

3.2.3 Forest Management System

Broadly, there are 6 main forest management systems in practice in Thailand with the following issues:

1) Reforestation Program

- Nursery to produce seedling of teak and non-teak hardwood species.
- Planting and maintainance of seedling.
- Two plantation systems as follows:

1. Traditional planting system

Every step is carried out by employees of the body responsible for the planting and trees for timber is the only crop. It is used by the RFD, by logging concessionaires in reforesting the logged areas for fulfillment of the concession contracts, and in private reforestation schemes.

2. Taungya system

This originated in Burma in 1856 and was introduced to Thailand in 1906 by the RFD in a modified form. It was later modified further into the forest village system and then used by RFD. Planting is carried out by farmers who are allowed to cultivate between the trees until the crops are shaded out. In the forest villages forest establishment is integrated with the settlement of the farmers and their families into villages and the carrying out of many kinds of development work.

- Reforestation problems include lack of know-how in planting some species, having insufficient seeds for planting season, lack of knowledge in producing seedlings, and coping with natural hazards such as drought, fire, plant diseases, and insects.
- Problems at the reforestation sites are typically poor fertility soils, weeding by Imperata cylindrica, and illegal possession by local villagers.

2) Forest Village Program

- Selecting already encroached forest by villagers to set up a forest village by allocating rights to occupy, but not the rights of ownership up to 15 rai of land for farmland and homelot to each family.
- Providing basic village needs such as water supply, road, school, public health service, credit, extension, etc. and assistance to establish an agricultural cooperative.
- Hiring the forest villagers at a fair rate to plant community forest in the area around the forest village, in order to produce short-rotation wood for domestic use such as for firewood, fencing, etc.

- Problems arisen from local villagers include complaints on the inadequacy land provision for supporting a family (15 rai per family), conflict on the formerly squatters having more than 15 rai land to be reduced to 15 rai herein, fear on unaccomplishment of the already occupying land when reallocated, fear on harm by the people who first cleared the land before forest village establishment, and damage on the plantation by the opponents or the losers.

- Problems caused by influential or interested people such capitalists, traders, financiers, teachers, policemen, soldiers, local administrators, etc. who often oppose and refuse to cooperate with other government officers and threaten to forestry officers.

3) National Forest Land Allotment

- Land allotment rights namely in Thai as "Sor Tor Kor" given to people occupying in national forest before 1 January 1982.

- Land allotment size not more than 15 rai per family and site at less than 30° slope suitable for agriculture and excluded from a watershed or scenic area.

- Land allotment rights holder must watch for trespassing in the forest or near the road out of the area.

- Problems on giving land allotment rights as misunderstood as cancelling reserved forest area due that there is practically encouragement in planting agro-crops instead of planting forest. Further forest destruction is also due to a misunderstanding that the given Sor Tor Kor land allotment rights will be soon upgraded as the Nor Sor 3 ones.

4) Forest Plantation

- National forest land not less than 10,000 rai is selected for plantation on each 1,000 rai plot per year, on continuous basis of 10 years at least.

- Forest village of 50-100 rai for 100 families each having 0.5-1 rai for homelot and 10 rai for farmlot of 2 family members to earn income from hired forest plantation with 3 years quality for special bonus.

- Villages having not less than 15 children at the age of 6-7 years old or for the first level in primary school (Phrathom one), will be provided a temporary school with teachers.

- Public utility provision includes water and electricity supply, temple and monks, sanitation and health service, and village welfare shop.

- Problems include on obtaining seeds especially valuable species which result in raising fast-growing species of a quick payback period of 15-20 years as substitution.

5) Land Reform

- Land unsuitable for agriculture up to 20% of the land reform area is preserved for planting forest with 5-year forest management budget provided by ALRO.
- The ALRO arranges for the ALRO provincial officials to have training in establishing and protecting forests for extending the understanding on need for forest protection and villagers cooperation amongst the villagers. In case of trespassing, the ALRO provincial officials firstly persuade trespasser to move out and then remove by ALRO Act through courts.
- Problems on trespassing often causing by uncertain boundary of forest area, limited agricultural land, no forest plantation, and lack of authority to audit forest plantation.

6) Self-Help Settlement

- Settlements to help poverty people, people moved from flooding areas, people in border provinces and infiltrated areas, people of socially and politically sensitive, and economic development.
- Agroforestry with field cropping, orchard plantation and livestocking, alongside provision of cooperatives and industries.
- Problems on land quality, member people of former occupation outside of agriculture and agricultural product marketing.

3.2.4 Forest Villages and Land Reform Reforestation Areas

There are 4 forest villages in the project area which are also within the project land reform area. Each village is targeted to plant averagely 100 rai per village a community forest within 1998; while the land reform area in individual village is also averaged at 100 rai per village for integrated farming. The community forest is outside of the land reform area and is undertaken by Royal Forest Department. There are the other four plots of unsuitable land within the land reform area which can be planted another community forest, having approximately areas of totally 1,150 rai.

3.2.5 Forest Dependency and Forest Uses

The relation of forest with villages around the forest is indicated by percentage of forest dependency which the number of forest dwellers in a village is inverse related to the size of agricultural land holding of cultivators in that village. The So villagers harvest forest resources mainly for household consumption with less for sales due to transportation difficulty. Variety of forest resources include timber, bamboo, firewood and charcoal production, wild vegetables and fruits, bamboo shoots, mushrooms and in the past, hunting for wild animals.

There are 2 villages comprising Ban Nong Khlong and Ban Nong Mu which are classified as highly forest dependency ranging 70%-100%. Both villages are in watershed forest of Huai Kha Na and Huai Lak Reservoirs respectively. Also, there are other 5 surveyed villages classified as moderately forest dependency between 50-70% comprising Ban Tui, Ban Na Lak, Ban Phang Daeng, Ban Phon Swang, and Ban Huai Lao.

The highly forest dependent villagers visit the forest more frequently on mostly weekly basis. There is no seasonal difference in each visit. The surveyed villagers depend on the forest for firstly source of firewood and secondly source of food.

Currently, the villagers only depend on the conservation forest because community forest is not yet established in the study area. For household consumption, it was found that more than 90 % of the villagers or about 500 households of 8 villages in Tambol Phang Daeng depend on the forest for source of firewood, vegetables and mushrooms. About 50 % or 260 households of the community, earn their income from selling mushrooms and vegetables harvested in the forest.

The consumptive users are approximately five folds of the productive users. Family uses of forest products with less users include, in order, branch cutting, medical plant collection, logging, animal hunting, animal husbandry and bird hunting. In comparison with those for selling, they are respectively bird hunting, animal hunting, medical plant collection, branch cutting, fuelwood collection, and logging.

3.2.6 Forest Management

Community forest is not yet established in the study area, however the project on community forest has been planned by the Royal Forestry Department. In the study area, the surveyors found private forests in Ban Phon Swang, Ban Tiu and Ban Huai Lao, comprised indigenous species. They however found a private Eucalyptus forest only in Ban Na Lak. Furthermore, there are public forests comprised mostly indigenous species. As a buffer zone, these forests locate between the conservation forest and the village homelots. Some cassava and rice fields were observed in the buffer zone, but some sugarcane fields were found only in buffer zone between Ban Na Lak, Ban Phon Swang and the conservation forest.

Based on the forest survey through the questionnaire, as conservation forest users, the surveyed villagers normally do not strictly follow the local rules which are as follows :

- First ; *no logging*
- Second ; *no hunting*
- Third ; *no burning*
- Forth ; *no noisiness.*

3.2.7 Fuel Consumption

Fuelwood is the main source of the surveyed households consuming mostly up to 600 kilograms per year. Firewood is just for a consumptive use whereas charcoal is for both consumptive and productive uses. It was found that only villagers of Ban Phang Daeng consume just charcoal. None of villager in the study area uses gas as fuel source because it is first expensive, and second difficult to purchase.

3.2.8 Stream Ecology

In stream ecosystems, fundamental energy supplied to the tropic structure derives from 2 sources which are 1) photosynthetic activity of green plants : algae and higher plants, and 2) imported organic mater : plant materials entering the stream through leaf fall and run-

off. The primary producers along with the incoming organic matter provide a feed source for primary consumer, including zooplankton, benthic invertebrate and rough and forage fish. The primary consumers in turn are energy suppliers for secondary consumers or carnivores such as predaceous insects and game fish. Dead organic matters produced from all of the trophic levels are ultimately passed to decomposes particulate bacteria and fungi. Here, dead organic matters are then broken down and used by the primary consumers. As a consequence, nutrients are released for recycling to primary producers.

The results of physical parameters conducted in Huai Lak and Huai Kha Na, showed no significant difference of ecology in each riverside. Nevertheless, the present activities and the topography around each stream are different. The surreyor found the streamside characteristics of Huai Kha Na with steeper sloped and fertiled forest area whereas they found more flat valley paddy field and stream human settlement along Huai Lak. The stream water quality and flow have an effect on the living organisms in each habitat.

3.2.9 Planktons

Fourteen (14) plankton species, consisted of 10 phytoplankton species and 4 zooplankton species are observed in two streams : Huai Lak and Huai Kha Na. The dominant plankton species found are *Spimlina sp.*, *Oscillatoria sp.*, *Spirogyra sp.*, *Nodularia sp.*, and *Copepod sp.*. This is a typical planktonic composition of running water ecosystem found in general small streams in Thailand. The details of plankton species observed in each stream is described as follows:

1) Huai Lak

In Huai Lak, the total plankton species observed are 13 species : 9 phytoplankton species and 4 zooplankton species with the average density of 14.14 cells per litre or 12.34 cells and 1.80 cells of phytoplankton and zooplankton respectively. The dominant species are *spimlina sp.* and *Oscillatoria sp.* The distribution of plankton found at upstream is greater than another site due to the less canopy of stream side tree enable light penetration.

2) Huai Kha Na

In Huai Kha Na, the total plankton species observed are 4 species which are only phytoplankton species with the average density of 2.68 cells per litre and there found a small difference between density of phytoplankton species observed upstream and downstream. The dominant species are *Nodularia sp.* and *Spirogyra sp.*

The number and density of plankton species observed in Huai Lak is greater than ones observed in Huai Kha Na due to the greater in size of river width, the less canopy of river side tree and the higher velocity of water current. The average density of plankton is considered relatively low as compared to those of other rivers such as the Maekong (50,000 cells/m³) and the Mae Klong River (260,000 cells/m³).

The plankton species observed in both stream basin are generally indigenous species of Thailand region and the ones mostly observed are *Spimlina sp.* and *Oscillatoria sp.* Their stream productivity is considerably low and dependent on nutrient enrichment.

3.2.10 Aquatic Invertebrate (Benthos)

Fifteen (15) families, consisted of 11 families of aquatic insect larvae and the others of nematode, shrimp, tubifid and gastropod are observed in the two streams. The aquatic Invertebrate species observed in both stream bed are generally indigenous species of Thailand region. The dominant groups of the aquatic insect observed are mayfly and dragonfly. The species diversity of each stream is vary on the distance from upstream. The number and density of aquatic invertebrate is higher at the site near village and less at upstream due to available nutrient and the details of aquatic invertebrate species observed in each stream is described as follows:

1) Huai Lak

In Huai Lak, the total benthos species observed are 11 species : 9 species of aquatic insect larvae, the other two species are of nematode and shrimp with the average density of 60.43 cells/m³. The highest density of benthos is found at downstream (111 cells/m³), as a result of more organic matters discharged from Ban Nong Mu. This is again to prove that their stream productivity is dependent on nutrient enrichment. Those of which found at dam site and upstream are 37 and 33.3 cells/m³ respectively.

The species diversity of benthos has the highest value when measured downstream, but decreased when measured upstream. The species diversity of benthos measured at upstream, downstream and dam site are 0.85, 1.63 and 1.03 respectively.

2) Huai Kha Na

In Huai Kha Na, the total benthos species observed are 7 species : 3 species of aquatic insect larvae, the other 4 species are of nematode, tubifid, shrimp and gastropod with the average density of 51.8 cells/m³. There is no significantly difference between density of species collected at upstream and damsite which are 43.1 and 55.5 cells/m³ respectively.

3.2.11 Fish Fauna

/m³ In rainy season when the survey was carried out, the surveyors found a very local fisheries activity in small streams such as Huai Lak and Huai Kha Na due to a small number of fish and a few fish species. Instead, the fishermen would catch the fish in "Huai Bang Sai" where Huai Lak and Huai Kha Na flow into. The fish species in stream basin are mainly detritivorous and dermasal types of generally indigeous species of Thailand region. No migratory fish species were observed.

List of fish founa observed in Huai Bang Sai are of at least 8 species as follows:

- | | |
|------------------------|--|
| Family Mastacembelidae | - Pla Kathing (<i>Mastacembelus armatus</i>) |
| Family Cyprinidae | - Pla Lai (<i>Fluta alba</i>) |
| | - Pla Sui (<i>Rasbora sp.</i>) |
| | - Pla Tapian (<i>Puntius gonionotus</i>) |
| | - Pla Tapian Jul (<i>Puntius binotatus</i>) |

Family Clariidae	- Pla Duk Dan (<i>Clarias batrachus</i>)
Family Bagridae	- Pla Kot Kao (<i>Mystus wyckii</i>)
Family Ophicephalidae	- Pla Chon (<i>Ophicephalus striatus</i>)

3.3 HUMAN USE VALUES

3.3.1 Land Use Patterns

Tambon Phang Daeng is a community locating at agricultural zone type of forest land classification, and surrounded by conservation zone. Therefore, the main land use pattern of the community is forest covered up to 82.85%. Agricultural land use covers around 11.57% of the community land. Major cropping pattern of its agricultural land is upland crops; followed by orchards and ricefields respectively. The community has a public land which is neither forest nor agriculture, covering about 1,513 rai which will probably become community forest up to 1,000 rai in 1998.

It is recorded that about 27,293 rai or 98% of agricultural land use of the community are outside the ARI area which covers only 597 rai. (Community Agricultural Office, 1997) Therefore, it can be presumed that, the present agricultural land is mainly illegally in the conservation zone, including the proposed reservoir areas.

3.3.2 Agricultural Land Use Problems

Water supply is the most problematic in terms of inadequate amount and storage deficiency both during dry and wet seasons; as revealed by 70 respondents through questionaired interview in 7 villages. Another main problem is economically concerned with low price of marketed produce, high hauling cost to the far away market, and expensive agricultural inputs including fertilizers, pesticides, and seeds. Debts are unlikely problematic because very few of villagers have more than 20,000 baht/household in debt. Major source of loan is from the Agriculture and Cooperative Bank. No problem on acidic or saline soils exists.

In consequence, water storage development and marketing and product pricing are essentially highly demanded. Soil fertility improvement, yield seed application, and credit provision demands are of less priority. Constructing Huai Lak and Huai Kha Na Reservoirs in conjunction with market improvement are perceived as the key requirements to successfully sustainable development in Tambon Phang Daeng. Water shortage in a drought year had damaged about 2,120 rai cultivation area totally from every villages or about 7.6% of total agricultural land use.

3.3.3 Water Supply and Water Use

Natural water supply in Tambon Phang Daeng is from streams comprising mainly Huai Lao in conjunction with Huai Bang Sai at Ban Nong Khlong and its further downstream confluence with Huai Whai Din at Ban Na Lak. There are two small reservoirs on Huai Whai Din and Huai Rai with storage capacities at 59,650 and 4,000,000 cubic meters and irrigable lands at 350 and 1,500 rai respectively. Both small reservoirs are the tributaries of Huai Bang Sai; which are used for cultivation and livestocking. All villages in this community are normally flood-free.

For upstream villages, it is found that:-

- Huai Lak is used only by Ban Nong Mu, and is not adequate especially for livestocking and cultivation.
- Huai Lao is used by two villages of Ban Nong Khlong and Ban Huai Lao, it is considerably adequate for cultivation and livestocking in Ban Nong Khlong but inadequate for both uses in Ban Huai Lao.
- Huai Kha Na is not used by any surveyed villagers in any villages.

For downstream villages, it is found that:-

- Huai Bang Sai is the only water supply source of Ban Phang Daeng, Ban Tui, Ban Na Lak, and Ban Phon Swang. All of them perceived as not adequacy for livestocking and cultivation.

The main water supply for domestic use is shallow wells in every villages; and perceived entirely as inadequacy.

3.3.4 Public Utility

Main trunk road of the community is the provincial highway route no.2287 under paved condition with year round usable. There are two latteritic feeder roads fringe of the main trunk roads; comprising first intersection, at Ban Nong Mu; and second intersection, at Ban Nong Khlong and Ban Huai Lao. However, there is only a automotor pass bridge crossing Huai Bang Sai at Ban Nong Khlong. The bridge crossing this stream at Ban Nong Mu is only for pedestrian-and-motorcycle passage. The village council at Ban Nong Mu demanded that, during constructing Huai Lak Reservoir, this bridge should be reconstructed and improved as automotor pass for construction materials hauling. Most of the surveyed villagers perceive that their feeder roads are only seasonally usable; not all year-round.

Tambon Phang Daeng two preschool children centers are allocated in Tambon Phang Daeng and serving 80 children. There are also 6 primary schools consisting of 42 teachers and 939 students; and 1 primary school with 20 teachers and 132 students. The teacher-to-student ratio in primary and secondary schools are respectively at 1:22 and 1:7. Thereby, most of the surveyed villagers perceived that the schools are adequate.

There is only are public health station in Tambon Phang Daeng; but it is not quite convenient to reach due to a problem on transportation. Moreover, there are malaria and worm diseases prevalent highly herein, thus the majority of surveyed villagers perceived this facility as deficient.

Wats in the community are perceived by most of the surveyed villagers as adequacy.

3.4 QUALITY OF LIFE VALUES

3.4.1 Socio-economics

3.4.1.1 Village Household Profile

The total households of Tambon Phang Daeng are 516 families; of which only 48 households are enlisted as the ALR farmers. Family size is averaged at 4-6 people/household.

In the Huai Lak proposed impoundment area, there are 27 families presently cultivating therein. They are almostry villagers from Ban Nong Mu (25 families) and few from Ban Na Lak (2 families). About 12 households of such total 27 families in the reservoir area have also other cultivation lands; whereas the other 13 households are landless outside of the reservoir and the rests, 2 households are unknown.

For the Huai Kha Na proposed inundation area, there are 16 households currently cultivating herein. All of them are villagers from Ban Nong Khlong. They include 11 landless households and 7 households having land outside the reservoir area.

3.4.1.2 Compensation and Displacement

No homelots are permanently constructed in the two proposed reservoir areas. Based on the result of socio-economic Impact survey on 70 surveyed villagers in 7 villages, it was found that the villagers in Ban Nong Mu, where the Huai Lak Reservoir is located, mainly accepted the compensation of 10,000-30,000 baht/rai. This rate is also desirable for villagers at Ban Nong Khlong, where the Huai Kha Na Reservoir is situated because it is reasonably higher than the official land value rate as shown in Table 3.4-2. Unaffordable compensation is the main problem for unacceptable involuntary displacement. There is thus no need for displacement; but highly needed for fair compensation.

Table 3.4-2 Official Land Value Rating of Tambon Phang Daeng since 8 November 1995

Land Value		Land Use Type	Location	Village
Baht/sq.wah	Baht/rai			
50	20,000	Residential Land Use	Beside Provincial Highway Route no.2287 (within 40 m)	Ban Phang Daeng Ban Tiu Ban Na Lak
40	16,000	Residential Land Use	Beside Latteritic Roads/Access Roads (within 40 m)	Ban Nong Mu Ban Nong Khlong Ban Huai Lao Other Village
25	10,000	Residential Land Use	Away from Provincial Highway, Latteritic Roads/ Access Roads	Every Villages
25	10,000	Agricultural Land Use	Beside Latteritic Roads/Access Roads (within 40 m)	Every Villages
20	8,000	-	Outside of the Above Lands	Every Villages

Source : Provincial Land Office of Mukdahan

3.4.1.3 Attitude Survey

There are 70 surveyed villagers of 7 villages on their attitudes towards the project activities.

1) **Willingness to participate in ALR reservoirs and irrigation development**:- All of them intend to participate.

2) **Impact perception on ALR reservoirs development**:- Major negative impacts are land loss and loss of firewood source. Ban Nong Mu and Ban Nong Khlong have more adverse impact perceptrors than the others. On positive side, beneficial impacts are mainly agricultural gain, water supply, and fishery. All surveyed villagers in 7 villages have more-or-less equal positive perceptrors on such benefits.

3) **ALR reservoirs development justification**:- Nearly all of the surveyed villagers support on the ALR reservoirs development, even there are less numbers of those already known on the ALR reservoirs development than those unknown. The villagers at Ban Nong Mu have more cultivated land inside the Huai Lak Reservoir than those at Ban Nong Khlong who have less cultivated land inside the Huai Kha Na. Main cropping in the inundation areas are rice and cassava.

4) **Participation in integrated ALR reservoirs development**:- Most of them intend to participate in cropping conversion practice. Some of them devote their labour, comment, and knowledge as participatory contribution to ALR reservoirs development. There are less number of surveyed villagers who participate in terms of land devotion and compensation acceptance. Very few or nearly none concern with cash contribution.

5) **Participation in integrated ALR training**:- Nearly all of the survey villagers attempt to attain training on, in order of interest, (i) integrated farming, (ii) soil management, (iii) community reforestation, (iv) market cropping, and (v) handicraft/household industry.

3.4.1.4 Farm Occupation and Occupational Migration

Most of the surveyed villages in all villages are not dry season emigrants. Probably, they are Thai So ethnic group of least communication with outside economy; even they have adapted themselves in many ways with neighbour Thai villages. Farm occupation relies mainly on rice and casava with poor income of averagely 8,107 baht per household per year. The dry season emigration is basically for income earning due to water shortage for farming.

3.4.2 Ethnic Characteristics

All of the villagers in 8 villages of Tambon Phang Daeng are Thai So. These villages should be established not less than 100 years ago whereas the Laos from Ban Phone Sin at the opposite side of Maekong River established as Mukdahan Town about 200 years ago.

However, So tribe in Phu Phan range who were the ancestors of the study villages should be established more than 200 years ago before the Laos immigration into Mukdahan. They had been some ethnic hilltribe of So tribe who mostly resided between Udon Thani, the

Nong Han Swamp, and the Mekong River. They were Australia-Asiatic origin people with a strong infusion of Melanesian blood, resulting in a rather dark skin.

The original So hilltribe might be assimilated by the Lao Wieng or Wieng Chan within 200 years ago probably at the time of Mukdahan Town establishment by the Lao Wieng immigration, and becoming the so-called Lao So. About 100 years afterwards, the Lao So changed themselves into Thai So. This is due to the ethnic nature of many adaptability with the Lao ways of living and then with the Thai neighbours.

The Thai So adaptation results in their present dress as same as the normal Thais. There are Buddhist wat in the villages which means that their formerly ancestor spirit belief is gradually discipating. Tribe unique ceremony is rarely performed now although the village headmen attempt to conserve it. The ceremony is related to rice culture and ancestor spirit belief such as:-

- In Thai, *Ngarn Boon Khao Kong*
- In Thai, *Ngarn Boon Khao Sard*
- In Thai, *Ngarn Boon Khao Din*
- In Thai, *Ngarn Liang Phee*.

Khao is meaned as rice and Phee is refered to spirit. Ngarn is translated as the ceremony.

In general, this Thai So villages of Tambon Phang Daeng are not one of the major So ethnic group settlements in Thailand; and they have adapted themselves to become as Laos, and then, Thai neighbours.

3.4.3 Health and Sanitary Conditions

Amphoe Dong Luang has been watched as warning districts having higher parasitic infections than other districts in Mukdahan Province. As shown in Table 3.4-8, the prevalent rates of hookworm and liver fluke in Amphoe Dong Luang are respectively at 31.96% and 13.79% as compared with such at 10.97% and 3.81% of Mukdahan Province.

There are also considerably high prevalent rates of Pneumonia and Malaria in Tambon Phang Daeng respectively at 894.75/100,000 people and 1,930.77/100,000 people as compared with such at 480.49/100,000 people and 120.92/100,000 people of Amphoe Dong Luang (see Table 3.4-9).

Nevertheless, there are normal nutritive preschool children in Tambon Phang Daeng at 94.20% which are more than such of Amphoe Dong Luang and Mukdahan Province respectively at 80.10% and 86.47%.

The higher parasitic infections of Amphoe Dong Luang is basically due to unsanitary way of fish cooking. The also higher prevalent rates of Pneumonia and Malaria may be due to the weekly forest visit of villagers in Tambon Phang Daeng without prevention. The higher normal nutritive preschool children may be due to available food, mushrooms, and vegetables from the villages nearby forest and streams.

Table 3.4-8 Prevalent Rate of Hookworm and Liver Fluke Infections in Dong Luang District

(Unit: %)

Locality	Faecal-Oral Water-Borne Parasitic Diseases	
	Hookworm	Liver Fluke
Mukdaham Province (1997)	10.97	3.81
• Dong Luang	31.96	13.79
• Kam Cha-I	12.26	2.86
• Wan Yai	8.03	10.94
• Don Yai	4.38	2.18
• Nikhom Kamsoi	0.93	
Thailand's Historical Record		
• 1953, Southern Thailand	51.0	
• 1967, Udon Thani	15.9	
• 1968, Chiang Rai	4.6	
• 1969, Nakhon Ratchasima	20.4	
• 1972, Lampang	8.5	
• 1975, Nakhon Ratchasima	35.4	
• 1976, Khon Kaen	6.3	
• 1977, Nong Khai	3.1	
• 1980, Chum Phom	61.2	
• 1991, whole regions		17.48
• 1991, Northeastern Thailand		24.0
• 1991, Northern Thailand		26.1
• 1991, Central Thailand (some provinces)		12.0

Source: Mukdaham Provincial Health Office (1997)

Table 3.4-9 Prevalent Rate of Pneumonia and Malaria in Tambon Phang Daeng

Epidemic Disease	Prevalent Rate (per 100,000 people)	
	Dong Luang District	Tambon Phang Daeng
1. Diarrhia	1,744	1,012
2. Pneumonia	480	895
3. Eye irritation	261	259
4. Malaria	121	1,931
5. Dysentery	229	118
6. Mumps	29	0
7. Food poisoning	226	141
8. Chicken Pox	70	0
9. Pulmonary Tuberculosis	22	24
10. Influenza	19	0

Source: Mukdaham Provincial Health Office (1997)

3.4.4 Tourism Resources

Huai Lak and Huai Kha Na are both located outside the Huai Huad National Park established since 28 July 1988. There is however a waterfall on the nearby Huai Lao within the National Park. The waterfall can be accessed mostly by hiking, motorcycle and by car; starting from the 27 th kilometer of the provincial highway route no.2287 at Ban Phang Daeng and then travelling by access road of 6 kilometers to Ban Nong Khlong. Afterthere, there will be pedestrian or motorcycle ridership at the other 4 kilometers to the waterfall. Also, an access road is available by car to the waterfall.

Besides, there is another scenic tourism resource; Phu Tham Nok situated north of Ban Phang Daeng.

Huai Lak and Huai Kha Na are not enlisted as tourist potential. However, Huai Kha Na--where there are bolders and rock outcrops at streambanks--still of local recreational potential; even not up to provincial tourist one.

CHAPTER 4

IMPACT ASSESSMENT

4.1 ASSESSMENT BASES

4.1.1 Key Impacts

Even there is only development plan on Huai Lak Reservoir, the following key issues of primary interest on the impact of dam construction will be taken into comparison with Huai Bang Sai Pump & Wier and Huai Lao Pump & Weir as follows:

Social environment :

- Involuntary settlement
- Adjustment & regulation of water rights
- Impact on rural economy

Natural environment :

- Impact on ecosystems (animal, plant, fish, etc.)
- Damage to aesthetic sites
- Breaking of slopes, soil erosion and soil sedimentation
- Impact on downstream and under groundwater.

However, the impact assessment guidelines for dam and reservoir will be applicable only on Huai Lak Reservoir.

4.1.2 Initial Examination

JICA study team has conducted an initial environmental examination of the integrated agriculture development in the ALR areas including construction of ponds, reservoirs, roads and irrigation facilities, change of cropping pattern, and formation of farmer's organizations.

There are concerned items in case of problem with Huai Lak Reservoir, Huai Bang Sai Pump and Weir, and Huai Lao Pump and Weir; as follows:

- Involuntary resettlement : for dam construction.
- Conflict among people : conflict among villagers for irrigation water.
- Impact on negative people : project includes the area of ethnic minorities.
- Increase in income disparities : expenses for seeds, fertilizer, etc. will be a heavy burden for income farmers.
- Increased use of agrochemicals : use of chemical fertilizer will increase.
- Residual toxicity of agrochemicals : use of high toxic agrochemicals may increase a little.
- Damage to aesthetic sites : encroachment of the conservation forest will not be stopped. Some dams are planned in the conservation forest.

- Negative impact on important or indigenous fauna and flora : encroachment of the forest will bring the negative impact if there are important species.
- Degradation of ecosystem with biological diversity : encroachment of the forest will bring the degradation of ecosystems.
- Decrease of tropical rain forests and wild lands : construction of dams in the conservation forest.
- Soil erosion : action for soil conservation will not be done and soil erosion will not be stopped.
- Deterioration of soil fertility : action for soil conservation will not be done and the deterioration of soil fertility will be serious.
- Devastation of hinterland : devastation of forest will be contented to cut trees or the get farmland.
- Change in surface water hydrology : failure of management of reservoir will bring some problems.
- Inundation : construction of dam will decrease the victim of inundation in the lowland.
- Sedimentation : sedimentation in reservoir.
- Riverbed degradation : at the downstream of reservoir.

4.2 KEY IMPACTS COMPARISON

4.2.1 Huai Lak Reservoir

1) Impact on Social Environment

1.1) Involuntary Settlement : There will be 27 families cultivating in the Huai Lak Reservoir area. Most of them up to 25 households are villagers of Ban Nong Mu; representing 37% of the total 67 families of this village who will be affected by the reservoir development or having some negative impact. Even if the desirable land compensation rate is given, the landless farmers will clear another farmland in the conservation forest. Therefore, it is essential to have a negotiation between government and all villagers about the compensation rate and the prevention of further illegal farming by the compensated farmers.

1.2) Adjustment & Regulation of Water Rights : Totally 1,530 rai (816 rai wet season and 714 rai dry season) will be benefited from the project's irrigation development. With average ARL land holding at 12.4 rai/household, the 816 rai ARL wet season irrigable area could benefit to about 66 households; representing 52% of the total 126 households in Ban Nong Mu and Ban Na Lak which are both main irrigating villages. This can be judged as having some positive impact. Totally 100% of the surveyed villagers in both villages intend to participate in the adjustment and regulation of water rights through water user groups. Nevertheless, in problem

case on conflict amongst themselves especially between the two groups in their own two villages; the impact will become some negative one.

1.3) Impact on Rural Economy : In 1995/1996 year of integrated farming practice in 44 provinces including the Northeastern Region when was just 3 years after the plan implementation, about 5.38% incrementation in net agricultural household income has been resulted (perennial orchard had not yet been fruitful in 3 years) and land conversions had been consequent in reduction in upland crop plantation area by 35.79%, improvement in rice plantation by 12.77%, and increase in orchard plantation by 32.42%. The increase in net income in the Northeastern Region was about 2,100 Baht/households as follows:-

Region	Net Agricultural Income		% Change
	Before (Baht/household)	After (Baht/household)	
Northeastern	24,426.01	26,526.77	+ 8.60
Northern	13,203.19	28,792.46	+ 118.07
Southern & Western	32,502.87	25,920.38	- 20.25
Totally Average	25,026.44	26,374.01	+ 5.38

Nevertheless, the topographic nature of Ban Nong Mu and Ban Na Lak on the Phu Phan Range is similar to Northern Region than the general Northeastern Region. The change should be important positive impact ranging from 8.60 to 118.07% (averaging 63%). Nevertheless, if there are some problem on income disparities especially the remaining villagers outside of the irrigation area up to 48% of total village households of Ban Nong Mu and Ban Na Lak.

2) Impact on Natural Environment

2.1) Impact on Ecosystems : There will be a decrease in tropical rain forest mainly mixed deciduous forest up to 741 rai in the inundation reservoir area; having existing forest of 653.5 rai and cultivation area of 87.5 rai. Because they are classified as an additional conservation zone of Phu Phan Reserve Forest, the impact should be judged as serious negative.

Nevertheless, there are mainly reptiles and amphibians totally 38 species and 65 birds inhabiting in the reservoir (which are 87% of the total 119 species) that are mostly adaptive to the changing environment. The negative impact on biodiversity is thus of not serious significance.

2.2) Damage to Aesthetic Sites : This damsite and its reservoir is planned on the 741 rai additional conservation zone. There are no stopping on such encroachment as additionally 181 rai of additional conservation zone is also irrigated. The impact is seriously negative on aesthetic sites.

2.3) Breaking of Slopes, Soil Erosion and Soil Sedimentation : During the land clearing for constructing damsite and reservoir area, the increase in soil erosion could be from present condition of 20.58 ton/rai/year up to 66.38 ton/rai/year due partly to

the change in slope length and slope steepness from L.S. = 1.19 to L.S. = 2.87. The reservoir area thus could have sediment up to 49,188 ton/year in the annual runoff of 4.56 MCM; resulting in suspended solid not less than 10.8 mg/l contributed by the eroded soils which is 25% of the present suspended solid of Huai Lak ranging from 40-44 mg/l (averagely 42 mg/l). If action for soil conservation is not be done, the impact could be assessed as serious negative during construction stage. However, such impact will stop after impoundment during operation stage.

2.4) Impact on Downstream and Under Groundwater : Damsite elevation at 185 mMSL is approximately higher than the downstream Ban Nong Mu (140 mMSL) at 45 m. and the downstream Ban Na Lak (110 mMSL) at 75 m. The groundwater depth is 6 m. for shallow wells and 60 m depth for deep wells. Therefore, there should be change of unknown extent in groundwater hydrology especially shallow wells; but no significantly change for deep wells.

4.2.2 Huai Bang Sai Pump & Weir

1) Impact on Social Environment

1.1) Involuntary Settlement : The weirsite is located on stream, thus no compensation is needed. The pumphouse requires negligible areal extent beside Huai Bang Sai, the impact is considerably none.

1.2) Adjustment & Regulation of Water Rights : There are two downstream villages of Ban Nong Khlong and Ban Phang Daeng. Both villagers are totally 100% willing to participate in their own water user groups. In case of problem on conflict amongst the two groups, the impact should be some extent negative.

1.3) Impact on Rural Economy : Given that the economy of the irrigable villages is improved by 63% income incrementation as assumption for Ban Nong Mu and Ban Na Lak, there will be 121 families (1,500 rai irrigable area) benefits with the remaining 32 households being disparities in income in the two villages of totally 153 families.

2) Impact on Natural Environment

2.1) Impact on Ecosystems : As the weirsite is on stream, no impacts on terrestrial fauna and flora could be expected.

2.2) Damage to Aesthetic Sites : No additional conservation zone is encroached by the weirsite; implying that no damage is to any aesthetic sites.

2.3) Breaking of Slopes, Soil Erosion, and Soil Sedimentation : There is no land clearing to provide any impoundment area because the water is retained on stream. No breaking of slopes leading to soil erosion and soil sedimentation is expected.

2.4) Impact on Downstream and Under Groundwater : Weirsite elevation at 150 mMSL is the same as Ban Nong Khlong (150 mMSL) and lower than Ban Phang Daeng (180 mMSL). Thus, there will be no impact on deep wells (60 m depth) but be unknown impact on shallow wells (6 m depth).

4.2.3 Huai Lao Pump & Weir

1) Impact on Social Environment

1.1) Involuntary Settlement : Because the weirsite is located on stream, there is no compensation. Also, the pumphouse which requires negligible areal extent will be considerably of none impact on involuntary settlement.

1.2) Adjustment & Regulation of Water Rights : There is only one downstream village of water users at Ban Huai Lao. In case of problem on conflict amongst water users, the impact will be confined in only one village.

1.3) Impact on Rural Economy : Assuming there will be 63% income incrementation in Ban Huai Lao by 35 households which include all the villagers in this village. No impact on problematic case of income disparities could be expected.

2) Impact on Natural Environment

2.1) Impact on Ecosystem : Because the weirsite is on stream, no impact on terrestrial fauna and flora could be anticipated.

2.2) Damage to Aesthetic Sites : Also, because the weirsite is not extended to cover any additional conservation zone, there will be no damage to the aesthetic sites.

2.3) Breaking Slopes, Soil Erosion, and Soil Sedimentation : There is no land clearing to encourage any inundation area due that the water is stored on stream. None of breaking of slopes inducing soil erosion and soil sedimentation is anticipated.

2.4) Impact on Downstream and Under Groundwater : The elevations of Huai Lao Weir and Ban Huai Lao downstream irrigation are the same at 160 mMSL. Therefore, there will be no impact on deep wells (60 m depth) but be unknown impact on shallow wells (6 m depth).

4.3 HUALAK RESERVOIR IMPACTS

4.3.1 Physical Resources Impacts

1) Surfacewater Hydrology : The catchment runoff of Huai Lak Reservoir at 4.56 MCM will be totally stored by the reservoir. The regulation of the river maintenance flow has not been yet established in Thailand. However, based on an engineering estimation (Southern Seaboard Project, 1996), the river maintenance flow for small stream and river, wider stream are approximately 20% and 10% of runoff respectively. Therefore, about 20% of the runoff or 0.03 cum/s will be discharged to retain downstream hydrological regime. Water loss will be calculated in the detailed design.

2) Surfacewater Quality : There are 70-100% of surveyed villagers perceived pesticides as expensive and 20-30% of them could not purchase from their own villages of Ban Nong Mu and Ban Nong Khlong. Pesticides are all nil in all sampling stations of Huai Lak. It is thus anticipated that none of the pesticide residues should be increased.

Nevertheless, there will be an increase in the suspended solids due to land clearing during construction by 25% or 10.8 mg/l as compared with the present concentrations averaged at 42 mg/l. No such suspended solids incrementation perpetuates when the reservoir starts to inundate.

3) **Groundwater** : The difference in elevations at 45 m between the reservoir and Ban Nong Mu and at 75 m between the reservoir and Ban Na Lak could result in hydraulic gradient in groundwater level especially the shallow wells of 6 m depth. However, the change in groundwater levels at 60 m depth deep wells could not be expected due that the influence area by about 5 m depth reservoir storage is incomparable.

4) **Soils** : Land clearing could result in soil loss of up to 49,188 ton/year; in which there are 935 ton of organic matter loss basing on 1.4-2.4% or averaging 1.9% organic matter in soil sample testing.

5) **Geology and Siesmicity** : constructing a small reservoir damsite with 5.32 MCM storage capacity could not induce any siesmicity. The Mukdahan area is classified as minor risk to earthquake without any previous statistics on siesmic occurrence.

6) **Sedimentation and Erosion** : There will be change in slope length and steepness from presently L.S. = 1.19 to L.S. = 2.87 due to land clearing to construct a reservoir; resulting increased in soil erosion from the existing 20.58 ton/rai/year to 66.38 ton/rai/year.

7) **Climate** : No significant local microclimate change is expected for such a consideraby small storage of 5.32 MCM within the 1.19 sq.km. surface area.

4.3.2 **Ecological Resource Impacts**

1) **Fishery Resources** : Huai Lak Stream is not a breeding ground of fish in the study area and they are mainly not migatory fish. The construction of dam will not affect the biodiversity of fishery resources. The loss of benthos at 33-37 individual/sq.m. of the stream width at 5 m and stream length (to-be-inundated) at 3.5 km will be about 0.58-0.65 million individuals. However, when the reservoir impoundment at 5 depth inhabitable by benthos up to 1.19 sq.km., the benthos could recovery themselves up to 39.27-44.03 million individuals.

The fishery benefit from reservoir could be about 15 kg/rai/year or 11.16 ton/year. With 30 Baht/kg fish value, the annual benefit could be up to 0.3 million Baht.

2) **Aquatic Ecology** : Change from running water to standing water of Huai Lak should not affect any existing phytoplankton, zooplankton and benthos biodiversity. This is because all the species found are adaptable in the standing water habitats.

3) **Wildlife** : All reptiles and amphibians up to 38 species found in the inundation area are well adaptive to standing water habitat. Birds, accounting at 65 species, will be migrated out during construction and be back for feeding after impoundment. The

remaining mammals of 16 species could be also emigrated if the tree cutting begin from the streambed towards higher elevations.

4) **Forests** : Mixed deciduous forest in the impoundment area is presently encroached by cultivation area. The loss of inundated forest biodiversity will not be significant because they could be found at the nearby Phu Phan Reserve Forest and Huai Huad National Park.

5) **Reservoir Ecology** : As the fish productivity is not so high at 11.16 ton/year, they should mainly be consumed by households. No fishing villages beside the reservoir will be settled as the area is in the RFD additional conservation zone.

4.3.3 **Human Use Values Impacts**

1) **Water Supply** : In the first years of reservoir storage, because the live storage capacity at 5.32 MCM is excessive of the catchment runoff at 4.56 MCM, there might be some downstream water shortage. This water supply problem should be temporary and ended up at about the beginning of the 3th year of impoundment. Allocation of water from Huai Lak Reservoir through distributive irrigation system is mainly for 816 rai of wet season rice and 714 rai of dry season soybean and other upland crops cultivation.

2) **Aquaculture** : Fish ponds may not be encouraged in the irrigated area of Huai Lak Reservoir; due to limited available land. Instead, fish fingerlings of the native species such as Pla Tapien (*Puntius gonionotus*) or typical species including Pla Nil (*Tilapia nilotica*) could be released into the reservoir resulting in fish productivity up to 15 kg/rai/year from the existing stream production at 10 kg/rai/year.

3) **Transportation** : There should be an enlargement of the bridge crossing Khlong Huai Sai and an asphaltic pavement of the main road towards the reservoir; for hauling construction heavy equipment. Afterwards, they will become the public infrastructure of Ban Nong Mu and vicinity villages during post-construction. As Huai Lak is not navigable, there is no impact on navigation especially fishing boats due to constructing dam as barrier.

4) **Flood Control** : As the damsite elevation at 185 mMSL is higher than Ban Nong Mu and Ban Na Lak respectively at 45 m and 75 m, therefore, it will help remedy natural flooding on the two villages in flood years.

5) **Mineral Development** : None of economic deposits of valuable mineral resources is in the proposed reservoir area.

6) **Land Use** : Within the 741 rai of Huai Lak Reservoir, there are agricultural land of about 87.5 rai to be inundated. The other remaining 653.5 rai are forest land.

4.3.4 **Quality of Life Values**

1) **Socio-economics** : All (100%) of the 6 surveyed villages, except for nearly all (90%) in another one village of Ban Phang Daeng, accept the reservoir development. Increased income earning due to integrated farming could be from upland cropping

and rice growing within the first 5 years; afterwards more income improvement should be additionally from orchard plantation.

2) Compensation and Resettlement : No permanent settlers as housing are present in the reservoir area; revealing no need for resettlement. Nevertheless, compensation to the villagers currently cultivating therein should be needed. There are about 79.3 rai illegally owned and 8.2 rai legally owned cultivation areas in Huai Lak Reservoir. The desirable compensation rate of the interviewed villagers during the socio-economic survey is between 10,000-30,000 Baht/rai. However, the government should further negotiate with compensated villagers who also desire to have the negotiation.

3) Public Health : Spread of the existingly high prevalence of parasitic infection comprising 31.96% hookworm and 13.79% liver fluke in Amphoe Dong Luang could be prevented by sanitary cooking especially fish. Because there are no human settlement upstream of Huai Lak Reservoir, then the reservoir fish parasites should be to certain extent free from human hosts.

4) Recreation and Aesthetics : The reservoir could become a local amenity area to the villagers especially Ban Nong Mu; but not so significance to being developed as a tourism resource.

5) Archaeology and Historical Treasures : No profound evidence on archeological artefacts or historical treasures exists in the proposed reservoir area.

CHAPTER 5

MITIGATION AND MONITORING

5.1 GENERAL RECOMMENDATIONS

5.1.1 Initial Examination

JICA study team has formulated mitigation for hypothetical problems. Concerned items with Huai Lak Reservoir, Huai Bang Sai Pump and Weir, and Huai Lao Pump and Weir include:

- Involuntary resettlement : good communication of ALRO and people is required in advance and appropriate compensation estimate is necessary.
- Conflict among people : encouragement activities of RFD in villages is required.
- Adjustment of water or fishing rights : continuous supervision of MOAC is required.
- Degradation of ecosystems with biodiversity : encouragement activities of MOAC in villages is required.
- Decrease of tropical rain forests and wild lands: special care during the construction, plantation and its management is required around the damsite.
- Soil erosion : encouragement activities of MOAC in villages is required.
- Sedimentation : conservation of natural forest in the upperstream is required.

5.1.2 Impact Assessment

This EIA survey has further specified the mitigation recommended in the IEE as follows:-

- 1) Compensation and resettlement action plan should be based on desirable compensation rate by the affected villages at considerably sound and implementable.
- 2) Rural infrastructure development accordingly to the request by village council should help reduce conflict among people.
- 3) Reservoir deforestation to prevent eutrophication and catchment reforestation to reduce erosion should be implemented to reimburse the degradation and depletion of tropical rain forest ecosystems.
- 4) Adjustment of water rights and water allocation should be self-management by village's water user groups under supervision by MOAC.
- 5) Design modification such as sluicing gate for sediment discharge or fish ladder/fish path should be considered at appropriate conditional sites.

5.2 SPECIFIC RECOMMENDATIONS

5.2.1 Huai Lak Reservoir

5.2.1.1 Compensation and Resettlement Action Plan

1) Rationale

There are 27 families residing cultivating in the proposed impoundment area of 741 rai Huai Lak Reservoir. There are 87.5 rai cultivating area during topographic survey comprising 79.3 rai illegally and 8.2 rai legally owned lands. Based on questionnaire survey, the villagers mainly accept a land compensation rate of 10,000-30,000 Baht/rai which is 3 folds of the official land value. Even if the desirable land compensation rate is given, the landless farmers will clear another farmland in the conservation forest. Therefore, it is essential to have a negotiation between government and all villagers about the compensation rate and the prevention of further illegal farming by the compensated farmers.

Since there are no houses existence within the reservoir area, no resettlement plan is needed. The cropping pattern is rice and corn; thus, no property compensation is also required.

2) Objective

To prevent obstacle to Huai Lak Reservoir development caused by unacceptable land compensation rate.

3) Responsible Agency

ALR Mukdahan Office

4) Action Area

741 rai impoundment area of Huai Lak Reservoir at Ban Nong Mu

5) Procedure

5.1) ALR Mukdahan Office and Ban Nong Mu Village Council arrange a meeting with the 27 families for land compensation rate agreement between 10,000-30,000 Baht/rai.

5.2) Compensation payment schedule should be one time and once before land clearing for dam construction.

5.3) List of the names of the 27 families cultivating in the proposed reservoirs (in Thai) is shown in Table 5.2-1 for facilitating the ALR Mukdahan officers.

Table 6.2-1 List of Villagers Cultivating in Huai Lak Reservoir

No	Name (in Thai)	Village	Having Other Cultivation Area	
			Yes	No
1	นายเสริม เชื้อคำสด	B. Nong Mu		/
2	นายเพ็ญ เชื้อคำสด	B. Nong Mu		/
3	นายทอง เชื้อคำสด	B. Nong Mu		/
4	นายรัก เชื้อคำสด	B. Nong Mu	/	
5	นายลิ้น เชื้อคำสด	B. Nong Mu		/
6	นายขวาง เชื้อคำสด	B. Nong Mu	/	
7	นายหน้า เชื้อคำสด	B. Nong Mu	/	
8	นายเสวย เชื้อคำสด	B. Nong Mu		/
9	นายเพ็ญ เชื้อคำสด	B. Nong Mu	/	
10	นายลม เชื้อคำสด	B. Nong Mu		/
11	นายเสริม เชื้อคำสด	B. Nong Mu	/	
12	นายคร เชื้อคำสด	B. Nong Mu	/	
13	นายเต็ม เชื้อคำสด	B. Nong Mu	/	
14	นายอิม เชื้อคำสด	B. Nong Mu	/	
15	นายทาง เชื้อคำสด	B. Nong Mu	/	
16	นายเนือง เชื้อคำสด	B. Nong Mu		/
17	นายวี เชื้อคำสด	B. Nong Mu		/
18	นายไทย เชื้อคำสด	B. Nong Mu		/
19	นายเศษ เชื้อคำสด	B. Nong Mu	/	
20	นายชาย เชื้อคำสด	B. Nong Mu		/
21	นายคีน เชื้อคำสด	B. Nong Mu	/	
22	นางเลื่อง เชื้อคำสด	B. Nong Mu	/	
23	นางเพ็ญ เชื้อคำสด	B. Nong Mu		/
24	นางเทียน เชื้อคำสด	B. Nong Mu		/
25	นายเป็ญ เชื้อคำสด	B. Nong Mu		/
26	Unknown	B. Na Lak	-	-
27	Unknown	B. Na Lak	-	-

6) Budget

Even if the desirable compensation rate of some villagers is between 10,000-30,000 Baht/rai, the government should further have a negotiation with compensated villagers about the compensation rate.

7) Timing

1 year before land clearing for dam construction.

8) Evaluation

Annual reporting by ALR Mukdahan Office.

5.2.1.2 Rural Infrastructure Development Plan

1) Rationale

The bridge crossing Huai Bang Sai towards Ban Nong Mu is presently available only for pedestrian-and-motorcycle passage. The latteritic main road towards Huai Lak Reservoir is ended at Ban Nong Mu and there is a temporary cart track to the reservoir area. The village council of Ban Nong Mu asks for enlargement of the bridge up to car passage and asphaltic pavement of the village's main latteritic road and improvement of the reservoir's cart track available for construction heavy equipment transport.

2) Objective

To improve rural infrastructure of Ban Nong Mu for facilitating both construction of Huai Lak Reservoir and post-construction use by villagers

3) Responsible Agency

ALRO

4) Action Area

Bridge crossing Huai Bang Sai and the main latteritic road to Ban Nong Mu and also the temporary cart track towards Huai Lak Reservoir.

5) Procedure

JICA Study-Team takes into account on the infrastructure planning in this project.

6) Budget

Included in the project's feasibility study.

7) Timing

Included in the project's development schedule.

8) Evaluation

Accounted in the project's benefit economic study.

5.2.1.3 Reservoir Deforestation and Catchment Reforestation Programs

1) Rationale

Mixed deciduous forest in the impoundment area of Huai Lak Reservoir and the undergrowth seedlings and saplings must be totally cleared before inundation as to prevent accumulation of biomass nitrogen and subsequently excessive nitrogen fixation and finally eutrophication or reservoir water pollution.

As a general request by OEPP, at least 1 or 2 folds of catchment forest area should be provided by project proponent through budgeting responsible agency for reforestation. Considering large users for family uses of the 7 surveyed villages, the reforest species should include such for firewood, vegetable and mushroom. Also, there will be a 100 rai-per-village community forest established at 4 villages including Ban Phon Swang, Ban Tiu, Ban Na Lak, and Ban Phang Daeng. The community forest species should be provided for firewood, vegetable and mushroom collection.

2) Objective

To prevent reservoir's water pollution caused by eutrophication as well as to reimburse the reservoir's forest loss by the same aerial amount of reforest extent for villagers use as firewood, vegetable and mushroom sources.

3) Responsible Agency

DF Mukdahan Office

4) Action Area

653 rai deforestation (741 rai - illegal farmland 88 rai) in Huai Lak Reservoir and another 741 rai reforestation in catchment area of the reservoir within Phu Phan Reserve Forest.

5) Procedure

5.1) DF Mukdahan Office Proposes reforestation area to ALRO for approval of the budget and then reforestation in degraded forest by DF Mukdahan Office. Priority areas of reforestation include :

- Reservoir Catchment Forest
- District Forest
- Province Forest.

5.2) DF Mukdahan Office conduct approval deforestation survey and then deforestation by Forest Industry Organization under budget of ALRO.

6) Budget

1,000 Baht/rai for reforestation (totally 0.741 million Baht) and 1,500 Baht/rai for deforestation (totally 0.980 million Baht). The grand total budget to be prepared by ALRO is 1.721 million Baht.

7) Timing

Within 5 years after impoundment for catchment reforestation and about 1 year prior to inundation for reservoir deforestation.

8) Evaluation

DF Mukdahan Office Annual Reporting.

5.2.1.4 Water Rights and Water Allocation Plan

1) Rationale

The evaluation of integrated farming implementation by Agricultural Economic Office, MOAC in 1995/1996 year of agricultural recovery plan in 9,480 villages of 44 provinces including. The Northeastern Region reveals that; (a) return of livestock is of efficiency at net income of 2,348 Baht/household/year, (b) return of pond fishery is not efficient due to net income of 580 Baht/household/year, and (c) return of integrated cultivation rice-upland crop-fruit tree (for the first 3 years tree) is also efficient at 5,003 Baht/household/year. Orchard will be more effective after the 5th to 10th year depending on types of fruit tree. Villages in Tambon Phong Daeng intend to grow sweet tamarind and pamele if water resources are available.

2) Objective

To efficiently allocate water for effective integrated farming implementation under water rights.

3) Responsible Agency

ALR Mukdahan Office

4) Action Area

1,530 rai irrigation area of Huai Lak Reservoir

5) Procedure

5.1) ALR Mukdahan Office follow the JICA agricultural development plan in this study.

5.2) ALR Mukdahan Office in coordination with Ban Nong Mu village council establish a Water User Group with functions to control water rights at scheduled timing and to manage the payment fees.

6) **Budget**

Included in the agricultural development plan.

7) **Timing**

Accordingly to the agricultural development plan.

8) **Evaluation**

May be on an every-3-years basis.

5.2.2 Huai Bang Sai Pump and Weir

5.2.2.1 Fish Ladder/Fish Path Design Alternative

1) **Rationale**

Huai Lao, Huai Lak or Huai Kha Na are not accounted by local villagers as their main fishing ground. Instead, Huai Bang Sai is the major one. The stream is considerably upstream from the Mackong River confluence with inland river. Also, the survey does not find any migratory fish. However, there is a laws of DOF to have fish path for weir or dam construction. Such fish path should be considered as an alternative design prepared if required.

2) **Objective**

To follow legal requirement on fish ladder/fish path if any migatory fish species exist.

3) **Responsible Agency**

ALRO

4) **Action Area**

Weirsite of Huai Bang Sai.

5) **Procedure**

JICA design engineer taken into consideration on the fish ladder based on the following fishery criteria:

- (1) flow rate < 1-3 m/s
- (2) slope > 1:10
- (3) fish migration period : wet season.

6) **Budget**

Included in the project's feasibility study.

7) **Timing**

Included in the project's development schedule

8) **Evaluation**

Annual observations during wet seasons.

5.2.2.2 **Sluicing Gate Sediment Discharge Design**

1) **Rationale**

Huai Bang Sai have seral tributaries including Huai Lak, Huai Lao and Huai Kha Na having catchment erosion rates presently at 8-20 ton/rai/year. Soil surface disturbance during cultivation could result in incremental soil erosion up to 66-160 ton/rai/year. With 352,500 rai catchment area of Huai Bang Sai, the present erosion could be up to 2.82-7.05 million ton/year and furthermore if disturbed soil surface. Thus, sluicing gate for sediment discharge is needed.

2) **Objective**

To present weirfront sedimentation due to catchment soil erosion.

3) **Responsible Agency**

ALRO

4) **Action Area**

Weirsite of Huai Bang Sai.

5) **Procedure**

JICA design engineer taken into consideration on the sluicing gate sediment discharge design. The officers of ALR Mukdahan Office must periodically operate the gate as scheduled by this feasibility study.

6) **Budget**

Included in the project's feasibility study.

7) **Timing**

Included in the project's development schedule.

8) **Evaluation**

Annual Observations during gate operations.

I. INVENTORIES

APPENDIX I. INVENTORIES

Contents

1. Inventory of LRAs in the Study Area.....	I-1
1.1 Introduction of Inventory.....	I-1
1.2 Inventory based on the Kor Chor Chor 2 Khor 2537.....	I-1
1.3 Inventory of Natural, Social and Rural Condition.....	I-3
1.4 Explanation of the Inventories.....	I-5
2. Inventory of the Villages in the LRAs.....	I-15
2.1 Village List by the LRAs.....	I-15
2.2 Village List by Provinces.....	I-15
3. Inventory of the Kor Chor Chor 2 Khor 2537.....	I-30
3.1 Inventory of the Summary Item of the Kor Chor Chor 2 Khor 2537.....	I-30
3.2 Survey Sheet of the Kor Chor Chor 2 Khor 2537.....	I-43

Tables

Table 1-1	Inventory List of LRAs in the Study Area.....	I-4
Table 2.1-1	Village List by the LRAs.....	I-16
Table 2.2-1	Village List of the LRAs in Khon Kaen Province.....	I-22
Table 2.2-2	Village List of the LRAs in Mahasarakham Province.....	I-24
Table 2.2-3	Village List of the LRAs in Mukdahan Province.....	I-26
Table 2.2-4	Village List of the LRAs in Sakhon Nakhon Province.....	I-28
Table 3.1-1	Contents of the Kor Chor Chor Summary Data.....	I-30
Table 3.1-2	Averaged Summary Data of Kor Chor Chor 2 Khor 2537.....	I-32
Table 3.1-3	Summary of Kor Chor Chor 2 Khor 2537.....	I-33
Table 3.2-1	Survey Sheet of Kor Chor Chor 2 Khor and Item to the Village Inventory.....	I-43

Figures

Figure 1-1	Electrification (Kor Chor Chor 2 Khor 2537).....	I-5
Figure 1-2	Transportation (Kor Chor Chor 2 Khor 2537).....	I-5
Figure 1-3	Wood and Fuel Sources (Kor Chor Chor 2 Khor 2537).....	I-6
Figure 1-4	Income Levels (Kor Chor Chor 2 Khor).....	I-6
Figure 1-5	Paddy Yield (Kor Chor Chor 2 Khor 2537).....	I-7
Figure 1-6	Upland Crop Yield (Kor Chor Chor 2 Khor 2537).....	I-7
Figure 1-7	Dry Season Farming (Kor Chor Chor 2 Khor 2537).....	I-8
Figure 1-8	Potable Water (Kor Chor Chor 2 Khor 2537).....	I-8
Figure 1-10	Development Level (Kor Chor Chor 2 Khor 2537).....	I-10
Figure 1-11	Mean Annual Rainfall of Each LRA in the Study Areas.....	I-10
Figure 1-12	Elevation of Each LRA in the Study Area.....	I-11
Figure 1-13	Degree of Slope of Each LRA in the Study Area.....	I-11
Figure 1-14	Distribution of slopes in Each LRA in the Study Areas.....	I-12

Figure 1-15	Catchment Area and Its Ratio to Each LRA in the Study Areas	I-12
Figure 1-16	Maximum Elevation of Catchment Area of Each LRA in the Study Areas.....	I-13
Figure 1-17	Irrigation Area and Irrigation Ratio in Each LRA in the Study Areas.....	I-13
Figure 1-18	Improvement of Rural Roads and Densities in Each LRA in the Study Area.....	I-14

Chapter 1 Inventory of LRAs in the Study Area

1.1 Introduction of Inventory

An inventory has been prepared for grasping the present condition of LRAs in the study area. The inventory covers the evaluation result of the Kor Chor Chor 2 Khor 2537 (Information System for Village Development 1994) and the data which are newly obtained in each LRA by this study such as meteorology, topography, acreage, population, households, rural infrastructures, etc.. Table 1-1 shows the results of inventory of each study LRA.

1.2 Inventory based on the Kor Chor Chor 2 Khor 2537

1) Evaluation Criteria of the Kor Chor Chor 2 Khor

The Kor Chor Chor 2 Khor has been carried out for each village through the country once every two years by the National Rural Development Committee since 1982. It is evaluated from 37 items by certain evaluation criteria. There are three (3) levels of score for evaluation, and one of three scores is given to each item after evaluation. Score 3 is given to higher evaluation, and Score 1 to lower evaluation. Score 2 is given to moderate level of evaluation. After taking all the scores of 37 items into consideration, the level of development of each village is evaluated based on the number of the items which are evaluated as Score 1. The greater the number of Score-1s there are, the lower the level of development. Development priority is given to villages with a low level of development. 9 selected key items out of 37 and the level of development have been compiled in the inventory. The criteria for evaluation are summarized as follows:

a. Infrastructure condition

a-1 Electrification

Score	Description
3	Over 50 % of total households have electricity.
2	Less than 50 % of total households have electricity.
1	No electricity available.

a-2 Transportation

Score	Description
3	(a) 4 wheel trucks have access during wet season within 10 minutes to Amphoe, or (b) Over 60 % of total households have a motorcycle, or (c) Less than 15 minutes to Amphoe by boat or train, or less than 25 minutes by other ways.
2	(a) 4 wheel trucks have access not so often during wet season, within 15 minutes to Amphoe, or (b) 40 - 60 % of total households have a motorcycle, or (c) 15-30 minutes to Amphoe by boat or train or 25-40 minutes by other ways.
1	(a) No access in wet season, or (b) Less than 40 % of total households have a motorcycle, or (c) Over 30 minutes to Amphoe by boat or train or over 40 minutes by other ways.

a-3 Wood and Fuel Sources

Score	Description
3	Most people use charcoal or firewood . Wood source not over 5 km and not from the reserved forest.
2	Most people use charcoal or firewood . Wood source 6-10 km and not from the reserved forest.
1	Most people use charcoal or firewood . Wood source over 10 km and from the reserved forest.

b. Income, production and employment

b-1 Income Level

Score	Description
3	The percentage of households with annual income of more than 30,000 baht is over 70%.
2	The percentage of households with annual income of more than 30,000 baht is 50% to 70%.
1	The percentage of households with annual income of more than 30,000 baht is less than 50%.

b-2 Paddy Yield

Score	Description
3	Most households produce paddy over 371 kg/rai.
2	Most households produce paddy 271 - 370 kg/rai.
1	Most households produce paddy less than 270 kg/rai.

b-3 Upland Crop Yield

Score	Description
3	Yield of the first ranking crops grown by majority of households are as by the following criteria: Maize: > 450 kg/rai Soybean: > 250 kg/rai Mung bean: > 120 kg/rai Groundnut: > 250 kg/rai Millet: > 240 kg/rai Sesame: > 120 kg/rai Sugarcane: > 9,000 kg/rai Cassava: > 2,400 kg/rai Cotton: > 200 kg/rai Kenaf: > 220 kg/rai
2	Maize: 350 - 450 kg/rai Soybean: 200 - 250 kg/rai Mung bean: 100 - 120 kg/rai Groundnut: 200 - 250 kg/rai Millet: 200 - 240 kg/rai Sesame: 100 - 120 kg/rai Sugarcane: 7,000 - 9,000 kg/rai Cassava: 2,100 - 2,400 kg/rai Cotton: 160 - 200 kg/rai Kenaf: 180 - 220 kg/rai
1	Maize: < 350 kg/rai Soybean: < 200 kg/rai Mung bean: < 100 kg/rai Groundnut: < 200 kg/rai Millet: < 200 kg/rai Sesame: < 100 kg/rai Sugarcane: < 7,000 kg/rai Cassava: < 2,100 kg/rai Cotton: < 160 kg/rai Kenaf: < 180 kg/rai

b-4 Dry Season Farming

Score	Description
3	Over 50 % of households are cultivating the following crops: paddy - paddy, or paddy - short term field crops in dry season
2	20 - 50 % of households are cultivating above crops:
1	Less than 20 % of households are cultivating above crops:

c. Water resource

c-1 Potable Water

Score	Description
3	Over 95% of total households in the village have adequate potable water through the year.
2	63 - 94% of total households in the village have adequate potable water through the year.
1	Less than 63% of total households in the village have adequate potable water through the year.

c-2 Water for Agriculture

Score	Description
3	Farmers practice dry season farming and use surface water or ground water or have adequate water for second cropping.
2	Farmers practice dry season farming and use the water remaining in the form of rain or do not practice/use water or no problem of water for short/long life field crops, vegetables or flowering/ornamental orchards or fruit orchards.
1	There is a problem with inadequate water for second cropping, short/long life field crops, vegetable plantation or flowering/ornamental and fruit orchards.

d. Level of Development

d-1 Level of Development

Score	Description
3	Out of 37 items, 0 to 5 have a score of 1.
2	Out of 37 items, 6 to 10 have a score of 1.
1	Out of 37 items, 11 to 37 have a score of 1.

2) Inventory of the Kor Chor Chor 2 Khor 2537

Given scores of 9 items have been revised by subtracting 2 from the score to vary in a

range between -1 and +1 for better illustration for understanding. After revision of the score, each village has been sorted and arranged into the relevant LRA. Average values have been calculated for each item in 35 LRAs.

On the other hand, score of the development level was not revised, and utilized as the same score of the original evaluation.

Above results are described in Table 1-1 as the inventory. The results of Kor Chor Chor inventory are illustrated in Figure 1-1 to Figure 1-11.

1.3 Inventories of Natural, Social and Rural Conditions

Other than the Kor Chor Chor 2 Khor, newly obtained data for each LRA have been also compiled in the inventories of natural, social and rural conditions. They are also compiled in Table 1-1 in the form of an inventory. These results are also illustrated in Figure 1-12 to Figure 1-18.

1.4 Explanation of the Inventories

Figure 1-1 shows the present condition of electrification in each LRA. The figure shows that all LRAs are above the standard from the viewpoint of electrification. More than 50% of households are served with electricity in 24 LRAs. In the remaining 11 LRAs, electricity is available for around 50 % of households. However, all villages have been already electrified by the recent activities of electrification in the study LRAs.

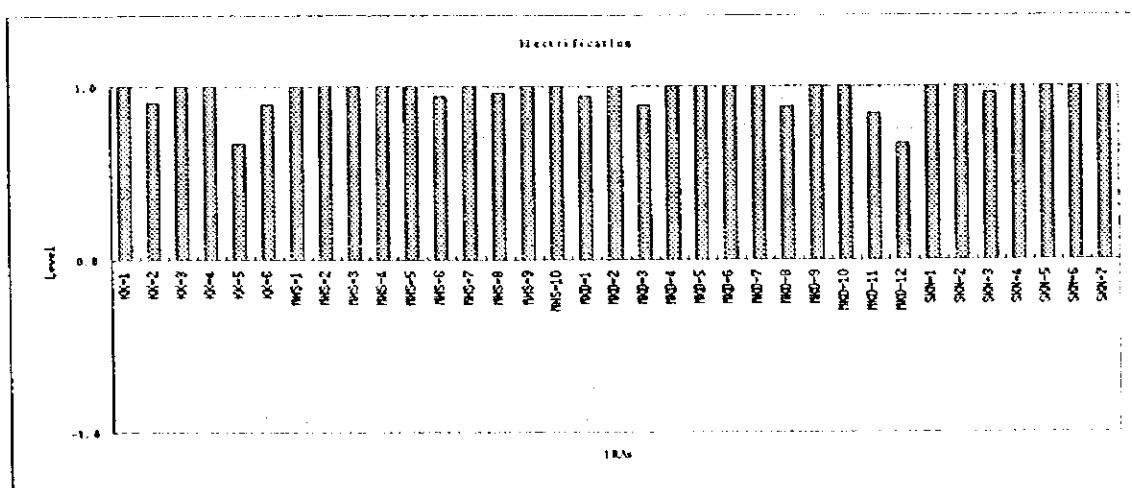


Figure 1-1 Electrification (Kor Chor Chor 2 Khor 2537)

Figure 1-2 shows the accessibility to the nearest Amphoe town from each LRA. In 3 LRAs, they are accessible within 10 minutes by a four wheel truck, or over 60% of all households have a motorcycle. In other LRAs, they are accessible within 15 minutes by a truck, or 40 to 60% of all households have a motorcycle . In some villages in 2 LRAs (Mukudahan No.2 and No.12), four wheel trucks are not accessible in wet season, or less than 40% of all households have a motorcycle.

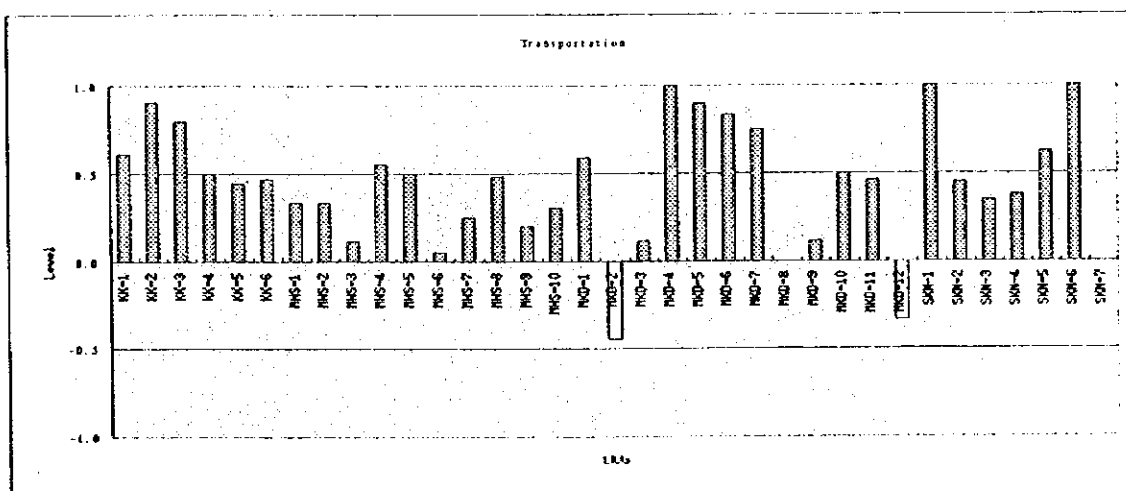


Figure 1-2 Transportation (Kor Chor Chor 2 Khor 2537)

Figure 1-3 shows the source of wood fuel. High scores are given to Maha Sarakham, and low scores to Sakon Nakhon and Mukudahan. Khon Kaen gets medium scores. This means that a high score is given to the provinces where wood source is far from the village

and a low score to the opposites. From this fact, following conclusions can be drawn:

- In areas, where wood sources are distant and difficult to get, illegal firewood collection rarely occurs, and a good score is given from an environmental viewpoint.
- While in areas, where conservation forests are nearby, illegal collection of firewood is easy so a low score is given.
- More attention is necessary to the latter areas for preserving the conservation forests from an environmental viewpoint.
- However, on the other hand, fuel source development should be encouraged for the former areas by such means as agro-forestry.

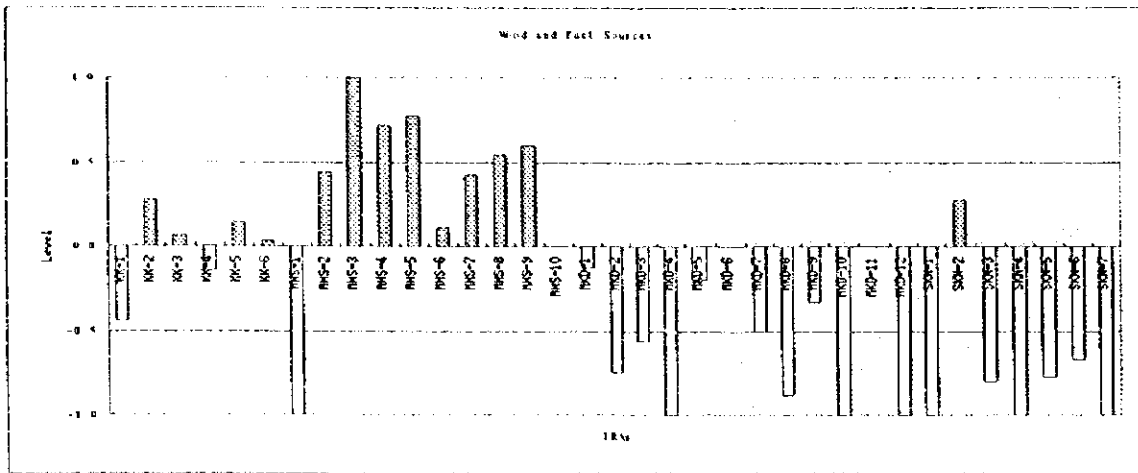


Figure 1-3 Wood and Fuel Sources (Kor Chor Chor 2 Khor 2537)

Figure 1-4 shows the income level in each LRA. In 13 LRAs out of 35, the annual income level is 30,000 Baht per household for over 70% of all households. In most LRAs other than 13 LRAs, 50 to 70% of households earn 30,000 Baht per annum. However, in two LRAs as SKN 2 and SKN 7, income of 30,000 Baht is earned by less than 50% of households.

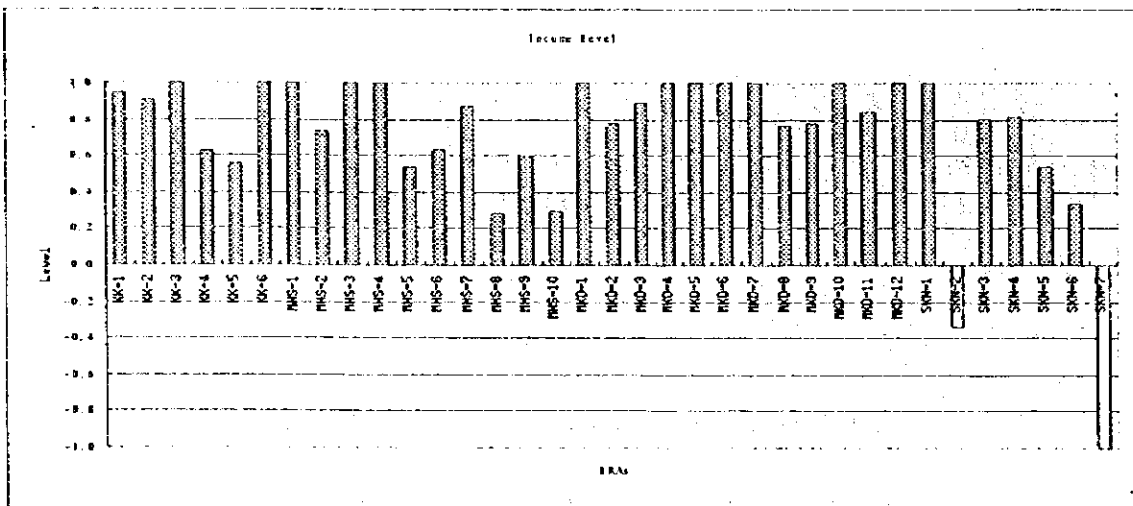


Figure 1-4 Income Levels (Kor Chor Chor 2 Khor)

Figure 1-5 shows level of paddy rice yield in each LRA. The level is quite low in most LRAs. Only some villages in 6 LRAs realize a yield of more than 371 kg/rai. In many villages, yields are less than 270 kg/rai.

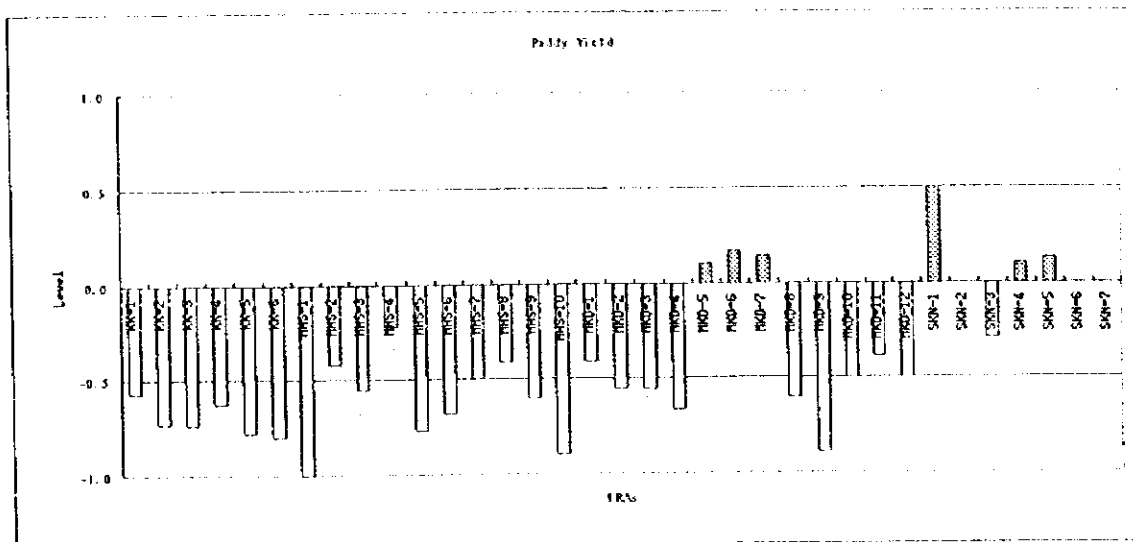


Figure 1-5 Paddy Yield (Kor Chor Chor 2 Khor 2537)

Figure 1-6 shows the yield of first ranking upland crops in each LRA. Cassava and sugarcane are the prevailing upland crop in the study areas. Only two LRAs; Maha Sarakham No.5 and Mukudahan No.4, realize a high yield in upland crop cultivation. Yields are low in most LRAs.

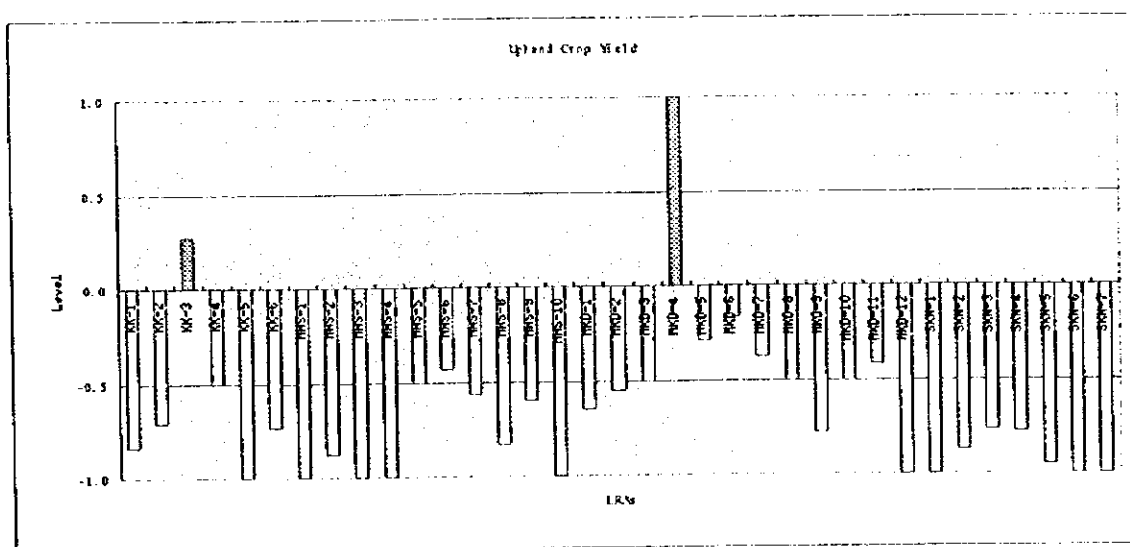


Figure 1-6 Upland Crop Yield (Kor Chor Chor 2 Khor 2537)

Figure 1-7 shows achievements of dry season farming. Only one LRA; Khon Kaen No.5, achieves dry season farming by over 50% of households, but only by less than 20% to 50% of households in other LRAs. Villages in the Khon Kaen No.5 LRA are partly covered at the southern edge by the Nong Wai Irrigation Project, which is one of the large-scale irrigation projects in the Upper Northeastern Region. In this irrigation project area,

some irrigation water is available even in the dry season, and some upland crops are cultivated in the dry season. In other areas, a limited number of farm ponds and small-scale irrigation projects are only the major water source, but these sources are not capable of retaining a sufficient amount of water for dry season farming, only for home consumption or some local marketing. It thus appears that the capacity for dry season farming is limited in most LRAs in the study areas.

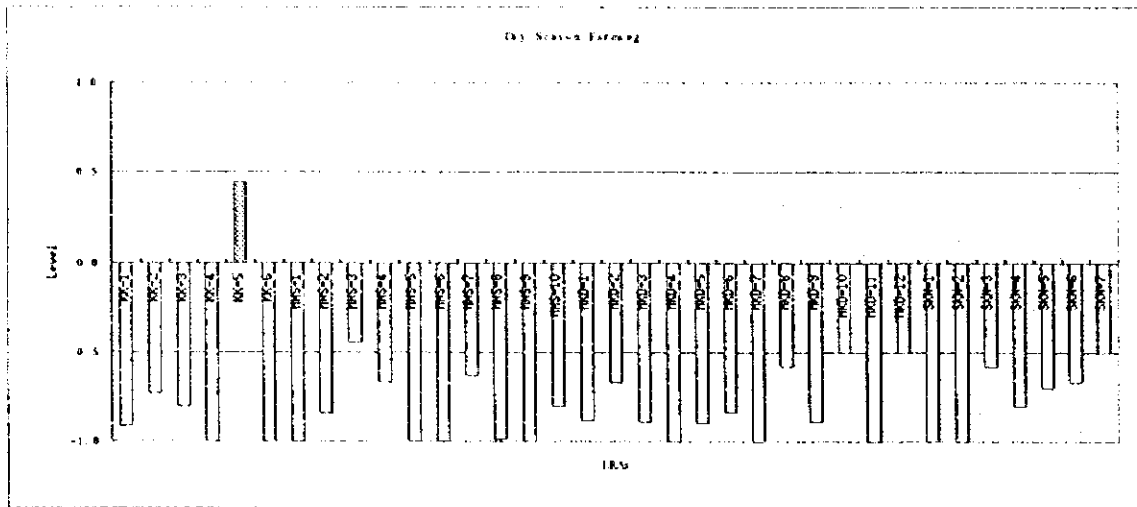


Figure 1-7 Dry Season Farming (Kor Chor Chor 2 Khor 2537)

Figure 1-8 shows the availability of potable water in LRAs in the study areas. There is no LRA where potable water is sufficiently available through the year. In about half the LRAs, potable water is available only for less than 63% of households. This means that securing potable water is one of the most urgent, priority projects in the study areas. From the viewpoint of this aspect, village water supply works have been implemented rapidly in the areas so that the supply ratio has reached 79% in average by the data from the agencies concerned.

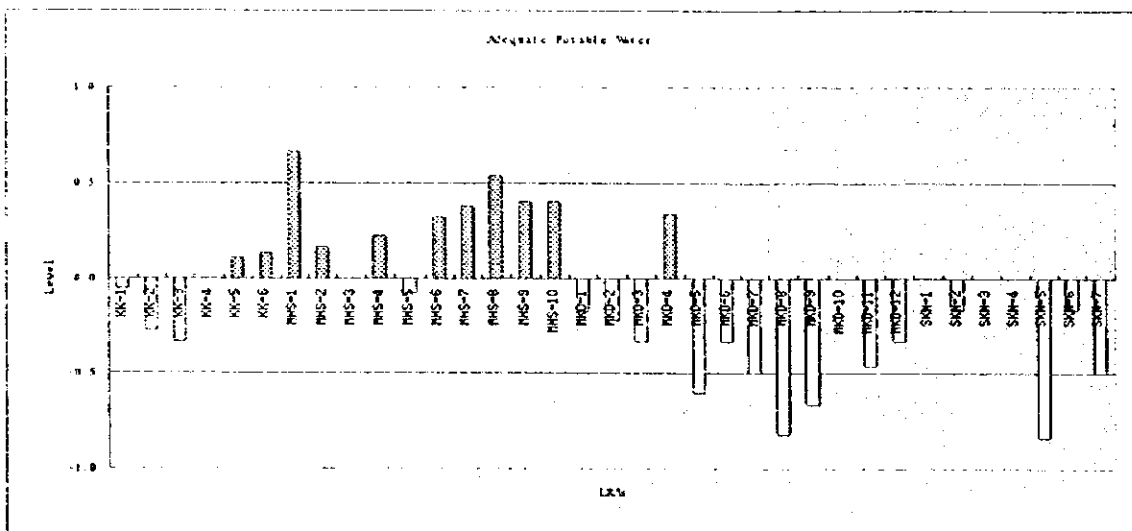


Figure 1-8 Potable Water (Kor Chor Chor 2 Khor 2537)

Figure 1-9 shows water availability for dry season farming in the study areas. Most LRAs do not have enough water for dry season farming. Only Sakon Nakhon No.7 is reported to have adequate water for second crop farming. However, dry season farming is not vigorous in this LRA as shown in Figure 1-7. In this LRA, no well operated SSIPs are available so that irrigation area is negligible. On the other hand in Khon Kaen No.5, it is reported that over 50% of households are engaged in dry season farming as shown in Figure 1-7. However, Figure 1-9 shows low availability of water for dry season farming. It will be, therefore, necessary to confirm the actual efficiency of the irrigation projects at particular key LRAs. Some low land irrigation nearby outside the LRAs may affect the evaluation in Kor Chor Chor.

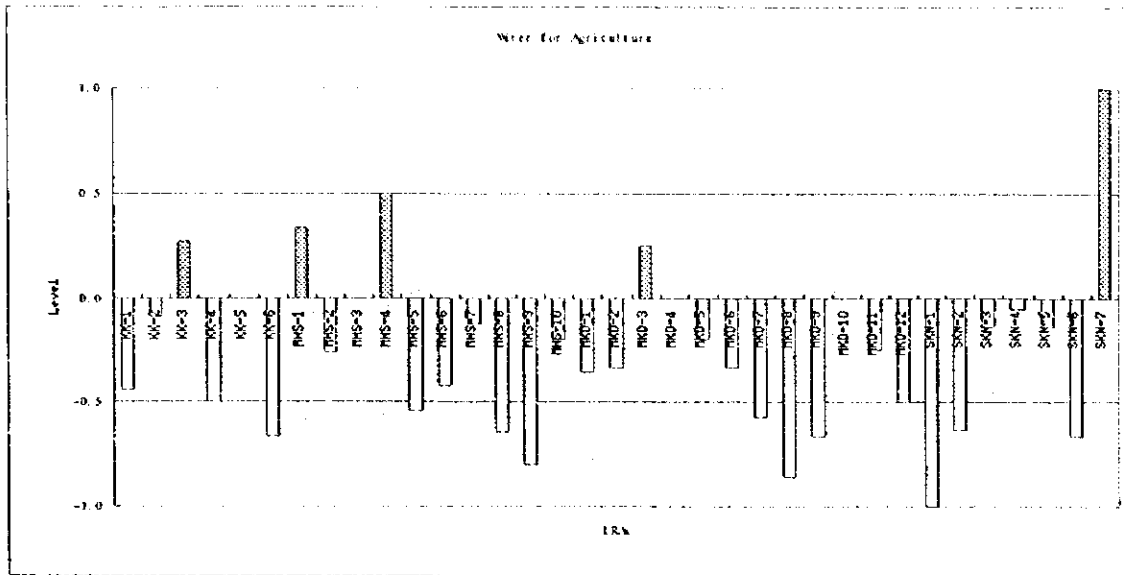


Figure 1-9 Water for Agriculture (Kor Chor Chor 2 Khor 2537)

Figure 1-10 shows development level in each LRA. Most LRAs of Sakon Nakhon and Some of Mukudahan seem to be more severe than other two provinces. Provincial average of development levels is low in Sakon Nakhon and Mukudahan, little low in Khon Kaen, and medium in Mahasarakham as below:

Average of Development Level

Province	Khon Kaen	Maha Sarakham	Mukudahan	Sakon Nakhon	Average
Level	1.8	2.0	1.7	1.3	1.7

All villages in three LRAs; SKN-1, SKN-7 and MKD-12, are classified as level 1 development level, that is very poor in development. They are followed by SKN-5 and MKD-8 respectively.

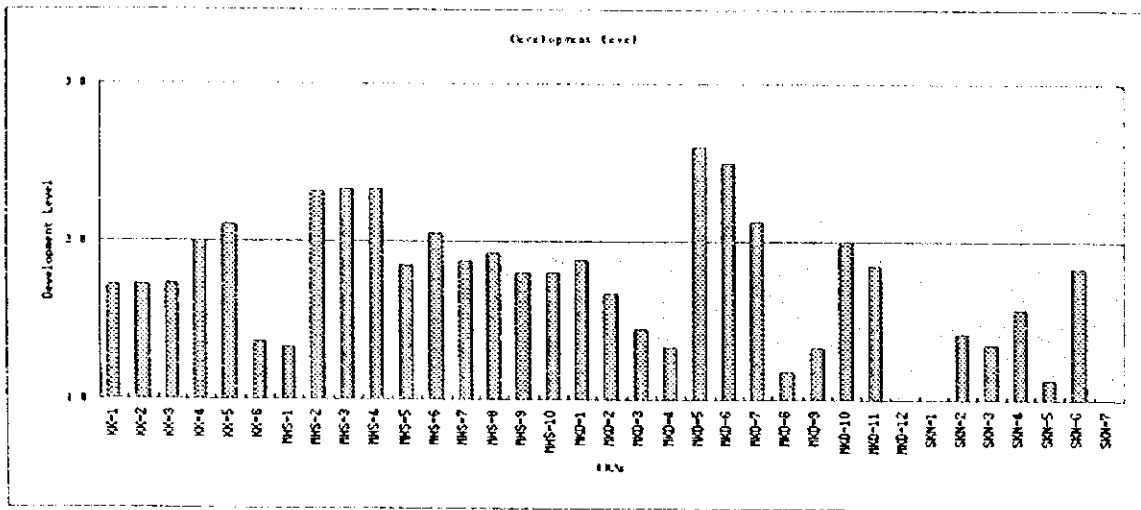


Figure 1-10 Development Level (Kor Chor Chor 2 Khor 2537)

Figure 1-11 shows the mean annual rainfall in each LRA. Annual rainfall of over 1,600 mm is as high in Sakon Nakhon and Mukudahan as it is in most LRAs. On the other hand, it is as low at most LRAs in Khon Kaen and Maha Sarakham as 1,000 to 1,200 mm.

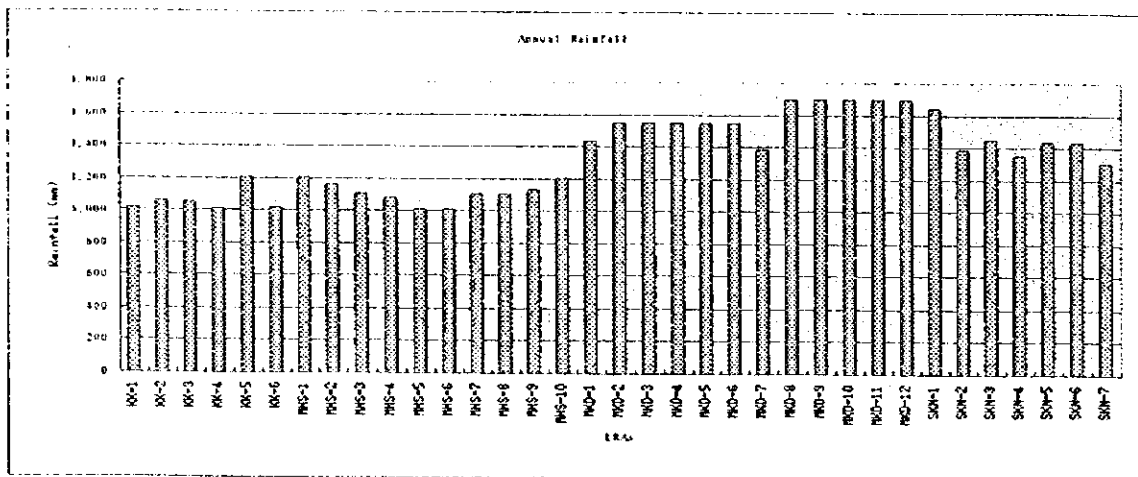


Figure 1-11 Mean Annual Rainfall of Each LRA in the Study Areas

Figure 1-12 shows the elevation range of each LRA. Elevation ranges are lower in Maha Sarakham and Khon Kaen, while higher in Mukudahan and Sakon Nakhon. Average elevations range from 190 m in Maha Sarakham to 213 m in Mukudahan and Sakon Nakhon. Average elevation of the study LRAs is 204 m. As shown in the figure, maximum elevation reaches 500 m in Mukudahan No.5

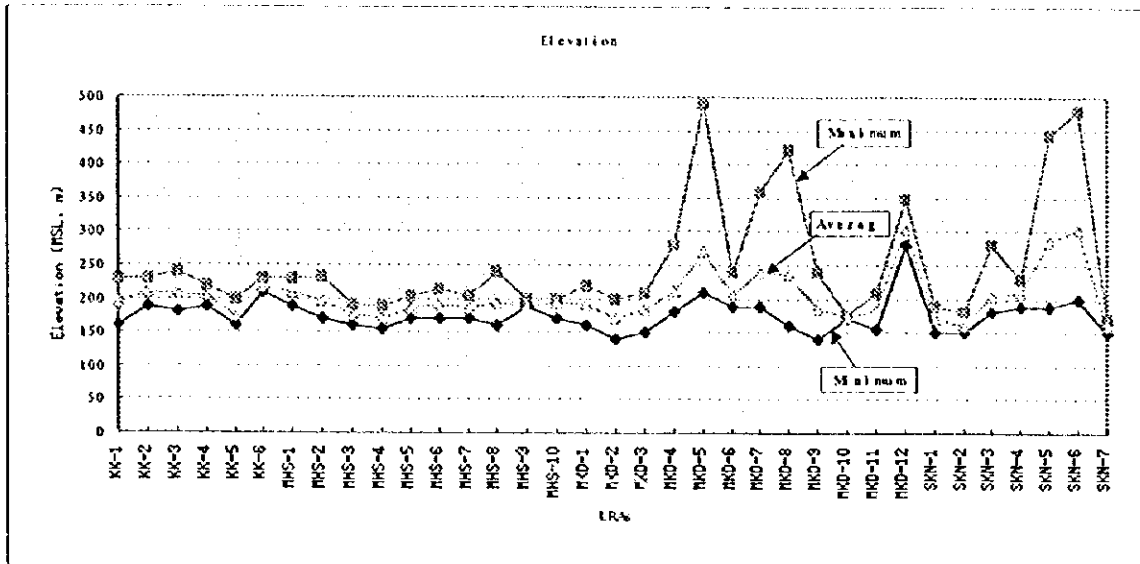


Figure 1-12 Elevation of Each LRA in the Study Area

Figure 1-13 shows the degree of slope of the LRAs. Side slope is usually steeper than main drain slope as shown in the figure. Side slope generally ranges from 2 to 4 %, while main drain slope is 1 to 2 %. Mukudahan No. 6 and No.12 are extremely steep compared to other LRAs. These two LRAs are located on the steep slope of the extension of the Phu Phan Range so that soil protection is essential in the areas.

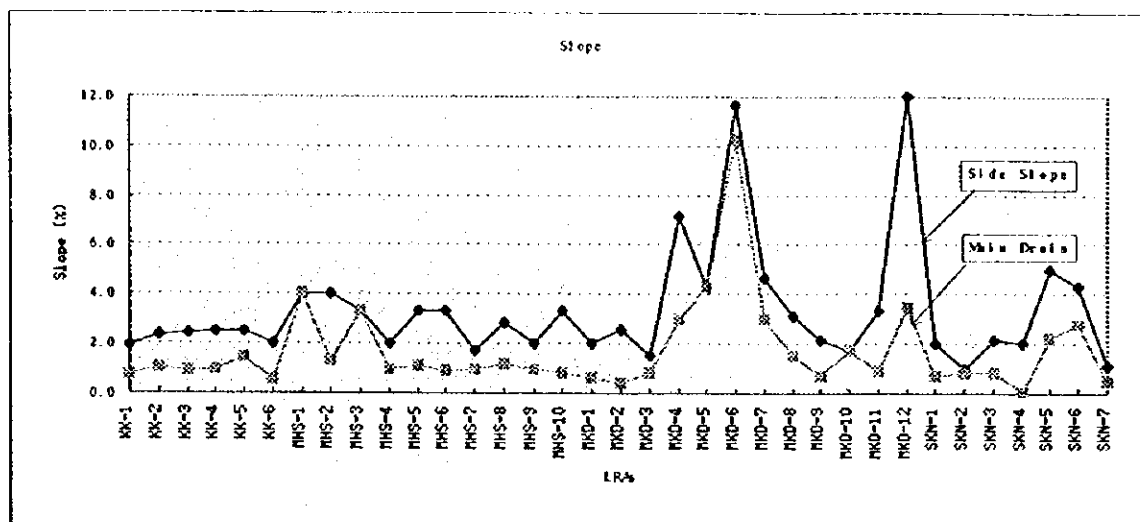


Figure 1-13 Degree of Slope of Each LRA in the Study Area

Figure 1-14 shows the distribution ratio of slopes by area in each LRA. Slopes are divided into three ranges, that are 0 - 2%, 2% - 5%, and over 5%. As shown in the figure, Steeper area largely extents in Mukudahan No.4, No.5, No.6, No.7, No.12 and Sakon Nakhon No.5.

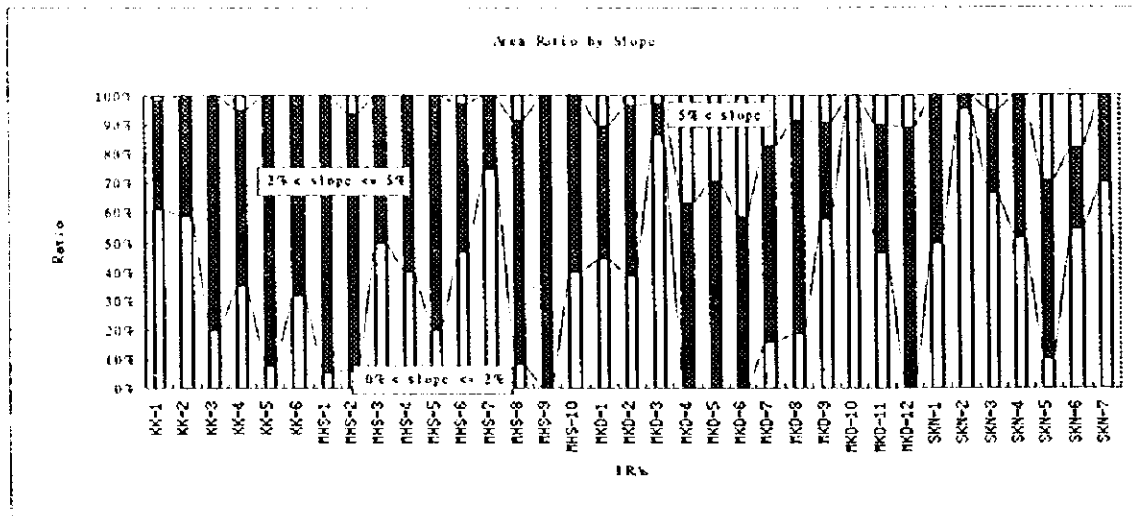


Figure 1-14 Distribution of slopes in Each LRA in the Study Areas

Figure 1-15 shows the catchment area of each LRA and its ratio to the LRA. when the ratio is 1, the catchment area is equal to the LRA itself. This means that no catchment flows into the LRA and no water resources flows into the area. Therefore, all necessary water resources are to be developed within the LRA or pumped up from the outside area. If the ratio is larger than 1, there is a catchment area outside the LRA. When the ratio is higher, more water resources can be expected in the form of runoff from outside. From this aspect of water resources potential, the potential is higher in Sakon Nakhon and Mukudahan than other provinces. Khon Kaen has some outside water resources potential as in KK-1, KK2, KK3 and KK5. On the other hand, the potential of Maha Sarakham is limited within the LRAs.

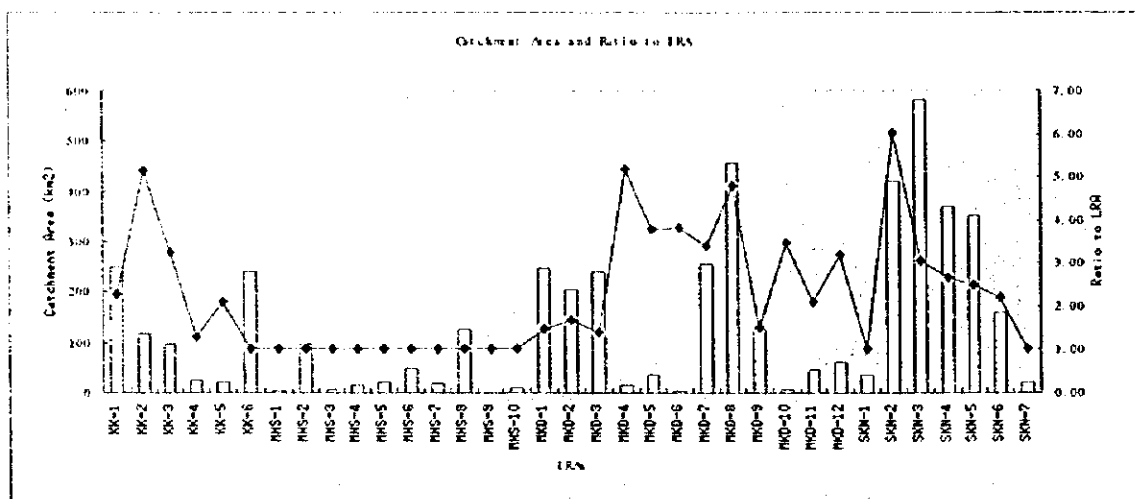


Figure 1-15 Catchment Area and Its Ratio to Each LRA in the Study Areas

Figure 1-16 shows the maximum elevation of the catchment area of each LRA. The elevations are generally high in Mukudahan, Sakon Nakhon and some in Khon Kaen but low in Maha Sarakham and in most LRAs in Khon Kaen. In Khon Kaen and Sakon Nakhon, the maximum elevation reaches over 600 m where catchment areas extent to the high ranges.

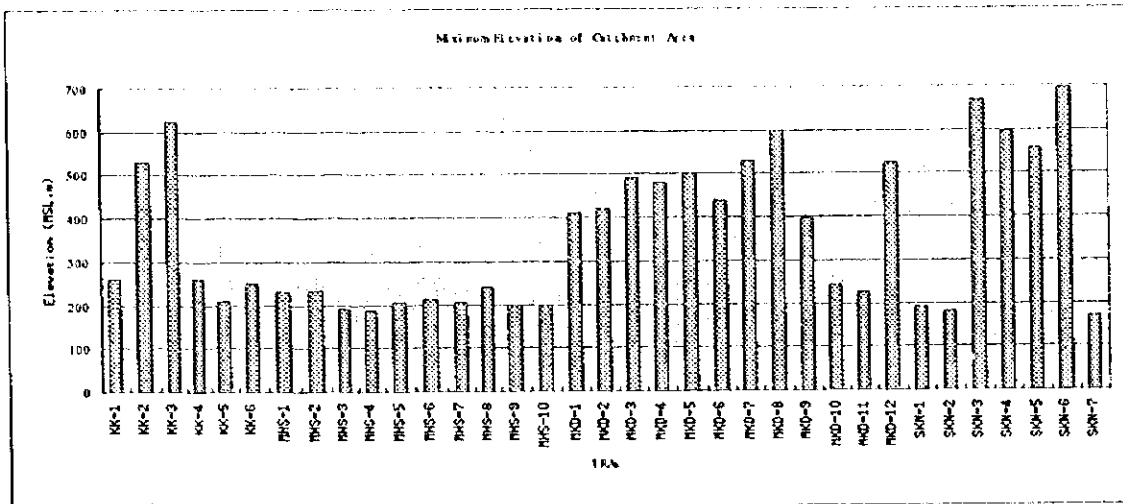


Figure 1-16 Maximum Elevation of Catchment Area of Each LRA in the Study Areas

Figure 1-17 shows irrigation area and irrigation ratio in each LRA. Irrigation area and irrigation ratio have so far reached 36,730 rai and 2.7% in total, but largely differed by the areas. Both are generally low in Khon Kaen and Mahasarakham but high in Mukudahan and Sakon Nakhon. In Khon Kaen, only KK-1 is extremely high due to the pump irrigation by DEDP from the Chi river, and slightly in KK-6 by SSIPs. In Mukudahan and Sakon Nakhon, MKD-8, MKD-12, SKN-3 and SKN-5 are extremely high because of many royal irrigation projects under RID.

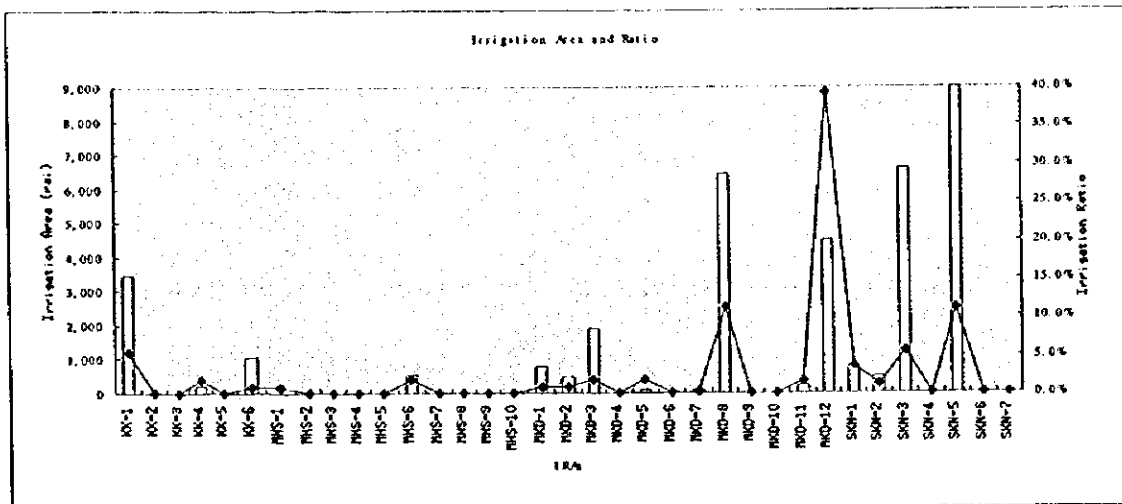


Figure 1-17 Irrigation Area and Irrigation Ratio in Each LRA in the Study Areas

Improvement of rural roads are now rapidly carried out , so that improvement has reached about 300 km in the study areas. This is equivalent to the density of 136 m/km². Improvement was carried out in maximum extent of 129 km and 192 m/km² in Sakon Nakhon among four provinces. On the other hand, it is lowest extent only of 18 km and 53 m/km² in Mahasarakham.

Rural Road Improvement by Provinces

Province	Khon Kaen	Mahasarakham	Mukudahan	Sakon Nakhon	Total
Length	75 km	18 km	78 km	129 km	300 km
Density	174 m/km ²	53 m/km ²	102 m/km ²	192 m/km ²	136 m/km ²

Figure 1-18 shows the length and the density of improvement of the rural roads in each LRA. Maximum improvement was achieved in SKN-5, where improvement reached about 60 km. It is followed by MKD-11 with 44 km, SKN-4 with 36 km, and KK-6 with 32 km. Maximum improvement density is 5,300 m/km² in MKD-6, and followed by MKD-11 with 2,000 m/km². MKD-6 is, however, small in the size of area so improvement density easily increases with a small-scale improvement.

The convenience of transportation shown in Figure 1-2 reveals that MKD-2 and MKD-12 receive a low evaluation compared to other LRAs. However, no improvement of rural roads has been carried out in these two LRAs. It is, therefore, recommended that improvement of the rural roads should be implemented effectively in harmony with Kor Chor Chor data.

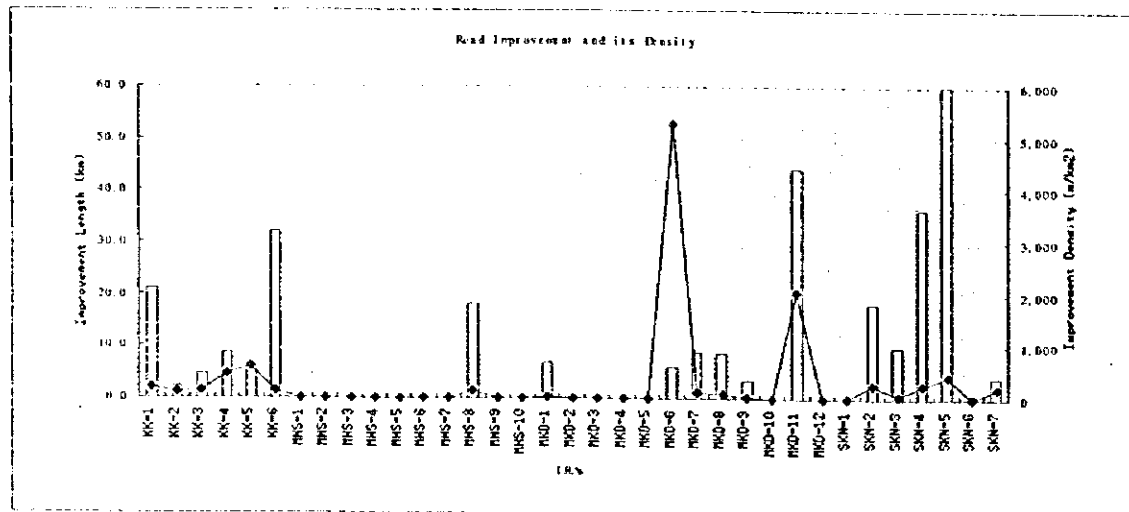


Figure 1-18 Improvement of Rural Roads and Densities in Each LRA in the Study Area