REPUBLIC OF COLOMBIA

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

VOLUME III
ANNEX

MARCH, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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1. METEOROLOGY

In order to grasp the meteorological characteristics of the project area, to formulate the propose farming plan, and to clarify the meteorological conditions as a criteria for establishing an irrigation and drainage project (particularly, estimation of evapotranspiration), the following studies were conducted.

1.1 Meteorological Observation Stations

The meteorological observation networks including hydrological observation in the Republic of Colombia are being managed systematically by HIMAT.

Among these, observation stations related to the project areas are 12 stations for the San Pedro de Iquaque and Santa Sofia sub-project areas and their vicinities, 5 stations for Caqueza sub-project area and its neighborhood and one station for Tibacue sub-project area. the last station which is being managed presently by the FEDECAFE, will be incorporated into the observaion networks managed by HIMAT in near future.

Locations of the observation stations are shown in Figures A.1.1, A.1.2 and A.1.3. The meteorological and hydrological data collected during the field study are also shown in Table A.1.1.

1.2 Temperature

As shown in Fig. A.1.4,. the temperature measured in the project areas and their neighboring areas in correlated with elevation of their locations.

Therefore, the temperature of each sub-project area can be estimated from the recorded data of the neighboring observation stations which are located at the same elevation. The following records are used for estimating temperature of the project areas.

San Pedro de Iguaque	:	Records of UPTC
Santa Sofia	:	Records of Villa Carmen
Caqueza	:	Records obtained by HIMAT (AGRO-CLIMATICO DEL AREA DE CAQUEZA) because of no available temperature records in vicinity of Caqueza sub-project area.
Tibacuy	:	Records of Tibacuy

Monthly temperatures in each sub-project area collected from the abovementioned stations are shown in Table 4.1.2. The average monthly temperatures are ranging from 12 to 14°C in San Pedro de Iguaque and Santa Sofia sub-project areas and 19 to 20°C in Caqueza and Tibacuy sub-project areas. Almost no seasonal fluctuation of temperature is observed.

1.3 Relative Humidity

The relative humidity of the project areas is taken from the records of the following observation stations located in and around the sub-project areas.

San Pedro de Iguaque	:	Records of Villa de Leiva
Santa Sofia	:	Records of Villa de Leiva
Caqueza	:	Records of Chingaza - Laguna
Tibacuy	:	Records of Tibacuy

The monthly relative humidity of each sub-project area estimated by the abovementioned records are shown in Fug. A.1.3. The average monthly relative humidity is ranging from 69 to 77% in San Pedro de Iguaque and Santa Sofia, 82 to 88% in Caqueza and 71 to 81% in Tibacuy sub-project areas.

1.4 Evaporation

Evaporation of the project areas is estimated at approximately 3.0 to 4.3 mm/day deriving from the records of Villa de Leiva (Table A.1.4.)

1.5 Wind Velocity

The wind velocity in the project areas is estimated from the records of Villa Carmen (2,600 m in elevation). The average monthly wind velocity at 2 m above ground surface is 2-3 m/s. (refer to Table A.1.5.)

Table A.1.5 Wind Velocity in Villa Carmen
(Corrected to wind velocity at 2m above ground surface)

Unit : m/s

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.7	2.5	3.1	2.5	2.6	2.9	3.3	3.0	2.8	2.5	2.1	2.3

1.6 Sunshine Hour

The sunshine hour in the project areas is estimated from th records of the following observation stations located in and around the project areas.

San Pedro de Iguaque	:	Records of Villa de Leiva
Santa Sofia	:	Ditto
Caqueza	:	Records of Chingaza - Laguna
Tibacuy	:	Records of Tibacuy

Monthly sunshine hours are

San Pedro de Iguaque and Santa Sofia	:	3.7 hrs/day (April, October) to 6.1 hrs/day (January)
Caqueza	:	2.0 hrs/day (June) to 4.4 hrs/day (January)
Tibacuy	:	3.8 hur/day (April) to 6.2 hrs/day (January)

(refer to Table A.1.6.)

1.7 Precipitation

(1) Precipitation and its Distribution Characteristics

Average annual precipitation of the project areas varies from 750 to 1,120 mm. (refer to A.1.7(1) to (4)) there are two types of precipitation distribution in the project areas.

One is a type of two peaks a year which can be observed in San Pedro de Iguaque, Santa Sofia dnd Tibacuy sub-project areas. Another type is of one peak a year which can be seen in Caqueza area. The latter is a characteristic of precipitation distribution in eastern slope area of the East Mountain Range.

The annual precipitation of each sub-project area can be divided into dry season and wet season as follows:

Table A.1.9 Distribution of Precipitation

Nameof Area	Annual Rainfall (mm)	Dry Season		Rainy Season	
		First Half (%)	Latter Half (%)	First Half (%)	Latter Half (%)
San Pedro de Iguaque	1,062	Jan-Mar(16)	Jun-Aug(14)	Apr-May(33)	Sep-Dec(37)
Santa Sofia	1,123	Jan-Feb(9)	Jun-Aug(9)	Apr-May(33)	Sep-Dec(41)
Caqueza	751	Sep-Apr(47)	- -	May-Aug(53)	- -
Tibacuy	1,094	Jan-Feb(12)	Jun-Sep(18)	Mar-May(31)	Oct-Dec(39)

Note : San Pedro de Iquaque: Record of 1981-1984
Santa Sofia: Record of 1966-1983
Caqueza: Record of 1957,1970-1984
Tibacuy: Record of 1956-1979

(2) Supplemental Precipitation Data

As indicated in Table A.1.7(1)-1, the observation duration of precipitation in San pedro de Iguaque is relatively short among the sub-project areas. Therefore, a correlation between precipitations in San Pedro de Iguaque area and Santa Sofia area is studied. Since more than 0.8 of correlation coefficient was obtained from the abovementioned study, the precipitation of long period in San Pedro de Iguaque area was estimated using the records of Santa sofia area. the results of the estimation are shown in Table A.1.7(1)-2.

The correlation equation of monthly precipitation is shown below.

$$Y = 0.922 X + 2.349$$

Where Y : Precipitation in San Pedro de iguaque area (mm)

X : Precipitation in Santa Sofia area (mm)

1.8 Particular Meteorology

(1) Precipitation in drought year

Fig. A.1.5 shows a distribution curve of probable annual precipitation. According to the distribution curve, probable annual precipitations (non-exceedance) of each sub-project area are as follows:

Table A.1.10 Probability of Annual Precipitation

(Unit : mm)

Sub-project Area	Probable (non-exceedance) Precipitation	
	50%	75%
San Pedro de Iguaque	1,020*	890*
Santa Sofia	1,120	980
Caqueza	760	680
Tibacuy	1,070	960

* : Estimated from records of Santa Sofia during 1966 to 1980.

(2) Precipitation in dry season

Monthly precipitations of each sub-project area in dry season of drought year are as follows:

(2) Precipitation in dry season

Monthly precipitations of each sub-project area in dry season of drought year are as follows:

Table A.1.11 Precipitation in Dry Season

Name of Sub-Project Areas	Minimum mm / Month Occured	Second Min. mm / Month Occured	Third Min. mm / Month Occured	Observ. Period
San Pedro de Iguaque				
First Half	0.0 / Jan. '83	5.6 / Feb. '83	20.0 / Jan. '81	'81 - '84
Latter Half	3.2 / Sep. '83	9.0 / Aug. '83	10.2 / Jun. '84	
Santa Sofia				
First Half	0.0 / Feb. '73	3.0 / Jan. '83	5.0 / Jan. '75	'66 - '83
Latter Half	2.0 / Jul. '69	3.0 / Jul. '76	3.0 / Aug. '82	
Caqueza				
Year-round	0.0 / Jan. '57	0.0 / Jan. '77	0.0 / Jan. '81	'57 and '70 - '84
Tibacuy				
First Half	5.8 / Jan. '75	10.4 / Feb. '77	12.7 / Jan. '66	'56 - '79
Latter Half	4.0 / Jul. '76	7.3 / Jun. '65	12.5 / Aug. '67	

(3) Successive No Rain Days

The successive no rain days recorded at the observation points are shown below.

Table A.1.12 Successive No Rain Days

Observation Point (Observ. period)	Longest Days Date occured	Second Longest Days Date occured	Third Longest Days Date occured
Santa Sofia ('66 - '83)	32 days 1/2-2/2,'83	31 days 7/12-8/12,'79	31 days 3/12-4/11,'81
Caqueza ('70 - '84)	52 days 12/2-2/16,'80	51 days '76 12/19-'77 2/6	48 days '78 12/9-'77 2/6
Tibacuy ('62 - '81)	48 days 7/2-8/18,'76	29 days '74 12/4-'75 1/1	27 days '76 12/23-'77 1/18

Note : Rainfall less than 1 mm is considered as no rainfall.

For cultivaion of coffee in the Tibacuy sub-project area, the rainfall distribution during the flowering stage (April, May and October, November) is substantially affected to the coffee production. During the flowering stage of coffee, the successive no rain days in Tibacuy area are as follows:

The longet : 19 days (1975 4/4 - 4/22)
Second longest : 15 days (1977 4/7 - 4/21)
Third longest : 13 days (1980 11/19 - 10/31)

(4) Probable Maximum Daily Precipitation

The probable maximum daily precipitations in each sub-project area are shown below.

Table A.1.13 Probable Maximum Daily Precipitation

Observation Point	Probable precipitation (mm)	
	2 years	5 years
San Pedro de Iguaque	42	50
Santa Sofia	43	52
Caqueza	30	37
Tibacuy	49	57

Note : refer to Figure A.1.6

1.9 Evapotranspiration

For predicting th evapotranspiration, various methods are presented. the evapotranspiration of this project was estimated by the Penman method which is usually adopted by HIMAT. (refer to the FAO irrigation and Drainage Paper No.24) The evapotranspiration (ETP) of each sub-project area in the monthly basis predicted by the modified Penman method are shown in Table A.1.8.

The temperature, relative humidity, wind velocity and sunshine hour used for predicting evapotranspiratin are explained in 1.2, 1.3, 1.5 and 1.6, respectively.

The latitude and elevation of each sub-project area are as below.

	Latitude	Elevation
San pedro de Iguaque	5°36' North	3,000 m
Santa Sofia	5°44' "	2,500 m
Caqueza	4°25' "	1,500 m
Tibacuy	4°20' "	1,500 m

Table A.1.1 Recorded Items of Each Observation Station

Observation Station	Elevation (m)	Precipitation	Temperature	Relative Humidity	Evaporation	Sunshine Hour	Atmosphere Pressure
(BOYCA)							
BERTA	1.700	1952-1980	1955-1980	1955-1980	1956-1970	1956-1978	1955-1980
ARCABUCO	2,600	1972-1984					
COMBITA	2,820	1958-1984					
UPTC	2,690	1962-1982	1965-1980	1964-1980	1962-1984		
VILLA CARMEN	2,600	1968-1982	1968-1980	1968-1980		1969-1984	
RAQUIRA	2,290	1958-1984					
SABOYA	2,550	1974-1984					
SAN PEDRO DE IGUAQUE	2,985	1981-1984					
EL EMPORIO	2,120	1964-1984					
VILLA DE LEIVA	2,250	1968-1979	1969-1979	1969-1979	1969-1979	1969-1978	1969-1979
PASADENA	2,133	1965-1983	1962-1981				
SANTA SOFIA	2,370	1966-1983					
(C/MARCA)							
AQUEZA	1,600	1957-1984					
CHINGAZA-LAGUNA		1966-1978		1965-1978		1970-1978	
CHUZA	1,987	1971-1978					
MONTERREDONDO		1967-1980					
UNE		1968-1969					
TIBACUY	1,500	1956-1979	1956-1980	1956-1980		1956-1980	

Table A.1.2 Temperature of Sub-project Areas

(Unit: °C)

Sub-Project Area	Station	Elevation (m)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
San Pedro de Iguaque	UPTC	2,690	Mean	12.8	13.5	13.8	13.4	13.1	12.5	11.9	12.1	12.6	13.2	13.4	12.9
			Max	15.7	16.1	16.8	14.2	15.0	14.8	14.0	14.2	15.0	15.3	15.2	15.1
			Min	12.2	12.5	12.8	12.8	12.6	11.7	11.3	11.5	11.9	12.5	12.4	12.1
Santa Sofia	Villa Carmen	2,600	Mean	13.5	13.9	14.2	14.2	14.0	13.5	12.9	13.1	13.3	13.7	13.8	13.4
			Max	14.2	14.8	15.2	15.1	14.8	14.0	13.3	13.6	14.0	14.0	14.1	14.0
			Min	12.9	13.0	13.2	13.6	13.5	12.9	12.5	12.6	12.7	13.0	12.8	12.8
Caqueza	*		Mean	19.0	20.0	20.0	20.0	19.0	19.0	20.0	20.0	19.0	19.0	19.0	19.0
			Max	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
			Min	14.0	14.0	15.0	15.0	15.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Tibacuy	Tibacuy	1,550	Mean	19.3	19.5	19.5	19.3	19.2	18.9	19.1	19.4	19.6	19.4	18.8	19.0
			Max	20.6	21.0	20.7	20.3	19.9	20.1	20.2	20.2	21.0	20.1	19.7	20.0
			Min	17.6	18.1	18.5	18.5	18.6	17.8	18.0	18.4	18.7	18.2	18.0	17.6

* Temperature of Caqueza is taken from "Estudio Agro-Climatico del Area de Caqueza" HIMAT.

Table A.1.3 Relative Humidity in Sub-project Areas

(Unit: %)

Sub-Project Area	Station	Elevation (m)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
San Pedro de Iguaque, Santa Sofia	VILLA DE LEYVA	2,250	Mean	73	74	74	77	75	73	69	71	71	75	77	77
			Max	80	83	80	82	81	81	75	76	79	80	82	82
			Min	65	67	66	68	70	67	60	64	63	70	71	73
Caqueza	CHINGAZA - LAGUNA	1,895	Mean	82	82	85	86	88	88	88	88	88	86	85	84
			Max	87	89	90	91	90	91	90	94	97	89	90	90
			Min	75	74	77	81	86	82	82	82	85	81	82	79
Tibacuy	TIBACUY	1,550	Mean	77	77	78	81	81	79	74	72	71	78	82	80
			Max	85	90	90	87	86	85	81	82	89	87	89	89
			Min	63	68	67	74	76	71	68	66	60	71	78	69

Table A.1.4 Evaporation in Sub-project Areas

Observation Station	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
VILLA DE LEYVA	2,250	Mean	116.1	106.6	114.5	99.3	108.0	127.7	120.8	124.9	112.8	99.6	90.1	91.7
		Maximum	177.9	145.6	160.8	144.4	130.3	332.3	140.1	149.2	152.2	135.3	102.6	127.0
		Minimum	83.6	72.5	64.1	66.3	70.2	74.3	102.7	109.0	91.7	70.6	76.4	37.8

Table A.1.6 Sunshine Hours in Sub-project Areas

(Unit: Hours)

Sub-Project Area	Station	Elevation (m)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
San Pedro de Iguaque, Santa Sofia	VILLA DE LEIVA	2,250	Mean	190.1	151.6	145.6	111.0	130.7	136.9	153.0	144.1	124.2	116.2	128.6	151.4
			Max	219.3	189.1	191.9	140.7	147.8	167.3	186.0	181.2	159.4	175.4	164.6	230.2
			Min	141.0	113.3	119.5	73.8	109.5	83.9	118.0	111.1	92.4	76.0	96.3	44.0
Caqueza	CHINGAZA - LAGUNA	1,895	Mean	136.8	121.3	90.7	74.4	72.7	60.2	80.6	88.9	84.4	91.3	105.1	111.4
			Max	196.4	182.1	122.4	107.2	102.6	75.3	127.2	116.3	112.3	112.0	113.0	197.1
			Min	73.0	75.4	41.7	46.9	47.2	37.7	42.8	59.8	61.1	57.1	84.7	28.3
Tibacuy	TIBACUY	1,500	Mean	190.8	158.6	140.1	114.1	127.9	130.7	152.1	143.6	140.1	140.0	141.7	177.5
			Max	218.2	195.9	154.7	228.4	173.8	178.1	180.1	186.0	184.8	204.0	234.1	268.9
			Min	85.7	97.2	75.4	80.9	90.6	103.2	90.9	97.0	100.7	93.3	86.5	75.4

Table A.1.7 (1) Monthly Precipitation in San Pedro de Iguaque

Observation Station : San Pedro de Iguaque

(Unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1981	20.0	63.0	53.0	302.0	297.0	51.0	50.0	70.0	118.0	148.0	160.0	58.0	1,390.0
1982	103.0	137.0	-	-	-	-	75.0	105.0	83.5	178.0	97.2	99.0	878.5
1983	0.0	5.6	57.7	149.1	106.2	58.0	19.0	9.0	3.2	42.0	71.7	140.0	661.5
1984	57.4	88.5	38.4	105.4	86.5	10.2	93.7	14.1	111.0	68.0			
Mean	45.1	73.5	49.7	185.5	163.2	39.7	59.4	49.5	78.9	109.2	109.6	99.0	1,062.5
Max	103.0	137.0	57.7	302.0	297.0	58.0	93.7	105.0	118.0	178.8	160.0	140.0	302.0
Min	0.0	5.6	38.4	105.4	86.5	10.2	19.0	9.0	3.2	42.0	71.7	58.0	0.0

Table A.1.7 (2) Monthly Precipitation in Santa Sofia

Observation Station : Santa Sofia

(Unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1966	23.5	6.0	112.5	65.0	118.0	90.5	70.5	52.5	59.0	193.0	112.0	64.0	966.5
1967	57.5	38.0	116.0	189.0	184.5	80.5	33.0	50.0	55.0	85.0	78.5	92.0	1,059.0
1968	34.5	28.0	110.0	298.0	68.0	185.0	12.0	18.0	108.0	218.0	147.0	40.0	1,266.5
1969	28.0	87.0	50.1	168.0	127.0	99.5	2.0	42.0	64.0	360.0	255.5	66.0	1,349.0
1970	58.0	23.0	40.0	97.5	120.0	69.0	53.0	72.0	105.0	142.0	195.0	97.0	1,071.5
1971	133.0	85.0	177.0	110.0	191.0	101.0	34.0	86.0	152.1	133.0	118.0	80.0	1,400.1
1972	120.0	58.0	92.0	284.0	68.0	87.0	53.0	94.0	32.0	77.0	179.0	95.0	1,239.0
1973	31.0	0.0	65.0	106.0	93.0	107.0	67.0	62.0	140.0	150.0	194.0	106.0	1,121.0
1974	20.0	73.0	109.5	133.5	105.0	106.5	33.0	31.0	131.0	168.0	172.0	8.0	1,090.5
1975	5.0	75.0	89.0	87.0	192.0	64.0	95.0	77.0	92.0	205.0	62.0	119.0	1,162.0
1976	23.0	69.0	102.0	170.0	57.0	49.0	3.0	12.0	40.0	180.0	94.0	59.0	858.0
1977	9.0	69.0	63.0	52.0	72.0	44.0	96.0	45.0	95.0	109.0	119.0	27.0	800.0
1978	5.0	51.0	139.5	208.0	93.0	103.0	70.0	26.0	83.0	178.0	88.0	60.0	1,104.5
1979	23.0	90.0	98.0	139.0	202.0	86.0	81.0	96.0	91.0	204.0	266.0	33.0	1,409.0
1980	6.0	85.0	40.0	86.0	68.0	89.0	35.0	34.5	77.0	221.0	110.0	62.0	913.0
1981	15.0	55.0	19.0	202.0	259.0	69.0	47.0	57.0	72.0	146.0	120.0	50.0	1,111.0
1982	97.0	141.0	164.0	248.0	112.5	24.0	33.5	3.0	94.0	252.0	136.0	63.0	1,368.0
1983	3.0	15.0	38.5	198.0	155.5	77.0	43.0	18.5	31.0	120.0	74.5	158.0	932.0
Mean	38.4	58.2	90.3	157.8	127.0	85.1	47.8	48.7	84.5	174.5	140.0	71.1	1,123.4
Max	133.0	141.0	177.0	298.0	259.0	185.0	96.0	96.0	152.1	360.0	266.0	158.0	360.0
Min	3.0	0.0	19.0	52.0	57.0	24.0	2.0	3.0	31.0	77.0	62.0	8.0	0.0

Table A.1.7 (3) Monthly Precipitation in Caqueza

Observation Station: Caqueza

(Unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1957	0.0	24.0	39.1	12.2	17.8	72.3	122.7	78.2	97.5	50.9	16.2	14.2	545.1
1970	20.8	10.8	40.1	101.8	149.8	105.3	120.7	125.7	81.4	108.4	40.8	25.6	931.5
1971	13.9	42.5	56.0	98.2	123.8	123.8	168.2	106.6	100.2	91.3	44.5	25.6	994.6
1972	37.3	14.1	77.6	44.0	151.0	81.5	48.9	97.0	29.9	60.8	60.5	10.5	713.1
1973	5.8	0.8	14.6	35.5	87.2	124.9	97.5	146.3	113.6	83.6	19.7	28.9	758.4
1974	25.0	42.0	21.4	82.5	143.7	76.0	89.9	66.8	61.0	71.2	61.6	1.5	742.6
1975	4.2	20.8	40.3	58.0	106.7	129.2	91.5	133.8	67.9	66.5	44.0	49.1	812.0
1976	5.1	5.1	43.9	90.8	119.3	113.9	82.7	64.5	43.4	55.0	88.0	13.2	724.9
1977	0.0	37.2	14.7	66.2	62.7	78.0	123.5	74.5	51.6	72.1	51.5	5.1	637.1
1978	3.5	13.3	17.6	43.8	76.3	108.6	91.9	122.5	99.7	29.5	23.3	22.9	652.9
1979	12.4	0.1	43.0	112.0	51.4	100.7	55.8	89.6	43.8	146.3	89.3	17.7	762.1
1980	26.4	25.8	25.3	99.7	71.3	121.0	51.2	88.1	65.6	103.8	17.1	17.9	713.2
1981	0.0	18.9	1.3	73.4	116.8	73.9	70.0	54.2	70.6	79.0	92.0	10.5	660.6
1982	43.2	17.1	54.5	140.5	86.4	49.9	138.4	105.8	53.5	63.0	31.4	16.8	800.5
1983	7.7	62.5	63.1	109.7	76.4	25.1	140.8	84.6	51.7	58.5	32.4	27.0	739.5
1984	-	63.4	12.7	55.1	126.2	199.3	98.0	132.8	60.4	23.3	31.3	-	802.5
Mean	13.7	24.9	35.3	76.5	97.9	99.0	99.5	98.2	68.2	72.7	46.5	19.1	751.5
Max	43.2	63.4	77.6	140.5	151.0	199.3	168.2	146.3	113.6	146.3	92.0	49.1	199.3
Min	0.0	0.1	1.3	12.2	17.8	25.1	48.9	54.2	29.9	23.3	16.2	1.5	0.0

Table A.1.7 (4) Monthly Precipitation in Tibacuy

Observation Station: Alberto Williamson

(Unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1956	136.8	192.6	164.9	73.4	107.6	81.9	23.9	49.5	63.1	191.0	108.8	175.0	1,368.5
1957	22.2	46.7	209.5	155.6	143.2	16.2	24.2	22.6	56.3	210.4	157.9	40.4	1,105.2
1958	54.2	80.2	54.0	92.3	63.8	37.3	12.2	39.1	21.4	176.6	121.5	115.4	868.0
1959	44.9	14.5	18.7	72.6	243.3	127.4	68.5	21.2	19.9	211.1	169.1	58.4	1,069.6
1960	95.0	131.2	80.4	99.5	75.1	45.6	29.8	69.3	23.7	210.6	68.5	122.2	1,050.9
1961	74.5	54.8	114.5	178.7	55.9	28.9	69.5	17.8	18.6	171.3	179.9	33.4	997.8
1962	55.3	54.3	103.5	66.9	98.2	79.5	39.7	37.9	55.5	97.1	90.8	143.6	922.3
1963	78.0	130.0	52.7	160.8	245.0	29.9	103.5	23.3	25.7	140.2	238.1	57.0	1,285.0
1964	17.5	29.2	32.5	8.4	104.9	78.4	77.6	63.7	49.8	230.9	147.9	71.6	984.4
1965	29.3	15.6	69.3	134.7	85.4	7.3	11.0	58.2	18.4	201.9	296.3	86.8	1,014.2
1966	12.7	68.3	130.0	83.2	96.9	107.3	53.9	52.4	117.0	92.1	300.9	179.1	1,292.9
1967	20.1	31.9	139.1	171.6	115.8	71.8	29.1	12.5	27.0	80.2	194.1	95.2	988.4
1968	95.2	112.6	37.3	281.7	53.1	136.3	21.8	36.3	60.9	206.3	281.6	98.3	1,421.4
1969	54.6	40.6	26.3	150.8	108.2	34.3	7.3	16.1	46.4	310.4	173.6	28.0	996.6
1970	65.4	108.0	68.5	97.8	134.3	45.1	41.0	36.5	89.0	173.6	211.6	12.2	1,083.0
1971	155.0	59.8	101.2	88.1	134.6	47.5	37.8	55.2	51.4	119.0	140.0	77.7	1,067.3
1972	147.6	71.9	109.5	198.4	85.1	91.4	11.4	49.3	49.2	86.6	226.4	79.1	1,205.9
1973	21.9	34.7	20.8	65.8	67.9	33.6	37.4	96.7	80.5	133.0	142.5	315.0	1,049.8
1974	191.0	168.9	287.8	156.0	59.4	31.7	12.7	29.1	57.2	117.4	72.6	14.3	1,198.1
1975	5.8	174.5	159.7	155.8	99.0	46.7	175.3	41.5	48.9	152.3	173.0	162.4	1,394.9
1976	18.2	73.6	236.7	69.7	30.5	39.6	4.0	18.1	83.6	251.9	113.2	95.7	1,034.8
1977	15.9	10.4	105.2	152.9	54.5	33.5	28.6	19.1	96.9	82.3	159.1	41.4	799.8
1978	18.2	24.4	178.7	99.3	73.8	65.7	23.8	12.6	77.8	151.4	77.4	96.1	899.2
1979	39.5	48.2	118.0	123.0	90.3	108.8	57.9	56.8	40.9	104.4	331.8	40.2	1,159.8
Mean	61.2	74.0	109.1	125.4	101.0	59.4	41.7	39.0	53.3	162.5	174.0	93.3	1,094.1
Max	191.0	192.6	287.8	281.7	245.8	136.3	175.3	96.7	117.0	310.4	331.8	315.0	331.8
Min	5.8	10.4	18.7	65.8	30.5	7.3	4.0	12.5	18.4	80.2	68.5	12.2	4.0

Table A.1.8 Evapotranspiration and Related Factors

1. San Pedro de Iguaque

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T mean (°C)	12.8	13.5	13.8	13.4	13.1	12.5	11.9	12.1	12.6	13.2	13.4	12.9
Tv	10.8	11.5	11.7	11.9	11.3	10.6	9.6	10.0	10.4	11.1	11.9	11.5
Bs (Hr)	6.1	5.4	4.7	3.7	4.2	4.6	4.9	4.6	4.1	3.7	4.3	4.9
U2 (m/s)	2.7	2.5	3.1	2.5	2.6	2.9	3.3	3.0	2.8	2.5	2.1	2.3
ETP(mm/day)	2.70	2.91	3.24	3.02	3.06	3.07	3.25	3.19	3.12	2.86	2.56	2.43
ETP(mm/month)	83.83	81.62	100.32	90.60	94.77	92.16	100.81	98.87	93.73	88.74	76.86	75.18

2. Santa Sofia

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T mean (°C)	13.5	13.9	14.2	14.2	14.0	13.5	12.9	13.1	13.3	13.7	13.8	13.4
Tv	11.3	11.8	2.0	12.5	12.0	11.3	10.3	10.7	10.9	11.8	12.2	11.9
Bs (Hr)	6.1	5.4	4.7	3.7	4.2	4.6	4.9	4.6	4.1	3.7	4.3	4.9
U2 (m/s)	2.7	2.5	3.1	2.5	2.6	2.9	3.3	3.0	2.8	2.5	2.1	2.3
ETP(mm/day)	2.76	2.94	3.26	3.07	3.12	3.15	3.33	3.26	3.17	2.89	2.58	2.45
ETP(mm/month)	85.46	82.28	101.21	92.21	96.60	94.52	103.22	101.21	95.20	89.49	77.42	75.90

3. Caqueza

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T mean (°C)	19.0	20.0	20.0	20.0	19.0	19.0	20.0	20.0	19.0	19.0	19.0	19.0
Tv	18.0	19.2	19.9	20.1	19.4	19.4	20.6	20.6	19.4	18.4	18.7	18.5
Bs (Hr)	4.4	4.3	2.9	2.5	2.3	2.0	2.6	2.9	2.8	2.9	3.5	3.6
U2 (m/s)	2.7	2.5	3.1	2.5	2.6	2.9	3.3	3.0	2.8	2.5	2.1	2.3
ETP(mm/day)	2.93	3.19	3.10	3.10	2.88	2.81	3.03	3.09	2.96	2.98	2.73	2.65
ETP(mm/month)	90.72	89.19	99.44	93.00	89.16	84.40	93.97	95.78	88.94	92.27	81.94	82.26

4. Tibacuy

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T mean (°C)	19.3	19.5	19.5	19.3	19.2	18.9	19.1	19.4	19.6	19.1	18.8	19.0
Tv	17.2	17.5	17.7	18.1	18.0	17.2	16.4	16.2	16.2	17.2	17.8	17.6
Bs (Hr)	6.2	5.7	4.5	3.8	4.1	4.4	4.9	4.6	4.7	4.5	4.7	5.7
U2 (m/s)	2.7	2.5	3.1	2.5	2.6	2.9	3.3	3.0	2.8	2.5	2.1	2.3
ETP(mm/day)	3.25	3.42	3.61	3.36	3.33	3.39	3.73	3.80	3.80	3.33	2.90	2.92
ETP(mm/month)	100.63	95.71	111.83	100.93	103.38	101.67	115.56	117.66	114.04	103.16	87.06	90.55

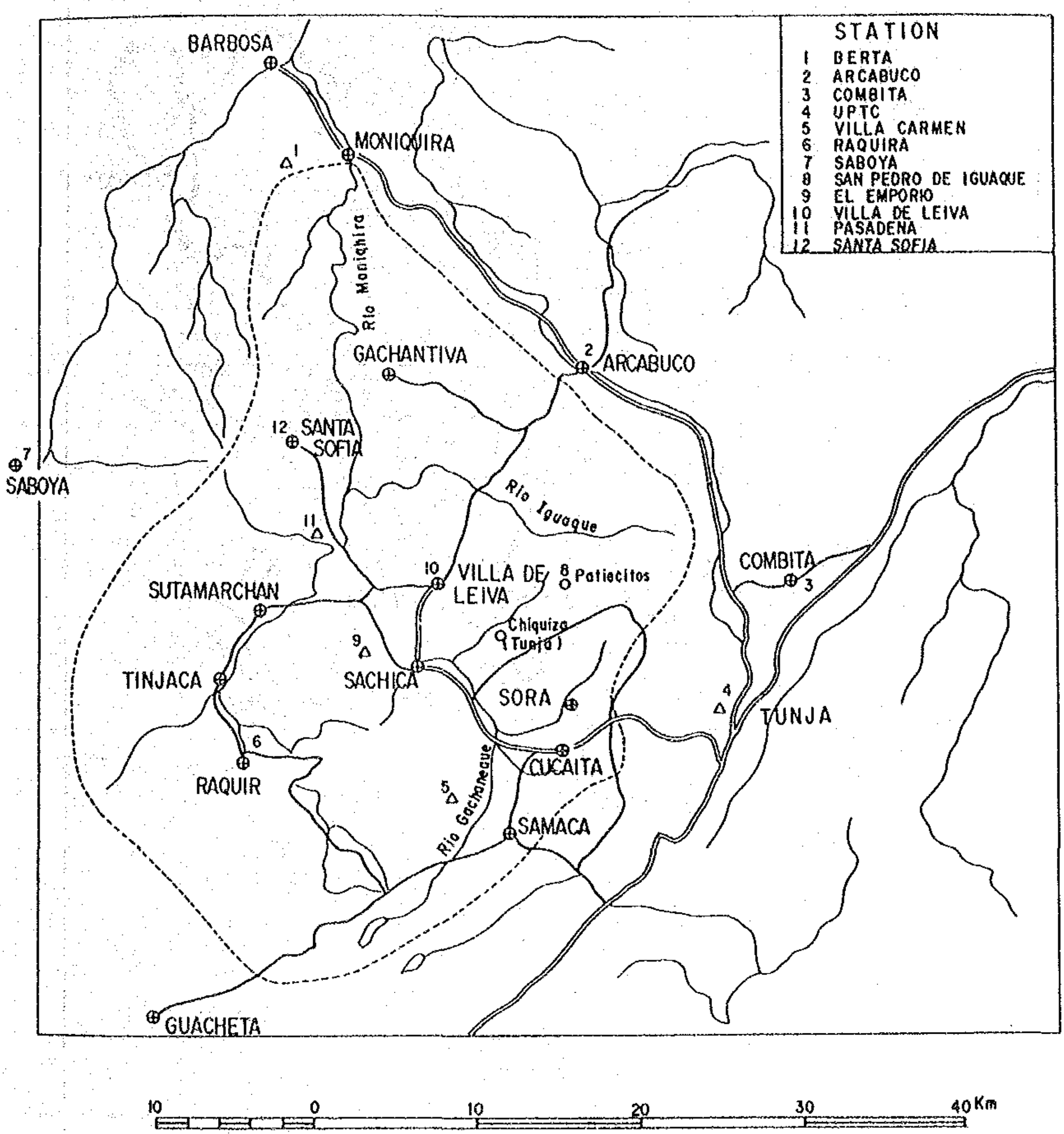

Fig.A.1.1 Locatio of Meteorological Observation Stations in San Pedro de Iguaque and Santa Sofia and their Neighboring Area

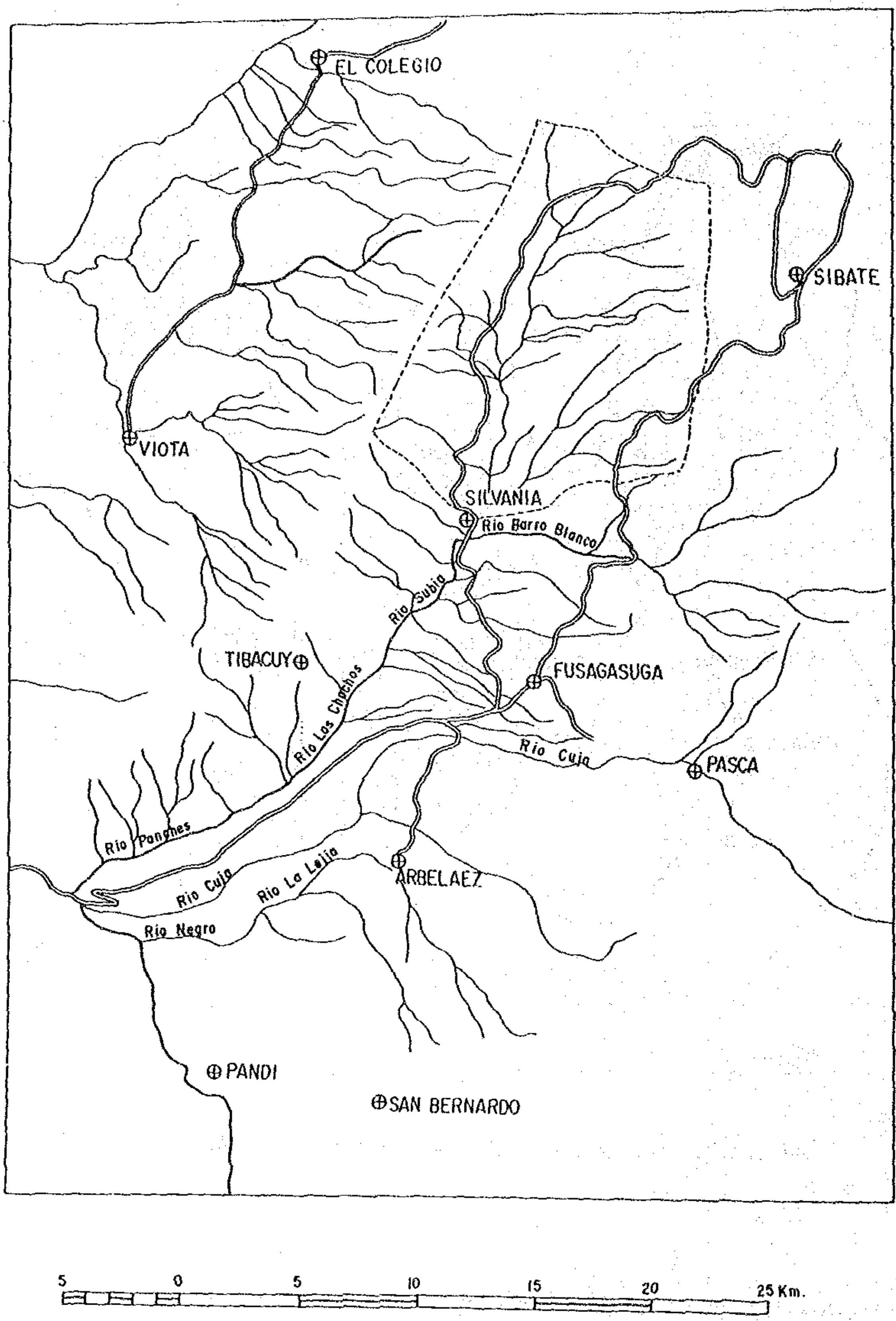

Fig.A.1.2 Location of Meteorologocal Observation Stations in Tibacuy and Neighboring Area

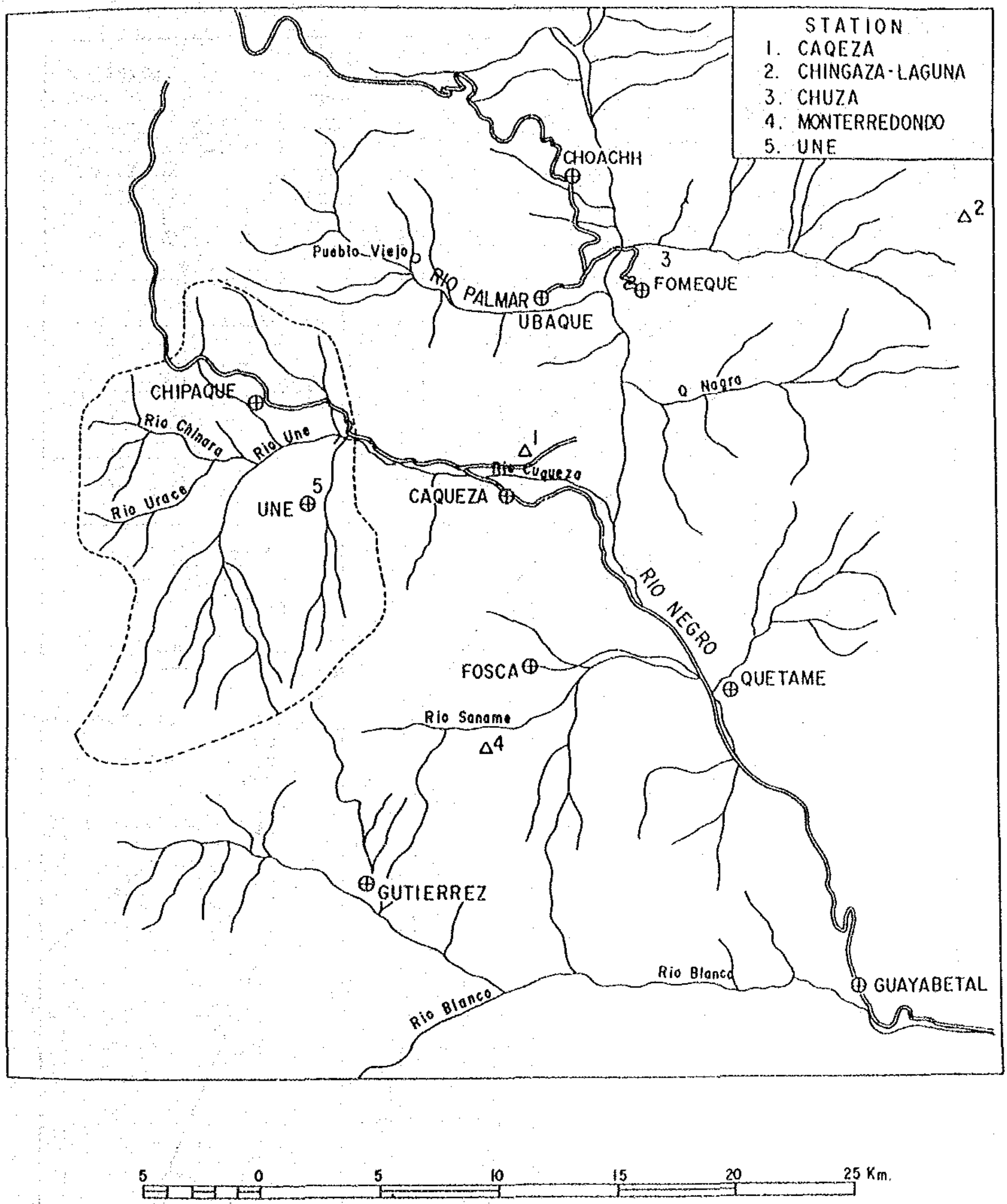

Fig.A.1.3 Location of Meteorological Observation Stations in Caqueza and its Neighboring Area

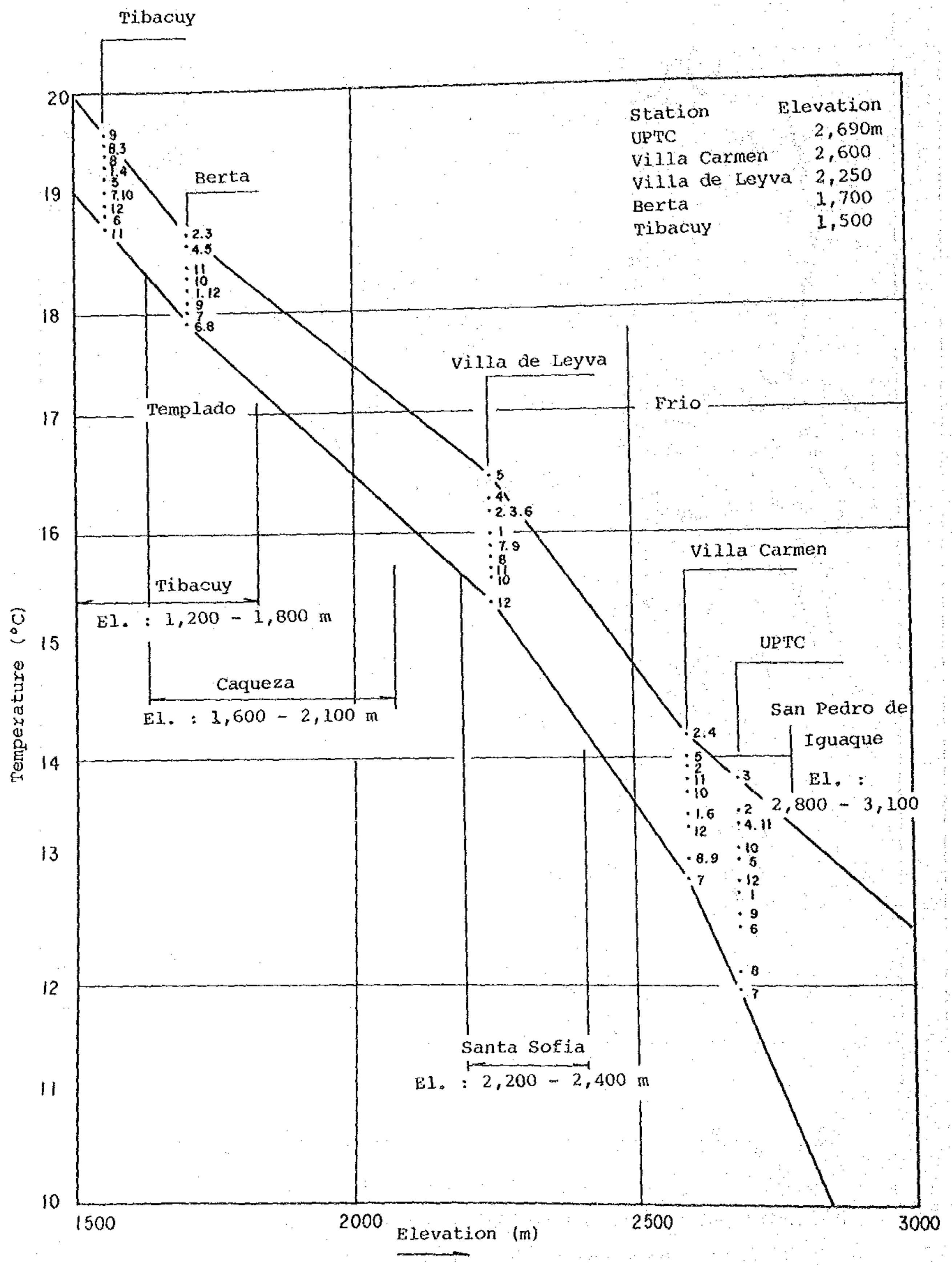

Fig. A.1.4 Correlation Chart between Elevation and Temperature

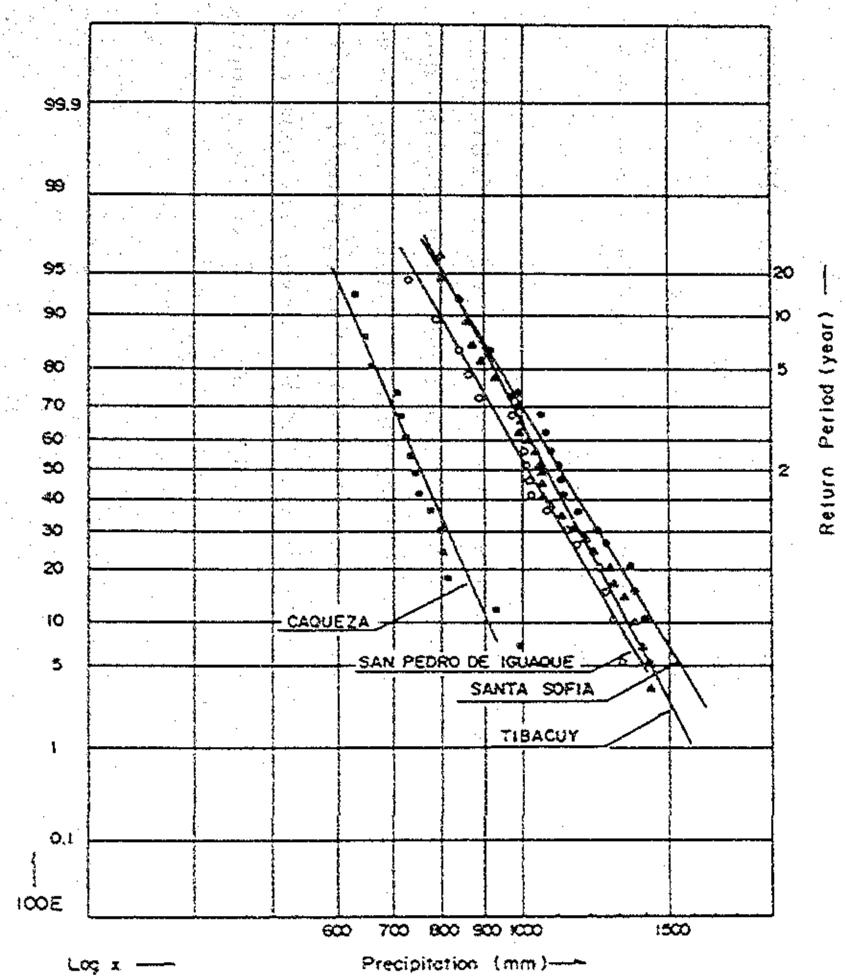

Fig. A.1.5 Distribution Curve of Probable Annual Precipitation

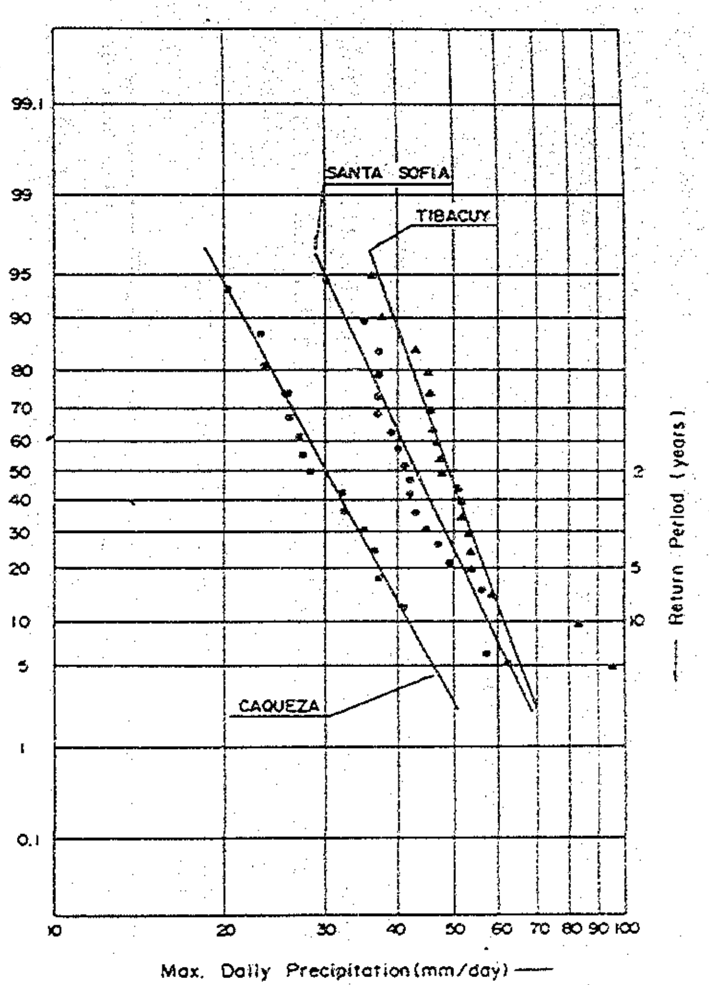

Fig. A.1.6 Distribution Curve of Probable Daily Precipitation

2. HYDROLOGY

2.1 Project areas and related Rivers

2.1.1 Rivers related project Areas

The following three rivres are running through the sub-project areas and their neighboring areas, and are being observed by HIMAT in long terms. Their locations are shown in Figures A.1.1, A.1.2 and A.1.3.

Table A.2.11 Location of Gauging Station

Name of Rivers	Watershed* (km^2)	Relation to the Project Areas	Observation Period
Moniquira	1,116	San pedro de Iguaque and Santa Sofia areas are located in this watershed.	1975 - 1984
Une	165	A tributary branched off at upstream of the Caqueza river. Caqueza area is located in the Caqueza river basin.	1972 - 1984
Subia	156	A tributary branched off at upstream of the Chochos River, of which watershed Tibacuy area is located in.	1966 - 1984

* : Watershed area above the gaging stations.

The monthly discharges of these rivers are shown in Table A.2.1, A.2.2 and A.2.3. Since the Moniquira and Subia Rivers are flowing down the western slope of the East Mountain range where two times rainy season a year are prevailing, two times of peak rive discharge, namely in May and November are observed. The other hand, the Une River has peak river discharge only once a year, in June, because the Une River is running through eastern and western direction.

The average runoff coefficient of these rivers are shown below. The Moniquira River has low average rounoff coefficient due to its relatively large area of watershed.

Table A.2.12 Estimated Runoff Coefficient

Name of River	Average (m^3/s)	Annual Discharge (mm)	Annual Precipitation (mm)	Runoff Coefficient (%)
Moniquira	11.74	331	1,144*	29
Une	4.74	906	1,736**	52
Subia	3.06	619	1,094***	57

* : Average precipitation of Reaquira, Villa Carmen, Villa de Leiva, Iguaque, Archbuco and Santa Sofia.

** : Estimated average precipitation in the watershed of the Une River.

*** : Average precipitation of Tibacuy.

2.1.2 Streams in Sub-project Areas

The streams which can be expected to be water sources for the project area are shown in the below Table. Watershed area of all streams are less than 20 km^2.

Table A.2.13 Situation of the Streams in Project Area

Name of project area	Name of River System	Name of River	Name of Stream	Length (km)	Average slope (%)	Water-shed (km^2)	Elevation of the confluence
San Pedro de Iguaque	Moniquira	Iguaque	Yerba-buena	4.5	6.0	9.4	2,850
	ditto	ditto	Carrizal	6.5	5.2	10.9	2,860
Santa Sofia	Moniquira	Moniquira	Paponegro	4.3	16.9	3.9	2,360
	ditto	ditto	Bengala	4.7	17.4	3.3	2,360
	ditto	ditto	La Cruz	4.7	14.5	2.7	2,130
	ditto	ditto	Camelo	5.5	17.4	5.8	2,190
	ditto	ditto	La Laja	4.8	17.7	6.8	2,190
	ditto	ditto	Piedras	5.5	15.5	8.4	1,950
Caqueza	Caqueza	Cazueza	Negra	4.1	18.3	3.3	1,500
	ditto	ditto	Blanca	3.5	25.3	2.8	1,550
Tibacuy	Chochos	Chochos	San Jose	4.8	18.9	8.3	1,150
	ditto	ditto	Boza	3.3	23.1	4.6	1,030

These streams have no gaging station and are out of the observation networks managed by HIMAT. In view of such conditions, the Mission selected six streams among the above-listed streams in consultation with HIMAT and has commenced observation of river discharge since May 1986.

2.2 Runoff Analysis

The irrigation water of sub-project areas will be supplied from diversion weirs constructed in the nine streams running through the project areas. As indicated in the below Table, the drainage areas of these diversion weirs are relatively small and less than several square kilometers.

Table A.2.14 Location of Proposed Diversion Weirs

Name of sub-project area	Name of Streams	Proposed intake Structures	Drainage area (km^2)	Remarks
San Pedro de	Carrizal	Carrizal No. 1	5.6	
Iguaque	Yerna-	Yernabuena No. 1	2.9	Including the drain-
	buena	(Pilot project)	(0.6)	age area of $0.6km^2$
		Yarnabuena No. 2		for Yerbuena No. 2
Santa Sofia	Piedras	Piedras	3.0	
	La Laja	La Laja	3.0	
	Camelo	Camelo	3.7	
	Palonegro	Palonegro	2.4	Supplemental water source: 1 reservoir
Caqueza	Negra	Negra No. 1	1.4	
	"	Negra No. 2	1.3	
	"	Negra No. 3	1.0	
	Blanca	Blanca No. 1	1.4	
	"	Blanca No. 2	1.1	Supplemental water source: 4 reservoirs
Tibacuy	San Jose	San Jose No. 1	3.6	
	"	San Jose No. 2	1.1	Pilot

Because the past recordings of the river discharge are as mentioned before, runoff analysis was conducted by the following methods after the project areas were classified into two categories. One category includes San Pedro de Iguaque and Santa Sofia sub-project areas where observaion of stream discharges are being carried out. Another category contains Caqueza and Tibacuy sub-project areas where records of steam discharge are not available.

San Pedro de Iguaque and San Sofia sub-project areas:

Based on the discharge records obtained during the field study, runoff analysis of these sub-project areas was undertaken using the Multiple Regression Runoff Method.

Caqueza and Tibacuy sub-project areas:

Due to improper gaging records obtained from rectangular weir which was installed in the San Jose Stream of Tibacuy sub-project area, runoff analysis of these areas was conducted by using the discharge records of the observation stations which are located in the Une and Subia Rivers, the nearest and related rivers.

Details of the runoff analysis are described below.

2.2.1 San Pedro de Iguaque and Santa Sofia sub-project areas

(1) Discharge observatin points and methods

Since May 1986, discharge observation has been conducted by HIMAT using triangular weir. Conditions of the observation points in each stream are as follows:

Table A.2.15 Location of Discharge Observation Points

Name of Sub-project Area	Name of Stream	Elevation of Observ. Point (m)	Drainage Area (km^2)	Soil and Vegetation of Drainage Area
San Pedro Iguaque	Yerbabuena	2,975	2.94	Mostly field and grass land Partly forest. Soil layer is relativel thick. Flat area (swampy) in the upstream area.
Santa Sofia	La Cruz	2,970	0.83	Forest and grass land
	Camelo	2,650	1.05	Partly orchard Soil layer is relatively thick.
	Palonegro	2,650	1.00	Potable and domestic water have been taken.
	Guatoque	2,550	0.65	

Location of the observation points of the streams are shown in Figures A.2.1 and A.2.2.

Over depth of the triangular weirs were measured twice a day by stuff installed upstream of the triangular weirs. Stream discharges are calculated applying the following formulae.

Name of stream	Formulae
Yerbabuena	$Q = 1.03\ h^{2.47}$
La Cruz	$Q = 0.83\ h^{2.47}$
Camelo	$Q = 0.98\ h^{2.47}$
Palonegro	$Q = 1.02\ h^{2.47}$
Guatoque	$Q = 1.25\ h^{2.47}$

(2) Observation Results

The observed steam discharges and hydrograph are shown in Table A.2.4 and A.2.5 and Figures A.2.3 and A.2.4.

The precipitation records which are indicated in the Table and Figures above-mentioned were obtained from the rainfall gagiang stations of which locations are shown in Fugure A.2.1 and A.2.2.

The runoff coefficient during observation period were calculated from the abovementioned hydrograph and are shown below.

Table A.2.16 Runoff Coefficients of the Streams

Name of Stream	Observation Period	Total Rainfall (mm)	Total Discharge (mm)	Runoff Coefficient (%)
Yebabuena	6/1 - 7/31 '86	67	15	23
La Cruz	5/1 - 7/14 '86	205	186	91
Camelo	5/1 - 7/14 '86	205	135	66
Palonegro	5/1 - 7/14 '86	205	19	9
Guatoque	5/1 - 7/14 '86	205	139	68

The base flows of each stream are expected as follows:

Table A.2.17 Base Flows of the Streams

Name of Stream	Base Flow liter/sec	Drainage Area km^2	Unit Base Flow liter/sec/km^2
Yerbabuena	6.0	2.94	2.04
La Cruz	3.0 - 2.0	0.83	3.61 - 2.4
Camelo	5.0 - 3.0	1.05	4.76 - 2.9
Palonegro	1.0	1.0	1.0
Guatoque	4.0	0.65	6.2

(3) Runoff Analysis

As mentioned above, the correlation between the observed rainfall and runoff was analyzed statistically (by method of least square) and formulated a runoff model (unit graph).

Namely, $Q_{(i)} = \sum_{v=1}^{n} h_{(v)} \cdot R_{(i-v)}$

where $Q_{(i)}$: Daily discharge 1/s
$h_{(v)}$: Unit discharge $1/s/km^2$
$R_{(i-v)}$: Daily rainfall mm

1) Direct Discharge

After analyzd by the above method the discharge amount (direct discharge) caused by unit rainfall is shown in the below Table.

Table A.2.18 Discharge Curve by Unit Rainfall

Unit: $l/s/km^2$

Name of Stream	Days									
	0	1	2	3	4	5	6	7	8	9
San Pedro de Iguaque Yerbabuena	0.12	0.14	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.00
Santa Sofia										
Camelo	0.44	0.43	0.42	0.37	0.32	0.27	0.22	0.17	0.14	0.11
Palonegro	0.40	0.34	0.28	0.26	0.24	0.22	0.20	0.16	0.13	0.12
Guatoque	0.75	0.54	0.31	0.28	0.24	0.22	0.18	0.15	0.12	0.12

Name of Stream	Days				
	10	11	12	13	Total
San Pedro de Iguaque					
Yerbabuena	-	-	-	-	
Santa Sofia					
Camelo	0.08	0.04	0.01	0.00	3.02
Palonegro	0.12	0.11	0.00	-	2.58
Guatoque	0.11	0.00	-	-	3.02

Note : As mentioned in the above (2), the runoff coefficient at la Cruz during the observation period (from 5/16 to 7/14 '86) is 91%, and is larger than the coefficient of the other neighboring streams which have a long term observation records. Such large percentage as 91% is considered to be improper for formulaing a model of the low discharge analysis. Therefore, the runoff coefficient at La Cruz is discarded for this analysis.

The results of the analyses are presented graphically in Fug. A.2.5.

Theses models are inherent to each stream. However, the topography, soil conditions and vegetations, etc. in watershed of Yerbabuena are almost same as those of the other streams in San Pedro de Iguaque. Therefore, it is considered that the runoff model of Yerbabuena can be applicable to the other streams running through San Pedro de Iguaque sub-project area.

In Santa Sofia sub-project area, topography, soil conditions, vegetations and drainage area of watershed of all streams are almost similar each other. therefore, an unified runoff model is convenient for runoff analyses of many number of small streams.

In view of the foregoing, the runoff models of San Pedro de Iguaque and Santa Sofia sub-project areas are decided as follows:

Table A.2.19 Runoff Models

(Unit: $l/s/km^2$)

Type of Model	Days											
	0	1	2	3	4	5	6	7	8	9	10	11
San Pedro de Iguaque												
I	0.12	0.14	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.00		
Santa Sofia												
II	0.53	0.44	0.34	0.30	0.27	0.24	0.20	0.16	0.13	0.12	0.10	0.05

(refer to Figure A.2.5)

2) Base Flow

As explained in the above paragraph (1), the base flows are as follows:

Table A.2.20 Base Flows of the Streams

Name of Stream	Base Flow $l/s/km^2$
San Pedro de Iguaque	
Yerbabuena :	2.04
San Sofia	
La Cruz :	2.40 - 3.61
Camelo :	2.90 - 4.76
Palonegro :	1.0
Guatoque :	6.2

At Yerbabuena, minimum discharge of 2.1 $l/s/km^2$ was actually recorded in February 1986 during dry season. Therefore, discharge of 2.0 $l/s/km^2$ is considered to be reasonable as low flow during dry season. since the other streams in San Pedro de Iguaque area have almost same watershed features as those of Yerbabuena, the discharge of 2.0 $l/s/km^2$ is applied for low flow (base flow) of all streams in the area.

As for the streams in Santa Sofia area, discharge of 1.0 - 6.2 $l/s/km^2$ were actually measured as the low flow during dry season. However, rainfall distributiion during the observation period is slightly heavy compared with that of the drought year. Therefore, 2.4 $l/s/km^2$ was adopted with safety as the low flow (base flow) during dry season for each stream in the area.

In case of Palonegro, some amount of water is taken from upstream of the area. Therefore, this matter should be considered when water utilization plan on the stream is formulated.

3) Justification of Discharge

The results of discharge computation from rainfall during the observation period, using the model established in the above paragraphs 1) and 2), are shown in Figure A.2.6 and A.2.7 (1) - (2). the following coments are noted on the results in comparison with the actually measured data.

The estimated peak discharge in the hydrograph s less than the measured data.

Discharges during decreasing stage are almost similar in both case.

Because the results of this analysis is used for estimation of the available water amount which can be taken from the diversion weirs in the related streams, the abovementioned model in which the discharge during decreasing stage is similar to the measured discharge, is applied for each stream.

4) Available water amount

Through the abovementioned process, the available water amount of each stream in San Pedro de Iguaque and Santa Sofia sub-project areas was estimated from the rainfall records and are shown in Table A.2.6 and A.2.7.

2.2.2 Caqueza and Tibacuy Sub-project Areas

(1) Runoff analysis of Caqueza area

Stream discharges in Caqueza area is estimated from the measured discharge for 19 years observation period in the Une River (165 km^2 of drainage area) which is a tributary of upstream of Caqueza river and located in the watershed where the area is also situated. Three rainfall gaging stations are existed in and around the project area. They are Une in the Une river basin and Monterredondo located 13 km south of the project area in addtion to Caqueza. Observation period of these stations including discharge measurement are as follows:

Station	Observed Year																				Elevation of Station
	57	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	
Rainfall																					
Une		...	—	—																	2,400
Caqueza					—	—	—	—	—	—	—	—	...	—	—	—	—	—	...	...	1,600
Monterredond		—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—			1,300
Discharge (D.A=165km2)																					
Une River		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1,940

... Lack of Record

1) Method of discharge estimation

As indicated in Figure, correlation between year-round distribution ratios of measured data (rainfall and discharge) is quite high each other. Therefore, discharge amount of Caqueza area is estimated by the following formula.

$$Q_c = Q_u \times \frac{R_c}{R_u}$$

where Q_c : Discharge of Caqueza

Q_u : Discharge of Une

R_c : Rainfall in Caqueza

R_u : Rainfall in Une

2) Rainfall ratio between Une and Caqueza

There are no rainfall data which measured simultaneously in the past at Une and Caqueza. Therefore, the rainfall ratio between Une and Caqueza is calculated through the measured data of the Monterredondo station. The rainfall ratio between each rainfall gaging station is as follows:

Une / Monterredondo = 0.76

Monterredondo / Caqueza = 2.9

Therefore,

Une / Caqueza = 0.76 x 2.9 = 2.2

The annual rainfall of Une is considered to be 2.2 times of annual rainfall of Caqueza.

3) Estimation of unit monthly discharge in Caqueza area

The unit monthly discharge in Caqueza area is estimated by the following process.

Estimated unit monthly discharge in Caqueza area

= Unit monthly discharge of the Une River
x (Average annual rainfall ratio of Caqueza/ Une)

= Unit monthly discharge of the Une River x 1 / 2.2

The estimation results of unit discharge in Caqueza area are shown in Table A.2.9.

(2) Runoff analysis of Tibacuy area

The same method as Caqueza area was applied for estimation of discharge in Tibacuy area. In other words, the stream discharge of Tibacuy area is estimated from the measured discharge of the Subia River (156 km^2 of drainage area) during 13 years observation period, because the Subia River is a tributary, upstream of the Chochos river system where the area is also located. It is considered that the modification of discharge is not necessary because topography and vegetation of the area are almost same as those of the Subia river watershed.

The unit monthly discharges estimated through the above process are shown in Table A.2.10.

Furthermore, the low flow during dry season was estimated at around $3 l/s/km^2$ in normal year. It is considered that the above low flow can be applicable to the Tibaquy area, because the measured low flow during dry season was 19 - 22 l/s (CA = 5.45 km^2) which was measured in August 1986 with a rectanglar weir installed by HIMAT.

Table A.2.1 Monthly Discharge of Moniquira River (m^3/s)

Observ. Station : Moniquira
Municipio : Moniquira
River System : Moniquira River

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
1975	2.377	4.243	6.916	8.520	28.19	10.25	15.87	9.542	11.10	20.00	36.15	24.64	14.82
1976	6.055	6.659	24.87	27.46	25.07	11.32	5.416	3.135	3.360	18.34	18.49	7.432	13.13
1977	2.287	1.289	4.316	7.347	4.994	5.623	4.290	5.265	7.400	15.34	30.56	4.577	7.77
1978	1.673	2.055	5.213	31.7	15.10	13.43	7.085	3.123	4.596	15.66	12.00	11.33	10.25
1979	2.513	2.182	8.103	21.69	23.36	22.99	6.819	5.806	12.01	35.25	54.19	14.70	17.47
1980	4.729	6.403	3.636	5.069	6.324	8.063	2.994	1.934	2.367	15.55	10.85	6.916	6.24
1981	4.019	3.90	4.423	24.47	55.07	15.78	6.706	5.235	6.650	11.52	22.75	8.161	14.06
1982	10.14	10.13	16.95	40.35	28.59	5.887	3.261	2.268	3.133	22.37	12.41	8.097	13.64
1983	2.906	1.539	2.465	15.46	22.31	9.833	2.216	1.819	1.887	5.681	6.403	9.310	6.82
1984	5.555	11.89	7.731	11.92	19.83	18.41	11.66	6.787	19.15	18.47	17.90	8.124	13.12
Mean	4.225	5.029	8.461	19.40	22.88	12.16	6.632	4.491	7.165	17.82	22.17	10.33	11.73
Max	10.14	11.89	24.87	40.35	55.07	22.99	15.87	9.42	19.15	35.25	54.19	24.64	55.07
Min	1.673	1.289	2.465	5.069	4.994	5.623	2.216	1.819	1.887	5.681	6.403	4.577	1.29

Table A.2.2 Monthly Discharge of Une River (m^3/s)

Observ. Station : Caqueza
Municipio : Caqueza
River System : Une River

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
1966	3.678	2.976	3.763	1.476	1.286	4.197	6.677	8.099	3.703	2.695	3.689	7.940	4.18
1967	1.188	0.656	1.069	3.398	11.80	17.30	17.68	14.10	5.531	2.914	3.424	1.562	6.72
1968	0.938	1.126	0.806	5.449	3.963	8.760	10.70	6.745	5.410	6.212	5.158	1.929	4.77
1969	1.726	1.724	0.817	4.776	6.283	5.146	6.079	4.836	3.505	7.078	3.262	1.768	3.92
1970	1.459	1.271	1.285	3.565	5.552	9.953	6.529	8.763	6.488	8.716	6.282	1.648	5.13
1971	1.044	1.417	1.845	4.193	6.112	7.358	6.972	4.925	4.781	3.032	2.614	1.459	3.81
1972	3.170	1.792	1.466	2.403	4.850	3.603	3.100	2.780	1.134	0.651	2.043	1.423	2.37
1973	0.812	0.543	0.518	1.120	3.690	6.149	6.426	7.975	13.17	4.815	5.425	3.328	4.50
1974	0.979	1.121	1.344	3.124	7.855	5.064	7.139	5.679	2.930	3.059	5.384	1.561	3.77
1975	0.767	0.801	1.765	1.440	7.089	11.07	10.47	13.12	8.504	8.010	8.646	8.772	6.71
1976	1.570	1.367	1.775	3.017	5.594	11.75	11.94	6.788	5.642	2.439	3.288	1.644	4.74
1977	0.731	0.663	0.770	1.376	1.868	3.619	6.561	3.336	3.551	2.615	6.895	1.581	2.80
1978	1.400	1.545	2.102	4.382	6.249	9.760	4.684	5.128	3.342	2.927	1.562	0.889	3.66
1979	0.203	0.206	0.313	3.339	3.763	7.888	3.930	5.089	2.990	5.979	8.070	4.252	3.84
1980	1.648	1.267	1.199	8.772	10.76	16.89	5.348	4.849	6.434	8.056	2.955	1.525	5.81
1981	0.965	0.919	8.243	9.144	12.14	11.55	9.503	6.574	7.736	9.524	4.709	1.564	6.88
1982	1.676	1.208	1.907	8.152	6.486	6.344	12.08	12.44	5.500	5.048	3.331	2.510	5.56
1983	2.159	2.498	2.501	5.488	7.009	7.849	11.19	8.330	7.402	5.076	2.267	2.925	5.39
1984	1.652	3.698	1.578	2.129	6.249	12.97	8.74	10.58	5.925	4.468	4.704	2.543	5.44
Mean	1.461	1.461	1.846	4.039	6.242	8.801	8.197	7.367	5.457	4.911	4.406	2.675	4.74
Max	3.678	3.698	8.243	9.144	12.14	17.30	17.68	14.10	13.17	9.524	8.646	8.772	17.68
Min	0.203	0.206	0.313	1.120	1.286	3.603	3.100	2.780	1.134	0.651	1.562	0.889	0.20

Table A.2.3 Monthly Discharge of Subia River (m^3/s)

Observ. Station : Silvania
Municipio : Silvania
River System : Subia River

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
1972	5.810	4.986	3.248	5.327	9.655	3.480	1.152	0.258	0.203	1.27	4.573	4.790	3.73
1973	1.190	0.607	1.074	1.793	0.945	0.910	0.406	1.110	6.147	5.603	6.297	8.261	2.86
1974	6.452	9.718	7.584	5.110	5.619	1.650	1.081	0.255	0.100	0.994	4.470	2.035	3.76
1975	1.113	2.350	4.003	2.600	4.906	1.627	2.332	1.358	2.707	3.206	3.583	6.474	3.02
1976	1.755	4.232	6.158	6.361	5.915	1.936	1.086	0.492	1.866	9.888	6.119	2.181	4.00
1977	0.414	0.319	0.449	1.510	1.310	1.559	0.662	0.628	1.719	3.557	3.511	1.845	1.46
1978	0.590	0.390	0.761	3.079	1.730	1.469	1.030	0.427	0.684	1.414	1.894	3.838	1.45
1979	1.254	0.650	2.092	3.848	3.003	3.195	1.555	1.194	3.337	5.603	9.140	2.962	3.15
1980	2.108	4.184	1.824	3.572	2.885	3.888	1.578	1.906	1.272	3.314	3.241	3.569	2.78
1981	1.893	1.595	1.425	4.174	6.852	4.255	2.774	1.671	1.386	4.435	4.677	2.732	3.16
1982	3.710	3.896	6.063	11.470	5.825	2.680	0.999	0.477	0.434	2.748	6.224	3.708	4.02
1983	2.615	1.379	1.924	7.038	4.853	1.481	0.569	0.416	0.231	1.917	3.448	3.576	2.42
1984	3.700	2.234	1.767	3.523	5.654	3.521	1.717	1.915	4.793	3.805	9.448	5.071	3.93
Mean	2.508	2.811	2.952	4.570	4.550	2.435	1.303	0.935	1.914	3.673	5.125	3.926	3.06
Max	6.452	9.718	7.584	11.47	9.655	4.255	2.774	1.915	6.147	9.888	9.448	8.261	11.47
Min	0.414	0.319	0.449	1.510	0.945	0.910	0.406	0.255	0.100	0.994	1.894	1.845	0.10

Table A.2.4 Observed Stream Discharge

(Q. Yerbabuena)

June			July		
Date	Pe	Q	Date	Pe	Q
1	1.0	7	1	0.5	12
2	5.0	6	2	2.5	14
3	2.0	9	3	0	11
4	1.6	8	4	0.7	11
5	0.4	6	5	0.1	10
6	0	11	6	0.3	11
7	0.2	8	7	0.7	11
8	0.1	7	8	0	10
9	0	7	9	0.1	10
10	0	6	10	0	9
11	0	6	11	0.1	10
12	0	6	12	0	10
13	0	6	13	0	8
14	0.5	6	14	0	8
15	0.1	6	15	1.0	7
16	0	7	16	0	10
17	6.6	6	17	5.0	10
18	1.0	6	18	0	10
19	0	6	19	0	7
20	4.3	6	20	0.1	7
21	4.5	6	21	0	7
22	3.0	6	22	2.5	6
23	5.0	6	23	3.5	6
24	1.0	6	24	0.1	7
25	2.0	7	25	1.1	7
26	4.0	6	26	0	7
27	3.5	21	27	0	7
28	0	21	28	0.1	7
29	2.6	19	29	0	6
30	0	18	30	0	6
			31	0	6
Total	48.4	252		18.4	268

Note: Pe : Rainfall mm
Q : Discharge l/s

Table A.2.5 Observed Stream Discharge (1)

MAY

Date	Pe mm	Palonegro	Discharge 1/s		
			La Cruz	Camelo	Guatoque
1	1.7	19	36	29	36
2		22	36	25	33
3	5.3	17	36	23	30
4		19	36	23	33
5	2.7	24	58	39	44
6	23.5	30	67	42	37
7	0.8	24	50	35	23
8	0.2	20	46	32	23
9		20	42	29	21
10		20	42	29	18
11	0.8	20	42	29	18
12		22	46	29	18
13	3.1	20	46	29	18
14	4.3	20	46	29	18
15		19	46	29	18
16	0.5	19	39	29	18
17		(19)	39	35	(18)
18		(19)	39	16	(18)
19		19	36	5	(18
20	2.7	(16)	(36)	5	(18)
21		(14)	(36)	5	(18)
22		(11)	(36)	5	(18)
23	30.0	9	36	12	(18)
24	27.4	10	33	21	21
25		23	18	10	8
26	14.5	9	46	26	18
27	3.7	10	30	16	11
28	1.8	20	27	59	45
29	3.2	20	39	35	26
30		9	30	29	21
31		10	36	35	18
Total	126.2	553	1,231	765	700

Note: Pe : Rainfall mm
Q : Discharge 1/s

Table A.2.5 Observed Stream Discharge (2)

JUNE

Date	Pe mm	Palonegro	Discharge l/s		
			La Cruz	Camelo	Guatoque
1	8.9	20	(30)	32	18
2	1.9	9	24	16	13
3	1.0	9	27	32	13
4	11.9	9	24	21	11
5	1.1	9	24	14	10
6	21.5	52	22	32	21
7	1.3	19	46	46	13
8		9	36	39	13
9	2.5	9	33	26	11
10		3	33	23	10
11		3	22	18	10
12		3	22	16	10
13		4	15	14	10
14	2.5	3	14	14	8
15	2.0	9	15	14	7
16		3	15	11	7
17		3	15	11	7
18		3	14	8	7
19		3	14	8	7
20		3	10	8	7
21		3	10	8	5
22		2	9	8	4
23		2	9	8	30
24	5.3	1	8	8	8
25	3.1	1	8	8	5
26		1	5	8	4
27		2	10	9	4
28	5.0	2	8	8	4
29		2	5	8	4
30	1.9	3	8	21	4
Total	69.9	207	535	497	285

Note: Pe : Rainfall mm
Q : Discharge l/s

Table A.2.5 Observed Stream Discharge (3)

JULY

Date	Pe mm	Palonegro	Discharge 1/s		
			La Cruz	Camelo	Guatoque
1	5.3	2	5	26	4
2		1	5	14	4
3	0.9	1	4	9	4
4		1	4	5	4
5	0.4	2	5	5	4
6		2	4	5	4
7	0.5	1	4	5	4
8		1	4	5	4
9		1	3	5	4
10	1.5	1	4	5	4
11		1	3	5	4
12		1	3	5	4
13		1	2	5	4
14		1	2	3	4
15					
16	19.0				
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
Total	27.6	17	52	102	56

Note: Pe : Rainfall mm
Q : Discharge 1/s

Table A.2.6 Unit Monthly Discharge in San Pedro de Iguaque

(l/s/km²)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	2.3	2.9	3.6	3.9	3.3	3.6	2.6	2.3	3.6	4.5	4.2	2.3
1975	2.0	2.9	2.9	3.3	4.5	2.9	3.6	2.9	3.3	4.5	3.3	3.6
1976	2.3	2.9	3.3	4.5	2.6	2.6	2.0	2.3	2.6	4.5	3.3	2.9
1977	2.0	2.6	2.9	2.6	2.9	2.6	3.3	2.6	3.3	3.6	3.6	2.3
1978	2.0	2.6	3.6	5.1	2.9	3.6	2.9	2.3	2.9	4.5	3.3	2.6
1979	2.3	3.3	3.3	3.6	4.8	3.6	2.9	3.3	3.6	4.5	5.8	2.3
1980	2.0	3.3	2.6	2.9	3.3	3.3	2.3	2.3	2.9	5.1	3.6	2.9
1981	2.3	2.9	2.3	4.5	5.1	3.3	2.6	2.6	2.9	3.9	3.9	2.6
1982	2.9	4.2	4.3	5.4	3.9	2.3	2.6	2.3	3.3	5.4	3.9	2.9
1983	2.0	2.3	2.6	4.5	4.2	2.9	2.6	2.0	2.3	3.6	3.3	4.2
Mean	2.2	3.0	3.1	4.0	3.8	3.2	2.7	2.5	3.1	4.4	3.8	2.9

Table A.2.7 Unit Monthly Discharge in Santa Sofia

(1/s/km^2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	5.4	9.4	12.4	15.4	11.4	13.4	6.4	3.4	13.4	21.4	17.4	4.4
1975	2.4	9.4	9.4	10.4	19.4	10.4	13.4	8.4	11.4	18.4	12.4	13.4
1976	4.4	9.4	12.4	19.4	7.4	6.4	3.4	3.4	5.4	19.4	11.4	8.4
1977	3.4	7.4	7.4	7.4	10.4	7.4	10.4	7.4	9.4	13.4	14.4	5.4
1978	2.4	7.4	11.4	25.4	9.4	14.4	9.4	4.4	9.4	20.4	11.4	7.4
1979	4.4	12.4	11.4	12.4	22.4	13.4	7.4	9.4	14.4	17.4	31.4	6.4
1980	3.4	10.4	5.4	8.4	10.4	11.4	5.4	5.4	8.4	24.4	12.4	8.4
1981	5.4	7.4	4.4	19.4	25.4	11.4	7.4	7.4	10.4	13.4	15.4	7.4
1982	11.4	16.4	16.4	26.4	15.4	4.4	5.4	3.4	9.4	27.4	15.4	8.4
1983	3.4	3.4	6.4	19.4	17.4	10.4	7.4	4.4	5.4	13.4	11.4	18.4
Mean	4.6	9.3	9.7	16.4	14.9	10.3	7.6	5.7	9.7	18.9	15.3	8.8

Table A.2.8 Ratio of Annual Rainfall

(Monterredondo - Caqueza)

Year	Annual Rainfall Monterredondo (mm)	Annual Rainfall Caqueza (mm)	Ratio of Rainfall Monterredondo/Caaqueza
1970	2,551.4	931.5	2.7
1971	2,593.9	994.6	2.6
1972	-	(713.1)	-
1973	2,161.5	758.4	2.9
1974	2,081.9	742.6	2.8
1975	2,349.6	812.0	2.9
1976	2,596.8	724.9	3.6
1977	2,011.0	637.1	3.2
1978	(1,929.8)	-	-
1979	1,995.2	762.1	2.6
1980	2,005.4	713.2	2.8
Mean	2,260.7	786.3	2.9

(Une - Monterredondo)

Year	Annual Rainfall Une (mm)	Annual Rainfall Monterredondo (mm)	Ratio of Rainfall Une/Monterredondo
1968	1,786	2,531	0.71
1969	1,758	2,134	0.82
Mean	1,772	2,134	0.76

Table A.2.9 Unit Monthly Discharge in Caqueza

($1/s/km^2$)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1966	10.1	8.2	10.4	4.1	3.5	11.6	18.4	22.3	10.2	7.4	10.2	21.9
1967	3.3	1.8	2.9	9.4	32.5	47.7	48.7	38.8	15.2	8.0	9.4	4.3
1968	2.6	3.1	2.2	15.0	10.9	24.1	29.5	18.6	14.9	17.1	14.2	5.3
1969	4.8	4.7	2.3	13.2	17.3	14.2	16.7	13.3	9.7	19.5	9.0	4.9
1970	4.0	3.5	3.5	9.8	15.3	27.4	18.0	24.1	17.9	24.0	17.3	4.5
1971	2.9	3.9	5.1	11.6	16.8	20.3	19.2	13.6	13.2	8.4	7.2	4.0
1972	8.7	4.9	4.0	6.6	13.4	9.9	8.5	7.7	3.1	1.8	5.6	3.9
1973	2.2	1.5	1.4	3.1	10.2	16.9	17.7	22.0	36.3	13.3	14.9	9.2
1974	2.7	3.1	3.7	8.6	21.6	14.0	19.7	15.6	8.1	8.4	14.8	4.3
1975	2.1	2.2	4.9	4.0	19.5	30.5	28.8	36.1	23.4	22.1	23.8	24.2
1976	4.3	3.8	4.9	8.3	15.4	32.4	32.9	18.7	15.5	6.7	9.1	4.5
1977	2.0	1.8	2.1	3.8	5.1	10.0	18.1	9.2	9.8	7.2	19.0	4.4
1978	3.9	4.3	5.8	12.1	17.2	26.9	12.9	14.1	9.2	8.1	4.3	2.4
1979	0.6	0.6	0.9	9.2	10.4	21.7	10.8	14.0	8.2	16.5	22.2	11.7
1980	4.5	3.5	3.3	24.2	29.6	46.3	14.7	13.4	17.7	22.2	8.1	4.2
1981	2.7	2.5	22.7	25.2	33.4	31.8	26.2	18.1	21.3	26.2	13.0	4.3
1982	4.6	3.3	5.3	22.5	17.9	17.5	33.3	24.3	15.2	13.9	9.2	6.9
1983	5.9	6.9	6.9	15.1	19.3	21.6	30.8	22.9	20.4	14.0	6.2	8.1
1984	4.6	10.2	4.3	5.9	17.2	35.7	24.1	29.1	16.3	12.3	13.0	7.0
Mean	4.0	3.9	5.1	11.1	17.2	24.2	22.6	20.3	15.0	13.5	12.0	7.4

Table A.2.10 Unit Monthly Discharge in Tibacuy

($1/s/km^2$)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1972	37.2	32.0	20.8	34.1	61.9	22.3	7.4	1.7	1.3	8.1	29.3	30.7
1973	7.6	3.9	6.9	11.5	6.1	5.8	2.6	7.1	39.4	35.9	40.4	53.0
1974	41.4	62.3	48.6	32.8	36.0	10.6	6.9	1.6	0.6	6.4	28.7	13.0
1975	7.1	15.1	25.7	16.7	31.4	10.4	14.9	8.7	17.4	20.6	23.0	41.5
1976	11.3	27.1	39.5	40.8	37.9	12.4	7.0	3.2	12.0	63.4	39.2	14.0
1977	2.7	2.0	2.9	9.7	8.4	10.0	4.2	4.0	11.0	22.8	22.5	11.8
1978	3.8	2.5	4.9	19.7	11.1	9.4	6.6	3.0	4.4	9.1	12.1	24.6
1979	8.0	4.2	13.4	24.7	19.3	20.5	10.0	7.7	21.4	35.9	58.6	19.0
1980	13.5	26.8	11.7	22.9	18.5	24.9	10.1	12.2	8.2	21.2	20.8	22.9
1981	12.1	10.2	9.1	26.8	43.9	27.3	17.8	10.7	8.9	28.4	30.0	17.5
1982	23.8	25.0	38.9	73.5	37.3	17.2	6.4	3.1	2.8	17.6	39.9	23.8
1983	16.8	8.8	12.3	45.1	31.1	9.5	3.6	2.7	1.5	12.3	22.1	22.9
1984	23.7	14.3	11.3	22.6	36.2	22.6	11.0	12.3	30.7	24.4	60.6	32.5
Mean	16.1	18.0	18.9	29.3	29.2	15.6	8.3	6.0	12.3	23.5	32.9	25.2

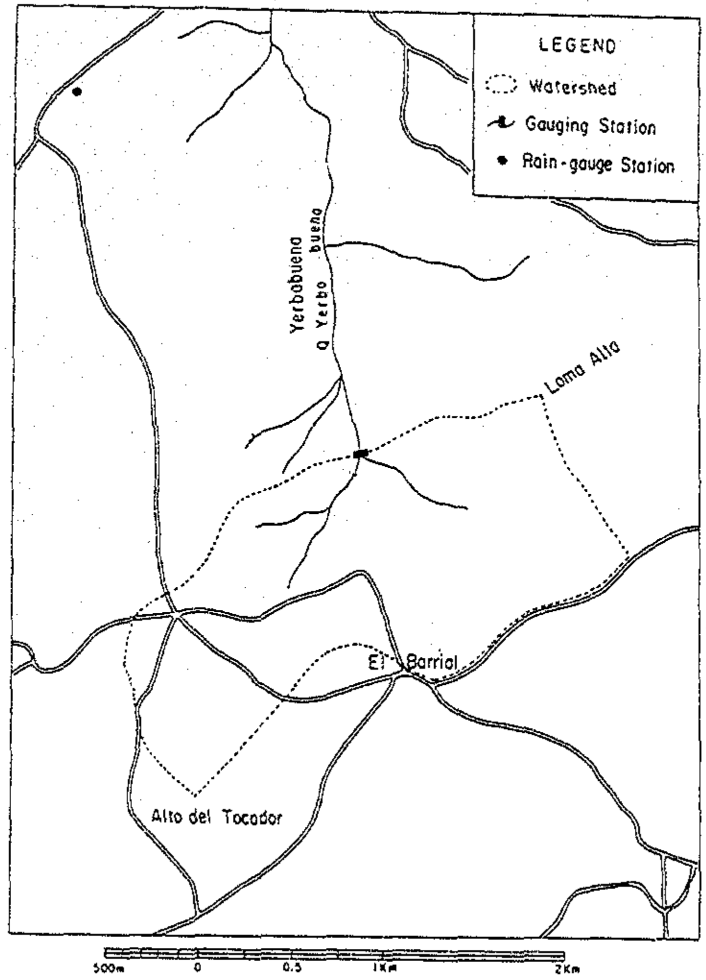

Fig. A.2.1 Location of Observation Points in San Pedro de Iguaque

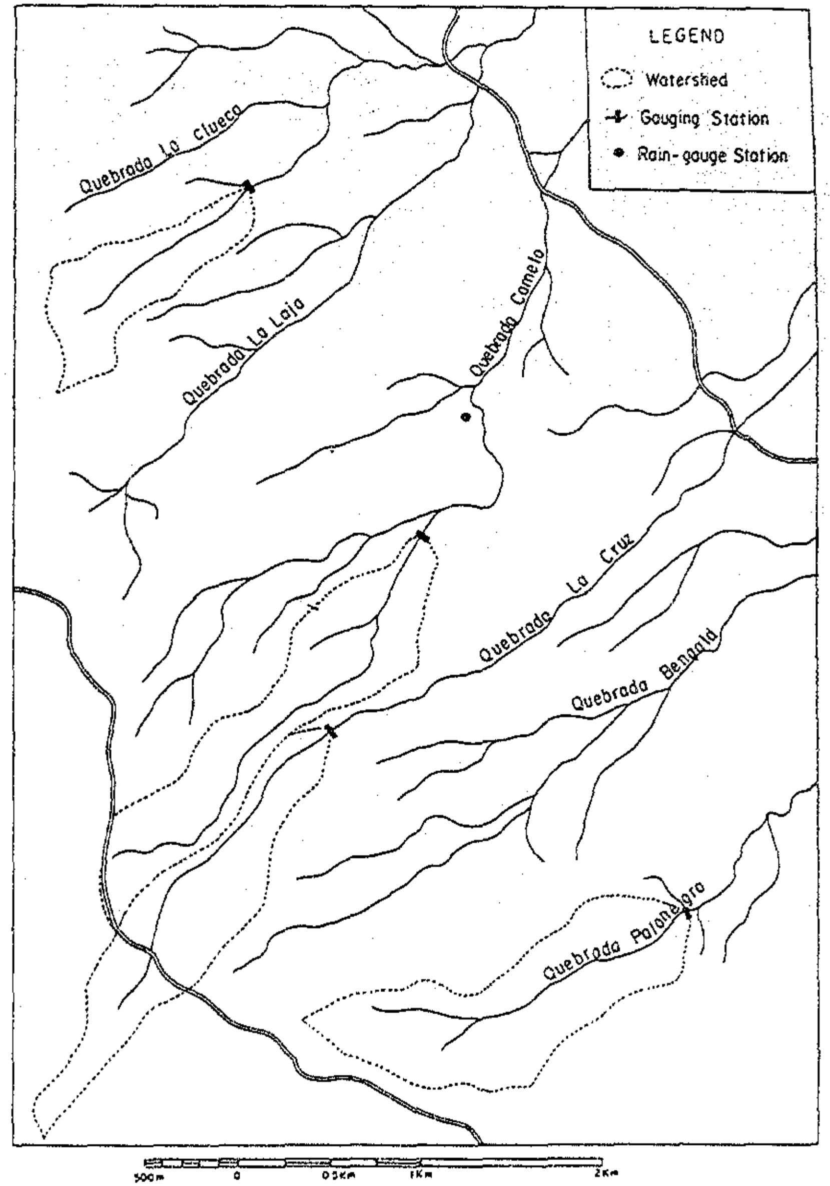

Fig. A.2.2 Location of Observation Points in Santa Sofia

Table C.3.3 (3) ECONOMIC PARITY PRICE OF FARM PRODUCT

(Import Parity Price: Kidny Bean) (Unit: Coℓ.$/ton)

Item	US$	Coℓ.$
1. World Market Price/1	496.16	
2. Freight and Insurace	74.87	
3. CIF Price (1+2)	571.03	
4. Equivalent in Coℓ.$/ton/2		132,764
5. Landing and Port Charges		12,762
6. Transport to Market in Bogota		4,600
7. Transport to Farm Gate/3		2,000
8. Economic Price at Farm Gate (4+5+6-7)		148,126

Remarks) /1: Price in June 1986

/2: US$ 1 = Coℓ.$193.76 x 1.2 = Coℓ.$232.5

(Shadow exchange rate is 1.2)

/3: According to field survey

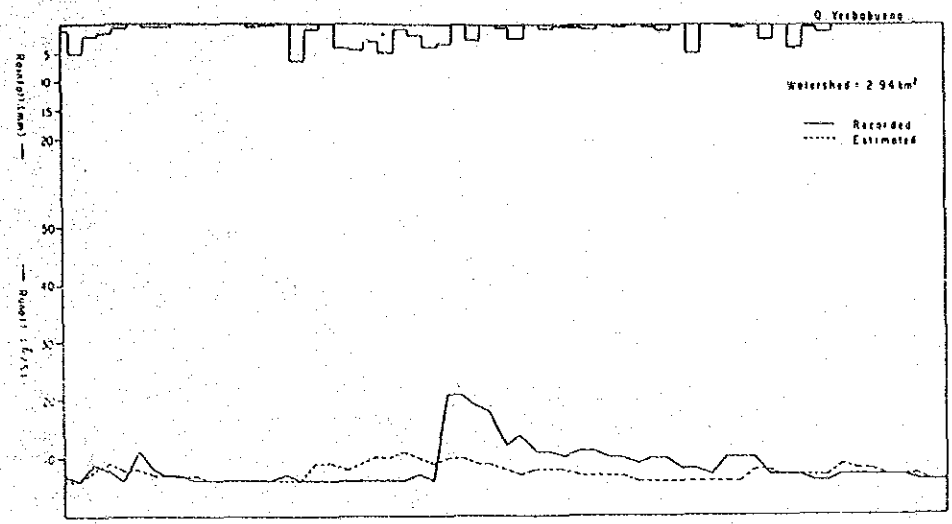

Fig. A.2.6 Comparison between Estimated Discharge and Measured Discharge
- Q. Yerbabuena -

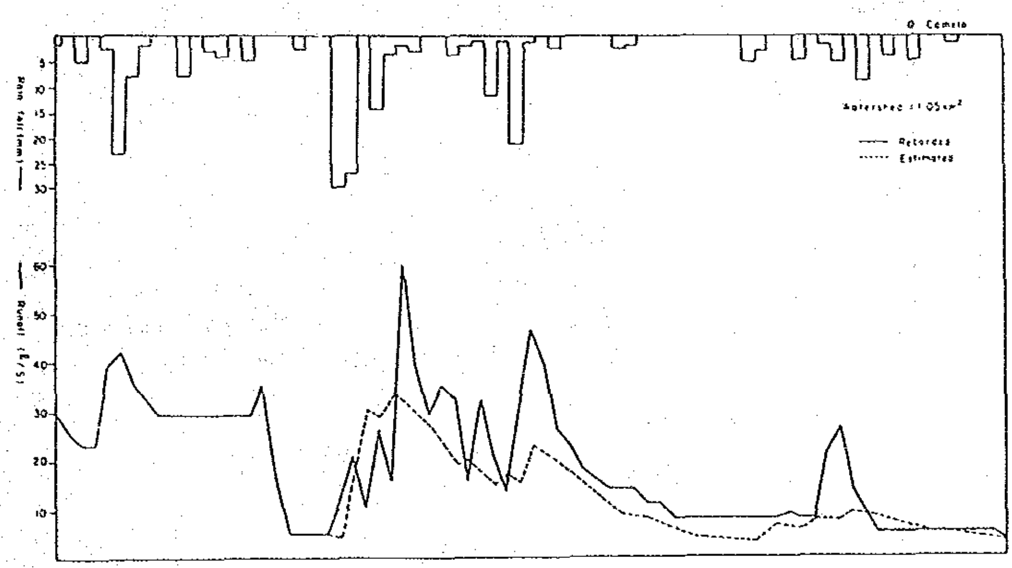

Fig. A.2.7(1) Comparison between Estimated Discharge and Measured Discharge
- Q. Camelo -

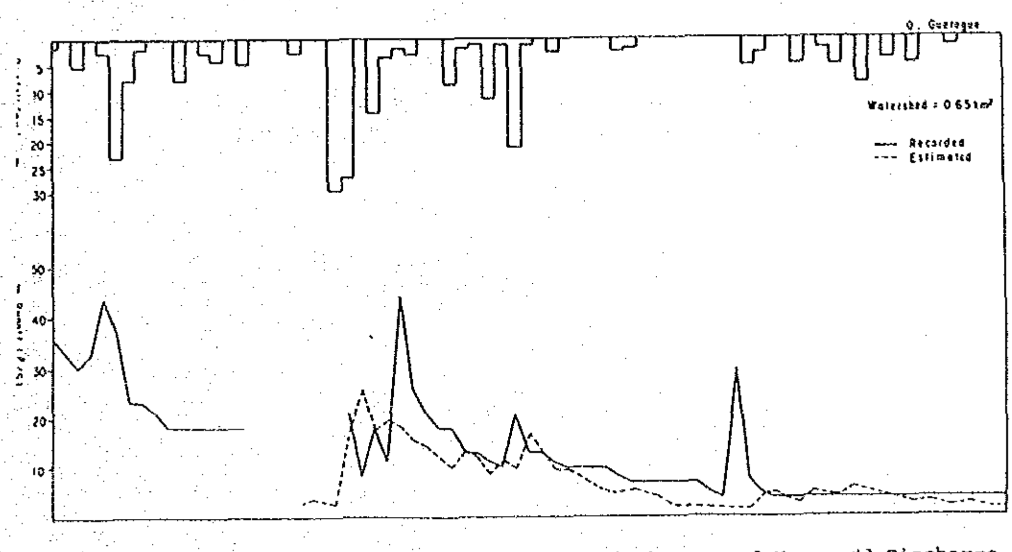

Fig. A.2.7(2) Comparison between Estimated Discharge and Measurdd Discharge
- Q. Guatoque -

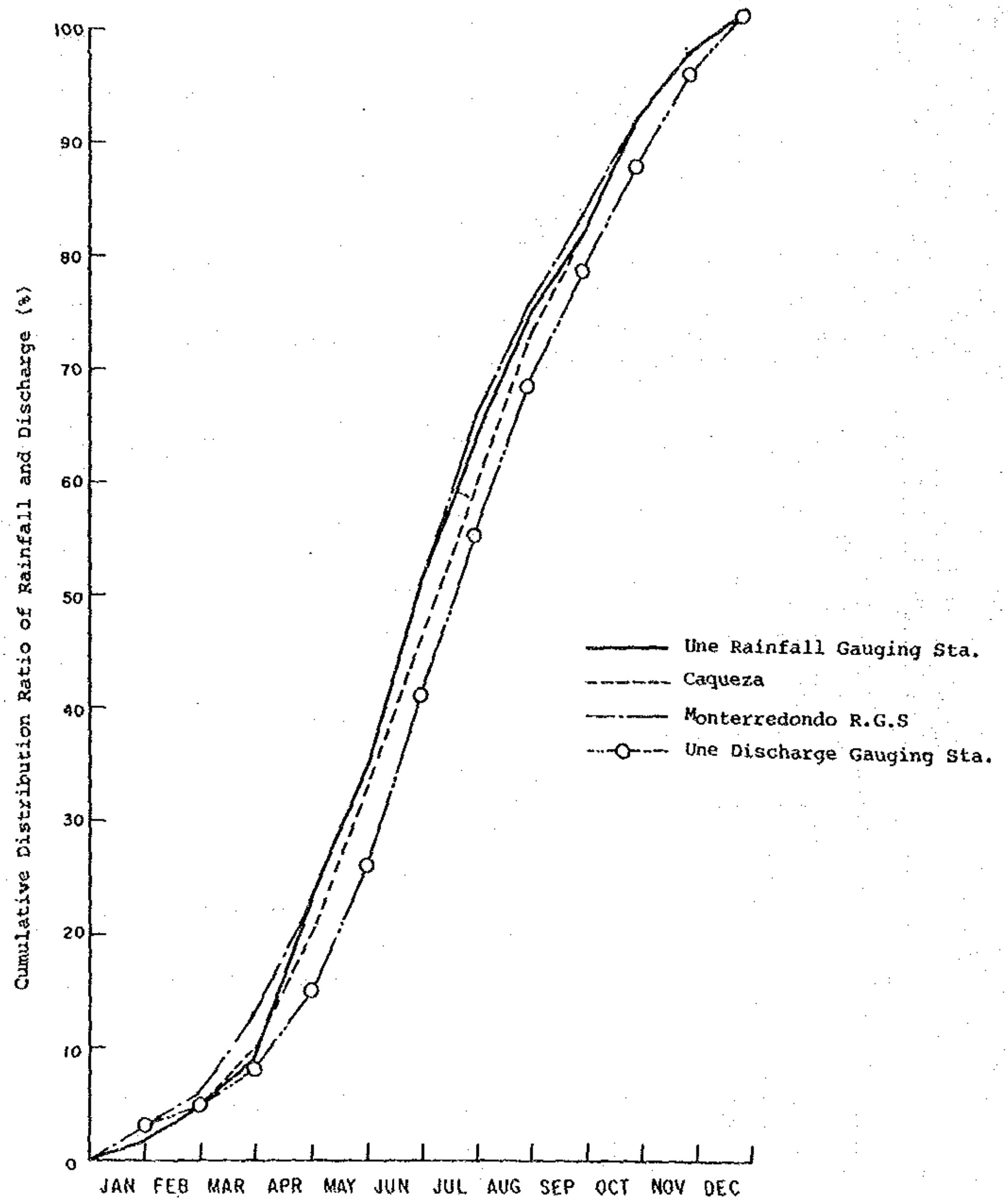

Fig. A.2.8 Distribution Ratio of Une River Discharge and Rainfall in and around Caqueza

ANNEX B SOIL LAND UTILIZATION

ANNEX B SOIL AND LAND UTILIZATION

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1 Physical Conditions

Outline of physical conditions in the sub-project areas is shown in Table B.1.1

Table B.1.1 Outline of Physical Conditions

Sub-Project Area	SAN PEDRO DE IGUAQUE	SANTA SOFIA	CAQUEZA	TIBACUY
1. Climate				
Annual Temperature	12~14°C	13~14°C	19~20°C	19~20°C
Annual Precipitation	960mm	1100mm	720mm	1100mm
Climatic Division	Cool	Cool	Warm or Mild	Warm or Mild
2. Tophography				
Altitude	2800~3200m	2200~2700m	1600~2200m	1200~2000m
Main Gradient	3~12%	7~12%	7~25%	7~25%
3. Geology				
Soil Material	Mainly weathered shale and-or its re-sedimentation	Mainly weathered sedimentary rocks and their re-sedimentation. Existences of stone outcrops.	Slope sediments. Weathered sedimentary rock.	Weathered slates and sandstones. Clayey slope sediments. Volcanic ashes Existences of stone outcrops.

2 Soil

2.1 Soil Distribution

(1) San Pedro de Iguaque

Soil of this sub-project area consists mainly of weathered shale and/or its re-sedimentation accompanied with clay and sand strata (Association CABRERA:CB). The soil texture is medium or fine grain size, the permeability is preferable and the depth of soil is as large as 100cm at flatlands while it shallows out of 30-50cm at slope areas. This soil is classified in 10 soil phases according to the gradient and extend of erosion.

(2) Santa Sofia

Soil of this sub-project area consists mainly of weathered sedimentary rocks (mainly slate and shale) and their resedimentation (Association SAN ISIDRO:SI). The soil texture is medium to fine grain size, the permeability is preferable and the depth of soil is generally in order of 50 to 100cm. This soil is classified in 10 soil phases according to the gradient, erosion extent and existences of rock outcrops.

(3) Caqueza

Soil of this sub-project area consists mainly of slope sediments comprising clay and silt (Association GIRON DE RESGUARDO:GR) and weathered sedimentary rock (mainly slate)(Association LLANO LARGO:LO).

The former has fine grain soil texture and satisfactory permeability, and the depth of soil is in the order of 50 to 100cm. This soil is classified in 5 soil phases by gradient. On the other hand, the latter type of soil has medium grain texture, and it has shallow soil depth in the order of 30 to 50cm, because it is distributed on steep slope areas.

(4) Tibacuy

Soil of this sub-project area is classified in soils consisting of volcanic ashes (Consociacion EL CAPRICHO;CP), of weathered slates and sandstone (Association EL PLAN:PL) and of clayey slope sediments (Consociation LA PORTADA:LP, LA GRANJA:GN, INCOR:IN, BALSILLAS:BL). Most of these soils have fine grain texture. Each soil has satisfactory permeability and the depth of soil is in the order of 50 to 100cm.

The results of soil distribution in the sub-project areas are summarized as shown in Table B.2.1.

Table B.2.1 Soil Distribution

SAN PEDRO DE IGUAQUE	Soil	CBab	CBbc	CBc	CBcd	CBde	CBe	CBef	CBef$_1$	CBef$_2$	CBef$_3$
	area (ha)	305	910	85	600	480	120	610	50	220	310
SANTA SOFIA	Soil	SIc	SIbc	SIcd	SIcd$_1$	SIcd$_1$p	SIde	SIde$_2$	SIef	SIef$_2$	SIef$_4$
	area (ha)	240	640	445	200	340	855	90	680	230	160
CAQUEZA	Soil	GRc	GRcd	GRde	GRe	GRef$_2$	LOef$_1$				
	area (ha)	190	325	420	65	115	35				
TIBACUY	Soil	CPcdp	PLcd$_1$p	PLef$_1$p	LPcd$_1$p	GNbc$_1$p	INc$_1$p	BLd$_1$p	BLef$_2$p		
	area (ha)	160	190	85	215	40	10	40	495		

Note: suffix a - f: slope(%) suffix 1 - 4: erosion suffix p: stone outcrop

a - 1 1 - light
b - 3 2 - moderate
c - 7 3 - strong
d - 12 4 - very strong
e - 25
f - 50

Refer to Fig.B.2.1 (1)-(4)

2.2 Chemical Properties of Soils

Results on chemical analysis of soils in the sub-project areas are shown in Table B.2.2.

Chemical properties of topsoil in the sub-project areas are as follows:

(1) San Pedro de Iguaque

Soil reaction is strong to weak acid (pH3.9 to 5.1). Organic carbon, total nitrogen and cation exchangeable capacity are high, exchangeable bases are low, base saturation is medium to low, available phosphorus is medium to high and thus fertility is moderate to low.

(2) Santa Sofia

Soil reaction is strong to weak acid (pH4.6 to 6.5). Organic carbon, total nitrogen and cation exchangeable capacity are medium to high, exchangeable bases and base saturation are low to medium, available phosphorus is very low and thus fertility is moderate to low.

(3) Caqueza

Soil reaction is weak acid to neutral (pH5.3 to 6.7). Organic carbon and total nitrogen are medium, cation exchangeable capacity and exchangeable bases are medium to high, base saturation is very high, available phosphorus is medium and thus fertility is moderate to high.

(4) Tibacuy

Soil reaction is strong to weak acid (pH4.4 to 6.0). Organic carbon, total nitrogen and cation exchangeable capacity are medium to high, exchangeable bases and base saturation are high, available phosphorus is low and thus fertility is moderate to high.
According to results on chemical analysis, soils in sub-project

areas are acid and soil nutrients are not enough for growth of crops, particular soils in San Pedro de Iguaque and Santa Sofia are short of soil nutrients. Consequently, improvement of acid soils by lime application and fertilizer application are to be adopted at seeding and/or transplanting time. Moreover, additional fertilizers are to be applied corresponding to the growing stage. The standard quantity of lime and fertilizer application is as follows:

Liming material	2	kg/ha
Compound fertilizer	200-300	kg/ha
Urea fertilizer	100	kg/ha

Table B.2.2 Chemical Characteristics of Soils (1)

Soil	Depth cm	Horizon	Particle Size% sand	silt	clay	Texture	pH	C %	N %	C.E.C.	Ex.C. m.e./100g Ca	Mg	K	Na	T.B.	B.S. %	P ppm
IGUAQUE (CB)	0 - 22	A1				CL	5.1	H	H	>30					<5		<17
	22 - 91	A2				L	5.3										
	91 - 128	A3				HC	5.0										
	128 - 170	B21				HC	4.8										
	170 -	Cg				HC	4.8										
SANTA SOFIA (SI)	0 - 20	Ap1	29	35	36	LiC	4.8	3.67	0.40	35.3	0.6	0.5	1.2	0.1	2.4	6.8	89
	20 - 50	Ah	23	33	44	LiC	5.0	2.70	H	35.9	0.4	0.2	0.6	0.1	1.3	3.6	4
	50 - 70	AB	31	33	36	LiC	5.5	2.59	H	38.2	0.4	0.1	0.6	0.1	1.2	3.1	2
	70 - 100	B	19	35	46	HC	5.3	0.42	L	22.3	0.3	0.4	0.2	0.2	1.1	4.9	11
	100 - 130	BC	17	33	50	HC	5.1	0.14	L	22.5	0.3	0.3	0.2	0.1	0.9	4.0	2
CAQUEZA (GR)	0 - 12	A				HC	5.8	M	M	30.8					20.0	64.9	22
	12 - 38	B				HC	6.4			33.7					25.8	76.5	3
	38 - 67	C				HC	6.7			32.0					30.5	95.3	3
	67 - 89	Cca				—	7.2			31.1					69.4	—	4
(LO)	0 - 11	A				L	5.3	M	M	15.5					5.9	38.1	7
	11 - 35	BC				L	5.0			16.0					4.6	28.8	4
TIBACUY (CP)	0 - 20	Ap	64	26	10	L	5.7	6.73	VH	37.0	3.0	1.7	0.2	0.2	5.1	13.8	5
	20 - 40	AB	56	36	8	L	5.6	3.82	VH	39.8	0.2	0.2	0.0	0.2	0.6	1.5	4
	40 - 80	Bw	68	30	2	SL	5.7	2.56	H	39.1	0.2	0.2	0.0	0.0	0.5	1.0	4
	80 - 100	C	70	26	4	SL	5.7	1.53	L	22.5	0.2	0.2	0.0	0.1	0.5	2.2	13
(PL)	0 - 10	Ap	28	30	42	LiC	4.7	2.88	H	29.7	7.0	5.4	0.4	0.2	13.0	43.8	2
	10 - 32	Bw	24	34	42	LiC	5.0	1.82	M	19.8	5.6	2.4	0.2	0.2	8.4	42.4	7
	32 - 80	C	6	22	72	HC	4.9	0.34	L	23.2	3.7	3.7	0.2	0.2	7.8	33.6	4
(LP)	0 - 15	Ap	35	27	38	LiC	5.3	2.60	M	26.3	7.8	3.1	0.2	0.2	11.3	43.0	9
	15 - 40	Bw	30	30	40	LiC	5.1	1.50	L	20.2	5.3	2.9	0.2	0.2	8.6	42.6	4
	40 - 100	C	15	34	51	HC	5.0	0.30	L	19.0	4.0	2.3	0.2	0.2	6.7	35.3	3
(GN)	0 - 10	Ap	30	40	30	LiC	5.9	3.00	H	19.8	7.3	4.8	2.6	0.4	15.1	76.3	23
	10 - 32	E	34	32	34	LiC	5.0	1.20	L	14.5	4.4	3.6	1.6	0.4	10.0	69.0	2
	32 - 57	Bt	26	24	50	HC	5.1	0.61	L	19.6	3.7	4.9	1.5	0.7	10.8	55.1	1
	57 - 80	C	16	24	60	HC	5.2	0.48	L	25.3	3.7	6.9	0.5	1.8	12.9	51.0	1
(IN)	0 - 70	Ap	34	28	38	LiC	6.0	1.70	M	21.6	11.0	2.0	0.4	0.3	13.7	63.4	9
	70 - 105	Bt	16	26	58	HC	6.1	0.40	L	25.7	14.5	7.6	0.3	1.0	23.4	91.1	8
(BL)	0 - 33	Ap	28	36	36	LiC	5.8	1.20	L	16.5	7.6	3.2	0.2	0.3	11.3	68.5	2
	33 - 79	Bw1	24	34	42	LiC	5.7	1.20	L	23.3	14.9	2.4	0.4	0.3	18.0	77.3	3
	79 - 109	Bw2	16	38	46	HC	5.9	0.27	L	25.0	18.6	5.7	0.3	0.5	25.1	100	35
	109 - 115	C	22	32	46	HC	5.9	0.23	L	19.4	6.1	5.7	0.2	0.6	12.6	64.9	3

Source : HIMAT reports

Note ; C : Organic carbon (L : Low<1.5 , M : Medium1.6~2.5 , H : High2.6~4.0 , VH : Very High>4.1)
N : Total nitrogen (L : <0.15 , M : 0.16~0.25 , H : 0.26~0.30 , VH : >0.31)
C.E.C. : Cation exchangeable capacity (mil - equivalent per 100gram)
Ex.C. : Exchangeable cations (bases)
Ca(Calcium), Mg(Magnesium), K(Potassium), Na(Sodium)
T.B. : Total bases
B.S. : Base saturation
P : Available phosphorus(part per million)

Table B.2.2 Chemical Characteristics of Soils (2)

Soil	Depth cm	Horizon	Particle Size% sand	silt	clay	Texture	pH	C %	N %	C.E.C.	Ex.C.m.e./100g Ca	Mg	K	Na	T.B.	B.S. %	P ppm
IGUAQUE (CBbc) No.1	0 - 25	Ap	14	56	30	SiC	4.2	3.02	H	24.5	0.4	0.2	0.4	0.2	1.2	4.9	210
	25 - 36	B2	4	62	34	SiC	4.7	1.10	L	13.6	0.2	0.2	0.2	0.2	0.8	5.9	2
	36 - 100	C	16	58	26	SiC	4.7	0.13	L	14.3	0.2	0.2	0.1	0.1	0.6	4.2	2
(CBab)No.2	0 - 28	A11	20	52	28	SiC	3.9	5.69	VH	35.5	0.4	0.2	0.5	0.2	1.3	3.7	180
	28 - 53	A12	26	46	28	LiC	4.1	4.95	VH	35.1	0.2	0.2	0.2	0.1	0.7	2.0	6
	53 - 70	A13	18	40	42	LiC	4.3	2.73	H	25.7	0.2	0.2	0.1	0.1	0.6	2.3	1
	70 - 100+	B2	2	38	60	HC	4.6	1.51	L	14.4	0.2	0.2	0.2	0.2	0.8	5.6	2
(CBcd) No.3	0 - 23	Ap	28	40	32	LiC	4.6	2.77	H	21.3	2.8	0.4	0.6	0.2	4.0	18.8	43
	23 - 70	A1	22	30	48	HC	4.4	3.18	H	33.5	0.2	0.2	0.2	0.2	0.8	2.4	4
	70 - 92	B1	16	32	52	HC	4.7	1.12	L	20.2	0.4	0.2	0.1	0.2	0.9	4.5	2
	92 - 100+	B2	16	30	54	HC	5.1	0.49	L	15.0	0.4	3.6	0.1	0.1	4.2	28.0	1
(CBde) No.4	0 - 25	Ap	30	34	36	LiC	4.1	5.40	VH	39.6	0.4	2.8	1.3	0.2	4.7	11.9	66
	25 - 38	A11	30	32	38	LiC	4.1	5.75	VH	49.1	0.4	0.4	0.7	0.2	1.7	3.5	6
	38 - 86	A12	64	24	12	SL	4.3	7.27	VH	51.5	0.4	0.4	0.1	0.2	1.1	2.1	7
	86 - 113	B1	36	28	36	LiC	4.7	1.63	L	23.0	0.4	0.2	0.1	0.2	0.9	3.9	2
	113-130+	B2	28	34	38	LiC	5.0	0.69	L	10.7	0.4	0.2	0.1	0.1	0.8	7.5	2
SANTA SOFIA ($SIcd_1$) No.1	0 - 20	Ap	4	50	46	HC	6.5	1.66	M	17.5	9.6	3.6	1.6	0.4	15.2	86.9	14
	20 - 70	A1	2	52	46	HC	5.0	1.59	M	15.8	1.2	0.8	0.4	0.4	2.8	17.7	1
	70 - 100+	BC	2	50	48	HC	5.9	0.97	L	16.2	3.2	2.8	0.5	1.2	7.7	47.5	1
(SIbc) No.2	0 - 10	Ap	16	40	44	LiC	4.7	3.38	VH	28.8	6.0	0.8	0.2	0.3	7.3	25.3	3
	10 - 40	A1	10	36	54	HC	5.0	2.52	H	25.3	5.6	0.8	0.2	0.2	6.8	26.9	1
	40 - 63	B2	10	22	68	HC	5.4	0.70	L	21.9	9.7	0.8	0.2	0.5	11.2	51.1	1
	63 - 100+	BC	6	38	56	HC	5.8	0.48	L	17.7	11.5	0.8	0.2	0.4	12.9	72.9	1
(SIc) No.3	0 - 10	Ap	22	46	32	LiC	4.9	2.59	M	21.5	2.4	0.8	0.4	0.2	3.8	17.7	11
	10 - 37	A11	16	42	42	LiC	4.8	1.11	L	16.0	2.4	0.4	0.1	0.1	3.0	18.8	1
	37 - 48	A12	20	34	46	HC	4.9	1.68	M	23.3	3.2	0.4	0.1	0.2	3.9	16.7	2
	48 - 70	B1	16	32	52	HC	5.5	0.69	L	11.5	5.3	2.0	0.1	0.1	7.5	65.2	1
	70 - 100+	B2	12	30	58	HC	5.9	0.34	L	13.3	8.3	1.6	0.1	0.2	10.2	76.7	1
(SIde) No.4	0 - 12	A11	18	42	40	LiC	4.6	3.96	VH	29.0	0.8	0.8	0.3	0.1	2.0	6.9	3
	12 - 43	A12	20	46	34	LiC	4.7	3.76	VH	20.4	0.4	0.2	0.1	0.1	0.8	3.9	1
	43 - 70	B21	16	28	56	HC	5.0	0.20	L	12.1	0.4	0.2	0.1	0.2	0.9	7.4	2
	70 - 100+	B22	18	26	56	HC	5.2	0.20	L	10.9	0.4	0.2	0.1	0.1	0.8	7.3	1
CAQUEZA (GRde) No.1	0 - 17	Ap	4	40	56	HC	6.0	2.04	M	23.3	14.9	2.8	0.8	0.3	18.8	80.7	41
	17 - 53	B2	6	44	50	HC	6.1	1.36	L	20.4	12.2	2.4	0.4	0.4	15.4	75.5	1
	53 - 100+	BC	4	40	56	HC	6.6	1.24	L	23.1	16.9	2.0	0.4	0.6	19.9	86.1	1
(GRcd) No.2	0 - 15	Ap	26	38	36	LiC	6.1	1.69	M	13.7	4.8	2.4	1.1	0.1	8.4	61.3	1
	15 - 23	A1	14	34	52	HC	5.5	1.22	L	15.1	4.1	1.6	1.3	0.1	7.1	47.0	2
	23 - 100+	B2	16	28	56	HC	5.5	0.96	L	17.7	4.9	2.0	1.1	0.1	8.1	45.8	8
(GRc) No.3	0 - 17	Ap	36	34	30	LiC	6.7	2.45	M	15.9	8.2	4.5	0.8	0.2	13.7	86.2	250
	17 - 35	B2	22	30	48	HC	5.7	1.01	L	15.8	4.8	4.4	0.9	0.2	10.3	65.2	12
	35 - 100+	C	14	30	56	HC	5.7	0.88	L	12.1	5.7	2.0	0.8	0.2	8.7	71.9	16
TIBACUY ($GNbc_1p$) No.1	0 - 32	A1	28	38	34	LiC	4.4	2.04	M	20.8	4.1	3.3	0.3	0.2	7.9	38.0	62
	32 - 60	B2	14	34	52	HC	4.7	0.67	L	20.4	4.5	4.1	0.3	0.2	9.1	44.6	1
	60 - 100+	BC	16	28	56	HC	5.0	0.40	L	20.4	3.7	5.3	0.3	0.8	10.1	49.5	1
($GNbc_1p$) No.2	0 - 35	A1	32	34	34	LiC	5.4	2.52	M	20.4	7.3	4.1	0.4	0.2	12.0	58.8	1
	35 - 60	B2	20	24	56	HC	4.9	0.95	L	23.3	4.1	2.4	0.3	0.2	7.0	30.0	1
	60 - 100+	BC	24	20	56	HC	4.8	0.67	L	21.2	2.4	2.8	0.3	0.3	5.8	27.4	1

2.3 Irrigation Factors

(1) Basic Intake Rate

Results of intake rate tests by the Cylinder method is shown in Table B.2.3 and Fig.B.2.2.

Soil moisture regime at examining time was in very humid in Caqueza, on the other hand, it was in moderate to dry in other three sub-project areas. Therefore, basic intake rate shows the most small value in Caqueza.

(2) Available Water

Water retention capacity and available water of soil in the sub-project areas are shown in Table B.2.4.

According to those results, field capacity (at 0.1 atmospheric pressure) and permanent wilting point water content (at 15 atmospheric pressure) of soils in the sub-project areas are summarized as follows, and available water (field capacity permanent wilting point) to be calculated on the basis of setting up the depth of root zone as 100cm is as follows:

Sub-ProjectArea	Field Capacity (Volume %)	Permanent Wiltingpoint (Volume %)	Average Available Water (mm/m)
San Pedro de Iguaque	29-62	14-40	181.6
Santa Sofia	30-57	16-30	174.6
Caqueza	18-43	12-30	103.5
Tibacuy	26-37	18-31	75.4

Table B.2.3 Result of Intake Rate Tests

Sub-Project Area	Site No. (Crop)	Accumulated Infiltration (mm)	Intake Rate (mm/hr.)	Basic Intake Rate (mm/hr.)	Field Capacity of Top-Soil (vol.%)
San Pedro de Iguaque	№1 Pilot zone (Potato)	$D=21.9T^{0.82}$	$I=1{,}080T^{-0.18}$	464	33.7
	№2 Pilot zone (Potato)	$D=13.1T^{0.76}$	$I=597T^{-0.24}$	181	36.1
Santa Sofia	№1 Q.Palonegro (Maize)	$D=31.3T^{0.76}$	$I=1{,}430T^{-0.24}$	433	32.9
	№2 Q.La Curz (Maize)	$D=22.5T^{0.62}$	$I=837T^{-0.38}$	106	36.0
	№3 Q.Palonegro (Curuba)	$D=30.3T^{0.77}$	$I=1{,}400T^{-0.23}$	451	29.2
Caqueza	№2 Q.Negra (Maize and Kidney bean)	$D=6.9T^{0.52}$	$I=215T^{-0.48}$	14.2	29.1
Tibacuy	№1 Pilot zone (Coffee plantation)	$D=29.8T^{0.74}$	$I=1{,}320T^{-0.26}$	356	32.9
	№2 Pilot zone (Pasture)	$D=7.3T^{0.62}$	$I=272T^{-0.38}$	34.6	34.4

Note ; Accumulated Infiltration $D=CT^n$

Intake Rate $I=60CnT^{n-1}$

Basic Intake Rate $Ib=60Cn\{600(1-n)\}^{n-1}$

Table B.2.4 Water Retention Capacity and Available Water

Site No.	Depth cm	Horizon	Texture	Water Retention Capacity vol % Atmospheric pressure				Available Water (Root Zone 0~1m)		
				0.1	0.3	5	15	vol.%	mm	mm/m
Iguaque No.1	0 - 25	Ap	SiC	31.0	28.1	18.7	14.3	16.7	41.8	208.9
	25 - 36	B2	SiC	53.8	36.0	27.9	25.3	28.5	31.4	
	36 - 100+	C	SiC	36.2	29.3	18.3	15.0	21.2	135.7	
No.2	0 - 28	A11	SiC	44.3	38.7	29.5	25.9	18.4	51.5	190.6
	28 - 53	A12	LiC	54.3	47.1	39.2	34.0	20.3	50.8	
	53 - 70	A13	LiC	45.6	37.5	32.3	30.7	14.9	25.3	
	70 - 100+	B2	LiC	54.4	48.4	37.4	33.4	21.0	63.0	
No.3	0 - 23	Ap	LiC	38.8	30.4	18.2	14.4	24.4	56.1	121.8
	23 - 70	A1	HC	35.7	31.0	29.3	25.4	10.3	48.4	
	70 - 92	B1	HC	28.7	27.4	26.8	25.6	3.1	6.8	
	92 - 100+	B2	HC	34.8	29.2	25.9	21.7	13.1	10.5	
No.4	0 - 25	Ap	LiC	39.9	33.3	30.6	25.6	14.3	35.8	204.9
	25 - 38	A11	LiC	49.1	40.7	26.7	22.4	26.7	34.7	
	38 - 86	A12	SL	61.5	55.3	44.4	40.0	21.5	103.2	
	86 - 113	B1	LiC	50.1	42.2	33.0	27.8	22.3	31.2	
	113 - 130+	B2	LiC	51.1	42.3	28.6	23.8	27.3	—	
Santa Sofia No.1	0 - 20	Ap	HC	37.9	31.3	22.0	18.2	19.7	39.4	176.1
	20 - 70	A1	HC	38.7	31.4	22.0	17.9	20.8	104.0	
	70 - 100+	BC	HC	31.3	25.4	25.2	20.4	10.9	32.7	
No.2	0 - 10	Ap	LiC	35.5	30.4	23.3	20.0	15.5	15.5	192.4
	10 - 40	A1	HC	41.9	36.5	28.6	24.2	17.7	53.1	
	40 - 63	B2	HC	56.8	46.1	29.5	23.7	33.1	76.1	
	63 - 100+	BC	HC	38.4	33.6	29.1	25.5	12.9	47.7	
No.3	0 - 10	Ap	LiC	29.8	24.8	21.8	18.2	11.6	11.6	155.6
	10 - 37	A11	LiC	30.8	24.1	21.3	16.7	14.1	38.1	
	37 - 48	A12	HC	44.5	38.9	33.8	29.5	15.0	16.5	
	48 - 70	B1	HC	40.1	33.9	30.6	25.8	14.3	31.5	
	70 - 100+	B2	HC	43.4	35.8	29.2	24.1	19.3	57.9	
No.4	0 - 12	A11	LiC	48.0	39.6	37.4	30.9	17.1	20.5	174.4
	12 - 43	A12	LiC	43.9	36.4	26.5	22.0	21.9	67.9	
	43 - 70	B21	HC	35.4	27.4	26.1	20.1	15.3	41.3	
	70 - 100+	B22	HC	30.4	22.0	21.4	15.5	14.9	44.7	
Caqueza No.1	0 - 17	Ap	HC	38.4	35.5	25.0	24.7	13.7	23.3	121.5
	17 - 53	B2	HC	35.1	30.1	25.2	24.8	10.3	37.1	
	53 - 100+	BC	HC	43.4	32.7	31.6	30.4	13.0	61.1	
No.2	0 - 15	Ap	LiC	25.0	21.6	18.7	17.5	7.5	11.3	113.3
	15 - 23	A1	HC	29.4	25.5	21.6	20.3	9.1	7.3	
	23 - 100+	B2	HC	33.7	27.0	23.0	21.4	12.3	94.7	
No.3	0 - 17	Ap	LiC	34.1	26.3	18.5	17.8	16.3	27.7	75.8
	17 - 35	B2	HC	22.6	19.7	17.9	16.8	5.8	10.4	
	35 - 100+	C	HC	18.2	14.2	13.0	12.4	5.8	37.7	
Tibacuy No.1	0 - 32	A1	LiC	30.7	24.8	19.0	18.4	12.3	39.4	83.8
	32 - 60	B2	HC	28.6	23.0	21.0	20.6	8.0	22.4	
	60 - 100+	BC	HC	25.5	22.8	20.8	20.0	5.5	22.0	
No.2	0 - 35	A1	LiC	32.0	27.3	25.6	24.1	7.9	27.7	66.9
	35 - 60	B2	HC	36.6	32.6	31.2	30.7	5.9	14.8	
	60 - 100+	BC	HC	33.4	30.2	28.0	27.3	6.1	24.4	

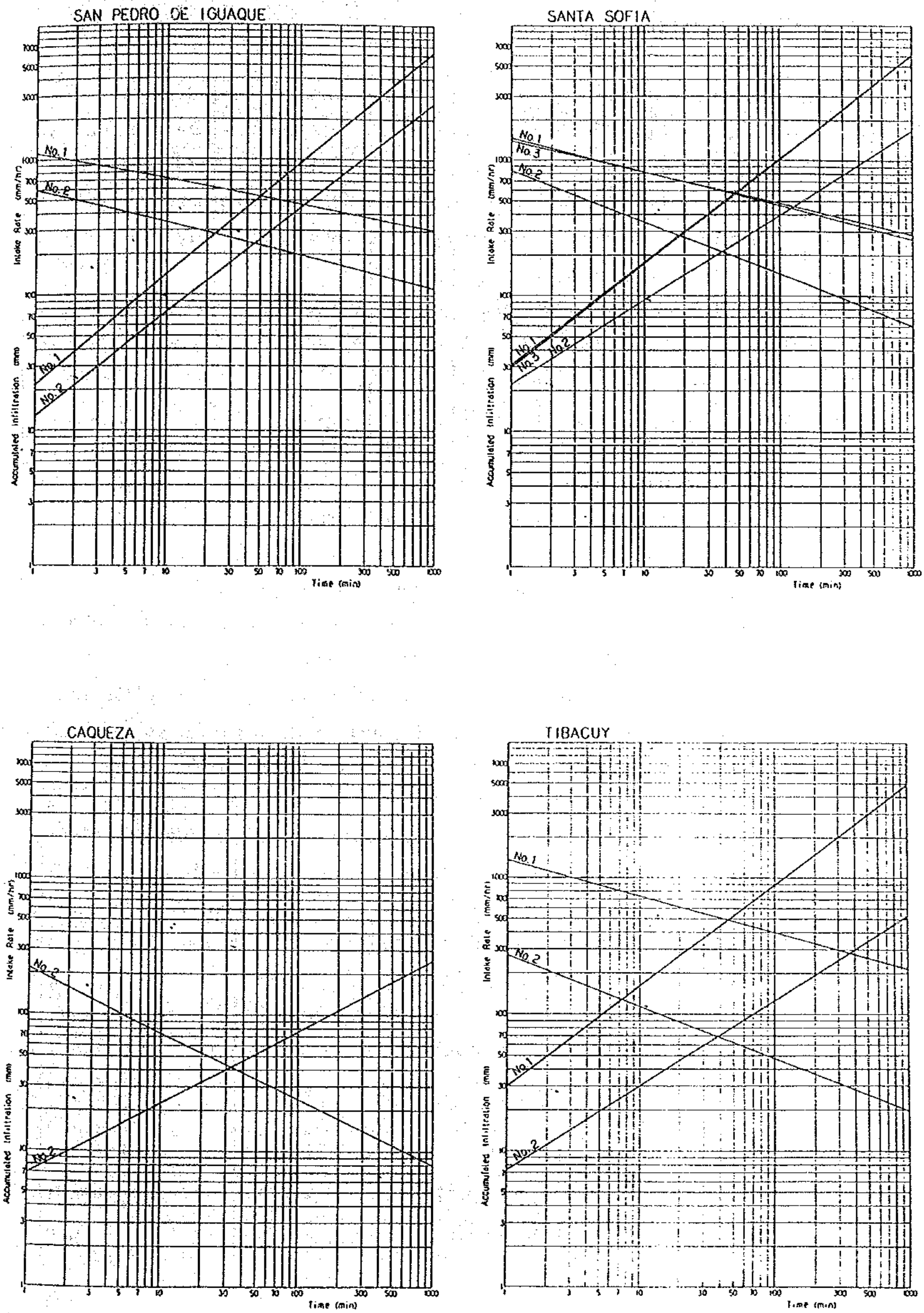

Fig. B.2.2 Infiltration Curve

3 Land Classification

The classification followed the framework of Land Classification System adopted by Soil Conservation Service of the U.S. Department of Agriculture. However, modifications were made to fit the local conditions. The classification factors are the soil texture, depth of soil and topography (gradient and erosion) as shown in Table B.3.1.

Land class 1 to 4 are suitable for cultivation and land class 5 to 8 are unsuitable for cultivation . A brief description of each class is given as follows;

Class 1:Lands with few limitations that restrict their use

Class 2:Lands with some limitations that reduce the choice of plants or require moderate conservation practices

Class 3:Lands with severe limitations that reduce the choice of plants or require special conservation practices

Class 4:Lands with very severe limitations that restrict the choice of plants or require very careful management

Class 5:Lands with little or no erosion hazards but with other limitations that restrict their use largely to pasture, rangeland, woodland, or wildlife food and cover

Class 6:Lands with severe limitations that make them generally unsuited to cultivation and restrict their use largely to pasture, rangeland, woodland, or wildlife food and cover

Class7:Lands with very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife

Class 8:Lands with limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or to aesthetic purposes

The results of land classification in the sub-project areas are shown in Table B.3.2. and Fig.B2.3 (1)-(4)

Table B.3.1 Basis of Land Classification

Item	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
1. SOIL Soil Texture	L-LiC	L-LiC	CL-HC	CL-HC	CL-HC	CL-HC	CL-HC	CL-HC
Depth of Soil(cm)	>150	>120	>90	>90	>60	>60	>30	>30
pH	5.5-7.0	5.0-7.0	4.5-7.5	4.5-7.5	4.0-8.0	4.0-8.0	4.0-8.0	4.0-8.0
2. TOPOGRAPHY Slope(%)	1-3	3-7	3-7-12	7-12-25	12-25-50	12-25-50	25-50-	25-50-
Erosion	Non	Non	Non or Light	Non or Light	Non or Light	Light or Moderate	Moderate or Strong	Strong

Table B.3.2 Land Classification

Unit: ha (%)

Land Class \ Area	SAN PEDRO DE IGUAQUE	SANTA SOFIA	CAQUEZA	TIBACUY
Arable Land				
Class 1				
Class 2				
Class 3	1,300 (35)	880 (23)	190 (16)	50 (4)
Class 4	1,080 (29)	1,500 (39)	745 (65)	605 (49)
Sub Total	2,380 (64)	2,380 (62)	935 (81)	655 (53)
Non-Arable Land				
Class 5				
Class 6	780 (21)	1,020 (26)	100 (9)	85 (7)
Class 7	220 (6)	320 (8)	115 (10)	495 (40)
Class 8	310 (9)	160 (4)		
Sub Total	1,310 (36)	1,500 (38)	215 (19)	580 (47)
Total	3,690 (100)	3,880 (100)	1,150 (100)	1,235 (100)

4 Land Utilization

(1) Present Land Utilization

The agriculture in the sub-project areas is namely carried on by small-scale farmers, except for a part of landowner so called "Finca" (large-scale farmer).

In San Pedro de Iguaque, almost of the cultivated land and grassland are scattered on the undulated and slope areas of the Loma Alta and Cuchilla Las Cruces ranging around 3,000m in altitude. On the other hand, the southern part of the sub project area is eroded, and the forestlands are left in the steep slopes along streams.

In Santa Sofia, grasslands including cultivated lands extend mainly except for the eroded districts in the southern part of this sub-project area, and in the western part with altitudes above approximately 2,500m, cultivation of curuba is conducted by the member of the Curuba Cooperative.

In Caqueza, the land is classified into the plateau of the Alto La virgen located over 2,100m in altitude and the slope area with undulations. The plateau is covered by grassland and the slope area is used for cultivation except for steep places.

In Tibacuy, land utilization pattern has distinct characteristics according to the altitude. The upper reaches more than 1,800m in altitude are used for grasslands, the areas ranging from 1,500m to 1,800m in altitude are used for coffee plantations and in the areas under 1,500m in altitude there are wastelands comprising very small-scale farmlands and grasslands.

Present land utilization, which became clear as a result of aerial photographs and field survey, is shown in Table B.4.1.

(2) Land Utilization Plan

The form and area of land utilization in the sub-project areas will remain unchanged according to the following reasons.

1) In this irrigation project, it is the principal object to increase the productivity of cultivated land by using effectively new irrigation facilities.

2) In terms of water resources in and around the project area, it is presumably difficult to secure sufficient water for the whole cultivated lands in the sub-project areas. Therefore, it will be not made a plan to develop newly cultivated land and/or change grassland into cultivated land.

3) In viewpoints of the countermeasure of soil conservation, grassland and forestland existing around cultivated land will be preserved in its present condition.

4) For the coffee plantation in Tibacuy, FEDECAFE has intention of changing part of coffee plantations into cultivated land in future on condition that gross coffee production will be kept up. But the coffee plantation area remains at present level because there is not a concrete plan at present in FEDECAFE.

(3) Soil Conservation

Soil erosion of cultivated land and grassland in the sub-project areas is not remarkable at this stage. On the other hand, soil erosion exists in the lower part of Los Robles and Soavita stream in San Pedro de Iguaque and in the right lower part of Palonegro stream in Santa Sofia. In those soil erosion areas, it is necessary to afforest and grow grass in order to recover vegetation.
Farmer and organization concerned as one body have need of pushing forward the countermeasures of soil conservation in slope areas, and it is necessary that each farmer gives careful consideration to the

following points at least in viewpoints of farm management.

1) Cancellation of fallow land and bare land (culture of effective crops such as green manure and so on for keeping and increasing the soil productivity, and afforestation)

2) Adoption of conservation cropping (contour cropping, belt cropping and non-tilled cropping)

Moreover, in regional unit (water-use organizations and municipalities) complete equipment of farm drainage, road drainage, farm road and so on and/or their everyday maintenance will be necessary.

Table B.4.1 Present Land Utilization

Unit: ha (%)

Land Category \ Area	SAN PEDRO DE IGUAQUE	SANTA SOFIA	CAQUEZA	TIBACUY
Cultivated land	1,184 (32)	360 (9)	589 (51)	43 (3)
Grass land	741 (20)	1,833 (47)	294 (26)	333 (27)
Forest land	1,071 (29)	1,318 (34)	220 (19)	195 (16)
Waste land	580 (16)	250 (7)	– (–)	325 (26)[1]
Coffee plantation	– (–)	– (–)	– (–)	304 (25)
Others [2]	114 (3)	119 (3)	47 (4)	35 (3)
Total	3,690 (100)	3,880 (100)	1,150 (100)	1,235 (100)

Note: 1) Including very small-scale cultivated land
2) Including roads, streams and housing lots

Table B.4.2 Arable Land Classification by Valley

Unit: ha

Area	Valley	Arable land (ha)			Total
		Class 3	Class 4	Class 6	
SAN PEDRO DE IGUAQUE	Carrizal[1]	108	92	–	200
	Yerbabuena[2]	114	46	–	160
	Soavita[3]	87	33	–	120
	Hight land[4]	371	333	–	704
	Sub Total	680	504	–	1,184
SANTA SOFIA	Palonegro[5]	33	20	–	53
	Camelo[6]	77	41	–	118
	La Laja	56	36	–	92
	Piedras	4	44	–	48
	Salitrillos	9	40	–	49
	Sub Total	179	181	–	360
CAQUEZA	Negra	34	290	–	324
	Blanca	35	75	–	110
	Carmen[7]	5	150	–	155
	Sub Total	74	515	–	589
TIBACUY	San Jose	5	38	–	43
	(Coffee Plantation)	(25)	(147)	(65)	(237)
	Bosa (Coffee Plantation)	–	(67)	–	(67)
	Sub Total	5(25)	38(214)	–(65)	43(304)
TOTAL		938(25)	1,238(214)	–(65)	2,176(304)

Note: 1) Including Mamarita, 2) Including Los Robles, 3) Including La Pila and Zo.Moyeta, 4) Areas more than 3,100m in altitude, 5) Including Bengala and Boliver, 6) Including La Qurz and Tambor, 7) Including Capellania and Seai

SAN PEDRO DE IGUAQUE

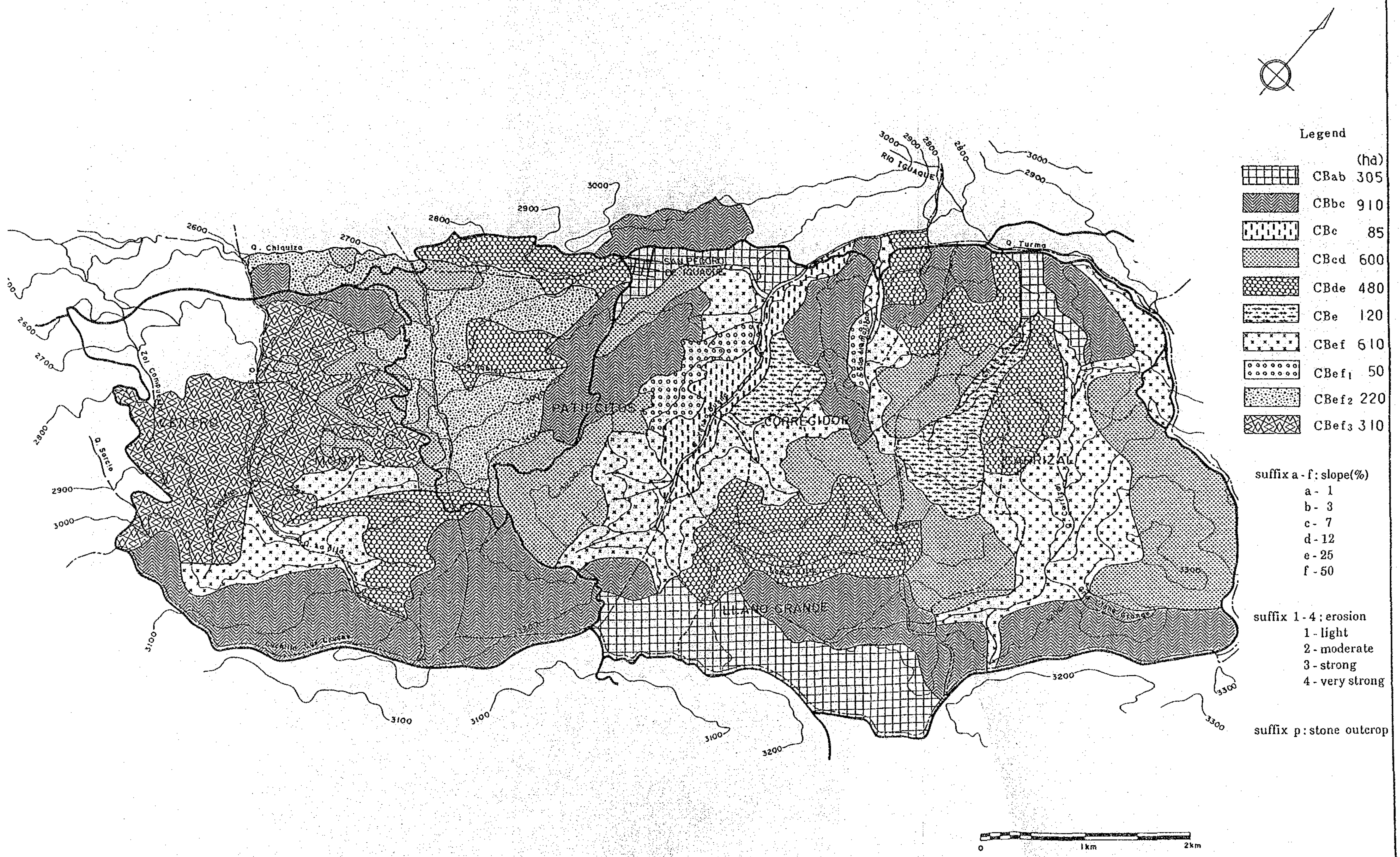

Fig. B.2.1 SOIL DISTRIBUTION MAP (1)