effective. Organic fertilizers such as composite and green manure crops should be applied.

As measures against salt damage to crops, the Department of Land Development gives the following instructions;

Class 1:	Unsuitable for cropping
Class 2;	To leach soluble salt in soils before starting cultivation and select salt-tolerance crops
Class 3;	To cultivate salt-tolerance crops
Class 4;	To leach soluble salt in soils
Class 5;	No particular measures are required.

At present, leaching is the most practical method of preventing crops from salt damage. Other possible methods are planting salt-tolerance trees, supplying fertilizers to compensate for lost fertilizer, improving physical properties of soils, and cultivating salt-tolerance crops.

Soil erosion means losses of natural resources which is the base of crop cultivation. Sedimentation is a serious problem in maintenance of reservoirs and canals. "Soil erosion in Thailand" published by DLD in 1981 reveals that soils in 79 percent of land in Yasothon province and 54 percent of land in Ubon Ratchathani province are erodible, and furthermore about 65 percent of these lands are severely subject to erosion (625-6,044 ton/ha/year). Land use as paddy field is one of the most effective countermeasures against soil erosion; however, special attention shall be given when lands are used as upland fields.

3-3. Water Resources Development

3-3-1. Surface Water

The annual rainfall in the basin varies from 1,400 mm to 1,800 mm. Rainfall rapidly drains outside the basin through the rivers of Sebai, Sebok and Tung Lung except for rain water used for rainy season paddy cropping extending over the basin, due to lack of reservoirs and forest lands. Control of runoff from the basin, estimated at about 4,900 million cubic meter per year, is important in regional water resources development. Groundwater in the basin does not have good potentials for large scale irrigation purpose due to limited water yield and high contents of salt and/or iron ion. Thus groundwater exploitation will be limited to a small scale development for domestic and irrigation use.

All paddy fields are cropped with paddy during the rainy season. Supply of irrigation water to supplement rain on paddy fields is needed in the early planting period and late growing period of paddy when little rain falls. Dry season cropping relies on irrigation. For the development of water resources for irrigation, it is required to provide storages to retain excess water from periods of high flow for use during periods of drought. Water resources development by means of drawing of free-flowing water with weirs or pumps has to regulate runoff from large catchment areas so as to satisfy irrigation demands during extremely low flows. For effective development of limited water resources available in the Sebai-Sebok basin, priority shall be given to projects of storage scheme.

In the low-lying area along the rivers of Sebai, Sebok and Tung Lung, there exists no good natural dam and reservoir site favorable from the topographical point of view. The flows of these three rivers will be used for irrigation by pumping because the rivers have a flat grade and the topography does not allow river diversion by gravity.

Out of annual runoff of 4,936 MCM from the total watershed (8,540 sq.km), runoff from a catchment area of 3,692 sq.km (or, equivalent to about 40 percent of the total area) is being used for irrigation by the existing irrigation projects. Accordingly, about 2,945 MCM of annual runoff from the remaining watershed area (4,848 sq.km) is left for future development.

Potential Surface Water Resources

Item	Sebai	Sebok	Tung Lung	Total
1. Watershed Area (sq.km)	3,950	3,730	860	8,540
2. Annual Runoff (MCM)	1,631	2,671	634	4,936
3. Existing Projects				
- Watershed Area (sq.km)	2,169	1,344	179	3,692
- Storage (MCM)	94	39	3	136
4. Development Potential				
- Watershed Area (sq.km)	1,781	2,386	681	4,848
- Annual Runoff (MCM)	735	1,708	502	2,945

As a result of water quality investigation of surface water at 23 sites made during the survey period, no problem for irrigation use in terms of electric conductivity (EC) and PH exists.

3-3-2. Groundwater

There are four kinds of aquifers in the basin. Fresh water with yield ranging from 50 - 200 gpm (approx. 190 - 750 l/min) is obtained from more than 90 percent boreholes in the Quaternary aquifers which consist of unconsolidated deposits and alluvium, and fresh water with yield ranging from 20 - 100 gpm (approx. 75 - 380 l/min) is obtained from 80 percent to 95 percent boreholes in the upper Khorat aquifers; however, in the flat land flooded in the rainy season and lowland where salt bearing bed rocks are present, brackish to salty water is obtained from 50 percent to 90 percent boreholes.

According to "The Hydrogeological Map of Northern Thailand (1973)" published by the Department of Mineral Resources (DMR), there was large distribution of brackish to salty water at the south of Amphoe Amnat Charoen in the middle Sebai basin. Moreover, according to groundwater quality which was investigated during the study period, brackish to salty water with maximum conductivity of 9,700 μ.mho/cm is detected in the south of the salty water area mentioned above, viz. in the middle to lower Sebai basin and Sebok basin.

The distribution of saline soil land is consistent with the salty water area, which is also identical with the distribution of the Maha Sarakam Formation. It was presumed that brackish to salty water and saline soils may mostly originate in the rock salt within the Maha Sarakham Formation. The development of groundwater resources may cause the expansion of distribution of salty water in the central to southern area of the basin, as it was confirmed that the distribution of brackish water has been expanded since 1973 in the middle to lower Sebai and Sebok basin.

Groundwater in the basin contains a large quality of iron ion. The contents of groundwater in 90 percent boreholes are more than 0.3 ppm which is the maximum acceptable contents of the drinking water prescribed by WHO, and the contents in 70 percent boreholes are more than 1.0 ppm which is the maximum acceptable contents in case of the unavoidable circumstances prescribed by WHO and Thai government.

	Number of Borehole Conformable to the Drinking Water Standard		
Province	Boreholes Containing iron ion	Boreholes with iron ion less than 0.3 ppm	Boreholes with iron ion less than 1.0 ppm
Ubon Ratchathani	469	38	129
Yasothon	409	57	138
Total	878	95	267

According to the distribution ratio of boreholes with good quality groundwater with less than 1.0 ppm iron ion contents, the groundwater conformable to the drinking water standard was obtained from more than 40 percent boreholes at Amphoe Si Muang Mai in the Tung Lung basin and Amphoe Tan Sum in the lower Sebok basin. Therefore, the unconformable groundwater with high contents of iron ion is meagerly distributed in these areas. At other Amphoes, the ratio of boreholes with unconformable groundwater ranges from 20 to 40 percent.

The acceptable contents of iron ion as irrigation water has not been provided in Thailand and in Japan. Although groundwater in the basin may not be available for drinking water owing to the high iron ion contents, groundwater is available for irrigation water in the fresh water area under no influence of salty water in the Tung Lung basin, the upper Sebai basin and the left bank of the upper Sebok basin. The Khok Kruat Formation in the upper Khorat aquifers and the middle Khorat aquifers are distributed in the Tung Lung basin and the left bank of the upper Sebok basin, and the yield is less than 30 gpm (approx. 100 l/min).

3-4. Irrigated Agriculture Development

3-4-1. Basic Approach

Areal spread of farmland has been the main measure to increase the crop production in the basin. Newly opened forest lands are apt to suffer from drought damage and eventually the soil fertility of the land become worse year by year. To cope with this serious issue, all technology for agricultural development of the basin should be improved in quality and be applied intensively.

Much progress has been made in irrigation project, and in 1987, there was about 19 percent of irrigable area in Thailand. In the Northeast, Sakon Nakhon and Kalasin provinces were above 10 percent, and Yasothon and Ubon Ratchathani provinces were in the lowest group with below five percent. This fact reflected in the land use intensity that national average in 1985/86 was 110.2 percent, while those of Yasothon and Ubon Ratchathani provinces, grouped as agro-economic zone 2, was 97.27 percent, the fourth lowest group among 19 agro-economic zones in Thailand. Aiming at increasing the land use intensity of the basin, at least, to the national average, irrigation projects shall be implemented.

3-4-2. Major Crops

Stored water will be firstly released for irrigation of the rainy season paddy cropping in order to stabilize and increase paddy production. About 70 percent of areas will be covered with high yielding varieties (HYV). At present, RD 6 and NSP are popular for glutinous paddy, and for non-glutinous paddy KDM 105 and NG 19 are being used. In future, Neo Ubon 1 (glutinous) and RD 15, Khao Pak Mawn 148, Khao Jao Chumpas 60 (non-glutinous) will be introduced as HYV.

In the dry season, stored water will be used for upland crops which will be cultivated in paddy fields and proposed area under upland crop is about 20 percent of the irrigable paddy fields. New varieties and advanced cultivation technology will be introduced both in the rainy season and dry season croppings.

Based on the available data and information on experimental farms and other projects of similar nature, target yields are projected on conditions that on-farm facilities are developed and sufficient agricultural supporting services are implemented. About ten years is forecasted before the target yields can be achieved.

Target Yield

Crop	Kg/rai
Rainy Season Paddy	500-640
Groundnut	250
Soybean	250
Sweet Corn	2,000
Water Melon	3,000
Chili	1,200

3-4-3. Agricultural Development Supporting Services

Increase in productivity of any crop can only be attained with many supporting sectors. Their functions are compound, and any of them can become the limiting factor of production promotion when it does not function properly. Some of them are marketing, agro-industry and institutional cooperation.

The basin is located far from big markets such as Bangkok, and only local towns like Ubon Ratchathani and Yasothon are main markets of most farmers. Since marketability is one of the biggest incentives to crop production, the development of their market is of great importance and crops to be cultivated should be carefully selected to meet the market demands. Relatively, agro-industry should be encouraged in and around the basin.

Canning factories or processing factories to utilize local agricultural products are the biggest incentive to farmers.

Many governmental organizations are closely related to agricultural development. Based on the present conditions, there seems to be some room for improvement of the relationship among organizations in the field of information exchange and trial in the farmer's' fields, etc.

3-4-4. Irrigation and Drainage

(1) Irrigation

Water needed for growing rainy season paddy and dry season upland crop is estimated at 970 mm and 459 mm, respectively, while 707 mm and 31 mm of water is fed by rainfall for the former and the latter. Thus, net irrigation water to be supplied amounts to 263 mm for rainy season paddy and 428 mm for upland crops with a total of 691 mm/year. Monthly variation of water needed for growing crops and effective rainfall reveal that supplemental irrigation is essential to successful crop growing during the period from January to April for dry season upland crops and October and November even in the rainy season for paddy.

A proposed irrigation project will provide for water source facilities such as a dam and reservoir or a diversion weir for the control of river flows, and irrigation water supply system down to the on-farm level. RID will be in charge of the operation and maintenance of irrigation facilities. On-farm water management would be made by a water users' association to be established by farmers.

The scale of the proposed dam and reservoir is decided with a practical maximum dam height in order to store as much as possible the excess water during the high flood season. Possible reservoir capacities are not so large as compared to the potential irrigable area. This irrigation plan aims firstly to extend irrigation area of the rainy season paddy cropping and secondly to introduce irrigated upland cropping as a second crop during the dry season. The area of upland crops is limited to 20 percent of the rainy season paddy so as to expand irrigable area of the rainy season paddy taking into consideration the potentials of water resources development.

In the basin there exist saline soils along the Sebai and Sebok river. For crop cultivation in these areas, additional water supply shall be provided in order to control salts in the root zone at a specified level. In the present situation, the additional water (LR; Leaching Requirement) is estimated with

the equation recommended in the FAO Irrigation and Drainage Paper No.24 as follows;

$$LR = \frac{ECw}{5\,ECe - ECw} \times \frac{1}{Le}$$

where; ECw = electric conductivity of irrigation water (mmho/cm)

ECe = electric conductivity of saturation extract for a given crop appropriate to the tolerable degree of yield depression (mmho/cm)

In estimating LR, 100 percent of potential yield of paddy is proposed; thus ECe is 3.0 mmho/cm. LR is computed at three percent of irrigation water on condition that ECw is 0.2 mmho/cm and a leaching efficiency (Le) is 0.6 for sandy soils.

(2) Drainage

The removal of excess irrigation water and rainfall from the soil surface in time is necessary to prevent damage to crops and keep water from ponding on the soil surface. In consideration of water storage function of paddy fields and the water tolerance of paddy to some extent, it is proposed to install drainage systems with a drainage capacity to drain during three days 70 percent of three days maximum successive rainfall which may occur once in five years. The drainage modulus at on-farm level by river basin is given below;

Drainage Modulus at On-farm Level

Basin	Design Rainfall (mm)	l/s/ha	(l/s/rai)
Sebai	217	5.8	0.9
Sebok	128	6.5	1.0
Tung Lung	245	6.7	1.1

In the saline soil areas, salinity control is imperative for the establishment of permanent irrigated agriculture. Since soluble salts are transported in soils in the water phase, their distribution and removal are controllable by water management. The control of root-zone salinity is the main objective of subsurface drainage.

Since water moves through the soils, the soils may be a limiting factor in planning the subsurface drainage system. Detailed information on the soils prevailing in the saline soil areas is not available at the moment; however, from the experience of the drainage planning in the similar projects where alluvial soils are typically found, proposed open drains in the saline soils areas may need to be installed at a depth of 1.0 - 1.5 m with a space of around 30 m.

3-5. Overall Basin Plan

3-5-1. Needs of Overall Basin Plan

In response to the urgent requirements of irrigated agriculture development in the basin, many irrigation projects have been implemented by the governmental agencies such as Royal Irrigation Department, Accelerated Rural Development Office, Department of Land Development and others concerned. All irrigation projects so far constructed are small and medium scale projects because the basin has no potentialities of locations of large scale water resources development due to the topographic conditions prevailing in the area. Under the present situation, water resources development has been individually planned and implemented by several governmental agencies with little regard to full development of water resources in the area.

The needs for integrated water resources development arise from the relationship between the availability of water and its possible use. 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.

To attain full development of land and water resources for agriculture use, irrigation projects should be implemented in close coordination with other agencies concerned by following the overall basin plan. The overall basin plan has been prepared with aim to formulate an orderly water development that may ensure individual water projects optimum benefits for the people in the Sebai-Sebok basin.

3-5-2. General Plan

(1) New Development

Water resources development in the basin requires some form of artificial storage and regulation of free-flowing water resources. Based on the results of map analyses and site reconnaissance surveys, development

potentialities of water resources are assessed including several projects of which pre-feasibility reports have been prepared by RID.

Watershed areas so far developed with the existing projects are identified on the topographic maps scaled 1:50,000. Out of 8,540 sq.km watershed areas, 4,848 sq.km are left undeveloped. For further water resources development first priority is given to storage schemes, and then to run-of-river schemes where there is no possible dam site.

In conformity with the demarcation by Thai government of water resources development projects, potential storage projects are classified into two: medium scale irrigation project (MSIP) and small scale irrigation project (SSIP). In the basin there is no possibility of large scale irrigation project. Run-of-river schemes consist of river pumping and river diversion with weirs. All irrigation projects commanded by gravity with weirs belong to SSIP.

A reconnaissance report entitled "Survey of Water Resources, Mun and Chi River Basins, NE Thailand" prepared in March 1965 by the Bureau of Reclamation, United States Department of Interior presented the location of a possible large scale dam site of Lam Sebai project, being located about 15 km northeast of Amphoe Pa Tiu. The reconnaissance report estimated the storage capacity at 300 MCM with a dam height of 16 meters. It has been 25 years since the reconnaissance report was prepared. In the proposed reservoir area of Lam Sebai project, there are now seven SSIP, a number of villages and vast paddy fields with the area of not less than 60,000 rai. Hence, in this study on the Sebai-Sebok Basin Development Project, the above-mentioned Lam Sebai project was not identified as potential large scale irrigation project.

The Electricity Generating Authority of Thailand (EGAT) prepared a project report on the Pak Mun Multipurpose Project to construct a dam and reservoir on the lower reaches of the Mun river where three rivers of Sebai, Sebok and Tung Lung flow in. Part of paddy fields located at the downstream reaches of the Sebok river are included in irrigable areas under the Pak Mun project, for which RID has a plan to undertake a detailed survey on irrigation development related to the Pak Mun project. The Sebai-Sebok overall basin plan presents a proposal that part of paddy fields along the downstream reaches of both the Sebai and Sebok rivers be supplied with irrigation water from the Pak Mun Project.

Details of storage schemes and run-of-river schemes are given in sections 3-6 and 3-7, respectively. With the proposed new development projects, except for projects under the Pak Mun project, 36,990 ha of paddy fields will be irrigated as summarized below:

New Development Project

Project	Nos. of Projects	Irrigable Area (ha)
Storage Scheme		
- Medium Scale Project	26	26,010
- Small Scale Project	87	4,350
Sub-total	113	30,360
Run-of-River Scheme		
- River Pumping	41	4,030
- River Diversion	40	2,600
Sub-total	81	6,630
Total	194	36,990

(2) Rehabilitation

Out of six existing medium scale irrigation projects, four projects are in need of rehabilitation because they are not functioning as originally expected due to its aged and insufficient facilities. Tung Ma Hew areas located at the downstream reaches of the Sebok river have not been irrigated since 1978 because of damages to pumping facilities. Accordingly, the Tung Ma Hew project constructed by the National Energy Authority (NEA) and DLD has been proposed for implementation of rehabilitation work.

Rehabilitation Project

Project	Irrigable Area (ha)	Remarks
Huai Pho	880	Medium scale irrigation project
Ron Nam Sap	70	- do -
Nong Chang Yai	1,200	- do -
Huai Tamkhae	1,680	- do -
Tung Ma Hew	1,260	Pak Mun related project
Total	5,090	

(3) Total Proposed Irrigable Area

Out of the potential runoff from the undeveloped watershed areas of 4,848 sq.km, runoff from 1,529 sq.km watershed areas might be developed by means of storage and the remainder (3,319 sq.km) by river pumping and river diversion where topography does not permit construction of dams. The total irrigable area amounts to 36,990 ha. In addition, when Pak Mun related pump irrigation projects such as Tung Ma Hew and others are implemented, 5,400 ha of paddy fields will be irrigated, totaling 42,390 ha of proposed irrigable area.

After the implementation of all projects as proposed the irrigable area in the Sebai-Sebok basin will increase from 21,320 ha to 63,710 ha (or, equivalent to 18 percent of the total existing paddy fields).

Summary of Overall Basin Plan

Project	Catchment Area (sq.km)	Irrigable Area (ha)	Storage (MCM)
Existing Project-203 Projects	3,559	16,230	105.4
Rehabilitation-5 Projects	133	5,090	29.8
Sub-total	3,692	21,320	135.2
New Development Projects			
Storage-113 Projects	1,529	30,360	209.1
Run-of-River-81 Projects	3,319	6,630	-
Pak Mun Related 7 Projects	-	5,400	-
Sub-total	4,848	42,390	209.1
Total	8,540	63,710	344.3

3-5-3. Implementation Schedule of Overall Basin Development Project

As stated above, the present irrigated area in the basin occupies only six percent of the total paddy fields, far less than the country average of about 20 percent, which may be one of the causes for low agricultural productivity in the basin. With the implementation of the proposed irrigation projects, irrigable area in the basin will increase by 42,390 ha.

The implementation and operation of the projects involve many governmental agencies and villagers concerned and need such agricultural supporting services as extension of improved farming management, prompt supply of farm input materials, proper water management and so on. There is a financial conflict with other development projects when the Sebai-Sebok basin development project is proposed to be implemented on a short term program.

The basin development projects will be implemented under two development programs: the short term development program with a target year of 1996 and the middle term development program to be completed in the year of 2006.

For the development of relatively limited water resources in the basin, first priority shall be given to the medium scale irrigation projects of storage schemes, as the most effective way of water resources development. Out of 26 medium scale irrigation projects, 14 high priority projects are proposed on the short term development (refer to Section 3-9), together with the proposed projects related to the Pak Mun Project.

Five rehabilitation projects including Tung Ma Hew project will be implemented as early as possible under the short term development program as they have experiences of irrigation so that quick and high economic return could be expected with relatively low investment costs.

The proposed small scale irrigation projects will be implemented continuously year by year under the middle term development program, taking into consideration the potentiality of water resources as planned in this study. 12 medium scale irrigation projects ranked as low priority are included in the middle term development program.

Table 3-1 presents the proposed implementation schedule of the Sebai-Sebok basin development project as summarized as follows;

Summary of Implementation Schedule

Project	Irrigable Area (ha)	Estimated Cost (M฿)
Short Term Development (1990 - 1996)		
- 14 Medium Scale Storage Projects	18,750	1,608
- Pak Mun Related 7 Pump Projects	5,400	362
- 5 Rehabilitation Projects	5,090	75
Total	29,240	2,045
Middle Term Development (1990 - 2006)		
- 12 Medium Scale Storage Projects	7,260	1,085
- 87 Small Scale Storage Projects	4,350	300
- 40 Small Scale River Diversion Projects	2,600	200
- 41 River Pumping Projects	4,030	300
Total	18,240	1,885
Grand Total	47,480	3,930

3-6. Storage Scheme

3-6-1. Potential Dam Site

(1) Medium Scale Irrigation Project

In the Sebai basin, hills at an elevation of 100 to 200 meter above mean sea level extend in the north of the basin, and possible dam sites are mostly located on the fringe and of the hills, ranging from 160 to 180 meter in elevation. Seven possible dam sites were selected. Many small scale irrigation projects were constructed on the relatively flat terrace at an elevation of 115 to 130 meter above mean sea level.

In the Sebok basin, many tributaries join the Sebok river in the northeast of the basin, having a relatively sharp grade of 1/500 to 1/1,000. Many possible dam sites on the upper reaches of the tributaries having topographic characteristics of folds of hills can be found in the said basin. 14 possible dam sites were selected, and there are many possible dam sites other than 14 selected sites, although a small scale. In the southwestern basin, there exist relatively flat hills with less possibilities of construction of medium scale dams and reservoirs; the Nong Chang Yai existing project is only an exception to locate here.

In the Tung Lung basin, topography of which is similar to that of the Sebok basin, five possible dam sites were selected on the upper reaches of the tributaries at an elevation of 150 to 170 m above mean sea level.

As a result of reconnaissance site surveys and preliminary studies on the project scale, 26 of medium irrigation projects of storage schemes have been identified, as detailed in the Section 3-9. Summary of 26 medium scale irrigation projects are given below (refer to Table 3-2);

Potential Medium Scale Irrigation Project

Basin	Nos. of Project	Catchment Area (sq.km)	Storage (MCM)
Sebai	7	147	50.6
Sebok	14	388	97.0
Tung Lung	5	125	26.8
Total	26	660	174.4

(2) Small Scale Irrigation Project

There are potentialities of small scale water resources development on the middle terrace of 2,173 sq.km with an elevation of 130 to 160 meter above mean sea level. From the experience of the small scale irrigation projects implemented by RID in the Sebai basin, the followings are learnt; i) Runoff from 40 percent watershed is used for storage schemes and 60 percent for river diversion schemes, ii) average watershed area is 10 sq.km for one storage scheme and 33 sq.km for one run-of-river scheme, and iii) an average storage capacity per project is about 0.5 MCM, or equivalent to 0.04 MCM per sq.km of watershed area.

Based on the above-mentioned results, it is assumed that 87 small scale storage projects could be constructed in the area covering 2,173 sq.km, as summarized as follows;

Potential Small Scale Storage Project

Basin	Nos. of Project	Catchment Area (sq.km)	Storage (MCM)
Sebai	24	238	9.5
Sebok	46	458	18.3
Tung Lung	17	173	6.9
Total	87	869	34.7

3-6-2. Irrigable Area

RID has prepared topographic maps (scaled 1:10,000) for the selected 10 dams and reservoirs for the study. Preliminary reservoir operation studies were conducted for 10 years (1972 to 1986) for the purpose of estimating the irrigable area. Irrigable area for another 16 projects was assumed based on results of the said operation studies. Irrigable area of small scale storage projects is estimated on condition that a 20 sq.km catchment area can secure irrigation water for 100 ha of paddy fields. Total irrigable area with the proposed storage scheme is given as follows;

Irrigable Area with Storage Scheme

Item	Sebai	Sebok	Tung Lung	Total
1) Medium Scale Irrigation Project				
Nos. of Project	7	14	5	26
Irrigable Area (ha)	7,000	14,460	4,550	26,010
2) Small Scale Irrigation Project				
Nos. of Project	24	46	17	87
Irrigable Area	1,190	2,290	870	4,350
3) Total Irrigable Area (ha)	8,190	16,750	5,420	30,360

Beneficial areas are selected among existing paddy fields located at the immediate downstream of the proposed reservoirs so as to apply gravity irrigation. In accordance with the policy of the Government, any small scale irrigation project shall be planned and implemented by the governmental agencies in response to official request from the villagers concerned. In this sense, locations of the small scale irrigation projects can not be identified at present; however, for the sake of drawing an overall basin development plan, a trial has been made to show potential project sites on the maps deemed technically feasible in due consideration of topographic conditions and availability of water resources.

3-7. Run-of-River Scheme

3-7-1. River Diversion and River Pumping

Irrigation projects of run-of-river scheme to draw free-flowing water are proposed in areas where there is no possibility to construct storage project. Being situated below the adjacent field level, the streams have to be lifted either by pumps located near the irrigation area or by a diversion structure that may have to draw the water a considerable distance upstream.

A diversion structure is constructed across a river to raise its water level to a controllable elevation, from where it can flow by gravity through an irrigation canal to an irrigation area. Therefore, the location of a river diversion is limited to such river with a moderate grade. River pumping is proposed where a river has a flat grade, which otherwise require a high diversion structure and long supply canals to provide gravity irrigation.

Monthly irrigation water requirements and probable monthly runoff were compared to determine the critical month in irrigation planning, and as a result November was pronounced as the critical month in rainy season paddy irrigation and require a catchment area as large as 50 times of a paddy field area.

Selection of favorable sites for river diversion and river pumping on the topographic maps resulted in the development of runoff from 2,016 sq.km catchment area for river diversion and 1,303 sq.km catchment area for river pumping. River pumping projects are distributed over the lowlying areas at an elevation below 130 m above mean sea level along the main rivers.

Potential Run-of-River Project

Item	Sebai	Sebok	Tung Lung	Total
Catchment Area (sq.km)				
River Pumping Projects	1,039	853	124	2,016
River Diversion Projects	357	687	259	1,303
Total	1,396	1,540	383	3,319

3-7-2. Irrigable Area

Potential irrigable areas by river diversion are marked on the topographic maps after consideration of topographic information. As for potential irrigable areas by river pumping, the extent of areas deemed suitable for pumping are marked on the map. It could be said in this connection that one unit of pump with a bore diameter of 300 inch can draw water enough to irrigate about 100 ha of paddy fields.

Irrigable Area with Run-of-River Scheme

Item	Sebai	Sebok	Tung Lung	Total
1. River Pumping				
Nos. of Projects	21	17	3	41
Irrigable Area (ha)	2,080	1,700	250	4,030
2. River Diversion				
Nos. of Projects	11	21	8	40
Irrigable Area (ha)	710	1,370	520	2,600
Total (ha)	2,790	3,070	770	6,630

3-7-3. Projects Related to Pak Mun Project

According to the Summary report prepared by EGAT in March, 1988, the following are objectives of the Pak Mun multipurpose project as given below:

- To develop multipurpose project such as hydropower generation, agriculture and fisheries;
- To keep normal water level at El.108.0 m by construction of a 17 m high dam across the downstream reaches of the Mun river;
- To generate 280 GWH per annum of hydropower with 4 units of 34 MW power plant;
- To supply pumped irrigation water for farm land of 25,600 ha; and
- To develop fisheries of the Mun river

The Pak Mun project controls annual runoff of 24,000 MCM from the catchment area of 117,000 sq.km inclusive of the Sebai-Sebok basin of 8,540 sq.km by constructing a dam and reservoir with an effective storage capacity of 115 MCM for multipurpose use. The Sebai-Sebok irrigation development project has proposed to provide for storage dams with a combined capacity of about 210 MCM, far less than the annual inflow to the Pak Mun reservoir.

The feasibility study report (SOGREAH, October 1985) described that the new available resource would enable the irrigation of 100,000 ha and the limiting factor, which is at present the availability of water, would no longer be the hydrology of the Mun river, but the total area of irrigable land and the high cost of such an operation in certain areas around the reservoir. The Pak Mun project selected 25,600 ha of farm lands for pumping irrigation after consideration of land use, the quality of soil and the elevation of land above the reservoir levels, of which a 1,140 ha area is located on the downstream reach of the Sebok river.

The Tung Ma Hew area (1,260 ha), being situated downstream of the above-mentioned 1,140 ha area, is preferably to be incorporated in the Pak Mun project. Furthermore, there are vast lowlying paddy fields along the both banks of the Sebai and Sebok rivers, of which 3,000 ha of paddy fields located on the downstream reaches are proposed to receive supplemental irrigation water from the Pak Mun project, totaling 5,400 ha of paddy fields to be included in the Pak Mun project.

3-8. Rehabilitation Scheme

3-8-1. Medium Scale Irrigation Project

The existing six medium scale irrigation projects were reviewed. The 13.5 m high dam of Puttha Utthayan project was rehabilitated in 1987 under the USAID. The Huai Tamkhae dam with a height of 18.5 m was recently constructed in 1986. Other four dams ranging four to six meters in height do not need rehabilitation works.

Irrigation canals of the Huai Pho and Rong Nam Sap project constructed in 1952 and 1953 respectively, have to be rehabilitated by concrete lining and enlargement of canal conveyance capacities. The rehabilitation of irrigation canals of the Puttha Utthayan and Nong Chang Yai was completed by RID during the period 1982 to 1987.

With regard to the on-farm development, terminal irrigation facilities shall be constructed in a total area of 3,827 ha including irrigable areas under the projects of Huai Pho, Rong Nam Sap, Nong Chang Yai and Huai Tamkhae. RID will start the works in 1990 for the Huai Tamkhae project (1,680 ha) and Rong Nam sap project (67 ha), as given in Table 3-3.

3-8-2. Tung Ma Hew Project

The Tung Ma Hew project having an area of 1,260 ha, which was constructed by NEA and DLD, is situated on the downstream reaches of the Sebok river and is used to be irrigated with pumped water. The area suffered considerable damages from high floods in 1968 and 1978, and since then irrigation has not been practised except small scaled areas irrigated temporarily with portable pumps. Farmers concerned have strong request for rehabilitation of the following project facilities.

- Irrigable area : 1,260 ha
- Pumping station : 6 units x 150 HP x 1.5 cu.m/s
- Main canals : 9.9 km

- Secondary canals : 18.0 km
- Flood protection dikes : 9.0 km
- Fish ponds : 4 ponds

3-9. Priority Project

3-9-1. Medium Scale Irrigation Project

(1) Selection of Project Site

In the initial stage of Phase I study, RID presented to the study team 33 potential storage projects as medium scale irrigation project, of which five projects have been studied on a preliminary level by RID to determine technical soundness of the project in response to the strong request by farmers concerned.

Selection of potential project sites was made firstly by using topographic maps scaled 1:50,000 and aerial photographs. Later, field reconnaissance survey was conducted. As a result of the selection of potential project sites, one site was added and eight sites were excluded from the list of potential project sites, leading to selection of 26 potential projects of storage scheme.

Location of 26 Projects

Basin	Province	Nos. of Project	Catchment Area (sq.km)
Sebai	Ubon Ratchathani	2	32
	Yasothon	5	115
Sebok	Ubon Ratchathani	14	388
Tung Lung	- do -	5	125
Total		26	660

The topographical maps of the four project sites were prepared by RID before the commencement of this study. During the Phase I field survey period, RID survey team prepared the profile maps of 26 potential dam sites and 11 reservoir area maps scaled 1:10,000.

(2) Geology at Dam Site

The geological survey was based on examination of existing materials and investigation of 62 dug pits at 15 proposed dam sites.

The bedrock for each dam foundation which is the sandstone within the Khorat Group lies less than three meters depth below the ground surface. This sandstone layer gently dips at about 10° constant, and the principal fault and sheared zone which cut the geological structure of the bedrock are not predominant at each dam sites. Therefore, the important problem, except the permeability of the bedrock with latent cracks as the intercalated crackly shale with rich bedding, is not found in dam foundation. The problem in the permeability of the bedrock could be easily solved by foundation treatment. However, the overburden is very thin at every dam site because of the distribution at shallow depth, and embankment material, especially impervious material is poor in quantity not only at dam sites but also in reservoir areas. This deficiency of the embankment material is an important problem at every dam site.

(3) Hydrology

In order to estimate the dependable runoff at potential dam sites, relationship between monthly rainfall and runoff was analyzed. To develop a model for estimating the monthly runoff at potential dam sites, discharge data at M127, M132 and M141 were applied. The developed equation is as follows;

$$\Sigma Q = 2.2008 \times 10^{-6} \times (\Sigma R)^{2.6268}$$

where;

Q: cumulative monthly runoff from April (mm)
R: cumulative monthly rainfall from April (mm)

Design floods for dam spillway were estimated by applying a triangle hydrograph constructed by peak discharge, flood concentration time and a base length of hydrograph. The designed flood hydrograph was prepared based on the maximum flood recorded in December, 1986 at M132 gauging station having a catchment area of 101 sq.km. As a frequency of flood, a flood with a return period of 500 years for emergency spillway and 100 years for service spillway are adopted according to the criteria for MSIP storage dams of Project Planning Division, RID.

(4) Effective Storage and Irrigable Area

In principle, a reservoir is planned to have a storage capacity equivalent to annual average runoff at the dam site. The capacity of the dam is preliminarily determined with a practical maximum dam height, and the pre-determined storage capacity was compared with average annual runoff at the dam site, leading to the selection of smaller capacity as a tentative reservoir

capacity for an examination of reservoir operation to estimate a proposed irrigable area.

The reservoir operations were simulated for selected 10 projects that have detailed topographic maps of the proposed dam and reservoir sites for the periods of ten years from 1977 to 1986 on a monthly basis.

The reservoir operation studies were carried out by substituting variable irrigation water requirements in the equation to obtain the maximum irrigation area on condition that water shortage is allowed once in ten years from a viewpoint of project economy.

Effective storage and irrigable areas of the remaining 16 projects were assumed by applying the relationship between irrigable area/effective storage and average annual inflow/effective storage resulted from the reservoir operation studies for 10 projects. As a result, the total storage capacity and irrigable paddy field for 26 projects amounts to 174.4 MCM and 26,010 ha, respectively, as shown in Table 3-5.

(5) Dam and Irrigation Facilities

Design floods for designing dam spillway are determined by flood routing taking into account storage effect of flood water above normal water surface. According to the results of flood routing analysis for 10 reservoirs that have topographic maps of dam and reservoir, the relationship between magnitude of peak flood and designed discharge for spillway was obtained and was applied preliminarily in estimating the design discharge for the other 16 reservoirs.

Considering the flat topographic conditions at the dam sites i.e., in the most steep slope dam site, the dam span and length ratio is about 30, the earth fill type dam will be generally applicable. Therefore, the earth fill type dam is adopted for the preliminary design of dams in the selection of priority projects.

Major criteria for dam planning are as follows;

- Dam type : Earth fill type dam with slope of 1:3.0 at upstream and 1:2.5 at downstream
- Width of dam crest : 6.0 m
- Freeboard : 1.5 m from maximum high water level
- Sediment volume : 150 cu.m/year/sq.km x 100 years x catchment area

The estimated height and embankment volume of dam range from 7.6 m to 18.5 m and 26,400 cu.m to 449,000 cu.m, respectively (Table 3-4).

The layout of the main irrigation canal system is made based on the topographic maps with the scale of 1:50,000. The alignment of canal is planned to enable the paddy fields to be irrigated by gravity, running in parallel with contour lines as far as possible so that the number of appurtenant structures like drops and the quantity of earthwork are reduced to a certain extent. The main and lateral canals will be constructed to command a project area down to a terminal irrigation block of 300 rai (48 ha). Main and lateral canals are designed to be trapezoid channels with concrete lining having a conveyance capacity of 10 l/s/rai, while on-farm ditches with a conveyance capacity of 24 l/s/rai.

(6) Preliminary Cost Estimate

The construction costs of 26 medium scale irrigation projects were tentatively estimated to determine the priority of projects based on the above-mentioned project layout, for which current unit construction costs of RID projects were applied. Dam construction costs were estimated based on dam embankment volume and design flood discharge for spillway; Baht 100 per cu.m for dam embankment, and Baht 200,000 per cu.m/sec for spillway.

Canal construction costs were estimated based on unit costs per meter by canal types which were determined in relation to designed canal capacities. Unit rates of each canal type are as follows:

Canal Type	L1	L2	L3	L4	L5	L6	L7	L8
Unit Rate (Baht 1,000/m)	1.2	1.3	1.4	1.6	1.7	1.8	2.5	2.6

In addition to the construction costs, other costs required for the implementation of projects, such as surveys, right-of-way, engineering and administration, operation and maintenance equipment, and consulting services were estimated at a rate of 20 percent of the construction costs. Ten percent of physical contingencies were added.

Table 3-5 presents the estimated project costs. The estimated total project costs for 26 medium scale irrigation projects amount to Baht 2,696.3 million at a price level of 1987 in which price escalation is not estimated.

3-9-2. Selection of High Priority Projects

(1) Preliminary Selection

For the development of water resources for irrigated agriculture in the basin, first priority will be given to the implementation of the medium scale irrigation projects of storage schemes that regulate flood flows to release for irrigation use during the months of low flows. The evaluation of priority among proposed 26 medium scale irrigation projects of storage schemes is conducted to prepare a staged implementation program from viewpoints of project economy, engineering and scoio-economy.

RID has already set forth an implementation program of four projects of BA-1, BA-2 and BA-6 in the Sebai basin and BO-2 in the Sebok basin to commence construction works in 1990 under the Sixth National Plan. Hence, four projects are excluded from the evaluation.

As a first step for selection, the economic evaluation for each project was made by applying the cost/benefit ratio (B/C). The B/C ratio was calculated at a discount rate of five percent taking into account the preliminary level of the structural plan, agricultural plan and estimation of project cost and benefit.

Six projects viz., BO-6, BO-8, BO-9, BO-12, BO-19, TL-2 with B/C ratios of less than 1.0 were considered to be low priority projects. And, the following 16 medium scale irrigation projects were finally selected for priority evaluation.

16 Projects to be Evaluated

Sebai Basin	Sebok Basin	Tung Lung Basin
BA-4	BO-3, BO-14	TL-1
BA-5	BO-10, BO-15	TL-3
BA-8	BO-11, BO-17	TL-5
BA-9	BO-13, BO-18	TL-6
4 Projects	8 Projects	4 Projects

(2) Selection Criteria

The evaluation of priority project was based on the following six parameters which were prepared through the data and information obtained during the Phase I stage investigation period:

1) B/C ratio : High priority shall be accorded to projects with a high B/C ratio.

2) Scale of irrigable area:
The larger the area, the larger the impact of the project.

3) Reservoir area conditions:
Construction of such a dam and reservoir which have a large farm land, houses and public facilities in its reservoir area might cause a social problem apart from increasing project costs.

4) Income level : In order to alleviate income disparity, the area where income is at low level shall be developed with high priority.

5) Soil suitability: Soil conditions in the beneficial area shall be suitable for crop cultivation.

6) Civil work conditions:
Such civil work conditions especially at the dam site as foundation, embankment materials, accessibility, etc. shall be considered.

The B/C ratio ranging between 1.0 and 1.8 was classified into eight grades of A to H while other parameters into three grades of A to C. Table 3-6 presents the specifications and scoring of six parameters.

(3) High Priority Projects

16 medium scale projects were grouped into three by applying the selection criteria mentioned above. The scores of projects vary from 49 to 11 with an average of 25 against full score of 55 for six parameters. Five projects whose scores were higher than the average were ranked as Group A with top priority and 11 projects were ranked as Group A' (five projects) and Group B (six projects). Furthermore, the remaining six projects (BO-6, BO-8, BO-9, BO-12, BO-19, TL-2), which have the B/C ratio of less than 1.0, were considered low priority and ranked as Group C.

Grouping of 16 Medium Scale Project

Group	Score	Sebai	Sebok	Tung Lung	Total
A	49	-	BO-11	-	1
	41	-	BO-18	-	1
	29	-	BO-13	-	1
	27	BA-5	-	TL-6	2
	Sub-total	1	3	1	5
A'	25	BA-9	BO-17	-	2
	23	-	BO-3	-	1
	21	BA-8	-	TL-5	2
	Sub-total	2	2	1	5
B	19	-	BO-10	TL-1	2
	19	-	BO-14	TL-3	2
	17	BA-4	-	-	1
	11	-	BO-15	-	1
	Sub-total	1	3	2	6
Total		4	8	4	16

The Phase I study for the Sebai-Sebok basin development project has reached a conclusion, on a reasonable basis, that five top priority projects classified under Group A should be early implemented. The feasibility studies will be carried out in the succeeding Phase II study. A summary of five high priority projects is given below:

Summary of Five High Priority Projects

Code No.	Project	Basin	Catchment Area (sq.km)	Gross Project Area (ha)
BA-5	Lam Se	Sebai	22.4	1,370
BO-11	Huai Khum Kham	Sebok	36.8	3,650
BO-13	Huai Kham Phak Wan	Sebok	13.5	1,110
BO-18	Huai Na Khai	Sebok	31.3	3,100
TL-6	Huai Soob	Tung Lung	35.7	1,830

3-10. Improvement of Rainfed Agriculture

As mentioned earlier, with the implementation of the Sebai-Sebok overall basin plan, irrigable area of paddy fields will increase to 63,710 ha, or equivalent to 18 percent of the existing paddy fields of 346,000 ha. The remaining existing farm lands which are not covered by the proposed overall

basin plan will be cultivated under rainfed environment as before unless any other improvement measure is taken.

The average annual rainfall in the basin is about 1,600 mm, which is more than the amount of evapo-transpiration of paddy or upland crops. Due to the monsoon climate with the pronounced dry season, irrigation is a necessity in the dry season, and irrigation is often required even in the rainy season because of uncertainty of rainfall patterns.

Based on results of research and surveys so far made in the Northeast by government agencies and universities, discussions on the improvement of rainfed agriculture in the basin were made from the viewpoint of conservation of water and soil, two major input resources for agriculture.

3-10-1. Previous Studies

Improvement of rainfed agriculture in the Northeast has been taken up by Thai organizations for long time. At present moment, some other activities are under progress. Some main projects are summarized below;

(1) Northeast Rainfed Agricultural Development Project (NERAD)

The headquarters is located at the suburb of Khon Kane city and the project period covers nine years from 1981-1989. The purpose of the project is to establish at representative Tambons in the Northeast a model agricultural development program for increasing farm productivity and farm income, particularly among lower income farmers. The project partners are some departments of MOAC of Thailand, USAID and College of Agriculture, University of Kentucky, USA.

The main works successfully achieved by the project are the following:

- Direct sown rice
- Cooperative buying groups
- Modified shallow wells
- Pre-rice green manure
- Papaya ringspot virus disease control
- Simple farm implements
- Raising fish in paddy fields
- Shallot production from seed

- Kenaf varietal improvement
- Native chicken improvement
- Soil fertility improvement by liming
- Integrated water resources utilization
- Sericulture improvement

(2) Khon Kaen University (KKU)

The approaches of KKU are based on cropping mixed farming or integrated farming system. The main activity is KKU - USAID Farming System Research Project which started since 1984. It is the succession of Cropping System Project funded by Ford Foundation. A report "Studies on Models of Mixed - Farming as related to administration and management of natural resources and ecosystem, a case study of Ubon Ratchathani. Thailand", was selected. The objectives of this work are as follows;

- To study the types of farm management and land use recently adopted by farmers.
- To develop appropriate models of mixed-farming systems.
- To assess the economic merits of each of the proposed models.
- To evaluate the impact of the proposed models of mixed-farming on the natural resources.
- To provide related information for all proposed models.

According to the above report, 14 models of Mixed-Farming (10 for rainfed and 4 for irrigated areas) suitable for existing land ecosystem of Ubon Ratchathani province are proposed.

(3) Tung Kula Ronghai Project

This is a rural development project being implemented under the assistance of the Australian Government, and some Thai departments under MOAC such as RID, DLD and DOA are concerned. Tung Kla Ronghai area covers 3,360 sq.km located at the west of the Sebai-Sebok area. The major problems in the area are flood, drought and poor soil condition such as low fertility and salinity.

The goal of the project is to improve the standard of living of the rural people in the area through increased net income, food supply and community participation. The components of the project are as follows;

- Land remodeling
- Ground water development
- Water resources study
- Fisheries development
- Upland reforestation
- Research and extension
- Community development
- Technical assistance support

The project was started in 1977 to complete in 1989. Although the situation is not the same to the Sebai-Sebok area, there are many useful information applicable to the Sebai-Sebok area; especially water resources development study for the dry season and crop cultivation technology developed in the area. For instance, one of them is the construction of ditches in paddy fields to provide water for the succeeding dry season irrigation, and the late cultivation of paddy to save irrigation water supply, and so on.

(4) Agricultural Development Research Center in Northeast (ADRC)

The center was initiated in May, 1985 under the assistance of JICA. Khon Kaen University, DLD and DOA have joined in the research. Main activities achieved by the center are as follows;

- Plant breeding
  - Physic nut (Jatrophia curcas L)

- Agronomy of crops
  - Introduction of buck-wheat etc.
  - Salinity tolerance of tree crops
  - Plant growth regulator
  - Introduction and study of bamboo

- Soil Fertility
  - Intercropping of Stylosanthes hamata cv verano.
  - Ploughing effect. etc.

- Soil Survey
  - Micromorphological analysis such as movement of clay in soil
  - Ground water and salt
  - Chemical fertilizer in soil series

- Agro-climatology
  - Evapotranspiration under different land use.

- Hydrology
  - Pond construction technology

For the second phase (1988 - 1993) assessment of natural environment and resources, improvement of crop performance, and improvement of soil conditions are tentatively proposed.

3-10-2. Approaches to the Improvement of Rainfed Agriculture

(1) Conservation of Water

The water storage projects proposed in the overall basin plan will retain excess water in two to three months of high flow for use during months of low flow. The proposed run-of-river projects will draw free-flowing water with weirs or pumps without river flow regulation. Generally, it is expected that there are abundant surplus river water in two to three months in the rainy season except for the extreme dry year. Among the several engineering measures, there are two ways of water conservation applicable to the Sebai-Sebok; namely small scale water resources development and moisture conservation.

a) Small Scale Water Resources Development

In the Sebai-Sebok basin, groundwater, flows of small streams and rain water are being left for use for improvement of rainfed agriculture. Regarding groundwater, geo-hydrological studies were made in the previous chapter and the area with potentiality of groundwater exploitation is shown on the master plan map. The expected groundwater yields are 75 to 380 l/min. Development of small streams for irrigation may be less effective unless storage is provided, because of rapid drainage of stream flow. Water stored in

small stream channels with check structures may be used for irrigation in the succeeding early dry season.

To fully utilize rain water, a farm pond in paddy field will be constructed to store excess rain water in two to three months during the rainy season and use it for irrigation in coming season. Such facilities are existing in the Northeast where is suffering from lack of rainfall.

b) Moisture Conservation

In addition to small scale water resources development, physical means of retaining rainfall and irrigation water on the land and reducing evaporation losses from the soil surface are also applicable to the improvement of rainfed agriculture. Moisture conservation entails application of modified tillage and crop management practices, including;

- Deep ploughing
- Contour cultivation and level bench terracing
- Natural and artificial mulching
- Preservation of rain water in natural marsh, swamps, etc.

(2) Water Saving Cultivation

① Late or delayed cultivation of photo-sensitive paddy varieties can reduce the growing period by cutting extra vegetative phase, saving irrigation water eventually.

② The amount of water necessary for crop cultivation is decided by rainfall in the growing period, water holding capacity of the soil and depth of root of the crop. Irrigation is needed for vegetable crops cultivation which have shallow root system but tree crops have deep root system and need less amount of water as compared to annual crops.

(3) Soil Conservation

a) Improvement of Soil Fertility

① Green Manure

Soils with low soil fertility are predominant in the Northeast. To overcome this, trials on green manure cropping are being carried on in Northeast Rainfed Agricultural Development Project (NERAD) and in Thai-International Rice Research Institute (IRRI) Cooperation Project. The results show that cowpea and black bean in upland condition and Sesbania in wet paddy condition are suitable as green manure crops.

② Intercropping

The Department of Agriculture, MOAC in the Agricultural Development Research Center in Khon Kane carried out a trial of intercropping of Stylosanthes hamata cv. verano in cassava plantation as cover crop in 1987/88. Cassava was planted with no tillage and intercropped Stylosanthes was cut at the height of 7-10 cm to avoid competition with the main crop. This system yielded highest root and top weight of cassava. Enrichment of nutrient in soil for crop with low cost is to be introduced for agricultural production in the area.

(4) Countermeasures Against Saline Soils

According to the report "Characteristics and Management of Salt Affected Soils in the Northeast of Thailand" written by Dr. Somsri Arunin, DLD, the development strategy of saline soil areas includes three principles, viz., prevention, reclamation and short term salinity control. The prevention measures shall be of long term nature, the reclamation is a medium term measure, and the short term salinity control is an immediate countermeasure with low cost. The report emphasizes that in case of implementation of a development plan of a saline soil area, it should be multidisciplinary and integrated.

The outline of three development strategies are given as follows;

a) Prevention of Salinity

- Lowering of groundwater level by reforestation
- Introduction of deep rooted, salt tolerant perennial plants

- Deep interceptor drains installed on catchment area.

b) Reclamation of Saline Soils

- Leaching; Drainage systems based on analysis of hydrological data are required. Leveling of land increase leaching efficiency.

- Others ; In case of a depression area with shallow saline groundwater where reclamation measures are not feasible, the area may be possible to be turned to a pond for raising fish such as tilapia nilotica, or to salt tolerant forage grass land.

c) Short Term Salinity Control

① Leaching

In case of paddy cultivation, planting should be waited until early rain has reduced the salt content of soils. In case of sodic soil reclamation by leaching, it is observed sometimes that permeability of water in soil decreases so rapidly and leaching efficiency become very slow. Application of Ca^{++} to leaching water or into the soil can prevent this phenomenon by keeping permeability.

② Leveling of Micro-relief in Paddy Fields

③ Application of Organic Matter

Organic matter application such as rice hull, animal manure, green manure or groundnuts shell is effective for compensation of fertility losses and improvement of physical structure of soils.

④ Cultivation of Salt Tolerant Plants or Varieties

It is advisable to cultivate plans which have different salt tolerance according to the salinity of soil. As for varieties, the following paddy varieties are suitable for moderately saline conditions in the Northeast; Hom Om, Wam Sa Gui, Kao Ruang, Daeng Woi, Jumping Jack, Kao Ta Ooh, RD8, Kam Pae 41, Khao Hang Ban, Khao Dog Mali Klang, RD 1, Ko Deo, and Neo San Pa Tong.

Local minor varieties which have high salt tolerance as the results of screening in farmers' fields for long periods are going to be replaced by new varieties. It should be emphasized to collect and preserve these specific varieties to use in saline conditions though

they may have rather poor yielding potential. They have much adaptability to the specific condition.

⑤ Improvement of Paddy Cultivation Practices

- Higher planting density:

  20 cm x 20 cm is recommended for transplanting density in general but in saline soil conditions, higher planting density like 15 cm x 20 cm is recommendable to secure yield components such as tiller number and grain number.

- Older seedling:

  Transplanting of older seeding, around 35 ~40 days, is recommendable than young seedling. Older seeding has generally higher tolerance and has more chance to survive.

- Delayed planting:

  Delayed planting, either direct seeding or transplanting, after leaching out the salt in paddy fields by early rain is necessary.

- Split application of fertilizer:

  Split application of fertilizer is one of the basic methods of paddy cultivation and it is especially important in the fields of saline soils.

- Mulching:

  Surface mulch reduces evaporation from soils preventing the salt being brought to the surface by capillary action.

3-10-3. Improvement of Rainfed Agriculture

(1) Retention of Rain Water in Farm Ponds

According to the study made by NERAD, the following problems on the use of small scale water resources including village ponds and rehabilitated swamps are presented;

- Farm ponds were often far away from villages and were not effectively used.
- The land surrounding the pond was often owned by relatively few farmers and consequently their benefits were inequitably distributed, and
- No water distribution structure or water management system was provided for the resources and use of the water was very inefficient.

For further development of rather limited water resources in the basin, construction of small scale diversion weirs or storage dams on small streams will be done by farmers and local government agencies. Therefore, detailed information on topography and hydrology is to be prepared including the boundaries of catchment area, water level and elevation of farm land, run-off of streams and so on.

Giving attention to the fact that the average annual rainfall over the basin is more than crop water requirements, preliminary studies have been made to determine appropriate size of a farm pond to be dug at paddy field areas on the following condition;

- Land for the pond to be provided by farmers concerned,
- A group of 10 farmers with 34 ha of paddy fields,
- Annual rainfall of 1,400 mm, or 1,800 mm, and
- Area of a farm pond;

  1.7 ha (5 percent of paddy fields)

  3.4 ha (10 percent of paddy fields)

As a result, a 1.7 ha farm pond with a two meter water depth can supply 60 percent of irrigation demand for the rainy season paddy in areas having 1,400 mm rainfall, and 75 percent in areas with 1,800 mm rainfall. With a farm pond of 3.4 ha, 75 percent and 100 percent of irrigation demand can be supplied for the 1,400 mm rainfall areas and 1,800 mm rainfall areas, respectively.

In areas where there is no irrigation project, efforts shall be made to supplemental irrirrigation necessary to increase yields of rainy season paddy to some extent, not intending to attain 100 percent of potential yields. A yield response to irrigation water supply is not simple, being affected by varieties, growing stage and fertilizer application. Water shortage during the reproduction growth stage generally affects yields of paddy more than water shortage during the vegetative growth stage.

Although 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 costs of farm ponds and canals, paddy yield projection, institutional and financial support of the Government, better use of rain water on a farm level is one of effective measures for improvement of rainfed agriculture in the Sebai-Sebok basin where comparatively abundant rainfall is expected in the normal year.

(2) Tree Crops and Animal Husbandry

Tree crops need less amount of water compared with annual crops in the condition of cultivation in field. Moreover fertilization of tree crop is limited to root zone (localized deep placement) and amount of compost to increase soil fertility is also much less than that of the annual crop. In animal husbandry, less water is also needed and production of barnyard manure is one of the merits of the industries. But introduction and extension of appropriate fodder crops for livestock, which is now in progress, will be necessary.

(3) Watershed Classification and Management

For the above mentioned tree crops introduction and animal husbandry development, land classification according to watershed concept will be necessary and the agricultural development in each class (zone) classified by the concept should be concentrated on the designated crop(s) to the zone.

The Office of the National Environment Board (ONEB) developed the watershed classification system for allocation of watershed areas based on the best currently available data for such parameters as slope, elevation, land form, geology, soils and forest cover. Land areas are mapped in five major watershed areas as summarized as follows;

Watershed Class 1:	Project forest Class 1A are areas of protection forest and head water source areas. Class 1B are areas having similar physical features and environments as Watershed Class 1A, but portion of the area have been cleared for agricultural use or occupied by villagers. These areas require special soil conservation protection measures and where possible should be replanted to forest or maintained in permanent agro-forestry.
Watershed Class 2:	Commercial forest Areas may be used for grazing or for certain crops.

Watershed Class 3:	Fruit tree plantations Covering upland areas with steep slopes and less erosive land forms, these areas are usually used for fruit tree plantations or certain agriculture crops, and may be used for commercial forests, grazing or their uses.
Watershed Class 4:	Upland farming Areas of gently sloping lands, suitable for row crops, fruit trees, and grazing
Watershed Class 5:	Lowland farming Gently sloping to flat areas, used for paddy fields or other agricultural uses, with few restrictions.

The Government of Thailand has a plan to use this classification system for the whole country by the end of 1992.

(4) Researches

Urgent researches are needed for the following fields.

- Prevention of seepage of water and evaporation from reservoir or pond;
- Water saving crop cultivation system;
- Late (delayed) cultivation technology of paddy;
- Fertilizer application method to paddy;
- Crop cultivation technology before and after paddy cropping;
- Breeding and introduction of drought and salt resistant crops and varieties; and
- Possibility of utilization of groundwater for agriculture.

TABLE 3-1. IMPLEMENTATION SCHEDULE OF OVERALL BASIN DEVELOPMENT PROJECT

Description	Irrigable Area (ha)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
		1990 - 1996							1997 - 2001					2002 - 2006				
1. Short Term Development Plan (1990-1996)																		
1.1 Storage Scheme																		
- RID Planned MSIP: 4 Projects (BA-1, BA-2 BA-6, BO-2)	4,490																	
- MSIP Group A : 5 Projects (BA-3, BO-11 BO-13, BO-18, TL-6)	8,780																	
- MSIP Group A' : 5 Projects (BA-8, BA-9 BO-3, BO-17, TL-5)	5,480																	
1.2 Run-of-River Scheme with Pak Mun Project			Pak Mun Dam															
- Tung Ma Hew Pump Project	1,260																	
- Sebai-Sebok Pump Project	4,140																	
1.3 Rehabilitation Scheme: 4 MSIP Projects	5,090																	
Sub-total	29,240																	
2. Middle Term Development Plan (1990-2006)																		
2.1 Storage Scheme																		
- MSIP Group B : 6 Projects (BA-4, BO-10 BO-14, BO-15, TL-1, TL-3)	5,330																	
- MSIP Group C : 6 Projects (BO-6, BO-8 BO-9, BO-12, BO-19, TL-2)	1,930																	
- SSIP : 87 Projects	4,350																	
2.2 Run-of-River Scheme																		
- SSIP Weir Project	2,600																	
- SSIP Pump Project	4,030																	
Sub-total	18,240																	
Total	47,480																	

TABLE 3-2. LIST OF MEDIUM SCALE IRRIGATION PROJECTS

Basin	Province	Code No.	Project	Catchment Area (sq.km)	Storage (MCM)
Sebai	Yasothon	BA-1	Huai Phong (*)	45.2	13.9
	Ubon Ratchathani	BA-2	Huai Ban (*)	14.5	2.1
	Yasothon	BA-4	Huai Pong Pode	8.7	3.4
	- do -	BA-5	Lam Se	22.4	9.7
	- do -	BA-6	Huai Yang (*)	25.0	4.6
	- do -	BA-8	Huai San	13.7	8.9
	Ubon Ratchathani	BA-9	Huai Hin Lat	17.5	8.0
	Sub-total		7 Projects	147.0	50.6
Sebok	Ubon Ratchathani	BO-2	Huai Si Tho (*)	28.2	8.0
	- do -	BO-3	Huai Phra Lao (*)	23.0	6.2
	- do -	BO-6	Huai Kum Bi	16.4	1.1
	- do -	BO-8	Huai Saen Si	25.0	1.7
	- do -	BO-9	Huai Na Pho	26.4	0.3
	- do -	BO-10	Huai Khu Lu	44.7	6.3
	- do -	BO-11	Huai Khum Kham	36.8	22.0
	- do -	BO-12	Huai Thi	38.4	3.3
	- do -	BO-13	Huai Kham Phak Wan	13.5	10.6
	- do -	BO-14	Huai Tham	17.0	5.0
	- do -	BO-15	Huai Phai Ban	21.2	4.8
	- do -	BO-17	Huai Yang	14.6	6.3
	- do -	BO-18	Huai Na Khai	31.3	18.3
	- do -	BO-19	Huai Ba Hang	51.3	3.1
	Sub-total		14 Projects	387.8	97.0
Tung Lung	Ubon Ratchathani	TL-1	Huai Tung Lung	40.3	7.8
	- do -	TL-2	Huai Khut	18.8	1.2
	- do -	TL-3	Huai Ngu Luamg	11.4	2.9
	- do -	TL-5	Huai Chalung	35.7	6.7
	- do -	TL-6	Huai Soob	18.5	8.2
	Sub-total		5 Projects	124.7	26.8
	Total		26 Projects	659.5	174.4

Note: (*) Pre-feasibility study by RID

TABLE 3-3. LIST OF PROPOSED REHABILITATION PROJECTS

Project	Catchment (sq.km)	Storage (MCM)	Irrigable Area (ha)	Rehabilitation Work		
				Dam	Main Canal	On-farm
1. Huai Pho	17	5.4	880	-	Enlaregement - 17.9km	880 ha
2. Ron Nam Sap	1.7	0.4	70	-	Lining - 1.7km	70 ha
3. Nong Chang Yan	62	7.7	1,200	-	(Completed in 1982-87)	1,200 ha
4. Huai Thamkhae	52	16.3	1,680	-	-	1,680 ha
5. Tung Ma Hew	-	-	1,260	-	Dike - 9km Pump station - 6 Canal - 27.9km	1,260 ha
Total	132.7	29.8	5,090		3 Projects	5 Projects
6. Phuttha Utthayan	62	15.3	2,560	Constructed in 1987	Constructed in 1986	-
7. Sa Saming	2	1.0	120	-	-	-
Total	64	16.4	2,680			

TABLE 3-4. MAJOR FEATURES OF MEDIUM SCALE IRRIGATION PROJECTS (1/4)

Description	Huai Phong (BA-1)	Huai Ban (BA-2)	Huai Pong Pode (BA-4)	Lam Se (BA-5)	Huai Yang (BA-6)	Huai Sun (BA-8)	Huai Hin Lat (BA-9)
1) Location							
- Changwat	Yasothon	Ubon Ratchathani	Yasothon	Yasothon	Yasothon	Yasothon	Ubon Ratchathani
- Amphoe	Loeng Nok Tha	Senang Knikhom	Kut Chum	Loeng Nok Tha	Pa Tiu	Loeng Nok Tha	Amnat Charoen
2) River							
- Basin	Sebai	Sebai	Sebai	Sebai	Sebai	Sebai	Sebai
- Catchment Area (sq.km)	45.2	14.5	8.7	22.4	25.0	13.7	17.5
3) Reservoir							
- Total Storage Capacity (MCM)	14.50	2.35	3.5	10.00	4.85	9.10	8.26
- Dead Storage Capacity (MCM)	0.62	0.24	0.1	0.34	0.28	0.21	0.26
- Effect. Storage Capacity (MCM)	13.88	2.11	3.4	9.66	4.57	8.89	8.00
- High Water Level (El.m)	184.5	170.7	189.0	179.3	150.6	177.6	172.6
- Normal Water Level (El.m)	183.5	170.0	188.2	178.5	149.6	177.0	172.0
- Low Water Level (El.m)	176.3	166.2	181.0	171.4	144.0	168.4	164.8
4) Dam							
- Crest EL (m)	186.0	172.0	190.5	180.8	152.0	179.1	174.1
- Width of Dam Crest (m)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
- Length of Dam (m)	500	960	570	1,380	950	1,490	1,260
- Height of Dam (m)	13.0	12.0	13.6	13.7	12.2	15.6	17.6
- Embankment Volume ('000 cu.m)	112.0	157.3	151.9	239.1	257.0	441.6	338.1
- Design Flood (cu.m/s)	214	120	41	68	177	29	36
5) Distribution System							
- Irrigable Area (ha)	2,070	400	460	940	830	1,200	1,100
- Main Canal (km)	25.7	3.4	5.7	16.3	13.2	13.1	17.4

TABLE 3-4. MAJOR FEATURES OF MEDIUM SCALE IRRIGATION PROJECTS (2/4)

Description	Huai Si Tho (BO-2)	Huai Phra Lao (BO-3)	Huai Kum Bi (BO-6)	Huai Saen Si (BO-8)	Huai Na Pho (BO-9)	Huai Khu Lu (BO-10)	Huai Khum Kham (BO-11)
1) Location							
- Changwat	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani
- Amphoe	Amant Charoen	Non Ngam	Phana	Kut Khao Pun	Kut Khao Pun	Trakan Phutphon	Trakan Phutphon
2) River							
- Basin	Sebok	Sebok	Sebok	Sebok	Sebok	Sebok	Sebok
- Catchment Area (sq.km)	28.2	23.0	16.4	25.0	26.4	44.7	36.8
3) Reservoir							
- Total Storage Capacity (MCM)	8.40	6.55	1.4	1.9	0.7	7.0	22.50
- Dead Storage Capacity (MCM)	0.44	0.35	0.3	0.2	0.4	0.7	0.55
- Effect. Storage Capacity (MCM)	7.96	6.20	1.1	1.7	0.3	6.3	21.95
- High Water Level (El.m)	177.0	172.9	160.5	140.5	160.0	160.3	163.5
- Normal Water Level (El.m)	176.0	172.0	159.5	139.5	158.8	159.3	162.5
- Low Water Level (El.m)	168.5	165.4	157.1	136.2	158.1	154.0	152.2
4) Dam							
- Crest El (m)	178.5	174.4	162.0	142.0	161.5	161.8	165.0
- Width of Dam Crest (m)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
- Length of Dam (m)	455	1,530	820	800	870	870	1,160
- Height of Dam (m)	15.5	15.9	10.0	7.6	9.8	10.5	18.5
- Embankment Volume ('000 cu.m)	251.7	309.6	94.9	93.5	86.5	123.4	333.8
- Design Flood (cu.m/s)	86	79	192	349	344	247	107
5) Distribution System							
- Irrigable Area (ha)	1,190	1,100	200	310	50	1,130	3,400
- Main Canal (km)	10.5	20.7	5.2	5.0	1.2	9.5	37.6

TABLE 3-4. MAJOR FEATURES OF MEDIUM SCALE IRRIGATION PROJECTS (3/4)

Description	Huai Thi (BO-12)	Huai Kham Phak Wan (BO-13)	Huai Tham (BO-14)	Huai Phai Ban (BO-15)	Huai Yang (BO-17)	Huai Na Khai (BO-18)	Huai Ban Hung (BO-19)
1) Location							
- Changwat	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani
- Amphoe	Trakan Phutphon	Trakan Phutphon	Trakan Phutphon	Trakan Phutphon	Trakan Phutphon	Tan Sum	Tan Sum
2) River							
- Basin	Sebok	Sebok	Sebok	Sebok	Sebok	Sebok	Sebok
- Catchment Area (sq.km)	38.4	13.5	17.0	21.2	14.6	31.3	51.3
3) Reservoir							
- Total Storage Capacity (MCM)	3.8	10.80	5.3	5.1	6.47	18.78	3.9
- Dead Storage Capacity (MCM)	0.6	0.20	0.3	0.3	0.22	0.47	0.8
- Effect. Storage Capacity (MCM)	3.3	10.60	5.0	4.8	6.25	18.31	3.1
- High Water Level (El.m)	171.5	145.1	140.5	141.0	130.7	137.7	130.5
- Normal Water Level (El.m)	170.3	144.5	139.8	140.0	130.0	137.0	129.3
- Low Water Level (El.m)	166.6	136.5	133.5	135.0	124.0	130.0	127.0
4) Dam							
- Creat EL (m)	173.0	146.6	142.0	142.5	132.2	139.2	132.0
- Width of Dam Creat (m)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
- Length of Dam (m)	700	1,410	1,100	1,300	1,350	2,150	720
- Height of Dam (m)	12.7	14.3	11.8	13.3	12.2	15.7	10.0
- Embankment Volume ('000 cu.m)	71.9	432.3	191.7	175.1	288.5	449.0	67.1
- Design Flood (cu.m/s)	349	25	116	158	50	65	303
5) Distribution System							
- Irrigable Area (ha)	590	1,340	900	860	830	2,000	560
- Main Canal (km)	5.9	13.7	9.4	11.3	9.9	26.4	7.1

TABLE 3-4. MAJOR FEATURES OF MEDIUM SCALE IRRIGATION PROJECTS (4/4)

Description	Huai Tung Lung (TL-1)	Huai Khut (TL-2)	Huai Ngu Luam (TL-3)	Huai Chalung (TL-5)	Huai Soob (TL-6)
1) Location					
- Changwat	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani	Ubon Ratchathani
- Amphoe	Trakan Phutphon	Trakan Phutphon	Sri Muang Mai	Sri Muang Mai	SriMuang Mai
2) River					
- Basin	Tung Lung	Tung Lung	Tung Lung	Tung Lung	Tung Lung
- Catchment Area (sq.km)	40.3	18.8	11.4	35.7	18.5
3) Reservoir					
- Total Storage Capacity (MCM)	8.44	1.5	3.1	7.23	8.50
- Dead Storage Capacity (MCM)	0.60	0.3	0.2	0.54	0.28
- Effect. Storage Capacity (MCM)	7.84	1.2	2.9	6.69	8.22
- High Water Level (El.m)	166.1	170.0	182.7	171.1	170.0
- Normal Water Level (El.m)	165.0	169.0	182.0	170.0	169.0
- Low Water Level (El.m)	159.2	166.5	176.5	163.9	160.2
4) Dam					
- Crest EL (m)	167.6	171.5	184.2	172.6	171.5
- Width of Dam Crest (m)	6.0	6.0	6.0	6.0	6.0
- Length of Dam (m)	1,970	250	1,350	480	1,570
- Height of Dam (m)	14.3	9.8	11.7	12.3	17.7
- Embankment Volume ('000 cu.m)	283.4	26.4	162.2	77.0	304.0
- Design Flood (cu.m/s)	215	134	82	214	71
5) Distribution System					
- Irrigable Area (ha)	1,460	220	520	1,250	1,100
- Main Canal (km)	21.0	3.0	2.7	19.1	20.3

TABLE 3-5. IRRIGABLE AREA AND PRELIMINARY PROJECT COST OF MEDIUM SCALE IRRIGATION PROJECTS

Code No.	Project	Irrigable Area (ha)	Project Cost (฿1,000)	Project Cost (or ¥ Million)
BA-1	Huai Pong	2,070	143,100	744
BA-2	Huai Ban	400	84,400	439
BA-4	Huai Pong Pode	460	45,400	236
BA-5	Lam Se	940	87,900	457
BA-6	Huai Yang	830	112,600	586
BA-8	Huai Sun	1,200	116,400	605
BA-9	Huai Hin Lat	1,100	98,400	512
BO-2	Huai Si Tho	1,190	112,600	586
BO-3	Huai Phra Lao	1,100	107,800	561
BO-6	Huai Kum Bi	200	72,900	379
BO-8	Huai Saen Si	310	114,900	597
BO-9	Huai Na Pho	50	103,100	536
BO-10	Huai Khu Lu	1,130	110,400	574
BO-11	Huai Khum Kham	3,400	186,800	971
BO-12	Huai Thi	590	117,000	608
BO-13	Huai Kham Phak Wan	1,340	103,700	539
BO-14	Huai Tham	900	82,600	430
BO-15	Huai Phai Ban	860	93,200	485
BO-17	Huai Yang	830	78,000	406
BO-18	Huai Na Khai	2,000	149,500	777
BO-19	Huai Ban Hung	560	106,600	554
TL-1	Huai Tung Lung	1,460	147,700	768
TL-2	Huai Khut	220	45,800	238
TL-3	Huai Ngu Luam	520	53,700	279
TL-5	Huai Chalung	1,250	116,600	606
TL-6	Huai Soob	1,100	105,200	547
	Total 26 Projects	26,010	2,696,300	14,020

Note: Exchange rate of ฿1.00 = ¥5.2

TABLE 3-6. EVALUATION CRITERIA AND SCORING

Parameter	Class	Score	Specifications
1. Project Economy	A	30	B/C ratio 1.7
	B	26	= 1.6 - 1.69
	C	22	= 1.5 - 1.59
	D	18	= 1.4 - 1.49
	E	14	= 1.3 - 1.39
	F	10	= 1.2 - 1.29
	G	6	= 1.1 - 1.19
	H	2	= 1.0 - 1.09
2. Scale of Irrigable Area	A	5	more than 2,000 ha
	B	3	1,000 - 1,999 ha
	C	1	less than 1,000 ha
3. Reservoir Area Conditions	A	5	paddy fields of less than 50 ha/no houses/no existing facility
	B	3	paddy fields of 51 - 150 ha/ several houses/some facilities
	C	1	paddy field of more than 150 ha/more than 10 houses/some small reservoirs
4. Income Level	A	5	less than ฿6,000/year/family
	B	3	฿6,001 - 10,000/year/family
	C	1	more than ฿10,000/year/family
5. Soil Suitability	A	5	
	B	3	
	C	1	
6. Civil Work	A	5	good foundation/available conditions for core material
	B	3	normal
	C	1	bad foundation/difficult obtaining of core material

CHAPTER IV. PROJECT AREA

CHAPTER IV. PROJECT AREA

4-1. Project Location and Area

The projects that would be implemented with high priorities under the proposed overall basin development program are the isolated five medium scale irrigation projects of Lam Se, Huai Khum Kham, Huai Kham Phak Wan, Huai Na Khai and Huai Soob. These projects are scattered in the river basin of Sebai, Sebok and Tung Lung, as given below;

Location of Proposed Projects

Project	River Basin	Province	Amphoe
Lam Se	Sebai	Yasothon	Loeng Nok Tha
Huai Khum Kham	Sebok	Ubon Ratchathani	Trakan Phutphon
Huai Kham Phak Wan	Sebok	Ubon Ratchathani	Trakan Phutphon
Huai Na Khai	Sebok	Ubon Ratchathani	Tan Sum
Huai Soob	Tung Lung	Ubon Ratchathani	Sri Muang Mai

The project areas were selected among the 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 based on the topographic maps scaled 1:10,000 , aero-photographs scaled 1:4,000 and field reconnaissance,paddy fields occupy 72 percent of the total project area and forests 23 percent.

Present Land Use

- Unit: ha -

Project	Paddy Field	Forest	Village	Others	Total
Lam Se	1,151	86	56	77	1,370
Huai Khum Kham	2,706	727	128	89	3,650
Huai Kham Phak Wan	994	48	6	62	1,110
Huai Na Khai	2,164	807	31	98	3,100
Huai Soob	959	828	17	26	1,830
Total	7,974	2,496	238	352	11,060

4-2. Physical Condition

4-2-1. Topography and Geology

(1) Lam Se Project Area

The Lam Se project area is broadly divided into two characteristic areas in terms of topography. One is the catchment area that extends east and west, being bounded on the north by the ridge rising to 200 to 250 meters above the mean sea level. The other is the irrigation area that is formed into a half oval shape basin opened southeastward along the contour line of El. 170 m. The gradient of the Lam Se is very gentle as 5/1,000 in the catchment area and 2/1,000 in the irrigation area. The Lam Se flows toward the east in the catchment area, turns to the south at the dam site and flows out to the southeast from the irrigation area.

The middle Jurassic mainly composed of sandstone predominates in the irrigation area and the upper Jurassic mainly composed of sandstone and siltstone predominates in the dam site to the catchment area. The lower Cretaceous predominates in the north of the catchment area. The boundary between the middle Jurassic and the upper Jurassic is consistent with the contour line of El. 170 m, and the one between upper Jurassic and the lower Cretaceous is consistent with the contour line of El. 200 m . Although the geological structure in the project area is characteristic of the half dome structure with the axis of anticline trending southeast, this axis is consistent with the ridge extending southeastward of which peaks form a line. The topography reflects the geological structure.

(2) Huai Khum Kham Project Area

The mountains which enclose the catchment area in this project area range in altitude from 180 to 200 m and extend northwestward. The rivers flow toward southwest almost at right angle to the direction of the mountains. So, the drainage pattern shows the parallel pattern with a high drainage density and a low drainage frequency. The gradient of the Huai Khum Kham is 5/1,000 in the catchment area and 4/1,000 in the irrigation area.

The irrigation area is dominated by the lower Cretaceous mainly composed of sandstone intercalated with shale and conglomerate, and the dam site and more upper areas are dominated by the middle Cretaceous mainly composed of sandstone intercalated with shale and siltstone. The bed generally strikes N 70° W and dips 10° to 20° SW, and forms the gentle and conformable succession.

(3) Huai Kham Phak Wan Project Area

The elevation of mountains which surround the catchment area is comparatively low with about 160 meters above the mean sea level, and its catchment area is the smallest among the five projects. The contour lines generally extend toward west-northwest and the rivers flow toward west-southwest crossing the contour lines. The drainage pattern is the parallel pattern with a high drainage density and a low drainage frequency. The gradient of the Huai Phak Wan is 3.75/1,000 in the catchment area and is 2/1,000 in the irrigation area.

The central and southern parts of the irrigation area are dominated by the upper Cretaceous mainly composed of sandstone, siltstone and shale including rock salts and anhydrite. The area from the northern part of the irrigation area to the catchment area is dominated by the middle Cretaceous mainly composed of sandstone intercalated with siltstone and shale. The bed generally strikes N 60° W and dips 10° to 15° SW, and forms the gentle and conformable succession.

(4) Huai Na Khai Project Area

The ridges surrounding the catchment area range an altitude from 150 to 160 meters above the mean sea level and extend northeastward. The Huai Na Khai flows in parallel with the ridge and its tributary does not grow. The drainage pattern is the parallel pattern with a low drainage density and a low drainage frequency. The gradient of the Huai Na Khai is 4.3/1,000 in the catchment area and 2.1/1,000 in the irrigation area.

The project area is dominated by the middle Cretaceous while the downstream of the irrigation area is dominated by the upper Cretaceous.

(5) Huai Soob Project Area

The mountains that strung out from the Phu Phan range with an elevation of 200 to 250 meters above the mean sea level extend southeastward. The ridge which surround the catchment area is derived from these mountains, ranges in altitude from 180 to 200 meters above the mean sea level, and generally extends southward. The rivers form the dendritic pattern with a low drainage density and a high drainage frequency, and flow toward south-southwest.

The irrigation area and dam site are dominated by the middle Cretaceous and the catchment area is dominated by the lower Cretaceous. The

boundary between the middle Cretaceous and the lower Cretaceous is consistent with the contour line of El. 160 m. The bed generally strikes N 50° W and dips 10° to 15° SW.

4-2-2. Hydrology

(1) Rainfall

There exist 37 rain gauge stations in the Sebai-Sebok basin, out of which four stations of Loeng Nok Tha, Trakan Phutphon, Si Muang Mai and Sa Saming Tank are located in and around the project areas. The observation has been conducted since 1952. These rainfall stations, however, have records on daily rainfall, and there is no record on hourly rainfall which is necessary for the estimation of the design flood discharge. In view of this hourly rainfall record was then conducted at Muang Ubon Ratchathani meteorological station.

The annual average rainfall in the project areas amounts to about 1,600 mm, of which 1,500 mm are concentrated in the rainy season, especially in June to August. The average amount for three months is about 1,000 mm. The average rainfall in the dry season from December to April shows only 100 mm, which is insufficient to cultivate the dry season crop without irrigation water.

Dry periods frequently occur in June or July and normally last two or three weeks. As a result the project areas have suffered from water shortages. On the other hand the areas have often suffered from heavy rainfall caused by tropical depression and typhoon in August to September.

(2) Runoff

Six stream stations exist in and around the project areas. The annual average runoff coefficients at these stations range from 24 to 46 percent. The river runoff concentrates in July to October, and about 90 percent of rainfall during April to June is infiltrated into the ground and paddy field. There is no river runoff in December to March. The annual rainfall loss amounts to about 1,000 to 1,100 mm.

Observed river runoff and annual runoff coefficients are summarized as follows:

Annual Rainfall and Annual Runoff Coefficient

Stream Gauging Station	Catchment Area (sq.km)	Average Annual Rainfall (mm)	Average Annual Runoff (mm)	Average Annual Runoff Coefficient (%)	Observed Period of Runoff
M.32	1,654	1,527	455	30	1965-'85
M.32A	1,535	1,422	343	24	1968-'72
M.69	2,132	1,567	642	41	1971-'86
M.132	101	1,545	390	25	1986
M.141	382	1,808	839	46	1987
M.127	414	1,794	649	36	1987

4-2-3. Soil and Land Classification

(1) General

In the Phase II study, the soil survey was conducted for the existing paddy fields, in order to check the distribution of soil series by soil auger boring and interpretation of the soil maps (1: 100,000) prepared by Department of Land Development. The characteristics of each soil series were confirmed through the observation of soils in excavated pits and boring cores as well as the results of soil analysis made by RID during the Phase I study.

The topography of project areas is classified into two; alluvial lowland formed by rivers and terrace formed through intermediate erosion and sand sedimentation by small rivers. The most part of project areas is located on terraces, and alluvial lowlands have been developed only at small areas of flood plains spreading along rivers. The bedrocks are mainly sandstone and conglomerate.

(2) Soil Classification

The results of the soil survey show that there are eight soil mapping units in the project area of 11,060 ha and the main soil series are the Roi Et series, Korat-Phon Phi Sai association and Borabu complex ; these three mapping units cover about 77 percent of the whole project area as shown in Table 4-1.

(3) Characteristics of Soil

Most of the soil is sandy soil formed through weathering of sandstones and conglomerates, and it is low in fertility and acid. The details of the characteristics of soil series are shown in Table 4-2 and the overall physical - chemical characteristics of the surface horizon are as follows:

- The soil is sandy loam or loamy sand with a high content of sand, and the water holding capacity is rather low.
- The bulk density is as high as 1.50 to 1.70 g/cm^3, and the porosity is as low as 34 to 44 percent The soil is compact, and the structure is immature.
- pH (H_2O 1:1) is 5.0 to 5.4 (strongly acid).
- The base exchange capacity is 2.8 to 6.0 m.e. / 100g, while the base saturation percentage is as low as 15 to 29 percent. It includes a small quantity of exchangeable bases.

(4) Land Classification

The land to be classified is existing paddy fields already developed. Since the drainage condition of the paddy fields in the project area is to be improved, standard values for land classification are defined into four factors; namely, soil texture, topsoil depth, effective soil depth and natural fertilities. The standard values adopted are shown in Table 4-3.

The existing paddy fields of 7,974 ha in the project areas are classified in terms of suitability for paddy cultivation into four classes: Class I (very well), Class II (well), Class III (moderately) and Class IV (poorly), which are shown below:

As is indicated, 97 percent of the existing paddy fields are ranked as Class III; there are no Class I and IV paddy fields as shown in the following table.

Land Classification of Project Area

- Unit: ha -

Project	Class I	Class IIs	Class IIIs	Class IV	Total
Lam Se	-	196	955	-	1,151
Huai Khum Kham	-	41	2,665	-	2,706
Huai Kham Phak Wan	-	-	994	-	994
Huai Na Khai	-	-	2,164	-	2,164
Huai Soob	-	-	959	-	959
Total	-	237	7,737	-	7,974
(%)	(0.0)	(3.0)	(97.0)	(0.0)	(100)

Note : II s and III s mean that some soil problems exist in class II and III.

(5) Soil Management

The soil in the project area is extremely coarse textured and poor in content of organic matter. The shortage of clay minerals to maintain the nourishment necessary for growing plants also results in deficiency of cations. Consequently, soil management techniques should be more elaborative and precise taking into account the result of the experiments undertaken in the region.

To control such soils and increase productivity, firstly, it is necessary to provide organic matter. Since the project area has extremely distinct dry and wet seasons, a heavy degradation and consumption of organic matter in the soil shall occur. Therefore it is necessary to add organic matter to the soil continuously to increase the fertility of soil. Compost of rice straw, for example, is required at the rate of more than three tons per ha per year. Secondly, adequate amounts of chemical fertilizers such as nitrogen, phosphorus and potassium should also be applied. Since the soil in the project area is poor in maintaining fertility, split dressing of fertilizer is required. Thirdly, cultivation of a green manure and plowing it into soil should be considered. In that case liming will be helpful for utilizing absorved nutrients by a green manure. In addition, deep tillage is other effective method of improving the productivity of soil.

4-3. Agriculture

To understand the agricultural condition of project areas in detail, field survey of 20 farm households which were randomly selected from each area, altogether 100 households, was carried out by RID and JICA Team. Present conditions of farming mainly based on the information collected by the interview of farmers are presented below.

4-3-1. Population and Households

Total population of five projects covering nine villages and 36 Muban was 15,853 as of 1988. Total number of households amount to 2,592, of which 2,310 households (or, 89 percent) are engaged in agriculture with a farm population of 14,060 (Table 4-4). No other occupation than agriculture was reported.

4-3-2. Farm Size, Farming Pattern and Land Tenure

According to agricultural statistics, 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.

The farm survey shows that all farmers in the project areas have only paddy fields except for Lam Se area where farmers have upland fields equivalent to 15 percent of total farm land (Table 4-5). No dry season cropping is practised in these survey farms and the average of cropping intensity is 73 percent.

Table 4-6 gives the land tenure showing that 94 percent of farm lands are owned by farmers and tenanted lands occupy only six percent. The ownership is highest in Huai Na Khai area, which is nearly 100 percent, and lowest in Huai Khum Kham, 84 percent.

Regarding land certificate, Table 4-7 shows the detail of it. Nor Sor 3 Kor and Nor Sor 3 are the two main land certificates covering about 84 percent of all farm households on an average, being followed by PBT6 and SK1. Nor Sor 3 is issued by the Department of Land to private land. Transfer of ownership and collateral for loans are the two of immediate benefits of the right of holding of it.

4-3-3. Paddy Cropping

Almost 90 percent of paddy fields are cropped with high yielding varieties, and glutinous paddy is dominant. According to the survey, 90 percent of paddy are of glutinous except for 100 percent in Huai Khum Kham area. The rate of compound fertilizer application is between 10 kg to 20kg per rai , with an average of 15.4 kg/rai (or equivalent to 96.3 kg/ha), which is less than one third of the rate recommended by DOA.

Insect damage is the second largest problem regarding paddy production, following drought damage; however, insecticide was applied to only one tenths of the whole paddy fields. No herbicide was applied.

According to the agricultural statistics of Thailand (1986/87), about 84 percent of paddy fields was harvested on an average of last four years in Ubon Ratchathani and Yasothon Provinces. The field survey shows that only 78 percent of paddy planted area is harvested in the five project areas as the average (Table 4-8), 91 percent in Lam Se area and 60 percent in Huai Soob area. Additional survey of three project areas carried out by JICA Team indicated that about 87percent of paddy fields were planted, and 69 percent of which were harvested. Judging from these figures, nearly 30 percent of paddy fields were actually not being used for production.

The average paddy yield per harvested area was 175 kg/rai (or, 1.1 ton/ha), with a variation from 231 kg/rai (1.4 ton/ha) in Lam Se area to 129 kg/rai (0.8 ton/ha) in Huai Soob area (Table 4-8). According to the above mentioned survey, the average yield of three project areas ranges from 320kg/rai (or, 2 ton/ha) to 132 kg/rai (or, 0.9 ton/ha). Among three project areas, Huai Na Khai area has water problems and its yield yearly fluctuates very much when compared with others. No difference in paddy yield is observed between glutinous and non-glutinous.

4-3-4. Animal Husbandry

The specific features regarding animal husbandry are that the number of buffaloes in the areas is as much as three times of the national average (1.3 heads per farm, 1986), and the number of other livestock per farm is far less than the national average (Appendix C. Agriculture). The total number of buffaloes in the Northeast amounts to about 4.4 million heads, 70 percent of the whole country; however, the increasing ratio becomes rather stagnant in the recent years. It looks that the number of buffaloes in both provinces, Yasothon and Ubon Ratchathani, is distributed in proportion to their farmland areas in Amphoes. But among Tambons no such tendency is observed.

Animal husbandry, especially buffalo and cattle, is recommendable in order to improve rainfed agriculture in the Sebai - Sebok basin, for which fodder crop cultivation is prerequisite, however, since the feeding materials are limited at present in these areas, only half of these big animals can be raised with paddy straw according to nutritious calculation.

4-3-5. Inland Fisheries

The Department of Fisheries (DOF) has taken integrated effort to the development of inland fisheries in the Northeast by constructing village fish ponds, supplying fingerlings, training farmers, etc. There are about 10 kinds of fish species; viz., tillapia nil, common carp, cat fish , prawn, and so on.

In the project ares, fish culture is not practised yet, although inland fisheries around the project areas could be observed based on a report of DOF on inland fisheries activities in the Amphoe of Trakan Phutphon where the following two projects of Huai Khum Kham and Huai Kham Phak Wan are located;

(1) Pond Fish Culture

In 1986~87, there were 63 farmers in the Amphoe of Trakan Phutphon and the area was 6.25 rai (1 ha). Out of 63 farmers, 29 suffered a big loss due to disease of fish and the remaining 34 farmers who had 2.5 rai harvested 503 kg of fish catch (201 kg/rai). 61 percent of the harvest were consumed by themselves and the rest was sold at a price of 4,380 Baht.

The total area of fish ponds was 10.15 rai (or , 1.6 ha) for 82 farmers in 1988, of which 36 farmers were from Tambon Ku Sa Korn. Training course was held in 1988 for three times with a total participants of 86 farmers. 59 fish ponds were excavated in 1987 and 105 ponds in 1988, as one of the extension activities.

(2) Farm Fisheries

In 1986~87, nine rai of paddy fields (1.4 ha) were used for fish culture, of which three rai were irrigable and six rai were under rainfed condition. Yield was 25.9 kg/ rai (162 kg/ha) in irrigable area. In 1988, fish farmers were 17 and area was 20 rai (3.2ha). Training course was also held and the number of participants was 30.

Fish culture in paddy field has been one of the subjects in other projects. NERAD Project reported that the average fish yield increased from 18.2 kg/rai (114 kg/ha) in 1984 to 43.8 kg/rai (274 kg/ha) in 1985 in the fields of 65 farmers. It also reported a remarkable increase in rice yield caused by fish culture.

Tung Kla Ronghai Project reported the comparison of fish yield between cage and paddy field culture in a report of Nov. 1987. Ubon Farming System Research and Development Unit has been taking up the problem of rice- fish

farming, and the conclusion so far obtained on fish culture in paddy field according to the report ' On-Farm Rice-Fish Farming System Research in Ubon Province, Northeast Thailand", which was presented to the First International Rice-Fish Workshop, March 11~25, 1988, are as follows:

- Rice-fish culture is rather low-risk and provide high quality protein to poor farmers. Extra income is also expected.
- Rice yield usually seems to have positive effect by fish culture in paddy field.
- The practice obtains only modest profit and has potential for helping a large number of needy people.

4-3-6. Extension Services

Several government agencies have their own activities in the area. Many offices related to agriculture are under the Ministry of Agriculture and Cooperatives such as RID, DOAE, DOA, DLD, LDD, DOF and RFD.

The agency responsible to extension services is the Department of Agricultural Extension (DOAE), which is headquartered in Bangkok. There are provincial DOAEs, which has a branch office in each Amphoe in the province. Many active extension agents are under Amphoe office and their duties are to closely contact with farmers directly and teach them cultivation techniques and to collect information from them. Each Tambon has also some agents to assist in communication between DOAE offices and farmers.

The main activities assumed in 1988 by Yasothon agricultural extension office are summarized as follows;

(i) Crop production extension

- Exportable crop ; paddy, cassava
- Import substitution crop ; groundnuts
- Domestic consumption ; soybean, sticky rice

(ii) Production system improvement

- Inter cropping
- Crop rotation

(iii) Agricultural extension for special areas

- Land reform area
- King's project area

(iv) Agro-industry system improvement

(v) Participation of farmers in extension activities

(vi) Promotion of farmers' group

(vii) Strengthening of extension services

- Seed supply
- Prevention of insect damage
- Prevention of disease damage

(viii) Improvement of extension services

(ix) Improvement of working efficiency of agents

TABLE 4-1. DISTRIBUTION OF SOIL SERIES

Unit:ha(%)

Soil Name	Symbol	Project *				
		BA-5	BO-11	BO-13	BO-18	TL-6
Roi Et Series	Re	522(38.1)	2,231(61.1)	427(38.5)	775(25.0)	-
Korat-Phon Phi Sai Assoiation	Kt/Pp	-	584(16.0)	200(18.0)	1,966(63.4)	-
Borabu Complex	BbC	-	-	-	-	1,830(100)
Korat Series	Kt	147(10.7)	775(21.2)	-	-	-
Roi Et-On Association	Re/On	-	20(0.6)	483(43.5)	359(11.6)	-
Korat, high-Phon Phi Sai Association	Kt-h/Pp	508(37.1)	-	-	-	-
Sithon Series	St	167(12.2)	40(1.1)	-	-	-
Roi Et, loamy	Re-l	26(1.9)	-	-	-	-
Total		1,370(100)	3,650(100)	1,110(100)	3,100(100)	1,830(100)

Note:* BA-5 ; Lam Se, BO-11 ; Huai khum Kham, BO-13 ; Huai Kham Phak Wan, BO-18 ; Huai Na Khai, TL-6 ; Huai Soob

TABLE 4-2. CHARACTERISTICS OF SOIL SERIES

Soil Series / Characteristics	Re	Re-l	Re/On	Kt	Kt/Pp	Bbc	Kt-h /Pp	St
Texture(surface) [1]	SL	SL-L	LS-SL	LS-SL	LS-SL	SL-L	SL-L	SL-L
Depth(cm)								
to Subsurface Horizon	33	31	28	36	30	35	15	20
to laterite of rock	72	90	43	70	80	67	60	90
Physics Properties (surface)								
Hardness (g/cm^3)	19	17	21	17	18	18	-	-
Porosity (%)	40	43	36	40	42	41	-	-
Chemical Properties(surface)								
pH (1:1)	5.3	5.2	5.2	5.2	5.1	5.5	-	-
C.E.C.(m.e.q/100g)	3.7	5.4	5.7	4.0	7.0	2.5	-	-
Base Saturation (%)	27	25	15	24	21	25	-	-
Organic Matter (%)	0.41	0.58	0.51	0.54	0.56	0.39	-	-

Note: [1] SL; Sandy Loam, L; Loam, LS; Loamy Sand

TABLE 4-3. STANDARD OF LAND CLASSIFICATION FOR PADDY

	Class I	Class II s	Class III s	Class IV
Texture				
Surface	loam to clay	sandy loams to clay	loamy sands to clay	loamy clay to heavy clay
Subsurface	sandy clay loam to clay	sandy clay loam to clay	loam to clay	sand to heavy clay
Depth				
to subsurface horizon	< 30 cm	< 40 cm	< 50 cm	> 50 cm
to laterite or base rock	> 90 cm	> 60 cm	> 30 cm	< 30 cm
Chemical properties (Surface)				
C.E.C.(m.e.q/100g)	> 8.0	> 4.0	> 2.0	< 2.0
ECx10³ (0-100 cm)	< 4 mmho/cm	< 8 mmho/cm	<16 mmho/cm	>16 mmho/cm
pH(H_2O)	5 to 8	5 to 9	4.5 to 9	< 4.5, > 9.0
Base saturation(%)	> 30	> 25	> 15	< 15

Note: II s and III s mean some soil problems exist in class II and III.

TABLE 4-4. POPULATION AND HOUSEHOLD IN THE PROJECT AREA

(unit: households, persons)

Project	Total Household 2/	Total Population 2/	Farm Household 3/				
			Household	Percent of Farm Household	Population	Agricultural Area (ha)	Average Size of Farm (ha)
1. Lam Se	564	3,237	490	87	2,960	2,250	4.6
2. Huai Khum Kham	941	6,057	860	91	5,330	3,120	3.6
3. Huai Kham Phak Won	352	1,979	320	91	1,990	1,120	3.5
4. Huai Na Khai	481	3,083	420	87	2,460	2,180	5.2
5. Huai Soob	254	1,497	220	87	1,320	1,100	5.0
Total	2,592	15,853	2,310	89	14,060	9,770	4.2

Source: 1/--- "Provincial Statistics, 1988", NSO, Office of Prime Minister.

Notes : 2/--- Total of Muban concerned with the Projects.

3/--- estimated based on 1980 Population and Housing Census.

TABLE 4-5. LAND UTILIZATION OF A SURVEYED FARM AND CROPPING INTENSITY

Crop	Average of all Project		Lam Se		Huai Khum Kham	
	% of holding Farm	Area (rai)	%	Area (rai)	%	Area (rai)
Paddy	100	23.2	100	18.3	100	20.5
Upland	3	0.2	15	1.1	0	0
Fallow	23	4.6	0	0	15	0.9
Not-cleared	24	4.0	30	3.9	15	0.9
Pasture	1	-	0	0	5	0.2
Total		32.0		23.3		22.5
Cropping Intensity:						
Wet Season	73.2 %		83.2 %		91.7 %	
Dry Season	0		0		0	

Crop	Huai Kham Phak Wan		Huai Na Khai		Huai Soob	
	%	Area (rai)	%	Area (rai)	%	Area (rai)
Paddy	100	33.6	100	12.4	100	31.1
Upland	0	0	0	0	0	0
Fallow	10	2.5	70	17.3	20	2.1
Not-cleared	25	5.5	25	4.6	25	5.3
Pasture	0	0	0	0	0	0
Total		41.6		34.2		38.4
Cropping Intensity:						
Wet Season	80.8 %		36.2 %		81.0 %	
Dry Season	0		0		0	

Source: Field Survey by RID and JICA Team

TABLE 4-6. LAND TENURE OF SAMPLE FARM

Kind of Tenure \ Project / Farm	Average			Lam Se			Huai Khum Kham		
	Household Number(%)	Area (rai)	% of Total	Household Number(%)	Area (rai)	% of Total	Household Number(%)	Area (rai)	% of Total
All Farm Land :									
Own	98.0	31.0	94.3	95.0	21.9	91.3	100.0	19.8	84.0
Rent (additional)	3.0	0.6	1.7	0	0	0	5.0	1.0	4.2
Free cultivation	8.0	1.3	4.0	5.0	2.1	8.8	15.0	2.8	11.8
Total		32.9	100.0		24.0	100.0		23.6	100.0
Cultivated Area :									
Own	95.0	21.7	93.0	95.0	18.1	93.5	90.0	17.0	83.0
Rent (additional)	3.0	0.6	2.4	0	0	0	5.0	1.0	4.9
Free cultivation	5.0	1.1	4.6	5.0	1.3	6.5	10.0	2.5	12.2
Total		23.4	100.0		19.3	100.0		20.5	100.0

Kind of Tenure \ Project / Farm	Huai Kham Phak Wan			Huai Na Khai			Huai Soob		
	Household Number(%)	Area (rai)	% of Total	Household Number(%)	Area (rai)	% of Total	Household Number(%)	Area (rai)	% of Total
All Farm Land :									
Own	95.0	41.5	97.0	100.0	34.7	99.9	100.0	36.9	94.4
Rent (additional)	5.0	0.9	2.0	0	0	0	5.0	1.0	2.4
Free cultivation	5.0	0.5	1.1	10	0	0.1	5.0	1.3	3.2
Total		42.9	100.0		34.7	100.0		39.2	92.9
Cultivated Area :									
Own	95.0	32.3	96.3	100.0	12.4	100.0	95.0	28.9	92.9
Rent (additional)	5.0	0.9	2.5	0	0	0	5.0	1.0	3.1
Free cultivation	5.0	0.4	1.2	0	0	0	5.0	1.3	4.0
Total		33.6	100.0		12.4	100.0		31.2	100.0

Source: Field Survey by RID and JICA Team.

TABLE 4-7. LAND HOLDING OF SAMPLE FARM

(unit: %)

Certificate	Average		Lam Se		Huai Khum Kham		Huai Kham Phak Wan		Huai Na Khai		Huai Soob	
	Number of Farm	Area	Number of Farm	Area	Number of Farm	Area	Number of Farm	Area	Number of Farm	Area	Number of Farm	Area
N.S. 3 K.	48.0	48.5	73.7	60.0	25.0	21.2	42.1	47.7	60.0	74.1	40.0	33.1
N.S. 3	43.9	35.0	21.1	10.7	40.0	41.5	63.2	48.7	45.0	25.9	50.0	39.1
S.K. 1	13.3	6.9	15.8	2.6	35.0	22.8	0	0	0	0	15.0	15.2
B.C.	0	0	0	0	0	0	0	0	0	0	0	0
P.B.T. 6	12.2	9.0	15.8	23.7	10.0	13.2	15.8	3.5	5.0	0	15.0	12.5
S.T.K.	1.0	0.4	5.3	2.7	0	0	0	0	0	0	0	0
T.C.	1.0	0	0	0	0	0	0	0	5.0	0	0	0
Others	0	0	0	0	0	0	0	0	0	0	0	0
Total		100.0		100.0		100.0		100.0		100.0		100.0

Source: Field Survey by RID and JICA Team.

TABLE 4-8. PLANTED, HARVESTED PADDY AND YIELD IN A SURVEYED FARM

Area and Yield \ Project	Average	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob
Planted (rai)	23.2	18.3	20.5	33.6	12.4	31.1
glutinous	21.2	16.7	20.5	26.8	12.3	29.5
non-glutinous	2.0	1.6	0	6.8	0.1	1.6
Harvested (rai)	18.3	16.7	18.0	30.3	7.8	18.5
glutinous	16.4	15.1	18.0	23.8	7.7	17.2
non glutinous	1.9	1.6	-	6.5	0.1	1.3
Harvest/Plant (%)	78.4	91.3	87.9	90.2	62.9	59.5
Yield (kg/rai)						
per planted area	141	211	183	137	98	77
glutinous	142	217	183	135	95	78
non-glutinous	166	149	-	146	320	49
per harvested area	175	231	208	152	156	129
glutinous	177	239	208	152	152	134
non-glutinous	171	149	-	153	320	62

Source: Field Survey by RID and JICA Team

TABLE 4-9. PLANTED AND HARVESTED PADDY AREA IN A SURVEYED FARM IN SELECTED PROJECT SITES

Item \ Project / Unit	Lam Se		Huai Na Khai		Huai Soob	
	rai	%	rai	%	rai	%
Total Paddy Field	17.6	100	25.8	100	30.3	100
Planted P. F.	16.0	91	21.7	84	26.3	87
Harvested P. F.	11.5	66	17.7	69	21.9	73
Yield (kg/rai)	320		168		139	

Source : Field Survey by JICA Team

Note : 1) Number of randomly sampled farmers in the three project sites are 7, 8 and 6 respectively

2) Planted area is means of 1987~1989

3) Harvested area and yield are means of 1987 ~1988

CHAPTER V. PLAN OF DEVELOPMENT

CHAPTER V. PLAN OF DEVELOPMENT

5-1. Project Purposes

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 area, and to introduce dry season upland cropping as the second crop. At present all paddy fields are cropped to paddy in the rainy season under rainfed condition, and no dry season cropping is practised. The project area has annual rainfall of 1,600 to 1,800 mm on the average, being relatively high in Thailand; however, about 70 percent of annual rainfall concentrate in three months of the rainy season and furthermore it fluctuates monthly, yearly. The uncertainty of rainfall pattern often causes delay in timely planting and in the worst case the harvest fails.

According to the village survey made by the Thai-authority , 81 percent of total villages in Ubon Ratchathani province reported a shortage of water for domestic use in the dry season, as one of the serious problems the villagers confronted. With the above situation in view, the project aims secondly to supply water for the domestic use of villagers living within the project area.

To accomplish the said purpose, the Sebai-Sebok irrigation project will implements the following development plan in 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
   - 1.1 Construction of dam and reservoir
   - 1.2 Water supply for irrigation and domestic use
2. Irrigated Agriculture Development Plan
   - 2.1 Construction of irrigation canal system
   - 2.2 Construction of drainage canal
   - 2.3 Construction of on-farm facilities
   - 2.4 Strengthening of extension services
3. Village Pond Plan
   - 3.1 Construction of village pond
   - 3.2 Water supply for daily consumption and cattle watering
   - 3.3 Fish culture in village pond

5-2. Water Resources Development

5-2-1. River Runoff

(1) Runoff Synthesis

The runoff at the five proposed dam sites was synthesized by establishing a proper runoff model. For the development of the runoff model, discharge data in 1986 at M132 stream gauging station(110 sq.km of catchment area) were adopted. Figure 5-1 gives the comparison of estimated discharge with observed discharge in 1986 at M132 station.

The runoff at the proposed dam sites was synthesized for last 20 years from 1968 to 1987, a summary of which is given below;

Average Annual Rainfall and Runoff

Project	Rainfall Station	Annual Rainfall (mm)	Annual Runoff (MCM)	Runoff Coefficient (%)
Lam Se	72042	1,641	13.5	36.7
Huai Khum Kham	67082	1,714	23.3	37.0
Huai Kham Phak Wan	67082	1,714	8.5	37.0
Huai Na Khai	67112	1,670	20.1	38.4
Huai Soob	67112	1,670	11.9	38.4

(2) Design Flood

Flood records are not available for the determination of probable design floods, and design floods are estimated by analytical method using the maximum probable 3-day consecutive rainfall with a return period of 500 years and maximum probable daily rainfall with a return period of 100 years. Daily rainfall was arranged on an hourly basis by applying the Talbot type rainfall intensity equation through frequency analysis of hourly rainfall data at Muang Ubon Ratchathani meteorological station. The hydrographs are arranged on a hourly basis by applying the runoff-function method. The estimated probable design peak floods are summarized as follows:

Project	Design Peak Flood: Catchment Area (sq.km)	Peak Discharge (cu.m/s): 100 Year	Peak Discharge (cu.m/s): 500 Year
Lam Se	22.4	222	256
Huai Khum Kham	36.8	239	308
Huai Kham Phak Wan	13.5	157	192
Huai Na Khai	31.3	316	362
Huai Soob	18.5	239	270

The estimated peak discharge and yield with the return period of 100-year were cross-checked by the envelop curve for peak specific yield as shown in Figure 5-2 which was developed based on the design flood of existing and under-construction dams nearby the project area. The estimated specific yield is compared with the curve, and two values are almost close. Thus, the estimated peak discharge are technically justifitable.

(3) Sediment

Design sediment has been proposed at 150 cu.m/sq.km/year, making reference to design sediment of 122 cu.m/sq.km/year for Huai Saback project and 115 cu.m/sq.km/year for Huai Lin Jhon project, being both located in the Sebai-Sebok basin.

5-2-2. Water Requirements

(1) Irrigation

The main purpose of irrigation is to stabilize and increase the productivity of rainy season paddy. In the dry season, 20 percent of the irrigation area on an average will be supplied with irrigation water for upland crop farming. The irrigated area under the existing RID projects in the basin fluctuates between three to 44 percent depending on the water availability of a year.

Following the proposed cropping pattern and calendar, water for crop consumptive use is calculated by using the Modified Penman method. The irrigation diversion water requirement is the amount of irrigation water necessary at the head of irrigation systems, including crop consumptive use, water for land preparation, percolation through paddy fields, and loss water from irrigation system.

Irrigation diversion water requirement by crop is summarized below;

Irrigation Diversion Water Requirement

Crop	Field Water 1/ Requirement (mm)	Irrigation Diversion 2/ Water Requirement (mm)
Rainy Season Paddy		
- H.Y.V.	887	1,478
- L.V.	1,002	1,670
Average	922	1,536
Dry Season Upland Crop	463	926

Note: 1/: Effective rainfall and loss water are excluded.
2/: Effective rainfall is excluded.

Monthly Field Water Requirement

- Unit: mm -

Month	Paddy	Upland Crop	Month	Paddy	Upland Crop	Month	Paddy	Upland Crop
Dec.	-	13	Apr.	-	47	Aug.	221	-
Jan.	-	98	May	-	-	Sep.	201	-
Feb.	-	111	Jun.	40	-	Oct.	205	-
Mar.	-	194	Jul.	178	-	Nov.	77	-

(2) Village Pond

The project will provide for one village pond per village in the project area to retain water for use of daily consumption by villagers, cattle watering and pond fish culture. The proposed reservoirs will supply the village ponds with water through the proposed irrigation canals for a five-month period from December to April.

Water requirements for daily consumption of villagers are estimated at the rate of 45 l/day per capita, which is referred to the standard of ARD, for 70 percent of the projected population in 1988. It is assumed that 30 percent of population will obtain water from the existing facilities and/or others. Drinking water will be obtained from a shallow well to be constructed around the village pond.

Water requirements for cattle watering are calculated at the rate of 57 l/day/head for buffalo and 50 l/day/head for cattle. Around 6,700 heads of cattle and buffaloes are being raised in the project areas. Four mm/day of water to replenish water losses of evaporation are considered as water requirements for fishery operation in the village pond.

Total water requirements of village ponds are summarized as hereunder;

Village Pond Water Requirements

- Unit: l/s -

Project	Nos. of Pond	Domestic Use	Cattle Watering	Fish Culture	Total (m^3/day)
Lam Se	5	2.0	1.4	2.9	544
Huai Khum Kham	11	4.0	1.4	4.3	838
Huai Kham Phak Wan	5	1.0	0.7	1.6	285
Huai Na Khai	10	2.0	1.2	3.0	536
Huai Soob	5	1.0	0.5	2.0	302
Total	36	10.0	5.2	13.8	2,505

5-2-3. Water Utilization

(1) Reservoir Operation Study

In order to determine irrigable area with the proposed cropping pattern and the given effective storage, reservoir operations were simulated on a 10-day basis for a period of 20 years from 1968 to 1987. The reservoir operation simulation was run by substituting the variable irrigation diversion water requirement into the equation to obtain the maximum irrigable area on condition that water shortage is allowed three times in 20 years which may be justified from the view - point of project economy. In the operation study, water losses from reservoir such as seepage and evaporation were taken into account. As a result of the reservoir operation study, the proposed irrigable area is given as follows;

Proposed Irrigable Area

Project	Effective Storage (MCM)	Irrigable Area (ha)	
		Rainy Season Paddy	Dry Season Upland Crop
Lam Se	8.50	1,100	220
Huai Khum Kham	19.48	2,600	520
Huai Kham Phak Wan	8.19	950	190
Huai Na Khai	16.11	2,100	420
Huai Soob	7.59	920	180
Total	59.87	7,670	1,530

The results of reservoir operation study are illustrated on Figures 5-3 to 5-7. The average annual water supply for 20 years of operation (1968 to 1987) 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

(2) Reservoir Operation Rule

For the effective operation so as to enable water supply for rainy season paddy cropping and dry season upland crop farming of 20 percent area as proposed, a reservoir operation rule curve is set forth based on the results of reservoir operations for 20 years, as follows;

Reservoir Operation Rule

- Unit: MCM -

Month	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob
End of June	173.0	155.1	138.1	134.9	155.9
End of July	173.9	157.0	139.1	135.3	157.7
End of September	177.1	160.7	142.1	137.0	160.6
End of November	175.2	178.3	140.3	135.3	157.9
End of March	173.3	155.8	138.1	133.8	155.7

When a reservoir water level drops below the reservoir operation rule curve, reservoir release shall be limited to a certain extent in consideration of growing stage of paddy and reservoir contents available for irrigation use. In such cases, water saving irrigation shall be practiced; rotational irrigation, deferred cropping calendar, and so on.

The said reservoir operation study shows that irrigable area of dry season upland crop varies annually from five to 35 percent depending on the water availability with an annual average of 20 percent. The relation between effective storage at the end of November and irrigable area in the succeeding dry season is developed based on the results of reservoir operation study for 20

years. Irrigable area of upland crop to start in January shall be planned taking the effective storage at the end of November into account.

Effective Storage and Irrigable Upland Area

- Unit: MCM -

Irrigable Area (%)	Effective Storage of the End of November				
	Lam Se	Huai Khum Kham	Huai Kham Phak Wan	Huai Na Khai	Huai Soob
5	1.7	1.0	1.0	3.2	1.4
10	2.1	2.0	1.3	4.1	1.7
15	2.6	4.5	1.5	5.0	2.0
20	3.0	5.0	2.4	7.5	2.4
25	4.0	9.5	5.0	7.7	3.7
30	4.5	13.7	5.2	9.0	4.1
35	5.0	14.0	5.5	9.4	4.7

5-3. Irrigation Development

5-3-1. Selection of Irrigable Lands

The proposed irrigable lands have been selected from the existing paddy fields located at the immediate downstream of the proposed reservoir. After plotting the land classification and canal routes on topographic maps (scale 1:10,000), the paddy fields that can be served by gravity with the proposed canal system are identified. High or isolated areas have been excluded.

Total irrigable area of proposed five projects amounts to 7,670 ha. General plans of the projects are illustrated in Annex 3.

5-3-2. Irrigation

(1) Irrigation Water Requirements

(a) Crop

Crop consumptive use (ET crop) is obtained as ET crop = $K_c \times ETo$ where K_c is crop coefficient and ETo is reference evapotoranspiration of a crop. ETo is estimated by using the modified Penman method following the FAO irrigation and

drainage paper No. 24. Table 5-1 and 5-2 give ETo and K_c, respectively.

Crop Consumptive Use (ET crop)

- Unit: mm -

Month	ET crop	Month	ET crop	Month	ET crop
Jan.	140	May	172	Sep.	132
Feb.	146	Jun.	143	Oct.	143
Mar.	199	Jul.	157	Nov.	148
Apr.	197	Aug.	143	Dec.	132

(b) Other Water

250 mm of water for land saturation and puddling for 30 days are required for land preparation of a paddy field, including soil saturation and standing water of 50 to 70 mm. Based on results of field percolation tests made during this study and planning of the existing Huai Pho project, the average percolation loss is assumed to be 2.0 mm/day.

Pre-irrigation water requirements for upland crop cultivation are estimated at 80 mm in total in consideration of soil textures prevailing in the project areas.

(c) Effective Rainfall

A part of rainfall is used for irrigation. From the experience of on-farm development projects under the Greater Mae Klong irrigation project, the following assumption is made to estimate the effective rainfall for irrigation(ER);

Effective Rainfall (ER)

- Unit: mm -

Crop	Effective Rainfall	Upper Limit	
		Monthly Basis	10-day Basis
Paddy	0.75 R	200	70
Upland	0.75 R	120	50

Note : R = Monthly or 10-day rainfall

(d) Irrigation Efficiency

For the proposed projects, the following irrigation efficiencies are assumed making reference to FAO irrigation and drainage paper.

Irrigation Efficiency

Item	Paddy	Upland Crop
Application	0.75	0.60
Conveyance	0.80	0.80
Overall	0.60	0.50

(e) Irrigation Diversion Requirements

Irrigation diversion requirements are obtained by adding water losses to field water requirements. The peak irrigation diversion requirement occurs in August, as given below:

Peak Irrigation Diversion Requirement

Project	Peak Diversion Requirement (cu·m/s)	Irrigation Area (ha)
Lam Se	1.76	1,100
Huai Khum Kham	4.16	2,600
Huai Kham Phak Wan	1.52	950
Huai Na Khai	3.36	2,100
Huai Soob	1.47	920

(2) Upland Crop Irrigation

Upland crop irrigation is the application of water to land having a deficiency of moisture for optimum crop growth. Moisture effective for crop growth varies depending on soil texture. The total readily available moisture content (TRAM) of the project area is low mainly due to homogeneous soil textures. Irrigation intervals and the amount of water application are given as follows;

Irrigation Application and Interval

Project	TRAM (mm)	Interval (day)	Application (mm)
Lam Se	21	4	20
Huai Khum Kham	35	7	35
Huai Kham Phak Wan	35	7	35
Huai Na Khai	12	2	10
Huai Soob	21	4	20

Notes : Average Crop consumptive use of 5.0 mm/day

At the peak water demand stage, irrigation for upland crop will be operated for 12 hours a day, while canal capacities are determined on a 24-hour conveyance basis. Accordingly regulation is generally needed to fill this time gap ; however, in the project areas, 12 hours a day operation for upland crop irrigation is practicable without any regulation pond under the proposed irrigation canal system because the irrigation area of upland crop is only 20 percent of the irrigable paddy fields based on which the capacities of irrigation system is designed.

(3) Water Duty

(a) Irrigation Canal

Generally speaking, the relative water duty (expressed per unit area) of a canal system may be variable according to the scale of command area of the canal system. The smaller the command area, the larger the unit water duty is designed (or, vice versa), because land preparation, which is one of the determinative factors to design of a canal conveyance capacity, is usually done in a relatively short term.

In consideration of the proposed scale of command area of the main irrigation systems ranging from 380 ha (or about 2,400 rai) to 1,530 ha (or about 9,600 rai) and availability of labor forces for land preparation, the Sebai-Sebok project proposes to undertake land preparation in 45 days to cover the whole project area. The peak irrigation water requirement shall occur in August where land preparation water is needed, based on which the water duty for designing capacities of a irrigation canal system is proposed to be 1.6 l/s/ha, or equivalent to 0.26 l/s/rai (Table 5-3).

- Net water requirement	:	79.9÷10	=8.0	mm/day
- Irrigation efficiency	:	0.6		
- Water duty	:	8.0÷0.6	=13.3	mm/day
			=1.6	l/s/ha
			=0.26	l/s/rai

(b) On-farm Facilities

The proposed main canal systems distribute irrigation water down to a terminal irrigation block of 100 rai (or 16 ha). Land preparation in one terminal irrigation block shall complete in 30 days. Thus, water duty of designing farm ditches is proposed at 2.28 l/s/ha, or equivalent to 0.36 l/s/rai.

$$Qp = \{\frac{1}{n} \times p + \frac{1}{n} (n-1) \times d\} \frac{A}{E} = 2.28 \text{ l/s/ha}$$

where; Qp = peak field water requirement

n = 30 days

p = land preparation water = 150 mm/day

d = percolation and ET crop = 7 mm/day

A = irrigation area = 1.0 ha

E = irrigation efficiency = 0.6

5-3-3. Drainage

(1) Drainage Modulus

The removal of excess irrigation water and rainfall from the soil surface is necessary to prevent damage to crops. Heavy rain falls mostly in consecutive three days. In consideration of water storage function of paddy fields and the water tolerance of paddy to some extent, the following criteria for design of a drainage system are proposed;

Design rainfall : Maximum three days consecutive rainfall

Return period : Five years

Drainage modulus : 70 % of the design rainfall for three days

Drainage Modulus at a Farm Level

Item	Sebai	Sebok	Tung Lung
Design Rainfall (mm)	212.3	238.2	245.0
70 % of above	149.0	167.0	172.0
Drainage Modulus (mm/day)	50.0	56.0	58.0
(l/s/ha)	5.8	6.5	6.7
(l/s/rai)	0.9	1.0	1.1

RID applies the reduction factor depending on the size of drainage area to design drainage canal capacities after consideration of the characteristic of

rainfall prevailing in Thailand. Making reference to the reduction factor developed for the Chao Phya project, the following reduction factor and the modified drainage modulus are proposed for the Sebai-Sebok project.

Modified Drainage Modulus

Drainage Area (rai)	Reduction Factor	Drainage Modulus (l/ s/rai)		
		Sebai	Sebok	Tung Lung
0~2,000	1.00	0.90	1.00	1.10
2,000~5,000	0.92	0.83	0.92	1.01
5,000~10,000	0.84	0.76	0.84	0.92
10,000~20,000	0.76	0.68	0.76	0.84

(2) Drainage Canal

The project areas have many natural channels that are connected to main rivers and serve as flood ways during the rainy season. The project provides for drainage canals for several areas in four projects where natural channels are not developed.

Proposed Drainage Canal

Project	Nos. of Canal	Length (km)	Drainage Area(ha)
Lam Se	3	3.79	161
Huai Khum Kham	2	3.42	320
Huai Kham Phak Wan	1	1.01	193
Huai Soob	1	2.28	243

5-4. Village Pond Development

The Sebai-Sebok project will provide for 36 of village ponds for purpose of retaining water for domestic use, cattle watering and raising fish in the ponds. Each village will have one pond to be located along the proposed irrigation canals. The number and size of village pond are given as follows:

Proposed Village Pond

Project	Type-1, 10 rai (130m × 130 m)	Type-2, 5 rai (90m × 90 m)	Type-3, 3 rai (70m × 70 m)	Total
Lam Se	2	1	2	5
Huai Khum Kham	1	3	7	11
Huai Kham Phak Wan	-	1	4	5
Huai Na Khai	-	1	9	10
Huai Soob	1	-	4	5
Total	4	6	26	36

5-5. Agriculture Development

5-5-1. Selection of Crops

Stored water in the proposed reservoirs is firstly used for irrigation to stabilize rainy season paddy cropping. In the dry season, the water is planned to be used for upland crops which will be introduced to 20 percent of paddy fields in each project. Selection of crops to be cultivated in the irrigable paddy fields in the dry season mentioned above was done after discussion with heads of selected villages, extension officers in Amphoes and staffs of provincial extension office was made regarding soil fertility, farmers' willingness, their experience, extension policy and marketability.

Out of many candidate crops, groundnuts, soybean, sweet corn, string bean, water melon and chilli are selected and planned as shown on Figure 5-8.

Three or four crops are allocated to each project site. Groundnuts will cover 55 to 60 percent of dry seasons cropping area in every sites, soybean or sweet corn will be planted to 30 percent of the area in all five sites and string bean, water melon and chilli will be planted by five to 10 percent of each site. Details are given in Appendix.

5-5-2. Yield Projection

(1) Paddy

Yield per rai of paddy in the rainy season is about 200 kg/rai (1.3 ton/ha) in both provinces under present rainfed conditions, according to Agricultural Statistics of Thailand, Crop Year 1987/88. Judging from the previous data, it may be difficult to level up this yield due mainly to lack of

irrigation water and poor soil fertility. But a FAO trial shows the yield of 430 kg/rai (2.7 ton/ha), and another report suggests 500 kg/rai (3.1 ton/ha) as the target.

Under these conditions it is proposed to have 550 kg/rai (3.4 ton/ha) as the target yield in the rainy season with project. The target yield will be attained under the condition of enough and appropriate irrigation, fertilization and good management using high yielding varieties. Green manure cropping before rice cultivation will become one of the recommendable practices in the area. Direct seeding of paddy is also supposed to be another technology to be adopted. A simple direct seeding machine was developed by NERAD project.

(2) Groundnuts and Soybean

Leguminous crops are fundamentally recommended to the area for increasing soil fertility. Groundnuts have been cultivating in the area for a long time but soybean is rather new crop. DOAE has been trying to extend soybean cultivation in the area. Both groundnuts and soybean have high percentage of edible oil and other nutrients and their nutritious values are very high, especially protein of soybean. Yields of both crops are proposed at 250 kg/rai (1.6 ton/ha).

(3) Sweet Corn and String Bean

These crops are quite popular in the area and familiar with the people judging from the interviews with farmers and extension officers. Yields are forecasted to be 2,000 kg/rai (12,500 kg/ha) and 1,500 kg/rai (9,375 kg/ha), respectively.

(4) Water Melon

Water melon has been very famous as a cash crop especially in Yasothon province and it also became popular in irrigable areas in Ubon Ratchathani recently. It is said that harvesting time of water melon in these two provinces are different due to the time lag of rice cultivation and therefore no competition between the product of two provinces is observed in the market. Yield is suggested as 3,000 kg/rai (18,750 kg/ha).

(5) Chilli is also well known cash crop in the area but has been cultivated rather in limited area. Its yielding capacity in Ubon Ratchathani is very high

because of the special variety "Hua Lua". Since it needs an integrated technology and laborious works, extra investment at the beginning, and guidance to the farmers by DOAE will be necessary. Yield is projected as 1,200 kg/rai (7,500 kg/ha)

5-5-3. Improvement of Crop Production Technology

To achieve the yield target of these crops proposed to the irrigable area of paddy field in the dry season, careful management, more labour force and investment will be necessary. For instance, chilli cultivation needs initial investment of electricity for pumping sometimes, application of manure and labour force for management and harvesting.

In case of paddy cultivation, some selected farming technologies are as follows;

- Late (delayed) planting
- Direct seeding
- Split application of fertilizer
- Green manure cultivation before paddy planting
- Selection of short term crops to utilize remaining soil moisture before and after paddy cultivation.

Late (delayed) planting is for avoiding the damage caused by the drought due to rainfall interruption at the beginning of the rainy season. Details of farming methods are discussed in Appendix.

Direct seeding is closely related with late planting method. To meet the necessity of late planting or labour shortage for transplanting, direct seeding which is becoming popular in other areas, will be most appropriate. The yield of directly seeded paddy may have slightly less yield than the transplanted paddy but it is economical and can be introduced to the area.

According to the field survey, five percent of farmers in Lam Se, Yasothon province has small tractors but no farmer in other project areas in Ubon Ratchathani province possess it. Labour and human forces may be concentrated in future. To cope with this situation, direct seeding of paddy will be indispensable under the present condition.

As a basic technology, application of fertilizer in such a sandy area like gray podosolic soils in the areas should be splited into several times. This will