

7. FEASIBILITY STUDY FOR PRIORITY AREAS

7-1. Existing Conditions of Priority Areas

1) Location and Area

The outlines of the Priority Areas are as follows:

Outline of the Priority Areas

Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan
No. of LRA	KK-No6	MHS-No5	SKN-No3 - 1	MKD-No8-2
Amphoes related to Priority Area	Ban Phai, Nong Hong Song, K.A. Non Sila	Borabu Na Chuk	Kut Bak	Dong Luang
Total Area (rai)	43,400	18,200	33,900	10,700
Farm Land (rai)	36,700	14,600	25,100	8,600
No. of Households	1,840	1,220	2,510	660
Population	9,200	6,100	12,550	3,300

2) Land Use

Major crops in the Priority Areas are paddy, cassava and sugarcane, and some fruit trees, vegetables, mulberry, maize, kenaf, etc. are also cultivated as minor crops. Planted areas of crops in the Priority Areas are shown below:

Planted Areas of Crops in the Priority Areas

Crops	Khon Kaen		Maha Sarakham		Sakhon Nakhon		Mukdahan		Total	
	Area (rai)	(%)	Area (rai)	(%)	Area (rai)	(%)	Area (rai)	(%)	Area (rai)	(%)
Paddy	7,760	21.1%	6,690	45.8%	12,850	51.2%	3,200	37.2%	30,500	35.9%
Cassava	7,576	20.6%	4,824	33.0%	7,956	31.7%	3,894	45.3%	24,250	28.5%
Sugarcane	13,478	36.7%	1,880	12.9%	2,990	11.9%	767	8.9%	19,115	22.5%
Fruit	105	0.3%	600	4.1%	1,304	5.2%	485	5.6%	2,494	2.9%
Vegetable	30	0.1%	106	0.7%		0.0%		0.0%	136	0.2%
Mulberry	411	1.1%	500	3.4%		0.0%		0.0%	911	1.1%
Maize		0.0%		0.0%		0.0%	167	1.9%	167	0.2%
Kenaf		0.0%		0.0%		0.0%	87	1.0%	87	0.1%
Fallow Land	7,340	20.0%		0.0%		0.0%		0.0%	7,340	8.6%
Total	36,700	100.0%	14,600	100.0%	25,100	100.0%	8,600	100.0%	85,000	100.0%

3) Livestock

Cattle, buffaloes, chickens are the major livestock in the Priority Areas. Cattle and pigs are raised for farm family income.

Livestock in the Priority Areas

Livestock	Khon Kaen		Maha Sarakham		Sakhon Nakhon		Mukdahan		Total	
	head	head/H.H	head	head/H.H	head	head/H.H	head	head/H.H	head	head/H.H
Cattle	1,468	0.8	984	0.8	4,403	1.8	393	0.6	7,248	1.2
Buffalo	306	0.2	526	0.4	3,589	1.4	1,983	3.0	6,404	1.0
Duck	182	0.1	576	0.5	2,978	1.2	720	1.1	4,456	0.7
Chicken	7,863	4.3	5,877	4.8	22,133	8.8	4,530	6.9	40,403	6.5
Pig	130	0.1	480	0.4	1,266	0.5	408	0.6	2,284	0.4
No. of H.H	1,840		1,220		2,510		660		6,230	

Note : H.H = Household

4) Farm Pond

The number of farm ponds constructed in the Priority Areas is 850 as shown below and it corresponds to the rate of one farm pond / six farm families.

Number of Existing Farm Pond

Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan	Total/Ave.
Nos. of farm ponds	330	280	180	60	850
Ratio of ILLI with Pond	18%	23%	7%	10%	14.8%

5) Farm Road

The Priority Areas have farmed roads of 221 km long that is equivalent to the density of 2.6 m/rai (16 m/ha). 47 % of total farmlands in the Priority Areas are accessible directly from road. However, different Priority Area has very much different farm road density and accessibility.

Length of Existing Farm Road

Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan	Total/Ave.
Length	116 km	69 km	24 km	12 km	221 km
Density	3.2m/rai	4.7m/rai	1.0m/rai	1.4m/rai	2.6m/rai
Accessibility	65%	66%	27%	36%	47%

6) People's Organization

The memberships of BAAC, Agricultural Cooperatives and other organization are as follows:

Membership of People's Organization

Membership (%)	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan	Average
BAAC	65.6%	37.7%	17.4%	0.0%	30.2%
Agri. Cooperative	28.8%	35.1%	23.7%	75.0%	40.7%
Housewives' Group	40.0%	2.6%	13.6%	13.0%	17.3%
Young Farmers' Group	20.8%	0.0%	7.6%	34.0%	15.6%
Product. Saving Group	27.2%	1.3%	14.5%	0.0%	10.8%
Other Organization	13.6%	6.5%	1.6%	38.0%	14.9%

7) Farm Household Income

The average farm income of Khon Kaen Priority Area is estimated to be 28,000 baht that is rather higher than those in other Priority Areas. The reason why the farmers in Khon Kaen Priority Area have the highest farm income is that they can grow sugarcane and get a higher income. In addition, better road access enables farmers to save on transportation cost for their products and inputs. The average farm household income in the Priority Areas are as follows:

Farm Household Income				
(unit : baht/year)				
Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan
Farm Income	28,500	10,100	12,600	11,400
Non-Farm Income	16,300	21,500	9,600	6,500
Total	44,800	31,600	22,200	17,900

7-2. Farming Plan

1) Farming Type

In the basic development plan, twelve farming types (Types A - L) have been proposed. These farming types can be simplified into five models according to their similarity as shown below:

<Farming Model>

Model 1 : Paddy + Integrated Farming (Farming Types A, B, C)

Model 2 : Upland Crops + Integrated Farming (Farming Types D,G)

Model 3 : Upland Crops + Integrated Farming + Livestock (Farming Types E,F)

Model 4 : Agroforestry + Integrated Farming (Farming Types H,L)

Model 5 : Agroforestry (Farming Types I, J, K)

The farming models in each Priority Area are shown below. There is no Priority Area having the farming model 5.

Farming Model								
Farming Model	Khon Kaen		Maha Sarakham		Sakhon Nakhon		Mukdahan	
	Ratio	Area	Ratio	Area	Ratio	Area	Ratio	Area
Model 1	34%	L, M	30%	L, M	64%	L, M, U	52%	L, M, U
Model 2	33%	U, M	30%	L, M	12%	U	16%	U
Model 3	33%	U, M	40%	L, U, M	12%	U	16%	U
Model 4					12%	U	16%	U
Model 5								

Note : L : Lowland, U : Upland, M : Mixed Land

2) Agricultural Development Plan

The present and planned cropped areas are shown below:

Present and Planned Cropped Areas

Crops	Khon Kaen			Maha Sarakham			Sakhon Nakhon			Mukdahan		
	Present	Planned	Differ.	Present	Planned	Differ.	Present	Planned	Differ.	Present	Planned	Differ.
Paddy	7,760	7,371	(-)389	6,690	5,421	(-)1,269	12,850	12,350	(-)500	3,200	3,040	(-)160
Cassava	7,576	3,743	(-)3,833	4,824	1,130	(-)3,694	7,956	3,644	(-)4,312	3,894	2,467	(-)1,427
Sugarcane	13,478	15,553	2,075	1,880	1,520	(-)360	2,990	2,110	(-)880	767	760	(-)7
Mulberry	411	411	0	500	500	0	0	0	0	0	0	0
Fruit Tree	105	1,969	1,864	600	600	0	1,304	3,640	2,336	485	964	479
Grassland	0	1,370	1,370	0	3,080	3,080	0	0	0	0	0	0
Vegetable	30	1,083	1,053	106	809	703	0	590	590	0	165	165
Maize	0	0	0	0	0	0	0	0	0	167	84	(-)83
Kenaf	0	0	0	0	0	0	0	0	0	87	44	(-)43
Fast G. Tree	0	0	0	0	0	0	0	1,156	1,156	0	415	416
Fallow Land	7,340	3,060	(-)4,280	0	0	0	0	0	0	0	0	0
Farm Pond, etc.	0	2,140	2,140	0	1,340	1,340	0	1,610	1,610	0	660	660
Total	36,700	36,700	0	14,600	14,600	0	25,100	25,100	25,100	8,600	8,600	0

3) Agricultural Infrastructure Development Plan

a) Farm Road

The farm road construction can increase road accessibility necessary to practice successful integrated farming. After implementation of the projects proposed, total length of farm road become 526 km from present 221 km. The projects can improve on the road accessibility from 47 % to 86 % and increase the road density from 2.6 m/rai to 6.2 m/rai.

Present and Planned Road Density and Accessibility

Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan	Total/Ave.
Present					
Length	116 km	69 km	24 km	12 km	221 km
Density	3.2m/rai	4.7m/rai	1.0m/rai	1.4m/rai	2.6m/rai
Accessibility	65%	66%	27%	36%	47%
Planned					
Length	197 km	101 km	171 km	57 km	526 km
Density	5.4m/rai	6.9m/rai	6.8m/rai	6.6m/rai	6.2m/rai
Accessibility	92%	93%	82%	75%	86%

b) Farm Pond

The projects will provide farm ponds of 1,750 and wells of 750 for 40 % of all farm families and the percentage of farm families who have a farm pond increase from 14 % at present to 54 %.

Number of Farm Ponds

Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon		Mukdahan	Total	
			Farm Pond	Well		Farm Pond	Well
Nos. of Household	1,840	1,220	2,510		660	6,230	
Existing Pond	330	280	180		60	850	
Newly Constructed	740	490	250	750	270	1,750	750
Total Nos. of Pond	1,070	770	430	750	330	2,600	750

4) Necessary Supporting Services for Farmers

In case that ALRO implements agricultural development project as a main implementing agency, ALRO should take responsibility for serving the following farmers' training for 37 villages in the Priority Areas.

a) Trainees

Field Working Group is assigned to select four progressive farmers from each village. Therefore, in 37 villages there will be 148 progressive farmers to be trained. Selection will base on readiness of the farmers in the project in term of cooperation, diligence and positiveness. It is aimed that these progressive farmers will serve as the project resources persons at farm level to disseminate what they learn from the training course to their fellow farmers while working on their own farms.

b) Training Subjects and Description

Training will be separated into four categories i.e. training for crop production, training for animal production, training for integrated farming system and plant propagation, and training for leadership. In general, farmers have basic knowledge in agricultural subjects, therefore, training is provided to familiarize them with technological innovation of respective commodities. To facilitate the training manual, booklet and brochure concerning the subjects should be provided. These documents will help the farmers for understanding class lectures and for shortening training period.

c) Training for Crop Production

Training for crop production comprises rice production, field crop production, vegetable production, fruit production and sericulture. It is proposed that one full day is required for each commodity. Therefore, five days are needed for this category.

d) Training for Animal Production

Training for animal production comprises beef cattle raising, grassland management, poultry raising, pigs raising, and fish culture. This training course will also take five days - one day for each subject.

e) Training for Integrated Farming System and Plant Propagation

Training for integrated farming system and plant propagation comprises introduction of integrated farming system, farm planning, farm accounting, and plant propagation. This training course takes four days; two days will be spent for introduction of integrated farming system, half a day each for farm planning and farm accounting, and one day for plant propagation.

f) Training for Leadership

Training for leadership comprises the items shown below. This training course takes five days.

- i) Training in managerial skills, business, production know-how, marketing, finance and general administration; This is to widen leaders' knowledge required for forming,

managing and strengthening farmers' organization.

- ii) Training in community forest management and environmental conservation; This is to introduce to the farmers basic concept of community forest and know-how for community forest management and to teach importance of environmental conservation, especially conservation of forest.

7-3. Project Implementation Program

1) Project Implementation Organization

Because the proposed development plan covers various components, i.e. agricultural infrastructure development, agricultural development, non-farming employment promotion and necessary supporting services for farmers, ALRO cannot handle all the components alone. Hence the project goal can be achieved only through the coordination of these activities with those of other agencies involved in the project. In order to assure smooth and successful implementation of this project, several levels of coordination are needed for project implementation, national level coordination of plans and budgets, provincial level coordination of local government agencies and project level coordination of manpower.

It is recommended that three levels of coordinating committee and field working groups be established as follows:

Committee Structure for Project for Project Coordination

Structure	Chairman	Secretary	Members	Major Functions
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Project Executive Committee</div> <p style="text-align: center;">↓</p>	Chairman: MOAC Deputy Permanent Secretary Vice Chairman: Secretary General of ALRO	Deputy Secretary General of ALRO as Project Director (P/D)	DGs of involved officers and Depts.	Formulated Policy or Program in accordance with the scope of the project. Approve annual plans, to coordinate and resolve any problems
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Project Coordinating Committee</div> <p style="text-align: center;">↓</p>	Project Director(P/D)	ALRO Division Director as Project Manager	Division Director of involved Divisions	Working-level officials from involved agencies, reviewing policy, operation plans and budget to coordinate and resolve any problems
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Provincial Coordinating Committee</div> <p style="text-align: center;">↓</p>	Provincial Deputy Governor	Director of PLRO as Field Project Manager	Provincial and District officials involved in the project	To coordinate and supervise overall works at the provincial level
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Field Working Group</div>	Field Project Manager	Chief of Land Reform Management Branch	Active agencies in the project at Amphor level and local organizations	To cooperate and coordinate at the field level

2) Summary of Project Costs

The project costs are summarized as shown below:

Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan
1. Construction Work				
- Farm Pond	27,750	18,375	23,592	10,125
- Farm Road	47,620	26,315	63,149	18,760
Sub-Total	75,370	44,690	86,741	28,885
2. Engineering	10,944	6,701	14,245	4,027
3. Administration	7,537	4,469	8,674	2,889
4. Physical Contingencies	9,385	5,586	10,966	3,580
Total	103,236	61,445	120,626	39,381
5. Price Escalation	8,845	5,263	10,436	3,412
Grand Total	112,081	66,708	131,062	42,793
Cost / rai	3.05	4.57	5.22	4.98

Note : This project cost includes only cost of farm pond and farm road construction project.

3) Operation and Maintenance Cost

The necessary O / M cost is estimated as shown below:

Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan
Annual O / M Cost	3,735,000	2,132,000	4,725,000	1,437,000
Beneficiary Area (rai)	36,700	14,600	25,100	8,600
Cost per rai	102	146	188	167

Note : This O/M costs include only costs for farm pond and farm road construction project.

4) Project Implementation Schedule

The project implementation schedule is planned as shown below:

Item	1999	2000	2001	2002	2003	2004	2005
1) Project Preparation*1							
2) Agri. Infra. Development							
3) Farmers' Training*2							
4) Supporting Services by Agencies concerned							

Note) *1 : Including establishment of project implementation organization, detailed design study, preparation of contract documents, selection of contractor, etc.

*2 : including farmers' training and supporting services in the Project Areas .

5) Benefit

The benefits obtainable in the project of each Priority Area are summarized as shown below:

Project Benefits (unit : 1,000 baht)				
Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan
Benefit W/O Project	43,429 (46,828)	19,065 (21,284)	11,417 (12,616)	40,830 (45,389)
Benefit W/ Project	60,241 (69,986)	25,638 (32,881)	15,783 (19,196)	54,948 (67,431)
Incremental Benefit	16,812 (23,158)	6,573 (11,597)	4,366 (6,580)	14,118 (22,042)
Incre. Benefit / rai	0.458 (0.629)	0.450 (0.794)	0.507 (0.765)	0.562 (0.878)

Note : Figures without a parenthesis are amount of benefits from crop production and inland fishery.

Figures in parentheses are amount of benefits from crop production, inland fishery and livestock breeding.

6) Project Evaluation and Sensitivity Analysis

The results of project evaluation and sensitivity analysis are summarized as shown below:

EIRR and Results of Sensitivity Analysis				
Items	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan
i) EIRR (%)	17.7 (24.7)	10.6 (21.0)	11.4 (19.6)	10.9 (18.2)
ii) B / C Ratio	1.37 (1.89)	0.92 (1.62)	0.96 (1.50)	0.94 (1.57)
iii) Sensitivity (EIRR) Cost 10 % Up.	15.9 (23.0)	9.1 (19.0)	9.8 (16.4)	9.4 (17.1)

7) Farm Budget Analysis

After implementation of the projects, the farm families with a land of average acreage in each Priority Area can earn an increased annual profit from agriculture as shown below.

Annual Profit from Agriculture unit : baht (magnification)			
Province	Lowland	Upland	Mixed Land
Khon Kaen	71,090 (3.7)	76,630 (2.7)	55,060 (2.1)
Maha Sarakham	36,450 (3.4)	38,890 (3.6)	36,440 (3.4)
Mukdahan	41,500 (2.9)	39,150 (3.5)	-
Sakhon Nakhon	40,240 (2.9)	38,740 (2.9)	-

By practicing proposed integrated farming, income of farmers in the Priority Areas will improve dramatically and make it possible to accomplish better living conditions. The farm pond based integrated farming will extend widely if the farmers satisfy their present farm family incomes because incomes from agriculture shown in table above are higher than the present farm family incomes. However, such incomes are not so high except those in Khon Kaen. The practical introduction of integrated farming will depend on whether the farmer has opportunities for non-farm employment obtainable high income or not.

7-4 Recommendations

- 1) In the Study Area, the potential for water resources development is very low and more than 90% of farming families in the area have no other choice but to depend for their water for farming either on farm ponds and/or wells. In view of this, the implementation of integrated agricultural development projects including construction of farm roads coupled with the provision of farm ponds and/or wells in the selected area may contribute a lot to increasing farmers' income and to conserve the forest reserve areas adjacent to LRAs through the introduction of integrated farming and can be considered necessary to be actively promoted.

In all stages of the project implementation, special attention should be paid to the conservation and rehabilitation of natural resources and the environment, and necessary measures such as farmers' training in environmental conservation, community forest management, etc. should be taken as a part of the project implementation.

- 2) In order to maintain the effectiveness of project implementation, the project areas should meet the following conditions in principle.
 - a) Implementation priority given to less developed areas.
 - b) Establishment of productive farmers' groups.
 - c) Establishment of marketing groups.
 - d) Farmers are willing and active in forming and/or already having groups consisting of the majority of farmers.

These conditions will place a considerable burden on the shoulders of farmers. However, it should be understood that ALRO takes sufficient responsibility and provide strong support to farmers in establishing productive farmers' groups and marketing groups. All this support to farmers shall preferably be carried out with due cooperation by the government agencies concerned, leader farmers in the project areas and NGO personnel as much as possible.

- 3) Because the project covers various development components, well coordination among government agencies concerned is of great importance for smooth and successful implementation of the project. It is, therefore, recommended that the project implementation organizations composed of three coordinating committees and field working groups as shown in Clause 7-3 be established. As the activities of the field working groups have much more effect on farmers' own interests and a successful issue of the project, the coordinating committees should provide strong and sufficient support for them.

The field working groups should have intensive consultation with farmers' groups about the following key elements and should provide necessary support for them.

- a) Establishment of necessary farmers' groups for better project implementation.
 - b) Introduction and expansion of integrated farming, ecological farming, agro-forestry, etc.
 - c) Creation of marketing systems at village level.
- 4) All the government agencies concerned are currently working to provide free farm ponds with 1,200m³ storage capacity for farm families in rainfed areas. There are, however, a number of farm families in need of expansion of farm pond storage capacity for more stabilized farm management and increasing of farm income, and for this purpose there is considerable demand by active farmers for longer term and lower interest rate loans for the construction of larger farm ponds and operation funds. Other than this, there is a need for long, medium and short term loans in order to support the establishment of productive farmers' groups and marketing groups and for daily farming activities and management. In order to make these loans available in co-operation with BAAC, the Agricultural Land Reform Fund shall be strengthened in terms of its operation and amount of capital.
- 5) To ascertain the positive effects to be derived from the integrated development plan, relevant farmers themselves and such rural communities would have to be better developed to a certain level. From this viewpoint, the following measures are considered very important and should be pushed forward in parallel with the development project implementation.
- a) Farmers' participation in project implementation
 - b) Strengthening of farm families and their communities
 - c) Development of human potential
 - d) Farmers' participation in forest management
- 6) ALRO should support progressive farmers and communities who are presently engaged in integrated farming, ecological farming, agro-forestry, etc. in LRAs. They are expected to be leaders in expansion of a sustainable agriculture in LRAs. In-Paeng Network in Sakhon Nakhon Priority Area, which is a network of several tens of communities surrounding the Phu Phan Range, is a local environmental organization aiming at native plant conservation and alternative agriculture. "Forest is life, love the forests as you love yourself." is the slogan of the Network. Because the activities of the Network are very beneficial for conservation and rehabilitation of forests and environments, expansion of sustainable agriculture in LRAs, etc., ALRO should incorporate their activities in the development projects and should provide technical and financial support, if necessary.

- 7) It is necessary to prepare 1/4,000 scale topo maps covering all the project area to finalize the project development plan and for briefing/explanation of the project plan to relevant farmers. The scale 1/4,000 is the same as the cadastral map. For this reason, it is recommended that ALRO take necessary measures to strengthen the capacity of section/divisions concerned with topo maps to cover more than the annual development target.
- 8) Thailand has been experiencing an acute economic crisis as well as unemployment. Laid-off workers, who had migrated to Bangkok from rural areas such as LRAs, have now returned to these areas. In LRAs of the Northeastern Region where natural conditions are least favorable in terms of production potential and the ratio of poor people is the highest in Thailand, it is assumed that the ratio of poor people has been increasing and the degree of poverty has been becoming more serious. Because it is difficult to take non-farming jobs at present, the implementation of integrated agricultural development projects, which leads the way to absorb the workers laid off and returned to rural areas through its job creation in the dry season and to boost the livelihood of LRAs, should be promoted without delay with due consideration on the social benefits to be derived.

By introducing the integrated farming system in LRAs, the labor requirement will be increased by about 50% more than the current farming system.

- 9) The development project should be implemented by considering existing development level, poverty, various development potentials, etc. of the project area, efforts as a model project, size of the project, etc. Especially, the project for the LRAs with small acreage should be implemented together with the projects for adjacent LRAs and the projects for the LRAs with large acreage should be implemented by subdividing the project area into some areas of adequate acreage.

PART-I PHASE I STUDY (BASIC DEVELOPMENT PLAN)

CHAPTER 1 INTRODUCTION

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1.1 Background of the Study

The Agricultural Land Reform Office (ALRO) has been undertaking agricultural land reform in accordance with the Agricultural Land Reform Act to enable landless farmers to have their own land for cultivation and to improve their living standards. The implementation of agricultural land reform is categorized as three main activities, namely; "land provision", "land distribution", and "development".

1) "Land Provision" and "Land Distribution"

Since 1975, 35.4 million rai of public land and 0.4 million rai of private land were designated as Land Reform Areas (LRAs), and 8.3 million rai have been allocated to about 455,000 households. ALRO intends to distribute at least 1.8 million rai (100,000 household) each year.

2) "Development"

As to development, ALRO undertakes infrastructure development such as provision of water resources, access roads, small irrigation facilities, etc. as well as income generation and the restructure of agricultural production. Other activities such as agricultural extension and credit, public health, etc. remain the responsibilities of other government agencies, and ALRO plays a coordinating role in this regard. The development of LRAs has been continuing since 1975 though most LRAs are still found in less-developed poor areas.

Promotion of land productivity of LRAs, through the development of water resources, irrigation and drainage systems, access roads to farmland and public infrastructure, improvement of soil fertilities, farming management, marketing of produce and so forth, is the most important activity for achieving successful land reform.

ALRO, therefore, recognized the necessity of formulating a master plan for integrated agriculture development in LRAs in order to meet the increasing number of requests for early implementation of the development projects. In the preparation of the master plan, due consideration should be given to actual problems confronted by rural people with different natural and socio-economic backgrounds. In this context, ALRO has decided to implement the study by dividing all LRAs into several regions covering the whole country.

As the initial stage of the implementation of the study, top priority has been given to LRAs in the four provinces of Khon Kaen, Maha Sarakham, Mukdahan and Sakon Nakhon in the Upper Northeastern Region, the poorest region, where about 1.38 million rai (221 thousand ha) of land were transferred in 1993 to ALRO for the implementation of agricultural land reform.

After this, the Government of the Kingdom of Thailand requested the Government of

Japan in July 1994 to conduct a feasibility study on integrated agricultural development in the LRAs selected in the four provinces mentioned above. In response to this request, JICA, the official agency responsible for the implementation of technical cooperation programs of the Government of Japan, dispatched a Study Team to the Kingdom of Thailand.

1.2 Objectives of the Study

The objectives of the Study are:

- a) To confirm the existing conditions and constraints, to select priority areas (Phase-I), and to conduct a feasibility study for the priority areas in each development category (Phase-II).
- b) To establish guidelines consisting of Guideline (1) for classification of the areas into development categories and selection of priority areas, and Guideline (2) for formulating a development plan for each category.
- c) To carry out, in the course of the study, technology transfer to Thai counterpart personnel concerned.

1.3 Necessity of the Study

As mentioned in Chapter 1.1 "Background of the Study", the development of LRAs has been continuing since the Agricultural Land Reform Act was enacted in 1975. However, it may be said that most LRAs are still less developed areas due to some development constraints including natural constraints such as low run-off during the dry season, only a few storage reservoir sites, etc., budgetary constraints, institutional constraints, etc.

Agro-economic data on LRAs in the country are shown below:

a) Size of household (persons)	4.6
b) Land holding (rai/household)	29.3
c) Net assessed farm income per household (baht)	63,700
d) Upper limit of poverty band for five person household (baht)	48,000
e) Percentage of poor households below the upper limit (%)	46.5

Source: Selected Data on Land Reform Areas, ALRO, Sept. 1996

The ratio of poor people in 1992 was estimated at about 13 per cent of the country's population and about 22 per cent in the Northeastern Region. One of the targets of regional and rural development to be implemented by the Thai Government is to reduce the ratio in the country to 10 per cent during the 8th plan period (1997-2001). As can be seen in the above table, the ratio of poor people in LRAs is about 46 per cent and is too high when compared with the ratio in the country as a whole. Judging from this situation, the development of LRAs is of utmost importance in reducing the ratio of poor people in the country as well as income

disparities between the highest income group and the lowest income group. And ALRO has recognized the urgent need of formulating a master plan for development of LRAs accounting for 35.8 million rai.

Under such circumstances, this Study has been carried out in order to formulate an integrated agricultural development plan for selected LRAs in four provinces in the Northeastern Region which consist of about 46 per cent of all LRAs, and includes the provision of the guidelines for classification of these LRAs into development categories, selection of priority areas and formulation of a development plan for each category. Accordingly, it is said that the need for this Study is very high because the results of the Study, together with such projects as the Huai Kha Khaeng Buffer Zone Project by DANCED and ALRO, are expected to be one of the guidelines when ALRO formulates development plans for LRAs in the near future.

1.4 National Rural Development Policy

1.4.1 The 8th Plan

In the past development plans including the 7th Plan covering the period 1992-1996, the national economic and social development concept has largely been based on the acceleration of economic growth and an impressive performance to date has been attained in terms of the growth rate as a whole. On the other hand, however, rapid economic growth has resulted in little benefits for rural areas and the standard of living of rural farmers remains poor, contributing to a wider income disparity between urban and rural areas. In view of this, under the 8th Plan, the development concept has been adjusted from growth-oriented to people-centered development. More particularly, the 8th Plan emphasizes the fostering and promotion of regional and rural development so as to reduce the number of rural poor and to shift economic activities from urban to rural areas so that more employment opportunities can be created in rural areas. In proceeding with any development activities, the 8th Plan requires more attention to environmental conservation and people's participation in it.

Table 1.4-1 Major Objectives and Targets set under the 8th Plan :

Items	Objective/Target	Time Limit
Population	(60.6 m) 62.9 million	2001
Birth Ratio	(2.17 %) 1.9%	2001
Population Growth Rate	(1.2%) 1.0%	2001
Agricultural Population	(51%) 45%	2001
Economic Growth Rate	8%	Average
Inflation Rate	Lower than 4.5%	2001
Unemployment Rate	0.3%	2001
Domestic Savings/GDP	10%	2001
Income Disparity (middle and lower income groups' combined share of national income)	More than 50%	2001
Poverty Ratio	Lower than 10%	2001
Electrification	All families	2001
Rural Water Supply	70% of villages	2001
Public I/D telephones	All villages	2001
Highways connecting Urban Centers	1,000 km. or more	2001
Rural Roads connecting Villages (ARD plan)	3,700 km. or more	2001
Basic Education	(6 years) 9 years	2001
Technical University Graduates	40%	2001
Reduction of Soil Erosion	More than 1 m. rai	2001
Forest Conservation	More than 25% of total	2001
Mangrove forest Conservation	More than 0.1 m. rai	2001

Note : () 1997 figure.

Under the 8th Plan, the amount of absolute poverty is envisaged to be less than 10% of the total population. The poverty line has been fixed on a regional basis and publicly announced by NESDB. For the Northeastern Region, the poverty line fixed for the year 1996 was about 9,520 Baht/year (26 Baht = 129 Yen/day).

1.4.2 Rural Development Policy

According to the 8th plan, rural development has been envisioned the directives mentioned below;

- a) Rural people possess a management potential
- b) Rural people possess opportunity and equality
- c) Rural society to be desired is society that is peaceful, kindness, warmth in families and strong communities.
- d) Natural resources will be the foundation of sustainable development, and without deleterious effects to the environment
- e) An efficient administrative system will be made available for rural development

In order to achieve the hopes and plans for rural development during the implementation of the 8th plan, area-approach with people familiar with the region and locality will be the center of development, and the strategies can be identified as follows:

- a) Strengthening the community for the development of human potential that will subsequently result in the development of the economy, culture, family and community of rural people.
- b) Restructuring agricultural practice so that more options for occupational development are available to farmers while this restructuring can, at the same time, support the conservation and rehabilitation of natural resources and the environment.
- c) Decentralization program of growth to the regions and locality aims at job creation for, and income distribution to, rural people in the regions and locality.
- d) Development of natural resources and conservation and rehabilitation of the environment as a source of livelihood and well being for rural people in the pertinent regions.
- e) Improvement of administration and management.

1.4.3 Agricultural Development Policy

Agricultural development under the implementation of the 8th Plan will aim at increasing farmers' income, maintaining the economic stability of the agricultural sector and supporting the overall economic growth of the country. In achieving these aims, however, it is noted that among those programs to be involved under the 8th Plan, measures for improvement of production efficiency and promotion of restructuring agricultural production system are particularly important ones and the outcomes are of great concern.

The average growth target for the agricultural sector under the implementation of the 8th Plan has been set at 2.9% per annum. During the 8th Plan, the main objectives of agricultural development can be summarized as follows:

- a) To maintain the capacity for competitiveness of agricultural commodities in the world market through advances in production efficiency, improving the quality of produce to satisfy market demand.
- b) To conserve natural resources through sustainable development without destruction of natural resources and the environment.
- c) To develop and strengthen human resources and farmers' organizations, and to upgrade standard of living leading to better quality of life.

1.5 Provincial Development Plan

Provincial development plans will conform with the 8th National Economic and Social Development Plan, the Regional Development Plan, the Provincial Investment Plan and other government policy related to provincial development.

The development policy of the central government shall reflect the needs from the local governments, therefore, any planning be originated from Tambon level, through District

level and finally added to the planning at provincial level. By this, the provincial development plan will enable down top.

1.5.1 Strategies for Provincial Development Plan

Considering the geographic location, natural resources and development potential of the provinces involved, the strategies for the provincial development plan for the four provinces in the Study Area during the implementation of the 8th Plan can be summarized as follows:

1) Khon Kaen

- a) Improving standard-of-living by providing all knowledge necessary to people's organizations and groups, and to enhance their participation in development activities.
- b) Development of human resources for supporting a production restructuring program by promoting and encouraging more efficient coordination between the government sector, the private sector and farmers at every stage of implementation.
- c) Expansion of productivity and marketing as well as opportunity of employment under the program named Rural Development of Decentralization of Growth to Regions and Localities.
- d) Management of natural resources and environment
- e) Increasing the security through formulation and implementation of accelerated comprehensive development project in sensitive areas.
- f) Improvement of the administrative system by increasing capability of government officials and all local organizations at every level.
- g) Improvement of infrastructure by developing domestic and agricultural water resources, communication systems and public infrastructure.
- h) Protection from and eradication of narcotics.

2) Mahasarakham

- a) Expansion of educational opportunities in the form of both formal and informal programs and promotion of a technical college for technician and skilled labor.
- b) Promotion for production of livestock, poultry, mango and bamboo shoot for agro-processing and fast growing eucalyptus trees as the major agricultural activities.
- c) Promote cottage industries and upgrade local industries to marketing standard.
- d) Develop Maha Sarakham as an attractive town for tourism.

3) Sakhon Nakhon

- a) Develop Sakhon Nakhon as a center for education of the Upper Northeastern Region that will promote the establishment of a vocational college, a convention center and a vocational training center.

- b) Develop Sakhon Nakhon as a small-scale agro-industrial province with a major role in the development of modern agriculture, the agro-processing industry, and promotion of cottage industries.
 - c) Develop Sakhon Nakhon as an attractive town for tourism together with conservation of natural resources and the environment.
- 4) Mukdahan
- a) Development Mukdahan as a center of a communication system linked with Indochinese countries.
 - b) Develop Mukdahan as an education center. Encourage an Indochina student exchange program and expand a skilled labor-training institute at Mukdahan.
 - c) Development of freshwater fisheries.
 - d) Develop Mukdahan as a center for tourism.
 - e) Development of border trade and services.
 - f) Development of livelihoods by developing agricultural water resources and increasing non-farm employment.

1.5.2 Strategies for Agricultural Sector

The strategies for the agricultural sector of each province are same and are summarized below.

- a) Accelerating water resource development.
- b) Transforming agricultural production in irrigated areas towards production of high valued product.
- c) Promoting livestock, pasture and fruit trees in rainfed areas.
- d) Increasing the value of agricultural products by mean of agro-processing.
- e) Improving productivity and product quality by offering improved technology and management practices to farmers.
- f) Promoting contract farming and establishing future markets for agricultural commodities.
- g) Changing the rules and regulations that impede agro-business trading, particularly those on the trading, slaughtering, and moving of livestock.

1.6 Agricultural Land Reform

1.6.1 Agricultural Land Reform

The agricultural Land Reform Act, B.E 2518 (1975), which had Sections 14 and 15 added in the Agricultural Land Reform Act (No.3) B.E. 2532 (1989), was promulgated for the following reasons, as mentioned in Land Reform Bulletin 214.

“Thailand is an agricultural country and the majority of the population is engaged in farming; therefore, land is essential and forms the primary basis of agricultural production. However, it appears at present that farmers are facing critical problems due to the loss of land ownership rights and increase in tenancy. They have to pay land rent with exorbitant rate. Soil degradation has resulted in low agricultural yield. The farmers are continually underprivileged and disadvantaged in the land tenancy and marketing system. This causes socioeconomic and political unrest at the national level. Consequently, it is very vital for the State to solve these problems urgently by means of land reform so as to allocate land to the farmers and maximize the uses of land, together with improvements in the agricultural production and marketing systems in pursuit of equity to the farmers. In response to the policy of the State to reduce the socioeconomic gap among the people, as stipulated in the Constitution, it is essential that this Act be enacted”

The major objectives of agricultural land reform are summarized as follows:

- a) To enable farmers to have their own land for cultivation,
- b) To develop farming and improve production inputs, production and marketing facilities, etc. to ensure better economic and social conditions for farmers,
- c) To promote farmers’ organizations,
- d) To promote education, public health, public utilities, and public facilities for rural betterment, and
- e) To reduce the ratio of poor people.

The organization established for the implementation of agricultural land reform under the Act is shown in Figure 1.6-1, and the role of each implementing body is as follows:

1) Agricultural Land Reform Office (ALRO)

ALRO is a public body having the status equivalent to a Department and has the power and duty to undertake agricultural land reform implementation in accordance with the Agricultural Land Reform Act.

2) Provincial Land Reform Office (PLRO)

PLROs are established under ALRO having the power and duties to carry out agricultural land reform activities as prescribed by the Agricultural Land Reform Executive Committee and Provincial Land Reform Committees.

3) Agricultural Land Reform Executive Committee (ALRC)

The Executive Committee consists of the Minister of MOAC as Chairperson, the Permanent Secretaries of MOAC, Commerce, Interior and Industry, the Director Generals of governmental organizations concerned, the Manager of BAAC, farmers’ representatives, etc. The Secretary-General of ALRO serves as member and secretary.

The Executive Committee has the power, duties and responsibilities of prescribing policies, measures, rules or regulations concerning land reform implementation undertaken by

ALRO as well as supervising ALRO's administration, and also has the power, duties and responsibilities indicated in Section 19 of the Act.

4) Provincial Land Reform Committee (PLRC)

The Provincial Land Reform Committee consists of a Provincial Governor as Chairperson, the Directors of Provincial Offices of governmental organizations concerned, etc. The Director of PLRO acts as member and secretary.

The Provincial Land Reform Committee has the power, duties and responsibilities of establishing operational measures and procedures taken by the Provincial Land Reform Office, and has the power, duties and responsibilities indicated in Section 20 of the Act.

1.6.2 Agricultural Land Reform Office (ALRO)

The implementation of agricultural land reform under the Act will be composed of three activities; "land provision", "land distribution" and "development", and the role and responsibilities of ALRO will be mainly devoted to the two activities of "land distribution" and "development".

1) Land Provision

Land reform areas consist of public land and private land that is purchased or expropriated from landowners. However, there is very little private land and it accounts for only 1.2% of all LRAs. Most public land is encroached forest reserve areas that are almost fully occupied by farmers and are transferred to ALRO from the Royal Forestry Department.

2) Land Distribution

Land distribution involves cadastral survey, checking of ownership, issue of land use certificates, etc. and is carried out by the Land Reform Operating Division, the Land Reform Financing Division and PLROs.

At present, the target of ALRO for land distribution is more than 1.8 million rai (100,000 household) per year, and ALRO has not followed the unrealistic policies of the Accelerated Agricultural Land Reform Master Plan for 1992 to 1999 and the original Master Plan for 1992 to 2006.

3) Development

The development of LRAs by ALRO will be divided into two main activities as shown below:

a) Infrastructure Development:

Infrastructure development within LRAs by ALRO is carried out by the Engineering Division and includes provision of water resources, access roads, small irrigation facilities, etc.

b) Income generating activities and restructuring of agricultural production:

These activities include construction of farm ponds for integrated farming, establishment of cooperatives, etc. and will be mainly carried out by the Land Reform Operation Division and the Land Reform Financing Division.

Other activities such as provision of village roads, medium and large-scale irrigation facilities, agricultural extension, credit, etc. will be implemented by other governmental agencies. In the case that such development activities are included in integrated agriculture development projects in LRAs, ALRO will coordinate with the other agencies who have direct responsibility for those activities. Its role as coordinating agency is one of the most important roles of ALRO in developing LRAs.

ALRO has set up the following three development levels;

- Level-1 :Provision of basic agricultural infrastructure so as to meet farmers' subsistence level (Basic Development Stage)
- Level-2 :Provision of water supply and marketing facilities with the aim of improving living conditions and increasing farmers' income in addition to provision of the infrastructure of Level-1 (Rural Development Stage)
- Level-3 :Further improvement of conditions of agricultural production and farmers' living conditions of with land consolidation in addition to Levels 1 and 2 (Land Consolidation Stage)

The development level of the ALRO project has been decided by taking into account the degree of development potentiality and farmers' readiness, amount of available budget, etc.

ALRO currently has 1,184 staff in its central office organized into eight administrative units as shown in Figure 1.6-1. The Divisions with a large number of staff are the Engineering Division, which has 340 staff and is responsible for engineering, construction work carried out by force account or contract and maintenance work, the Land Reform Operation Division (266 staff) and the Research and Planning Division (208 staff). In addition, Provincial Land Reform Offices have been established in 68 provinces and have 1,223 staff in total.

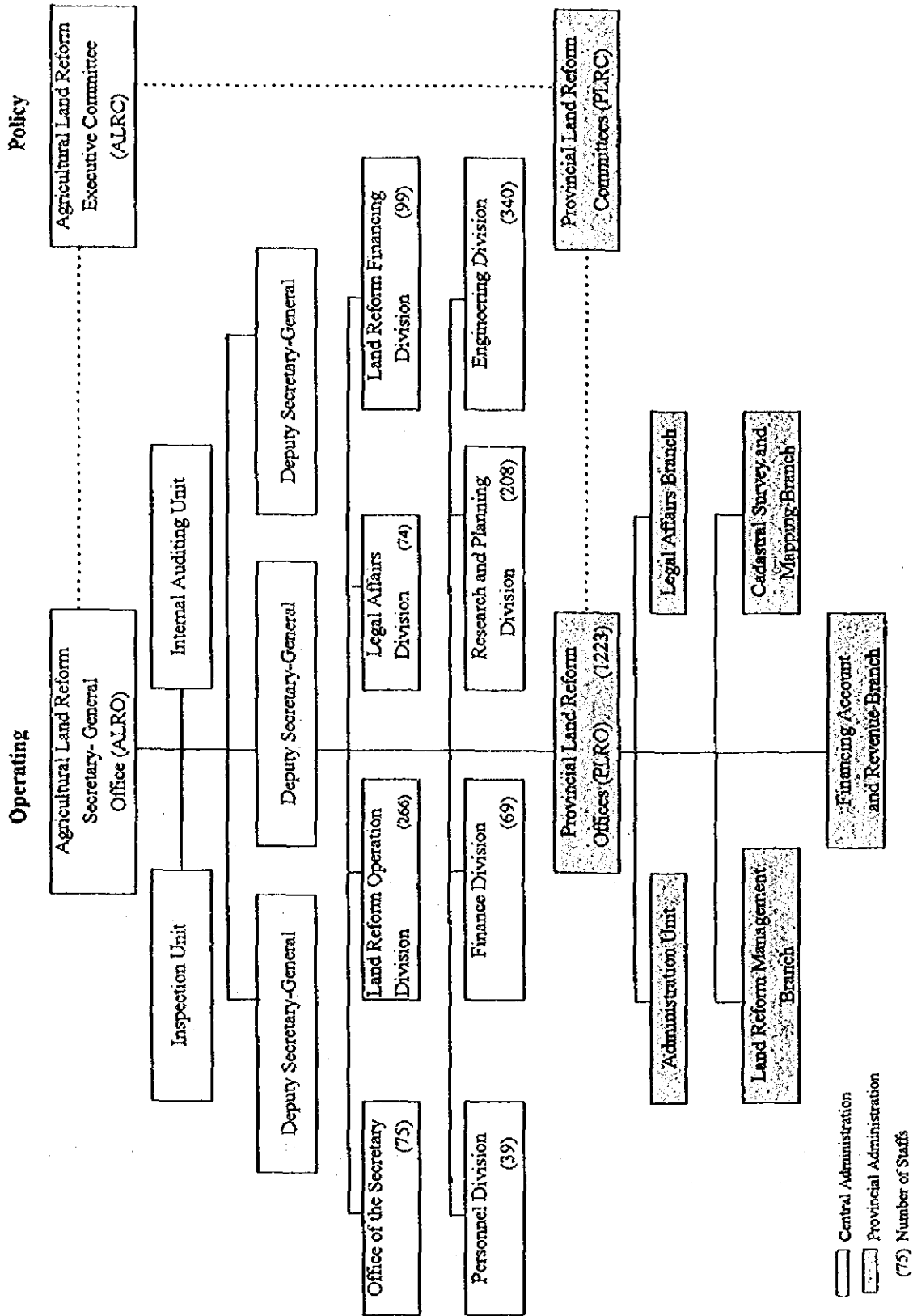


Figure 1.6-1 Organization of Agricultural Land Reform Implementation

b) **Income generating activities and restructuring of agricultural production:**

These activities include construction of farm ponds for integrated farming, establishment of cooperatives, etc. and will be mainly carried out by the Land Reform Operation Division and the Land Reform Financing Division.

Other activities such as provision of village roads, medium and large-scale irrigation facilities, agricultural extension, credit, etc. will be implemented by other governmental agencies. In the case that such development activities are included in integrated agriculture development projects in LRAs, ALRO will coordinate with the other agencies who have direct responsibility for those activities. Its role as coordinating agency is one of the most important roles of ALRO in developing LRAs.

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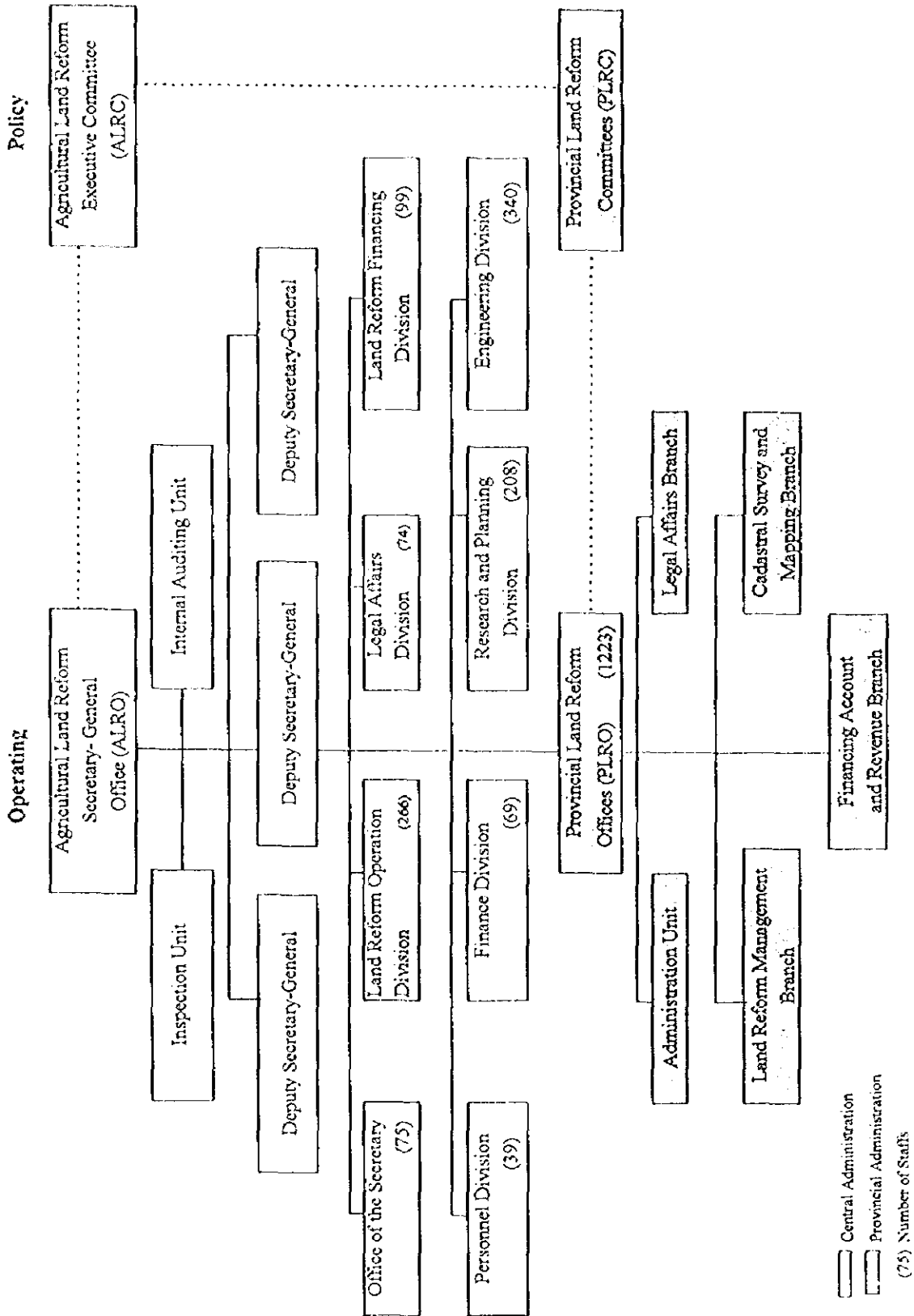


Figure 1.6-1 Organization of Agricultural Land Reform Implementation

The annual budget for fiscal year 1996 was as shown below;

Annual Budget (1996)		
	(million baht)	
1. Government Budget	843,200	
2. MOAC	74,300	
3. ALRO	2,166	(100%)
- Preparation Administration	605	(28%)
- Land Distribution	872	(40%)
- Infrastructure Development	526	(24%)
- Income Generation, etc.	108	(5%)
- Special Projects	55	(3%)

1.7 Government Organization for Development of LRAs

At present, rural development projects may be divided into two types namely, regular projects under each agency, and the projects under the program named rural development and decentralization of growth to the regions and locality. Under the existing administrative structure, the administrative body has been divided into three separate bodies, i.e. central administration, local administration and local government. Regarding the development of LRAs, there are many activities such as infrastructure, agriculture and community development and various government agencies involved in relevant development projects.

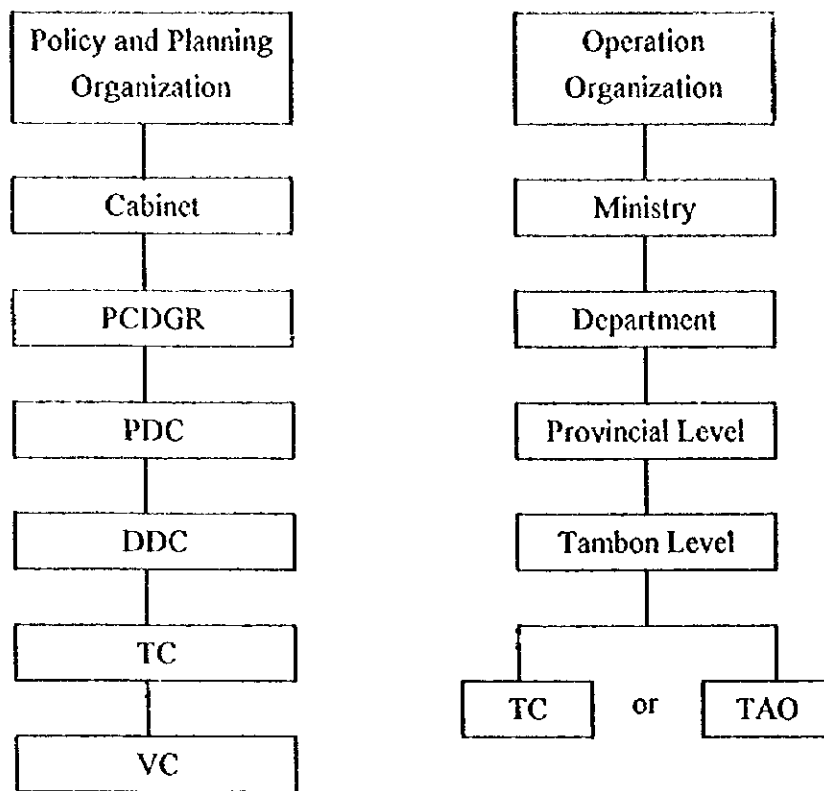
As for regular development projects under each government agency, operational organization at the central level is in the form of Ministries and Departments. Departments have provincial offices and Amphoe offices. In some cases, there are Tambon offices. According to the Agricultural Land Reform Act, the Agricultural Land Reform Executive Committee and Provincial Land Reform Committee shall have the responsibility of prescribing policies and monitoring implementation programs and ALRO's administration, and also act as external coordination with other Ministries and agencies concerned at the central level and the provincial level respectively. Furthermore, there are the Offices of Agriculture and Cooperatives in many provinces performing internal coordination with all agencies under the jurisdiction of MOAC. In some provinces, an Agriculture Development Committee presided over by the Director of the Office of Agriculture and Cooperatives. This Committee is performing an important role in integrated agricultural development projects in LRAs.

For implementation of rural development and decentralization of growth to the regions and locality, government organization serving the development administration is composed of:

- 1) A National Committee, named policy committee for rural development and decentralization of growth to the regions and locality, consists of the Prime Minister as Chairperson, Ministers and representatives of the private sector as committee members. The Secretary General of NESDB acts as member and secretary. This organization has responsibility for the determination of policy, programs, budget and implementation. In addition, there are various sub-committees with different activities, such as sub-committee for decentralization of growth to the regions and locality.
- 2) A Provincial Development Committee has responsibility for planning, implementation and administration at the provincial level.
- 3) A District Development Committee has responsibility for planning, implementation and administration at the district level.
- 4) Organization at Tambon level using the existing organization of Tambon Council or Tambon Administrative Organization.

The structure, authority and function of each organization at the national level, provincial level and district level are certified for operation by the Regulations of the Office of the Prime Minister. Figure 1.7-1 shows rural development and decentralization Programs Organization System.

At present, three main infrastructure development activities are being conducting in LRAs, namely, the provision of roads, domestic water and agricultural water. The main government implementing agencies for infrastructure development are shown in Table 1.7-1 and for activities of agricultural production in Table 1.7-2.



Notes:

- PCDGR = Policy Committee for Decentralization of Growth to the Regions and Locality
- PDC = Provincial Rural Development Committee
- DDC = District Rural Development Committee
- TC = Tambon Rural Development Committee
- VC = Village Rural Development Committee
- TC = Tambon Council
- TAO = Tambon Administrative Organization

Figure 1.7-1 Rural Development and Decentralization Programs Organization System

Table 1.7-1 Main Governmental Agencies for Implementing the Rural Infrastructure Development Plan of the 8th National Plan

Agencies Involved	Domestic Water Supply			Agricultural Water Use				Road
	Wells	Ponds	Piped Water Supply	Large Scale	Medium Scale	Small Scale	Farm Pond	
MOAC								
ALRO	x	x				x	x	x
DLD		x				x		
CPD						x	x	
MASU		x				x		
RID		x		x	x	x	x	
DOF						x		
MOI								
DOLA	x	x	x			x		
ARD	x	x	x			x		x
PWD	x		x			x		x
PWA			x					
Ministry of Public Health								
DOH	x	x	x					
Ministry of Industry								
DMR	x							
Ministry of Science, Technology and Environment								
DEDP				x	x			

Notes: MOAC Ministry of Agriculture and Cooperatives
 MOI Ministry of Interior
 MASU Mobile Agricultural Service Unit, MOAC
 DOLA Department of Local Administration

Table 1.7-2 Main Governmental Agencies for Supporting Agricultural Production Activities

Activities	Governmental Agencies								
	ALRO	DLD	DOA	DOAE	DOF	DOL	RFD	CPD	BAAC
Research & Development		x	x		x	x	x		
Extension Services				x					
Technology Transfer		x	x	x	x	x	x	x	
Training of Officials		x	x		x	x	x		
Training of Farmers				x				x	
Demonstration		x	x	x	x	x	x		
Subsidize Production Input				x				x	
Cooperatives Promotion	x							x	x
Analysis Services		x	x		x				
Legal Activities	x		x		x	x	x	x	
Agricultural Credit	x			x				x	x
Marketing				x				x	x

CHAPTER 2 THE STUDY AREA

CHAPTER 2 THE STUDY AREA

2.1 Administrative Division

The national administrative system is of great importance to the development of the country. It serves as an instrument of the government and as an institution trusted by the people. In general, the national administrative system is divided into three separate bodies as follows:

- a) Central Administration under the principle of centralization.
- b) Local Administration following the principle of decentralization.
- c) Local Government under the principle of dispersal of power.

At the central administration level, it consists of various Ministries, each of which is divided into Departments, Divisions and Sections. Each Ministry is headed by a Minister, and a Permanent Secretary is the top civil servant in each Ministry, whereas each Department is headed by a Director General.

Local administration includes provinces, districts, subdistricts, and villages. A province has a Governor and one or two Deputy Governors, and each district (Amphoe) has a Nai Amphoe and one or two assistants (Palad Amphoe). Subdistricts are headed by a Kamnan and every village by a Phuyaiban.

In general, the Governor is the chief provincial administrator who is under the direct authority of the Ministry of Interior. He is responsible for all public matters concerning the province and its surrounding districts. Although the Governor is the top civil servant in the province, he or she does not have direct authority over officials of those government agencies outside the Ministry of the Interior. Some Departments have their own independent field agencies, for example, the Department of Highways has no formal connections with provincial and district authorities.

Table 2.1-1 shows the administrative division, area, population, and household by Amphoe related to the Study Area, and village and acreage in the Study Area.

2.2 Area and Population

2.2.1 Area

The Study Area covers 35 Land Reform Areas in the four provinces of Khon Kaen, Mahasarakham, Sakon Nakhon and Mukdahan in the Upper Northeastern Region.

Table 2.1-1 Administrative Division, Area, Population and Household by Amphoc related to the Study Area and Village, and Acreage in the Study Area (1/2)

Province	Amphoc	Administrative Division			Whole Amphoc		Study			
		Tambon	Village	Municipalities	Sanitary District	Area (Km ²)	Population	Household	Village	Acreage (Km ²)
Khon Kaen	Muang Khon Kaen	17	208	1	1	958.2	253,027	78,637	4	13.78
	Ban Phai	10	93	1	1	888.2	91,176	26,618	13	94.45
	Phon	12	113	1	-	424.0	73,078	17,673	5	25.07
	Nam Pong	12	147	-	2	675.0	108,399	22,478	6	10.01
	Manchakiri	8	105	-	1	923.0	73,853	15,266	27	29.40
	Nong Song Hong	12	125	-	1	511.6	74,370	14,080	6	57.53
	Chon nabor	8	77	-	1	312.5	51,236	10,251	17	65.02
	Wang Noi	6	61	-	1	277.0	32,369	8,108	5	9.25
	Wnag Yai	5	46	-	1	223.0	28,710	5,403	8	36.40
	Ban Fnag	7	66	-	1	342.0	51,420	n.a	14	27.61
	Puai Noi	4	29	-	1	137.5	19,030	3,735	7	47.70
	K. A Phochai	4	37	-	1	238.0	25,072	5,183	6	12.50
									118	428.71
Mahasarakham	Muang Mahasarakham	14	178	1	1	556.69	151,056	30,358	10	18.13
	Chiang Yun	10	147	-	1	402.03	84,450	17,290	17	11.95
	Kosum Phusai	14	214	-	1	827.87	186,174	24,095	22	101.99
	Borabu	15	175	-	1	681.62	107,598	21,314	40	99.96
	Wapi Pathum	15	215	-	1	605.77	113,156	20,008	5	7.40
	Na chuak	10	125	-	1	528.79	59,116	11,332	16	26.95
	Na Dun	9	91	-	1	248.44	35,169	6,677	7	21.00
	K. Amphoc Kut Rung	5	61	-	-	267.00	34,214	6,993	32	54.08
									149	341.46

Table 2.1.1-1 Administrative Division, Area, Population and Household by Amphoe related to the Study Area and Village, and Acreage in the Study Area (2/2)

Province	Amphoe	Administrative Division			Whole Amphoe			Study		
		Tambon	Village	Municipalities	Sanitary District	Area (Km ²)	Population	Household	Village	Acreage (Km ²)
Sakhon Nakhon	Muang Sakhon Nakhon	16	163	1	2	1,184	176,172	34,229	2	19.09
	Kut Bak	3	22	-	1	456	30,759	5,471	17	185.98
	Nikhon Nam Oon	4	28	-	-	162	12,611	2,412	6	29.71
	Phanna Nikhom	10	99	-	1	534	75,401	14,662	13	94.20
	Sawang Daen Din	16	156	-	2	1057	144,998	28,297	2	11.00
	Charoen Silp	5	42	-	1	314	40,453	6,937	10	58.72
	Waritch Phum	5	60	-	1	445	53,470	8,683	5	57.31
	Kham Takla	4	46	-	1	402	35,877	6,261	2	18.24
	Ben Muang	9	78	-	1	850	64,201	11,463	1	36.50
	Akat Amnuai	8	69	-	1	585	63,565	11,333	-	2.88
	Phang Khon	5	52	-	1	384	49,022	8,175	-	5.34
	K. Amphoe Phu Phan	4	43	-	-	559	31,259	6,189	26	154.19
									84	673.16
	Mukdahan	Muang Mukdahan	12	130	1	-	1,235	116,722	25,137	30
Dong Luang		6	50	-	-	1,070	32,250	5,835	25	136.80
Don Tan		7	50	-	1	511	39,500	7,286	10	107.49
Nihom Kham Soi		7	77	-	1	377	41,840	7,799	12	129.50
Kham Cha I		9	79	-	1	646	44,590	8,089	6	70.00
Nong Soong		6	44	-	-	410	20,054	4,105	11	48.43
	Grand Total								94	766.76
									445	2,210.09

Source: Khon Kaen, Mahasarakham, Sakon Nakhon and Mukdahan Provincial Office, 1996

The number of LRAs in each province and their acreage are as follows:

Table 2.2-1 LRAs in each Province

Province	Nos. of LRAs	Total Area	Farm Land	Distributed Area
Khon Kaen	6	267,920rai	263,000rai	185,000rai
Maha Sarakham	10	21,610	214,860	15,000
Sakhon Nakhon	7	420,750	409,360	416,000
Mukdahan	12	479,270	470,390	73,000
Total	35	1,386,550	1,357,610	689,000

The Study Area is administratively composed of 38 Amphoe in 4 provinces. There are 12 Amphoe in Khon Kaen, 8 in Mahasarakham, 12 in Sakon Nakhon and 6 in Mukdahan. Of these, no Amphoe was fully covered by the Study Area. Approximately, only 4 Amphoe covered more than 50% of LRAs, i.e. Amphoe Kut Bak and King Amphoe Phu Phan in Sakon Nakhon, Amphoe Dong Luang in Mukdahan and King Amphoe Kut Rung in Mahasarakham.

2.2.2 Population

The Northeast Region or Esarn is the largest region in the country, covering one-third of the whole Kingdom. It is the poorest region in terms of natural resources, economy and personal income. Over the last decade, population in the Northeastern Region has increased from 18 million to about 20 million. The people have many ethnic origins. Most of them are Thai-Lao ethnic groups. By 1992, approximately 87% of all households in the Northeastern Region were in outside municipal areas and outside sanitary districts. Most of the area is considered to be rural.

The population of farm families who have a land in LRA, average land holding and number of the households could be summarized as follows :

Table 2.2-2 Population & Number of Farm Families in the Study Area

Province	Population	Land Holding (rai/H.H)	Nos. of Households
Khon Kaen	61,400	22	12,280
Maha Sarakham	59,500	18	12,360
Sakon Nakhon	129,900	17	25,980
Mukdahan	142,100	16	28,420
Total	392,900	18	79,040

The people in Sakon Nakhon and Mukdahan are of various ethnic origins, such as Phu-Thai, Thai-Yor, Thai-Yoy Thai Ka Leng, Thai So and Thai Ka Tark in Sakon Nakhon and Phu-Thai, Thai Yor, Thai Ka, Thai So, Thai Ka Leng, Thai Sake and Thai Kula in Mukdahan. These people migrated from what is now the Lao People's Democratic Republic to settle in these two provinces several centuries ago.

In 1996, the average growth rate of population in Mukdahan was estimated at about 1.74% per annum. According to estimations by the Khon Kaen and Mahasarakham Provincial Offices, the average population growth rate during 1995-2000 will be 1.15% per annum and 1.00% per annum in Khon Kaen and Mahasarakham province respectively.

The majority of the people in the four provinces have been working in agricultural sector since ancient times. Agriculture is important for the social and economic situation of the people. However, farming activities in the Northeastern Region predominantly take place in wet season. Hence, the seasonal migration to urban areas or to towns occurs after the end of the wet season harvest because of the inability of cultivation of dry season crops in most of the areas. The labour force composition of the four provinces in the Study Area in 1996 (February) is shown in Table 2.2-3.

Table 2.2-3 Labour Force Composition (as of Feb. 1996) (1/2)

Khon Kaen Province		Maharakham Province	
Total Population	1,740,485 (100%)	Total Population	940,887 (100%)
13 years and over	1,313,789 (75.48%)	13 years and over	705,390 (74.97%)
under 13 years	426,696 (24.52%)	under 13 years	235,497 (25.03%)
Labour Force Population	918,007 (52.74%)	Labour Force Population	472,082 (50.17%)
Non-Labour Population	395,782 (22.74%)	Non-Labour Population	233,308 (24.80%)
Housewife	66,802 (16.89%)	Housewife	77,904 (33.39%)
Student	189,835 (47.96%)	Student	89,096 (38.19%)
Unemployed Persons	24,555 (2.68%)	Unemployed Persons	8,313 (1.76%)
Young Persons old age Persons unable to work		Young Persons old age Persons unable to work	
Others	139,145 (35.15%)	Others	66,308 (28.42%)
Total Employed Persons	893,452 (97.32%)	Total Employed Persons	463,769 (98.24%)
Seasonally in active labour force	30,854 (3.45%)	Seasonally in active labour force	61,425 (13.24%)
Regular Employed Persons	862,598 (96.55%)	Regular Employed Persons	402,344 (86.76%)
Agriculture Section	307,867 (35.69%)	Agriculture Section	212,859 (52.90%)
Non-agriculture Section	554,731 (64.31%)	Non-agriculture Section	189,485 (47.10%)

Source: National Statistical Office, Office of The Prince Minister

Table 2.2-3 Labour Force Composition (as of Feb. 1996) (2/2)

Sakon Nakhon Province		Mukdahan Province	
Total Population	1,004,486 (100%)	Total Population	280,590 (100%)
13 years and over	722,791 (71.96%)	13 years and over	201,192 (71.70%)
	under 13 years 281,697 (28.04%)		under 13 years 79,397 (28.30%)
Labour Force Population	523,914 (52.16%)	Labour Force Population	152,815 (54.46%)
	Non-Labour Population 198,877 (19.80%)		Non-Labour Population 48,377 (17.24%)
	- Housewife 60,522 (30.43%)		- Housewife 11,935 (24.67%)
	- Student 83,821 (42.15%)		- Student 19,724 (40.77%)
	- Young Persons old age Persons unable to work		- Young Persons old age Persons unable to work
Total Employed Persons	502,513 (95.92%)	Total Employed Persons	138,517 (90.64%)
	Unemployed Persons 21,401 (4.08%)		Unemployed Persons 14,298 (9.36%)
	Seasonally in active labour force		Seasonally in active labour force
	68,291 (13.59%)		376 (0.27%)
Regular Employed Persons	434,222 (86.41%)	Regular Employed Persons	138,141 (99.73%)
	Agriculture Section 191,195 (44.03%)		Agriculture Section 79,944 (57.87%)
	Non-agriculture Section 243,027 (55.97%)		Non-agriculture Section 58,197 (42.13%)

Source: National Statistical Office, Office of The Prince Minister

2.3 Provincial Economy

Khon Kaen Province which has a population of nearly 1.7 million has the role of being one of the economic hubs in the Upper Northeastern Region. The GPP of Khon Kaen in 1994 was 51,300 million baht and ranked third in the Northeastern Region. The major industries, which employ about 29,000 workers, are textiles and agri-processing. Large- and medium- scale industries are closely related to raw agricultural materials in local and surrounding areas. Most-medium and small-scale factories are both local and sub-regional market-oriented.

The province also plays an important role as a regional warehouse for various commodities. Goods imported from elsewhere are re-distributed to surrounding provinces and other regions, and Khon Kaen has a well-developed road network.

Major export items are agricultural products and processed agri-products such as rice, sugar, pulp and paper, garments, handicrafts, silk products, papaya, fish etc. Import items are construction materials, machinery, fertilizer, chemicals, fuel, electrical appliances, automobile spare parts etc.

Table 2.3-1 Top 4 Sector and the Output Percentage of GPP in each Province as of 1994

Whole Country	%	N.E Region	%	Khon Kaen	%
1.Manufacturing	28.2	1.Wholesale and Retail	21.3	1.Manufacturing	22.9
2.Wholesale and Retail	16.4	2.Agriculture	19.0	2.Wholesale and Retail	15.5
3.Services	12.6	3.Services	16.0	3.Services	14.2
4.Agriculture	10.2	4.Manufacturing	10.2	4.Construction	9.9
5.Others	32.6	5.Others	33.5	5.Others	37.5

Mukudahan	%	Sakhon Nakohn	%	Maha Sarakham	%
1.Wholesale and Retail	21.6	1.Wholesale and Retail	23.7	1.Wholesale and Retail	22.0
2.Agriculture	20.7	2.Agriculture	19.1	2.Agriculture	21.0
3.Construction	12.7	3.Services	15.5	3.Services	19.9
4.Services	11.6	4.Construction	10.7	4.Construction	9.4
5.Others	33.4	5.Others	31.0	5.Others	27.7

Maha Sarakham Province which borders Khon Kaen in the south-east only accounts for one-tenth of that in Khon Kaen in the economic scale. Its main industries are the wholesale and retail trade of goods and agriculture. Major export items are raw agricultural products such as rice, sugarcane, cattle, and cotton products for industrial products. As the province is not self-sufficient in food supply, agricultural products such as poultry, cattle, vegetables, and fish are being brought from other regions. Furthermore, as manufacturing industry is not so well developed, industrial products such as consumer goods, fertilizer, chemicals, fuel, electrical appliances, and automobile spare parts come mainly from Khon Kaen Province.

Mukudahan Province which borders the Mekong River also has a Northeastern typical regional economy structure much like that of Maha Sarakham. However, if an international

bridge between Laos and Thailand were constructed, as a connecting point of international trade, the economic growth potential of Mukudahan province would be immense.

Sakhon Nakhon Province also has the same regional economy structure as those of Mukudahan and Maha Sarakham. But the degree of dependency on neighboring big cities is lower. Sakohn Nakhon purchases industrial goods from a big neighboring city, Udon Thani.

Regional economic analysis can be summarized as follows.

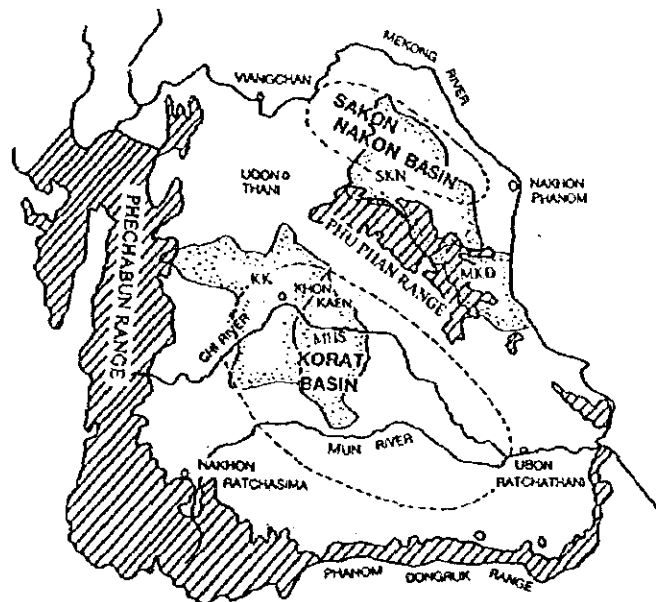
Principal provinces with fairly large populations and some manufacturing industry play important roles as regional economic hubs in that goods from elsewhere are re-distributed to surrounding provinces and other regions. Furthermore, these provinces attract investment from Bangkok-based companies.

In provinces with typical regional economic structure in the Northeastern Region, that is, the latter three provinces, the main industries are wholesale and retail trade of goods and agriculture. Major export items are raw agricultural products such as rice, sugarcane etc. which are bought and sold in local and neighboring cities. And consumer goods and industrial goods such as fertilizer, chemicals, fuel, electrical appliances, automobile spare parts come from large neighboring cities and Bangkok.

2.4 Topography and Geology

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. The flatland slopes gently to the east. Elevation of the flatland ranges from 150 m to 190 m (MSL). The undulating land forms the 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 the steeper and higher ranges such as the Phu Phan Range which runs along the



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

Figure 2.4-1 Physiography of the Northeast Thailand

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.

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. More detailed topographical factors are described in Table 2.15-1.

2) Geology

The study LRAs are usually dominated by Mesozoic sedimentary rocks (Khorat Group) consisting of the Jurassic to the Upper Cretaceous excluding the Huai Hin Lat Formation. Quaternary unconsolidated sediments unconformably overlie the Mesozoic. The stratigraphy in the study area is composed of the following formations and deposits:

- Mesozoic Era

Nam Phong Formation

Phu Kradung Formation

Phra Wihan Formation

Sao Khau Formation

Phu Phan Formation

This formation forms the mountain ranges like as Phu Phan Range, mainly composed of sandstone and silt stone.

Khok Kruat Formation

This formation lies under Maha Sarakham Formation and contains gypsum. It outcrops in some cases at the piedmont of Phu Pham Range. It is necessary to conduct careful geological investigation, when it outcrops in the reservoir area.

Maha Sarakham Formation

It lies extensively under the quaternary deposits. It causes salinization in the area due to rock salt contained in this formation.

- Cenozoic Era

Quaternary Deposits

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

3) Salt Problem

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 2.4-1. 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 the rock salt strata thickly deposited in Maha Sarakham Formation. 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. (Details are in Figure 2.4-1 in Appendix D)

4) Sandy Topsoil and Clayey Subsoil

Northeastern Region is also well known as the area where sandy topsoil widely spreads. LRAs are also covered by sandy soil in general especially in upland fields.

Two different hypotheses have been proposed about the forming the sandy cover. One is windblown and washout. ADRC stands on windblown hypothesis in "Salt-affected Area in Northeast Thailand, Nature, Properties and Management, ADRC, JICA December 1994". They considered that sandy materials were blown and supplied everywhere in Northeast Thailand from the surrounding mountain ranges in dry climate during glacial epochs. Clayey or loamy subsoil generally lies under sandy topsoil. There exists this subsoil also in LRAs which contributes to water tightness of farm ponds. Thickness of sandy topsoil is considered about one meter from the field reconnaissance survey. However, its thickness differs and reaches to two to three meters by lacerations. It is recommended to check the depth of sandy topsoil by auger boring where farm pond development is proposed.

5) Soil Erosion in the LRAs

There are no serious soil erosions in the LRAs, but some can be observed in upland fields plowed to the sloping direction. Some steep land accounts for about 7% or 15,500 ha of the area, where the slope is over 5%, as shown in Table 2.15-1.

Soil erosions are observed in a part of deteriorated forests, where illegally invaded recently, rather than in LRAs. Although these soil erosions are not yet grasped, it is necessary to prevent encroachment in order to decrease soil erosion by increasing productivity in the LRAs.

2.5 Meteorology and Hydrology

2.5.1 Meteorology

1) General Climate

The climate within the Study area is influenced by two seasonal monsoons and inter-tropical convergence zone. The monsoons are designated as the southwest monsoon and the northeast monsoon and create two typical seasons; rainy and dry during the year.

The rainy season begins in mid-May and ends around mid-October. It is a period of frequent and heavy rainfall, high humidity, maximum cloudiness and tropical temperatures.

The heaviest rainfall generally occurs in August and September.

The dry season normally starts from mid-October and prevails until the middle of February. It is characterized by relatively little rainfall, low humidity, least cloudiness, and low temperature.

The summer season starts from the cession of the northeast monsoon which is approximately in the middle of February and ends around mid-May. The weather in this period is rather hot with high temperature and low rainfall and humidity.

2) Data used for Analysis of Meteorology

Climatic data are necessary to understand the present condition and characteristics of the study area for a study of potential development of water resources. Data of temperature, humidity, wind velocity and sunshine duration are collected from MD (Table 2.5-1). Rainfall data and discharge data are collected from RID and DEDP. The location of stations used for analysis is shown Figure.B-1, B-2.

Table 2.5 -1 Synoptic Meteorological Stations

Province	Khon Kaen	Maha Sarakham	Mukdahan	Sakon Nakhon
Station	Khon Kaen	Kosum Phisai	Mukdahan	Sakon Nakhon
Index Station	48381	48382	48383	48356
Latitude	16 26 N	16 15N	16 32 N	17 09 N
Longitude	102 50 E	103 04 E	104 43 E	104 08 E

3) Temperature

Temperature data are collected from MD and averaged over a 30-year period from 1966 to 1995. These data are measured at the capital of each province except Maha Sarakham (Kosum Phisai) The temperature is tropical and average values are a maximum of 30.7°C in April at Kosum Phisai to a minimum of 21.8°C in December at Sakon Nakhon on a monthly basis. The average of maximum temperature is 36.5°C in April at Khon Kaen and 28.3°C in December in Mukdahan is the lowest.

Table 2.5-2 Temperature (°C)

Mean	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Khon Kaen	23.0	25.6	28.5	30.1	29.0	28.5	28.0	27.5	27.1	26.3	24.5	22.6	26.7
Maha Sarakham	23.6	25.7	28.3	30.7	29.5	28.7	28.3	27.8	27.7	26.3	24.7	23.0	27.0
Mukdahan	22.5	24.9	28.0	29.6	28.9	28.2	27.8	27.2	27.3	26.2	24.2	22.0	26.4
Sakon Nakhon	22.1	24.4	27.4	29.1	28.3	27.9	27.7	27.2	27.2	26.2	24.1	21.8	26.1
Mean Max.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Khon Kaen	30.5	32.9	35.4	36.5	34.7	33.4	32.8	31.9	31.7	31.4	30.8	29.8	32.7
Maha Sarakham	30.5	33.0	35.3	36.5	34.9	33.4	32.9	32.4	31.8	31.1	30.4	29.5	32.6
Mukdahan	29.4	31.7	34.4	35.6	34.0	32.3	31.9	31.1	31.4	30.8	29.4	28.3	31.7
Sakon Nakhon	28.9	31.0	33.7	34.9	33.3	32.1	31.7	31.0	31.2	30.8	29.8	28.4	31.4

(data source : MD)

4) Humidity

Relative humidity data are collected from MD and are averaged over a 30-year period from 1966 to 1995, same as temperature data. Humidity values show a fluctuation from 59% in March at Khon Kaen to 83% in August at Mukdahan and Sakon Nakhon. Among the four stations, the value at Mukdahan and Sakon Nakhon are higher than those of Khon Kaen and Maha Sarakham by 3 to 4% during June and August. The difference of each value among the four stations comes close in February and September at 1%.

Table 2.5-3 Relative Humidity (%)

Mean	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Khon Kaen	61	62	59	62	72	76	77	80	82	77	70	66	71
Maha Sarakham	67	64	61	64	73	76	77	79	82	78	72	69	72
Mukdahan	66	63	60	63	74	79	80	83	81	75	69	68	72
Sakon Nakhon	66	63	61	65	76	80	81	83	82	75	69	67	72

(data source : MD)

5) Wind velocity

Wind data are collected from MD in the form of average velocity and prevailing wind direction. Wind velocity at Mukdahan has a higher monthly average and also a yearly average of 4.9 knots and 3.2 knots respectively. Meanwhile, it blows calmly at Maha Sarakham ranging from 0.5 knots to 1.7 knots and with an annual average of 1.0 knots.

The prevailing wind blows in two major directions. One is the northeast or east in direction prevailing from October to February, the other is south or southwest in direction prevailing from March to May.

Table 2.5-4 Wind (Knots)

Mean	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Khon Kaen	1.5	1.7	2.1	2.1	2.2	2.6	2.6	2.4	1.4	1.6	1.9	1.8	2.0
Maha Sarakham	0.6	0.9	1.1	1.4	1.1	1.7	1.4	1.2	0.5	0.6	0.8	0.9	1.0
Mukdahan	3.5	3.3	3.3	3.0	2.4	2.5	2.6	2.4	2.1	3.6	4.9	4.3	3.2
Sakon Nakhon	3.1	3.5	3.4	2.7	2.2	2.3	2.5	2.4	1.7	2.3	2.8	2.7	2.6
Prevailing wind	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Khon Kaen	NE	NE	S	S	S	SW	SW	SW	SW	NE	NE	NE	
Maha Sarakham	NE	NE,E	S	S	S	S	SW	S	S	NE	NE	NE	
Mukdahan	NE	NE,E	S	S	S	S	SW	S	S	NE	NE	NE	
Sakon Nakhon	E	E	E	E,SE	S	SW	SW	SW	E	E	E	E	

(data source : MD)

6) Sunshine Duration

Sunshine duration data are collected from the Meteorological Department but there no observations are made at Cesium Phisai and Mukdahan. There is not so great a difference in sunshine duration (hr.) between Khon Kaen and Sakon Nakhon. It normally shines for more than 200 hr. except during June to September in the rainy season. Annual sunshine duration comes to 2,600 hrs in both Khon Kaen and Sakon Nakhon.

7) Rainfall and Drought

Rainfall data is one of the most important hydrological variables in any study of potential development of water resources. 22 rainfall stations, which are within/close to the study LRAs, have been selected as representative to each study area as shown in Table B-1, Appendix-B. These data are from the relevant government agencies RID, EGAT, MD and DEDP.

Average annual rainfall in Khon Kaen and Maha Sarakham is around 1,000 mm, and around 1,400 mm in Mukdahan and Sakon Nakhon as shown in Table 2.5-5.

Rainfall in the northeastern region as tropical climate differs greatly from year to year, season and also by region. Average rainfall is generally applied for the calculation of study in present situation and probable rainfall by unexceedance is applied for study of feature development potential. (see Table 2.5-5)

Table 2.5-5 Average and Drought Rainfalls at KK, MHS and MKD, SKN

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Year
KK MHS													
Average	68.2	154.9	134.8	120.5	141.7	244.4	90.3	11.8	5.4	3.7	13.0	32.2	1,021.0
Return P5	54.1	122.8	106.9	95.6	112.4	193.8	71.5	9.4	4.3	3.0	10.3	25.5	809.4 (79%)
Return P10	48.6	110.2	96.0	85.8	100.9	173.9	64.2	8.4	3.8	2.7	9.2	22.9	726.5 (71%)
MKD.SKN													
Average	80.3	194.9	247.5	230.5	315.8	240.2	76.1	2.9	3.3	3.4	5.6	25.0	1,425.5
Return P5	68.6	166.7	211.6	197.1	270.0	205.4	65.1	2.5	2.8	2.9	4.8	21.4	1,218.8 (85%)
Return P10	63.1	153.2	194.5	181.2	248.2	188.8	59.8	2.3	2.6	2.7	4.4	19.7	1,120.5 (79%)

(Note)

(average data : RID)

representative station 01040801(refer to 14022) for KK,MHS, 010222909(refer to 50180) for MKD,SKN.

Return P5 and Return P10 are calculated in proportion to the ratio of probable return year value and average value.

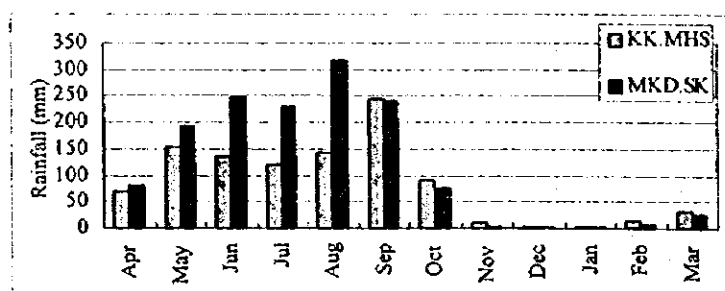


Figure 2.5 -1 Average and Drought Rainfall at KK, MHS and MKD, SKN

Regarding the distribution of daily rainfall, dry spells (serial-no-rain-days) are often observed of more than 7 days during month from May to September. One case recorded as sample at Station 21120 in Maha Sarakham in 1991 is shown. Of the monthly rainfall distribution concerned, a depression is found in July. Depressions in the rainy season and dry spells should be carefully studied in a later stage of the study, especially under rained irrigation system condition without any supplement water.

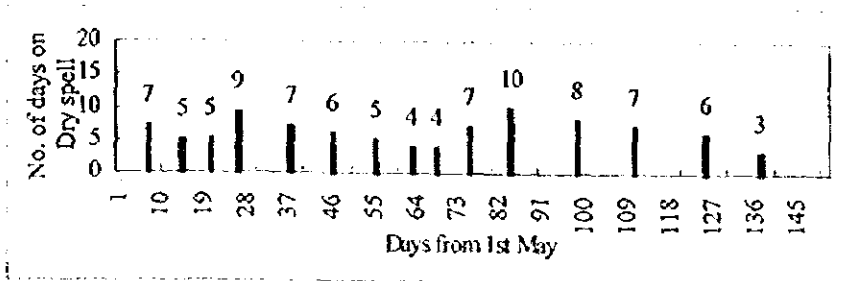


Figure 2.5-2 Occurrence of Dry Spells

2.5.2 Hydrology

1) Data used for Hydrology Analysis

Discharge data were collected from RID and DEDP, and data analysis is based on data from these two sources. The locations of discharge gauging stations used for analysis are shown in Figure B-1 and B-2.

2) Runoff Analysis and Runoff Coefficient

Runoff analysis and runoff coefficient are studied with the data collected from 17 measuring stations. The amount of runoff should differ according to the amount of rainfall, rainfall density, land slope of the catchment area, soil etc. Specific yield (liter/second/sq.km) is calculated for each station using the amount of discharge and discharge area. There is a general tendency regarding calculated specific yield that when the discharge area is larger, the specific yield is lower. And, when the discharge area is smaller, the specific yield is higher. The relation between specific yield and discharge area regress linearly on a logarithmic graph. The discharge height (discharge/discharge area: mm) is also calculated easily to grasp the amount of discharge in "mm".

Table 2.5 -6 Specific Yield and Runoff Height

Stream	Station	Dis. area (sq km)	Spec. Yield (l/s/sq km)	Runoff height(mm)
Huai Khan Thae Yai	KH85	28	19.0	600
Huai Bang-1	KH79	110	14.1	443
Huai Sai	KH84	48	21.0	643
Chi	E 9	11,020	5.4	170
Chi	E 8A	30,764	3.9	123
Chi	E 1	29,778	4.0	127
Huai Nam Man	KH57	79	11.0	345
Huai Nam Phung	KH21B	641	10.3	325
Song Khram	KH60	1,177	7.2	192
Songkham	KH74	2,145	23.6	510
Huai Bang-1	24001	702	20.7	652
Huai Bang Sai	23805	925	14.3	450
Huai Bang Sai	23801	1,340	13.3	419
Huai Bang Sai	23803	1,240	14.1	445
Huai Bang Sai	23804	1,220	13.3	421
Chi	41002	10,200	13.3	113
Chi	42001	28,500	6.9	78
Nam Un Dam		1,100	11.9	376
Nam Phung Dam		269	14.7	463

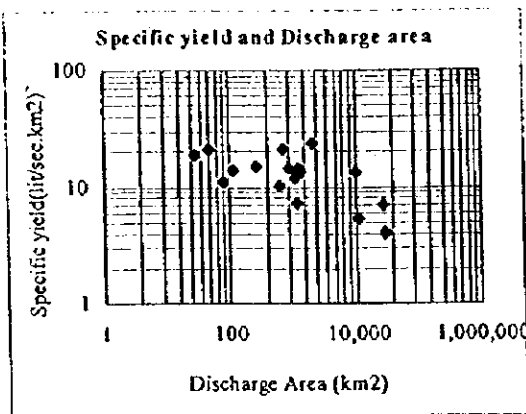


Figure 2.5-3 Specific Yield and Discharge Aea

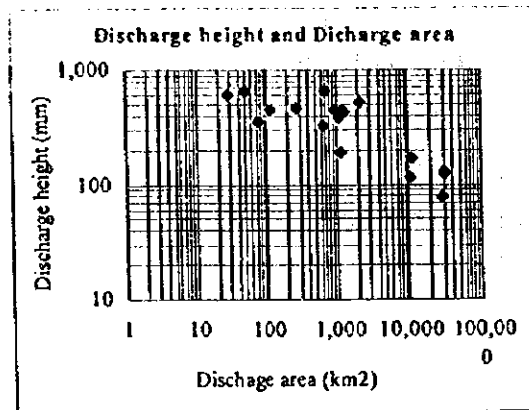


Figure 2.5-4 Discharge Height and Drainage Area

Runoff coefficient analysis is also carried out at the discharge stations comparatively with small discharge area on a monthly and also annual basis. Representative rainfall for a particular catchment area is compiled as weighted rainfall by of Thiessen method. There is a tendency on the runoff coefficient to increase from May to September or October in accordance with the start of rain and increase in rainfall in fairly small discharge areas. A major target in this study is concentrated on the medium or small scale water resource potential and also small ponds. A certain relation can be seen between runoff coefficient and discharge area on a logarithmic graph. For the estimation of discharge for particular catchment area such as a

reservoir or pond, the runoff coefficient of a 5-year return period is adopted in this study.

Table 2.5-7 Runoff Coefficient and Discharge Area

Station	Discharge area(km ²)	Runoff Coefficient (%)			period	Thiessen weight
		ReturnP 2	ReturnP 5	ReturnP10		
KH57	79	12.25	7.44	6.06	1978 - 1986	[50092]*1.0
KH79	110	34.96	26.69	22.85	1984 - 1994	[64032]*0.5, [64070]*0.5
KH81	48	44.53	34.51	29.76	1987 - 1994	[64032]*1/3, [64052]*1/3, [64070]*1/3
KH85	28	38.81	23.76	17.52	1987 - 1993	[64032]*0.5, [64070]*0.5
Nam Un Dam	1100	27.37	21.99	19.61	1974 - 1986	[50042]*0.5, [50180]*0.5
					1987 - 1995	[50042]*1/3, [50180]*1/3, [50362]*1/3
Nam Phung Dam	269	32.24	21.96	17.22	1969 - 1994	[50102]*1.0

(Note) [] in column indicate rainfall station code applied for weight rainfall

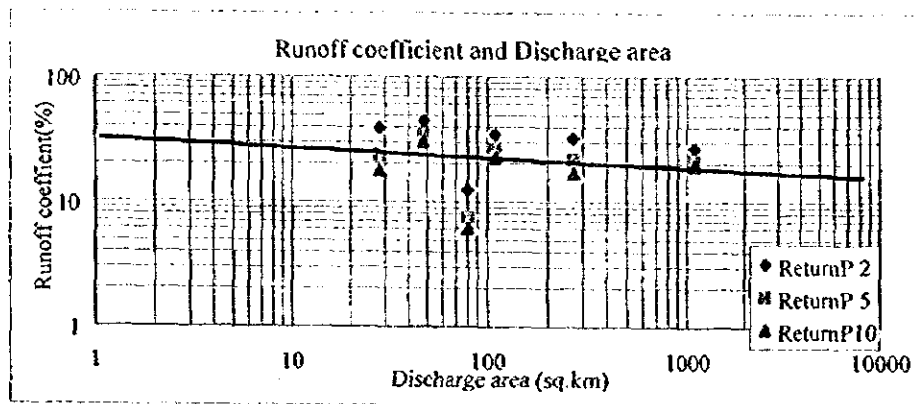


Figure 2.5 -5 Runoff Coefficient and Discharge Area

Runoff coefficients are estimated from the figure 2.5-5 as follows.

Table 2.5-8 Adopted Runoff Coefficient

Discharge area (km ²)	runoff coefficient (%)
~ 5	30
~ 10	29
~ 20	28
~ 30	26
~ 40	26
~ 50	25
~ 100	24
~ 500	19

(Note) Runoff coefficient for 5-year Return Period

3) Perennial Rivers in the Study Areas

If river water flows through out the year, utilization of it is easy and convenient both from quantitative and economical aspects. As most of the base flow is normally occupied by the vested water users and water for environment control is becoming more important, river water use should be carefully studied so as to examine present flow at various points and also

water use downstream. In the study LRAs, present water use of the perennial rivers is only at KK-1 in Khon Kaen by pump. Potential perennial rivers for the study LRAs can be considered to be Nam Phung river in Sakon Nakhon, and Huai Bang Sai and Huai Ban I rivers in Mukdahan as well as Chi River in Khon Kaen. Flow analysis of those rivers is detailed in Chapter 5 in Appendix B.

4) Groundwater and Water Quality

The main users of groundwater at the present time are village populations. During the rainy season most households have a large earthenware jar to collect water from roof runoff. Village groundwater supplies are obtained from either:

- a) Tubewells drilled to about 20 to 30 meters depth by either DMR, ARD or PWD and fitted with a hand-pump. Each village has at least one tubewell and sometimes three.
- b) Wells bored in alluvium or in a weathered surface soil profile. The maximum depth of a bored well is 5 to 6 meters and the water is extracted by rope and bucket. As a trial estimation base on Kor Chor Chor 2 Khor data, some 8,000 wells are considered to be existing in the villages concerned to LRAs as mentioned in Section 2.6.2.

The largest concentrated use of groundwater is a number of small and large industries, and livestock breeding farms use groundwater from deep tubewells. Groundwater in this area is also used for private household supply.

A Groundwater Resource Evaluation Pilot (GREP) Project was undertaken by the Department of Mineral Resources with assistance from the Thai-Australia Northeast Village Water Resource Project, over a 6,560 km² area centered on the city of Khon Kaen in northeast central Thailand. The objective of the project was not only to define the groundwater resources of the area and their potential for development, but also to develop a methodology for groundwater resource evaluation which could be replicated across northeast Thailand. The project presented a Groundwater Map for each Changwat in the region, at a scale of 1:100,000. These maps indicate areas where conditions of higher groundwater quality and higher well yield using a classification with four levels in both expected well yield and groundwater quality. And aquifers are classified according to their potential for exploitation by GREP.

Expected well yield as groundwater potential is indicated on the groundwater map classified as four degrees i.e. (1) potential less than 2 cu.m/hr, (2) potential from 2 to 10 cu.m/hr, (3) potential from 10 to 20 cu.m/hr and (4) potential more than 20 cu.m/hr. Most portion of individual study area has a potential less than 2 cu.m/hr and potential from 2 to 10 cu.m/hr. The proportion of potential less than 2 cu.m/hr is about 60 %, 30%, 45% and 47 % in Khon Kaen, Maha Sarakham, Mukdahan and Sakon Nakhon respectively. And the proportion of potential from 2 to 10 cub.m/hr is about 20 %, 60%, 50% and 44% in Khon Kaen, Maha Sarakham, Mukdahan and Sakon Nakhon.

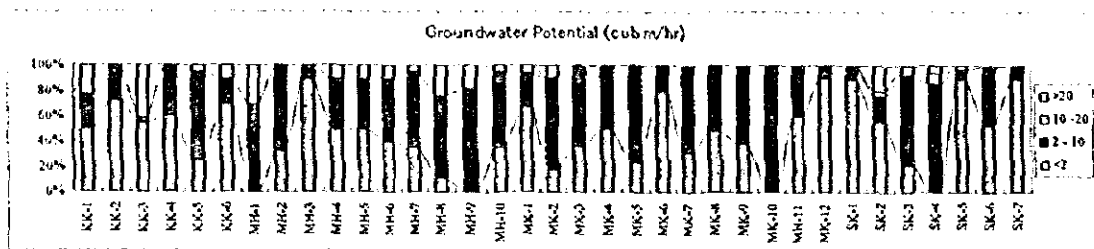


Figure 2.5-6 Groundwater Potential in Each LRA

Density of chloride is classified into four categories such as (1) density less than 200 mg/lit, (2) density from 200 to 600 mg/lit (3) density from 600 to 1,000 mg/lit and (4) density more than 1000 mg/lit, and these classifications are indicated on the map. Majority of density distribution in Khon Kaen study area is less than 200 mg/lit as about 62% of total area, and less than 600 mg/lit covers 80 % of whole area. On the other hand ,whole area classified as density less than 200 mg/lit in Sakon Nakhon study area.

Table 2.5-9 Groundwater Quality

Study Area	Acreage (ha)	Chloride density (mg/l)			
		< 200	200 - 600	600 - 1,000	> 1,000
Khon Kaen	42,871	0.62	0.18	0.06	0.14
Sakon Nakhon	66,583	1.00	0.00	0.00	0.00

5) Water Losses from Farm Pond

Water losses from a farm pond are composed of evaporation from surface and seepage from bed and side of pond.. Field survey on seepage was carried out at 38 existing farm ponds in a period from December 1997 to January 1998 in each priority area. Seepage was measured by means of measuring the change of water level descending in two to four days. Seepage loss was estimated by subtracting evaporation loss and rainfall from the descending depth. Evaporation loss was estimated from potential evapotranspiration in the Area.

The values of seepage from pond vary mostly from 0 to 0.6 cm/day and dominant values are concentrated from 0.1 to 0.4 cm/day. In this study, 0.2 cm/day is adopted as seepage from farm pond taking a tendency of seepage into consideration.(Chapter 3, Appendix B)

2.5.3 Evapotranspiration and Crop Water Requirement

1) Potential Evapotranspiration (ETo)

Several empirical formulas were developed to estimate ETo using meteorological data, such as temperature, humidity, wind velocity and solar radiation. In Thailand, a modified formula is found to be suitable to describe potential evapotranspiration. Estimated potential evapotranspiration within the study area is shown as follows.

Table 2.5-10 Potential Evapotranspiration (ET_o) in the Study Area

Province	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Khon Kaen	3.9	4.8	5.9	6.0	4.8	4.2	4.2	3.8	4.0	4.3	4.0	3.6
Maha Sarakham	3.9	4.8	5.9	6.0	4.8	4.2	4.2	3.8	4.0	4.3	4.0	3.6
Mukdahan	4.5	5.3	6.3	6.1	4.9	4.2	4.2	3.7	3.9	4.6	4.7	4.3
Sakon Nakhon	4.3	5.2	6.1	6.0	4.8	4.2	4.2	3.3	4.0	4.4	4.2	3.9

(Data Source : AIT: study of potential development of water resources in the Mae Khong Basin)

2) Crop Factors (K_c)

Crop factor, in general, depends on age and the growth period of crops. Crop factors used in this study are shown in Table 2.5-11

Table 2.5-11 Crop Factors (K_c)

Month	Crops and Crop Factors (K _c)								Farm Pond
	Wet Season Rice	Soybean	Sweet corn	Water melon	Vegetables	Maize	Tomato	Fruit tree	
1	0.96	0.63	0.65	0.79	1.11	0.71	0.69	0.90	1.10
2	1.24	1.12	0.96	1.44	1.16	1.30	0.97	0.90	1.10
3	1.28	0.97	0.65	1.15		1.13	1.10	0.90	1.10
4	1.11	0.61		0.56		0.62	0.85	0.90	1.10
5	0.84			0.41				0.90	1.10
6								0.90	1.10
7								0.90	1.10
8								0.90	1.10
9								0.90	1.10
10								0.90	1.10
11								0.90	1.10
12								0.90	1.10
Average.	1.09	0.83	0.75	0.87	1.14	0.94	0.90	0.90	1.10

(Note) arranged to the monthly basis from the weekly basis that is applied by RID. (Weekly basis crop factor is described in Table B-3 in Appendix B)

3) Crop Water Requirement

Water requirement of crop is the amount of water required for crop growth. It is estimated by multiplying the potential evapotranspiration by crop factor as below.

$$ET = K_c * ET_o$$

where

ET = water requirement (mm/day)

K_c = crop factor

ET_o = potential evapotranspiration or reference crop evapotranspiration (mm/day)

Water requirement of crops in Khon Kaen, Maha Sarakham, Mukdahan and Sakon Nakhon is calculated in accordance with the cropping calendar which is shown in Figure 2.5-7. The results are shown in Table 2.15-12 and Table 2.15-13.

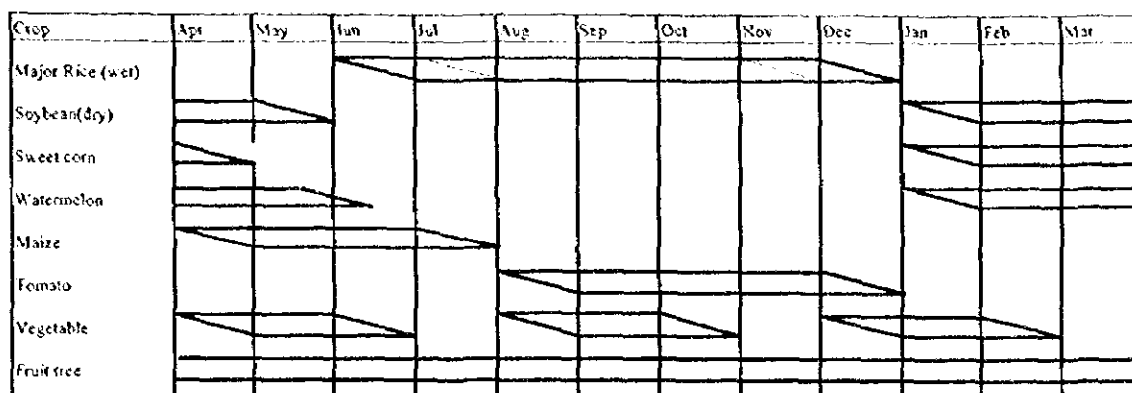


Figure 2.5-7 Cropping Calendar of Main Crops in the Study Areas

Table 2.5 -12 Water Requirement of Major Crops in KK and MHS

Crops	Monthly Water Requirement (mm)												Total (mm)
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Wet S. Rice				150	387	208	213	208	52				1,218
Soybean	116									81	157	199	553
Sweet corn										79	130	124	333
Water melon	154	70	26							46	161	229	686
Maize	128	194	139										461
Tomato					78	117	145	95					435
Vegetable		166	87			133	95			135	100		716
Fruit tree	162	134	113	117	106	108	120	108	100	109	121	165	1,463

Table 2.5 -13 Water Requirement of Major Crops in MKD, SKN

Crops	Monthly Water Requirement (mm)												Total (mm)
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Wet S. Rice				150	387	204	204	218	58				1,221
Soybean	118									94	173	212	597
Sweet corn										92	143	132	367
Water melon	156	71	26							53	177	245	729
Maize	130	198	139										467
Tomato					80	115	155	107					457
Vegetable		169	87			130	101			155	110		752
Fruit tree	165	137	113	117	103	105	128	127	120	126	134	176	1,551

4) Effective Rainfall

It is proposed several empirical method for the calculation of effective rainfall in Thailand. Out of these methods, the empirical method recommended for North-Eastern part of Thailand is applied in this study. Calculation is divided into two ways, one is for period of October effecting 100 % up to 50 mm, effecting some proportion in excess of 50 mm by up to 200 mm and maximum as 100 mm when it more than 200 mm. Another is for period for April to September and November to March effecting 100 % up to 100 mm, effecting some proportion in excess of 100 mm by up to 400 mm and maximum as 160 mm when it more than 400 mm.

Annual effective rainfall based on monthly rainfall is counted as 841 mm in average year and 726 mm in return period 5 year in Khon Kaen and Maha Sarakham. While, 917 mm in average year and 854 mm in return period 5 year in Mukdahan and Sakon Nakhon. (Details are in Chapter 7, Appendix B)

5) Water Balance in Rainfed Farming

Effective rainfall is not enough to grow crops even in the rainy season in the study area. The shortage of water has been calculated for average year and 1/5 year based on rainfall in Table 2.5-5. The results are in Table 2.5-14.

Table 2.5-14 Water Shortage of Crops under Rainfed Condition

Crop	Region	Water Requirement (mm)	Effectuated rain (mm)		Shortage(mm)		Ratio of shortage(%)	
			Av.	Rp 5	Av.	Rp 5	Av.	Rp 5
Wet S. Rice	KK MHS	1,218	479	418	739	800	61	66
	MKD.SKN	1,211	512	479	699	732	58	60
Soybean	KK MHS	553	117	93	436	460	79	83
	MKD.SKN	597	114	98	483	499	81	84
Sweet corn	KK MHS	333	49	39	284	294	85	88
	MKD.SKN	367	34	29	333	338	91	92
Water melon	KK MHS	686	213	189	473	497	69	72
	MKD.SKN	729	211	195	518	534	71	73
Vegetables	KK MHS	716	447	413	269	303	38	42
	MKD.SKN	752	432	416	320	336	43	45
Maize	KK MHS	461	317	298	144	163	31	35
	MKD.SKN	467	353	335	114	132	24	28
Tomato	KK MHS	435	291	272	144	163	33	37
	MKD.SKN	457	270	260	187	197	41	43
Fruit tree	KK MHS	1,463	783	700	680	763	46	52
	MKD.SKN	1,551	765	733	786	818	51	53

(Note) Effectuated rain: rainfall water supplied for crops as effective rainfall (mm)

Shortage : [water requirement]-[effective rainfall], ratio of shortage: [shortage] / [water requirement]

In wet season rice cultivation, shortage of water after getting effective rainfall is counted as 66 % of requirement and 60 % with return period 5 year in KK,MHS and MKD, SKN respectively. According to the soybean, sweet corn and watermelon planted as dry season crop, shortage is counted at 70 to 90 % of requirement. It means that those crops certainly need irrigation when cultivated in dray season. While, the shortage in fruit tree as annually crop and vegetable with three crops in a year are counted at 52 to 53% and 42 to 45 % with return period 5 year in KK, MHS and MKD, SKN respectively. Maize and tomato proposed as wet season crops count the shortage of water 35 to 28 % and 37 to 43 % in KK,MHS and MKD, SKN respectively.

2.6 Water Resources

2.6.1 Present Surface Water Resources Development

1) General Condition of Surface Water Resources Development

Northeastern region is well known as the region where water resources are scarce and of saline problems of soil and groundwater. Centering at Khon Kaen and Maha Sarakham, dry lands are extending where annual rainfall is about 1,000 mm and saline soils and groundwater are widely extending in the flat low land. Rainfall gradually increases going to the east toward Sakon Nakhon and Mukdahan and it reaches 1,400 mm in annum.

In the Northeastern Region, most rivers are seasonal and unstable even in rainy season, so that water resources development has been carried out by small and medium scale reservoirs under RID since many years ago. Large-scale reservoirs have been very limitedly developed due to topographical difficulties such as flat and less in undulation. Perennial rivers are very limited in the region, as the Chi River in Khon Kaen and Mahasarakham, the Songkhram River and the Nam Phung River in Sakon Nakhon, and the Huai Bang Sai and the Huai Bong I River in Mukdahan. Although many pump irrigation projects have been developed by DEDP in those perennial rivers since 1965, their service area is limited only at the vicinity of the rivers. Among many water resources development projects, following projects are relating to the LRAs.

2) Large Scale Water Resources Development relating to the LRAs

Nam Un and Nam Phung reservoirs are relating to the LRA, which locate at the downstream of the LRA in Sakon Nakhon province. Major dimensions of the Nam Un and the Nam Phung dams are as shown in Table 2.6-1.

Table 2.6-1 Major Dimensions of the Nam Un and the Nam Phung Dams

Name of Reservoirs	Nam Un Dam	Nam Phung Dam
Operated by	RID	EGAT
Completed Year	1974	1965
Purposes	Irrigation : 185,800 rai	Hydropower : 6.3MW Irrigation : not defined
Location	A. Phang Kone, Sakon Nakhon Map: 5743-I, x680, y130	A. Kut Bak, Sakon Nakhon Map: 5742-I, x910, y770
River	Nam Un	Nam Phung
Catchment Area	1,100 km ²	269 km ²
Annual Inflow	1974 - 96	1969 - 95
Max.	824 MCM (1990)	219 MCM (1990)
Min.	165 MCM (1997)	54.3 MCM (1997)
Average	414 MCM	125 MCM
Water Level	(MSL)	(MSL)
Max. H.W.L.	187.6 m (*)	285.5 m (*)
N.W.L.	185 m (*)	284 m (*)
Min. W.L.	175 m (*)	270 m (*)
Effective storage capacity	477 MCM (*)	165.5 MCM (*)
Related LRA	SKN-3,4	SKN-5

(Note) (*): Study of Potential Development of Water Resources in the Me Kong River Basin, Volume II Main Report, NESDB by AIT, 1994

Nam Phung dam was constructed by EGAT in 1965, and Num Un Dam by RID in 1974. The former dam is utilized exclusively for hydropower generation, and the latter for irrigation. The former locates at the downstream of SKN 5, and the latter at SKN 3-1, 3-2 and SKN 4. No water is available to those LRAs from the reservoir unless pumping up from the reservoir.

As shown in Table 2.6-2 and Figure 2.6-1, average annual inflows to the Nam Phung and the Nam Un dams are 414 MCM and 125 MCM respectively. Spill had occurred 6 times for 27 years in the Nam Phung dam, and only one time for 23 years in the Nam Un dam.

Table 2.6-2 Inflow and Spill of the Nam Phung and the Nam Un Dams

Nam Phung Dam			Nam Un Dam		
Year	Inflow (MCM)	Spill (MCM)	Year	Inflow (MCM)	Spill (MCM)
1969	56.323				
1970	198.226				
1971	176.945	12.761			
1972	89.637				
1973	65.747				
1974	145.815		1974	335	
1975	102.181		1975	454	
1976	61.823		1976	277	
1977	54.293		1977	165	
1978	169.138		1978	441	
1979	106.551		1979	543	
1980	133.592		1980	367	
1981	137.351		1981	510	
1982	84.218		1982	362	
1983	87.455		1983	212	
1984	147.348		1984	479	
1985	88.803		1985	283	
1986	100.479		1986	382	
1987	165.012	9.252	1987	521	
1988	101.211		1988	402	
1989	104.099		1989	384	
1990	219.259	64.665	1990	824	509.8
1991	204.264	44.100	1991	444	
1992	145.637		1992	405	
1993	80.728		1993	347	
1994	186.336	8.749	1994	456	
1995	145.570	0.037	1995	438	
			1996	483	
Average	124.503	5.169		414	22.2
Maximum	219.299	64.665		824	509.8
Minimum	54.293	0.037		165	509.8

(Data Source) Nam Phung Dam (EGAT), Nam Un Dam (RID)

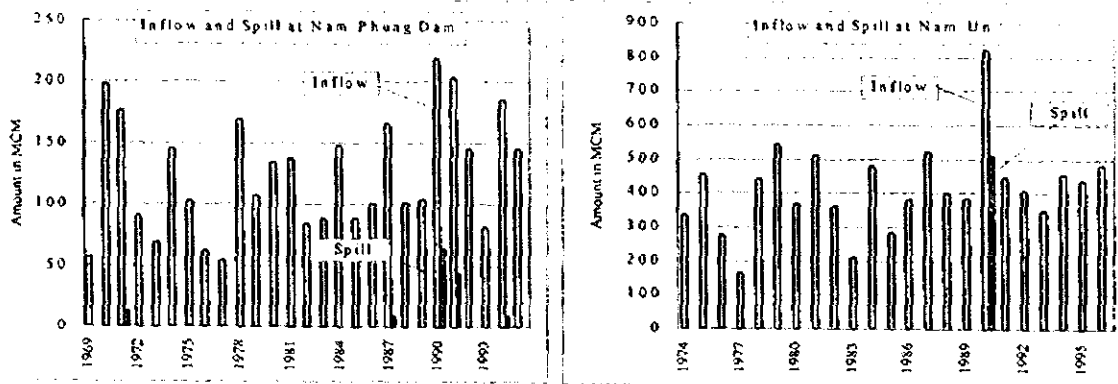


Figure 2.6-1 Inflow and Spill of the Nam Phung and the Nam Un Dams

If frequent spill occurs from the reservoir, there is a possibility to develop water resources in the upstream basin. However, spill had so seldom occurred that there is very less potential of additional water resources development in the said LRAs.

3) Surface Water Resources Development in the LRAs

There are 46 well-operated existing irrigation projects in the LRAs, which are utilizing surface water resources. 46 projects are composed of 5 medium-scale, 39 small-scale and 2 pump irrigation projects. Total irrigation area is 36,730 rai or 2.7% of the total farm land in the LRAs.

Table 2.6-3 Existing Irrigation Projects in the LRAs

Province	Farm Land (rai)	Number of Well Operated Projects				Irrigated Area (rai)					MSIP+SSIP	
		Total	MSIPs	SSIPs	Pump Irrigation	MSIPs	SSIPs	Pump irri.	Total	Irrigation Ratio	Storage Capacity (MCM)	Catchment (km ²)
Khon Kaen	263,000	12	0	10	2	0	1,750	3,000	4,750	1.8%	1.3	17.9
Maharakham	213,290	3	0	3	0	0	550	0	550	0.3%	0.3	6.0
Mukdahan	470,390	22	1	21	0	1,500	13,030	0	14,530	3.1%	26.1	264.9
Sakon Nakhon	409,360	9	4	5	0	14,100	2,800	0	16,900	4.1%	17.9	51.1
Total	1,356,040	46	5	39	2	15,600	18,130	3,000	36,730	2.7%	45.7	339.9

(Note) 1) Above table is not including Huai Kra Choe Dam, which is under-construction.

2) Details are described in Table 2.11-3.

4) Relation between Storage Capacity and Irrigation Area

Relation between storage capacity and irrigation area has been analyzed as shown in Figure 2.6-2 using the data of existing irrigation projects in the LRAs. This relation can be applied for estimating the approximate irrigation area of proposed reservoirs in the LRAs.

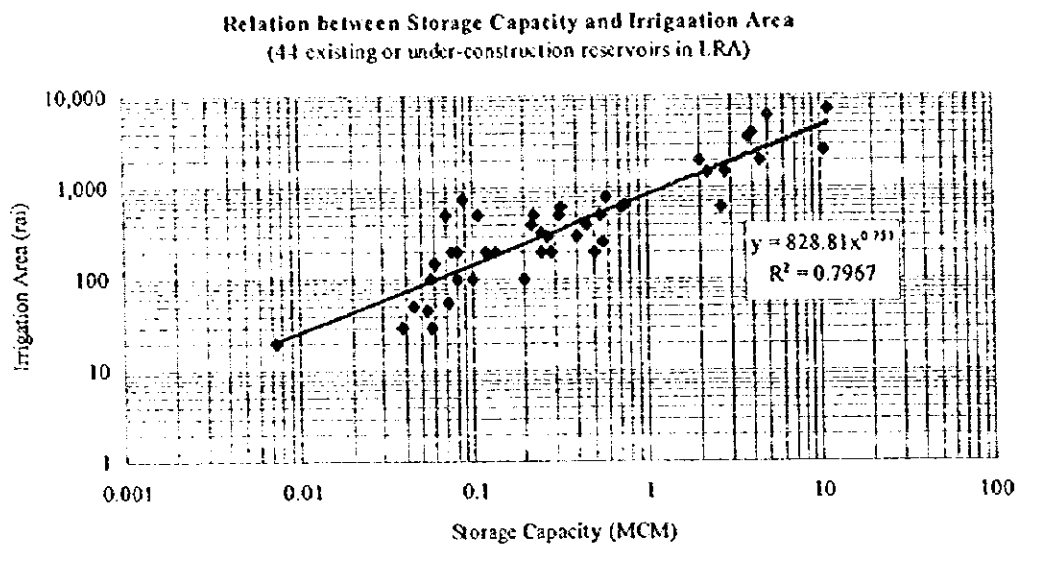


Figure 2.6-2 Relation between Storage Capacity and Irrigation Area

2.6.2 Present Groundwater Development

As mentioned in Section 2.5.2 4) "Groundwater and water Quality", potential of groundwater development is quite limited in the LRAs. However, groundwater has been developed mainly by private wells in the LRAs. Based on the K-C-C information, it is estimated that around 8,000 wells have been developed in the study LRAs as shown in Table 2.6-4. Out of total wells, 65% are concentrated in Sakon Nakhon province especially in Phu Phan area. Private wells share 76% while public wells only 24%. Private wells is mostly shallow type and utilized for domestic water. On the other hand, public wells are utilized for water supply for the villages. Most wells are concentrated in the residential area of the villages, and very limited for irrigation purposes.

Table 2.6-4 Distribution of Wells in the Study LRAs

Province	Public Wells	Private Wells	Total	Ratio
Khon Kaen	223	304	527	6.6%
Maharakham	655	693	1,348	16.8%
Mukdahan	484	458	942	11.7%
Sakon Nakhon	550	4,653	5,203	64.9%
Total	1,912	6,108	8,020	100%
Ration	23.8%	76.2%	100%	

(Notes) 1) estimated based on Kor Chor Chor 2 Khor 2537. (Information System for Village Development 1994)

2) Detail estimation and number of wells in each LRA are shown in Table 2.6-5.

2.6.3 Suitability of Small Reservoir Development

Depending on the land suitability map for small reservoir development, each study area has been assessed on its suitability. The results are summarized as below:

- a) Well or moderately suited lands are generally limited only about 14% of the LRAs.
- b) While, unsuited lands are also limited in 8% of the area.
- c) Most area is assessed as poorly suited area for small reservoir development due to some restrictions as salt-affected area in Mahasarakham, high seepage land in Mukdahan and well drained and salt-bedrock in Khon Kaen.

Although there are difficulties on construction of small reservoirs in the LRAs, small-scale reservoirs and large number of farm ponds are constructed in the area due to high demand of water necessities. It is required for construction of reservoirs to prevent and minimize seepage from the reservoirs in such poorly suited land, which covers extensive area in the LRAs. Detail distribution of suitability is in the Appendix D Section 2.3.

Table 2.6-5 Estimated Existing Wells in the Study LRAs

Study LRA	Available Data from K-C-C					Total of		Estimated wells		
	Number of		Number of wells			villages	Households	Public wells	Private wells	Total wells
	villages	households	public	private	total					
KK1	18	2,013	54	9	63	37 (35)	3,144	89	15	104
KK2	4	765	13	35	48	11 (10)	1,014	19	51	70
KK3	4	1,487	0	2	2	25 (15)	2,063	0	5	5
KK4	1	41	0	2	2	8 (3)	266	0	35	35
KK5	9	1,163	20	191	211	9	1,163	20	191	211
KK6	12	1,033	38	3	41	37 (32)	2,230	95	7	102
MHS1	3	234	14	0	14	3	234	14	0	14
MHS2	13	1,318	29	45	74	19	2,071	46	71	117
MHS3	-	-	-	-	0	9	767	29	36	65 *1
MHS4	9	1,589	49	28	77	9	1,589	49	28	77
MHS5	13	1,361	52	63	115	13	1,361	52	63	115
MHS6	17	1,617	51	16	67	20	1,809	57	18	75
MHS7	8	1,406	44	145	189	10	1,653	52	170	222
MHS8	30	5,244	123	98	221	75 (72)	11,405	279	222	501
MHS9	5	406	14	0	14	5	406	14	0	14
MHS10	4	424	11	15	26	17 (16)	2,272	63	85	148
MKD1	18	2,095	79	264	343	19	2,191	83	276	359
MKD2	8	873	33	9	42	11	1,214	46	13	59
MKD3	9	1,295	40	19	59	11	1,518	47	22	69
MKD4	3	324	16	17	33	3	324	16	17	33
MKD5	10	1,054	37	1	38	10	1,069	38	1	39
MKD6	4	418	25	1	26	6 (4)	418	38	2	40
MKD7	8	1,000	25	102	127	8	1,000	25	102	127
MKD8	16	1,994	47	6	53	19 (18)	2,213	55	7	62
MKD9	8	856	45	0	45	11	1,275	67	0	67
MKD10	2	198	7	4	11	2	198	7	4	11
MKD11	14	2,012	55	14	69	14	2,012	55	14	69
MKD12	3	740	7	0	7	3	740	7	0	7
SKN1	2	495	3	0	3	2	495	3	0	3
SKN2	-	-	-	-	0	12 (10)	3,822	28	0	28 *2
SKN3	22	4,590	126	1,109	1,235	29 (25)	5,858	187	1,642	1,829
SKN4	11	2,355	59	513	572	24 (21)	4,708	135	1,172	1,307
SKN5	2	326	11	111	122	24	3,150	106	1,073	1,179
SKN6	-	-	-	-	0	6	3,172	87	766	853 *3
SKN7	-	-	-	-	0	2	604	4	0	4 *4
KK	48	6,502	125	242	367	127 (104)	9,880	223	304	527
MHS	102	13599	387	410	797	180 (176)	23,567	655	693	1,348
MKD	103	12859	416	437	853	117 (114)	14,172	484	458	942
SKN	37	7766	199	1733	1932	99 (90)	21,809	550	4,653	5,203
Total	290	40,726	1,127	2,822	3,949	523 (484)	69,428	1,912	6,108	8,020

(Source) Kor Chor Chor 2 Khor 2537 (Information System for Village Development 1994)

(Notes) 1) Following data are excluded from the K-C-C data due to low reliability.

Village VKK112 Nong Wang Nang Pao (KK6)

1,2211,1112,332

Village VSKN26 Oon Khok (SKN3)

1,0533,6914,744

2) Following LRAs are estimated by other LRA data due to no information.

*1: same proportion as LRA MHS5.

*2: same proportion as LRA SKN1.

*3: same proportion as LRA SKN3

*4: same proportion as LRA SKN1

3) () in Total of villages: villages of which households numbers are available.

2.7 Soil and Land Use

2.7.1 Soil Characteristics

1) Soil Classification System

Department of Land Development (DLD) uses the US Taxonomy, 1975 as a soil classification system. In this soil classification system, there are two classification levels; one is great soil group, and the other is detailed soil series group. Great soil group has rather rough information, whereas the soil series group has more detail and sufficient information for intensive land use planning. In Phase I Study, great soil group has been applied for analysis. General soil map of great soil groups is reported in Figure E-1 to E-4 in Appendix E, however some modification has been carried out through field reconnaissance observation because the map is too large in scale and too rough for detail investigation of soil. Relation between great soil group and detailed soil series group is explained in Table E-6 of Appendix-E.

2) Great Soil Groups

Soil groups of the Study Area are summarized in Table 2.7-1. Major soils in the Study Area are three soils, such as 5S, 30L and 33L. Those soils extends extensively on the area and cover about 96% of the area. Other than major three soils, minor soils as 14C, 18L and 42 can be found in some limited areas. Major problems of the soil are low fertility and sandy or coarse texture except 14C and 30L, which are clayey or loamy, and extending in flat lowlands mostly cultivated with paddy rice. Lowland 5S are basically sandy, but it is also suited for paddy rice cultivation because of high content of clayey and loamy soil by long time sifting process.

3) Major Soils

a) 33L (Loamy Paleustults)

This soil is loamy Paleustults and most common in the LRAs (59%) especially in Sakon Nakhon and Mukdahan where it covers 70% and 83% respectively. This soil is covering the gently to steeply sloping lands and its texture is medium too coarse with well to moderately well drainage. The soil fertility is low and cultivated with several upland crops such as cassava, sugarcane, and kenaf etc..

For the soil 33L, some modification have been carried out in SKN 6.1 LRA through field reconnaissance observation. Although SKN 6.1 is reported as covered with 33L in Figure E-3 of Appendix E, but this area is extensively cultivated with paddy rice. This area was identified as covered with 30L for 80% of the area and with 33L for 20%, because the area had been topographically formed as an independent alluvial flood plain through long time sedimentation process in the mountain range.

Table 2.7-1 Soil Distribution in the Study Area

LRAs No.	Area (rai)	Soil Group (referring to Figure E-1toE-4 in Appendix E)	Soil Distribution (rai)							
			SS ⁽¹⁾		14C	18L	30L	32K	33L	42
			Lowland	Upland						
KK 1	67,640	33L:90%, 5S:5%, 14C:5%	1,010	2,370	3,380					60,880
KK 2	14,130	33L/30L:60%, 5S:40%	1,690	3,960			4,240			4,240
KK 3	18,370	33L/30L					9,185			9,185
KK 4	11,740	5S	3,520	8,220						
KK 5	6,250	33L/30L					3,125			3,125
KK 6	149,790	5S:90%, 33L:10%	40,440	94,370						14,980
MHS 1	2,640	30L					2,640			
MHS 2	59,690	5S:90%, 33L/30L:10% ⁽²⁾	2,690	51,040			600			5,360
MHS 3	3,080	5S/18L	80	1,460		1,540				
MHS 4	9,510	33L/30L ⁽²⁾					950			8,560
MHS 5	18,200	33L/30L ⁽²⁾					1,820			16,380
MHS 6	29,790	5S:40%, 33L:20%, 30L:20%, 33L:30L:20% ⁽²⁾	600	11,310			6,555			11,325
MHS 7	10,940	33L/30L ⁽²⁾					1,095			9,845
MHS 8	79,620	5S:90%, 33L/30L:10% ⁽²⁾	3,580	68,080			800			7,160
MHS 9	310	5S	20	290						
MHS 10	4,830	30L					4,830			
MKD 1	103,580	33L/30L:50%, 33L:40%, 42:10%					25,900			67,320 10,360
MKD 2	75,840	33L								75,840
MKD 3	106,490	33L:95%, 42:5%								101,170 5,320
MKD 4	1,860	33L:65%, 42:35%								1,210 650
MKD 5	6,030	33L:70%, 42:30%								4,220 1,810
MKD 6	700	33L:70%, 42:30%								490 210
MKD 7	47,020	33L/30L:90%, 42:10%					21,160			21,160 4,700
MKD 8 1	33,040	33L:90%, 42:10%								29,740 3,300
MKD 8 2	10,730	33L:80%, 42:20% ⁽³⁾								8,580 2,150
MKD 8 3	9,940	33L								9,940
MKD 8 4	5,710	33L								5,710
MKD 9 1	28,530	33L								28,530
MKD 9 2	23,710	33L:90%, 32K:10%						2,370		21,340
MKD 10	1,180	33L								1,180
MKD 11 1	6,880	33L								6,880
MKD 11 2	6,550	33L								6,550
MKD 12	11,480	33L:90%, 42:10%								10,330 1,150
SKN 1	22,810	33L								22,810
SKN 2	43,580	33L:75%, 14C:25%			10,900					32,680
SKN 3 1	80,920	33L/30L					40,460			40,460
SKN 3 2	6,650	33L/30L					3,325			3,325
SKN 3 3	32,540	33L/30L:50%, 33L:50%					8,140			24,400
SKN 4	86,520	33L/30L					43,260			43,260
SKN 5 1	16,740	33L:70%, 32K/33L:30%						2,510		14,230
SKN 5 2	72,500	33L								72,500
SKN 6 1	23,400	30L:80%, 33L:20% ⁽⁴⁾					18,720			4,680
SKN 6 2	21,890	33L/30L:50%, 32K:50%					5,470	10,950		5,470
SKN 7	13,200	33L								13,200
KK 6 6	267,920		46,660	108,920	3,380	0	16,550	0		92,410 0
MHS 10 10	218,610		6,970	132,180	0	1,540	19,290	0		58,630 0
MKD 12 17	479,270		0	0	0	0	47,060	2,370		400,190 29,650
SKN 7 11	420,750		0	0	10,900	0	119,375	13,460		277,015 0
Total 35 44	1,386,550		53,630	241,100	14,280	1,540	202,275	15,830		828,245 29,650

(Notes)

(*)1) Lowland 5S is estimated at 25% of total 5S in Khon Kaen and 5% in Mahasarakham taking topographical characteristics into consideration.

(*)2) 33L/30L is generally composed of 50% of 33L and 50% of 30L, but 90% of 33L and 10% of 30L in Mahasarakham from topographical viewpoint.

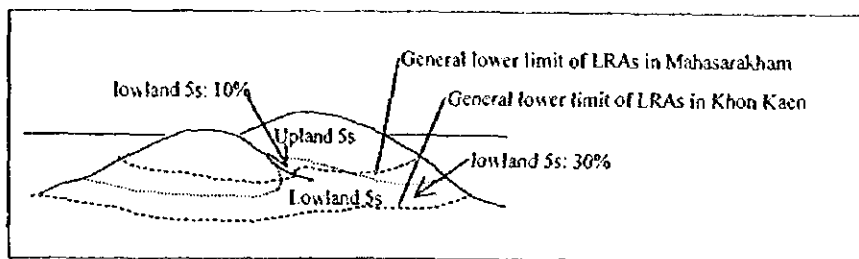
(*)3) In MKD-8 2, Soil No.42 is reported as major soil in Figure E-1, Appendix E, but it was modified to be 33L for 80% and 42 for 20% by field reconnaissance observation.

(*)4) In SKN-6 2, Soil No. 33L is reported as major soil in Figure E-3, Appendix E, but it was identified to be 30L for 80% and 33L for 20% by field reconnaissance observation.

b) 5S (Sandy Quartzipsamments)

This soil is deep, gently sloping, excessively drained sandy soil, and with low fertility. It is very common in Khon Kaen and Maha Sarakham. It covers about 60% of the LRAs in the two provinces. This soil is classified into two different soils from a viewpoint of locality; namely upland 5S and lowland 5S.

Upland 5S is sandy and cultivated with upland crops, such as cassava and sugarcane, and pasture crops, whereas lowland 5S is basically sandy but rich in clay and loam by long term silting and utilized for paddy rice cultivation. Lowland 5S has been assumed at 30% in Khon Kaen LRAs, 10% in Mahasarakham LRAs taking topographical characteristics into consideration. LRAs are generally locating at rather high portion of mounds or hills in Maha Sarakham, but at lower portion in Khon Kaen as shown in a figure below;



Lowland 5S generally locates at foothills and valleys in the area so that the ratio of lowland 5S is high in the LRAs of Khon Kaen.

c) 30L (Loamy Paleaquults)

This soil is deep, level to nearly level, poorly drained, medium or loamy, and , with low to moderate fertility. It is commonly found in flat lowlands or in a valley in LRAs. It covers about 15% of the LRAs, and it is cultivated mainly with paddy rice.

d) 33L/30L

It is association of Loamy Paleustults 33L (50%) and Loamy Paleaquults 30L (50%). In Maha Sarakham, however its composition has been revised to 90% of 33L and 10% of 30L taking same reason as 5S as mentioned above.

e) 14C (Clayey Tropaquepts)

This soil is extending only along the large rivers in alluvial flood plain. It appears only along the Chi river in Khon Kaen No.1 LRA and along the Songkram river in Sakon Nakhon No.2 LRA. It is clayey, deep in soil depth, level in slope, poor in drainage, and moderate in fertility. It is generally cultivated with paddy rice.

f) 18L (Loamy Dystropepts)

This soil appears associated with 5S (5S/18L) only in Maha Sarakham No.3 LRA which is located at the top of hilly topography. In this LRA, healthy trees are protected by villagers and extensively still remaining. Farmers are cultivating cassava among those trees, and grazing

cattle. The soil is heavy sandy, deep, gentle in slope, excessive in drainage, and very low in fertility.

g) 32K (Skeletal Plinthustults)

This soil appears only in hilly LRAs in Phu Phan Range, Sakon Nakhon No.5-1 and No.6-2, and Mukdahan No.9-2. The soil is shallow to very shallow, moderately sloping, well to moderately well drained, gravelly soils including areas with laterite or bedrock near the surface.

h) 42 (Slope Complex)

This soil is minor from a general viewpoint of whole Study Area, but very extensive in Mukdahan province. This soil extends largely in mountainous area in Mukdahan where extensive forestry is reserved by RFD. Consequently, this soil appears at the sloping lands in LRAs of Mukdahan along the mountainous area.

Most area of MKD-8.2 LRA is reported as covered by this soil as shown in Figure E-1, but it was identified as 80% of 33L and 20% of 42 soil by field reconnaissance observation.

2.7.2 Land Use

Based on 1/50,000 top-maps and aerial photographs, land use in the Study Area is assumed as shown in Table 2.7-2.

Table 2.7-2 Existing Land Use

Study Area	Land Use (rai)				
	Swamp., Reservoirs & Rivers	Low land & Bush	Paddy	Orchard & Upland	Residence & Others
Khon Kaen	950	0	40,900	222,100	3,970
Maha Sarakham	0	0	35,000	179,860	3,750
Mukdahan	3,980	0	103,860	366,530	4,900
Sakon Nakhon	440	5,000	96,690	307,670	10,950
Total	5,370	5,000	276,450	1,076,160	23,570
Raito	0.4%	0.4%	19.9%	77.6%	1.7%

As shown in above Table, most area about 80% is utilized as upland, and paddy shares only about 20%. In Khon Kaen and Maha Sarakham, share of upland is higher as more than 80%, and paddy is less as 15%. On the other hand, upland is less and paddy is high in Mukdahan and Sakon Nakhon.

2.8 Agriculture

2.8.1 Major Crops

1) Cropped Acreage and Crop Production

The acreage under major crops in the Study Area in 1994 / 1995 crop-year are estimated in the table shown below (details are given in Table 2.8-3).

Table 2.8-1 Cropped Area in the Study Area (unit : rai)

Crops	Khon Kaen	Maha Sarakham	Sakhon Nakhon	Mukdahan	Total	
Rice	40,900	33,310	96,690	103,860	274,760	(20.2%)
Cassava	151,210	157,410	274,580	205,410	788,610	(58.1%)
Sugarcane	57,740	12,560	17,620	137,600	225,520	(16.6%)
Others	13,150	11,580	20,470	23,520	68,720	(5.1%)
Total	263,000	214,860	409,360	470,390	1,357,610	(100%)

Cassava accounts for the largest acreage among major crops in the Study Area, with a share of 58% of the total cropped acreage, and it is followed by rice paddy and sugarcane. The acreage under sugarcane has been concentrated in two provinces, Khon Kaen and Mukdahan where sugar-mills have been established, and sugarcane is planted on a contract-farming basis. The annual amounts of production of major crops are shown below:

Table 2.8-2 Production of Major Crops

Crops	Cropped Acreage (rai)	Yield (kg/rai)	Production (ton)
Paddy	274,760	245	67,300
Cassava	788,610	2,000	1,577,200
Sugarcane	225,520	8,500	1,916,900

2) The calendar of major crops are illustrated as follows:

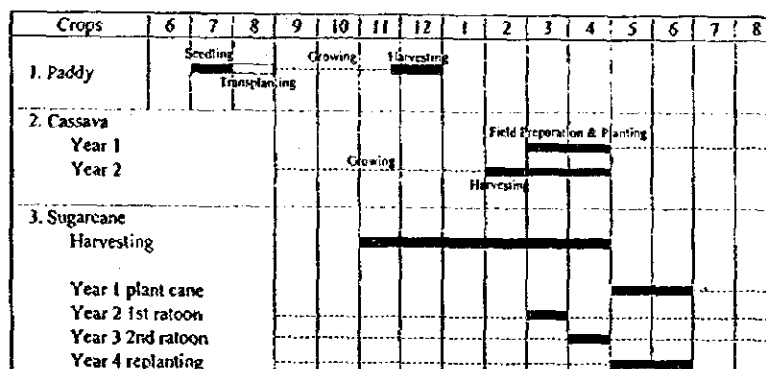


Figure 2.8-1 Calendar of Major Crops

Table 2.8-3 Cropped Area of 35 LRAs

Province	LRA	Farm Land (rai)	Paddy (rai)	Cassava (rai)	Sugarcane (rai)	Other Crops (rai)	Ratio of Cassava Field (%)	Paddy Self- Sufficiency (%)
Khon Kaen	KK 1	65,560	11,150	39,370	11,820	3,220	77	66
	KK 2	13,940	1,690	7,130	4,390	730	62	39
	KK 3	17,910	4,500	8,060	4,560	790	64	113
	KK 4	11,490	750	3,010	7,090	640	30	21
	KK 5	6,180	940	1,140	3,790	310	23	56
	KK 6	147,920	21,870	92,500	26,090	7,460	78	71
	Total	263,000	40,900	151,210	57,740	13,150	72	67
Maha Sarakham	MIIS 1	2,640	0	2,330	150	160	94	0
	MIIS 2	59,680	0	50,280	5,840	3,560	90	0
	MIIS 3	3,080	0	2,730	170	180	94	0
	MIIS 4	9,510	0	8,470	470	570	95	0
	MIIS 5	14,600	6,690	4,820	1,880	1,210	72	114
	MIIS 6	29,660	8,120	17,940	2,310	1,290	89	140
	MIIS 7	10,940	7,810	2,900	40	190	99	202
	MIIS 8	79,610	10,060	63,960	1,440	4,150	98	50
	MIIS 9	310	0	270	20	20	93	0
	MIIS 10	4,830	630	3,710	240	250	94	24
Total	214,860	33,310	157,410	12,560	11,580	93	56	
Sakon Nakhon	SKN 1	22,560	2,810	16,880	1,580	1,290	91	53
	SKN 2	43,260	15,560	17,660	8,230	1,810	68	184
	SKN 3	118,470	27,690	81,450	3,390	5,940	96	51
	SKN 4	85,530	21,880	58,050	1,430	4,170	98	101
	SKN 5	81,800	3,190	71,920	1,540	5,150	98	11
	SKN 6	44,540	22,440	19,200	1,450	1,450	93	222
	SKN 7	13,200	3,120	9,420	0	660	100	147
Total	409,360	96,690	274,580	17,620	20,470	94	74	
Mukdahan	MKD 1	102,760	23,750	42,370	31,580	5,060	57	77
	MKD 2	74,900	8,130	36,060	26,430	4,280	58	36
	MKD 3	104,180	32,370	27,080	40,120	4,610	40	101
	MKD 4	1,760	260	1,090	310	100	78	47
	MKD 5	6,020	1,250	3,390	1,070	310	76	70
	MKD 6	710	60	460	150	40	75	29
	MKD 7	44,890	20,280	20,010	3,020	1,580	87	146
	MKD 8	57,040	7,000	37,750	9,080	3,210	81	41
	MKD 9	52,040	8,250	19,420	21,560	2,810	47	53
	MKD 10	1,180	630	410	100	40	80	180
	MKD 11	13,430	1,880	8,710	2,100	740	81	47
	MKD 12	11,480	0	8,660	2,080	740	81	0
Total	470,390	103,860	205,410	137,600	23,520	60	73	
Grand Total	1,357,610	274,760	788,610	225,520	68,720	78	70	

Source : OAE, 1995

a) Rice

Rice paddy is entirely cropped in monsoon season, glutinous rice constitutes about 80% of paddy out of the total paddy output and non-glutinous rice accounts for the rest 20%. Farmers employ such high yielding varieties as RD6 (glutinous) and RD15 (non-glutinous) which DOAE recommend them to grow. Many farmers follow transplanting of these varieties, but direct sowing be gradually diffused over the rainfed paddy areas as promoted by DOAE. Paddy yields per unit area range 160 to 320 kg / rai, remaining fairly low levels as compared to the average yield, 450 kg / rai recorded in the Central Region where fertile soils are distributed and irrigation has been practiced. Paddy production greatly varies with annual precipitation and rainfall patterns, in such a way that the difference in the maximum and minimum production during four years (1991 ~ 1994) reaches 30%. Paddy yields in the Study Area are widely variable as shown in the following table, with a tendency that lower yields are found in paddy fields located at the bottom of valley basin. However, very poor correlation are observed between yield levels and topography or these and soil types.

Table 2.8-4 Paddy Yield in the Study Area

LRA's	non-gluti.	gluti.	LRA's	non-gluti.	gluti.	LRA's	non-gluti.	gluti.	LRA's	non-gluti.	gluti.
KK - 1	266	201	MHS-4	206	231	MKD-3	240	281	MKD12	238	299
KK - 2	345	184	MHS-5	176	223	MKD-4	268	279	SKN-1	308	260
KK - 3	195	287	MHS-6	205	207	MKD-5	241	304	SKN-2	252	222
KK - 4	217	222	MHS-7	153	226	MKD-6	241	304	SKN-3	281	381
KK - 5	329	202	MHS-8	213	207	MKD-7	264	306	SKN-4	281	370
KK - 6	161	216	MHS-9	216	219	MKD-8	238	299	SKN-5	278	276
MHS-1	239	202	MHS10	239	202	MKD-9	259	256	SKN-6	320	311
MHS-2	346	259	MKD-1	265	266	MKD10	238	299	SKN-7	222	191
MHS-3	212	232	MKD-2	257	274	MKD11	238	299	Average	244	250

Source : OAE, 1995

Number of hand tractors held by the farmers in the Study Area has been increased, and more farmers practice paddling by machinery. However, most farm practices for paddy such as transplanting, weeding, manuring pest/disease control and reaping are still dependent on manual labor. Many farmers has obtained certain level of farming techniques for paddy cropping, but under rainfed system they are obliged to retard transplanting if monsoon rain fails to fall. Transplanting with seedlings grown too tall by the delay of the monsoon onset often leads to poorer tillering and fewer panicles per hill, eventually ending up in poor yields.

Generally, single or compound chemical fertilizers are used for manuring paddy. Usual doses farmers employ constitutes around 5 kg per rai as nitrogen component, each 1 kg per rai as phosphorus and potassium, respectively. Actually, only ten LRAs are self-sufficient with paddy for meeting home-consumption out of 35 LRAs as given in Table 2.8-3, where the mean

rate of self-sufficiency of paddy comes to 70%.

b) Cassava

Cassava can even grow on poor soils without any manuring, can tolerate against drought and readily grown by any farmers, and this is why it has become so much popularized over the upland fields in the Study Area. But the problem has arisen in declining trends of the prices of cassava and rice, and the Government has carried out a farm production restructuring policy that aims at conversion of acreage under cassava into that for other crops. As a result, acreage cropped by cassava has been gradually decreased, with the policy target set at 15% of the conventional acreage to be cropped with other crops. As future prospect farmers continue to grow cassava as a major crop in their rain-fed fields still for a long period in the Study Area, because its profitability per unit acreage is comparable to that of paddy

Local varieties and Rayong 1 are most popular for cassava production, the yield of which amounts to 2 ton / rai, with considerable variability among the LRAs. The yields in the LRAs of Maha Sarakham tend to be lower due to infertile sandy soils, whereas those in Sakon Nakhon show higher levels owing to wider coverage of loamy soils.

Table 2.8-5 Yield of Cassava and Sugarcane in the Study Area (kg/rai)

LRAs	Cassava Yield	Sugarcane Yield	LRAs	Cassava Yield	Sugarcane Yield	LRAs	Cassava Yield	Sugarcane Yield	LRAs	Cassava Yield	Sugarcane Yield
KK - 1	2,079	8,713	MHS -4	1,790	6,570	MKD-3	1,824	8,388	MKD12	1,819	7,775
KK - 2	2,121	9,874	MHS -5	1,836	7,431	MKD-4	2,059	10,212	SKN -1	2,045	10,210
KK - 3	1,980	8,727	MHS -6	1,761	8,081	MKD-5	1,896	7,217	SKN -2	1,892	8,692
KK - 4	2,129	7,512	MHS -7	1,781	8,360	MKD-6	1,896	7,217	SKN -3	2,078	11,169
KK - 5	2,046	9,161	MHS -8	1,786	9,448	MKD-7	1,920	7,188	SKN -4	2,114	10,369
KK - 6	2,035	10,566	MHS -9	1,841	8,360	MKD-8	1,819	7,775	SKN -5	2,196	9,357
MHS -1	2,163	9,647	MHS10	2,163	9,647	MKD-9	1,779	6,801	SKN -6	2,046	7,963
MHS -2	1,639	10,020	MKD-1	1,808	6,920	MKD10	1,819	7,775	SKN -7	2,000	8,565
MHS -3	1,791	6,346	MKD-2	1,914	8,764	MKD11	1,819	7,775	Average	1,934	8,526

Source : OAE, 1995

c) Sugarcane

Cropping of sugarcane has become popular in Khon Kaen and Mukdahan where sugar-mills have been located, and almost all production has been on the contract basis between mills and growers. The farm profit from sugarcane amounts almost twice as much as that from paddy or cassava, and the prices of procurement by the mills have been guaranteed by the government. This advantage has made sugarcane the only remunerative crop that the growers in the Study Area can take advantage by the stable gain. As sugarcane requires deep plowing, the land preparation prior to planting cane is performed by large-size tractors dispatched and leased from the mills. Other farm practices, such as weeding and manuring are done by manual labor, and harvesting is also for the most part manually practiced by hired labor.

Sugar-mills provide sugarcane growers with seed cane, fertilizers and chemicals, offer services of farm credits and technical instructions. Growers raise the same varieties as specified by the mills on contract, including Taiwanese (Formosa) ones such as F-140, F-154 and F-156 as majority, but Australian varieties such as Q-73 bred in the Suphanburi Upland Crop Research Institute and Thai-varieties such as Chainat 1 exploited by the Chainat Upland Crop Research Institute are sometimes employed.

The contracted cultivation of sugarcane is scheduled so that constant supply of cane to the mills can be secured by adjusting the harvest period among contracted growers. Here the procurement prices have been fixed according to the standard where sucrose concentration in cane should be kept at 10 % brix. Major harvesting season falls in dry season, that is, from November to April, and average cane yield per rai is 8.5 ton / rai. Once growers plant cane, they manage to harvest it by ratooning for a couple of years or so, thus they can save cost and labor for planting, but cane yield gradually dwindles as the time elapse after the planting. Especially, if cane is planted and ratooned on poor soils, the resulting yield begins to erode seriously from the third year. In addition, as cane cultivation requires an enormous quantity of soil water, chemical fertilizers including potassium, fungicides and pesticides, machinery tillage and farm labor, incurring high production cost accounting for over 70% of the gross farm margin, consuming much soil fertility, it tends to impose a heavy burden on the small size growers. Since cane sucrose content decreases at the rate of 1% per day by the action of inverting enzymes in cane tissue, it is essential to cultivate it in the field with an easy access to the means of transport for bulky harvest.

Standard cultivation criteria for major crops recommended by DOAE are as follows :

Table 2.8-6 Cultivation Criteria for Major Crops

Crop	Major Rice Paddy	Cassava	Sugarcane
Target Yield (kg/rai)	360	2,000	8,000-12,000
Major Varieties	R.D.6, Khao Dok Mali 105	Rayong 1, 3, 5, 90	F154, 140, 156
Seeding Rate (quantity/rai)	5 kg of paddy	2,000 stem shoots	5,000 cane stems
Fertilizer Doses	Vegetative Growth Period 16-16-8 (25~40kg/rai) Panicle Formation Stage 46-0-0 (9~14kg/rai)	for newly or re-planting 15-15-15 (25 kg/rai) or 13-13-21 (35 kg/rai) plus Urea (8 kg/rai)	before planting, basal dressing 15-15-15 (100~200kg/rai) or 16-16-16 and top-dressing, 75~90 days after planting ammonium-sulfate 60kg/rai
Pest/Disease Control	against virus infested by brown plant-hopper : Carbofuran 5 kg rai	measures for sucking damages by white fly : Deicophol against damage by cassava red spider mite : Monocrotophos * 15 ml / 1 ltr. water	against amy-worm, and stem borer : Furadan tablets 3%
Farm machinery and practices	power tiller (2-wheel), thresher	4-wheel tractor manual digging	4-wheel tractor manual reaping
Farm labor requirement (man-day/rai)	6	5	first year 22, later 2 years: 7
Optimum month for planting	April ~ May	March ~ May	October ~ December
Main Harvesting Period	November ~ December	February ~ April	September ~ November

Note : or Metamidophos 35 ml / 20 ltr. of solvent water

2.8.2 Animal Husbandry and Inland Fisheries

1) Animal Husbandry

Major livestock kept by four provinces concerned constitutes cattle, buffaloes, swine, duck and chicken.

Table 2.8-7 Major Livestock in Four Provinces (unit : head)

Province	Beef + Dairy Cattle	Buffaloes	Swine	Ducks	Chickens
Khon Kaen	243,897	151,881	65,826	423,552	2,629,057
Maha Sarakham	161,011	140,481	56,494	234,266	685,482
Sakon Nakhon	116,678	158,517	36,056	230,790	708,634
Mukdahan	57,211	99,844	22,827	70,376	466,862
Total	578,797	550,723	181,203	958,984	4,490,035

Source : Agricultural Statistics of Thailand, 1994/1995

The distribution of cattle and buffalo herds among Amphoes concerned and average number of their heads kept per farm household are given in the following table:

Table 2.8-8 Number of Buffalo and Cattle (unit:head)

LRAs	Buffalo	Cattle	LRAs	Buffalo	Cattle	LRAs	Buffalo	Cattle	LRAs	Buffalo	Cattle
KK - 1	2,996	7,332	MHS - 4	632	789	MKD-3	11,052	7,656	MKD12	617	7,775
KK - 2	688	1,096	MHS - 5	1,684	1,693	MKD-4	176	177	SKN - 1	1,107	10,210
KK - 3	900	1,714	MHS - 6	1,827	1,556	MKD-5	593	641	SKN - 2	1,534	8,692
KK - 4	547	634	MHS - 7	1,075	1,138	MKD-6	68	74	SKN - 3	12,910	11,169
KK - 5	198	407	MHS - 8	5,133	7,746	MKD-7	4,513	4,165	SKN - 4	5,190	10,369
KK - 6	6,685	10,157	MHS - 9	23	23	MKD-8	3,135	2,704	SKN - 5	5,131	9,357
MHS - 1	357	335	MHS10	438	411	MKD-9	9,780	4,085	SKN - 6	3,420	7,963
MHS - 2	2,189	8,441	MKD-1	17,132	7,891	MKD10	64	55	SKN - 7	624	8,565
MHS - 3	396	509	MKD-2	9,530	6,308	MKD11	723	623	Total	113,067	104,722

Source : DOL, 1995

Number of Buffalo and Cattle per Household (unit:head/household)

LRAs	Buffalo	Cattle	LRAs	Buffalo	Cattle	LRAs	Buffalo	Cattle	LRAs	Buffalo	Cattle
KK - 1	0.89	2.17	MHS - 4	1.13	1.41	MKD-3	1.73	1.20	MKD12	0.91	0.78
KK - 2	0.79	1.25	MHS - 5	1.43	1.44	MKD-4	1.60	1.61	SKN - 1	1.05	0.83
KK - 3	1.13	2.14	MHS - 6	1.58	1.34	MKD-5	1.66	1.80	SKN - 2	0.91	0.76
KK - 4	0.76	0.88	MHS - 7	1.39	1.47	MKD-6	1.66	1.80	SKN - 3	1.19	1.14
KK - 5	0.59	1.22	MHS - 8	1.28	1.93	MKD-7	1.62	1.50	SKN - 4	1.19	0.80
KK - 6	1.08	1.65	MHS - 9	1.47	1.44	MKD-8	0.91	0.78	SKN - 5	0.91	0.77
MHS - 1	0.82	0.77	MHS10	0.82	0.77	MKD-9	3.16	1.32	SKN - 6	1.69	1.56
MHS - 2	0.76	2.93	MKD-1	2.79	1.29	MKD10	0.91	0.78	SKN - 7	1.47	1.00
MHS - 3	1.09	1.40	MKD-2	2.12	1.40	MKD11	0.91	0.78	Average	1.44	1.33

The patterns of livestock holding in four provinces concerned indicates that average herds kept per individual farm are limited to 1 ~ 3 heads for cattle and buffalo, 0 ~ 3 heads of pig, of which buffalo herds have declined year after year in parallel with the decreasing demand for draught animals substituted by farm machinery, which has been observed throughout Thailand since 1970s. Notwithstanding, in two provinces, i.e., Mukdahan and Sakon Nakhon, buffalo herds still outweigh those of cattle.

The quantity of livestock production in the Northeastern Region centered by Khon Kaen has been marking a positive growth for these years, at an annual rate of 5.1% for pork and of 9.7% for beef, meanwhile the increment of herds kept by these provinces has recorded only half of the growth rate as much as that attained by meat production, due mainly to bullish prices of purchased feeds caused by the drop of exchange rate of Baht. The increase of the herd of beef cattle has been concentrated only in Khon Kaen, whereas the trends in other three Changwats merely indicate leveled-off or slightly increased herds of draught / meat cattle. The limiting factor in the expansion of meat cattle lies in lack of accompanied feed production base and staggered progress in the marketing system for raw meat and milk.

The following table gives the relationship between currently held cattle / buffalo herds and feed availability in four provinces concerned (live weight of an adult cattle is estimated at 350 kg / head).

Table 2.8-9 Feed Availability in Four Provinces (unit : head, rai, 1,000 ton)

Province	Khon Kaen	Maha Sarakham	Mukdahan	Sakon Nakhon
Buffalo, adult equiv. head	218,127	138,317	62,474	160,851
Beef Cattle, ditto	146,119	78,905	36,484	99,617
Annual Demand for TDN	418.9	249.8	113.8	299.5
Area of Grassland/Pasture	54,551	10,837	8,887	67,138
Annual Grass:TDN supply	36.7	7.3	6.0	45.2
Acreage of Paddy Field	1,997,770	1,678,278	377,758	1,667,332
Ann. Weed:TDN supply	5.6	1.1	0.9	21.8
Annual Paddy Production	490.5	446.4	108.4	393.5
Ann. Straw:TDN supply	165.1	150.3	36.5	132.4
Annual Cassava Production	622.8	302.0	200.5	250.5
Ann. Cassava:TDN supply	16.9	8.2	5.5	6.8
Ann. Supply of Cane Residue	2,762.9	144.7	667.0	161.1
Ann. Cane:TDN supply	251.8	13.2	60.8	14.7
Total Annual TDN supply	476.1	180.1	109.6	206.1
Demand~Supply Balance	57.3	-69.7	-4.2	-93.4

The table shown above implies that feed supply can meet the current feed demand only in Khon Kaen, while it slightly fails to meet the feed demand in Mukdahan, whereas in other two provinces serious deficit in feed supply has been caused that would probably be met by supplemental supply with purchased blended or concentrate feeds. In Khon Kaen and Mukdahan bagasse and molasse as by-products of sugar industry may fairly contribute to the alleviation of feed deficit. Cost of feed procurement accounts for 42% of the total production cost of livestock industry, exceeding that of breed calves (30%). Fattening of beef cattle has been promoted mainly in Maha Sarakham, where 25 ~ 35% of farm households keep 2 ~ 5 heads of beef cattle, earning a net benefit equivalent to about five thousand bahts per annum. As to livestock health, there has not been reported any serious epidemic livestock disease like F.M.D. since 1990, the year of outbreak of swine cholera.

2) Inland Fisheries

Inland fisheries have not been popularized within the Study Area. Very few farm households have been engaged in fish culture in their farm ponds for home consumption. Commercial scale fish farming has rarely been found, but farmers used to catch natural fish in the streams, creeks, natural ponds and medium or small sized reservoirs.

Pisciculture in artificial farm ponds has been diffused not only in Thailand but also in Viet Nam and Cambodia where model farming has been promoted with fish culture. In Thailand, Tilapia has so far been commonly introduced because it is quite resistant against such changes in water quality as eutrophication, it can be fed with cheap feeds (where feed cost accounts for only less than 10% of the total fish-farming cost) and it can grow so faster that the size of fish may reach around 30 cm within a year after releasing fingerlings. Other than Tilapia (locally called Pla Mor Ted), carp (Pla Nai), tropical tawes (Pla To Pien), tropic cat-fish (Pla Duk Dam), climbing perch (Pla Mor), sapat siam (Pla Slid) and grass carp (Pla Chao Fue) are used for culture depending on the environmental conditions in farm ponds and culture techniques. Fish farming can bring a net profit equivalent too three times as much as paddy cultivation using the same area.

As self supplied feeds, puppet of silk-worm, cassava cake and rice bran can be fed and as manure for weed that can be fed to fish, cow dung, pig manure, chicken dropping and rice bran can be utilized.

2.8.3 Sericulture and Reforestation

1) Sericulture

The reason why North Eastern Region has become a center of sericulture in Thailand resides with the presence of hitherto traditional techniques, suitable rearing season falling in August to December and abundant rearing labor available at cheaper wage. However, if one wants to initiate sericulture as side-business, he will have to provide enough time and fund to be invested to the procurement of rearing equipment, establishment of mulberry garden of

appropriate acreage, securing skilled labor required for several times of silk-worm rearing throughout the year, mastering rearing techniques etc., implying that this is not at all an easy side-job. Sericulture business is forecast to shift gradually to poverty suffering areas of Viet Nam, Nepal, Burma and other developing countries where cheaper labor wage will prevail, given the influence and negative impact of cheap Chinese silk that has affluent share of production in the world, entailing in staggered income of rearing farm from sericulture. This has imposed Thailand sericulture farms and silk industry a new issue, how to improve quality standard and how to add high value rather than expanding silk production from now onward. In fact, as imports of material silk thread to Thailand has been increased, the character of the country begins to change from the producer to the processor of silk.

Anyway, silk-worm rearing has become popular in Maha Sarakham and Khon Kaen within the Study Area, where 27% and 11% of farm households, respectively, have been engaged in sericulture, gaining an auxiliary income equivalent to 3 ~ 6 thousand bahts a year per rearing farm. Silk spinning is engaged in two levels, reeling mills and sericulture farms, and this activity is strongly supported by the extension wing as a basal component of diffusing techniques, because silk / cocoon prices have been kept stable even though the levels have not been attractive. They fluctuate in the range of 1,400 bahts / kg for first class filature as warp, 1,250 bahts / kg for second class and 1,050 bahts / kg for third class, 800 bahts / kg for first class filature as weft, 700 bahts / kg for second class and 500 bahts / kg for third class. The labor wage offered to housewives engaged in silk weaving work stays around 120 bahts per day, and this offers an attractive auxiliary income for them. The types of sericulture observed in the Study Area can be tabulated as follows:

Table 2.8-10 Types of Sericulture

Type of Sericulture	a) traditional type	b) improved type	c) modernized type
area of mulberry garden	0.25 rai / farm	about 1 rai / farm	over 5 rai / farm
Annual rearing scale / farm	10 trays / 5 times a year	40 trays	over 50 trays
Annual cocoon yield / farm	less than 10 kg	around 30 kg	over 50 kg
Variety of Silk Worm	only local poly-voltine	polyvoltine & bi-voltine	cross bred poly x bi-voltine
State of rearing house	using living quarter	The same as left or semi-permanent chamber	independent rearing house
acquired technical level	Low quality weft production	Average of rearing farm	disinfection with formalin
farm economic function	Mainly home consumption	home consuming and for sale	exclusive sale to brokers

The statistics of sericulture for four provinces concerned is given in the following table:

Table 2.8-11 Statistic of Sericulture in Four Provinces

Province	Number of Households	Area of Mulberry Cultivation (rai)	Weft Silk Production (kg)	Cocoon Production (kg)
Khon Kaen	37,882	36,363	152,485	54,517
Maha Sarakham	49,369	44,331	217,047	200
Sakon Nakhon	2,624	2,823	8,715	7,263
Mukdahan	115	1,312	632	32,934
Total	89,990	84,829	379,511	94,914

Source : Agricultural Statistics of Thailand, 1994/1995

2) Reforestation

In the past, the forestry in the Study Area was healthy and covered a vast area. Until the people moved in the forests to looking for:

- food supply and hunting;
- agriculture land;
- fuel for cooking the food;
- timber, poles and other forest for construction and commercial purpose.
- land for grazing their livestock.

At present, the forestry is found mostly in the west and the south of the Northeastern Region. The government has many reforestation projects. One of the project is to encourage the farmers to plant forest trees on their own land for 2-50 rai by using the local forest trees and the government will subsidize the money at 3,000 baht per rai for the period of 5 years. After 5 years all the trees planted will belong to the farmers. By this project, the government has the objective of increasing the forestland, but is not quite successful because farmers have limited land and most of the land is paddy field. Reforestation for big area is difficult. The Restructure of Agricultural Production System is also promoted the acacia etc. Even there are many projects to promote the reforestation but the increase of population to together with high value of land make farmers sell their lands to the city men, which are not occupied in agriculture. Farmers are then looking for new piece of land again. It is quite difficult to maintain the forest area at 25% of the total area. Agroforestry is one of strategy to be used in the Northeastern Region, it is not however well accepted. It needs more understanding from all the people concerned.

2.8.4 Farming Type and Integrated Farming

1) Farming Type

Five types of farming practiced by farmers can usually be found in the Study Area namely:

- a) Rice
- b) Rice and Field Crops (cassava or sugarcane)
- c) Rice and Field Crops and Cattle Raising
- d) Integrated Farming
- e) Rice and Plantation of Fast Growing Trees or Agroforestry

a) Rice

Farmers in the Study Area who cultivate only paddy rice are mostly a small holder having a land not exceeding 5 rai.

b) Rice and Field Crops

Most farmers in the Study Area usually cultivate rice and cassava or rice and sugarcane.

c) Rice and Field Crops and Cattle Raising

At present, this farming type is popular in the Study Area and percentage of farmers practicing this farming type are estimated to be about 30 %.

d) Integrated Farming

In the Study Area, integrated farming can be observed on farmland with farm ponds. Most farmers here grow fruit trees and vegetables around their ponds and raise livestock on the land. Fish are also bred in these ponds. The numbers of farmers practicing integrated farming are still few in the Study Area.

e) Rice and Plantation of Fast Growing Trees or Agroforestry

This farming type is not commonly practiced in the Study Area. At present, there is a group of farmers practicing this farming type in LRAs near forests in Sakon Nakhon.

Agroforestry is a management system for using land through the integrate in of forestry, agriculture and livestock activities within the same area or by rotating the three in order to enable production. The agroforestry system can be subdivided into 4-system namely:-

- Multiple Cropping System (including Ecological Farming)
- Forestry and Agriculture
- Forestry and Livestock Breeding
- Forestry and Agriculture and Livestock Breeding

2) Integrated Farming

It is very difficult to practice dry season farming in rainfed areas. However, even in these areas, farmers can secure water from farm ponds. Using farm ponds, farmers can improve their farming. Integrated farming is one basic farming type with a combination of many kinds of farm enterprise such as rice production, livestock breeding, vegetable and fruit tree cultivation. Inland fishery also has important role in it. Because farm ponds are essential for the practice of livestock breeding for drinking water, irrigation of nursery rice seedlings, vegetables and other crops.

Integrated farming is based on a cycle among types of farming, which can utilize the farm and farm by-products effectively. For example, by product of upland crops can be used for cattle feed and cattle dung can be used for rice and upland crops fertilizer. The cycle can also save production costs by utilizing the by-products effectively.

There are many types of integrated farming as a result of combining the farming practice such as vegetable cultivation and livestock breeding, fruit trees cultivation and fishery.

At present, there are many farmers interested in practicing integrated farming. The Thai Government and NGOs are promoting, encouraging and supporting farmers in many aspects of this, especially the provision of farm ponds. In 1994, the Royal Irrigation Department (RID) has supported farmers to construct about 1,400 small farm ponds. From these ponds, Khon Kaen has the highest number and Mukdahan has smallest number. (Data is shown in Appendix F, Table F-5.)

2.8.5 Agricultural Machinery

Numbers of agricultural machinery in LRAs are shown below. For number of the agricultural machinery per household, Khon Kaen and Maha Sarakham are high and Mukdahan is low.

Table 2.8-12 Estimated Number of Agricultural Machinery

LRAs	House holds	Number of Agricultural Equipment				Average Number of Equipment per 100 Households			
		Two wheel tractors	Four wheel tractors	Water pumps	Threshers	Two wheel tractors	Four wheel tractors	Water pumps	Threshers
KK-1	3,382	961	6	496	18	28.4	0.168	14.7	0.526
KK-2	875	328	3	257	9	37.5	0.309	29.4	1.077
KK-3	800	323	3	129	6	40.4	0.405	16.1	0.757
KK-4	724	201	2	193	5	27.7	0.213	26.7	0.706
KK-5	335	190	2	87	2	58.4	0.995	25.9	0.651
KK-6	6,167	2,155	9	942	13	35.5	0.143	15.3	0.211
MHS-1	436	176	0	17	6	29.0	0.035	3.9	0.105
MHS-2	2,877	1,367	5	653	10	47.5	0.176	22.7	0.352
MHS-3	363	90	1	43	2	24.7	0.141	13.3	0.556
MHS-4	559	137	1	68	3	24.5	0.153	12.2	0.503
MHS-5	1,175	313	2	108	2	26.7	0.209	9.2	0.194
MHS-6	1,158	336	1	172	5	29.0	0.105	14.9	0.405
MHS-7	722	179	2	40	1	23.2	0.239	5.2	0.152
MHS-8	4,007	1,415	9	295	8	35.3	0.217	7.4	0.191
MHS-9	16	6	0	3	0	37.7	0.167	18.6	0.261
MHS-10	535	155	0	21	1	29.0	0.035	3.9	0.105
MKD-1	6,136	1,116	10	888	3	18.2	0.166	14.9	0.051
MKD-2	4,493	1,088	12	691	7	24.2	0.277	15.4	0.156
MKD-3	6,407	1,460	19	1,015	9	22.9	0.298	15.8	0.135
MKD-4	110	33	0	16	0	30.0	0.339	14.8	0.254
MKD-5	357	94	3	47	2	26.3	0.803	13.3	0.428
MKD-6	41	11	0	5	0	26.3	0.803	13.3	0.428
MKD-7	2,786	636	13	311	7	22.8	0.460	11.1	0.246
MKD-8	3,453	580	8	128	6	16.8	0.238	3.7	0.164
MKD-9	3,095	551	5	492	1	17.8	0.176	15.9	0.046
MKD-10	70	12	0	3	0	16.8	0.238	3.7	0.164
MKD-11	796	134	2	29	1	16.8	0.238	3.7	0.164
MKD-12	680	114	2	25	1	16.8	0.238	3.7	0.164
SKN-1	1,055	431	5	89	8	41.1	0.430	8.4	0.770
SKN-2	1,689	680	3	209	9	40.3	0.201	12.4	0.506
SKN-3	10,840	3,032	8	1,163	7	28.0	0.075	10.7	0.067
SKN-4	4,354	1,226	5	514	13	28.2	0.110	11.8	0.289
SKN-5	5,595	1,573	14	684	60	28.1	0.249	12.2	1.078
SKN-6	2,026	520	4	286	4	25.7	0.221	14.1	0.202
SKN-7	423	152	1	63	2	35.8	0.186	15.0	0.375
KK	12,283	4,197	25	2,104	53	34.17	0.20	17.13	0.43
MHS	11,858	4,124	21	1,425	32	34.66	0.18	11.98	0.27
MKD	28,474	5,858	74	3,653	37	20.51	0.26	12.85	0.13
SKN	25,982	7,617	40	3,008	103	29.32	0.15	11.58	0.40
Total	78,587	21,776	160	10,190	225	27.71	0.20	12.97	0.29

(Note) estimated based on Arphoe data in 1997. (DOAE Provincial Office)

Source : DOAE, 1995