

REPUBLIC OF COLOMBIA  
FEASIBILITY STUDY  
ON  
THE SMALL SCALE IRRIGATION  
PACKAGE PROJECT IN SLOPE AREA

VOLUME I  
MAIN REPORT

MARCH, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY





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JAPAN INTERNATIONAL COOPERATION AGENCY

国際協力事業団

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## P R E F A C E

In Response to the request of the Government of the Republic of Colombia, Japanese Government decided to conduct a feasibility study on the Small Scale Irrigation Package Project in Slope Area and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Colombia a survey team headed by Mr. Narao Takemura, Naigai Engineering Co., Ltd., from February 1986 to March 1986 and July to September 1986.

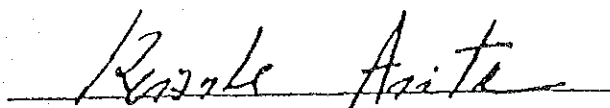
The team exchanged views on the Project with the officials concerned of the Government of the Republic of Colombia and conducted a field survey.

After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Colombia for their close cooperation extended to the team.

March, 1987

A handwritten signature in black ink, reading "Keisuke Arita", is written over a horizontal line.

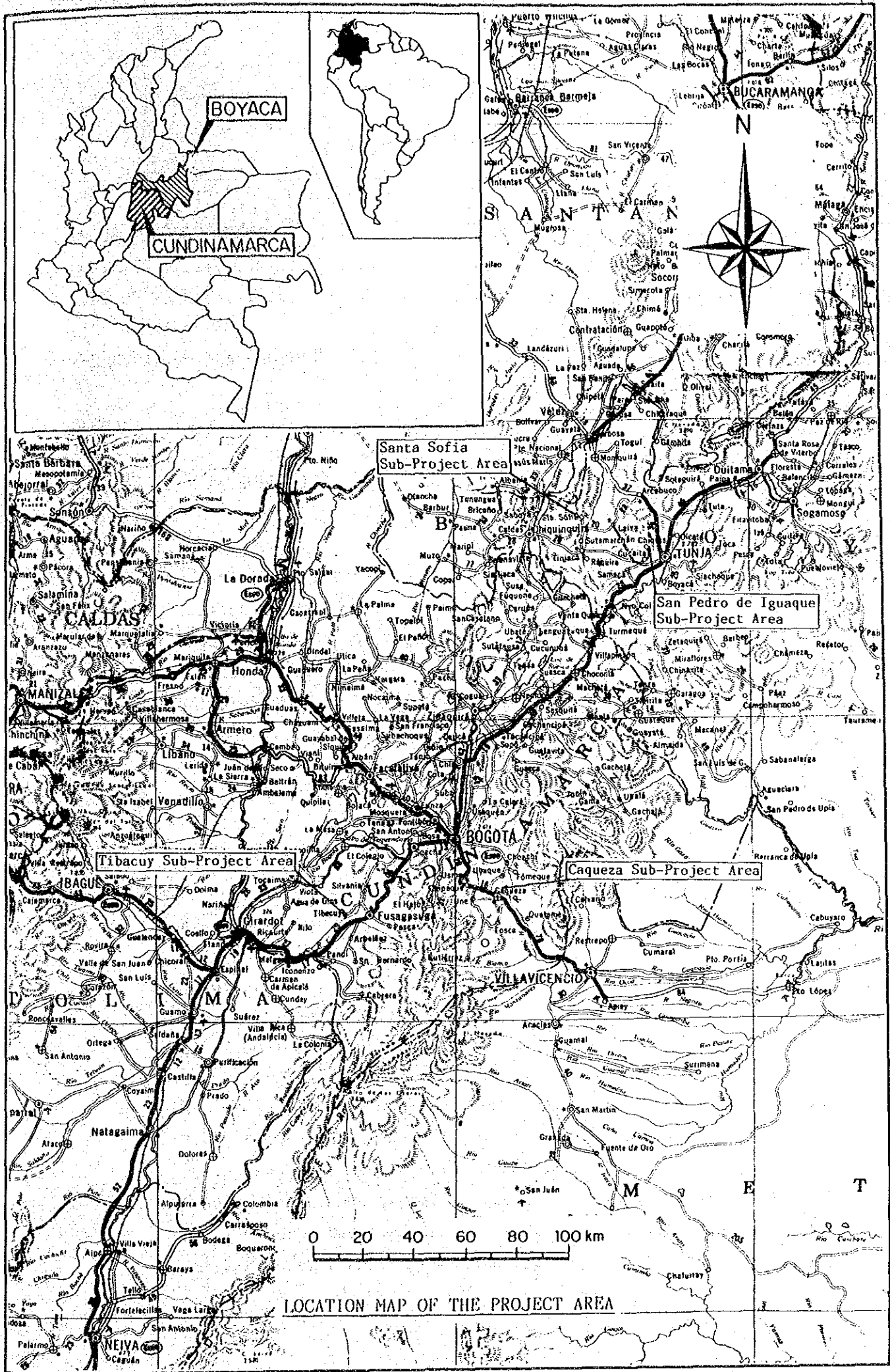
Keisuke Arita

President

Japan International Cooperation Agency







LOCATION MAP OF THE PROJECT AREA



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## GLOASARY OF TERMS

<u>Abbreviation or symbol</u> (Organization)	<u>Definition</u>
HIMAT	Instituto Colombiano de Hidrologia, Meteorologia y Adecuacion de Tierras
INCORA	Instituto Colombiano de la Reforma Agraria
ICA	Instituto Colombia Agropecuario
MA	Ministerio de Agricultura
DNP	Departamento Nacional de Planeacion
DANE	Departamento Administrativo Nacional de Estadisticas
INDERENA	Instituto Nacional de los Recursos Naturales Renovables y del Ambiente
IGAC	Instituto Geografico "Augustin Codazzi"
IDEM	Instituto de Mercadeo Agropecuario
CORABASTOS	Corporacion Financiera de Fomento Agropecuario y Exportaciones
DRI	Fondo de Desarrollo Rural Integrado
INAGRARIO	Almacenes Grales de Deposito de la Caja Agraria IDEMA y Banco Ganadero
SENA	Servicio Nacional de Ambiente
FEDECAFE	Federacion Nacional de Cafeteros
EMCOPER	Empresa de Comercializacion de Productos Perecederos
Caja Agraria	Caja Credito Agraria (Agrarian Bank)
Banco Ganadero	Cattle Breeders' Bank
Banco Cafetero	Coffee Producer Bank

### (Administrative Unit)

Departamento	Department (Largest administrative district)
Municipio	City, Town, Village
Vereda	Parish

(Stream)

Q.	Quebrada	Stream
Zo.	Zanjon	Deep ditch
	Chorro	Small stream

(Measurement Unit)

mm	Milimeter
cm	Centimeter
m	Meter
Km	Kilometer
m <sup>2</sup>	Square Meter
ha	Hectare
km <sup>2</sup>	Square kilometer
g	Gram
Kg	Kilogram
ton	Ton
l	Litre
sec	Second
min	Minute
hr	Hour
m/s	Meter per second
m <sup>3</sup>	Cubic meter
m <sup>3</sup> /sec	Cubic meter per second
°C	Centi grade
%	Percentage

(Monetary Unit and Conversion Table)

Col.\$	Colombian Peso
U.S.\$	United States Dollar
1 US\$	= Col.\$193.76

(The average official exchange rate of June, 1986)

## SUMMARY



## SUMMARY

### 1. SUMMARY OF THE PROJECT

#### 1.1 Objectives of the Project

The Government of the Republic of Colombia has put emphasis in the agricultural development in slope area of the Andes region, where dominates mini and small scale farmer, as one of the national policy giving highest priority and the authorities concerned are taking various measures based on this principle.

As a link of the above measures, the small scale irrigation program is formulated by the HIMAT in order to increase production of food by using land effectively in slope area and generate working opportunity.

The small scale irrigation project areas for which were adopted by the Government of Japan, divided into four sub-project areas; San Pedro de Iguaque, Santa Sofia, Caqueza and Tibacuy.

The objective of the project is to provide irrigation facilities, to stabilize and improve the income of the farmers, especially of mini and small scale farmers cultivating in the project area, and to contribute to economy of the region.

The above-mentioned four sub-project areas have specific characteristics respectively in the conditions of location, therefore, this project will make a model of the small scale irrigation project in slope area which will be implemented in future.

#### 1.2 Problems of the Project and Necessity of the Development

In the Project area, the crops corresponding to the natural conditions such as potato in San Pedro de Iguaque, curuba in Santa Sofia, tomato and onion in Caqueza, and coffee in Tibacuy are planted currently in addition to the crops for home-consumption.

However, the farmers' cultivating in the Project area are compelled to keep low productivity and unstable farm management due to the various constraints as described below.

- The project area is located in high elevated area with low temperature. The growing period of the crops is longer than the other area because of the relatively short sunshine hours.
- The climate of the project area is divided clearly into the dry season and the wet season. During dry season, ordinary crops can not be harvested without irrigation.
- During dry season, the price of the agricultural products rises and the excess labor is produced in agriculture.
- There are lot of small scale farmers in the project area. The fund for the farm management is insufficient.
- It is difficult to improve efficiency of the farming due to slope area.
- Erosion of the top soil in the project area is concerned.
- The economy of the farmers who plant coffee in Tibacuy is unstable because the international market price of coffee is fluctuated and natural conditions are less favorable than the other coffee production area.

One of the most effective countermeasure is provision of irrigation facilities which are earnestly desired by the concerned farmers. When the irrigation facilities are provided, cultivation of the desired crops becomes possible even in dry season, and the following merits are expected.



- The crop production will increase and the farmers gain more profit through shipment of the crops to the market at the time of higher price.
- Stable production of the crops.
- Increase of employment opportunity during dry season.

Therefore, the Project should be materialized as early as possible.

### 1.3 Characteristics of the Sub-Project Area

The characteristics of the sub-project area to which should have due consideration should be given on the occasion of the project formulation are as follows:

#### (1) San Pedro de Iguaque

- The sub-project area is situated in high elevation, cool climate zone (cold climate zone in some places) and unfavorable conditions in view of economic location. (long distance from main road)
- Volume of water source is scarce.

The distance between water source and benefited area is long, and the difference of their elevation is small. But it is possible to construct new reservoirs in Carrizal and Yerbabuena system.

#### (2) Santa Sofia

- The sub-project area is situated in high elevation and cool climate zone.
- The water source has comparatively ample amount of water. The distance between water source and benefited area is short, and the difference of their elevation is large.

No appropriate site for reservoir exists except Palonegro river basin.

(3) Caqueza

- The climate is warm and mild.
- The farming scale is extremely small. (1.3 ha/farm-household in average)
- Dry and rainy seasons occur once a year in each, but dry season extends over long period. (a specific feature in eastern slope of the Oriental mountain range) The quebrada (small stream) is dried up in dry season.

(4) Tibacuy

- The climate is warm and mild.
- In the sub-subject area, coffee is mainly cultivated.

**1.4 Basic policy of the Project Formulation**

In course of the project formulation, the following are taken into consideration.

- The project area should be of small scale in order to materialize effect of the project at earliest.
- The cost of the facilities should be as low as possible.
- The priority in distribution of irrigation water should be given to the small scale farmers in the project area.

The following items have been considered to make the project formulation corresponding to the characteristics in each sub-project area.

- Farm management plan;

The condition of location of each area.

Farming scale of farmer and distribution of labor force.

- Cropping pattern:

Availability of water resources.

Effective use of water resources supposing the possibility for installation of irrigation facilities.

- Irrigation facilities and its method.

Proposition of irrigation facilities and its method considering the condition of location, cropping pattern, operation and maintenance for the facilities.

## 1.5 Contents of the Project

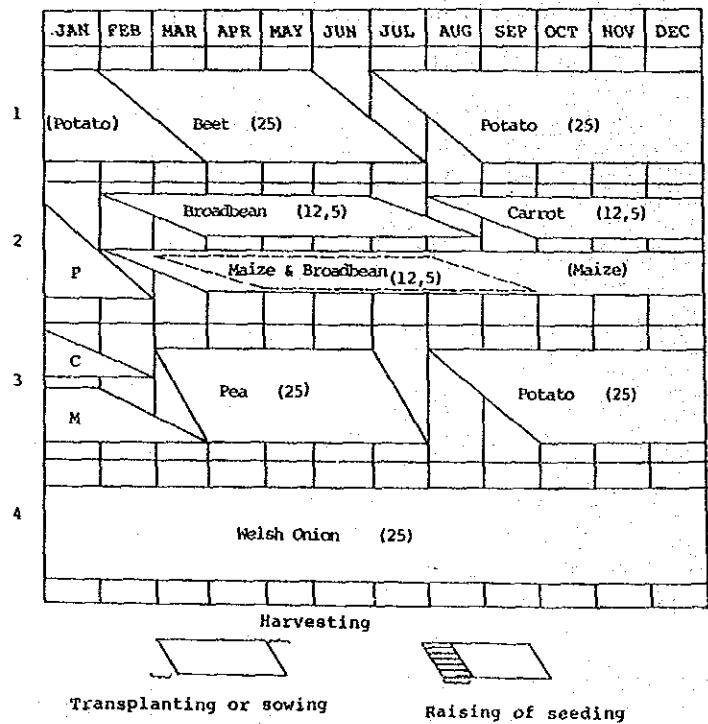
### 1.5.1 San Pedro de Iguaque

#### (1) The proposed area

Farmland of 1,184 ha is scattered in this sub-project area. The sub-project area is fixed at 162 ha which consists of Carrizal Irrigation System (120 ha), Yerbabuena Irrigation System (42 ha, including the pilot area of 26 ha). Farmland of which is located higher than water source is excluded, besides, an area of which cannot conduct water economically is also excluded. (See General plan)

#### (2) Cropping pattern

The sub-project area is 2,800-3,100 m in altitude and is coolness climate. Further this area is located in a long way off from the main roads (damage of crops by transporting). The following cropping pattern is proposed considering these conditions.



#### (3) Water requirement and available water amount

According to the above-mentioned cropping pattern, the consumptive use and the diversion water requirement are calculated as follows:

where evapotranspiration is estimated using the Penman method.

the irrigation efficiency is assumed at 80%.

- Monthly consumptive use

Unit: mm/day											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.4	2.3	2.4	2.6	2.6	3.0	2.7	2.3	2.3	2.4	2.4	2.1

- Annual diversion water requirement and available water amount

Irrigation system	Irrigable area (ha)	Diversion water requirement		Available water amount
		Monthly	max.(l/s)	Droughty (l/s)
Carrizal	120	24.5		11.2-30.2
Yerbabuena No.1	26	5.3		4.7-12.6
Yerbabuena No.2	16	3.3		1.2- 3.2

(4) Facilities plan

- Carrizal irrigation system

- Reservoir :  $V = 40,000 \text{ m}^3$  H = 4 m, L = 85 m
- Diversion weir : Fixed type H = 2 m, L = 4 m
- Driving channel : Open canal with stone pitching L = 4,000 m
- ditto - : Pipeline  $\phi$  2-4" L = 1,550 m
- Farm pond : Reinforced concrete 8 units

- Yerbabuena No.1 irrigation system

- Diversion weir : Fixed type H = 2.1 m, L = 3.5 m, 1 place
- ditto - : Fixed type H = 2.0 m, L = 3.0 m, 1 place
- Driving channel : Open canal with stone pitching L = 2,470 m
- ditto - : Pipeline  $\phi$  4" L = 1,250 m
- Farm pond : Reinforced concrete 5 units

- Yerbabuena No.2 irrigation system

- Reservoir :  $V = 13,500 \text{ m}^3$  H = 2.5 m, L = 100 m
- Driving channel : Pipeline  $\phi$  2.1/2" L = 1,650 m

(5) Irrigation method

Sprinkler irrigation : Nozzle pressure : 1.0-2.0 kg/cm<sup>2</sup>

Irrigation interval of 7 days

(6) Estimated construction cost

Col.\$ 27.4 millions (170 thousand Col.\$/ha)

(7) Increased production value and benefits

46,057,000 Col.\$/year, 16,786,000 Col.\$/year

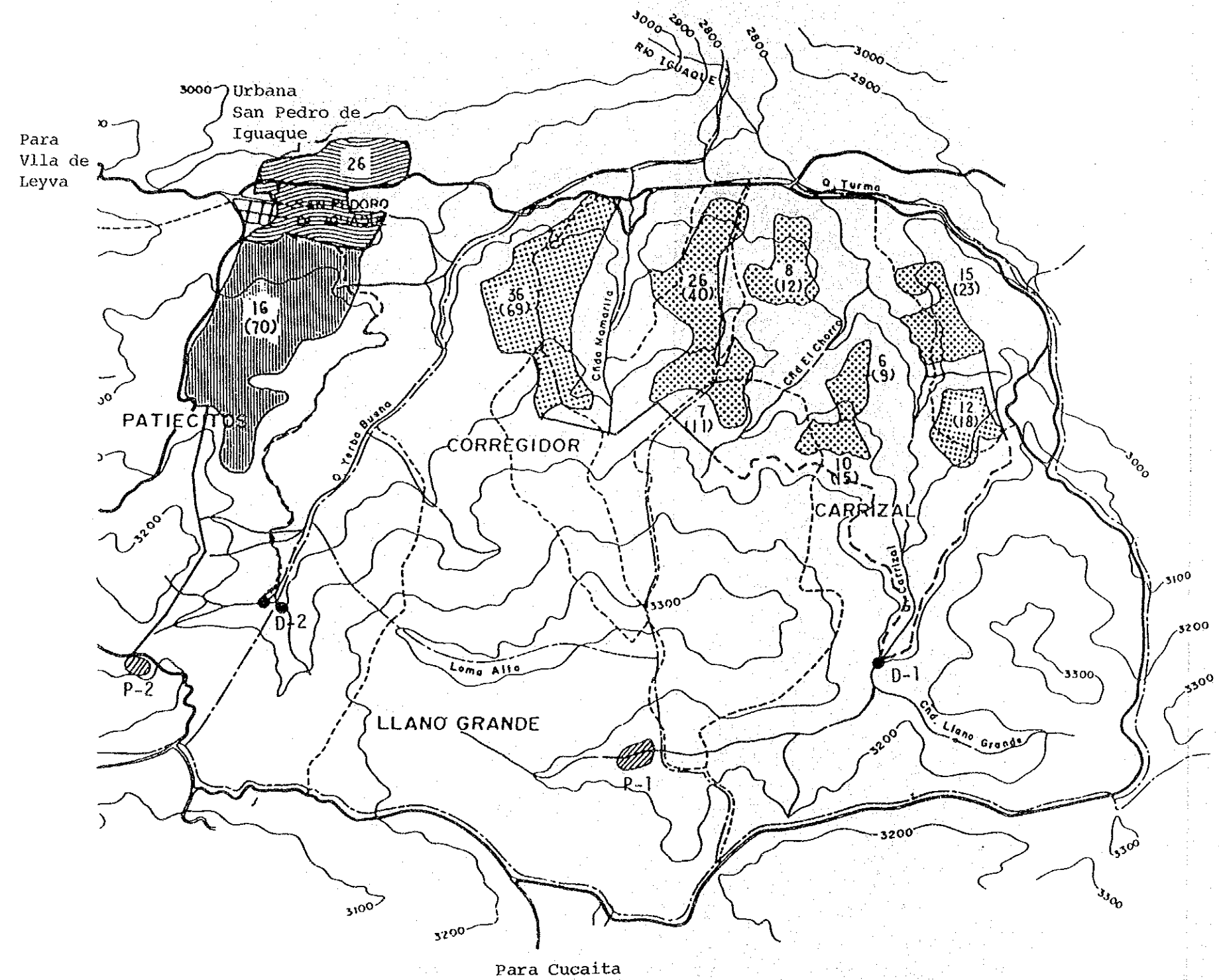
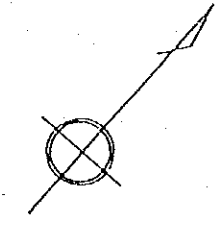
(8) Internal rate of return

24%

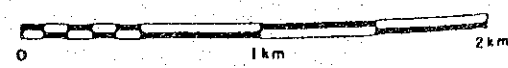
(9) Project implementation plan

Judging from farmer's interest for the irrigation farming, the construction will be considered to commence in order of Yerbabuena and Carrizal irrigation systems.

# GENERAL PLAN : SAN PEDRO DE IGUAQUE



	D-1	D-2	P-1	P-2
E.L. (m)	3,100	2,987	3,160	3,170
Q (l/s)	24.5	5.3	—	3.3
C.A. (km <sup>2</sup> )	2.50	2.34	3.10	0.60







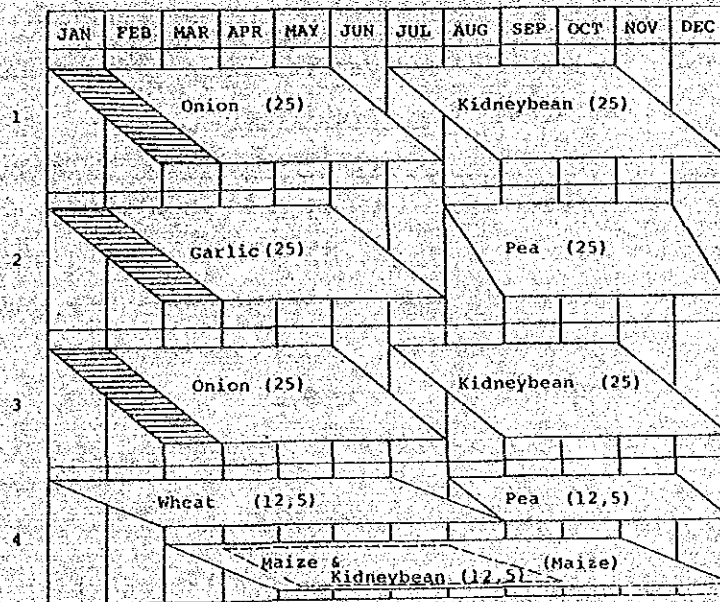
1.5.2 Santa Sofia

(1) The proposed area

Farmland of 360 ha is scattered in this sub-project area. The sub-project area is fixed at 293 ha which consists of Piedras irrigation system (55 ha), La Laja irrigation system (72 ha) and Camelo irrigation system (74 ha), including the pilot area of 28 ha) and Palonegro irrigation system (38 ha). (See General plan)

(2) Cropping pattern

The sub-project area is 2,200-2,400 m in altitude and is coolness climate. Taking into consideration the irrigation water is relatively accessible, the cropping pattern is proposed as follows:



(3) Water requirement and available water amount

According to the above-mentioned cropping pattern, the consumptive use and the diversion water requirement are calculated as follows:

where : evapotranspiration is estimated using the Penman method.  
the irrigation efficiencies is assumed at 80% in Palonegro irrigation system and 85% in the other irrigation systems.

- Monthly consumptive use

												Unit: mm/day
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1.8	1.9	2.4	2.6	2.9	3.1	2.0	2.1	2.5	2.6	2.3	2.2	

- Annual diversion water requirement and available water amount

Irrigation system	Irrigable area(ha)	Diversion water requirement	Available water amount
		Monthly max.(l/s)	Droughty(l/s)
Piedras	55	11.5	7.1 - 93.3
La Laja	72	15.0	5.0 - 92.9
Camelo	74	15.4	2.1 - 110.6
(Pilot)	28	5.8	
Palonegro	38	8.4	2.5 - 73.2

(4) Facilities plan

- Piedras irrigation system

Diversion weir	:	Fixed type	H = 2 m	L = 3.5 m
Driving channel	:	Pipeline	ϕ 2 - 4"	L = 2,500 m
Farm pond	:	Reinforced concrete		4 units

- La Laja irrigation system

Diversion weir : Fixed type H = 2 m, L = 3.5 m  
Driving channel : Pipeline  $\phi$  2-4" L = 2,950 m  
Farm pond : Reinforced concrete 5 units

- Camelo irrigation system (including pilot area 28ha)

Diversion weir : Fixed type H = 2 m, L = 3.5 m  
Driving channel : Pipeline  $\phi$  1.1/4-4" L = 2,222 m  
Farm pond : Reinforced concrete 2 units  
- ditto - : pond 2 sites

- Palonegro irrigation system

Diversion weir : Fixed type H = 2 m, L = 3.5 m  
Driving channel : Open canal with stone pitching L = 1,750 m  
- ditto - : Pipeline  $\phi$  1.1/2-3" L = 3,500 m  
Farm pond : reinforced concrete 6 units

(5) Irrigation method

Sprinkler irrigation : Nozzle pressure : 2.0 kg/cm<sup>2</sup>  
Irrigation interval of 7 days

(6) Estimated construction cost

Col.\$ 39.3 millions (164 thousand Col.\$/ha)

(7) Increased production value and benefits

111,538,000 Col.\$/year, 66,019,000 Col.\$/year

(8) Internal rate of return

56%

(9) Project implementation plan

Judging from farmer's interest for the irrigation farming, and the natural conditions in this area, the construction is desirable to commence in due course as follows:

1. Palonegro
2. Camelo
3. La Laja
4. Piedras

However, camelo irrigation system (28 ha) will be carried out earlier than another system taking serious view of a demonstration effect as pilot project.





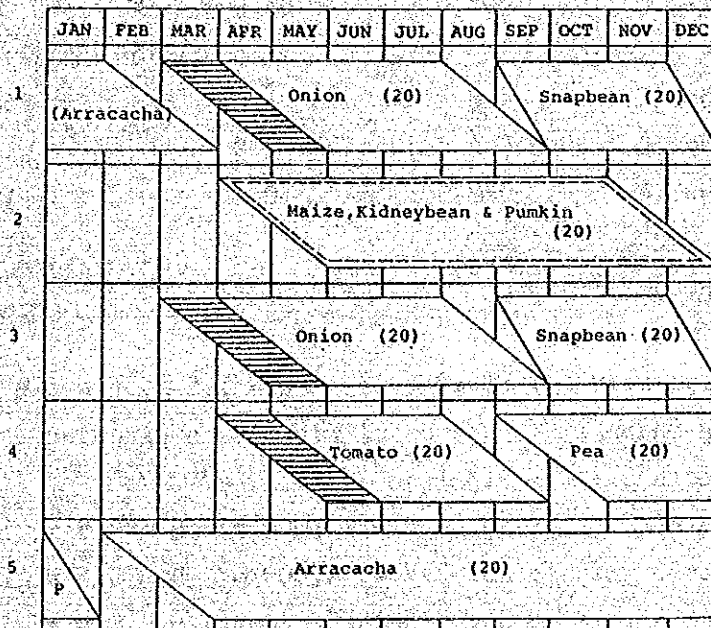
### 1.5.3 Caqueza

#### (1) The proposed area

Farmland of 589 ha is scattered in this sub-project area. The sub-project area is fixed at 417 ha except farmland of which is located higher than water source and area of which is impossible to conduct water economically.

#### (2) Cropping pattern

This sub-project area is 1,600-2,100 m in altitude and is mild climate (coolness climate in a part). Rainfall is converged into the rainy season. Dry season is formed among December to March, and it is difficult to secure the irrigation water in the dry season due to small watershed. According to these natural conditions, the cropping pattern is proposed as follows:



(3) Water requirement and available water amount

According to the above-mentioned cropping pattern, the consumptive use and the diversion water requirement are calculated as follows:

where evapotranspiration is estimated using the Penman method, the irrigation efficiency is assumed at 85%.

- Monthly consumptive use

Unit: mm/day											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.7	2.6	2.9	2.7	2.4	2.6	3.0	3.1	2.6	2.7	2.7	2.6

- Annual diversion water requirement and available water amount

Irrigation system	Irrigable area (ha)	Diversion water requirement		Available water amount
		Monthly	max.(l/s)	Droughty (l/s)
Negra-Blanca	403	88.9		3.2-285.5 (for 5 diversion weirs)
Reservoir No. 1	8	1.8		0.03- 2.3
Reservoir No. 2,3	4	0.9		0.03- 2.3
Reservoir No. 4	2	0.4		0.03- 2.3

(4) Facilities plan

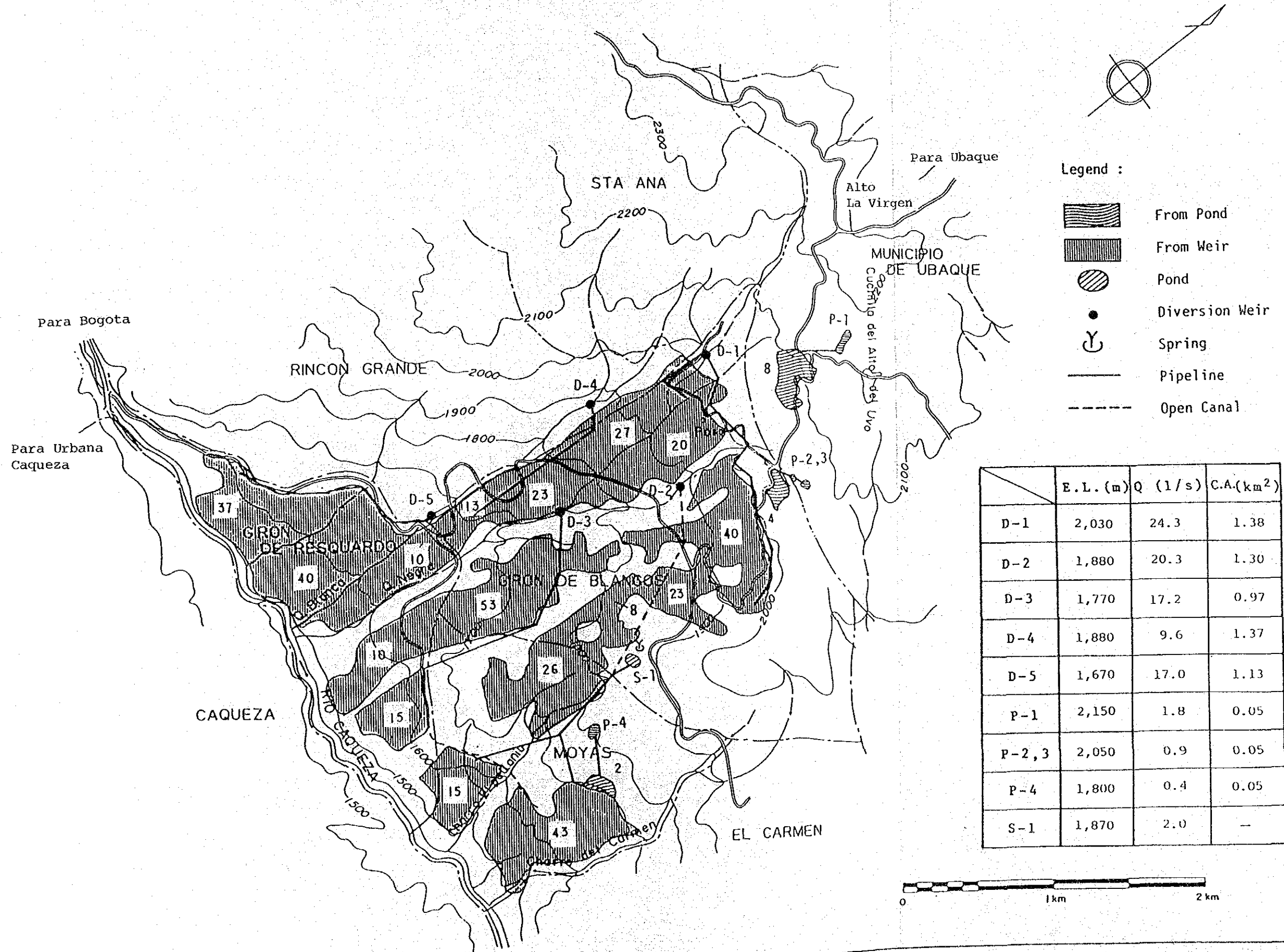
Diversion weir	: Fixed type	H = 1.5 m, L = 3-4 m, 5 place
Driving channel	: Open canal with stone pitching	L = 1,300 m
- ditto -	: Pipeline $\phi$ 1.1/2-4"	L = 6,650 m
Reservoir	: No. 1 V = 10,000 m <sup>3</sup>	H = 3.5 m, L = 35 m
- ditto -	: No. 2 V = 4,000 m <sup>3</sup>	H = 3.5 m, L = 30 m
- ditto -	: No. 3 Reinforcement	H = 1.0 m, L = 20 m
- ditto -	: No. 4 Reinforcement	H = 1.0 m, L = 30 m
Farm pond	: Reinforced concrete	29 units



- (5) Irrigation method  
Sprinkler irrigation : Irrigation interval of 5 days
- (6) Estimated construction cost  
Col.\$ 54.7 millions (131 thousand Col.\$/ha)
- (7) Increased production value and benefits  
145,572,000 Col.\$/year, 79,794,000 Col.\$/year
- (8) Internal rate of return  
57%
- (9) Project implementation plan

Having considered farmer's interest for the irrigation farming, the preparatory period will be taken considerably before commencement of construction. Therefore, it seems that the construction will be commenced lately among four sub-projects.

# GENERAL PLAN: CAQUEZA





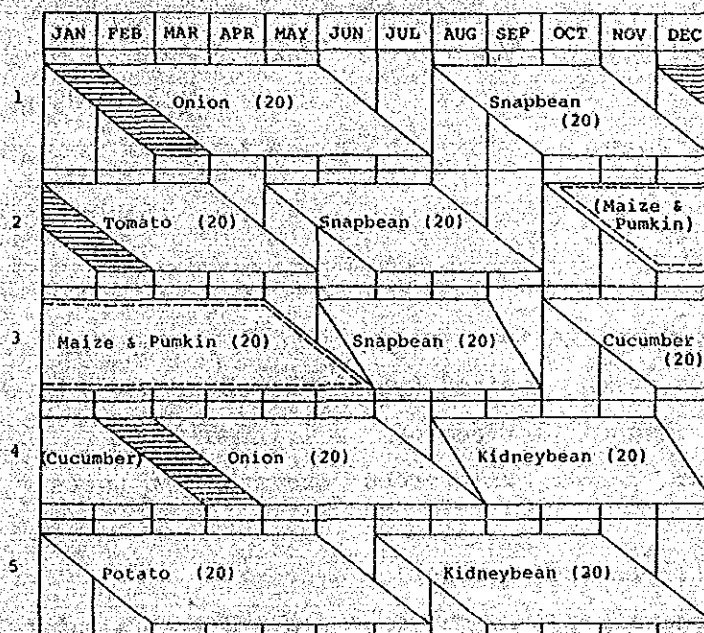
#### 1.5.4 Tibacuy

##### (1) The proposed area

Farmland of 343 ha (including coffee plantation of 304 ha) is extended in this sub-project area. The sub-project area is fixed at 253 ha (including coffee plantation of 210 ha) except an area of which is impossible to conduct water economically. (See General plan)

##### (2) Cropping pattern

The sub-project area is 1,200-1,800 m in altitude and is mild climate. Most of farmland is already used as a coffee plantation, therefore, irrigation facilities plan of this area will be carried out aiming at stabilized coffee production. In the area under annual crop cultivation, the following cropping pattern is proposed considering the conditions of location,



(3) Water requirement and available water amount

According to the above-mentioned cropping pattern (but, irrigation water will be supplied on April, May, October and November), the consumptive use and the diversion water requirement are calculated as follows:

where evapotranspiration is estimated using the Penman method, the irrigation efficiency is assumed at 85%.

- Monthly consumptive use

Unit: mm/day											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.7	2.4	3.0	3.0	3.2	3.1	3.4	3.3	3.2	3.0	2.5	2.4
-	-	-	3.1	3.0	-	-	-	-	3.0	2.6	-

- Annual diversion water requirement and available water amount

Irrigation system	Irrigable area (ha)	Diversion water requirement		Available water amount
		Monthly	max.(1/s)	Droughty (1/s)
San Jose No. 1	243	50.9		2.2-228.2 (for 3 diversion weirs)
San Jose No. 2	15	3.1		0 -114.2

(4) Facilities plan

- San Jose No.1 irrigation system

Diversion weir : Fixed type H = 2 m, L = 3 m, 3 places  
 Driving channel : Pipeline  $\phi$  1.1/2-6" L = 4,700 m  
 Farm pond : Reinforced concrete 16 units

- San Jose No.2 (pilot) irrigation system

Diversion weir : Fixed type H = 2 m, L = 4.5 m  
 Driving channel : Pipeline  $\phi$  1.1/2" L = 295 m  
 Farm pond : Reinforced concrete 3 units

(5) Irrigation method

Ordinary upland : sprinkler irrigation, irrigation interval of 5 days

Coffee plantation : Mini-sprinkler irrigation (low-angle), irrigation interval of 5 days

(6) Estimated construction cost

Col.\$ 34.4 millions (133 thousand Col.\$/ha)

(7) Increased production value and benefits

64,455,000 Col.\$/year, 38,328,000 Col.\$/year

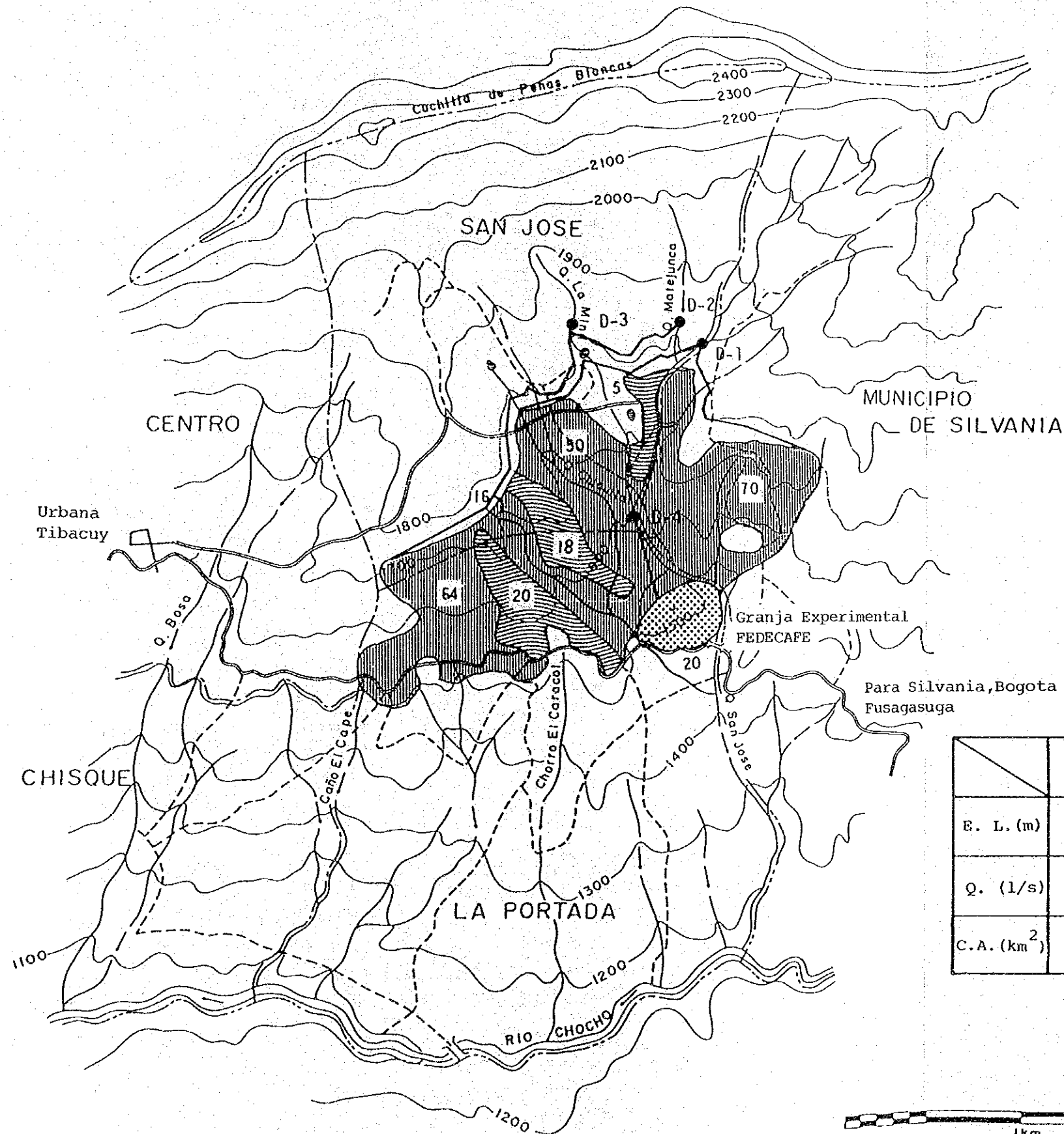
(8) Internal rate of return






41%

(9) Project implementation plan

With the object of a publicity to irrigation effect for farmers, the experimental plantation of FEDECAFE (15 ha) which is well prepared the conditions of location as demonstration farm is desirable to carry out previously as the pilot area.

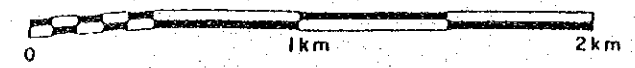
# GENERAL PLAN: TIBACUY



- Legend :
-  Coffee land
  -  Ordinary Land
  -  Pilot Farm
  -  Diversion Weir
  -  Pipeline

Para Sylvania, Bogota y Fusagasuga

	D-1	D-2	D-3	D-4
E. L. (m)	1,820	1,820	1,820	1,701
Q. (l/s)	25.7	12.9	12.3	3.1
C.A. (km <sup>2</sup> )	1.82	0.91	0.87	1.85







## 2. Conclusion and Recommendation

### 2.1 Conclusion

The study on necessity, feasibility and viability of the small scale irrigation project in San Pedro de Iguaque, Santa Sofia, Caqueza and Tibacuy sub-project areas resulted in the following conclusion.

- (1) Taking into consideration the present land use and availability of water resources from the streams, the irrigable area of each sub-project area was studied and decided as follows:

San Pedro de Iguaque	162 ha
Santa Sofia	239 ha
Caqueza	417 ha
Tibacuy	258 ha
Total	1,076 ha

All of the above mentioned irrigable area are currently under cultivation.

- (2) Considering the available water amount from the stream, it will be possible that cropping intensity of the ordinary farm during dry season in San Pedro de Iguaque, Santa Sofia and Tibacuy sub-project areas can be increased. As for Caqueza sub-project area and coffee plantation in Tibacuy sub-project area, it is preferable to make water use plan aiming at preventing drought damage during wet season.

In addition to the major crops which have been cultivating, it is desirable to introduce to the proposed cropping pattern the vegetables such as welsh onion, carrot for San Pedro de Iguaque, onion, carrot and garlic for Santa Sofia, and onion, tomato and cucumber for Caqueza and Tibacuy sub-project areas.



- (5) After completion of the project, increment of the gross income attributed to the increasing agricultural production is anticipated at Col.\$367 million and the benefit of the project will be expected at Col.\$200 million.
- (6) Based on the invested cost to the project and benefit attributed to the project, the internal rate of return of the project was calculated. The internal rate of return of each sub-project area is as follows:

San Pedro de Iguaque	24%
Santa Sofia	56%
Caqueza	57%
Tibacuy	41%

Sensitivity analysis of the internal rate of return is also examined taking into account the possible fluctuation of commodity price and productivity. The result of the analysis is 18-54%.

## 2.2 Recommendation

- (1) The Government of the Republic of Colombia is requested to prepare necessary action for commencement of the project implementation as early as possible.

At the first stage of the project implementation, development of the pilot areas in each sub-project area except Caqueza sub-project area (26 ha in Yerbabuena No.1 system, 28 ha in Camelo system and 15 ha in San Jose No.2 system) should be implemented. Subsequently, development of the remaining irrigation systems should be carried out.

- (2) In order to materialize the project benefit successfully, establishment of the comprehensive farming technology including O/M of the project and water management, etc. after completion of the project, and extension services for the concerned farmers on farming technology are indispensable.

The development of the pilot areas as mentioned before is one of the above indispensable items. Additionally the following items are also proposed.

- Organization of water users' association and instruction of technology to the concerned technicians.
- Strengthening of the supporting organization for the farmers coordinating the existing supporting organization.
- Training of instructors on farm management including water management and soil conservation.
- Strengthening of the cooperatives (particularly regarding to distribution system).

(3) Regarding the project, items to be studied in the future are as follows:

- Scattered farm of small lot and high elevation area where irrigation water can not be applied with gravity from the nearby stream are excluded from the project area. It should be considered that small scale of reservoirs are constructed by the concerned farmers and water is stored in the reservoir during rainy season which will be able to use for irrigation in this area. Irrigation water amount per ha required for one or two months of sowing and planting period of the crops will be about 400 m<sup>3</sup>.
- A large scale of eroded areas are not existed in the project area. However, wasted area due to soil erosion can be seen in the neighboring area. Necessary action should be taken in this area in order to prevent further damage caused by extending erosion.
- Vehicular traffic through the connecting roads from main roads to the project areas are practicable. However, in order to accelerate the development of rural area, pavement and up-grade of the roads should be carried out in the future.

(4) Items to be carried out continuously by HIMAT

- Observation of precipitation and stream discharge in the project area

In order to contribute better detailed design and operation and maintenance of irrigation facilities, observation of precipitation and stream discharge should be continued, using the triangular and rectangular weirs which were installed during the previous field study.

- Ownership of farmland and land holding condition

Under the project, only the existing farmland is irrigated due to lack of enough irrigation water available. However, detailed survey on ownership and utilization condition of farmland owned by each farmer (location and area of farms to be irrigated) should be carried out before the forthcoming detailed design.