KU-KUN	HUAI TUK CHOO	5838 III	135.0	1,275	28.6	26.1	42.8	25.0	1,500	1,257	26,740	226.3	120.3	346.6	13.0
87	"	"	HUAI SA-RA	"	158.0	1,187	30.5	25.1	41.2	11.0	1,460	214	19,020	30.0	85.6	115.6	6.1
88	"	"	HUAI O-TA-LAP	5838 II	17.0	1,275	3.6	3.3	5.4	15.0	600	156	2,840	21.8	12.8	34.6	12.2
89	"	"	HUAI O-KAEW	"	19.0	1,275	4.0	3.7	1.0	4.0	600	15	1,000	2.1	4.5	6.6	6.6
90	"	"	HUAI CHAN	"	40.0	1,191	7.8	6.4	10.5	23.0	300	215	6,430	38.7	28.9	67.6	10.5

No.	CHANG-WAT	AMPHOE	PROJECT	RTSD MAP NO. (1: 50,000)	Drain-age Area	Ave. Annual Rainfall	Ave. Annual Runoff	Regula-table Runoff	Reser-voir Capacity	DAM			Ser-vice Area	CONSTRUCTION COST			Cost per Rai
										Height	Length	Embank. Volume		Dam	Irrig. & Drain.	Total	
					Sq.Km.	MM	MCM	MCM	MCM	M	M	CUM x10³	Rai	(฿x10⁴)	(฿x10⁴)	(฿x10⁴)	(฿x10³)
91	SRISA-KET	KHUN HAHN	HUAI TAB	5838 II	110.0	1,191	25.2	20.9	34.1	30.0	1,200	1,422	20,980	256.0	94.4	350.4	16.7
92	"	"	HUAI TA BANG	5837 I	25.0	1,191	4.9	4.0	6.6	15.0	700	182	3,430	25.5	15.4	40.9	11.9
93	"	"	HUAI DAN-I	5937 IV	33.0	1,257	6.9	6.1	10.0	17.0	1,000	329	5,630	46.1	25.3	71.4	12.7
94	"	"	HUAI DAN	"	22.0	1,247	4.5	4.0	6.6	10.0	1,000	123	3,020	17.2	13.6	30.8	10.2
95	"	"	HUAI SANG KOD	"	47.0	1,247	9.7	8.6	14.1	10.0	800	98	6,520	13.7	29.3	43.0	6.6
96	"	"	HUAI TA-KHOB	"	43.0	1,647	12.3	14.4	2.0	4.0	700	17	1,000	2.4	4.5	6.9	6.9
97	"	KANTRA-LUK	HUA KA-YUNG	"	149.0	1,247	30.7	27.1	44.4	27.0	800	776	27,770	139.7	125.0	264.7	9.5
98	"	"	HUAI CHAN HORM	5942 II	8.8	1,247	1.8	1.6	2.6	12.1	520	91	1,220	12.7	5.5	18.2	14.9

Note 1. Proposed damsites are preliminarily selected by RID Regional Office VI.
Data of drainage area, annual rainfall, dam height and dam length are same as the original dimensions prepared by RID VI.

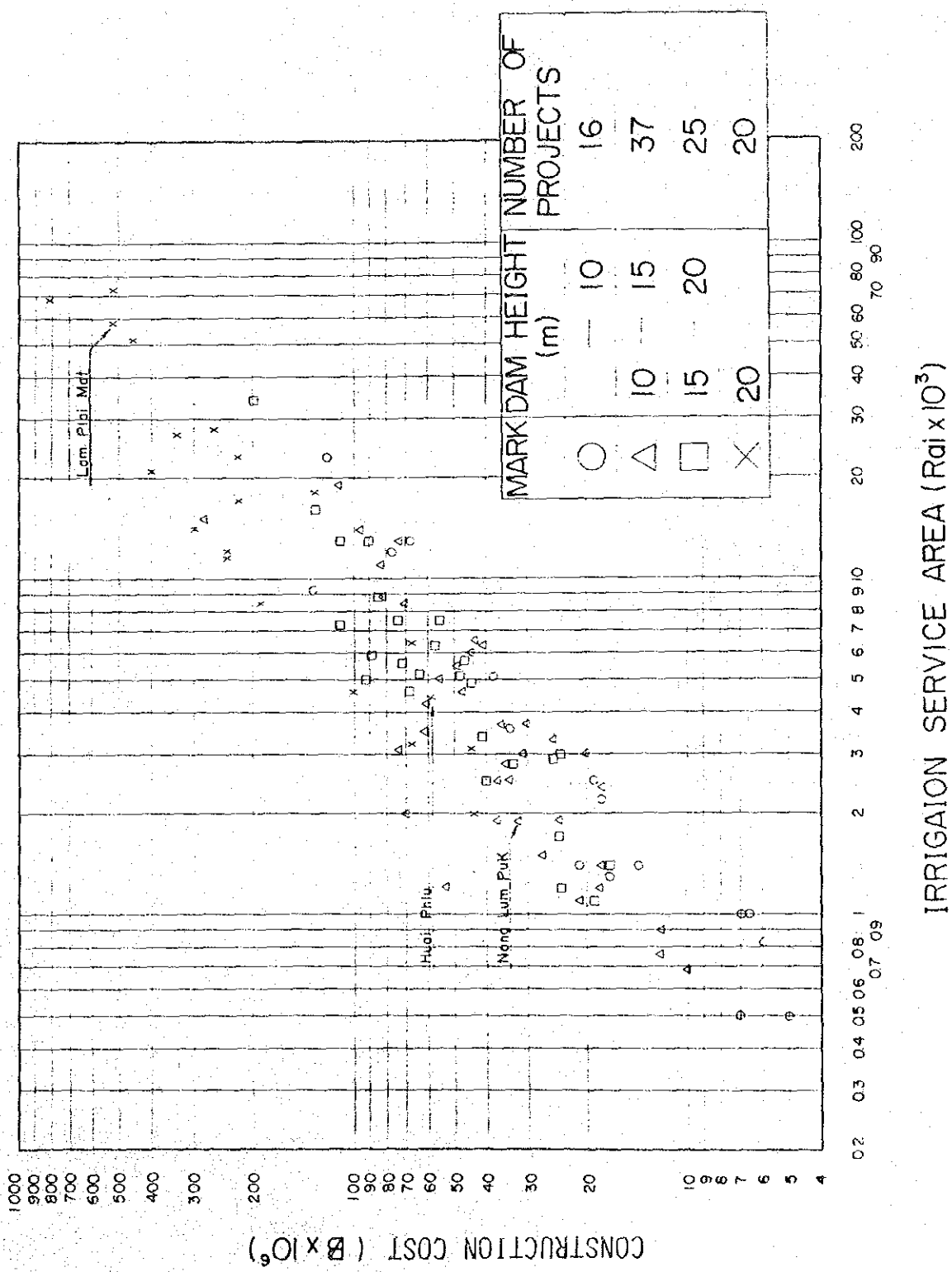
2. Data of annual runoff, reservoir capacity, dam embankment volume, service area and construction cost are reviewed by the result of Feasibility Study.

3. Dam embankment volume is approximately estimated by the formula as shown in Figure 3-2 in this report.

4. Construction cost of dam is approximately estimated based on an average unit rate of ฿ 180/m^3 for dam more than 20 m height and ฿ 140 for dam less than 20 m height.

5. Construction cost of irrigation/drainage canal is approximately estimated by an average unit rate of ฿ 4,500/Rai.

Figure 2-1. Relation : Service Area - Construction Cost
Dam Height



Therefore, the definition of SMSIP is proposed so as to cover the scale of those 75 to 80 sub-projects with dam height of lower than 20m and with the construction cost of less than ₦100 million.

Scale of Project	Construction Cost (₦ million)
Large Scale	more than 200
Medium Scale	100 - 200
Small Medium Scale (Dam height lower than 20m and canal system)	4 - 100
Small Scale (small dam and without canal system)	less than 4

2.3. Planning Concept of Irrigated Agriculture

The poverty conditions in the rural area of the Lower Northeast region are caused by the low productivity of the wet season paddy due to lack of irrigation water.

The irrigated agriculture plan in the region, therefore, should be drawn up with the following concepts:

(1) A storage dam should be provided to control the river runoff with seasonal and annual fluctuation and to use it for the supplemental irrigation water for the wet season paddy.

(2) Since water resources are limited as compared with the existing paddy area suffering from water shortage, the irrigation water developed by the storage dam should be supplied to the existing wet season paddy area, as large as possible, in order to stabilize the productivity of the wet season paddy at first. The irrigation for the upland crops in the dry season should be minimized, from the viewpoint of the effective water utilization and the marketability in the region.

2.4. Project Facility and Implementation Agency

As for SSIP, RID constructs only the storage dam as water resources facility, but does not construct the canal system in the service area, which is expected to be constructed by farmer's group in the service area.

Since MSIP and SMSIP consist of a project which is larger than SSIP and includes several muban (villages) in the service area, the project will be composed of not only the dam but also the canal system covering the service area of 20 to 30 ha, and will be carried out by RID.

On-farm work at the terminal area of less than 20 to 30 ha and muban communal facility including muban pond, fishery facility and domestic water supply facility will be constructed by the water users' association consisting of farmers under control of the Department of Local Administration (DOLA) of the Ministry of Interior. Toward this end, strong technical assistance by the governmental agency concerned and minimum financial support by the government will be required for their construction.

Scale of on-farm work in RID criteria of MSIP is presently about 50 ha and canal system of up to 50 ha is designed and constructed by RID. It is recommendable, however, to reduce the scale of on-farm work down to 20 to 30 ha in the Northeast Thailand from viewpoint of farmer's ability to carry out the work and water management on field as well as farmer's financial status.

2.5. Operation and Maintenance of Facility

As for SSIP, the operation and maintenance of the reservoir has been carried out by the farmers' group except complicated and difficult repair of reservoir, which has been made by RID.

This kind of operation and maintenance will also be introduced to SMSIP, namely, the operation and maintenance of reservoir, main canal and on-farm will be made by the water users' association which will be newly established in each sub-project area. However, the scale of project facilities in SMSIP is fairly large as compared with the scale of SSIP, so that the water users' association cannot manage the facilities immediately after its completion.

It is desirable that the water users' association will select several young people from muban concerned as the future representative of operation and maintenance, and train them at the existing irrigation facilities of RID. After completion of SMSIP, trained young people will be engaged in the operation and maintenance of the facilities newly completed.

RID will continue the technical assistance till the farmer's water users' association can fully operate the new facilities by themselves. RID will only carry out monitoring of facilities after transferring it to the water users' association.

2.6. Project Selection and Implementation

Many projects of MSIP, especially SMSIP are expected to be implemented in Northeast Thailand. However, the basic data to formulate the project plan are considerably scarce, so that the following procedures will be made for planning, selection and implementation of the project.

(1) Overall Basin Study

An overall basin study is the planning work to find and select the MSIP and SMSIP in two or three large basins with a drainage area of about 4,000 to 5,000 sq.km.

In general, about 20 to 30 sub-projects with a technical possibility will be found in two or three large basins (about 10 sub-projects at each large basin). These 20 to 30 sub-projects will be screened, based on the adequate screening criteria at each basin. Finally, 10 to 15 sub-projects will be selected as one package project in accordance with not only technical and economic possibility, but also socio-economic aspect.

Large or medium scale projects may be found on the process of the overall basin study but will be excluded from SMSIP. The large or medium scale projects will be studied independently as one project and their project area should be clearly separated from SMSIP area.

(2) Feasibility Study of Package Project

The selected 10 to 15 sub-projects will be studied from viewpoint of technical, economic, social and political aspects, and their feasibility report, including implementation program, will be prepared.

The content of the feasibility study for a package project will be basically same as the ordinary one. However, the rationalized and simplified method to formulate the plan will be introduced in order to manage a large number of sub-projects and accelerate the planning work.

(3) Farmers' Cooperation with Project Planning

The Thai government agencies concerned will explain the outline of the project to muban farmers, after completion of the selection of a package project and grasp the farmers' reaction and request.

Since the limitation of service area will be identified at the middle stage of the feasibility study, the government agencies concerned will have close contact with the muban people related to the project and try to organize a water users' association with the farmers' group participating.

As a result of the above procedures and progress, the water users' association of the farmers' group will be established to carry out the construction of the on-farm and muban communal facility at the proposed service area. Then the water users' association will submit the request for project implementation to the government.

(4) Implementation Program

A package project of SMSIP consisting of 10 to 15 sub-projects will require the project cost of more than ฿500 million and will be implemented under the loan from international financing agency. Two kinds of loan will be considered for SMSIP. One is a package loan which requires complete feasibility study for all sub-projects on the same level. The other is a sector loan which requires complete feasibility study for 3 to 4 core sub-projects. Both loans for engineering services and construction will be made at the same time for early project implementation.

The implementation of the project will proceed as follows:

Feasibility Study ⟶ Request of Loan ⟶
Project Appraisal ⟶ Loan Procedures ⟶
Implementation

2.7. Flow Chart of Implementation

The procedures from the selection of study basin to operation and maintenance of the Projects are shown in Figure 2-2.

Since 75 to 80 SMSIP sub-projects will be expected in the Lower Northeast region, it is recommendable to establish a special committee for the development of water resources in the Lower Northeast for smooth and successful implementation.

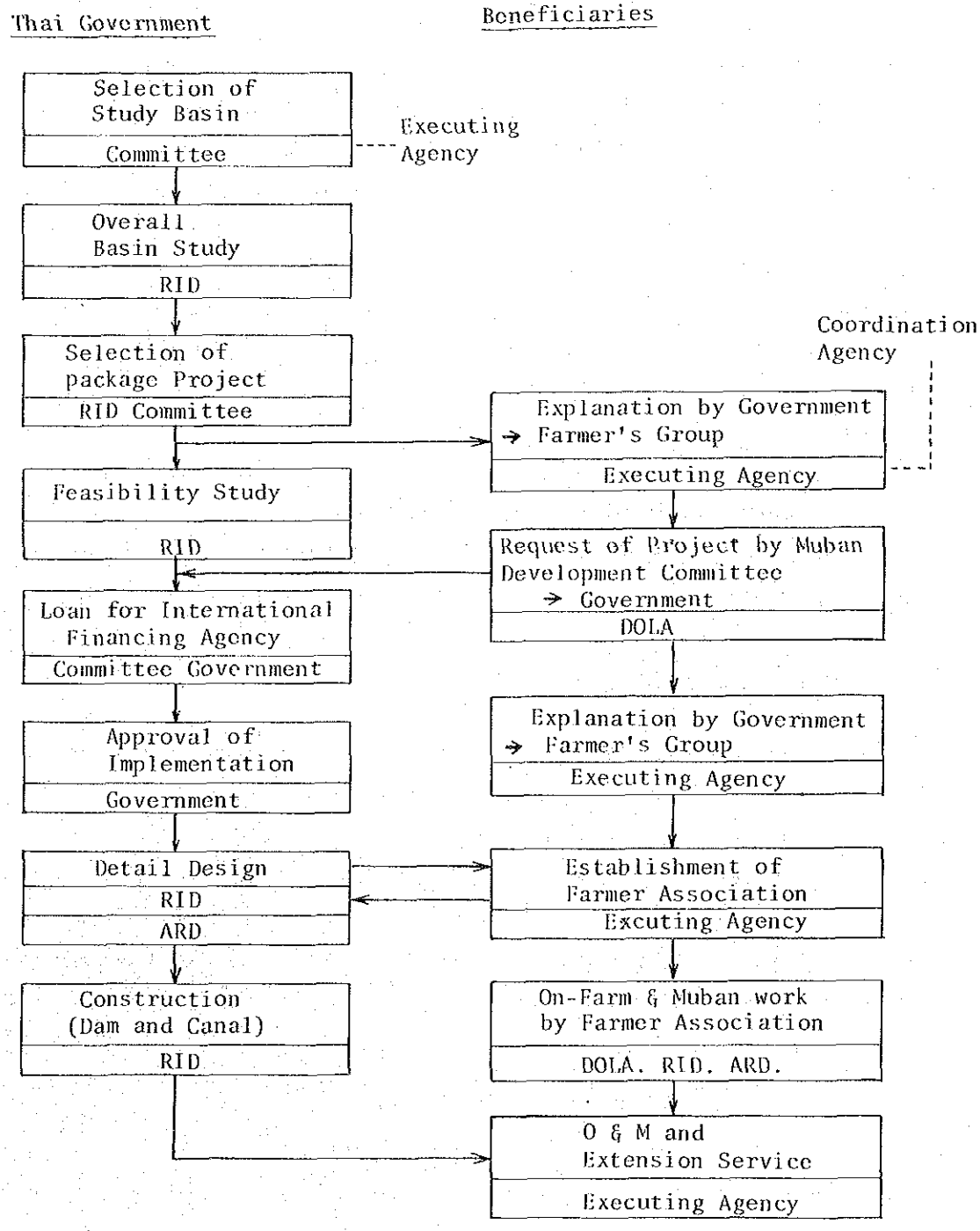
Figure 2-2 Flow Chart of Planning, Implementation and O/M for SMSIP

Executing Agencies

Ministry of Agriculture and Agricultural Cooperative
- Royal Irrigation Department (RID)
- Department of Agricultural Extension (DOAE)
- Department of Fishery (DOF)
- Department of Livestock Development (DOLD)
- Department of Cooperatives Promotion (DOCP)

Ministry of Interior
- Department of Local Administration (DOLA)
- Community Development Department (CDD)
- Office of Accelerated Rural Development (ARD)

Bank for Agriculture and Agricultural Cooperative



CHAPTER 3 CRITERIA AND GUIDELINE FOR OVERALL BASIN STUDY

CHAPTER 3. CRITERIA AND GUIDELINE FOR OVERALL BASIN STUDY

The overall basin study will be made on the basis of basin unit and consists of two steps of various surveys and planning, and the selection study of SMSIP.

The surveys and planning are carried out with the following purposes:

(1) To make clear the necessity of irrigated agriculture development by grasping present socio-economic and agricultural conditions in the basin.

(2) To collect, arrange and analyze the basic data and information related to development plan for irrigated agriculture and water supply of B.N.H-type (Basic Human Needs) by providing storage reservoir.

(3) To find the number of possible SMSIP sub-projects.

The selection study is made with the following purposes:

(1) To estimate approximate scale and cost of the sub-projects based on the study of technical and economic possibility.

(2) To prepare a package project consisting of sub-projects with the first priority to carry out the feasibility study.

The screening process for the proposed sub-projects will be as follows:

(1) To prepare a list of proposed damsites with a possibility of development of the existing paddy field by using the map of scale 1:50,000.

(2) To check the possibility of reservoir and dam by the reconnaissance field survey, considering topographical and geological conditions of the damsite (first screening).

(3) To evaluate necessity and priority of development for each sub-basin through overall basin study (second screening).

(4) To prepare the map of scale 1:10,000 by aerophoto at the reservoir and damsite to be proposed by the first and second screening.

(5) To analyze the approximate scale of reservoir, dam, and limitation of irrigation service area for the proposed sub-projects in the second screening (third screening).

(6) To estimate approximate project cost for the proposed sub-projects in the third screening (fourth screening).

(7) To evaluate project economy and farmer's income, and to carry out the final selection of sub-projects with the first priority.

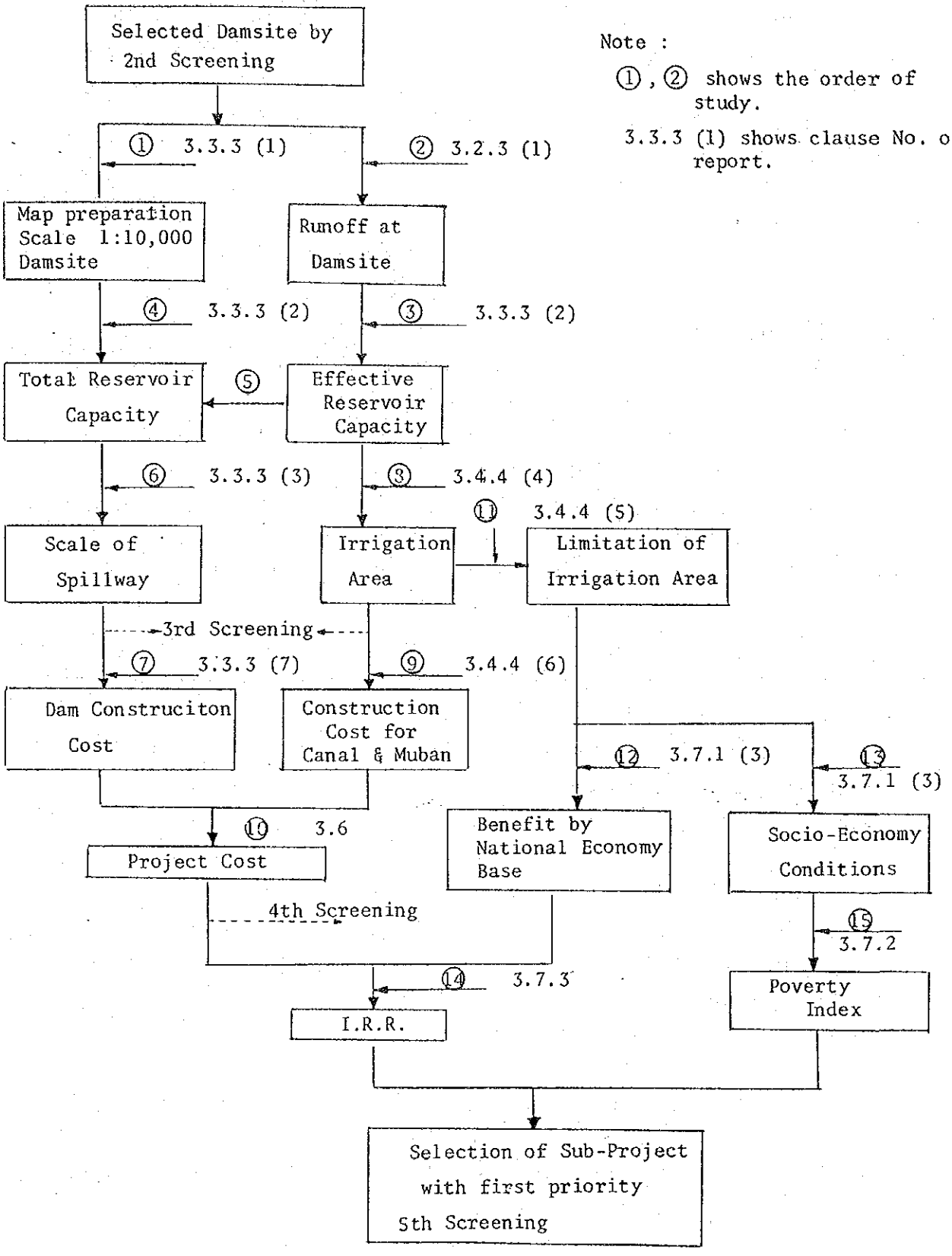
(8) To determine a package project consisting of sub-projects, with the first priority by the government.

The screening order for SMSIP after second screening is shown in Figure 3-1.

The overall basin study will be carried out by full utilization of existing data being kept in the governmental authority concerned, and by the field reconnaissance survey with a period as short as possible.

The important subject to be studied in the overall basin study and its criteria/guideline are described below.

Figure 3-1. Order of Planning for SMSIP Sub-Project



3.1. Division into Sub-Basin

Since it is rather difficult to study a basin with a large area of about 4,000 to 5,000 sq.km in a lump, the study will be made dividing the basin into several adequate sub-basins, taking into consideration the river system, present development level, existing irrigation conditions and the possibility of a reservoir. This method can accelerate study progress to obtain accurate data and information in the basin.

The overall basin study in this Feasibility Study has been made by dividing Lam Plai Mat basin into four sub-basins and Lam Chi Noi basin into seven sub-basins. An example of the divided sub-basins in the Study is shown in Forms 3-2 to 3-7.

3.2. Meteorological and Hydrological Study

3.2.1. Data Collection and Arrangement

(1) Geographical Study of the River System

Geographical characteristics of the river system are analyzed based on the map of scale 1:50,000. The area measurement of each sub-basin and preparation of river profile will be made in accordance with confirmation of river course and border of each sub-basin. An example of the data arrangement is shown in Form 3.1.

(2) Meteorological and Hydrological Data

Existing meteorological and hydrological data including observation periods and methods in and around the basin are collected from RID and NEA and Meteorological Department.

The gauging station is plotted on the map of scale 1:50,000 and 1:250,000. The border of the sub-basin is clarified by the river system to measure the basin area. The representative meteorological gauging station for each sub-basin is selected by Tiessen Polygon method.

The following data will be collected and arranged:

- Location and observation period of gauging station.
- Daily, monthly and annual rainfall.
- Monthly and annual temperature, humidity, evaporation, wind velocity and sunshine hour (including data for estimation of crop water requirement by modified Penman method).
- Daily, monthly and annual runoff.
- Water level and rating curve at the observation station.
- Maximum flood discharge, water quality and sedimentation data.

The maximum flood discharge capacity and sedimentation data are collected from the previous report already planned and implemented in and around the basin.

3.2.2. Field Survey and Supplemental Observation

Since the density of meteorological and hydrological observation in the basin is considerably low, all observation stations in and around the basin will be checked in the field survey, and supplemental observation for the existing data will be made with minimum requirement.

The following work is carried out in the field survey:

- Confirmation of existing gauging station and check of accuracy for observation.
- Observation of river regime such as water level, river width, sedimentation, etc.
- Observation of runoff and inspection of water quality at the river with a possibility of SMSIP.

- Selection of location and measuring equipment for new gauging station for meteorological and runoff observation and establishment of observation method.

Installation of new gauging station will be made immediately after completion of the selection study of sub-projects with the first priority at the final stage of overall basin study.

3.2.3. Analysis of Meteorology and Hydrology

(1) River Runoff

No long-term observation data would be available at the proposed damsite of SMSIP in the medium scale basin. The river runoff, therefore, is estimated by the synthetic method of areal rainfall and rainfall-runoff model.

In accordance with the result of the Feasibility Study, the runoff at damsite to make a reservoir plan will require at least about a 15-year observation.

- Areal monthly rainfall is selected by Tieseen Polygon method.
- Rainfall-runoff model is analyzed by the correlation between the runoff data nearby the basin and its rainfall.

The correlation between rainfall and runoff in the Lower Northeast has the following particular characteristics. When accumulated areal rainfall and accumulated runoff from January are plotted on the logarithmic paper, the accumulated runoff shows very small value until the accumulated rainfall reaches about 300 mm. In case the accumulated rainfall is over 300 mm, the accumulated runoff increases with the close relation of the accumulated rainfall.
(The relation between runoff and rainfall shows a straight line on the logarithmic paper.)

It is also clarified that the fairly accurate rainfall-runoff model can be obtained, if the observation data for at least two years are available.

The monthly runoff with a long period could be estimated approximately by this method ignoring small runoff amount to be brought by accumulated rainfall of 300 mm, which does not give much influence to the reservoir plan. It is rather difficult, however, to estimate the runoff with a short period of five or ten days by this runoff model. This model will only be applied for the estimation of monthly runoff, which is sufficient to make the reservoir operation plan with accuracy in the Lower Northeast basin.

This rainfall-runoff model is influenced by land use conditions, especially water utilization in the paddy field. It is necessary, therefore, to modify the model by the difference between natural vegetation and evapotranspiration of paddy field taking into consideration of seepage amount and cultivated area of paddy field.

In accordance with the result of analysis for M93 gauging station at the Huai Seo of the Chi Noi basin in the Feasibility Study, the following formula has been developed under the condition without paddy field.

$$\text{Runoff} = 2.854 \times 10^{-11} \times \text{Areal Rainfall}^{4.98}$$

(Unit, mm, Accumulation from January)

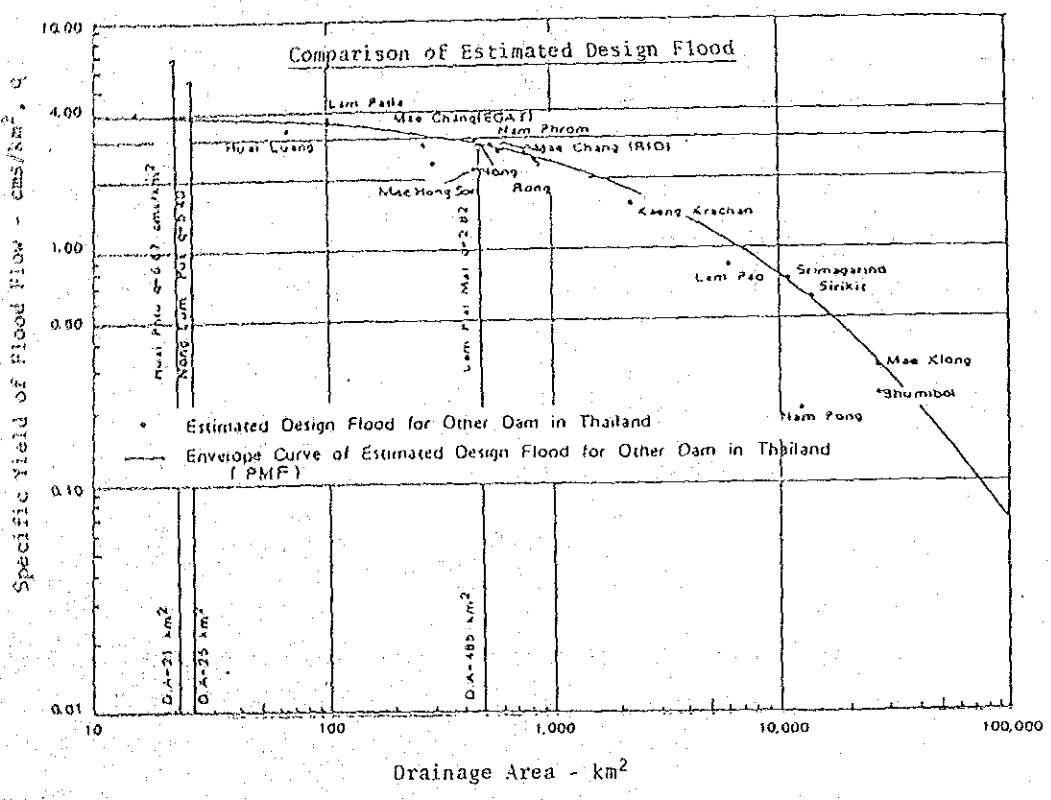
(2) Design Flood Discharge Capacity for Spillway

Flood discharge capacity with 500 year-return period is adopted for the spillway design of the dam in accordance with the criteria in RID.

In the Feasibility Study, the flood discharge capacity for spillway with 500-year return period has been analyzed based on the unit hydrograph made by daily rainfall at the gaging stations of Lam Sae and Lahan Sai located in the adjoining basin of the Project Area.

The estimated flood discharge capacity is compared with an envelope curve based on the design flood capacity for other dams in Thailand as shown in the following figure. This envelope curve has a good correlation with the result of Feasibility Study and can be used for estimation of flood discharge capacity in spillway.

However, this flood discharge capacity is reviewed, based on the rainfall data actually observed at the gaging station in each project area, because the rainfall intensity in the Lower Northeast Region varies substantially with the weather depression in the different basin.



The design flood discharge capacity for spillway is determined taking into consideration the surcharge effect of the reservoir area on the estimated flood discharge capacity.

Although about 30 percent surcharge effect by the reservoir surface area has been taken in three dams of the Project area, the surface effect in the other dams will be separately studied based on the reservoir surface area, overflow depth of spillway, flood discharge capacity, etc

(3) Sedimentation in Reservoir

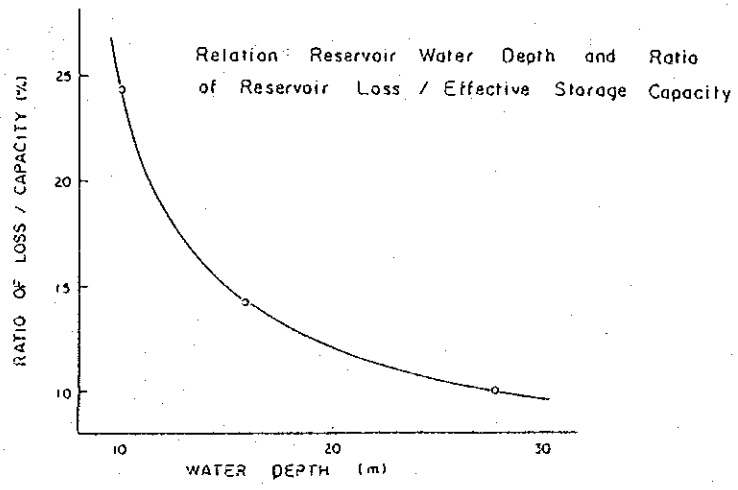
Sedimentation in reservoir is planned as about 150 cu.m/sq.km/ year for 100-year period in the Northeast Thailand basin in accordance with RID criteria. This value is agreeable by judging from the existing reservoir conditions in Northeast Thailand.

(4) Water Losses in Reservoir

In the Feasibility Study, the water losses from reservoir have been estimated on a monthly basis taking into consideration the seepage and evaporation losses as follows:

Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Losses(mm)	108	71	66	64	61	56	63	109	139	143	134	141	1,155

The average reservoir losses against the effective reservoir capacity based on the parameter of maximum water depth in the reservoir area analyzed as shown in the following figure, in accordance with the result of reservoir operation of the Feasibility Study. This idea will only be applied for the project in the Lower Northeast region.



3.3. Reservoir and Dam Plan

3.3.1. Data Collection and Arrangement

Topographical maps, aero-photos, outline of MSIP and SMSIP preliminary study by RID, the report of the reservoir project already completed, etc. are collected as data for the study of the reservoir and dam.

(1) Selection of the Reservoir Site on Map

The possible reservoir sites are selected at first on a map of scale 1:50,000 with the following points:

- It is generally rather difficult to obtain the necessary reservoir capacity at the damsite with a small drainage area, for example, of less than 30 sq.km, due to a steep river slope. The dam with a height of more than 10 m will be planned in such small basin.

- There is some possibility to provide the dam with a long length and a low height downstream of the basin due to the gentle river slope and control of a big runoff.

- Access roads and compensation subjects such as villages and cultivation lands are confirmed.

(2) Arrangement of Existing Data

The following data are analyzed based on the previous project report:

- Relation between annual runoff and reservoir capacity.
- Design flood discharge capacity of the spillway.
- Sediment and seepage amount in the reservoir.
- General geology and available construction material in and around the basins.

3.3.2. Field Reconnaissance Survey

The selected reservoir sites using a map of scale 1:50,000 are screened by the field reconnaissance survey with the following consideration (first screening).

- Topographical conditions for damsite abutments, dam length and storage possibility are confirmed at the site, because the selected damsite using a map of scale 1:50,000 with contour interval of 10 to 20 m sometimes presents considerable different topography features at the site as compared with the features on the map, especially the damsite to be planned with a low height dam.

- The river features and runoff conditions at the damsite are carefully grasped. The river width has a close relation with the runoff in the basin and is one of the important data for the hydrological analysis of the river.

- The dam foundation and spillway alignment is preliminarily surveyed taking into consideration the topography and engineering geology, especially the seepage condition through the reservoir and dam foundation. In case the dam foundation is formed by pervious layer, the depth of pervious foundation will be checked by test pits.

- The borrow area for earth material is tentatively surveyed, especially location, and distance from the damsite and approximate quantity.

- The access roads to the damsite and borrow area as well as villages and cultivation area in the reservoir area are checked at the field survey.

3.3.3. Preliminary Plan for the Reservoir and Dam

(1) Preparation of a Map of Scale 1:10,000

As for the reservoir site which has been screened by the field survey, the map of scale 1:10,000 is prepared by aero-photo, because it is rather difficult to make a plan for the reservoir including the reservoir capacity, dam height and dam length, by using a map of scale 1:50,000.

(2) Approximate Reservoir Capacity

The H-A and H-V curve in the reservoir is prepared, based on a map of scale 1:10,000 and is used for basic data to estimate the reservoir capacity.

Since the existing wet season paddy area, suffering from water shortage, is extended to a large area in the basin as compared with water resources, a reservoir with a large capacity will be planned as far as the project economy allows.

The relation among the drainage area, annual runoff, effective reservoir capacity has been analyzed in the Feasibility Study as shown below:

	Lam Plai Mat	Lam Chi Noi	Huai Phlu
A. Drainage Area (sq.km)	485	25	21
B. Annual Mean Runoff (MCM)	77.4	4.4	4.6
C. Effective Reservoir Capacity (MCM)	90	4.0	6.0
B/A (mm)	160	175	219
C/B	1.2	0.9	1.3

The effective reservoir capacity to be planned in the Lower Northeast basin will be considered as much as 1.0 to 1.3 times the annual mean runoff and will be increased in accordance with the scale of the drainage area and areal rainfall.

(3) Dam Type and Standard Section

In accordance with the study of 98 medium scale projects in the Lower Northeast basin shown in Figure 2-1, 75 to 80 percent of the sub-projects with a dam height of lower than 20 m are to be considered as SMSIP. Therefore, the criteria and guideline of the dam in SMSIP are prepared for the dam with a height of lower than 20 m.

- The dam type is planned with the homogeneous earthfill type, with a horizontal and vertical filter drain in the downstream zone.

- The dam standard section is designed with a crest width of 6.0 m and dam slope of 1:3.0 for upstream and 1:2.5 for the downstream.

- The width of the cut-off trench is 6.0 m to 8.0 m depending on the dam height (6.0 m for dam height of lower than 15 m).

- Freeboard is one meter for the dam height of lower than 15 m and 1.0 + 0.05H m for the dam height of 15 to 20 m.

In case the dam height is higher than 20 m, the zone type earthfill will be adopted from the viewpoint of dam stability, availability of impervious material and construction cost. However, it is rather difficult to provide the criteria and guideline for the dam standard section, which will be determined by available construction material, geological condition in the dam foundation and dam height. In general, the crest width of 8.0 m, core trench width of 50 percent against the reservoir depth, core crest width of 4.0 m, etc. will be adopted for the dam height of higher than 20 m.

(4) Geological and Construction Material Survey

It is not necessary to carry out the geological investigation by core drillings and construction material survey by test pits in the overall basin study. The geological conditions at the dam foundation and borrow areas are only made by a view survey. However, the contents of the geological and borrow area surveys for the future feasibility study will be grasped.

(5) Spillway

The spillway site is also approximately selected using a map of scale 1:10,000 and by the field survey at the damsite, taking into consideration the flood discharge capacity.

The spillway structure is planned by the overflow concrete weir of non-controlled type and the chute/stilling basin placed on rock foundation or compacted overburden formation without concrete lining. Since the spillway head is small in case of the dam with low height, the spillway structure except overflow weir will be designed without concrete structure in order to minimize the construction cost.

The overflow depth of the weir in the spillway will be 1.0 m for the dam height of lower than 15 m and 1.0 to 1.5 m for the dam height of 15 to 20 m.

(6) Estimation of Embankment Volume

Although the dam embankment volume can be estimated accurately using a map of scale 1:10,000, the following method, as shown in Figure 3-2, is also applicable to grasp an approximate embankment volume in case the damsite is formed with the flat topography and the dam foundation does not require deep excavation.

In accordance with the estimation of the embankment volume of the three dams in the Feasibility Study, the difference of embankment volume between the estimation in the above calculation and the accurate estimation is less than 10 percent as follows:

	Lam Plai Mat	Nong Lum Puk	Huai Phlu
i) Approximate Estimation:			
Dam height on map	32.6 m	12 m	20 m
Dam length on map	1,100 m	1,100 m	650 m
	1.3	1.10	1.10
Approximate volume	1,524,000 m^3	189,000 m^3	292,000 m^3
ii) Accurate Volume in F/S	1,656,000 m^3	190,000 m^3	274,000 m^3
iii) Ratio	0.92	0.99	1.07

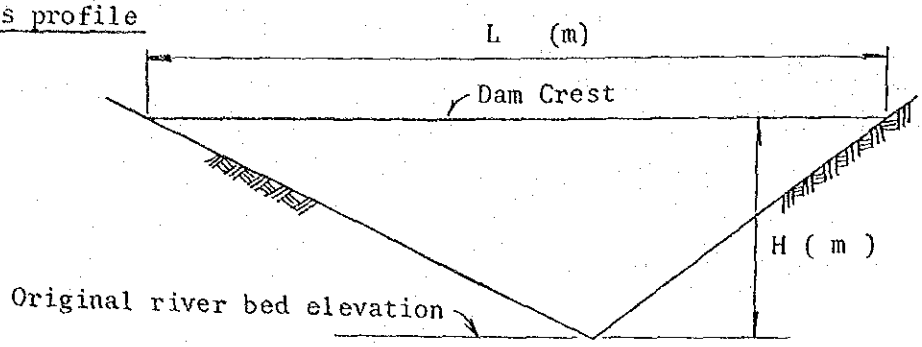
(7) Dam Construction Cost

The dam construction cost is approximately grasped, based on the dam embankment volume and average unit rate against the embankment volume. The average unit rate of the three sub-projects is estimated on the basis of 1983 price, as follows:

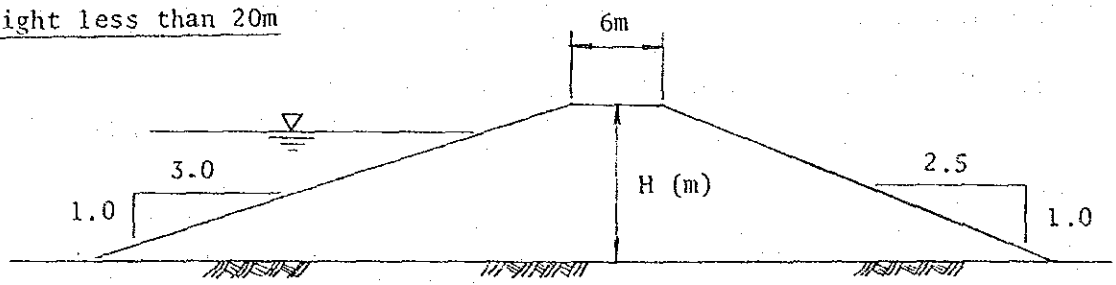
Lam Plai Mat ฿286.2 million / 1,656,000 m^3 = ฿173/m^3
Nong Lum Puk ฿24.3 " / 190,000 = ฿128/m^3
Huai Phlu ฿42.4 " / 275,000 = ฿154 m^3

Figure-3-2. Calculation of the Dam Embankment Volume

Dam axis profile



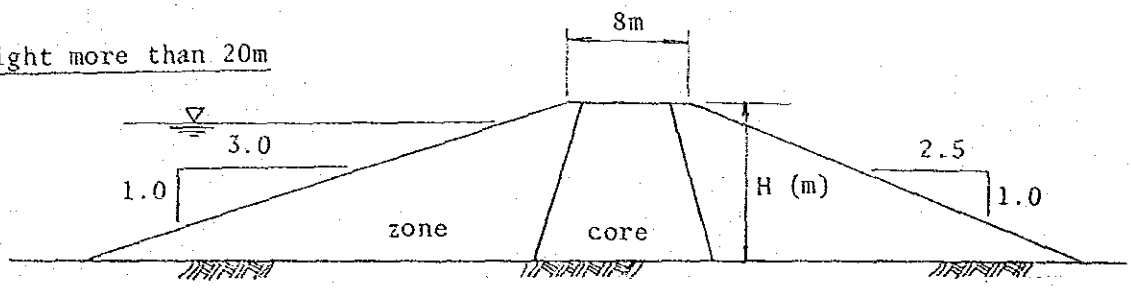
Height less than 20m



Section Area, $A = (6+6+5.5H) \times 1/2 \times H = 2.75H^2+6H$

Volume $V = 1/3 \times A \times L \times \alpha = (0.92H+2) \times H \times L \times \alpha$

Height more than 20m



Section Area, $A = (8+8+5.5H) \times 1/2 \times H = 2.75H^2 + 8H$

Volume $V = 1/3 \times A \times L \times \alpha = (0.92H+2.7) \times H \times L \times \alpha$

where, α is increased factor for embankment due to the stripping and cut off trench excavation on dam foundation.

Trench excavation with a shallow depth	α = 1.10
Trench excavation with a deep depth	α = 1.20- 1.30

In general, the average unit rate for the low dam will be cheaper than the high dam, because the low dam does not require deep excavation at the cutoff trench and grouting works.

The spillway construction cost will also have a big influence on the dam construction cost and will occupy about 30 percent against the dam total construction cost.

The following analysis for unit rate is also made:

(i) Unit rate for the dam construction cost excluding the spillway cost:

Lam Plai Mat,	฿207.5 million	/	1,656,000 m^3	= ฿125/cu.m
Nong Lum Puk,	฿16.9 "	/	190,000	= ฿ 88 "
Huai Phlu,	฿34.1 "	/	275,000	= ฿124 "

As is clear in the above table, the unit rate of the two dams with grouting works is almost the same and higher than the unit rate without grouting works.

Although it is rather difficult to judge the average unit rate for the dam cost on the basis of only three projects, ฿130/cu.m for the dam with grouting work and ฿90/cu.m for the dam without grouting work, will be tentatively considered.

(ii) Unit rate for the spillway construction cost

The spillway in the Lower Northeast basin will be constructed at the damsite with similar topographical and geological conditions. Only the overflow weir will be constructed by a concrete structure and the chute/stilling basin will be constructed by open excavation.

In the above conditions, the section area of the overflow weir and chute/stilling basin will be in proportion to the flood discharge capacity. Therefore, the unit rate for the spillway construction will be possible to estimate on the basis of the flood discharge capacity. In accordance with the result of the Feasibility Study, the following unit rate is prepared:

Lam Plai Mat	฿78.7 million	/	1,366 cu.m/sec	=	฿57,600/cu.m/sec.
Nong Lum Puk	฿7.4 "	/	135 "	=	฿54,600 "
Huai Phlu	฿8.3 "	/	140 "	=	฿59,300 "

The unit rate for the spillway construction will be judged as about ฿60,000/cu.m/sec, taking into consideration some allowance for the above unit rate.

Since the dam construction cost in SMSIP will occupy about 70 percent against the total construction cost including canal construction, the sub-projects with a high dam construction cost will be excluded in this stage as the third screening. The dam construction cost per hectare for the three sub-projects are analyzed as follows:

Lam Plai Mat	฿286.2 million	/	9,100 ha	=	฿31,500/ha (US$1,360)
Nong Lum Puk	฿24.3 "	/	300 ha	=	฿81,000/ha (US$3,520)
Huai Phlu	฿42.4 "	/	700 ha	=	฿60,600/ha (US$2,630)

3.4. Irrigation and Drainage Plan

3.4.1. Data Collection and Arrangement

Data for the irrigation and drainage plan are collected from the existing report for which the project had been completed or planned in and around the basin and arranged as follows:

- Location and irrigation area including the service area boundary are plotted on a map of scale 1:50,000 and the outline of the existing irrigation project is summarized. The existing irrigation project will include not only the medium scale but the SSIP.

- Amount of water being used in each existing irrigation project except the SSIP is grasped in accordance with the river runoff, reservoir capacity and planned cropping area. This water amount is excluded from the irrigation plan newly made in the overall basin study.

- Crop water requirement, diversion water requirement and drainage requirement per unit area is grasped, based on the existing irrigation project report and used for the irrigation plan in the overall basin study.

- Construction cost for the irrigation and drainage canals and on-farm work is also collected from the existing irrigation project report and used for the cost of the sub-project service area being planned in the overall basin study.

3.4.2. Field Survey

(1) Survey in the Existing Irrigation Area

The following field survey is carried out at the existing irrigation area to obtain supplemental data:

- Present conditions of water supply from the reservoir, diversion weir and canals including outline of irrigation facilities.

- Water utilizing conditions by farmers at the terminal irrigation area.

- Location and outline of the SSIP (only reservoir capacity and irrigation area).

(2) Survey of MSIP, especially proposed SMSIP

The following survey is carried out for the downstream service area where the proposed dam has a possibility to be constructed. The survey is made on the basis of a map of scale 1:50,000 and aerophotos.

- Water utilizing conditions at the paddy field by rainfall inundation and streams.

- Flood and inundation damage in the area.

- Selection of canal alignment and location of the weir to be related with the reservoir.

- Consideration of the irrigation method newly introduced at the terminal area.

3.4.3. Data Arrangement for the Existing Irrigation Area

The location, river name, drainage area and irrigation area related to the existing major irrigation facilities are plotted on a map of scale 1:50,000. The list of the project is summarized and divided into the MSIP and the SSIP.

Table titled "Development for Irrigation Area" will be made based on the unit sub-basin as shown in Forms 3-2 to 3-7, which has been prepared in the Overall Basin Study.

The existing development conditions in each sub-basin will be compared and used for the selection of the sub-basin area to be newly developed.

In case imperfect irrigation facilities are found in the overall basin study, the recommendation for the irrigation facilities to be rehabilitated, improved and newly constructed will be prepared, taking into account the urgency of the project, farmer's poverty condition in the area, project economy, etc. The project area placed under the imperfect irrigation facilities should be separated from SMSIP area.

3.4.4. Preliminary Plan for the Service Area

(1) Outline of Water Demand

The basic concept of SMSIP in the Lower Northeast is to supply water to villages and service areas as large as possible having the following two objectives:

- To supply supplemental irrigation water to stabilize the wet season paddy.
- To supply irrigation water for the dry season upland crops which are cultivated in the paddy field and to supply water to the muban communal facility such as village pond, fishery facility and domestic water supply in order to improve the farmer's life and to increase the farmer's income.

The water demand for each purpose is classified in accordance with the result of the Feasibility Study, as follows:

	Lam Plai Mat		Nong Lum Puk		Hua Phlu	
	(MCM)	(%)	(MCM)	(%)	(MCM)	(%)
Wet season paddy	46.8	85.9	1.54	80.2	3.60	87.4
Wet season nursery	3.1	5.7	0.12	6.2	0.15	3.6
Dry season upland crop	3.2	5.9	0.13	6.8	0.20	4.9
Domestic water	1.4	2.5	0.13	6.8	0.17	4.1
Total	54.4	100	1.92	100	4.12	100

The service area of SMSIP to be planned in the Lower Northeast will generally have the above water demand pattern.

(2) Crop Water Requirement

Crop water requirement is estimated by the modified Penman formula in the Feasibility Study, based on the following meteorological data at Nakhon Ratchasima:

Temperature	:	1951-80
Mean Humidity	:	1951-80
Mean Maximum Humidity	:	1951-80
Mean Wind Velocity	:	1975-82
Mean Wind Velocity in daytime	:	1975-82
Mean Wind Velocity in night	:	1975-82
Mean Cloudness	:	1951-80

The following crop water requirement is estimated in the Feasibility Study considering the evapotranspiration value and crop factor:

(Unit: mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Evapotranspiration	118	123	164	159	140	126	124	115	102	121	1,117	115	1,524
Paddy (Non-photo)						5.7	139	150.6	164.8	197.5	120.5	13.9	793.4
Paddy (photo)						36.6	144.8	152.8	168.1	199.6	165.5	55.8	923.2
Upland crops	67.3	80.6	84.5	8.7								59.1	300.2
Nursery bed					5.0	127.5	280.7	168.3	18.0				599.5

(3) Effective Rainfall

The value of effective rainfall differs by crop water requirement in the paddy/upland crop field, field conditions, and rainfall amount/intensity in the cropping calendar.

The effective rainfall and field irrigation requirement in the Feasibility Study has been estimated by the following criteria:

$$WD_n = WD_{n-1} + R_n - WR_n$$

where WD_n = field water level at the end of the day n (mm)

WD_{n-1} = field water level at the end of the previous day n-1 (mm)

R_n = rainfall on the day n (mm)

WR_n = total field water requirement on the day n (mm)

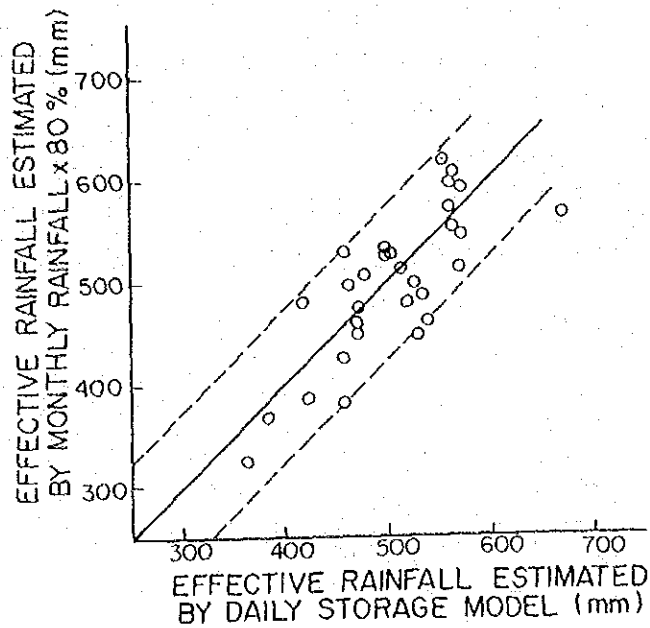
In case of paddy field,

Maximum Water Level + 135 mm (WDmax.) ..... The water depth is not allowed to rise above 135 mm. Eventual excess water is assumed to be drained.

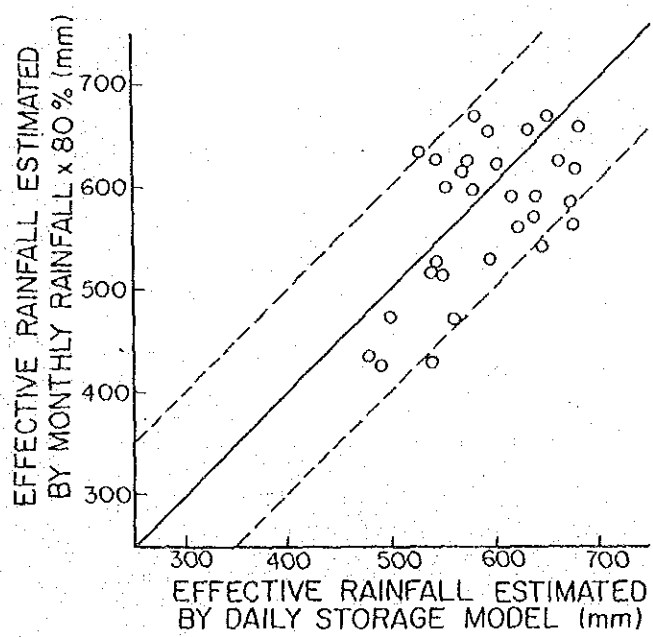
Normal Water Level + 90 mm (WDnor.) ..... As soon as the water depth falls below 45 mm, an irrigation application of 45 mm or more is made to maintain the normal water depth of 90 mm.

Minimum Water Level + 45 mm (WDmin.)

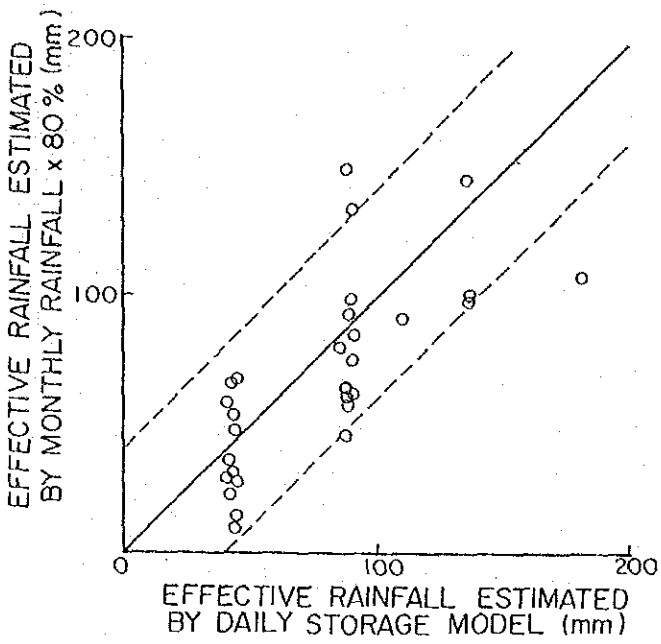
NON-PHOTOSENSITIVE PADDY



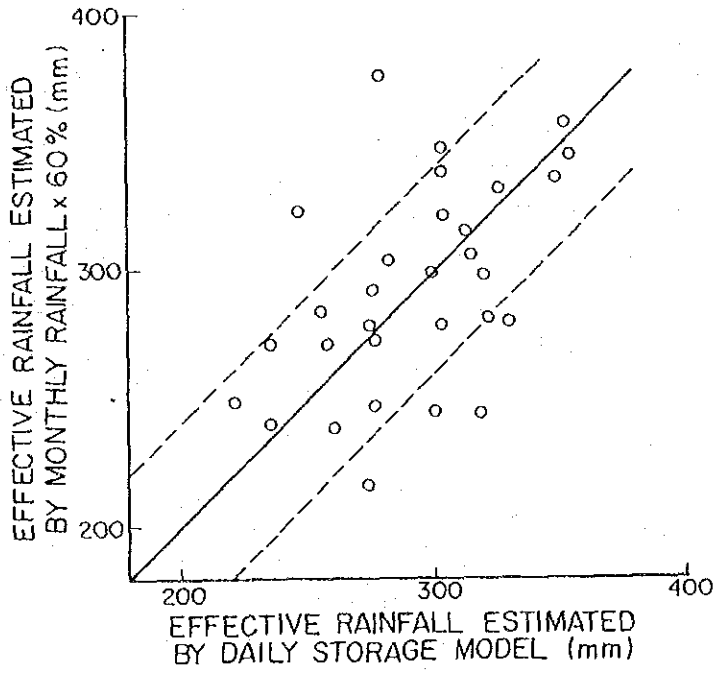
PHOTOSENSITIVE PADDY



VEGETABLE



SEED BED



In case of upland crop,

Maximum Water Level = Ground Surface (WDmax.)	:	0 mm
Normal Water Level (WDnor.)	:	-15 mm
Minimum Water Level = WHC (WDmin.)	:	-60 mm

The above table shows comparison data of effective rainfall between 80 percent value of monthly rainfall and the value estimated by daily water operation during 30 years in the Feasibility Study. Although some fluctuations are found in two values, the estimation of effective rainfall based on 80 percent for monthly rainfall will mostly be acceptable in the overall basin study.

(4) Irrigation Efficiency

The irrigation efficiency adopted for the Feasibility Study is as follows:

Field irrigation efficiency (Ea)		
For paddy field	85%	
For upland field	85%	
Efficiency on-farm ditches (Eb)	85%	
Water Delivery Efficiency (Ec)		
For lining canal	85%	
For earth canal	70%	) average 80%
Total Efficiency (Ea.Eb.Ec)		
For paddy field	58%	
For upland field	58%	

(5) Relation between Irrigation Area and Effective Reservoir Capacity

The relation between irrigation area and effective reservoir capacity is as follows in accordance with the result of the Feasibility Study:

	Lam Plai Mat	Nong Lum Puk	Huai Phlu
Catchment Area (sq.km)	485	25	21
Annual Mean Rainfall (mm)	1,065	1,065	1,312
Annual Mean Runoff (mm/km^2)	160	175	219
-do- (MCM)	77.4	4.4	4.6
(A) Irrigation Area (ha)	9,100	300	700
(B) Effective Capacity (MCM)	90	4.0	6.0
A/B (ha/MCM)	101	75	117
B/A (MCM/ha)	0.010	0.013	0.009

The irrigation service area will be assumed at 0.009 to 0.013 times the effective reservoir capacity in the above table.

On the other hand, the effective reservoir capacity of 1.0 million cu.m could irrigate the service area of 75 to 117 ha.

In case the SMSIP is planned in the Lower Northeast basin, the following guideline will be considered:

Areal rainfall	1,000 mm	90 ha/MCM
Areal rainfall	1,300 mm	100 ha/MCM

(6) Selection of the Service Area

The agricultural area in SMSIP will be generally extended on a large scale on both banks of the river as compared with the scale of available water in the reservoir. Therefore, the service area of the project is determined depending on the availability of reservoir water as mentioned in the above guideline and based on a map of scale 1:50,000, aerophoto, and the study of canal alignment.

It is not recommendable to select the service area downstream far from the damsite and to supply the water by diversion weir ignoring the upstream service area, because the water released from the reservoir downstream will be taken by the farmer living in the upstream area. Therefore, the service area in the SMSIP is selected downstream of the damsite and irrigated directly by canal originating from the reservoir.

(7) Construction Cost for Service Area

The construction cost for service area consists of the canal networks, on-farm work and muban communal facility. The cost will be estimated approximately by unit rate per unit service area. In accordance with the Feasibility Study, the unit rate per hectare in the three sub-projects is as follows:

Lam Plai Mat, ฿268.9 million / 9,100 ha = ฿29,100/ha
Nong Lum Puk, ฿9.51 " / 300 " = ฿31,700/ha
Huai Phlu, ฿21.32 " / 700 " = ฿30,500/ha

This cost includes the construction work of canal system of up to 20 to 30 ha, on-farm and muban communal facility. The average unit rate of ฿30,000/ha will be adopted for the approximate estimation of the service area.

3.5. Socio-Economic and Agricultural Survey

3.5.1. Data Collection

Following data related to amphoe and tambon are prepared in each sub-basin:

(1) Administrative Boundary

Since the boundary of the sub-basin and amphoe/tambon is not confirmed, the boundary is clarified on a map of scale 1:50,000 so as not to overlap. It is necessary to confirm the administrative boundary by the National Statistical Office and changwat concerned, because the boundary is changed or divided year by year.

The relation of boundary between sub-basin and amphoe is clarified by drawing the amphoe boundary on a map of scale 1:50,000. The area of amphoe at each sub-basin is measured by a planimeter. Furthermore, the relation of the area between statistical data and measured data will be clearly grasped.

(2) Population and Household

Numbers of villages, total population and household farmers' population and households at present and their movements are grasped based on data of the National Statistical Office and changwat concerned.

(3) Soil and Land Use

The soil map of scale 1:100,000 prepared by the Department of Land Development (DOLD) is collected. This map shows the agricultural land capability and will be used to judge agricultural productivity in the service area to be irrigated.

Since the land reclamation, deforestation, and cassava planting have progressed in the upper area of the Lower Northeast basin, particular attention will be paid to the variation of land use year by year. The land use being presented on a map of scale 1:100,000 is considerably inaccurate and it is necessary to judge the present land use by the aerophoto prepared recently (scale 1:20,000).

(4) Agricultural Productivity

Data for the paddy and upland crops area, cropping intensity of major crops, harvested area and yield of crops per unit area collected at the amphoe office of the Department of Agricultural Extension (DOAE). In addition, the same data at the changwat level are collected from the Office of Agricultural Economics (OAE) and compared with data of DOAE. Data for a five-year period will be required.

3.5.2. Field Survey

(1) Soil and Present Land Use

The survey at the representative places in the service area is only made in accordance with collected data. When the unsurveyed soil is found at the field survey, such soil conditions are assumed by observation survey.

(2) Muban Socio-Economic Survey

The interview with the chief of the village and farmers will be made at a representative village in each sub-basin. Subjects to be interviewed consist of history of village, relationship of village people, socio-economic conditions, agriculture, livestock and fishery conditions, problems and difficulty in villages, and necessity of development. The information collected in the interview will help the selection of the SMSIP with the first priority.

3.5.3. Data Analysis

Since the boundary of amphoe and sub-basin is not confirmed, the data for each sub-basin are arranged by proportion of area between amphoe and sub-basin and summarized in the table mentioned below.

- Table 1 "Land Use and Population" (see Form 3-8) - All areas, area of paddy field, upland crops and other land, population and its density, population growth, farm population and household, average cultivation area per unit household, farm population density, etc. will be presented in this table.

- Table 2 "Annual Change of Land Use (see Form 3-9) - All area, area of paddy, upland crop and other lands of the specified past years and recent year will be presented in this table. Annual changing ratio of land use is also shown in this table.

- Table 3 "Relation between Land Use and Land Classification (see Form 3-10) - The land classification of paddy field (5 classes), present land use for paddy and upland crops and their comparison will be shown in this table. Especially, the comparison of cultivation area and areal rainfall in the sub-basin will be made based on the relation of suitable soil for paddy and present land use.

- Table 4 "Productivity of Wet Season Paddy (see Form 3-11) - Paddy field area, farm household, cropping intensity, harvested ratio, yield per unit area and productivity index will be summarized in this table.

Comparison of farm income in each sub-basin is one of the important study subjects. The income of farmers engaged in cultivation of paddy field has a close relation with a productivity of wet season paddy and could be assumed in accordance with the productivity value in Table 4 and the cultivation area of paddy and upland crop in Table-1.

SMSIP with the first priority to be selected will be studied, based on careful judgment of the above Table 4 and Table "Development of Irrigation Area" mentioned in Section 3.4.3, taking into consideration the necessity of water resource development in each sub-basin and the relation between the existing irrigation area and proposed SMSIP area. In this study, particular attention is paid to the relation between SMSIP and SSIP.

The second screening for proposed SMSIP will be made from viewpoint of the service area through the study mentioned above.

3.6. Estimation of the Project Cost

The following simplified method will be introduced for the project cost estimation of the proposed SMSIP consisting of 20 to 30 sub-projects, because the project cost estimation is made only for the fourth screening work of the sub-projects.

3.6.1. Construction Cost

(1) Dam Construction Cost

The cost is estimated with the following criteria using the method mentioned 3.3.6 (6) and (7).

(Embankment Volume x Approximate Unit Rate) + (Planned Flood Discharge Capacity x Approximate Unit Rate)

Approximate unit rate is as follows:

฿90/cu.m for dam consisting of impervious dam foundation, less excavation and no grouting work.

฿130/cu.m for dam consisting of pervious dam foundation, much excavation and grouting work.

฿60,000/cu.m/sec for planned flood discharge capacity in in spillway.

(2) Canal Construction Cost

The cost is estimated as follows:

(Irrigation Area x Approximate Unit Rate)

Approximate Unit Rate is considered as ฿30,000/ha as mentioned in 3.4.4(6) above.

3.6.2. Other Cost

The other costs for O/M equipment, right-of-way, administration, consultant and survey work will be estimated by percentage against the construction cost. About 20 percent against construction cost is adopted in the feasibility study.

3.6.3. Project Cost

The project cost is estimated as follows with a contingency allowance of 10 percent.

(Construction Cost x 1.2) x 1.1 = Construction Cost x 1.3

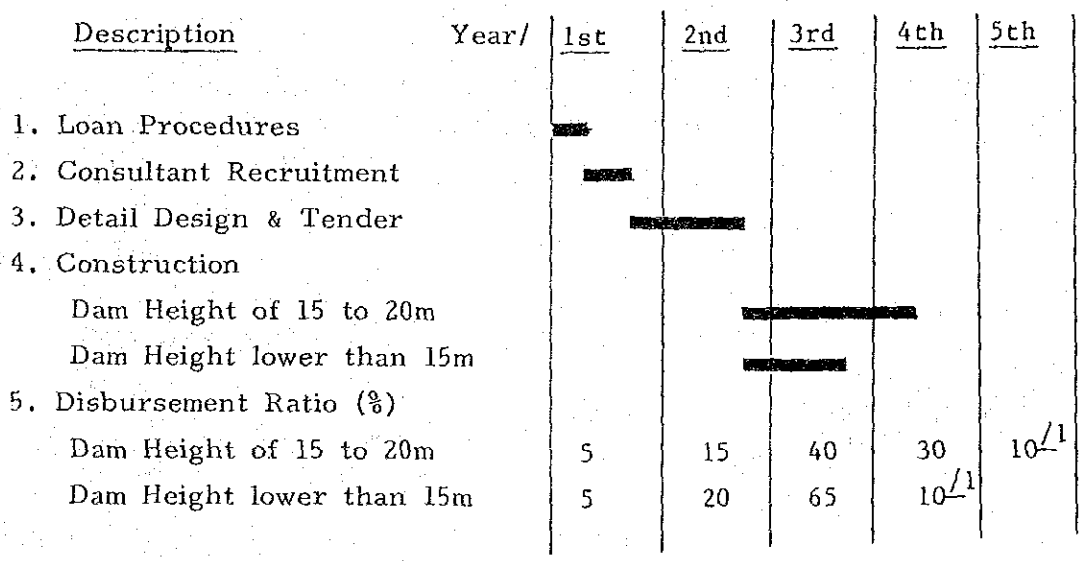
The project cost per hectare for the three sub-projects in the feasibility study is as follows:

Sub-Project	Project Cost (฿ '000)	Area (ha)	Cost/Ha (฿)	(US$)
Lam Plai Mat	768,610	9,100	84,500	3,700
Nong Lum Puk	42,860	300	142,900	6,200
Huai Phlu	82,420	700	117,700	5,100

The fourth screening work will be made by the above cost/ha. The sub-projects with cost/ha of more than ฿140,000 (US$6,000/ha) will be excluded at the fourth screening taking into consideration the above cost and the construction cost of 98 sub-projects in the Lower Northeast as shown in Fig. 2-1.

3.6.4. Implementation and Disbursement Schedule

Although SMSIP will be carried out as a package project consisting of 10 to 15 sub-projects, each sub-project will be made with the following implementation and disbursement schedule after completion of the feasibility study.



/1... In case the construction is made on a Contract basis, 10 percent retention for construction cost will be paid one year after completion of construction.

3.7. Selection of Sub-Project with First Priority

3.7.1. Estimation for Socio-Economic Benefit

(1) Data Collection

The following data are collected for the proposed SMSIP sub-project area, which has remained in the fourth screening (item 3.6.3). A sub-project in SMSIP generally consists of about 10 muban in 2 to 3 tambon.

- The name of tambon and muban is confirmed at the changwat office related to the sub-project area.

- Data such as cultivation area and cropping pattern for each crop, and harvested area at the tambon level are collected by the Department of Agricultural Extension Service (DOAE). Data for population, household, livestock, machine, farmers' association at the tambon level are collected by National Statistical Office.

- Date on agricultural production cost at the changwat level are collected by the Department of Agricultural Economics.

- The registered condition of cultivation area in the reservoir is confirmed at the Department of Land Development Office in amphoe. The cost of land acquisition is also surveyed at RID Regional Office.

(2) Socio-Economic Survey in Muban

The representative two muban for each sub-project area are selected at the amphoe office. The following survey is carried out for the representative five farmers in each muban (about 70 farmers).

- Cropping intensity, harvested ratio and yield/ha for wet season paddy.

- Working days and wages for work except agriculture in order to estimate the farmers' extra income.

- General present conditions in each muban.

(3) Data Arrangement and Analysis

(Private Sector Economy)

The project benefits to be derived from the private economic standpoint would be approximated by using an indicator of the income growth in the farm households with and without the SMSIP that would be easy to use and persuade. The farm household income which would be closely related to the rural poverty and also is employed as a political index within the government administration, would contribute to evaluation of the project from the important aspect of BHN (Basic Human Needs).

Farm household income at present is largely divided into two, viz. from agriculture and non-agriculture. The former income would be estimated on the basis of the financial analysis of sample farmers from collected data, and the latter would be approximated through arrangement and analysis of the information obtained in the muban socio-economic survey. Other income such as gift and remittance from outside would be negligibly small in the Lower Northeast region. The household income thus approximated will be compiled, taking an average income level and distribution of the households in the absolute poverty division (the annual per capita income of less than ฿3,500 in the 1982/83 level) on the basis of each sub-project.

The farm household income with the project which will be an increase in the agricultural income would be approximated through the financial analysis of sample farms with the project. This study is in connection with the financial analysis of the net production value in the national economic term in the case with the project which will be explained later. Since the financial analysis including the farm budget analysis is not included in the overall basin study, this approximation should do away with useless formalities.

To this end, an average farm household income and its distribution in the absolute poverty on the basis of each SMSIP sub-project will be compared with those at the national and regional level and other meaningful income indicators.

(National Sector Economy)

The national economic benefits are a difference of the net production value with and without the project. The following procedures should be employed in approximating the benefits:

- Effort will be made to use adequate data through sufficient cross-checking work for the collected information prior to the arrangement and analysis.

- Farm gate price of the crops is based upon survey data at the changwat level by OAE and MOAC. The present and future economic prices of rice, which is an export crop, are based upon the World Bank's commodity price forecasts weighted to reflect the actual composition of exports by grade and working back to the farm gate, excluding all taxes and adjusting domestic costs by applying specific conversion factors to state all values in terms of border prices expressed in domestic currency.

- The items for production cost in crop cultivation are composed of seeds, fertilizers, pesticides, human and animal labor and others. The farm gate price of fertilizers is converted from the imported price based upon the World Bank projection price. The labor is properly shadow-priced at its opportunity cost without the project with underemployment and with the project with increase in employment opportunities.

- Attention is paid to the calculation of production cost for the wet season rainfed paddy in the rates of its planting and harvesting.

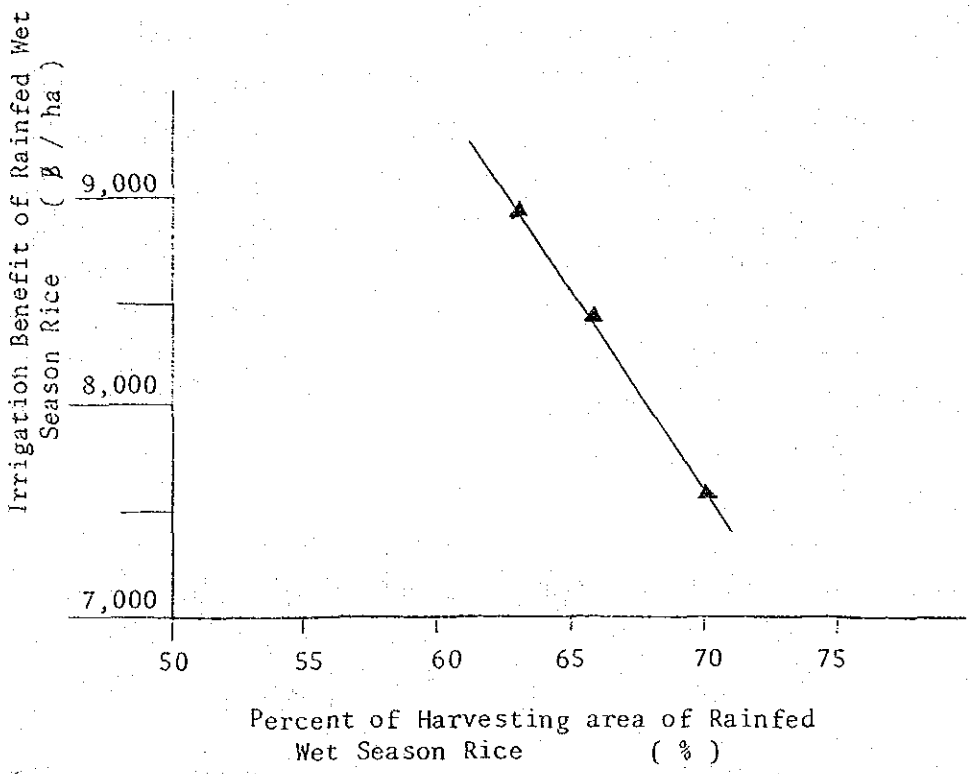
- Proposed irrigated field crops to be introduced during the dry season intend to provide a meaningful increase in employment opportunities and cash income for the farm households who belong to the categories of "paddy main" and "paddy + upland crops". The Feasibility Study indicates that a managerial size of such crops by each household which are generally cultivated by female workers such as wives, sometimes helped by unmarried and/or married daughters, would be 2 rai or 0.32 ha to the maximum extent, and number of the households would be about 60 percent of "paddy main" and 40 percent of "paddy + uplnad crops". Taking into account the possible marketing potential prevailing in the Lower Northeast region, introduction of groundnuts, mung beans, baby corn, shallot and chili would be popular. The Feasibility Study shows that about 10 percent of the irrigated wet season paddy cultivation area would be planted with dry season field crops, which should be managed at one cooperative cultivation block per one muban based upon special land-lease arrangement, because of the irrigation convenience and traditional social system.

- It would be profitable to provide one muban communal pond per muban, that is, a possible magnification of a farm pond or night storage reservoir for the dry season field crop irrigation where the muban people develop the fisheries and take drinking and domestic water for themselves and animals during the dry season. In addition, it would be beneficial to supply water to the muban collective nurseries for rainfed paddy within the muban. It is believed that these operations should promote the villagers' strong cooperation with the muban and with the project as a whole. Other economic benefits would be generated from the fisheries development in the RID-constructed reservoir and the possible foreshore cultivation of field crops during the wet season in the foreshore of reservoir when its water level is low. Value of the above explained economic benefits would not be so significant and its estimate is too complicated and time-consuming, so that its detailed inclusion in the Overall Basin Study is not recommendable.

According to the Feasibility Study, the total national economic benefits and their major diversion at full development per ha of the wet paddy irrigation area in each of the three sub-projects are given below:

Sub-Project /	Lam Plai Mat		Nong Lum Puk		Huai Phlu	
	Per Ha (฿)	%	Per Ha (฿)	%	Per Ha (฿)	%
Irrigation Area	(9,100 ha)		(300 ha)		(700 ha)	
Irrigation: Wet Season Paddy	8,921	83.4	8,587	68.2	7,717	77.7
Irrigation: Dry Season	1,436	13.4	1,583	12.6	913	9.2
Others	336	3.2	2,374	19.2	1,307	13.1
Total	10,693	100	12,584	100	9,937	100

Great effort has been made to identify meaningful relations between (1) indicators of planting and harvesting rates, yield level and productivity index (harvesting rate x yield) for the current wet season rainfed paddy and (2) per ha economic benefits to be derived from the project. As a result, the following salient relation of the harvesting rate for current wet season rainfed paddy with the per ha economic benefits of wet season irrigated paddy has been given:



The above finding would lead towards the preparation of a guideline to approximate per ha economic benefits at full development for the SMSIP:

- It appears that the work load to approximate the economic benefits for the SMSIP through arrangement and analysis of the various collected data as introduced previously that are deemed normal procedures would be heavy and an obstacle to speedy implementation of the overall basin study.

- It would be possible to rationalize an approximation of the total economic benefits to be derived from each of the SMSIP by employing the unique relation of the current harvesting rate for rainfed paddy to the per ha economic benefits from wet season irrigated paddy in the above figure.

- The above table also explains that the economic benefits other than the irrigated paddy is 27 percent and 37 percent of the total in the sub-projects of Nong Lum Puk and Huai Phlu, respectively, that belong to the SMSIP. This means that 1.36 to 1.56 times as much as the economic benefit from the wet season irrigated paddy is equivalent to the total economic benefits. This increasing rate would be given, taking into account the social situations prevailing in muban covering each of the SMSIP sub-projects; however, there would be no possibility to make a simple guideline. It is assumed that even if the increasing rate fixed at 1.4 is used as a conservative rate, any harmful effects would not be encountered in evaluation of each SMSIP sub-project which is described later.

- As mentioned above, the simplification for approximation of the total economic benefits expected from the project will be achieved; however, it should be imperative to carry out from every corner detailed comparison and evaluation of the current socio-economic conditions involved in all of the proposed SMSIP sub-projects, which should be the basic foundation for accrual of the expected benefits, through arrangement and analysis of the collected data. It is recommended that further review of relation of the rainfed paddy harvesting rate with the economic benefits from the wet season irrigated paddy should be made with available data for future study of the SMSIP.

3.7.2. Project Evaluation from the Regional and Private Economic Aspects

(1) The SMSIP in the Lower Northeast region should be implemented with a development concept of stabilizing the productivity of the wet season paddy and providing water-based basic social services for the area and with the purpose of alleviation of poverty in the area. Therefore, the project evaluation should be made by not only the national economic base but also the regional and private economic aspects to increase the farmer's income by the project.

First of all, all of the SMSIP sub-projects, as already selected in the fourth screening, should be ranked in order from the sub-project with the higher present income level of the farm households to that of the lower one. Subsequent comparison with the following information available in NESDB would be effective:

	Income Level				
	Poor	Marginal	Better-off	Wealthy	Average
Annual Income Range for Rural Thailand, 1982/83 Level					
(฿ per capita)	3,500/1	3,500 to 4,670	4,670 to 7,000	7,000	
Income Distribution of Rural Households in Northeast Region					
1) No. of Households, 1975/76/2	0.44	0.27	0.22	0.07	1.00
2) Ave. of Household Income (฿), 1982/83	17,450	25,270	37,480	77,620	28,537
3) Ave. Household Size, 1975/76	6.76	6.01	5.38	4.69	6.11
4) Ave. Per Capita Income (฿), 1982/83	2,581	4,204	6,967	16,550	4,633

/1... The poverty line based upon the expenditures for the recommended minimum requirements of food and non-food items.
/2... NESDB explains there would not be a change at present.

(2) Discussion of the income in the SMSIP would be made from two aspects, viz., (1) its average level of the farm households concerned and (2) its distribution. There would not be an appropriate analytical method to deal with the both collectively. It is suggested that the priority ranking of the SMSIP sub-projects for earlier implementation, taking into account the income level and poverty, would be made with the following index:

Poverty Index for each of the SMSIP sub-projects:

$$= \frac{\text{Average Household Income in Rural Northeast}}{\text{Ave. Household Income in Sub-Project}} \times \text{Distribution of Households in Poverty Group in Sub-Project}$$

The Feasibility Study indicates:

	Lam Plai Mat	Nong Lum Puk	Huai Phlu	Northeast Rural
Ave. Annual Per Capita Income (฿)	3,580	8,320	4,450	4,630
Ave. Household Size	6.0	6.1	6.3	6.1
Ave. Annual Household Income (฿)	21,470	50,760	28,060	28,860
Distribution of Households in Poverty Group (%)	63	31	56	44
Poverty Index	0.83	0.17	0.56	0.44

It is observed that one of the selection criteria for the SMSIP sub-projects would be to exceed 0.44 of the poverty index in the rural Northeast average.

(3) For reference, the poverty indices for the three sub-projects with the project conditions at full development that are enumerated on the 1982/83 price level in the Feasibility Study are as follows:

Sub-Project /	Lam Plai Mat	Nong Lum Puk	Huai Phlu
Ave. Annual Per Capita Income (฿)	5,470	9,170	5,410
Ave. Household Size	6.0	6.1	6.3
Ave. Annual Household Income (฿)	32,830	55,940	34,110
Distribution of Households in Poverty Group (%)	20	27	40
Poverty Index	0.17	0.14	0.33

Subsequently, the project evaluation of the three sub-projects from the regional and private economic aspects is carried out through the new introduction of a Poverty Alleviation Rate:

$$\text{Poverty Alleviation Rate} = \text{Poverty Index without the Project} - \text{Poverty Index with the Project}$$

The rates are 0.66 for Lam Plai Mat, 0.03 for Nong Lum Puk and 0.12 for Huai Phlu. It is understood that a remarkable improvement of the income level and a substantial alleviation of the absolute poverty are forecast through implementation of the Lam Plai Mat sub-project.

(4) Since approximation of the present income level of the farm households and its distribution by the four-type income classification is made in the Overall Basin Study as explained in para. 3.7.1, only the poverty index for each of the sub-projects at present is available. It can be considered that the SMSIP sub-project which has a higher poverty index is qualified as the likely feasible sub-project with the higher priority for earlier implementation. Attention should be paid to the fact that the poverty alleviation rate should not contain any factor of the project cost.

3.7.3. Project Evaluation from the National Economic Viewpoint

(1) This type of project evaluation with an indicator of the Internal Rate of Return (IRR) is to discuss the SMSIP sub-project on the basis of development administration and policy from the national social and economic point of view. The IRR is an important indicator for decision-making for the public sector investment with limited financial and budgetary sources in the Thai Government. It appears that the standard or minimum IRR is variable in accordance with the public investment needs and the environment and is normally defined by the social rate of discount at that time.

(2) The IRR is calculated by using the project costs as are explained in para. 3.6 and the economic benefits as are described in para. 3.7.1.

- Yearly stream of the project costs:

  The initial investment cost is distributed on a yearly basis in accordance with the project implementation schedule, and annual recurrent operation and maintenance cost after construction, that would be equivalent to about 1.5 percent of the initial investment is added. In the cost stream, the cost to replace the mechanical equipment at required time is also incorporated. The initial investment cost is divided into the domestic currency cost from the government contribution and the foreign currency cost (probably 55 percent of the total) to be financed by an international financing agency. Since the common unit of account used in the economic analysis is uncommitted public income measured at border prices, specific conversion factors for a number of broad categories of goods and services produced or consumed by the project are used to express all values in terms of the common unit of account. The specific conversion factors in converting from domestic to border prices that are currently available are 0.92 of the standard conversion, 0.84 of the capital goods and 0.88 of the construction.

The Feasibility Study in the case of the Nong Lum Puk and Huai Phlu sub-projects indicates that when the total financial cost is taken at 100 percent, the total economic cost is equivalent to 77.5 percent for the initial investment and 92 percent for recurrent operation and maintenance. It can be considered that these ratios would be applied as one of the criteria for the SMSIP planning.

- Yearly stream of the project benefits

The development period from water operations in the first year after the project construction until the accrual of the projected benefits at full scale for the SMSIP sub-project would be given, taking into due consideration the institutional strength and cooperative unit of farmers or villagers, the promotive and technical services by the government line agencies concerned, the transformation from rainfed paddy to irrigated, fisheries development in the RID-constructed reservoir and so forth.

The Feasibility Study on the Nong Lum Puk and Huai Phlu sub-projects assumes the following patterns during the 10-year development period.

Year /	1	2	3	4	5	6	7	8	9	10
Development Rate/*	0.55	0.76	0.90	0.95	0.99	0.99	1.00	1.00	1.00	1.00

/*... The full projected benefits are taken at 1.00.

When the farmland, which is legally registered, is submerged under the project, its annual net production value of distribution in the benefit stream is negative.

- The calculation period of the IRR is taken at 30 years, being sufficient for the preliminary project study. In the SMSIP sub-projects in the Lower Northeast region where the streams of costs and benefits are almost identical in their patterns respectively, it is assumed that value of the IRR for each sub-project would be indirectly obtained by grasping a proper relation between (1) the project initial investment costs per ha of wet season irrigated paddy and (2) the project full benefits per ha of wet season irrigated paddy. Because of only two samples in the Feasibility Study, this examination has been deferred.

(3) It has been learned that the present standard or minimum IRR for the RID-operated large and medium scale projects that is applied by NESDB is 12 percent. In addition, there is the fact that when the discussion meeting between RID and JICA was held in June 1983 for the selection of the sub-projects for the subsequent Feasibility Study (Study B), RID implied 10 percent of the minimum IRR for the SMSIP.

Generally speaking, it is considered that the number of SMSIP sub-projects which have the IRR higher than 12 percent would be limited to a lesser extent because each of the SMSIP sub-projects has a small dam with a rather higher construction cost against the scale of irrigation service area. It is, therefore, assumed that, if regulated by a higher IRR, the number of the SMSIP sub-projects for immediate implementation would be small.

Taking into account the development concept of the SMSIP, that water-based social services for more spatial area covering several poor rural villages as compared with the spot-type SSIP in the Lower Northeast region are contemplated with an important target of the BHN-type factor and also of the quick yielding nature, it may be allowed to lower the standard or minimum IRR for the SMSIP apart from the general criteria to be applied for the possible public investment in the government. It is, then, suggested to take about 8 percent for

the minimum IRR for each of the SMSIP sub-projects. For reference, it is noted that in the Overall Basin Study (Part A), the number of the sub-projects with the IRR higher than 8 percent was seven out of the twelve sub-projects that were taken for final selection.

Moreover, there is a tendency that the government pays attention to the IRR for a package project which comprises several sub-projects. Accordingly, there would be additional need to discuss the minimum IRR of the SMSIP package project, say at 10 percent.

Notes:

(1) Social Rate of Return

With the recently growing interest in income distribution in Thailand, it has become apparent that the benefits of national economic growth have not reached the lowest income group of country, and it is becoming increasingly important to take account of the benefit distribution in the selection and design of projects.

To help the developing countries decision-makers in this kind of effort, "The Social Cost-Benefit Analysis" has been developed over the past twenty years by the UNIDO and World Bank through its introduction by Little-Mirrlees and Squire-Vander Tak and is still being refined.

The formulation so far employed converts economic benefits to social benefits by the addition of a term representing the net social benefit of incremental private consumption resulting from the project. It is said that when reflecting on the fact that most of the project beneficiaries will have incomes below the national average even at the full project development and that the present government policy places moderate emphasis on redressing such imbalances, the social rate of return is above the economic rate; in other words, there is the case that a new irrigation project might be considered socially justifiable even though the analysis shows that such a project would not be economically justified.

As a tool for evaluating the SMSIP in the Lower Northeast region, the social cost-benefit analysis appears most useful at the early stages of the project cycle for selecting between project areas on the basis of their average income or consumption level relative to the national average. Once the area is selected, conventional economic analysis becomes more important for project design and preparation.

Effort has been made during the course of the Feasibility Study to apply social cost-benefit analysis to the SMSIP to assess the usefulness of its methodology and to discuss the feasibility of sub-projects with rather low economic returns taking into account the government policy to alleviate the chronic poverty situations currently prevailing in the Lower Northeast region. It has been identified, however, that there would be some difficulties to apply it, owing to some constraints and many assumptions involved. It is additionally considered that the social rate of return of the projects for their evaluation would not be authorized in near future.

(2) In addition to the above-mentioned two factors for evaluation of the SMSIP, viz., poverty index at present and IRR for the project, further insight by the government would be incorporated for proper selection of the possible sub-projects from the political benefit and social security points of view. It is considered that the opinion and intention of the changwat office concerned and the Second Army Region, Ministry of Defense who are very familiar with the local situations prevailing in the Lower Northeast region shall be reflected for selection of the feasible sub-projects.

CHAPTER 4 CRITERIA AND GUIDELINE FOR FEASIBILITY STUDY OF PACKAGE PROJECT

CHAPTER 4. CRITERIA AND GUIDELINE FOR FEASIBILITY STUDY OF PACKAGE PROJECT

4.1. Basic Concept on Feasibility Study

The feasibility study for a package project of SMSIP is basically intended to make clear the feasibility of the project from the technical and socio-economic aspect. The feasibility study of SMSIP, however, will be made in a short period considering the rationalized and simplified subject to be studied because the SMSIP consists of a large number of small medium scale sub-projects and is placed on the extension line of SSIP. On the other hand, the subjects to be required for appraisal of the international financing agency will be carefully studied.

The following subjects to formulate feasibility study of SMSIP are particularly considered.

(1) The river runoff analysis is an essential subject to make a reservoir and irrigation plan of SMSIP because no runoff data are existing in the project area of SMSIP.

(2) The water balance study to determine the suitable reservoir capacity and adequate irrigation area is carried out on the basis of river runoff, water demand and scale of irrigation area.

(3) Preliminary design of the dam and canal system is made by a rationalized and simplified method. It is not necessary, however, to carry out the preliminary design for the lateral canal, on-farm work and muban communal facility.

(4) Project cost is very carefully studied for loan appraisal by the international financing agency and Thai government. However, a rationalized and simplified method is introduced.

(5) Since the project benefit will be assumed by the result of the overall basin study, agricultural and socio-economic survey are not required principally in the feasibility study.

Only supplemental survey will be made in case the irrigation service area is changed as compared with the area in the overall basin study.

(6) Project evaluation is made on the basis of IRR in accordance with the project cost to be carefully estimated and the approximate benefit mentioned in the item 4 above.

(7) Project implementation program is prepared by the same method as the ordinary feasibility study.

4.2. Review and Additional Survey for Basic Data

4.2.1. Hydrological Survey

Existing hydrological data are reviewed by observation data at the gauging station which has been installed after the overall basin study. The river runoff with a 20-year period is assumed by the rainfall-runoff model prepared in each sub-basin based on the above hydrological data.

In the Feasibility Study, the Multiple Regression Model for Lam Plai Mat and the Tank Model for Nong Lum Puk and Huai Phlu has been prepared as the rainfall-runoff model. Tank model will be applied for future hydrological study of SMSIP because the program for the Tank Model has been already placed in the computer center of RID.

The design flood discharge capacity of spillway and sediment in the reservoir is estimated by the analyzed value in the overall basin study.

4.2.2. Soil Survey and Preparation of Land Use and Land Classification Map

The soil survey is only made at the area which has been indicated as the area with soil problem in the overall basin study. Test pits and auger borings are made by the criteria of one point per 50 ha.

The present land use, land classification and land use plan are studied in each sub-project based on the map of scale 1:10,000 newly prepared. The result of land use and land classification map are used for the irrigation plan for the service area.

4.2.3. Survey Work

The following survey work is carried out for the preliminary design of the project facilities. The work will be commenced before the feasibility study and completed during the field work of the feasibility study.

(1) Topographical Survey

- Installation of basic benchmarks and control points will coordinate at damsite and service area.

- Preparation of plane map with scale 1:2,000 at the damsite.

- Preparation of plane map with scale 1:10,000 by aerophoto for the irrigation area.

(2) Geological Survey

The following core drillings with permeability and penetration tests are made at the damsite.

	Dam Lower than 20 m	Dam Higher than 20 m
(i) Length less than 500 m -		
Rock and impervious burden	2	4
Pervious overburden	4	6
(ii) Length more than 500 m -		
Rock and impervious burden	3	5
Pervious overburden	5	7 - 8

The permeability test is made at the five-meter stage and by Lugeon method. Penetration test is made in overburden with two-meter stage.

(3) Borrow Area Survey

Auger borings, one hole per 100 m grid and depth of 3 m test pits, one pit per 250 m grid and depth of 5 m.

(4) Laboratory Test

The physical property test is only made for the dam height lower than 20 m on the basis of one sample per 100,000 cu.m embankment volume. The test item is as follows:

- Field moisture content
- Specific gravity and grain size analysis
- Plasticity index, liquidity index and shrinkage limit
- Content of water solve component of soils
- Chloride content of soil

The earth material is classified by the Unified Soil Classification System.

The following dynamic test is made additionally for the dam height higher than 20 m.

- Compaction test
- Permeability test --- two points by different moisture content and density
- Triaxial test --- -ditto-

(5) Test for Sand and Gravel Material

- Test pit : one pit per 100 grid and depth of 5 m
- Test item : specific gravity, absorption test
  grain size analysis

(6) Rock Test

The following rock test is made for samples taken from quarry site and boring core.

- Specific gravity and absorption test
- Sodium sulfate soundness
- Compression test

4.3. Water Use Plan of Reservoir

4.3.1. Irrigation Requirement

The crop water requirement is made by the modified Penman formula estimating crop-potential evapotranspiration and crop factor. The monthly irrigation requirement for wet season paddy and dry season upland crop is estimated for a 20-year period. The effective rainfall to estimate the irrigation requirement is considered as 80% of monthly rainfall.

The water demand for the nursery bed in the service area, except project area and domestic water supply in dry season, is estimated by a constant ratio for the irrigation requirement of wet season paddy and dry season upland crop.

$$\text{Water demand} = \text{Requirement for wet season paddy } (1 + \alpha) + \text{Requirement for upland Crop } (1 + ß)$$

Where, α : ratio of irrigation requirement between wet season paddy and nursery bed.

ß : ratio of water requirement between dry season upland crop and domestic supply.

The value of and ß is assumed as follows, based on the study for Huai Phlu Sub-Project:

$$\alpha = 5.6 = 6.0\%, \qquad ß = 93.3 = 100\%$$

4.3.2. Suitable Scale of Project

Both factors of irrigation area and the reservoir capacity are unknown in the water use plan of SMSIP of the Lower Northeast Basin. The suitable reservoir capacity, therefore, will be studied by trial and error method.

(1) Water Balance Study in Reservoir

The basic factor of water balance study in the reservoir is (1) effective reservoir capacity to be estimated by the relation of annual average runoff and effective reservoir capacity and (2) irrigation area to be assumed by the relation of effective reservoir capacity and irrigation area.

The basic factor can be obtained from the result of overall basin study mentioned in Chapter 3.

In the Feasibility Study, the scale of reservoir capacity and irrigation area is determined by several water operations by trial and error method. As the result of water operation of 20 years, the reservoir has the most suitable capacity in case a water shortage takes place in the reservoir of 5 to 10% against the water demand in the service area.

The water balance study in the reservoir will be made for several cases that the scale of irrigation area is changed by the scale of reservoir capacity. The changing limit will be as follows:

For reservoir capacity : each 0.5×10^6 cu.m
For irrigation area : each 50 ha

(2) Determination of Most Suitable Scale

- Suitable area to be irrigated without water shortage in wet and ordinary year is assumed at first (IA).

- Reservoir operation of about 20 years including wet, ordinary and dry year is carried out on the basis of combination of several scales of IA and reservoir capacities.

- The water shortage takes place in water operation of a dry year and the decreased irrigation area influenced by the water shortage is estimated (DA).

- (IA x 20 years - DA)/20 years presents average irrigation area in 20 years, (AIA).

On the other hand, the construction cost of dam and canal will be considered separately (TDC).

The suitable scale of project will be determined by the relation of AIA and TDC. The scale of project presenting small value of TDC/AIA is generally considered to be suitable. However, the frequency of water shortage in 20 years and scale of water shortage in a dry year is also considered to determine the suitable scale of project. In case the frequency of water shortage takes place more than once every three to four years, and reduced irrigation area by water shortage reaches more than 35% of planned irrigation area in a dry year, such a project will not be recommendable from the viewpoint of water management to the service area even if TDC/AIA presents small value.

4.3.3. Water Operation Study

The final water operation study is made after determination of a suitable scale of project as mentioned in 4.3.2 above. In this water operation, the countermeasures for water shortage in a dry year are considered. Namely, the irrigation area will be decreased in a dry year, taking into consideration the remaining reservoir capacity, otherwise, the planted service area expecting reservoir water will be damaged by water shortage in a dry year.

The following concepts will be introduced in water operation:

(1) The irrigation area to be planted will be decided at the beginning of March, taking into consideration the plantation of wet season paddy to be started in June. The irrigation area to be reduced will be determined under negotiation and agreement with the farmers' association in the muban.

(2) Judgment whether the irrigation area is reduced or not will be made by the conditions of remaining reservoir storage at the end of February. Namely, when the reservoir water level reaches below some control water level in a dry year, the irrigation rotation to reduce some irrigation zone area is introduced.

Some control water level and irrigation area to be reduced are not changed by the remaining reservoir capacity in February but fixed in order to carry out smooth irrigation rotation and easily set up the irrigation zone to be reduced.

In accordance with the reservoir operation study of three sub-projects, the following conditions for reservoir capacity and irrigation area to be reduced are found:

	Lam Plai Mat	Nong Lum Puk	Huai Phlu
(i) Effective Capacity (MCM)	90	4.0	6.0
(ii) Remaining Storage (MCM)	25.9	1.7	1.9
(iii) Ratio (ii)/(i) (%)	28.8	42.5	31.7
(iv) Irrigation Area to be reduced in dry year (%)	20.0	25.0	35.0

4.4. Preliminary Design of Dam

The preliminary design of the dam is made based on the map of scale 1:10,000 and 1:2,000, and the result of survey work mentioned in 4.2.3 above.

The following rationalized and simplified method is introduced for the preliminary design of the dam with a height lower than 20 m in SMSIP. However, the ordinary design method is applied for the dam with height higher than 20 m in MSIP.

4.4.1. Dam Height Lower Than 20 m

(1) Dam Type and Standard Section

The dam is planned as the homogenous fill type with vertical and horizontal drain at the downstream zone.

The following dam slope is adopted, based on the physical property test of soil.

Embankment Material	Upstream Slope	Downstream Slope
GC, GM	3.0	2.0
SC SM	3.0	2.0
CL ML	3.5	2.5
CH MH	4.0	2.5

(2) Dam Foundation Treatment

(i) Stripping on dam foundation is expected as 0.5 m.

(ii) A cutoff trench is provided at the center of the dam and deposit materials with N value of less than 15 and permeability value of more than 1×10^{-3} cm/sec are excavated. The width of the cutoff trench is designed with 6.0 m for dam height lower than 15 m and 8.0 m for dam height of 15 to 20 m.

(iii) Curtain grouts are not required for the dam lower than 15 m. However, curtain grouts will be required for dam height of 15 to 20 m consisting of pervious foundation with a permeability of 10^{-3} to 10^{-4} cm/sec. The blanket grout will be adopted for both upper banks with a low height. Grouting work is designed with three rows, three-meter interval at each hole and 50% depth against water depth of reservoir. Quantity of cement milk to be injected is expected as 50 kg per linear meter of drilling hole.

(iv) Other dimensions for dam will be as follows:

	Dam Height Lower than 15m	Dam Height 15 to 20 m
Crest width (m)	6.0	6.0
Free board (m)	1.0	1.0 + 0.5 H
Thickness of vertical drain (m)	1.5	1.5
Thickness of horizontal drain (m)	1.0	1.0
Thickness of riprap (m)	0.5	0.5

A vertical drain is placed 6.0 m downstream from the dam center and 4.0 m below the full water level. The sand and gravel material in the riverbed is used for vertical drain and mixed material of sand in the riverbed and crushed gravel is used for horizontal drain. (The riverbed material is difficult to find and expensive in the Lower Northeast region.)

(3) Spillway

The planned flood discharge capacity is estimated by unit capacity per drainage area as described in 3.2.3(2). The design flood discharge capacity for spillway is made considering surcharge effect in reservoir within the overflow depth of 1.0 to 1.5 m at weir and will be reduced by about 30% against the planned flood discharge capacity. The overflow weir is designed with the type of chute or double side flow channel and made of concrete.

The chute and stilling basin to release flood is basically placed at rock foundation and designed without concrete lining. In case the dam height is lower than 15 m and spillway site is located far from the dam body, the spillway might be placed at the overburden foundation without excavation up to rock formation to minimize construction cost. However, an overflow weir made of concrete is placed at firm and consolidated overburden formation and chute/stilling basin is protected by riprap.

(4) Intake Facilities

Two inlet mouths with different elevation are planned at the inlet structure, one is located at a little higher elevation than the designed low water level as the permanent intake. The other is placed at a little lower elevation than the low water level of reservoir to take the water below the low water level in case the reservoir will empty in dry year. This lower intake mouth will be plugged when sediment will reach the mouth elevation. The conduit pipe is designed with a circular section and concrete structure protected by steel liner, and embedded in the dam foundation. The gate for water control and energy dissipation is designed at the end of conduit pipe.

4.4.2. Dam Height Higher Than 20 m

It is rather difficult to provide the criteria and guideline for the dam height higher than 20 m. The dam will be designed considering conditions of topography, engineering geology and structure function. However, the following criteria will be applicable:

(1) Type and Standard Section

The zone type with center core will be recommended and the dam standard section is designed with the result of the dynamic property test of soil.

(2) Foundation Treatment

(i) Stripping on the dam foundation is designed to a thickness of 0.5 to 1.0 m.

(ii) The deposit material with N-value of less than 20 and permeability of 1×10^{-4} are excavated up to rock foundation at core trench. The width of core trench is designed with 50% of water depth in reservoir.

(iii) Curtain grout is planned with three rows and three-meter interval at each hole. The depth of grout is expected to be 50-60% against the water depth of reservoir.

(iv) Other dimensions of dam are considered as follows:

- Crest width	:	more than 8.0 m
- Freeboard	:	calculated by wave height in reservoir
- Vertical drain	:	placed along core zone with 2.0 m thickness
- Horizontal drain	:	thickness of 2.0 m
- Riprap	:	thickness of 1.0 m

(3) Spillway

Spillway is designed with the same criteria as SMSIP except the following items:

- Overflow depth at overflow weir is designed with topographical and geological conditions.

- All structures are placed at rock formation.

Spillway site, consisting of overburden, chute and stilling basin is designed with concrete structure.

(4) Intake Facilities

The design criteria for intake facilities is the same as the SMSIP, but conduit pipe will be embedded in the rock formation.

4.4.3. Quantity Calculation

Quantities having a large influence on the construction cost are excavation of the dam foundation and spillway, dam embankment, spillway

concrete, curtain grout, conduit pipe and control gate. The quantity is calculated noting the following items:

- Excavation quantity for the dam foundation and spillway is estimated by drawing the cross-section at adequate interval along axis based on the map of scale 1:2,000 (interval of 100 m is applied for dam).

  Since some of the excavation material will be used for embankment material, excavation material will be classified depending on its availability such as rock and earth.

- Concrete quantity is estimated, based on the drawings prepared by preliminary design.

- Quantity of conduit pipe and gate is estimated simply by linear meter and diameter.

4.5. Preliminary Design of Canal System

4.5.1. Selection of Main Canal Alignment

Alignment of the main canal is selected on map of scale 1:10,000 and by the field survey in the service area. The final service area irrigated by reservoir water is determined by the selection of the canal alignment, which is carried out in the following manner:

(1) The service area will be selected from the upstream area just below the damsite and extended to the downstream area according to available reservoir water. It is not recommendable to select the downstream area far from the damsite excluding the upstream area, because the reservoir water to be released from the damsite will be taken by the farmer in the upstream area and the construction cost of canal to be extended to the downstream area from the damsite will be increased.

(2) Since the service area is generally expanded along both banks of the river with slender shape, the canal alignment will be placed at both banks. The canal alignment will not cover all the existing paddy area along the river but 80 to 90% area. Only the nursery for wet season paddy will be supplied for 10 to 20% of the remaining area which is not covered with canal alignment.

(3) Canal alignment is planned to cover the terminal area of 20 to 30 ha in the service area taking into consideration that the farmer can construct and manage the on-farm work.

(4) Canal alignment is placed nearby the SSIP reservoirs and villages, to use the reservoir as regulating pond of canal water and to supply the canal water for village ponds.

4.5.2. Design of Main Canal

The canal design is made on the basis of RID criteria but the following consideration will be made:

(1) Design discharge capacity of canal will be assumed as 1.3 l/ha/sec.

(2) Concrete lining is applied for canal having a bottom width of more than 0.5 m. The thickness of concrete lining for canal will be as follows:

Discharge Capacity	Thickness
0 - 2.5 cu.m/sec	5.0 cm
2.5 - 5.0	6.0
5.0 - 15.0	7.0

(3) Maximum discharge velocity is 1.2 m/sec for the concrete lining canal and 0.8 m for the earth canal.

(4) The maintenance road is placed at mountain side.

4.5.3. Lateral Canal, On-Farm and Muban Communal Facilities

Since the construction cost per hectare for the lateral canal, on-farm work and muban facility will mostly be the same at any service area, its design will be required in the detail design stage. The cost for these facilities is estimated by unit rate per hectare, which is introduced from a similar project area.

4.5.4. Quantity for Main Canal

Quantity of the main canal is estimated by the canal profile prepared by the map of scale 1:10,000. Since the earth work quantity will be different depending on the canal in each sub-project due to topographical conditions, careful calculation will be made taking into consideration the balance of quantity for excavation and fill.

Quantity of crossing structures to be placed at the stream is also different by topographical and runoff conditions of the stream. Therefore, number of structures and its quantity is carefully estimated.

The quantity of other works related to the canal will mostly be similar to any canal in the sub-project and only different depending on the discharge capacity.

4.6. Preparation of Implementation Program

The loan request of a package project for SMSIP to the international financing agency will be made after completion of the feasibility study. It is recommendable to submit the request together with the engineering service loan and construction loan for

SMSIP in order to shorten the period of loan procedures and to accelerate the implementation of the project. In case the loan request is divided into the engineering service loan and construction loan, the construction loan will be made after the completion of detail design works under the engineering service loan, so that its loan procedure will require at least one year and the construction work will be delayed accordingly.

In case the loan request for the engineering service and construction is submitted together with the international financing agency, particular attention will be paid to the project cost and project evaluation, which is satisfactory to the appraisal of international financing agency.

4.6.1. Project Cost

The project cost will be estimated carefully so as not to bring a big variation after the implementation of the project. However, the following rationalized and simplified estimation method will be introduced in order to accelerate the cost estimate of 10 to 15 sub-projects.

(1) Unit Rate for Major Works

The common and variable unit rate will be considered in the major construction works so that it is convenient to estimate the common and variable unit rate depending on the construction method and available construction materials.

The major works with the common unit rate in each sub-project will be as follows:

- Spreading and compaction of dam embankment.
- Excavation and fill by using excavated material.
- Grouting works at dam foundation.

- Mixing and placing of concrete except materials of aggregate, cement and reinforcing bar. (Common unit rate is classified in spillway, intake, and canal lining.)
- Related structure of canal depending on its scale.
- Construction work at the service area such as the lateral canal, on-farm work and muban communal facility.

The major works with variable unit rate in each sub-project will be as follows and their unit rate will be variable mostly depending on the transportation distance.

- Stripping and excavation at the dam foundation, spillway and intake depending on distance to the spoil bank.
- Collection and transportation of embankment material from borrow area depending on distance.
- Conduit pipe per linear meter depending on the diameter.
- Gate per set depending on the diameter, or section.
- Aggregate depending on the distance from the borrow area.
- Fill of the canal from the borrow area depending on the distance.

The overhead of 20% will be considered for unit rate due to the works on the basis of a contract. The unit rate is classified into foreign and local currency.

(2) Construction Cost

The construction cost is estimated by the quantity and unit rate and the cost of 10 to 20% against the net construction cost of the dam and canal is added as the preparatory, temporary and miscellaneous work. Construction cost is also classified into foreign and local currency.

(3) Other Costs

The following other costs are also estimated based on the foreign and local currency:

- Purchasing cost of equipment for operation and maintenance preparing the list of equipment and taking into consideration of all sub-projects. The cost will belong to the foreign currency portion.

- Cost for land acquisition and compensation in the reservoir and service area is estimated with ฿2,000 per rai and the local currency.

- Cost of survey for detail design including topo-survey, geological survey, borrow area survey, laboratory test, etc. will be estimated depending on the result of the feasibility study. Since the SMSIP has no large or medium scale dam, the cost of survey will be approximately about 3.0% against construction cost.

- Administration cost will be estimated at about 5% against construction cost.

- Cost of consulting services is estimated based on manning schedule for detail design and construction supervision.

- Cost of physical contingency is considered at about 10% against the construction cost and other costs.

4.6.2. Implementation Schedule

- The implementation of SMSIP after conclusion of a loan by the international financing agency and approval of Thai government will be carried out in three groups

consisting of three to five sub-projects as shown in Figure 4-1, and will be completed within seven years after the feasibility study.

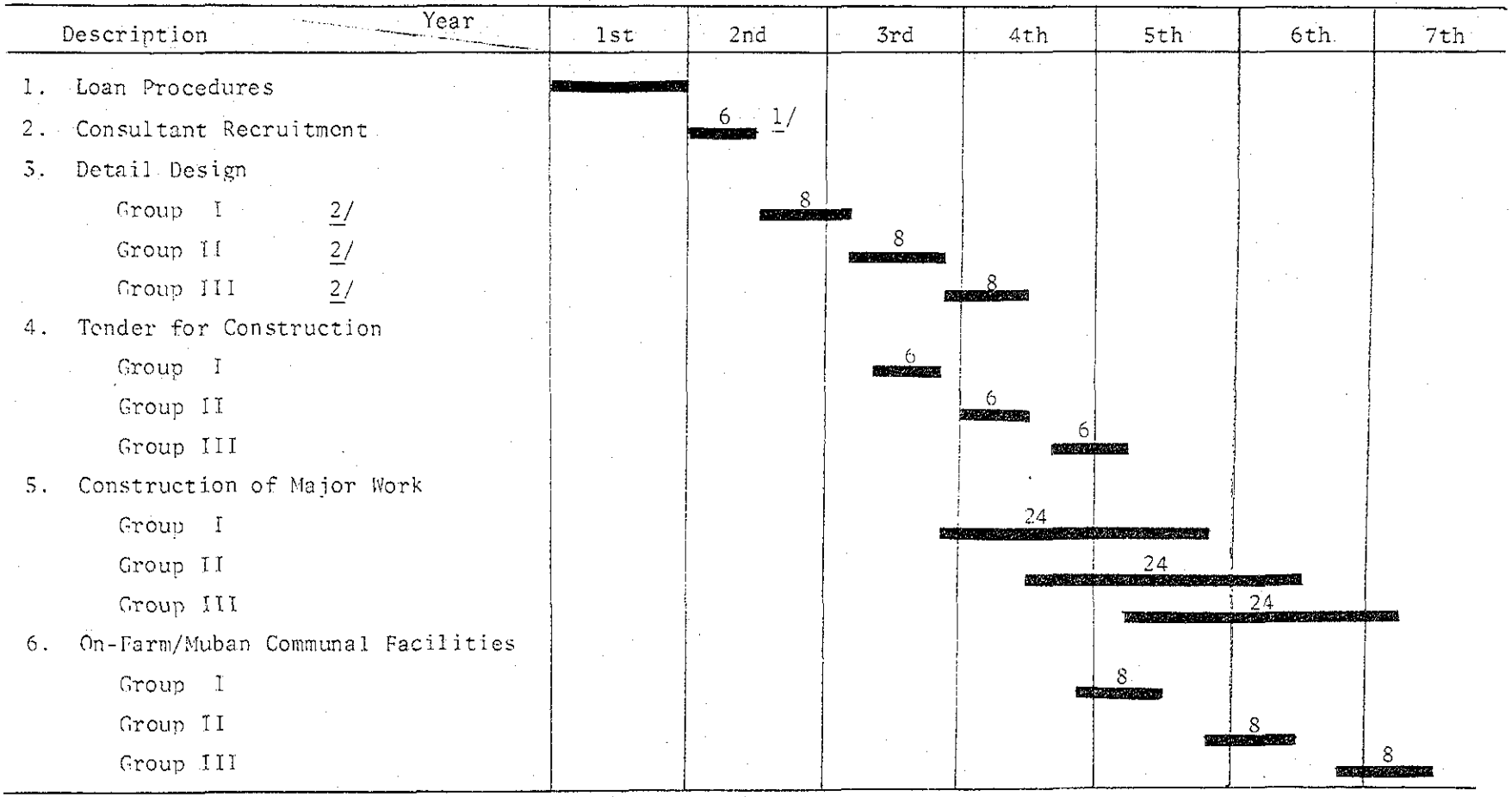
- The implementation agency concerned for the project will be clarified for the request and appraisal of the international financing agency and for the approval of Thai government.

- The detail work schedule and disbursement schedule will also be prepared.

4.6.3. Project Evaluation

The project evaluation has been made based on the ordinary method of computing the IRR in the feasibility study.

Figure 4-1. Implementation Schedule for SMSIP



Note 1/ Numbers on the line show working period.

2/ Group I, II, and III consists of 3 to 5 sub-projects respectively.

FORM

Configuration of Major River Courses in the Lam Plai Mat and Lam Chi Noi Basins

(1) Mae Nam Mun

Location	Distance (km)	Cumulative Distance (km)	Elevation (EL-M)	River Slope	Drainage Area (sq.km)	Coordination 1:50,000 Map
Mae Nam Khong	0	0	(98.4)			
Lam Don Noi	7.2	7.2				
Huai Tunglung	9.9	17.1				
Contour - 100	7.3	24.4	100.0			
Huai Kwang	10.3	34.7				
M11	6.7	41.4	(101.1)		115,687	
Lam Dom Yai	13.4	54.8		1/13,340		
Lam Se	6.1	60.9				
M7	34.3	95.2	(104.6)		106,673	
Lam Se Bai	18.2	113.4				
Mae Nam Chi	10.7	124.1	(106.5)			
Huai Phap	11.2	135.3				
Haui Khayung	6.2	141.5				
Contour - 110	56.3	177.8	110.0			
Huai Samran	11.6	189.4				
M10	3.6	193.0	(110.7)			
M5	48.4	241.4	(113.0)		44,275	
Huai Thap Than	11.3	252.7		1/21,510		
Lam Sieo	14.4	267.1				
M4	101.2	368.3	(118.9)		34,654	
Huai Rawi	19.2	387.5				
Contour - 120	5.4	392.9	120.0			
Lam Chi Noi (B)	18.0	410.9	(121.5)			UB397-908
M6	38.8	449.7	(124.7)	1/11,960	28,450	
M6A	23.3	473.0	(126.7)		28,275	
Huai Takong	16.2	489.2				
Contour - 130	23.2	512.5	130.0			
M104	56.4	568.9	(133.2)			
Lam Thamen Chai	31.0	599.9				
Lam Plai Mat (A)	54.2	654.1	(138.3)	1/16,980	(-5,838)	TC583-000
Lam Nam Khen	25.2	679.3				

Development of The Irrigation Systems

Sub-Basin	Sub-Basin Area				Large-Scale		Medium-Scale			Small-Scale		Irrigable Area			
	Total		Paddy Field		No. of Projects	Irrigable Area	No. of Projects	Irrigable Area		No. of Projects	Irrigable Area	As of 1983		At full Development	
								As of 1983	At full develop.						
	Sq.km.	%	Sq.km.	%		rai		rai	rai			rai	%	rai	%
			(A)			(rai)		(rai)	(rai)			(B)	B/A	(C)	C/A
Lam Plai Mat Basin															
1. Upper Lam Plai Mat	1,901	33	247	13	0	0	1	2,500	2,500	11	5,866	8,366	5.4	8,366	5.4
2. Lam Sai Yong	318	5	105	33	0	0	0	0	0	2	605	605	0.9	605	0.9
3. Lam Nang Rong	1,984	34	357	18	0	0	4	2,100	113,295	41	36,419	38,519	17.3	149,714	67.0
4. Lower Lam Plai Mat	1,635	28	948	58	0	0	3	3,160	3,160	14	4,900	8,000	1.4	8,060	1.4
Total	5,838	100	1,657	28	0	0	8	7,760	118,955	68	47,790	55,550	5.4	166,745	16.1
Lam Chi Noi Basin															
1. Upper Lam Chi Noi	747	15	232	31	0	0	1	0	1,500	2	1,000	1,000	0.7	2,500	1.7
2. Huai Seo	431	8	134	31	0	0	1	0	2,900	7	6,270	6,270	7.5	9,170	10.9
3. Huai Dae Ngao	339	7	132	39	0	0	0	0	0	3	1,130	1,130	1.4	1,130	1.4
4. Huai Khon	357	7	175	49	0	0	1	2,600	2,600	10	4,420	7,020	6.4	7,020	6.4
5. Huai Iabaek	890	17	463	52	0	0	0	0	0	6	1,610	1,610	0.6	1,610	0.6
6. Huai Saneng	697	14	342	49	0	0	2	50,800	50,800	10	2,490	53,290	24.9	53,290	24.9
7. Lower Lam Chi Noi	1,636	32	818	50	0	0	1	6,000	6,000	25	7,973	13,973	2.7	13,973	2.7
Total	5,097	100	2,296	45	0	0	6	59,400	63,800	61	24,893	84,293	5.9	88,693	6.2

Summary of the Existing RID Irrigation Projects

No.	Division	Large Scale (No. of Projects)	Medium-Scale No. of Projects	Medium-Scale Total Drainage Area (sq.km)	Medium-Scale Irrigable Area as of 1983 (rai)	Medium-Scale Irrigable Area At full Develop. (rai)	Small-Scale No. of Projects	Small-Scale Drainage Area Upstream MS Dams (sq.km)	Small-Scale Drainage Area Downstream MS Dams (sq.km)	Small-Scale Irrigable Area (rai)
1.	Lam Plai Mat Basin (Total Area = 5,838 sq.km, Paddy Field = 1,657 sq.km)									
A.	Upper Lam Plai Mat	-	1	(weir)	2,500	2,500	11	-	55.5	5,866
B.	Huai Sai Yong	-	-				2	-	5.5	605
C.	Lam Nang Rong	-	4	632	2,100	(128,100) 113,295	41	40.0	42.1	36,419
D.	Lower Lam Plai Mat	-	3	33	3,160	3,160	14	-	89.0	4,900
	Total	-	8	665	7,760	118,955	68	40.0	192.1	47,790
			As of 1983		7,760 + 47,790 = 55,550 rai or 8,888 ha					
			At Full Development		118,955 + 47,790 = 166,745 rai or 26,679 ha					
2.	Lam Chi Noi Basin (Total Area = 5,097 sq.km, Paddy Field = 2,296 sq.km)									
A.	Upper Lam Chi Noi	-	1	13	-	1,500	2	-	17.0	1,000
B.	Huai Seo	-	1	28	-	2,900	7	-	61.0	6,270
C.	Huai Lae Ngao	-	-				3	-	55.0	1,130
D.	Huai Khon	-	1	31	2,600	2,600	10	77.0	30.5	4,420
E.	Huai Tabaek	-	-				6	-	42.5	1,610
F.	Huai Saneng	-	2	640	50,800	50,800	10	49.0	-	2,490
G.	Lower Lam Chi Noi	-	1	16	6,000	6,000	23	-	157.1	7,973
	Total	-	6	728	59,400	63,800	61	126.0	363.1	24,893
			As of 1983		59,400 + 24,893 = 84,293 rai or 13,487 ha					
			At Full Development		63,800 + 24,893 = 88,693 rai or 14,190 ha					

Form-3-4

Inventory of the Medium-Scale Irrigation Projects

- Existing and Proposed for Subsequent Study 1/ in the Two sub-Basins. Lam Plai Mat and Lam Chi Noi -

Sub-Projects		Drainage Area (sq.km)	Irrigable Area (rai)	Remarks
1. Lam Plai Mat Sub-Basin				
A. Existing Projects (8)				
1. Huai Hin Weir	(Upper Lam Plai Mat)	34	2,500	1. Irrigaiton facilities not completed. 2. Water shortage.
2. Khlong Manao Tank	(Lam Nang Rong)	69	8,000	1. Dam completed in 1980. 2. Irrigation facilities not completed.
3. Nong Thalok Tank	(Lam Nang Rong)	15	2,100	Completed.
4. Lam Nang Rong	(Lam Nang Rong)	450	100,000	1. Dam completed in 1983. 2. No irrigation facilities.
5. Lam Pathia	(Lam Nang Rong)	100	18,000	Dam completed in 1985.
6. Huai Noi Tank	(Lower Lam Plai Mat)	4	810	Completed.
7. Huai Yai Tank	(Lower Lam Plai Mat)	6	1,050	Completed.
8. Huai Khinu Tank	(Lower Lam Plai Mat)	25	1,500	Completed.
Sub-total		699	133,760	
B. Projects Proposed for Selection to the First Priority Package II/ (8)				
P-1. Lam Plai Mat	(Upper Lam Plai Mat)	485		
P-2. Huai Phriak	(Upper Lam Plai Mat)	112		
P-3. Huai Hin	(Upper Lam Plai Mat)	51		
P-4. Huai Toei	(Upper Lam Plai Mat)	37		
P-5. Nong Lum Puk	(Upper Lam Plai Mat)	25		
P-6. Huai Sadao	(Upper Lam Plai Mat)	32		
P-7. Nong Wah	(Upper Lam Plai Mat)	23		
P-8. Lam Changhan	(Lam Nang Rong)	156		
Sub-total		901		
2. Lam Chi Noi Sub-Basin				
A. Existing Projects (6)				
1. Sawannapha Tank	(Lower Lam Chi Noi)	31	2,600	Completed.
2. Huai Sawai Tank	(Lower Lam Chi Noi)	16	6,000	Completed.
3. Am Pun Tank	(Huai Saneng)	(211)	4,600	Completed.
4. Huai Saneng Tank	(Huai Saneng)	640	46,200	Completed.
5. Huai Ta Kao	(Upper Lam Chi Noi)	13	1,500	1. Dam completed in 1982. 2. No irrigation facilities.
6. Huai Mekha	(Lam Seo)	28	2,900	1. Dam completed in 1982. 2. No irrigation facilities.
Sub-total		728	63,800	
B. Projects Proposed for Selection of the First Priority Package II/ (4)				
C-1. Ban Kramang	(Lower Lam Chi Noi)	2,764		
C-2. Upper Huai Siew	(Lam Seo)	(45)		
C-3. Huai Phlu	(Lam Seo)	(22)		
C-4. Huai Kra Bun Riew	(Upper Lam Chi Noi)	(36)		
Sub-total		2,764		

Note: 1. Total area of the Sub-basin : Lam Plai Mat .... 5,858 sq.km
Lam Chi Noi .... 5,097 sq.km ..... 10,935 sq.km

2. See the subsequent sheets for detail.

1/.... To identify the first priority package.

II/.... After the second screening in the Study A.

Existing and Proposed Irrigable Area by Projects
- Lam Plai Mat Sub-Basin -

No.	Project	Category	Source Work: River at Damsite	Coordinates in 1:50,000 Maps	Drainage Area (sq.km)	Irrigable Area (rai)	Remarks
Group A: Existing Projects							
A.1	Upper Lam Plai Mat						
1.	Huai Hin Weir	Weir	Huai Hin (Lam Plai Mat)	Weir TA 200-878	(34.0) No data	2,500	Weir and left main canal constructed. Right main canal under construction.
A.2	Lam Nang Rong						
2.	Khlong Manao Tank	Dam & Weir	Khlong Manao (Lam Nang Rong)	Dam TA 576-816	69.0	8,000	Dam completed in 1980. Storage capacity: 2.6 MCM. Irrigation facilities under construction.
3.	Nang Thalok Tank	Dam & Weir	? (Lam Nang Rong)	Dam TB 620-230	13.2	2,100	Completed. Including water supply for Amphoe Nang Rong (Town). Storage capacity: 2.8 MCM.
4.	Lam Nang Rong	Dam & Weir	Lam Nang Rong	Dam TA 595-816	450.0	100,000	Dam constructed in 1983. Storage capacity: 150.0 MCM. No detailed plan of irrigation facilities.
5.	Lam Pathia	Dam & Weir	Lam Pathia (Lam Nang Rong)	Dam TA 782-845	100.0	18,000	Dam construction to be completed in 1985. Storage capacity: 25.4 MCM. No detailed plan of irrigation facilities.
	Sub-total				632.2	128,100	
A.3	Lower Lam Plai Mat						
6.	Huai Noi Tank	Dam	Huai Takhop (Huai Yai Lam Plai Mat)	TB 682-675	3.8	810	Completed in 1953.
7.	Huai Yai Tank	Dam	Huai Yai (Lam Plai Mat)	TB 683-695	5.5	1,050	Completed in 1957. Near Amphoe Lam Plai Mat (Town).
8.	Huai Khinu Tank	Dam	? (Lam Plai Mat)	TB 686-615	22.6	1,300	Completed in 1961.
	Sub-total				*31.9*	*3,160*	
	Total (8 Projects)				698.1	133,760 (or 21,400 ha)	
Group B: Proposed Projects							
B.1	Upper Lam Plai Mat						
P-1	*Lam Plai Mat*	*Dam & Weir*	Lam Plai Mat	*Dam* TA 237-827	485	54,375	275 km upstream of river mouth.
P-2	Huai Phriak	Dam & Weir	Huai Phriak (Lam Plai Mat)	Dam TA 181-821	112	8,438	Satellite for P-1 irrigation project.
P-3	Huai Hin	Dam	Huai Hin (Lamp Plai Mat)	Dam TA 191-878	31	1,250	Upstream of existing Huai Hin Weir.
P-4	Huai Toei	Dam	Huai Toei (Huai Thon Huai *Chai Kong Lam* Plai Mat)	Dam TA 353-870	37	2,063	Isolated.
P-5	Nong Lum Puk	Dam	Huai Nong Lumpuk (Lam Plai Mat)	TA 295-984	25	1,563	Satellite for P-1 irrigation project.
P-6	Huai Sadao	Dam	Huai Sadao (Lam Plai Mat)	TA 331-986	32	1,875	Satellite for P-1 irrigation project.
P-7	Nong Wah	Dam	Huai Pong Sakae (Lam Plai Mat)	TA 473-917	23	1,250	Satellite for P-1 irrigation project.
	Sub-total				748	70,814	
B-2	Lam Nang Rong						
P-8	*Lam Changhan*	*Dam*	*Lam Changhan* - Nam Nang Rong	TA 708-834	156	11,875	
	Total (8 Projects)				904	82,689	

Form-3-6

Inventory of the Small-Scale Irrigation Program

- In the Two Sub-Basins, Lam Plai Mat and Lam Chi Noi, as of 1983 Construction -

NO.	Division	No. of Projects (A)	Total Drainage Area (sq.km)	Total Irrigable Area (D) (rai)	Division Area		Density of Project		
					Total (B) (sq.km)	Paddy Field (C) (rai)	(B)/(A)	(C)/(A)	(D)/(C) (%)
1.	Lam Plai Mat Sub-Basin								
A.	Upper Lam Plai Mat	11	55.5	5,866	1,901	154,375	173	14,034	3.8
B.	Huai Sai Yong	2	5.5	605	318	65,625	159	32,813	0.9
C.	Lam Nang Rong	41	82.1	36,419	1,984	223,125	48	5,442	16.2
C.1	Lam Nang Rong	31	70.6	26,853					
C.2	Lam Changhan	3	10.5	610					
C.3	Lam Pathia	7	1.0	3,090					
D.	Lower Lam Plai Mat	14	89.0	4,900	1,635	592,500	116	42,321	0.8
	Total	68	232.1	47,790	5,838	1,035,625	86	15,230	4.61
2.	Lam Chi Noi Sub-Basin								
A.	Upper Lam Chi Noi	2	17.0	1,000	747	145,000	374	72,500	0.7
B.	Huai Seo	7	61.0	6,270	431	83,750	62	11,964	7.5
C.	Huai Lae Ngao	3	53.0	1,130	339	82,500	113	27,500	1.4
D.	Huai Khon	10	107.5	4,420	357	109,375	36	10,938	5.4
E.	Huai Tahaek	6	42.5	1,610	890	289,375	148	48,229	0.6
F.	Huai Saneng	10	49.0	2,490	697	213,750	70	21,375	1.0
G.	Lower Lam Chi Noi	23	157.1	7,973	1,636	511,250	71	22,228	1.6
G.1	Upstream Railway	15	78.3	3,510	711		47		
G.2	Downstream Railwy	8	78.8	4,473	925		116		
	Total	61	489.1	24,893	5,097	1,435,000	83	23,525	1.7

Note: See the subsequent sheets for detail.

Form-3-7

Inventory of Existing Projects

No.	Project	Coordinates in 1 : 50,000 Maps	Drainage Area (sq.km)	Storage Capacity (MCM)	Irrigable Area (rai)	Remarks
Lam Plai Mat Basin						
A. Upper Lam Plai Mat (to confluence of Lam Nang Rong)						
	M-S: P-1 proposed	TA 237-827				Main river.
	M-S: P-2 proposed	TA 181-821				Huai Phliak (- Main)
	M-S: P-3 proposed	TA 191-878				Huai Hin (- Main)
	Huai Hin Weir	TA 200-878				Left main canal constructed under SSIP.
1.	Ban Nong Krathurn	TA 224-891	(?)	Weir	Domestic	? (- Plai Mat Main)
	M-S: P-4 proposed	TA 353-870				Huai Toei (- Huai Thon - Main)
	M-S: P-5 proposed	TA 295-984				Huai Nong Lumpuk (- Main)
	M-S: P-6 proposed	TA 531-986				Huai Sadao (- Main)
2.	Ban Nong Ta Back	TA 294-853	12.0	0.218	1,000	Huai Hin (- Huai Chai Kong - Main)
3.	Ban Nong Sanuan	TA 366-968	3.2	0.096	500	Huai Saphan (- Main)
4.	Ban Khok Ma-Muang Wan.	TA 434-943	(20)?	(0.209)	200	Main river, construciton in 1983.
	M-S: P-7 proposed	TA 473-917				Huai Pong Sakae (- Main) construction in 1983.
5.	Ban Don Nang Ngam	TA 480-965	1.3	0.25	100	Huai Khok Nam (- Main)
6.	Ban Khok Mai Daeng	TA 514-880	6	0.156	1,500	Lam Plai Mat Noi (- Main)
7.	Ban Khok Loi	TB 485-012	18	0.33	700	Huai Changko (- Main)
8.	Ban Chum Saeng	TB 548-161	12	Weir	1,066	? (- Main)
	Huai Sai Yong	TB 574-250				
9.	Ban Na Chan	TB 527-342	(?)	Weir	800	Huai Luk (- Main)
10.	Ban Khok Prasat	TB 585-384	1.5	0.18	Domestic Irrigation	Huai Noi (- Main)
11.	Ban Ta Khro	TB 604-414	1.5	0.3825	?	Huai Noi (- Main)
	Lam Nang Rong	TB 713-415				
	Total (11)		55.5	1.613	5,866	
B. Huai Sai Yong (to confluence with Lam Plai Mat)						
1.	Ban Dong Bang	TB 370-100	2.5	0.1074	Domestic	Huai Lung Kat (- Huai Sai Yong)
2.	Ban Khok Pak	TB 450-186	3.0	0.179	605	? (- Huai Sai Yong)
	Lam Plai Mat	TB 574-250				
	Total		5.5	0.2864	605	
C.1. Lam Nang Rong						
1.	Ban Khlong Pong	TA 505-750	2.5	1.01	197	? (- Nan Rong Main)
2.	Ban Khlong Hin	TA 510-728	12	1.073	1,500	? (- Main) Construction 1983.
3.	Khlong Yang	TA 468-676	5.5	0.40	500	? (- Huai Lakoh Phinang - Main)
4.	Ban Khok Phet	TA 487-694	12	0.216	100	Huai Lahox (- Main) Construction 1983.
5.	Ban Nang Rong	TA 503-680	(?)	(?)	600	? - (Huai Lakoh Phinang - Main)

LAND USE AND POPULATION

Sub-Basin	Total Area		1978 Land Use: Paddy Field		Upland		Others		Total Polulation: 1980 Total	1980 Density	1970-80 Growth Rate	Farm Population: 1980 Total	1980 Household	Per Household Land Use: Paddy Field	Upland	Total	B/A
	sq.km.	%	sq.km.	%	sq.km.	%	sq.km.	%	'000 (A)	per sq.km.	% per year	'000 (B)	'000	Ha	Ha	Ha	
LAM PLAI MAT BASIN																	
1. Upper Lam Plai Mat	1,901	33	247	13	190	10	1,464	77	128	67	5.2	106	17	1.5	1.1	2.6	0.75
2. Lam Sai Yong	318	5	105	33	16	5	197	62	31	97	1.5	25	4	2.6	0.4	3.0	0.81
3. Lam Nang Rong	1,984	34	357	18	119	6	1,508	76	136	69	4.0	94	16	2.2	0.7	2.9	0.69
4. Lower Lam Plai Mat	1,635	28	948	58	278	17	409	25	216	132	2.1	184	30	5.2	0.9	4.1	0.85
TOTAL	5,838	100	1,657	28	603	10	3,578	62	511	88	3.2	409	67	2.5	0.9	3.4	0.80
LAM CHI NOI BASIN																	
1. Upper Lam Chi Noi	747	15	232	31	57	5	478	64	74	99	9.0	63	11	2.1	0.5	2.4	0.85
2. Huai Seo	431	8	131	31	30	7	267	62	44	102	7.6	37	6	2.2	0.5	2.7	0.84
3. Huai Lae Ngao	339	7	132	39	10	3	197	58	35	103	7.5	30	5	2.6	0.2	2.8	0.86
4. Huai Khon	357	7	175	49	11	3	171	48	43	120	3.0	37	6	2.9	0.2	3.1	0.86
5. Huai Tabaek	890	17	463	52	18	2	409	46	110	123	4.9	88	15	3.1	0.1	3.2	0.80
6. Huai Sancog	697	14	342	49	21	3	334	48	95	136	4.0	73	13	2.6	0.2	2.8	0.77
7. Lower Lam Chi Noi	1,636	32	818	50	65	4	753	46	274	167	5.4	179	29	2.8	0.2	3.0	0.62
TOTAL	5,097	100	2,296	45	192	4	2,609	51	675	132	5.4	497	85	2.7	0.2	2.9	0.74

DATA SOURCE : Amphoe Level Data

Form-3-9

CHANGE OF LAND USE, 1963 - 1978

Sub-Basins	Total Area	1963				1978				1978-1963	
		Arable Land		Others		Arable Land		Others		Arable Land	Others
	Sq.km.	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%		
		(A)		(B)		(C)		(D)		(C/A)	(D/B)
LAM PLAI MAT BASIN											
1. Upper Lam Plai Mat	1,901	152	8	1,749	92	437	23	1,464	77	2.88	0.84
2. Lam Sai Yong	318	64	20	254	80	121	38	197	62	1.89	0.78
3. Lam Nang Rong	1,984	238	12	1,746	88	476	24	1,508	76	2.00	0.86
4. Lower Lam Plai Mat	1,635	687	42	948	58	1,226	75	409	25	1.78	0.43
TOTAL	5,838	1,141	20	4,697	80	2,260	39	3,578	61	1.98	0.76
LAM CHI NOI BASIN											
1. Upper Lam, Chi Noi	747	112	15	635	85	269	36	478	64	2.40	0.75
2. Huai Seo	431	56	13	375	87	164	38	267	62	2.93	0.75
3. Huai Lae Ngao	339	58	17	281	83	142	42	197	58	2.45	0.70
4. Huai Khon	357	61	17	296	83	186	52	171	48	3.05	0.58
5. Huai Tabaek	890	267	30	623	70	481	54	409	46	1.80	0.66
6. Huai Saneng	697	202	29	495	71	363	52	334	48	1.79	0.67
7. Lower Lam Chi Noi	1,636	687	42	949	58	883	54	753	46	1.29	0.79
TOTAL	5,097	1,443	28	3,654	72	2,488	49	2,609	51	1.72	0.71

DATA SOURCE : 1. "Census of Agriculture, 1963", NSO, Office of the Prime Minister.
2. "1978 Agricultural Census Report", NSO, Office of the Prime Minister.

NOTES : Arable land = Paddy field and Upland.

Form-3-10(1)

RELATION OF THE 1978 LAND USE WITH THE SOIL SUITABILITY FOR PADDY FIELD (1)

Sub-Basin	Total Area		Soil Suitability for Paddy (Wetland) Rice										1978 Land Use					
			Group P-I		Group P-II		Group P-III		Group P-IV		Group P-V		Paddy Field		Upland		Others	
	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%
Lam Plai Mat Basin																		
1. Upper Lam Plai Mat	1,901	33	0	0	0	0	209	11	95	5	1,597	84	247	13	190	10	1,464	77
2. Lam Sai Yong	318	5	0	0	6	2	22	7	16	5	274	86	105	33	16	5	197	62
3. Lam Nang Rong	1,984	34	0	0	79	4	337	17	119	6	1,449	73	357	18	119	6	1,508	76
4. Lower Lam Plai Mat	1,635	28	0	0	16	1	736	45	82	5	801	49	948	58	278	17	409	25
Total	5,838	100	0	0	101	2	1,304	22	312	5	4,121	71	1,657	28	603	10	3,578	62
Lam Chi Noi Basin																		
1. Upper Lam Chi Noi	747	15	0	0	0	0	144	19	5	7	598	80	232	31	37	5	478	64
2. Huai Seo	431	8	0	0	0	0	58	13	27	6	346	81	134	31	30	7	267	62
3. Huai Lae Ngao	339	7	0	0	0	0	132	39	6	2	201	59	132	39	10	3	197	58
4. Huai Khon	357	7	0	0	0	0	158	44	22	6	177	49	175	49	11	3	171	48
5. Huai Tabaek	890	17	0	0	0	0	419	47	67	7	404	46	463	52	18	2	409	46
6. Huai Saneng	697	14	0	0	0	0	442	64	12	2	243	35	342	49	21	3	334	48
7. Lower Lam Chi Noi	1,636	32	0	0	31	2	1,055	65	13	1	537	32	818	50	65	4	753	46
Total	5,097	100	0	0	31	1	2,408	47	153	3	2,506	49	2,296	45	192	4	2,609	51

Data Source : DLD, Detailed Reconnaissance Sil Map (1/100,000), 1974-75.

Group P-I ..... Soils very well suited for paddy land.
Group P-II ..... Soils well suited for paddy land.
Group P-III ..... Soils moderately suited for paddy land.
Group P-V ..... Soils poorly suited for paddy land.
Group V ..... Soils generally not suited for paddy land.

RELATION OF THE 1978 LAND USE WITH THE SOIL SUITABILITY FOR PADDY FIELD (2)

Sub-Basin	Total Area		Soil Suitability of 1978 Paddy Field: 1978 Total Paddy Field		Soil Suited for Paddy Group P-I to P-IV			Average Group Index of 1978 Paddy Field	Rainfall: Annual		Jun. to Oct.	
	Sq.Km.	%	Sq.Km. (A)	%	Sq.Km. (B)	%	B-A (Sq.Km.)		m.m.	Ratio	m.m.	Ratio
Lam Plai Mat Basin												
1. Upper Lam Plai Mat	1,901	100	247	13	304	16	+ 57	Group III. 2	1,151	0.97	812	0.94
2. Lam Sai Yong	318	100	105	33	44	14	- 61	Group IV. 2	1,162	0.98	841	0.97
3. Lam Nang Rong	1,984	100	357	18	535	27	+ 178	Group II. 7	1,240	1.04	928	1.07
4. Lower Lam Plai Mat	1,635	100	948	58	834	51	- 114	Group III. 3	1,188	1.00	866	1.00
Total	5,838	100	1,657	28	1,717	29	+ 60	Group III. 1	1,188	1.00	868	1.00
Lam Chi Noi Basin												
1. Upper Lam Chi Noi	747	100	232	31	149	26	- 83	Group III. 5	1,374	1.06	997	1.04
2. Huai Seo	431	100	134	31	85	19	- 49	Group IV. 0	1,417	1.09	1,035	1.08
3. Huai Lae Ngao	339	100	132	39	138	41	+ 6	Group III. 0	1,138	0.88	877	0.91
4. Huai Khon	357	100	175	49	180	50	+ 5	Group III. 1	1,138	0.88	877	0.91
5. Huai Taback	890	100	463	52	486	58	+ 23	Group III. 1	1,390	1.07	961	1.00
6. Huai Saneng	697	100	342	49	454	65	+ 112	Group III. 0	1,178	0.91	901	0.94
7. Lower Lam Chin Noi	1,636	100	818	50	1,099	68	+ 281	Group III. 0	1,323	1.02	993	1.03
Total	5,097	100	2,296	45	2,591	51	+ 295	Group III. 0	1,299	1.00	962	1.00

WET SEASON PADDY PRODUCTION

Sub-Basins	1978		1980		1981/82 Wet Season Paddy (dry year)								1979/80 - 1981/82 Wet Season Paddy (3 years-average							
	Paddy Field		Farm Household		Planted Area		Harvested Area		Yield		Productivity Index		Planted Area		Harvested area		Yield		Productivity Index	
	Ha	%	'000	%	%	Ratio	%	Ratio	Ton/Ha	Ratio	A X B	Ratio	%	Ratio	%	Ratio	%	Ratio	C X B	Ratio
	X				Y		Z (A)		(B)											
LAM PLAI MAT BASIN																				
1. Upper Lam Plai Mat	24,700	15	17	25	72.6	1.04	54.6	1.28	1.41	1.02	77	1.3	87.1	0.94	72.5	0.96	1.90	1.10	138	1.1
2. Lam Sai Yong	10,500	6	4	6	67.9	0.98	25.7	0.60	0.59	0.43	15	0.3	79.0	0.87	57.7	0.77	1.61	0.94	93	0.7
3. Lam Nang Rong	35,700	22	16	24	78.3	1.12	14.4	0.34	0.33	0.24	5	0.1	81.7	0.90	49.8	0.66	1.39	0.81	69	0.5
4. Lower Lam Plai Mat	94,800	57	30	45	65.4	0.94	52.3	1.22	1.53	1.10	80	1.4	96.5	1.06	87.7	1.16	1.82	1.06	160	1.2
TOTAL	165,700	100	67	100	69.5	1.00	42.7	1.00	1.38	1.00	59	1.0	90.8	1.00	75.3	1.00	1.72	1.00	130	1.0
LAM CHI NOI BASIN																				
1. Upper Lam Chi Noi	23,200	10	11	13	70.5	0.90	51.6	0.77	1.38	0.83	71	0.6	76.5	0.92	65.5	0.96	1.81	0.98	119	0.9
2. Huai Seo	13,400	6	6	7	80.5	0.64	19.5	0.29	0.77	0.46	15	0.1	67.2	0.81	51.9	0.76	1.61	0.87	84	0.7
3. Huai Lae Ngao	13,200	6	5	6	87.0	1.11	87.0	1.30	2.19	1.32	191	1.7	91.5	1.11	80.5	1.19	1.39	0.75	112	0.9
4. Huai Khon	17,500	8	6	7	78.7	1.01	78.7	1.17	2.19	1.32	172	1.5	91.9	1.11	72.6	1.07	1.44	0.79	105	0.8
5. Huai Taback	46,300	20	15	18	67.5	0.86	35.3	0.53	1.30	0.78	46	0.4	65.0	0.79	48.8	0.72	2.17	1.17	230	1.8
6. Huai Saneng	34,200	15	13	15	82.9	1.06	82.6	1.23	2.19	1.32	181	1.6	91.5	1.11	80.1	1.18	1.63	0.88	131	1.0
7. Lower Lam Chi Noi	81,800	35	29	34	87.8	1.12	84.9	1.27	1.67	1.01	142	1.3	90.3	1.09	86.3	1.27	1.99	1.08	172	1.4
TOTAL	229,600	100	85	100	78.3	1.00	67.1	1.00	1.66	1.00	111	1.0	82.8	1.00	67.9	1.00	1.85	1.00	126	1.0

DATA SOURCE : Amphoe Level data prepared by DAE, Changwat Offices, based upon the I = 50,000 topographical maps.

Yield data would below in reliability, and then it has been assumed that actual yield would be around 60 to 70 percent of the above mentioned.

NOTES : (1) Planted area = (X) X (Y)

(2) Harvested area = (X) X (Z)

(3) Productivity Index = When the planted area and harvested area are both 100 percent of the are of paddy field and the yield is taken at 1.6 ton per Ha that is the average of Thailand for wet season paddy, then the productivity index is 160.