CHAPTER 3 DEVELOPMENT PLAN

CHAPTER 3. Development Plan

3.1 Basic Concept

3.1.1 Basic Concept of Development

The formulation of the agricultural development plan in the Area of 19,500 ha is made considering the drawbacks to agricultural development, necessity for development and the basic concepts which are pointed out in the Master Plan, and attentions are paid in particular to the following items.

1) Respect for the intention of the Costa Rican authorities in this development.

The development is established in line with the government policy as confirmed at the meetings with the Costa Rican authori-ties concerned with the Project during the period of the study.

2) Measures Against Drainage and Flood

The most effective plan is proposed, based on the actual conditions confirmed by the newly prepared topographic map with a scale of 1:10,000, field investigation and a survey of the rivers. To this end, the scale and structure of the facilities for drainage and flood protection are decided in comparison with other alternatives.

3) Selection of Area to be Developed

The area to be developed is selected considering its topography, altitude, land classification, possibility of gravity drainage and environmental condition.

4) Consideration for the Environmental Conservation

Taking into consideration the impact on the natural environment by the development, arrangement, scale, structure and construction method of various facilities are studied.

5) Necessity of Operation and Maintenance

Although the drainage facilities are the most important facilities in this development plan, they are liable to be poorly managed due to difference from the irrigation facilities. Accordingly, the method of operation and maintenance will be studied and facilities that are easy to operate and maintain will be proposed.

6) Extension of Farming Techniques.

To invigorate the agricultural production activities the extension of farming techniques is indispensable for the farmers. The study shows the extension activities of farming techniques in this Area are insufficient. Accordingly the manner of these extension activities will be fully examined.

3.1.2 Area to be developed (Project Area)

The area to be developed is basically the Study Area except for the following:

1) Areas having unsuitable soil for farmland.

2) Swampy lowland along Canal del Tortuguero which presents difficulties for gravity drainage.

3) Virgin forest zones along Canal del Tortuguero and the large-scale natural forests which need to be set aside for environmental conservation.

4) Existing banana plantations.

5) Urban areas, the institutes' lot, and their experimental farm.

3.2 Drainage Improvement Plan

3.2.1 General

1) Purpose

The purpose of the drainage improvement plan is to rapidly drain the rainwater inundated on the farmland and to lower the groundwater tables to levels suitable for growth of agricultural products (to GL-0.5 m at least), with a view to utilizing the currently poorly drained areas more efficiently and to improving the agricultural productivity.

2) Basic Concepts

The basis concepts of the plan are as follows:

(1) The drainage improvement plan is considered on the premise that overflow from Rio Matina and Rio Barbilla will be prevented.

(2) Drainage is improved by gravity drainage, since the Area allows gravity drainage, except for the unexploited virgin forest area in the low land.

(3) The drainage improvement will be provided by an integrated drainage system covering the distance from the terminal drainage canals to the principal drainage canals.

(4) Whenever possible, the existing drainage facilities shall be utilized by rehabilitating them.

Proposed facilities are as follows:

. Lateral drainage canal
. Tertiary drainage canal
. Secondary drainage canal
. Principal drainage canal
. Related structures

Out of these facilities, the drainage canals in a standard block of farmland such as lateral and tertiary drainage canals are designed for model districts with poor drainage condition.

3) Area to be Improved

The improvement work shall apply to an area of 10,250 ha, which is the result of subtracting the area (1,420 ha) consisting of farmland (410 ha) with an elevation of less than 2 m and excluding the area (1,010 ha) in the proposed land use plan from the total area (11,670 ha) of Classes II - IV. (Annex F F.4.1)

3.2.2 Design Criteria

1) Design Rainfall

The rainfall data collected by the CATIE Station in the Study Area shall be used for the planning. As the design rainfall, probable rainfall with a return period of 5 years shall be employed. The design rainfall and rainfall intensity formula employed in the planning are as follows:

Design rainfall : R = 196 mm/day
Rainfall intensity: I = 229.0/t+4.0 (mm/hr)

Where, R: Probable rainfall with a return period of 5 years (mm/day)

I: Average rainfall intensity (mm/hr) in rainfall duration
t: Rainfall duration (hr)

2) Design Yield Discharge

A design yield discharge was calculated employing a rational formula. The rainfall intensities and design yield discharge per 1 km^2 as classified by flood concentration time are as shown in Table 3.2.1. (see to Annex F. F.5.2)

Table 3.2.1 Design Yield Discharge

Classification	Flood Concentration Time (hr)		Ave. Rainfall Intensity (mm/hr)		Design Yield Discharge ($m^3/s/km^2$)	
	Upper to Middle Stream	Middle- to Down- Stream	Upper to Middle Stream	Middle- to Down- Stream	Upper to Middle Stream	Middle- to Down- Stream
Principal Canal 1-5	5.0	12.0	25.4	14.3	3.175	1.787
Principal Canal 6-8	2.0	2.0	38.2	38.2	4.775	4.775
Secondary Canal	4.0	4.0	28.6	28.6	3.575	3.575

3.2.3 Plan of Principal Drainage Canals

1) Layout Plan

The layout of the principal drainage canals was planned taking fully into consideration the present drainage system and the below mentioned matters.

(1) With a view to making the best use of the topographic conditions of the Area, the principal drainage canals shall run in the north and south directions.

(2) The canals constructed by the banana plantations shall be made full use of, in order to reduce the construction cost.

(3) Water from the principal drainage canals, excepting those of the hilly areas lying south-west of the Study Area and the right bank area of Rio Barbilla, shall not be released to large rivers, considering the existing drainage system.

(4) Only the required minimum number of principal drainage canals shall be dug in the virgin forest area in order to maintain the natural environment.

Principal drainage canals No. 1 to No. 8 were planned out as described below. The result of layout of these canals is as shown in

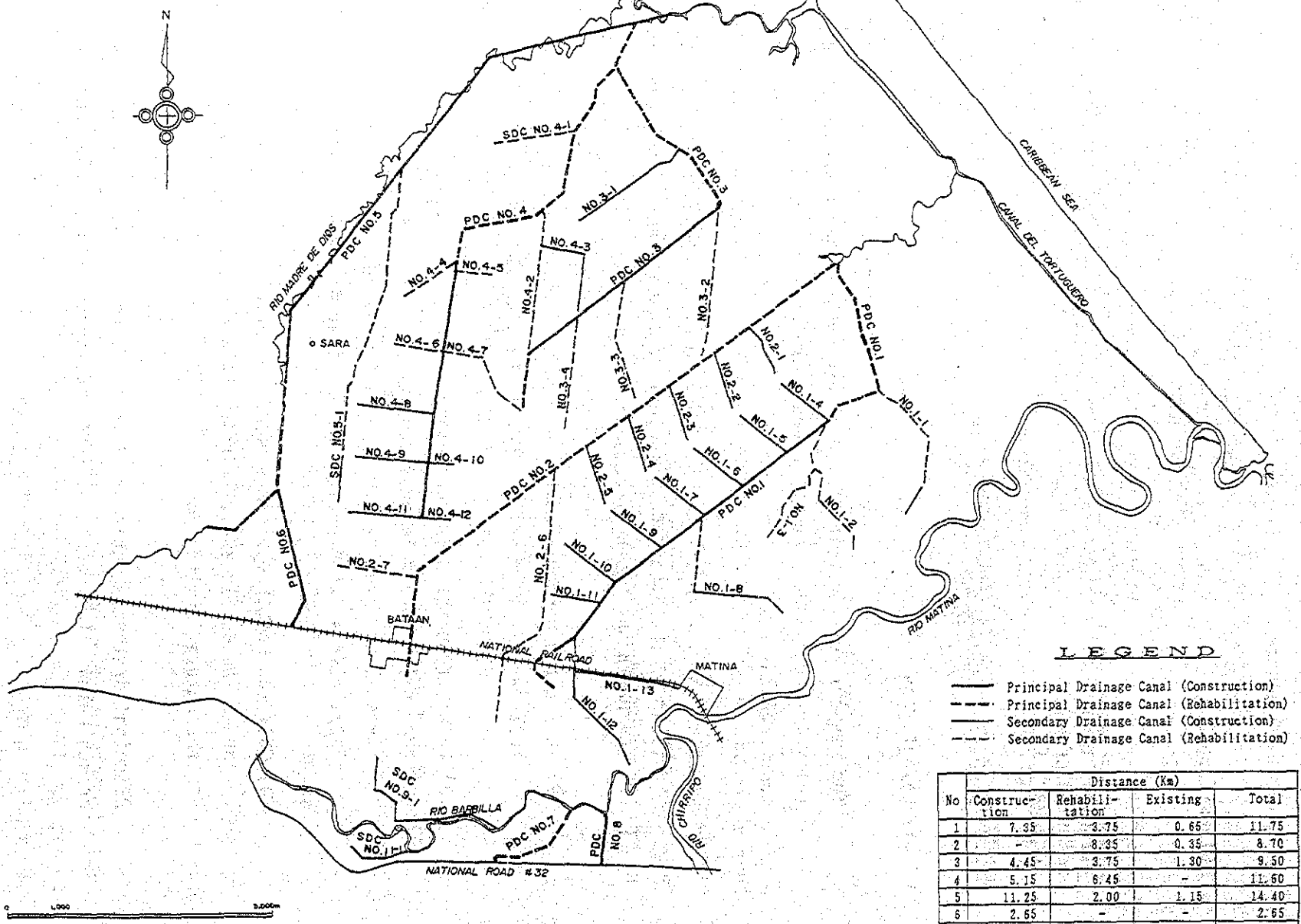


Fig. 3.2.1 Proposed Drainage Canal Network

LEGEND

- Principal Drainage Canal (Construction)
- Principal Drainage Canal (Rehabilitation)
- Secondary Drainage Canal (Construction)
- Secondary Drainage Canal (Rehabilitation)

No	Distance (Km)			
	Construction	Rehabilitation	Existing	Total
1	7.35	3.75	0.65	11.75
2	-	8.35	0.35	8.70
3	4.45	3.75	1.30	9.50
4	5.15	6.45	-	11.60
5	11.25	2.00	1.15	14.40
6	2.65	-	-	2.65
7	0.25	1.65	-	1.90
8	1.00	-	-	1.00

Fig. 3.2.1. The features of individual canals are shown in Annex F F.4.2.1.

The principal drainage canals are laid out at intervals of 2 to 2.5 km. The total length of the principal canals is 64.5 km. This includes the length of the existing canals which can be directly used (6.5 km) and which are used after rehabilitation (26 km). The length of the newly constructed principal drainage canals is 32 km. (see Table 3.2.2)

Table 3.2.2 Length of Proposed Principal Drainage Canal

Principal Canal	Existing (km)	Rehabilitation (km)	Construction (km)	Total (km)
No. 1	0.65	3.75	7.35	11.75
No. 2	0.35	8.35	-	11.70
No. 3	1.30	3.75	4.45	9.50
No. 4	-	6.45	5.15	11.60
No. 5	1.15	2.00	11.25	14.40
No. 6	-	-	2.65	2.65
No. 7	-	1.65	0.25	1.90
No. 8	-	-	1.00	1.00
Total	6.45	25.95	32.10	64.50

2) Design Drainage Discharge

The designed drainage discharges of the principal canals are as follows;

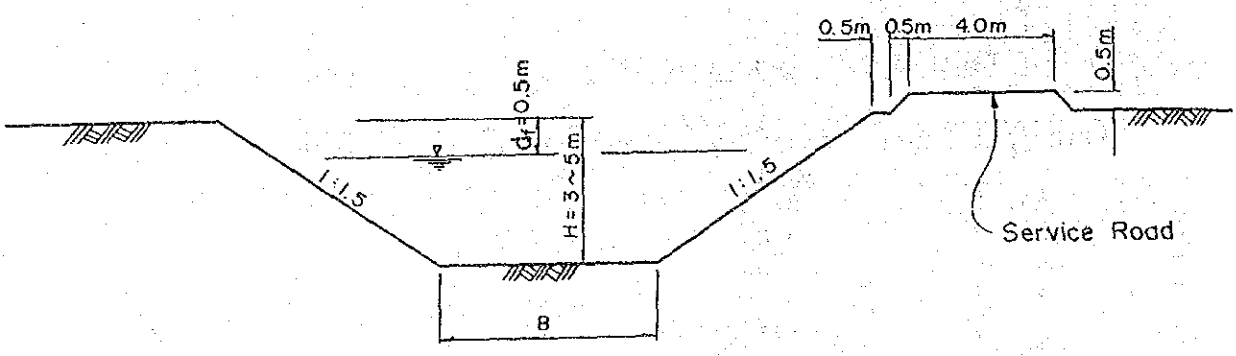
Table 3.2.3 Drainage Area and Design Drainage Discharge

Principal Canal	Drainage Area (km^2)			Design Drainage Discharge (m^3/s)		
	Upper-stream	Middle-stream	Down-stream	Upper-stream	Middle-stream	Down-stream
No. 1	3.60	13.35	41.90	11.40	42.40	74.90
No. 2	2.58	10.75	23.55	9.00	34.10	42.10
No. 3	2.20	5.00	19.90	7.00	15.90	35.60
No. 4	2.05	9.40	48.00	6.50	29.80	85.80
No. 5	32.80	55.45	169.60	104.10	176.10	303.10
No. 6	-	-	16.20	-	-	77.40
No. 7	-	-	26.80	-	-	128.00
No. 8	-	-	14.30	-	-	68.30

3) Structure of Principal Drainage Canal

The principal drainage canals shall be earth canals considering

their objectives and economy. The slope gradient is planned to be 1:1.5 with a view to stabilizing the slope and to operation and maintenance. Along each of the principal drainage canals, a service road (4.0 m wide) shall be constructed. If there are roads to be run along principal drainage canals as planned by the Road Improvement Plan, such roads shall be used as service roads for the canals. (see Fig. 3.2.2 and Annex F F.4.2.3)



(Note) In case B=10m, the service road will be constructed at both sides of the canal.

Fig. 3.2.2 Proposed Cross-section of Principal Drainage Canal

4) Scale of Principal Drainage Canals

The depths of the principal drainage canals shall be 3 to 5 m, as planned taking into consideration the depths of the banana plantation canals, other existing canals to be utilized for this project and those of the secondary drainage canals to be newly constructed. Since the newly constructed canals are earth canals (unlined type), the water flow velocity should not be higher than 1.5 m/s even when in flood. The gradients and sizes of the principal drainage canals were planned based on this figure. (Annex F F.4.2.3)

Since the downstream ends of principal drainage canals No.1 to No.5 reach the virgin forest area, the water level will be affected by the inundation water level resulting in non-uniform flow. In view of this, the sizes for the downstream ends of the princi-

pal drainage canals No.1 to No.5 were calculated for non-uniform flows for the sake of safety of the plan. (Annex F.4.2.3)

3.2.4 Plan of Secondary Drainage Canals

1) Layout

The layout plan of the secondary drainage canals was made taking into consideration the layout of the principal drainage canals and the following items;

(1) The canals shall run along the topographic slopes. (2) The canals shall be laid out to allow the collection of drain water from all parts of the farmland.
(3) Whenever possible the existing drainage canals shall be utilized by rehabilitation.
(4) The canals shall be laid out so that the length of the branch canal becomes 1.0 to 1.5 km (taking a sample from the case of banana plantations).

The total number of planned secondary drainage canals is 40. The total length of the secondary drainage canals is 76 km (the existing canals directly usable 9 km, the existing canals usable after rehabilitation 25 km, and the canals to be newly constructed 42 km). (See Table 3.2.4)

Table 3.2.4 Length of Proposed Secondary Drainage Canal

Drainage System	Nos. of Canals	Existing (km)	Rehabilitation (km)	Construction (km)	Total (km)
No. 1	13	5.2	2.9	15.0	23.1
No. 2	7	1.0	5.3	5.3	11.6
No. 3	4	-	6.2	3.4	9.6
No. 4	12	3.0	4.0	11.7	18.7
No. 5	1	-	6.3	1.1	7.4
No. 6	-	-	-	-	-
No. 7	-	-	-	-	-
No. 8	-	-	-	-	-
No. 9	1	-	-	3.4	3.4
No. 10	1	0.2	-	0.9	1.1
No. 11	1	-	-	1.6	1.6
Total	40	9.4	24.7	42.4	76.5

(see Annex F F.4.3.2)

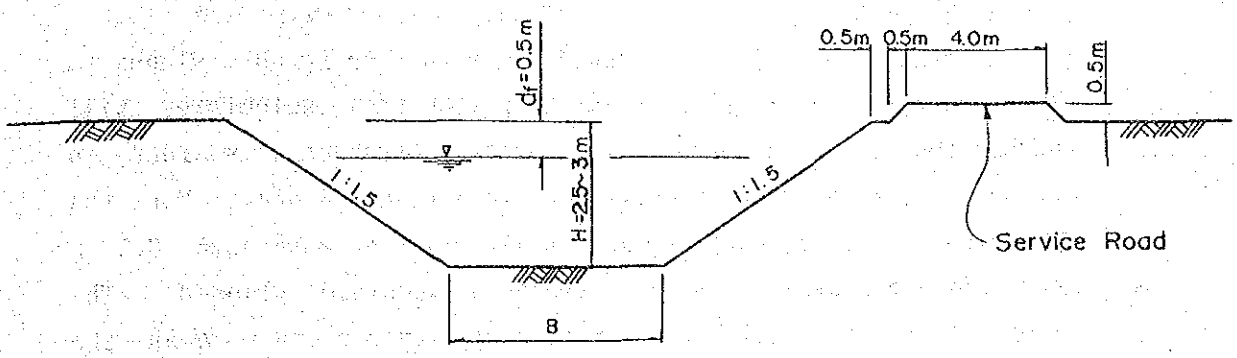
2) Design Drainage Discharge

The drainage area to be served differs for each of the secondary drainage canals, ranging from 0.45 to 8.90 km^2. The design drainage discharges are within a range of 1.6 to 31.8 m^3/s. (see Annex F F.4.3.1)

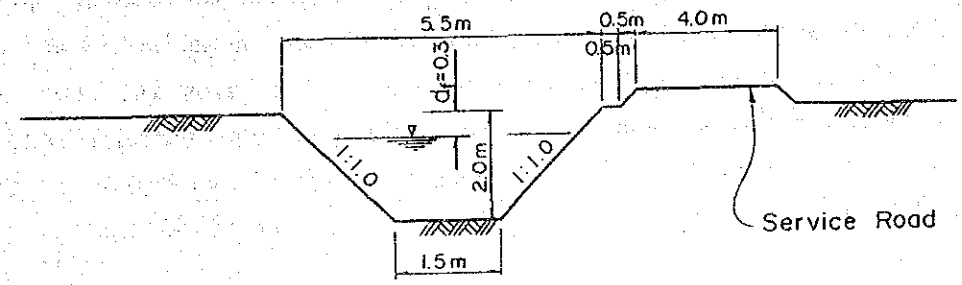
3) Structure and Scale

The secondary drainage canals also shall be earth canals (dug unlined). With regard to the fact that the tertiary drainage canal for the farmland of perennial crops is planned for a depth of 2.0 m, the minimum depth of the secondary drainage canals shall be 2.0 m. For the sake of stability of the slope and ease of service of the constructed canals, the side slopes of canals with a depth of 2.0 m and 2.5 to 3.0 m are respectively to be 1:1.0 and 1:1.5.

Service roads with a width of 4.0 m shall be constructed on only one side along each of the secondary drainage canals. (see Fig. 3.2.2)



Depth of Canal : 2.5 - 3.0 m



Depth of Canal : 2.0 m

Fig. 3.2.3 Proposed Cross-section of Secondary Drainage Canal

3.2.5 Related Structures

1) Drop Structures

If the canal gradients are planned along the topographic slopes in the south area where slopes are sharp, the flow velocities will become too fast. This area calls for drop structures in order to reduce the water flow velocities to less than 1.5 m/s. For the principal drainage canals, one installation for waterhead 0.5 m and sixteen installations for waterhead 1.0 m are planned. The drop structures shall be constructed of stones procured near the site.

2) Major Crossing Works

Some of the existing canals which are to be reused for this project may have crossings for railways and main roads. Investigation was made to find out whether such crossings allow the required amount of water to pass. The study indicated that, for the principal drainage canals, one of the bridges must be modified and one of the railroad crossings requires excavation below it. For the secondary drainage canals, one of the bridges must be modified.

3.3 Flood Protection Plan

3.3.1 General

1) Purpose

Floods often occur in the midstream and downstream areas of Rio Matina, Rio Barbilla and in the downstream area of Rio Chirripo. Water overflowing from these rivers is one of the main causes of poor drainage of the Study Area. The purpose of this plan is to prevent floods caused by Rio Matina, Rio Barbilla and Rio Chirripo in order to protect the residents and public installations as well as improving the farmland in the Study Area.

2) Policy of Plan

Flood protection facilities shall be constructed for the sections where the cross-sectional areas of the rivers are insufficient for the flood water levels. The facilities shall be not only for the Study Area but also for the right bank areas of Rio Chirripo and Rio Matina.

The downstream ends of the facilities shall be at the canal, taking into consideration the current state of land use and future development.

3.3.2 Design Criteria

1) Design Flood Discharge

Based on the result of investigation carried out when working out the Master Plan, the design flood discharges of the probable flood discharge with a return period of 5 years are used for the design flood discharge of the rivers as follows:

Rio Matina : $Q = 2,248 m^3/s$ (D.A. = $1,365 km^2$)
Rio Barbilla: $Q = 528 m^3/s$ (D.A. = $259 km^2$)
Rio Chirripo: $Q = 1,760 m^3/s$ (D.A. = $1,106 km^2$)

2) Design Outer Water Level

For the sake of safety of the plan, EL 0.51 m at the mouth of the Rio Matina in case of high spring tide shall be taken as the design outer water level. For Rio Barbilla and Rio Chirripo, the planned flood level at the upstream end of Rio Matina as calculated with hydraulics shall be taken as the design outer water level.

3.3.3 Plan of Flood Protection Facilities

1) Alternative Study for Flood Protection Facilities

There are two types of flood prevention work. One is to install

embankments and the other is to dig the river deeper in order to enlarge its cross-sectional area. The former method is classified further into two types. One is to make low banks so as to make the river wider and the other is to make high banks so as to make the river narrower.

For planning of this project, all three methods were studied and compared. (Annex F F.5.1)

CASE I : Make the river wider and the banks lower
CASE II : Make the banks higher and the river narrower as compared with Case I
CASE III: Dig the river deeper to increase its cross-sectional area

The estimated construction costs include site procurement cost, compensation cost for resettlement, etc., as well as the direct construction cost. The alternative study indicated that CASE II (an average bank height of 3.0m) is most economical.
Accordingly, CASE II is selected for planning this project.

Table 3.3.1 Comparison of Alternative Studies

Unit: ₡1,000

Alternative Case	Height of Banks (m)	Construction Cost			
		Direct Construction Cost	Site Procurement Cost	Compensation Cost	Total
CASE I	2.5	553,451	237,075	90,500	881,026
CASE II	3.0	556,401	80,720	4,200	651,322
CASE III	-	6,354,359	24,500	-	6,378,859

2) Scope of Flood Protection Work

Each of Rio Matina and Rio Barbilla heavily meanders in two sections. Meandering is undesirable from the viewpoint of safety of the banks in case of flood. Therefore, banks should be planned with short cuts for the meandering sections of the rivers.

Since the cross-section areas of the rivers vary considerably, the heights of the banks and widths of the rivers were calculated employing non-uniform flow calculation formulas. The calculation indicated that the required length of embankment for Rio Matina is

32.8 km, that for Rio Barbilla is 19.2 km, and that for Rio Chirripo is 4.1 km. (see Annex F F.5.1)

Table 3.3.2 Outline of Flood Protection Facilities

River	Expansion of Embankment Left Bank (Km)	Right Bank (Km)	Total (Km)	Height of Embankment (m)	River Width (m)
Rio Matina	16.4	16.4	32.8	1.00 - 4.00	300 - 640
Rio Barbilla	9.5	9.7	19.2	0.50 - 3.60	120 - 160
Rio Chirripo	2.0	2.1	4.1	2.00 - 3.60	130
Total	27.9	28.2	56.1		

3) Structure of Banks

The banks shall be constructed using the soil inside of the embanking area. Taking into consideration the stability of the banks and ease of maintenance, the structure of the banks shall be as shown in Fig. 3.3.1. Stability calculations were made employing the results of analysis of soils sampled at both sides of the river. The analysis resulted in a safety factor of 1.5 or more. (See Annex F F.5.2.2)

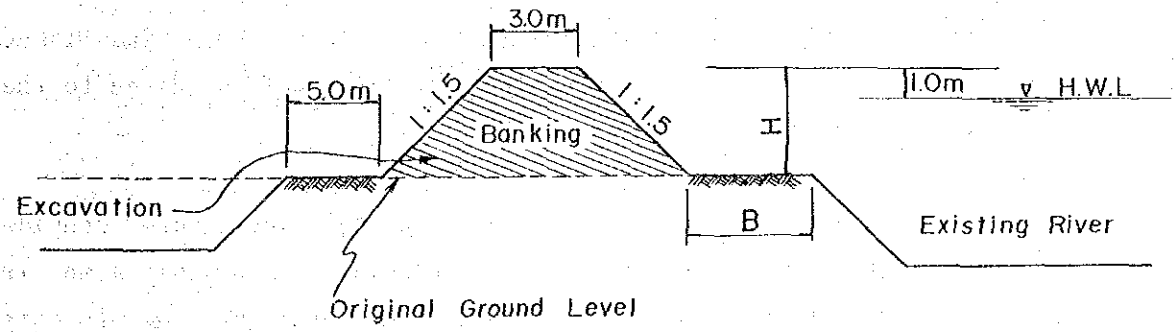


Fig. 3.3.1 Proposed Cross Section of Dike

4) Maintenance Roads

Routine maintenance work for the banks, especially after flooding, is necessary. The maintenance work will include removal of sedimented soil and sand, and elimination of grass from the major beds. For the maintenance machinery (bulldozers and dump trucks), access roads which lead to the river beds are required. Access roads shall be constructed at 2 km intervals.

3.4 Agricultural Production Plan

Implementation of this project will result in substantial drainage improvement of the farmland, and the agricultural productivity will be greatly enhanced. Crops and cropping pattern will be introduced to best suit the climate, soil, marketability, and the agricultural policies of the Government of Costa Rica so as to increase productivity by utilizing these improved conditions.

3.4.1 Land Use Plan

The land use plan shall be worked out with due consideration of the currently grown crops so that they will continue to be grown after the project is complete, so far as they are not inadequate with respect to land classification and soil condition.

Land for which the elevation is less than 2 meters is not included in the area to be improved, since such land will not allow gravity drainage and cannot be advantageously used as farmland. Most of this type of land in the Study Area is virgin forest.

For the areas whose utilization plans had already been established when the field survey was conducted, a priority shall be given to the plans so far as they are not suitable.

The virgin forests which lie along Canal del Tortuguero provide valuable natural environment. Since the elevation of this area is very low and the area does not allow efficient drainage, the forests should be left unexploited.

The large forest areas in the Area should also be left intact from the viewpoint that they provide a precious natural environment and are not suitable for farmland since their gradients are steep. Thus, the total area involved in this project is 11,560 ha, excluding the areas mentioned below.

Farmland with elevation of less than 2m	:	410 ha
Virgin forest along Canal del Tortuguero	:	3,380 ha
Large scale forest	:	1,740 ha
Banana plantation	:	1,960 ha
Urban areas, etc.	:	860 ha
Total		8,350 ha

The result of selecting the types of crops suitable for various classes of land is shown in Fig. 3.4.1. Referring to the above result and the agricultural production plan, the land use plan for the Study Area has been worked out as shown in Table 3.4.1.

Table 3.4.1 Proposed Land Use

Unit: ha

Classification	Present Area	Proposed Area	Increase and Decrease
Annual Crop Land	4,340	4,490	150
Bananas	1,960	4,000	2,040
Cacao	1,540	2,880	1,340
Plantains, Coconuts	620	1,000	380
Pepper	0	180	180
Pasture	3,510	560	-2,950
Virgin Forest	3,380	3,380	0
General Forest	1,740	1,740	0
Abandoned Plantations	1,550	0	-1,550
Others	860	1,270	410
Total	19,500	19,500	0

Note: Others include urban area, road, canal, institutes' lots and farmland with an elevation of less than 2 m.

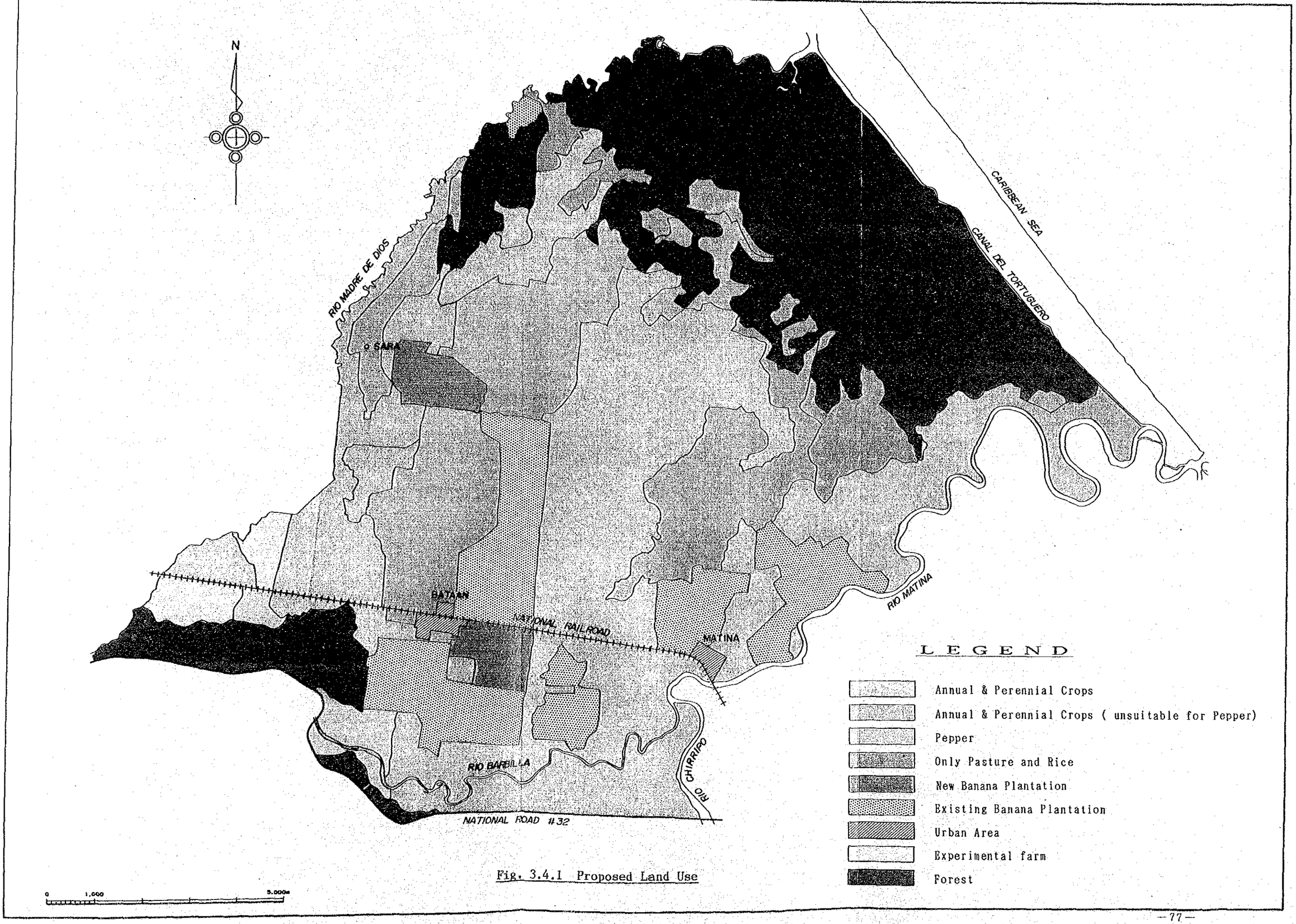


Fig. 3.4.1 Proposed Land Use

3.4.2 Agricultural Production Plan

The basic policy of the agricultural production plan is to increase total agricultural production and the farmers' income in the Project Area in accordance with the Master Plan.

Accordingly, the plan will be realized through expanding the cropping area by the improvement of cropping land intensity per farmer and selecting highly profitable crops. Based on this concept, the agricultural production plan is as follows:

1) Selection of Crops and Cropping Pattern

Selection of crops and cropping area will be done considering the coordination to the National Production Plan, soil property, agricultural technique, marketing and intention of the farmers in the Project Area.

Land classified unsuitable for planting general crops should be utilized as pasture. The introduction of beef cattle is planned for such areas. Selected crops and cropping area for the Project Area are shown in Table 3.4.2. The cropping area will be increased by approximately 80% than the present amount. The cropping pattern according to the proposed cropping area is shown in Fig. 3.4.1.

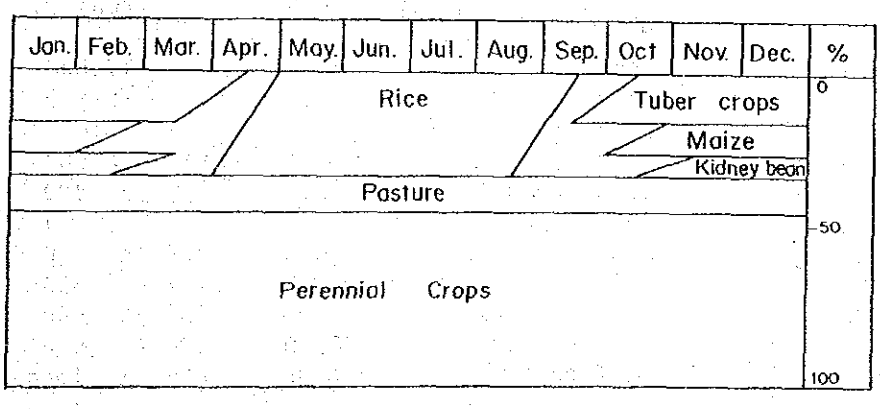


Fig. 3.4.2 Proposed Cropping Pattern

Table 3.4.2 Selected Crops and its Cropping Area

Unit: ha

Crops	Cropping Area	Area of Increase
1. Perennial crops:		
Bananas	2,040	2,040
Cacao	2,880	1,340
Coconuts	500	180
Plantains	500	200
Black pepper	180	180
Sub-total	6,100	3,940
2. Annual crops:		
Rice	2,900	0
Maize	540	190
Kidney beans	330	290
Tuber crops	720	480
Sub-total	4,490	960
3. Pasture	560	560
Total	11,150	5,460

2) Crop Yield and Production

The expected crop yield and agricultural production are summarized in Table 3.4.3, in accordance with the results of experimental cultivation and investigation by the MAG, CATIE and ASBANA in the Project Area and its surroundings. The change of total agricultural production in the Project Area for the target year (the year 2000) is calculated on the basis of the implementation schedule, as shown in Annex E. Table E.3.

Table 3.4.3 Proposed Yield and Production

Crops	Yield (ton/ha)	Production (ton)
1. Perennial crops:		
Bananas	49.0	117,600
Cacao	1.0	2,880
Coconuts	10.0	5,000
Plantains	17.0	8,500
Black pepper	2.2	400
2. Annual crops:		
Rice	4.5	26,100
Maize	2.5	1,350
Kidney beans	1.5	500
Tuber crops	11.0	7,920
3. Beef cattle	0.35	196?

3) Proposed Farm Input Requirement

To achieve the proposed yield, improvement is needed in agricul-

tural production input, especially fertilizer and the establishment of the farm working system. The breakdown of the necessary elements in agricultural production such as variety, recommended sowing density, fertilizer, and insecticide and herbicide for per ha are shown in Annex E Table E.1.

Guaranteed seeds prepared by the C.N.P. will be used for the annual crops. Sowing density and input of fertilizer and agricultural chemical per ha to achieve the proposed yield have been estimated based on the information prepared by B.N.C.R. Standards of the farm working system such as land preparation, sowing period and manuring practice and cropping calendar on the basis of the proposed input of materials for agricultural production are shown in Annex E Fig. E.1(1) to E.1(6).

4) Production Cost and Producer's Price

Production costs and producer's price are shown in Table 3.4.4. The breakdown of the production costs are summarized in Annex E Table E.2(1) to E.2(6). The cost of fertilizer and agricultural chemical will occupy a large part of the production costs: such as perennial crops approximately 60%, and annual crops approximately 40%.

The expected gross and net production values are tabulated in Table 3.4.4 on the basis of the proposed yield, production costs and producer's price.

Table 3.4.4 Expected Production Values

Crop	Production Cost	Producer's Price	Gross Production Values	Net Production Values
1. Perennial crops:				
Bananas	462,235	13,200	646,800	184,565
Cacao	44,171	95,000	95,000	50,829
Coconuts	61,737	8,600	86,000	24,263
Plantains	94,082	8,500	144,500	50,418
Black pepper	134,800	220,000	440,000	305,200
2. Annual crops:				
Rice	41,800	14,200	63,900	22,100
Maize	23,139	13,669	34,173	11,034
Kidney beans	36,750	35,788	53,682	16,932
Tuber crops	94,659	14,000	154,000	59,341
3. Beef cattle	10,080	50,000	17,500	7,420

3.4.3 Farm Household Economy Plan

1) Farm Scale and Farming Type

Since the new settlement project in the Project Area is not planned, the number of farm households is not changed. The expected average cropping area per farmer is 6.5 ha, approximately twice the present amount. The farm household economy after the implementation of the project will be analyzed focusing on the model farmer. Seven types of model farmer will be studied in accordance with the Master Plan, and the farm scale is the proposed average cropping area mentioned above.

The proposed farming types will be established on the following considerations, and the cropping patterns by farming type are presented in Annex E Fig. E.2 (1) to E.2 (2).

(1) Farm management is stabilized by diversifying farm income, and avoiding monoculture.

(2) Farming scale and cropping pattern to suit family labor are proposed.

(3) Annual crops will be rotated to keep the soil productivity and to distribute the labor force equally the year-round.

(4) For bananas, monocultivation by cooperatives and banana companies is adopted.

(5) Cattle breeding is adopted for medium and large-scale farmers, because this is difficult for small-scale farmers to manage stable.

2) Labor Requirement

The average annual labor requirement for small and medium-scale farmers is estimated to be 540 man-days: 300 man-days for farmer (annual working days: 300) and 240 man days for family labor (annual working days: 0.8 x 300).

With the extension of cropping areas and the conversion of cropping patterns, the labor requirement will be increased.

As described above, agricultural machinery will be introduced to adjust the supply and demand of farm labor. In addition, a farm working system is planned to suit for family labor.

Annex E Table E.1 (1) to E.1 (6) present the labor force requirement by each crop.

Currently, the unemployment portion (8.8%, about 4,700 persons) within the Project Area and its surrounding areas is supposed to be high and in this sense, if much labor is needed it will be procured from the surplus labor force in and surrounding the Project Area.

3) Household Incomes

The forecast of the household incomes has been calculated by farming types (Table 3.4.5). Household incomes are calculated deducting production costs and O/M costs from agricultural gross income. The expected incomes of household are anticipated to be increased in the range of 1.8 or 2.0 more times than those that would be without the Project.

The breakdown of the household incomes is presented in Annex E Table E.4 (1) to E.4 (7).

Table 3.4.5 Household Income

Unit:¢ /household

Farming Type	Agricultural Gross Income	Production Cost	Household Income
A: Cacao + Annual crops	796,741	410,918	385,823
B: Plantains + Annual crops	1,062,836	681,716	381,120
C: Coconuts + Annual crops	888,750	588,095	300,655
D: Black pepper + Annual crops	803,963	447,920	356,043
E: Rotation of Annual crops	991,381	635,894	355,487
F: Cattle breeding	875,000	504,000	321,000
G: Bananas	116,424,000	83,202,300	33,221,700

Note: Scale of cattle breeder is assumed to be an area of 50 ha

G: Bananas are managed by banana cooperatives (an area of 300 ha)

3.5 Road Network Plan

3.5.1 General

The density of the road network in the Area is still as low as 6.4 km/1,000 ha. This undeveloped road network forms a stumbling block to smooth delivery of agricultural equipment and products. Under these circumstances, an effective and economical road network will be planned in line with the Master Plan under the following basic policy;

1) A section of main road in the Area will be constructed as a branch from Route 32 to Sara through the mid-points of Bataan and Matina according to the Master Plan.

2) The existing roads and railroad remains and the service roads for the drainage canals will be utilized as far as possible.

3) A road density of about 7.0 m/ha will be targeted excluding for farm roads.

3.5.2 Design Criteria

The design criteria shown in Table 3.5.1 were set for the plan

with reference to the standards for Costa Rica. A planned typical cross section of the roads is shown in the Drawings.

Table 3.5.1 Design Criteria for Road Construction

Type	Construction Class	Effective Width (m)	Structure
Main Roads	Class III	6.5	Simple asphalt pavement
Trunk Roads	Class IV	6.0	Paved with gravel
Lateral Roads	Class V	4.8	Paved with gravel

(Note) Construction class according to MOPT's classification.

3.5.3 Proposed Road Network

The main road will be constructed to branch from Route 32 and will be extended to Sara through a point between Bataán and Matina which are major towns in the Area. The trunk roads, on the other hand, will be planned to connect communities at Bataán, Matina, Cuatro Millas and Goschen. Further, lateral roads branching out from the trunk roads will be constructed. Thus the road network as shown in the drawings is planned. The width and extension of each road are shown in Table 3.5.2.

Table 3.5.2 Extension of Proposed Roads

Classification	Width (m)	Construction (km)	Rehabilitation (km)	Total (km)
Main Road	6.5	5.4	10.6	16.0
Trunk Road	6.0	8.2	35.4	43.6
Lateral Road	4.8	58.8	19.7	78.5
Total		72.4	65.7	138.1
Road Density		9.5 m/ha		

3.5.4 Related Structures

Bridges are planned as a related structure for road. The location and the structure-scale of major bridges are as below.

River	Location	Structure	Width (m)	Length (m)
Rio Barbilla	La Pena	PC-T	7.3	130
- Ditto -	Davao	- Ditto -	4.3	130
Rio Madre de Dios	Veintiocho Millas	- Ditto -	4.3	49
- Ditto -	Sara	- Ditto -	7.3	43
- Ditto -	Goschen	- Ditto -	4.3	49

3.6 Land Consolidation Plan

The purpose of this plan is to increase agricultural productivity through the following projects:

- Consolidation of tertiary and lateral drainage canals in the farmland to provide improved drainage conditions

- Arrangement of farm roads to make the transportation of agricultural materials and machines for agricultural production to and from the farmlands very convenient.

1) Type of Drainage Canal

There are three types of drainage canals : drainage ditches, lateral drainage canals and tertiary drainage canals. A drainage ditch is installed by each farmer according to crops and soil quality. Waste water discharged from a drainage ditch is received by an lateral drainage canal, then flows to a tertiary drainage canal. The scale of each canal is determined in accordance with its drainage area. The target density for drainage canals, excluding drainage ditches, is 45m/ha. The scale of each canal is outlined as follows:

Tertiary drainage canal

Canal bottom width: 1.2 to 3.0 m

Canal depth : 1.5 to 2.5 m

Lateral drainage canal

Canal bottom width: 0.6 to 1.2 m

Canal depth : 1.0 to 1.25 m

2) Farm Road

The target for consolidation standard of farm roads is 25 m/ha. The structure is sandy gravel. The effective width and full width are 3.0 m and 4.0 m, respectively.

3) Model Planning

Model designs for these facilities described above are provided for three places: a district in which the above facilities are not installed, a district in which the above facilities are installed, but insufficiently, and a district expected to be used for banana plantations. The districts listed up for the model design are as follows;

Sara (model for a slightly improved district)	:	256 ha
North Bataán (model for unimproved district)	:	290 ha
Good Hope Sur and Sara (model for banana plantation)	:	220 ha

3.7 Rural Infrastructure Plan

As a result of field surveys, the well water quality test reveals the necessity of installing water supply and sewage treatment facilities. Therefore, the plans shown in Annex I.2 and I.3 are recommended for this Project.

1) Water Supply Facilities

For scattered houses, it is not economical to install a community water supply facilities. Each house should be supplied by a shallow well. However, since the water in relatively shallow less than 3 m deep, is more contaminated than in deeper wells, wells should be dug as deep as possible. Wells should be located at least 5 m away from water contamination sources, such as toilet pits, kitchen, pig pens, etc. Wells should be constructed in locations chosen as having good environmental conditions. Further sufficient space around the wells should be acquired. For safe drinking, well water should be boiled.

Installation of small-scale water supply systems for community use will be needed in five areas: Goschen, Davao, Barmonte Oeste, a part of Bataán, and Cuatro Millas. Of these, Cuatro Millas, having about 60 households, was selected as the model area of the water supply system installation. The approximate project cost of the model area is estimated to be ₡1,620,000.

2) Sewage Treatment Facilities

In most of the farm households, infiltration pits are used for toilets. Once they are filled, new pits will be dug in other locations. Sewage from bathing area and kitchens is drained by excavated shallow ditches. The locations of toilet pits and drainage ditches should be carefully selected so as not to be too close to wells.

Sewage treatment by soil will be very effective if the activity of the bacteria in the soil is used to the maximum level by installing a trench 50 cm below the ground surface. The Sewage Treatment Improvement Plan is shown in Annex I.2.

3.8 Agricultural Promotion Plan

3.8.1 General

It is essential to strengthen agricultural promotion to make a success of the Limon Agricultural Development Project. The following plan especially should be established;

- Strengthening of agricultural supporting services
- Improvement of the farmers' organization
- Agricultural machinery center plan; and,
- Establishment of post-harvest facilities

Since the production of bananas, cacao and tuber crop is mainly for export in this Project, international marketing analysis is also carried out (Annex H.4, H.5.). According to the results, bananas, of which main markets are the United States, Western Germany and Italy, can be expected a stable export. Cacao and tuber crops which are

mainly exported for the U.S., there is no anxious. Especially, tuber crops are expected the sharp increase in the export judging from the latest export tendency.

For grading of the agricultural products to be exported to the United States, the official grade standards developed by the USDA which describe the quality requirements for each grade of a commodity, should be applied. In general, Costa Rican exporters have been packing commodities for the United States and European countries based on the U.S. grades and standards.

3.8.2 Agricultural Supporting Organization Reinforcement Plan

It is also essential to strengthen the agricultural supporting services to achieve the development plan stressing drainage improvement, and to increase the agricultural productivity. The following items should be strengthened:

1) At least ten (10) field technology and livestock inspectors should be staffed in each office in Bataan MAG and IDA.

2) Adequate transportation facilities and an audio-visual car should be provided to train the farmers.

3) Training by extension personnel is needed for agricultural technique and especially in the proper quality control for crops products such as dried cacao seeds, tuber crops and other export crops.

3.8.3 Farmers' Organization Improvement Plan

Agricultural production for the crop diversification of the Area (Zone B) will be increased by planting about 3,940 ha of perennial crops (cacao, bananas) and about 960 ha of annual crops mainly such as tuber crops. If these agricultural products are produced by each farmer individually, the quality of products and shipping time do not become uniform, and shipping cannot be done with such price that

gives an advantage to farmers. Therefore, establishment of farmers' organization by themselves are planned to intend to produce excellent products meet the standard. It is needed to establish the farmers' organization that farmers are easy to accept and participate.

The existing on-going agricultural cooperatives will be continued. Farmers who are not members of the agricultural cooperatives at present, should be encouraged to participate.

The organization of agricultural cooperatives is referred to as the coffee cooperative. Though the management of the cooperatives is handled by the farmers themselves, coordination in technical guidance by MAG and IDA is needed. The requirements for joining the group is shown in the Master Plan Report on 4.8.2(1), "Agricultural Production Cooperatives", and the proposed agricultural cooperatives plans are shown in Annex H Fig. H.3.8.1.

The proposed sites for the farmers' organizations are as follows:

A) Proposed cacao production and post-harvest cooperatives sites

1. Veintiocho Millas	2. Luzon
3. Margarita	4. Matina
5. Cuatro Millas	6. Siete Millas

B) Proposed tuber crops production and processing cooperatives site

- Sara

C) Plan for establishing cooperative for banana production

Several cooperatives (Santa Marta, Good Hope Sur and others, total area 1,360 ha) will be established in the Study Area in accordance with the cooperative method. The operation will be the same as that of "Coop Bataán". Other banana plantations (680 ha) will be managed by the local enterprises participating in ASBANA.

These farmers' organizations (production cooperatives) will be established with post-harvest and processing facilities. The functions of INFOCOOP and the necessary data for cooperative establishment are shown in the Annex H H.7.

The production cooperatives are managed by five (5) representatives; namely, the general manager, and managers of the general affairs department, production department, post-harvest department, and sales/purchasing department, who are elected by the members. In principle, the management is controlled by each section manager who is employed by the cooperative.

3.8.4 Agricultural Machinery Center Plan

The farmers in the Area have a farmland of about 8.7 ha on an average. The farmers rent the required agricultural machineries from large-scale farmers or specialized renters. Therefore, farmers often cannot work their crops at proper time if they cannot procure agricultural machinery. It is ideal that each farmer to have his own machinery. However, the farmers do not have enough funds to buy machinery, so, for the purposes of promotion of mechanization in agriculture and the increase of agricultural productivity, an agricultural machinery center will be established. The proposed center is shown in Annex H Fig. H 3.8.2.

1) Management of Center

The management of the proposed agricultural machinery center is mainly undertaken by IDA Region Department and by Bataán office along with the MAG extension department and the Bataán branch office, because there are many settler-farmers in the Study Area. The functions of the machinery center are as follows:

(1) Responsibility for agricultural machinery

a) Inspecting and maintaining machinery - IDA Bataán Office
b) Lending and receiving machinery - IDA Bataán Office
c) Collecting rental fees - IDA Bataán Office

(2) Operation of machinery

This machinery is generally operated by the farmers themselves, but in case an operator is needed, the production cooperatives obtain an operator for the farmer.

(3) Coordination of the machinery use: MAG Extension Office, Bataán

(4) Budget and staff: IDA Central and Extension Dept., MAG

2) Agricultural Machinery Plan

The major agricultural machinery in this plan is as follows:

(Unit: number)

Machinery	Bataan District	Sara District	Total
1. Tractor 43 HP (with harrow, plough and trailer)	5	5	10
2. Bulldozer, 11 tons	1	-	1
3. Medium-size combine for paddy	1	1	2
4. Tuber crops harvester	5	5	10
5. Sprayer (engine)	5	5	10
6. Soil cutter for air injection into earth	5	5	10
7. Pick-up, 2 tons	1	1	2
8. Motor cycles	3	3	6
9. Other accessories	1	1	2
10. Workshop	1	1	2

3) Workshop

The center should have a workshop with an area of over 336 m^2 for repairs and maintenance of machinery, and regular inspection for large and medium-sized agricultural machinery. Necessary workshop equipment is shown in Annex H H.8.

3.8.5 Post-harvest Facilities Plan

According to the agriculture production plan, the production will increase from the middle of the 1990's. Marketing by the private sector is more active than the public sector. Due to lack of marketing information, transportation system, agro-processing facilities, and capital, the majority of farmers are being gradually affected by the influence of the middlemen in the production price. The proposed post-harvest facilities would increase income and supplemental value in the first stage processing of agricultural production. The following organization and facilities are proposed with the assumption that the management is handled by the farmers themselves.

1) Processing Facilities for Tuber Crops and Coconut

Processing facilities for export coconut, tuber crops for washing, drying, quality grading system, packing are established. The contents of processing facilities are as follows;

1. Product collection and shipment,and trucks for transportation
2. Washing facilities and grading equipment for tuber crops.
3. Weighing and packing equipment
4. Operation office

2) Cacao Fermentation and Drying Facilities

A processing system for cacao fermentation and drying facilities managed by the farmers' group are to be established. One unit cooperative serves about 500 ha with one post-harvest facility. The proposed cacao production acreage will be 2,880 ha in the Study Area, and cacao producers' processing system facilities with the following accommodation are proposed at six sites:

Unit Processing Facilities

1.	Fermentation box	19.44 m^2 (3 stages)
2.	Drying house	144 m^2
3.	Dryer	1 unit
4.	Moisture tester and packing facilities	1 unit

The details of these facilities are shown in Annex H Fig. H.3.8.4 (1) to (4).

3.9 Impact on Environment

In the occasion of establishment of the agricultural development project in this Area, the impact considered to environment is as follows:

1) Conservation of Forests

The virgin forests (3,380 ha) are located in the low-lying swampy area along Canal del Tortuguero and are favored with precious resources. Accordingly, this area is excluded from the area to be developed by leaving around as present condition considering the conservation of environment.

Since the general forests (1,740 ha) are of large scale and have sharp slopes in some places, these forest areas are also excluded from the development plan taking into consideration the land use plan. (see 2.6.1 and 3.4.1)

2) Inundation

Assuming that the project was implemented, ordinary inundation level of low-lying swampy area having virgin forests does not change comparing with present condition except in time of flooding. Hence it is considered not to affect the ecology of animals which live in these forests.

Furthermore, the inundation does not affect Canal del Tortuguero, and also it does not affect the navigation of ships.

3) Amount of Accumulated Sediments

In large rivers, sands will be deposited near the river-mouths by flooding from the upperstream of such rivers. This situation is the same as examined in 2.2.2(3). It is estimated that 17,500 m^3 of sediments have been accumulated during past four years in Canal del Tortuguero.

As a result of the analysis, it is considered that the amount of accumulated sediments in the canal is unchanged.

This Canal is very important to navigate sightseeing boats for the Tortuguero National Park and cargo boats for inhabitants. Hence it is necessary that the authorities concerned operate and maintain Canal del Tortuguero.

CHAPTER 4 PROJECT IMPLEMENTATION PLAN

Chapter 4 Project Implementation Plan

4.1 Organization for Project Implementation

4.1.1 Organization for Project Implementation

In the implementation of this project, it is advisable that SENARA, IDA, MAG and JAPDEVA have an inter-relationship and jointly set up a board for this purpose, to make decisions for the whole project. SENARA is in charge of the project implementation since SENARA is a much experienced organization set up for planning and executing irrigation and drainage projects. Supporting organizations are CNP in production, SBN in finance and credit, as well as MIDEPLAN in coordination for the agriculture development project of the Atlantic Region. The organization is structured as follows.

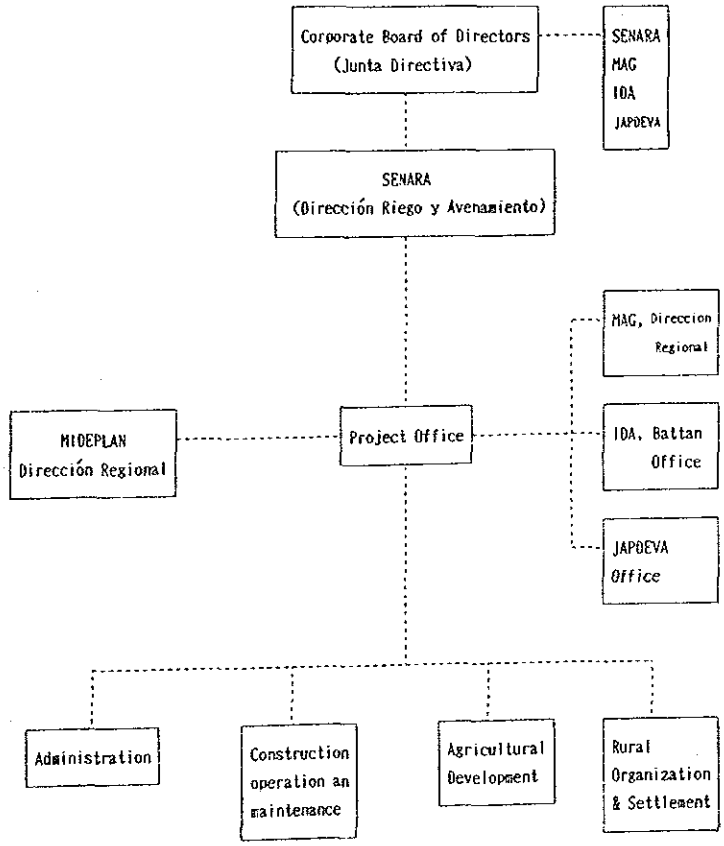


Fig. 4.1.1 Project Organization Chart for Implementation

4.1.2 Site Office

The Site office as a subordinate office of the project office is installed in Bataan in the center of the area. The main activities and scale are as follows:

1) Planning and adjustment of detailed design, determination of implementation program, work planning, process control, design change, actual measurement, quality control, issue of a work completion proof, etc. are provided.

2) Number of people needed for the site office is shown in the table below.

Job	Number of personnel
Manager	1
Administrator	1
Engineer	1
Technician	2
Staff member	2
Clerk	2
Driver	2
Guard	2
Servant	1
Total	14

3) Annual management cost for the above items which is covered by local currency is estimated to be ₱4,030,000. (Annex L L.2)

4.2 Project Implementation Plan

4.2.1 Project Implementation Method

In order to save construction costs, earth required for banking and roads will be collected from around the construction site, and there will no specific place to collect earth therefrom. Nevertheless, road bed materials and gravel for pavement which cannot be secured from around the construction site will be collected from upstream portions of Rio Barbilla and Rio Madre de Dios, which provide a boundary for the Area as described above. If only the area side of these rivers were covered, the construction work could not be effective. Therefore, the other side must also be included in the work.

The following order of implementation is desirable;

First priority works	: Main and trunk road works
Secondary priority works	: Flood protection work, principal drainage canal work
Third priority works	: Secondary, tertiary, and lateral drainage canal works Lateral and farm road works

4.2.2 Implementation Schedule

Considering work volume, number of needed construction machines correlation between sub-works and climate condition, the construction period and process are decided.

1) Preparation Period

One year will be required for detailed design including route survey of the proposed drainage canals, river banks and roads, and topographical and geological surveys of the planned places of bridges and preparation of tender documents, and one fourth of a year for tender evaluation.

2) Road and Bridge Construction

Construction of main roads and trunk roads will begin the earliest of all because they may be used for construction. Lateral roads and farm roads, which are deeply related with tertiary and lateral drainage canals, will be constructed at the same time.

3) Flood Protection Work

The banking work for rivers and the excavation for short-cutting them, which involves a considerable volume of work and are less related to other works, will be started after completion of the associated main and trunk roads. The entire construction will take about one and a half year. A drainage canal is excavated along

the line of dike constructed, and the dike will be constructed by applying the earth derivated from the drainage canal.

4) Drainage Improvement Work

The work for drainage improvement, which involves the most work volume of all items of the project, will consume a long period of time. This work will be started after construction of related roads which will be used to complete the work, and take one and a half years.

5) Implementation schedule

The work will be implemented according to the schedule described below.

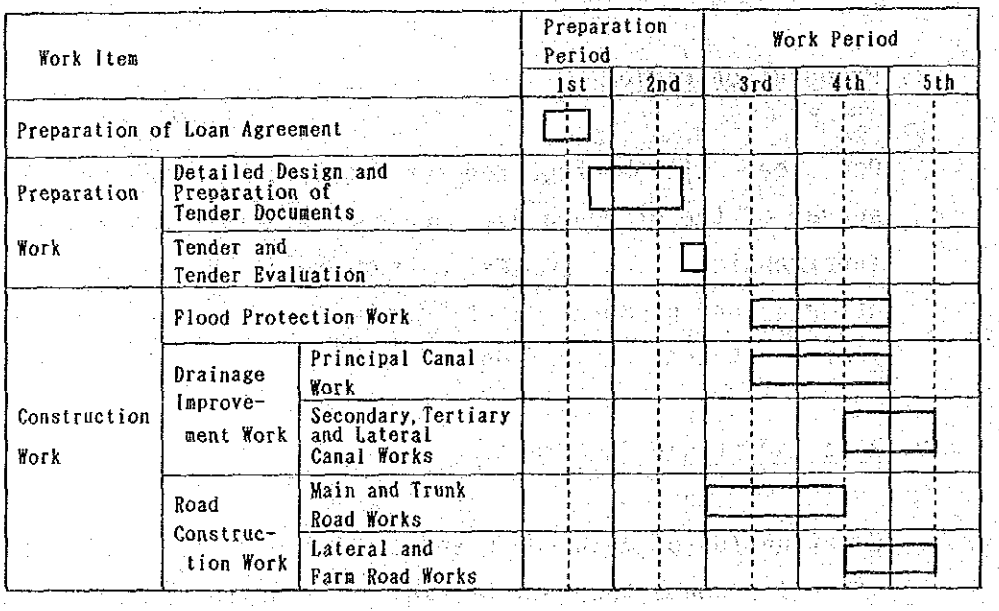


Fig. 4.2.1 Project Implementation Schedule

4.3 Operation and Maintenance Plan

4.3.1 Basic Policy

After completion of the Project, if facilities are not properly maintained and administered, the estimated effectiveness will not be attained. Especially, in this Area, owing to climate conditions (high temperature and much rain). It is required that drainage canals and

roads are maintained and accurately controlled. In this plan, the basic policy for operation and maintenance of facilities is as follows:

. Rivers	:	Under MOPT's control
. Principal and secondary drainage canals	:	Under SENARA's control
. Main roads within	:	To be transferred to MOPT
. Lateral roads	:	To be transferred to the cantons
. Tertiary and lateral drainage canals	:	Under the control of an canal co-operatives formed by farmers
. Farm roads	:	ditto

4.3.2 Organization for Operation and Maintenance

SENARA installs an operation and maintenance (O/M) office for the facility control. This O/M office performs the operation and maintenance of the facilities which SENARA is in charge of and also provides conferences and instruction for the facilities operated and maintained by other organizations or cooperatives. The structure of this O/M office is as follows:

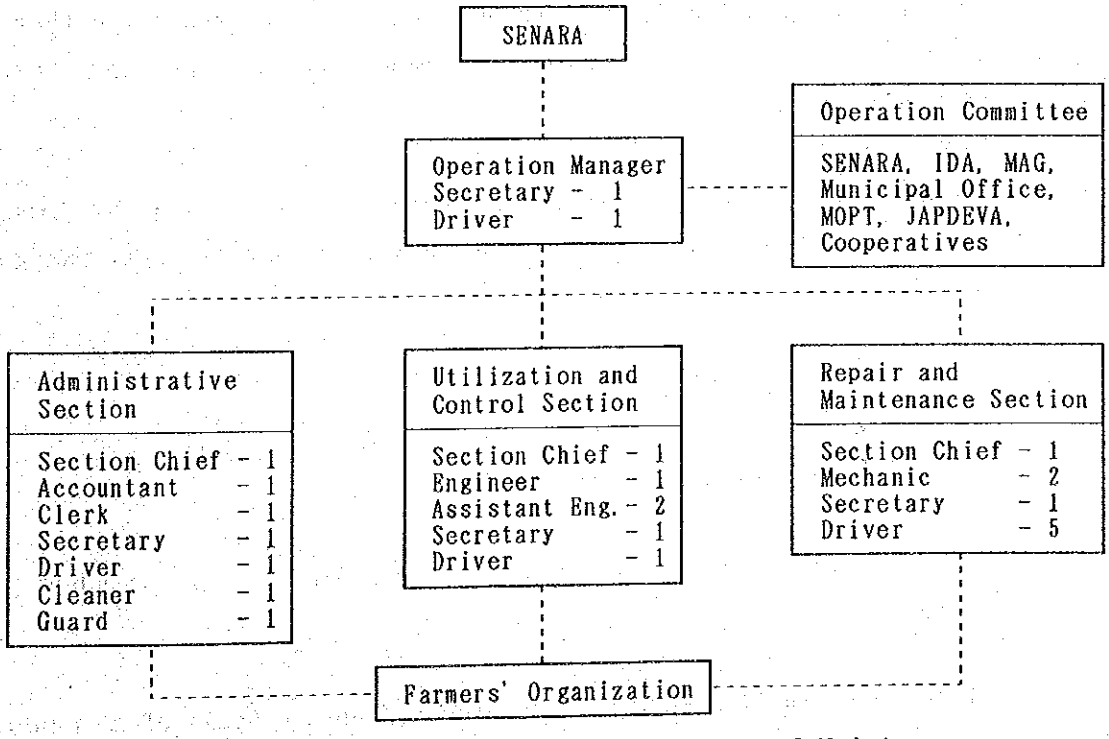


Fig. 4.3.1 Organization Chart for Operation and Maintenance

The building used as the site office formerly will be used as the O/M office with attached facilities. All management cost for the O/M office are provided by beneficiary farmers.

4.3.3 Equipment for Operation and Maintenance

The machinery required for O/M activities are described below. (Annex K K.2)

Machine	Spec.	Number
Backhoe	0.7 m^3	1
Motor grader	180 ps	1
Dragline	1.2 m^3	1
Bulldozer	13.5 t	1
Dump truck	11 t	1
Pick-up	1 t	3
Motor cycles	125 cc	2

4.3.4 Operation and Maintenance Cost

The operation and maintenance of the facilities is considered to require an estimated ¢16,811,000 per year, on the assumption that the machinery and vehicles are to be replaced with new ones upon expiry of their useful life.

All the costs required for this purpose will be paid by beneficiary farm households, each of which will assume a yearly charge of ¢1,282 per ha.

4.4 Estimation of Project Cost

4.4.1 Basic Conditions

The project cost was calculated according to the standard set forth below.

1) The construction work will be executed on the basis of a contract system, with all the necessary construction machinery supplied by

the contractor at his cost. Expenses for the construction machinery will therefore be defrayed as machine rental.

2) The price of the construction machinery and materials will be calculated taking the actual domestic commodity price in Costa Rica into account.

3) The unit price used in the neighborhood of the Area by SENARA, MOPT and IDA will be employed as a unit construction price. Overhead fee and Physical contingency are included in the unit price and they cover 45.5 % of the unit price.

4) The exchange rate of the Colon (¢) against the U.S. dollar is set to ¢68.75 per U.S. dollar current as of the end of December, 1987.

5) The contingencies will be divided into physical and price contingencies. The former will be included in the unit price. The price contingency will be adopted at 13.7% of net construction cost with reference to similar project in Costa Rica.

4.4.2 Project Cost Estimation

The project cost includes drainage improvement costs, flood protection costs, road improvement costs, land consolidation cost and other construction costs such as the land acquisition cost and consultation fees. The total project cost is estimated at ¢3,706,680,000 (US$53,910,000) as shown in Table 4.4.1.

Table 4.4.1 Project Cost

Unit: ¢ 1,000

Item of Works		Foreign Currency	Domestic Currency	Total	Remarks
Inside Area	Drainage Improvement	779,509	176,595	956,104	
	Flood Protection	449,163	74,006	523,169	
	Roads and Bridges	223,685	64,932	288,617	
	Land Consolidation	232,046	89,374	321,420	
	Sub-total	1,684,403	404,907	2,089,310	
	Small Scale Water Supply System	782	7,217	7,999	
	Agricultural Processing Facilities	110,682	12,298	122,980	
	Agricultural Machinery Centers	79,310	0	79,310	
	Sub-total	190,774	19,515	210,289	
	Land Acquisition Cost	0	82,497	82,497	
	Consulting Fee	192,314	21,368	213,682	
	Administration Cost	649	10,145	10,794	
	Sub-total	192,963	114,010	306,973	
	Price Contingency	283,363	74,192	357,555	
	Total	2,351,503	612,624	2,964,127	
Outside Area	Drainage Improvement	225,617	43,998	269,615	Rio Madre de Dios
	Flood Protection	231,703	38,712	270,415	
	Roads and Bridges	7,390	3,651	11,041	
	Sub-total	464,710	86,361	551,071	
	Land Acquisition Cost	0	43,988	43,988	
	Consulting Fee	49,596	5,510	55,106	
	Administration Cost	199	3,116	3,315	
	Sub-total	49,795	52,614	102,409	
	Price Contingency	70,460	18,613	89,073	
	Total	584,965	157,588	742,553	
Grand Total		2,936,468	770,212	3,706,680	

(Note) Outside area works means works on the opposite sides of Rio Madre de Dios and Rio Matina

CHAPTER 5 PROJECT EVALUATION

CHAPTER 5 Project Evaluation

5.1 Economic Evaluation

5.1.1 Terms of Evaluation

The evaluation has been made using the following indicators:

- Economic Internal Rate of Return (EIRR)
- Benefit-Cost Ratio (B/C)
- Net Present Value (NPV)

The following parameters are employed in the economic evaluation of the Project

1) The term of evaluation are set up over 50 years after commencement of the Project. The replacement cost of the O & M equipment is calculated assuming that the equipment is replaced at the time when the durable life of the equipment is terminated within 50 years.

2) The Colon is used for evaluation. The exchange rate of US$ 1.00 = ₡68.75 is adopted as the official rate in December 1987.

3) Farm gate price is adopted for the price of agricultural products as economic price. The parity prices based on the international market price are applied to some crops.

4) The production cost considering the lists of cost for agricultural production in 1987 prepared by BCCR.

5) The economic price for labor wage, ₡47.19/hr of the opportunity cost which is considered as the wage on banana plantations and the unemployment ratio in the Area is used.

6) Interest for farm credit is not included in the production cost for calculation of the EIRR.

5.1.2 Project Benefit

The expected benefit with the Project consists mainly of an increase in crop production and saving in cost of transportation by road construction and improvement.

1) The benefit by crop production is evaluated with an incremental production value which represents the difference between the with project estimates and the without project estimates.

The benefit obtained by crop production will be increased as a result of increase in yield which is expected through the diffusion of the new farming system and the extension of the harvest area. The total increased benefit in target term is as follows:

Table 5.1.1 Project Benefit

Unit: ₡1,000

	Without Project	With Project	Increased value
Gross value of production	339,721	2,206,870	1,867,149
Production cost	268,737	1,134,849	866,112
Net value of production	70,984	1,072,021	1,001,037

2) The benefit of saving in cost of transportation for agricultural products and input materials is calculated at ₡ 16,473,000 annually (Annex M Table M.1.5).

3) The benefit of reduction of banana's damage loss is estimated at ₡ 110,603,000 annually. Accordingly, annual benefit is estimated at ₡1,128,113,000 in total, i.e. ₡86,050/ha.

5.1.3 Project Cost

1) Project Cost

Project cost involves construction, procurement of equipment for operation and maintenance, engineering services and administration costs. The annual disbursement schedule of the project cost is as follows:

Table 5.1.2 Annual Outlay

Unit:₡1,000

Year	1st year	2nd year	3rd year	4th year	5th year
Project Cost	20,446	153,602	363,775	981,084	637,754

2) Operation and Maintenance Cost

Annual operation and maintenance cost is as follows:
(see Annex K K.2)

Table 5.1.3 Annual Operation and Maintenance Cost

Item	Amount(₡1,000)
Wages of staff personnel	4,997
Running cost of vehicles	237
Cost of office supplies	100
Running cost of O&M equipment	6,923
Reserve fund	368
Total	12,625

3) Replacement Costs

Replacement costs in the project life are summarized below.

Table 5.1.4 Replacement Cost

Equipment	Spec.	Life (Year)	Unit Replacement Cost (₡ 1,000)
Backhoe	0.7 m3	15	10,048
Motorgrader	180 ps	15	6,161
Dragline	1.2 m3	15	28,135
Dump truck	11 t	8	2,036
Bulldozer	13.5 t	15	5,606
Pick up	1 t	5	2,550
Motorcycle	125 t	3	275

5.1.4 Economic Internal Rate of Return and Benefit-Cost Ratio

The economic evaluation for the Project has been made on the assumption that the project life is 50 years. The economic internal rate of return (EIRR) is calculated based on the benefit and the cost mentioned above, and the result is as obtained EIRR = 23.0%. (See Table 5.1.5 Calculation of EIRR)

On the other hand, the benefit-cost ratio (B/C) and the net present value (N.P.V.) at 85, 10% and 18% discount rate are as follows:

Table 5.1.6 B/C and NPV

		Discount Rate		
		8%	10%	18%
B/C	(%) 2.39	1.50%	1.40%	1.07%
NPV	(₡1,000)	170,270,461	111,496,743	10,632,413

As a result, this Project is highly rated in a term of the EIRR, and also has high value with respect to the NPV. Hence, this Project is economically feasible.

5.1.5 Sensitivity Analysis

Sensitivity analysis has been made in the event of a variation in project cost and reduction of crop price or yield.(Annex M Table M.1.8(1) to M.1.8(3))

		EIRR
1) Project cost increased by 20%	:	20.7%
2) Crop price or yield reduced by 10%	:	20.0%
3) Combination of (1) and (2)	:	18.0%

5.2 Financial Evaluation

5.2.1 Project Costs

The estimated project cost except for the costs for water supply facilities, post-harvest facilities and agricultural machinery center is ₡ 3,467,596,00 in total and annual disbursement of the project cost is proposed as follows:

Table 5.2.1 Annual Disbursement of Project Cost

Year	Project cost	F/C	L/C
1	32,565	27,625	4,940
2	270,072	110,263	159,809
3	612,705	510,687	102,018
4	1,509,351	1,277,030	232,321
5	1,042,903	793,963	248,940
Total	3,467,596	2,719,568	748,028

Assuming that the foreign currency portion of the project cost will be financed from an international monetary institution and the remainder is assumed to be covered by the government.

5.2.2 Amortization of Foreign Currency

The amortization schedule for a foreign currency loan is set under the following conditions:

Annual interest rate	:	4%
Loan period	:	25 years
Grace period	:	5 years
Amortization	:	2 repayments annually with constant amount uniformity of the principal

The maximum amount of foreign repayment including interest payment will reach US$ 3,466,000.

Amortization schedule (repayment) is shown in Table 5.2.2.

5.3 Financial Analysis of Model Farmers

5.3.1 Profit and Loss

Taking into consideration the proposed cropping pattern, farm scale and local conditions, the profit and loss for the model farmers at target year will be calculated.

1) Family labor is excluded from production costs.

2) Farm credit for agricultural production is based on the conditions of BNCR, and annual interest rate of the credit is to be 24% for the short term and 15% for the long term. The loan period is decided in consideration of the cultivation period.

The result of the calculations is shown in Annex M, Table M.2.1 (1) to (5) Profit and Loss Statement and Table M.2.2 (1) to (5) Cash Flow of Model Farmer. As the result indicated, a sharp improvement of farm household economy will be expected for farm conditions of the

model farmers after completion of the Project.

However, since the financing of farmers is foreseen a difficulty in the initial stage, it is desirable to give permission of the total amount of credit for farming fund during the early three years.

5.3.2 Possibility of Burden for Maintenance and Withdrawal Charges

Through the project implementation, the farmers in the project area would gain considerable profit from the Project. Accordingly, if SENARA collects a portion of the project cost and operation and maintenance cost in the shape of O & M charge from the beneficiaries, the O & M charge is estimated as follows:

1) Operation and Maintenance Cost

According to the cost calculation based on the operation and maintenance plan, the amount to be borne per ha is estimated at ₡ 1,282 annually.

2) Withdrawal Cost

Out of the total project cost, annual withdrawal cost counted as a burden of the beneficiaries is ₡15,297,696, i.e., annual amount to be borne per ha is estimated at ₡ 1,167. The withdrawal period is assumed to be 30 years with a grace period of 5 years on the basis of the similar projects for agricultural development in Costa Rica.

Consequently, the O&M charge as maintenance and withdrawal charges equivalent to ₡ 2,449 per ha appears to be adequate.

It is expected that the beneficiaries will be able to bear the estimated total charge in the 4th year after completion of the Project.

5.4 Social Evaluation

After completion of the Project, it is expected to provide such

positive effects as the increase in agricultural productivity, the creation of employment opportunities and stabilized farm management, which are described as below.

1) Through the efficient agricultural productivity brought by the provision of drainage facilities in existing farmland and the development of road networks, the increase of agricultural production that can be achieved over the current level is about 97,000 tons.

2) Since an increase in planted area for the farmer's own use will absorb the labor force of the farmer's family, a labor force of 240 persons annually in self-farming is secured.

3) The introduction of high-profit crops and the strengthening of agricultural supporting organizations will generate a stable farming environment. In agricultural income of the average farmer, an annual increase in income of more than ₡ 180,000 to ₡ 200,000 is expected.

4) The farmland (410 ha) with an elevation of 2.0 m and less is excluded from the area to be developed, however, it seems that this is not an obstacle to living and farm management of the farmer concerned to this farmland.

On the other hand, as the indirect impact, a considerable enhancement in the living standards and stabilization of farm household economy, increase in quantity of agricultural input materials and equipment, and acceleration of the vitalization of the economy of the surrounding areas is expected. Further this Project is expected to contribute to the development of the region and Costa Rica.

Table 5.1.5 Calculation of EIRR

(UNIT : ¢1,000)

YEAR	PROJECT COSTS				INCREMENTAL BENEFIT	PROJECT RETURN
	CONSTRUCTION COST	O & M COST	PRODUCTION COST	TOTAL		
1	20,446	0	0	20,446	0	-20,446
2	153,602	0	0	153,602	0	-153,602
3	363,775	0	0	363,775	0	-363,775
4	981,084	0	0	981,084	0	-981,084
5	637,754	0	0	637,754	0	-637,754
6	0	12,625	1,019,824	1,032,449	222,202	-810,247
7	0	12,625	783,997	796,622	1,498,253	701,631
8	0	12,900	856,177	869,077	1,664,254	795,177
9	0	12,625	861,113	873,738	1,779,534	905,796
10	0	15,175	866,112	881,287	1,969,178	1,087,891
11	0	12,900	866,112	879,012	1,975,347	1,096,335
12	0	12,625	866,112	878,737	1,994,225	1,115,488
13	0	14,661	866,112	880,773	1,994,225	1,113,452
14	0	12,900	866,112	879,012	1,994,225	1,115,213
15	0	15,175	866,112	881,287	1,994,225	1,112,938
16	0	12,625	866,112	878,737	1,994,225	1,115,488
17	0	12,900	866,112	879,012	1,994,225	1,115,213
18	0	12,625	866,112	878,737	1,994,225	1,115,488
19	0	12,625	866,112	878,737	1,994,225	1,115,488
20	0	65,475	866,112	931,587	1,994,225	1,062,638
21	0	14,661	866,112	880,773	1,994,225	1,113,452
22	0	12,625	866,112	878,737	1,994,225	1,115,488
23	0	12,900	866,112	879,012	1,994,225	1,115,213
24	0	12,625	866,112	878,737	1,994,225	1,115,488
25	0	15,175	866,112	881,287	1,994,225	1,112,938
26	0	12,900	866,112	879,012	1,994,225	1,115,213
27	0	12,625	866,112	878,737	1,994,225	1,115,488
28	0	12,625	866,112	878,737	1,994,225	1,115,488
29	0	14,936	866,112	881,048	1,994,225	1,113,177
30	0	15,175	866,112	881,287	1,994,225	1,112,938
31	0	12,625	866,112	878,737	1,994,225	1,115,488
32	0	12,900	866,112	879,012	1,994,225	1,115,213
33	0	12,625	866,112	878,737	1,994,225	1,115,488
34	0	12,625	866,112	878,737	1,994,225	1,115,488
35	0	65,475	866,112	931,587	1,994,225	1,062,638
36	0	12,625	866,112	878,737	1,994,225	1,115,488
37	0	14,661	866,112	880,773	1,994,225	1,113,452
38	0	12,900	866,112	879,012	1,994,225	1,115,213
39	0	12,625	866,112	878,737	1,994,225	1,115,488
40	0	17,211	866,112	883,323	1,994,225	1,110,902
41	0	12,900	866,112	879,012	1,994,225	1,115,213
42	0	12,625	866,112	878,737	1,994,225	1,115,488
43	0	12,625	866,112	878,737	1,994,225	1,115,488
44	0	12,900	866,112	879,012	1,994,225	1,115,213
45	0	65,200	866,112	931,312	1,994,225	1,062,913
46	0	12,625	866,112	878,737	1,994,225	1,115,488
47	0	12,900	866,112	879,012	1,994,225	1,115,213
48	0	14,661	866,112	880,773	1,994,225	1,113,452
49	0	12,625	866,112	878,737	1,994,225	1,115,488
50	0	15,450	866,112	881,562	1,994,225	1,112,663
51	0	12,625	866,112	878,737	1,994,225	1,115,488
52	0	12,625	866,112	878,737	1,994,225	1,115,488
TOTAL	2,156,661	782,741	40,763,927	43,703,329	90,871,993	47,168,664

INTERNAL RATE OF RETURN (IRR) = 23.0%

Table 5.2.2 Repayment Schedule of Foreign Loan

Unit: US$ 1,000

Year in Order	Foreign Loan	Accumulated Foreign Loan	Interest Payment	Capital Payment	Total Payment
1	402	402	16		16
2	1,604	2,006	80		80
3	7,428	9,434	377		377
4	18,575	28,009	1,120		1,120
5	11,549	39,558	1,582	1,884	3,466
6		37,674	1,507	1,884	3,391
7		35,790	1,432	1,884	3,316
8		33,906	1,356	1,884	3,240
9		32,022	1,281	1,884	3,165
10		30,138	1,206	1,884	3,090
11		28,254	1,130	1,884	3,014
12		26,370	1,055	1,884	2,939
13		24,486	979	1,884	2,863
14		22,602	904	1,884	2,788
15		20,718	829	1,884	2,713
16		18,834	753	1,884	2,637
17		16,950	678	1,884	2,562
18		15,066	603	1,884	2,487
19		13,182	527	1,884	2,411
20		11,298	452	1,884	2,336
21		9,414	377	1,884	2,261
22		7,530	301	1,884	2,185
23		5,646	226	1,884	2,110
24		3,762	150	1,884	2,037
25		1,878	75	1,878	1,953
26		0	0	0	0

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

Chapter 6 Conclusions and Recommendations

6.1 Conclusions

In conducting a feasibility study of the Study Area, a development plan over an area of 19,500 ha (including 11,150 ha actually developed), has been formulated and the plan has been studied from technical, economic and social standpoints. As a result, the following conclusions are obtained:

1) Factors hampering current agricultural production are insufficient drainage facilities, flooding of rivers, an insufficient road network, and lack of arrangement of farmlands, resulting in a low land use rate and low productivity.

   In addition, there are also such problems as insufficient organization of extension services for agricultural management techniques. and a shortage of agricultural financing. However, it is confirmed that the execution of the development plan proposed by this Project would obviate these adverse factors and help to develop the agriculture in the Project Area while improving the welfare of local residents.

   It is thus of urgent necessity to implement the Project.

2) From the technical and economic viewpoints, the following plans to be implemented are proposed:

Drainage Improvement Plan:		
Principal drainage canals		
	New construction	32.10 km
	Rehabilitation	25.95 km
Secondary drainage canals		
	New construction	42.40 km
	Rehabilitation	24.70 km
Flood Protection Plan:		
	Embankment	56.10 km

Agricultural Production Plan:

Main crops to be introduced

bananas, cacao, coconuts, plantains, pepper, rice, maize kidney beans, tuber crops and beef cattle

Road Network Plan:

Main and trunk roads

New construction	13.60 km
Rehabilitation	46.00 km

Lateral roads construction

New construction	58.80 km
Rehabilitation	19.70 km

Land Consolidation Plan:

New construction of tertiary and lateral drainage canals
New construction of farm roads

Rural Infrastructure Plan:

Water supply facilities 5 village

Agricultural Promotion Plan:

a. Strengthening of agricultural supporting organizations,
b. Improvement of farmers' organizations,
c. Establishment of two agricultural machinery centers,
d. Establishment of six post-harvest facilities

3) The estimated project cost for the implementation, in U.S. dollar equivalent, is as follows:

Foreign currency	:	US$ 42,712,000
Local currency	:	US$ 11,203,000
Total	:	US$ 53,915,000

4) The period for implementation of the Project is reasonably set at 4.25 years including the period of detailed design.

5) If the Project is implemented successfully as planned, the benefits expected to be obtained by increased production of agricultural products and reduced transportation costs will be equivalent to ₡ 1,128,113,000 per year.

6) The internal rate of return (IRR) as determined from the expenses and benefit of the Project will be 23.0% over an assumed project life of 50 years. Further, this figure may vary between 20.7% and 18.0% according to the results of sensitivity analysis taking future conditions charges into account.

These results, with a higher economic evaluation than for other similar projects in the country of Costa Rica, indicate the superiority of this Project.

7) In this development plan, virgin forests and large scale forests are excluded from the area to be developed because of environmental reservation. As a result of examination on the impact to environment of the Area, it is confirmed that the impact does not cause problems in particular. It also can be confirmed that the sedimentation will not change from the present state though the sediment transportation from the river may increase slightly.

6.2 Recommendations

1) The implementation of this Project will not only benefit the inhabitants in the Area directly but also have a socio-economic impact on the country as well as the Area. The Government of Costa Rica is requested to take measures for the implementation of this Project based on this feasibility study.

2) Further, preparations should be made for the following items at the same time:

(1) Establishment of an implementation organization based on the project implementation plan suggested.
(2) Explanation of the Project to the residents in the Study Area.
(3) Acquisition of the necessary land according to the plan.

3) If the Project under consideration is to be successful, the following items are also important and should be stressed during the progress of the Project:

(1) Establishment of an organization for operation and maintenance of the facilities.
(2) Strengthening and enlargement of the proposed agricultural supporting organization.
(3) Instructions on the establishment of the proposed farmers' organization.
(4) Construction of an agricultural equipment center commensurate with the increase in the cultivated area.
(5) Construction of post-harvest facilities commensurate with the increase in production volume.

4) Rio Matina and Rio Madre de Dios are located on the boundary of the Study Area. The construction related to these rivers, therefore, should cover both the locations included in the Area and those of the opposite side, outside of the Area.

5) There are forests including virgin forests. Especially, the virgin forests extending in low marshland along Canal del Tortuguero are inhabited by valuable animals and are also an important tourism resource. The plan takes special care in environmental protection of these forests, and the above area is excluded from the proposed Project Area to be developed. Under the circumstances, however, efforts must be made to protect this environment from unauthorized entry or other adverse factors.

6) Study on the system of agricultural credit which can ensure the farming fund smoothly for the farmers.

APPENDIX

APPENDIX - 1 : MEMBER LIST OF COSTARICAN PERSONNEL CONCERNED

	NAME	POSITION
(SENARA)	Ing. Fernando Estrada B.	Gerente General
	Ing. José Carlos Salas F.	Jefe Oficina de Planificación Counterpart, Leader Project Evaluation
	Ing. Luis Diego Castillo V.	Jefe Dirección de Riego y Avenamiento Counterpart Coordinator Irrigation and Drainage
	Ing. Sergio Salas	Dirección de Riego y Avenamiento Counterpart, Irrigation and Drainage Survey, Design and Project Implementation
	Ing. W.Murillo	Counterpart, Meteorology and Hydrology
	Ing. J.C.Valverde	Counterpart, Agriculture
	Ing. J.Manix	Counterpart, Soil and Land Use
	Ing. B.Quiros	Counterpart, Land Consolidation
	Ing. O.Solis	Counterpart, Agro-economy and Marketing

ANNEX - 2 : MEMBER LIST OF STUDY TEAM

Field in Charge	Name
Team Leader	Mr. Yasuo MAEDA
Sub-Leader & Land Use	Mr. Takahisa ISOZUKA
Irrigation and Drainage	Mr. Kazuyoshi NAGATA
Agronomist	Mr. Tetsuo MIZOBE
Survey, Design and Project Implementation	Mr. Kazunari NAGATA
Meteorology and Hydrology	Mr. Toyotaka NIWA
Soil	Dr. Tamotsu OGATA
Project Evaluation	Mr. Yoshihiro UCHIDA
Land Consolidation	Mr. Minoru YAHATA
Settlement and Rural Development	Mr. Kunio TAKAGAKI
Agro-Economy and Marketing	Mr. Tetsuo DOKIYA