TABLE 2-6 RUN-OFF DISCHARGE AND WATER DEMAND IN HUAI KAO SAN BASIN

| Month | Run-off Discharge | Water Rights: Div. Irrigation | Water Rights: Water Req. | Water Rights: Domestic Water Req. | Total Demand | Rate of Water Use |
|---|---|---|---|---|---|---|
| | (MCM) (1) | (mm) (2) | (MCM) (3) | (MCM) (4) | (MCM) (5)=(3+4) | (%) (5)/(1) |
| 1. Design Year | | | | | | |
| May | 1.12 | 61.5 | 0.92 | 0.14 | 1.06 | 24.0 |
| Jun. | 9.66 | 52.9 | 0.80 | 0.12 | 0.92 | 4.4 |
| Jul. | 27.52 | 20.6 | 0.31 | 0.05 | 0.36 | 1.3 |
| Aug. | 36.63 | 12.0 | 0.18 | 0.03 | 0.21 | 0.4 |
| Sep. | 28.30 | 33.5 | 0.50 | 0.08 | 0.58 | 1.2 |
| Oct. | 6.57 | 53.4 | 0.80 | 0.12 | 0.92 | 4.9 |
| Nov. | 1.17 | 7.5 | 0.11 | 0.02 | 0.13 | 5.1 |
| Total | 110.97 | 241.4 | 3.62 | 0.56 | 4.18 | Ave. 5.9 |
| 2. Normal Year | | | | | | |
| May | 4.17 | 82.6 | 1.24 | 01.9 | 1.43 | 34.3 |
| Jun. | 20.67 | 17.5 | 0.26 | 0.04 | 0.30 | 1.5 |
| Jul. | 28.33 | - | - | - | - | - |
| Aug. | 57.94 | - | - | - | - | - |
| Sep. | 46.92 | - | - | - | - | - |
| Oct. | 18.95 | - | - | - | - | - |
| Nov. | 2.56 | 38.1 | 0.57 | 0.09 | 0.66 | 25.8 |
| Total | 179.54 | 138.2 | 2.07 | 0.32 | 2.39 | Ave. 8.8 |

Note :
- Catchment area of Huai Kao San is 281 sq.km (see Figure 2-18)
- Cropping areas in the above basin are 1,504 ha.
- Diversion water requirements corresponds to those in designed year with return period of 5-year and normal year.
- Domestic and other water demands are assumed at 15 percent of irrigation water requirements.

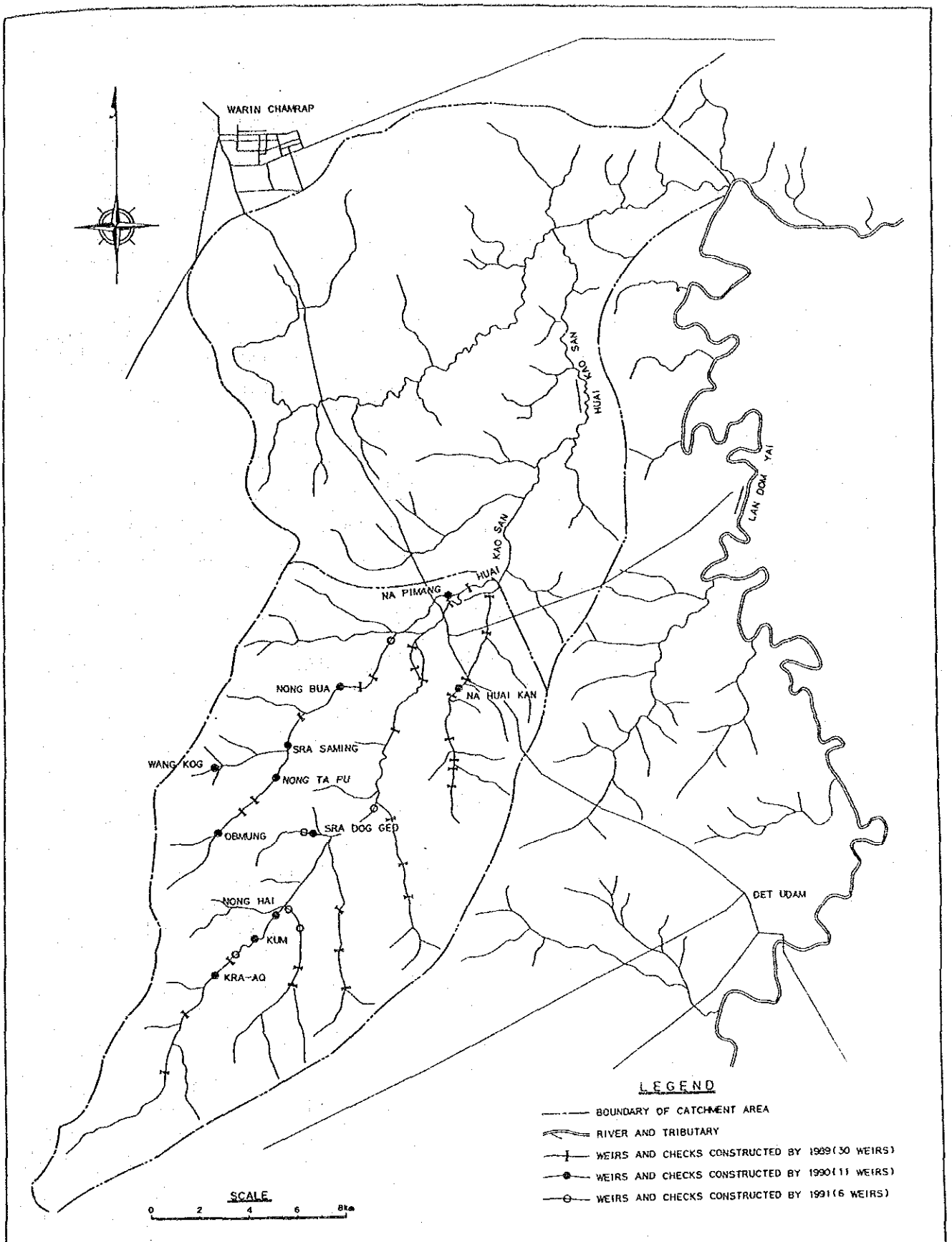



**FIGURE 2-18 LOCATION OF EXISTING IRRIGATION FACILITIES IN HUAI KAO SAN BASIN**

## 2. 10 Drainage Conditions

The catchment area of the Dom Yai river basin has a gentle gradient of about 1/1,500 from south to north under partially undulating topography and consists of sandy soil in soil texture.

Presently, the situations in the river basin do not show severe drainage problems, except in areas located in low lying altitude under depressed topography near the constructed weirs. This situation forcibly causes the periodical stagnation of water during the wet season, especially from August to October. These low lying areas are left as non-utilized areas.

There are no drainage facilities at the farm level. The excess water in the fields will be drained from field to field by the notches provided on the levee of the fields. Since the wet season paddy is normally planted in June, following land preparation in May, it is sufficiently grown enough to cope with such periodical inundations in relatively low lying areas.

Figure 2-19 indicates the prevailing inundation conditions in the basin.

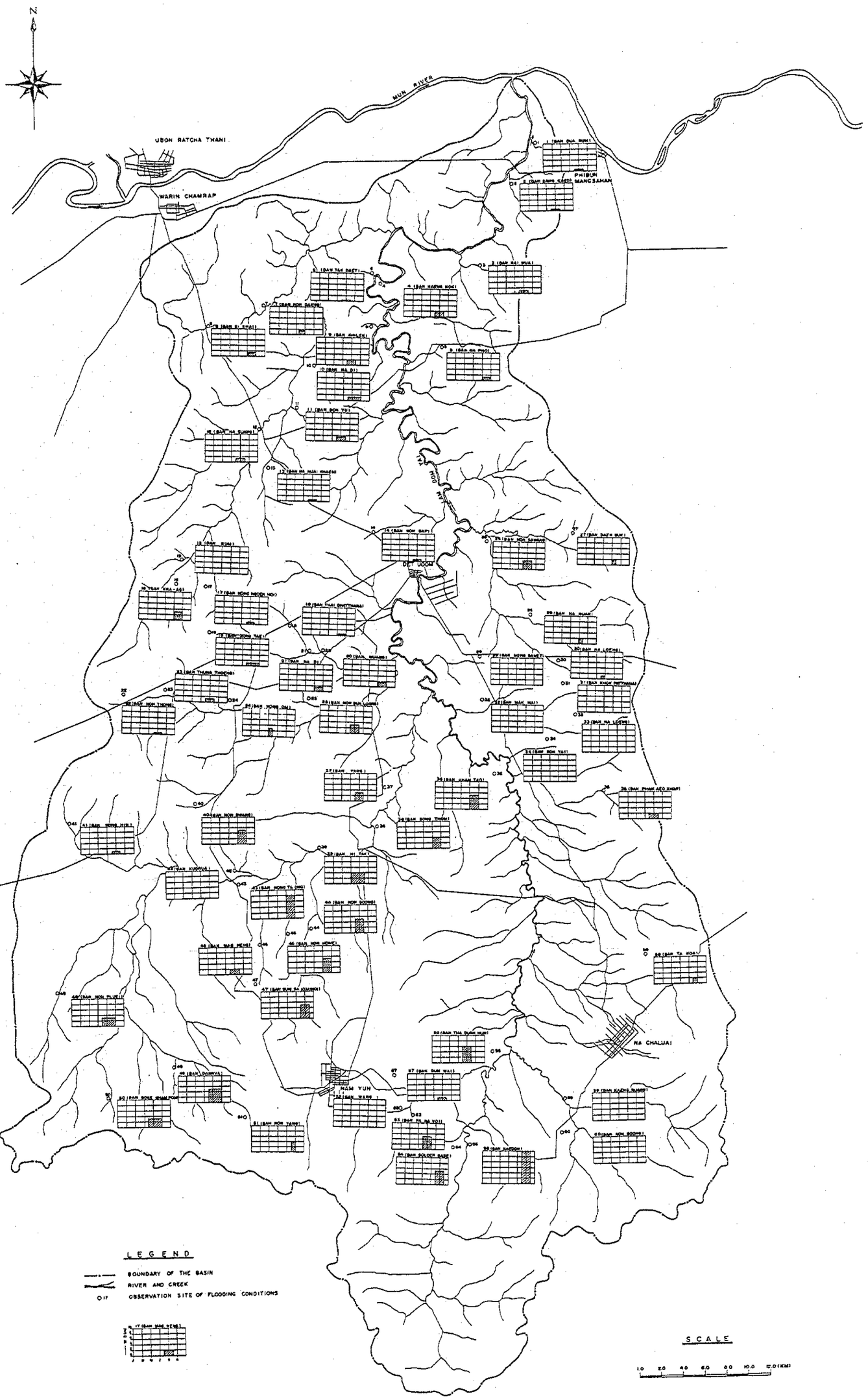



FIGURE 2-19 PRESENT INUNDATION CONDITIONS IN THE BASIN

## 2. 11 Environmental Conditions

### 2. 11.1 Introduction

In the last three decades, Dam construction has been proposed for the water resource development project in Thailand. Man-made reservoirs have caused bodies of water to replace forest areas, cultivated land, human settlement, cultural resource, and infrastructure. Normally, the area of reservoir is estimated at 10 percent of the catchment area as in previous projects in Thailand. Therefore, there are quite wide forest areas that have been lost due to the water resources development projects, but they can be retrieved by the utilization of storage water for irrigation, hydro-electric generation, fish culture, and recreation. However, some groups of people have disagreed with this plan saving that items cannot be compensated for particularly losses of forest trees, wild animals, good land for agriculture, cultural heritage, and invaluable nature. This is the reason why water resources development projects with dam construction cannot be smoothly implemented in Thailand.

The Lam Dom Yai Basin Irrigation Project is expected to provide water to increase land productivity, particularly that of rice paddy areas. There is no problem as far as engineering technical know-how and for socio-economic returns, but the question of environmental impact has arisen. This Paragraph was organized to focus on the issues of environmental effects.

Environmental parameters were chosen to evaluate the probable effects of the Lam Dom Yai Basin Irrigation Project. They are forestry, wildlife, land use, water flow, sediment yields, irrigation potentials, and socio-economics. Site visits had been made to observe all eight potential dam-sites, in conjunction with the literary reviews available in the libraries, government agencies, and previous researches during the Phase I field work. As a result of the basin study, it was found that some parameters may be carefully emphasized, such as forestry, wildlife, soil erosion, water sources areas, and compensation. Moreover, the Environmental Impact Assessment (EIA) study has been recommended to be implemented intensively before taking action on the project.

### 2.11.2 Existing Watershed Resources

The Lam Dom Yai basin is one of the biggest sub-watershed areas of Mun-Chi river basin, and it is located in the south-western part of Ubon Ratchathani and South-eastern part of Si Sa Ket Provinces in the Lower Northeast Region of Thailand. The total area is approximately about 4,905 sq.km which includes Ubon Ratchathani 4,474 sq.km and Si Ket 431 sq.km.

In the forest areas, desirable land for agriculture was taken, which caused a depletion of forest areas. Looking at the 1988-report of the Royal Forest Department it was found the forest covers about 20.6 percent of the whole area of Ubon Ratchathani Province of 389,100 ha (2,432.1 thousand rai), and the deduction rate during the period between 1985 - 1988 was about 1,500 ha (9.5 thousand rai) per annum.

Of the Ubon Ratchathani Province, approximately 26 percent of the land is for pasture and range, 40 percent for crop cultivation, and 1.4 percent for fishery resource areas, while the others is either forest or idle land. Judging from such a figure of cultivated land, this Province should be the richest area for agricultural products, but this is not the actual situation. Poor soils with low water holding capacity as well as a lack of water are the problems. Increasing water yields and their distribution are hopeful solution for current problems such as, like food crops and protein source production. Increasing soil productivity and water distribution capabilities are vital objectives for watershed management.

Considering population and households on-site in the basin, the total number of people amounted to 395,000 with a density of 91.7 persons/sq.km with about 69,100 households with average family size 5.7 people.

In reality, more than one-third of the people are poor because of low yields of agricultural products. Unavoidably, natural resources have to be utilized without care of planning. Finally, degradation of watershed resources have been occurring for the last two decades.

### 2.11.3 Watershed Management in Practice

1) Principle and Background

Watershed management is defined as "the management of land for optimum quantity, desirable quality, and regulation of water flow along with soil erosion control, flood reduction and well-planned utilization of natural resources" (Chunkao, 1983).

This unit area is comprised of three groups of watershed resources, namely biotic, abiotic, and social resources. They have related components, i.e., species diversity, quantity of each species, proportions among species (vertical and horizontal portions of total species diversity), and distribution of each species.

Chunkao (1983) proposed the principals of watershed management under three consecutive-important issues: i) land-use planning, ii) resources utilization and conservation measures, and iii) pollution control and self-recovery.

2) Land-Use and Its Effects

The Lam Dom Yai basin, having been identified as a poor and less educated area, has conventional utilization practices which occur in every village, particularly crop cultivation, fuel wood harvesting, and log timber cutting. Unavoidably, land is becoming less fertile and productive. The main factor would be the change in the ecological characteristics of the land. These changes are causing the losses of accumulative nutrients, especially from forest trees. In other words, the change in the land-use, from forest to cropland or other types, usually causes a loss of nutrients due to the action of removing forest trees. Nutrient losses usually occur from the consequent removal of trees, which increases surface flows and sedimentation.

This is the background information as to why the Lam Dom Yai basin is found with poor soil and low productivity, and it is the cause for the lower incomes of the local people. Furthermore, the total cover of forest area, its distribution, and any information to support its losses cannot be found. Therefore, an intensive study should be conducted before implementing the project.

3) Reflection on Mis-using Resources

The witness can normally see a evidence of mis-using resources in the basin, such as traces of soil erosion, sand-paved surface soils, denuded-splash-tree distribution, infertile soils, flooding tracks, and siltation areas. However, the indicators which are reflected as the environmental problems will be discussed as follows;

a) Forestry and Wildlife

Ubon Ratchathani has a forest that approximately covers 20.6 percent with a depletion rate of about 1,500 ha (9,500 rai) per annum. According to DLD's land-use map in 1988, the basin has been covered with dense forest. An observation was made during our site visit, which revealed that areas around the proposed dam-sites and reservoirs are only covered with forest trees at four out of eight sites. Only two forest types were found in the basin, i.e., dry-dipteracarp and mixed-deciduous forests; in wetland and cultivated areas, some wetland and farm forest were also found. Generally speaking, the tree density as an indicator of healthy and wealthy structure showed the forest was under disturbed conditions everywhere. This was a sign found in all existing forests in the basin. Since there is no data available concerning wild animal studies, the information presented in this report was obtained through interviews and discussions with experts.

b) Water Flow and Its Regime

According to RID's data measured from 1966 to 1989, the flow pattern is generally divided into two periods: first, between 1966 and 1978, and secondly, between 1978 and 1989. The average water flow was estimated during the first period at about 423,000 cu.m/sq.km/year, the second period at about 495,000 cu.m/sq.km/year, and the average for the whole period was at about 470,000 cu.m/sq.km/year.

The reason why water flow has increased might be i) siltation on the stream bed at the measuring point which caused an increase of flow rate, ii) patchy-clear cutting and illegal exploitation by local people reached at the optimum cover of approximately 70 percent to decrease the water loss by evapotranspiration and iii) clearing forest cover, thus causing more impact

between raindrop and soil surface, inducing finer materials to block soil pores. This is the phenomena which are decreasing infiltration and percolation, and increasing surface water.

It would seem that the Lam Dom Yai basin was given some water flow at a moderate amount as compared with other existing area data. Conclusively speaking, there is no regulation for forest cover affecting the amount of annual flow, so far. In other words, the existing forest cover of all basins can function in the same role as those with water yields of the watershed areas.

c) Waste and Pollution

In the past, waste and pollution control, one of three principles of watershed management, could not be initiated in the basin, because it was quite far from towns and beyond social control. Generally speaking, the situation of watershed resources indicates that waste and pollution can exist, at least water pollution, debris from fermenting fiber plants, soil pollution, and erosion. Pesticides and fertilizer are other pollutants that occur in the basin. It is hard to assess the positive or negative impacts from the project, therefore careful consideration will be required.

3) Sediment Yield and Soil Erosion Conditions

The average suspended yield was investigated at Det Udom during 1978 - 1987 (10-year period). The bedload had about 20 percent of suspended sediment yields. The total sediment will be 75.6, 99.6 and 44.4 ton/sq.km/year of average, maximum, and minimum, respectively. By setting standards, the Lam Dom Yai basin could be characterized as having slightly more than it should, but this is not a serious condition. The field survey found that soil loss is occurring in the basin, especially from cultivated areas, stream banks, and some hilly areas. However, it can be stated that the suspended sediment yields of the Lam Dom Yai basin can be classified as normal.

September is the month of maximum sediment yield of 23.17 ton/sq.km/year. This is not a large quantity and could not cause any serious problems, but there is a loss of nutrients whenever a rainstorm occurs.

4) Development and Rural Management Activities

To support agricultural activities and provide sustainable income for local people, many projects must be encouraged to initiate development and rural management activities, such as water resources development, transportation development, tourism, and health programs in the rural areas. Unfortunately, the basin has not been given any specific information.

The site visit discovered that many development and rural management activities have been undertaken in the basin. A forest development program has been conducted for years, such as protection programs, national parks and recreation, wildlife sanctuary, land consolidated programs, and privatized-community forest manipulation, and reforestation. Eucalyptus is the main species to be grown, but further research will be needed.

Fishery products have been collected since 1969 by the Department of Fisheries. The gross product for 1989 was surveyed and estimated at about 3,110 tons for the whole Province of Ubon Ratchathani. The amount of production has mostly been received from the Mun river. If the man-made reservoir under the Lam Dom Yai basin irrigation project was needed to initiate an intensive study of fisheries, then its productivity must be included in the programs of EIA study.

5) Archaeological and Cultural Environments

Although there are no worries concerning the archaeological issues in the basin, as reported by the Ministry of Education, the intensive study should pay more attention at the dam-sites and impounded areas. However, the report recommended any development programs to avoid the area of Phu-Arng and some remote areas which have the possibility of the existence of archaeological remains as well as historic cultural environment.

There are no reports of the culture of the basin, but stories from the older generation have been documented during site visits. Some cultural differences between groups have been observed.

# CHAPTER III. OVERALL AGRICULTURAL DEVELOPMENT PLAN

# CHAPTER III. OVERALL AGRICULTURAL DEVELOPMENT PLAN

## 3. 1 Objectives of the Development Plan

As stated in the previous chapter, factors which impede the development of this area of poverty and thus cause are as follows:

Shortage of irrigation water

- Contrary to the intense rainfall of the wet season, very little rainfall can be expected during the dry season; as a result, the dry season cropping rate is extremely low.
- Flat topography forms very few good dam-sites because it is not conducive to gravity irrigation, therefore pumps are required to lift water, and rainfed agriculture prevails in the area, resulting in the low productivity of crops.
- Groundwater for irrigation cannot be expected to be properly utilized due to low yielding alluvial aquifers.
- The upper-basin of the Lam Dom Yai is prohibited as it is the national defense boundary , but reservoirs built by medium and small-scale dam constructions function as the national boundary first and for irrigation second, therefore they cannot release water which results in the limited irrigable area.

Deteriorated soil conditions

- Being composed mostly of sandy soils, the farmland has low field capacity with low organic matter content and low fertility, which causes low productivity of crops.

Inbalance of farming crops and undeveloped marketing

- The main crop is wet season paddy, taking up 85 percent of the whole cropping area.
- As for agro-product marketing, the introduction of new crops does not interest the local people, because of their old habits and customs and from their lack of knowledge.
- Agro-product marketing has remained undeveloped because the area is located very far from the Metropolitan Area.

Others

- The illegal reclamation of agricultural land, that excuses the reckless act of tree cutting in national and non-national forests, is responsible for forest destruction and environmental deterioration.

Therefore, objectives of the project are to establish the following development plan with the improvement of the above-mentioned impeding factors:

- As a result of the study so far, it was found that agricultural land of about 232,200 ha (1,451.3 thousand rai) exists in the basin as land resources. Almost all of this agricultural land has been rainfed. (Irrigated areas amount to only 10,630 ha (66.4 thousand rai) during the wet season and 1,470 ha (9.2 thousand rai) during the dry season). The water resource development plan of the Lam Dom Yai basin should be established in order to facilitate as much irrigated agriculture in the river basin as possible.

- The river run-off of the Lam Dom Yai has remarkably large fluctuations between the wet season, May to October, and the dry season, November to April, because more than 90 percent of the annual mean rainfall of about 1,470 mm in the basin falls during the wet season. Accordingly, one aim of the study should be arranged to secure as many water source facilities as possible. The possibilities of the construction of reservoirs, namely the headwork, pumping stations, etc. on large, medium and small-scale, should be surveyed and examined.

- With paddy fields totally 186,800 ha (1,167.5 thousand rai), within the agricultural land of 232,200 ha, stabilization of irrigation water supply for the paddy fields during the wet season should come foremost, and an introduction plan for dry farming during the dry season using remaining irrigation water and the cropping pattern should be established.

- In the remaining areas of rainfed agriculture, soil moisture preserving measures (mulching), small-scale village ponds construction, organic matter supply by green manure cultivation, should be conducted. Therefore, the concrete plans should be established.

- On the other hand, the establishment of a land utilization plan for forests is also important. The plans for reserving measures for the natural forests, reforestation and the conversion of degraded forest to farming or dwelling areas, should organized up and conducted.

- The establishment of a staged development plan and the selection of one or two high priority projects, in conformity with the selecting criteria, is of notable importance for the following Feasibility Study.

## 3. 2 Sectional Development Plan

### 3. 2. 1 Water Resources Development Plan

Surface water and groundwater are expected to serve as water resources. Although the annual mean rainfall in the river basin is 1,490 mm, the seasonal distribution widely fluctuates. Effective utilization of this surface water is indispensable for the development plan. However, there is only a low possibility of groundwater resource development for irrigation, which will only be partially utilized.

The overall river basin of 4,905 sq.km has an annual mean run-off of 2,080 MCM during a 1/5 probable drought year. Since an area of 352 sq.km corresponds to about seven percent of the whole river basin, the area has been utilized as the catchment area for existing projects and projects to be implemented soon. An annual mean run-off of about 1,930 MCM is to be generated from the remaining river basin of 4,553 sq.km and will be used for potential developments in the future.

When considering the pattern of irrigation demand, it must be acknowledged that the water sources for irrigation require equalization of run-off by means of water storage. The water resource development through diversion works has no storing function and requires a fairly large catchment area compared to storage dam works. In order to utilize the limited water resources efficiently, an implementation of irrigation projects with reservoirs should be conducted.

There is agricultural land of 232,200 ha (1.451.3 thousand rai) corresponding to 47.3 percent of the whole river basin. The distribution condition of the agricultural land is shown in the table below. It is found that 87 percent of those areas are distributed at the upper and middle-basins of the river.

Distribution Condition of Agricultural Lands

| Basin | Catchment Area | Rate of Catchment Area | Area of Agricultural Land | Distribution Rate of Agri-Cultural Land | Rate of Agricultural Land Area |
|---|---|---|---|---|---|
| | A (sq.km) | (%) | B (sq.km) | (%) | B/A (%) |
| Upper | 2,741 | 56 | 1,090 | 47 | 40 |
| Middle | 1,537 | 31 | 920 | 40 | 60 |
| Lower | 627 | 13 | 312 | 13 | 48 |
| Total | 4,905 | 100 | 2,322 | 100 | 47 |

The water resource development plan for the river basin was formulated based on the following conceptions;

For the upper-basin of the river, a medium-scale irrigation project with a benefited area less than 4,000 ha will be applied. That is, good storage dam-sites on large or larger medium-scale will not exist in the upper-basin due to topographic restriction; agricultural land in the upper-basin has to be irrigated by smaller medium-scale reservoirs. Gravity irrigation from the reservoirs to the benefited areas will be possible, but only to a small extent.

For the middle and lower-basins of the river, large and medium-scale irrigation projects are applied. Except for a few sites mentioned below, there are no good storage dam-sites, either large or medium-scale. Water resources development for large or medium-scale is possible if an abundance of river run-off at the sites of the main Dom Yai river, or at some tributaries with large catchment areas is used. The vast agricultural lands at the middle and lower-basins of the river are meant to be irrigated by the water resources to be developed at the mentioned sites. Good intake sites for gravity irrigation, however, have been hard to find due to gentle riverbed slopes; pumping will be unavoidably needed for water resource development.

As for the agricultural lands that aren't irrigable through the above-mentioned projects, water resource developments by such small-scale irrigation projects like small-scale ponds, weirs construction and so forth, will be needed. Although many project plans involving these types can be established, the details will not be specified here in view of the objectives of this study.

As a sort of small-scale water source, construction of a village pond is useful to sustain vegetable cultivation, fish culture and animal husbandry is useful for the improvement of rural life. This project, however, will not be specified for either of the studies in the same manner as the above small-scale irrigation project.

In case of water utilization at the planned reservoir sites in the large and medium-scale irrigation projects, five percent of the river run-off should be released downstream and be appropriated as the water source for the small-scale water resource development projects, such as the above-stated small-scale irrigation projects, village pond construction projects, etc.

### 3. 2. 2 Land Resource Development Plan

1) Land-Use Plan

a) Land-Use Planning for Crop Cultivation

Land to be used for crop cultivation in the basin can be planned in two zones as follows;

The first zone confines the area in which the irrigation project can potentially be developed based on existing water resources. This area is quite small and characterized by narrow bands of soil running along both sides of the Lam Dom Yai. It is low, flat land that has very poorly drained soil with medium to high soil fertility and the potential of hydrogen (pH) ranging around 5.5 - 6.0.

The land in this zone should be used for growing rice. Land leveling is necessary and for maintaining soil fertility, organic and inorganic fertilizers should be applied. Inundation is a problem for this area during the wet season, therefore, cropping patterns should be properly designed.

The second zone encompasses a vast area of rainfed agricultural land. The physiographic position (land form) ranges from river levees, nearly flat, undulating to rolling. This causes difficulties in the development of

irrigation projects in the zone. Nevertheless, land in this zone can be used for growing rice and upland crops.

The area for paddy rice is situated within the basin, especially around the east and west parts of Amphoe Det Udom. The top soil texture of this area ranges from sandy soil to loamy soil, while the sub-soil is of a clay texture. Therefore, before planting, paddy soil should be improved and soil fertility should be maintained.

The areas suitable for upland and tree crops lie in the central and southern part of the basin, and scatters around the northern part. The texture of top soil ranges from sandy to sandy loam and intermingles with clay. Soil pH is about 5.5 - 6.0 and the soil is deep and moderately well drained.

b) Land-Use Planning for Forest

Even in the irrigated area, irrigation water shortages can also occur, when the amount of water from natural water resources is insufficient. This phenomenon increases as a consequence of the lack of forest area to intercept and supply water resources in the long run. These situations inevitably affect the basin too. Therefore, land-use planning for forest is one of paramount significance for the basin. The following land-use planning projects for the forest areas suggested for the basin (See Figure 3-1).

Natural Forest

Most natural forest area is undulating, rolling and located in mountainous area with high mountain ranges. The soil is shallow with outcrops of rock. The forest is undisturbed and lies in a permanently reserved forest area. There is also a small area of natural forest that lies outside the cited area. This small area has been used for cultivation to grow kenaf and cassava. Later, the yields of these crops have dropped dramatically and the land has become deserted. This small area, thus, became a degraded forest. Most natural forests lie in Amphoe Nam Yun, for example, Yod-Dom wildlife Sanctuary Area, Phu Dong, Na-Yoi National Park and Lam Dom Yai Left Bank Forest (southern). These areas must not be disturbed by any form of land use.

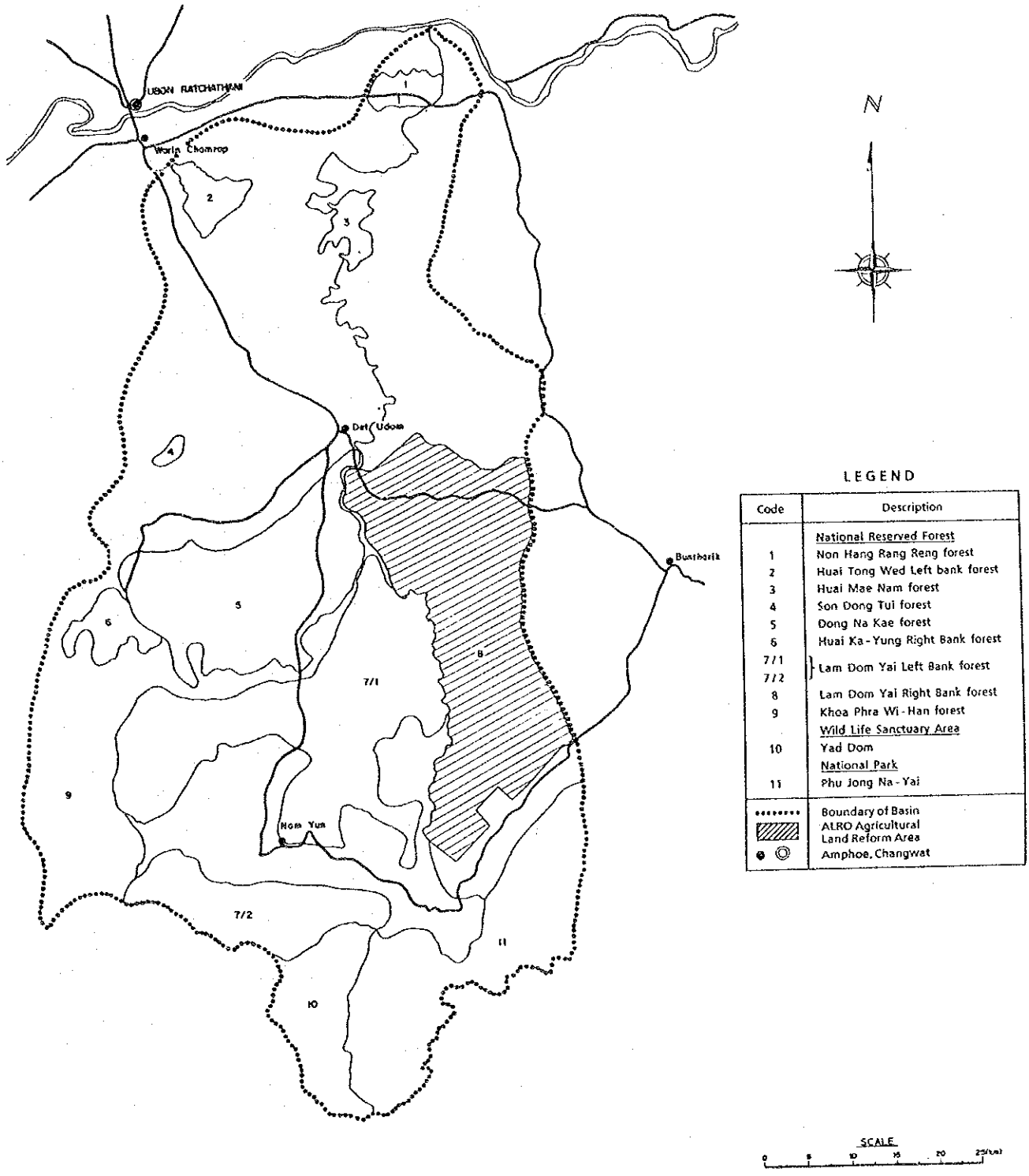



**FIGURE 3-1 FOREST LAND-USE PLAN**

Reforestation Area

Most reforestation area lies in the National Reserved Forest and the Permanent Forest, including the area outside the Permanent Reserved Forest. These areas are unsuitable for agricultural use, because the slope is high, the soil is shallow with rock outcrops and the soil is low in fertility. The areas are small and located north of Amphoe Nam Yun; they are scattered around the central and northern part of the basin. The suggestion is that this small area should be reforested by villagers or by the private sector (See Figure 3-1).

Transformation of Degraded Forest Area into Agricultural Area

Areas in Permanent Forest and National Reserved Forest have been encroached upon and used for growing crops such as paddy rice and upland crops. Since soil and topography are suitable for agricultural use, villagers should be educated and guided as to how to develop and improve these areas and grow crops efficiently. This area is scattered among the National Reserved Forest in Non Hang Rang Raeng Forest, Huai Mae Non Forest, Huai Tong Wed Left Bank Forest, Dong Na Kae Forest, Lam Dom Yai Left Bank Forest (northern) and Lam Dom Yai Right Bank Forest.

c) Land-Use Planning for Villages

According to the present land-use in the basin, it can be seen that the residential area covers about 4.8 percent of the total area. The rate of population growth in the previous years was quite high, 1.5 - 2.0 percent annually. As a consequence, the demand for residential land has increased, especially around the town of Amphoe Det Udom and other new and large villages. Suggestions for the basin are given only in the directional aspects of urbanization of the community. Namely, urbanization should be directed to the areas which are on upland unsuitable for agriculture.

The proposed land-use plan in the basin is decided as shown below, considering the land-use plan and proposed project facilities in the project;

**Proposed Land-Use Plan**

| Land Category | Area (ha) | Percent (%) |
|---|---|---|
| Cultivation Area | | |
| Paddy Field | 177,500 | 36.2 |
| Upland Field | 44,500 | 9.1 |
| Sub-total | 222,000 | 45.3 |
| Non-Cultivation Area | | |
| Forest | 193,400 | 39.4 |
| Residential Areas | 23,600 | 4.8 |
| Public & Other Areas | 51,500 | 10.5 |
| Sub-total | 268,500 | 54.7 |
| Total | 490,500 | 100.0 |

Note: *Proportion of area for project facilities such as canals and roads is assumed to be five percent in the project.*

2) Introduction of Community Forest

The basin was covered by relatively dense forest until the 1950's. After farmers began to settle in the area, forest began to be converted into paddy and cultivated land under rainfed conditions. The greater part of the dense forest has disappeared due to reclamation by settlers. In the tropical regions, the organic matter content of the soil rapidly decreased because of forest destruction, and the land productivity is low. In opposition to this social damage, the importance of ecological stability is growing.

a) Agro-forestry

The purpose of agro-forestry is to systematically develop a method and technique for land use which optimizes the positive interaction between trees and crops. Accordingly, agro-forestry is able to achieve production with higher yields, persistency and variety, than conventional and traditional single-crop modes. The ongoing agro-forestry has the following three features:

- Taking restrictive factors for current land use into account and farming, a new mode of land use is to be constructed to utilize a combination of trees and crops.

- New opportunities to raise the income levels of small-scale farmers are created.

- While maintaining soil fertility of the soil through the prevention of erosion and the supply of organic matter, trees and shrubbery can be grown for useful products such as wood, feed and fruit.

At present, the Royal Forestry Department (RFD) and the forest authorities are promoting the introduction of community forests through agro-forestry. The project is characterized as follows;

- By having representatives and councilors elected by illegal settlers on public land, their settlements in the land are planned.

- The government distributes 2.5 ha (15.6 rai) of farmland per family, free of charge, divided from the community forest. Further, supports are given to the social infrastructures (roads, water-supply works and schools), agricultural product delivery systems, etc. However, their ownership and selling rights of these lands are not codified.

b) Concept of Community Forest

Community forest is defined as the management system for a forest; planning and use depend on their purposes and economic profits, and are based on the following four concepts. It is divided into two groups; the primitive community forest and the newly-developed community forest.

| | | | |
|---|---|---|---|
| i) | Ecology | : | Human beings as a part of the ecological system. |
| ii) | Agricultural development | : | Forest is an important resource for agriculture. |
| iii) | Competence | : | Regional dispersion of industries and public management. |
| iv) | Utilization | : | Supply of wood under smooth management. |

Primitive community forest

- Forest for traditional ceremonialism *1
- Prevention of soil erosion
- Hunting area
- Recreation site
- Food resources (mushroom, fruit, etc.)*2

Newly-developed community forest

- Wood supplies by village management
- Forest for school education
- Construction of forest temples
- Land for public use
- Community management of national forest lands

*1 People have authorized the forest as an object of their spiritual belief.

*2 In Thailand, medicinal plants collected from forests are indispensable for the villagers' lives. They consist of more than 30,000 species, and are utilized for 72 disease conditions .

c) Management and Constitution of Community Forest

The community forest is a union that manages the forests for the benefit of the community inhabitants themselves. It is an ecological system aiming at the symbiosis of human beings and nature (trees and wildlife). Key points in its management are as follows:

- Utilization and cooperative management of forest areas (tree planting, etc.)
- Regulations and criteria
- Public organization (Public council)
- Support by outsiders

To conserve the present natural environment in the basin, introduction of this type of community forestry to the area will be indispensable.

### 3. 2. 3 Irrigation Plan

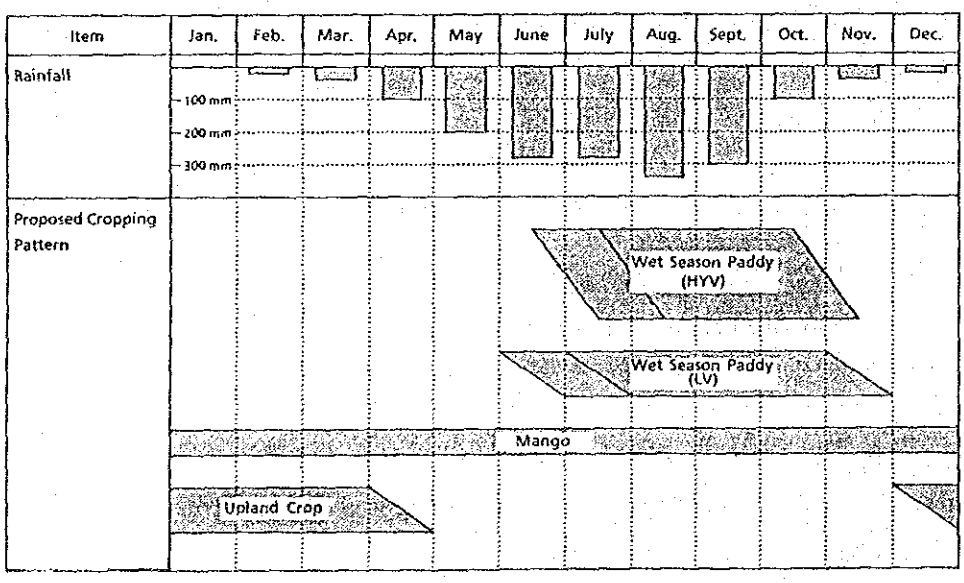
1) Irrigation Water Requirement

a) Proposed Cropping Pattern

The proposed cropping pattern for the overall agricultural development plan is planned as shown in the following figure; paddy sharing 30 percent of the local variety and 70 percent of the high yield variety, will be planted for the entire irrigation area during the wet season with the consideration of the climatological conditions in the region, such as the abundant rainfall between May and September.

On the other hand, during the dry season, upland crops are planned for an area of 15 percent of the whole irrigation area, after due consideration of the fact that the main objectives of irrigation for crops are to provide supplemental water supplies for the wet season paddy to stabilize and to increase its yield of wet season paddy, and scarce available irrigation water sources in the dry season in the basin.

**Proposed Cropping Pattern**



b) Crop Water Requirement

Crop water requirement is estimated on the basis of the following procedures;

- Potential evapotranspiration (ETo) is estimated applying the modified Penman Method using climatological data observed at Ubon Ratchathani meteorological station (1961 - 1990).
- Monthly consumptive use of water for crops (actual evapotranspiration ETa) is calculated by multiplying the ETo value by crop coefficient (Kc)[1/] corresponding to growth stages of the crops.
- Crop water requirement on a 10-day basis is estimated based on the proposed cropping pattern. For this estimation, the following values are counted;
  - Percolation rates in paddy fields are assumed at 2.0 mm/day throughout the growing period of paddy.
  - Additional water supply for land preparation of paddy field is decided at 250 mm.

c) Diversion Water Requirement

The diversion water requirement is calculated by adding effective rainfall and irrigation efficiency to the crop water requirement. The criteria for the calculation of the effective rainfall and irrigation efficiency used for the calculation are as follows;

Effective Rainfall

Two types of weighted rainfall are used to estimate the diversion water requirement, that is, type-1 represented by Nam Yun station and type-2 by Det Udom station, respectively.

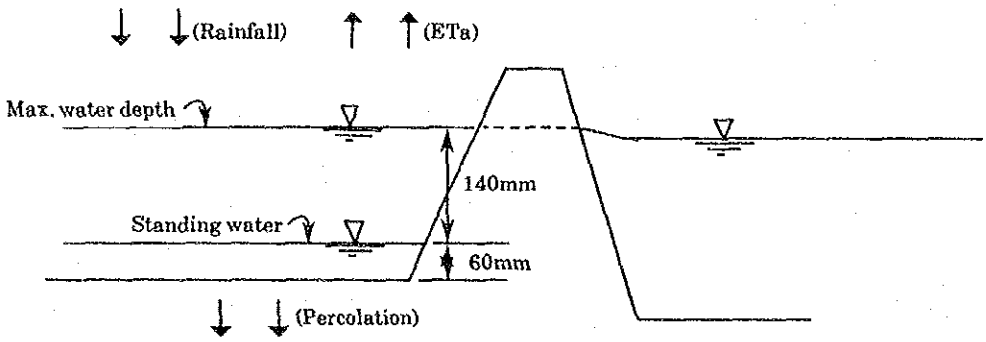
Effective rainfall for the paddy field is estimated by analyzing the daily water balance between the rainfall mentioned above and crop water requirement based on the following conditions;

---

1/: derived from "Crop Coefficient and Pan Coefficient" Water Requirement Research, Irrigated Agricultural Section, O/M Division, October, 1990.

- The minimum standing water in the field is 60 mm.
- The rainfall at the water depth more than 200 mm (notch of levee is placed at the height of 200 mm) in the field will be drained as waste water.
- Irrigation water will be supplied to a depth of 80 mm in the field, if water depth in the field become lower than the minimum standing water of 60 mm.

Illustration of Water Balance in Paddy Field




For determining effective rainfall for upland crops during the dry season, TRAM (total readily available moisture) value of 25 mm was adopted as the maximum depth of effective rainfall. The TRAM value was analyzed through physical soil tests conducted during the Phase II field works.

Irrigation Efficiency

The irrigation efficiency should be determined on the basis of the prevailing topography and proposed irrigation method. In the project, the following irrigation efficiencies were adopted;

| Irrigation Efficiency | Paddy Field (%) | Upland Field (%) |
|---|---|---|
| Application efficiency | 80 | 70 |
| Operation efficiency | 80 | 80 |
| Conveyance efficiency | 85 | 90 |
| Overall efficiency | 55 | 50 |

Following the afore-mentioned procedures, 10-day diversion water requirement for 30 years (1960 - 1989) are estimated. The following table

indicates annual and maximum diversion water requirements (DWR) by a respective return period of 1/2-years (normal year) and 1/5-years (designed year) in case of the proposed cropping pattern (Type-I) with a cropping intensity of 115 percent as a whole.

**Annual Diversion Water Requirement**

(unit: mm)

| Item | Upper-Basin (Type-I) | Middle/Lower-Basin (Type-2) |
|---|---|---|
| Annual DWR | | |
| Normal Year (1/2-Year) | 478.5 | 332.8 |
| Designed Year (1/5-Year) | 546.4 | 386.2 |

Note: Monthly diversion water requirement for 30 years is tabulated in Table 3-1.
Diversion water requirement in designed year is of a three year average as mentioned below;
Upper-basin : 1965, 1979, 1984
Middle/Lower basin: 1966, 1970, 1985

2) Delineation of Irrigation Area and Canal Systems

The area to be irrigated by developed water resources will be delineated on the map of scale 1/50,000, taking into account the available water sources to be developed, land suitability for cultivation, and the topography of the area. And irrigation systems of main and lateral canals will be planned on the basis of designed criteria and the canal density used in RID.

Furthermore, on-farm facilities such as farm ditches, farm drains and farm roads in the unit area of about 30 to 50 ha (190 to 310 rai) will be planned at the sampled area(s). The provision of on-farm facilities, which will be implemented with the participation of related farmers will be needed to expect effective water use for irrigation.

Benefited areas equipped with those irrigation and drainage facilities will be divided into separate sections having areas of about 5,000 to 6,000 ha (31.3 to 37.5 thousand rai) for operation and maintenance of the project.

Unit irrigation water requirement for designing the irrigation canal systems has been decided as follows;

## TABLE 3-1 MONTHLY DIVERSION WATER REQUIREMENT IN EACH BASIN

Upper-Basin (Rainfall Type-1)

(unit : mm)

| Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961 | 51.16 | 56.01 | 49.90 | 18.33 | 5.25 | 83.85 | 56.18 | 112.27 | 0.00 | 4.93 | 8.39 | 44.91 | 491.18 |
| 1962 | 50.78 | 55.38 | 35.51 | 9.24 | 6.93 | 71.07 | 56.46 | 33.89 | 0.00 | 4.93 | 8.40 | 52.33 | 384.92 |
| 1963 | 50.78 | 55.38 | 43.93 | 18.03 | 6.94 | 23.57 | 54.63 | 157.95 | 0.00 | 4.93 | 5.06 | 50.45 | 471.65 |
| 1964 | 50.78 | 55.38 | 43.61 | 15.12 | 1.56 | 92.71 | 76.30 | 98.59 | 76.43 | 4.93 | 6.75 | 50.45 | 572.61 |
| 1965 | 50.78 | 46.28 | 45.33 | 15.29 | 5.15 | 19.55 | 122.31 | 94.03 | 1.84 | 72.06 | 6.90 | 52.33 | 531.85 |
| 1966 | 50.78 | 55.38 | 35.67 | 15.25 | 0.00 | 91.61 | 37.83 | 6.20 | 1.76 | 93.08 | 8.40 | 52.33 | 448.29 |
| 1967 | 50.78 | 55.38 | 50.81 | 9.51 | 5.00 | 52.33 | 82.32 | 9.62 | 0.00 | 5.10 | 8.33 | 50.68 | 379.86 |
| 1968 | 50.78 | 55.38 | 49.75 | 9.53 | 3.52 | 10.21 | 137.78 | 21.75 | 0.00 | 5.31 | 8.40 | 52.33 | 404.74 |
| 1969 | 50.78 | 55.38 | 50.81 | 11.05 | 6.65 | 13.75 | 42.47 | 164.35 | 0.00 | 1.78 | 8.52 | 50.68 | 456.22 |
| 1970 | 50.78 | 55.38 | 50.81 | 9.71 | 6.73 | 10.73 | 64.42 | 55.43 | 0.00 | 4.88 | 8.41 | 50.47 | 367.75 |
| 1971 | 50.78 | 55.38 | 50.81 | 9.51 | 3.29 | 6.59 | 54.93 | 124.64 | 1.76 | 4.93 | 8.41 | 52.30 | 423.33 |
| 1972 | 50.78 | 55.38 | 52.15 | 8.16 | 6.90 | 3.56 | 23.49 | 162.24 | 6.93 | 3.29 | 6.94 | 50.45 | 430.27 |
| 1973 | 50.78 | 55.38 | 50.81 | 9.46 | 1.52 | 80.12 | 90.70 | 39.13 | 14.53 | 5.05 | 8.39 | 52.35 | 458.22 |
| 1974 | 50.78 | 55.38 | 35.79 | 15.05 | 3.54 | 83.61 | 44.50 | 56.58 | 0.32 | 5.00 | 5.20 | 52.30 | 408.05 |
| 1975 | 49.38 | 50.11 | 48.67 | 9.21 | 5.13 | 46.45 | 90.47 | 54.10 | 0.00 | 3.52 | 3.37 | 45.55 | 405.96 |
| 1976 | 50.78 | 55.38 | 42.08 | 9.37 | 3.40 | 40.25 | 122.10 | 73.64 | 40.85 | 3.29 | 6.75 | 43.16 | 491.05 |
| 1977 | 50.78 | 55.38 | 42.01 | 16.93 | 6.90 | 61.72 | 133.20 | 118.76 | 0.00 | 24.56 | 11.91 | 52.30 | 574.45 |
| 1978 | 50.78 | 55.38 | 29.47 | 11.63 | 3.40 | 99.28 | 146.82 | 80.67 | 66.82 | 7.15 | 4.99 | 50.47 | 606.86 |
| 1979 | 50.78 | 55.38 | 50.81 | 8.13 | 4.92 | 32.68 | 37.44 | 125.99 | 124.39 | 6.53 | 8.41 | 50.47 | 555.93 |
| 1980 | 50.78 | 55.08 | 50.82 | 9.53 | 5.11 | 29.19 | 111.46 | 232.66 | 0.00 | 3.32 | 6.79 | 50.45 | 605.19 |
| 1981 | 50.78 | 55.38 | 43.74 | 15.60 | 5.06 | 13.63 | 3.49 | 1.64 | 52.54 | 22.86 | 5.02 | 52.49 | 322.23 |
| 1982 | 50.78 | 55.23 | 37.74 | 7.65 | 6.85 | 6.44 | 131.35 | 122.76 | 0.00 | 1.64 | 3.37 | 52.30 | 476.11 |
| 1983 | 50.78 | 54.59 | 43.77 | 18.26 | 5.24 | 32.87 | 3.37 | 56.01 | 40.25 | 0.00 | 8.41 | 52.33 | 365.88 |
| 1984 | 50.78 | 55.38 | 50.12 | 9.51 | 4.88 | 47.04 | 235.35 | 36.00 | 0.00 | 3.29 | 8.27 | 50.68 | 551.30 |
| 1985 | 50.78 | 54.74 | 43.53 | 15.60 | 3.52 | 100.25 | 127.76 | 228.83 | 27.95 | 69.34 | 8.41 | 52.30 | 783.01 |
| 1986 | 51.16 | 56.01 | 41.65 | 17.03 | 4.82 | 68.28 | 75.57 | 1.68 | 3.52 | 6.57 | 6.73 | 43.07 | 376.09 |
| 1987 | 50.78 | 55.38 | 50.81 | 12.59 | 5.11 | 4.90 | 1.84 | 183.59 | 0.00 | 4.93 | 3.37 | 52.35 | 425.65 |
| 1988 | 50.78 | 55.38 | 44.25 | 6.46 | 5.11 | 4.60 | 162.09 | 46.29 | 53.33 | 4.88 | 8.43 | 50.68 | 492.28 |
| 1989 | 50.78 | 55.38 | 37.68 | 15.48 | 5.11 | 150.03 | 157.23 | 93.04 | 5.53 | 5.05 | 8.42 | 50.45 | 634.18 |
| 1990 | 50.78 | 54.62 | 35.70 | 18.72 | 3.54 | 112.19 | 121.56 | 3.29 | 1.76 | 1.64 | 6.88 | 50.45 | 461.13 |
| | | | | | | | | | | | | | |
| Ave. | 50.76 | 54.86 | 44.62 | 12.50 | 4.70 | 49.77 | 86.85 | 86.52 | 17.35 | 12.96 | 7.20 | 50.46 | 478.54 |

Middle/Lower Basin (Rainfall Type-2)

(unit : mm)

| Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961 | 57.98 | 55.74 | 43.74 | 18.45 | 5.11 | 88.93 | 16.78 | 1.67 | 0.00 | 4.93 | 8.39 | 44.65 | 346.37 |
| 1962 | 50.78 | 55.38 | 37.37 | 9.24 | 6.97 | 77.37 | 18.45 | 0.00 | 0.00 | 4.93 | 8.40 | 52.33 | 321.22 |
| 1963 | 50.78 | 55.38 | 43.93 | 18.03 | 5.24 | 6.05 | 0.00 | 0.00 | 0.00 | 4.93 | 5.06 | 50.45 | 239.85 |
| 1964 | 50.78 | 55.38 | 43.77 | 15.37 | 0.00 | 83.50 | 26.58 | 0.00 | 1.78 | 4.93 | 6.75 | 50.45 | 341.29 |
| 1965 | 50.78 | 47.90 | 50.40 | 7.64 | 6.89 | 5.52 | 3.37 | 1.64 | 10.46 | 161.57 | 6.78 | 52.33 | 405.28 |
| 1966 | 50.78 | 55.38 | 35.67 | 15.17 | 0.00 | 74.31 | 1.69 | 0.00 | 1.76 | 96.59 | 8.40 | 52.33 | 392.08 |
| 1967 | 50.78 | 55.38 | 50.81 | 9.51 | 5.11 | 9.26 | 1.73 | 1.65 | 0.00 | 4.88 | 8.38 | 50.68 | 248.17 |
| 1968 | 50.78 | 55.38 | 49.80 | 9.53 | 4.85 | 3.53 | 0.00 | 0.00 | 0.00 | 6.82 | 8.43 | 50.68 | 239.80 |
| 1969 | 50.78 | 55.38 | 50.81 | 11.05 | 6.65 | 10.84 | 3.37 | 1.64 | 0.00 | 3.38 | 8.34 | 50.45 | 252.69 |
| 1970 | 50.78 | 55.38 | 50.81 | 9.62 | 6.67 | 1.23 | 1.69 | 0.00 | 1.78 | 141.89 | 8.41 | 50.47 | 378.73 |
| 1971 | 50.78 | 55.38 | 50.81 | 9.51 | 3.40 | 1.84 | 1.69 | 1.68 | 1.76 | 16.90 | 8.40 | 52.33 | 254.48 |
| 1972 | 50.78 | 55.38 | 52.15 | 8.20 | 8.43 | 2.91 | 1.69 | 1.61 | 1.76 | 3.29 | 6.86 | 50.47 | 243.53 |
| 1973 | 50.78 | 55.38 | 50.81 | 9.32 | 1.53 | 80.12 | 20.14 | 0.00 | 0.00 | 6.78 | 8.55 | 52.30 | 335.71 |
| 1974 | 50.78 | 55.38 | 36.17 | 15.05 | 3.40 | 2.91 | 5.20 | 0.00 | 3.40 | 5.12 | 5.00 | 52.33 | 234.74 |
| 1975 | 49.38 | 50.20 | 50.38 | 10.81 | 5.05 | 1.84 | 5.06 | 1.64 | 1.61 | 3.43 | 5.04 | 45.55 | 229.99 |
| 1976 | 51.04 | 56.36 | 43.30 | 9.44 | 3.40 | 35.66 | 1.65 | 0.00 | 0.00 | 3.34 | 6.77 | 42.76 | 253.72 |
| 1977 | 50.78 | 55.38 | 42.01 | 16.93 | 6.96 | 48.22 | 81.65 | 79.87 | 0.00 | 52.20 | 8.03 | 52.33 | 494.36 |
| 1978 | 50.78 | 55.38 | 34.55 | 13.73 | 3.40 | 124.91 | 146.23 | 1.64 | 9.37 | 123.83 | 5.11 | 50.47 | 619.40 |
| 1979 | 50.78 | 55.38 | 50.81 | 9.47 | 5.24 | 10.75 | 50.57 | 37.71 | 79.56 | 7.41 | 11.92 | 50.47 | 420.07 |
| 1980 | 50.78 | 55.38 | 52.15 | 9.21 | 6.94 | 22.49 | 1.81 | 38.55 | 0.00 | 3.49 | 6.83 | 50.45 | 298.08 |
| 1981 | 50.78 | 55.38 | 50.81 | 8.27 | 6.85 | 11.77 | 3.37 | 0.00 | 1.81 | 6.51 | 6.75 | 52.35 | 254.65 |
| 1982 | 50.78 | 55.38 | 44.36 | 9.38 | 8.51 | 5.26 | 1.69 | 0.00 | 0.00 | 4.91 | 6.73 | 50.45 | 237.45 |
| 1983 | 50.78 | 55.38 | 50.81 | 11.05 | 6.90 | 4.82 | 4.98 | 1.69 | 198.69 | 1.76 | 8.42 | 50.45 | 445.73 |
| 1984 | 50.78 | 55.38 | 43.19 | 14.74 | 3.61 | 148.36 | 74.06 | 62.12 | 0.00 | 3.29 | 6.85 | 50.45 | 512.83 |
| 1985 | 50.78 | 55.38 | 44.36 | 13.13 | 3.45 | 25.31 | 53.12 | 0.00 | 1.68 | 80.96 | 7.22 | 52.31 | 387.70 |
| 1986 | 50.78 | 55.38 | 44.36 | 16.59 | 5.09 | 10.74 | 1.69 | 1.66 | 1.76 | 3.40 | 7.02 | 52.33 | 250.80 |
| 1987 | 50.78 | 55.38 | 44.48 | 18.52 | 6.85 | 21.13 | 1.81 | 1.64 | 0.00 | 4.93 | 3.37 | 50.47 | 259.36 |
| 1988 | 50.78 | 55.38 | 52.15 | 6.13 | 3.40 | 2.20 | 83.68 | 39.38 | 128.41 | 42.86 | 8.43 | 50.68 | 523.48 |
| 1989 | 50.78 | 55.38 | 37.68 | 7.96 | 6.59 | 28.44 | 5.06 | 4.93 | 22.27 | 50.69 | 8.40 | 52.33 | 330.51 |
| 1990 | 50.78 | 55.38 | 27.64 | 9.61 | 3.48 | 19.44 | 0.00 | 3.29 | 0.00 | 5.05 | 6.87 | 50.47 | 232.01 |
| | | | | | | | | | | | | | |
| Ave. | 50.98 | 55.00 | 45.34 | 11.69 | 5.00 | 32.32 | 20.69 | 9.47 | 15.50 | 28.83 | 7.33 | 50.55 | 332.80 |

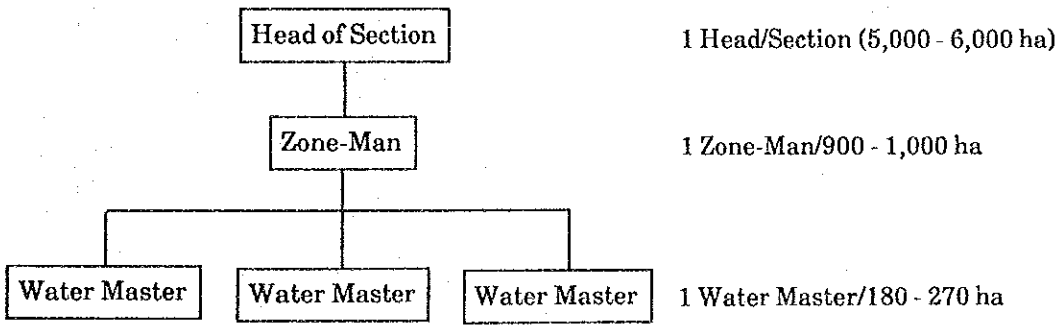
| | | |
|---|---|---|
| Main canal(Irrigation area > 2,000 ha) | : | q = 1.00 lit/sec/ha |
| Lateral Canal(Irrigation area 2,000 - 1,000 ha) | : | q = 1.50 |
| (Irrigation area 1,000 - 200 ha) | : | q = 2.10 |
| (Irrigation area 200 - 40 ha) | : | q = 2.90 |

Note: Details of these estimations are referred to the paragraph 5.5 "Irrigation Development Plan".

3) Water Distribution and Management

Irrigation water is conveyed through main and lateral canals. The gate operations will be carried out by RID staff as Water Masters who are to be assigned at every 180 to 270 ha (1.1 to 1.7 thousand rai), corresponding to three groups of Water Users' Associations, which will be newly organized in the benefited area. Each Section previously mentioned will be further divided into several Zones, and water distribution in each Zone is to be managed by a Zone-Man as shown below;

Organization of Water Management




RID has the responsibility of water distribution at the location of turn-out, which will cover the terminal irrigation areas of 300 to 500 ha (1.9 to 3.1 thousand rai), while the water distribution and management lower than the turn-out will be made by the Water Users' Association established by farmers.

Meteorological observation stations will be set up and daily rainfall will be observed, and those records are to be used for water management in the area.

Allocation of irrigation water on a daily basis will be made on a weekly basis (from Friday to Thursday), and calculations of daily water demands will be made taking into account the cropping pattern, agreed unit water requirement and effective rainfall observed in the previous week. These calculations are to be carried out by computers installed in the Head Office.

### 3. 2. 4 Irrigated Agricultural Plan

1) Proposed Cropping Pattern

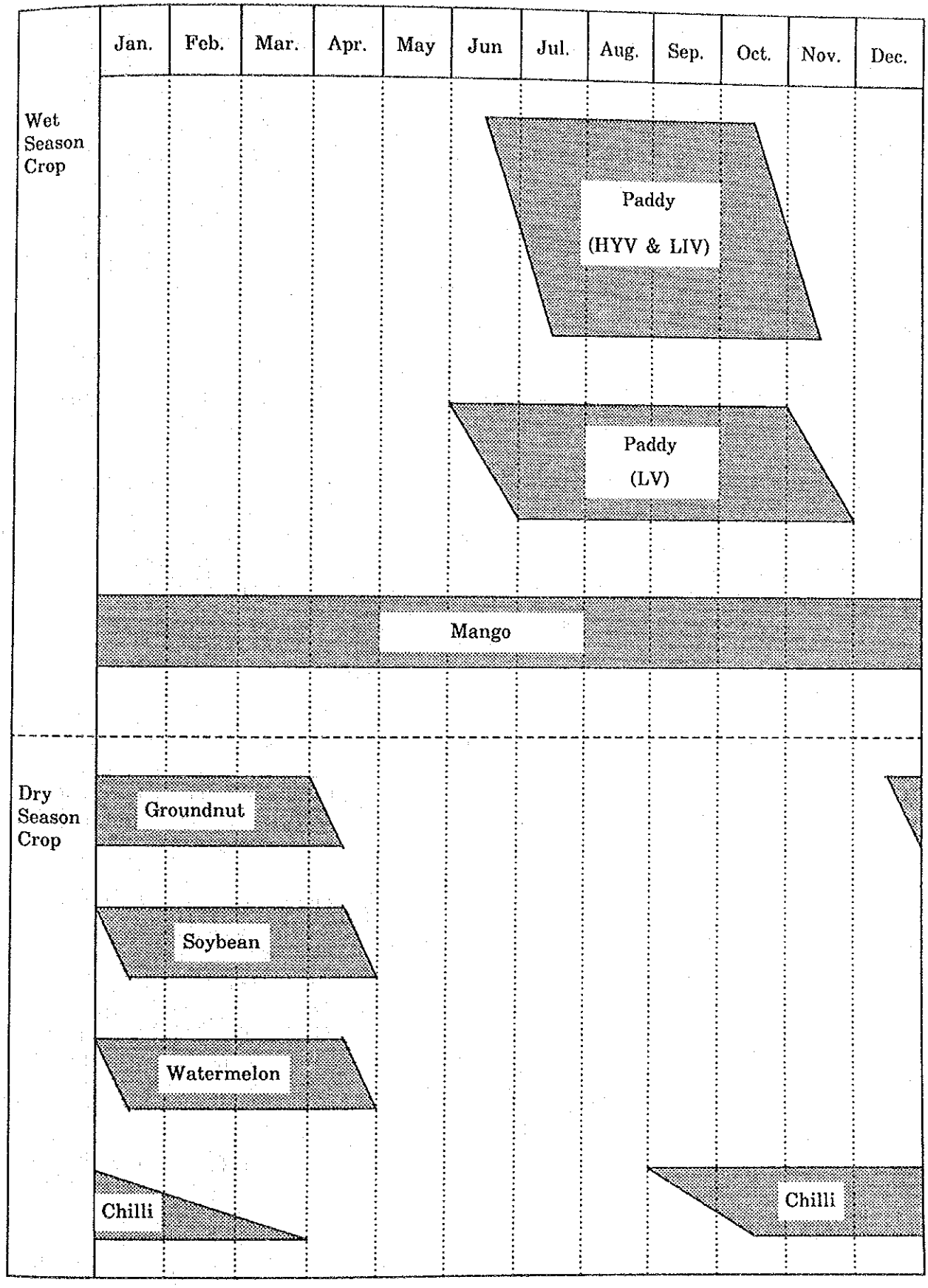
Irrigation water to be supplied by the proposed reservoir is mainly used for wet season paddy to stabilize its production. For dry season crops, such as groundnut, soybean, watermelon and chilli, 15 percent of the proposed dry season crop areas will be irrigated. Mango as perennial crop will be introduced to promote agricultural diversification. The proposed cropping pattern is shown in Figure 3-2, taking into account the consultation with the Provincial Agricultural Extension Office, extension workers of Amphoe Offices, and the village chief in each Muban about crop marketability and soil quality.

2) Improvement of Farming Practices

Enforcement in the following farming practices is advised for the improvement of current agricultural productivity in the basin.

- The soil fertility of the basin is poor, and organic matter content is minimal in the top and/or sub-surface soil layer. Therefore, it is necessary to input compost and/or green manure for paddy soils. Pasture production increases for both feed and green manure output.
- Fish breeding in paddy fields is an important source of protein for farm households. Moreover, such fish breeding in the paddy fields has proven to increase paddy yield.
- Extremely low paddy yield can be seen locally in the basin. This is primarily caused by disease and insects. It is essential to prevent such a phenomenon, therefore, disease resistant seeds must be introduced and dispersed among farmers in the area.

FIGURE 3-2 PROPOSED CROPPING PATTERN



- Under the existing quality of rice seeds, the quality of rice is relatively low. Preserving better seeds and sowing on a nursery bed are required for the production of the quality rice.

- Disease and insects of kenaf and maize are dominant among the upland crops. Crop rotation, application of resistant varieties, and seed preparation for planting before seeding are advisable.

- On upland fields in sloping areas, introduction of contour farming is effective for prevention of soil erosion.

- Cassava should be cultivated by crop rotation, since soil productivity decreases gradually.

- For groundnut cultivation, land preparation and soil improvement by spraying lime is required along with the selection of better quality seeds and crop rotation.

- Module bacteria is effective for cultivation of groundnuts, mungbeans, etc. It is necessary to instruct farmers that soils, which had formerly been cultivated for pulse, should enrich the area for groundnuts, mungbeans, etc. Pulse crops are also effective where land has been used repeatedly for same-crop cultivation to avoid disease and poor growth, and for the disinfection of seeds.

- For fruit trees, instructions with characteristics of species, improvement through grafting, etc. should be given to farmers.

- Considering cultivation conditions of rainfed paddy, grassland development should be promoted for livestock promotion as long as possible.

- Diffusion of sericulture by the establishment of a silkworm egg breeding center and promoting mulberry cultivation is suggested.

- Other recommendation include: a)countermeasures for watershortage in livestock production, b) sanitary improvement (infectious disease, vaccine, etc.), and c) preserving pasture seeds.

3) Proposed Crop Productivity

a) Crop Selection

The stored water in the reservoir, to be constructed by the project, will be supplied as supplementary irrigation water for wet season paddy. Stable and high yielding paddy production are expected. According to the Seventh National Economic and Social Development Plan (1992 - 1996), a plan for increasing mango production is recommended to promote diversification and also stabilize farm income. Mango is good as a commercial crop and it comes into major fruit trees under the present situation in the basin. Therefore, the existing cultivation technique and marketing system are applicable to this crop. Irrigation water supply for an area of 15 percent of the proposed project area will be made in the dry season.

The crops to be introduced during the dry season are upland crops such as groundnuts, soybeans, watermelons and chilli, which were proposed on the basis of the extension plan, farmer's experience and marketability with staff in the Provincial and Amphoe Agricultural Extension Office and Upland Crop Research Center (refer to Figure 3-3).

b) Target Yield of Crops

Paddy

The paddy seeds that were developed at the rice research center of DOA are the most common. The varieties of non-glutinous rice, such as KDML 105 and RD 15, etc., are mainly planted, and the varieties of glutinous rice, RD 6 and RD 8, etc., are planted as typical species.

Water shortages are the greatest cause of low productivity in the basin. It is possible to expect a target yield equal to those of similar projects of the Lam Dom Noi and Sebai-Sebok Projects.

Mango

Mango can adapt to any kind of soil but drainage conditions are very important. Fructification depends on dry conditions during the flowering stage

(January - March). Natural resources in the basin suit the conditions. Biennial bearing will decrease by enough management practices after the project. 680 pieces of fruit per tree or 9,375 kg/ha will be expected.

Groundnuts and Soybeans

A high yield of groundnuts and soybeans grown with the improved water supply is expected after the project. Cultivation of pulse crops are encouraged by the Provincial Agricultural Extension Office, because planting them improves the soil condition. The target yield for crops was settled by environ project referrals.

Watermelons

In Ubon Ratchathani Province, watermelons grown in the producing district are sent to Bangkok. According to a production cost survey in OAE, the yield gives actual results of about 16,070 - 22,680 kg/ha, and adjacent projects have shown equivalent yields. In the basin, higher productivity levels are expected since irrigation water is to be supplied.

Chilli

In Ubon Ratchathani Province, chilli has high production rates and are popular with farmers as a cash crop. With the proposed water supply, stabilized production will be expected.

The target yield of crops to be irrigated are shown below;

**Proposed Target Yield of Crops**

| Crops | Yield | | Present Yield |
|---|---|---|---|
| | kg/ha | kg/rai | |
| Paddy | 3,438 | 550 | 1,413 kg/ha*1 |
| Mango | 9,375 | 1,500 | |
| Groundnuts | 1,563 | 250 | 1,363 |
| Soybean | 1,250 | 200 | 1,125 |
| Watermelon | 25,000 | 4,000 | |
| Chilli (fresh) | 15,625 | 2,500 | |

Note: *1 based on 1989/90 data in Ubon Ratchathani and Si Sa Ket Provinces.

4) Proposed Variable Costs and Income of Products

The increase in crop yield for wet season paddy and the introduction of upland crop in the dry season will be expected with the supply of irrigation water, improvement of the farm management and strengthening of the agricultural extension activities.

The proposed variable costs are estimated as shown below, taking into account the data and information obtained from DOAE, the Report on Agriculture and the Soil Analysis of the Lam Dom Noi District, and the results of the farm household economic survey, as below;

Net Income by Irrigated Crops in Future

| Crops | Yield | Farmgate Price | Gross Income | Variable Cost | Fixed Cost | Net Income |
|---|---|---|---|---|---|---|
| | (kg/ha) | (Baht/kg) | (Baht/ha) | (Baht/ha) | (Baht/ha) | (Baht/ha) |
| Paddy (Wet) | 3,438 | 3.4 | 11,689 | 5,448 | 713 | 5,528 |
| Groundnuts | 1,563 | 7.1 | 11,097 | 8,638 | 648 | 1,811 |
| Soybean | 1,250 | 7.3 | 9,125 | 6,656 | 648 | 1,821 |
| Watermelon | 25,000 | 0.9 | 22,500 | 14,830 | 706 | 6,964 |
| Chilli | 15,625 | 7.0 | 109,375 | 73,644 | 788 | 34,943 |

As mentioned above, the remarkable increase in agricultural production and farm income in the basin will be expected from the high productivity and the introduction of upland crops during the dry season; these will be produced with the development of the Lam Dom Yai basin.

5) Increase of Farmer's Income

The favorable farming conditions gained from the project will bring forth results such an increase in farm income, improvement of farming, living standards of farmers, and etc.

As described in 2.8.2, "Farmers' Income and Poverty Conditions", the average farm in the upper, middle and lower-parts of the basin is set up by the farm household economic survey. In the future, increase in the farmers income can be correlated to crop yield increases, despite the increase of agricultural

input. As shown in the following table, the gross income from wet season paddy production will be 49,555 - 57,035 Baht and its increased income attains 29,395 - 36,550 Baht. Besides, the irrigated crops in the dry season, as represented to the middle-basin, will produce the gross income of 9,120 Baht. This is additional income for the farmer. Accordingly, the gross farm income of the average farm in the middle-basin will amount to 62,533 Baht.

As a result, it is possible that the benefited farmers in the area will be elevated from the low-income group being ensured at the high income level by stabilized farming.

Farmer's Income in the Future

(Unit: Baht)

| Item | Upper-Basin | Middle-Basin | Lower-Basin |
|---|---|---|---|
| Cropping Area | 4.25 ha (26.58 rai) | 5.24 ha (32.73 rai) | 4.50 ha (28.13 rai) |
| Gross Income | 60,106 | 65,803 | 61,690 |
| Variable | 31,114 | 33,220 | 31,252 |
| Overhead Cost | 1,986 | 3,057 | 3,168 |
| Net Income | 27,006 | 29,526 | 27,270 |
| Family Labor | 12,902 | 14,756 | 14,021 |
| Farmers' Income | 27,006 | 29,526 | 27,270 |

6) Improvement of System and Institution for Production Promotion

On the grounds that most farmers in the basin hold conservative views and have low levels of faming and education, the attitude of the farmers concerning the introduction of new crops is negative as a whole, and they are liable to persist in the practices of traditional farming. However, due to the introduction of irrigated agriculture and project implementation, farmers can raise their maximum profits and restrict crop opportunity failures to a minimum; it is possible to establish an integrated farming system by developing the farming potentials of farmers, through a change in farmers' consciousness.

With the improvement of the production promotion system of the project, it is necessary to take measures concerning these matters mentioned above. It seems that the results of the studies on the "Northeast Rainfed

above. It seems that the results of the studies on the "Northeast Rainfed Agricultural Development (NERAD) Project", conducted by the Northeast Regional Office of Agriculture, MOAC, are very useful for agricultural promotion in the basin, and the results to be adopted from the promotion are numerous.

Furthermore, due to the aquisition of new farming techniques through the introduction of irrigated agriculture, the strengthening of in-service training for extension workers and agents and the technical transfer training for farmers must be conducted. Production promotion is closely connnected with the marketing of products, nevertheless, there are no existing marketing facilities in the area. Therefore, establishment of post harvest facilities for paddy should be planned. Moreover, the strengthening of the marketing section of Marketing Organization of Farmers (MOF), which does not fulfill its marketing function at present, is desired. Soybean is one of the project's new crops, but actually, a marketing system does not exist in the area or its surroundings. Consequently, it is desirable to actualize the Soybean Marketing Scheme promoted by BAAC in the basin, in addition to the establishment of local markets.

As mentioned above, an improvement plan is proposed comprising the following;

- Diffusion of irrigation techniques for wet season paddy
- Diffusion of appropriate cropping pattern and farming techniques
- Acceleration of farmland consolidation
- Diffusion of fruit growing
- Diffusion of freshwater fishery (raising fish in the paddy, fish ponds, village fish ponds, school fish ponds)
- Diffusion of animal breeding (raising chicken in the garden, hygiene and vaccination for cattle, village breeding area)
- Diffusion of reforestation (village forest, community forest with grass)
- Provision of a marketing system for products
- Expansion of BAAC client group

DOAE is being improved and strengthened by the National Agricultural Extension Project and the Tambon Agricultural Center has been set up under the project at the Tambon level. Suitable guidance is expected to be provided by strengthening institutions and training extension workers and agents.

Fortunately, there are two research centers (for rice and upland crops) of DOA and a seed center of DOAE adjoining the area. An appropriate system is needed for conducting training and guidance programs for extension workers and agents and also for progressive farmers of the benefited area with the project through the effective use of these facilities. Especially, due to the lack of experience for irrigated agriculture in the area, the strengthening of training and guidance on this matter is necessary. In addition, the establishment ademonstration farm utilizing farmland owned by a progressive farmer is being considered.

The expansion and the strengthening of farmer institutions are indispensable for the development of the rural community, so it is desirable to strive for expansion based on existing institutions which are actively supported by the Provincial and Amphoe Agricultural Extension Offices. This is in connection with the issue of the improvement plan of the production promotion system.

### 3. 2. 5 Improvement Plan of Rainfed Agriculture

To improve the present rainfed agriculture, the following measures are considered.

1) Moisture Preservation

In order to effect moisture preservation by preserving the soil moisture in the fields and reducing evaporation from the soil surface, the following methods are considered;

Mulching Method

Mulching is not only effective for the drought, but it is also useful for the prevention of soil erosion, hence, it helps infiltrate surface flow water with heavy rain. It is preferable to use the pulse plants, ie. intercropping with main crops, as material for mulching. Additionally, the improvement and maintenance of soil productivity by growing pulse plants as the after-crop of main crop cultivation can be expected.

As regards the crop cultivation management, uniformity of planting is required. Non-uniformity of planting cannot increase the productivity. Therefore, uniform land preparation, well-suited fertilization, moisture preservation, and procurement of fine seeds are necessary.

Green Manure Cultivation

The basin covers the areas of sandy soil with poor organic substances. Under the circumstances, the aim of soil preservation for paddy is to increase the organic matter of soil by means of green manure cultivation. In the Northeast Rainfed Agricultural Development Project, which has been managed by the Northeast Regional Office of Agriculture in Khon Kaen, the method has been studied.

2) Construction of Small-Scale Village Ponds

In the basin, the annual mean rainfall is about 1,470 mm. The rainfall is mostly concentrated in the wet season. Consequently, supplemental irrigation water during the wet season, obtained through construction of village ponds, will enable increased and stabilized paddy yield. Such systems can be seen in rural areas of the Northeast, which has an unstable rainfall. Since the system mentioned is acceptable to farmers, the construction of small ponds in the villages should be promoted.

## 3.3 Water Resource Development Plan

### 3.3.1 Selection of Reservoir Sites

For the effective development of the water resources and for the expansion of irrigation areas in the basin, it is not only necessary to develop smaller medium-scale reservoirs, but also large-scale or larger medium-scale reservoirs. However, since there are few suitable sites for large-scale and larger medium-scale reservoirs, smaller medium-scale reservoirs are concurrently planned.

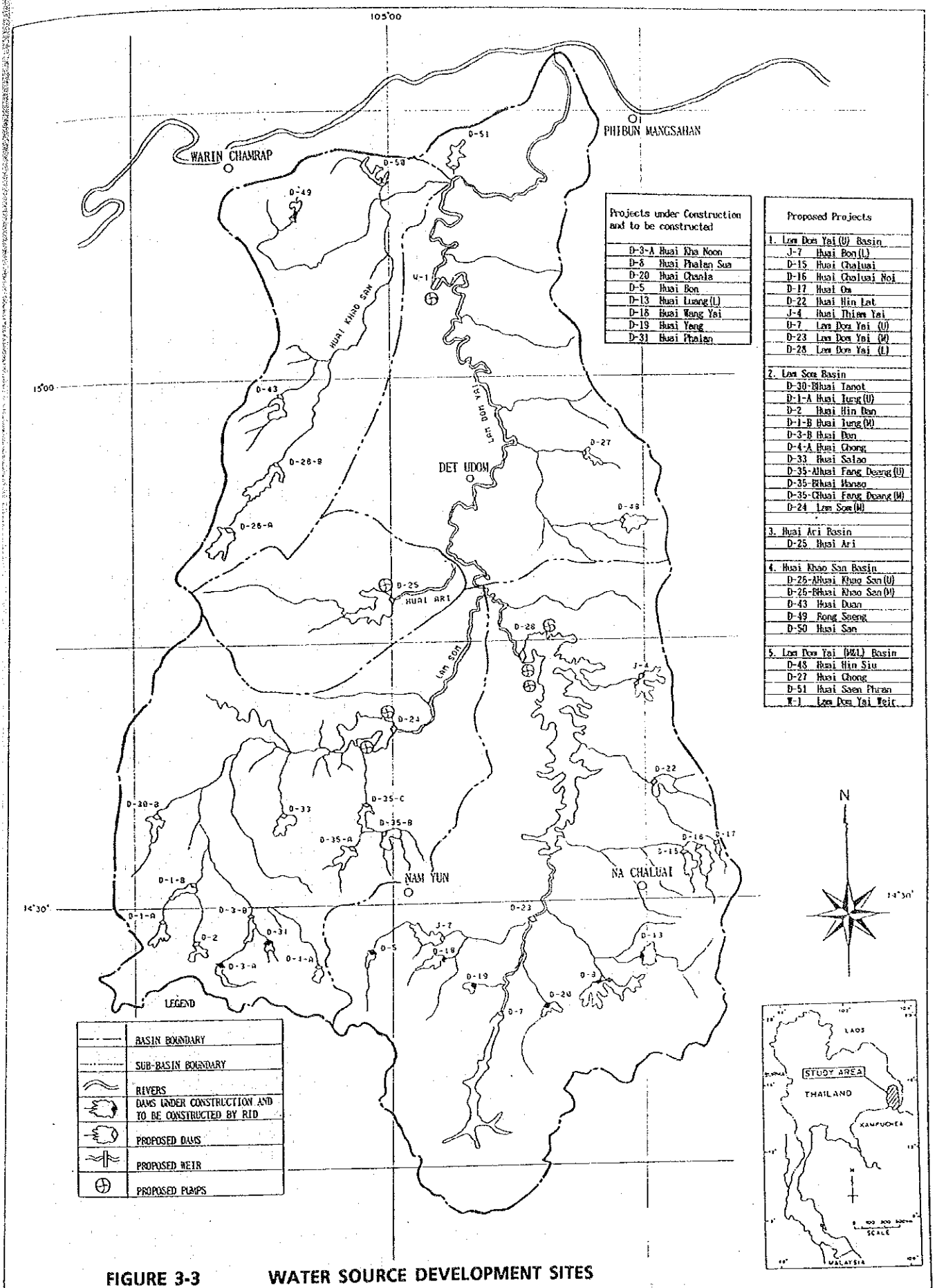
The selection of new water source sites for water source development was made based on a 1/50,000 topographical map, and 29 new developable water source sites were found in the whole basin (see Figure 3-3). The locations of these sites are shown by sub-basin on the table below.

New Water Resources Development Plan

| Item | Water Source Site | | | | | |
|---|---|---|---|---|---|---|
| | Lam Dom Yai (U)1/ | Lam Som | Huai Ari | Huai Khao San | Lam Dom Yai (M&L)2/ | Total |
| Catchment Area (sq.km) | 1,561 | 1,104 | 274 | 608 | 1,358 | 4,905 |
| Water Storage Plan (pls.) | | | | | | |
| - Larger-Scale | 2 | - | - | - | - | 2 |
| - Larger Medium-Scale | - | 1 | 1 | - | - | 2 |
| - Smaller Medium-Scale | 6 | 10 | - | 4 | 4 | 24 |
| Run-of-River Plan (pls.) | | | | | | |
| - Smaller Medium-Scale | - | - | - | - | 1 | 1 |
| Total | 8 | 11 | 1 | 4 | 5 | 29 |

1/ U : Upper-stream 2/ M: Middle-stream L: Lower-stream

The detail of water resources development plan by sub-basins is described in Annex E.




Projects under Construction and to be constructed

| | |
|---|---|
| D-3-A | Huai Kha Noon |
| D-8 | Huai Phalan Sua |
| D-20 | Huai Chanla |
| D-5 | Huai Bon |
| D-13 | Huai Luang(L) |
| D-16 | Huai Wang Yai |
| D-19 | Huai Yang |
| D-31 | Huai Phalan |

Proposed Projects

| | |
|---|---|
| **1. Lam Dom Yai(U) Basin** | |
| J-7 | Huai Bon(L) |
| D-15 | Huai Chaluai |
| D-16 | Huai Chaluai Noi |
| D-17 | Huai Os |
| D-22 | Huai Hin Lat |
| J-4 | Huai Thien Yai |
| D-7 | Lam Dom Yai (U) |
| D-23 | Lam Dom Yai (M) |
| D-28 | Lam Dom Yai (L) |
| **2. Lam Som Basin** | |
| D-30-B | Huai Tanot |
| D-1-A | Huai Tung(U) |
| D-2 | Huai Hin Dan |
| D-1-B | Huai Tung(M) |
| D-3-B | Huai Don |
| D-4-A | Huai Chong |
| D-33 | Huai Salao |
| D-35-A | Huai Fang Deang(U) |
| D-35-B | Huai Manao |
| D-35-C | Huai Fang Deang(M) |
| D-24 | Lam Som(M) |
| **3. Huai Ari Basin** | |
| D-25 | Huai Ari |
| **4. Huai Khao San Basin** | |
| D-26-A | Huai Khao San(U) |
| D-26-B | Huai Khao San(M) |
| D-43 | Huai Duan |
| D-49 | Rong Saeng |
| D-50 | Huai San |
| **5. Lam Dom Yai (M&L) Basin** | |
| D-48 | Huai Hin Siu |
| D-27 | Huai Chong |
| D-51 | Huai Saen Phran |
| W-1 | Lam Dom Yai Weir |

**FIGURE 3-3 WATER SOURCE DEVELOPMENT SITES**

### 3. 3. 2 Irrigation Areas According to Water Source Development and Their Evaluation

1) Conditions of Water Balance Study

For the water balance study of the enter river basin, the following conditions were set up.

- The water balance study will be made on a monthly basis.
- For water balance study, run-off discharge and unit irrigation requirements of a 1/5 probable drought year will be taken as the values for a basic year.
- For an estimate of run-off discharge for each sub-basin, the run-off discharge at D-28 on the Dom Yai river is used. Incidentally, 95 percent of the run-off discharge at each reservoir site is regarded as effective river flow for each reservoir and the remaining five percent of run-off is retained as the water to be compulsorily released into the lower-basin and as the water right of SSIP and small-scale water source facilities.
- The total water area and water capacity of the medium-scale reservoir that is to be planned, were estimated with a 1/50,000 topographical map. The dimensions of such large-scale and larger-medium scale reservoirs as D-28, D-23, D-24, and D-25 were examined based on a 1/10,000 topographic map.
- Estimate of irrigation requirement were evaluated on the basis of the cropping intensity of the wet season paddy being 100 percent and that of dry season crops, 15 percent. The cropping period for wet season paddy was determined as the period from the middle of June to the middle of November and that for dry season dry crops from the beginning of December to the middle of April, in order to utilize the rainfall effectively. The irrigation requirement was finally estimated monthly, examining crop consumptive use, effective rainfall, field losses and irrigation efficiency. As a result, the water requirement for the upper-basin and for the middle and the lower-basin were found to be 546 mm/year and 386 mm/year, respectively.
- As for reservoir losses, it was regarded that the evaporation amount from the reservoir surface was 70 percent of that from a gauge, and the percolation from a reservoir was equal to three percent of its storage capacity.

- In the water balance study, water balance calculations for the upstream reservoirs were conducted for the first time; the consequent overflow discharge was added to the flowing discharge into the reservoirs downstream and then the run-off discharge downstream was estimated.

- The water balance study on weirs was made every tenth day. The water demand was tightest in March.

2) Irrigable Area

The summary of the water balance study is shown in Table 3-2, (including the projects under construction and to be constructed by RID). Details are shown in Annex E.

From the development mentioned above, it can be seen that water resources can be utilized for irrigation in the Dom Yai river basin. The rate of water resource utilization will reach 21 percent; it will increase rapidly from the existing six percent. The irrigated area is also increased from the present 15,660 ha (97.9 thousand rai) to 100,830 ha (630.2 thousand rai) corresponding to a high irrigation rate of 45 percent of the entire planned agricultural land.

However, the remaining agricultural land of 55 percent will be left unchanged for rainfed agriculture.

TABLE 3-2 SUMMARY OF OVERALL RIVER BASIN WATER BALANCE STUDY AND IRRIGABLE AREA

| Item | Lam Dam Yai (U) | Lam Som | Huai Ari | Huai Khao San | Lam Dom Yai (M&D) | Total |
|---|---|---|---|---|---|---|
| 1. Smaller Medium-Scale Reservoir | | | | | | |
| Total Run-off (MCM) | 217 | 115 | - | 62 | 32 | 426 |
| Total Effect. Storage Capa. (MCM) | 106 | 36 | - | 14 | 6 | 162 |
| Total Water Utili. Amount (MCM) | 84 | 57 | - | 12 | 8 | 161 |
| Total Reservoir Losses (MCM) | 44 | 21 | - | 15 | 5 | 85 |
| Total Overflow Amount (MCM) | 89 | 37 | - | 35 | 19 | 180 |
| Irrigable Area (ha) | 15,630 | 10,510 | - | 3,140 | 1,950 | 31,230 |
| 2. Larger Medium-Scale and Large-Scale Reservoir | | | | | | |
| Total Run-off (MCM) | 497 | 276 | 89 | - | - | 862 |
| Total Effect. Storage Capa. (MCM) | 205 | 7 | 19 | - | - | 231 |
| Total Water Utili. Amount (MCM) | 213 | 18 | 28 | - | - | 259 |
| Total Reservoir Losses MCM) | 70 | 10 | 13 | - | - | 73 |
| Total Overflow Amount (MCM) | 214 | 248 | 48 | - | - | 510 |
| Irrigable Area (ha) | 55,170 | 4,770 | 7,160 | - | - | 67,100 |
| 3. Smaller Medium-Scale Reservoir | | | | | | |
| Total Run-off (MCM) | - | - | - | - | 499 | 499 |
| Total Effect. Storage Capa. (MCM) | - | - | - | - | 10 | 10 |
| Total Water Utili. Amount (MCM) | - | - | - | - | 489 | 489 |
| Irrigable Area (ha) | - | - | - | - | 2,500 | 2,500 |
| 4. Total | | | | | | |
| Total Run-off (MCM) | 714 | 391 | 89 | 62 | 531 | 1,787 |
| Total Water Utili. Amount (MCM) | 297 | 75 | 28 | 12 | 18 | 430 |
| Irrigable Area (ha) | 70,800 | 15,280 | 7,160 | 3,140 | 4,450 | 100,830 1/ |

1/ : including the irrigable area of 8,960 ha by projects under construction and to be constructed by RID.

Total Irrigable Area by Overall River Basin Water Resource Development

| Irrigation Project | Irrigable Area (ha) | Ratio to Planned Agri. Land (%) |
|---|---|---|
| 1. Present Conditions | | |
| a) Existing small-scale irrigation projects and other small-scale water resources development project | 6,700 | 3 |
| Sub-total | 6,700 | 3 |
| 2. Proposed Water Resource Development Plan | | |
| a) Irrigation projects under construction or to be constructed by RID | 8,960 | 4 |
| b) Newly proposed projects | 91,870 | 41 |
| Sub-total | 100,830 | 45 |

Note: 1. The irrigation area of existing small-scale water resources development projects is not counted in the proposed water resources development plan, because the former irrigation area is mostly included in the latter one.
2. The area of planned total agricultural land is 222,000 ha

### 3.3.3 Water Resources Distribution Plan

The total amount of developed water resource is obtained by adding all the water resources developed at 29 new sites to the one developed at the eight reservoirs under construction or to be constructed by RID. The water will be distributed according to the following courses.

- The amount of water developed at smaller medium-scale reservoirs will be utilized for total agricultural land of 31,230 ha (195.2 thousand rai) just downstream from each reservoir by gravity irrigation system.
- The amount of water developed at the D-28 reservoir, located in the middle-basin of the Lam Dom Yai, will be utilized for the agricultural land of 30,970 ha (193.6 thousand rai) on both the banks just downstream of the reservoir and in the lower-basin of Lam Som by a pumping irrigation system.

- The D-7 reservoir located in the upper-basin of the Lam Dom Yai has a good potential for water resource development, but it does not have a benefited area downstream from the reservoir. Accordingly, in order to effectively utilize the water resources to be developed, to extend the irrigable area, and to distribute the water resources uniformly, the amount of water developed at the reservoir will be utilized for agricultural land in the adjacent sub-basins by a kind of catchment area conversion, that is, for agricultural land of 24,200 ha (151.3 thousand rai) in the three sub-basins to the west of this sub-basin, as Lam Som, Huai Ari and Huai Khao San. The amount of water developed will be conveyed and irrigate the benefited areas by way of reservoirs of D-28 and D-24 by pumping irrigation systems.

- The amount of water developed at the D-24 reservoir located in the middle-reaches of Lam Som sub-basin will be utilized for agricultural land of 4,770 ha (29.8 thousand rai) to the rear of the reservoir, in the middle-reaches of the Lam Som sub-basin by a pumping irrigation system.

- The amount of water developed at the D-25 reservoir located in the lower-reaches of Huai Ari sub-basin will be utilized for agricultural land of 7,160 ha (44.8 thousand rai) in the higher portion on the left bank in the middle-reaches of Lam Dom Yai sub-basin by a pumping irrigation system.

- The amount of water developed at the W-1 weir, located in the lower-basin of Lam Dom Yai main stream, will be utilized for agricultural land of 2,500 ha (15.6 thousand rai) on the left bank of the lower-basin of Lam Dom Yai main stream by a pumping irrigation system.

The water resources distribution plan made by the above courses is summarized in Table 3-3 from a viewpoint favoring irrigable area by sub-basin. The irrigated area rates of existing agricultural land in five sub-basins range from 37 to 58 percent. As a result, the water resource development amount is mostly uniformly distributed to the Lam Dom Yai basin.

Figure 3-4 shows the developed water resource distribution plan and the location of the irrigable areas in the Lam Dom Yai basin, and Figure 3-5 shows the relationship of the irrigable area among the major reservoirs schematically.

## TABLE 3-3 IRRIGATED AREAS BY WATER SOURCE DEVELOPMENT AND THEIR EVALUATION

| Item | | Lam Dam Yai (U) | Lam Som | Huai Ari | Huai Khao San | Lam Dom Yai (M&D) | Total |
|---|---|---|---|---|---|---|---|
| Watershed Area (sq.km) | | 1,561 | 1,104 | 274 | 608 | 1,358 | 4,905 |
| Agricultural Land (sq.km) | | 471 | 550 | 137 | 317 | 745 | 2,220 |
| Irrigated Area (sq.km) | | 172 | 223 | 80 | 173 | 360 | 1,008 |
| Water Resource Distribution Plan | | | | | | | |
| - Smaller Medium-Scale Reservoirs | (sq.km) | 156 | 105 | - | 31 | 20 | 312 |
| - D-28 Reservoir | (sq.km) | 16 | 50 | - | - | 244 | 310 |
| - D-7 Reservoir | (sq.km) | - | 20 | 80 | 142 | - | 242 |
| - D-24 Reservoir | (sq.km) | - | 48 | - | - | - | 48 |
| - D-25 Reservoir | (sq.km) | - | - | - | - | 71 | 71 |
| - W-1 Weir | (sq.km) | - | - | - | - | 25 | 25 |
| Irrigated Area Rate | (%) | 37 | 41 | 58 | 55 | 48 | 45 |

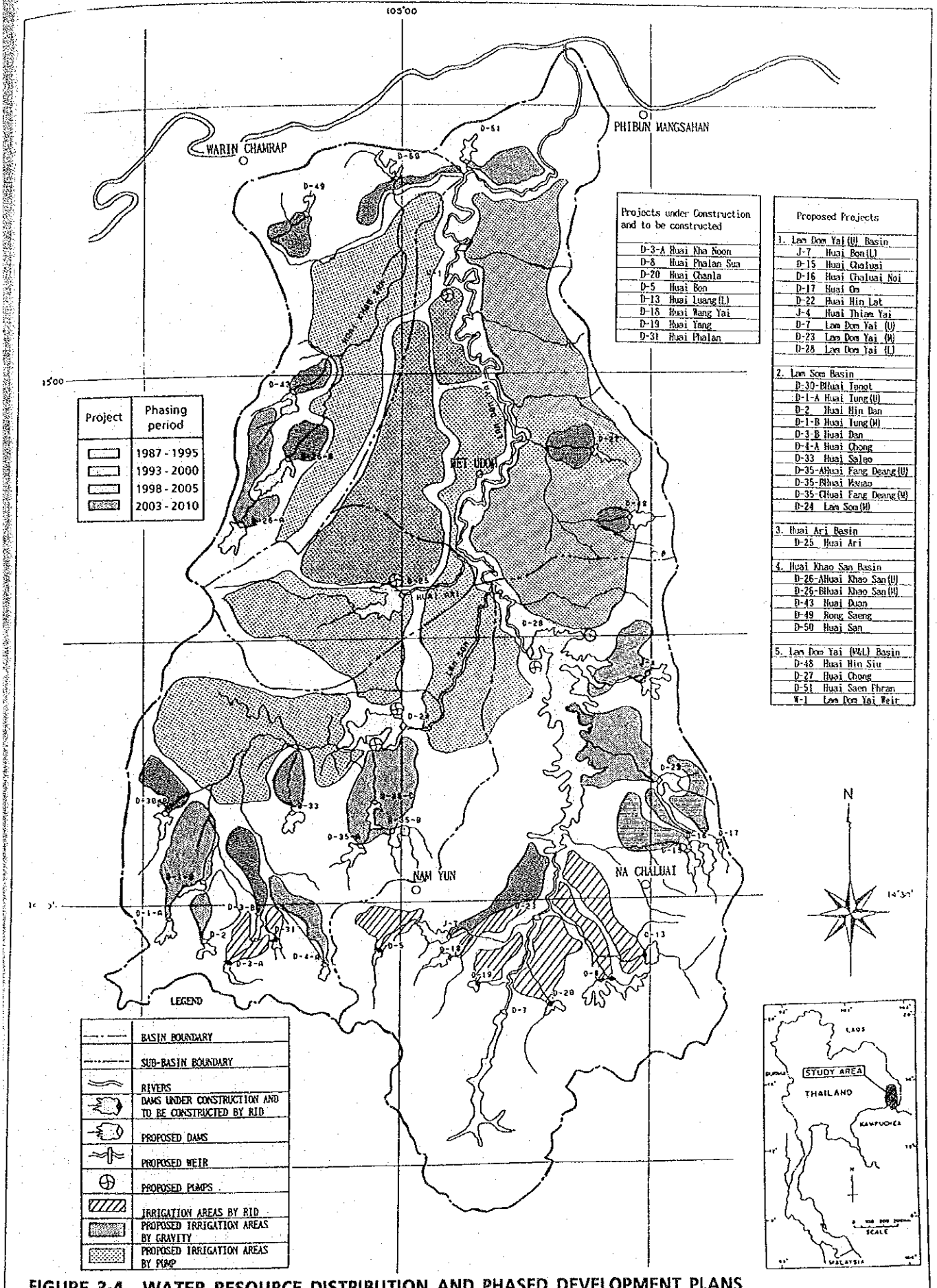
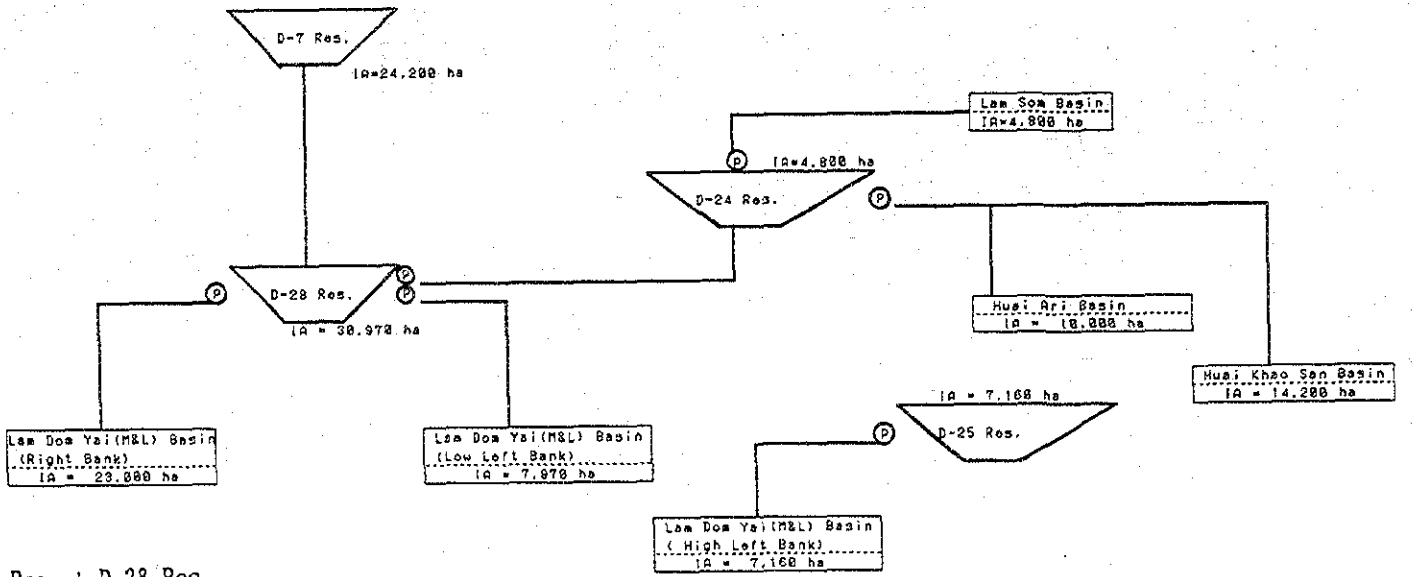


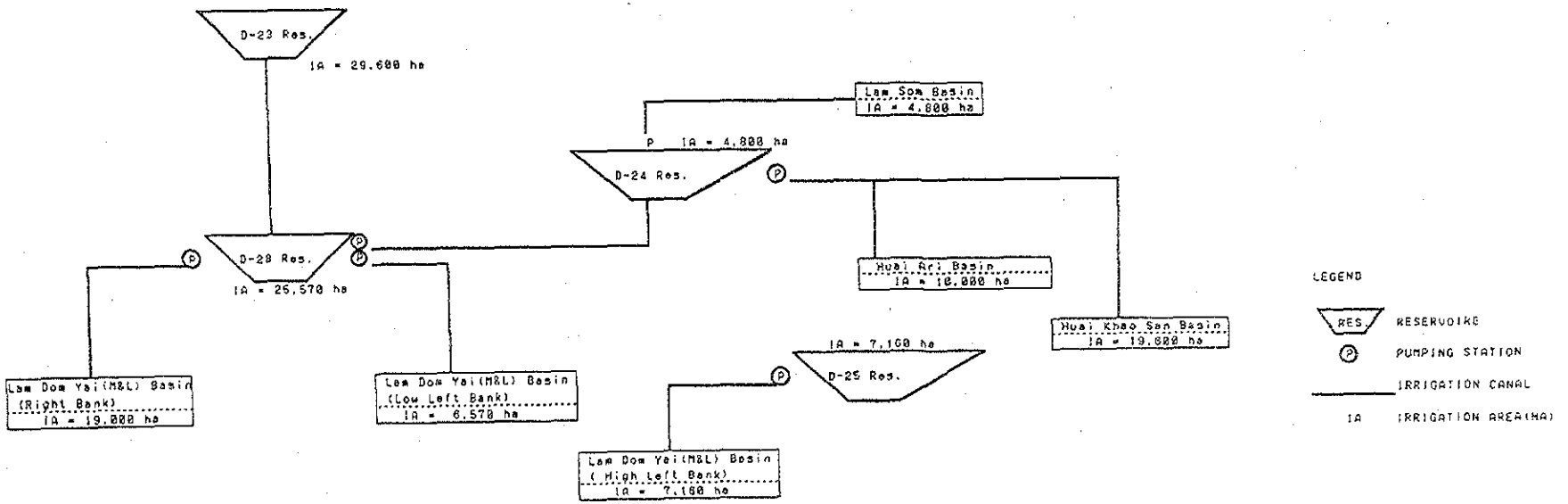

**FIGURE 3-4 WATER RESOURCE DISTRIBUTION AND PHASED DEVELOPMENT PLANS**

FIGURE 3-5 DIAGRAM OF WATER RESOURCES DISTRIBUTION PLAN AND ITS IRRIGATED AREA

Plan A: D-7 Res. + D-28 Res.




Plan B: D-23 Res. + D-28 Res.



### 3. 3. 4 Phased Development Plan for Water Resources in the Overall River Basin

The phased development plan for water resources in this river basin is established through consideration of the following items, and its phased development plan is shown in Figure 3-4.

- The eight projects under construction or to be constructed will be completed by 1995 as scheduled, and the new reservoir construction will be performed during a period of 18 years from 1993 to 2010.
- The water resource development will be implemented in three phases which have a unit development period of eight years including a construction period of five years.
- For the first period of development (1993 - 2000), the D-28 reservoir will be built as the core of the water resource development of the main river basin, while eight smaller medium-scale irrigation development projects of 24 projects will be constructed with a water resource development efficiency (available irrigation water rate to the amount of water resources flowing into the reservoirs) higher than 70 percent.
- For the second period of development (1998 - 2005), the D-7 and D-24 reservoirs will be constructed; construction will be judged according to the D-7 reservoir. Additionally eight smaller medium-scale irrigation sites with water rates higher than 50 percent will be constructed.
- For the third period of development (2003 - 2010), the W-1 weir, D-25 reservoir and the remaining 10 smaller medium-scale irrigation projects will be conducted.

The details of the phased development plan for water resources concerning the overall river basin, as determined by the above mentioned criteria, is shown in the following table. The rate of phased development in each area in the river will be raised gradually to 21, 38 and 45 percent, respectively.

## Phased Development Plan of Water Resources in Overall River Basin

| Phasing (Period) | Large-Scale or Larger Medium-Scale Projects | | Smaller Medium-Scale Projects | | Irrigation Area Rate (%) |
|---|---|---|---|---|---|
| | Project Name | Irri. Area (ha) | Project Name | Irri. Area (ha) | |
| Under Construction/to be Constructed (1987-1995) | - | - | D-5, D-18, D-19, D-20, D-8, D-13, D-3-A, D-31 | 8,960 | 4 |
| First-Phase Development (1993-2000) | D-28 | 30,970 | D-15, D-16, D-17, D-1-A, D-2, D-4-A | 5,770 | 21 |
| Second-Phase Development (1998-2005) | D-7<br>D-24 | 24,200<br>4,770 | D-22, J-4, D-33, D-35-A, D-35-B, D-35-C, D-26-A, D-51 | 9,630 | 38 |
| Third-Phase Development (2003-2010) | W-1<br>D-25 | 2,500<br>7,160 | Other 10 Projects | 6,870 | 45 |
| Total | | 69,600 | | 31,230 | |

## 3. 4 Water Source Facility Plans and Their Project Costs

### 3. 4. 1 Water Sources Facility Plans

1) New Water Source Facility Plan

a) Reservoir Plan

Designed Flood Discharge

For the designed flood discharge of the dam, a 1/500 year probable flood discharge is adopted, and the designed flood discharge for spillway is determined adding the storage effect of the reservoir.

Dam Type

Since the topography for dam-sites is generally very flat, dam feature coefficient will ranges from 20 to 50. Considering the above, an earthfill type should be adopted as a dam type. As a result of the survey on the existing volume of embankment materials, it can be considered that the embankment materials can be procured near to the dam-sites.

Dam Dimension

Based on the 1/50,000 topographic map, the dam axis profiles surveyed by RID during the fieldwork, and the 1/10,000 reservoir area plane, dam dimensions of the respective proposed project areas are determined as shown in Table E-2, Annex E.

The dam-planning standard adopted for determining the dimensions is as follows;

- Dam type : Earthfill type dam with slope of 1 : 3.0 and upstream and 1 : 2.5 downstream
- Dam crest width :

| Height of Dam (H) | Width of Dam Crest |
|---|---|
| $H < 20$ m | 6 m |
| $20 \leqq H < 40$ m | 8 m |
| $H \geqq 40$ m | 10 m |

- Dam clearance : 2.0 m above highest water level
- Sediment volume : 100 cu.m/year/sq.km × 100 year × catchment area (sq.km)

The dam height and volume roughly estimated are 10.0 to 48.0 m and 8,000 to 1,038,000 cu.m, respectively. Detailed dimensions of the dam are given in Annex E.

b) Weir Plan

The weir to be provided on the lower-basin of the Lam Dom Yai is a rubber dam type of three meter in height.

c) Pumping Station Plan

In this plan, seven pumping stations, as shown below, are planned. The total heads necessary for lifting water range from 10.5 to 26.5 m.

Pumping Station Plan

| Project | No. of Pumping Stations | Location of Station |
|---|---|---|
| D-7 : Lam Dom Yai (U) | 2 | On the left bank of D-28 reservoir and on the left bank of D-24 reservoir. |
| D-24 : Lam Som | 1 | On the right bank of D-24 reservoir. |
| D-25 : Huai Ari | 1 | On the left bank of D-25 reservoir. |
| D-28 : Lam Dom Yai (L) | 2 | On both of banks of D-28 reservoir. |
| W-1 : Lam Dom Yai Weir | 1 | On the left bank of W-1 weir. |

2) Water Source Facility Improvement Plan

Midium-Scale Irrigation Projects (MSIP)

Although the reservoirs of Huai Chanla and Huai Phalan Sua have recently been constructed, the stored water in the reservoir is not effectively utilized for irrigation purposes without complete provision of necessary irrigation facilities.

Small-Scale Irrigation Projects (SSIP)

Many small-scale irrigation projects have been constructed all over the country, aiming mainly at stabilizing the civil administration. 52 SSIP, with an irrigation area of 4,220 ha (23.4 thousand rai), executed by RID requires reservoir dredging and body improvement owing to age variation and lack of operation and maintenance. So far, there have been no irrigation canals built by the beneficiaries of almost all the project areas. For this reason, water sources facility improvements and irrigation canals constructions will be needed.

### 3. 4. 2 Project Costs

For the purpose of judging the priorities of respective projects, preliminary and rough project costs were estimated. For the estimate, the unit costs in the D-28 Lam Dom Yai Project, which were estimated through the Feasibility Study were used.

The project costs are composed of the costs of construction of the main facilities, land acquisition, construction of terminal facilities, agricultural supporting facilities, O/M equipment, survey and design, administration, engineering service, physical contingency and price escalation. The construction costs and the land acquisition costs were estimated using the following expressions. The others were calculated by the ratio of the direct or indirect construction costs.

- Dam construction = unit embankment cost × embankment volume + unit cost for spillway discharge × design flood discharge

  where, unit embankment cost = 185 Baht/cu.m (excluding spillway cost)

  unit cost for spillway = 181,000 Baht/cu.m/sec

- Weir construction cost = unit cost for rubber dam × weir length

  where, unit cost of rubber dam = 800,000 Baht/m (assuming that dam height is three meter)

- Pumping station construction cost = unit cost for pumping station × total motor output

  where, unit cost for pumping station = 48,500 Baht/kw

- Canal construction cost = unit canal cost × benefited area

  where, unit canal cost = 23,000 Baht/ha

- Terminal facilities cost = unit cost for terminal facilities × benefited area

  where, unit terminal facilities cost = 16,000 Baht/ha

- Land acquisition cost = high water reservoir area × 1.1 × unit purchasing cost

  where, unit purchasing cost = 70,000 Baht/ha (11,200 Baht/rai)

The project costs for respective projects and the unit development cost per hectare of irrigable areas estimated using the above-stated conditions are shown in Table 3-4. The unit development costs per hectare for the six priority plans selected in the previous paragraph range from 120,000 to 190,000 Baht/ha, which are ranked in the average position in the list of 31 project plans.

## TABLE 3-4 DEVELOPMENT COST PER HECTARE

| Code No. | Project | Irrigable Area (A) | Project Cost (C) | Unit Development (C/A) |
|---|---|---|---|---|
| | | (ha) | (million Baht) | (1,000 Baht/ha) |
| J-7 | Huai Bon (L) | 1,970 | 284 | 144 |
| D-15 | Huai Chaluai | 850 | 95 | 112 |
| D-16 | Huai Chaluai Noi | 590 | 102 | 173 |
| D-17 | Huai Om | 650 | 124 | 191 |
| D-22 | Huai Hin Lat | 2,240 | 245 | 109 |
| J-4 | Huai Thiam Yai | 1,130 | 129 | 114 |
| D-7 | Lam Dom Yai (U) | 24,200 | 2,822 | 117 |
| D-23 | Lam Dom Yai (M) | 29,600 | 3,936 | 133 |
| D-28 (A) | Lam Dom Yai (L) | 30,970 | 4,209 | 136 |
| D-28 (B) | Lam Dom Yai (L) | 25,570 | 3,691 | 144 |
| D-30-B | Huai Tanot | 380 | 78 | 206 |
| D-1-A | Huai Tung (U) | 2,000 | 195 | 97 |
| D-2 | Huai Hin Dan | 630 | 103 | 163 |
| D-1-B | Huai Tung (M) | 210 | 75 | 359 |
| D-3-B | Huai Dan | 950 | 127 | 134 |
| D-4-A | Huai Chong | 1,050 | 451 | 430 |
| D-33 | Huai Salao | 740 | 88 | 119 |
| D-35-A | Huai Fang Deang (U) | 1,100 | 127 | 116 |
| D-35-B | Huai Manao | 1,200 | 123 | 102 |
| D-35-C | Huai Fang Deang (M) | 1,490 | 237 | 159 |
| D-24 | Lam Som (M) | 4,770 | 887 | 186 |
| D-25 | Huai Ari | 7,160 | 935 | 131 |
| D-26-A | Huai Khao San (U) | 1,240 | 159 | 128 |
| D-26-B | Huai Khao san (M) | 380 | 99 | 261 |
| D-43 | Huai Duan | 240 | 59 | 245 |
| D-49 | Rong Saeng | 630 | 74 | 118 |
| D-50 | Huai San | 650 | 81 | 125 |
| D-48 | Huai Hin Siu | 370 | 54 | 147 |
| D-27 | Huai Chong | 490 | 78 | 159 |
| D-51 | Huai Saen Phran | 1,090 | 117 | 108 |
| W-1 | Lam Don Yai Weir | 2,500 | 274 | 109 |

## 3. 5 Selection of Priority Development Projects

### 3. 5. 1 Preliminary Selection of Priority Development Projects

Vast agricultural land without irrigation facilities is left in the Lam Dom Yai Basin. A small-scale irrigation project and a smaller medium-scale irrigation project have only limited irrigation capacities. That is, since the storage capacity and/or the effective water depth of planned reservoirs for these projects are rather small, the utilization efficiency of water resources will become low, because of much losses from large reservoirs and amounts of overflow from the spillway. Therefore, as a priority development project, an area with large irrigation areas and a water source of high potential utilization will be selected.

In the upper-basin of the Dom Yai river basin, smaller medium-scale irrigation projects have been advanced by RID. On the other hand, in the middle and lower-basins of the river, these projects have not yet been implemented. In the overall irrigation development plan, therefore, it will be vital to make and rapidly develop the irrigation projects for agricultural land in the middle and lower-basins.

From the above-mentioned viewpoint, the priority development project to be selected must have a larger medium-scale or large-scale irrigation project with a large irrigation area and high potential utilization efficiency of water resources, that is, having a benefited area larger than 4,000 ha (25.0 thousand rai) in the middle and lower-basins of the river basin.

The irrigable area by the 29 new water sources selected in the river basin are shown in Table 3-4, and the following six plans consisting of five projects were initially selected as priority agricultural development projects.

Agricultural Development Project Areas with High Priority

| Project | | | Irrigable Area (ha) |
|---|---|---|---|
| D-7 | : | Lam Dom Yai (U) | 24,200 |
| D-23 | : | Lam Dom Yai (M) | 29,600 |
| D-24 | : | Lam Som | 4,770 |
| D-25 | : | Huai Ari | 7,160 |
| D-28(A) | : | Lam Dom Yai (L) | 30,970 |
| D-28 (B) | : | Lam Dom Yai (L) | 25,570 |

1) D-28(A) : This is the D-28 project when D-28 reservoir is linked with D-7 and D-24 reservoirs. An area of 30,970 ha is the irrigable area only by the D-28 reservoir.

2) D-28(B) : This is the D-28 project when D-28 reservoir is linked with D-23 and D-24 reservoirs. An Area of 25,570 ha is the irrigable area only by D-28 reservoir.

### 3. 5. 2 Selection of Priority Development Project

As described in the previous paragraph, six project plans with high priority development are selected as a result of the initially selection from 31 project plans consisting of 29 projects. This paragraph discusses the final selection of high priority development projects in the basin.

Table 3-5 show the major features of project plans.

1) Criteria for Selection of Priority Development Project

- B/C ratio : High priority shall be accorded to projects with a high B/C ratio.
- Scale of irrigable area : The larger the area the larger the impact influence across the area.
- Reservoir area conditions : If construction of such a dam and reservoir required that areas accommodating large farm land, houses and public facilities had to be submerged, social problems may result in addition to the increasing project costs.

## TABLE 3-5 MAJOR FEATURES OF INITIALLY SELECTED IRRIGATION PROJECTS

| Description | Lam Dom Yai(U) (D-7) | Lam Dom Yai (D-23) | Lam Som (D-24) | Huai Ari (D-25) | Lam Dom Yai(L) (D-28)(A) 1/ | Lam Dom Yai(L) (D-28)(B) 2/ |
|---|---|---|---|---|---|---|
| 1) Location | | | | | | |
| - Changwat | Ubon Ratchathani | Ubon Ratchathani | Ubon Ratchathani | Ubon Ratchathani | Ubon Ratchathani | Ubon Ratchathani |
| - Amphoe | Nam Yun | Nam Yun | Det Udom | Det Udom | Det Udom | Det Udom |
| 2) River | | | | | | |
| - Catchment Area (sq.km) | 261.7 | 395.9 | 605.9 | 223.4 | 767.6 | 633.4 |
| - Annual Runoff (MCM) (R.P=1/5) | 104.3 | 207.2 | 276.0 | 89.0 | 487.9 | 464.5 |
| 3) Irrigation area | | | | | | |
| - Wet Season (ha) | 24,200 | 29,600 | 4,770 | 7,160 | 30,970 | 25,570 |
| - Dry Season (ha) | 3,630 | 4,440 | 720 | 1,070 | 4,650 | 3,840 |
| 4) Reservoir | | | | | | |
| - High Water Level (EL.m) | 161.0 | 160.0 | 142.0 | 141.0 | 141.0 | 141.0 |
| - Normal Water Level (EL.m) | 160.0 | 159.0 | 141.0 | 140.0 | 139.5 | 139.5 |
| - Low Water Level (EL.m) | 156.0 | 150.3 | 139.8 | 136.1 | 134.5 | 134.5 |
| - Reservoir Area (sq.km) | 1.8 | 21.9 | 6.5 | 8.5 | 39.1 | 39.1 |
| - Total Storage Capacity (MCM) | 103.4 | 92.0 | 13.1 | 21.0 | 117.1 | 117.1 |
| - Dead Storage Capacity (MCM) | 2.6 | 4.0 | 6.1 | 2.2 | 12.5 | 12.5 |
| - Effective Storage Capacity (MCM) | 100.8 | 88.0 | 7.0 | 18.8 | 104.6 | 104.6 |
| 5) Dam / Diversion Work | | | | | | |
| - Crest Elevation (m) | 200.0 | 162.0 | 144.0 | 143.0 | 143.0 | 143.0 |
| - Width of Dam Crest (m) | 10.0 | 8.0 | 6.0 | 6.0 | 8.0 | 8.0 |
| - Length of Dam (m) | 300.0 | 1,930.0 | 1,090.0 | 2,050.0 | 2,000.0 | 2,000.0 |
| - Elevation of Riverbed (EL.m) | 158.0 | 141.6 | 133.3 | 129.5 | 125.7 | 125.7 |
| - Height of Dam (m) | 47.0 | 25.4 | 15.7 | 18.5 | 21.5 | 21.5 |
| - Embankment Volume (1,000 cu.m) | 656.0 | 946.0 | 137.0 | 310.0 | 817.0 | 817.0 |
| - Design Flood Discharge(cu.m/sec) | 342.0 | 590.0 | 916.0 | 253.0 | 641.0 | 641.0 |

| 6) Pump Facility | D-28 | D-24 | D-28 | D-24 | | | Left Bank | Right Bank | Left Bank | Right Bank |
|---|---|---|---|---|---|---|---|---|---|---|
| - Designed Discharge (cu.m/sec) | 24.20 | 24.20 | 29.60 | 29.60 | 4.77 | 7.16 | 7.97 | 23.00 | 6.57 | 19.00 |
| - Delivery Water Level (EL.m) | 145.0 | 155.0 | 145.0 | 155.0 | 155.0 | 147.0 | 148.0 | 158.0 | 148.0 | 158.0 |
| - No. of Pump | 15 | 15 | 18 | 18 | 3 | 5 | 5 | 16 | 5 | 11 |
| - Pump Capacity/Unit (cu.m/min) | 96.8 | 96.8 | 98.7 | 98.7 | 95.4 | 85.9 | 95.6 | 86.3 | 83.9 | 85.4 |
| - Total Head (m) | 13.5 | 17.6 | 13.5 | 17.6 | 17.6 | 14.0 | 16.5 | 26.5 | 16.0 | 26.0 |
| - Pump Type | V.V 3/ | V.V | V.V | V.V | V.V | V.V | V.V | V.V | V.V | V.V |
| - Pump Bore (mm) | 900 | 900 | 1,000 | 1,000 | 900 | 900 | 900 | 900 | 900 | 900 |
| - Power per Pump Unit (Kw) | 370 | 450 | 370 | 500 | 450 | 300 | 400 | 600 | 400 | 700 |

Note; 1/ Lam Dom Yai(L) (D-28) (A) : (D-7) + (D-28) + (D-24)
2/ lam Dom Yai(L) (D-28) (B) : (D-23) + (D-28) + (D-24)
3/ V.V : Vertical volute pump
Present conditions of preliminary selected project sites are shown in Table G-1 in Annex G.

- Income level : In order to alleviate income disparity, the area where income is at a low level shall be developed as first priority.
- Soil suitability : Soil conditions in the benefited area shall be suitable for crop cultivation.
- Civil work situations : Civil work situations at the dam-site, i.e., foundation, embankment materials, accessibility, etc. shall be considered.
- Environmental conditions : Social problems in the reservoir mentioned above should be assessed to evaluate the environmental conditions, and also scaling checklist method using for 18 environmental parameters is applied for the evaluation.

2) Selection of Priority Development Projects

By applying the above-mentioned criteria and procedures, comprehensive evaluation for the priority development project was primarily conducted from technical, economic and social viewpoints, and the evaluation results are shown in Table 3-6.

Evaluation results are summarized as follows;

- The D-7 project plan has the highest project economy with a B/C ratio of 0.98 in case of an interest rate of seven percent; It is followed in the order of the project plan by D-23, D-28(A), D-25, D-28(B), and D-24.
- However, the D-7 project plan situated near the national border of Cambodia has a law and order problems, accordingly the necessary survey and investigation are not possible at present. On the other hand, the D-23 project plan, which is an alternative plan of the D-7 project plan has low project economy compared with that of D-7, because of high project costs (2,913 million Baht), and there also exists problems of compensation as a result of dam construction.
- The D-24 project plan has the lowest project economy, due to its relatively small benefited area in scale in comparison with the scale of project facilities, although such compensation problems are not observed, as shown in Table 3-5.

## TABLE 3-6 EVALUATION OF PRIORITY DEVELOPMENT PROJECT

| Description | Lam Dom Yai (U) (D - 7) | Lam Dom Yai (D - 23) 1/ | Lam Som (D - 24) | Huai Ari (D - 25) | Lam Dom Yai (L) (D-28) (A) 2/ | Lam Dom Yai (L) (D-28) (B) 3/ |
|---|---|---|---|---|---|---|
| A) Project Features | | | | | | |
| - Irrigation Area (ha) | 24,200 | 29,600 | 4,770 | 7,160 | 30,970 | 25,570 |
| - Project Cost (million Baht) 4/ | 2,088 | 2,913 | 656 | 692 | 3,115 | 2,731 |
| - Project Benefit (million Baht) 5/ | 189 | 245 | 39 | 52 | 243 | 200 |
| - B/C Ratio ( i = 7.0 %) | 098 | 0.87 | 0.62 | 0.79 | 0.80 | 0.76 |
| B) Evaluation by Parameter 6/ | | | | | | |
| 1) Project Economy | 20 | 10 | 5 | 5 | 10 | 5 |
| 2) Scale of Irrigation Area | 3 | 5 | 1 | 1 | 5 | 3 |
| 3) Reservoir Area Conditions | 5 | 1 | 5 | 1 | 1 | 1 |
| 4) Income Level | 3 | 3 | 3 | 3 | 3 | 3 |
| 5) Soil Suitability | 3 | 3 | 3 | 3 | 3 | 3 |
| 6) Civil Work Conditions | 3 | 3 | 3 | 3 | 3 | 3 |
| 7) Environmental Conditions | 3 | 1 | 3 | 1 | 3 | 3 |
| Total Score | 40 | 26 | 23 | 18 | 28 | 21 |

Note : 1/ D - 23 plan is alternative one of theD - 7 plan.
2/ Lam Dom Yai (L) (D - 28) (A) : (D - 7) + (D+28) + (D - 24)
3/ Lam Dom Yai (L) (D - 28) (B) : (D - 23) + (D - 28) + (D - 24)
Note : 4/ Price escalation is not included in the project cost (See Table G-2).
5/ Project benefits consist of incremental crop benefits and inland fishery benefits (See Table G-15).
6/ Evaluation criteria is shown in Table G-3.

- In the comparison of project economy between both the linked project plan of D-7 + D-28 + D-24 and D-23 + D-28 + D-24, the plans have almost equal B/C ratios of 0.76 ~ 0.80 (interest rate i = 7.0 percent), however, the latter project plan is placed at a disadvantage due to the compensation problems resulting from D-23 reservoir.

Through the careful study mentioned-above, it was found out that the project plan of D-28 (A) is considered to be the most prioritized one, from technical, economical and social viewpoints. And also, since D-28 (A) project plan has the following advantageous points compared with the other plans, this project plan was decided to be the highest priority development project in the basin.

- The vast benefited areas of 30,970 ha (193.6 thousand rai) in D-28 (A) Plan will have a big influence economically in the Dom Yai river basin, and the project plan will contribute to raising the living-standards of the local people living in depressed areas, which will be covered by the benefited areas of the plan.

- The benefited areas located immediately downstream from the D-28 dam lie at a relatively flat and low altitude on both banks of the Dom Yai river. However, pumping facilities will be needed to lift irrigation water for the area. In this case, pump running costs are considered to be relatively low, because the wet season rainfall is efficiently utilized and operation time is short.

- Det Udom, which is the main township for administration and commerce is situated in the central part of the basin. Accordingly, it is considered that the activities of agricultural supporting and marketing services will be easily obtained.

- As for compensation problems, there exist about 1,930 ha (12,063 rai) of farmland and about 324 households to be submerged by the construction of D-28 dam. For countermeasures against these problems, attention will be given to the available resettlement areas not only in Ubon Ratchathani Land Reform Project Area, which is under the implementation by ALRO on the right bank of Dom Yai river as well as an the land of the Royal Forest Department on the left bank of the river.

As mentioned above, the irrigation project plans for the D-28 reservoir have been drawn up three times already by RID. The first plan was made in

1957. The dam-site was located lower than the present site. Two more modifications for the reservoir scale and location plan followed due to compensation problems resulting from submersion.

According to the last project plan made in 1982, in which the dam-site moved further upstream than the first and the second sites; the large-scale reservoir had the following dimensions;

| | | |
|---|---|---|
| Storage Capacity | : | 480 MCM |
| Reservoir Area | : | 85 sq.km |
| Normal Water Level | : | 143. 5 m (MSL) |
| Dam Height | : | 25.8 m (in which cutoff length was regarded as 5.0 m) |
| Dam Length | : | 3,400 m |
| Irrigation Area | : | 44,240 ha (276.5 thousand rai) |

In the present plan made by the Study Team, the dam-site is to be situated in the same place as the third plan, although the scale of the reservoir was made smaller considering compensation problems and the project economy. The dimensions are as follows:

| | | |
|---|---|---|
| Storage Capacity | : | 117.1 MCM |
| Reservoir Area | : | 39.1 sq.km |
| Normal Water Level | : | 139.5 m (MSL) |
| Dam Height | : | 21.5 m |
| Dam Length | : | 2,000 m |
| Irrigation Area | : | 30,970 ha (193.6 thousand rai) |

# FEASIBILITY STUDY

# CHAPTER IV. PROJECT AREA

# CHAPTER IV. PROJECT AREA

## 4.1 Location of Study Area

According to the results of the overall basin study of the Lam Dom Yai Basin Irrigation Project, the D-28 project was selected as the highest priority project in the basin.

However, the Feasibility Study Area of 71,700 ha (448.1 thousand rai) in total including alternative site of areas to be benefited by the D-28 reservoir was selected for study purposes on the both banks of the Dom Yai river.

The right bank is 52,890 ha (330.6 thousand rai) in area. It extends from immediately downstream of the proposed D-28 dam to national route 217, and it is bound by the Lam Dom Yai on the west side, and by the catchment boundary on east side of the area. As for the left bank, 18,810 ha (117.6 thousand rai) are located in the southern part of Muang Det Udom, and are being developed on both banks of the Som river.

These areas administratively belong to four Amphoe (District), that is, Amphoe Phibun Mangsahan, Det Udom, Na Chaluai and Nam Yun, respectively. But most of the land belongs to Amphoe Det Udom.

## 4.2 Physical Conditions

### 4.2.1 Topography and Geography

Topography of the Study Area is relatively flat with a gentle slope of about 1/1,500 from south to north, but some undulated topography can be observed in the area. Elevation of the topography varies from about EL.150 m to EL.120 m above mean sea level. Present conditions of the area are summarized as follows;

Present Conditions in the Study Area

| Items | Left Bank Area | Right Bank Area | Total |
|---|---|---|---|
| Administration | | | |
| No. of Amphoe | 3 | 1 (2) | 4 (5) |
| No. of Tambon | 9 | 8 (15) | 17 (24) |
| Area (ha) | | | |
| Cultivated Area | 14,400 | 35,920 | 50,320 |
| Non-cultivated Area | 4,410 | 16,970 | 21,380 |
| Total | 18,810 | 52,890 | 71,700 |
| Population | | | |
| Population (person) | 16,860 | 40,040 | 56,900 |
| Density (person/sq.km) | 89.6 | 75.7 | 79.4 |

There are 50,320 ha (314.4 thousand rai) of cultivated area under rainfed conditions excluding the parts with irrigation systems. Total irrigated areas are estimated at about 850 ha (5.3 thousand rai) with ten irrigation systems as a whole.

### 4.2.2 Hydrology

1) Rainfall

Rainfall in the Lam Dom Yai basin tends to increase from the upper to lower basins. Since the Study Area extends in a long and narrow shape along the Dom Yai river course, rainfall distribution shows different patterns within the area. On the basis of the Thiessen Polygon applied for the Lam Dom Yai basin, rainfall in the area can be divided into two areal patterns. One is for the watershed area of the proposed D-28 dam and the other is for the area to be irrigated by the dam. Areal rainfalls composing point rainfall values of Nam Yun, Buntharik and Det Udom are considered as those for the watershed area. On the other hand, point rainfall values observed at the Det Udom can be applied to the proposed irrigation area. Areal ratio of the watershed area is as follows;

| Gauging Station | Areal Ratio (%) | Area (sq.km) |
|---|---|---|
| Nam Yun | 76.7 | 956.3 |
| Buntharik | 19.5 | 243.1 |
| Det Udom | 3.8 | 47.4 |
| Total | 100.0 | 1,246.8* |

* : Direct watershed area

Monthly-basis mean rainfall values at each gauging station and the estimated areal rainfall at the watershed area of each proposed dam is as follows;

**Monthly Mean Rainfall and Areal Rainfall**

(unit: mm)

| Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Det Udom | | | | | | | | | | | | |
| 0.7 | 1.7 | 21.3 | 91.8 | 207.0 | 265.3 | 254.2 | 302.2 | 288.6 | 129.2 | 34.0 | 1.5 | 1,597.4 |
| Buntharik | | | | | | | | | | | | |
| 0.6 | 1.4 | 19.3 | 77.3 | 183.6 | 259.9 | 248.3 | 303.4 | 271.2 | 97.8 | 33.3 | 6.4 | 1,502.6 |
| Nam Yun | | | | | | | | | | | | |
| 0.7 | 6.2 | 26.0 | 87.1 | 211.3 | 175.3 | 145.0 | 177.4 | 343.9 | 143.0 | 37.6 | 2.5 | 1,356.1 |
| Watershed area of the proposed dam | | | | | | | | | | | | |
| 0.7 | 5.3 | 28.6 | 84.7 | 213.8 | 196.2 | 174.0 | 210.9 | 325.5 | 135.2 | 38.4 | 3.2 | 1,416.4 |

On the other hand, successive no-rainfall days during the proposed irrigation periods for wet season paddy are estimated at a minimum of 12 days and a maximum of 56 days based on 39-years of rainfall records. Those successive no-rainfall days noticeably occur in October. Occurrence in June, July and May follows October. Probable successive no-rainfall days in each return period are as follows;

| Return Period | Successive No-rainfall Days During Irrigation Period | |
|---|---|---|
| | May to June | May to Dec. |
| (year) | (day) | (day) |
| 2 | 6 | 28 |
| 5 | 10 | 41 |
| 10 | 14 | 50 |
| 50 | 25 | 70 |
| 100 | 30 | 79 |

2) Run-off

The watershed area at the proposed D-28 dam-site is calculated as 1,560.9 sq.km (975.6 thousand rai) using the topographic map of 1 to 50,000 in scale. Out of the total watershed area, six RID and other governmental agency reservoir projects are being planned and/or completed in the upper-basin. The related watershed area to the proposed dam amount to 314.1 sq.km

(196.3 thousand rai). In view of the conservative estimate of available inflow to the proposed reservoir, a direct watershed area of 1,246.8 sq.km (779.3 thousand rai) is used to calculate the reservoir inflow.

Two water-level gauging stations, M80 of RID at Det Udom and 53801 of NEA at Ban Fang Phe, are located near the proposed dam-site. The Ban Fang Phe gauging station is located in the proposed reservoir area. General features of these gauging stations are as follows;

**Outline of Gauging Station**

| Gauging Station | Code No. | Watershed Area (sq.km) | Mean Annual Areal Rainfall (mm) | Mean Annual Run-off (MCM) | Run-off Coefficient |
|---|---|---|---|---|---|
| Det Udom | M80, RID | 3,363 | 1,417 | 1,524 | 0.32 |
| Ban Fang Phe | 53801, NEA | 1,410 | 1,369 | 687 | 0.36 |

To estimate the run-off discharge at the proposed dam-site, a run-off model using the Tank model method has been developed through the Phase-I study of the project. The model was calibrated by the record observed at 53801 at Ban Fang Phe.

For the Feasibility Study of the project, a daily basis run-off from the proposed watershed area is recomputed by the developed run-off model taking the watershed area and areal rainfall into account. Summaries of the computed results are as follows;

**Mean Monthly Run-off**

(unit: MCM)

| Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average year | | | | | | | | | | | | |
| 3.7 | 2.1 | 2.0 | 1.7 | 17.5 | 45.6 | 61.7 | 108.6 | 211.6 | 110.6 | 19.9 | 6.2 | 591.0 |
| 1/5-Low water year | | | | | | | | | | | | |
| 4.2 | 2.6 | 2.3 | 1.9 | 6.9 | 31.0 | 70.4 | 121.2 | 184.1 | 63.7 | 7.3 | 5.2 | 500.8 |
| 1/5-High water year | | | | | | | | | | | | |
| 5.4 | 3.4 | 3.0 | 3.5 | 40.1 | 93.9 | 84.7 | 119.4 | 184.1 | 149.2 | 13.2 | 8.1 | 699.1 |

| Item | Mean Annual Run-off (MCM) | Run-off Coefficient (%) |
|---|---|---|
| Max. | 1,100.8 | 47 |
| Min. | 258.5 | 21 |
| Mean | 591.0 | 33 |

The 0.474 MCM/sq.km of mean annual specific discharge can be obtained through the run-off calculation. This estimated value shows almost the same value as M80 of 0.453 MCM/sq.km and Ban Fang Phe of 0.487 MCM/sq.km, respectively.

### 4.2.3 Soil and Land Classification

Based on the detailed soil map (1:100,000 in scale) of Ubon Ratchathani Province, the Report of Soil Survey of Changwat Ubon Ratchathani (1971), Land Use Planning of Northeastern Thailand (1984), soil survey in the second phase of the study (November, 1991) and the results of the soil survey conducted by the Study Team in the Study Area, the detailed description of soil characteristics and land classification of the area is as follows;

1) Soil Classification

The Soil Survey Report of the Department of Land Development (DLD) revealed that Ubon Ratchathani Province is occupied by 30 soil series, of which 24 soil series appear in the Lam Dom Yai basin. The 12 soil series in the Study Area can be grouped into seven soil sub-groups as shown below;

- Oxic Paleustult (Kt)
- Aeric Paleaquult (Re, Re-1)
- Ustoxic Quartzipsamment (Ng)
- Typic Plinthustult (Pp)
- Aquic Quartzipsamment (Ub)
- Typic Plinthaquult (Pn)
- Oxic Plinthaquult (On)

Source: Guideline to Soil Series and Classification of Thailand, DLD (1981)

Distributions of each soil series in the area are as follows;

Distribution of each Soil Series

(unit: ha)

| Soil Classification | Left Bank Area | Right Bank Area | Total |
|---|---|---|---|
| 1. Korat (Kt) | 10,930 | 15,200 | 26,130 |
| 2. Korat - Phon Phisai Asso. (Kt/Pp) | - | 17,730 | 17,730 |
| 3. Roi Et - On Association (Re/On) | - | 7,560 | 7,560 |
| 4. Roi Et - (Re) | 2,520 | 4,210 | 6,730 |
| 5. Roi Et - Phen Association (Re/Pn) | 100 | 1,890 | 1,990 |
| 6. Nam Phong (Ng) | - | 4,240 | 4,240 |
| 7. Phon Phisai (Pp) | 2,220 | 200 | 2,420 |
| 8. Phen (Pn) | 1,260 | 260 | 1,520 |
| 9. Alluvial Complex (Ac) | 1,610 | - | 1,610 |
| 10. Ubon (Ub) | - | 890 | 890 |
| 11. Roi Et, Loamy Phase (Re-1) | 170 | 300 | 470 |
| 12. On (On) | - | 410 | 410 |
| Total | 18,810 | 52,890 | 71,700 |

The distribution of the identified soil series mentioned above was illustrated on a soil map (see Figure C-4, Annex C), which was compiled on the basis of a Detailed Reconnaissance Soil Map (1: 100,000 in scale) prepared by DLD and confirmed through the field survey results, which were conducted during the fieldwork.

2) Soil Characteristics

Most of the soil series in the Study Area are characterized by sandy loam and loamy sand soils. Sand and silt is high in soil texture. The soil pH is around 4.5 - 6.0. The soil fertility and organic matter are low.

The detailed descriptions of the major characteristics of each soil series are given in Annex C.

3) Land Classification

Land classification of the Study Area was made based on the soil group map (1:50,000 in scale) of Ubon Ratchathani Province prepared by the DLD (1990). The land classification map illustrates land suitability for commercial crops in the form of "land unit", as shown in Figure C-6, Annex C. In this

report, land unit is regarded as land class using the capital letter "L" followed by numbers as follows;

| | | |
|---|---|---|
| L1 - L4 | : | suitable for paddy rice |
| L5 - L8 | : | suitable for upland crops |
| L9 | : | suitable for certain crops as soil is saline |
| L10 - L12 | : | suitable for fruit and trees |
| L13 | : | mountainous area |
| L14 | : | suitable for other purposes than agriculture |

Areas covered, definition and suggestions of each land class in the Study Area are described as follows, according to the Land Classification System of the DLD.

## Land Classification

(unit: ha)

| Land Class | Definition | Left Bank Area | Right Bank Area | Total |
|---|---|---|---|---|
| Suitable for Paddy Rice | | | | |
| L1 | Suitable for paddy rice, in areas where water resources exist; annual crops or vegetables can be grown in the dry season. | 10 | 540 | 550 |
| L2 | Suitable for paddy rice with a risk of water shortage when rainfall is erratic as soils in most areas are sandy and some areas are high and steep. | 7,520 | 19,300 | 26,820 |
| L4 | Suitable for paddy rice, upland crops and pasture. | 4,010 | 40 | 4,050 |
| Suitable for Upland Crops | | | | |
| L5 | Suitable for upland crops and vegetables. | 910 | 980 | 1,890 |
| L6 | Suitable for upland crops and vegetables, although soils are sandy and fertility is low in nature. | 4,940 | 3,260 | 8,200 |
| L7 | Moderately suitable for upland crops or suitable for pasture since soils are very sandy with very low fertility. | 110 | 13,200 | 13,310 |
| L8 | Suitable for upland crops, however, land is currently renovated for growing rice. | 1,310 | 13,240 | 14,550 |
| Suitable for Fruit and Trees | | | | |
| L12 | Suitable or moderately suitable for fruits and trees as soil contains gravel or has layers of rock in the subsoil. | - | 2,330 | 2,330 |
| | Total | 18,810 | 52,890 | 71,700 |

Most of the soils in the Study Area are suitable for paddy rice. These soils comprise about 44 percent of the total area. The second of these soils is suitable for upland crops. An appropriate management of soils in each land class is suggested as follows;

L1 : Apply fertilizer and maintain soil fertility.

L2 : Water resources are needed if water shortages occur, or when land use is changed to more suitable operation.

L4 : Exploit the land as described according to land suitability.

L5 : Apply fertilizer and maintain soil fertility; in some areas, land should be used with soil and water conservation measures.

L6 : Organic fertilizer and cover crops should be used; inorganic fertilizer should be used strictly as recommended (rate and time) so as to reduce nutrients loss.

L7 : Organic fertilizer and cover crop should be used; inorganic fertilizer should be used strictly as recommended (rate and time) so as to reduce nutrients' loss.

L8 : Land should be used according to land suitability and should be fertilized.

L12 : Planting should be prepared and organic and inorganic fertilizers be applied with measures of soil and water conservation.

4) Soil Management

Soils in the Study Area are commonly coarse-texture soils with high sand content followed by silt and clay, respectively. They are also characterized by low organic matter content and poor soil fertility. The field survey conducted by the Study Team indicated that economic yields of crops such as rice, cassava and kenaf are considerably low. Such low productivity of crop yield is attributable to poor soil management and inappropriate cultural farming practices by farmers.

To maintain or increase soil productivity as well as soil fertility in the Study Area, the following is suggested as appropriate measures;

Increase in Organic Matter Content

Coarse-texture soil with low organic matter content result in poor soil fertility and productivity. Accordingly, it is recommended that organic fertilizer should be applied. Compost, farm yard manure or green manure, when applied, will increase organic soil matter content. The organic fertilizer

improves soil structure as well as captures plant nutrients that otherwise would be leached away from plant roots, and released for plant use.

Unfortunately, compost or farm yard manure is required in large quantities and it is bulky to handle. These facts impose difficulty for farmers and makes organic fertilizer use a burden. Green manure, however, offers a relatively practical way to increase organic soil matter. The green manure crops, especially legume crops, in association with nodule bacteria, can convert atmospheric nitrogen into organic matter that is available for plant use.

Generally, green manure crops are planted prior to the main crops, and plowed down a few days before plowing. Then the main crop is planted. Seeds of several green manure crops such as Crotalaria, Seebania and Lablab are available through the respective offices of the DLD. The incorporation of rice straw into soil as done by farmers may be inappropriate as the C/N ratio of rice straw is wide (C/N ratio > 33:1). Such wide C/N ratio reflects nitrogen immobilization and causes a period of soil nitrogen shortage. Due to the tropical climate, increasing the soil organic matter content with green manure crops should be done continuously for long periods of time.

Increase in Soil Fertility

An immediate increase in soil fertility for growing crop plants can be carried out through the application of inorganic chemical fertilizer. Farmers in the Study Area rarely apply fertilizer to their crops. Moreover, after harvesting crop straw it is returned to the soil in small quantifies. Additionally, farmers usually burn crop straw in an inappropriate manner.

Dry, senescent plant material contains a certain amount of plant nutrients that would be available to plants if incorporated into the soil. Thus, it is necessary to use (inorganic) chemical fertilizer in the Study Area.

Increase in Soil pH

Most soils in the area are acidic with a pH of about four to six. Acidity causes scarcity of most plant nutrients. Simultaneously, it increases toxicity of certain elements such as Al (Aluminum) and Mn (Manganese).

Therefore, the use of $CaCo^3$ or $Ca(OH)^2$ or Dolomite to increase the level of soil pH is indispensable and highly recommended.

## 4.3 Present Agriculture

### 4.3.1 Land-Use

The present land-use in the Study Area, of which the total area is estimated at 71,700 ha (448.1 thousand rai) was categorized as shown below, according to the following land-use data relating to the Study Area; i) current Land-Use Map (1 : 100,000 in scale) prepared by the Department of Land Development (DLD) (1988), ii) Agricultural Reports of 1989 and 1990 on Land-Use for Wet and Dry Season Crops prepared by Provincial Agricultural Extension Office, and iii) through field survey.

**Present Land-Use**

| Land Category | Left Bank Area (ha) | Right Bank Area (ha) | Total (ha) |
|---|---|---|---|
| Paddy Field | 11,530 | 29,830 | 41,360 |
| Upland Field | 2,280 | 1,510 | 3,790 |
| Fallow | 590 | 4,580 | 5,170 |
| Forest | 4,240 | 16,450 | 20,690 |
| Residential Area and Other | 170 | 520 | 690 |
| Total | 18,810 | 52,890 | 71,700 |

It was found out through the field survey that the above-mentioned forest area was deciduous forest and had been utilized for cultivation land, mostly for paddy field, through illegal occupation by local people at present. The forest land encompasses a part of the following national reserved forest.

- Huai Mae Non Forest
- Dong Na-Kae Forest
- Lam Dom Yai Left Bank Forest
- Lam Dom Yai Right Bank Forest

The report published by the Royal Forest Department (1988) indicates that the real forest area is only three percent in the Dong Na-Kae

Forest and 45 percent in Lan Dom Yai Left Bank Forest, respectively. A part of the Lam Dom Yai Right Bank Forest in the Study Area is subject to land reform procedure for agricultural purposes by the Agricultural Land Reform Office (ALRO).

### 4. 3. 2 Water Use

As mentioned in Overall Basin Study in Part-I, most of the land has been used only for wet season paddy cultivation with the exception a few areas having small-scale irrigation facilities, the land has relied on rainfall. The wet season paddy cultivation usually starts with the land preparation works at the beginning of May, which just corresponds to the start of the wet season in the north-eastern region. In order to meet rainfed farming in the area, the size of paddy field is relatively small, about 300 sq.m (20 m × 15 m), with high levee.

On the other hand, there exists 854 ha (5.4 thousand rai) of irrigated land having irrigation facilities. These were constructed by those agencies of RID, ARD and farmers' group. The following table indicates the irrigation areas constructed by related government agencies in the Study Area.

**Existing Irrigation Projects**

| Item | Left Bank | | Right Bank | | Total |
|---|---|---|---|---|---|
| | RID | ARD | RID | ARD | |
| No. of Project | 1 | 1 | 7 | 1 | 10 |
| Irrigation Area (ha) | 32 | - | 822 | - | 854 |

Most of the irrigation projects mentioned above are categorized as small-scale irrigation projects constructed by RID; these irrigation projects consist of water source facilities like small dams, ponds, diversion work without intake facilities and irrigation canals. Farmers belonging to the irrigation systems, therefore, are using small pumps to lift irrigation water, which will be held by farmers themselves. The planted crops under the irrigation conditions are groundnut, vegetable, watermelon, chilli, etc.

### 4. 3. 3 Population, Farm Household and Farm Labor Force

The Study Area encompasses four Amphoes as an administrative division of Ubon Ratchathani Province; Det Udom, Phibun Mangsahan, Nam Yun and Na Chaluai. Population, farm household and farm labor force in the area are as follows:

1) Population

The total population in the Study Area is shown below (refer to Table 4-1);

| Item | Left Bank Area | Right Bank Area | Total |
|---|---|---|---|
| Population (person) | 16,860 | 40,040 | 56,900 |
| No. of Household (house) | 2,900 | 6,770 | 9,670 |
| Family Size (person/house) | 5.8 | 5.9 | 5.9 |
| Population Density (person/sq.km) | 89.6 | 75.7 | 79.4 |

2) Farm Household

According to the provincial data of Ubon Ratchathani Provincial Statistical Office, the number of farm households is about 2,790 (96 percent of the total households) in the left bank area and about 6,100 (90 percent of the same) in the right bank area (refer to Table 4-1).

3) Farm Labor Force

As the result of the farm survey conducted during the field work of Phase II Study, the farm labor force per farm household is estimated at 3.92 people per 5.81 people that compose a family. Consequently, the total farm labor force in the Study Area is assumed to be about 10,900 in the left bank area, and 23,900 in the right bank area, and respectively. The animal labor force per farm household is estimated at 2.64 heads in the area.

Monthly labor requirement for the entire crop and paddy area (transplanted) is estimated as follows; under conditions of 25 days per month of human labor, and 15 days and 30 days of land preparation of nursery and paddy field respectively as animal labor are estimated.