No.

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

PRE-FEASIBILITY STUDY ON THE UPPER PASAK MEDIUM SCALE IRRIGATION PROJECT

FINAL REPORT
ANNEX VOL.2

V. AGRICULTURE AND AGRO-ECONOMY
VI. IRRIGATION
VII. COST ESTIMATE
VIII. PROJECT ECONOMY

MARCH 1982

JAPAN INTERNATIONAL
COOPERATION AGENCY

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5.1 PRESENT CONDITION OF AGRICULTURE

5.1.1 Present Land Use

During 20 years from 1958 to 1978, Thailand decreased her forest area to just one half, while increased area under farm holding by about double (57.6 million rai to 116.4 million rai), area under paddy also by about double (37.3 million rai to 73.2 million rai), and area under upland crops by almost 5 times (5 million rai to 24 million rai).

The same situation is met with in Phetchabun Province. The land use in Phetchabun Province in 1971 and 1977 is summarized in Table 5.1 based on the Statistical Report of Changwat Phetchabun. Paddy field doubled in 7 years, area under upland crops increased by 125 percent and area under vegitables tripled.

The present land use in the Lom Sak and Phetchabun district is shown as follows based on the land use map with a scale of 1:100,000.

Area	Lom Sak District		Phetchabun District	
	rai	%	rai	%
Paddy Field	187,500	(48)	202,500	(31)
Upland	176,250	(45)	275,000	(41)
Forest	1,250	(0)	101,880	(15)
Idle Land	25,630	(7)	87,500	(13)
Total	390,630	(100)	666,880	(100)

Paddy fields mainly extend over riverside which are covered with fertile alluvial soils. Most of these paddy fields are cultivated with only wet season paddy because no irrigation water is available throughout dry season. Maize is the main crop grown in the both districts, followed by rice. Upland planting maize mainly extends over terraces and elevated alluvial fans along the skirt of hillside. Some of these maize lands are planted with beans as second crop after maize is harvested. The forest lands in the hilly area is not used for cultivation due to steep slope, sharp undulation, shallow soil depth, etc. It is basically maintained as a reserve land to protect erosion, ecological destoration, etc.

Most of the areas in which the four projects would be implemented are covered with well-developed paddy field, planting only wet season paddy due to constraint of irrigation water during dry season.

5.1.2 Cropping Calendar

Cropping in Thailand is divided into two different categories.

1) In areas where the irrigation systems are completed, paddy is the main crop. After harvesting paddy, other crops such as legume, tabacco and vegetable follow, depending on their marketability.

2) In rainfed areas which cover 85% of the total cultivated area, many kinds of crops are planted such as paddy, sugar cane, maize, cotton, etc. In these areas, two crops can be grown in part, for example soybean, mungbean, sesame or sorghum can be grown as the second crops after paddy or maize.

Phetchabun province is one of the corn granary in the northern Thailand. Crops in Phetchabun province are multifarious and sometimes crops planted vary year by year. As an example, area and order of priority of crop sown by district in 1980 are as follows.

Crop	Lom Sak District		Phetchabun District	
	($x10^3$rai)	(order)	($x10^3$rai)	(order)
Paddy	134	(1)	178	(2)
Maize	101	(2)	190	(1)
Mungbean	19	(3)	31	(3)
Peanut	4	(6)	3	(4)
Soybean	0		3	(5)
Cotton	6	(5)	2	(7)
Tabacco	8	(4)	0	
Sesame	0		2	(6)
Sweet Potato	1	(7)	0	

The present cropping carendar in Phetchabun province is presented in Fig. 5.1. Paddy cultivation is concentrated in the wet season because of extremely limited irrigation water resources during dry season. The cultivation pattern is directly affected by depth of annual rainfall. The area planted and/or harvested sharply fluctuates year by year, depending on the available water throughout growing season. The wet season paddy is usually planted in June thru July. After harvesting the wet season paddy, farmer sows mungbean, soybean, tabacco and vegetables as second crops of paddy field and harvested them before commencement out of land preparation for wet season cropping. The paddy cultivation during dry season is quite rare in the province due mainly to shortage of water resources.

The maize is mainly planted in the upland at onset of the southwestern monsoon, generally April thru May, and harvested in July thru August. After harvesting maize, farmer usually sows mungbean, soybean, sorghum, etc., and harvests them in November at the end of wet season.

5.1.3 Farming Practices and Inputs

In Thailand, paddy is cultivated mostly in wet season and a minor portion, about 6% of the total, is estimated to be grown in dry season. In general, paddy can be grown anytime in a year, provided that water is available.

In the northern region, cropping period of paddy is as follows.

Description	1st Crop	2nd Crop
Sowing	Mid. Jun. - Jul.	Mid. Feb. - Mid. Mar.
Transplanting	Aug. - Early Sep.	Mid. Mar. - Mid. Apr.
Harvesting	Mid. Oct. - Nov.	Mid. May - Jun.

(1) Plowing, harrowing and leveling

Prior to sowing to nursery, broadcasting and transplanting, plowing is made by buffaloe or cattles. Sometimes small hard-tractor is used through hire-service.

(2) Nursery and transplanting

Seeding to nursery is usually made by using paddy soaked in winter at a rate of 160 kg per rai. Nursling is pulled out 30 - 45 days after sowing. Transplanting is made by hand. Sometimes free exchange of labour is practiced by community group at a neighbourhood or extended family level.

(3) Fertilizer application

Fertilizers are seldom applied to paddy cultivation. Thai farmers are not accustomed to use manure generally.

(4) Water management

Farmers' concern is whether or not irrigation water reaches the paddy fields. In general, shallow water at the early stage after transplanting, 10 - 30 cm depth of water at the growing period and draining off of water at the lactescence formation period are known as a standard practice.

(5) Weeding

Weeding by hand is practiced 1 - 2 times in the growing season. Intercultivation is not done in this region.

(6) Crop protection

Occurrences of damages by insects are reported. A few farmers use duster for preventing diseases and pests. Community prevention measures have not been practiced yet so far.

(7) Harvesting

Harvesting of paddy is done by hand with sickle. Stalk with panicle is cut 50 cm long and laid down on the field for 3 - 4 days to dry. The dried harvest is hauled to the threshing floor which is prepared in advance at the elevated place. Harvested products are spread over the threshing floor and let buffaloe and cattles tramp over them. Pedal threshers are being introduced. Winnowing by wind is still used prevailingly in this region.

5.1.4 Crop Yield and Production

Major crops produced in the Phetchabun province comprise paddy, maize and beans. The yields of major crops under present condition in the province are estimated on the basis of data obtained from "Agricultural Statistics of Thailand", as given in the following table.

(Unit: kg/rai)

Year	Paddy	Mungbean	Soybean	Groundnut	Maize
1971/72	407	250*	215*	343*	345
72/73	505*	126	144	169	279*
73/74	439	118	169	211	500*
74/75	442	158	180	252	426
75/76	461	99	157	261	411
76/77	427	91	168	196	441
77/78	326*	78*	98*	193	321
78/79	427	91	172	168	405
79/80	330*	93	126	148*	379

As shown in the above table, the yields widely fluctuate year by year due to wide variation of annual rainfall and unexpected damages caused by flood, insect and diseases. The present crop yields are therefore estimated at the average values neglecting the upper and lower extreme values marked with "*" in the above table, and the results are as follows.

Paddy	434 kg/rai (2.7 t/ha)
Mungbean	111 kg/rai (0.7 t/ha)

Soybean	159 kg/rai (1.0 t/ha)
Groundnut	207 kg/rai (1.3 t/ha)
Maize	389 kg/rai (2.4 t/ha)

The crop productions in the Phetchabun province are estimated at paddy of 325×10^3 ton, mungbean of 31×10^3 ton, soybean of 12×10^3 ton and maize of 483×10^3 ton as presented in Table 5.2.

5.1.5 Land Tenure and Land Holding

The Government of Thailand issued "Agricultural Land Reform Act", aiming at better allocation of land resources and redeeming land for farm in 1975. Since then, the land ownership has been substantially improved.

In the Phetchabun province, owner farmer is predominant accounting to about 84% in number and about 85% in area, respectively in 1978 as shown below.

Description	No. of Household		Area	
	(Number)	(%)	($\times 10^3$rai)	(%)
Owner farmer (Owned)	69,690	84.2	2,098	85.0
Tenant (Rented)	6,890	8.3	138	5.6
Partial tenant	5,110	6.2	212	8.6
Others	1,080	1.3	21	0.8
Total	82,770	100.0	2,469	100.0

Average size of owner farmer is about 30 rai, while that of tenant is only about 20 rai. Partial tenants operate fairly large land of about 41 rai on an average. The following table shows average size of land holding classified into land ownership in the province and districts concerned with the project.

Description	Phetchabun Province (rai)	Phetchabun District (rai)	Lom Sak District (rai)
Owner farmer	30.1	28.0	21.0
Tenant	41.4	38.6	21.0
Partial tenant	20.0	18.3	8.6
Average size	29.9	28.5	20.5

The average farm size in the Phetchabun province increased substantially from about 19 rai in 1963 to about 30 rai in 1978 mainly due to rapid expansion of paddy land developed and uplands reclaimed from the forest. The following table shows the average farm size in the Phetchabun province in both 1963 and 1978, based on the Agricultural Census.

1963					1978				
Size of Farm Land (rai)	No. of Farm (10^3)	(%)	Area of Farm (10^3rai)	(%)	Size of Farm Land (rai)	No. of Farm (10^3)	(%)	Area of Farm (10^3rai)	(%)
					Under 2	0.9	1.1	0.2	0
2 - 6	7.2	15.5	27.1	3.1	2 - 6	5.8	7.0	22.4	0.9
6 - 15	17.1	36.7	165.9	18.8	6 - 15	17.3	20.7	172.2	7.0
15 - 30	13.9	29.8	283.1	32.0	15 - 30	26.7	32.0	553.3	22.4
30 - 45	5.0	10.7	172.6	19.5	30 - 50	19.3	23.1	694.7	28.1
45 - 60	2.0	4.3	99.7	11.3	50 - 60	4.9	5.9	253.7	10.3
60 -140	1.3	2.8	103.6	11.7	60 -140	7.8	9.4	618.9	25.1
Over 140	0.1	0.2	31.7	3.6	Over 140	0.7	0.8	154.0	6.2
Total	46.6	100.0	883.7	100.0	Total	83.4	100.0	2,469.4	100.0

The above table shows that approximately 76% of formers are within the range from 6 to 50 rai of land holding which is rather even distribution of land. About 10% of large holding farmers, however, occupy still about 30% of farm land in 1978.

5.1.6 Agro-Economic Situation in Districts and Townships

Four irrigation project areas fall on the following administrative units.

Project Area	Province	District	Township	Access to Municipality
Huai Saduang Yai	Phetchabun	Lom Sak	Tha Ibun	Far (15 km)
Huai Khon Kaen	Phetchabun	Lom Sak	Huai Rai	Far (13 km)
			Ban Tiew	Moderate
			Ban Sok	Moderate
			Pak Chong	Far (15 km)
Huai Yai	Phetchabun	Phetchabun	Huai Yai	Far (17 km)
			Ban Khok	Moderate
			Don Mullek	Moderate
			Sa Diang	Near (2 km)
Khlong Chaliang Lab	Phetchabun	Phetchabun	Na Pa	Moderate

The condition of the existing roads linking to municipality of Phetchabun and Lom Sak is generally fair being available for vans loaded with passengers or commodities, but some parts of roads are severely damaged by inundation.

Remote townships from the municipality suffer from low population density. Area of holding by farm is large but ratio of paddy fields in the holding is small as the case of townships i.e. Tha Ibun, Huai Rai, Pak Chong and Huai Yai as shown in Table 5.3. On the other hand, townships located less remote (moderate) suffer from dense population and hence, smaller holding, ratio of paddy field in the holding being greater. Townships Ban Tiew, Ban Sok, Ban Kok and Don Mullek fall in this case as shown also in Table 5.3. The case for Sa Diang township is rather simple. It is located near Phetchabun municipality. For this township to be relieved from heavy nutritional burden, agriculture should be labour-intensive or technically-advanced.

The nutritional density which is one of the socio-economic indicators in the area is estimated dividing population by paddy field as shown below.

Township	Population (person)	Paddy Field (rai)	Nutritional Density (person/rai)
Lom Sak District	138,255	134,366	1.03
Tha Ibun	7,797	9,133	0.85
Huai Rai	7,532	6,250	1.21
Ban Tiew	5,943	4,800	1.24
Ban Sok	6,505	7,714	0.84
Pak Chong	6,170	6,580	0.94
Phetchabun District	153,884	178,589	0.86
Huai Yai	6,526	8,612	0.76
Ban Khok	10,285	13,075	0.79
Don Mullek	5,596	14,374	0.39
Sa Diang	14,517	6,572	2.21
Na Pa	9,710	13,824	0.70

5.2 AGRICULTURAL DEVELOPMENT PLAN

5.2.1 Basic Concept for Agricultural Development

The Fifth National Economic and Social Development Plan (1982 - 1986) is now being drawn up by the National Economic and Social Development Board (NESDB). In the past two decades, the country experienced rapid growth, about 7 percent per year. But this growth resulted in gross distortions and related problems in the economy. Although agriculture has been responsible for 60 percent of export income and 75 percent of national employment, the countryside was neglected, agricultural land became scarce as population grew and agricultural productivity fell.

The Fifth Plan aims at a more balanced development, less production in industry and less concentration in urban areas to alleviate ill effects to rural proverty. The Government has identified 214 districts in 37 Provinces as absolute proverty area, in which rural development will get top priority. The Government commits to give small-scale farmers better credit facilities, guaranteed prices, irrigation works, reservoirs, electricity, better seeds and fertilizers. The aim is to raize agricultural productivity by 4.5% annually over the next 5 years.

In conformity with the objectives of the National Economic and Social Development, the Government mainly aims at amendment of disparity in incomes and attainment of people's public peace with the implementation of the irrigation project. To attain the major objectives, the project would be purposed to extend the stabilized irrigated agriculture through exploitation of new water resources in tributaries. The basic concepts for agricultural development of the project are described as follows.

(1) Unit yield of wet season paddy would be increased through proper supplemental irrigation throughout wet season and introduction of improved technology of irrigation agriculture,

(2) Total planted area of wet season paddy would be stabilized with stable water supply from newly exploited water sources,

(3) The project must play a leading role for improvement of the living standards of extended rural population. In this context, extensive agriculture would be basically oriented as far as the economic feasibility of the project would be sustainable, and

(4) Special attention would be paid to crop diversification in comformity with the Governmental policy.

5.2.2 Recommendable Cropping Pattern

Supply of exploited irrigation water leads to increase of cropping intensity and/or change of crops and cropping calendar. The following principles would be applied for layout of cropping pattern.

(1) The cropping pattern must conform with the concept of the national development plan,

(2) The cropping pattern must meet social tradition in and around the area and must be acceptable by farmers,

(3) The cropping pattern must be of low-intensity as possible to use the limited exploited water resources in the extended area, and

(4) The cropping pattern must be practical with limited farm labour and farm machinery.

On the basis of the above principles, paddy in wet season and beans in dry season would be recommended for the respective project areas. Dry season paddy is not proposed because it requires large water requirement, about 2 times of that of beans. In determining the optimum crop intensity, the comparative study is made in due consideration of exploitable water resources in the respective project areas. The explanation of this study is given in ANNEX VI and the result shows that the optimum crop intensity would be 135 percent for the Lom Sak area and 125 percent in the Phetchabun area, respectively.

The recommendable cropping pattern is determined as follows based on the above descriptions and is illustrated together with agro-climatic data in Fig. 5.2.

Description	Lom Sak Area	Phetchabun Area
Wet season		
Paddy		
Local variety	50%	50%
High yield variety	50	50
Dry season		
Beans	35	25
Crop Intensity	135%	125%

Note: Lom Sak Area - Huai Saduang Yai and Huai Khon Kaen Project area

Phetchabun Area - Huai Yai and Khlong Chaliang Lab Project area

Nursery for local variety of paddy is seeded in the beginning of May. Transplanting starts in the middle of June and lasts until the end of July. Hurvesting commences in the middle of October and ends by the end of November when the dry season starts in the project area.

For high yielding variety, nursery is seeded in the beginning of June. Transplanting starts in the middle of July and lasts until the end of August. Harvesting is made in the same harvesting period of the local variety.

After the wet season paddy is harvested at the onset of the dry season, upland crops such as mungbean, soybean, groundnut, etc. are sown in the middle of January on 35 percent of total paddy field in case of Huai Saduang Yai and Huai Khon Kaen area, and 25 percent of total paddy field in Huai Yai and Khlong Chaliang Lab area, and harvested by the end of April. The remaining 65 percent and 75 percent of paddy field in the respective areas are laid fallow throughout dry season owing to the limited water resources. The cultivation area for the dry season crops would be shifted in each project area by annual rotation.

In each project area, there is no constraints for germination of seeds of paddy and upland crops throughout year, blessed with relatively constant high temperature and high humidity. In the recommendable cropping pattern, the harvest season of paddy is laid out in the beginning of dry season so as to smoothly operate the harvesting and processing of paddy.

5.2.3 Anticipated Crop Yield and Production

The present crop yields in the project areas are not so high with wide fluctuation year by year due to unstable irrigation water supply and unexpected damages caused by flood, insect and diseases. After completion of the project, the crop yields would be stabilized and increased through stable supply of irrigation water, improvement of irrigation practices and further expansion of agricultural support services.

The anticipated crop yields of paddy and beans recommended for the project are estimated in due consideration of the existing irrigation projects/1 in the area and similar irrigation projects in Thailand.

Crop	Without Project		With Project	
Paddy	kg/rai	(t/ha)	kg/rai	(t/ha)
Local variety	434	(2.70)	640	(4.00)
High yield variety	640	(4.00)	800	(5.00)
Beans	160	(1.00)	320	(2.00)

Based on the above crop yields, the following annual crop productions at the full development stage are expected for each project area.

/1: According to the questionaire results for the farmers in the Sri Chan and Pasak Left Bank Irrigation Project areas, the present yield of paddy (local variety) is judged to be 650 - 700 kg/rai.

(1) Huai Saduang Yai Project

Crop	Cropping Area (ha)	Crop Production (ton)
Paddy		
Local variety	3,000	12,000
High yield variety	3,000	15,000
Beans	2,100	4,200

(2) Huai Khon Kaen Project

Crop	Cropping Area (ha)	Crop Production (ton)
Paddy		
Local variety	2,200	8,800
High yield variety	2,200	11,000
Beans	1,540	3,080

(3) Huai Yai Project

Crop	Cropping Area (ha)	Crop Production (ton)
Paddy		
Local variety	750	3,000
High yield variety	750	3,750
Beans	375	750

(4) Khlong Chaliang Lab Project

Crop	Cropping Area (ha)	Crop Production (ton)
Paddy		
Local variety	115	460
High yield variety	115	575
Beans	58	116

5.2.4 Price Forecast

Surplus paddy to be produced in the project areas after the completion of the project would be partly marketed to domestic markets and be mostly exported to foreign countries in shortage of food. Therefore, future economic price of paddy would be forecasted on the basis of the "Price Prospects for Major Primary Commodities" published by IBRD. The economic farmgate price of paddy is estimated at Baht 7,700 (US$350) per ton for high yield variety in 1990 level. Future economic price of local variety is assumed to be about 5 percent cheaper than that of high yield variety.

The increased production of upland crops to be produced in the project areas would be locally marketed and consumed. Market prices of major upland crops have recently shooted up year by year. But no sufficient data are available for the forecast of future economic prices of respective upland crops. Therefore, the future economic price of beans, as well as that of paddy, would be forecast on the basis of the price prospects by IBRD and estimated at Baht 11,000 (US$500) per ton in 1990 level.

5.2.5 Net Production Value Without and With Project

The net crop production value is estimated based on the forecast prices of crops and production costs. The unit net production values for paddy and beans are calculated as shown in Table 5.4 and summarized as follows.

Crop	Unit Net Production Value			
	Without Project		With Project	
Paddy	kg/rai	($/ha)	kg/rai	($/ha)
Local variety	2,351	(668)	3,726	(1,059)
High yield variety	4,008	(1,139)	5,010	(1,423)
Beans	1,230	(349)	2,880	(818)

Table 5.1 Land Use in Phetchabun Province in 1971 and 1977

Description	1971			1977		
	(x10^{3}rai)	%	%	(x10^{3}rai)	%	%
Total Land	6,978.7	(100.0)		6,978.7	(100.0)	
Total Area of Holding	2,045.2	(29.3)	(100.0%)	2,857.6	(40.9)	(100.0)
Homestead	127.3		(6.2)	40.6		(1.4)
Paddy Field	760.2		(37.2)	1,410.0		(49.6)
Upland Crop Area	1,058.1		(51.7)	1,274.9		(44.6)
Tree Area	70.7		(3.5)	54.1		(1.8)
Vegetable Area	8.9		(0.4)	27.3		(0.9)
Wood Land	2.1		(0.1)			
Idle Land				37.7		(1.3)
Grass Land				7.6		(0.3)
Others	17.7		(0.9)	5.2		(0.2)
Forest				1,537.5	(22.0)	
Unspecified	4,933.5	(70.7)		2,583.7	(37.0)	

Source: Statistical Report of Changwat Phetchabun, 1972 and 1980.

Table 5.2 Crop Production in Phetchabun Province

Year	Item	Crop: Paddy	Maize	Mungbean	Soybean
1971/72	Planted Area (1,000 rai)	648	468	107	23
	Production (1,000 ton)	264	161	21	5
1972/73	Planted Area (1,000 rai)	519	1,196	19	12
	Production (1,000 ton)	262	333	2	1
1973/74	Planted Area (1,000 rai)	608	800	147	64
	Production (1,000 ton)	267	400	17	11
1974/75	Planted Area (1,000 rai)	516	1,220	178	96
	Production (1,000 ton)	228	520	28	17
1975/76	Planted Area (1,000 rai)	1,111	1,669	180	29
	Production (1,000 ton)	513	686	18	5
1976/77	Planted Area (1,000 rai)	765	1,161	322	25
	Production (1,000 ton)	327	512	29	4
1977/78	Planted Area (1,000 rai)	835	1,428	529	188
	Production (1,000 ton)	272	458	41	18
1978/79	Planted Area (1,000 rai)	1,244	1,608	682	192
	Production (1,000 ton)	531	651	62	33
1979/80	Planted Area (1,000 rai)	804	1,658	641	77
	Production (1,000 ton)	265	628	60	10
Average	Planted Area (1,000 rai)	783	1,245	312	78
	Production (1,000 ton)	325	483	31	12

Source: Agricultural Statistics of Thailand

Table 5.3 Socio-Economic Indicators by Township

Township	1 Population Density (Person/km^2)	2 No. of Holding (Nos.)	3 Area of Holding (x10^{3}Rai)	4 Paddy Field (x10^{3}Rai)	5 3 / 2 (Rai/No.)	6 4 / 2 (Rai/No.)
Lom Sak District	78	16,230	1,135.0	134.4	69.9	8.3
Tha Ibun	70	915	69.4	9.1	75.8	9.9
Huai Rai	134	1,058	35.0	6.3	33.1	6.0
Ban Tiew	212	980	17.5	4.8	17.9	4.9
Ban Sok	325	876	12.5	7.7	14.3	8.8
Pak Chong	27	872	141.3	6.6	162.0	7.6
Phetchabun District	60	25,213	1,608.8	178.6	63.8	7.1
Huai Yai	17	1,221	230.6	8.6	188.9	7.0
Ban Khok	141	1,698	45.6	13.1	26.9	7.7
Don Mullek	112	1,269	31.3	14.4	24.7	11.3
Sa Diang	549	746	16.5	6.6	22.1	8.8
Na Pa	71	1,393	85.6	13.8	61.5	9.9

Source: Township Statistics, 1980, 1981

Table 5.4 Unit Net Crop Production Value

Description		Without Project			With Project		
		Paddy L.C	Paddy H.Y.V	Beans	Paddy L.C	Paddy H.Y.V	Beans
1 Yield	(kg/rai)	434	640	160	640	800	320
2 Price	(฿/t)	7,260	7,700	11,000	7,260	7,700	11,000
3 Production Value 1 x 2	(฿/rai)	3,151	4,928	1,760	4,646	6,160	3,520
4 Variable Cost	(฿/rai)	710	800	460	800	950	520
Homed Labor	(฿/rai)	300	350	230	350	400	300
Hired Labor	(฿/rai)	300	250	130	250	150	0
Materials	(฿/rai)	100	150	90	150	300	150
Repairs & Others	(฿/rai)	10	50	10	50	100	70
5 Fixed Cost	(฿/rai)	90	120	70	120	200	120
6 Production Cost 4 + 5	(฿/rai)	800	920	530	920	1,150	640
7 Net Production Value 3 - 6	(฿/rai)	2,351	4,008	1,230	3,726	5,010	2,880

Note: L.C = Local Variety
H.Y.V = High Yield Variety

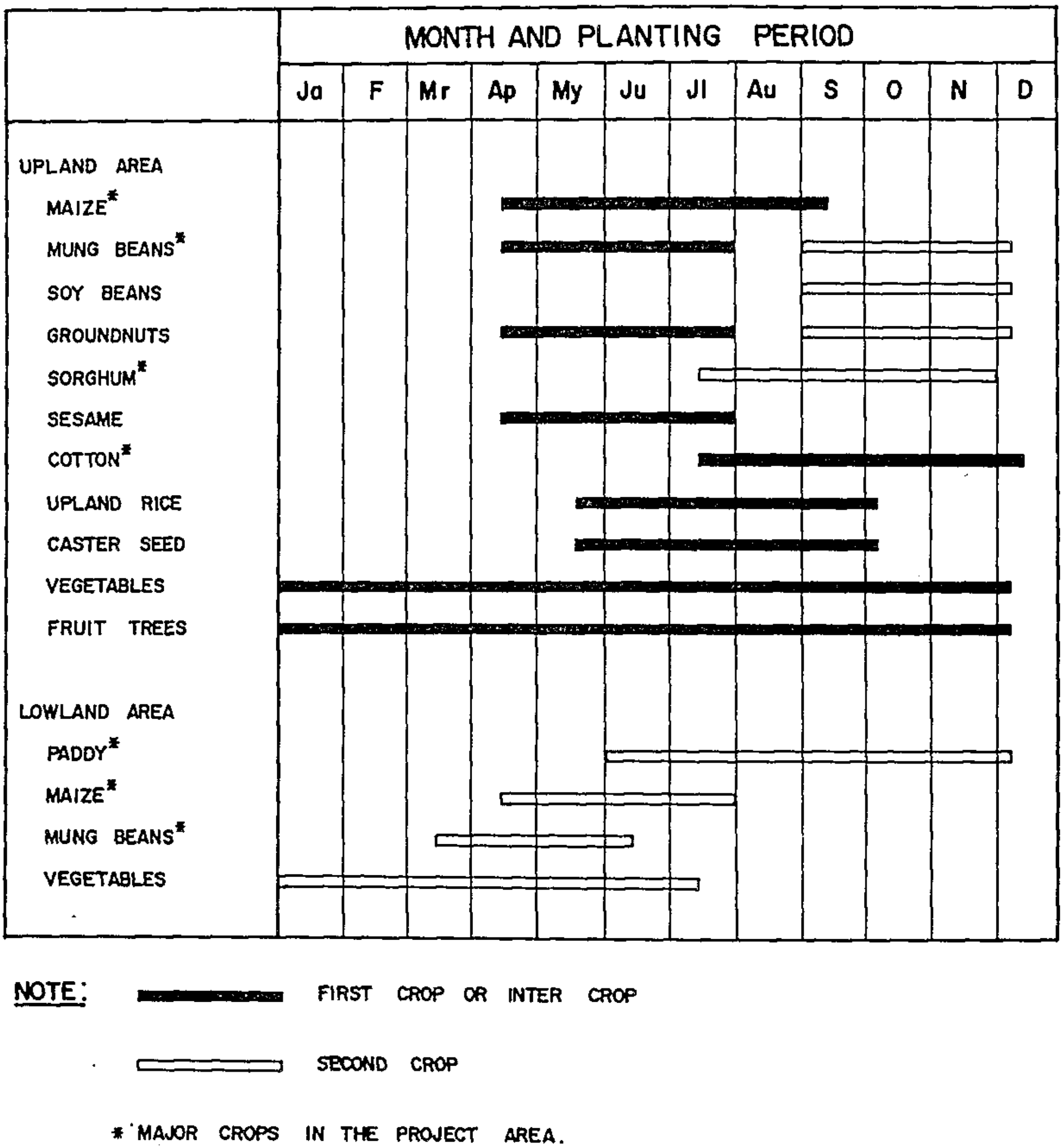

Fig. 5.1 PRESENT CROPPING CALENDAR

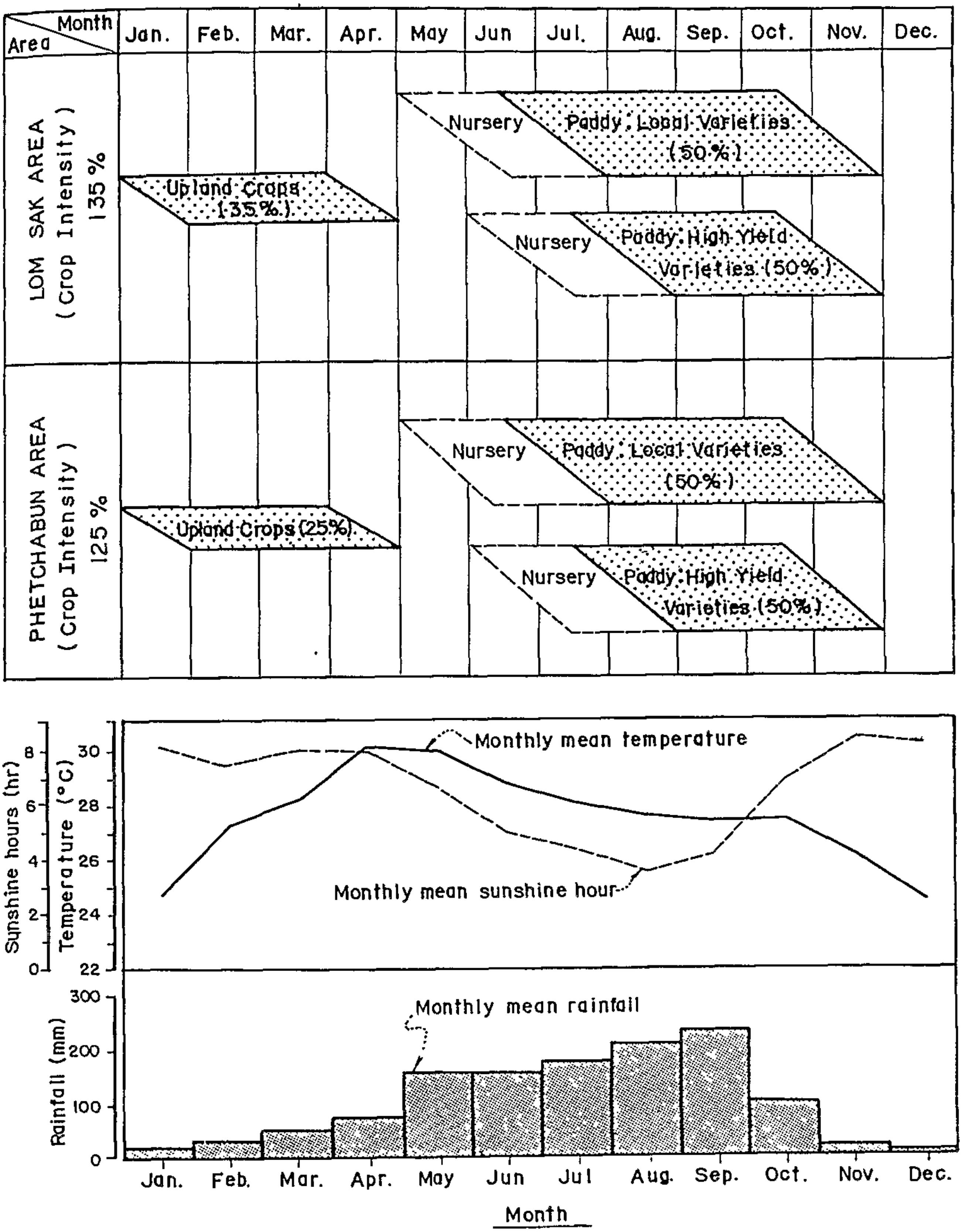

Fig. 5.2 RECOMMENDABLE CROPPING PATTERN

ANNEX VI

IRRIGATION

ANNEX VI IRRIGATION

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6.1 PRESENT CONDITION OF IRRIGATION SYSTEM

6.1.1 Existing Irrigation Projects

Irrigation development in the Upper Pasak river valley is relatively low. Only four small and medium scale irrigation projects have been implemented so far by the Central Government in the valley. The location of these project areas is shown in Fig. 6.1 and the general descriptions for these projects are given as shown below.

(1) Pasak Left Bank Irrigation Project

The Pasak Left Bank irrigation project area of 31,460 rai (5,030 ha) is located eastward the Lom Sak municipality and slenderly extends north to south along the left bank of the Pasak river. The major facilities of the project comprise a diversion weir constructed across the main stream of the Pasak river, and main and lateral irrigation canal system. The capacity of main canal at the head regulator is designed to be about 5.4 m^3/sec and the canal density is to be about 11.7 m/ha. The greater portion of the canal system is still unlined. The irrigation system of this project is presented in Table 6.1 and Fig. 6.2, schematically. This project was completed in 1969. The irrigation water supply for the whole commanding area of 31,460 rai (5,030 ha) is basically limited with the wet season. During the dry season, the project can irrigate only the area of 5,000 rai (800 ha) because of the depleted flow in the Pasak river. According to the operation records at the diversion weir site, about 24 MCM of irrigation water have been annually diverted into the commanding area on 20% recurrence drought.

(2) Huai Pa Daeng Irrigation Project

The Huai Pa Daeng irrigation project area is located at about 15 km westward the Phetchabun municipality. This project serves about 13,560 rai (2,170 ha) during only wet season and supplements the potable, domestic and industrial water supplies of the Phetchabun municipality. A medium scale reservoir of about 18.7 MCM has been created by constructing earthfill dam for the stable irrigation and municipal water supplies. Main and lateral canal system is networked to irrigate the service area and to convey the municipal water with the canal density of about 16.4 m/ha as shown in Table 6.2 and Fig. 6.3. The project was constructed in 1977 and since then, it has been operated for four years.

(3) Sri Chan Irrigation Project

The Sri Chan irrigation project area is located at about 10 km northeast the Lom Sak municipality. The area of about 6,000 rai (960 ha) extends north to south along the right bank of the Pasak river. The primitive Sri Chan intake weir was initially constructed with timber by farmers themselves in 1940. Since then, the weir has been periodically washed away by flooding. In response to the strong request of the beneficiary farmers, the Central Government decided to construct a perennial concrete weir in early 1981. The substantial construction works will start at the onset of dry season in 1982.

(4) Wang Bon Weir Irrigation Project

The Wang Bon Weir irrigation project area is located westward the Lom Sak municipality. The service area of about 2,000 rai (320 ha) is bounded by the National Highway Route 12 in the north and by the Chun river, a tributary of the Pasak river, in the south. The irrigation water resources of the project depends on the Chun river by constructing a timber intake weir. The weir was washed away by intensive flood in 1975. In response to the request of farmers, the weir was reconstructed by RID in 1978.

6.1.2 Existing Village Irrigation Systems

In the project area, small scale village irrigation systems have been developed depending their irrigation water resources on small tributaries of the Pasak river.

(1) Huai Khon Kaen Area

Huai Khon Kaen area is located at about nine (9) km east of the Lom Sak municipality. It is approximately bounded by the main irrigation canal of the Pasak Left Bank Irrigation Project on the west and by the Huai Nam Duk on the south. The northern and eastern boundaries are skirted with terrace lands extending along foots of eastern hilly ranges. The area extends about 15 km from north to southward and it is 2 km wide on an average. Administratively, the area comes under four townships of the Lom Sak district; i.e. Huai Rai, Ban Tiew, Ban Sok and Pak Chong.

In this area, there exist five weirs on Huai Khon Kaen. All of them are quite primitive structures constructed with local materials and washed away by periodical flooding. Existing canal system is unlined and deteriorated due to poor maintenance works. The section of canal is usually greater than that required for its commanding area. The density of the existing canal is estimated to be less than 10 m per ha. Fig. 6.4 shows the existing irrigation system of the Huai Khon Kaen area, schematically.

(2) Huai Yai Area

Huai Yai area is located at due east of the Phetchabun municipality and slenderly extends about 14 km from the west to eastward with an average width of about 2 km, astride the district road stretching out from the Phetchabun municipality to Huai Yai village. It is approximately bounded by the Huai Yai on the north, by the Huai Nam Sai on the south and by the Khlong Mai Daeng on the west. The eastern boundary is extended to the foot of eastern hill. Administratively, the area comes under four townships of the Phetchabun district; i.e. Huai Yai, Ban Khok, Dong Moon Laek, and Sadiang.

There exist five intake weirs and two diversion structures on the Huai Yai. Most of them have been constructed with concrete by the district office concerned and relatively better maintained. The existing canals aligned in the area are almost unlined and much deteriorated. The existing irrigation system of this area is shown schematically in Fig. 6.5.

(3) Khlong Chaliang Lab Area

Khlong Chaliang Lab area is located at southeast of the Phetchabun municipality. In parallel with the Huai Yai area, it slenderly extends about 10 km from east to westward with an average width of 2 km, astride the district road aligned between the Phetchabun municipality and the Chaliang Lab village. It is approximately bounded by Khlong Chaliang Lab on the north, by low terrace land extending on the south and by the Khlong Kung on the west. The eastern boundary is extended to the foot of eastern hill. Administratively, the area belongs to Na Pa township of the Phetchabun district.

In the area, there exist six intake weirs on the Khlong Chaliang Lab for irrigation water supply. Most of them have been perennially constructed with concrete by the district office. The existing canals are almost unlined and deteriorated due to poor maintenance works. The canal density is estimated to be less than 10 m per ha, it is too low to better manage irrigation water. Fig. 6.6 shows the existing irrigation system of the Khlong Chaliang Lab area, schematically.

6.2 IRRIGATION DEVELOPMENT PLAN

6.2.1 Available Irrigation Water Resources

The irrigation water resources of four projects would be dependent on four tributaries of the Pasak river, i.e. Huai Saduang Yai, Huai Khon Kaen, Huai Yai and Khlong Chaliang Lab. The water resources endowed in each tributary would be exploited by construction of the storage dam. The annual runoff and exploitable water resources at the proposed dam sites are assessed as listed below in view of hydrology, topography, and dam engineering.

Tributary	Catchment Area (km^2)	Annual/1 Runoff (MCM)	Useful Storage Capacity (MCM)
Huai Saduang Yai	96	21.16	14.04
Huai Khon Kaen	322	70.96	24.78
Huai Yai	78	19.14	7.12
Khlong Chaliang Lab	77	18.90	1.53

/1: 20% recurrence of droughty year

6.2.2 Irrigation Water Requirement

The calculation on irrigation water requirement is made by monthly basis, based on the meteorological records and the recommendable cropping patterns.

(1) Meteorological Data

Meteorological data of Phetchabun station are available for the estimate of potential evapotranspiration. The average for 25 years from 1951 to 1975 are given below:

(i) Mean Monthly Air Temperature (t)

(°C)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
24.7	27.3	38.2	30.9	29.8	28.7	28.0	27.5	27.4	27.4	26.1	24.5

(ii) Mean Monthly Relative Humidity (Hm)

(%)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
62.0	60.0	60.0	62.0	72.0	78.0	81.0	83.0	84.0	78.0	71.0	64.0

(iii) Mean Monthly Sunshine Duration (n)

(hr/day)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
8.00	7.44	7.99	7.92	6.62	4.98	4.28	3.45	4.22	6.89	8.54	8.24

(iv) Mean Monthly Wind Velocity (U_2)

(miles/day)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
75.1	73.0	85.5	95.9	87.6	91.7	91.7	87.6	66.7	77.1	85.5	85.5

(v) Mean Monthly Pan Evaporation

(mm/month)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
137	149	199	219	172	160	130	122	113	138	134	135

(2) Potential Evapotranspiration (ETp)

Potential evapotranspiration is estimated by the following two empirical formulas and the estimated values are cross-checked by observed pan evaporation records.

(i) Penman Method

The Penman method is as follows;

$$ETp = \frac{\Delta \cdot H + 0.27 \cdot Ea}{\Delta + 0.27}$$

$$H = (1 - r) \cdot Rs - \sigma \cdot Ta^4 \cdot (0.56 - 0.092\sqrt{ed}) \cdot (0.10 + 0.90 \cdot \frac{n}{N})$$

$$Ea = 0.35 \cdot (ea - ed) \cdot (1 + 0.0098 \cdot U_2)$$

where,

ETp	:	Potential evapotranspiration (mm/day)
H	:	Daily heat budget (mmH_2O/day)
Rs	:	Solar radiation (mmH_2O/day) $Rs = Ra \cdot (a + b \cdot \frac{n}{N})$
a, b	:	Experimentally determined constants a = 0.10, b = 0.7 (See Table 6.3)
Ra	:	Extra terrestrial radiation (mmH_2O/day) (See Table 6.4)
n	:	Sunshine hours (hr/day)
N	:	Maximum possible sunshine hours (hr/day) (See Table 6.5)
r	:	Reflection coefficient r = 0.25 (See Table 6.6)
$\sigma \cdot Ta^4$	:	Radiation from field surface (mmH_2O/day) (See Table 6.7)
σ	:	Stefan constant
Ta	:	Temperature (°AbS)
Ea	:	Evaporation (mmH_2O/day)
ea	:	Saturation vapor pressure (mmHg) (See Fig. 6.7)
ed	:	Actual vapor pressure (mmHg) ed = ea x Hm
Hm	:	Relative humidity (%)
U_2	:	Wind velocity (miles/day)
Δ	:	Slope of saturation vapor pressure (See Fig. 6.8) $\frac{d\ ea}{d\ T}$

The calculation process is shown in Table 6.8.

(ii) Radiation Method

The radiation method is as follows;

$$ETp = C \ (W \cdot Rs)$$

where,

ETp	: Potential evapotranspiration (mm/day) (See Fig. 6.9)
Rs	: Solar radiation (mmH_2O/day) $Rs = Ra \ (a + b \cdot \frac{n}{N})$
Ra	: Extra terrestrial radiation (See Table 6.4)
a, b	: Experimentally determined constants (See Table 6.3) a = 0.10, b = 0.70
n	: Sunshine hours (hr/day)
N	: Maximum possible sunshine hours (hr/day) (See Table 6.5)
W	: Weighting factor which depends on temperature and altitude (See Table 6.9)
C	: Adjustment factor which depends on mean humidity, Hm (%) and day-time wind velocity, U_2 day time (m/sec)
Hm	: Relative humidity (%)
U_2 day-time	: Daytime wind velocity at 2 m above the field (m/sec) U_2 day-time = $K \cdot U_2$
U_2	: Wind velocity at 2 m above the field (m/sec)
K	: Correction factor to obtain U_2 day-time (See Table 6.10)

The calculation sheet is given in Table 6.11.

(iii) Calculation Results

Potential evapotranspiration is calculated by the above two empirical formulas as tabulated below and illusted in Fig. 6.10.

Potential Evapotranspiration

Method	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Penman (mm/day)	3.6	3.7	5.2	5.6	5.5	3.8	3.3	2.8	3.0	3.9	4.0	3.6	
Radia-tion (mm/day)	4.2	4.5	5.2	5.5	4.2	3.4	3.0	2.7	2.7	4.1	4.4	4.2	
Average (mm/day)	3.9	4.1	5.2	5.6	4.9	3.6	3.2	2.8	2.9	4.0	4.2	3.9	
Average (mm/month)	121	115	161	168	152	108	99	87	87	124	126	121	(1,469) mm/year

(iv) Cross-Check by Observed Pan Evaporation

The averaged potential evapotranspiration of the above two formulas and the recorded pan evaporation are compared, as shown in Fig. 6.11.

To relate pan evaporation to potential evapotranspiration, 80% of coefficient is given, taking account climate and environmental conditions around the evaporation pan.

Converted from Observed Pan Evaporation

(mm/month)

Location	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Observed Ep	137	149	199	219	172	160	130	122	113	138	134	135	(1,808) mm/year
Esti-mated ETp	110	120	159	175	138	128	104	98	90	110	107	108	(1,447) mm/year

Comparing the derived values from the two empirical formulas with the recorded pan evaporation, the averaged potential evapotranspiration derived from Penman and Radiation is applicable to the project.

(3) Crop Coefficient (Kc)

The crop coefficient (Kc) is estimated as shown below, based on the "Actual Measurements by Irrigated Agriculture Section, RID".

Estimated Crop Coefficient

Crops	Month 1st	2nd	3rd	4th	5th
Local Varieties	1.0	1.13	1.32	1.26	1.1
High Yield Varieties	1.05	1.33	1.32	1.13	
Upland Crops	0.44	0.92	0.72	0.62	

The crop coefficient based on the actual measurements by Irrigated Agriculture Section of RID in 1979 is shown as follows.

Crops	Month 1st	2nd	3rd	4th	5th	6th	7th
Local Varieties	1.0	1.0	1.2	1.35	1.3	1.21	1.1
High Yield Varieties	1.0	1.25	1.35	1.3	1.1		
Upland Crops	0.4	0.7	1.0	0.8	0.5		

(4) Consumptive Use (Cu)

The consumptive use (Cu) is calculated by the following formula.

$$Cu = Kc \cdot ETp$$

where,

Cu : Consumptive use

Kc : Crop coefficient

ETp : Potential evapotranspiration

(5) Percolation (P)

The percolation loss of 1.0 mm/day is incorporated in the calculation of the irrigation water requirement, in due consideration of textural profiles of representative soil extending in the project area.

(6) Effective Rainfall (Re)

The effective rainfall is estimated by "Effective Rainfall Chart" authorized by RID as shown in Fig. 6.12 and rainfall records in Lom Sak and Phetchabun stations.

Table 6.12 shows the estimated effective rainfalls with the frequency of 20% of droughty year in Lom Sak area and Phetchabun area.

(7) Farm Water Requirement (Fw)

Paddy

The farm water requirement (Fw) for paddy is expressed by the following formula.

$$Fw = Wp + (Wn + Wd)$$

where,

Fw : Farm water requirement for paddy field

Wp : Water requirement for main paddy field after transplanting

Wn : Nursery water requirement

Wd : Puddling water requirement

The water requirement for main paddy field (Wp) is expressed by the following formula.

$$Wp = (Cu + Pc - Re) \times Ic$$

where,

Wp : Water requirement for main paddy field

Cu : Consumptive use for paddy

Pc : Percolation loss in paddy field

Re : Effective rainfall for paddy

Ic : Crop intensity

The nursery water requirement (Wn) is given by the following formula.

$$Wn = Sn + Pwn$$

$$Sn = (1.5 \cdot n \cdot d - Re) \times \frac{Au}{20}$$

$$Pwn = (Pw - Re) \times \frac{Au}{20}$$

where,

- Wn : Nursery water requirement
- d : Potential evapotranspiration (ETp) + Percolation loss (P)
- Re : Effective rainfall
- $\frac{Au}{20}$: Ratio of transplanting area to total paddy field area
- Pw : Puddling water

The puddling water requirement (Wd) is presented by the following formula.

$$Wd = (Pw - Re) \times Ap$$

where,

- Wd : Puddling water requirement
- Pw : Puddling water (150 mm)
- Re : Effective rainfall
- Ap : Ratio of puddling area

<u>Upland Crops</u>

The farm water requirement (Fw) for upland crops is presented by the following formula.

$$Fw = (Cu - Re) \times Ic$$

where,

- Fw : Farm water requirement for upland crops
- Re : Effective rainfall
- Ic : Crop intensity

(8) Irrigation Efficiency (E)

The irrigation efficiency (E) is usually defined as follows.

$$E = \frac{Ea}{100} \times \frac{Eco}{100} \times 100 \ (\%)$$

where,

Ea : Water application efficiency (%)

Eco : Water conveyance & operation efficiency (%)

The applied irrigation efficiency is shown in the following table.

Applied Irrigation Efficiency

Crop	Ea (%)	Eco (%)	E (%)
Paddy	70	80	56
Upland Crop	60	80	58

(9) Diversion Water Requirement (Dw)

The diversion water requirement is calculated by the following formula.

$$Dw = Fw \times \frac{100}{E}$$

where,

Dw : Diversion water requirement

Fw : Farm water requirement

E : Irrigation efficiency

The calculations are shown in Table 6.13 to 6.22, and summarized in Table 6.23 on the basis of the recommendable cropping patterns as shown in Fig. 5.2, Annex-V.

6.2.3 Alternative Study of Crop Intensity

In order to determine the optimal irrigable area, the alternative study for the crop intensity is made based on the exploitable water resources assessed in view of hydrology, topography and dam engineering.

From the calculation result of the unit irrigation water requirement based on the recommendable cropping pattern mentioned in the previous section, the water requirements for the various crop intensities such as 100%, 125%, 150%, 175% and 200% are estimated as shown in Table 6.24 (1) and (2).

The relation between the crop intensity and the irrigable area is summarized as follows and the calculation sheets are given in Table 6.25 (1) to (15).

Name of Project Area	Crop Intensity				
	100%	125%	150%	175%	200%
	ha	ha	ha	ha	ha
Huai Khon Kaen	6,100	4,600	3,400	2,700	2,200
Huai Yai	2,100	1,400	1,000	800	650
Khlong Chaliang Lab	350	230	150	100	80

Note: 1) Cropping Pattern

Wet season - paddy 100%
Dry season - Bean 0 - 100%

2) The Huai Saduang Yai Project area is excluded from this study since the available water in the storage dam will be used supplementary for the Sri Chan and the Pasak Left Bank Irrigation Project areas.

Using the above relation between the crop intensity and the irrigable area, the economic study is roughly made on the following assumptions to select the optimum crop intensity in each area;

(i) Economic construction cost

80% of estimated construction cost

(ii) Crop yield

Crop	without project t/ha	with project t/ha
Paddy; Local variety	3.0	4.0
High yield variety	-	4.5
Bean	1.0	2.0
Maize	2.0	-

(iii) Economic price of crop

	$/ton
Paddy; Local variety	320
High yield variety	350
Bean	600
Maize	200

(iv) Net economic return

Without project	70% of value of output
With project	80% of value of output

(v) Project life

50 years after completion of construction works

The calculation processes for the estimation of the Benefit-Cost ratio (B/C) are shown in Table 6.26 to 6.28, and the result is summarized as shown below and graphed in Fig. 6.14.

Description	Crop Intensity				
	100%	125%	150%	175%	200%
1. Huai Khon Kaen					
(i) Irrigable Area (ha)	6,100	4,600	3,400	2,700	2,200
(ii) Economic Cost ($x10^3$$)	24,246	22,369	20,865	19,988	19,361
(iii) Economic Benefit ($x10^3$$)	36,610	36,937	33,705	30,971	28,595
(iv) B/C (i = 8%)	1.51	1.65	1.62	1.55	1.48
2. Huay Yai					
(i) Irrigable Area (ha)	2,100	1,400	1,000	800	650
(ii) Economic Cost ($x10^3$$)	4,259	3,802	3,533	3,394	3,295
(iii) Economic Benefit ($x10^3$$)	11,839	10,714	9,751	9,334	8,909
(iv) B/C (i = 8%)	2.78	2.82	2.76	2.75	2.70
3. Khlong Chaliang Lab					
(i) Irrigable Area (ha)	350	230	150	100	80
(ii) Economic Cost ($x10^3$$)	1,913	1,842	1,801	1,766	1,756
(iii) Economic Benefit ($x10^3$$)	1,973	1,772	1,453	1,167	1,092
(iv) B/C (i = 8%)	1,03	0.96	0.81	0.66	0.62

In determining the optimum crop intensity, the following basic concepts for agricultural development should also be considered together with the above result of the alternative study;

(1) Unit yield of wet season paddy would be increased through proper supplemental irrigation throughout wet season and introduction of improved technology of irrigated agriculture.

(2) Total planted area of wet season paddy would be stabilized with stable water supply from newly exploited water sources.

(3) The project must play a leading role for improvement of the living standards of extended rural population. In this context, extensive agriculture would be oriented as far as the economic feasibility of the project would be sustainable.

(4) Special attention would be paid to crop diversification in conformity with the Governmental policy.

Judging from the above considerations, the following crop intensities are applied to the respective project areas;

Huai Khon Kaen Area : 135%

Huai Yai Area : 125%

Khlong Chaliang Lab Area : 125%

6.2.4 Delineation of Irrigable Area

In the Lom Sak area, the demand of water resources comprises irrigation requirement, municipal water supply and downstream maintenance flow, and in the Phetchabun area, it comprises only irrigation requirement and downstream maintenance flow. The Huai Khon Kaen, Huay Yai and Khlong Chaliang Lab reservoirs would fully serve irrigation water for newly delineated area. However, the Huai Saduang Yai reservoir would supplementary supply irrigation water for the existing Sri Chan and Pasak Left Bank Irrigation Project areas, the water resources of which mainly depend on the mainstream of the Pasak river.

To estimate an optimal irrigable area, the water balance study is made as given in Annex IV on the basis of the supply and demand of water resources. The optimal irrigable area is estimated in the droughty year of 20% recurrence through the study as shown below.

River System	Supply	Exploited Water Resources (MCM)	Irrigable Area (rai)	Crop Intensity (%)
Huai Saduang Yai	Supplemental irrigation and municipal water	14.04	37,500 (6,000 ha)	135
Huai Khon Kaen	Full irrigation and municipal water	24.78	27,500 (4,400 ha)	135
Huay Yai	Full irrigation	7.12	9,380 (1,500 ha)	125
Khlong Chaliang Lab	Full irrigation	1.53	1,440 (230 ha)	125

To delineate the irrigable area specified above, the criteria on delineation are laid down as mentioned below, taking into account of the existing land use, capable land resources, etc.

Criteria-1 : Irrigable area would be delineated in the vicinity of the exploited site of water resources as far as possible.

Criteria-2 : To quickly reap the project return and to save investment, irrigable area would be delineated in the existing paddy field, in principle.

Criteria-3 : In case available water resources are allowable, delineation would be extended over existing upland and plantation area.

(1) Huai Saduang Yai Area

The lower basin of the Huai Saduang Yai reservoir is sharply undulating and mostly used for cultivation of upland crops. Land resources for irrigated agriculture are extremely limited and scattered. Therefore, against the criteria-1 mentioned above, the exploited water in the reservoir would be released in the original river channel and used in the remote area from the exploited site. The Sri Chan and Pasak Left Bank Irrigation Project areas extend over the right and left bank of the Pasak river, respectively. The both areas depend their irrigation water resources on the unstable and non-regulated natural flow of the Pasak river and are subject to habitual drought damages. Supplemental irrigation water supply is essential for both areas to practice stable irrigated agriculture. Consequently, about 37,500 rai (6,000 ha) under the both project areas would be delineated for the service area of the Huai Saduang Yai reservoir.

(2) Huai Khon Kaen Area

Land resources for irrigated agriculture are limited at the lower basin of the Huai Khon Kaen reservoir. In due consideration of reservoir planning, lands lower than 185 m contour lines would be delineated for the service area, including some extent of uplands and plantation areas. The service area would be extended to southward along the main canal of the Pasak Left Bank Irrigation Project so as to meet 27,500 rai (4,400 ha) of the irrigable area of the Huai Khon Kaen reservoir.

(3) Huai Yai Area

The exploited water resources are extremely limited compared with the land resources suitable for irrigated agriculture in the Huai Yai basin. According to the criteria-1 and -2, the irrigable area of 9,380 rai (1,500 ha) would be delineated from the upper basin to the lower basin.

(4) Khlong Chaliang Lab Area

This area also remains under similar condition to the Huai Yai area in view of the exploited water and the land resources. The same concepts contemplated for the delineation of the Huai Yai area would be also employed for the delineation of the irrigable area in the Khlong Chaliang Lab area. Only 1,440 rai (230 ha) of the irrigable area would be delineated from the upper basin in the left bank of the Khlong Chaliang Lab. Large extent of the existing paddy field is not incorporated in the irrigable area due to the shortage of the exploited water resources.

6.2.5 Proposed Irrigation System

The layout of the irrigation system is made by use of the available topographic maps of scale 1:10,000 and 1:50,000 together with site inspection in the course of the study. The proposed irrigation systems for four project areas are described as follows. With regard to the drainage systems, no technical drainage systems would be developed with the projects, since the project areas are rather steep, relatively better drained by natural creeks, and the limited water resources must be effectively used.

(1) Huai Saduang Yai Area

The storage water of the Huai Saduang Yai reservoir is proposed to be used as the supplemental supply for the Sri Chan Irrigation Project area and the Pasak Left Bank Irrigation Project area, since there are scarcely cultivable lands in the downstream of the dam due to the topographic condition.

The Sri Chan Irrigation Project area has 6,000 rai (960 ha) of irrigable area and at present, the irrigation water is supplied temporarily from the Pasak river by small pumps. In 1982, a perennial weir will be constructed by RID at about 3 km downstream from the confluence of the Pasak river and the Huai Saduang Yai.

The Pasak Left Bank Irrigation Project covering 31,460 rai (5,030 ha) of irrigable area has been operated by RID. This project was completed in 1969. The project facilities comprise an intake weir located at about 8 km downstream from the Sri Chan weir, and 59 km of the main and lateral irrigation canals.

As the existing irrigation facilities of the above two projects have been fully facilitated, no rehabilitation and/or upgrading work would be envisaged in these areas in relation to the development plan of the Huai Saduang Yai project. The crop intensity would be increased from the existing 115 percent to 135 percent as more water supply is available.

The storage water of the Huai Saduang Yai dam is released to the river and conveyed to the above two project areas through the Huai Saduang Yai and the Pasak river. No canals would be newly proposed to be constructed, since the said existing areas are fairly provided with sufficient irrigation system well maintained. The irrigation water for the Sri Chan Irrigation Project area and the Pasak Left Bank Irrigation Project area can be taken from the Pasak river involving the regulated flow of the Huai Saduang Yai dam through two intake weirs located at about 3 km and 11 km downstream from the confluence of the Pasak river and the Huai Saduang Yai, respectively. It can be distributed to the irrigable areas using the existing irrigation facilities. The irrigation plan of the Huai Saduang Yai Project is shown in Table 6.29(1) and Fig. 6.15(1).

(2) Huai Khon Kaen Area

The irrigable area of 27,500 rai (4,400 ha) is delineated with the proposed crop intensity of 135 percent comprising the existing paddy field of 15,000 rai (2,400 ha) and the existing upland and plantation area of 12,500 rai (2,000 ha). The irrigation water is obtained directly from the Huai Khon Kaen dam and conveyed to the irrigable area through two main canals, namely right main canal (RMC) and left main canal (LMC). The main canals are planned to be constructed newly at the elevated area as far as possible in order to extend the irrigable area. The total length of the main canals is 42.0 km consisting of 6.9 km of RMC and 35.1 km of LMC. The right main canal is connected to the main canal of the Pasak Left Bank Irrigation Project for supplemental supply of irrigation water to the said project area in pluvious year and municipal water supply in future.

Nine laterals and sub-laterals are aligned to distributed the irrigation water to the field from the main canals and the canal length totals 42.3 km. Out of the total length, about 70 percent or 29.5 km are proposed to be aligned along the existing canals with some improvement works. Table 6.29(2) and Fig. 6.15(2) present the proposed irrigation plan of the Huai Khon Kaen area.

(3) Huai Yai Area

The irrigable area of 9,380 rai (1,500 ha) is delineated with the proposed crop intensity of 125 percent covering the existing paddy field. The area can be supplied the irrigation water by one main canal and three laterals and sub-laterals. The main canal would be directly stretched out from the outlet structure of the Huai Yai dam. The total length is 12.3 km, of which 5.6 km is aligned along the existing canals with some improvement works.

To distribute the irrigation water from the main canal to the field, 16.3 km of canal in total are proposed as the laterals and sub-laterals, and out of them, about 42 percent or 6.8 km are newly proposed and about 58 percent or 9.5 km of the existing canals are proposed to be improved. The proposed irrigation plan of the Huai Yai area is shown in Table 6.29(3) and Fig. 6.15(3).

(4) Khlong Chaliang Lab Area

The irrigation water is obtained directly from the dam and distributed to the irrigable area of 1,440 rai (230 ha) through one main canal and two laterals. The length of main canal extends to 2.3 km comprising the new canal of 0.8 km and the existing canal of 1.5 km. The laterals total 2.8 km, of which the new canal is 0.4 km and the existing canal is 2.4 km. The existing canals are required to be improved to incorporate in the proposed irrigation system. Table 6.29(4) shows the proposed irrigation plan and Fig. 6.15(3) presents the proposed irrigation canal system of the Khlong Chaliang Lab area.

6.2.6 Preliminary Design of Irrigation Facilities

The pre-feasibility level design of the irrigation facilities is made by use of the topographic maps with the scale of 1:10,000 and 1:50,000.

Each project except for the Huai Soduang Yai Project includes the following main irrigation works;

(i) Concrete lined main irrigation canals,

(ii) Unlined lateral and sub-lateral irrigation canals, and

(iii) Structures related to main, lateral and sub-lateral irrigation canals.

The main canals are basically proposed to be lined with concrete, and the laterals and sub-laterals be unlined. All of the irrigation canals have trapezoidal cross sections with a side slope of 1:1.5. Along the banks of canals, the operation and maintenance roads are provided. The proposed typical canal sections are shown in Fig. 6.16, and the dimensions of canals in the respective areas are presented in Table 6.30 and Fig. 6.17.

In relation to the irrigation canal works, a large number of structures are required to fully function the canal system. From the viewpoint of functions, the following structures are to be provided;

(i) Structures for distribution of irrigation water
- regulator, turnout

(ii) Structures for regulation of water level
- check, drop

(iii) Structures for conveyance of irrigation water over or under road, river, stream, etc.
- siphon, aqueduct, culvert, bridge

(iv) Structures for protection of canal
- spillway, cross drain

The major structures required for each project are roughly accounted as shown in Table 6.31.

6.3 WORK QUANTITY

Based on the preliminary design of irrigation facilities described in the previous paragraph, the work quantity for each project is estimated as summarized below.

Description	Project Area		
	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
1. Main Canals			
a) New Canal Length (km)	42.0	6.7	0.8
b) Existing Canal Length (km)	0.0	5.6	1.5
c) Excavation (m^3)	149,500	24,500	3,200
d) Embankment (m^3)	141,600	23,800	3,000
e) Lining Concrete (m^3)	14,300	3,100	310
f) Laterite Pavement (m^3)	31,500	9,200	1,700
g) Land Acquisition (m^2)	714,500	148,300	22,700
2. Laterals & Sub-laterials			
a) New Canal Length (km)	12.8	6.8	0.4
b) Existing Canal Length (km)	29.5	9.5	2.4
c) Excavation (m^3)	36,500	14,900	2,100
d) Embankment (m^3)	33,200	13,100	2,000
e) Laterite Pavement (m^3)	12,700	4,900	1,600
f) Land Acquisition (m^2)	263,700	109,400	18,200
3. Canal Structures			
a) Regulator (nos.)	8	3	1
b) Turnout (nos.)	53	22	4
c) Siphon (nos.)	3	1	0
d) Culvert (nos.)	40	13	3
e) Drop (nos.)	40	31	17
f) Cross Drain (nos.)	28	5	0

Table 6.1 Irrigation System of Pasak Left Bank Irrigation Project

Name of Canal	Canal Length (km)	Canal Discharge (m^3/sec)	Irrigation Area Gross (Rai) (ha)	Irrigation Area Net ∠1 (Rai) (ha)	Remarks
MC	24.50	1.373	8,960.63 (1,433.70)	8,064.56 (1,290.33)	˙Irrigation Water Requirement 1.06 ℓ /sec/ha
1R-MC-L	12.20	1.123	7,345.51 (1,175.28)	6,610.96 (1,057.75)	˙Canal Density 11.7 m/ha
2R-MC-L	4.90	0.645	4,213.63 (674.18)	3,792.27 (606.76)	
3R-MC-L	6.00	0.732	4,786.48 (765.84)	4,307.83 (689.25)	
4R-MC-L	7.30	0.819	5,343.04 (854.89)	4,808.75 (769.40)	
1R-4R-MC-L	4.00	0.659	4,309.37 (689.50)	3,878.45 (620.55)	
Total	58.90	5.351	34,958.66 (5,593.39)	31,462.82 (5,034.04)	

Note: ∠1 Net area = Gross area x 0.9

Name of Canal	Irrigation Block	Irrigable Area (rai) Gross	Net (Gross x 0.9)
MC	1	907.50	816.75
	2	285.63	257.06
	3	259.38	233.44
	4	292.50	263.25
	5	236.25	212.63
	6	233.13	209.81
	7	194.37	174.93
	8	443.13	398.82
	9	250.00	225.00
	10	445.62	401.06
	11	320.00	288.00
	12	373.13	335.82
	13	331.25	298.13
	14	350.00	315.00
	15	406.89	366.19
	16	413.75	372.38
	17	254.38	228.94
	18	213.12	191.80
	19	180.00	162.00
	20	266.88	240.19
	21	323.12	290.81
	22	327.50	294.75
	23	274.37	246.93
	24	228.75	205.88
	25	803.75	723.37
	26	346.25	311.62
	Total	8,960.63	8,064.56

Name of Canal	Irrigation Block	Irrigable Area (rai) Gross	Net (Gross x 0.9)
1R-MC-L	1	409.38	368.44
	2	522.71	470.44
	3	778.13	700.32
	4	187.50	168.75
	5	696.88	627.19
	6	434.38	390.94
	7	701.25	631.13
	8	500.00	450.00
	9	484.38	435.94
	10	553.13	497.82
	11	168.75	151.87
	12	434.38	390.94
	13	340.63	306.57
	14	487.13	438.42
	15	646.88	582.19
	Total	7,345.51	6,610.96
2R-MC-L	1	676.06	608.45
	2	291.69	262.52
	3	841.69	757.52
	4	560.44	504.40
	5	687.50	618.75
	6	806.25	725.63
	7	350.00	315.00
	Total	4,213.63	3,792.27

Name of Canal	Irrigation Block	Irrigable Area (rai) Gross	Net (Gross x 0.9)
3R-MC-L	1	453.13	407.82
	2	644.81	580.33
	3	576.06	518.45
	4	276.06	248.45
	5	439.56	395.60
	6	244.81	220.33
	7	364.56	328.10
	8	318.75	286.88
	9	445.81	401.23
	10	293.75	264.38
	11	428.12	385.31
	12	301.06	270.95
	Total	4,786.48	4,307.83
4R-MC-L	1	273.75	246.38
	2	521.44	469.30
	3	328.94	296.05
	4	698.94	629.05
	5	414.37	372.93
	6	581.87	523.68
	7	298.12	268.31
	8	440.00	396.00
	9	243.12	218.81
	10	421.25	379.13
	11	346.87	312.18
	12	409.37	368.43
	13	365.00	328.50
	Total	5,343.04	4,808.75

Name of Canal	Irrigation Block	Irrigable Area (rai) Gross	Net (Gross x 0.9)
1R-4R-MC-L	1	643.75	579.37
	2	459.37	413.44
	3	566.25	509.63
	4	710.00	639.00
	5	851.25	766.13
	6	1,078.75	970.88
	Total	4,309.37	3,878.45
	GRAND TOTAL	34,958.66	31,462.82

Table 6.2 Irrigation System of Huai Padaeng Project

Name of Canal	Canal Length (km)	Canal Discharge (m^3/sec)	Irrigation Area Gross (rai) (ha)	Irrigation Area Net (rai)*1 (ha)	Remarks
LMC	8.80	0.501	3,133.80 (501.41)	2,507.10 (401.14)	Irrigation Water Requirement 1.25 l/sec/ha Canal Density 16.4 m/ha
1R-LMC-L	6.80	0.564	3,524.40 (563.90)	2,819.50 (451.12)	
2R-LMC-L	4.90	0.533	3,328.80 (532.61)	2,663.00 (426.08)	
RMC	5.90	0.524	3,276.25 (524.20)	2,621.00 (419.36)	
1L-RMC-L	5.90	0.354	2,213.75 (354.20)	1,771.00 (283.36)	
2L-RMC-L	3.30	0.236	1.473.13 (235.70)	1,178.50 (188.56)	
Total	35.60	2.712	16,950.13 (2,712.02)	13,560.10 (2,169.62)	

Note: *1 Net area = Gross area X 0.8

Table 6.3 Experimentally Determined Constants

$$Rs = (a + b \cdot n/N) \cdot Ra$$

Source		Location or Range of Locations	Constants a	Constants b	Latitude (°)
As listed by Linacre (1967)					
Fitzpatrick	(1965)	Kimberley, S.Africa	0.33	0.43	16 S
Cockett et al.	(1964)	Central Africa	0.32	0.47	15 S
Page	(1961)	Dakar, Senegal	0.10	0.70	15 N
Yadov	(1965)	Madras, India	0.31	0.49	13 N
Davies	(1965)	Kano, Nigeria	0.26	0.54	12 N
Smith	(1960)	Trinidad	0.27	0.49	11 N
Stanhill	(1963)	Benin City , Nigeria	0.26	0.38	7 N
		Mean	0.26	0.50	13°
Davies	(1965)	Accra, Ghana	0.30	0.37	6 N
Black et al.	(1954)	Batavia (Djakarta)	0.29	0.59	6 S
Page	(1961)	Kinshasa, Zaire	0.21	0.52	4 S
Page	(1961)	Singapore	0.21	0.48	1 N
Glover et al.	(1958b)	Kabete, Kenya	0.24	0.59	1 S
Page	(1961)	Kisangani, Zaire	0.28	0.40	1 S
Rijks et al.	(1964)	Kampala, Uganda	0.24	0.46	0
		Mean	0.25	0.49	3°

Table 6.4 Extra Terrestrial Radiation (Ra)

(mm/H20/day)

	Northern Hemisphere											
Latitude	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
20	11.2	12.7	14.4	15.6	16.3	16.4	16.3	15.9	14.8	13.3	11.6	10.7
18	11.6	13.0	14.6	15.6	16.1	16.1	16.1	15.8	14.9	13.6	12.0	11.1
16	12.0	13.3	14.7	15.6	16.0	15.9	15.9	15.7	15.0	13.9	12.4	11.6
14	12.4	13.6	14.9	15.7	15.8	15.7	15.7	15.7	15.1	14.1	12.8	12.0
12	12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5
10	13.2	14.2	15.3	15.7	15.5	15.3	15.3	15.5	15.3	14.7	13.6	12.9
8	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3
6	13.9	14.8	15.4	15.4	15.1	14.7	14.9	15.2	15.3	15.0	14.2	13.7
4	14.3	15.0	15.5	15.5	14.9	14.4	14.6	15.1	15.3	15.1	14.5	14.1
2	14.7	15.3	15.6	15.3	14.6	14.2	14.3	14.9	15.3	15.3	14.8	14.4
0	15.0	15.5	15.7	15.3	14.4	13.9	14.1	14.8	15.3	15.4	15.1	14.8

Table 6.5 Maximum Possible Sunshine Hours (N) for Different Months and Latitudes

Northern Lats	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Southern Lats	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
50°	8.5	10.1	11.8	13.8	15.4	16.3	15.9	14.5	12.7	10.8	9.1	8.1
48	8.8	10.2	11.8	13.6	15.2	16.0	15.6	14.3	12.6	10.9	9.3	8.3
46	9.1	10.4	11.9	13.5	14.9	15.7	15.4	14.2	12.6	10.9	9.5	8.7
44	9.3	10.5	11.9	13.4	14.7	15.4	15.2	14.0	12.6	11.0	9.7	8.9
42	9.4	10.6	11.9	13.4	14.6	15.2	14.9	13.9	12.6	11.1	9.8	9.1
40	9.6	10.7	11.9	13.3	14.4	15.0	14.7	13.7	12.5	11.2	10.0	9.3
35	10.1	11.0	11.9	13.1	14.0	14.5	14.3	13.5	12.4	11.3	10.3	9.8
30	10.4	11.1	12.0	12.9	13.6	14.0	13.9	13.2	12.4	11.5	10.6	10.2
25	10.7	11.3	12.0	12.7	13.3	13.7	13.5	13.0	12.3	11.6	10.9	10.6
20	11.0	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
15	11.3	11.6	12.0	12.5	12.8	13.0	12.9	12.6	12.2	11.8	11.4	11.2
10	11.6	11.8	12.0	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5
5	11.8	11.9	12.0	12.2	12.3	12.4	12.3	12.3	12.1	12.0	11.9	11.8
0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0

Table 6.6 Reflection Coefficient (r)

	Water Surface	Surface covered with Crops
r	0.05 - 0.07	0.15 - 0.25

Table 6.7 Values of σTa^4 for Various Temperatures for the Penman Method

Temperature, K (°Abs)	$\sigma \cdot Ta^4$ mm H_2O/day	Temperature, °F	$\sigma \cdot Ta^4$ mm H_2O/day
270	10.73	35	11.48
275	11.51	40	11.96
280	12.40	45	12.45
285	13.20	50	12.94
290	14.26	55	13.45
295	15.30	60	13.96
300	16.34	65	14.52
305	17.46	70	15.10
310	18.60	75	15.65
315	19.85	80	16.25
320	21.15	85	16.85
325	22.50	90	17.46
		95	18.10
		100	18.80

Table 6.8 **Calculation Sheet of Potential Evapotranspiration (ETp)**

(Penman Method)

ETp = (Δ· H + 0.27·Ea) / (Δ + 0.27)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Mean monthly temperature: t (C°)	24.7	27.3	28.2	30.9	29.8	28.7	28.0	27.5	27.4	27.4	26.1	24.5
(F°)	76.5	81.1	82.8	87.6	85.6	83.7	82.4	81.5	81.3	81.3	79.0	76.1
2. Mean monthly relative humidity: Hm	62	60	60	62	72	78	81	83	84	78	71	64
3. Sunshine rate : $\frac{n}{N}$ (= S)	0.71	0.64	0.67	0.63	0.52	0.38	0.33	0.27	0.35	0.58	0.75	0.74
4. Wind velocity: U2 (miles/day)	75.1	73.0	85.5	95.9	87.6	91.7	91.7	87.6	66.7	77.1	85.5	85.5
5. Mean monthly extra terrestrial radiation: Ra (mm H20/day)	12.0	13.3	14.7	15.6	16.0	15.9	15.9	15.7	15.0	13.9	12.4	11.6
6. Reflection coefficient: r = 0.25												
7. (1-r) = 0.75												
8. A = (a+b $\frac{n}{N}$) (= 0.1 + 0.7 X (3))	0.6	0.55	0.57	0.54	0.46	0.37	0.33	0.29	0.35	0.51	0.63	0.62
9. B = Ra(1-r) (a+b$\frac{n}{N}$) (= (5) X (7) X (8))	5.40	5.49	6.28	6.32	5.52	4.41	3.94	3.41	3.94	5.32	5.86	5.39
10. Vapor Pressure (a) Saturated, ea	23.5	27.5	29.0	34.0	32.0	30.0	29.0	27.5	27.5	27.5	25.0	23.5
(b) Actual, ed = HmXea (= (2) X (10a))	14.6	16.5	17.4	21.1	23.0	23.4	23.5	22.8	23.1	21.5	17.8	15.0
(c) $\sqrt{ed}$	3.82	4.06	4.17	4.59	4.80	4.84	4.85	4.77	4.81	4.64	4.22	3.87
11. σ Ta^4	15.8	16.3	16.6	17.2	16.9	16.7	16.5	16.4	16.4	16.4	16.1	15.8
12. (0.56 + 0.092$\sqrt{ed}$)												
13. (0.10 + 0.90$\frac{n}{N}$)												
14. I = σTa4 (0.56 - 0.092$\sqrt{ed}$) (0.10 + 0.90$\frac{n}{N}$) (= (11) X (12) X (13))	2.44	2.69	2.06	1.58	1.14	0.85	0.75	0.68	0.80	1.36	2.14	2.47
15. H = Ra (1-r) (0.21 + 0.52) $\frac{n}{N}$ - Ta^4 (0.56 - 0.092 ed) (0.10 + 0.90 $\frac{n}{N}$) (= (9)-(14))	2.96	2.80	4.22	4.74	4.38	3.56	3.19	2.73	3.14	3.96	3.72	2.92
16. 0.35 (ea-ed) (= 0.35 X (10a) - (10b))	3.11	3.85	4.67	4.52	3.15	2.31	1.93	1.65	1.54	2.10	2.52	2.98
17. (1 + 0.0098 U2) (1 + 0.0098 X (4))												
18. Ea = 0.35 (ea-ed) (1+0098 U2) (= (16) X (17))	5.40	6.60	8.58	8.77	5.85	4.39	3.66	3.07	2.55	3.69	4.63	5.48
19. Δ	0.77	0.88	0.9	1.05	1.00	0.94	0.92	0.88	0.88	0.88	0.83	0.77
20. Δ · H (= (19) X (15))	2.28	2.46	3.80	4.98	4.38	3.35	2.93	2.40	2.76	3.48	3.09	2.25
21. 0.27 Ea, (= 0.27 X (18))	1.46	1.78	2.32	2.37	1.58	1.19	0.99	0.83	0.69	1.00	1.25	1.48
22. Δ· H + 0.27 Ea, (= (20) + (21))	3.74	4.24	6.12	7.35	6.96	4.54	3.92	3.23	3.45	4.48	4.34	3.73
23. Δ + 0.27, (= (19) + 0.27)	1.04	1.15	1.17	1.32	1.27	1.21	1.19	1.15	1.15	1.15	1.10	1.04
24. (Δ· H + 0.27 Ea)/(Δ + 0.27) : ETp	3.6	3.69	5.23	5.57	5.48	3.75	3.29	2.81	3.0	3.9	3.95	3.59

Table 6.9 Weighting Factor (W) at Different Temperatures and Altitude

Temperature °C	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
W at altitude (m)																
0	.55	.58	.61	.64	.66	.68	.71	.73	.75	.77	.78	.80	.82	.83	.84	.85
500	.57	.60	.62	.65	.67	.70	.72	.74	.76	.78	.79	.81	.82	.84	.85	.86
1000	.58	.61	.64	.66	.69	.71	.73	.75	.77	.79	.80	.82	.83	.85	.86	.87
2000	.61	.64	.66	.69	.71	.73	.75	.77	.79	.81	.82	.84	.85	.86	.87	.88
3000	.64	.66	.69	.71	.73	.75	.77	.79	.81	.82	.84	.85	.86	.88	.88	.89
4000	.66	.69	.71	.73	.76	.78	.79	.81	.83	.84	.85	.86	.88	.89	.90	.90

Table 6.10 Correction Factor (K) of Wind Velocity

U day/ U night Ratio	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Correction Factor (K)	1.0	1.2	1.3	1.43	1.5	1.56	1.6

Table 6.11 Calculation Sheet of Potential Evapotranspiration (ETp)

(Radiation Method)

ETp = C (W Rs)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Mean monthly extra terrestrial radiation; Ra (mm H20/day)	12.0	13.3	14.7	15.6	16.0	15.9	15.9	15.7	15.0	13.9	12.4	11.6
2. Constant; a = 0.10 b = 0.70												
3. Sunshine rate; $\frac{n}{N}$ = S	0.71	0.64	0.67	0.63	0.52	0.38	0.33	0.27	0.35	0.58	0.75	0.74
4. Rs = (a + b X $\frac{n}{N}$) Ra (=(0.10 + 0.70 X 3 X 1)	7.16	7.29	8.36	8.44	7.42	5.86	5.26	4.54	5.18	7.03	7.75	7.17
5. Mean monthly temperature; t (C°)	24.7	27.3	28.2	30.9	29.8	28.7	28.0	27.5	27.4	27.4	26.1	24.5
6. Weighting factor effect of radiation; W	0.73	0.77	0.77	0.79	0.78	0.78	0.77	0.77	0.77	0.77	0.75	0.74
7. Mean monthly relative humidity; Hm (%)	62.0	60.0	60.0	62.0	72.0	78.0	81.0	83.0	84.0	78.0	71.0	64.0
8. Mean monthly wind velocity; U2 (m/s)	1.9	1.8	2.1	2.4	2.2	2.3	2.3	2.2	1.6	1.9	2.1	2.1
9. U daytime/U nighttime (= 1.5)												
10. K (= 1.2)												
11. U2 daytime = k U2	2.3	2.2	2.5	2.9	2.6	2.8	2.8	2.6	1.9	2.3	2.5	2.5
12. W Rs,	5.23	5.61	6.44	6.67	5.79	4.54	4.05	3.50	3.99	5.41	5.81	5.31
13. ETp, (mm/day)	4.2	4.5	5.2	5.5	4.2	3.4	3.0	2.7	2.7	4.1	4.4	4.2

Table 6.12 Effective Rainfall (Re)

(20% recurrence of droughty year)

(Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1. Lom Sak Area													
Rainfall	0	0.9	55.2	57.5	81.3	161.4	80.5	211.2	170.8	83.8	16.5	6.7	925.8
Paddy	-	-	-	-	74	126	72	152	114	64	16	-	618
Upland Crops	0	0	32	36	-	-	-	-	-	-	-	-	68
									(Total effective rainfall:				686)
2. Phetchanbun Area													
Rainfall	0	2.3	38	36.6	160.8	108.8	133.1	167.0	189.0	90.4	0.3	17.3	943.6
Paddy	-	-	-	-	126	92	108	128	126	68	0	-	648
Upland Crops	0	2	36	34	-	-	-	-	-	-	-	-	72
									(Total effective rainfall:				720)

Table 6.13 Nursery and Puddling Water Requirement for Local Varieties of Paddy, Lom Sak Area

	May I	May II	Jun I	Jun II	Jul I	Jul II
(1) Nursery Water Requirement						
Au	$\frac{1}{6}$	$\frac{1}{2}$	$\frac{5}{6}$	$\frac{5}{6}$	$\frac{1}{2}$	$\frac{1}{6}$
Au x $\frac{1}{20}$	$\frac{1}{120}$	$\frac{1}{40}$	$\frac{1}{24}$	$\frac{1}{24}$	$\frac{1}{40}$	$\frac{1}{120}$
Re (mm/half month)	37	37	63	63	36	36
ETp (mm/half month)	73.5	78.4	54.0	54.0	48.0	51.2
P (mm/half month)	15	16	15	15	15	16
Sn (mm/half month)	0.8	2.6	1.7	1.7	1.5	0.5
Pwn (mm/half month)	0.9	1.9	1.5	0.7		
Wn (mm/half month)	1.7	4.5	3.2	2.4	1.5	0.5
(2) Puddling Water Requirement						
Ap			$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{6}$
Wd (mm/half month)			14.5	29.0	38.0	19.0
(3) Nursery & Puddling Water Requirement (mm/half month)	1.7	4.5	17.7	31.4	39.5	19.5
(4) Diversion Water Requirement (mm/half month)	3.0	8.0	31.6	56.1	70.5	34.8

Table 6.14 Water Requirement for Local Varieties of Paddy

(Lom Sak Area)

LOCAL VARIETIES OF PADDY

	Jun I	Jun II	Jul I	Jul II	Aug I	Aug II	Sep I	Sep II	Oct I	Oct II	Nov I	Nov II
(1) Crop Intensity (Ic)												
Early Crop		$\frac{1}{6}$	$\frac{11}{24}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{2}{6}$	$\frac{1}{24}$	
Late Crop			$\frac{1}{24}$	$\frac{2}{6}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{11}{24}$	$\frac{1}{6}$
Total		$\frac{1}{6}$	$\frac{1}{2}$	$\frac{5}{6}$	1	1	1	1	1	$\frac{5}{6}$	$\frac{1}{2}$	$\frac{1}{6}$
(2) Crop Coefficient (Kc)												
Early Crop		1.0	1.0	1.13	1.13	1.32	1.32	1.26	1.26	1.10	1.10	
Late Crop			1.0	1.0	1.13	1.13	1.32	1.32	1.26	1.26	1.10	1.10
Weighting Ave.		1.0	1.0	1.08	1.13	1.23	1.32	1.29	1.26	1.20	1.10	1.10
(3) Potential Evapotranspiration (ETp)												
*1		54	48	51.2	42	44.8	43.5	43.5	60	64	63	63
(4) Consumptive Use (Cu)												
*1		54	48	55.3	47.5	55.1	57.4	56.1	75.6	76.8	69.3	69.3
(5) Percolation (P)												
*1		15	15	16	15	16	15	15	15	16	15	15
(6) Effective Rainfall (Re)												
*1		63	36	36	76	76	57	57	32	32	8	8
(7) 4+5-6												
*1		6.0	27.0	35.3	0	0	15.4	14.1	58.6	60.8	76.3	76.3
(8) Farm Water Requirement (FWR)												
7 x Ic *1		1.0	13.5	29.4	0	0	15.4	14.1	58.6	50.7	38.2	12.7
(9) Diversion Water Requirement												
*1		1.8	24.1	62.5	0	0	27.5	25.2	104.6	90.5	68.2	22.7

*1 Unit; mm/half month

Table 6.15 Nursery and Puddling Water Requirement for High Yield Varieties of Paddy, Lom Sak Area

	Jun I	Jun II	Jul I	Jul II	Aug I	Aug II
(1) Nursery Water Requirement						
Au	$\frac{1}{6}$	$\frac{1}{2}$	$\frac{5}{6}$	$\frac{5}{6}$	$\frac{1}{2}$	$\frac{1}{6}$
Au x $\frac{1}{20}$	$\frac{1}{120}$	$\frac{1}{40}$	$\frac{1}{24}$	$\frac{1}{24}$	$\frac{1}{40}$	$\frac{1}{120}$
Re (mm/half month)	63	63	36	36	76	76
ETp (mm/half month)	54	54	48	51.2	42	44.8
P (mm/half month)	15	15	15	16	15	16
Sn (mm/half month)	0.3	1.0	2.4	2.7	0.2	0.1
Pwn (mm/half month)	0.7	1.5	1.9	1.0		
Wn (mm/half month	1.0	2.5	4.3	3.7	0.2	0.1
(2) Puddling Water Requirement						
Ap			$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{6}$
Wd (mm/half month)			19.0	38.0	24.7	12.3
(3) Nursery & Puddling Water Requirement (mm/half month)	1.0	2.5	23.3	41.7	24.9	12.4
(4) Diversion Water Requirement (mm/half month)	1.8	4.5	41.6	74.5	44.5	22.1

Table 6.16 <u>Water Requirement for High Yield Varieties of Paddy</u>

(Lom Sak Area)

	Jul I	Jul II	Aug I	Aug II	Sep I	Sep II	Oct I	Oct II	Nov I	Nov II
(1) Crop Intensity (Ic)										
Early Crop		1/6	11/24	1/2	1/2	1/2	1/2	2/6	1/24	
Late Crop			1/24	2/6	1/2	1/2	1/2	1/2	11/24	1/6
Total		1/6	1/2	5/6	1	1	1	5/6	1/2	1/6
(2) Crop Coefficient (Kc)										
Early Crop		1.05	1.05	1.33	1.33	1.32	1.32	1.13	1.13	
Late Crop			1.05	1.05	1.33	1.33	1.32	1.32	1.13	1.13
Weighting Ave.		1.05	1.05	1.22	1.33	1.33	1.32	1.24	1.13	1.13
(3) Potential Evapotranspiration (ETp)										
*1		51.2	42	44.8	43.5	43.5	60	64	63	63
(4) Consumptive Use (Cu)										
*1		53.8	44.1	54.7	57.9	57.9	79.2	79.4	71.2	71.2
(5) Percolation (P)										
*1		16	15	16	15	15	15	16	15	15
(6) Effective Rainfall (Re)										
*1		36	76	76	57	57	32	32	8	8
(7) 4+5-6										
*1		33.8	0	0	15.9	15.9	62.2	63.4	78.2	78.2
(8) Irrigation Water Requirement										
7 x Ic *1		5.6	0	0	15.9	15.9	62.2	52.8	39.1	13.0
(9) Diversion Water Requirement										
*1		10.0	0	0	28.4	28.4	111.1	94.3	69.8	23.2

*1 Unit; mm/half month

Table 6.17 Nursery and Puddling Water Requirement for Local Varieties of Paddy, Phetchabun Area

	May I	May II	Jun I	Jun II	Jul I	Jul II
(1) Nursery Water Requirement						
Au	$\frac{1}{6}$	$\frac{1}{2}$	$\frac{5}{6}$	$\frac{5}{6}$	$\frac{1}{2}$	$\frac{1}{6}$
Au x $\frac{1}{20}$	$\frac{1}{120}$	$\frac{1}{40}$	$\frac{1}{24}$	$\frac{1}{24}$	$\frac{1}{40}$	$\frac{1}{120}$
Re (mm/half month)	73.5	78.4	54.0	54.0	48.0	51.2
ETp (mm/half month)	15	16	15	15	15	16
P (mm/half month)	0.6	2.0	2.4	2.4	1.0	0.4
Sn (mm/half month)	0.7	1.5	1.7	0.9		
Pwn (mm/half month)	1.3	3.5	4.1	3.3	1.0	0.4
Wn (mm/half month)						
(2) Puddling Water Requirement						
Ap			$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{6}$
Wd (mm/half month)			17.3	34.7	32.0	16.0
(3) Nursery & Puddling Water Requirement (mm/half month	1.3	3.5	21.4	38.0	33.0	16.4
(4) Diversion Water Requirement (mm/half month)	2.3	6.3	38.2	67.9	58.9	29.3

Table 6.18 Water Requirement for Local Varieties of Paddy

(Phetchabun Area)

LOCAL VARIETIES OF PADDY

	Jun I	Jun II	Jul I	Jul II	Aug I	Aug II	Sep I	Sep II	Oct I	Oct II	Nov I	Nov II
(1) Crop Intensity (Ic)												
Early Crop		1/6	11/24	1/2	1/2	1/2	1/2	1/2	1/2	2/6	1/24	
Late Crop			1/24	2/6	1/2	1/2	1/2	1/2	1/2	1/2	11/24	1/6
Total		1/6	1/2	5/6	1	1	1	1	1	5/6	1/2	1/6
(2) Crop Coefficient (Kc)												
Early Crop		1.0	1.0	1.13	1.13	1.32	1.32	1.26	1.26	1.10	1.10	
Late Crop			1.0	1.0	1.13	1.13	1.32	1.32	1.26	1.26	1.10	1.10
Weighting Ave.		1.0	1.0	1.08	1.13	1.23	1.32	1.29	1.26	1.20	1.10	1.10
(3) Potential Evapotranspiration (ETp)												
*1		54	48	51.2	42	44.8	43.5	43.5	60	64	63	63
(4) Consumptive Use (Cu)												
*1		54	48	55.3	47.5	55.1	57.4	56.1	75.6	76.8	69.3	69.3
(5) Percolation (P)												
*1		15	15	16	15	16	15	15	15	16	15	15
(6) Effective Rainfall (Re)												
*1		46	54	54	64	64	63	63	34	34	0	0
(7) 4+5-6												
*1		23	9	17.3	0	7.1	9.4	8.1	56.6	58.8	84.3	84.3
(8) Irrigation Water Requirement												
7 x Ic *1		3.8	4.5	14.4	0	7.1	9.4	8.1	56.6	49.0	42.2	14.1
(9) Diversion Water Requirement												
*1		6.8	8.0	25.7	0	12.7	16.8	14.5	101.1	87.5	75.4	25.2

*1 Unit; mm/half month

Table 6.19 Nursery and Puddling Water Requirement for High Yield Varieties of Paddy, Phetchabun Area

	Jun		Jul		Aug	
	I	II	I	II	I	II
(1) Nursery Water Requirement						
Au	$\frac{1}{6}$	$\frac{1}{2}$	$\frac{5}{6}$	$\frac{5}{6}$	$\frac{1}{2}$	$\frac{1}{2}$
Au x $\frac{1}{20}$	$\frac{1}{120}$	$\frac{1}{40}$	$\frac{1}{24}$	$\frac{1}{24}$	$\frac{1}{40}$	$\frac{1}{120}$
Re (mm/half month)	46	46	54	54	64	64
ETp (mm/half month)	54	54	48	51.2	42	44.8
P (mm/half month)	15	15	15	16	15	16
Sn (mm/half month)	0.5	1.4	1.7	2.0	0.5	0.2
Pwn (mm/half month)	0.9	1.7	1.6	0.8		
Wn (mm/half month)	1.4	3.1	3.3	2.8	0.5	0.2
(2) Puddling Water Requirement						
Ap			$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{6}$
Wd (mm/half month)			16.0	32	28.7	14.3
(3) Nursery & Puddling Water Requirement (mm/half month)	1.4	3.1	19.3	34.8	29.2	14.5
(4) Diversion Water Requirement (mm/half month)	2.5	5.5	34.5	62.1	52.1	25.9

Table 6.20 **Water Requirement for High Yield Varieties of Paddy**

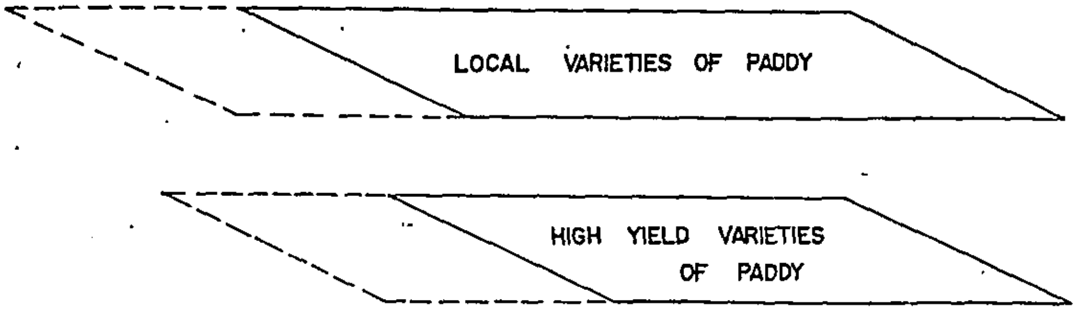
(Phetchabun Area)

HIGH YIELD VARIETIES OF PADDY

	Jul I	Jul II	Aug I	Aug II	Sep I	Sep II	Oct I	Oct II	Nov I	Nov II
(1) Crop Intensity (Ic)										
Early Crop		$\frac{1}{6}$	$\frac{11}{24}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{2}{6}$	$\frac{1}{24}$	
Late Crop			$\frac{1}{24}$	$\frac{2}{6}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{11}{24}$	$\frac{1}{6}$
Total		$\frac{1}{6}$	$\frac{1}{2}$	$\frac{5}{6}$	1	1	1	$\frac{5}{6}$	$\frac{1}{2}$	$\frac{1}{6}$
(2) Crop Coefficient (Kc)										
Early Crop		1.05	1.05	1.33	1.33	1.32	1.32	1.13	1.13	
Late Crop			1.05	1.05	1.33	1.33	1.32	1.32	1.13	1.13
Weighting Ave.		1.05	1.05	1.22	1.33	1.33	1.32	1.24	1.13	1.13
(3) Potential Evapotranspiration (ETp) *1		51.2	42	44.8	43.5	43.5	60	64	63	63
(4) Consumptive Use (Cu) *1		53.8	44.1	54.7	57.9	57.9	79.2	79.4	71.2	71.2
(5) Percolation (P) *1		16	15	16	15	15	15	16	15	15
(6) Effective Rainfall (Re) *1		54	64	64	63	63	34	34	0	0
(7) 4+5-6 *1		15.8	0	6.7	9.9	9.9	60.2	61.4	86.2	86.2
(8) Irrigation Water Requirement 7 x Ic *1		2.6	0	5.6	9.9	9.9	60.2	51.2	43.1	14.4
(9) Diversion Water Requirement *1		4.6	0	10.0	17.7	17.7	107.5	91.4	77.0	25.7

*1 Unit; mm/half month

Table 6.21 Summary of Water Requirement for Paddy



	May		Jun		Jul		Aug		Sep		Oct		Nov	
Lom Sak Area														
1. Local Varieties														
W. Req. for N&P	3.0	8.0	31.6	56.1	70.5	34.8								
W. Req. after Transp.				1.8	24.1	62.5	0	0	27.5	25.2	104.6	90.5	68.2	22.7
Total	3.0	8.0	31.6	57.9	94.6	97.3	0	0	27.5	25.2	104.6	90.5	68.2	22.7
	(11.0)		(89.5)		(191.9)		(0)		(57.2)		(195.1)		(90.9)	
2. High Yield Varieties														
W. Req. for N&P			1.8	4.5	41.6	74.5	44.5	22.1						
W. Req. after Transp.						10.0	0	0	28.4	28.4	111.1	94.3	69.8	23.2
Total			1.8	4.5	41.6	84.5	44.5	22.1	28.4	28.4	111.1	94.3	69.8	23.2
			(6.3)		(121.1)		(66.6)		(56.8)		(205.4)		(93.0)	
Phetchabun Area														
1. Local Varieties														
W. Req. for N&P	2.3	6.3	38.2	67.9	58.9	29.3								
W. Req. after Transp.				6.8	8.0	25.7	0	12.7	16.8	14.5	101.1	87.5	75.4	25.2
Total	2.3	6.3	38.2	74.7	66.9	55.0	0	12.7	16.8	14.5	101.1	87.5	75.4	25.2
	(8.6)		(112.9)		(121.9)		(12.7)		(31.3)		(188.6)		(100.6)	
2. High Yield Varieties														
W. Req. N&P			2.5	5.5	34.5	62.1	52.1	25.9						
W. Req. after Transp.						4.6	0	10.0	17.7	17.7	107.5	91.4	77.0	25.7
Total			2.5	5.5	34.5	66.7	52.1	35.9	17.7	17.7	107.5	91.4	77.0	25.7
			(8.0)		(101.2)		(88.0)		(35.4)		(198.9)		(102.7)	

Note:

Unit; mm/half month
(Unit; mm/month)

W. Req. for N&P : Water Requirement for Nursery and Puddling
W. Req. after Transp.: Water Requirement after Transplant

Table 6.22 **Water Requirement for Upland Crops**

(Lom Sak Area)

(1) Lom Sak Area

UPLAND CROPS

	Jan I	Jan II	Feb I	Feb II	Mar I	Mar II	Apr I	Apr II
(1) Crop Intensity (Ic)								
Early Crop	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	
Late Crop		$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$
Total	$\frac{1}{4}$	$\frac{3}{4}$	1	1	1	1	$\frac{3}{4}$	$\frac{1}{4}$
(2) Crop Coefficient (Kc)								
Early Crop	0.44	0.44	0.92	0.92	0.72	0.72	0.62	
Late Crop		0.44	0.44	0.92	0.92	0.72	0.72	0.62
Weighting Ave.	0.44	0.44	0.68	0.92	0.82	0.72	0.69	0.62
(3) Potential Evapotranspiration (ETp)								
*1	58.5	62.4	61.5	53.3	78.0	83.2	84	84
(4) Consumptive Use (Cu)								
*1	25.7	27.5	41.8	49.0	64.0	59.9	58.0	52.1
(5) Effective Rainfall (Re)								
*1	0	0	0	0	16	16	18	18
(6) Farm Water Requirement								
*1	6.4	20.6	41.8	49.0	48.0	43.9	30.0	8.5
(7) Pre-Irrigation Requirement								
Ap	$\frac{1}{2}$	$\frac{1}{2}$						
Pre-irrigation requirement	20	20						
*1								
(8) Total 6 + 7								
*1	26.4	40.6	41.8	49.0	48.0	43.9	30.0	8.5
(9) Diversion Water Requirement								
*1	55.0	84.6	87.1	102.1	100.0	91.5	62.5	17.7
	(139.6)		(189.2)		(191.5)		(80.2)	

*1 Unit; mm/half month

Table 6.22 Water Requirement for Upland Crops

(2) Phetchabun Area

UPLAND CROPS

	Jan		Feb		Mar		Apr	
	I	II	I	II	I	II	I	II
1. Crop Intensity (Ic)								
Early Crop	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	
Late Crop		$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$
Total	$\frac{1}{4}$	$\frac{3}{4}$	1	1	1	1	$\frac{3}{4}$	$\frac{1}{4}$
2. Crop Coefficient (Kc)								
Early Crop	0.44	0.44	0.92	0.92	0.72	0.72	0.62	
Late Crop		0.44	0.44	0.92	0.92	0.72	0.72	0.62
Weighting Ave.	0.44	0.44	0.68	0.92	0.82	0.72	0.69	0.62
3. Potential Evapotranspiration (ETp)								
*1	58.5	62.4	61.5	53.3	78.0	83.2	84.0	84.0
4. Consumptive Use (Cu)								
*1	25.7	27.5	41.8	49.0	64.0	59.9	58.0	52.1
5. Effective Rainfall (Re)								
*1	0	0	1	1	12	12	12	12
6. Farm Water Requirement								
*1	6.4	20.6	40.8	48.0	52.0	47.9	34.5	10.0
7. Pre-Irrigation Requirement								
Ap	$\frac{1}{2}$	$\frac{1}{2}$						
Pre irrigation requirement *1	20	20						
8. Total 6 + 7								
*1	26.4	40.6	40.8	48.0	52.0	47.9	34.5	10.0
9. Diversion Requirement								
*1	55.0	84.6	85.0	100.0	108.3	99.8	71.9	20.8
	(139.6)		(185.0)		(208.1)		(92.7)	

*1 Unit; mm/half month

Table 6.23 Summary of Irrigation Water Requirement in Lom Sak Area and Phetchabun Area

(Unit: mm/month)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Lom Sak Area												
- LV					11.0	89.5	191.9	0	52.7	195.1	90.9	
(50%)					5.5	44.8	96.0	0	26.4	97.6	45.5	
- HYV						6.3	126.1	66.6	56.8	205.4	93.0	
(50%)						3.2	63.1	33.3	28.4	102.7	46.5	
- UC	139.6	189.2	191.5	80.2								
(35%)	48.9	66.2	67.0	28.1								
Total	48.9	66.2	67.0	28.1	5.5	48.0	159.1	33.3	54.8	200.3	92.0	0
Unit W.R. (ℓ/sec/ha)	0.18	0.27	0.25	0.10	0.02	0.19	0.59	0.12	0.21	0.75	0.35	0
Phetchabun Area												
- LV					8.6	112.9	121.9	12.7	31.3	188.6	100.6	
(50%)					4.3	56.5	61.0	6.4	15.7	94.3	50.3	
- HYV						8.0	101.2	88.0	35.4	198.9	102.7	
(50%)						4.0	50.6	44.0	17.7	99.5	51.4	
- UC	139.6	185.0	208.1	92.7								
(25%)	34.9	46.3	52.0	23.2								
Total	34.9	46.3	52.0	23.2	4.3	60.5	111.6	50.4	33.4	193.8	101.7	0
Unit W.R. (ℓ/sec/ha)	0.13	0.19	0.19	0.08	0.02	0.23	0.42	0.19	0.13	0.72	0.39	0

Note: LV - Local Varieties of Paddy
HYV - High Yield Varieties of Paddy
UC - Upland Crops

Table 6.24 Irrigation Water Requirement for Alternative Study of Crop Intensity

(1) Lom Sak Area

(Unit: m^3/ha)

Month	Crop Intensity				
	100%	125%	150%	175%	200%
Jan.	0	349	698	1,047	1,396
Feb.	0	473	946	1,419	1,892
Mar.	0	479	958	1,436	1,915
Apr.	0	201	401	602	802
May	55	55	55	55	55
Jun.	480	480	480	480	480
Jul.	1,591	1,591	1,591	1,591	1,591
Aug.	333	333	333	333	333
Sep.	548	548	548	548	548
Oct.	2,003	2,003	2,003	2,003	2,003
Nov.	920	920	920	920	920
Dec.	0	0	0	0	0
Total	5,930	7,432	8,933	10,434	11,935

Note: Cropping Pattern: Wet season - Paddy 100%

Dry season - Beans 0 - 100%

Table 6.24 Irrigation Water Requirement for Alternative Study of Crop Intensity

(2) Phetchabun Area

(Unit: m3/ha)

Month	Crop Intensity				
	100%	125%	150%	175%	200%
Jan.	0	349	698	1,047	1,396
Feb.	0	463	925	1,388	1,850
Mar.	0	520	1,041	1,561	2,081
Apr.	0	232	464	695	927
May	43	43	43	43	43
Jun.	605	605	605	605	605
Jul.	1,116	1,116	1,116	1,116	1,116
Aug.	504	504	504	504	504
Sep.	334	334	334	334	334
Oct.	1,938	1,938	1,938	1,938	1,938
Nov.	1,017	1,017	1,017	1,017	1,017
Dec.	0	0	0	0	0
Total	5,557	7,121	8,685	10,248	11,811

Note: Cropping Pattern: Wet season - Paddy 100%
Dry season - Beans 0 - 100%

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(1) Name of Dam Huai Khon Kaen, Crop Intensity 100% (Drainage Area 322 km^2)

Month	Inflow				Water Demand				
	1	2 *1	3 *2	4	5	6	7	8	9
	Flow (20% recurrence of droughty year) ($x10^3m^3$)	Evaporation ($x10^3m^3$)	Precipitation ($x10^3m^3$)	Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	Irrigation (6,100 ha) CI = 100% ($x10^3m^3$)	Water Supply (5,000 m^3/day) ($x10^3m^3$)	Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	Total Demand 5+6+7 ($x10^3m^3$)	Required Storage 8 - 4 ($x10^3m^3$)
Jan.	9	134	1	-124	0	155	862	1,017	1,141
Feb.	39	146	2	-105	0	140	779	919	1,024
Mar.	496	195	20	321	0	155	862	1,017	696
Apr.	1,203	215	39	1,027	0	150	835	985	0
May	9,607	169	142	9,580	336	0	862	1,198	0
Jun.	11,767	157	159	11,769	2,928	0	835	3,763	0
Jul.	8,047	127	125	8,045	9,705	0	862	10,567	2,522
Aug.	22,664	120	223	22,767	2,031	0	862	2,893	0
Sep.	15,634	111	176	15,699	3,343	0	835	4,178	0
Oct.	1,468	135	42	1,375	12,218	0	862	13,080	11,705
Nov.	19	131	1	-111	5,612	150	835	6,597	6,708
Dec.	9	132	1	-122	0	155	862	1,017	1,139
Total	70,962	1,772	931	70,121	36,173	905	10,153	47,231	24,935

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
24,780 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(2) Name of Dam Huai Khon Kaen, Crop Intensity 125% (Drainage Area 322 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (4,600 ha) CI = 125% ($x10^3m^3$)	6 Water Supply (5,000 m^3/day) ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5+6+7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	9	134	1	-124	1,605	155	862	2,622	2,746
Feb.	39	146	2	-105	2,176	140	779	3,095	3,200
Mar.	496	195	20	321	2,203	155	862	3,220	2,899
Apr.	1,203	215	39	1,027	925	150	835	1,910	883
May	9,607	169	142	9,580	253	0	862	1,115	0
Jun.	11,767	157	159	11,769	2,208	0	835	3,043	0
Jul.	8,047	127	125	8,045	7,319	0	862	8,181	136
Aug.	22,664	120	223	22,767	1,532	0	862	2,394	0
Sep.	15,634	111	176	15,699	2,521	0	835	3,356	0
Oct.	1,468	135	42	1,375	9,214	0	862	10,076	8,701
Nov.	19	131	1	-111	4,232	150	835	5,217	5,328
Dec.	9	132	1	-122	0	155	862	1,017	1,139
Total	70,962	1,772	931	70,121	34,188	905	10,153	45,246	25,032

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
24,780 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(3) Name of Dam Huai Khon Kaen, Crop Intensity 150% (Drainage Area 322 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (3,400 ha) CI = 150% ($x10^3m^3$)	6 Water Supply ($5,000\ m^3/day$) ($x10^3m^3$)	7 Downstream Requirement ($0.1\ m^3/sec/100\ km^2$) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	9	134	1	-124	2,373	155	862	3,390	3,514
Feb.	39	146	2	-105	3,216	140	779	4,135	4,240
Mar.	496	195	20	321	3,257	155	862	4,274	3,953
Apr.	1,203	215	39	1,027	1,363	150	835	2,348	1,321
May	9,607	169	142	9,580	187	0	862	1,049	0
Jun.	11,767	157	159	11,769	1,632	0	835	2,467	0
Jul.	8,047	127	125	8,045	5,409	0	862	6,271	0
Aug.	22,664	120	223	22,767	1,132	0	862	1,994	0
Sep.	15,634	111	176	15,699	1,863	0	835	2,698	0
Oct.	1,468	135	42	1,375	6,810	0	862	7,672	6,297
Nov.	19	131	1	-111	3,128	150	835	4,113	4,224
Dec.	9	132	1	-122	0	155	862	1,017	1,139
Total	70,962	1,772	931	70,121	30,370	905	10,153	41,428	24,688

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
24,780 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(4) Name of Dam Huai Khon Kaen, Crop Intensity 175% (Drainage Area 322 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (2,700 ha) CI = 175% ($x10^3m^3$)	6 Water Supply (5,000 m^3/day) ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 +6 +7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	9	134	1	-124	2,827	155	862	3,844	3,968
Feb.	39	146	2	-105	3,831	140	779	4,750	4,855
Mar.	496	195	20	321	3,877	155	862	4,894	4,573
Apr.	1,203	215	39	1,027	1,625	150	835	2,610	1,583
May	9,607	169	142	9,580	149	0	862	1,011	0
Jun.	11,767	157	159	11,769	1,296	0	835	2,131	0
Jul.	8,047	127	125	8,045	4,296	0	862	5,158	0
Aug.	22,664	120	223	22,767	899	0	862	1,761	0
Sep.	15,634	111	176	15,699	1,480	0	835	2,315	0
Oct.	1,468	135	42	1,375	5,408	0	862	6,270	4,895
Nov.	19	131	1	-111	2,484	150	835	3,469	3,580
Dec.	9	132	1	-122	0	155	862	1,017	1,139
Total	70,962	1,772	931	70,121	28,172	905	10,153	39,230	24,593

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
24,780 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(5) Name of Dam Huai Khon Kaen, Crop Intensity 200% (Drainage Area 322 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (2,200 ha) CI = 200% ($x10^3m^3$)	6 Water Supply (5,000 m^3/day) ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	9	134	1	-124	3,071	155	862	4,088	4,212
Feb.	39	146	2	-105	4,162	140	779	5,081	5,186
Mar.	496	195	20	321	4,213	155	862	5,230	4,909
Apr.	1,203	215	39	1,027	1,764	150	835	2,749	1,722
May	9,607	169	142	9,580	121	0	862	983	0
Jun.	11,767	157	159	11,769	1,056	0	835	1,891	0
Jul.	8,047	127	125	8,045	3,500	0	862	4,362	0
Aug.	22,664	120	223	22,767	733	0	862	1,595	0
Sep.	15,634	111	176	15,699	1,206	0	835	2,041	0
Oct.	1,468	135	42	1,375	4,407	0	862	5,269	3,894
Nov.	19	131	1	-111	2,024	150	835	3,009	3,120
Dec.	9	132	1	-122	0	155	862	1,017	1,139
Total	70,962	1,772	931	70,121	26,257	905	10,153	37,315	24,182

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
24,780 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(6) Name of Dam Huai Yai, Crop Intensity 100% (Drainage Area 78 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (2,100 ha) CI = 100% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement ($0.1\ m^3/sec/100\ km^2$) ($x10^3m^3$)	8 Total Demand 5 +6 +7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	5	96	1	-90	0	0	209	209	299
Feb.	30	104	5	-69	0	0	189	189	258
Mar.	105	139	13	-21	0	0	209	209	230
Apr.	291	153	28	166	0	0	202	202	36
May	1,986	120	92	1,958	90	0	209	299	0
Jun.	1,695	112	84	1,667	1,271	0	202	1,473	0
Jul.	3,522	91	125	3,556	2,344	0	209	2,553	0
Aug.	3,708	85	128	3,751	1,058	0	209	1,267	0
Sep.	7,062	79	178	7,161	701	0	202	903	0
Oct.	713	97	47	663	4,070	0	209	4,279	3,616
Nov.	25	94	4	-65	2,136	0	202	2,338	2,403
Dec.	0	95	0	-95	0	0	209	209	304
Total	19,142	1,265	705	18,582	11,670	0	2,460	14,130	7,146

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
7,120 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(7) Name of Dam Huai Yai, Crop Intensity 125% (Drainage Area 78 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (1,400 ha) CI = 125% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/100 km^2) ($x10^3m^3$)	8 Total Demand 5+6+7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	5	96	1	-90	489	0	209	698	788
Feb.	30	104	5	-69	648	0	189	837	906
Mar.	105	139	13	-21	728	0	209	937	958
Apr.	291	153	28	166	325	0	202	527	361
May	1,986	120	92	1,958	60	0	209	269	0
Jun.	1,695	112	84	1,667	847	0	202	1,049	0
Jul.	3,522	91	125	3,556	1,562	0	209	1,771	0
Aug.	3,708	85	128	3,751	706	0	209	915	0
Sep.	7,062	79	178	7,161	468	0	202	670	0
Oct.	713	97	47	663	2,713	0	209	2,922	2,259
Nov.	25	94	4	-65	1,424	0	202	1,626	1,691
Dec.	0	95	0	-95	0	0	209	209	304
Total	19,142	1,265	705	18,582	9,970	0	2,460	12,430	7,267

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
7,120 x 10^3m^3

Table 6.25 <u>Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity</u>

(8) Name of Dam Huai Yai, Crop Intensity 150% (Drainage Area 78 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (1,000 ha) CI = 150% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	5	96	1	-90	698	0	209	907	997
Feb.	30	104	5	-69	925	0	189	1,114	1,183
Mar.	105	139	13	-21	1,041	0	209	1,250	1,271
Apr.	291	153	28	166	464	0	202	666	500
May	1,986	120	92	1,958	43	0	209	252	0
Jun.	1,695	112	84	1,667	605	0	202	807	0
Jul.	3,522	91	125	3,556	1,116	0	209	1,325	0
Aug.	3,708	85	128	3,751	504	0	209	713	0
Sep.	7,062	79	178	7,161	334	0	202	536	0
Oct.	713	97	47	663	1,938	0	209	2,147	1,484
Nov.	25	94	4	-65	1,017	0	202	1,219	1,284
Dec.	0	95	0	-95	0	0	209	209	304
Total	19,142	1,265	705	18,582	8,685	0	2,460	11,145	7,023

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
7,120 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(9) Name of Dam Huai Yai, Crop Intensity 175% (Drainage Area 78 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (800 ha) CI = 175% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	5	96	1	-90	838	0	209	1,047	1,137
Feb.	30	104	5	-69	1,110	0	189	1,299	1,368
Mar.	105	139	13	-21	1,249	0	209	1,458	1,479
Apr.	291	153	28	166	556	0	202	758	592
May	1,986	120	92	1,958	34	0	209	243	0
Jun.	1,695	112	84	1,667	484	0	202	686	0
Jul.	3,522	91	125	3,556	893	0	209	1,102	0
Aug.	3,708	85	128	3,751	403	0	209	612	0
Sep.	7,062	79	178	7,161	267	0	202	469	0
Oct.	713	97	47	663	1,550	0	209	1,759	1,096
Nov.	25	94	4	-65	814	0	202	1,016	1,081
Dec.	0	95	0	-95	0	0	209	209	304
Total	19,142	1,265	705	18,582	8,198	0	2,460	10,658	7,057

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
7,120 x 10^3m^3

Table 6.25 <u>Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity</u>

(10) Name of Dam Huai Yai, Crop Intensity 200% (Drainage Area 78 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (650 ha) CI = 200% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement ($0.1\ m^3/sec/100\ km^2$) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	5	96	1	-90	907	0	209	1,116	1,206
Feb.	30	104	5	-69	1,203	0	189	1,392	1,461
Mar.	105	139	13	-21	1,353	0	209	1,562	1,583
Apr.	291	153	28	166	603	0	202	805	639
May	1,986	120	92	1,958	28	0	209	237	0
Jun.	1,695	112	84	1,667	393	0	202	595	0
Jul.	3,522	91	125	3,556	725	0	209	934	0
Aug.	3,708	85	128	3,751	328	0	209	537	0
Sep.	7,062	79	178	7,161	217	0	202	419	0
Oct.	713	97	47	663	1,260	0	209	1,469	806
Nov.	25	94	4	-65	661	0	202	863	928
Dec.	0	95	0	-95	0	0	209	209	304
Total	19,142	1,265	705	18,582	7,678	0	2,460	10,138	6,927

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
7,120 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(11) Name of Dam Khlong Chaliang Lab, Crop Intensity 100% (Drainage Area 77 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (350 ha) CI = 100% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	4	29	0	-25	0	0	206	206	231
Feb.	30	31	1	0	0	0	186	186	186
Mar.	103	42	4	65	0	0	206	206	141
Apr.	288	46	8	250	0	0	200	200	0
May	1,960	36	28	1,952	15	0	206	221	0
Jun.	1,673	34	25	1,664	212	0	200	412	0
Jul.	3,477	27	37	3,487	391	0	206	597	0
Aug.	3,660	26	38	3,672	176	0	206	382	0
Sep.	6,971	24	53	7,000	117	0	200	317	0
Oct.	703	29	14	688	678	0	206	884	196
Nov.	24	28	1	-3	356	0	200	556	559
Dec.	0	28	0	-28	0	0	206	206	234
Total	18,893	380	209	18,722	1,945	0	2,428	4,373	1,547

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
1,530 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(10) Name of Dam Huai Yai, Crop Intensity 200% (Drainage Area 78 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (650 ha) CI = 200% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	5	96	1	-90	907	0	209	1,116	1,206
Feb.	30	104	5	-69	1,203	0	189	1,392	1,461
Mar.	105	139	13	-21	1,353	0	209	1,562	1,583
Apr.	291	153	28	166	603	0	202	805	639
May	1,986	120	92	1,958	28	0	209	237	0
Jun.	1,695	112	84	1,667	393	0	202	595	0
Jul.	3,522	91	125	3,556	725	0	209	934	0
Aug.	3,708	85	128	3,751	328	0	209	537	0
Sep.	7,062	79	178	7,161	217	0	202	419	0
Oct.	713	97	47	663	1,260	0	209	1,469	806
Nov.	25	94	4	-65	661	0	202	863	928
Dec.	0	95	0	-95	0	0	209	209	304
Total	19,142	1,265	705	18,582	7,678	0	2,460	10,138	6,927

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
7,120 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(11) Name of Dam Khlong Chaliang Lab, Crop Intensity 100% (Drainage Area 77 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (350 ha) CI = 100% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	4	29	0	-25	0	0	206	206	231
Feb.	30	31	1	0	0	0	186	186	186
Mar.	103	42	4	65	0	0	206	206	141
Apr.	288	46	8	250	0	0	200	200	0
May	1,960	36	28	1,952	15	0	206	221	0
Jun.	1,673	34	25	1,664	212	0	200	412	0
Jul.	3,477	27	37	3,487	391	0	206	597	0
Aug.	3,660	26	38	3,672	176	0	206	382	0
Sep.	6,971	24	53	7,000	117	0	200	317	0
Oct.	703	29	14	688	678	0	206	884	196
Nov.	24	28	1	-3	356	0	200	556	559
Dec.	0	28	0	-28	0	0	206	206	234
Total	18,893	380	209	18,722	1,945	0	2,428	4,373	1,547

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
1,530 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(12) Name of Dam Khlong Chaliang Lab, Crop Intensity 125% (Drainage Area 77 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (230 ha) CI = 125% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	4	29	0	-25	80	0	206	286	311
Feb.	30	31	1	0	106	0	186	292	292
Mar.	103	42	4	65	120	0	206	326	261
Apr.	288	46	8	250	53	0	200	253	3
May	1,960	36	28	1,952	10	0	206	216	0
Jun.	1,673	34	25	1,664	139	0	200	339	0
Jul.	3,477	27	37	3,487	257	0	206	463	0
Aug.	3,660	26	38	3,672	116	0	206	322	0
Sep.	6,971	24	53	7,000	77	0	200	277	0
Oct.	703	29	14	688	446	0	206	652	0
Nov.	24	28	1	-3	234	0	200	434	437
Dec.	0	28	0	-28	0	0	206	206	234
Total	18,893	380	209	18,722	1,638	0	2,428	4,066	1,538

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
1,530 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(13) Name of Dam Khlong Chaliang Lab, Crop Intensity 150% (Drainage Area 77 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (150 ha) CI = 150% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	4	29	0	-25	105	0	206	311	336
Feb.	30	31	1	0	139	0	186	325	325
Mar.	103	42	4	65	156	0	206	362	297
Apr.	288	46	8	250	70	0	200	270	20
May	1,960	36	28	1,952	6	0	206	212	0
Jun.	1,673	34	25	1,664	91	0	200	291	0
Jul.	3,477	27	37	3,487	167	0	206	373	0
Aug.	3,660	26	38	3,672	76	0	206	282	0
Sep.	6,971	24	53	7,000	50	0	200	250	0
Oct.	703	29	14	688	291	0	206	497	0
Nov.	24	28	1	-3	153	0	200	353	356
Dec.	0	28	0	-28	0	0	206	206	234
Total	18,893	380	209	18,722	1,304	0	2,428	3,732	1,568

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
1,530 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(14) Name of Dam Khlong Chaliang Lab, Crop Intensity 175% (Drainage Area 77 km^2)

Month	Inflow				Water Demand				
	1 Flow (20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (100 ha) CI = 175% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	4	29	0	-25	105	0	206	311	336
Feb.	30	31	1	0	139	0	186	325	325
Mar.	103	42	4	65	156	0	206	362	297
Apr.	288	46	8	250	70	0	200	270	20
May	1,960	36	28	1,952	4	0	206	210	0
Jun.	1,673	34	25	1,664	61	0	200	261	0
Jul.	3,477	27	37	3,487	112	0	206	318	0
Aug.	3,660	26	38	3,672	50	0	206	256	0
Sep.	6,971	24	53	7,000	33	0	200	233	0
Oct.	703	29	14	688	194	0	206	400	0
Nov.	24	28	1	-3	102	0	200	302	305
Dec.	0	28	0	-28	0	0	206	206	234
Total	18,893	380	209	18,722	1,026	0	2,428	3,454	1,517

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
1,530 x 10^3m^3

Table 6.25 Calculation Sheet of Irrigable Area for Alternative Study of Crop Intensity

(15) Name of Dam Khlong Chaliang Lab, Crop Intensity 200% (Drainage Area 77 km^2)

Month	Inflow				Water Demand				
	1 Flow 20% recurrence of droughty year) ($x10^3m^3$)	2 *1 Evaporation ($x10^3m^3$)	3 *2 Precipitation ($x10^3m^3$)	4 Adjusted Flow 1 + 2 + 3 ($x10^3m^3$)	5 Irrigation (80 ha) CI = 200% ($x10^3m^3$)	6 Water Supply ($x10^3m^3$)	7 Downstream Requirement (0.1 m^3/sec/ 100 km^2) ($x10^3m^3$)	8 Total Demand 5 + 6 + 7 ($x10^3m^3$)	9 Required Storage 8 - 4 ($x10^3m^3$)
Jan.	4	29	0	-25	112	0	206	318	343
Feb.	30	31	1	0	148	0	186	334	334
Mar.	103	42	4	65	166	0	206	372	307
Apr.	288	46	8	250	74	0	200	274	24
May	1,960	36	28	1,952	3	0	206	209	0
Jun.	1,673	34	25	1,664	48	0	200	248	0
Jul.	3,477	27	37	3,487	89	0	206	295	0
Aug.	3,660	26	38	3,672	40	0	206	246	0
Sep.	6,971	24	53	7,000	27	0	200	227	0
Oct.	703	29	14	688	155	0	206	361	0
Nov.	24	28	1	-3	81	0	200	281	284
Dec.	0	28	0	-28	0	0	206	206	234
Total	18,893	380	209	18,722	943	0	2,428	3,371	1,526

Note: *1 - Pan evaporation data x 0.7
*2 - Rainfall data x 0.75

Useful Storage
1,530 x 10^3m^3

Table 6.26 Calculation Sheet of Economic Cost for Alternative Study of Crop Intensity

Crop Intensity	Huai Khon Kaen Area		Huai Yai Area		Khlong Chaliang Lab Area	
100%	Dam	18,704,000$	Dam	2,984,000$	Dam	1,784,000$
	Irri. 6,100 ha x 1,411 $/ha =	8,607,000$	Irri. 2,100 ha x 693 $/ha =	1,455,000$	Irri. 350 ha x 592 $/ha =	207,000$
	Total	27,311,000$	Total	4,439,000$	Total	1,991,000$
125%	Dam	18,704,000	Dam	2,984,000	Dam	1,784,000
	Irri. 4,600 x 1,411 =	6,491,000	Irri. 1,400 x 693 =	970,000	Irri. 230 x 592 =	136,000
	Total	25,195,000$	Total	3,954,000$	Total	1,920,000$
150%	Dam	18,704,000	Dam	2,984,000	Dam	1,784,000
	Irri. 3,400 x 1,411 =	4,797,000	Irri. 1,000 x 693 =	693,000	Irri. 150 x 592 =	89,000
	Total	23,501,000$	Total	3,677,000$	Total	1,873,000$
175%	Dam	18,704,000	Dam	2,984,000	Dam	1,784,000
	Irri. 2,700 x 1,411 =	3,810,000	Irri. 800 x 693 =	554,000	Irri. 100 x 592 =	59,000
	Total	22,514,000$	Total	3,538,000$	Total	1,843,000$
200%	Dam	18,704,000	Dam	2,984,000	Dam	1,784,000
	Irri. 2,200 x 1,411 =	3,104,000	Irri. 650 x 693 =	450,000	Irri. 80 x 592 =	47,000
	Total	21,808,000$	Total	3,434,000$	Total	1,831,000$