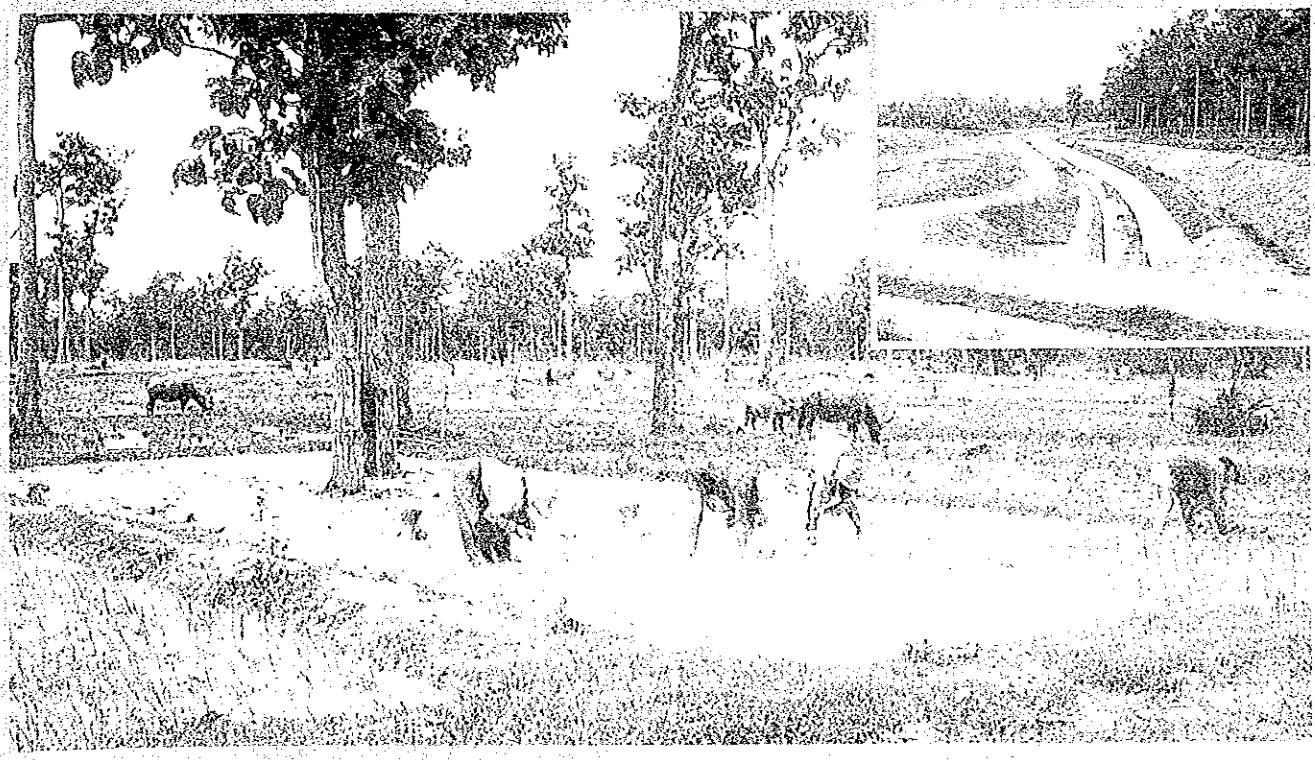
KINGDOM OF THAILAND

FEASIBILITY STUDY ON SEBAI-SEBOK BASIN DEVELOPMENT PROJECT

VOLUME 1 MAIN REPORT



FEBRUARY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

KINGDOM OF THAILAND

FEASIBILITY STUDY

ON

SEBAI-SEBOK BASIN DEVELOPMENT PROJECT

IN

THE NORTHEAST REGION

VOLUME 1 : MAIN REPORT

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JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Japanese Government decided to conduct a study on Sebai-Sebok Basin Development Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Kingdom of Thailand a study team headed by Mr. Kunio Ohta from October, 1988 to November, 1989.

The team held discussions with the officials concerned of the Government of the Kingdom of Thailand and conducted a field survey in Sebai-Sebok Basin in the Northeast Region. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will contribute to the development of the Project and to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

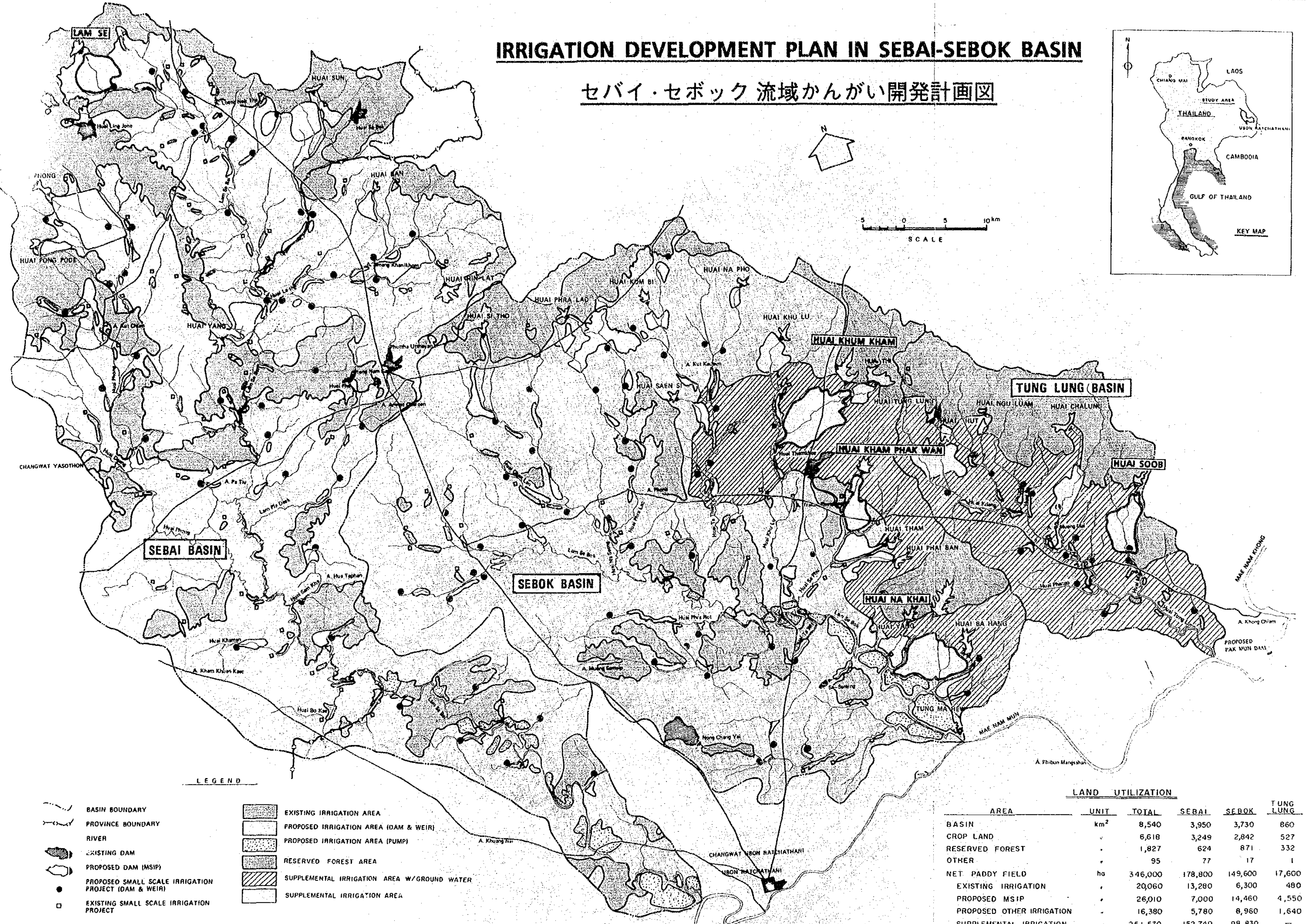
February, 1990

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

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



LAM SE
HUAI SUN
HUAI BAN
HUAI PONG PODE
HUAI YANG
HUAI SI THO
HUAI PHRA LAO
HUAI KOM BI
HUAI NA PHO
HUAI KHU LU
HUAI KHUM KHAM
HUAI SAEN SI
HUAI TUNG LUNG
HUAI NGU LUAM
HUAI CHALUN
TUNG LUNG BASIN
HUAI KHAM PHAK WAN
HUAI SOOB
HUAI THAM
HUAI PHAI BAN
HUAI NA KHAI
HUAI YANG
HUAI BA HANG
TUNG MA HEW
SEBAI BASIN
SEBOK BASIN
CHANGWAT YASOTHON
CHANGWAT UBON RATCHATHANI
UBON RATCHATHANI
MAE NAM MUN
MAE NAM KHONG
PROPOSED PAK MUN DAM
A. Khong Chiam
A. Phibun Mangsahan
Nong Chang Yai
A. Kham Khuen Kaeo
SCALE
5 0 5 10 km
N
LAOS
CHIANG MAI
STUDY AREA
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UBON RATCHATHANI
BANGKOK
CAMBODIA
GULF OF THAILAND
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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

IRRIGATION DEVELOPMENT PLAN
IN SEBAI-SEBOK BASIN

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ABBREVIATIONS AND UNIT

Agencies

ARDO	Accelerated Rural Development Office, MOI
CDD	Community Development Department, MOI
DOA	Department of Agriculture, MOAC
DLD	Department of Land Development, MOAC
DMR	Department of Mineral Resources, MI
DOAE	Department of Agricultural Extension, MOAC
EGAT	Electricity Generating Authority of Thailand
FAO	Food and Agriculture Organization of the United Nations
JICA	Japan International Cooperation Agency
MD	Meteorology Department
MI	Ministry of Industry
MOAC	Ministry of Agriculture and Cooperatives
MOI	Ministry of Interior
MPH	Ministry of Public Health
NESDB	Office of National Economic and Social Development Board, PMO
NSO	National Statistics Office
PMO	Prime Minister's Office
PWD	Public Welfare Department, MOI
RFD	Royal Forestry Department, MOAC
RID	Royal Irrigation Department, MOAC

Other Abbreviations

BA	Sebai Basin
BO	Sebok Basin
TL	Tung Lung Basin
F/S	Feasibility Study
GDP	Gross Domestic Product
GRP	Gross Regional Product
GPP	Gross Provincial Product
HYV	High Yield Varieties
LV	Local Varieties
EIRR	Economic Internal Rate of Return
NPV	Net Present Value/Net Production Value
B/C	Benefit Cost Ratio
GPV	Gross Production Value
F.C	Foreign Currency
L.C	Local Currency
C.I.F	Cost, Insurance and Freight
F.O.B	Free on Board
O & M	Operation and Maintenance
H.W.S	High Water Surface
N.W.S	Normal Water Surface
L.W.S	Low Water Surface
SSIP	Small Scale Irrigation Project
MSIP	Medium Scale Irrigation Project

Glossary

Park	Region
Changwat	Province
Muang	Capital of Province
Amphoe	District
Tambon	Sub-district
Muban	Village
Mae Nam	Large river
Nam	A meidum-size river
Lam	A small river
Kwae	A tributary of a river
Huai	A rivulet

Unit

Rai	Unit of land measurement
Baht	Unit of Thai Currency
mm	Millimeter
cm	Centimeter
m	Meter
cu.m	Cubic meter
MCM	Million Cubic Meter
cu.m/s	Cubic meter per second
km	Kilometer
sq.km	Square kilometer
g	Gram
kg	Kilogram
ton	Metric ton
ha	Hectare
El	Elevation above mean sea level
MSL	Mean Sea Level
C°	Degree Centigrade
mmho/cm	Millimho per centimeter
HP	Horsepower
ppm	Parts per million

Units of Measurement

Rai	= 0.16 hectares	= 1,600 sq.m
Hectare	= 6.25 rai	= 10,000 sq.m
$1.00	= Baht 25.00	= ¥ 140.0

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 delimitated 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 indicates 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;

New Development Project

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

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 construted 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

Project	Nos. of Project	Irrigable Area (ha)	Irrigable Area (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
Total	26	29,240	182,800
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
Total	180	18,240	114,000
Grand Total	206	47,480	296,800

(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)	Project Area (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.

Present Land Use

(unit: ha)

Project	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 it 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

Crop	Kg/rai	(ton/ha)
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

Item	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob
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

Item	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob
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

Item	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Soob
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

Type	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob
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;

Project Cost

(unit: Baht million)

Project	Local Currency	Foreign Currency	Total
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;

Annual Disbursement

(unit: Baht million)

Year	Local Currency	Foreign Currency	Total
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.

EIRR

Project	(%)
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 ares 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.

Farm Income

(unit: Baht)

Item	Without Project	With Project
1. Farm Sine (rai)	20	19.19
2. Agricultural Income		
- Crops	7,638	39,038
- Livestocks	3,433	3,433
- Fishes	-	6,614
Total	11,071	49,085
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 feaibility study indicates that the Sebai-Sebok irrigaiton 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									

CHAPTER I. INTRODUCTION

CHAPTER I. INTRODUCTION

1-1. Background of the Study

The Government of Thailand has set forth the rural development programme, one of the most important policies in the Sixth National Economic and Social Development Plan implemented in 1987, placing an emphasis on the rural poverty alleviation and rectification of income disparity. The Northeast, the poorest region, is the target area for rural development uninterruptedly to be dealt with in the Sixth Plan. Continuous efforts have been made in the Northeast to develop land and water resources to alleviate poverty through increase in productivity of agriculture, the key industry in the region.

Japan International Cooperation Agency (hereinafter referred to as "JICA") carried out in 1984 a feasibility study on the Lower Northeast Medium Scale Irrigation Package Project. In the same year, the Government of Thailand requested the Government of Japan to extend technical aid for the implementation of a feasibility study on Sebai-Sebok Basin Development Project, as a sister project of the above-mentioned medium scale irrigation package project. In response to the request of the Government of Thailand, JICA dispatched to Thailand a Preliminary Survey Team in April, 1988.

In accordance with the Scope of Work agreed upon between JICA and the Royal Irrigation Department of the Ministry of Agriculture and Cooperatives (hereinafter referred to as "RID"), JICA dispatched the Feasibility Study Team (hereinafter referred to as "Team") to Thailand on October 3, 1988 to conduct the study. The study was carried out for a period of two years and the feasibility study reports have been prepared in February, 1990. The reports consists of Volume 1 Main Report, Volume 2 Appendix and Volume 3 Drawings.

1-2. Objective and Scope of Work

The objectives of the study are (i) to review the existing and under-study projects and to evaluate the potentials of water resources and land resources for agricultural development in the Sebai, Sebok and Tung Lung basin, (ii) to identify groups of agricultural development projects, improvement and/or new, with priorities in the basin, and (iii) to carry out a feasibility study for the priority agricultural development projects.

The study covers the basins of Sebai, Sebok and Tung Lung located in two provinces of Ubon Ratchathani and Yasothon in the Northeast region,

having an area of 8,540 sq.km. The study was implemented in two phases as follows;

Phase I Study (Overall Basin Study)

- to review existing and under-study projects and evaluate the potentials of water resources and land resources for agricultural development;
- to identify potential agricultural development projects, improvement and/or new, and to clarify the projects according to their priority, and
- to recommend the stage of basin development

Phase II Study (Feasibility Study)

- to carry out the feasibility study for a group of high priority projects as identified and ranked in the Phase I study.

This feasibility report presents the results of Phase I and Phase II studies undertaken in close cooperation with RID and other governmental agencies concerned. In Phase I study, five of high priority projects, namely, Lam Se, Huai Khum Kham, Huai Kham Phak Wan, Huai Na Khai and Huai Soob, have been identified as high priority project among many potential projects of storage and run-of-river scheme. Phase II study has clarified technical soundness and economic feasibility of the above five high priority projects.

The list of members of JICA team and RID officials concerned is given in Annex 1. Annex 2 presents main reference and data collected for the study.

1-3. National Policy on Rural Development

The rural development program is the most important program continuing from the Fifth Plan, reflecting the high priority given by the Government as well as the private sector. Despite the large government investment in the construction and improvement of water resources over the period of previous five National Plans, solution of rural poverty problems was pursued only to a limited extent and in rather limited target areas. Many villages still lack water resources for agricultural production and daily consumption. In addition, low agricultural productivity continues to burden the rural population.

Under the Sixth Plan, the Government has adopted a new operational plan that will concentrate on actual problems confronted by the rural

population in different areas. The nature of these problems will determine the areas and priorities for implementation. Target areas consist of backward rural areas, middle level rural areas and progressive rural areas as given below;

a) Backward areas in need of immediate development are defined as areas in which most of the people are economically deprived and which face four or five of the following problems; inconvenient communications, insecure land tenure, low production or incomes, poor health, shortage of water for domestic consumption and lack of knowledge concerning methods of self-improvement;

b) Middle level areas, the second priority in development, are areas in which most people are economically deprived and which are affected by one to three of the preceding problems; and

c) Progressive areas are those in which most of the people have high production potential; such areas enjoy reasonably favourable economic conditions and suffer from few of the problems mentioned above.

In the Northeast region in which the study area is located, there are 2,684 village classified as backward areas, or equivalent to 46 percent of the total backward areas (5,787 village) in the country, while only 16 percent of progressive areas (or 1,845 villages) against 11,621 villages in total in the country.

1-4. National Policy on Water Resources Development

1-4-1. Water Resources Development Project

Reservoir construction is one of the most practicable means to develop water resources in Thailand. According to data and information of RID and the Electricity Generating Authority of Thailand (EGAT), leading agencies for water resources development, total storage capacities of reservoirs in 1988 amounted to about 69,300 MCM, of which about 9,800 MCM (or 14 percent) of reservoir capacities were constructed in the Northeast region.

According to the national water resources administrative policy revised by the Prime Minister's Office and effected on April 14,1988, the scope of large, medium and small scale water resources projects are defined as follows:

- Large scale water resources projects refer to all types of projects that have a storage capacity of more than 100 MCM or a reservoir area of more than 15 sq.km or an irrigation area of

more than 80,000 rai (12,800 ha). The construction covers a period of more than four years;

- Medium scale water resources projects are those types of projects that have a storage capacity of not more than 100 MCM or a reservoir area of not more than 15 sq.km or an irrigation area of not more than 80,000 rai (12,800 rai). The construction covers a period of one to four years;
- Small scale water resources projects are projects for which reservoirs, ponds, irrigation canals, deep wells, shallow wells, or others are constructed with a construction cost of not more than 10 Million Baht. The construction is to be completed within one year.

1-4-2. Irrigation Development Project

The Ministry of Agriculture and Cooperatives (MOAC) adopted an operation plan (1998-1991) relevant to land and water resources development in association with the Sixth National Plan. Although the Government has tried to develop water resources for many years, about 80 percent of cultivated land still relies on rain water which is an obstacle to increase production and income of farmers. The major factors that restrict the expansion of irrigated area are: 1) physical limitation of water resources development, and 2) ineffective utilization of previously constructed large scale irrigation projects. To overcome such difficulties in the expansion of irrigated area, MOAC has decided the following policy;

- to accelerate the implementation of medium scale irrigation project in order to increase irrigable area at an average rate of 200,000 rai (32,000 ha) per year;
- to improve and increase the efficiency of utilization of large scale irrigation projects by providing a suitable project administration system for close cooperation among government agencies concerned and by encouraging the private sector to participate in agricultural development; and
- to develop and rehabilitate small scale irrigation projects including groundwater development projects into the basin development system.

In line with the MOAC's policy as mentioned above, RID planned to implement three large scale, 35 medium scale and 471 small scale irrigation projects during the three years period of 1989 to 1991. By completing these large and medium scale irrigation projects, storage capacities and irrigable area are expected to increase by about 600 MCM and 157,000 rai (25,100 ha),

respectively; thus the total irrigable area will amount to 27 percent of the total cultivated land in Thailand.

CHAPTER II. GENERAL DESCRIPTION OF THE BASIN

CHAPTER II. GENERAL DESCRIPTION OF THE BASIN

2-1. Location

The Sebai-Sebok basin, the study area, is situated on the southeastern flank of the Khorat Plateau in the northeast of Thailand extending to the north of the city of Ubon Ratchathani at about 70 km east of the confluence of the Mun river with the Mekong river, the Thai-Laotian border. The river system in the basin is composed of the Sebai, Sebok and Tung Lung rivers that flow into the Mun river.

The basin is roughly rectangular in shape, extending up to about 110 km from the Mun river and about 80 km in width. The basin falls within Ubon Ratchathani and Yasothon provinces having a total area of about 8,540 sq.km; 3,950 sq.km for the Sebai, 3,730 sq.km for the Sebok and 860 sq.km for the Tung Lung.

2-2. Topography and Geology

2-2-1. Topography

The basin is delimitated by the Phu Phan range in the north and northeast, by the branch of the Phu Phan range in the west and by the flood plains of the Mun river in the south. In the north of the basin, the mountains generally ranging in altitude from 200 to 250 m extend northwestward at the upper Sebok basin and the upper Tung Lung basin, and its extension line is bent to the westward or southwestward at the upper Sebai basin. The peneplanation flat plain ranging in altitude from 100 to 150 m extends in the southern area of the basin.

The Sebai river, the biggest river in the basin, flows toward southwestward in parallel with the Sebok and Tung Lang rivers, and the tributaries run to the southwestward or southward. The drainage pattern of the basin is thus dendritic.

2-2-2. Geology

The geology of the basin consists of the Mesozoic sedimentary rocks within the Khorat Group, which is widespread in the Khorat Plateau, and the Quaternary which covers the Mesozoic. The Mesozoic is divided into seven formations; namely, Nam Phong formation, Phu Kradung formation, Phra Wihan formation, Sao Khua formation, Phu Phan formation, Khok Kruat

formation and Maha Sarakham formation. However, the Nam Phong formation, the lowest formation in the Khorat Group, is not formed in the basin.

The basin is divided into two areas in terms of geological structure. One is the central to southern area where the geological structure is simple and the bed trends northwest to west and gently dips southward. And the other is the northern area characterized by the prevalence of the fold structure. In the upper Sebai basin, the beds are broadly folded with low dips into northwest-trending anticline which plunges southeast and northwest at low angles. In the upper Sebok basin and the upper Tung Lung basin, the geological structure consists of the series of west-trending to northwest-trending folds.

2-3. Meteorology and Hydrology

2-3-1. Meteorology

The basin has a tropical monsoon climate with a pronounced dry season. The rainy season extends from May to October. Annual rainfall varies from about 1,800 mm on the southeastern part to about 1,400 mm on the northwestern part of basin with an average of 1,600 mm. Monthly average rainfall is highest in August and lowest in January.

Cyclonic storms originated in the South China Sea and the Pacific Ocean sometimes enter Thailand mostly during the period September to November. The storms diminish in intensity as they come across the Indo-China Peninsula, but bring heavy rainfall to the basin as tropical storms or tropical depressions.

The mean monthly temperature varies from 30°C in April to 23°C in December (Ubon Ratchathani), a range of only 7°C. The monthly mean relative humidity of Ubon Ratchathani for 30 years had an average of 73 percent with the lowest in March of 62 percent while the highest took place in September, 83 percent. Maximum mean monthly evaporation of 216 mm occurs in March and the minimum of 129 mm in September, in Ubon Ratchathani, respectively. Table 2-1 gives meteorological data observed for 30 years from 1956 to 1985 at Ubon-Ratchathani.

2-3-2. Hydrology

There are 10 water gaging stations in the basin and river discharge data are available at six stations, of which two stations of M32 (catchment area of 1,654 sq. km) and M69 (catchment area of 2,132 sq.km) have relatively long term discharge records-30 years (1954-1983) for M32 and 18 years (1971-1988)

for M69. Aerial rainfall was estimated by Thiessen method based on rainfall data at 37 rainfall stations in and around the basin. The discharge data at M32 and M69 below summarize the annual runoff coefficients of the rivers;

Long Term Annual Runoff

Gaging Station	Annual Runoff(MCM)	Annual Rainfall(mm)	Annual Runoff Coefficient(%)
M32: Sebai River	753 (356~1,312)	1,527 (1,188~1,845)	30 (18~43)
M69: Sebok River	1,369 (497~2,413)	1,567 (1,048~2,063)	41 (24~60)

The annual maximum floods occur mostly in August or September. The maximum floods recorded were 669 cu.m/s (or, 0.40cu.m/sec/sq.km) of the Sebai river at M32 station in 1978 and 888 cu.m /sec (or, 0.42 cu.m/sec/sq.km)of the Sebok river at M69 in 1979.

2-4. Soils and Land Use

2-4-1. Soils

(1) Soil Classification

According to the data provided by the Department of Land Development, there are 30 soil series in the basin. These 30 soil series have been classified into eight great soil groups. Main great soil groups and their areas are outlined below;

Distribution of Great Soil Groups

Great Soil Group	Symbol of Soil Series	Area (ha)
Low humic gley soils	Re, Re-1, Re/on,Ub, Ud, Pn, Re/Pm	264,700
Gray podzolic soils	Kt, Ng, Sk	245,100
Gray or red-yellow podzolic soils	Kt-d, Kt-h, Kt/Pp, Kt-h/Pp	126,600
Gray-red-yellow podzolic soils	Bb, BCb, Sc	137,600
4 other great soil groups	Tm, Cm, Ac, Pm, Km St, Pp, Wm. Yt, Bt	80,000
Total		854,000

(2) Land Classification

In classification of land regarding the suitability for paddy cropping, standard values were given to five elements of natural properties; they are, soil texture, effective depth of soils, slope, drainage and natural fertility. Land in the basin was classified into four classes; Class 1 (very well), Class 2 (well), Class 3 (moderately), and Class 4 (poorly). According to this classification, there is no Class 1 land in the basin, however, about 65 percent of the land is evaluated as suitable for paddy cropping as shown below:

Land Classification

Item	Class 1	Class 2	Class 3	Class 4	Total
Area					
(1,000 ha)	-	264.7	289.9	299.4	854.0
(%)	-	31	34	35	100

(3) Saline Soils

The data provided by the Department of Land Development (DLD) show that saline soils are broadly formed in the middle and down stream reaches of the Sebai basin and the middle reaches of the Sebok basin, totaling 354,700 ha, or equivalent to 42 percent of the basin. According to the definition by DLD, land was classified in terms of salt affected area as follows; land where salt crystals (NaCl) are formed over more than 50 percent of land surface in the dry season is classified as Class 1, 10-50 percent as Class 2, 1-10 percent as Class 3, less than one percent as Class 4. Class 5 is defined as soils which might be salty being underneath the elevated ground with salt bearing rocks, and as soils in the plain areas which have a possibility of salt crystallization.

Distribution of Saline Soils

-Unit: ha-

Classification	Sebai	Sebok	Tung Lung	Total
Saline Soils				
-Class 1	130	-	-	130
-Class 2	560	-	-	560
-Class 3	25,790	49,340	-	75,130
-Class 4, 5	137,760	141,120	-	278,880
Sub-total	164,240	190,460	-	354,700
Non Saline Soils	230,760	182,540	86,000	499,300
Total	395,000	373,000	86,000	854,000

2-4-2. Land Use

Surveys were conducted based on the map of current land use (scale 1 :500,000) prepared by DLD in 1986. Paddy fields currently occupy 64 percent of the area, and upland fields 13 percent. Thus, the total percentage of cultivated areas is as high as 77 percent. This is attributable to the fact that deforestation occurred in parallel with the population increase in the area.

Present Land Use in Gross Area

- Unit: ha -

Category	Sebai	Sebok	Tung Lung	Total
Paddy Field	260,400	234,300	52,700	547,400
Upland	64,500	49,900	-	114,400
Forest Land	62,400	87,100	33,200	182,700
Swamp	5,700	-	-	5,700
Others	2,000	1,700	100	3,800
Total	395,000	373,000	86,000	854,000

2-5. Agriculture

2-5-1. Crop Cultivation Area

In the basin there is farm land of 661,800 ha in gross, of which according to data of the Department of Agricultural Extension (DOAE), net area of farm land is 374,600 ha. The following table showing area by crop in the basin reveals that paddy fields are extremely dominant-88 percent and 94 percent for Yasothon and Ubon Ratchathani provinces, respectively. Among many kinds of upland crops planted in the basin, kenaf, cassava and groundnuts as well as vegetables, such as water melon and chili are predominant..

Farm Land in Net Area

- Unit: ha -

Province	Paddy Fields	Upland	Fruit Tree	Flower	Total
Yasothon	94,150	9,797	2,337	478	106,762
Ubon Ratchathani	251,850	13,323	1,967	735	267,875
Total	346,000	23,120	4,304	1,213	374,637

2-5-2. Cropping Pattern

According to "Agricultural Extension Plan, Crop Year 1987-1991", there are three cropping patterns in the low land, upland and high land in Yasothon province.

Low land conditions;

- Groundnut is planted in the middle of January following the rainy season paddy cropping.
- Water melon or vegetable in the dry season is planted immediately after harvesting rainy season paddy.

Upland conditions;

- Cassava occupies the whole field all the year-round starting from the beginning of the rainy season.
- Kenaf is planted starting in the early rainy season and is harvested in the middle of the rainy season; then, groundnut is planted immediately.
- Kenaf is harvested a little later than the above mentioned pattern, at the end of rainy season, and is followed by water melon.

High land conditions;

- Groundnut or vegetable is cultivated starting from the middle of January following upland paddy cropping in the rainy season.
- Groundnut is the crop for the rainy season being followed by water melon to be planted by making use of remaining soil moisture.

According to DOAE, Ubon Ratchathani, cropping patterns in the province are classified into two: paddy field condition and upland condition.

Paddy field condition;

- Chili is cultivated in the dry season with irrigation after the rainy season paddy is harvested.
- Water melon and other vegetable are cropped after the rainy season paddy cropping.
- Sweet corn, groundnut or soybean are cropped in January after the rainy season paddy cropping.

Upland condition;

- Kenaf in the rainy season is followed by water melon.
- Cassava mono-culture through the year starting at the beginning of the rainy season.

2-5-3. Yield of Major Crops

Paddy, the dominant crop, is mostly transplanted (97 percent) and about 58 percent of paddy is of glutinous. The yield of rainy season paddy in the basin is 1.9 tons/ha for Yasothon province and 1.7 tons/ha for Ubon Ratchthani province, as compared to the national average of 2.0 tons/ha (2.4 tons/ha for the North and 2.3 tons/ha for the Central region). Non-glutinous paddy yields slightly higher than glutinous paddy. Transplanted paddy yields obviously higher than broadcasted or others . Though the area is very limited in two provinces, the yields of dry season paddy are much higher than that of rainy season paddy.

Kenaf is abundant and one of the most important crops in the basin. Two provinces produced about 14 percent of national total production in 1986/87 but yield is as low as 1.09 tons/ha for Yasothon province and 0.95 tons/ha for Ubon Ratchathani province, while the national average yield was 1.12 tons/ha.

The crop productivity in the basin is low due to i) lack of irrigation facilities, ii) low soil fertility, iii) saline problem soils, iv) low level of fertilizer application, and v) lack of technical knowledge of farmers.

2-5-4. Farm Management

(1) Farmers' Problems

The number of villages that have problems in daily life and farming activities were surveyed by DOAE and DLD. Among ten problems, top three problems confronted by farmers are i) paddy cultivation, ii)dry season cropping and iii) cooperative activities as given below;

Number of Village with Problem

Problem	Yasothon	Ubon Ratchathani	Total
Water Resources	29	138	167
Paddy Cultivation	49	298	347
Upland Cropping	18	56	74
Dry Season Cultivation	50	271	321
Chicken Feeding	18	86	104
Draft Animal	3	21	24
Fuel	26	82	108
Credit System	0	11	11
Cooperative Activity	41	258	299
Others	30	91	121

(2) Paddy Cropping

Out of the total farm households in the related Amphoes, about 75 percent are self-sufficient with rice. The survey also shows that only 1.3 percent and 5.4 percent of farm households in the related Amphoes are employing double cropping of paddy.

Information on paddy cropping being adopted by farmers at present are available from the regular survey carried out by DOAE in two provinces, for which about 10 percent of households were selected. Results of survey are summarized as follows;

Yield: Majority of cultivation is made under rainfed conditions. The yield of non glutinous rice is slightly higher than that of glutinous. Productivity of Yasothon province looks higher than that of Ubon Ratchathani province.

Variety: Majority of varieties is non photo sensitive one. Local varieties are being used only by 3-6 percent of all farm households.

Seeding: Seeding is mostly practised during the period from mid-May to mid-July in both provinces, but many farmers in Yasothon province started seeding in the beginning of this period.

Fertilizer: Application of 20-35 kg/rai of fertilizer (15:15:15) is recommended by authorities concerned; however, most farmers are applying less fertilizer than the recommendation. The number of Amphoes that apply fertilizer of less than 10 kg/rai amount to 62 percent and 29 percent for Yasothon province and Ubon Ratchathani provinces, respectively.

Drying: Drying of paddy in fields for three days is most popular.

Winnowing; No winnowing is practised by 20 -25 percent of farmers.

2-6. Irrigation and Drainage

2-6-1. Irrigable Area

RID has constructed six medium scale irrigation projects (MSIP) for irrigation purpose in the basin, with a combined storage capacity of nearly 46 MCM serving 6,347 ha (39,700 rai) of irrigated paddy field as of 1988. There are 119 small scale irrigation projects (SSIP) constructed by RID and 80 small water resources development projects by the Accelerated Rural Development Office (ARDO) of MOI and the Department of Land Development (DLD) of MOAC, with an irrigable area of 9,393 ha (58,722 rai). In addition to the above

existing irrigation projects, two medium scale irrigation projects with proposed irrigable area of 4,320 ha (27,000 rai) are under construction to be completed in 1990.

The total potential irrigable area of paddy field is estimated at 346,000 ha net, while the total irrigable area of the above existing projects amounts to 20,060 ha, or equivalent to about six percent of the cultivated area.

Due to lack of irrigation and storage facilities, agricultural production in the basin is limited to the rainy season paddy cropping depending on flood flows or rain. Small quantities of water are diverted from stream channels with simple diversion facilities, or with small portable pumps to supply irrigation water during critical periods of the rainy season. Dry season irrigation is limited to small area near the ponds or streams.

Irrigation practices of the existing six medium scale projects were observed from the records during the last 10 years as follows;

- During the rainy season all farm land is cropped with paddy;
- During the dry season about 10 percent of farm land is irrigated for upland cropping and only one percent for paddy cropping;
- Main upland crops are groundnut, sweet corn and chili; and
- Land use intensity varies yearly from 103 to 144 percent, depending on water-availability, with an average of 110 percent.

2-6-2. Irrigation and Drainage Practice

The existing storages release water intermittently, as a supplement to effective rainfall for the rainy season paddy cropping at the request of farmers, while continuous water release is made during the dry season for upland crop cultivation. The water release rate falls within 0.7 to 1.0 1/s per ha (or 0.11 to 0.16 1/s per rai) depending on the kinds of crops and growing stage. From the experience of the Puttha Utthayan irrigation project, the present irrigation practice is summarized as below;

- For the rainy season paddy cropping, water is released with 24 hours operation during land preparation period and critical drought days in the growing stage of paddy at the rate of 6mm/day, or equivalent to 0.7 1/s per ha (or 0.11 1/per rai);
- For the dry season upland cropping, continuous irrigation of 24 hours per day is practised for five days a week except Saturday and

Sunday at the rate of 8.6mm/day, or equivalent to 1.0 1/s per ha (or 0.16 1/s per rai); and

- Furrow irrigation is practised for upland cropping for eight hours per day.

Under the circumstance that irrigation water supply is lacking, farmers make efforts to hold water at their paddy fields and thus drainage facilities are not well developed. Excess rainfall on fields flows over the small ridges of the fields to downstream, causing inundation at low depressions.

In low land located along both banks of the Sebai and Sebok rivers, paddy fields are often inundated by overflows of the rivers causing damages to paddy, especially along the downstream of the rivers. Being situated at the downstream of the Sebok river, Tung Ma Hew area provided nine km long dikes for protection of paddy fields of 1,260 ha against floods from the Sebok river.

Salty soils are broadly distributed in the middle and downstream reaches of the Sebai basin and the middle reaches of the Sebok basin. Most land is used as paddy fields. Soluble salts in the soils are accumulated to surface of land by capillary rise of water during the period when paddy is not growing. The main source of soluble salts in the soils may be salt deposits in soil parent materials and shallow water tables. The economical means of controlling soil salinity and its harmful effects is to produce a flow of low-salt water through the root zone and to maintain a downward flow by drainage systems.

2-7. Water Resources

2-7-1. Surface Water

The average annual rainfall over the basin with a watershed area of 8,540 sq.km is estimated at about 1600 mm, of which 580mm of rainfall (or, 4,900 MCM) flows out as river streams. As stated above, there are 207 irrigation projects with a total storage capacity of 135 MCM, which can control only three percent of annual runoff from the whole basin (refer to Table 2-2).

As a result of Phase I study, the problems relevant to water resources development in the basin were pointed out as follows;

a) Rainfall fluctuates seasonally and yearly. Supplemental irrigation is needed even in the rainy season, especially at the initial stage of the growing periods of paddy. About 70 percent of annual rainfall concentrate on three months in the rainy season. For effective water

resources development, seasonal or yearly regulation of river flow is required.

b) Runoff from the area is hardly controlled for irrigation purpose due to lack of water resource facilities.

c) Topography of the basin does not allow the construction of large scale dams and reservoirs.

d) The forest land was decreased by 3.18 million rai during 13 years periods from 1973 to 1985 in Ubon Ratchathani province and 0.15 million rai during 10 years periods from 1970 to 1985 in Yasothon province.

e) The basin is covered mostly with thin sandy soils of low water holding capacities.

f) There are a number of small scale reservoirs with such problems as sedimentation, slope erosion of dam body, destruction of spillway, etc. Therefore, rehabilitation of those facilities by dredging of ponds, repairing of facilities and improvement of O&M method shall be required.

g) As for the construction of dam, embankment materials of good quality especially core materials are limited in quantity due to sandy soil prevailing in the basin.

2-7-2. Groundwater

Shallow wells with a depth of less than 10m were constructed at each village. Groundwater in the shallow wells is used for domestic purpose. Shallow groundwater is not available for water resources to be developed throughout the year because it is dried up in January every year. There are about 900 of boreholes with a depth of more than 30m, being constructed by public offices. Manual pumps were installed in boreholes for drawing up deep groundwater; deep groundwater is not well utilized in many villages, except domestic use during the dry season, because of the breakdown of the pumps and the trouble on water quality.

In terms of hydrogeological study, four kinds of aquifers exist in the basin. One kind of which is the unconsolidated aquifer in river terraces and active flood plains. The others are the groundwater bearing bed rocks in flat land, high terraces, hills and cuestas.

The unconsolidated aquifer consists of older and younger alluvium, gravel sand, silt and clay, and is distributed along the Mun river and a few main tributaries. In the predominant area of aquifer consisting of gravelly and sandy deposits, fresh water is obtained from more than 90 percent of boreholes and the yield ranges from 50 -200 gallons per minute (approximately 190- 750 l/min) at 100 feet or less of available draw-down (hereafter, figures in regard to the yield show the yield at 100 feet or less of available draw-down and gallon per minute is abbreviated as 'gpm'), and moreover, in the predominant area of aquifers which consist of sandy and clayey deposits, about 80 percent of boreholes have fresh water and the yield range is 10 -50 gpm (approx. 40- 190 l/min).

However, at the sandy and clayey aquifer area where rock salt bearing bed rock exists, almost boreholes have brackish to salty water.

The upper Khorat aquifer consists of the cretaceous rocks, red,reddish brown and grayish brown shale, siltstone and sandstone with rock salt, gypsum and anhydrite, and moreover, the upper Khorat aquifer has the largest distribution in the study area. In the medium high terraces area of the mound and depression-type topographical area with the remnances of erosional surface, 80 percent through 95 percent of boreholes, except in lowland where drilling may result in salty water, have fresh water with 20 -100 gpm (approx. 75 - 380 l/min) yield range. In the flat land flooded in the rainy season, the depression within the higher relief areas and salt efflorescent areas on ground surface, 50 percent through more than 90 percent of boreholes have salty water.

The middle Khorat aquifer consists of the Jurassic rocks;yellowish gray to grayish pink massive sandstone with conglomerate of Phu Phan Formation on top, grayish red to olive gray massive thick bedded quartzose sandstone of Phra Wihan Formation at bottom, dark reddish brown to brownish gray sandstone, shale and siltstone of Sao Khua Formation in between. In cuestas and isolated hills, fresh water with the yield range of only 20 gpm (approx. less than 75 l/min) may be obtained from about 50 percent of boreholes.

The lower Khorat aquifer consists of the lower Jurassic rocks; dark brown, grayish brown, and variegated shale, soft slabby micaceous sandstone of Phu Kradung Formation. In the peneplain-type topographical area, almost 100 percent of boreholes has fresh water. Water generally yields from the depth at 80-200 feet (approx. 25-60 m) and its yield range is 20 -100 gpm (approx. 75 - 380 l/min); however, groundwater is meager at the deeper zone.

2-8. Socio-Economic Profile

2-8-1. Administration and Population

In terms of administrative structures, the basin is composed of 11 Amphoes in Ubon Ratchathani province and five Amphoes in Yasothon province (Table 2-3). Historically, Yasothon province was established in 1983 by separating several amphoes from former Ubon Ratchathani province.

Total population of the basin was 1,166 thousand in 1980 and grew to 1,293 thousand in 1987 at an average annual growth rate of 1.5 percent. Table 2-4 shows the population of the basin. Population is classified by another category of municipality area and rural area, and according to this classification it is observed that the population density is as high as 255 persons/ sq. km in the municipalities of Ubon Ratchathani and Yasothon and low in the rural area (96 persons/sq. km), with an average population density of 116 person/ sq. km, which may show the centralization of inhabitants to local town.

The total number of household in the basin is estimated at 200 thousand in 1980 and 212 thousand in 1987. When the average numbers of household in 1980 (5.8 persons) is compared with 6.1 persons in 1987, it might be said that the persons per household has a tendency to increase in number. In the study area about 90 percent of households are engaged in agriculture.

2-8-2. Gross Provincial Product and Income Level

The Northeast region, composing of 17 provinces, has the agriculture-oriented sectoral structure and is classified as a low development area in many aspects. Two provinces of Yasothon and Ubon Ratchathani,half area of which covers the basin, are also agriculture-oriented. The gross provincial product (GPP) of two provinces is presented to show their sectoral structure in comparison with that of whole Kingdom (Table 2-5).

The share of GPP of the primary sector in two provinces, 20.3 percent in Ubon Ratchathani province and 21.3 percent in Yasothon province, is a little higher than the country average of 18.8 percent. The share of the secondary sector (16.6 percent and 9.2 percent) is vice versa lower than 28.3 percent of the average of the country. GPP of the tertiary sector in two provinces is observed as comparatively large and has grown up to 54.5 percent in Ubon Ratchathani province and 62.5 percent in Yasothon province; however it shall be noted that most of people in the basin are engaged in agriculture. The above fact may suggests that the low productivity of agriculture sector at present is accompanied with some distortion of market mechanism of this sector.

The income level of households by Amphoes covering the basin is shown in Table 2-6 so as to show the difference among Amphoes. The table shows that 52 percent of households have annual income of less than Baht 6,000. According to the report, there are four categories of classifying households by their income prepared by NESDB in 1987 levels: namely, the poor (below Baht 9,000), the marginal (Baht 9,000 -13,200), the better off (Baht 13,200 -19,800) and the wealthy (over Baht 19,800). And 43 percent of households in the Northeast region are classified as poor. According to the report of NESDB regarding poverty density, 12 Amphoes among 16 Amphoes in the basin were classified as areas with high density of poverty line (Table 2-7).

2-8-3. Present Level of Social Development

The poverty eradication policy established in the Fifth National Plan has been replaced in the Sixth National Plan by the method of finding adequate measures for such village as have problems on living conditions. As for income level indication there has been problems on credibility according to NESDB. The development level has been surveyed on a village basis by the Community Development Department (CDD), MOI and the National Statistics Office (NSO) by using six indicators. Basing on the results of the above survey, the number of villages in two provinces which are ranked as Level I (lower than national average) are given below;

Some Indications of Development Level

	Yasothon		Ubon Ratchathani	
Indicator	Nos. of Village	(%)	Nos. of Village	(%)
Electrification	202	(30)	796	(33)
Professional Training	279	(41)	1,310	(55)
Wage Rate	655	(96)	2,279	(95)
Rice Cultivation	587	(86)	2,039	(85)
Dry Season Farming	513	(76)	1,812	(76)
Domestic Water	525	(77)	1,936	(81)

Note: Total number of villages is 679 for Yasothon province and 2,393 for Ubon Ratchathani province.

The Government of Thailand has undertaken the task of rural development mainly by several governmental organizations such as RID for irrigation, ARDO for urgent project, the Department of Public Works (DPW) for small water supply, CDD for small rural projects, and the Department of Fisheries (DOF) for inland fisheries, etc., even though each provincial office has also formed its own development plan. In the implementation stage, the above-

mentioned agencies are in charge of executing project and some projects such as small scale irrigation projects are turned over to farmers' self-management during the operation and maintenance stage. As for planning of rural development, NESDB is responsible for formulating plans based on the surveys to be conducted mainly by the National Statistics Office (NSO) and CDD.

As for the road and transportation, the main network of national and provincial road and transportation are comparatively well developed. However, the farm to market roads as well as village roads in the remote areas, except those connected to RID's project sites, are poor.

In parallel with the shortage of irrigation, many villages have suffered from inadequate water supply for drinking and daily use both in quality and quantity.

Rural electrification is relatively advanced to a certain level even though there remain some villages without electricity. The electrification ratio is 63 percent in Ubon Ratchathani province and 61 percent in Yasothon province. The Provincial Electricity Authority (PEA) continues its efforts to electrify the rural areas in the basin and, in future as the demand increases, PEA will plan to take necessary measures to cope with the development level.

In the basin as well as the two provinces, farmers associations have not been active (Table 2-8). Therefore the present farmer's association in two province should be encouraged to take certain adequate measures such as installation of irrigation system to a large extent. The basin has several constraints besides the physical conditions for agricultural development, among which, the financial constraint for the farmer has been considered as one of the major problems. In this field, credits extended by the Bank of Agriculture and Agricultural Cooperatives (BAAC) have contributed in the past years. In accordance with the increase of agricultural production, the amount and extent of credits might also be increased in future.

TABLE 2-1. METEOROLOGICAL DATA AT UBON RATCHATHANI

Station : Ubon Ratchathani
Index No. : 48407
Latitude : 15°15'N
Longitude : 104°52'E

Elevation of Station above MSL : 123 m
Elevation of barometer above MSL : 127 m
Height of thermometer above ground : 1.5 m
Height of wind vane above ground : 15.0 m
Height of rain gage above ground : 0.8 m

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Pressure (+1000 or 900 mbr.)													
Mean	13.56	11.59	9.99	8.37	7.06	6.07	6.02	5.89	7.44	10.13	12.43	13.68	9.35
Extreme Maximum	25.20	23.32	23.28	20.56	14.63	13.35	13.45	13.73	16.13	18.36	21.46	23.45	25.20
Extreme Minimum	3.41	1.05	0.99	98.90	99.82	96.15	96.57	97.33	97.46	1.35	1.75	4.14	96.15
Mean Daily Range	5.14	5.60	5.74	5.56	4.96	4.28	4.10	4.21	4.51	4.52	4.42	4.64	4.81
Temperature (°C)													
Mean	23.5	25.9	28.6	29.6	28.8	28.1	27.6	27.2	27.0	26.5	25.0	23.4	26.8
Mean Maximum	30.9	33.3	35.4	35.9	34.4	32.7	32.0	31.4	31.2	31.3	30.7	30.1	32.4
Mean Mimimum	16.8	19.4	22.4	24.3	24.6	24.4	24.1	23.9	23.7	22.4	20.0	17.6	22.0
Extreme Maximum	36.0	38.6	40.2	41.3	41.0	38.5	36.2	37.8	34.6	34.8	35.3	34.9	41.3
Extreme Minimum	8.5	11.7	13.0	15.9	19.4	21.0	20.2	20.7	20.5	15.7	13.0	8.5	8.5
Relative Humidity (%)													
Mean	65.0	63.2	62.1	66.1	75.2	79.5	80.5	82.7	83.2	77.4	71.8	68.5	72.9
Mean Maximum	86.7	83.7	81.2	83.1	89.8	92.2	92.5	93.7	94.2	90.3	87.3	87.2	88.5
Mean Minimum	41.1	40.8	41.3	45.8	55.6	62.3	64.5	66.9	67.3	60.4	53.1	47.1	53.9
Extreme Minimum	22.0	23.0	20.0	21.0	32.0	37.0	47.0	46.0	42.0	30.0	26.0	25.0	20.0
Dew Point (°C)													
Mean	15.7	17.6	19.9	21.9	23.5	23.8	23.7	23.7	23.6	21.9	19.1	16.7	20.9
Evaporation (mm)													
Mean-Pan	174.9	174.3	216.1	210.8	184.0	161.9	163.9	151.7	129.1	164.1	173.1	173.0	2,076.9
Cloudness (0-10)													
Mean	3.9	4.3	4.9	6.2	7.5	8.3	8.3	8.8	8.3	6.6	5.2	4.4	6.4
Sunshine Duration (hr)													
Mean	292.5	261.3	269.6	257.2	244.3	194.4	201.5	170.5	165.2	233.8	260.8	269.0	2,820.1
Visibility (km)													
0700 L.S.T.	7.5	6.3	5.9	7.5	10.4	11.0	10.8	10.4	10.2	10.7	10.4	9.1	9.2
Mean	10.5	8.5	7.4	8.9	11.7	12.0	11.9	11.5	11.5	12.2	12.4	11.9	10.9
Wind (Knots)													
Prevailing Wind	NE	N	S	S	S	S	S	SW	S	N	NE	NE	-
Mean Wind Speed	3.7	3.2	3.1	3.0	3.1	3.8	3.9	4.0	2.6	3.9	5.7	5.1	-
Maximum Wind Speed	32	46	42	56	60	60	41	68	46	55	40	50	68
Rainfall (mm)													
Mean	0.6	12.6	40.9	85.6	213.6	261.9	274.6	322.6	294.3	100.5	22.4	1.8	1,631.4
Mean Rainy Days	0.4	1.3	3.6	7.5	15.2	18.5	19.6	22.2	20.1	10.8	3.6	0.7	123.5
Greatest in 24 hr	4.8	62.0	124.1	100.2	138.5	189.4	203.9	141.1	130.3	113.4	71.8	8.2	203.9
Day/Year	27/64	27/85	14/60	12/78	18/56	4/72	7/70	18/70	5/68	9/67	5/64	15/66	7/70

Note: Observation for 30 years from 1956-1985, except evaporation of 24 years from 1962-1985.

TABLE 2-2. SUMMARY OF EXISTING WATER RESOURCES DEVELOPMENT PROJECT

Item		Sebai	Sebok	Tung Lung	Total
Watershed Area	(sq.km)	3,950	3,730	860	8,540
Annual Rainfall	(mm)	1,482	1,694	1,691	1,596
Annual Runoff	(mm)	413	716	737	578
	(MCM)	1,631	2,671	634	4,936
Paddy Field	(ha)	178,800	149,600	17,600	346,000
Existing Projects					
(1) MSIP					
- Nos. of Projects		5	3	-	8
- Storage	(MCM)	65.45	24.94	-	90.39
- Irrigable Area	(ha)	7,667	3,000	-	10,667
(2) SSIP					
- Nos. of Projects		76	37	6	119
- Storage	(MCM)	23.58	12.10	2.54	38.22
- Irrigable Area	(ha)	3,326	2,037	192	5,555
(3) SSWR					
- Nos. of Projects		41	38	1	80
- Storage	(MCM)	4.88	1.61	0.06	6.55
- Irrigable Area	(ha)	2,287	1,263	288	3,838
(4) Total					
- Nos. of Projects		122	78*	7	207
- Storage	(MCM)	93.91	38.65	2.60	135.16
- Irrigable Area	(ha)	13,280	6,300	480	20,060

Notes: MSIP : Medium scale irrigation project by RID
SSIP : Small scale irrigation project by RID
SSWR : Small scale water resouries project by ARD and DLD
* : Tung Ma Hew pump project (1,260 ha) is not included.

TABLE 2-3. ADMINISTRATIVE STRUCTURE

	Total Area (sq.km)	Administration		
		Tambon	Muban (Village)	Nos. of Houses
Yasothon Province				
1. Muang Yasothon	454.00	15	145	18,029
2. Kham Khuan Khaeo	638.05	12	90	9,716
3. Kut Chum	492.00	9	96	8,084
4. Loeng Nok Tha	1,234.91	13	132	15,044
5. Pa Tiu	217.00	5	43	4,808
Sub-total	3,035.96	54	506	55,681
Ubon Ratchathani Province				
1. Muang Ubon Ratchathani	939.38	16	172	38,736
2. Amnat Charoen	815.58	17	224	21,430
3. Senangkhankhom	546.00	5	50	5,772
4. Hua Taphan	425.00	8	75	6,641
5. Kuang Nai	782.82	17	152	13,543
6. Kutkhoa Pun	330.00	5	58	4,573
7. Muang Samsip	927.54	12	134	10,371
8. Phana	498.00	6	78	6,297
9. King A. Tan Sum	169.00	6	55	3,681
10. Si Muang Mai	1,300.00	10	102	7,026
11. Trakan Phutphon	1,366.45	18	194	11,579
Sub-total	8,099.77	120	1,294	129,649
Total	11,135.73	174	1,800	185,330

Source: Provincial offices of Yasothon and Ubon Ratchathani

TABLE 2-4. POPULATION AND HOUSEHOLD

Province, Amphoe	Population			Household	
	1980	1987	(per sq.km)	1980	1987
Yasothon Province					
1. Muang Yasothon	114,518	124,676	(275)	17,268	20,121
2. Kham Khuan Khaeo	63,589	67,717	(106)	9,651	10,962
3. Kut Chum	54,300	62,052	(126)	8,248	9,023
4. Loeng Nok Tha	91,424	100,387	(81)	14,451	18,411
5. Pa Tiu	28,352	30,510	(141)	5,021	5,357
Sub-total	352,183	385,342	(127)	54,639	63,874
Ubon Ratchathani Province					
1. Muang Ubon Ratchathani	202,549	229,913	(245)	36,419	42,719
2. Amnat Charoen	126,740	148,164	(182)	22,971	27,110
3. Senangkhankhom	32,386	34,668	(63)	5,553	6,912
4. Hua Taphan	43,571	48,017	(113)	7,896	7,452
5. Khuang Nai	94,400	102,741	(131)	17,084	14,968
6. Kutkhoa Pun	30,838	33,346	(101)	5,181	5,649
7. Muang Samsip	69,831	74,102	(80)	12,342	11,382
8. Phana	49,758	50,936	(102)	9,059	7,813
9. King A. Tan Sum	24,516	27,093	(160)	4,404	3,976
10. Si Muang Mai	45,302	50,741	(39)	8,194	7,440
11. Trakan Phutphon	93,561	107,895	(79)	16,102	12,616
Sub-total	813,452	907,616	(112)	145,204	148,037
Total	1,165,635	1,292,958	(116)	199,843	211,911

Source: Statistical report of Ubon Ratchathani and Yasothon province, Population census and annual survey of Population

TABLE 2-5. GROSS PROVINCIAL PRODUCT AT CURRENT MARKET PRICES

- Unit: Million Baht -

Description	Ubon Ratchathani			Yasothon			Whole Country	
	1980	1986	(%)	1980	1986	(%)	1986	(%)
Primary Sector								
Agriculture	3,543	2,800	(19.8)	1,264	848	(21.3)	183,038	(16.7)
- Crops	2,750	1,847		947	647		124,906	
- Livestock & Others	793	953		317	201		58,132	
Mining & Quarrying	39	66		0	0		23,347	
Sub-total	3,582	2,866	(20.3)	1,264	848	(21.3)	206,385	(18.8)
Secondary Sector								
Manufacturing	649	962		93	88		226,572	
Construction	524	1,172		145	234		55,683	
Electricity & Water Supply	43	211		6	42		28,182	
Sub-total	1,216	2,345	(16.6)	244	364	(9.2)	310,437	(28.3)
Tertiary Sector								
Transportation & Communication	689	1,585		308	619		101,828	
Trade	2,179	3,791	(26.8)	744	1,251	(31.5)	204,094	(18.6)
Banking & Other Services	1,039	2,327		260	613		226,484	
Sub-total	3,907	7,703	(54.5)	1,312	2,483	(62.5)	532,406	(48.5)
Public Administration & Defence	657	1,220	(8.6)	154	278	(7.0)	49,138	(4.4)
GPP/GDP	9,362	14,134	(100)	2,974	3,973	(100)	1,098,366	(100)
Per Capita GPP/GDP (฿)	5,873	8,039		6,342	8,058		20,860	

Source: NESDB

TABLE 2-6. INCOME LEVEL BY AMPHOE

Province, Amphoe	Below ฿6,000		฿6,000-10,000		฿10,000-20,000		Over ฿20,000		Total	
	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
Yasothon Province										
1. Muang Yasothon	7,345	49	4,848	32	1,894	13	977	6	15,064	100
2. Kham Khuan Khaeo	1,932	30	2,950	47	989	15	525	8	6,396	100
3. Kut Cham	3,812	50	2,439	32	870	11	540	7	7,661	100
4. Loeng Nok Tha	9,045	61	3,424	23	1,282	9	1,017	7	14,768	100
5. Pa Tiu	2,357	55	1,416	33	377	9	146	3	4,296	100
Sub-total	24,491	51	15,077	31	5,412	11	3,205	7	48,185	100
Ubon Ratchathani Province										
1. Muang	8,484	48	4,912	28	2,964	16	1,421	8	17,781	100
2. Amnat Charoen	10,154	48	6,819	32	2,996	14	1,324	6	21,293	100
3. Senangkhanikhom	3,099	63	1,081	22	549	11	220	4	4,949	100
4. Hua Taphan	2,694	39	2,565	37	1,093	16	527	8	6,879	100
5. Khuang Nai	6,621	47	5,030	35	1,697	12	833	6	14,181	100
6. Kutkhoa Pun	3,144	70	857	19	322	7	170	4	4,493	100
7. Muang Samsip	5,629	51	3,294	30	1,386	13	707	6	11,016	100
8. Phana	3,366	55	1,708	28	756	12	314	5	6,144	100
9. King A. Tan Sum	2,333	62	1,015	27	265	7	131	4	3,744	100
10. Si Muang Mai	4,699	67	1,618	23	472	7	179	3	6,968	100
11. Trakan Phutphon	7,283	55	4,146	31	1,307	10	531	4	13,267	100
Sub-total	57,506	52	33,045	30	13,807	12	6,357	6	110,715	100
Total	81,997	52	48,122	30	19,219	12	9,562	6	158,900	100

Source: Provincial Office data in 1986

TABLE 2-7. DENSITY INDEX OF POVERTY LINE

Province, Amphoe	Density Index
Yasothon Province	
1. Muang	0.889
2. Kham Khuan Khaeo	1.248
3. Kut Cham	0.774
4. Loeng Nok Tha	0.963
5. Pa Tiu	1.119
Ubon Ratchathani Province	
1. Muang	1.091
2. Amnat Charoen	1.130
3. Senangkhanikhom	1.241
4. Hua Taphan	1.195
5. Khuang Nai	0.948
6. Kutkhoa Pun	1.270
7. Muang Samsip	1.053
8. Phana	1.134
9. King Amphoe Tan Sum	1.087
10. Si Muang Mai	1.164
11. Trakan Phutphon	1.160

Source : NESDB

Remarks : 1 = Medium density of poverty line
$>$ 1 = High density of poverty line
$<$ 1 = Low density of poverty line

TABLE 2-8. AGRICULTURAL AND OTHER COOPERATIVES

(1) Ubon Ratchathani Province

Amphoe	Developed Farmers Group		Under Developed Farmers Group		Young Farmers Group	
	Nos.	Member	Nos.	Member	Nos.	Member
1. Muang Ubon Ratchathani	5	897	7	933	7	166
2. Amnat Charoen	6	1,389	4	299	8	268
3. Senangkhanikhom						
4. Hua Tapan	1	140	3	334	5	136
5. Khuang Nai	12	2,136	1	148	8	105
6. Kukhoa Pun						
7. Muang Samsip	6	862	3	483	13	248
8. Phana	1	79	5	569	4	67
9. King A. Tan Sum			2	261	4	91
10. Si Muang Mai			7	671	2	49
11. Trakan Phutphon			7	862	5	112
Sub-total	31	5,503	39	4,560	59	1,303
Other 10 Amphoes	12	2,422	42	5,886	85	2,005
Total	43	7,925	81	10,446	144	3,308

Source: Office of Agricultural Extension, Ubon Ratchathani

(2) Yasothon Province

Kind of Cooperative	Nos.	Member	Value of Holding Shares
1. Agricultural Cooperatives			
- General agri. cooperatives	10	7,010	10,791,150
- Swing agri. Cooperatives	1	420	110,900
- Federal Cooperatives	1	9	848,800
Sub-total	12	7,439	11,750,850
2. Saving Cooperatives	5	5,273	54,454,929
3. Shop Cooperatives	4	1,194	239,500
4. Service Cooperatives	1	75	176,800
Sub-total	10	6,542	54,871,229
Grand Total	22	13,981	66,622,079

Source: Report of Provincial Office of Yasothon

CHAPTER III. BASIN DEVELOPMENT STUDY

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3-1. Objective of Development

The Sebai-Sebok basin in the Northeast of Thailand has long been an economically depressed area with high level of poverty, low agricultural productivity and an uneven income distribution. About 90 percent of households are engaged in farming and about 20 percent of its gross domestic production is generated by agriculture. The yield of rice, major crop in the basin, is low as compared to other regions in Thailand due to lack of technology and natural resources.

More than 90 percent of annual rainfall is concentrated in the rainy season from May to October. During the dry season, water is not available for agriculture purposes. Soils in the basin are characterized by sandy texture, thin top layer and comparatively low fertility.

Agriculture in the basin is not well advanced. As all existing irrigation projects covering about six percent of the existing paddy fields are based on the small or medium scale water sources, there is little dry season cropping, thus resulting in low land use intensity.

In line with the development objectives for the Sixth National Plan, the development of the basin aims to increase farm income through water resource development for agriculture with control of distribution to farmland and intensive backup from agricultural extension services.

3-2. Land Resources Development

In the current land use, the farmland ratio is extremely high, reaching 77 percent, while the forest land ratio is as low as 22 percent. From the viewpoint of the land classification, the area suitable for paddy cropping is estimated at 65 percent of the basin, which suggest that almost all potential areas have already been developed and no more area left for new development. Under these circumstances, the target of land resources development in the basin is to improve the productivity of the existing farmlands. To achieve this target, soil management and countermeasures against salt damage to crops would be required.

In order to increase the fertility of soils prevailing in the area, which are of sandy texture and poor in maintaining fertility, repeated partial fertilization with nitrogenous and phosphatic fertilizers will be particularly