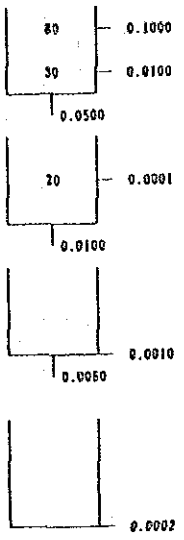
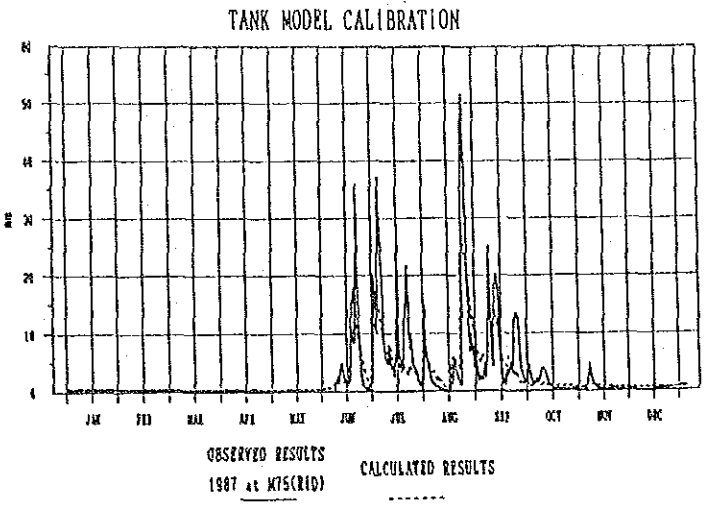
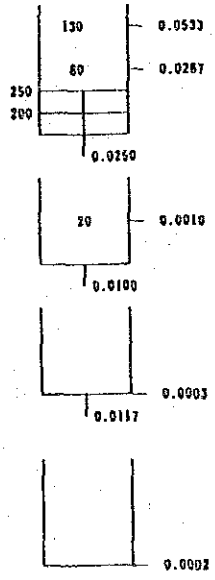
(1) Tank Model for the drainage area of less than 600 sq.km





(2) Tank Model for the drainage area of more than 600 sq.km



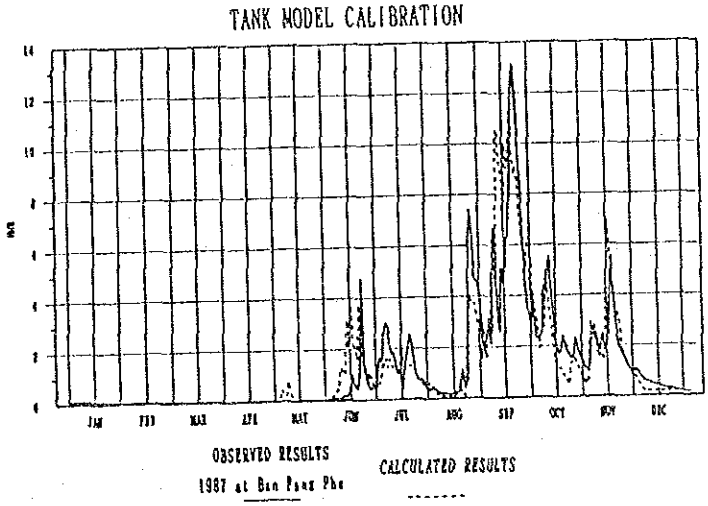


FIGURE 2-3 RUN-OFF SIMULATION BY TANK MODEL METHOD

units is estimated using the unit of rainfall and the unit of run-off from the basin. Unit run-off of the lower, middle and upper-basins are as follows;

Unit Run-off by Basin

(unit : mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Upper-Basin													
A:	1.8	0.8	0.6	0.5	10.0	21.3	20.3	49.5	159.0	88.2	14.5	3.5	367.0
B:	2.1	0.9	0.5	0.3	4.4	18.3	33.8	46.8	145.3	48.8	4.2	2.5	307.7
C:	1.1	0.5	0.2	0.1	15.2	12.3	34.3	63.8	190.8	68.6	16.7	4.0	407.5
Middle-Basin													
A:	3.1	1.8	1.5	2.0	18.3	56.8	99.9	146.8	161.1	74.0	12.6	5.1	582.9
B:	3.6	1.9	1.3	2.4	2.2	66.3	89.1	112.3	90.0	0.4	7.4	3.8	440.7
C:	2.2	1.1	0.7	1.6	20.6	29.2	175.8	169.9	178.8	93.3	11.9	5.0	690.2
Lower-Basin													
A:	3.1	2.0	1.7	2.9	15.7	73.6	100.8	206.2	167.0	67.4	9.0	5.0	654.6
B:	2.7	1.4	0.9	0.6	4.0	34.3	98.0	130.4	100.7	23.4	4.2	2.4	402.7
C:	3.9	2.7	2.5	2.6	42.7	50.3	88.0	254.9	244.2	148.4	12.0	7.7	859.9

Note: A : Average Year (mean value of 30-year from 1960 to 1986)
B : Low-water year (1/5 probability of non-exceedance)
C : High-water year (1/5 probability of exceedance)

d) Basin Run-off

Composite run-off from the sub-basin is summarized below in conformity with the annual run-off of lower, middle and upper- basin in the Lam Dom Yai basin. Run-off distribution on the monthly basis is illustrated in Figure 2-4.

Run-off by Each Basin

Basin	Area	Average Year			1/5 Lower-Water Year			1/5 High-Water Year		
		R (A)	RF (B)	B/A	R (A)	RF (B)	B/A	R (A)	RF (B)	B/A
	(sq. km)	(mm)	(MCM)		(mm)	(MCM)		(mm)	(MCM)	
Upper	2,740.7	1,356	1,346	0.36	1,190	1,151	0.35	1,501	1,490	0.36
Middle	1,537.4	1,597	896	0.36	1,372	677	0.32	1,802	1,061	0.38
Lower	626.9	1,730	410	0.38	1,388	252	0.29	2,054	539	0.42
Whole	4,905.0	1,468	2,652	0.37	1,272	2,080	0.33	1,666	3,090	0.38

Note: R : Rainfall RF : Run-off

4) Run-off Characteristics

Based on the above-mentioned table, run-off from the whole Lam Dom Yai basin is estimated at 2,080 MCM (424 mm) which corresponds to the average areal rainfall of 1,272 mm from a low-water year. This areal rainfall

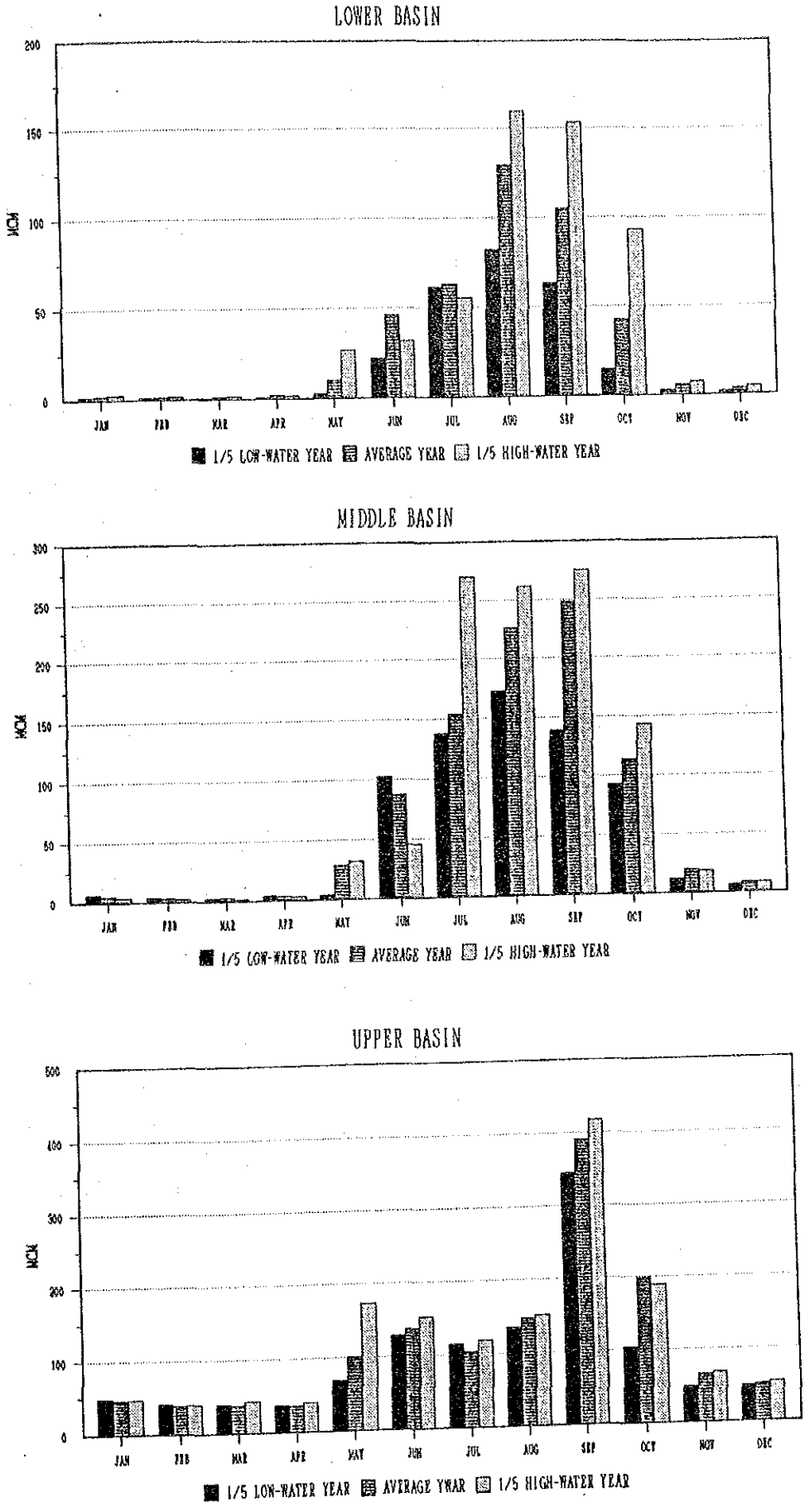


FIGURE 2-4 **MONTHLY RUN-OFF DISCHARGE IN UPPER, MIDDLE AND LOWER-BASIN**

has a probability of 1/5. Over 90 percent of the basin run-off occurs during the wet season from May to October. Even during the wet season, basin run-off is distinguished in September as upper-basin, in July, August and September as middle-basin, and in August and September as lower-basin. The basin run-off is closely related to the rainfall distribution of the basin. These phenomena show that run-off in the upper-basin is stable regardless of low-water and high-water years; that is why forest areas remain. On the contrary, the run-off from the middle and lower-basins which do not correlate to the rainfall are faster than the upper-basin run-off, therefore farmland has been widely developed.

5) Water Quality

Water quality of surface flow at potential dam-sites in the basin has been observed throughout the course of field investigation. The examined items include temperature (T), electric conductivity (EC), turbidity (Tur), dissolved oxygen (DO) and pH. The observed results and standards of water quality at the U.S Salinity Laboratory are shown below;

Water Quality of Surface Flow

Location	Date	Q	T	pH	EC	Tur	DO
		(cu.m/s)	(°C)		(µs/c)	(mg/1)	(%)
Lam Dom Yai (D23)	13 Jun. '91	12.43	28	7.3	10	69	5
	9 Jul. '91	5.81	32	7.4	40	62	5
	13 Nov.'91	9.00	27	6.6	31	16	6
	17 Dec. '91	2.06	26	6.9	39	8	8
Lam Dom Yai (D28)	12 Jun. '91	9.23	28	7.6	10	92	4
	9 Jul. '91	9.25	31	7.4	40	73	6
	12 Nov.'91	11.47	28	6.6	35	20	7
	16 Dec. '91	2.64	26	6.5	45	9	6
Lam Som (D24)	13 Jun. '91	1.15	29	6.9	10	58	3
	10 Jul. '91	0.71	33	7.7	60	44	7
	13 Nov.'91	5.03	28	6.5	31	24	6
	17 Dec. '91	1.19	27	6.5	31	56	6
Huai Ari (D25)	12 Jun. '91	0.90	28	6.1	20	35	4
	9 Jul. '91	4.38	33	7.6	50	140	4
	12 Nov.'91	0.30	28	6.7	58	25	4

Location	Date	Q	T	pH	EC	Tur	DO
		(cu.m/s)	(°C)		(µs/c)	(mg/1)	(%)
Lam Som (J1)	13 Jun. '91	7.39	27	6.9	20	75	44
	9 Jul.' 91	1.91	33	7.2	30	82	6
	12 Nov.'91	7.23	29	6.6	33	66	6
	16 Dec. '91	1.51	27	6.5	35	33	7
Huai Bon (J7)	13 Jun. '91	14.93	27	7.1	10	5	4
	10 Jul. '91	2.35	29	8.1	70	31	6
	13 Nov.'91	2.47	25	6.6	26	7	8
	17 Dec. '91	0.46	25	6.6	33	4	7
Huai Fang Deang (D-29)	14 Jun.' 91	0.04	31	7.5	20	17	2
	10 Jul. '91	0.04	32	7.7	70	44	4
	13 Nov.'91	0.21	29	6.5	47	36	4
	17 Dec. '91	0.06	28	6.7	42	12	7
Huai Fang Deang (J2)	14 Jun. '91	-	30	6.9	10	44	2
	10 Jul. '91	-	31	7.9	60	50	4
	13 Nov.'91	-	28	6.5	33	22	3
	17 Dec .'91	-	27	6.5	33	38	4
Standard 1/				6.5-9.2	<250		5>

Note; 1/ : Standard values of US Salinity Laboratory

In comparison with the U.S. salinity laboratory standard, no harmful effects of irrigation use, in terms of pH and EC, can be found in the water quality of the surface flow in the basin.

2.4 Water Resources

2.4.1 Surface Water

1) River Systems

The Lam Dom Yai is one of the tributaries branching off from the right bank of the Mun river; it originates from the Phanom Dong Rek (Range) located on the border of Cambodia, and flows into the Mun river. The whole catchment area and the length of the main river are equivalent to 4,905 sq.km and 238 km. The riverbed slope of this river being very gentle, the main riverbed slope in the 190 km section from the conference shows a figure of 1 to 4,600. Since the Lam Dom Yai basin only has a small portion of mountainous area, large tributaries have not formed. Consequently very few good dam-sites for reservoirs can be found.

The basin is composed of areas of original forest and open forest of 39.4 percent, and agricultural land of 47.4 percent.

The outline of the six main tributaries are shown in the following table, and the river system is schematically shown in Figure 2-5.

Outline of Major Tributaries

Tributary	Location	Catchment Area (sq.km)	River Length (km)	River Slope	Altitude in the Basin (El. m)
Huai Khao San	Left Bank	608	66	1/1,400	106-171
Huai Along	Right Bank	235	28	1//750	120-163
Huai Ari	Left Bank	274	42	1/1,000	123-192
Lam Som	Left Bank	1,104	96	1/1,200	124-567
Huai Luang	Right Bank	255	26	1/120	140-694
Huai Bon	Left Bank	238	17	1/90	143-500

2) Run-off Characteristics

The Lam Dom Yai basin is being blessed with a mean annual rainfall of 1,470 mm; it can be said that the basin has an abundant supply of water resources. It has an annual river run-off of 90 percent, however, this concentrates during the six months of wet season (May to October), so water

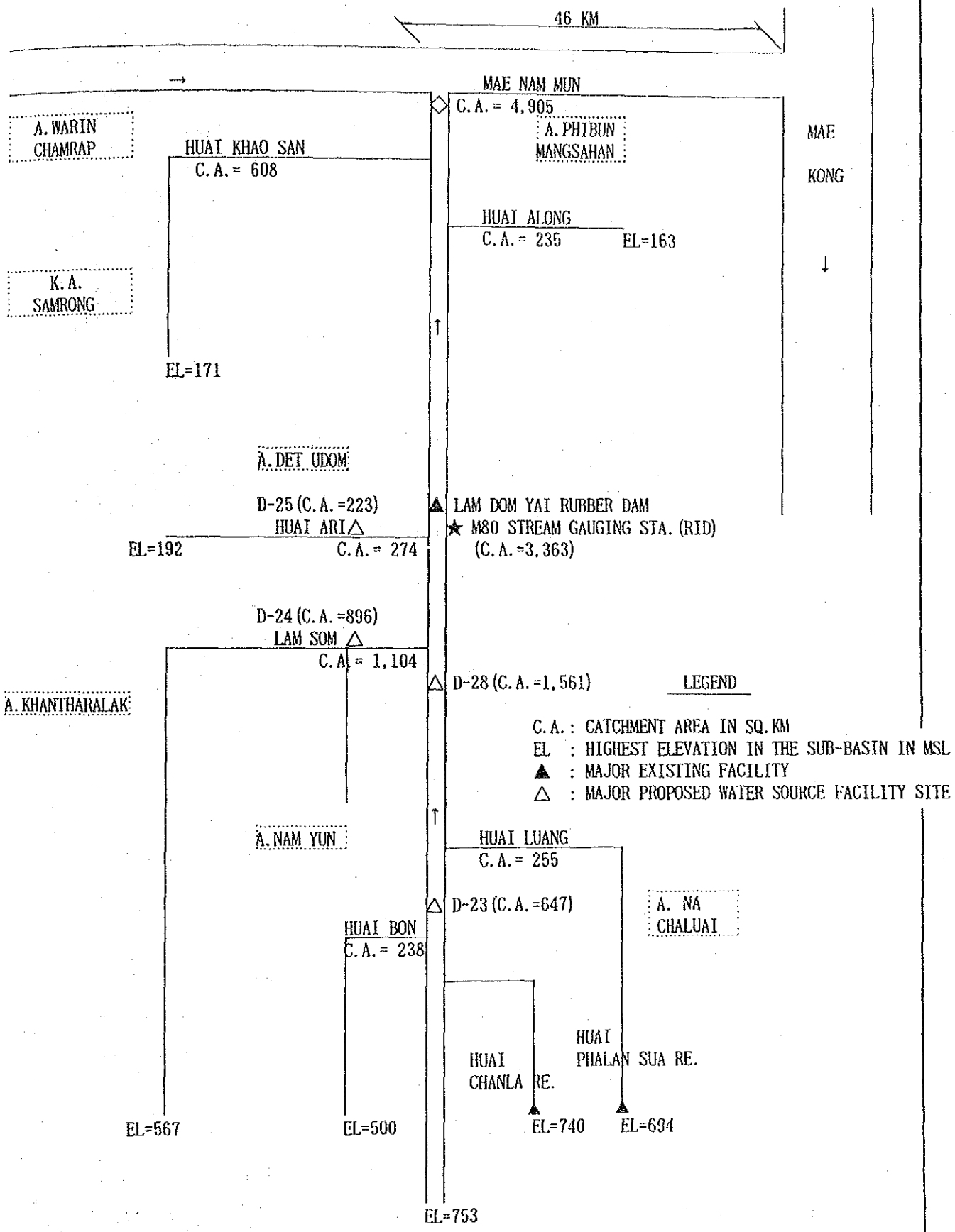


FIGURE 2-5 SCHEMATIC DIAGRAM OF RIVER SYSTEM

source facilities with storage functions will be needed for supplying a stable supply of irrigation water. The plan for water source facilities in this river basin was established about 34 years ago as the Dom Yai River Basin Project of RID (1957). The plan was a large-scale project with 14 reservoirs. A revised plan was set up in 1982, but it was not activated due to the problems of appropriate appropriate compensation for submersion by reservoirs to be constructed. The dimension of the existing irrigation facilities are shown in the following table. In this river basin, there are 127 small-scale reservoirs, ponds, weirs and pumping stations. They were constructed by RID, DLD, ARD, NEA and DOLA in 1971, as small-scale water resources development projects for irrigation and domestic water supply.

The projects under construction and to be constructed are shown in the following table and Table 2-2, amounting to eight, all of which are located in the upper-basin of the river basin. They are mainly conducted by RID. Two of the projects are medium-scale irrigation projects, in which reservoir construction has been accomplished; the canal networks of irrigation to the agricultural land are still under construction.

The other six projects called Phanom Dong Rek are projects mainly for the defense of the national border area near Cambodia and Laos; one of these has been implemented already.

Irrigation Projects, Constructed and Under Construction

Excuting Agency	No. of Projects	Project No. by Type of Facilities				Storage Capacity	Catchment Area	Const. Year
		Reservoir	Pond	Weir	Pump	(MCM)	(sq.km)	
1. Projects Constructed								
RID (SSIP)	52	33	-	19	-	19.24	-	1979-91
DLD	7	2	-	5	-	0.17	-	1983-87
NEA	4	-	-	-	4	-	-	1980-94
ARD	30	2	25	3	-	0.57	-	1971-90
DOLA	34	-	-	34	-	-	-	1986-89
Sub-total	127	37	25	61	4	19.98	-	-
2. Projects Under Construction								
RID (MSIP)	2	2	-	-	-	50.40	168.7	1988-92
RID (PDRP)*1	1	1	-	-	-	8.00	31.9	1990-95
Sub-total	3	3	-	-	-	58.40	200.6	-
3. Projects to be Constructed								
RID (PDRP)	5	5	-	-	-	41.56	151.4	1992-95
Total	135	45	25	61	4	119.94	352.0	-

Note: *1: Phanom Dong Rek Program

TABLE 2-2 PROJECTS UNDER CONSTRUCTION AND TO BE CONSTRUCTED

Project		D-3-A Huai Kha Noon	D-8 Huai Phalan Sua	D-20 Huai Chanla		
Location						
- Changwat		Si Sa Ket	Ubon	Ubon		
- Amphoe		Kantharalak	Nam Yun	Nam Yun		
- Tambon		Sao Thong Cha	Dom Pradit	Dom Pradit		
River Run-off						
Catchment Area	(sq.km)	31.9	114.7	54.0		
Mean Annual Rainfall	(mm)	1,331.3	1,508.2	1,430.0		
Mean Annual Run-off	(MCM)	9.27	50.00	24.50		
Reservoir						
- Reservoir Surface Area	(sq.km)	2.30	11.7	3.2		
- Total Storage Capa.	(MCM)	8.00	33.50	16.90		
- Dead Storage Capa.	(MCM)	0.72	1.12	0.60		
- Effec. Storage Capa.	(MCM)	7.28	32.38	16.30		
- High Water Level	(m)	201.50	171.43	171.86		
- Normal Water Level	(m)	200.0	170.00	170.00		
- Low Water Level	(m)	193.50	163.50	160.50		
Dam						
- Length of Dam	(m)	820	2,170	3,850		
- Height of Dam	(m)	16.7	13.50	20.0		
- Embankment Volume	(1,000 cu.m)	-	560	1,280		
- Spillway Design Dis.	(cu.m/s)	12.6	63.0	47.0		
Irrigation System						
- Irrigable Area	(ha)	560	1,096	2,272		
Implementation						
- Project Status		Under Const.	Under Const.	Under Const.		
- Construction Period	(Project)	1990-92 (PDR)	1988-92 (MSIP)	1987-99 (MSIP)		
- Construction Cost	(MB)	82	154	114		

Project		D-5 Huai Bon	D-13 Huai Luang (Lower)	D-18 Huai Wang Yai	D-19 Huai Yang	D-31 Huai Phalan
Location						
- Changwat		Ubon	Ubon	Ubon	Ubon	Ubon
- Amphoe		Nam Yun	Na Chaluai	Nam Yun	Nam Yun	Nam Yun
- Tambon		Si Vichien	Na Chaluai	Dom Pradit	Dom Pradit	Ta Kao
River Run-off						
Catchment Area	(sq.km)	25.0	65.0	35.4	20.0	6.0
Mean Annual Rainfall	(mm)	1,468.6	1,468.6	1,468.6	1,491.7	1,505.9
Mean Annual Run-off	(MCM)	9.66	26.66	14.51	8.10	2.8
Reservoir						
- Reservoir Surface Area	(sq.km)	0.46	2.48	1.78	1.00	0.75
- Total Storage Capa.	(MCM)	6.44	18.00	9.80	5.67	1.65
- Dead Stroage Capa.	(MCM)	0.55	1.46	0.59	0.44	0.05
- Effec. Storage Capa.	(MCM)	5.89	16.54	9.21	5.23	1.60
- High Water Level	(m)	211.00	186.45	180.00	179.50	-
- Normal Water Level	(m)	209.50	185.00	178.60	178.20	188.25
- Low Water Level	(m)	190.00	174.50	168.40	168.14	184.50
Dam						
- Length of Dam	(m)	840	2,240	1,075	1,500	700
- Height of Dam	(m)	37.5	24.0	20.0	19.0	5.8
- Embankment Volume	(1,000 cu.m)	1,444	1,459	444	-	-
- Spillway Design Dis.	(cu.m)	106.3	160.0	146.9	-	-
Irrigation System						
- Irrigable Area	(ha)	848	2,080	1,200	640	240
Implementation		Wating for	Wating for	Wating for	Wating for	Wating for
- Project Status		Construction	Construction	Construction	Construction	Construction
- Construction Period	(Project)	1992-93(PDR)	1992-93(PDR)	1992-93(PDR)	1994-95	1992(PDR)
- Construction Cost	(MB)	115	153	84	54	5

3) Potential for Developing Surface Water

The whole river basin of 4,905 sq.km has a mean annual run-off of 2,652 MCM. The river basin of 352 sq.km corresponding to about seven percent of the whole river basin, as shown in the below table, is regarded as the catchment area for the projects constructed, under construction and to be constructed at the upper-basin. The remaining catchment area of about 4,553 sq.km which can produce about 2,460 MCM a year will have development potential to be utilized in the future.

Potential for Developing Surface Water

Item	Dimension
Catchment Area (km^2)	4,905
Mean Annual Run-off (MCM)	2,652
Projects Constructed	
(Small-Scale Water Source Development Projects)	
- Catchment Area (km^2)	-*1
- Storage Capacity (MCM)	20
Projects Under Construction and to be Constructed (MSIP, PDRP)	
- Catchment Area (km^2)	352
- Storage Capacity (MCM)	98
Future Development Potential	
- Catchment area (km^2)	4,553
- Mean Annual Run-off (MCM)	2,460

*1 : Existing small-scale water source development project areas are to be including in the future water source development project areas. Then, the run-off from the catchment area of about 600 sq.km is estimated as future development potential.

2.4.2 Groundwater

1) Groundwater Conditions

Data on about 300 existing wells were collected during the fieldwork study. The hydrogeological and water quality maps, with a scale of 1 : 100,000, also prepared for the analysis of groundwater potential as shown in Figure 2-6 and Figure 2-7. The data was mainly collected from the Department of Mineral Resources (DMR) in Bangkok and Ubon Ratchathani.

The Basin is situated in the southeastern part of the Khorat Plateau. As shown in Figure 2-6, the aquifers in the area are classified and listed

FIGURE 2-6 HYDROGEOLOGICAL MAP IN THE BASIN

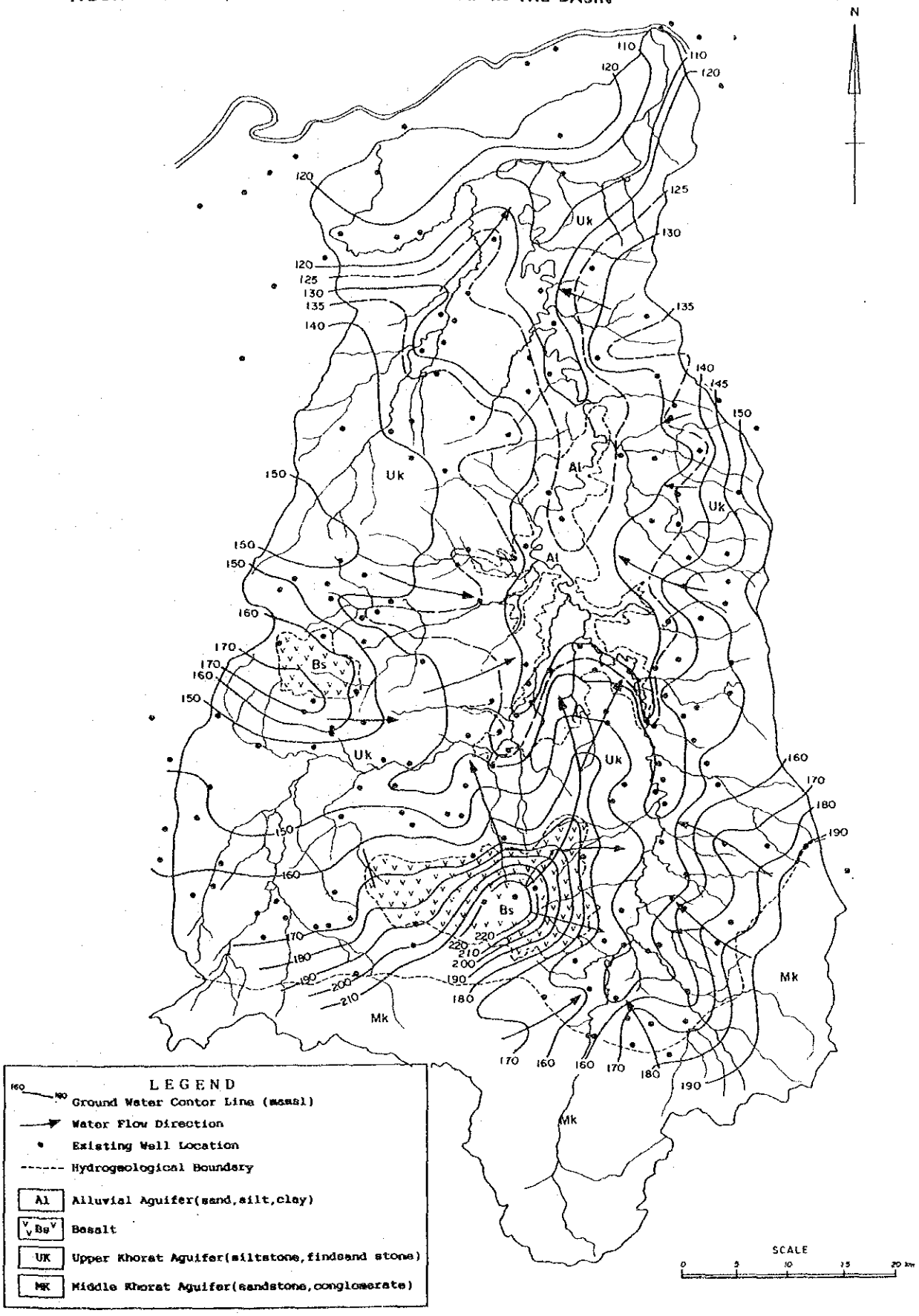
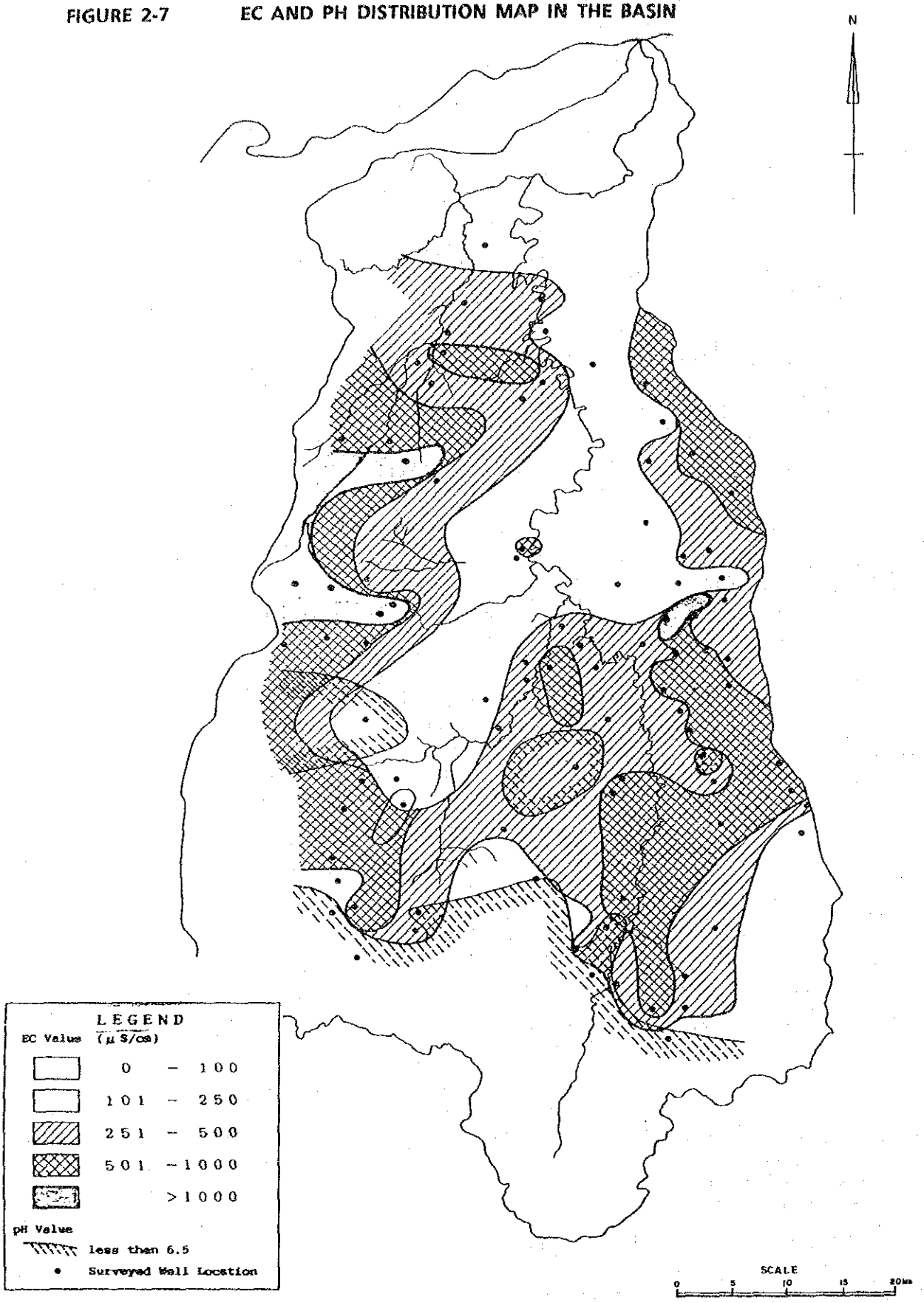


FIGURE 2-7 EC AND PH DISTRIBUTION MAP IN THE BASIN



according to their rock types and water-bearing characteristics, ranging from youngest to oldest, namely, Alluvial aquifer, Basalt, Upper Khorat aquifer and Middle Khorat aquifer*1. Most wells in the area are situated in the Alluvial and Upper Khorat aquifer: the latter consists of fine sandstone and siltstone including rock salt, and has low coefficient of permeability less than 5×10^{-4} cm/sec, and the former also has low permeability less than 5×10^{-3} cm/sec *2.

Groundwater in the area is widely utilized for drinking purposes. This is due to the shortage of surface water during the dry season, however, there are no wells for irrigation.

As shown in the following table, an average specific capacity in the area is 0.52 cu.m/hr/m (0.14 ℓ/sec/m), and this means that one well is expected to yield 0.14 ℓ/sec in drawdown of one meter of water table.

When an average drawdown of 13.1 m is applied to the calculation, the expected yield of one well will be as follows;

$$13.1\ \text{m} \times 0.14\ \ell/\text{sec/m} = 1.83\ \ell/\text{sec/one well}$$

According to the above calculation, irrigable area is estimated at less than two hectares, since one liter per second of water can irrigate one hectare.

Summary of Existing Well Structure & Pumping Test Data

Item	Depth (m)	GWL (m)	Yield (cu.m)	Drawdown (m)	Specific Capacity (cu.m/hr/m)
Maximum	82.9	16.4	32.60	42.1	3.43
Minimum	15.2	0.6	0.68	1.8	0.03
Average	32.5	5.4	4.76	13.1	0.52

Note: *1 : Vachi Ramnarong, 1985, Review on Groundwater in the North-Eastern Thailand.

**2 : RID, 1987 to 1991, Geological Investigation Reports in Ubon Ratchathani and Si Sa Ket Provinces.

2) Water Quality of Groundwater

Field tests of water quality of the 94 selected wells were tested for Electric Conductivity (EC), Hydrogen-ion concentration (pH) and Temperature (°C) using a portable kit.

A summary of the tests is shown in the following table and illustrated in Figure 2-7.

Summary of Water Quality Test

Range of EC (µS/cm)	No. of Wells	Range of pH	No. of Wells
< 100	2	<6.5	14
100 - 250	19	6.5 - 9.2	80
251 - 500	37	>9.2	0
501 - 1,000	30		
1,001 - 5,000	6		
> 5,000	0		
Total	94		94

Authorized by U.S. Salinity Laboratory, an acceptable upper value for irrigation for most crops and soils is 250 µS/cm, and the standard pH value of Drinking Water for Thailand is 6.5 - 9.2.

The following table shows that EC values of 78 percent in the investigated wells exceed acceptable upper values, and pH values of 15 percent. The distribution of EC which exceeds the acceptable limit covers an area of more than 50 percent. This mostly occurs in two areas; one is distributed in the eastern mountainous area bounded by the Lam Dom Noi basin, and consists of the Phuphan Formation, and the other is distributed in the western hilly area bounded by the Huai Khayung basin, and consists of the Muha-Sarakham Formation. The high value of EC probably results from the geology in the area. The temperature of the groundwater ranges from 27.5 to 31.1°C and is suitable for rice cultivation.

3) Groundwater Potential

The aquifer distribution in the area is composed of fine sandstone, siltstone and unconsolidated alluvial deposits. Fine sandstone and siltstone are generally semi or impermeable layers, and the yield is low as stated in previous paragraph. The unconsolidated deposits also have a low yield. It seems that irrigable area of each well is less than two hectares (12.5 rai), and one well is required for two farmers (average farmland for one farmer in the area is one hectare), therefore, large-scale construction plans and running costs are needed for groundwater development.

EC value exceeds the acceptable limit of 250 µS/cm in more than 50 percent of the area, and it seems that many wells drilled for irrigation are most likely to produce saline water.

From these results, it is concluded that groundwater development for irrigation is not suitable for the area unless it involves small-scale irrigation in limited areas, where adequate yield and water quality can be obtained or there is no potential for surface water.

2. 5 Geology and Embankment Materials

2. 5. 1 Field Investigations

Geological investigations were carried out in the area, and geological maps of seven dam-sites, that is, D-23, D-24, D-25, D-28, D-29, J-1 and J-7, were made. Topographic maps with a scale of 1 : 10,000 in D-23, D-24, D-25, D-28 and J-1 have been obtained from RID, and the field investigations were performed based on these maps. In D-29 and J-7, however, investigations were carried out by these topographic maps with a scale of 1 : 50,000. Furthermore, aero-photograph interpretations have been conducted at the sites of D-25 and D-28.

18 test pits were excavated near the dam axis of six dam-sites, namely, D-23, D-24, D-25, D-28, D-29 and J-7 for the observation of geology and embankment materials. 22 soil samples were taken from the pits and their characteristics were analyzed in the RID laboratory in Nonthaburi, Bangkok.

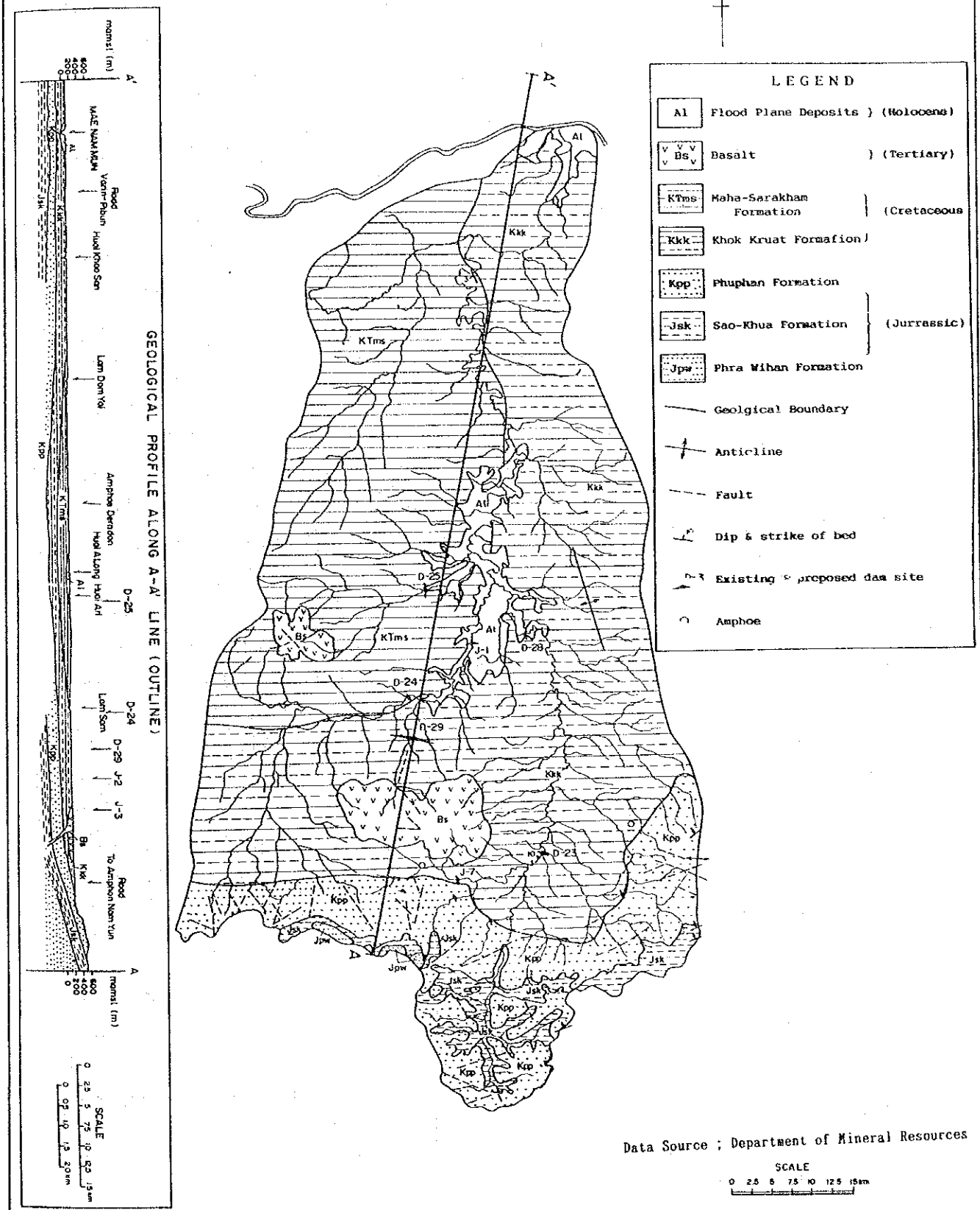
2. 5. 2 Topography and Geology in the Area

The area including preliminary selected dam-sites is a monotonous plane, broken by gently rolling hills. The altitude of the area is between 130 and 180 m above mean sea level.

It is apparent from aero-photographs and topographic maps that the Lam Dom Yai and its tributaries have changed their courses back and forth across the basin. Many of these ancient meanders are recognized from aero-photograph by their topographic expression and vegetation. The meanders have formed thick deposits of sand, silt and clay. These areas are called flood planes; they are thickly covered by fertile soil and are found near swamp areas. The bed-rock forms low ridges, where the soil is less fertile, more sandy and less conducive to rice cultivation.

Basement rocks, found in areas mentioned above, consist mostly of fine to medium sandstone and siltstone of the Khok Kruat Formation as shown in Figure 2-8, however, they are covered by lateritic soils, residual soils, river terrace deposits, flood plane deposits, talus and recent river deposits. The

FIGURE 2-8 GEOLOGICAL MAP IN THE BASIN



outcrops of the basement rocks, therefore, are very poor, with the exception of the D-23 dam-site. The geological structures of these dam-sites have been mainly presumed from the test pits, geographical surveys and existing data.

It is difficult to assess the thickness of unconsolidated layers and the characteristics of basement rocks; the assessment should be conducted after detailed investigations. However, the geological structures around the dam-sites are drawn with field surveys, test pits and aero-photographs to assist with calculations for the design and cost of dam construction.

2. 5. 3 Dam-Site Geology

1) D-23 Lam Dom Yai (M)

The dam-site is situated in the upperstream of the Lam Dom Yai; it meanders through rolling hills, and forms a narrow flood plane and steep river banks. The estimation of gradients found around the slopes of the hills around the dam-site are about 1/50 on the right bank and about 1/80 on the left bank.

The area consists of the Khok Kruat Formation, residual soils, talus deposits and flood plane deposits. The Khok Kruat Formation, composed of slightly hard sandstone intercalated by siltstone, is exposed on the river floor and the left bank around the dam-site. On the riverbed, alternating beds of siltstone and fine to medium grained sandstone are observed. It seems that the sandstone is impermeable, however, the thin siltstone bed is well jointed and has high permeability. The excavation line of the dam foundation will reach a maximum depth of seven meters.

2) D-24 Lam Som

The dam area is composed of gently sloping hills and a nearly level river floor. The Lam Som, flowing gently from west to east, forms a wide flood plane up to 500 m wide near the dam-site; a number of swamps exist on the flood plane. Slopes near the dam-sites have gradients of about 1/180 at both banks, and the land is almost cultivated.

Because it is covered by unconsolidated layers, such as residual soils, hard laterite, talus deposits and flood plane deposits, the bedrock does not crop out. However, in the test pits of P-2 and P-3, completely to slightly weathered alternating beds of sandstone and siltstone were observed, and the bed belongs to the Maha Sarakham Formation. The rocks are presumably permeable and the excavation line of the dam foundation will be more than three meters deep.

3) D-25 Huai Ari

Terrain found within the dam area includes gently sloping alluvial surface and a nearly level river floor. The Huai Ari river flowing from west to east forms a wide flood plane reaching 700 m in width around the dam axis. The river meanders in a small radius with a gradient of about 1/650. Old river courses are recognized on the plane through aero-photograph interpretation; some of the swamps are being utilized for irrigation. The gently sloping alluvial surfaces have gradients of about 1/100 at the left bank, and about 1/50 at the right bank. The majority of land around the dam-site is cultivated except for the forest area along the river. The farmland consists of sandy to silty soil.

The geology in the dam area is composed of basement rock, residual soils, talus and flood plane deposits. With adverse conditions of a heavy cover of unconsolidated sediments, it is difficult to assess the rock quality of the dam foundation. In the test pits, however, highly weathered fine to silty and permeable sandstone intercalated by mudstone was observed. The permeable sandstone is a member of the Maha-Sarakham Formation.

Residual soils, one to two meters thick, have originated from the Maha-Sarakham Formation. They were observed on the flatland between rolling hills, and consist of sand, silt and mud. Lateritic soils, one meter thick, are found in the test pits and river banks covered by talus deposits.

Talus overlying the Maha-Sarakham Formation is distributed on the slopes of the rolling hills, and consists of fine to silty sand from the observation of the test pits. The talus is loose and presumably two to three meters thick.

The excavation line of the dam foundation is presumably more than six meters deep near the river floor.

4) D-28 Lam Dom Yai (L)

The dam-site is situated halfway up the Lam Dom Yai; the river meanders from east to west around the dam-site, and forming a wide flood plane. The old river courses are recognized by aero-photograph interpretation, and are swamps utilized for irrigation. The slopes of the rolling hills have gradients of 1/25 on the right abutment and 1/15 on the left abutment.

The area consists of the Khok Kruat Formation, residual soils, talus and flood plane deposits. The Khok Kruat Formation in the dam-site is covered by thick soils, therefore, the evaluation of rock quality is difficult. From the observation of the test pits and residual soils, however, it seems that the formation is composed of fine to silty sandstone intercalated by siltstone and conglomerate. The highly weathered layer of the basement rock is presumably two to three meters thick and permeable.

Residual soils, three to five meters thick, are highly weathered rock and consist of fine sand, silt and clay. Talus, a maximum of three meters thick, is distributed at the foot of the rolling hills, and composed of sand, silt and clay. Flood plane deposits distributed widely along the river have accumulated through the transportation of the river, and consist of loose sediments such as fine sand, silt and clay. The deposits are presumably of one to three meters thick.

The excavation line of the dam foundation is presumably more than seven meters deep around the river floor.

5) D-29 Huai Fang Deang (L)

The dam has two rivers, namely Huai Fang Deang and its tributary called as Huai Dom Rong; the dam length is more than 2,000 m. The area is mostly composed of very gentle sloping hills and nearly level river floors.

Basement rock does not crop out, since heavily covered unconsolidated layers, and the estimated excavation line will be less than three meters deep.

6) J-1 Lam Som (L)

The dam area is mostly composed of gently sloping hills and almost level river floor, and in places, relatively steep sloping hills. The Lam Som river around the dam-site meanders back and forth, and forms wide flood plane.

No basement rock crops out, because it is covered by heavy unconsolidated sediments, such as residual soils, talus deposits and flood plane deposits. These deposits are presumably more than five meters thick.

7) J-7 Huai Bon

Terrain found within the dam area includes alluvial surface and a flood plane that are nearly level. The Huai Bon river flows from west to east with a gentle gradient, and the flood plane around the dam axis is about 400 m wide.

The area is composed of the Khok Kruat Formation, residual soils which originate from rock formation, talus deposits and flood plane deposits. The Khok Kruat Formation does not crop out of the river floor or the test pits. However, because of heavy cover of unconsolidated sediment, the excavation line of the dam foundation is presumably seven meters deep near the river.

2. 5. 4 Embankment Materials

Test pits were dug at the dam-site of D-23, D-24, D-25, D-28, D-29 and J-7 for the observation and confirmation of embankment materials, and especially for impervious materials. Typical soil samples were taken from the pits and the physical properties were analyzed in the RID laboratory. The results of the test are summarized in Table 2-3.

The soil samples collected in each dam-site consist of residual soils originated from basement rocks, talus deposits, terrace deposits, recent river deposits, etc. In the field investigation and the observation of the test pits, residual soils distributed in rolling hills were found more adequate for impervious materials. As shown in Table 2-3, the coefficient of permeability is less than 10^{-5} cm/sec, and low natural water moisture and optimum water moisture indicate that the soils are appropriate for construction work.

TABLE 2-3 SUMMARY OF SOIL LABORATORY TESTS

Test of Pit No.	Geology	Class *1	Gs *2	Wn (%)*3	IP (%)*4	Wopt (%) *5	K (cm/sec)*6
D-23 (P-1)	Terrace Deposit	CL	2.69	18.6	11.20	-	-
D-23 (P-2)	Terrace Deposit	SM	2.68	11.0	-	12.5	2.13E-05
D-24 (P-1)	Residual Soil	CL	2.71	16.9	9.80	-	-
D-24 (P-1)	Residual Soil	CL	2.75	18.0	13.30	-	-
D-24 (P-2)	Residual Soil	CH	2.69	26.2	44.00	21.9	2.41E-08
D-24 (P-3)	Residual Soil	ML	2.73	26.3	12.50	20.7	1.73E-08
D-25 (P-1)	Residual Soil	ML	2.69	14.4	-	-	-
D-25 (P-2)	Talus	CL	2.73	14.5	7.60	-	-
D-25 (P-3)	Laterite	CL	2.74	15.7	12.30	-	-
D-25 (P-4)	Residual Soil	MH	2.81	23.1	20.30	27.8	3.46E-08
D-25 (P-4)	Siltstone	CL	2.76	24.5	22.10	17.2	9.69E-08
D-28 (P-1)	Talus	CL	2.62	14.0	14.00	-	-
D-28 (P-1)	Residual Soil	CL	2.73	15.1	13.90	16.5	5.80E-08
D-28 (P-2)	Residual Soil	SM	2.74	14.2	0	-	-
D-28 (P-2)	Residual Soil	SM-SC	2.67	9.3	5.50	12.0	3.31E-07
D-28 (P-3)	Residual Soil	GM-GC	2.66	17.7	6.40	-	-
D-28 (P-3)	Residual Soil	SC	2.73	16.7	8.50	-	-
D-28 (P-3)	Residual Soil	SC	2.67	15.0	9.30	12.7	2.36E-07
D-29 (P-2)	Laterite	SC	2.68	20.4	15.50	16.8	2.96E-08
J- 7 (P-1)	Residual Soil	CL	2.71	16.7	13.00	-	-
J- 7 (P-2)	Flood	SM	2.62	7.7	-	-	-
J- 7 (P-3)	Residual Soil	CL	2.70	14.8	10.10	13.6	2.40E-07

*1 : Engineering Soil Classification System
*2 : Specific Gravity
*3 : Natural Water Moisture Content
*4 : Plasticity Index
*5 : Optimum Moisture Content
*6 : Coefficient of Permeability

In other unconsolidated deposits, impervious soils are found in alternating pervious beds, such as fine to medium sand, and it seems that the quality control for core materials is difficult to achieve. Those deposits, therefore, are more suitable for semi-pervious or pervious materials.

The presence of impervious materials was revealed by the field investigation and by the observation of test pits, however, using accurate maps, detailed surveys of material should be conducted for the volume and locations.

Hard rocks appropriate for dam embankments could not be found in the dam areas and their perimeters, however, two basalt layers are distributed in the basin as shown in Figure 2-8. In the area of Amphoe Num Yun, plant crushing is operated by a private company, and the rock quality is adequate for riprap materials and a coarse aggregate of concrete. Fine aggregate for drainage and concrete can be obtained from the Mun river.

2. 6 Soil and Land-Use

2. 6. 1 Soil Characteristics

Most soils in the basin are formed from alluvial sediments derived from sandstone and conglomerate. The land forms are classified into four categories; alluvial plains, low terraces, middle terraces and hills, but major soils covering the basin are those on low and middle terraces. They occupy about 75 percent of the total area.

Soils in the area belong to 24 soil series which are categorized into 15 soil sub-groups, according to the USDA Taxonomic Units.

Soil Classification in the Basin

Soil Series	Area (sq.km)	Percent (%)
1) Korat (Kt)	1,744.0	35.6
2) Slope Complex (Sc)	693.0	14.1
3) Korat-Phon Phisai Association (Kt/Pp)	667.1	13.6
4) Roi Et (Re)	480.7	9.8
5) Nam Phong (Ng)	386.6	7.9
6) Phon Phisai (Pp)	203.4	4.1
7) Roi Et - On Association (Re/On)	113.6	2.3
8) Roi Et - Phen Association (Re/Pn)	113.1	2.3
9) Ubon (Ub)	92.5	1.9
10) Buntharik (Bt)	92.4	1.9
11) Others	318.6	6.5
Total	4,905.0	100.0

Source: Soil Survey Report of the Department of Land Development (1981)

Most of these soil series are characterized by sandy, sandy loam and loamy sand. Soil texture is high with sand and silt. The soil pH is around 4.5 to 6.0. The soil fertility and organic matter are low.

2. 6. 2 Land Classification

According to the land classification systems by DLD, the land suitability of the basin has been classified as follows; it has been found that

40.0 percent of land is suitable for paddy rice, 44.6 percent is suitable for upland crops and vegetables, and the remaining area is for fruits and trees. However, the area suitable for paddy rice may face on water shortage as the monsoon trough moves up away from the country and top soil of the area is mostly sandy and some area is high steep (36 percent of suitable area).

Although the area suitable for upland crops and vegetables is as large as 44.6 percent, the area that is most suitable for upland crops and vegetables is only 5.3 percent. The remaining area (39.3 percent) has some limitations to be overcome such as low fertility, coarse texture, etc. Additionally, there is the area (10.3 percent) which is unsuitable for any economic crops because of topography such as mountainous terrain with soil with rocky outcrop (See Table 2-4).

2.6.3 Land-Use

Currently, in the basin, forest land make up 39.4 percent and agricultural land is about 47.4 percent as shown below. Of the total area used for agriculture, 38.1 percent is used for paddy rice and only 9.3 percent is used for upland field.

Present Land-Use

Land Category	1988 Area (ha)		1988 (%)
Cultivation Area			
Paddy Field	186,800		38.1
Upland Field	45,400	*1	9.3
Sub-total	232,200		47.4
Non-Cultivation Area			
Forest	193,400		39.4
Residential Area	23,600		4.8
Public & Other Area	41,300		8.4
Sub-total	258,300		52.6
Total	490,500		100.0

Note: *1 : inclusive of fallow area of 12,200 ha
Data Source : Land-Use Map (1 : 100,000) prepared by DLD, Agricultural Reports of 1989 and 1990 prepared by Provincial Agricultural Extension Office, and 1988 Statistic Data

TABLE 2-4 LAND CLASSIFICATION IN THE BASIN

Land Classification	Description	Area (ha)	Area (%)
Suitability for Paddy Rice			
L1	Suitable for paddy rice ; in area water resources exist, annual crops or vegetables can be grown in the dry season	3,614	0.7
L2	Suitable for paddy rice at a risk of water shortage when rainfall is erratic, as soils in most area are sandy and some areas are with high steeps	176,536	36.0
L4	Suitable for paddy rice, field crops and pasture	19,157	3.9
Suitability for Upland Crops			
L5	Suitable for upland crops and vegetables	25,880	5.3
L6	Suitable for upland crops and vegetables although soils are sandy and fertility is low in nature	46,700	9.5
L7	Moderately suitable for upland crops or suitable for pasture as soils are very sandy in very low fertility	58,700	12.0
L8	Suitable for upland crops however, lands are currently renovate for growing rice	86,967	17.8
Suitability for Fruits and Trees			
L10	Suitable for fruits and trees	3,615	0.7
L12	Suitable or moderately suitable for fruits and trees as soil contains gravel or having layer of rock in subsoil	18,723	3.8
Mountainous Area			
L13	High mountainous areas, rolling topography with rock outcrops or irregular hilly areas having rock outcrops mixed with soil unsuitable for economic crops	50,607	10.3
	Total	490,499	100.0

Nevertheless, land use for agriculture is constantly increasing since forest encroachment results from the demand for land for growing crops.

The forest in the basin is mainly national reserved forest. This area is a degraded area that has been transformed for other purposes. The natural forest areas are those of Yod Dom Wild Life Sanctuary Area, Phu Jong Na-Yoi National Park and Lam Dom Yai left bank forest area (southern part) only.

The residential area or village area, including the public area, accounts for 13.2 percent of the total area. Housing demands, which have increased with population growth, may be the reason for the high percentage of residential area.

2. 7 Agricultural Conditions

2. 7. 1 Land Ownership

According to the 1988 Intercensal Survey of Agriculture, the land holdings by size and area in Ubon Ratchathani Province, which occupy most of the area in the basin is dominated by areas between 1.6 and 6.4ha (10 and 40rai), and the tenure form is mainly own occupied land (97.1 percent).

Most of the forest in the basin is a national reserved forest as mentioned in the paragraph of 2. 6. 3 "Land Use". However, the considerable forest has been changed to farmland by illegal reclamation. These reserved forest areas are still classified as the same, although they are now farmland.

Because of such a land ownership pattern, detailed data and information on this matter are incomplete at present. Only the urban area and its surroundings and the agricultural land reform project area are complete. Under these circumstances, land ownership has been calculated from the results of the survey on farm household economics, which was conducted in the upper, middle and lower- area in the basin during the fieldwork.

The total number of farms in the basin is 61,782; 84.5 percent are owned by small-scale farmers with areas of less than 6.4 ha (40 rai) which accounts for 69.8 percent of the area. 15.5 percent are owned by medium-scale farmers with areas of less than 12 ha (75 rai) which accounts for 30.2 percent of the area. On that account, large-scale farmers are not in existence.

The average land holding size is 4.67 ha (29.20 rai) in the upper-basin, 5.71 ha (35.65 rai) in the middle-basin, and 4.65 ha (29.06 rai) in the lower-basin. Regarding the status of land holding, owned farmers account for nearly 100 percent in the whole basin.

Land tenure and land certificates in the upper, middle and lower-basins are as follows:

Land Tenure by Average

Items	Upper -Basin		Middle -Basin		Lower -Basin	
	No. of Plots	Area	No. of Plots	Area	No. of Plots	Area
Owned Land	2.8	4.13 ha (25.79 rai)	2.7	5.08 ha (31.72 rai)	2.9	4.64 ha (28.97 rai)
Rented Land						
Addition. Rent	-	-	-	-	-	-
Rented Only	-	0.02 ha (0.10 rai)	-	-	-	-
Other farms given to operate free	0.5	0.47 ha (2.92 rai)	0.5	0.56 ha (3.52 rai)	-	-
OtherLand						
Co-op. Land	-	-	-	-	-	-
Resettle. Land	-	-	-	-	-	-
Public Land	-	-	0.1	0.01 ha	-	-
Reserve.forest	-	0.06 ha (0.38 rai)	-	(0.06 rai)	0.1	0.01 ha (0.09 rai)
Others	-	-	-	-	-	-
Total Area	3.4	4.67 ha (29.20 rai)	3.3	5.65 ha (35.30 rai)	3.0	4.65 ha (29.06 rai)

Data source : Farm household economic survey conducted by JICA Study Team in 1991.

Farm Size on Land Tenure by Average

(Unit : rai)

Farm Size	Upper -Basin			Middle -Basin			Lower -Basin		
	Owned	Rent	Others	Owned	Rent	Others	Owned	Rent	Others
Small Farms									
Min. Size	10.0	4.0	10.0	4.0	0.0	6.0	0.0	0.0	0.0
Max. Size	20.0	4.0	15.0	17.0	0.0	20.0	0.0	0.0	0.0
Medium Farms									
Min. Size	24.0	0.0	21.0	21.0	0.0	35.0	23.0	0.0	0.0
Max. Size	40.0	0.0	33.0	40.0	0.0	35.0	35.0	0.0	0.0
Large Farms									
Min. Size	48.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0
Max. Size	61.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0

Data source : Farm household economic survey

Small Farmer	:	0.25 - 20 rai	(0.04 - 3.2 ha)
Medium Farmer	:	20 - 40 rai	(3.2 - 6.4 ha)
Large Farmer	:	40 rai	(6.4 ha -)

Land Certificate for Arable Land (Owned Land)

(Unit : %)

Type of Land Title Document	Upper-Basin	Middle-Basin	Lower-Basin	Total Area
Title Deed	2.7	2.8	11.2	3.7
Nor Sor 3 Kor	2.0	26.9	48.4	18.5
Nor Sor 3	36.3	42.0	27.1	38.8
Nor Sor 2 (ALRO)	12.8	0.0	0.0	6.3
Sor Khor 1	0.0	3.3	0.0	0.1
Phor Bor Thor 6	33.3	16.9	0.0	21.6
Sor Thor Ko	8.6	0.0	0.0	4.2
No Certificate	4.3	8.1	13.3	6.8
Total	100.0	100.0	100.0	100.0

Data source: Farm household economic survey

Title Deed : who possesses a complete land right certificate

N.S.3K : who has land right capable of making transactions
(whose land has already been surveyed)

N.S.3 : who has a land right capable of making transactions.
(whose land has only been confirmed in aero-photograph)

N.S.2 : who has a only cultivation and dwelling rights incapable of making transactions.
(whose land is located in the place where land reform has been executed)

S.K.1 : who is able to have only cultivation and dwelling rights incapable of making transaction.
(who is obtainable when it is 10 to 15 years after illegal instruction, and the good second generation only is able to apply for N.S.3 in his generation)

P.B.T.6 : who has only cultivation and dwelling rights incapable of making transactions.

S.T.K : who has only cultivation and dwelling rights incapable of making transactions.

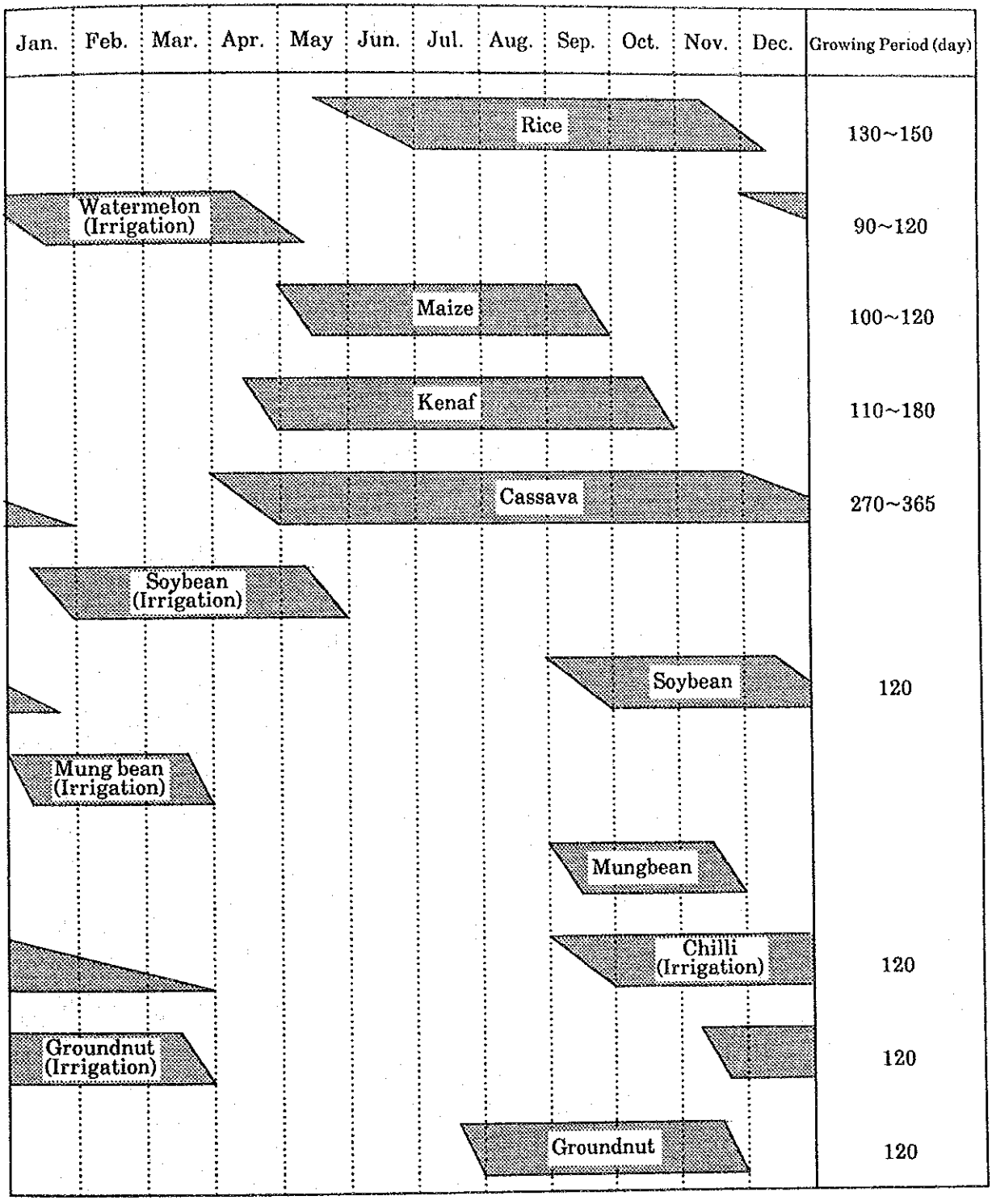
No certificate: who is an illegal farmer.

From the above-mentioned figures, it can be seen that most of the farmers in the area have owned land and the average farm size is dominated by medium size farms.

2. 7. 2 Cropping Pattern and Cultivation Area

Present cropping patterns in the basin are shown in Figure 2-9. Agricultural land in the area, which was described in the previous paragraph on "Soils and Land Use" is estimated to be about 232,200 ha (1,451.2 thousand rai). The planted area of each major crop for the agricultural land is shown below.

FIGURE 2-9 PRESENT CROPPING PATTERN



Present Cropping Area

Crop	Planted Area (ha)	Proportion for Total (%)
Paddy (Wet Season)	186,800	84.8
Non-glutinous	73,600	33.4
Glutinous	113,200	51.4
Paddy (Dry Season)	400	0.2
Sub-total	187,200	85.0
Upland Crops		
Cassava	12,700	5.8
Kenaf *1	13,000	5.9
Maize	2,500	1.1
Groundnuts	500	0.2
Others (water melon,others)	800	0.4
Sub-total	29,500	13.4
Fruit Trees		
Mango	1,100	0.5
Cashewnut	200	0.1
Others	900	0.4
Sub-total	2,200	1.0
Vegetables	1,400	0.6
Total	220,300	100.0

Note : *1 Kenaf includes jute.
Date source: National Statistical Office (NSO), 1988
Provincial Agricultural Extension Office 1990

Total cropping intensity of the agricultural land is estimated to be about 95 percent on the basis of mainly wet season rice in rainfed conditions. In the dry season, cropping is scarce due to the shortage of irrigation water. However, some dry season crops such as the second crop of rice, groundnuts, maize, cucumbers, and watermelons are observed in some area, where irrigation water is available, though they are restricted to small areas.

2.7.3 Crop Productivity

The gross production amount and yield per hectare of each major crop in the basin is tabulated below.

Production and Yield of Major Crops

Crop	Production (ton)	Average Yield (kg/ha)
Paddy (Wet Season)	233,000	1,248
Non-glutinous	94,000	1,273
Glutinous	139,000	1,232
Paddy (Dry Season)	1,200	3,219
Sub-total	234,200	
Upland Crops		
Cassava (Dry)	79,900	6,313
Kenaf *1	17,000	1,300
Maize	7,100	2,900
Groundnuts	720	1,300
Fruit Trees		
Mango	5,000	4,675
Cashewnut & Others	210	881
Vegetables	-	-

Note: *1 Kenaf includes jute.
Data source: National Statistical Office (NSO) 1988

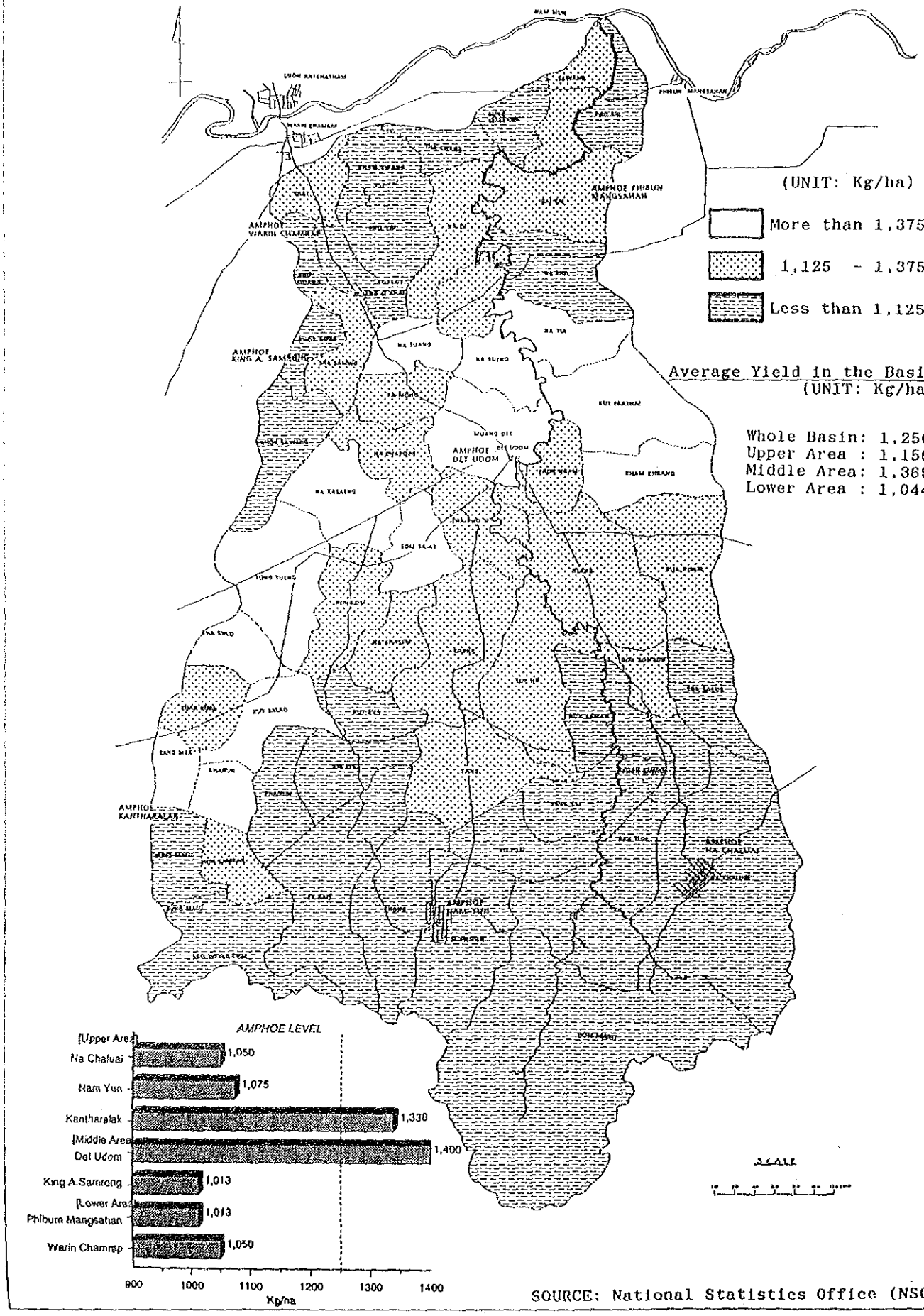
The yield of non-glutinous rice is a little higher than that of glutinous rice, but it doesn't always show the same tendency in the basin. The average yield of paddy is lower than that for the whole kingdom. Cassava and kenaf are the most important crops in the area. The estimated yield for each crop compared to the average yield of the whole kingdom is 95 percent and 108 percent.

Figure 2-10 indicates the distribution of present paddy yield in the basin.

2.7.4 Farming Practices

The main agricultural crop in the basin is wet season paddy; it occupies 84.8 percent of the total planted area. Upland crops such as cassava, kenaf (including jute), maize, and groundnuts, correspond to 13.4 percent; they

FIGURE 2-10 DISTRIBUTION OF PRESENT PADDY YIELD PER TAMBON IN THE BASIN



SOURCE: National Statistics Office (NSO)

are cultivated in both wet and dry seasons. The main fruit trees include mango, cashewnut, and papaya; they correspond to 1.0 percent and are densely cultivated around farm households throughout the basin. Especially, mango occupies 48 percent of the total fruit area. Fruits and vegetables, such as watermelon and chilli peppers, are grown in the producing district and are sent to Bangkok by merchants. Other vegetables, accounting for less than one percent, are cultivated for personal consumption by farmers.

Based on the results of the agriculture and agro-economic survey, conducted during the fieldwork, farming characteristics of the farm households can be summarized as follows;

Agricultural production in the basin is carried out mainly by small-scale farm owners. About 97.1 percent of the farmers living in the basin own their farms, but their holding areas are small-scale. Their farming characteristics are reflected by the natural and social conditions of the upper, middle and lower-basin in the Lam Dom Yai, hence, river basin has been settled and developed from the lower to upper-basins. Moreover, those external developments of farm land have encouraged an outbreak of illegal immigrants to the middle and upper-basins.

The present, cultivation mode of major crops are as follows.

1) Paddy Rice

Raising of Seedlings:

The seedlings period is during May and June. Nursery bed preparation begins with raising the water using small-sized pumps. The normal seedling rate is 60 to 70 kg/ha. 20 to 30 days after sowing, seedlings can be transferred. However, if no rain falls, plowing and land preparation cannot progress, thus, transplanting can't be carried out.

Plowing and Land Preparation:

After soil is softened in the wet season, cattle power is utilized to plow fields for land preparation. Sometimes, a large-type rented tractor is used, and walking-type tractors are also used.

Transplanting:

Generally, transplanting is carried out by family labor. However, large-scale farmers employ peripheral farmers as labor. In July and August during the transplanting period, three or four packs of seedings per stock are transplanted through the process of cutting at around 40 cm leaf edges of grown seedlings that are up to 60 to 70 cm tall. Ubon Ratchathani Province has been the producing district for glutinous rice, while Si Sa Ket Province has been producing non-glutinous rice due to traditional eating habits.

Harvesting:

Rice stocks are reaped at heights of 30 cm above field surfaces. They are dried on the ground for five or six days, then bundled and conveyed to threshing places. Because removing grains of the Indica type is easy, a simple method of threshing on the ground is commonly used. After threshing is completed, farmers sell the unhulled rice to merchants. The unhulled rice is transported to rice-polishing plants, where a water-content check and rating assessment are carried out to determine selling prices. For example, in 1989/1990, the price was 2.7 Baht/kg for glutinous rice and 3.5 Baht/kg for non-glutinous rice.

Variety:

According to the reports of extension workers from each Amphoe, the situation regarding variety and labor in the basin is as follows.

	Rate	
Varieites	(%)	
Khao Dawk Mali 105 (Non-glutinous)	50	
RD 6 (Glutinous)	40	
RD 15 (Non-glutinous)	4	
RD 8 (glutinous)	2	
Local variety	4	
Labor Situation		
Average family labor per farm household	3.3	persons
Employees per farm household	3.8	persons
Working days for paddy per year	85	days
Total working days per year	142	days

2) Cassava

Cassava is cultivated on dry lands, where weeding is required only at the initial stage. Therefore, it is controlled at low costs. The planting density is 1m×1m, and 10,000 stocks/ha(1,600stocks/rai). Cassava breeding is carried out using cuttage. The cultivation period is approximately ten months. Cassava is sold to a merchant or factory immediately after harvesting, this is because its tuberous roots are damaged by digging.

3) Kenaf

The production in the Provinces of Ubon Ratchathani and Si Sa Ket amounted to 39,000 tons (25 percent of Thailands total production) in 1988. Kenaf production has decreased annually. However, it remains an important crop in the basin.

The appropriate temperature for growing kenaf is between 16 and 27°C, and the growing period is four or five months. Any quality of soil, such as fluvial sand soil, laterite or sandy soil is suitable for its growth, though low and swampy places are not suitable. Seeds are sown in levees of 20 to 30 cm width in May or June. When the blooming period has come, stocks are pulled up, collected, and dried by sun light. Then, 30 to 40 stocks are packed in a bundle, and after cutting the end, the bottom portion is immersed in water for two or three days to soften the hard part. Then, they are horizontally immersed for 10 to 20 days to collect fibers. The collected fibers are composed of about 16 percent dried stem, i.e., 900 to 1, 350 kg/ha (144 to 216 kg/rai).

4) Maize

Maize production ranks third of all crop production in Ubon Ratchathani and Si Sa Ket Provinces.

After the beginning of the wet season, plowing and land preparation are carried out. Like cassava cultivation, a large type tractor is used for riding, and walking-type tractors and cattle power are also used. Seeds are sown by hand. Seeds are an excellent kind of Flint-type SWAN 1 with high yield and downy mildew resistance. Planting is carried out with 50,000 seedlings/ha

(8,000 seedlings/rai) and in the planting density 75 cm × 75 cm or 50 cm × 50 cm. The sowed amount is 25 kg/ha (4 kg/rai).

5) Groundnuts

Since groundnuts can be cultivated even in dry fields, they produce a good yield as the second dry crop of paddy. They are beneficial as a cash crop and are regarded as crop in the basin. The cultivated and recommended varieties are as follows.

1) So Kho 38	red seed	Valencia type *1
2) Lampang	white seed	Valencia type
3) Thainan No.9	white seed	Valencia type semi-prostrate

*1 Valencia type: standing, big stem with four to six branches, long pod, grows in 130 to 150 days, cultivated in arid fields.

For the wet season crop, seeds are sown in May or June and harvested in September. The dry season crop is cultivated only where irrigation water is available. The seeds are sown in January or February as the second crop after rice and harvested in March or April. The planting density is 50 cm × 20 cm - - - seeds are planted 20 cm apart in rows which are 50 cm apart. The required amount of the seeds with hull is 75 to 95 kg/ha (12 to 15 kg/rai). As the standard cropping patterns, the following are considered:

Groundnuts - Maize
Groundnuts - Soybeans
Rice - Groundnuts - Rice - Soybeans

6) Fruit Trees

Mango, cashewnut, papaya, tamarind, jackfruit, and others are cultivated in orchards. Some are densely cultivated around farm households.

7) Vegetables

Cucumbers, cauliflower, welsh onions, maize, watermelons, litchi and others are cultivated as self-supply vegetables around Muban (villages).

Present problems facing crop cultivation are as follows;

- Low level of paddy productivity because the soil fertility is low,
- No stabilized irrigation water supply,
- Poor irrigation facilities,
- Shortage of input fertilizer,
- Difficulty in introducing a new crop through selling due to traditional custom and lack of farmer's willingness and knowledge.

2. 7. 5 Livestock and Inland Fishery

1) Livestock

Livestock breeding is an important activity after paddy and cassava cultivation in the northeast region of Thailand. Livestock has a tremendous amount of resistance to droughts and floods, which are a threat to agricultural products. However, the livestock environment involves coarse feed supplies which are tight during the dry season due to the high temperature and a water shortage. Accordingly, large-scale stock raisers encounter problems of poor meat quality and milk quantity. Therefore, improvement of their raising conditions is both necessary and indispensable in order to ensure steady development of the livestock.

Buffaloes are raised for cultivation labor, and cattle such as Australian and American brahmins are bred for both meat supply and labor. However, ordinary farmers cannot respond easily to livestock promotion plans, because it needs a large amount of funds, and there has been a great deal of disease among the animals. The number of livestock in the basin is shown below;

Number of Livestock (1990)

Amphoe	Buffalo	Cattle	Swine	Ducks	Chicken	Geese
Warin Chamrap	15,500	4,326	3,586	38,660	84,795	349
Det Udom	50,117	9,083	9,663	50,062	222,128	507
Phibum Mungsahan	5,514	1,471	782	11,354	34,588	84
Na Chaluai	9,915	2,379	1,214	17,720	34,389	-
Nam Yun	14,884	3,381	6,912	11,046	39,094	345
King A. Samrong	3,637	557	601	4,225	13,584	-
Kantharalak	1,637	2,243	3,871	-	-	-
Total	119,204	23,440	26,629	133,067	428,578	1,285

Data source: Department of Livestock

2) Inland Fishery

Inland fishery is regarded as an important item for supplying protein sources in the basin because of poor transportation from the coast. Particularly, insufficient roads, a shortage of refrigerator systems, and undeveloped processing are problems. Each Muban has community raising ponds. Farmers stock the ponds and each paddy field with fry in May with fish which weight about 300 - 500 g each; they can be caught in October. The condition of inland fishery is shown below;

Condition of Inland Fishery (1989)

Amphoe	Number of Farmers (Persons)			Area (ha)		
	Pond	Paddy Field	Total	Pond	Paddy Field	Total
Warin Chamrap	116	3	119	18.0	30.0	48.0
Det Udom	142	3	145	21.3	0.6	21.9
Phibum Mungsahan	165	17	182	18.5	5.0	23.5
Na Chaluai	9	12	21	2.0	2.1	4.1
Nam Yun	9	5	14	1.6	1.4	3.0
King A. Samrong	13	2	15	1.1	0.2	1.3
Kantharalak *1	-	-	-	-	-	-
Total	454	42	496	62.5	39.3	101.8

Amphoe	Production (ton)			Yield (kg/ha)		
Warin Chamrap	73.97	8.76	81.73	4,053.9	292.0	4,345.9
Det Udom	35.70	0.08	35.78	1,676.1	133.3	1,809.4
Phibum Mungsahan	45.23	4.00	49.23	2,444.9	800.0	3,244.9
Na Chaluai	1.07	0.54	1.61	535.0	257.1	792.1
Nam Yun	1.92	0.53	2.45	1,200.0	378.6	1,578.6
King A. Samrong	1.47	0.03	1.50	1,336.4	150.0	1,486.4
Kantharalak *1	-	-	-	-	-	-
Total/Average	158.36	13.94	172.30	1,874.4	335.2	2,209.5

Note: *1 Inland fishery in Kantharalak is at self-supply level.
Data source: Statistic data, 1989

2. 7. 6 Supply and Demand of Products

Ubon Ratchathani Province's basic staple is glutinous rice. The glutinous rice production was 1.7 times more than non-glutinous in 1987/1988. Recently, non-glutinous rice production has been promoted by the agricultural

extension office, but at present more than 90 percent of non-glutinous rice is sent to Bangkok for urban area food supplies and export.

According to NESDB, the annual population growth rate for the period from 1990 to 2000 is expected to be 1.3 percent, and the total increase has been estimated at approximately 260,000 for the year 2000. If food consumption is 237 kg/capita, the same level as the present, an annual increase in production of more than 6,000 ton will be a needed during the next ten years for the Province. The stable supply of rice will be a problem in the future. The present situation of supply and demand is shown below, but consumption and seeding rates are based on the statistical method in DOAE.

Supply and Demand of Rice in Ubon Ratchathani Province

Item	Non-glutinous	Glutinous	Total/Average
Planted area (ha)	264,663	455,220	719,883
Yield (kg/ha)	1,530	1,481	1,500
Production (ton) (A)	404,934	674,181	1,079,115
Consumption (ton) (B) *1	20,247	27,132	292,379
Consumption rate (B/A) (%)	5.0	40.4	27.1
Seed (ton) (C) *2	8,271	14,226	22,496
Seed rate (C/A) (%)	2.0	2.1	2.1
Sale (ton) (D) *3	376,417	387,823	764,240
Sale rate (D/A) (%)	93.0	57.5	70.8

Note: *1 Consumption:
Non-glutinous : Consumption rate.... five percent of annual production
Glutinous : No. of households ..... 191,373 (6 persons/household)
per capita consumption ... 237 kg/person/year
*2 Seeding rate : 31 kg/ha
*3 Sall : To other regions
Data source: DOAE, Agricultural Statistics of Thailand 1989/1990

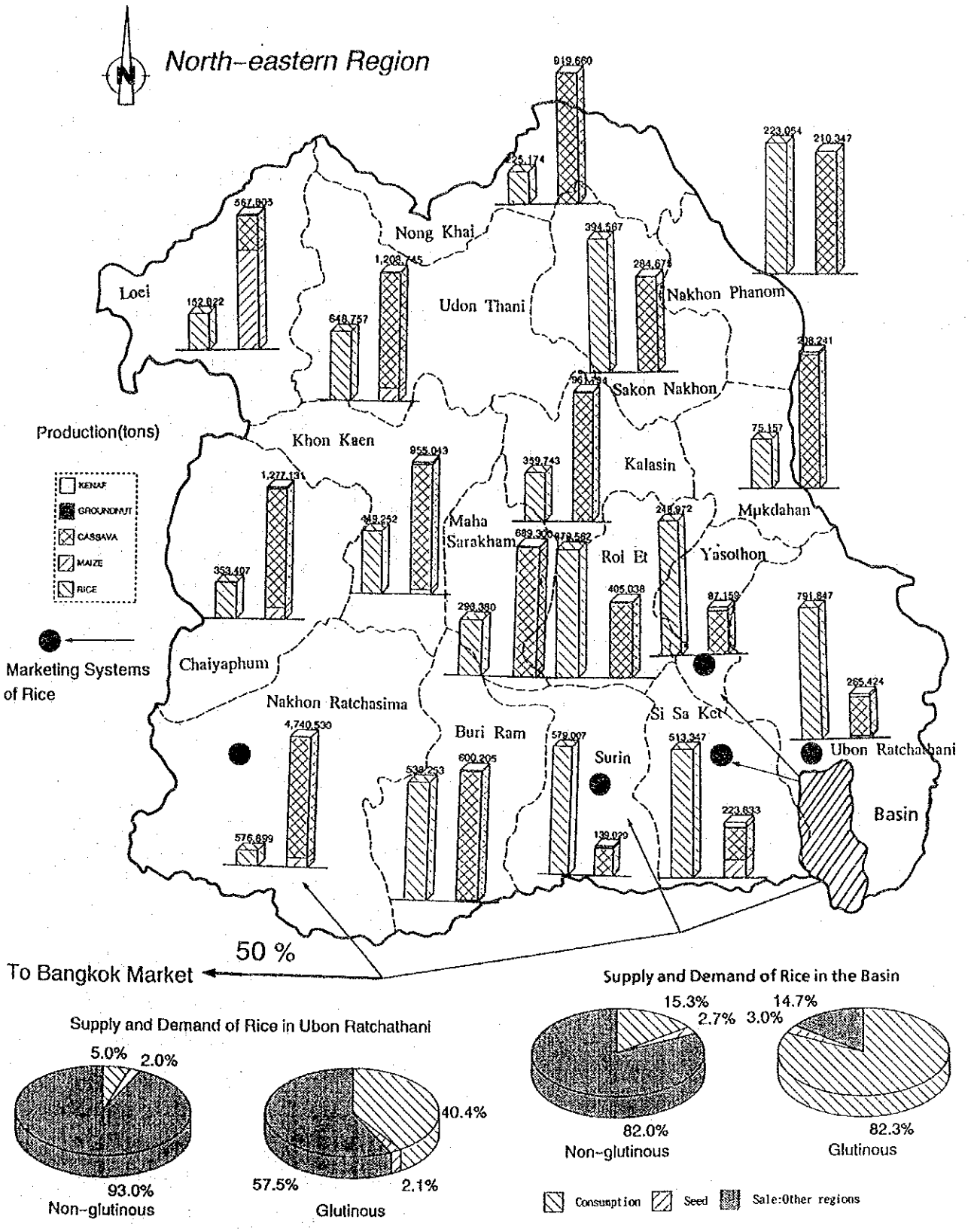
On the other hand, according to the agriculture and agro-economic survey during fieldwork, non-glutinous rice appeared predominantly for commercial use, while glutinous rice was for self-sufficiency. Glutinous rice is used especially for wage goods. The high consumption rate of over 80 percent means that while farmers' strongly demand basic food, commercialization of non-glutinous rice has deeply infiltrated the rural area of northeast Thailand.

Farmer's Supply and Demand of Rice in the Basin

Item	Non-glutinous	Glutinous	Total/Average
Production (ton)(A)	3,550.4	3,467.6	7,018.0
Consumption (ton) (B)	542.5	2,852.5	3,395.0
Consumption rate (B/A) (%)	15.3	82.3	48.4
Seed (ton) (C)	94.9	102.3	197.2
Seed rate (C/A) (%)	2.7	3.0	2.8
Sale (ton)(D)	2,913.0	509.8	3,422.8
Sale rate (D/A) (%)	82.0	14.7	48.8
Wage and rent (E) (ton)	-	3.0	3.0
Wage and rent rate	-	0.1	

Data source: Agro-economic Survey (Sample survey of farm household)

Figure 2-11 shows the supply and demand of agricultural products by region and basin.



SOURCE: Agricultural Statistics of Thailand 1989/90 (DOAE)
Agricultural Statistics of Thailand 1989/90 (OAE)
Agro-Economic Survey 1991.6

FIGURE 2-11 **SUPPLY AND DEMAND OF AGRICULTURAL PRODUCTS BY REGION AND BASIN**

2. 8 Agro-Economic Conditions

2. 8. 1 Valuable Cost and Income of Products

Major crops produced in the basin are rice (glutinous and non-glutinous), kenaf, cassava, maize and groundnut. As for fruit tree crops, mangos and cashew nuts are mainly grown.

Income obtained from crop production is estimated on the basis of farm gate price and the production cost prepared by OAE and the results of the farm household economic survey, as shown below;

Net Income of Major Crops

Crop	Yield	Farmgate Price	Gross Income	Variable Cost*1	Fixed Cost*2	Net Income
	(kg/ha)	(Baht/kg)	(Baht/ha)	(Baht/ha)	(Baht/ha)	(Baht/ha)
Annual Crop						
Paddy	1,250	3.2	4,000	3,694	713	- 407
Cassava	13,125	0.6	7,875	6,799	776	300
Kenaf	1,581	4.8	7,511	6,752	731	28
Maize	2,900	1.3	3,770	2,783	975	12
Groundnut	1,306	7.1	9,314	8,770	648	- 104
Perennial Crop						
Mango	4,675	3.0	14,025	12,851	742	432
Cashew nuts	881	13.0	11,444	6,452	2,244	2,748

Data Source: National Statistical Office (NSO), 1998 and farm household economic survey.
*1 : Variable cost: Input materials and labor costs, etc.
*2 : Fixed cost : Tax and interest, etc.

Although paddy is a dominant crop in the basin, it's income in the area appears fairly low as compared to that on the national level of 1,950 kg/ha (312 kg/rai). Also, the production cost / input is low when compared with that on the national level of 35,656 Baht/ha (5,705 Baht/rai) by reflecting low income. In the case of paddy production, the net income shows a deficit because of the human labor cost (non cash), i. e., its production is facilitated by manpower. It seems that such low productivity is caused by lack of water and poor soil conditions in the area.

Annual output, input and income from these crops in the basin can be estimated as follows;

Annual Output, Input and Income of Major Crops

(Unit : 1,000 Baht)

Crop	Output	Input	Income
Annual Crops			
Paddy	747,064.0	689,726.8	57,337.2
Cassava	99,634.5	86,020.9	13,613.6
Kenaf	97,877.8	87,998.8	9,879.0
Maize	9,293.0	6,860.1	2,432.9
Groundnut	5,159.4	4,858.6	300.8
Perennial Crops			
Mango	15,133.0	13,866.2	1,266.8
Cashew Nuts	2,769.4	1,208.0	1,561.4

Data Source: National Statistical Office (NSO), 1988

The output of paddy respectively accounts for 25.4 percent of Ubon Ratchathani Province and 6.5 percent of Si Sa Ket Province.

2. 8. 2 Farmers' Income and Poverty Conditions

As described in the preceding paragraph, the low income from paddy production entails low farm income of farmers who depend for their incomes on rainfed agriculture and is reflected in the poverty.

To grasp the actual conditions for farmers in the basin, the economic survey of the farm households was carried out. The sample of farmers surveyed were selected at random in the villages and classified into three areas of the basin, such as upper, middle and lower-basin. According to the results of the survey, the average farmers' income in each area had been estimated as follows;

Average Farmers' Income in the Study Area

Item	Upper-Basin	Middle-Basin	Lower-Basin
Cropping Area	4.25 ha	5.24 ha	4.50 ha
	(26.58 rai)	(32.73 rai)	(28.13 rai)
Farm Income	29,628	33,911	17,939
Non Farm Income	2,500	8,672	8,538
Gross Income	32,128	42,583	26,477
Production Cost 1/	7,371	10,933	6,435
Living Expenses	24,705	24,930	20,875
Total Expenditure	54	6,720	-833

Data Source: Farm household economy survey

Note: 1/: Excluding family labor costs and non cash material.

Average family size:

Upper-basin : 6.28

Middle-basin : 6.04

Lower-basin : 5.88

The circumstances reported in the survey found that a large number of farmers live under difficult conditions for maintaining a living based only on farm income. Therefore, the farmers get off-farm income from working wages earned on larger farmers or in the Bangkok labor market. A proportion of off-farm income, among gross family income, amounts to about 15 percent or more. Viewing the farm household economy, it appears in deficit throughout the whole basin. It gather from these figures that a deficit makes up by off-farm income. According to the results of the survey, the living expense of farmers would be estimated at 24,350 Baht annually.

Concerning the rural poverty, the National Economic and Social Development Board (NESDB) set forth the poverty line in cooperation with the Thai Development Research Institute (TDRI) Fund. According to the NESDB report, the poverty line in the rural areas is 4,141 Baht/household/year (1988/89) at the village level. Poverty incidence (1988/89) at the village level in the Northeast is 39.87. This figure is very high as compared with the whole Kingdom of 23.67.

The poverty distribution in the basin has been based on the village survey conducted by the NSO. In the NSO's survey, annual household income groups are classified into four groups; under 6,000 Baht/year - poverty, 6,000 to 10,000 Baht/year - marginal poor, 10,000 to 20,000 Baht/year -moderate, and

20,000 Baht/year and over - wealthy. In the basin, the poverty group occupies about 42 percent, and it reaches 76 percent including marginal poor groups. Judging from this figure, the poverty incidence in the basin seems to be higher than that of the Northeast. Particularly, the poor group (poverty and marginal poor) of Amphoe Na Chaluai and Amphoe Kantharalak respectively account for 84 percent and 80 percent. The following table shows the poverty distribution at the Amphoe level.

Poverty Distribution in the Basin

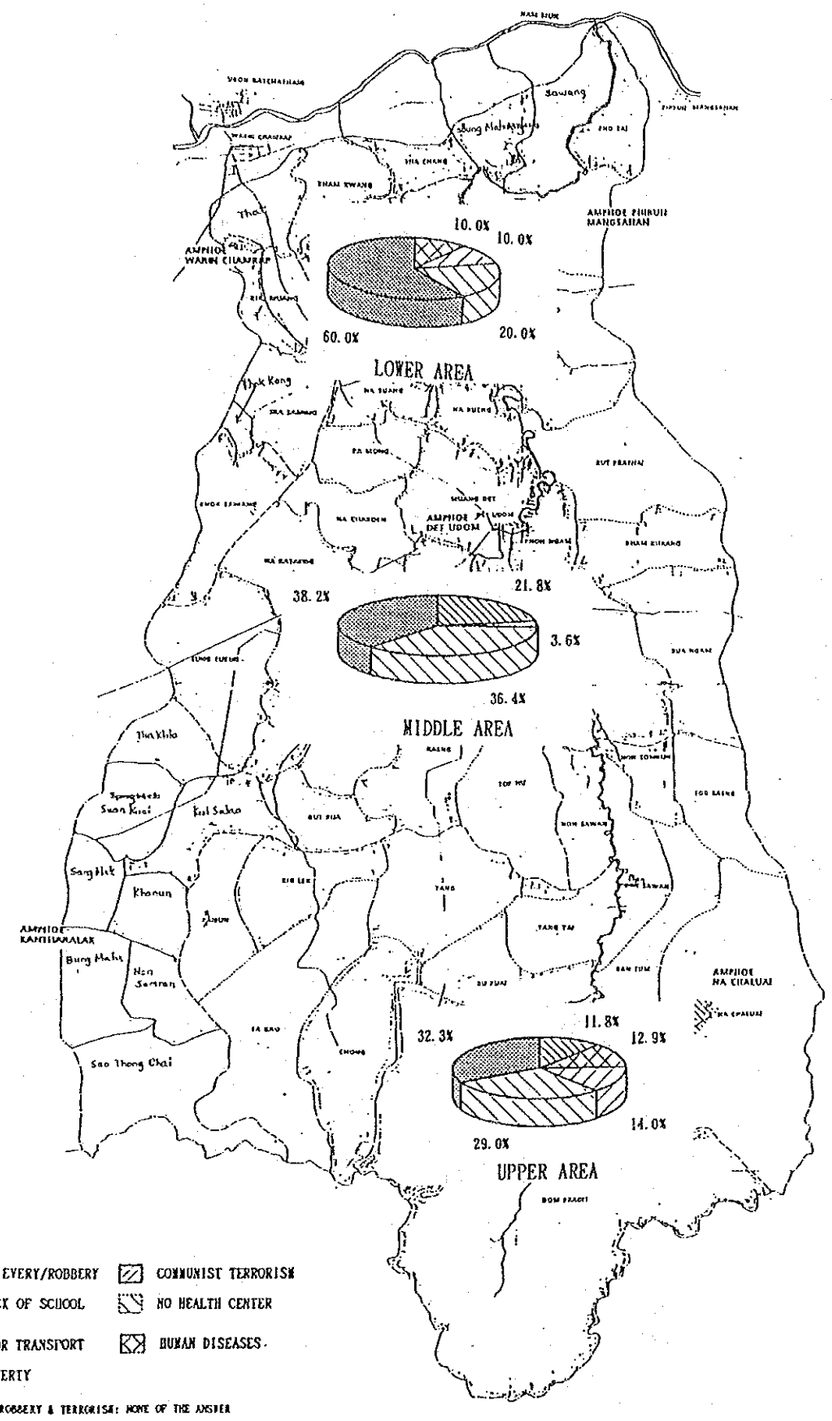
(Unit : %)

Amphoe (District)	Poverty	Marginal	Total
Wartin Chamrap	48	31	79
Det Udom	34	34	68
Phibun Mangsahan	32	41	73
Na Chaluai	53	31	84
Nam Yun	36	35	71
King A. Samrong	39	39	78
Kantharalak	52	28	80
Average	42	34	76

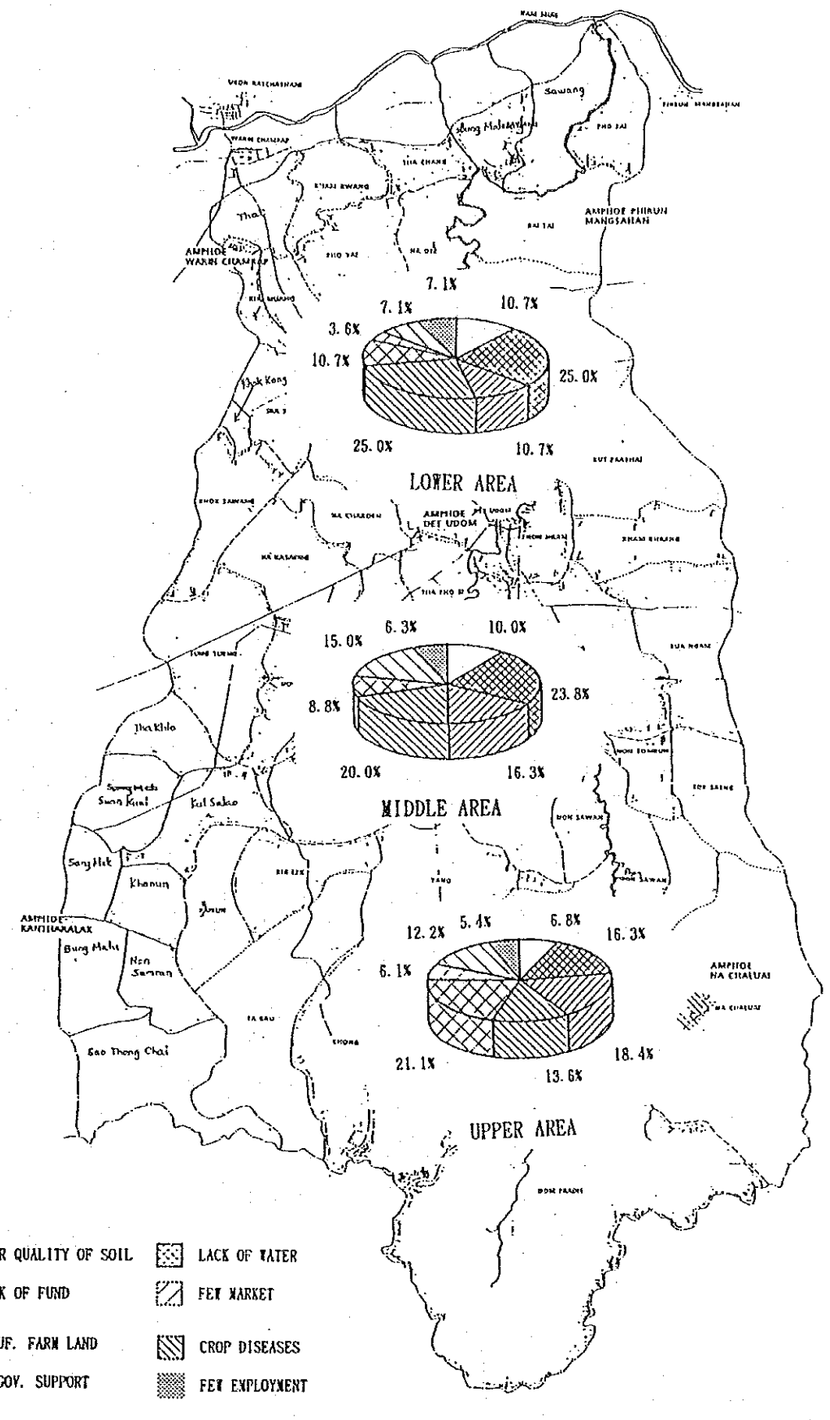
Data Source : Village survey, NSO

In term of poverty eradication in the basin, the improvement of agricultural conditions such as a stabilized supply of water for agriculture, creation of job opportunities through integrated farming and so on, are urgently needed. Under these circumstances, the National Rural Development Center, NESDB, has established the development criteria in rural areas on the national level and prepared the data base on rural development urgency.

Details of socio-economic development conditions and poverty distribution in the basin are shown in Figure 2-12 to Figure 2-14, and their details are shown in Annex H.



SOCIAL PROBLEM OF FARMERS



ECONOMIC PROBLEM OF FARMERS

FIGURE 2-12 SOCIAL AND ECONOMIC PROBLEMS OF FARMER IN THE BASIN

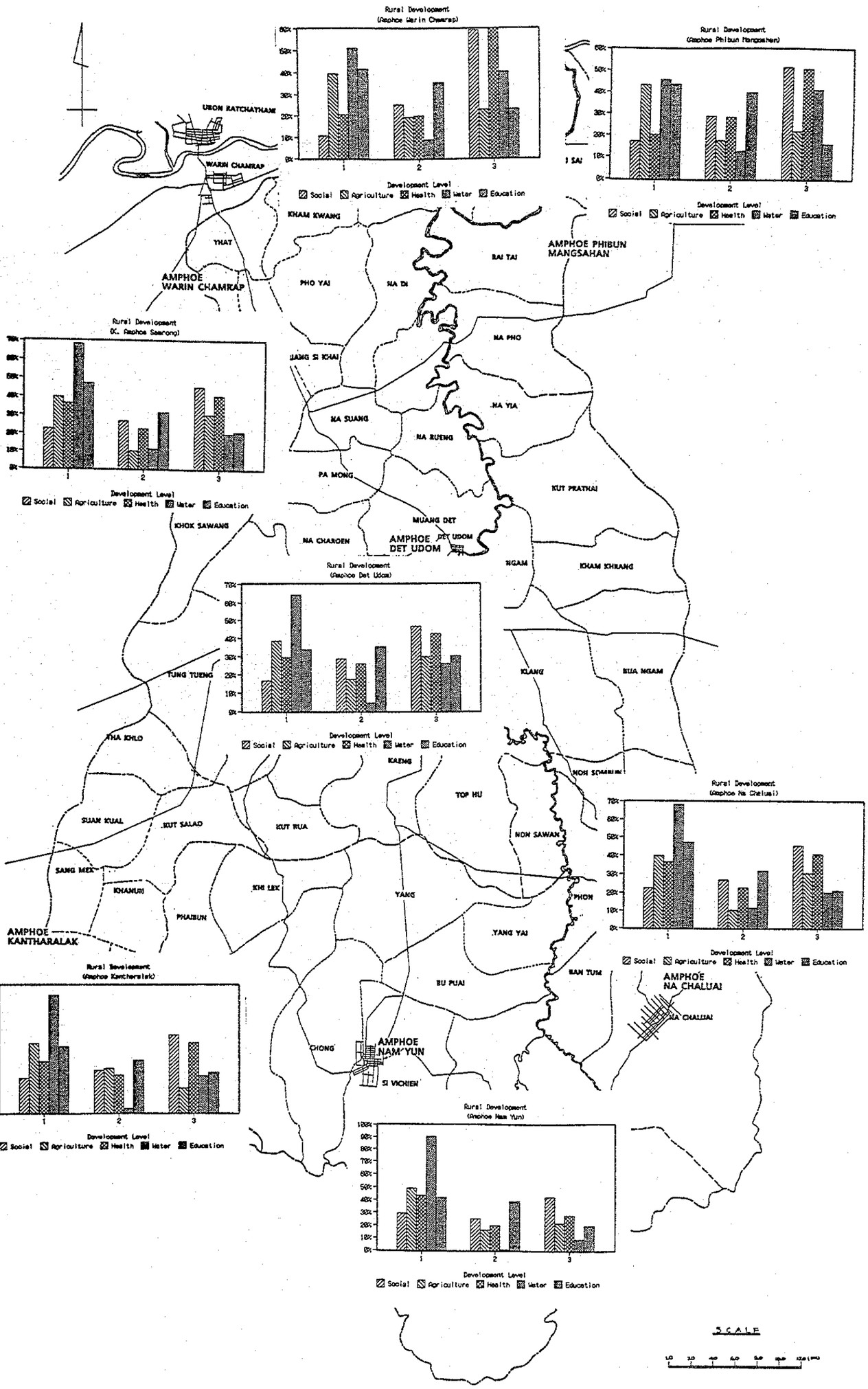


FIGURE 2-13 SOCIAL, AGRICULTURE AND WATER RESOURCE DEVELOPMENT LEVEL BY AMPHOE

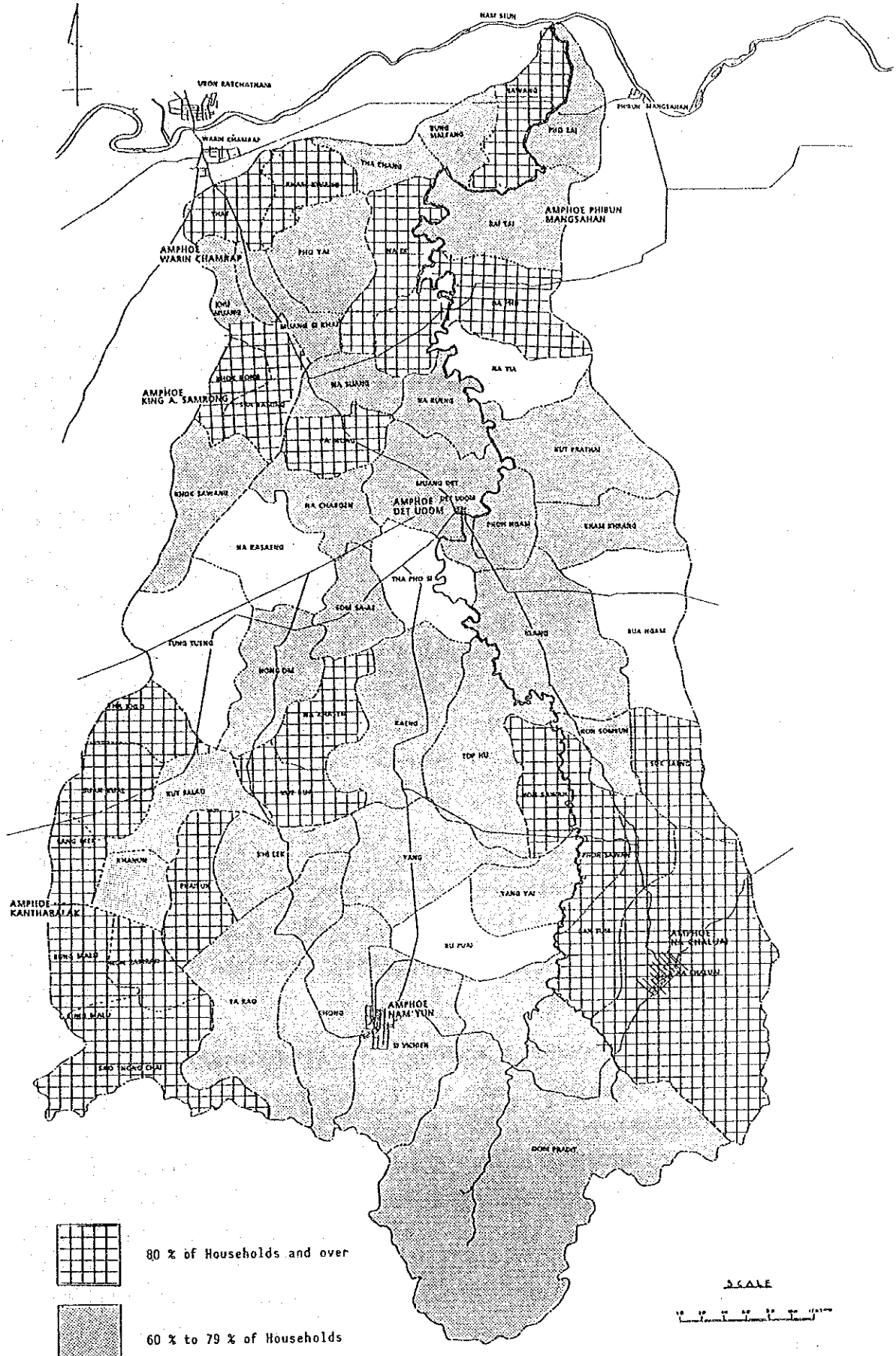


FIGURE 2-14 POVERTY DISTRIBUTION IN THE BASIN

2. 8. 3 Marketing Systems of Products

Agricultural products excluding vegetables produced in the basin have been marketed in the area by middlemen, village merchants, rice millers, jute factories.

1) Rice

Ubon Ratchathani Province is one of the big rice production areas in the North-eastern Region. Its production amounted to 791,847 tons for the crop year 1989/90 and accounts for 4.3 percent of the national production. This production is considered to be high among rice production Provinces in Thailand.

According to a commercial officer of Ubon Ratchathani Province, about 100 percent of non-glutinous rice and a small volume of glutinous rice produced in the basin is assumed for marketing. Of the rice for marketing, 50 percent is shipped to the Bangkok market and to exporters, and the rest is shipped to local markets in the surrounding Provinces such as Si Sa Ket, Surin, Nakhon Ratchasima and Yosothon. There are three local markets in Ubon Ratchathani Province; Warin Chamrap, Det Udom and Amnat Charoen. Two markets, Warin Chamrap and Det Udom, perform important roles as rice collection centers in the basin.

Most of the rice producing farmers sell their crops at the farm or threshing yards to village merchants or middlemen; this is because they have no storage, warehouse or post-harvest facilities and transportation. Consequently, they cannot wait for favorable prices in the market notwithstanding low prices.

The government agencies, including the Marketing Organization of Farmers and their Cooperatives, intervene in paddy market by purchasing rice from the producing farmers as an attempt to upgrade paddy prices. However, due to limited budgets, complicated regulations and lack of transportation from the Provinces, the government's rice purchase scheme is delayed.

Some large rice mills in the basin engage in wholesaler and warehousing in addition to milling. Existing mill facilities in the basin are as shown below;

Mill Facilities in the Basin

Amphoe (District)	Large	Medium	Small
Warin Chamrap	14	47	31
Pibun Mangsahan	11	77	17
Det Udom	27	315	64
Nam Yun	4	10	-
Na Chaluai	3	67	19
King A. Samrong	3	66	11

Data Source: Provincial Data, MOI
Note : Large : 20 Hp and over
Medium: 5 to 20 Hp
Small : 3 to 5 Hp

2) Cassava and Kenaf

Cassava (tapioca) is an important export crop for Thailand, following rice and rubber. Hitherto, it has been vigorously exported to the European Community (EC) market, but the price occasionally fell and trade would be sluggish from oversupply. However, exports have been abundant due to success in penetrating non-EC markets. Export values for tapioca occupied 10.4 percent of the total values of export agricultural products in 1989.

The annual production of cassava in Ubon Ratchathani Province is 232,039 ton and accounts for 1.4 percent of the national production. Annual production in the area is about 166,916 ton and accounts for 71.9 percent of the provincial production. Cassava produced in the area is handled by village merchants and/or tapioca factories in Warin Chamrap and Nam Yun. Tapioca factories in the area are as below;

Tapioca Factories in the Basin

Amphoe (District)	Large	Medium	Small
A. Warin Chamrap	1	1	4
A. Nam Yun	-	3	1

Kenaf and jute are the most important fiber crops in the Northeast and they are the agricultural exports of Thailand. Australia, Egypt and the United States of America are Thailand's principal markets.

Production in Ubon Ratchathani Province, equivalent to 17,112 ton, accounts for about 11.5 percent of national production. Annual production in the area is about 16,575 ton and accounts for 96.9 percent of the provincial

production. This crop is collected directly from farmers and put into marketing channels. Besides, the jute factories in Warin Chamrap buy directly from the producing farmers. There are four jute factories in Warin Chamrap; one large factory, one medium size factory and two small factories.

3) Maize and Groundnut

Maize is one of the exported agricultural products of Thailand and is one of the main crops in the Northeast. However, its production in Ubon Ratchathani Province, 13,515 ton, is equivalent only to 0.3 percent of the national production. Most of it is grown in the upper-part of the basin; 7,250 ton are produced annually, occupying 53.6 percent of the provincial production.

The main producing area of groundnut in Thailand is in the North. Production of groundnut in Ubon Ratchathani Province, 2,758 ton, is 1.7 percent of the national production. Groundnut production in the area is 648.6 ton.

Maize and groundnut produced in the area are dealt with through the same channel as paddy. Most groundnut is shipped to Si Sa Ket and Nakhon Ratchasima by middlemen.

4) Mango and Cashew Nut

Mango, Kaeo variety, is mainly grown in the area and is for family consumption. In recent years, farmers of the area began producing mango on a commercial basis with the assistance and support of BAAC; a small amount of mango is shipped to the domestic markets. However, current shipping amounts are small.

Cashew nuts in the area are grown in the upper-part of the basin and operated by Mah Boon Krong Sirichai Cashew Nuts Co., Ltd., Bangkok, a plantation company. This tree crop is not grown by small-scale farmers, but by medium and large-scale farmers that are cultivating the land with good soil condition. BAAC assists producing farmers by collecting produce for sale to the same company.

Figure 2-15 shows the marketing situations of agricultural products in the basin.

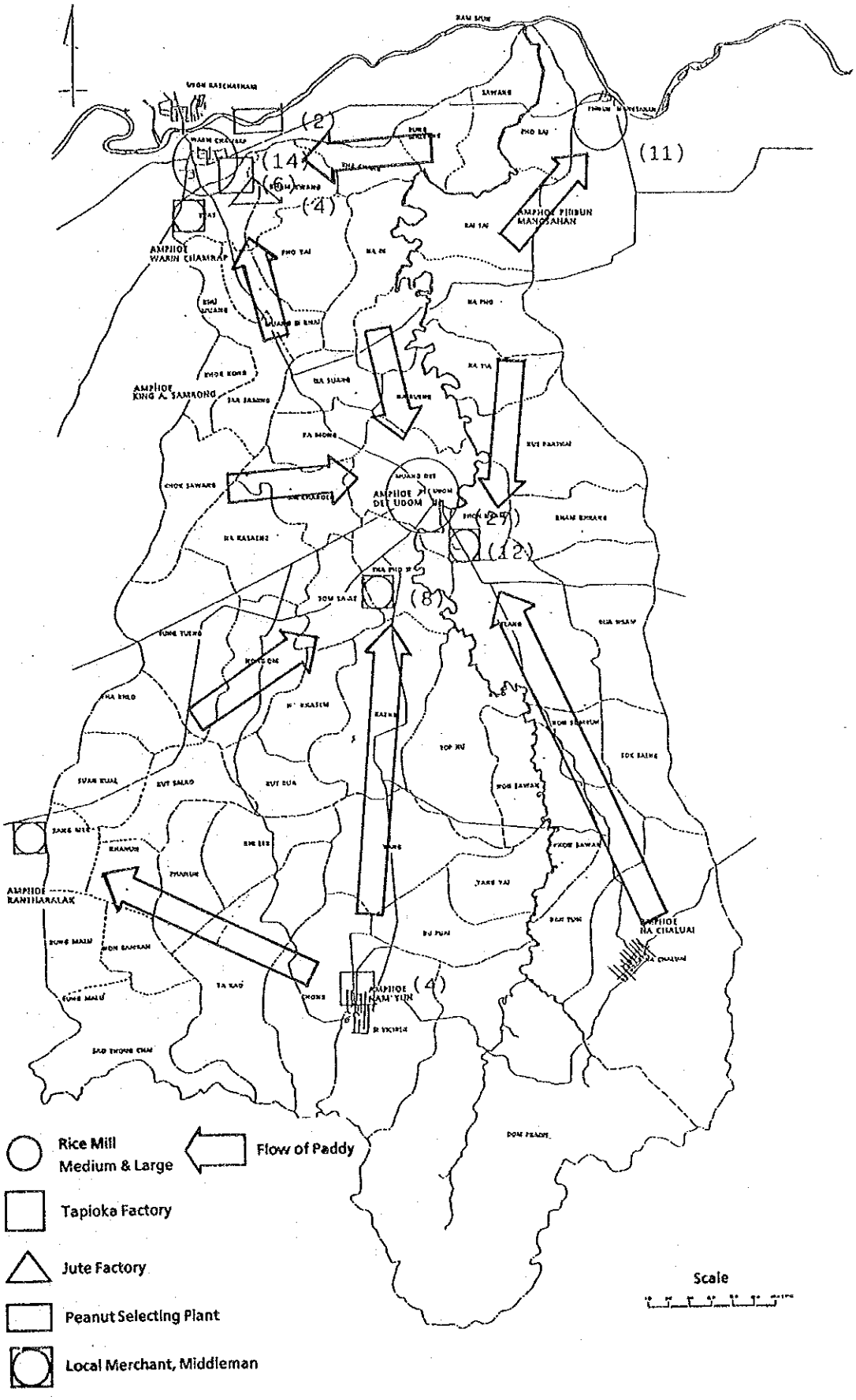


FIGURE 2-15 MARKETING SITUATION OF AGRICULTURAL PRODUCTS

2. 8. 4 Supporting Services of Government

Public supporting services for farmers in the basin are conducted by the following agencies;

1) Ministry of Agriculture and Cooperatives (MOAC)

a) Agricultural Extension Services

In the area, Provincial Agricultural Extension Office of Department of Agricultural Extension (DOAE) carries out agricultural extension activities, such as assistance and guidance for farming and support and guidance for farmers' organizations. There are six Amphoe Agricultural Extension Offices in the basin and these offices have an extension worker and some individual village-based extension agents in each Tambon. The strengthening of extension activities in the area is carried out based on the concept of National Agricultural Extension Project (NAEP). However, a ratio of extension worker to farm families is 1:1,700 at present, though the project ratio is 1:1,000.

b) Extension Seeds Distribution Services

Seed Center No.10: Ubon Ratchathani, Seed Division, DOAE is established in the same place as the Provincial Agricultural Extension Office. The center produces " Extension Seeds " of rice, groundnut and soybean, and distributes the seeds to farmers through the Amphoe Agricultural Extension Office, BAAC Field Office and Agricultural Cooperatives.

c) Agricultural Research

Agricultural research of the Department of Agriculture (DOA) in the Lower Northeast Thailand is conducted at two centers; Ubon Rice Research Center and Ubon Field Crops Research Center.

- Rice Research Center

  The center is a key site of the Thai-IRRI Collaborative Project in Thailand, and its major research works involve integrated nutrient

management, green manure development and utilization for rice-based cropping systems and a long-term trial on sulfur fertilization in wetland rice. Another task is handing the production and distribution of rice foundation seeds over to DOAE.

Field Upland Crop Research Center

The center is under the Field Crop Research Institute, DOA, and the research work at the center involves the following;

- Attacking the wide variety of problems arising at all stages of the production and the process of upland crops such as sesame, castor, cowpea, cassava, kenaf, maize, groundnut, and soybean,
- Transfer of the technology to agricultural extension agencies,
- Production and distribution of foundation seeds of castor, sesame, cowpea, kenaf, groundnut, sorghum and soybean and handing these over to DOAE.

d) Livestock Promotion

The Provincial Livestock Office, under the Department of Livestock, conducts livestock raising promotions, prevention of epidemics and hygiene control for domestic animals by veterinarians and livestock promotion workers in the Amphoe Livestock Office.

The Beef Cattle Raising Promotion Project in the Northeastern region starts from 1991. Amphoe Nam Yun is designated as one of the four project areas in the region. However, in general the promotional activities of livestock has been facing a hard situation due to the spread of animals' diseases.

e) Freshwater Fishery Promotion

Freshwater fishery promotion is conducted by the Ubon Freshwater Fish Promotion Center of the Department of Fisheries. The activities of the center involve the production of fry fish, the promotion of freshwater fish raising and the distribution of fry fish to villages and farmers. In the area, the Freshwater Fishery Development and Promotion Projects as pilot projects have been conducted from 1991.

f) Agricultural Land Reform

In the basin, Ubon Agricultural Land Reform Office (ALRO) is now carrying out the Ubon Agricultural Land Reform Project. The project area is located in the middle and upper-basins of the right bank of the Lam Dom Yai and its area covers about 39,000 ha (243.8 thousand rai).

2) Ministry of Interior (MOI)

Small-scale and urgent rural development projects are conducted by the Accelerated Rural Development (ARD) Office at the provincial level. The projects aim to improve the living environment in the rural areas through the construction of rural roads, bridges, weirs, ponds and wells for drinking water. The Department of Local Administration (DOLA) at the provincial level also conducts urgent small-scale projects.

3) Marketing Organization of Farmers (MOF)

The supporting activities of the MOF, Ubon Ratchathani Office, is mainly selling fertilizer for farmers at low prices and emergency subsidy for paddy at a sharp decline of price.

2. 8. 5 Farmers' Institutions

As the farmers' institutions in the basin are agricultural cooperatives at the Amphoe level, farmers' groups, farm women's clubs and farm youth clubs are agricultural associations at the village (Muban) level.

1) Agricultural Cooperatives

There are eight agricultural cooperatives in the basin. The activities of these cooperatives mainly involve agricultural credit and the sale of agricultural input as fertilizer for the members. Most of the cooperatives in the area are not particularly active. The following table shows the agricultural cooperatives in the area.

Agricultural Cooperative Related to The Study Area

Name of Cooperatives	Members
Warin Chamrap Agricultural Cooperatives	3,270
Det Udom Agricultural Cooperatives	4,740
Lam Dom Yai Agricultural Cooperatives	503
Phibun Mangsahan Agricultural Cooperatives	2,379
Na Chaluai Agricultural Cooperatives	784
Nan Yun Agricultural Cooperatives	1,269
Samrong Agricultural Cooperatives	613
Kantharalak Agricultural Cooperatives	2,700

Data Source : CPD and BAAC

2) Farmers' Groups

Farmers' groups are organized at the village level in the area. Each group sets up an association at the Tambon (Sub-District) level, and links closely with the Marketing Organization for Farmers (MOF) which is a nation-wide organization. The MOF was established with the aim of supporting the marketing of products and supplying fertilizer for farmers, but, unfortunately, it only supplies fertilizer. There are 34 groups of farmers with 5,154 members.

3) Farm Women's Club

There are 39 clubs with 932 members in the area. The club aims to give farm women, as agricultural producers, the opportunity to develop their potential, to develop their skills and capabilities. Farm women are helped in terms of various steps of production activities, knowledge and services to farm women as farmers and to support the role of farm women in farm family development. The club activity is supported by extension work from the Provincial and Amphoe Agricultural Extension Office.

4) Farm Youth Club (4-H Club)

The Farm Youth Club is organized by young village people between the ages of 10 and 25. There are 41 clubs with 959 members in the area. These clubs were established for spreading knowledge and skills that make rural life more productive and attractive, teaching people to work cooperatively together and introducing leadership experiences.

2. 8. 6 Agricultural Credit

The Bank for Agriculture and Agricultural Cooperatives (BAAC) is a public agricultural credit institution that provides financial services to farmers and farmer institutions to promote agricultural development. Most of the farmers in the basin have benefited from the bank by the provision of financial assistance in the form of loans for agricultural production, investment, and marketing purposes. The Ubon Ratchathani Branch especially supports the marketing of mango and cashew nuts by the farmers producing them.

In the area, there are three sub-branches belonging to BAAC's Ubon Ratchathani Branch; Warin Chamrap, Det Udom, and Phibun Mangsahan. A sub-branch of Si Sa Ket Branch is in Kantharalak.

In BAAC's Ubon Ratchathani Branch, 82.6 percent of the total amount of loans (763 million Baht) in 1990 were short term loans. And, in Si Sa Ket Branch, 85 percent of the total amount of loans (90.4 million Baht) were also short term loans. These figures show that most of the clients of BAAC are small-scale farmers.

Client farmers of BAAC are organized at the village level through the "BAAC Client Group" in order to obtain agricultural credit from BAAC. About 32 percent of the total farm households are BAAC's clients. Farmers who are not members of organized client groups have to get credit through agricultural cooperatives. According to the results of the farm household economic survey, the amount of loan per farm household in the area ranges from 5,000 to 20,000 Baht, depending on the farm. The client groups in the area are as follows;

BAAC's Client Group Related to The Study Area

Amphoe	No. of Group	Members
Warin Chamrap	116	1,303
Det Udom	629	7,259
Phibun Mangsahan	56	696
Na Chaluai	150	1,633
Nam Yun	368	4,097
King A. Samrong	24	355
Kantharalak	391	4,566
Total	1,739	19,909

Data Resource : BAAC

2.8.7 Rural Infrastructure

The rural communities of Thailand are generally developed by the centering of a temple in every village. There are 547 temples in the basin. As for social infrastructures, primary schools are established in every village; the total number is 432. The average number of pupils varies from 20 to 35 per school a year in the rural area; There are only a few secondary school in each Amphoe. Generally, the ratio of pupils who go on to the next stage of secondary school is very low in the rural area.

Presently, the public health facility is located in the center of Tambon and village. The number of Health Centers, placed in the center of Tambon, is 90; the number of Public Health Services (with a residing nurse and midwife), that perform the role of health care for rural inhabitants, is 58. This health system covers about 2,700 rural inhabitants per facility. However, there are six hospitals in the basin and each hospital has ten beds.

The diffusion rates of electrification in the basin seem rather high as compared with surrounding areas; its rate is 68 percent, but it does not supply the electricity for scattered houses in the rural areas. The rate of electrification by Amphoe related with the basin is shown below.

Village roads connected to each village are constructed yearly under the Khor Sor Chor project, which is managed by the Department of Local

Administration (DOLA) in the Changwat Office. Some of these roads are paved by asphalt, however, most of the village roads are without pavement. These situations cause inconveniences for rural communication and transportation of agricultural products and input materials.

Village water supply facilities consisting of wells (shallow and deep), pumps and containers for drinking purposes are provided by the Community Development Department, Ministry of Interior. The diffusion rates of the village water supply facilities are shown in the following table.

Diffusion of Electricity and Village Water Supply

Amphoe	Electric	Village Water Supply					
		Well		Pump		Container	
	(%)		(%)		(%)		(%)
Warin Chamrap	72	317	(4.3)	535	(7.3)	1,440	(19.7)
Det Udom	81	870	(3.3)	647	(2.5)	7,621	(29.1)
Phibun Mangsahan	66	207	(5.2)	53	(1.3)	1,162	(29.0)
Na Chaluai	51	235	(4.3)	78	(1.4)	2,244	(41.0)
Nam Yun	63	512	(5.6)	351	(3.8)	2,164	(23.7)
King A. Samrong	69	484	(29.1)	59	(2.9)	349	(21.0)
Kantharalak	75	503	(4.7)	582	(5.5)	631	(6.0)
Average	68	3,132	(4.9)	2,295	(3.6)	15,611	(24.3)

2.9 Irrigation Conditions

2.9.1 Outline of Existing Irrigation Projects

The total cultivated area in the Lam Dom Yai basin is about 232,200 ha (1,451.3 thousand rai), which is equivalent to 47.4 percent of the total basin area of 490,500 ha (3,065.6 thousand rai). The agricultural farming in most of the land experiences rainfed conditions that rely on rainfall, especially between the wet season from May to October; irrigated farm land is estimated at about 10,600 ha (66.3 thousand rai), of which project executing agencies are RID, DLD, ARD, NEA, DOLA and ALRO as shown in the following table. The respective irrigation projects implemented by these agencies will be described in the following:

Summary of Present Irrigation Projects in Lam Dom Yai Basin

Project	Irrigation Area (ha)		Canal Length (km)	Remarks
	Wet Season	Dry Season		
RID Project				
Medium-Scale	3,930	930	54	3 Projects
Small-Scale	4,220	-	-	52 Projects
Sub-total	8,150	930	54	
DLD Project	500	100	-	7 Projects
ARD Project	350	-	-	30 Projects
NEA Project	1,050	200	12	4 Projects
DOLA Project *1	(380)	(170)	-	34 Projects
ALRO Project	200	70	-	including groundwater
Total	10,630	1,470	66	

*1 : Area in parenthesis shows a part of 34 projects.
*2 : Existing irrigation projects are shown in Table F-1, in Annex F.

Figure 2-16 shows the location of each project.

1) RID Irrigation Project

The Medium and Small-Scale Irrigation Projects (MSIP and SSIP) in the Lam Dom Yai basin have been implemented by the MSIP and the SSIP Divisions in RID. Presently, two MSIP, Huai Chanla and Huai Palan Sua, have been constructed and one MSIP of Huai Kha Noon is in the process of construction as a part of the Phanom Dong Rek Program. The total irrigation

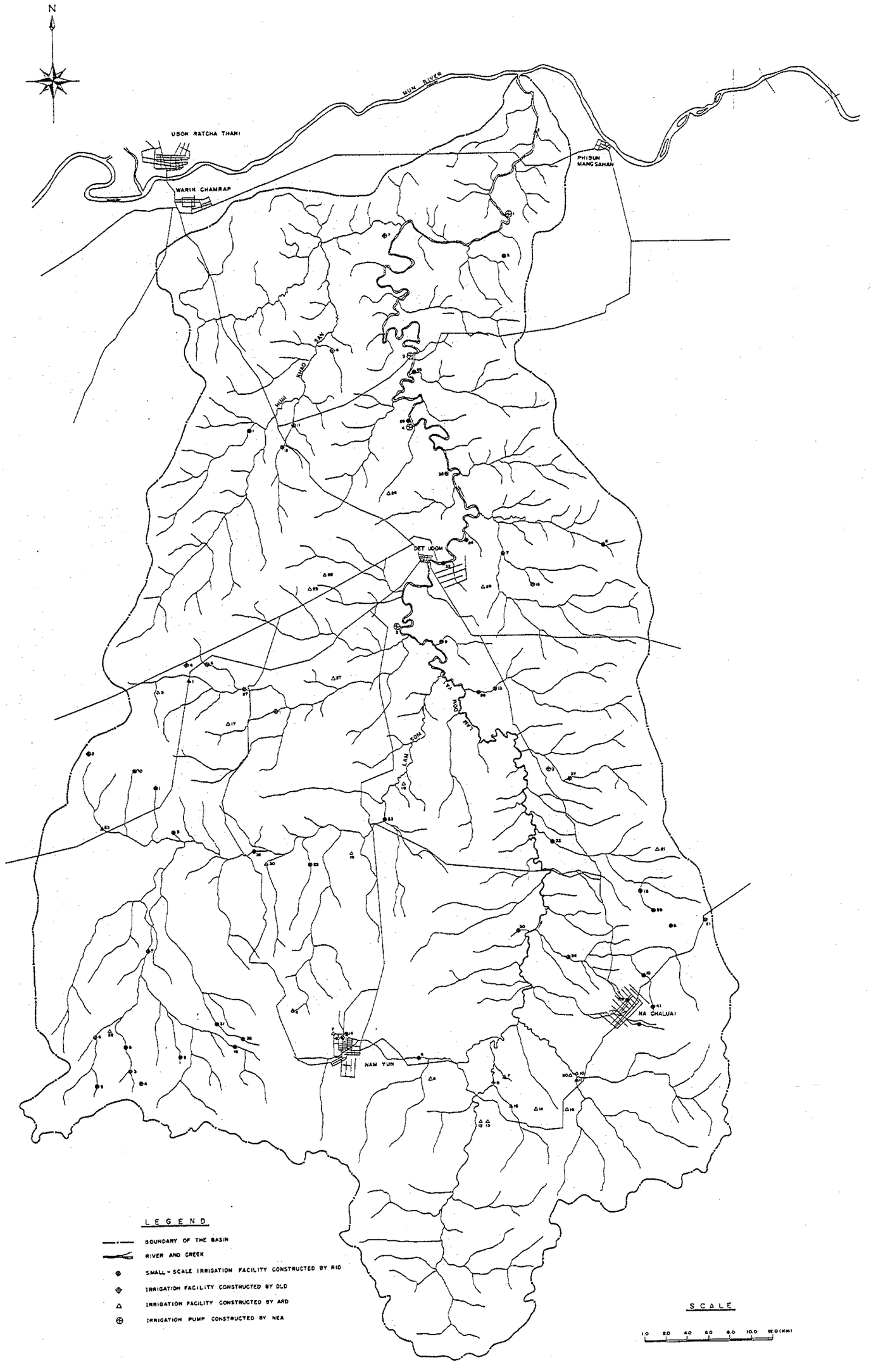


FIGURE 2-16 DISTRIBUTION OF EXISTING IRRIGATION PROJECTS

areas concerning the projects are approximately 3,930 ha (24.6 thousand rai) during the wet season and 930 ha (6.8 thousand rai) during the dry season.

The operation and maintenance of the Huai Chanla dam was turned over to the Provincial Irrigation Office (PIO) in 1990 under the jurisdiction of the Regional Irrigation Office (RIO) V, and its management is conducted by the PIO.

On the other hand, with regards to the SSIP in the basin, 52 SSIP projects, by means of tanks and concrete and rubber weirs, have been constructed by SSIP Division RID, since 1979. The total irrigated area is about 4,200 ha (26.3 thousand rai) during the wet season; unfortunately, water supply during the dry season cannot be expected, due to an completed absence of water resources. Operation and maintenance works of the SSIP are to be made by the Tambon (Sub-District) Committee after the project have been turned over from RID and other executing agencies.

In both the MSIP and SSIP projects, RID has the responsibility for the construction of main facilities such as dams, diversion works, main and lateral canals and turn-outs, and on-farm facilities located lower than the turn-outs as farm ditches, farm drains and farm roads are to be placed under the responsibility of the farmers themselves. However, there are no on-farm facilities provided at the on farm-level, because of no capability of farmers from technical and budgetary viewpoints.

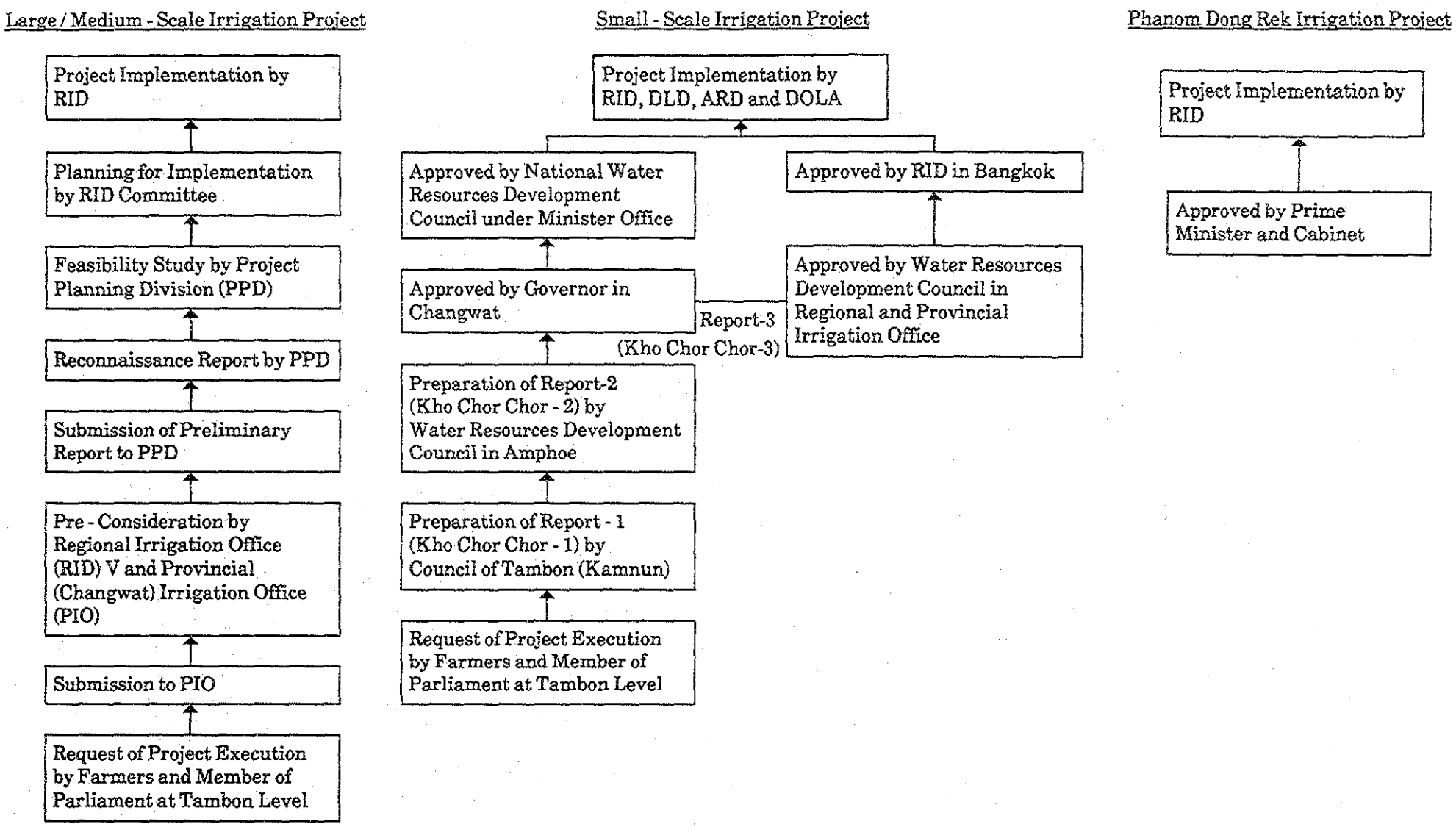
Formation and construction procedures of MSIP, SSIP and the Phanom Dong Rek project are shown in Figure 2-17.

2) DLD Irrigation Project

Department of Land Development (DLD) has its own irrigation and water resources development projects. In the basin, seven projects consisting of tanks, weirs, ponds and shallow well constructions have been carried out, regardless that the scale of the irrigated area is only 70 ha (440 rai) on average during the wet season. Major activities of DLD are summarized as follows;

- On-farm development (land terracing)
- Soil improvement

FIGURE 2-17 PROCEDURES OF FORMULATION AND IMPLEMENTATION FOR EACH TYPE OF PROJECT



- Water resources development (small-scale)
- Improvement of natural creek and stream
- Promotion of inland fishery
- Demonstration of farming technology

3) ARD Irrigation Project

The Accelerated Rural Development (ARD) Department has also been conducting irrigation and water resource development projects from the view point of rural development, since 1971. In the Lam Dom Yai basin, there exist water resource facilities such as ponds, tanks, and weirs. Major activities of ARD are as follows;

- Water resources development (small-scale)
- Construction and improvement of rural roads and bridges

4) NEA Irrigation Project

National Energy Authority (NEA) has carried out pump irrigation projects since 1980 using the Dom Yai river flow as a water source. Four pump irrigation projects exist here (two are under construction) having a total irrigated area of about 1,050 ha (6.6 thousand rai) during the wet season.

In the pump irrigation systems, main and lateral irrigation canals, inclusive of on-farm level, are provided. They are very well maintained by NEA and related farmers in the area. In addition to these maintenance works by farmers, farmers must pay about 50 percent of required electricity charges to NEA, and its rate is about 190 to 500 Baht/ha/crop, which varies depending upon the capacity and the number of required head of pumps. The basic electric charge paid to the Provincial Electric Authority (PEA) by NEA is 1.17 Baht/kwh, of which 0.60 Baht is paid for farmers.

5) DOLA Irrigation Project

Department of Local Administration (DOLA), Ministry of Interior, has implemented rural construction work projects (Khor Sor Chor projects) with technical assistance supported by other related government agencies concerned since 1986. The following lists the major works conducted by Khor Sor Chor projects.

- Construction of village roads, bridges and buildings
- Provision of village water supply
- River improvement
- Irrigation water development using pond, tank and weir
- Construction of small-scale water distribution canal
- Provision of rice mill
- Employment promotion

In the Lam Dom Yai basin, there exist 34 Khor Sor Chor projects for an area of 380 ha (2.4 thousand rai), which have been implemented with the participation of local people.

6) ALRO Irrigation Project

The Agricultural Land Reform Office (ALRO) started the Ubon Ratchathani Land Reform Project in 1990 in an area of about 48,000 ha (300.0 thousand rai) extending between the township of Det Udom and Na Chaluai, which is developing on the right bank of the Lam Dom Yai, where about 39,000 ha (243.8 thousand rai) of suitable cultivation land exists. According to the ALRO information, out of the 39,000 ha of land, about 24,500 ha (153.1 thousand rai) of land are illegally occupied by local people comprising 6,600 households.

With regards to irrigation water supply for these areas, ALRO has a plan to provide small-scale irrigation facilities such as weirs, ponds, wells and pumps. Major rural development component of the project are shown below;

i) Local organization development
   - Local community and institutional development

ii) Agricultural development
   - Increase in agricultural income by land reform area of 16 ha (100 rai) (target of 8,500 Baht/household)
   - Increase in additional income
   - Improvement of marketing system

iii) Infrastructural development
   - Water resources development
   - Road development

iv) Environmental management
- Natural resources conservation

The four year implementation period extends from October 1990 to December 1994.

2. 9. 2 Project Facilities Constructed by RID

The project facilities constructed by RID can be classified into three types, large-scale, medium-scale and small-scale irrigation projects depending upon the size of the areas benefited, reservoir areas and project cost as mentioned in Chapter I.

These types of irrigation projects are explained as follows:

- Large-Scale Irrigation Project (LSIP)

  RID will establish an Operation Office; operation and maintenance (O/M) works will be done under the auspices of the Office.

- Medium-Scale Irrigation Project (MSIP)

  The project facilities of the MSIP will be maintained and operated by Ubon Ratchathani (Provincial) Irrigation Office, and administration offices will not be provided in the project area. Operations of headgates and regulators will be done by government employees under the guidance of the Irrigation Office mentioned above.

- Small-Scale Irrigation Project (SSIP)

  The project facilities of SSIP will be turned-over to the Provincial Irrigation Office after the completion of the project facilities, and operation and maintenance of the project facilities will be performed by farmer's groups to be set up within isolated canal systems with the support from the project promotion agencies. In case that the project facilities are damaged by floods or other causes, repair costs will be burdened in accordance with the required total amounts as shown below;

Less than 5,000 Baht	:	- Tambon Water Resources Council (TWDC)	100%
5,000 to 150,000 Baht	:	- TWDC	20%
		- Changwat Local Admini.	30%
		- Local Government of Promotion Agency	50%
More than 150,000 Baht	:	- Local Government of Promotion Agencies	100%

In the Lam Yai river basin, two medium-scale irrigation projects, Huai Chanla and Huai Palan Sua have been constructed by RID under the Southern Esarn (north) Water Resources Development Project. The dams constructed under the project have two functions, first, as national security and second, as an irrigation water supply. Therefore, the reservoir capacities for both dams are decided without any relation to the required water demand which covers proposed beneficial areas.

Table 2-5 shows the major dimension of facilities of the Huai Chanla and Huai Palan Sua Projects.

2. 9. 3 Irrigation Practices

As mentioned before, medium and small-scale irrigation facilities, such as reservoir, tank, pond and weir were constructed in the Dom Yai river basin by governmental agencies concerned. These irrigation areas are limited to about 10,630 ha (66.4 thousand rai), which is equivalent to merely 4.6 percent of the total cultivation area. Therefore, most of the basin farm land relies heavily on rainfall.

Under these conditions, during the wet season, the areas situated near the weirs and tanks which are provided in tributaries and streams obtain river water for paddy cultivation by means of these facilities, and the introduced water flows down to lower paddy field through upper paddy fields. These situations normally start at the beginning of May, which corresponds the start of land preparation work for wet season paddy. However, during a drought year, the start of land preparation would be delayed until June due to lack of rainfall in May, as for example in 1991.

TABLE 2-5 MAJOR DIMENSION OF HUAI PHALAN SUA AND HUAI CHANLA

	Huai Palan Sua	Huai Chanla
1. Meteorological Data		
Annual average rainfall	1,508.2 mm	1,430.0 m
Annual maximum rainfall	1,906.0 mm	-
Average rainy day	90.6 day	-
Annual inflow	50.0 MCM	24.5 MCM
Max. inflow (50 year return period)	70.15 cu.m/sec	-
Annual average evaporation	1,495 mm	-
Sediment yield	0.2 mm/year/sq.km	-
Sediment (50 year)	87,000 cu.m	-
2. Reservoir Dimension		
Catchment area	114.7 sq.km	54.0 sq.km
Reservoir surface area at NWL	9.3 sq.km	-
Reservoir surface area at HWL	11.7 sq.km	-
Reservoir capacity at NWL	33.5 MCM	16.9 MCM
Reservoir capacity at HWL	48.5 MCM	-
Dead storage capacity	1.1 MCM	0.6 MCM

3. Dam Dimension	Huai Phalan Sua	Huai Bon	
Crest elevation	EL 173.5 m	EL 173.5 m	-
Cret width	8.0 m	8.0 m	8.0 m
Dam length	1,100 m	1,070 m	3,850 m
Dam height (max)	13.5 m	13.1 m	20.0 m

4. Spillway Dimension		
Spillway type	Chute spillway	Chute spillway
Crest elevation	EL 170.0 m	-
Max. water level	WL 171.43 m	-
Spillway length	44.0 m	-
Max. flood discharge	63 cu.m/sec	-

5. Canal Outlet	Right Outlet	Left Outlet	
Max. discharge	5.00 cu.m/sec	2.3 cu.m/sec	6.2 cu.m/sec
Bed elevation	163.5 m	163.5 m	-
Conduit diameter	1.5 m	0.9 m	-
Conduit length	78.0 m	98.4 m	-

6. Canal System		
Right main canal	14.80 km	-
Left main canal	11.85 km	-
Secondary / tertiary canals	1.16 km	-
Total	27.81 km	-
7. Service area and canal		
Total service area	1,098 ha	2,272 ha
RID construction	874 ha	-
Soldier construction	224 ha	-
8. Construction and turn-over		
Dam and intake	1988 to 1989	1987 to 1989
Canal and on-farm	1991 to 1992	-

The size of paddy field is generally very small with an area of about 300 sq.m (20 m × 15 m). Levee of paddy field is relatively high in order to maintain equal water depths in the field and expect an effective utilization of rainfall as much as possible under the rainfed farming.

On the other hand, during the dry season most of the farmlands are not utilized for cultivation due to lack of irrigation water sources. However, in some areas in the basin, cassava, kenaf, maize and etc. are planted under the rainfed conditions, while groundnut, vegetable, watermelon and chilli are grown in an area of about 1,470 ha (9.2 thousand rai) using pump facilities.

2. 9. 4 Water Right in the Basin

1) Present Water Right Facilities

As described in paragraph 2.9.1, "Outline of Existing Irrigation Projects", prevailing irrigation facilities to be considered as having water rights have been constructed by related government agencies such as RID, DLD, ARD, NEA, DOLA and ALRO in the Dom Yai river and its tributaries; these facilities in each project are summarized as follows;

Existing Irrigation Project

Project	No. of Project	Irrigation Area in Wet Season (ha)
RID Project	55	8,150
DLD Project	7	500
ARD Project	30	350
NEA Project	4	1,050
DOLA Project	34	(380) *1
ALRO Project	-	200
Total	130	10,630

Note: *1 Area in parenthesis shows a part of 34 projects.

These irrigation facilities are presently playing an important role in diverting and storing irrigation water for these areas.

In addition to the irrigation facilities mentioned above, one liquor factory named Surathip Yukhonthorn Factory, which is located downstream

from the Dom Yai river crossing of the provincial road (rout No. 217), takes water from the Dom Yai river into the factory using pump facilities throughout the year. According to the obtained data, the annual intake volume from 1990 amounted to 253,800 cu.m with a maximum volume of about 24,600 cu.m in October, which is equivalent to 0.48 cu.m/sec for the whole year and 0.55 cu.m/sec in October, respectively.

Of the water right mentioned above, the water taken by Surathip Yukhonthorn Factory is regarded as a non-objective facility in terms of water rights. This disposition is due to the factory's location in the lower area. Because, it is affected by the backwater of the Mun river and by considerable amounts of return flow from the upper-reaches of the basin.

2) Study on Water Rights Discharge

Under these circumstances, prevailing water rights that divert irrigation water in each sub-basin, should be taken into account for the formulation of the water distribution plan of the developed water resources.

For the study concerning water rights in the basin, the typical sub-basin of Huai Kao San, a tributary located in middle-basin of the Lam Dom Yai, was selected as shown in Figure 2-18. The sub-basin has a catchment area of 281 sq.km with the gentle topography from southwest to northeast. Annual average rainfall around the area amounts to about 1,600 mm. The total cultivated area in the basin is calculated at 1,504 ha (9.4 thousand rai) with 47 weirs and checks in total; it was constructed by the government agencies concerned at the end of 1990.

Table 2-6 indicates the study result showing run-off discharge and required water demand for the wet season in both cases of designed and normal years. As a result, it was discovered that the rate of water usage against run-off discharge was estimated at about six to nine percent in both cases for designed and normal years. Therefore, the rate of water release for water rights from the proposed dam was decided at five percent of the inflow discharge to the dam, after due considerations of return flow of released irrigation water.