D.5 INSTALLATION OF AUTOMATIC WATER LEVEL GAUGE

In Work II of Phase I, the ten (10) automatic water level gauges sent by JICA had been installed in order to measure the water level of the river.

From the results of the field survey and discussion with C.R.Q. regarding the hydraulic conditions of the river, the construction methods at the specific site, the maintenance after against theft, the following stations have been selected (See FIG. D.5.1):

Station	Name of River	Catchment Area
No. 1	Quindio River downstream	387.0 Km2
No. 2	Quindio River upstream	201.0 Km2
No. 3	Buenavista Stream	39.6 Km2
No. 4	Roble River	120.2 Km2
No. 5	Espejo River	144.4 Km2
No. 6	Santo Domingo River	135.3 Km2
No. 7	Verde River	83.7 Km2
No. 8	Cristales Stream	27.9 Km2
No. 9	Rojo River	114.9 Km2
No. 10	San Jose River	68.3 Km2

The structure of said stations has been designed, considering the standard design of the HIMAT and the criteria of Colombia.

In and around said stations, the main present situation is that most rivers measured have topographically the typical site for hydraulic conditions: namely, the cross-section of said rivers vary easily due to the steep slope of the longitudinal section, and due the sedimentation caused by flood. Therefore, special attention must be paid to the maintenance such as keeping a control after a flood flow occurs, sweeping the sedimentation materials in and around the well and around the pipes installed for the water entering the well from the river, and so on.

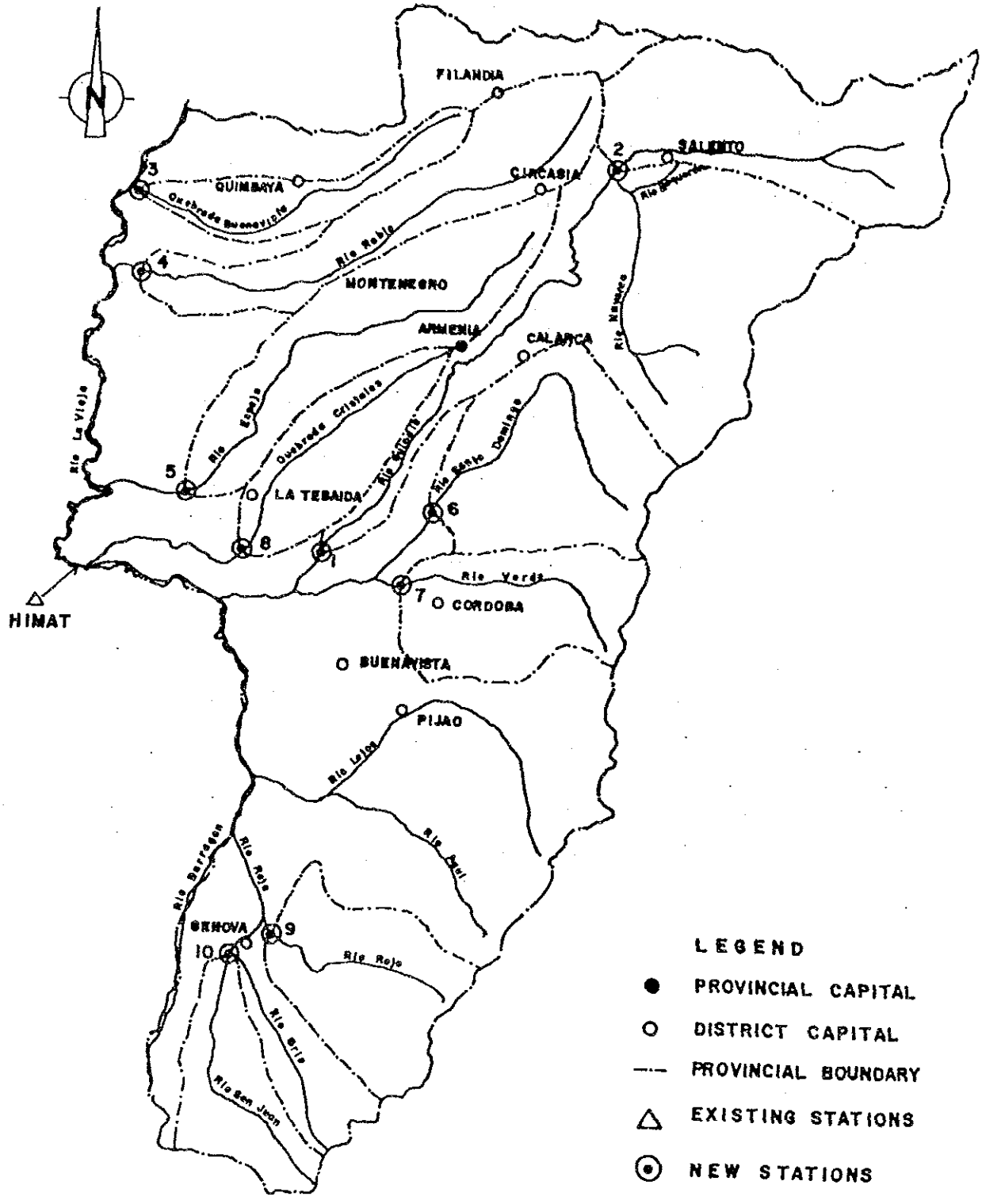

FIG.D.5.1. LOCATION MAP OF AUTOMATIC WATER LEVEL GAUGING STATION

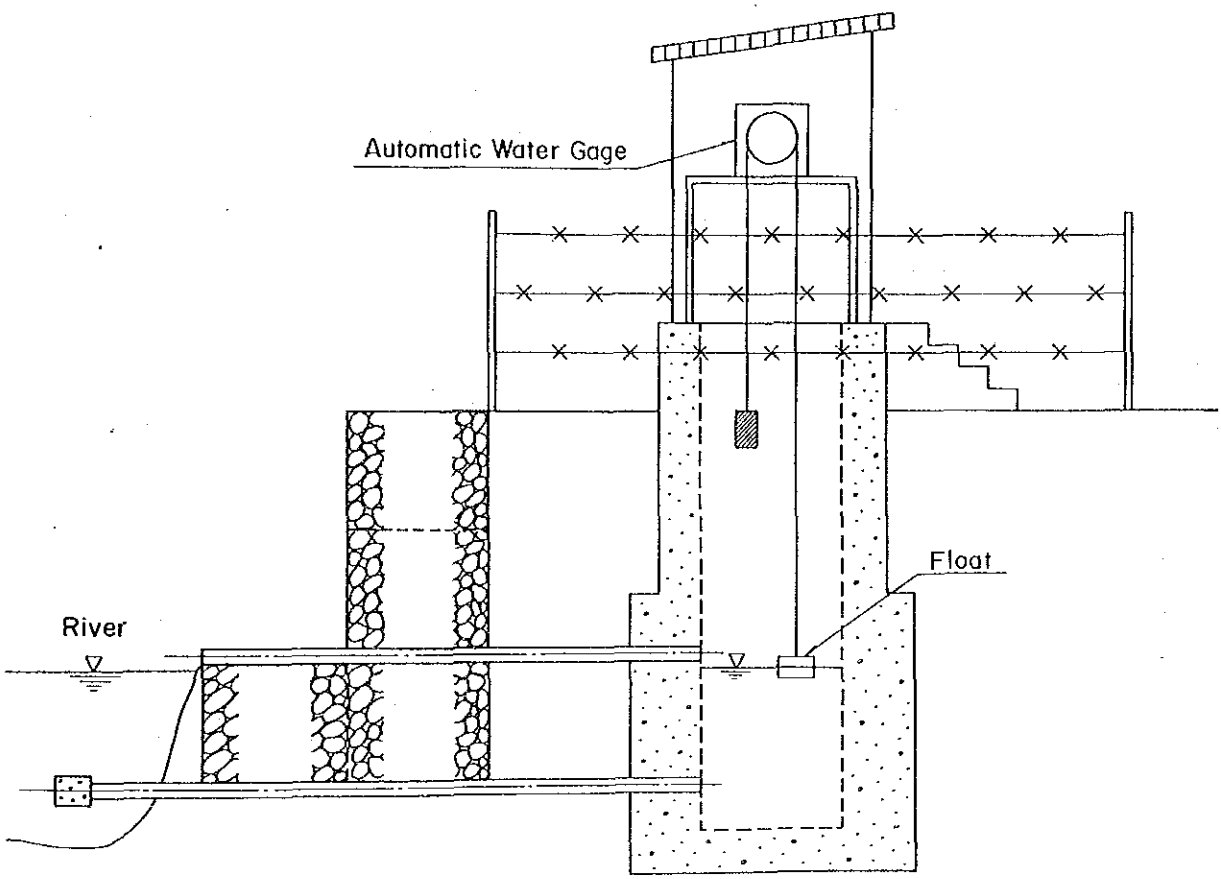

FIG. D.5.2 STANDARD PROFIL OF WATER GAGE STATION

ANNEX E : SOIL

ANNEX E : SOIL

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ANNEX E: SOIL

E.1 SOIL SURVEY

Soil survey was made mainly to confirm existing soil data of important soil units for crop cultivation. The survey was consist of field observation and chemical analysis.

(1) Field Observation

Field observation was conducted by boring and profile pit to identify the soil map prepared by the study. A total of 92 points including 14 profile pit were surveyed. Representative soil profiles are shown in E.2.

(2) Chemical Analysis

Soil analysis of 112 samples was entrusted IGAC and ICA. Sampling points were shown in Fig. E.1.1. Items and methods of analysis were as follows:

a) Mechanical analysis
b) pH values determined by H2O
c) P values determined by Bray II method
d) CEC values determined by pH 7.0 ammonium acetate solution
e) Exchangeable cation (K,Ca,Mg,Na,Al)
f) Base saturation
g) Total N
h) Organic material

Results of chemical analysis are shown in E.3.

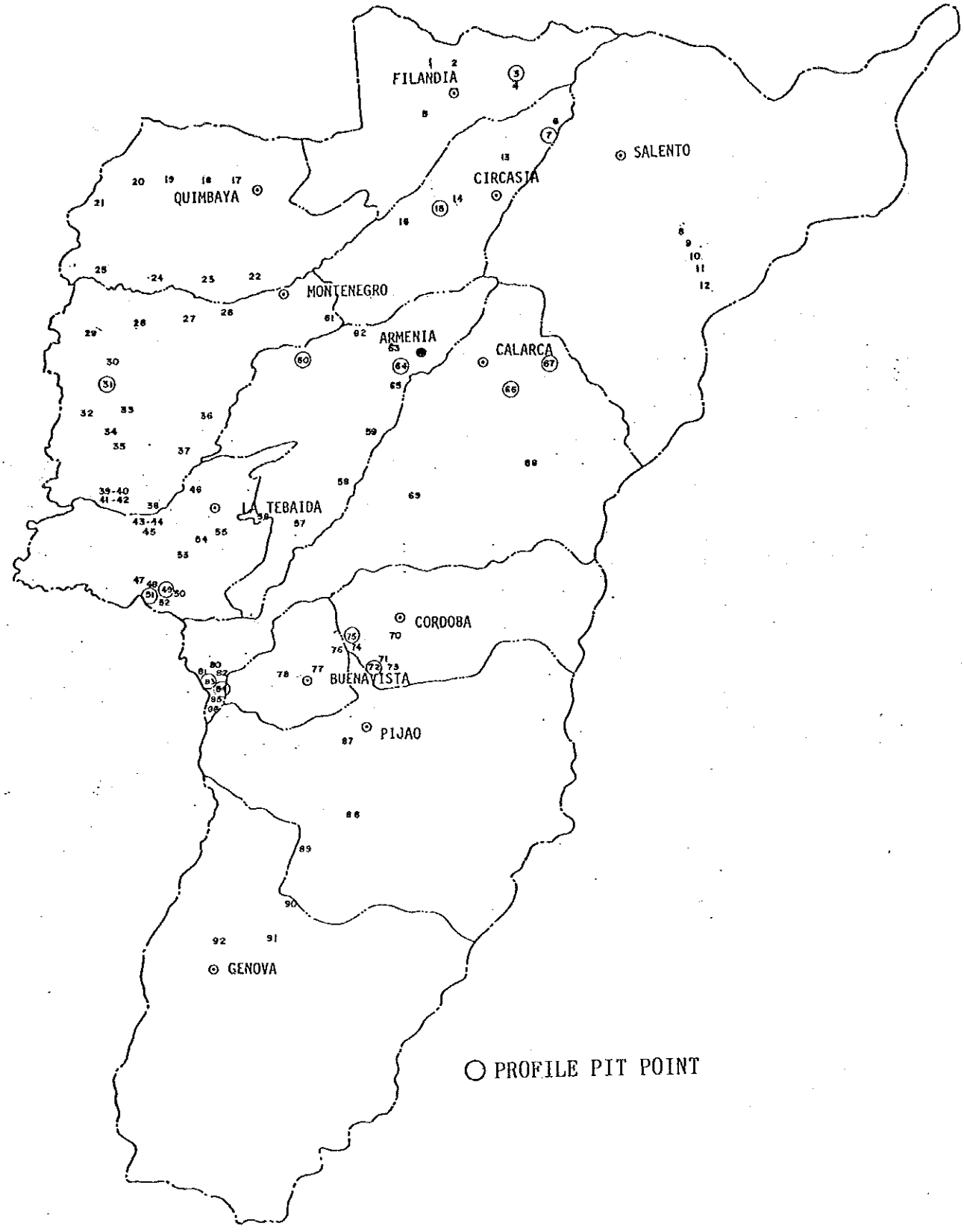


FIG. E.1.1 SOIL SAMPLING POINT

E.2 SOIL PROFILE

Description of representative soil profiles is as follow:

Sample No.	7
Soil Name	Chinchina(CH)
Present Landuse	Pasture
Drainage	Moderately drained
Land Form	Allmost flat
Parent Material	Volcanic ash

Profile Description

Depth in cm	Description
A0 0 - 13	Brown(7.5 YR 4/4) dry; sandy loam; moderate medium subangular; many medium and fine pores; many coarse and fine roots; wavy boundary.
A1 13 - 59	Dark brown(10 YR 3/4) dry; sandy loam; moderate medium angular; many medium and fine porse; many coarse and fine roots; wavy boundary.
AB 59 - 70	Brown(7.5 YR 4/3) dry; sandy roam; moderate medium subangular; many medium and fine porse; many fine roots; wavy boundary.
B 70 -	Bright brown(7.5 YR 5/6) dry; sandy cray loam; moderate medium angular; many fine porse.

Sample No.	3
Soil Name	Filandia(FI)
Present Landuse	Forest
Drainage	Moderately drained
Land Form	Undurating
Parent Material	Volcanic ash

Profile Description

Depth in cm	Description
A0 0 - 4	Very dark brown(7.5 YR 2/3) dry; sandy loam; moderate medium angular; many medium and fine pores; many medium and fine roots; wavy boundary.
A 4 - 21	Dark brown(7.5 YR 3/4) dry; sandy loam; moderate medium and fine angular; many

	medium and fine porse; medium and fine roots; smooth boundary.
AB 21 - 30	Brown(7.5 YR 4/4) dry; sandy loam; moderate medium and fine angular; common medium and fine pores; commone medium and fine roots; smooth boundary.
B1 30 - 54	Brown(10 YR 4/6) moist; clay loam; moderate medium and fine subangular; common medium and fine pores; common medium and fine roots; smooth boundary.
B2 54 -	Brown(10 YR 4/6) moist; loamy clay; moderate medium and fine angular; few medium and fine pores; few fine roots.

Sample No.	60
Soil Name	Montenegro(MN)
Present Landuse	Plantain
Drainage	Moderately drained
Land Form	Undulating
Parent Material	Volcanic ash

Profile Description

Depth in cm	Description
Ap 0 - 22	Dark brown(10 YR 3/3) dry; sandy loam; weak medium and fine subangular; many medium and fine pores; many medium and fine roots; smooth boundary.
A 22 - 35	Brownish black(10 YR 2/2) dry; sandy loam; weak medium and fine subangular; many medium and fine pores; many medium and fine roots; smooth boundary.
B1 35 - 75	Dull yellowish brown(10 YR 5/4) dry; sandy loam; no structure; common medium and fine pores; few roots; smooth boundary.
B2 75 -	Dull yellow(2.5 Y 6/4) dry; loamy sand; no structure; common medium and fine pores; no root.

Sample No.	64
Soil Name	Quindio(QD)
Present Landuse	Pasture
Drainage	Moderately drained
Land Form	Undurating
Parent Material	Volcanic ash

Profile

Depth in cm	Description
Ap 0 - 10	Dark reddish gray(2.5 YR 3/1) dry; sandy loam; moderate medium and fine subangular; many medium and fine pores; many medium and fine roots; smooth boundary.
A1 10 - 26	Grayish brown(7.5 YR 4/2) dry; sandy loam; moderate medium subangular; many medium and fine pores; many medium and fine roots; smooth boundary.
AB 26 - 40	Dull yellowish brown(10 YR 5/4) dry; loamy sand; weak medium and fine angular; common medium and fine pores; common medium and fine roots; smooth boundary.
B 40 - 97	Yellowish brown(2.5 Y 5/4) dry; loamy sand; weak medium and fine subangular; few pores; common medium and fine roots; smooth boundary.
C 97 -	Dull yellow(2.5 Y 6/3) dry; sand; no structure; many fine pores; no root.

Sample No.	31
Soil Name	Malabar(MB)
Present Landuse	Pasture
Drainage	Slightly poorly drained
Land Form	Flat
Parent Material	Volcanic ash

Profile Description

Depth in cm	Description
A 0 - 27	Graysh brown(7.5 YR 5/2) moist; sandy loam; moderate medium and fine angular; many medium pores; many medium and fine roots; wavy boundary.
Bt 27 - 43	Brown(10 YR 4/6) moist; clay loam; strong medium and fine angular; many fine pores; many fine roots; wavy boundary.
B 43 -	Brown(10 YR 4/6) moist; sandy loam; weak medium and fine angular; many medium pores; many fine roots.

Sample No.	83
Soil Name	Rio Quindio(RQ)
Present Landuse	Sorghum
Drainage	Poorly drained
Land Form	Flat
Parent Material	Alluvial

Profile Description

Depth in cm	Description
Ap 0 - 13	Brownish black(2.5 Y 3/2) moist; loam; moderate medium angular; many medium and fine pores; many fine roots; smooth boundary.
A 13 - 26	Yellowish gray(2.5 Y 4/1) moist; with spot of reddish brown(5 YR 4/6); sandy loam; moderate medium subangular; many medium pores; many fine roots; smooth boundary.
B1g26 - 37	Brown(10 YR 4/4) moist; sand; no structure; many medium pores; many fine roots; smooth boundary.
B2g37 - 42	Dark grayish yellow(2.5 Y 5/2) moist; with spot of brown(10 YR 4/6); sand; no structure; many medium pores; many fine roots; smooth boundary.
B3g42-	Grayish olive(5 Y 5/2) moist; with spot of dark reddish brown; clay; strong medium subangular; common fine pores; many fine roots.

E.3 RESULT OF SOIL ANALYSIS

1) Soil Unit 2) Sample No. 3) Soil Texture 4) Total Exchaneable Cation Except Al 5) Organic Carbon 6) Soil Fertility H:High M:Medium L:Low

1	2	3	pH	N	P	Exchangeable Cation me/100g					CEC	Satu.	5	6
				%	ppm	K	Ca	Mg	Na	Al	4	me/100g	%	C%	
C	11	SL	5.4	0.41	9.0	0.6	2.8	0.4	0.3	0.4	4.1	23.7	17.3	4.62	H
II	12	SL	4.8	0.76	8.0	0.1	0.4	0.2	0.1	2.7	0.8	30.4	2.6	4.86	M
C	8	SL	5.5	0.58	3.0	0.4	4.5	0.8	0.2	0.4	5.9	39.2	15.1	7.14	H
III	9	SL	5.4	0.47	8.0	0.2	2.7	0.6	1.2	0.4	4.7	26.4	17.8	4.53	H
	10	SL	5.3	0.36	9.0	0.6	1.6	0.4	0.1	0.4	2.7	19.4	13.9	2.82	M
GE	88	SL	5.7	0.28	28.0	0.2	10.6	2.0	0.1	--	12.9	24.3	53.1	2.68	H
TB	67	SL	5.3	--	10.0	0.6	1.3	0.4	0.1	0.3	2.4	--	--	3.70	-
		SL	5.1	--	42.7	0.2	1.8	0.3	0.2	0.3	2.5	--	--	0.90	-
RL	87	SL	5.3	0.35	7.0	0.8	8.2	3.6	0.3	0.2	12.9	26.0	49.6	3.02	H
CH-RL	89	SL	5.2	0.56	1.0	0.6	8.2	3.6	0.2	0.4	12.6	43.4	29.0	6.80	H
CH-BV	73	LS	5.8	NA	6.0	1.0	6.5	1.6	0.1	NA	9.2	26.3	35.0	4.51	H
	75	SL	5.4	--	8.4	0.6	6.0	0.9	0.1	0.4	7.6	--	--	6.60	-
		SL	5.2	--	5.9	0.2	4.9	1.0	0.1	0.6	6.2	--	--	2.80	-
CH	6	SL	5.6	0.52	4.0	0.2	1.2	1.2	0.2	NA	2.8	42.5	6.6	6.74	M
	7	SL	5.0	--	9.1	0.2	1.1	0.7	0.1	0.7	2.2	--	--	7.70	-
		SL	5.0	--	2.1	0.1	0.6	0.3	0.2	0.5	1.2	--	--	6.90	-
	13	LS	5.3	0.85	2.0	0.4	3.2	1.6	0.1	1.0	5.3	40.9	13.0	8.88	M
	54	SL	4.9	0.27	33.0	0.4	3.2	0.8	0.1	0.8	4.5	16.3	27.6	2.38	H
	55	SL	5.7	0.21	27.0	0.7	8.2	1.2	0.2	NA	9.7	14.7	41.6	2.86	H
	56	SL	6.0	0.08	11.0	0.5	2.4	0.4	0.1	NA	3.4	15.9	21.4	1.70	M
	57	SL	5.6	0.19	2.0	0.4	8.6	0.8	0.1	NA	9.9	17.5	56.6	1.83	H
	72	LS	4.9	--	1.5	0.1	1.1	0.4	0.1	0.7	1.7	--	--	6.10	-
		SL	4.9	--	3.0	0.1	0.6	0.3	0.2	0.9	1.2	--	--	3.70	-
		SL	4.8	--	1.5	0.1	0.6	0.3	0.1	1.0	1.1	--	--	3.30	-
FI	1	SL	5.2	0.60	2.0	0.2	0.4	0.4	0.2	0.8	1.2	37.5	3.2	6.81	M
	2	SL	4.7	0.68	2.0	0.2	0.4	0.4	0.1	0.4	1.1	35.0	3.1	5.27	M
	3	SL	5.3	--	1.5	0.2	1.0	0.4	0.1	0.6	1.7	--	--	9.40	-
		SL	5.1	--	3.6	0.1	0.4	0.2	0.2	0.4	0.9	--	--	5.60	-
	4	LS	5.6	0.64	3.0	0.1	0.8	0.4	0.3	NA	1.6	36.6	4.4	5.27	M

	5	LS	5.1	0.63	2.0	0.1	0.8	0.4	1.1	0.8	2.4	45.1	5.3	7.64 M
MN	16	LS	6.0	0.65	9.0	0.5	18.4	2.8	0.3	NA	22.0	40.9	53.8	7.59 H
	37	SL	5.6	0.18	6.0	0.8	6.6	2.4	0.1	NA	9.9	19.4	51.0	2.34 M
	38	SL	5.7	0.18	5.0	0.6	6.1	0.8	0.1	NA	7.6	14.3	53.1	1.70 M
	43	SL	5.8	0.09	2.0	0.1	6.9	2.8	0.2	NA	10.0	13.9	71.9	1.50 M
	44	SL	6.0	0.02	2.0	0.2	9.9	3.6	0.5	NA	14.2	22.9	62.0	0.34
	45	SL	6.6	0.04	3.0	0.1	11.9	3.6	1.0	NA	16.6	26.9	61.7	0.41
	46	SL	5.5	0.09	6.0	0.9	5.1	1.0	0.1	0.4	7.1	19.2	37.0	1.56 M
	53	SL	5.7	0.21	27.0	0.7	8.2	1.2	0.2	NA	10.3	14.7	70.1	2.86 H
	58	LS	5.1	0.09	18.0	0.2	1.6	0.4	0.1	0.8	2.3	20.6	11.2	2.81 M
	60	SL	5.6	--	38.9	0.5	5.0	1.0	0.1	0.2	6.6	--	--	4.30 -
		SL	5.6	--	33.0	0.4	4.2	0.6	0.1	0.2	5.7	--	--	3.00 -
		SL	5.1	--	60.2	0.2	0.8	0.3	0.1	0.3	1.4	--	--	1.7 -
	61	LS	5.7	0.32	4.0	0.2	4.6	0.8	0.3	NA	5.9	26.3	22.4	3.54 M
	62	SL	5.5	0.38	11.0	0.2	4.7	2.0	0.1	0.4	7.0	23.7	29.5	3.88 M
CH-MN	14	LS	5.1	0.51	2.0	0.1	0.6	0.2	0.2	1.0	1.1	29.1	3.80	5.33 M
	15	LS	5.3	0.49	1.0	0.1	0.4	0.2	0.1	0.6	0.8	29.9	3.30	5.40 M
QD	59	LS	5.7	0.08	11.0	0.2	6.8	0.6	0.1	NA	7.7	24.3	31.7	3.63 H
	63	LS	5.1	0.27	10.0	0.2	1.2	0.4	0.1	0.8	1.9	23.9	7.9	3.84 M
	64	SL	5.2	--	4.4	0.1	1.8	0.5	0.1	0.6	2.5	--	--	4.60 L
		SL	5.3	--	6.7	0.1	1.2	0.4	0.1	0.5	1.8	--	--	2.40
	65	SL	5.9	0.19	21.0	0.3	7.9	0.6	0.1	NA	8.9	25.2	35.3	3.91 H
B	30	SL	6.2	0.23	63.0	1.0	6.5	2.4	0.2	NA	10.1	15.5	65.2	1.63 H
	31	SL	5.4	0.22	2.0	0.1	4.9	2.0	0.2	0.2	7.2	16.7	43.1	1.84 M
		SL	5.9	0.10	2.0	0.1	8.2	5.3	0.4	NA	14.0	30.2	46.4	0.78
	32	SL	5.3	0.13	26.0	0.7	2.8	1.2	0.2	0.2	4.9	9.8	50.0	1.22 M
	33	SL	6.2	0.23	63.0	1.0	6.5	2.4	0.2	NA	10.1	15.5	65.2	1.63 H
	34	SL	5.9	0.18	34.0	0.9	6.5	3.6	0.4	NA	11.4	14.7	77.6	1.56 H
	35	SL	5.8	0.15	11.0	0.2	7.8	0.8	0.2	NA	9.0	15.1	59.6	1.56 M
	39	SL	6.0	0.20	2.0	0.6	8.2	2.8	0.2	NA	11.8	22.7	52.0	2.26 H
		SL	6.4	0.04	4.0	0.5	8.5	5.5	0.2	NA	14.7	29.3	50.2	0.77
		CL	6.5	0.02	2.0	0.3	7.1	5.4	0.3	NA	13.1	19.6	66.8	0.28
		SL	6.4	0.01	3.0	0.2	5.2	5.2	0.4	NA	11.0	16.9	65.1	0.27
RQ	47	SiCl	5.3	0.19	33.0	0.6	3.6	1.2	0.4	0.2	5.8	11.4	50.9	1.36 H
	48	SiCL	5.4	0.19	34.0	0.9	4.2	3.4	0.5	0.2	9.0	12.6	71.4	1.56 H
	49	L	4.9	0.26	21.0	0.6	4.2	1.2	0.4	0.6	6.4	15.9	40.3	2.52 M
		SiCL	5.5	0.15	19.0	0.2	4.1	1.0	0.1	0.4	5.4	11.4	47.4	0.74
	50	HC	5.0	0.22	33.0	0.3	3.8	0.8	0.2	0.6	5.1	14.7	34.7	1.63 M
	51	SiL	5.6	--	27.6	0.8	4.1	1.9	0.3	0.2	7.1	--	--	4.60

	SiL	5.7	--	22.5	0.5	5.5	2.7	0.1	0.2	8.8	--	--	3.90	
52	SiL	5.4	0.25	22.0	0.6	7.3	3.6	0.2	0.2	11.7	16.1	72.7	2.06	H
80	SiL	5.5	0.42	13.0	0.1	7.3	4.9	0.2	0.2	12.5	20.6	60.7	3.43	H
81	L	5.4	0.30	14.0	0.1	7.3	4.5	0.2	0.2	12.0	17.1	70.2	2.44	H
82	SiL	5.3	0.41	13.0	0.1	6.1	4.5	0.2	0.4	10.9	19.6	55.6	3.06	M
83	SiL	5.3	0.13	22.0	0.1	6.1	2.4	0.2	0.2	8.8	11.4	77 2	1.02	M
	SiL	6.1	0.09	7.0	NA	11.0	3.6	0.2	NA	14.8	19.8	74.7	0.68	
84	SiL	6.0	--	41.4	0.2	6.7	3.2	0.2	NA	10.3	--	--	3.90	
	SiL	6.0	--	52.3	0.1	4.7	2.1	0.2	NA	7.1	--	--	1.90	
	HC	6.2	--	59.1	0.1	8.6	4.8	0.2	NA	13.7	--	--	1.50	
85	SiL	5.4	0.20	26.0	0.1	6.2	2.0	0.2	0.2	8.5	13.5	63.0	1.63	M
86	SiCL	5.1	0.17	16.0	0.2	6.5	2.4	0.1	0.4	9.2	14.7	62.6	1.50	M

E.4 SOIL FERTILITY EVALUATION

Soil fertility was evaluated in order to the method of IGAC. The method is as follows:

TABLE E.4.1 STANDARD OF SOIL FERTILITY

	pH	Range	<4.5 >8.5	4.6-5.0 7.9-8.4	5.1-5.5 7.4-7.8	5.6-6.0	6.1-7.3
	H20 1:1	Point	1	2	3	4	5
	Saturation	Range	>60	60 - 30	29 - 15	14 - 5	<5
	% of Al	Point	1	2	3	4	5
	CEC	Range	5	5 - 10	11 - 15	16 - 20	>20
	me/100g	Point	1	2	3	4	5
B	Saturation	Range	<10	10 - 35	36 - 50	51 - 70	>70
a	%	Point	0.5	1.0	1.5	2.0	2.5
s	Total	Range	<4	4 - 8	8.1- 12	12.1-16	>16
e	me/100g	Point	0.5	1.0	1.5	2.0	2.5
O C	Cold	Range	<1.3	1.4-2.6 >10	2.7-4.0 8.1-10	4.1-5.2 8.0-6.6	5.3-6.5
r a							
g r		Point	1	2	3	4	5
a b	Medium	Range	<0.5	0.6-1.7 >7.6	1.8-2.9 6.5-7.6	3.0-4.1 5.4-6.5	4.2-5.3
n o							
i n		Point	1	2	3	4	5
c	Hot	Range	<0.2	0.2-0.5	0.51-1.7	1.71-2.9	>3.0
		Point	1	2	3	4	5
	P ppm	Range	<10	10 - 20	21 - 30	31 - 40	>40
		Point	1	2	3	4	5
	K me/100g	Range	<0.1	0.1-0.2	0.21-0.3	0.31-0.4	>0.4
		Point	1	2	3	4	5

$$Ft=(0.7F1 + 0.3F2)0.285$$

F1 : Total point of topsoil(0-25cm)
F2 : Total point of subsoil(25-50cm)

TABLE E.4.2 EVALUATION OF FERTILITY

Ft	Fertility
More than 8.4	Very high
8.4 - 6.8	High
6.7 - 5.2	Medium
5.1 - 3.6	Low
Less than 3.6	Very low

Basically, the evaluation is used to calculate above formula. In the case of only surface soil data, however, the evaluation is applied a following formula.

$$Ft=(F1)0.285$$

E.5 SOIL CHARACTERISTICS

As a result of analyzing data from the reconnaissance survey and chemical analysis, physical and chemical properties by unit are summerized in Table E.5.1. Most of soil in the area is affected by volcanic ash. According to the U.S.D.A. Soil Taxonomy classification, Dystrandept is the most dominant great group soil in the area, which covers more than 60 % of the area and is mainly distributed in the undulating hill and the mountain area. The second greatest group soil is Hapludoll, which covers about 15 % of the area and distributed mainly in Genova and Pijao. Generally, soils in the area show good physical and chemical characters and medium to high fertility. They have no any constrain for crop cultivation except three soil units as follow.

Soil Unit	Constrain
1) Rio Quindio	Poor Drainage
2) Rio La Vieja	Superficial Soil Depth
3) Coldillera Central I	Consist of Lava

Soils are categorized generally prevailing condition of climate, vegetation, topography and parent materials. Therefore, soil in the area can be classified into 7 great groups as shown in Table E.5.2.

TABLE E.5.1 SOIL CHARACTERISTICS AND DISTRIBUTION

Soil Unit	Parent1) Material	Soil Characteristics pH	CEC	Tex-ture	Drain-age	Soil Depth	Fertility	Soil Distribution Altitude(m)	Slope(%)
CI	L	--	--	--	--	--	--	>3,500	>55
CII	V,M	M	H	M	M	S-P	M-H	>3,000	>20
CIII	V,M	M	H	M	M	M-P	M-H	2,000-3,000	>20
GE	V,M	M	M-H	M	M	S-M	M-H	1,000-2,000	10-55
CE	V,M	M	M-H	M	M	S-M	M	1,850-2,000	25-55
TB	V,M	M	M-H	M	M	S-P	M	1,500-2,000	15-25
RL	V,M	M	H	M	M	S-M	H	1,200-2,000	10-25
PB	V,I	M	M	M	M	S-M	M	1,800-2,000	20-55
BV	V,I	M	M-H	M	M	S-M	M-H	1,200-2,000	20-55
LC	V,I	M	L-M	M	M	VS-M	M	1,100-1,500	6-25
CH	V	M	M-H	M	M	M-P	M-H	1,100-2,000	2-10
FI	V	M	H	M	M	M-P	M	1,800-2,200	4-6
MN	V	M	M-H	M	M	P	M-H	1,100-1,700	2-6
QN	V	M	H	M	M	P	M-H	1,200-1,700	2-6
MB	V	M	M-H	M	P-M	P	M-H	1,000-1,200	2-4
RV	S	M	L-M	C-M	M	VS-S	L-M	950-1,200	6-15
RQ	A	M	M	F-M	P	M-P	M-H	950-1,200	0-4

Parent Material: I: Igneous Rock L: Lava M: Metamorphic Rock V: Volcanic Ash
S: Sedimentary Rock A: Alluvial Soil
pH : L: Low >5.0 M: Moderate 5.0-6.0 H: High 6.0<
CEC : L: Low <10meq/100g M: Medium 10-20meq/100g H: High 20meq/100g<
Drainage: P: Poor M: Moderate H: High
Texture: F(Fine): HC,SiC C(Coarse): S,LS M(Medium): Others
Soil Depth : VS: Very Superficial <25cm S: Superficial 25-50cm M: Medium Profound 50-90cm P: Profound 90-150cm
Fertility: See Soil Fertility Evaluation
Source: Study Team,IGAC,FEDECAFE
Soil Symbol and Name :

Symbol	Name	Symbol	Name
CI	:Cordillera Central I	PB	:Patio Bonito
CII	:Cordillera Central II	Bv	:Buenavista
CIII	:Cordillera Central III	LC	:La Concha
GE	:Genova	CH	:Chinchina
CE	:Cedral	FI	:Filandia
TB	:El Tablazo	MN	:Montenegro
Rl	:Rio Lejos	QN	:Quindio
		MB	:Malabar
		RV	:Rio La Vieja
		RQ	:Rio Quindio

TABLE E.5.2 SUMMERY OF SOIL CHARACTERISTICS

Group	Soil Unit	Classification	Main Character	Area(%)
1) Undulating to rolling area area along river	LC,RV	Dystrandept Hapludalf Hapludoll	Low pH, Moderate drainage, Thin soil layer, Low fertility	5.9
2) Almost flat area	MB	Dystrandept Tropudalf	Medium pH, Slightly poor drainage, Thick soil layer, Medium to high fertility	3.3
3) Flat area	RQ	Tropofluvent	Medium pH, Poor drainage, Thick soil layer, Medium fertility	2.0
4) Undulating hill area	QD,MN,FI, CH	Dystrandept	Medium to low pH, Moderate drainage, Thick soil layer, Medium to high fertility	30.1
5) Undulating to steep area	GE,BV,TB, RL,PB,CE	Hapludoll Dystrandept Dystropept	Medium pH, Moderate drainage, Thin to thick soil layer, Medium fertility	20.2
6) Mountain area	C II, C III,	Dystrandept Dystropept	Low pH, Moderate drainage, Thin to thick soil layer, Medium to high fertility	37.6
7) No vegetation area	C I	Cryorthent Cryopsament	Consist of lava	0.9

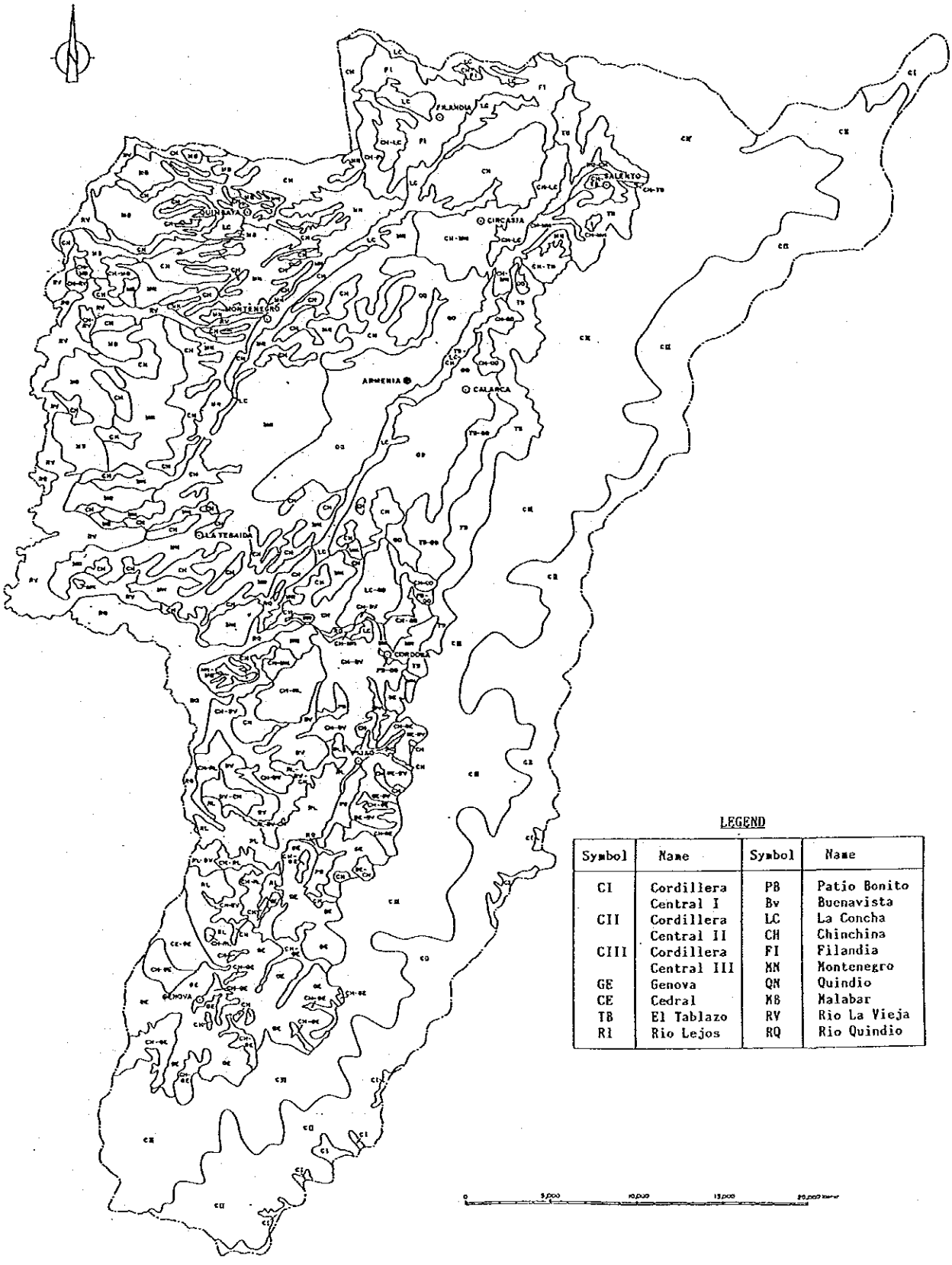
E.6 SOIL DISTRIBUTION

Soil map and area by soil unit are shown in Fig. E.6.1 and Table E.6.1 .
According to the map, soil in the study area is classified into 17 units. The soil are categorized generally by prevailing condition of climate, vegetation, relief class and parent material. However, in the area, different soil units are distributed mainly according to altitude. Fig. E.6.2 shows the distribution of soil unit by altitude.

TABLE E.6.1 AREA BY SOIL UNIT

Group	Area (%)	Group	Area (%)
Undulating to Rolling Area	5.9	Undulating to Steep Area	20.2
RV	2.9	GE	3.9
CH - RV	0.2	TB	3.0
LC	1.5	PB	0.6
TB - LC - CH	0.4	BV	0.6
		RL	1.5
CH - LC	0.9	GE - CE	2.1
Almost Flat to Undulatin Area	3.3	GE - BV	0.7
MB	3.3	RL - BV	0.1
Flat Area	2.0	RL - BV - CH	0.2
RQ	1.9	CH - BV	2.2
RQ - CH	0.1	CH - GE	1.4
Undulating Hill Area	30.1	CH - TB	0.3
		CH - RL	1.8
QD	5.2	Pb - QD	0.2
MN	11.0	TB - QD	1.0
		LC - QD	0.6
FI	0.5	Mountain Area	37.6
CH	10.3	C II	13.2
CH - FI	0.4	C III	24.4
CH - MN	1.6	No Vegetation Area	0.9
CH - QD	0.8	C I	0.9
CH - MB	0.2		
MN - MB	0.1		
Total Area is 1,946.7 . Km^2			

Source : Remote Sensing Team



LEGEND

Symbol	Name	Symbol	Name
CI	Cordillera Central I	PB	Patio Bonito
CII	Cordillera Central II	Bv	Buenavista
CIII	Cordillera Central III	LC	La Concha
GE	Genova	CH	Chinchina
CE	Cedral	FI	Filandia
TB	El Tablazo	MN	Montenegro
RI	Rio Lejos	QN	Quindio
		MB	Malabar
		RV	Rio La Vieja
		RQ	Rio Quindio

FIG. E.6.1 SOIL MAP

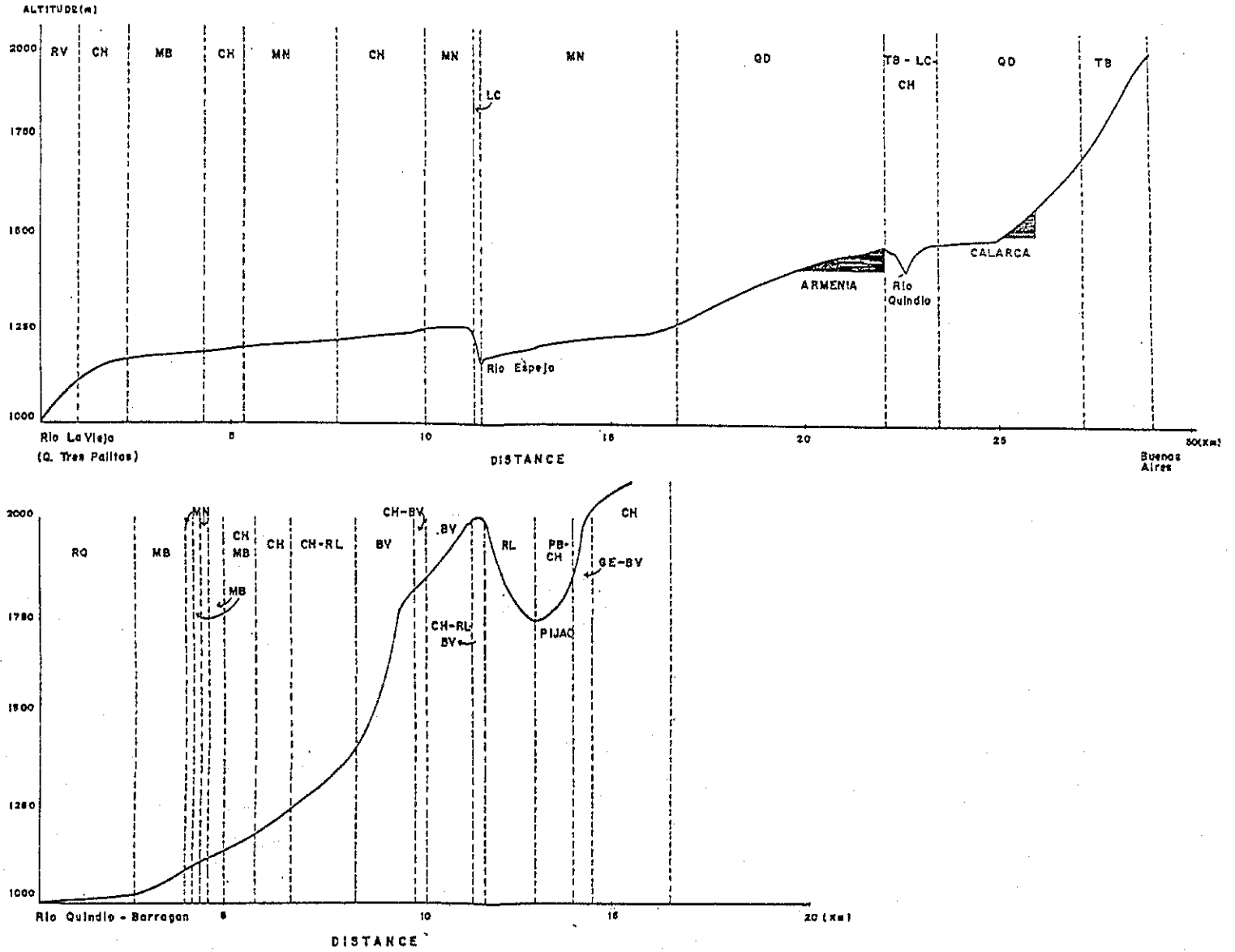


FIG. E.6.2 SOIL DISTRIBUTION BY ALTITUDE

ANNEX F : LAND USE

ANNEX F: LAND USE

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ANNEX F : LAND USE

F.1 EXISTING LAND USE/LAND TENURE

F.1.1 Existing Land Use

A land use map of Quindio on a scale of 1 to 50,000 was prepared in the Study. An outline of existing land use map is shown in Fig.F.1.1 and an area by land use unit is shown in Table F.1.1.

According to the land use map, the existing of the Department of Quindio is 1946.7 km2.

The land of 139 thousand ha or 71 percent of the total area is utilized for agricultural purposes. Of the area, Coffee cultivation (31.4%) and pasture (35.6%) are by far the most dominant land use,together covering 66.9 percent of the study area. Forest, upland crop and urban cover 51.3, 8.3 and 1.6 thousand ha, which are equivalent to 26.4, 4.2 and 0.8 percent, respectively.

In short, the land use in the area can be characterized by:

a) Upland crop : 1,000 - 1,200m above sea level

b) Coffee : 1,000 - 1,800m above sea level(18-22℃)

c) Pasture : >1,700m and 950 - 1,200m above sea level

d) Forest : >2,000m above sea level and steep slope area

Distribution of main land usage is as follows :

1) Upland Crop

Upland crop cultivated area is mainly distributed in Armenia, Calarca, La Tebaida, Montenegro, and Quimbaya. These five municipalities share 94 percent of cultivation in Quindio.

2) Coffee

Coffee cultivated area is the second most widespread land use in the study area, especially so Armenia(36.5%), Buenavista (68.5%), Circasia(52.3%), Montenegro(50.0%) and Quimbaya(62.9%) where the crop covers more than 50 percent of the each municipal.

3) Pasture

Pasture is most widespread land use in Quindio. It is mainly distributed in the the mountain area. Especially Filandia (44.0%), Genova(35.1%), Pijao(44.3%) and Salento(48.7%) where it covers more than 40 percent of each municipal area.

4) Forest

Forest area is mainly distributed in the mountain area such as Salento(44.8%), Pijao(35.6%) and Genova(40.4%). These three municipalities share 74 percent of the total forest area in Quindio.

F.1.2 Land Use Evaluation

The section highlights the major problem of existing land use with a view to identifying development opportunities. Main problem are as follows:

1) According to FEDECAFE, the area suitable for coffee is the area between 1,300 and 1,800m above sea level. According to Caja Agraria, however, the coffee yield of the incapable area such as La Tebaida and Montenegro is almost the same or higher than that of capable area. It mainly contributes to the introduction of the Caturra variety which is suitable for higher temperatures in comparison with other varieties. Therefore, it can be said that the coffee capable area is extends from the border of the area at 21.5°C(1,200m).
(Source: Manual Del Cafetero Colombiano)

According to Sena, the coffee yield of the area above 1,800m above sea level is low because of low temperature. Coffee cultivation of the steep slope area is resulting in a top soil loss with operation of weeding etc..

2) The study area has already expanded its farm land to an almost maximum limit, and farms encroached into the area less suitable or un suitable for development or areas to be conserved, such as steep slope and mountain areas. This inappropriate land use results in a top soil loss and erosion. These situation are regularly observed in many of the areas farms and the main factor of these area also the cause of bad soil management.

3) Forestry cover only 26.4 percent of the area. Generally, minimum forest area keeping the ecological balance in tropical area is one third of area.

Better development and maximum utilization of land always go together with land preservation. It should be noted that ecological balance in the tropical area is very sensitive and difficult to restore for it's original ecosystem.

F.1.3 Land Tenure

According to IGAC, a survey using modern technology on the registration of land has been started since 1983. The distribution of farm holdings by size in Quindio is shown in Table F.1.2. The average size per holding showed a decrease from 9.6 ha in 1983 to 8.1 ha in 1986. In 1983, it is equivalent to about two thirds of

the national average.

However, the average size of holding in Salento, Cordoba, Pijao, Genova and La Tebaida, where grazing land is dominant, is much higher than that of the departmental average.
(See following Table)

About 43 percent of the holdings in the area are less than 3.0 ha in size but they account for only 3.6 percent of the total cultivated area. On the other hand, about 6 percent of the holdings in the more than 50 ha category account for more than 53 percent of the total cultivated area. According to IGAC, this trend has shown no change since 1970.

AVERAGE LAND TENURE

Area	Armenia	Buenavista	Calarca	Circasia	Cordoba	Filandia	Genova
ha	3.8	5.9	5.4	3.3	12.7	4.0	15.3

	La Tebaida	Montenegro	Pijao	Quimbaya	Salento	Quindio	Colombia
	17.9 1/	7.0	16.0	4.9	22.8	8.1	14.9 2/

1/: 1985 2/: 1983
Source: IGAC 1986

According to FEDECAFE, coffee farmers constitute for the largest agricultural group in the area,accounting for 7,827 households in 1980. The average size per coffee holdings is 12.0 ha and the average coffee planted area is 8.3 ha.

F.1.4 LAND PRICE

For the purpose of getting acquainted with up-to-date, a survey on land price by means of direct interview to landowners was conducted by the Study Team. Price shows average by area that landowners want to sail their farm land.

Municipality	Location 1)	Area	No of 2) Farmers	Total Hectar	Price Col.$/ha
Armenia	1	San Juan	7	38.5	2,280,285
	2	La Patria	2	20.5	2,617,350
	3	San Pedro	2	10.8	1,562,000
	4	El Caimo	2	37.0	3,230,540
	5	Puerto Espejo	2	18.5	1,815,405
	6	Mesopotaía	1	2.5	1,562,000
	7	Tigreros	1	1.8	1,000,000
	8	La Revancha	1	38.0	2,344,000
Buenavista	9	La Cabaña	3	85.0	1,320,000
	10	El Balso	1	19.0	790,000
	11	Las Gurrías	1	3.0	450,000
	12	La Mina	1	21.0	595,000
Calarcá	13	Chagualá	4	17.5	1,071,000
	14	Aguacatal	4	24.0	1,770,000
	15	La Bella	3	16.0	2,312,000
	16	Bohemia	3	24.0	1,730,000
	17	Santo Domingo	3	41.0	1,073,000
	18	Buenos Aires	2	1.5	2,134,000
	19	Puerto Rico	2	14.5	1,380,000
	20	La Granja	1	3.5	570,000
	21	Quebrada Negra	1	64.0	1,500,000
	22	La Albania	1	19.0	1,500,000
	23	La Virginia	1	64.0	1,500,000
	24	Santo Domingo Bajo	1	20.0	1,500,000

Circasia	25	El Congal	3	19.0	552,000
	26	Barcelona Alta	3	8.0	1,095.000
	27	Barcelona Baja	3	17.0	895,000
	28	Naranjal Alto	3	17.0	615,000
	29	La Siria	2	9.0	955,000
	30	Naranjal	2	7.0	1,285,000
	31	Riobamba	1	13.0	700,000
	32	Piamonte	1	8.0	1,500,000
	33	San Antonio	1	9.5	700,000
	34	Pinares	1	17.0	882,000
	35	La Cristalina	1	16.0	700,000
Córdoba	36	Rio Verde Alto	2	29.5	575,000
	37	Rio Verde Medio	1	32.0	450,000
	38	Guayaquil	1	30.0	500,000
	39	Jardín Alto	1	8.5	353,000
	40	Alto Del Oso	1	2.0	500,000
	41	La Playa	1	29.5	1,017,000
Filandia	42	Fachadas	10	30.5	923,000
	43	La Castalia	7	54.0	844,000
	44	La India	5	42.0	583,000
	45	Bambuco	2	44.0	618,000
	46	Los Tanques	1	10.0	1,600,000
Génova	47	San Juan Alto	2	31.0	300,000
	48	La Coqueta	1	43.0	250,000
	49	El Cedral	1	42.0	476,000
	50	La Primavera	1	14.0	357,000
	51	El Dorado	1	4.5	1,250,000
	52	El Recreo	1	10.5	425,000
	53	El Cairo	1	60.0	500,000
	54	La Granja	1	10.0	470,000
	55	Cedral Alto	1	13.0	470,000
La Tebaida	56	La Popa	3	20.5	1,710,000
	57	Padilla	1	16.5	1,800,000
	58	La Argentina	1	16.5	1,000,000

Montenegro	59	Cantores	4	27.0	1,777,000
	60	Calle Larga	3	23.5	1,912,000
	61	Baraya	2	6.5	2,308,000
	62	El Gigante	2	28.0	995,000
	63	Risaralda	2	35.0	1,852,000
	64	La Paloma	2	10.0	1,700,000
	65	La Cabaña	1	7.0	1,000,000
	66	Santa Rita	1	7.0	1,430,000
	67	La Esmeralda	1	4.5	1,770,000
	68	San José	1	25.0	1,500,000
	69	El Castillo	1	1.5	3,330,000
Pijao	70	Cinabrio	4	133.0	414,000
	71	Patio Bonito	1	38.0	395,000
	72	Las Pizarras	1	16.0	625,000
	73	Río Azul	1	9.5	550,000
	74	La Playa	1	38.0	1,333,000
	75	Carnicero	1	135.0	222,000
Quimbaya	76	Morelia	10	95.0	1,319,000
	77	La Carmelita	4	19.0	1,871,000
	78	El Vigilanto	3	8.5	1,153,000
	79	Naranjal	1	2.5	1,200,000
	80	La Española	1	2.0	1,000,000
	81	La Montaña	1	17.5	1,800,000
Salento	82	San Juan	3	26.0	1,069,000
	83	Palestina	3	14.0	714,000
	84	La Nubia	1	6.5	923,000
	85	El Agrado	1	6.0	800,000

1): Location of each number correspond to number of Fig. F.1.2.
2): No. of interviewee by area

TABLE F.1.1 AREA OF EXISTING LAND USE

(unit:km2)

Landuse / Municipality	Coffee	Upland Crop	Tree Crop	Pastere	Forest	Urban 1)	Idle Land	Total	Ratio (%)
Armenia	72.7	15.9	0.3	11.1	5.5	8.1	0.9	114.5	5.9
Buenavista	26.7	0.6	0	9.0	2.5	0.1	0	38.9	2.0
Calarca	104.7	9.7	0.7	73.3	34.6	2.5	0.7	226.2	11.6
Circasia	46.3	0	0	33.0	8.6	0.7	--	88.6	4.6
Cordoba	33.7	0	0.4	41.5	34.4	0.2	0.1	110.3	5.7
Filandia	37.5	0.2	0	44.4	18.5	0.3	0	100.9	5.2
Genova	57.6	1.2	0	104.2	119.9	0.3	13.7	296.9	15.3
La Tebaida	27.8	18.5	0.8	26.5	6.5	0.9	1.0	82.0	4.2
Montenegro	74.5	19.3	0.4	36.3	17.1	1.2	--	148.8	7.6
Pijao	40.5	1.1	0	97.0	78.0	0.2	2.2	219.0	11.2
Quimbaya	74.6	14.4	1.2	19.8	7.5	1.1	0	118.6	6.1
Salento	13.7	1.6	0	195.8	180.1	0.4	10.4	402.0	20.6
Total	610.3	82.5	3.8	691.9	513.2	16.0	29.0	1946.7	
Ratio(%)	31.4	4.2	0.2	35.5	26.4	0.8	1.5		100.0

1) Include air port

RATIO

(unit:%)

Land use / Municipality	Coffee	Upland Crop	Tree Crop	Pasture	Forest	Urban 1)	Idle Land	Total
Armenia	63.5	13.9	0.2	9.7	4.8	7.1	0.8	100.0
Buenavista	68.5	1.5	0	23.2	6.5	0.3	0	100.0
Calarca	46.3	4.3	0.3	32.4	15.3	1.1	0.3	100.0
Circasia	52.3	0	0	37.2	9.7	0.8	--	100.0
Cordoba	30.5	0	0.4	37.6	31.2	0.2	0.1	100.0
Filandia	37.2	0.2	0	44.0	18.3	0.3	0	100.0
Genova	19.4	0.4	0	35.1	40.4	0.1	4.6	100.0
La Tebaida	33.9	22.6	1.0	32.3	7.9	1.1	1.2	100.0
Montenegro	50.0	13.0	0.3	24.4	11.5	0.8	--	100.0
Pijao	18.5	0.5	0	44.3	35.6	0.1	1.0	100.0
Quimbaya	62.9	12.2	1.0	16.7	6.3	0.9	0	100.0
Salento	3.4	0.4	0	48.7	44.8	0.1	2.6	100.0
Total	31.4	4.2	0.2	35.5	26.4	0.8	1.5	100.0

1) Include air port
Source: Remote Sensing Team

TABLE F.1.2 LAND TENURE

Size (%)	1983 Number of Farmers	(%)	1983 Ha	(%)	1985 Number of Farmers	(%)	1985 Ha	(%)
1>	5,125	22.5	1,282.0	0.6	5,240	21.9	1,347.9	0.7
1-3	4,672	20.5	5,392.2	2.5	5,017	20.9	5,632.7	2.9
3-5	2,926	12.9	6,609.8	3.0	3,170	13.2	7,352.2	3.8
5-10	3,876	17.0	15,613.0	7.2	4,107	17.1	16,598.8	8.6
10-15	1,690	7.4	11,873.6	5.4	1,859	7.8	12,560.2	6.5
15-20	1,093	4.8	10,498.7	4.8	1,080	4.5	10,782.7	5.6
20-50	2,130	9.4	35,714.9	16.4	2,227	9.3	37,084.5	19.2
50-100	733	3.2	27,211.1	12.5	760	3.2	27,363.1	14.2
100-200	306	1.4	26,222.3	12.0	310	1.3	26,939.0	13.9
200-500	142	0.6	20,949.8	9.6	124	0.5	19,252.0	10.0
500-1,000	41	0.2	13,967.2	6.4	39	0.2	14,540.7	7.5
1,000-2,000	19	0.1	10,648.5	4.9	20	0.1	10,120.5	5.2
>2,000	4	--	32,156.6	14.7	1	--	3,617.0	1.9
Total	22,757	100.0	218,139.7	100.0	23,954	100.0	193,191.0	100.0

Source: IGAC

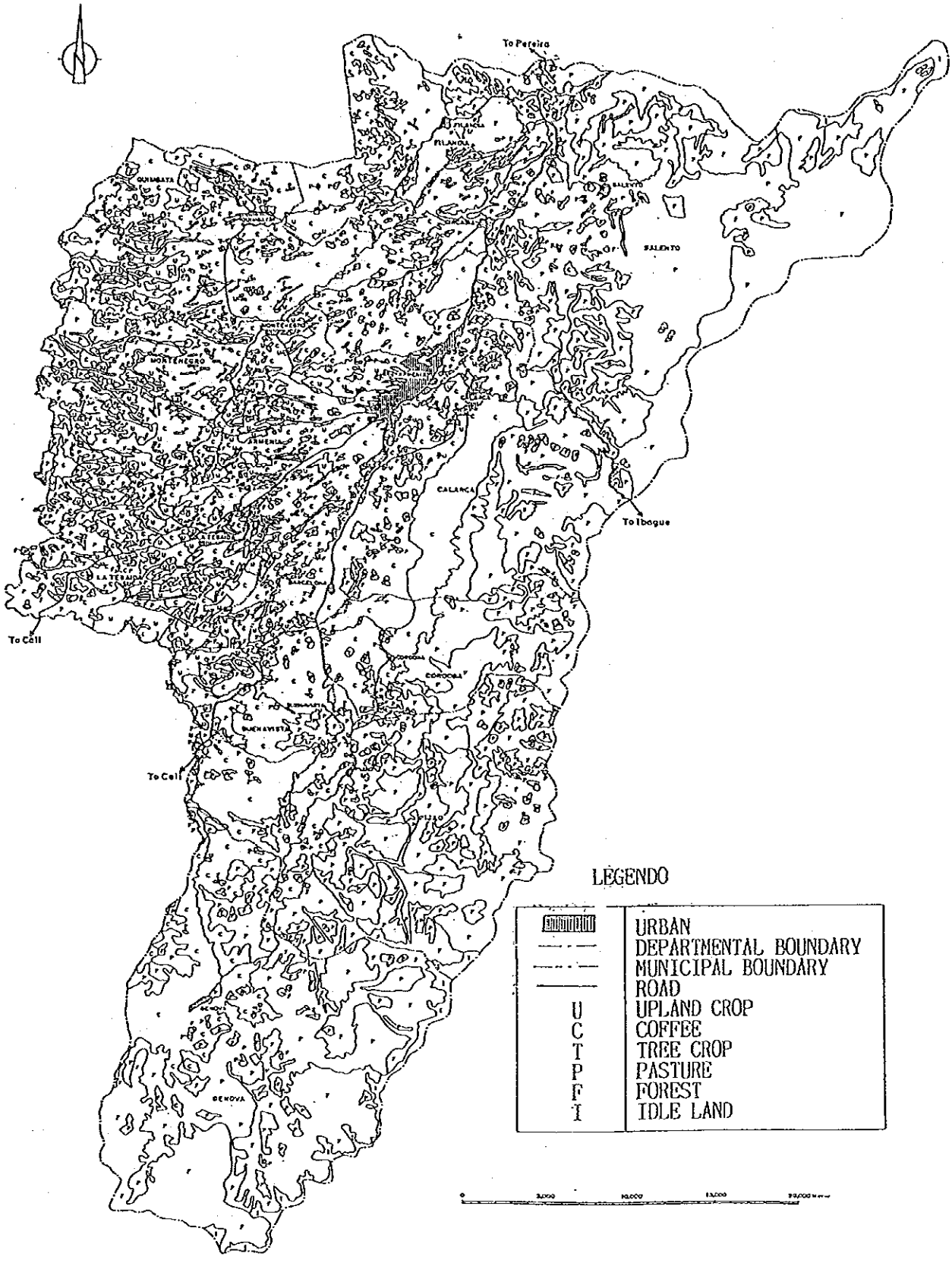

FIG. F.1.1 EXISTING LAND USE MAP

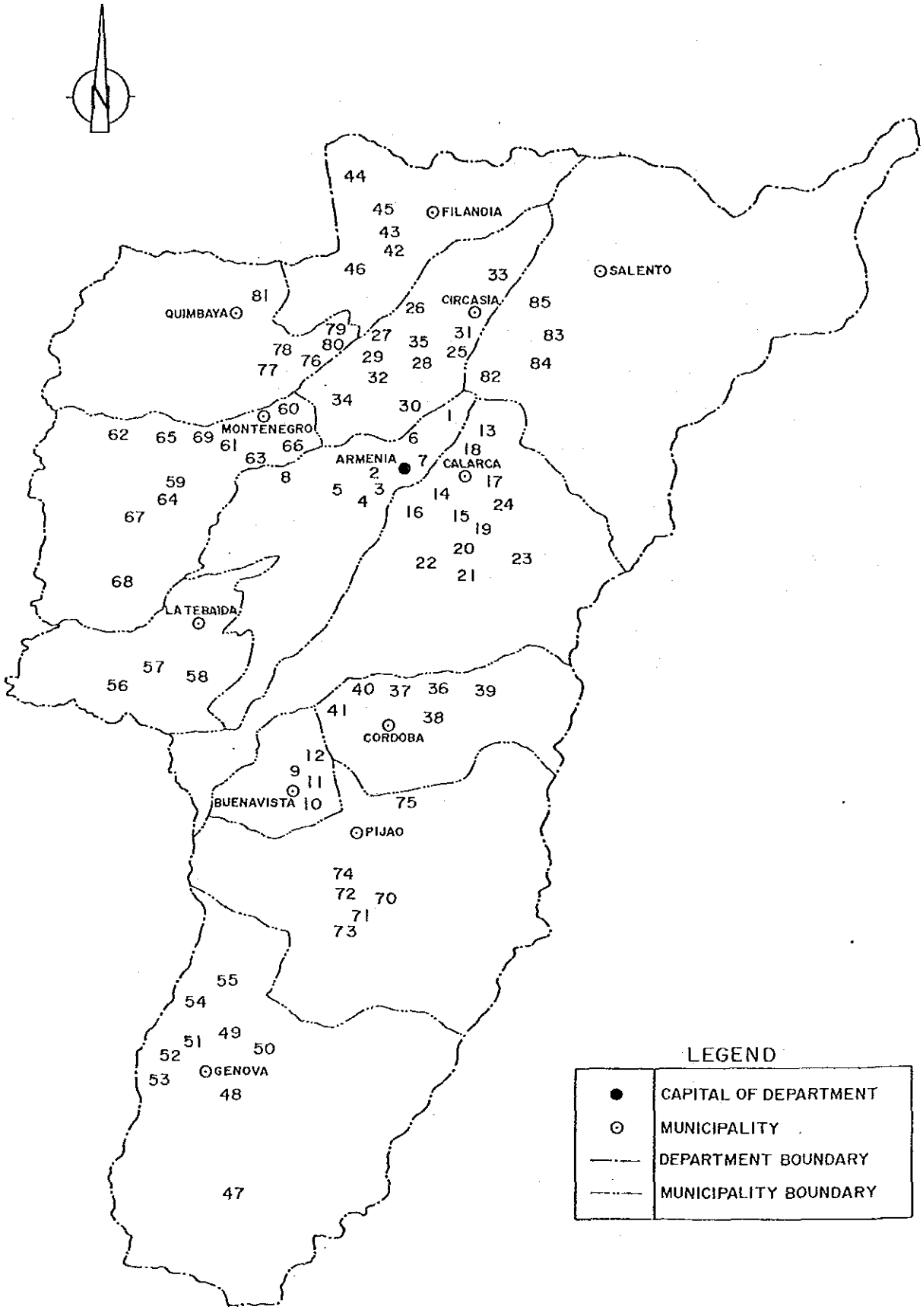

FIG. F.I.2 LAND PRICE

F.2 LAND CAPABILITY

Land Classification Map was prepared by the Remote Sensing Team. However, a land capability map was prepared by the Study Team mainly based on soil characteristics and slope condition to modify more practical for land use planning. Land on the map is classified into 9 categories. Fig.F.2.1 shows the land capability map and Table F.2.1 shows general description of land capability.

An evaluation of land by category explains below:

Category 1 : Area with no limitation or only minor limitations to any agricultural development

Soil in the area are suitable for the widest range of crops. They can be profitably cultivated under a moderate level of management. These soils occur on almost flat (2-4%). They have good water holding and well suited to continuous on sustained yield bases.

Category 2 : Area with minor limitation of slope

Soils in the area have good water holding and nutrient-retaining capacities. They area suitable for the widest range of crops. However, the relief class is undulating (4-6%). Management practices may include moderate erosion control such as counter ploughing for upland crop cultivation.

Category 3 : Area with moderate limitation of slope

Soils in the area have good water holding, nutrient-retaining capacity and effective soil layer. They are suitable for wide range of crops. However, the relief class is undulating to rolling (6-15%). The area is necessary to moderate conservation practices such as level for upland crop cultivation and has no limitation or only minor limitation for perennial crop cultivation.

Category 4 : Area with strong limitation of slope

Soils in the area have good water holding, nutrient-retaining capacity and effective soil layer. These soils are suitable for wide range of crops. However, the relief class is rolling (15-25%). The area is the best for perennial crop cultivation and necessary to intensive conservation practices such as bench terrace for crop cultivation.

Category 5 : Area with very strong limitation of slope

Soils in the area have no or minor limitation except soil layer. The relief class is steep (25-55%) and the effective soil layer is partialy thin. The area is necessary to severe restriction for crop cultivation and severe conservation practices such as cover crop and step terrace for crop cultivation.

Category 6 : Area with limitation of drainage

Soil in the area has limitation of poor drainage. It restricts the choice of crop and require drainage control measure. The relief class is flat (0-4%).

Category 7 : Area with limitation of soil layer

Soils in the area have limitations of thin effective soil layer and partialy acidic. The relief class is undulating to rolling (6-25%). The area is necessary to severe restriction for crop cultivation and severe conservation practices. The area is the best for improved glass.

Category 8 : Area with limitations of very steep slope and soil layer

Soils in the area are slightly acid and soil layer is thin. The relief class is very steep (>55%). The area is the best allowed to continue primary and regenerating forest.

Category 9 : No vegetation area

The area consists of lava and cannot be rectified.

TABLE F.2.1 SUMMERY OF LAND CAPABILITY

Category	Soil Unit	Soil pH	Soil Depth	Drainage	Slope (%)	Countermeasure
1	CH,MB,MN, QD	Moderate	Medium to Thick	Moderate	2-4	--
2	CH,FI,MN, QD	Moderate	Medium to Thick	Moderate	4-6	Counter Ploughing
3	CH,BV,MN, QD,RL,TB	Moderate	Medium to Thick	Moderate	6-15	Levee
4	BV,CH,GE, RL,TB,CII, CIII	Moderate	Medium to Thick	Moderate	15-25	Bench Terrace
5	CE,GE,PB, RL,TB,CII, CIII	Moderate	Medium to Thick	Moderate	25-55	Step Terrace,Cover Crop,Improved Grass
6	RQ	Moderate	Medium to Thick	Poor	0-4	Drainage
7	RV,LC	Moderate	Thin	Moderate	6-25	Improved Grass
8	CII, CIII	Moderate	Thin	Moderate	>55	Conservation
9	CI	--	--	--	--	Unrectifiable

TABLE F.2.2 AREA OF LAND CAPABILITY

(unit: km2)

Category / Municipality	1	2	3	4	5	6	7	8	9	Total
Armenia	84.9	21.7	1.2	--	1.1	--	5.6	--	--	114.5
Buenavista	--	--	15.5	18.9	3.7	0.8	--	--	--	38.9
Calarca	65.9	--	29.8	29.5	66.1	13.8	4.3	16.8	--	226.2
Circasia	2.9	78.9	--	1.2	--	--	5.6	--	--	88.6
Cordoba	1.5	--	20.0	33.7	34.0	--	--	21.1	--	110.3
Filandia	--	75.4	--	--	--	--	25.5	--	--	100.9
Genova	--	--	35.7	27.6	109.0	0.2	0.8	113.0	10.6	296.9
La Tebaida	31.4	--	11.0	--	1.9	15.9	21.8	--	--	82.0
Montenegro	108.2	--	8.1	--	6.4	--	26.1	--	--	148.8
Pijao	--	--	23.2	52.3	136.8	1.4	--	5.3	--	219.0
Quimbaya	86.3	15.8	--	--	4.3	--	12.2	--	--	118.6
Salento	0.6	7.8	32.1	107.3	119.9	--	11.9	114.0	8.4	402.0
Total	381.7	199.6	176.6	270.5	483.2	32.1	113.8	270.2	19.0	1,946.7
Ratio(%)	19.6	10.2	9.1	13.9	24.8	1.7	5.8	13.9	1.0	100.0

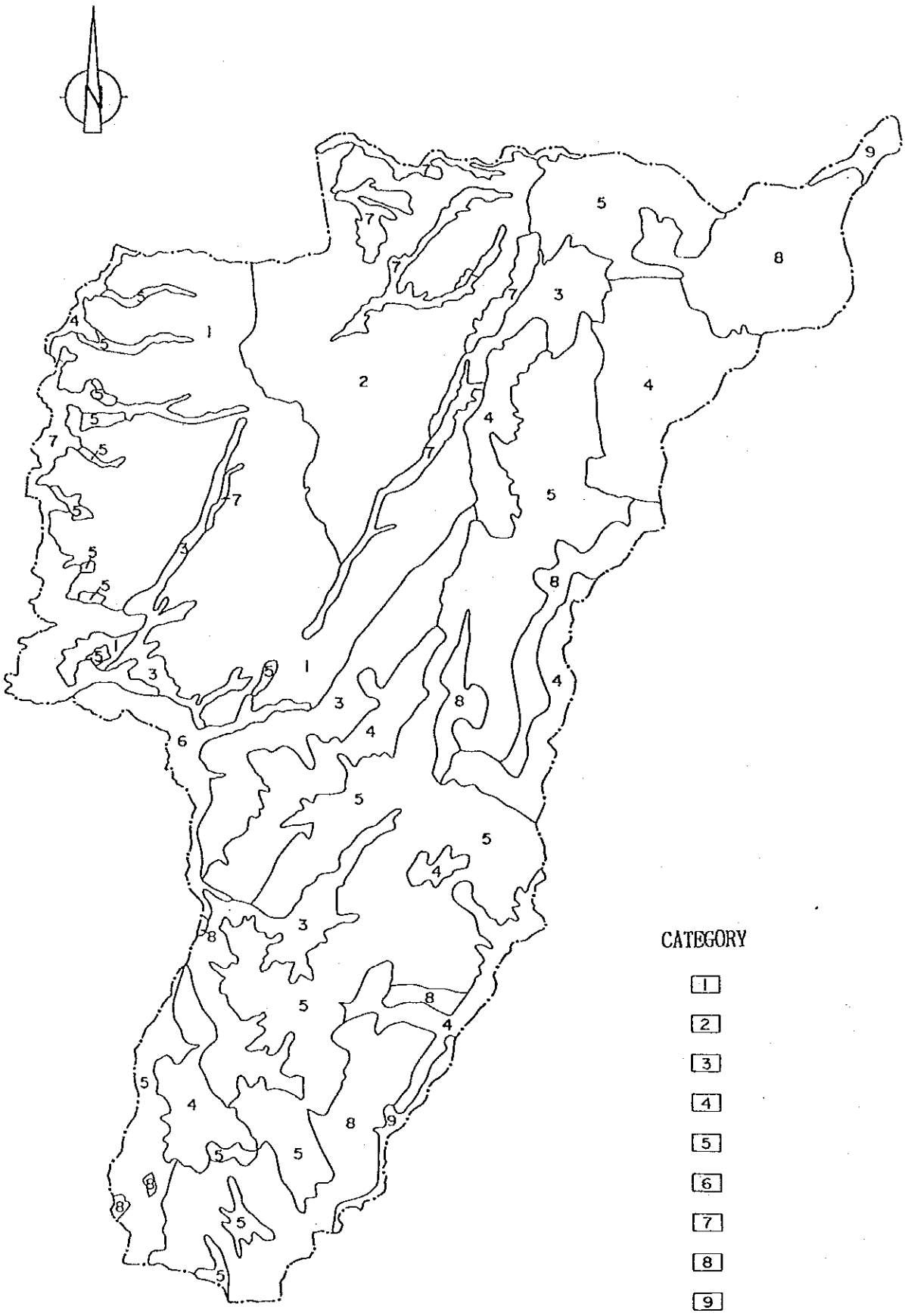

FIG. F.2.1 LAND CAPABILITY MAP

F.3 FUTURE LAND USE

F.3.1 FUTURE LAND USE FORMATION

The basic concept for future land use based on the development concept is as follows:

a) Maintain existing forest area and expand forest area for land conservation, disaster prevention and the keeping of water resources.

b) Land use considering the natural and socio-economic condition by region.

Considering the existing situation and the future land use formation based on above concepts, the area could be characterized into 7 zones, as shown in Fig.F.3.1. Summary of the future land use formation by zone is shown in Table F.3.1 and explained as follows:

Zone 1 : Grazing Area

Existing land use of the area is mainly pasture. As the land is characterized by very thin soil layer, it is impossible to use crop cultivation. Therefore, the future land use formation of the area will be for grazing and aims at increasing productivity with extension of appropriate technology.

Zone 2 : Intensive Agricultural Area

Existing land use of the area is upland crop, coffee and pasture. However, the coffee yield is much lower than that of zone 3. The area is endowed with the fertile soil and good topographic condition but comparatively low precipitation. Therefore, the area will be suitable for upland crop cultivation and increase productivity with intensive and stable farming system, by means of the expanding of high technology and improving agricultural infrastructure such as irrigation, farm road and etc.. The production will be expected to supply the agro-based industry. Low yield coffee will be improved. Citrus will be introduced to the slope area and supplied to industry which is under construction in the area.

Zone 3 : Coffee Cultivation Area

Coffee is by far the most wide spread crop, with plantain and cassava also popular as mainly a shadow crop of coffee in the area. The area is characterized as the highest productivity zone in the province. However, the area will confront problems of water pollution caused by coffee waste and runoff of top soil caused by bad management. Therefore, the area will aim at keeping high productivity by means of improving living conditions and expanding soil management technology.

Zone 4 : Integrated Farming Area (Vegetable)

Existing land use is pasture with low productivity and forest. The area is characterized by small farmers, however, coffee cultivation is not evident. As the area is endowed with good natural conditions for crop cultivation, the development potential is high. Therefore, the area will develop as an integrated farming mainly vegetables to improve productivity. It also aim at encouraging small farmer. To achieve the aim, improvement of infrastructure, extension system and farmer's organization will be necessary.

Zone 5 : Integrated Farming Area (Perennial Crop)

Existing land use is mainly pasture and plotted with forest. The area is confronted with the problem of outflow of population caused by low productivity and also land desolation caused by inappropriate land use and land management in the steep slope area. As the area is suitable for perennial crop, there will be aims at increasing productivity by integrated farming mainly cultivating perennial crop and improving agricultural infrastructure.

Zone 6 : Pasture and Conservation Area

Existing land use is forest and pasture. The area is characterized by low productivity and land desolation because of the complicated topographic condition. The area is dotted with riverheads. Therefore, expanding forest area will be necessary for keeping natural conditions and riverheads. The area where left in pasture will be considered for management technology and for the introduction of improved grass to keep natural conditions.

Zone 7 : Conservation Area

Existing land use is forest, no vegetation area or pasture. The area consists of very steep slope area and lava area. Therefore, the area is not suitable any agricultural development. The area will be conserved for disaster prevention.

TABLE F.3.1 SUMMARY OF FUTURE LAND USE FORMATION

Zone No.	Future Formation	Existing Landuse	Altitude (m)	Character	Improvement
1	Grazing	Pasture	950-1,100	Thin Soil Layer Low Productivity	Extension, Farm road
2	Intensive Agriculture	Upland Crop, Coffee Pasture	950-1,200	Fertile Soil,Good Topographic Condition,Little Precipitation	Irrigation,Farm Road,Extension,
3	Coffee Cultivation	Coffee Plantain Cassava	1,200-1,800	Water Pollution, Runoff Soil,High Productivity	Water Treatment, Soil Management, Diversification
4	Integrated Farming (Vegetable)	Pasture Forest	1,650-2,000	Fertile Soil,Flat, Much Precipitation, Many Small Farmer, Low Productivity	Farm Road,Organization of Small Farmer,Extension
5	Integrated Farming (Tree Crop)	Pasture Forest	1,800-2,500	Steep Slope,Land Desolation,Outflow of Population,Low Productivity,	Farm Road,Extendsion,Reforestation,Conservation
6	Pasture and Conservation	Pasture Forest	2,000-3,000	Steep Slope,Land Desolation,Many Riverhead,	Reforestation, Extension,Conservation
7	Conservation	Forest Idle Land	3,000<	No Suitable for Cultivation	Reforestation, Conservation

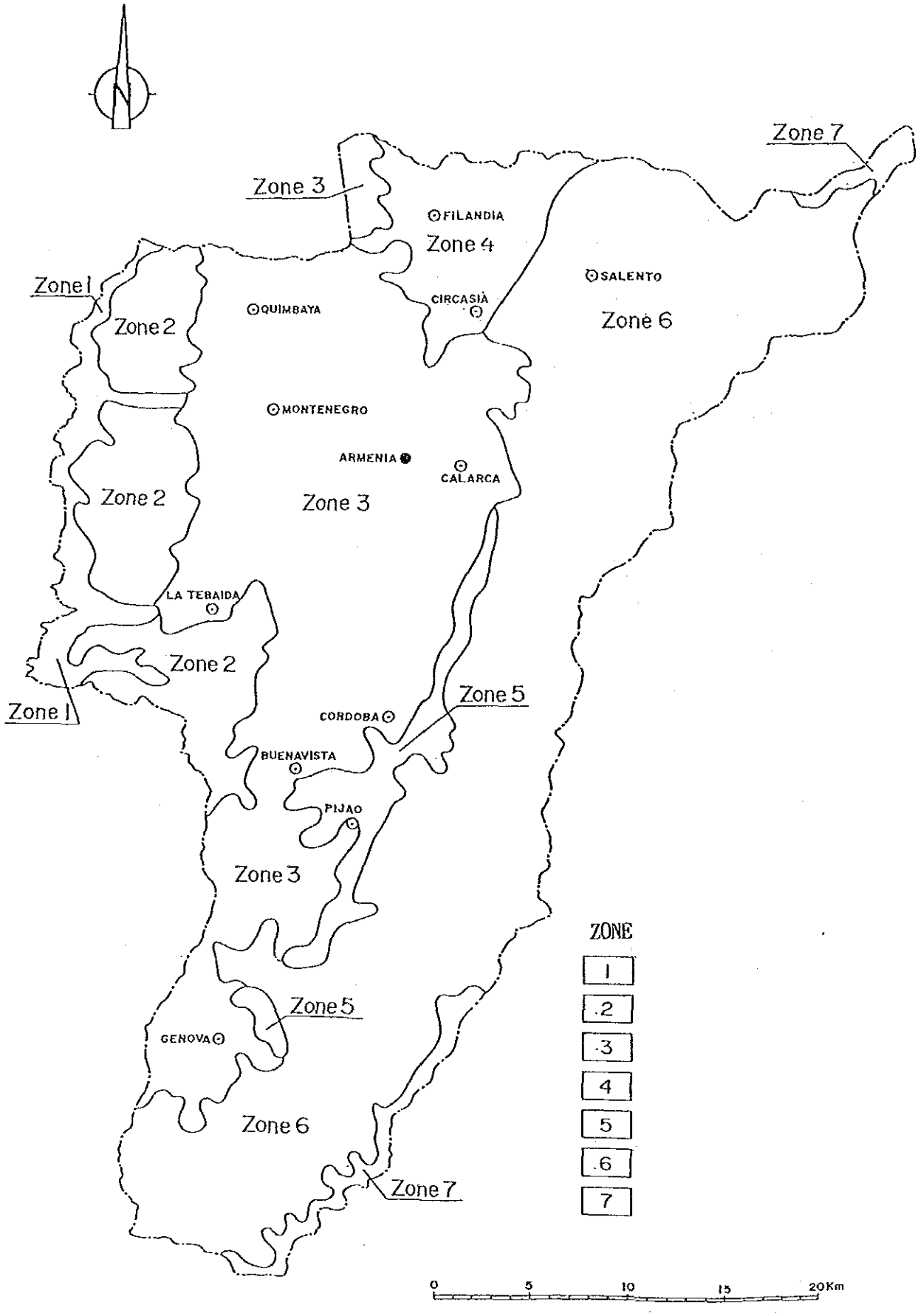

FIG. F.3.1 FUTURE LAND USE FORMATION

F.3.2 FUTURE LAND USE PLAN

Future land use map is prepared based on the future land use formation by zone, see Fig F.3.2.

(1) Future Land Use Plan by Category

1) Coffee

Coffee cultivated area maintains it's area in principle. However, the low productive area would be expected to be converted into intensive agriculture on the map, if it is to be remunerative for the farmer. The coffee cultivated area will decrease on the map, which is drawn up only for suitable areas. However, its productivity will be increased by intensive cultivation and diversification.

2) Upland Crop

Upland crop cultivated area will expand mainly into pasture, where is suitable for upland crop cultivation and low productivity. Increasing productivity will be achieved by means of suitable and socio-economic conditions.

3) Pasture

Pasture area will be decreased to encourage productivity and conservation of the whole province. However, livestock producion will be encouraged by means of improvement of grass and rearing technology.

4) Tree crop

Tree crop cultivation area will be expanded in suitable and slope areas, mainly a conversion from existing pasture. Suitable tree crop will be cultivated by area.

5) Forest and Conservation

Existing forest area will be kept in principal and also the area will be expanded for conservation, disaster prevention and the keeping of riverheads. Logging will be considered in the area.

(2) Future Land use Plan by Zone

1) Zone 1 Grazing Area (altitude: 950 - 1,100 m)

Zone 1 is utilized as the grazing land area at present. This zone is not suitable for utilization as cultivated land because of thin soil layers and accordingly should be continuously used as grazing land subject to improvement of productivity through introduction of intensive animal raising techniques.

The present grass land has seen long years since it was once improved and significant deterioration is found. In addition, many slopes cause damage due to land erosion. Besides soil conservation measures proposal to be taken for Zone 1 is to introduce pasture grasses such as mata-raton and leucanal, and renew grass by means of land reclamation without cultivation. At present, cattle farming depends on continuous pasturage, which should be converted into rotary pasturage for improvement of productivity. In the future, the cattle farmers' cooperative will be established by use of the feed lot system. As a result, productivity is expected to be improved to a great extent.

2) Zone 2 Intensive Agriculture Area (altitude: 950 - 1,200 m)

Zone 2 is mainly utilized as upland crop, coffee farms and grass land, however, coffee yield in this zone is inferior to other suitable coffee production areas. Zone 2 has fertile soil containing much clay distributed over a wide range, and has relatively flat topography. Meteologically, this zone features high temperature and relatively less precipitation. Coffee harvested is subject to damage by rust and insects such as "Mancha de Hierro" because of high temperature and high humidity. Generally, the coffee does not grow up well, so productivity is low. For example, the yield is 1.2-1.4 ton per ha among improved varieties, and 0.8-1.0 ton per ha among traditional varieties. In addition, bad berries such as "Passilla" grow at a high rate.

Annual crops such as sorghum and soybeans are not cultivated under sufficient cropping control partly because of expensive agricultural chemicals and fertilizers. The grass land has less productivity like Zone 1. In consideration of the above, Zone 2 is recommended to be occupied mainly by upland crop for the future and improvement of productivity shall be attained by means of intensive agriculture into which irrigation and drainage, improved infrastructure, and high culture techniques are to be introduced. Proposed measures are as explained below.

a. Coffee

Improvement of productivity and quality of coffee involves sufficient fertilizing control, planting enough trees to shield sunlight, intercropping with citrus, and multi-purpose irrigation, all of which prove effective. In particular, an alternative should be studied on substitute crops for the coffee culture area suffering low productivity.

b. Upland Crops

Productivity would be sufficiently improved providing that crops (feed crops, oil crops, and fruits) suitable for natural conditions in Zone 2 are introduced and the following crops allow supplying by-products for producing assorted feed and agricultural product processing as required by the Department.

- Introduction of new varieties

- Pest control, and appropriate fertilizing

- Soil management

- Mechanization by use of middle-scale agricultural machinery matching the topography

- Irrigation and drainage

3) Zone 3 Coffee Cultivation Area (altitude: 1,200 - 1,800 m)

At present Zone 3 produces plantain and cassava in addition to the main product, coffee. Land in this zone offers the highest productivity of the Department. Problems that the Zone 3 confronts are water pollution caused by coffee wastes, and land slide at slopes; diversification of coffee plantations is also expected anxiously. Therefore, the present zone should be oriented to preservation of natural environments and productivity stabilized at soil management, and diversification of crops through intercrop and mixed cropping with coffee.

There is a great difference in productivity of coffee between the improved and traditional varieties. The higher the altitude of the coffee plantation, the less introduced are the improved varieties; for example, about 80 % of coffee plantations at an altitude of 1,600 - 1,800 m employ the traditional varieties. The reason why introduction of the improved varieties is delayed is lack of farmer's income in addition to improvement of credit conditions. The practical proposals to intensify coffee plantations at highland are as presented below.

- To promote the introduction of improved varieties by enhancing credit conditions.

- To increase income from crops other than coffee by planting such intercrops with coffee as "luro", tree tomato, etc. so that farm management might be improved.

- To throughly perform fertilizing and pest control.

- To perform soil conservation measures through reclamation of terraces, trash mulching, etc.

Measures to intensify production per unit of land shown below are generally applicable to the whole coffee culture areas.

- To plant trees (Guamo, etc.), as measures to protect coffee plantations (those with intercrops with plantain in particular) attacked by strong wind.

- To realize stumping of coffee trees for improved varieties, which face in 8 - 9 years. In order to compensate the resulting reduction in earnings, vegetables and beans shall be intermediately planted in the lower land, and beans in the highland.

- To introduce multiple-purpose irrigation.

4) Zone 4 Integrated Farming (Vegetables - Livestock) Area (altitude: 1,650 - 2,000 m)

Zone 4 is now utilized as the grazing and forestall land, but productivity is low. Many small farmers other than coffee growers are concentrated in this zone. However, Zone 4 has high potential for the vegetable production base, favored with natural conditions such as meteorology, soil, and topography and the most suitable for vegetable production of the Department. Therefore, the mixed management system consists of vegetables and livestock production shall be introduced and farmers' organization shall be encouraged to bring up the poorest farmers; the improvement of infrastructure as well as productivity in the area shall be also facilitated. Relatively high precipitation and volcanic ash soils may cause surface land sliding if grass land is converted into upland crop area.

In view of soil conservation, cropping pattern should be determined for each slope as shown in Table F.2.1.

Production of quality vegetables is expected by: introduction of varieties to cope with natural conditions in this area; mechanization; the cropping pattern free from injury by continuous cropping; and proper measures to prevent damage from blight and insects. On the other hand, the additional income for small farmers would be assured by introduction of swine production on a contract basis. In this contract farmers system, the management body (cooperative) owns and operates a commercial-base breeding center, sells contracted small farmers the cub hogs of its own breeding, and provides technical assistance to farmers for breeding. Farmers breed the cub hog depending mainly on feed from agricultural by-products. The management body collects pork hog bred by small farmers and markets it, while the management body pays minor farmers a commission for breeding. Pork runs short not only in the department but in surrounding departments, therefore planned and organized pork hog production is very prospective.

5) Zone 5 Integrated Farming (Tree Crop - Livestock) Area (altitude: 1,800 - 2,500 m)

Zone 5 is now utilized mainly as grazing land, in which forests are scattered. Generally, productivity in this zone is low. Steep slopes as well as inappropriate landuse and soil management cause disaster and rural-urban migration, both of which are serious problems. Zone 5 shall be developed by encouraging farmers' organization, introducing the mixed farming oriented to animal raising

and tree crops suitable for topography, and by improving productivity through adequate provision of infrastructure. In view of cool climate and soil conservation, fruits (apple, "luro", and tree tomato) in large local demand will be mainly introduced for the perishables market and food processing. High quality products are expected by labor-saving as a result of proper farming, pest control, and introduction of small-scale agricultural machines. For animal raising, the pork hog production on a contract basis is envisaged as is the case with Zone 4.

6) Zone 6 Pasture and Conservation Area(altitude: 2,000 - 3,000 m)

Zone 6 is used for grass land and forest land, and productivity is inferior. Steeper slope often cause damage such as erosion and land sliding. Meteorological and topographical conditions makes it impossible to utilize as cultivated fields.

It is recommended that the forest area should be conserved and grass land improved in order to cultivate water resources and maintain ecological balance through alleviation of flood, erosion, and other disasters. It is also an important issue to improve productivity of animal husbandry in this zone, although the grass land area will be decreased. For this purpose, continuous raising shall be positively converted into rotary raising, while bred cattle will be sequentially upgraded. More particularly, seed bulls such as Holstein will be introduced to artificially inseminate hybrid cows from the traditional breed and the Cebu breed. Productivity will be further improved by partially promoting the pen breeding system (for pregnant cows, production cows, and the young). In view of cool climate in Zone 6, grass land will be positively improved by introduction of leguminous pasture (such as rusan, arrowroots, and centro). The present carrying capacity, as low as 0.35 - 0.49 head/ha, may be increased by at least 50 - 100% through improvement of grass land and upgrading of breeding cattle. Implementation of the above measures would make it possible to maintain and increase the present cattle farming while still increasing the forest area preserved in Zone 6.

7) Zone 7 Conservation Area (altitude: 3,000 m or higher)

Zone 7 consists of forest land, grass land, and arid mountain, and exhibits steepest slopes of the Department. It is almost infeasible to conduct farming and livestock activities in this zone. Development of this zone may subject to occurrence of disaster and as a result whole Zone 7 is advisable to be conserved.

Future landuse map, with target year set at 2,005, is shown in Fig. F.3.3. The map was drown to display the most effective and realizable features, which can feasibly be obtained by the target year to achieve the year, ie features that will enable the achievement of landuse formation.

TABLE F.3.2 FUTURE LAND USE

(Unit: km2)

Landuse / Municipality	Coffee	Upland Crop	Tree Crop	Pasture	Forest	Urban 1)	Idle Land	Total
Armenia	93.4	0	0	0	5.5	14.7	0.9	114.5
Buenabista	32.6	0	3.7	0	2.5	0.1	0	38.9
Calarca	104.2	15.0	9.7	23.8	68.8	4.3	0.4	226.2
Circasia	46.3	31.2	0	1.3	8.6	1.2	0	88.6
Cordoba	34.0	0	10.4	10.9	54.6	0.3	0.1	110.3
Filandia	37.7	26.4	0	18.0	18.5	0.3	0	100.9
Genova	57.5	0	6.2	40.0	179.0	0.5	13.7	296.9
La Tebaida	8.2	37.9	10.4	18.3	5.7	1.5	0	82.0
Montenegro	50.4	55.5	6.2	17.5	17.1	2.1	0	148.8
Pijao	42.0	0	25.3	53.6	95.6	0.3	2.2	219.0
Quimbaya	56.6	36.0	4.3	12.2	7.5	2.0	0	118.6
Salento	15.3	0	0	104.4	271.3	0.6	10.4	402.0
Total	578.2	202.0	76.2	300.0	734.7	27.9	27.7	1946.7
(%)	29.7	10.4	3.9	15.4	37.8	1.4	1.4	100.0

1) Include airport

TABLE F.3.3 LAND USE IN 2005

(unit:km2)

Landuse / Municipality	Coffee	Upland Crop	Tree Crop	Pastere	Forest	Urban 1)	Idle Land	Total
Armenia	69.5	15.9	0.3	11.1	5.5	11.3	0.9	114.5
Buenavista	26.7	0.6	0	9.0	2.5	0.1	0	38.9
Calarca	101.0	17.0	3.7	35.8	65.0	3.3	0.4	226.2
Circasia	46.3	6.4	7.6	18.8	8.6	0.9	--	88.6
Cordoba	33.7	0	0.4	41.5	34.4	0.2	0.1	110.3
Filandia	37.5	0.2	0	44.4	18.5	0.3	0	100.9
Genova	57.5	1.7	1.5	80.0	142.1	0.4	13.7	296.9
La Tebaida	25.7	21.7	3.3	23.6	6.5	1.2	0	82.0
Montenegro	69.1	19.9	7.4	33.7	17.1	1.6	--	148.8
Pijao	40.5	1.6	1.5	79.9	93.1	0.2	2.2	219.0
Quimbaya	74.2	14.4	1.2	19.8	7.5	1.5	0	118.6
Salento	13.7	1.6	0	195.8	180.1	0.4	10.4	402.0
Total	595.4	101.0	26.9	593.4	580.9	21.4	27.7	1946.7
(%)	30.6	5.2	1.4	30.5	29.8	1.1	1.4	100.0

1) Include airport

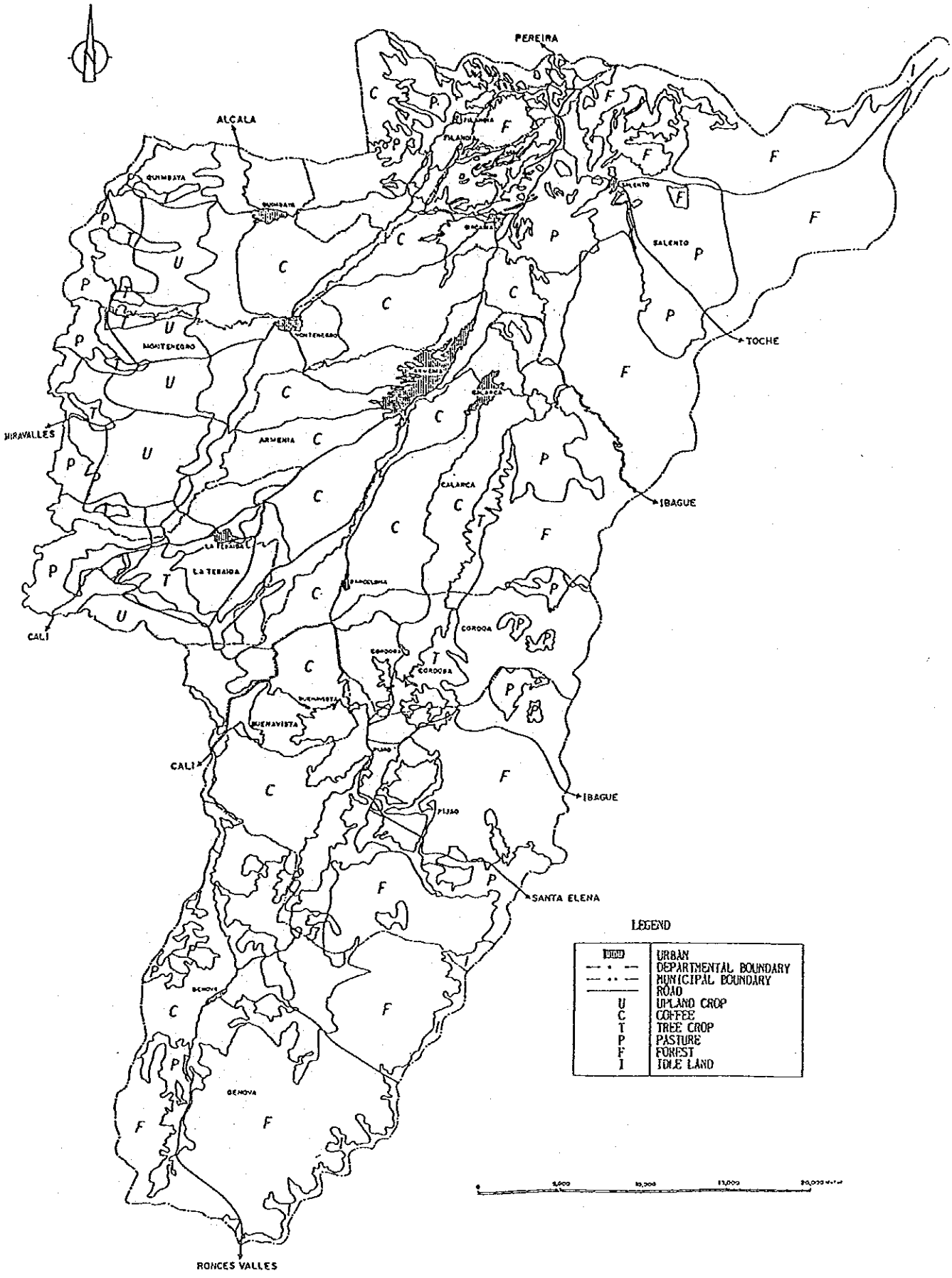

FIG. F.3.2 FUTURE LAND USE MAP

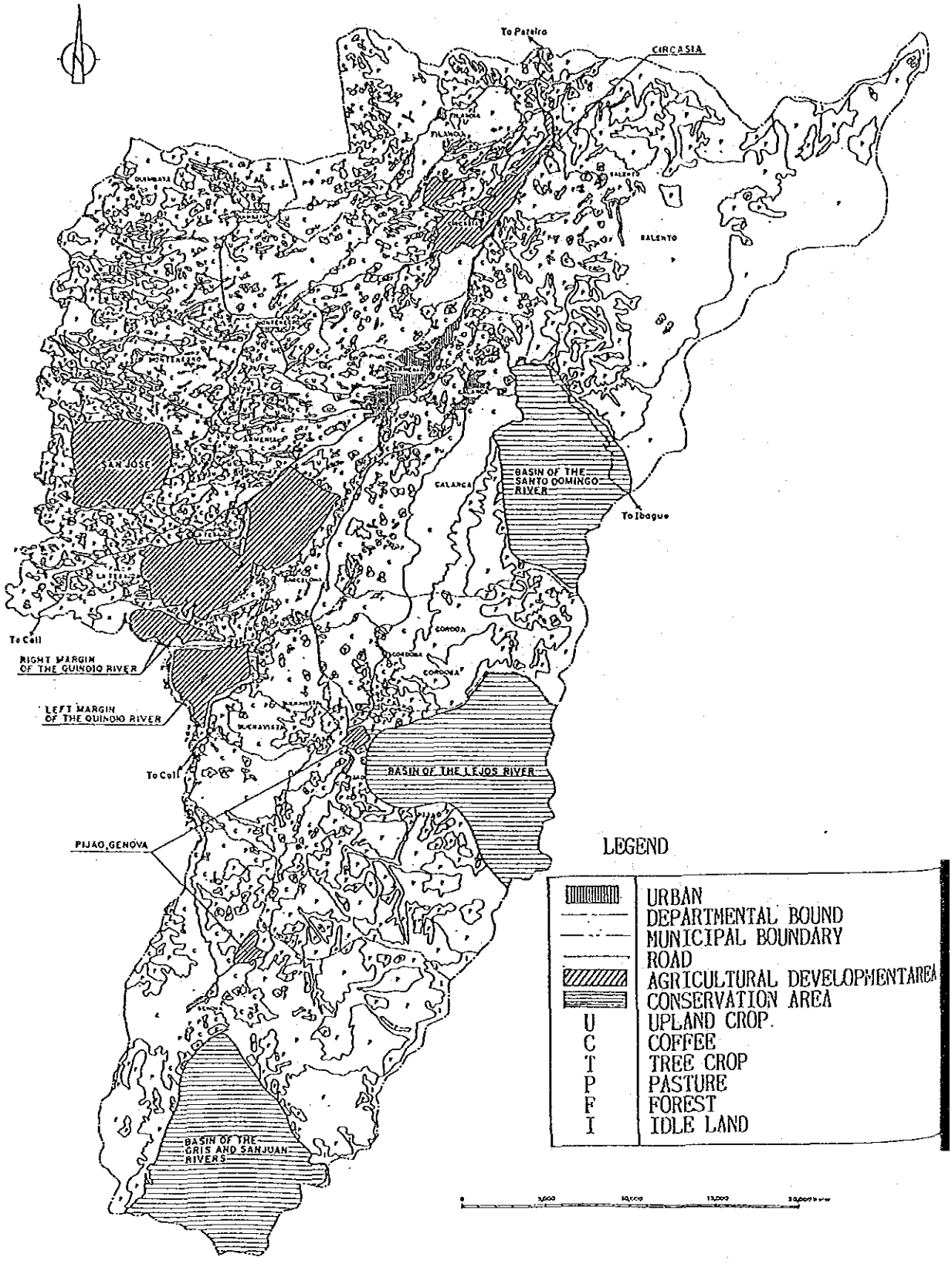

FIG. F.3.3 LAND USE MAP IN 2005

ANNEX G : WATER QUALITY AND WATER QUALITY IMPROVEMENT

ANNEX G : WATER QUALITY AND WATER QUALITY IMPROVEMENT

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ANNEX G : WATER QUALITY/IMPROVEMENT

G.1 WATER QUALITY

G.1.1 Existing Situation

The study area is located in the Quindio Basin. In this basin, about eight-thousand coffee plantations are extended.

The waters of the Quindio River and its tributaries are used for domestic and agricultural use not only in these basins but also their lower reachies (La Vieja River basin). While the waste waters such as coffee treatment water and domestic sewage from the urban areas of Armenia, Calarca, etc. flow into these rivers without any treatment, and the water qualities in these rivers are getting worse year by year.

Accordingly, the Quindio Basin has many unsolved problems in connection with water quality. Hence the purpose of the study in this field is to clarify the present water quality conditions in the basin and to establish the countermeasures for providing domestic and agricultural good quality water.

G.1.2 Approach

To grasp the present conditions on water quality in the Quindio Basin, the following studies were examined:

a. Collection of available information and data
b. Field survey and water sampling
c. Laboratory analyses of the samples

Data and information were mainly collected from C.R.Q, C.V.C, etc,.

The field survey and water sampling were carried out at the observation points selected in rivers and main streams.

On the occasion of the selection, the followings are considered (refer to Fig. G-1,2):

a. To cover whole area of the Quindio Basin
b. To compare between contaminated water and upstream water
c. To examine water quality before and after the confluence of the rivers and the main streams;
d. To analyze continuously and systematically for variations of water qualities

The laboratory analysis were carried out at C.R.Q and C.V.C for eight months, from February to September.

The outline of the laboratory analyses is as follows:

Site	: 32 points	
Time of sampling	: February	(JICA)
	March	(JICA)
	April	(JICA)
	May	(C.R.Q)
	June	(C.R.Q)
	July	(JICA)
	August	(JICA)
	September	(JICA)
Items for analysis	: pH EC S-T S-S DO BOD	
	COD N-NH3 N-NO2 T-K	
	P-PO4 ABS	
	Alkalinity Hardness	
	Coliform Groups	
	Ca^{++} Mg^{++} Na^{+} K^{+}	
	Cl^{-} SO_4^{--} CO_3^{--} HCO_3^{-}	
	Cu Fe Hg Cr Zn	
Laboratory	: CVC (for Na,K and metals)	
	CRQ (for other items)	

At the point No.11 in the Quindio River and No.18 in the Espejo River, the water samples were collected every two hours for 24 hours.

G.1.3 Present Conditions of Water Quality

(1) The Standards of Water Quality

The standards of water quality for domestic use, irrigation water , etc,. have been established by the Ministry of Health, Colombia (Decreto No. 1594, del 26 de Junio de 1984).

These standards are only stipulated pH, ions, heavy metals, A.B.S and coliform groups, however, those of BOD, COD, SS and EC are not yet set up.

The standards on control for waste water form factories, butcheries, tanneries, etc,. are not exact and this waste water flows into rivers and streams without any treatment.
(But,recently,the standard limit of waste water from tannery was set up and was stopped to drain waste water without any treatment. It is necessary for a tannery to install a treatment plant.)

Accordingly, the studies for the water qualities executed in accordance with the standard of the Ministry of Health.

But, the standard limits were granted that of BOD is less than 5 ppm, and of SS is less than 20 ppm.

The representative water quality standards are summarized as follows :

STANDARDS OF WATER QUALITY (DECREE No.1594, CLOMBIA)

ITEM	ART 38 1/ for human & domestic	ART 39 for potable water	ART 40 for agri-cultural	ART 41 for pecuary	ART 42 for recrea-tion 1	ART 43 for recrea-tion 2	ART 46 for industrial
N	1.0	1.0	-	-	-	-	-
AS	0.05	0.05	0.1	0.2	-	-	-
Ba	1.0	1.0	-	-	-	-	-
Cd	0.01	0.01	0.01	0.05	-	-	-
CN	0.2	0.2	-	-	-	-	-
Zn	15.0	15.0	2.0	25.0	-	-	-
Cl	250.0	250.0	-	-	-	-	-
Cu	1.0	1.0	0.2	0.5	-	-	-
Fe	0.002	0.002	5.0	-	0.002	-	-
Cr	0.05	0.05	0.1	0.1	-	-	-
PCB	No Detectable		-	-	-	-	-
Hg	0.002	0.002	-	0.01	-	-	-
N-NO3	10.0	10.0	-	100.0	-	-	-
N-NO2	1.0	1.0	-	10.0	-	-	-
pH	5.0-9.0	6.5-8.5	4.5-9.0	-	5.0-9.0	5.0-9.0	5.0-9.0
Ag	0.05	0.05	-	-	-	-	-
Pb	0.05	0.05	5.0	0.1	-	-	-
Se	0.01	0.01	0.02	-	-	-	-
SO4=	400.0	400.0	-	-	-	-	-
ABS	0.5	0.5	-	-	0.5	0.5	0.5
Coll.T	20,000	1,000	5,000	-	1,000	5,000	5.000
Coll.F	2,000	-	1,000	-	200	-	-
Al	-	-	5.0	5.0	-	-	-
Be	-	-	0.1	-	-	-	-
Co	-	-	0.05	-	-	-	-
F	-	-	1.0	-	-	-	-
Li	-	-	2.5	-	-	-	-
Mn	-	-	0.2	-	-	-	-
Mo	-	-	0.01	-	-	-	-
Ni	-	-	0.2	-	-	-	-
V	-	-	0.1	-	-	-	-
B	-	-	3.0-4.0	5.0	-	-	-
Salt Cont.	-	-	-	3,000	-	-	-
DO(%)	-	-	-	70.0	-	70.0	70.0

Note:1/ The figures in the 2nd column (ART-38) shows the values of raw water quality to be treatmented.

(2) Water Qualities In Rivers And Streams

During the period of field studies, the samples for water quality analysis were taken at 33 points in the Quindio Basin.

The results of the laboratory analysis are as follows:

a) Ions: The Key-Diagram, in which the water qualities are indicated by cations (Ca^{++}, Mg^{++}, Na^{+}, K^{+}) and anions (Cl^{-}, SO_4^{--}, CO_3^{--}, HCO_3^{-}), shows that the waters in the Quindio River Basin are all of carbonic-calcium ($Ca(HCO_3^{-})_2$) type.

In general, the origin of such type of water is surface and ground waters which are not contaminated waste water from mine areas.

Therefore, this type of water can be used for irrigation, domestic and industrial uses without any treatment (Refer to FIG.G-3).

b) Diagram on classified irrigation water:
Irrigation water was classified based on the electric conductivity (EC) which is indicated in micromhos per centimeter and the sodium absorption ratio ($SAR = Na \sqrt{(Ca + Mg)/2}$).

According to the diagram, all water samples taken from the Quindio river basin are of S.1 Group (= Low sodium water), and their electric conductivity are of C.1 Group (= Low salinity water). And in general, these type waters have good condition for irrigation, and no problem for any kind of crops. (Refer to FIG. G-4)

c) Heavy metals: Among the water samples mercury (Hg), chromium (Cr), copper (Cu) and zinc (Zn) were analyzed, but any and all values of these heavy metals were less than the standard limits. And the values of Hg and Cr
were less than critical analysis.

d) pH: The normal range for several uses is pH 4.5 - 9.0.

The values of pH range from 7.0 to 9.0, and no problem for use.

e) A.B.S: Standard limit for A.B.S (Alkyl Benzene Sulphonate) is set up less than 0.5 ppm. All values of the observation points except the Espejo river (ES2, ES3) were less than the limit.

f) Coliform Groups: The standard limit is set up at the value less than 1,000 - 20,000 MPN/100ml. The waters at only two

points (SD1 and QU1) were under the limit.

g)BOD: Standard limit of BOD is not yet set up, but generally the limit should be given at the value less than 5 ppm. Therefore, the guide line for this study is given at the value less than 10 ppm for BOD. From this point of view, the waters at Espejo river exceeded that of guide line.

Relation between Decree No. 1594 and present status of water quality is shown in TABLE G-1.

The results of water analysis at each observation point are shown in TABLE G-2. And existing situation by month at each point are shown in Fig. G-5, and indications of each item are shown in Fig. G-6.

(3) Classification of the Present Water Quality

1) Principal Component Analysis

The classification of present water quality is made by a method of principal component analysis. The result is shown in TABLE G-3.

The scatter map of result is shown in FIG. G-7.

(a) The first group : The water quality of this group has the best condition. This group consists of upper streams of the Roble, Lejos, Sto.Domingo, Barragan and Vieja rivers.

(b) The second group :This group has good conditions. The Roble river, upper-part of the Quindio river and the Verde river come under this group.

(c) The third group :Consists of slightly bad conditions. Five rivers fall under this group - the Cristales, the Buenavista, and mid-streams of the Lejos, the Quindio and the Sto.Domingo rivers.

(d) The fourth group :Bad. The mid and down-parts of the Espejo river come under this group.

(e) The fifth group :Worst. This group consists of the mid-streams of the Espejo river.

According to the result of classification, the water qualities at the sites classified as the first,fourth and fifth groups are suitable in any season, but of the sites come down at the second and third groups get worse in the coffee harvest season, for instance the Roble, the Cristales, and the Buenavista rivers.

The classification map is shown in FIG. G-8.

2) IFSN Method

The IFSN method was improved in the U.S.A in 1973. This method is widely used in Colombia.

In this method, overall results of water analysis such as the values of pH, S-T, DO, BOD, N-NO3, P-PO4, Turbidity, Coliform Groups and margin of temperature in water and air are assessed.

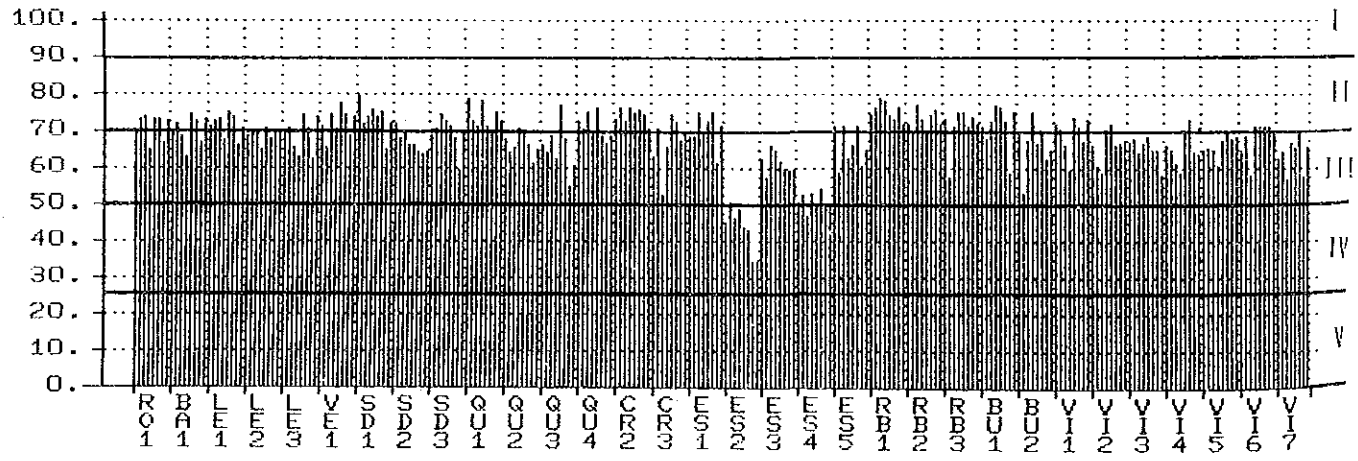
Each item is awarded a weight correspond to the observed value, while the weight is granted in consideration of its reliability or importance.

The weights are shown in FIG. G-9.

The degree of water pollution is shown by totalized score of each item, and is divided into five ranks.

According to this method, the water quality of this area is divided into three ranks.

The results are as follows:



Note:

Class	Degree	Remark
I	100 - 91	Excellent
II	90 - 71	Good
III	70 - 51	Ordinary
IV	50 - 26	Bad
V	25 - 0	Very Bad

(4) The Coffee Wastes

1) General

Coffee wastes at the stage of processing are divided into three major wastes such as pulp, pulping waste and fermentation wash water.

The pulp is the most troublesome waste in potentiality, but it is generally recovered and used for fodder or fertilizer. Therefore, the pulp is not a direct cause of water pollution. But, when it rains, the pulp scattered on the field as a fertilizer is washed away and it becomes highly pollutant.

The fermentation wastes flow directly into rivers and streams without any treatment, therefore it can be said that these wastes are main factor of water pollution.

The period during which coffee wastes have an especially harmful effect on water quality is in April, May, October and November.

In these seasons, the rivers and streams that are the source of water supply are affected from coffee wastes. Above all, the water problem is getting worse in the Roble and Cristales rivers.

As for the water for washing, the coffee farms that take their water directly from small streams have no problem, but the farms in the central part that have no small streams bat have available water from the rivers, are affected by the coffee waste.
The coffee farms around La Tebaida suffer serious damages from water quality.

2) The Water Requirement For Washing

The water requirement for washing is about 10 - 50 liters per kilogram of finished coffee, and the main uses of water in coffee processing are as follows:

a) to transport bean to pulpers
b) to transport pulp to a hopper or pile
c) to transport beans to fermentation vats
d) to wash fermented beans
e) to transport fermented beans to drying patios
f) miscellaneous uses, such as acting as a trap for stones and as a method of separating floaters for hydraulic classification of beans, and as boiler water.

According to C.R.Q, the water requirement for washing is as follows:

.for fermentation wash water : 10.2 lit./kg
.for coffee berry wash water : 5.6 lit./kg
. total : 15.8 lit./kg
(C.R.Q: Tratamiento residuos liquidos beneficio del cafe)

3) Characteristics of Coffee Waste Water

According to C.R.Q report, the characteristics of coffee waste water are as follows:

Item	Depulping			Fermentation		
	Min	Max	Mean	Min	Max	Mean
BOD (ppm)	360	11,600	6,380	540	10,400	4,490
COD (ppm)	806	23,860	10,310	310	15,220	6,250
SS (ppm)	79	3,680	2,170	695	6,030	2,900
ST (ppm)	590	15,140	7,450	1,370	12,550	5,500
pH	3.5	4.9	4.3	3.6	4.8	4.1

The pollutant loads are calculated by the mean values.

The effects of coffee waste water in rivers and streams are observed hourly for a 24-hour period. The results are shown in FIG. G-12,13,14,15 and 16.

4) Existing Situation of Coffee Production

Existing situation of coffee production in the area is as follows:

Height (m)	1,450 m	1,350 m	1,200 m	Total
Cultivated area(ha)	20,772	21,667	19,511	61,950
Area %	33.5	35.0	31.5	100.0
Month				Mean
1	18.64 %	2.36 %	0.0 %	7.07 %
2	3.92	1.12	0.75	1.94
3	7.85	5.26	20.43	10.91
4	29.44	3.00	14.10	15.35
5	4.32	2.84	1.15	2.80
6	1.07	1.50	0.28	0.97
7	0.0	4.09	1.24	1.82
8	0.0	15.49	3.80	6.62
9	3.14	17.36	9.40	10.09
10	11.57	22.74	11.78	15.55
11	8.83	14.21	22.91	15.15
12	11.18	9.96	14.11	11.68

Monthly coffee products are shown in FIG. G-10. Distribution map of coffee farms in this area is shown in FIG. G-11.
The situation of farm sizes of coffee plantations is shown in TABLE G-4.
(Sources of all datas are FEDECAFE report in 1986 and 1987.)

5) Results of Questionnaire for Coffee Farm

Results of questionnaire for coffee farm are as follows:

a. Days from harvest to treatment

(1) the day	: 71.7 %
(2) the next day	: 28.3 %

b. Source of water for treatment

(1) groundwater	: 2.5 %
(2) stream	: 23.8 %
(3) river	: 4.0 %
(4) potable water	: 30.3 %
(5) other	: 39.4 %

c. treatment of coffee pulp

(1) compost	: 96.8 %
(2) scatter in field	: 1.1 %
(3) bury	: 2.1 %
(4) burn	: 0.0 %

d. water quality for processing

(1) good	: 94.7 %
(2) ordinary	: 0.0 %
(3) bad	: 5.3 %

e. quantity of water

(1) sufficient	: 86.2 %
(2) ordinary	: 3.7 %
(3) short	: 10.1 %

f. discharging place of coffee waste water

(1) field	: 4.1 %
(2) stream	: 53.3 %
(3) river	: 8.2 %
(4) permeated into soil	: 18.5 %
(5) pit	: 15.9 %

g. stockyard for coffee pulp

(1) having	:	41.9 %
(2) not	:	58.1 %

h. necessity facilities

(1) improvement of treatment water	:	25.3 %
(2) treatment plant for coffee pulp	:	19.0 %
(3) treatment plant for waste water	:	30.4 %
(4) composting plant	:	11.4 %
(5) others	:	13.9 %

(5) Rural Sewage and Waste

1) General

The study area has a population of about three hundred and eighty thousand in total. The rivers and streams in this area receive rural sewage and wastes from the cities of Armenia, Calarca, Montenegro, etc. and waste waters from butcheries and tanneries.

The total treatment capacity of the waste water is about one hundred thousand tons per day. All cities in the area have constructed sewerage systems, but, this waste water flows into rivers and streams without any treatment.

The ratios of discharged sewage into the rivers are as follows:

the Espejo river :60 % (from Armenia, Montenegro Circasia)
the Quindio river:17 % (from Armenia and Calarca)
the Roble river : 2 % (from Montenegro, Circasia and Filandia)

And the ratios of dscharged sewage from each city are as follow:

Urban area -----	Armenia	:	50 %
	Calarca	:	14 %
Rural area -----	Montenegro	:	8 %
	Circasia	:	5 %
	Filandia	:	3 %
	Others	:	20 %

Sewage system in this area is shown in FIG. G-17.

2) Pollutants Load of Sewage

According to C.R.Q, basic load of sewage are as follows:

Item	Unit	28.AUG.1984	30.AUG.1984	Mean
population		293	293	293
water requirement	lit./day.man	117	145	131
BOD	gr./day.man	34.7	25.7	30.2
COD	gr./day.man	46.2	62.6	54.4

Basic pollutants load are summarized as follows:

Daily water requirement : 130 lit./day.man
BOD : 30 gr./day.man
COD : 55 gr./day.man

As abovementioned, existing load at each city is computed as follows:

	population (1985 year)			pollutant load (1985 year)			
				urban		rural	
	urban	rural	total	discharge (t/day)	BOD (kg/day)	discharge (t/day)	BOD (kg/day)
Armenia	180,200	6,930	187,130	23,426	5,405	901	208
Buenavista	1,130	2,145	3,275	147	34	279	65
Calarca	37,670	14,806	52,476	4,897	1,130	1,925	445
Circasia	10,940	7,084	18,024	1,422	329	921	213
Cordoba	2,300	2,755	5,055	299	69	358	83
Filandia	3,917	6,965	10,882	509	118	905	209
Genova	4,921	4,903	9,824	640	148	637	147
La Tebaida	15,912	2,591	18,503	2,069	478	337	78
Montenegro	21,937	7,469	29,406	2,852	658	971	224
Pijao	4,160	3,630	7,790	541	125	472	109
Quinbaya	20,262	9,146	29,408	2,634	608	1,189	274
Salento	2,508	3,579	6,087	326	75	465	108
total	305,857	72,003	377,860	39,762	9,177	9,360	2,163

G.1.4 Subjects

The basic characteristics of water quality in the study area are as follows:

a. The water pollution in the study area is ongoing from year to year owing to human activity.

b. In particular, urban wastes affect the water quality.

c. The coffee wastes have a harmful effect on the water quality of some rivers and streams during April, May, October and November.

d. The ongoing of the water pollution in the center of the study area is remarkable - Armenia and Calarca.

e. Countermeasures for items of A.B.S, N-K, DO, BOD and Coliforms are needed.

And, rivers and streams with serious problems are as follow:

a. Always polluted (urban waste)

Mid- and down-stream of the Espejo river
Mid-stream of the Quindio river
Mid-stream of the Sto.Domingo river

b. Polluted part of the time (coffee waste)

the Cristales river
the Roble river
the Barragan river
the Buenavista river

c. Low polluted (rural waste)

Mid-stream of the Lejos river

G.2 WATER QUALITY IMPROVEMENT

G.2.1 Master Plan

(1) General

The Quindio is one of the sources of the La Vieja river, and the area is abundant in natural resources. But the Quindio has two troublesome problems, one is coffee wastes from coffee farms, the other is the domestic sewage from the urban area. This waste water flows into the rivers and streams without any treatment as described in G.1.1. Therefore, the water quality is getting worse year by year.

On the other hand, these rivers and streams are sources of domestic and agricultural use, and the problem of water quality is getting worse.

Accordingly, the Quindio is urged to take the measures for providing good quality domestic and agricultural water.

(2) Improvement Strategy

The rivers and streams are a vital natural resource that provide water, food and recreation for human beings as well as habitats for aquatic plants and animals.

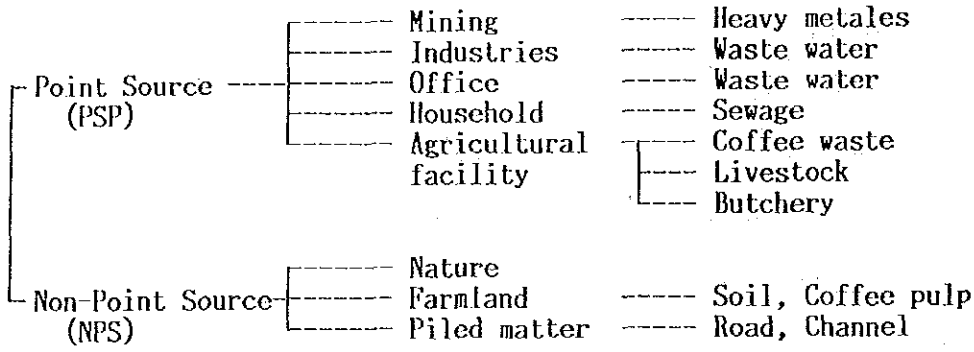
Human developments and their activities, cultural pollution, lead to a much larger input pollutants which quickly accelerate the polluting.
Preventing or slowing the rate of cultural pollution can only be achieved by halting or severely limiting the excessive pollutant inputs to the rivers and streams.

Therefore, Governments shall take action as soon as possible in case the reduction of pollution is feasible and significant even if the scientific studies have not been completed.

Once this is accomplished, natural chemical, physical and biological processes in the aquatic ecosystem will act towards gradually improving the water quality and the recovery process will begin.

Above mentioned, in the area, there are two basic factors to accelerate water pollution. One is Point Source Pollutant Load (PSP load), and the other is Non-Point Source Pollutant Load (NPS load).

Classification of individual source pollutant load is as follows:



In this study area, there are three basic factors which influence the water pollution problem. One is source of nature, another is the urban factor and the last is the agricultural factor. But the factor of nature is rather weak, remaining two factors are more influential to the water pollution.

In the Quindio, water pollution of rivers and streams arise from discharging without any treatment of coffee waste and domestic sewage. Therefore, it may be said that water quality will be improved if these two factors are cleared away.

It is the most ideal that the source of the polluting matter is to be cleared away, but it needs a great amount of expenses and time. Accordingly, staged program shall be established for the way of cutting down of the pollutants.

In view of the above, the strategies for water quality improvement are as follows:

.Water environmental control and conservation
.Each watershed is a unit for improvement
.To set up the object of improvement on each watershed
.To clear away the pollutant matter
.The removal of actual sources of pollution and the prevention of potential sources of pollution in watershed
.Coffee wastes and domestic sewage treatment are promoted for the same time
.The sewage treatment of the central part of the area should be promoted by the city planning
.The manner of improvement is established by the scale of coffee farms

(3) Restraint and Potentiality

The restraints of the water quality improvement are as follows:

.The area is studded with coffee farms
.The natural feature of the area is complex
.Therefore the intensive treatment does not work
.There is a wide gap in economic power among coffee farms, and they are short of funds for coffee waste treatment plant
.Each coffee farm already has coffee bean treatment system
.All cities have been constructed with sewerage systems, and these sewage do not directly do any damage to the inhabitants
.Therefore, there is a lack of understanding about the water pollution
.The area does not have an adequate efficient staff of engineers

The potentiality is as follow:

.The necessity of improving water quality has been understood.
.C.R.Q is now studying coffee waste treatment plant

(4) The Object of Improvement

For ensure the living environment which is suitable for his health and agricultural use, and for the satisfactory existence of future generations, the method of water quality improvement is studied with respect to coffee waste and the sewage treatment.

To effectively promote water improvement in each watershed the following system should be set up:

.To push education and enlightenment for environmental protection (Agrotechnical Center)
.To improve and expand the systematic study of coffee waste water treatment plant
.To improve the system of economic aid such as subsidy and finance
.To prohibit dumping coffee pulps and rubbish into rivers and streams.
.To make clear the efficient standard of coffee waste water
.To make clear the environment quality standard on each river and streams
.To improve monitoring system for watch on water pollution in each watershed

Water quality should be decided by complex indeces, such as pH, EC, DO, BOD, SS and Coliform groups, etc. DO (Dissolved Oxygen)and BOD (Biochemical Oxygen Demand)in these indeces are indeces for organic matter content, and these are used to show pollutant degree. DO and BOD have a correlative relationship on theoretical. To say, DO ratio is decreased by a rise of BOD degree. But DO ratio is ruled by oxygen suplly from not only the water but also the atmosphere. Therefore, in case of a rapid stream, DO ratio is rised by aeration effect from the air, even if high BOD value situation. In this area, aeration effect is shown remarkable. (refer to FIG. G-21)
As a result, BOD value would be proposed in this area for index of organic matter content.

Making allowance for water use in this area, the object of improvement in each watershed is as follows:

ITEM	TARGET	WATERSHED
for potable water	BOD 1ppm	the Rojo, the Verde Upstream's of the Lejos, the Sto.Domingo, the Quindio and the Roble
for agricultural	BOD 5ppm	the Barragan, the B/Vista and the Cristales Mid and down streams of the Lejos, the Sto.Domingo, the Quindio and the Roble
for industrial	BOD 10ppm	the Espejo

To be realized the objective water quality, loads that have to cut down in each watershed are as follows:

cutting down (%)	watershed
90 % >	the B/vista,the Roble,the Cristales,the Barragan
90 - 80	the Sto.Domingo,the Verde
80 - 70	the Espejo,the Lejos
70 - 60	the Quindio,the Lojo

G.2.2 Coffee Waste Water Quality Improvement

(1) Load of Coffee Waste Water

The pollutants load of coffee waste water at BOD on each watershed are as follows:

watershed	coffee area (ha)	maximum product (t/month)	water require (t/month)	BOD load (t/month)	BOD load (%)
Buenavista	2,900	1,060	7,300	33	4.4
Roble	7,100	1,770	18,100	81	7.9
Espejo	6,400	1,600	16,300	73	9.8
Cristales	6,600	1,650	16,800	75	10.2
Quindio	6,300	1,570	16,100	72	9.7
Sto.Domingo	6,700	1,670	17,100	77	10.3
Verde	2,300	570	5,900	26	7.0
Lejos	6,000	1,500	15,300	69	9.2
Rojo	3,600	900	9,200	41	5.6
Barragan	1,900	470	4,900	22	3.0
Vieja	9,000	2,470	25,200	113	11.8
San Felipe	4,300	1,070	11,000	49	7.8
Barbas	1,040	260	2,700	12	3.3
Total	65,040	23,960	165,900	743	100.0

At the low water that return period is 5 years, the pollutant load of BOD on each watershed are as follows:

watershed	BOD load (g/s)	Flow (t/s)	BOD (ppm)	Target BOD (ppm)	Cut down BOD (%)
Buenavista	12.57	0.20	62.85	5	92.0
Roble	31.43	0.63	49.89	5	90.0
Espejo	28.29	0.79	35.81	10	72.1
Cristales	29.19	0.47	62.11	5	91.9
Quindio	27.84	2.14	13.01	5	61.6
Sto.Domingo	29.63	0.94	31.52	5	84.1
Verde	10.33	0.42	25.60	5	80.5
Lejos	26.49	1.16	22.84	5	78.1
Rojo	16.16	1.25	12.93	5	61.3
Barragan	8.53	0.13	65.62	5	92.4

(2) Method of Improvement

As for coffee waste, there are five measures to be taken.

a.Control over the time of coffee bean treatment.
This method is to level the coffee waste by changing the time for peak coffee bean treatment.

This method can not drastically clear up problem of water quality, but at least it can smooth out an ultra uneven situation on water quality.

This method has limits, and is of no use at water shortage season.

b.Dilution

This method does not produce a drastic improvement of water quality.

b-1.Dilution at each point source
Coffee waste is discharged after diluted with water by farmers. If the concentration of discharge is 100ppm for BOD, it should be diluted about forty-five fold concentration.
Under this method an administrative advice should be given out, because the control of coffee waste is left to each coffee farm.
In the case where is great capacity of water for dilution, this method is very easy. But there is not so much possibility in the areas where are poor in water resources such as central parts of the study area.

b-2.Dilution in watershed

In the case of this method, control of water quality is done by reservoirs in each watershed. A quantity of water for dilution should be decided under careful consideration with regards to the time of coffee bean treatment. Monitoring system of water quality must be kept in a watershed.
The quantity of water for dilution is about ten-fold for the average flow of river.

c.Improvement of assimilation capacity of river

This method gives improved self-purification characteristics by building some facilities in a river or stream.
This facility has an effect on downstream, but it has no effect for an upstream. Therefore, points for facilities

should be selected under careful consideration.

For example are as follows:

.Improvement of assimilation capacity with stones and artificial contact materials.
.Improvement of areation capacity with drop-facilities
.Improvement of natural areation capacity with expansion of rivers and streams
.Improvement of sedimentation capacity with setting basin

d.Centralized treatment of coffee waste

this method produces a drastic effect on water quality improvement, because coffee waste itself is treated. But suitable costs for construction, operation and maintenance are required. Long term corrective measures have high initial cost but may be less expensive in the long run.

d-1.Gathering coffee waste water

Coffee waste water discharged from each coffee farm is gathered through channels, pipe-lines or vacuum-car, and treated by a treatment plant.

This method is suitable for watershed improvement, but in case where watershed has complex configuration or be dotted with coffee farms, it will mean increasing construction cost of channels or pipe-lines.

But if the condition of watershed is good, this method may be a profitable system, because it can make the best use of existing coffee bean treatment facilities.

d-2.Gathering coffee bean and doing total treatment

Gathering coffee bean from each coffee farm, and doing total treatment in a treatment plant. This system will be composed of two facilities such as coffee bean treatment and coffee waste water treatment plants.

Therefore, existing coffee bean treatment facility of each farm will become useless. But in the case where an area has complex configuration and is dotted with coffee farms, this system may be a profitable method. For those reason this treatment is done as a wole, and operation and maintenance are simple, and stable water quality can be expected. On using this system, an organization obtaining coffee farm's consent and a leader are indispensable conditions.

e.Individual treatment

Coffee waste is treated at each point source. A new treatment plant for coffee waste is added to existing system. In this case, complex treatment plant is not suitable, because operation and control is left to each coffee farm.

Summarized methods of water quality improvement for coffee waste are as follows:

Method/Item	Organization Control	Existing facility	Water quality Improve	Work easy or not	Construction Cost	Op. & Cont.	Plot of Work	Total Evaluation
a.Control time	1	5	0	5	5	1	5	6
b.Dilution								
b-1.Source point	2	5	0	4	4	4	4	5
b-2.Watershed	1	5	0	1	1	3	3	7
c.Assimilation	4	5	3	3	4	2	3	4
d.Centralized								
d-1.Coffee waste	4	5	5	3	3	4	4	1
d-2.Coffee bean	3	0	5	5	4	5	4	3
e.Individual	4	5	5	4	3	3	4	2

Each method has its merits and demerits, finally the water quality the area can not be improved if loads are not cut down. Therefore, water quality improvement in the area should be carried out along with the method of d-1, d-2, e. or their compound.

(3) Selection of Treatment Plant

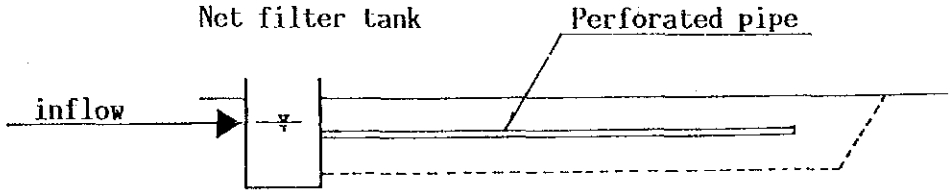
The characteristics of coffee waste are high load, low pH and there are seasonal limits, etc.

Taking into consideration the above situation, the six treatment methods such as (i) Land Treatment, (ii)Lagoon, (iii) Aerated Lagoon, (iv) Activated Sludge Process, (v) Intermittent Cyclic Process and (vi) UASB(Upflow Anaerobic Sludge Blanket) Process were selected for study.

The system flow of each method is as follows:

(i) Land Treatment

This method, in short, relies on the physicochemical function of soil and the purifying function of organisms occurring in the soil by discharging waste water directly into the soil. This is one of the oldest method, but ot does not mean that it is destined to be discontinued. For example, in recent years this method is used in the U.S.A to treat waste water especially those from household and food processing plants.

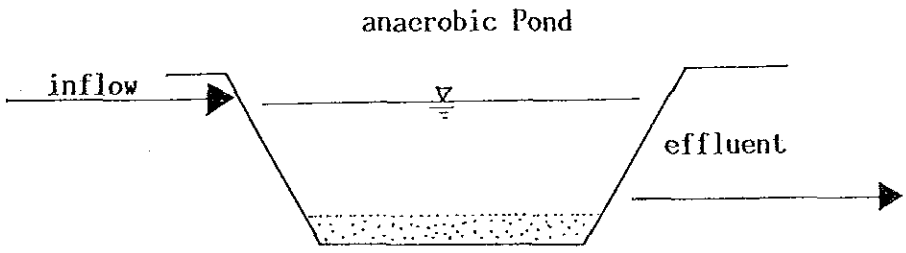


(ii) Anaerobic Pond

This is one process that consumes the least amount of energy, and is suited to treat waste water of a relatively high concentration. In this process, the waste water in a pond is anaerobically decomposed by anaerobic organisms.

The advantages of this process are simple construction of treatment plant, easy maintenance and low operation cost and small energy need.

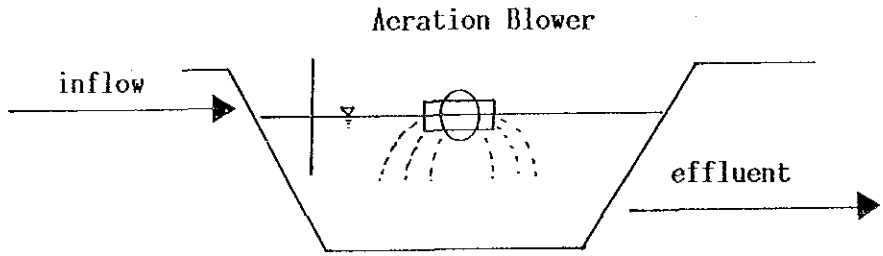
The disadvantages are an offensive odor, tendency to cause environmental pollution, the need to dispose the final sludge and large plot for plant.



(iii) Aerated Lagoon

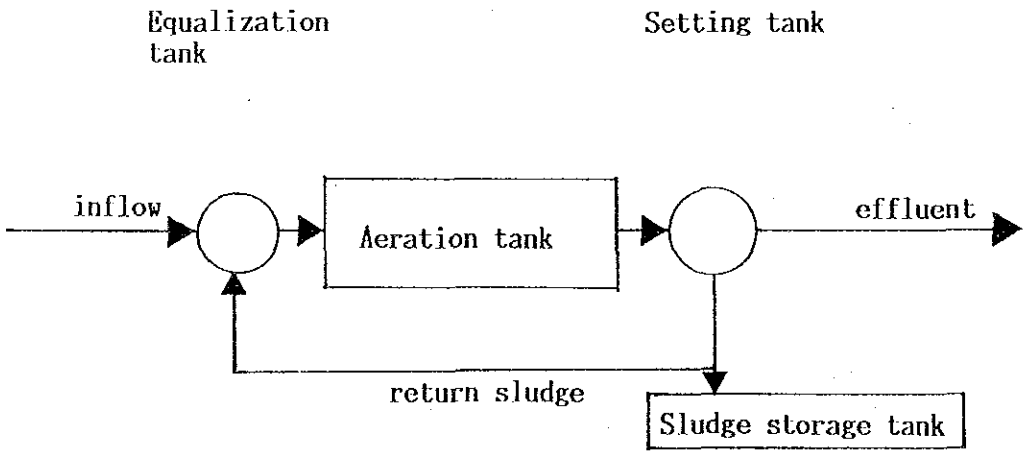
This process is useful where wide space can be obtained because this process has simple ficlities, low maintenance and operating costs, and the ability ot treat a large quantity of waste water.

The principle of this process is the aeration treatment of waste water using a lagoon and aeration device, and this is a variation of the activated sludge process. This process, however, is apt to be affected by the temperature, and is not suited for cold districts.



(iv) Activated Sludge Process

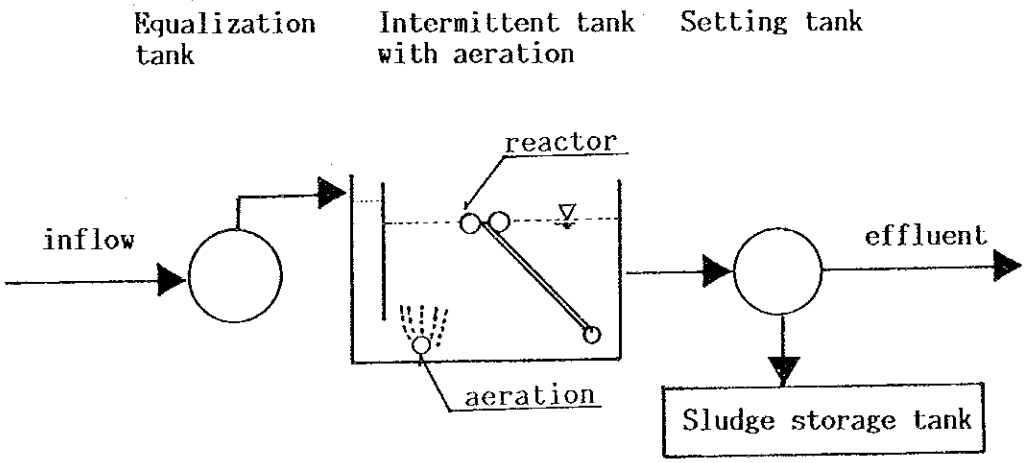
This is one of the most widely used waste water treatment process today. It was first put to practical use in England and it has become popular because of its high purification rate, continuous availability of the purification effect by organisms at a steady rate, relatively small generation of offensive odor, etc. As a result, this process is widely used to treat municipal sewage. The shortcomings of this process are said to be the relatively large amount of sludge produced and its high sensitivity to change in the condition of waste water. Moreover, this process needs large energy and high opreation costs.



(v) Intermittent Cyclic Process

This process developed in recent year, and this is a variation of the activated sludge process. This process has both phase of aerobic and anaerobic treatment process.

In the intermittent aeration, aeration is turned on and off several times to alternately create aerobic and anaerobic conditions for simultaneous removal of organic substances, nitrogen, and phosphate. Subsequently, intermittent aeration is stopped for some time to allow a setting for solid-liquid separation. In the final drawing, the decanter -- held during the intermittent aeration and settling above the highest water level in the reactor -- lowers and quietly draws out the clear effluent the. Upon descent to the predetermined level,the decanter automatically ascends back to the standby position. This completes one cycle. Several cycles of operation are performed daily.

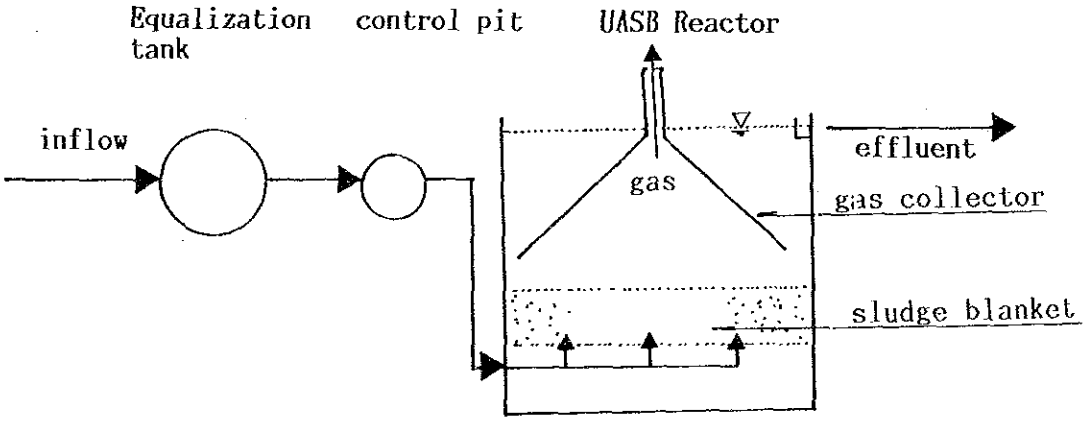


(vi) UASB Process

U.A.S.B (Upflow Anaerobic Sludge Blanket) Process is a variation of the Methanogenic Digesting process using a sludge blanket of granule.
This process was first put to practical use in the Netherlands to treat waste water especially those from food processing plants.

The advantages of this process are:
-Simple construction of treatment plant.
-Easy maintenance and low operating cost.
-No energy need.
-Small final sludge.

The disadvantages are:
-Grawing of granul needs high technically process.
-Grawing of granul needs long times.



The items of evaluation are:

.Easier maintenance and operation
.No use of special medicines
.Plot of work for treatment plant
.Simple mechanism of the system
.Lower cost of construction, maintenance and operation

The results of evaluation are as follows:

	Re-moval-Ratio	Deten-tion Time	Recov-ery	Plot of Work	Con-struc-tion Cost	Elec-trici-ty	Mante-nance & Op.	Total eval-uation
1.Land Treatment	3	2	5	3	5	5	2	2
2.Anaerobic Pond	4	1	5	1	4	5	3	5
3.Areated Lagoon	5	2	5	2	3	3	4	4
4.Activated Sludge	5	4	4	3	2	2	2	6
5.Inter. Cyclic	5	4	5	3	3	3	3	3
6.UASB	5	3	4	5	4	5	3	1

The constraints in the area are an insufficient supply of electric power and lack of leading engineers. Therefore, if a facility requires high rate aerated system and high level technique in maintenance and operation, it is not suitable for this area.

Coffee waste is not continual, but has a blank period for tow or three months in a year, during which a treatment system should have good recovery.

As a result, UASB method and Land Treatment system get a position in the area for coffee waste treatment system.

(4) Scope of the Area for Coffee Waste Treatment

Water quality improvement will be achieved step by step in accordance with point at which contamination takes place, and an imrovement unit is to be installed in the watershed of each river and stream.

Improvement stages are as follows:

.First stage : the Q.Cristales and the Roble rivers
.Second stage : the Espejo and the Sto.Domingo rivers
.Third stage : the Quindio, The Buenavista and the Barragan
.Fourth stage : the Rojo, the Lejos and the Verde rivers

G.2.3 Rural Sewage

(1) Method of Improvement

The Quindio is divided into two parts, one is rural area, the other is urban area.

The sewage treatment in urban area is being improved by the city planning.

On the other hand, each city in the rural area already has a sewerage system. Accordingly, the sewage treatment project for the rural area is constructed pipe-line net work to connect existing sewerage system to final treatment plant.

Stages for improvement are as follows:

Stage	Rural Area	Urban Area
.First stage:	La Tebaida, Circasis and Pijao	Armenia
.Second stage:	Filandia, Montenegro and Quimbaya	Calarca
.Third stage:	Salent and Cordoba	
.Forth stage:	Buenavista and Genova	

(2) Selection of Treatment Plant

Many different treatment methods to improve the water quality are prevailing in the world. Taking into consideration the following merits, the seven treatment methods were selected for the study.

.Easier maintenance and operation
.No use of special medicines
.Easier sludge treatment
.simple mechanism of the system
.Lower cost of construction, maintenance and operation
.Less power consumption

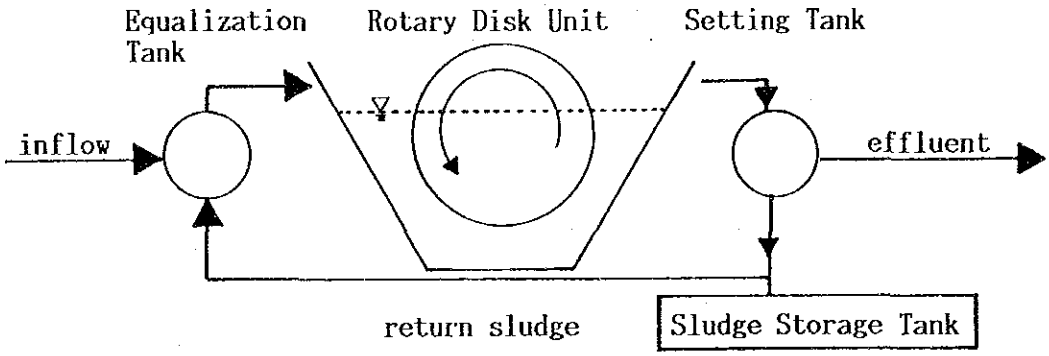
the seven treatment methods are as follows:

(i) Land Treatment
(ii) Rotary Disk Process
(iii)Oxidation Ditch
(iv) Areated Lagoon
(v) Activated Sludge
(vi) Intermittent Cyclic
(vii)Contact Aeration

The system flow of treatment methods are as follows:

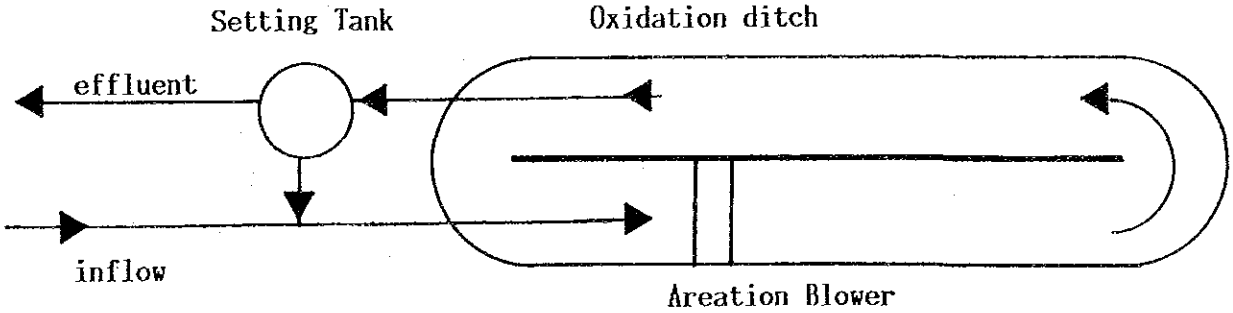
1.Rotary Disk Process

The process uses discs which pass through waste water and air alternatingly as they rotate. The water is purified by organisms generated over the surface of the rotary discs, and this can be considered as a kind of bio-film processes.
The advantages of this process, when compared with the activated sldge process, lie in easy maintenance and operation and consumes less energy. This process is suited for a relatively small-scale treatment plant for household or industrial waste water. The rotary discs are made of plastic or metal or other materials, but each rotary disc must be thick and strong enough so that it can be used for long time. In general, this process is used for the aerobic treatment of waste water, but it can also be used for anaerobic treatment.



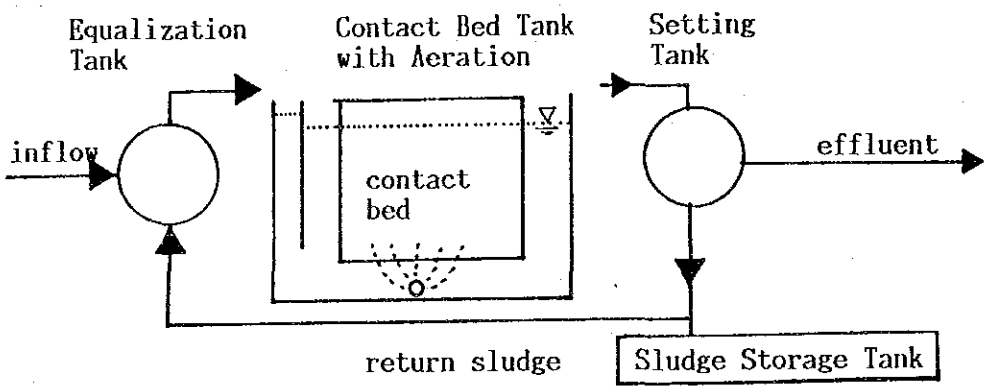
2.Oxidation Ditch

Waste water is circulated in the linked ditch with aeration. The water is subjected to both aerobic and anaerobic treatment by circulating the ditch. This system is simple one, and maintenance and operation can be easily performed, but large lot is necessary.



3.Contact Aeration Process

Diverse microorganisms are supplied into waste water and the contact filter bed by covering the entire treatment tank with soil or artifical filter material. Iligh treatment can be easily performed and deodorization and the decrease of sludge are possible.



The results of evaluation are as follows:

	Re-moval-Ratio	Deten-tion Time	Recov-ery	Plot of Work	Con-struc-tion Cost	Elec-trici-ty	Mante-nance & Op.	Total eval-uation
1.Land treatment	3	2	5	3	5	5	2	3
2.Rotary Disk	4	4	3	3	3	3	4	4
3.Oxidation Ditch	4	3	4	1	3	3	4	5
4.Aerated Lagoon	5	2	5	2	3	3	4	4
5.Activated Sludge	5	4	4	3	2	2	3	6
6.Inter. Cyclic	5	4	5	3	3	3	3	2
7.Contact Aeration	5	4	5	3	3	3	3	1

Regarding the central part in the cities where population is concentrated, sewage treatment system gives Contact Aeration Process or Intermittent Cyclic Process a position.

On the other hand, the studded farms around the city have a distributed and localized treatment system by taking advantage of the natural assimilation capacity of soil and microorganisms.

G.2.4 Water Quality Improvement Plan

The long-term planning in 2005 year is as follows:

a. Coffee waste treatment

.The Cristales river	(670 Coffee Farms)
.The Sto.domingo river	(900 Coffee Farms)
.The Roble river	(640 Coffee Farms)
.The Espejo river	(840 Coffee Farms)

b. Rural sewage treatment

.La Tebaida	(for Q.Cristales	Population 23,000)
.Circasia	(for the Roble and the Espejo river	20,000)
.Pijao	(for the Lejos river	8,000)

c. Without project

.Armenia City sewage treatment	(Population 260,000)
.Calarca City sewage treatment	(Population 60,000)

G.2.5 Coffee Waste Water Treatment Model Plan

(1) Selection of the Area

The Q.Cristales, which is the most affected by coffee waste, is selected as a model project area in the long-term planning list.

The target of water quality is less than 5 ppm at BOD for agricultural use.

The coffee farms in the area are classified as follows:

unit	*number*	*total cultivated field*
more than 30 ha	55	4,100 ha
30 - 5 ha	330	2,000 ha
less than 5 ha	285	490 ha
total	670	6,600 ha

(2) Model Plant Plan

This plan is to be studied with the following four alternatives:

a. Individual system
b. Cooperative treatment system of coffee bean
c. Centralized treatment system of waste by channels
d. Centralized treatment system of waste by vacuum-car

1) Individual System

This system aims at installing an individual coffee waste water treatment at each coffee farm.

Large and middle sized coffee farms (more than 5 ha) discharging great deal of coffee waste water are getting about 90 percent of total coffee cultivated area. Therefore, cutting down effect of pollutant load is shown by improvement of coffee waste water for large and middle sized coffee farms.

It will be reasonable that the small sized coffee farms (less than 5 ha) have simple individual treatment system for coffee waste water in their farm site, because their waste water is very little.

Above mentioned, treatment facilities in this case are as follows:

.Small sized farm : 285 units (Land treatment system)
.Large and middle sized farm: 385 units (UASB Method)

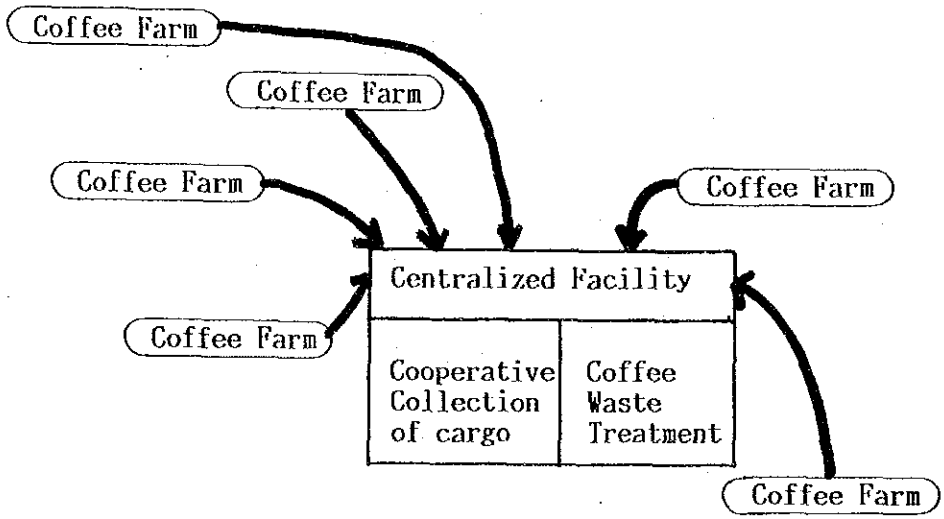
2) Centralized Treatment System of Coffee Bean

This plan is such that the coffee bean is collected form farmers living along the Q.Cristales, and the bean and coffee waste is treated in the coffee processing industry. To operate well the system, farmers in the area must be organized. he system to be introduces is similar to that of the centralized treatment system of the coffee farmers' cooperative in Montenegro.

The cooperative consists of ten big farmers and it made a coffee cultivation contract with them. Coffee bean collected from them is processed and also coffee waste is treated with the cooperative facilities. he cooperative would extend membership to small-to-medium sized coffee farmers.

The plan would extend the centralized treatment system to all coffee cultivating farmers living along Q.Cristales.

The main process of the system is shown as follows:



Constraints of the plan are as follows:

a. Some farmers already invested in their own treatment facilities. Therefore, these existing facilities will be useless.
b. Classification of coffee bean is necessary.
c. Adjustment of coffee harvest is necessary to prevent concentration of process.
d. Improvement of access road is necessary to transport fresh coffee bean from farmers to centralized facilities.

Advantages from adapting to the system are as follows:

a. The problem of water pollution caused by coffee waste is settled at the root points.
b. Expenses of construction and maintenance are saved because of the centralized system.
c. A community in the area is formed by the cooperative.

U.A.S.B method is recommended as a treatment facilities of the project.

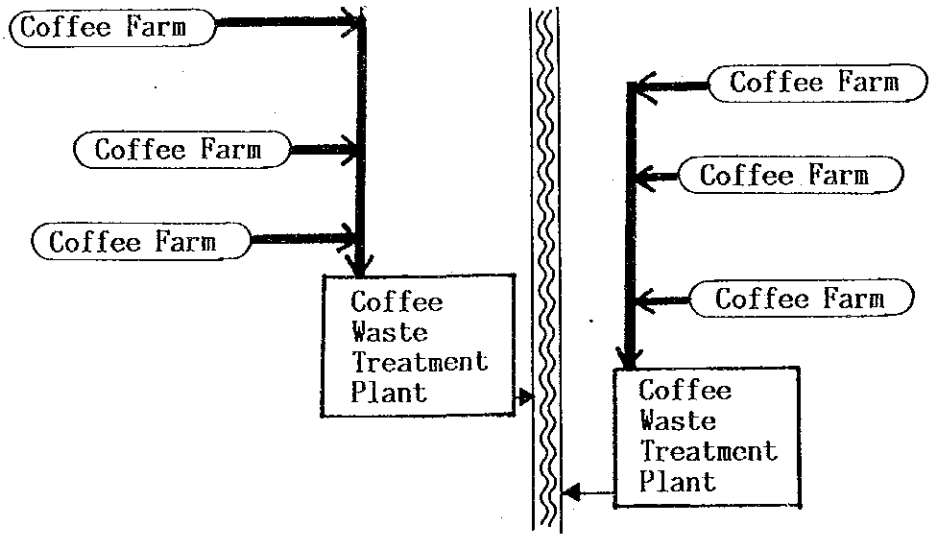
Treatment facilities are as follows:

.Cooperative treatment plant : 1 unit
.Large sized farm's treatment plant : 55 units
.Small sized farm's treatment plant :285 units

3) Centralized Treatment System of Coffee Waste by Channels

The plan is that coffee waste is collected from each farmer through a waste pipe or channel and taken to the treatment center.

The main process of the plan is shown as follows:



Constraints of the plant are as follows:

a. In consideration of the topographical condition of the area, expenses of waste pipe construction might be expected to be high or a number of treatment facilities might be expected to be installed.

b. Maintenance fee is also expected to be high.

c. Inspection of waste pipe is necessary.

Advantages of the systems are as follows:

a. The problem is settled at the root points.

b. Existing facilities and skillfulness of farmer are used efficiently.

U.A.S.B method is recommended.

Treatment facilities are as follows:

.Centralized treatment plant	:	33 units
.Channel	:	165 km
.Plant for large sized farmer	:	55 units
.Plant for small sized farmer	:	285 units

4) Centralized Treatment System of Coffee Waste by Vacuum-car

Coffee waste water is collected by vacuum-cars. This system has a wide degree of flexibility compared with channels, but each coffee farm needs a pit to stock coffee waste water.

Treatment facilities are as follows:

.Centralized treatment plant	:	11 units
.Vacuum-car	:	11 units
.Stock pit	:	330 units
.Plant for large sized farmer	:	55 units
.Plant for small sized farmer	:	285 units

(3) Model Plant

The low water (return period is 5 years) in the Cristales river is 0.74 t/sec. In this case, the water quality at BOD is turned to be 62 ppm by the coffee waste water. To getting the target of water quality (less than 5ppm at BOD), BOD load should be cut down more over 92%. Therefore, if discharging water quality is 100 ppm at BOD, all coffee farms should be equipped with some treatment facilities for coffee waste water.

Summarized system of water quality improvement for coffee waste are as follows:

Facility	indivi-dual	Coopera-tive	By channel	By vacuum
For large sized farmer	55	55	55	55
For middle sized farmer	330	-	-	-
For small sized farmer	285	285	285	285
Cooperative	-	1	-	-
Central treatment	-	-	33	11
Channels (km)	-	-	165	-
Vacuum-car	-	-	-	11
Pit for waste water	-	-	-	330

The direct construction cost of each model plan is as follows:

(Unit: in million of Col.$)

Model Plan	Direct Cost
1.Individual System	1,020
2.Joint Treatmant System	720
3.Centralized by Channel	850
4.Centralized by Vacuum lorry	680

Accordingly, the vacuum-car system gets a position for coffee waste water treatment in this area (the lowest in cost) and this system makes better use of existing facilities and technique for coffee bean processing.

The Cristales area has following features.

Item	Unit	Small Farmer	Medium Farmer	Large Farmer
Cultivated area	ha	490	2,000	4,110
Coffee Farmer	number	285	330	55
Area par farm	ha/farm	1.7	6.1	74.7
Area par 30 farms	ha/30	-	181.8	-
Unit product	ton/ha	0.25	0.25	0.25
Peak product	ton/month	0.4	45.5	18.7
Unit discharge	m3/ton	10.2	10.2	10.2
Peak discharge	m3/month	4.1	464.1	190.7
Treatment time	time/month	10	10	10
Discharge par time	m3/time	0.4	50.0	20.0
Treatment system		Land Treatment	UASB	UASB
Net filter tank	unit	1	-	-
	size(m)	1.2*1.2*1.4	-	-
Trench	unit	4	-	-
	size(m)	0.5*0.5*5.0	-	-
Storage pit	unit	-	2	-
	size(m)	-	3.0*3.0*1.5	-
Equalization tank	unit	-	1	1
	size(m)	-	4.0*4.0*2.5	2.0*2.0*2.5
Control pit	unit	-	1	1
	size(m)	-	2.5*2.5*1.5	1.5*1.5*1.5
UASB reactor	unit	-	1	1
	size(m)	-	7.5*7.5*4.5	4.0*4.0*4.3

Each treatment system is shown in FIG. G-20.

(4) Coffee Waste Water Treatment Plan

Coffee waste treatment plan on each watershed that be cleaned up the objective improvement are as follows:

Stage	Watershed	Target of water quality (BOD)	Cut down pollutant load (BOD)	Plan of facilities				
				Large farmer	Small farmer	Treat-ment	Vacuum car	Pit
First	Cristales	5 ppm	92 %	55	285	11	11	330
	Roble	5 ppm	90 %	15	535	11	11	330
Second	Espejo	10 ppm	72 %	35	-	12	12	360
	Sto.Domingo	5 ppm	84 %	50	-	15	15	435
Third	Buenavista	5 ppm	92 %	15	260	8	8	245
	Quindio	5 ppm	62 %	35	-	-	-	-
	Barragan	5 ppm	92 %	10	60	4	4	110
Fourth	Verde	1 ppm	81 %	30	-	8	8	240
	Lejos	1 ppm	78 %	50	-	12	12	345
	Lojo	1 ppm	61 %	15	-	-	-	-
Total				310	1,140	81	81	2,395

The target years of each stage are as follows:

.Until 2005 year: First and Second stages
.After 2005 year: Third and Fourth stages