

No. 2

**THE REPUBLIC OF COLOMBIA**

**THE FEASIBILITY STUDY ON**

**THE ARIARI RIVER BASIN**

**INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT**

**MAIN REPORT**



**NOVEMBER 1989**

**JAPAN INTERNATIONAL COOPERATION AGENCY  
(JICA)**

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マイクロ  
フィルム作成

## PREFACE

In response to a request from the Government of the Republic of Colombia, the Government of Japan decided to conduct a feasibility study on the Ariari River Basin Integrated Agricultural Development Project and entrusted the study to Japan International Cooperation Agency (JICA).


JICA sent to the Republic of Colombia a study team headed by Dr. Shoji KANATSU, Pacific Consultants International Co., Ltd. three times from August, 1988 to September, 1989.

The team held discussions with the concerned officials of the Government of the Republic of Colombia and conducted field surveys in the Ariari river basin. After the team returned to Japan, further studies were made and the present report was prepared.

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

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

November, 1989



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Kensuke YANAGIYA  
President

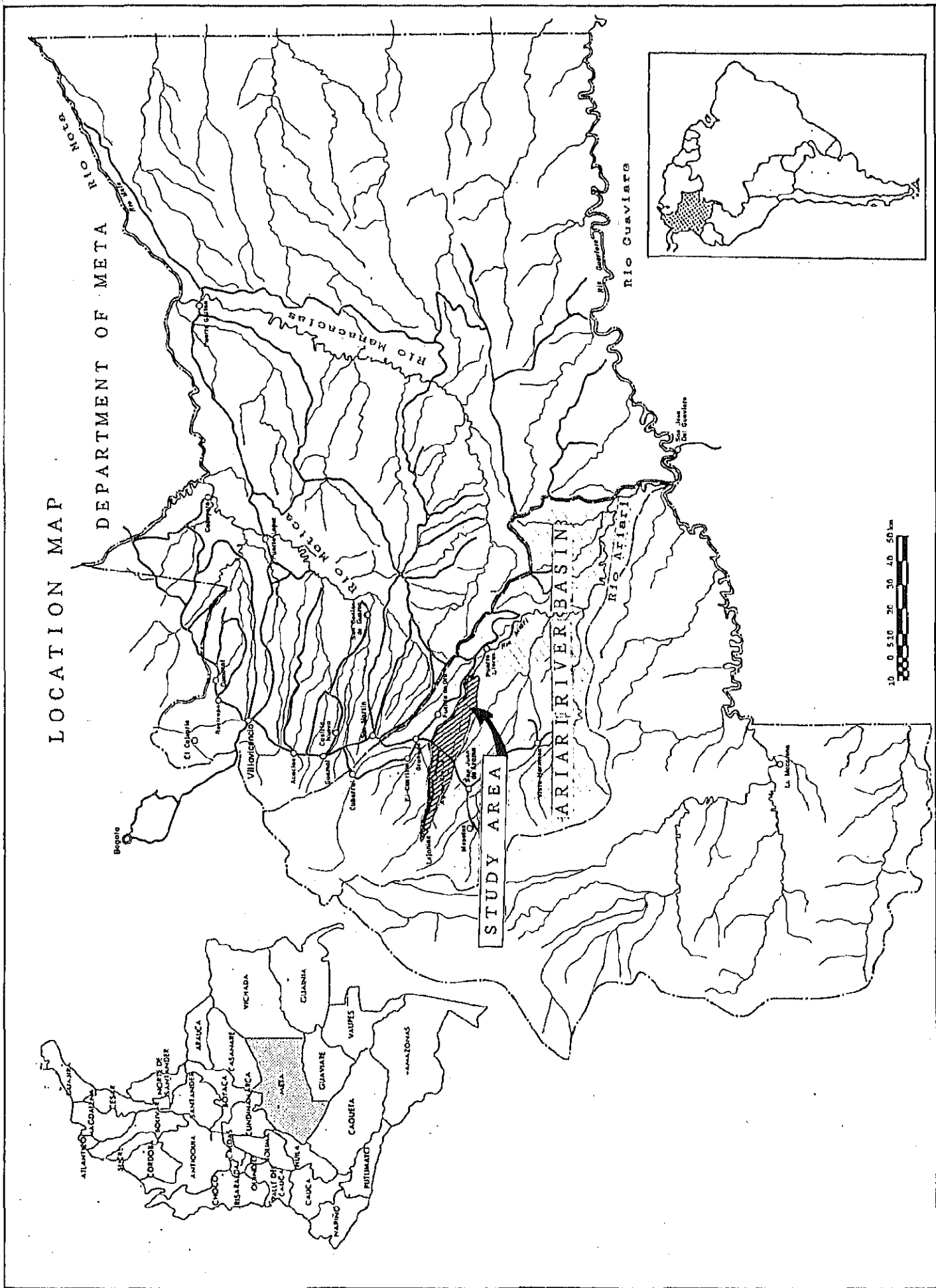
Japan International Cooperation Agency





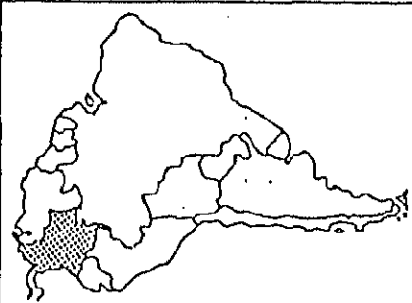
# LOCATION MAP

## DEPARTMENT OF META



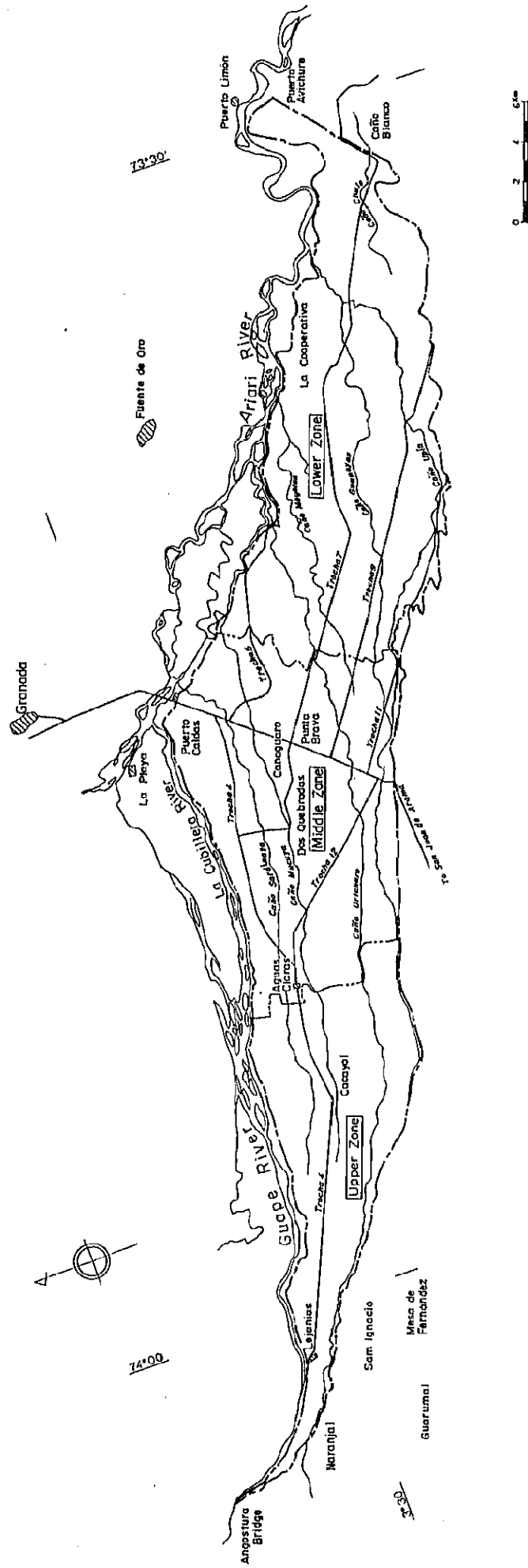
**STUDY AREA**

**ARIARI RIVER BASIN**

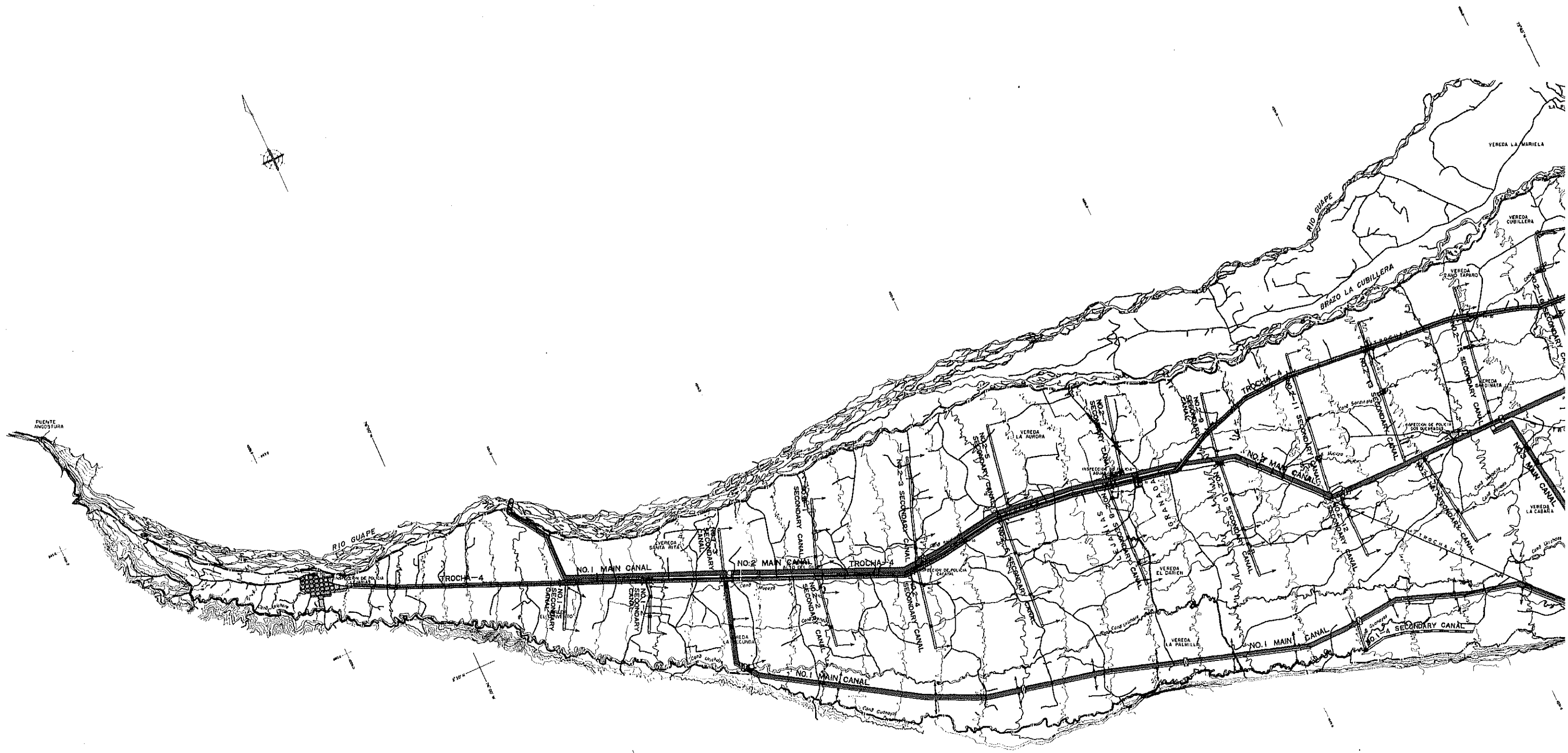




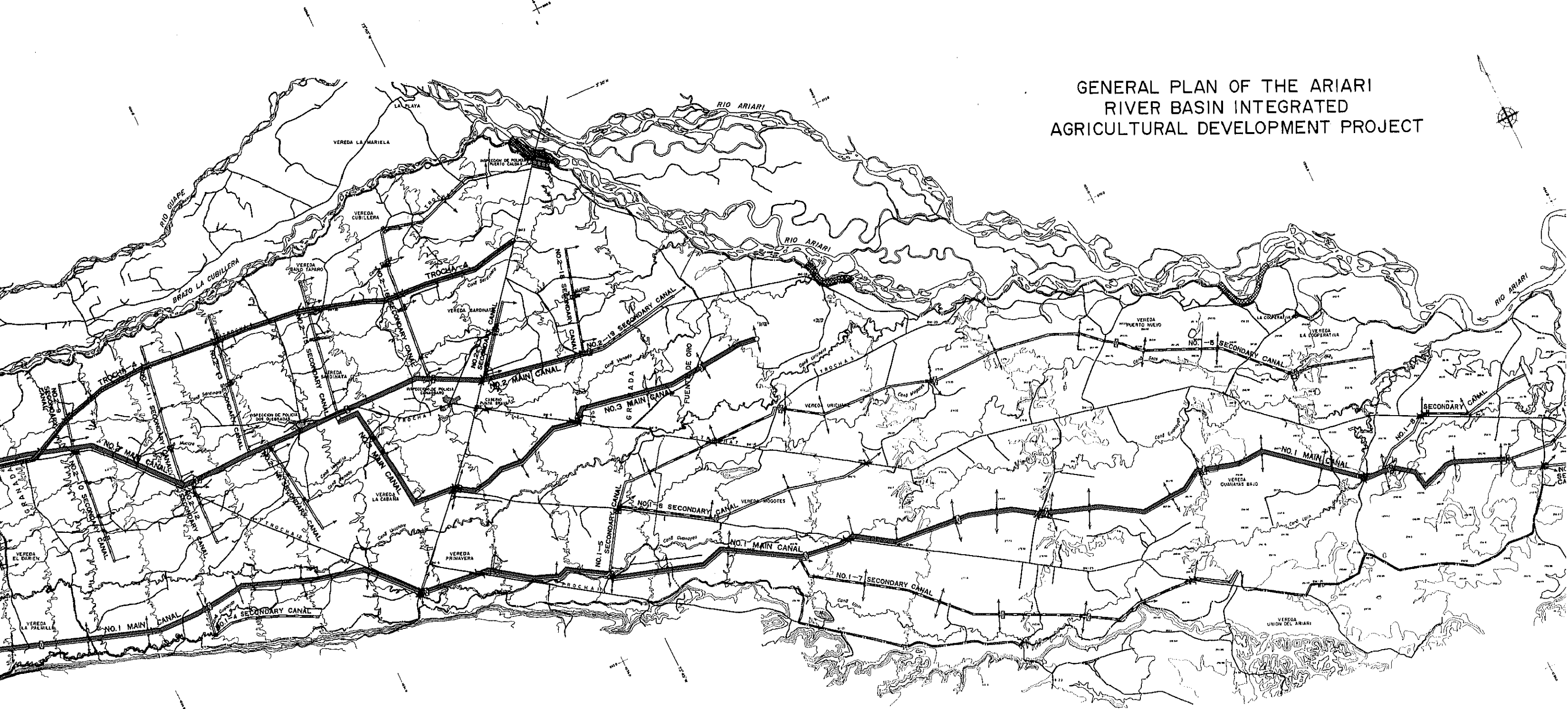
# THE STUDY AREA



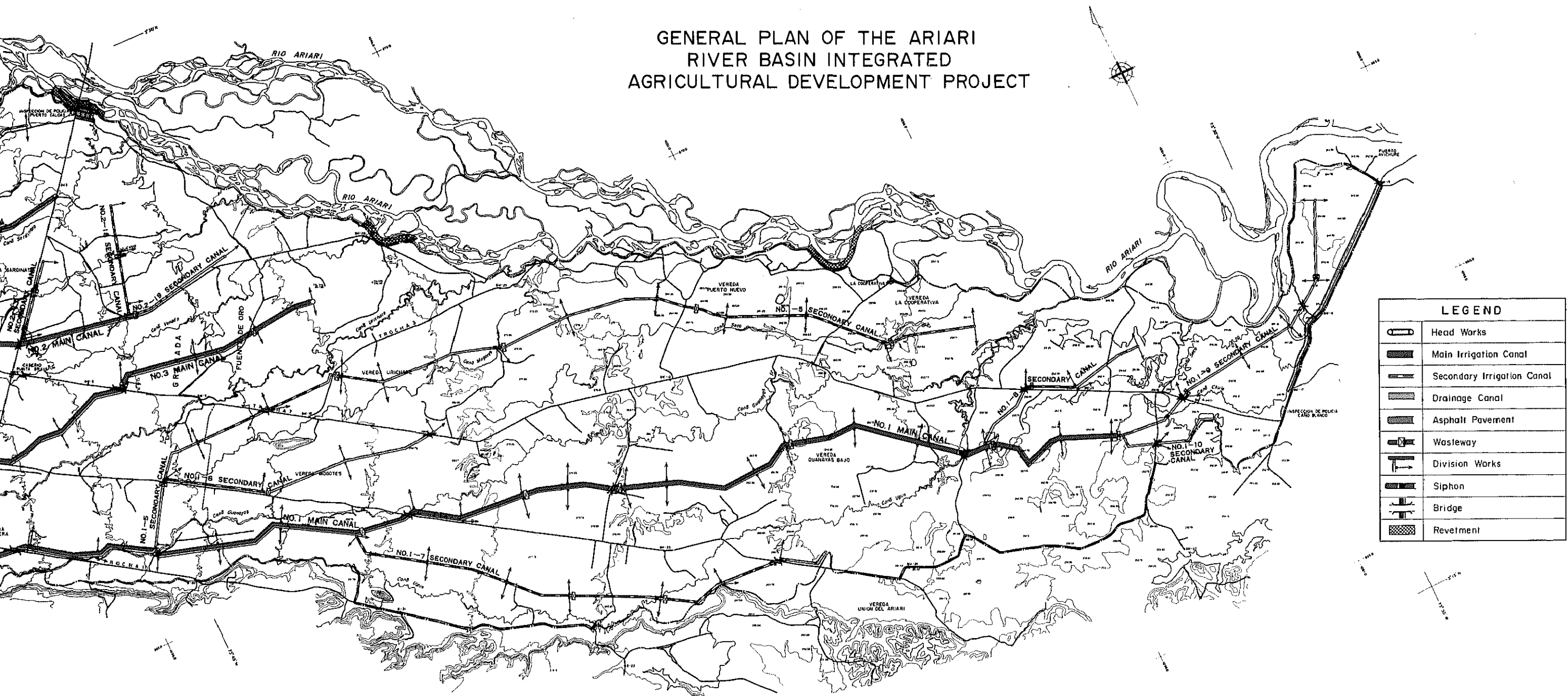




GENERAL PLAN OF THE ARIARI  
RIVER BASIN INTEGRATED  
AGRICULTURAL DEVELOPMENT PROJECT



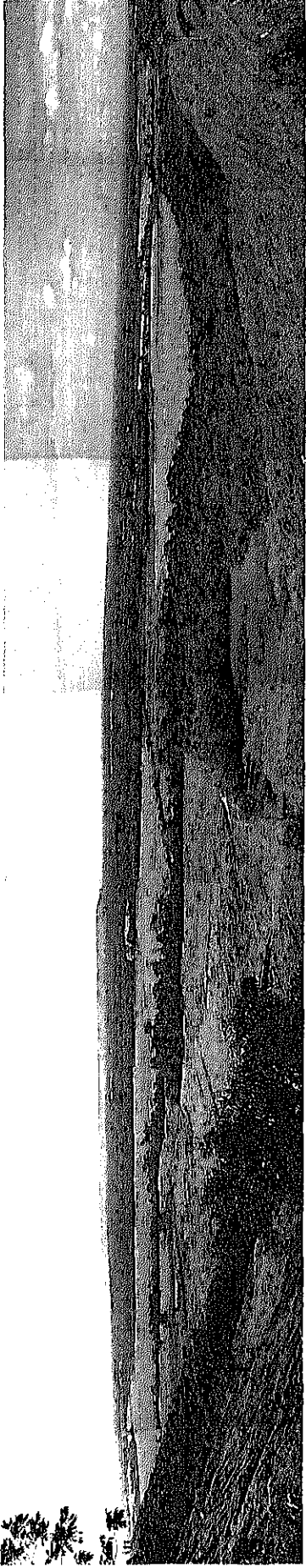
# GENERAL PLAN OF THE ARIARI RIVER BASIN INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT



| LEGEND |                            |
|--------|----------------------------|
|        | Head Works                 |
|        | Main Irrigation Canal      |
|        | Secondary Irrigation Canal |
|        | Drainage Canal             |
|        | Asphalt Pavement           |
|        | Wasteway                   |
|        | Division Works             |
|        | Siphon                     |
|        | Bridge                     |
|        | Revetment                  |







THE STUDY AREA



EXISTING PADDY FIELD



SUMMARY  
AND  
RECOMMENDATION



## SUMMARY AND RECOMMENDATIONS

### 1. INTRODUCTION

This Report describes the result of the Feasibility Study on the Ariari River Basin Integrated Agricultural Development Project in the Republic of Colombia.

The report consists of main report, annexes and drawings.

### 2. BACKGROUND OF THE STUDY

- 2.1 The Economic and Social Development Plan and Programs 1987-1990 addresses an eradication of absolute poverty with strategies employed on amelioration of living conditions among rural population and activation of rural economic activity. In line with these strategies, the Government of the Republic of Colombia has given high priority on the development of the Eastern Plains which is extended at the foot of the Eastern Andes Range, and envisages to implement various projects in phases.

Among the candidate projects awaiting for implementation, it is identified that the development of the Ariari river basin is the most immediate project, and thus the Government of Colombia requested the Government of Japan for technical assistance to implement the feasibility study of the Project. In response to this request, the Government of Japan dispatched the preliminary survey mission to Colombia in February 1988 to discuss and conclude the Scope of Work for the Study. As a result, the Study was started in August, 1988.

- 2.2 The objectives of the Study are:

- to formulate an optimum integrated agricultural development plan with attention paid towards the maximum utilization of potential resources available in the area;

- to verify technical and socio-economic feasibility of the formulated development plan; and
- to transfer relevant technology to Colombian counterparts in the course of the Study.

### 3. THE STUDY AREA

3.1 The study area is located to the south-east of Bogota, about 150km away and is covered by alluvial plains extended between plateaus along the Ariari and Guape rivers. The study area has an extension of 41,100 ha and according to administrative jurisdiction the Area is divided into the following three zones:

|  |           |
|--|-----------|
| Municipality of Lejanías (the Upper Zone)      | 9,100 ha  |
| Municipality of Granada (the Middle Zone)      | 15,400 ha |
| Municipality of Fuente do Oro (the Lower Zone) | 16,600 ha |
| <hr/>  |           |
| Total  | 41,100 ha |

3.2 Each zone has the following features.

|   | UPPER ZONE (LEJANIAS)                            | MIDDLE ZONE (GRANADA)   | LOWER ZONE (FUENTE DE ORO)  |
|---|--|---|---|
| 1. Area (ha)  | 9,100  | 15,400  | 16,600  |
| 2. Topography   | Composite fan                                    | Composite fan & Alluvial plains                                   | Alluvial plain  |
| - Land Elevation (m.A.S.L.) Above Sea Level             | 788 - 470  | 470 - 290   | 290 - 240   |
| - Average Gradient                                      | 1/60<br>(Consistent gradient)                    | 1/120<br>Consistent gradient)                                     | 1/500<br>(Little undulation in central part)                      |
| 3. Annual Rainfall (mm)                                 | 3,500  | 3,000   | 2,500   |
| 4. Soils  | Fan Deposit                                      | Fan & Alluvial Deposit  | Alluvial Deposit  |
| - Texture   | Coarse (Gravel) - Fine                           | Coarse (Gravel - Fine   | Medium - Fine   |
| - Fertility   | Medium - Low                                     | High - Low  | High - Low  |
| 5. Major Populated Area                                 | Lejanías<br>Cacayal                              | Aguas Claras, Des Quebradas, Canaguaro, Puerto Caldas             | La Cooperativa<br>Caño Flanco                                     |
| 6. Population   | 8,160  | 5,870   | 3,760   |
| 7. No. of Farmers                                       | 210  | 570   | 520   |
| 8. Land Tenure  |  |   |   |
| - Proportional Distribution by Farm Size 1)             | 6:4:1  | 7:3:0.1   | 4:5:1   |
| - Proportional Distribution by Coverage Area 1)         | 2:6:2  | 3:6:1   | 1:6:3   |
| - Status of Land Tenure                                 | Settlers of agrarian reform, Independent farmers | Independent farmers   | Independent farmers   |
| 9. Major Crop   | Pasture, papaya, plantain, maize                 | Upland rice, paddy rice, soyabean, plantain, cacao, pasture       | Upland rice, paddy rice, pasture, plantain, soyabean              |
| 10. Irrigation System                                   | ---  | Water is taken from caños by gravity and supplied to paddy fields | Water is taken from caños by gravity and supplied to paddy fields |
| 11. Drainage  | Good   | Some inundated area are founded along caños in the rainy season   | Consistent poor drainage areas are found                          |
| 12. Drainage due to flooding of Guape and Ariari Rivers | No substantial drainage area is found            | No substantial drainage area is found                             | Some farmlands are damaged at outflows of caños                   |
| 13. Bank erosion  | Urgent measures area not required                | Some roads and farmlands are eroded                               | Some roads and farmlands are eroded                               |

Note: 1) Small farm (less than 20 ha) ; Medium farm (20 - 100 ha) ; Large farm (more than 100 ha).

3.3 Prevailing constraints grasped by means of collected data and information are compiled so that development proposal can be clearly identified.

| Prevailing Constraints  | Development Proposal   | Development Plan   |
|---|--|--|
| <b>Water and Land Use</b>   |  |  |
| - Ineffective utilization of water and land due to lack of water in the dry season and unknown factors of irrigation farming      | - Better utilization of water and land by provision of irrigation system               | - Land use plan and irrigation plan                      |
| - Prevention of crop production and farm mechanization due to topographic and soil characteristics                                | - Agricultural management and crop production to accord with characteristics of sector | - Agricultural management and crop production plans      |
| <b>Agriculture</b>  |  |  |
| - Difficulty of systematic agriculture due to different level of farm development   | - Improvement of extension services, education and orientation                         | - Institutional services and farmers' organization plans |
| - Instable farmers' economy because of lack of planned agricultural management  | - Promotion to organize farmers' association   | - ditto  |
| - Inconvenience for agricultural management because of lack of financial resources  | - Improvement of agricultural credit services system                                   | - Agro-products marketing and agro-industry plans        |
| <b>Rural Infrastructure</b>   |  |  |
| - Discomfort of rural life and inconvenience for effective transportation of products due to under-developed rural infrastructure | - Improvement of rural infrastructure  | - Rural infrastructure plan                              |



| Prevailing Constraints   | Development Proposal                              | Development Plan                                 |
|--|---|--|
| <b>Disaster Prevention and Land Conservation</b>   |   |  |
| - Damages of farmland and road due to flooding and fluvial erosion on banks  | - Provision of disaster prevention measures       | - Land conservation and disaster prevention plan |
| <b>Implementation of Project</b>   |   |  |
| - Covering all the investment of project to beneficiaries that puts pressure on financial management of small farmers  | - Less burden to small farmers                    | - Recommendations on burden system               |
| - Less experience in irrigation farming that require the support of organization and substantial period to obtain new technology and extend O/M for facilities | - Implementation of appropriate development level |  |

#### 4. THE PROJECT

##### 4.1 OBJECTIVES OF THE PROJECT

Development of agricultural activity in the area is constrained by lack of water in the dry season. The Project aims to ease prevailing constraints in view of increasing agricultural production per unit of land, activating regional economy and ameliorating living standard of rural population.

##### 4.2 BASIC DEVELOPMENT CONSIDERATIONS

###### 1) Imposition of project cost

In compliance with governing law, the total project cost shall be, in general, imposed on beneficiaries of the Project.

###### 2) Development goal

The majority of farmers in the area have less experience in irrigation farming without endowed with adequate knowledge in technology for the husbandry. In addition, there are distinctive imbalance among farmers in terms of size of land holding and financial capability. Under the situation, it is essential that the development plan should be formulated in such manner as to generate expected benefits as soon and sure as possible. Bearing this point in mind, the development goal of the Project should be established in such level as can be practically attained by farmers from economic and technical viewpoints.

###### 3) Proposed crops

Proposed crops for the Project has been selected in due consideration of the parameters given below:

- Physical and social condition
- Cropping technology of farmers

- Sensitivity to irrigation system
- Marketability
- Productivity per farmer

Rice is identified as the most suitable crop for the area, thus paddy shall be the core product of the Project. Apart from paddy, major crops of the Project are as follows:

Annual crops -- maize, soybean, sorghum

Tree and perennial crops -- plantain, papaya, cacao, oil palm

Non-traditional crops -- sunflower, kidney bean

#### 4) Sources of irrigation water

In order to irrigate the whole area suitable for paddy field in addition to the surface water of the Guape river supplemental provision from the Ariari river or construction of a reservoir on the upper reach of the Guape river is critical. Nevertheless, from viewpoints of economic return and farmers' capability to repay the investment as well as operation and maintenance of facilities, it is concluded that the proposal which depend exclusively on surface water of the Guape river is the most practical plan.

#### 5) Land use

Land use plan has been incorporated following the criteria given below:

- The whole lands allocated to rice field shall be irrigated.
- Forest shall not be exploited in terms of environmental conservation.
- 22% of the actual pasture land will be shifted into crop cultivation land.
- Extension of lands with perennial and tree crops shall not have substantial change.

#### 6) Development area and irrigable area

The development area shall be 35,140 ha, which is equivalent to the whole study area (41,100 ha) minus forest, rivers, canals, urban area and other unproductive area (5,960 ha in total).

On the other hand, irrigable area by gravity reaches 23,815 ha. Lands included in development area but alienated from irrigable area are 11,325 ha in total which comprise the following lands:

- Right-of-way for canals and other facilities
- Topographically infeasible lands to irrigate by gravity
- Pasture lands

#### 7) Filed irrigation system

An extensive and large-scaled farming using large machinery and light aircraft is common in the study area. In terms of efficient water utilization, it is desirable that fields should be prepared in level and in smaller lots, but these preparation calls for heavier burden to farmers. Therefore, for inundating fields the Project does not contempt land preparation including leveling but borders are to be reclaimed along counter lines. For uplands, furrow irrigation system will be employed.

### 4.3 LAND USE ALTERNATIVES

#### 4.3.1 Introduction

In accordance with basic development policies cited before, land use alternatives have been proposed in view of expanding paddy fields as much as possible.

Each alternative plan present following features.

Alternative I-1: To expand paddy field up to 18,990 ha for both semesters.

Alternative I-2: The same extension will be allotted to paddy for the first semester, while the actual extension of rice (upland and paddy) will be maintained for the second semester; the rest of land for the second semester will be used for upland of annual crops.

Alternative II-1: To plant rice in 15,070 ha of land for both semesters.

Alternative II-2: To plant rice in the same extension for the first semester, while rice field will be reduced to 10,000 ha and the remaining 5,070 ha will be covered by annual crops.

The evaluation result has lead to the conclusion that the Alternative I-2 which has the highest rate of return and is secured with consistent supply of irrigation water taking water from the Guape river is the optimum alternative plan of land use.

#### 4.4 DEVELOPMENT PLANS

##### 1) Land use plan

On the basis of the Alternative I-2, land use plan for the Project area has been proposed in the following manner.

|        | Arable Land |              |                 |            |         |           | Improductive Land |  |       |        |
|--------|-------------|--------------|-----------------|------------|---------|-----------|-------------------|--|-------|--------|
|        | Paddy Field | Annual Crops | Upland          |            |         | Sub-Total | Forest            | Urban Area, Residential Area, Road, Rivers, etc. | Total |        |
|        |             |              | Perennial Crops | Tree Crops | Pasture |           |                   |  |       |        |
| Upper  | Semester I  | 2,715        | 505<br>(130)    | 1,020      | 1,110   | 2,600     | 7,950             | 720  | 430   | 9,100  |
| Zone   | Semester II | 1,860        | 1,360<br>(130)  | (60)       | (430)   | (2,600)   | (3,220)           |  |       |        |
| Middle | Semester I  | 8,300        | 405<br>(25)     | 590        | 710     | 3,395     | 13,400            | 1,500  | 500   | 15,400 |
| Zone   | Semester II | 6,600        | 2,045<br>(25)   | (10)       | (10)    | (3,395)   | (3,430)           |  |       |        |
| Lower  | Semester I  | 7,975        | 360<br>(220)    | 760        | 240     | 4,205     | 13,540            | 2,660  | 400   | 16,600 |
| Zone   | Semester II | 6,550        | 1,785<br>(220)  |            |         | (4,205)   | (4,425)           |  |       |        |
| Total  | Semester I  | 18,990       | 1,270<br>(375)  | 2,370      | 2,060   | 10,200    | 34,890            | 4,880  | 1,330 | 41,100 |
|        | Semester II | 15,070       | 5,190<br>(375)  | (60)       | (440)   | (10,200)  | (11,075)          |  |       |        |

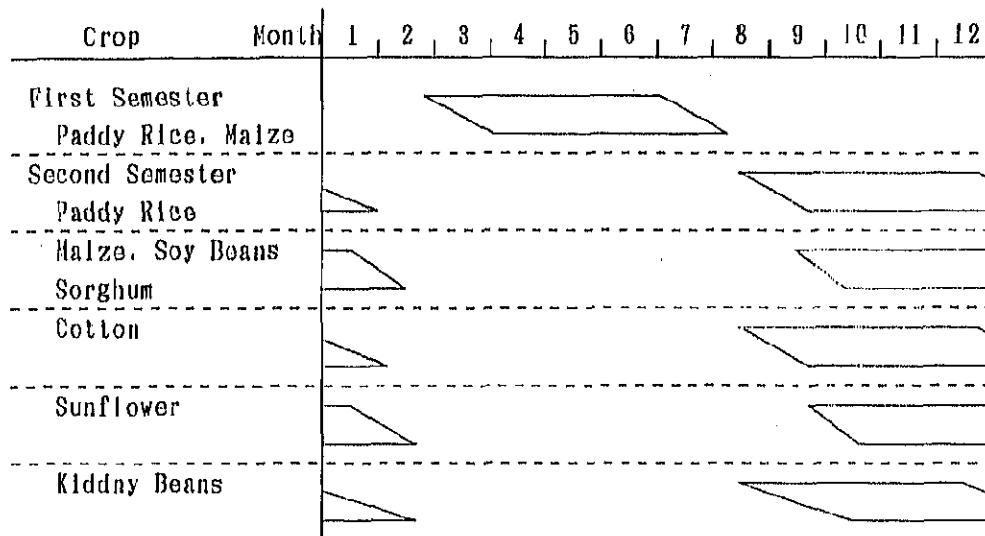
Note: Figures in parenthesis represent extension of dry land

2) Farming system plan

With the provision of irrigation system, no arable land will be left in fallow in the dry season, and the cropping intensity will rise from 135% to 158%. An efficient application of fertilizers and chemicals together with an adequate water management is envisaged in paddy fields.

Cropping calendars and target yields are as given below.

CROPPING CALENDARS



### TARGET UNIT YIELD

|                    | Actual<br>Situation | With Project |
|--------------------|---------------------|--------------|
| Crops (ton/ha)     |                     |              |
| Rice               |                     |              |
| Paddy              | 4.1                 | 5.5          |
| Upland rice        | 3.3                 |              |
| Other Annual Crops |                     |              |
| Maize              | 1.6                 | 2.0          |
| Soybean            | 1.6                 | 1.8          |
| Sorghum            | 2.6                 | 3.0          |
| Others *1          | 1.0                 | 1.5          |
| Perennial Crops    |                     |              |
| Plantain           | 6.0                 | 10.0         |
| Cacao              | 0.45                | 0.63         |
| Papaya             | 20.0                | 22.0         |
| Oil palm           | 1.8                 | 3.8          |
| Others *2          | 2.0                 | 17.0         |
| Cattle (kg/ha)     | 202                 | 260          |

\*1: Represented by cotton

\*2: Represented by maracuya

### 3) Agro-products marketing plan

With an implementation of the Project, the output of agro-products will increase three times as much as the actual situation. Nevertheless, in view that more labor force is demanded for farming activity, substantial surplus labor force for the agro-industry will not be available. Under the situation, it is recommended that marketing and processing facilities should be developed in or around urban area of the municipality of Granada. Furthermore, the CESCO project which envisages the combine development programs and projects proposed by cooperatives existing in the Ariari Region and to form an integrated marketing center is being promoted. The implementation of this CESCO project is expected to contribute to improve marketing system of the area.



#### 4) Instructional supporting plan

In order to familiarize farmers with irrigation farming and to generate expected project benefits, it is essential that adequate supporting services should be provided to farmers. The following services, among others, are envisaged.

| <u>Description of Services</u>                         | <u>Responsible Institution</u> |
|--|--------------------------------|
| Cropping technology of paddy at model farm             | Fedearroz                      |
| Cropping technology of non-traditional crops           | ICA                            |
| Operation and maintenance of facilities                | HIMAT                          |
| Farm mechanization                                     | SENA                           |
| Management and administration of farmers' organization | SENA/Fondo-DRI                 |

As for farmers' organization, water users' association is proposed.

#### 5) Irrigation and drainage plan

Flood irrigation is proposed as the field irrigation system; borders in parallel with counter lines are to be prepared in paddy field which are to be irrigated by gravity, while uplands will be irrigated in furrow along counter lines.

All crops except pasture will be irrigated in a total area of 23,815 ha and irrigation plan has been established on the basis of the return period of one for five years. In accordance with land use and cropping plans and considering climatological and soil conditions, the crop water requirement is calculated for each zone. The maximum water requirements, which falls on January, reaches 36.7m<sup>3</sup>/s.

The irrigation network has been designed in such a manner as to construct more facilities to cross over caños, to save the length of main canals, and to install more dense branch canals.

On the other hand, as to drainage system, existing caños will be used as the main canal system. Land located along caños and are subject to frequent flooding shall be alienated from development area. Drainage plan within fields is established on the basis of 1/5 year return period. The allowable flooding time shall be 24 hours for paddy and 4 hours for upland, but shall not be longer than 4 hours, for the Project area is featured by mixture of paddy field and upland.

As a result of study on drainage capacity at major points of caños, it has been disclosed that rehabilitation work is necessary for caños of Venado and Avichule.

#### 6) Rural infrastructure plan

Rural infrastructure has a nature to serve for public interests, thus it is not a practical way to include their investment cost into the cost for the Project, because the whole Project cost is repaid by farmers. In addition, within the context of the PNR, relevant institution is conducting development of rural infrastructure in its respective responsible field. All of these considerations lead to conclude that rural infrastructure other than road system which is directly associated with agricultural production shall not be contemplated in the Project.

It is judged that the density of road network which comprises existing provincial road (trocha) and farm road (privately owned) and proposed access road along canals and in-farm road will be sufficient in terms of quantity. On the other hand, so as to satisfy qualitative development, a simple pavement for the Trocha 4 is recommended to be included in the Project. Development of the provincial roads will be entrusted to FNCV.

Both access road and in-farm road proposed in the Project shall be paved with gravel.

7) Land conservation and disaster prevention plan

Damage or loss of farmland due to flooding and bank erosion of the Guape and Ariari rivers is a major component of disaster prevailing in the Project area.

The majority of lands subject to frequent flooding is covered by unproductive trees and bushes in the upper and middle zones. Meanwhile in the lower zone, these lands will be used as a plantation for plantain. Damages caused by flooding in these lands are negligible and flood mitigation plan shall not be proposed in the Project accordingly.

Land erosion is very common in both banks of the Guape and Ariari rivers and an immediate rehabilitation work is required in connection with the following three sections which are on the point of land loss.

- 1.0km upper and lower reach from Puerto Caldas
- 1.0km in which Trocha 5 contacts the Ariari river (Caño Uenado)
- 2.0km around La Cooperativa

#### 4.5 FACILITIES PLAN

Features of facilities designed in the Project are as summarized below.

1) Headworks

| Facilities     | Item   | Dimensions                     |
|----------------|--------|--------------------------------|
| Fixed Weir     | Length | : 187m, Width: 24m, Height: 3m |
| Movable Weir   | Length | : 10m, Width: 27m, 2 sets      |
| Riprap         | Length | : 15m, Width: 210m             |
| Intake         | Width  | : 5m, Height: 2m, 5 sets       |
| Settling Basin | Length | : 50m, Width: 45m              |

## 2) Irrigation structures

| Facilities          | Item     | Dimensions                       |
|---------------------|----------|----------------------------------|
| Principal Canal     | Length   | : 94.9km (2 lines)               |
|                     | Gradient | : 1/950 - 1/4,050                |
|                     | Section  | : refer to Fig. 4-5-2            |
|                     | Lining   | : Concrete lining and unlined    |
| Secondary canal     | Length   | : 113.0km (29 lines)             |
|                     | Gradient | : 1/700 - 1/3,400                |
|                     | Section  | : refer to Fig. 4-5-2            |
|                     | Lining   | : Concrete lining and unlined    |
| Drop Structure      | Place    | : 356                            |
|                     | Head     | : 1.0 - 2.0m                     |
|                     | Type     | : Water Cushion Type             |
| Diversion Structure | Place    | : 6                              |
|                     | Type     | : Longitudinal separation Type   |
| Culvert             | Place    | : 138                            |
|                     | Span     | : 3.5 - 14.5m                    |
| Inverted Siphon     | Place    | : 161                            |
|                     | Type     | : Box Culvert, Pipe (RC) Culvert |

## 3) Drainage canal

| Canal    | Length (km) | B1 (m) | B2 (m) | H1 (m) | Gradient of Canal | Design Flood Discharge (m <sup>3</sup> /s) |
|----------|-------------|--------|--------|--------|-------------------|--|
| Avichure | 5.0         | 2.5    | 6.5    | 2.0    | 1/2,000           | 6.0  |

## 4) Terminal facilities

| Facilities     | Dimension                          | Length |
|----------------|------------------------------------|--------|
| Tertiary Canal | B: 0.5m, H: 0.6m                   | 5m/ha  |
| Terminal Canal | B: 0.3m, H: 0.5m                   | 20m/ha |
| Terminal Drain | B: 0.5m, H: 0.6m                   | 20m/ha |
| Farm Road      | T.W: 4.0m<br>Type: Gravel Pavement | 15m/ha |

#### 5) Revetment Works

| Location       | Item              | Dimension |
|----------------|-------------------|-----------|
| Puerto Cardas  | Length<br>Section | 1,000m    |
| Caño Venado    | Length            | 1,000m    |
| La Cooperativa | Length<br>Section | 2,000m    |

#### 6) Roads

| Item            |      | Trocha 4 | Service | Road   | Farm Road |
|-----------------|------|----------|---------|--------|-----------|
|                 |      |          | Type A  | Type B |           |
| Total Width     | (m)  | 8.0      | 8.0     | 6.0    | 4.0       |
| Effective Width | (m)  | 6.0      | 6.0     | 4.5    | 3.0       |
| Pavement        |      | Asphalt  | Gravel  | Gravel | Gravel    |
| Pavement Thin   | (cm) | 7        | 20      | 20     | 20        |

| Description             | Cost       |           |            |
|-------------------------|------------|-----------|------------|
|                         | F/C        | L/C       | Total      |
| Construction Cost       | 9,381,480  | 7,658,149 | 17,038,29  |
| Land Acquisition Cost   | 0          | 205,216   | 205,216    |
| Procurement Cost of O/M | 694,356    | 0         | 694,356    |
| Administration Cost     | 0          | 90,063    | 90,063     |
| Engineering Fee         | 1,353,357  | 529,581   | 1,882,938  |
| Sub-total               | 11,429,193 | 8,483,009 | 19,912,202 |
| Physical Contingency    | 1,509,608  | 1,210,487 | 2,720,095  |
| Total                   | 12,938,801 | 9,693,496 | 22,632,297 |

#### 4.6 COMPONENTS OF THE PROJECT

In view that an integrated rural development including amelioration of living standard for rural population may come true, it is advisable that the Project should comprise not only irrigation and drainage sector but also such high-priority components in the social infrastructure sector as pavement of

rural roads and rehabilitation of the banks in the Ariari river. Nevertheless, an obstacle to implement this integrated project is that any project under the responsibility of HIMAT should be covered all of its investment by its beneficiaries. Therefore, if road improvement and bank rehabilitation works, which are featured by high contribution to unclassified public interest, are included in the present Project, heavier burden will be imposed on farmers (in particular, small and medium farmers) within the Project area.

Bearing above consideration in mind, the Project to be implemented by HIMAT shall comprise exclusively irrigation and drainage sector, and road pavement and bank rehabilitation will be entrusted to other agencies concerned.

#### 4.7 PROJECT COST

The total project cost is estimated at Col\$18,457 million, of which the foreign currency portion covers Col\$10,425 million (56%) and the local currency portion covers Col\$8,032 million (44%). Breakdown of the total project cost is as follows:

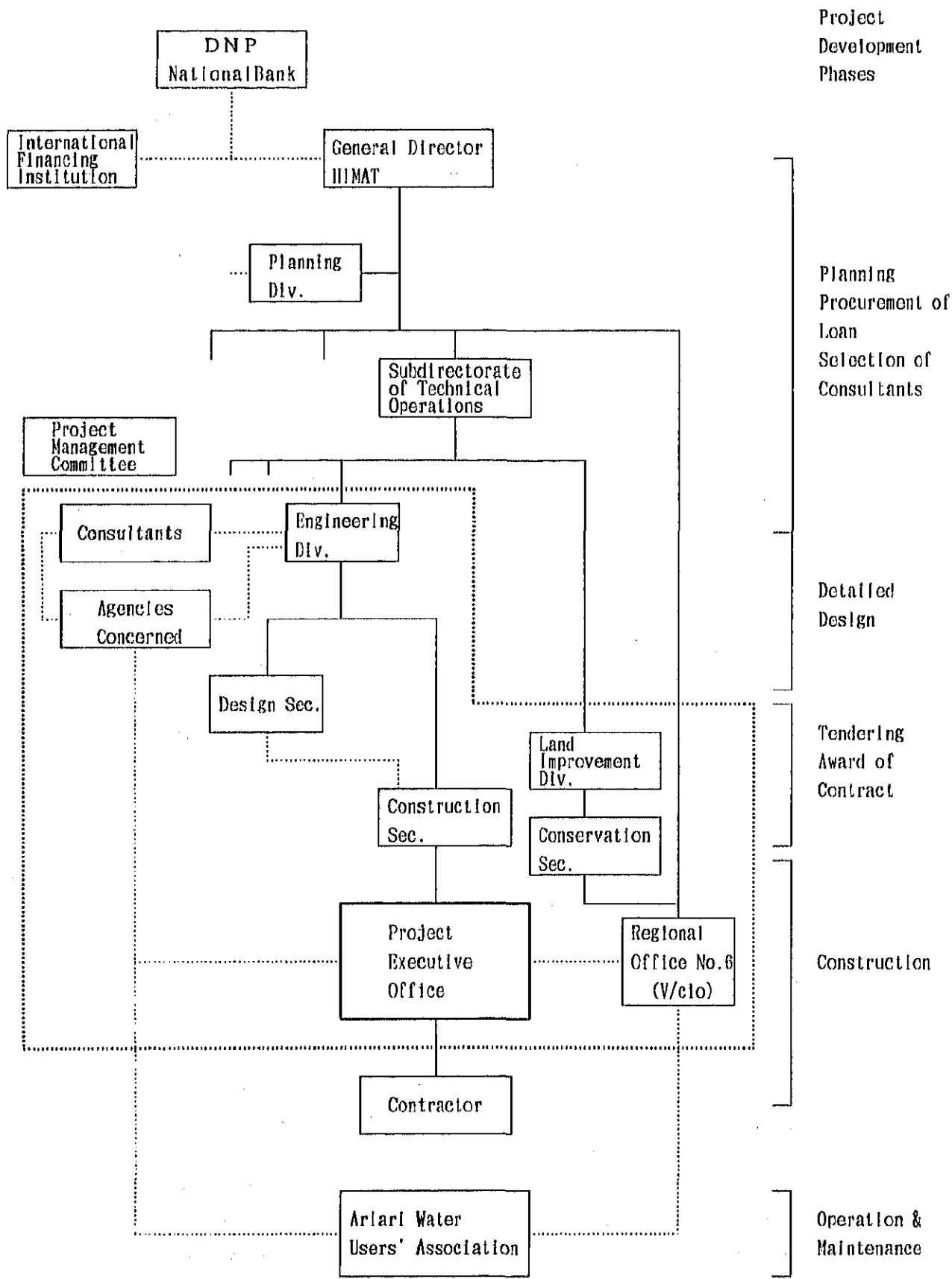
Unit: 1,000 Col.\$  
(1,000 U.S.\$)

| Items                         | Foreign<br>Currency<br>Portion | Local<br>Currency<br>Portion | Total                  |
|-------------------------------|--------------------------------|------------------------------|------------------------|
| 1. Construction Cost          | 7,195,918<br>(21,638)          | 6,213,004<br>(18,682)        | 13,408,992<br>(40,320) |
| 2. Land Aquisition Cost       | 0                              | 205,216<br>(617)             | 205,216<br>(617)       |
| 3. Procurement Cost of<br>O/M | 694,356<br>(2,088)             | 0                            | 694,356<br>(2,088)     |
| 4. Administration Cost        | 0                              | 90,063<br>(271)              | 90,063<br>(271)        |
| 5. Engineering Fee            | 1,353,357<br>(4,070)           | 529,581<br>(1,592)           | 1,882,938<br>(5,662)   |
| 6. Sub-total                  | 9,243,631<br>(27,795)          | 7,037,864<br>(21,163)        | 16,291,495<br>(48,958) |
| 6. Physical Contingency       | 1,181,773<br>(3,554)           | 993,716<br>(2,988)           | 2,175,489<br>(6,542)   |
| Total                         | 10,425,404<br>(31,349)         | 8,031,580<br>(24,151)        | 18,456,984<br>(55,500) |
| %                             | 56.5                           | 43.5                         | 100                    |

## 5. PROJECT MANAGEMENT PLAN

### 5.1 PROJECT IMPLEMENTATION ORGANIZATION

The Project executing agency shall be HIMAT. The rural infrastructure such as road, bank protection and so on will be implemented by other relevant organizations with an eye to diffusing the objective of the Project to farmers in the area as well as expecting more adequate institutional supporting services (credit, technical assistance), the Project Executing Committee shall be established with a participation of farmers at a stage of project planning. Proposed project management organization is as illustrated below.



PROJECT MANAGEMENT ORGANIZATION



## 5.2 PROJECT IMPLEMENTATION SCHEDULE

The whole project period shall be 84 months which consist of 18 months for detailed design, six months for tendering and tender evaluation, and 60 months for construction of civil works. The detailed design period includes topographic survey, geotechnical investigation and preparation of tender documents.

## 5.3 OPERATION AND MAINTENANCE PLAN

The task for operation and maintenance (O/M) of completed irrigation and drainage facilities shall be entrusted to water users' association. It is prerequisite that institutional supporting services should be rendered by HIMAT and other related organizations such as Fedearroz, ICA and SENA covering a period sufficiently long to ensure that the experience necessary for efficient management can be imparted to responsible persons of the association.

## 6. PROJECT EVALUATION

### 6.1 EVALUATION CRITERIA

- The evaluation of the Project shall cover those items which are directly related with agricultural production.
- The period for which the evaluation will be made shall be 50 years including detailed design service and construction work.
- The currency used for the project evaluation is Colombian peso. The exchange rate of Colombian peso to U.S. dollar is US\$1=Col\$332.56 which is the average rate in December 1938.
- Economic price of inputs is calculated multiplying their market prices by 0.7.

## 6.2 ECONOMIC EVALUATION

The economic internal rate of return (EIRR) of the Project has been calculated at 17.2% and B/C ratio at 1.27 subject to the discount rate of 12%.

## 6.3 FINANCIAL EVALUATION

The financial internal rate of return (FIRR) is calculated at 23.4% and the B/C ratio at 1.60 using the discount rate of 12%.

## 6.4 SENSITIVITY ANALYSIS

A sensitivity analysis has been made to know how the result would be affected by changes in such crucial factor as price and yield of agro-products, production and construction cost, and combination of these changes. The result of sensitivity analysis is summarized below:

| Factors   | EIRR | FIRR |
|---|------|------|
| (1) Basic   | 17.2 | 23.4 |
| (2) Construction cost increased by 10%                | 15.9 | 21.8 |
| (3) Construction cost reduced by 10%                  | 18.7 | 25.3 |
| (4) Price and yield of agro-products increased by 15% | 20.5 | 27.2 |
| (5) Price and yield of agro-products reduced by 15%   | 13.6 | 19.3 |
| (6) Production cost increased by 15%                  | 15.9 | 22.1 |
| (7) Production cost reduced by 15%                    | 18.4 | 24.8 |
| (8) Combination of favorable three factors            | 23.4 | 30.7 |
| (9) Combination of unfavorable three factors          | 11.3 | 16.5 |

## 6.5 FINANCIAL ANALYSIS

It is assumed that foreign currency portion of the Project will be covered with loan from international banking institution. Provided that repayment conditions of the loan is incorporated as annual interest rate of 7%, grace period of 5 years and an amortization period of 25 years, the maximum annual repayment amount including interest will reach US\$4,322 thousand.

As a result of profit and loss analysis carried out on model farms - they selected among existing farmers in the area considering farming pattern and farm size -, it has been concluded that any model farm will enjoy an improvement of economic situation and be able to repay construction cost of facilities. .

#### **6.6 EVALUATION OF SOCIO-ECONOMIC IMPACT**

The implementation of the Project will directly contribute to an increase of agricultural production, generating job opportunity for both family and hired labor, and stable farming practice. The indirect contribution of the Project may be enumerated as follows:

- Living standard of farmers will be enhanced owing to far more stable flow of income;
- Expansion of the trade of inputs will activate the economic activity of adjacent areas; and
- The project, as pilot project for the future development of the Eastern Plains, become an example for regional and national development.

#### **6.7 ENVIRONMENTAL EVALUATION**

The Project is an agricultural development project with attention paid to improvement of arable land with provision of irrigation system, and exploitation of existing forests and caños is alienated from development concept of the Project. In this connection, there will not be a substantial change in terms physical feature of the area, thus the quality of water, air and soil will not be deteriorated badly. Furthermore, healthy environmental circumstances can be preserved during the construction period with adequate construction supervision practice.

## **6.8 COMPREHENSIVE EVALUATION**

The Project will bring an increase of agricultural production associated with expansion of cultivated area, elevating cropping intensity and increase of unit yield, consistent supply of food, and generation of more job opportunity and elevation of income level, and these factors combined will contribute for the enhancement of living standard of the people living within and adjacent to the project area. The implementation of the Project will have positive impact on improvement of public welfare and productive activity, and on the national economy accordingly.

The above consideration leads to the conclusion that the implementation of the Project is justified from economic and financial evaluations for which tangible benefits were employed. In addition, enough socio-economic effects are also expected.

## **7. RECOMMENDATIONS**

### **7.1 EARLIER COMMENCEMENT OF THE PROJECT**

In view of the socio-economic impact of the Project not only the Project area but also on the national economy, a recommendation will be made for the immediate commencement of the Project.

### **7.2 SCOPE OF THE PROJECT**

Under the prevailing practice in Colombia, tertiary facilities are developed by farmers themselves. The expected benefits of the present Project will not be attained until these tertiary facilities are provided together with main and secondary works. Thus, it is advisable that HIMAT's supervisory services should be extended to tertiary facilities. In addition, the Project cost for such works of highly public interests as road improvement and river bank protection should not be imposed on farmers and should be, in general, excluded from farmers' obligation accordingly.

### 7.3 PROJECT MANAGEMENT ORGANIZATION

Although HIMAT shall be a core organization responsible for project management, it is essential that collaboration will be provided by other agencies like MOPT, Departmental Office of Meta. Thus, it is recommended that a project executive committee should be incorporated with participants composed of responsible person of each organization. In particular, in connection with improvement and rehabilitation of roads to be implemented by MOPT, a coordination will be made within the committee so that demarcation of each organization may be clearly defined and implementation of works may be facilitated.

In this Project, participation of local population is indispensable in such fields as acquisition of construction site, etc. Therefore, it is advised that an organization in which local population can be joined at planning stage of the Project should be established and institutional supporting services such as formation of a water users' association, extension and technology assistance of irrigation farming should be provided as earlier as possible.

### 7.4 MITIGATION OF BURDEN FOR FARMERS

In compliance with governing law in Colombia, all project cost shall be imposed on beneficiaries of the Project. Nevertheless, as far as relevant laws and regulations permit, it is advisable that some measures in favor of small farmers should be taken; an example of this measures is credit services with longer amortization period and inferior interest rate.

### 7.5 DETAILED DESIGN

In advance to conducting detailed design for major structures and irrigation and drainage canals, it is prerequisite that detailed topographic survey and geological and geotechnical investigations should be carried out on proposed sites for referred structures.

It is recommended that design criteria for the headworks work should be established after collecting necessary data from hydraulic model test.

#### **7.6 CONSTRUCTION WORK**

Before the commencement of the Project, prudent coordination should be made in respect of land acquisition of proposed sites for construction of facilities.

With an eye to generating benefits as effective and early as possible, an implementation of construction work will be made with first priority given to irrigation facilities.

Farmers whose farming activity will be interrupted due to construction work of the Project should be given a chance to be employed as construction worker.

#### **7.7 OPERATION AND MAINTENANCE OF FACILITIES**

The success of the Project depends largely on how effectively operate and maintain project facilities. This task shall be to the responsibility of an association to be formed by beneficiaries of the Project. In order to reinforce the said association, technical assistance from HIMAT shall be essential at the stage of planning the Project, so that the association may work effectively immediately after structures are available.

#### **7.8 SUPPORTING SERVICES TO FARMERS**

The integration and re-structuring of technical assistance and research sector is desirable so that an effective supporting services should be rendered consistently to farmers. In particular, to cope with expansion of irrigation farming, it is recommended that model farms should be established within the Project area.

Tertiary facilities within fields are to be developed by farmers, so loan with longer repayment period and lower interest rate in favor of financially handicapped farmers should be considered. And, an arrangement to respond an increased demand of credit is also required.

At the same time, an improvement of marketing system effective enough to meet the increased output of agro-products and related farmers' organization is expected.

#### **7.9 ENVIRONMENTAL CONSERVATION**

It is forecasted that further progress of development than the actual situation has positive influence on conservation of environmental aspects in the future. Some legal arrangement are necessary lest exploitation of forestal resources should be accelerated.

In order to prevent the deterioration of soil and water quality caused by application of chemicals to fields, it is required that an appropriate cropping technology should be extended to farmers and environmental conservation laws should be enacted as earlier as possible.

As for alleviation of river bank erosion, an immediate measures within the area can not be solved the problem fundamentally. An integrated planning to cover the whole catchment area is of importance.

#### **7.10 EXTENTION OF OBERVATION PERIOD**

Climatological and hydrological data to be collected from instruments installed within this Study is highly attributable not only to the present Project but also to other projects of similar nature. In this regard, a continuous observation of climatological and hydrological behavours is desired.

#### **7.11 HYDROELECTRIC POWER GENERATION**

The topographic conditions in the upper and middle zones are so steep that many drop works are designed within the irrigation network. It is viable to make better use of energies coming from said drops for hydro-electric power generation, in case demand for electric power increases within the area. In such case, an integrated planning for electric power supply should be made coordinating with ICEL, a responsible organization for power supply.



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## ABBREVIATION AND MEASURE

### 1. Organization

|                |  |   |
|----------------|--|---|
| ANUC           | Asociación Nacional de Usuarios Campesinos                         | National Association of Rural Users                                 |
| CAJA AGRARIA   | Caja de Crédito Agrario, Industrial y Minero                       | Agricultural, Industrial and Mining Credit Fund                     |
| CESCO          | Centro Regional de Servicios a la Comercialización                 | Regional Marketing Services Center                                  |
| CIAT           | Centro Internacional de Agricultura Tropical                       | International Tropical Agriculture Center                           |
| CNC            | Compania Nacional de Chocolate                                     | National Chocolate Company  |
| COAGROARIARI   | Cooperativa Agropecuaria de Ariari                                 | Ariari Agricultural and Livestock Cooperation                       |
| COAGROLEJANIAS | Cooperativa Agropecuaria de Lejanías                               | Lejanías Agricultural and Livestock Cooperation                     |
| CRECED         | Centro Regional de Extension Capacitacion y Difusion de Tecnologia | Regional Center for Extension, Training and Diffusion of Technology |
| DANE           | Departamento Administrativo Nacional de Estadísticas               | National Statistics Department                                      |
| DNP            | Departamento Nacional de Planeación                                | National Planning Department  |
| ECOPETROL      | Empresa Colombiana de Petróleos                                    | Colombian Petroleum Enterprise                                      |
| EMSA           | Electrificadora del Meta S.A.                                      | Meta Electric Company   |
| FAO            |  | Food and Agricultural Organization of the United Nations            |
| FEDEALGODON    | Federación Nacional de Algodoneros                                 | National Federation of Cotton Growers                               |
| FEDEARROZ      | Federación Nacional de Arroceros                                   | National Federation of Rice Growers                                 |

|           |  |  |
|-----------|--|--|
| FEDECACAO | Federación Nacional de Cacaoteros  | National Federation of Cacao Growers                               |
| FENALCE   | Federación Nacional de Cultivadores de Cereales                          | National Federation of Cereals Growers                             |
| FFA       | Fondo Financiero Agropecuario  | Agricultural Finance Fund  |
| FNCV      | Fonao Nacional de Camino Vecinal   |  |
| FONAM     | Fondo de Acueductos y Alcantarillados del Meta                           | Meta Water Supply and Sewage Fund                                  |
| Fondo-DRI | Fondo de Desarrollo Rural Integrado                                      | Integrated Rural Development Fund                                  |
| HIMAT     | Instituto Colombiano de Hidrología, Meteorología y Adecuación de Tierras | Colombian Institute of Meteorology, Hydrology and Land Improvement |
| ICA       | Instituto Colombiano Agropecuario  | Colombian Institute of Agriculture and Livestock                   |
| ICEL      | Instituto Colombiano de Energía Eléctrica                                | Colombian Institute of Electric Energy                             |
| IDEMA     | Instituto de Mercadeo Agropecuario                                       | Agricultural Market Institute                                      |
| IGAC      | Instituto Geográfico Agustín Codazzi                                     | National Geographic Institute                                      |
| INCORA    | Instituto Colombiano de la Reforma Agraria                               | Colombian Institute of Agrarian Reform                             |
| INDERENA  | Instituto de Recursos Naturales Renovables                               | National Institute of Renovatable Natural Resources                |
| JICA      |  | Japan International Cooperation Agency                             |
| MOPT      | Ministerio de Obras Públicas y Telecomunicación                          | Ministry of Public Works and Telecommunication                     |
| PROCAME   | Procesadora de Cacao del Meta S.A.                                       | Cacao Processing Company   |
| SENA      | Servicio Nacional de Aprendizaje   | National Apprenticeship Service                                    |

|                     |   |  |
|---------------------|---|--|
| USDA                |   | United States Department of Agriculture                        |
| USOCOELLO           | Asociacion de Usuarios de Riego del Río Coello  | Beneficiary's Association of Coello River Irrigation District  |
| USOSALDAÑA          | Asociación de Usuarios de Riego del Río Saldaña | Beneficiary's Association of Saldaña River Irrigation District |
| <b>2. Plans</b>     |   |  |
| PNR                 | Plan Nacional de Rehabilitación                 | National Rehabilitation Plan                                   |
| <b>3. Chemistry</b> |   |  |
| EC                  |   | Electric Conductivity  |
| PH                  |   | Hydrogen Ion Concentration                                     |
| SAR                 |   | Sodium Absorption Ratio  |
| <b>4. Economy</b>   |   |  |
| B/C                 |   | Benefit Cost Ratio   |
| CIF                 |   | Cost, Insurance and Freight                                    |
| EIRR, TIER          | Tasa Interna Economica de Retorno               | Economic Internal Rate of Return                               |
| FIRR, TIFR          | Tasa Interna Financiera de Retorno              | Financial Internal Rate of Return                              |
| FOB                 |   | Free on Board  |
| GDP, PIB            | Producto Interno Bruto                          | Gross Domestic Product   |
| GRP, PRB            | Producto Regional Bruto                         | Gross Regional Product   |
| IVA                 | Impuesto al Valor Agregado                      | Value Added Tax  |
| NPV, VAN            | Valor Actual Neto                               | Net Present Value  |

## 5. Length

|    |   |            |
|----|---|------------|
| mm | : | millimeter |
| cm | : | centimeter |
| m  | : | meter      |
| km | : | kilometer  |

## 6. Area, Volume and Weight

|                 |   |                   |
|-----------------|---|-------------------|
| cm <sup>2</sup> | : | square centimeter |
| m <sup>2</sup>  | : | square meter      |
| km <sup>2</sup> | : | square kilometer  |
| há              | : | hectare           |
| l               | : | liter             |
| G               | : | galon             |
| m <sup>3</sup>  | : | cubic meter       |
| g               | : | gram              |
| kg              | : | kilogram          |
| t               | : | ton               |
| Saco            | : | saco = 62.5kg     |

## 7. Derived Measures

|  |   |   |
|--|---|---|
| m/s, m/sec                             | : | meter per second                          |
| m <sup>3</sup> /s, m <sup>3</sup> /sec | : | cubic meter per second                    |
| t/há, ton/há                           | : | ton per hectare                           |
| m <sup>3</sup> /km <sup>2</sup>        | : | cubic meter per square kilometer          |
| mm/día                                 | : | millimeter per day                        |
| m <sup>3</sup> /km <sup>2</sup> /año   | : | cubic meter per square kilometer per year |
| l/s, l/sec                             | : | liter per second                          |
| t/há                                   | : | ton per hectare                           |

## 8. Electric Measures

|     |   |               |
|-----|---|---------------|
| KW  | : | kilowatt      |
| KV  | : | kilovolt      |
| KWH | : | kilowatt-hour |
| GWH | : | gigawatt-hour |

## 9. Currency

|       |   |                      |
|-------|---|----------------------|
| US\$  | : | United States Dollar |
| Col\$ | : | Colombian Peso       |
| ¥     | : | Japanese Yen         |

## 10. Temperature, Height, etc.

|          |   |                       |
|----------|---|-----------------------|
| °C       | : | degrees in centigrade |
| m.a.s.l. | : | meter above sea level |
| EL., GL. | : | elevation             |
| %        | : | percent               |
| N°       | : | number                |
| HP       | : | horsepower            |
| caño     | : | small stream          |





CHAPTER 1

INTRODUCTION



## CHAPTER 1: INTRODUCTION

### 1.1 BACKGROUND OF THE STUDY

The Economic and Social Development Plan and Programs 1987-1990, which has been elaborated under the present Barco Administration as fundamentals to materialize its administrative policies, addresses an eradication of absolute poverty; within this context, plans and programs to render assistance to poor peasants who produce nothing more than self-consumable crops and to farmers who live in depopulated rural area alienated from regional development are envisaged so as to ameliorate living conditions of these peasants and farmers and to activate regional economic performance. Pursuant to this policy, HIMAT (Instituto Colombiano de Hidrologia, Meteorologia y Adecuacion de Tierras), the executing agency in charge of development and operation of agricultural infrastructure, incorporated definite development strategies (November 1986) and has examined land improvement projects to be implemented in coming four years. In particular, a high-priority is placed on the development of piedmont area located in the plains of the Llanos Orientals Region in view that: 1). neither public nor private sector has scarcely invested despite high development potentials endowed to the area, 2). generally speaking, agricultural activity has been in small scale and under-developed, 3). with stable provision of water resources, the expansion of agricultural output in efficient manner and shorter period is viable and 4). geographical advantage in terms of marketing agricultural products is prominent. Under these circumstances, it is expected that development projects would be implemented in the area one after another.

Among the candidate projects waiting for implementation, HIMAT has identified the development of the Ariari river basin as the most immediate project and thus requested the Government of Japan to implement a feasibility study of the Project (the Study) under

its technical cooperation program. In response to this request, the Government of Japan through Japan International Cooperation Agency (JICA) dispatched the preliminary survey mission to Colombia, in February, 1988 to discuss and conclude the Scope of Work for the Study. As a result, the Study was started in August, 1988.

## 1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are:

- (1) to formulate an optimum integrated agricultural development plan in the study area;
- (2) to verify technical and socio-economic feasibility of the selected project in the study area; and
- (3) to transfer the relevant technology to Colombian counterparts in the course of the Study.

## 1.3 STUDY AREA

The Study area (the Area) is situated in the western part of the Department of Meta between 3°18' to 3°35' north latitude, and 73°30' to 74°03' west longitude. The Area is extended from the northwest to the southeast along the Ariari and Guape rivers, principal tributary of the first, with approximately 66.5km of longitude and 12.5km of width in maximum, covering an area of approximately 41,100ha. According to administrative jurisdiction the Area is divided into the following three zones:

|  |          |
|--|----------|
| Municipality of Lejanias (the Upper Zone)      | 9,100ha  |
| Municipality of Granada (the Middle Zone)      | 15,400ha |
| Municipality of Fuente de Oro (the Lower Zone) | 16,600ha |

---

|       |          |
|-------|----------|
| Total | 41,100ha |
|-------|----------|

#### 1.4 SCOPE OF THE STUDY

The Study items for 1988, 89 and scope of the Study are as follows:

- (1) Preparatory Work in Japan
  - Establishment of basic approach and methodology of the Study
  
- (2) Phase I of the Study (21/August - 31/October, 88)
  - 1) Field Work in Colombia
    - Collection and analysis of data and information
    - Field survey
    - Identification of constraints and potentials of development
  
  - 2) Home Office Work in Japan
    - Analysis of data and information collected
    - Analysis of the field work
    - Formulation of basic concepts and development plans
  
- (3) Phase II of the Study
  - 1) Field Work in Colombia (31/January - 28/Maroh, 89)
    - Additional collection and analysis of data and information based on the basic development plans
    - Supplementary detailed field survey based on the basic development plans
  
  - 2) Home Office Work in Japan
    - Formulation of the development plan, implementation plan and schedule
    - Estimation of the Project cost and benefits
    - Project evaluation
    - Recommendation of the Project

(4) Reporting

- Explanation and discussion of the draft final report
- Preparation of the final report

CHAPTER 2

NATIONAL  
AND REGIONAL  
SOCIO-ECONOMIC  
BACKGROUND





## CHAPTER 2: NATIONAL AND REGIONAL SOCIO-ECONOMIC BACKGROUND

### 2.1 CHARACTERIZATION OF THE REPUBLIC OF COLOMBIA

#### 2.1.1 Physical and Socio-economic Features

The Republic of Colombia lies to the north-western edge of the South American Continent with the latitude  $4^{\circ}13'30''S$  -  $12^{\circ}26'46''N$  and the longitude  $66^{\circ}50'54''W$  -  $79^{\circ}02'33''W$ . The territorial extension is 1.14 million  $km^2$ , which is divided into 23 departments, 4 intendancies and 5 commissaries.

According to topography and climate, the country can be split up into six regions: Caribe, Pacific, Andean, Amazon, Eastern Llanos and San Andres y Providencia. These regions are delimited by Eastern, Central and Western Mountain Ranges that stretch the country from north to south.

Colombia, located in the torrid zone, has no clearly distinguished seasons. But it offers several different climates which vary according to altitude. The hot region, from sea level to 1,000m above sea level, has an average temperature of 24 to 26°C. Temperate zone with an altitude in the range of 1,000 - 2,000m above sea level has an average temperature between 17°C and 24°C. The cold region, whose altitude varies from 2,000m to 3,000m above sea level is featured by an average temperature of 8 - 17°C. There are also perpetual snow region located higher than 4,000m above sea level.

According to the National Census conducted in 1985, Colombia had a population of 27,867 thousand which had been growing at an annual rate of 2.52% since 1973. The population of the Special District of Bogota was 3,983 thousand occupying 14.3% of the national population. The population of Bogota had increased at a remarkably high pace of 7.3% per annum between 1964 and 1973 as a result of vast flow of immigrants from other parts of the

country, but the pace had slowed down from that time on reducing an average growth rate to 2.81% for the period of 1973 - 1985. Urban population accounted for 67.2% of the total population.

The distribution of Colombian population by age group is as follows: 37.5% (0 - 14 years old), 56.5% (15 - 60 years old) and 6.5% (older than 60 years). And the economically active population (in Colombia people older than 12 years are taken into account) was estimated to be 19,336 thousand in 1985. The rate of unemployment in four biggest cities (Bogota, Medellin, Cali and Baranquilla) was in the level of 12.5% as of December 1986.

The imbalance of income level among people is prominent and it is reported that urban employees get disposable household income three times as much as laborers. Legal minimum wage as of January 1987 was Col\$683.66/day. An average household expenditure was around Col\$85,000/month (1984 - 1985) and the Engel's coefficient was estimated at 25%.

Colombian Gross Domestic Product (GDP) had grown at an average rate of 5.7% yearly in the 1970s, but from 1980 to 1985, as a consequence of world-wide recession, its growth was decelerated to as low as 2.1% per annum. In 1986 and 1987, the Colombian economy recovered from the said sluggish performance obtaining an annual growth rate of 5.1% and 5.4%, respectively.

Referring to preliminary estimate of DANE (current price base), major sectors which contributed greatly to GDP formation are: manufacturing (23.6%), agriculture, forestry and fishery (17.1%), commerce (13.4%) and personal and governmental services (12.4%). On the other hand, higher annual growth rate was recorded during 1970 - 1987 in order of: communications (10.9%), electricity, gas & water (6.9%), fishery (6.5%) and construction (5.7%). Manufacturing and agriculture, forestry and fishery--the two key sectors of GDP--had been slack in the period obtaining such inferior growth rate as 4.3% and 3.3%, respectively. These figures are below GDP's average rate of 4.4%.

External trade in Colombia is represented by agriculture and mining sector for exports and raw materials and capital goods for imports. From 1981 to 1984, deficit in foreign trade had been registered due to depressed price of coffee in the international market, but in 1985 the government's imports restriction policy had driven the situation to positive. Furthermore, the largest trade balance of US\$1,992 million was recorded in 1986 owing to "coffee bonanza"--sharp appreciation of international price on account of worsened output of Brazilian products. The current account balance which comprises services and transfers in addition to trade balance also achieved surplus in 1986 after five-year (1981 - 1985) continuous loss. The balance of payments for the same year accounted for a surplus of US\$1,464 million. In 1987, a surplus of trade balance dwindled by US\$54 million on account of increase in imports. Consequently, the balance of payment turned down to deficit again for the year.

The net international reserve as of September 1988 was US\$3,673 million, which is US\$2,000 million fewer than the highest level of 1981. The external debt has been increasing in Colombia with higher pace than the growth of GDP and its percentage to GDP ascended to 42% in 1987.

Since 1967 Colombia implemented an exchange control system, under which the Central Bank has total control or a monopoly of foreign exchange entering or leaving the country. The exchange rate is set at the discretion of the Central Bank, which adjust it in view of maintaining a constant real exchange rate. As of December 1988, an average exchange rate of Colombia peso against US dollar was 332.5.

The largest trade partner of Colombia is the U.S.A.; the Colombia - U.S.A. trade represented 30% in total exports and 34% in imports for the year of 1986. Other countries which participated major portion in trade with Colombia are West Germany, Netherland, Japan and Venezuela as export partners, and Japan, West Germany, Venezuela and Spain as import partners.

Since the middle of the 1970s, a major concern of Colombian government has been directed toward stabilization of consumer price. The rate of inflation, although it is by no means low, had been maintained in such a relatively moderate level as in the range of 16.6% (1983) and 28.8% (1979) for the last decade in comparison with other Latin American countries. Food price has been always fluctuated higher than other commodities, thus the stabilization of prices in Colombia depends on the behavior of food price.

Colombia had long known for its prudent management of public finance, which had been maintained in surplus from 1976 to 1980. In recent years, however, the Government's financial situation became distressed because of expansion of public expenditure and high ratio of tax evasion. In 1987 the deficit of public finance reached Col\$89,956 million, which is 1.3% of GDP.

#### 2.1.2 Agricultural Aspects

##### (1) GDP and the agricultural sector

In 1987, according to the preliminary estimate of the Central Bank, the agricultural sector including forestry and fishery generated Col\$140,411 million at the constant price of 1975. For the last decade (1978-1987), the rate of growth of the sector had been stagnant; the output in the period rose at as low as 2.3% per annum, which was inferior to the yearly growth rate of the GDP (3.1%). Consequently, the participation of the agricultural sector in GDP fell down from 38% in 1950 and 29% in 1970 to 22% in 1987.

##### (2) Land use and land tenure

It is estimated that about 14.4 million ha of land in Colombia, or equivalent to 12.6% of the national territory (114 million ha) is arable for agricultural purpose, whereas land capable for pasture corresponds to 19.3 million (16.9% of the total). On the

other hand, in 1985 crops harvested area and grazing or rough grazing land accounted for 3.9 million ha and 22.6 million ha, which intimates that there remains considerable margin of arable land for the expansion of agricultural production and some portion of them is actually used for grazing land due to the lack of infrastructure or other reasons.

Land tenure by size in the national level is, like in other Latin American countries, characterized by imbalanced distribution; small and medium land owners with holding less than 10 ha represent 78.1% of the total number of properties but only 8.8% of the total rural land, while 60.8% of the rural lands is held by only 3% of the land owners with holding more than 100 ha.

### (3) Agricultural output

Coffee, the mainstay of the Colombian economy, accounted for close to 20% of the total value of crop production in 1987. Next to coffee, following crops registered higher contribution to national production value of crops: sugarcane (8.9%), plantain (8.3%), "panela" (7.2%), potato (7.1%) and rice (6.6%).

The crops which showed a higher growth in production for the period of 1979 - 1988 are: oil palm (268%), cacao (179%), banana (145%), kidneybean (141%) and cotton (136%). Of these crops, the growth of oil palm, cacao and cotton is attributable to an expansion of harvest area, while an improvement of unit yield has brought increase of production for the case of banana and kidneybean. On the other hand, a stagnation or recession in production was reported in respect to cassava, soybean, maize and rice. Among these crops, as far as rice is concerned, a decline of harvest area has adversely affected an improvement of unit yield. The inactivity of production for the rest of crops (cassava, soybean and maize) is due to combined stagnation in harvest area and unit yield.

(4) Trade in agricultural products

In 1987, the trade surplus of agricultural sector reached US\$1.97 million. This surplus owed in its great majority to coffee; if coffee is excluded from consideration, the surplus in agricultural sector would be reduced to as little as US\$318 thousand.

Up to 1960, the participation of coffee in total national exports had been more than 90% in value terms and coffee contributed greatly to finance the government's budget. In recent years (1982 -1985), because of an expansion of exports other than agro-products, the contribution of coffee to total national exports has reduced to around 50%. Nevertheless, in 1986, coffee share was recovered to as high as 58.5%, attributable to coffee bonanza caused by sharp rise of price in international market which was rooted in the decline of Brazilian products. In contrast with this, in 1987, the contribution of coffee to the total exports reduced to the lowest level (32.9%) in the history because of the slack of international price (US\$1.23/pound compared with US\$2.20/pound in 1986).

In relation with the other agro-products, there has been a large expansion in exportation of banana and cut flowers, while there has been a decline in the share of exports such as cotton, sugar and beef in recent years.

The importation of foods and agriculture-related materials and inputs accounted for 7.2% of the total imports in value terms for 1987, which was declined from 9.6% of average rate for the previous three years 1983 - 1986. A sharp drop in food and agriculture related materials and inputs both in value and volume in 1987 is due to the government's policy of import restriction. With respect to individual product, the share of wheat recorded the highest with the participation of more than one-fourth (25.8%); subsequently, soybean (12.9%), beef fat (5.7%) lentil (4.9%), and soybean oil (4.4%) were much imported in 1987. The

importation of maize and sorghum shows a decreasing tendency. Finally, it is worth while to note that the imported volume of foods had increased at an average rate of 8.5% p.a. between 1970 to 1985, which is considered as a very high pace of expansion considering the yearly population growth rate of 2.5%.

(5) Labor force

In 1984, the agricultural sector provided the greatest opportunity of employment within the country's labor market; it accounted for 33% of the total employment. As the case of contribution to the GDP, the importance of the agriculture sector was reduced relatively in recent years; the participation of the sector, which registered 56% of the nation's a total employment in 1951, declined to 49% in 1964, 35% in 1980, and 33% in 1984, as cited above.

2.1.3 National Development Plan

(1) General

The four year socio-economic development plan (1987 - 1990) envisages an achievement of two targets simultaneously; a less social distortion and a consistent economic growth.

The first will be carried out with a slogan "eradicate absolute poverty" under a social climate of national reconciliation. Investment will be made in the interest of bettering the physical infrastructure in rural and marginal urban areas, and of human resources. The second will be realized by intensification of production base as well as expansion of market, domestic and external.

The average annual increase rate of GDP during the plan period is set at 5% with the average increase of 5 - 6% in employment. Public investment will be focused on social overhead capital and on areas less developed and having strategical importance.

Private investment is desired to increase by tax reform and more liberal foreign investment rules, which were declared at the end of 1986. The real annual increase rate of 6 - 7% in the export income is expected by the efforts of agriculture and mining sectors, in which the value of non-traditional export goods is to be raised by 15% per annum. The domestic demand is expected to be sustained favourably by the efforts of manufacturing and construction sectors.

The main objective of the macro-economic policy is to keep the economy growing while restricting inflation. The rate of deficit of fiscal budget to the GDP is to be below 3%, and the amount of the external debt will be around US\$2 billion per annum. The net borrowing for the plan is 7.3% of the total budget, for the 52.7% of which the government seeks resources outside the country, and domestic for the rest.

## (2) Agriculture Sector

Policies of the agriculture sector aim to recover the dynamism of production and to endow farmers with resources that will permit them to enhance their living conditions and capacity for generating income. Additionally, with a view of attaining consistent economic growth, actions of the Government shall be directed to increase exportable products.

With a view of attaining above-mentioned objective, a total of Col\$273,000 million (4.5% of the total budget) will be allocated to the agricultural sector, which represents an yearly of growth 11%. Of the total budget for the agricultural sector, 21.8% will be financed by external loans.

The sectorial development plan will be implemented by five different institutions affiliated to the Ministry of Agriculture. 24.9% of the budget will go to the Fondo DRI, through which integrated assistance to the farmers are carried out. This budget will be procured equally by domestic and external resources. 22.7% will go to INCORA, which functions as a major



work force of agrarian reform. ICA, the chief agency for research and technology transfer will receive 22.6%, and HIMAT, which aims at improving and preserving the quality of farmland, will get 19.8%.

The budget for the National Plan for Rehabilitation is included in this sector. Those areas which will not be covered by the Fondo-DRI will be taken care of by this provision. The amount reaches Col.\$50,293 million, and is distributed to all the institutions but EMCOPER.

## 2.2 CHARACTERIZATION OF THE DEPARTMENT OF META

### 2.2.1 Physical and Socio-economic Features

The Department of Meta is located in the central part of the Republic of Colombia with latitudes between 1°32'30"N and 4°57'30"N and longitudes between 70°2'30"W and 74°57'00"W.

The total extension of the Department reaches 85,635km<sup>2</sup> (DANE), the second largest department next to Caqueta, covering about 7.5% of the national land. In accordance with topography, the territory of the Department can be divided into the following five sub-regions: Eastern Range (12,300km<sup>2</sup>), Mountain Foot (10,619km<sup>2</sup>), Natural Reserve of the Macarena (11,313km<sup>2</sup>), Savanna (45,301km<sup>2</sup>) and Middle Basin of the Guayabero River (6,100.5km<sup>2</sup>).

The tropical humid climate dominates the whole of the Department. Temperatures are high throughout the year, mean monthly values are in the range of 25°C and 27°C. There are two clearly defined seasons determined by rainfall: rainy season (April - November) and dry season (December - March). Mean annual rainfall fluctuates widely from 4,500mm at the foot of the Eastern Range to 2,000mm in Savanna sub-region.

The Department was created relatively new, in 1959. Presently there are 24 municipalities including the capital city of Villavicencio.

Referring to 1985's national census, the Department had a population of 412,312 inhabitants, of which 174,602 lived in Villavicencio. The population of the Department has been growing rapidly with annual growth rate of 3.85% since 1973, very high pace compared with the national average (2.52%). This high rate of population growth has been brought by accelerated flow of immigrants from other parts of the country; the said census indicates that, of the total population in Meta only 40% were native of the same department (national average was 64%). It is predicted that the population of Meta will rise to around 800,000 in 2,000, if the prevailing growth rate will be kept in the future.

The infrastructure is under-developed in the Department. Relevant to transportation system, the shortage of road network constitutes one of constraints on development of the potentials of Meta. The paved road of 115km which links Villavicencio with Bogota is the only access for the Department to transport its products to the largest consumption market of the Republic. This road, however, is a "bottleneck" for the departmental economy, because, with maximum slope of 16% and innumerable curves, traffic is compelled to be sluggish and it happens to be closed sometimes due to inadequate maintenance. The total length of roads existing as of 1984 was 5,200km of which only 220km (4%) were paved. The principal paved roads passing through the Department are: Villavicencio - Puerto Lopez (83km) and Villavicencio - Granada (85km).

The air traffic communicates Villavicencio with alienated towns from road transportation. However, the majority of air traffic is represented by light aircrafts, the service of which is limited within "Llanos Orientales" with irregular service time. As an exception, jet aircrafts are serving regularly between

Villavicencio and Bogota. Furthermore, fluvial transportation is developed in some parts of the Department but its contribution to the regional economy is negligible.

Of 24 municipalities in Meta, only 9 municipalities actually have access to electric services provided by Electrificadora del Meta (EMSA), subsidiary and regional company of ICEL (Colombian Institute of Electric Energy). The rest are supplying electric power by means of generators. In these municipalities, the benefit of electric service is limited to urban area.

Besides electric power, other social infrastructure such as water supply and sewage treatment system is deficiently provided. The coverage indexes of these three services are inferior to the national average (85's census) and less than half (46.7%) of families in the Department are provided with all these three services (national average is 57%).

In 1982, the GRP of Meta accounted for close to 1.5% of GDP. The agricultural and livestock sector is the mainstay of the departmental economic activity, which shared more than half (53%) of the GRP, and 3.5% of the national agricultural and livestock production. In this connection, the performance of the departmental economy is greatly affected by the agricultural and livestock sector.

This particular case is the economic performance for the year 1986. In this year, due to decline in output (23.5%) of rice and sorghum--the leading products in Meta, the progress of the agricultural and livestock sector was negative, and, consequently, the regional economic performance, as a whole, remained inactive. In the same year, the stagnation of economic vitality was also true in the other sectors such as commerce, construction and mining, except for the exploitation of crude oil which was boosted with a growth rate of 9% from the previous year.

## 2.2.2 Agricultural Aspects

### (1) Agricultural Sector

Endowed with potential and abundant natural resources, the Department of Meta is considered to be one of the leading agricultural regions in the country. It is estimated that about two millions ha of land or equivalent to 23% of the departmental territory is potential land for crop husbandry. Nevertheless, it is worth while to indicate that, of this extension, only 215 thousand ha (10.7%) of land is presently used for agricultural purpose. This fact indicates that there remains a great opportunity to put lands into production in the future.

Rice is a leading crop cultivated in the Department. The output of rice in Meta is the second largest next to Tolima in the national level. However, there is a remarkable difference in terms of cropping practice between these two major regions; in Tolima, close to 100% of rice is produced in irrigated fields, while in Meta about 43% of the same is produced in rain-fed areas. This difference in cropping practice is reflected in the productivity - 5.0 ton/ha in Meta against 6.0 ton/ha in Tolima. The principal production areas of rice are: Villavicencio, San Carlos de Guaroa, Fuente de Oro and Puerto López. Rice, both in irrigated and rain-fed areas, occupies 40% of the total cultivated area of crops in the Department.

Apart from rice, crops accounting for large cultivated area in the Department Area: African palm (15.8%), Sorghum (10.3%), Plantain (8.7%), coffee (7.0%), maize (5.6%) and cacao (4.0%). - (Cifras Agrícolas 1987 - URPA). Of these crops, African palm and cacao contributed largely to the national production with participation of 13.0% and 8.3%, respectively.

(2) Livestock sector

Since vast land is available for grazing, cattle raising is extensively conducted in the Department. This can be supported by the fact that the lands distributed for grazing in Meta are the largest in the country (accounts for 24% of the share), while the number of cattle heads represents only 5.5% of the total number of cattle in Colombia. Thus, in Meta, one cattle occupies on an average of 4.0 ha of grazing land, and five times as extensive as the national average.

Breeds of cattle raised in Meta are represented in their great majority by "Cebu" or its crossing with other breeds. These cattle are bred mainly for meat production, and the dual purpose (meat and dairy) of farming is scarcely practiced.

Regardless of being consumed locally, the principal destination of cattle raised in the Department is Bogotá, where about 60% of meat consumption depends on Meta's cattle. However, cattle are directly transported to Bogotá without being slaughtered and processed and hence the meat and sub-products processing industry has been less developed in Meta.

The sub-sectors of swine and poultry farming and fish production are urban-developed in comparison with cattle farming.

### 2.2.3 Regional Development Plan

The development plans and programs in the Department of Meta is to be implemented through three main channels. Firstly, large-scaled infrastructure development projects such as irrigation, road network, water and mineral resources development, etc. are entrusted to the Central Government or quasi-governmental institutions. On the other hand, smaller size of productive infrastructure development or social infrastructure are the responsibility of the departmental government office and the National Rehabilitation Plan (P.N.R.)

As far as the former is concerned projects are not matured yet in the short run, whereas short-term development projects are already formulated for the latter. For the impulse of the development of Meta, the departmental congress has approved a total of 21 projects to be implemented in the coming three years (1989 - 1991). Of these 21 projects, the following three are considered to be of importance:

- Meta Agro-industry Fund:

to promote development of agro-industry such as meat freezing plant, soyabean processing factory, cassava processing factory, assorted animal fodder production plant, etc.

- Petroleum Fund for Public Works:

with a contribution by ECOPETROL (Colombian Petroleum Enterprise) to promote construction of infrastructure for public interest.

- Meta Water Supply and Sewerage Fund (FONAM):

to facilitate coverage of water supply and sewerage system for all municipalities of the Department.

The P.N.R. is being carried out in the Department since 1986 in line with the National Development Plan. In Meta, the P.N.R. covers eleven municipalities (Cubarral, El Castillo, Fuente de Oro, Granada, La Macarena, Lejanias, Meseta, Puerto Lleras, Puerto Rico, San Juan de Arama and Vistahermosa). These 11 municipalities cover 40% of the departmental extension and 33% of the population. For the period of 1989 - 1991, under the P.N.R., a total of Col\$26.9 billions will be distributed to: economic infrastructure (37.4%), production activity (34.5%), social area (20.8%), social infrastructure (6.8%) and strengthening of public institutions (0.5%).

Table 2-1-1 POPULATION AND ITS GROWTH RATE IN COLOMBIA

| <u>YEAR</u> | <u>POPULATION</u> | <u>ANNUAL AVERAGE GROWTH RATE (%)</u> |
|-------------|-------------------|---------------------------------------|
| 1938        | 8.044             |                                       |
| 1951        | 11.902            | 2.58 (1938-51)                        |
| 1964        | 17.485            | 2.96 (1951-64)                        |
| 1973        | 20.667            | 1.88 (1964-73)                        |
| 1985        | 27.807            | 2.52 (1973-85)                        |

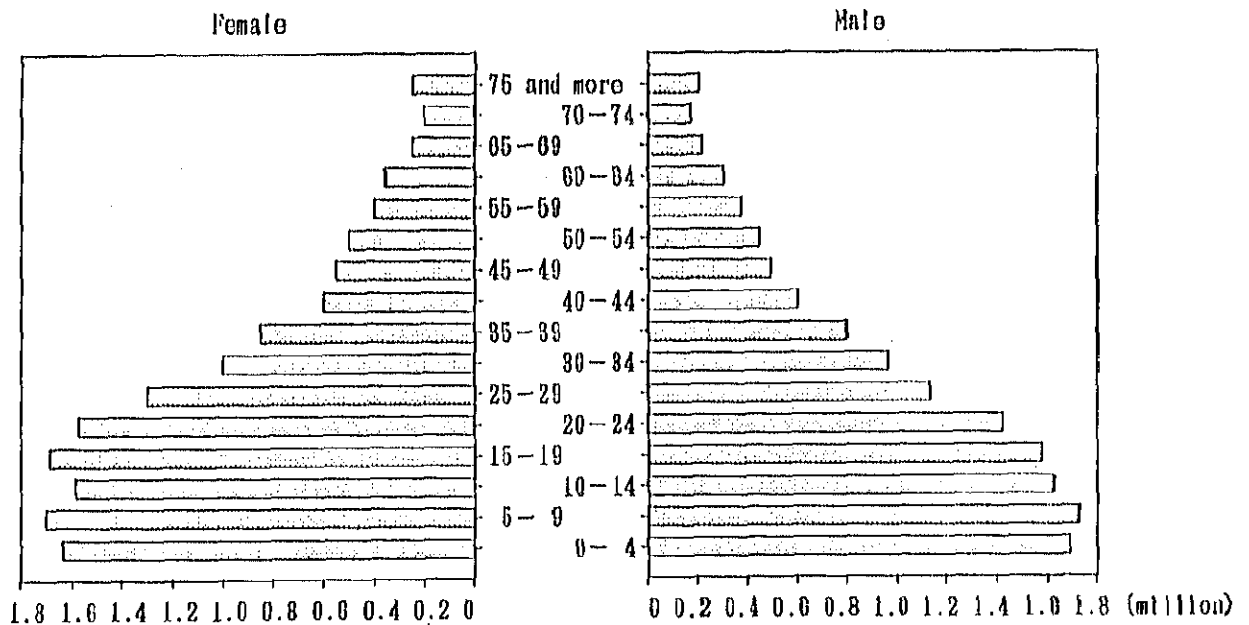


Fig. 2-1-1 Population Pyramid in Colombia (1985)

Table 2-1-2 GROSS DOMESTIC PROJECT

| Year | GDP              |             |                         |             | GDP per Capita |             |                         |             |
|------|------------------|-------------|-------------------------|-------------|----------------|-------------|-------------------------|-------------|
|      | Current Prices   |             | Constant Prices of 1975 |             | Current Prices |             | Constant Prices of 1975 |             |
|      | Million of Col\$ | Variation % | Million of Col\$        | Variation % | Col\$          | Variation % | Col\$                   | Variation % |
| 1970 | 132,768          | -           | 307,496                 | -           | 6,190          | -           | 14,336                  | -           |
| 1971 | 155,886          | 17.4        | 325,825                 | 6.0         | 7,108          | 14.8        | 14,857                  | 3.6         |
| 1972 | 189,614          | 21.6        | 350,813                 | 7.7         | 8,456          | 19.0        | 15,644                  | 5.3         |
| 1973 | 243,160          | 28.1        | 374,398                 | 6.7         | 10,611         | 25.5        | 16,338                  | 4.4         |
| 1974 | 322,384          | 32.6        | 395,910                 | 5.7         | 13,753         | 29.6        | 16,890                  | 3.4         |
| 1975 | 405,108          | 25.7        | 405,108                 | 2.3         | 16,902         | 22.9        | 16,902                  | 0.1         |
| 1976 | 532,270          | 31.4        | 424,263                 | 4.7         | 21,728         | 28.6        | 17,319                  | 2.5         |
| 1977 | 716,029          | 34.5        | 441,906                 | 4.2         | 28,610         | 31.7        | 17,657                  | 2.0         |
| 1978 | 909,487          | 27.0        | 479,835                 | 8.5         | 35,584         | 24.4        | 18,754                  | 6.2         |
| 1979 | 1,188,817        | 30.7        | 505,119                 | 5.4         | 45,565         | 28.0        | 19,360                  | 3.2         |
| 1980 | 1,579,130        | 32.8        | 525,765                 | 4.1         | 59,316         | 30.2        | 19,749                  | 2.0         |
| 1981 | 1,982,773        | 25.6        | 537,736                 | 2.3         | 73,021         | 23.1        | 19,803                  | 0.3         |
| 1982 | 2,497,298        | 25.9        | 542,836                 | 0.9         | 90,207         | 23.5        | 19,608                  | -1.0        |
| 1983 | 3,054,137        | 22.3        | 551,380                 | 1.6         | 108,252        | 20.0        | 19,543                  | -0.3        |
| 1984 | 3,856,584        | 26.3        | 569,855                 | 3.4         | 134,187        | 24.0        | 19,828                  | 1.5         |
| 1985 | 4,965,883        | 28.8        | 587,561                 | 3.1         | 169,684        | 26.5        | 20,077                  | 1.3         |
| 1986 | 6,701,425        | 34.9        | 617,527                 | 5.1         | 224,973        | 32.6        | 20,731                  | 3.3         |
| 1987 | 8,779,424        | 31.0        | 650,588                 | 5.4         | 289,567        | 28.7        | 21,457                  | 3.5         |

Source: REVISTA DEL BANCO DE LA REPUBLICA, October 1988



Table 2-1-3 BALANCE OF PAYMENT

|                          | Unit: US \$ Million |      |      |       |       |       |       |       |       |       |
|--------------------------|---------------------|------|------|-------|-------|-------|-------|-------|-------|-------|
| I T E M                  | 1978                | 1979 | 1980 | 1981  | 1982  | 1983  | 1984  | 1985  | 1986  | 1987  |
| I. CURRENT ACCOUNT       | 330                 | 512  | 104  | -1722 | -2885 | -2826 | -2050 | -1220 | 493   | -542  |
| A. Trade Balance         | 667                 | 537  | 13   | -1333 | -2076 | -1317 | -404  | 149   | 1992  | 1299  |
| Exports                  | 3219                | 3515 | 4296 | 3397  | 3282  | 3147  | 3623  | 388.2 | 5477  | 5240  |
| Imports                  | 2552                | 2978 | 4283 | 4750  | 5358  | 4464  | 4027  | 3734  | 3486  | 3932  |
| B. Services Balance      | -410                | -127 | -74  | -631  | -978  | -1673 | -1945 | -1883 | -2272 | -2550 |
| Financial Services       | -301                | -255 | -211 | -427  | -787  | -918  | -1240 | -1354 | -1137 | -1294 |
| Others                   | 109                 | 128  | 137  | -204  | -191  | -755  | -705  | -479  | -1135 | -1256 |
| C. Transfers             | 73                  | 102  | 166  | 242   | 169   | 164   | 299   | 464   | 774   | 700   |
| II. CAPITAL ACCOUNT      | 142                 | 977  | 945  | 2039  | 2231  | 1436  | 944   | 1850  | 1097  | 515   |
| A. Long-term capital     | 0                   | 761  | 723  | 1618  | 1593  | 1522  | 1566  | 2058  | 2363  | 960   |
| B. Short-term capital    | 142                 | 216  | 222  | 421   | 638   | -86   | -622  | -208  | -1266 | -445  |
| III. RESERVE ADJUSTMENT  | 0                   | 24   | 24   | 24    | 0     | -67   | 20    | -39   | 50    | 62    |
| IV. ERRORS AND OMISSIONS | 188                 | 98   | 162  | -100  | -47   | -266  | -175  | -307  | -173  | -11   |
| CHANGE IN NET RESERVES   | 660                 | 1611 | 1235 | 241   | -701  | -1723 | 1261  | 284   | 1467  | 24    |

Sources : Banco de la Republica

Table 2-1-4 CROP PRODUCTION IN COLOMBIA (1988)

| C R O P S                   | Planted Area     |            | PRODUCTION<br>Volume (ton) | Unit<br>Yield (ton/ha) | O u t p u t        |            |
|-----------------------------|------------------|------------|----------------------------|------------------------|--------------------|------------|
|                             | Area (ha)        | %          |                            |                        | Value <sup>1</sup> | %          |
| <b>I . Annual Crops</b>     |                  |            |                            |                        |                    |            |
| Cotton                      | 232,030          | 7.0        | 383,240                    | 1.65                   | 4,098.7            | 4.6        |
| Kidneybean                  | 125,800          | 3.8        | 99,900                     | 0.79                   | 1,455.5            | 1.6        |
| Maize                       | 635,500          | 19.3       | 880,500                    | 1.39                   | 4,039.7            | 4.5        |
| Potato                      | 170,800          | 5.2        | 2,491,900                  | 14.59                  | 6,374.3            | 7.1        |
| Rice                        | 372,200          | 11.3       | 1,784,900                  | 4.80                   | 5,850.9            | 6.6        |
| Sorghum                     | 265,700          | 8.1        | 681,100                    | 2.53                   | 2,451.3            | 2.7        |
| Soybean                     | 55,370           | 1.7        | 101,100                    | 1.83                   | 990.8              | 1.1        |
| Vegetables                  | 102,330          | 3.1        | 1,457,200                  | —                      | 5,422.2            | 6.1        |
| <b>II . Permanent Crops</b> |                  |            |                            |                        |                    |            |
| Banana                      | 25,050           | 0.8        | 1,140,000                  | 45.51                  | 2,146.6            | 2.4        |
| Cacao                       | 118,840          | 3.6        | 57,700                     | 0.49                   | 1,694.8            | 1.7        |
| Cassava                     | 160,800          | 4.9        | 1,321,530                  | 8.22                   | 2,110.4            | 2.4        |
| Oil Palm                    | 55,210           | 1.7        | 168,750                    | 3.06                   | 2,636.7            | 3.0        |
| Panela                      | 230,800          | 7.0        | 1,187,960                  | 5.16                   | 6,440.1            | 7.2        |
| Plantain                    | 378,130          | 11.5       | 2,530,480                  | 6.69                   | 7,399.3            | 8.3        |
| Sugarcane                   | 108,000          | 3.3        | 1,390,400                  | 12.87                  | 7,946.1            | 8.9        |
| Fruits                      | 54,050           | 1.6        | 877,455                    | —                      | 2,134.1            | 2.4        |
| <b>Total</b>                | <b>3,298,850</b> | <b>100</b> | <b>—</b>                   | <b>—</b>               | <b>89,296.1</b>    | <b>100</b> |

Source : ANUARIO ESTADISTICAS DEL SECTOR AGROPECUARIO 1988  
Ministerio de Agricultura

Note : 1) Constant Price of 1975 (Coi\$ Million)

Table 2-2-1 SOCIAL FEATURES OF THE DEPARTMENT OF META

|                                | National   | Meta (Share)    |
|--------------------------------|------------|-----------------|
| 1. Extention (km)              | 1,141,748  | 85,635 ( 7.5%)  |
| 2. Population                  |            |                 |
| 1) Total                       | 27,837,932 | 412,312 (1.48%) |
| 2) Distribution by             |            |                 |
| 0-14                           | 36.1%      | 38.3%           |
| 15-39                          | 44.0%      | 43.5%           |
| 40-59                          | 13.9%      | 13.7%           |
| 60 and more                    | 6.0%       | 4.5%            |
| 3) Annual Growth               |            |                 |
| Rate (1973-1985)               | 2.52%      | 3.85%           |
| 3. Unemployment Rate           | 4.3%       | 1.9%            |
| 4. Educational Level           |            |                 |
| 1) Without Any Education       | 11.5%      | 9.0%            |
| 2) Primary                     | 49.2%      | 53.6%           |
| 3) Secondary                   | 29.8%      | 27.0%           |
| 4) University                  | 7.7%       | 3.8%            |
| 5) Without Information         | 1.8%       | 5.8%            |
| 5. Illiteracy Rate             | 6.8%       | 10.7%           |
| 6. Coverage of Social Services |            |                 |
| 1) Electricity                 | 78.2%      | 61.2%           |
| 2) Water Supply                | 69.7%      | 65.9%           |
| 3) Sewerage                    | 69.2%      | 54.7%           |
| 4) Without Any Service         | 17.7%      | 17.2%           |

Source : Colombia - Censo 85, DANE

Table 2-2-2 CROP PRODUCTION IN META (1988)

| C R O P S | Production (ton) |         |      | Unit Yield(ton/ha) |      |
|-----------|------------------|---------|------|--------------------|------|
|           | National         | Meta    | (%)  | National           | Meta |
| Cotton    | 410.000          | 5.200   | 1.3  | 1.78               | 1.30 |
| Rice      | 1.866.800        | 409.100 | 11.3 | 4.98               | 4.93 |
| Malze     | 999.500          | 23.900  | 2.4  | 1.45               | 1.75 |
| Sorghum   | 796.900          | 46.000  | 0.6  | 2.82               | 2.30 |
| Soybean   | 153.220          | 11.360  | 7.4  | 2.13               | 1.60 |
| Cacao     | 55.400           | 4.186   | 7.6  | 0.51               | 0.57 |
| "Panela"  | 1.181.960        | 11.800  | 1.0  | 5.09               | 4.72 |
| Oil Palm  | 170.000          | 26.100  | 15.4 | 2.98               | 2.61 |
| Plantain  | 2.480.000        | 86.100  | 3.5  | 6.53               | 7.00 |
| Cassava   | 1.321.530        | 34.500  | 2.6  | 8.22               | 7.50 |

Source: Boletín Estadísticas Agropecuarias. Marzo 1988.  
Ministerio de Agricultura

CHAPTER 3

THE STUDY AREA



## CHAPTER 3: THE STUDY AREA

### 3.1 PHYSICAL CONDITION

#### 3.1.1 Topography and Geology

##### (1) Topography

The study area (the Area) is located in the eastern side of the Eastern Range and is extended in a plain between San Martin plateau on the northern side and San Juan de Arama plateau on the southern side. The altitude of the Area varies from approximately EL 240m to EL 788m.

The gradient of the Upper Zone is steep varying between approximately 1/50 and 1/100. The gradient of the Middle and the Lower Zones ranges between approximately 1/100 to 1/200 and 1/200 to 1/2,000, respectively. Thus the gradient of the Lower Zone is the most gentle.

The Upper Zone is constituted with composite fans of slightly waved morphology. However, erosion is not developed heavily. Three river terraces are recognized discontinuously on both banks of the Guape river in this zone.

The Middle Zone corresponds to the transitional zone between composite fans and alluvial plains. Concaved morphologies are found among hills and show poor drainage areas. Clearly distinguished natural levee has not been developed.

The Lower Zone is constituted with alluvial plain. Some small streams flow down meandering with relatively low density in the eastern gently sloped plain.

(2) Rivers

The Area is situated in the Ariari river system. The Ariari river system originates in the Eastern Range located at the departmental boundary between Meta and Huila and flows into the Guaviare, Meta and Orinoco rivers, successively. This river system has its own outfall in the Carribbean Sea of Venezuela. The Ariari river system flows straightly through deep valley of mountain area because of their steep slope of river bed. On the other hand, rivers meander greatly through jungles and plains.

The Ariari and its tributary the Guape, which located in the northern boundary of the Area, show unstable wandering and meandering in many parts of their courses because of frequent flooding and river bed fluctuation.

In the Area small streams (caños) flow from west to east and the majority of them have confluence with the Ariari river. The major caños are: Sardinata, Mucuya, Urichare, Upím, etc.

The specific features of the main rivers and caños are shown in the Table 3-1-1.



Table 3-1-1 Specific Features of Main Rivers and Caños

| River (R)<br>Caño (C) | River<br>Length<br>(km) | Altitude<br>(m A.S.L.) | River Bed<br>Slope | Catchment<br>Area<br>(km <sup>2</sup> ) | Note |
|-----------------------|-------------------------|------------------------|--------------------|---|------|
| Guape-Ariari R.       | 83.5                    | 250- 780               | 1/ 70-1/800        |   | *4   |
| Sardinata C.*1        | 39.1                    | 295- 580               | 1/ 70-1/240        | 39.5                                    |      |
| Mucuya C.*2           | 70.4                    | 290- 610               | 1/ 60-1/200        | 65.0                                    |      |
| Venado C.             | 17.6                    | 280- 380               | 1/120-1/300        | 22.1                                    |      |
| Urichare C.           | 65.6                    | 270-1,600              | 1/ 80-1/300        | 73.5                                    |      |
| Mogotes C.            | 19.4                    | 260- 320               | 1/230-1/690        | 18.1                                    |      |
| Seco C.               | 19.0                    | 250- 310               | 1/320-1/560        | 16.8                                    |      |
| Upin C.*3             | 93.5                    | 250- 550               | 1/100-1/730        | 152.0                                   |      |
| Chule C.              | 7.0                     | 245- 300               | 1/100-1/500        | 22.4                                    |      |

\*1 included Taparq C.

\*2 included Venado C. and Venadito C.

\*3 included Guanayas C.

\*4 between Pte. Angostura and Pto. Avichure

### (3) Geology

The Area is situated eastward from Guaicaramo Fault which is the eastern boundary of the Eastern Range. Three geological formations in the order of time are recognized in the Area: Metamorphic rocks, Sedimentary rocks and Non-consolidated sediments. The characteristics of each formation are described as follows:

#### 1) Metamorphic rocks

The Area provides outcrops of hard black and green phyllites to the west from the point approximately 600m east of the Angostura bridge. Clear schistosity with gentle dip and slight foldings are recognized. Rock quality is generally fresh, but some weathered parts show rock-slide forming colluvial slope because of the concentration of clay minerals and groundwater actions.

## 2) Sedimentary rocks

In the Area, these rocks are recognized at the foot of San Juan de Arama plateau, a part of piedmonts of the Eastern Range, concaved parts and some parts of the Guape river. These rocks are generally gray and light yellow clay or silt, light yellow sandstone (0.3 - 2.5m in thickness), and coal bed (0.1 - 5cm in thickness) are recognized in small portion. Plant fossils such as root, trunk and leave are observed. Moreover, ripple marks are shown near Lejanías that may indicate a littoral sedimentary environment.

## 3) Non-consolidated sediments

Non-consolidated sediments were deposited during the Quaternary and can be divided into alluvial, colluvial and fluvial sediments.

### a) Alluvial sediments

These sediments are extensively distributed eastward from the Eastern Range showing alluvial fans, alluvial plains and terraces.

Alluvial fans are differentiated according to distinct time of formations: Recent and Ancient alluvial deposits.

Ancient alluvial deposits were formed by gravitational and hydraulic forces during orogenic movement on the piedmont belt zone of the Llanos. The deposits are distributed in San Martin and San Juan de Arama plateaus, monadnocks and hills in the Area and the surroundings.

Recent alluvial fans were formed by hydraulic force of main rivers in the concaved zone surrounded by ancient alluvial deposits. Principal lithofacies are pebble, gravel, sand and silt. Pebble and gravel are distributed in the surroundings of the fan apex, on the other hand, toward the margin of fan,

the fine sediments become more predominant. This type of fan is recognized in the Upper Zone and the greater portion of the Middle Zone.

Alluvial plains were formed in their majority by transportation and sedimentation of the Ariari river and are widely distributed in a part of the Middle Zone and most of the Lower Zone. Sand, silt and clay are the principal lithofacies. Bedded sedimentary structure is generally recognized, but cross-bedding is also shown partly.

Terraces are shown on both margins of the Guape river in the Upper Zone which is principally constituted with pebble, gravel, sand and silt and silt with clear beds of different grain size of almost 3m at the maximum.

b) Colluvial sediments

Colluvial sediments are distributed on foot of plateau and piedmont consist of heterogeneous materials of gravels, coarse sand and silt. This type of sediments are formed by: gravitational sliding, debris of deposits on hard rocks, sliding of clay rocks, tectonic movement (fault), etc. These sediments are unstable because of the formation of many waterways due to good permeability.

c) Fluvial sediments

These sediments were formed during the Holocene by fluvial hydrodynamic force. Topographic feature is shown such as river bed, low river terrace and flood plain along the Guape and Ariari rivers consist of silt, sand and gravel.

### 3.1.2 Meteorology and Hydrology

#### (1) Available data

The rainfall observation at 22 rainfall stations including 7 meteorological stations in the Ariari River basin have been made for a period of 3 to 20 years. The river discharge at 5 stations has also been observed and it is revealed that 4 to 9 years of the river discharge data are available. However, of these stations, only a few stations which have short period of observation data are directly related with the study area (See Table 3-1-2 and Fig. 3-1-1).

#### (2) Meteorology

The meteorological condition in the study area can be summarized as follows:

|                                |   |  |
|--------------------------------|---|--|
| Climate                        | : | Tropical humid   |
| Annual Rainfall                | : | 2,500 - 3,500mm<br>(The variation depends on altitude)<br>- Rainy season from April to November<br>(85% of annual rainfall)<br>- Dry season from December to March<br>(15% of annual rainfall) |
| Temperature                    | : | Mean Temperature of 26°C almost constant<br>throughout the year<br>Mean Annual Maximum Temperature -36°C<br>Mean Annual Minimum Temperature -17°C  |
| Relative Humidity              | : | Mean-82% (Rainy Season -85%, Dry Season -<br>75%)  |
| Duration of Bright<br>Sunshine | : | Annual Mean -5 hours/day   |
| Mean Wind Velocity             | : | 1.5m/s   |

(3) Hydrology

1) Rainfall analysis

- The correlation between annual rainfall and altitude in the Ariari basin was studied and following results were obtained.

Correlation coefficient (R) = 84%

Correlation formula (Annual Rainfall)

$$= 1,428 + 4.668 \times (\text{Altitude})$$

- Correlation of monthly rainfall between rainfall stations was studied and additional data were provided using the correlation coefficient over 75%.
- Correlation of 10 days rainfall between stations which are located in or near the study area were studied and a correlation coefficient lower than 60% were obtained for all of them.
- Probability analysis of the rainfall data was carried out and the annual rainfall pattern of drought year for 2, 5, 10 and 20 year return period was analyzed for the 15 stations which hold data of comparatively longer period. And, using the data of stations at Lejanias and Caño Blanco where observation has been made for a period of 9 years, and taking correlation between altitude and rainfall of other stations into account, the annual rainfall pattern and effective rainfall at Aguas Claras and La Cooperativa were estimated.  
  
Effective rainfall was estimated on the basis of parameters employed by U.S Bureau of Reclamation. The results are shown in Table 3-1-3 (See ANNEX C).
- Probability analysis of the annual maximum 24 hours rainfall was carried out to estimate that of 2, 5, 10 and 20 year return period. The results of this analysis are summarized below:

Table 3-1-4 Annual Maximum 24 Hours Rainfall

| Station                 | Altitude<br>(m) | Return Period<br>(mm) |       |       |       |
|-------------------------|-----------------|-----------------------|-------|-------|-------|
|                         |                 | 1/2                   | 1/5   | 1/10  | 1/20  |
| Lejanías<br>(Angostura) | 800             | 111.3                 | 143.6 | 164.1 | 183.1 |
| Aguas Claras            | 420             | 100.6                 | 134.0 | 155.8 | 176.3 |
| La Cooperativa          | 250             | 91.5                  | 125.8 | 148.6 | 170.4 |
| Puerto Limon            | 245             | 90.5                  | 124.9 | 147.9 | 169.8 |

- Probability analysis of the continuous drought days was carried out in respect of stations in the study area and its vicinity. The results are as summarized below.

Table 3-1-5 Continuous Drought Days

| Station                 | Altitude<br>(m) | Return Period<br>(day) |     |      |      |
|-------------------------|-----------------|------------------------|-----|------|------|
|                         |                 | 1/2                    | 1/5 | 1/10 | 1/20 |
| Lejanías<br>(Angostura) | 800             | 21                     | 35  | 45   | 55   |
| Puerto Limon            | 245             | 24                     | 38  | 50   | 61   |

## 2) Runoff Analysis

### a) Droughty Discharge Analysis

#### 1) Droughty discharge of the Guape River

The droughty discharge at the Angostura bridge of the Guape River (basin area of 775 km<sup>2</sup> with a mean discharge of 76 m<sup>3</sup>/s) was estimated as shown below:

Table 3-1-6 Droughty Discharge at Angostura

| Discharge  | Return Period<br>(m <sup>3</sup> /s) |      |      |      |
|--|--------------------------------------|------|------|------|
|  | 1/2                                  | 1/5  | 1/10 | 1/20 |
| River Discharge (m <sup>3</sup> /s)<br>(Angostura) | 18.0                                 | 12.2 | 9.9  | 8.4  |
| Specific Discharge (l/s/km <sup>2</sup> )          | 23.2                                 | 15.7 | 11.5 | 10.8 |

The monthly river discharge pattern at the Angostura bridge is shown in Fig. 3-1-2.

ii) Discharge of caños

Mean discharge of the main caños in the Area was estimated as shown below:

Table 3-1-7 Mean Water Discharge of Main Caños (m<sup>3</sup>/s)

| Caños     | Return Period |             |             |             |
|-----------|---------------|-------------|-------------|-------------|
|           | 1/2           | 1/5         | 1/10        | 1/20        |
| Guanayas  | 0.85(29.61)   | 0.65(23.24) | 0.58(20.47) | 0.52(18.45) |
| Urichare  | 0.61(56.10)   | 2.23(46.70) | 2.02(42.43) | 1.87(39.22) |
| Mucuya    | 0.76(32.01)   | 0.57(23.73) | 0.48(20.29) | 0.43(17.65) |
| Sardinata | 0.61(32.93)   | 0.46(24.24) | 0.39(21.01) | 0.34(18.52) |

( ): Specific Discharge l/s/km<sup>2</sup>

b) Flood Analysis

1) High water discharge of the Ariari and Guape Rivers

- Flood analysis of the Guape and Ariari Rivers was carried out using the Storage Function Method. The flood discharge at specific site of the Guape River and Ariari River was estimated as shown below.

Table 3-1-8 Flood Discharge of the Guape and Ariari River (m<sup>3</sup>/s)

| Sites         | Basin Area (km <sup>2</sup> ) | Return Period |       |       |       |
|---------------|-------------------------------|---------------|-------|-------|-------|
|               |                               | 1/2           | 1/5   | 1/10  | 1/20  |
| Lejanías      | 775.5                         | 296           | 363   | 404   | 441   |
| Puerto Caldas | 3,012.2                       | 723           | 819   | 905   | 922   |
| Puerto Lleras | 3,790.8                       | 880           | 995   | 1,061 | 1,120 |
| Platanal      | 4,657.2                       | 846           | 951   | 1,010 | 1,061 |
| Puerto Rico   | 6,250.4                       | 1,025         | 1,154 | 1,225 | 1,287 |

ii) High water discharge of caños

The flood discharge at the main caños was estimated the Rational Formula. The result is shown below:

Table 3-1-9 Flood Discharge of the Main Caño

| Caños     | Basin Area<br>(km <sup>2</sup> ) | Return Period<br>(m <sup>3</sup> /s) |       |       |       |
|-----------|----------------------------------|--------------------------------------|-------|-------|-------|
|           |                                  | 1/2                                  | 1/5   | 1/10  | 1/20  |
| Guanayas  | 28.1                             | 87.2                                 | 121.6 | 144.7 | 166.9 |
| Urichare  | 47.7                             | 117.2                                | 170.4 | 207.4 | 243.7 |
| Mucuya    | 23.9                             | 59.2                                 | 89.7  | 111.5 | 133.3 |
| Sardinata | 18.6                             | 47.7                                 | 72.6  | 90.5  | 108.3 |



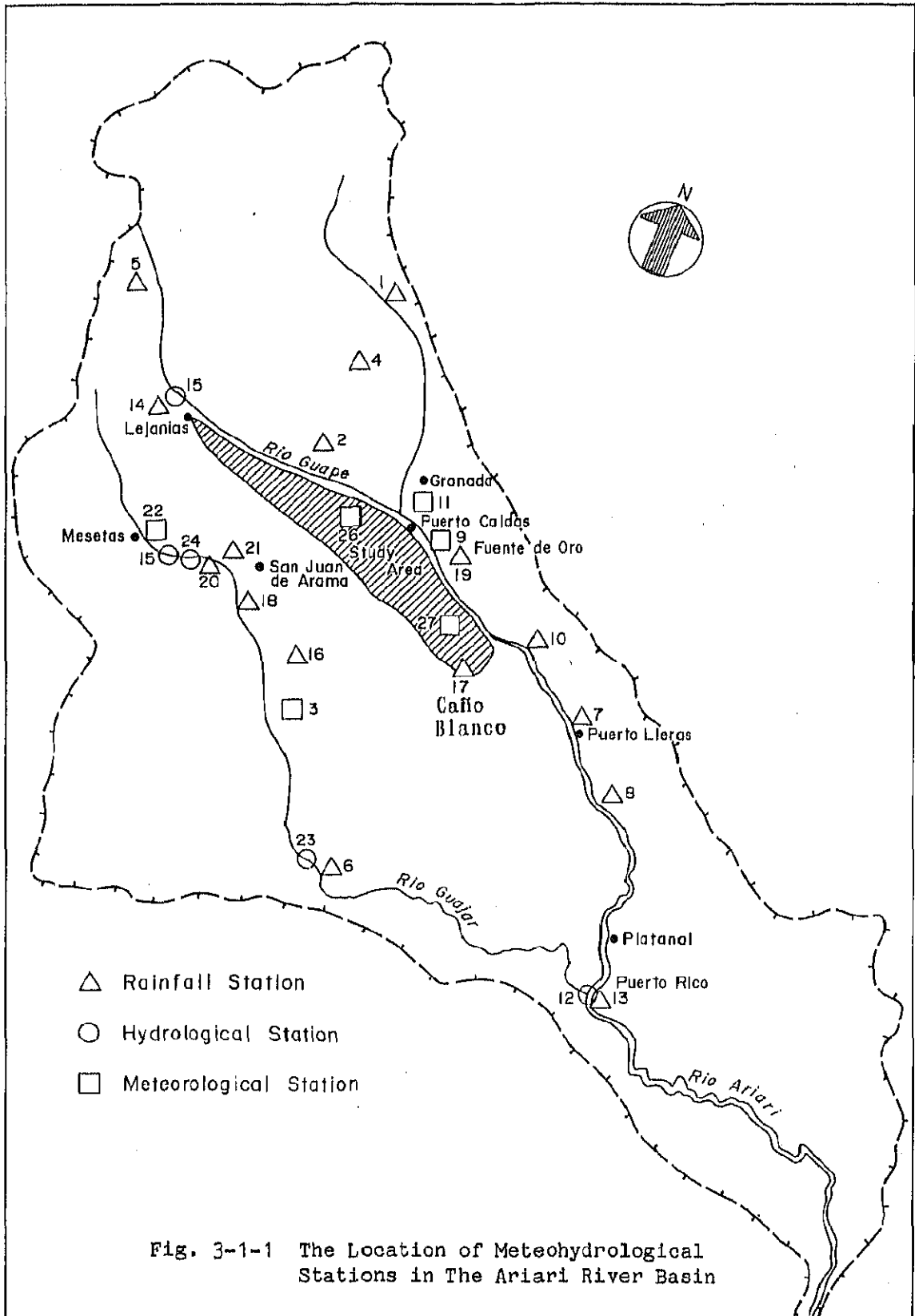


Fig. 3-1-1 The Location of Meteorohydrological Stations in The Ariari River Basin

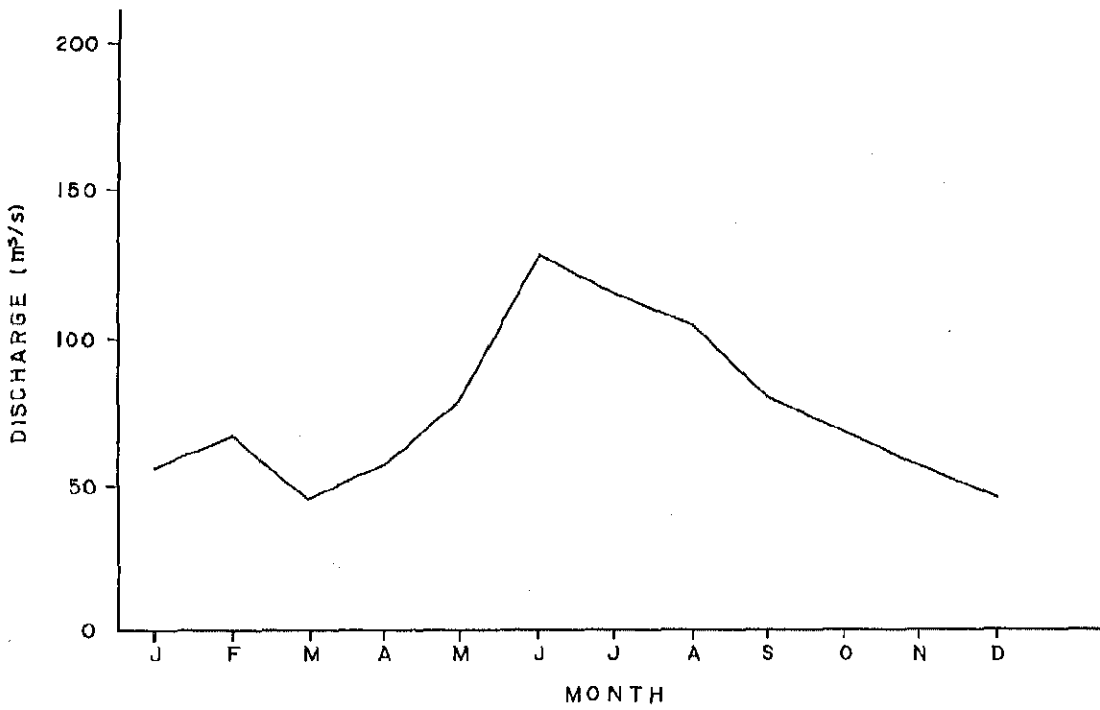


Fig. 3-1-2 River Discharge at The Angostura Bridge on the Guape River

Table 3-1-2 SUMMARY OF METEOROLOGICAL AND HYDROLOGICAL STATIONS

| Station                       | Coordinates | Elevation | Observation Period |    |    |    |
|-------------------------------|-------------|-----------|--------------------|----|----|----|
|                               |             |           | 1960               | 70 | 80 | 90 |
| 1. San Luis de Cubarral (PM)  | 0347, 7351  | 600       |                    |    |    |    |
| 2. Mesa de Yamanes (PM)       | 0333, 7352  | 600       |                    |    |    |    |
| 3. Vistahermosa (CO)          | 0302, 7344  | 325       |                    |    |    |    |
| 4. Calime (PM)                | 0340, 7352  | 800       |                    |    |    |    |
| 5. Las Dantas (PM)            | 0354, 7411  | 3996      |                    |    |    |    |
| 6. Piñalito (PM)              | 0259, 7338  | 245       |                    |    |    |    |
| 7. Puerto Lleras (PM)         | 0317, 7323  | 245       |                    |    |    |    |
| 8. Tierra Grata (PM)          | 0312, 7319  | 191       |                    |    |    |    |
| 9. Los Naranjos (CO)          | 0328, 7343  | 220       |                    |    |    |    |
| 10. Puerto Limon (CO)         | 0322, 7330  | 255       |                    |    |    |    |
| 11. La Holanda (CO)           | 0331, 7343  | 360       |                    |    |    |    |
| 12. Puerto Rico (LM)          | 0301, 7310  | 187       |                    |    |    |    |
| 13. Puerto Rico (PM)          | 0256, 7314  | 230       |                    |    |    |    |
| 14. Lejanias (PM)             | 0331, 7406  | 800       |                    |    |    |    |
| 15. Guape-Lejanias (LM)       | 0332, 7405  | 840       |                    |    |    |    |
| 16. Campo Alegre (PM)         | 0312, 7345  | 260       |                    |    |    |    |
| 17. Caño Blanco (PM)          | 0315, 7331  | 240       |                    |    |    |    |
| 18. Las Micos (PM)            | 0313, 7351  | 500       |                    |    |    |    |
| 19. Fuente de Oro (PM)        | 0328, 7338  | 300       |                    |    |    |    |
| 20. Penas Blancas (PM)        | 0319, 7355  | 440       |                    |    |    |    |
| 21. San Juan de Arama (PM)    | 0321, 7353  | 410       |                    |    |    |    |
| 22. Mesetas (CO)              | 0321, 7402  | 620       |                    |    |    |    |
| 23. Guejar Piñalito (LM)      | 0257, 7340  | 200       |                    |    |    |    |
| 24. Guejar Piñas Blancas (LG) | 0319, 7355  | 440       |                    |    |    |    |
| 25. Guejar el Limon (LM)      | 0319, 7400  | 570       |                    |    |    |    |
| 26. Aguas Claras (CO)         | 0328, 7351  | 520       |                    |    |    |    |
| 27. La Cooperativa (CO)       | 0322, 7342  | 280       |                    |    |    |    |

Note : (PM) Rainfall Station  
(LM), (LG) Hydrological Station  
(CO) Meteorological Station

Table 3-1-3 (1) Rainfall Pattern and Effective Rainfall for Design Year  
Station Caño Blanco

| Month  | Return Period |             |             |             |
|--------|---------------|-------------|-------------|-------------|
|        | 1/2           | 1/5         | 1/10        | 1/20        |
| JAN    | 34 ( 32)      | 30 ( 28)    | 28 ( 26)    | 26 ( 25)    |
| FEB    | 86 ( 75)      | 76 ( 68)    | 71 ( 64)    | 68 ( 61)    |
| MAR    | 154 ( 102)    | 136 ( 97)   | 127 ( 94)   | 121 ( 92)   |
| APR    | 306 ( 108)    | 270 ( 108)  | 253 ( 107)  | 240 ( 106)  |
| MAY    | 300 ( 108)    | 265 ( 108)  | 248 ( 107)  | 235 ( 106)  |
| JUN    | 355 ( 108)    | 314 ( 108)  | 294 ( 108)  | 279 ( 108)  |
| JUL    | 269 ( 108)    | 237 ( 106)  | 223 ( 106)  | 211 ( 106)  |
| AUG    | 271 ( 108)    | 239 ( 106)  | 224 ( 105)  | 213 ( 106)  |
| SEP    | 194 ( 105)    | 172 ( 103)  | 161 ( 103)  | 153 ( 102)  |
| OCT    | 333 ( 108)    | 294 ( 108)  | 276 ( 108)  | 262 ( 108)  |
| NOV    | 218 ( 106)    | 193 ( 105)  | 181 ( 104)  | 171 ( 103)  |
| DEC    | 69 ( 63)      | 61 ( 56)    | 58 ( 53)    | 55 ( 50)    |
| Annual | 2539 (1130)   | 2287 (1102) | 2144 (1084) | 2033 (1074) |

Table 3-1-3 (2) Rainfall Pattern and Effective Rainfall for Design Year  
Station La Cooperativa

| Month  | Return Period |             |             |             |
|--------|---------------|-------------|-------------|-------------|
|        | 1/2           | 1/5         | 1/10        | 1/20        |
| JAN    | 52 ( 48)      | 46 ( 43)    | 43 ( 40)    | 40 ( 38)    |
| FEB    | 161 ( 103)    | 141 ( 99)   | 132 ( 96)   | 125 ( 93)   |
| MAR    | 131 ( 96)     | 115 ( 90)   | 108 ( 87)   | 102 ( 84)   |
| APR    | 177 ( 103)    | 155 ( 102)  | 145 ( 100)  | 137 ( 98)   |
| MAY    | 305 ( 108)    | 267 ( 108)  | 250 ( 107)  | 236 ( 106)  |
| JUN    | 256 ( 108)    | 224 ( 105)  | 210 ( 106)  | 198 ( 105)  |
| JUL    | 465 ( 108)    | 408 ( 108)  | 381 ( 108)  | 361 ( 108)  |
| AUG    | 213 ( 106)    | 187 ( 104)  | 174 ( 103)  | 165 ( 103)  |
| SEP    | 269 ( 108)    | 236 ( 106)  | 221 ( 106)  | 209 ( 106)  |
| OCT    | 250 ( 107)    | 220 ( 106)  | 205 ( 106)  | 194 ( 105)  |
| NOV    | 229 ( 105)    | 201 ( 106)  | 187 ( 104)  | 177 ( 103)  |
| DEC    | 112 ( 89)     | 98 ( 82)    | 92 ( 78)    | 87 ( 75)    |
| Annual | 2620 (1189)   | 2298 (1159) | 2148 (1141) | 2031 (1125) |

Note: Figures in parenthesis represent effective rainfall

Table 3-1-3 (3) Rainfall Pattern and Effective Rainfall for Design Year  
Station Aguas Claras

| Month  | Return Period |             |             |             |
|--------|---------------|-------------|-------------|-------------|
|        | 1/2           | 1/5         | 1/10        | 1/20        |
| JAN    | 25 ( 24)      | 21 ( 20)    | 19 ( 18)    | 18 ( 17)    |
| FEB    | 223 ( 106)    | 189 ( 105)  | 173 ( 103)  | 161 ( 103)  |
| MAR    | 148 ( 101)    | 125 ( 93)   | 114 ( 90)   | 106 ( 87)   |
| APR    | 302 ( 108)    | 255 ( 108)  | 233 ( 106)  | 217 ( 106)  |
| MAY    | 237 ( 106)    | 200 ( 106)  | 184 ( 104)  | 171 ( 103)  |
| JUN    | 339 ( 108)    | 287 ( 108)  | 263 ( 108)  | 244 ( 106)  |
| JUL    | 378 ( 108)    | 319 ( 108)  | 293 ( 108)  | 272 ( 108)  |
| AUG    | 343 ( 108)    | 290 ( 108)  | 266 ( 108)  | 247 ( 106)  |
| SEP    | 269 ( 108)    | 227 ( 105)  | 208 ( 106)  | 194 ( 105)  |
| OCT    | 340 ( 108)    | 287 ( 108)  | 263 ( 108)  | 245 ( 106)  |
| NOV    | 177 ( 103)    | 149 ( 101)  | 137 ( 97)   | 127 ( 94)   |
| DEC    | 79 ( 70)      | 67 ( 61)    | 61 ( 56)    | 57 ( 53)    |
| Annual | 2804 (1157)   | 2368 (1131) | 2169 (1112) | 2019 (1095) |

Table 3-1-3 (4) Rainfall Pattern and Effective Rainfall for Design Year  
Station Lejanias

| Month  | Return Period |             |             |             |
|--------|---------------|-------------|-------------|-------------|
|        | 1/2           | 1/5         | 1/10        | 1/20        |
| JAN    | 64 ( 58)      | 52 ( 48)    | 47 ( 44)    | 43 ( 40)    |
| FEB    | 125 ( 93)     | 101 ( 84)   | 91 ( 78)    | 83 ( 72)    |
| MAR    | 181 ( 104)    | 147 ( 101)  | 132 ( 96)   | 120 ( 92)   |
| APR    | 332 ( 108)    | 270 ( 108)  | 242 ( 106)  | 221 ( 106)  |
| MAY    | 368 ( 108)    | 298 ( 108)  | 267 ( 108)  | 244 ( 106)  |
| JUN    | 372 ( 108)    | 302 ( 108)  | 271 ( 108)  | 247 ( 106)  |
| JUL    | 302 ( 108)    | 245 ( 106)  | 220 ( 106)  | 201 ( 106)  |
| AUG    | 294 ( 108)    | 239 ( 106)  | 214 ( 106)  | 196 ( 105)  |
| SEP    | 289 ( 108)    | 234 ( 106)  | 210 ( 106)  | 192 ( 105)  |
| OCT    | 357 ( 108)    | 289 ( 108)  | 259 ( 108)  | 237 ( 106)  |
| NOV    | 215 ( 106)    | 175 ( 103)  | 157 ( 103)  | 143 ( 100)  |
| DEC    | 119 ( 91)     | 96 ( 81)    | 86 ( 75)    | 79 ( 70)    |
| Annual | 3019 (1209)   | 2448 (1168) | 2194 (1142) | 2005 (1114) |

Note: Figures in parenthesis represent effective rainfall