LAO PEOPLE's
DEMOCRATIC REPUBLIC
MASTER PLAN
AND
FEASIBILITY STUDY
ON

THE INTEGRATED AGRICULTURAL RURAL DEVELOPMENT PROJECT

IN
SAVANNAKHET PROVINCE

ANNEX

JUNE 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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DRAFT FINAL REPORT

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ANNEX I

METEOROLOGY AND HYDROLOGY

ANNEX I

METEOROLOGY AND HYDROLOGY

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1. Introduction

The objective of the hydrological study is to grasp the hydrological characteristics of the Study area, to provide useful information necessary for the implementation of the agriculture development plan. The following activities were conducted.

- Data collection
- Review of previous project reports
- Interview with government authorities
- Reconnaissance survey
- Field inspection of dam and water intake sites
- Current measurement
- Data arrangement
- Hydrological analysis
- Software programming for water balance calculation

2. Meteo-hydrological Data

Meteorology and Hydrology Department, the Ministry of Agriculture and Forestry is responsible for the management of all stations in LAO PDR.

At present, 16 meteorological stations and 20 hydrologic stations are operated in the Project area, including Thailand.

Table I -1 shows the lists of code numbers, station names, location, datum level, etc.

The following are the meteo-hydrological data obtained and their respective sources:,

* Rainfall Data

Monthly:	Savannakhet	1987-1990
	Seno	1961-1990
	M. Phine	
	Sepone	
Daily:	Savannakhet	1980-1989
	Seno	1980-1989
Maximum (1 day):	Seno	1962-1990
* Meteorological Data:	Savannakhet	1980-1989
* Gauge Height Record:	Mekong at Khemarat	1970-1989
	Mekong at Nakhon Phanom	1972-1989
	Xe Bang Hieng at B. Kendone	1960-1984
	Xe Bang Hieng at Keng Tangane	1976-1988
	Xe Champhone at Kengkok	1978-1988
	Xe Champhone at Donheng	1987-1988
	Xe Banghiang at Xe Bangfai	1960-1989

3. Climate

3.1 General

LAO P.D.R. is situated in the tropical zone with a monsoonal regimen. The climatic environment is conditioned by its geographic position and local topographic differences. The climate varies from the dry zones in the plain areas along the Mekong valley with an annual precipitation below 1,700 mm to the humid zones in the mountain area with over 3,000 mm annually (from Vangvieng to the Boloven plateau, including the mountain range in Lao-Vietnam border).

3.2 Climate Condition in Study Area

The Study area has a tropical climate which is dominated by the southwest monsoon. The monsoon, carrying moisture from the Indian Ocean, brings heavy rainfall between mid-May and mid-October. The northeast monsoon between November and mid-February brings cool air from Siberia and mainland of China.

The annual rainfall at Savannakhet varies between 1,000 mm and 1,650 mm during 1967-1989. The average depth is about 1,400 mm. The average depth at Seno is about 1,700 mm.

The annual average temperature is about 26°C and the monthly temperature ranges from 21°C to 30°C.

The relative humidity ranges from 75% to 82% during the rainy season and 64% to 68% in other periods. Table I -2 summarizes the pan evaporation, mean wind velocity and sunshine hours at Savannakhet.

3.3 Meteorological Event in 1991

Savannakhet province was hit by severe floods in August and September, 1991. Inundated paddy fields in Xe Champhone amounted to 20,000 ha.

The rainy days in August at Xe Champhone and Seno lasted for 22 and 24 days, respectively. Monthly rainfall depth at Seno, Kengkok and Xe Champhone were 530 mm, 585 mm and 769 mm, respectively. Maximum 1 day rainfall were 104.5 mm at Seno. The storms in August and September were named Typhoon Frid and Choevi.

4. Rainfall

4.1 Annual Rainfall

Table I-3 shows the monthly and annual rainfall depths at Seno from 1961 to 1989 and Savannakhet from 1967 to 1989. The annual depth at Seno adjacent to the Project area ranges from 1,200 mm to 3,250 mm, and the average depth is around 1,700 mm. It can be noticed that the annual depth fluctuates a lot.

Table I-4 shows the sorting order of the annual depth at Seno.

4.2 Storm Rainfall

The 24 hours rainfall depth at Seno has been observed from 1962. The annual maximum depth data is collected for the frequency analysis below:

Maximum 24 Hours Rainfall Depth (Seno)

Year	Depth (mm)	Year	Depth (mm)
1962	122.1	1977	167.0
1963	163.0	1978	439.0
1964	133.0	1979	157.0
1965	280.0	1980	107.0
1966	81.4	1981	75.0
1967	171.0	1982	84.5
1968	88.9	1983	70.0
1969	218.5	1984	103.5
1970	81.6	1985	82.1
1971	97.0	1986	61.0
1972	229.0	1987	70.3
1973	206.0	1988	156.5
1974	170.0	1989	101.4
1975	129.0	1990	146.0
1976	89.0		

The depth in 1978 was too extreme, compared to the depth of other years. For the frequency analysis, it will be rejected from the data group as abnormal.

4.3 Frequency Analysis

The probable analysis of 24 hours rainfall for Seno were carried out using 3 methods (Log-normal, Takase, Gumbel-Chow).

The values of the different return periods by the 3 methods are as summarized below.

Probable Rainfall at Seno

(mm)

T (YR)	Log-Normal	Takase	Cumbel-Chow
10	185	187	185
20	212	215	211
30	228	231	226
50	247	251	245
80	265	270	263
100	274	279	271
200	300	307	297

The values listed in the Table are almost similar.

5. Hydrology

5.1 Basin Condition

The Xe Banghiang and Xe Bangfai passing Savannakhet and Khammouane province of the Project area are large tributaries of the Mekong river.

(1) Xe Banghiang Basin

The Xe Banghiang basin has a catchment area of 19,600 km^2 and occupies most of Savannakhet province through which the river flows westwards before joining the Mekong at Khemarat. The Keng Done and Keng Tangane falls are situated in the Xe Banghiang's meandering downstream reach. The Xe Champhone and Xe Xangxoy are large tributaries and join the main river through the Xe Noy, about 15 km upstream of Keng Done.

(2) Xe Bangfai Basin

The Xe Bangfai is a medium-sized tributary of the Mekong, with a catchment area of 9,470 km^2. It is located on the left bank of the Mekong and joins the opposite Thatphanom, in northeast Thailand, some 55 km downstream of Thakhek. The lower basin of the Xe Bangfai, downstream from the Xe Bangfai bridge, is subject to inundation during the flood season.

The flow regime of Xe Banghiang at B. Keng Done and Xe Bangfai at the Bridge are listed in Table I -5.

5.2 Flooding Area

Flood occurs mostly during the southwest monsoon season, from May to September.

Flood in the Study area can be classified into the following two types:

* Seasonal floods of the Mekong river which directly affect the Xe Ban Fai plain
* Flash floods from main tributaries

Seasonal floods occur from the end of July to early September when southwest monsoon blows. It strongly rains continuously for several days and storm rainfall sometimes last for 2 or 3 days.

Flash floods occur mostly in Xe Banghiang, Xe Bangfai, Xe Champhone and other tributaries.

(1) Xe Bangfai Basin

The lower Xe Bangfai flooding area is affected by the water level of Mekong river during the southeast monsoon season from the middle of May to October.

The following table shows the maximum water levels of major flood years between 1970 'and 1984 at Xe Bangfai Bridge.

Flood Maximum Water Level
(Xe Bangfai Bridge)

Year	Date	Xe Bang Fai Max.W.L. (m)
1961	25 August	+144.92
1970	27 August	+144.66
1972	31 July	+144.45
1974	30 August	+144.38
1975	3 September	+144.70
1978	12 August	+144.40
1984	18 August	+144.15

Fig. 5-1 shows the hydrograph of the above years, showing flood levels varying between 135.0 and 145.0 E.L. with more than one month of 140.0 m E.L. Fig. 5-2 shows the flooded area in the Xe Bangfai lower basin, where the total area is about 30,000 ha.

(2) Xe Champhone Basin

The following table shows the maximum water levels of the Xe Champhone river in the years 1976 to 1988 at Kengkok and Mekong river in Khemarat, Thailand.

Flood Maximum Water Level

Year	Date	Kengkok Max.W.L. (m)	Khemarat W.L. (m)
1976	7 August	+137.70	+130.28
1977	8 September	+137.71	+125.92
1978	17 August	+141.24	+128.78
1979	26 September	+137.68	+126.42
1980	8 September	+137.90	+130.36
1981	11 August	+137.56	+129.73
1982	27 September	+136.64	+124.66
1983	11 October	+136.11	+123.16
1984	4 August	+137.66	+124.95
1985	12 August	+137.78	+126.81
1986	29 August	+137.60	+124.91
1987	11 September	+137.20	+125.65
1988	5 August	+138.08	+123.83

Fig. 5-3 shows the hydrographs from the year 1985 to 1988 at Kengkok and Khemarat, illustrating that the water levels of the rivers around Kengkok reach 130.0 to 140.0 E.L. in the southwest monsoon season. Therefore, the lower areas of Kengkok are facing serious problems of drainage. The year 1988 has the lowest rice production among the recent years due to flood, showing a demand for drainage countermeasure in areas with 137.0 m and 138.0 m E.L.

5.3 Water Resources Potentials

The values of the Water resources were roughly estimated by the district as shown on Table I -6 and Fig. 5-4.

The NUDP/FAO Group conducted a study on the water resources in Savannakhet Province in January 1990.

Table I -6 Water Resources in Savannakhet Province

District	Area (km2)	Average Flow (mm)	Average Flow (ℓ/sec/km2)
Saybouly	1,109.9	600	19
Atsaphang Thong	2,992.9	1,050	33
Outhoumphone	942.6	700	22
Khanthalouly	1,033.4	600	19
Champhone	786.9	700	22
Song Khone	1,372.9	600	19
Songbouly	1,527.1	850	27
Thapangthong	2,930.8	700	22
Nanhom	1,141.4	1,500	47
Phince	2,699.4	1,050	33
Tchepone	3,254.7	1,650	52
Nong	1,928.3	1,150	36

These values may be useful for roughly grasping the water resources potential in view of rainfall depth, based on the following findings:

* Average annual rainfall at the stations in Savannakhet province varies from 1,400 mm to 2,200 mm.
* Annual evapo-transpiration loss is about 800 mm.

5.4 Discharge Observation

Current measurements were done at 7 sites during the 24th-25th of December 1990. The discharge measurements are as follows:

H. Bak at the dam site:	200 ℓ/sec
H. Bak at B. Khamthao:	30 ℓ/sec
H. Xay at the bridge:	no flow
H. Namphou at the bridge:	90 ℓ/sec
H. Namphou + H. Xay	92 ℓ/sec
H. Pangha at B. Dontoum:	42 ℓ/sec
H. Pangha + H. Phou:	172 ℓ/sec

Though no surface flow was measured in H. Xay, the surface flow in H. Namphou was stable in the drought season.

5.5 Discharge for Water Balance Calculation

H. Bak dam and H. Xay dam are proposed for the agriculture development project. For the required reservoir capacity checking, water balance calculation for the irrigation scheme should be based on the discharge at the water intake and dam sites.

With the consideration of the discharge observation and annual run-off due to rainfall, the discharge at the sites were derived under the following conditions:

* the drought year 1985 as the hydrological standard year for irrigation scheme
* direct run-off coefficient due to rainfall is about 0.35
* base flow assumed for the following catchment
    - H. Bak Dam-Site
    - H. Namphou
    - H. Pangha

Table I-7 shows the discharge at the dam and water intake sites for the water balance calculation.

6. Flood

6.1 Method

(1) Rational Formula

The rational formula method is generally considered to be one of the best methods used for flood estimation in small catchment area. In this study, the probable peak discharge for the dam sites is assumed below:

Rational formula: $Qp = 1/3.6*f*r*A$

Qp : peak discharge (m^3/sec)
f : run-off coefficient
r : rainfall intensity (mm/h)
A : catchment area (km^2)

(2) Run-off Coefficient

The run-off coefficient is assumed based on the technical report made by the UNDP/FAO Team. In this study, the maximum value 0.3 is considered as the conservative values given for the safety side to the planning.

Characteristic of catchment areas	bare	Bushes normal	dense
Evenly plowed surface	0.3	0.25	0.20
Uneven surface	0.2	0.15	0.10

(3) Flood Concentration Time

The time of concentration is estimated through the use of the Kirpich formula used in the discharge calculation in LAO P.D.R.

Kirpich formula: Tc = 0.0078*(L^0.77)*(S^-0.385) min

Tc : concentration time (min)
L : channel length (ft)
S : slope

Tc by Kirpich formula for H. Xay and H. Bak dam sites were derived as follows:

Dam Site	Tc
H. Bak	1.42
H. Xay	1.92

(4) Rainfall Intensity

The authorized rainfall intensity curve for Savannakhet and Seno area has not yet been researched. For this study, the empirical formula estimated from the probable 24 hours rainfall was applied.

Mononobe formula: I = (R24)/24*(24/Tc)^0.667

I : rainfall intensity (mm/h)
R24 : rainfall in 24 hours (mm)
Tc : concentration time (hr)

The probable 24 hours rainfall at Seno was discussed in Chapter 4.3. In LAO P.D.R., the Gumbel method was commonly used in probability analyses. The probable 24 and 1 hours rainfall derived by the use of the Gumbel and Mononobe methods are listed below:

Probable Rainfall at Seno

Return Period	1 Day (mm)	1 Hour (mm)
10	185	55
20	211	63
30	226	67
50	245	73
80	263	78
100	271	80
200	297	88

6.2 Probable Discharge

The probable discharge for H. Bak and H. Xay dam sites were calculated using the Rational Method.

Probable Discharge at Dam Sites

(m^3/sec)

Return Period	H. Bak	H. Xay
10	131	55
20	150	63
30	160	67
50	174	73
80	186	78
100	193	80
200	211	88

Table I - 1 Meteorologic Stations

METEORORLOGIC STATIONS

CODE NUMBER	STATION	OPERATION	LOCATION	
			LATITUDE	LONGTITUDE
170404	THAKHEK	LAO PDR	17 25'	104 48'
160504	DONG HENE	LAO PDR	16 00'	105 48'
160505	KENG KOK	LAO PDR	16 26'	105 12'
160502	SENO	LAO PDR	16 40'	105 00'
160405	SAVANNAKHET	LAO PDR	16 33'	104 45'
	M. PHINE	LAO PDR		
	SEPONE	LAO PDR		
	SONBOURY	LAO PDR		
	PAKSONG	LAO PDR		
	SEBANG NOOANE	LAO PDR		
	MUONG NONG	LAO PDR		
	BAN VEUNE	LAO PDR		
170403	NAKHON PHANOM	THAILAND		
160503	KHEMARAT	THAILAND		
160401	MUKDAHAN	THAILAND		

HYDROLOGIC STATION

RIVER	STATION	LOCATION		DATUM
		LATITUDE	LONG TITUDE	
MEKONG	KHEMARAT	16 04.0'	105 12.0'	108.38 /M.S.L
MEKONG	SAVANNAKHET	16 33.7'	104 44.8'	125.41 /M.S.L
MEKONG	NAKHON PHANOM	16 57.0'	104 44.0'	120.0 /T.B.M
SE BANG FAI	SE BANG FAI	17 04.3'	105 59.1'	125.0 /M.S.L
SE BANG FAI	BAN THA KHAM	16 54'	104 47'	15.507 /T.B.M
SE BANG FAI	BAN PAK SE	16 57'	104 47'	14.903 /T.B.M
SE BANG FAI	BAN TON HEN	17 03'	105 54'	17.00 /T.B.M
SE BANG FAI	BAN XAYSOUNG	17 05'	104 50'	15.00 /T.B.M
SE BANG FAI	BAN PHAK	16 59'	104 59'	16.344 /T.B.M
SE CHAMPHONE	KENGKOK	16 27.0'	105 12'	129.98 /M.S.L
SE CHAMPHONE	DONHENG	16 02'	105 17'	
SE PON	BAN MUANG	16 40'	106 18'	14.313 /T.B.M
SE XANGXOY	BAN PHALANE	16 39'	105 34'	10.05 /T.B.M
SE LANGONG	MUANG NONG	16 22'	106 31'	10.967 /T.B.M
SE BANG NOUAN	JBAN SE BANG	16 01'	105 29'	
SE THAMOUAK	NOUAN HIGHWAY	16 35'	105 55'	
SE BANG HIENG	BAN KENG DONE	16 35'	105 19.0'	121.9 /M.S.L
SE BANG HIENG	TCHEPON	16 11.1'	106 14.5'	19.149 /T.B.M
SE BANG HIENG	KENG TANGANE	16 40.5'	105 23'	115.38 /T.B.M
SE BANG HIENG	THAKONG	16 06'		

Table 1 - 2 Monthly Meteorological Statistics at Savannakhet

Elevation: 155m above MSL
Latitude: 16 33' N
Longitude: 104 45'E

		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
Mean Temperature	(°C)	21.6	25.1	27.6	29.5	29.1	28.2	28.4	27.7	27.5	26.4	23.9	20.9	26.3
Mean Daily Maximum	(°C)	28.9	31.7	33.9	34.9	33.6	31.7	32.0	31.2	31.3	30.9	29.0	27.7	31.4
Mean Daily Minimum	(°C)	14.4	18.6	21.2	24.1	24.6	24.8	24.8	24.3	23.6	22.0	18.8	14.4	21.3
Extreme	(°C)	5.1	9.8	6.3	16.0	19.0	20.0	20.4	20.1	20.0	14.5	9.0	5.2	5.1
Mean Relative Humidity	(%)	67	68	64	67	74	79	79	82	78	75	71	68	73
Mean Daily Maximum	(%)	96	94	88	89	93	93	93	94	94	93	92	93	93
Mean Daily Minimum	(%)	39	41	40	45	55	64	69	62	58	50	42	52	
Evaporation	(mm)	3.3	4.0	4.7	5.0	4.7	4.1	3.9	3.8	3.7	3.8	3.6	3.0	3.8
Wind	(m/s)	2.5	1.8	1.9	1.8	1.3	1.5	1.4	1.4	1.4	2.0	2.6	2.7	
Sunshine	(hrs)	8.9	8.8	8.1	8.1	7.3	5.4	5.6	4.6	5.7	7.3	8.6	8.7	7.3
Rainy days		0	1	2	6	13	16	14	19	13	7	2	0	8
Rainfall		2	9	33	82	148	266	212	310	229	88	4	1	1,384

Table I - 3 Monthly Rainfall at Savannakhet (1967 ~ 1989)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1967	0.0	0.0	1.7	71.2	151.3	138.9	161.7	131.7	360.3	13.6	0.3	0.0	1031
1968	0.0	0.0	81.8	22.2	113.4	161.7	129.3	42.7	405.8	57.5	0.0	0.0	1014
1969	0.0	12.8	48.5	76.2	201.7	113.3	367.8	238.3	331.5	24.3	0.4	0.0	1415
1970	0.0	0.5	78.0	83.3	212.3	282.6	200.8	368.9	97.4	22.7	0.0	0.0	1347
1971	0.0	49.4	39.5	93.7	110.1	318.0	340.8	166.4	231.7	54.0	0.0	12.2	1416
1972	0.0	42.4	27.6	90.3	68.3	372.6	347.0	377.1	184.4	168.3	0.6	0.0	1679
1973	0.0	0.0	6.4	68.7	154.3	158.6	194.6	221.3	183.0	24.2	0.0	0.0	1011
1974	2.5	0.0	7.9	128.4	67.5	233.1	272.9	572.2	200.1	27.5	0.7	0.0	1513
1975	0.3	37.5	31.3	13.9	217.6	396.2	305.1	329.2	114.1	48.6	0.0	0.6	1494
1976	0.0	9.6	32.0	145.7	111.6	140.0	289.3	339.0	346.0	206.2	3.8	0.0	1623
1977	2.0	0.0	8.0	81.9	43.1	67.5	117.0	341.6	401.6	5.3	0.0	0.0	1068
1978	0.0	8.8	110.6	28.9	175.0	395.2	271.1	419.9	253.6	2.8	0.0	0.0	1666
1979	0.0	8.0	0.0	99.3	131.5	411.7	88.9	242.4	211.9	0.0	0.0	0.0	1194
1980	0.0	10.7	32.0	122.8	131.4	254.4	249.1	104.6	545.4	170.1	14.3	0.0	1635
1981	0.4	20.6	26.7	93.2	222.4	412.0	229.7	202.6	55.9	86.1	17.4	0.0	1367
1982	0.0	1.0	25.1	60.7	139.8	210.2	68.8	453.1	331.7	166.4	24.6	0.0	1481
1983	4.7	1.4	0.0	78.1	156.4	287.5	67.4	403.9	145.9	176.8	0.0	0.0	1322
1984	0.0	0.0	50.2	146.8	186.4	285.5	265.8	415.4	183.5	129.5	0.0	0.0	1663
1985	36.6	5.0	43.1	49.3	86.1	444.2	118.5	374.3	121.3	128.6	0.0	0.0	1407
1986	0.0	0.0	0.0	123.1	277.3	259.9	158.8	315.9	128.0	107.4	21.9	0.5	1393
1987	0.0	8.3	15.7	40.7	127.7	386.5	247.9	336.6	227.1	63.6	0.0	0.0	1454
1988	0.0	0.4	6.3	72.8	197.5	158.4	164.6	307.9	43.4	189.5	0.0	0.0	1141
1989	0.0	0.0	95.2	103.9	119.2	225.8	234.1	411.6	150.3	148.6	0.0	0.0	1489
	2.0	9.4	33.4	82.4	148.0	266.0	212.8	309.6	228.5	87.9	3.7	0.6	1384

MONTHLY RAINFALL at SENO (1961 ~ 1990)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1961	0.0	0.0	17.9	32.2	355.8	630.0	178.1	466.1	477.2	146.4	0.0	0.0	2304
1962	0.0	0.9	24.2	58.9	104.6	174.8	402.2	458.8	356.8	27.6	7.8	0.0	1617
1963	0.0	0.0	26.3	14.4	175.1	520.6	272.1	322.2	169.0	44.3	15.7	0.0	1560
1964	0.0	0.0	45.5	82.3	378.8	354.4	142.2	302.4	517.5	122.2	2.8	0.0	1948
1965	0.0	18.5	107.9	108.8	184.7	447.7	301.4	421.5	207.9	108.3	0.0	0.0	1907
1966	0.0	3.6	45.1	195.3	339.2	123.0	268.6	321.3	123.9	25.9	3.9	20.0	1471
1967	0.0	0.0	8.5	125.1	196.8	194.5	411.3	167.1	438.0	10.2	3.8	0.0	1555
1968	0.0	12.7	27.2	65.9	139.0	234.4	110.7	226.2	344.9	31.0	0.0	0.0	1192
1969	4.0	0.0	40.9	39.5	229.1	146.2	520.0	157.3	285.5	48.0	0.0	0.0	1471
1970	0.0	18.1	8.9	90.3	215.2	318.0	156.7	427.7	183.1	27.6	0.0	0.0	1446
1971	0.0	87.5	13.0	37.4	129.1	417.1	330.1	258.5	193.2	41.3	0.7	14.1	1522
1972	0.0	34.9	68.6	106.0	90.9	252.3	614.8	776.2	196.3	321.6	0.2	0.0	2462
1973	0.0	0.0	0.0	37.4	409.9	733.1	818.9	501.9	682.8	67.6	0.0	0.0	3252
1975	12.6	60.4	93.7	49.5	811.9	256.6	269.9	399.8	187.9	215.7	0.0	0.0	2358
1976	0.0	2.0	86.7	121.0	104.5	141.0	436.3	317.9	232.1	55.9	0.0	0.0	1497
1978	0.4	0.8	52.0	41.2	115.5	274.9	232.4	678.0	386.3	3.5	0.5	0.0	1786
1979	0.0	0.0	0.0	55.4	260.8	246.4	86.4	323.9	250.7	0.0	0.0	0.0	1224
1980	0.0	3.7	57.0	44.0	197.7	249.8	220.5	145.3	640.9	77.8	4.4	0.0	1641
1981	0.0	21.2	27.0	64.8	224.2	397.7	242.3	395.5	40.3	147.5	8.8	0.0	1569
1984	0.0	0.0	8.8	68.7	138.6	284.8	372.8	563.2	122.6	193.1	34.5	0.0	1787
1985	17.1	5.0	14.5	49.2	116.0	323.8	203.9	303.0	100.6	118.6	0.0	0.0	1252
1986	0.0	0.0	28.4	39.2	272.7	386.2	189.3	343.5	96.4	145.9	0.0	0.0	1502
1987	0.0	11.9	10.0	26.6	152.9	213.2	346.8	211.7	216.9	45.3	1.9	0.0	1237
1988	0.0	4.0	3.8	131.1	168.3	286.1	179.9	502.6	53.2	154.8	0.0	0.0	1484
1989	0.0	0.0	133.6	190.8	145.7	100.9	445.3	268.7	287.8	134.4	0.0	0.0	1707
1990	5.8	158.3	14.8	41.9	111.3	379.3	361.8	369.4	270.2	77.7	4.9	0.0	1795
	1.5	17.1	37.1	73.7	221.9	311.1	312.1	370.4	271.6	92.0	3.5	1.3	1713

Table I - 4 Annual Rainfall Order at Seno (1961 ~ 1990 : 26 years)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1968	0.0	12.7	27.2	65.9	139.0	234.4	110.7	226.2	344.9	31.0	0.0	0.0	1192
1979	0.0	0.0	0.0	55.4	260.8	246.4	86.4	323.9	250.7	0.0	0.0	0.0	1224
1987	0.0	11.9	10.0	26.6	152.9	213.2	346.8	211.7	216.9	45.3	1.9	0.0	1237
1985	17.1	5.0	14.5	49.2	116.0	323.8	203.9	303.0	100.6	118.6	0.0	0.0	1252
1970	0.0	18.1	8.9	90.3	215.2	318.0	156.7	427.7	183.1	27.6	0.0	0.0	1446
1969	4.0	0.0	40.9	39.5	229.1	146.2	520.0	157.3	285.5	48.0	0.0	0.0	1471
1966	0.0	3.6	45.1	195.3	339.2	123.9	268.6	321.3	123.9	25.9	3.9	20.0	1471
1988	0.0	4.0	3.8	131.1	168.3	286.1	179.9	502.6	53.2	154.8	0.0	0.0	1484
1976	0.0	2.0	86.7	121.0	104.5	141.0	436.3	317.9	232.1	55.9	0.0	0.0	1497
1986	0.0	0.0	28.4	39.2	272.7	386.2	189.3	343.5	96.4	145.9	0.0	0.0	1502
1971	0.0	87.5	13.0	37.4	129.1	417.1	330.1	258.5	193.2	41.3	0.7	14.1	1522
1967	0.0	0.0	8.5	125.1	196.8	194.5	411.3	167.1	438.0	10.2	3.8	0.0	1555
1963	0.0	0.0	26.3	14.4	175.1	520.6	272.1	322.2	169.0	44.3	15.7	0.0	1560
1981	0.0	21.2	27.0	64.8	224.2	397.7	242.3	395.5	40.3	147.5	8.8	0.0	1569
1962	0.0	0.9	24.2	58.9	104.6	174.8	402.2	458.8	356.8	27.6	7.8	0.0	1617
1980	0.0	3.7	57.0	44.0	197.7	249.8	220.5	145.3	640.9	77.8	4.4	0.0	1641
1989	0.0	0.0	133.6	190.8	145.7	100.9	445.3	268.7	287.8	134.4	0.0	0.0	1707
1978	0.4	0.8	52.0	41.2	115.5	274.9	232.4	678.0	386.3	3.5	0.5	0.0	1786
1984	0.0	0.0	8.8	68.7	138.6	284.8	372.8	563.2	122.6	193.1	34.5	0.0	1787
1990	5.8	158.3	14.8	41.9	111.3	379.3	361.8	369.4	270.2	77.7	4.9	0.0	1795
1965	0.0	18.5	107.9	108.8	184.7	447.7	301.4	421.5	207.9	108.3	0.0	0.0	1907
1964	0.0	0.0	45.5	82.3	378.8	354.4	142.2	302.4	517.5	122.2	2.8	0.0	1948
1961	0.0	0.0	17.9	32.2	355.8	630.0	178.1	466.1	477.2	146.4	0.0	0.0	2304
1975	12.6	60.4	93.7	49.5	811.9	256.6	269.9	399.8	187.9	215.7	0.0	0.0	2358
1972	0.0	34.9	68.6	106.0	90.9	252.3	614.8	776.2	196.3	321.6	0.2	0.0	2462

Table I - 5 Flow Regime of Xe Banghiang and Xe Bangfai

Xe Banghiang (cu.m/sec)

YEAR	Max.	High	Medium	Low	Drought	Min.	Average
1960			(Lack of some data)				
1961	6,360.00	1,130.00	176.00	53.00	4.00	0.00	964.18
1962	4,950.00	666.00	146.00	66.10	3.70	1.00	572.83
1963	5,440.00	911.00	107.00	47.20	3.70	0.20	647.72
1964	7,070.00	538.00	167.00	41.80	4.00	0.00	666.91
1965	2,250.00	466.00	111.00	65.20	3.70	0.20	333.88
1966	3,970.00	376.00	148.00	42.70	2.70	0.00	448.52
1967	4,100.00	375.00	116.00	48.10	4.00	1.00	417.98
1968	7,540.00	277.00	89.20	39.10	2.30	1.00	418.24
1969	4,930.00	117.00	451.00	40.90	1.60	0.20	475.54
1970	4,220.00	185.00	619.00	44.00	1.00	0.20	490.85
1971	5,760.00	170.00	840.00	55.30	3.60	0.00	624.69
1972			(Lack of some data)				
1973	2,790.00	107.00	550.00	47.20	5.40	0.00	435.48
1974			(Lack of some data)				
1975	4,710.00	192.00	476.00	52.60	2.80	0.00	546.56
1976	4,020.00	131.00	371.00	31.90	4.80	0.00	337.49
1977	3,150.00	62.20	190.00	31.90	4.60	1.00	268.92
1978			(Lack of some data)				
1979			(Lack of some data)				
1980			(Lack of some data)				

Xe Bangfai (cu.m/sec)

YEAR	Max.	High	Medium	Low	Drought	Min.	Average
1973	2,990.00	653.00	104.00	39.80	25.70	22.80	441.41
1974	3,220.00	556.00	94.60	30.20	26.90	25.70	497.04
1975	3,320.00	522.00	97.30	31.80	26.90	25.40	515.34
1976	3,190.00	569.00	89.40	34.50	30.00	29.20	446.55
1977	2,870.00	265.00	42.00	32.20	27.50	26.60	246.74
1978							
1979	2,780.00	300.00	68.20	30.80	17.00	15.00	380.97
1980	2,760.00	273.00	50.30	25.10	19.10	17.90	243.87
1981	2,000.00	589.00	111.00	26.60	19.90	17.60	420.82
1982	1,850.00	393.00	53.20	31.40	17.70	16.70	278.22
1983	1,190.00	263.00	39.10	24.60	19.30	17.20	151.35
1984	3,140.00	411.00	116.00	28.00	18.60	16.70	427.44
1985				(Lack of some data)			
Average	2,755.45	435.82	78.65	30.45	22.60	20.98	368.16

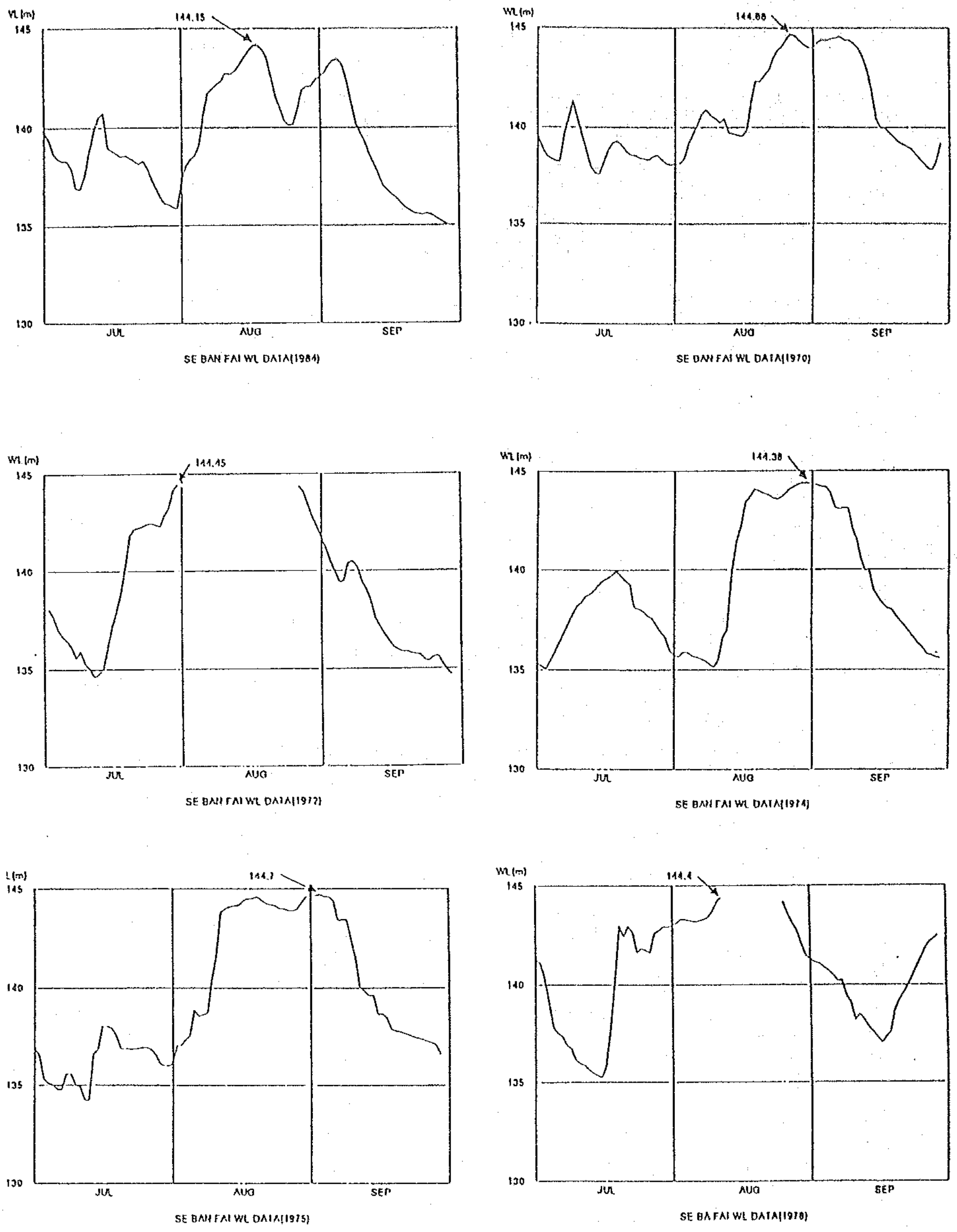


Fig. I - 1 Xe Bangfai Flood Hydrograph

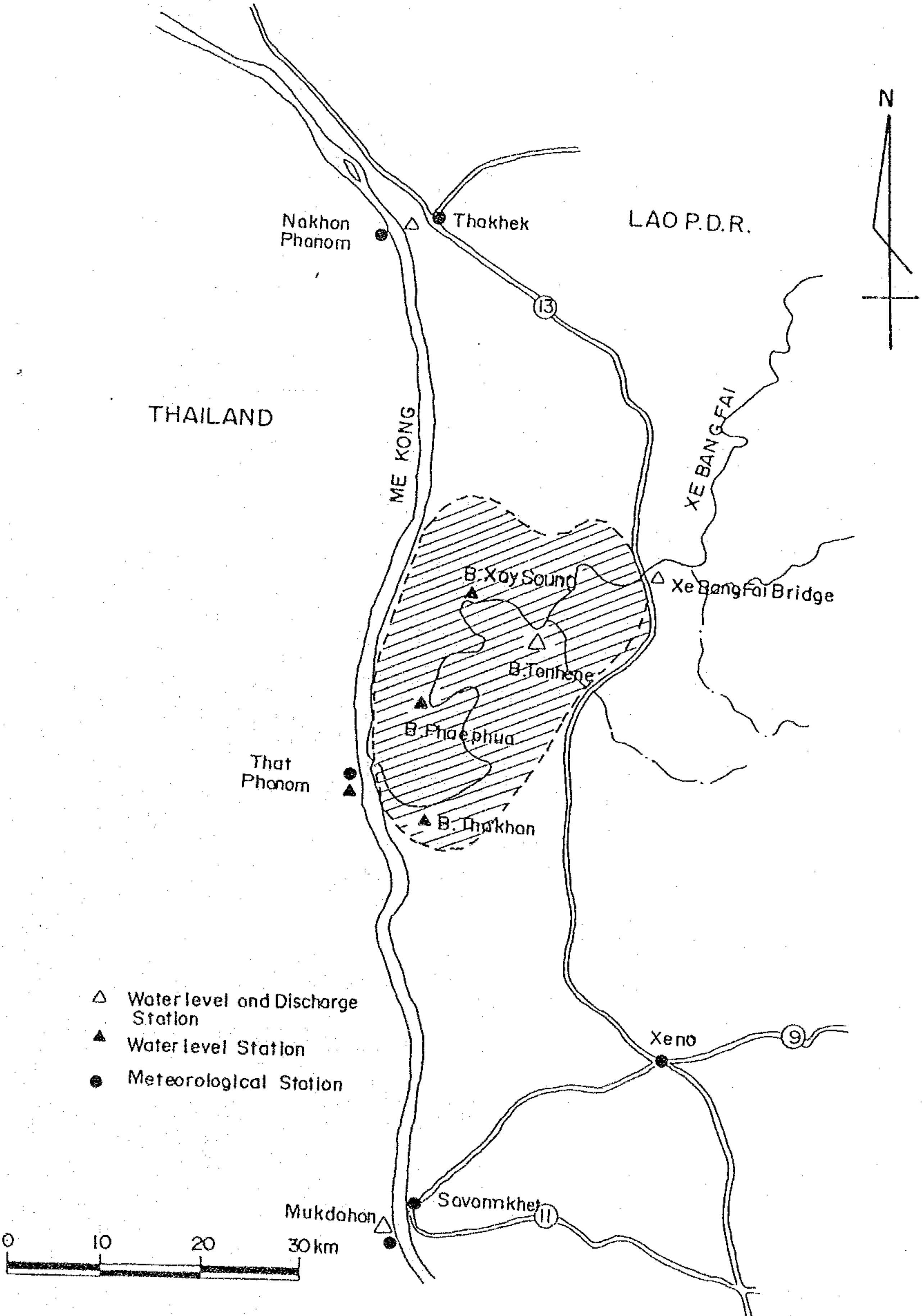
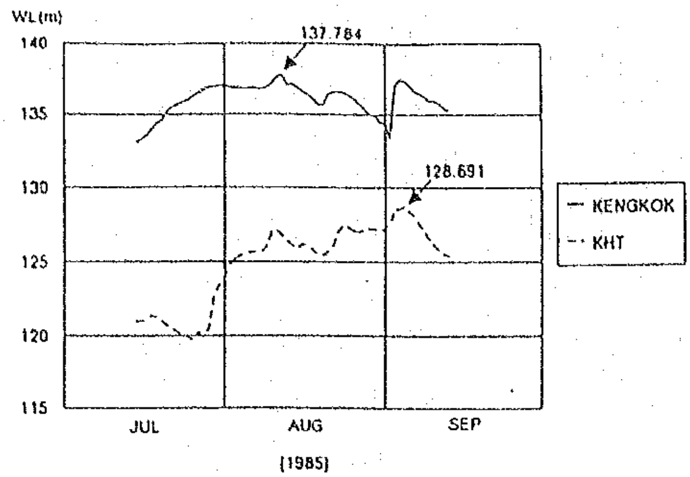
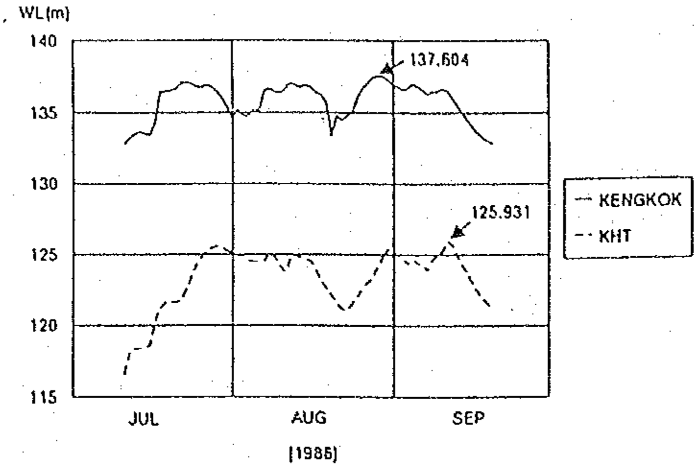
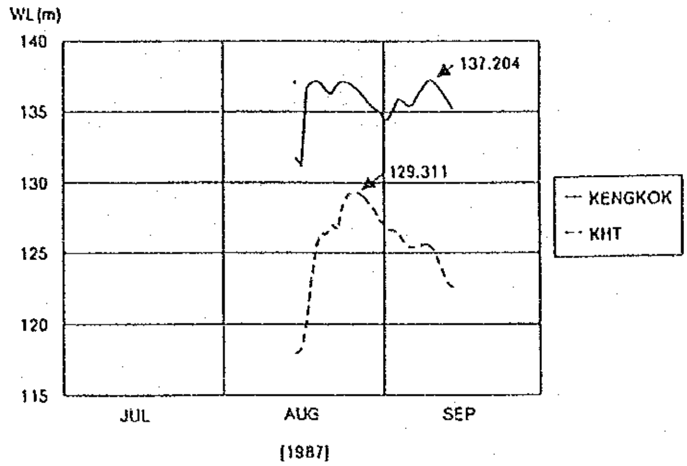


Fig. I - 2 Xe Bangfai Flood Area







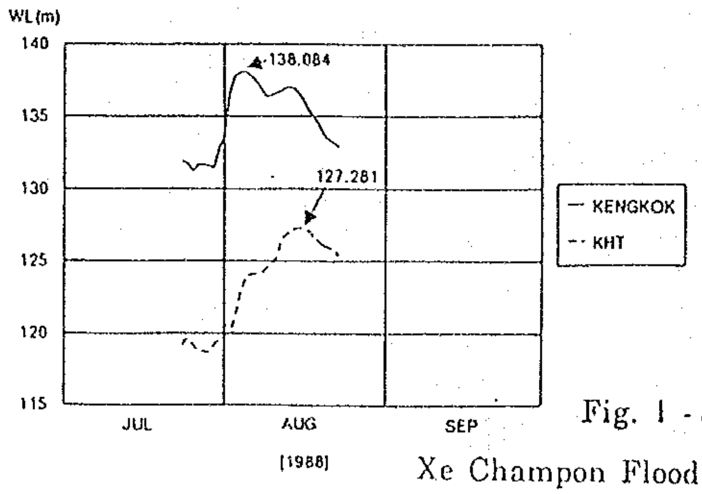


Fig. I - 3

Xe Champon Flood Hydrograph

Fig. I - 4
Rough Data of Water Resources
Savannakhet Province
(S=1:1,000,000)

ANNEX II

SOILE AND LANDUSE

ANNEX II

SOILS AND LAND USE

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1. General

The present soil and land classification studies aim at identifying major soil groups and their distribution in the Project area to evaluate the endowed land resources, and also to examine the suitability of land for irrigation development,.

Soil survey is carried out in three steps, i.e. preliminary observation, field survey, and soil chemical analysis. Existing topographical maps and the results of previous soil studies are fully referred to for the study. Soil classification of the project area is made in conformity with the system of FAO/UNESCO Legend for "Soil Map of the World".

Land Classification study is made in accordance with the Japanese standard which is considered to be more practical than the frameworks of FAO and USDA systems.

2. Soils

2.1 Methodology of Soil Survey

Soil survey in the project area is carried out in three steps, i.e. preliminary observation, field survey, and chemical and physical analysis.

In the preliminary observation, topography and vegetation of the Project area is initially studied by examining the topographic map (5,000, 1991).

In the field survey, soil profile survey and sampling are made by excavating 11 exploratory pits and by boring 32 pits with boring sticks. Location of survey sites are shown in Fig. II - 1.

Chemical and physical characteristics of the samples taken during the field survey are examined in the following items.

Item of laboratory analysis

Samples of representative 11 pits are analyzed at the soil laboratory of MAF. Methods of analysis are given in Table II - 1. Items examined are: i) pH (H2O, KCI), ii) Electric Conductivity, iii) Organic matter, iv) Carbon, v) Calcium carbonate, vi) Total nitrogen, vii) Available phosphorus, viii) Total phosphorus, ix) Total potassium, x) Exchangeable bases (Hh, Ca, Mg, Na, K), xi) % of element in sorption complex (Hh, Cam Mg, K), xii) Soil particle size distribution and texture, and xiii) Density.

2.2 Physiology

2.2.1 Environment of soil formation

The climate in and around the project area is distinctly characterized by two seasons, namely the rainy and the dry season. Annual mean temperature is 26.3°C with monthly mean values varying from 14.4°C in January to 34.9°C in April. Annual mean rainfall is 1.384 mm, out of which about 84% falls during the rainy season, May to September.

The project area is geologically composed of ancient alluvial deposits and dilluvial soils, mainly consisting of sandstone shale and siltstone. These alluvial materials correlate with those in the upstream of the H. Bak river and the Nam Phou river, which are composed of sandstone, micachist, gneiss and granite.

2.2.2 Topography and vegetation

The elevation of the project area ranges from EL 142 m to EL 166 m with gentle slops and undulations from the North-west to the South-east.

The area is categorized into two relieves and the vegetation of each category is as follows:

(1) Upper Pediment (EL: higher than 150 m, Topography: erosion surface)
From rim of the flat to undulating area being extended in a shape of a horseshoe.
This area is mosaic of woodland, wasteland, small pond, spring and rain field paddy fields. Some of the rainfed paddy field is not being cultivated, showing that the area is not marginally suitable for growing rice.

(2) Lower Pediment (EL: lower than 150 m, Topography: Alluvial valleys)
It occupies central part of the Project area, and has flat to micro reliefs. Most of the area is covered by rainfed paddy field. A part of the area was covered by water for only a short period at the time of flooding.

2.3 Results of Field Survey and Laboratory Analysis

Soil field survey was carried out through field reconnaissance, test pit. 11 test pits and 32 were conducted. Location of survey sites are shown in Fig. II - 1.

2.4 Soil Classification

The soil classification of the project area was made in conformity with the system of "The Soil Map of the World" compiled by FAO and UNESCO in 1974. As a result of the observation on diagnostic soil characteristics and profile features, the soils in the project area were classified into four groups. 38% of the soils in the project area belong to Acrisols. Besides that, the Fluvisols and cambisols are also found in the project area.

Soil map is prepared considering the factors of soil texture, relief conditions and soil depth as shown in Fig. II - 1. Area extent of each soil unit is shown in Table II - 5.

The major characteristics and distribution of each soil class are as follows:

2.4.1 Acrisols

The acrisols extend broadly over the Project area. Acrisols are typical soils in the humid tropical area and are characterized by a base saturation of less than 50% in the B horizon at less than 120 cm depth where clay has illuviated. Acrisols develop on flats of ancient alluvial deposits which are broadly distributed at the monsoon climate areas. The mother rock is delicate and weathered, and is leached to elluviated layer clay. They are acidic and podsolized in the surface horizon and ferric and aluminum illuviate in the lower layer.

The top soils are slightly acidic (pH 5.5 - 6.0), and has the texture of sandy loams or clay loam. The subsoils are more acidic than the top soils and the texture ranges from silty clay to clay. Soil profile shows remarkably poor soil structure with ferric characteristic (mottles of ferric oxides and oxidic concretion or hardened plinthite at least 25 cm thick) within 100 cm from the surface.

Clay mineral of Acrisols is mainly of Kaolinite which is characterized as having low cation exchange capacity (CEC), low base saturation degree, and high acidity, which are obvious in the data obtained from the laboratory analysis, and especially low phosphorus content.

Generally, the soils lower than EL 150 m have a depth of more than one meter. This difference is considered to be caused by the soil conservation effect of covering vegetation.

2.4.2 Fluvisols

The soils classified under Fluvisols are located at the southwest boundary of the H. Bak district. The area is 226 ha in measurement and is mainly made up of waste lands, small ponds and rainfed paddy fields.

The soils are primarily made from recent alluvium deposits on a hardpan depression.

The profile of soil has no particular diagnostic features except for very few weak mottling formation in the shallow depth. The typical horizon sequence is A/B/C. The A horizon is brownish black (5 YR 2/2) in matrix color, clay loam to clay, medium and weak sub-angular blocky structures, friable when wet and slightly hard when dry, and has gradual and smooth boundaries with the B horizon.

The B horizon is brownish black (7.5 YR 3.2) in matrix color, clayey in texture, and has diffuse and smooth boundary with the C horizon.

The C horizon is dull to dark brown (7.5 YR 3/4) in matrix color, gravelly clayey in texture.

2.4.3 Gleysols (Humic Gleysols)

The soils of this unit develop rather widely over the depression along the H. Bak and H. Phou River in the flat portion of the Project area. The area is 559 ha and cultivated with rainfed paddy.

The land covered with this soil develops on the recent alluvial deposits. It gets inundated during the rainy season and has high ground water table even in the dry season. Typical soil horizon sequence is A/C and the effective soil depth is shallow and limited by the groundwater which exists only in 30 - 40 cm from the ground surface even in the rainy season.

The A horizon has high moisture content, grayish black in color, very fine clay, massive structure, firm, and has clear and smooth boundary with the C horizon.

The C horizon is grayish in color, clay to silty clay, and contains low organic carbon.

With regard to physical properties, the soils have relatively high moisture holding capacity with very low permeability coefficient. This soil area is suitable for paddy cultivation but not for the crops.

2.4.4 Cambisols

The Cambisols extend over the upper pediment of the Project area.

The top-soil and subsoil are slightly acidic (pH 5.5 - 6.0) with the texture of sandy loam to clay loam. Soil profile shows remarkably poor structure with ferric characteristics (mottles of ferric oxides and lateritic gravels) below to 150 cm from the surface.

Clay mineral of Cambisols has low cation exchange capacity (CEC) and low base saturation degree, which are obvious in the data obtained from the laboratory analysis, and especially low phosphorus content, too.

Generally, the Area with an elevation higher than 150 m EL (upper pediment), has a Cambisol thickness of more than one meter, however, some area are shallow.

3. Land Classification

3.1 Land Classification System

Land classification of the Project area is made in accordance with the land classification system formulated by the National Institute of Agricultural Science, Japan.

Generally, the land classification criteria to be applied to an objective area should be selected in consideration of the natural condition and socio-economic condition prevailing in the area. In this view, the systems of USDA (US Department of Agriculture), USBR (US Bureau of Reclamation) and FAO are examined in addition to the Japanese one.

The USDA system is a system for the assessment of land capability mainly against soil erosion. The USBR system is for the assessment of land productivity of arid area for upland crops. The FAO system is devised for the assessment of world-wide agriculture and soils. All of them do not serve as detailed criteria for suitability for irrigated paddy cultivation, and therefore, are considered to be difficult to apply to the Project area. Since the Japanese system is originally devised for the purpose of assessing land capability for paddy cultivation, its use in this study is proposed.

In the Japanese system, lands are classified into 4 capability classes, i.e., I, II, III and IV. Each class is defined as follows:

- Class I ; Land has almost no limitation for crop production and/or no risk of soil conservation. It is naturally fertile and has a great potential for crop production without applying any soil improvement practices.

- Class II ; Land has some limitations for crop production and/or some risks of soil conservation, and requires some soil improvement practices for normal crop production.

- Class III ; Land has many limitations for crop production and/or is likely to be subject to risks of soil conservation, and fairly intensive improvement practices are required.

- Class Ⅳ; Land has great natural limitations than those in Class Ⅲ, but can be utilized for cultivation of some specific crops under very careful management.

3.2 Factors to Decide the Capability Class

Land is classified under the above four classes in each factor and finally determined at the lowest class among all classes of the factors. The 13 factors shown below are evaluated for the assessment of the production capability of both paddy and upland crops.

	Factor	Code
1.	Thickness of top soil	(t)
2.	Effective depth of soil	(d)
3.	Gravel content in top soil	(g)
4.	Easiness of plowing	(p)
5.	Permeability under submerged condition/1	(I)
6.	Stage of redox potential/1	(r)
7.	Wetness of land/2	(w)
8.	Inherent fertility	(f)
9.	Content of available nutrients	(n)
10.	Degree of hazard	(i)
11.	Frequency of hazard	(a)
12.	Slope/2	(s)
13.	Erosion	

Note: /1 factor for paddy only
/2 factor for upland crop only

The factors of the land capability classes are explained as follows

(1) Thickness of top soil (code: t)

Top soil is the first horizon where plant roots can easily penetrate, and generally corresponds to the plowed layer. The classes are grouped according to the thickness of top soils as follows (when effective depth of soil (d) is placed under class Ⅳ, this factor also is placed under class Ⅳ).

t (cm)	Class	
	Paddy	Upland
more than 25	I	I
25 - 15	I	II
less than 15	II	III

(2) Effective depth of soil (code: d)

Effective depth of soil is the depth down to bedrock, hard pan or gravel layer which plant roots can not penetrate. The classes are grouped according to the effective soil depth as follows:

d (cm)	Class	
	Paddy	Upland
more than 100	I	I
100 - 50	I	II
50 - 25	II - III	III
less than 25	IV	IV

Note: The Japanese system classified the land with a soil depth of 25 - 15 cm as Class Ⅲ and that of 15 cm deep or less as Class Ⅳ. For the Project area, however, lands with a soil depth of less than 25 cm is classified as Class Ⅳ, taking into account the local conditions.

(3) Gravel content in top soil (code: g)

Gravel contents in top soil are expressed by the percentage of the exposed surface area of gravel on the soil profile, and are graded according to the following classes:

g (%)	Class	
	Paddy	Upland
more than 5	I	I
5 - 10	I	II
10 - 20	I - II	II - III
20 - 30	II - III	III - IV
more than 50	IV	IV

(4) Easiness of plowing (code: p)

The Easiness of plowing largely depends upon the quantity and quality of clay and organic matter and moisture condition. In order to estimate the class of this factor, the following 4 sub-factors are used:

i) Soil texture of top soil;

	Content of clay	Content of sand
1. Coarse	less than 15%	more than 85%
2. medium	less than 15%	less than 85%
3. fine	15 - 25%	–
4. very fine	more than 25%	

ii) Stickiness of top soil;

1. not and/or slightly sticky
2. sticky
3. very sticky

iii) Consistence when dry;

1. loose
2. hard
3. very hard

These sub-factors are combined altogether to determine the capability classes stated below:

Sub-factors			Class	Criteria
i)	ii)	iii)		
1	1	(2)/1	I	Easy to slightly
2	2	2	I	difficult
2	2	2	I	
2	2	3	II	Moderately difficult
3	3	3	II	
2	2	3	III	Very difficult
	3	3	III	
3				

/1: limitation by dry condition

(5) Permeability under submerged condition (code: I)

This factor affects irrigation water requirement, soil temperature, and leaching of the nutrients or development of reduced condition of the soil. This standard factor is evaluated mainly by the combination of soil texture and the presence of compact layer within 50 cm from the surface, as sub-factors:

i) Soil texture;

		Content of clay	Content of sand
1.	very fine :	More than 25%	–
2.	fine :	15 - 25%	–
3.	medium :	less than 15%	less than 85%
4.	coarse :	less than 15%	more than 85%

ii) Compactness;

1. compact : more than 14.0 kg/cm^2 by hardness meter
2. medium : 14.0 - 1.4 kg/cm^2 by hardness meter
3. loose : less than 1.4 kg/cm^2 by hardness meter

These sub-factors are combined altogether to determine the capability classes stated below:

Sub-factors		Class	Criteria
i)	ii)	Paddy	
1	1	I	Poorly to imperfectly permeable
1	2	I	
2	2	I - II	Moderately to favorably permeable
3	2	II	
3	3	III	Favorably to excessively permeable

(6) State of redox potential (code: r)

This factor indicates the risk of root damage owing to the strong reduction of soil, resulting in low rice production. The following sub-factors are used for the evaluation of this factor.

i) Content of easily decomposable organic matter in top soil;

1. low : Less than 10 mg NH_4 - N/100 g
2. medium : 10 - 20 mg NH_4 - N/100 g
3. high : more than 20 mg NH_4 - N/100 g

ii) Content of free iron oxides in top soil;

1. high : more than 1.5% for dry soil
2. medium : 1.5 - 0.8%
3. low : less than 0.8%

iii) Degree of Gleyification;

1. weak : no gley horizon within 50 cm from the surface
2. medium : gley horizon exists within 50 cm
3. strong : gley horizon exists throughout profile or exists below plowing layer

These sub-factors are combined altogether to determine the capability classes stated below:

Sub-factors			Class	Criteria (Risk of root damage)
i)	ii)	iii)		
1	1	2	I	None to weak
1	3	2	I	
2	1	2	I	
1	1 - 2	3	II	Moderate to strong
1	3	3	II	
2	1 - 2	3	II	
3	1	2	II	
2	3	3	III	Very strong
3	2	2	III	
3	1	3	III	
3	3	2	III	

(7) Wetness of land (code: w; wet condition, (w); dry condition)

This factor is only applied to upland crops. This factor is used for the estimation of wet or drought injury of upland crops and trees, and is evaluated by the combination of the following sub-factors:

i) Permeability;

1. high
2. medium
3. low

ii) Water holding capacity (evaluated by available moisture);

1. high	:	more than 20%
2. medium	:	20 - 10%
3. low	:	less than 10%

iii) Moisture condition;

(2) dry (Limitation by dry condition)

1. slightly moist
2. moist
3. wet

These sub-factors are combined altogether to determine the capability classes stated below:

Sub-factors			Class	Criteria (Risk of root damage)
i)	ii)	iii)		
1	3	(2)/1	(IV)	None to weak
1	3	1	(III)	
1	2	1	(II)	
1	1	1	I	Moderate to strong
2	2	2	II	
1 - 3	1	3	III	
3	2	3	IV	Very strong

/1: limitation by dry condition

(8) Inherent fertility (code: f)

Inherent fertility is evaluated by the combination of the following 3 sub-factors:

i) Nutrient holding capacity (evaluated by CEC);

1. high : more than 20 meg/100g
2. medium : 20 - 6 meg/100g
3. low : less than 6 meg/100g

ii) Nutrient fixation power (evaluated by coefficient of P_2O_5 absorption);

1. very low : less than 700 (mg P_2O_5/100 g dry soil)
2. low : 700 - 1,500 (mg P_2O_5/100 g dry soil)
3. medium : 1,500 - 2,000 (mg P_2O_5/100 g dry soil)
4. high : more than 2,000 (mg P_2O_5/100 g dry soil)

iii) Base status in soil (evaluated by base saturation degree);

1. good : more than 50%
2. medium : 50 - 30%
3. poor : less than 30%

These sub-factors are combined altogether to determine the capability classes stated below:

(a) For paddy

Sub-factors			Class	Criteria
i)	ii)	iii)		
1	1 - 2	2	I	Fertile
2	1 - 2	1	I	
1	1 - 2	3	II	Medium
1	3 - 4	2	II	
2	1 - 2	2	II	
3	1	2	II	
2	3 - 4	3	III	Infertile
3	2	2	III	
3	3 - 4	3	III	

(b) For upland crops

Sub-factors			Class	Criteria
i)	ii)	iii)		
1	2	1	I	Fertile
2	1	2	I	
1	1	3	II	Medium
2	1	3	II	
2	1 - 2	2	II	
1	3	1	II	
1	3	2	II	
1	3	3	III	Infertile
2	4	2	II - III	

(9) Content of available nutrients (code: n)

Contents of available nutrients in soil are closely related to the inherent soil fertility, and evidently influence cultivation practices. The capability class is evaluated by the combination of the following sub-factors:

i) Content of exchangeable calcium;

1.	high	:	more than 200 CaO meg/100g
2.	medium	:	200 - 100 CaO meg/100g
3.	low	:	less than 100 CaO meg/100g

ii) Content of exchangeable magnesium;

1.	high	:	more than 25 MgO mg/100g
2.	medium	:	25 - 10 MgO mg/100g
3.	low	:	less than 10 mg/100g

iii) Content of available potassium;

1.	high	:	more than 15 K_2O mg/100g
2.	medium	:	15 - 8 K_2O mg/100g
3.	low	:	less than 8 K_2O mg/100g

iv) Content of available phosphate;

1.	high	:	more than 10 P_2O_5 mg/100g
2.	medium	:	10 - 2 P_2O_5 mg/100g
3.	low	:	less than 2 P_2O_5 mg/100g

v) Content of available nitrogen;

1. high : more than 20 ammonia - N mg/100g
2. medium : 20 - 10 ammonia - N mg/100g
3. low : less than 10 ammonia - N mg/100g

vi) Content of available silica;

1. high : more than 15 SiO_2 mg/100g
2. medium : 15 - 5 SiO_2 mg/100g
3. low : less than 5 SiO_2 mg/100g

vii) Content of micro-elements (evaluated by the risk of deficiency);

1. none and/or weak
2. medium
3. serious

viii) Acidity (evaluated by pH (H_2O));

Paddy	Upland			
1	1	weak	:	more than 6.0
2	2	medium	:	6.0 - 5.0
3	3	strong	:	5.0 - 4.5
3	4	very strong	:	less than 4.5

these sub-factors are combined altogether and finally capability is classified as follows:

Class	Criteria
I	high
II	Medium
III	Low

(10) Degree of hazard (code: i)

This factor means limitation caused by the presence in excess of substances such as sulphur compounds, soluble salts, heavy metals, etc. Dependent sub-factors for this factor are as follows:

i) Presence of harmful substances;

(a) Harmful sulphur compounds

1. none
2. slightly
3. moderately
4. seriously

(b) Salts content (evaluated by chlorine content as an indicator)

1.	Low	:	less than 0.1% for dry soil
2.	Medium	:	0.1 - 0.3%
3.	high	:	more than 0.3%

(c) Heavy metals

1. Low
2. Medium
3. high
4. seriously

ii) Physical hazard

Presence of bedrocks, pans, compact layers or gravel layers that disturb root development within 50 cm of the surface, and difficultly of their removal:

1. none
2. slightly
3. very difficult

The class of this factor is decided by the lowest grade among the dependent subfactors:

Class	Criteria
I	high
II	Medium
III	Low
IV	seriously

(11) Frequency of hazard (code: a)

This factor is mainly influenced by natural environmental condition. The class of this factor is determined by the combination of the following two dependent subfactors:

i) Risk of overhead flooding inundation;

1. none and/or rarely : no risk if rainfall with high intensity occurs
2. slightly : even if inundation occurs due to high rainfall intensity, excess water is drained out shortly afterwards
3. very difficult : inundation continuous for a long period if rainfall with high intensity occurs

ii) Risk of land creep;

1. none
2. slightly
3. very difficult

The class of this factor is determined by the lowest grade of two dependent subfactors:

Class	Criteria
I	high
II	Medium
III	Low
IV	seriously

(12) Slope (code: w)

This factor is applied to upland crops only. The class of this factor is decided by the combination of the following sub-factors:

i) Natural slope as a main dependent sub-factor: 5 grades as shown in the following table.

ii) Direction of slope

iii) Artificial slope

Sub-factors		Class
(°)	(%)	
less than 3	less than 6	I
3 - 8	6 - 14	I
8 - 15	14 - 28	III
15 - 25	28 - 47	IV
more than 25	more than 47	IV

(13) Erosion (code: e)

The class of this factor is determined by the combination of the following subfactors:

i) Occurrence of rill or gully;

		Occurrence of Rill	Occurrence of Gully
1.	none	none	none
2.	rarely	rarely	none
3.	moderately	sometimes	none
4.	frequently		exist

ii) Resisting power to water erosion;

1. strong
2. medium
3. weak

iii) Resisting power to wind erosion;

1. strong
2. medium
3. weak

Class	Criteria
I	None or very slightly
II	Slightly
III	Seriously
IV	Very seriously

3.3 Results of Land Classification

The land classification study for the Project area is made in accordance with the abovementioned specification. As a result of classification, 14 groups are identified as shown in Table II - 6, and their distribution is shown in Fig. II - 5. The area extent of each capability class is as follows:

Class		Nyod H. Bak	Namphou	Total
Paddy	Upland			
III	IV	1,183	834	2,017
IV	IV	399	127	526
Total		1,582	961	2,543
Village, Stream, Pond		43	39	82

The lands classified into classes I, II and III are regarded as suitable for agricultural development. Consequently, 2,017 ha has been evaluated as suitable for paddy cultivation. For cultivation of upland crops, all of the land are unsuitable under the present condition (Fig. II - 4).

4. Land Use

4.1 Present Land Use

Present land use is studied by examining the 1991 topographic map (1:5,000) and interviewing local people (preliminary study) and conducting field survey (confirmation).

The lands in the project area are classified into seven categories comprising rainfed paddy field, upland crop field, grass land, forest, waste land pond and stream and village. Present land use in the project area is illustrated in Fig. II - 5.

2. The extent of each category is as follows:

	H. Bak				Area (ha)	
	area (ha)	%	area (ha)	%	Area (ha)	%
Rainfed paddy field	1.170	72	835	83	2.005	76
upland crop field	12	1	3	-	15	1
Grass field	230	14	59	6	289	11
Forest	102	6	18	2	120	5
Waste land	68	4	46	5	114	4
Pond and stream	35	2	37	4	72	3
Village	8	1	2	-	10	-
Total	1.625	100	100	100	2.625	100

The project area has been developed and used as paddy fields for a long time. The paddy fields are almost rainfed with single cropping of rice during the rainy season, and double cropping fields are for using spring water or manual irrigation. The paddy fields are classified by elevation, such as highland paddy field (NAH - PON), and medium land paddy field (NAH - RUP). Early maturing varieties, medium maturing varieties and late maturing varieties are planted, respectively. These classification are closely concerned with water resources and flood conditions. Farmers prefer to plant these three types of paddy varieties together.

The upland crop fields are classified into normal upland fields and burnt fields, however the area of the burnt field is few. Home gardens are cultivated in some parts of residential areas and paddy fields and fruit trees, vegetables spices and fiber crops are planted in a small scale.

Paddy field during the dry season, and a part of the forest area are used as pasture area for buffaloes and cattles.

4.2 Cropping Pattern

The project area is characterized as a paddy mono - cultural area. Almost all of the paddy fields are cultivated under rainfed condition in the rainy season. In the dry season of 1991, few hectares of paddy fields located in the B. Namphou - Nua (Namphou district) were irrigated by spring and then cultivated. The present cropping pattern is shown in Fig. II - 4.

4.3 Paddy Field

Paddy field survey in the project area is carried out in two steps, i. e. statistical survey and field survey.

(1) Statistical survey

Statistical paddy field of Kanthaboulhy district and Champhone district (inclusive of project area) was 2,817 kg/ha (1986 to 1990, without 1988).

Statistical paddy field

Name of District	Year	Harvested area (ha)	Paddy Production		
			Total (ton)	kg/ha	
Kanthabouly	1986	11.333	30.599	2.700	
	1987	11.044	31.363	2.850	
	1988	6.500	10.573	1.627	Flooding
	1989	10.570	30.133	2.851	
	1990	10.129	32.122	3.171	without
	M			2.893	1988
Champhone	1986	17.227	39.622	2,300	
	1987	17.857	47.321	2.650	
	1988	8.900	16.285	1.830	Flooding
	1989	17.285	47.063	2.890	
	1990	15.074	47.138	3.127	without
	N			21.742	1988

Source: Savannakhet Agriculture Section 1990

(2) Field Survey

Case I. Paddy yield of Tasano Seed Farm survey

Variety name	Paddy ;yield (ton/ha)		Fertilizer (kg/ha)
	every year	maximum year	
Rd - 16	3.5	4.0	50 × 2
Hommary	2.5	3.0	50 × 2
Sampatton	2.0		50 × 2
Floating rice	1.0	1.5	–

Source: Interview record of Tasano Seed Farm (No. 1990)

Case 2. Quadrant sampling survey

No. of Sampling field	1	2	3	4
	(B. DON-HOSI)	(NAMPHOU-TAI)	B. DONG-KHNKHOU)	(B.DONG-KALOHNG)
Soils	Cambisols	Aorisols	Cambisols	Aorisols
Date	Sept. 27,'91	Sept. 27,'91	Sept. 30,'91	Sept. 30,'91
Variety Name	early glutinous	early KAO.I.KAM	early MAKKADO	early KAOMAN-DO
Planting density (hill/m²)	16.0	16.2	24.3	23.0
Compound fertilizer (kg/ha)	none	100	100	none
Growth and development	unbalance	good	second	ordinary
Crop situation	Normal crop	Bumper	Normal crop	Normal crop

No. of Sampling field	1	2	3	4
Farmers' Interview paddy field (ton/ha)	-	1.8	-	-
Number of fruitful ear (per m^2)	51.3	81.1	102.1	73.7
Number of ripening paddies (per m^2)	3.635	7.027	7.267	5.587
Ratio of winnowed paddies (%)	57.8	63.8	47.5	76.0
1,000 - grain weight paddy (g)37.15	37.15	39.70	36.40	39.30
Weight of winnowed paddy (g/m^2)	73.1	143.5	125.78	140.5
Weight of paddy screenings (g/m^2)	44.7	11.450	104.3	68.3

4.4 Proposed Land Use

As a result of land capability classification, as described in 3 of land classification, an area of 2.017 ha is classified into class I, II and III for crop cultivation. Grass lands and forest areas, where sails are shallow and contain gravel in top soil, and waste lands are cliffs or erose areas classified as unsuitable land for development.

Further, the land use plan is determined, taking the present land use and topographic conditions for irrigation into consideration in addition to the result of land classification. Some of the areas are classified as unsuitable, but are presently cultivated as paddy field included in the irrigation area. Further, net irrigation area will be 1,655 ha of which 950 ha belongs to the H. Bak district area and 705 ha in the Namphou district area. Irrigation shall be further implemented in existing rainfed paddy fields of 1,655 ha. Infrastructures including irrigation facilities will occupy 263 ha, consisting of 195 ha of present rainfed paddy field, 37 ha of grass land, 15 ha of forest, 14 ha of waste land and 2 ha of pond and stream. Land demarcation for the future land use is given in Table II - 4.

For the area where the soil is composed of gleysols, acrisols and cambisols (Soil map, Fig. II - 2), rotational cropping of rice and upland crops are proposed considering the suitability of soils, soil improvement and necessity of crop diversification. Net area proposed for rotational cropping is 1,610 ha, consisting of 950 ha in the H. Bak district and 660 ha in the Namphou district.

The proposed future land use map is given in Fig. II - 6, and the land use area is summarized as follows:

4.5 Selection of Crops

After completion of the project construction, the existing rainfed paddy field will be upgraded to year - round irrigation and more intensive land use of the farm land will become possible. Crop selection and determination of cropping pattern for the project are made from the following viewpoint:

(1) Marketability of products

(2) Acceptability of farmers

(3) Suitability of land and climate for crops

(4) Profitability of crops for both farmers and nation as whole

(5) Agricultural policy of both Central Government and Savannakhet Province

In due consideration of the above factors, paddy rice is proposed as the main crop, and peanut, garlic and vegetable crops are proposed as upland crops to be cultivated in the dry season.

(1) Rice

Rice is the most suitable crop in the major part of the Project area in view of the prevailing market and climate. On account of its high expected yield and fairly stable price, rice is the most profitable crop for farmers. Farmers have long since experience rice cultivation and are eager to adopt irrigated cultivation to maximize production.

Since small rice farmers and hinterland people of the project suffer from seasonal or chronic rice shortage, and Lao PDR is still a potential rice exporter, the increase in rice production is expected to contribute to the minimization of the use of foreign currency. Rice is consequently proposed as the principal crop in both the rainy season and dry season.

(2) Upland crops

Introduction of upland crops is proposed in the dry season in some 1,610 ha of land,in which soil are medium textured. The shortage in rice is expected to be considerably alleviated after the completion of the project, and crop diversification will be the main subject for future agricultural development.

Even now, the diversification of agriculture by the expansion of the production of non-rice crops is advocated as one of the objectives of the Government's agricultural policy, as shown in Annex IV. In addition, the demands for raw agro-industrial materials have been increasing in accordance with the promotion of the agro-industry as a substitute for importation. As recommendable upland crops, the following few are selected.

(2) - i) Peanuts

Fairly large market is expected for this crop. Some countries have been inquiring on the export of this crop. Peanut is cultivated only for the domestic market as food at present. The yield of peanut in this proposed area is very low, but peanut cultivation is suitable in the area.

(2) - ii) Garlic

Garlic is one of the most profitable crop due to its high market price. Presently, most garlic products have been consumed in Vientiane, and they come from the northern high plateau.

On the other hand, some percentages are imported from Thailand due to the short supply of local products.

Garlic has a big demand not only in the domestic market but also in neighboring countries like Vietnam, Thailand and Cambodia.

Therefore, garlic is also one of the crops recommended for the Project.

Other upland crops were not recommended for the Project due to the following reasons:

Unsuitable climate	(coffee, cardamom, tea)
Small market scale	(vegetables, fruits)
Relatively shallow soils	(Maize, sugarcane, tobacco)

4.6 Proposed Cropping Pattern

Cropping patterns which project condition are determined in order to sustain farming and achieve a high yield based on the above crop selection. The proposed cropping pattern is shown in Fig. II - 2.

Table II - 1 Proposed Land Use

	Present Land Use						Proposed Land Use					
	H. Bak		Namphou		Total		H. Bak		Namphou		TOTAL	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Rainfed Paddy Field	1,170	72	835	83	2,005	76	110	7	45	5	155	6
Irrigated Paddy Field	-	-	-	-	-	-	-	-	45	4	45	2
Paddy/Upland Crop Field	-	-	-	-	-	-	950	58	660	66	1,610	61
Upland Crop Field	12	1	3	-	15	1	12	1	3	-	15	1
Grassland	230	14	59	6	289	11	200	12	52	5	252	9
Forest	102	6	18	2	120	5	89	5	16	2	105	4
Waste land	68	4	46	5	114	4	59	4	41	4	100	4
Pond and Stream	35	2	37	4	72	3	34	2	36	4	70	3
Village	8	1	2	-	10	-	8	1	2	-	10	-
Infra - Structure	-	-	-	-	-	-	163	10	100	10	263	10
Total	1,625	100	1,000	100	2,625	100	1,625	100	1,000	100	2,625	100

Table II-2 Physical and chemical properties of Pit Samples Nov-1991 (Part 1/2)

Profile No.	Horizon	Depth cm	Particle size distribution (mm·%) >2.0	2.0~0.2	0.2~00.2	0.02~0.002	<0.002	Texture	Density (g/cm3) Bulk	Specific	Porosity (%)	PH H2O	KCl	EC (μs/cm)	$CaCO_3$ (%)	C (%)	OM (%)	C/N
101	A	0~20	-	71.3	10.3	12.0	6.4	Ls	1.48	2.54	41.73	5.1	4.2	27.44	0.00	0.42	0.72	15
	B	20~40	-	47.7	20.2	20.9	11.2	S1	1.50	2.53	40.71	5.2	4.2	27.44	0.04	0.40	0.69	14
102	A	0~8	-	7.6	61.8	17.7	12.9	S1	1.51	2.53	40.31	5.9	4.2	26.46	0.08	0.24	0.41	9
	A'	8~25	-	10.1	63.0	20.0	2.9	Ls	1.50	2.54	40.94	6.0	4.1	48.02	0.00	0.20	0.34	7
103	A	0~20	-	38.5	31.9	17.2	12.4	S1	1.48	2.52	41.26	6.3	5.0	24.50	0.04	0.28	0.48	13
	B	20~40	-	5.8	69.2	14.1	10.9	S1	1.49	2.53	41.10	4.9	3.9	27.44	0.00	0.44	0.76	13
104	A	0~20	-	49.3	26.9	12.5	11.3	S1	1.40	2.55	41.17	5.9	5.0	78.38	0.08	0.80	1.38	14
	B	20~40	-	47.3	20.1	18.6	14.0	S1	1.51	2.52	40.07	5.5	4.4	40.18	.00	0.52	0.90	12
	C	40~60	-	44.2	19.9	25.0	10.9	S1	1.50	2.53	40.71	5.5	4.3	26.46	0.00	0.60	1.03	13
105	A	0~20	-	17.2	64.4	11.6	6.8	Ls	1.51	2.53	41.10	5.7	4.5	42.14	0.04	0.56	0.97	13
	B	20~40	-	17.4	59.0	15.2	8.4	S1	1.50	2.54	40.71	5.6	4.2	34.30	0.00	0.41	0.71	16
106	A	0~20	-	44.1	30.1	7.2	18.6	S1	1.50	2.54	40.94	7.0	6.6	196.0	0.20	0.52	0.90	6
	B	20~40	-	36.3	26.3	29.4	18.0	S1	1.51	2.54	40.55	6.1	5.2	63.70	0.00	0.56	0.97	9
	C	40~60	-	41.0	18.3	17.3	23.4	Sc1	1.55	2.53	39.73	5.7	4.6	67.62	0.00	0.60	1.03	9
107	A	0~20	58.9	28.2	52.2	12.7	6.9	Ls	-	2.54	-	5.8	4.6	45.08	0.04	1.24	2.14	11
	B	20~40	72.4	29.1	30.5	27.4	13.0	S1	-	2.54	-	5.7	4.3	24.50	0.00	0.84	1.45	12
108	A	0~20	-	30.3	31.3	19.6	18.8	S1	1.50	2.53	40.71	5.4	4.5	60.76	0.00	1.28	2.21	11
	B	20~40	-	18.5	32.7	13.2	25.6	Sc1	1.53	2.53	39.52	5.5	4.2	53.90	0.00	0.64	1.10	11
109	A	0~20	-	39.5	21.9	16.9	21.7	Sc1	1.54	2.54	39.37	6.1	5.2	61.74	0.04	0.84	1.45	14
	B	20~40	-	32.6	32.3	14.3	20.8	Sc1	1.54	2.53	39.13	6.9	5.4	82.32	0.00	0.44	0.76	10
110	A	0~20	-	18.2	55.2	13.1	13.3	S1	1.51	2.53	40.31	8.4	7.0	2450.00	0.60	0.64	1.10	11
	B	20~40	-	13.4	59.5	14.0	26.1	Sc1	1.53	2.54	39.76	8.2	7.1	24.50	0.08	0.64	1.10	11
111	A	0~20	-	4.4	54.0	30.3	11.3	S1	1.49	2.54	41.33	5.5	4.1	166.60	0.00	0.40	0.69	14
	B	20~40	-	6.2	53.1	24.1	16.6	S1	1.51	2.52	40.07	5.4	3.7	294.0	0.00	0.40	0.69	13
	C	40~60	-	6.3	47.8	20.5	25.4	Sc1	1.53	2.54	39.73	5.2	3.8	343.0	0.00	0.52	0.90	12

Table II - 2 Physical and chemical properties of Pit Samples Nov-1991 (Part 2/2)

Profile No.	Horizon	Nitrogen Total (%)	Total P_2O_5 (%)	Available P (mg/100)	Fixed P_2O_5 (%)	Total K_2O (%)	Water-Soluble K_2O (mg/100)	Cation exchange capacity of soil (me/100g) Hh	Ca	Mg	K	Na	S	T	Element in Sorption complex (%) Hh	Ca	Mg	K	Na	B.S %
101	A	0.028	0.009	0.74	41.26	0.23	1.60	1.40	0.60	0.30	0.02	0.09	1.01	2.41	58.09	24.90	12.45	0.83	3.73	41.91
	B	0.028	0.009	0.91	43.71	0.08	2.40	1.75	1.10	0.05	0.04	0.14	1.33	3.08	56.82	35.71	1.62	1.30	4.55	43.18
102	A	0.028	0.009	0.91	28.73	0.20	2.00	2.28	1.30	0.70	0.03	0.29	2.32	4.60	49.57	28.26	15.22	0.65	6.30	50.43
	A'	0.028	0.014	1.14	39.68	0.27	1.60	3.68	2.70	1.45	0.03	0.78	4.96	8.64	42.59	31.25	16.78	0.35	9.03	57.41
103	A	0.022	0.005	0.69	36.36	0.52	1.20	0.53	0.90	0.40	0.02	0.17	1.49	2.02	26.24	44.55	19.80	0.99	8.42	73.76
	B	0.034	0.012	1.03	58.96	0.11	2.40	2.63	1.30	0.35	0.04	0.15	1.84	4.47	58.84	29.08	7.83	0.89	3.36	41.16
104	A	0.056	0.023	0.69	49.63	0.09	9.20	2.10	1.50	0.40	0.17	0.13	2.20	4.30	48.84	34.88	9.30	3.95	3.02	51.16
	B	0.042	0.021	1.37	52.09	0.15	10.80	2.10	1.10	0.20	0.19	0.12	1.61	3.71	56.60	29.65	5.39	5.12	3.23	43.40
	C	0.048	0.018	1.03	43.71	0.19	7.20	2.63	1.00	0.15	0.14	0.65	1.94	4.57	57.55	21.88	3.28	3.06	14.22	42.48
105	A	0.042	0.009	0.86	45.23	0.18	9.20	2.28	1.10	0.15	0.17	0.12	1.54	3.82	59.69	28.80	3.93	4.45	3.14	40.31
	B	0.028	0.006	1.49	34.93	0.19	8.80	2.10	0.45	0.90	0.16	0.16	7.67	3.77	55.70	11.94	23.87	4.24	4.24	44.30
106	A	0.084	0.023	2.63	35.87	0.03	10.80	0.35	4.40	1.05	0.23	0.16	5.84	6.19	5.65	71.08	16.96	3.72	2.58	94.35
	B	0.062	0.023	1.15	44.66	0.02	12.40	1.75	1.70	0.50	0.24	0.14	2.58	4.33	40.12	39.26	11.54	5.54	3.23	59.58
	C	0.064	0.023	0.80	41.60	0.22	12.40	1.93	1.60	0.20	0.23	0.20	2.23	4.16	46.39	38.46	4.81	5.53	4.81	53.61
107	A	0.112	0.025	0.74	39.47	0.05	16.40	4.03	2.80	0.80	0.35	0.19	4.14	8.17	49.33	34.27	9.79	4.28	2.33	50.67
	B	0.070	0.025	1.49	27.66	0.02	10.40	3.85	2.40	1.30	0.22	0.20	4.12	7.97	48.31	30.11	16.31	2.76	2.51	51.69
108	A	0.112	0.018	1.37	40.17	0.18	12.00	3.85	1.95	0.55	0.22	0.17	2.89	6.74	57.12	28.93	8.16	3.26	2.52	42.88
	B	0.056	0.014	1.14	41.23	0.01	8.00	2.98	1.55	1.60	0.17	0.23	3.55	6.53	45.64	25.74	24.50	2.60	3.52	54.36
109	A	0.062	0.012	1.49	43.44	0.33	4.00	1.58	2.10	0.20	0.07	0.20	2.57	4.15	38.83	50.60	4.82	1.69	4.82	61.93
	B	0.042	0.009	2.17	24.12	0.08	5.20	0.88	2.50	1.50	0.08	0.60	4.68	5.56	15.83	44.96	26.99	1.44	10.79	84.17
110	A	0.056	0.039	1.83	36.01	0.02	4.00	0.35	21.00	3.50	0.09	16.00	40.59	40.94	0.85	51.29	8.55	0.22	39.08	99.14
	B	0.056	0.048	2.29	19.93	0.09	3.60	0.18	17.65	4.85	0.08	16.00	38.58	38.76	0.46	45.54	12.52	0.21	41.28	99.55
111	A	0.028	0.009	0.86	48.19	0.03	2.00	2.63	1.50	0.20	0.03	0.60	2.33	4.96	53.02	30.24	4.03	0.60	12.10	46.98
	B	0.034	0.016	1.14	41.23	0.16	2.80	6.13	2.30	0.70	0.04	1.34	4.38	10.51	58.33	21.88	6.66	0.38	12.75	41.67
	C	0.042	0.016	0.63	44.73	0.27	2.40	6.30	2.75	1.05	0.04	1.70	5.54	11.84	53.21	23.23	8.87	0.34	14.36	46.79

Table II - 3 Results of Land Classification

Symbol of Factor for Assessment of Land Capability		t P/1	t U/2	d P	d U	g P	g U	p P	p U	l P	l U	r P	r U	w P	w U (W)/3 W/4	f P	f U	n P	n U	i P	i U	a P	a U	s P	s U	e P	e U	Synthetical Assessment P	Synthetical Assessment U	Area (ha) Namphou	Area (ha) H.Bak	Area (ha) Total
Gleysols	-1	II	II	I	I	I	I	I	II	II	–	III	–	–	(II) IV	II	III	III	III	I	I	III	IV	–	III	–	II	III rna II tlf	IV wa III fna II tpe	239	292	531
	-2	II	II	I	I	I	I	I	II	III	–	III	–	–	(III) IV	II	III	III	III	IV	IV	III	IV	–	III	–	II	IV ia III lrn II tf	IV wia III (w)fns II tpe	13	15	28
Acrisols	-1	II	II	I	I	I	I	I	I	II	–	I	–	–	(III) III	II	III	III	III	I	I	III	IV	–	II	–	IV	III na II tlf	IV ae III (w)wfn II ts	460	408	868
	-2	II	II	I	I	I	I	I	I	III	–	I	–	–	(III) III	II	III	III	III	IV	IV	III	IV	–	II	–	IV	IV i III lna II tf	IV iae III (w)wfn II ts	29	62	91
Combisols	-1	II	II	I	I	I	I	II	III	II	–	I	–	–	(IV) I	III	III	III	III	I	I	I	II	–	III	–	II	III fn II tpl	IV (w) III pfns II tae	135	358	493
	-2	II	II	I	I	I	I	II	III	III	–	I	–	–	(IV) I	III	III	III	III	IV	IV	I	II	–	III	–	II	IV i III lfn II tp	IV (w)i III pfns II tae	85	211	296
Fluvisols	-1	II	II	II	III	II	II	II	II	II	–	I	–	–	(IV) IV	II	III	II	III	III	IV	I	III	–	II	–	II	III i II tdgplfn	IV (w) wi III dfna II tgpse	–	125	125
	-2	III	III	IV	IV	III	IV	IV	IV	II	–	I	–	–	(IV) IV	II	III	II	III	IV	IV	I	III	–	II	–	II	IV dpi III tg II lfn	IV dgp(w)wi III tfna II se	–	111	111
																												Total		961	1,582	2,543
																												Village,	Stream, Pond	39	43	82

Remark: /1: Paddy field, /2: Upland crop field, /3: Dry season, /4: Rainy season

Table II - 4 Land Demarcation for Future Land Use (Total Project Area)

(ha)

Proposed Land Use / Present Land Use	1 Rainfed Paddy Field	2 Irrigated Paddy Field	3 Paddy/ Upland Crop Field	4 Upland Crop Field	5 Grass Land	6 Forest	7 Waste Land	8 Pond and Stream	9 Village	10 Infra-structuer	11 Total
1. Rainfed Paddy Field	155	45	1,610							195	2,005
2. Upland Crop Field				15						–	15
3. Grassland					252					37	289
4. Forest						105				15	120
5. Waste Land							100			14	114
6. Pond and stream								70		2	72
7. Village									10	–	10
8. Total	155	45	1,610	15	252	105	100	70	10	263	2,625

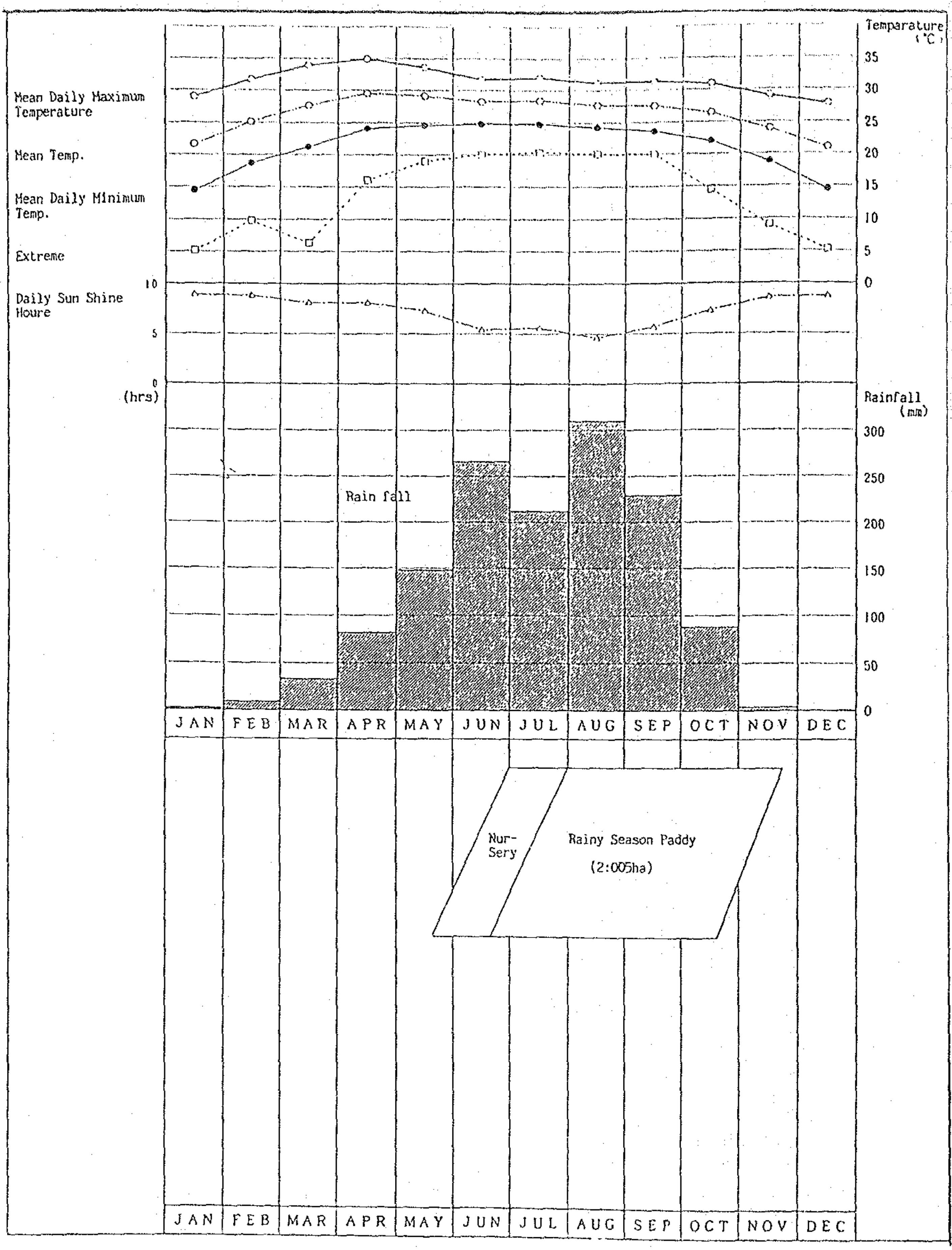


Fig. Present Cropping Pattern and Climatic Condition

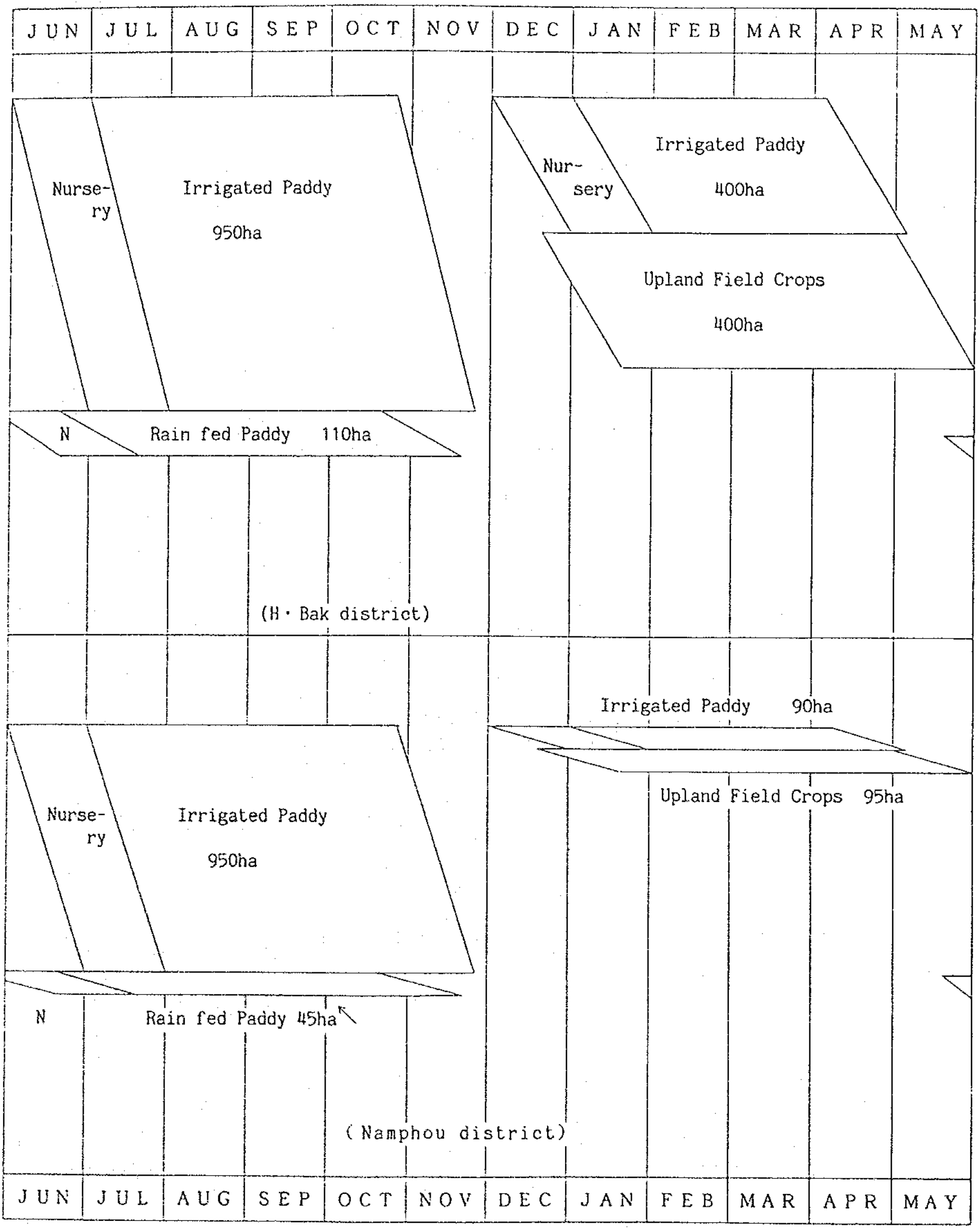


Fig. II-2 Proposed Cropping Pattern

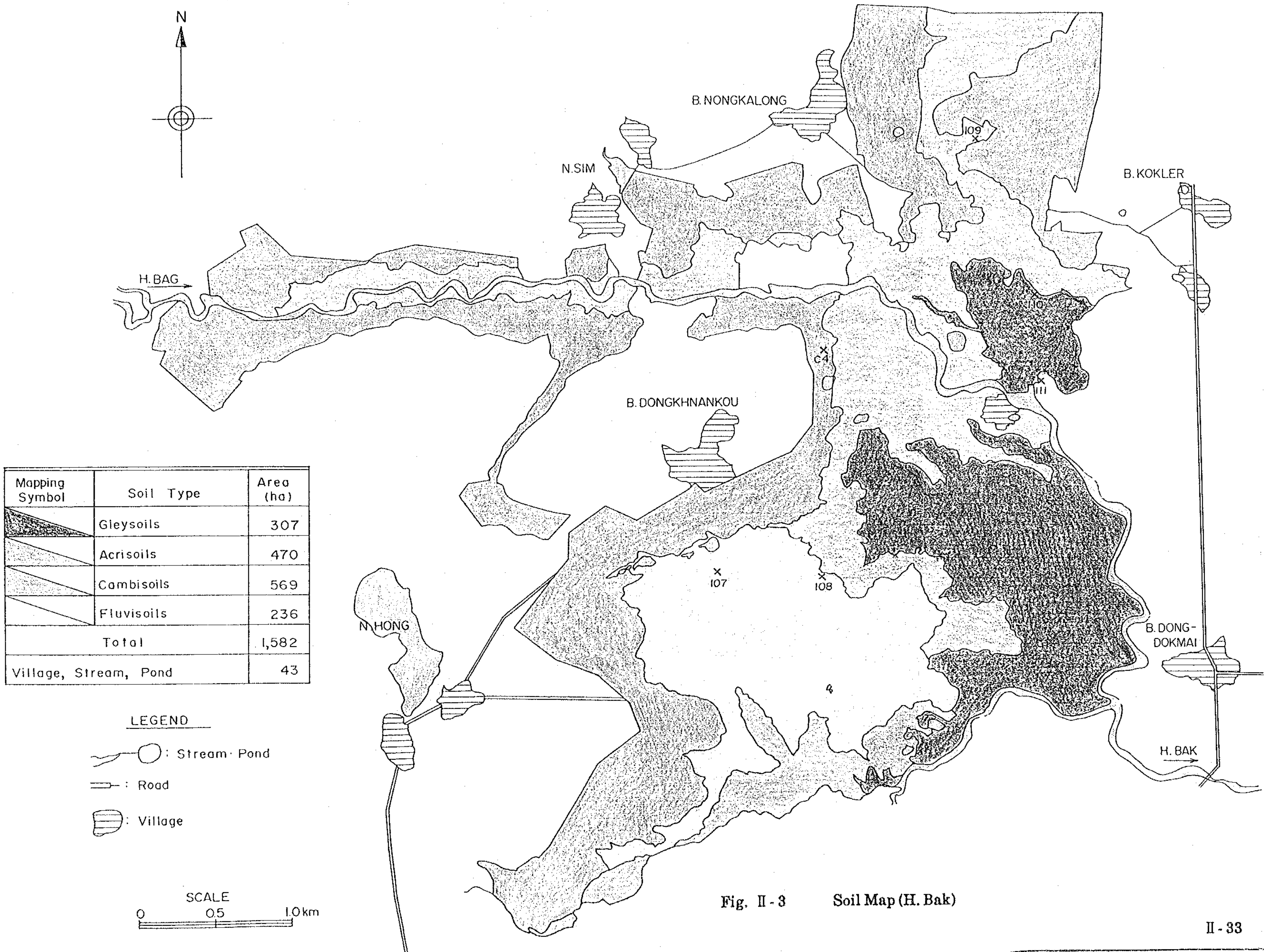
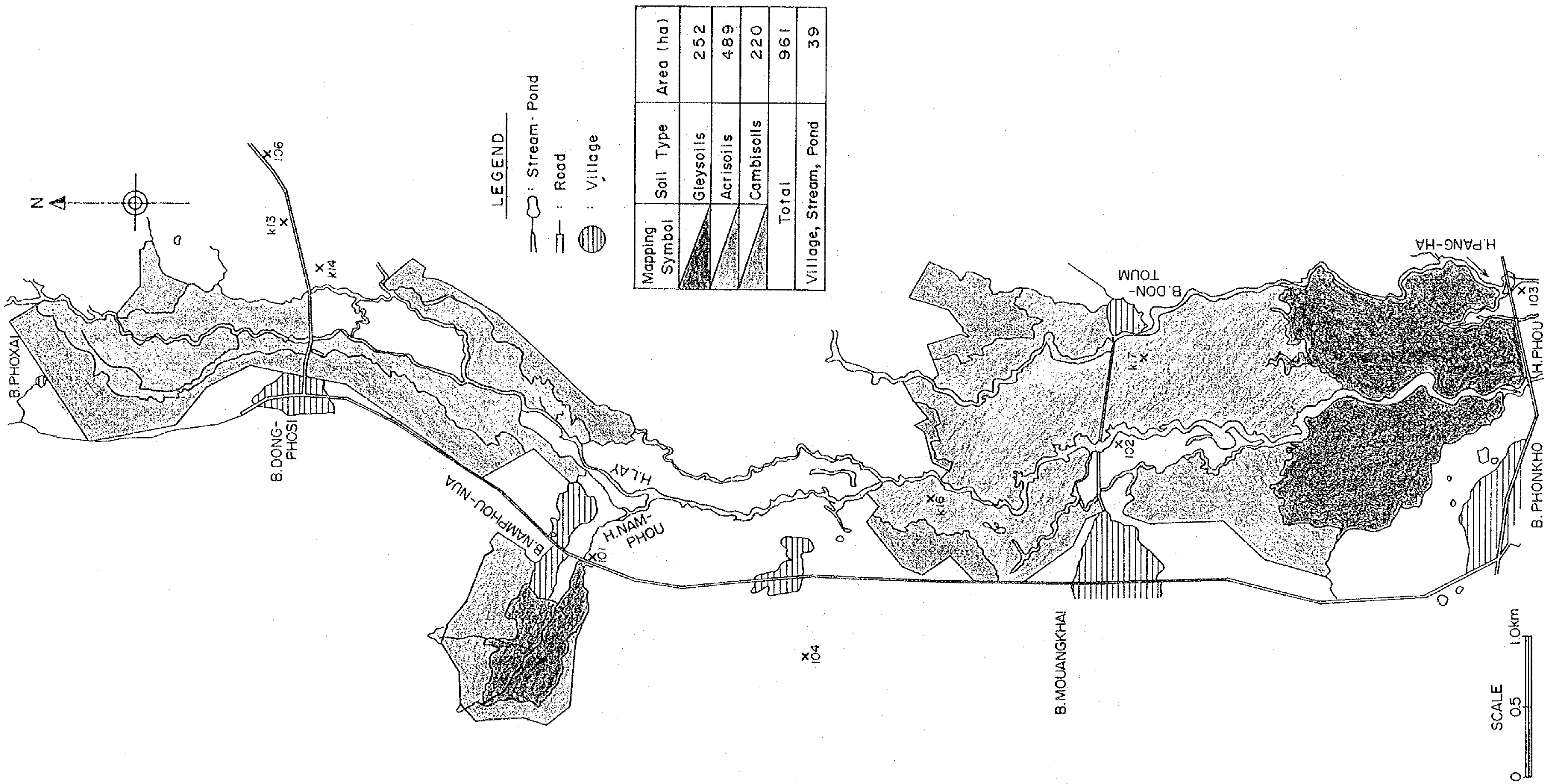
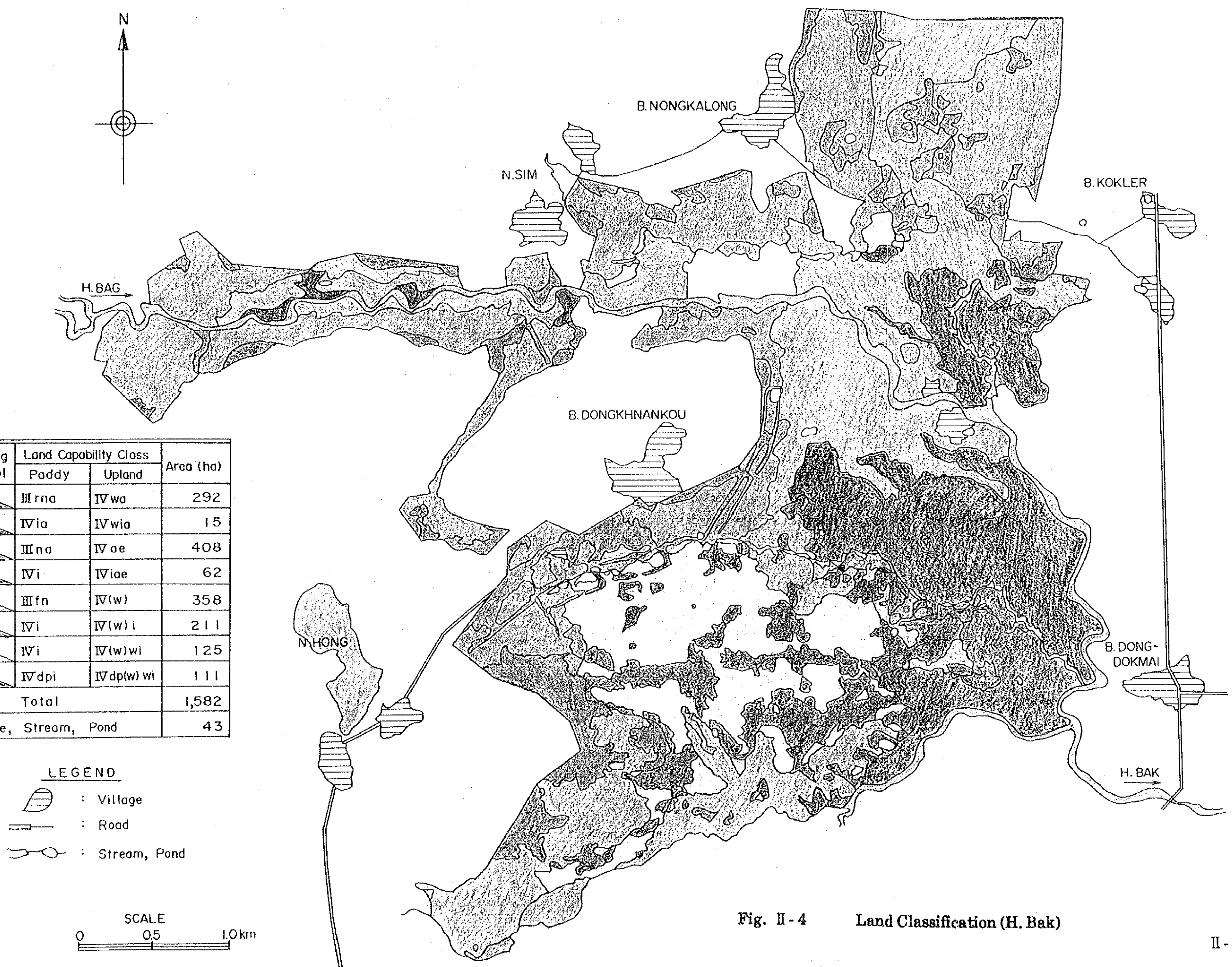


Fig. II-3 Soil Map (H. Bak)



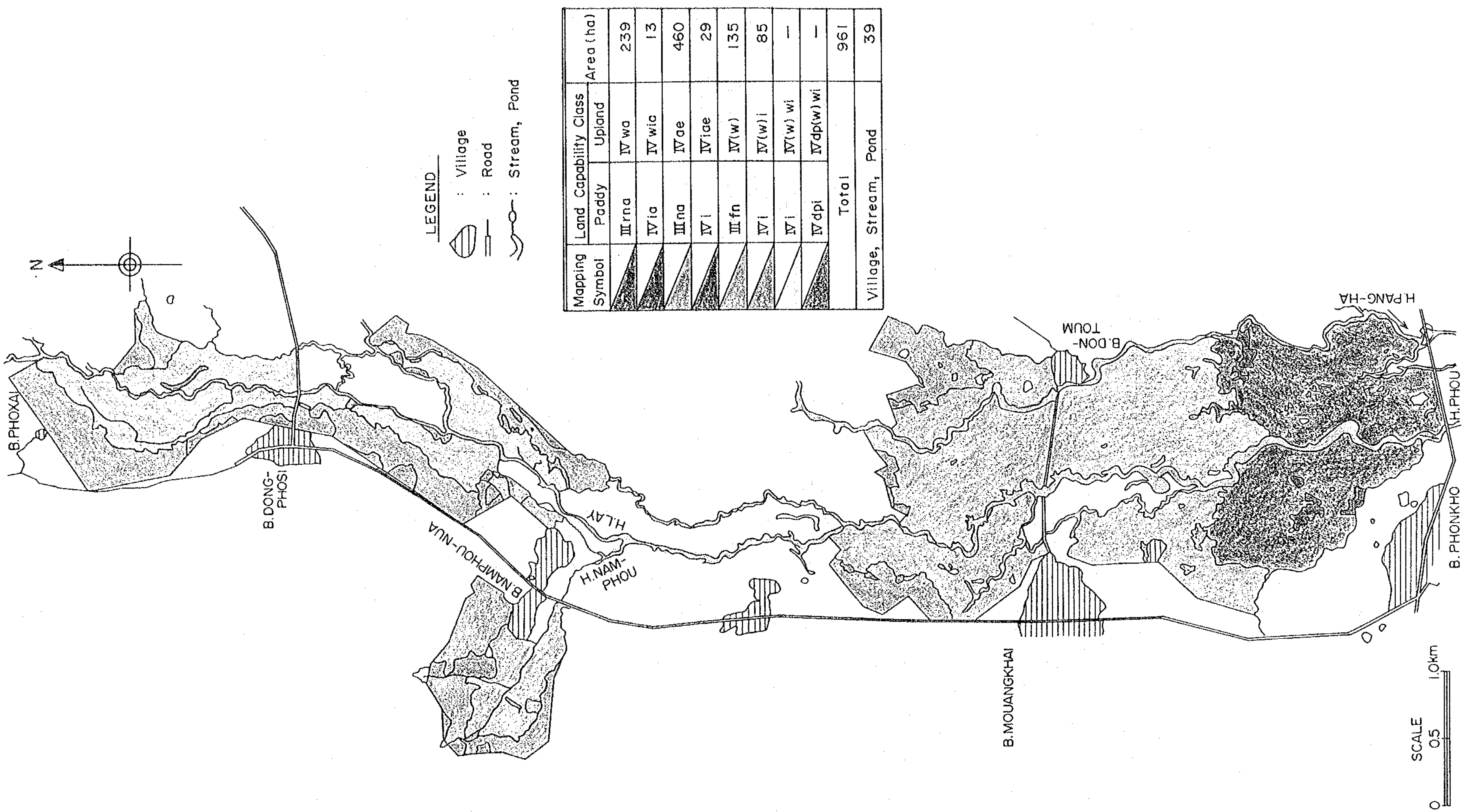
Mapping Symbol	Soil Type	Area (ha)
	Gleysoils	252
	Acrisoils	489
	Cambisoils	220
Total		961
Village, Stream, Pond		39

Fig. II-3 Soil Map (Namphou)



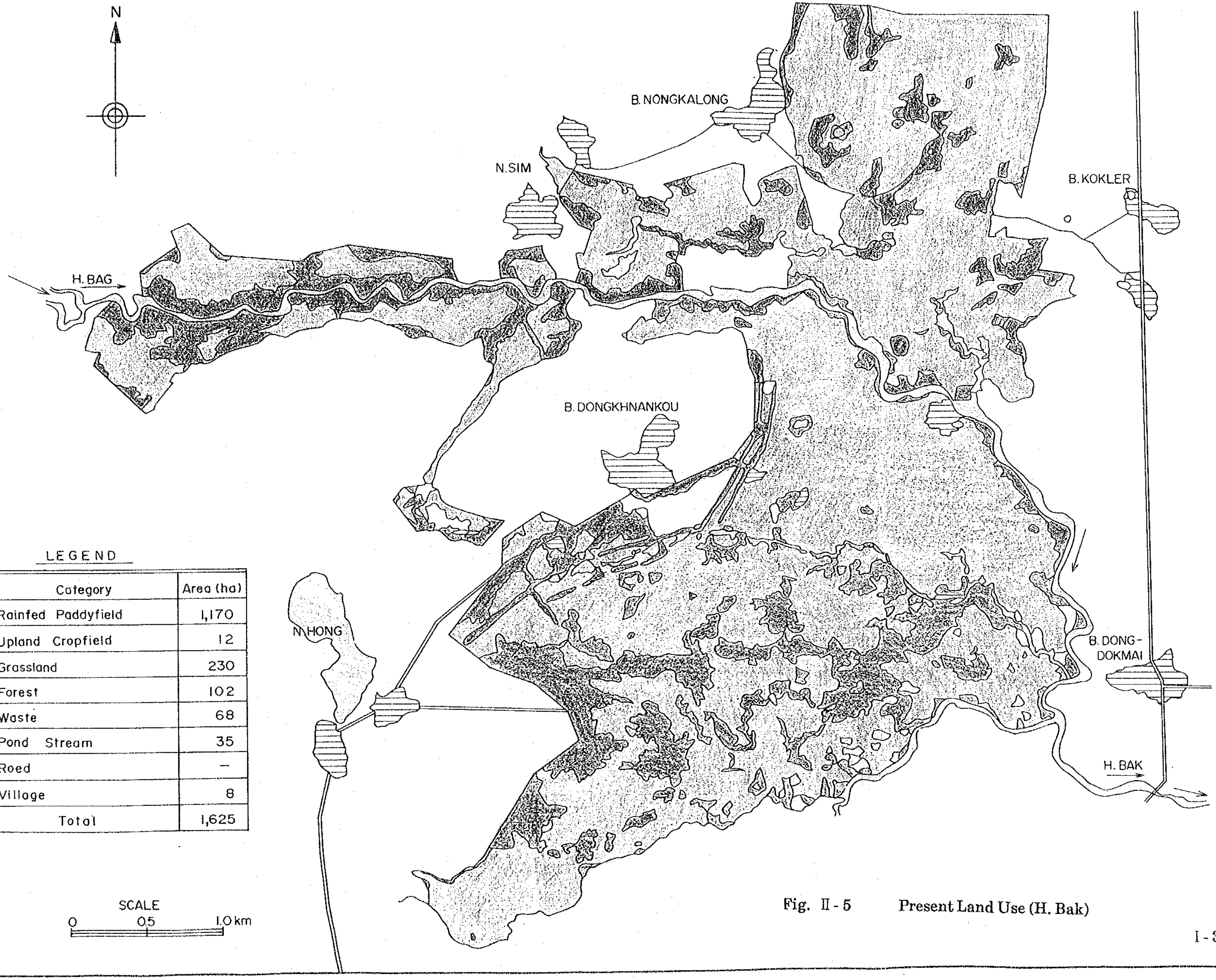
Mapping Symbol	Land Capability Class		Area (ha)
	Paddy	Upland	
	III rna	IV wa	292
	IV ia	IV wia	15
	III na	IV ae	408
	IV i	IV iae	62
	III fn	IV (w)	358
	IV i	IV (w) i	211
	IV i	IV (w) wi	125
	IV dpi	IV dp(w) wi	111
Total			1,582
Village, Stream, Pond			43

Fig. II-4 Land Classification (H. Bak)



Mapping Symbol	Land Capability Class		Area (ha)
	Paddy	Upland	
	Ⅲrna	Ⅳwa	239
	Ⅳia	Ⅳwia	13
	Ⅲna	Ⅳae	460
	Ⅳi	Ⅳiae	29
	Ⅲfn	Ⅳ(w)	135
	Ⅳi	Ⅳ(w)i	85
	Ⅳi	Ⅳ(w) wi	—
	Ⅳdpi	Ⅳdp(w)wi	—
Total			961
Village, Stream, Pond			39

Fig. Ⅱ-4　　Land Classification (Namphou)



LEGEND

Symbol	Category	Area (ha)
	Rainfed Paddyfield	1,170
	Upland Cropfield	12
	Grassland	230
	Forest	102
	Waste	68
	Pond Stream	35
	Roed	–
	Village	8
	Total	1,625

Fig. II-5 Present Land Use (H. Bak)

LEGEND

Symbol	Category	Area (ha)
	Rainted Paddyfield	835
	Upland Cropfield	3
	Grassland	59
	Forest	18
	Waste	46
	Pond, Stream	37
	Road	—
	Village	2
	Total	1,000

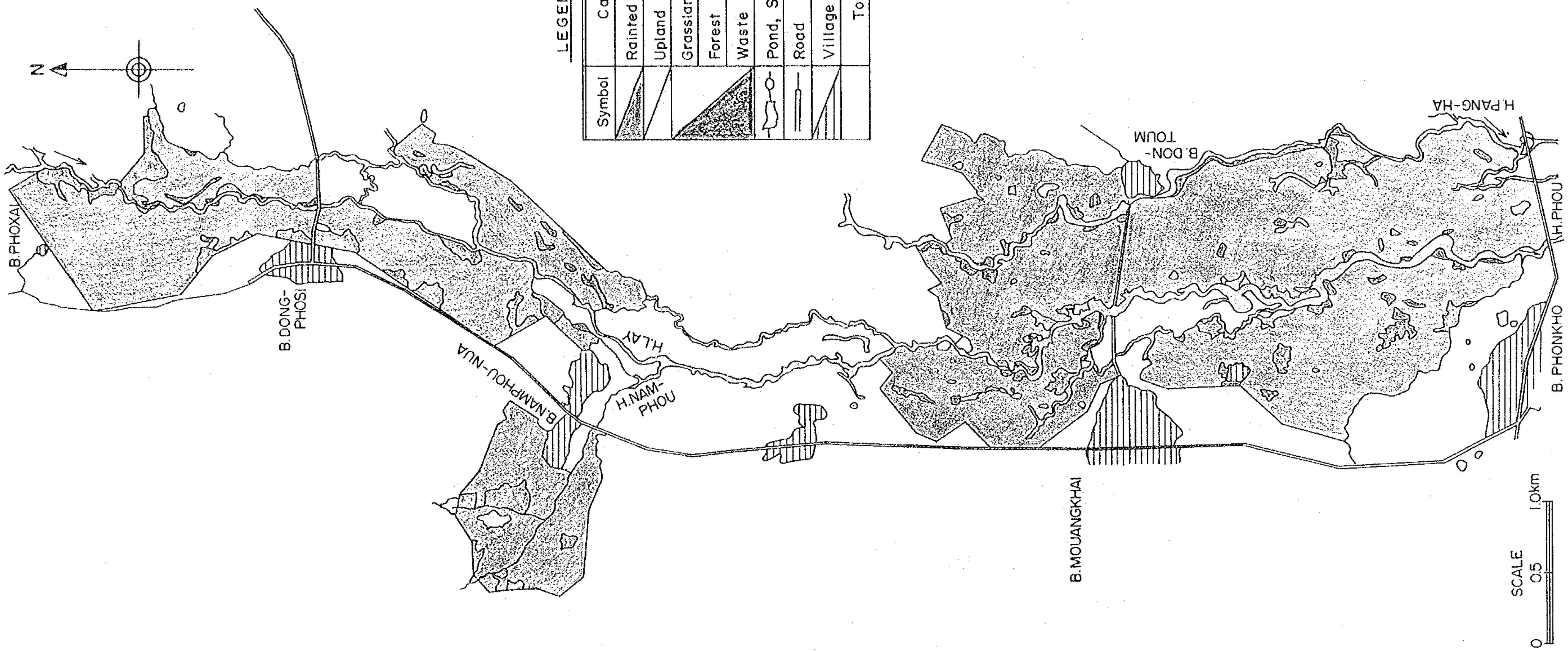
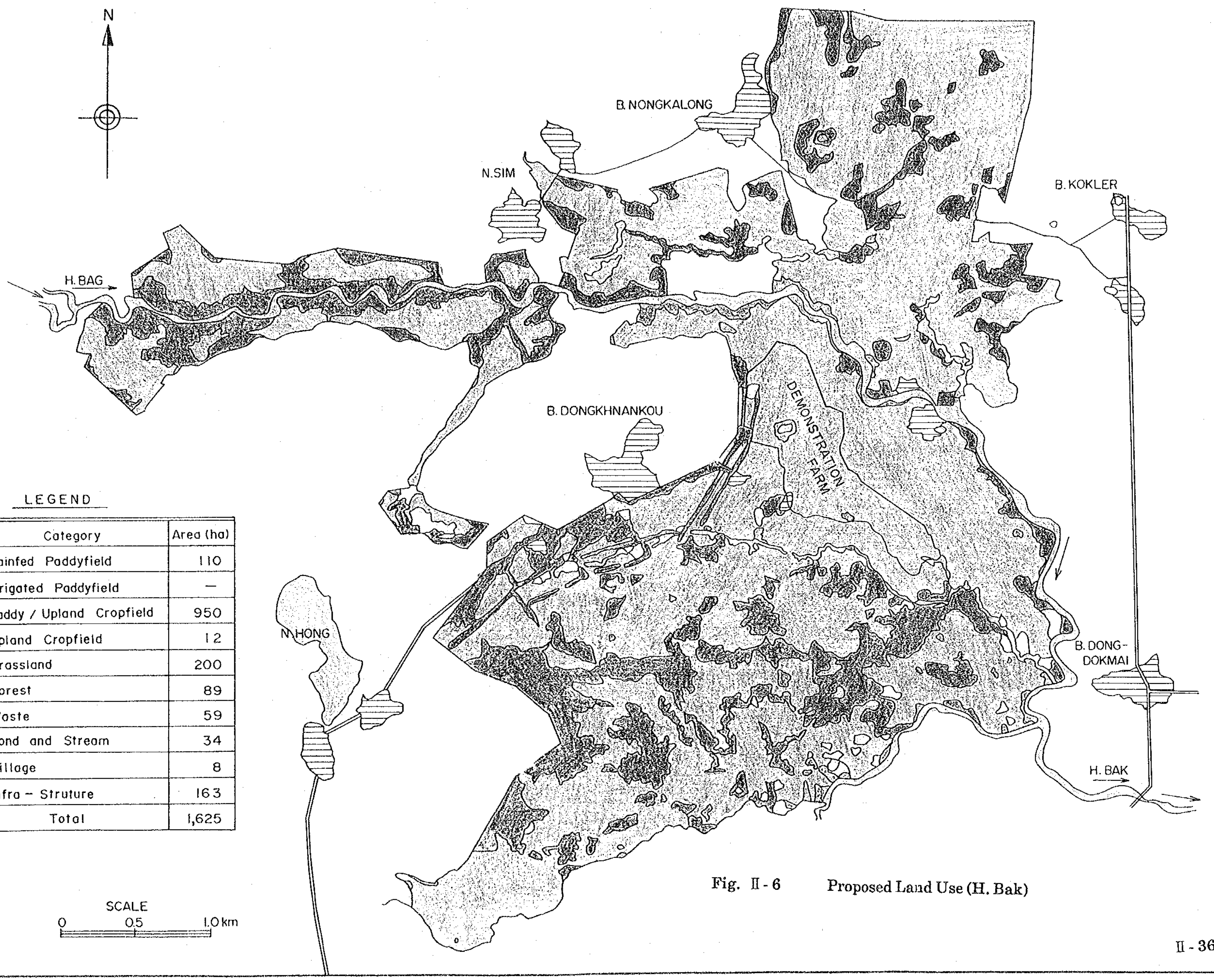


Fig. II-5 **Present Land Use (Namphou)**



LEGEND

Symbol	Category	Area (ha)
	Rainfed Paddyfield	110
	Irrigated Paddyfield	—
	Paddy / Upland Cropfield	950
	Upland Cropfield	12
	Grassland	200
	Forest	89
	Waste	59
	Pond and Stream	34
	Village	8
	Infra – Struture	163
	Total	1,625

Fig. II - 6 Proposed Land Use (H. Bak)