

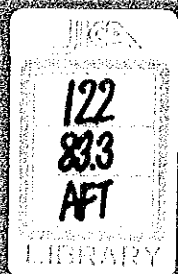
KINGDOM OF THAILAND

**FEASIBILITY STUDY
ON
SEBAI-SEBOK BASIN DEVELOPMENT PROJECT**

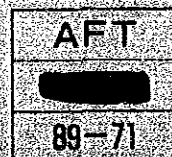
EXECUTIVE SUMMARY



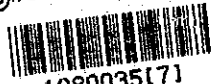
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KINGDOM OF THAILAND

FEASIBILITY STUDY

ON

**SEBAI-SEBOK BASIN DEVELOPMENT
PROJECT**

EXECUTIVE SUMMARY

FEBRUARY 1990

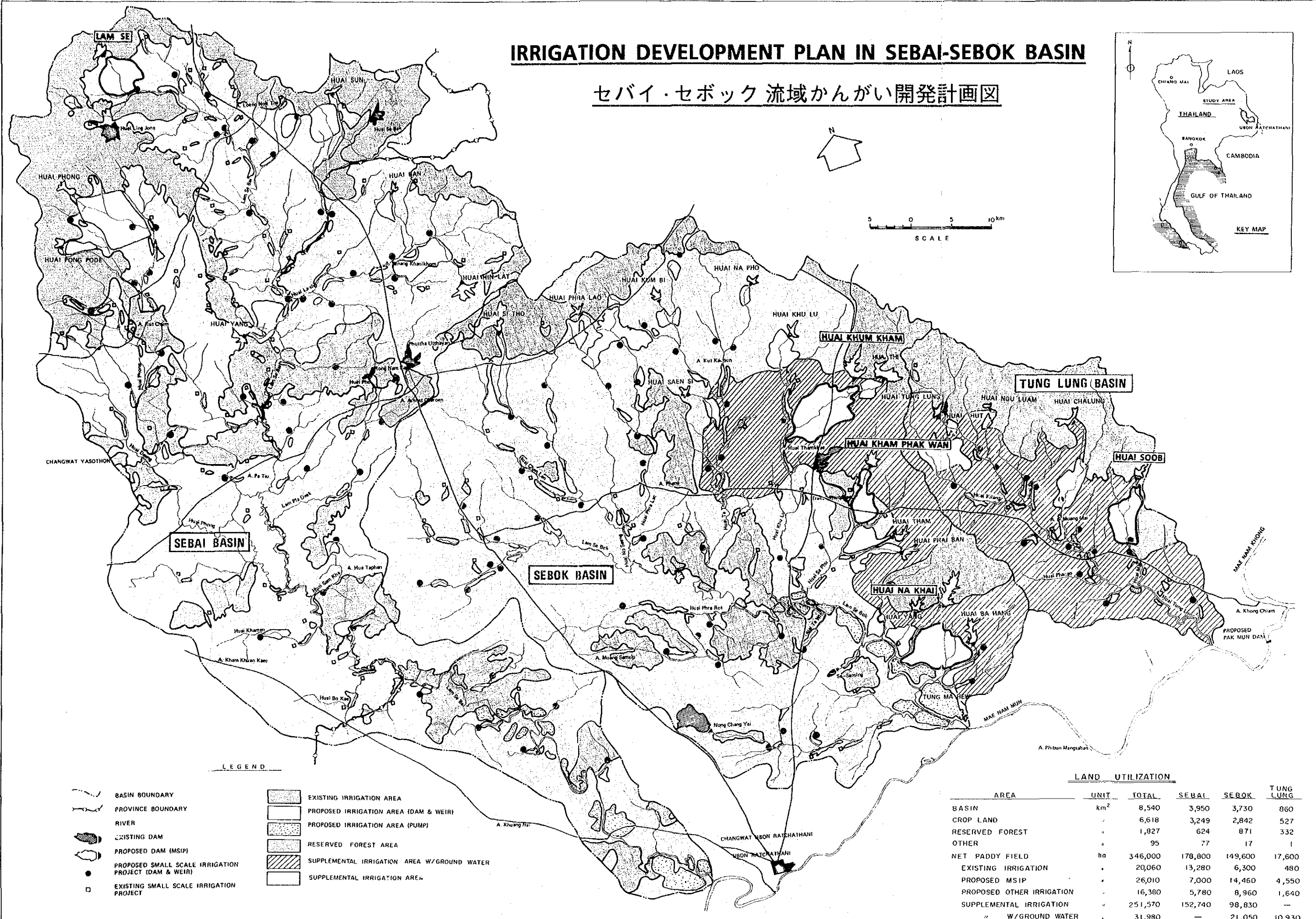
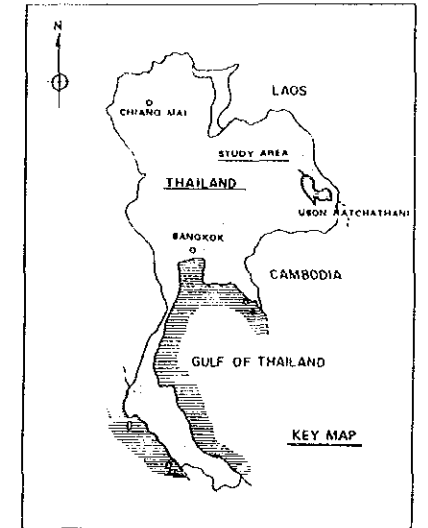
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IRRIGATION DEVELOPMENT PLAN IN SEBAI-SEBOK BASIN

セバイ・セボック流域かんがい開発計画図



LEGEND

- BASIN BOUNDARY
- PROVINCE BOUNDARY
- RIVER
- EXISTING DAM
- PROPOSED DAM (MSIP)
- PROPOSED SMALL SCALE IRRIGATION PROJECT (DAM & WEIR)
- EXISTING SMALL SCALE IRRIGATION PROJECT
- EXISTING IRRIGATION AREA
- PROPOSED IRRIGATION AREA (DAM & WEIR)
- PROPOSED IRRIGATION AREA (PUMP)
- RESERVED FOREST AREA
- SUPPLEMENTAL IRRIGATION AREA W/GROUND WATER
- SUPPLEMENTAL IRRIGATION AREA

LAND UTILIZATION

| AREA | UNIT | TOTAL | SEBAI | SEBOK | TUNG LUNG |
|---------------------------|-----------------|---------|---------|---------|-----------|
| BASIN | km ² | 8,540 | 3,950 | 3,730 | 860 |
| CROP LAND | " | 6,618 | 3,249 | 2,842 | 527 |
| RESERVED FOREST | " | 1,827 | 624 | 871 | 332 |
| OTHER | " | 95 | 77 | 17 | 1 |
| NET PADDY FIELD | ha | 346,000 | 178,800 | 149,600 | 17,600 |
| EXISTING IRRIGATION | " | 20,060 | 13,280 | 6,300 | 480 |
| PROPOSED MSIP | " | 26,010 | 7,000 | 14,460 | 4,550 |
| PROPOSED OTHER IRRIGATION | " | 16,380 | 5,780 | 8,960 | 1,640 |
| SUPPLEMENTAL IRRIGATION | " | 251,570 | 152,740 | 98,830 | — |
| W/GROUND WATER | " | 31,980 | — | 21,050 | 10,930 |

SUMMARY AND RECOMMENDATION

SUMMARY AND RECOMMENDATION

(General Description of Basin)

01. Being located in the southeastern flank of the Khorat plateau in the Northeast region of Thailand, the agriculture of the Sebai-Sebok basin with a total area of 854,000 ha is low because of insufficient natural resources and technology. Furthermore, many villages in the basin are confronted with the social problems such as inconvenient communications, insecure land tenure, low production or low incomes, shortage of water for domestic consumption and others, and are ranked as the backward area in need of immediate development as defined by the National Economic and Social Development Board (NESDB).

02. The Sebai-Sebok basin is composed of three river basins of the Sebai, Sebok and Tung Lung which are tributaries of the Mun river, one of the biggest rivers in the Northeast, and covers two provinces of Ubon Ratchathani and Yasothon. The basin is delimited in the north and northeast by the Phu Phan range with an elevations of 200 to 250 meters above the mean sea level, and in the south by the flood plains of the Mun river with an elevation of around 100 meters above the mean sea level. About 77 percent of lands are utilized for agriculture; 64 percent as paddy field and 13 percent as upland field. The forest occupies 21 percent of the basin.

03. The basin has a tropical monsoon climate with a pronounced dry season. The rainy season usually extends from May to October. Annual rainfall varies from 1,800 millimeters on the southeastern part of the basin to 1,400 millimeters on the northwestern part of the basin, having an average of 1,600 millimeters. Cyclonic storms originated in the South China Sea and the Pacific Ocean sometimes enter Thailand mostly during the period September to November. The storms bring heavy rainfall to the basin as tropical storms or tropical depressions. Rate of runoff from the watershed falls within 30 to 40 percent of annual rainfall.

04. According to land classification on the suitability for paddy field, there is no Class 1 land classified as most suitable in the basin, whereas 65 percent of lands classified into Class 2 (relatively acceptable) and Class 3 (marginally suitable); 35 percent of lands are not suitable for paddy cultivation. Lands where salt crystals (NaCl) were formed on the dried soil surface in the dry season are found along the rivers of Sebai and Sebok, of which 75,000 ha of lands (or, equivalent to nine percent of the total area) need some countermeasures to prevent crops from salt damages.
05. Farm lands in the basin amount to 374,600 ha; 346,000 ha for paddy fields and only 28,600 ha for upland fields. The yield of rainy season paddy is 270 kg/rai (or, 1.7 ton/ha) in Ubon Ratchathani province and 300 kg/rai (or, 1.9 ton/ha) in Yasothon province, while the national average is 320 kg/rai, or equivalent to 2.0 ton/ha. Lack of water sources and irrigation facilities causes unstable paddy cultivation so that about 20 percent of the total paddy fields are usually not harvested. Major upland crops are cassava, kenaf, groundnut, water melon and chili.
06. The average farm size on an Amphoe basis is 2.8 to 3.4 ha (or 18 - 21 rai). About 75 percent of farm households produce rice enough for home consumption. Double cropping of paddy is scarcely practiced because of lack of water sources in the dry season. The Departments of Agricultural Extension and Land Development jointly conducted a farm household survey in two provinces regarding problems in daily life and farming activity, revealing that most serious problems were paddy cropping, dry season cropping, cooperative activity and water resources.
07. Six medium scale irrigation projects are in operation and two medium scale irrigation projects are under construction. There are 199 small scale projects so far implemented as of 1988; 119 small scale irrigation projects by the Royal Irrigation Department and 80 small scale water resources projects by the Accelerated Rural Development Office (ARDO) and the Department of Land Development. Total irrigable area of these 207 projects amounts to 20,060 ha (125,400 rai), or equivalent to only six percent of the total existing paddy fields.

With a combined storage capacity of nearly 46 million cubic meters (MCM) of the existing six medium scale irrigation projects, 6,347 ha of paddy fields have a stable harvest of rainy season paddy, and dry season cropping of groundnut, sweet corn, chili and so on is annually

introduced to three to 44 percent of the irrigable area depending on the water availability of a year.

08. Out of 1,600 millimeters of annual rainfall over the basin, about 580 millimeters of rainfall contribute to river surface runoff. A combined storage capacity of 135 million cubic meters for 207 irrigation projects can regulate only three percent of total river runoff for irrigation use. The topography of the basin does not allow to construct any large scale dam and reservoir, and hence water resources development in the basin has to rely on the construction of small to medium scale dams and reservoirs.
09. Total population of the basin was 1.17 million in 1980 and had grown to 1.30 million in 1987 at an annual increasing rate of 1.5 percent. About 90 percent of households were engaged in agriculture; however, only 20 percent of the gross product of two provincials were generated by agricultural sector in 1986. 52 percent of households in two provinces had annual income of less than 6,000 Baht in 1986.

(Basin Development Plan)

10. Areal spread of farm land has been the main measure of increase in crop production in the basin. Newly opened land from forest is apt to suffer losses from drought and eventually the soil fertility becomes worse year by year. Notwithstanding the land classification as mentioned earlier that 65 percent of lands were cultivable for paddy, around 70 percent of lands are being used for paddy cropping, which in other words may indicate that all arable lands have been developed and there is no room for new development of land resources for paddy cultivation.

Under the situation, agricultural development in the Sebai-Sebok basin should be directed to improvement of agricultural productivity of the existing farm land, especially of the paddy fields.

11. Irrigation should be introduced with the aim to stabilize and then increase the productivity of rainy season paddy, the main crop in the basin. Double cropping of paddy is not proposed for agriculture development in the basin with a view to distributing the limited water resources to large areas as much as possible, as can be seen in the

existing irrigation projects in the Northeast. The proposed basin development plan also aims to introduce irrigation of dry season upland crops for 20 percent of the project area.

12. According to water quality investigation of deep wells constructed in the basin, there is large distribution of brackish to salty water. The distribution of the salty water and saline soils is identical with the distribution of the Maha Sarakham Formation, and it is assumed that the brackish to salty water may mostly originated in the rock salt in the Maha Sarakham Formation.

In the basins of Tung Lung and upper Sebai and the left bank areas of the upper Sebok basin, groundwater without salt content is available. The groundwater can be exploited for irrigation of upland crops but not for paddy because of relatively low yields of deep groundwater ranging from 75 to 380 liter/minute.

13. The average annual water yield of the basin is estimated at 4,900 million cubic meters, and the development of such water resources is the key to agricultural development. The water resources development in the basin requires some forms of artificial storage and regulation of free-flowing water resources.

The possibility of water resources development in the basin is relatively limited in comparison with water demand for the potential irrigable area, due to topography of possible water source sites and climate where rainfall is concentrated within a short season. The basin development plan has been prepared with aim to formulate an orderly development that may ensure individual water project optimum benefits for the people in the Sebai-Sebok basin.

14. The potentiality of water resources development has been assessed to formulate an overall irrigation plan. The runoff from watershed area of 4,848 square kilometers out of total 8,540 square kilometers of the basin is the object of water resources development, for which first priority is given to storage schemes and then to run-of-river schemes where there is no possible dam site. A diversion structure is proposed across a river to raise its water level to a controllable elevation, from where it can flows by gravity through an irrigation canal. River

pumping is proposed where a river has a flat grade, which otherwise require a high diversion structure and long supply canals.

Outlines of new irrigation projects proposed under the basin development plan are given below;

| <u>New Development Project</u> | | | |
|--------------------------------|------------------------|-----------------------|----------------|
| <u>Project</u> | <u>Nos. of Project</u> | <u>Irrigable Area</u> | |
| | | (ha) | (rai) |
| Storage Scheme | | | |
| - Medium Scale Project | 26 | 26,010 | 162,600 |
| - Small Scale Project | 87 | 4,350 | 27,200 |
| <u>Sub-Total</u> | <u>113</u> | <u>30,360</u> | <u>189,800</u> |
| Run-of-River Scheme | | | |
| - River Pumping | 41 | 4,030 | 25,100 |
| - River Diversion | 40 | 2,600 | 16,300 |
| <u>Sub-total</u> | <u>81</u> | <u>6,630</u> | <u>41,400</u> |
| <u>Total</u> | <u>194</u> | <u>36,990</u> | <u>231,200</u> |

15. The Electricity Generating Authority of Thailand (EGAT) has prepared a project report on the Pak Mun Multipurpose Project to construct a dam and reservoir with an effective storage capacity of 115 million cubic meters on the lower reach of the Mun river in which three rivers of Sebai, Sebok and Tung Lung flow. Part of paddy fields located at the downstream reach of the Sebok river are included in irrigable area under the Pak Mun project. This Sebai-Sebok basin development plan presents a proposal that 5,400 ha of paddy fields along the downstream reaches of both the Sebai and Sebok rivers be supplied with irrigation water from the Pak Mun project, all projects being of river pumping.

16. Total irrigable area of new irrigation development projects amounts to 36,990 ha. In addition, when the Pak Mun related projects are implemented, 5,400 ha of paddy fields will be irrigated, totaling 42,390 ha of proposed irrigable area.

Out of six existing medium scale irrigation projects, four projects of Huai Pho (880 ha), Ron Nam Sap (70 ha), Nong Chang Yai (1,200 ha) and Huai Thamkhae (1,680 ha) are in need of urgent rehabilitation because they are not functioning as originally planned due to aged and insufficient facilities. In addition to the rehabilitation of four medium scale irrigation projects, rehabilitation is proposed for Tung Ma Hew irrigation project constructed by the Department of Land Development and the National Energy Authority with an irrigable area of 1,260 ha,

being located on the downstream reach of the Sebok river, where irrigation has not been practiced since 1978 because of damages to pumping facilities and irrigation canals.

17. The present irrigable area of paddy fields shares only six percent of the total paddy fields, far less than the national average of around 20 percent, which is one of the reasons for low agricultural productivity of the basin. By implementing the irrigation projects proposed in the basin development plan, the total of irrigable area will increase to 62,450 ha (390,000 rai) from the existing irrigable area of 20,060 ha, or equivalent to 18 percent of the total paddy fields.

It is recommendable that the proposed irrigation projects be implemented under two programs of the short term development with a target year of 1996 and the middle term development with a target year of 2006. The short term development program includes 14 medium scale irrigation projects, seven pump irrigation projects related to Pak Mun project, and five rehabilitation projects, as given below;

Implementation Schedule of Basin Development Plan

| <u>Project</u> | <u>Nos. of Project</u> | <u>Irrigable Area</u> | |
|--|------------------------|-----------------------|----------------|
| | | (ha) | (rai) |
| Short Term Development (1990 - 1996) | | | |
| - Medium Scale Projects | 14 | 18,750 | 117,200 |
| - Pak Mun Related Pump Projects | 7 | 5,400 | 33,800 |
| - Rehabilitation of Medium Scale Projects | 5 | 5,090 | 31,800 |
| <u>Total</u> | <u>26</u> | <u>29,240</u> | <u>182,800</u> |
| Middle Term Development (1990 - 2006) | | | |
| - Medium Scale Storage Projects | 12 | 7,260 | 45,400 |
| - Small Scale Storage Projects | 87 | 4,350 | 27,200 |
| - Small Scale River Diversion Projects | 40 | 2,600 | 16,300 |
| - River Pumping Projects | 41 | 4,030 | 25,100 |
| <u>Total</u> | <u>180</u> | <u>18,240</u> | <u>114,000</u> |
| <u>Grand Total</u> | <u>206</u> | <u>47,480</u> | <u>296,800</u> |

(High Priority Medium Scale Irrigation Project)

18. As a result of analyses of topographic maps and aero-photographs and field reconnaissance survey, 26 possible dam sites were identified.

Topographic surveys of dam axes were made preliminarily to determine a scale of reservoir. There is no possibility of location of the large scale project due to topographic condition of the basin, and the selected 26 projects are classified into the medium scale irrigation project according to the demarcation of project set forth by the Government.

Out of 26 projects, four projects of Huai Phong (BA-1), Huai Ban (BA-2), Huai Yang (BA-6) and Huai Si Tho (BO-2) are scheduled by the Royal Irrigation Department to be implemented in 1990 under the Fifth National Plan. The benefit-cost ratios of the remaining 22 projects are assessed, and as a first step of priority project selection, 16 projects are selected for further consideration of their priority, excluding six projects with low benefit-cost ratios.

19. As a second step, evaluation of 16 projects is done with respect to six parameters, i.e., ① benefit-cost ratio, ② scale of irrigable area, ③ condition of reservoir area, ④ income level, ⑤ soil suitability for agriculture, and ⑥ condition of site for construction of engineering works. As a result, priority is given to ten projects, among which top five projects are warranted for early implementation of feasibility study. General information of five high priority projects are given as follows;

High Priority Project

| Code No. | Project Name | River Basin | Catchment Area(sq. km) | Project Area | |
|----------|--------------------|-------------|---------------------------|--------------|--------|
| | | | | (ha) | (rai) |
| BA-5 | Lam Se | Sebai | 22.4 | 1,370 | 8,560 |
| BO-11 | Huai Khum Kham | Sebok | 36.8 | 3,650 | 22,810 |
| BO-13 | Huai Kham Phak Wan | Sebok | 13.5 | 1,110 | 6,940 |
| BO-18 | Huai Na Khai | Sebok | 31.3 | 3,100 | 19,380 |
| TL-6 | Huai Soob | Tung Lung | 35.7 | 1,830 | 11,440 |

20. The existing farm lands which are not covered by the proposed basin development plan are obliged to be cultivated under rainfed environment as before unless any other improvement measure is taken. Three principal ways of improving rainfed agriculture are ① conservation of water, ② water saving cultivation, and ③ soil conservation. Among several engineering measures, two ways of water conservation applicable to the Sebai-Sebok basin are moisture conservation and retention of rain water in a farm pond. Moisture conservation entails application of modified tillage and crop

management practices including mulching techniques, level bench terracing, contouring, deep ploughing, etc.

Giving attention to fact that the average annual rainfall of 1,600 millimeters over the basin is more than the amount of crop water requirements, construction of a farm pond with an appropriate size in paddy field area is a subject worthy of careful study. Better use of rain water on a farm level is one of the effective measures to improve rainfed agriculture in the Sebai-Sebok basin where comparatively abundant rainfall is expected in the normal year, though there are several issues to solve, i.e., appropriate size of a farm pond which farmers may have willingness to provide their lands, acceptable construction cost of farm pond and canal, paddy yield projection, institutional and financial support of the Government and so on.

(Project Area)

21. The project areas are selected among potential areas located at the immediate downstream of the proposed reservoirs, and the total gross project area amounts to 11,060 ha including villages, forest and others. According to the land use survey, paddy fields occupy 72 percent of the total project area and forest 23 percent.

| Project | <u>Present Land Use</u> | | | | (unit: ha) | |
|--------------------|-------------------------|--------|----------|--------|------------|--------|
| | Paddy | Forest | Villages | Others | Total | |
| | | | | | (ha) | (rai) |
| Lam Se | 1,151 | 86 | 56 | 77 | 1,370 | 8,560 |
| Huai Khum Kham | 2,706 | 727 | 128 | 89 | 3,650 | 22,810 |
| Huai Kham Phak Wan | 994 | 48 | 6 | 62 | 1,110 | 6,940 |
| Huai Na Khai | 2,164 | 807 | 31 | 98 | 3,100 | 19,380 |
| Huai Soob | 959 | 828 | 17 | 26 | 1,830 | 11,440 |
| Total | 7,974 | 2,496 | 238 | 352 | 11,060 | 69,130 |

22. The farm household survey was conducted during this study period for randomly selected 20 farm households per project, totaling 100 samples for five projects. According to the survey, agriculture in the project area is summarized that the average farm size is 4.2 ha, ranging from 3.5 ha of Huai Kham Phak Wan area to 5.2 ha of Huai Na Khai area, all farmers have only paddy fields except for Lam Se area where farmers have a few upland fields, and paddy yields range from 129 kg/rai in

Huai Soob area to 231 kg/rai in Lam Se area with an average of 175 kg/rai (or, 1.1 ton/ha) for five project areas.

In the project areas, paddy cultivation is entirely dependent on seasonal rainfall. The high variability of rain renders the success of paddy cultivation uncertain in the project areas where planting of paddy must conform with the fluctuating rainy season. Farm surveys show that paddy was planted to 87 percent of paddy fields and 79 percent of which were harvested on an average for two years of 1987 and 1988.

(The Project)

23. The Sebai-Sebok irrigation project is planned making its first aim to stabilize and increase the productivity of rainy season paddy, the basic crop in the areas, and to introduce dry season upland cropping as second crop. The project aims secondly to supply water for the domestic use of villagers living within the project areas.

To accomplish the said purposes, the Sebai-Sebok irrigation project will implement the following development plans at five project areas of ① Lam Se, ② Huai Khum Kham, ③ Huai Kham Phak Wan, ④ Huai Na Khai, and ⑤ Huai Soob.

1. Water Resources Development Plan

- Construction of dam and reservoir
- Water supply for irrigation and domestic use

2. Irrigated Agriculture Development Plan

- Construction of irrigation canal system
- Construction of drainage canal
- Construction of on-farm facilities
- Strengthening of extension services

3. Village Pond Plan

- Construction of village pond
- Water supply for daily consumption and cattle watering
- Fish culture in village pond

24. The surface area and volumes of water at given elevations are found from contour maps of the reservoir sites at a scale of 1:10,000. Inflow to the reservoirs is synthesized by developing a proper runoff model based on actual records of rainfall and runoff in 1986 at M132 stream gaging station with a catchment area of 110 sq.km. In order to clarify

appropriate project size with the proposed cropping pattern and the given effective storage capacity, reservoir operation studies are simulated on a 10-day basis for the period of 20 years from 1968 to 1987. With a combined effective storage capacity of 59.87 million cubic meters, the project could supply water for irrigating 7,670 (or 48,000 rai) ha of rainy season paddy and 1,530 ha (or 9,600 rai) of dry season upland crops, including domestic water of 36 villages, as given below;

Proposed Irrigable Area

| Project | Effective Storage (MCM) | Irrigable Area | | | |
|--------------------|-------------------------|--------------------|--------|------------------------|-------|
| | | Rainy Season Paddy | | Dry Season Upland Crop | |
| | | (ha) | (rai) | (ha) | (rai) |
| Lam Se | 8.50 | 1,100 | 6,900 | 220 | 1,380 |
| Huai Khum Kham | 19.48 | 2,600 | 16,300 | 520 | 3,260 |
| Huai Khan Phak Wan | 8.19 | 950 | 5,900 | 190 | 1,180 |
| Huai Na Khai | 16.11 | 2,100 | 13,100 | 420 | 2,620 |
| Huai Soob | 7.59 | 920 | 5,800 | 180 | 1,160 |
| Total | 59.87 | 7,670 | 48,000 | 1,530 | 9,600 |

The reservoir operation studies show that irrigable area of dry season upland crops varies annually from five to 35 percent depending on the water availability of a year, with an annual average of 20 percent of the project area. The average annual water supply for 20 years of operation was used as follows;

Annual Average Water Use

(unit: MCM)

| Item | Lam Se | Huai Khum Kham | Huai Kham Phak Wan | Huai Na Khai | Huai Soob |
|------------------------|--------|----------------|--------------------|--------------|-----------|
| Irrigation Diversion | 9.16 | 19.24 | 7.06 | 15.15 | 7.77 |
| Village Pond Diversion | 0.08 | 0.13 | 0.05 | 0.08 | 0.05 |
| Reservoir Losses | 1.35 | 2.10 | 1.16 | 2.12 | 0.94 |
| Reservoir Spills | 3.38 | 3.03 | 0.80 | 3.67 | 3.47 |
| Total | 13.97 | 24.50 | 9.07 | 21.02 | 12.23 |

25. Stored water is firstly used for irrigation of rainy season paddy, and in the dry season water is supplied for upland crops which is introduced to 20 percent of paddy fields on the annual average. Selection of upland crops is done after discussions with heads of villages, extension officers

in amphoes and staffs of provincial offices were made regarding farmers' experience and willingness, soil suitability, marketability and extension policy, leading to selection of groundnut, sweet corn and water melon, now being extended around the project areas, and soybean and chili for which the agricultural extension office is making efforts to extend.

Based on the available data and information on experimental farms and other projects of a similar nature, target yields are projected on condition that on-farm facilities are developed and sufficient agricultural supporting services are implemented.

Target Yields

| <u>Crop</u> | <u>Kg/rai</u> | <u>(ton/ha)</u> |
|------------------|---------------|-----------------|
| Wet Season Paddy | 550 | (3.4) |
| Groundnut | 250 | (1.6) |
| Soybean | 250 | (1.6) |
| Sweet Corn | 2,000 | (12.5) |
| Water Melon | 3,000 | (18.8) |
| Chili | 1,200 | (7.5) |

(Project Engineering)

26. The earth fill type dam is recommended for the project, basing on the topographic and geological conditions of the sites and the quality and quantity of construction materials available at the sites, together with the economy of construction work.

Judging from the geological conditions, amount of construction materials and easiness of constructions method at each project site, grouting and earth blanket methods are applicable for seepage control in the dam foundation. Since the rock surfaces are shallow and the rock layers are of relatively high permeability at the dam sites except for Lam Se, the grouting method is applicable to the seepage control through foundations. As for the Lam Se dam site, the earth blanket method is proposed because of deep soil layers with relatively impervious permeability and sufficient amount of core materials available at the proposed borrow area.

Major features of the proposed dam are as follows;

Major Features of Dam

| <u>Item</u> | <u>Lam Se</u> | <u>Huai Khum Kham</u> | <u>Huai Kham Phak Wan</u> | <u>Huai Na Khai</u> | <u>Huai Soob</u> |
|------------------------------------|---------------|---------------------------|-------------------------------|-------------------------|------------------|
| Dam Height (m) | 16.0 | 20.5 | 14.5 | 17.5 | 19.5 |
| Dam Length (m) | 1,680 | 1,150 | 1,320 | 2,750 | 1,630 |
| Embankment (1,000 m ³) | 331 | 355 | 401 | 600 | 391 |
| Crest Elevation (El. m) | 181.0 | 165.0 | 146.5 | 140 | 164.5 |

27. The conveyance capacities of irrigation canals are based on a water duty of 0.26 l/sec/rai (or, 1.60 l/sec/ha). Irrigation canals are designed to be trapezoid channels with concrete lining, and will be constructed to command a project area down to a terminal irrigation block of 100 rai (or, 16 ha). Major features of irrigation system are summarized as follows;

Irrigation System

| <u>Item</u> | <u>Lam Se</u> | <u>Huai Khum Kham</u> | <u>Huai Kham Phak Wan</u> | <u>Huai Na Khai</u> | <u>Huai Soob</u> |
|----------------------------|---------------|-------------------------------|-------------------------------|-------------------------|------------------|
| Design Capacity (cu.m/sec) | 0.90 | 2.29 | 1.52 | 3.37 | 0.86 |
| Main Canal (km) | 19.33 | 44.25 | 12.20 | 26.77 | 28.21 |
| Secondary Canal (km) | 11.42 | 27.72 | 12.91 | 21.14 | 12.37 |
| Total Length (km) | 30.75 | 71.97 | 25.11 | 47.91 | 40.58 |

28. In order to remove excess irrigation water and rainfall from the soil surface, drainage improvement is proposed. The drainage modulus is determined on condition that 70 percent of the maximum three-day consecutive rainfall with a return period of five years be drained in three days. In designing capacities of drainage canals, the reduction factor depending on the size of drainage area is considered. Being located on the middle-high terraces, drainage of the project areas is generally in good condition, except for some areas where have no natural channel to connect with a river. The project will provide for drainage canals for such areas having a total drainage area of 917 ha, as given below;

Drainage Canal

| <u>Item</u> | <u>Lam Se</u> | <u>Huai Khum Kham</u> | <u>Huai Kham Phak Wan</u> | <u>Huai Soob</u> |
|----------------------------|---------------|---------------------------|-------------------------------|------------------|
| Drainage Area (ha) | 161 | 320 | 193 | 243 |
| Design Capacity (cu.m/sec) | 0.95 | 2.08 | 1.25 | 1.63 |
| Canal Length (km) | 3.79 | 3.42 | 1.01 | 2.28 |

29. For effective water management at a farm level, construction of farm ditches with a design capacity of 0.36 l/sec/rai (or, 2.28 l/sec/ha) is proposed, together with construction of farm drains, for all irrigable areas of 7,670 ha. The project will provide for 36 village ponds, one pond per village, to retain water for domestic and cattle use. Drinking water is obtained through shallow wells to be constructed around a village pond. Fish will be raised in the village pond. Nos. of village pond are given below;

Major Features of Village Pond

| <u>Type</u> | <u>Lam Se</u> | <u>Huai Khum Kham</u> | <u>Huai Kham Phak Wan</u> | <u>Huai Na Khai</u> | <u>Huai Soob</u> |
|-------------|---------------|---------------------------|-------------------------------|-------------------------|------------------|
| 1; 10 rai | 1 | 1 | - | - | 1 |
| 2; 5 rai | 2 | 3 | 1 | 1 | - |
| 3; 3 rai | 2 | 7 | 4 | 9 | 4 |
| Total | 5 | 11 | 5 | 10 | 5 |

(Implementation Program)

30. The Royal Irrigation Department (RID) will be the executing agency responsible for implementing the Sebai-Sebok irrigation project. The project would be implemented with a loan from an international financing agency as a package project composed of five projects. RID will appoint a project director whose assignment is promotion and coordination of the project under the control of Medium Scale Project Construction Division.

RID will employ consulting engineers in the fields of dam, canal, civil work, geology, irrigation and bidding. The consultants shall assist RID in review of project planning, detail design of dam and canal, cost estimate, preparation of bid documents, tendering and contracting, quality control of construction works and general supervision of the project implementation. The total input of consulting services is 85

man-months (50 man-months for Thai consultants and 35 man-months for foreign consultants) for detail design stage, and is 150 man-months for construction supervision stage; 100 man-months for Thai consultants and 50 man-months for foreign consultants.

31. The project will be implemented over eight years from 1990 to 1997. RID will commence detailed topographic surveys of canal and dam sites in the second half of 1990. The detail design will be completed in two years 1991 to 1992 by employing consultants.

The construction of dams is scheduled to start in the dry season of 1993 at five construction sites, having construction periods of two years for Lam Se, Huai Khum Kham and Huai Kham Phak Wan and three years for Huai Na Khai and Huai Soob. The construction of canals and on-farm facilities will commence one year before the completion of dam construction with a construction period of two years.

In accordance with the above mentioned schedule, the construction works will be completed in April, 1996 to start irrigation for rainy season paddy in 1997 for three projects of Lam Se, Huai Khum Kham and Huai ham Phak Wan, while the construction of two projects of Huai Na Khai and Huai Soob will be completed in April, 1997. Attached table shows the implementation schedule of the project.

32. The estimated project cost amounts to 1,517 Baht million at a 1989 price level, of which 722 Baht million (or, equivalent to 48 percent) are foreign currency component. The project cost includes 10 percent of physical contingencies and price escalation contingencies. In the calculation, a foreign exchange rate of US\$1.00 = Baht 25.00 = ¥ 140 is applied. The project cost is summarized as follows;

| <u>Project</u> | <u>Project Cost</u> | | <u>Total</u> |
|--------------------|-----------------------|-------------------------|--------------|
| | <u>Local Currency</u> | <u>Foreign Currency</u> | |
| Lam Se | 108.9 | 93.3 | 202.2 |
| Huai Khum Kham | 225.0 | 205.5 | 430.5 |
| Huai Kham Phak Wan | 113.8 | 104.7 | 218.5 |
| Huai Na Khai | 199.7 | 179.0 | 378.7 |
| Huai Soob | 147.7 | 139.7 | 287.4 |
| Total | 795.1 | 722.2 | 1,517.3 |

Annual disbursement schedule based on the implementation schedule of the project is summarized as follows;

| <u>Annual Disbursement</u> | | | |
|----------------------------|---------------------------|-----------------------------|--------------|
| (unit: Baht million) | | | |
| <u>Year</u> | <u>Local Currency</u> | <u>Foreign Currency</u> | <u>Total</u> |
| 1990 | 6.5 | 4.4 | 10.9 |
| 1991 | 7.7 | 15.9 | 23.6 |
| 1992 | 4.4 | 13.8 | 18.2 |
| 1993 | 64.2 | 43.5 | 107.7 |
| 1994 | 194.3 | 219.6 | 413.9 |
| 1995 | 304.8 | 247.6 | 552.4 |
| 1996 | 178.3 | 144.4 | 322.7 |
| 1997 | 34.9 | 33.1 | 68.0 |
| Total | 795.1 | 722.2 | 1,517.3 |

(Project Evaluation)

33. Quantitative benefits in monetary terms from the project would be divided into agriculture and fishery production benefits; namely, crop production benefit in the irrigation service area and fish production in the reservoirs and village ponds. The economic internal rate of return (EIRR) of the package of five projects is estimated at 8.6 percent. EIRR of the project might be not so high as the economic indicator. However, agriculture is still the main industry in Thailand in spite of low productivity industry, and the implementation of the project will play an important role in correcting the differential in living standard among regions in the country.

From all these considerations, it is reasonably concluded that the Sebai-Sebok irrigation project is economically feasible from the standpoint of the national economy.

| <u>EIRR</u> | |
|------------------------------|------------|
| <u>Project</u> | <u>(%)</u> |
| 1. Lam Se | 8.0 |
| 2. Huai Khum Kham | 8.5 |
| 3. Huai Kham Phak Wan | 8.9 |
| 4. Huai Na Khai | 9.7 |
| 5. Huai Soob | 7.4 |
| Package of the Five Projects | 8.6 |

34. Apart from the profitability of the project from the standpoint of the national economy, the impact of the project on the farmers concerned in the project area is evaluated as it is highly important to consider the profitability of the farmers concerned. The representative farmer having 20 rai (3.2 ha) of paddy fields is assumed to have annual net income of around 20,000 Baht in the situation of without project.

With the implementation of the project, annual net income of the representative farmer will increase to about 58,000 Baht, 2.9 times as much as the net income in the situation of without project. The representative farmer will be able to have annual net farm income of 49,000 Baht, as given the following table.

| <u>Farm Income</u> | | |
|----------------------------|------------------------|---------------------|
| | (unit: Baht) | |
| <u>Item</u> | <u>Without Project</u> | <u>With Project</u> |
| 1. Farm Size (rai) | 20 | 19.19 |
| 2. Agricultural Income | | |
| - Crops | 7,638 | 39,038 |
| - Livestocks | 3,433 | 3,433 |
| - Fishes | - | 6,614 |
| <u>Total</u> | <u>11,071</u> | <u>49,085</u> |
| 3. Non Agricultural Income | 8,871 | 8,871 |
| 4. Total Farm Income | 19,942 | 57,956 |

(Recommendation)

35. It is recommended that five (5) medium scale irrigation projects of Lam Se, Huai Khum Kham, Huai Kham Phak Wan, Huai Na Khai and Huai Soob should be accomplished as a package project of Sebai-Sebok irrigation project close to the proposed implementation schedule.

The feasibility study indicates that the Sebai-Sebok irrigation project is technically sound and economically feasible with the economic internal rate of return of 8.6 percent, based on primary benefits only. The estimated economic internal rate of return shows that the project will contribute significantly to the development of the economy of the Sebai-Sebok area, being located in the Northeast, the poorest region. With the implementation of the project, the representative farmer with a farm size of 20 rai paddy fields will be able to have annual net income of 49,000 Baht from agricultural production only.

36. To give active support to the irrigated agriculture development, the establishment of water users' associations and strengthening of agricultural extension services are recommended.

The project will provide for on-farm facilities for complete distribution and drainage systems extending to individual farms for effective water management on a farm level. The responsibility of operation and maintenance of the on-farm facilities will fall on the farmers under the guidance of the Royal Irrigation Department.

In order to increase agricultural productivity, the agriculture development includes the introduction of upland crop cultivation in the dry season, and the current rainfed agriculture is to be converted to the irrigated agriculture. To this end, the government support should be strengthened with respect to agricultural extension services i.e., prompt supply of farm inputs such as fertilizer, seeds, chemicals and so on, improved farming practices and advanced farm management.

37. It is recommended that, prior to initiation of detail design and construction, additional investigations in the fields of topography, geology, soil engineering and hydrology be carried out without delay as proposed in the feasibility study.

The feasibility study was based on the topographic maps with a scale of 1:4,000 for the project areas and 1:2,000 for the dam sites. Further topographic surveys are required for the proposed borrow areas and construction sites of heavy structures. Additional geological investigations include geophysical prospecting, drilling, test pits, auger boring and soil tests at the proposed dam and reservoir sites. Hydrological observations shall be initiated at the proposed dam sites with respect to rainfall, river runoff and sedimentation.

38. Concerning the basin development plan prepared for effective and orderly development of water resources of the Sebai-Sebok basin, the followings are recommendable;

(1) Implementation of feasibility studies for medium scale irrigation projects and rehabilitation projects which are proposed under the short term development plan; feasibility studies of the Pak Mun related pump irrigation projects shall be scheduled in line with a progress of the study of the Pak Mun multipurpose development by EGAT.

- (2) Implementation of new water resources development projects shall be planned carefully as not to have minus impact on the existing projects and waste the potential of water resources development, in due consideration of the basin development plan which was prepared basing on the overall study of the existing projects, water availability, topography of possible dam sites, and estimated water demand of the Sebai-Sebok basin.
- (3) According to the site investigations of the existing small and medium scale irrigation projects, many projects have engineering problems such as deficient capacities of spillway, unsuitable embankment materials, insufficient compaction of soil, collapse of concrete structures and decrease in storage capacities due to sediment. As water resources development in the Sebai-Sebok basin has to rely on the implementation of small and medium scale projects, criteria of project planning and design shall be drawn up taking account of the physical characteristics of the basin.
- (4) For the improvement of rainfed agriculture over the area where is not covered with the proposed irrigation projects, corresponding to 82 percent of the total existing paddy fields, conservation of water and soil are indispensable. Among several countermeasures to this end, construction of a farm pond to retain excess rain water on paddy fields is the most attractive. The annual average rainfall over the Sebai-Sebok basin is 1,600 millimeters, relatively high when compared to the national average, which exceeds the consumptive use of crops. Therefore, studies on technical soundness, profitability of project, and institutional and financial support of the Government shall be carried out towards early implementation of a farm pond project.

Implementation Schedule of Sebai-Sebok Irrigation Project

| Work Item | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1. Feasibility Study | ===== | | | | | | | | |
| 2. Loan- - Engineering Service for Detail Design - Construction | | ===== | ===== | ===== | ===== | ===== | ===== | ===== | ===== |
| 3. Topographic Survey and Land Acquisition | | ===== | ===== | ===== | ===== | ===== | ===== | ===== | ===== |
| 4. Detail Design | | | ===== | ===== | ===== | ===== | ===== | ===== | ===== |
| 5. Construction Tendering and Contract | | | | ----- | ----- | ----- | ----- | ----- | ----- |
| (1) Lam Se Project (BA-5; 1,100 ha, or 6,900 rai) - Dam - Canal, on-farm works and village pond | | | | ===== | ===== | ===== | ===== | ===== | ===== |
| (2) Huai Kham Pak Wan Project (BO-13; 950 ha, or 5,900 rai) - Dam - Canal, on-farm works and village pond | | | | ===== | ===== | ===== | ===== | ===== | ===== |
| (3) Huai Khum Kham Project (BO-11; 2,600 ha, or 16,300 rai) - Dam - Canal, on-farm works and village pond | | | | ===== | ===== | ===== | ===== | ===== | ===== |
| (4) Huai Na Khai Project (BO-18; 2,100 ha, or 13,100 rai) - Dam - Canal, on-farm works and village pond | | | | ===== | ===== | ===== | ===== | ===== | ===== |
| (5) Huai Soob Project (TL-6; 920 ha, or 5,800 rai) - Dam - Canal, on-farm works and village pond | | | | ===== | ===== | ===== | ===== | ===== | ===== |
| 6. Procurement of O & M Equipment - Tendering and Contract - Manufacturing and Delivery | | | | ----- | ----- | ----- | ----- | ----- | ----- |
| 7. Consulting Services - Detail Design - Construction Supervision | | | ===== | ===== | ===== | ===== | ===== | ===== | ===== |

IMPLEMENTATION SCHEDULE OF OVERALL BASIN DEVELOPMENT PROJECT

| Description | Irrigable Area (ha) | | 1992 - 1996 | | | | | 1997 - 2001 | | | | | 2002 - 2006 | | | | |
|---|---------------------|------|-------------|------|------|------|------|-------------|------|------|------|------|-------------|------|------|------|------|
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 1. Short Term Development Plan (1990-1996) | | | | | | | | | | | | | | | | | |
| 1.1 Storage Scheme | | | | | | | | | | | | | | | | | |
| - RID Planned MSIP: 4 Projects (BA-1, BA-2, BA-6, BO-2) | | | | | | | | | | | | | | | | | |
| - MSIP Group A : 5 Projects (BA-5, BO-11, BO-13, BO-18, TL-6) | | | | | | | | | | | | | | | | | |
| - MSIP Group A' : 5 Projects (BA-8, BA-9, BO-3, BO-17, TL-5) | | | | | | | | | | | | | | | | | |
| 1.2 Run-of-River Scheme with Pak Mun Dam | | | | | | | | | | | | | | | | | |
| - Tung Ma Hw Pump Project | | | | | | | | | | | | | | | | | |
| - Sebai-Sebok Pump Project | | | | | | | | | | | | | | | | | |
| 1.3 Rehabilitation Scheme: 4 MSIP Projects | | | | | | | | | | | | | | | | | |
| <u>Sub-total</u> | | | | | | | | | | | | | | | | | |
| 2. Middle Term Development Plan (1990-2006) | | | | | | | | | | | | | | | | | |
| 2.1 Storage Scheme | | | | | | | | | | | | | | | | | |
| - MSIP Group B : 6 Projects (BA-4, BO-10, BO-14, BO-15, TL-1, TL-3) | | | | | | | | | | | | | | | | | |
| - MSIP Group C : 6 Projects (BO-6, BO-8, BO-9, BO-12, BO-19, TL-2) | | | | | | | | | | | | | | | | | |
| - SSIP : 87 Projects | | | | | | | | | | | | | | | | | |
| 2.2 Run-of-River Scheme | | | | | | | | | | | | | | | | | |
| - SSIP Weir Project | | | | | | | | | | | | | | | | | |
| - SSIP Pump Project | | | | | | | | | | | | | | | | | |
| <u>Sub-total</u> | | | | | | | | | | | | | | | | | |
| <u>Total</u> | | | | | | | | | | | | | | | | | |

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