2.3.2 Farming Practice

In the area, mixed cropping of fruit trees, especially mangosteen, in the high evelation land, and cultivation of upland crops except for rainy season in the lower land are practiced. However, both lands are easily affected by the flood. The area is classified into five in accordance with the present farming practice and the damaged level by flood.

Ⅰ. Flood affected area, not growing fruit trees.
Ⅱ. Flooded area, but not damaged, still growing fruit trees.
Ⅲ. Swamp, cannot grow any crops.
Ⅳ. Low and wet land, grass, mixed fruit trees.
Ⅴ. Highland, mixed fruit trees.

Farmers try to replant fruit trees in the relatively higher elevation land of the Ⅰ. Some of the land, however, suffer from flooding every year. Consequently, planted trees are uprooted. At present, coconut, bamboo and banana remain in such flooded area. In the low and wet land, vegetables and upland crops are planted, but, also suffer from flooding every year. Consequently, the productivity of land is becoming very low due to repeated sediment and erosion.

The Ⅴ land is a less damaged area, where mixed cropping of fruit trees is practiced satisfactorily. In the depression of the Ⅳ, some fruit trees are planted, but, the growth is poor due to higher water table.

Based on the survey, classified land is summarized as follows (refer to Figure 2-9).

Present Land Classification in Lan Saka F/S Area

Class	Area (rai)	Percentage (%)
Ⅰ. Flood affected area	322.62	56.0
Ⅱ. Flooded area	47.08	8.2
Ⅲ. Swamp	27.03	4.7
Ⅳ. Low and wet land	87.03	15.1
Ⅴ. Highland	92.28	16.1
Total	576.04	100.0

Note : Each area is estimated based on the topo-map and survey.

2.3.3 Farmer's Organization

The farmers in this area practice farming under the agricultural organization in Lan Saka district as mentioned in 5.3.6, PART 1. All farmer's organizations in the F/S area are informal type. The existing farmer's organization can be summarized as follows.

(1) Wat Chan Village

(1)-1 Thrift and Credit Group.

This farmer's group has been established in 1987. All farmers in this village and some farmers in other village are members. There are two types of members namely, regular and special members. The regular members have to deposit money 100 Baht per member every month, while special members can deposit money at their own discretion. The amount of deposit for special members should be more than 100 Baht for each payment. Operation and management of this farmer's group are being carried out by a selected committee. The committee consists of five members; chairman, treasurer, and other three members. The followings are the basic information of this group.

Operation fund as of 1995	:	1.0 million Baht
Member	:	208 households
Interest rate	:	1% /month
Term of repayment	:	30 months
Maximum lending amount	:	Three times of accumulated deposit.
Dividend	:	10%

(1)-2 Operation and maintenance on water supply system

Besides the farmer's organization as afore-mentioned, the farmers in resettlement village Wat Chan have established village water supply fund for operation and maintenance of domestic water supply. They can collect water charge and manage the water supply system successfully.

(2) Yan Yao Village

(2)-1 Thrift and Credit Group

This farmer's organization has been established in 1993 with the operation fund of about 2,000 Baht. The operation and management are being carried out by a committee consisting of 12 executive members selected from all members. All

farmers in this village are members. Basic information of this farmer's organization can be summarized as follows.

Operation fund as of 1995	:	200,000 Baht
Member	:	100 households
Interest rate	:	1%/month
Term of repayment	:	Short term
Dividend	:	20%

According to the interview, the farmers in this area prefer credit services through this group in this village for the expenses of farm inputs and labour.

2.3.4 Agricultural Supporting Services

The agricultural supporting services in this area at present can be described as follows.

(1) Agricultural credit

At present, there is no commercial bank in Amphoe Lan Saka, and BAAC is the only one at the unit level. Demand of agricultural credit through BAAC and ACs has increased slowly. However, the farmers in this area prefer credit services for short-term repayment through thrift and credit groups in their villages as mentioned in 2.3.3.

(2) Fertilizers and chemical products

Farmers usually practice mixed cropping of mangosteen, durian, rambutan, etc. Supply of fertilizer is made through private sectors, ACs at Amphoe level and the credit-in-kind programs of BAAC. Demand of fertilizer is rather low. Mixed cropping is difficult for applying fertilizer and spray chemical to control insects and disease. Special formula of chemical fertilizers or some kinds of pesticide may not be available in the area.

(3) Consultation and extension services

At present, consultation and extension services on major activities in agricultural development such as cultivation method, land use and selection of cropping pattern, soil improvement and use of fertilizer and chemicals are not adequate.

(4) Marketing business

The farmers in Wat Chan village have established two (2) places of agricultural products collection to central market in Nakhon Si Thammarat. The local merchants purchase all of agricultural products at this collection point in the morning and then sent to central market. The difference between market price and farm-gate price is very small.

2.4 Agricultural and Rural Infrastructures

2.4.1 Irrigation and Drainage Facility

In the F/S area there exists no major irrigation facility, and irrigation is not a common practice in the mixed orchards before and after the flood because 1) Unlike rambutan or durian, most of the surviving crops, such as mangosteen, banana or coconut are mature crops and do not require severe soil moisture control. 2) Some rainfall, though below crop requirement, can be expected in the dry months. 3) Groundwater level is relatively high, about 2-4 m below ground surface and is within the reach of roots of the tree crops and the conductivity of the soil is very high, in the order of 10^{-3}cm/s.

As part and parcel of the land use program, irrigation is planned to irrigate the young fruit seedlings to be planted on the restored land.

Except for the natural river which is also the drainage system for the F/S area, no prominent drainage canal exists. Flooding is a frequent event in rainy season. Due to the steep topography, about 1/50-1/100, flood velocity is very high, and this has caused heavy sand deposition on farmland, damage by drifting wood and bank erosion (see Figure 2-10).

In a normal year, water level in this part of Tha Di river rises to about 2-3 m above normal level only a few hours after heavy rain occurs and subsides in a couple of hours after the peak flood level. These flash floods cause frequent flooding, to a depth of 15-50 cm, in the upper region of the F/S area. Field reconnaissance has shown that flooding is a more serious problem in the lower region as it usually lasts longer (9 hours for 1/10 probability flood) and when it subsides it always leave behind thick sand sediment. Preventing flood intrusion and draining away surface runoff are part and parcel of the problem.

Runoff from the undulating slope on the left bank is drained through the natural depressions along the rolling village road. Except for the bridges across Tha Di river and the tributaries, simple pipe crossing structures are used to drain water at these depressions along the roads. Some of the pipe crossings are in bad conditions and should be improved and well

maintained. Surface runoff in the F/S area is drained by small drains and at 2-3 locations under the road through 300 mm pipes. A detail drainage planning is required when planning land use for the marshland and the restored land.

2.4.2 Agricultural and Rural Infrastructure

As mentioned in 5.4.2. of PART 1, the condition of the partially concrete-paved major village road in the right bank is becoming worse with each rainy season. The foundation and road shoulder of the concrete-paved section were eroded at a few locations during last rainy season. This could be attributed to the lack of side drains along this road. The rolling single-lane village road in the left bank is basically unpaved. The condition of the sediment paved section, though limited in length, is relatively good. The lack of side drains have caused serious erosion in the rest of the length of the road and trafficability has largely been reduced. The condition of the single-lane unpaved road connecting the two major roads in the upstream region is bad, with potholes and deteriorated pipe crossings. The conditions of the concrete-paved road linking the two major roads in the lower region is fairly good. However, to ensure smooth trafficability, paving should be conducted on the short length which was left unpaved so far.

The bridge in the lower region which was destroyed by the spate in 1994 should be restored. Since this branch of Chawang river has become the major affluent, larger flow area is required and the bridge should be extended to about 30 m or longer.

To ensure smooth farming activity and to maintain good trafficability new farm roads are planned to link to the existing ones, forming more comprehensive road networks.

Electricity supply is available to almost all of the villagers. In Wat Chan some of the deep wells are used to supplement drinking water and house chore use. Rain-jar and shallow wells are generally used for living.

CHAPTER 3

DEVELOPMENT PLAN IN THE BAN NA SAN AREA

CHAPTER 3 DEVELOPMENT PLAN IN THE BAN NA SAN AREA

3.1 Basic Approach

3.1.1 Development Constraints

Based on the development approach as described in 6.1, PART 1, development plan for the F/S area are formulated, taking account of the following development constraints.

- This area is apt to suffer agricultural loss caused by flood intrusion with rock, gravel and debris flowing from upstream. In some parts of the area, cultivation is abandoned.
- It is difficult to introduce new crops into the low-lying land along the river due to the thick sediment.
- In some parts of the flood affected orchards, fruit trees had been planted. The growth of those trees, however, is generally poor due to the low soil fertility.
- Infrastructural facilities at farm level are not provided for land conservation and effective farming.
- Supporting services for propagation of farming techniques including soil improvement are not active.

3.1.2 Alternative Development Plans

Based on the present conditions and development constraints, the following alternative development plans are considered.

Case-1: For preventing flood intrusion, embankment is constructed along the Chawang river. Present whole waste land may be used as an agricultural land by means of intensive soil and soil layer improvement.

Case-2: Coarse sand, rock and gravel are deposited thick and widely in the waste lands along the Chawang river. Even though flood damage is alleviated by constructing embankment, much investment for soil and soil layer improvement will be required. Therefore, such waste lands are planned as an uncultivated area, from viewpoints of cost-benefit. Embankment is constructed in the limited sections, considering topography, flooding condition and soil characteristics. The agricultural land rehabilitation area is less than that of the case-1.

3.2 Land Use

3.2.1 Basic Concept

As described in 1.3, present land use is categorized into the following:

(1) Fruit bearing plantation which are located in a relatively higher elevation area, flood damage was not serious so that the trees are still growing.

(2) Flood damaged pre-fruit bearing plantation where the depth of the sediment is deep. The fruit trees were planted by farmers after the disaster, which are too young to bear fruit.

(3) The waste land where cultivation is abandoned after the disaster due to thick sediment of rock, gravel and debris.

For land use plan formulation, the following approaches are taken based on the above-mentioned present land use conditions.

- For land (1) and (2), present land use practice is continued. New farming techniques are introduced based on the growing conditions of the planted trees.

- In land (3), for the waste land located between land (1) or (2) fruit trees are introduced. For those along the Chawang river, the following plans are applied by alternative development plan.

Case-1: In the whole waste land, the trees are planted with intensive soil/soil layer improvement.

Case-2: Planting of fruit trees is limited in the higher elevation land along the river and the marshy area.

Then, rambutan is selected as the fruit tree from viewpoints of social and natural conditions of the area.

3.2.2 Land Use Classification and Area

Based on the above-mentioned approach, land use is classified as follows.

Present land	Land Use Plan	Necessary Measure
Fruit bearing plantation	Same as the present	Improvement of farming
Pre-fruit bearing plantation	Same as the present	Improvement of farming Soil improvement
Waste land	Fruit tree	Improvement of farming Soil/soil layer improvement

Land use area is planned by alternative development plan, shown in Figure 2-11 (refer to A-4, Appendix A).

3.3 Drainage Improvement

3.3.1 Basic Approach

Based on the following speculations, drainage improvement of land improvement and conservation planning in the F/S area should be intertwined with flood intrusion problems. Drainage improvement should consider engineering methods to keep out flood intrusion and/or agricultural methods to accommodate floods while draining away excess surface/flood water as swiftly as possible.

1) Less frequent flooding at raised farmland

After the 1988 flood, farmlands in the middle and downstream area of the F/S area were raised by sediment deposits to about 1-1.5 m above the original ground level. As can be seen from sedimentation survey report farmlands covered with thick sediment (1 m - 1.5 m) were once fertile paddy fields. Now that the farmlands have been raised, they are less susceptible to smaller floods and to some extents on-farm drainage has improved. This has enable introduction of fruit tree cultivation in some of the raised farmlands, which brings more revenue than paddy growing. However, about one half of the stretch of sand deposit (100 rai) along the left bank of Chawang river and the patch of marshland (36 rai) in the lower reach are still not reclaimed. They remain as the flood plain of Chawang river, prone to flooding in the rainy months.

2) Relatively short duration of inundation

Since the topography of the F/S area is relatively simple, sloping eastward parallel to Chawang river and with a steep gradient of about 1/100 to 1/200, inundation is never a compelling problem. Except for the marshland at the lower reach, flooding is not a frequent event now and it usually lasts for only a couple of hours. For 1/2 and 1/10 probability rainfall, discharge above 100 m^3/s lasts for about 5 and 10 hr, respectively. The impact of this relatively short flood phenomena

on 2-3 years old or fully grown fruit crop is not serious. However, drainage canals parallel to the existing pipeline and in the marshland, when constructed, can help to drain away more swiftly surface runoff of heavy rainfall and/or intruding flood water.

3) Long flood intrusion locale

From the hydraulic calculation it is perceived that the flow sections of Chawang river at and immediately downstream of the F/S area are insufficient to drain the deluge caused by larger rainfall in the rainy months. Flood water from Chawang river intrudes mainly along the upper and middle area.

4) Design year, land use and flood impacts on socio-economy

In the F/S area farmland is mainly used to cultivate fruit trees. The main village (Ban Huai Hun) is located outside the F/S area. The few farmhouses are located on higher ground and are unaffected at all by flood. Only those farmhouses unaffected/undamaged by the deluge in 1988 remained inhabited. Under such conditions, 1/10 probability is adopted as the drainage requirement.

3.3.2 Dike Construction

1) Hydraulic calculation

Non-uniform flow is used to estimate the flood level of Chawang river. The survey data (cross-section) conducted by RID immediately after the flood is used.

Design flood discharge	:	1/10 probability 425 m^3/s
Length of channel	:	2,586 m (16,543 m in total)
Average slope of riverbed	:	1/93
Interval of stations	:	200-500 m

2) Cases for comparison (dike construction)

Two cases are adopted for comparison in this study; 1) Case-1: Complete dike construction (2,200 m) throughout the entire length of Chawang river, 2) Case-2: Limited dike construction (1,150 m) at the upper end and at the marsh land in the lower end (refer to Figures 2-12 and 2-13).

a) Case-A Complete dike construction

Earth dike, enforced with gabion protection, is planned at location as shown in Figure 2-12. It is planned to withstand 1/10 probability flood discharge, as according to the drainage requirement of planning agricultural land. Therefore it must be reiterated that the earth dike is by no means absolute in keeping out flood of all degrees. The dike is planned on the flood plain as close as possible to the river while taking advantage of the natural terrace (At ×362 on 93.7 m elevation, × 357 on 88.8 m, × 352 on 83.3 m, and ×347 on 77.4 m, refer to Figure 10, E-58, Appendix E). The height of the dike will be 0.5 m - 2.5 m and will occupy a width of 6 m - 20 m. The material for construction will be mainly the stones and sand found in the flood plain (refer to Figure 2-14).

b) Case-B Limited dike construction at the upper end and at the marsh land in the lower end.

In Case-B, flood protection is planned for the farmland in the upper end and the marsh land in the lower end (refer to Figure 2-13). The land in the middle area will be subject to flooding and cannot be reclaimed for agricultural purpose. The structure of dike is basically that of Case-A.

Detail on hydraulic calculation, cross-section and dimensions of the respective cases are shown in Table 4, E-31, Appendix E.

3.3.3 Drainage Canal

To drain off more swiftly excess surface water resulting from heavy rainfall and to shorten inundation time should flood water of Chawang river intrude into the farmland, drainage canals (D1, D2, D3, D4 and D5, total length 2,045 m) are planned at locations shown in Figures 2-12 and 2-13, and Figure 1, E-42, Appendix E. D1 provides drainage for the farmland in the lower area and drains into Thuat river. D2 is the main drain and drains away excess water from the upper area and the surface runoff from the slopes outside the F/S area. The network of D3, D4 and D5 provides drainage for the marsh land. A gate is located at D3 to keep out flood water in Chawang river. Design discharge (0.1-1 m^3/s) of the respective canal is based on hydrological estimation. Due to the steep topography, the average design gradient is 1/400 (refer to Table 20, E-43, Figure 2, E-44, Appendix E). Drop structures are planned in the canals to keep flow velocity with the allowable velocity.

Pipe crossing structures are planned at locations where the canals are crossed by road. The deteriorated existing crossing structures are also replaced.

3.4 Agriculture

3.4.1 Cropping System

According to the land use plan, the land is divided into three areas; fruit bearing plantation, pre-bearing fruit plantation, and wastelands. The land use areas by each growth condition of trees in both plantation areas are planned based on the 1.3.2, as follows.

The Area by Each Growth Condition of the Fruit Trees

Unit: rai (%)

Fruit tree	Poor	Fair	Normal	Good	Total
Y.R.	59.64	171.30	11.73	18.05	260.72
O.R.	-	-	85.63	-	85.63
Y.D.	-	11.73	43.12	-	54.85
O.D.	-	-	-	1.05	1.05
C.N.	-	-	8.50	-	8.50
Total	59.64	183.03	148.98	19.10	410.75

Note: Y.R. = Young rambutan (pre-bearing)
O.R. = Old rambutan (bearing)
Y.D. = Young durian (pre-bearing)
O.D. = Old durian (bearing)
C.N. = Cashew nut
The area does not include the area of planned roads.

Fruit trees are planted in the wastelands, and they are used as the orchard land. The land use area in each case is as follows.

Present land use	Planned orchard area (rai)	
	Case-1	Case-2
Grass land	94.96	88.46
Marsh	35.59	35.59
Sand land	89.36	32.96
Total	219.91	157.01

3.4.2 Farming Practice

Farming practice is examined by each land use classification.

(1) Bearing and pre-bearing fruit plantations

The fruit yield by each growth condition is assumed based on the standard of normal growth with a control of 100%, as follows.

Unit: %

Growth condition	Rambutan	Durian
① Good	+20	+10
② Normal	100	100
③ Fair	-20	-15
④ Poor	-30	-30

① Land with good tree growth requires no soil improvement, but the productivity could be increased by applying suitable fertilizer management.

② Land with normal growing trees had exchanged deposited soil with lower original soil for shallower deposited area, and dressed with new soil for deeper deposited area. Therefore soil/soil layer improvement is not required, but it is possible to reach the production level of the ①, if the amount and way of applying fertilizer will be improved in accordance with the standard method of the DOAE.

③ Since the land with normal tree growth requires more soil/soil layer improvement, filling with shale or others around trees and an increase of fertilizer use to reach the standard level are necessary.

④ The land with poor tree growth requires the same methods as the ③ and drainage improvement. As the measures, filling with shale or others, improvement of the drainage condition and increase of fertilizer use up to the standard level are effective.

(2) Waste land

Soil of the waste land is not suitable for paddy and upland crop cultivation due to low fertility and low water holding capacity because of the deposited coarse sand with gravel. For the fruit tree plantations, soil improvement such as exchanging deposited soil with lower original soil, soil dressing, and filling new clay soil on the planting spot has to be taken. After the improvement, farm management should be carried out in the same way as the above.

Rambutan, durian, and mangosteen are the suitable fruit trees. Durian has high productivity, but has to be planted on fertile land with good drainage conditions since the roots are easily damaged by harmful insects and rot under poor drainage conditions. Cultivation management of this fruit is difficult than the others, and it takes many years to fruit. For mangosteen, it takes seven (7) years and needs a shading tree when they are young. On the other hand, rambutan cultivation has been carried out by the farmers in the area, and they know its farming techniques very well. Rambutan could be harvested in the fourth year after plantation. Since profitable intercropping by vegetables and upland crops is not possible due to low soil fertility, pre-bearing period of fruit trees should be shorter.

According to the above consideration, planted crops in waste land would be rambutan and durian. The cropping areas are allocated at the same rate of the present share. As intercrops, Legumes such as Alfalfa and Kudzu are planted to cover the land surface and improve fertility.

The general cultivation method for rambutan and durian is in 6.6.1, PART 1. Cashew nut is as follows.

Planting density is 6 m×6 m or 45 trees per rai. Fertilizer N15 : P15 : K15 is applied at 0.1 kg per tree in the 1st to 3rd crop year, 0.5 kg in the 4th to 5th, 1.0 kg in the 6th to 7th, 2.0 kg after 8th. Fruits can be harvested after 3rd year since planting and the following yields are expected.

Year	3	4	5	6	7	8 - 12	13 - 17
Yield (kg/tree)	0.5	1.5	3.0	5.0	6.0	7.0	8 - 10

3.4.3 Yield and Production

The production plan for fruit trees are as follows.

(1) Present fruit trees

Fertilizer management and plan of production are examined in accordance with each growth condition in ①-④, 3.4.2.

① : The productions of rambutan and durian will be increased by 10% and 5%, respectively, with the application of fertilizer as follows. Organic fertilizer (compost), 30 - 50 kg per tree per year and fertilizer 15 : 15 : 15 or 16 : 16 : 16 with 0.5 kg greater than the standard amount per tree are applied. These fertilizers are applied four times a year since they resolve instantly when soil is included in little

organic matter and the temperature is high. Lime is applied 400 kg per tree every year.

②-④: In addition to the improvement method mentioned in 3.4.2, the fertilizer of the ① is applied to reach the production level of the ①.

(2) Fruit trees in waste land

Planting density is 10 m × 10 m on rehabilitated agricultural field. For high lands of grass and sand or marshland, a planting hole would be 4 m in diameter and 50 cm in depth. The hole will be filled with the mixture of shale and deposited soil and filling of 50 cm high will be constructed. For lower sandy area, filling of 4 m in diameter and 1 m in height will be constructed.

The soil for dressing or filling should be improved for pH5.5 to 6.5 with lime. In addition to that, phosfatic fertilizer with 500g mixed with soil or 30-50 kg of poultry manure for each planting hole will be applied.

The yield with the above cultivation methods would be as follows.

Yield of Rambutan

Unit: kg/rai

Year	4	5	6	7	8	9	10
Standard Tree	115	580	746	1,067	1,213	1,233	1,252
Moderate Bearing Tree	138	696	895	1,280	1,456	1,480	1,502
Best Bearing Tree	152	766	985	1,408	1,602	1,628	1,652

Yield of Durian

Unit: kg/rai

Year	5	6	7	8	9	10
Standard Tree	250	1,000	1,500	2,300	2,500	2,500
Moderate Bearing Tree	275	1,100	1,650	2,530	2,750	2,750
Best Bearing Tree	289	1,155	1,733	2,625	2,888	2,888

Note:
- Standard tree is under the normal growth tree.
- Moderate bearing tree is under the good growth condition.
- Best bearing tree is based on much more fertilizer amount than that of standard.

3.5 Soil and Soil Layer Improvement

3.5.1 Method of Soil and Soil Layer Improvement

(1) Land classification

Land for improvement plan is classified into five, by considering the depth of deposited soil, soil structure, existence of gravel, mottling and soil texture of top soil. Besides the above, the followings are considered for basic approach of classification. The land is classified as shown in Table 2-5.

(2) Method of soil improvement

For the F/S area, the following steps are required to maintain good soil condition.

1) Improvement of soil physical property

- Mulching by organic material residuum.
  - Effect : Supply nutrients, improve soil structure, increase soil water retention capacity.
  - Method : Apply organic material residuum around tree.
- Growing cover crops.
  - Effect : Prevent soil erosion, maintain soil structure, increase soil water retention capacity.
  - Method : Seed between the planted tree.

2) Improvement of soil chemical property

- Application of calcareous material.
  - Effect : Correct soil acidity.
  - Method : Requirement of Calcium Carbonate from Arrhenius' table ($CaCO_3$ kg/ha · 20 cm). From the table, 500~1,000 kg/ha is needed in the area.

Soil \ Humus contents	Low	Medium	High
Sandy	500	1,000	1,500-3,000
Sandy clay loam	500-1,000	1,000-1,500	2,000-3,000
Loamy	1,500	2,500	3,500
Light clay	2,500	3,500	4,000
Heavy clay	3,000	4,000	4,500
Humus	4,000-8,000	-	-

- Continuous input of organic compost

  Effect : Maintain and increase soil fertility, increases soil buffer action.

  Method : Make compost from plant and /or crop residuum.

- Application of slow release fertilizer

  Effect : Release continuously nutrients, increase crop production.

  Method : Purchase from private sector and apply

3) Improvement of soil biological property

- Growing leguminosae crop

  Effect : Supply nitrogen by nitrogen fixation, increase soil micro-organisms.

  Available variety of crops:

  - Phaseolus lathyroides L. Thua phee, named in Thai.
  - Centrosema pubescens Benth. Thua lai, named in Thai.
  - Phaseolus atropurpureos Moc. Siratro, named in English.

Application of soil conditioners such as crosslinked polymers may be considered in future, as a new improvement technique to increase soil water holding capacity.

(3) Method of soil layer improvement

The following treatments will be considered for the F/S area.

1) Removal of rocks, cobblestone and wood debrise

   If these are abundant in rooting zone, normal growth may not be expected. Such obstacles should be removed, taking account of root development. Improvement area is 4 m in diameter around tree, and 50 cm in depth,

2) Soil mixing with lower original soil

   If depth of deposited soil is comparatively shallow, this method is very useful for improvement of soil fertility. Improvement area is the same as the above.

3) Soil dressing by clayey soil on farm land

   This method is an effective method for improvement of sandy soil including gravels, which increases nutrient holding capacity and soil buffer action. This method is applied to the fruit tree already planted. Improvement area is 4 m in diameter around tree, and 30 cm in depth.

4) Mixing of deposited and clayey soils for soil dressing

   This method is applied for new planting trees in the wasteland. First, deposited soil is dug down to 40 ~ 50 cm in depth, after that, mix with clayey soil and fill in. Improvement area is the same extent as the above, but 50 ~ 100 cm in depth.

For the above 3) and 4), clayey soil has to be procured. According to the survey, the soil is distributed around the F/S area, of which the amount is more than enough to supply to the area (detail is shown in Table F.30~F.31 and Figure F.8, Appendix F).

Based on (2) and (3), improvement method is complied by considering the land classification and the land use plan, as shown in Table 2-6 (refer to Table F.26 and Figure F.7, Appendix F).

3.5.2 Soil and Soil Layer Improvement Area by Land Use

The above improvement method is applied by each field classified with growing condition, taking account of the followings.

- For pre-bearing trees with poor growth, it is difficult to transplant with soil/soil layer improvement.
- There are some fields carried out with soil improvement by farmers. But, the improvement level is different from each field.
- As mentioned in 3.4, the growth of trees and crop management are also different.

As a result, total improvement area by alternative development plans is summarized in Table 2-7 (detail is shown in Table F.28, Appendix F).

According to the Table, soil and soil layer improvement area is mainly in the sand deposited land, the grass land and the marshy, occupied in class V (150 cm <). And, detail data of improvement area and requirement cost are shown in Table F.32~F.34, Appendix F.

3.6 Irrigation Improvement

3.6.1 Basic Approach

In the F/S area irrigation is a common practice to supplement water in dry season and to control soil moisture in the flowering stage. The existing irrigation method, i.e. pumping water into the individually owned low-head sprinkler system, is reckoned as practical and suitable for irrigating fruit tree in the restored land. A 7-day irrigation rotation and a combined water resource from Chawang and Mui rivers, with the existing ponds as useful storage facility for river water of the non-irrigation hours, are planned. Water requirement is estimated assuming that

the whole area is used for fruit tree. Since the difference in land use is slight, no distinction is made for the alternative improvement cases.

3.6.2 Water Source

(1) Irrigable area

The irrigable area depending on river water of Chawang and Mui rivers is estimated by the following method.

(a) Calculation of water balance for tree crops considering water requirement and effective rainfall.

(b) Calculation of utilizable amount of river water considering intake discharge and release discharge which is determined as droughty discharge corresponding to 1/10 non-exceedance probability.

(c) Calculation of irrigable area considering the water balance for tree crops and the utilizable amount of river water. In this case, irrigation time is assumed to be from 8 to 24 hours taking into account the temporary storage of water in farm ponds.

The irrigable area is estimated for periods of peak demands with low amount of available river water occurring specially in March or April for tree crop, which is shown in the table below (refer to Table B.3.6~B.3.11, Appendix B).

Estimated Irrigable Area in the F/S Area

Unit : ha

Place of water source	Catchment area (Sq.km)	Return period		
		2 years	5 years	10 years
Existing weir of Mui River	36.2	60~210	20~80	10~50
Junction of Mui and Chawang Rivers	104.0	160~590	60~230	30~120

(2) Water source

As seen in the above table, in March and April of a normal year (1/2 probability) the amount of river water diverted at the weir in Mui river is sufficient for target area of 101 ha. Whereas that of 1/10 probability dry year, even if completely diverted, is sufficient to irrigate only 30 ha, or about 30% of the F/S area. Since Chawang river has a larger discharge compared with that of Mui river, the combined river water quantity at the confluence further downstream is

sufficient to irrigate about 120 ha during dry months of 1/10 dry year. Therefore, to overcome water shortage, it is necessary to tap as frequent as possible water in Chawang river to supplement dry month requirement during dry year.

Estimation of storage capacity of the existing ponds shows that water stored in the ponds is large enough to meet the demand for one day (15 ha/day) (refer to Table21, E-45, Appendix E). As mentioned below, with proper management and close cooperation among the farmers the ponds can function as reliable water resource, tapping river flow during non-irrigating hours.

Therefore, irrigation improvement work is limited to pipeline installation in the restored land.

3.6.3 Irrigation and Water Use Group

The farmers in the F/S area are inspired into grouping themselves into strong users' cooperative group, 1) to ensure access of water in the pipeline to all farmers, 2) to arbitrate and monitor water use in order to avert crop failure, especially during the dry months and 3) to marshal operation and maintenance of irrigation and drainage facilities and road, and removal of sand and gravel deposited in the pipeline.

Tapping river water in Chawang and Mui rivers during non-irrigation hours is the easiest way to meet the demand of dry year. Water shortage can be met by 1) using water in the pipeline and Chawang river (farmers without ponds) and the ponds (farmers with ponds) during daytime and 2) pumping water from the pipeline and/or Chawang river into the ponds during non-irrigating hours, e.g. during night time, and use them as backlog and/or to irrigate the command area of the ponds.

3.7 Agricultural and Rural Infrastructural Improvement

3.7.1 Basic Approach

Since agricultural production is the major activity in the F/S area the main features of the proposal for infrastructure improvement are focused on facility pertinent to agricultural activity.

- Road density in the F/S area is small. With the land restoration program road density will be increased.

- The condition of road crossing structures in the F/S area is deteriorating. Pipe crossing structures are proposed 1) to replace the existing ones, 2) at depressions along the existing road and 3) at locations where the new drainage canal crosses the existing and new road.

3.7.2 Farm Road Planning

Farm roads (R1-R4, total length 1.2 km) are planned as shown in Figures 2-12 and 2-13. With effective width 2 m, only single passage of a vehicle is possible. The new roads will provide easy access to the rivers and orchards, making it easy for the transportation of 1) materials and equipments for bank protection and flood intrusion prevention in times of emergency and 2) materials and products of agricultural activity. Should the dike of the improvement alternative cases be constructed, the planned farm roads will form a network by linking the existing road to the road on the dike. The road on the dike will be used as farm road and O & M road for the dike and river.

3.8 Farm Land Conservation

3.8.1 Soil Surface Protection

The most basic method for farm land conservation is control of surface coverage on the ground. For soil surface protection, some farmlands have to be covered with erosion tolerant crops which function as preventing evaporation loss from the surface and rise in soil temperature during dry season. In and around the area, Centrosime, Caloapsgonium and Kudzu species are available as the local cover crop. In practice, these species are seeded by mixing around planted fruit trees. Seeding has to be spaced at least 1.0m from the tree, to avoid competition for soil moisture. Those crops are seeded in the area reclaimed for fruit tree cropping. In the area where trees are already planted, ground surface is covered with grass or other coverage crops.

3.8.2 Conservation Measures by Structures

In order to control surface run-off and to prevent soil erosion, some structural measures have to be taken.

(1) Ditch

Ditch is not planned in the fields planting fruit tree except for poor drainage areas, since their ground surface has been covered with the erosion tolerant crops. In the newly reclaiming land for fruit tree, the slope is gentle from one to three degree. The deposited soil is the sandy soil with high permeability. The soil surface is planned to be protected by cover crops as mentioned in 3.8.1. Therefore, farmlands seem to be stable and safe against erosion. Ditch may not be planned, except in some plots.

(2) Collecting Canal

Collecting canal may not be planned in most fields. But, a few canals may be planned at the downstream area (refer to 3.3.3 and Figures 2-12 and 2-13). The type is designed as grassed waterways.

3.9 Agricultural Supporting Services

3.9.1 Strengthening Program for Farmer's Organization

According to the present policy of the government, the cooperative is the ultimate goal of farmer's institution, while the farmer's group is an intermediate organization waiting for further development become full scale of ACs. The major problems of farmer's organization in the F/S area may be summarized as follows.

- Inadequate technical supporting services
- Lack of qualified staff
- Weakness in cooperative discipline

In order to achieve the goals of strengthening program for farmer's organization, the following basic plans are deemed as necessary.

a) Encourage strengthening of existing farmer's group and campaign for establishment of farmer's group in accordance with the specific kind of activities such as, rambutan plantation, handicraft and marketing.

b) Campaign for creation of qualified leaders of farmer and promote training services on administration and management of the organization.

c) Encourage and support existing informal farmers groups to be registered farmers groups with intensive technical assistance from the government agencies concerned.

d) Formulate strong back-up body by provincial and/or amphoe levels in all activities related to strengthening farmer's organization not only at the initial stage of establishment but also during the subsequent operation period.

3.9.2 Agricultural Supporting Services

The agricultural supporting services is one of essential component for agricultural development. It covers quite broad scopes of activity and can affect the cost of crop production to a great extent. The major problems in agricultural supporting services in the F/S area at present may be summarized as follows.

- Weakness in technical know-how
- Lack of marketing information
- Interest rate for long-term credit
- Inadequate agricultural extension services

In order to overcome the above mentioned problems and for an effective implementation of proposed project, the basic concept concerning agricultural supporting services should be consisted of the following issues.

a) Formulate intensive consultation and/or extension services on modern agricultural technology, particularly cultivation method and soil improvement techniques. Technical materials and periodic visits of extension workers should be provided.

b) Encourage provision of special long term credit for rehabilitation and conservation programs in the devasted farmland. The interest rates for this programs should be provided by technical agencies concerned.

c) Encourage strengthening of marketing business and formulate updated marketing information systems related to market demand and market prices of each type of products.

d) Formulate quality control and operation guidance system to assure proper quality and use major agricultural inputs, particularly chemical fertilizers and chemicals.

e) Formulate and support soil improvement programs in sediment deposited farmland. Provision of technical know-how on soil/soil layer improvement and training services are necessary.

In conclusion, the basic concept as above mentioned is aimed at raising farmers' income levels and improvement of soil/soil layer in devasted farmland.

For an effective implementation and strengthening farmers' organization, project operation should have technical assistance in the form of a technical advisory group, as mentioned in 6.7.2, PART 1. A technical advisory group should be staffed with subject specialists of different fields such as, horticulture, soil improvement and conservation, farmer's organization, marketing and agricultural credit. Technical service activities advised by these specialists should be planned as an agricultural supporting project. Test field constructed by the Study Team is useful for service activities.

3.10 Facility Design and Planning

The following criteria are adopted for facilities design and planning pertaining to restoration and conservation program.

3.10.1 Dike Planning

The following standard design criteria are adopted for dike design.

- High Water Level (HWL)

  HWL is the water level of 1/10 probability flood discharge.

- Gabion protection

  Gabion protection is designed to the level of HWL to resist embankment erosion caused by unstable near critical flow and the resulting swells/waves. The velocity of flow at this part of Chawang river is near critical or critical due to the steep river profile.

- Side slope

  Since the main material for the dike fill is sandy soil, a gentler slope, 1 : 2.5 is planned. This slope was adopted by RID for river improvement work further downstream.

- Freeboard (Fb)

  The equation $Fb = 0.05 \times d + hv$ (0.05 or 0.15) gives $Fb = 0.8$ m for velocity (V) = 3 m/s and depth (d) = 4 m. The design discharge of about 500 m^3/s also requires a minimum Fb of 1.0 m.

- Berm, crest width

To increase stability of dike a berm 2.0 m is planned at HWL. At 1.0 m above HWL is the crest of the dike. The width of crest is 2.5 m to accommodate a sediment paved farm road.

- Sodding

The front berm (2 m) and the exposed surface of the dike will be covered with a blanket of bermuda/vetiver grass planted by a method such as hydro-seeding. Before a complete and permanent turf is achieved, usually in 6 months, the surface must be covered with mulch and/or grass. Bermuda grass is a perennial local variety grass and with long roots can withstand dry conditions. Bermuda grass blanket will be interspersed by rows of vetiver grass.

- Farm road on dike

Sediment paved road (effective width 2 m) will be constructed on the crest, allowing single passage of a vehicle. The length of dike is planned as follows.

Development alternatives	Length (m)	Crest elevation (EL.m)	Discharge (m^3/s)
Case 1: Complete dike	2,200	75.6~100.6	425
Case 2: Semi dike	1,150		425
- Upstream	950	90.7~100.6	
- Downstream	200	75.6 ~ 80.0	

3.10.2 Farm Land Consolidation

According to the land use plan proposed, land clearing and land grading will be conducted on the restored land to consolidate the grassland and marshland for the respective croppings. For fruit tree, spot consolidation is sufficient. Cover crop is introduced to prevent soil erosion and to improve soil. Soil dressing and covering crops should be carried out with soil/soil layer improvement.

Land consolidation is not necessary for fully grown and pre-bearing orchards.

3.10.3 Irrigation and Drainage Facility

(1) Irrigation facility

Low head sprinkler system is proposed for irrigating fruit tree in the restored land.

(2) Drainage facility

The following standard design criteria is adopted for planning drainage canal and appurtenant facilities.

a) Drainage canal
Open trapezoidal channel with side slope 1 (vertical) : 1.5 (horizontal). Average gradient = 1/400. Coefficient of roughness n = 0.035. Five (5) types of standard sections, B = H = 0.7, 1.0, 1.5, 2.0, 2.5 are adopted (B & H are width & depth in m)

b) Drop structure (Reinforced concrete with mortar riprap)
Three (3) types of standard sections, B1 = H1 = H2 = 0.7, 1.0, 1.5, and B2 = 2.2, 2.3, 2.5, are adopted. (B1 & B2 are width in m before and after drop, H1 & H2 are water depth in m before and after drop).

c) Pipe crossing structure
Four (4) types of standard sections, D = 600, 800, 1000, 1000×2, B1 = 0.7, 1.4, 1.6, 3.1, and B2 = 0.7, 1.4, 1.6, 3.1, and B2 = 1.0, 1.5, 2.0, 2.0, are adopted (D is diameter in mm, B1 & B2 are width and length in m at entrance). Reinforced concrete pipes are used.

d) Drainage check gate structure (Reinforced concrete pipe with mortar riprap)
Three (3) types of standard sections, B = 1.5, 2.0, & 2.5 m, diameter of pipe = 0.6, 0.8, 1.0 m (B is width in m before gate) are adopted. To prevent submergence, the slide gate is installed at the inside of dike.

The followings are the results of hydraulic planning and designing of drainage canal and the appurtenant structures.

a) Drainage canal

Drainage	Canal Type	Discharge	Length	Average gradient
D1	I	0.31	490	1/400
D2	II	1.13	870	1/400
D3	I	0.21	360	1/400
D4	I	0.11	135	1/400
D5	I	0.10	190	1/400
Total			2,045	

b) Drop structure and drainage check gate

Drainage canal	Drop				Check gate			
	I	II	III	Total	I	II	III	Total
D1			4	4				
D2	2	2	1	5				
D3	3	1		4	1			1
D4		1		1				
D5	2			2				
Total	7	4	5	16	1			1

c) Road crossing structure

Drainage canal	Type				
	I	II	III	IV	Total
D1	1				1
D2			1	2	3
D3	1				1
D4					
D5					
Total	2		1	2	5

3.10.4 Farm Road

The following table gives the respective type and length of farm road planned to improve transportation. All the newly planned roads are of Type II.

Road	Type	Length (m)
R1	II	400
R2	II	195
R3	II	256
R4	II	349
Total		1,200

The standard types of farm road proposed are as follows.

Type	Width (m)	Base course (m)
I	3.0	0.5
II	2.0	0.5
III	2.0	-

3.10.5 Agricultural Supporting Services

The results of the test plot monitoring will be extended to the farmers through agricultural supporting service. The local stations of DLD will be the center of the service and experts will be dispatched for the purpose. The following equipment and facility will be necessary.

Equipment	Unit
Pick-up truck	1
Station wagon	1
Motor-bicycle	2
Spray	1

All proposed facilities and improvement area for land rehabilitation are summarized by the alternative plan as follows.

Table 2-8 Proposed Facilities and Improvement Area (Ban Na San)

Project	Case-1	Case-2
Drainage Improvement		
- Dike (m)	2,200	1,150
- Drainage canal (m)	2,045	2,045
- Appurtenant structures (unit)	21	21
Irrigation Development		
- Installation of low head sprinkler system (rai)	220	157
Farm Land Consolidation		
- Land clearing (rai)	95	95
- Land grading (rai)	220	157
Soil/Soil Layer Improvement		
- Improvement area (rai)	458	411
Farm Road Improvement		
- Farm road (m)	1,200	1,200
Agricultural Supporting Activities		
- Equipment and facilities (set)	1.0	1.0

3.11 Environmental Impact

3.11.1 Environmental Impact by the Project Implementation

According to the IEE results, proposed projects will not give an absolutely negative impact on present natural and social environment in and around the area considering the objectives such as rehabilitation of flood affected agricultural land, conservation of land and water resources, and resumption of farming activities on the rehabilitated agricultural land, and characteristics and scales of the projects.

Submission of the EIA report prescribed in the Enhancement and Conservation of Natural Environmental Quality Act is not required for the proposed projects (refer to Table K.3.1, Appendix K). Therefore, they can be implemented right away after the feasibility study under the DLD as the implementing body.

As mentioned above, impact on the social and natural environment is slight, but some impacts are recognized through resumption of agriculture. Therefore, the items which cause the impact should be cleared. There is no difference between environmental impacts by each alternative case.

(1) Environmental impact during construction

Construction activities will give the negative impact on the environment in and around the area. Degree and reduction methods of the impact are as follows.

- Impact on downstream basin/downstream area

The embankment will be constructed along the Chawang river. Since deposited soil on the river and farmland is used for the materials, river water will be contaminated during the accumulation of the soil. As a result, the construction will give an negative impact on the downstream ecosystem.

However, considering deposited soil is coarse, environmental effect by water contamination will be gone instantly after the construction work. If the temporary construction is carried out properly, there will be little impact by the runoff sediment. In addition to that, construction avoiding the flooding period can minimize the impact on the channel by the deposit of runoff sediment.

- Impact on living environment by embankment construction

Since construction site is away from the residential area and its scale is small, construction activities will not give negative impacts such as noise, water contamination, etc. on living condition of the residents. No residents exist relying on the river as a living water source.

(2) Environmental impact after the construction

When the construction is completed, devastated agricultural land will be rehabilitated and farming activities will be resumed. Then, following impacts on existing natural and social environment can be expected.

- Natural environment in the area

After flood affected agricultural land is rehabilitated, fruit trees and covering crops will be planted in accordance with soil/soil layer improvement. Vegetation on the bare land will be recovered, and ecosystem which have been destroyed by each flood could be preserved. Recovering vegetative area of the case-1 is larger than that of the case-2.

- Residents' socio-economic activities

By the completion of embankment construction, flood intrusion to the farm land will be reduced, and land will be covered with vegetation. Because of the above, labor such as sediment removal on farm land by each flood and soil management for fertility improvement after soil erosion could be saved.

Compared with the impacts on rural life and financial benefit of beneficial farmers through implementation of the alternatives, case-1 is more positive since some parts of the waste land can not be restored in the case-2.

After farm land rehabilitation and resumption of farming activities, the importance of management of the agricultural facilities constructed through this project will be recognized. In this connection, proper maintenance and management activities for these facilities are required. These activities will be defined specifically through farmers participation to this project. Since their activities scale is small, they can be included in daily farming activities. Therefore they will not influence on existing farmers organizations and socio-economic activities.

According to the above analysis, the negative impact on natural and social environment in and around the area is very slight, and the project implementation and operation will not be restricted taking account of the environment.

3.11.2 Environmental Conservation Plan

After the project implementation, following deteriorations on environmental condition in accordance with the spread of farming practice are predicted.

- Deterioration of soil fertility and conservation function by improper soil management
- Deterioration of water quality by improper fertilizer management
- Negative impact on farming activities by unmanaged agricultural facilities

To perceive these problems and take measures to meet the situation quickly, establishment of environmental monitoring organization is required. Its activities are as follows.

- Monitoring of farming condition on rehabilitated agricultural land
- Monitoring of maintenance and management condition of agricultural facilities
- Planning and design of countermeasures for new environmental impact
- Coordination of related agencies for implementation of environmental projects

Since these activities can be practiced as part of the daily maintenance and management activities, they will be carried out by the farmers' organizations in this area. Surat Thani branch office of DLD will monitor them. Monitoring activities on farming condition in the mountainous area is also important for the prevention of landslides. This environmental monitoring organization should coordinate monitoring items in cooperation with RFD and diffuse the conservation methods for the mountainous area.

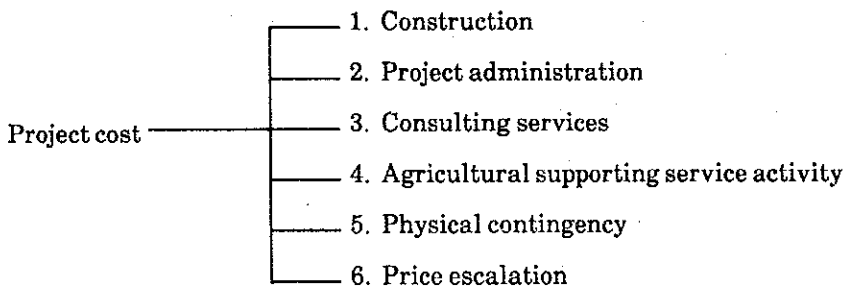
3.12 Project Cost

3.12.1 Basic Condition

(1) Implementation mode

The construction works shall be carried out on a contract basis, considering the characteristics and the scale of the project.

(2) Component of project cost



1. Construction cost

This item includes the construction costs estimated based on respective unit costs including construction materials, fuel and oil, labor, and depreciation and repairing cost of the construction equipment, and overhead of contractor.

2. Project administration

Project administration under construction is consisted of salary of temporary employees, communication, water and electric supply charge of temporary office, etc..

3. Consulting services

This cost includes consulting fees for detailed design of the proposed facilities and construction supervision, survey and investigation cost. The cost shall be estimated at about 10% of 1 and 2.

4. Agricultural supporting services activity

This item covers the cost for agricultural supporting services activities to be conducted in the F/S area. The major one is the cost of experts required for activities, which is estimated based on the number of staff and their expenses.

5. Physical contingency

The allocation of contingency is made to cover minor differences between the actual and estimated quantities, unexpected difficulties in construction works and so forth. The contingency equivalent to 10% of the above-mentioned items has been applied.

6. Price escalation

Price escalations of 2.5% per annum for the foreign currency portion and 4.5% for the local currency portion are allowed respectively.

(3) Unit prices of materials

The unit cost is estimated based on the data collected from DLD, taking into account the costs such as efficiency of the construction equipment, labor, materials, and operation cost of the construction equipment. Applied unit cost is based on Thai fiscal year 1994 prices. The rate of foreign and local currency portions is applied by basic materials. Details are shown in Appendix M.

(4) Overhead cost

Overhead cost for construction works which consists of management, profit, tax, compensation fund and insurance is applied as follows.

① Construction cost
② Management and profit ····· 17% of ①
③ Tax and others ····· 8% of ① + ②

3.12.2 Project Cost

The total project cost including price escalation for four years of implementation period is estimated as follows (refer to Appendix M).

Unit : 1,000 Baht

Project	Case-1	Case-2
1. Construction Cost		
- Drainage Improvement	24,522	14,875
- Irrigation Development	5,560	4,346
- Land Consolidation	506	408
- Soil/Soil Layer Improvement	2,516	2,257
- Farm Road Improvement	241	241
- Agricultural Supporting Facilities	1,920	1,920
Sub-total	35,265	24,047
2. Project Administration	2,003	2,003
3. Consulting Services	3,526	3,078
4. Agricultural Supporting Activities	7,068	7,068
Sub-total (1~4)	47,862	36,196
5. Physical Contingency	4,786	3,620
Sub-total (1~5)	52,648	39,816
6. Price Escalation	8,217	6,158
Grand total	60,865	45,974

3.13 Project Implementation Program

3.13.1 Project Management and Implementation

(1) Project Coordination

According to the proposed project implementation, development plan covers various components, then DLD could not solely handle all the components. However, most of the components are under management of Ministry of Agriculture and Cooperations. In order to assure smooth and successful implementation of this project, it is, therefore, recommended to establish three levels of coordinating committee and one project unit task force as follows.

a) Project Executive Committee
b) Project Coordinating Committee
c) Surat Thani Provincial Coordinating Committee
d) Ban Na San Project Unit Task Force

The Project Executive Committee will be the top executive body taking leadership of external coordination among the agencies concerned. While Project Coordinating Committee would be set as a DLD internal coordination. At the provincial level, coordination is through Surat Thani Provincial Coordinating Committee. In order to assure smooth coordination at the field level, Ban Na San Project Unit Task Force will be established. These committees basically have their major functions as follows.

a) To formulate policy and/or program in accordance with the scope of the project.
b) To supervise the overall works.
c) To coordinate and resolve any problems and difficulties in project implementation.

The detailed composition and responsibility of the above mentioned committees are described in the Appendix A-2.

(2) Project Executing Agency

Under the Project Executive Agency by appointing a project director who act as secretary of the Project Executive Committee as well as a chairman of the Project Coordinating Committee. The Deputy Director General of DLD shall work as the Project Director supervising the overall work performance. Under the supervision by the Project Director, two project managers would be appointed, one is Bangkok office project manager for planning, management and administrative activities, another is field project manager for supervision of day-to-day operation in the project area and report the progress of works to DLD Bangkok office. Field project manager should receive full support from DLD Regional Office 11 and Surat Thani provincial DLD station throughout the implementation period.

3.13.2 Implementation Schedule

Project implementation schedule is planned and programmed to allocate five years after completion of the feasibility study. It includes necessary procedure for fund arrangement, coordinating works, detailed design and tendering for facilities construction.

Besides construction of facilities, promotion of farming practice including soil/soil layer improvement is one of the most important factors for successful and smooth project

implementation. For the promotion, therefore, various activities for setting up farmer's organization aiming to encourage the related farmers to participate the project and to coordinate the project implementation with the Ban Na San Project Unit Task Force, are required. Those activities are scheduled in parallel with the project coordination works. Agricultural supporting service project is initiated early in the implementing stage before completion of construction, as promoting activities for improvement of farming practice can be carried out in the fields where trees have been already planted. The implementation schedule is shown in Figure 2-15.

3.13.3 Project Operation and Maintenance

(1) Responsible Agency

The proposed project for the F/S area can be divided into two major categories, i.e. engineering works and technical services. The engineering works may be consisted of two types namely, major facilities or public facilities and on-farm facilities. The operation and maintenance (O&M) of major facilities such as embankment for preventing flood intrusion, gabion for slope protection, etc., will be responsible of the government agencies concerned since they require skilled professionals, high O&M cost and adequate guidelines and standards. The major tasks of O&M works of the constructed public facilities are summarized as follows.

a) Inspection and repair for the constructed public facilities, i.e., dikes, slope protection, etc.
b) Observation and data collection and analysis of water levels and discharges of main channels and meteorological data.

In order to promote participation of the villagers, the O&M responsibilities of the constructed facilities at the farm level or in the villages for common use such as, farm ponds, irrigation and drainage ditches, shall be undertaken by beneficiaries through the farmer's groups to be organized under the direction of DLD together with village committee. In this connection, the government agencies concerned should provide technical and material assistance through periodic/occasional visits to the project sites.

For successful O&M by beneficiaries, participation of the villagers in all stages of project implementation is necessary.

(2) Organization for O&M

In consideration of RID's responsibilities for O&M of major facilities constructed by RID, the O&M works shall be carried out by O&M staff of Surat Thani RID provincial office under the

supervision of RID regional office. Generally, the government agencies concerned will carry out their O&M works by the existing organization. During the project implementation, in parallel with construction of various facilities, it is desirable to have positive participation of beneficial farmers and preparation of operation and maintenance organization for the facilities by mainly farmers themselves. The beneficiaries should be organized as farmer's groups for O&M at the farm level. For successful water management, particularly during the dry season, farmer's group for O&M should play a vital role in preparation of water allocation program and regulation of water at the diversion weir under the guidance and technical assistance from DLD.

(3) Operation and Maintenance Cost

The cost consists of the cost for periodic visits or monitor to the project sites, repair cost for constructed facilities and administration cost for operation and maintenance, which is estimated at 734,000 Baht (case-1) and 500,000 Baht (case-2) per annum.

3.14 Project Justification

3.14.1 Economic Evaluation

(1) Introduction

The objectives of the project are to rehabilitate the farmland which has been buried under sand by the 1988 disaster and to conserve agricultural land. And so, for project evaluation, it is necessary to assess from both farmland rehabilitation benefit and agricultural production increment benefit. However, it is difficult to quantify the former. As a substitutive evaluation method the benefit can be estimate based on project cost itself or land market price. In any case, it must be recognized that rehabilitation project like this one has important economic effects of which quantification is difficult, as well as the agricultural production increment benefit which is usually used for project evaluation.

The project evaluation based on incremental agricultural production benefits is estimated from both financial evaluation calculated with financial prices which are the actual average market prices and economic evaluation calculated with economic prices which are adjusted from financial prices. Both evaluations are presented by the indicators such as benefit/cost (B/C) ratio, internal rate of return (IRR) and net present value (NPV). Financial evaluation is necessary in order to estimate the budget balance of the project from the viewpoint of the project's own finance, and economic evaluation is necessary in order to assess the budget balance of the project from the viewpoint of the national economy as a whole, adjusting financial prices to economic or border prices, excluding transfer items like import tax, interest, etc..

As for this project, two plans are proposed based on dike construction method, that is,

complete dike construction and semi-dike construction. Accordingly, the project evaluation is executed for these two plans. The results of the economic analysis are furnished as comparison and examination data for economic precedence, and contribute to the recommendations of comprehensive project justification.

(2) Project cost

The project cost is composed of investment costs and annual operation/maintenance costs for the institutions and facilities constructed by the project. These costs are calculated in both financial and economic categories, depending on the cost estimation methods. The financial cost includes physical and price contingencies, which have been calculated based on the rate adopted in the recent RID projects, i.e. , the physical contingencies is an annual rate of 10% in the successive years, and that of the price is 4.5%. The economic cost is calculated from the financial cost by excluding price contingencies and taxes but including physical contingencies, adjusted by conversion factors. The conversion factors for local currency costs are shown below.

Conversion Factors

Items	Conversion factors
Standard conversion factor (SCF)	0.94
Transportation	0.67
Farm mechanization	0.70
Agro-chemicals	0.94
Civil works	0.76
Building	0.84
Roads	0.80
Consolidation works	0.74
Unskilled labor (Opportunity cost and SCF)	0.61

According to the project implementation schedule, annual investment requirement and the annual operation/maintenance costs for the project are shown as follows.

1) Investment cost for the project

Unit : 1,000 Baht

	Case-1		Case-2	
	Financial	Economic	Financial	Economic
1st year	5,219	4,592	4,680	4,128
2nd year	23,647	18,193	17,401	14,100
3rd year	29,588	21,642	21,482	16,491
4th year	2,411	1,833	2,411	1,833
total	60,865	46,260	45,974	36,552

Source : Project cost estimation

Remark : 1st year is 1996

2) Annual operation/maintenance cost

Unit : 1,000 Baht

	Case-1		Case-2	
	Financial	Economic	Financial	Economic
Annual year	734	611	500	417

(3) Project benefit

The project benefits will mainly occur in rehabilitated and conserved orchard which are now buried under sand and in the reclaimed land with dike construction, irrigation and drainage improvement, land and soil improvement and farm roads improvement. In the existing orchard, the growth of rambutan and durian is poor and will benefit good growth through the project implementation. The project benefit is expressed as the financial and economic difference in net production values estimated on the financial and economic prices with and without project.

1) Price

Net production value of agricultural production is expressed as the difference between production value and cost. Both output and input are calculated with financial and economic prices of the composed commodities. Financial prices of non-traded goods are the latest actual average market prices in the project area, and traded goods are adjusted by adding or deducting local costs such as handling, transport, margin, etc.. Economic prices are adjusted by the conversion factors. Both prices are then adjusted to farm gate prices.

Since the economic effects of this project will occur from the year 2000, financial and economic prices of traded goods of output and input are projected to the year 2000 in 1994's constant price by using the commodity price trends forecasted by the World Bank. As the

above price procedure, financial prices are adjusted by adding or deducting local costs and economic prices are adjusted by SCF and CFs from financial prices. Moreover, the opportunity cost of unskilled labor is calculated by demand/supply balance of farm labor which has been acquired from the farm household economic survey in the study area.

The main financial and economic unit prices are shown below.

Unit Prices

Unit : Baht/ton, man/day

		1994		2000	
		Financial	Economic	Financial	Economic
Produces	Rambutan	8,280	9,500	11,060	12,390
	Durian	11,750	12,390	14,070	14,810
Fertilizers	15-15-15	7,290	7,240	8,340	8,080
	16-20- 0	5,440	5,220	6,190	5,970
	16-16- 8	6,010	5,780	6,850	6,600
	12-24-12	8,650	8,400	9,920	9,650
	46- 0- 0	6,600	6,320	7,520	7,220
	urea	6,430	6,190	7,230	6,980
	13-13-21	5,270	5,020	5,970	5,700
Unskilled labor		100	65	100	61

2) Benefits by crops

1 Benefit area

a) Sandy land, grass land and marshy area

The area of these lands which will be rehabilitated by the project is 220 rai, of which 189 rai will be planted to rambutan and 31 rai durian, in case-1, and 135 rai rambutan and 22 rai durian, in case-2.

b) Existing orchard

The area of existing orchards which will benefit from the project is the same, 243 rai, in both case-1 and case-2, of which 231 rai is rambutan and only 12 rai durian, with average 4 years old young trees.

2 Benefits

Net production values per rai by crops are presented in Table 3.14.3.1~12, Appendix-I.

Rambutan starts to bear fruit from 4 years old and durian from 5.

Newly planted sandy land, grass land and marshy area will remain as present situation in the case of without the project, so it is assumed that there will be no benefits in the future without the project. Moreover, it is assumed that young fruit trees in the existing orchard will be 8 years old at completion of project.

The project benefits in case-1 and case-2 are shown below.

Case-1

Unit : 1,000 Baht

Tree Age	Financial			Economic		
	Newly planted	Existing	Total	Newly planted	Existing	Total
1	-1,141	1,240	-99	-1,116	1,106	-10
2	-683	993	310	-537	1,146	609
3	-722	1,028	306	-570	1,139	569
4	-636	1,028	392	-359	1,139	780
5	452	1,028	1,480	991	1,139	2,130
6	1,205	1,028	2,233	1,836	1,139	2,975
7	2,133	1,028	3,161	2,951	1,139	4,090
8	2,840	1,028	3,868	3,760	1,139	4,899
9	2,971	1,028	3,999	3,907	1,139	5,046
10	3,005	1,028	4,033	3,951	1,139	5,090
~						

Case-2

Unit : 1,000 Baht

Tree Age	Financial			Economic		
	Newly planted	Existing	Total	Newly planted	Existing	Total
1	-956	1,240	284	-799	1,106	307
2	-488	993	505	-383	1,146	763
3	-516	1,028	512	-407	1,139	732
4	-468	1,028	560	-256	1,139	883
5	309	1,028	1,337	707	1,139	1,846
6	847	1,028	1,875	1,311	1,139	2,450
7	1,510	1,028	2,538	2,107	1,139	3,246
8	2,014	1,028	3,042	2,685	1,139	3,824
9	2,108	1,028	3,136	2,790	1,139	3,929
10	2,132	1,028	3,160	2,821	1,139	3,960
~						

(4) Financial evaluation and economic evaluation

The economic analysis of project with quantifiable benefits is executed by comparing the benefits and costs. Both are discounted to the present values by the opportunity cost of capital of 12% in Thailand during the economic life which is assumed for 30 years. No residual value is assumed at the end of the discounted period in view of the nature of civil work. To calculate the internal rate of return (IRR), the discount rate of 5% is also adopted, which is a special rate for small scale development project in Thailand. The results of the analysis are shown below.

Benefit · Cost (B/C) Ratio and Internal Rate of Return (IRR)

		Discount rate	Case-1	Case-2
Financial Evaluation	B/C Ratio	5%	0.81	0.68
		12%	0.37	0.32
	Net Present Values (NPV) (Benefits PV-Costs PV) (1,000 Baht)	5%	-9,540	-15,154
		12%	-24,380	-25,674
Economic Evaluation	B/C Ratio	5%	1.04	1.08
		12%	0.48	0.51
	EIRR (%)		5.6	6.1
	Net Present Values (NPV) (Benefits PV-Costs PV) (1,000 Baht)	5%	1,789	2,846
		12%	-19,949	-14,774

Based on the above assumptions, for the economic evaluation, the estimated benefit-cost (B/C) ratios discounted for 12% of both case-1 and case-2 are under 1.0, indicating that economic internal rates of return (EIRR) is less than the opportunity cost of capital, 12%. This is due to the long period (4 ~ 5 years) between completion of construction works and production values of fruit trees compared with other crops and the newly planted area occupies a large part of the benefit area. However, the EIRRs of both case-1 and case-2 exceed the special capital rate of 5%. Accordingly, in that sense, this rehabilitation and conservation project is feasible and is economically appropriate.

The EIRR of case-2 is 6.1% and case-1 is 5.6%, accordingly in view of economic performance, case-2 barely exceeds case-1. However, it can be said that there is little difference between the two from the viewpoints of an economic preference.

Besides, as the EIRRs of the project are less than the opportunity cost of capital of 12%, sensitivity analysis is not carried out on the major project variations and risks.

(5) Other economic effects

1) Rehabilitation benefit

As mentioned above, since this project is a rehabilitation and conservation project, the effects of rehabilitation are the project benefits. However, it is difficult to quantify and to calculate the benefits. As a method, approach from substitutive evaluation based on farm land market price may be applied. According to the farm economic survey conducted in the study area, the average farm land price on the plain was 50,000 Baht per rai. In view of the location's condition, the price has no speculative factor and is considered the marginal production price of the farmland. Accordingly, by assuming that a value corresponds to 5% of 50,000 Baht, i.e., equal to land rent rate is an annual rehabilitation benefit, present values capitalized at discount rate of 5% for 30 years are shown below as the trial calculation of the rehabilitation benefits of the sandy land, grass land and marshy area in both case-1 and case-2.

Present Values (PV) (Tentative)

Unit : 1,000 Baht

	Case-1	Case-2
Present Values (PV)	7,670	5,400

2) Increase of employment

Various secondary and intangible benefits can be expected from the implementation of the project. Though small in scale, the most important thing is the increase of employment opportunities in this village during the construction period. According to the cost estimation, unskilled labor requirements for the investment of the project is counted at about 200 man/day during the four years of implementation.

Besides, constant labor employment for operating and maintenance of the project is also required.

Furthermore, new agricultural labor for fruit cultivation in the rehabilitated farmland is required. Additional labor after completion of improvement works in the existing orchard land are also required, which is estimated to be 30 - 40% of whole labor requirement. Consequently, about 3,700 ~ 4,000 man/days annually will be required after stable production stage when the trees are more than 10 years old.

(6) Impact on farm household economy

The increase of farm net income and farm household income of representative medium farmer by resulting from better farm management on improved farmland conditions after the project are estimated as follows.

Unit : Baht

	Present	After project
Farm net income	65,925	169,526
Non-agricultural net income	50,000	-
Farm household income	115,925	169,526
Household expenditures	113,900	132,552
Farm household economic surplus	2,025	36,974

Remark : Present income is based on the farm economic survey, and income after the project is based on the balance of farm economic budget after stable production (10 years and over).

With implementation of the project farm income will increase to 169,526 Baht after stable production. The farmer is likely to do much better, without having to work part time job. Their life will attain to the standard level of a large farm size farmer, and farm household surplus will be 37,000 Baht. With the surplus, the farmers can afford to invest in improvement of farm management, living condition, education and savings. However, the balancing of budget will be possible from the 6th year for rambutan and durian growing. Accordingly, until then it is necessary to support farm household economy with incomes from existing orchards and non-agricultural activities.

3.14.2 Overall Evaluation

Two alternative development plans have been examined. The results of economic analysis show that both plans are less feasible from the economical point of view, compared with general agricultural development projects. The economic internal rate of return of case-2 is slightly higher than that of case-1. These values are estimated based on quantitative economic benefits of increment agricultural production after land rehabilitation. However, it can be considered that there is no difference between the two from the general view of economic evaluation.

For comprehensive evaluation, besides the economical examination, non-quantitative benefits have to be considered. The purpose of the project is to ensure sustainable farming by restoring the flood affected area. Considering the project characteristics, case-1 is probably in line with social demands for land restoration and will give more social impact on the flood affected

farmers. The case-1 will also more greatly contribute to creation of agricultural employment opportunity, stabilization of farmer's living and environmental conservation. The difference of the project cost between the cases is small, taking financial capacity of the implementing agency into consideration.

Based on the above consideration, technical and financial aspects of DLD, case-1 is recommended as the land rehabilitation and conservation project.

Economic internal rate of return (EIRR) of case-1 is low, 5.6%, since economic return of fruit trees will be generated from four to five years after planting. However, the value is higher than 5.0% which is generally applied to specific small scale government projects.

As a conclusion, therefore, the proposed project, case-1, is considered to be feasible.

CHAPTER 4

DEVELOPMENT PLAN IN THE LAN SAKA AREA

CHAPTER 4 DEVELOPMENT PLAN IN THE LAN SAKA AREA

4.1 Basic Approach

4.1.1 Development Constraints

Development plan for the F/S area is formulated based on the development approach as described in 7.1, PART 1. According to the survey results, development constraints are summarized as follows.

- Run off from the upstream flows with washed soil into the agricultural land and causes erosion, sediment and soil loss in the field. It is impossible to plant new crops or fruit trees.
- Present land is covered with thick sediment of sandy soil. For crop production, therefore, some measures including soil improvement have to be taken.
- Irrigation and drainage facilities for soil and water conservation and effective farming are not provided with farmland.
- Supporting service activities for propagation of farming techniques including soil improvement are not carrying out in the area.

4.1.2 Alternative Development Plans

(1) Subdivision of the area

The area is divided based on the present land use and topographical conditions.

Upstream area	:	Long and narrow area affected by flooding between the river and the slope of hinterland
Downstream area	:	Flood affected area formed after the disaster between the two rivers.

(2) Alternative Development Plans

The main subject for reconstruction of agriculture is the prevention of flood intrusion which needs much requirement of the construction period and the project cost. Therefore, the following prevention measures are considered by the divided area.

Upstream

Measure-① : Embankment is constructed at whole sections along the river, in order to introduce fruit tree cropping into the flood affected area.

Measure-② : Embankment is not constructed. But, in order to alleviate flood damage to the affected area, vegetative protection measure which covers with crops on the slope along the river, is taken. This measure prevents the inflow of sediment and retards intruding velocity of flooding water into the agricultural land.

Downstream

Measure-① : Embankment to prevent the flood intrusion is constructed along the river, which makes fruit tree planting possible.

Measure-② : Flood damage in the downstream area is characterized by spreading the debris flow intruded from the upper part of the area into the lower part. For prevention of the such flood intrusion, embankment is constructed at the only upper part along the river. Flooding from the lower part is allowed since it is not accompanied with sand and debris and flooding time is short. In the lower part, therefore, the slope of the river is rehabilitated by vegetative measure.

Taking account of the above mentioned measures, the following development alternatives are combined.

	Measure for upstream		Measure for downstream	
Alternative Case	①	②	①	②
Case - 1	applied	-	applied	-
Case - 2	applied	-	-	applied
Case - 3	-	applied	applied	-
Case - 4	-	applied	-	applied

Note : Measure ① is the full construction of embankment along the river.
Measure ② for the upstream is the vegetative protection.
Measure ② of the downstream is the construction of embankment in the upper stream and the vegetative protection work in the down stream.

Land rehabilitation and conservation plan is studied by the alternative in the following sections.

4.2 Land Use

4.2.1 Basic Concept

Land use plan is approached by the classified land as mentioned in 2.3.2, taking the possibility of fruit tree cropping into consideration.

Class - I : Fruit tree cropping is possible if flood damage is alleviated. Upland crop or vegetable may be planted in the area which flood damage remains severe and groundwater is high during wet season.

Class - II : This class belongs in the higher elevation land, of which flood damage is not so severe that fruit tree farming can be practiced. Therefore, the present mixed cropping is continued without any improvements.

Class - III : This class land is the swamp area accumulating run-off water from the hinterland. In order to make fruit tree cropping possible, drainage system has to be provided, as well as a lot of requirements of soil layer improvement. Therefore, this class land is utilized as an inland fishery pond from viewpoints of effective land use.

Class IV : Fruit tree cropping is possible by means of the provision of drainage canals to lower groundwater table. Upland crops, however, may be planted depending on the flooding condition.

Class V : No flood damage occurs in this class land. Mixed cropping of fruit trees is conducted same as the present.

Mangosteen is selected as a fruit tree by taking the social and natural conditions of the area into consideration as mentioned in 8.1.2, PART 1.

4.2.2 Land Use Classification and Area

Based on the above basic ideas, land use is planned as follows.

Fruit tree (direct planting)	: Fruit tree planting in the higher elevation land where flood damage can be mitigated by construction of the embankment.
Fruit tree (direct planting)	: Fruit tree planting on a raising bed which makes to keep groundwater table lower than 1.0 m below the ground surface. The maximum height of the bed is 0.5m, considering construction cost and difficulty in maintenance works.

Upland crop : Upland crop is planned as cash crop in the area which is located in the lower elevation land and inundation is prolonged and groundwater is always higher than 1.0m below the ground surface during wet reason.

Inland fishery : Small fishery pond is planned in the land of Class Ⅲ.

By being applied the above land use methods, land use area is classified by an alternative plan, as follows.

Land Use		Case - 1	Case - 2	Case - 3	Case - 4
Fruit tree (direct planting)		224.90	134.60	178.67	88.37
Fruit tree (raising bed)		28.42	45.64	28.42	45.64
Upland crop	upstream	–	–	74.36	74.36
	downstream	76.90	172.33	76.90	172.33
Inland fishery		24.27	24.27	24.27	24.27
Mixed cropping *1		139.17	139.17	139.17	139.17
Public use land *2		85.03	62.68	56.90	34.55
Total		578.69	578.69	578.69	578.69

Note : *1 : Land use is the same as the present.
*2 : Area for roads, canals and embankment.
Details are shown in Appendix A-2.

As an example, land use plan of the case-3 is shown in Figure 2-16 (refer to Appendix A-5).

4.3 Drainage Improvement

4.3.1 Basic Approach

As mentioned in 4.1.2, drainage improvement in the F/S area is planned separately for the upstream (X130-X115) and the 'islet' in the downstream (X115-X90). The followings are the restricting factors and basic approach.

(1) Difference in flood impact

The damage caused by flood in the upstream area is smaller than that in the 'islet'. In the upper area, flood intrusion is smaller and usually leaves behind less silt/sand deposit, trash and drifting logs/woods. In the islet, flood water in Tha Di river, constantly brings new supply of sediment and the constant supply of new deposit are the main reasons why most of the land in the islet remains unrehabilitated.

(2) Frequency, inundation depth and duration

Due to the nature of runoff, occurring in the form of flash floods, the F/S area is constantly 'haunted' by floods, a few times in one rainy season. The topography of the F/S area is relatively simple, sloping in the direction of Tha Di river and the average gradient is 1/600. In a normal year, inundation is about 0.15 - 0.5 m and last for 1-3 hours at location 37 m and above. At elevation 36 m and lower inundation can be as deep as 1.5 m or more, and last longer. In 1988, flood water was very deep, about 2-3.5 m, and lasted for 1-2 days. More damage is caused by sand sediment, floating logs/wood than by flood water itself because the inundation period is relatively short for most of the floods occurred so far. Therefore, for large floods, keeping out sand, rubbish, trash and floating logs/wood is more important than keeping out the flood water.

(3) Long flood intrusion locale due to backwater effect

From the hydraulic calculation it is clear that the flow sections of Tha Di river at and immediately downstream of the F/S area are insufficient to drain deluge of large rainfall. Due to the backwater effect of the small flow sections, flood intrusion occurs along the whole length (X130-X95 in Figure 2-10) of the river in the F/S area. Inundation is seldom caused by insufficiency of flow gradient, as proven by the relatively short inundation duration.

(4) Design year, land use and flood effects on socio-economy

Except for the farm houses on the relatively high ground in the upper region, the restored land in the upper region and the islet will be mainly used to cultivate fruit trees and upland crops. Thus flood effects on the F/S area is mainly confined to agriculture production. 1/10 probability is the design drainage requirement.

4.3.2 Dike Construction

(1) Hydraulic calculation

Non-uniform flow is used to estimate flood level of 1/10 probability discharge. Survey data conducted by RID after the flood in 1988 is used for this purpose. The conditions of hydraulic speculations are as follows.

Design discharge (1/10)	:	757 m^3/s
Length of channel	:	4,500 m (15,000 m in total)
Average gradient	:	1/493
Station interval	:	500 m

Details are shown in Table 11~14, E-37 and E-38, Appendix E. Calculation was also made for 1/50, 1/5 and 1/2 probability. The difference in water depth between 1/50 and 1/10 is about 1 m. Therefore with 1 m freeboard, the dike can withstand the discharge of 1/50.

(2) Cases for comparison

Four (4) cases are studied for comparison: Case-A (with dike) and Case-B (without dike) for the upstream area, and Case-C (ring dike) and Case-D (semi-ring dike) for the lower area (see Figure 2-17 and 2-18).

a) Upstream area (X130 - X115)

Case-A: Complete dike construction with gabion and vegetative protection throughout the length of Tha Di river.

The dike (2,000 m) is planned on the flood plain as close as possible to the river while taking advantage of the natural terrace (At X130 on 36.5 m elevation, X125 on 36.1 m, X120 on 34.9 m, X115 on 33.5 m, refer to Figure 11, E-59, Appendix E). The dike is 1.5 - 2.5 m above the hinterland and will occupy a width of 20-25 m.

The materials for dike construction will come mainly from the flood plain of Tha Di river. Gabion protection will prevent erosion and bank scouring of 1/10 probability discharge (H.W.L.) (refer to Figure 2-14).

Case-B: Without dike construction. Vegetative protection only

Almost all of the land in the upper area is inundated when there is no dike. However, vegetative protection will help to retard intruding velocity and thus reduce damage caused by sand sedimentation and drifting woods. The area affected by flood of 1/2 and 1/10 probability rainfall is shown in Figure 5-7, E-48~E-50, Appendix E.

b) Downstream area (the islet)

Case-C: Ring dike (polder) construction with gabion and vegetative protection.

The ring dike (3,000 m) is planned taking advantage of the natural terrace (At X110 on 33.6 m, X105 on 32.6 m, X100 on 31.5 m, and X95 on 30.7 m, refer to Figure 11, E-59, Appendix E). The dike is 1-4 m above the farmland and will occupy a width of 15-30 m.

With ring dike construction farmland inside, it is protected from flood intrusion. Inundation is caused by surface runoff inside the dike after closing of the drainage gate.

Inundation estimation shows that elevation 31 m and below will be affected for a couple of hours. Area is inundated by surface runoff of 1/2 and 1/10 probability rainfall.

Case-D: Semi-ring dike construction at the upper fringe of islet

The semi-ring dike (1,000 m, spanning over X105 - X110) is actually the upper part of the ring dike in Case-C (refer to Figure 2-17). The height of the dike is between 1 m - 3 m and will occupy a width of 15 m - 25 m. It is planned to prevent overflowing of river discharge at X110 while tolerating flood intrusion at and around X105. It is anticipated that supply of sediment in the islet will cease by stopping the overtopping. The islet is inundated by intrusion and backwater effect of Tha Di river.

For Case-C and D the old channel in the islet connecting the left and right channels will be filled up and reclaimed for agricultural use (refer to Table 15, Appendix M). According to the villagers, this was the original channel of Tha Di river before the 1988 flood.

4.3.3 Drainage Improvement

To enhance drainage in the depression and swampy area and to shorten inundation time, a network of drainage canal (D1, D2 & D3, see Figure 2-17), emptying into Tha Di river through drainage gate, is planned to drain the upstream region and about 1.0 km^2 of rolling hill in the left bank. The surface runoff rolling hill is drained into the upstream region through crossing structures located at the natural depressions along the road. The islet in the downstream is drained by D4. Drainage requirement (0.4 - 4.4 m^3/s) is determined by hydrological study. Drop and pipe crossing structures are also planned to ensure proper drainage. The deteriorated crossing structures will be replaced (refer to Figure 1 in E-42, Figure 2, E-44, and Table 20, E-43, of Appendix E).

4.4 Agriculture

4.4.1 Plan of Cropping System

As mentioned in 4.2.2, land use for the F/S area is classified as follows.

① Mixed cropping of fruit trees is practiced, same as the present. No plan of new cropping.
② Fruit trees direct plantation on higher elevation land
③ Fruit trees plantation on rising bed

④ Upland crops cultivation on lower elevation land

⑤ Inland fishery in the swampy land

These land use areas by each alternative case are in 4.2.2.

4.4.2 Farming Practice

The deposited soil in this area is a mixture of fine and coarse sands. However, the original soil under the deposited soil is silt loam or silt clay loam, and soil/soil layer improvement is possible by exchanging or mixing lower original soil with deposited soil. In this case, the application of organic matter is necessary because of insufficient base element.

Fruit tree cultivation is practiced on higher land with a groundwater level of 1.0 m below surface. This groundwater condition has to be also applied for fruit trees on the rising bed. Upland crops and vegetables are cultivated on lower land, where farmlands are easily damaged, from January to September except for heavy rainfall season between October and December (refer to Figure 2-19).

In this area, mangosteen, rambutan, durian, longkon, banana, young coconut, mango, betel nut, etc. could be planted. In these fruit trees, mangosteen and longkon require fast growing shading trees such as the banana. The harvesting time of rambutan is rather late in Lan Saka area compared to other regions, consequently, the market price tends to be lower. The cultivation of durian is more difficult than the other fruit trees, and intensive soil and drainage improvement is required.

On the other hand, this area is well known as producing mangosteen, and farmers have knowledge about mangosteen cultivation. Therefore, mangosteen plantation is planned for this area. Farming methods for mangosteen is in 6.6.1, PART 1. Before planting the trees in the F/S area, soil/soil layer improvement as mentioned in 4.5.1 is required, but the scale of improvement is smaller than in Ban Na San.

In the F/S area, an intercropping may be carried out considering the properties of the deposited soil. Profitable upland crop or vegetable which is the income source for pre-bearing period, is cropped with shading trees between the planted trees.

Fish culture can be practiced in the swampy area. Major fish in this region is tilapia. The growing period is about three to four months except for heavy rain season. Juvenile can be obtained from DOF, Nakhon Si Thammarat. But, excretion of livestock and rice bran are also available for fish growing.

During fish growing, ponding water has to be drained by one-third of total capacity in a month. This drained water may be used for irrigation for fruit trees.

4.4.3 Yield and Production

(1) Mangosteen and banana

The production plan for mangosteen is applied in accordance with the following fertilizer management.

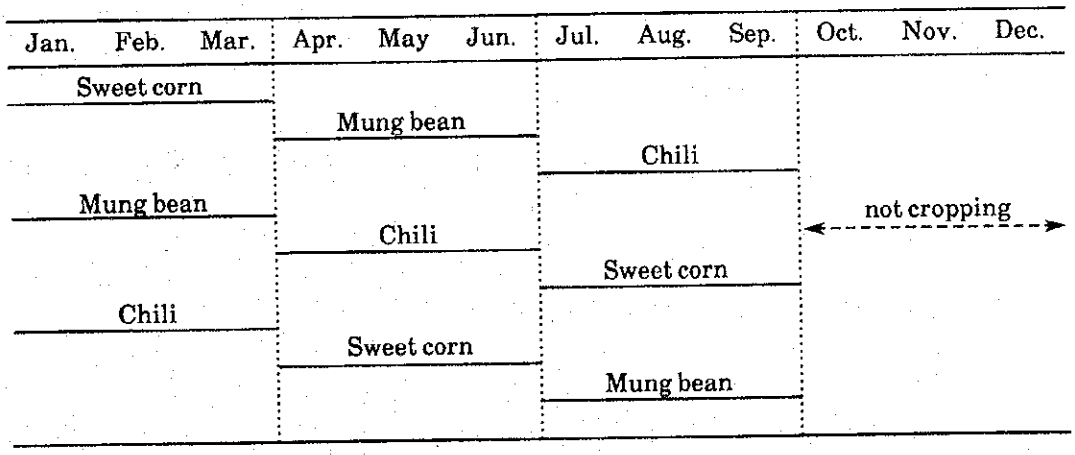
The phosfatic fertilizer (30%) with 500 g/tree for each planting hole is applied before planting, and fertilizer N15:P15:K15 or 16:16:16 is applied with 0.3 kg greater than the standard amount per tree per year. From the 7th year, 2-3 kg/tree at flower bud level, 1-2 kg after fruitage, and 1-2 kg after four to five weeks after bloom, are applied. Organic matter (poultry manure) with 30-50 kg/tree/year and 0.2 kg/tree of lime are also applied. The yield is expected at 15% greater than the standard level (refer to 6.6.1, PART 1, and Table H-8-3 and H-9-3, Appendix H).

Year	7	8	9	10
Yield (kg/rai)	184	552	1,104	1,288

Bananas are intercropped as the shading trees. Harvest will start in the first crop year. The yield is normally 1,000 - 1,600 kg/rai.

(2) Upland crop and vegetable

Suitable crop for the deposited soil in the area is described in 6.6.2 and 7.6.2, PART 1. In practice, there are many choices with profitable rotation. For the F/S area, a rotation of sweet corn, mung bean and chili is proposed as most profitable pattern. Farming method of these crops is also described in 6.6.2 and 7.6.2, PART 1.



(3) Fishery pond

The size of the fishery pond in mountainous Lan Saka area is normally 5 m × 10 m and 2 m in depth, in accordance with data and information on operation unit by one farm household from DOF. Therefore, the same size is constructed near the drainage canal in the swampy area.

Fishing opportunity is expected to double in a year. In this case, if water supply, feeding, procurement of juvenile are well-managed, the production of tilapia is expected at 5 kg/m^3 in fishing, according to the standard of DOF. The first catch is carried out by using nets without drainage and the second by complete drainage before the flooding time.

4.5 Soil and Soil Layer Improvement

4.5.1 Method of Soil and Soil Layer Improvement

(1) Land classification of F/S area

Land is classified into five, same as in Ban Na San. The result is shown in Table 2-9.

For land classification, the following different points compared with the Ban Na San are considered.

- Gravel content is lower and soil texture is consisted of fine grain particles.
- Fruit tree cropping area is mixed by many kinds of trees. Intercropping may be introduced for new planting trees.
- Hill and mountain are included in the F/S area.
- The livestock is bred partially.

(2) Method of soil improvement

Soil improvement by land classification available in the area is as follows (refer to 3.5.1).

1) Improvement of soil physical property

Mulching by using organic material residuum and covering crops are applied, same as in Ban Na San.

2) Improvement of soil chemical property

Input of calcareous material and organic compost, and application of slow release fertilizer are useful for improvement.

3) Improvement of soil biological property

Mulching and growing leguminosae crop are useful, same as in Ban Na San.

(3) Method of soil layer improvement

The following treatments will be considered for soil layer improvement (refer to 3.5.1).

1) Soil mixing with lower original soil
Improvement area is planned at 4 m in diameter around tree and 50 cm in depth.

2) Soil dressing of clayey soil on farm land
Improvement area is the same as the 1), but, the depth is 10 cm.

3) Rasing bed
This method is applied to the inundated area. In construction, present top soil has to be refilled on the top of bed.

Based on the (2) and (3), improvement methods are studied as shown in Table 2-10 (refer to Table F.27, Appendix F).

For soil dressing, new clayey soil has to be procured. According to the soil survey, the soil is available around the F/S area (refer to Table F.30~F.31 and Figure F.9, Appendix F).

4.5.2 Soil and Soil Layer Improvement Area by Land Use

According to the present land use, mixed cropping of fruit trees are cultivated barely. The improvement area is estimated by the alternative plans and the distribution of deposited soil, by considering the followings (refer to Table F.29, Appendix F).

- In case of less damaged areas, soil and soil layer improvements are not necessary.
- Swamp area is utilized for fish ponds, so that the improvement is not needed.
- Hill land is used, same as the present farming.

The result is shown in Table 2-11. According to the Table, soil and soil layer improvement should be conducted mainly in class V (150 cm<) area.

Detail of the area and the cost requirement for improvement are shown in Table F.32 and F.35~F.38, Appendix F.

4.6 Irrigation Improvement

4.6.1 Basic Approach

As mentioned in 2.4.1, in the F/S area irrigation is not a common practice because some rainfall can be expected in the dry months and drought effect on fully grown mixed orchard on 'porous' soil underlain by shallow ground water is small. However, irrigation should be introduced on the restored land, especially during root development stage of young trees. Also, irrigation should be promoted on the upland field to increase and stabilize yield, qualitatively and quantitatively. Low head sprinkler system for orchard and spraying hose for upland field irrigation, both fed by portable pumps, are proposed.

Water requirement is estimated for a 7-day irrigation rotation by modified Penman Method and the basic meteorological data (refer to Table 5, E-4, Appendix E). No distinction in irrigation requirement is made between the proposed development alternatives (Case-1 to 4) because the difference in land use is small and water resource is abundant.

4.6.2 Water Source

(1) Irrigable area

The irrigable area depending on the river water of Tha Di river is estimated with the same method mentioned in 3.6.2. It is determined for periods of peak demands and low amount of available river water occurring especially in March or April for tree crop, which is shown in the table below (refer to Table B.4.6~B.4.8, Appendix B).

Estimated irrigable area in the F/S area

Unit : ha

Place of water source	Catchment Area (Sq.km)	Return Period		
		2 years	5 years	10 years
Tha Di River in the F/S area	75	590~2,140	190~700	70~240

(2) Water resource

After soil improvement more land will come under fruit tree and upland crops cultivation. This will result in new demand and competition for irrigation water. Based on the following facts, water in Tha Di river and shallow wells are planned as the water resource. Portable pumps are

used to pump water from Tha Di river and shallow wells to irrigate farmland in the vicinity of the respective sources.

- Tha Di river never dries up, not even in 1/10 probability dry year. The irrigable area of 1/10 discharge is estimated at 70 - 240 ha for April, which is larger than the land allocated for cultivation (about 100 ha).

- Groundwater level is relatively high, about 3 - 4 m below ground surface in the dry months. Fluctuation in water level is relatively small.

- Hydraulic conductivity is very high ($\times 10^{-2}$/cm).

- A shallow well is easy and cheap to install and maintain.

- The command area of a shallow well is estimated at 8 ha (refer to Figure 3, E-46, Appendix E). Intermittent pumping cycle, one hour pumping follows by one hour intermission is proposed.

Low head sprinkler system and spraying hose are proposed to irrigate fruit crop and upland cultivation, respectively.

4.7 Agricultural and Rural Infrastructure Improvement

4.7.1 Basic Approach

The main features of agricultural and rural infrastructure improvement in the F/S area are the proposal of;

- Sediment paved farm road to increase road density and facilitate agricultural production.

- Repair work for the existing major village road to ensure smooth and safe traffic.

- Replacement of deteriorated crossing structures.

4.7.2 Farm Road Planning

In the upstream area, farm road (R1, R2 and R3) are planned to link to the existing ones (see Figure 2-17 and 2-18). The road on the dike will be used as farm road and O & M road for the dike. In the islet, R4 is planned along drainage canal D4 to improve transportation.

Since many villages are located along the rolling village road in the left bank and most of its length is unaffected by flooding, it is proposed that about 1,750 m be paved with sediment.

The condition of road crossing structures in the F/S area is deteriorating, especially those found along the rolling village road in the left bank. To enhance drainage and to prevent surface erosion on these roads, pipe crossing structures are proposed at depressions along the existing and newly proposed roads. Small side drain is also proposed along the upper side of the roads, especially along the upper side of the rolling village road in the left bank to cut off and drain away runoff from the rolling slope.

The bridge destroyed by the 1994 flood should be restored with a larger section based on the following river condition; i = 1/600, V = 2.5 m/s, Q = 300 m^3/s, about 1/2 of the design flood discharge.

4.8 Farm Land Conservation

4.8.1 Soil Surface Protection

Present cultivated land is generally covered with grass or tree. For soil and water conservation, land reclamation has to be minimized and the land has to be kept green as possible.

From viewpoints of water erosion control in the bare or reclaimed land in the downstream area, upland crops or cover crop such as Centrosime, Caloapsgonium and Kudzu species, is effective same as in Ban Na San. As another cover crop, vetiver grass is available. It is planted in strips at moderate intervals in the sloped ground surface. This grass grows easily and fast and its root is tolerant against erosion, which is applied into the slop protection works of embankment and raising bed. The stump can be procured through DLD. Bamboo is also available in the area. The root is strong enough for soil erosion. It should be planted in an erosive slope and field, as a guard fence against sand and debris flows.

4.8.2 Conservation Measures by Structures

Some facilities are planned for soil and water conservation in the farmland.

(1) Ditch

In general, the interval of ditch should be determined by the gradient of farmland since soil erosion develops in the sloped ground surface. The slope of present farmland is almost flat or less

than 1.0 degree, according to the topographic survey. In addition, in the land use plan farmlands are not bare, but covered with some crops and grass. Therefore, the lands seem to be stable and safe against rainfall erosion. Ditch may not be planned.

(2) Collecting canal

The canal is planned, considering the existence of swamp, the present waterways and the catchment area. The type is designed as the grassed waterways.

After flooding, mixed cropping is practiced evenly in the whole deposited area, so that present land use boundary is not clear. In the study, therefore, the route of canal are planned by taking account of the only topographic condition. The route has to be rearranged in the implementation stage through the related farmer's cooperation. The canals are planned as shown in Figure 2-17 and 2-18.

4.9 Agricultural Supporting Services

4.9.1 Strengthening Program for Farmer's Organization

All farmer's organizations in the F/S area are unregistered farmer's groups with the single purpose. The major constraints for further development regarding farmer's organization are almost same as in Ban Na San. Most farm households are a community of strong solidarity. The basic plan for strengthening program for farmer's organization can be listed as follows.

a) Encourage strengthening capability of the existing staff of informal farmer's group through proper training arrangement on administration and management of the organization.

b) Encourage special program for creation of qualified leaders of farmer.

c) Compaign for establishment of farmer's group in accordance with the specific kind of activities such as, mangosteen plantation, upland crop and vegetable, handicraft and marketing.

d) Formulate strong back-up body by provincial and/or amphoe levels in all activities related to strengthening the farmer's organization.

4.9.2 Agricultural Supporting Services

F/S area is well known as a fruit tree area. Most farmers have a traditional technique for mixed cropping and average farm size is rather small. The present problems in agricultural supporting services are almost the same as in Ban Na San. In order to enable agricultural supporting services to solve the existing problems, emphasis should be given to technical know-how on improvement traditional cultivation into modern cultivation technology together with soil improvement/conservation and proper land use. The basic plans dealing with the following measures are deemed as necessary.

a) Formulate public campaigns for changing traditional cultivation method into modern cultivation technology.

b) Carry out intensive consultation and/or extension services on modern cultivation techniques, land use and soil/soil layer improvement.

c) Encourage provision of special fund with low interest rates for rehabilitation of existing orchard farm under technical assistances from technical agencies concerned.

d) Formulate and support soil improvement programs in sediment deposited farmland and provide technical know-how on soil/soil layer improvement.

e) Encourage strengthening of marketing business and formulate updated marketing information systems related to market demand and market prices of each type of products in the village.

f) Encourage supply of major agricultural inputs, particularly fertilizers and chemicals, together with quality control and operation guidance for proper usage.

g) Promote knowledge on agro-processing, handicraft making from agricultural by-products and cottage industries to families for raising farmer's income levels.

To overcome the above-mentioned subjects, a technical advisory group should be organized, same as in Ban Na San. This group provides technical services for the project implementation body and farmer's groups, under the full support of DLD's station in Nakhon Si Thammarat.

4.10 Facility Design and Planning

4.10.1 Dike Planning

The following standard design criteria are adopted for dike design. Criteria on high water level (HWL), gabion protection, side slope, slope protection (sodding) and road on dike is described in 3.10.1.

- Freeboard (Fb)

The equation gives Fb = 0.9 m for velocity (V) = 3 m/s and depth (d) = 6 m. The design discharge of over 800 m^3/s also requires a minimum Fb of 1.0 m.

With Fb=1 m the dike can withstand a discharge of 1/50 probability. To be on the safe side, gabion protection should be implemented up to the crest at meanders where the gut/flow hits the dike/bank.

- Berms

Two berms of 2 m each, and crest of 3 m are planned to increase stability (refer to Figure 12, E-60, Appendix E). The front berm is planted to water erosion tolerant grass. The middle berm is planted to fast growing local/native varieties of bamboo. Sediment paved road of (effective width 2 m) will be constructed on the crest, allowing single passage of a vehicle. Passing places must be provided.

Trees will be planted in two rows on the crest. The inside slope of the dike may be planted to fruit trees in pockets and no horizontal ditches should be dug for the purpose. The farmers may harvest the bamboo shoots and products from the trees.

It was interesting to observe that natural river channel planted bamboo is minimally eroded after flood. Bamboo and grass will retard velocity and enhance silt and/or sand settling outside the dike. They will also help to keep out rubbish, trash and drifting logs/wood.

The following table gives the dimensions of the dike for the respective improvement alternatives.

Improvement alternatives	Length (m)		Crest elevation (EL.m)	
	Upstream	Downstream	Upstream	Downstream
Case-1	2,000	3,000	36.2~40.2	33.9~36.6
Case-2	2,000	1,000	36.2~40.2	35.6~36.6
Case-3	-	3,000	-	33.9~36.6
Case-4	-	1,000	-	35.6~36.6

4.10.2 Farm Land Consolidation

For the area proposed for fruit tree cultivation, reclamation should be conducted while causing minimum disturbance to the existing vegetative cover. Limited land clearing and grading will be performed in the newly planning upland crop and vegetable intercropping area after dike construction. In some of the areas proposed for fruit tree bed will be constructed. Land clearing and grading may be conducted on the entire area of the land for upland crop only after completion of dike construction.

Small fish ponds (5×10 m, 2 m in depth) will be constructed in the marshland together with the canals for drainage improvement.

4.10.3 Irrigation and Drainage Facility

1) Irrigation facility

Low head sprinkler system and spraying hose, fed by portable pump installed in shallow wells (1.0 m in diameter, 6 - 7 m deep with 3 m water depth and 1 m draw-down), are proposed for irrigating fruit tree and upland crops in the restored land.

2) Drainage facility

Design criteria and standard type adopted for planning drainage canal and appurtenant facilities are described in 3.10.3. The followings are the results of hydraulic planning and designing of drainage canal and the appurtenant structures.

a) Drainage canal

Area	Canal	Type	Discharge (m^3/s)	length (m)	Average gradient
Upstream	D1	Ⅳ	3.52	1,000	1/1,000
	D2	Ⅰ	0.46	600	1/300
	D3	Ⅳ	4.42	300	1/1,000
Downstream	D4	Ⅱ	1.07	625	1/400
Total				2,525	

b) Drop structure and drainage check gate

Area	Canal	Drop				Check gate			
		Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅰ	Ⅱ	Ⅲ	Ⅳ
Upstream	D1	4			4				
	D2	1			1				
	D3							1	1
Downstream	D4	2	1		3	1			1
Total		7	1		8	1		1	2

c) Road crossing structure

Area	Canal	Type				
		Ⅰ	Ⅱ	Ⅲ	Ⅳ	Total
Upstream	Side drain	10				10
	D1			1	1	2
	D2	1	1			2
	D3					
Downstream	D4			1		1
Total		11	1	2	1	15

4.10.4 Farm Road

The following table gives the respective type and length of farm road planned to improve transportation. All the newly planned roads are of type Ⅱ (refer to 3.10.4 and Figure 2-17 and 2-18).

Area	Type	Length (m)
R1	II	50
R2	II	150
R3	II	200
R4	II	700
Total		1,100

About 70% of the major village road (2,500 m) in the left bank requires patching and is proposed to be paved with sediment. Side drain (0.2 m depth × 0.3 m width) is proposed along the upper side of all roads to cut off and drain away surface runoff. The bridge destroyed by the flood in 1994 should be restored with a larger flow section. Construction of a new bridge is not necessary since damage to the bridge is slight. Restoration work will be limited to enlarging flow section and restoring the right abutment and riprap.

Concrete slab	:	5 m × 2 (expanded section 10 m)
Hand/Guard rail	:	5 m × 2 × 2
Foundation (abutment)	:	1 set
Gabion	:	20 m

4.10.5 Agricultural Supporting Services

Same as in Ban Na San, the results of the test plot monitoring will be extended to the farmers through agricultural supporting service. The local stations of DLD will be the center of the service and experts will be dispatched for the purpose. The following equipment and facility will be necessary.

Equipment	Unit
Pick-up truck	1
Station wagon	1
Motor-bicycle	2
Spray	1

All proposed facilities and improvement area for land rehabilitation are summarized by the alternative plan as follows.

Table 2-12 Construction Quantity by Development Alternative Plan

Project	Case-1	Case-2	Case-3	Case-4
Drainage Improvement				
- Dike (m)	5,000	3,000	3,000	1,000
- Drainage canal (m)	2,525	2,525	2,525	2,525
- Appurtenant structures (unit)	25	25	25	25
Irrigation Development				
- Installation of low head sprinkler system (rai)	253	180	207	134
- Supply of spraying hose (rai)	77	-	77	-
- Shallow well, portable pump (unit)	7	7	7	7
Farm Land Consolidation				
- Land clearing, land grading, etc. (rai)	129	70	130	70
- Inland fishery (rai)	24	24	24	24
Soil/Soil Layer Improvement				
- Improvement area (rai)	330	352	358	381
Farm Road Improvement				
- Construction of road (m)	1,100	1,100	1,100	1,100
- Rehabilitation of road surface (m)	1,750	1,750	1,750	1,750
- Rehabilitation of bridge (unit)	1	1	1	1
Agricultural Supporting Activities				
- Equipment and facilities (set)	1	1	1	1

4.11 Environmental Impact

4.11.1 Environmental Impact by the Project Implementation

According to the results of the IEE, proposed projects will not give an absolutely negative impact on existing social and natural environment. Considering the construction scale of engineering works such as embankment construction and soil layer improvement, submission of the EIA report in Thailand is not required (refer to Table K.3.1, Appendix K). Therefore, the implementing organization can carry out the projects right after the feasibility study. However, some impacts on social and natural environment during construction period in and around the area are recognized. Impact degree and countermeasures for major environmental items should be cleared. There is no difference between environmental items by each alternative case since the

difference between cases comes from the extension of the embankment and the rehabilitating areas of each land use.

(1) Environmental impact during construction

Construction activities will give an impact on the environment in and around the area.

- Impact on downstream basin/downstream area

The embankment along the Tha Di river will be constructed. Since deposited soil on the river is used as the construction materials, accumulation work of the soil will cause the runoff of silt, deposit on the downstream basin and the negative impact on river ecosystem. However, if the temporary construction of canals and others is carried out properly and by avoiding flooding period, environmental impact on downstream could be minimized same as the Ban Na San area. Determination of adequate construction plan is necessary in detailed design stage.

- Impact on living environment by embankment construction.

The village road is used to reach the construction site. Since this road is used as the daily living road by the residents around the area, the exposition for them is required before the project implementation. The water quality of shallow wells in the area may be contaminated, but no villagers use this water for their daily need and the construction will not give a negative impact on their life directly.

(2) Environmental impact after the construction

Following environmental impact can be expected in accordance with the extension of farming activities.

- Natural environment

By embankment construction, flood damage will be reduced and restored agricultural land will be covered with fruit trees and upland crops. As a result, vegetation will be recovered and ecosystem can be preserved.

- Socio-economic activities

Same as the Ban Na San, labor such as removal of sediment on the ground and soil surface management can be saved. On the other hand, maintenance of constructed facilities are required. Especially, proper management of planted bamboo and crops on the embankment surface can make the achievement of the project objectives and the

development of sustainable agriculture, which will be operated by farmers in a daily farming practice. Therefore it will not give an impact on existing farmers organizations and socio-economic activities of farmers.

4.11.2 Environmental Preservation Plan

Similar to Ban Na San, establishment of the observation organization is required. Its members will be from the Nakhon Si Thammarat branch office of DLD and farmers' groups as mentioned in 3.11.2. It will operate daily monitoring activities, planning and design for environmental preservation, coordination of related agencies for the implementation of the proposed environmental projects and others. In this area, runoff condition of flood may be changed because of the deposited sand on the Tha Di river, and it will give an negative impact on farming practice in the downstream area. Therefore, continuous monitoring activities on changes of the river bed and removal of heavy deposit are required. In addition, it is needed to coordinate observation activities with RFD for conservation of mountainous slopes.

4.12 Project Cost

4.12.1 Basic Condition

Basic condition for cost estimation is the same as in Ban Na San.

4.12.2 Project Cost

The total project cost including price escalation for five years implementation is estimated as follows (refer to Table 3-6, Appendix M).

Project Cost

Unit : 1,000 Baht

Project	Case-1	Case-2	Case-3	Case-4
1. Construction Cost				
- Drainage Improvement	93,481	48,743	61,728	16,990
- Irrigation Development	3,451	2,518	2,986	2,053
- Land Consolidation	2,323	1,779	2,326	1,779
- Soil/Soil Layer Improvement	2,225	1,668	1,984	1,493
- Farm Road Improvement	593	593	593	593
- Agricultural Supporting Facilities	1,920	1,920	1,920	1,920
Sub-total	103,993	57,221	71,537	24,828
2. Project Administration	2,003	2,003	2,003	2,003
3. Consulting Services	6,276	4,405	4,977	3,109
4. Agricultural Supporting Activities	7,155	7,155	7,155	7,155
Sub-total (1~4)	119,427	70,784	85,672	37,095
5. Physical Contingency	11,943	7,078	8,567	3,710
Sub-total (1~5)	131,370	77,862	94,239	40,805
6. Price Escalation	23,595	13,846	16,844	7,110
Grand total	154,965	91,708	111,083	47,915

4.13 Project Implementation Program

4.13.1 Project Management and Implementation

(1) Project Coordination

For proposed project implementation in Lan Saka, Project Executive Committee and Project Coordinating Committee in the central government level should be organized, same as in Ban Na San. Nakhon Si Thammarat Provincial Coordinating Committee and Lan Saka Project Unit Task Force are also set up as executive body in the local level (refer to Appendix A-2).

(2) Project Executive Agency

The principles of project executive agency for Lan Saka are the same as Ban Na San. Then, Nakhon Si Thammarat provincial DLD station will act as supporting office at the field level.

4.13.2 Implementation Schedule

Project implementation schedule is planned based on the same ideas as in the Ban Na San. Construction works requires longer period, compared with the Ban Na San.

Agricultural supporting service activity should also be initiated as early as possible, in order to set up a farmer's organization for coordination with farmers on the construction of embankment (refer to Figure 2-20).

4.13.3 Project Operation and Maintenance

(1) Responsible Agency

Proposed projects are characterized as the same as in Ban Na San. The major tasks of O&M works of the constructed facilities will be carried out by the government agencies concerned. The facilities as farm level shall be undertaken by farmer's groups.

(2) Organization for O&M

Same as Ban Na San, the government agency concerned, will carry out O&M works of constructed facilities.

O&M works have to be executed under close cooperation with farmer's groups in two villages. In this connection, O&M groups shall be organized by each village. Management of the slope of embankment and removal of sand and gravel settling along the embankment are the most important job by the groups.

(3) Operation and Maintenance Cost

The annual operation and maintenance cost for constructed facilities is estimated as follows. Major requirement comes from repair and maintenance for embankment.

Unit : 1,000 Baht

Case	O & M Cost
1	1,342
2	881
3	1,024
4	557

4.14 Project Justification

4.14.1 Economic Evaluation

(1) Introduction

The F/S area is located along the Tha Di river and is divided into upstream and downstream areas. Four development alternative plans are proposed based on the types of dike as shown below. Accordingly, project evaluation is executed for each of the four plans. The results of economic analysis are furnished as comparison and examination data for economic precedence and contributed to the comprehensive justification of the project.

Four Cases of Development Alternatives

Case	Upstream Area	Downstream Area
1	dike	polder dike
2	dike	semi-dike, vegetation
3	no dike (vegetation)	polder dike
4	no dike (vegetation)	semi-dike, vegetation

(2) Project cost

The investment and operation/maintenance costs for the cases are shown below.

1) Investment cost

Unit : 1,000 Baht

	Case-1		Case-2	
	Financial	Economic	Financial	Economic
1st year	8,118	7,087	5,870	5,152
2nd year	44,776	33,706	26,160	20,610
3rd year	47,628	33,993	27,502	20,721
4th year	52,407	35,744	30,140	21,711
5th year	2,036	1,485	2,036	1,485
Total	154,965	112,015	91,708	69,679

Source : Project cost estimation

Note : 1st year is 1996.

Unit : 1,000 Baht

	Case-3		Case-4	
	Financial	Economic	Financial	Economic
1st year	6,558	5,743	4,314	3,812
2nd year	31,565	23,899	12,950	10,072
3rd year	33,692	24,433	13,608	10,095
4th year	37,232	25,718	15,007	10,511
5th year	2,036	1,485	2,036	1,485
Total	111,083	81,278	47,915	35,975

Note : 1st year is 1996.
CF for unskilled labor is 0.59.

2) Annual operation/maintenance cost

Unit : 1,000 Baht

	Case-1		Case-2	
	Financial	Economic	Financial	Economic
Annual year	1,342	889	881	585

Unit : 1,000 Baht

	Case-3		Case-4	
	Financial	Economic	Financial	Economic
Annual year	1,024	680	557	371

(3) Project benefit

The benefit will occur on the rehabilitated and conserved farmlands which are now deposited with sand and marshy land. Most of the rehabilitated land will be planted to fruit trees and only very limited land will be allocated for fish ponds in upstream area. The majority of the land will be orchard and some of it is for upland crop and vegetables in the downstream area. On the orchard in the upstream area, only mangosteen, which is a special product and is most suitable for this area, will be planted by direct planting method. In the downstream area mangosteen will be planted by both direct planting and risen bed planting methods. On the area for upland crop in both up and down stream areas, sweet corn, mung bean and chili will be planted three times a year by rotation cropping, except in the rainy season. These upland crops will be planted as inter-cropping crops in the directly planted mangosteen orchard until the mangosteen

starts to bear fruits. Banana will also be planted as shading trees for the mangosteen during that period. The representative fish in the fish pond is Tilapia.

1) Price

The main financial and economic unit prices in the project area are shown below.

Unit Prices

Unit : Baht/ton, man/day

	Year 1994 price		Year 2000 price	
	Financial	Economic	Financial	Economic
Products				
Mangosteen	10,920	12,310	14,220	15,750
Banana	3,100	4,500	5,520	7,010
Sweet corn	2,280	3,680	4,090	5,640
Mung bean	7,570	8,050	9,100	9,640
Chili (dried)	28,200	30,160	34,650	36,850
Tilapia	13/m^2	12/m^2	15/m^2	14/ m^2
Fertilizer				
K - P - N				
15 - 15 - 15	7,390	7,110	8,440	8,150
16 - 20 - 0	5,540	5,290	6,280	6,030
16 - 16 - 8	6,110	5,850	6,940	6,670
12 - 24 - 12	8,750	8,470	10,010	9,710
46 - 0 - 0	6,710	6,390	7,620	7,300
urea	6,520	6,250	7,320	7,040
13 - 13 - 21	5,380	5,090	6,080	5,780
Unskilled labor	120	75	120	71

2) Benefits by crops

1. Benefit area

Benefit areas are shown in the following tables.

Unit : rai

	Case-1		Case-2	
	Before bearing	After bearing	Before bearing	After bearing
- Mangosteen	253	253	180	180
- Banana	127	-	90	-
Sub-total	380	253	270	180
- Sweet corn, mung bean and chili				
Inter cropping	90	-	54	-
Upland crops	77	77	-	-
Sub-total	167	77	54	-
- Fish pond	24	24	24	24
Total	571	354	348	204

Unit : rai

	Case-3		Case-4	
	Before bearing	After bearing	Before bearing	After bearing
- Mangosteen	207	207	134	134
- Banana	104	-	67	-
Sub-total	311	207	201	134
- Sweet corn, mung bean and chili				
Inter cropping	71	-	35	-
Upland crops	77	77	-	-
Sub-total	148	77	35	-
- Fish pond	24	24	24	24
Total	483	308	260	158

Note
1. Production of 7 years old of mangosteen is very little, and so the bearing year is assumed to be 8 years old.
2. The area of banana is assumed to be 50% of mangosteen area.
3. Inter cropping area of upland crops is assumed to be 40% of directly planted mangosteen area.

2. Benefits

Net production values by crops per rai are presented in Table 4.14.3.1~12, Appendix -I.

Mangosteen is produced from trees of 7 and over years old. Benefits of the development cases are shown in the following tables.

Case-1 Unit : 1,000 Baht

Years after planting	Financial			Economic		
	Fruits	Upland crops	Total	Fruits	Upland crops	Total
1	-1,231	3,722	2,491	-810	8,001	7,191
2	-425	4,427	4,002	-134	9,204	9,070
3	-473	4,427	3,954	-179	9,204	9,025
4	-595	4,427	3,832	-268	9,204	8,936
5	-706	4,427	3,721	-352	9,204	8,852
6	-770	4,427	3,657	-406	9,204	8,798
7	-321	4,427	4,106	185	9,204	9,389
8	662	2,106	2,768	1,261	4,387	5,648
9	2,380	2,106	4,486	3,331	4,387	7,718
10	2,996	2,106	5,102	4,051	4,387	8,438
~						

Note : Benefits of upland crops include that of fishery.

Case-2 Unit : 1,000 Baht

Years after planting	Financial			Economic		
	Fruits	Upland crops	Total	Fruits	Upland crops	Total
1	-875	1,283	408	-577	2,765	2,188
2	-302	1,511	1,209	-95	3,152	3,057
3	-336	1,511	1,175	-127	3,152	3,025
4	-423	1,511	1,088	-190	3,152	2,962
5	-502	1,511	1,009	-250	3,152	2,902
6	-547	1,511	964	-288	3,152	2,864
7	-228	1,511	1,283	133	3,152	3,285
8	472	122	594	897	270	1,167
9	1,694	122	1,816	2,370	270	2,640
10	2,132	122	2,254	2,882	270	3,152
~						

Note : Benefits of upland crops include that of fishery.

Case-3 Unit : 1,000 Baht

Years after planting	Financial			Economic		
	Fruits	Upland crops	Total	Fruits	Upland crops	Total
1	-1,006	3,323	2,317	-642	7,124	6,482
2	-347	3,949	3,602	-109	8,213	8,104
3	-385	3,949	3,564	-146	8,213	8,067
4	-486	3,949	3,463	-218	8,213	7,995
5	-577	3,949	3,372	-287	8,213	7,926
6	-628	3,949	3,321	-331	8,213	7,882
7	-261	3,949	3,688	152	8,213	8,365
8	542	2,105	2,647	1,031	4,387	5,418
9	1,947	2,105	4,052	2,723	4,387	7,110
10	2,451	2,105	4,556	3,312	4,387	7,699
~						

Note : Benefits of upland crops include that of fishery.

Case-4 Unit : 1,000 Baht

Years after planting	Financial			Economic		
	Fruits	Upland crops	Total	Fruits	Upland crops	Total
1	-651	885	234	-428	1,907	1,479
2	-224	1,033	809	-71	2,163	2,092
3	-249	1,033	784	-95	2,163	2,068
4	-313	1,033	720	-142	2,163	2,021
5	-372	1,033	661	-187	2,163	1,976
6	-406	1,033	627	-215	2,163	1,948
7	-168	1,033	865	98	2,163	2,261
8	351	122	473	667	270	937
9	1,259	122	1,381	1,762	270	2,032
10	1,585	122	1,707	2,143	270	2,413
~						

Note : Benefits of upland crops include that of fishery.

(4) Financial and economic evaluation

The results of analysis for financial and economic evaluation are shown in the following table.

Benefit Cost (B/C) Ratio and Internal Rate of Returns (IRR)

		Discount Rate	Case-1	Case-2	Case-3	Case-4
Financial Evaluation	B/C Ratio	5%	0.38	0.24	0.48	0.33
		12%	0.20	0.12	0.25	0.16
	Net Present Values (NPV) (Benefits PV-Costs PV) (1,000 Baht)	5%	-92,870	-68,240	-56,801	-32,181
		12%	-94,652	-62,292	-63,842	-31,515
Economic Evaluation	B/C Ratio	5%	1.01	0.57	1.26	0.79
		12%	0.56	0.31	0.70	0.42
	EIRR (%)		5.3	(-)	8.7	(-)
	Net Present Values (NPV) (Benefits PV-Costs PV) (1,000 Baht)	5%	1,536	-29,286	20,609	-7,604
		12%	-37,580	-37,071	-18,907	-16,289

Note : (-) shows less than 5.0%.

Based on the above table, the estimated economic internal rate of return (EIRR) of case-1 and case-3 exceed the special capital rate (5%), and are less than the opportunity cost of capital (12%). This is caused by the benefits from upland crops which produce immediately after completion of the construction works and last long after the bearing age of fruit trees. Accordingly, economic viability of the project without the benefits of upland crops is very low. Depending on the project cost, it is difficult to attain a certain level of economic value with benefits coming from fruit trees alone. Efficient use of the rehabilitated lands for upland crops contributes greatly to the economic viability of project. Both case-1 and case-3 are feasible and are economically appropriate as rehabilitation and conservation project of agricultural land.

The EIRR of case-1 is 5.3% and case-3 is 8.7%, accordingly in view of economic preference, case-3 obviously exceeds case-1.

(5) Other economic effects

1) Rehabilitation benefits

Like in Ban Na San F/S area, the present value of rehabilitated land based on farmland market price is shown as the results of preliminary analysis. According to farm

household economic survey, the average farmland price on the plain was 20,000 Baht per rai.

Present value (PV) (Tentative)

Unit : 1,000 Baht

	Case-1	Case-2	Case-3	Case-4
Present value (PV)	3,619	2,393	3,006	1,790

2) Increase in employment

The increase of employment opportunities during the construction period (5 years) is estimated at 250-300 man/day.

Besides, the annual labor employments for operation and maintenance of the project are required.

Furthermore, additional agricultural labor for fruits and upland crops cultivation in the rehabilitated farmlands will have to be hired after stable production stage of the fruit trees. The new labor requirement is estimated to be 30% ~ 40% of the whole labor. For case-3, as an example, 10,000 man/days annually is expected after stable production (10 years).

(6) Impact on farm household economy

The increase of farm net income and farm household income of a representative medium farmer through better farming and fertilizer application on the rehabilated farmland are estimated in the following table.

Unit : Baht

	Present	After project
Farm net income	31,279	74,140
Non-agricultural net income	18,000	-
Farm household income	49,279	74,140
Household expenditures etc.	30,300	45,200
Farm household economic surplus	16,979	28,940

Remark : Present income is based on farm economic survey, and income after the project is based on the balance sheet of farm economic budget after stable production (10 years and over years).

With the project implementation, farm net income will increase to 74,140 Baht after stable production. Living condition of the farmers will attain to the standard level of amphoe, and the farm household economic surplus will be about 29 thousand Baht. With the surplus, farm management is likely to be much better, without part time job. However, the balancing of budget will be possible from the 8th year for mangosteen. Accordingly, until then, it is necessary to support farm household economy with incomes from existing orchards, upland crops and non-agricultural activities.

4.14.2 Overall Evaluation

Four (4) alternative development plans have been examined. The results of economic analysis shows that all of the economic internal rate of return (EIRR) is lower than the opportunity cost of capital in Thailand (12%). However, the EIRR of cases-1 and -3 is higher than 5.0% which is the interest rate for small scale government project.

Compared quantitatively the economic viability, case-3 (ring dike construction in the downstream part) is the highest, with 8.7% of EIRR.

The purpose of the project is to restore the flood-affected farmland, like in Ban Na San F/S area. By implementing the project, sand deposition and soil loss caused by the flood can be prevented.

Consequently, fruit trees will probably be planted through preventing further deterioration of land resources. For comprehensive evaluation of the project, non-quantitative benefits and effects from socio-economic points of view have to be considered. In the area, the project would produce many social positive impacts on the flood-affected farmers.

Case-3, deemed feasible on the above considerations, is recommended as the land rehabilitation and conservation project.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

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5.1 Conclusion

In this study, the agricultural land rehabilitation and conservation projects in Ban Na San and Lan Saka districts have been formulated. The proposed projects consist of construction works for drainage improvement, irrigation development and soil/soil layer improvement and agricultural supporting activities for new farming practice, which are based on the institutional system and engineering capability of DLD and other governmental agencies concerned.

The projects will produce many social benefits and environmental conservation effects by restoring the farmland, although the economic viability in a quantitative sense is low. As a conclusion, therefore, the projects are considered to be feasible.

The Seventh National Economics and Social Development Plan has emphasized that national agricultural developments should be conducted under land use concepts with natural resources conservation, public finance, and engineering services should be given for such developments. The projects meet the aims of the national development policy and the social demands for restoring the flood affected farmland. It will bring active farming and many social benefits through implementation of the project. It will also contribute to the relief of flood affected people, stabilization of farming and improvement of rural life.

5.2 Recommendations

It is recommended to implement the proposed projects with due attention to the following.

- For smooth and successful implementation of the projects, it is a prerequisite to carry out the agricultural supporting service project for propagation of soil improvement and land conservation methods, in addition to the provision of infrastructure. In some parts of the flood affected area, fruit trees had been planted. The growth of the trees, however, is poor. Technical assistance and services should be provided urgently for the farmers concerned, as the agricultural supporting service project, before the proposed project is launched.

- Improper management of farmland may cause deterioration of land resources. To ensure sustainable agriculture and to prevent deterioration of natural environment by applying soil/water conservation measures, it is a prerequisite from the initial implementation stage to have positive participation of the related farmers for cooperation and understanding about the projects.

- To realize farmer's participation, it is required to approach the present farmer's groups. For that purpose, a strengthening and supporting program should be scheduled in parallel with the provision of the facilities.

- In order to mitigate sand deposition on the farmland caused by the flood disaster, environmental destruction which may have been brought by commercial use of forests in the river basin, have to be prevented. Monitoring activities to manage land use in the forest area, have to be taken in cooperation with RFD. Promotion and training activities on proper land use and soil conservation measures should also be programmed.

- For successful implementation of the proposed project in Lan Saka, it is required to manage and operate the embankment facility well.