Huai Yai. Any stream can not be seen in the river courses during dry season except small puddles.

(2) Geology

The Pa Mo Gravel Bed, forms the rolling hill with about 30 m in maximum thickness and it thins toward the east where the terrace deposits are unconformably overlaid.

The Terrace Deposits are widely distributed in the area and the thickness attains a maximum of more than 15 m in Ban Chad. The Deposit is mainly composed of silty/clayey fine sand in the upper part and clayey layer with lateritic gravels in the base.

The Alluvial Deposits are distributed in the recent flood plain with a thickness of one meter.

The thick loam extensively overlies the area.

Natural conditions of the Pilot Area is shown in Hydrogeological Map of the Pilot Area (see Figure 7-1).

7-2-3 Soil and Land Use

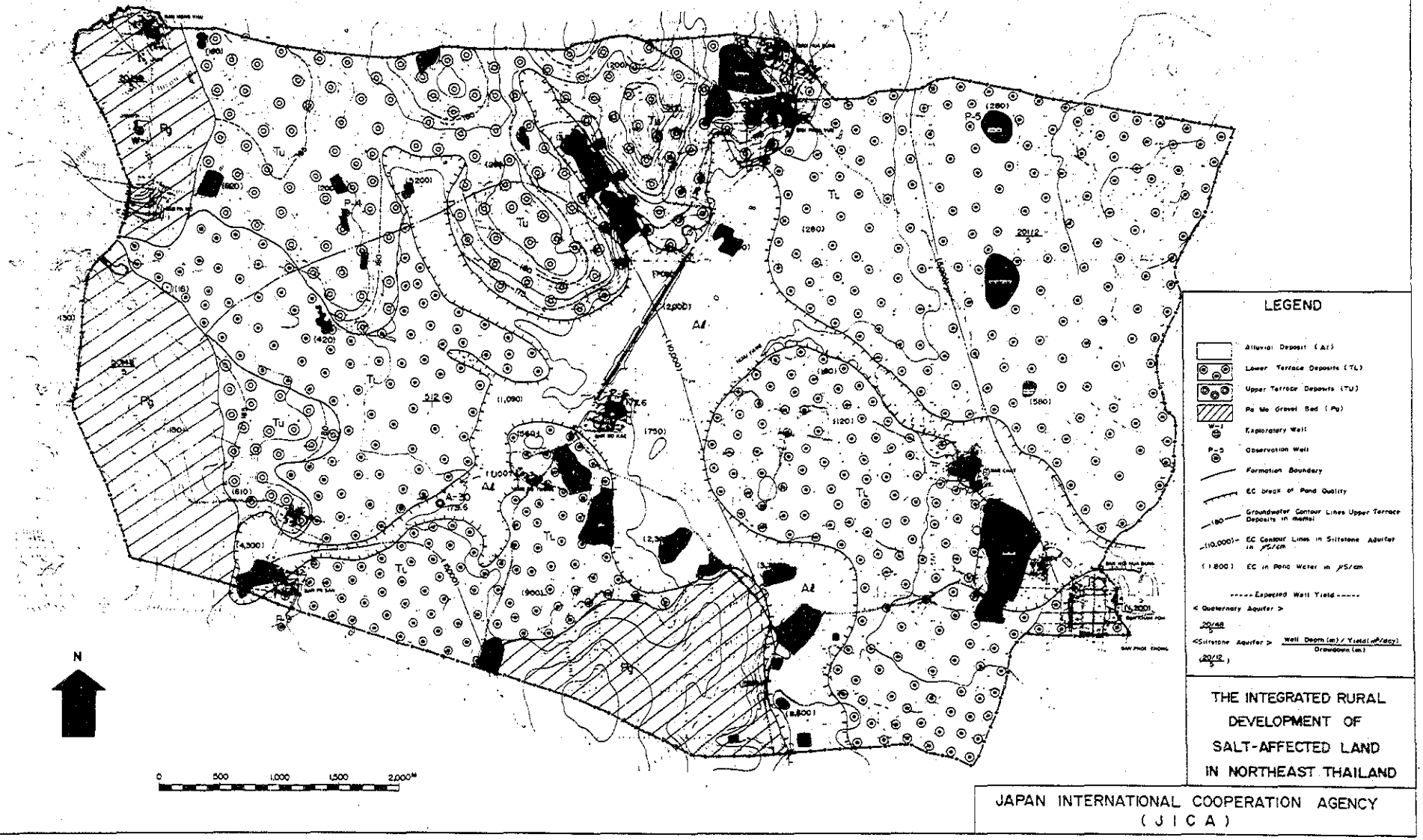
(1) Soils

To understand the soil characteristics and distribution in the Pilot Area, totally 160 soil profiles were investigated by auger boring (1.8 m deep). In addition, 16 representative sites were selected as sampling site and totally 75 samples were taken from each layer for chemical analyses. Also 68 undisturbed samples were taken by using core cylinder for physical analyses. Furthermore, clay mineralogy analysis was made for 3 samples. A map showing the location of soil profiles surveyed, columnar sections of soil profile, and results of chemical and soil analyses are shown in APPENDIX C-13~C-18.

The Pilot Area expands from low terrace to middle terrace. Based on the investigation data, soil map of the Pilot Area was prepared (Figure 7-2) and the area of each category is summarized as Table 7-1.

Soils having yellowish brown color and sandy texture in the entire profile (S/S, S/Sg) occupy 760 ha or 16.2 % of the total Pilot Area at the highest portion. These soils belong to Nam Phong Series. On the footslope of hills, soils having sandy surface and loamy substrata (S/M) occupy 690 ha or 15.1 % of the Pilot Area. The predominant soils in middle and low terraces are the soils having sandy surface but

FIGURE 7-1 HYDROGEOLOGICAL MAP OF PILOT AREA



clayey substrata with laterite/gravel layer at various depth (S/Cg, S/Cg-m, S/Cg-s) which occupy totally 1,300 ha or 28.5 % of the Pilot Area, These soils mainly belong to Korat Series but the soils having laterite/gravel layer at shallow depth are identified as Phon Phisai Series. Soils having sandy soil but clay substrata without laterite/gravel layer (S/C), which belong to Roi Et Series, occupy 880 ha or 19.3 % of the Pilot Area,. At the depressions near the foot of hills in the central portion of the Pilot Area, saline-sodic soils, which have accumulated sodium salt and show high pH, occupy 200 ha or 4.4 % of the Pilot Area. Soil stratigraphy of the saline-sodic soils is not different from other soils but saline-sodic soils usually have an impermeable layer at shallow depth. At the eastern periphery of the Pilot Area, extremely clayey texture soils occupy 600 ha or 13.2 % of the Pilot Area, which are poorly drained. These soils become muddy during the rainy seasons, on the other hand, they become very hard during the dry seasons.

(2) Salt-Affected Land

Salinity classification in the Pilot Area was made by the similar criteria to those in the study area. Salt patch coverage was measured by aerophoto interpretation and field check. Salt-affected land distribution is shown in Figure 7- 3 and the area of each class is given in Table 7-2. Aerophotos used for interpretation were taken in 1983 (or in 1976). After field check, the increasing trend of salt patches was recognized. In the Pilot Area, which was selected as a typical salt-affected area, severely salt-affected lands occupy 4.2 % of the total Pilot Area, that is, larger than that of the study area. Salt-free land could not be found in the Pilot Area.

(3) Land Use

Present land use in the Pilot Area was studied by interpretation of aerophotos scaled 1:15,000 and by field check. Figure 7-4 shows the present land use in the Pilot Area and the area of each category is given in Table 7-3. Rainfed paddy fields expand most of low terrace. Severely salt-affected lands are abandoned crop cultivation and left as barren. Middle and high terraces are mainly occupied by cassava fields or secondary forests.

Sericulture is one of characteristic activities in the Pilot Area, and small-scale mulberry farms can be seen throughtly in the area. Cattle breeding is also active in the Pilot Area, however, the cattle are raised with poor fodder such as wild grasses or rice straw in the paddy fields under fallow, and wildgrasses or crop residue in the

secondary forests. Intensive pasture cannot be found in the Pilot Area.

Table 7-1 Soils in the Pilot Area

Symbol	Description	Area		
		ha	rai	%
S/S	Sandy texture in entire profile	680	4,250	14.9
S/Sg	Sandy texture in entire profile with laterite gravel layer	60	370	1.3
S/M	Sandy surface soil and loamy substrata	690	4,310	15.1
S/C	Sandy surface soil but clayey substrata	880	5,500	19.3
S/Cg	Sandy surface soil but clayey substrata with laterite/gravel layer at moderately deep depth	400	2,500	8.8
S/Cg-m	Sandy surface soil but clayey substrata with laterite/gravel layer at moderately shallow depth	510	3,190	11.2
S/Cg-s	Sandy surface soil but clayey substrata with laterite/gravel layer at moderately shallow depth	390	2,440	8.5
M/C	Loamy surface soil and clayey substrata	140	870	3.1
M/Cg-m	Loamy surface soil and clayey substrata with laterite/gravel layer at moderately shallow depth	270	1,690	5.9
C/C	Clayey texture in entire profile	190	1,190	4.2
SA	Saline-sodic soil	200	1,250	4.4
W	Reservoir	150	940	3.3
Total		4,560	28,500	100.0

FIGURE 7-2 SOIL MAP IN THE PILOT AREA

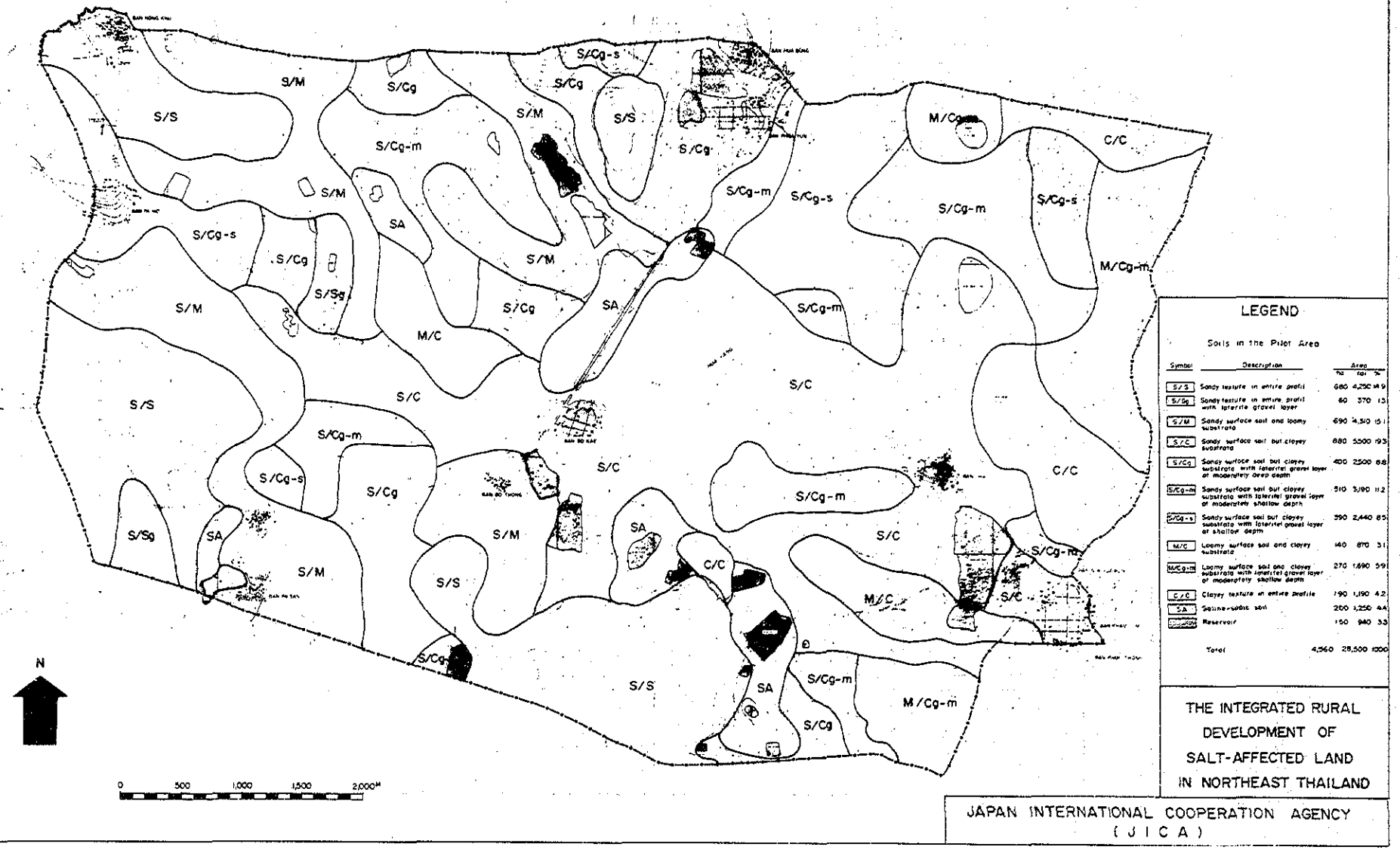


Table 7-2 Salinity Classification in the Pilot Area

Salinity Class	Area		
	ha	rai	%
1 Severely Salt-Affected Land with salt patches more than 50% of ground surface	190	1,190	4.2
2 Moderately Salt-Affected Land with salt patches 10-50% of ground surface	340	2,120	7.5
3 Slightly Salt-Affected Land with salt patches 1-10% of ground surface	590	3,690	12.9
4 Potentially Salt-Affected Land without salt patches at present	1,370	8,560	30.0
5 Upland with salt bearing layer underneath	1,920	12,000	42.1
6 Salt-Free Land	—	—	—
W Resevoir & Natural swamp	150	940	3.3
Total	4,560	28,500	100.0

FIGURE 7-3 SALINITY CLASSIFICATION IN THE PILOT AREA

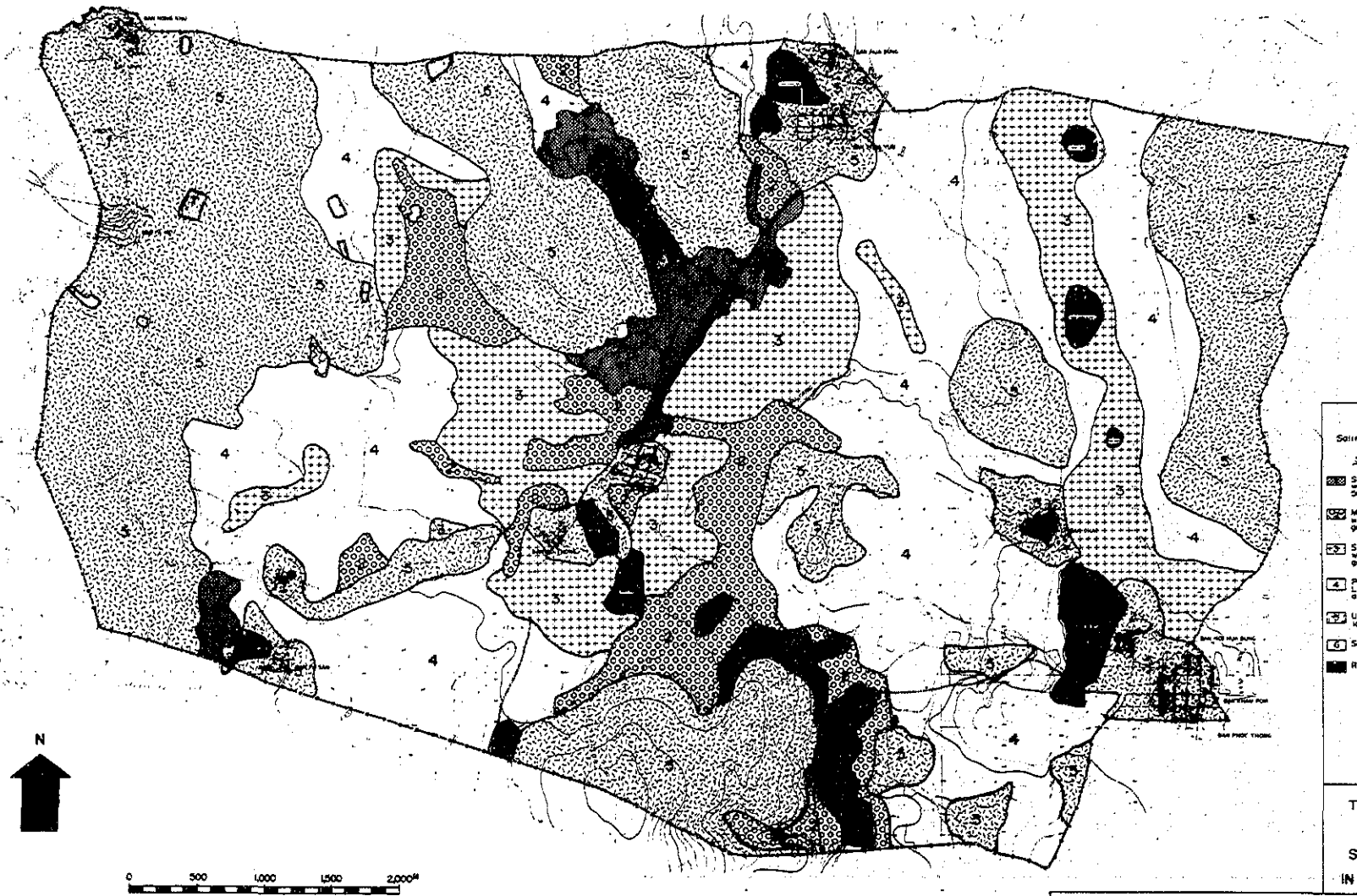
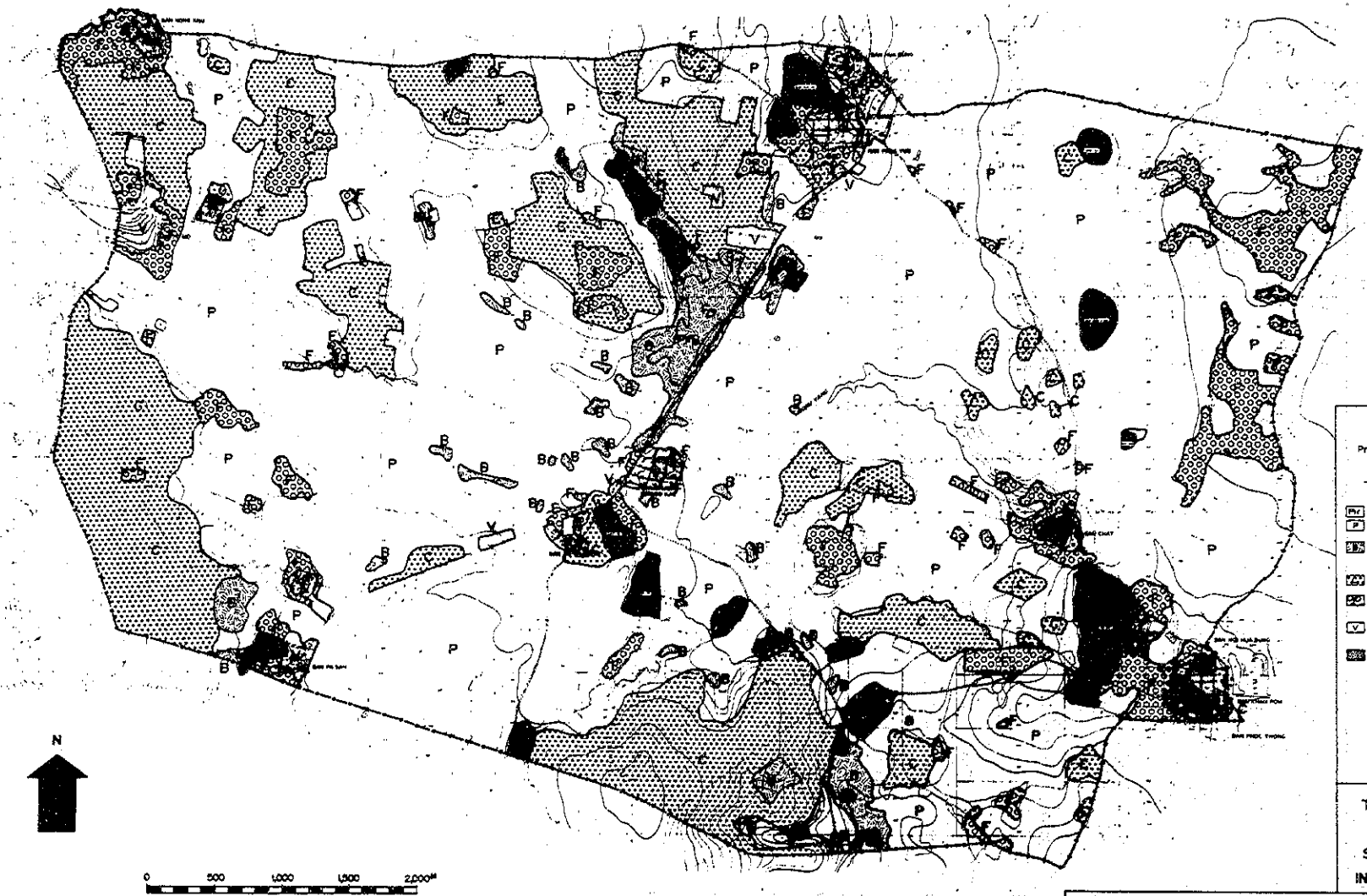


Table 7-3 Present Land Use in the Pilot Area

Land Use	Area		
	ha	rai	%
Lowland			
Paddy, irrigated	0	0	0
Paddy, rain-fed	3,020	18,870	66.2
	3,020	18,870	66.2
Barren land	110	690	2.4
Upland			
Field crops	840	5,250	18.4
Forest	320	2,000	7.0
Village and Miscellaneous	120	750	2.7
Reservoir	150	940	3.3
Total	4,560	28,500	100.0

FIGURE 7-4 PRESENT LAND USE IN THE PILOT AREA



LEGEND

Present Land Use in the Pilot Area

Land Use		Area ha	Area rai	Area %
	Lowland			
Pir	Paddy irrigated	0	0	0
P	Paddy rainfed	3,020	18,870	66.2
B	Barren	100	690	2.4
	Upland			
F	Field crops	840	5,250	18.4
Fo	Forest	320	2,000	7.0
V	Village and Miscellaneous	120	750	2.7
Res	Reservoir	150	940	3.3
	Total	4,560	28,500	100.0

THE INTEGRATED RURAL DEVELOPMENT OF SALT-AFFECTED LAND IN NORTHEAST THAILAND

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

7-2-4 Agriculture

The situation of the agriculture in the Pilot Area is not different from that of the study area. But the strongly salt affected land ratio is higher and the farming conditions are more hard.

The present situation of agriculture in the villages related to Pilot Area is as follows: ("Related village" indicates the villages of which all area or a part of area is included in the Pilot Area.)

The area of the Pilot Area is 55% of that of related villages (APPENDIX D Figure D-2). We analyzed agricultural situation of the Pilot Area using the statistical data of the related villages, and if necessary, estimated the value of the Pilot Area as 55% of the related villages value.

(1) Present Farming Situation

Based on the aerophotograph the present areas of paddy fields and upland fields in the Pilot Area were estimated at 3,020 ha, and 840 ha respectively.

From the statistical data (1988) the areas of paddy fields and upland fields were estimated at 2,290 ha and 410 ha, respectively. Those values show the low cropping intensity in this area and the room for increasing intensity is remained. The reason of the low cropping intensity may be as follows :

- Lack of profitable crops under natural conditions. Lower profitability from agriculture compared with the profit from other sector.

- Total farm household in the Pilot Area is 11,000 in number. One household has 2.5 ha (16 rai) of culture land, 2.1 ha (13 rai) of paddy field and 0.4 ha (2.3 rai) of cropping upland field.

- The paddy field ratio to total culture land ranges by village from 50% to 96%.

The kinds of cropping field crops in 1989 are cassava (51% of total upland field), kenaf (8%), sugarcane (7%) and mulberry (31%).

The difference of paddy yields in villages is influenced by the annual rainfall. In 1988, it was a normal year, the paddy yield in each village of the Pilot Area ranged 50-400 kg/rai. In 1990, it was

an abundant year, the range of paddy yield in each village was decreased to 200-400 kg/rai.

The transplanting of the seedling is carried out soon after rainfall, but some areas are used to be remained without planting because of rainfall shortage. As a measure against this situation, the direct seeding method to dry paddy field was promoted by the extension office but it is not extended to farmers as yet.

The maximum paddy area can be grown by one farmer was estimated at 0.8 ha (5 rai) under traditional growing practices. With three family labors the maximum cultivable area is around 2.4 ha (15 rai). If the area is larger a supplement labour will be necessary. Hiring of labor is usually done in this area, especially for growing upland cash crops such as kenaf.

The density of sericultural farmers is higher in the Pilot Area. In Ban Pa Mo which located at the hillside, 95% of farmers grow mulberry field of 0.48 ha (3 rai) in average. On the other hand in the paddy field area such as Kham Pom village there are small-scale sericulture farmers with mulberry fields of around 0.16 ha (1 rai).

For example farmers in Phra Yun village, using 0.32 ha (2 rai) of mulberry field, harvested cocoon 75 kg, reeled rawwsilk 8 kg, weaved 37 unit of fabrics and get 22,000 Baht. In general farmers grow 1 rai of mulberry field and sell the raw silk and get around 2,200 Baht as crude income.

A few sericultural farmers grow bivoltine silkworm by using a larger mulberry field. For example farmers growing 1.12 ha (7 rai) of mulberry field, raised silkworm 12 times a year and get 480-600 kg of cocoon a year and sold it for 56,700 Baht.

Requests from sericultural farmer were summed up in Ban Pa Mo as follows : Improvement of reeling machine, Control of root rot disease, Training for "Madmee" silk production. These requests will be important to develop sericulture in this area.

The higher density area of livestock is found at the east side and south side of the study area where many cattle are raising. In the Pilot Area, mainly buffalo is grown for farming (heads of cattle is less than 20% of buffalo). The average raising number of buffalo is 1.2 heads per farm household. Raising practice is traditional one, using the reidues of crop production and wild grass as feedstuff. There is no pasture land, but farmers use the paddy and upland fields after harvested, communal land, unused land for cropping, and hillside

bush land as the source areas for feedstuff. But the supply of feedstuff is unstable. In dry season buffaloes loss weight, sometimes farmers have to sell their buffalo in dry season and buy buck them at the beginning of rainy season.

Raising fish is practicing by using private small farm ponds and communal village ponds. In Ban Pa Mo there are 54 fish raising farm households (22% of all farm households). Now 13 households are constructing new ponds. Their desire to make ponds is very strong (APPENDIX D to D-2).

7-2-5 Irrigation, and Drainage

(1) Irrigation

In the Pilot area, there exist four weirs locally called "Fai" and 14 storage ponds locally called "Nong". However, no irrigation facilities to carry out intensively irrigation can be found. Almost paddy fields are rain-fed.

The three weirs among all four units are located at the Huai Yang which flows down through the center of the Pilot Area and another unit is located at the upper stream of the Huai Yai which flows down the northeastern part of the Pilot Area. The structure of these wiers is the simple floating type. Its height is below two meters. These weirs are constructed by reinforced concrete block. One of these weirs, called "Monk weir", has pipe culvert and headrace canal of 600 m length. It conveys water to the Nong Phan Nam storage pond. Another three weirs with stop-log gates have no headrace canal.

Almost 14 storage ponds in the Pilot Area do not have pumping facilities. They are located at depressions of low land or constructed by digging on a flat plain. These strage ponds have their water level lower than the paddy fields around. Irrigation has not been applied.

The Nong Phan Nam storage pond, which is constructed with embankment, supplies water through Monk weir. This pond has enough water and there are some paddy fields taking water overflowed through the spillway.

All ponds are unlined. Some ponds are not useful due to salinity conducted by groundwater in the Pilot Area.

Almost paddy fields in the Pilot Area are ramified. Each paddy field is connected though the outlet of the levee for discharging water from a paddy field with a high elevation to a low one. Paddy fields

with a lower elevation has a tendency to take precedence for plantation.

Levee of each paddy field is 50-70 cm high to store the rainfall on paddy field as much as possible.

According to results of water requirement and infiltration study, the percolation amount is below 1 mm/day, an adequate faculty to save the loss of stored rainfall,. (refer to APPENDIX Figure F-1-2 ~ F-1-5)

A headrace canal of five km length is digged out for multipurpose use, including conveyance of irrigation water from Nong Khu weir located on Yai river in the Northwestern part of the Pilot Area to the Nong Pra Yun storage pond. However, the condition of this canal is unsatisfied with its depth in the high land portion and soil eroson from its unlined slope.

Water management in the Pilot Area is practiced by the village committee, depended on the facility level. Operation and management works are not carried out intensively.

(2) Drainage

In the Pilot Area, Huai Yang flows generally eastwards. The river gradient is steep, averaging about 1:400. The drainage of the Pilot Area is carried out mostly by this river. Drainage facilities are not provided because there are no flooding and inundation problems in the Pilot Area.

7-2-6 Rural Infrastructure

(1) Rural Roads

The main road in the Pilot Area is the provincial highway No. 2062 passing through its middle in the direction from northeast to southwest. This highway has an eight meter-width and asphalt pavement.

In the Pilot Area, a network of seven main rural roads connects to its 15 related villages. These rural roads are unpaved or partly sediment paved with a width of four to seven meters. As these roads are flooding at topographically low parts during the rainy season, which causes earthfall and erosion at these parts, repair works are required on these eroding portions during the dry season.

Besides, the conditions of heavy dust during the dry season,

especially when being passed by vehicles, and muddy surface during the rainy season are observed. These rural roads need to be paved for portions passing through villages.

The density of rural roads in the Pilot Area is considered sufficient but the number of drainage culverts under these rural roads is not sufficient at now.

(2) Rural Water Supply

In the Pilot Area only two villages Nong Khu and Phra Yun are supplied with running water.

For Nong Khu village, groundwater is pumped up from a deep tube well of the village-wat. This water is stored in three tanks and supplied to all 124 village-households by piping. Villagers use this running water for domestic purpose and drinking also. At the time being, there are no problems regarding the water quality as well as equipments.

For Phra Yun village, groundwater is pumped up by a solar pump and supplied to three common places in the village by piping. The water quality, however, is not preferable for drinking. Villagers use this water for domestic purpose only.

For drinking purpose, villagers in the Pilot Area collect rain water in concrete jars and tanks for using through the year. In case of water shortage during the dry season, they use water from nearby shallow wells for drinking, except for village Nong Khu.

In two villages Pa San 1 and 2, villagers have no suitable wells for drinking due to the severely salt-affected soils. They must go to neighbouring villages for taking their drinking water.

(3) Other Rural Infrastrutures

The electricity is supplied from the Nam Phong power station to all villages in the Pilot Area. All households in this area are electrified. Regarding other social infrastructures such as education and health care, the situation is considered in proper conditions as notified in the Figure 7-5 and Table 7-4.

7-2-7 Agro-Economy

In general, the situation of agro-economy in the Pilot Area is almost similar to the study area where most households are engaged in rain-fed paddy cultivation as their prime and basic economic activity

for producing this staple food for self-consumption.

In some land portions, especially some uplands in Tambon Phra Yun, upland crops such as cassava, mulberry, kenaf etc. are planted as cash crops.

The idea of producing paddy for self-consumption has been originated from severe natural conditions, especially previous drought experiences, making their basic structure of farming as well as its traditional agro-economy up to now in the rural Northeast.

Paddy cultivation, every year, starts from June-July with the rainy season and its harvest is done by the end of December. During this season farmers try to stock available rainfall in small paddy plots for paddy cultivation to cope with the erratic rainfall pattern in this region.

As a matter of facts, all paddy-plots are hardly to be cultivated in a same time due to lack of rainfall precipitation. Yields of each plot, therefore, are based on this production procedure, estimated as only one-half of its total paddy area is cultivated.

The production of paddy is for self-consumption, not for selling, even in case of exceeding the required quantity of annual consumption. Farmers store the whole yield for avoiding its purchase in case of no production in a drought year.

Recently, some farms have produced tomato, watermelon, chilli and eggplant under contracts of some seed firm(s), but these areas are very limited by available sources of agricultural water.

Next to the lack of agricultural water, the lack of a marketing system of agricultural inputs and outputs has made difficulties for farmers to have opportunities for earning other farming incomes.

Regarding off-farm incomes, cottage industries such as weaving, making mats etc., have been practiced but in small scale, almost for home-use. These works could not produce proper incomes at the time being due to products of low technology.

FIGURE 7-5 SOCIO-ECONOMIC INFRASTRUCTURE

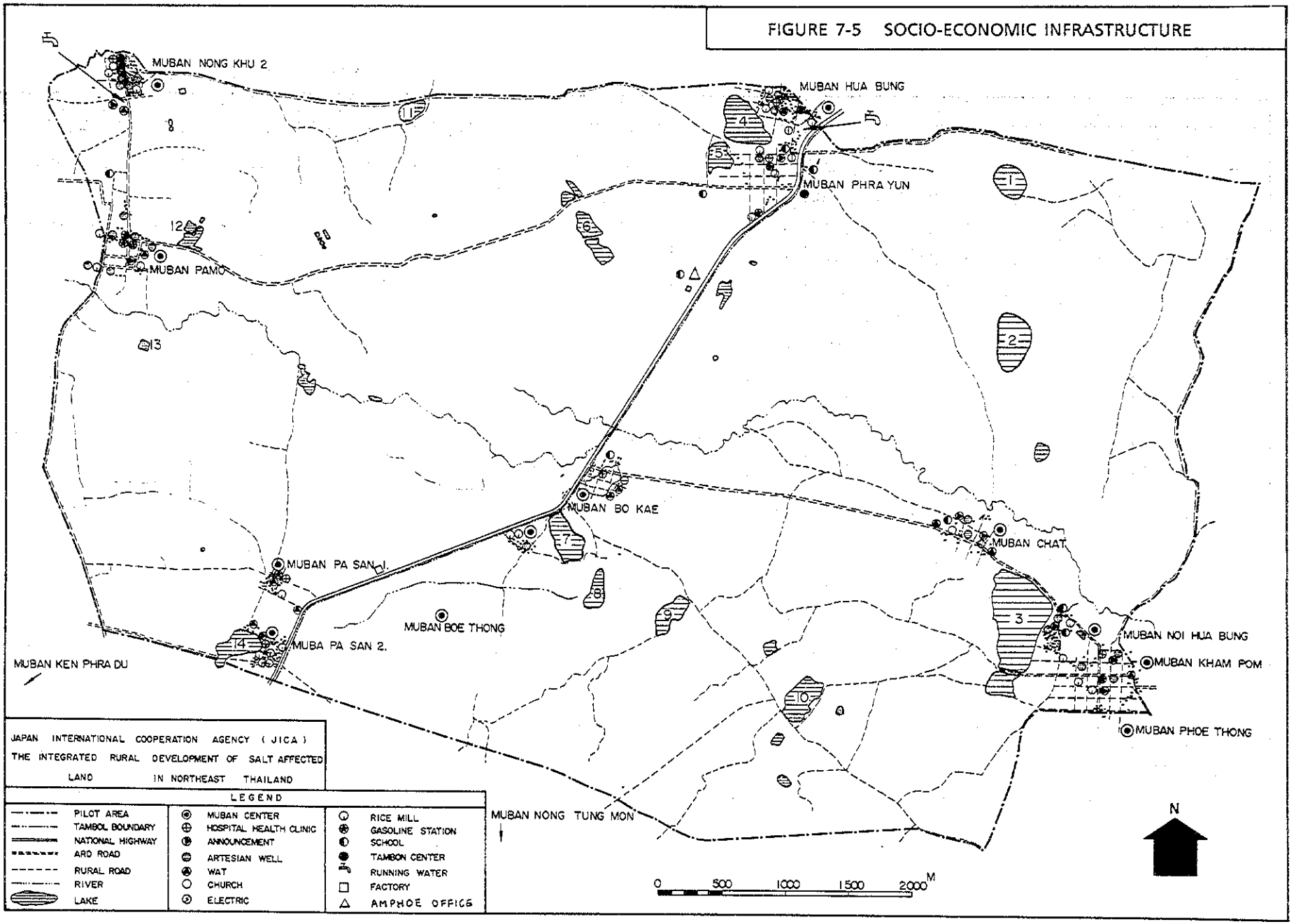


Table 7-4 Socio-Economic Situation in the Pilot Area

Tambon & Muban	Households	Population	School		Health Care		Drinking Water			Electri-city	Post Office	Bamk	Cooper-ative
			Primary	Secon-dary	Hospital	Clinic	Rain	Well	City				
Tambon Pra Yun													
1. Pra Yun	289	1,682	1	1	1	1	Yes	available	No	OK	1	1	1
2. Hua Bung	178	1,169	1	0	1	1	Yes	available	No	OK			
3. Mong Khu	124	614	1	0	0	1	Yes	No	Yes	OK	-		-
4. Pa Mo 6	169	866	1	0	0	0	Yes	available	No	OK	-		-
5. Ken Pradu	120	664	1	0	0	0	Yes	available	No	OK	-		-
6. Pa San 1	101	548	1	0	0	0	Yes	No	No	OK	-		-
7. Pa San 2	86	424	1	0	0	0	Yes	No	No	OK	-		-
8. Pa Mo 11	112	598	0	0	0	0	Yes	available	No	OK	-		-
(Sub-total 1)	(1,179)	(6,565)	(7)	(1)	(2)	(3)					(1)	(1)	(1)
Tambon Khan Pon													
1. Khan Pon	289	1,324	1	0	0	1	Yes	available	No	OK	-	-	-
2. Noichan Bung	95	484	1	0	0	0	Yes	available	No	OK	-	-	-
3. Chad	190	1,015	1	0	0	0	Yes	available	No	OK	-	-	-
4. Bo Kae	189	954	1	0	0	0	Yes	available	No	OK	-		-
5. Mong Thung Mon	24	141	1	0	0	0	Yes	available	No	OK	-	-	-
6. Bo Thong	63	316	0	0	0	0	Yes	available	No	OK	-	-	-
7. Phoe Thong	168	862	1	0	0	1	Yes	available	No	OK	-	-	-
(Sub-total 2)	(1,018)	(5,096)	(6)	(0)	(0)	(2)					-	-	-
Total	2,197	11,661	13	1	2	5					1	1	1

Source : Village Survey, 1989, NSO

7-3 Development Plan

7-3-1 Land Use Plan

Land use plan for the Pilot Area was formulated in accordance with the similar basic concept to those adopted for the study area. The Pilot Area was selected to include the typical salt-affected area, accordingly, the salinity control was particularly taken into consideration. Proposed land use is shown in Figure 7-6 and area of each category is given in Table 7-5.

Severely salt-affected lands are located along the national road from south of Ban Phra Yun to Ban Bo Kae, along the road connecting Ban Bo Kae and Ban Thong Mon, and the foothill near Ban Pa San. A marketing/processing center and a technical training center will be constructed at the adjacent land of Amphoe Office. The rest of severely salt-affected land will be used as pasture with salt-tolerant grasses (mainly Atriplex spp.) occupying 210 ha or 4.6 % of the total area. Most land in the low terrace which are slightly-moderately salt-affected land or potentially salt-affected land, will be used as paddy fields occupying 2,150 ha or 47.2 % of the total area. Three irrigable areas (totally 380 ha) are included in the total area. The paddy field area will decrease from 3,020ha at present to 2,150ha in future. However, the rice production will increase owing to expansion of irrigated area and also expansion of actually planted area, that is, present planted area is less than 50% of total paddy fields. Consequently, the rice production will meet the demand of increased local population in future. In upland surrounding the lowland, agroforestry will be widely introduced (1,840 ha or 40.3 % of the Pilot Area). Agroforestry systems to be introduced in the Pilot Area are divided into following 4 types;

Tree + Fruits
Tree + Mulberry
Tree + Cash Crops
Tree + Pasture

(Tree + Fruits) will be allocated to the surroundings of village. (Tree + Mulberry) will be allocated to the land having good access for convenient work. (Tree + Pasture) will be distributed to the entire Pilot Area. The extents of mulberry farm and pasture were determined to meet the projected demand of silkworm rearing plan and cattle grazing plan in the future. (Tree + Cash Crops) and (Tree + Pasture) systems will be rotated, that is, cash crops will be intercropped during the first 2 years when tree canopy is still small, afterwards, ruzi and hamata will be sown and cattle grazing is undertaken for 3

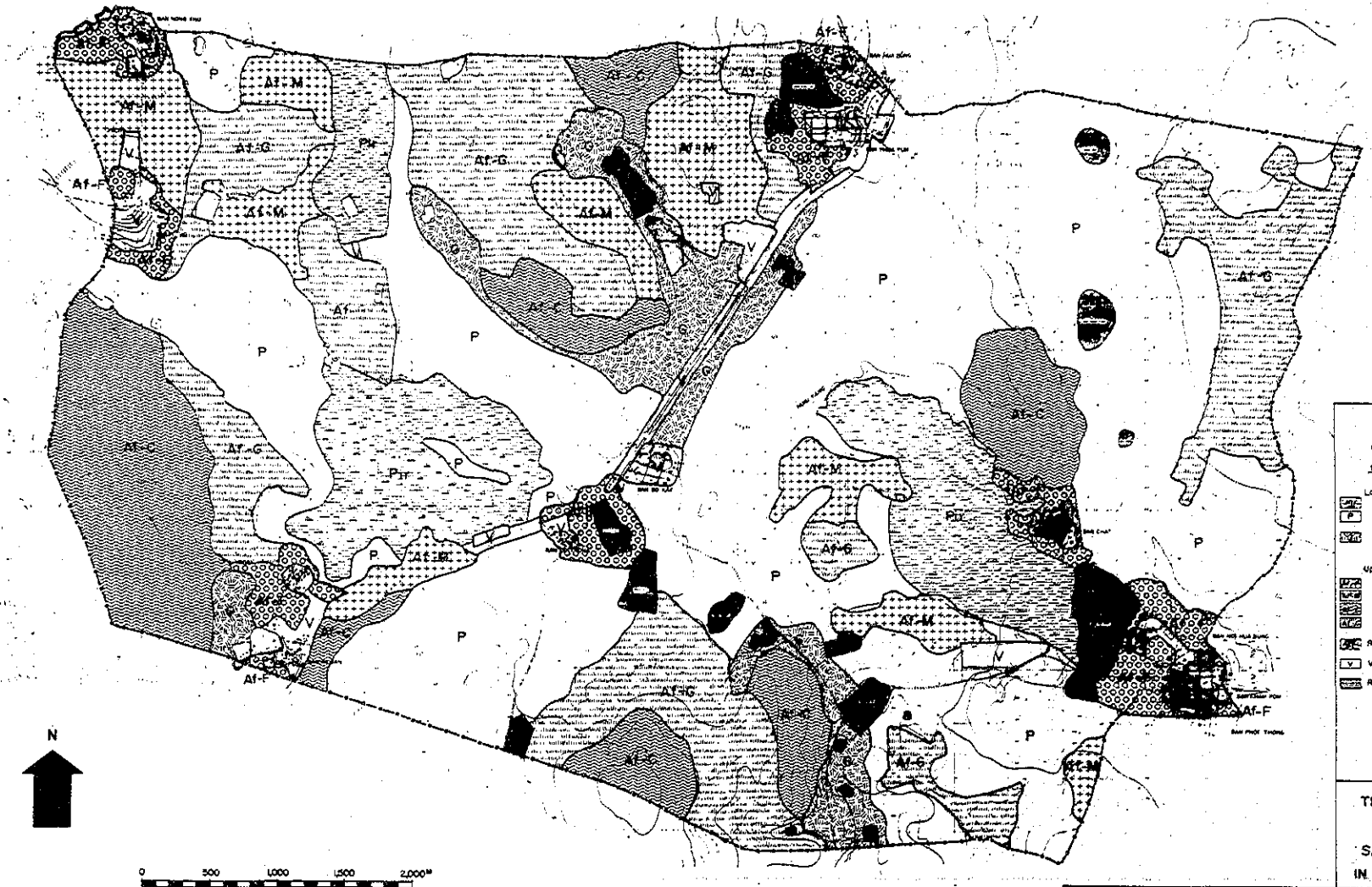
years. Steep slope where forest grazing is unsuitable will be used for hedgerow intercropping under (Tree + Cash Crop). These agroforestry systems will be newly introduced to the Pilot Area, therefore, extension and demonstration activities to the farmers are essential.

Reservoir area will increase from 150 ha to 180 ha because of construction of irrigation facilities.

Table 7-5 Land Use Plan in the Pilot Area

Land Use System	Area		
	ha	rai	%
Lowland			
Paddy, irrigated	380	2,380	8.4
Paddy, rainfed	1,770	11,050	38.8
	2,150	13,430	47.2
Barren land	210	1,310	4.6
Upland			
Agroforestry, Fruits	180	1,130	3.9
Agroforestry, Mulberry	360	2,250	7.9
Agroforestry, Cash crop	500	3,120	11.0
Agroforestry, Pature	800	5,000	17.5
	1,840	11,500	40.3
Reserved Forest	—		—
Village and public use	180	1,130	3.9]
			3.9
Reservoir	180	1,130	
Total	4,560	28,500	100.0

FIGURE 7-6 LAND USE PLAN IN THE PILOT AREA



LEGEND

Land Use Plan in the Pilot Area

Land Use System		Area ha	rai	%
Lowland				
Paddy, irrigated		390	2,440	8.6
" rainfed		1,780	10,990	38.6
		2,170	13,430	47.2
Pasture on salt-affected land		210	1,310	4.6
Upland				
Agroforestry	Fruits	180	1,130	3.9
	Mulberry	360	2,250	7.9
	Cash crop	500	3,120	11.0
	Pasture	800	5,000	17.5
		1,840	11,500	40.3
Reserved Forest		-		-
Village and public use		180	1,130	3.9
Reservoir		180	1,130	3.9
Total		4,560	28,500	100.0

THE INTEGRATED RURAL DEVELOPMENT OF SALT-AFFECTED LAND IN NORTHEAST THAILAND

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

7-3-2 Agricultural Development Plan

(1) Objectives and Strategies

The objectives and strategies of agricultural development in the Pilot Area is not different from that of the study area.

The ratio of paddy field area to the agricultural land in each village is different by their location. Near the hillside, Ban Phra Yun, Ban Pa Mo and Ban Kaen Pradu have 62%, 69% and 60%, respectively in the paddy field ratio.

In the lower land Ban Non Phua Bun, Ban Chat and Ban Phua Bun have higher paddy field ratios of 93%, 96% and 91%, respectively.

In the former area, field crops, meat cattle and sericulture will become main crops as well as paddy cultivation.

In the latter area, paddy will be a main crop and small scale sericulture will be adopted. Fruit garden will be developed near the villages. The harvested fruit will be consumed in the villages and be sent gradually to regional markets.

In the irrigation area, especially in the double cropping area, the intensive agriculture will be developed and the culture of cash crops such as vegetables will be introduced.

(2) Contents of the agricultural development plan

The cropping plan, yield and production in the pilot area are shown Table 7-6. The paddy field area decreases, but it is almost same the actual planted area of 1988.

The target rice production was set at 3,000 ton, it is about 2.2 times of the present production in usual year. About 32% of rice production will be produced in the irrigated area, then the drastic decrease in rice production in drought year will be avoided in some degree. The present population of the Pilot Area is estimated at 6,200 people, and the rice production per person will be 485 kg.

At the 10% of the irrigated land, vegetables such as tomato, watermelon will be grown intensively after the harvest of the rainy season rice.

In the supplement irrigation area, the rice yield will increase and stabilize and farmers will keep the rice for self consumption. Then,

the diversification of growing crops will be promoted.

The cropping pattern, calendar of farming practices, input materials and labor distribution in the double cropping under irrigation were shown in APPENDIX D Figures D-5 ~ D-7, Tables D-25, D-26, respectively.

At the upland area, introduction of agroforestry systems will improve the soil and extend the kind of survival crops and finally the land utilization ratio will reach to 100%.

When the land use plan realized, the average area of paddy field and upland field per farmer will become 1.92 ha (12 rai) and 1.6 ha (10 rai), respectively. At present, the cropping area per farmer is 2.56 ha (16 rai)-paddy 13.9, upland field 2.3 rai-, increase of upland field area is remarkable.

However, nearly a half of the upland area is pasture land and major part of the area will be covered with perenial tree crops such as fruit and mulberry. To establish the tree crop and pasture, input materials and labor are necessary to a certain degrees. After establishment, the management is more easy than annual crop.

The growing area of the cash crops will be 350 ha and this area is equal to the present planted area of cassava. The production of cassava will be same as the present production.

In agroforestry, the area ratio of tree and crop is flexible but in general line planting type, crops hold around 70% of the land area, and multipurpose tree such as fodder, manure, fuel tree will be grown in 30% of the land area. To avoid competition, trees should be trimmed several times a year, but decrease of crop yield is unavoidable until the improvement effect will appear.

The projected number of cattle or buffalo is 2,600 head, this is 1.7 times of present number, average heads of farmer will be about 2.4 head. (APPENDIX D Table D-28).

Planned mulberry field area is 57.6 ha (360 rai), it is 4.3 times that of in 1989. In future, the bivoltine sericulture will be increased in this area too, and in this case the standard management size of a farm household will be expand to 0.64 ha (4 rai). At present the number of sericultural farmer is estimated at about 600 houses and a half of them is estimated to change their sericulture from polyvoltine to bivoltine.

Final production will be 2.3 ~ 3.4 ton of raw silk and 90 ton of

Table 7-6 Target of Agricultural Production (Pilot Area)

Land use plan		Irrigation wet	Irrigation dry	Area	Crops, Target yield: Wet season	Crops, Target yield: Dry season	Target production		Present Production
Lowland	Paddy	I		380 [320]	t/ha (kg/rai) Rice 3.0 (480)	t/ha (kg/rai)	ha 320	t 960	** Paddy area 3,020 ha (18,870rai) Harvested A. 920 ha (5,750rai) Yield 1.5t/ha. Harvested area (240kg/rai.Harvested area) Production 1,380 t
	Paddy (Second Crop)		I			Tomato 23.0(3,680)	5	115	
						Watermelon 13.1(2,100)	5	65	
						Groundnut 2.3(370)	11	25	
						Sweetcorn 9.9(1,580)	11	110	
	Paddy	R		1,770	Rice 1.9 (300) / Harvested area	-	1,060 ha (Harvest.A)	2,010 t (Rice)	
	Pasture (Salt A.L)	R	R	210	Atriplex spp. Salt tolerant grass/tree		Cattle,Buffalo 250 head		
Upland	Fruit /tree	R	R	180	Mango 3.1 t/ha (500) Juckfruit 6.3 (1,000) S.Tamarind 1.0 (160)		80 ha 50 50	250 t 315 50	
	Mulberry /tree	R	R	360 [290]	Bivoltine cocoon 0.4 (60) Multivoltine cocoon 0.3 (40)		230 ha 60	Cocoon 90 t Cocoon 20	Multivoltin field 80 ha Yeild 110 kg/ha Cocoon porduction 9 t
	Cash crop /tree	R	R	500 [350]	Cassava 18.8 (3,000) Kenaf (stalk) 5.6 (900) Sugarcane 37.5 (6,000)		190 ha 130 30	3,570 t 730 1,130	4,460t (1988)-1,560 t (1989) 240 - 120 150 - 680
	Pasture /tree	R	R	800 [560]	Ruzi (dry m.) 7.2 (1,150) Hamata (dry m.) 6.9 (1,100)		390 ha 170 *Cattle/Buffalo 2,681	2,810 t 1,170	Cattle/Buffalo 1,570 head

Notes: I-Irrigation, R-Rainfed, [ ] the net planting area of main crops. *-Total heads in the polot area
**-Paddy area was based on the Aerophoto data.

bivoltine cocoon. To promote bivoltine sericulture, the higher technique will be necessary.

Also on the traditional polyvoltine sericulture, the room for technical improvement is very large.

(3) Technological problems

The most important problems to be solved in the Pilot Area should be the countermeaures to salt-affected land.

One of the countermeasures is to introduce of the salt tolerant crops to the strongly affected area. In this plan Atriplex spp.was chosen as tolerant crops. This species is used for feedstuff in Australia and its high tolerance to saline soil is already proved.

In Thailand, however, the research for introduction is going on, but there is no example of cultivation in the farmer's field.

Beside this there is some promising species as follows :

- Tamargo (Prosopis tamargo, leguminous, evergreen small arboreal tree, fodder tree)
- Silt grass (Paspalum vaginatum, Gramineae, perennial hearb, for pasture)
- Mesquite (Prosopis, leguminous, tall shrub, fodder tree)

These crops are grown at special area and not popular over the world. To introduce these exotic species, following items should be noticed, that is, adaptability to the environment, prevention of epidemics and insects, spreading as wild vegetation. Dr. S. Arunin reported on the salt tolerant natural vegetation in Thailand (reference D-3), utilization of those plants should be studied.

To the slightly salt-affected area, introduction of Barmuda grass, Hybrid napiergrass should be studied.

Agronomical countermeasures to salt affected area is as follows.

According to the study carried out at Phra Yun village by ADRC, at the place covered with white salt patch, there is a thin impermeable soil layer near the ground surface. This layer contains salts and is the secondary source of the salt to the patch. As countermeasure, break up of the impermeable layer, controll of the evaporation from soil surface, protection from the salt water and fine clay which flow into paddy, were shown. These measures should be adopted to our plan.

The growing method of paddy in the salt-affected area was studied by DLD, by the synthesized technique of following measures the paddy yield was increased to 300-500 kg/rai from 100-150 kg/rai, input of organic matter, adoption of salt tolerant varieties, planting of matured seedling with long distance, manuring, irrigation, controll of pest, covering of soil surface with straw. Paddy itself is not so tolerant to salt and around 7 mmho/cm the growth decrease to a half of normal growth (APPENDIX D Figure D-3, Table D-22,D-23).

DLD pick up following varieties as salt tolerant variety-Khao Dawk, Mali 105, RD-6, RD-8, RD-7, these should be adopted to our plan as much as possible.

Field crops grown under irrigation in dry season will be apt to recieve salt affects, so the growing crops is better to be selected from salt tolerant crops. Leguminus crop such as groundnut is weak to salt affect then it should be change to cowpea or more tolerant crops in the salt-affected area.

7-3-3 Countermeasures for Salt-Affected Area

It should be emphasized that the confined effect has caused the saline groundwater to emerge in the surface of the siltstone. An engineering proposal on the countermeasures for salt-affected area is to prevent dispersion of saline groundwater in the unconsolidated layers after it emerged to the surface of the siltstone.

The saline groundwater flows eastward through the gravel beds until the terminal of the bed and it decreases flow velocity where more low permeable layers of the terrace and alluvial beds are underlain. A location of the terminal is identical with a topographic break between an upper and lower terraces.

A drainage on the terminal of the gravel beds can play the most important role to prevent dispersion of the saline groundwater. A proposed site for this drainage is along a tributary of Huai Yai on the left bank.

According to the laboratory test, estimated permeability of the drainage material is 5×10^{-4} cm/sec.

To accelerate seepage, a drainage should be excavated until the surface of siltstone. Based on the geophysical prospecting, an altitude of siltstone surface near the proposed site ranges from 170 to 175 MSL.

Although the most recommendable way to manage the drained saline groundwater is an evaporation in the pond, to flush out the drained water to the lakes and Lam Chi on the east end of the area through the existing channel and/or constructed drainage is also one of recommendable alternative plan when the environmental assessment is properly cleared.

A problem arised for the drainage which constructed a crossing point of Huai Yai and Highway. Depth of the drainage is about 2.2 mbgs which is about 40 cm below the top of siltstone and EC in the siltstone is more than 20,000 μS/cm. Although groundwater table of the siltstone in the dry season indicates 10 cm below the top of siltstone, it may be rised above the top of siltstone during rainy season and drain to the down-stream where the siltstone aquifer decreases EC to less than 2,000 μS/cm.

From this fact it is concluded that the drainage should be backfilled up to the enough height from the top of siltstone to prevent groundwater seepage to the channel.

Based on the view of irrigation and water management of view in the Pilot Area, a plan of measure for salt-affected damages shall be established in consideration of preventive measures. It is obviously effective to carry out irrigation for infiltrate the salt concentrated water from soil or groundwater this prevents salt reaching into the root zone of crops. Preventive measures to the salt concentration promoted by a poor water management shall be considered also.

If salt leaching to the root zone from groundwater or deep soil is prevented, the direction of soil water flow must be to kept as gravity direction during the planting period. Irrigation which supplies water continuously is a very effective measure; especially ponding irrigation on paddy fields is the most effective measure for salt affected damages. When upland irrigation is carried out in salt effected areas, the irrigation plan shall be considered also on the leaching amount which will be added to the general water consumption. Water seepage from storage ponds and canals, as a loss of limited water resources, will be conducted to the groundwater level under these irrigation facilities. This water quality will be worse due to the infiltration of groundwater containing a high salt concentration into irrigation facilities. Therefore irrigation facilities shall be made with adequate lining, depended on facilities scale and economical point of view. Water delivery, management and water quality management to supply adequate water quality and amount. In the salt-affected area, if these water managements are not carried out intensively, salt-affected damages will be enlarged in the whole irrigation area. According to

the scale of facilities and social customs, the Water User's Group as management organization shall be established by farmers based on the village committee. However, related public organizations such as DLD or RID, shall be joined with the Water User's Group in the management works. Especially when the adjustment on water-use is required or facilities are fatally damaged by disaster, technical and economical assistances from these public organizations are quite important.

7-3-4 Irrigation and Drainage Plan

(1) Irrigation Water Requirements

Irrigation water requirements are obtained basing on plan, crop pattern and the FAO irrigation and drainage paper No. 24. Data used for Nong Way-Nam (NW-NP) project adjacent to the Pilot Area are referred.

1) Crop Consumptive Use (Et crop)

Evapotranspiration (ETo) was estimated by using the meteorological data for the period of 30 years (1956-1985) at Khon Kaen. Crop consumption use can be obtained as crop coefficient (Ko), which is varied of each crop growing stage.

2) Other Water Requirements

Land preparation period is 30 days and pudding water requirement is 300mm, water requirement for nursery and others is 100mm. Percolation loss is 1.0 mm/day cosidering the data of NW-NP project and the result of water requirement study in paddy field.

3) Effective Rainfall

1984 monthly rainfall at Amphoe Phra Yun with a 3-year return period was adopted. Effective rainfall coefficient was adopted 75%, being used on a irrigation plan in Thailand.

4) Irrigation Efficiency

Irrigation efficiencies are assumed referring to FAO irrigation and drainage and paper No.24 as shown in the following.

	Conveyance efficiency	Water application efficiency	Overall efficiency
paddy	80 %	75 %	60 %
upland	80 %	60 %	50 %

5) Leaching Requirement (LR)

It is a very important factor for leaching salt from soils by irrigation and drainage. Leaching on irrigation paddy field is done through puddling water and on-paddy field water storage, considered as the growing period of rice. For upland the gross water requirement shall be added to leaching requirement. Leaching requirement can be estimated making reference to FAO irrigation and drainage paper No.24 as follows.

In estimating LR, 100% of potential yield of upland crop is proposed; thus ECe is 1.7 mmhos/cm. LR is computed at 21% of gross water on condition that ECw is 0.8 mmhos/cm and a leaching efficiency (Le) is 50% (for clay and sandy soils).

6) Gross water requirement

Gross water requirement is estimated at 1000 mm/year. Net water requirement is 577 mm/year.

(2) Irrigation Facilities Plan

1) Plan of irrigation area

Three sites are selected. Two are located in paddy area between main road and Yang river, another is along a canal to Nonk weir. Areas of two sites (No.1; up-stream, No.2; downstream) along the Yang river are 158 ha for No.1 and 166 ha for No.2. Each site is divided into three blocks of around 50 ha by considering efficiency of water management.

Area along the canal to Nonk weir is 57 ha and is planned at one block. Total area of planned irrigation areas is 381 ha. Beneficial areas of each site and block and location are shown in Figure 7-7.

Table 7-7 Proposed Irrigation Area in Pilot Area

No.1 on upperstream, Gross Irrigation Area, 161.4 ha

	Block areas (ha)	Pond area (ha)	Reservoir area (ha)
A	64.5	-	6.3
B	43.0	4.3	-
C	50.1	5.0	-
	157.6	9.3	6.3

Net irrigation area: 133.5 ha

No.2 on Downstream, Gross Irrigation Area, 169.9 ha

	Block areas (ha)	Pond area (ha)	Reservoir area (ha)
A	71.3	-	7.5
B	47.3	4.7	-
C	47.6	4.8	-
	166.2	9.5	7.5

Net irrigation area: 141.0 ha

No.3 Nakphreecha Plan Efficiency

Gross irrigable area (ha)	Pond area (ha)	Net irrigable area (ha)
56.8	4.8	46.8

Gross irrigable area 157.6 + 166.2 + 56.8 = 380.6 ha
Net irrigable area 113.5 + 141.0 + 46.8 = 321.3 ha

2) Irrigation Facilities Plan

Irrigation facilities are planned, based on the water storage in river systems taking account of the present condition of irrigation and water resources in the Pilot Area as follows;

Table 7-8 Proposed Irrigation Facilities

	No.1	No.2	No.3
(1) Weir			
a) Water intake point	Huai yang Waeng Hin Kon weir	Huai yang 1.5km form a main road.	Nong Ku weir
b) Weir height	3.0m	3.0m	-
c) length, height	l=400m H=3.0m	l=200m H=3.0m	-
(2) Pond			
a) Pond area			
A Block	6.3 ha	7.5 ha	4.8 ha
B Block	4.3 ha	4.7 ha	-
C Block	4.0 Ha	4.8 ha	-
Total	15.6 ha	17.0 ha	4.8 ha
b) Active depth	3.5 m	3.5 m	3.5 ha
(3) Canal			
a) Headrace length	1600 m	2200 m	-
b) Second canal length			
a) Pond area			
A Block	1600 m	2200 m	1700 m
B Block	500 m	400 m	-
C Block	1100 m	500 m	-
Total	3200 m	3100 m	1700 m
c) Third canal length			
A Block	3300 m	3900 m	3400 m
B Block	2100 m	1700 m	-
C Block	2300 m	1800 m	-
Total	7700 m	7400 m	2400 m
(4) Check gate (site)			
a) Pond area			
A Block	8	8	7
B Block	4	2	-
C Block	5	2	
Total	17	12	-

(3) Water Management Plan

Main items needed for water management are water distribution, maintenance and water quality.

1) Management of Water Distribution

According to the irrigation plan, the operation of gates and pumps and regulation of water use in droughty stage will be done for the distribution of a suitable amount of water up to the furthest inlet.

2) Maintenance

For keeping function of facilities such as pond and canal etc., daily check, clearance and repair and emergency measures will be done.

3) Water Quality Management

In salt-affected areas such as the Pilot Area, it is important to check the quality of water in ponds and reservoirs. Salinity should be measured at least once in a week for decision of whether usable or not for irrigation.

For above items 1) and 2) it is better to be done by farmers by joining with the water management organization and for 3) by officials of organization such as DLD Regional office (5) working with the water management organization.

4) Drainage Plan

The proposed drainage plan covers an area of 820 ha, including moderately salt-affected land (300 ha) and slightly salt-affected land (520 ha). The proposed drainage area will be mainly used for paddy fields in land use planning. Main features of drainage facilities such as interceptor drains, evaporation ponds and field drains are as follows;

- Proposed drainage area 820 ha
- No. of interceptor drains 5
- Total length of interceptor drains 9.6 km
- No. of evaporation ponds 5
- No. of field drains 4
- Total length of field drains 6.1 km

FIGURE 7-7 LOCATION MAP OF PLANNED IRRIGATION AREA (PILOT AREA)

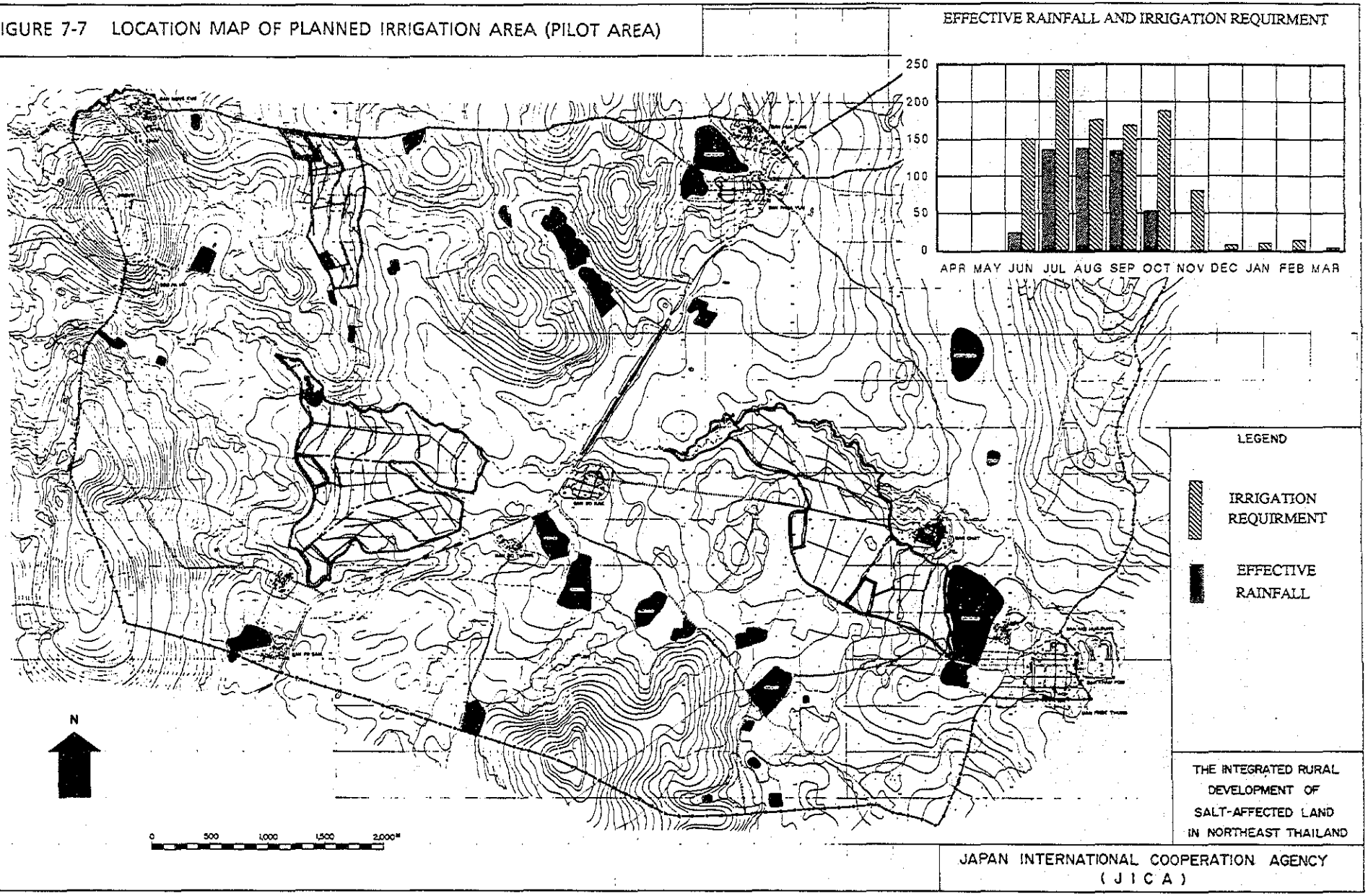


FIGURE 7-8 PROPOSED DRAINAGE CANAL

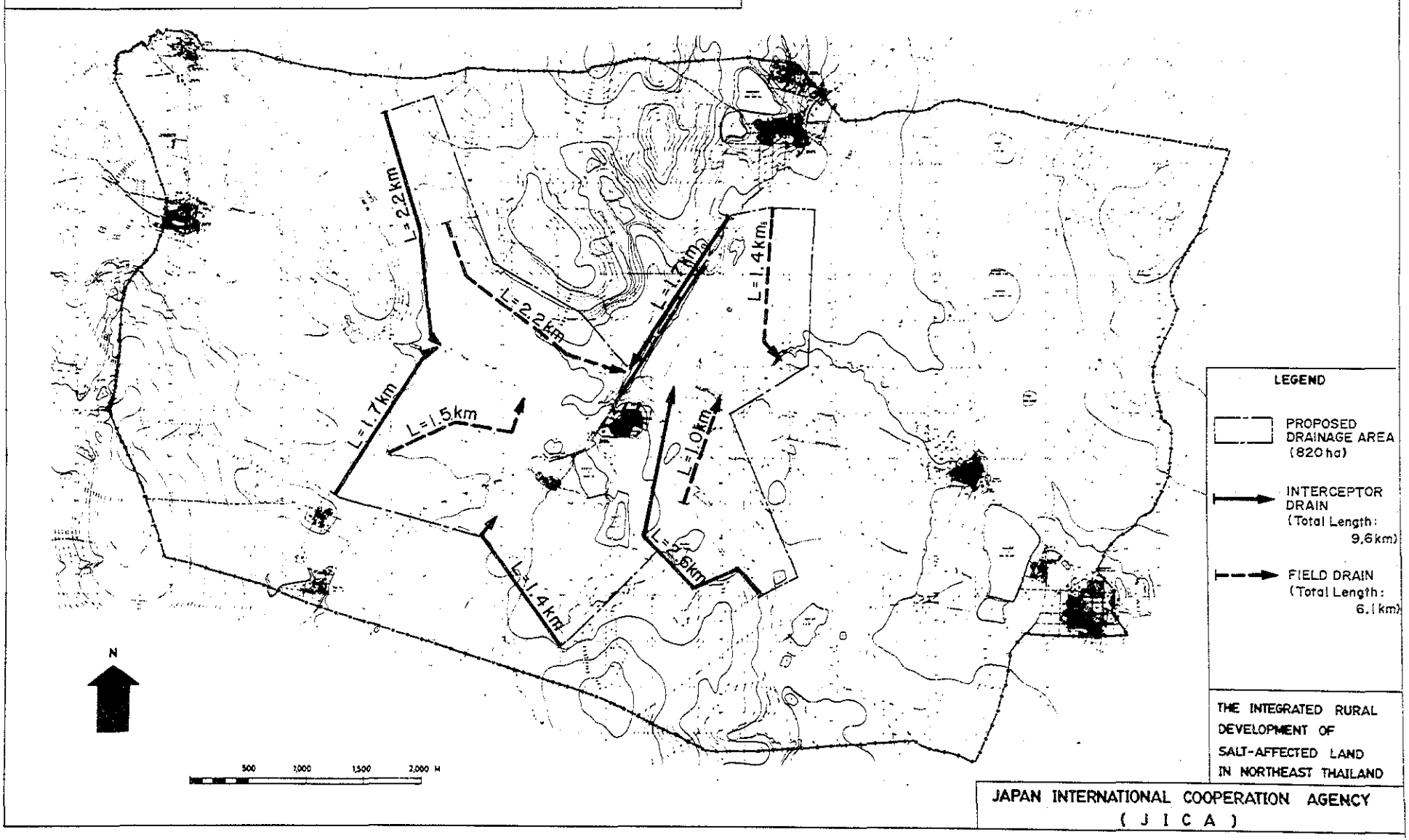
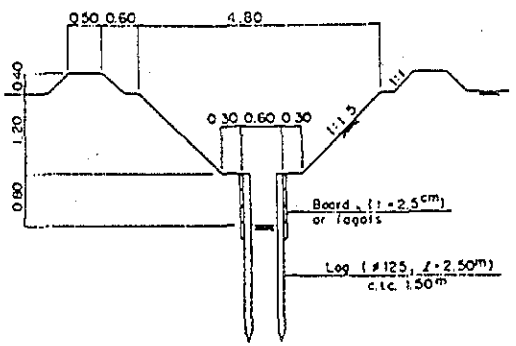
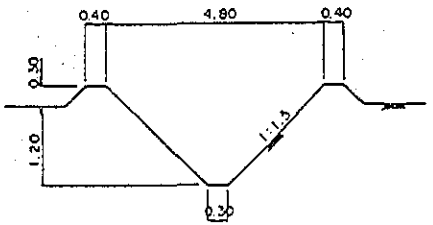


FIGURE 7-9 DRAINAGE FACILITIES

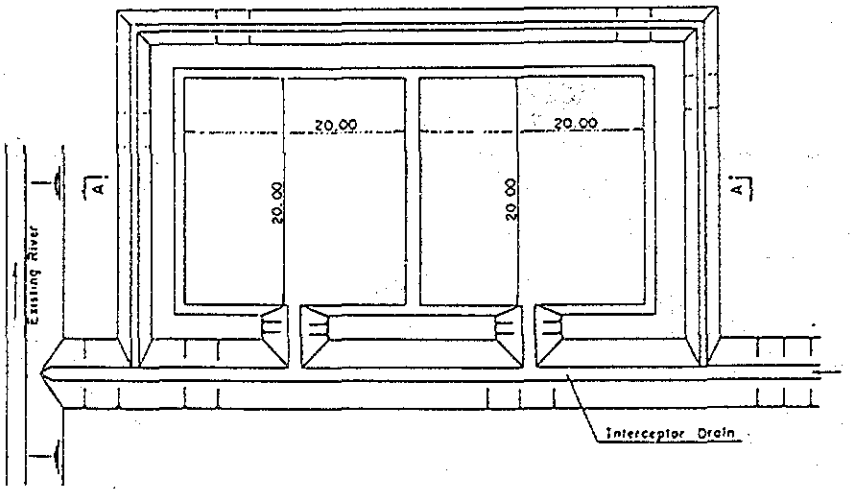
Interceptor Drain



Field Drain

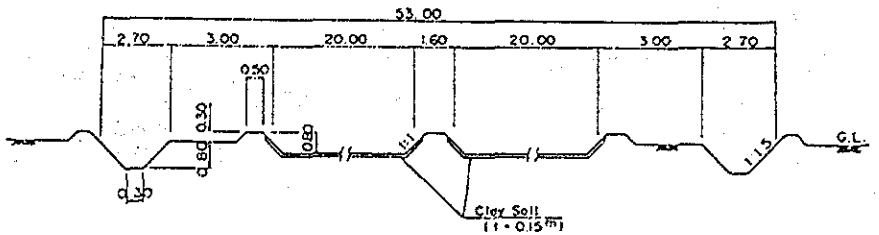


Evaporation Pond



PLAN

SECTION A-A



7-3-5 Rural Infrastructure Plan

(1) Rural Roads

As the density of rural roads in the Pilot Area is considered sufficient, the construction of new roads is not planned. From the present traffic in this area the widening of existing road-width is also not necessary. Earth filling for road embankment, however, is planned at topographically low parts in order to prevent flooding during the rainy season. Besides, drainage culverts will be provided under these portions.

In village areas, main rural roads are to be paved by asphalt in order to prevent heavy dust by passing vehicles during the dry season and muddy surface during rainy season.

(2) Rural Water Supply

The rural water supply in the Pilot Area is planned in the same manner of the Master Plan Study (see Section 4-7-3).

The following facilities are proposed:

1) Facilities for drinking water supply to two villages, Pa San 1 and 2, where drinking water is required seriously.
2) Facilities for drinking water supply to two villages, Phra Yun and Hua Bung, in the center of Amphoe Phra Yun
3) Facilities for water supply to facilities in the Amphoe-office compound
4) Facilities for water supply to the Phra Yun Central Market for washing purpose

(3) Other social infractructures

Other social infrastructures such as facilities for technical training, recreation, market etc. are notified in Social Service Plan.

For public sanitation, the construction of concrete-made septic tank for each household is recommended.

7-3-6 Social Service Plan

Following facilities are considered to be established.

(1) Sports and Recreation Facilities

A multi-purposed sporting ground with recreation facilities will be established at the soccer ground in front of the present Amphoe-office.

(2) Technical Training Facilities

These facilities consist of following three components.

- A Training Building
- A "Madmee" and Handicraft Factory for Training Purpose
- A Food Processing Factory for Training Purpose

The Training Building is subjected to be used for administration, classrooms and workshops.

The factories will be used for dual purposes, training and producing goods for local raw distribution.

These facilities will be installed in the compoud of Amphoe-office.

(3) Marketing Distribution

The Phra Yun Central Market consists of six portions, namely 1) vegetables and fruit, 2) fish and meat, 3) other food staffs, 4) daily goods etc., 5) refreshment-shops and 6) related facilities.

Installations of goods-storage and slaugter house should be considered near to the parking area.

Details on these facilities are described in 7-3-7 "Proposed Facilities".

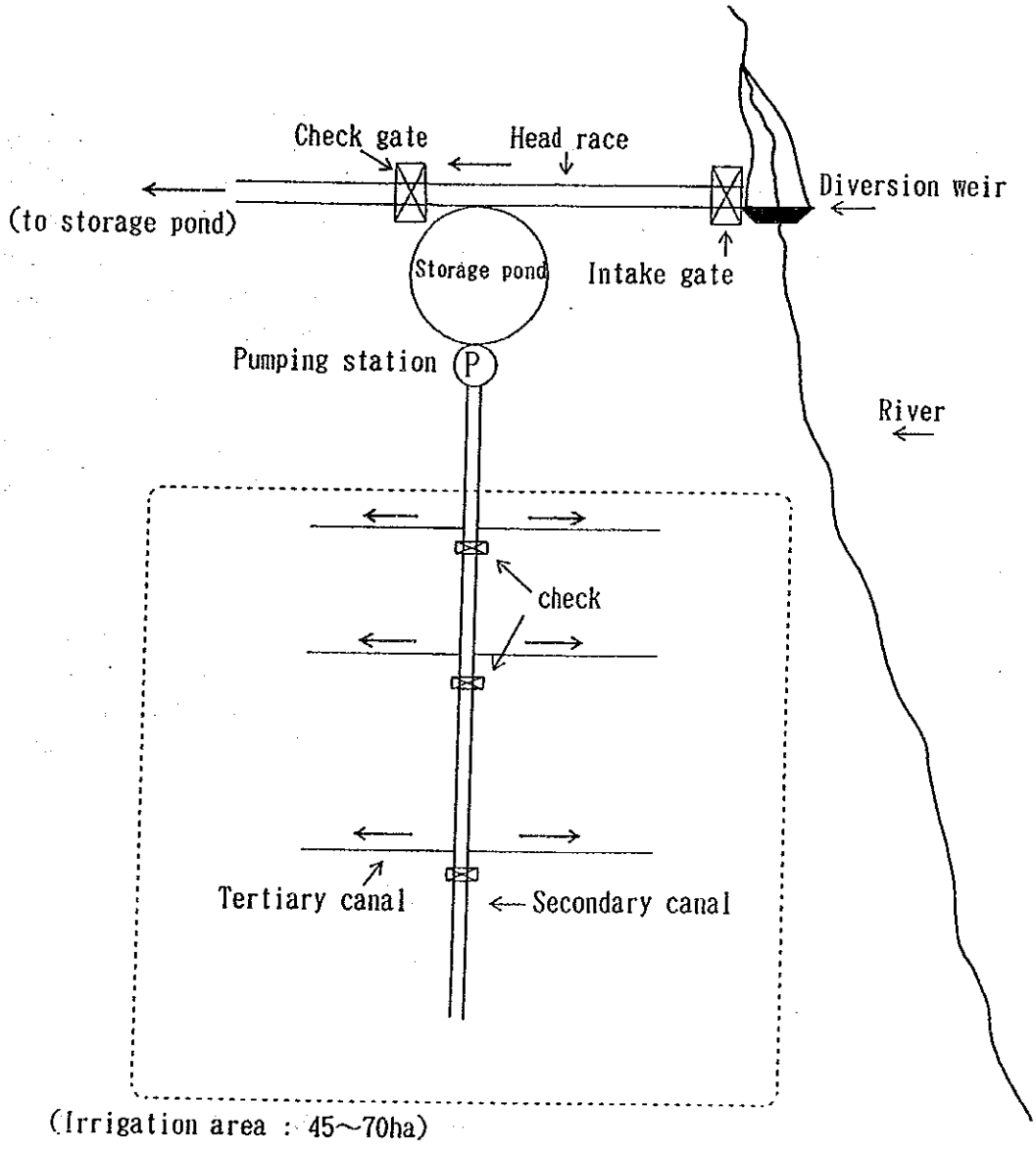
7-3-7 Proposed Facilities

(1) Irrigation Facilities

Diversion weirs, head race canals, storage bonds, pumping stations, irrigation canals and their appurtenant structures such as check gates are provided as irrigation facilities in the Pilot Area.

The irrigation system is shown in the following Figure.

Figure 7-10 Proposed Irrigation Facilities



1) Diversion weir

Diversion weirs with fixed-type concrete structure are to be constructed in the Yang river in the Pilot Area. The height of the weir is so determined that water can flow by gravity through the diversion weir into the strage pond. Earth filling of the river embankment is required at upstream portion which will be covered by the back water.

An intake gate is installed at the weir in order to lead water to head race canal.

2) Head race canal

A head race canal is proposed to convey water from the intake to the storage pond by gravity. A concrete lining is provided on the canal surface.

3) Storage pond

A storage pond is planned to store irrigation water through the head race canal at the higher part of the irrigation area. In order to prevent intrusion of saline water from the outside and to prevent leakage of water from the pond, lining is required. As the capacity of the storage pond is high, the soil cement lining will be provided on the slopes and bottom of the pond to save the construction cost. Effective water depth of the storage pond is set up at 3.5 m due to the limitation of land (about 5 ha).

A pumping station is planned at the storage pond to lift water to the irrigation canal during the period that water can not flow by gravity from the pond to the irrigation canal.

4) Pumping station

Two pumps with the same diameter are to be required in order to apply to the fluctuation of water demand during a year, and to make easy for changing parts in maintenance. As for power, diesel engines are provided due to the difficulty of obtaining the electric power at the pumping station.

Scale of pumping station is as follows :

Design lifting water	:	0.16 to 0.20 cu.m/sec.
Total pump head	:	8 m
Pump diameter	:	200 mm × 2 heads
Power	:	11 to 15 kw per pump

5) Irrigation canals

A secondary canal is arranged at the same direction with the topographical slope. Meanwhile, teritiary canals are at the same

direction with contour lines. These canals are planned as trapezoid sections with soil-cement lining. Check structures of stop log type are provided on the secondary canal in order to control the required design water levels in tertiary canals.

A drop structure will be constructed, if necessary, to maintain the design slope of the secondary canal.

Design criteria of irrigation canals are as follows :

Canal	Canal slope	Design discharge (m^3/s)	Bed width (m)	Water depth (m)	Side slope
Secondary canal	1/1,000	0.16-0.20	0.40	0.34-0.38	1:1
Tertiary canal	1/5,000	0.04	0.30	0.28	1:1

(Coefficient of roughness : n = 0.016)

(2) Drainage Facilities

Main drainage facilities in the Pilot Area are proposed as follows :

1) Interceptor Drain

Sheathing type of interceptor drain with 2 m depth is adopted to minimize the constructing land width.

Five interceptor drains with total length of 9.6 km are planned in the Pilot Area.

2) Evaporation Pond

An evaporation pond will be provided at the end of interceptor drain with an area of 800 sq.m (20 m × 40 m) and a depth of 0.5 m.

3) Field Drain

Unlined field drains are planned at the depth of 1.2 m below the ground surface. Four of field drains with 6.1 km length are proposed in the Pilot Area.

(3) Rural Road

The following constructions are planned for the improvement of rural roads in the Pilot Area :

1) Earth filling of road embankment and provision of drainage culverts

Earth filling : 10 places, 100 m length per one portion

Drainage culverts : 10 places, 10 m length of concrete pipes (Ø600)

2) Road pavement in village areas
Subjected villages : 15 villages, 500 m length per one village
Paving conditions : Asphalt, 3 m width and 3 cm chickness

(4) Facilities for rural water supply

Following facilities for rural water supply are planned in the Pilot Area :

1) Facilities for Drinking Water Supply

a) Villages Pa San 1 and 2
Population : The present population (about 1,000 persons from 200 families) is adopted.
Water resource : The groundwater (the quaternary aquifer ; Pa Mo gravel bed) located in the western hilly area of these villages is pumped up by means of 2 wells.
Designed lifting water : 48 × 1/2 cu.m/day/well (8 hours/day)
48 l/day/person
Depth of the well : 30 m
Designed water level : GL-20 m
Supply system : Deep well (Submerged pump)
→ Distribution Tank
→ Public water taps

b) Villages Phra Yun and Hua Bung in Amphoe Phra Yun
Population : Present population of about 2,800 persons
Supply amount per persons : 45 l/day/person
Proposed daily supply amount : 45 l/day × 2,800 = 126 cu.m/day
Water resource : The Phra Yun pond
Water resource : Pond (pump) → Purification facilities → Public water taps
Supply system : Pond (pump) → Purification facilities → Public water taps

2) Water Supply System for the Phra Yun Amphoe Office Compound
Subjected facilities : 20 cu.m/day
Proposed daily supply amount : The Phra Yun pond
Water resource : The Phra Yun pond
Supply system : By using the distribution system for 2 villages, Phra Yun and Hua Bung, the water is

distributed to subjected facilities in the Phra Yun Amphoe office compound.

3) Supply System of Washing Water to the Phra Yun Central Market
   Proposed daily supply amount : 15 cu.m/day
   Water resource : The Phra Yun pond
   Supply system : same as 2)

(5) Facilities for Social Service

Following buildings are planned as social service facilities in the Pilot Area :

1) Sports Ground in Amphoe Office Compound
   The soccer ground in front of the present Amphoe Office would be made into a multi-purposed sports ground.

Details of the sports ground are as follows.

a) A soccer ground with a meeting hall for communication-purpose
b) A 4m-width running track around the soccer ground
   (L: 400~450m)
c) A 100-seat concrete-stand with locker-room and shower & WC
d) Sports equipment (1 set)
e) Lighting installation (1 set)

2) Phra Yun Central Market

a) Land area : 8,000 sq.m
b) Office and storage
   Floor area : 450 sq.m (15 m × 30 m)
   Structure : R.C.type, brick wall
c) Market building
   Floor area : 1,600 sq.m (40 m × 40 m)
   Structure : Steel frame type, no wall, slate roofing

3) Technical Training Center
a) Training building
   Total floor area : 1,100 sq.m (1F : 20m×30m, 2F : 20m×25m)
   Floor Partition
   * Training Rooms : 700 sq.m (1F & 2F)
   * Show Room : 60 sq.m (1F)
   * Dormitory : 120 sq.m (2F)
   * Corridors and Stairs : 220 sq.m (1F & 2F)
   Structure : R.C.type

b) Handicraft factory (for training purpose)

Floor area : 750 sq.m

Structure : Steel frame type, concrete block well

c) Food processing factory (for training purpose)

same as b)

Equipments for the Technical Training Center are notified in APPENDIX K.

7-3-8 Project Cost

(1) Project Cost

1) Bases of Estimation

The project cost is estimated based on the following conditions at a 1991 price level.

- The construction cost is estimated based on the work quantity and the project implementation schedule.
- Unit rates for estimation of the construction cost are adopted mainly current unit rates employed in DLD, and ARD and RID, if necessary.
- 10 percent of physical contingencies are considered. Price escalation contingencies are based on Manufactures Unit Value Index, World Bank (Oct. 1990) for foreign currency component and Weighted Producer Price Index, Bank of Thailand (Dec. 1989) for local currency component, respectively.
- A foreign exchange rate of US $ 1.00=Baht 25.00 is applied.

2) Component of Project Cost

The Component of project cost consists of construction, procurement of equipment, agricultural extension service, land acquisition, administration, consulting services, and physical and price contingencies.
The construction works consist of irrigation and drainage facilities, rural road, rural water supply facilities, reforestation and social service facilities. Those works will be executed on a contract basis.

3) Project Cost

The project cost for the Pilot Area amounts to 315 million Baht, of which 120 million Baht are local currency and 195 million Baht are foreign currency component. The project cost is summarized as shown in Table 7-9.

Table 7-9 Project Cost of the Pilot Area

Items	Cost (×1,000 Baht)		
	L/C	F/C	TOTAL
1. Construction cost			
(1) Irrigation facilities	33,955	56,861	90,816
(2) Drainage facilities	8,669	1,723	10,392
(3) Rural road	1,494	2,076	3,570
(4) Rural water supply facilities	3,300	7,276	10,576
(5) Reforestation	6,224	-	6,224
(6) Social Service facilities	22,106	30,919	53,025
Sub-total	75,748	98,855	174,603
2. Equipment	1,742	34,853	36,595
3. Agricultural extension service	2,533	2,756	5,289
4. Land acquisition cost	1,784	-	1,784
5. Project administration	8,381	2,095	10,476
6. Consulting service	1,399	20,428	21,827
Total 1. ~ 6.	91,587	158,987	250,574
7. Physical contingency	9,159	15,898	25,057
Total 1. ~ 7.	100,746	174,885	275,631
8. Price Contingency	19,108	20,679	39,787
Grand Total	119,854	195,564	315,418

(2) Annual Project Cost

Annual project cost is based on the project implementation schedule and the summary is shown in Table 7-10.

Table 7-10 Annual Project Cost

Year	Cost (×1,000 Baht)		
	L/C	F/C	TOTAL
1st.	3,793	17,825	21,618
2nd.	58,674	103,205	161,879
3rd.	57,387	74,534	131,921
Total	119,854	195,564	315,418

7-3-9 Project Implementation Programme

(1) Organization and Management

1) Project Implementing Agencies

The following committees have to be established and to give necessary directives and strong commitments, to guide and coordinate actions of governmental agencies concerned both in Bangkok and in Changwat in order to ensure the successful performance of the Project.

- Ministerial Level Committee
- Sub-committee for project Level
- DLD Working Committee

Activities of these committees are mentioned in Chapter 5, 5-1 "Organization and Management".

2) Project Implementing Agencies

The five governmental agencies under the above committees should be responsible for the following functions.

- Department of Land Development (DLD), MOAC
  Planning and construction of irrigation and drainage facilities.

- Office of Accelerated Rural Development (ARD), MOI
  Planning and construction and O/M of rural road.

- Royal Forestry Department
  Planning and implementation of reforestation.

- Amphoe Office, MOI
  Planning and construction of rural water supply and social service facilities.

- Department of Agricultural Extension (DOAE), MOAC
  Assistance in organizing Farmers' Groups.

3) Implementation Schedule

After completion of fund arrangement for the project, construction works covering detailed design and land acquisition will be carried out. The construction works are composed of

irrigation and drainage facilities, rural roads, rural water supply facilities, reforestation, and social service facilities.

It is considered that the implementation of irrigation and drainage facilities is subjected to be commenced first, and rural water supply and social facilities are to be constructed in later years.

The project implementation period for these construction works including design works is scheduled for three years as shown in Figure 7-10.

(2) Operation and Maintenance

1) Responsible Agency

The project of the Pilot Area involes the same components as those of the study area. The following agencies are responsible for maintenance and operation as mentioned in Chapter 5, 5-2 "Operation and Maintenance".

- Irrigation and Drainage ---------- Water User's Group
- Rural Road ---------- ARD
- Rural Water Supply ---------- Water User's Group and Amphoe Office
- Reforestation
  (Forest Reserved Land) ---------- RFD
  (No-Forest Reserved Land) ------- Producer Grouping
- Social Service ---------- Amphoe Office

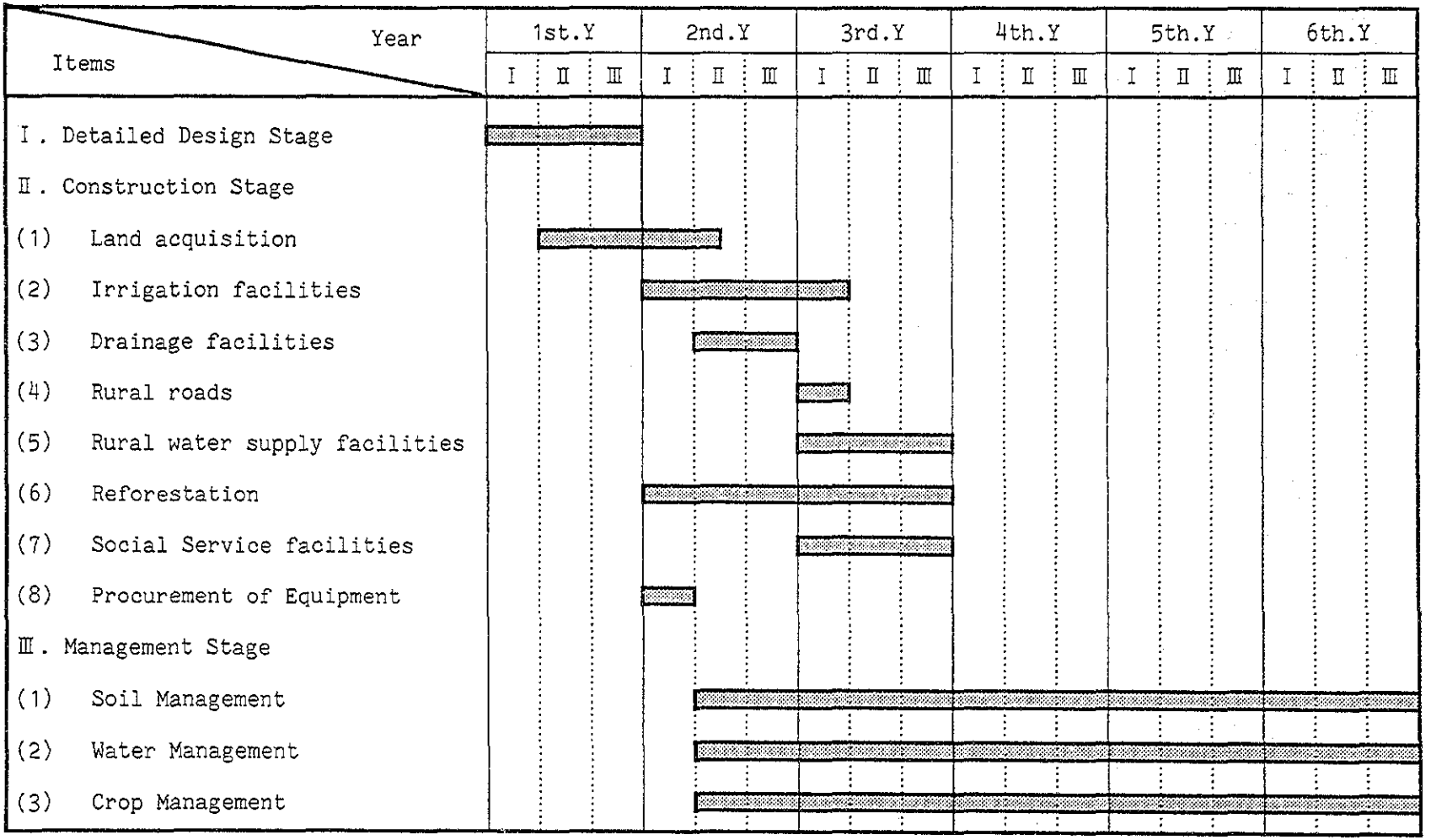
2) Operation and Maintenance Cost

After the construction works are completed, the following costs will be born every year for operation and maintenance of the project.

Table 7-11 Annual Operation and Maintenance Cost

Description	Cost (×1,000 Baht)
(1) Maintenance cost for facilities	776
(2) Operation cost for pumps	943
(3) Administration	2,967
Total	4,686

Figure 7-11 Implementation Schedule for the Pilot Area



(3) Consulting Services

The proposed project involves various components, for which coordination among related agencies shall be required. In this connection and for smooth implementation of the project, engineering consultants shall be mobilized. They are responsible for assisting DLD and other agencies preparation of detailed design tendering activity, and supervision of construction works.

7-3-10 Project Evaluation

(1) Introduction

1) Method of Evaluation

The project aims to enhance the living standards of the local peoples in the salt-affected land of the Northeast Thailand and to rectify income distribution between the rural area and others in Thailand. To achieve the above two objectives, the Project places the emphasis on the improvement of rain-fed agriculture and the development of irrigation, agroforestry, rural road, market and agricultural supporting services. The Project is one of the important regional development plans deeply related to the major governmental development policies.

The economic evaluation has been made by calculating an economic internal rate of return (EIRR) with sensitivity analysis, in which a project cost and a tangible benefit are to be calculated by applying an economic price (accounting price). The EIRR can be worked out by discounting both streams of economic cost and benefit over a period analysis with several discount rates. On the other hand, a sensitivity analysis is one of method to check the risk of the project to be affected by change of key factors. Project cost and benefits were estimated for 50 years as the project life by constant price as of 1990.

In this study, the farm budget analysis has been carried out as the project financial analysis. The prices to be applied for this analysis is derived on the basis of market prices of the respective good and service.

2) Prices

All prices to be applied have been estimated on the basis of the recent available information and data so far obtained as of the 1990. Out of input and output, the internationally traded goods and services have been estimated on the basis of their border prices, by quoting "Price Forecast for major Primary Commodities" published by the World Bank. In addition, in order to calculate their economic prices of internally traded goods and services, the following conversion factors have been quoted from the recent information provided by the World Bank:

Standard conversion factor · · · · · · · · · · · 0.92
Conversion factor for consumption · · · · · · · · 0.95

Conversion factor margin of middleman etc. · · 0.70
Conversion factor Construction · · · · · · · · 0.88
Conversion factor Transportation · · · · · · · 0.87
Conversion factor Farm labour · · · · · · · · 0.92

(2) Financial and Economic Cost

The total of project capital cost for the Pilot Area is estimated at 315.4 million Baht in financial value, which is equivalent to 143.4 million Baht in economic value. The project cost of financial base was converted to the border price by applying the standard conversion factor.

The conversion factor is also applied to the conversion for economic value of operation and maintenance cost. The operation and maintenance cost with project reaches 3.0 million Baht per year on a financial base and 2.8 million Baht per year on an economic base.

On the assumption that the Project will be started in 1993, annual project cost is tabulated as shown below ;

Financial and Economic Project Cost

(unit: million Baht)

Year	Capital Cost		O & M Cost		Total Project Cost	
	Financial	Economic	Financial	Economic	Financial	Economic
1992	–	–	–	–	–	–
1993	19.5	6.6	–	–	19.5	6.6
1994	143.5	74.3	–	–	143.5	74.3
1995	112.6	62.5	–	–	112.6	62.5
1996	–	–	3.0	2.8	3.0	2.8

(3) Project Benefits

From the national socio-economic point of view, various kinds of directly and indirectly associated benefits would be created from the Project. And, the project benefits consist of quantifiable and unquantifiable benefit.

The Crops production benefits which are the major tangible benefit and expressive in monetary terms shall be applied to the comparative study with the project costs. In other words, the Project includes such components as saline groundwater drainage system development, irrigation system development, rural road development, rural water supply facilities development, reforestation development, social

facilities development, and improvement of agri-supporting services, and realization of the Project will ensure to give favorable effects in increase of farmers income together with upgrading of all villagers living standard.

The quantifiable benefit of the Project is as follows:

Project Benefits

Items	Benefits (million Baht)
Agriculture (include Livestock)	15.6
Fishery	0.5
Domestic Water Supply	0.8
Rural Road	0.5
Total	17.4

(4) Economic Evaluation or the Project

1) Comparison of Cost and Benefit

- Economic Internal Rate of Return

The Economic Internal Rate of Return (EIRR) of the Project is estimated at 9.5 percent. Judging from the fact that the opportunity cost of capital in Thailand is 10 to 15 percent, EIRR of the Project is a little low as the economic index. However, agriculture of which benefit is the main benefit of the Project is the main industry in the country in spite of low productivity industry, and the implementation of the Project will pay the effective availability of resources and an important role in correcting the differences in living standards among regions in the country.

As for the method of Project evaluation on the development of salt-affected lands, however, there considered several alternative ideas. It is assumed with this concern that the crop out of salt content in the agricultural land is caused largely by some artificial works, but provision of drainage facilities for the purpose of salt wash-out is different in its nature from irrigation facilities for increased crop production. It is rather considered to be some measures for improvement of environmental condition. For this sake, therefore, the comparison of benefit and cost was made without taking into account the cost needed for salt wash-out.

The alternative EIRR of the Project is estimated at 13.3 percent, and it can be compared with the economic indexes of the other agricultural development projects.

- Sensitivity Analysis

Analyses have been made to test the sensitivity of the rate to other parameters than those considered probable in the initial calculation. The parameters employed are reduction in benefits, delay in benefits, increase in project costs, and combinations of these parameters.

Reduction in Benefit

If there were no efforts in crop cultivation technique by the farmers, good cooperation among the farmers, or effective supporting to the farmer by the government through agricultural extension service, it is impossible to accomplish target benefit. If benefits are reduced by 10 percent, EIRR will fall to 8.1 percent, respectively.

Delay in Benefit

Delay in benefit buildup may result from no effective supporting to the farmers by government through agricultural extension services for introduction of irrigated agriculture and agro-forestry, and improvement of rain-fed agriculture. If the agricultural extension service is not completed to bring delay in benefit by five years, EIRR will fall to 8.3 percent.

Economic Indicators of the Project

(unit: Present Value ··· Million Baht)

Alternative	NPV & B/C, discount rate at 8%				Economic Internal Rate of Return
	Present Value		Net Present Value	Benefit Cost Ratio	
	Benefit	Cost			
	(a)	(b)	(a)-(b)	(a)/(B)	
1. Proto-type (1)	144.57	127.11	17.46	1.14	9.5
2. Proto-type (2)*	144.57	93.40	51.17	1.55	13.3
3. 10% increase in capital cost	144.57	137.35	7.22	1.05	8.6
4. 10% reduction in benefit	128.22	127.11	1.11	1.01	8.1
5. Five-year delay in benefit	130.73	127.11	3.62	1.03	8.3
6. Combination of 3 and 4	128.22	137.35	-9.13	0.93	7.3
7. Combination of 3 and 5	130.73	137.35	-6.62	0.95	7.6
8. Combination of 4 and 5	116.05	127.11	-11.06	0.91	7.1
9. Combination of 3, 4 and 5	116.05	137.35	-21.30	0.84	6.5

Note ; * Without the cost of salt wash-out and social services.

2) Farm Budget Analysis

The farm budget analysis has been made for the average size at 3.0 ha (19 rai) of the owner farmers. The implementation of the Project will make it possible for those farmers to raise their living standard with the increase in cropping intensity and its yield.

Farm Income With-Project

(unit: ha, Baht/year)

Items	Future Without-Project	Future With-Project	
		Rain-fed Paddy Area	Irrigated Paddy Area
1. Cultivated Area	3.0	3.0	3.0
2. Total Cropping Area	1.2	1.8	2.6
3. Gross Income	7,272	22,826	26,988
4. Farm Household Income	2,712	4,896	10,790

The Project gives more benefits to the irrigated paddy farmers, while the small size rain-fed paddy farmers will not always receive the Project benefit. Therefore, it should be considered essential to give these small and rain-fed paddy farmers the intensive guidance about cash crop cultivation through extension service.

3) Socio Economic Impacts of the Project Implementation

EIRR of the Project is a little low as the economic index. However, the implementation of the project will give strong socio-economic impacts on the nation, the Northeast region and the Project Area as unquantifiable benefits as mentioned in the followings:
(Refer to Chapter 6, 6-3 "Project Benefits")

- Improvement of the rural people's living standard through promotion of diversified agriculture with enrichment of vegetation to mitigate salt affection.

- Implementation of the Project gives local peoples not only rural welfare but also alleviating uneven development between the regions.

- The Project will enable the beneficiaries to keep close communication with each other as well through village cooperation activities, introduction of new farming system, rural road network, technical training and recreational facilities.

- The water supply project will be served for saving women and children's labor works and improve the public health.

CHAPTER 8 CONCLUSION AND RECOMMENDATION

8-1 Conclusion

Development of water resources have to concentrate on developing small-scale water resources existing in the study area in which inhabitants will be easily able to participate in the development implemented by DLD and to conserve natural environment without causing troubles on large-scale land aquisition and land submersion under water.

The overall land use system proposed in this study should be introduced with combination of soil and water conservation measures including reforestation and agroforestry to proceed the sustainable development with environment soundness.

Countermeasures to mitigate salinity problems in the salt-affected land are requisite to be executed basing on full understanding of mechanizum on salt emergence from hydrogeological aspect and precise analysis of problem soils.

Project implementation of the Pilot Area selected in the study lead to demonstrate the technical, economic and social feasibility of proposed agriculture systems in the salt-affected lands and to play a role as a model in solving salt-affected prolbems in the Northeast Thailand.

Promotion of sericulture and provisions of the agricultural processing/marketing center, training center and recreation facilities create employment opportunities as well as attract women and youth in development.

Although the economic feasibility of the Pilot Area is a little lower than the other projects, the project have strong impacts upon socio-economic activities in the area and induces to alleviate the poverty and raise up the living standard of inhabitants.

8-2 Recommendation

It is recommendable to promptly implement the Pilot Area with duly attention to the followings.

(1) The observation networks provided by the JICA Study Team such as wells, piezometers and staff gauges on rivers and ponds have to be kept monitoring by DLD.

(2) DLD have to demonstrate the technical feasibility of soil conservation works in this project as a model to solve salt-affected problems, applying the results of recent reseach and equipments listed in the study.

Organization of DLD have to be strengthened for the smooth implementation of this soil and water conservation project in salt-affected areas in respect to software and hardware with technical and economic assistance of experts and equipments.

(3) To realize prompt commencement of the project implementation, the proposed committees have to be provided soonest possible.

(4) Project implementing agencies have to give farmers employment opportunity in the implementation of the project.

To attain the full development of the study area, and to mitigate salt-affected land by means of sufficient supply of leaching water in both seasons, available water resources existing outside the study area is recommendable to be transmitted to the area in future in cooperation with related agencies from a view point of overall water resources management in the region.