2.7.2 Cropping Pattern and Cultivation Area

1) Main crops in the Study Area

Main crops in the Study Area are rice including glutinous and non-glutinous rice, cassava, sugarcane, soybean, maize, mungbean, vegetables and certain kind of fruits.

Rice.....Thailand produce about 20 million tons of paddy rice per year, 60 % of which is for domestic consumption and the remainder for exporting, contributing 20 % to total exports and occupying about 40 % of the world paddy market. World market price affects the planting area, fluctuating from 8.6 million ha to 9.6 million ha over a 7-year period.

Cassava.....Cassava is one of the major crops together with paddy. From 80 to 90 % of total production exported to EC. However, exports are limited because of agreement between EC and Thailand. The government plans to decrease the cassava area by 192,000 ha between 1994 and 1996 according to restructuring policy of agricultural production.

Sugarcane.....World Bank estimates that sugar prices will appreciate toward the year 2000 to 2005, compared to the existing price of 208 $/ton. The Thai government has a plan to move sugar mill from the Central Plain and Eastern Region to the North and Northeastern Region in line with the national policy on rectification of regional income disparities. Sugarcane area in the Study Area will be increased within 2 to 3 years.

Soybean.....Import of vegetable oil into Thailand has been increasing due to the high demand in the domestic market because of improvement in people's daily life, especially in the urban areas. Soybean oil is considered as the premium oil in Thailand. Farm gate prices and profitability of soybean are higher than cereal crops and soybean is relatively resistant for drought. Agricultural restructuring policy and present market conditions will encourage farmers to plant soybean, resulting in stable increase in cropping areas.

Maize.....Maize has been planted in the areas in where paddy rice cannot be planted because of limited water and soil availability. Demand for maize in the domestic market is increasing according to an increased demand of

raw material for animal breeding. Maize, baby corn and sweet corn are promising crops from an agroeconomic point of view.

Mungbean.....Mungbean maintains good farm gate prices at the same level as the previous years because of brisk demand in the domestic market. They are mainly processed into noodles. Strong demand for mungbean noodles is attributed to people's preference in food. It is forecasted that the area for mungbeans will be increased, particularly in Udon Thani under the national agricultural policy which aims at restructuring of production.

Vegetables.....Vegetable consumption of the Thai people has increased from 40 kg/capita/year in 1970/71 to 70 kg/capita/year in 1991/92. This tendency will continue with the progress of the economic growth of Thailand and the agricultural policy which encourages planting of value-added crops. Planting of vegetables increases the cropping intensity, although it depends on water availability throughout the year.

Fruits.....Planting of fruit trees is one of the major policies in the restructuring of agricultural production, and Thailand is known as the exporting country of fruits such as mango, durian and pineapple etc. to Hong Kong, Japan, Malaysia and so on. In addition to vegetables, fruit production for domestic consumption and export will be increased.

2) Cropping Pattern

The cropping season for the main crops in the Study Area is showed in Appendix F, Figure 2.7-1.

The cropping season of annual crops is slightly different by area according to the natural conditions, and cropping season of each crop may be customized among farmers in each district and village. However, the farmers are considering the relationship between water conditions such as the begining time of the rainy season or the water supply from river and reservoir and the water demand of crops on their long experience, and then they decide the cropping season for each crop.

As shown in the following two figures, the cropping season of annual crops are divided into three types, these are (1) crops which are cultivated

mainly in the rainy season such as rainfed rice and corn, (2) crops to be mainly cultivated in dry season, such as soybean, tobacco and baby corn, and (3) crops to be cultivated throughout the year, such as sugarcane, pineapple and cassava.

However, the cropping season of each crops is not fixed, many crops can be grown in any season, if sufficient water is supplied. For example, soy bean, corn, sweet corn and some other upland crops can grow both in upland fields in the rainy season and in paddy field in the dry season after rainfed rice has been harvested.

3) Cultivated Area

Actual planted areas of crops in each field in the Study Area are summarized in Table 2.7-2. The more detailed planted area are shown in Table 2.7-2 (Udon Thani province) and Table 2.7-3 of Appendix F (Nong Khai and Nong Bua Lamphu provinces) respectively.

As shown in Table 2.7-2, the ratio of planted paddy fields in the rainy season in the 1993/94 crops year was 80.1 %. This is a low value, mainly due to a lower planted area in Udon Thani province than usual. The ratio of planted paddy fields in the rainy season is over 95% in most years.

The ratio of planted area of second rice was 0.5 %. If it is estimated that the upland crops in dry season were planted in dry season paddy, the ratio of planted area to paddy field is 1.6 %. So, total cropping intensity in paddy field is only 2.1 %. As the low planted area in dry season paddy field, many reasons can be mentioned, those are shortage of irrigation facilities, insecurity of water supply, low yield and low farmgate price of agricultural products and so on. However, insufficiency of irrigation facilities may be one of main reasons. It can be proved by the fact that about 80 % of farmers in the area are expecting the establishment of the irrigation facilities (Survey by the Study team).

Table 2.7-2 Actual Planted Area in each Field in 1993,94 Crop Year

(Unit:ha)

Field	Study Area		Rainy Season	Ratio(%)	Dry Season	Ratio(%)
Paddy field	335,247		268,543	80.1	1,573	0.5
Upland field	98,232	y. round	52,968	53.9	52,986	53.9
		r.season	9,985	10.2		
		d.season			5,386	5.5
		(sub-total)	62,953	64.1	58,372	59.4
Vegetables	5,684				4,295*	75.6
Fruits & Preen	15,976		15,976	100.0	15,976	100.0
Flower	65		65	100.0	65	100.0
Others	5,314					
Total	460,518		347,537		80,281	

Notes : 1) Source: Summarized from the data of agricultural statistics in each provinces.
2) *Many vegetables are cultivated both in the rainy and in the dry season.

4) Affects of Policy on Cultivated Area

The Thai government included Guidelines for Agricultural Development in the 7th-5 year Social Economic Development Plan, and each province decided to restructure the agricultural production and system plan according to the national plan. In the plan of each province, some areas of traditional crops such as cassava and second rice, etc. has decreased. The cropping area of second rice has decreased markedly, and the planted area of cassava is now slightly decreasing.

However, the planted area of cassava was 42,037 ha in the Study Area in 1993/94 crop year, and the ratio of planted area to the total agricultural land was 9.1 %. It is the biggest area among upland crops in the Study Area, which shows that cassava is the most suited crop to the infertile upland field in the Study Area.

Planted area of sugarcane is 9,218 ha in the Study Area, and the ratio of planted area to the total agricultural land is 2.0 %, and the crop is cultivated in all districts in the province with cassava, but other upland crops such as soybean, corn, kenar, jute and pineapple etc. are cultivated in small and limited areas.

Each province is encouraged to cultivate soybean, sweet corn, baby corn and vegetables as value-added and cash crops for the development of

agriculture and to reduce poverty, but the actual planted areas of soybean, corn and vegetables in the Study Area in the 1993/94 crop year are 1,229 ha, 12,335 ha, 4,295 ha respectively. The ratios of planted area to total agricultural land in the Study Area are only 0.27, 2.68 and 0.93 % respectively. These upland crops and vegetables are very promising because of the increased demand of local people and are recommended to cultivate, for making the farmer's income rise up and for abolishing the income disparity. It is necessary to increase the cropping area and to introduce cash crops in every district in the province.

5) Cultivated Area for Glutinous Rice

Relating to the cultivated area of crops, another problem is the large area of glutinous rice to total area of major rice in the three provinces. Table 2.7-3 shows two year's data on the ratio of cultivated area of glutinous rice in the three provinces. The data show that the area of glutinous rice to total major rice is over 80 % in Nong Khai and over 75 % in Udon Thani and Nong Bua Lamphu. This high ratio of planted area of glutinous rice to total major rice may be caused by the following two reasons; (1) Glutinous rice is the staple food for the inhabitants of the Northeastern Region, and (2) Yield of both glutinous and non-glutinous rice is very low, so it needs a large cultivated area of glutinous rice to satisfy the demand of the inhabitants. However, these facts prove that the most of the rice produced in the area is consumed by the inhabitants in the area or by farmers themselves. Increasing the yields both glutinous and non-glutinous rice is very important for the development of agriculture of the Area and expanding the self-sufficient economy.

Table 2. 7-3 Planted Area and Ratio of Glutinous Rice

(Unit: ha)

Province	Nong Khai		Udon Thani		Nong Bua Lamphu	
Crop year	1992/93	1993/94	1992/93	1993/94	1992/93	1993/94
Glutinous R.	160,249	150,532	272,088	196,683	108,182	100,430
Non-gluti R.	38,917	35,859	76,744	58,965	35,756	30,727
Ratio of glut. rice to total area	80.5	80.8	78.0	76.9	75.2	76.7

Area sources: Changwat agricultural statistics.

2.7.3 Crop Productivity

Regarding crop productivity, there are two problems. One concerns the yield of the crops per unit area and the other concerns the total production. Table 2.7-6 of Appendix F shows the changes in the average yields of main crops in the Study Area from crop year 1988/89 to 1994/95, the average yield in these years, standard deviation and coefficient of variation (%). From the table, it is clear that the variation of yield of each crop by year is comparatively low for these years. This is proved by the value of coefficient of variation, apart from the maize yield and mungbean in Udon Thani and Nong Bua Lampho and that of sugarcane in Nong Bua Lamphu (the yield for the 1993/94 crop year may be a mistaken calculation).

On the other hand, comparing the yield of major rice in Nong Khai and Udon Thani with that of the whole Kingdom, it can be pointed out that the yield of major rice in these three provinces are generally lower than that of the whole Kingdom. By the agricultural statistics of each province, the ratio of the yield of major rice in Nong Khai and Udon Thani (include Nong Bua Lampho) is only in 75 to 87 % that of whole Kingdom. The reason for the low yield of major rice in two provinces (not only two provinces but also throughout the North-eastern Region) may be caused by the low soil fertility of paddy field and some meteorological conditions such as irregularity of rainfall and the begining time of the rainy season in the Area.

Yields of major rice in two provinces and the ratio of yield to those of whole Kingdom are as follows.

Province / Year	1989/90	1990/91	1991/92	1992/93	1993/94
Yield (kg/ha):					
Nong Khai	1,575	1,569	1,713	1,750	1,631
Udon Thani	1,556	1,669	1,738	1,688	1,538
Whole Kingdom	2,031	1,813	2,094	2,031	2,063
Ratio (%):					
Nong Khai	77.5	86.5	81.8	86.8	79.1
Udon Thani	76.6	92.1	83.0	83.1	74.6

Source: Agricultural Statistics of Thailand 1993/94 Crop Year.

These factors can be recognized in corn and soybean. The unit yields of corn in Udon Thani in the last four years (1990 to 93 crop years) are about 95 % that of the whole Kingdom, and the unit yield of soybean in two provinces in the four years are 97 and 100 % in Nong Khai and Udon Thani respectively compared with those of the whole Kingdom. However, the yield of cassava and sugarcane are not very different from the whole Kingdom, because the areas are the main production areas of the two crops.

Table 2.7-7 of Appendix F shows the changes in the total production of main crops in the crop year 1988/89 to 1994/94. As shown in the table, the changes in the total production of main crops in each year is larger than that of the yield. This is clear from the value of the standard deviation and the coefficient of variation. The fact that the CV of the yield is not so large, but the CV of total production is very large. The variations in planted or harvested area of major rice are the cause of the large variation of total production of each crop. The reason for much large variations of planted or harvested area is not clear, but some meteorological unpredictability will cause these differences in planted area and the total production.

2. 7. 4 Farming Practices

Table 2.7-8 of Appendix F shows the number of farming machines owned by the holders and the number of holdings reporting the use of machinery and equipment for agriculture in Udon Thani including Nong Bua Lamphu. Table 2-7-9 of Appendix F shows those of Nong Khai. Table-2-7-8 shows that the comparatively large number of farming machines such as tractors, power tillers and sprayers are owned by the farmers even in 1988, and it will be clear that the number of farming machines owned by the farmers has increased in the most recent year, though the exact number is not clear. From the survey of the Study Team on the agricultural condition in the Study Area, the number of power tillers are now used for puddling and leveling of paddy field by farmers prior to transplant the rice.

However, considering the rice cultivation, many tasks are still practiced by human power. For example, on the management of rice cultivation, rice transplanting, weed control, fertilizer spraying, harvesting and threshing are mostly done by hand even though puddling and leveling of paddy fields before transplanting the rice are now carried out by machine.

Regarding upland crops, especially sugarcane, field management such as plowing the field before transplanting the young shoot is done by tractor of factory because the sugarcane fields are wide and deep plowing is necessary for the growth of sugarcane. However, except plowing, some management such as weed control and fertilization and harvesting of sugar cane are mostly done by hand, and harvesting (cutting the stem and taking off the leaves and head) are practiced mostly by workers and the harvested stems are carried directly in to the factory.

Transplanting of young cassava stems and the harvesting of cassava are mostly practiced by the farmers themselves. Many works for cultivation of other upland crops and vegetables are done almost entirely by man power. However, in the Study Area, many tasks in the field such as rice transplanting, harvesting of rice and cassava are practiced through the cooperation of small groups of relatives and neighbors.

Considering the techniques of rice cultivation, most of the farmers have their own technique for rice cultivation. Farmers know the relation between climatic condition and the growth of rice. However, the pattern of rainfall in the rainy season is not the same but changeable and variable, and the begining of the rainy season is not fixed. Many farmers are obliged to transplant spindly grown rice seedlings due to a delay of the rainy season and the lack of water for transplanting. It causes the few tillering, low number of heads and low yield of major rice.

Regarding the fertilization of major rice, farmers usually use straight and mixed fertilizer to quicken the growth. The amount of nitrogen per rai is almost 10 kg, and the amount of phosphate and potassium is 1 to 2 kg per rai respectively. For upland crops, mixed fertilizer, cow dung and chicken dropping are used to stimulate growth. However, farmers seldom use herbicides on insecticides for upland crops.

2.7.5 Livestock and Inland Fishery

1) Livestock

Numbers of livestock throughout the province and in the Study Area are shown in Table 2.7-10 of Appendix F. The data is of 1993.

The Northeastern Region had about 74 % of the buffaloes and 36 % of the beef cattle for breeding in the whole Kingdom in both 1991 and 1992. However, buffaloes are now decreasing in number. For example, the numbers of buffaloes in Udon Thani were about 310 thousand in 1990, but in 1992, the number was 296 thousand. Conversely, cattle are now increasing in number. For example, the number of cattle in Nong Khai was about 42 thousand in 1990, increasing to 79 thousand in 1994. The number of chicken are also increasing according to the increased demand for meat.

Most of the livestock are bred for consumption or work, while only a few are for commerce and their income. The animals for consumption of local people are duck and chicken. The animal for work are buffaloes and cow, and when the farmers need money or the animals increase in number, they are sold. Swine is bred for sell. In general, breeding swine does not require a large investment. Some farmers, who are capable of investing and with high technology, are operating large scale swine farm. Most buffaloes and cattle are fed on the grassland and paddy field after harvesting the rice.

2) Inland Fishery

Inland fishery is more active and flourishing in Nong Khai than Udon Thani, because there are more abundant water and larger areas of swamps in Nong Khain than in Udon Thani. The number of household and ponds, total area of pond and production in Nong Khai is shown in Appendix Table 2.7-11, and that of Udon Thani in 1993 and 94 is shown in Appendix Table 2.7-12.

The main fishes in the fresh water fish pond in Udon Thani were snake head fish, catfish, climbing parch, local carp and Nile telapia. These fishes are mostly consumed by their family and some of them are sold in local markets.

Many inland fishery in the Area are joining with the breeding of chicken and duck through the use of dropping. The dropping of poultry are taking a important role as the feed of fishes. The income of inland fishery are bigger than rice and upland crops in general, and the demand of fishes as the daily food are now increasing, so fishery are expecting to develop more widely in the Area.

2.7.6 Supply and Demand for Products

Many kinds of agricultural commodities are produced as described earlier. Those agricultural commodities are divided into three groups; (1) are those which are mostly consumed in the district such as glutinous rice, vegetables, some kinds of fruit and fish, and (2) those which are utilized mostly as materials for industry such as sugarcane, cassava, kenaf and jute, and (3) are the commodities used for farm industry such as tomatoes and pineapple. Among these groups, the first production group is largely affected by the demand and supply relation in the district.

The relationship between demand and supply of agricultural products in the first group are discussed with reference to glutinous rice, vegetables and fish.

Total production of glutinous rice vary according to year and district, so the quantity of of glutinous rice for the inhabitants in the Area also varies by district and by year. Some districts such as Muang Udon Thani, glutinous rice supplies are under 200 kg/person/year, and some district such as Phon Phisai, Phibul Rak, Kut Chap and Ban Phu supplies over 500 kg/person/year, even though average amount of glutinous rice which is consumed by person in a year is not clear. However, an average amount over 300 kg of paddy rice/person/year may be adequate amount for the people living in the Areas.

As for vegetables and fish in the Study Area, it is clear that the supply of vegetables and fish is insufficient in all provinces. In Nong Khai and Udon Thani, the amount of vegetables is 22 to 23 kg /person /year, but in Nong Bua Lamphu, it is only 5.6 kg. Perhaps farmers in this area may grow vegetables in their home gardens, and therefore the production in these area may be inaccurate.

Nong Khai supplies over 12 kg of fish/person/year, but in Udon Thai the supply is only 2.3 kg/person/year. The data shows that in all the provinces, extension of production of vegetables and inland fish is necessary.

Relating further on the values of demand and supply of crops and fish, comparison can be obtained by calculating the total production and the number of inhabitants and the amounts of supply of glutinous rice and paddy rice

(undulled rice). Before eating, it needs polishing and losses will occur during the process of transportation to the consumers. Weight loss by polishing and some another loss are calculated at about 35 % in rice, and loss from producers to consumers on vegetables and fish are counted at about 30 % and 20 % respectively. Consequently, the supply of glutinous rice, vegetables and fishes are summarized as in Table 2.7-4.

Table 2.7-4 Average Amount of Supply of Rice, Vegetables and Fishes

(Unit : kg/person/year)

Province	Glutinous Rice			Vegetables	Fish
Year	1992	1993	1994	1993	1993
Nong Khai	333	262	-	16.4	10.0
Udon Thani	-	203	287	15.5	1.8
Nong Bua Lamphoe	-	248	379	3.9	-

The demand for vegetables per person is estimated at 40 kg, and in recent years as 70 kg/person/year, so, the above results require the enlargement of the vegetable field to more than three or four times in every province, and fishponds should be also enlarged at the same rate.

2.8 Agro-Economic Conditions

2.8.1 Agroeconomic Characters

Agricultural condition and rural life in the Study Area have been changed since 1980s. Commercialized agriculture has been developed with introducing of tobacco and tomatoes, particular in Nong Khai, in 1980s, and fishery has also developed in 1990s. It is notable that tomatoes and tobacco cropping had been promoted in terms of contract farming between farmers and agricultural processing factory. However, these can be said only for Nong Khai which is facing to the Mekong river.

Even in the rural areas, consuming society has been tend to prevail along with the economic growth of Thailand. TV sets and motorcycles are diffused rapidly in the whole rural areas which are purchased on off-farm incomes by migrant workers. Two-wheels power tillers are also diffused and animal power has been mostly converted to these machinery. Recently, migrant workers working in Bangkok and other places are usually observed,

Table 2.8-1 Agro-Economic Conditions, Whole Changwat Basis

	Whole Thailand	Northeastern	Nong Khai	Udon Thani	Nong Bua Lamphu
1. Total Land (ha)	51, 311, 502	16, 885, 434	733, 228	1, 558, 939	385, 909
2. Population					
1990	56, 303, 273	19, 828, 941	797, 344	1, 770, 669	439, 110
1993	58, 336, 072	20, 170, 986	853, 706	1, 398, 991	463, 046
Annual Increase (%)	1. 19	0. 57	2. 30	-7. 55	1. 78
3. Population Density (1993)	114	119	116	90	120
4. No. of Farm households					
1987	4, 989, 508	2, 101, 938	80, 819	170, 337	65, 195
1991	5, 130, 531	2, 183, 557	84, 822	165, 599	76, 532
Change	1. 03	1. 04	1. 05	0. 97	1. 17
5. Average Farm Size in 1991 (ha)	4. 15	4. 23	4. 65	5. 10	3. 15
6. Land Use in ha	(1991)	(1991)	(1991)	(1991)	(1994)
Paddy	11, 090, 080	6, 075, 655	227, 912	530, 674	156, 779
Field crops	5, 362, 981	2, 152, 788	107, 183	219, 471	73, 078
Fruit trees	3, 215, 746	295, 057	11, 968	22, 515	10, 246
Vegetables	137, 309	22, 454	1, 241	1, 221	1, 290
Grassland	113, 090	63, 171	3, 581	6, 043	
Idle land	579, 401	330, 680			
Others	227, 744	83, 403	33, 370	46, 257	
Total	20, 726, 351	9, 023, 208	385, 255	826, 181	241, 393
7. Irrigable Areas in ha (1993)	4, 536, 978	756, 114	23, 542	31, 848	NA
8. Crop Yields (ton/ha in 1993/94)					
Major rice	2. 06	1. 64	1. 63	1. 54	NA
Second rice	4. 08	2. 25	2. 22	1. 99	NA
Cassava	13. 81	13. 56	12. 65	14. 52	NA
Maize	2. 73	2. 68	2. 69	3. 17	NA
Sugarcane	47. 31	45. 79	41. 68	42. 56	NA
9. Gross Production Value (GPV) in 1993					
Per capita GPV (Bahts)	54, 082	16, 818	19, 705	16, 424	10, 702
Per ha of land (Bahts)	61, 747	19, 972	22, 628	19, 428	20, 131
10. Agricultural GPV (million Bahts) in 1993					
Crops	175, 622	46, 604	2, 283	3, 667	NA
Livestock	32, 921	10, 554	327	987	NA
Fisheries	46, 830	1, 169	106	83	NA
Forestry	4, 664	26	6	0	NA
Agricultural services	10, 767	2, 767	99	311	NA
Simple agro-processing	44, 167	6, 853	354	508	NA
Total	314, 971	67, 973	3, 175	5, 556	NA
Per capita (Bahts)	5, 376	3, 369	3, 719	3, 971	NA
Per ha of farm holding areas (Bahts)	14, 792	7, 353	8, 041	6, 580	NA
11. Farm Economy (Bahts/family/year-1991/92)					
Gross farm income	35, 042	19, 026	23, 334	21, 634	18, 436
Farm expenditure	23, 812	12, 963	12, 652	10, 564	6, 647
Net farm income	11, 230	6, 063	10, 682	11, 050	11, 789
Off-farm income	22, 930	19, 147	23, 733	22, 174	20, 733
Net farm household income	34, 161	25, 210	34, 415	33, 224	32, 522
Farm household expense	35, 432	24, 005	31, 760	23, 543	22, 781

Source. Agricultural Statistics of Thailand
Statistical Yearbook, NSO
Note. Nong Bua Lamphu was administratively separated from Udon Thani in 1993

particularly in young generation, which resulted in reduce of young farm labour forces and in appreciation in farm labour costs. Result of the farm economic survey shows about 30 % of farmers go outside to get off-farm incomes. In Nong Khai, however, dry season crops such as tomatoes, tobacco, stringbean are widely planted along the Mae Khong river and some farmers answered to interview that they will not go out and stay in villages if water would be available in the dry season with the implementation of the project.

Trade between Laos and Thailand through the Friendship Bridge are increasing over these two years and Thai has an excess of exports over imports to Laos. As per agricultural products Thai exports sugar, rubber products, rice and milk products, and while wood/logs are the main exporting commodities from Laos.

Agroeconomic and some socioeconomic conditions in the three Changwats are summarized in Table 2.8-1.

1) Total Land

Udon Thani has the largest land among the three Changwats, followed by Nong Khai and Nong Bua Lamphu. These three Amphoes occupy 15.2 % of the Northeastern Region and 5.9 % of the national land.

Share of the Study Area, covering 860,720 ha, is 5.1 % of the Northeaster Region and 1.7 % of the national land, as well.

2) Population

Annual increases in population from 1990 to 1993 in the three Changwats are estimated at 2.3 % in Nong Khai, -7.6 % in Udon Thani and 1.8 % in Nong Bua Lamphu. Decrease in Udon Thani province is because of administrative separation of Nong Bua Lamphu in 1993.

3) Population Density

Population density in Nong Bua Lamphu, which has the smallest area is the highest at 120 persons per sq.km, followed by Nong Khai.

4) Number of Farm Households

Excluding Udon Thani province in which administrative separation was taken place in 1993, number of farm households have been increasing slightly.

5) Farm Size

An averaged farm size in the three Changwats are calculated at 4.65 ha in Nong Khai, 5.10 ha in Udon Thani and 3.15 ha in Nong Bua Lamphu.

6) Land Use

There are some difference in the present land use. Paddy land in Udon Thani and Nong Bua Lamphu account for about 65 % of the farm holding area but 59 % in Nong Khai, which indicates higher dependence on the rainfed paddy production in the former two(2) Changwats. On the contrary, Nong Khai is considered as the leading Changwat in crop diversification among the three Changwats.

7) Irrigable Area

Ratios of the irrigable area in both Changwat are lower than 21.3 % of the national average, 6.1 % in Nong Khai and 3.9 % in Udon Thani.

8) Crop Yields

Though this must be compared using periodic data, paddy yield which is the major crop in the Area are generally lower than the national average.

9) Gross Production Value(GPV)

As compared with the national average, gross production values (gross provincial product) per capita in the three Changwats are lower, particularly in Nong Bua Lamphu. GPV per ha of land is the highest in Nong Khai at 22,628 Baht/ha, followed by Nong Bua Lamphu.

10) Agricultural GPV

Some differences in the structure of agricultural production can be pointed out. The following table shows the composition of agricultural production value in percentage:

	Nong Khai	Udon Thani
Crops	71.8 %	66.0 %
Livestock	10.3	17.8
Fisheries	3.4	1.5
Forestry	0.2	0.0
Agricultural Services	3.1	5.6
Simple agricultural Processing	11.2	9.1

Despite its small farm holding areas, Nong Khai province produces higher value in agricultural production per hectares of the farm holding area than Udon Thani. This implies the difference in cropping intensity, crop diversification by planting value-added crops and water availability, especially in dry season. Actually, Nong Khai province, facing Mekong river, is blessed in water availability more than Udon Thani which is located at inland. These land condition of the Changwat might affect the agricultural production structure and production value. For example, 17.8 % of agricultural GPV depend on livestock sector in Udon Thani, which can be managed with small water requirement.

For agro-processing, Nong Khai province produces higher value than Udon Thani in which there are four(4) tomato processing factories with 1,580 ton/day capacity and one(1) pineapple processing factory with 700 ton/day capacity.

11) Farm Economy

Incomes of farm households are divided into two (2) categories, that is, farm income and off-farm income. In comparison of net farm income, farmers in the three (3) Changwats are considered being living on lower income level. Ratio of off-farm income in the net farm household income are 69 % in Nong Khai, 67 % in Udon Thani and 64 % in Nong Bua Lamphu , respectively, which

are mostly the same level as the national average. These implies higher dependence on off-farm income to meet annual expenses.

2.8.2 Profitability of Crops

Farmers in the Study Area tend to save farm input such as fertilizers and agro-chemicals in considering risks of unstable rainfall and farmgate prices of crops, resulting in lower crop yield. The break-even point of rainy season paddy in Udon Thani was estimated at 3,085 Baht/ha which is equivalent to about 60% of 5,103 Baht/ha of the whole country (refer to Figure 2.8-1).

The profitabilities of some selected crops are estimated based on the data collected in the farm economic survey conducted in November to December in 1995(refer to Table 2.8-2). This table shows that profitabilities of the traditional crops such as paddy, cassava, maize are low, and this can be applied not only to the Study Area but also to the whole Thailand. In the contrast to these traditional crops, vegetable, fruit trees produce good profits. This phenomenon reflects the structural change in Thai agriculture, which is largely in response to opportunities in the world market. Low farmgate price of the traditional crops causes low interest in agricultural production, particularly in dryseason irrigated paddy cultivation among farmers and also causes emigrant to urban areas.

In comparison with the crops planted in the rainfed condition, crops in the irrigated condition shows higher yield which indicates an effectiveness of irrigation on crop production.

2.8.3 Marketing System for Farm Products

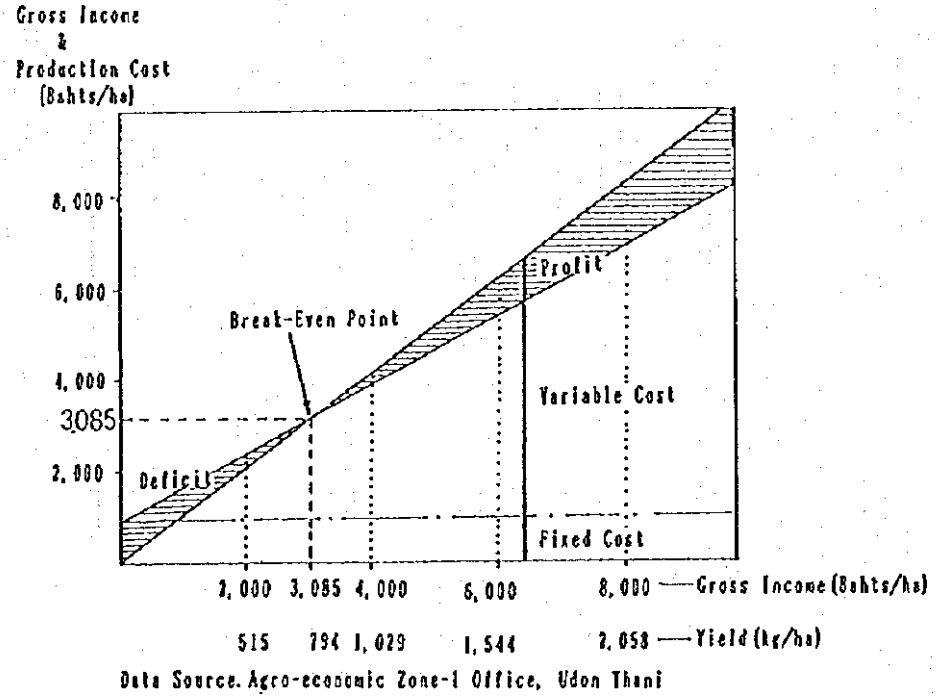
Figure 2.8-2 shows the marketing channels of the selected crops. For paddy, which is the major crops in the Study Area, farmers sell paddy after securing paddy for home consumption. On the basis of the farm economic survey, amount of paddy for marketing was estimated at 38.4% of the total production. Some 30% of which is glutinous rice and 79.4% is non-glutinous rice, respectively. This implies that glutinous rice is for home consumption and non-glutinous rice for marketing. Tomatoes mainly planted in Nong Khai are sold to processing factory in Nong Khai with which farmers make contract farming. Sugarcane is transported to the sugar mill at Khumphawapi in Udon Thani.

Table 2.8-2 Profitability of Crops

(Unit: Bahts/ha))

	Yield (kg/ha)	Farmgate Price (Bahts/kg)	Gross Income (Bahts/ha)	Production Cost (Bahts/ha)	Net Income (Bahts/ha)
Rainfed					
Paddy (TP)	1,471	4.01	5,898	4,080	1,818
Paddy (BC)	1,206	4.01	4,836	2,900	1,936
Upland Paddy-wet	1,500	4.65	6,975	1,160	5,815
Maize	2,670	2.36	6,301	5,470	831
Cassava	11,660	0.78	9,095	7,750	1,345
Sweet corn	2,110	2.00	4,220	2,580	1,640
Sugarcane	62,500	0.40	25,000	23,000	2,000
Soybean	1,125	8.20	9,225	5,730	3,495
Irrigated					
Paddy (TP)	2,040	4.01	8,180	5,870	2,310
Paddy (BC)	2,090	4.01	8,381	3,150	5,231
Soybean	1,336	8.20	10,955	5,730	5,225
Sweet corn	2,675	2.00	5,350	3,240	2,110
Cucumber	12,500	2.67	33,375	12,990	20,385
Stringbean	2,030	10.00	20,300	9,800	10,500
Tomato-wet	13,450	3.33	44,789	10,510	34,279
Tomato-dry	15,260	3.33	50,816	12,480	38,336

Source. Farm Economic Survey Nov. 1995



Data Source. Agro-economic Zone-1 Office, Udon Thani

Figure 2.8-1 Break-Even Chart of Wet Season Paddy-Udon Thani

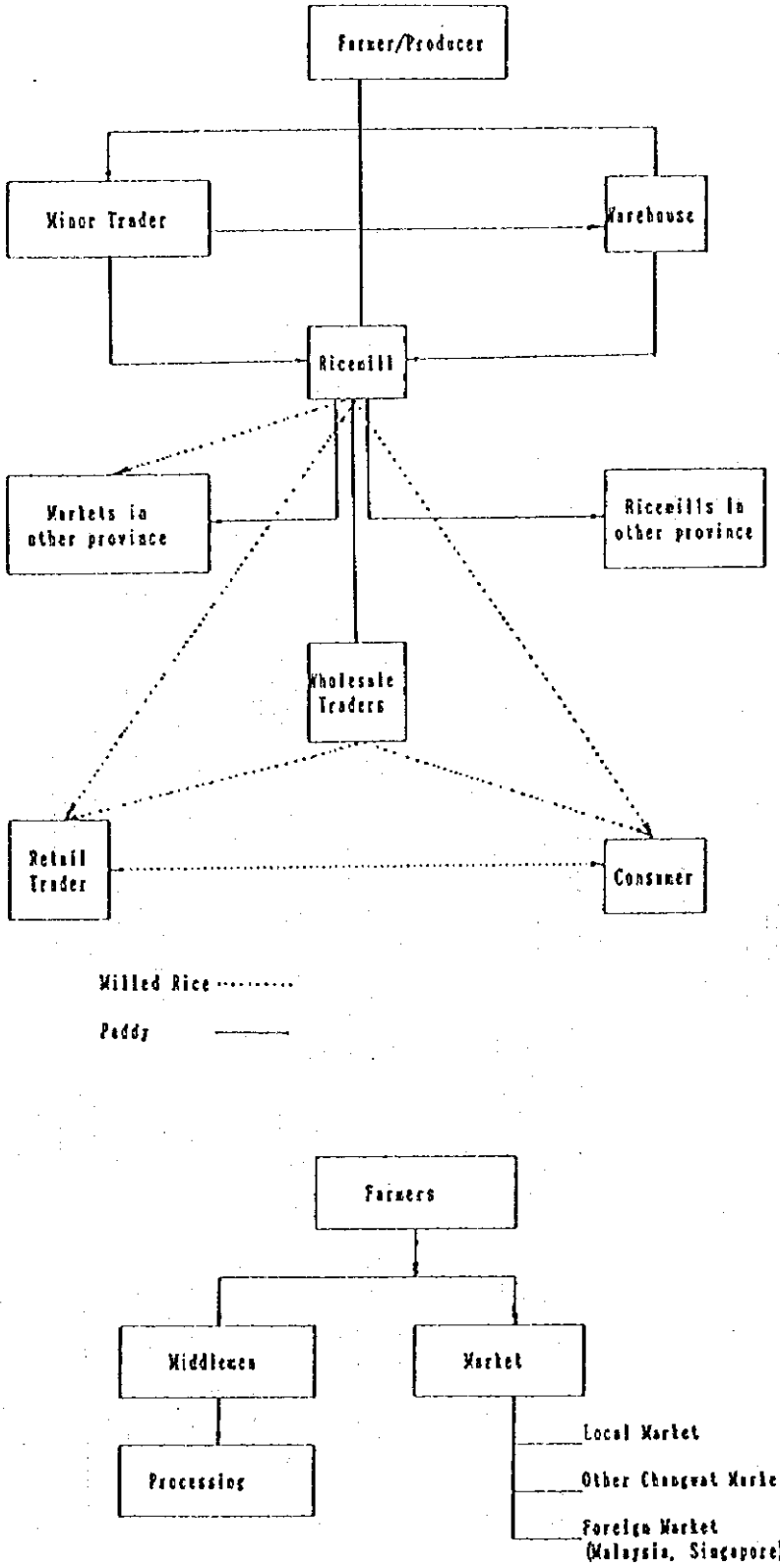


Figure 2.8-2 Marketing Channel of Agricultural Products

Marketing activities of the agricultural cooperatives are weak in paddy marketing because of its emphasis on crediting services. This is resulted in disadvantages to farmers in bargaining paddy with buyers. Buyers subtracts costs on transportation and fuel from purchasing cost. At present paddy marketing can be said being a buyer's market. The Ministry of Commerce has been trying to improve these marketing conditions by setting up so called "meeting market", in which officers supervise weighing method and paddy prices when farmers sell paddy to buyers at this market.

In Khon Kaen province which is located at southern part of the Study Area, there are sugar mills, paper manufacturing factory, milk processing factory and slaughterhouse and so on.

2. 8. 4 Farm Household Income and Poverty Condition

Average annual household income and net farm household income including off-farm income in Thailand and Northeastern Region in 1991/92 are estimated as shown below:

	Whole Kingdom	Northeastern
Household income	84,744 (100)	78,348 (100)
Gross farm income	35,042 Baht	19,026 Baht
Cash farm expense	23,812	12,963
Net farm income	11,230	6,063
Off-farm income	22,930	19,147
Net farm household income	34,160 (40)	25,210 (32)

Disparity in income between household and farm household in the whole Thailand and Northeastern Region are 40% and 32%, respectively.

As compared with the farm income of whole Thailand, annual net farm household incomes of 34,415 Bahts in Nong Khai, 33,224 Bahts in Udon Thani, and 32,522 Bahts in Nong Bua Lamphu are mostly placed on the same level and higher than that of Northeastern Region.

As well as the comparison in net farm household income, net farm income excluding off-farm income must be compared. According to Table 2.8-3, annual net farm income in Nong Khai, Udon Thani and Nong Bua Lamphu are

Table 2.8-3 Net Income and Expenditure of Farm Household(1991/92)

(unit:Bahts/Households/year)

Changwat	Amphoe	Cash Farm Income ①	Cash Farm Expenditure ②	Cash Off-Farm Income ③	Cash Off-Farm Expenditure ④	Net Cash Farm Income ⑤=①-②	Net Cash Household Income ⑥=③+⑤	Saving ⑦=(①+③)-(②+④)
Nong Khai								
Whole Changwat		23,334	12,652	23,733	31,760	10,682	34,415	2,655
Study Area								
	1. Muang Nong Khai	16,638	10,662	37,504	39,059	5,976	43,480	4,421
	2. Tha Bo	52,954	18,372	30,537	55,231	34,582	65,119	9,888
	3. Phon Phisai	19,149	9,993	15,138	23,593	9,156	24,294	701
	4. Si Chiang Mai	39,466	13,550	19,207	35,117	25,916	45,123	10,006
	5. Sang Khom	27,064	19,265	23,016	32,880	7,799	30,815	-2,065
	6. Sra Khrai	included in Muan Udon Thani						
Udon Thani								
Whole Changwat		21,634	10,584	22,174	23,543	11,050	33,224	9,681
Study Area								
	1. Muang Udon Thani	19,035	14,567	45,570	39,024	4,468	50,038	11,014
	2. Kut Chap	30,408	23,796	33,613	38,908	6,612	40,225	1,317
	3. Kumphawapi	35,700	2,527	3,843	1,063	33,173	37,016	35,953
	4. Thung Fon	17,017	16,930	17,324	27,237	87	17,411	-9,826
	5. Ban Dung	11,990	10,990	14,478	23,729	1,000	15,478	-8,251
	6. Ban Phu	17,275	4,715	3,183	4,652	12,560	15,743	11,091
	7. Phen	13,659	10,387	36,402	38,105	3,272	39,674	1,569
	8. Sang Khom	5,707	3,455	13,402	18,584	2,252	15,654	-2,930
	9. Nong Wua So	33,027	18,705	46,536	38,584	14,322	60,858	22,274
	10. Nong Han	20,093	11,314	28,407	32,130	8,779	37,186	5,056
	11. Nam Som	31,023	3,076	906	5,755	27,947	28,853	23,098
	12. Phibul Rak	included in Nong Han						
Nong Bua Lamphu								
Whole Changwat		18,436	6,647	20,733	22,781	11,789	32,522	9,741
Study Area								
	1. Muang Nong Bua Lamphu	25,520	13,607	42,380	35,515	11,913	54,293	18,778
	2. Na Klang	21,427	1,639	1,557	3,193	19,788	21,345	18,152
	3. Suwannakhuha	14,427	1,662	1,335	2,585	12,765	14,100	11,515
	4. Na Wang	included in Na Klang						

Source. Guideline for agricultural and cooperation development master plan, 1994-1996.
Agricultural Economic Zone 1 Office, Udon Thani
Note. Adjusted by the Study Team

10,682 Baht, 11,050 Baht and 11,789 Baht, respectively, which are slightly lower than that of whole Thailand.

Annual off-farm income in the three Changwat are 23,733 Baht in Nong Khai, 22,174 Baht in Udon Thani and 20,733 Baht in Nong Bua Lamphu, respectively, which shows mostly even to the whole Thailand but bigger than that of the Northeastern Region.

Analysis on the farm household income shows that there exists income disparity even among Amphoe in the Study Area. Furthermore, these Amphoe could be divided into two(2) groups, that is, 11 Amphoe having bigger farm income than off-farm income and 11 Amphoe with bigger off-farm income than farm income. Bigger gross farm income in Nong Khai than Udon Thani and Nong Bua Lamphu might be considered being due to water availability.

NESDB estimates poverty threshold at 6,500 Bahts per capita per year, equivalent to about 33,800 Baht/family/year applying to 5.2 averaged family size in the Study Area. Therefore, nine (9) among 20 Amphoe in the Study Area do not meet poverty line based on this minimum family income.

2. 8. 5 Agricultural Supporting Services

1) Agricultural Extension Services

The Department of Agricultural Extension (DOAE) is primarily responsible for providing agricultural advice to farmers. Under the head office of the Department of Agricultural Extension, Northeastern Regional Agricultural Extension Office exists at Khon Kaen, covering 17 provinces in the region with six (6) plant protection units, one (1) sugarcane pest control units and eight (8) seed centers. The Regional Agricultural Extension Office provides not only a guideline for agricultural extension service but also training opportunity for farmer's leaders and farmers. Agricultural extension workers are not disposed in the office.

The Provincial Agricultural Extension Offices (PAEO) are also disposed in each Changwat, Udon Thani, Nong Bua Lamphu and Udon Thani, to implement extension services in line with the Regional Office. PAEO is composed of three branches, that is, Planning, Extension and Production

Development, Pest Protection and Eradication. Agricultural extension workers are working for giving farmers advice to solve problems on agricultural production. The Provincial Extension Office provides training for farmers in group unit by using demonstration farms and training facilities under the Department of Agricultural Extension.

Under the Provincial Agricultural Office, Amphoe Agricultural Extension Office (AAEO) exists in each Amphoe to give guidance on agricultural production through agricultural extension workers who contact farmers on farm level. There are two branches in AAEO, that is, Organization of Farmer Development, Production and Extension Branches. About one half of extension workers are working as the Tambon extension worker and have meeting every months at the Amphoe Extension Office to discuss the extension plans and the matter to be solved.

Extension services for livestock and fisheries are implemented by the Provincial Livestock Office and Provincial Fishery Office, respectively.

2) Agricultural Input Supply Services

Most of the seed is obtained by retaining crop grain from farm production and exchange with neighbours. A few farmers purchase seed, mainly for upland crops such as maize, soybean and groundnuts from merchant and DOAE. Private sector is the main supplier of fertilizer and followed by the agricultural cooperatives, marketing organization for farmers and BAAC(Bank for Agriculture and Agricultural Cooperatives). Agricultural chemicals like herbicides and fungicides are supplied entirely by the private sector.

3) Agricultural Experiment and Research

In Udon Thani, Sericulture Research Institute is disposed to implement experimental activities on improvement of mulberry cropping, breed improvement, improvement of silkworm raising etc. under the Department of Agriculture in Bangkok.

In Nong Khai, Rice and Temperate Cereals Experimental Station is disposed to implement crop tests on cultivation of paddy and wheat and variety

suitable for the Areas. One Fishery Experimental Station exists in Nong Khai province.

2. 8. 6 Farmers' Organization

1) Farmers Institution

Government officially acknowledges the farmer's institutions in Thailand. They can be classified largely into two types namely the cooperatives and the farmers' groups. The cooperatives are the final goal of farmers' institutions while the farmer's group is an intermediate organization waiting for further development to become a full scale cooperative. The following gives the status of farmer's institution as well as possible problems in future development.

2) Status of Cooperative

The cooperative means a group of people who give cooperation to each other and must make registration in accordance with the provisions of the act. The Cooperative Promotion Department of MOAC will be responsible for every type of cooperative activities that include the following six major kinds at presents.

- Agricultural Cooperatives
- Land Settlement Cooperatives
- Fishery Cooperatives
- Consumers' Cooperatives
- Thrift and Credit Cooperatives
- Service Cooperatives

Table 2.8-4 shows the number of cooperatives and members by region as of January 1994. Agricultural cooperatives' members are double the national average in the Study Area in Udon-Thani.

3) Status of Water Users' Organization

The Water User's Organization can be cataglorized into 2 main groups.

Table 2.8-4

Number of cooperatives and member by type of cooperative by region on January 1,1994

Region	Cooperatives federations		Agricultural cooperatives		Fishery Cooperatives		Land-Settlement cooperatives		Thrift and credit cooperatives		Consumer cooperatives		Services Cooperatives	
	Federations	Cooperatives	Cooperatives	Number of members	Cooperatives	Number of members	Cooperatives	Number of members	Cooperatives	Number of members	Cooperatives	Number of members	Cooperatives	Number of members
Northeastern	17	352	716	1,430,458	5	1,448	11	15,817	162	286,257	67	55,806	44	5,778
Northern	18	257	496	932,335	6	1,665	28	34,237	159	203,411	67	79,318	90	18,164
Central Plain	25	286	490	599,983	22	3,297	38	41,050	538	1,028,854	158	504,943	145	70,925
Southern	14	147	274	324,882	13	1,620	18	18,636	107	130,039	59	47,011	31	8,327
Total	74	1,042	1,976	3,287,358	46	8,030	95	109,740	966	1,648,561	351	687,078	310	103,194
Study Area														
N-Bua Lam Phu			11	10,347					1	210	1	575	1	87
Nong Khai	1	18	37	57,681	1	107			5	10,081	2	485	1	31
Udon Thani	1	20	30	104,623	1	1,255			14	28,344	3	3,615	1	1,119
Total	2	38	78	172,651	2	1,362	0	0	20	38,635	6	4,675	3	1,237

(1) Non-legistimated group:
- (Elementary) Water Users' Group

(2) Legistmated group
- Water Users' Association
- Water Users' Cooperatives

Table 2.8-6 shows number of The Water Users' Organization and member by type type of The Water Users' Organization by Study Area.

4) Status of Water Users' Groups and Water Users' Association

The water users' associations were established to create better understanding of water application, to coordinate with RID personnel in operations and maintenance and also to perform credit and marketing functions.

Kud Ling Ngor water users' association, in Amphoe Muang Udon Thani, was the first water users' association in Thailand. It has been in operation since 1968. At present, the operation performance of this water users' association is quite good. The present water users' association in the Study Area member 6 associations with total of about 11,933 households.

Water Users Groups eventually link together to form Water Users' Associations and become legal entities after registration at the provincial office. The Water Users' Associations president is elected by the Water Users Groups for two year term. The Water Users' Associations also pioneered the collection water fees, for Operation and Maintenance services.

Water Users' Associations collect money for membership fees Operation and Maintenance, fine for non-participation in on-farm maintenance and profit from marketing activities and donations. Funds are deposited in savings banks.

5) Status of Water Users' Cooperatives

Water users cooperative is a legitimate Water Users' Organization supported by cooperatives. The objective of Water Users' Cooperatives primary

Table 2.8-5

Average number of cooperatives and member by type of cooperative by province on January 1,1994

Region	Cooperatives federations		Agricultural cooperatives		Fishery Cooperatives		Land-Settlement Cooperatives		Thrift and credit cooperatives		Consumer cooperatives		Services Cooperatives	
	Federations	Cooperatives	Cooperatives	Members	Cooperatives	Members	Cooperatives	Members	cooperatives	Members	Cooperatives	Members	Cooperatives	Members
Northeastern	1	21	1	1,997	1	290	1	1,438	1	1,767	1	833	1	131
Northern	1	14	1	1,880	1	278	1	1,223	1	1,279	1	1,184	1	202
Central Plain	1	11	1	1,224	1	150	1	1,080	1	1,912	1	3,196	1	489
Southern	1	11	1	1,186	1	125	1	1,035	1	1,215	1	797	1	269
Total	1	14	1	1,664	1	175	1	1,155	1	1,707	1	1,957	1	333
Study Area														
N-Bua Lam Phu	1		1	941					1	210	1	575	1	87
Nong Khai	1	18	1	1,559	1	107			1	2,016	1	243	1	31
Udon Thani	1	20	1	3,487	1	1,255			1	2,025	1	1,205	1	1,119

Table 2.8-6

Number of The Water Users' Oraganization and member by type of The Water Users' Oraganization

Name of Chagwat	WUG			IWUG			WUA			WUC			Total	
	Amount	Rai	Members	Amount	Rai	Members	Amount	Rai	Members	Amount	Rai	Members	Rai	Member
U-don Thani	67	39,150	2,640	0	0	0	3	6,808	410	1	6,300	305	52,258	3,355
NONG khai	93	36,390	4,185	0	0	0	3	5,125	239	1	2,626	99	44,141	4,523
Nong Bua Lam Phu	25	16,849	973	0	0	0	0	0	0	0	0	0	16,849	973
Total	185	92,389	7798	0	0	0	6	11933	649	2	8926	404	113,248	8851
Average	1	499	42	0	0	0	1	1989	108.17	1	4463	202		

aim is water management. The boundary covered by a Water Users' Cooperative is determined according to the same principle used by a water users association and water users group. The evident difference compared to a water user's association is that a water user's cooperated aims to run business for benefit that will go to the members as income.

Table 2.8-7 shows the number of Water Users' Cooperatives and members by type of project.

The survey on present status of Water Users' Organization was conducted, in the form of a questionnaire survey under instruction and consultation of the study team with the cooperation of RID Udon Thani Provincial Office, for 10 completed large and medium scale projects and 13 selected DEDP pumping projects. The summary of the survey results is shown in Table 2.8-8.

2.8.7 Agricultural Credit Services

Major credit institutions for farmers are agricultural cooperatives and BAAC. Lending from commercial banks has been small.

BAAC has 10 branch offices in Udon Thani, 3 branches in Nong Bua Lamphu and 4 branches in Nong Khai, respectively and provides loan to individual farmers, agricultural cooperatives and farmer's institutions.

BAAC provides the following three types of loans:

- Short term credit

  Subject: purchasing seeds, fertilizers, agricultural chemicals, postponent of selling crops

  Interest: 9% for less than 30,000 Baht, 11% for above 30,000 to 60,000 Baht, 3% for postponent of selling crops

  Repayment: within 12 to 18 months, 8-10 months for postponent of selling crops

Table 2.8-7
Number of Water User Cooperative as of May 31,1993

	Cooperative Dept.	DEDP	RID of Land Consolidation	Total
Cooperative	29	328	74	431
Member	6,299	38,895	14,482	59,676
Area	161,725	605,279	632,956	1,399,960

Remark Water user group in Land Consolidation area 4812 groups
Member 132,904 Household
Area 1,560,728 Rai

Collected Result of Expenses in Water Operation and Maintenance at 30 September 1992

Unit:Bath

Detail	1990	1991	1992 (Year)
Operation expense	11,257,014	15,899,364	20,961,571
Maintenace Expense			
By using money	5,005,918	3,274,174	3,159,165
By manpower devotion Å¶	1,927,379	7,253,311	4,465,017

Table 2.8-8 Summary Results of Survey on Present Status of Water User's Organization in the Study Area

Items of Question	Medium Scale Project RID	Pumping Project DEDP
I. Planning		
1. Known by the farmer before construction	90 %	100 %
2. Agreed by the farmer about the project	100	100
3. Project orientation by government official	80	100
II. Present Physical Condition		
1. General Physical Condition		
Good	40	85
Fair	50	15
Inactive	10	0
2. There are on farm systems	30	23
3. Available water during dry season	50	100
4. General condition of canal systems		
Good	44	46
Fair	56	54
Inactive	0	0
5. Need some repairment	10	62
6. Need physical improvement	10	85
III. Operation and Maintenance		
1. Water users are involved in O & M	60	100
2. Water users are satisfied O & M	90	100
3. They have an agreement for maintenance	70	85
4. They have an agreement for operation	60	100
IV. Water User's Organization (WUO)		
1. WUO establishment	50	100
2. Established more than 3 years after construction	100	69
3. WUO was established officially	80	46
4. There are other activities besides O & M	60	85
Marketing	30	50
Agricultural Credit	30	50
5. Satisfy with the activity of WUO	100	100
V. Utilization		
1. The project is useful to the farmers	100	100
2. Water use better than before project		
Wet season irrigation	100	92
Dry season irrigation	80	100
Domestic water use	100	0
Livestock water use	100	54
Fishery water use	100	85

Notes: 1) All RID medium scale projects in the study area are surveyed (10 projects included Huai Luang Project).
2) The sample of DEDP pumping projects in the study area are 13 projects.
3) Percentage against all answers.

- Medium term credit

  Subject: machinery, agricultural equipment

  Interest: 9.5% for less than 30,000 Baht, 11% for 30,000 - 60,000 Baht, 12.25% for 60,000 - 1,000,000 Baht, 14.5% for above 1,000,000 Baht

- Long term credit

  Subject: 4 wheel tractor, large equipment, dairy cow farm, fruit and perennial farm

  Interest: 9% for less than 30,000 Baht, 10% for 30,000 - 60,000 Baht, 11.25% for 60,000 to 1 million Baht, 13.5% for more than 1 million Baht

In addition to the loan categories shown above, BAAC also provides loan in line with the government policy of the restructure of agricultural production. This loan is applied for long-term credit with the condition of an annual interest of 5% and 15 years repayment. At present, certain crops, particularly paddy, cassava, coffee and pepper, are considered to be in over-supply, resulting in unattractive prices. The purpose of this special loan is that farmers use this loan to increase their production efficiency, for example, by changing from the production of paddy to the production of fruits and perennial trees, diversified farming, livestock, fisheries, fast-growing trees, vegetables, cut-flowers and other short-term crops.

BAAC provides loan for agro-industry such as processing of pineapple, baby corn, coconut and so on at an annual rate of 7%.

Table 2.8-9 shows the lending operation in the three (3) Changwat concerned to the Study Area.

2.8.8 Rural Infrastructure

There are three (3) major national highway with concrete pavement, rout 2, rout 210 and rout 22 are available to connect the provincial capitals.

Table 2.8-9 Loans Operation for Farmers of BAAC

(unit: 1,000 Babts)

Changwat Amphoe	Total	Short-Term Loans			Credit, Cash and Medium-Term Loans			Long-Term Loans			Payment on Loans	
		Loans Disbursed	Repayment	Out-standing	Loans Disbursed	Repayment	Out-standing	Loans Disbursed	Repayment	Out-standing	Repayment	Out-standing
Nong Khai (1993)												
Whole Changwat	829,591	594,846	527,919	570,622	90,551	74,236	104,360	86,599	23,149	153,541	256	1,068
Study Area												
1. Muang Nong Khai	122,484	87,578	71,715	73,098	12,599	13,454	14,081	21,973	5,867	35,234	40	71
2. Tha Bo	78,131	61,928	54,182	55,850	12,706	9,525	12,081	5,689	1,581	10,139	-	61
3. Phon Phisai	134,239	117,751	103,622	107,323	9,147	10,055	11,273	924	2,248	15,629	4	14
4. Si Chiang Mai	57,550	39,454	31,718	37,859	6,230	6,055	7,071	4,490	949	12,564	-	56
5. Sang Khom	16,722	11,951	8,937	10,479	2,146	749	2,520	1,685	247	3,723	4	-
Sub-total	409,126	318,662	270,175	284,609	42,828	39,838	47,025	34,761	10,892	77,289	48	202
Udon Thani (April 1990-March 1991)												
Whole Changwat	1,040,546	884,763	371,149	513,614	583,253	247,430	335,823	186,894	48,595	138,299	40,435	52,810
Study Area												
1. Muang Udon Thani	89,410	73,831	27,522	46,309	48,627	18,348	30,279	17,627	5,159	12,468	1,544	354
2. Kut Chap	61,560	49,886	19,895	29,991	32,873	13,264	19,609	11,104	3,029	8,075	1,983	3,885
3. Kumphawapi	144,130	120,315	52,587	67,728	79,342	35,058	44,284	21,150	2,915	18,235	5,332	13,883
4. Thung Fon	15,260	12,769	5,085	7,684	8,414	3,390	5,024	3,105	1,036	2,069	778	483
5. Ban Dung	76,623	59,568	24,386	35,182	39,262	16,257	23,005	14,681	5,204	9,477	7,819	8,969
6. Ban Phu	127,586	115,288	50,140	65,148	76,022	33,426	42,596	25,113	7,572	17,541	1,619	2,301
7. Phen	41,044	30,750	11,478	19,274	20,252	7,650	12,602	8,708	3,518	5,190	2,928	3,978
8. Sang Khom	14,607	11,148	4,128	7,020	7,342	2,752	4,590	2,602	711	1,891	601	1,106
9. Nong Wua So	57,487	52,626	22,856	29,770	34,702	15,237	19,465	11,483	3,467	8,016	624	236
10. Nong Han	87,421	69,587	26,475	43,112	45,838	17,650	28,188	15,233	3,625	11,608	4,322	4,513
11. Nam Som	63,852	58,198	25,557	32,641	38,380	17,038	21,342	10,843	2,054	8,789	2,109	1,090
Sub-total	778,990	653,966	270,107	383,859	431,054	180,070	250,984	141,649	38,290	103,359	29,659	40,798
Nong Bua Lamphu (April 1990-March 1991)												
Whole Changwat	316,238	258,481	116,349	142,132	170,498	77,586	92,932	52,732	14,480	38,272	28,496	42,952
Study Area												
1. Muang Nong Bua Lamphu	53,927	50,314	24,112	26,202	33,207	16,075	17,132	10,155	3,099	7,055	3,829	8,537
2. Na Klang	108,356	75,237	31,845	43,392	49,602	21,230	28,372	16,628	4,944	11,684	11,049	24,908
3. Suwannakhuha	51,067	46,564	20,975	25,589	30,714	13,983	16,731	8,934	2,044	6,890	1,445	1,857
Sub-total	218,350	172,115	76,932	95,183	113,523	51,288	62,235	35,717	10,087	25,629	16,323	35,302
Total	1,406,468	1,144,743	617,214	763,651	587,405	271,196	360,245	212,127	59,269	205,277	46,030	76,302

Source Statistical Reports of Changwat, NSO

However, road capacity will soon require widening width with increasing transportation.

Contrary to these national highways, feeder roads and rural roads are, in general, not paved and flooded sometimes during rainy season, resulting in causing problems of marketing agricultural crops and daily lives of the village people.

The provincial power offices of each Changwat are responsible for supplying electricity. In the Study Area, currently 98.5 % of village in Nong Khai, 98.2 % in Udon Thani and 97.3 % in Nong Bua Lamphu are supplied electricity, respectively.

Compared to providing electricity, domestic water supply system for the rural areas are very poor, because of giving priority to the municipal areas. An earthenware pot for storing rain is still usually observed in the rural areas.

There are 554 schools in Nong Khai and 1, 250 in Udon Thani. Some 40 hospitals and 108 health centers in Nong Khai, 23 hospitals in Udon Thani, are provided for educational and public utility for the people.

2. 8. 9 Result of the Farm Economic Survey

1) Samples

The farm economic survey was conducted in each river basin, interviewing 200 farmers selected at random. The river basins were also divided into three areas, that is, upstream, middlestream and downstream, respectively.

2) Family Size and Farm Labour

Average family size and farm labour force per family were estimated at 4.69 and 3.09. Full-time farm labour in the Study Area was 55.2 % and part-time was 10.8 % (refer to Figure 2.8-3).

The classification of working hours per week for people of 13 years old and upward is shown in Part-5 of Appendix G. It can be said from this table in Thai farming society, men and women play an equal role in agricultural

Table 2.8-10 Characteristics of the River Basins

	Huai Luang Basin			Huai Mong Basin			Nam Suai Basin	
	Upstream	Middlestream	Downstream	Upstream	Middlestream	Downstream	Upstream	Downstream
1. Family Size (persons)	4.66	4.60	5.03	4.05	4.90	5.20	4.30	4.65
2. Farm Labour Status (persons)	2.97	2.83	3.33	2.97	3.40	3.70	2.55	3.20
3. Farm Size (ha)	4.32	4.83	3.04	4.27	4.67	4.91	3.37	2.55
4. Educational States of Farm Family.	Primary (%) 86.9	Primary (%) 93.1	Primary (%) 87.7	Primary (%) 83.4	Primary (%) 86.7	Primary (%) 84.3	Primary (%) 90.3	Primary (%) 98.5
5. Land Use (paddy %)	81.8	79.6	69.8	65.0	79.5	68.8	87.5	90.1
6. Irrigated Area (%)	7.3	3.3	27.3	3.7	9.9	0	0	18.7
7. Fallow Land (%)	10.5	8.1	3.2	4.5	2.4	14.2	3.3	1.4
8. Estimated Cropping Intensity (%)	84.2	82.1	100.2	94.4	96.0	82.4	91.2	99.4
9. Migrant Workers (%)	28.6	60.6	20.0	30.0	20.0	20.0	30.0	50.0
10. Family Income (B/year)								
Net Farm Income	11,996	16,573	24,193	26,232	44,582	33,158	10,545	33,835
Off-Farm Income	73,186	32,634	59,397	33,230	25,320	41,622	40,955	24,333
Total	85,182	49,207	83,590	59,462	69,902	79,730	51,500	47,168
11. Condition of Basic Minimum Needs (BMN)	8-11/37	7-8/37	9-11/37	8-14/37	6-11/37	9-15/37	10-13/37	3-14/37
12. Intention to Integrated Farming (Yes %)	54.3	60.0	53.3	30.0	40.0	30.0	20.0	15.0
13. Projects to be Implemented with Priority	Irrigation	Irrigation	Irrigation	Irrigation	Irrigation	Irrigation	Irrigation	Irrigation
(1st Priority %)	60.0	57.1	53.3	60.0	75.0	60.0	75.0	75.0

Source. Farm Economic Survey, December 1995
Note. Figures of item 11 means the number of categories which are not met in comparison of the Target.

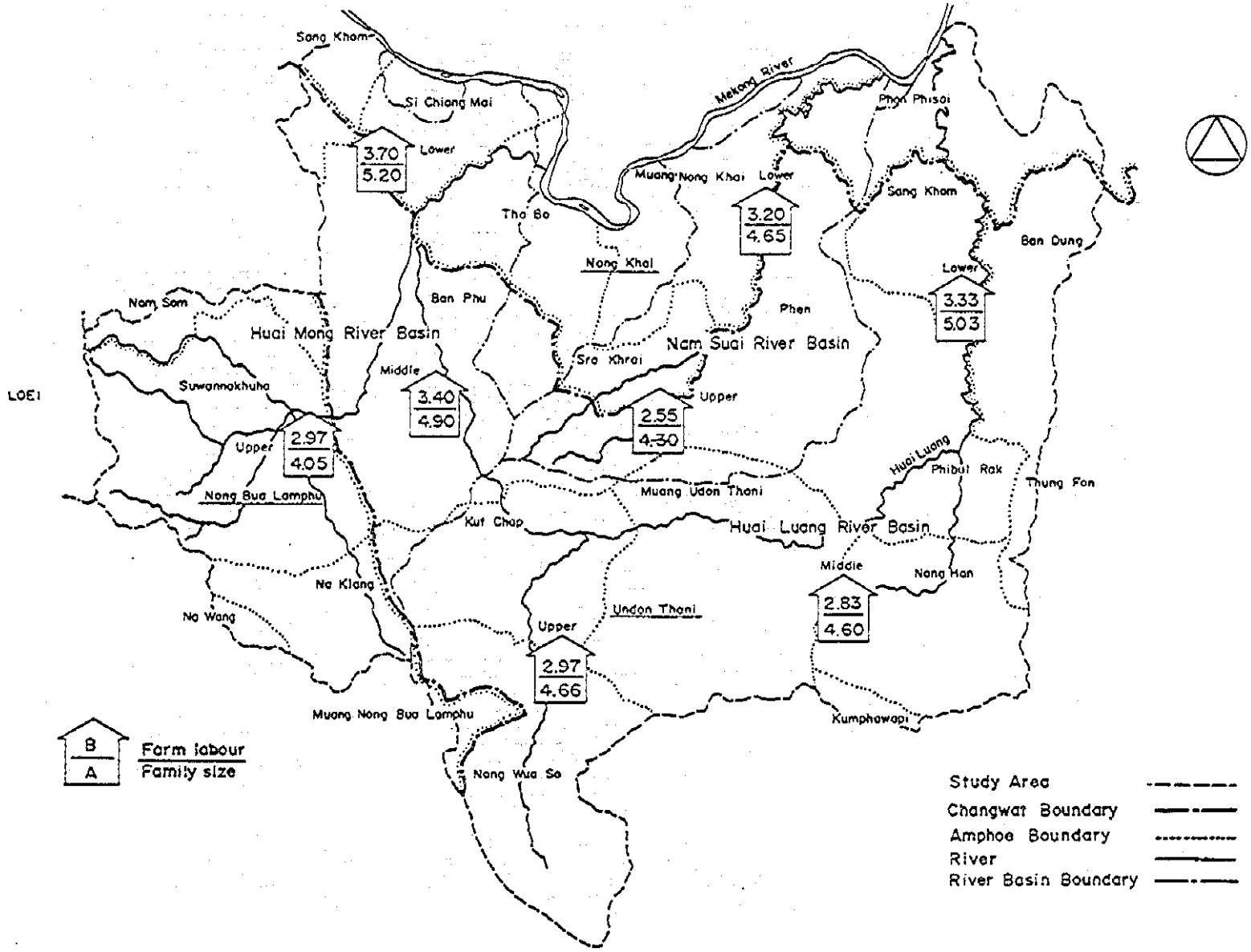


Figure 2.8-3 Family Size(persons)

production. Both are involved in all agricultural activities such as planting, weeding, harvesting and threshing and so on. Men usually do the hard physical work like sloughing. Men are engaged for hired labour and construction works within or outside the village. Women workers play a substantial role in the livestock and aquacultural sectors. Women also contribute to off-farm incomes of the family working in cottage industry such as weaving etc. Fetching water is the main task of women and children. According to the farm economic survey, they spend about 15 hours per month for this work. Working hours of the rural wives interviewed in the farm economic survey are mainly concentrated on farm practice with the highest percentage of 37 %.

3) Farm Size

Average farm size in the Study Area was 4.08 ha per farm and 4.62 ha in the Huai Mong basin, the smallest was 3.16 ha in Nam Suai basin (refer to Part-5 of Appendix G)).

4) Educational Status of Farm Families

89.4 % of farm families completed only primary school level on average, showing low the educational status of them (refer to part-5 of Appendix G).

5) Ratio of Irrigated Area

Ratio of irrigated area in the Study Area was 8.0% and 27.2 % downstream of the Huai Luang river basin was the highest, however, generally speaking irrigated areas in the Study Area are negligibly small (refer to Part-5 of Appendix G).

6) Land Use

High percentage of paddy field shows that agriculture in the Study Area depends on rice farming. But downstream of the Huai Mong river basin and Huai Luang Basin the crops are more diversified than in other areas (refer to Part-5 of Appenidx G).

Table 2.8-11 Classification of Working Hours per Week for 13 Years old Upward (1994)

(unit:person)

		Working Hours per Week									
	Total	Less than 10 hrs	10~19	20~29	30~39	40~49	50~59	60~69	70~79	80~89	90~99
Udon Thani	565,907	2,798	24,852	24,710	73,718	127,688	169,329	56,653	63,907	16,628	5,624
	100.00	0.49	4.39	4.37	13.03	22.56	29.92	10.01	11.29	2.94	0.99
Male	362,091	960	18,767	14,716	42,185	79,364	113,277	40,687	42,130	8,612	1,393
	100.00	0.27	5.18	4.06	11.65	21.92	31.28	11.24	11.64	2.38	0.38
Female	203,816	1,838	6,085	9,994	31,533	48,324	56,052	15,966	21,777	8,016	4,231
	100.00	0.90	2.99	4.90	15.47	23.71	27.50	7.83	10.68	3.93	2.08
Nong Khai	444,930	1,563	6,065	17,826	43,098	85,883	177,805	32,478	71,230	5,932	3,049
	100.00	0.35	1.36	4.01	9.69	19.30	39.96	7.30	16.01	1.33	0.69
Male	260,878	960	3,805	8,489	22,223	38,339	117,386	20,147	45,639	3,143	747
	100.00	0.37	1.46	3.25	8.52	14.70	45.00	7.72	17.49	1.20	0.29
Female	184,052	603	2,260	9,337	20,875	47,544	60,420	12,331	25,591	2,789	2,302
	100.00	0.33	1.23	5.07	11.34	25.83	32.83	6.70	13.90	1.52	1.25
Nong Bua Lamphu	216,623	-	4,431	9,460	22,427	62,145	62,751	19,304	34,825	143	1,137
	100.00		2.05	4.37	10.35	28.69	28.97	8.91	16.08	0.07	0.52
Male	137,888	-	2,873	5,120	14,495	33,799	42,638	13,447	24,782	85	649
	100.00		2.08	3.71	10.51	24.51	30.92	9.75	17.97	0.06	0.47
Female	78,733	-	1,558	4,339	7,932	28,346	20,112	5,857	10,043	58	488
	100.00		1.98	5.51	10.07	36.00	25.54	7.44	12.76	0.07	0.62

Source. NSO

Table 2.8-12 Distribution of working in a Year of Farmers Wives

(unit:%)

	Farm Practices	Child Care	Cooking	Washing	Fetching Water	Animal Care	Cleaning House	None
Huai Luan Basin								
Upper Stream	33.43	4.00	20.43	11.57	8.43	4.14	12.14	5.86
Middle Stream	34.43	6.29	17.86	11.00	7.29	4.00	12.14	7.00
Down Stream	41.50	6.00	18.83	11.50	5.33	4.00	12.83	0.00
Sub-Total	36.20	5.40	19.05	11.35	7.10	4.05	12.35	4.50
Huai Mong Basin								
Upper Stream	37.00	3.00	20.25	13.25	6.50	1.75	18.25	0.00
Middle Stream	31.00	5.00	20.00	11.00	3.75	2.00	11.25	10.00
Down Stream	44.25	4.75	19.25	11.75	5.00	2.25	12.75	0.00
Sub-Total	39.42	4.25	19.83	12.00	5.08	2.00	14.08	3.33
Nam Suai Basin								
Upper Stream	32.47	4.74	21.84	12.89	5.79	3.42	13.16	5.79
Down Stream	42.11	4.21	16.32	13.68	5.00	5.26	13.42	0.00
Sub-Total	37.24	4.47	19.08	13.29	5.39	4.34	13.29	2.89
Total	37.37	4.87	19.29	11.92	6.16	3.48	13.06	3.84

7) Ratio of Migrant Workers

Some 30 % of farmers or their families go to other areas to earn off-farm incomes. Of which 35 % go to Bangkok, 48 % remain inside the province and 11 % in other regions, earning 16,270 Baht/family on average (refer to Part-5 of Appenidx G).

8) Estimated Cropping Intensity

Though the number of samples was small, cropping intensity was calculated to understand the farming conditions. As a result, the highest were in the downstream of the Huai Luang river basin(refer to Part-5 of Appenidx G).

9) Ratio of Fallow Land

Ratio of fallow land was highest downstream of the Huai Mong river basin and second in the upstream of the Huai Luang river basin in which the capital of Udon Thani is located. The main reason given for the existance of fallow land was "lack of farm labour" (refer to Part-5 of Appenidx G).

10) Farmer's Intentions Regarding Integrated Farming

The government is now promoting integrated farming. In line with this policy, farmer's intentions were requested to make certain of their interests in the policy. However, farmer's intentions were not so high. Relatively higher intentions are seen in the Huai Luang river basin (refer to Part-5 of Appenidx G).

11) Basic Minimum Needs

Other than the farm economic survey, Basic Minimum Needs (BMN) was also studied to understand the quality of life in each province and Amphoe by using the data of the Ministry of Interior. There are 37 categories for evaluating BMN and the quality of life can be judged by counting the number of target categories which are unfulfilled. As a result, it can be said that the quality of life in the Huai Mong and Nam Suai river basins are generally low compared to that of the Huai Luang river basin (refer to Part-5 of Appenidx G).

12) Projects to be Implemented with Priority

Some 63 % of the farmers want to implement irrigation projects as their highest priority. Higher rates are seen in the Nam Suai Basin. Apart from this, studies on BMN also show that the constraints in safe drinking water provision are common in the rural areas (refer to Figure Part-5 of Appenidx G).

13) Farmer's Intention Regarding Farming Types

There are some differences among farmers interviewed. Major paddy combined with fruit trees occupied about 30 % in the Huai Luang river basin and major paddy combined with dairy cattle counts 28 % and 30 % in the Huai Mong river basin and Nam Suai basin, respectively.

2.9 Irrigation and Drainage Conditions

2.9.1 Irrigation Practices

1) Source, Responsible Agencies and Practices

Irrigation in the Study Area is from surface water developed by means of various sizes of projects undertaken mainly by RID and DEDP. RID categorized their projects into Large, Medium and Small according to their capacity, beneficiary area and cost. DEDP's projects are designed for pump irrigation. In the Study Area, RID has Huai Luang Project, which is a large scale project in the upstream of Huai Luang river with an irrigation area of 13,960 ha (85,970 rai).

In the case of large scale projects, there is good water distribution system up to on-farm level with Water Users' Associations (WUA). Water is distributed by a rotation system. In particular, Huai Luang has a rotation of 7 days on and 7 days off. The command area of the main canal system is sub-divided into zones and every zone has a group leader(from user's side). Water allocation is done from the written request by the individual farmer to the group leader. The group leader then recommends the request to the zone leader. Zone leader sends it to O/M of RID. The request is done every week. Due to the good contact system the whole procedure does not take long time. When water is

allocated to a certain farm ditch, on farm management is done by the farmers themselves but presence of RID Water Master is also noticeable. Sometimes even for on-farm distribution, rotation is followed.

In the case of medium-scale projects, only a few have a good water distribution systems. Some have only main canals and Water Users' Group. Where there is no Water Users' Group, water distribution is performed on weekly basis request by the farmers to the RID appointed caretaker of the canal system, and on the basis of the request the caretaker opens/closes the gate of the main/lateral canals.

There are two types of small scale projects. One is construction of weirs across the river and the other type is small reservoir development. RID does only the weir/reservoir construction. Distribution system and on-farm system supposed to be constructed by the farmers. But in most cases there is little distribution system. Therefore, purpose of small scale projects to serve agricultural uses has not been achieved.

In the Study Area DEDP has a large scale project called the Huai Mong project in the downstream of the Huai Mong river. The practice is to pump water from the reservoir to the main distribution system and farmers group do the on-farm management. The DEDP has also many other individual pumps in the Study Area on the bank of the rivers to withdraw irrigation water. In the dry season DEDP's pumps along the Mekong are one of the means for irrigation water for the dry season crops.

Apart from these irrigation practices, in the dry season farmers use their small capacity pumps (5-10 l/s) to withdraw water from the source nearby or carry water by buckets/pots manually from the nearest source to irrigate vegetable fields.

Irrigation efficiency varies from project to project. For example Huai Luang Project has 45% efficiency. But in the same province, in the case of medium scale projects this varies from 56-64%. However, an average of 50% efficiency would be an ideal.

As mentioned earlier, O/M of irrigation facilities is carried out by the O/M section of each provincial office or by the separate O/M departments in the case of large scale project.

According to the State Irrigation Act (1942) landowners receiving services from irrigation works should pay irrigation service fees of not more than 3baht/ha and volumetric charge was set at not more than 0.05baht/cu.m. But no agency has so far tried strictly to implement this law including RID. On the other hand, DEDP collects electricity charge from the beneficiaries at a rate of about 50%.

As a matter of fact, in the Study Area irrigation is done only as supplementary irrigation in the rainy season. Dry season irrigation is not practiced widely. There could be two reasons for this trend. One is lack of water and the other is lower profits from agricultural products.

Owing to these facts, the irrigated area in the Study Area is very low. Existing arable land in the Study Area is estimated at 460,000 ha (2,875,000 rai), of which the irrigated area is 41,280 ha (258,010 rai), which accounts for only 9% of the arable land.

2) Basin-wise Irrigated Area

As it is described that irrigation is provided from water developed by various projects, detail of their coverage (basin-wise) has been compiled and is presented below. Locations of existing projects are shown in the Figures 2.9-1.

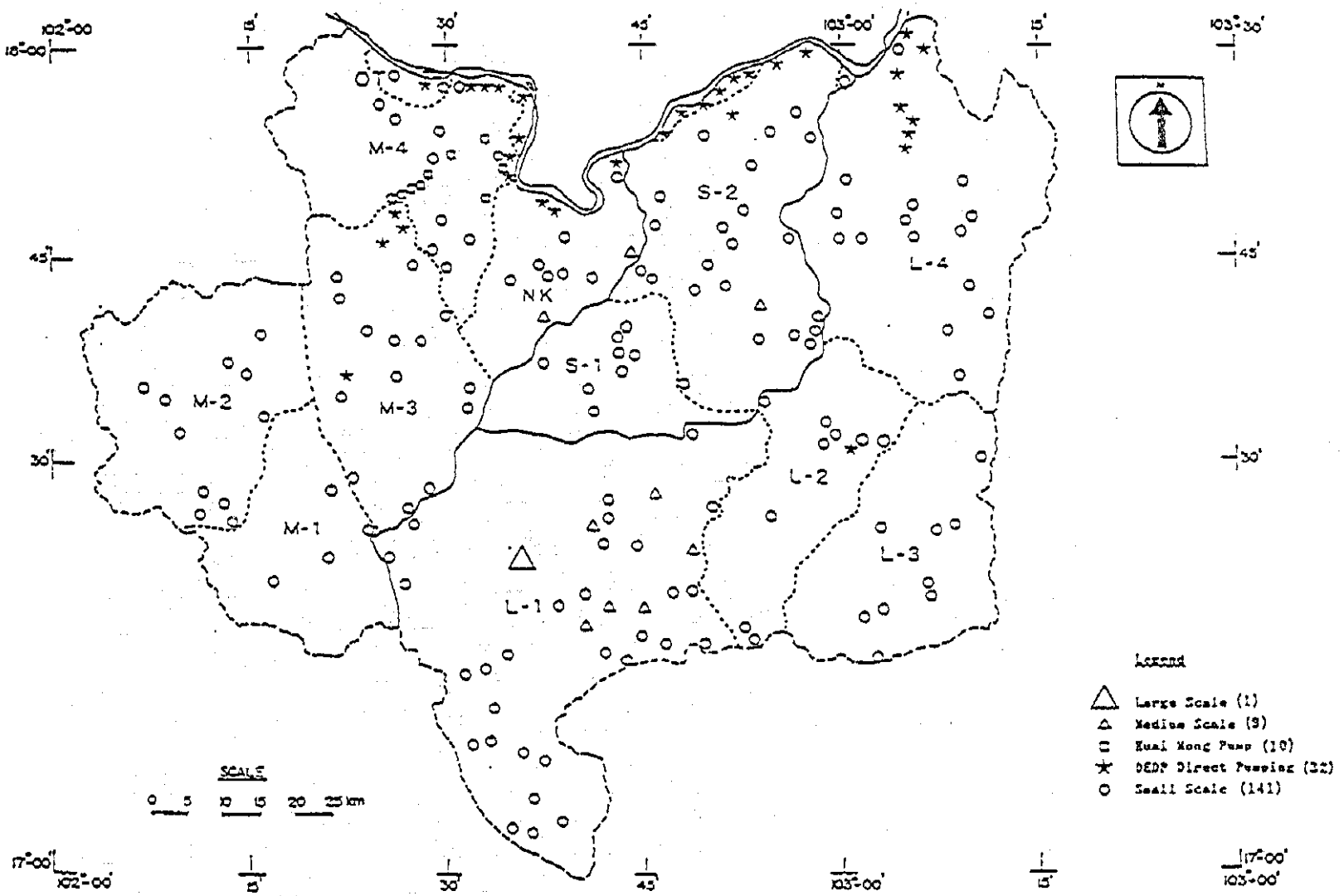


Figure 2.9-1 Location of Existing Projects

Project Type	Agency	Mong Basin	Suai Basin	Luang Basin	NK Basin	OT Basin	Total (ha)	Total (rai)
A.Existing								
Large	RID	0	0	13,760	0	0	13,760	85,970
Medium	RID	0	70	1,640	1,980	0	3,690	23,080
Small	RID	2,552	2,400	4,280	424	24	9,680	60,500
H.M.Proj	DEDP	3,170	0	0	0	0	3,170	19,820
Pumping	DEDP	3,075	1,332	1,850	650	2,323	9,230	57,690
Dredg.	RID	350	525	875	0	0	1,750	10,940
Total (existing)		9,147	4,327	22,405	3,054	2,347	41,280	258,010
B. Proposed Projects								
L. H. Luang		0	0	19,200	0	0	19,200	120,000
Nam Suai Basin		0	17,750	0	0	0	17,750	110,940
Medium (17)		4,290	1,920	3,810	990	0	11,010	68,810
Small (263)		6,070	2,378	10,450	1,250	0	20,148	125,930
Total (proposed)		10,360	22,048	33,460	2,240	0	68,108	425,680
Grand total (existing + proposed)							109,388	683,690

2.9.2 Water Rights

Although diversified utilization of water resources and competition among various water users have grown rapidly in the recent years the law and regulation regarding development/management have not been established accordingly. In Thailand three irrigation laws have been enacted during the past, started with King Mengrai about 1,400 years ago. In 1939 People's Irrigation Act was established, and State Irrigation Act was enacted in 1942. All these Acts are related to irrigation, water fees and O/M fee collection, not for water right. In the past, undeveloped river basins had abundant water to exploit. At present, the various conflicts among the water users have grown up in many areas of the country. Therefore, to establish laws/regulations to protect the people's water rights has become essential.

2.9.3 Drainage Conditions

In the Study Area, drainage is provided through natural streams/canals. Apart from downstream, drainage does not cause problems in the other parts of the Study Area. In an exceptional case, as happened 1995, the upper reaches of the Study Area suffered substantially from insufficient drainage which caused flooding in many areas of Udon Thani and Nong Bua

Lamphu. Heavy rainfall at the beginning of August and September was the reason for this disaster.

According to the preliminary report, in Udon Thani, the area affected by floods was 84,000 ha (531,020 rai). The flood also damaged 16 RID irrigation structures (projects) totally or partially.

In Nong Bua Lamphu, most affected areas were Suwanna Khuha and Na Klang amphoe. Total flooded area of the province was about 15,382 ha (96,137 rai) for a period of two weeks.

In Nong Khai province, the duration of inundation was longer than any other year and flooded area was much more than a usual year, about 69,490 ha (435,314 rai). Damage of public structures was also accountable. Damaged structures include 12 irrigation facilities, 15 bridges and 43 schools.

The reasons for this flood are the inefficient drainage due to high water level in the Mekong and insufficient storage facilities for the runoff generated in the area by the heavy rainfall.

2.10 Environmental Conditions

2.10.1 Introduction

Thailand's first environmental act of legislation was enacted in 1975 and amended in 1978. The latest act was passed in 1992, the so called "Improvement and Conservation of National Environmental Quality Act". This latest act provides for a reorganization/establishment of three new Departments of Environmental concerned under the Ministry of Science, Technology and Environment (MOSTE). The most concerned Department in the project proponents such as RID, DEDP, etc. is the Office of Environmental Policy and Planning (OEPP) which is inn charge of the evaluation of Environmental Impact Assessment (EIA).

Based on the aforementioned act, MOSTE proclaimed a Ministerial Regulation (MR) in August 1992 regarding the project type and size in which

the project proponent must prepare and submit an EIA to the OEPP for comment.

As for Dam/Reservoir and Irrigation projects, the project sizes which are under the MR are as follows:

Dam/Reservoir	:	Reservoir surface area of not less than 15 sq.km and/or reservoir capacity of not less than 100 MCM.
Irrigation	:	Irrigation area of not less than 12,800 ha (80,000 rai)

The stepwise procedure is as follows:

OEPP evaluates the proposed EIA and reports their comments to the National Environmental Board (NEB), and NEB submits comments to the Cabinet for final decision (approved or rejection of the project).

It should be noted that, under the mentioned act NEB is chaired by the Prime Minister and the committee secretary is the permanent secretary of MOST.

Apart from the Environmental Act, there are Cabinet resolutions as of March 15 and 17, 1992 regarding the utilization of forest land and resources. The resolution as proposed by the Royal Forest Department (RFD) provided that, of those project proponents, whose sites are located in Conserved Forests, must prepare and submit Environmental Impact Evaluations for approval. The practical procedure is divided into 3 categories according to project costs, as follows:

Case 1 : Project costs of not less than 200 million baht : The EIA must be prepared and follow the procedure as it is a project under the aforementioned MR.

Case 2 : Project costs of not less than 50 million baht but less than 200 million baht : The Initial Environmental Examination (IEE) must be prepared and submitted to the RFD.

Case 3 : Project costs of less than 50 million baht, The Environmental Checklist must prepared and submit to the RFD.

In most cases, the utilization of Forest Land can be approved by the cabinet (practically now by MOAC).

2. 10. 2 Environmental Conditions

1) Water Quality

Water quality is naturally dependent upon the geological conditions, soil characteristics as well as land uses of its catchment area. A community utilize a part of quality of water passed through it and release the altered quality to other community for reuse. In the Study Area, water is largely used for agricultural purposes, particularly in rice plantations.

Water is needed for people as well as the environment, and the quality of natural water for the environment as well as development is of prime important. The suitability of water for irrigation is contingent upon the mineral content. Salt may harm plant growth physically by limiting the uptake of water through modification of osmotic processes, or chemically by metabolic reactions, for instance, the effects of toxic substances. The effects of salt on soils, causing changes in soil structure, permeability and aeration in which plants will ultimately be affected. It is therefore, development project should take into account the alternation of hydra regime, particularly the drainage of both surface and groundwater which might induce salt concentration in the root zones.

Three water samplings were randomly taken at the end of November 1995, from 3 water resources, of the Study Area, namely :

Huai Luang Reservoir .... Amphoe Kut Chap
Bung Puan Reservoir ..... Amphoe Ban Phue
Nong Sri Charoen ..... Amphoe Phen

Results of analysis are as follows :

	pH	EC×10⁶ (at 25°C)	Part Per Million										
			Ca	Mg	Na	K	HCO^3	CL	SO_4	NO_4	PO_4	SAR	Turbidity
Husi Luang	7.5	141	16.8	3.3	3.9	43	72.6	7.4	1.0	0.45	ND	0.2	6.0
Bung Puan	6.8	57	6.0	1.2	2.3	2.7	26.8	4.2	2.9	0.05	ND	0.1	5.0
Nong Sri Charoen	7.1	90	5.0	1.7	11.5	0.8	17.7	19.9	2.9	0.05	ND	0.5	3.0

In terms of salt chlorine relative effects, these samples show water of excellent quality condition, but in terms of basic nutrients the water is of poor quality. However, for a particular project, more detailed analysis covering a wide range of quality parameters should be conducted.

It should also be noted that some of the quality parameters show that among the water samples those qualities are probably in the category of first class water as classified by the Natural Environment Board in January 1986.

2) Forest

In general, the extent of forest in the Study Area is similar to the whole Northeastern Region. Its main characteristic is characterized by a sparse distribution of wood trees of dry dipterocarp and mixed deciduous forest an agricultural land, stream banks, hills and along such rights of way as highways.

Generally they are of limited diversity, with the number of species for each community limited not only on trees but also for other kind of plants, herbs and climbers or ground flora.

Recent study also reveals that density of dry dipterocarp forest in the Northeastern Region is only about 62 cu.m/ha, while 120 cu.m/ha in the Northern Region. Poor soil quality is also an important factor.

While economic growth and housing are of the main causes of forest encroachment, the enforcement of the forest protection law and local tradition are mechanisms which maintain those trees of moderate size in agricultural land.

In 1961, forest land in Udon Thani represented 45 % of the total provincial area. The forests of good condition are limited on the western part of Udon Thani where there is high terrain. In order to protect the forest as for as

possible, the Cabinet had passed a resolution the so called "The Utilization of Forest Land and Resources in the Forest Conserved Area" in March 1992. The resolution proclaimed that the environmental impact study at a certain degree must be prepared by the project proponent in cases with the project is located in the conserved forest area. For Udon Thani, the conserved forest area is mostly situated in the western part. In addition, the watershed classification of Huai Mong, Nam Suai and Huai Luang basins were also proclaimed by a Cabinet resolution in February 1995. Such classification categories basin land use and its measurement into 5 classes. The first class is the most concerned with water resources development since the resolution regarded 1A class areas for headwaiter purposes only. For 1B class utilization can be made in case it is needed, and in such case the EIA must be conducted and presented for approval.

3) General Ecology

The swampy areas at the lower reaches of Huai Mong, Nam Suai and Huai Luang rivers are quite similar in general ecological conditions, prior to the recent development for irrigation purpose. They are all small tributaries of the Mekong river and ecological conditions are under the sole influence of the seasonal water level of that river.

The general condition is a marshy floodplain extending throughout the entire lowland with the 3 tributaries and their branches meandering through, and several patches of marshes ranging in sizes from 10 to 270 ha. These marshes lie scattered along the wide patches of rice fields with one crop of wet season rice per year, together with patches of remaining degraded dry dipterocarp woodland. Along the entire lengths of the tributaries, discontinuous large or small patches of floodplain occurring along their banks habitats dominated with waterlogged-resistant plants and wild bamboo clumps.

Prior to the irrigation development, these 3 tributaries were intermittent in the dry season and flooded during the wet season. With development for irrigation purposes and building of dikes/dams or weirs across the waterways, thus blocking up the natural inflow and out-flow of the tributaries.

The benthic faunas known to inhabit the tributaries are mainly the invertebrates, such as the annelidas (segmented worms), the nematodes

(roundworms) and the freshwater snails of the genus Mekongia and fresh-water clams of the genus Corbicula; those two latter species are more abundant in the rainy season, while the first two occur in the dry season. Regarding the planktons, those phytoplanktons are relatirely few such as the Aphanocapsa, Fragilaria, Oscillatoria, Fediastrum, Pennate Diatoms, etc. The zooplanktons comprise the sarcodinan Arcella and Difflugia, and the rotifers (mainly Brachionus), and crustacean larvae in the dry season, whereas the wet zooplanktons are dominated by the same set of sarcodinans, rotifers, with some ciliated Vorticalla.

At least 30 freshwater fish species have been reported in the Study Area, especially in the Huai Luang river. Most of them are flowing-water species and common in the Northeastern Region.

The known valuable species can be defined as those rare or endangered species known to occur in the Study Area, they are :

Mae Khong Herring or Laotian Shad Family : Clupeidae
Tenualosa thibeaudaui (Durand, 1940)

This freshwater herring is frequently found at the river mouths and in the Mekong river; they sometimes enter the tributaries in the flooding season. Endangered species (TISTR, 1993)

Freshwater Dorab Family : Cyprinidae
Macrochirichthys macrochirus (Valencinennes, 1844)

The inhabitant of the large rivers and adjoining streams are becoming scarce, due to polluted water to which it is highly sensitive. Endangered species (TISTR, 1993)

Jullien's Golden Carp Family : Cyprinidae
Probarbus jullieni Sauvage, 1880

The young of this rare species have been reported in the Huai Luang river. Some may still exist in the Study Area. Endangered species (TISTR, 1993)

Princess Chulabhorn's Barb Family : Cyprinidae

Amblypharyngodon chulabhornae Kottelat & Vidhayanon, 1994

This small barb is named after beloved Princess Chulabhorn and found living abundantly in the Study Area in small schools.

Endemic species to Thailand

Mae Khong Giant Catfish Family : Pangasiidae
Pangasianodon gigas Chevey, 1930

Largest freshwater catfish which is found only in the Mekong river is overfished in the spawning season every year.

Endangered species (TISTR, 1993)

Fishing Cat Family : Felidae
Prionailurus viverrinus (Bennett, 1833)

The only mammal species found inhabiting the Study Area, notably in the patches of forest along the stream banks.

Rare species

Comb Duck Family : Anatidae
Sarkidiornis melanotos (Pennant, 1769)

Reported breeding in the forest patches in the vicinity of Nong Hua Khu non-hunting area, Ban Phu District, Udon Thani province; with the local total of up to 10 individuals.

Endangered species (TISTR, 1993)

White-winged Wood Duck Family : Anatidae
Cairina scutulata (S. Muller, 1842)

Flocks of this very rare duck species frequently come to forage for food in the Study Area. Already known to occur in Udon Thani and Nong khai provinces.

Endangered species (TISTR, 1993)

The valuable species known to occur in the Study Area include 8 species, of which 5 are the freshwater fish, 1 mammal and 2 water birds. Six are

considered endangered species, according to the Thailand Institute of Scientific and Technological Research (1993, Endangered Species and Habitats of Thailand. Kurusapha Ladprao, Bangkok. 243 pp.) The rest are an endemic fish species and a rare mammal species.

4) Public Health

With regard to the environmental impact of water resouces/ irrigation development on public health, those water borne diseases such as liver fluke (Opisthorchis Viverrine), Malaria and the blood fluke (Schistosomiasis) are of potent parasitic diseases in which their hosts, vectors and habitat as well as the prevalent/cases must be under closed investigation.

The liver fluke, in former days, was an endemic disease among people in the Northeastern region. The spread of disease was caused by two main factors, the local habit of eating raw fish and outdoor releasing faeces.

Malaria was once spread all over the country, but the decate long continuous campaign of Malaria eradiction by the Ministry of Public Health has resulted in a very few case now, despite strong external factors from neighbouring countries.

The spread of schistosomiasis in Egypt following the construction of the Aswan Dam is a classic case. In Thailand, so far, there were only mentions that it is a very difficult task to control the disease once it begins to spread. There were, however, results of 2 investigations conducted in the Mekong and Mun river in which the schistome cases and the snail vectors were found respectively.

A short visit to the Udon Public Health Office revealed that, during these days there were only a few cases of Malaria while liver fluke cases were fewn than before. There are no cases of the schistome.

5) Archaeology

Amphoe Nongharn of Udon Thani is famous as the location of a prehistoric site. Ban Chiang is on a name list of world heritage sites. The presence of archaeological remains indicated the significance of the area.

Concerning these historic sites, there are 4 such sites located in Udon Thani namely;

a) Amphoe Nongharn-Ban Jeed subdistrict

The site is an old temple with pagoda surrounded by wall. It is a deserted temple, the so called "Khao Sathan Jom".

b) Amphoe Bamphue-Muang Pan subdistrict

The sites are, a 36 meters Pagoda which covers a stone of the what believed to be the Buddha's foot, the so called "Phraputabat Buabok" and the "Phrapulabat Buabasn" which is of the similar style.

c) Amphoe Bamphue - Muang Pan subdistrict

The site is a stone table (prehistoric period), the so called "Hor Nang U-sa".

d) Amphoe Nong Bua Lamphu - Nong Bua subdistrict

The site is an ancient town dating back to 1767.

CHAPTER 3. OVERALL AGRICULTURE AND WATER RESOURCES DEVELOPMENT PLAN

CHAPTER 3. OVERALL AGRICULTURE AND WATER RESOURCES DEVELOPMENT

3.1 General Description

Field survey and data collection has been carried out in order to understand the national policy on agriculture and water resources development, natural conditions, socio-economic conditions, etc. in the Study Area. Data and information of many completed and proposed water resources development projects implemented by RID and other agencies such as DEDP were also collected and reviewed.

Based on the results of these survey works, the needs of agriculture and water resources development, water resources potential and development constraints will be identified and then planning considerations will be established. The overall agriculture and water resources development plans will be formulated according to the planning considerations.

It should be kept in mind that the agricultural area occupies more than 50 % of the Study Area, while there are a only few storage damsites. It means that most parts of the existing agricultural area remain as rainfed areas even after water resources development has been carried out to be maximum possible. Agricultural development plan for the rainfed agricultural area will be outlined in this chapter. However, the movement of farmers who engage in rainfed agriculture to local non-agricultural employment should be facilitated because the income obtained from the rainfed agriculture is not enough to enjoy life.

The existing and proposed irrigation areas are estimated as shown in Table 3.1-1 and summarized as follow.

Agricultural Land in the Study Area

	Wet Season	Dry Season
Irrigated Area	109,000 ha(684,000 rai)	22,000 ha(137,000 rai)
Rainfed Area	351,000 ha(2,186,000 rai)	-
Total	460,000 ha(2,870,000 rai)	22,000 ha(137,000 rai)

Table 3.1-1 Existing and Proposed Irrigation Area

Project	Nos. of Project (No.)	Storage Capacity (MCM)	Irrigation Area		Crop Intensity (%)
			Wet Season	Dry Season	
1. Huai Mong River Basin					
1) Existing					
RID-Medium Scale	-	-	-		
RID-Small Scale	33	8.78	2,552ha(15,950rai)	-	100
RID-Swamp & Farm Pond	-	2.38	350ha(2,190rai)	-	100
DEDP-Pump Irrigation	11	-	3,075ha(19,220rai)	460ha(2,880rai)	115
DEDP-Huai Mong Project	1	26.00	3,170ha(19,820rai)	480ha(3,000rai)	115
Sub-Total	45	37.16	9,147ha(57,180rai)	940ha(5,880rai)	
2) Proposed					
Medium Scale	7	45.60	4,290ha(26,810rai)	1,350ha(8,440rai)	131
Small Scale	86	15.40	6,070ha(37,940rai)	-	100
Sub-Total	93	61.00	10,360ha(64,750rai)	1,350ha(8,4400rai)	
2. Nam Suai River Basin & Other Basin					
1) Existing					
RID-Medium Scale	3	10.64	2,050ha(12,810rai)	310ha(1,940rai)	115
RID-Small Scale	37	13.11	2,848ha(17,800rai)	-	100
RID-Swamp & Farm Pond	-	3.58	525ha(3,280rai)	-	100
DEDP-Pump Irrigation	13	-	4,305ha(26,910rai)	650ha(4,060rai)	115
Sub-Total	53	27.33	9,728ha(60,800rai)	960ha(6,000rai)	
2) Proposed					
Medium Scale	2	27.10	2,910ha(18,190rai)	972ha(6,080rai)	133
Small Scale	50	6.30	3,628ha(22,680rai)		100
Nam Suai Basin Project	1	215.00	17,750ha(110,940rai)	7,100ha(44,370rai)	140
Sub-Total	53	248.40	24,288ha(151,810rai)	8,072ha(50,450rai)	
3. Huai Luang River Basin					
1) Existing					
RID-Large Scale	1	113.30	13,760ha(85,970rai)	2,030ha(12,700rai)	115
RID-Medium Scale	6	12.45	1,640ha(10,270rai)	250ha(1,540rai)	115
RID-Small Scale	52	16.47	4,280ha(26,750rai)	-	100
RID-Swamp & Farm Pond	-	5.96	875ha(5,470rai)	-	100
DEDP-Pump Irrigation	8	-	1,850ha(11,570rai)	280ha(1,740rai)	115
Sub-Total	67	148.18	22,405ha(140,030rai)	2,560ha(15,980rai)	
2) Proposed & On-going					
Medium Scale	8	38.9	3,810ha(23,810rai)	561ha(3,510rai)	115
Small Scale	127	16.2	10,450ha(65,310rai)	-	100
DEDP-Lower Huai Luang Project	1	154.87	19,200ha(120,000rai)	7,680ha(48,000rai)	140
Sub-Total	136	209.97	33,460ha(209,120rai)	8,241ha(51,510rai)	
4. Whole River Basin					
1) Existing	165	212.67	41,280ha(258,010rai)	4,460ha(27,860rai)	
2) Proposed & On-going					
Medium Scale	17	111.60	11,010ha(68,810rai)	2,883ha(18,030rai)	
DEDP-Nam Suai Basin Project	1	215.00	17,750ha(110,940rai)	7,100ha(44,370rai)	
DEDP-Lower Huai Luang Project	1	154.87	19,200ha(120,000rai)	7,680ha(48,000rai)	
RID-Small Scale	263	37.90	20,148ha(125,930rai)	-	
Sub-Total	282	519.37	68,108ha(425,680rai)	17,663ha(110,400rai)	
Total	447	732.04	109,388ha(683,690rai)	22,123ha(138,260rai)	
			≒109,000ha(684,000rai)	≒22,000ha(137,000rai)	

Based on the figures shown in the above table, the agricultural development plan will be established for the Study Area.

3.2 Regional Development Plan

3.2.1 Target Year

The first National Economic and Social Development Plan was prepared in 1961. It covered a 6-year implementation period until 1966. Subsequent plans were prepared every 5 years. At present, the 7th plan (1992-1996) is currently under implementation.

The main objective of this Study is to conduct a master plan study on the integrated agriculture and water resources development project of Huai Mong, Nam Suai and Huai Luang River Basins. Taking into consideration the limited number of proposed medium scale projects in the Study Area and the implementation period of the National Economic and Social Development Plan, the target year of the development is set to be the year of 2006 or the end of the 9th Plan period (2001-2006).

3.2.2 Development Plan

1) Regional Development Plan

The 7th plan provides guidelines for the decentralization of urban development and infrastructure services to the regions. For the Northeastern Region, the development guidelines are summarized as follows:

a) Promote development of industrial estates using raw material found in the region as well as from neighboring countries. The industrial estates will serve as major economic bases of the region.

b) Support regional trade and services, particularly promotion of tourism in the area of historic, artistic and cultural attractions which will be linked with world-class tourism destinations in neighboring countries. In addition, trade and service centers should be developed to support the opening up of the

countries of Indochina to serves as a coordinating center of foreign financial and technical assistance to rehabilitate Indochina.

c) Develop Khon Kaen as a center of trade, services, transport and education of the region so as to support the restoration of Indochina countries. Udon Thani will be developed as a center of trade and services in the Upper Northeastern Region. In addition, Nakhon Ratchasima will be developed as an industrial center to be linked with Eastern Seaboard and other urban centers in the lower part of the Northeastern Region.

2) Provincial Development Plan

Provincial development plan in the study area will conform with the regional development plan by NESDB and other government policies related to provincial development. Considering the geographical location, natural resources and development potential of the province, the provincial development strategies of three provinces in the Study Area will be summarized as follows:

a) Udon Thani

- Develop Udon Thani as a center of trade and services in the Upper Northeastern region to be linked with a border trade point at Tha Sadet at Nong Khai and Tha Kham at Mukdahan.

- Develop Udon Thani to be an industrial province which is supported by import of raw materials for industrial production from the countries of Indochina and export of products to the subregion.

- Develop Udon Thani as a center for tourism and transportation for the Upper Northeast.

- Develop agro-processing industry for export.

b) Nong Khai

- Develop Nong Khai as a border trade point (Tha Sadet) which will be linked with Udon Thani, center of trade and services of the Upper Northeastern Region.

- Develop Nong Khai to be an international tourism center linked with Indochina countries and South China.

- Develop Nong Khai to be a center of supporting tourism services along the Mekong river.

c) Nong Bua Lamphu

- Develop Nong Bua Lam Phu to be an important satellite town with the major role in agricultural produce, agro-industrial and industrial products.

- Develop Nong Bua Lam Phu to be an attractive town for tourism which will be linked with Loei, Udon Thani, Nong Khai and Khoan Kaen.

In order to bring about well-balanced development based on the above mentioned development strategies of each province and to provide guidelines for all of the agencies concerned, the development guidelines of each province in the Study Area have been prepared. The summary of development guidelines for Udon Thani, Nong Khai and Nong Bua Lam Phu are presented in Table D.4-1, D.4-2 and D.4-3 in Appendix D.

3.2.3 Domestic and Industrial Water Demand

In general, future domestic water demand depends on the size of population to be served in the urban and rural areas in the target year and consumption rate per capita. According to past records, it is assumed that piped water supply facilities will be available for 85 % of the urban population with a consumption rate of 220 liter/day and 50 % of the rural population with 120 liter/day in the target year 2006. Based on the assumption mentioned above, total future domestic water demand in the Study Area is estimated as shown

below.(For details of water supply in 1994 by PWA and estimated domestic water demand in 2006, see Table 3.2-4 and 3.2-5 in Appendix.)

Domestic Water Demand in the Study Area

(unit : 1,000 cu.m)

Province	Water Supply in 1994 by PWA	Water Demand in 2006		Total
		Urban Area	Rural Area	
Udon Thani	13,035	21,275	12,677	33,952
Nong Khai	3,404	3,707	6,740	10,447
Nong Bua Lamphu	675	1,638	2,103	3,741
Total	17,114	26,620	21,520	48,140

The industrial sector in the Study Area is still in an embryonic stage and largely consists of simple agro-processing factories. Therefore, the industrial water use is the smallest as compared with the water use of other sectors. In the Study Area, the industrial estate development by Industrial Estate Authority of Thailand (IEAT) in Muang Udon Thani with a total area of about 3,000 rai(480ha) will only be viable after 1996. Annual water demand for this industrial estate, which will be supplied from Huai Luang reservoir, is estimated at approximately 10 MCM by using a unit rate of water supply of 14 cu.m/rai/day.

3.3 Premises of the Development

3.3.1 Water Demand

1) Agricultural Water Demand

From the review of the Huai Luang Irrigation Project and its reservoir operation the following facts can be understood. Water demand for the subject project will made on the basis of these facts.

Wet Season	Dry Season	Total
1. Irrigation Area 13,760 ha (85,970 rai)	2,030 ha (12,700 rai)	15,790 ha (98,670 rai)
2. Agricultural Water Use 49.6 (MCM)	31.4 (MCM)	81.0 (MCM)
3. Cropping Intensity 100 %	14.8 %	114.8 %
4. Water Demand Per Ha. 3,600 cu.m/ha	15,500 cu.m/ha	19,100 cu.m/ha
5. Storage Capacity		118.5 MCM (including dead storage)

At present, total arable land in the Study Area is about 460,000 ha (2,870,000rai) and irrigable land by the existing, on-going and proposed projects is estimated to be 109,000 ha (684,000rai). Which means rainfed area remains as 351,000 ha (2,186,000 rai).

Based on the result of farm economic/inquiry survey, assuming about 80% (1st priority 63%, 2nd priority 15%) of the farmers will irrigate 100% of their land during the wet season and 15 % during the dry season, then the agricultural water demand for the Study Area may be calculated as follows.

Agricultural Water Demand

Wet season = 460,000 ha×0.8×3,600 m^3/ha = 1,320 MCM
Dry season = 460,000 ha×0.8×0.15×15,500 m^3/ha = 860 MCM
Sub-total = 2,180 MCM

2) Water Demand and Availability

From the water demand and availability, a balance of water use may be made.

A. Water demand
i) Agricultural water demand = 2,180 MCM
ii) Industrial water demand = 10 MCM
iii) Domestic water demand = 50 MCM
Total = 2,240 MCM
Required Storage Capacity = 2,640 MCM.....(1)
(assuming 15% reservoir loss)

B. Available Storage Capacity

From existing projects	=	213 MCM
From on-going & proposed projects	=	519 MCM
Total	=	732 = 730 MCM.....(2)

Balance (2)-(1) = (-)1,910 MCM

Which means the Study Area has a serious water shortage problem due to a few effective storage damsites in the Study Area. And available water can irrigate only 23% of the total agricultural land in the Study Area.

3. 3. 2 Surface Water Potential and its Use

In chapter 2, the water potential in each sub-basin has been tabulated. However, tha water potential should be taken as the river runoff in the case where no water resources development has been carried out in that sub-basin. In fact, there are many water resources development projects (large, medium and small) existing in the basins.

Considering the above and also the future water resources development activity in the basins, an attempt has been made to estimate the existing water resources potential and the future potential taking into consideration the projects to be implemented in the basins. In Table 3.3-1, the number of existing and proposed projects in each sub-basin with their respective capacities is presented.

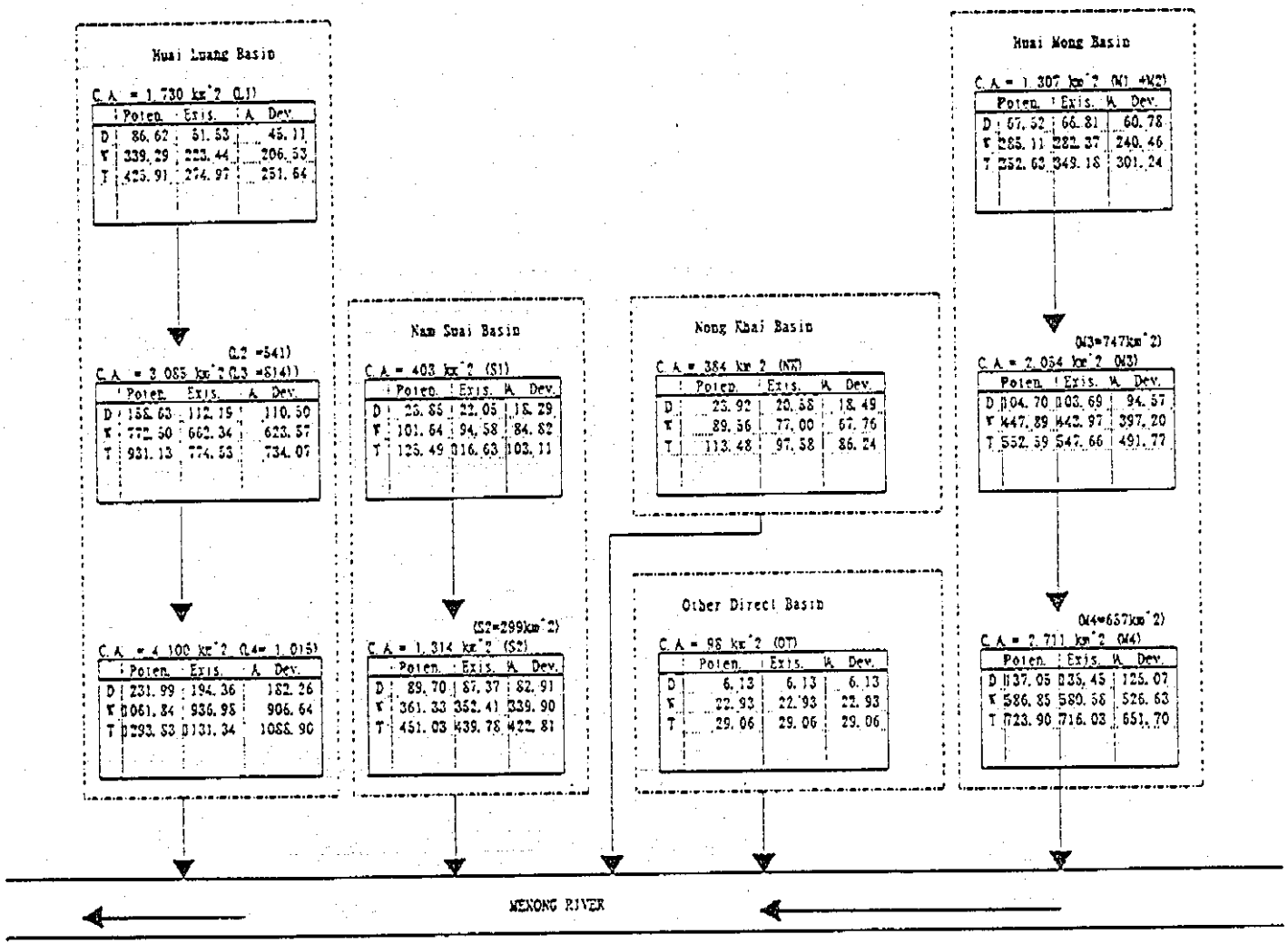
The water balance study has been carried out for the period of twenty years (1974-93) on a ten-day cycle balance of inflow, outflow and reservoir volume. From the study it was learnt that annual runoff potential of 1989 has a close value of twenty years average value and 1976 has a value of 1/5 year probability. Outcome of the study is presented in Appendix C. This study reveals that the Study Area has an annual water potential of 2,611.30 MCM and with a 1/5 year probability is 1,913.23 MCM.

The result of the water balance for the Study Area for an average year i.e. 1989 and 1/5 year probability i.e. 1976 area tabulated and presented in the Figures 3.3-1 and 3.3-2.

Table 3.3-1 Detail of Sub-basins

Sub-basin number	Existing Project Type										Proposed Project Type						Proposed DEDP Projects		
	Small			Medium			Large			DEDP pumps	Small			Medium			Large		
	No.	Stor. (MCM)	B.A. (ha)	No.	Stor. (MCM)	B.A. (ha)	No.	Stor. (MCM)	B.A. (ha)	No. B.A. (ha)	No.	Stor. (MCM)	B.A. (ha)	No.	Stor. (MCM)	B.A. (ha)	No.	Stor. (MCM)	B.A. (ha)
M1	2	1.87	288	-							9	2	1,076						
M2	5	4.23	1,084	-							14	9.3	1,616	5	29.6	2,490			
M3	3	1.57	830	-						5 1,130	4	2	2,498	1	9.8	800			
M4	6	1.11	350	-			1	26	3,170	6 1,945	4	2.1	880	1	6.2	1,000			
Sub-Total	16	8.78	2552	0	0	0	1	26	3170	11 3,075	31	15.4	6,070	7	45.6	4,290			
S1	18	9.46	1,760								4	1.9	530	1	17.5	1,920			
S2	4	0.25	640	1	0.19	70				4 1,332	7	3.7	1,848				1	215	17,750
Sub-Total	22	9.71	2400	1	0.19	70	0	0	0	4 1,332	11	5.6	2,378	1	17.5	1920	1	215	17750
L1	13	5.09	1,962	6	12.45	1,640	1	113.3	13,760		4	1.8	2,852	7	31.6	3,210			
L2	5	3.63	768								10	7.5	2,431						
L3	6	1.52	630							1 232	16	5	3,647	1	7.3	600			
L4	12	6.23	920							7 1,618	4	1.9	1,520				1	155	19,200
Sub-Total	36	16.47	4,280	6	12.45	1,640	1	113.3	13,760	8 1,850	34	16.2	10,450	8	38.9	3,810	1	155	19,200
NK	3	3.4	424	2	10.45	1,980				2 650	2	0.7	1,250	1	9.6	990			
Sub-Total	3	3.4	424	2	10.45	1,980				2 650	2	0.7	1,250	1	9.6	990			
OT		-	24							7 2,323									
Sub-Total		-	24							7 2,323									
Grand Total	77	38.36	9,680	9	23.09	3,690	2	139.3	16,930	32 9,230	78	37.9	20,148	17	111.6	11,010	2	370	36,950

Note: 1,750 ha from dredging is not included
Number of small scale projects are only reservoirs



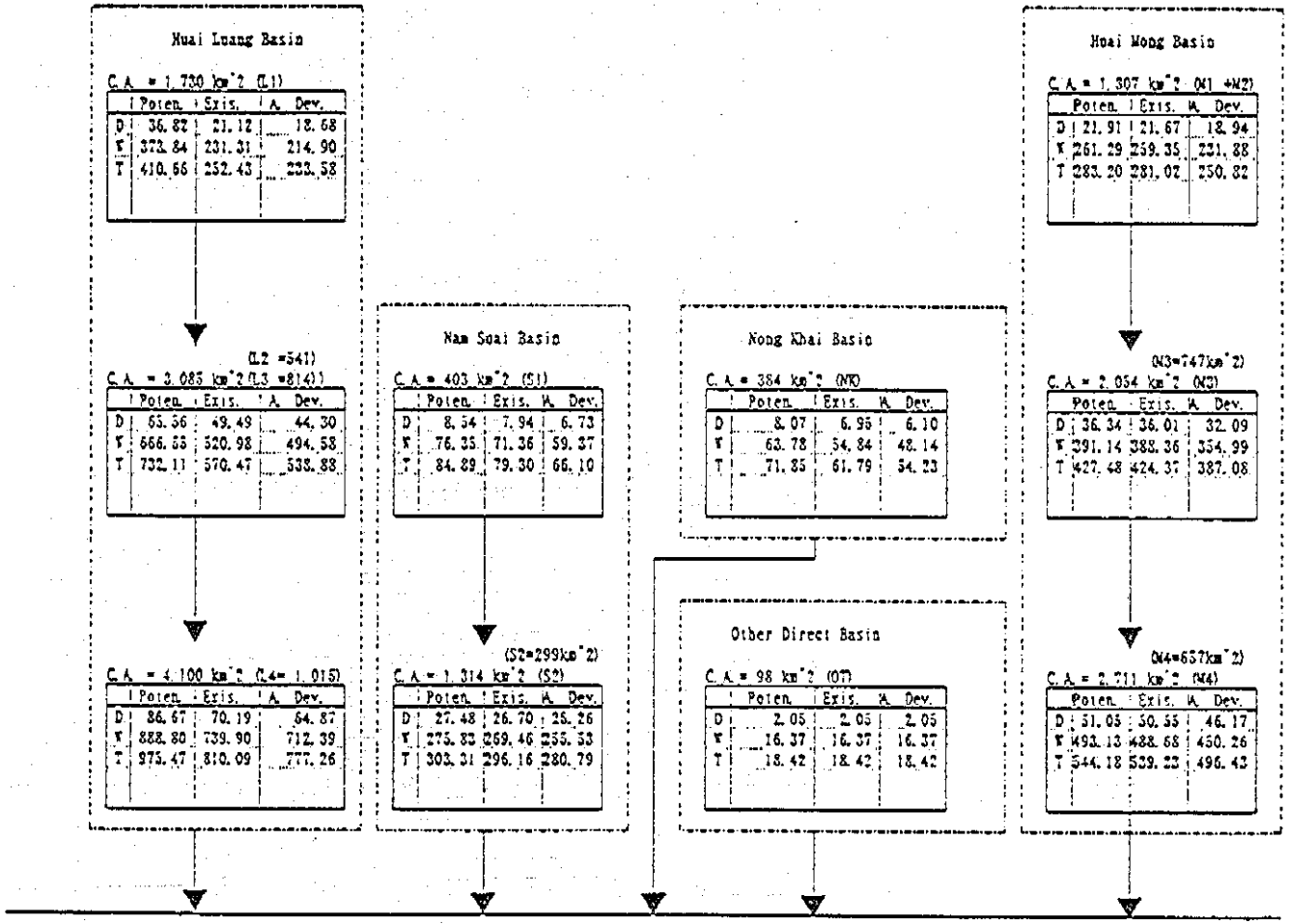
Note: Storage Volume of existing Huai Mong, proposed Nam Suai and Lower Huai Luang projects are not included

WHOLE BASIN
C.A=8,607km^2 (1) (2) MCM

	Poten.	Exis.	A. Dev.	(1)-(2)	
D	482.79	443.88	414.86	29.02	MCM
W	2122.51	1969.90	1863.86	106.04	MCM
T	2611.30	2413.78	2278.72	135.06	MCM

Figure 3.3-1 Change of Runoff Potential in the Three River Basins

Average Year (1989)
(Unit: MCM)



Note: Storage Volume of existing Huai Mong, proposed Nam Suai and Lower Huai Luang projects are not included

WHOLE BASIN
C.A=8,607km^2 (1) (2)

	Poten.	Exis.	A. Dev.	(1)-(2)
D	175.32	156.44	144.45	11.99 MCM
W	1737.91	1569.25	1482.69	86.56 MCM
T	1913.23	1725.69	1627.14	98.55 MCM

Figure 3.3-2 Change of Runoff Potential in the Three River Basins

1/5 Drought Year (1976)
(unit: MCM)

3. 3. 3 Development Constraints

The main objectives of agricultural development in relation to the Study are to improve the living conditions of farm families and to stem the emigration from rural areas through water-based development. To accomplish the objectives, the following strategy will be adopted.

- Increase of irrigated agriculture, focused on diversified cropping.
- Development of rural industry, based on the products of diversified cropping and integrated farming.
- Introduction of integrated farming, especially to rainfed agriculture areas.
- Promotion of small scale projects to serve the basic necessities of rural life.

However, there are some constraints against the integrated agriculture and water resources development as listed below:

1) Natural Constraints

a) Low run-off during the dry season and flooding during rainy season.
b) Lack of water resources for assured irrigation due to a only few storage damsites.
c) High cost of groundwater withdrawal for irrigation.

2) Agro-Economic Constraints

a) Low productivity of crops:

Generally crop yields in the Study Area are lower than the national average. For example, major rice yield from 1990/91 to 1993/94 are lower by 17%, and bigger difference is observed in the second rice yield.

This attributes to low fertility of soil and subsistence-style of farm management.

b) Declining farmgate prices for traditional crops :

Index of farmgate prices of some traditional crops shows a low annual price increase which causes lack of interest in agricultural production, particularly for dry season irrigated cultivation among farmers. On the other hand, consumer prices have been increasing at an annual average of 4.37%.

Compared to these traditional crops, farmgate prices for some vegetables and upland crops show higher profits than cereal crops.

c) Higher income obtainable from urban employment:

Together with the declining prices for traditional crops, income disparity between agricultural sector and other industrial sector has discouraged farmers from investing in increased agricultural production. Agricultural development will need to focus on increasing the incomes of these farmers.

d) Low farm household income and income disparity

Average annual incomes of household in the country and Northeastern Region are estimated at 84,744 Baht and 54,300 Baht, respectively, according to the Household Socio-Economic Survey by NSO. Household income in the rural areas of the Northeastern Region is 48,336 Baht per year.

Compared with the incomes mentioned above, annual farm household incomes of 34,415 Bahts in Nong Khai and 33,224 Bahts in Udon Thani, respectively, are lower than that of villages in the Northeastern Region. In addition, analysis of farm household income shows that income disparity exists even among Amphoe in the Study Area. The Study Area consists of 22 Amphoe, of which nine (9) Amphoe have bigger farm incomes than off-farm income and thirteen (13) Amphoe have bigger off-farm incomes than farm income.

3) Institutional Constraints

a) Insufficient integrating activities between RID and other agencies, such as DEDP in planning and construction of the irrigation projects.

b) Insufficient participation by farmers in water allocation and in on-farm water management.

c) Insufficient information on demand for agricultural products at the Changwat level.

3. 3. 4 Planning Considerations

The items that should be considered in planning agricultural development and water resources development including the irrigation and flood protection projects will be derived from the constraints shown in Table 3.3-2, the objectives of the development and the national policy, are shown below:

1) for Agricultural Development Plan

- Diversified cropping on new and rehabilitated irrigation project.
- Optimum use of irrigation water.
- Rural industry based on the products from diversified cropping and integrated farming.
- Integrated farming, especially in rainfed areas.
- Sustainable farming to obtain the appropriate level of agricultural production every year.
- Strengthening agricultural extension services on the introduction of diversified cropping.
- Strengthening credit services and agricultural cooperatives.

2) For Water Resources Development Plan /Irrigation and Flood Protection Plan

- Promotion of large and medium scale projects to expand the areas of assured irrigation during the dry season.
- Promotion of a wide range of small scale projects to encourage the poor rural areas.
- Improvement of irrigation efficiency.
- Encouragement of participation by farmers in water allocation and in on-farm water management.

Table 3.3-2 Constraints and Planning Considerations

Constraints	Planning Considerations
1) Natural Constraints a) Low run-off during the dry season and flooding during the wet season	a) Storage dams are required for the dry season irrigation. b) Large and medium-sized reservoirs are capable of supporting irrigated agriculture during the dry season, but small reservoirs with average capacity of approximately 0.45 MCM can not serve the dry season irrigation. c) Inundation in the lower reaches of the rivers are caused by river floods and high water level of the Mekong river. Flood mitigations by diking and draining the land by pumps will be economically not feasible.
b) Lack of water resources for assured irrigation due to a few sufficient storage damsites.	a) The quantity of water resources to be developed in the Study Area will be limited. b) Therefore, the following items should be considered in planning the projects. - Optimum use of irrigation water. - Improvement of irrigation efficiency.
c) High cost of groundwater drawal for irrigation.	a) Groundwater development is not feasible for extensive irrigation.
2) Agro-Economic Constraints. a) Low productivity of crops.	a) Crop productivity of agricultural land should be increased by the introduction of sustainable farming.
b) Declining farmgate prices for the traditional crops. c) Higher income obtainable in urban employment. d) Low farm household income and income disparity.	a) Restructuring will be recommended to focus on diversified cropping and integrated farming, which will need to strengthen agricultural extension services and to train farmers. b) Rural industry based on the products of diversified cropping and integrated farming should be developed to stem the emigration from rural areas. c) Movement of farmers to local non-agricultural employment should be facilitated.
3) Institutional Constraints a) Insufficient integrating activities between RID and other agencies, such as DEDP in planning and constructing the irrigation projects.	a) RID should be responsible for overall planning for irrigation projects and for constructing the projects.
b) Insufficient participation by farmers in water allocation and in on-farm water management.	a) Farmer's participation in water allocation and on-farm water management should be promoted for efficient use of limited water resources. However, the allocation of water and its distribution is usually decided by RID without adequate participation by farmer. Establishment of Water User's Organization should be accelerated as possible.
c) Insufficient information on demand and prices of agricultural products.	a) Setting up of the systems to inform the present demand and prices of agricultural products to the farmers will be necessary to encourage farmers for agricultural investment.

- The national policy implies priorities for water use as:
  1. Domestic water use.
  2. Industrial water use.
  3. Agricultural water use.

3. 4 Environmental Aspects of the Development

3. 4. 1 Potential Environmental Effects of Dam/Reservoir Project

The principal environmental concerns are for forest protection and resettlement of villages.

Where population resettlement is required, compensation is necessary in the form of cash or land, or both. The compensation should be the same as the value of the land and house which is to be evacuated, loss of income and inconvenience of moving. Water resources development projects, if possible should be planned to avoid resettlement, but if this is not possible it should be kept to a minimum. The reason for minimizing resettlement is that it uproots the lives of the evacuees and usually has negative impacts on the environment. The resettlement should be located away from a forest reserve area to lessen the negative environmental impacts.

A dam of the Huai Mong Project selected for a detailed master plan study will be constructed within the Forest Conservation Zone. Since the construction cost of the dam is estimated at 44 million baht, an Environmental Impact checklist must be prepared and submitted to the RFD/OEPP for land use permission. The checklist is shown in Appendix J.

3. 4. 2 Potential Environmental Effects of Swampy Area Development

As for the Nam Suai Basin project which will be implemented by DEDP, its storage capacity, reservoir area and irrigation area are larger than the size indicated in a Ministerial Regulation of MOSTE, therefore a detailed EIA will be required.

The detailed EIA is primarily classified into the following four categories.

1) Physical Resources

- Surface water hydrology
- Surface water quality
- Groundwater hydrology
- Groundwater quality
- Soils
- Geology and seismology
- Erosion and sedimentation
- Climate

2) Ecological Resources

- Fisheries
- Aquatic biology
- Wildlife
- Forests

3) Human Use Values

- Agriculture and irrigation
- Aquaculture
- Water Supplies
- Navigation
- Reclamation
- Power
- Flood Control
- Dedicated area use
- Industry
- Agro-industry
- Mineral Development
- Highway and railway
- Land use

4) Quality of Life

- Socio-economic values
- Resettlement

- Culture and historical values
- Archaeological values
- Public health
- Nutrition

A full scale environmental study covering the above items is required for large scale dam/irrigation projects such as the subject project.

The results of the preliminary environmental survey are as follows:

1) Ecology in Wetland

The abrupt change from a slow-flowing habitat to a stagnant one will certainly have many effects on the ecological components, because the originally inhabiting species of plants and animals will be forced to abandon the grounds or adapt to the newly-created habitat. Aspects to be considered are:

Fish Production

Each reservoir has its own tendency to increase considerably in the first 3-4 years of the impoundment, then decreasing drastically after that, because of the wider water surface areas will receive a great deal of nutrients from the surrounding banks and the decomposition of the submerged shore vegetation.

Fish Diversity

The blockage of the waterway will inevitably affect the biodiversity of the fish fauna, because the flowing-inhabiting fish species will be all died out and no more species will invade into the Study Area. So the created reservoirs will become favorable sites only for the stagnant water fish species.

Fish Seasonal Movement

It is because of the loss of the floodplain areas on both banks of the waterways and the blockages of the waterways, that the local movement of the fish from the Mekong River into and out of the waterways becomes impossible, thus reducing the genetic gene flow among the fishes.

Utilization by Wildfowl

As shown from the above, this site serves as an essential wintering ground for migratory birds. They come annually in thousands, and among them are some rare and endangered species. The area's suitability for this particular role needs to be investigated.

Outbreak of Aquatic Weeds

Because of the existence of the stagnant habitat and widespread accumulation of nutrients, the aquatic weeds, especially the submerged and floating types, will become abnormally abundant, thus causing decreases in fish production, obstructing local navigation, and blocking the water gates and irrigation canals.

Outbreak of Freshwater Snails

The favored habitat for the snails (Bithynia spp.), the important host for the larvae of the human liver flukes, is most likely to be produced in the stagnant water of the reservoirs, thus negatively impacting the health of the local population.

2) Wildlife Resources

Not only the plant species will be affected by the impoundment projects, but the animal species that depending on them will also be impacted. It is of interest to consider the following:

Loss of Terrestrial Habitat

The flooded river line forest will be essential nesting or foraging sites for local wildlife species, especially birds and mammals. Many of them will disappear or be forced to leave the area for less-suitable ones.

Increase of Aquatic Habitats

This considerably enlarged habitat will favor the multiplication of many fish and amphibian species, as well as aquatic reptiles. This can cause dramatic changes in the entropic levels in the ecosystem.

Outbreak of the Post Species

Many pest species, such as the rice field rodents and seed-eating birds, can increase their local populations to outbreak level. So the nearby cultivated fields are vulnerable to their attacks.

3. 5 Agricultural Development Plan

3. 5. 1 Basic Concept of Agricultural Development

There are many constraints to the existing agriculture in the Study Area. These are low yield, low productivity of crops and low farmgate prices for products. These are preventing farmers from improving their farm conditions and the development of agriculture in the Study Area. Many farmers are going to the big cities to earn money during the dry season, which is one reason for the low cropping intensity in the dry season.

In order to break down the existing constraints, and improve the farmers' conditions, many kinds of action plans will be requested. In these plans, selection of promising crops and improving the cultivation techniques of these crops with an intensification of farm support systems will be the basic concept for agricultural development.

The following figure is a flow chart showing the agricultural development plan in the Study Area, and agricultural development plan in the Study Area will be described according to the flow.

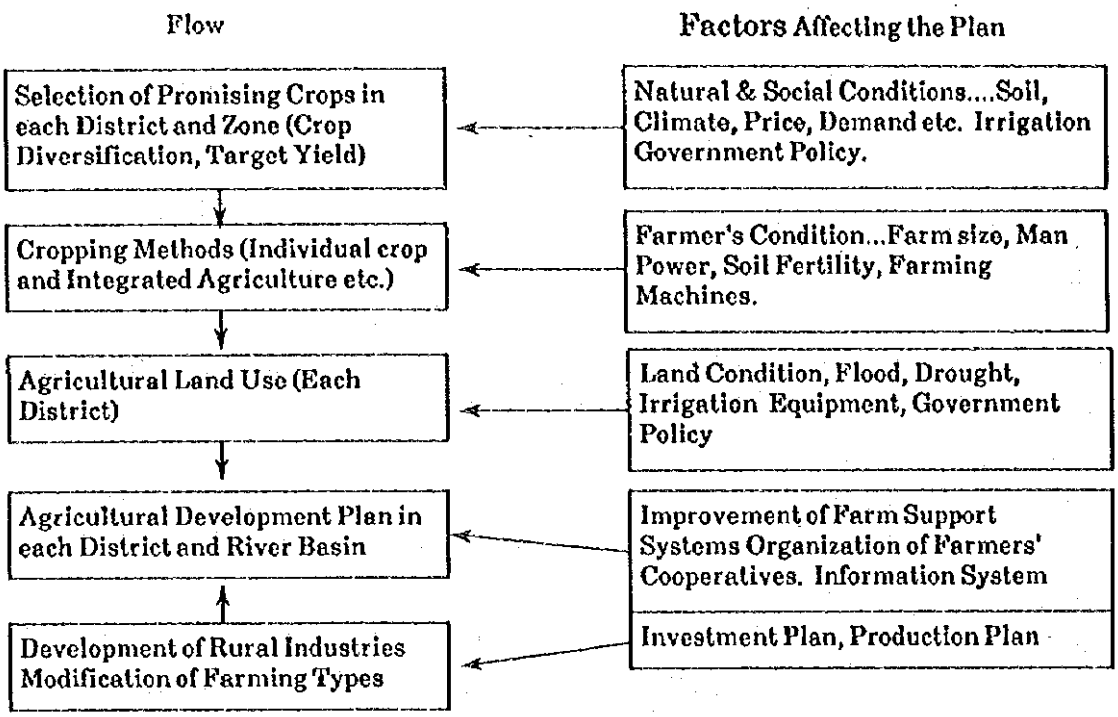


Fig. 3. 5-1 Flow Chart for Agricultural Development Planning

3. 5. 2 Selection of Promising and Suitable Crops

The areas that are to be used for the introduction of promising crops in the Study Area are in the following three fields; (1) Paddy with dry season irrigation to increase the area and crops, (2) Upland field to introduce the new crops substituting low-income traditional crops such as cassava, (3) Fallow and vacant land to be utilized more effectively.

Therefore, in the project, promising crops will be selected to be introduced in these three fields. However, these fields have different natural conditions such as soil moisture, soil fertility, weather conditions and are also differ in economic conditions such as distance from big cities. So, the crops should be selected considering these natural and economic conditions. Government policy also influences the selection of crops.

Some examples of promising and suitable crops for introduction in these fields in the Study Area are shown in Table 3.5-1 of Appendix F.

The crops mentioned in Table 3.5-1 of Appendix H are some examples of suitable and promising crops in the Study Area. Other crops may be more suitable than the above mentioned. Farmers can select the promising crops according to the natural and social conditions of their area.

3. 5. 3 Cropping Plan for Promising Crops

The objectives of water resources development and irrigation are not only to supply water to the crops but also to enable the introduction of many kinds of promising crops. Farmers can introduce many kinds of suitable crops according to their natural and economic condition. Crop diversification will be realized by the introduction of such promising crops as high income and high demand. Crop diversification will also incorporate new farming techniques especially in the irrigation area.

The following are outlines of cropping plans of promising and suitable crops in the Study Area. These crops will be expected to increase their area substituting for the traditional crops such as major rice and cassava.

1) Leguminous Crops

Soy bean, muang bean and groundnuts are cultivated as dry season crops in irrigated paddy fields. They should be sown just after harvesting the major rice. Early sowing can use the soil moisture remaining in paddy field and suppress the growth of weeds. They can also be introduced in upland field during the wet season. The crops have high priority as cash crops and for soil improvement.

2) Cereal Crops

Sweet corn and baby corn can be cultivated as dry season crops after harvesting the rice in irrigated paddy fields. These crops can be cultivated with different sowing times to avoid the concentration at harvesting time. Maize and sorghum for feed production can be cultivated as rainy season crops in upland field.

3) Vegetables

Production of vegetables is insufficient in the area. High demand for fresh and new vegetables can be expected according to improving living standard. Many kinds of vegetables such as cucumber, cabbage, string bean, lettuce, chinese kale, and some spicy crops can be cultivated as dry season crops of the paddy field in irrigated area. These vegetables can also be cultivated as rainy season crops in upland fields. Cultivation of vegetables is more laborious than rice and upland crops. So, relay or rotational cropping can break up the concentration of labor on management and harvesting of vegetables, booking and shipping of the products.

Production of vegetables are also divided into two categories; one is fresh vegetables for inhabitants in the Area, the other is for industries and export. In future, the latter is expected to develop further and increase in the area.

4) Industrial Crops

Some industrial crops such as tomatoes, tobacco and pineapple are cultivating in the area especially in the areas along Mekong River. These crops have sustained some damage due to continuous cropping. So, it is necessary to cultivate rotationally with some cereal crops such as maize. Mulberry for sericulture and tea can be introduced in some areas

5) Flower and Ornamental Crops

Rose, Chrysanthemum, Aster and Mariegold are expected to be cultivated more widely as cut and pot flowers accompanying the improvement of life quality. In general, these flowers require long periods for growing, so it is difficult to introduce in dry season paddy fields.

6) Fruit Trees

Mango is suitable in most of the upland field. Sweet tamarind is also suitable in fertile soil. Sour tamarind can be cultivated in poor soil in the Study Area. Cashew nuts have high and wide demand and are expected to be planted in a wider area. Coconut, Papaya, Longan and Lemon also have high

adaptability in the area. It is intended that fruit trees will be increased in the area substituting for cassava.

7) Bamboo and Fast-growing Trees

Sweet bamboo and fast-growing trees will use the area as a substitute for cassava and to use vacant land.

8) Grassland for Cattle

Beef cattle are expected to increase in number according to changes in food custom. However, most of the beef cattle in the Northeast are feeding mostly on wild grass and rice straw. To produce high-quality beef, it is required to feed them with grass of high quality. Some areas of cassava field and open land have been converted into grassland.

3. 5. 4 Yield Projection and Target Yield for Promising Crops

For promising crops as mentioned above, target yields in target year (2006) are shown in Table 3.5-3 of Appendix H.

The target yield for promising crops in the target year (2006) is one objective value which was calculated by appending some factors that were proved by the inclination of the average yield in recent years.

3. 5. 5 Land Use Plan

The land use in the Study Area will change with the introduction of promising crops as mentioned above. However, projecting the land use plan for promising and suitable crops in the Study Area, government policy and the provincial restructuring of agricultural production and a system plan for each province should be considered in addition to the introduction of promising crops.

In the restructuring plan, the decreasing of the traditional croping area over the three years (from 1994 to 1996) and the substitution activities are described for each province in the Project Area. The outline of the Restructuring of the Agricultural Production and System Plan in Udon Thani, Nong Khai and Nong Bua Lamphu are shown in Table 3.5-1;

Table 3. 5-1 Restructure of Agricultural Production and System Plan in Three Provinces

Activities	Udon Thani	Nong Khai	Nong Bua Lamphu	Total
Decreasing the area of traditional crops (Unit ; rai)				
Second Rice	4,263	6,195	4,379	14,837
Improper Paddy	53,557	33,545	0	87,102
Cassava	99,613	89,087	12,183	200,883
Total	157,433	128,827	16,562	302,822
Substitution Activities				
Fruit trees	37,896	2,516	2,064	42,476
Vegetables	0	0	263	263
Cut Flower	316	471	0	787
Integrated Agriculture	26,332	8,694	5,903	40,929
Sweet Bamboo	43,426	45,103	6,830	95,359
Fast Growing Trees	32,125	60,021	834	92,980
Grassland	17,338	12,022	668	30,028
Total	157,433	128,827	16,562	302,822

Source: Office of Agricultural Economics Zone, 1. OAE

The actual land use plans for the target year (2006) in each province of the Study Area are projected referring to the [Restructure Plan] of each province. The natural and social conditions of each province and the demand for agricultural products are considered in the land use plan. The results are shown in Table 3.5-5, 3.5-6 and 3.5-7 of Appendix H.

In the project shown in these Tables, the decrease in areas of paddy field are estimated to be very little over the next ten years, because major rice is the fundamental crop in the Study Area. On the other hand, it is estimated that the area of cassava will be decreased in one-half of the area in Udon Thani and Nong Khai and will be decreased in 60 % of the existing area in Nong Bua Lamphu over the next ten years.

Regarding second rice, the area under cultivation is now decreasing markedly. Second rice is very easy and labor-saving to cultivate. Farmers and their wives have some skill at rice cultivation. So, in is plan, it is projected to cultivate second rice in low land paddy field which has adequate water as a more suitable crop in the dry season.

As shown the in tables, decreased area of paddy field will be converted to fields for integrated agriculture including farm ponds, vegetable fields, fields for flowers and ornamental crops and industrial crops, such as tomato, tobacco and pineapple.

Of the cassava fields, most will be converted to fruit trees, bamboo shoots, fast-growing trees such as Eucalyptus and grassland for beef cattle. The area of grassland is estimated from the number of cattle and buffaloes in each province.

As a result of the restructuring plan for each province and the projection of land use plan in the Study Area, the cropping area of promising crops in the Study Area in the target year is as shown in Tables 3.5-8 of Appendix H.

The land use plan was projected referring to the Restructuring of Agricultural Production and System Plan in 1994 to 1996 for each province and the demand and supply for each crop.

The decreased areas of traditional crops were as follows; Second rice will be decreased in area to 44.5% of the existing area, and cassava will be decreased in area to 50.9 % of the existing area. The substitutional crops which will be increased in area are Fruit trees, Bamboo, Eucalyptus and grassland etc..

3. 5. 6 Integrated Agriculture with Inland Fishery and Poultry

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

Integrated agriculture should be based on a cycle among types of farming which can utilize the farm land 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 alternate between broiler chickens and fishery. This cycle can also save production costs by utilizing the by-products effectively.

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

Table 3.5-2 is one example of integrated agriculture which combines rice, inland fishery with breeding of broiler chicken and upland crops cultivation.

Table 3. 5-2 A Model for Integrated Farming (Rain fed Area)

(Unit Area : rai)

Section	Wet Season	Dry Season	Perennial	Remarks
Rainfed Rice	6	0		
Green manure crop	0	3		After harvesting rice
Fish-cum paddy*	(3)			Breeding of carps in paddy
Farm pond	4	4		
Broiler Chicken			4,000	1,000 heads 4 times
Upland Field	4			In the case, 2 upland crops
Sweet corn	(2)			are cultivated rotationally
Soy Bean	(2)			
Vegetables	0.5	0.5		2 times in a year
Mango			25 trees	Around pond & boundary
Dwelling	0.5	0.5		
Total Area (rai)	15	8.0		

Note* Fish-cum paddy is used in growing season of major rice.

In the above case, the total area of integrated farming for one family is 15 rai (2.4 ha). It is comparatively small scale in area; larger scale areas can be practiced up to 25 rai (4 ha). Other crops such as baby corn, ground nut and fruit trees can be introduced in paddy or upland field. The breeding of beef cattle can also be combined in integrated farming.

The farming cycle among enterprises will reduce the cost of agricultural products markedly compared to farming of a single crop.

3.5.7 Changes in the Farming Types

There are many farming types in the existing cultivated parts of the Study Area. There are not only differing farm enterprises or combinations, but also differing scales of labor force, size of fields and capital equipment in each farm household. The combination of farm enterprises and size of fields and capital equipment will change with the implementation of the projects such as crop diversification in irrigated areas and integrated agriculture in the Study Area. It will effect a change in farming types in the Study Area.

The main farming types in the Study Area following implementation of the projects are listed below. As large scale farming is not the policy of Thailand, so, size of labor force, and acreage of fields in the following tables are drawn from the farm economic survey in the Study Area.

Some Examples of Farming Types in the Study Area following Implementation of the Projects.

A. Irrigation Area

(1) Paddy farming with dry season crops ..... Major rice in wet season, Soybean, Sweet corn, baby corn etc. in dry season

(2) Paddy and industrial crop farming ..... Small area of Major rice in wet season and some industrial crops such as tomato and tobacco in dry season

(3) Paddy and vegetable farming ..... Major rice in wet season and vegetables in dry season

B. Non-Irrigation Area

(4) Upland farming ..... Cassava and Sugar cane cultivation in all year round

(5) Paddy with livestock farming ..... Major rice in wet season and beef cattle breeding.

(6) Paddy and fishery farming ..... Major rice in wet season and fish and chicken rearing in fish pond

Existing main farming types in the Study Area are more simple than above described. For example, (1) Paddy farming with only major rice in wet

season (farmers are moving to the big cities during the dry season), (2) Upland farming with sugar cane and cassava, (3) Paddy farming with some upland crops and so forth may be the main types. These types cannot get enough money for living.

After implementation of these irrigation projects, new farming types will be introduced in including the new dry season crops in dry season paddy, cultivation of vegetables in dry season paddy. Inland fishery with chicken and animal breeding will also increase farmer's income along with the above mentioned activities.

3.5.8 Development of Rural Industry

Some rural industries that are based on agricultural products are now on-going in the Study Area, such as a tomato factory, pineapple factory, rice polishing factory etc..

For the development of rural areas, the introduction of rural industries is very important, because many agricultural products can increase their value by the manufacturing process, and farmers can gain employment opportunities.

Rural industries based on agricultural products as a result of the development of integrated agriculture and diversified crops and animal products will be as follows in addition to the existing rural industries;

1) Pickles and Canned Vegetables

Canned pickles of some vegetables are now sold in the market, canned pickle cucumber, Chinese cabbage for export, and vinyl packing will be expected to increase the demand.

Cucumber, egg plant and some kinds of cabbage are manufactured for canned food or vacuum packing by salting, and baby corn by boiling.

2) Ham and Sausage from Beef, Pork and Chicken

There are some processing factories in the Study Area but more can be developed by the increase of beef cattle and chicken.

3) Feed Factory for Fish and Livestock

So much maize, sorghum and cassava are being produced in the Study Area, they can be easily manufactured into a suitable concentrated feed for livestock, chicken and fish by combining the cereals and starch of cassava.

4) Mung Bean Sprouts, Chilled or Refrigerated Fruits

Mung bean sprouts, chilled or refrigerated fruits, canned fruits, cake and candy from rice pellets, these are easily processed from local products.

Agriculture in the Study Area is expected to develop by irrigation from water resources development. Progress in agricultural production by crop diversification and integrated agriculture will also contribute to the development of the Area.

Many kinds of investment will enable the plans to go ahead which is both expected and welcomed.

3.6 Water Resources Development Plan

3.6.1 Basic Concept of Water Resources Development

1) Effective Utilization of Available Water Resources

The water resources in the Study Area are available only during the rainy season because of the rainfall distribution and presence of very little forest area. To retain the water during the rainy season, the construction of the large and medium scale reservoirs will be effective means. However, available reservoir sites are limited, due to topography and the social constraints. Thereby, the small scale projects will play a more important role in the water resources development in the Study Area. For an increase of water resources utilization, quite a number of reservoirs and weirs have been constructed so far, and the construction of the reservoirs and weirs will be continued in the future, also. The reservoir sites can be found not only in the mountainous area but also in the middle reaches of the rivers, since the possible reservoir sites in the low reaches of the river have been scheduled to be utilized as reservoirs by the

agency other than the RID. The natural reservoirs will be utilized as storage reservoirs by providing a dike around the reservoir, depending on the topographical and hydraulic conditions.

2) Improvement of Existing Irrigation Facilities

In the Study Area with a limited quantity of the water resources, the rehabilitation and/or improvement of existing irrigation facilities, such as reservoirs, weirs, natural reservoirs, swamps, ponds etc., will enhance the efficiency of the water resources use with low construction costs and less social constraint. Those projects will be realized by means of improvement and/or rehabilitation of the existing reservoirs, canal and structures as well as on-farm facilities, dredging of reservoirs, swamps, ponds, streams, etc. to utilize the limited water resources, available.

3) Flood Mitigation

The flood and inundation problems, on the other hand, have occurred not only in the lower reaches of the rivers but also in the upper and middle reaches, due to the narrow and meandering nature of the rivers, narrow span of bridges and blocked waterways due to construction of roads. In turn, the low runoff discharge rate of the river stream cause the such low flow capacity of the stream and flood. The dredging and training of the rivers/streams will bring about not only flood mitigation but also an increase of runoff discharge, storage of water in the river course and natural reservoirs along the river. These strategies will be applied to the small scale projects. Nevertheless, in planning the rivers/streams, both flood control and water utilization schemes will be incorporated.

3. 6. 2 Water Resources Development Strategy

The strategy of water resources development will be discussed for the area included the project areas which are already scheduled or planned by the agency other than the RID, such as Lower Huai Luang project area and Nam Suai Basin project area.

The small scale irrigation projects will be extended as the first priority projects, in order to distribute the benefits from the irrigation throughout the

Study Area to as many beneficiaries as possible. The potential of the large and medium scale water resources development projects in the Study Area may be limited, due to the physical conditions, such as rainfall, topography, soils, etc., and social constraints.

In the development plan to the year 2006, therefore, about 30 % of the land area will be irrigated in future by providing small scale irrigation projects. The first priority will be given to the upper and middle reaches of the Huai Mong river basin and upper reaches of the Nam Suai river basin.

In parallel to the implementation of the small scale projects, the rehabilitation and improvement of existing irrigation systems projects will be scheduled for implementation, reviewing the water balance in the related drainage area. The river improvement, including water impounding in natural reservoirs, will also be given priority.

The water resources development projects will require construction of reservoirs including water impounding in natural reservoirs, construction of weirs, rehabilitation/improvement of existing facilities, dredging of reservoirs, ponds and rivers.

For the improvement and upgrading of distribution canals, a pipeline system will be introduced, taking into account effective utilization of the water resources, lessening of right-of-way problems and introduction of upland crop irrigation. When buried pipeline is used to convey irrigation water, the conduit can follow the most direct route from the water supply to outlet points, rather than following field contours. Weed problems and loss of productive land area eliminated because crops can be planted up to or over the buried pipeline. Generally, the pipelines that offer greater seepage control, ease of water diversion, and reduced maintenance have a higher initial cost. Accordingly, the followings will be required for construction of the pipeline distribution system.

- The pipeline distribution system should be formulated according to sound planning.
- The pipeline distribution systems constructed should be used permanently by the beneficiary farmers.

Implementatiom of pipeline distribution project will be carried out as shown in Figure 3.6-1 and summarized below.

1) To establish Water Users' Group (WUG) in the Project Planning Stage

To establish WUG in early stage of the project implementation is of most importance because the RID should select a location of pumping station, project area, routes of the pipeline, etc,. after negotiating with the representatives of the beneficiary farmers.

2) Assumption of Available Water Supply and Irrigation Area

Available water supplies in normal year and drought years should be assumed as accurately as possible. Possible irrigation areas during both periods of the wet season and the dry season will be calculatd based on the assumed available water supply. The planned irrigation area should be calculated based on the availabe water supply for 1/5 drought year or more severe drought year.

The planned irrigation area and its planning process should be explained for satisfaction of the WUG.

3) To decide Project Area

The project area corresponding to the planned irrigation area will be selected in the field nearest to the water resource as much as possible.

4) Design of Project Facilities

The project facilities from the water supply to outlet points in each field block will be designed and its project cost and O/M cost will be estimated. The estimated O/M cost should be informed to the WUG and the RID should confirmed that the WUG can bear the O/M cost, for further implementatin of the project.

Pipeline distribution projects requested by WUG or farmers are given a priority according to project cost per ha, socioeconomic conditions in each project area, etc,. and the projects with higher priority will be implemented within the limits of budget allocated.

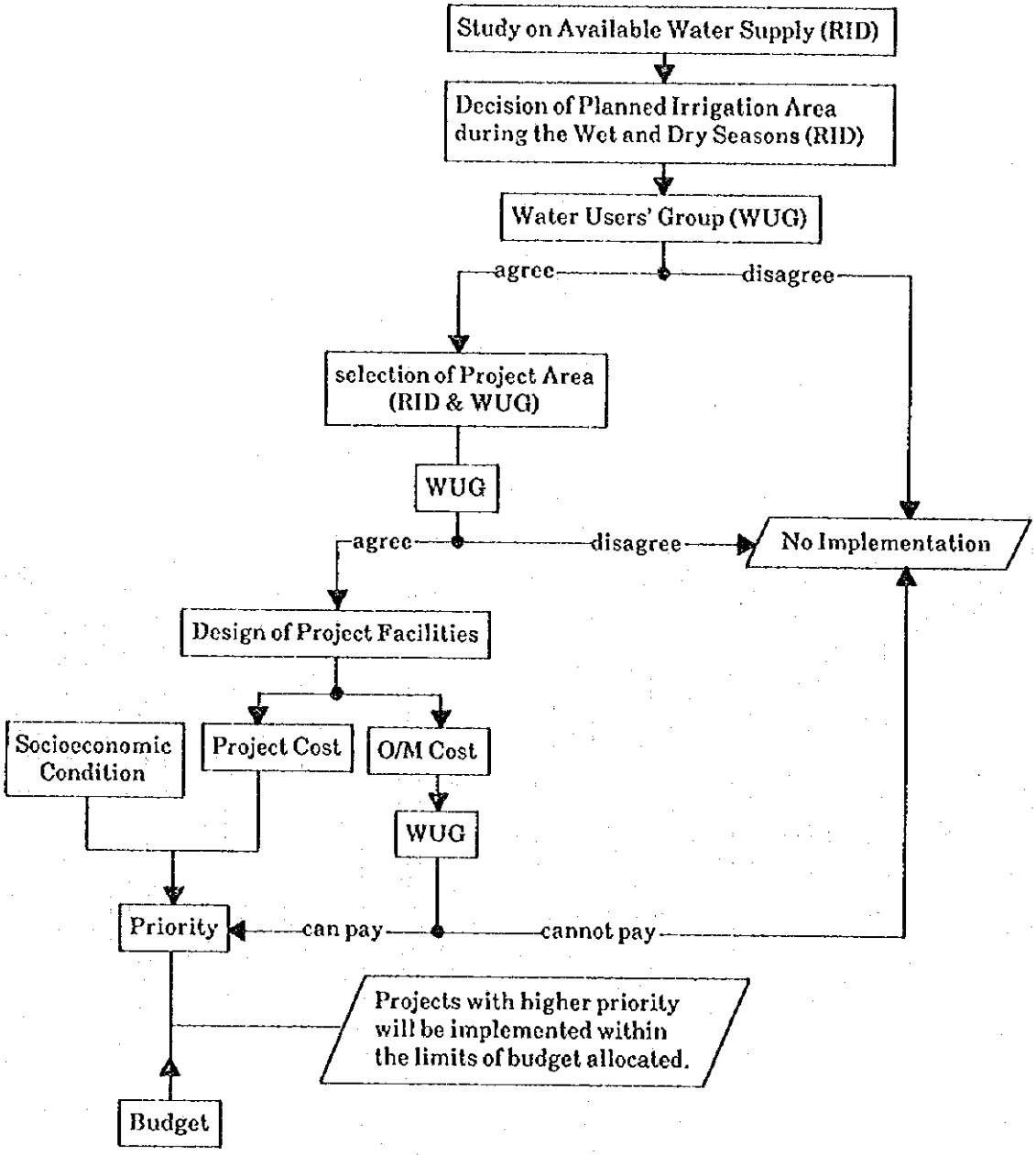


Figure 3.6-1 Implementation Procedure for Pipeline System

To irrigate the farm land with elevation above EL. 200m in the southern area of the Huai Mong Upper reaches and hilly land above EL. 180m, a pumping irrigation scheme with a long pipeline and high water head will be used to take the water from the reservoirs in the lower reaches, as gravity irrigation by providing the water source within the respective catchment areas is impossible due to topographical conditions. The pumping irrigation scheme from the Mekong river may be one of the alternatives. However, since the Mekong river is an international river, the schemes have to be studied carefully in the future.

3.6.3 Proposed Water Resources Development Projects

1) Large Scale Irrigation Project

The existing Huai Luang project shall be improved immediately in terms of water management. This project has been completed in 1984 but will be reexamined first in its water head distribution to farm plots, particularly in the area of the Right Main Canal which was constructed mainly for the purpose of domestic water supply to the Udon Thani urban area.

The improvement project will provide the heightening of the dam to ensure better spillway operations, improvement of the diversion dam to increase the quantity of diversion water and get a sufficient water head to convey the water to the Right Main Canal, remedial measures to the canals and structures and increase of check structures for proper water distribution, road crossings and bridges, and widening of O&M roads along the lateral canals for the convenience of operation and maintenance and passage of farming machines. In addition to the civil works, the preparation of an operation and maintenance manual is urgently required to operate the reservoir effectively. Those proposed works will be studied soon by the RID.

There are the following DEDP projects in the lower reaches of Huai Mong, Nam Suai and Huai Luang rivers.

Project	Irrigation Area
- Huai Mong Project (existing)	3,170 ha
- Nam Suai Basin project (planned)	17,750 ha
- Lower Huai Luang project (on-going)	19,200 ha

The purposes of these projects include both irrigation and flood protection, but main purpose is to irrigate by using water impounded in a reservoir created at lowland in each lower reach of above three rivers.

2) Medium Scale Irrigation Projects

Seventeen (17) medium scale projects of the nineteen (19) reservoir projects identified as future projects, have been examined from engineering and economical points of view, since the beneficiary areas of two (2) proposed projects, Huai Yai and Huai Chiam reservoir projects, have already been scheduled to be irrigated by pumps and to be reservoir areas under an agency other than the RID.

As the result of evaluation, the reservoirs located in hilly land have shallow water with wide water surface area, like a plate, and therefore reservoirs to be constructed in mountainous areas will have huge construction costs apart from a few projects. All of the projects have low economic internal rates of return and can hardly be evaluated in terms of feasibility for agricultural benefits. So that the projects will be evaluated in terms of its ability to satisfy social and human needs.

The proposed projects for each river basin are tabulated in the numbers, storage volume, irrigation area and costs, as shown below:

Proposed Medium Scale Irrigation Projects

River Basin	Numbers	Storage V. (MCM)	Irrigation Area (ha)	Costs (Million B.)
Huai Mong Basin	7	45.6	4,290	1,581
Nam Suai Basin	1	17.5	1,920	468
Huai Luang Basin	8	38.9	3,810	1,377
Nong Khai East Drainage A.	1	9.6	990	212
Total	17	111.6	11,010	3,638

In addition to the new projects, the improvement and rehabilitation of seven (7) existing projects have been proposed, which include rehabilitation/ improvement of dams, canals and structures, construction of appurtenant structures, drainage improvement and on-farm facilities development. By implementation of the Projects, the irrigated land area is expected to increase

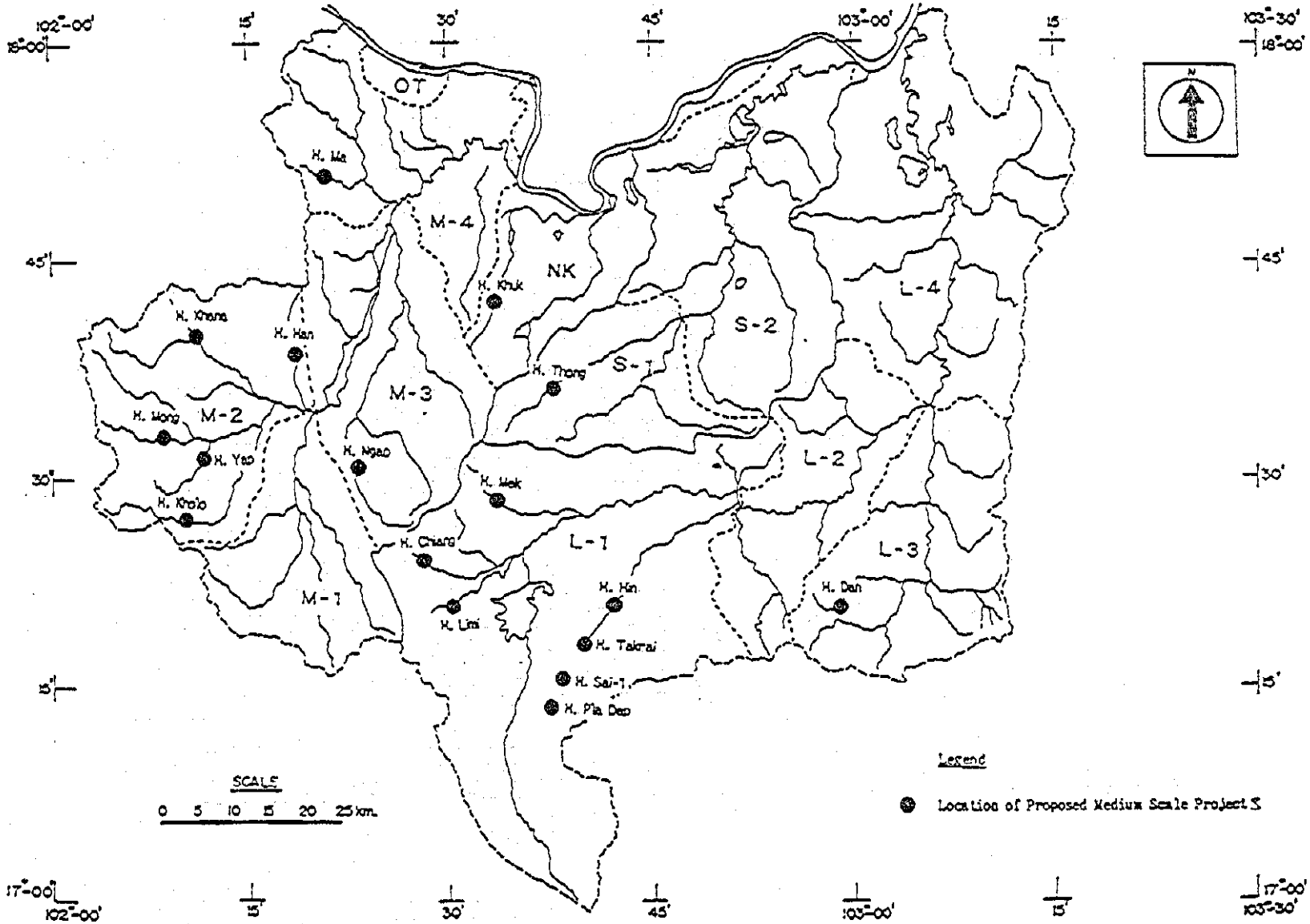


Figure 3.6-2 Location of Proposed Medium Scale Projects

by 1,560 ha from 2,600 ha at present to 4,160 ha in future. The project costs are estimated to be about 222.7 million baht excluding price escalation.

3) Small Scale Irrigation Projects (SSIP)

The number of small scale irrigation projects proposed for the future up to the year 2006 have been estimated to amount to amount to 263 projects with an irrigation area of some 20,150 ha including 33 pumping irrigation projects with an irrigation area of some 2,610 ha, which has been proposed to be double the area of existing small scale projects. The SSIP will share about 30 % of the land area to be irrigated in future up to the year 2006 together with the programmed MSIP and other agencys' projects or 65 % of land area proposed for the RID irrigation projects.

The small scale projects will be implemented by the RID for water resources development; for the purposes of the irrigation, domestic water, water for livestock and fishery. The provision of domestic water will give first priority to irrigation and other purposes.

The project will provide three (3) types of facilities, such as reservoir, weir and pumping station. The reservoirs will be constructed in the form of a reservoir dam, village pond, farm pond, public pond and fish pond (drainage water tank), which will provide the water for domestic use, irrigation, livestock and fisheries. The river water impounding in natural reservoirs located along the river may be categorized into these reservoir works. If such reservoirs are located far from the river, it will be necessary to construct weirs upstream to get sufficient water head and feeder canal to convey the water to the reservoirs. The weir will be constructed to impound the water, in many cases, for irrigation and domestic use rather than the original purposes to control the water flow and discharge into a canal.

The pumping facilities including delivery pipes and tank/pond will be provided to supply water to the villagers for garden farming and cultivation of cash crops, such as vegetables and flowers, giving first priority to domestic use.

The proposed small scale irrigation projects for each basin are summarized, as follows:

Proposed Small Scale Irrigation Projects

River Basin	Numbers			Storage	Irrigation	Costs
	Res.&W.	Pump	Total	V.(MCM)	Area(ha)	(M.B.)
Huai Mong Basin	78	8	86	15.4	6,070	563
Nam Suai Basin	30	2	32	5.6	2,378	178
Huai Luang Basin	107	20	127	16.2	10,450	726
Nong Khai East Drainage A.	15	3	18	0.7	1,250	96
Total	230	33	263	37.9	20,148	1,563

In addition to new projects, the existing facilities constructed under the SSIP program will require rehabilitation and/or improvement, anticipating the recovery of function of facilities, increase storage capacity, improve water management, protect from floods, be better utilized by farmers and ensure other beneficial results. The proposed rehabilitation and improvement of SSIP will need 121 projects up to the year 2006, assuming that about 40 % of the existing projects and 20 % of the future projects completed in the early stages will be rehabilitated and/or improved.

4) Dredging Projects

The dredging projects, to recover storage capacity of existing reservoirs, swamps, rivers, streams, village ponds, farm ponds and public ponds, have been extensively implemented by the RID, and will be extended actively in the future. The dredging works have been implemented satisfactorily according to the beneficiaries and is still in demand from many villages. The impounded water from dredging is used for domestic and irrigation uses. In future, assuming that this dredging works will be successfully implemented, 138 projects are scheduled up to 2006.

5) River Dredging and Training Projects

The Huai Luang river is narrow and extremely meandering and causes flooding along the river banks. To mitigate the damages due to floods, the Huai Luang will be dredged and trained for about 88 km from the downstream of Huai Luang diversion dam up to the confluence of Huai Dan, because the land below EL. 160 m and river land downstream of Huai Luang has been scheduled to be used for reservoirs in the other agency's plan. The design discharge was computed by applying 1/50 year's flood.

6) Weir Construction Projects

The weirs will be constructed after the Huai Luang river improvement works, to retain the necessary water level to divert water for the water impounding of the natural reservoirs and the supplemental water to the reservoirs constructed near the river. In addition, the available water to be retained in the river course will also be used for domestic and irrigation water along the river. Three (3) weirs are proposed in the middle reaches of Huai Luang, because of irrigable land below the Ban Wa Noi, Amphoe Muang Udon Thani is planned to be irrigated by the other agency. The storage volume in the river course will be about 1.4 MCM.

7) River Water Impounding Project

The river water will be impounded in the natural reservoirs and the reservoirs constructed near the river, since the possible reservoir sites are limited, due to topographical and social constraints. The problems to be solved in this projects are drainage from the surrounding area of the reservoir, since most natural reservoirs lie in depressed land which collect the drained water. If the alternative drainage schemes are not available, the water will be diverted starting from October. Therefore, this plan can be applied to the reservoirs where drainage problems are solved but may not be applied to the reservoirs with drainage problems near small river, because the water flow are scarcely available in the small rivers in October. The identified projects are located along the middle reaches of Huai Luang up to the confluence of Huai Dan. The number of identified projects is eight (8) with a storage volume of about 26.8 MCM. The impounded water will be used for the domestic purposes and the irrigation water for diversified crops in the dry season.

8) Huai Mong River Polder Project

The Huai Mong river in the middle reach, interconnects with several streams, and forms a flood plain during the rainy season. River improvement will be required but may be realized only after 20 years. Before the improvement of the river, the flood plain can be reclaimed by providing a dike along the river, taking the future plan of the river improvement into account. As the plan up to the year 2006, four (4) Dike Projects are proposed to create arable land of some 6,900 ha, and providing weirs for the irrigation.

3. 6. 4 Water Resources Development in Each River Basin

1) Huai Mong River Basin

a) Upper Reach

The Huai Mong upper reach is classified into two sub-basins, which are the Huai Mong upstream sub-basin with a moderate amount of surface water, and Huai Nam Bon sub-basin endowed with comparatively limited water resources, in terms of water resources development. The rivers in the Huai Mong upstream sub-basin have some water available in the dry season, while the rivers in the Nam Ban sub-basin have flash floods in the rainy season and are dried up in the dry season.

The medium scale projects have been identified for the study, which are five reservoir projects on Huai Kholo, Huai Mong, Huai Yap, Huai Khana and Huai Han in the Huai Mong upstream sub-basin. The total irrigable area is expected to be some 2,490 ha for rainy season crops and some 1,000 ha for dry season crops. The dam site for Huai Mong reservoir is suitable in terms of topography and geology but are located within the forest conservation area. Huai Kholo and Huai Khanan reservoirs have a constraint in the large submerged land area. The economic internal rate of return is generally low. Thereby, the reservoir water will be allocated for domestic use and other various purposes. Huai Yap reservoir,in particular, might as well be used for supplemental water supply to Huai Mong Project area and/or mainly for the domestic water supply. The project costs are estimated to be about 1,581 million baht in the total.

Small scale projects are also expected for the construction of small reservoirs, farm ponds and weirs, for the purposes of irrigation, domestic water, livestock and inland fisheries. The construction of small reservoirs and weirs only for irrigation purposes may be expected in the Huai Mong upstream basin but limited to the Huai Nam Bon basin. About 35 SSIPs to be constructed, 5 pumping irrigation projects, 16 Improvement projects of SSIPs and 25 dredging projects are scheduled up to the year of 2006.

b) Middle Reach

On the west part of the middle reach along side the Phuphan mountain range, only small scale projects are expected, because of the topography. The flood plain should be provided first with the flood protection dikes to alleviate flooding. In the hilly land, the potential for medium scale projects may be limited due to topographic conditions, and the water resources development may be desirable for small scale projects.

The medium scale project for the study is proposed for Huai Ngao at Ban Na Ngam, Amphoe Ban Phu, Udon Thani province. The catchment area of the proposed reservoir is some 85.3 sq.km. The irrigable land area will be some 800 ha. The project costs are estimated to be about 290.7 million bath. The project has economic feasibility but due to a large submerged land area in the reservoir has implementation problems.

Small scale projects for small reservoirs, weirs and farm ponds construction will be provided. Most projects are expected to consists of construction of small reservoirs and farm ponds from the standpoint of topography. The plan is expected to construct 33 SSIPs includ in 3 pumping projects, improvement of 12 SSIPs and 23 Dredging Project for the future up to the year 2006.

Aside from the irrigation projects, four Huai Mong river polder projects are planned to be constructed for the future up to the year 2006.

c) Lower Reach

The hilly land, located in the west of the lower reach, has potential for water resources development because the forested mountainous land extends in the west and heavy rainfall is expected. While, terrace lands in the east of the lower reaches have less water resources development potential, due to poorly forested and undulated land. The flood plain in the center has less potential for development without the flood control projects but may be irrigated for the dry season crops by pump.

One (1) medium scale project has been identified for the study. The service area are estimated to be some 1,000 ha. The project has a low internal

rate of return but may be feasible for implementation, which will be implemented by the RID, starting in 1996.

The small scale projects are expected mainly to construct the small reservoirs and farm ponds in the hilly and terrace lands. Construction of 13 SSIPs, the improvement of 8 SSIPs and 31 dredging projects are scheduled for the future up to the year 2006.

2) Nam Suai River Basin

a) Upper Reach

The upper reaches of the Nam Suai river basin is poorly forested and undulating in topography. Most rivers are dried up during the dry season. The possible reservoir sites are limited in terms of topography. Nevertheless, one medium scale project is identified for the study in the upstream reaches of Huai Thong.

The Huai Thong reservoir project is a medium scale project, located in Amphoe Ban Phu, Udon Thani province, and planned to irrigate a land area of some 1,920 ha and 700 ha in the rainy and dry seasons, respectively. The dam can be of the earthfill type. The estimated project costs are about 468.4 million baht. However, problems are encountered due to a large submerged land area in the reservoir.

Small scale projects are also expected mainly to construct ponds but may be fewer in number due to topographical conditions. The construction of about 7 SSIPs including 3 pumping projects, improvement of 13 SSIPs and 9 dredging projects are scheduled for the future, up to the year 2006.

b) Lower Reach

The medium scale projects have not been identified but the improvement of Huai Nong Song Hong is expected in the future up to the year 2006, since most farm land is included in the Study Area for Nam Suai Basin project. So that the water resources development projects other than the aforementioned project will be scheduled as small scale projects, which are

scheduled to implement 25 SSIPs, rehabilitation of 10 existing ones and 35 dredging projects up to the year 2006.

3) Huai Luang River Basin

a) Upper Reach

Seven (7) medium scale projects have been identified for the study, Huai Hin Lat, Huai Sari No.1, Huai Takrai, Huai Pla Dap, Huai Limi, Huai Mek and Huai Chiang reservoir projects. Among them, five (5) projects are located within the catchment area of the existing Huai Luang reservoir. The proposed projects are small, some 120 ha to 500 ha, or about 310 ha on average, in the irrigable area, except Huai Hin Lat reservoir project with an irrigable land area of some 1,100 ha in Amphoe Muang, Udon Thani province. Total irrigable area are some 3,210 ha for rainy season crops and some 470 ha for dry season crops. Thereof, Huai Mek reservoir may as well be used for supplemental water for the existing Huai Luang project. All reservoirs may be of the earthfill type of dam. The project costs are estimated to be about 1,100 million baht in the upper reaches basin.

The small scale projects have been planned for implemention as follows: 25 construction projects for reservoirs and weirs, 12 projects for the construction of pumping facilities, 18 projects for the improvement of the existing ones and 37 dredging projects up to the year 2006.

The existing irrigation systems, particularly in the large scale and medium scale projects will be rehabilitated for improved irrigation efficiency and to facilitate water management. The rehabilitation and improvement projects will be composed of the improvement of the existing Huai Luang diversion dam, minor repairs to the main and secondary canals and structures, and upgrading of on-farm facilities for the Huai Luang project. For five (5) medium scale projects, the rehabilitation of canals and structures, provision of check structures and gated turnout, upgrading of on-farm facilities are required. The total costs for the rehabilitation and improvement of existing irrigation projects will be approximately 365.3 million baht.

In addition to the irrigation component, the Huai Luang will be improved by the dredging and river training of 41.5 km long from the existing

Huai Luang diversion dam to the confluence of Huai Suang Luang. At the same time, three (3) weirs will be constructed to deliver the water to the natural reservoir and retain the water in the river course. Five (5) natural reservoirs will be used for the irrigation and domestic water supply source by providing a dike around the reservoirs and dredging.

b) Middle Reach

Only one project will be proposed for the study upstream of the Huai Dan river basin, which is possible to irrigate a land area of some 600 ha in the rainy season and 240 ha in the dry season, with project cost estimated at about 290.7 million baht. However, it was found that the small scale project was already constructed near the proposed dam site by the provincial office. So that, some plan modification may be required.

The small scale projects to be implemented are 30 projects through the construction of small reservoirs and weirs, 8 projects as construction of pumping facilities, 12 improvement projects of existing ones and 23 dredging projects of existing natural reservoirs/ponds for irrigation and domestic water supply purposes.

In addition, the Huai Luang, below the confluence of Huai Suang Luang up to the confluence of the Huai Dan, will be improved by means of dredging and river training. At the same time, water impounding of two (2) natural reservoirs and one (1) weir construction are expected to be implemented in future projects up to the year 2006.

c) Lower Reach

The low-lying land is currently flooded in the rainy season and endowed a number of natural reservoirs and swamps, and farmland below an elevation of EL. 170m has been scheduled to be irrigated under the Lower Huai Luang Projects. In the hilly land, the narrow paddy fields are distributed along the tributaries, and there is a suitable reservoir damsite with low potentiality, because of topography with wider valley to the downstream.

No medium scale projects are planned. The small scale projects scheduled for construction are 18 in number as small reservoirs and weirs, 11