No. 11

REPUBLIC OF COSTA RICA
SERVICIO NACIONAL DE AGUAS SUBTERRANEAS
RIEGO Y AVENAMIENTO (SENARA)

LIMON INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

(THE FEASIBILITY STUDY)

VOLUME II

ANNEX

OCTOBER 1988

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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Annex A. Socio-Economics

A. 1 General Description of Canton Matina

The Canton Matina was established legally as an administrative unit of the Province of Limon, by the Law No. 4344 dated June 24, 1969, and consists of three districts such as Matina, Bataan and Carrandi.

Municipal office of the Canton is placed at the urban area of Matina district. An area and population of the Canton Matina are as follows:

District	Area Km^2	Population	No. of Family	Den'ty per Km^2
Matina	354.37	3,964	969	11
Bataan	213.26	6,712	1,578	31
Carrandi*	205.01	4,047	1,049	20
Total	772.64	14,723	3,596	19

Note : * This district is excluded from the Project Area.
Resource : Census 1984

The settlers in the Project Area immigrated from the surrounding areas and the whole country. In the Canton, there are partially found Bajo Chirripo and Chirripo indian communities of the ethnic group of Cabecar.

The principal economic activities in the Canton are agriculture and livestock, and are cultivation of banana, cacao, plantain and cattle breeding.

Geographically, the Canton Matina is located in 10°00'52" north latitude and 83°18'35" west longitude, and the maximum width is of 47 km, in the direction of north to south, from the mouth of Estero Madre de Dios, in the Caribbean Sea to about 1,500 m up the confluence of Rio Boyei and its arm.

A.2 Public Administrative Organization in the Canton

The public administrative organizations in the Canton are as follows:

Sector	Organization	Type and location
Settlement	IDA	Office in Bataan
Health	Ministry of Health	Health station in all the districts
	Caja Costarricense de Seguro Social	
	Instituto Costarri-sence Acueductos y Alcantarillados	Office in Matina
Labor and Social Security	Instituto Mixto de Ayuda Social	Office in construc-tion
Education	Ministry of Public Education	Colegio Agropecua-rio (Agricultural High School) in Bataan and Primary Schools in all the Canton.
Financings	Banco Nacional de Costa Rica	Branch office in Bataan
Agriculture and Livestock and Natural Resources	Ministry of Agriculture and Livestock	Office in Bataan
	Consejo Nacional de Production	Shop in Matina Shop and storage in Bataan

As local organization in the Canton Matina, there are three development associations; one in each district.

Respect to cooperatives are enumerated as the followings; Coope 28 millas, in Bataan are located Coope Agro, Coope Bataan, Coope 5, Coope Buena Esperanza and Coopebana R.L.

The syndicates are banana company and municipal office. In addition this Canton has the services of Red Cross.

Basic necessities in the Canton Matina are as follows:

Sector	Necessities
Health	Latrinazation, Supply of domestic water, Waste disposal, Construction, repairing or relocation of slaughterhouse.
Recreation and Culture	Cultural and Recreation Center, Sport Ground and Gymnasium
Settlement	Housing program
Labor and Social Security	Creation of employment source
Agricultural development	Order of land tenure structure Acceleration of land ownership registration Prevention of indiscriminate deforestation
Other	Development of capable men Measures of transport

- In the Canton Matina, there are Matina forest reserve, Barbilla reserve and Pacuare reserve, and these reserves occupy 1%, 2% and 7% respectively in the whole Canton's area.

Revenue and expenditure of the Canton Matina are;

Revenue ; Banana tax, capital transfer from public revenue, resident tax, construction tax, testimonial tax, subsidy of public organization, and collecting charge of graves in Rio Barbilla and Rio Chirripo.

Expenditure ; Administration cost, construction and service expenditures, cost for liabilities and personnel expenses.

Administrative work of Municipal office in Matina are collection of public taxes and charges, support for community's works, cadastral work, assistance to the public administrative organizations, garbage collection, administration of public cemetery and slaughterhouse, cleaning and maintenance of cantonal road and its ditch.

Annex B Meteorology and Hydrology

Annex B. Meteorology and Hydrology

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B.1 Meteorology

B.1.1 Representative Meteorological Station for the Study Area

As a representative meteorological station, La Lola synoptic station is selected comparing the rainfall with ones at Agrodisa, ASBANA and Perla rainfall stations. (see Table B.1.1)

B.1.2 Meteorological Data

Meteorological data for the Study Area is shown in Table B.1.2.

Table B.1.1 Comparison of Rainfall Distribution

Daration	Limon	La Lola	Ave.	Agrodisa	ASBANA	Perla
1987						
May	231	242	256	320	210	239
Jun.	209	294	215	212	208	224
Jul.	198	278	325	318	251	407
Aug.	369	316	343	323	321	385
Total	1,007	1,130	1,139	1,173	990	1,255

(Note): Ave. = 1/3 X (Agrodisa + ASBANA + Perla)

Table B.1.2 Meteorological Data

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total/Mean	Period
Precipitation *														
(mm)	301	235	139	238	255	313	418	330	221	229	384	461	3,524	1970-85
Temperature **														
Max (℃)	29.7	30.0	30.5	30.8	31.1	30.7	29.9	30.4	30.8	30.8	29.9	29.7	30.4	1961-85
Min (℃)	19.6	20.4	20.9	21.5	22.1	22.3	22.0	21.9	22.1	21.8	21.4	20.7	21.4	- do -
Mean(℃)	24.3	24.6	25.3	25.7	26.1	26.0	25.4	25.6	25.9	24.7	25.1	24.7	25.3	- do -
Relative Humidity *														
(%)	85	84	82	82	82	86	87	86	83	84	87	87	84	1973-81
Wind Velocity **														
(km/hr)	6.6	6.5	7.0	7.2	6.3	5.7	6.1	5.9	6.1	5.9	6.5	6.7	6.5	1971-84
Wind Direction **	West or Southwest													1970-84
Pan Evaporation (A) **														
(mm/month)	93	112	129	132	127	102	93	127	117	115	93	89	1,329	1970-76
Sunshine Duration *														
(hr/month)	144	142	164	143	156	119	95	121	133	143	114	117	133	1972-82
Pressure **														
(mb)	1,013	1,013	1,012	1,012	1,011	1,011	1,011	1,011	1,010	1,010	1,011	1,012	1,011	1970-85

(Note) * : La Lola meteorological Station
** : Limon Synoptic meteorological Station

B.2 Hydrology

B.2.1 Flood Discharge of River

1) Method of Flood analysis

Flood discharge originating from large mountainous area is estimated by a runoff function method as follows;

The direct flood discharge caused by rainfall of r (mm/hr) during a unit time (t_o hr), can be expressed by the following equations.

$$Q = 0.2778 \,.\, A \,.\, f \,.\, r \,.\, [e^{-\alpha t'} (\alpha t' + 1) - e^{-\alpha t} (\alpha t + 1)]$$
$$= 0.2778 \,.\, A \,.\, f \,.\, r \,.\, D$$

$$t' = t - t_o$$

Where:

A : Drainage area (km^2)
f : Runoff coefficient
r : Rainfall (mm/hr)
α : Modules definited by the following equation

$$\alpha = 2.30 \log\left(\frac{tp}{tp - 1}\right)$$

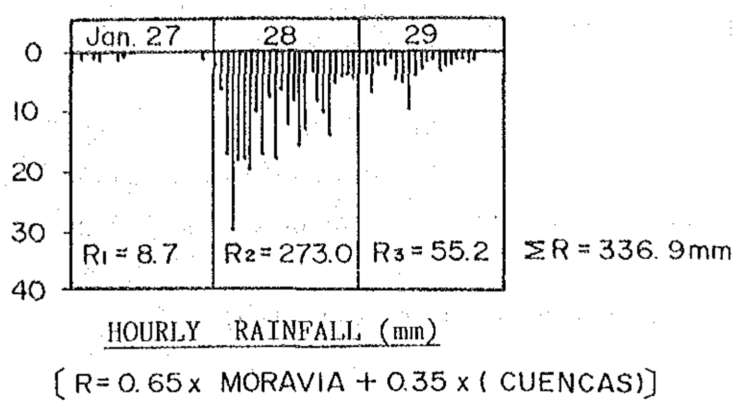
tp: Flood concentration time (hr)
 $tp = L/W$
 $W = 72 \ (H/L)^{0.6}$
  L: River length from the origin (Km)
  W: Average velocity of river flow (Km/hr)
  H: Height difference in the section of L
D : Distribution rate of discharge
t_o : Unit time for calculation (= 1.0 hr)

Accordingly, the discharge caused by some rainfall, during some period is estimated by the synsesization of each discharge obtained by above equations.

2) Estimation of Runoff Modulus

A) Runoff Coefficient (f)

Using the observed hydrograph, Jun. 27 to 29, 1988 at Playa Hermosa stream gauging station having a drainage area of 821 km^2 in Rio Chirripo, the value of a runoff coefficient is estimated. Comparing observed hydrograph with estimated one with a runoff coefficient of 0.55, the shape and value of both hydrographies are almost close as shown in Fig. B.2.1. Therefore, an effective rainfall contributing to a flood is estimated by multiplication estimated f-value to hourly rainfall.



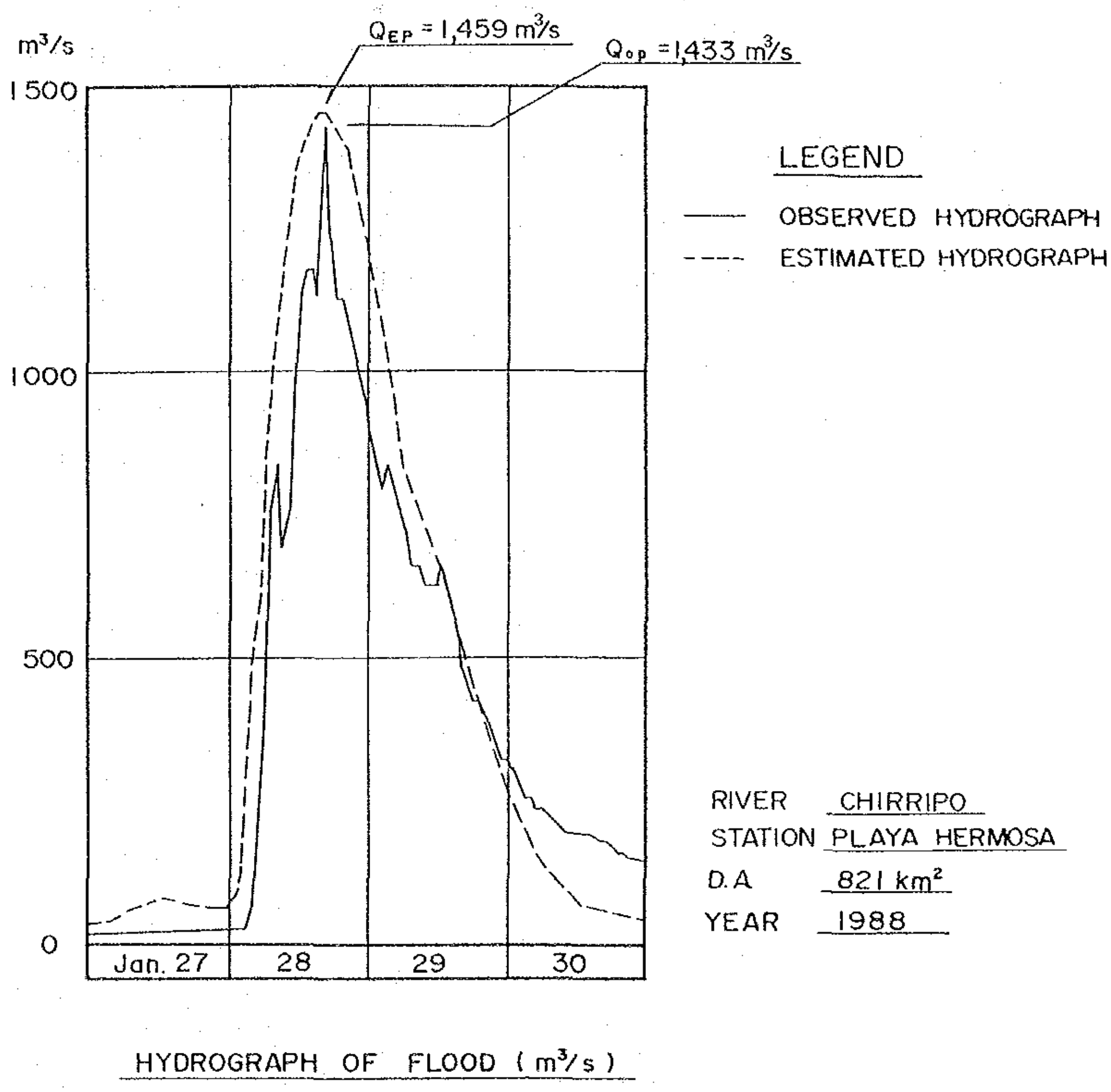


Fig. B.2.1 Comparison with Observed Flood and Estimated Flood

B) Flood concentration Time (tp)

Using a topography map with a scale of 1:200,000, the river length and height difference in related watershed of rivers, and obtained flood concentration times are shown in Table B.2.1.

Table B.2.1 Flood Concentration Time (tp)

Watershed	D.A. (km2)	River Length (km)	El. Highest (m)	El. Lowest (m)	Average Velocity (m/s)	tp (hr)
Rio Chirripo	1,096	75	3,820	4	3.35	6.0
Rio Barbilla	269	40	1,400	4	2.67	4.0

Moreover, based on estimated tp, distribution rate of discharge is illustrated in Fig. B.2.2.

Fig. B.2.2 Distribution Rate of Discharge

Rio Chirripo (tp = 6.0 hr)

UNIT TIME = 1.0(HR)
ALFA = 0.132
TOTAL OF THE DISTRIBUTION RATE = 1.000

DAY	HOUR	DISTRIBUTION RATE
1	0.0	0.000
	1.0	0.015
	2.0	0.037
	3.0	0.052
	4.0	0.061
	5.0	0.066
	6.0	0.067
	7.0	0.066
	8.0	0.063
	9.0	0.060
	10.0	0.056
	11.0	0.051
	12.0	0.047
	13.0	0.043
	14.0	0.038
	15.0	0.034
	16.0	0.031
	17.0	0.027
	18.0	0.024
	19.0	0.021
	20.0	0.019
	21.0	0.016
	22.0	0.014
	23.0	0.012
2	0.0	0.011
	1.0	0.009
	2.0	0.008
	3.0	0.007
	4.0	0.006
	5.0	0.005
	6.0	0.005
	7.0	0.004
	8.0	0.003
	9.0	0.003
	10.0	0.002
	11.0	0.002
	12.0	0.002
	13.0	0.002
	14.0	0.001
	15.0	0.001
	16.0	0.001
	17.0	0.001
	18.0	0.001
	19.0	0.001
	20.0	0.001
	21.0	0.001
	22.0	0.001
	23.0	0.001
3	0.0	0.001

Rio Barbilla (tp = 4.0 hr)

UNIT TIME = 1.0(HR)
ALFA = 0.287
TOTAL OF THE DISTRIBUTION RATE = 1.000

DAY	HOUR	DISTRIBUTION RATE
1	0.0	0.000
	1.0	0.034
	2.0	0.079
	3.0	0.100
	4.0	0.105
	5.0	0.102
	6.0	0.093
	7.0	0.083
	8.0	0.072
	9.0	0.061
	10.0	0.051
	11.0	0.043
	12.0	0.035
	13.0	0.029
	14.0	0.023
	15.0	0.019
	16.0	0.015
	17.0	0.012
	18.0	0.010
	19.0	0.008
	20.0	0.006
	21.0	0.005
	22.0	0.004
	23.0	0.003
2	0.0	0.002
	1.0	0.002
	2.0	0.001
	3.0	0.001
	4.0	0.001
	5.0	0.001

Table B.2.2 Probable Rainfall

Watershed	Rio Chirripo *)			Rio Barbilla **)		
Return Period(yrs)	2	5	10	2	5	10
1-day max. rainfall(mm/1-day)	134	205	259	128	187	233
2-day max. rainfall(mm/2-days)	197	309	395	196	283	349
3-day max. rainfall(mm/3-days)	236	361	451	229	340	425

Note)
Y : Areal Rainfall

*) Y1 = 0.49 x (Moravia) + 0.26 x (Cuencas) + 0.25 x (Boston)
**) Y2 = 0.37 x (La Lola) + 0.10 x (Boston) + 0.30 x (Pacuare) + 0.23 x (Moravia)

3) Design Rainfall

(A) Daily Arrangement of Design Rainfall

According to the Master Plan Study, maximum 3 days' consecutive rainfall with a return period of 5-year is adopted as the design rainfall. The result of probability analysis is shown in Table B.2.2. Taking into consideration the distribution of rainfall in past flood time, front-heading type's distribution is adopted as follows;

First day : (Max. 1-day rainfall)
Second day : (Max. 2-days rainfall - Max. 1-day rainfall)
Third day : (Max. 3-days rainfall - Max. 2-day rainfall)

(B) Hourly Arrangement of Design Rainfall

Hourly arrangement of design rainfall is estimated the following equation:

$$rt = R_{24}/24. \ (24/t)^{0.6}$$

where
rt : Average rainfall intensity for t hours (mm/hr)
R_{24}: Daily rainfall (mm)
t : Duration of rainfall (hr)

The calculated hourly rainfalls are arranged in the manner which rt is in position of 12 th hour and, r2 and r3 in later and before the rt.

Obtained results are shown in Table B.2.3 (1) and B.2.3 (2)

Table B.2.3 (1) Design Rainfall in Watershed of Rio Chirripo

Time (hr)	1st Day		2nd Day		3rd Day	
	Rainfall (mm)	Effective R. (mm)	Rainfall (mm)	Effective R. (mm)	Rainfall (mm)	Effective R. (mm)
1	3.6	1.98	1.8	0.99	0.9	0.50
2	3.8	2.09	1.9	1.05	1.0	0.55
3	4.0	2.20	2.0	1.10	1.0	0.55
4	4.3	2.37	2.2	1.21	1.1	0.61
5	4.6	2.53	2.3	1.27	1.2	0.66
6	5.1	2.81	2.6	1.43	1.3	0.72
7	5.6	3.08	2.8	1.54	1.4	0.77
8	6.4	3.52	3.2	1.76	1.6	0.88
9	7.5	4.13	3.8	2.09	1.9	1.05
10	9.3	5.12	4.7	2.59	2.4	1.32
11	13.4	7.37	6.8	3.74	3.4	1.87
12	57.5	31.63	29.2	16.06	14.6	8.03
13	18.4	10.12	9.3	5.12	4.7	2.59
14	10.9	6.00	5.5	3.03	2.8	1.54
15	8.3	4.57	4.2	2.31	2.1	1.16
16	6.9	3.80	3.5	1.93	1.7	0.94
17	6.0	3.30	3.0	1.65	1.5	0.83
18	5.3	2.92	2.7	1.49	1.3	0.72
19	4.8	2.64	2.4	1.32	1.2	0.66
20	4.4	2.42	2.3	1.27	1.1	0.61
21	4.1	2.26	2.1	1.16	1.0	0.55
22	3.9	2.15	2.0	1.10	1.0	0.50
23	3.7	2.04	1.9	1.05	0.9	0.50
24	3.5	1.93	1.8	0.99	0.9	0.50
Total	205.0	112.75	104.0	57.20	52.0	28.60

Table B.2.3 (2) Design Rainfall in Watershed of Rio Barbilla

Time	1st Day		2nd Day		3rd Day	
(hr)	Rainfall (mm)	Effective R. (mm)	Rainfall (mm)	Effective R. (mm)	Rainfall (mm)	Effective R. (mm)
1	3.2	1.76	1.7	0.94	1.0	0.55
2	3.4	1.87	1.8	0.99	1.0	0.55
3	3.6	1.98	1.9	1.05	1.1	0.61
4	3.9	2.15	2.0	1.10	1.2	0.66
5	4.2	2.31	2.2	1.21	1.3	0.72
6	4.6	2.53	2.4	1.32	1.4	0.77
7	5.1	2.81	2.6	1.43	1.6	0.88
8	5.8	3.19	3.0	1.65	1.8	0.99
9	6.8	3.74	3.5	1.93	2.1	1.16
10	8.5	4.68	4.4	2.42	2.6	1.43
11	12.2	6.71	6.3	3.47	3.7	2.04
12	52.5	28.88	26.9	14.80	16.0	8.80
13	16.8	9.24	8.6	4.73	5.1	2.81
14	9.9	5.45	5.1	2.81	3.0	1.65
15	7.6	4.18	3.9	2.15	2.3	1.27
16	6.3	3.47	3.2	1.76	1.9	1.05
17	5.4	2.97	2.8	1.54	1.7	0.94
18	4.8	2.64	2.5	1.38	1.5	0.83
19	4.4	2.42	2.3	1.27	1.3	0.72
20	4.1	2.26	2.1	1.16	1.2	0.66
21	3.8	2.09	1.9	1.05	1.1	0.61
22	3.5	1.93	1.8	0.99	1.1	0.61
23	3.3	1.82	1.7	0.94	1.0	0.55
24	3.2	1.76	1.6	0.88	1.0	0.55
Total	187.0	102.85	96.0	52.80	57.0	31.35

4) Flood Discharge of River

Based on the obtained distribution ratio of discharge and areal rainfall, hourly design flood discharges of Rio Chirripo and Barbilla are tabulated in Table B.2.4 (1) and B.2.4 (2) respectively.

The design flood discharge of Rio Matina is obtained by counting up these of above rivers, and the peak flood discharge, 2,248 m^3/s, occurs in 18th hour from the beginning of design rainfall.

Table B.2.4 (1) Design Flood Hydrograph - Rio Chirripo

DRAINAGE AREA = 1096.000Km2 BASE FLOW = 55.000m3/s

TIME	EFFECT. RAINFALL	DIRECT FLOW		BASE FLOW	RUNOFF
(HR)	(mm)	(mm)	(m3/s)	(m3/s)	(m3/s)
1.0	1.98 *	0.030	9.042	55.000	64.042
2.0	2.09 *	0.105	31.848	55.000	86.848
3.0	2.20 *	0.213	64.935	55.000	119.935
4.0	2.37 *	0.346	105.463	55.000	160.463
5.0	2.53 *	0.498	151.677	55.000	206.677
6.0	2.81 *	0.664	202.090	55.000	257.090
7.0	3.08 *	0.842	256.406	55.000	311.406
8.0	3.52 *	1.034	314.707	55.000	369.707
9.0	4.13 *	1.245	379.094	55.000	434.094
10.0	5.12 *	1.487	452.648	55.000	507.648
11.0	7.37 *	1.787	544.143	55.000	599.143
12.0	31.63 *	2.514	765.340	55.000	820.340
13.0	10.12 *	3.486	1061.440	55.000	1116.440
14.0	6.08 *	4.299	1308.930	55.000	1363.930
15.0	4.57 *	4.894	1489.930	55.000	1544.930
16.0	3.86 *	5.299	1613.170	55.000	1668.170
17.0	3.30 *	5.516	1679.250	55.000	1734.250
18.0	2.92 *	5.601	1705.090	55.000	1760.090
19.0	2.64 *	5.570	1695.790	55.000	1750.790
20.0	2.42 *	5.484	1669.600	55.000	1724.600
21.0	2.26 *	5.332	1623.240	55.000	1678.240
22.0	2.15 *	5.123	1559.700	55.000	1614.700
23.0	2.04 *	4.913	1495.820	55.000	1550.820
24.0	1.93 *	4.691	1428.070	55.000	1483.070
25.0	0.99 *	4.420	1345.700	55.000	1400.700
26.0	1.05 *	4.149	1263.160	55.000	1318.160
27.0	1.10 *	3.894	1185.420	55.000	1240.420
28.0	1.21 *	3.617	1101.280	55.000	1156.280
29.0	1.27 *	3.366	1025.280	55.000	1080.280
30.0	1.43 *	3.136	954.601	55.000	1009.600
31.0	1.54 *	2.942	895.761	55.000	950.761
32.0	1.76 *	2.747	836.406	55.000	891.406
33.0	2.09 *	2.588	791.081	55.000	846.081
34.0	2.59 *	2.484	756.149	55.000	811.149
35.0	3.74 *	2.441	743.100	55.000	798.100
36.0	16.06 *	2.610	794.503	55.000	849.503
37.0	5.12 *	2.940	894.936	55.000	949.936
38.0	3.83 *	3.205	975.827	55.000	1030.830
39.0	2.31 *	3.374	1027.110	55.000	1082.110
40.0	1.93 *	3.458	1052.790	55.000	1107.790
41.0	1.65 *	3.482	1060.220	55.000	1115.220
42.0	1.49 *	3.428	1043.610	55.000	1098.610
43.0	1.32 *	3.322	1011.210	55.000	1066.210
44.0	1.27 *	3.218	979.663	55.000	1034.660
45.0	1.16 *	3.070	934.718	55.000	989.718
46.0	1.10 *	2.923	889.763	55.000	944.763
47.0	1.05 *	2.784	847.516	55.000	902.516
48.0	0.99 *	2.641	804.160	55.000	859.160
49.0	0.50 *	2.454	747.055	55.000	802.055
50.0	0.55 *	2.291	697.345	55.000	752.345
51.0	0.55 *	2.142	652.117	55.000	707.117
52.0	0.61 *	1.986	604.669	55.000	659.669
53.0	0.66 *	1.847	562.282	55.000	617.282
54.0	0.72 *	1.717	522.740	55.000	577.740
55.0	0.77 *	1.609	489.784	55.000	544.784
56.0	0.88 *	1.501	457.029	55.000	512.029
57.0	1.05 *	1.416	431.230	55.000	486.230
58.0	1.32 *	1.350	411.076	55.000	466.076
59.0	1.87 *	1.318	401.340	55.000	456.340
60.0	8.03 *	1.368	416.340	55.000	471.340
61.0	2.59 *	1.528	462.622	55.000	517.622
62.0	1.54 *	1.646	501.152	55.000	556.152
63.0	1.16 *	1.725	525.316	55.000	580.316
64.0	0.94 *	1.763	536.708	55.000	591.708
65.0	0.83 *	1.771	539.095	55.000	594.095
66.0	0.72 *	1.739	529.386	55.000	584.386
67.0	0.66 *	1.681	511.841	55.000	566.841
68.0	0.61 *	1.625	494.774	55.000	549.774
69.0	0.55 *	1.547	470.915	55.000	525.915
70.0	0.55 *	1.469	447.159	55.000	502.159
71.0	0.50 *	1.395	424.846	55.000	479.846
72.0	0.50 *	1.321	402.092	55.000	457.092
73.0	0.00 *	1.222	372.043	55.000	427.043
74.0	0.00 *	1.130	344.047	55.000	399.047
75.0	0.00 *	1.041	317.054	55.000	372.054
76.0	0.00 *	0.946	288.114	55.000	343.114
77.0	0.00 *	0.857	260.952	55.000	315.951
78.0	0.00 *	0.771	234.693	55.000	289.693
79.0	0.00 *	0.694	211.315	55.000	266.315
80.0	0.00 *	0.616	187.623	55.000	242.623
81.0	0.00 *	0.547	166.641	55.000	221.641
82.0	0.00 *	0.484	147.284	55.000	202.284
83.0	0.00 *	0.430	130.802	55.000	185.802
84.0	0.00 *	0.362	110.215	55.000	165.215
85.0	0.00 *	0.315	95.757	55.000	150.757
86.0	0.00 *	0.274	83.552	55.000	138.552
87.0	0.00 *	0.239	72.622	55.000	127.622
88.0	0.00 *	0.206	62.731	55.000	117.731
89.0	0.00 *	0.183	55.659	55.000	110.659
90.0	0.00 *	0.157	47.700	55.000	102.700
91.0	0.00 *	0.132	40.315	55.000	95.315
92.0	0.00 *	0.116	35.273	55.000	90.273
93.0	0.00 *	0.097	29.415	55.000	84.415
94.0	0.00 *	0.085	25.768	55.000	80.768
95.0	0.00 *	0.075	22.861	55.000	77.861
96.0	0.00 *	0.066	20.188	55.000	75.188
97.0	0.00 *	0.053	16.245	55.000	71.245
98.0	0.00 *	0.047	14.178	55.000	69.178
99.0	0.00 *	0.042	12.665	55.000	67.665
100.0	0.00 *	0.038	11.438	55.000	66.438
101.0	0.00 *	0.034	10.446	55.000	65.446
102.0	0.00 *	0.031	9.582	55.000	64.582
103.0	0.00 *	0.029	8.728	55.000	63.728
104.0	0.00 *	0.027	8.107	55.000	63.107
105.0	0.00 *	0.024	7.450	55.000	62.450
106.0	0.00 *	0.023	6.880	55.000	61.880
107.0	0.00 *	0.020	6.144	55.000	61.144
108.0	0.00 *	0.012	3.547	55.000	58.547
109.0	0.00 *	0.009	2.606	55.000	57.606
110.0	0.00 *	0.007	2.137	55.000	57.137
111.0	0.00 *	0.006	1.784	55.000	56.784
112.0	0.00 *	0.005	1.498	55.000	56.498
113.0	0.00 *	0.004	1.245	55.000	56.245
114.0	0.00 *	0.003	1.026	55.000	56.026
115.0	0.00 *	0.003	0.825	55.000	55.825
116.0	0.00 *	0.002	0.639	55.000	55.639
117.0	0.00 *	0.002	0.472	55.000	55.472
118.0	0.00 *	0.001	0.304	55.000	55.304
119.0	0.00 *	0.001	0.152	55.000	55.152

Table B.2.4 (2) Design Flood Hydrograph - Rio Barbilla

DRAINAGE AREA = 269.000Km2 BASE FLOW = 13.500m3/s

TIME (HR)	EFFECT. RAINFALL (mm)	DIRECT FLOW (mm)	DIRECT FLOW (m3/s)	BASE FLOW (m3/s)	RUNOFF (m3/s)
1.0	1.76 *	0.060	4.471	13.500	17.971
2.0	1.87 *	0.203	15.140	13.500	28.640
3.0	1.98 *	0.391	29.220	13.500	42.720
4.0	2.15 *	0.601	44.932	13.500	58.432
5.0	2.31 *	0.822	61.441	13.500	74.941
6.0	2.53 *	1.046	78.147	13.500	91.647
7.0	2.81 *	1.274	95.204	13.500	108.704
8.0	3.19 *	1.511	112.933	13.500	126.433
9.0	3.74 *	1.768	132.089	13.500	145.589
10.0	4.68 *	2.066	154.403	13.500	167.903
11.0	6.71 *	2.467	184.346	13.500	197.846
12.0	28.83 *	3.710	277.210	13.500	290.710
13.0	9.24 *	5.304	396.313	13.500	409.813
14.0	5.45 *	6.329	472.893	13.500	486.393
15.0	4.18 *	6.798	507.941	13.500	521.441
16.0	3.47 *	6.888	514.707	13.500	528.207
17.0	2.97 *	6.691	499.967	13.500	513.467
18.0	2.64 *	6.355	474.822	13.500	488.322
19.0	2.42 *	5.925	442.692	13.500	456.192
20.0	2.26 *	5.451	407.325	13.500	420.825
21.0	2.09 *	4.981	372.183	13.500	385.683
22.0	1.93 *	4.549	339.919	13.500	353.419
23.0	1.82 *	4.125	308.200	13.500	321.700
24.0	1.76 *	3.752	280.385	13.500	293.885
25.0	1.27 *	3.387	253.120	13.500	266.620
26.0	1.32 *	3.067	229.178	13.500	242.678
27.0	1.38 *	2.770	207.013	13.500	220.513
28.0	1.43 *	2.523	188.521	13.500	202.021
29.0	1.54 *	2.330	174.122	13.500	187.622
30.0	1.65 *	2.171	162.241	13.500	175.741
31.0	1.76 *	2.044	152.748	13.500	166.248
32.0	1.93 *	1.970	147.218	13.500	160.718
33.0	2.20 *	1.933	144.467	13.500	157.967
34.0	2.59 *	1.937	144.759	13.500	158.259
35.0	3.36 *	2.000	149.428	13.500	162.928
36.0	3.19 *	2.331	174.196	13.500	187.696
37.0	3.95 *	2.748	205.323	13.500	218.823
38.0	2.86 *	3.035	226.775	13.500	240.275
39.0	2.37 *	3.169	236.786	13.500	250.286
40.0	2.84 *	3.187	238.146	13.500	251.646
41.0	1.82 *	3.092	231.055	13.500	244.555
42.0	1.71 *	2.963	221.848	13.500	235.348
43.0	1.60 *	2.818	210.569	13.500	224.069
44.0	1.49 *	2.652	198.153	13.500	211.653
45.0	1.38 *	2.482	185.479	13.500	198.979
46.0	1.32 *	2.321	173.415	13.500	186.915
47.0	1.27 *	2.162	161.560	13.500	175.060
48.0	1.21 *	2.019	150.838	13.500	164.338
49.0	0.72 *	1.867	139.478	13.500	152.978
50.0	0.77 *	1.716	128.210	13.500	141.710
51.0	0.83 *	1.571	117.412	13.500	130.912
52.0	0.83 *	1.445	107.968	13.500	121.468
53.0	0.88 *	1.340	100.106	13.500	113.606
54.0	0.99 *	1.255	93.773	13.500	107.273
55.0	1.05 *	1.190	88.943	13.500	102.443
56.0	1.16 *	1.151	86.034	13.500	99.534
57.0	1.32 *	1.135	84.805	13.500	98.305
58.0	1.54 *	1.143	85.425	13.500	98.925
59.0	1.98 *	1.186	88.586	13.500	102.086
60.0	5.45 *	1.380	103.137	13.500	116.637
61.0	2.53 *	1.638	122.422	13.500	135.922
62.0	1.71 *	1.816	135.713	13.500	149.213
63.0	1.38 *	1.897	141.782	13.500	155.282
64.0	1.21 *	1.907	142.504	13.500	156.004
65.0	1.10 *	1.857	138.747	13.500	152.247
66.0	0.96 *	1.779	132.940	13.500	146.440
67.0	0.94 *	1.682	125.678	13.500	139.178
68.0	0.88 *	1.578	117.906	13.500	131.406
69.0	0.83 *	1.474	110.148	13.500	123.648
70.0	0.77 *	1.376	102.830	13.500	116.330
71.0	0.77 *	1.281	95.743	13.500	109.243
72.0	0.72 *	1.196	89.381	13.500	102.881
73.0	0.00 *	1.092	81.570	13.500	95.070
74.0	0.00 *	0.968	72.301	13.500	85.801
75.0	0.00 *	0.836	62.459	13.500	75.959
76.0	0.00 *	0.710	53.066	13.500	66.566
77.0	0.00 *	0.597	44.576	13.500	58.076
78.0	0.00 *	0.495	37.023	13.500	50.523
79.0	0.00 *	0.406	30.348	13.500	43.848
80.0	0.00 *	0.332	24.791	13.500	38.291
81.0	0.00 *	0.269	20.118	13.500	33.618
82.0	0.00 *	0.216	16.177	13.500	29.677
83.0	0.00 *	0.172	12.838	13.500	26.338
84.0	0.00 *	0.138	10.318	13.500	23.818
85.0	0.00 *	0.108	8.045	13.500	21.545
86.0	0.00 *	0.086	6.401	13.500	19.901
87.0	0.00 *	0.068	5.089	13.500	18.589
88.0	0.00 *	0.054	4.037	13.500	17.537
89.0	0.00 *	0.039	2.937	13.500	16.437
90.0	0.00 *	0.029	2.187	13.500	15.687
91.0	0.00 *	0.022	1.642	13.500	15.142
92.0	0.00 *	0.017	1.237	13.500	14.737
93.0	0.00 *	0.012	0.912	13.500	14.412
94.0	0.00 *	0.009	0.657	13.500	14.157
95.0	0.00 *	0.006	0.478	13.500	13.978
96.0	0.00 *	0.005	0.350	13.500	13.850
97.0	0.00 *	0.003	0.231	13.500	13.731
98.0	0.00 *	0.002	0.169	13.500	13.669
99.0	0.00 *	0.001	0.111	13.500	13.611
100.0	0.00 *	0.001	0.054	13.500	13.554

B.2.2 Sedimentation of Canal del Tortuguero

The amount of sedimentation changes before and after the completion of the Project. This causes by the increment of flood flowing down to the downstream without overtopping from new river bank to be constructed.

Based on the discharge data obtained at the stream gauging stations of Rio Chirripo and Rio Barbilla, the daily discharge of Rio Matina during latest three years, 1982 to 1984, is estimated. Using these data and the drainage capacity of Rio Matina, the overflow discharge in present status is estimated. As a result, the amount of overflow discharge for these three years corresponds to 3 % of total amount of discharge composing of bigger discharge than average daily discharge. Namely, after completion of the project, the flood concentrating to the down-stream will become 1.03 times as much as that of present status. (See Table B.2.5) Accordingly, the increment of sedimentation also will become 1.03 times as much as that of present status.

As to the erosion of the Study Area, though it is fact that the Area become erosionable by the development, the change on this subject after completion of the Project is very little because of the gently gradient in topography and soil texture with little particle. Accordingly, the design yield of soil erosion is adopted as the value of $100m^3/Km^2/year$.

Table B.2.5 Overflow Discharge of Rio Matina

Year	1982				1983				1984			
	Sum of Mean Daily Discharge 1)	Sum of Mean Daily Discharge of more than Average Discharge 2)	Sum of Overflow Discharge 3)	Number of Overflow	Sum of Mean Daily Discharge	Sum of Mean Daily Discharge of more than Average Discharge	Sum of Overflow Discharge	Number of Overflow	Sum of Mean Daily Discharge	Sum of Mean Daily Discharge of more than Average Discharge	Sum of Overflow Discharge	Number of Overflow
Month	$m^3/s/mon$	$m^3/s/mon$	$m^3/s/mon$	times/mon	$m^3/s/mon$	$m^3/s/mon$	$m^3/s/mon$	times/mon	$m^3/s/mon$	$m^3/s/mon$	$m^3/s/mon$	times/mon
Jan.	4,818	4,131	-	-	2,750	781	-	-	5,197	3,751	-	-
Feb.	2,992	0	-	-	1,365	0	-	-	2,110	630	26	1
Mar.	3,101	269	-	-	2,532	844	64	1	2,983	1,508	120	1
Apr.	2,795	0	-	-	1,261	0	-	-	994	0	-	-
May	4,404	2,883	-	-	3,041	550	-	-	2,098	452	-	-
Jun.	6,392	6,392	-	-	2,959	140	-	-	3,104	887	-	-
Jul.	9,960	9,960	1,531	2	3,030	263	-	-	3,366	1,023	-	-
Aug.	5,143	4,534	-	-	3,482	1,261	-	-	5,267	4,723	-	-
Sep.	4,305	3,494	-	-	3,786	2,325	-	-	4,492	4,019	-	-
Oct.	5,622	5,622	-	-	5,119	4,885	-	-	4,552	2,975	-	-
Nov.	4,410	3,572	-	-	5,043	3,690	-	-	4,854	4,181	-	-
Dec.	2,723	0	-	-	2,550	0	-	-	6,181	4,556	773	3
Total	56,465	40,857	1,531	2	36,918	14,739	64	1	45,198	28,705	919	5

(Notes) 1) 1.33 x (Daily Discharge at playa Hermosa) + 1.20 x (Daily Discharge at Barbilla)
2) Average discharge for three years, 1982-1984 : 126.4 m^3/s
3) (Mean daily discharge) - (Drainage Capacity of Rio Matina : 418m^3/s)

B.3 Quality of Well-Water

Table B.3.1 Location of Selected Well for Water Analysis

No.	Location	Depth of Well (m)	Assortment of Utilization
1	Matina	41	Common
2	Cuatro Millas	2.5	Private
3	Hilda(1)	6.0	Private
4	Margarita	3.0	Private
5	Luzon	1.6	Private
6	Leite	Deep Well	Common
7	Berta	4.8	Private
8	Sara Norte	1.9	Private
9	Davao	18	Common
10	28 Millas	Spring Water	Common
11	Hilda (2)	3.0	Private
12	Santa Marta	39	Common
13	Bataan	Deep Well	Common
14	Sara	-	Private

(Note) The sampling of No. 1 to No. 10 was achieved in Feb.,'88 and of No. 11 to No. 14 in Jul., '87.

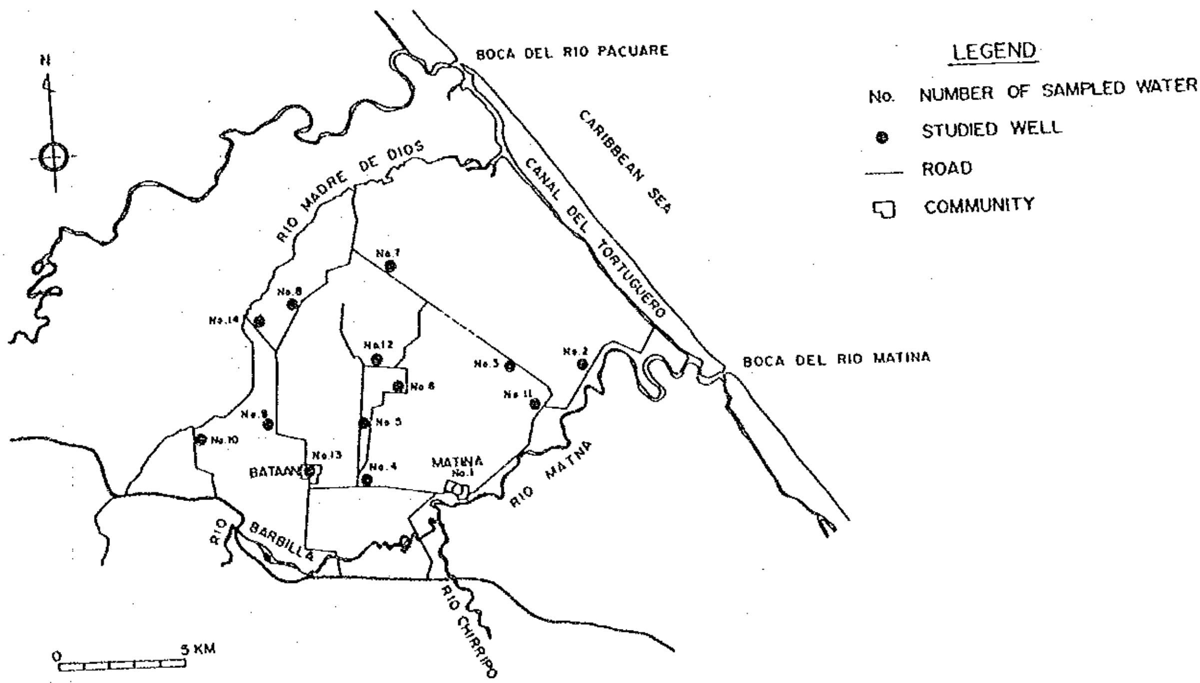


Fig. B.3.1 Location of Studied Well

Table B.3.2 Analysis of Well Water

Substance	Unit	WHO Standard	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13	No. 14
PH		7.0～8.5 (6.5～9.2)	7.85	7.30	6.60	7.00	6.85	8.10	6.70	6.75	8.05	7.70	6.53	7.78	7.84	6.96
Colour	TCU	15*	0	22	22	2	2	5	2	8	2	0	45	2	2	2
Turbidity	NTU	5*	0.32	5.0	7.3	1.6	0.44	0.34	0.84	2.0	0.14	0.22	5.0	10.0	2.0	7.5
Total Hardness	mg/l	100～500*	170	435	222	152	114	50	99	94	82	71	-	-	-	-
Iron (Fe)	mg/l	0.3(1.0)*	0.24	0.81	1.1	0.37	0.28	0.19	0.59	0.19	0.0	0.5	0.11	0.07	0.07	0.07
Sulphate (SO_4)	mg/l	400*	12	0	6	0	4	0	3	0	2	0	-	-	-	-
Chloride (Cl)	mg/l	200(400)	7	31	14	20	11	11	13	8	5	6	-	-	-	-
Fluoride (F)	mg/l	1.0(1.5)	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	<0.1	< 0.1	< 0.1	<0.1	< 0.1	0.26	0.22	0.20	0.32
Nitrate ($N-NO_3$)	mg/l	40(80)	5.4	1.7	2.9	2.0	2.5	<1.0	< 1.0	< 1.0	<1.0	1.0	-	-	-	-
Coliform Group	groups	nil in 50ml	Neg.	> 2400	> 2400	> 2400	> 2400	7	> 2400	> 2400	Neg.	Neg.	>24000	6700	1	>24000

(Notes)
* : For guide Line, ( ) : Max. allowable values

Annex C Soils

Annex C. Soils

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C.1 General

The data, on which the explanation in the main report base, are presented in detail. The values measured on the physical and chemical properties of the soil samples are compared among the soil families, but the comparisons among the soil series are forced to be omitted, because enough sample size to compare them could not be obtained. Besides, some supplemental explanations on the land classification and soil management are mentioned.

C.2 Method of Investigation

Soil survey was conducted using a 1:50,000 scaled base map, by investigations on soil profiles of 10 pits and boring checks of 62 points with an auger. Thus, the surveyed points in the Area amount to be 82 in all, 20 pits including 10 pits at the Master Plan Study, and 62 boring points, as indicated in Fig. C.2.1.

Soil samples, amounted to 89, taken by a core-sampler from each horizon at the pits, but only from the surface layer (about 30 cm at the boring points, "Three phases of soil", rate of solid, moisture and air phases in certain volume, and from which values of bulk density and water content by weight were calculated. Thirty samples taken from 10 pits in this survey were determined for their chemical properties, and 52 samples, including 22 boring samples were estimated for their particle size distributions, at the research institutions in Costa Rica, with their established method.

C.3 Description of Soil Profiles

All observations are conducted on the moist soils. Descriptions on structures are used the abbreviations below and properties of soil profiles are illustrated in Fig. C.3.2.

Shape : sAB for subangular blocky
Ma for massive
Grade : W for weak, M for moderate and S for strong
Size : F for fine, M for Medium, C for coarse

Example ; WM - sAB : Weak medium subangular blocky
MM - sAB : Moderate medium subangular blocky
SC - sAB : Strong coarse subangular blocky

Soil horizon designation used is based on FAO's Revised Guideline FAO, Guidelines for Soil Profile Description, 2nd ed., pp.18-23 (1977)

No.73 : Camino Dond; Matina, Elevation: 12m Vegetation: A cacao garden

A_{11} : 0-16cm ; brownish black (10YR3/2) SiCl, SC-sAB extremely hard, firm in the friability sticky, common in organic matter, no mottles, abundant of fine to medium roots - smooth gradual boundary.

A_{12} : 16-31cm ; dark brown (10YR3/4), LiC, SC-sAB extremely hard, firm in the friability, sticky, common in organic matter, no mottles, many of fine to medium roots, smooth gradual boundary.

B_{21} : 31-68 cm ; dull yellowish brown (10YR4.5/3) LiC, SC-sAB, extremely hard, very firm very sticky, few in organic matter, no mottles, common of fine roots, smooth gradual boundary.

B_{22} : 68-130 cm^{+} ; dull yellowish brown (10YR5/4), HC, MM-sAB, for other things very similar to horizon above.

Groundwater level: 130 cm

No.80: Near entrance; B-Line2, Matina; Elevation: 22 m, Glass land next to Cacao garden, the natural dike of Rio Barbilla.

A_{11} : 0-15cm: Yellowish gray (2.5Y4/1), SiCL, SC,SC,sAB, very hard, firm in friability, sticky, many organic matter, no mottles, many fine to medium roots, smoothly gradual boundary.

A_{12} : 15-30 cm: brown (7.5YR4/5), SiCL, SC-sAB, for other things very similar to horizon above, but common organic, matter.

B_2 : 30-98cm+ : brown (10YR4/5), SiC, MM-SAB, for other things similar to horizon above but no organic matter.

Groundwater level: >120 cm

No.76 : Davao, Bataan, 19 m in elevation,a grassland with rather dry condition.

A : 0-15 cm : brownish black (10&R 3/2), SiL, WM-SaB, hard, friable, sticky, common of organic matter, no mottles, many fine to medium roots, smoothly gradual boundary.

B_{21} : 15-25 cm : brown (10YR4/4), L, WM-SaB, very similar to horizon above for other things but very few organic matter.

B_{22} : 25-50 cm : brown (10yR4/4), SiCL, MM-sAB very hard, very friable, sticky, no mottles, clear boundary.

II C: 50-80 cm+ : brown (10YR4/4),S, no structure, abundant round stones (5-20 cm in long diameter).
Groundwater level : > 120 m.

No.17 : Sara, Bataan, 7 m in elevation, a rice field, standing water in depression.

Ap : 0-15 cm: dark brown (10YR2.5/3), CL, MM-sAB, very hard, friable, sticky, common of organic matter, faint few of Fe mottles many fine roots smoothly gradual.

B_2 : 15-70+ : brown (10YR4/4), SiL, MM-sAB, very similar to horizon above but almost no organic matter.
Groundwater level: 70 cm

No.28 : Barro Matina Norte, 4 m in elevation, grazing grassland with big trees. Natural dike of Rio Matina, good drainage.

A_{11} : 0-11 cm: dark grayish yellow (2.5Y3.5/2), SiCL, SM-sAB, very hard, friable,sticky, common of organic matter, faint few of the Fe mottles, many fine roots, smoothly gradual boundary.

A_{12} : 11-34 cm: yellowish brown (25Y4.5/5), SiL, SM-sA very similar to horizon above but color, and texture.

A_{13}: 34-51 cm: yellowish brown (2.5Y5/3.5), SiL, WM-sAB, very similar to horizon above but weakly developed structure.

IIAB: 51-97cm+: yellowish brown (2.5Y4.5/3.0), L, WM-sAB, hard, friable, sticky, faint few of Fe mottles.
Nearly similar to horizon above but texture.
Groundwater level: 97 cm

No. 37 : ASBANA, 17 m in elevation, Grassland ("Gamalote") natural dike of Rio Madre de Dios, good drainage.

A_{11} : 0-14 cm: dark brown (10YR 3.5/3.5), SiCL, MM-sAB, slightly hard, friable, sticky, common of organic matter, faint, few Fe mottles, abundant fine to medium roots smooth, clear boundary.

A_{12} : 14-20 cm grayish yellow (2.5Y4.5/2), SiCL, MM-SAB, very hard, friable, sticky, few of organic matter, faint but common Fe mottles (dark reddish brown 5YR3/3) many of fine to medium roots smooth clear boundary.

A_{13} : 20-51 cm: dark grayish yellow (2.5Y5/1.5), SiCL, MM-sAB. Very similar to horizon above but harder and common of fine to medium roots.

B_{21} : 51-80 cm: dull yellowish brown (10YR4.5/5), CL WM-SAB, very hard, friable, sticky, faint, distinct many Fe mottles (dark reddish brown), few of fine root, smoothly clear boundary.

B_{22} : 80-100cm : dull yellowish brown (10YR5/5), CL WM-sAB, very similar to horizon above but distinct abundant Fe mottles, of reddish

brown (5YR 4/6), smooth clear boundary.
I C: 100-105 cm+ : dull yellowish orange (10YR7/3), S, hard, loose in friability, no sticky, none structure distinct abundant Fe mottles.
Groundwater level : 105 cm

No.47 : ASBANA, 18 m in elevation, grassland (being growth of fruit trees next to this land inferior to No. 37)

A_{11} : 0-10 cm: Mixed(7:3) brownish block (10YR3.5/2) and brown gray (10YR5.5/1) CL, MM-sAB, hard friable, slightly sticky, common of organic matter, faint, few Fe mottles abundant of fine to medium roots. smooth and clear boundary.

A_{12} : 10-27 cm :dull yellowish brown (10YR5/3.5), CL, MM-SAB, few of organic matter, many of fine to medium roots, for other thins very similar to horizon above.

B_{21} : 27-46 cm: Mixed (1:1) of graynish yellow brown (10YR5/2), CL, MM-SAB, Many, dull reddish brown (5YR4/4.5) Fe and many, brown black (10YR2/2) Mn mottles, common fine roots, smooth gradual.

II B_{22}: 46-80 cm: very similar to horizon above but texture (SL), WM-SAB and abundant Mn.

B_{23}: 80-93 cm: similar to horizon above but colors increased brown gray (Mixed ratio: 1:2), Texture (L), Many orange (5YR5.5/8) Fe and common Mn mottles. Smooth clear boundary.

III C : 93-110 cm+: Sand abundant orange Fe mottles

Groundwater level: 110 cm

No. 54 : ED 13, Cocoa Experiment Station, Lola, 50 m in elevation, Grassland.

Ag : 0-20 cm : brownish black (10YR2/2.5), CL, MM-sAB, very hard, friable, sticky, common of organic matter, few of Fe and Mn mottles, abundant fine to medium roots, wave clear boundary.

Bg1 : 20-40 cm: grayish yellow brown (10YR4/2.5), CL, MM-sSAB, similar to horizon above but few of organic matter, common Fe and abundant Mn mottles and many fine roots, smooth gradual boundary.

Bg2 : 40-65 cm + : very similar to horizon about but texture (SiC), very sticky, WM-sAB and common fine roots.

Groundwater level : 65 cm

No.60 : North 2 Km from Matina, 9 m in elevation, grazing grassland next to banana garden, moderately good drainage.

A : 0-10 cm : brownish black (10YR3/2), SiC, SM-sAB very hard, friable, sticky, common of organic matter, few Fe and Mn mottles.
Many of fine to medium roots, smooth gradual boundary.

Bg1 : 10-37 cm: yellowish gray (2.5Y4.5/1), SiC, very similar to horizon above but common Fe and Mn mottles. Smoothly gradual boundary.

Bg2: 37-57 cm + : very similar to horizon above but texture (SL) many Fe and Mn mottles and common of fine roots.

Groundwater level: 57 cm

No. 66 : Near airport of Bataan. 11 m in elevation, grazing grassland with thin forestry. Wet on the surface.

Ag1 : 0-10 cm : brownish black (10YR3/2), CL, MM-sAB, hard, friable, sticky, common of organic matter, common Fe mottles, abundant fine to medium roots, smooth gradual boundary.

Ag2 : 10-23 cm: Mixed color (1:1) of dull yellowish brown (10YR4/3) and Olive black (7.5Y4/1), SiL, MM-sAB, similar to horizon above but many, dark reddish brown Fe and few Mn mottles and many fine to medium roots. Smooth gradual boundary.

Bg1 : 23-50 cm : brown (10YR 4/5), L, WS-sAB, hard, friable, slightly, stickly, Many Fe and common Mn mottles, common fine roots, smooth gradual boundary.

Bg2 : 50-75 cm: grayish brown (10YR4/2), L, very similar to horizon above but many Mn mottles and few fine roots.

Groundwater table: 75 cm

No. 20 : Belta de Matina, 4 m in elevation, grassland, standing water in the depression.

Ag : 0-19 cm : dark olive brown (2.5Y3.5/3), CL, MM-sAB, extremely hard, very friable, slightly sticky, common of organic matter, reddish brown (5YR4/6) many Fe mottles, many fine to medium roots, smooth clear boundary.

Bg1 : 19-39 cm : brown (10YR3.5/4), CL, WM-sAB, extremely hard, friable, sticky, faint few Fe mottles, few fine roots, smooth gradual boundary.

Bg2 : 3 9-73 cm+ : dull yellowish brown (10YR5/4), SL, WM-sAB, very hard, friable, sticky, faint, few Fe mottles, few fine roots.

Groundwater level: 73 cm

No. 10 : Belta de Matina, 5 m in elevation, grassland, standing water in the depression.

Ag1 : 0-5 cm : gray (7.5Y5/1), SiC, WS-sAB very hard, friable, very sticky, many of organic matter, abundant brown (7.5YR4/4) Fe and Mn mottlings, abundant fine to medium roots, smooth gradual boundary.

Ag2 : 5-13 cm: very similar to horizon above but texture (SiCL), color of Fe bright brown (7.5YR5/8) and MN brownish black (7.5YR2/2), smooth gradual boundary.

Bg1 : 13-30 cm: very similar to horizon above but texture (SiC)

Bg2 : 30-70 cm + : very similar to horizon above but increased gray in color (7.5Y6/1) and texture (SiCL)

Groundwater table : 70 cm

No. 12 : Sara Bataan 5 m in elevation, rice field, standing water in the depression.

Ap : 0-15 cm: dark brown (10YR3.5/2.5), LiC, MM-sAB, very hard, friable, slightly sticky, common of organic matter, faint, few Fe mottles, many fine roots, smooth gradual boundary.

Ag : 15-22 cm : greenish gray (7.5GY5/1), LiC, MM-sAB, very hard, friable slightly sticky, few Fe and Mn mottles, many fine roots, smooth clear boundary.

Bg : 22-48 cm : brown (10YR4/5), SiCL, WM-sAB, very hard, very friable, slightly sticky, very many Fe mottles, few vertical greenish gray (7.5 GY5/1) strips, common fine roots.

Groundwater level : 50 cm

No. 48 : 4 Km north from Bataan, 12 m in elevation, rice field, many standing water in depression.

Apg : 0-7 cm: dark grayish yellow (2.5Y4/2), SiC, WS-sAB, very hard, friable, sticky, many of organic matter, few Fe mottles, many fine roots, smooth gradual boundary.

Ag : 7-22 cm : Mix (2:1) of brownish gray (10YR4/1) and gray (10Y5/1), LiC, WS-sAB, extremely hard, friable, sticky,few, reddish brown

(2.5YR4/6) Fe mottles many fine roots, smooth gradual boundry

Bg1 : 22-42 cm: very similar to horizon above but texture (CL) and common Fe mottles.

Bg2 : 42-65 cm +: very similar to horizon above but texture (SiCL), very many dark olive (7.5Y4/3) to brown (7.5YR4/4) Fe and Mn mottles.

Groundwater level 65 cm

No. 42 : Santa Marta, 7 m elevation, grazing grassland, standing water in the depression

AG : 0-12 cm : greenish gray (7.5GY5/1), SiC, MM-sAB, hard, friable, sticky, many organic matter, common Fe mottles, many fine to medium roots, smooth gradual boundry

Bg : 12-60+ cm : greenish gray (7.5GY5/1), SiC, similar to horizon above but few organic matter, abundant brown to dull brown Fe and Mn mottles.

Groundwater level : 60 cm

No. 65 : Bataan, 12 m in elevation, grassland.

AG : 0-10 cm : greenish gray (7.5GY5/1), SiCL, MM-sAB hard friable, sticky, common organic matter, many Fe and common Mn mottles. Many fine roots, smooth gradual boundry

Bg : 10-70 cm + : very similar to horizon above but abundant brown Fe and Mn mottles.

Groundwater level : 70 cm

No. 56 : 3 km north from Bataan, 13 m in elevation, grazing grassland.

Ag : 0-20 cm: dark greenish gray (10GY4/1), CL, Ma, very hard, friable, sticky, common organic matter, many bright reddish brown (5YR5/8) Fe mottles, many fine roots, smooth gradual boundry.

G : 20-45 cm + : Bluish gray (10BG6/1), SiCL, Ma, very hard,friable, sticky, few organic matter, very many orange (5YR6/8) Fe mottles, common fine roots.

Groundwater level : 45 cm

No. 2 : Goschen, Bataan 3 m in elevation, grassland, 10 from canal

Ag : 0-10 cm: Mix (1:1) of gray (7.5Y5/1) and brown (7.5YR4/4), LiC, WM-sAB, hard, friable, sticky, many organic matter, very many Fe and Mn mottles, many fine roots, smooth gradual boundry.

Bg : 10-30 cm + : Mix (7:3) of gray (7.5Y5/1) and brown (7.5YR4/4), WM-sAB, common organic matter, very many Fe and Mn mottles.

Groundwater level : 30 cm

No. 3 : San Juan de Goschen, 6 m in elevation, rice field, standing water in depression

Ag : 0-20 cm: dark green gray (10GY4/1), LiC, Ma, hard, friable, sticky, few organic matter, many, bright reddish (5YR5/8) Fe mottles, many fine roots, smooth gradual boundry.

G : 20-37 cm + : bluish gray (7.5GY5/1), HC, Ma hard, friable, sticky, few organic matter, very many, orange (5YR6/8) Fe and many Mn mottles, common fine roots.

Groundwater level : 37 cm

No. 26 : Barro Matina Norte, 4 m in elevation, back low land of Rio Matina, rice field, standing water.

Apg : Mix (1:1) of bluish gray (7.5 GY5/1) and brown (7.5YR4/4), SiC, Na, hard friable, sticky, common organic matter, few Fe mottles, many fine roots, smooth gradual boundry.

G1 : 10-40 cm: bluish gray (7.5GY5/1), SiCL, Na similar to horizon above but many Fe mottles.

G2 : 40-63 cm + : very similar to horizon above but very many Fe mottles.

Groundwater level : 63 cm

C.4 Soil Texture and Particle Size Distribution

Elevation, groundwater level and soil texture of the surveyed points are shown in Table C.4.1. The particle sie distributions are shown in Table C.4.2. The difference among the soil families are shown in table C.4.3 with summarized values.

As for the difference of soil textures among the soil families, the fine and very fine textures increase in proportion to the imperfect drainage as the family b, c, d and e, while the medium texture decrease inversely. However, for the family a, in spite of having the good drainages, the fine and very fine textures occupy dominant, indicate the importance of the development of soil structure for the drainage.

For the percentages of each particle size are in the order of their size bellow:

(1)Sand (%)

For the surface soil : c(35), b(33), e(32), d(28), a(25)
For the sub-soil : b(44), C(40), e(24), a(19)

For the surface soil, the difference is very small while for the sub soil, rather large, and the deviation in family a is also large.

(2)Silt (%)

For the surface soil: a(53), b(44), d(44), c(42), e(41)
For the sub-soil : a(55), e (46), c(42), b(41)

For the surface soil, the differences are small like sand percentage, with the exception of the family a, but for the sub-soil, the same tendencies as the surface soil. The family a soils are very silty.

(3) Clay (%)

For the surface soil: d(28), e(27), b(24), c(23), a(22)
For the sub-soil : e(30), a(26), c(19), b(15)

The differences of clay percentage are larger than for sand and silt percentages in the surface soil, and the family d and e soils have larger values than the other groups, and the more remarkable differences are also seen in the sub-soil in proportion to the drainage except the family a. Thus, from the point of view of the particle size distribution, the parent materials of the family a are estimated to be clearly different from other four families.

C.5 The Three Phases of Soil, Water Saturation Degree, Water Content by Weight and Bulk Density

The values measured on these items have very close relations to the excess water in soil.

The measured values on the surface soils (almost correspond to A horizon) are shown in Table C.5.1, however, the values on each horizon in the pits are in Table C.5.2. The differences of these values among the soil families are summarized in Table C.5.3

The values for each item are in the order of their size below:

(1) Rate of solid phase (Sv)

For the surface soil : a(39), b(37), C(36), d(35), e(35)
For the sub-soil : c(43), a(41), b(40).

For the surface soil, the differences between the family a and the families c, d and e group are seen but with small one, for the family b intermediary values between them. For the sub-soil, the differences among the family seem to be rather small, although the values are unknown because of submerging condition. However, the values for sub-soil are clearly larger than the one for surface soil, indicating firm condition of the soil hardness in the lower layers.

(2) Rate of moisture phase (Mv)

For the surface soil : d(63), e(62), c(59), b(57), a(53)
For the sub-soil : a(55), b(55), c(54)

Although the differences among the families are clear for the surface soil, because of proportional and imperfect drainages, the differences are hardly seen for the sub-soil. This would indicate a very important characteristic for the behavior of water in soils of the Area.

(3)Water content by weight (Mo)

For the surface soil : e(69), d(68), c(64), b(60), a(53),
For the sub-soil : a(51), b(50), c(47)

The tendency of the differences among the families are almost same as for the Mv values for both soils.

(4)Water saturation degree (Mv/p)

For the surface soil : d(96), e(95), c(93), b(91), a(88)
For the sub-soil : c(95), a(92), b(91)

Although the differences are small, the tendency of the differences are as same as for the values of Mo in both soils

(5)Rate of air phase (Va)

For the surface soil : a(7.7), b(5.5), c(4.7), e(3.4), d(2.4),
For the subsoil : b (5.4), a(4.7), c(3.7)

The differences among the families are the largest in the three phases of soil in both soils and deviations of the values in a family are also the largest among the three phases, although the differences are larger for the surface soil.

(6)Porosity (P)

For the surface soil : e(65), d(65), c(64), b(63), a(61)
For the sub-soil : b(60), a(59), c(57)

The differences among the soil families are small for the surface soil except the family a, and for the sub-soil, the tendency is almost same as the one for the surface soil with the exception of the family c, having the smallest values which mean the firmer body in lower layer than other groups.

(7) Bulk density (d)

For the surface soil : a(1.05), b(1.00), c(0.96), d(0.94), e(0.93)
For the sub soil : c(1.15), a(1.10), b(1.10)

For the surface soil, the order of the values follows family a, b, c, d and e, because of proportional drainage of the soil and the quantities of organic matter and volcanic ash in the surface soils. From this result, the materials of the family a would be also estimated to be different from the other groups.

However, for the sub-soil, the differences among the families are hardly seen.

In Table C.5.4, the sample sizes divided depending on their bulk densities in three ranks and their percentages occupied in the total sized for each family are shown.

For the family a and b, the samples with less 0.89 in the bulk density occupy only 18 and 15% , while for the family d and e the values are 46 and 43% respectively.

For the family c, this value is 29%, intermediate between them. According to the definition of the volcanic ash soil, which has less than 0.85 in bulk density. The surface soil of the family d and e could contain far more volcanic ash than other families.

In table C.5.5, the relation of the bulk density divided in the three ranks and the three phases of soil and other items are presented. According to this data, the clear relations are observed between the bulk density and the rate of solid phase, moisture phase, the porosity and the water content by weight, but for the rate of air phase and water saturation degree, the relation does not always seem to be clear.

C.6 Chemical Property (Soil Fertility)

Results of the soil analysis for each horizon in the pits are shown in Table C.6.1 and C.6.2. The differences of the chemical properties in surface soil (A horizon) and Sub-soil (below B horizon) among the soil families are summarized in Table C.6.3 and C.6.4. Sample size for the family d is so small that the results for this family are arranged together with the one for the family e, having most similar conditions to the family d, as shown in these table.

However, since the sample sizes for the chemical properties are not seemed to be enough to compare the differences among the families, only some important things for soil management related to the chemical properties are mentioned as follows:

1) As for the plant disease, since the climate of the Area, high temperature and heavy rainfall, would hasten the spreading of several plant disease, keeping a healthy nutritive condition for plants would be required to increase the resistance against the diseases. Potassium deficiency caused by the base-unbalances, low natural supplying power of zinc, in some soils also

manganese and iron together, low available phosphorus contents caused by fixing of allophone from the volcanic ash and excess supply of nitrogen at the early stage of installing artificial drainage should be taken into consideration for appropriate nutrient controls.

2) As for physical properties of the soil. As shown in the description of the soil profiles in C.3, the soils of the Area are generally firm in spite of wet conditions. This hardness are thought to be resulted from the high degree of calcium saturation and rather high content of 2:1 type clay. However, this condition also would be apt to cause compaction in sub-soil by heavy loading on the land surface.

C.7 Land Classification

The soils in the Area, which is a plain in topography and secure against erosion, have no gravely to stony layers and rock beds to prevent growth of plants roots within about one meter in depth, with few exceptions. Moreover, their chemical properties are generally good for plant growth, being rich in plant nutrients excepting with few elements.

Therefore, the excess water in soil caused by frequent flood and imperfect natural drainage is estimated as the common and biggest problems to limit the landuse for agriculture.

Finally, effects of countermeasure for the flood and drainages could be the key to regulate the landuse, and remarkably increased capability for the landuse would be expected depending upon these effects. On these reasons, in the Main Report, the land classification after the land improvement as well as the one for the existing lands are mentioned.

C.8 Soil Management

Based on the informations already described in C3-C5, as the countermeasure for the excess water problems, the following items below should be taken into consideration.

1) Installing a usual drainage ditch would be in closer density than usual, special for the b-3 series and the family c soils, to exclude the water in surface soil rapidly and efficiently.

2) Introducing green manure plants with deep roots in cropping-systems should be achieved for the development of macro pores in subsoils, contributing to drainage.

3) For the clayey soils in the family b and c, culture of perennial crops such as fruit trees and cassava, of which cultivation do not need big machines, would be favorable;after drainage effects become to be visible, the bad effects of soil compaction caused by driving the machines will be available.

4) When introducing annual crops with using big machines for their culture, deep plaughing (at least about 30 cm in depth) would be desirable once in a few years.

5) Well rotting organic materials should be used for crop culture such as animal manures before the application would be desirable, not to intensify the reductive condition in soils, unfavorable one for the growth of upland crops, caused by the hasty decomposition of the materials.

Table C.4.1 Elevation, Groundwater Level and Texture of the Survey Points

Soil Series Asso.	Point No. *2)	Elevation m	G.W. *1)	Texture
a-1	36	3	d	SiC
	72	12	d	SiL
	73	12	d	SiCL
	78	16	m	CL
	80	22	d	SiCL
	81	17	d	SiL
	82	17	d	SiCL
a-2	74	19	d	L
	75	19	d	SiL
	76	19	d	SiL
	77	18	d	SiL
b-1	4	5	d	CL
	7	5	d	SiCL
	9	5	d	SiC
	11	8	d	SiCL
	17	7	m	CL
	23	8	d	CL
	28	3	d	SiCL
	29	4	d	SiL
	30	11	m	SiL
	37	17	d	SiCL
	47	18	d	CL
b-2	54	> 50	m	CL
	62	40	d	SiL
b-9	6	5	s	SiCL
	31	8	d	L
	41	8	m	SiL
	43	5	d	L
	44	4	d	SiL
	50	11	m	LiC
	51	8	d	L
	52	4	s	SiL
	53	4	d	SiL
	55	17	m	SiCL
	58	11	d	SiL
	60	9	m	SiC
	67	11	m	SiC
	69	7	m	CL
	71	12	d	SiL
c-1	61	7	m	SiCL
	68	8	d	SiL
	66	11	m	SiL
c-2	20	3	m	CL
	25	6	d	CL
	32	6	m	CL
	38	15	d	CL
	55	17	m	SiCL
	63	16	d	SiL
	64	16	d	SiL
	70	14	d	SiCL
c-3	8	5	d	C
	10	5	m	SiC
	12	5	s	LiC
	18	12	m	SiC
	39	11	s	SiL
	48	12	m	SiC
d-1	33	6	d	SiCL
	45	5	d	SiL
	49	11	m	SiCL
	57	11	m	SiC
	65	11	m	LiC
d-2	5	3	d	SiC
	13	4	m	LiC
	14	3	m	CL
	15	3	m	CL
	21	2	d	C
	24	7	d	SiCL
	42	7	m	SiC
e-1	16	7	m	SiCL
	19	4	s	SiCL
	27	3	m	SL
	56	13	s	CL
	79	19	s	SiCL
e-2	1	3	s	LiC
	2	3	s	LiC
	3	4	s	LiC
	22	8	m	CL
	26	4	m	SiC
	34	3	s	C
	35	5	s	SC
	40	12	s	CL
	46	7	s	SiL
	59	11	s	CL

Remarks: *1) Groundwater level:
Shallow (s): < 50 cm
Medium (m): 50 - 80 cm
Deep (d): > 80 cm

*2) Surveyed point No :Pit point

Table C.4.2 Composition of Particle Size (1)

Soil Family	Soil Series	Pit No.	Horizon (*)	Sand (%)	Silt (%)	Clay (%)	Texture
a	a-1	36	A (1)	19	55	26	SiC
		73	A_{11} + A_{12}(1)	16	60	24	SiCL
			B_{21} (2)	16	53	31	LiC
			B_{22} (3)	16	50	34	LiC
		80	A_{11} (1)	14	62	24	SiCL
			A_{12} (2)	16	60	24	SiCL
			B_2 (3)	2	68	30	SiC
		82	A (1)	19	56	25	SiCL
	a-2	75	A (1)	55	30	15	L
			A (1)	28	55	17	SiCL
		76	B_{21} (2)	48	37	15	L
			B_{22} (3)	16	61	23	SiCL
b	b-1	4	A (1)	33	42	25	CL
		7	A (1)	16	63	21	SiCL
		9	A (1)	20	51	29	SiC
		17	Ap (1)	39	41	20	CL
			B_2 (2)	41	51	8	SiL
		23	A (1)	39	38	23	CL
		28	A_{11} (1)	33	49	18	SiCL
			A_{12} (2)	31	59	10	SiL
			A_{13} (3)	38	57	5	SiL
			II AB (4)	58	39	3	L
		37	A_{11} + A_{12}(1)	33	49	18	SiCL
			A_{13} (2)	26	55	19	SiCL
			B_{21} + B_{22}(3)	44	39	17	CL
		47	A_{11} (1)	42	36	22	CL
			A_{12} (2)	49	29	22	CL
			B_{21} (3)	34	44	22	CL
			B_{22} (4)	74	17	9	SL
			B_{23} (5)	54	39	7	L
	b-2	54	Ag	34	41	25	CL
			Bg_1	42	41	17	CL
			Bg_2	26	45	29	SiCL
	b-3	50	A	46	19	35	LiCL
		55	A	32	47	21	LiC
		60	A	26	48	26	SiC
			Bg_1	24	50	26	SiC
			Bg_2	73	14	13	SL

*( ): Abbreviate the horizons indicating order in the profiles

Table C.4.2 Composition of Particle Size (2)

Soil Family	Soil Series	Pit No.	Horizon (*)	Sand (%)	Silt (%)	Clay (%)	Texture
c	c-1	61	Ag (1)	30	47	23	SiC
		66	Ag_1 (1) Ag_2 (2) Bg_1 (3) Bg_2 (4)	48 38 56 60	35 48 31 31	17 14 13 9	CL SiL L L
	c-2	20	Ag (1) Bg_1 (2) Bg_2 (3)	53 56 76	24 21 16	23 23 8	CL CL SL
		32	Ag (1)	43	38	19	CL
		38	Ag (1)	31	44	15	CL
		65	Bg (2)	27	40	29	LiC
		70	Ag_1 (1)	18	48	25	SiCL
	c-3	10	Ag_1 (1) Ag_2 (2) Bg_1 (3) Bg_2 (4)	30 16 22 18	52 46 52 64	30 24 26 18	SiC SiCL SiC SiCL
		12	Ap + Ag (1) Bg (2)	36 36	35 48	29 16	LiC SiCL
		18	Ag (1)	39	35	26	LiC
		48	Ag_1 (1) Ag_2 (2) Bg_1 (3) Bg_2 (4)	16 28 38 26	58 43 43 57	26 29 19 17	SiC LiC CL SiCL
d	d-1	45	Ag (1)	29	58	13	SiL
		5	Ag (1)	26	47	27	SiC
	d-2	13	AG (1)	39	23	38	LiC
		42	AG (1) Bg (2)	20 18	46 54	34 28	SiC SiC
e	e-1	56	Ag (1) G (2)	41 34	44 48	15 18	CL SiCL
		79	AG (1)	27	50	23	SiCL
		1	AG (1)	34	39	27	LiC
		2	Ag (1) Bg (2)	26 26	44 46	30 28	LiC SiC
		3	Ag (1) G (2)	24 29	32 22	44 49	LiC HC
		22	A	35	42	23	CL
		26	G_1 G_2	14 8	58 68	28 24	SiC SiCL
		35	AG	54	19	27	SC
		59	AG	31	43	26	CL

*( ): Abbreviate the horizons indicating order in the profiles

Table C.4.3 Summarized Composition of Particle Size in the Soil Family

Soil Family		Surface Soil			Sub-Soil		
		Sand (%)	Silt (%)	Clay (%)	Sand (%)	Silt (%)	Clay (%)
a	X̄	25.2	53.0	21.8	19.0	54.8	26.2
	SD	15.4	11.6	4.6	15.3	10.8	6.9
	SD／X̄	61.1	21.9	21.2	80.4	19.7	26.4
	n	6			6		
b	X̄	32.8	43.7	23.6	43.9	41.4	14.8
	SD	8.7	10.6	4.9	16.2	13.7	8.1
	SD／X̄	26.5	24.2	20.6	37.0	33.1	55.0
	n	12			12		
c	X̄	35.1	41.6	23.3	39.6	41.5	18.8
	SD	12.2	10.0	5.0	17.2	13.7	7.0
	SD／X̄	34.9	24.1	21.3	43.5	33.1	37.2
	n	10			10		
d	X̄	28.5	43.5	28.0	-	-	-
	SD	7.9	14.7	11.0	-	-	-
	SD／X̄	27.7	33.8	39.2	-	-	-
	n	4			-		
e	X̄	31.8	41.2	27.0	24.3	46.0	29.8
	SD	11.3	11.0	7.7	11.3	18.8	13.5
	SD／X̄	38.0	26.6	28.6	46.6	40.9	45.2
	n	9			4		

X̄: Mean, SD: Standard deviation, n : size of sample, SD／X̄ : %

Table C.5.1 Values of the Three Phase of Soil, Bulk Density and Water Saturation Degree (Surface soil) (1)

		Sv (%)	Mv (%)	Va (%)	P (%)	do	Mo (%)	Mv/P (%)
a-1	36	28.3	63.3	8.4	71.7	0.76	83.6	88.3
	72	32.1	54.0	13.9	67.9	0.86	62.6	79.5
	73	35.5	58.1	6.5	64.5	0.98	59.6	90.1
	78	35.1	50.4	14.5	64.9	0.94	53.6	77.7
	80	35.7	56.1	8.2	64.3	0.96	58.7	87.2
	81	41.8	53.3	4.9	58.2	1.12	47.6	91.6
	82	46.5	43.6	9.9	53.5	1.25	35.0	81.5
a-2	74	42.9	50.8	6.3	57.1	1.15	44.2	89.0
	75	44.3	52.2	3.5	55.7	1.19	43.9	93.7
	76	43.9	50.3	5.8	56.1	1.18	42.7	89.7
	77	44.0	53.8	2.2	56.0	1.18	45.6	96.1
b-1	4	37.9	57.1	5.0	62.1	1.02	56.3	91.9
	7	41.1	57.5	1.4	58.9	1.10	52.3	97.6
	9	38.2	61.0	0.8	61.8	1.02	59.6	98.7
	11	37.9	60.4	1.7	62.1	1.02	59.4	97.3
	17				N.D.			
	23	44.3	52.1	3.6	55.7	1.19	43.9	93.5
	28				N.D.			
	29	48.7	38.8	12.5	51.3	1.31	79.7	75.6
	30	40.1	58.6	1.3	59.9	1.07	54.6	97.8
	37	36.8	54.7	8.6	63.2	1.02	53.8	86.6
	47	36.2	54.8	9.1	63.8	1.00	54.9	85.9
b-2	54	36.2	58.1	5.7	63.8	0.97	59.8	91.1
	62	41.5	53.1	5.4	58.5	1.11	47.8	90.8
b-3	6	31.7	65.0	3.3	68.3	0.85	76.6	95.2
	31	40.0	53.6	6.4	60.0	1.07	50.0	89.3
	41	34.6	59.9	5.5	65.4	0.93	64.6	91.6
	43	36.0	57.1	6.9	64.0	0.97	59.2	89.2

Table C.5.1 Values of the Three Phase of Soil, Bulk Density and Water Saturation Degree (Surface soil) (2)

		Sv (%)	Mv (%)	Va (%)	P (%)	do	Mo (%)	Mv/P (%)
b-3	44	38.9	57.4	3.7	61.1	1.04	55.1	93.9
	50	31.5	54.0	4.5	68.5	0.84	64.0	78.8
	51	35.2	57.3	7.5	64.8	0.94	60.8	88.4
	52	37.7	60.0	2.3	62.3	1.01	59.4	96.3
	53	34.3	59.5	6.2	65.7	0.92	64.7	90.6
	55	29.6	69.7	0.7	70.4	0.79	87.9	99.0
	58	42.9	52.3	4.8	57.1	1.15	45.5	91.6
	60	35.0	61.1	3.9	65.0	0.94	65.1	94.0
	67	30.2	50.9	18.9	69.8	0.81	63.0	72.9
	69	34.4	63.0	2.6	65.6	0.92	68.3	96.0
	71	36.0	52.8	11.2	64.0	0.97	54.7	82.5
c-1	61	35.8	59.5	4.7	64.2	0.96	62.0	92.7
	68	41.2	57.8	1.0	58.8	1.10	52.4	98.3
	66	35.0	61.5	3.5	65.0	0.94	65.6	94.6
c-2	20	N.D.						
	25	33.9	52.7	13.4	66.1	0.91	58.0	79.7
	32	32.9	61.4	5.7	67.1	0.88	69.8	91.5
	38	45.5	48.7	5.8	54.5	1.22	39.9	89.4
	55	29.6	69.7	0.7	70.4	0.79	87.9	99.0
	63	40.8	52.2	7.0	59.2	1.09	47.8	88.2
	64	40.6	57.4	2.0	59.4	1.09	52.8	96.6
	70	41.4	54.7	3.9	58.6	1.11	49.3	93.3
c-3	8	36.9	59.8	3.3	63.1	0.99	60.5	94.8
	10			N.D. (Sub-soil only)				
	12	30.6	62.8	6.6	69.4	0.80	78.5	90.5
	18	26.0	69.0	5.0	74.0	0.70	99.0	93.2
	39	32.4	62.7	4.9	67.6	0.87	72.2	92.8
	48	35.3	61.5	3.2	64.7	0.95	64.9	95.1

Table C.5.1 Values of the Three Phases of Soil, Bulk Density and Water Saturation Degree (Surface soil) (3)

		Sv (%)	Mv (%)	Va (%)	P (%)	do	Mo (%)	Mv/P (%)
d-1	33	38.4	58.1	3.5	61.6	1.03	56.5	94.3
	45	41.7	55.3	3.0	58.3	1.12	49.5	94.9
	49	38.9	60.3	0.8	61.1	1.04	57.9	98.7
	57	39.7	59.2	1.1	60.3	1.06	55.6	98.2
	(65)	35.4	62.5	2.2	64.6	0.96	65.0	96.7
d-2	5	36.3	63.2	0.5	63.7	0.97	65.0	99.2
	13	32.3	63.3	4.4	67.7	0.87	73.2	93.5
	14	30.0	70.0	0.0	70.0	0.80	87.1	100.0
	15	31.8	63.5	4.7	68.2	0.85	74.5	93.1
	21	33.3	66.7	0.0	66.7	0.89	74.9	100.0
	24	33.8	60.2	6.0	66.2	0.91	66.4	90.9
	42	29.4	68.1	2.5	70.6	0.79	86.5	96.5
e-1	16	39.3	57.7	3.0	60.7	1.05	54.8	95.1
	19	37.7	61.3	1.0	62.3	1.01	60.7	98.4
	27	42.9	54.3	2.8	57.1	1.15	47.2	95.1
	56				N.D.			
	79	40.5	54.5	4.7	59.5	1.09	50.0	91.6
	1	25.9	70.9	3.2	74.1	0.70	102.0	95.7
	2	36.2	58.7	5.1	63.8	0.97	60.5	92.0
	3	36.0	61.6	2.4	64.0	0.95	64.7	96.3
	22	44.3	54.9	0.8	55.7	1.19	46.2	98.6
	26	31.4	65.1	3.5	68.6	0.84	77.4	94.9
	34	30.6	68.0	1.4	69.4	0.82	82.9	98.0
	35	29.6	64.2	6.2	70.4	0.79	81.1	91.2
	40	32.9	65.5	1.6	67.1	0.88	74.4	97.6
	46	34.0	55.3	10.7	66.0	0.91	60.7	83.8
	59	27.3	71.0	1.7	72.7	0.73	97.1	97.7

(the soil three phases are for sub-soil)

Table C.5.2 Values of the Three Phases of Soil Bulk Density and Water Saturation Degree (in each horizon) (1)

Soil family	Point No.	Hori-zon	Sv (%)	Mv (%)	A (%)	P (%)	do	Mo (%)	Mv/P (%)
a	73	1	35.5	58.1	6.5	64.5	0.98	59.6	90.1
		2	34.5	60.7	4.9	65.5	0.96	63.3	92.7
		3	35.6	61.8	2.7	64.4	0.97	63.8	96.0
	80	1	35.7	56.1	8.2	64.3	0.96	58.7	87.2
		2	40.0	53.8	6.2	60.0	1.07	50.2	89.7
		3	42.6	51.6	5.8	57.4	1.14	45.3	89.9
	76	1	43.9	50.3	5.8	56.1	1.18	42.7	89.7
		2	48.1	48.5	3.4	51.9	1.29	37.6	93.4
		3	43.8	51.2	5.0	56.2	1.17	43.6	91.1
b	37	1	36.8	54.7	8.6	63.2	1.02	53.8	86.6(90.4)
		2	40.2	54.9	5.0	59.8	1.12	49.3	91.8(91.5)
		3	38.1	55.1	6.9	61.9	1.09	50.6	89.0(89.4)
	47	1	36.2	54.8	9.1	63.8	1.00	54.9	85.9(86.4)
		2	40.6	52.1	7.4	59.4	1.14	45.9	87.7(88.1)
		3	36.8	59.5	3.8	63.2	1.01	58.7	94.1(94.0)
		4	40.2	52.2	7.7	59.8	1.15	45.6	87.3(87.6)
	54	1	36.2	58.1	5.7	63.8	0.97	59.8	91.1
		2	41.2	56.4	2.4	58.8	1.10	51.1	95.9
		3	41.6	54.8	3.6	58.4	1.11	49.2	93.8
	60	1	35.0	61.1	3.9	65.0	0.94	65.1	94.0
		2	41.6	51.8	6.6	58.4	1.11	46.5	88.7
		3	N.D.						

Table C.5.2 Values of the Three Phases of Soil Bulk Density and Water Saturation Degree (in each horizon) (2)

Soil family	Point No	Hori-zon	Sv %	Mv %	A %	P %	do	Mo %	Mv/P %
c	66	1	35.0	61.5	3.5	65.0	0.94	65.6	94.6
		2	43.6	49.3	7.1	56.4	1.17	42.2	87.4
		3	44.2	50.3	5.5	55.8	1.19	42.4	90.1
		4	43.7	50.8	5.5	56.3	1.17	43.4	90.2
	10	2	33.5	61.2	5.3	66.5	0.90	68.1	92.0
		3	41.8	55.8	2.4	58.2	1.12	49.8	95.9
		4	38.5	61.1	0.4	61.5	1.03	59.2	99.3
	12	1	30.6	62.8	6.6	69.4	0.80	78.5	90.5
		2	44.1	53.4	2.5	55.9	1.20	44.5	95.5
	48	1	35.3	61.5	3.2	64.7	0.95	64.9	95.1
		2	41.1	56.2	2.7	58.9	1.08	51.8	95.4
		3	45.4	50.2	4.4	54.6	1.22	41.1	91.9
		4	43.6	54.0	2.4	56.4	1.17	46.2	95.7
d	42	1	29.4	68.1	2.5	70.6	0.79	86.5	96.5
		2	36.6	56.8	6.6	63.4	0.97	58.7	89.6
e	2	1	36.2	58.7	5.1	63.8	0.97	60.5	92.0
	3	1	36.0	61.6	2.4	64.0	0.95	64.7	96.3(95.2)
	26	1	31.4	65.1	3.5	68.6	0.84	77.4	94.9

Table C.5.3 Summarized Values of the Three Phases of Soil, Bulk Density and Water Saturation Degree

Soil Layer	Soil Group		Sv (%)	Mv (%)	Va (%)	P (%)	do	Mo (%)	Mv/P (%)
Surface Soil		X̄	39.1	53.3	7.7	60.9	1.05	52.5	87.7
	a	sSD	6.0	5.0	3.9	6.0	0.16	13.3	5.8
	(n:11)	SD/X̄	15.3	9.4	50.6	9.9	15.2	16.3	6.6
		X̄	37.2	56.9	5.5	62.8	1.00	60.0	90.6
	b	SD	4.4	5.7	4.1	4.4	0.12	10.1	6.9
	(n:26)	SD/X̄	11.7	10.0	74.5	7.0	12.0	16.8	7.6
		X̄	37.9	59.4	4.7	64.1	0.96	64.0	92.6
	c	SD	4.4	5.8	3.1	5.3	0.14	15.8	4.7
	(n:15)	SD/X̄	11.7	9.8	66.0	8.3	14.6	24.7	5.1
		X̄	35.9	62.5	2.4	65.0	0.94	67.9	96.3
	d	SD	5.3	4.5	2.1	4.2	0.11	12.5	3.1
	(n:11)	SD/X̄	14.7	7.1	87.5	6.5	11.7	18.4	3.2
		X̄	35.1	61.6	3.4	65.1	0.93	68.6	94.7
	e	SD	4.2	6.0	2.6	5.7	0.15	17.8	4.0
	(n:14)	SD/X̄	11.9	9.7	76.5	8.8	16.1	25.9	4.2
Sub-Soil		X̄	34.9	54.6	4.7	59.2	1.10	50.6	92.1
	a	SD	5.7	5.4	1.4	5.2	0.13	10.8	2.4
		SD/X̄	16.2	9.9	29.0	8.7	11.5	21.3	2.6
		X̄	40.8	54.6	5.4	60.0	1.10	49.6	91.0
	b	SD	5.2	5.4	2.0	1.7	0.04	4.2	3.3
		SD/X̄	12.6	9.9	37.0	2.9	3.9	8.5	3.6
		X̄	42.9	53.5	3.7	57.1	1.15	46.7	93.5
	c	SD	2.1	3.8	2.1	2.1	0.06	5.9	3.8
		SD/X̄	4.9	26.2	56.7	3.7	5.4	12.6	4.0

Sv: Volumen rate of Solid, Mv: Of moisture, Va: Of air,
P : Porocity (Mv+Va), do: Bulk density, Mo: Water content by wheight,
Mv/p: Water saturation degree

Table C.5.4 Distribution of Bulk Density in the Soil Family (Surface Soil Only)

(Sample Size)

Soil family	do (Bulk density)			
	≦0.89	0.90～0.99	≧1.00	Total
a	2(18)	3(27)	6(55)	11
b	4(15)	8(31)	14(54)	26
c	4(29)	5(36)	5(36)	14
d	5(46)	2(18)	4(36)	11
e	6(43)	3(21)	5(36)	14
Total	21(28)	21(28)	34(45)	76

( ): Percentage in total

Table C.5.5 Relation between Bulk Density and Three Phases of Soil, Water Content and Water Saturation Degree

Class of do		do	Sv (%)	Mv (%)	A (%)	P (%)	Mo (%)	Mv/P (%)
≦	X̄	0.815	30.47	64.24	4.81	69.52	79.44	92.4
	SD	0.057	2.16	5.55	4.51	2.14	10.86	7.2
0.89 (n:21)	SD/X̄	(7.0)	(7.1)	(8.6)	(93.8)	(3.1)	(13.7)	(7.8)
0.90 ~	X̄	0.948	35.30	58.45	6.26	64.70	61.78	90.4
0.99	SD	0.024	0.88	3.44	3.65	0.88	3.85	5.6
(n:21)	SD/X̄	(2.5)	(2.5)	(5.9)	(58.3)	(1.4)	(6.2)	(6.2)
≦	X̄	1.106	41.13	54.76	4.11	58.87	51.53	92.9
	SD	0.076	2.93	4.76	2.89	2.93	7.89	5.2
1.00 (n:34)	SD/X̄	(6.9)	(7.1)	(8.7)	(70.3)	(5.0)	(15.3)	(5.6)

X̄: Mean, SD: Standard deviation, n: Size of sample, SD/X̄: %

Table C.6.1 Contents of Exchangeable Bases and Organic Matter, and Soil pH (1)

Soil family	Point No.	Hori-zon	pH (H2O)	pH (Kcal)	Exchangeable base (me/100g) Ca	Mg	K	Al	Sum	Ca Saturation (%)	OM (%)
a-1	73	1	6.8	5.6	47.7	1.70	0.21	0.03	49.64	96.2	2.75
		2	6.7	5.7	34.2	2.94	0.21	0.04	37.39	91.4	2.11
		3	6.1	4.9	33.5	3.34	0.21	0.11	37.16	90.1	0.64
a-2	80	1	6.5	5.5	35.8	5.83	0.66	0.07	42.36	84.4	3.26
		2	6.3	5.2	54.0	6.33	0.25	0.07	60.65	89.0	1.03
		3	6.2	4.0	41.4	7.83	0.35	0.51	50.09	82.8	1.79
	76	1	6.0	4.7	45.3	4.67	1.64	0.10	51.71	87.6	7.34
		2	6.3	4.7	41.0	4.00	1.01	0.12	46.13	88.9	3.13
		3	6.5	4.8	61.3	3.33	0.47	0.10	65.20	94.0	0.71
b-1	17	1	6.1	4.9	25.0	7.16	1.40	ND	33.56	74.4	2.72
		2	6.7	4.9	27.0	5.33	0.40	ND	32.73	82.6	1.84
	28	1	6.0	4.7	16.0	4.99	0.60	ND	21.59	74.1	3.34
		2	6.2	4.8	20.6	5.16	0.50	ND	26.26	78.3	1.48
		3	6.2	4.4	19.6	3.99	0.40	ND	23.99	81.7	1.09
		4	6.2	4.3	17.2	3.66	0.50	ND	21.36	80.4	0.85
	37	1	5.3	4.7	23.0	1.18	0.21	0.36	24.75	92.7	3.14
		2	5.7	4.9	25.3	1.17	1.02	0.22	27.71	91.3	1.60
		3	5.3	4.8	22.8	1.00	0.66	0.22	24.68	92.3	0.77
	47	1	4.9	4.7	21.0	2.25	0.97	0.36	24.58	85.4	2.88
		2	5.7	4.2	42.0	19.17	0.30	0.75	62.22	67.5	0.54
		3	6.0	4.5	41.8	20.50	0.20	0.61	63.11	66.2	0.27
		4	6.4	4.4	42.0	19.17	0.24	0.30	61.71	68.1	0.41
		5	6.6	4.6	42.0	21.84	0.20	0.22	64.26	65.3	0.14
b-2	54	1	5.8	4.3	36.6	8.33	1.13	0.61	46.67	78.4	4.47
		2	6.2	4.4	50.6	10.67	0.86	0.15	62.28	81.2	1.47
		3	6.0	4.4	46.9	12.50	0.87	0.17	60.44	77.6	0.83
b-3	60	1	5.8	5.1	62.5	5.50	0.62	0.12	68.74	91.0	7.79
		2	5.8	5.3	32.0	7.00	0.39	0.10	39.49	81.0	5.94
		3	5.5	4.9	42.0	9.50	0.39	0.10	51.99	80.8	0.90
c-1	66	1	5.4	4.1	28.1	8.00	1.85	0.24	38.19	73.6	6.38
		2	5.1	4.1	51.6	8.50	0.67	0.49	61.26	84.2	1.09
		3	6.0	4.4	48.9	6.67	0.39	0.27	56.23	87.0	0.32
		4	6.2	4.4	41.4	6.00	0.31	0.15	47.86	86.4	0.71

Table C.6.1 Contents of Exchangeable Bases and Organic Matter, and Soil pH (2)

Soil family	Point No.	Hori-zon	pH (H2O)	pH (Kcal)	Exchangeable base (me/100g) Ca	Mg	K	Al	Sum	Ca Saturation (%)	O M (%)
c-2	20	1	5.8	4.9	17.8	4.99	0.90	-	23.69	75.1	4.74
		2	6.2	4.3	16.0	4.83	0.45	-	21.28	75.1	1.87
		3	6.1	4.4	14.3	7.33	0.30	-	21.93	65.3	1.16
c-3	10	1	5.3	4.6	81.0	7.17	0.49	0.46	189.12	95.7	7.66
		2	5.8	4.8	28.2	9.00	0.33	0.15	37.68	74.8	6.38
		3	5.9	4.9	21.2	10.50	0.31	0.17	32.18	65.8	2.05
		4	6.1	4.8	23.8	13.67	0.35	0.10	37.92	62.8	0.71
	12	1	5.3	4.4	30.0	8.66	0.50	0.30	39.46	75.9	4.24
		2	4.7	4.6	31.5	8.50	0.67	0.46	41.13	76.6	0.94
	48	1	5.9	4.7	41.6	9.33	0.96	0.12	52.01	80.0	12.70
		2	5.6	4.7	52.4	10.00	0.70	0.24	63.34	82.8	-
		3	6.2	4.5	64.0	10.00	0.53	0.10	74.63	85.9	-
		4	6.0	4.3	58.6	9.17	0.55	0.22	68.54	85.5	-
d-2	42	1	5.9	4.7	30.8	11.67	0.31	0.24	43.02	71.6	10.90
		2	6.2	4.7	48.8	11.50	0.27	0.15	60.72	80.4	0.90
e-1	56	1	6.1	4.8	36.5	0.99	1.50	-	38.99	93.6	2.48
		2	6.3	5.1	28.0	8.66	0.80	-	37.46	74.7	1.55
e-2	2	1	5.3	4.6	24.1	8.67	0.31	0.51	33.64	71.7	9.93
		2	6.1	4.4	36.5	9.50	0.59	0.15	45.74	79.9	3.70
	3	1	5.4	4.4	17.3	12.33	0.50	0.36	30.49	56.7	1.45
		2	5.0	4.2	18.3	15.00	0.38	0.06	33.74	54.3	1.19
	26	1	6.7	5.4	39.4	4.50	0.45	0.05	44.40	88.7	4.02
		2	6.7	5.6	71.0	3.67	0.43	0.07	75.10	94.5	3.32

Table C.6.2 Contents of Soluble Phosphorus and Micronutrients and Base-balance (1)

Soil family	Point No.	Hori-zon	Soluble P (ppm)	Soluble (ppm) Fe	Cu	Zn	Mn	Ca/Mg	Ca/K	Mg/K	Ca+Mg/K
a	73	1	12	93	16	2	53	28.1	227.0	8.1	235.0
		2	15	73	15	1	22	11.6	163.0	14.0	177.0
		3	18	72	9	1	17	10.0	160.0	15.9	175.0
	80	1	27	310	35	1	12	6.1	54.2	8.8	63.1
		2	16	287	13	1	10	8.5	8.5	25.3	241.0
		3	20	284	5	1	13	5.3	118.0	22.4	141.0
	76	1	31	318	6	1	11	9.7	27.6	2.8	30.5
		2	40	252	3	1	6	10.3	40.6	4.0	10.1
		3	12	231	4	1	7	18.4	130.0	7.1	138.0
b	17	1	21	ND	ND	ND	ND	3.5	17.9	5.1	23.0
		2	15	ND	ND	ND	ND	5.1	67.5	13.3	80.8
	28	1	21	ND	ND	ND	ND	3.2	26.7	8.3	35.0
		2	14	ND	ND	ND	ND	4.0	41.2	10.3	51.5
		3	14	ND	ND	ND	ND	4.9	49.0	10.0	59.0
		4	19	ND	ND	ND	ND	4.7	34.4	7.3	41.7
	37	1	21	124	30	3	99	19.5	110.0	5.6	115.0
		2	31	97	26	2	47	21.6	24.8	1.1	26.0
		3	26	96	22	1	31	22.8	34.5	1.5	36.1
	47	1	21	103	20	3	88	9.3	21.6	2.3	24.0
		2	26	14	21	23	79	2.2	140.0	64.0	204.0
		3	22	13	22	27	97	2.0	209.0	103.0	312.0
		4	18	14	6	14	16	2.2	175.0	79.9	255.0
		5	16	9	8	16	8	1.9	210.0	109.0	319.0
	54	1	67	311	45	39	83	4.4	32.4	7.4	39.8
		2	14	253	8	2	12	4.7	58.8	12.4	71.2
		3	14	238	9	2	7	3.8	53.9	14.4	68.3
	60	1	20	237	16	1	51	11.4	101.0	8.9	110.0
		2	6	320	13	1	20	4.6	82.1	17.9	100.0
		3	6	254	8	1	12	4.4	108.0	24.4	132.0

Table C.6.2 Contents of Soluble Phosphorus and Micronutrients and Base-balance (2)

Soil family	Point No.	Hori-zon	Soluble P (ppm)	Soluble (ppm) Fe	Cu	Zn	Mn	Ca/Mg	Ca/K	Mg/K	Ca+Mg/K
c	66	1	10	416	5	2	86	3.5	15.2	4.3	19.5
		2	11	278	4	1	27	6.1	77.0	12.7	89.7
		3	34	240	2	1	5	7.3	125.0	17.1	142.0
		4	32	232	2	1	1	6.9	134.0	19.4	153.0
	20	1	15	ND	ND	ND	ND	3.6	19.8	5.5	23.0
		2	7	ND	ND	ND	ND	3.3	35.6	10.7	46.3
		3	7	ND	ND	ND	ND	2.0	47.7	24.4	72.1
	10	1	16	327	8	3	426	25.1	369.0	14.6	384.0
		2	7	324	10	3	207	3.1	85.5	27.3	113.0
		3	9	246	11	3	102	2.0	68.4	33.9	102.0
		4	4	240	7	2	20	1.7	68.0	39.1	107.0
	12	1	23	123	11	3	147	3.4	60.0	17.3	77.3
		2	13	92	6	1	15	3.7	47.0	12.7	59.7
	48	1	28	370	10	2	91	4.5	43.3	9.7	53.1
		2	33	299	9	2	10	5.2	74.9	14.3	89.1
		3	14	254	7	1	22	6.4	121.0	18.9	140.0
		4	22	245	4	1	12	6.4	107.0	16.7	123.0
d	42	1	9	302	8	1	155	2.6	99.4	37.7	137.0
		2	10	218	3	1	6	4.2	181.0	42.6	223.0
e	56	1	21	ND	ND	ND	ND	36.9	24.3	0.7	25.0
		2	18	ND	ND	ND	ND	3.2	35.0	10.8	45.8
	2	1	37	318	6	2	402	2.8	77.7	28.0	106.0
		2	35	301	4	2	21	3.8	61.9	16.1	78.0
	3	1	12	144	13	3	142	1.4	34.6	24.7	59.3
		2	10	70	10	3	88	1.2	48.2	39.5	87.6
	26	1	20	346	14	1	20	8.8	87.6	10.0	97.6
		2	24	368	13	1	79	19.3	165.0	8.5	174.0

Table C.6.3 Summarized Contents of Exchangeable Bases and Organic Matter, and Soil pH in the Soil Family

Soil family	Horizon		pH (H2O)	pH (Kcl)	Exchangeable base (me/100g) Ca	Mg	K	Al	Sum	Ca Saturation (%)	O (%)
a	Surface	X̄	6.43	5.27	42.93	4.07	0.84	0.07	47.90	89.4	4.45
		SD	0.40	0.49	6.29	2.13	0.73	0.04	4.91	6.1	2.52
		SD/X̄	6.3	9.4	14.7	52.3	87.0	50.2	10.3.0	6.8	56.5
		n	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Sub	X̄	6.35	4.88	44.23	4.63	0.42	0.16	49.44	89.4	1.57
		SD	0.22	0.56	11.14	1.99	0.31	0.17	11.67	3.7	0.97
		SD/X̄	3.4	11.5	25.2	42.9	73.2	109.0	23.6	4.2	61.6
		n	6.0	6.0	6.0	6.0	6.0	4.0	6.0	6.0	6.0
b	Surface	X̄	5.65	4.73	30.68	4.90	0.82	0.36	36.65	82.7	4.06
		SD	0.46	0.27	17.02	2.76	0.43	0.20	18.19	8.2	1.93
		SD/X̄	8.1	5.6	55.5	56.3	52.2	55.6	49.6	9.9	47.5
		n	6.0	6.0	6.0	6.0	6.0	4.0	6.0	6.0	6.0
	Sub	X̄	6.04	4.63	33.70	10.05	0.50	0.28	44.45	78.2	1.30
		SD	0.40	0.31	11.37	7.42	0.26	0.22	17.76	8.6	1.43
		SD/X̄	6.7	6.7	33.7	73.8	52.4	78.5	40.0	11.0	110.0
		n	14.0	14.0	14.0	14.0	14.0	10.0	14.0	14.0	14.0
c	Surface	X̄	5.54	4.54	29.4 (59.7)	7.63	0.94	0.28	38.34	80.1	7.14
		SD	0.29	0.30	9.8 (68.3)	1.68	0.55	0.14	11.59	9.1	3.39
		SD/X̄	5.2	6.7	33.2 (114)	22.0	58.9	50.5	30.2	11.3	47.5
		n	5.0	5.0	4.0 (5.0)	5.0	5.0	4.0	4.0	5.0	5.0
	Sub	X̄	5.83	4.52	37.7	8.68	0.46	0.24	47.00	77.7	1.69
		SD	0.48	0.24	17.3	2.33	0.15	0.14	17.83	9.0	1.84
		SD/X̄	8.1	5.4	45.9	26.9	33.6	57.6	37.9	11.6	109
		n	12.0	12.0	12.0	12.0	12.0	10.0	12.0	12.0	9.0
d + e	Surface	X̄	5.88	4.78	29.6	7.63	0.61	0.29	38.11	76.5	5.76
		SD	0.57	0.38	9.0	4.83	0.50	0.19	5.97	14.8	4.36
		SD/X̄	9.7	7.9	30.5	63.3	82.4	67.0	15.7	19.4	75.8
		n	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	5.0
	Sub	X̄	6.06	4.80	40.5	9.67	0.49	0.11	50.55	76.8	2.13
		SD	0.63	0.56	20.4	4.15	0.21	0.05	17.20	14.5	1.29
		SD/X̄	10.5	11.7	50.4	42.9	42.1	44.8	34.0	18.9	60.4
		n	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	5.0

Table C.6.4 Summarized Contents of Soluble Phosphorus and Micro-nutrients, and Base-balances in the Soil Family

Soil family	Horizon		Soluble P (ppm)	Suluble (ppm) Fe	Cu	Zn	Mn	Ca/Mg	Ca/K	Mg/K	Ca+Mg/K
a	Sur-face	$\overline{X}$	23.3	240.0	19.0	1.3	25.0	14.6	103.0	6.6	110.0
		SD	10.0	128.0	15.0	0.6	24.0	11.8	108.0	3.3	110.0
		SD/$\overline{X}$	43.0	53.2	77.5	44.4	95.9	80.8	106.0	49.7	100.0
		n	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Sub	$\overline{X}$	20.2	200.0	8.0	1.0	13.0	10.7	103.0	14.8	126.0
		SD	10.1	101.0	5.0	0.0	6.0	4.4	64.0	8.3	94.0
		SD/$\overline{X}$	49.9	50.4	62.5	-	47.4	40.7	62.4	56.2	74.9
		n	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
b	Sur-face	$\overline{X}$	28.5	194.0	28.0	11.5	80.0	8.6	51.6	6.3	57.8
		SD	18.9	98.0	13.0	18.4	21.0	6.3	42.1	2.4	42.9
		SD/$\overline{X}$	66.2	50.4	46.1	160.0	25.8	73.5	81.6	38.8	74.2
		n	6.0	4.0	4.0	4.0	4.0	6.0	6.0	6.0	6.0
	Sub	$\overline{X}$	17.2	131.0	14.0	8.9	33.0	6.4	92.0	33.5	125.0
		SD	7.2	123.0	8.0	10.2	32.0	6.8	65.6	38.2	103.0
		SD/$\overline{X}$	41.7	93.8	54.2	114.0	96.1	107.0	71.3	114.0	82.7
		n	14.0	10.0	10.0	10.0	10.0	14.0	14.0	14.0	14.0
c	Sur-face	$\overline{X}$	18.4	309.0	9.0	2.5	188.0	8.0	101.0	10.3	111.0
		SD	7.1	129.0	3.0	0.6	161.0	9.6	151.0	5.6	154.0
		SD/$\overline{X}$	38.5	41.8	29.4	23.1	85.8	119.0	149.0	54.7	139.0
		n	5.0	4.0	4.0	4.0	4.0	5.0	5.0	5.0	5.0
	Sub	$\overline{X}$	16.1	245.0	6.0	1.6	42.0	4.5	82.6	20.6	103
		SD	11.2	61.0	3.0	0.8	65.0	2.1	32.6	8.9	34
		SD/$\overline{X}$	69.5	25.1	53.2	52.7	154.0	46.5	39.5	43.2	32.5
		n	12.0	10.0	10.0	10.0	10.0	12.0	12.0	12.0	12.0
d	Sur-face	$\overline{X}$	19.8	278.0	10.0	1.8	180.0	10.5	64.7	20.2	85.0
		SD	10.9	91.0	4.0	1.0	160.0	15.0	33.3	14.8	43.5
		SD/$\overline{X}$	55.0	32.7	38.6	53.2	89.0	143.0	51.5	73.1	51.2
		n	5.0	4.0	4.0	4.0	4.0	5.0	5.0	5.0	5.0
e	Sub	$\overline{X}$	19.4	239.0	8.0	1.8	49.0	6.3	98.2	23.5	122.0
		SD	10.5	128.0	5.0	1.0	41.0	7.3	69.2	16.3	74.0
		SD/$\overline{X}$	54.3	53.7	60.0	53.2	83.8	116.0	70.4	69.3	60.6
		n	5.0	4.0	4.0	4.0	4.0	5.0	5.0	5.0	5.0

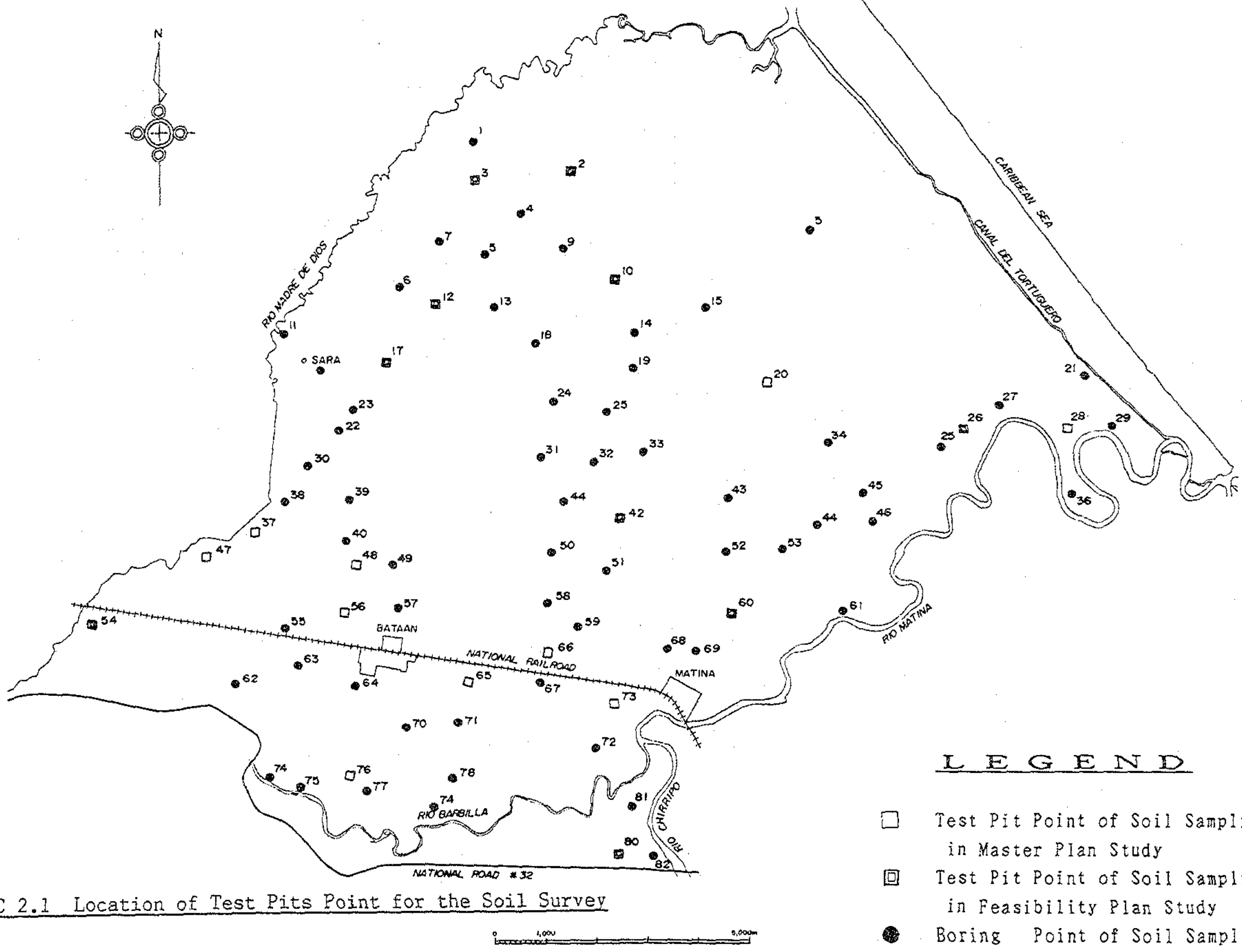
Table C.6.5 Specification of the Fertility Classification

Chemical Items \ Fertility			Low	Medium	High
pH(H_2O)			≦ 5.5	5.6 ～ 6.5	> 6.5
Sum of Cationes		me/100 ml	≦ 5.0	5.1 ～ 25.0	> 25.0
Exchangable	Ca	me/100 ml	≦ 4.0	4.1 ～ 20.0	> 20.0
Exchangable	Mg	me/100 ml	≦ 1.0	1.1 ～ 5.0	> 5.0
Exchangable	Ka	me/100 ml	≦ 0.2	0.2 ～ 0.6	> 0.6
Soluble	P	Kg/ml	≦ 10.0	11.0 ～ 20.0	> 20.0
Soluble	Zn	Kg/ml	≦ 2.0	2.1 ～ 10.0	> 10.0
Soluble	Mn	Kg/ml	≦ 5.0	6.0 ～ 50.0	> 50.0
Soluble	Fe	Kg/ml	≦ 10.0	10.0 ～ 100.0	> 100.0
Soluble	Cu	Kg/ml	≦ 2.0	3.0 ～ 20.0	> 20.0
			Unbalance (Low)	Balance (Optimum)	Umbalance (High)
Ca/Mg		(me/100 ml)	≦ 2.0	2.1 ～ 5.0	> 5.0
Ca/K		(me/100 ml)	≦ 5.0	5.1 ～ 25.0	> 25.0
Mg/K		(me/100 ml)	≦ 2.5	2.6 ～ 15.0	> 15.0
Ca+Mg/K		(me/100 ml)	≦ 10.0	10.1 ～ 40.0	> 40.0

(MAG)

Table C.7.1 Specification of the Land Classification

Characteristics of Soil or land	class/ Symbol	I	II	III	IV	V	VI	VII	VIII
Drainage	h_1	Well		moderatly well or excess	Imperfectly	Poorly			Excess Very poorly Extremly poorly
Groundwater level	h_2 (cm)	Very deep (>150) deep (100 - 150)	Moderatly deep (75 - 150)	Slightly deep (50 - 75)	shallow (20 - 50)		Very shallow (5 - 20)		Surface (<5)
Inundation	h_3	no danger	slightly	moderatly	severely	Extremely			
Effective depth of soil	S_1 (cm)	Very deep (>150) deep (100 - 150)	moderatly deep (75 - 100)	Slightly deep (50 - 75)	shallow (20 - 50)		Very shallow		
Uper soil texture (0 - 30 cm)	S_2	SL - L - SiL SCL-CL-SiCL	LS --- S HC - LiC - SC	gravelly SSiL - SL			Very fine (HC: >60%clay)		Sandy gravel or Gravelly fine
Sub-soil texture	S_3	SL - L - SiL SCL-CL-SiCL HC - LiC - SC	LS --- S		gravelly	HC (>60% clay)		Very gravelly	
Gravel on land surface	S_6 (%)	none (<5)	few (5 - 15)	moderatly abundant (15 - 40)	abundant (40 - 80)		Very abundant (60 - 80)		Extremly abundant (>80)
Stones on land surface	S_7 (%)	none	few (< 1)	moderatly few (1 - 3)	many (3 - 15)	abundant (15 - 60)		Stony (60-80)	Severely stony (>80)
Gravel in soil profile	S_8 (%)	almonst none (< 5)	few (5 - 10)	moderatly abundant (10 - 15)	abundant (15 - 40)		Very abundant (40 - 60)		Extremly abundant (>60)
Stones in soil profile	S_9 (%)	almost none (< 0.1)	few (0.1 - 1)	medium (1 - 3)	rich (3 - 15)	Very rich (15 - 50)		Severe (50-80)	Excess (>80)



L E G E N D

□ Test Pit Point of Soil Sampling in Master Plan Study

⊡ Test Pit Point of Soil Sampling in Feasibility Plan Study

● Boring Point of Soil Sampling

Fig. C 2.1 Location of Test Pits Point for the Soil Survey

Fig. C.3.2 Columnar Diagrams of Soil Profiles (1)

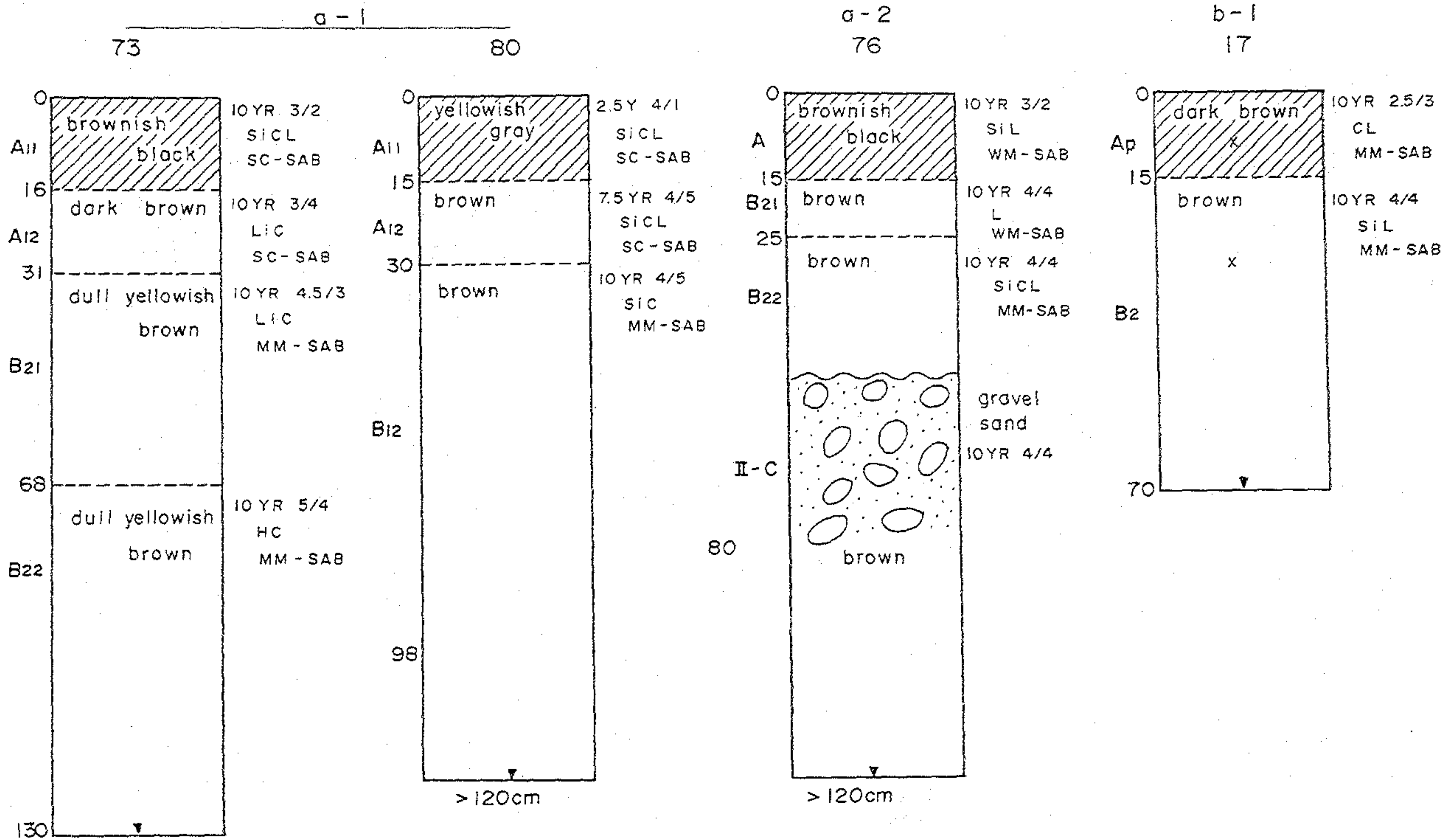


Fig. C.3.2 Columnar Diagrams of Soil Profiles (2)

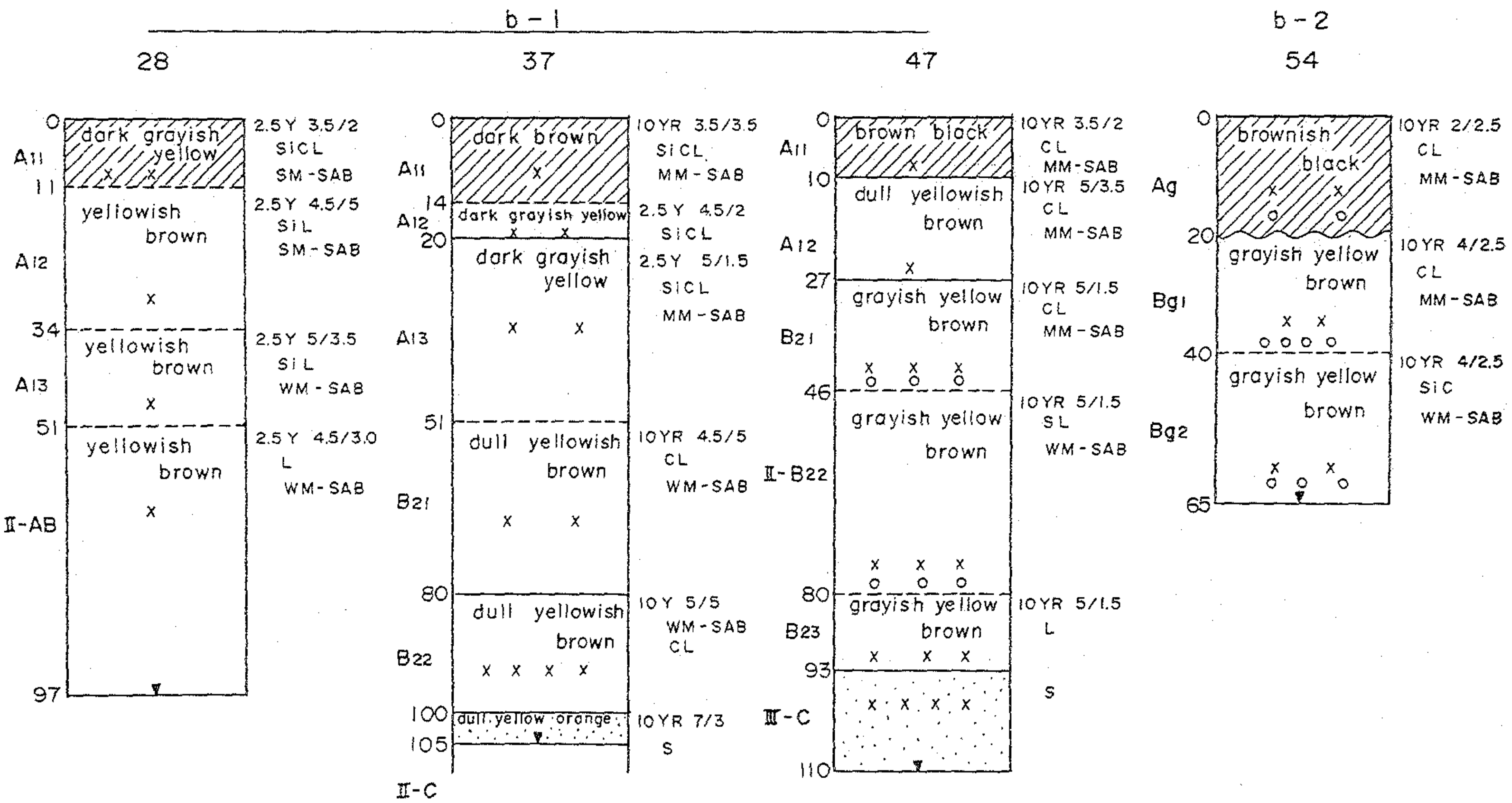


Fig. C.3.2 Columnar Diagrams of Soil Profiles (3)

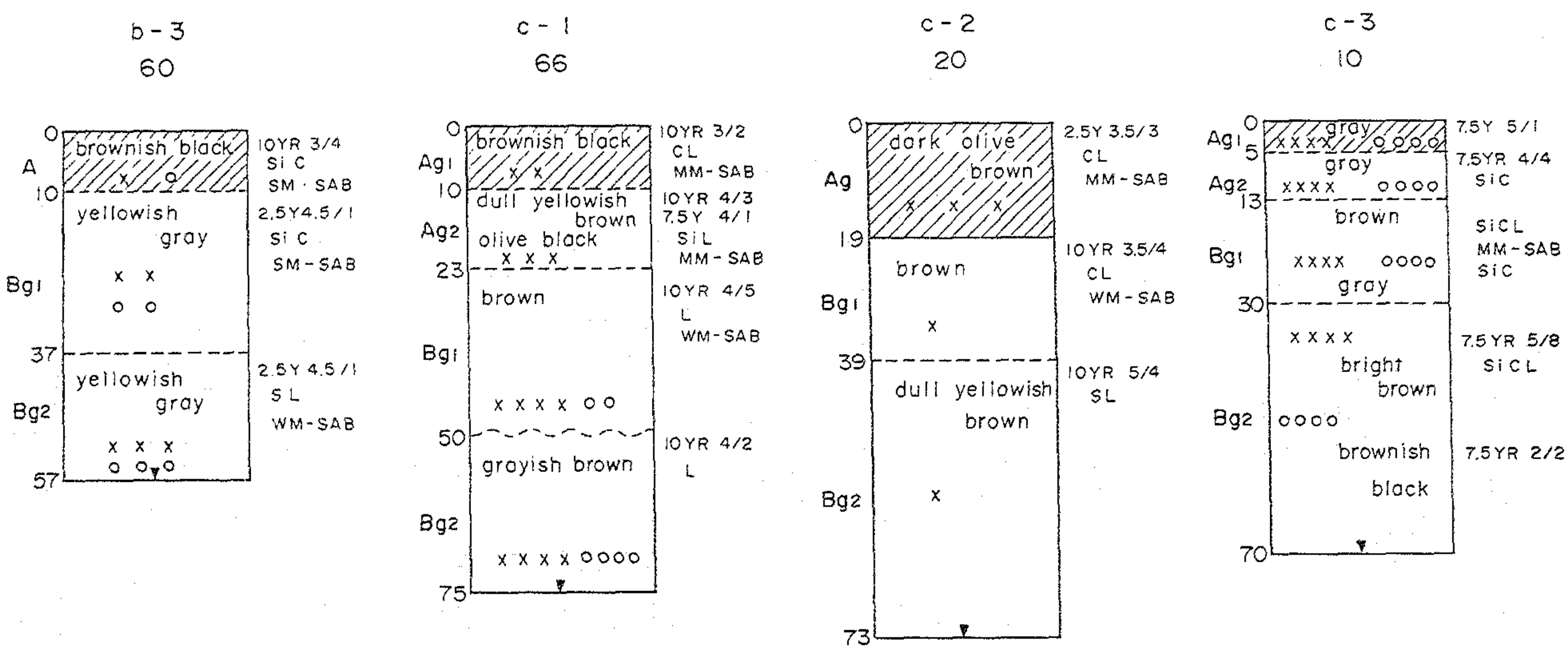


Fig. C.3.2 Columnar Diagrams of Soil Profiles (4)

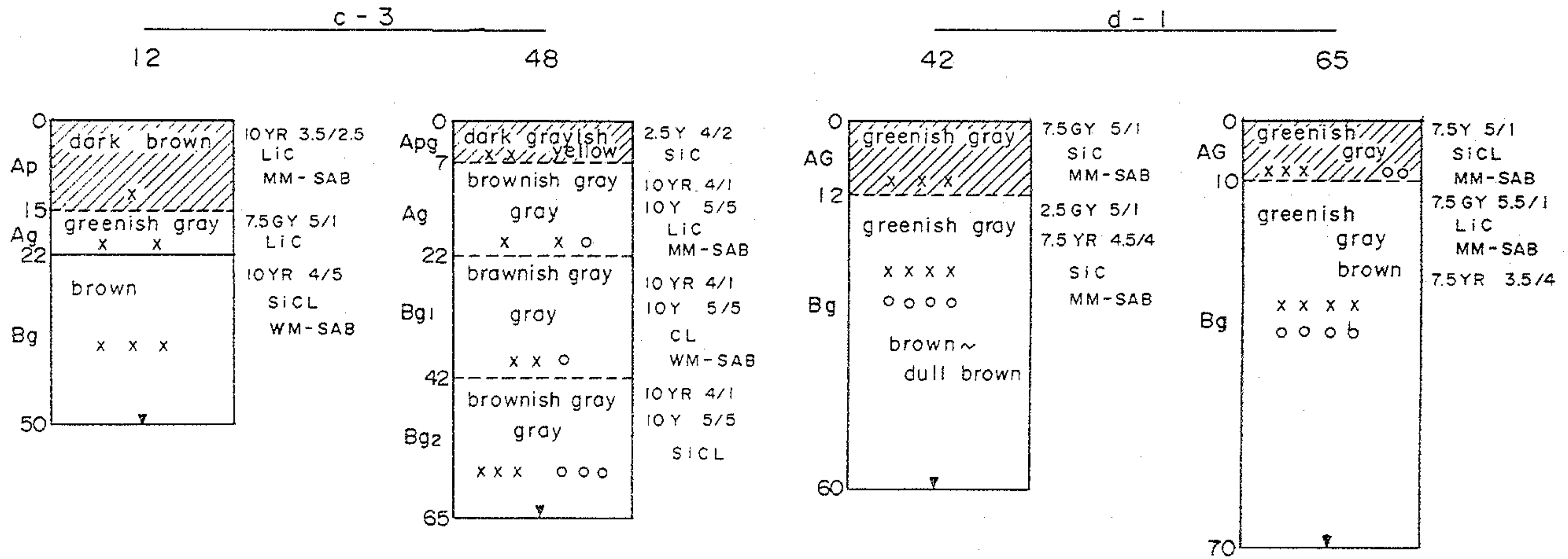
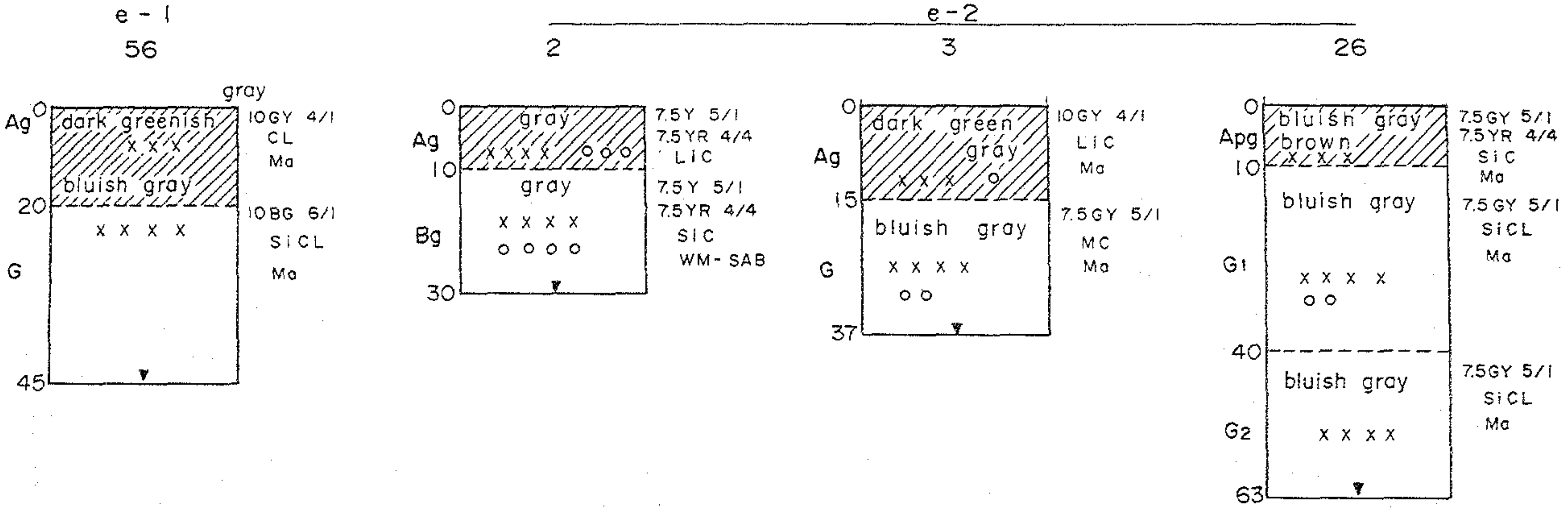


Fig. C.3.2 Columnar Diagrams of Soil Profiles (5)



1. Color: Munsell's soil color name
   Hue Value/Chroma, humidity
   Example: 10YR3/1, moist

2. Texture: USDA System

clay	C
silt, -y	Si
sand, -y	S
loam, -y	L

Example: Sandy clay loam
SCL

3. Structure: Grade:

no structure	NS
weak	W
moderate	M
strong	S

Size:

fine	F
medium	M
coarse	C

Shape:

granular	G
angular blocky	AB
subangular blocky	sAB
prismatic	Pr
platy	Pl
massive	Ma

Example: Weak medium subangular blocky
WMsAB

4. Mottles:

few	x
common	x x
many	x x x
abundant	x x x x

5. Concretions:

iron	x
manganese	○

6. Horizon Boundary:

abrupt	———
clear	———
gradual	- - - - -
diffuse	:::::::::
wavy	∿∿∿

7. Groundwater Level: ▽

Annex D Land Use

Annex D. Land Use

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D.1 Area by Elevation

An area classified by elevation of the Study Area, which measured on newly-prepared topographical map with a scale of 1:10,000, is as follows:

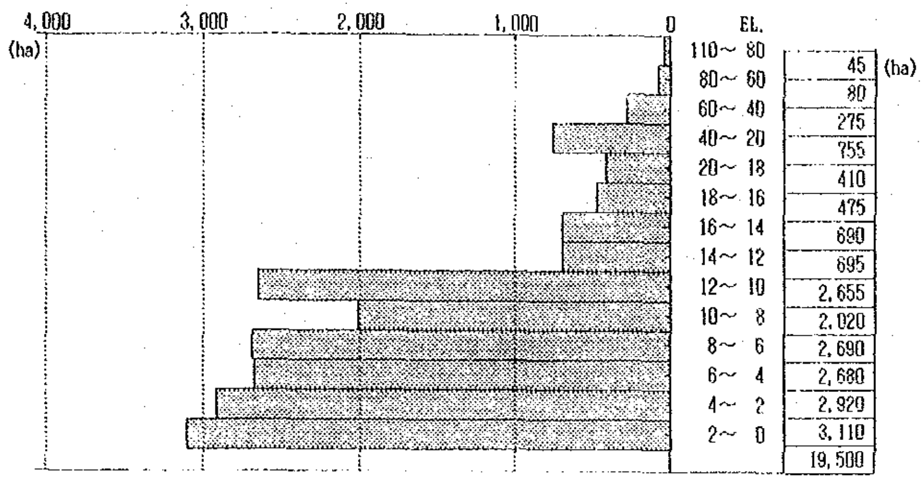

Fig. D. 1 Area Classified by Elevation

D. 2 Land Use Plan

D.2.1 Area to be Developed

In the Study Area, the area to be undeveloped is as follows:

(1)	Farmland under the elevation of 2.0 m	:	410 ha
(2)	Virgin forests along Canal del Tortuguero	:	3,380 ha
(3)	Large scale forest	:	1,740 ha
(4)	Existing banana plantations	:	1,960 ha
(5)	Others	:	860 ha
	Total	:	8,350 ha

The others include urban area, road, canal, research's lots and experimental station.

Accordingly, the area to be developed is 11,150 ha.

D.2.2 Selection of Suitable Area

Based on the land classification, the suitable area for farming of introduced crops are selected as follows and details are shown in Fig. D.1.

(1) Unsuitable area for crop cultivation except for rice and pasture : 560ha (*Class VII)

(2) Unsuitable area for only pepper : 3,410 ha (Class IV)

(3) Suitable area for pepper : 250 ha (Class II) and a part of Class VI)

(4) Suitable area for proposed crops : 6,930 ha (Class II and III)

Total :11,150 ha
(*Land classification)

D.2.3 Land Use Plan

Considering the agricultural production plan based on the suitable areas for the above crops selected by land classification, the land use plan of this area was established as shown in Table D.2.

Table D.2 Land Use Plan

Land Category	Present	With Project											
		Annual Crops	Banana	Cacao	Platain	Coco	Black Pepper	Grass Land	Virgin Forest	General Forest	Abandaned Plantation	Others	Total
Annual Crops	4,340	3,920	280	0	0	0	110	0	0	0	0	30	4,340
Banana	1,960	0	1,960	0	0	0	0	0	0	0	0	0	1,960
Cacao	1,540	0	0	1,540	0	0	0	0	0	0	0	0	1,540
Platain, Coco	620	0	0	0	300	240	0	0	0	0	0	80	620
Grass Land	3,510	570	1,550	0	200	260	70	560	0	0	0	300	3,510
Virgin forest	3,380	0	0	0	0	0	0	0	3,380	0	0	0	3,380
General Forest	1,740	0	0	0	0	0	0	0	0	1,740	0	0	1,740
Abandaned Plantation	1,550	0	210	1,340	0	0	0	0	0	0	0	0	1,550
Others	860	0	0	0	0	0	0	0	0	0	0	860	860
Total	19,500	4,490	4,000	2,880	500	500	180	560	3,380	1,740	0	1,270	19,500

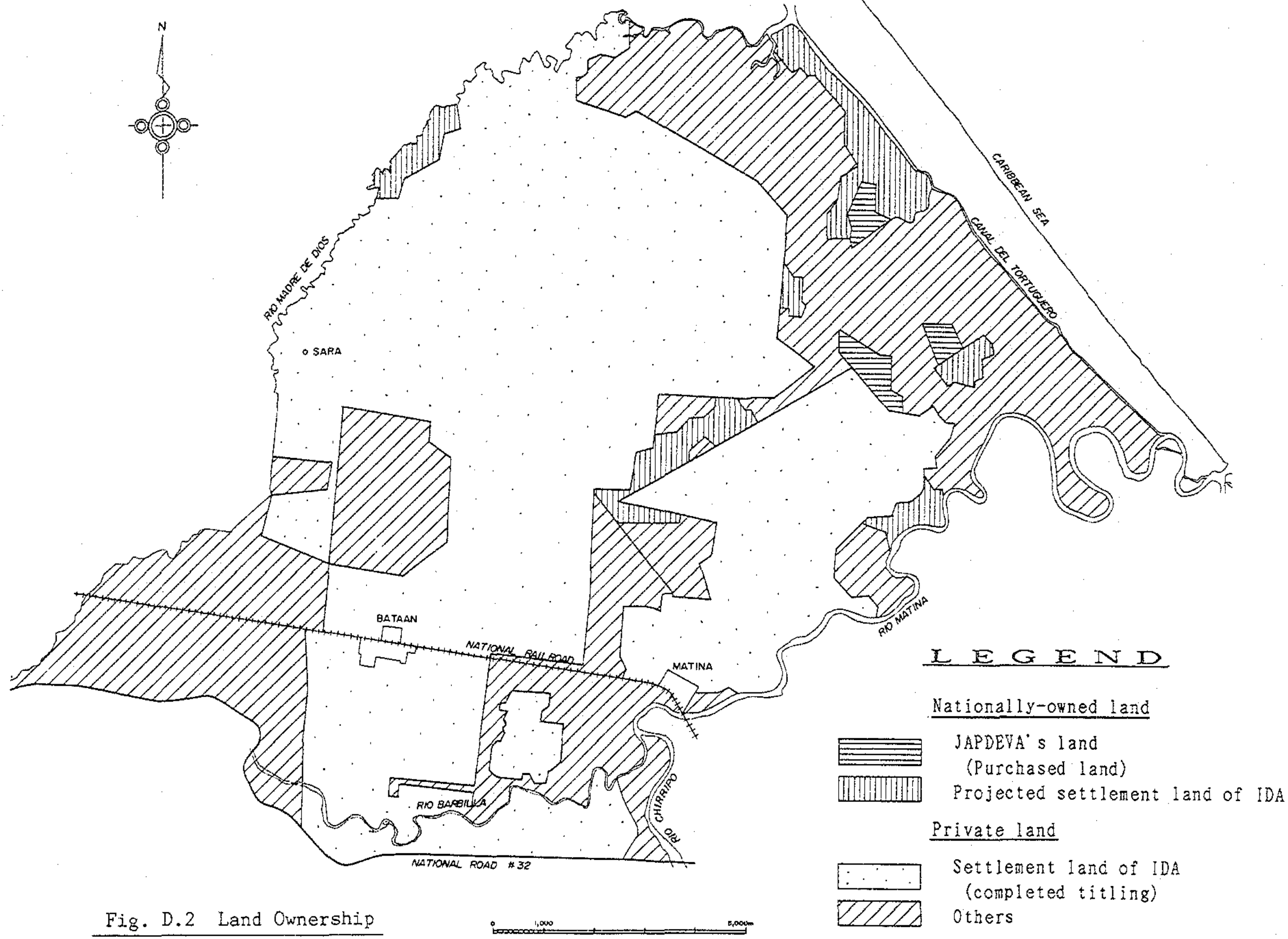

Fig. D.2 Land Ownership

Annex E Agriculture

Annex E. Agriculture

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E.1 Agricultural Development in the Atlantic Region and the Study Area

E.1.1 An Overview of the Present Situation

Between the years of 1963 and 1973 agricultural production in the Atlantic Region changed dramatically; in 1963 the region contributed approximately 8.0% of the total agricultural production of the country, but ten years later this contribution had grown to 21.0%. (SEPSA, 1980) This extraordinary growth was induced during the 1960's primarily by the development of perennial crops such as cacao, plantain ,etc.,for the market.

Despite this rise in production, in 1973 only 28% of the total land in the region was classed as farms, (That is, of the 979.8 thousand hectares in the region only 278.2 thousand hectares were in farms). Of land in farms, only 18.0% was actually dedicated to the cultivation of crops, another 25.7% was in pasture, 37.5% was in forest and 18.7% was in charrales, pantanos and tacotales. (Censo de Agropecuario 1973)

This situation has undoubtedly changed greatly. Since 1973 thousands of people have migranted to the region, particularly to the Limon and Pocosi-region, attracted by the expansion of employment with banana companies and by the availability of land of farms.

Projections estimated that the population of the Atlantic Region will grow from 200.0 thousand in 1985 to 241.0 thousand in 1990. (MIDEPLAN, Proyecciones Demogaraficas para Costa Rica, 1970-2000) Of this number it is estimated that some 70% will be living in rural ares.

E.1.2 Main Agricultural Production

In general, the following crops are predominant in the ares of the Study Area and Atlantic Region described below;

(1) Banana production

Banana is the most important crop of the Study Area and the Atlantic Region. It is estimated that during 1980 there were approximately 18,000ha in production of which almost half were directly under the ownership of three major transnational companies. (BANDECO, Standard Fruit, Chiriqui Land Company) The other half was in the hands of independent growers and a few cooperatives.

(2) Cacao production

In the Study Area and the coast fringe of the its surrounding area, there are many small producers (less than 10ha) of Cacao. The area of Cacao cultivation extends on both sides of the railway line and widens somewhat in its extent around Matina and Bataan.

Most of the Cacao plantations are more than 40 years old and many have not been cared for properly. It is believed that improper care (especially failure to remove vines and overgrowth) have contributed to the condition favorable for the on set of the Monillia fungus. It is estimated that national production level have fallen from 10,000 t in 1973 to 3,500 t in 1987 (SEPSA, 1987).

(3) Coconut production

Coconut palms are also grown along the costal strip mainly in the area north of Limon, though there are considerable stands of trees along the southern costal strip as well. In 1973 there were almost 1,000ha in coconut production, however, the amount of coconut produced has been quite low. There are several projects which hope to increase production substantially.

(4) Plantain production

Plantain is dispersed throughout most of the region. It is frequently used as a secondary crop by many small and medium-scale farmers . However, in the last 5 years plantain has been developed as an export crop in larger commercial stands principally in Bataan and Matina.

(5) Other crops

Rice is scattered throughout the Study Area, because it was grown by many farmers as a cash crop. In part of the Bataan, Matina, Sara, Limon and other IDA's settlement area where there are flat, rice is cultivated in large parcels with mechanized equipment and small-scale farmers by hand.

Other types of crops are relative by minor in terms of their production values and the area in which they are grown. One finds kidney beans, taro, yam, cassava and a variety of other tubers, and maize grown widely in the Study Area, but the are usually part of a subsistence crop. In the last few years there has been a surge interest in the production of special high value crops for the export market.

E.2 Distribution of Farm Household and Types of Farmers in the Study Area

E.2.1 Distribution of Farm Household

The majority of the production farmers of the major crops are distributed around the Bataan, Sara, Santa Marta, Luzon, Goschen, Cuatro Millas, Matina and Veintiocho Millas. The four areas among them, such as Bataan, Sara, Santa Marta and Luzon include eleven of the fourteen IDA's settlement lands and make up a village mainly composed of the IDA's settlement farmers.

Hence, there are numerous small-scale farmers in these areas. The land holding size per farmer and the type of farm management are similar within the Area.

In the other areas, the number of the settlement farmers is smaller then the above mentioned areas, and also, the land holding size and type of farm management differ within the same area. Especially, in Goschen and Cuatro Millas, the medium-scale and large-scale farmers occupy most of the area.

E.2.2 Relationship between Crop and Farm-Scale

In general, cacao, plantain, coconut, and rice are crops found most frequently on small-scale farmers of less than 12 ha. As the scale of farm enlarges, the relative importance of these crops tends to diminish.

Banana production begins to predominate on farms of between 200 and 300 ha. Farms in this scale range also tend to divide their lands between the production of crops like bananas and pasture for cattle. The largest farms, those of more than 200 ha, are almost exclusively devoted to the production of banana and its associated crop of bamboo, or to the rising of cattle. On the other hand, spices and chili peppers can be grown profitably on quite small farms.

E.3 Agricultural Production Plan

E.3.1 Remarks for Agricultural Production

It is necessary to consider the following improvement of the agricultural technique of the small-scale farmers along with the implementation of flood protection and drainage improvement.

1) Improvement on the input of the agricultural production materials

Important factor in rising agricultural production is whether farmers have access to necessary inputs. These include the right variety of seed, fertilizer, pesticides, herbicides and mechanization (when needed and if appropriate to the crop and condition of farm household economy), and access to technical advise from MAG, IDA and other agricultural supporting services.

In the Study Area, access and use of these types of inputs varies considerably depending on the type of crop, the scale of holding, the type of holding, the farmers capital or credit position and the efficiency of services offered by private and public institutions . The highest level of technology or found on the largest and medium-scale of farmers, especially the large banana plantations and rice farmers. There they obtain the highest productivity through the extensive use of fertilizer, pesticide and herbicides, and mechanical devices, though these banana plantations and rice farmers are also labor intensive. On the other hand, most of the small-scale farmers that are dedicated to subsistence production like maize, kidney bean, and perennial crops such as plantain and coconut, use very few technical inputs. There are many problems with the invasion of bad weeds and diseases and there are no programs to prevent this.

2) Formulation of the cropping rotation system

After completion of the drainage improvement, along with the extension of the all season cropping of the annual crops, the appearance of the damage of continuous cropping many be expected, The formulation of the cropping rotation system will be effective for the prevention of damage caused by continuous cropping and for the conservation of the soil fertility.

3) Improvement of harvest season

The favorable harvesting period for perennial crops in the Area is from December to April. Especially, in the case of cacao, about 70% of the yearly production is concentrated during this period. Furthermore, the Area has much rain all year round, and no seasonal variations in the rainy season. From these circumstances, as showed in the Main Report the following problems on the crop harvesting can be presented.

(a) A peak in labor requirement due to concentration of the favorable harvesting period.

(b) A decreased in the yield because of missing the favorable harvesting period.

(c) A increase in the moisture ratio of crops and a decrease in the quality of the crops because of insufficiency in drying.

To solve these problems, the adjustment of the harvesting period and extension of the post harvest techniques are needed. The agricultural experimental station of La Lola and ASBANA have already developed the hybrid seeds such as practice of artificial pollination for the control of the harvesting period.

The following Table E.1 and E.2 are shown the details of the farm inputs requirements and it costs for the formulation of agricultural production plan. In addition, the standard of agricultural working system will be proposed of Fig. E.1.

Table E.1 Farm Input Requirement per ha.

Crop	Variety	Seed (kg/ha)	Chemical Fertilizers(kg/ha) (N - P205 - K20 - Ca - Mg)	Pesticides Quantity	Pesticides Chemicals	Herbicides Quantity	Herbicides Chemicals
1.Perrenial					Daconil	-	Malathion.E.C
					Benlate		Diazinon.E.C.
Banana	Valery y			-	Manzate		Lannate(90%),
	Grand Nailne	1,100 unit	665 180 4,300 90 1,100		Triton XS-75		Depterex P.S.
			(18 - 10 - 6 - 5 - -) : 665	10 Kg	Sistemic		Sevin(80%)
Cacao	UF 296XCC-18	1,111 unit	Foliar: 3.75 lit	10 kg	Contacto	2 lit	Foliar
			(20 - 7 - 12 - 3 - 1.2): 162				
Coconut	Enano Dorado	284 unit	Amonium: 405	1.0 lit	Benlate	3.0 kg	Glifosato
			(12 - 24 - 12 - -): 460				
Plantain	Curare	1,155 unit	UREA: 460	120 kg	Carbofuran	-	-
			(18 - 5 - 15 - 6 - 2): 2,304	1.0 kg	Benlate	1.0 lit	Metamidofs
				1.0 kg	Captafol		
Black Peper	Kallivalle	1,700 unit		1.0 kg	Cuprico	1.0 lit	Malathion
				1.0 kg	Macozeb	1.5 kg	Mirex
2. Annual Crops							
			(10 - 30 - 10 - -): 170	6.0 kg	Kasugamicina	4.0 lit	Foxin
Rice	C.R.1113	115	UREA (20 - 0 - 0) : 300			0.5 lit	Decametrina
			(10 - 30 - 10) : 175			2.0 kg	Foliar
Maize	Tico U-7	23	UREA(20 - 0 - 0) : 200	3.0 lit	Atrazina	1.0 lit	Metil Parathion
			(10 - 30 - 10) : 200	2.5 kg	Macozeb	0.3 lit	Decametrina
Kindney Bean	Mexico-80	53	Foliar : 3.0	0.5 kg	Benlate		
	Xantosoma		(20 - 3 - 20 - -): 150	3.0 lit	Paraquat	1.0 lit	Metamidofs
Tuber Corps	Violanceo	2,500		1.0 kg	Diuron		
(Tiquisque)	y Sagittifolium						

Source: (1) BANCO NACIONAL DE COSTA RICA, AVIOS 1987
(2) EL CULTIVO DEL BANANO, EUNED 1983
(3) CONSEJO NACIONAL DE PRODUCCION, EL CULTIVO DE PLATANO COMO SOMBRA TEMPORAL DEL CACAO. 1987
(4) ASBANA, REVISTA DE LA ASOCIACION BANANERA NACIONAL,1987

Table E.2 Production Cost (1) Annual Crops

unit: ¢

Item \ Crop	Rice	Maize	Kidney Bean	Tuber Crop
1 Labors				
Labor	8,127	7,840	12,298	47,182
Machinery	7,568	5,983	7,583	10,368
Sub-Total	15,695	13,823	19,881	57,550
2 Materials				
Seed	5,283	1,015	3,280	9,450
Fertilizer	6,678	5,517	3,576	6,113
Herbicide	6,252	886	3,069	8,048
Insecticide	3,647	910	3,011	1,283
Fungicide	3,516	-	1,560	2,556
Other	-	-	-	1,253
Sub-Total	25,376	8,328	14,496	28,703
3 Others				
Transport	728	988	2,373	8,406
Total (1+2+3)	41,800	23,139	36,750	94,659

SOURCE: Production Costs of Table E.2.(1) to (6);
(1) BANCO NACIONAL DE COSTA RICA (1987)
(2) CONSEJO NACIONAL DE PRODUCCION (1987)
(3) COSTOS DE PRODUCCION Y RENDIMIENTOS (INVERSION NICOA S Y M S.A. 1987)
(4) COSTOS DE INVERSION DE SIEMBRA DE BANANO, ASBANA (1987)

Table E.2 Production Cost (2) Cacao

unit: ¢

Item \ Year	1	2	3	4
1 Labors				
Labor	25,344	11,368	24,585	24,585
2 Materials				
Plant	15,600	-	-	-
Marking Post	588	-	-	-
Fertilizer	10,673	6,463	11,238	11,238
Herbicide	-	-	-	-
Insecticide	8,921	3,105	1,037	1,037
Fungicide	1,620	1,134	3,240	3,240
Adhesive	1,026	513	616	616
Shade Tree	810	-	-	-
Sub-Total	39,238	11,215	16,131	16,131
3 Others	1,064	600	1,035	1,035
Total (1+2+3)	65,646	23,183	41,751	41,751

Table E.2 Production Cost (3) Coconut

unit: ¢

Item \ Year	1	2	3	4	5
1 Labors					
Labor	23,264	15,581	14,254	16,070	24,032
2 Materials					
Marking Post	292	-	-	-	-
Plant	11,360	-	-	-	-
Fertilizer	3,202	3,241	20,217	29,593	29,927
Insecide	3,096	3,634	3,634	716	895
Herbicide	6,147	4,099	4,099	4,039	4,099
Fungicide	926	1,389	1,389	1,852	1,852
Other	154	154	154	206	206
Sub-Total	25,177	12,517	29,493	36,466	36,979
3 Others	1,873	293	518	696	726
Total (1+2+3)	50,314	28,391	44,265	53,232	61,737

Table E.2 Production Cost (4) Plantain

uint: ¢

Item \ Year	1	2
1 Labors		
Labor	32,720	31,851
Machinery	2,120	-
Sub-Total	34,840	31,851
2 Materials		
Seed	11,550	-
Fertilizer	11,229	16,717
Insecticide	18,481	36,962
Support Pole	-	5,832
Other	1,156	-
Sub-Total	42,416	59,079
3 Others	3,118	3,152
Total (1+2+3)	80,3746	94,082

Table E.2 Production Cost (5) Banana

unit: ¢

Item \ Year	1	2
1 Labors		
Labor	79,456	80,200
2 Materials		
Plant	76,000	-
Fertilizer	118,552	129,754
and others	222,139	234,281
Sub-Total	416,691	364,035
3 Others	3,000	18,000
Total (1+2+3)	499,147	462,235

:production costs not included operation costs

Table E.2 Production Cost (6) Black Pepper

uint: ¢

Item \ Year	1	2	3
1 Labors			
Labor	61,795	31,854	80,886
Machinery	14,971	-	-
Sub-Total	76,766	31,854	80,886
2 Materials			
Plant	178,750	-	-
Support Pole	74,250	-	-
Fertilizer	37,377	39,682	44,168
Herbicide	2,256	2,236	2,236
Insecticide	20,807	1,176	1,176
Fungicide	2,994	2,994	2,994
Other	206	767	767
Sub-Total	316,640	46,855	51,341
3 Others			
Freight	8,342	2,318	2,578
Transport	17,875	-	-
Sub-Total	26,217	2,318	2,578
Total (1+2+3)	419,623	81,027	134,805

Fig. E.1 Farm Working System (1)

Crop	Season	J	F	M	A	M	J	J	A	S	O	N	D	Working System: Technical Note	Working System: Man power	Remarks
Cacao	Cropping period													Plantain apply for shade tree untill 2nd. year.		
	Sowing & transplanting Period													Cropping density : 1,111 unit/ha (2m x 2m)	person 2, hr./ha 1.5	Transplanting of hybrid nursery
	Flowering													Cultivate condition: Temperature : 21 c Prec- : 1,500mm/year ipitation pH : 6 to 7 soil: Franco arcillo - arenoso, Arcillo - arenoso effective:120-150 cm soil profund	person 2, hr./ha 1.5	Artificial pollination
	Harvesting														person 2, hr./ha 0.5	
	Fertization														person 1, hr./ha 0.7	
	Control of disease & wood													Sprayer & duster	1, 0.5	For monilia diseases

Fig. E.1 Farm Working System (2)

Crop	Season	J	F	M	A	M	J	J	A	S	O	N	D	Working system: Farm machinery	Working system: Man power	Remarks
Banana	Cropping period													Plantation system by cooperation	person 1, hr./ha 1; person 1, hr./ha 1	
	Sowing & transplanting period													Cropping density : 1,100 unit/ha; Sowing system by "Hexagonal or Doble surco"	person 2, hr./ha 1.5	
	Flowering															
	Harvesting														person 2, hr./ha 2.0	
	Fertization													Sprayer & duster	person 1, hr./ha 0.5	
	Control of disease & weed													Air plane	person 1, hr./ha 0.2	

Fig. E.1 Farm Working System (3)

Crop	Season	J	F	M	A	M	J	J	A	S	O	N	D	Working system: Farm machinery	Working system: Man power	Remarks
Coconut	Cropping period	←											→	Tractor 1 unit Bottom plow 1hr./ha Disk plow 1hr./ha	person hr./ha 1 1 1 1	leveling & grading
	Sowing & transplanting period													Cultivate condition; Temperature:21-30 c Precipitation: 2,500 mm/year EL. : 0 - 600 m pH. : 5 - 7.5 Cropping density : 6 x 8 m		
	Flowering															
	Harvesting														person hr./ha 1 0.5	
	Fertization													Pesticide sprayer & 0.3hr./ha duster	person hr./ha 2 0.5	
	Control of diseas & weed														person hr./ha 1 0.5	

Fig. E.1 Farm Working System (4)

Crop	Season	J	F	M	A	M	J	J	A	S	O	N	D	Working system	Working system: Man power	Remarks
Plantain	Cropping period	←											→	Tractor 1 unit Bottom plow 1hr./ha Disk plow 1hr./ha	person hr./ha 1 1 1 1	
	Sowing & transplanting period													Cropping density 3 x 3 or 3.25 x 3.25 system by "cuadro o pata de gallo"		
	Flowering													cultivate condition; Temperatur: 23-30 c Precipitation: 2,500 mm/year	person hr./ha 2 1hr./ha	
	Harvesting													pH : 6 - 6.5 EL.: 0 - 800 m	person hr./ha 2 1hr./ha	
	Fertization													Sprayer & duster	person hr./ha 2 0.5hr./ha	
	Control of disease & weed													Combine 0.8hr/ha	person hr./ha 1 0.8hr./ha	

Fig. E.1 Farm Working System (5)

Crop	Season	J F M A M J J A S O N D	Working system: Farm machinery	Working system: Man power	Remarks
Pepper	Cropping period		Supporting Pole : length : 3 - 4 m, across :10 - 15 cm	person hr./ha 2 2	
	Sowing & transplanting period		Cultivate condition: Temperature :25-30 c E.L : 1,000 m pH : 5.5 - 6.5 Cropping density : 2.5 m x 2.5		
	Flowering			person hr./ha 2 2	
	Harvesting			person hr./ha 2 1	
	Fertilization		Pesticide sprayer & duster 0.5/ha	person hr./ha 1 1	
	Control of disesases & weed			person hr./ha 2 0.7hr./ha	

Fig. E.1 Farm Working System (6)

Crop	Season	J F M A M J J A S O N D	Working system: Farm machinery	Working system: Man power	Remarks
Rice	Land preparation		Tractor 1 unit Bottom plow 1hr./ha Disk plow 1hr./ha	person hr./ha 1 1 1 1	
	Cropping period		Total growing period estimated 120 days. 1st crop is around April to August. 2nd.crop(occational) is around Oct. to Jan.		
	Sowing		Grain drill 0.5hr./ha	person hr./ha 2 1hr./ha	
	Fertization	1st dressing; top dressing		person hr./ha 2 1hr./ha	
	Control of disease & weed		Sprayer & duster	person hr./ha 2 0.5hr./ha	
	Harvesting		Combine 0.8hr/ha	person hr./ha 1 0.8hr./ha	

Fig. E.1 Farm Working System (7)

Crop	Season	J F M A M J J A S O N D	Working system: Farm machinery	Working system: Man power	Remarks
Mize	Land preparation		Tractor 1 unit Bottom plow 1hr./ha Disk plow 1hr./ha	person hr./ha 1 1 1 1	leveling & grading
	Cropping period		-Total growing period estimated 90 days. -Flowering time is around at middle of June.		
	Sowing		Grain drill 0.5hr./ha		
	Fertization	basal dressing top dressing top dressing		person hr./ha 2 0.5	
	Control of disease & weed	pesticide weeding	Pesticide sprayer & duster 0.5hr./ha	person hr./ha 2 0.5	
	Harvesting			person hr./ha 2 0.5	

Fig. E.1 Farm Working System (8)

Crop	Season	J F M A M J J A S O N D	Working system: Farm machinery	Working system: Man power	Remarks
Kidney bean	Land preparation		Trctor 1 unit Bottom plow 1hr./ha Disk plow 1hr./ha	person hr./ha 1 1 1 1	leveling & grading
	Cropping period	Flowering	-Total growing period estimated 120 days. -Flowering time is around of principale of Feb.		
	Sowing			person hr./ha 2 2	
	Fertization	basal dressing top dressing		person hr./ha 2 1	
	Control of disease & weed	pesticide weeding	Pesticide sprayer & duster 0.5/ha	person hr./ha 1 1	
	Harvesting			person hr./ha 2 0.7hr./ha	

Fig. E.1 Farm Working System (9)

Crop	Season	J	F	M	A	M	J	J	A	S	O	N	D	Working system: Farm machinery	Working system: Man power	Remarks
Tuber Crops	Land preparation					--								Tractor 1 unit Bottom plow 1hr./ha Disk plow 1hr./ha	person hr./ha 1 1 1 1	
	Cropping period						—	—	—	—	—	—				
	Sowing						~								person hr./ha 2 2hr./ha	
	Fertization						— 1st dressing			— top dressing					person hr./ha 2 1hr./ha	
	Control of disease & weed						—			—				pesticide weeding	person hr./ha 2 1hr./ha	
	Harvesting											~		cultivator 0.8hr/ha	person hr./ha 2 0.8hr./ha	

E.3.2 Change of the Total Agricultural Production in the Project Area

The expected total agricultural production in the Project Area for the target year, is calculated on the basis of the proposed cropping area and estimated yield.

The following shows change of the total agricultural production in the Project Area for the target area.

Table E.3 Change of the Expected Total Agricultural Production

Crop / Year	Perennial Crop					Annual crop				Beef
	Banana	Cacao	Coconut	Plantain	Peper	Rice	Maize	Bean	Tuber	
1992/1993	0	0	0	0	0	20,230	804	263	5,720	105
1993/1994	112,800	0	0	5,000	90	26,100	965	362	5,720	107
1994/1995	117,600	1,152	0	8,500	400	26,100	1,179	500	6,435	131
1995/1996	117,600	2,880	2,750	8,500	400	26,100	1,350	500	7,150	156
1996/1997	117,600	2,880	2,750	8,500	400	26,100	1,350	500	7,865	196
1997/1998	117,600	2,880	3,250	8,500	400	26,100	1,350	500	7,920	196
1998/1999	117,600	2,880	5,000	8,500	400	26,100	1,350	500	7,920	196
1999/2000	117,600	2,800	5,000	8,500	400	26,100	1,350	500	7,920	196

E.3.3 Agricultural Household Economy

In consideration of farming pattern, farm-scale and production costs of model farmers will be calculated in case of farm management under the proposed farming pattern.

The results of these calculations are shown in the following table E.4. The cropping pattern depends on the farming patterns are presented on Fig. E.2.

Table E.4 Agricultural Household Economy (1)

A Pattern : Cacao + Annual Crops

Item	Planted Area(ha)	Yield (t/ha)	Production(t)	Producer Price(¢/t)	Total (¢)
1. Income					
(1) Cacao	5.0	1.0	5.0	95,000	475,000
(2) Rice	1.0	4.5	4.5	14,200	63,900
(3) Tuber Crops	1.5	11.0	16.5	14,000	231,000
(4) Kidney Bean	0.5	1.5	0.75	35,788	26,841
Total					796,741
2. Outgo					
(1) Production Cost(¢)					410,918
- Labor	207,974				
- Seed	21,098				
- Fertilizer	73,825				
- Agro-Chemicals	59,530				
- Farm Machinery	26,911				
- Others	21,580				
(2) O/M Cost(¢)					8,814
(3) Living Expense(¢)					140,000
Total					559,732
3. Net Reserve					237,009

Table E.4 Agricultural Household Economy (2)

B Pattern : Plantain + Annual Crops

Item	Planted Area(ha)	Yield (t/ha)	Production(t)	Producer Price(¢/t)	Total (¢)
1. Income					
(1) Plantain	4.0	17.0	68.0	8,500	578,000
(2) Rice	2.5	4.5	11.3	14,200	159,750
(3) Tuber Crops	2.0	11.0	22.0	14,000	308,000
(4) Maize	0.5	2.5	1.25	13,669	17,086
Total					1,062,836
2. Outgo					
(1) Production Cost(¢)					681,716
- Labor	246,005				
- Seed	32,614				
- Fertilizer	98,547				
- Agro-Chemicals	231,891				
- Farm Machinery	42,647				
- Others	30,012				
(2) O/M Cost(¢)					8,814
(3) Living Expense(¢)					140,000
Total					830,530
3. Net Reserve					232,306

Table E.4 Agricultural Household Economy (3)

C Pattern : Coconut + Annual Crops

Item	Planted Area(ha)	Yield (t/ha)	Production(t)	Producer Price(¢/t)	Total (¢)
1. Income					
(1) Coconut	4.0	10.0	40.0	8,600	344,000
(2) Rice	2.5	4.5	11.3	14,200	159,750
(3) Tuber Crops	2.5	11.0	27.5	14,000	385,000
Total					888,750
2. Outgo					
(1) Production Cost(¢)					588,095
- Labor	234,400				
- Seed	36,832				
- Fertilizer	151,685				
- Agro-Chemicals	90,638				
- Farm Machinery	44,840				
- Others	29,700				
(2) O/M Cost(¢)					8,814
(3) Living Expense(¢)					140,000
Total					736,909
3. Net Reserve					151,841

Table E.4 Agricultural Household Economy (4)

D Pattern : Black Peper + Annual Crops

Item	Planted Area(ha)	Yield (t/ha)	Produc-tion(t)	Producer Price(¢/t)	Total (¢)
1. Income					
(1) Black Peper	0.5	2.2	1.1	220,000	174,600
(2) Maize	5.0	2.5	12.5	13,669	55,168
(3) Kidney Bean	5.5	1.5	8.3	35,788	93,126
(4) Rice	1.5	4.5	6.8	14,200	33,150
Total					803,963
2. Outgo					
(1) Production Cost(¢)					447,920
- Labor	159,472				
- Seed	31,039				
- Fertilizer	79,354				
- Agro-Chemicals	74,325				
- Farm Machinery	82,973				
- Others	20,755				
(2) O/M Cost					8,814
(3) Living Expense					140,000
Total					596,734
3. Net Reserve					207,229

Table E.4 Agricultural Household Economy (5)

E Pattern : Rotation of Annual Crops

Item	Planted Area(ha)	Yield (t/ha)	Production(t)	Producer Price(¢/t)	Total (¢)
1. Income					
(1) Rice	5.0	4.5	22.5	14,200	319,500
(2) Tuber Crops	3.0	11.0	33.0	14,000	462,000
(3) Maize	3.0	2.0	7.5	13,669	102,517
(4) Kidney Bean	2.0	1.5	3.0	35,788	107,364
Total					991,381
2. Outgo					
(1) Production Cost(¢)					635,894
- Labor	230,297				
- Seed	64,370				
- Fertilizer	75,432				
- Agro-Chemicals	123,404				
- Farm Machinery	102,059				
- Others	40,332				
(2) O/M Cost(¢)					8,814
(3) Living Expense(¢)					140,000
Total					784,708
3. Net Reserve					206,673

Table E.4 Agricultural Household Economy (6)

F Pattern : Cattle(50ha by medium or large-scale farmer)

Item	Planted Area(ha)	Yield (t/ha)	Produc-tion(t)	Producer Price(¢/t)	Total (¢)
1. Income					
(1) Cattle	50.0	0.35	17.5	50,000	875,000
Total					875,000
2. Outgo					
(1) Production Cost(¢)					504,000
(2) O/M Cost(¢)					67,800
(3) Living Expense(¢)					140,000
Total					711,800
3. Net Reserve					163,200

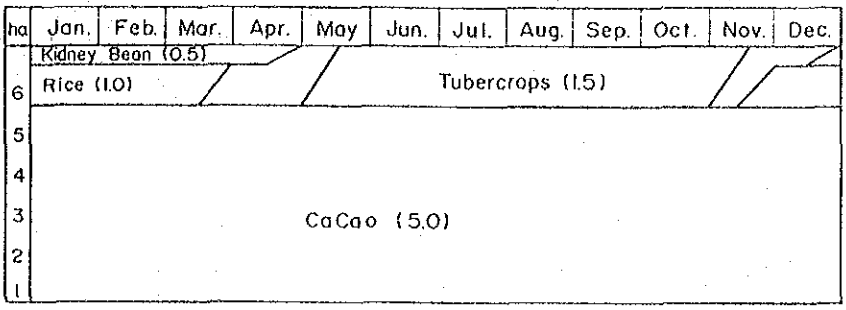
Table E.4 Agricultural Household Economy (7)

G Pattern : Banana Mono-Culture(300ha by banana cooperation system)

Item	Planted Area(ha)	Yield (t/ha)	Produc- tion(t)	Producer Price(¢/t)	Total (¢)
1. Income					
(1) Banana	300	49.0	14,700	13,200	194,040,000
Total					194,040,000
2. Outgo					
(1) Production Cost(¢)					168,514,200
- Labor	30,893,700				
- Fertilizer	51,490,200				
- Others	86,130,300				
(2) O/M Cost(¢)					406,800
(3) Others					5,400,000
Total					174,321,000
3. Net Reserve					19,719,000

PATTERN: Fig. E.2 (1) Cropping Pattern by Farm Management Type

A



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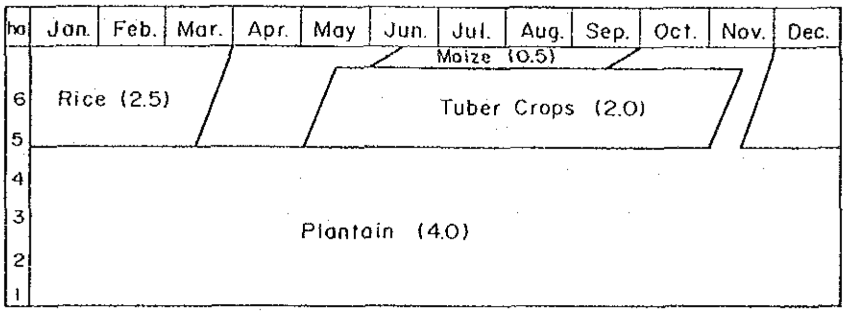

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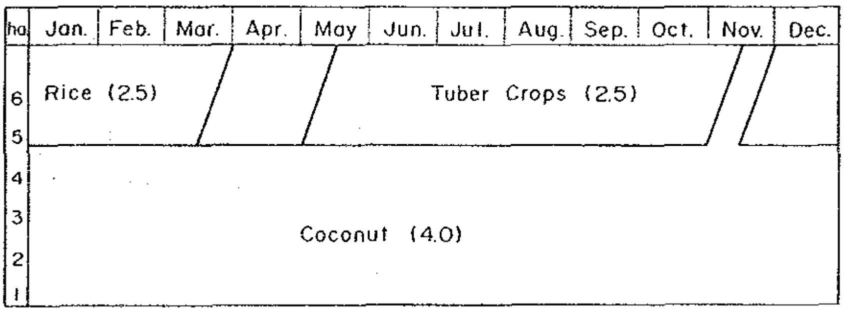
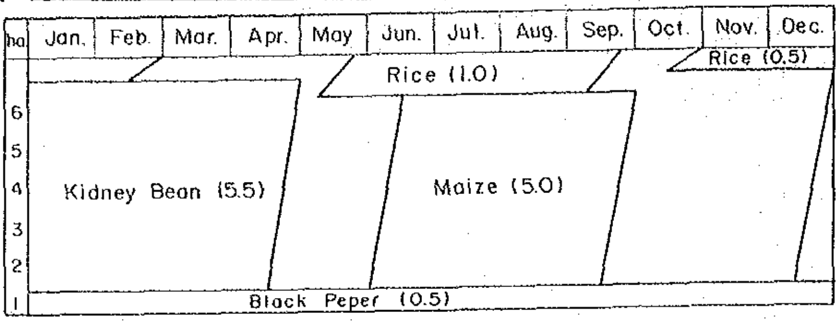


PATTERN: Fig. E.2 (2) Cropping Pattern by Farm Management Type

D



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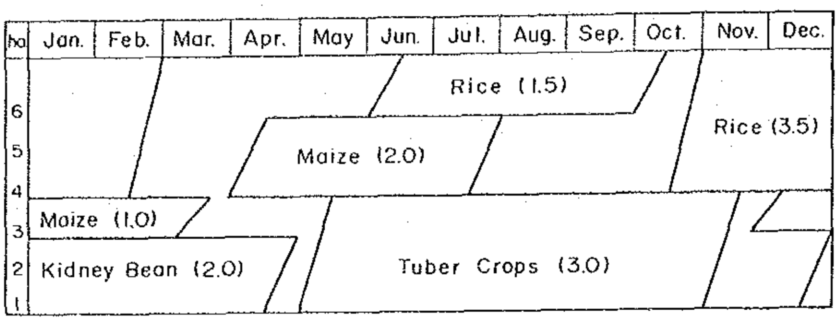

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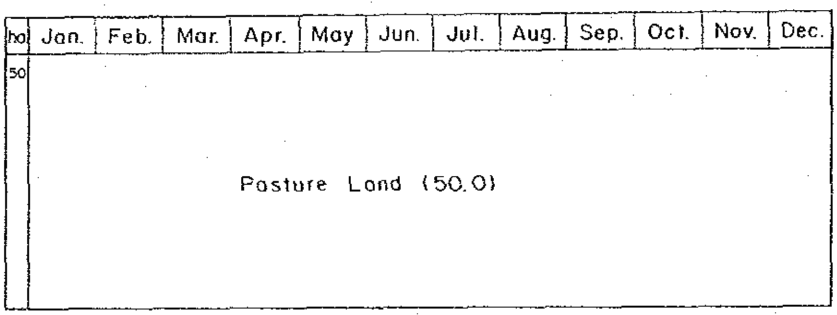

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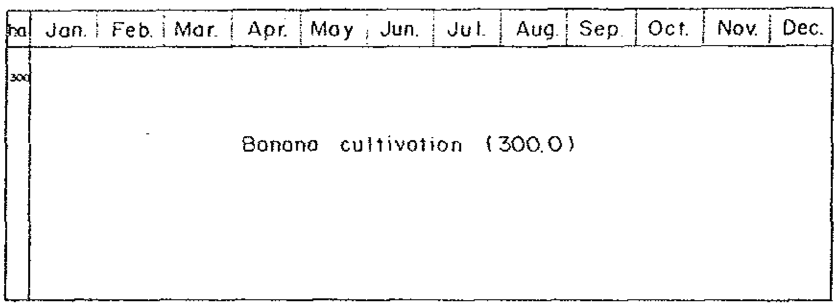

E.3.4 Farm Management Survey

The summary of the farm management survey in the Study Area is shown Table E.5. The main income source of farmers can be classified into two: agricultural income and non-agricultural income. Agricultural income in the Study Area has been mainly gained by production of rice, cacao, tiquisque(taro), coconut, plantain and animal husbandry. Rice production is the most important income source followed by cacao and plantain.

The average age of the head of a family is 50.5 years old. Landholdings range from 4 ha to 55 ha (with an average of 11.3 ha, and 70 % of farmer operating on less than 10.0ha). Generally, 35.0% of land is cultivated in the Zone B Study Area, while the rest are fallow lands. No further expansion of cultivation area is expected since there are lack of drainage improvement, technical assistance, agricultural finance and agricultural machines.

Production sales average is 82,000 colones/year based on the 30 average farmers. Seeds, fertilizers, pesticides and rented agricultural machineries occupy the main costs of production. The ratio of production costs to gross farm income is estimated at 30.0 % per average farmer. Total farm income of an average farmer is about 182,000 colones. On the other hand, household expenditure consits of food, housing, clothing, electricity, household furnishing, medical care, communication and education, etc.

Annual total living cost is estimated at about 120,000 colones in an average, or 10,000 colones per month. In general, the average farmer in the Study Area dose not receive an adequate farm income to support a family. They also depend on their non-farming income sources.

Table E.5 Summary of Farm Management Survey (1)

Location : Canton of Matina

No	General				Cropping System					
	District	①No. of family(person) ②No. of family Labor	Working day/year	Land Holding Type (*1)	Cropping Area(ha)	Farm Management Type & Area (ha)	Yield (t/ha)	Fallow Land (ha)	Cropping Intensity (%)	Technical Assistance
1	Bataan Sara	① 5 ② 2	300	① 55.0 ② Owner ③ 1980	5.0	Cattle 30 head	0.25	50.0	10.0	-
2	Bataan Sara	① 3 ② 2	300	① 9.0 ② Owner ③ 1963(IDA)	9.0	Rice 6.0 Cacao 3.0	2.7 0.4	-	167.0	IDA
3	Bataan Luzon	① 8 ② 2	100	① 10.0 ② Owner ③ 1965(IDA)	3.0	Cacao 3.0	0.3	7.0	30.0	-
4	Bataan Luzon	① 9 ② 3	300	① 8.0 ② Owner ③ 1961(IDA)	4.0	Cacao 0.1 Kidney bean 3.0 Maize 0.2 Rice 0.7	0.7 0.2 0.7 2.5	4.0	50.0	-
5	Bataan Centro	① 5 ② 1	315	① 4.0 ② Owner ③ 1980(IDA)	3.0	Rice 2.0 (double cropping) Cacao 1.0	3.0 0.3	1.0	130.0	MAG

Household Economy			
Agricultural Income(¢/year)	Non-Agricultural Income(¢/year)	Living Cost (¢/month)*2	Problem for Farm Management
-	216,000 (From Banana Farm)	① 15,000 ② 10,000 ③ 5,000	Credit Poor Drainage
65,000	130,200 (Mainly from Banana Farm)	① 17,000 ② 12,000 ③ 5,000	Credit Technical Assistance Poor Drainage
500	240,000 (Mata de C.R)	① 13.000 ② 10,000 ③ 3,000	Poor Drainage
144,000	156,000 (Large Ranch)	① 18,000 ② 15,000 ③ 3,000	Poor Drainage Credit
128,000	-	① 10,000 ② 8,000 ③ 2,000	Poor Drainage Successor

Remarks :

* 1) ① Land Holding Area(ha)
  ② Land Owner or Tenant
  ③ Registered Year

* 2) ① Total Living Cost
  ② Food
  ③ Others(electricity, water etc.,)

Table E.5 Summary of Farm Management Survey (2)

Location : Canton of Matina

No	General				Cropping System					
	District	①No. of family (person) ②No. of family Labor	Working day/year	Land Holding Type (*1)	Cropping Area (ha)	Farm Management Type & Area (ha)	Yield (t/ha)	Fallow Land (ha)	Cropping Intensity (%)	Technical Assistance
6	Bataan Sara	① 3 ② 1	320	① 8.0 ② Owner ③ 1963(IDA)	6.2	Cacao 2.0 Rice 4.0 Maize, Kidney bean 0.1	0.3 2.8 0.1	1.8	130.0	IDA MAG
7	Bataan 28millas	① 6 ② 2	200	① 11.0 ② Owner ③ 1978(IDA)	5.0	Cacao 5.0	0.2	6.0	50.0	-
8	Bataan Matina	① 5 ② 1	270	① 15.0 ② Owner ③ 1980(IDA)	5.0	Plantain 5.0	5.0	10.0	30.0	-
9	Matina 4 millas	① 3 ② 1	300	① 5.0 ② Owner ③ -	4.5	Plantain 2.5 Cacao 1.5 Coco 0.5	7.5 0.2 2.0	0.5	90.0	-
10	Matina 5 millas	① 5 ② 1	330	① 4.0 ② Owner ③ 1974(IDA)	2.0	Maize 1.0 Cacao 1.0	1.0 0.1	2.0	50.0	-

Household Economy			
Agricultural Income(¢/year)	Non-Agricultural Income(¢/year)	Living Cost (¢/month)*2	Problem for Farm Management
200,000	-	① 12,500 ② 11,000 ③ 1,500	Technical Assistance Poor Drainage Successor
10,000	180,000 (Banana Farm)	① 13,000 ② 11,000 ③ 2,000	Poor Drainage
78,000	144,000 (Banana Farm)	① 15,000 ② 10,000 ③ 5,000	Poor Drainage
100,000	-	① 8,000 ② 6,000 ③ 2,000	Marketing Credit
10,000	144,000 (Rice Farm)	① 8,000 ② 6,000 ③ 2,000	Poor Drainage

Remarks :

* 1) ① Land Holding Area(ha)
② Land Owner or Tenant
③ Registered Year

* 2) ① Total Living Cost
② Food
③ Others(electricity, water etc.,)

Table E.5 Summary of Farm Management Survey (3)

Location : Canton of Matina

No	General				Cropping System					
	District	①No. of family (person) ②No. of family Labor	Working day/year	Land Holding Type (*1)	Cropping Area(ha)	Farm Management Type & Area (ha)	Yield (t/ha)	Fallow Land (ha)	Cropping Intensity (%)	Technical Assistance
11	Matina 5 Millas	① 5 ② 1	330	① 16.0 ② Owner ③ 1986(IDA)	3.0	Cacao 2.0 Plantain 1.0	0.3 10.0	13.0	20.0	MAG
12	Matina 6 Millas	① 4 ② 2	310	① 30.0 ② Owner ③ 1953	6.0	Cacao 5.0 Pasture 1.0	0.2 0.25 (7 head)	24.0	20.0	-
13	Matina 7 Millas	① 3 ② 1	310	① 3.0 ② Owner ③ 1987	0.5	Plantain 0.2 Coconut 0.3	5.0 -	2.5	20.0	MAG
14	Bataan Goschen	① 7 ② 3	320	① 15.0 ② Owner ③ 1970(IDA)	3.1	Arroz 3.0 Kidney Bean 0.1	3.5 0.2	11.9	40.0	IDA
15	Bataan Goschen	① 7 ② 1	300	① 20.0 ② Owner ③ 1975	3.0	Rice 2.5 Maize 0.4 Tuber crop 0.1	3.0 0.7 5.0(Taro)	16.0	30.0	-

Household Economy			
Agricultural Income(¢/year)	Non-Agricultural Income(¢/year)	Living Cost (¢/month)*2	Problem for Farm Management
96,000	-	① 8,000 ② 6,000 ③ -	Credit Poor Drainage
10,000	216,000 (Banana Farm)	① 13,000 ② 10,000 ③ 3,000	Credit Technical Assistance Production Materials
72,000	36,000 (Rice Farm)	① 8,000 ② 6,000 ③ 2,000	Poor Drainage
50,000	60,000 (Daily labor)	① 8,000 ② 7,000 ③ -	Poor Drainage Credit
30,000	180,000 (Daily labor)	① 10,000 ② 9,000 ③ 1,000	Poor Drainage

Remarks :

* 1) ① Land Holding Area(ha)
② Land Owner or Tenant
③ Registered Year

* 2) ① Total Living Cost
② Food
③ Others(electricity, water etc.,)

Table E.5 Summary of Farm Management Survey (4)

Location : Canton of Matina

No	General				Cropping System					
	District	①No. of family(person) ②No. of family Labor	Working day/year	Land Holding Type (*1)	Cropping Area(ha)	Farm Management Type & Area (ha)	Yield (t/ha)	Fallow Land (ha)	Cropping Intensiy (%)	Technical Assistance
16	Bataan Berta	① 2 ② 1	300	① 11.0 ② Owner ③ 1983(IDA)	1.0	Plantain 1.0	6.0	10.0	10.0	-
17	Bataan La Lora	① 4 ② 1	310	① 7.0 ② Owner ③ 1960(IDA)	2.0	Cacao 2.0	0.4	3.0	30.0	MAG
18	Bataan 28Millas	① 4 ② 2	300	① 5.0 ② Owner ③ 1970	2.0	Cacao 1.0 Banana 0.5 Tuber 0.5	0.2 - 5.0	3.0	40.0	MAG
19	Matina RioMadre de Dios	① 6 ② 3	300	① 5.0 ② Owner ③ 1963	2.0	Cacao 2.0	0.3	3.0	40.0	IDA
20	Matina Barbilla Norte	① 6 ② 1	300	① 5.5 ② Owner ③ 1975	2.0	Arroz 1.0 Cacao 0.5 Coco 0.5	3.0 0.1 -	3.0	55.0	-

Household Economy			
Agricultural Income(¢/year)	Non-Agricultural Income(¢/year)	Living Cost (¢/month)*2	Problem for Farm Management
5,000	144,000 (Dily labor)	① 7,000 ② 5,000 ③ 2,000	Credit Poor Drainage
30,000	240,000 (Banana Farm)	① 15,000 ② 10,000 ③ 5,000	Credit Technical Assistance
20,000	216,000 (Mata de C.R)	① 17,000 ② 13,000 ③ 4,000	Poor Drainage
30,000	240,000 (Port Limon)	① 10,000 ② 8,000 ③ 2,000	Poor Drainage Credit
20,000	96,000 (JAPDEVA)	① 9,000 ② 7,000 ③ 2,000	Poor Drainage

Remarks :

* 1) ① Land Holding Area(ha)
② Land Owner or Tenant
③ Registered Year

* 2) ① Total Living Cost
② Food
③ Others(electricity, water etc.,)

Table E.5 Summary of Farm Management Survey (5)

Location : Canton of Matina

No	General				Cropping System					
	District	①No. of family (person) ②No. of family Labor	Working day/year	Land Holding Type (*1)	Cropping Area(ha)	Farm Management Type & Area (ha)	Yield (t/ha)	Fallow Land (ha)	Cropping Intensiy (%)	Technical Assistance
21	Matina Davao	① 7 ② 3	310	① 7.0 ② Owner ③ 1980(IDA)	3.6	Rice 2.0 Platain 2.0 Tuber 0.5 Maize 0.1	2.8 0.5 5.0 1.0	3.4	50.0	IDA
22	Bataan Centro	① 6 ② 1	330	① 10.0 ② Owner ③ 1979(IDA)	4.0	Rice 1.0 Cacao 2.0 Maize, Kidney 1.0	3.0 0.2	6.0	40.0	MAG
23	Bataan Amsterdum	① 5 ② 1	300	① 8.0 ② Owner ③ 1973	3.0	Plantain 1.5 and Cacao 1.5	7.0 0.2	5.0	40.0	-
24	Bataan Amsterdum	① 5 ② 1	320	① 8.0 ② Owner ③ 1973(IDA)	3.0	Rice 2.0 Tuber 1.0	3.5 4.0	5.0	40.0	IDA
25	Bataan Pacuarito	① 4 ② 1	330	① 5.0 ② Owner ③ 1982	3.1	Mize, Kidney 0.1 Cacao 1.0 Coco, platain 2.0	- 0.1 -	1.9	62.0	-

Household Economy			
Agricultural Income(¢/year)	Non-Agricultural Income(¢/year)	Living Cost (¢/month)*2	Problem for Farm Management
150,000	120,000 (Banana Farm)	① 11,000 ② 9,000 ③ 2,000	Credit Poor Drainage
110,000	-	① 8,000 ② 7,000 ③ 1,000	Credit Technical Assistance Successor
20,000	96,000 (Dily labor)	① 8,000 ② 6,000 ③ 2,000	Poor Drainage
25,000	84,000 (Daily labor)	① 7,000 ② 6,000 ③ 1,000	Poor Drainage Credit
12,000	84,000 (Daily labor)	① 5,000 ② 4,000 ③ 1,000	Poor Drainage

Remarks :

* 1) ① Land Holding Area(ha)
② Land Owner or Tenant
③ Registered Year

* 2) ① Total Living Cost
② Food
③ Others(electricity, water etc.,)

Table E.5 Summary of Farm Management Survey (6)

Location : Canton of Matina

No	General				Cropping System					
	District	①No. of family (person) ②No. of family Labor	Working day/year	Land Holding Type (*1)	Cropping Area (ha)	Farm Management Type & Area (ha)	Yield (t/ha)	Fallow Land (ha)	Cropping Intensiy (%)	Technical Assistance
26	Bataan Sara	① 7 ② 2	330	① 10.0 ② Owner ③ 1975(IDA)	6.0	Rice 5.0 Cacao 1.0	2.2 0.2	4.0	110.0	Agro Bataan IDA
27	Bataan Luzon	① 6 ② 2	310	① 8.5 ② Owner ③ 1979(IDA)	6.0	Rice 5.0 Cacao 1.0	2.0 0.1	2.0	70.0	-
28	Matina Rio Madre de dios	① 8 ② 2	320	① 11.0 ② Owner ③ 1976(IDA)	4.0	Cacao 4.0 (Harvesting Area 2.5)	0.3	7.0	36.0	MAG
29	Bataan Centro	① 7 ② 2	300	① 15.0 ② Owner ③ 1980(IDA)	6.8	Rice 6.0 Other (Maize, Kidney beans) 0.8	3.0	7.2	85.0	IDA
30	Bataan Amsterdum	① 5 ② 1	300	① 10.0 ② Owner ③ 1975(IDA)	3.5	Rice 2.0 Maize 0.5 Kidney bean 0.5 Tuber 0.5	3.0 1.0 0.8 4.5	6.5	40.0	

Household Economy			
Agricultural Income(¢/year)	Non-Agricultural Income(¢/month)	Living Cost (¢/month)*2	Problem for Farm Management
180,000	-	① 13,000 ② 9,000 ③ 4,000	Credit Poor Drainage
92,000	30,000 (Daily labor)	① 11,000 ② 9,000 ③ 2,000	Credit Technical Assistance
52,000	72,000 (Banana Farm)	① 10,000 ② 8,500 ③ 1,500	Poor Drainage
87,000	60,000 (Daily labor)	① 10,000 ② 8,000 ③ 2,000	Poor Drainage Credit
42,000	48,000 (Daily labor)	① 7,000 ② 6,000 ③ 1,000	Poor Drainage

Remarks :

* 1) ① Land Holding Area(ha)
  ② Land Owner or Tenant
  ③ Registered Year

* 2) ① Total Living Cost
  ② Food
  ③ Others(electricity, water etc.,)

Annex F Drainage

Annex. F Drainage

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F.1 Current Drainage System and Its Situation

F.1.1 Drainage System

Using a newly prepared topographical map of scale 1:10,000, field investigation were conducted on the drainage system in the Areas.

1) Topographical Characteristics

The Study Area slopes down from southwest to northeast. The gradient of the virgin forest, the lowest place in the surveyed area, is 1/3,000 to 1/4,000.

2) Characteristics of Rio Matina, Rio Barbilla and Rio Chirripo

The direct basins of Rio Matina and Rio Chirripo are small. All drained water from the left side basin of the Rio Barbilla flows into the river. On the other hand, the right side basin is small.

3) Characteristics of the Present Drainage System

The present drainage system is shown in Fig. F.1.1. The basins classified by the drainage system is shown in Table F.1.1.

. Most of the drained water inside the Study Area goes through the existing canal and small rivers, before finally pouring into Canal del Tortuguero running parallel to the Caribbean shoreline.

. The total basin area of the eleven tributaries flowing into the three large rivers -- Rio Matina, Rio Barbilla and Rio Chirripo -- is 1,750 ha.

. The virgin forest located in the lowest part of the study area becomes inundated at the time of flooding.

F.1.2 Existing Drainage Facilities

1) Canal Constructed by Banana Plantation

The canal constructed by the plantation and used as the main drainage canals has a large drainage cross-section (3 to 5 m in depth, 2 to 12 m in bottom width, 8 to 20 m in top width) inside and immediately downstream the plantation, and is well maintained. The canal becomes smaller in its cross section downstream the plantation (2 to 2.5 m in depth, 4 to 5 m in bottom width, 8 to 10 m in top width) and is left without maintenance service.

2) Small Canals in the Abandoned Farm Land

Small canals running through the abandoned farm land are often found in the Sara settlement. The canal serving as the main drainage system inside the settlement measures 2.5 meters in depth, 3 meters in bottom width and 10 meters in top width. Terminal ditches (1.5 meters in depth, 2.0 meters in bottom width, 6.0 meters in top width) are placed at an interval of 150 meters but with no maintenance service.

3) Other Small Canals

Although very few in numbers, there exist small artificial canals constructed by the settlers. One of them measures 1 meters in depth, 1 meter in bottom width and 3 meters in top therefore, are not effective in discharging rain water and dealing with decline of ground water levels.

4) Small Rivers

Rio Madre de Dios, Rio Veintiseis, and Rio San Miguel have their watersheds outside the Study Area, while those of other small rivers are located within.

The small rivers with radically meandering courses flow toward the virgin forest; the areas of the rivers' cross sections are small compared with that of their basins and lush growth of grass within and on the shores of the rivers serve to diminish their draining effectiveness. Many small rivers are recognizable inside the forest on the topographical map.

5) Canal del Tortuguero and River Mouths

Refer to the Master Plan Report, Annex F. F.2.4 and F.2.5 for conditions of Canal del Tortuguero and river mouths.

6) River Crossing Facilities

Bridges or culverts are provided where a railway or a road crosses canals or small rivers. Bridges are installed in some places where a railway or road crosses Rio Madre de Dios with a large cross section or other canals constructed by banana plantations. Main road bridges have concrete structure whereas minor ones are made of wood. Culverts (600 to 800 cm in diameter) are often found where a road crosses small canals or rivers with small cross sections.

Because of their small cross sections in relation to drainage capacity, upstream culverts often get inundated in case of rainfalls and the water overflows over the road in some places.

Table F.1.2 shows the drainage facilities' extensions by the drainage system.

F.2 Drainage Situation in Farming Area

F.2.1 Drainage Situation

1) Situation of Inundation

A) Poor Drainage Area

(1) Farming area in flat land

The farming area, excluding banana plantations with canals, are without an adequate drainage system and become to be inundated every year when there is a flood at rio Matina, Rio Barbilla or Rio Chirripo, and the situation is worse downstream.

Based on interviews, topographical characteristics discharge system and the situation of the existing drainage facilities, the following areas are considered to be susceptible to inundation three or four times a year, lasting for two to three days.

. West of Cuatro Millas
. East of Luzon settlement
. North of Santa Maria
. North of Bataan
. Areas around Goshen
. Right side of Barbilla

(2) Farming lands inside the abandoned plantation

Despite terminal ditches running-east-west and the main drainage system arranged north-south, the settlement has similar inundation problems as the areas shown in (1) above. This is because Rio Madre de Dios and Rio Veintiseis overflow when there is heavy rainfall.

The Luzon settlement, however, has a good drainage condition as it is located next to the main canal of the banana plantation and has a higher elevation level in relation to the surrounding area.

B) Areas with Good Drainage

(1) Downstream Rio Matina

There is a good drainage area on the left side of downstream of Rio Matina. A number of factors contribute to this: the area is located in the upper end of the basin, and has high water permeability and sharp slope. However, it gets inundation when there is a flood at Rio Matina.

(2) Farming area with high gradient

The southwestern area of the study area, where there are cacao farming, secondary forests and grass land, is free of inundation due to its high gradient at 1/50 to 1/200.

(3) Banana plantations

The six plantations (1,960 ha) inside the study area are free of inundation at the time of rainfalls thanks to the well-organized drainage system.

2) Underground Water Levels

Water levels of the wells used by the farmers in the study area were used as a substitute for underground water levels. The justification is that the wells are located within or next to the farmland in the Area have roughly the same elevation as farmland.

F.2.2 Analysis on Existing Drainage System and Poor Drainage Areas

F.2.2.1 Drainage Analysis

Possible causes of poor drainage in the Study Areas are shown below.

(1) Water discharge ability of canals and natural small rivers are inadequate.

(2) There are no adequate drainage systems inside farm land to discharge surface water after rainfalls.

(3) The large rivers overflow into the Study Area when there is flood.

Drainage water from the Study Area goes down and stays temporarily at the virgin forest, the place with the lowest elevation, before finally pouring into the Caribbean Sea out of the river mouths.

Drainage analyses have been made possible by the two factors shown below.

. A new 1/10,000-scale map has been prepared, contributing to clearer topographical features of the area.

. Survey has been made for Rio Matina, Rio Barbilla, and Rio Madre de Dios.

1) Case of Drainage Analyses

The hilly area in the southwest and the right side of rio Barbilla are excluded from the analysis. In order to grasp the effects of large-river flooding on the Study Area, analysis conditions were set as follows:

CASE I : Occurance of flood at large rivers with a return period of five-year and rainfalls with a return period of five-year within the study area.

CASE II: Occurrence of rainfalls with a return period of five-year within the Study Area, but no occurrence of floods.

2) Method of Drainage Analysis

(1) Basic formula

The drainage phenomena in this Area are classified as follows by the topographic features:

a) Rain that falls in the Area and river water that overflows from large rivers naturally flow down toward virgin forest. (Flow phenomenon)

b) The river water that reaches the lowlands and the rain that falls in the Area stay in the lowlands and then flows down though river mouths into the Caribbean Sea. (Storage phenomenon)

As a result, the following formulas are applied to the phenomena of flow of water in the Area;

. Equation of motion

$$\frac{1}{g} \cdot \frac{\partial V}{\partial t} + \frac{\partial}{\partial x} \cdot \left(\frac{V^2}{2g}\right) + \frac{V}{g \cdot A} \cdot q \cdot \frac{\partial h}{\partial x} - i + \frac{n^2 V|V|}{R^{4/3}} = 0$$

. Equation of continuity

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q$$

where i : Gradient of river course
h : Water depth
V : Flow velocity
R : Hydraulic radius
n : Manning's roughness coefficient
A : Cross section of flow
q : Lateral inflow
x : Distance
t : Time
g : Acceleration of gravity

The water depth (h) and the flow velocity (v) are determined by approximate solution with differentiation of the equations of motion and continuity.

The following equation is applied to the storage phenomenon;

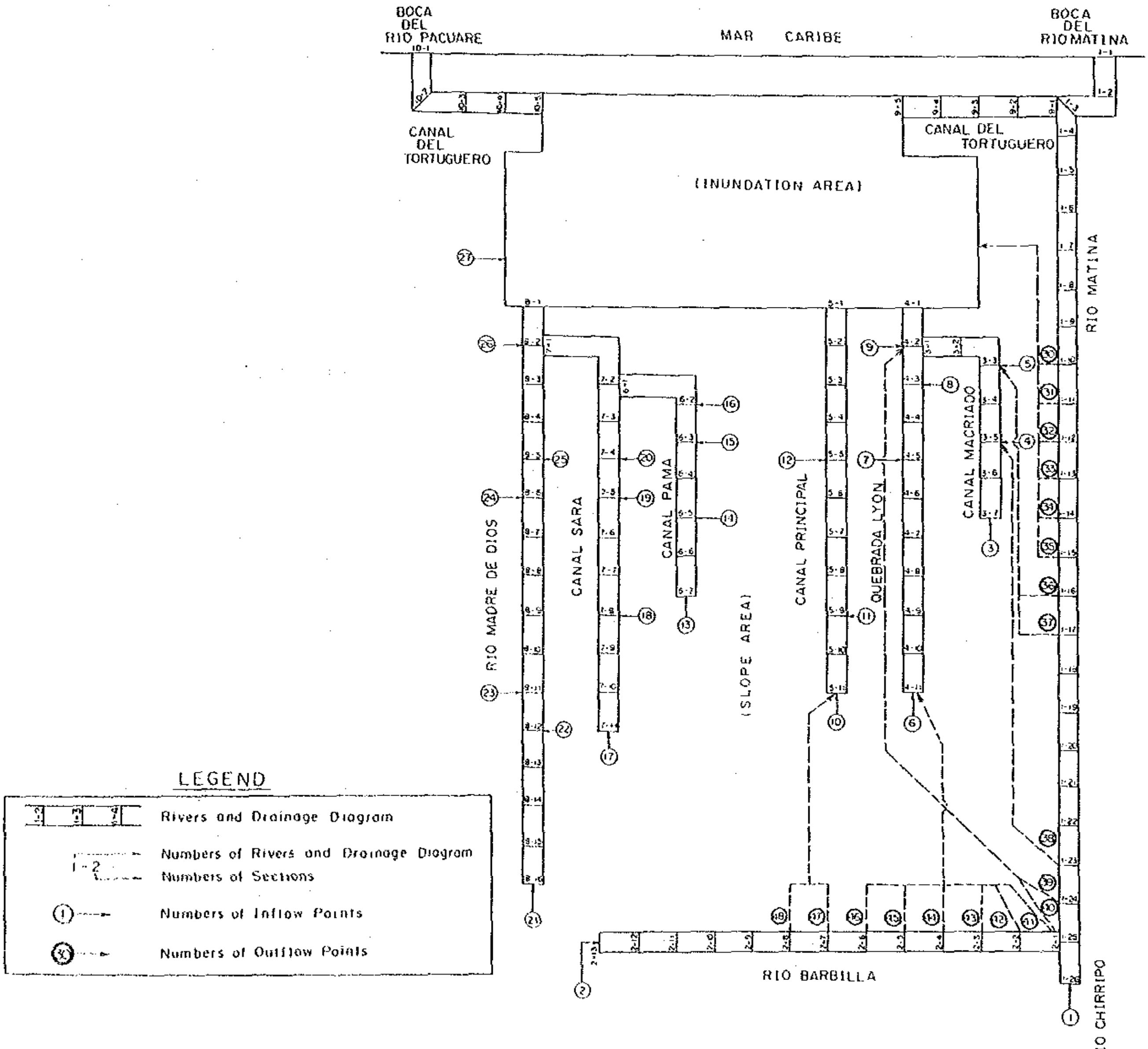
$$dV/dt = I - \bar{O}$$

where V : Flood volume
t : Time
I : Inflow into lowlands
$\bar{O}$: Outflow from lowlands

By use of these equations, the change of inundation water level will be obtained by the change in flood volume. (It is assumed will be obtained by the change in flood volume. (It is assumed that there is no water level gradient in the flooded area)

(2) Calculation Model of rivers and drainage systems

The area is divided into six drainage systems and three rivers presented in the diagram below. The result of river survey is used to determine the cross-section of the rivers and the gradient of the river beds. Also, a topographical map of 1/10,000 is used for the topographical section and topographical gradient.



(3) Flood volume of large rivers

Data used for drainage analysis area as follows;

a) Flood volume of large river (Matina, Barbilla and Chirripo), see Annex B, Table B.2.4.
b) Rainfall : Five-year probability at La Lola
c) Tide level of Caribbean Sea.

3) Result of Analysis

A flood condition diagrams were prepared as shown in Fig. F.2.2 for the inside parts of the Area fro the result of drainage analysis.

The result of analysis shows that:

(1) The floods from large rivers overflow to the Area and increase the stagnant water in the Area. In comparison between Fig. F.2.1 and F.2.2, it is seen that the depth of the stagnant water is increased by 30 cm to 70 cm by the floods from large rivers. the stagnant water increases by more than 30 cm in farm lands measuring 3,300 ha (expect for virgin forest)

(2) The floods from large rivers have an effect on the stagnant water in the following areas in the eastern half of the Area.
   . South area of Matina
   . Areas surrounding Quebrada Lyon
   . West area of Cuatro Millas
   . The area of virgin forests

(3) The stagnant water has a great depth in the following areas, as confirmed also by the field study:

   . The low-lying virgin forests
   . Areas surrounding Quebrada Lyon

. West area of cuatro Millas
. Sara settlement Areas surrounding Goschen

On the other hand, the change in stagnant water in present status is shown Fig. F.2.3. The maximum level of stagnant water occur 26 hours after initiation of precipitation and rises to EL 1.86 m. The Stagnant of water more than EL 1.00 m continues for 49 hours.

F.2.2.2 Poor Drainage Area

The drainage situations of the whole area (19,500 ha) are classified in categories from I to VII. The classification, which is shown in the Master-Plan report and Annex F, has been carried out based on several factors: presence of artificial drainage systems, topographical features, average depth of inundation and underground water conditions during the rainy season.

Classification II, III and IV show poor drainage.
The criteria used for the classification are show below.

. Classification based on result of CASE I.

II : Depth of flooding water - over 60 cm
III : Depth of flooding water - 30 cm - 60 cm
IV : Depth of flooding water - less than 30 cm

. Based on the on-site field study, the following places are included in classification IV: areas with the depth of flooding water less than 0.30 meters but without adequate drainage facilities, or areas with high ground water levels at the time of rainfalls.

. The areas on the right shore of Rio Barbilla are excluded from the drainage analysis. Based on the on-site field study (conditions of drainage facilities, interviews concerning drainage condition), it has been decided to include the areas in classification classification III.

F.2.2.3 Damage of Inundation

Frequent inundation and poor drainage constitute major factors which the expansion of agricultural production.

Calculations have been made about an anticipated increase in agricultural products, both in volume and value, that would follow with an improvement on the existing drainage system. Table F.2.2 shows the result of the calculation.

These values were estimated based on the result of the present land utilization survey. However,the farm land with an elevation of less than 2 meters was excluded form the calculation as it is very difficult to improve the drainage condition of such areas.

Anticipated increases in crop production per 1.0 ha and the prices per 1.0 ton in Annex F. F.3.4 of the Master Plan Report were used to calculate. As a result, it has been learned that the anticipated increase in annual production is approx. 5,200 tons, of US $1,616,000 in value.

F.3 Flood

Rio Matina runs northeastward in the eastern edge of the Study Area. In the area near the southern end, Rio Barbilla flows eastward in parallel to National Route 32 and later joints with Rio Matina. Rio Matina, rio Barbilla and Rio Chirripo are treated as the three large rivers.

In the western end of the study area, Rio Madre de Dios runs northward. This river differs from the other three major rivers in the following points, and is therefore treated as a small river (refer to Clause F.1).

. Its basin in the mountainous area outside the Study Area is very small (29 km^2).

. Of the total river basins (191 km^2), most (169 km^2) lies in flat land.

. With canals and small rivers pouring into the river, it plays a role of the main drainage canal.

. The river is small in scale.

F.3.1 River Conditions

1) Rio Matina

The river length from the confluence of Rio Chirripo and Rio Barbilla to Canal del Tortuguero near the Caribbean Sea is 21.5 km. The river basins is 1,365 km^2.

The river meanders more radically in downstream. The meandering is especially noticeable at places 3 km and 9.5 km upstream from Canal del Tortuguero.

The elevation of the river bed is EL. 3.9 m at the point where is confluence with Rio Chirripo, whereas it is EL. -2.9 m at the confluence with Canal del Tortuguero. The average gradient of the river is 1/2,200; sloping in downstream become gentle at an average of 1/9,000.

The cross section of the river is as follows: 115 to 290 m in width and 6 to 12 m in depth in upper reach; 95 to 145 m in width and 0.5 m in depth in middle reach; and 85 to 154 m in width and 4.5 to 7.5 m in depth in downstream of the river.

2) Rio Barbilla

The river length form the point where the river crosses National Route 32 to the confluence with Rio Matina is 12 km. The area of the basin is 269 km^2 at the confluence with Rio Matina.

The river in downstream is more meandering than upstream in degree of frequency and in places.

The elevation of the rive bed is EL. 21.0 m at the point where the river merges with National Route 32, and EL. 3.9 m at the confluence with Rio Matina. The average gradient in places upstream is 1/450, and the slope get down more gentle to 1/1,300 downstream of the river.

The upper reach of the river is wider in width but smaller in depth than the down reaches: upper reach: 69 to 120 m in width and 1.5 to 8.5 m in depth; down reaches: 45 to 115 m in width and 5 to 10 m in depth.

3) Rio Chirripo

The river length from the point where the river crosses National Route 32 to the confluence with the Rio Matina is 3.2 km. The area of the basin is 1,096 km^2 at the confluence with Rio Matina.

The river meanders in S shapes before merging with Rio Matina: its degree of meandering is moderate compared with the other two rivers.