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CHAPTER 1 INTRODUCTION OF LRAS AND DIVISION INTO THE SUB-LRAS

1) Numbering of LRAs in the Study Area

The study area is composed of 35 land reform areas (LRAs). However, some of those LRAs are large in area size and contain different characteristics. The 35 LRAs have been divided into 116 Topo-LRAs by the topographical and water resources potential aspects. However, the Topo-LRAs are so detail for the study that the areas are grouped into 44 areas with adequate size for the study. Such grouped areas are defined as Sub-LRAs for the study.

Table 1-1 Number of the Study Area and Sub-study Area

Province											
Khon Kaen (KK)			Mahasarakham (MH)			Mukdahan (MK)			Sakhon Nakhon (SK)		
LRA No.	Topo-LRAs	Sub-LRAs	LRA No.	Topo-LRAs	Sub-LRAs	LRA No.	Topo-LRAs	Sub-LRAs	LRA No.	Topo-LRAs	Sub-LRAs
1	10	1	1	1	1	1	5	1	1	1	1
2	7	1	2	3	1	2	4	1	2	3	1
3	7	1	3	1	1	3	5	1	3	7	3
4	1	1	4	1	1	4	3	1	4	2	1
5	2	1	5	1	1	5	3	1	5	9	2
6	3	1	6	1	1	6	2	1	6	5	2
			7	1	1	7	4	1	7	1	1
			8	5	1	8	5	4			
			9	1	1	9	6	2			
			10	1	1	10	1	2			
						11	2	2			
						12	2	1			
7	30	6	10	16	10	12	42	17	7	28	11
LRAs : 35 areas Sub LRAs : 44 areas Topo-LRAs : 116 areas											

2) Sub-LRAs

Following table shows the grouping of the Topo-LRAs into the Sub-LRAs taking similarity of topography, land use, accessibility and distance of each topo-LRA as criteria. Table 1-2 shows the restructure of Sub-LRAs. Boundary of each Sub-LRA is shown in Figure 1-1 to Figure 1-11.

Table 1-2 Restructure of the Sub-LRAs

LRAs		Consideration of Grouping	Sub-LRAs	
No.	Topo-LRAs		Group-fng	Numbers
KK1	10	This area is fragmented into 10 sub-areas, however, those sub-areas are similar in topographical conditions and adjacent to the economic forests. Although some sub-areas are facing to the Chi River, the area is to be considered as one area.	1 - 10	1
KK2	7	This area is fragmented into 7 sub-areas, however, it may considered as one area which is adjacent to the economic forests.	1 - 7	1
KK3	7	As same as above reasons, the area is considered as one area.	1 - 7	1
KK4	1	This area is composed of one single area, and upland crop cultivation is prevailing in high land and paddy cultivation in some low land.		1
KK5	2	This area is divided into 2 sub-areas due to differences of catchment area. Although KK5-2 has a large catchment comparing to the development area, development area is so small that the KK5 is to be considered as one area.	1 - 2	1
KK6	3	Although this area is so large that it has been divided into 3 sub-areas, topographical and land use characteristics are almost same, and economic forests are also uniformly scattered in the area. Consequently, it is to be considered as one sub-LRA.	1 - 3	1
MHS1	1	The land reform area is scattered in the economic forests, and similar in land use.		1
MHS2	3	This area is large in size and formed by three major mounds. The area is composed of only economic zone, but the land is mostly utilized for upland crops and less trees in the fields. The land is almost similar in topography and land use in spite of large area, it is, therefore, to be considered as one area.	1 - 3	1
MHS3	1	This area is composed of only economic zone and a narrow and long stretch in shape on the ridge, where upland cultivation is partly conducted among natural trees. This area is considered as one single area where such natural trees are preserved and utilized harmonizing with cultivation.		1
MHS4	1	This area is composed of one single area on a mound and formed only by economic zone. However, trees are few in this area, and upland crop cultivation is prevailing as well as plantation of eucalyptus. This area is also considered as one area for full agricultural use.		1
MHS5	1	This area is also composed of one single area on a mound. However, the area is composed of economic zone and agricultural zone. Upland crop cultivation is prevailing in the agricultural zone, while good natural forests are partly remaining in the economic zone. This area shall be considered as one single area where remaining natural forests are to be utilized in a sustainable way.		1
MHS6	1	This area is composed of economic and agricultural zones in one single area on a mound as same condition as MHS5. This area shall be also considered as one single area where remaining natural forests are to be utilized in a sustainable way.		1
MHS7	1	This area is also composed of economic zone in one single area on a mound, but natural trees are very few in the field. Upland crop cultivation is prevailing at high land and paddy cultivation at gentle sloping land. This area shall be considered as one single area for full agricultural use.		1
MHS8	5	This area is the largest land reform area in Maha Sarakham composed of 5 sub-areas on several large mounds. The land is formed by gentle mounds and similar in topography through the area. The area is composed mostly of economic zone, but trees are very few in the field and upland crop cultivation is prevailing at high land while paddy cultivation in at gently sloping land. Therefore, this area shall be considered as one single area although the area is quite large.	1 - 5	1
MHS9	1	This area is very small and composed of one single area on a mound. The land is mostly cultivated with upland crops although the area is classified into economic zone. The area shall be considered as one single area.		1
MHS10	1	This area is composed of economic zone on mounds. Although classified in economic zone, the land is mostly utilized for upland cultivation and very scarce in trees. Topography and land use are similar through the area, so that the area shall be considered as one single area.		1
MKD1	5	Area is large and the conservation forests are locating around the area. The area is gently sloping and extending at the foot of forest mountains. Present land use is similar through the area like paddy and upland mixture. There is no particular distinguishes on land use at present so that the area shall be considered as one area.	1 - 5	1
MKD2	4	Most areas are located on gently sloping land except MKD2-4 sub-area. This sub-area is located at steeper slope, however its area is rather small in size. It is, therefore, to be considered as one area.	1 - 4	1
MKD3	5	The area extends on the rather flat lands sandwiched by the narrow stretches of mountains. Topographies are almost similar except MKD3-5, which is locating at narrow lands at the foot of isolated mountain. Since the area can be considered in similar land use, the area is to be studied as one single area.	1 - 5	1

LRAs		Consideration of Grouping	Sub-LRAs	
No.	Sub-Areas		Group-ing	Numbers
MKD4	3	The area is separated into 3 fragmented lands. However, each land is rather small and similar in topography. Therefore, it shall be studied as one area.	1 - 3	1
MKD5	3	to be studied as one single area as same reason as MKD4.	1 - 3	1
MKD6	2	to be studied as one single area as same reason as MKD4.	1 - 2	1
MKD7	4	The area is separately extending at the south-eastern piedmont of the mountainous ranges. Among 4 sub-areas, MKD7-4 locates little far from other sub-areas. However, topographical conditions are similar through the area, so that the area shall be considered as one single area.	1 - 4	1
MKD8	5	This area is separated into 5 sub-areas from topographical view point. On the other hand, it will be grouped into 4 areas from the aspects of location and investment on water resources development. - locating at remote from the capital of province, but developed on water resources and land improvement. (MKD8-1, 2) - locating little close to the capital of province, but less developed on water resources and land improvement. This area shall be divided into 2 areas. (MKD8-3 &5) - locating at same location of MKD8-3, but developed by Huai Rai Reservoir (MSIP) by RID. (MKD8-4)	1 - 2 3 4 5	4
MKD9	6	This area is separated into 6 sub-areas. Among 6 sub-areas, three are close to the Rout 212 and other three are little far from the main road. Therefore, this area shall be considered as 2 areas.	1 - 3 4 - 6	2
MKD10	1	to be studied as one single area as same reason as MKD4.		1
MKD11	2	Villages of sub-area MKD11-1 are irrigated by the Huai Chanod reservoir since 1984, while only one village of sub-area MKD11-2 by the pump irrigation since 1996. Although both sub-areas are surrounded by the economic forests and similar in land use, but different in irrigation experience. It is, therefore, studied separately.	1 2	2
MKD12	2	The area is fragmented into 2 sub-areas, but both areas are well developed on farm road system and similar on land use. Therefore, this land shall be considered as one single area.	1 - 2	1
SKN1	1	This area is mostly composed of agricultural zone in one single area. Economic zone is locating only at the northern edge of the area. The area is mostly cultivated with rice, sugarcane and plantation of eucalyptus and rubber trees. Cassava cultivation is not prevailing in the area, but natural trees are scarce. The area is extending on a undulated mound, and not distinguished on differences of land use by the locations. Therefore, this area shall be studied as one single area.		1
SKN2	3	Sub-areas are able to be classified into 2 types. One is upland prevailing area (SKN2-1 & 2), and the other is paddy prevailing area (SKN2-3). However, both areas are cultivated mostly by same village people, so that it is difficult to clarify the differences of the areas by social data. Therefore, this area shall be considered as one area as mixedly cultivated both for upland and paddy.	1 - 3	1
SKN3	7	This area has 7 sub-areas in different locations. Those sub-areas can be classified into following 3 groups: - locating at upstream of Nam Un dam and having a certain potential of water resources development. (SKN3-1,2,3,4) - locating at upstream of Nam Un dam but less potential of water resources unless by pump irrigation from Nam Un reservoir. (SKN3-5) - locating at downstream of Nam Un dam but not receiving water supply from the dam due to higher elevation than canal. Some SSIP reservoirs are serving this area. (SKN3-6,7)	1 - 4 5 6,7	3
SKN4	2	This area is divided into 2 sub-areas, and both sub-areas are located in upstream of Nam Un dam. Sub-area SKN4-1 has a certain potential of water resources development, while SKN2-2 has a less potential. However, there is no clear distinguish between tow areas because no water resources development has been conducted so far. Therefore, this area shall be considered as one area.	1 - 2	1
SKN5	9	This area has 9 sub-areas surrounding the Nam Phung reservoir. Those sub-areas can be classified into following two groups: - locating and fragmenting in outside of the catchment area of Nam Phung dam, and surrounded by the conservation forest. (SKN5-1 to 5) - locating at upstream of Nam Phung dam and partly irrigated by the small scale reservoirs. (SKN5-6 to 9)	1 - 5 6 - 9	2
SKN6	5	This area has 5 sub-areas in the south-western Phu Phan ranges. Those sub-areas can be classified into following 2 groups: - locating at the isolated flat basin bounded by the steep conservation forest ranges, and paddy cultivation is prevailing. (SKN6-1) - locating at the steep to gentle slope along the conservation forest ranges, and upland crop cultivation is prevailing. (SKN6-2 to 5)	1 2 - 5	2
SKN7	1	This area is surrounded by the economic forests, and upland crop cultivation is prevailing in high land and paddy cultivation in some low land.		1
KK 6	30			6
MHS 10	16			10
MKD12	42			17
SKN 7	28			11
Total 35	116			44

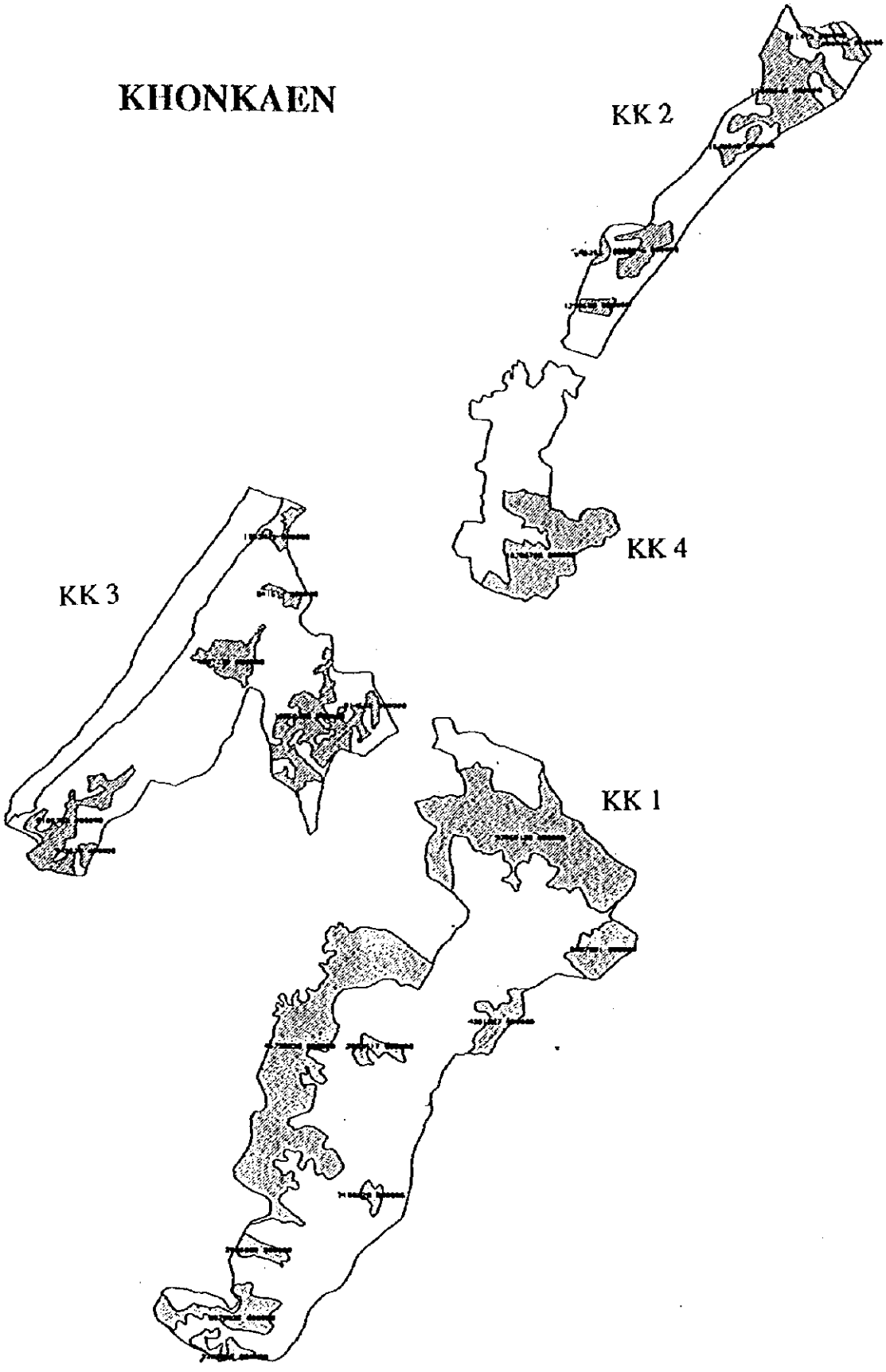


Figure 1-1 Sub-LRAs in Khon Kaen (KK 1, KK 2, KK 3, KK 4)

KHONKAEN

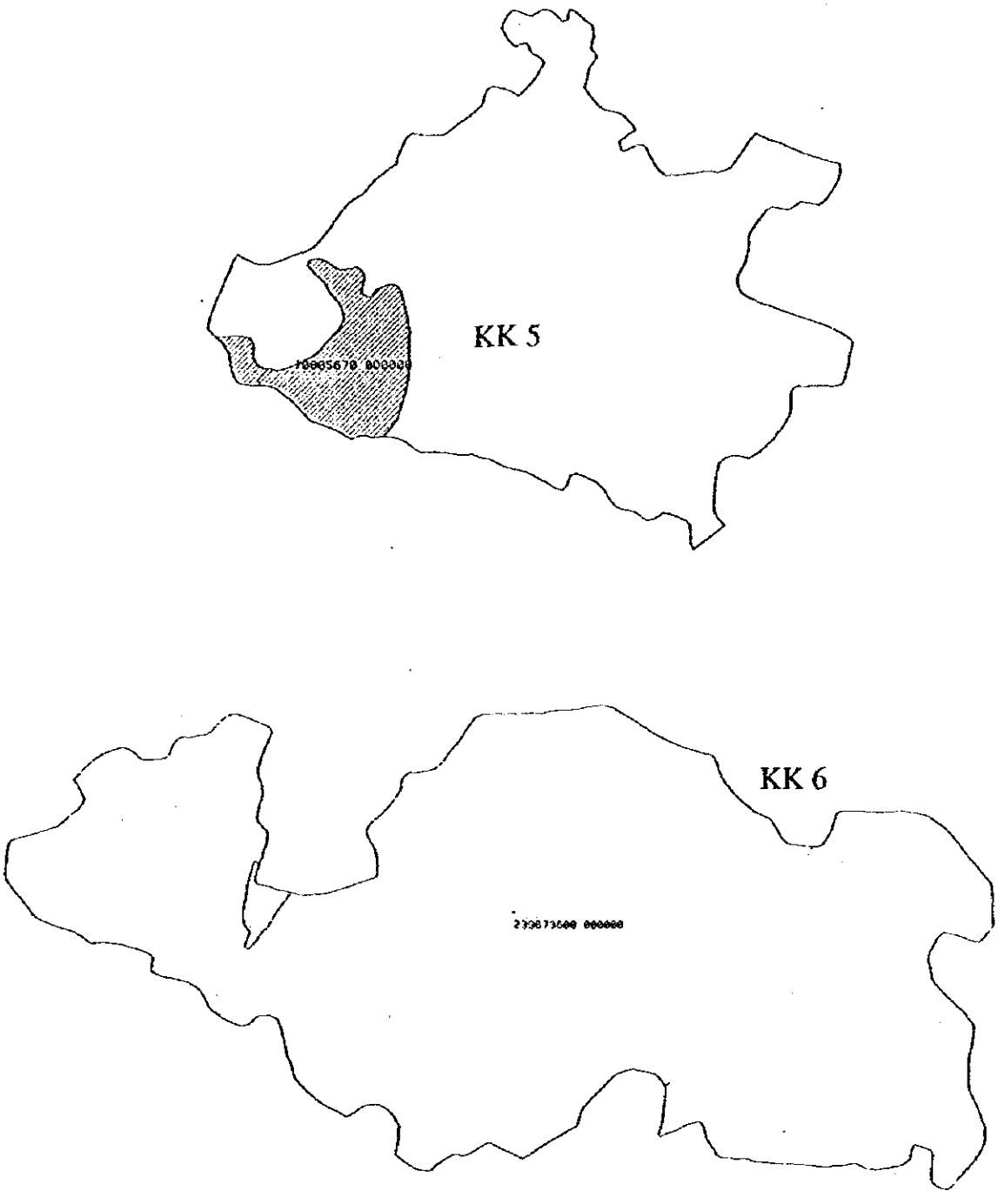


Figure 1-2 Sub-LRAs in Khon Kaen (KK 5, KK 6)

MAHA SARAKHAM

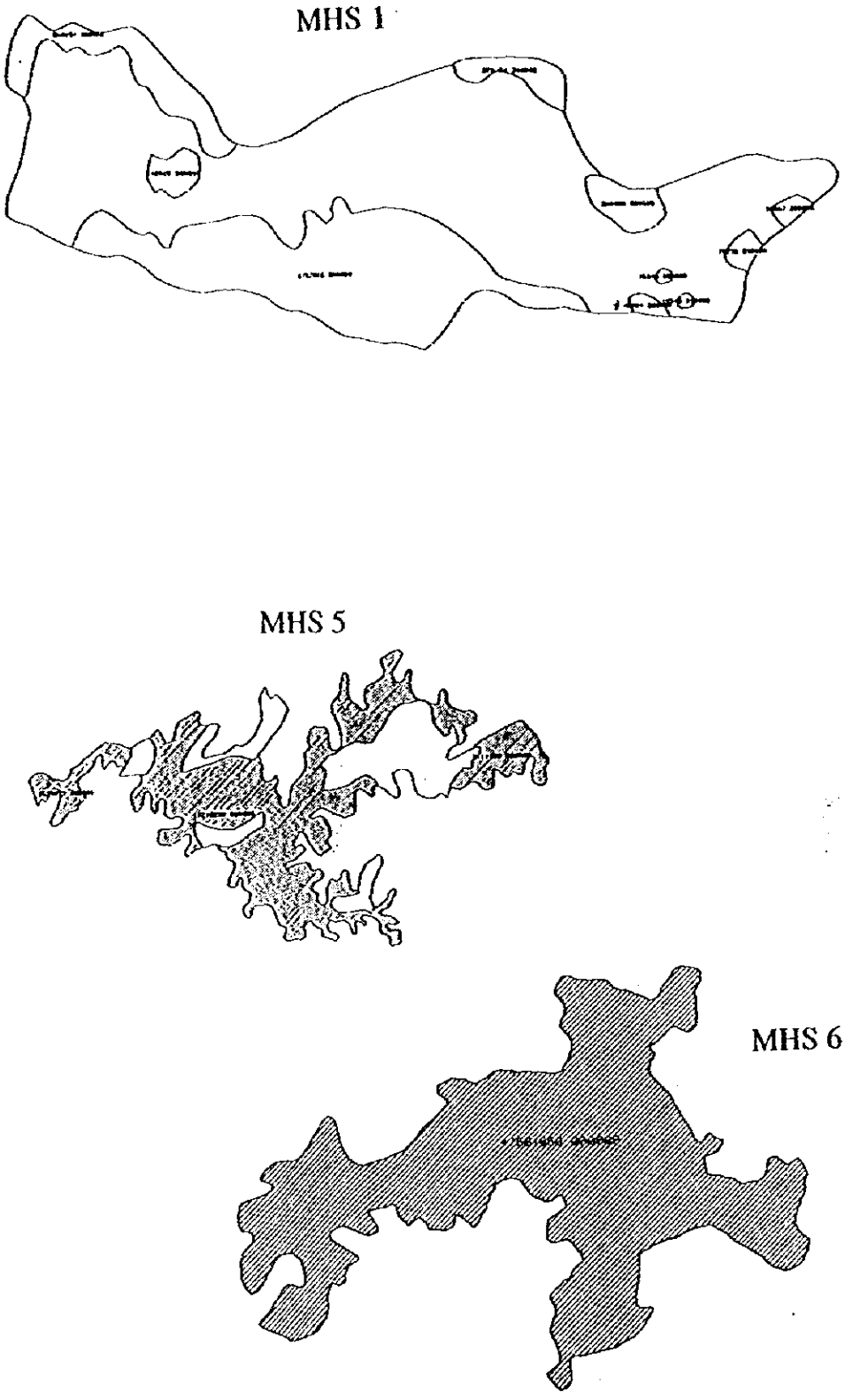


Figure 1-3 Sub-LRAs in Mahasarakham (MHS 1, MHS 5, MHS 6)

MAHA SARAKHAM

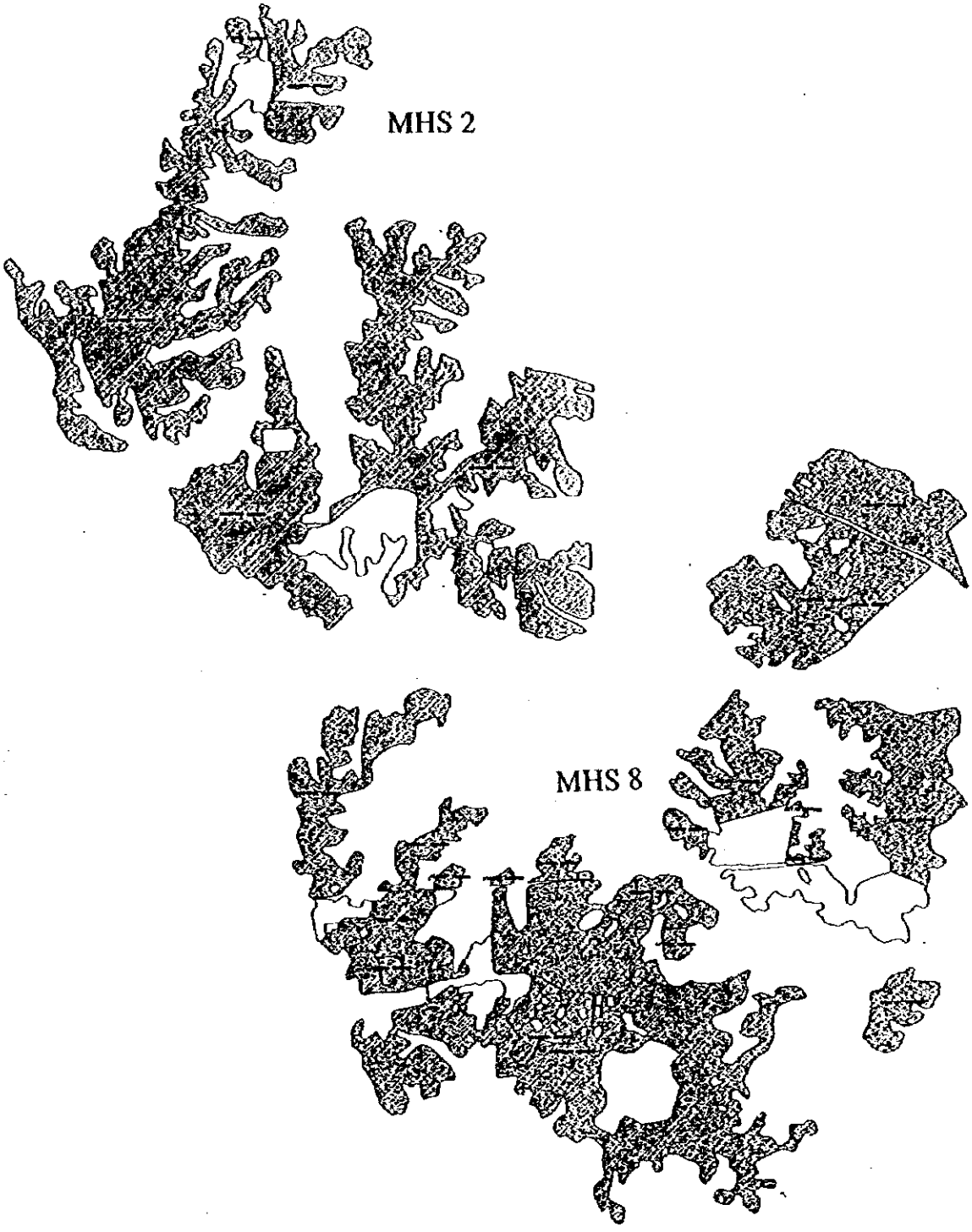


Figure 1-4 Sub-LRAs in Mahasarakham (MHS 2, MHS 8)

MAHA SARAKHAM

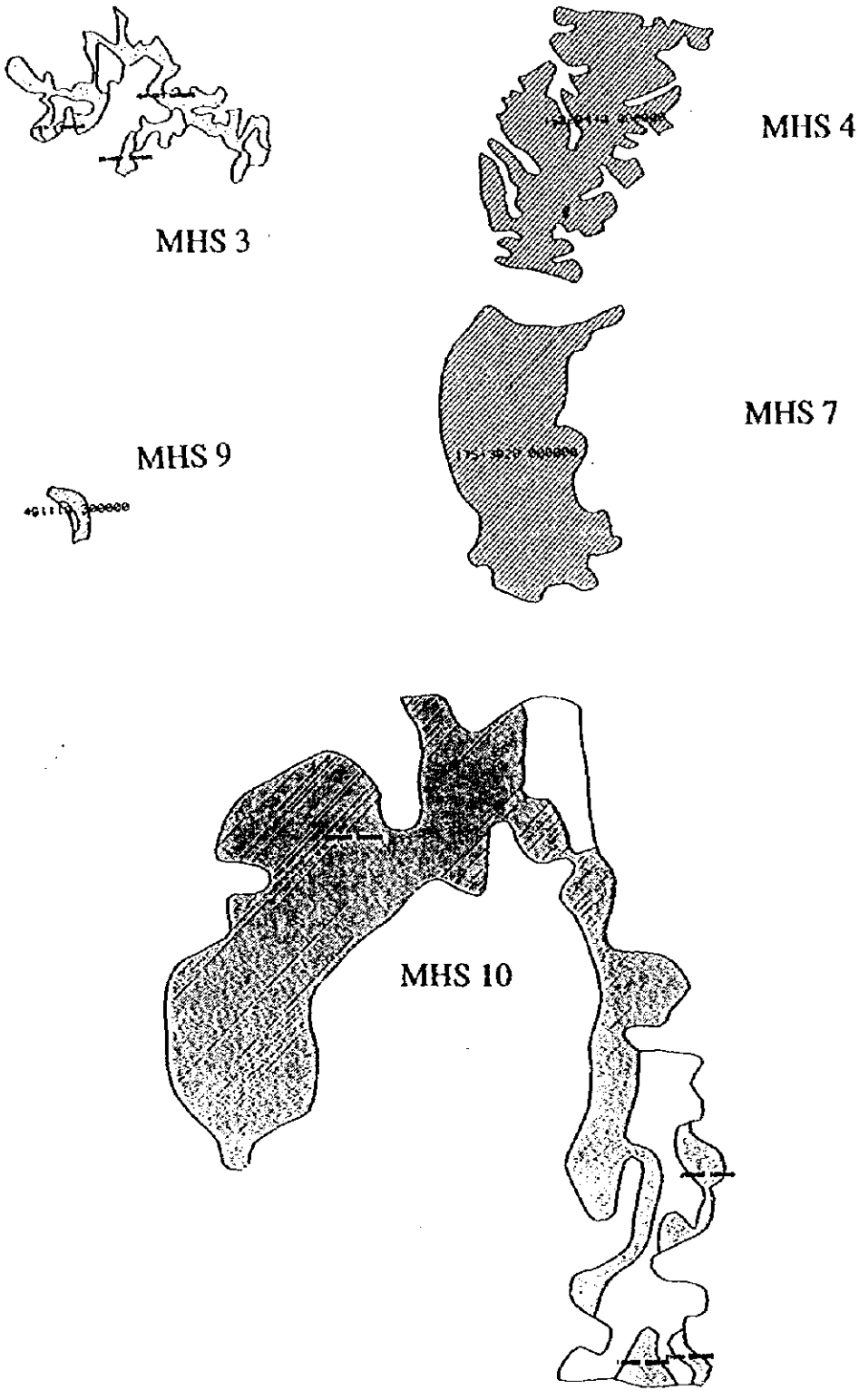


Figure 1-5 Sub-LRAs in Mahasarakham (MHS 3, MHS 4, MHS 7, MHS 10, MHS 9)

MUKDAHAN

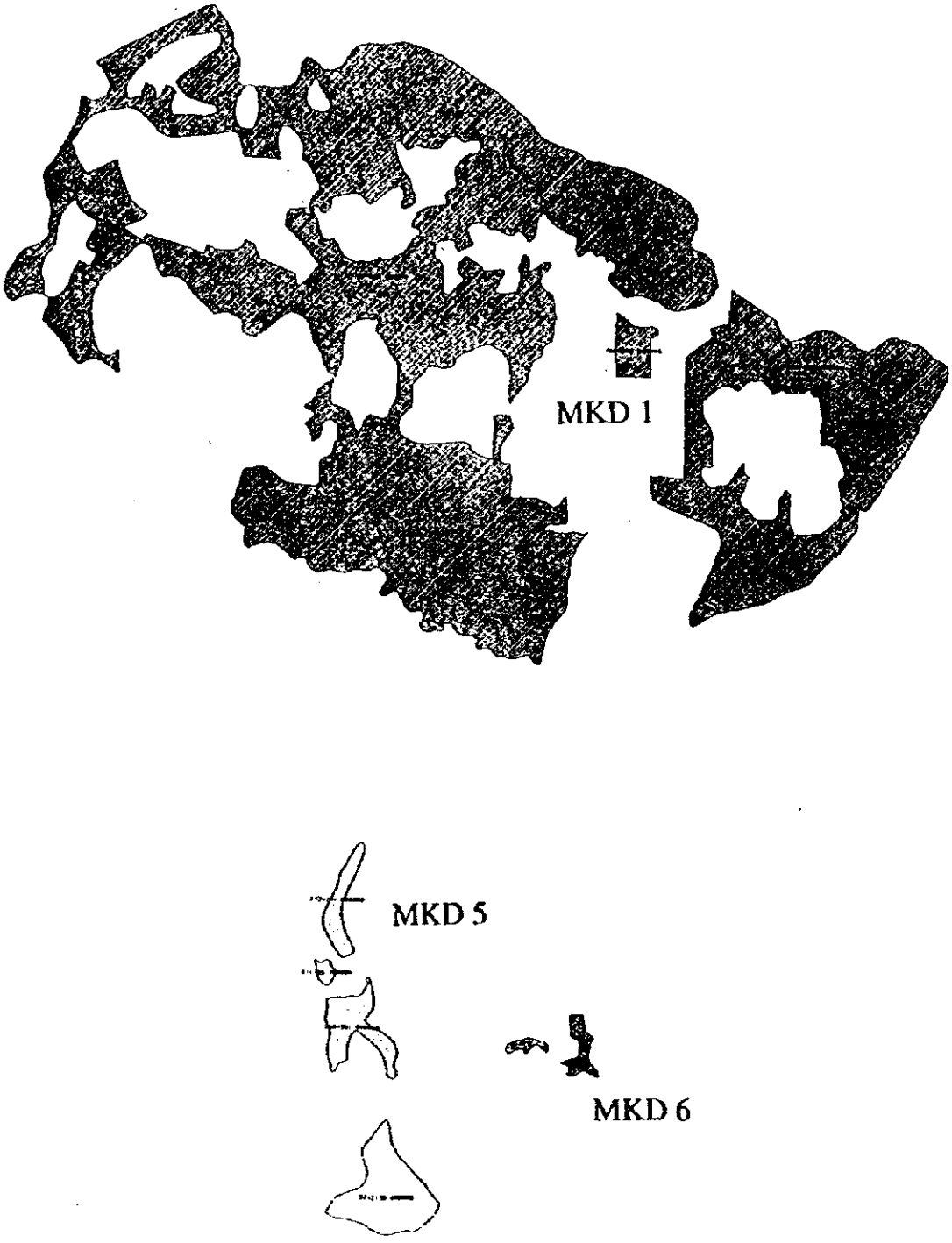


Figure 1-6 Sub-LRAs in Mukudahan (MKD 1, MKD 5, MKD 6)

MUKDAHAN

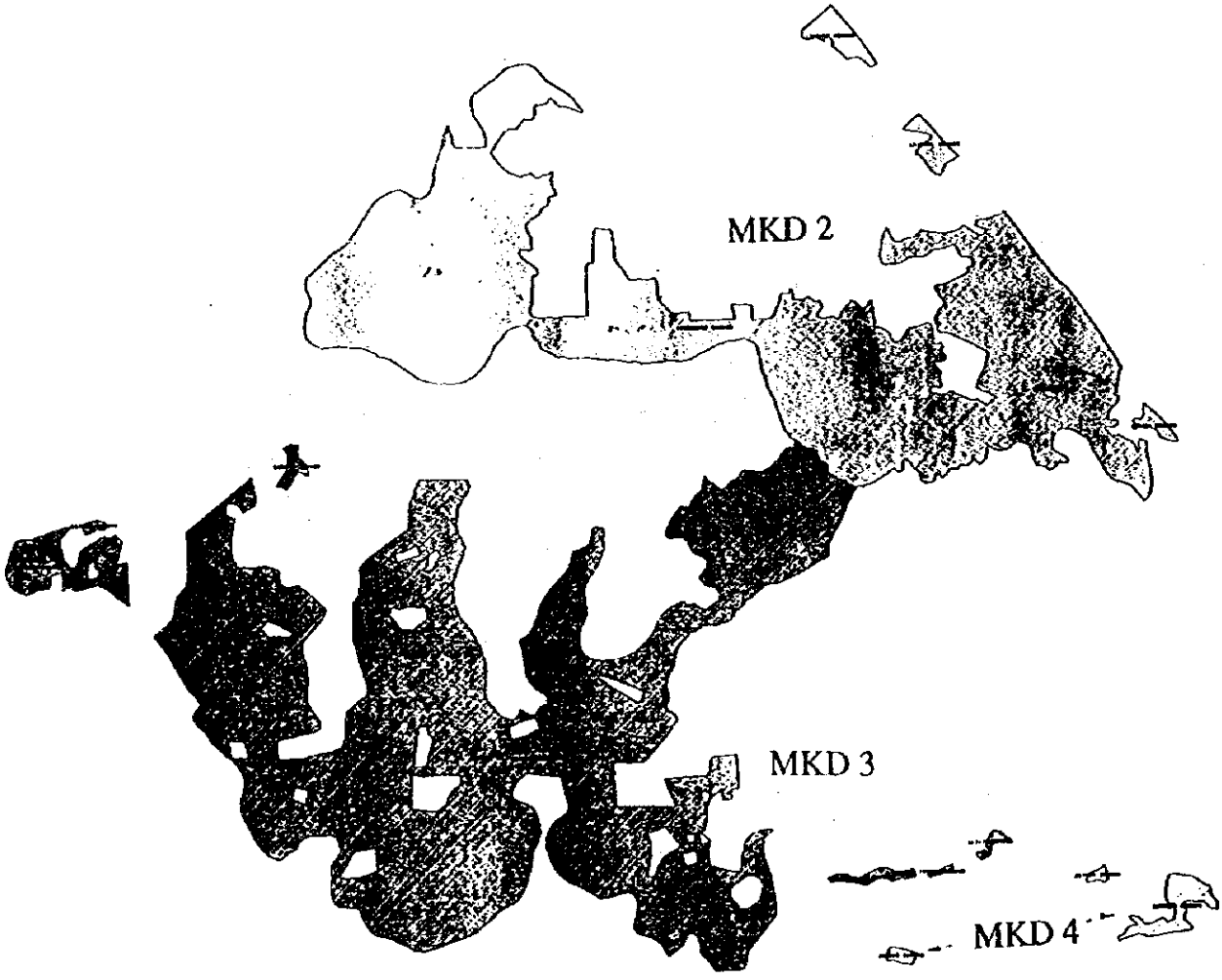


Figure 1-7 Sub-LRAs in Mukudahan (MKD 2, MKD 3, MKD 4)

MUKDAHAN

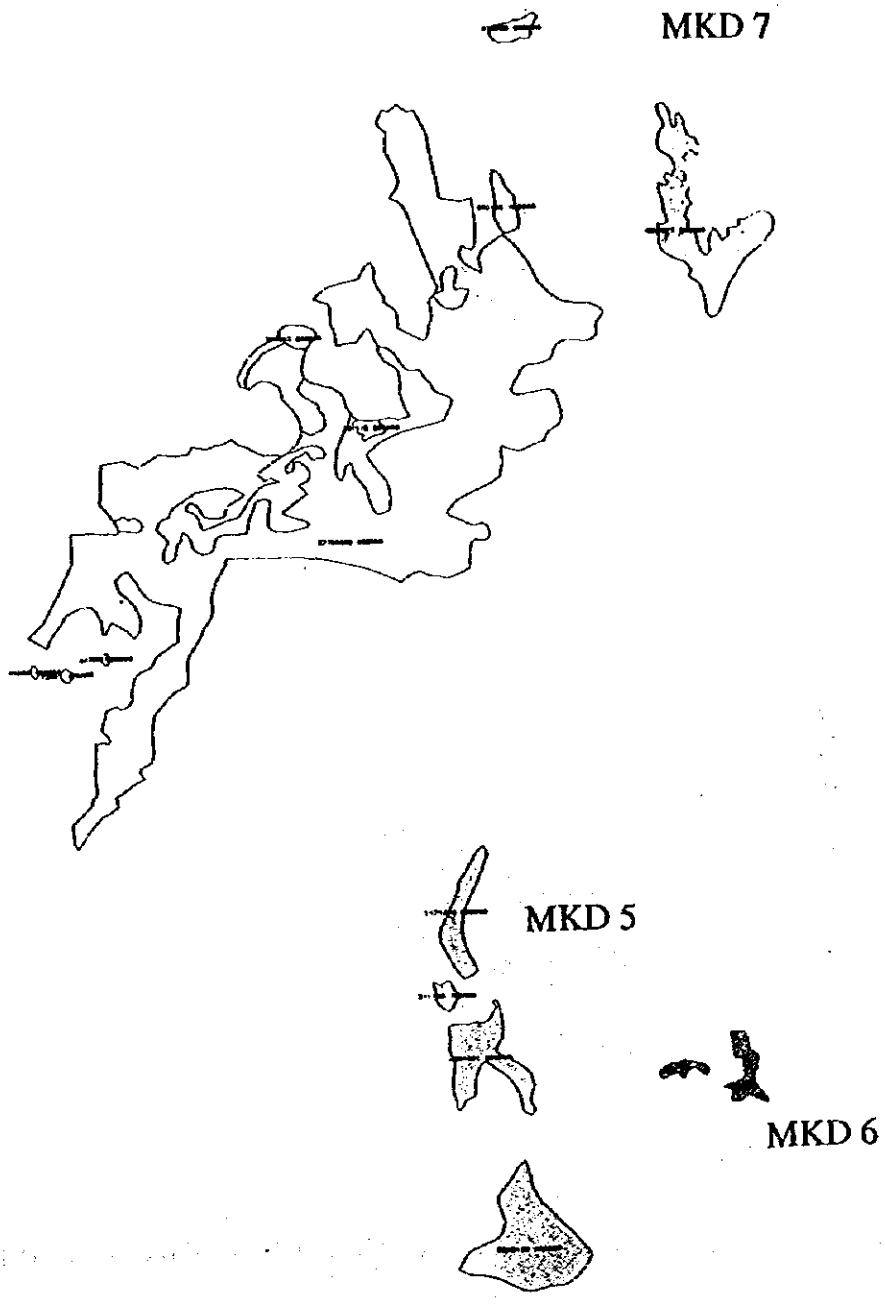


Figure 1-8 Sub-LRAs in Mukudahan (MKD 7)

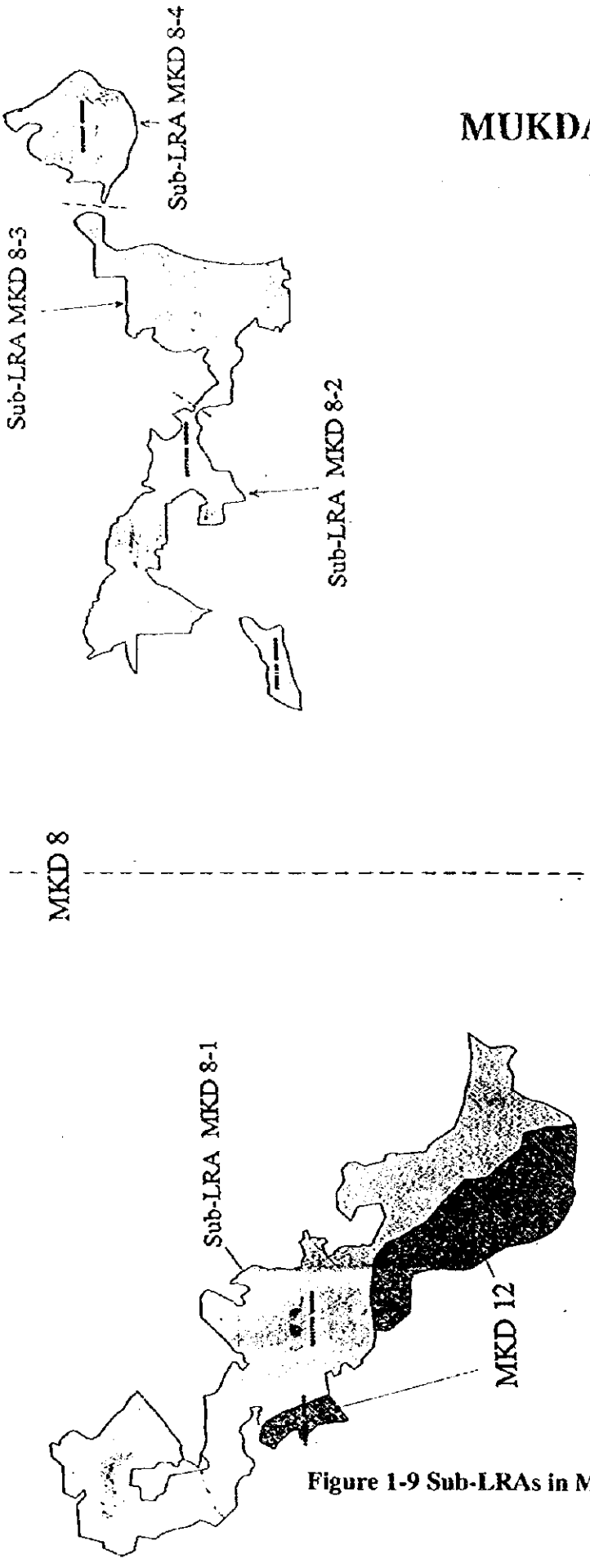


Figure 1-9 Sub-LRAs in Mukudahan (MKD 8, MKD 12)

MUKDAHAN

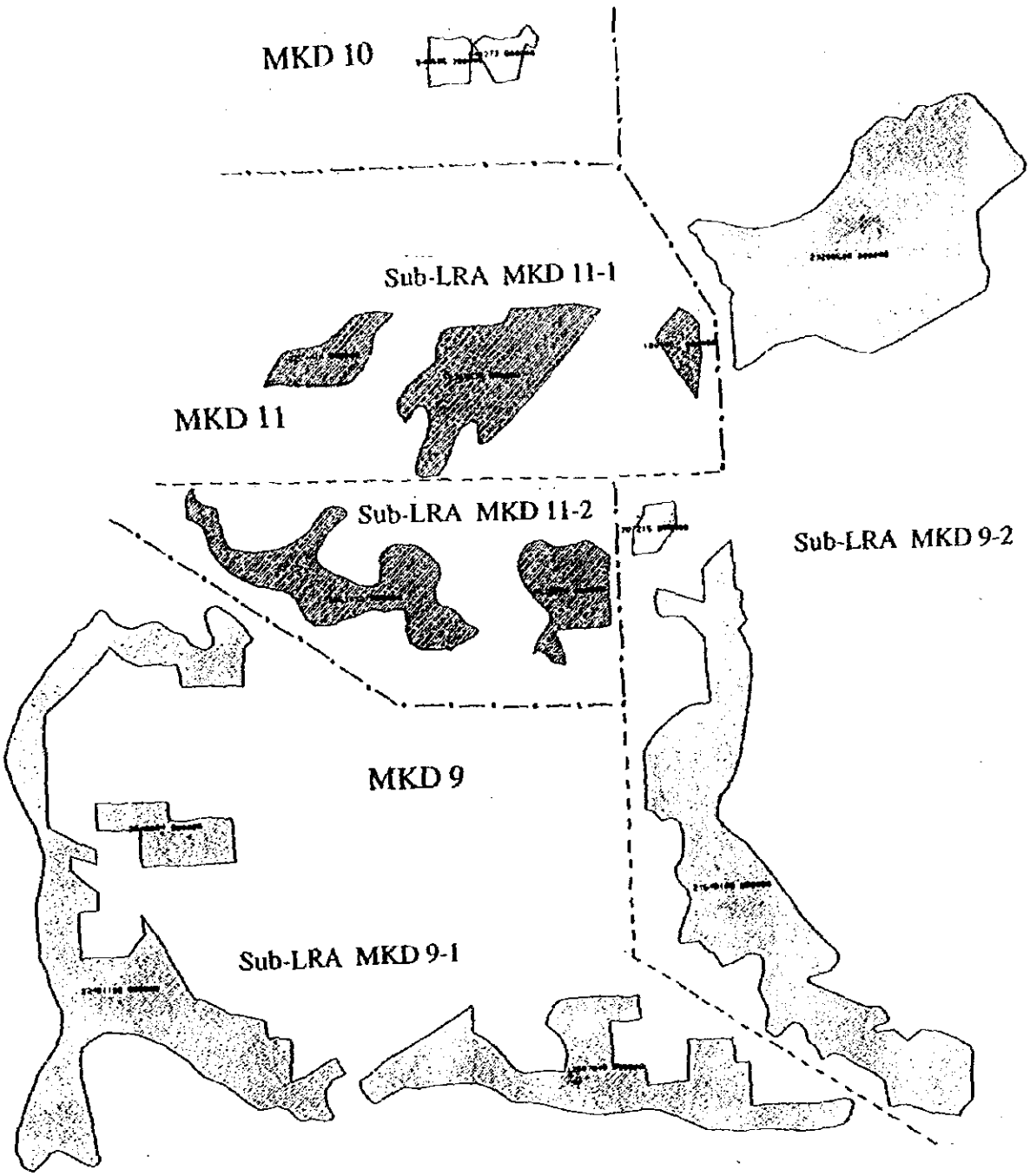


Figure 1-10 Sub-LRAs in Mukudahan (MKD 9, MKD 10, MKD 11)

SAKON NAKHON

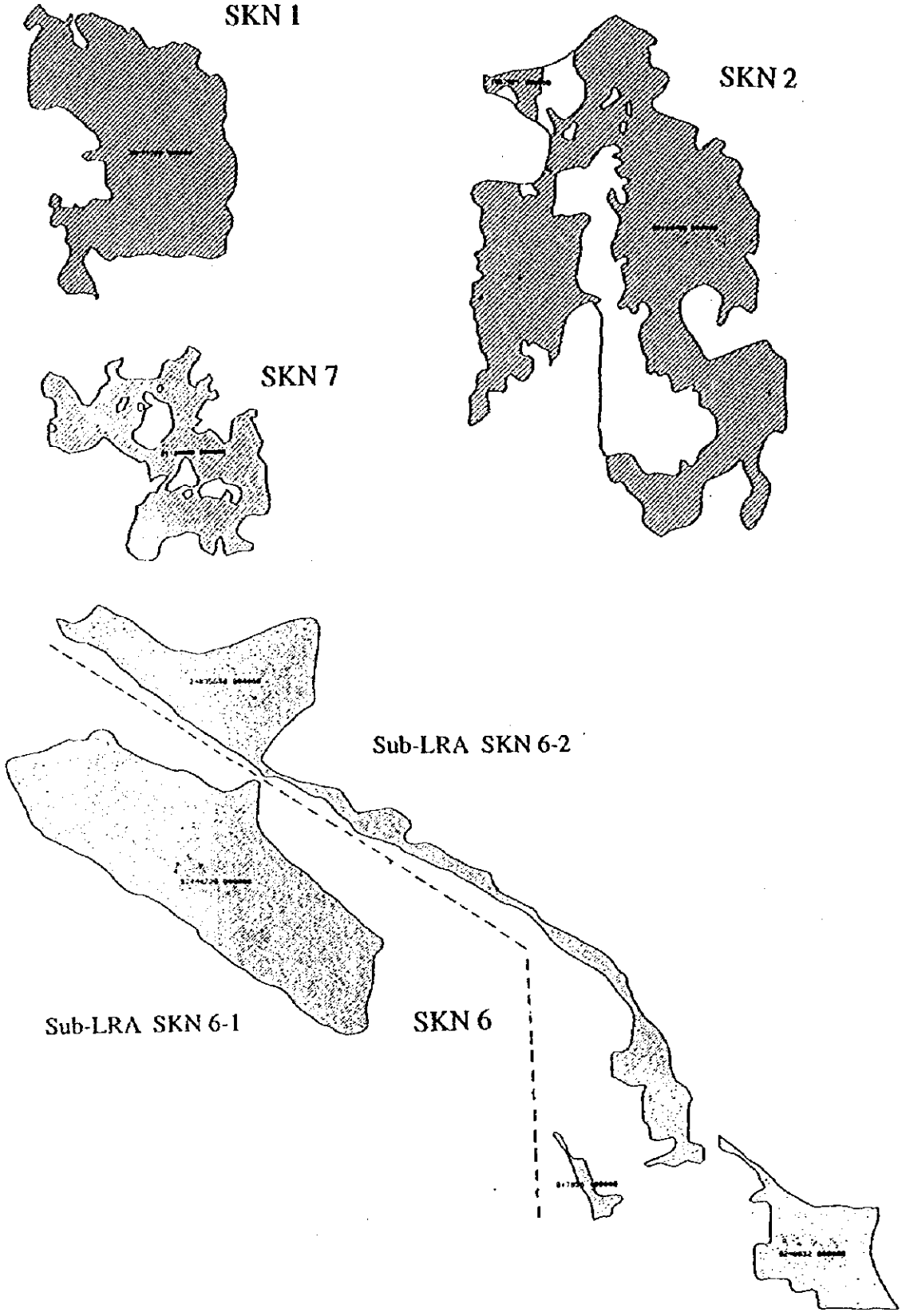


Figure 1-11 Sub-LRAs in Sakon Nakhon (SKN 1, SKN 2, SKN 6, SKN 7)

SAKON NAKHON

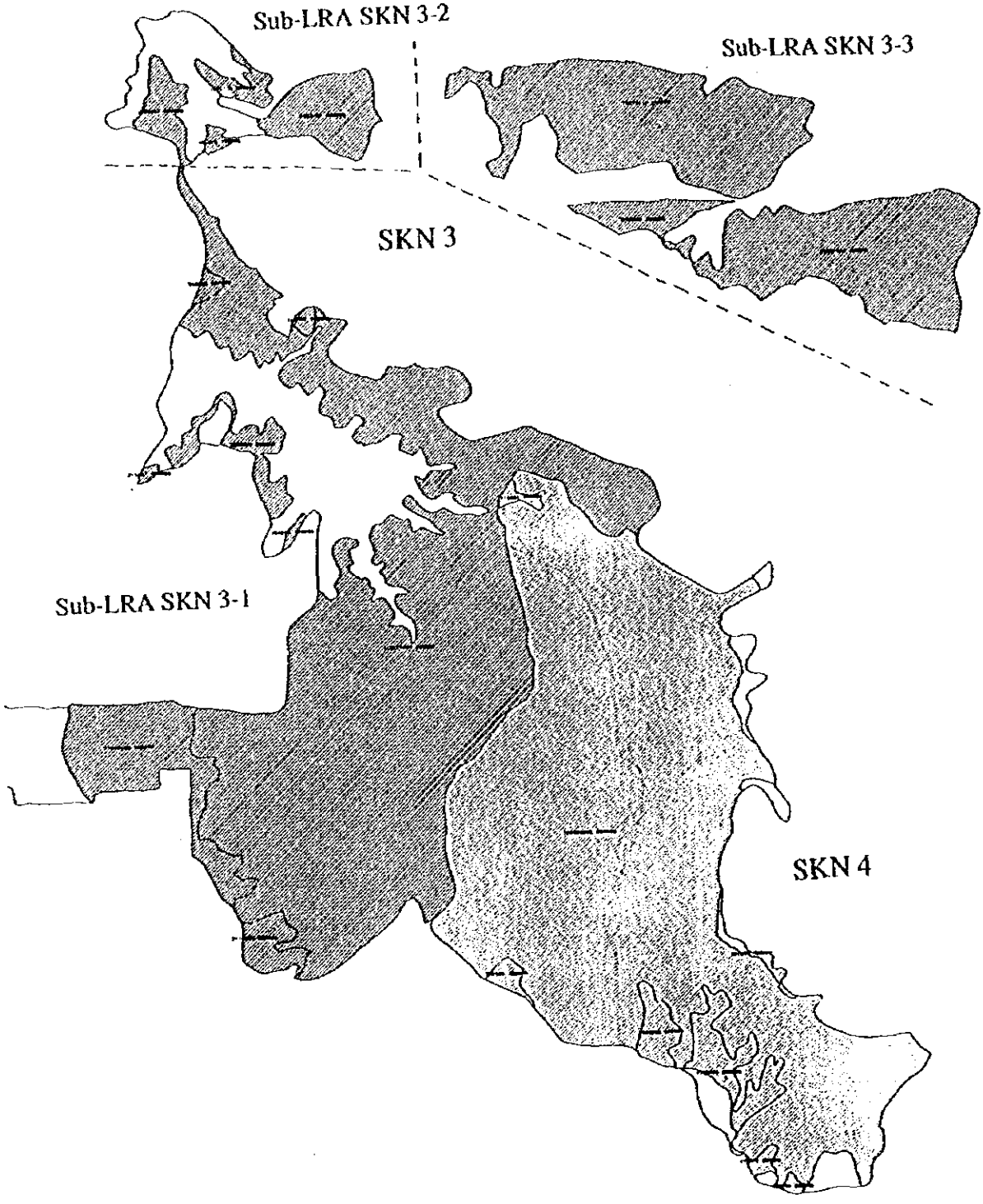


Figure 1-12 Sub-LRAs in Sakon Nakhon (SKN 3, SKN 4)

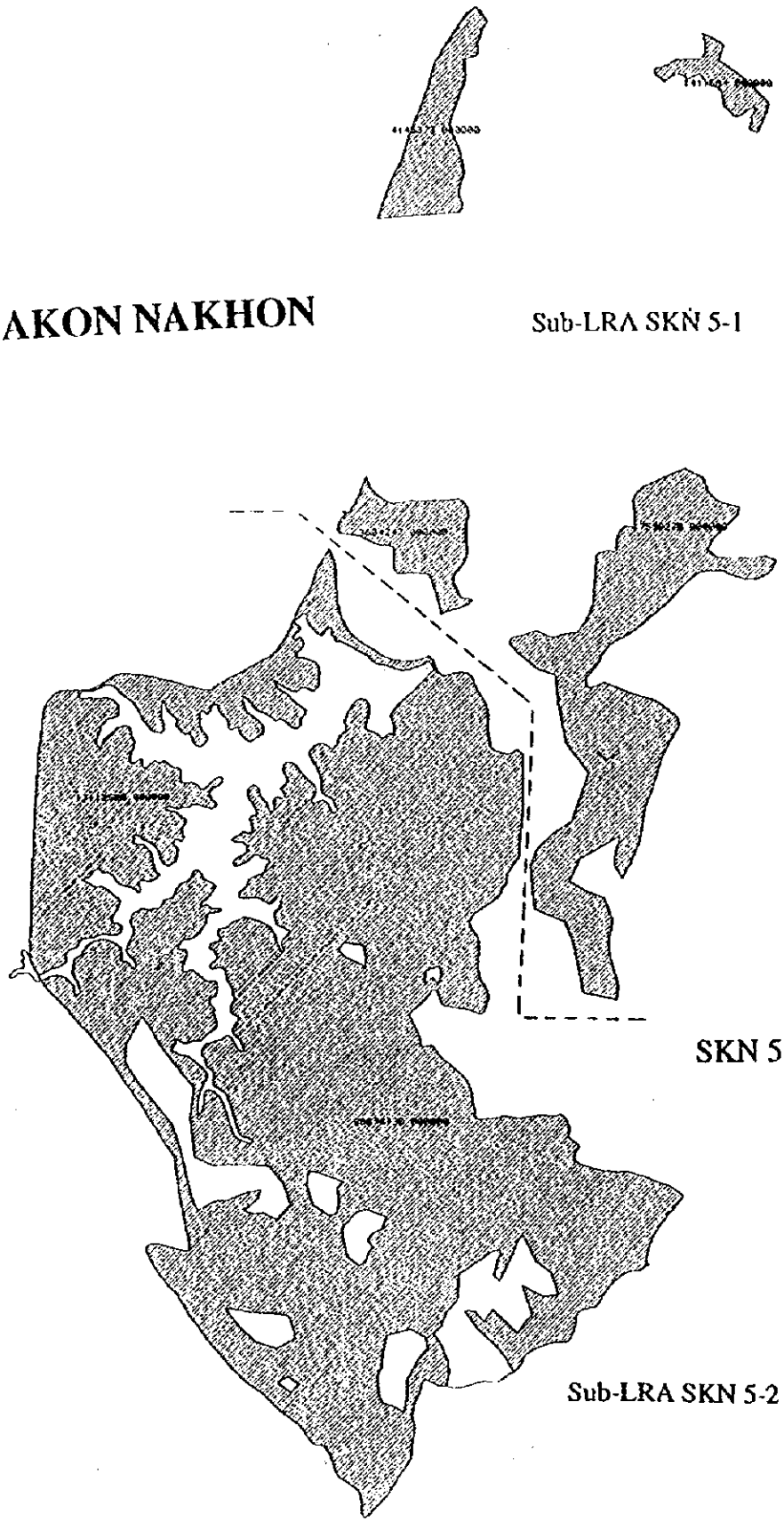


Figure 1-13 Sub-LRAs in Sakon Nakhon (SKN 5)

CHAPTER 2. NATURAL CONDITION OF LRAS

2.1 Topography

The study area is located in the Upper Northeastern Region bounded in the south by Khon Kaen, Maha Sarakham, Kalasin and Mukdahan Provinces. The Upper Northeast region is composed of very gently rolling and flatland with some undulations. Flatland slopes gently to the east. Elevation of flatland ranges from 150 m to 190 m (MSL). Undulating land forms isolated lower hills in Maha Sarakham and in the southern part of Khon Kaen Province. The elevation of these hills is about 200 m to 240 m. In other areas, undulations form steeper and higher ranges such as the Phu Phan Range which runs along the southwestern edge of Mukdahan and Sakon Nakhon Provinces. Another high range runs from north to south crossing the western part of Khon Kaen Province. The highest elevation of all the high ranges reaches 695 m. Large dams, such as the Ubolrat Tana, the Nam Un and the Nam Phun Dams, have been constructed in these high ranges.

(Data Source) Salt-affected area in Northeast Thailand Nature, Properties and Management Technical Paper No. 15, 1994 ADRC (JICA)

Figure 2.1-1 Physiography of the Northeast Thailand

The study area, which is composed of 35 LRAs, is located mostly in higher locations in the region, such as on the isolated lower hills in Maha Sarakham; at the foot of high ranges in Khon Kaen; and in the high ranges in Mukdahan and Sakon Nakhon. Consequently, the topography of LRAs in the latter two provinces is steeper than in the others. Taking the above topographical characteristics into consideration, 35 LRAs will be divided into further smaller 44 sub-areas. (described in Section 1.1 in Appendix-D)

Topography and land use have been analysed on 1:50,000 map, and the results are described in Table 2.1-1 to 2.1-6 as below;

Table 2.1-1 Topographical Characteristics of the Study LRAs

Study Area		Acreage		Elevation (m)			slope (%)		Area by Slope (ha)			Major Land Use (ha)					Catchment Area		
No.		Ac (rai)	A (ha)	min.	max.	ave.	Side slope	Main drain	0 - 2 %	2 - 5 %	more than 5 %	swamp reservoir rivers	low land bush	paddy	orchard upland	residence others	CA (km2)	Ratio CA/A	max. El (m)
KK	1	67,640	10,824	160	230	194	1.9	0.8	6,620	3,968	146	145	0	1,795	8,704	190	248	2.29	260
KK	2	14,130	2,260	190	230	210	2.4	1.0	1,341	919	0	0	0	270	1,960	30	117	5.16	530
KK	3	18,370	2,940	180	240	208	2.4	0.9	578	2,362	0	5	0	720	2,145	70	96	3.27	625
KK	4	11,740	1,879	190	220	205	2.5	1.0	658	1,127	94	0	0	120	1,719	40	25	1.33	260
KK	5	6,250	1,001	160	200	175	2.5	1.5	78	923	0	2	0	150	839	10	23	2.10	210
KK	6	149,790	23,967	210	230	217	2.0	0.5	7,563	16,404	0	0	0	3,500	20,167	300	240	1.00	232
MHS	1	2,640	422	190	230	210	4.0	4.0	21	401	0	0	0	0	422	0	4	1.00	230
MHS	2	59,690	9,549	170	232	196	4.0	1.3	600	8,308	641	0	0	0	9,549	0	95	1.00	232
MHS	3	3,080	492	160	192	176	3.3	3.3	246	246	0	0	0	0	492	0	5	1.00	192
MHS	4	9,510	1,521	155	189	172	2.0	1.0	608	913	0	0	0	0	1,521	0	15	1.00	189
MHS	5	13,030	2,085	170	204	187	3.3	1.1	417	1,668	0	0	0	500	1,585	0	21	1.00	204
MHS	6	29,790	4,766	170	214	192	3.3	0.9	2,240	2,383	143	0	0	1,300	3,446	20	48	1.00	214
MHS	7	10,940	1,751	170	204	187	1.7	1.0	1,313	438	0	0	0	1,250	501	0	18	1.00	204
MHS	8	79,620	12,738	160	240	193	2.9	1.2	1,012	10,595	1,131	0	0	1,610	11,128	0	127	1.00	240
MHS	9	310	49	190	200	190	2.0	1.0	0	49	0	0	0	0	49	0	0	1.00	200
MHS	10	4,830	773	170	200	195	3.3	0.8	309	464	0	0	0	100	673	0	8	1.00	200
MKD	1	103,589	16,574	160	220	191	2.0	0.6	7,397	7,427	1,748	20	0	3,800	12,642	110	246	1.48	413
MKD	2	75,840	12,134	140	200	171	2.6	0.5	4,711	6,968	455	10	0	1,300	10,684	140	205	1.69	418
MKD	3	106,490	17,038	150	210	183	1.6	0.9	14,776	1,715	547	160	0	5,180	11,488	210	239	1.40	454
MKD	4	1,860	297	180	280	212	7.2	3.0	0	188	109	6	0	42	239	10	15	5.18	491
MKD	5	6,030	963	210	490	270	4.3	4.3	0	684	279	0	0	200	763	0	36	3.77	500
MKD	6	700	113	190	240	208	11.7	10.3	0	66	47	0	0	10	103	0	4	3.83	410
MKD	7	47,020	7,522	190	360	240	4.6	3.0	1,199	5,025	1,298	260	0	3,245	3,937	80	255	3.39	530
MKD	8	59,420	9,506	160	420	236	3.1	1.5	1,772	6,909	825	180	0	1,120	8,006	200	456	4.80	600
MKD	9	52,240	8,357	140	240	185	2.2	0.7	4,828	2,738	791	0	0	1,320	7,007	30	127	1.52	393
MKD	10	1,180	188	170	175	173	1.7	1.7	188	0	0	0	0	100	88	0	6	3.45	245
MKD	11	13,430	2,149	155	210	183	2.4	0.9	991	938	210	0	0	300	1,849	0	45	2.11	228
MKD	12	11,480	1,837	280	350	303	12.0	3.5	0	1,630	207	0	0	0	1,837	0	59	3.20	525
SKN	1	22,810	3,650	150	190	170	2.0	0.7	1,825	1,825	0	20	350	450	2,810	20	37	1.00	190
SKN	2	43,580	6,972	130	150	160	1.0	0.8	6,631	341	0	20	450	2,490	3,982	30	419	6.01	190
SKN	3	120,110	19,215	180	260	203	2.1	0.8	12,792	5,446	977	30	0	4,430	14,525	230	583	3.04	667
SKN	4	86,520	13,844	190	230	210	2.0	0.1	7,160	6,684	0	0	0	3,500	10,194	150	369	2.67	595
SKN	5	89,240	14,278	190	463	285	5.0	2.2	1,395	8,699	4,184	0	0	510	12,578	3,190	352	2.47	558
SKN	6	45,290	7,245	280	450	305	4.3	2.8	3,924	2,013	1,308	0	0	3,590	3,535	120	159	2.20	695
SKN	7	13,200	2,112	150	172	161	1.1	0.5	1,478	634	0	0	0	500	1,612	0	21	1.00	172
KK		267,920	42,871	160	240	201	2.3	1.0	16,889	25,703	280	152	0	6,545	35,534	640	746	1.74	825
MHS		213,440	34,146	155	240	190	3.0	1.6	6,766	25,465	1,915	0	0	4,760	29,366	20	341	1.00	240
MKD		479,230	76,676	140	490	213	4.7	2.6	33,862	34,298	6,516	636	0	16,617	58,643	760	1,694	2.21	600
SKN		420,750	67,316	130	490	213	2.5	1.1	35,205	25,642	6,469	70	800	15,470	43,226	1,250	1,941	2.88	695
Total		1,381,380	221,009	140	490	204	3.1	1.6	94,721	111,108	15,180	858	800	43,392	172,769	3,190	4,722	2.14	695
Ratio									42.9%	50.3%	6.9%	0.4%	0.4%	19.6%	78.2%	1.4%			

Table 2.1-2 Topographical Characteristics of Sub-LRAs in the Study Area

Study Area			Acreage		Elevation (m)			slope (%)		Area by Slope (ha)			Major Land Use (ha)					Catchment Area		
No.		Sub-LRA	Ar (rai)	A (ha)	min	max	ave.	Side slope	Main drain	0 - 2 %	2 - 5 %	more than 5 %	swamp reservoir rivers	low land bush	paddy	orchard upland	residence others	CA (km2)	Ratio CA/A	max. EL. (m)
KK	1		67,640	10,824	160	230	194	1.9	0.8	6,670	3,968	186	145	0	1,285	8,704	190	248	2.29	260
KK	2		14,130	2,260	190	230	210	2.4	1.0	1,341	919	0	0	0	270	1,960	30	117	5.16	530
KK	3		18,370	2,910	180	230	208	2.4	0.9	578	2,362	0	5	0	720	2,145	20	96	3.27	625
KK	4		11,740	1,879	190	220	205	2.5	1.0	658	1,127	94	0	0	120	1,719	40	25	1.31	266
KK	5		6,250	1,001	160	200	173	2.5	1.5	78	923	0	2	0	150	839	10	21	2.10	210
KK	6		159,790	23,967	210	230	217	2.0	0.5	7,563	16,404	0	0	0	3,500	20,167	300	240	1.00	232
MHS	1		2,640	422	190	230	210	4.0	4.0	21	401	0	0	0	0	422	0	4	1.00	230
MHS	2		59,690	9,549	170	232	196	4.0	1.3	600	8,308	641	0	0	0	9,549	0	95	1.00	232
MHS	3		3,080	492	160	192	176	3.3	3.3	246	246	0	0	0	0	492	0	5	1.00	192
MHS	4		9,510	1,521	155	189	172	2.0	1.0	608	913	0	0	0	0	1,521	0	15	1.00	189
MHS	5		13,030	2,085	170	204	187	3.3	1.1	417	1,668	0	0	0	500	1,585	0	21	1.00	204
MHS	6		29,799	4,766	170	214	192	3.3	0.9	2,240	2,383	143	0	0	1,300	3,446	20	48	1.00	214
MHS	7		10,949	1,751	170	204	187	1.7	1.0	1,313	438	0	0	0	1,250	501	0	18	1.00	204
MHS	8		79,620	12,738	160	240	193	2.9	1.2	1,012	10,595	1,131	0	0	1,610	11,128	0	127	1.00	240
MHS	9		310	49	190	200	190	2.0	1.0	0	49	0	0	0	0	49	0	0	1.00	200
MHS	10		4,830	773	170	200	195	3.3	0.8	309	464	0	0	0	100	673	0	8	1.00	200
MKD	1		103,580	16,572	160	220	191	2.0	0.6	7,397	7,427	1,748	20	0	3,800	12,642	110	246	1.48	413
MKD	2		75,840	12,134	140	200	171	2.6	0.5	4,711	6,968	455	10	0	1,300	10,684	140	205	1.69	413
MKD	3		106,490	17,038	150	210	183	1.6	0.9	14,776	1,715	547	160	0	5,180	11,488	210	239	1.40	494
MKD	4		1,860	297	180	280	212	7.2	3.0	0	188	109	6	0	42	239	10	15	5.18	491
MKD	5		6,030	963	210	490	270	4.3	4.3	0	684	279	0	0	200	763	0	36	3.77	500
MKD	6		700	113	190	240	208	11.7	10.3	0	66	47	0	0	10	103	0	4	3.63	410
MKD	7		47,020	7,522	190	360	240	4.6	3.0	1,199	5,025	1,298	260	0	3,245	3,937	80	255	3.39	530
MKD	8	1	33,040	5,286	220	420	308	4.0	2.0	0	4,822	464	150	0	320	4,736	80	179	3.38	525
MKD	8	2	10,730	1,716	160	220	190	5.0	2.5	172	1,201	343	0	0	300	1,356	60	194	11.31	600
MKD	8	3	9,930	1,590	170	200	185	2.0	0.7	795	795	0	30	0	0	1,530	30	64	4.04	562
MKD	8	4	5,710	914	180	200	190	0.5	0.5	805	91	18	0	0	500	384	30	19	2.08	436
MKD	9	1	28,530	4,564	140	200	168	2.1	1.0	3,213	897	454	0	0	800	3,744	20	54	1.18	200
MKD	9	2	23,710	3,793	150	240	202	2.3	0.4	1,615	1,841	337	0	0	520	3,263	10	73	1.93	397
MKD	10		1,180	188	170	175	173	1.7	1.7	188	0	0	0	0	100	88	0	6	3.45	245
MKD	11	1	6,880	1,101	165	210	188	1.7	0.4	991	110	0	0	0	200	901	0	21	1.92	220
MKD	11	2	6,550	1,048	155	200	178	5.0	1.4	0	838	210	0	0	100	948	0	24	2.32	226
MKD	12		11,480	1,837	280	350	303	12.0	3.5	0	1,630	207	0	0	0	1,837	0	59	3.20	525
SKN	1		22,810	3,650	150	190	170	2.0	0.7	1,825	1,825	0	20	350	450	2,810	20	37	1.00	190
SKN	2		43,580	6,972	150	180	160	1.0	0.8	6,631	341	0	20	450	2,490	3,982	30	419	6.01	180
SKN	3	1	80,920	12,946	190	220	201	2.2	1.2	10,535	1,925	485	0	0	3,510	9,506	130	480	3.71	667
SKN	3	2	6,650	1,064	190	205	198	2.0	0.3	532	426	106	0	0	20	1,044	0	11	1.00	205
SKN	3	3	32,540	5,205	180	280	210	2.0	0.5	1,224	3,095	386	30	0	1,100	3,975	100	93	1.78	422
SKN	4		86,520	13,844	190	230	210	2.0	0.1	7,160	6,684	0	0	0	3,500	10,184	160	369	2.67	595
SKN	5	1	16,740	2,679	190	340	257	5.0	1.7	188	1,955	536	0	0	110	2,459	110	71	2.64	554
SKN	5	2	72,500	11,599	290	443	321	5.0	2.8	1,207	6,734	3,658	0	0	400	10,119	1,080	281	2.43	558
SKN	6	1	23,400	3,744	215	260	238	1.0	0.5	2,996	636	112	0	0	3,130	464	100	61	1.62	695
SKN	6	2	21,890	3,501	200	430	321	5.1	3.3	928	1,377	1,196	0	0	410	3,071	20	99	2.82	625
SKN	7		13,200	2,112	150	172	161	1.1	0.5	1,478	634	0	0	0	500	1,612	0	21	1.00	172
KK	6	6	267,930	42,871	160	240	201	2.3	1.0	16,888	25,703	280	152	0	6,545	35,534	640	746	1.74	625
MHS	10	10	213,440	34,146	155	240	190	3.0	1.6	6,766	25,465	1,915	0	0	4,760	29,366	20	341	1.00	240
MKD	12	12	479,270	76,676	140	490	209	4.1	2.2	35,862	34,298	6,516	636	0	16,617	58,643	780	1,694	2.21	600
SKN	7	11	420,750	67,316	150	480	222	2.6	1.1	35,205	25,642	6,469	70	800	15,470	49,226	1,750	3,941	2.88	695
Total	35	44	1,381,380	221,009	140	490	206	3.0	1.4	94,721	111,108	15,180	858	800	43,392	172,769	3,190	4,722	2.14	695
Ratio				5,023						42.9%	50.3%	6.9%	0.4%	0.4%	19.6%	78.2%	1.4%			

Table 2.1-3 Topographical Characteristics by Topo-LRAs in Khon Kaen

Study Area No.	LRAs	Sub-LRAs	Acreage (rai)	Acreage (ha)	Elevation (m) min.	Elevation (m) max.	Elevation (m) ave.	Typical slope (%) side slope	Typical slope (%) main drain	Acreage by Slope (ha) 0 - 2 %	2 - 5 %	more than 5 %	Major Land Use (ha) swamp reservoir & rivers	low land bush	paddy	orchard upland	village	Catchment area CA (km²)	max. EL (m)	Major Vegetation of CA	Land use of Downstream of Study Area
KK	1	1	7,810	1,250	160	180	170	2.0	0.5	1,250	0	0	5	0	10	1,215	20	26.6	200	forest, upland	Chi river
KK	1	2	15,240	2,455	160	180	170	2.5	0.8	2,086	266	123	100	0	400	1,915	40	47.55	250	E. forest	Chi river
KK	1	3	4,060	650	170	190	180	2.0	2.0	650	0	0	0	0	100	550	0	7.7	296	E. forest	paddy
KK	1	4	28,530	4,574	160	200	180	3.7	0.5	1,133	3,400	0	40	0	900	3,574	60	115.14	260	E. forest	paddy
KK	1	5	2,730	436	210	230	220	3.7	1.0	436	0	0	0	0	60	376	0	9.96	260	E. forest	paddy
KK	1	6	1,300	208	190	200	195	2.5	0.6	0	208	0	0	0	0	198	10	10.18	230	E. forest	E. forest
KK	1	7	730	117	210	220	215	1.3	0.6	117	0	0	0	0	55	52	10	5.17	260	E. forest	E. forest
KK	1	8	1,330	210	183	220	203	2.9	0.6	62	84	63	0	0	40	150	25	8	250	E. forest	paddy
KK	1	9	4,360	698	180	230	205	0.6	0.4	698	0	0	0	0	220	448	30	15.39	250	E. forest	paddy
KK	1	10	1,410	226	200	210	205	2.0	1.0	226	0	0	0	0	0	226	0	2.26	210	upland	paddy
KK	2	1	1,000	160	190	215	203	4.0	0.6	0	160	0	0	0	0	160	0	5.6	235	E. forest	paddy
KK	2	2	550	88	210	220	215	2.5	1.0	0	88	0	0	0	0	78	10	2.18	235	forest, upland	paddy
KK	2	3	3,930	1,269	200	230	215	2.2	0.3	698	571	0	0	0	150	1,119	0	24.19	230	paddy	paddy
KK	2	4	920	153	200	220	210	2.0	1.4	153	0	0	0	0	0	153	0	2.25	230	E. forest	paddy
KK	3	5	2,590	399	170	210	200	2.8	0.8	299	100	0	0	0	80	299	20	80.49	530	paddy	paddy
KK	2	6	430	65	210	220	215	2.0	2.0	65	0	0	0	0	40	25	0	0.65	220	upland	paddy
KK	2	7	780	124	210	220	215	1.0	1.0	124	0	0	0	0	0	124	0	1.24	220	upland	E. forest
KK	3	1	810	135	230	240	235	1.7	1.7	135	0	0	1	0	0	134	0	7.85	556	E. forest	paddy
KK	3	2	590	94	210	220	215	3.3	0.8	0	94	0	0	0	20	74	0	11.74	520	E. forest	paddy
KK	3	3	3,060	489	210	230	220	2.5	0.7	0	489	0	0	0	160	299	30	21.49	625	E. forest	paddy
KK	3	4	7,840	1,255	180	220	200	2.5	0.4	0	1,255	0	0	0	100	1,125	30	23.45	230	E. forest	paddy
KK	3	5	515	82	190	170	180	3.3	0.4	0	82	0	0	0	20	62	0	1.87	210	E. forest	paddy
KK	3	6	5,070	811	158	250	204	2.0	0.8	406	405	0	6	0	370	431	10	28.51	511	E. forest	Huai Sang Mi
KK	3	7	460	74	190	200	195	1.7	1.7	37	37	0	4	0	0	70	0	1.14	220	E. forest	upland
KK	4		11,740	1,879	190	220	205	2.5	1.0	658	1,127	94	0	0	120	1,719	40	24.59	260	E. forest	paddy
KK	5	1	5,660	906	160	200	180	2.5	0.4	45	861	0	2	0	150	744	10	15.06	210	E. forest	paddy
KK	5	2	590	95	160	170	165	2.5	2.5	33	62	0	0	0	0	35	0	5.95	190	E. forest	upland
KK	6	1	23,310	3,730	210	238	224	2.0	0.5	1,492	2,238	0	0	0	340	3,390	40	37.3	232	upland	paddy
KK	6	2	86,730	13,877	155	251	220	2.0	0.6	4,163	9,714	0	0	0	2,100	10,577	200	138.77	210	upland	paddy
KK	6	3	39,250	6,306	165	230	208	2.0	0.5	1,908	4,452	0	0	0	1,100	5,200	60	63.6	206	upland	paddy
Total Av.			267,920	42,871	191	214	202	2.2	0.9	16,888	25,703	280	152	0	6,545	35,534	640	746.06	283		
(Notes)			1) Topographical data has been derived from 1:50,000 map															max.	625		
			2) Acreage of LRAs have been measured by a digitizer in ALRO																		

Table 2.1-4 Topographical Characteristics by Topo-LRAs in Mahasarakham

Study Area No.			Acreage (rai)	Acreage (ha)	Elevation (m) min.	Elevation (m) max.	Elevation (m) ave.	Typical slope (%) side slope	Typical slope (%) main drain	Acreage by Slope (ha) 0 - 2 %	2 - 5 %	more than 5 %	Major Land Use (ha) swamp reservoir & rivers	low land bush	paddy	orchard upland	village	Catchment area CA (km²)	max. EL (m)	Major Vegetation of CA	Land use of Downstream of Study Area
MHS	1		2,640	422	190	230	210	4.0	4.0	21	401	0	0	0	0	422	0	4.22	230	upland	plantation
MHS	2	1	25,490	4,078	170	232	201	4.0	1.4	408	3,466	204	0	0	0	4,078	0	49.78	232	upland	paddy
MHS	2	2	10,190	1,630	180	210	195	4.0	1.3	0	1,385	245	0	0	0	1,630	0	16.30	210	upland	paddy
MHS	2	3	24,010	3,841	180	206	193	4.0	1.3	192	3,457	192	0	0	0	3,841	0	38.41	206	upland	paddy
MHS	3		3,080	492	160	192	176	3.3	3.3	246	246	0	0	0	0	492	0	4.92	192	upland	paddy
MHS	4		9,510	1,521	155	189	172	2.0	1.0	608	913	0	0	0	0	1,521	0	15.21	189	upland	paddy
MHS	5		13,030	2,085	170	204	187	3.3	1.1	417	1,668	0	0	0	500	1,585	0	20.85	204	upland	paddy
MHS	6		29,790	4,766	170	214	192	3.3	0.9	2,240	2,383	143	0	0	1,300	3,446	20	47.66	214	upland	paddy
MHS	7		10,940	1,751	170	204	187	1.7	1.0	1,313	438	0	0	0	1,250	501	0	17.51	204	upland	paddy
MHS	8	1	15,960	2,553	160	190	175	4.0	1.0	0	2,298	255	0	0	250	2,303	0	25.53	190	upland	paddy
MHS	8	2	13,390	2,142	170	209	190	2.0	1.0	857	1,285	0	0	0	70	2,072	0	21.42	209	upland	paddy
MHS	8	3	12,790	2,045	170	220	195	3.3	0.8	0	1,738	307	0	0	0	2,045	0	20.45	220	upland	paddy
MHS	8	4	35,550	5,688	170	240	205	3.0	1.0	0	5,119	569	0	0	1,200	4,488	0	56.88	240	upland	paddy
MHS	8	5	1,940	310	190	207	199	2.0	2.0	155	155	0	0	0	90	220	0	3.10	207	upland	paddy
MHS	9		310	49	190	200	195	3.3	2.0	0	49	0	0	0	0	49	0	0.49	200	upland	paddy
MHS	10		4,830	773	170	200	185	3.0	3.0	309	464	0	0	0	100	673	0	7.73	200	upland	paddy
Total Av.			213,440	34,136	133	209	191	3.1	1.6	6,266	25,465	1,915	0	0	4,260	29,366	20	341.46	209		
(Notes)			1) Topographical data has been derived from 1:50,000 map																		
			2) Acreage of LRAs have been measured by a digitizer in ALRO																		

Table 2.1-5 Topographical Characteristics by Topo-LRAs in Mukdahan

Study Area No.			Acreage (rai)	Acreage (ha)	Elevation (m) min.	max.	ave.	Typical slope (%) side slope	main drain	Acreage by Slope (ha) 0 - 2 %	2 - 5 %	more than 5 %	Major Land Use (ha) swamp reservoir & divers	low land bush	paddy	orchard upland	village	Catchment area CA (km²)	max. EL (m)	Major Vegetation of CA	Land use of Downstream of Study Area
MKD	1	1	6,530	1,045	180	220	200	2.3	1.0	885	105	52	0	0	300	725	20	17.9	309	paddy	paddy
MKD	1	2	32,240	5,158	160	210	185	0.4	0.3	3,971	774	413	0	0	2,100	3,028	30	72.9	238	upland	paddy
MKD	1	3	18,340	2,941	180	220	200	2.5	0.6	147	2,500	294	10	0	400	2,501	30	55.8	413	upland	MKD1-4
MKD	1	4	25,750	4,120	160	220	190	2.0	0.4	2,060	1,236	824	0	0	300	3,800	20	54.2	413	upland	Huai Bang L
MKD	1	5	20,680	3,308	160	200	180	4.0	0.8	331	2,812	165	10	0	200	2,588	10	45.0	389	forest	paddy
MKD	2	1	26,630	4,261	150	200	175	3.3	0.3	0	4,267	0	10	0	600	3,607	50	62.8	320	paddy	Huai Bang L
MKD	2	2	8,140	1,302	150	180	165	3.0	0.5	326	781	195	0	0	170	1,072	60	46.8	318	paddy	Huai Bang L
MKD	2	3	39,150	6,264	140	200	170	1.0	0.5	4,385	1,754	125	0	0	320	5,714	30	82.7	396	paddy, forest	Huai Bang L
MKD	2	4	1,890	301	165	200	175	3.0	0.5	0	166	135	0	0	10	293	0	13.1	418	forest	Paddy
MKD	3	1	3,600	576	170	200	185	2.5	0.5	288	230	58	0	0	300	266	10	10.0	246	upland, paddy	Huai Khilek L
MKD	3	2	16,710	2,673	170	210	190	1.0	0.7	2,673	0	0	410	0	980	1,574	40	41.5	491	upland, paddy	Huai Khilek L
MKD	3	3	45,000	7,200	160	200	180	0.8	0.2	6,120	720	360	30	0	3,600	3,510	60	90.2	494	upland, paddy	Huai Yai
MKD	3	4	40,440	6,470	150	200	175	1.0	0.4	5,694	647	129	10	0	300	6,060	100	94.3	494	upland	Huai Bang L
MKD	3	5	740	118	180	190	185	2.5	2.5	0	118	0	10	0	30	78	0	2.9	340	forest	paddy
MKD	4	1	240	38	200	280	240	15.0	2.0	0	0	38	0	0	0	38	0	1.8	491	forest	paddy
MKD	4	2	150	24	180	190	185	2.5	5.0	0	24	0	2	0	22	0	0	0.0	423	forest	paddy
MKD	4	3	1,470	235	180	240	210	4.0	2.0	0	164	71	4	0	30	201	10	4.6	329	forest	paddy
MKD	5	1	930	148	220	490	355	3.8	3.8	0	81	67	0	0	100	48	0	3.5	500	Forest	Paddy
MKD	5	2	1,820	291	220	240	230	5.0	5.0	0	131	160	0	0	0	291	0	10.0	430	Forest	Paddy
MKD	5	3	3,280	524	210	240	225	4.0	4.0	0	472	52	0	0	100	424	0	22.8	425	Forest	Paddy
MKD	6	1	190	31	200	240	220	20.0	20.0	0	0	31	0	0	0	31	0	0.5	430	Forest	Paddy
MKD	6	2	510	82	190	200	195	3.3	0.6	0	66	16	0	0	10	72	0	3.8	440	Forest	Paddy
MKD	7	1	37,290	5,967	210	290	245	3.0	0.4	597	4,475	895	160	0	2,300	3,437	70	218.7	510	Forest	Paddy
MKD	7	2	330	52	220	360	290	10.0	10.0	0	0	52	0	0	25	27	0	5.6	530	Forest	Paddy
MKD	7	3	3,120	499	190	220	205	3.0	0.9	0	349	150	100	0	160	239	0	11.0	380	Forest	Huai Mak R
MKD	7	4	6,280	1,004	200	240	220	2.5	0.6	602	201	201	0	0	760	234	10	19.3	440	Forest	Paddy
MKD	8	1	8,190	1,310	220	420	320	3.0	2.7	0	1,244	66	0	0	20	1,290	0	51.9	511	Forest	Huai Bang S
MKD	8	2	24,850	3,976	240	350	295	5.0	1.3	0	3,578	398	150	0	300	3,446	80	136.9	525	Forest	Huai Bang S
MKD	8	3	10,730	1,716	160	220	190	5.0	2.5	172	1,201	343	0	0	300	1,356	60	194.1	600	Forest	Huai Bang S
MKD	8	4	9,940	1,590	170	200	185	2.0	0.2	795	795	0	30	0	0	1,530	30	64.2	562	Forest	Huai Bang S
MKD	8	5	5,710	914	180	200	190	0.5	0.5	805	91	18	0	0	500	384	30	19.0	436	Forest	Paddy
MKD	9	1	14,560	2,329	140	170	155	2.0	0.9	1,518	466	349	0	0	100	2,219	10	23.9	178	Paddy	Paddy
MKD	9	2	500	80	180	200	190	2.5	2.5	40	0	40	0	0	0	80	0	0.8	200	Upland	Upland
MKD	9	3	13,470	2,155	140	150	160	1.7	0.3	1,659	431	65	0	0	700	1,445	10	25.0	200	Upland	Paddy
MKD	9	4	7,880	1,260	150	210	180	3.3	0.3	378	882	0	0	0	300	960	0	15.0	232	Upland	Paddy
MKD	9	5	14,050	2,248	170	220	195	1.0	0.5	1,237	674	337	0	0	200	2,048	0	49.7	397	Forest	Paddy
MKD	9	6	1,780	285	220	240	230	2.5	0.7	0	285	0	0	0	20	255	10	8.4	360	Ng. 9-5	Paddy
MKD	10		1,180	188	170	175	173	1.7	1.7	188	0	0	0	0	100	88	0	6.5	245	Forest	Paddy
MKD	11	1	6,880	1,101	165	210	188	1.7	0.4	991	110	0	0	0	200	901	0	21.3	220	Forest	Paddy
MKD	11	2	6,550	1,048	155	290	178	5.0	1.4	0	838	210	0	0	100	948	0	24.3	228	Forest	Huai Bang S
MKD	12	1	1,290	207	290	300	295	20.0	3.0	0	0	207	0	0	0	207	0	8.2	480	forest	MKD8-2
MKD	12	2	10,190	1,630	280	350	315	4.0	4.0	0	1,630	0	0	0	0	1,630	0	50.6	525	forest	MKD8-2
Total/Av.			479,220	76,676	183	236	210	3.9	2.0	35,662	34,298	6,516	636	0	16,617	58,643	780	1,693.7	395		
(Notes)			1) Topographical data has been derived from 1:50,000 map.																		
			2) Acreage of LRAs have been measured by a digitizer in ALRO.																		

Table 2.1-6 Topographical Characteristics by Topo-LRAs in Sakon Nakhon

Study Area No.			Acreage (rai)	Acreage (ha)	Elevation (m) min.	max.	ave.	Typical slope (%) side slope	main drain	Acreage by Slope (ha) 0 - 2 %	2 - 5 %	more than 5 %	Major Land Use (ha) swamp reservoir & divers	low land bush	paddy	orchard upland	village	Catchment area CA (km²)	max. EL (m)	Major Vegetation of CA	Land use of Downstream of Study Area
SKN	1		22,810	3,650	150	190	170	2.0	0.7	1,825	1,825	0	20	350	450	2,810	20	36.50	190	upland	bush
SKN	2	1	30,990	4,959	160	180	170	1.4	0.9	4,711	248	0	0	0	1,200	3,739	20	49.59	180	upland	paddy
SKN	2	2	980	156	155	160	155	0.9	0.9	156	0	0	0	0	0	146	10	62.56	180	paddy	paddy
SKN	2	3	11,610	1,857	150	160	155	0.6	0.6	1,764	93	0	20	450	1,290	97	0	306.57	180	paddy	Songkhram
SKN	3	1	19,160	3,065	190	210	200	2.4	2.4	2,146	766	153	0	0	600	2,405	60	109.55	522	paddy, forest	Nam Un res.
SKN	3	2	2,510	402	190	210	200	2.0	2.0	382	20	0	0	0	10	382	10	4.02	210	upland	Nam Un res.
SKN	3	3	17,690	2,830	190	210	200	2.0	0.1	2,688	142	0	0	0	1,000	1,810	20	84.80	240	SKN4-2	Nam Un res.
SKN	3	4	41,560	6,649	190	220	205	2.5	0.1	5,320	997	332	0	0	1,200	4,909	40	281.49	667	C. forest	Nam Un res.
SKN	3	5	6,650	1,064	190	205	198	2.0	0.3	532	426	106	0	0	20	1,044	0	10.64	205	upland	Nam Un res.
SKN	3	6	15,680	2,508	180	205	190	2.0	0.3	376	1,881	251	30	0	250	1,668	60	47.68	378	forest	paddy
SKN	3	7	16,860	2,697	180	280	230	2.0	0.6	1,348	1,214	135	0	0	350	2,307	40	44.97	422	forest	paddy
SKN	4	1	50,710	8,114	190	230	210	2.0	0.1	4,868	3,246	0	0	0	2,400	5,604	110	312.14	595	forest, paddy	Nam Un res.
SKN	4	2	35,810	5,730	190	230	210	2.0	0.1	2,292	3,438	0	0	0	1,100	4,580	50	51.30	230	upland	SK3-3
SKN	5	1	880	141	190	200	195	5.0	5.0	63	71	7	0	0	0	141	0	8.41	460	forest	orchard
SKN	5	2	2,590	415	300	340	320	5.0	0.8	0	311	104	0	0	0	395	20	4.15	340	upland	forest
SKN	5	3	2,310	369	300	320	310	5.0	1.4	37	221	111	0	0	0	299	70	3.69	320	upland	forest
SKN	5	4	5,060	810	200	240	220	5.0	0.8	41	607	162	0	0	50	740	20	36.10	554	forest	Nam Phan ri
SKN	5	5	5,900	944	200	280	240	5.0	0.6	47	755	142	0	0	60	884	0	18.44	533	forest	Nam Phan ri
SKN	5	6	3,310	530	290	300	295	5.0	5.0	0	530	0	0	0	0	380	150	7.30	514	forest	Nam Phan re
SKN	5	7	11,250	1,800	290	320	305	5.0	5.0	0	1,710	90	0	0	0	1,170	630	141.00	553	forest	Nam Phan re
SKN	5	8	53,560	8,569	290	443	367	5.0	0.2	857	4,284	3,428	0	0	100	8,269	200	91.19	443	forest	Nam Phan re
SKN	5	9	4,380	700	290	340	315	5.0	0.4	350	210	140	0	0	300	300	100	42.00	558	forest	Nam Phan re
SKN	6	1	23,400	3,744	215	260	238	1.0	0.5	2,996	636	112	0	0	3,180	464	100	60.54	695	C. forest	paddy
SKN	6	2	8,950	1,432	200	240	220	2.5	1.0	859	573	0	0	0	250	1,172	10	23.22	537	C. forest	paddy
SKN	6	3	6,580	1,052	230	360	295	8.0	8.0	0	526	526	0	0	100	952	0	49.02	695	C. forest	paddy
SKN	6	4	5,780	925	220	360	290	7.0	1.3	0	278	647	0	0	30	895	0	25.55	610	C. forest	paddy
SKN	6	5	580	92	480	480	480	3.0	3.0	69	0	23	0	0	30	52	10	0.92	480	upland	paddy
SKN	7		13,200	2,112	150	172	161	1.1	0.5	1,478	634	0	0	0	500	1,612	0	21.12	172	upland	paddy
Total/Av.			420,750	67,316	219	262	241	3.3	1.5	35,205	25,642	6,469	70	800	15,430	49,226	1,750	1940.56	409		
(Notes)			1) Topographical data has been derived from 1:50,000 map.															max	695		
			2) Acreage of LRAs have been measured by a digitizer in ALRO.																		

2.2 Geology

The study areas are normally dominated by the Mesozoic sedimentary rocks (Khorat Group) consisting of the Jurassic to the upper Cretaceous excluding the Huai Hin Lat Formation. The Quaternary unconsolidated sediments unconformably overlies the Mesozoic. The stratigraphy in the study area is summarized as below:

(1) Mesozoic Era

Nam Phong Formation
This formation is comprised of reddish-brown, and brown sandstone and conglomerate with pebbles of quartz, quartzite, chert, igneous rocks, red siltstone,red sandstone of up to 10 cm in diameter. The other is brown and reddish-brown shale and siltstone.

Phu Kradung Formation
This formation consists of brown, reddish-brown, and purplish-red, micaceous shale, brown and gray, micaceous, small scale cross-bedded siltstone and sandstone and some lime-noduled conglomerate.

Phra Wihan Formation
This formation is mainly composed of white and pink, orthoquarsitic, pebble layering on the upper bed, massive, cross-bedded sandstone. Perhaps some reddish brown and gray shale and conglomerate are commonly comprised.

Sao Khau Formation
This formation is mainly composed of sandstone, reddish-brown, micaceous siltstone, grayish-brown and reddish-brown;shale, purplish-brown and brick-red, micaceous, and lime-noduled conglomerate.

Phu Phan Formation
This formation is mainly composed of sandstone, white, pale-orange, commonly pebbly with pebbles of quartz, chert, red siltstone, and igneous rocks of up to 5 cm. in diameter, cross-bedded, with shale and conglomerate interbedded.

Khok Kruat Formation
This formation consists of sandstone, siltstone, shale, and lime-noduled conglomerate, reddish-brown gray, grayish-white, and brown, with gypsum at the upper part.

Maha Sarakham Formation
This formation is composed of mudstone, shale, siltstone and fine-grained sandstone, reddish-brown, red, and brick-red, with rock salt and other evaporates at the lower part.

(2) Cenozoic Era

Quaternary Deposit
The alluvial and terrace deposits mainly consist of gravel, sand, silt and clay.

Table 2.2-1 Stratigraphy of The Study Areas

ERA	PERIOD	FORMATION	DESCRIPTION
Cenozoic	Quaternary		Alluvial deposits: gravel, sand, silt, clay and lateritic soil.
Mesozoic	Cretaceous	Maha Sarakham	Sandstone, siltstone & shale with rocksalt, potash, gypsum and anhydrite: brick red to purplish red
		Khok Kruat	Sandstone: brown to reddish brown, micaceous. Shale&Siltstone: pale brown, micaceous, with lime nodule conglomerate.
		Phu Phan	Sandstone: white to pale orange, commonly pebbly, cross bedding with some shale and conglomerate.
	Jurassic	Sao Khua	Sandstone: reddish brown to gray, mostly micaceous. Siltstone, Shale and Conglomerate: purplish-red to brick red.
		Phra Wihan	Sandstone: thick bedded, cross bedded, quarsitic white, with some reddish brown and gray shale.
		Phu Kradung	Shale: reddish brown, micaceous. Siltstone and Sandstone: brownish-gray, small-scale cross-bedded
	Triassic	Nam Phong	Sandstone: reddish-brown. Conglomerate: pebble quartz, igneous rocks, siltstone, sandstone. Shale & Siltstone: brown and reddish brown.

Table 2.2-2 Comparison of the Geological Condition in each province

Province	Formation	Amphoe
Khon Kaen	Qa	Muang, Chinnabot, Mancha Khiri, Ban Phai,Phon, Nong Song Hong
	Qt	Chonnabot, Mancha Khiri, Nam Phong
	Maha Sarakham	Muang, Chonnabot, Mancha Khiri, Nam Phong, Ban Fang, Ban Phai, Phon, Nong Song Hong
	Khok Kruat	Chonnabot, Mancha Khiri, Nam Phong, Ban Fang, Ban Phai, Phon
	Phu Phan	Nam Phong, Ban Fang, Phon
	Sao Khua	Nam Phong, Ban Fang
	Phra Wihan	Nam Phong, Ban Fang
	Phu Kradung	Nam Phong, Ban Fang
	Nam Phong	Nam Phong
Maha Sarakham	Qa	General
	Maha Sarakham	General
Mukdahan	Khok Kruat	Nikhom Kham Soi, Don Tan, Dong Luang
	Phu Phan	Muang, Nikhom Kham Soi, Don Tan, Dong Luang
	Sao Khua	Muang, Nikhom Kham Soi, Khamcha-i, Dong Luang
	Phra Wihan	Muang, Nikhom Kham Soi, Khamcha-i
	Phu Kradung	Muang, Khamcha-i
Sakon Nakhon	Qa	Warich Phum, Kham Ta Kla, Muang, Nikhom Nam Un, Sawang Daen Din
	Qt	Muang
	Maha Sarakham	Warich Phum,Ban Muang, Nikhom Nam Un, Sawang Daen Din
	Khok Kruat	Warich Phum,Kut Bak, Muang, Nikhom Nam Un
	Phu Phan	Warich Phum,Kut Bak, Muang, Nikhom Nam Un
	Sao Khua	Nikhom Nam Un
	Phra Wihan	Muang, Nikhom Nam Un
	Phu Kradung	Kut Bak

2.3 Suitability of Small Reservoir Development

Depending on the land suitability map for small reservoir development, each study is accessed on its suitability. The results are summarized as below:

- Total area of well and moderately suited lands (1 and 2) are generally small as about 14 % of the LRAs in total, while higher as 45 % in Sakhon Nakhon and lower as 2% in Mahasarakham.
- Unsuited lands for small reservoir are not high at about 8% of total LRAs.
- From a viewpoint of constraint of development, Mahasarakham occupies 64% of total slightly salt-affected areas (3.1), Mukdahan 78 % of high seepage lands (3.2), Khon Kaen 46% of well drained and salt-bedrock areas (3.4).

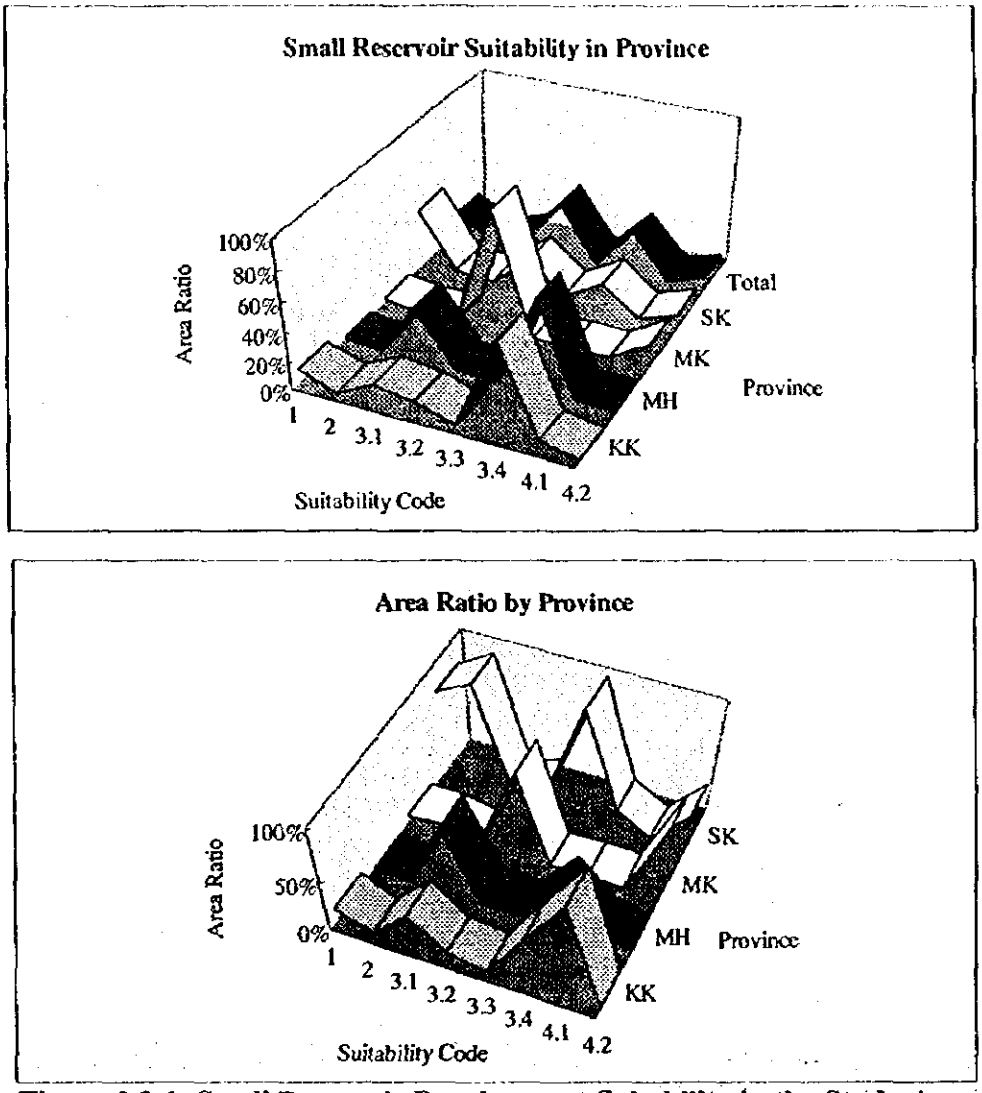


Figure 2.3-1 Small Reservoir Development Suitability in the Study Area

Table 2.3-1 Description of Suitability of Small Reservoir Development

Land Suitability	
Code	**Descriptions**
1	**Land well suited for small reservoir development** : Flat low land with somewhat poorly to poorly drained, clayey or loamy texture and good water storage capacity soil. Good water is yielded.
2	Land moderately suited for small reservoir development : Gently undulating upland with the soil of well drained, but clayey soil or clayey texture in subsoil and good water storage capacity. Good quality water is yielded.
3.1	**Land poorly suited for small reservoir development** : Flat low land with the soil of somewhat poorly or poorly drained, clayey or loamy texture and good water storage capacity. But it is the slightly or potential salt-affected area. Construction of small reservoir is risky since salt water will be yielded. To avoid this, the area should be surveyed and studied before construction of reservoir, and after construction special measures to prevent saline-water intrusion are needed.
3.2	**Land poorly suited for small reservoir development** : Gently undulating to undulating upland with well to moderately well drained, loamy texture and poor water storage capacity soil. To construct the reservoir special measures to increase water storage capacity of soil such as plastic lining, clay lining are needed.
3.3	**Land poorly suited for small reservoir development** : Gently undulating to undulating upland with well drained, clay texture and water storage capacity soil. But the underlying bedrock is the salt bearing rock. Construction of reservoir is risky since saline water will be yielded. To find out the appropriate location, the area should be surveyed and studied before construction of reservoir and special measures to prevent saline-water intrusion are necessary.
3.4	**Land poorly suited for small reservoir development** : Gently undulating to undulating upland with well drained, and sandy texture and poor water storage capacity soil. The underlying bedrock is the salt bearing rock. Construction of reservoir is risky since saline water will be yielded and the water quality will not be sufficient. To find out the appropriate location, the area should be surveyed and studied before construction of reservoir and special measures to prevent saline water intrusion as well as to increase water storage capacity of soil are needed.
4.1	**Land unsuited for small reservoir Development** : Low land with poorly drained soil in the strongly salt-affected area. Construction is very risky since, in most cases, the saline water is yielded. Any kind of measures applying to prevent saline water intrusion is expected to be unworthy.
4.2	**Land unsuited for small reservoir Development** : Hilly and mountainous area with steep slope and thin covering soil material. Land is poor water storage capacity. Any kind of measure applying to increase the water storage capacity of land is expected to be unworthy. :

(Data Source) Land Suitability Map for Small Reservoir Development in Northeast Region of Thailand, DLD and Mekong Secretariat, 1994

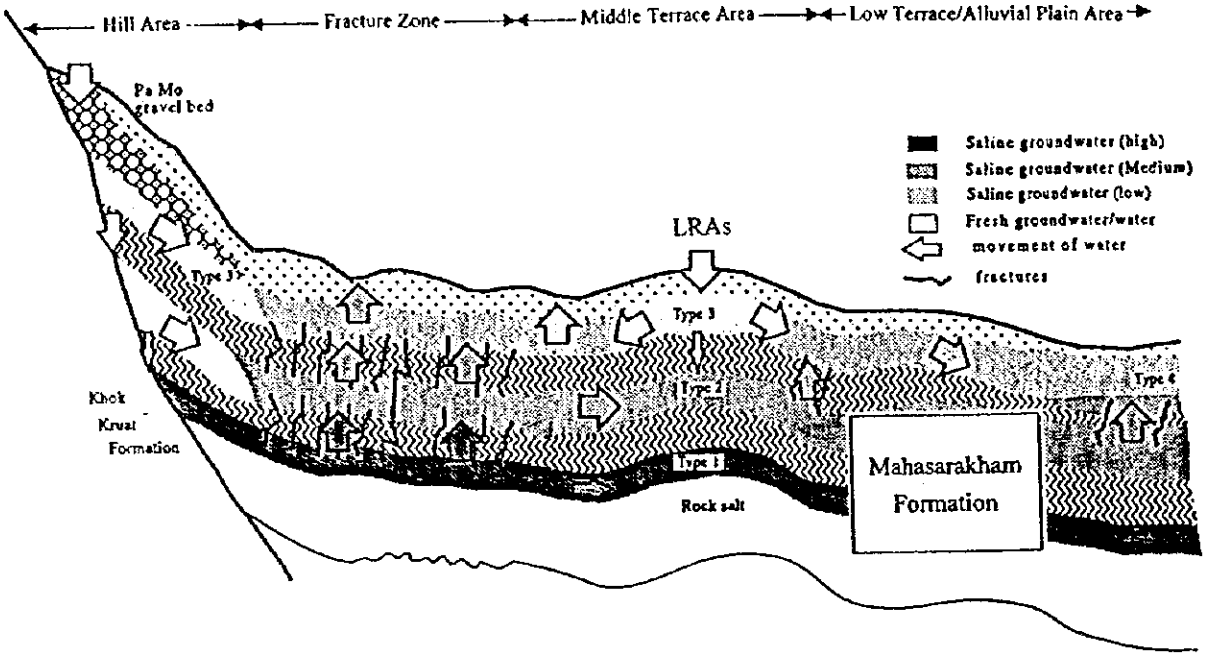
Table 2.3-2 Analysis of Suitability of Small Reservoir Development in the Study Area

Study Area		Area (ha)	Acreage by Suitability (ha)							
			Well suited	Moderately suited	Poorly Suited mainly due to				Unsuited due to	
					salt-affected soil	high seepage	salt bearing bedrock	sandy and salt bearing bedrock	strongly salt-affected soil	steep slope and thin soil
			1	2	3.1	3.2	3.3	3.4	4.1	4.2
KK	1	11,350	0	0	2,618	2,992	0	5,741	0	0
KK	2	2,375	1,535	0	605	0	0	235	0	0
KK	3	3,280	2,222	0	1,058	0	0	0	0	0
KK	4	1,790	358	0	537	895	0	0	0	0
KK	5	1,005	38	0	967	0	0	0	0	0
KK	6	23,760	0	0	0	0	0	21,384	2,376	0
MH	1	260	0	0	156	0	0	104	0	0
MH	2	10,340	0	0	1,928	0	0	8,413	0	0
MH	3	710	0	0	213	0	0	497	0	0
MH	4	1,530	612	0	918	0	0	0	0	0
MH	5	1,930	0	0	1,834	0	0	97	0	0
MH	6	3,210	0	0	1,605	0	0	1,605	0	0
MH	7	1,790	0	0	1,790	0	0	0	0	0
MH	8	14,150	0	0	3,145	0	0	11,005	0	0
MH	9	130	0	0	80	0	0	50	0	0
MH	10	990	0	0	792	0	0	0	198	0
MK	1	17,449	1,745	0	0	9,597	0	0	0	6,107
MK	2	9,007	0	0	0	8,557	0	0	0	450
MK	3	16,633	0	0	0	15,801	0	0	0	832
MK	4	222	0	0	0	222	0	0	0	0
MK	5	1,032	0	0	0	0	0	0	0	1,032
MK	6	112	0	0	0	112	0	0	0	0
MK	7	7,544	0	0	0	7,167	0	0	0	377
MK	8	10,368	0	0	0	8,294	0	0	0	2,074
MK	9	6,965	209	139	0	6,269	0	0	0	348
MK	10	205	0	0	0	205	0	0	0	0
MK	11	1,823	0	0	0	1,732	0	0	0	91
MK	12	1,958	0	0	0	1,860	0	0	0	98
SK	1	3,720	0	0	0	0	0	3,720	0	0
SK	2	6,610	0	0	704	0	1,762	4,144	0	0
SK	3	11,480	10,426	0	0	0	0	0	0	1,054
SK	4	13,050	13,050	0	0	0	0	0	0	0
SK	5	12,780	0	2,340	100	9,410	0	0	0	930
SK	6	7,300	0	0	441	3,680	0	0	0	3,179
SK	7	2,200	0	0	0	0	0	2,200	0	0
KK		43,560	4,153	0	5,785	3,887	0	27,360	2,376	0
MH		35,040	612	0	12,461	0	0	21,771	198	0
MK		73,318	1,954	139	0	59,816	0	0	0	11,409
SK		57,140	23,476	2,340	1,245	13,090	1,762	10,064	0	5,163
Total		209,058	30,195	2,479	19,491	76,793	1,762	59,195	2,574	16,572
Ratio of Suitability in Province										
	KK		10%	0%	13%	9%	0%	63%	5%	0%
	MH		2%	0%	36%	0%	0%	62%	1%	0%
	MK		3%	0%	0%	82%	0%	0%	0%	16%
	SK		41%	4%	2%	23%	3%	18%	0%	9%
	Total		14%	1%	9%	37%	1%	28%	1%	8%
Ratio of Suitability by Province										
	KK		14%	0%	30%	5%	0%	46%	92%	0%
	MH		2%	0%	64%	0%	0%	37%	8%	0%
	MK		6%	6%	0%	78%	0%	0%	0%	69%
	SK		78%	94%	6%	17%	100%	17%	0%	31%
	Total		100%	100%	100%	100%	100%	100%	100%	100%

(Note) Analysis has been made tentatively based on Land Suitability Map for Small Reservoir Development in Northeastern Region of Thailand by DLD and Mekong Secretariat.

2.4 Mechanism of Salinization in the Northeastern Region and Farm Pond Construction

Northeastern Region is well known as the salt-affected area. The salt-affected areas extent in the lowlands of Korat Basin and Sakon Nakhon Basin of which locations are shown in Figure 2.1-1 in Appendix D. It is considered that salt injuries are caused by salt which is transported to the ground surface from saline groundwater by capillary water. Groundwater is salinized by rock salt strata thickly deposited in Mahasarakham Formation as shown in Figure 2.4-1. As a result, salt-affected areas are concentrated in the lowland, and LRAs are saved from salt problems due to high elevation. However, since LRAs are connecting to the salt-affected lowland areas through groundwater, it is necessary to avoid the developments which are likely to raise groundwater table in the salt-affected lowland.



(Data Source) Data from ADRC, Khon Kaen

Figure 2.4-1 Schematic Model of Salinization

Farm ponds are not lined in most cases for preventing seepage from the bottom of the ponds. Seepage is considered to be one of the causes of salinity of the flat lowland as mentioned above. According to information of RID Provincial Office in Mahasarakham, seepage will gradually decrease due to sediment closure on the bottom. It is difficult to find cheap materials or measures for seepage prevention so the only choice may be to wait for natural closure by sediment. This matter is described in detail based on observation in Chapter 3 in Appendix B. Moreover, if farm ponds are connected with contour ditches for catching runoff effectively, farm ponds will work not only for trapping sediments but also for accelerating closure of seepage.

CHAPTER 3. PRESENT CONDITION AND VILLAGERS' DEMAND ON INFRASTRUCTURE

3.1 Introduction

This chapter grasps the present condition of infrastructure and villagers demand on it. Present condition is grasped mainly based on Kor Chor Chor 2 Khor 2537, and villagers demand based on sample survey in the study area. Sample interview survey regarding to infrastructure was carried out in the selected 44 villages in the study LRAs in June 1997 in order to know present development condition of infrastructure and villagers' mind on it. The interview was carried out to the village leaders in the selected villages. The detail results are presented in Table 3-3 to 3-4. Questionnaire form is presented in Table 3-5 and 3-6.

3.2 Diffusion Ratio of Commodities

Diffusion ratio of major commodities were surveyed, and results are shown in Table 3-3. The results are as follows;

1) Television: Diffusion is estimated at 85% in the areas.
2) Refrigerator: Diffusion is estimated at 43% in the areas.
3) Air conditioner: Almost no air conditioners are diffused yet.
4) Bike: Diffusion is estimated at 72% in the areas.
5) Pickup truck: Diffusion is estimated at 6% in the areas.
6) Sedan: Diffusion is estimated only at 0.2% in the areas.
7) Tiller: Diffusion is estimated at 49% in the areas. It means that almost half households have a tiller.
8) Gas: 15% of households are using gas for cooking. Utilization is high in Khon Kaen at 28% and low in Mukudahan only at 7%.

3.3 Natural Problems

Most villages, 93%, are suffering from drought in the areas. Soil erosion follows drought, and it occurs at about 30% of villages. Soil erosion is especially high in Khon Kaen and Mahasarakham at about 50% of villages. Salinity problems are not so high at about 12% of villages but little high in Khon Kaen and Mahasarakham. Floods and storms are not so severe but little severe in Sakon Nakhon and Mukudahan. (see Table 3-3)

3.4 Public Infrastructure

3.4.1 Electrification

All selected villages were already electrified. Out of 44 selected villages, three villages were reported as not electrified in 1994 by Kor Chor Chor 2 khor 2537. Those villages were however already electrified by the recent electrification program. On the other hand, coverage ratio of electrification is 93% of total households. (see Table 3-3.)

3.4.2 Public Telephone System

Although public telephone system is now rapidly expanding in the study areas, present diffusion is 30% of selected villages. It reaches 67% in Sakon Nakhon and 38% in Mukudahan, while 10% in Mahasarakham and 18% in Khon Kaen. (see Table 3-3.)

3.4.3 Public Transportation

Most villages have a public transportation to nearby towns and villages. It is generally operated privately by pickup trucks which are remodeled for passengers. It is usually operated under regular time schedule and utilized for commute to school and works. (see Table 3-3.)

3.4.4 Village Waterworks

1) Present Condition and Diffusion Ratio of Village Waterworks

The rural water supply works, especially village water supply works, are now rapidly carried out in the study LRAs. According to the information of Kor Chor Chor 2 Khor 2537, diffusion ratio of the village water supply works in the study LRAs has reached 79% that is higher than the target of 8th National Development Plan of 70%. The diffusion ratio in Khon Kaen and Mukudahan is already extremely high over 90%, while it is little less than 70% in Mahasarakham and Sakon Nakhon.

Table 3.1 Diffusion Ratio of the Village Water Supply Works in the Study LRAs

Province	Total Number of Villages	Villages not diffused	Diffusion Ratio
Khon Kaen	123	5	96%
Mahasarakham	163	58	64%
Mukudahan	108	6	94%
Sakon Nakhon	92	33	64%
Total	486	102	79%

(Note) Detail diffusion ratio of each LRA is presented in Table 3-2.

However, village water supply works are mostly utilized only for domestic purposes due to unfavorable water quality especially on taste. Villagers prefer to drink rainwater stocked in a rainjar than supply water of waterworks so that rainwater will be remained and utilized for drinking purpose even after equipped with a village water supply system. Serious hygienic problems are not reported on rainwater in the interview conducted in the study LRAs.

Main water source of the village water supply works is groundwater or pond water. Water is treated and pumped up to the elevated tank for distribution to each household through the distribution pipes. According to the sample survey in 44 villages, subscription ratio of village water supply works was about 70% in average. Some households, such as far from village or having own shallow well, have not membership of the water works in some cases.

Table 3-2 Village Water Works and Diffusion Ratio in Each LRA

Study Area	Total Village	Provided	Not Provided	Propagation(%)	Average(%)
KK-1	37	33	4	89.189	
KK-2	11	11	0	100.000	
KK-3	21	21	0	100.000	
KK-4	8	8	0	100.000	
KK-5	9	9	0	100.000	
KK-6	37	36	1	97.297	
KK-Total	123	118	5		95.9
MHS-1	3	3	0	100.000	
MHS-2	19	16	3	84.211	
MHS-3	9	6	3	66.667	
MHS-4	9	9	0	100.000	
MHS-5	13	9	4	69.231	
MHS-6	18	13	5	72.222	
MHS-7	8	5	3	62.500	
MHS-8	64	26	38	40.625	
MHS-9	3	2	1	66.667	
MHS-10	17	16	1	94.118	
MHS-Total	163	105	58		64.4
MKD-1	19	19	0	100.000	
MKD-2	11	11	0	100.000	
MKD-3	9	9	0	100.000	
MKD-4	2	2	0	100.000	
MKD-5	10	9	1	90.000	
MKD-6	0	0	0	-	
MKD-7	8	7	1	87.500	
MKD-8-1	7	7	0	100.000	
MKD-8-2	5	5	0	100.000	
MKD-8-3	4	3	1	75.000	
MKD-8-4	3	3	0	100.000	
MKD-9-1	2	2	0	100.000	
MKD-9-2	9	9	0	100.000	
MKD-10	2	2	0	100.000	
MKD-11	14	11	3	78.571	
MKD-12	3	3	0	100.000	
MKD-Total	108	102	6		94.4
SKN-1	2	2	0	100.000	
SKN-2	12	7	5	58.333	
SKN-3-1	22	16	6	72.727	
SKN-3-2	1	1	0	100.000	
SKN-3-3	6	4	2	66.667	
SKN-4	17	9	8	52.941	
SKN-5-1	2	1	1	50.000	
SKN-5-2	22	14	8	63.636	
SKN-6-1	5	5	0	100.000	
SKN-6-2	1	0	1	0.000	
SKN-7	2	0	2	0.000	
SKN-Total	92	59	33		64.1
Grand Total	486	384	102		79.0

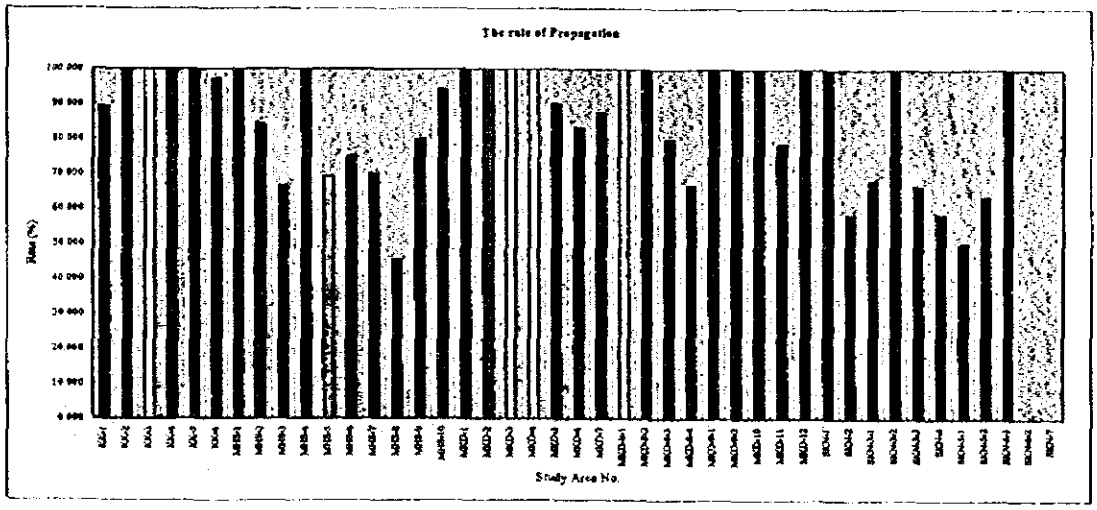


Figure 3-1 Diffusion Ratio of the Village Water Supply Works

2) Result of Sample Survey on Village Waterworks

Village waterworks cover 91% of selected villages while coverage ratio remains at 78%. Coverage ratio is quite high in Khon Kaen and Mahasarakham as 89% and 98% respectively, but low in Mukudahan and Sakon Nakhon as 66% and 57%. (see Table 3-3.)

3.4.5 Primary School

Almost villages, about 80%, have a primary school in the village in 44 sample villages. Even no primary school in the village, it exists in nearby village. Average distance to the school is only 250 m in the areas. Maximum distance is observed in Mahasarakham to be 1.5 km that is still walking distance for a student. (see Table 3-3.)

3.4.6 Health Centers

1) Present Condition of Health Center by Kor Chor Chor 2 Khor 2537

Figure 3-2 shows the number of villages covered by one health center by the information of DOH. On the other hand, Figure 3-3 shows the Kor Chor Chor 2 Khor's evaluation of the public health services. From both figures, evaluation of the Kor Chor Chor is closely related to the number of villages which is covered by one health center.

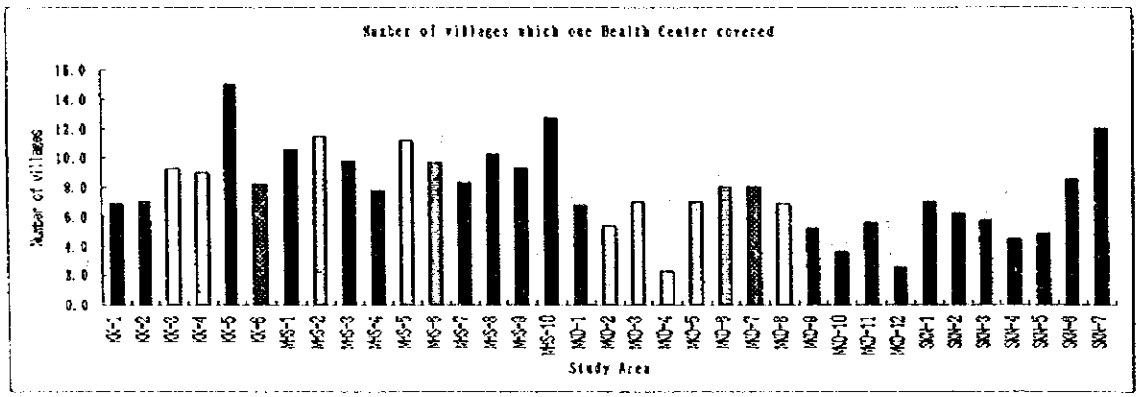


Figure 3-2 Number of Villages covered by One Health Center

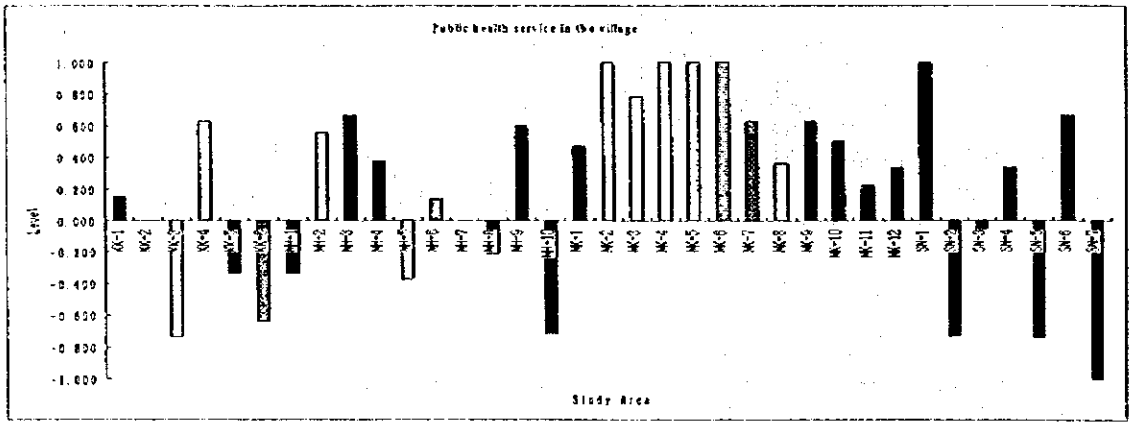


Figure 3-3 Evaluation of Public Health Service (Kor Chor Chor 2 Khor 2537)

From above figures, following five LRAs have been selected as the area where high

high quality of services are available on health care. In the selected areas, average number of villages cared by one health center was about 6 villages.

Selected LRAs where high quality services are available	Average Number of Villages cared by one health center
MKD-2	5.3
MKD-4	2.3
MKD-5	7.0
MKD-6	8.0
SKN-1	7.0
Average	5.92

On the other hand , the number of villages per one health center was 12 villages in SKN-7, where health service was evaluated as the lowest level.

2) Results of Sample Survey on Health Center

It is observed that only 30% of villages have a health center in the village. There is no health centers in selected villages in Mahasarakham. Average distance to the health center is 2.7 km in the areas, while it is far in Khon Kaen and Mahasarakham as to be 3.8 km and 3.5 km respectively.

3.4.7 Public Ponds

Many villages, 63%, have own public ponds in the village. However well operated ponds are only 54% mainly due to lack of water in the ponds.

3.5 Priority Infrastructure Development

Priority development regarding to infrastructure has been asked to the village leaders. Most leaders, 84%, put a priority on agricultural water development. It is followed by developments of on-farm roads, village link roads and link roads to the main road, that are 58%, 49% and 47% respectively.

Health center development is requested by 37% of village leaders in the areas. This request is especially high in Khon Kaen and Mahasarakham as to be 55% and 50% respectively. It is considered that it relates to the scarce existence of health centers in said two provinces.

Soil improvement and conservation are also high as 23% and 14%. Soil improvement is especially high as 55% in Khon Kaen.

Priority of village water works is very high only in none facilitated villages. On the other hand, improvement of electricity is also high as 19%. It means that reliability of electricity is not satisfied in many villages.

3.6 Sanitary and Health Affairs

3.6.1 Sanitary Affairs

Most households, 97%, have own toilets in their houses. Those toilets are emptied by evacuation service truck with a charge of 170 Baht per one service in average.

3.6.2 Health Service Affairs

1) Distance to the Nearest Health Centers

As mentioned above, average distance to the nearest health center and hospital is 3.8 km in the areas. However, it is little longer as 4.1 km for the villages which are not facilitated with a health center. From this fact, mast villages are accessible to the health centers or hospitals within 4 km from their villages.

2) Service Quality of Health Centers

(1)Preventive Hygiene

Preventive hygiene is satisfactorily carried out in the areas except few villages in Khon Kaen.

(2)Health Care Check

Health care check is also satisfactorily carried out but little lower than preventive hygiene.

(3)Medicine in Health Centers

Medicine is not enough in many centers about 44% of centers. More doctors and medicine are requested in Sakon Nakhon and Mukudahan.

(4)Medicine in the Villages and Households

Preparation of medicine is low in the villages and households. It is prepared only in 35% of villages and 19% of households.

Table 3-3 Diffusion Ratio of Major Commodity, Natural Problems, Public Infrastructure and Development Priority by Interviews

Administrative Location / 1997 June

Province	LRAs	Village No	Amphoe	Tambon	Muban No.	Village	Households	Population
KK	1	9	Chon nabot	Non Phayom	5	Nongtao	116	576
KK	1	10	Chon nabot	Non Phayom	6	Non Phayom	180	840
KK	2	47	Muang	Sawathi	14	Lad Na Piang	206	957
KK	3	54	Man Cha Kin	Na Ngam	10	Jang Tub Ma	73	-
KK	4	71	Ban Fang	Pa Manao	4	Hin Khong	138	654
KK	5	82	Nam Pong	Ban Kham	8	Lao Yai	103	544
KK	5	83	Nam Pong	Ban Kham	11	Sam Rong	164	1,000
KK	5	85	Nam Pong	Ban Kham	13	Lao Yai	109	564
KK	6	89	Ban Phai	Ban Han	8	Nong Nam Khun N	169	1,082
KK	6	95	Ban Phai	Pa Por	2	Pa Por	150	819
KK	6	101	Chon nabot	Por Daeng	5	Marp Ta Kla	130	411
MHS	1	1	Chieng Yun	Lao Dorkmai	1	Na Kham Noi	75	360
MHS	2	13	Kosum Phisai	Wang Yao	3	Hin Hae	130	900
MHS	3	20	Muang	Nong Pling	3	Nong Khu	175	1,200
MHS	3	31	Muang	Nong Pling	8	Sivilai	96	661
MHS	4	32	Muang	Ta Song Khon	5	Nong Ngua Noi	46	200
MHS	5	41	Borabu	Non Daeng	8	Sala	172	650
MHS	6	50	Na Chuk	Nong Ruea	9	Khok Lam	76	700
MHS	7	76	Borabu	Bo Yai	6	Dong Keng	215	1,150
MHS	8	139	K.A. Kut Rang	Huai Toei	10	Sun Rong	103	442
MHS	10	157	Chieng Yun	Chieng Yun	12	Non Hin Hae	102	505
MKD	1	3	Muang	Na Sok	1	Na Sok	118	1,223
MKD	2	21	Muang	Dong Yen	5	Khok Ta Bang	180	900
MKD	2	25	Dontan	Lao Mi	5	Na Yo	67	500
MKD	3	29	Ni Khom Khum Soi	Na Udom	5	Khum Lai	200	1,000
MKD	3	35	Ni Khom Khum Soi	Na Udom	10	Na Charoen	118	648
MKD	4	41	Don Tan	Parai	3	Ban Nong Mek	185	972
MKD	5	46	Nong Soong	Nong Soong Tai	1	Ban Loop Ping	96	502
MKD	6	48	Nong Soong	Nong Soong Tai	3	Ban Wang	128	689
MKD	7	58	Nong Soong	Non Yang	5	Khum Phok	195	735
MKD	8.3	64	Dong Luang	Nong Can	3	Phon Hai	80	300
MKD	8.2	67	Dong Luang	Phang Daeng	3	Tiu	118	710
MKD	8.1	72	Dong Luang	Khok Toom	7	Kaeng Nang	500	3,000
MKD	8.1	74	Dong Luang	Khok Toom	9	Park Chong	187	600
MKD	9.2	83	Muang	Kham Pa Lai	7	Ban Pa Wai	106	587
MKD	10	90	Dong Luang	Cha Nod Noi	1	Ban Cha Nod Noi	156	958
MKD	11.1	92	Dong Luang	Nong Bua	1	Ban Nong Bua	178	700
SKN	1	2	Ban Muang	Dong Mo Thong Tai	6	Dong Mo Thong	238	2,500
SKN	2	10	Chareon Sin	Nong Fang	3	Kham Chareon	78	360
SKN	3.1	15	Kut Bak	Kut Bak	1	Kut Bak	471	2,131
SKN	4	55	Kut Bak	Na Mong	5	Phon Ngam	430	2,066
SKN	6.1	86	Wanich Phum	Kham Bo	3	Ban Phu Wong	447	1,220
SKN	7	92	Kham Takla	Pan	6	Ban Fang	40	213
Khon Kaen			11				1,538	7,447
Mahasarakham			10				1,190	6,968
Mukdahan			16				2,613	14,024
Skon Nakhon			6				1,704	8,490
Total			43				7,045	36,929

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Village No	(0) Development level	(2) Electrification	(3) Transportation	(5) Wood fuel sources	(8) Income level	(10) Paddy yield	(11) Upland crop yield	(16) Dry season farming	(19) Household sanitation	(24) Potable water	(27) Agri. water	(32) School
9	2	1	1	1	1	-1	-1	-1	-1	1	-1	1
10	1	1	1	-1	1	-1		-1	0	0	-1	1
47	3	1	1	1	1	-1	-1	1	1	1	1	1
54	2	1	1	1	1	-1	1	-1	-1	-1	0	1
71	1	1	0	-1	0	-1		-1	1	0	-1	1
82	2	1	-1	-1	1	0	-1	-1	0	1	-1	0
83	2	1	1	1	-1	0	-1	0	0	-1	-1	1
85	1	-1	-1	1	1	-1	-1	-1	-1	-1	0	1
89	2	1	1	-1	1	-1	-1	-1	-1	0		0
95	1	-1	1	1	1	1	-1	-1	1	-1	-1	-1
101	1	1	1	1	1	-1	-1	-1	-1	-1	0	0
1	1	1	0	-1	1	-1	-1	-1	-1	1	1	0
13	3	1	0	1	1	0	-1	-1	1	0	0	1
20	2	1	1	1	1	-1	-1	-1	1	1	-1	1
31	2	1	0	1	1	-1	-1	0	1	-1	-1	1
32	3	1	0	1	1	0		-1	1	1	0	1
41	1	1	0	1	-1	-1	-1	-1	-1	1	-1	1
50	1	1	1	1	1	-1		-1	-1	-1	0	0
76	1	1	0		1	-1	-1	0	-1	-1	1	0
139	2	1	1	1	-1	-1		-1	0	1	-1	0
157												
3	3	1	1	-1	1	1	-1	-1	1	0	-1	1
21	2	1	0	-1	1	0	0	-1	-1	-1	-1	1
25	2	1	-1		1	-1	-1	-1	0	1	-1	1
29	2	1	0	-1	1	-1	-1	0	1	-1	1	1
35												
41	1	1	1	-1	1	-1	1	-1	-1	-1		0
46	2	1	0	-1	1	0	1	-1	-1	0	-1	1
48	3	1	1	1	1	1	1	-1	1	-1	-1	1
58	1	1	1	-1	1	0	-1	-1	-1	-1	-1	1
64	1	0	1	-1	-1		-1	-1	-1	-1	-1	-1
67	1	1	0	-1	1	-1	0	-1	-1	-1	-1	1
72	1	1	-1	-1	1		-1		-1	-1		0
74	1	1	0	-1	1				-1	-1	-1	1
83	1	1	0	-1	1	-1	-1	-1	-1	-1		1
90	2	1	1	-1	1	0	-1	-1	1	1	-1	0
92	2	1	1	-1	1	0	-1	-1	1	0	-1	1
2	1	1	1	-1	1	0	-1	-1	0	1	-1	1
10	1	1	0	1	-1	0	-1	-1	-1	0	-1	1
15												
55	2	1	-1	-1	-1	0		-1	-1	0	0	1
86	2	1	1	-1	0	0	-1	-1	0	0	-1	1
92	1	1	0	-1	-1	0	-1	0	-1	0	1	1
Ratio												
Khon Kaen	1.6	0.6	0.5	0.3	0.7	-0.6	-0.8	-0.7	-0.2	-0.2	-0.5	0.5
Mahasarakham	1.8	1.0	0.3	0.8	0.6	-0.8	-1.0	-0.8	0.0	0.2	-0.2	0.6
Mukdahan	1.7	0.9	0.3	-0.9	0.9	0.3	-0.4	-0.9	-0.3	-0.5	-0.8	0.7
Skon Nakhon	1.4	1.0	0.2	-0.6	-0.4	0.0	-1.0	-0.8	-0.6	0.2	-0.4	1.0
Total	1.7	0.9	0.4	-0.2	0.6	-0.5	-0.7	-0.8	-0.2	-0.2	-0.5	0.7

Diffusion Ratio (%) / Natural Problems

Village No	Television	Refrigerator	Air Conditioner	Bike	Pickup truck	Sedan	Tiller	Gas	Droughts	Floods	Storm	Hail	Fire from forest	Soil erosion	Saline soil	Sandy soil	Poor soil fertility	Insect disturb
9	80	40	0	100	5	0	65	20	Y	-	-	-	-	-	-	-	Y	-
10	90	50	0	80	30	0	50	60	Y	-	-	-	-	-	Y	-	Y	-
47	100	99	0	99	5	0	3	25	Y	-	-	Y	-	-	-	-	-	-
54	90	25	0	80	6	0	95	10	Y	-	-	-	-	-	Y	-	-	-
71	80	50	0	90	5	0	15	5	Y	-	Y	-	-	Y	-	-	-	-
82	80	50	0	30	10	0	90	30	Y	-	-	-	-	Y	-	-	-	-
83	100	70	0	100	10	0	80	20	Y	-	-	-	-	Y	-	-	-	-
85	90	60	0	50	3	0	3	20	Y	-	-	-	-	Y	Y	Y	-	-
89	40	10	0	15	1.8	0	20	30	Y	-	-	-	-	Y	-	Y	-	-
95	100	90	0	50	10	0.2	70	80	Y	-	-	-	-	Y	-	-	-	-
101	100	80	0	80	10	0	60	5	Y	-	-	-	-	-	-	-	Y	-
1	100	30	0	100	2.7	0	100	5	Y	-	-	-	-	Y	Y	Y	-	-
13	100	70	0	80	23	0	40	40	Y	-	-	-	-	-	Y	-	-	-
20	100	30	0	90	5.7	0	11	2	Y	-	-	-	-	Y	-	-	-	-
31	100	40	0	90	5.2	0	11	0	Y	-	-	-	-	Y	-	-	-	-
32	100	10	0	20	4.3	2.1	10	5	Y	-	-	-	-	-	-	Y	Y	-
41	95	40	0	90	2.9	0	40	10	Y	-	-	-	-	-	-	-	-	-
50	100	30	0	80	9.2	0	26	5	Y	-	-	-	-	-	-	-	-	-
76	80	60	0	80	2	0	70	20	Y	-	-	-	-	-	Y	-	-	-
139	100	9	0	50	1	0	90	5	Y	-	-	Y	-	Y	-	-	-	-
157	80	30	0	70	3	0	30	20	Y	-	-	-	-	Y	-	-	Y	-
3	70	30	0	80	20	0.8	80	20	Y		-	-	-	-	-	-	-	-
21	90	70	0	80	1.7	0	60	1.7	Y	Y	-	-	-	-	-	-	-	-
25	80	50	0	90	7.5	0	50	15	Y	Y	-	-	-	-	-	-	Y	-
29	80	70	0	50	5	0	30	5	Y	-	-	-	-	-	-	-	-	-
35	95	40	0	30	2.5	0.8	70	15	Y	-	-	-	-	-	-	-	-	-
41	50	25	0	40	1.6	0	25	3	Y	-	-	-	-	-	-	Y	Y	-
46	90	60	0	80	4.2	1	80	10	Y	-	-	-	-	-	-	-	-	-
48	90	60	0	100	20	0	60	20	Y	-	Y	-	-	-	-	-	-	-
58	90	80	0	100	1	0	70	10	Y	-	Y	-	-	-	-	-	-	-
64	80	30	0	50	0	0	25	0	Y	-	Y	-	-	Y	-	-	Y	-
67	20	1.7	0	6.8	0.8	0	7.6	1.7	Y	-	-	-	-	-	-	-	-	-
72	99	50	0	99	5	0.5	100	2	Y	-	-	-	-	-	-	-	-	-
74	30	20	0	90	1.6	0	30	0	Y	-	-	-	-	-	-	-	-	-
83	51	20	0	70	5.7	0	35	0	-	-	-	-	-	-	-	-	-	Y
90	70	50	0	70	5.1	0	60	5	Y	-	Y	-	-	-	-	-	-	-
92	80	50	0	90	5.6	0	60	10	Y	Y	Y	Y	-	-	-	-	-	-
2	100	50	0	100	2.9	0	80	30	Y	Y	-	-	-	-	-	-	-	-
10	50	10	0	10	3.8	0	30	15	Y	-	-	-	-	-	-	-	-	-
15	100	30	0	95	2.1	0.6	80	40	Y	Y	-	-	-	-	-	-	-	-
55	100	20	0	80	10	0	25	5	-	-	-	-	-	Y	-	-	-	-
86	80	60	0		6.7	0.2	40	5	-	-	-	-	Y	-	-	-	-	-
92	100	20	0	90	0	0	13	0	Y	Y	-	-	-	-	-	-	-	-
Number of villages which have problems																		
Khon Kaen									11	0	1	1	0	6	3	2	3	0
Mahasarakham									10	0	0	1	0	5	3	2	2	0
Mukdahan									15	3	5	1	0	1	0	1	3	1
Skon Nakhon									4	3	0	0	1	1	0	0	0	0
Total									40	6	6	3	1	13	6	5	8	1
Diffusion Ratio (%) / Ratio of villages which have problems																		
Khon Kaen	86	57	0	70	8.7	0.1	50	28	100%	0%	9%	9%	0%	55%	27%	18%	27%	0%
Mahasarakham	96	35	0	75	6.4	0.2	43	11	100%	0%	0%	10%	0%	50%	30%	20%	20%	0%
Mukdahan	75	44	0	70	5.5	0.2	53	7.4	94%	19%	31%	6%	0%	6%	0%	6%	19%	6%
Skon Nakhon	88	32	0	75	4.3	0.1	45	16	67%	50%	0%	0%	17%	17%	0%	0%	0%	0%
Total	85	43	0	72	6.3	0.2	49	15	93%	14%	14%	7%	2%	30%	14%	12%	19%	2%

Public Infrastructure

Village No	Electrification (%)	Public Telephone	Public Transportation	Village Waterworks (%)	Primary School (km)	Health Center (km)	Ponds: Public Ponds	Ponds: Well working (Yes or No)
9	100	N	Y	100	0	6	1	Y
10	100	Y	Y	100	0	0	2	Y
47	100	N	Y	80	0	4	0	-
54	100	N	Y	100	0	6	0	-
71	100	N	Y	100	0	8	4	Y
82	100	N	-	100	0	0	0	-
83	100	N	-	100	0	4	1	N
85	100	N	-	100	0	0	0	-
89	80	N	Y	100	0	8	1	Y
95	95	Y	Y	0	0	0	1	N
101	100	N	Y	100	0	6	2	Y
1	100	N	Y	100	0	6	0	-
13	100	N	Y	100	0	2	2	Y
20	100	N	Y	100	1.5	2	0	-
31	100	N	Y	100	1.5	2	0	-
32	100	N	N	100	1.5	8	0	-
41	100	N	Y	80	0	2	2	N
50	80	N	Y	100	1	4	3	Y
76	90	Y	Y	100	0	3	1	N
139	100	N	Y	100	1	0.5	2	Y
157	100	N	N	100	1	5	1	N
3	100	Y	Y	UC	0	0	1	N
21	100	Y	Y	70	0	5	1	Y
25	100	N	Y	80	0	4	2	Y
29	70	Y	Y	0	0	4	3	Y
35	98	Y	N	100	0	0	1	N
41	98	N	Y	98	0	0	1	N
46	100	Y	Y	100	0	3	3	Y
48	100	N	Y	90	0	4	0	-
58	100	N	Y	100	0	0	1	N
64	70	N	Y	20	0	2	0	-
67	90	N	Y	100	0	3	0	-
72	100	N	Y	20	0	0	1	N
74	80	N	Y	50	0	3	0	-
83	100	N	Y	50	0	2	0	-
90	100	N	Y	80	0	0	0	-
92	100	Y	Y	30	0.7	1	2	Y
2	100	Y	Y	100	0	0	1	Y
10	85	N	Y	60	0.5	5	4	N
15	100	Y	Y	40	0	0	1	Y
55	70	Y	Y	70	0	0	0	-
86	100	Y	Y	70	0	1	2	N
92	100	N	N	0	2	4	3	N
Number of villages which are facilitated								
Khon Kaen	11	2	8	10	11	4	7	5
Mahasarakham	10	1	8	10	4	0	6	3
Mukdahan	16	6	15	14	15	6	10	5
Skon Nakhon	6	4	5	5	4	3	5	2
Total	43	13	36	39	34	13	28	15
Ratio of villages which are facilitated								
Khon Kaen	100%	18%	73%	91%	100%	36%	64%	71%
Mahasarakham	100%	10%	80%	100%	40%	0%	60%	50%
Mukdahan	100%	38%	94%	88%	94%	38%	63%	50%
Skon Nakhon	100%	67%	83%	83%	67%	50%	83%	40%
Total	100%	30%	84%	91%	79%	30%	65%	54%
Coverage Ratio or Average Distance or Number								
Khon Kaen	98%			89%	0	3.8	1.09	
Mahasarakham	97%			98%	0.75	3.5	1.1	
Mukdahan	94%			66%	0.04	1.9	1	
Skon Nakhon	93%			57%	0.42	1.7	1.83	
Total	95%			78%	0.25	2.7	1.16	

Priority Infrastructure Development

Village No	Water: Agricultural water	Water: Drinking water	Water: Village waterworks	Roads: To Main Roads	Roads: To adjacent villages	Roads: Farm roads	Soil: Improvement	Soil: Conservation	Public Facility: Primary school	Public Facility: High school	Public Facility: Health center	Public Facility: Culture center	Flood protection	Electricity	Telephone	Community forest
9	1	-	-	1	1	-	1	-	-	-	1	-	-	-	-	-
10	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
47	2	-	-	-	-	1	4	-	-	-	-	-	-	3	3	-
54	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
71	1	-	-	2	2	2	3	3	-	-	4	-	-	-	-	-
82	1	-	-	2	2	2	-	-	-	2	2	-	-	2	2	2
83	-	-	-	-	-	-	-	-	-	2	1	-	-	-	2	-
85	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
89	2	-	-	1	1	3	3	-	3	-	3	-	-	3	-	-
95	2	-	1	3	3	3	3	3	-	-	-	-	-	-	-	-
101	1	-	-	1	1	-	1	-	-	-	1	-	-	-	-	-
1	1	-	-	2	2	2	-	-	-	-	3	-	-	-	-	-
13	2	-	-	1	1	2	-	-	-	-	-	-	-	-	-	-
20	2	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
31	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	1	-	2	-	-	-	-	-	3	-	3	-	-	-	-	-
41	1	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	1	1	-	-	-	-	-	1	-	-	-	-	-
76	2	-	-	-	-	-	-	-	-	-	1	-	-	3	-	-
139	2	-	-	1	1	2	-	-	-	-	2	-	-	-	-	-
157	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
3	-	-	-	1	1	1	-	-	-	-	3	-	-	2	-	-
21	2	-	-	3	3	3	-	-	-	-	1	-	-	4	-	-
25	1	2	-	3	3	3	-	-	-	-	4	-	-	-	-	-
29	1	-	1	2	2	-	-	-	-	-	-	-	-	-	-	-
35	1	-	-	2	2	2	-	-	-	-	-	-	-	3	-	-
41	1	-	1	2	2	2	-	-	-	-	-	-	-	-	-	-
46	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
48	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
58	1	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-
64	2	1	-	1	3	3	-	5	-	-	-	-	-	-	-	-
67	1	-	-	-	-	2	-	-	3	-	-	-	-	-	-	-
72	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74	1	2	-	-	-	3	5	-	-	-	6	-	-	4	-	-
83	-	-	-	2	2	2	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-
92	4	-	-	3	3	2	5	-	-	-	-	1	-	-	-	-
2	1	2	-	-	-	2	-	-	-	-	-	-	2	-	-	-
10	1	-	1	3	3	3	-	-	-	-	2	-	-	-	-	-
15	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
86	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
92	1	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-
Numbers > 1																
Khon Kaen	9	0	1	5	5	5	6	2	1	2	6	0	0	3	3	1
Mahasarakham	9	0	1	5	5	4	1	1	1	0	5	0	0	1	0	0
Mukdahan	12	3	2	9	10	14	3	1	1	0	4	1	0	4	0	0
Skon Nakhon	6	1	3	1	1	2	0	2	0	0	1	0	1	0	0	0
Total	36	4	7	20	21	25	10	6	3	2	16	1	1	8	3	1
Ratio																
Khon Kaen	82%	0%	9%	45%	45%	45%	55%	18%	9%	18%	55%	0%	0%	27%	27%	9%
Mahasarakham	90%	0%	10%	50%	50%	40%	10%	10%	10%	0%	50%	0%	0%	10%	0%	0%
Mukdahan	75%	19%	13%	56%	63%	88%	19%	6%	6%	0%	25%	6%	0%	25%	0%	0%
Skon Nakhon	100%	17%	50%	17%	17%	33%	0%	33%	0%	0%	17%	0%	17%	0%	0%	0%
Total	84%	9%	16%	47%	49%	58%	23%	14%	7%	5%	37%	2%	2%	19%	7%	2%
Average order of Development Priority																
Khon Kaen	1.3		1.0	1.7	1.7	2.2	2.4	3.0	3.0	2.0	2.0			2.7	2.3	2.0
Mahasarakham	1.6		2.0	1.4	1.4	1.8	1.0	1.0	3.0		2.0			3.0		
Mukdahan	1.5	1.7	1.0	2.4	2.4	2.0	4.0	5.0	3.0		3.5	1.0		3.3		
Skon Nakhon	1.0	2.0	1.0	3.0	3.0	2.5		2.0			2.0		2.0			
Total	1.4	1.8	1.1	2.0	2.0	2.0	2.7	2.7	3.0	2.0	2.4	1.0	2.0	3.0	2.3	2.0

(Note) Above results were obtained by the interview to the village leaders in the Study LRAs in June 1997.

Table 3-4 Present Condition of Health and Sanitary Affairs by Interview

Study LRAs			Administrative Location				Households Population		Sanitation		Health Affairs									
											Hospital and Health Center			Service / Requests						
Province	LRA	Village No.	Amphoe	Tambon	Moban No	Village	Households	Population	Diffusion Ratio of Toilet (%)	Evacuation (Baht)	Existence in village	Nearest Center	Distance (km)	Preventive Hygiene	Health Care Check	Medicine in Center	Medicine in Village	Medicine in Household	Insurance(%)	Requests
KK	1	9	Chon-nabot	Non Phayom	5	Nongtan	116	576	100	-	N	Non Phayon	6.0	Y	Y	Y	N	N	70	-
KK	1	10	Chon-nabot	Non Phayom	6	Non Phayom	180	840	100	-	Y	-	-	Y	Y	Y	Y	N	40	More Budget
KK	2	47	Muang	Sawathi	14	Lad Na Phang	206	937	100	-	N		4.0	Y	Y		N	Y		-
KK	3	54	Man Cha Kin	Na Ngam	10	Jang Tub Ma	73	-	100	-	N	Na Negum	6.0	Y	Y	Y	Y	N	30	
KK	4	71	Ban Fang	Pa Manao	4	Hin Khong	138	654	100	-	N		8.0	Y	Y	Y	N	N	35	
KK	5	82	Nam Pong	Ban Kham	8	Lao Yai	103	544	100	-	Y	-	-	N	N	Y	N	N	30	Good Doctor
KK	5	83	Nam Pong	Ban Kham	11	Sam Rong	164	1,000	100	50	Y		-	Y	Y	N	N	Y	100	Enough Equipment
KK	5	85	Nam Pong	Ban Kham	13	Lao Yai	109	564	100	-	Y	-	-	N	N	Y	N	N	30	Good Doctor
KK	6	88	Ban Phai	Ban Han	8	Nong Nam Khun Nua	169	1,082	100	-	N	Ban Han	8.0	-	-	-	-	-	-	-
KK	6	95	Ban Phai	Pa Por	2	Pa Por	150	819	100	-	Y	-	-	Y	Y	Y	N	N	50	
KK	6	101	Chon-nabot	Por Daeng	5	Marp Ta Kla	130	411	100	-	N	Por Daeng	7.0	Y	Y	Y	N	N	80	Good Doctor
MHS	1	1	Chueng Yun	Lao Dorkmai	1	Na Kham Noi	75	360	100	-	N	Krabank	6.0	Y	Y	Y	N	N	100	More big one
MHS	2	13	Kosum Phisai	Wang Yao	3	Hin Hae	130	900	100	-	N		8.0	Y	Y	N	N	N	50	Doctor not enough
MHS	3	30	Muang	Nong Phing	3	Nong Khu	175	1,200	100	-	N		2.0	Y	Y	Y	Y	Y	90	
MHS	3	31	Muang	Nong Phing	8	Sivilai	96	661	96	-	N		2.0	Y	Y	Y	Y	Y	90	
MHS	4	32	Muang	Ta Song Khon	5	Nong Ngua Noi	46	200	100	-	N		8.0	Y	Y	N	N	N	20	
MHS	5	41	Borabu	Non Daeng	8	Sala	172	850	100	-	N		2.0	Y	Y	N	Y	Y	50	
MHS	6	50	Na Chuk	Nong Rua	9	Khok Lam	76	700	80	-	N		4.0	Y	Y	N	Y	N	30	
MHS	7	76	Borabu	Bo Yai	6	Dong Kong	215	1,150	100	-	N	Ban Pua	3.0	Y	Y	Y	N	N	70	
MHS	8	139	K.A. Kut Rang	Hua Toei	10	Sam Rong	103	442	100	-	N		1.5	Y	Y	Y	Y	Y	100	Doctor & Equipment
MHS	10	157	Chueng Yun	Chueng Yun	12	Non Hui Hae	102	505	100	-	N	Chueng Yun	5.0	Y	Y	Y	N	N	30	
MKD	1	3	Muang	Na Sok	1	Na Sok	118	1,223	100	200	Y	-	-	Y	Y	N	Y	Y	50	
MKD	2	21	Muang	Dong Yen	5	Khok Ta Bang	180	900	100	100	N	Don Yen	5.0	Y	Y	N	Y	Y	50	Medicine & Equipment
MKD	2	25	Dontan	Lao Mi	5	Na Yo	67	500	100	75	N	Lao Mi	4.0	Y	Y	N	N	N	10	
MKD	3	29	Ni Khom Khum Soi	Na Udom	5	Khum Lau	200	1,000	100	-	N	Phu Phang Ma	4.0	Y	Y	Y	N	N	50	Expensive
MKD	3	35	Ni Khom Khum Soi	Na Udom	10	Na Charuan	118	648	100	-	N	Na Udom	0.1	Y	Y	Y	N	N	50	
MKD	4	41	Don Tan	Parai	3	Ban Nong Mek	186	972	100	-	Y	-	-	Y	Y	N	N	N	2	More Officer
MKD	5	46	Nong Soong	Nong Soong Tai	1	Ban Loop Ping	96	502	100	-	N		3.0	Y	N	N	N	N		Medicine
MKD	6	48	Nong Soong	Nong Soong Tai	3	Ban Wang	128	689	100	-	N		4.0	Y	N	N	N	N		Medicine
MKD	7	58	Nong Soong	Noa Yang	5	Khum Phok	195	735	100	-	Y	-	-	Y	Y	Y				
MKD	8.3	64	Dong Luang	Nong Can	3	Phon Hai	80	300	70	-	N	Ban Nong Can	2.0	Y	Y	Y	Y	N	60	
MKD	8.2	67	Dong Luang	Phang Daeng	2	Tu	118	710	40	-	N	Phang Daeng	3.0	Y	Y	Y	N	N	0	
MKD	6.1	72	Dong Luang	Khok Toom	7	Kaeng Nang	500	3,000	100	-	Y	-	-	Y	Y	Y	N	N	5	
MKD	8.1	74	Dong Luang	Khok Toom	9	Park Chong	187	600	100	-	N		3.0	Y	Y	N	N	N	80	
MKD	9.2	83	Muang	Kham Pa Lai	7	Ban Pa Wai	106	587	100	210	N		2.0	Y	Y	N	Y		10	
MKD	10	90	Dong Luang	Cha Nod Noi	1	Ban Cha Nod Noi	156	958	100	-	Y	-	-	Y	Y	Y				
MKD	11.1	97	Dong Luang	Nong Bua	1	Ban Nong Bua	178	700	100	300	N		1.0	Y	Y	N	Y	N	20	Doctor & Medicine
SKN	1	2	Ban Muang	Dong Mo Thong Tai	6	Dong Mo Thong	238	2,500	100	150	Y	under Construction							30	
SKN	2	10	Charoen Silp	Nong Pang	3	Kham Charoen	78	360	90	-	N		5.0	Y	Y	Y	Y	N	15	
SKN	3.1	15	Kut Bak	Kut Bak	1	Kut Bak	471	2,131	100	-	Y	-	-	Y	Y	Y	Y	N	60	More Doctor
SKN	4	55	Kut Bak	Na Mong	5	Phon Ngam	430	2,066	100	-	Y	-	-	Y	Y	Y	N	N	50	Doctor & Medicine
SKN	6.1	86	Wanch Phum	Kham Bo	3	Ban Phu Wong	447	1,220	100	-	N		1.0	Y	Y	N	Y	N	40	
SKN	7	92	Kham Takla	Pan	6	Ban Fang	40	213	100	300	N	Tambon Pan Hospital	4.0	Y	Y	N	N	N		Center in village
														Ratio of Yes						
Khon Kaen			11				1,538	7,447	100		45%		6.5	73%	73%	73%	18%	18%	54%	
Mahasarakham			10				1,190	6,968	98		0%		4.2	100%	100%	60%	50%	40%	63%	
Mukudahan			16				2,613	14,024	94		31%		2.8	100%	88%	44%	31%	13%	52%	
Sakon Nakhon			6				1,704	8,440	98		50%		3.3	83%	83%	50%	50%	0%	39%	
Total			43				7,045	36,929	97	173	30%		4.1	91%	86%	56%	35%	19%	47%	

(Note) Above results were obtained by the interview to the village leaders in the Study LRAs in June 1997.

Tale 3-5 Questionnaire on Generals and Infrastructures

Name of Village

Vil.no	Province	Amphoe	Tambon	Mo-no	Moban

1. Population and Households

	K-C-C 2438 (1995)	Leader (June 1997)
Households		
Population		

2. Generals

	K-C-C 2438 (1995)	Leader (June 1997)
General Infrastructures	(2):	- Electricity: yes, no (_____years since electrified, ____% of households)
		- Telephone: Public: yes, no Private: yes, no____phones
	(3):	- Transportation: _____ hours by car to Amphoe town.
		- Public Transportation (Bus): yes, no
		if yes, to where / Baht / times/day / hours: Amphoe; ; ;
	(24):	- Piped water supply system: yes, no
		if yes, ____% of households, ___years since established by _____)
		- Main water source of drinking water (rainjar, pipe water, well, _____)
	(19):	- Toilet: ____% of households having toilet. (____B/dip or ____B/m)
	(32):	- Primary school in village: yes, no (if no, distance to the nearest_____km)
		- Nearest secondary school: (in village, or _____ km from village)
		- Nearest hospital: (in village, or _____ km from village)
	Dry S. farm (16): Agri. water (27):	- Irrigation Facilities (not individual farm pond): yes, no
		if yes, _____rai irrigated for rice and dry season crop (_____)by
		MSIP : name:_____
		SSIP: name:_____ (reservoir, weir, pump by _____)
		Is it effectively used?: yes, no
		if no, due to (small capacity, poor maintenance, no outlet, no canal, heavy sediment, or seepage)
	Individual Farm Pond	- How many individual farm ponds are there in the village?
		approximately _____ponds, of which _____ % for integrated farming.
		Problems on farm pond
		☐no sufficient inflow(%) ☐ sediment(%) ☐ heavy seepage(%)
		☐heavy weeds (%), ☐too small for integrated farming,
		☐no sufficient labor force, ☐ too much labor for irrigation,
		☐no budget for integrated farming ☐no sufficient benefit ☐no market
Income level	(8):	Maximum: B_____/household/year
		Average : B_____/household/year
		Minimum: B_____/household/year
		Agricultural income (_____ %), None agricultural income (_____%)
		Percentage more than B30,000/household/year (____%)
Works in nearby major towns or cities (Daily work)		How many persons go to works to the near towns or cities every day?
		about_____ persons to (_____,_____,_____)
		Approximate necessary time to reach to the work town: ____hours by_____
		Do you think more persons able to go when roads are improved? yes, no
Migrant works		How many persons are now in far cities? (approximate_____ persons)
		Major working cities (Khon Kaen, _____,Bangkok)

Major Industries other than crops in the village		☐ particularly none ☐ silk weaving ☐ other household industry than silk weaving (_____) ☐ livestock ☐ milk marketing ☐ fisheries ☐ agro-product processing (milling, pickles, _____) ☐ agro-forestry (__rai, mushrooms, herbs, fuel wood, charcoal,_____) ☐ others (_____)
Energy	(5):	- existence of Community Forest: yes, no (if yes_____rai) - Energy consumption in the village: Fuel wood: _____% (B / kg) Charcoal: _____% (B / kg) Gas: _____% (B /50 kg)
Agriculture	Crop Yield rice(10): upland(11):	Major cash crops in the village: (plural answers acceptable) ☐:rice, ☐:cassava, ☐:sugarcane, ☐:vegetables, ☐:agro-forestry (eucalyptus, _____), ☐:others(_____) If rice is not a major cash crop, it is due to: ☐:mainly for home consumption, or ☐:only few cultivation due to problems on soil, water, topography, economical reasons or (_____).
Diffusion ratio		TV:_____%, Refrigerator_____%, Air conditioner_____%, Bike_____%, Pickup truck_____%, Sedan_____%, Tiller:_____%, Gas_____%
Natural Disaster		Are there any natural disasters in the village? (put order by 1, 2, 3, ...) ☐: Droughts ☐: Saline soil ☐: Soil fertility ☐: Floods ☐: Soil erosion ☐: Hail ☐: Others (_____)
Future Development		What is the priority of importance for future development for this village from an aspect of infrastructures? (by 1, 2, 3,..., duplicable like 1, 1, 2, 2, ...) ☐: agricultural water. ☐: drinking water. ☐: road improvement to the nearest main road. ☐: road improvement to the adjacent villages. ☐: farm road for cultivation. ☐: soil improvement on fertility ☐: soil protection from erosion ☐: flood protection ☐: electricity. ☐: gas. ☐: community forest for fuel preservation. ☐: primary school in the village. ☐: clinic nearby the village. ☐: others (_____)

3. Future Development Plan (Preliminary)>

		Do you think able to conduct the land consolidation for future development? :☐ yes ☐ no Do you think able to bare the land by land acquisition in your village for *Mother pond*: ☐yes ☐no Community pond: ☐yes ☐no Provision of new farm road: ☐yes ☐no Consolidation of individual farm pond: ☐yes ☐no

4. Social Infrastructures

<table>
<tr><th>Infrastructures</th><th>Questionnaire</th></tr>
<tr><td>4.1 Piped water system</td><td>If no piped water system;
<present water sources>
☐ Rainjars (_____% of households)
☐ Public wells (_____%)
☐ Private wells (_____%)
☐ Other sources (_____% _____)
<Piped water system was requested?>
☐ yes, ☐ no
- if no, why?_____
- if yes, when? _____ to what agency? _____</td></tr>
<tr><td>If piped water system is available</td><td>1) Water source: (well, spring, pond/reservoir, river, creek, others: name: _____)
2) Delivery system:
☐ to each private house, ☐ to community hydrants (numbers: ____ in the village)
3) Water charge (B___/m³), Do you think reasonable? (☐ high, ☐ acceptable, ☐ cheap)
4) Purpose of water
☐ drinking, ☐ washing, ☐ shower, ☐ bath tub water, ☐ toilet,
☐ livestock water ☐ others: (specify _____)
5) Capacity of supply: ☐ enough, ☐ not enough
if he can answer (Present: _____ lit/capita/day, Desired: _____ lit./capita/day)
6) Adequate through the year?: ☐ yes, ☐ no
if no,
How often in shortage: ____ months or days/year
How often stopped _____ days/year
mainly when; (_____)
Reason: (_____)
7) Water Quality: ☐ good, ☐ acceptable, ☐ not good (taste, salty, colour)
8) Maintenance of facilities
Who is responsible on operation: (☐ community, ☐ agency, _____)
Who is responsible for maintenance: (☐ community, ☐ agency, _____)
Is the system maintained and operated well? ☐ yes, ☐ no
If no, what problems?
<table>
<tr><th colspan="2">System</th><th>Problem</th></tr>
<tr><td></td><td>Water source</td><td>water shortage, weeds, pollution, others:</td></tr>
<tr><td></td><td>Pump</td><td>deterioration, mechanics, electricity, other:</td></tr>
<tr><td></td><td>Treatment system</td><td>deterioration, mechanics, chemical shortage, other:</td></tr>
<tr><td></td><td>Tank</td><td>deterioration, leakage, others:</td></tr>
<tr><td></td><td>Pipe</td><td>deterioration, leakage, others:</td></tr>
</table>
How solved:(_____)
Pressure: ☐ enough, ☐ acceptable, ☐ low, ☐ too low
9) Any request to agency?</td></tr>
<tr><td>4.2 Community Pond</td><td>1) How many community ponds are there in the village?___ ponds by (_____)
2) Is pond efficiently utilized ? ☐ yes ☐ no
If no, due to (water pollution, distraction of dike, seepage, sediment, weeds,)
3) How the village ponds are utilized in the village ?
(irrigation, livestock water, drinking water, domestic water, fisheries, swimming, environmental, others _____)
4) How is the collectable capacity of runoff ?
☐ good due to enough (catchment, collecting canal, rainfall, others: _____)
☐ poor due to not enough (catchment, collecting canal, rainfall, others:_____)
5) How is the capability of water keeping?
☐ good due to (blanket pavement, good maintenance of dike, others _____)
☐ poor due to (high seepage, high evaporation, leakage through dike, others _____)</td></tr>
</table>

If no community pond in village

6) if no community pond, do you need pond in the village ? ☐ yes, ☐ no
If need, for irrigation, livestock water, drinking water, domestic water, fisheries, swimming, environmental, others _____
If no need, why_____
7) Are there any problems for construction of community pond?
☐ yes (no land, land acquisition, no budget,_____), ☐ no

4.3 Well

1) How many wells are there in the village?
Public _____wells by _____
Private_____wells
2) What is the main purpose of wells in this village ?
☐ drinking ☐ domestic ☐ livestock ☐ garden water ☐ irrigation ☐ others
3) What is the quality of well water?
☐ good ☐ fair ☐ poor ☐ saline ☐ polluted ☐ other_____
4) Operation condition of wells (% or wells)

Condition	Public wells	Private wells
well working		
broken		
drying		
polluted		
saline		

5) Are Public wells periodically checked about quantity and quality of water , and equipment ? ☐ yes, ☐ no
If yes How often ? 1/ yrs, 1/ months
6) Do you need to construct wells ? ☐ yes, ☐ no
If yes ___wells,
Requested? ☐ yes, What agency:_____,when will be provided_____
☐ no

4.3 Rural Road

1) Do you need to improve rural road? ☐ yes, ☐ no
If yes,

from	to	new road	pavement	widening	Req.	Agency
		yes, no	yes, no	yes, no	yes, no	

4.4 Farm Road

1) Do you need to improve farm road? ☐ yes, ☐ no
If yes,

from	to	new road	pavement	widening	Req.	Agency
		yes, no	yes, no	yes, no	yes, no	

Table 3-6 Questionnaire about Medical Care Services

1. Are there some medical care centers or hospitals in the village? ☐ yes ☐ no

   If yes

   1) Is there enough kinds and quantity of medicine ? ☐ yes ☐ no
   2) Are there some activities about preventive hygiene ? ☐ yes ☐ no
   3) Is periodical health care checkup held ? ☐ yes ☐ no
   4) Do the villagers utilize often ? ☐ yes ☐ no
   5) Do you have some requests to the center or hospital ?_____

   If no

   1) Distance to the nearest center or hospital ?____km
   2) Are there some stores where sell medicines and bandages in this village ? ☐ yes ☐ no
   3) Do you need a center or hospital in this village ? ☐ yes ☐ no
      If no, reason ?_____
   4) Is there enough kinds and quantity of medicine ? ☐ yes ☐ no
   5) Are there some activities about preventive hygiene ? ☐ yes ☐ no
   6) Is periodical health care checkup held ? ☐ yes ☐ no
   7) Do the villagers utilize often ? ☐ yes ☐ no
   8) Do you have some requests to the center or hospital ?_____

2. Do you have some insurance systems ? ☐ yes ☐ no

   If yes, How many percentage of villagers are join ?____%
   If no, Do you need such systems ? ☐ yes ☐ no
      If no, Why the reason ?_____

3. Do almost villagers have some medicines in his home ? ☐ yes ☐ no

   If no, How to get the medicines if needed ?_____

CHAPTER 4. DESIGN STANDARD FOR INFRASTRUCTURES DEVELOPMENT

4.1 Design Standard for Irrigation Facilities

4.1.1 Definition of Project Scale

The scale of irrigation project which is categorized by RID is shown in Table 4.1-1.

Table 4.1-1 Scale Definition of Irrigation Project

	Large scale	Medium scale	Small scale
Construction cost (million baht)	more than 200	more than 4 less than 200	less than 4
Storage volume (mcm)	more than 100	10 to 100	-
Water surface area (km^2)	more than 15	-	-
Irrigation area (rai)	more than 80,000	-	-
Construction period (year)	more than 5 years	1 to 5 years	less than 1 year

4.1.2 Criteria of Pump Irrigation Project

Criteria of pump irrigation project are as shown in Table 4.1-2.

Table 4.1-2 Criteria of Pump Irrigation Project

Items	Description
1. Agency Responsible	DEDP
2. Project Size and Location	1) Project area normally to be 500 to 3,000 rai. 2) Irrigation area not more than 1 km from the water source. 3) Pipeline not more than 800 m in length from the pump station to the delivery tank. 4) Electric wiring not mote than 5 km in length. 5) Pump lift not more than 20 m in height from the water surface of the source.
3. Water Source	1) to be sufficient throughout the year. 2) not affecting people downstream regarding water usage through project implementation.
4. Irrigation	1) Rainy season: irrigation when necessary. 2) Dry season: Irrigation to start at the same time in each project to keep steady rotational irrigation. 3) Irrigation fee: B1.17/kwh (Water Users' Association: B0.60, DEDP: B0.57) 4) Diversion requirement: 0.24 lit/sec/rai (1.5 lit/sec/ha) as standard
5. DEDP Responsibilities	1) to construct the project facilities (pump station, pipeline to the project area, delivery tank, main concrete lining canal of more than 50 lit/sec capacity) 2) to operate pump in accordance with irrigation requirement of the project. 3) to maintain and repair facilities up to main canal. 4) to collect electric fees from farmers for PEA.
6. Farmers' Responsibilities	1) to request the project to DEDP, and organize " water users' association" for rationalized water utilization and collection of water charges. 2) to intend to cultivate throughout the year. 3) to contribute land for canalization. 4) to dig ditches of less than 50 lit/sec capacity to lead water to the farm lots. 5) to pay electric fee as a water charge depending on consumption of electricity for pumping. 6) to participate in receiving advice in agricultural technology. 7) to clear grass along canals and dredge canals before the beginning of the irrigation season. 8) to operate pumps after DEDP training.
7. Dimensions of Project Facilities	- Type of Pump Station Fixed type or Floating pontoon type (Fixed type has become scarce in recent years, but main type for the LRAs because rivers are rather small and unsteady for the floating pontoon type in the LRAs.) (*) - Pump, Motor and Pipeline (Actual head = 25m) Irrigation Area / Pump Capacity / Pump (Suction, Delivery) / Motor / Pipeline (Asbest Pipe) 500 rai / 100 lit/sec x 1 set / (14" x 400 mm x 1) / 75 kw x 1 set / 400 mm x 1 1,500 rai / 300 lit/sec x 1 set / (14" x 500 mm x 1) / 110 kw x 1 set / 500 mm x 1 3,000 rai / 300 lit/sec x 2sets / (14" x 600mm x 1) / 110 kw x 2sets / 600mm x 1 - Diversion Weir Diversion weir is not provided in normal case in the large rivers, but it may be necessary in the LRAs because low water flow is not sufficient for intake. (*)

4.1.3 Criteria of Reservoir Project

Design criteria of reservoirs follow basically the standard of United States Bureau of Reclamation (U.S.B.R).

- Width of crest Min. 4.00 m (7.00m) (Laterite pavement)
- Free board for dam Min. 1.00 m (1.80m)
- Free board for spillway Min. 0.80 m (1.00m)
- Embankment slope Up stream side 1 : 3.0
  Down stream side 1 : 2.5
- Protection of embankment body
  Up stream side Rip rap with ϕ 0.30m
  Down stream side Sodding

4.1.4 Criteria of Canal and Pipeline

- Type of canal: Trapezoid canal with concrete lining
- Side slope of canal: 1 : 1.5
- Velocity calculation of Canal: $V=1/n\ R^{2/3}\ I^{1/2}$ (Manning's formula)
  V : Velocity (m/s)
  n : Coefficient of roughness
  R : Hydraulic radious (m)
  I : Hydraulic gradient
- Coefficient of roughness " n "

Earth canal in good condition		0.0225
Earth canal in general condition		0.025
With concrete lining	$Q < 40\ m^3/s$	0.014
	$40 \leqq Q < 63$	0.015
	$63 \leqq Q$	0.016
Concrete pipe		0.013

- Allowable velocity

Concrete lining canal	Max.	$V \leqq 2.0$ m/s
	Min.	$V \geqq 0.8$ m/s
Unlined canal	Max.	$V \leqq 1.0$ m/s
Pipe	Max.	$V \leqq 3.0$ m/s

- Head loss formula of pipe
  $dh = 10.67 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L \times 1.1$
  dh : Head loss (m)
  C : Coefficient (100 for Steel pipe, 130 for R.C pipe, 150 for P.V.C pipe)
  D : Diameter of pipe (m)
  Q : Discharge (m^3/s)
  L : Pipe Length (m)
  1.1 : Miscellaneous loss
- Free board of Canal
  $Fb = 0.2 + 0.2 \times D$ (m)
  Fb : Free board (m)
  D : Water depth (m)

4.1.5 Criteria of Intake Installation to the Existing Non-gated Small Reservoir

Figure 4.1-1 shows the plan of intake installation to the existing non-gated small reservoirs in the area.

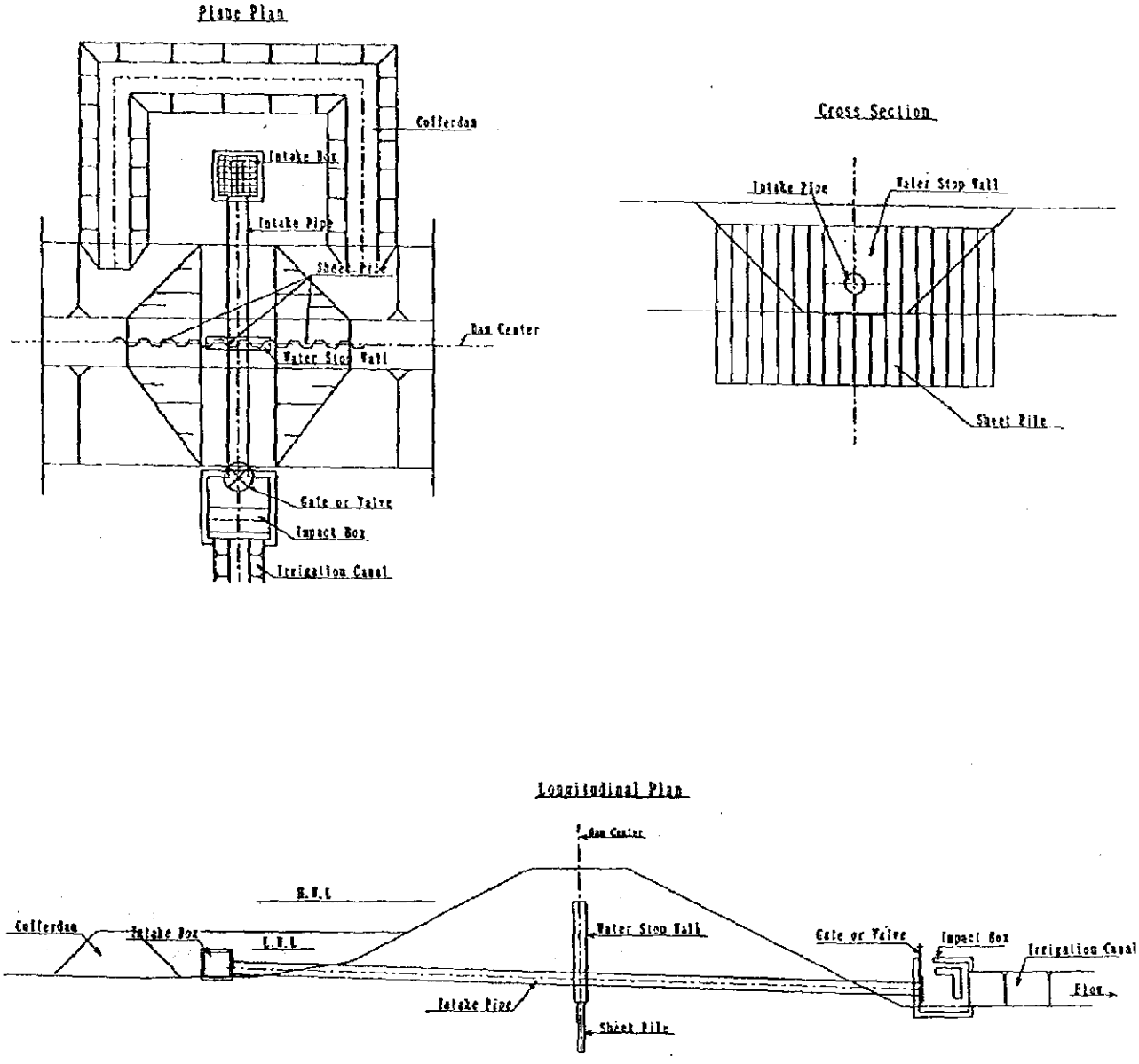


Figure 4.1-1 Installation Plan of Intake to the Existing None Intake Type Small Reservoir

4.2 Design Standard for On-Farm Facilities

4.2.1 Criteria of On-Farm Ditch

Design standard of on - farm ditch is basically following the U.S.B.R

- Flow formula Manning's open channel formula
- Coefficient of roughness
  n = 0.018 for farm ditch with concrete lining
  n = 0.030 for farm ditch without concrete lining
- Allowable maximum velocity
  1.0 - 1.5 m/s for farm ditch with concrete lining
  0.7m/s for farm ditch without concrete lining
- Inside and outside canal slope
  1:1 for cut section and fill section
- Bottom width of canal
  W = 0.30 m (Min.)
- Free board
  Fb= 0.20m (Min.)
- Berm width
  Minimum 0.5m

4.2.2 Criteria of Farm Road

1) Alignment of Farm Roads

Figure 4.2-1 show the standard alignment of farm roads in the LRAs. For ennobling to conduct integrated farming for many farmers as possible, accessibility has to be raised in the area.

i) Alignment of Main and Lateral Farm Roads

Main and lateral farm roads will be aligned utilizing existing farm roads as much as possible, because major access road systems are already established in most areas except in paddy dominant area. Improvement work as widening and laterite pavement will be major subjects for main and lateral farm roads.

ii) Alignment of On-farm Roads.

On-farm roads are not well developed yet in LRAs except where upland cash crops are dominant. In such areas, on-farm roads are already developed, and accessibility has reached some 60%. In those areas, improvement of on-farm roads is main subject, and additional new on-farm roads will be planned in accordance with the following criteria.

<Alignment Criteria of On-Farm Road>

- On-farm roads are to be aligned for farmers to able to conduct the integrated farming in many farm fields as possible.
- Many farm lands as possible are to be linked by a shorter road to minimize cost and land loss.
- On-farm roads are to be provided along the shorter side of land holdings to realize minimization of cost and land loss.
- When on-farm road is obliged to run along the longer side of land holdings, it should run along the boundary of larger holders.

- Existing footpaths are to be utilized as much as possible and widened as on-farm road.
- On-farm roads are to be aligned to link both ends to the lateral farm road to minimize the blind on-farm roads.
- In the area subject to flood, on-farm roads are to be paved with asphalt to protect from erosion.
- In such areas, generally paddy dominant area where land holdings are especially small and boundaries are complicatedly irregular, on-farm road development will be subject to delay until able to introduce land consolidation in the area.

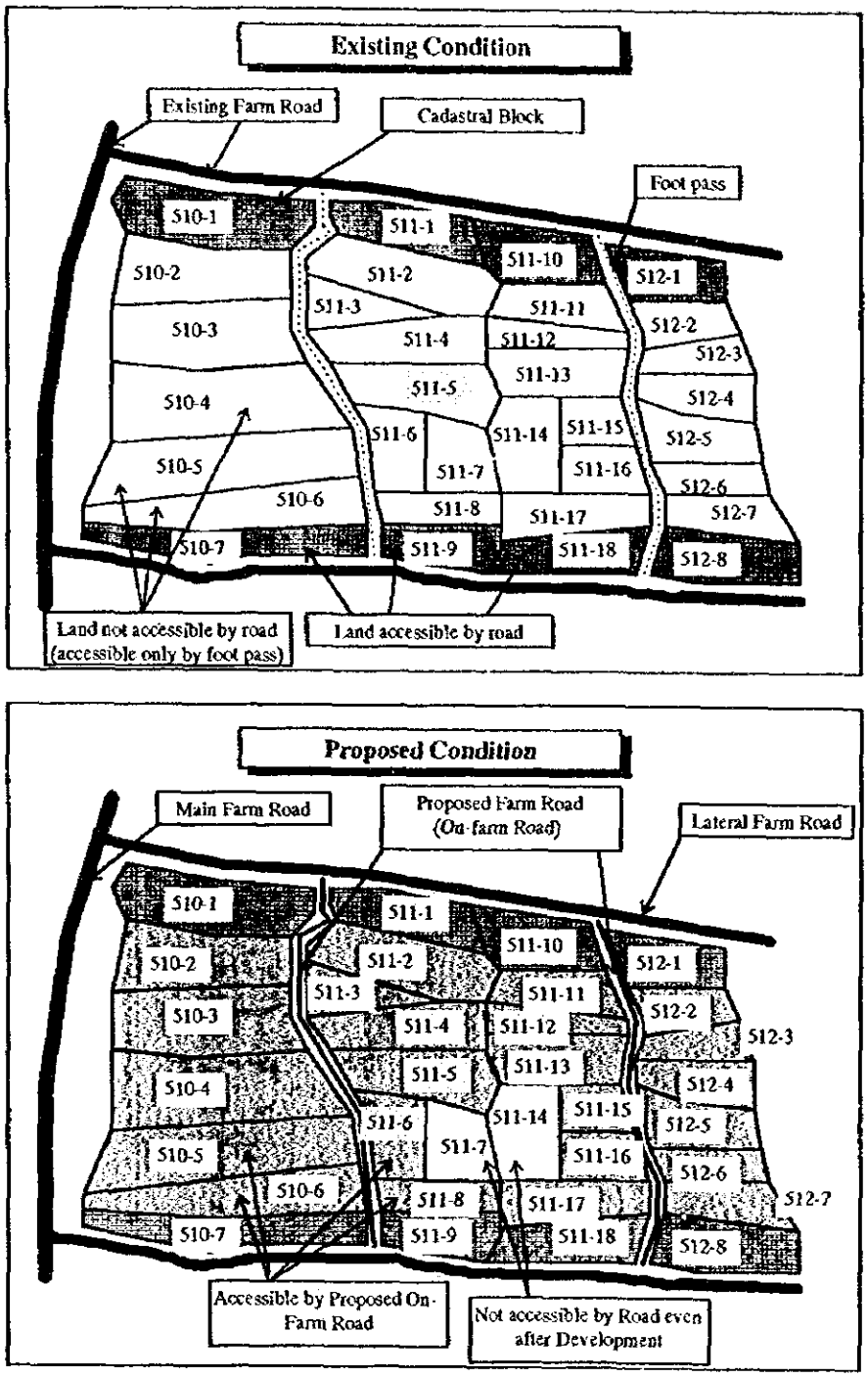


Figure 4.2-1 Standard Alignment of Farm Roads in the LRAs

2) Dimensions of Farm Roads

Table 4.2-1 Design Dimension of Farm Road

Category	Road Width (m)	Pavement	Max. longitudinal gradient (%)
Main Road	4.00	Laterite	12
Lateral Road	4.00	Laterite	12
On-Farm Road	2.00	Laterite	15

(Note) Asphalt pavement shall be provided at the places where subject to flooding.

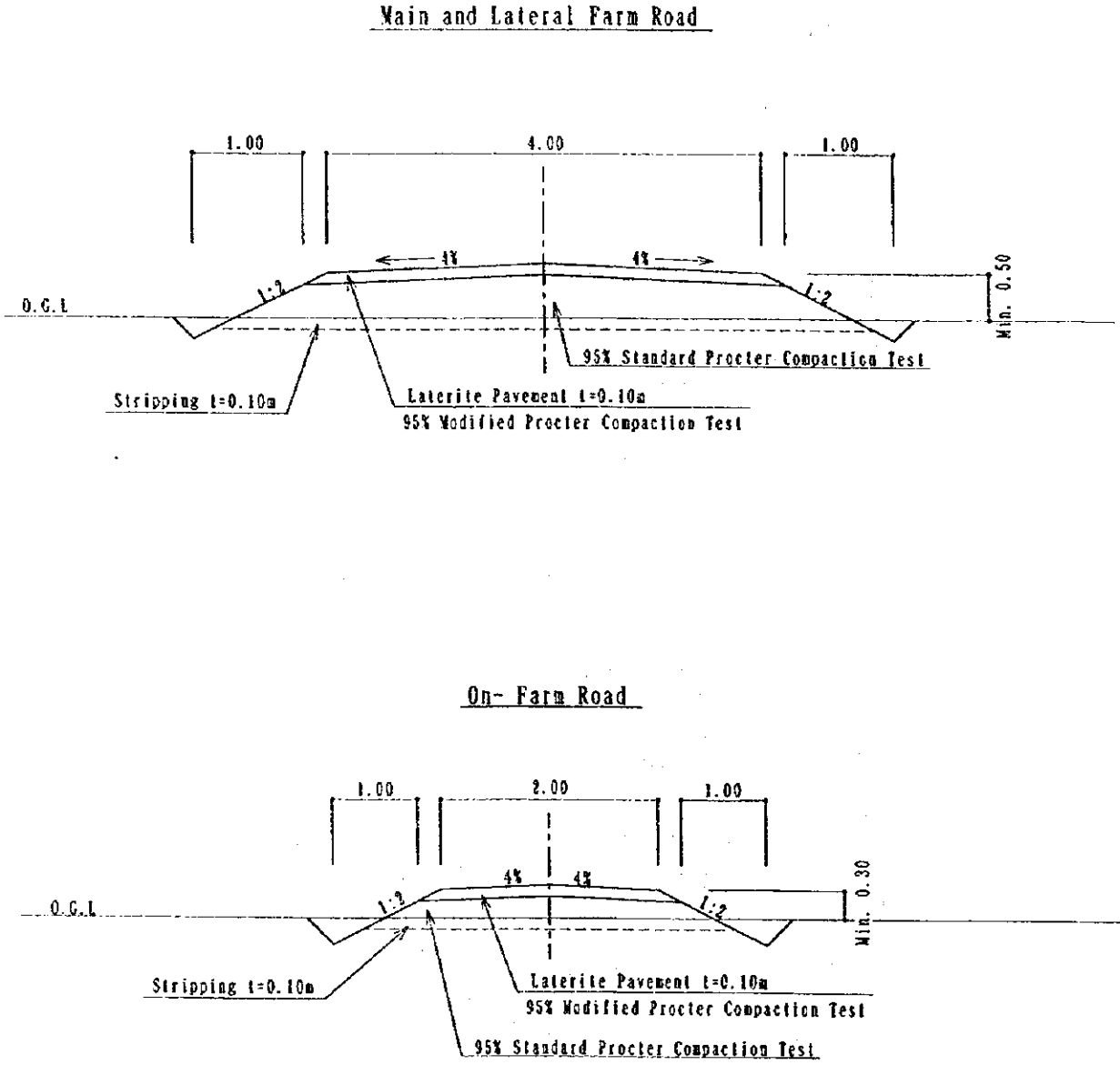
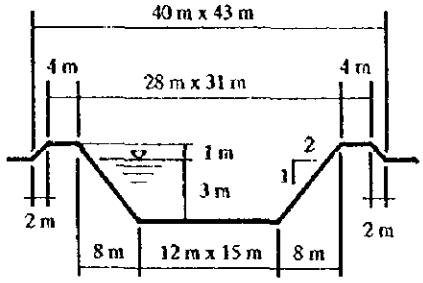
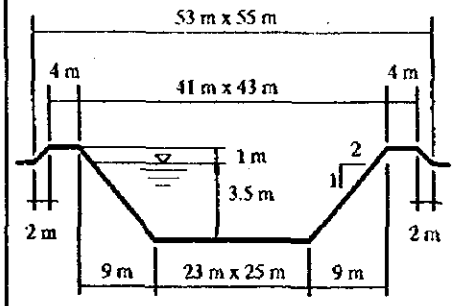
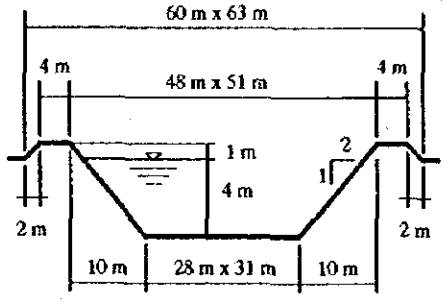


Figure 4.2-2 Typical Cross Section of Farm Road

4.2.3 Criteria of Farm Pond

Three cases of farm ponds, ordinary type 1,200 m^3, medium type 3,500 m^3 and large type 6,000m^3, have been investigated for development. Major elements of each case are summarized in Table 4.2-2.

Table 4.2-2 Design Standard of Different Types of Farm Pond

Farm Ponds	Elements	Khon Kaen Mahasarakham	Mukdahan Sakon Nakhon
Ordinary Farm Pond 1,200m^3 	Major Dimensions	Area Size = 40mx43m = 1,720m^2 (1.1rai) Depth = 3m, Side slope = 1:2	
	Min. Req. C. Area	3 rai	1.5 rai
	Irrigated Crops	1 rai (vegetables)	1 rai (vegetables)
	Irrigation System	Bucket Irrigation	Bucket Irrigation
	Construction Cost Pond Irrigation System Total	 B37,500 - B37,500	 B37,500 - B37,500
	Demarcation Government Farmer	 B37,500 0	 B37,500 0
	Min. Req. Labor	2 members	
	Net Agri. Income	B71,000/year	
Medium Farm Pond 3,500m^3 	Major Dimensions	Area Size = 53mx55m = 2,915m^2 (1.8rai) Depth = 3.5m, Side slope = 1:2	
	Min. Req. C.Area	16.5 rai	8.25 rai
	Irrigated Crops	1.0 rai (vegetables) 1.5 rai (Rice+D.S.crop) 2.5 rai	1.0 rai (vegetables) 1.5 rai (Fruit tree) 2.5 rai
	Irrigation System	Hose Irrigation by Tiller attached Pump	Micro-sprinkler System by Electric Pump
	Construction Cost Pond Irrigation System Total	 B98,900 B10,500 B109,400	 B98,900 B50,500 B149,400
	Demarcation Government Farmer	 B37,500 B71,900	 B37,500 B111,900
	Min. Req. Labor	2 members	
	Net Agri. Income	B98,500/year	
Large Farm Pond 6,000m^3 	Major Dimensions	Area Size = 60mx63m = 3789m^2 (2.4rai) Depth = 4m, Side slope = 1:2	
	Min. Req. C. Area	30 rai	15 rai
	Irrigated Crops	1 rai (vegetables) 3 rai (W.S.Rice+D.S.crop) 4 rai	1 rai (vegetables) 3 rai (Fruit tree) 4 rai
	Irrigation System	Hose Irrigation by Tiller attached Pump	Micro-sprinkler System by Electric Pump
	Construction Cost Pond Irrigation System Total	 B160,250 10,500 B170,750	 B160,250 68,000 B228,250
	Demarcation Government Farmer	 B37,500 B133,250	 B37,500 B190,750
	Min. Req. Labor	3 members	
	Net Agri. Income	B126,000/year	

(Note) Net agricultural income is composed of incomes both by rainfed and integrated agriculture of a standard farmer who has an average size of land of 20 rai.

An ordinary farm pond is provided to individual farmers for free by the government. It is a minimum size of farm pond which is able to irrigate 1 rai of vegetables year round. On the other hand, a large farm pond is an optional one which is to be prepared by farmers

themselves paying a cost of enlargement of pond and necessary irrigation facilities. It is a maximum size of farm pond which aims to conduct marketable farming. This size of farm pond is able to support 4 rai irrigated crops year round, that may be a maximum scale of integrated farming by family labors. Demarcation of farmers for a large farm pond is about B133,250 in case of hose irrigation, and about B190,750 in case of micro-sprinkler irrigation. A farmer can gain about B126,000 of net agricultural income by a large farm pond in a year, but only about B71,000 by a ordinary farm pond. A medium farm pond is positioned between an ordinary and a large farm pond. Farmer selects an appropriate farm pond based on elements of three cases of farm ponds in Table 4.2-2 taking his intention on farming, family labor size, farmland size and available catchment area etc. into consideration.

Detail drawing of farm pond is presented in Drawing No.1 in Chapter 8 in this Appendix D.

4.2.4 Criteria of Micro Irrigation System

1) Mini-sprinkler System

Micro irrigation system means the system which is composed of mini sprinkler or drip pipes. This irrigation system is suited especially for irrigating vegetables and fruit trees in the area. Drip irrigation is suitable in case using groundwater as a source, while sprinkler irrigation in case of surface water. Surface water generally contains sand and silt, and deteriorates in quality during storage in farm pond. In case drip irrigation system using surface water, small holes are easily closed by sediment and algae. It is, therefore, necessary to install a filter system for drip irrigation in case for surface water. When groundwater is available, drip irrigation system can be installed for irrigation but equipment is not common in the area. Mini-sprinkler system can be used both for surface water and groundwater, and it is commonly available in market and easier in operation and maintenance. Most of sediment and algae can be removed by a simple filter, and sediment and algae can be removed easily from a sprinkler head. Consequently, mini-sprinkler system has been studied for the irrigation system in the area.

2) Application of Mini-sprinkler System

It is recommended to introduce sprinkler irrigation system for fruit tree and vegetable farming with a large farm pond in Mukdahan and Sakon Nakhon. On the other hand, in Khon Kaen and Mahasarakham, hose irrigation by a tiller attached pump is recommended for a large farm pond system, because major irrigation is for wet season paddy.

Hose irrigation has been commonly conducted and experienced by farmers in the area, but sprinkler irrigation is relatively new and introduced only by very limited farmers in the area. It is, therefore, necessary to prepare a preliminary plan for clarifying reliability of sprinkler irrigation.

Proposed acreage of this system is 4 rai in total composed of 1 rai vegetables and 3 rai fruit tree. Water resource of the system is farm pond or well, and necessary water

capacity of farm pond for this system is 6,000m^3. Recommendable number of sprinkler heads are 25 heads for vegetables, 70 heads for fruit tree; and necessary power of pump unit is 2 inch and 1.5 kwh motor pump for farm pond; and 1 inch 0.37kwh motor pump for well. Necessary pressure head of sprinkler is 1.8 kg / cm^2 - 2.1 kg / cm^2 (25 - 30 lb / inch^2).

Required irrigation system by a large farm pond is summarized as below:

Crops and Acreage = Vegetables (1 rai) + Fruit Trees (3 rai) = 4 rai

Annual Irrigation Water in Average Year = 6,814 m^3/year (Table B-22 in Appendix B)

Typical design of 6,000m^3 farm pond is shown in Drawing No.1, and sprinkler layout is in Drawing No.36 and No.37 in this Appendix D.

3) Selection of the Sprinkler Head and Pump

Typical sprinkler heads available in Thailand and application for one rai vegetable irrigation are as shown in Table 4.2-3;

Table 4.2-3 Available Sprinklers and Cost in Thailand

Case	Specification of Sprinkler (per head)					Sprinkler System per Rai						
	Discharge	Pressure	Water Range	Made in	Price	Necessary Sprinkler Heads	Discharge	Pump Price	Sprinkler Price	Valve Price	Pipe Price	Total Cost
	(lit/min)	(kg/cm^2)	(m)		(B/head)	(nos.)	(lit/mim)	(B)	(B)	(B)	(B)	(B)
1	1.5	1	3	Thai	7	324	486	12,000	2,268	12,960	38,880	66,108
2	8.0	1.8	5	Thai	15	121	968	12,000	1,815	4,840	23,112	41,767
3	10.0	2.1	10	Thai	25	25	250	12,000	625	1,000	11,448	25,073
4	15.0	2.5	15	Israel	150	16	240	12,000	2,400	640	9,504	24,544

According to the above table, the cheapest system is Case 4. Sprinkler head of Case 4, however, is not so suited to the area, because spare parts are expensive and difficult to maintain comparing to others. Therefore, sprinkler head shall be selected in Case 3 for vegetable farm.

On the other hand, sprinkler head for fruit tree should be selected not only by cost but water spread range. Wide range sprinkler head is not suited to fruit tree, because water is interrupted by leaves and branches. Therefore, most suitable system for fruit tree should be Case 2, which is able to irrigate only root range of tree.

4) Alignment of Sprinkler System

Based on above study, recommendable sprinkler system is summarized as shown in Table 4.2-4, and plan will be as shown in Figure 4.2-3. (Detail Drawings are described in Drawing No.36 and No.37 in this Appendix-D)

Table 4.2-4 Selected Sprinkler System for Vegetables and Fruit Trees

	Vegetables	Fruit Trees	Total
Area	1 rai	3 rai	4 rai
Specification of Sprinkler			
Discharge	10.0 lit/min/head	8.0 lit/min/head	
Water Spread Range (diameter)	10 m	5 m	
Necessary number of Sprinkler Heads	25 heads	70 heads	95 heads
Total Discharge (lit/min)	250 lit/min.	560 lit/min.	Operation Range 250 - 560 lit/min.
Necessary Pressure	2.1 kg/cm^2	1.8 kg/cm^2	2.1 kg/cm^2

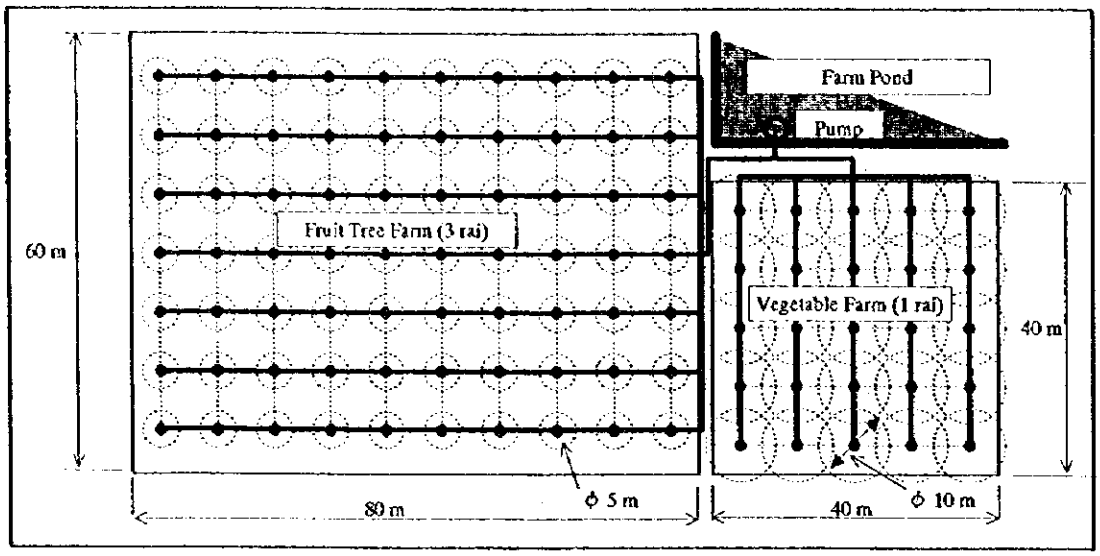


Figure 4.2-3 Typical Alignment of Sprinkler System for Large Farm Pond

5) Selection of Prime Mover of Pump

Irrigation system depending on farm pond is generally small to introduce an economically suitable engine, because available minimum engine in market is little larger than the required capacity in this irrigation system. On the other hand, small electric motor suited to the required capacity is available in market, but it is necessary to install an electric power line to the farm field.

To evaluate engine and motor, following cases have been investigated form an economic viewpoint.

Prime Mover	Pump	Discharge (lit/min)	Output Power	Remarks
Engine	ϕ 50 mm	200 - 650	3.8 HP	Minimum reliable engine in Market
Motor	ϕ 50 mm	180 - 600	1.5 kW	

Table 4.2-5 shows the result of cost comparison of engine and motor in 10 years life time. As shown in Table, total cost of electric motor is 107,168 Baht that is cheaper by about 30,000 Baht than that of engine. Consequently, electric motor is recommendable for sprinkler system in the area.

Table 4.2-5 Comparison of Cost for Engine and Electric Motor for Sprinkler System

Prime Mover	Output	Necessary Irrigation Hour (hr/yr)	Energy Consumption	Operation Cost (Baht/yr)	Price of Pump & Prime Mover (Baht)	Sprinkler System (Baht)	Power Line Cost (Baht)	Operation Cost (10yrs) (Baht/life)	Maintenance Cost (10yrs) (Baht/life)	Total (Baht/life)
Engine	3.8 HP	229	348 lit/yr	4,872	8,500	65,109	-	48,724	14,617	136,950
Motor	1.5 kW	229	28.6 kWh/month	1,312	8,000	65,109	17,000	13,122	3,937	107,168

(Notes) 1) Necessary Irrigation Water = 6,814 m^3/yr
2) Price of Gasoline = B14/lit. (Fuel consumption = 1.52 lit/hr for 3.8 HP Engine)
3) Assumed Total Pump Head = 21m, Discharge = 496 lit/min
4) Basic Electricity Charge = B109.35/month when consumption less than 100 kWh/month
5) Maintenance Cost = 30% of Operation Cost
6) Power line cost = 1,700m * B10/m = B17,000 [Aaverage distance from village to field in Sakon Nakon and Mukdahan (1.1km)×1.5 = Distance along farm road (1.7 km)]

6) Grouping of Electric Incoming System

It is found that electricity is to be selected as energy for sprinkler irrigation in the area. In this case, it is necessary to study incoming system of electricity to the field individually or in group.

Monthly consumption of electricity is found less than 100 kWh in individual farm. In this case, 109.35 Baht is charged as a basic electricity charge in each month. On the other hand, in case grouping incoming system, it is possible to reduce electricity charge less than individual incoming system. However, electricity charge should be shared in the group in this case.

Based on above consideration, individual and group incoming systems have been evaluated as shown in Table 4.2-6. It is found that the cheapest case is 4 members group at B31.48 for each member. It is, therefore, recommended to provide a group incoming system by 4 to 6 members.

Table 4.2-6 Comparison of the Electric Incoming Systems

Grouping	Energy Consumption (kWh/month)	Electricity Charge (B/month)	
		Group	Individual
1	28.6	109.35	109.35
2	57.2	109.35	54.68
3	85.8	109.35	36.45
4	114.4	125.91	31.48
5	143.0	158.80	31.76
6	171.6	191.69	31.95
7	200.2	224.58	32.08
8	228.8	257.47	32.18

(Note) 1) Individual Consumption = 28.6 kWh/month (Table 4.2-5)
2) Electricity Charge
B109.35/month for less than 100 kWh/month
B1.15/kWh beyond 100 kWh/month

4.3 Design Standard for Rural Road Facilities

Design criteria for the rural road is usually little modified by agencies based on the standard of Office of Prime Minister. Design criteria is as shown in Table 4.3-1.

Table 4.3-1 Standard for Rural Road (Office of Prime Minister)

Classification	Average of traffic(vehicles/day)	
	100~300	less than 100
Velocity (km/h)		
Plane area	60	60
Slope area	45	45
Hill area	30	30
Minimum scope (m)		
Plane area	144	144
Slope area	81	81
Hill area	36	36
Maximum slope (%)		
Plane area	5	5
Slope area	9	9
Hill area	12	12
Width of road (m)		
Plane area	6.00	3.50
Slope area	6.00	3.50
Hill area	6.00	3.50
Type of road surface	Laterite	Laterite

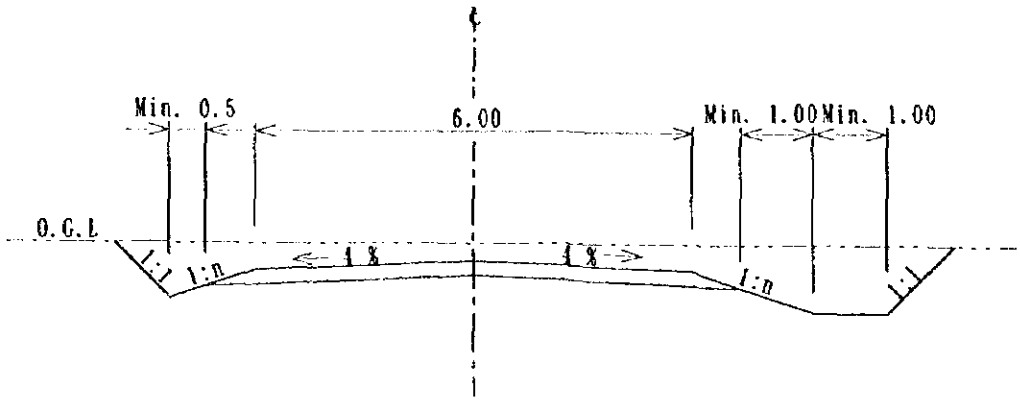
In this study, design standard of rural road is modified based on the above standard. Applied design standard for this study is as shown in Table 4.3-2.

Table 4.3-2 Design Standard for Rural Road in LRAs

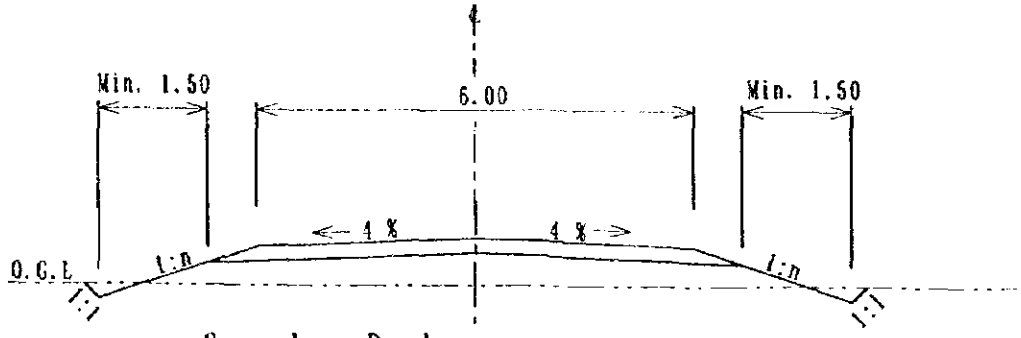
Classification	Average of traffic(vehicles/day)	
	100~300 Main Road	less than 100 Secondary Road
Velocity (km/h)		
Plane area	60	60
Slope area	45	45
Hill area	30	30
Minimum scope (m)		
Plane area	144	144
Slope area	81	81
Hill area	36	36
Maximum slope (%)		
Plane area	5	5
Slope area	9	9
Hill area	12	12
Width of road (m)		
Plane area	6.00	4.00
Slope area	6.00	4.00
Hill area	6.00	4.00
Type of road surface	Laterite Asphalt	Laterite Asphalt

The typical cross section of the main and the secondary roads are shown in Figure 4.3-1. This figure is following the ALRO design standard.

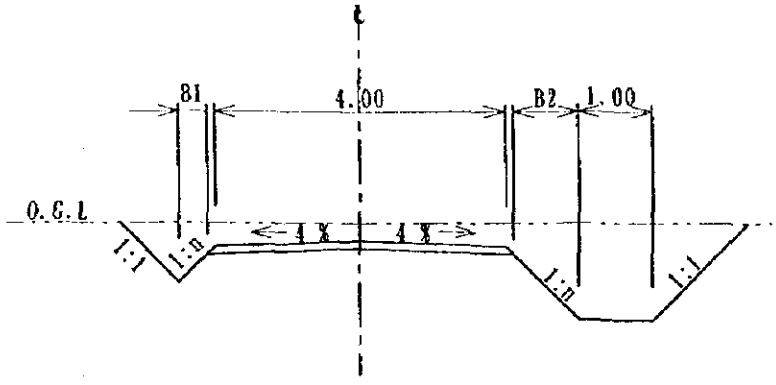
Main Road
Cutting Section



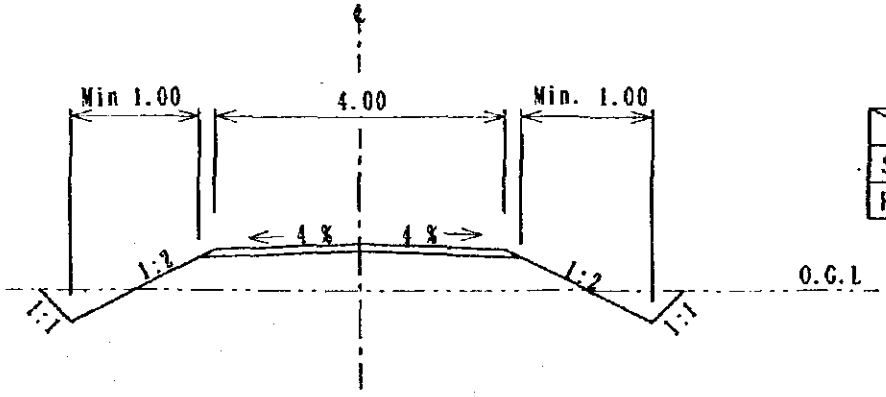
Banking Section



Secondary Road
Cutting Section



Banking Section



SLOPE 1:n

HIGHT (m)	SOIL		ROCK		HARD.R
	BANK.	CUT.	BANK.	CUT.	CUT.
0.30 - 1.00	3:1	3:1	2:1	1.5:1	0.5:1
1.00 - 3.00	2:1	2:1	1.5:1	1:1	0.25:1
OVER 3.00	1.5:1	1.5:1	0.75:1	0.75:1	0.25:1

Thickness of Pavement

	Laterite	Asphalt	
Main	0.20	Surface	0.05
		Base	0.20
Secondary	0.10	Surface	0.03
		Base	0.10

Surface ; Asphalt Concrete
Base ; Crusher Run

SLOPE 1:n

	n	B1	B2
SOIL	1:2	Min.1.0	Min.2.0
ROCK	1:1	Min.0.5	min1.0

Figure 4.3-1 Typical Cross Section of Rural Road

4.4 Water Quality Standard for Rural Water Supply

1) Main Agencies for Implementing the Rural Water Supply

The main agencies for the implementing the rural water supply is shown in Table 4.4-1.

Table 4.4-1 Main Agencies for Implementing the Rural Water Supply

Agencies	Wells	Ponds	Piped Water Supply
ALRO	○	○	○
DLD		○	
MASU		○	
RID		○	
DOLA	○	○	○
ARD	○	○	○
PWD	○		○
PWA			○
DOH	○	○	
DMR	○		
Changwat Office	○		○
Tambon Office	○		○

(Note) MASU: Mobile Agricultural Service Unit

2) The Water Quality Standard for Rural Water Supply

Water quality standard for the rural water supply is authorized by Thai government. So all concerned agencies have to follow this standard.

Standard quality for raw water is shown in Table 4.4-2, and standard for drinking water is shown in Table 4.4-3 . These standards are authorized by DOH.

Table 4.4-2 Raw Water Quality Standard

Parameter	Statistic Value	Unit	Categories of Water Resources *1				
			1	2	3	4	5
Physical and Biological Qualification							
1. Temperature	-	Degree Celsius	a	a	a	a	-
2. pH	-	-	a	5-9	5-9	5-9	-
3. DO	20% ile	mg / l	a	6	4	2	-
4. BOD	80 % ile	mg / l	a	1.5	2.0	4.0	-
5. Coliform Bacteria	80 % ile	MPN / 100	a				
Total Coliform				5,000	20,000	-	-
Fecal Coliform				1,000	4,000	-	-

(continued)

(continue)

Parameter	Unit	Maximum value for Water Resources Categories 2,3,and 4 2*
Organic Compounds		
6. NO_3-N	mg / l	5.0
7.NH_3-N	mg / l	0.5
Toxic Substances		
8. Phenol	mg / l	0.0005
9. As	mg / l	0.01
10. Siyanide	mg / l	0.005
Heavy Metal		
11. Cu	mg / l	0.1
12. Ni	mg / l	0.1
13. Mn	mg / l	1
14. Zn	mg / l	1
15. Hg	mg / l	0.002
16. Cd	mg / l	0.005 * 0.05 *
17. Cr	mg / l	0.05
18. Pb	mg / l	0.05
Radiation		
19. Total Radiation	Beccerrel / l	0.1
Chemicals for prevent and eliminate weed	mg / l	0.05
20. DDT	micro g / l	1
21. BHC	micro g / l	0.02
22. Dieldrin	micro g / l	0.1
23. Aldrin	micro g / l	0.1
24. Heptachlor & Heptachlor Epoxide	micro g / l	0.2
25. Pndrin = E	micro g / l	Must no be found

a = Naturally

*2 = Specification of Standard of Water Resources for category 2-4 , for Water Resource category 1 is according to naturally , and for category 5 is not specified .

* = Hardness is not over 100mg / l

** = Hardness is over 100mg / l

- Not specified

% - ile = Percentile value from all sample which collected to check continuously

(Amount and period for collections according to specification of National Natural Board Office)

Classification of Water Resources into 5 Categories

Category 1 : is natural water resource which without dirty water from every activities and can be utilized for
- Consumption after pasteurization
- Naturally expanding of basic life
- Conservation of water resource ecology system

Category 2 : is water resource with dirty water from some activities and can be utilized for
- Consumption after pasteurization and generally water quality improvement processing
- Aquatic animals conservation
- Fishery
- Swimming and water sports

Category 3 : is water resource with dirty water from some activities and can be utilized for
- Consumption after pasteurization and generally water quality improvement processing
- Agriculture

Category 4 : is water resource with dirty water from some activities and can be utilized for
- Consumption after pasteurization and specially water quality improvement processing
- Industry

Category 5 : is water resource with dirty water from some activities and can be utilized for
-Transportation

Table 4.4-3 Drinking Water Quality Standard

Parameter	Unit	Standard drinking water
pH		6.5-8.5
Color	Pt.Cob	15
Turbid	NTU	5
TDN	mg/l	1.000
Hardness	mg/l	500
Fe	mg/l	0.3
Mn	mg/l	0.1
Cu	mg/l	1.0
Zn	mg/l	5.0
Pb	mg/l	0.05
Cr	mg/l	0.05
Cd	mg/l	0.005
As	mg/l	0.05
Hg	μ g/l	1.0
So_4	mg/l	400
Cl^-	mg/l	250
No_3^-	mg/l	10
F^-	mg/l	1.5
Residual Free Chlorine	mg/l	-
Total coliform	NPN/100ml	0
Fecal coliform	NPN/100m	0

If the target of project is the water supply for the drinking water, it is necessary to satisfy both category 1 of Table 4.4-2 and all of Table 4.4-3.

3) The Project Scale Classification

The project scale classification is a little different at each agencies, but basically following the classification of Rural Development Committee.
So the project scale is classified this classification on this study.
The project scale classification which is authorized by Rural Development Committee is shown in Table 4.4-4.

Table 4.4-4 Classification for Project Scale of Water Supply Works

Scale	Capacity (m^3/hr)	Target Household
Small	no less than 2.0	less than 50
Medium	no less than 5.0	50-120
Large	no less than 10.0	more than 120

4) The Percapita Demand of Water Consumption

The percapita demand of water consumption which is authorized by Rural Development Committee is 50 lit / person / day.(Drinking 5 lit , Others 45 lit)
This value is used at DOH , NESDB and ARD also. So this value is used on this study.