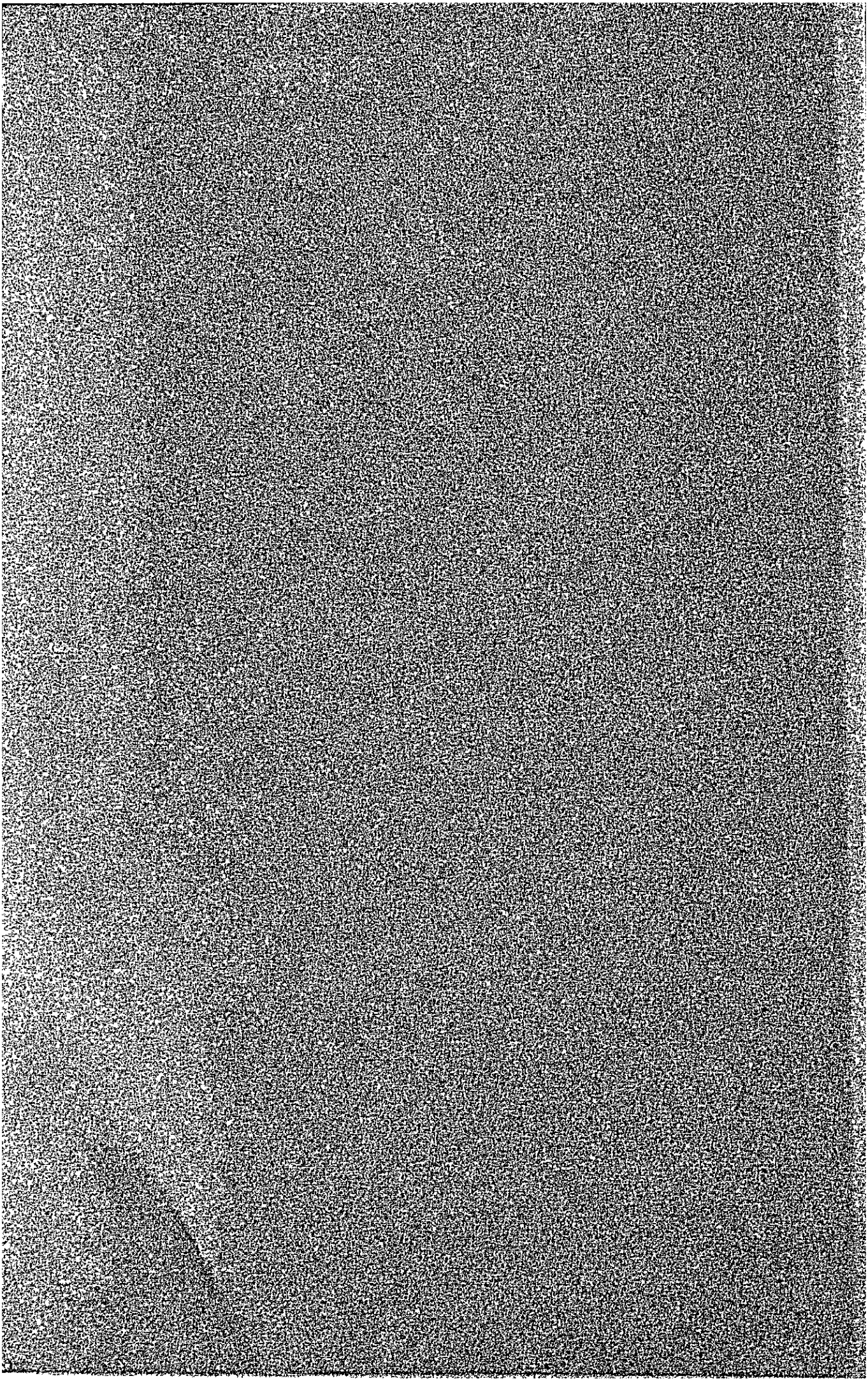
CHAPTER IV
FORMULATION OF DEVELOPMENT PLAN



CHAPTER IV

FORMULATION OF DEVELOPMENT PLAN

4.1 Objective

The objective of the project is to improve existing unsteady agriculture highly affected by the given natural condition through the most efficient utilization of available land and water resources. At present, the low productivity prevailing in the area is due to poor drainage condition caused by rainfall and river flooding. In order to increase the agricultural production and the living standard of the local farmers, the first task is to eliminate these drainage problems. In addition further development will be possible by introduction of irrigation and extending profitable crop cultivation.

4.2 Framework of the Development Plan

4.2.1 Basic Considerations

The major crop in the study area is pasture to produce beef cattle and this will continue even within the development framework for future.

In addition cacao and other crops are to be extended with introduction of improved cultivation techniques. For this purpose the following plans are to be formulated:

1. Drainage improvement plan to eliminate existing poor drainage conditions;
2. Farm road plan to improve transport and communication problems,
3. Reclamation plan of unutilized land and
4. Irrigation plan to make efficient utilization of available water resources.

In formulating the above plans, no drastic changes from the present state in the project area should not be intended since implementation of such development plan requires considerable amount of capital, manpower and time. Therefore, the step up analysis will be made in different development levels to minimize the project impact on farming pattern.

Considerations are to be given to the marketability, profitability and adoptability of crops in order to determine the crop types and the cropping area in the project. Agricultural extension services and their institutional aspects are other important points of view to be considered in project formulation.

It should be noted that considering existing state of the agriculture in the study area provision of sufficient and effective agri-

cultural extension services and agricultural credits is one of the most important factors of the project.

4.2.2 Development Framework

(1) Development Level

According to the above basic considerations three different development levels are proposed for formulation of alternative development plans.

Development Plan I

1. The most substantial crop is pasture for beef cattle raising. The productivity will be raised to the same level as farms with well drained area. The annual weight gain of cattle is planned to be 300 kg/ha/year.

2. The land improvement level is set as a groundwater level of more than 80 cm below from the ground surface and the occurrence of inundation is once in more than 2 years.

3. In addition, improvement will be made in the pasture with existing Braquiaria, moisture resistant true grass.

4. As a result, the cropping areas of cacao and cassava are extended to 1,000 ha and 320 ha, respectively.

Development Plan II

1. Additional annual weight gain of beef cattle above Plan I is sought. The set target is 340 kg/ha/year.

2. For this purpose Improvement of pasture is planned to replace existing moisture resistant true grass for mixed pasture of Angleton of true grass and Tropical Kudzu of legume.

3. In addition, the cropping areas of cacao and cassava are to be extended to 2,000 ha and 640 ha, respectively with suitable drainage conditions.

4. For these purposes, land improvement is required to maintain the groundwater level at 100 cm below from the ground surface and the occurrence of inundation is once in more than 5 years.

Development Plan III

1. The same level of drainage improvement as the Plan II is to be maintained.

2. Irrigation is to be introduced to protect drought at 5 year return period at 4,300 ha in the Zone C and D except for cacao orchards.

3. Irrigated crops are pasture, maize, sorghum, watermelon, papaya and pineapple.

4. The annual weight gain of beef cattle is to be increased to 595 kg/ha/year with irrigation of pasture and rotational grazing.

5. The land productivity is to be up-graded by the cropping rotation of pasture and irrigated crops.

6. Maize and sorghum are to be double cropped with mechanization and irrigation.

In order to content Development Plans above-mentioned the proposed land improvement levels by each plan are summarized below;

Plan I : to improve drainage conditions to

1. Groundwater levels at least 80 cm from the ground surface.
2. Occurrence of submergence not less than 2 years return period.

Plan II : to improve drainage conditions to

1. Groundwater levels at least 100 cm from the ground surface.
2. Occurrence of inundation not less than 5 years return period.

Plan III : to introduce irrigation to Level II

1. Drainage conditions in the same level as Level II.
2. Irrigation for the drought in 5 years return period.

The above there development plans are summarized in Table 4-1.

(2) Land Improvement Plan

1) Drainage

The gravity drainage method is proposed without mechanical facilities since the area which covers more than 80% of the project area inclines with 1/700 of longitudinal slope from the right bank of the Pamplonita River toward the Grita River.

The flood overflow of the Pamplonita River spreading over a wide area at present has to be collected into the drainage canals to drain to the Grita River.

No banks are to be constructed for land protection against inundation since the protection of land on the project area may cause further damage of flood in the land on the opposite side of the river.

Finally, no land inundation is to be allowed in the plan except for certain limited area in Zone A.

Table 4—1 Comparison of Development Plans

Development Plan	Land Improvement Plan			Production Plan				Remarks
	Land Improvement	Level of Improvement	Land Improvement Condition	Beef Cattle	Cacao	Cultivated Crops	Others	
Plan I Improvement of agricultural productivity based on the existing beef cattle business pattern	Improvement of drainage system	Level of good drainage site in study area.	Groundwater level from ground surface; more than 0.8 m. Submergence; once every 2 years. Ponding; no exist. Design rainfall; 2 years return period. Drainage capacity; for peak discharge.	Improvement of pasture existing (Braquiaria) Plowing of pasture once in 5 years. Being exhaustive of vaccination. Amplification of fattening of beef cattle.	Extension of Zones B, C (1,000 ha).	Extension in cultivable land (320 ha). Remaining of existing maize (40 ha).	Remaining of existing cashew nuts.	Consequences of backwater by the Zulia River
	Improvement of farm road							
Plan II Amplification of cacao and cassava on the appropriate drainage condition and introduction of superior pasture	Improvement of drainage	Improvement of drainage condition for cacao, cassava and superior pasture	Groundwater level from ground surface; more than 1.0 m. Submergence less than once in the 5 years by river flood and rainfall. Design rainfall; 5 years[2/] return period. Drainage capacity for peak discharge.	Improvement of pasture by superior species (Tropical Kudzu & Angleton). Plowing once in the 5 years and fertilization. Being exhaustive of vaccination. Extension of fattening of beef cattle.	Extension in proposed area of approx. 2,000 ha.	Extension of cassava in proposed area (640 ha). Remaining of existing maize.	Same to Plan I.	Consequences of backwater by the Zulia River
	Improvement of farm roads							
Plan III[1/] Intensification of farming by introduction of irrigation	Improvement of drainage	Same to Plan II	Same to Plan II.	Zones A, B: Same to Plan II. Zones C, D: Establishment of rotated grazing by irrigation Rotation of pasture and cultivated crops.	Same to Plan II.	Zones A, B: Extension of cassava in proposed area acreage (280 ha) Zones C, D: Planning two crops a year of maize and sorghum (2,660 ha) and watermelon (100 ha) Doing rotation with pasture.	Introduction of papaya and pineapple in Zone D.	Consequences of backwater by the Zulia River.
	Irrigation	Same to level of arrangement in Zulia District.	Drought discharge; once in the 5 years.					
	Improvement of farm roads							

1/ Irrigation zones; Zones C, D only therefore development level of Zones A, B will be same as Plan II.

2/ 5 years return period is used for projects of Zulia, Sibundoy, Lebrija, Tolima, etc.

2) Irrigation

Irrigation is to be introduced in the Plan III and applied at Zones C and D. Since drainage conditions in this area is favourable and even at present cultivation of some crops are practiced. For this reason a mixed farming pattern with beef cattle raising and irrigated crops will be established to maintain steady and sound agricultural production. Other reasons to limit irrigation at Zones C and D are:

1. limited available water source at maximum 7.5 m^3/s,
2. higher annual rainfall in Zones A and B, and
3. the close location of Zones C and D to the water source.

The land size of irrigation is to be 4,300 ha, the whole area excluding cacao and the right of way in the Zones C and D.

3) Farm road improvement

One bridge over the Pamplonita River is planned in addition to a farm road network consisting of inspection cum farm road along the canals.

(3) Production Plan

In order to formulate a production plan, the following considerations are made:

1. Extension of cropping area of existing crops in the project area,
2. The cultivation techniques of the crops are to be acceptable for the farmers in the project area and
3. Marketability and profitability of the crops are to be satisfactory.

(4) Effective Utilization of Supporting Services

Existing public institutes related to agricultural services are to be fully utilized for the successful results of the project. In addition, the necessary supporting system has to be established for supply of hybrid seeds, equipments and materials, and rental services of agricultural machniery.

4.3 Development Plan for Agriculture and Livestock

4.3.1 Land Use Plan

According to the basic considerations of formulation of the development plan, proposed land use by Zone is tabulated in Table 4-2. At present, forest land covers 2,640 ha of which approximately

Table 4–2 Projected Land Use

(Unit: ha)

	Present condition			Development plan				Total
	Agricultural land	Forest	Others		Plan I	Plan II	Plant III	
A zone	1,520	310	100	Beneficiary area(1/) Agricultural land Right of way Others(2/)	1,640(120) 1,560 80 290(190)	1,640(120) 1,560 80 290(190)	1,640(120) 1,560 80 290(190)	1,930
B zone	3,260	1,130	360	Beneficiary area(1/) Agricultural land Right of way Others(2/)	3,720(460) 3,540 180 1,030(670)	3,720(460) 3,540 180 1,030(670)	3,720(460) 3,540 180 1,030(670)	4,750
C zone	3,740	910	210	Beneficiary area(1/) Agricultural land Right of way Others(2/)	4,000(260) 3,800 200 860(650)	4,000(260) 3,800 200 860(650)	4,000(260) 3,600 400 860(650)	4,860
D zone	1,620	290	50	Beneficiary area(1/) Agricultural land Right of way Others(2/)	1,680(60) 1,650 30 100(230)	1,680(60) 1,650 30 100(230)	1,680(60) 1,600 80 100(230)	1,960
Total	10,140	2,640	720	Beneficiary area(1/) Agricultural land Right of way Others(2/)	11,040(900) 10,550 490 2,460(1,740)	11,040(900) 10,550 490 2,460(1,740)	11,040(900) 10,300 740 2,460(1,740)	13,500

1/( ) New development area 2/( ) Forest

30% is distributed along the river courses. These forest areas are to be reserved for protection of river banks against flooding. The 900 ha out of the remaining forest area is to be reclaimed for agricultural purposes since the land condition is suitable for agricultural production. The rest of the forest is to be reserved.

Therefore, the area benefiting from the project is 11,040 ha, which is the sum of the existing agricultural land and the new reclamation of the forest (900 ha).

The right of way and the benefiting area are summarized as below:

Plan	Benefiting Area	Right of way	Total
Plan I and II	10,550 ha	490 ha	11,040 ha
Plan III	10,300 ha	740 ha	11,040 ha

4.3.2 Production Plan

(1) Plan of Crop Types and Cropping Area

In order to determine crop types for the project considerations were given to the following aspects:

1. Natural condition in the project area,
2. Economic aspects of the crops and livestock (profitability and marketability), and
3. Required cultivation technique.

Analysis is made for 17 types of crops and livestock to be cultivated within and in the vicinity of the project area.

They are;

Livestock : Beef cattle (pasture) and pig

Orchard : Cacao, guava, cashew nut and cooking banana

Crops : Cassava, maize, sorghum, soybean, sugarcane, onion, garlic, tomato, watermelon, papaya and pineapple.

Through the study, soybean, onion, garlic and tomato are omitted due to climatic condition of the project area. Also, pig, sugar cane and guava were discarded from an economic point of view. Cooking banana is now cultivated as shade for inmatured cacao trees and is considered to be a supplementary crop of cacao. The production plan is made for the rest of the crops as shown in Table 4-3.

The background of the crops and livestock selected for the project is summarized below;

Table 4–3 Crop Type and Cropping Area

(Unit: ha)

	Present	Plan I	Plan II	Plan III
Beef Cattle (Pasture)	· Artificial pasture (30%) · Mostly Braquiaria · Natural grass land (70%)	· Whole area improvement · Braquiaria · Without fertilizer · Renewal every 5 years	· Whole area improvement · Angleton x Tropical Kudzu · With fertilizer & chemicals · Renewal every 5 years	[Zone C and D] Intensely used by rotation system
	(9,630)	(9,120)	(7,860)	(3,830) (1,380) (5,210)
Cacao	Zone B and C	· Zones B and C · Available Area (60%) · 143 farms (60%) · 7 ha every farm	· Zones A, B and C · 277 farms (all farms) · 7 ha every farm	
	(350)	(1,000)	(1,940)	(1,940)
Cassava	Zones A, B and C	· Zones A, B, C and D · Local varieties · Fertilizing · Partly mechanizing · 1 ha every farm	· Zones A, B, C and D · Improved varieties · Much fertilizing · Partly mechanizing · 2 ha every farm	[Zones C and D] · To change to irrigated crops -
	(50)	(320)	(640)	(280)
Maize (For self-consumption)	Zones B, C and D	· To remain much the same · Local varieties · Local or self-sufficient consumption		[Zone C and D] · To change to irrigated crops
	(40)	(40)	(40)	(10)
Cashew nut	Zone D	· To remain the same as present · No plan to enlarge because of processing and marketing in the area.		· To change to irrigated crops
	(70)	(70)	(70)	(0)
Irrigated crops			[Zone C and D] · Maize · Sorghum } Dual crops (2,660) Rotation to irrigated pasture · Watermelon · Payapa } Little scale (100) introduction apt for the market (100)	

1) Beef cattle (Pasture)

Beef cattle raising has been the most important agricultural item in the project area and farmers in the area are familiar with beef cattle raising. It is also expected to continue to be one of the major agricultural items there in future by all Plans, I, II and III. The cattle fattening method with pasture improvement is proposed in the development Plan I, II and III. And rotated grazing method is planned to employ in irrigated Zone C, D in the development Plan III. Beef cattle for fattening will be purchased in the Cucuta market.

No dairy cattle is to be introduced since climatic conditions are unfavourable and milk production of beef cattle is not projected because of its unprofitability.

Due to poor drainage conditions, natural pasture being predominating in the project area improvement of pasture is planned through plowing and application of lime (1,000 kg/ha) in the whole pasture land.

In the Plan I, the moisture resistant Braquiaria is extended to all the pasture with 5 years' renewal but no fertilizer application.

In the Plans II and III the land improvement level is higher enough to introduce mixed sawing with Tropical Kudzu of legume and Angleton of the true grass every 5 years' renewal. The advantage of the above mixed sawing is:

1. Tropical Kudzu supplement the productivity and nutrition of Angleton of the true grass during the dry season,

2. Phizobium of Tropical Kudzu fixing nitrogen in the air and promote the yield and nutrition of Angleton (Appendix 6.4.4),

3. Efficient utilization of subsurface nutrition will be maintained since root zone of the two pasture are different and

4. Mixed sawing improves nutritious contents and taste of pasture.

The ratio of the mixed sawing is recommended to be at 20% to 30% of Tropical Kudzu with the striped width of 2.5 - 5.5 m (CIAT expert, Dr. HAYASHI).

As for the yield of pasture in the Plan I, Zones A & B are set at 70% ∿ 80% of the colombian standard yield and Zones C & D are planned 100% of the standard yield (Appendix Table 6-4-3). In the Plan II the yield is planned 10 ∿ 15% more than the yield in the Plan I, due to introduction of Tropical Kudzu. In the Plan III, the yield of pasture in the Zones A and B is at the same level as the Plan II, but about 140 t/ha/year is expected in Zones C and D by application of irrigation and rotational graizing.

Since common graizing method is continuous graizing at present, the dune deposits is estimated to be 10%. In the Zones C and D of the Plan III, it is intended to increase the utilization efficiency of pasture and to reduce dune deposits.

Cropping areas of pastures in each Plan are as shown below;

Development Plan	Cropping Area of Pasture
I	9,120 ha
II	7,860 ha
III	5,210 ha

Planning elements such as cattle grazing capacity of pasture, weight gain of cattle and yield of pasture are summarized in Table 4-4.

Table 4–4 Livestock Productivity

Plan	Present		Plan I		Plan II		Plan III	
Zone	A•B	C•D	A•B	C•D	A•B	C•D	A•B	C•D
Grazing capacity (head/ha)	1.2	1.6	1.8	2.2	1.8	2.2	1.8	3.5
Yearly weight gain per head (kg)	100	100	150	150	170	170	170	170
Yearly weight gain per ha (kg)	120	160	270	330	306	374	306	595
Yearly gross yield per ha (kg)	45,000	60,000	60,000	100,000	90,000	115,000	90,000	140,000

Effect of the mixed sawing of leguminous pasture and efficiency of pasture utilization by graizing types are discussed in Appendix 6.4.4.

2) Cacao

The humid tropical climate is suitable for cacao production. Since the international market size and the price of cacao are favourable and there is possibility for exportation in future, INCORA intends to increase cacao production in the project area. Therefore extention of cacao area is planned in every Plan. However, the soil type in Zone D is not suitable for cacao cultivation and the drainage conditions in Zone A in the Plan I is unsuitable for cacao.

The proposed cropping area of cacao per farm is determined to be about 7 ha from the view point of management capacity of a single farm.

In the Plan I, cacao is to be extended to 1,000 ha on the suitable land. This size of cacao extention corresponds to that of INCORA's future program.

In the Plan II and III, the drainage conditions in Zone A will be improved suitable for cacao cultivation. Therefore, 7 ha of cacao in each farm in Zones A, B and C is planned. In Zone A, 260 ha is to be extended. The area corresponds to 80% of 320 ha being free from land inundation in more than 5 year return period.

3) Cashew Nut

At present cashew nut is planted on 70 ha of Zone D where soil conditions are suitable. In the Plan I and II, the cashew nut is to remain, however, it will be replaced by the more profitable irrigated crops for the Plan III.

4) Cassava

At present a traditional stock of cassava is cultivated for domestic consumption in the project area. Since required technique for cassava cultivation is not so difficult, the hybrid (CMC-76) developed for the tropical low lands by CIAT will be extend for the Plan II. The experimental cropping record of the unit yield of CMC-76 is approximately 40 t/ha.

Since cassava is maintaining high farm gate price and market price in the Department and also does not require complicated cultivation technique, extension of cassava will be easily accepted by the farmers. However, planting and harvesting of cassava require large volume of manual labour (60 man-day/ha/year). Considering drainage conditions, marketing and required family labour, the cropping area of cassava is determined to be 1 ∿ 2 ha. Accordingly it is proposed as below:

Plan I	320 ha (320 farms x 1 ha)
Plan II	640 ha (320 farms x 2 ha)
Plan III	280 ha (140 farms x 2 ha)

In the Plan III the irrigated crops are to be introduced in the Zones C and D.

5) Maize and Sorghum

At present maize is cultivated in the project area for domestic consumption and sorghum is irrigated in the nearby Zulia district.

Since profitability of the both crops is less than that of cassava it is not planned to extend cropping area of these crops in the Plan I and II. But present cropping area of only 40 ha for domestic consumption will be maintained.

In the Plan III it is planned to introduce mechanized double cropping of maize and sorghum under irrigation in the Zone C and D, This double cropping area is to be 2,660 ha which is planned to be rotated with pasture. The average cropping area is 13 ha in the Zone C, and 21 ha in the Zone D where soil conditions are not suitable for cacao production.

6) Watermelon, Papaya and Pineapple

These crops are cultivated in small areas in the Zone D at present and it is concluded through the study that the high quality products will be obtained by introduction of irrigation, fertilizing, and improved varieties. Marketability of these crops is satisfactory.

Considering the capacity of market, the cropping area is determined as 100 ha for watermelon, 50 ha for papaya and 50 ha for pineapple in Zone D at the Plan III.

Detailed cropping area is summarized in Table 4-5 and proposed cropping pattern is illustrated in Fig. 4-1.

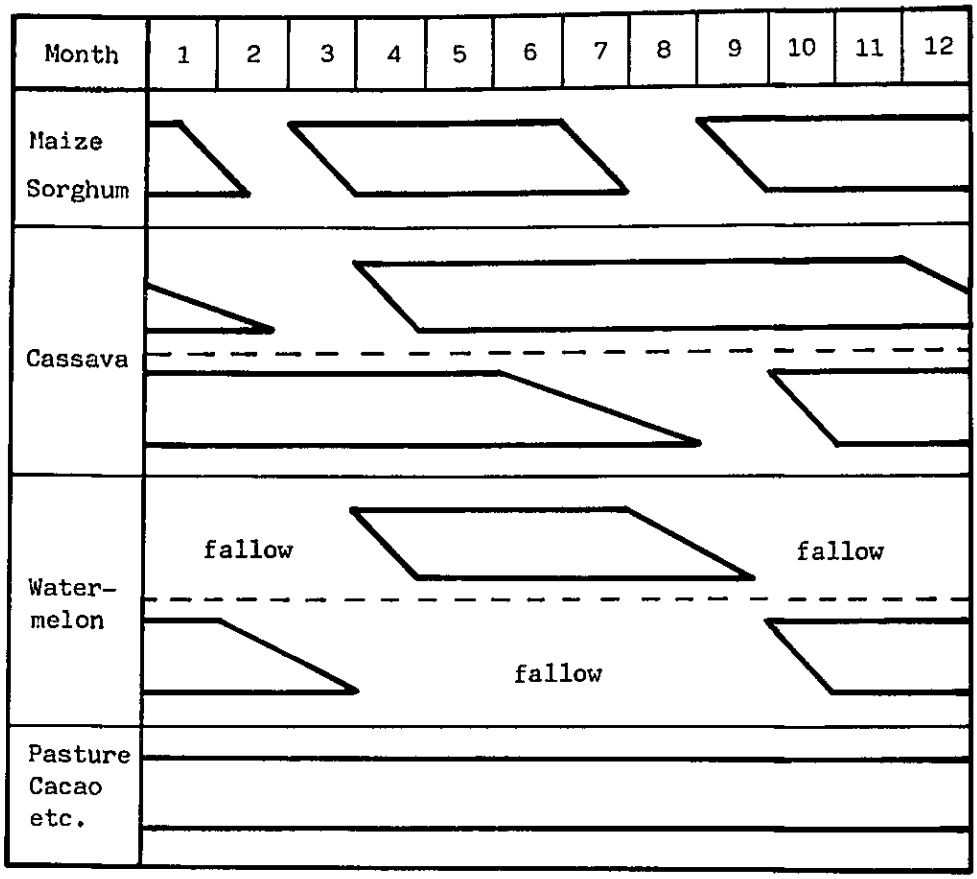


Fig. 4–1 Cropping Pattern

Rotation of land use is planned for Zone C and D at the Plan III. The rotation will be made between pasture and irrigated grain crops to promote productivity of the farm land.

The cropping area ratio of pasture and irrigated grain crops is planned 1 : 2. Renewal of the pasture being scheduled to be once in every 5 years, the rotation cycle is 15 years (Fig. 4-2). Cacao area is not included in the above land rotation.

Watermelon is single crop and included in the cropping area of maize and sorghum in the rotation schedule. Papaya and pineapple are rotated in every 4 years.

Table 4–5 Cropping Area

(Unit: ha)

Plan / Zone	Present Condition		Plan I		Plan II		Plan III	
A	Pasture	1,510	Pasture	1,520	Pasture	1,220	Pasture	1,220
38	Cassava	10	Cassava	40	Cassava	80	Cassava	80
farms					Cacao	260	Cacao	260
	Sub-total	1,520	Sub-total	1,560	Sub-total	1,560	Sub-total	1,560
B	Pasture	3,130	Pasture	3,000	Pasture	2,610	Pasture	2,610
102	Cassava	30	Cassava	100	Cassava	200	Cassava	200
farms	Maize	10	Maize	10	Maize	10	Maize	10
	Cacao	90	Cacao	430	Cacao	720	Cacao	720
	Sub-total	3,260	Sub-total	3,540	Sub-total	3,540	Sub-total	3,540
C	Pasture	3,450	Pasture	3,070	Pasture	2,550	Pasture (I)	880
137	Cassava	10	Cassava	140	Cassava	270	Maize &	
farms	Maize	20	Maize	20	Maize	20	Sorghum (I)	1,760
	Cacao	260	Cacao	570	Cacao	960	Cacao	960
	Sub-total	3,740	Sub-total	3,800	Sub-total	3,800	Sub-total	3,600
D	Pasture	1,540	Pasture	1,530	Pasture	1,480	Pasture (I)	500
43	Maize	10	Cassava	40	Cassava	90	Maize &	
farms	Cashew nut	70	Maize	10	Maize	10	Sorghum (I)	900
			Cashew nut	70	Cashew nut	70	Watermelon (I)	100
							Papaya (I)	
							(Pineapple)	100
	Sub-total	1,620	Sub-total	1,650	Sub-total	1,650	Sub-total	1,600
Total	Pasture	9,630	Pasture	9,120	Pasture	7,860	Pasture	3,830
320	Cassava	50	Cassava	320	Cassava	640	Pasture (I)	1,380
farms	Maize	40	Maize	40	Maize	40	Cassava	280
	Cacao	350	Cacao	1,000	Cacao	1,940	Maize	10
	Cashew nut	70	Cashew nut	70	Cashew nut	70	Maize &	
							Sorghum (I)	2,660
							Cacao	1,940
							Watermelon (I)	100
							Payapa (I)	
							(Pineapple)	100
	Total	10,140	Total	10,500	Total	10,500	Total	10,300

I: Irrigation

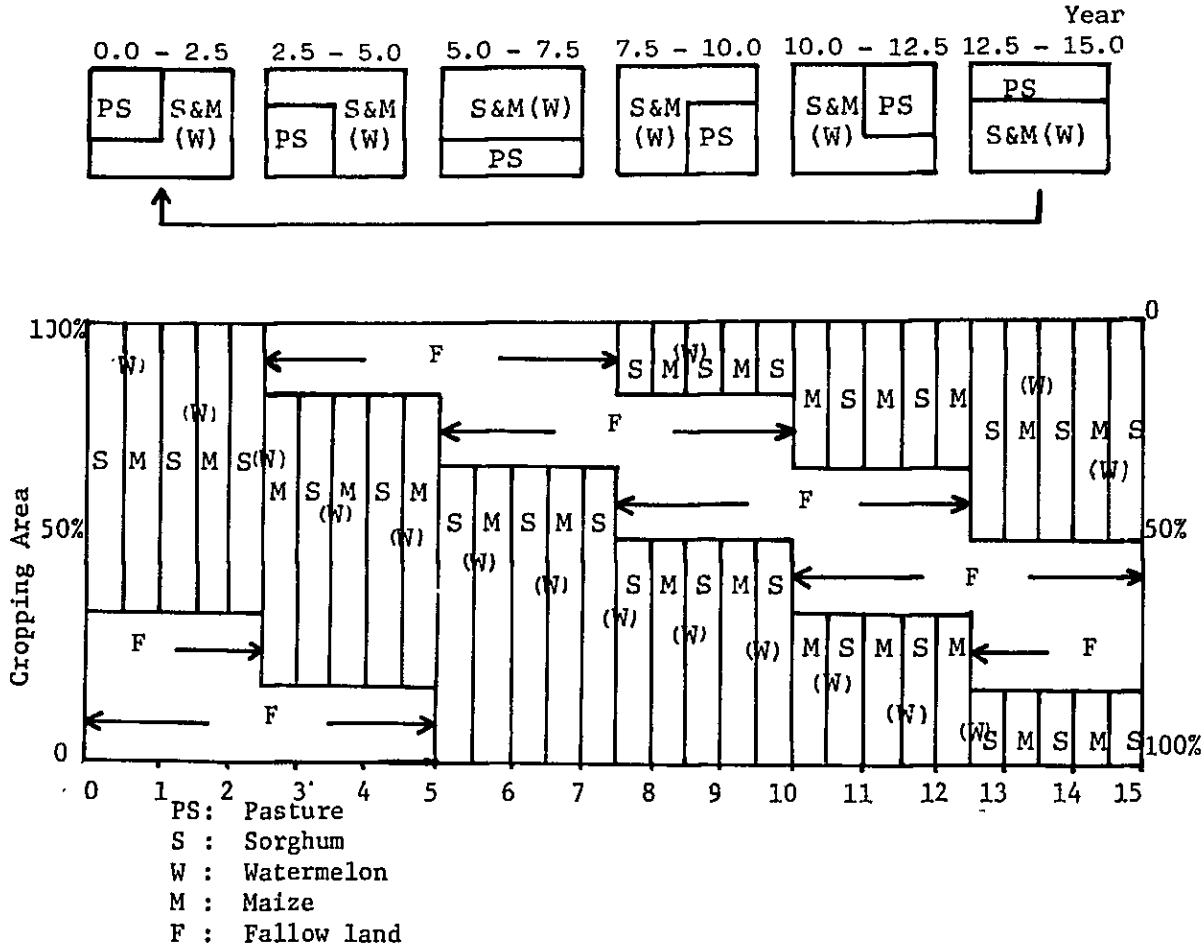


Fig. 4–2 Planting Rotation Model

(2) Proposed Cultivation Method

Proposed cultivation method of crops are summarized in Table 4-6.

(3) Unit Yield and Unit Production Cost

Unit yield of the crops is determined based on the result of the farm survey and data from ICA, DNP and OPSA with necessary adjustment from the view point of spatial conditions in the project area. Unit production cost of the crops is determined based on the result of the farm survey and the standard estimation made by Caja Agraria. Reference was also made to the market prices of material and equipment required for the crop production at Cucuta.

In order to obtain proposed yield, investigation has been made on mechanization, application of fertilizer and labour input in each Plan.

Unit yield and unit production cost are summarized in Table 4-7. Further details are shown in Appendix Table 6-7-1.

Table 4—6 Cultivation Method of Introduced Crops

Crops	Sowing/Planting	Fertilization	Disease/Pest	Weeding	Cropping Period	Harvest
Pasture	o 5 year's renewal Braquiaria 6 kg/ha (I) {Tropical Kudzu 1 kg/ha (II,III) {Angleton 6 kg/ha (II,III)	o Liming the soil (1 t/ha) No fertilizer (I) With fertilizer (Compound one) (II,III)		o Chemical weeding o Manual weeding	o 3 months o 5 years' renewal	
Cacao	o Hybrid varieties o Seedling bed in pots (Feb.-Mar.) o Transplanting after 6 months o 1110 seedlings/ha o Shade trees (cooking banana, etc.)	o Every 6 months o Compound fertilizer (350 kg/ha)	o Moniliasis (manual control)	o Every 3 months o Manual weeding	o 4 years	o For 25 years since 5th year o Every week harvest
Cassava	o Local varieties (I) o CMC-76 (II,III) o Planting in Apr. or Oct. o 10,000 seedlings/ha	o Compound fertilizer 200 kg (I) 350 kg (II,III)	o Bacterial disease (Chemical control)	o Mechanical weeding (twice) o Manual weeding	o 8 months	o Manual harvest (Nov.=Mar.)
Irrigation Maize	o Hybrid-white H-211 o Sowing in Aug.-Oct. o 25 kg seeds/ha	o Compound fertilizer (330 kg/ha)	o Chemical control	o Mechanical weeding o Manual weeding	o 120 days	o Mechanical harvest (Jan.-Feb.)
Irrigation Sorghum	o Hybrid varieties o Pioneer 311 o 20 kg seeds/ha	o Compound fertilizer (330 kg/ha)	o Chemical control	o Mechanical weeding o Manual weeding	o 100 days	o Mechanical harvest (June-Aug.)

Table 4—7 Yields and Production Costs

M·D = Man-day; COL$; Proposed Yield (t/ha or kg/ha)

Crops	Zone	Present	Level I	Level II	Level III
Pasture (Proposed Yield)/ Production Cost	A B	o Pasture fence o Labor 2.0 M·D	o Pasture improvement cost x 1/5; Fence o Chemical weeding o Seed (Braquiaria) o Labor 3.5 M·D	o Pasture improvement cost x 1/5; Fence o Fertilizer (50 kg); Chemical weeding o Improved seed (Angleton x Tropical Kudzu) o Labor 3.5 M·D	
		(45 t)/	(80 t)/8,988	(90 t)/9,658	
	C D	ditto	ditto	ditto	ditto o Fertilizer (100 kg)
		(60 t)/	(100 t)/8,988	(115 t)/9,658	(140 t)/10,808
Beef Cattle (Proposed Yield)/ Production Cost)	A B	o Pasture Cost o Medicine, etc. o Labor 1.0 M·D	o Pasture Cost o Medicine, etc. o Labor 1.8 M·D	o Pasture Cost o Medicine, etc. (Plan I + 105) o Labor 1.8 M·D	
		(120 kg)/5,400	(270 kg)/11,583	(306 kg)/12,358	
	C D	ditto	ditto o Labor 2.2 M·D	o Pasture Cost o Medicine, etc. (I + 35) o Labor 2.2 M·D	o Pasture Cost (Plan o Medicine, etc. II + 1,205) o Labor 3.5 M·D
		(160 kg)/7,200	(330 kg)/12,148	(374 kg)/12,852	(595 kg)/15,662
Cacao (Proposed Yield)/ Production Cost	o Fertilizer (200 kg) o Chemicals, etc. o Labor 60 M·D		o Fertilizer (350 kg) o Chemicals, etc. o Labor 90 M·D o Including the depreciation → of the first 4 year's cost		
	(0.52 t)/26,000		(0.8 t)/48,600	(0.9 t)/48,600	
Cassava (Proposed Yield)/ Production Cost	o Self-supplied seedings o Labor 34 M·D		o Local Varieties o Fertilizer (200 kg) o Chemicals o Partly mechanizing (9.5 H) o Labor 47 M·D	o Improved varieties o Fertilizer (350 kg) o Chemicals o Partly mechanizing (9.5 H) o Labor 59 M·D (more weeding).	
	(6 t)/10,180		(10 t)/42,250	(15 t)/54,350	
Maize (Proposed Yield)/ Production Cost	o Seed (Local, 25 kg) o Labor 25.5 M·D)		o Seed (Local, 25 kg o Fertilizer (180 kg) o Chemicals o Partly mechanizing (13.5 H) o Labor 9 M·D	o Seed (Improved, 25 kg) ditto	[Zones C and D] o Seed (Improved, 25 kg) o Fertilizer (330 kg) o Chemicals o All mechanizing (12 H) o Labor 5 M·D)
	(2 t)/10,160		(2.5 t)/27,150	(3 t)/27,150	(4 t)/32,300

Notes: 1/ Other crops' costs and detailed items are listed in Appendix. Table 6-7-3.

2/ These costs exclude the credit interests and include family labor.

H: hours M·D: Total Men required

(4) Farm Gate Price

The farm gate prices of crops used in the production plan in the project are determined by analysis of existing farm gate prices, market prices at Cucuta and available statistics.

Since no significant price distortion is observed in these farm gate prices, these farm gate prices, these farm gate prices are also used as the economic prices of crops.

The farm gate price of the crops are summarized in Table 4-8.

Table 4–8 Farm Gate Price

(Unit: COL$/kg)

Crop	Beef Cattle	Cacao	Cassava	Maize	Sorghum	Water-melon	Papaya	Pine-apple	Cashew Nut
Price	90	125	15 (Present & Plan I) 10 (Plan II & Plan III)	17	15	10	10	10	4 (nut) 42 (apple)

Notes on Table 4-8.

1. Although the farm gate price of cacao was 120 ∿ 125 COL$/kg in July, 1983. It rose to 140 ∿ 150 COL$/kg in November, 1983. The value of 125 COL$/kg from July, 1983 is applied.

2. The farm gate price of cassava varies between 15 COL$/kg and 20 COL$/kg. In the Plan I, the farm gate price in determined as 15 COL$/kg, however, since in the Plans II and III, the products will be marketed outside the project area, the average farm gate price in The Department is applied (10 COL$/kg).

3. Farm gate price of maize varies between 15 COL$/kg and 20 COL$/kg. The average farm gate price in The Department during four years from 1981 to 1983 was 17 COL$/kg.

4. Although IDEMA's purchase price of sorghum is 17 COL$/kg, 15 COL$/kg is used since the production cost and the market price of sorghum is cheaper than maize by 10%.

(5) Gross and Net Production Value

The gross and net production value of each crop according to the proposed cropping area, unit yield, production cost and farm gate prices are tabulated in Table 4-9.

Development plan's composition of land use, gross and net production value by crops are shown in Table 4-10, 4-11 and 4-12.

By the introduction of cacao and cultivated crops agricultural

Table 4- 9 Gross and Net Production Value

(COL$/ha)

Zone	Product	Present Condition		Plan I		Plan II		Plan III	
		G.P.V.	N.P.V.	G.P.V.	N.P.V.	G.P.V.	N.P.V.	G.P.V.	N.P.V.
A	Cattle	10,800	5,400	24,300	12,717	27,540	15,182	27,540	15,182
	Cacao	0	0	0	0	112,500	63,900	112,500	63,900
	Cassava	90,000	79,800	150,000	107,750	150,000	95,650	150,000	95,650
	Average	11,321	5,890	27,523	15,154	47,980	27,428	47,980	27,428
B	Cattle	10,800	5,400	24,300	12,717	27,540	15,182	27,540	15,182
	Cacao	65,000	39,000	100,000	51,400	112,500	63,900	112,500	63,900
	Cassava	90,000	79,800	150,000	107,750	150,000	95,650	150,000	95,650
	Maize	34,000	23,800	42,500	15,300	51,000	23,800	51,000	23,800
	Average	13,096	7,070	37,097	20,108	51,805	29,661	51,805	29,661
C	Cattle	14,400	7,200	29,700	17,552	33,660	20,808	53,550	37,888
	Cacao	65,000	39,000	100,000	51,400	112,500	63,900	112,500	63,900
	Cassava	90,000	79,800	150,000	107,750	150,000	95,650	0	0
	Maize, sorghum	34,000	23,800	42,500	15,300	51,000	23,800	128,000	65,000
	Average	18,225	9,690	44,744	25,941	63,935	37,028	105,668	58,079
D	Cattle	14,400	7,200	29,700	17,552	33,660	20,808	53,550	37,888
	Cassava	0	0	150,000	107,750	150,000	95,650	0	0
	Maize, sorghum	34,000	23,800	42,500	15,300	51,000	23,800	128,000	65,000
	Watermelon, papaya, cashewnuts	0	0	0	0	0	0	162,500	74,945
	Average	16,578	7,700	34,590	20,198	42,628	26,032	109,047	57,771
Total	Cattle	12,665	6,520	27,024	15,156	30,678	18,067	34,429	21,400
	Cacao	65,000	39,000	100,000	51,400	112,500	63,900	112,500	63,900
	Cassava	90,000	79,800	150,000	107,750	150,000	95,650	150,000	95,650
	Maize, sorghum	34,000	23,800	42,500	15,300	51,000	23,800	128,000	65,000
	Watermelon, payaya	0	0	0	0	0	0	162,500	74,945
	Average	15,278	7,960	38,044	21,490	53,453	31,417	78,943	43,622

Notes: G.P.V. = Gross Production Value
N.P.V. = Net Production Value

G.P.V. and N.P.V. of cashewnuts are included in average.
Sorghum is crop for Plan III.

operation is divertificated and enables the increase in land productivity.

Comparing the gross and net production value by Zone, Table 4-13 shows that the unit production value of Zone C is the highest in proposed development plans. On the other hand, that of Zone A is the lowest.

This is reflected by the extension of cropping area of cacao and cassava and the increase of production value by irrigation in Plan III.

Comparing existing unit production value with the average unit net production value in each Plan are as follow.

Plan	Increased average unit net production value as compared with existing one
I	2.7 times
II	3.9 times
III	5.5 times

Table 4–10 Sharing of Cropping Area

(%)

	Pasture	Cassava	Maize & Sorghum	Cacao	Others	Total
Present Condition	95.0	0.5	0.4	3.4	0.7	100
Plan I	86.4	3.0	0.4	9.5	0.7	100
Plan II	74.5	6.1	0.4	18.4	0.7	100
Plan III	50.6	2.7	25.9	18.8	2.0	100

Table 4–11 Gross Production Value Components

(%)

	Cattle	Cassava	Maize & Sorghum	Cacao	Others	Total
Present Condition	78.7	2.9	0.9	14.7	2.8	100
Plan I	61.4	12.0	0.4	24.9	1.3	100
Plan II	42.8	17.0	0.4	38.7	1.1	100
Plan III	22.1	5.2	41.9	26.8	4.0	100

Table 4–12 Proposed Net Production Value Components

(%)

	Cattle	Cassava	Maize & Sorghum	Cacao	Others	Total
Present condition	77.8	5.2	1.2	16.9	1.4	100
Plan I	61.0	15.2	0.3	22.7	0.8	100
Plan II	42.8	18.5	0.3	37.4	1.0	100
Plan III	24.6	6.0	38.5	27.6	3.3	100

Table 4–13 Gross and Net Production Value by Zone

Zone	Item	Present condition	Plan I	Plan II	Plan III
A	Area (ha)	1,520	1,560	1,560	1,560
	Gross production value(10^3 col$)	17,208	42,936	74,849	74,849
	Production cost (10^3 col$)	8,256	19,296	32,061	32,061
	Net production value(10^3 col$)	8,952	23,640	42,788	42,788
	N.P.V/ha	5,890	15,150	27,430	27,430
B	Area (ha)	3,260	3,540	3,540	3,540
	Gross production value(10^3 col$)	42,694	131,325	183,389	183,389
	Production cost (10^3 col$)	19,649	60,144	78,388	78,388
	Net production value(10^3 col$)	23,045	71,181	105,001	105,001
	N.P.V/ha	7,070	20,110	29,660	29,660
C	Area (ha)	3,740	3,800	3,800	3,600
	Gross production value(10^3 col$)	68,160	170,029	235,353	380,404
	Production cost (10^3 col$)	31,905	71,454	94,647	171,319
	Net production value(10^3 col$)	36,255	98,575	140,706	209,085
	N.P.V/ha	9,690	25,940	37,030	58,080
D	Area (ha)	1,620	1,650	1,650	1,600
	Gross production value(10^3 col$)	26,856	57,074	70,337	174,475
	Production cost (10^3 col$)	14,389	23,747	27,384	82,042
	Net production value(10^3 col$)	12,467	33,327	42,953	92,433
	N.P.V/ha	7,700	20,200	26,030	57,770
Total	Area (ha)	10,140	10,550	10,550	10,300
	Gross production value(10^3 col$)	154,918	401,364	563,928	813,117
	Production cost (10^3 col$)	74,199	174,641	232,480	363,810
	Net production value(10^3 col$)	80,719	226,723	331,448	449,307
	N.P.V/ha	7,960	21,490	31,420	43,620

(6) Study of Marketing

For the determination of proper production volume of each crop, attention was paid to the capacity of market. Study on supply and demand balance is shown in Appendix 6.5.

For the project formulation the nearby market in Venezuela is not taken into account for marketing projection of the products. Therefore, a large market place will be available for the project when the Venezuelan economy recovers from present recession. This is one of the positive aspects of the project.

1) Beef Cattle

The projected production of beef cattle is

Plan I	:	18,526 head/year
Plan II	:	15,760 head/year
Plan III	:	11,724 head/year

This is 5.5 to 3.5 times increase of production of the present annual production of the project area. Since a large volume of beef cattle is collected to Cucuta from outside of the district the products of the project area will easily replace these beef cattle being shipped to Cucuta.

Beef cattle will be collected to the cattle market at Cucuta, however, cattle for fattening is recommended to be purchased at the same cattle market or through farmer's cooperative from the outside of the district.

2) Cacao

Production of cacao is promoted by the Government of The Republic for domestic and international market.

Marketing system of cacao is established and controled by FEDE-CACAO and brokers at present. Therefore, the products will be marketed in a same manner at present in all the Plans and the products in the Plan II and III will be sufficient to operate one processing factory at nearby place of the project area.

3) Cashew Nut

The same marketing method above mentioned will continue.

4) Cassava

Projected production is:

Plan I	:	3,200 t/year
Plan II	:	9,600 t/year
Plan III	:	4,200 t/year

The product of the Plan I will be consumed around the project area, however, product in the Plan II and III will be marketed at Cucuta.

5) Maize and Sorghum

These are import substitute crops. In the Plan III approximately 10,000 t/year of each crop is planned to produce, which will contribute increase self sufficiency of these crops in The Republic.

The farm gate price of maize and sorghum are 17 COL$/kg and 15 COL$/kg, respectively. The circulation of these crops will be made by IDEMA.

6) Watermelon, Papaya and Pineapple

Projected production of these crops are:

Watermelon	:	1,500 t/year
Papaya	:	875 t/year
Pineapple	:	875 t/year

Since transport for long distance would damage the quality of products, the production is planned for the market demand in Cucuta.

4.3.3 Farm's Income Plan

(1) Farming Condition

Proposed farm's income and the detailed farming condition of proposed standard farm household are stated in Appendix 6.8.

When the project is implemented, extension of cropping area and improvement of cultivation techniques will require more labour than at present as shown in Appendix 6.8.

At present, the non-agricultural population in the project area is estimated to be 4,800. Although most of these people are assumed to be engaging in their own businesses, a latest unemployment rate is estimated to be more than 16% (SENALDE). Therefore, the future labour demand could be met by these latest unemployed persons in the project area and the adjacent area.

(2) Agricultural Income

Agricultural income is estimated based on the planned gross production value and agricultural expenses. The estimate of agricultural expenses is shown below:

Agricultural expenses = Production cost + water charge + interest on credits - family labour

The estimated agricultural income in each Plan is summarized in Table 4-14.

The detailed statements are shown in Appendix 6.8.

Table 4—14 Agricultural Income

(Unit: 10^3 COL$)

Zone \ Plan	Present	I	II	III
A	257	503	1,056	1,056
B	259	606	995	995
C	305	748	1,030	1,417
D	312	693	991	1,863
Average	286	666	1,017	1,300

Agricultural income of the Plan I, II and III are estimated to be 2.3, 3.6 and 4.5 times of present agricultural income, respectively.

(3) Farm's Income

Farm's income is estimated as the sum of agricultural income and non-agricultural income. Since the project requires more labour than the present farming pattern, non-agricultural income will be reduced in general.

Estimated farm's income by the project is summarized in Table 4-15.

Table 4—15 Farm's Income

(Unit: 10^3 COL$/year)

Zone \ Plan	Present	I	II	III
A	319	549	1,056	1,056
B	316	606	995	995
C	357	748	1,030	1,417
D	365	727	1,025	1,863
Average	340	676	1,021	1,300

At present the minimum salary in The Republic is approximately COL$108,000/year. Assuming the number of family labours are 3 persons/farm, the farm's income level of the project is estimated below:

Plan	Farm's Income with respect to Present Minimum Salary
I	2.2 times
II	3.3 times
III	4.2 times

4.4 Drainage Plan

4.4.1 Introduction

The prevailing poor drainage in the project area is mainly caused by:

1. Rainwater,
2. Flooding of the Pamplonita River and
3. Flooding of the Zulia River.

Solutions to the above problems are:

1. For rainwater

   To accelerate drainage, provision of drainage canals is planned.

2. For flooding of the Pamplonita River

   Flooded water is to be collected in drainage canals with an alignment to be determined based on analysis of land forms and flood overflow, and then drained outside of the project area.

3. For flooding of the Zulia River

   Considering the influence on the land in the opposite side of the river bank, no embankment is planned. Drainage canals are to be provided to drain flood water.

4.4.2 Drainage System

Existing natural streams and drainage canals are to be fully used for the location of the main drainage canal. Taking advantage of topographical conditions, the water on the right bank of the Zulia River is to be drained to the Zulia River. The drainage on the right bank of the Pamplonita River is to be led to the Grita and the Guaramito River.

The drainage on the left bank of the Pamplonita River is led to the Floresta River in the north and to the Pamplonita River in the south.

The density of lateral drainage canals is planned as every 500 m in Zones A and B in the same density of existing drainage canal at El Dave since these Zones are subjected to frequent floods.

In Zone C and D, the density of drainage canals is to be every 1 km since the effect of flooding in these Zones is smaller than the other two Zones and the gradient of ground surface is favourable for surface drainage.

For the planning of drainage canals, effort is made to attain consistency with location of irrigation canals.

Drainage canals are classified into 5 types:

Main canal (M.D)	Connected with lateral canals and drain to the river directly from relatively large area.
Secondary canal (S.D)	Drains directly to the river or outside of the project area from relatively small area without branch canals.
Lateral canals (L.D)	Branch canals of the main canals.
Interception Canal (I.D)	The canal located along the southern boundary of the project area to collect water from the south.
Tertiary Canal (T.D)	Drains within farms connecting to S.D and L.D.

In Zone B, the cross-section of drainage canal is to be modified to control flood water of the Pamplonita River in the magnitude of 5 year return period. Drainage network is shown in Fig. 4-3.

4.4.3 Design Drainage Discharge

(1) Design Rainfall

The maximum daily rainfall for the design is obtained by the statistical analysis of rainfall data in and around the project area.

Design Rainfall

144 mm/day at 5 year return period
116 mm/day at 2 year return period

The rainfall intensity within the concentration time is obtained using the formula below:

$$r_t = \frac{R_{24}}{24} \left(\frac{24}{t}\right)^k$$

where r_t = rainfall intensity within the concentration time (mm/hr)
R_{24} = 24 hours rainfall (mm)
t = time of concentration (hr)
k = constant (the value 1/2 is applied)

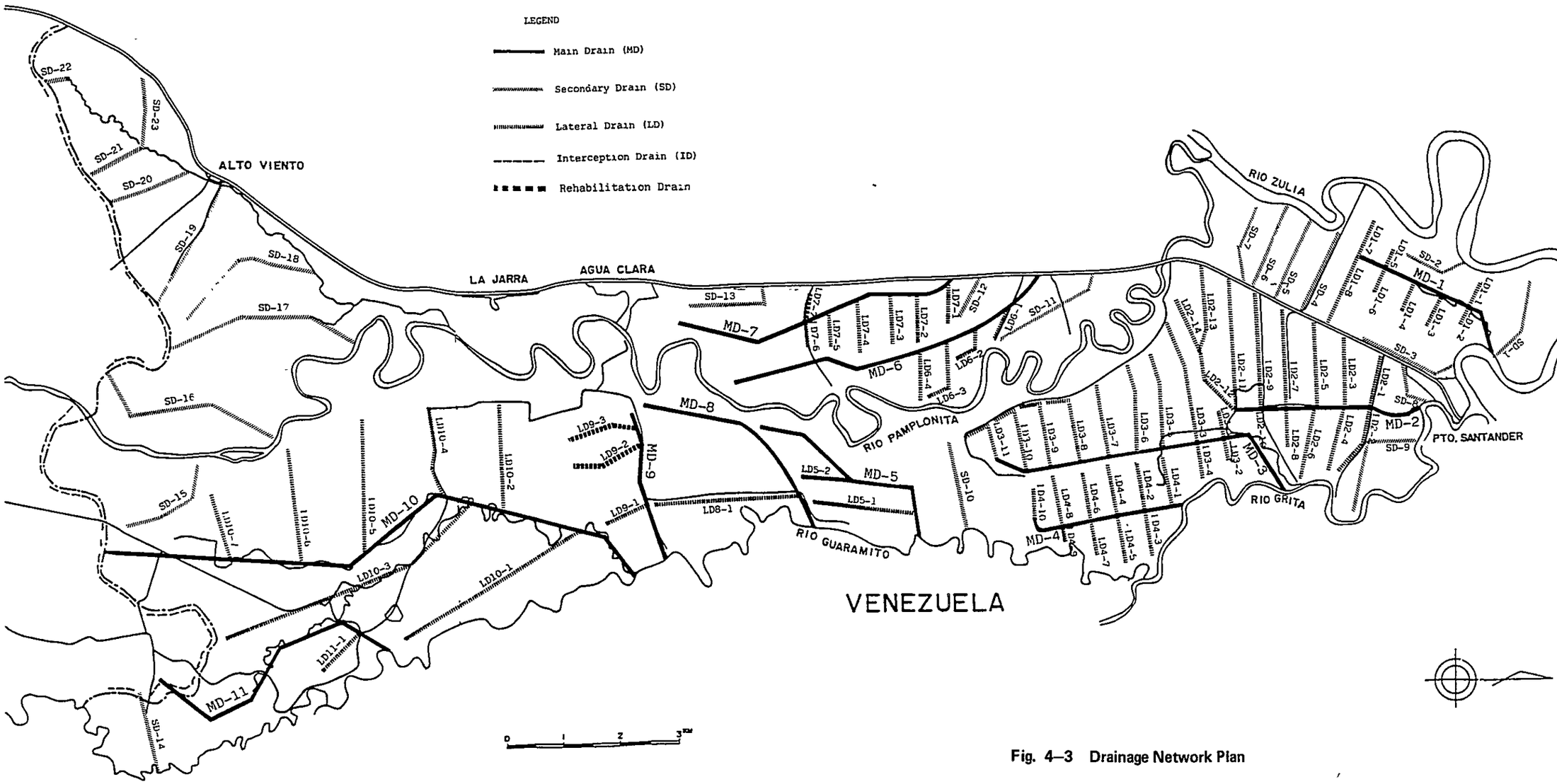


Fig. 4–3 Drainage Network Plan

(2) Time of Concentration

The time of concentration is obtained by the formula of California Bureau of Road;

$$t = \left(\frac{0.871 \times L^3}{h}\right)^{0.35}$$

Where L : length of longest water course from point of interest to watershed devide. (km)

h : elevation difference between headwater and site (m)

t : time of Concentration (hr)

(3) Design Drainage Discharge

The peak drainage discharge of the main canal and the secondary canal is obtained by the rational formula:

$$Qp = \frac{1}{360} f \times r \times A$$

where Qp : Peak drainage discharge (m^3/s)
f : run-off coefficient = 0.4
r : Rainfall intensity (mm)
A : Drainage area (ha)

$q = Qp/A$: unit draiange discharge ($m^3/s/ha$)

The peak drainage discharge of the lateral canals and the interception canal is estimated according to the unit drainage discharge of each connecting main canal as below:

$$Qp = q \times A$$

(4) Drainage of Floods

The drainage conditions after river floods will be much improved by provision of drainage canals. In Zone A, although the flooded area will not be greatly reduced, flood water will be drained immediately when the river water level goes down.

In Zone B, the flood water is to be drained through drainage canals to the Guaramito, the Grita and the Floresta River. Oxbow lakes along the river courses will function as regulating ponds.

In Zone C, the flood water will be stored in the oxbow lakes and depressions along the river course.

In Zone D, floods occur only over a limited area of the river course even at present, therefore, no significant problem occurs.

There is more than one day time lag between the rainfall peak in the project area and the peak of river flood (Fig. 3-18).

Therefore, drainage canals also function to drain flooded water in the project area after drainage of rainwater.

Table 4—16 Drainage Improvement

Zone	Source of flood	Present condition			Drainage plan	
		2-year frequency	5-year frequency	10-year frequency	I	II, III
A 1,930ha	Rainfall	Almost all area is poor drainage area. Inundation: Large scale			Difficult to cultivate for field crops.	Possible to cultivate for field crops.
	River	Flooding mainly by Zulia River	Other flooding by Pamplonita, Grita and Gueramito Rivers		Flooding area decreases.	
		F.A.=690ha	F.A.=1,650ha	F.A.=1,850ha	F.A.=520ha [170ha]	F.A.=1,310ha [340ha]
		After flooding, inundation continues.			After flooding, no inundation remains.	
B 4,750ha	Rainfall	Considerable area is poor drainage area. Inundation: Large to middle scale			Partly difficult to cultivate field crops	Possible to cultivate field crops
	River	Flooding mainly by Pamplonita River Partly by Grita-Guaramito River			Flooding water from Pamplonita River is controlled to flow into drainage canals. As for low-land along Pamplonita River, control is not proposed.	
		F.A.=230ha	F.A.=1,680ha	F.A.=2,980ha	F.A.=100ha [130ha]	F.A.=710ha [970ha]
		After flooding, inundation continues in considerable area				
C 4,860ha	Rainfall	Poor drainage area is predominant. Some area is well-drained. Inundation: Middle scale			Possible to cultivate field crops	Possible to cultivate field crops
	River	Flooding area is mainly low-land area along Pamplonita River.			Flooding is limited to low-land along Pamplonita River.	
		F.A.=130ha	F.A.=880ha	F.A.=1,590ha	F.A.=80ha [50]	F.A.=450ha [430]
D 1,960ha	Rainfall	Well-drained. Inundation: Small scale			Available for arable land	Available for arable land
	River	No problem	Limited to low-land along Pamplonita River		Limited to low-land along Pamplonita River.	
		F.A.=0	F.A.=90ha	F.A.=140ha	F.A.=0	F.A.=90

Note: F.A.: Acreage of flooding area (ha) Inundation: Comparative scale of 4 zones [ ]: Acreage of improved area
Arable land: Excluding cattle breeding

Area where drainage problem is caused by 2-year storm or flood is considered to be difficult to cultivate field crops.
Topographically suitable area is considered to be possible to cultivate field crops.

Comparison of drainage conditions between the present state and the project improved conditions are summarized in Tables 4-16, and 4-17 and illustrated in Fig. 4-4.

Table 4-17 Estimate of Flooding Area

(Unit: ha)

Duration	Return Period	
	2 years	5 years
1 day	700 [350]	2,560 [1,740]
3 days	-	270 [1,200]
5 days	-	-
7 days	-	-

Note: [ ]: Reduction of flooding area by the project implementation.

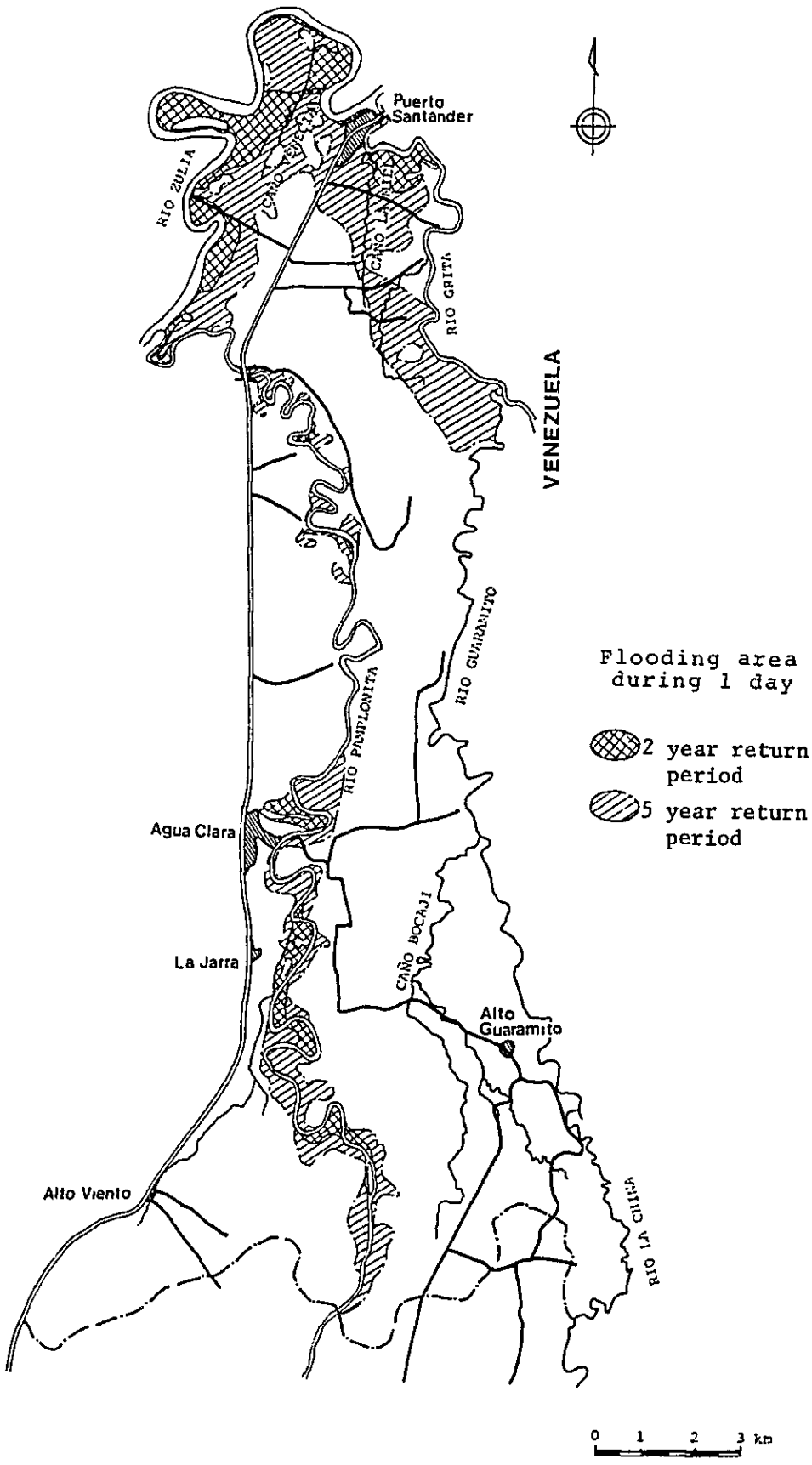


Fig. 4–4 Flooding Area with Drainage Plan

4.5 Irrigation Plan

4.5.1 Introduction

Irrigation is planned for 4,300 ha in Zone C and D in the Plan III (Section 4.2).

Design drought is 5 year return period. HIMAT plans to divert the water source of 7.5 m^3/s for the project from the canal Zulia.

The border irrigation with gravity flow is applied considering the prevailing ground surface slope of 1/700, the value of 6.4 mm/hr as basic intake rate, type of crops and existing technical level of farming. Design water requirement is determined according to the F.A.O. guideline (Crop water requirement, irregation and drainage paper, No.24).

4.5.2 Irrigation System

Layout of the irrigation canal system is illustrated in Fig. 4-5. Analysis of alternatives were made on the driving canal from the diversion of the canal Zulia to the left bank of the Floresta River and the river crossing method of the main irrigation canal at the Pamplonita River.

For this purpose, boring tests were made at both sites.

Driving Canal

Alternative	Length		Cost
Open channel	3,800 m	COL$	38,875,000
Tunnel	900m + 450m of open channel	COL$	137,119,000

Estimated construction cost of open channel is much smaller than the cost of tunnelling. In addition, ease of construction and access of the open channel is more suitable than tunnel. Operation and maintenance of the open channel is also advantageous. Therefore, the driving canal is determined to be open channel type.

River Crossing of the Main Canal

Alternative	Lenth		Cost
Siphon	250m	COL$	21,768,000
Aqueduct	250m	COL$	72,409,000

Excution of siphon construction is much easier than that of aqueduct, however, operation and maintenance of aqueduct is much easier than that of siphon. Considering the construction cost and bridge construction plan at Agua Clara, the river crossing is determined to be siphon.

The main irrigation canal is to be placed at the southern end of the project area, approximately along the contour line of 100 m. A.S.L.

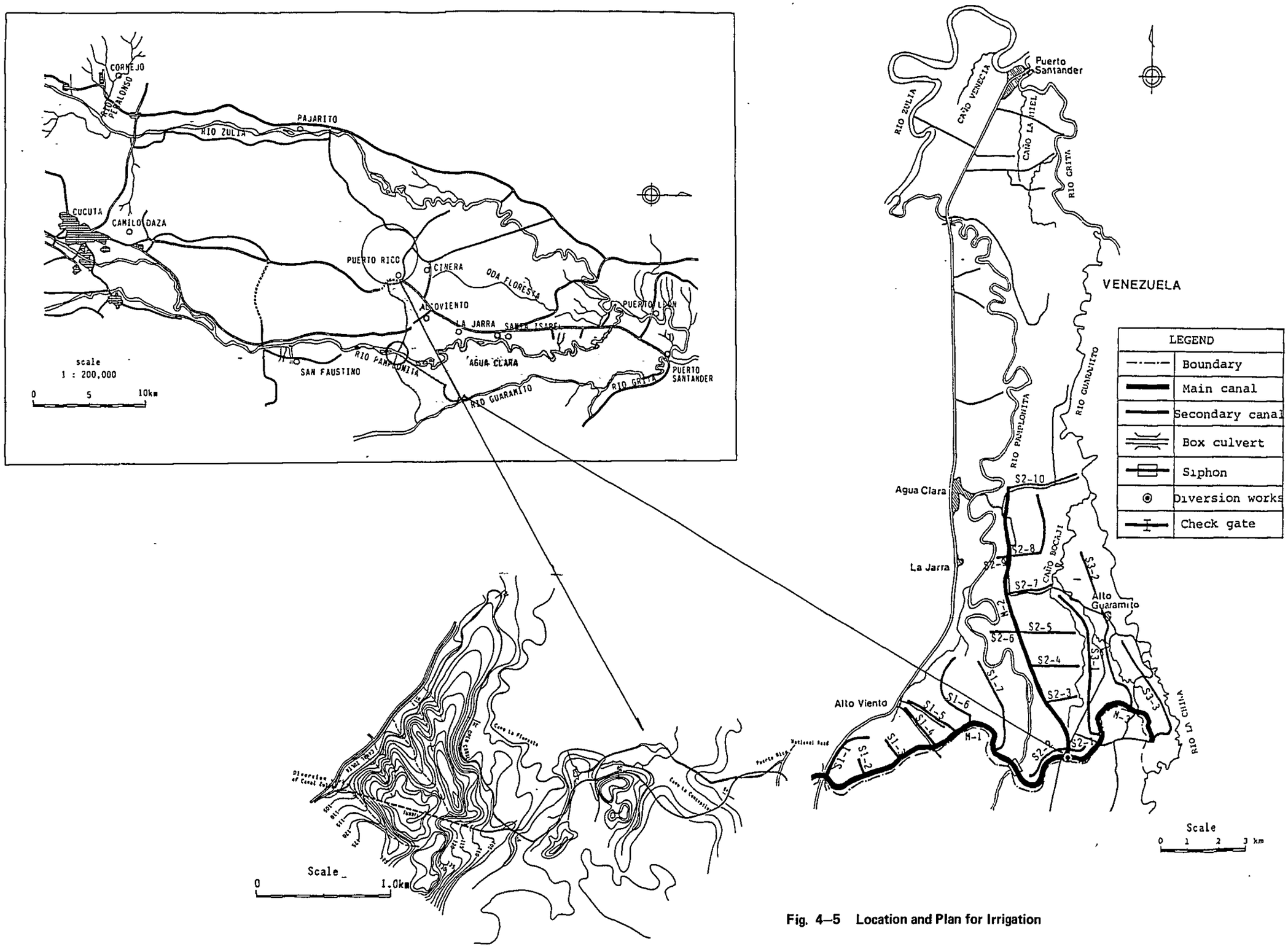


Fig. 4–5 Location and Plan for Irrigation

with a slope of 1 : 2,000. After crossing the Pamplonita River, the main canal is to be located along the main farm road.

Secondary canals are to be constructed along the existing farm roads where road distribute.

Tertiary canals are to be located every 200m considering the land slope and the length of border.

4.5.3 Determination of Water Requirement

(1) Design Water Requirement

In order to determine the depth of evapotranspiration, meteorological data at Santa Isabel is analysed for 10 years from 1971 to 1980 by the modified penman method. Taking evapotranspiration, effective rainfall and irrigation efficiency into consideration, the peak water requirement at drought in 5 year return period is estimated to be 11.5 mm/day (1.33 ℓ/s/ha) (Fig. 4-6). Since major crops by irrigation are maize and sorghum, the crop coefficient (Kc) is obtained as shown in Fig. 4-7. Since the rainfall in the project area covers a very limited area and the basic intake rate of soils is 6.4 mm/hr, daily rainfall less than 5 mm/day is eliminated from calculation of effective rainfall. The daily rainfall more than 50 mm/day is also discounted because the duration of rainfall sometimes extends almost 8 to 9 hours.

The irrigation efficiency of the project is determined to be 40% referring to the same efficiency applied in Zulia Project. The basis of irrigation efficiency estimation is shown below:

Field application efficiency	60%
Field canal efficiency	80%
Conveyance efficiency	85%

(2) Irrigation Interval

Irrigation interval is determined to be 14 days. Assuming total readily available moisture (TRAM) is 60% of available moisture (AM), TRAM is divided by the daily crop evapotranspiration (ET crop).

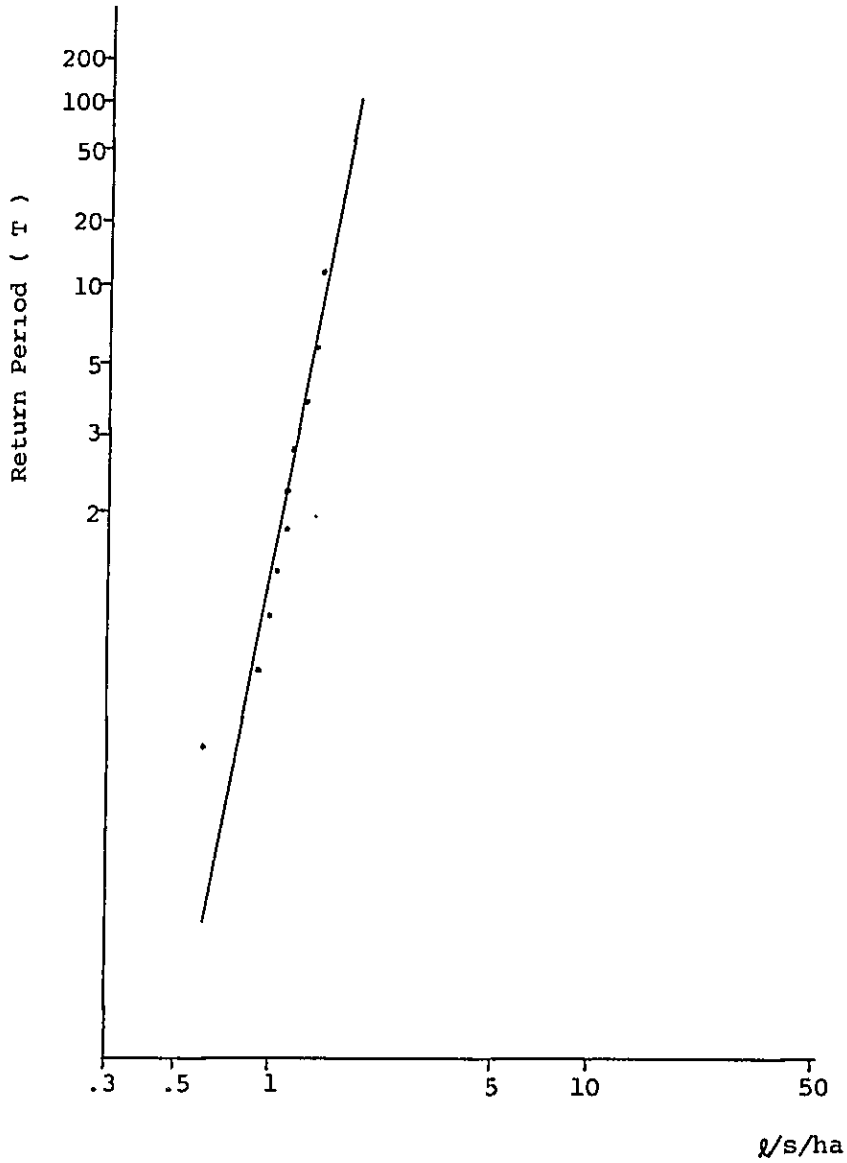
(3) Irrigation Method

Irrigation method is determined to be border irrigation. Duration of irrigation is planned with continuous supply for 24 hrs. The standard size of border is designed as 18 m wide and 200 m long as shown in Fig. 4-8.

(4) Water Requirement of Irrigation

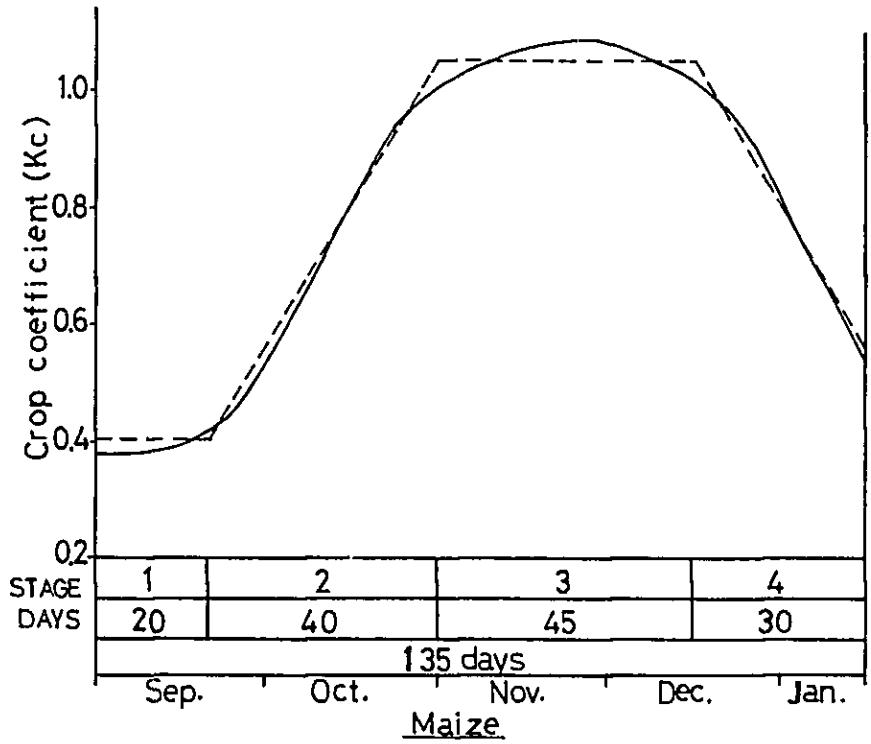
Based on the above calculation, total water requirement of the irrigation facility of the project is determined as 6.03 m^3/s.

The irrigation canal system is shown in Fig. 4-9 and standard cross-section of canals is shown in Fig. 4-10.



Year	Max. Water Requirement (ℓ/s/ha)	Year	Max. Water Requirement (ℓ/s/ha)	Return Period	Max. Water Requirement (ℓ/s/ha)
1971	1.000	1972	1.430	2	1.08
1972	1.430	1977	1.380	5	1.33
1973	1.280	1973	1.280	10	1.47
1974	1.120	1975	1.180	20	1.61
1975	1.180	1974	1.120	30	1.68
1976	1.120	1976	1.120	40	1.73
1977	1.380	1978	1.050	50	1.77
1978	1.050	1971	1.000	80	1.86
1979	0.620	1980	0.920	100	1.89
1980	0.920	1979	0.620	200	2.01
				500	2.16
				1,000	2.26

Fig. 4–6 Peak Gross Irrigation Requirement



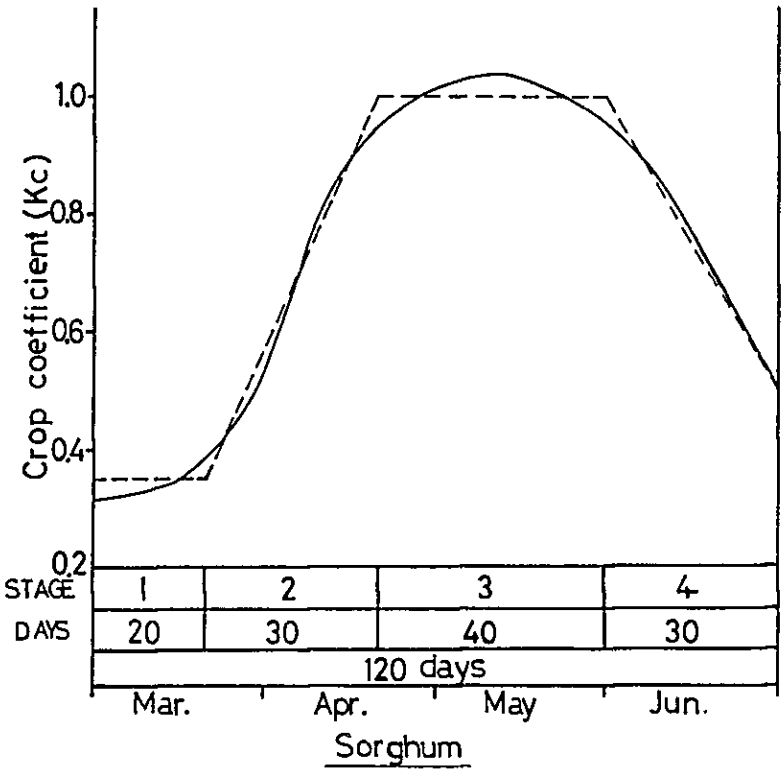


Fig. 4–7 Crop Coefficient Curve

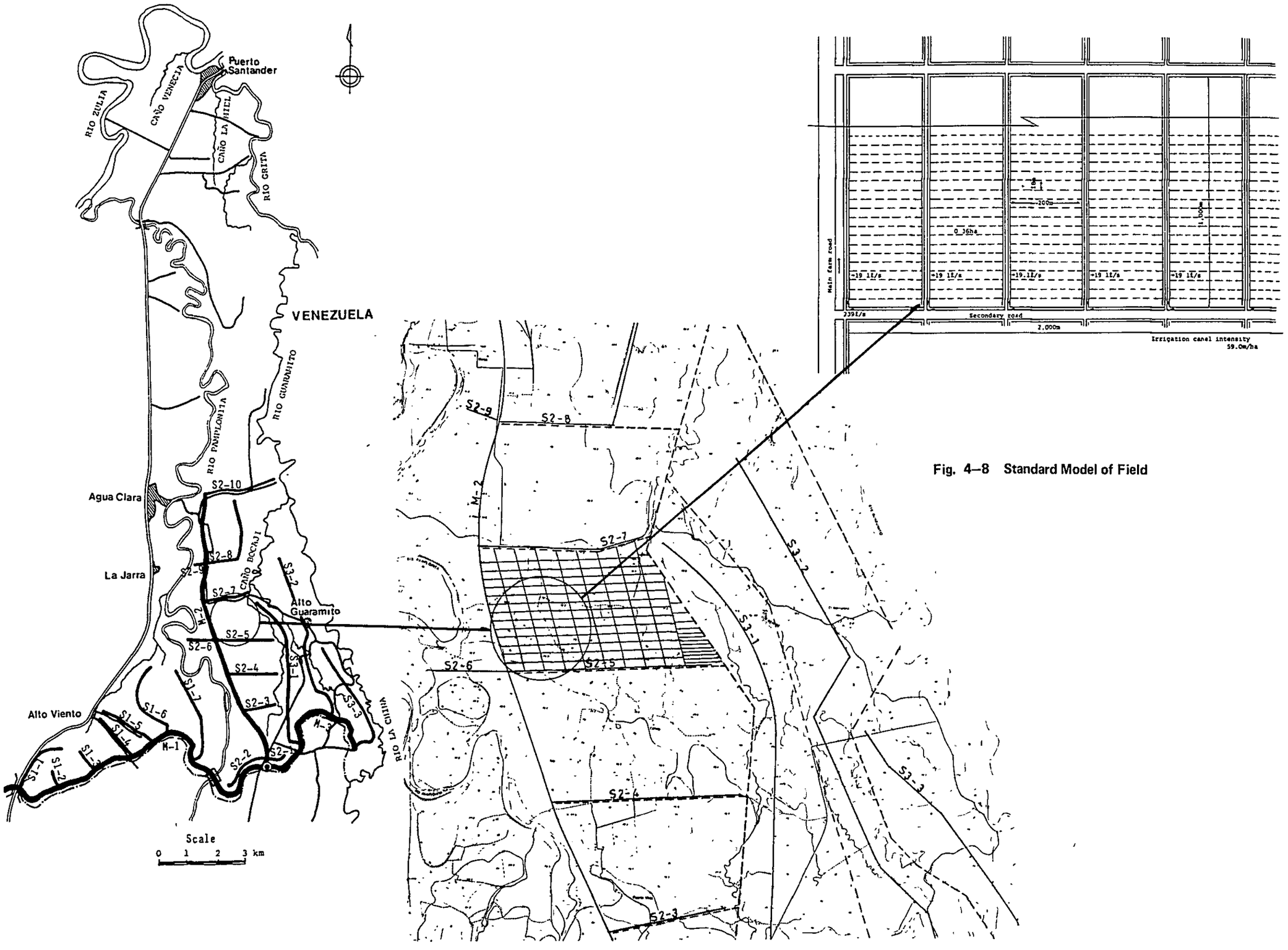


Fig. 4–8 Standard Model of Field

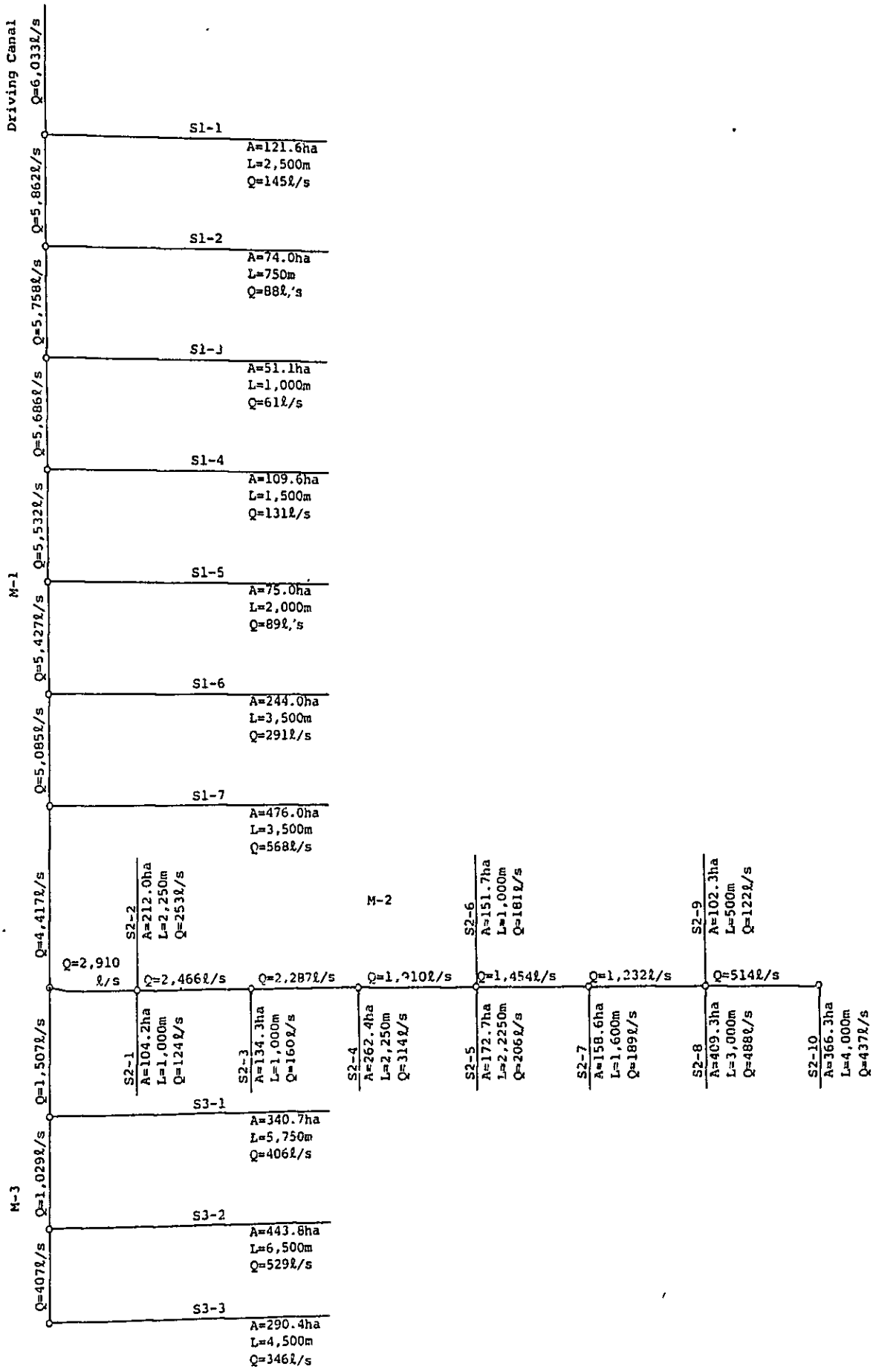
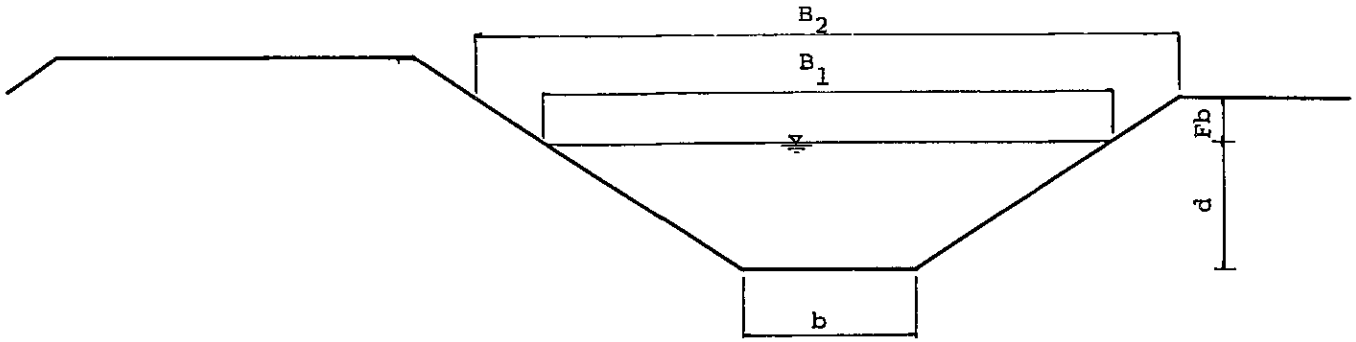


Fig. 4–9 Irrigation Network



Coefficient of roughness: 0.03 (unlined canal)

Canal Type			I	II	III	IV	V	VI	Remarks
Slope Gradient			1:1.5					1:1	
Slope of Canal Bed			1/2,000	1/1,000					
Discharge			6.0 m^3	3.0 m^3	1.5 m^3	0.6 m^3	0.3 m^3	0.02 m^3	
Canal bed width	b	(m)	2.00	2.00	1.00	0.50	0.50	0.30	
Water depth	d	(m)	1.76	1.05	0.93	0.70	0.50	0.18	
Width of water surface	B_1	(m)	7.28	5.15	3.79	2.60	2.00	0.66	
Flow area	A	(m)	8.1664	3.754	2.2274	1.085	0.625	0.0864	
Wetted perimeter	P	(m)	8.3458	5.786	4.353	3.024	2.303	0.809	
Hydraulic mean depth	R		0.9785	0.6488	0.5117	0.3588	0.2714	0.1068	
R2/3			0.9856	0.7494	0.6397	0.505	0.4192	0.2251	
Velocity	V	(m/s)	0.735	0.790	0.674	0.532	0.442	0.237	
Discharge	Q	(m^3s)	6.00	2.96	1.50	0.58	0.28	0.02	
Freeboard	Fb	(m)	0.30	0.30	0.30	0.30	0.30	0.30	
Width of canal	B_2	(m)	8.18	6.05	4.69	3.50	2.90	1.26	

Fig. 4—10 Study of Canal Section

4.6 Road Network Plan

4.6.1 Introduction

Since present road conditions are very poor in the project area, improvement of road network is one of the most important factors for the activation of the local economy.

For this reason, basic considerations of road network improvement are summarized below.

1. Improve road network in the area on the right bank of the Pamplonita River,

2. Inspection cum farm roads are to be the basic road network,

3. One bridge crossing over the Pamplonita River is necessary considering transportation of material, equipment for agriculture and agricultural products and

4. Easy access to Agua Clara is of another importance of the project for efficient agricultural extension services.

4.6.2 Road Network Plan

(1) Main Road

A main road is to be located along the main irrigation canal running level along the highest ground of the right bank of the Pamplonita River.

The southern end of the main road is to connect the existing road for San Faustino and extend to the north to the existing national road just beyond the bridge crossing over the Pamplonita River. Total length of main road is to be approximately 20 km (Fig. 4-11).

(2) Secondary Road

A secondary road is planned along the secondary lateral drainage and irrigation canals. Farm roads are to be placed along tertiary drainage and irrigation canals. These roads are to be inspection cum farm roads.

(3) Bridge

For the determination of bridge construction crossing over the Pamplonita River, analysis is made at two sites: the site at Agua Clara and the other site where an irrigation canal crosses the Pamplonita River. The site where the main irrigation canal crosses the Pamplonita River has advantages for transport of agricultural products from the southern part of the area on the right bank of the Pamplonita River to Cucuta. When the project is implemented, the volume of daily necessary goods and agricultural material and also agricultural products will increase considerably. Agua Clara will function as the terminal of these commodity and products and also play an important role as the center of the agricultural extension services.

Therefore, Agua Clara is determined as the construction site of the bridge for easy access from each part of the project area.

The road intensity of the project area is summarized as shown in Table 4-18 and the regional road network is shown in Fig. 4-11. The inter-relationship of secondary roads, farm roads and drainage canals is illustrated in Fig. 4-12.

Table 4–18 Density of Road

Class of Farm Road	Plan I	Plan II	Plan III	Remarks
Main farm road	3.6	3.6	3.6	Including national road
Secondary farm road	14.7	14.7	18.5	
Total	18.3	18.3	22.1	
Tertiary farm road	20.4	20.4	31.0	

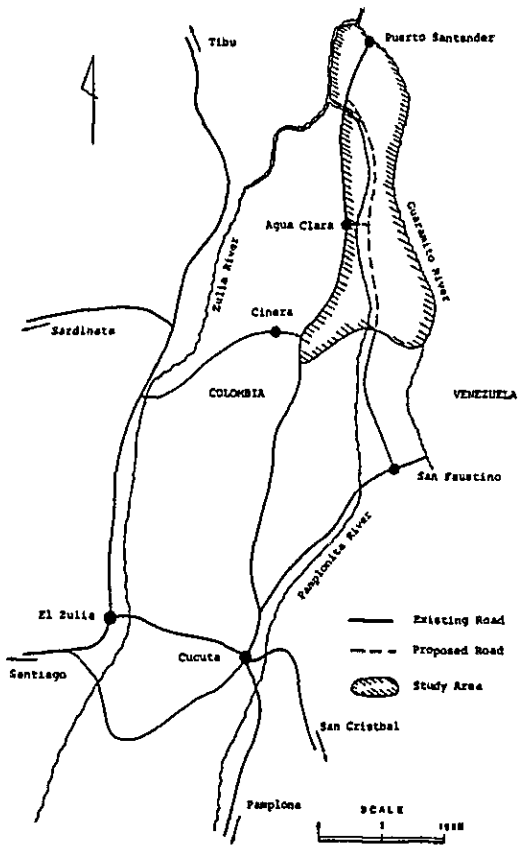
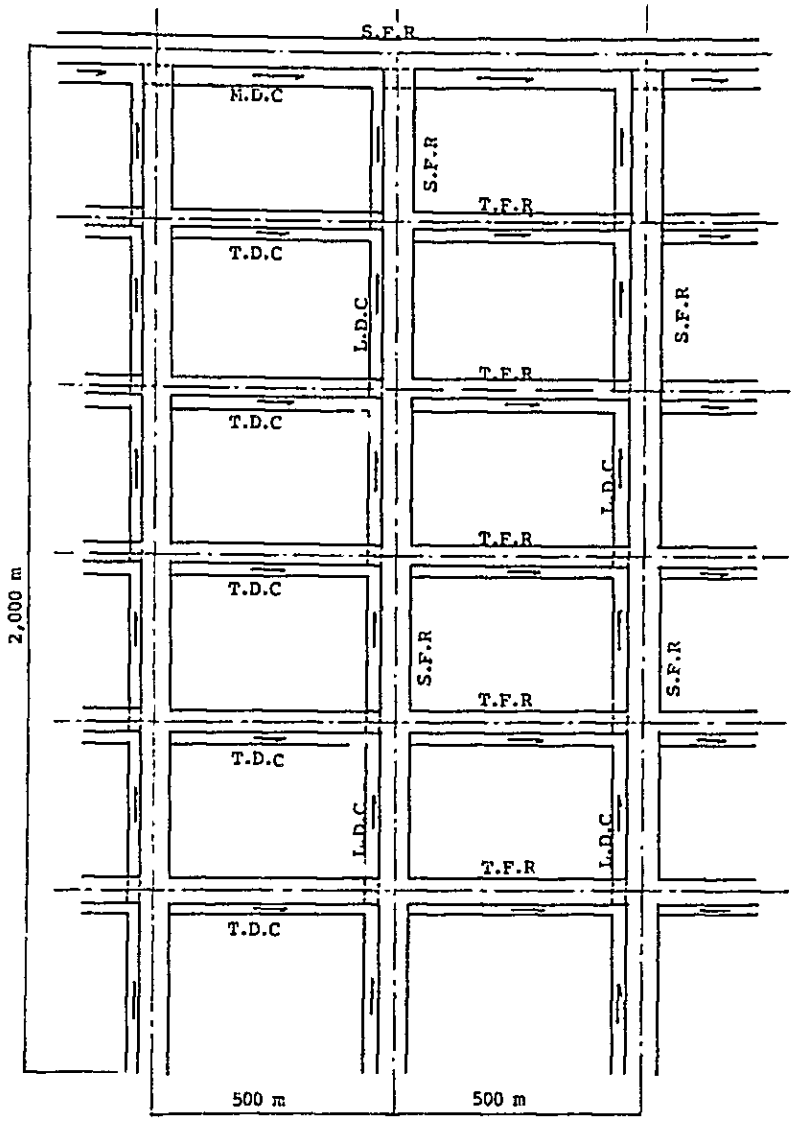


Fig. 4–11 Location of Main Farm Road



M.D.C : Main Drainage Canal
L.D.C :Lateral Drainage Canal
T.D.C : Tertiary Drainage Canal
S.F.R : Secondary Farm Road
T.F.R : Terciary Farm Road

Fig. 4–12 Farm Road Network

4.7 Facility Plan

Facilities required in the project are drainage canals and farm roads, however, in the Plan III, irrigation canals are proposed. In theis section, all the proposed facilities are summarized.

(1) Drainage Canal

Drainage canals are classified into 5 types (Section 4.4) and further classified into 6 groups according to design capacity (I-VI). In addition, a second design capacity is proposed for drainage of river floods. All the drainage canals are designed as earth canals. These are summarized in Table 4-19.

(2) Irrigation Canal

Four types of irrigation canals are proposed (Section 4.5) with siphons and culverts proposed to cross rivers. Proposed irrigation facilities are summarized in Table 4-20.

(3) Farm Roads

Three types of farm road cum inspection road are proposed (Section 4.6). The length and width of each type are summarized in Table 4-21.

Table 4-19 Drainage Facilities

Facilities		Plan I	Plan II	Plan III	Remarks
Main Canal	Canal	L: 50,550 m Q: 34 to 4.9 m^3/s I: 1/310 to 1/1,310 Earth Canal	L. 48,550 m Q: 44 to 6.1 m^3/s I: 1/310 to 1/1,310 Earth Canal	ditto to II	
	Drop I	7	7	7	
	Box Culvert	-	-	2	
Secondary Canal	Canal	L: 38,950 m Q: 23 to 0.39 m^3/s I: 1/160 to 1/1,130 Earth Canal	L: 38,950 m Q: 29 to 0.48 m^3/s I: 1/160 to 1/1,130 Earth Canal	L: 38,950 m Q. 29 to 0.48 m^3/s I. Approx. 1/700 Earth Canal	
	Drop I	40	49	49	
	Box Culvert	-	-	7	
Lateral Canal	Canal	L: 84,150 m Q: 9.5 to 0.40 m^3/s I: Approx. 1/700 Earth Canal	L. 84,150 m Q. 12 to 0.52 m^3/s I: Approx. 1/700 Earth Canal	L: 84,150 m Q: 12 to 0.52 m^3/s I: Approx. 1/700 Earth Canal	
	Drop I	9	13	13	
	Box Culvert	130	130	150	
Tertiary Canal	Canal	L: 276,000 m Q: Standard 1.2 m^3/s I: Approx. 1/700 Earth Canal	L. 276,000 m Q: Standard 1.5 m^3/s I Approx. 1/700 Earth Canal	L. 418,000 m Q: Standard 1.5 to 3.0 m^3/s I. ditto to II ditto to II	
	Box Culvert	70	70	160	
Interception Canal	Canal	L: 14,650 m Q: 6.9 to 0.03 m^3/s I: 1/600 to 1/2,000 Earth Canal	L. 14,650 m Q: 8 6 to 0 04 m^3/s I· 1/500 to 1/2,000 Earth Canal	ditto to II	
Special Type	Canal		L. 2,000 m Q. 120 m^3/s I: 1/600 Compound Cross-Section	ditto to II	MD-8

Note: L: Canal Length, Q: Design Discharge, I: Drain Slope

Table 4–20 Irrigation Facilities

Facilities			Plan I	Plan II	Plan III	Remarks
Driving Canal	Canal				L: 6,400 m Q: 6.0 m^3/s I. 1/2,000 Earth canal	
	Siphon	(A)			L: 180 m ø: 2,000 mm Floresta Stream	
		(B)			L: 320 m ø: 2,000 mm Floresta Stream	
	Conduit				1 unit	
Main Canal	Canal				L: 26,700 m Q: 5.9 to 1.5 m^3/s I: 1/1,000 to 1/2,000 Earth canal	
	Diversion works				1 unit	
	Shute				1 unit	
	Drop				2 units	
	Waste way				1 unit	
	Siphon (C)				1 unit	L = 250 m, ø 1,900 mm Pamplonita River
	Check gate				7 units	
Secondary Canal	Canal				L: 50,350 m Q: 0.06 to 0.57 m^3/s I: 1/1,000 Earth canal	
	Turnout				20 units	
	Conduit				196 units	
Tertiary Canal	Canal				L: 203,349 m Q: 0.02 m /s I: 1/1,000 Earth canal	

Table 4–21 Road and Bridge

Facilities	Plan I	Plan II	Plan III	Remarks
Main farm road				
1. New road	ℓ: 14,500 m B = 6.0 m	- do -	- do -	
2. Rehabilitation of existing road	ℓ: 6,250 m B = 6.0 m	- do -	- do -	
Secondary farm road	ℓ: 188,000 m B = 4.0 m	- do -	ℓ: 250,000 m B = 4.0 m	
Tertiary farm road	ℓ: 276,000 m B = 3.0 m	ℓ: 276,000 m B = 3.0 m	ℓ: 418,000 m B = 3.0 m	
Bridge—	96	- do -	- do -	