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

LIMON INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

(THE MASTER PLAN STUDY)

VOLUME II

ANNEX

OCTOBER 1988

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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Annex A. Socio-Economics

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A. Agricultural Organizations

National agricultural institutions concerned for each field such as agricultural credit, agricultural development, agricultural supporting, agricultural organization, etc., are as follows:

1) National Banking System (Sistema Bancario Nacional - SBN)

- Agricultural financing agency
  a. Anglo-Costa Rican Bank (Banco Anglo Costarricense - BAC)
  b. Costa Rican Central Bank (Banco Central de Costa Rica - BCCR)
  c. Agricultural Credit Bank of Cartago
     (Banco Credito Agricola de Cartago - BCAC)
  d. Costa Rica National Bank (Banco Nacional de Costa Rica - BNCR)

2) National Production Council (Consejo Nacional de Produccion - CNP)

- Agency for the promotion of agriculture and livestock production and the price control of basic foods.

3) Home Affairs Institute
   (Instituto de Fomento y Asesoria Municipal - IFAM)

- Guidance agency for local administrative organizations

4) Costa Rican Institute of Electricity
   (Instituto Costarricense de Electricidad - ICE)

- Agency for the electric power supply and telecommunication services

5) National Institute for the Promotion of Cooperatives
   (Instituto Nacional de Fomento Cooperativas - INFOCOOP)

- Agency for the promotion of cooperatives

6) National Institute for the Insurance
(Instituto Nacional de Seguros - INS)

- Agency of the social insurance and compensation insurance for production damage

7) Social Assistance Institute
(Instituto Mixto de Ayuda Social - IMAS)

- Assistance agency for people in the lower brackets of income

8) Agrarian Development Institute
(Instituto de Desarrollo Agrario - IDA)

- Agency for the land titling and settlement program

9) Board for Administration of Ports and Development of the Atlantic Basin
(Junta de Administracion Portuaria de Desarrollo de la Vertiente Atlantica - JAPDEVA)

- Agency for administration of ports and development of the Atlantic basin

10) Coffee Office (Oficina de Cafe - OFICAFE)

- Agency for administration of coffee production

11) Rice Office (Oficina de Arroz - OFIARROZ)

- Agency for administration of rice production

12) National Office of the Seeds (Oficina Nacional de Semillas - ONS)

- Agency for production and quality control of seeds

13) Grains and Seeds Research Center
(Centro de Investigaciones de Granos y Semillas - CIGRAS)

- Agency for grains and seeds investigations

14) Costa Rican Institute of Water Supply and Drainage
(Instituto Costarricense de Acueductos y Alcantarillado - ICAA)

- Agency for water supply and drainage

15) National Institute of Apprenticeship
(Instituto Nacional de Aprendizaje - INA)

- Agency for vocational training and faculties developments

16) National Services for Groundwater, Irrigation and Drainage
(Servicio Nacional de Aguas Subterraneas, Riego y Drenaje - SENARA)

- Agency for groundwater development and implementation of irrigation and drainage

17) Costa Rican Development Corporation
(Corporacion Costarricense de Desarrollo - CODESA)

- Official organization of intensification and assistance for private companies

18) National Banana Association (Asociacion Bananera Nacional - ASBANA)

- Research and administrative organization for banana production and development of perennial crops.

The following international agencies except for national agencies are established.

1) International Development Agency
(Agencia Internacional de Desarrollo - AID)

2) Central American Bank for Economic Integration
(Banco Centroamericano de Integracion Economica - BCIE)

3) Inter-American Development Bank
(BancoInteramericano de Desarrollo - BID)

4) International Bank for Reconstruction and Development
(Banco Internacional de Reconstruccion y Fomentacion - BIRF)

5) Tropical Agricultural Research and Training Center
(Centro Agronomico Tropical de Investigacion y Ensenanza - CATIE)

6) Inter-American Institute of Cooperation for Agriculture
(IICA)

7) Food and Agriculture Organization of the United Nations
(Organizacion Mundial para la Agriculture y la Alimentacion - FAO)

Table A.1 Population in Rural and Urban Area

	Total	Urban Area	Rural Area
	person	person	person
San Jose	890,434	653,191	225,243
Alajuela	427,962	107,192	320,770
Cartago	271,671	88,486	183,185
Heredia	197,575	80,938	116,637
Guanacaste	195,208	51,986	143,222
Puntarenas	265,883	60,664	205,219
Limon	168,076	50,797	117,279
National	2,416,809	1,075,254	1,341,555
Ratio(%)	100.0	44.5	55.5

Table A.2 Financial Conditions of National Banking System

Unit : 1 million US$

I t e m	1981	1982	1983	1984	1985
Ⅰ. Net International Money Reserve Fund	-6,783.8	-1,909.1	4,577.6	8,332.1	16,963.6
Ⅱ. Total of Net Credit	24,068.1	32,401.9	57,243.7	66,897.2	72,038.7
Domestic Net Credit	23,967.5	32,292.5	57,203.5	66,857.0	71,998.5
a) Government	6,555.1	6,417.3	8,981.4	9,968.1	8,960.3
b) Public Services	4,162.8	7,606.6	20,574.3	24,434.4	25,386.6
c) Private Sector	13,249.6	18,268.6	27,647.8	32,454.5	37,651.6
Credit for Foreign Countries	100.6	109.4	40.2	40.2	40.2
Ⅲ. Other Net Capital	39,567.4	50,028.8	79,168.0	88,605.6	110,876.9
Total (Ⅰ+Ⅱ+Ⅲ)	56,851.7	80,521.6	140,989.3	163,834.9	199,609.2
Ⅳ. Total Current Assets	31,383.6	49,690.0	64,732.9	74,693.0	87,830.8
Cash	20,574.7	31,585.8	40,124.2	46,273.1	55,708.6
Current Assets	10,808.9	18,104.2	24,608.7	28,419.9	32,122.2
Cash of Government	3,500.9	5,436.0	6,940.4	8,587.0	9,937.4
Current Accounts	7,308.0	12,668.2	17,668.3	19,832.9	22,184.8
Ⅴ. Foreign Debts	25,468.1	30,831.6	76,256.4	89,141.9	111,778.4
Total (Ⅳ+Ⅴ)	56,851.7	80,521.6	140,989.3	163,834.9	199,609.2

Note : The table shows a balance at the end of year.

Sourse : Statistics of Central Bank, October, 1986.

Table A.3 Financial Conditions of Government

unit : 1 million US$

	1981	1982	1983	1984	1985
A. Ordinary Expenditure	7,938.2	13,108.0	21,514.1	25,999.2	29,595.9
Consumption	3,944.2	6,124.9	8,813.1	10,530.1	12,738.3
Interests	1,069.1	1,869.9	3,042.6	3,920.5	5,074.6
Transfer	2,924.9	5,113.2	9,658.4	11,548.6	11,783.0
B. Capital Cost Expenditure	1,972.6	3,186.2	6,142.7	8,868.1	8,051.2
Investment in kind	1,201.4	1,444.4	2,843.2	4,251.7	3,167.0
Investment in fina -nce	32.8	222.8	129.7	273.3	88.0
Transfer	318.5	712.4	2,005.8	1,503.9	2,312.8
Amortization	419.9	806.6	1,164.0	2,839.2	2,483.4
C. Total of Expenditure (A+B) 1/	9,910.8	16,294.2	27,656.8	34,867.3	37,647.1
D. Ordinary Revenue	7,456.7	12,948.9	21,057.4	27,281.3	29,725.0
Tax	6,936.7	12,282.0	19,870.6	24,426.4	26,763.7
Non-Tax	509.6	638.0	1,150.7	1,240.8	1,709.4
Transfer	10.4	28.9	36.1	1,614.1	1,251.9
E. Deficit of Finace (D-C)	- 2,454.1	- 3,345.3	- 6,599.4	- 7,586.0	- 7,922.1
F. Current Accounts	- 481.5	- 159.1	- 456.7	1,282.1	129.1
G. Capital Raising	2,454.1	3,345.3	6,599.4	7,586.0	7,922.1
Foreign Countries	906.0	1,378.5	1,868.1	2,475.2	3,946.6
National	1,548.1	1,966.8	4,731.3	5,110.8	3,975.5

Note : 1/ Included Special Accounts Budget

Source : Statistics of Central Bank, October, 1986

Table A.4 Foreign Loan of Central Govenment

Unit : 1 million US$

	1981	1982	1983	1984	1985
Balance at the end of year	581.0	674.6	759.8	874.1	950.9

Source : Statistics of Central Bank, October, 1986
References of Ministry of Finance

Table A.5 Actual Export Record (FOB)

Unit : 1 million US$

	1981	1982	1983	1984	1985
Coffee	240.1	236.9	230.2	267.2	310.1
Banana	224.8	228.1	240.3	251.0	212.2
Beef	73.9	53.1	31.9	43.5	55.7
Sugar	42.0	16.6	23.9	35.5	10.4
Others *	427.3	335.7	246.2	409.2	374.6
Total	1,008.1	870.4	872.5	1,006.4	963.0

Note : * Including industrial goods and other agricultural products.

Source : Statistics of Central Bank, October, 1986

Table A.6 Exporting Volume of Agricultural Products

Unit : 1 million kg

	1981	1982	1983	1984	1985
Coffee	96.3	93.9	108.4	113.0	121.2
Banana	1,002.3	1,012.9	1,012.1	1,020.1	855.6
Beef	33.2	24.3	13.9	20.5	28.1
Sugar	72.1	54.8	54.0	88.7	32.0

Source : Statistics of Central Bank, October, 1986

Table A.7 Actual Import Records (CIF)

Unit : 1 million US$

Item	1981	1982	1983	1984	1985
Mining and Industrial Raw Material	532.2	391.5	428.0	464.9	445.3
Primary Agricultural Products	44.1	43.9	50.3	47.3	42.1
Non Durable Consumer Goods	165.0	134.4	167.7	171.2	181.8
Durable Consumer Goods	86.9	32.6	48.1	72.6	77.0
Machinery and Materials for Mining and Industry	79.1	42.4	53.3	68.7	73.1
Machinery and Materials for Agriculture	13.5	9.5	15.7	19.5	19.0
Machinery and Equipment for Construction	17.6	8.8	18.1	26.3	19.0
Machinery and Material for Transportation	65.7	61.3	30.9	50.9	58.0
Machinery and Materials for Others	82.5	45.2	34.1	46.9	52.1
Construction Materials	46.2	29.2	37.2	36.1	38.8
Fuel and Lubricant	75.5	86.6	100.0	83.3	85.7
Others	9.2	7.8	4.4	6.0	6.3
Total	1,208.5	893.2	987.8	1,093.7	1,098.2

Source : Statistics of Central Bank, October, 1986

Table A.8 Balance of International Payment

Unit : 1 million US$

I t e m	1981	1982	1983	1984	1985
A. Capital,Service,and Transfer					
One sided balance	- 409.0	- 297.0	- 283.4	- 154.9	- 173.8
Commodity Exchange	- 88.0	- 64.1	- 45.3	0.8	- 74.8
Export	1,002.6	869.0	852.5	997.5	930.4
Import	-1,090.6	- 804.9	- 897.8	- 996.7	-1,005.2
Loading	- 90.6	- 72.6	- 87.1	- 95.2	- 95.8
Other Transport	- 4.4	- 0.6	13.1	21.5	19.0
Travel	47.1	89.0	80.6	66.2	64.1
Investment Revenue	- 303.9	- 403.9	- 333.6	- 313.5	- 325.2
Direct Investment Revenue	5.1	5.0	6.7	- 7.8	- 31.0
Other Investment Revenue	- 309.0	- 408.9	- 340.3	- 305.7	- 294.2
Paid Interest	- 208.2	- 157.7	- 359.0	- 233.8	- 326.0
Accrued Interest	- 121.1	- 275.4	- 15.6	- 105.8	- 12.8
Others	20.3	24.2	34.2	33.4	44.6
Other Capital,	3.7	- 8.9	20.0	24.4	32.0
Service and Transfer					
Total of Capital and Service	- 436.1	- 332.9	- 352.3	- 295.8	- 374.5
One sided Exchange	27.1	35.9	68.9	140.9	206.9
B. Movement of Capital,	293.8	270.6	343.0	116.6	205.5
Reserve Fund					
Long Term Private Capital	25.8	36.0	22.1	20.3	51.8
Direct Investment	66.2	26.3	55.1	51.9	67.0
Borrowing (NET)	- 40.4	9.7	- 33.0	- 31.6	- 15.2
Short Term Private Capital	- 142.7	- 159.2	- 21.0	- 111.6	- 28.3
Deposit in Foreign Countries	- 58.5	- 117.4	- 55.2	- 115.7	- 67.5
Commercial Credit	- 84.3	- 41.6	33.8	6.6	42.7
Others	0.1	- 0.2	0.4	- 2.5	- 3.5
Long Term Public Capital	194.7	- 128.1	1,158.4	57.6	332.2
Receipt by Loan	324.3	234.9	1,406.6	407.7	713.2
Amortization	- 65.4	- 62.5	- 93.4	- 106.5	- 82.1
Durable Amortization	- 60.6	- 287.4	- 16.6	- 75.7	- 33.1

(Continue)

Item	1981	1982	1983	1984	1985
Amortization by Renegotiation	………	………	- 137.0	………	………
Term Expired, Amortization by Renegotiation	………	………	………	- 153.7	- 265.8
Others	- 3.6	- 13.1	- 1.2	- 14.2	………
Short Term Public Capital	216.0	521.9	- 816.5	150.3	- 150.2
Receipt by Loan	38.6	4.5	3.0	………	………
Amortization	- 10.3	- 10.0	- 7.3	- 0.1	………
Durable Amortization	60.6	287.4	16.6	75.7	33.1
Durable Interest	121.1	275.4	18.0	105.3	12.8
Canselled Durable Interest	………	………	- 288.7	- 18.0	- 70.8
Cancelled Durable Amortization	………	………	- 26.5	- 14.0	- 33.8
Amortization by Renegotiation	………	- 41.4	- 476.1	………	- 50.3
Interest by Renegotiation	………	- 12.3	- 77.4	………	- 34.5
Revalution of Gold	- 19.2	- 0.3	9.8	- 1.9	0.6
Issue of Gold Coinnage	- 27.7	6.5	7.6	- 13.8	11.3
Special Direct Assignment Fund for Revolving Fund	5.4	………	………	………	………
Others	5.5	11.8	4.5	17.1	- 18.6
C. Error, Omission and Unsettled Capital	68.5	164.4	80.3	108.1	118.2
D. International Money Reserve Fund (Reduction+Increase)	46.7	- 138.0	- 139.9	- 69.8	- 149.9
Total of Movement of Capital, Error, Omission and Net Reserve Fund	489.0	297.0	283.4	154.9	173.8

Note : Including adjustment of a balance of international payments.

Sourse : Statistics of Central Bank, October, 1986

Table A.9 Tendency of Agriculture and Livestock Production Value

	1981	1982	1983	1984	1985
Coffee	430.4	450.5	485.3	535.7	484.9
Banana	392.7	401.2	401.1	404.4	341.1
Sugar	84.3	86.9	90.4	104.3	104.8
Cocoa	9.7	7.3	4.5	8.6	9.2
Rice	125.5	83.2	140.5	149.5	121.2
Maize	25.6	25.8	29.4	34.5	37.6
Kidney bean	10.5	13.9	12.2	17.7	19.5
Sorghum	9.3	8.3	9.6	14.6	16.5
Cotton	1.3	1.4	3.1	3.0	3.1
Tabacco	7.3	5.8	8.4	10.3	8.2
Potato	15.6	23.7	24.6	20.8	32.2
Cassava	2.5	2.9	2.9	2.9	2.0
Plantain	43.6	48.1	45.6	39.6	39.1
Onion	2.3	2.9	3.0	3.8	5.6
Others	65.4	63.0	67.1	95.6	100.0
Sub-total	1,226.0	1,224.9	1,337.7	1,445.3	1,325.0
Livestock	241.7	202.0	165.2	208.1	267.4
Pig breeding	27.9	24.9	26.3	32.1	35.8
Poultry keeping	7.7	6.8	9.4	11.4	11.4
Milk	142.7	143.2	157.3	166.7	174.1
Egg	47.1	36.2	31.5	36.0	25.8
Sub-total	467.1	413.1	389.7	454.3	514.5
Wood (lumber)	80.6	64.2	47.2	50.0	50.0
Fishery	25.1	21.9	20.6	27.1	31.3
Other agricultur -al products	25.6	14.7	13.1	13.5	12.6
Total	1,824.2	1,738.8	1,808.3	1,990.3	1,933.4

Note : Price constant in 1966
Source : Statistics of Central Bank, october, 1986

Annex B Meteorology and Hydrology

Annex B. Meteorology and Hydrology

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B.1 Installation of New Hydro-meteorological Stations

The observation by three (3) automatic rain gauges, 14 staff gauges and three (3) water level recorders which were installed by the study team in cooperation with SENARA, in the period of the field study, are commenced from the following date.

Table B.1.1 New Installed Hydro-meteorological Stations

Instrument	Places	Observation dates
Automatic rain gauge	3	Early Apr. '87
Staff gauge	14	Middle Mar. '87
Automatic water level recorder	3	Late in May to middle Jun. '87

Based on the data obtained through the above instruments, the following facts become clear;

- There exist two (2) synoptic meteorological stations with long records at La Lola and Limon inside and outside the Study Area. In comparison of rainfall data of both stations with new rainfall stations installed by the study team, the representative rainfall station for the Study Area is La Lola (see Table B.1.2).

- The water level of the Navigable Canal changes by the tidewater level and the flood discharge coming from related watersheds. The ranges of water level fluctuation are relative to the distance from existing river-mouth, and the recorded maximum is about 1.2 m as shown in Fig. B.1.1.

- At the upper-stream of small and medium scale rivers, the rising and recessioning speeds of flood are very high, while at the down-stream, the speed is low.

- The occurrence of flood in large rivers such as Rio Reventazon, Rio Pacuare and Rio Matina has related closely to the rainfall in the Study Area. The rising speed of the floods in these rivers are very high but the recessing speed is low.

Table B.1.2 Comparison of Rainfall Distribution

Duration	Limon[1]	Agrodisa[2]	Asbana[2]	Perla[2]	La Lola[1]
Apr-First	(363)	–	–	–	(302)
Middle	130	221	302	258	324
Latter	97	103	39	45	41
Sub-total	227	324	341	303	365
May-First	26	46	33	40	37
Middle	134	211	114	177	132
Latter	72	64	60	22	74
Sub-total	232	321	207	239	243
Jun-First	42	28	40	35	115
Middle	113	127	137	141	144
Latter[3]	13	23	24	30	25
Sub-total	168	178	201	206	284
Total	627	823	749	748	892

Notes:

1) Existing meteorogical station
2) Newly installed rainfall station by JICA
3) June 21 - June 24

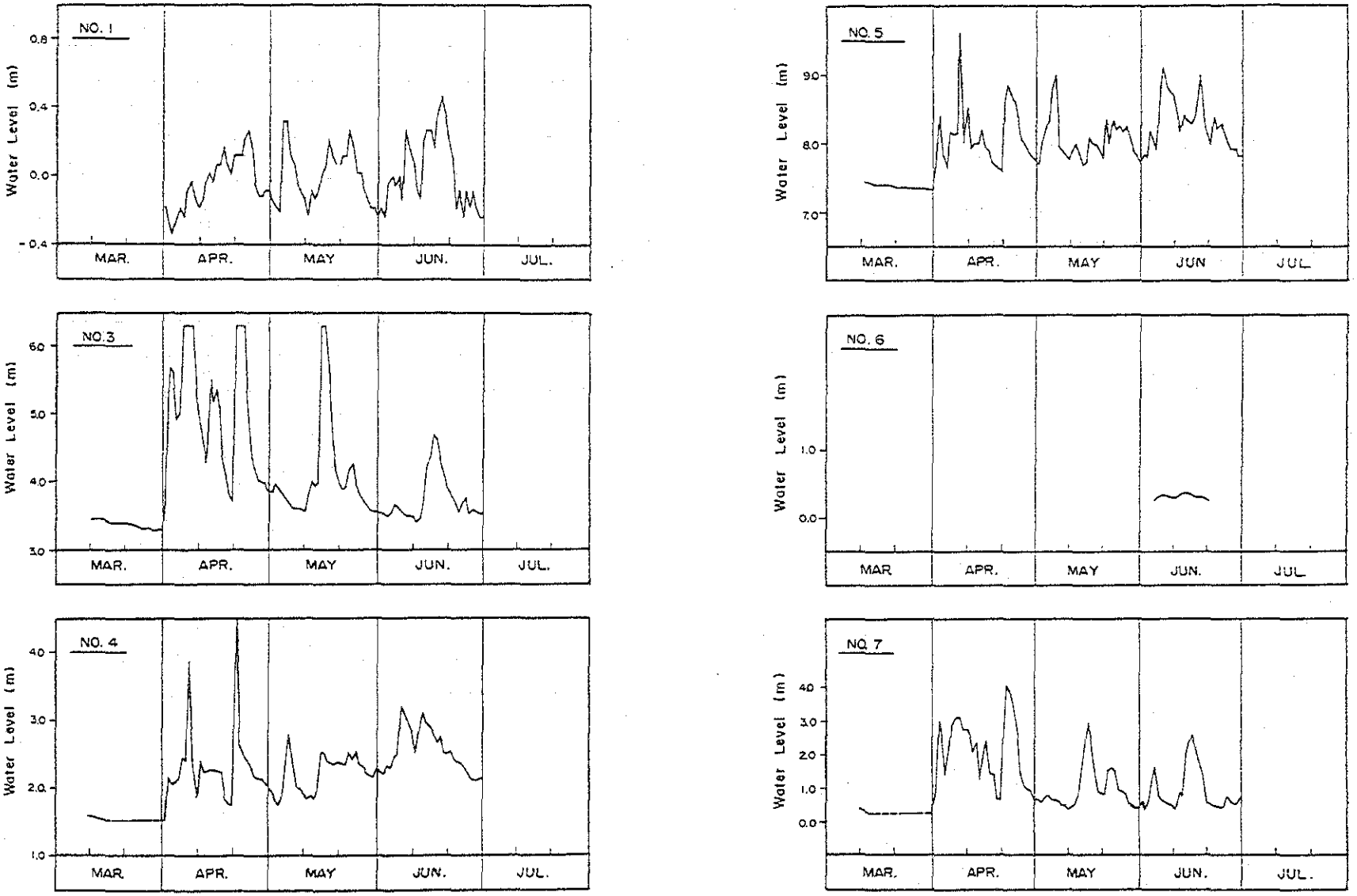
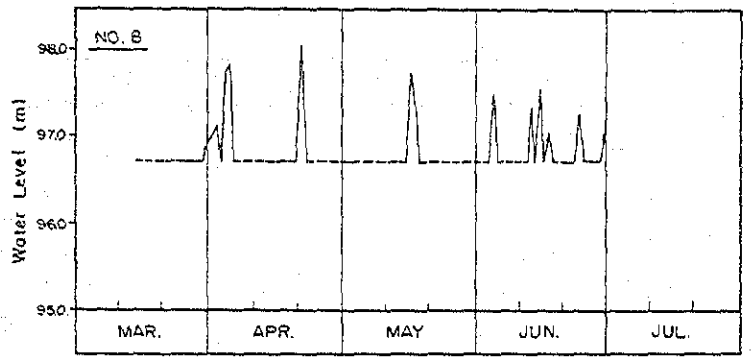
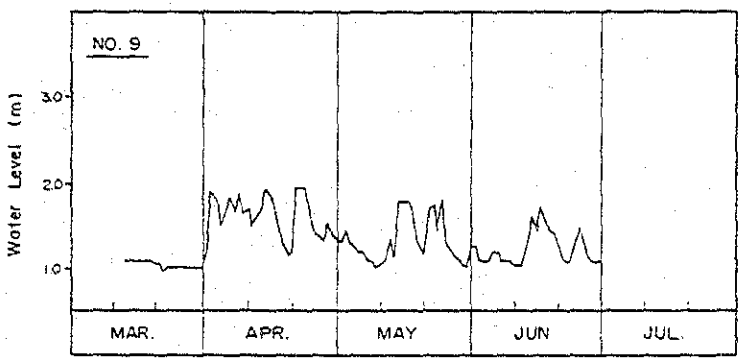
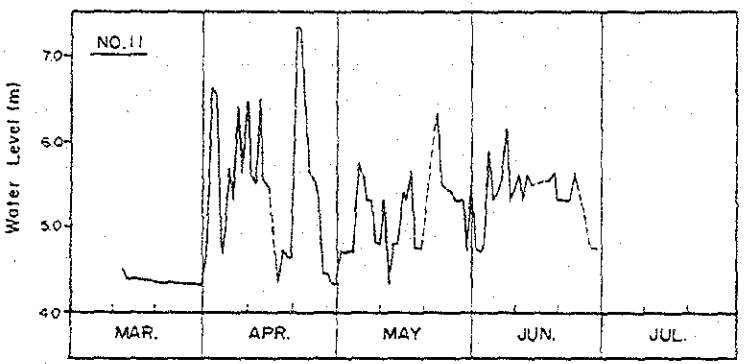
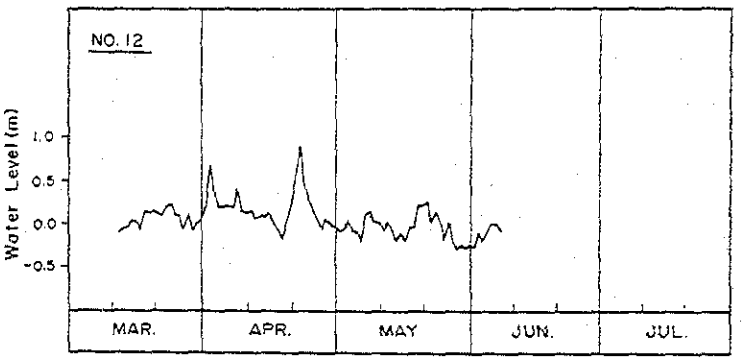


Fig. B.1.1 (1) Observed Water Level at Stream Gausing Station in the Study Area









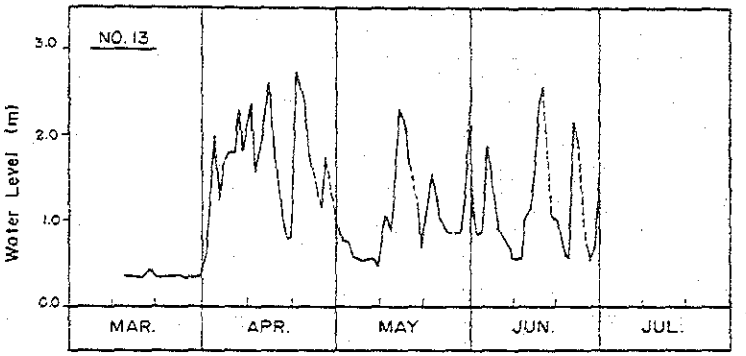


Fig. B.1.1 (2) Observed Water Level at Stream Gausing Station in the Study Area

B.2 Estimation of Consecutive Flood during a Long Period

B.2.1 Estimation Method of Flood Discharge

In heavy rainfall, the floods coming from both watersheds, large rivers' watersheds of 5,016 km^2 and small and medium rivers' watersheds of 632 km^2, are concentrated to the low land area along the coast.

As described in Main Report 3.1.5, two runoff models for large river's and small and medium river's watershed are developed respectively, then, the floods concentrating from whole watershed to low land area along the Navigable Canal are estimated by the specific yield discharges from the estimated hydrographs in model watersheds.

As the flood estimation method, a kinematic runoff method is applied as shown below;

Simplifying a runoff phenomena, it is composed of surface flow of rainfall on a slope and river flow catching surface flows from slope area, and the both flows are expressed by the following equations;

Surface Flow

$$h = kq^p \quad \cdots\cdots\cdots\cdots\cdots\cdots ①$$

$$\frac{\partial h}{\partial t} - \frac{\partial q}{\partial x} = r \quad \cdots\cdots\cdots\cdots\cdots\cdots ②$$

River Flow

$$W = KQp \quad \cdots\cdots\cdots\cdots\cdots\cdots ③$$

$$\frac{\partial w}{\partial t} + \frac{\partial Q}{\partial X} = I \quad \cdots\cdots\cdots\cdots\cdots\cdots ④$$

where :

t: Time
x: Distance
h: Water depth of a surface flow
q: Discharge per a slope with a unit width
r: Effective rainfall
W: Water cross section of river course
Q: Discharge in river course
I: Side flow per a unit length of river course
k,p: Constant numbers definite by a characteristics of slope. k is expressed by the following equation;

$$k = (N / S^{0.5})^p, \quad p=0.6$$

N: Equivalent roughness modulus
S: Gradient of slope

K,P: Constant numbers definite by a hydraulic characteristics of river course

In pragmatic, the runoff model can be simplified that the objected watershed is composed of a several sub-watersheds having rectangular slops with river course on the one side, and under the assumption that the flow modulusli are constant within a slope and a section of river course, moreover, r and I are also constant in a unit time, the flood routing is carried out.

1) Routing Method of Surface Flow on a Slope

Solving simultaneous equations ① and ②, characterlized equations are obtained, and the equations rewrited as follows are used for the calculation of flood routing:

In case of $rj \neq 0$,

$$qj = (qj\text{-}1^{p} + \frac{rj.t}{k})^{1/p}$$

$$hj = hj\text{-}1 + rj.t$$

$$Xj = \frac{qj - qj\text{-}1}{r_j}, \quad Xj = Xj\text{-}1 + Xj$$

} .....⑤

In case of $rj = 0$,

$$qj = qj\text{-}1$$

$$Xj = \frac{qj^{1-p}}{P.K} \; t, \quad Xj = Xj\text{-}1 + Xj$$

} .....⑥

Where;

j: Ordinal number of unit time (t) for calculation
rj: Effective rainfall during j-unit time
t: Unit time
qj: Runoff on j-unit time
hj: Water depth on j-unit time
Xj: Traveling distance of runoff during j-unit time

A surface flow started from a top of slope on a time of Ti, after a time elapsed, when Xj equal to a slope length (b), reachs the most down edge of the slope. In calculation successively, there often appears ordinary number of time such as;

$$Xj\text{-}1 < b \;,\; Xj > b$$

In such case, remaining distance to the end of slope (Xe) is shown as below equation;

$$Xe = b - Xj\text{-}1$$

And then, qe and te are obtained by the following equations of ⑦ and ⑧;

when rj = 0

$$qe = qj-1 + rj.Xe \qquad \cdots\cdots ⑦$$

$$te = \frac{K}{rj}\left(qe^{p} - qj-1^{p}\right)$$

when rj ≠ 0

$$qe = qj-1 \qquad \cdots\cdots ⑧$$

$$te = \frac{p.\ k}{qe^{1-p}} \ .\ Xe$$

where

qe: Runoff at the end of slope

te: Last traveling time of surface flow after (j-1)t

andthe arriving time of surface flow to the end of slope (Vi) can be expressed the following equation,

$$Vi = Ti + (j-1).t + te$$

2) Routing Method of River flow

Since the equations of river flow have the same form as those of surface flow, the routing can be made by the same manner as that of surface flow by changing the symbols in equations 5 - 8 as the following;

k → K , p → P , r → I , q → Q , h → W

Hereafter, the more details as to the flood estimation are shown in subsequent clauses.

B.2.2 Estimation of Flood occurred in Large Rivers' Watershed

(1) Model Watershed

Model River: Rio Reventazon
Drainage Area: 1,750 km^2 (at railway bridge)

(2) Probable Flood at Railway Bridge

- Probable peak flood discharges are obtained from the regression equations shown in Fig. 3.1.10 of Main Report.

- Probable consecutive flood discharges for three days are estimated by the regression equations described in Table B.2.1.

The probable floods at railway bridge estimated by these methods are shown in Table B.2.2.

Table B.2.2 Probable Flood at Railway Bridge

Return Period (yrs)	Peak Flood Discharge (m^3/s)	Consecutive Flood Discharge 1st Day (m^3/s)	2nd Day (m^3/s)	3rd Day (m^3/s)
5	2,536	824	1,017	588
10	3,316	1,137	1,384	729

(3) Hydrograph at the outlet of Rio Reventazon

The probable hydrographs at the outlet of Rio Reventazon are obtained from the following procedure:

- The probable hydrographs at railway bridge are estimated based on the probable floods tabulated in Table B.2.2.

- The constant numbers to be determined by the conditions of Rio Reventazon extending from railway bridge to the outlet with a stretch of 47 km in length are shown below equation;

$$W = KQ_p = 13.71\ Q^{0.605}$$

- Theriver flow model by the kinematic runoff method is applied to the estimation, then, the probable hydrographs at railway bridge are used as flood discharges at the beginning point of the modeled river course.

The estimated hydrographs at the outlet are tabulated, together with total runoffs from the large rivers' watersheds (D.A. = 5,016 km^2), in Table B.2.4.

B.2.3 Estimation of Flood occurred in Small and Medium Rivers' Watersheds

(1) Model Watershed

Model Watershed: Watershed of principal drainage canal B-2 (See, Fig. B.2.1)

Drainage Area: 41.4 km^2 (at the confluence with the Navigable Canal)

(2) Probable Hyetograph

The rainfall for the estimation of probable flood is adopted that of La Lola meteorological station. The probable hyetographs are shown in Table B.2.5. The runoff coefficient is adopted at 0.8

(3) Estimated Hydrograph

The estimated hydrographs at the mostdown point of model watershed are tabulated, together with total runoffs from the small and medium rivers' watershed (D.A. = 632 km^2), in Table B.2.5.

B.2.4 Estimation of Total Flood Discharge

The estimated flood discharges to be occurred from large rivers' watersheds having an area of 5,016 km^2 and from small and medium rivers' watersheds having an area of 632 km^2 , have been described respectively in the previous section.

The estimated peak discharge for small and medium rivers' watersheds are cross-checked by the regression equations on specific yield of peak discharge developed on the basis of recorded flood as shown in Fig. 3.1.10 of Main Report. The values estimated by the runoff model is compared with those by the regression equations and two values are almost close as shown in Table B.2.7. Thus, the estimated peak discharge are fully testified to be technical reasonable.

Table B.2.7 Comparison of Peak Discharge of Small and Medium Rivers' Watersheds (D.A. = 632 km^2)

Return Period (yrs)	Applied Method for Computation	
	Regression equation 1/ (m^3/s)	Runoff Model (m^3/s)
5	1,290	1,257
10	1,631	1,547

Note; $Q = 17.903 \times (D.A.)^{0.66333}$: R.P. of 5 years
$Q = 18.251 \times (D.A.)^{0.69668}$: R.P. of 10 years

Accordingly, total flood discharges can be obtained as the sum of these flood discharges. The hydrographs are shown in Table B.2.8 and the hourly flood discharge and the daily mean flood discharges are considered those of projection and present conditions at the low land area along the Navigable Canal respectively. These flood discharges are used in the inundation analysis for the low land area in subsequent section B.3.

Table B.2.1 Probable Consecutive Flood for 1-Day, 2-Days and 3 Days

Description	Reventazon	Pacuare	Barbilla	Blanco
(Drainage Area : km^2)	(1673)	(652)	(212)	(50)
5 Year Return Period				
1) 1-day (cu. m/s/1-day)	977	509	333	104
2) 2-days(cu. m/s/2-days)	1710	869	550	144
3) 3-days(cu. m/s/3-days)	2221	1152	631	165
10 Year Return Period				
4) 1-day (cu. m/s/1-day)	1291	683	462	127
5) 2-days(cu. m/s/2-days)	2277	1144	771	169
6) 3-days(cu. m/s/3-days)	2854	1514	849	192

(Notes) Relation Curve between D.A. and Consecutive Flood (Q)

1) $Q = 10.07 \times (D.A.)^{0.618}$
2) $Q = 11.14 \times (D.A.)^{0.684}$
3) $Q = 10.66 \times (D.A.)^{0.727}$
4) $Q = 11.89 \times (D.A.)^{0.637}$
5) $Q = 12.19 \times (D.A.)^{0.714}$
6) $Q = 11.57 \times (D.A.)^{0.755}$

Table B.2.3 (1) Hydrograph of Probable Flood at Railway Bridge

(P=1/5)

Time	Direct Fl.	Base Fl.	Total	Time	Direct Fl.	Base Fl.	Total	Time	Direct Fl.	Base Fl.	Total
hour	m^3/s	m^3/s	m^3/s	hour	m^3/s	m^3/s	m^3/s	hour	m^3/s	m^3/s	m^3/s
1	78	184	262	25	102	184	286	49	49	184	233
2	164	〃	348	26	213	〃	397	50	103	〃	287
3	246	〃	430	27	320	〃	504	51	155	〃	339
4	329	〃	513	28	428	〃	612	52	208	〃	392
5	412	〃	596	29	535	〃	719	53	260	〃	444
6	494	〃	678	30	643	〃	827	54	312	〃	496
7	576	〃	760	31	750	〃	934	55	364	〃	548
8	707	〃	891	32	920	〃	1,104	56	446	〃	630
9	982	〃	1,166	33	1,278	〃	1,462	57	620	〃	804
10	1,256	〃	1,440	34	1,635	〃	1,819	58	793	〃	977
11	1,532	〃	1,716	35	1,993	〃	2,177	59	967	〃	1,151
12	1,807	〃	1,991	36	2,352	〃	2,536	60	1,141	〃	1,325
13	1,532	〃	1,716	37	1,993	〃	2,177	61	967	〃	1,151
14	1,256	〃	1,440	38	1,635	〃	1,819	62	793	〃	977
15	982	〃	1,166	39	1,278	〃	1,462	63	620	〃	804
16	707	〃	891	40	920	〃	1,104	64	446	〃	630
17	576	〃	760	41	750	〃	934	65	364	〃	548
18	494	〃	678	42	643	〃	827	66	312	〃	496
19	412	〃	596	43	535	〃	719	67	260	〃	444
20	329	〃	513	44	428	〃	612	68	208	〃	392
21	246	〃	430	45	320	〃	504	69	155	〃	339
22	164	〃	348	46	213	〃	397	70	103	〃	287
23	78	〃	262	47	102	〃	286	71	49	〃	233
24	0	〃	184	48	0	〃	184	72	0	〃	184
Average	640	184	824	Average	833	184	1,017	Average	404	184	588

Table B.2.3 (2) Hydrograph of Probable Flood at Railway Bridge

(P=1/10)

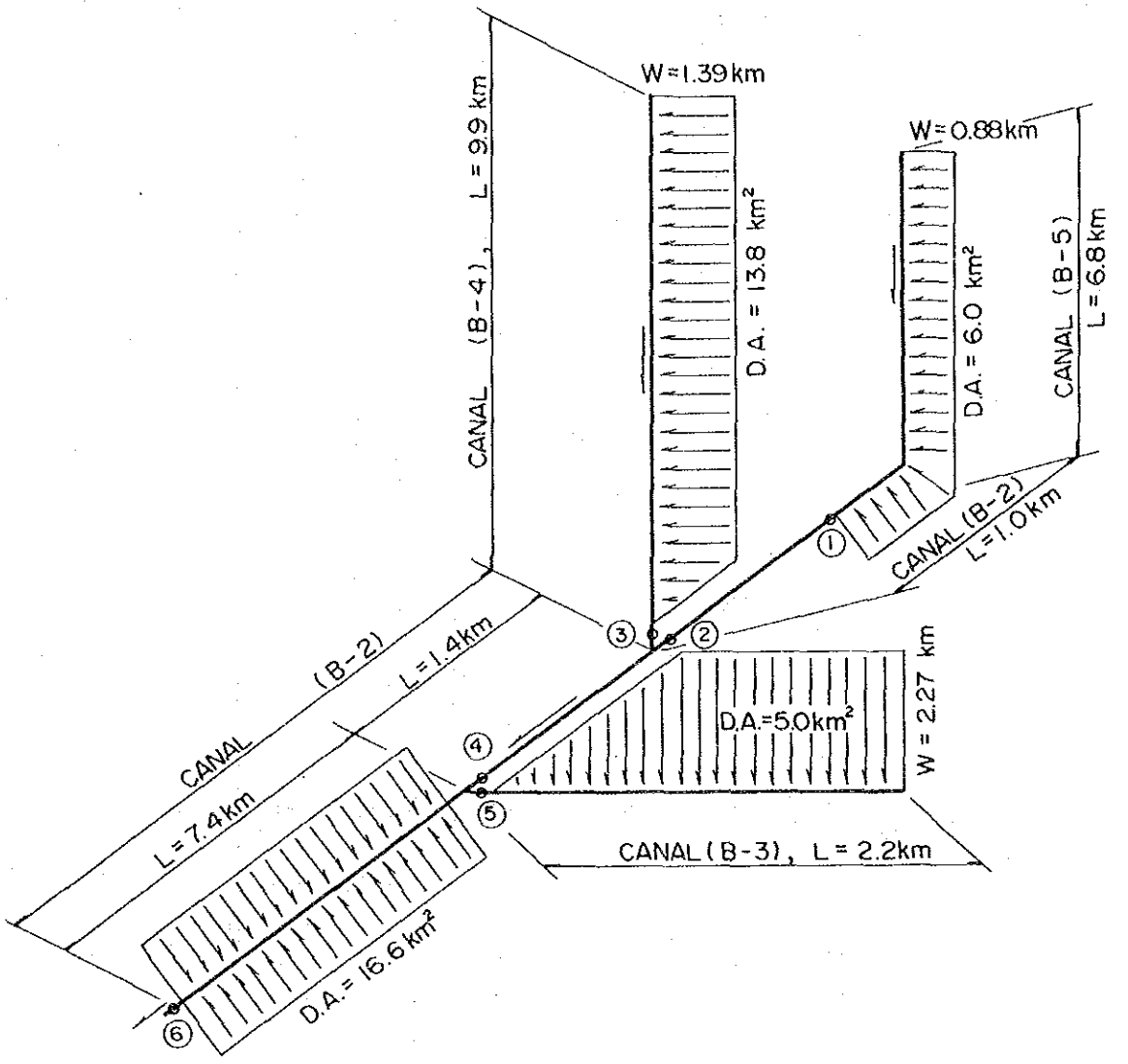
Time	Direct Fl.	Base Fl.	Total	Time	Direct Fl.	Base Fl.	Total	Time	Direct Fl.	Base Fl.	Total
hour	m^3/s	m^3/s	m^3/s	hour	m^3/s	m^3/s	m^3/s	hour	m^3/s	m^3/s	m^3/s
1	126	184	310	25	158	184	342	49	72	184	256
2	255	〃	439	26	321	〃	505	50	146	〃	330
3	384	〃	568	27	483	〃	667	51	220	〃	404
4	513	〃	697	28	646	〃	830	52	293	〃	477
5	641	〃	825	29	808	〃	992	53	367	〃	551
6	770	〃	954	30	970	〃	1,154	54	440	〃	624
7	899	〃	1,083	31	1,132	〃	1,316	55	514	〃	698
8	1,151	〃	1,335	32	1,449	〃	1,633	56	658	〃	842
9	1,485	〃	1,669	33	1,869	〃	2,053	57	849	〃	1,033
10	1,818	〃	2,002	34	2,289	〃	2,473	58	1,040	〃	1,224
11	2,152	〃	2,336	35	2,709	〃	2,893	59	1,231	〃	1,415
12	2,487	〃	2,671	36	3,132	〃	3,316	60	1,422	〃	1,606
13	2,152	〃	2,336	37	2,709	〃	2,893	61	1,231	〃	1,415
14	1,818	〃	2,002	38	2,289	〃	2,473	62	1,040	〃	1,224
15	1,485	〃	1,669	39	1,869	〃	2,053	63	849	〃	1,033
16	1,151	〃	1,335	40	1,449	〃	1,633	64	658	〃	842
17	899	〃	1,083	41	1,132	〃	1,316	65	514	〃	698
18	770	〃	954	42	970	〃	1,154	66	440	〃	624
19	641	〃	825	43	808	〃	992	67	367	〃	551
20	513	〃	697	44	646	〃	830	68	293	〃	477
21	384	〃	568	45	483	〃	667	69	220	〃	404
22	255	〃	439	46	321	〃	505	70	146	〃	330
23	126	〃	310	47	158	〃	342	71	72	〃	256
24	0	〃	184	48	0	〃	0	72	0	〃	0
Average	953	184	1,137	Average	1,200	184	1,384	Average	545	184	729

Table B.2.4 (1) Estimated Hydrograph of Probable Flood to be occurred from Large Rivers' Watersheds (Probability : 1/5)

Time (hour)	1st Day		2nd Day		3rd Day		Remarks
	q_1	Q_1	q_1	Q_1	q_1	Q_1	
1	184	527	684	1,961	783	2,244	
2	184	527	628	1,800	711	2,038	
3	184	527	573	1,642	644	1,846	q_1(m^3/s) :
4	184	527	521	1,493	579	1,660	Runoff of model
5	184	527	474	1,359	518	1,485	Watershed
6	184	527	428	1,227	457	1,310	at the outlet
7	184	527	382	1,095	399	1,144	(D.A.= 1,750 km^2)
8	184	527	338	969	402	1,152	
9	184	527	300	860	406	1,164	
10	184	527	266	762	410	1,175	Q_1(m^3/s) :
11	184	527	499	1,430	414	1,187	Total runoff
12	464	1,330	744	2,133	405	1,161	to be occured
13	663	1,900	952	2,729	359	1,029	from large
14	889	2,548	1,696	4,861	468	1,341	rivers' watersheds
15	1,569	4,497	2,324	6,661	574	1,645	(D.A.= 5,016 km^2)
16	1,848	5,297	2,362	6,770	1,025	2,938	
17	1,774	5,085	2,110	6,048	1,234	3,537	
18	1,581	4,532	1,861	5,334	1,196	3,428	
19	1,397	4,004	1,624	4,655	1,078	3,090	
20	1,226	3,514	1,404	4,024	964	2,763	
21	1,065	3,053	1,217	3,488	858	2,459	
22	930	2,666	1,049	3,007	757	2,170	
23	823	2,359	945	2,709	669	1,918	
24	743	2,130	859	2,462	597	1,711	
Average	708	2,029	1,010	2,895	663	1,900	

Table B.2.4 (2) Estimated Hydrograph of Probable Flood to be occurred from Large Rivers' Watersheds (Probability : 1/10)

Time (hour)	1st Day		2nd Day		3rd Day		Remarks
	q_1	Q_1	q_1	Q_1	q_1	Q_1	
1	184	527	862	2,471	974	2,792	
2	184	527	778	2,230	871	2,497	
3	184	527	702	2,012	773	2,216	q_1(m^3/s) :
4	184	527	626	1,794	682	1,955	Runoff of model
5	184	527	552	1,582	600	1,720	Watershed
6	184	527	489	1,402	522	1,496	at the outlet
7	184	527	426	1,221	445	1,275	(D.A.= 1,750 km^2)
8	184	527	363	1,040	367	1,052	
9	184	527	301	863	350	1,003	
10	184	527	1,008	2,889	394	1,129	Q_1(m^3/s) :
11	691	1,981	1,047	3,001	437	1,253	Total runoff
12	964	2,763	1,382	3,961	350	1,003	to be occured
13	1,399	4,010	2,145	6,148	569	1,631	from large
14	2,035	5,833	2,815	8,069	719	2,061	rivers' watersheds
15	2,502	7,171	3,261	9,347	1,148	3,290	(D.A.= 5,016 km^2)
16	2,485	7,123	2,936	8,415	1,473	4,222	
17	2,230	6,392	2,615	7,495	1,525	4,371	
18	1,987	5,695	2,308	6,615	1,387	3,976	
19	1,755	5,030	2,020	5,790	1,252	3,589	
20	1,533	4,394	1,756	5,033	1,122	3,216	
21	1,342	3,847	1,514	4,340	997	2,858	
22	1,179	3,379	1,341	3,844	887	2,542	
23	1,043	2,990	1,199	3,437	786	2,253	
24	950	2,723	1,083	3,104	704	2,018	
Average	997	2,858	1,397	4,004	793	2,273	



LEGEND

	SLOPE AREA AND SLOPE FLOW
	CANAL AND CANAL FLOW
①	POINT OF RUNOFF ESTIMATION

CONSTANT NUMBER OF SLOPE

GRADIENT : S = 0.001
EQUIVALENT ROUGHNESS : N = 1.0
CONSTANT NUMBER : k = 7.943

Fig. B.2.1 Runoff Model for Small and Medium Rivers' Watersheds

Table B.2.5 (1) Probable Hyetograph in the Study Area (P=1/5)

(mm)

Time	1st Day	Time	2nd Day	Time	3rd Day
1	0.5	25	1.3	49	0.3
2	0.7	26	1.6	50	0.3
3	0.8	27	1.8	51	0.4
4	1.0	28	2.2	52	0.5
5	1.2	29	2.7	53	0.6
6	1.5	30	3.3	54	0.7
7	1.9	31	4.3	55	1.0
8	2.6	32	5.9	56	1.3
9	3.6	33	8.3	57	1.8
10	5.6	34	12.7	58	2.8
11	9.6	35	21.8	59	4.8
12	20.1	36	45.8	60	10.0
13	13.4	37	30.5	61	6.7
14	7.2	38	16.4	62	3.6
15	4.5	39	10.2	63	2.3
16	3.0	40	6.9	64	1.5
17	2.2	41	5.1	65	1.1
18	1.7	42	3.9	66	0.9
19	1.3	43	3.0	67	0.7
20	1.1	44	2.4	68	0.5
21	0.9	45	2.0	69	0.5
22	0.7	46	1.6	70	0.3
23	0.6	47	1.4	71	0.3
24	0.3	48	0.9	72	0.1
Total	86.0	Total	196.0	Total	43.0

Table B.2.5 (2) Probable Hyetograph in the Study Area (P=1/10)

(mm)

Time	1st Day	Time	2nd Day	Time	3rd Day
1	0.8	25	1.6	49	0.4
2	0.9	26	1.8	50	0.4
3	1.0	27	2.1	51	0.5
4	1.2	28	2.5	52	0.6
5	1.5	29	3.1	53	0.7
6	1.9	30	3.9	54	0.9
7	2.4	31	5.1	55	1.2
8	3.2	32	6.8	56	1.5
9	4.6	33	9.6	57	2.2
10	7.0	34	14.6	58	3.3
11	11.8	35	24.8	59	5.6
12	24.6	36	51.4	60	11.7
13	16.5	37	34.5	61	7.9
14	8.9	38	18.7	62	4.3
15	5.5	39	11.6	63	2.6
16	3.8	40	8.0	64	1.8
17	2.8	41	5.8	65	1.3
18	2.1	42	4.4	66	1.0
19	1.7	43	3.5	67	0.8
20	1.3	44	2.8	68	0.6
21	1.1	45	2.3	69	0.5
22	0.9	46	1.9	70	0.4
23	0.8	47	1.6	71	0.4
24	0.7	48	1.6	72	0.1
Total	107.0	Total	224.0	Total	51.0

Table B.2.6 (1) Estimated Hydrograph of Probable Flood to be occurred from Small and Medium Rivers' Watersheds (Probability : 1/5)

Time (hour)	1st Day		2nd Day		3rd Day		Remarks
	q_2	Q_2	q_2	Q_2	q_2	Q_2	
1	0.00	0	15.90	244	67.08	1,024	
2	0.00	0	16.16	247	63.81	974	
3	0.00	0	16.27	248	60.75	927	q_2(m^3/s) :
4	0.00	0	16.32	249	57.73	881	Runoff of Model
5	0.01	0	16.41	251	54.75	836	Watershed at
6	0.03	0	16.61	254	51.80	791	the confluence
7	0.06	1	16.95	259	48.90	746	with the
8	0.12	2	17.57	268	46.16	705	Navigable Canal
9	0.20	3	19.27	294	44.57	680	(D.A.= 41.4 km^2)
10	0.37	6	22.77	348	43.09	659	
11	0.72	11	27.40	418	41.95	640	Q_2(m^3/s) :
12	1.67	25	33.73	515	40.81	623	Total runoff
13	3.80	58	43.64	666	40.93	625	to be occured
14	6.67	102	56.72	866	41.11	628	from small and
15	9.23	141	68.91	1,052	41.02	626	medium rivers'
16	11.17	171	76.42	1,167	40.08	612	watersheds
17	12.52	191	80.36	1,221	38.82	593	(D.A.= 632.0 km^2)
18	13.44	205	82.00	1,252	37.21	568	
19	14.11	215	82.31	1,257	35.51	542	
20	14.61	223	81.85	1,249	33.77	516	
21	15.01	229	80.35	1,227	30.04	489	
22	15.33	234	78.01	1,191	30.34	463	
23	15.60	238	74.57	1,138	28.73	439	
24	15.81	241	70.85	1,082	27.30	417	
Average	6.27	96	46.31	707	43.68	667	

Table B.2.6 (2) Estimated Hydrograph of Probable Flood to be occurred from Small and Medium Rivers' Watersheds (Probability : 1/10)

Time (hour)	1st Day		2nd Day		3rd Day		Remarks
	q_2	Q_2	q_2	Q_2	q_2	Q_2	
1	0.00	0	22.34	341	78.24	1,194	
2	0.00	0	22.13	338	74.58	1,139	
3	0.00	0	21.91	334	70.82	1,082	q_2(m^3/s) : Runoff of Model Watershed at the confluence with the Navigable Canal (D.A.= 41.4 km^2)
4	0.01	0	21.77	332	67.02	1,023	
5	0.02	0	21.74	332	63.19	965	
6	0.05	1	21.87	334	59.31	905	
7	0.10	2	22.39	342	55.21	843	
8	0.18	3	23.03	352	52.54	802	
9	0.33	5	23.97	366	50.54	772	
10	0.65	10	25.71	392	48.76	744	
11	1.25	19	30.51	466	47.50	725	Q_2(m^3/s) : Total runoff to be occured from small and medium rivers' watersheds (D.A.= 632.0 km^2)
12	2.63	40	40.71	621	46.95	717	
13	5.82	89	55.75	851	46.76	714	
14	9.84	150	73.85	1,127	46.87	716	
15	13.40	205	87.54	1,336	46.63	712	
16	16.07	245	95.85	1,463	45.24	691	
17	17.91	273	99.83	1,524	43.42	663	
18	19.17	293	101.30	1,546	41.45	633	
19	20.09	307	101.34	1,547	39.41	602	
20	20.81	318	99.85	1,524	37.40	571	
21	21.36	326	96.08	1,467	35.51	542	
22	21.82	333	91.57	1,398	33.83	516	
23	22.18	339	86.81	1,325	32.17	491	
24	22.44	343	82.22	1,255	30.51	466	
Average	9.01	138	57.09	872	49.75	759	

Table B.2.8 (1) Synthesized Probable Hydrograph at the Estuaries

(Probability : 1/5)

(m^3/s)

Time (hour)	1st Day			2nd Day			3rd Day		
	Q_1	Q_2	Total	Q_1	Q_2	Total	Q_1	Q_2	Total
1	527	0	527	1,961	244	2,205	2,244	1,024	3,218
2	527	0	527	1,800	241	2,047	2,038	974	3,012
3	527	0	527	1,642	248	1,890	1,846	927	2,773
4	527	0	527	1,493	249	1,742	1,660	881	2,541
5	527	0	527	1,359	251	1,610	1,485	836	2,321
6	527	0	527	1,227	254	1,481	1,310	791	2,101
7	527	1	528	1,095	259	1,354	1,144	746	1,890
8	527	2	529	969	268	1,237	1,152	705	1,857
9	527	3	530	860	294	1,154	1,164	680	1,844
10	527	6	533	762	348	1,110	1,175	659	1,834
11	527	11	538	1,430	418	1,848	1,187	640	1,827
12	1,330	25	1,355	2,133	515	2,648	1,161	623	1,784
13	1,900	58	1,958	2,729	666	3,395	1,029	625	1,654
14	2,548	102	2,650	4,861	866	5,727	1,341	628	1,969
15	4,497	141	4,638	6,661	1,052	7,713	1,645	626	2,271
16	5,297	171	5,468	6,770	1,167	7,937	2,938	612	3,550
17	5,085	191	5,276	6,048	1,227	7,275	3,537	593	4,130
18	4,532	205	4,737	5,334	1,252	6,586	3,428	568	3,996
19	4,004	215	4,219	4,655	1,257	5,912	3,090	542	3,632
20	3,514	223	3,737	4,024	1,249	5,273	2,763	516	3,279
21	3,053	229	3,282	3,488	1,227	4,715	2,459	489	2,948
22	2,666	234	2,900	3,007	1,191	4,198	2,170	463	2,633
23	2,359	238	2,597	2,709	1,138	3,847	1,918	439	2,357
24	2,130	241	2,371	2,462	1,082	3,544	1,711	417	2,128
Average	2,029	96	2,125	2,895	707	3,602	1,900	667	2,567

Q_1: Flood occured in watersheds of large rivers.
Q_2: Flood occured in watersheds of small and medium rivers.

Table B.2.8 (2) Synthesized Probable Hydrograph at the Estuaries

(Probability : 1/10)

(m^3/s)

Time (hour)	1st Day			2nd Day			3rd Day		
	Q_1	Q_2	Total	Q_1	Q_2	Total	Q_1	Q_2	Total
1	527	0	527	2,471	341	2,812	2,792	1,194	3,896
2	527	0	527	2,230	338	2,568	2,497	1,139	3,636
3	527	0	527	2,012	334	2,346	2,216	1,082	3,298
4	527	0	527	1,794	332	2,126	1,955	1,023	2,978
5	527	0	527	1,582	332	1,914	1,720	965	2,685
6	527	1	528	1,402	334	1,763	1,496	905	2,401
7	527	2	529	1,221	342	1,563	1,275	843	2,118
8	527	3	530	1,040	352	1,392	1,052	802	1,854
9	527	5	532	863	366	1,229	1,003	772	1,775
10	527	10	537	2,889	392	3,281	1,129	744	1,873
11	1,981	19	2,000	3,001	466	3,467	1,253	725	1,978
12	2,763	40	2,803	3,961	621	4,582	1,003	717	1,720
13	4,010	89	4,099	6,148	851	6,999	1,631	714	2,345
14	5,833	150	5,983	8,069	1,127	9,196	2,061	716	2,777
15	7,171	205	7,376	9,347	1,336	10,683	3,290	712	4,002
16	7,123	245	7,368	8,415	1,463	9,878	4,222	691	4,913
17	6,392	273	6,665	7,495	1,524	9,019	4,371	663	5,034
18	5,695	293	5,988	6,615	1,546	8,161	3,976	633	4,609
19	5,030	307	5,337	5,790	1,547	7,337	3,589	602	4,191
20	4,394	318	4,712	5,033	1,524	6,557	3,216	571	3,787
21	3,847	326	4,173	4,340	1,467	5,807	2,858	542	3,400
22	3,379	333	3,712	3,844	1,398	5,242	2,542	516	3,058
23	2,990	339	3,329	3,437	1,325	4,762	2,253	491	2,744
24	2,723	343	3,066	3,104	1,255	4,659	2,018	466	2,484
Average	2,858	138	2,996	4,004	872	4,876	2,273	759	3,032

Q_1: Flood occured in watersheds of large rivers.

Q_2: Flood occured in watersheds of small and medium rivers.

B.3 Inundation Analysis

The basic conditions for inundation analysis are described in 3.1.5 of Main Report and stage - storage curve is illustrated in Fig. B.3.1.

In this analysis, the probable floods with 5 and 10 years return periods in present situation and with 5 years return period in projection stage are chosen as the subject of the study.

The studied results are summarized in Table B.3.1 and the more details are shown in Table B.3.2.

Table B.3.1 Summary of Inundation Analysis

Case	Max. Ponding Water Level (m)	Inundation2/ Duration (hr)	Max. Ponding Area Inside Study Area (ha)	Max. Ponding Area Whole Area (ha)
Present Situation (w/o Project)				
P = 1/ 1/5	1.22	13	1,619	5,051
P = 1/10	1.45	32	3,312	7,042
Projection Stage (w/ Project)				
P = 1/5	1.58	25	4,269	8,196

Note; 1/ Probability

2/ Inundation duration with ponding water level of more than 1.0 m (MSL)

Table B.3.2.(1) Inundations Analysis (Present, P=1/5)

TIME (Hr)	Q-IN (m3/s)	Q-OUT (m3/hr)	① (m3/hr)	② (m3/hr)	③ (Ha)	④ (m)	⑤ (m)
1	2125.000	6518442.	1830129.	1830129.	465.00	0.293	-0.010
2	2125.000	7797391.	-147392.	1682737.	465.00	0.261	-0.060
3	2125.000	7816940.	-166939.	1515799.	465.00	0.225	-0.090
4	2125.000	7735269.	-85269.	1430530.	465.00	0.207	-0.100
5	2125.000	7643294.	6706.	1437236.	465.00	0.209	-0.090
6	2125.000	7550268.	99731.	1536967.	465.00	0.230	-0.060
7	2125.000	7457139.	192861.	1729828.	465.00	0.271	-0.010
8	2125.000	7392605.	257394.	1987222.	465.00	0.327	0.050
9	2125.000	7343473.	306527.	2293749.	465.00	0.393	0.120
10	2125.000	7293843.	356158.	2649907.	465.00	0.469	0.200
11	2125.000	7278401.	371597.	3021504.	465.00	0.549	0.280
12	2125.000	7148422.	501578.	3523082.	3173.00	0.609	0.350
13	2125.000	6663540.	986461.	4509544.	3173.00	0.640	0.410
14	2125.000	6413734.	1236265.	5745809.	3173.00	0.679	0.460
15	2125.000	6410672.	1239327.	6985137.	3173.00	0.718	0.490
16	2125.000	6620659.	1029341.	8014478.	3173.00	0.750	0.500
17	2125.000	6972679.	677321.	8691799.	3173.00	0.772	0.490
18	2125.000	7401089.	248908.	8940707.	3173.00	0.780	0.460
19	2125.000	7838190.	-188189.	8752518.	3173.00	0.774	0.410
20	2125.000	8278453.	-628454.	8124064.	3173.00	0.756	0.350
21	2125.000	8667605.	-1017605.	7106460.	3173.00	0.722	0.280
22	2125.000	9031397.	-1381397.	5725063.	3173.00	0.679	0.200
23	2125.000	9336706.	-1686705.	4038358.	3173.00	0.625	0.120
24	2125.000	9205614.	-1555616.	2482741.	465.00	0.433	0.050
25	3602.000	9332948.	1019963.	3502704.	3173.00	0.609	-0.010
26	3602.000	11030925.	1936276.	5438980.	3173.00	0.670	-0.060
27	3602.000	11762988.	1204209.	6643189.	3173.00	0.707	-0.090
28	3602.000	12172613.	794587.	7437777.	3173.00	0.732	-0.100
29	3602.000	12350697.	616501.	8054278.	3173.00	0.752	-0.090
30	3602.000	12341811.	625389.	8679667.	3173.00	0.771	-0.060
31	3602.000	12188888.	778314.	9457981.	3173.00	0.796	-0.010
32	3602.000	11965507.	1001694.	10459675.	3173.00	0.827	0.050
33	3602.000	11727476.	1239724.	11699399.	3173.00	0.866	0.120
34	3602.000	11472434.	1494768.	13194167.	3173.00	0.913	0.200
35	3602.000	11239280.	1727921.	14922088.	3173.00	0.968	0.280
36	3602.000	11033203.	1933998.	16856086.	3277.54	1.012	0.350
37	3602.000	10717712.	2249483.	19105570.	3537.08	1.042	0.410
38	3602.000	10499138.	2468065.	21573636.	3821.83	1.075	0.460
39	3602.000	10440007.	2527183.	24100820.	4113.49	1.109	0.490
40	3602.000	10563981.	2403217.	26504038.	4390.68	1.141	0.500
41	3602.000	10849554.	2117639.	28621678.	4635.00	1.169	0.490
42	3602.000	11261272.	1705933.	30327612.	4831.82	1.192	0.460
43	3602.000	11739774.	1227429.	31555042.	4973.44	1.208	0.410
44	3602.000	12290621.	676577.	32231620.	5051.50	1.217	0.350
45	3602.000	13581169.	-613961.	31617660.	4980.66	1.209	0.280
46	3602.000	16653046.	-3685842.	27931818.	4555.41	1.160	0.200
47	3602.000	18127416.	-5160214.	22771604.	3960.04	1.091	0.120
48	3602.000	18379466.	-5412269.	17359334.	3335.60	1.019	0.050
49	2567.000	16061913.	-4988762.	12370571.	3173.00	0.887	-0.010
50	2567.000	12610063.	-3368858.	9001712.	3173.00	0.782	-0.060
51	2567.000	12119580.	-2878376.	6123335.	3173.00	0.691	-0.090
52	2567.000	11615085.	-2373885.	3749450.	3173.00	0.616	-0.100
53	2567.000	10594354.	-1353154.	2396296.	465.00	0.415	-0.090
54	2567.000	9361888.	-120689.	2275607.	465.00	0.389	-0.060
55	2567.000	9078233.	162966.	2438573.	465.00	0.424	-0.010
56	2567.000	8989086.	252111.	2690684.	465.00	0.478	0.050
57	2567.000	8937425.	303771.	2994456.	465.00	0.543	0.120
58	2567.000	8767050.	474152.	3468608.	3173.00	0.608	0.200
59	2567.000	8239907.	1001294.	4469901.	3173.00	0.639	0.280
60	2567.000	7855543.	1385655.	5855557.	3173.00	0.683	0.350
61	2567.000	7667551.	1573650.	7429207.	3173.00	0.732	0.410
62	2567.000	7621488.	1619714.	9048921.	3173.00	0.783	0.460
63	2567.000	7725330.	1515872.	10564793.	3173.00	0.831	0.490
64	2567.000	7978451.	1262748.	11827541.	3173.00	0.870	0.500
65	2567.000	8337125.	904077.	12731618.	3173.00	0.899	0.490
66	2567.000	8753434.	487767.	13219385.	3173.00	0.916	0.460
67	2567.000	9222773.	18427.	13237812.	3173.00	0.915	0.410
68	2567.000	9670709.	-429509.	12808303.	3173.00	0.901	0.350
69	2567.000	10077701.	-836500.	11971803.	3173.00	0.875	0.280
70	2567.000	10470080.	-1226880.	10742922.	3173.00	0.836	0.200
71	2567.000	10806165.	-1564965.	9177956.	3173.00	0.787	0.120
72	2567.000	11013086.	-1771885.	7406070.	3173.00	0.731	0.050

① Ponding volume in a hour

② Accuumulated ponding volume

③ Ponding area

④ Inside water level

⑤ Outer sea level

Table B.3.2.(2) Inundations Analysis (Present, P=1/10)

TIME (Hr)	Q-IN (m3/s)	Q-OUT (m3/hr)	① (m3/hr)	② (m3/hr)	③ (Ha)	④ (m)	⑤ (m)
1	2996.000	8418392.	3065781.	3065781.	465.00	0.558	-0.010
2	2996.000	10630810.	154791.	3220572.	465.00	0.592	-0.060
3	2996.000	10979113.	-193511.	3027062.	465.00	0.550	-0.090
4	2996.000	10903601.	-118000.	2909062.	465.00	0.525	-0.100
5	2996.000	10787269.	-1669.	2907393.	465.00	0.524	-0.090
6	2996.000	10691125.	94476.	3001869.	465.00	0.545	-0.060
7	2996.000	10557350.	228250.	3230119.	465.00	0.594	-0.010
8	2996.000	10200298.	585300.	3815420.	3173.00	0.618	0.050
9	2996.000	9831097.	954503.	4769922.	3173.00	0.648	0.120
10	2996.000	9474878.	1310721.	6080644.	3173.00	0.690	0.200
11	2996.000	9156999.	1628602.	7709246.	3173.00	0.741	0.280
12	2996.000	8960129.	1825469.	9534715.	3173.00	0.798	0.350
13	2996.000	8899147.	1886448.	11421163.	3173.00	0.858	0.410
14	2996.000	8938196.	1847402.	13268565.	3173.00	0.916	0.460
15	2996.000	9095677.	1689920.	14958485.	3173.00	0.969	0.490
16	2996.000	9354584.	1431015.	16389500.	3223.71	1.006	0.500
17	2996.000	9555061.	1230537.	17620038.	3365.68	1.022	0.490
18	2996.000	9867250.	918357.	18538396.	3471.64	1.035	0.460
19	2996.000	10317527.	468081.	19006478.	3525.64	1.041	0.410
20	2996.000	10857177.	-71573.	18934906.	3517.39	1.040	0.350
21	2996.000	11388526.	-602923.	18331984.	3447.82	1.032	0.280
22	2996.000	11895187.	-1109589.	17222394.	3319.80	1.017	0.200
23	2996.000	12400881.	-1615282.	15607111.	3173.00	0.989	0.120
24	2996.000	12664078.	-1878477.	13728633.	3173.00	0.930	0.050
25	4876.000	14094028.	131972.	13860605.	3173.00	0.934	-0.010
26	4876.000	18287210.	-733608.	13126997.	3173.00	0.911	-0.060
27	4876.000	18666242.	-1112641.	12014355.	3173.00	0.876	-0.090
28	4876.000	18120460.	-566863.	11447492.	3173.00	0.858	-0.100
29	4876.000	17492408.	61195.	11508687.	3173.00	0.860	-0.090
30	4876.000	16857032.	696567.	12205254.	3173.00	0.882	-0.060
31	4876.000	16221005.	1332595.	13537849.	3173.00	0.924	-0.010
32	4876.000	15785606.	1767993.	15305842.	3173.00	0.980	0.050
33	4876.000	14719699.	2833901.	18139744.	3425.64	1.029	0.120
34	4876.000	13021043.	4532565.	22672310.	3948.59	1.090	0.200
35	4876.000	12688771.	4864829.	27537140.	4509.87	1.155	0.280
36	4876.000	12610688.	4942907.	32480048.	5080.16	1.220	0.350
37	4876.000	12619237.	4934351.	37414400.	5649.46	1.286	0.410
38	4876.000	12705354.	4848251.	42262652.	6208.83	1.351	0.460
39	4876.000	13468069.	4085523.	46348176.	6680.20	1.405	0.490
40	4876.000	15189461.	2364143.	48712320.	6952.97	1.437	0.500
41	4876.000	16783572.	770027.	49482348.	7041.81	1.447	0.490
42	4876.000	18317576.	-763989.	48718360.	6953.66	1.437	0.460
43	4876.000	19825366.	-2271760.	46446600.	6691.56	1.407	0.410
44	4876.000	20463430.	-2909840.	43536760.	6355.83	1.368	0.350
45	4876.000	20678882.	-3125264.	40411496.	5995.25	1.326	0.280
46	4876.000	20952542.	-3398948.	37012548.	5603.10	1.281	0.200
47	4876.000	21230780.	-3677192.	33335356.	5178.84	1.232	0.120
48	4876.000	21419532.	-3865934.	29469422.	4732.81	1.180	0.050
49	3032.000	21400754.	-7221684.	22247738.	3899.60	1.084	-0.010
50	3032.000	20526218.	-9611024.	12636714.	3173.00	0.896	-0.060
51	3032.000	14084134.	-3168935.	9467778.	3173.00	0.796	-0.090
52	3032.000	12571495.	-1656295.	7811482.	3173.00	0.744	-0.100
53	3032.000	12186742.	-1271543.	6539939.	3173.00	0.704	-0.090
54	3032.000	11754042.	-838842.	5701097.	3173.00	0.678	-0.060
55	3032.000	11279472.	-364274.	5336823.	3173.00	0.666	-0.010
56	3032.000	10753071.	162129.	5498952.	3173.00	0.671	0.050
57	3032.000	10265721.	649477.	6148430.	3173.00	0.692	0.120
58	3032.000	9832692.	1082507.	7230937.	3173.00	0.726	0.200
59	3032.000	9471462.	1443738.	8674675.	3173.00	0.771	0.280
60	3032.000	9233170.	1682028.	10356703.	3173.00	0.824	0.350
61	3032.000	9134334.	1780863.	12137566.	3173.00	0.880	0.410
62	3032.000	9145515.	1769681.	13907247.	3173.00	0.936	0.460
63	3032.000	9282396.	1632804.	15540051.	3173.00	0.987	0.490
64	3032.000	9460620.	1454580.	16994632.	3293.53	1.014	0.500
65	3032.000	9631169.	1284033.	18278666.	3441.67	1.031	0.490
66	3032.000	9949411.	965787.	19244454.	3553.10	1.044	0.460
67	3032.000	10407404.	507781.	19752236.	3611.68	1.051	0.410
68	3032.000	10952538.	-37331.	19714906.	3607.38	1.050	0.350
69	3032.000	11474008.	-558801.	19156106.	3542.91	1.043	0.280
70	3032.000	11986228.	-1071028.	18085078.	3419.34	1.028	0.200
71	3032.000	12499056.	-1583860.	16501217.	3236.60	1.007	0.120
72	3032.000	13120171.	-2204969.	14296247.	3173.00	0.948	0.050

① Ponding volume in a hour

② Accuumulated ponding volume

③ Ponding area

④ Inside water level

⑤ Outer sea level

Table B.3.2.(3) Inundations Analysis (Projection, P=1/5)

TIME (Hr)	Q-IN (m3/s)	Q-OUT (m3/hr)	① (m3/hr)	② (m3/hr)	③ (Ha)	④ (m)	⑤ (m)
1	527.000	1976294.	619478.	619478.	465.00	0.033	-0.010
2	527.000	2134334.	-237134.	382344.	465.00	-0.018	-0.060
3	527.000	2045487.	-148287.	234056.	465.00	-0.050	-0.090
4	527.000	1952345.	-55145.	178912.	465.00	-0.062	-0.100
5	527.000	1859201.	37998.	216910.	465.00	-0.053	-0.090
6	527.000	1766059.	131141.	348051.	465.00	-0.025	-0.060
7	528.000	2055010.	-155980.	192071.	465.00	-0.059	-0.100
8	529.000	1285167.	617463.	809533.	465.00	0.074	0.050
9	530.000	1545611.	-360619.	1170152.	465.00	0.151	0.120
10	533.000	1544270.	369220.	1539372.	465.00	0.231	0.200
11	538.000	1553784.	374167.	1913539.	465.00	0.311	0.280
12	1355.000	2855670.	576240.	2489779.	465.00	0.435	0.350
13	1958.000	5203748.	777742.	3267521.	3173.00	0.601	0.410
14	2650.000	6039611.	2275549.	5543070.	3173.00	0.673	0.460
15	4638.000	7111554.	6066487.	11609557.	3173.00	0.864	0.490
16	5468.000	9254692.	8961012.	20570570.	3706.10	1.062	0.500
17	5276.000	10548710.	8784731.	29355302.	4719.64	1.179	0.490
18	4737.000	11616233.	6390969.	35746272.	5457.00	1.264	0.460
19	4219.000	12496120.	3609219.	39355492.	5873.42	1.312	0.410
20	3737.000	15400703.	-1094440.	38261052.	5747.15	1.298	0.350
21	3282.000	17213010.	-4592480.	33668572.	5217.29	1.236	0.280
22	2900.000	17333624.	-6217488.	27451084.	4499.94	1.153	0.200
23	2597.000	16715911.	-6830432.	20620652.	3711.88	1.062	0.120
24	2371.000	15266583.	-6330961.	14289690.	3173.00	0.948	0.050
25	2205.000	12539572.	-4307752.	9981937.	3173.00	0.812	-0.010
26	2047.000	11879690.	-4230829.	5751108.	3173.00	0.679	-0.060
27	1890.000	10784526.	-3702636.	2048472.	465.00	0.340	-0.099
28	1742.000	7539372.	-1006212.	1042260.	465.00	0.124	-0.100
29	1610.000	6234442.	-204801.	837459.	465.00	0.080	-0.090
30	1481.000	5565032.	-5103.	832355.	465.00	0.079	-0.060
31	1354.000	5002150.	97039.	929394.	465.00	0.100	-0.010
32	1237.000	4498044.	162246.	1091640.	465.00	0.134	0.050
33	1154.000	4013468.	287842.	1379482.	465.00	0.196	0.120
34	1110.000	3721364.	352515.	1731998.	465.00	0.272	0.200
35	1848.000	4576848.	769691.	2501689.	465.00	0.437	0.280
36	2648.000	6672050.	1444749.	3946438.	3173.00	0.623	0.350
37	3395.000	7303876.	3595934.	7542372.	3173.00	0.736	0.410
38	5727.000	8522870.	7966692.	15509064.	3173.00	0.986	0.460
39	7713.000	10350048.	13901527.	29410592.	4726.02	1.179	0.490
40	7937.000	11979595.	16197123.	45607716.	6594.77	1.395	0.500
41	7275.000	18282120.	9079567.	54687284.	7642.33	1.517	0.490
42	6586.000	21017604.	3911483.	58598768.	8093.62	1.569	0.460
43	5912.000	21586280.	889847.	59488616.	8196.28	1.581	0.410
44	5273.000	21956208.	-1842344.	57646272.	7983.72	1.556	0.350
45	4715.000	22175774.	-4214184.	53432088.	7497.51	1.590	0.280
46	4198.000	22225460.	-6197588.	47234500.	6782.46	1.417	0.200
47	3847.000	22096876.	-7626392.	39608108.	5902.56	1.315	0.120
48	3544.000	21819054.	-8524373.	31083736.	4919.06	1.202	0.050
49	3268.000	21414806.	-9161489.	21922248.	3862.05	1.080	-0.010
50	3012.000	20542236.	-9245915.	12676333.	3173.00	0.897	-0.060
51	2775.000	13988292.	-3582459.	9093873.	3173.00	0.784	-0.090
52	2541.000	12336380.	-2778141.	6315731.	3173.00	0.697	-0.100
53	2321.000	11610035.	-2865041.	3450690.	3173.00	0.607	-0.090
54	2101.000	9568645.	-1615646.	1835044.	465.00	0.294	-0.060
55	1890.000	7472133.	-294662.	1540382.	465.00	0.231	-0.010
56	1857.000	6613971.	129638.	1670019.	465.00	0.259	0.050
57	1844.000	6381274.	280135.	1950154.	465.00	0.319	0.120
58	1834.000	6278094.	342007.	2292160.	465.00	0.392	0.200
59	1827.000	6228019.	361571.	2653732.	465.00	0.470	0.280
60	1784.000	6196446.	302065.	2955797.	465.00	0.535	0.350
61	1654.000	6000814.	183686.	3139483.	465.00	0.574	0.410
62	1969.000	5617998.	912852.	4052335.	3173.00	0.626	0.460
63	2271.000	5747937.	1893122.	5945457.	3173.00	0.685	0.490
64	3550.000	6663785.	3852384.	9797841.	3173.00	0.807	0.500
65	4130.000	8395939.	5445458.	15243299.	3173.00	0.978	0.490
66	3996.000	9824496.	4798280.	20041580.	3645.07	1.055	0.460
67	3632.000	10684233.	3035243.	23076824.	3995.26	1.095	0.410
68	3279.000	11409088.	1020145.	24096970.	4112.96	1.109	0.350
69	2948.000	11939863.	-741223.	23355748.	4027.44	1.099	0.280
70	2633.000	12385112.	-2348766.	21006982.	3756.45	1.067	0.200
71	2357.000	12708959.	-3735228.	17271754.	3325.50	1.018	0.120
72	2128.000	12742304.	-4676174.	12595579.	3173.00	0.895	0.050

① Ponding volume in a hour

② Accuumulated ponding volume

③ Ponding area

④ Inside water level

⑤ Outer sea level

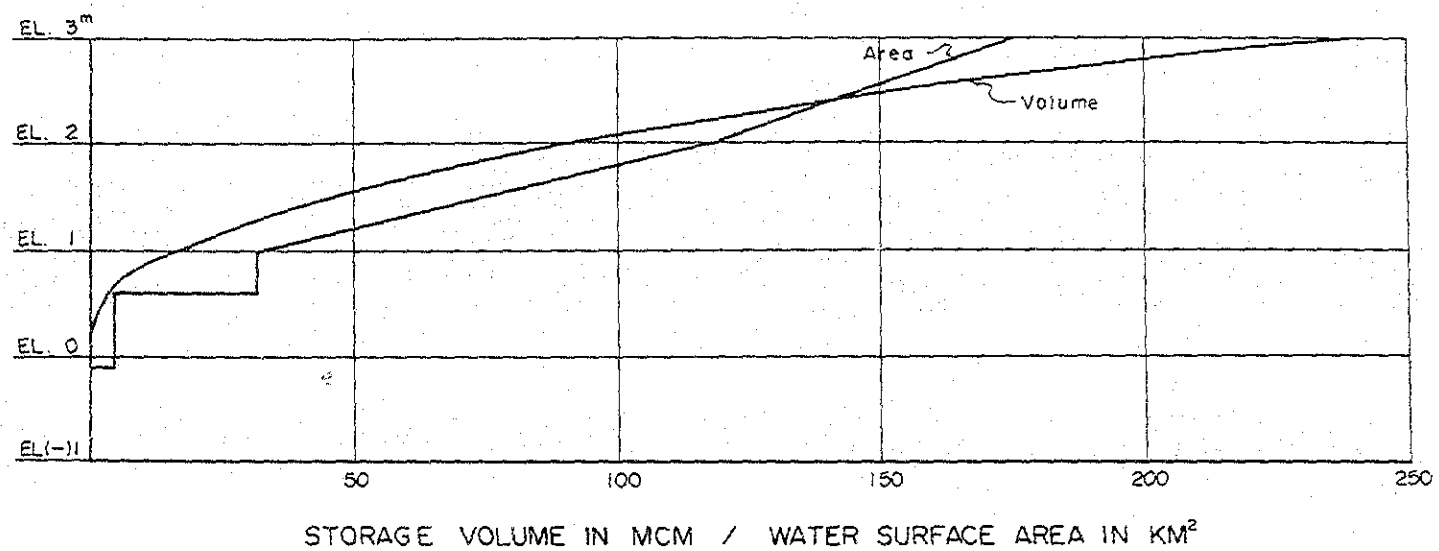


Fig. B.3.1 Storage Capacity of Low Lying Area

Annex C Soils

Annex C. Soil

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C.1 Method of Investigation

The soil survey has been conducted in two times separately, from March 5 to 13 and July 3 to 17, 1987, by observing the soil profiles of 26 pits in all and by taking soil samples from the each profiles for the laboratory analysis. At the 2nd survey, the core-samples were taken for the measurement of the three phase of soil (Solid, Liquid and Air). Some common chemical and physical analysis of the samples were conducted in the Research Institute of Agriculture, in the University of Costa Rica, while the measurement of the three phase of soil was done in SENARA with the special equipment provided by Japan[13].

As for the soil survey in the area, detailed surveys has been conducted by private company of the banana-plantation in their farms far long years since about 1920's. Recently a soil map (scale 1/200,000) and its interpretation were issued from MAG (1979)[1)2)3)], which were compiled with many survey reports and classified based on the soil taxonomy of USDA into the sub-group. A report on the soil survey and land classification in "The Storren Farm" located in the area, has been also issued from ITCO (IDA) in 1981[4].

Although these reports have furnished the soil classification and their distribution in this survey with much informations, the new informations for detail survey, land improvement and soil management have been made still more.

The moisture status of the field capacity for the core-samples has been established by keeping the samples on the sand -column of 30 cm in height above water-surface for three days by preventing evaporation of the water with vinyl cover. As the core-sample, taken with the special sampler, keeping the natural soil structure in the volume of 100 ml, has 5 cm in height, the moisture stress in t he center of the soil core (2.5 cm) on the sand column would become 32.5 cm above the water, indicating about PF1,5 or 0.03 Bar[13].

The measurements of the three phase of soil were conducted two times on the same sample before and after the treatment for "Field Capacity".

C.2 Characters of Soil Groups

As for the topography in the area, with an exception of alluvial fan from the alluvial deposit, most of the land would be considered to be an alluvial flood plains developed along the basins of the many rivers from the Talamanca Mountains, showing gentle slope with unevenness of the surface, such as natural levees, back water low-lands and swamps.

The soils developed on the flood plains are observed to be young and undeveloped in their genesis, classified as Entisol and Inceptisol, while the soils on the alluvial fan would be seen to be well withered soil, Ultisol[1),2)]. Being reported some organic soils, Histosol, in the swamps, the survey could not be conducted[1),2)] this time due to the traffic difficulty.

The outline of the pit-sites and their soil profiles are presented in Tables C.2.1 - C.2.2 and in Fig. C.2.1.

Based on these data, the characters of the soils in the genesis are considered as follows.

The most common soil forming factors throughout the area seemed to be a high temperature, about 25°C and a high rainfall, about 3,500 mm, in the means of a year, which would affect almost evenly on the land in the area in general. However, the difference in the influences of a inundation and the moisture status in soil would cause different soil forming processes. Thus, as indicated in Table C.2.3, the land elevation, groundwater level and drainage condition would be considered the most important criterions to distinguish the soils for classification. The duration of water saturation in soil such as submerging would affect the red-oxy potential of the soil, appearing on soil colors including mottling and concretion of Fe and Mn resulted from their chemical changes in farms, these characters on the profile would be considered as a important criterion for the soil classification too.

Thus, as indicated in Table C.2.4, the appearance frequency of the colors on profiles of the I-16 and I-2 soil groups, being distributed most widely in the area, the brown to brownish colors, corresponded to the Munsells' value 7.5 YR - 10 YR, appeared on 80% of the topsoils and 84% of subsoils in the I-16 group, while in the I-2 group, the colors in the same range appeared only 54% and 56% on both of the soils respectively. On the contrary, gray to bluish gray colors, corresponded to 2.5 Y to 10 BG, appeared on 46% of both of the soils in I-2 group. These phenomena would indicate development of more reductive conditions in the soils of I-2 group than in the I-16. Moreover, the I-2 group might seems to be divided in at least two subgroups, more oxidative one with brownish colors and more reductive one with graynish to bluish gray colors, being referred to "D" for the former and "W" for the latter.

Among the quality of the deposited parent materials of the soils, much attention would have to be payed on volcanic ash and lime stones. Because the former have high water holding capacity and would have much effects on the moisture statuses in the soils, while the latter would be main source of Ca-supply and affect on chemical properties of the soils.

The outline of characters of each sub-group of the soils indicated in Table C.2.3 seems to be as follows;

E-1 : The soils, distributed on low land with the elevation of about 2 to 4 m near the coast and being suffered from inundation frequently, show high moisture situations like nearly submergence almost all year round and the remarkable development of reductive status in the soils with grayish colors. Most of the soils would be form of relatively newer deposits, having lower content of organic matter in the area. Natural forestry and grassland occupy most of the land.

E-4 : The soils, chiefly distributed on the relatively higher land with the elevation of 10 to 30 m, near the highway laying along the edge of south-west of the area, being alluvial fan derived from alluvial deposit and detriment, slightly coarse texture and stony in some places, show deep groundwater

level, well drainage and fairly oxidative status in the soils with yellowish brown in dominant colors of the profiles, and the land-utilization for the fruit trees such as cacao, coconut and banana and the forests.

I-2W: The soils, distributed in the back water lowland of the main rivers, with elevations of about 4 to 8m, and being extremely suffered from inundations and of medium to fine textures, show shallow groundwater level, poor drainage and remarkable reductive status, in most cases with the gray horizon and the land-utilizations for rice, pastures, weakened cacao and natural forestry, and cover about 24% of the area.

I-2D: The soils, distributed in the back water lowland of the main rivers as the same as the I-2W, but being higher with elevations of about 8 to 10 m, more slightly danger in the inundations than the I-2W, and of medium texture, show moderately well to imperfect drainage and weakly developed reductive status with increasing yellowish brown in colors and the main land-utilization for rice, cacao, pastures and natural forestry, and cover about 19% of the area.

I-16: The soils, distributed on the higher land with elevations of 10 to 20 m such as the natural levees of the main rivers and neighboring places of the alluvial fan near the edge of south-west of the area, show deep groundwater level, well drainage, very slightly danger in the inundations and rather oxidative status with increasing the strength of brown in the colors and the main land-utilizations for banana, cacao, coconut and some kinds of upland crops, and cover about 24% of the area.

U-1: The soils distributed on the nearly highest land of the area, with elevation of 20 to 80 m, neighboring to the hill-side of the south-west edge of the area, having undulating topography with the slopes of about 5 to 10^{o} in gradients, being of alluvial fan derived from the alluvial deposit, well developed

in weathering, show clayey in the texture, strong acidity due to the leaching losses of the bases, abundantly stony from the surface into the soil, well drainage and deep groundwater level, and the main land-utilization for pastures, coconut, cacao and natural forestry, but cover only 1.4% of the area.

Table C.2.1 Outline of Soil Pit Sites

Pit No.	Location	Elevation	Land Form & Slope	Surface Stoniness	Vegetation & Land Use	Ground Water Level	Drainage
1	Soto Chare	12	Alluvial, Flat	None	Pasture	45 cm	Imperfectly
2	Larga Distancia	4	Alluvial, Flat	None	Pasture	70	Imperfectly
3	Punta de Riel	10	Alluvial, Flat	None	Pasture	53	Imperfectly
4	Marry Land	7	Alluvial(Natural Levee)	None	Pasture	100	Well
5	Sara	18	Alluvial(Natural Levee)	None	Pasture	85	Well
6	Free Man	5	Alluvial(Natural Levee)	None	Pasture	120	Well
7	Sara	14	Alluvial, Flat	None	Rice	70	Well
8	Nuevo Pueblo	17	Alluvial, Flat	None	Pasture	70	Moderatly Well
9	San Edmundo	4	Alluvial(Natural Levee)	None	Pasture	180	Well
10	Belta de Matina	5	Alluvial, Flat	None	Pasture	73	Imperfectly
11	Barro Matina Norte	4	Alluvial(Natural Levee)	None	Pasture	120	Well
12	Zenti	18	Alluvial(Natural Levee)	None	Upland Crop	>150	Well
14	Sabrio B.M	5	Alluvial, Flat	None	Pasture	50	Imperfectly
15	Cano Blanco (M.L.)	4	Alluvial(Plain), Flat	None	Pasture	75	Moderatly Well
16	San Juan de Goschen	8	Alluvial, Flat	None	Rice	37	Moderatly Well
17	Sara	12	Alluvial, Flat	None	Rice	90	Imperfectly
18	24 Millas (Matina)	12	Alluvial, Flat	None	Ditch	70	Well
19	Zapote Danto	3	Alluvial, Flat	None	Coconut	60	Well
20	Camino Dondi(Matina)	14	Alluvial Fan, Flat	None	Coconut	130	Well
21	Calle Chancho	62	Diluvial,Undulating	Many	Pasture	150	Well
22	San Alberto	20	Alluvial Fan, Flat	None	Canal	>200	Well
23	Exp. Sta. of ASBANA	14	Alluvial(Natural Levee)	None	Wild Grass	105	Well
24	Exp. Sta. of ASBANA	14	Alluvial(Natural Levee)	None	Wild Grass	110	Well
25	Liverpool	10	Alluvial(Natural Levee)	None	Upland Crop	68	Moderatly Well
26	Bambusar (M.L)	10	Alluvial(Natural Levee)	None	Upland Crop	>200	Well
27	Serina	17	Alluvial, Flat	None	Wild Grass	71	Moderatly Well

Table C.2.2 (1) List of Soil Profile

Pit No.	Horizon	Depth (cm)	Color (in moist)	Texture	Gravel	Hardness	Friability in moist	Stickiness & Plasticity	Structure 1)	Mottles & Concretion 2) (Color)	Roots 3)	Horizon boundary
5	A_1	0~20	Grayish yellow brown (10YR 4/2)	CL	few	very hard	friable	sticky, plastic	MMSAB	xx (faint)	F ~ M many	clear smooth
	B_{21}	20~55	Brown (10YR 4/4)	CL	few	extremly hard	friable	sticky, plastic	MMSAB	xx, x x	F common	gradual smooth
	B_{22}	55~85+	Brown (10YR 4/4)	SiCL	few	extremly hard	friable	sticky, plastic	MMSAB	xx, x	F few	
11	A_{11}	0~11	Dark grayish yellow (2.5Y 3.5/2)	SiCL	few	very hard	friable	sticky, plastic	SMSAB	x	F ~ M many	clear smooth
	A_{12}	11~34	Yellowish brown (2.5Y 4.5/5)	SiL	few	very hard	friable	sticky, plastic	SMSAB	x (faint)	F ~ M common	gradual smooth
	A_{13}	34~51	Yellowish brown (2.5Y 5/3.5)	SiL	few	very hard	friable	sticky, plastic	WMSAB	x (〃)	F few	clear smooth
	$\mathrm{II}AB$	51~97+	Yellowish brown (2.5Y 4.5/3)	L	few	hard	friable	sticky, plastic	WMSAB	x (〃)	F few	
23	A_{11}	0~14	Dark brown (10YR 3.5/3.5)	SiCL	few	slightly hard	friable	sticky, plastic	MMSAB	x (faint)	F ~ M abundant	clear smooth
	A_{12}	14~20	Dark grayish yellow (2.5Y 4.5/2)	SiCL	few	very hard	friable	sticky, plastic	MMSAB	xx (5YR 3/5) (Dark reddish brown)	F ~ M many	clear smooth
	A_{13}	20~51	Dark grayish yellow (2.5Y 5/1.5)	SiCL	few	very hard	friable	sticky, plastic	MMSAB	xx (〃)	F ~ M common	gradual smooth
	B_{21}	51~80	Dull yellowish brown (10YR 4.5/5)	CL	few	very hard	friable	slightly, plastic	WMSAB	xx (〃)	F few	gradual smooth
	B_{22}	80~100	Dull yellow orange (10YR 5/5)	CL	few	hard	friable	sticky, plastic	WMSAB	xxx (5YR 4/6) (Reddish brown)	F few	clear smooth
	$\mathrm{II}C$	100~105+	Dull yellow orange (10YR 7/3)	S	few	hard	loose	none, none	NS	-	none	
4	A_1	0~7	Gray (5Y 5.5/1)	LS	few	very hard	very friable	slightly, slightly plastic	MMSAB	—	F ~ M many	clear smooth
	B_2	7~70	Dull yellow orange (10YR 5.5/1)	LS	few	hard	very friable	slightly, slightly plastic	MMSAB	—	F common	gradual smooth
	$\mathrm{II}B_2$	70~100	Brownish gray (7.5YR 6/1)	SiCL	few	hard	friable	sticky, plastic	MMSAB	xx (5YR 3/5) (Dark reddish brown)	F few	
6	A_1	0~15	Brwon black (10YR 3/2.5)	LS	few	very hard	very friable	slightly, slightly plastic	SCSAB	xx (faint)	F ~ M abundant	clear smooth
	$\mathrm{II}B_2$	15~70+	Brown (7.5YR 4/4)	SiL	few	hard	friable	slightly, plastic	WMSAB	x (〃)		
9	A_1	0~20	Dark brown (10YR 3/3)	LiC	few	very hard	friable	slightly, plastic	SFG ~ SMSAB	x (faint)	F ~ M abundant	clear smooth
	B_2	20~50	Dull yellowish brown (10YR 5/3)	LiC	few	very hard	friable	stickly, plastic	SCSAB	x (10YR 5/6) (Yellowish brown) x	F common	
24	A_{11}	0~10	Brown black (10YR 2.5/2)	CL	few	hard	friable	slightly, slightly plastic	MMSAB	x (faint)	F ~ M abundant	clear smooth
	A_{12}	10~27	Dull yellowish brown (10YR 5.25/2)	CL	few	very hard	friable	slightly, slightly plastic	MMSAB	x (faint)	F ~ M many	clear smooth
	B_{21}	27~46	Grayish yellow brown (10YR 5/1.5)	CL	few	very hard	friable	slightly, slightly plastic	MMSAB	xxx (5YR 4/4.5) (dull reddish brown) x x x (10YR 2/2)	F common	gradual smooth
	$\mathrm{II}B_{22}$	46~80	〃	SL	few	hard	very friable	slightly, slightly plastic	WMSAB	xxx (〃) x x x (〃)	F few	gradual smooth
	B_{23}	80~93	〃	SL	few	hard	very friable	none, none	WMSAB	xxx (5YR 5.5/8) (orange)	none	clear smooth
	$\mathrm{III}C$	93~110+	〃	S (coarse)	few	?	loose	none, none	?	?	?	
12	A_1	0~25	Brwon (7.5YR 4.5/4)	L	few	extremly hard	very friable	slightly, slightly	WFG	—	F many	clear smooth
	$\mathrm{II}B$	25~75	Dull brown (7.5YR 5/4)	S	few	hard	loose	none, none	NS	—	F few	
26	Ap_1	0~6	Dark brown (7.5YR 4.5/4)	SiL	few	hard	very friable	slightly, slightly plastic	MMSAB	—	F many	gradual smooth
	Ap_2	6~21	Dull yellowish brown (10YR 4/3)	SiL	few	hard	very friable	slightly, slightly plastic	WMSAB	x (5YR 4/4) (dull reddish brown)	F common	gradual smooth
	$\mathrm{II}Ab$	21~26	Greenish yellow brown (10YR 4/2)	SiL	few	slightly hard	loose	none, none	NS	x (〃)	F few	gradual smooth
	B_2	26~96	Brown (10YR 4/4)	SiL	few	slightly hard	loose	none, none	NS	x (〃)	F few	

1) 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
  - Massive : Ma

Example : Moderate medium subangular blocky : MMSAB

Table C.2.2 (2) List of Soil Profile

Pit No.	Horizon	Depth (cm)	Color (in moist)	Texture	Gravel	Hardness	Friability in moist	Stickiness & Plasticity	Structure 1)	Mottles & Concrtion 2) (Color)	Roots 3)	Horizon boundary
8	A_1	0~14	Dull yellowish brown (10YR 4.5/3)	CL	few	very hard	friable	sticky, plastic	MMSAB	x (5YR 4/8) (Dull readish brown)	F ~ M abundant	clear smooth
	B_1	14~70	Dull yellowish brown (10YR 5/3.5)	CL	few	very hard	friable	sticky, plastic	WMSAB	x , x (5YR 4/6) (Reddish brown)	F ~ M common	
27	A_1	0~9	Brown black (10YR 3/3)	CL	few	hard	friable	sticky, plastic	MMSAB	x (faint)	F ~ M abundant	clear smooth
	B_1	9~71	Yellowish gray (2.5Y 4/1.5)	SiCL	few	very hard	friable	sticky, plastic	MMSAB	x x (2.5YR 3/5) (Dark reddish brown)	F ~ M common	
19	A_{11}	0~4	Brownish black (10YR 2.5/1.5)	S	few	extremly hard	very friable	slightly, slightly	WMSAB	-	F ~ M many	gradual smooth
	A_{12}	4~9	Brownish gray (7.5YR 5/1)	S	few	extremly hard	very friable	slightly, slightly	WMSAB	x (faint)	F ~ M many	gradual smooth
	B_2	9~24	Brown (7.5YR 4/4)	S	few	very hard	loose	none, none	WFSAB	x (〃)	F common	diffuse
	C	24~60	Olive black (7.5Y 3/2)	S	few	hard	loose	none, none	NS	x (〃)	F few	
7	Ap	0~15	Dark brown (10YR 2.5/3)	CL	few	very hard	friable	sticky, plastic	MMSAB	x (faint)	F ~ M many	clear smooth
	B_2	15~70	Brown (10YR 4/4)	SiL	few	very hard	very friable	sticky, plastic	MMSAB	x (〃)	F common	
18	BC	10~70	Greenish gray (7.5GY 5.5/1)	LiC	few	hard	friable	sticky, plastic	WMSAB	xxx (7.5YR 4.5/6) x x x (5YR 2/1)	none	—
10	A_{11}	0~19	Dark olive brown (2.5Y 3.5/3)	CL	few	extremly hard	very friable	slightly, plastic	MMSAB	x (5YR 4/6) (reddish brown)	F ~ M many	clear smooth
	A_{12}	19~39	Brown (10YR 3.5/4)	CL	few	extremly hard	friable	sticky, plastic	WMSAB	x (faint)	F common	gradual smooth
	A_{13}	39~73	Dull yellowish brown (10YR 5/4)	SL	few	very hard	friable	stickly, plastic	WMSAB	x (faint)	F few	
2	Apg	0~20	Dark greenish gray (10GY 4/1)	SiCL	few	very hard	friable	stickly, plastic	MA	xxx (5YR 5/8) (Bright reddish brown)	F many	clear smooth
	Bg	20~70	Bluish gray (5BG 5.5/1)	SiCL	few	very hard	friable	stickly, plastic	MA	xxx (5YR 6/8) (orange)	F common	
3	A_{11}	0~4	Brown (7.5YR 3.5/3)	L	few	very hard	friable	slightly, slightly	MMSAB	-	F many	gradual smooth
	A_{12}	4~24	Brownish gray (7.5YR 6/1)	SiCL	few	very hard	friable	stickly, plastic	WMSAB	xx (2.5YR 4/7) (Reddish brown)	F many	clear smooth
	B_2	24~53	Light brownish gray (7.5YR 7/1)	SiCL	few	very hard	very friable	stickly, plastic	WMSAB	xx (7.5YR 4/5) (Brown)	F common	
17	Ap_1	0~15	Dark brown (10YR 3.5/2.5)	LiC	few	very hard	friable	slightly, plastic	MMSAB	x (faint)	F many	gradual smooth
	Ap_2	15~22	Greenish gray (7.5GY 5/1)	LiC	few	very hard	friable	slightly, plastic	MMSAB	x x	F many	clear smooth
	B_2	22~48	Brown (10YR 4/5)	SiCL	few	very hard	very friable	slightly, slightly	WMSAB	xxx	F common	
16	Apg	0~20	Dark greenish gray (10GY 4/1)	LiC	few	hard	friable	stickly, plastic	MA	xxx (5YR 5/8) (Bright reddish brown)	F many	gradual smooth
	Bg	20~37	Bluish gray (10BG 6/1)	HC	few	hard	friable	stickly, plastic	MA	xxxx (5YR 6/8) (orange)	F common	
1	Apg	0~20	Dark greenish gray (10GY 4/1)	CL	few	very hard	friable	stickly, plastic	MA	xxx (5YR 5/8) (Bright reddish brown)	F many	clear smooth
	Bg	20~45	Bluish gray (10BG 6/1)	SiCL	few	very hard	friable	stickly, plastic	MA	xxx (5YR 6/8) (orange)	F common	
14	Apg	0~20	Greenish gray (10GY 5.5/1)	LiC	few	very hard	friable	stickly, plastic	MMG	xx (faint)	F abundant	clear smooth
	Bg	20~50	Gray (5Y 6/1)	SiCL	few	very hard	friable	stickly, plastic	MA	xxx (10YR 5/6) (yellowish brown)	F common	
21	A_1	0~4	Dull reddish brown (5YR 4/3.5)	LiC	common	extremly hard	friable	sticky, plastic	SMG	-	F many	gradual smooth
	B_1	4~38	Bright reddish brown (5YR 5/5)	LiC	common	extremly hard	friable	sticky, plastic	MMG	-	F common	

2) Mottles
few : —
common : x
many : xx
abundant : xxx

x : iron
x : Manganes

3) Roots
fine
medium (φ 1~2 mm / 2~5 mm) : F / M

Table C.2.3 Outline of characteristics of Soil Sub-Groups

Sub-group	Symbol	Land form & Slope	Stones on surface & in soils	Elevation (m)	Groundwater level (cm)	Natural drainage
Typic Tropaquent	E-1	Alluvial plain (Flood deposit)	Few	2 ~ 4	Shallow < 50	Poorly
Typic Tropaquent	E-4	Alluvial fan Almost flat	Few	10 ~ 30	Moderatly deep > 150	Well
Typic Tropaquept	I-2W	Alluvial plain (backwater lowland)	None	4 ~ 8	Shallow < 50	Imperfectly
Aeric Tropic Fluvaquept	I-2D	Alluvial plain (backwater lowland)	None	8 ~ 10	Slightly deep 50 ~ 75	Moderatly Well
Aeric Tropaqept	I-1G	Alluvial plain (Natural levee)	None	10 ~ 20	Moderatly deep > 150	Well
Oxic palehumult	U-1	Diluvial fan Undulating	Abundant	20 ~ 80	Moderatly deep > 150	Well
Typic Tropohumult	U-4	Residual soil Undulating	Abundant	80 ~ 120	Very deep > 20	Well
Humic Tropasaprist	H-1	Swamp	None	< 2	Very shallow 5 ~ 20	Very poorly

Table C.2.4 Frequency of Appearance of Color in Profiles of Main Soil Groups

Soil Group	Color[2] / Soil	7.5 YR	10 YR	2.5 Y	5 Y	7.5 GY, 5 BG 10 BG
I-16	Surface soil (10)[1]	30 % [3.8/3.3] brown	50 % [3.4/2.5] brownish black	10 % [3.5/2] dark grayish yellow	10 % [5.5/1] gray	0 % --
	Sub-soil (25)	12 % [4.7/3.0] dull brown	72 % [4.9/3.1] dull yellowish brown	16 % [4.8/3.3] Yellowish brown	0 % --	0 % --
I-2 (W+D)	Surface soil (11)	9 % [3.5/3.0] dark brown	45 % [3.2/2.6] brownish black	9 % [3.5/3.0] dark olive brown	0 % --	37 % greenish gray ~ dark greenishy gray
	Sub-soil (18)	28 % [5.5/2.0] grayish brown	28 % [4.3/4.1] brown	6 % [4/1.5] Yellowish gray	6 % [6/1] gray	32 % bluish gray ~ gray

1) Number of samples 2) Munsells' notation

Fig.C.2.1.(1) Columnar Diagrams of Soil Profile of Soil Series in Each Soil Order

I. Vertisol II. Inceptisol III. Molisol IV. Alfisol V. Histosol

NOTE: Diagrams attached with soil pit number were drawn from the present profile observations. The others were made from the profile descriptions in the SEA/FAO Report(1976). Abbreviations used in the diagram are referred to the legend below:

LEGEND for Columnar Diagrams of Soil Profile

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: ▽

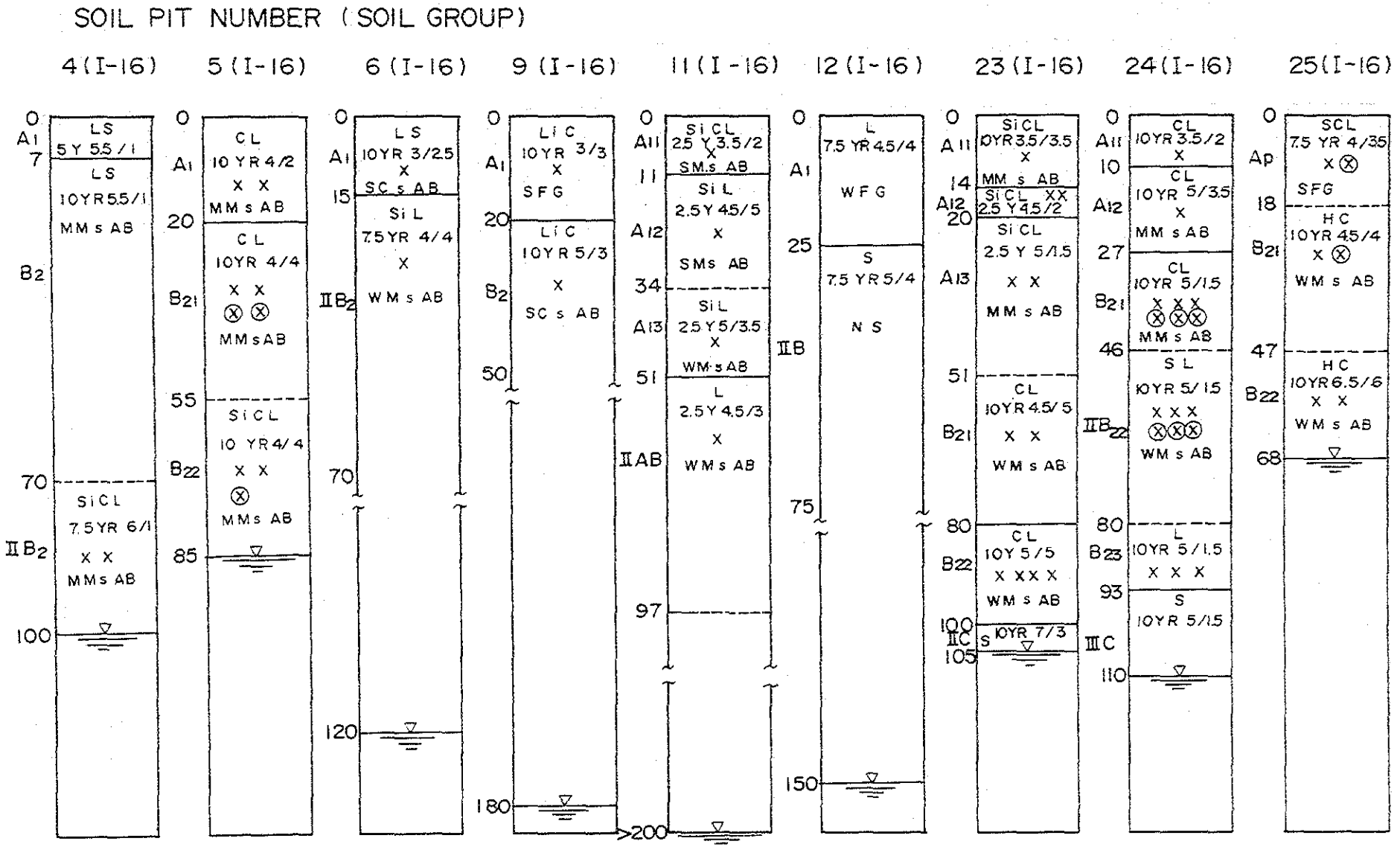

Fig.C.2.1.(2) Columnar Diagrams of Soil Profile of Soil Series in Each Soil Order

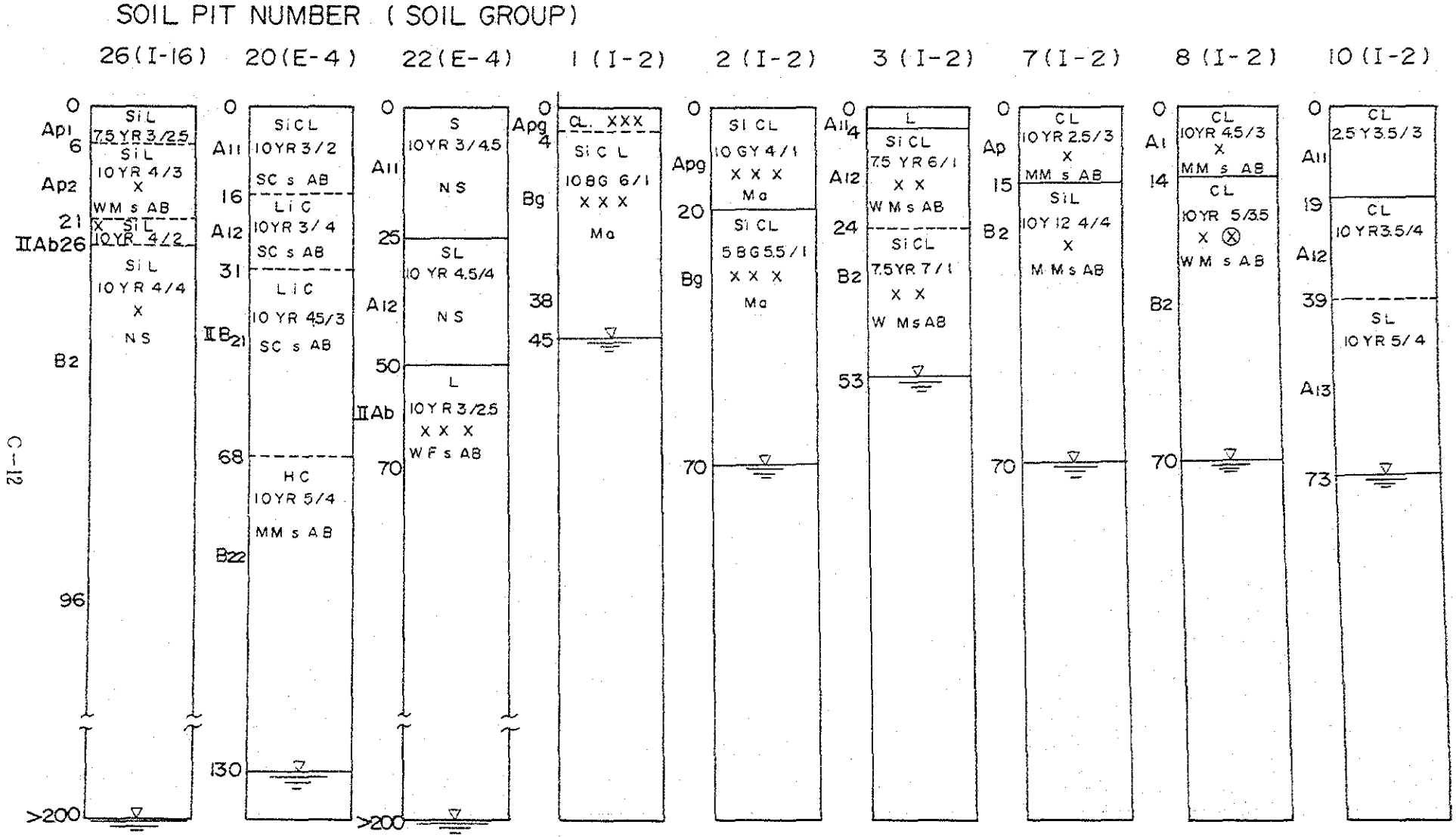

Fig.C.2.1.(3) Columnar Diagrams of Soil Profile of Soil Series in Each Soil Order

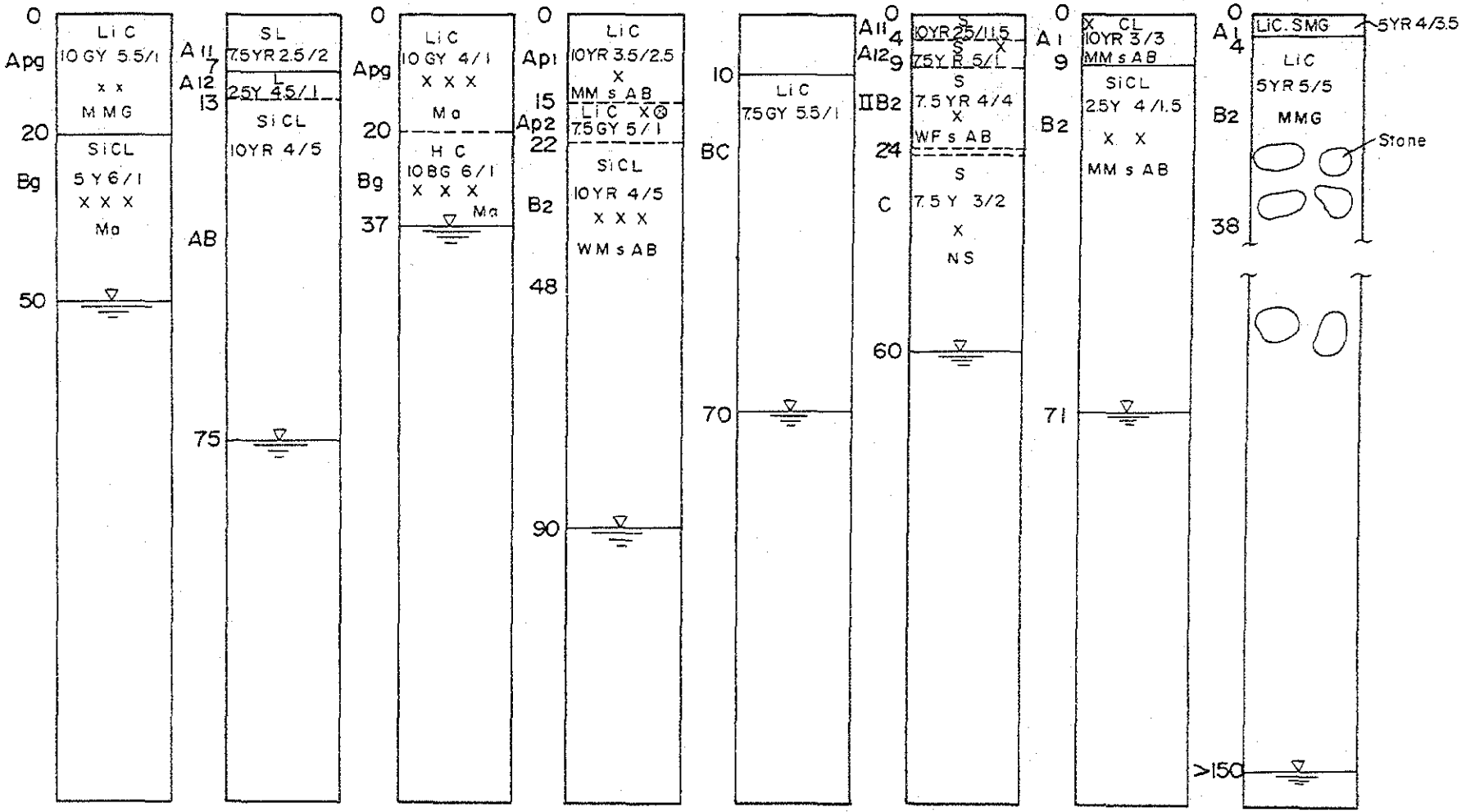

Fig.C.2.1.(4) Columnar Diagrams of Soil Profile of Soil Series in Each Soil Order

C.3 Physical Properties of Soils

The data on the particle size analysis and the soil texture are indicated in Tables C.3.1 and C.3.2, summarized and classified in two groups depending on the drainage conditions from the data presented in Table C.2.2 and C.3.3, showing the values in each profiles surveyed. As the soil genesis of the U-1 group seemed to be notably different from the others, the data of the U-1 were excluded from the one of other groups in the summarizing.

As shown in Table C.3.1, the frequencies of texture appeared in the layers surveyed in the area were 46% in clay loam and silty clay loam and 22% in loam, silt loam and sandy loam, thus, about 70% of the layers were seemed to be of the medium texture. While fine and coarse texture, like clay and sand, seemed to appear only less than in 20% respectively. In relation to drainage situation, the textures of clay loam and clay appeared with more frequencies in the I-2 group, having imperfect drainage, than in the I-16 group, having well drainage and more textures of loam and sand. Thus, the textures of the soil layers seems to be much concerned with drainage situation. The higher contents of clay in the I-2W group were also indicated in Table C.3.2.

The data on the distribution of the three phase of soil, apparent and true density and moisture ratio were presented in Table C.3.4, being summarized from the values measured on each layers of profiles under the field capacity indicated in Table C.3.5.

Showing smaller values in the apparent and true density for the I-2 group than for the I-16 would be resulted from the more accumulation of soil organic matters, being hasten under poor drainage, and more mixing of the volcanic ash described below in I-2 group. These things would be related to the facts that the I-2 group has lower percent in solid phase and higher percent in porosity and liquid phase than the I-16. Thus, the degree of water saturation of the soil pores and air phase percent showed as high as 94% and only 4.4% respectively for the surface soil in the I-2 group, even under the field capacity. While in sandy soils, the facts, being low in the water saturation degree in pores and high in the air

phase percent, especially in subsoils more than 20%, would indicate the well condition for drainage and air-supply to plant roots, though in silty topsoil like (a) in Table C.3.4 rather high liquid phase percent and lower air percent were observed.

As one of the criterions for the volcanic ash soil the apparent density lower than 0.85 is recognized[12], the layers having these values were summarized in Table C.3.4 as "Volcanic ash". According to the data, the volcanic ash showed not only low values in apparent and true density, and solid and air phases percent but also high values in porosity and liquid phase percent. Consequently, the higher the mixing degree of this material as a soil material, the worse condition for drainage would be produced under high rainfall, due to the high water holding capacity of the soils. For example, the grayish colors like the gray horizon observed just under surface soils in some profiles (pit No. 3, 15, 17, 19) would be considered to be resulted from reductive conditions caused by long-term water saturations of the upper layers having lots of the volcanic ash in rainy days. From this fact would likely suggest that for these soils, getting favorable effects to improve moisture status by drainage would not be so easy under the climatic condition of the area.

As for the difference of drainage situations between the soil groups, the data in Table C.3.6 would be considered to show the interesting facts. Namely, at the experiment for adjusting moisture in the core-samples to the field capacity, nearly 80% of the samples in the I-16 group and 56% one in the I-2 took up water from the sand column. These facts would indicate that most of the soil layers with about 70 to 100 cm in depths for the I-16 group, and only about half of the limited shallow layers for the I-2 group exist with dryer conditions than the field capacity, even under rain season, showing well drainage for the former group and imperfect one for the latter.

Table C.3.1 Frequency of Textures occurred in the horizons

(%)

Sub-group	Number of Horizon	HC～LiC	CL～SiCL	L,～SiL～SL	LS ～ S	Total
I-1G	37	16 (6)	41 (15)	27 (10)	16 (5)	100 (37)
I-2	31	19 (6)	52 (16)	16 (5)	13 (4)	100 (31)
Total	68	18 (12)	46 (31)	22 (15)	15 (10)	100 (68)

I-1G : Includes Pit No.20. I-2 : Includes Pit No.15.

( ) : Number of Horizon

Table C.3.2 Result of particle Size Analysis

(%)

Sub-group	Horizon	Sand	Silt	Clay
I-1G	Surface	47	37	16
	Sub	39	45	16
I-2D	Surface	56	29	15
	Sub	59	27	14
I-2W	Surface	39	38	23
	Sub	41	39	20

Table C.3.3 (1) Chemical and Physical Properties of Soil

Sub-group	Pit No.	Horizon (cm)	CEC me/100g	Ex-base Saturation %	T-N %	Sand %	Silt %	Clay %	Texture
I - 16	5	A_1	43.9	70.4	0.31	49	33	18	CL
		B_{21}	37.8	77.0	0.07	44	41	15	CL
		II B_{22}	19.8	83.7	0.03	26	59	15	CL
	11	A_{11}	35.3	61.2	0.30	33	49	18	SiCL
		A_{12}	32.7	80.4	0.10	31	59	10	SiL
		A_{13}	35.3	68.0	0.06	38	57	5	SiL
		II AB	30.5	70.0	0.04	58	39	3	L
	23	$A_{11}\cdot A_{12}$	48.2	50.6	0.20	33	49	18	SiCL
		A_{13}	49.2	55.9	0.14	26	55	19	SiCL
		$B_{21}\cdot B_{22}$	45.6	53.7	0.08	44	39	17	CL
	4	A_1	34.4	41.4	0.46	56	40	4	L
		B_2	30.5	52.2	0.11	56	40	4	L
		II B_2	36.6	(126)	0.09	19	53	28	SiC
	6	A_1	38.7	67.5	0.67	66	30	4	SL
		II B_2	36.6	57.6	0.09	29	63	8	SiL
	9	A_1	39.6	55.3	0.33	31	34	35	LiC
		B_2	33.5	68.7	0.10	28	39	33	LiC
	24	A11	46.0	52.6	0.20	42	36	22	CL
		A_{12}	40.6	(151)	0.12	49	29	22	CL
		B_{21}	43.4	(144)	0.11	34	44	22	CL
		II B_{22}	38.6	(159)	0.03	74	17	9	SL
		B_{23}	42.2	(152)	0.04	54	39	7	L
	12	A_1	27.5	69.3	0.15	63	24	13	L
		II B	19.4	85.6	0.05	96	1	3	S
	28	Ap_1	34.2	(150)	0.14	19	69	12	SiL
		Ap_2	27.4	(169)	0.13	19	72	9	SiL
		II Ab	29.4	(166)	0.12	12	76	12	SiL
		B_2	24.0	(175)	0.06	39	57	4	SiL
	25	Ap	41.0	(119)	0.30	71	7	18	SCL
		B_{21}	39.4	(123)	0.15	22	29	49	HC
		B_{22}	41.2	(123)	0.27	19	34	47	HC

Table C.3.3 (2) Chemical and Physical Properties of Soil

Sub-group	Pit No.	Horizon (cm)	CEC me/100g	Ex-base Saturation %	T-N %	Sand %	Silt %	Clay %	Texture
E - 4	20	A_{11}	45.0	(110)	0.15	16	60	24	SiCL
		A_{12}	47.2	79.2	0.13	16	53	31	LiC
		II B_{21}	47.2	78.6	0.07	16	50	34	LiC
	22	A11	14.6	(225)	0.05	89	7	4	S
		A_{12}	18.8	(153)	0.03	76	20	4	SL
		II Ab	32.6	88.3	0.31	56	33	11	L
E - 1	15	A_{11}	49.2	68.1	0.89	71	20	9	SL
		II A_{12}	41.0	73.9	0.44	44	37	19	L
		AB	37.2	74.7	0.14	24	55	21	SiCL
i - 2	8	A_1	41.7	55.1	0.41	46	36	18	CL
		B_2	19.4	74.4	0.15	41	34	25	CL
	27	A_1	43.8	(133)	0.68	49	34	17	CL
		II B_2	37.6	(152)	0.18	29	49	22	SiCL
	19	A11	28.6	92.0	0.39	91	5	4	S
		A_{12}	27.4	(126)	0.24	86	10	4	S
		II B_2	24.6	(123)	0.15	91	5	4	S
		C	18.4	(166)	0.13	94	2	4	S
	7	Ap	51.2	65.6	0.25	39	41	20	CL
		B_2	50.3	65.1	0.06	41	51	8	SiL
	18	BC	44.0	85.5	0.08	31	40	29	LiC
	10	A_{11}	39.6	59.9	0.54	53	24	23	CL
		A_{12}	35.7	59.6	0.14	56	21	23	CL
		A_{13}	28.0	78.5	0.05	76	16	8	SL
	2	Apg	39.6	91.3	0.38	31	51	18	SiCL
		Bg	33.5	94.9	0.09	41	54	5	SiCL
	3	A_{11}	37.8	62.2	0.77	56	39	5	L
		A_{12}	39.6	64.0	0.38	44	38	18	CL
		B_2	34.4	59.1	0.12	31	49	20	SiCL
	17	Ap_1・Ap_2	47.4	82.7	0.26	36	35	29	LiC
		B_2	41.0	99.3	0.07	36	48	16	SiCL
	16	Apg	43.0	70.0	0.27	24	32	44	LiC
		Bg	41.6	81.0	0.12	29	22	49	HC

Table C.3.3 (3) Chemical and Physical Properties of Soil

Sub-group	Pit No.	Horizon (cm)	CEC me/100g	Ex-base Saturation %	T-N %	Sand %	Silt %	Clay %	Texture
I - 2	1	Apg	49.0	79.5	0.30	41	44	15	CL
		Bg	52.5	71.4	0.09	34	48	18	SiCL
	14	Apg	39.8	78.4	0.22	29	42	29	LiC
		Bg	38.4	93.9	0.10	24	52	24	SiCL
U - 1	21	A_1	29.2	29.1	0.57	51	15	34	LiC
		B_2	28.2	(112)	0.28	46	15	39	LiC

Table C.3.4 Summary of Three Phase Distribution and Density of Soil

Soil		Three phases in Soil						Density	
Group	Horizon	Solid %	Liquid %	Air %	Porosity %	Degree of water saturation[2] %	Moisture Ratio[3] %	Apparent	True
I-16[1]	Surface	36.6	57.7	5.8	63.5	90.9	58.1	0.988	2.74
	Sub	38.5	56.0	5.6	61.6	90.9	54.2	1.023	2.77
I-2[1]	Surface	31.2	64.4	4.4	68.8	93.6	81.1	0.822	2.63
	Sub	36.6	57.7	5.8	63.5	90.9	58.6	0.844	2.75
Sandy Soil (a)	Surface	38.8	57.6	3.5	61.3	94.3	55.7	1.039	2.68
	Sub	32.7	46.7	20.6	67.3	69.4	50.9	0.916	2.81
Sandy Soil (b)	Surface	45.4	48.1	6.6	54.74	87.9	39.5	1.219	2.69
	Sub	44.0	27.9	28.1	56.0	49.8	23.6	1.193	2.72
Volanic Ash	Surface	28.7	66.4	4.9	71.3	93.1	90.2	0.749	2.61

I-16 : I-16 + pit No.20, I-2 : D + W + pit No.15, Sandy soil : a) Pit No.26, b) Pit No.19.
Volcanic ash : ← Surface layers of Pit No.15, 27, 2, 17.,
1) Excluded Sandy soil 2) Liquid/Porosity 3) Liquid/Solid (by weight)

Table C.3.5 (1) Three Phase Distribution and Density of Soil

Sub-group	Pit No.	Horizon (cm)	Solid %	Liquid %	Air %	Porosity %	Moisture Ratio by Vol. %	Moisture Ratio by Wt %	Density Apparent	Density True
I - 16	23	0 ~ 20	36.8	54.7	8.6	63.3	54.7	53.8	1.019	2.77
		20 ~ 51	40.2	54.9	5.0	59.9	54.9	49.3	1.117	2.78
		51 ~ 80	38.1	55.1	6.9	62.0	55.1	50.6	1.089	2.86
	6	0 ~ 10	36.9	60.2	2.9	63.1	60.2	63.0	0.946	2.57
		10 ~ 37	37.0	56.7	6.3	63.9	56.7	56.1	1.015	2.74
		37 ~ 60	35.2	49.1	15.6	64.7	49.1	66.0	1.013	2.87
		60 ~ 100	40.1	56.1	3.8	59.9	56.1	51.7	1.088	2.72
	9	0 ~ 23	34.4	65.1	0.6	65.7	65.1	67.8	0.960	2.80
		23 ~ 50	39.0	58.0	3.0	61.0	58.0	53.7	1.081	2.77
		50 ~ 80	39.0	59.1	2.0	61.1	59.1	54.8	1.078	2.77
	24	0 ~ 10	36.2	54.8	9.1	63.9	54.8	54.9	0.998	2.76
		10 ~ 27	40.6	52.1	7.4	59.5	52.1	45.9	1.138	2.81
		27 ~ 46	36.8	59.5	3.8	63.3	59.5	58.7	1.014	2.76
		46 ~ 80	40.2	52.2	7.7	59.9	52.2	45.6	1.148	2.86
	26	0 ~ 6	38.8	57.8	3.5	61.3	57.8	55.7	1.039	2.68
		6 ~ 21	34.7	54.0	11.4	65.4	54.0	57.1	0.947	2.74
		26 ~ 80+	30.7	39.4	30.0	69.4	39.4	44.6	0.884	2.88
	25	0 ~ 18	39.8	53.4	6.9	60.3	53.4	49.7	1.075	2.71
		18 ~ 47	39.9	55.7	4.4	60.1	55.7	51.5	1.083	2.72
		47 ~ 68	42.4	53.0	4.7	57.7	53.0	47.4	1.119	2.64
I - 2	27	0 ~ 9	32.1	64.5	3.5	67.9	64.5	78.0	0.827	2.58
		9 ~ 71	31.8	58.4	9.9	68.3	58.4	67.9	0.861	2.72
	19	0 ~ 9	45.4	48.1	6.6	54.7	48.1	39.5	1.219	2.69
		9 ~ 24	42.3	36.3	21.5	57.8	36.3	31.2	1.166	2.76
		24 ~ 50	45.8	19.4	34.9	54.3	19.4	15.9	1.220	2.67
	18	30 ~ 60	35.4	62.5	2.2	64.7	62.5	65.0	0.962	2.72
	2	0 ~ 20	26.9	68.2	5.0	73.2	68.2	92.5	0.737	2.75
	17	0 ~ 22	30.6	62.8	6.6	69.4	62.8	78.5	0.801	2.61
		22 ~ 48	44.1	53.4	2.5	55.9	53.4	44.5	1.203	2.74
	14	0 ~ 20	36.3	59.3	4.5	63.8	59.3	60.8	0.983	2.72
		20 ~ 50	40.4	54.3	5.3	59.6	54.3	48.3	1.131	2.81
	16	0 ~ 20	36.0	61.6	2.4	64.0	61.6	64.7	0.952	2.65

Table C.3.5 (2) Three Phase Distribution and Density of Soil

Sub-group	Pit No.	Horizon (cm)	Solid %	Liquid %	Air %	Porosity %	Moisture Ratio by Vol. %	Moisture Ratio by Wt %	Density Apparent	Density True
E - 4	20	0 ~ 31	35.5	58.1	6.5	64.6	58.1	59.6	0.976	2.76
		31 ~ 68	34.5	60.7	4.9	65.6	60.7	63.3	0.958	2.78
		68 ~ 90	35.6	61.8	2.7	64.5	61.8	63.8	0.970	2.73
E - 1	15	0 ~ 15	25.3	70.2	4.5	74.7	70.2	111.8	0.629	2.49
		15 ~ 50	32.4	59.5	8.2	67.7	59.5	67.1	0.886	2.74
		50 ~ 75	35.3	58.1	6.6	64.7	58.1	59.0	0.985	2.79

1) Under the Moisture of Field Capacity

Table C.3.6 Degree of Water Saturation of Soil

(%)

Pit No.	Horizon (cm)	At Sampling	Under Field Capacity	Δ
23	0 ~ 20	90.4	86.4	- 4.0
	20 ~ 50	91.5	91.7	+ 0.2
	51 ~ 80	89.4	88.9	- 0.5
6	0 ~ 10	94.6	95.4	+ 0.8
	10 ~ 34	89.4	90.0	+ 0.6
	37 ~ 60	69.4	75.9	+ 6.5
	60 ~ 100	89.8	93.4	+ 3.9
9	0 ~ 23	98.4	99.1	+ 1.1
	23 ~ 50	94.6	95.1	+ 0.5
	50 ~ 80	96.1	96.7	+ 0.6
24	0 ~ 10	86.4	85.8	- 0.6
	10 ~ 27	88.1	87.6	- 0.5
	27 ~ 46	94.0	94.0	± 0.0
	46 ~ 80	87.6	87.1	- 0.5
26	0 ~ 6	91.7	94.3	+ 2.6
	6 ~ 21	80.3	82.6	+ 2.3
	26 ~ 80	48.8	56.8	+ 8.0
25	0 ~ 18	88.2	88.6	+ 0.4
	18 ~ 47	92.3	92.7	+ 0.4
	47 ~ 68	91.7	91.9	+ 0.2
20	0 ~ 31	89.5	89.9	+ 0.4
	31 ~ 68	95.0	97.0	+ 2.0
	68 ~ 90	94.7	95.8	+ 1.1
15	0 ~ 15	93.3	94.0	+ 0.7
	15 ~ 50	86.9	87.9	+ 1.0
	50 ~ 75	91.7	89.8	- 1.9
27	0 ~ 9	94.1	95.0	+ 0.9
	9 ~ 71	85.9	85.5	- 0.4
19	0 ~ 9	86.5	87.9	+ 1.4
	9 ~ 24	60.9	62.8	+ 1.9
	24 ~ 50	47.1	35.7	-11.4
18	30 ~ 60	96.8	96.6	- 0.2
2	0 ~ 20	95.2	93.2	- 2.0
17	0 ~ 22	90.1	90.5	+ 0.4
	22 ~ 48	93.7	95.5	+ 1.8
14	0 ~ 20	94.2	92.9	- 1.3
	20 ~ 50	92.4	91.1	+ 1.3
16	0 ~ 20	95.2	96.3	+ 1.1

Δ : Difference between "At Sampling" and "Under Field Capacity"

+ : Means dryer condition than the field capacity at sampling.
- : Means wetter condition than the field capacity at sampling.

C.4 Chemical Properties of Soils

The data on chemical properties of the soils are presented in Tables C.4.1 and C.4.2, summarized from the data in each profiles indicated in Tables C.3.3, C.4.3, and C.4.4.

The generally higher contents of organic matter and nitrogen in the soil groups with imperfect drainage like the I-2, than the one with well drainage like the I-16 and E-4, would indicate a function of excess soil moisture to hasten the accumulation of organic matter in soils.

As one of characteristics of the soils in the area, the fairly high values, as much as 30 to 50 m.e. in the cation exchange capacity would be pointed out. These high values and rather low values in pH (KCl) would suggest the presence of lots of 2 : 1 type clay minerals and allophone in soils with under-withered stages.

Being the fairly high values in the exchangeable base content, especially Ca and the degree of base saturation of the soils in the area would be also one of the remarkable characters excluded with the U-1 group. Although most of these Ca would be supplied from debris of lime stones transported from the Talamanca Mountains, the mixing degree of these materials in soil layers seems to be much different between the soil groups. Namely, the soil layers with the values of above 100% in the base saturation degree exist 41% in the I-16 group while only 16% in the I-2.

As for soil acidity, being excluded with the U-1 group which is of strong acidity, most of the soils in the area show the weak to almost neutral reactions in active acidity, pH (H_2O) and fairly low concentration of exchangeable Al, from which any detrimental effects of soil acidity on crops would not occur at present situations. However, being fairly low in the potential acidity, pH (KCl), when lots of the bases would be lost in leaching water and harvest under advanced farming with artificial drainage, the soils would have relatively high possibility to become strong acid in future, by leaving under inappropriate soil managements.

At the present condition, it would seem to be deficiencies of K, P, Zn and Fe for crops to occur as nutritional detriments depending on the soil conditions and kind of crops. As for the potassium, though the soil layers surveyed having lower concentrations of available K than the critical value for crop growth seemed to be few, due to co-existing of the fairly higher concentration of exchangeable Ca and Mg than K the optimum base-balances[7] or plant growth between these bases were up-set in 70% of the soil layers, which would cause K-deficiency for crops by depressing the K-up take of the crops. As for the phosphorus, although only 17% of the soil layers surveyed showed the lower values of available P than the critical one for crop growth[7], as the soils mixed with lots of volcanic ash have rather high P fixation, especially for these soils, dressing enough available P would be expected to be very useful for crop production. As for the micro-nutrients, being of lower Zn concentrations than the critical one[7] and of nearly neutral in reaction in some soils, Zn deficiency would seem to occur relatively easily for crops in these soils. Moreover, for Fe when more oxidative soil conditions developed by effective drainage, since the solubility of Fe decreases especially in soils with neutral to weakly alkaline reactions, Fe-deficiency would rather easily occur for crops which need much Fe for growth, like rice.

Table C.4.1 Summary of Chemical Properties of Soil Sub-Group

Sub-Group	Horizon	OM %	T-N %	CEC me/100g %	Ex-base Saturation %	PH		Exchangeable (me/100g)				P ppm
						H^2O	Kcl	Ca	Mg	K	Total	
I-1S	Surface	4.00	0.31	38.9	73.7	5.67	4.75	22.8	4.71	0.79	28.30	30
	Sub	0.56	0.10	34.9	107	6.23	4.43	34.7	7.40	0.66	42.76	20
I-2D	Surface	4.75	0.43	41.3	86.4	5.55	4.85	24.1	8.75	2.42	35.27	62
	Sub	1.81	0.14	31.7	113	5.60	4.44	29.0	8.76	1.01	36.80	29
I-2W	Surface	4.43	0.39	42.3	74.9	5.59	4.69	22.5	7.54	1.80	31.84	26
	Sub	1.54	0.13	38.4	78.0	5.74	4.56	20.0	8.28	2.17	30.45	13
E-4 (20)	Surface	2.75	0.15	45.0	110	6.8	6.6	47.7	1.70	0.21	49.66	12
	Sub	1.38	0.10	44.2	78.9	6.4	5.3	33.9	3.14	0.21	37.23	17
E-1 (15)	Surface	15.00	0.89	49.2	68.1	4.9	4.8	22.7	8.33	2.45	33.53	42
	Sub	6.90	0.29	39.1	74.3	5.4	5.2	20.1	7.75	1.21	29.03	31
U-1	Surface	8.32	0.57	29.1	29.1	3.9	3.7	7.0	1.28	0.21	8.49	23
	Sub	4.41	0.28	28.2	112	4.5	4.4	30.3	0.70	0.66	1.68	18

Table C.4.2 Summary of Available Micro-Nutrients Content of Soil Sub-Group

(ppm)

Soil Group		Fe	Cu	Zn	Mn
I-16	Min. ~ Max.	9 ~ 124	5 ~ 30	1 ~ 150	8 ~ 188
	Mean	38.7	16.9	33.3	64.8
I-2	Min. ~ Max.	18 ~ 390	1 ~ 14	1 ~ 63	8 ~ 200
	Mean	157.3	8.8	8.3	87.8

Table C.4.3 (1) Chemical Properties of Soil Surveyed

Sub-group	Pit No.	Horizon	PH		Exchangeable me / 100g					Ca / K	Ca + Mg / K	Mg / K	MO %	Soluble P ppm
			H_2O	KCl	Ca	Mg	K	Al	Ca+Mg+K					
I - 16	5	A_1	5.7	4.3	19.4	6.83	1.0	--	27.23	19.4	26.2	6.8	2.91	15
		B_{21}	6.4	4.6	21.6	6.16	0.4	--	28.16	54.0	69.4	15.4	0.08	10
		B_{22}	6.4	4.4	12.0	4.16	0.4	--	16.56	30.0	40.4	10.4	tr.	13
	11	A_{11}	6.0	4.7	16.0	4.99	0.6	--	21.59	26.7	35.0	8.3	3.34	21
		A_{12}	6.2	4.8	20.6	5.16	0.5	--	26.26	41.2	51.5	10.3	1.48	14
		A_3	6.2	4.4	19.6	3.99	0.4	--	23.98	49.0	59.0	10.0	1.09	14
		II AB	6.2	4.3	17.2	3.68	0.5	--	21.38	34.4	41.4	7.3	0.85	19
	23	A_{11}, A_{12}	5.3	4.7	23.0	1.18	0.21	0.36	24.39	109.5	115.1	5.6	3.14	21
		A_3, B	5.7	4.9	25.3	1.17	1.02	0.22	27.49	24.8	25.9	1.2	1.69	31
		B_{21}, B_{22}	5.3	4.8	22.8	1.00	0.56	0.22	24.46	34.5	36.0	1.5	0.77	26
	4	A_1	5.9	4.8	12.6	4.66	0.8	--	18.16	14.0	19.2	5.2	4.31	15
		B_2	6.1	4.8	17.4	6.83	0.8	--	25.03	28.8	38.2	10.0	0.82	14
		II B_2	6.6	4.6	17.4	6.83	0.6	--	24.83	29.0	24.2	11.4	0.82	19
	8	A_1	5.9	5.1	19.9	5.33	0.9	--	26.13	22.1	28.0	5.9	10.29	40
		II B_2	6.3	4.9	16.0	4.66	0.4	--	21.06	40.0	51.7	11.7	0.31	18
	9	A_1	6.0	5.0	17.4	3.99	0.5	--	21.89	34.8	42.8	8.0	3.73	16
		B_2	6.6	5.0	17.3	5.33	0.4	--	23.03	43.3	56.6	13.3	0.54	9
	24	A_{11}	4.9	4.7	21.0	2.25	0.97	0.36	24.22	21.6	24.0	2.3	2.88	21
		A_{12}	5.7	4.2	42.8	19.17	0.38	0.75	61.47	140.0	203.0	63.0	0.54	26
		A_3	5.9	4.5	41.2	20.50	0.50	0.80	62.50	102.5	151.0	48.5	0.54	26
		II B_{21}	6.4	4.4	42.8	19.17	0.54	0.80	62.51	175.0	254.0	79.0	0.41	18
		B_{22}	6.6	4.6	42.0	21.84	0.20	0.22	64.04	210.0	319.2	109.2	0.14	16
	12	A_1	5.6	4.3	14.4	4.16	0.50	--	19.06	28.8	37.1	8.3	2.61	11
		II B	6.3	4.5	13.5	2.66	0.40	--	16.56	33.8	40.4	6.7	0.54	20
	26	Ap_1	6.7	5.8	42.4	7.00	2.04	0.11	51.44	20.8	24.2	3.4	5.14	44
		Ap_2	6.9	5.6	40.8	4.00	1.58	0.13	46.38	25.8	28.4	2.5	0.14	39
		II Ab	7.0	6.1	42.0	5.00	1.78	0.19	48.78	23.6	26.4	2.8	0.27	29
		B_2	6.7	5.2	37.0	3.33	1.63	0.13	41.96	22.7	24.7	2.0	0.14	19
	25	Ap	4.7	4.1	41.8	6.67	0.27	2.03	48.74	154.8	179.5	24.7	1.62	94
		B_{21}	5.3	4.3	42.0	2.66	0.88	1.83	46.26	48.5	55.4	6.9	0.68	34
		B_{22}	5.6	4.2	42.6	7.00	0.96	0.92	50.56	44.4	51.7	7.3	0.54	12

Table C.4.3 (2) Chemical Properties of Soil Surveyed

Sub-group	Pit No.	Horizon	PH		Exchangeable me / 100g					Ca / K	Ca + Mg / K	Mg / K	MO %	Soluble P ppm
			H_2O	KCl	Ca	Mg	K	Al	Ca+Mg+K					
E - 4	20	A_{11}	6.8	6.6	47.7	1.70	0.21	0.03	49.66	227.4	235.5	8.1	2.75	12
		A_{12}	6.7	5.7	34.2	2.94	0.21	0.04	37.40	163.1	177.1	14.0	2.11	15
		B_{21}	6.1	4.9	33.5	3.34	0.21	0.11	37.05	159.5	175.4	15.9	0.64	13
	22	A_{11}	6.0	5.3	31.5	1.25	0.21	0.07	32.96	150.0	155.9	6.0	2.45	17
		A_{12}	6.9	6.1	28.0	0.58	0.21	0.00	28.79	133.3	136.1	2.8	0.83	11
		II AB	6.1	5.6	27.0	1.34	0.46	0.15	28.80	58.7	61.6	2.9	4.29	29
E - 1	15	A_{11}	4.9	4.8	22.7	8.33	2.45	2.07	33.53	9.3	12.7	3.4	15.9	42
		A_{12}	5.7	5.4	20.7	8.00	1.53	0.50	30.28	13.6	18.8	5.2	6.77	40
		AB	5.1	4.9	19.4	7.50	0.88	0.16	27.78	22.0	30.6	8.5	7.03	22
I - 2	8	A_1	5.5	4.8	16.9	5.50	0.60	--	23.00	28.2	37.3	9.2	3.73	12
		B_2	6.1	4.6	9.0	4.99	0.40	--	14.39	22.5	35.0	12.5	1.32	10
	27	A_1	5.1	4.6	41.6	15.33	1.43	0.16	58.36	29.1	39.8	10.7	3.20	138
		B_2	5.4	4.7	42.4	14.34	0.60	2.42	57.34	70.7	94.6	23.9	0.54	36
	19	A_{11}	5.5	5.1	13.0	7.00	6.25	0.14	26.25	2.1	3.2	1.1	3.73	76
		A_{12}	4.9	4.2	26.0	4.67	3.80	0.64	34.47	6.8	8.1	1.2	3.01	45
		II B^2	5.0	4.2	25.3	3.83	1.18	0.73	30.26	21.4	24.6	3.2	1.79	59
		C	5.4	3.6	47.3	2.80	0.44	0.68	30.49	61.9	68.3	6.4	0.19	16
	7	Ap	6.1	4.9	25.0	7.16	1.40	--	33.56	17.9	23.0	5.1	2.72	21
		B_2	6.7	4.9	27.0	5.33	0.40	--	32.73	67.5	80.8	13.3	1.84	15
	18	BC	5.7	4.9	25.6	11.33	0.48	0.11	37.58	53.6	77.3	23.6	3.98	21
	10	A_{11}	5.8	4.9	17.8	4.99	0.90	--	23.69	19.8	25.3	5.5	4.74	15
		A_{12}	6.2	4.8	16.0	4.83	0.45	--	21.28	35.6	46.3	10.7	1.87	7
		A_{13}	6.1	4.4	14.3	7.33	0.30	--	21.93	47.7	72.1	24.4	1.16	7
	2	Apg	6.1	5.2	21.5	7.33	7.3	--	36.13	2.95	3.95	1.0	3.11	28
		Bg	6.6	5.3	19.0	5.83	10.5	--	35.33	1.81	5.06	0.6	0.39	22
	3	A_{11}	5.4	4.9	16.6	5.66	1.3	--	23.56	12.8	17.1	4.4	11.38	35
		A_{12}	5.3	4.7	14.8	5.50	5.0	--	25.30	2.96	4.06	1.1	3.18	13
		B_2	6.1	4.3	13.6	7.50	0.5	--	21.60	27.2	42.2	15.0	0.70	7
	17	Ap_1, Ap_2	5.3	4.4	30.0	8.66	0.5	0.30	39.16	60.0	77.3	17.3	4.24	23
		B_2	4.7	4.6	31.5	8.50	0.67	0.46	40.67	47.0	59.7	12.7	0.94	13
	16	Apg	5.4	4.4	17.3	12.33	0.50	0.36	30.13	34.6	59.3	24.7	1.45	12
		Bg	5.8	4.2	18.3	15.00	0.38	0.06	33.68	48.2	87.6	39.5	1.19	10

Table C.4.3 (3) Chemical Properties of Soil Surveyed

Sub-group	Pit No.	Horizon	PH		Exchangeable me / 100g					Ca / K	Ca + Mg / K	Mg / K	MO %	Soluble P ppm
			H_2O	KCl	Ca	Mg	K	Al	Ca+Mg+K					
I - 2	1	Apg	6.1	4.8	36.5	0.99	1.5	--	38.99	24.3	25.0	0.7	2.48	21
		Bg	6.3	5.1	28.0	8.66	0.8	--	37.46	35.0	45.8	10.8	1.55	18
	14	Apg	5.0	4.2	17.8	12.83	0.57	0.69	31.20	31.2	53.7	22.5	3.60	47
		Bg	5.4	4.3	24.8	11.33	0.92	0.50	37.00	26.9	39.2	12.3	2.84	22
U - 1	21	A_1	3.9	3.7	7.0	1.28	0.21	4.60	8.49	33.3	39.4	6.1	8.32	23
		B_2	4.5	4.4	30.3	0.70	0.66	1.68	31.61	45.8	46.9	1.1	4.41	18

Table C.4.4 Available Micro-Nutrients Content of Soil

Sub-group	Pit No.	Horizon	Fe	Cu	Zn	Mn
I - 16	23	A_{11}-A_{12}	124	30	3	99
		A_{13}	91	26	2	47
		B_{21}-B_{22}	96	22	1	31
	24	A_{11}	103	20	3	88
		A_{12}	14	21	23	79
		B_{21}	13	22	27	97
		II B_{22}	14	6	14	16
		B_{23}	9	8	16	8
	26	Ap_1	19	19	58	109
		Ap_2	17	24	34	50
		II B_{21}	17	19	31	40
		B_{22}	14	12	26	24
	25	Ap	16	12	83	188
		B_{21}	14	7	150	73
		B_{22}	13	5	28	23
I - 2	27	A_1	27	14	63	200
		B_2	18	9	20	168
	19	$A1_1$	301	3	5	89
		$A1_2$	380	7	3	107
		II B_2	235	4	1	38
		C	74	1	1	8
	18	BC	102	8	3	26
	17	Ap_1-Ap_2	123	11	3	147
		B_2	92	6	1	15
	16	Apg	144	13	3	142
		Bg	70	10	3	88
	14	Apg	143	14	5	98
		Bg	129	9	2	13
E - 4	20	A_{11}	93	16	2	53
		B_{12}	73	15	1	22
		B_{21}	72	9	1	17
	22	A_{11}	120	11	1	15
		A_{12}	80	7	2	5
		II A_{13}	109	130	3	32
E - 1	15	A_{11}	336	10	13	155
		A_{12}	191	11	5	100
		AB	152	11	2	11
U - 1	21	A_1	273	16	4	149
		B_2	317	13	2	117

C.5 Land Improvement and Soil Management

(1) Measures for Drainage

Although constructing facilities for controlling inundation and installing appropriate drainage would be considered to be the first step for establishment of advanced agriculture in the area, much devices would be required to get effective results.

The results on the soil of pit No.25 would indicate an example of the effective drainage on soil of fine texture, being usually thought to be rather difficult for getting effective results. In the case of No.25, in spite of the texture of heavy clay in the subsoil, by the drain ditches (about 50 cm in wide and 50 cm in depth) surrounded the field (about 50 m x 10 m), the improved soil moisture status was observed, such as having 53 to 56% in liquid phase, 4 to 7% in air phase and 47 to 52% in moisture ratio, within the depth of 68 cm, and showing relatively dryer condition in the I-16 group even under rainy season. Therefore, on this field corn, sorghum and soybean have been able to grow with considerable yields. However, it must be taken care to be acidic reactions of the soil, supposing to be caused by heavy dressing of fertilizers and well drainage.

For the soils containing lots of volcanic ash, it would be also considered to be difficult to get effective results of drainage, due to fairly high water holding capacity of this material. For this reason, trying such a thing would be expected on these soils as installing a mole drain just below the surface soil to hasten draining water in the surface layer and supply air to plant roots, besides the usual ditches and under-drains.

(2) Soil Management

Under the condition of high rainfall and high temperature, the factors on nutrition supply to crops would seen in general to affect much on the plant growth and yield. To clarify these factors in the soils of the area, a comparative investigation was conducted with two soils in ASBANA, pit No. 23 and No.24, the former showing better growth of the fruit trees than the latter. In the profile of No. 23, the textures of silty clay loam to clay loam were observed into the groundwater level of 100 cm, while in the No. 24, the layers of clay loam were observed only to the depth of 46 cm, followed with the layers of sandy loam, loam and sand to the depth of 110 cm, groundwater level. Thus, since the No. 23 soil has thicker layers of fine texture, it would be able to supply more plant nutrients than the No. 24, having coarser texture in the sub-layer in which the leaching losses of the nutrients would also occur easily. Besides these matters, the strong acid, 4.9 in pH (H_2O), in the surface soil of the No. 24 might be a cause of worse growth of the trees.

In general the effective drainages hasten decomposition of organic matter in soils. Since the activities of nitrifying bacteria become higher in soils rich in exchangeable Ca, the losses of nitrogen in the soils of the area, as leaching of nitrate accompanied by potassium and other bases, and nitrogenous gas would be apt to occur rather easily. In this way, since the artificial drainage not only exclude the excess water in soils but also change the physical, biological and chemical properties of the soils, appropriate soil management to fit these changes should not be forgotten.

C.6 Soil Classification

As for the high category classification based on the soil taxonomy of USDA, since the existence of excess water, tropical high temperature and some diagnostic epidons such as "Molic", "Umbric" and "Ochric" were observed in the soils of the area, the classification was presented as seen in Main Report in Table 3.1.18 deferring to MAG's classification (1979)[1),2)].

As for the lower category classification, although actual classification could not be obtained on the data surveyed this time, as the criterions to distinguish the soils the following items would be selected. (1) Elevation and Unevenness of land (depression or elevation), (2) Soil colors and Groundwater level (indicate drainage situation), (3) Texture of soil layers (fine, medium and coarse) and their Stratification, (4) Mixing degree of lime stone and volcanic ash in topsoil. The classification will be carried out in the next order, (1), (2), (3), (4).

The classification of capability of land use was carried out by the almost same way as practiced by ITCO (IDA) in The Storren Farm in the area (1981)[4)] based on the USDA system. Since rainfall, gradient of land, erodibility and soil fertility seemed in general to be of few differences in the area, as key factors distinguish the capability of land use on the whole, danger inundation, natural drainage, groundwater level, texture of top-soil and subsoil and stony and gravely of land were selected and classified the land of the area as II, III, IV, VI, VII and VIII classes. The land corresponded to I and V classes was not seemed to be recognized.

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Annex D Land Use Plan

Annex D. Land Use Plan

Fundamental idea to establish a plan for landuse in the Study Area seems to promote the development of agriculture for the stabilization of the peoples livelihood. For this purpose, the examine on plan for landuse is expected to do from many points of view, not constricting on crop production only, but on other products such as animal husbandry, fish culture, forestry as well as processing of these products.

For selection of the products (Crops) it seems fundamentally important to consider the suitability to the natural conditions and low cost technology first of all. Besides crop diversification is also required from ecological and economic reasons, it must be examined from the point of increasing chance of engagement for the people with serious consideration. The food and fodder processing in the area would be considered to increase the importance and necessity for reason of this.

Annex E Agriculture

Annex E. Agriculture

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E. 1 Main Agricultural Production Trend in the Country.

The trend of the main agricultural production in the country are shown in Table E.1 and Fig.E.1 (1),(2) and (3).

Agricultural production in the country is trend to stagnated in recent years. In particular, perennial crops for export such as coffee, bananas and sugar canes are reducing of their production.

On the other hand, the production of the basic food agricultural products such as rice, maize and vegetables and products of livestock are increasing.

Table E.1.1 Main Agricultural Production Trend in the Country

Year / Crops	1979	1980	1981	1982	1983	1984	1985	1986
1) Perennial								unit:1,000 t
Coffee	98.6	106.4	111.3	115.1	124.0	136.9	123.9	116.1
Banana	1,154.3	931.4	919.0	947.0	955.9	937.8	804.0	882.0
Sugar Cane	2,615.1	2,516.5	2,521.0	2,446.2	2,543.5	2,935.8	2,949.6	2,484.2
Cacao	10.4	5.3	5.0	3.5	2.2	3.0	3.5	3.8
Plantain	81.4	90.0	89.9	97.9	92.8	80.8	79.8	97.5
Coconut	n.d	n.d	n.d	n.d	10.0	10.0	11.0	8.4
2) Annual								
Rice	219.6	230.6	222.5	146.2	246.8	262.7	212.9	229.2
Maize	72.9	75.3	82.8	82.3	94.1	110.3	120.0	120.3
Kidney Bean	11.3	11.5	12.3	16.3	14.4	20.8	22.9	33.4
Sorgo	33.7	41.6	30.8	27.2	31.5	48.0	54.3	35.9
Tobaco	2.1	1.6	1.7	1.3	1.9	2.4	1.9	1.9
Cotton	1.1	0.8	0.6	0.6	1.3	1.3	1.3	0.6
3) Livestock								
Cattle (1,000head)	340.3	297.5	376.7	287.5	242.6	348.4	463.3	560.2
Milk (1,000/L)	306.1	308.3	310.3	297.7	326.9	345.8	360.7	397.0
Egg (1,000unit)	370.9	430.2	429.8	320.7	278.0	316.2	227.5	260.0
4) Forestry 1,000 m3	650.0	687.0	653.0	516.0	379.0	402.0	402.0	491.0
5) Fish	24.7	19.1	15.5	13.5	12.8	16.9	19.4	16.1

Source : (1) BANCO CENTRAL DE C.R. CIFRAS DE PRODUCCION AGROPECUARIO(1986)
(2) ASBANA(1987)
(3) SEPSA(1987)

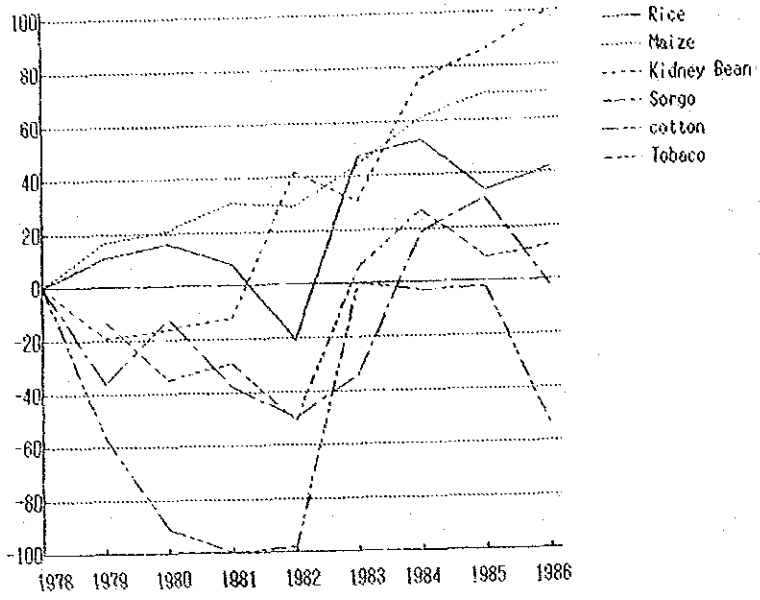

Fig. E.1 (1) Variation of the Main Agricultural Production

(Perennial Crops)

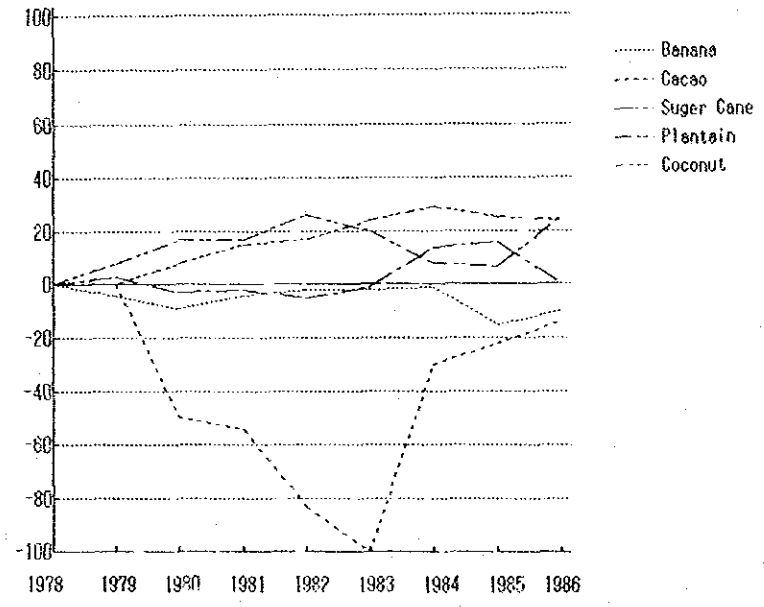

Fig. E.1 (2) Variation of the Main Agricultural Production

(Annual Crops)

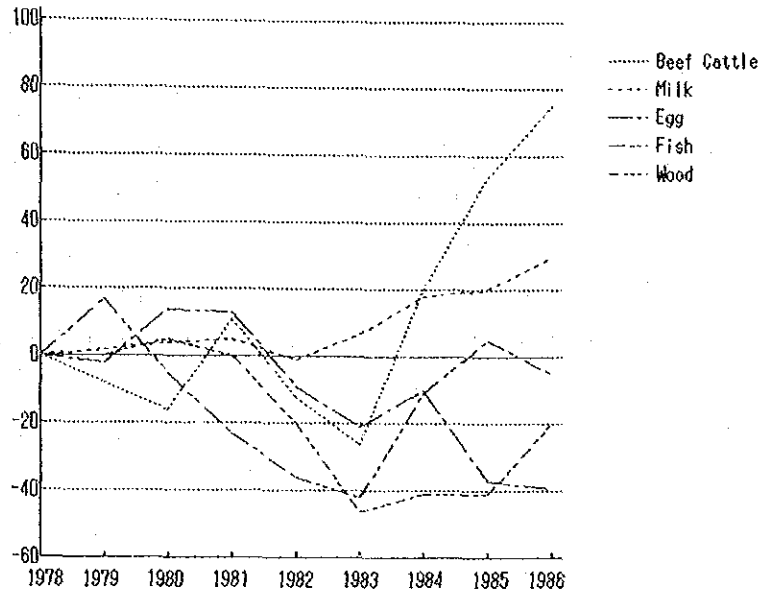

Fig. E.1 (3) Variation of the Main Agricultural Production (livestock and others)

E. 2 Data of Agricultural Production in the Study Area

(1) Agricultural land use

Agricultural land in the Study Area is divided into three types: ordinary farmland, pasture land and forest land. A large part of agricultural land is devoted to pasture. Most of the pasture land consist of natural pasture. The pasture land is found in the low-lying and poor drainage areas near the coastal line.

Ordinary farmland is cultivated with perennial and annual crops as follows:

- Perennial crops : Banana, Cacao, Coconut, Plantain,etc.
- Annual crops ; Rice, Maize, Tuber crops (cassava, taro), Kidney beans, etc.

Most of the ordinary farmland is found in relatively high land areas where there is good drainage near the roads and rivers.

According to the results of the field survey and talk with farmers in the Area, recent changes in land use in the Study Area shows the following trends:

a. Ordinary farmland

Rice crops prevail as a annual crop due to the fact that they can be cultivated under flooding conditions. Rice was one of the first crops introduced by the initial settlers and is cultivated as a crop for auto-sufficiency. There has been a gradual tendency to increase vegetable crops; such as tuber crops and kidney beans for the auto-sufficiency and as cash crops. Though the Government (C.N.P) is working to promote maize production, there has been no increase in planted area, because only the well drained land is cultivated during the dry season.

The cultivation of bananas is on the increase among perennial crops. The Government encourages th expansion of banana cultivation by farmers, but not by the banana plantation companies. The planted area of cacao, plantains, etc. is falling annually because of difficulties encountered in production life span, and damage caused by insects and diseases.

b. Pasture land

Land with poor drainage and flooding is used as pasture land; therefore the land is unmanaged. There is a tendency to increase pasture land as the abolition of cacao and plantain farms expands.

c. Forest land

Forest land is found in low lying area neighboring the seashore. The forest land is covered with scattered wild bush, coco-palms and pasture.

(2) Farm Management Type

The farm management type in th Study Area varies according to the scale of land holding. Farm management, according to the scale of land holdings, has specific features as follows:

a. Less than 5 ha. : Combined farming. Mainly cultivation of perennial crops such as bananas, plantains, cacao, etc.

b. 5 ha. to 12 ha. : Combined farming. Mainly cultivation crop of rice and perennial crops such as bananas, plantains and cacao, and cattle breeding

c. 12 ha. to 40 ha : Single crop. Rice or bananas and cattle breeding

d. Over 40 ha : Single crop. Rice or bananas

There are no distinctive divisions as to types of farming. According to the criteria of settlement by IDA, land holdings of up to 10 ha. are considered small-scale farms.

The following shows the numbers of the farmers' household, according to the distribution of the farmmanagement size in the Study Area.

Table E.2.1 Distribution of the Farm Management Size

Zone	A		B		C		D		Total	
Size(ha)	Farm No.	%	Farm No.	%	Farm No.	%	Farm No.	%	Farm No.	%
< 12	314	61.1	1,517	83.2	274	59.4	1,093	67.5	3,198	72.4
12 ~ 40	138	25.3	216	11.9	132	28.1	439	27.1	917	20.8
40 ~ 100	53	10.3	68	3.7	42	9.1	44	2.7	207	4.7
100 ~ 200	10	1.9	5	0.3	3	0.7	10	0.7	28	0.6
> 200	7	1.4	16	0.9	10	2.0	33	2.0	66	1.5
Total	514	100.0	1,822	100.0	461	100.0	1.619	100.0	4,416	100.0
Media		15.7		8.2		13.4		6.7		9.1

Source : (1) Settlement Register of IDA, 1986
(2) Farm Management Survey JICA, 1987

(2) Data of Agricultural production in the Study Area.

Table E.2.2 (1) Present Production Costs(Annual Crops)

(¢/ha)

Crop / Items	Rice	Maize	Kidney Bean	Tuber Crop
1 Labors				
Labor	7,029	7,839	8,945	47,181
Machinery	6,429	-	-	9,600
Sub-Total	13,458	7,839	8,945	56,781
2 Materials				
Seed	5,036	705	1,857	7,700
Fertilizer	4,796	3,422	2,369	4,340
Herbicide	3,922	545	1,421	5,456
Insecticide	1,688	420	985	519
Fungicide	1,628	-	231	854
Sub-Total	17,070	5,092	6,863	18,869
3 Others	526	298	305	1,160
Total (1+2+3)	31,094	13,229	16,113	76,810

Source: Production Costs of Table E.3 to 7:

(1) BANCO NACIONAL DE COSTA RICA (1987)

(2) CONSEJO NACIONAL DE PRODUCCION
Proyecto: El cultivo de Platano con sombra temporal del Cacao (1987)

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(INVERSION NICOA S Y M S.A. 1987)

(5) COSTO DE INVERSION DE SIEMBRA DE BANANO, ASBANA (1987)

(6) Farm Management Survey (1987)

Table E.2.2 (2) Present Production Costs(Cacao)

(¢/ha)

Item \ Year	1	2	3	4
1 Labors				
Labor	23,723	12,348	20,910	12,348
2 Materials				
Plant	14,664	–	–	–
Support Pole	490	–	–	–
Fertilizer	8,328	4,997	10,405	4,997
Insecticide	2,480	1,725	960	1,725
Fungicide	600	900	3,000	900
Adhesive	746	285	570	285
Shade Tree	650	–	–	–
Sub-Total	27,958	7,907	14,935	7,907
3 Others				
Transport	4,481	516	1,035	516
Total (1+2+3)	56,162	20,771	36,880	20,771

Table E.2.2 (3) Present Production Costs(Plantain)

Item \ Year	1	2
1 Labors		
Labor	14,529	11,680
2 Materials		
Seed	7,000	–
Fertilizer	5,360	2,373
Insecticide	5,700	17,112
Other	600	3,000
Sub-Total	18,660	22,485
3 Others	1,810	1,335
Total (1+2+3)	34,999	35,500

Table E.2.2 (4) Present Production Costs(Coconuts)

(₱/ha)

Item \ Year	1	2	3	4	5
1 Labors					
Labor	15,016	8,773	7,248	7,250	6,544
2 Materials					
Marking Post	100	—	—	—	—
Plants	5,600	—	—	—	—
Fertilizer	617	1,853	10,554	8,741	6,586
Insecide	75	2,243	2,243	331	—
Fungicide	171	857	514	857	850
Herbicide	1,265	2,530	1,200	1,265	1,265
Other	95	95	95	95	—
Sub-Total	7,924	7,578	14,606	11,289	8,701
3 Others	715	180	302	282	155
Total (1+2+3)	23,654	16,531	22,156	18,741	15,400

Table E.2.2 (5) Present Production Costs(Banana)

Item \ Year	1	2
1 Labors		
Labor	94,962	95,874
2 Materials		
Seed	70,750	—
Fertilizer	135,180	147,955
Fungicida	126,895	130,359
Herbicida	50,693	54,156
Nematicida	60,515	63,998
Other	15,315	18,778
Sub-Total	459,348	415,246
3 Others	2,800	16,880
Total	557,110	528,000

Table E.2.3 Production of Beef Cattle

Unit : head

Year	Domestic Consuption	Export	Total
1980	156,009	141,525	297,534
1981	188,195	188,510	376,705
1982	166,163	121,343	287,506
1983	166,967	75,611	242,578
1984	238,000	110,410	348,410
1985	304,989	158,250	463,239
1986	354,924	206,548	561,272

Source : (1) Banco Central de C.R.
CIFRAS de PRODUCCION
AGROPECUARIO 1976-1985 (1986)
(2) SEPSA (1987)

Table E.2.4 Possible Production Area of Cacao in the Atlantic Region

Canton	Distrito	Area (ha)
1. Sarapiqui		18,300
2. Pococi		24,670
3. Guacimo		20,340
4. Limon		13,600
5. Talamanca		24,200
6. Siquirres		15,600
	Siquirres	8,200
	Pacuarito	4,700
	Cairo	2,700
7. Matina		12,000
	Matina	6,400
	Bataan	3,200
	Carrandi	2,400
Total		128,710

Source : Area de Ejeccion del Prorama de Fomento Cacaotero, 1984, (SEPSA, MAG)

Table E.2.5 Change of the Yield and the Age of the Economical Life Span

Crops	Yield							Age of Life Span (year)
	(Year)1	2	3	4	5	6	7	
1.Perennial								
Banana	-	47.0	49.1					11
Cacao	-	-	-	0.4	1.0			25
Coconut	-	-	-	3.8	5.5	6.5	10.0	25
Plantain	-	10.0	12.0					11
Black Peper	-	0.5	2.2					12
2.Annual								
Rice	3.5	4.5						
Maize	1.5	1.8	2.2	2.5				
Kidney Bean	0.8	1.1	1.3	1.5				
Tuber	8.0	0.8	1.1	1.3	1.5			
3.Cattle kg	280	310	350					

Table E.2.6 (1) Production Costs with Project(Annual Crops)

Crop / Item	Rice	Maize	Kidney Bean	Tuber Crop
1 Labors				
Lobor	8,127	7,840	12,298	47,182
Machinery	7,007	5,540	7,021	9,600
Sub-Total	15,134	133,380	19,317	56,782
2 Materials				
Seed	5,283	1,015	3,281	9,450
Fertilizer	6,182	5,109	3,311	5,660
Herbicide	5,789	819	2,842	7,452
Insecticide	3,377	843	2,785	1,188
Fungicide	3,256	-	1,446	2,236
Other	-	-	-	1,160
Sub-Total	23,888	7,786	13,664	27,277
3 Others				
Transport	728	988	2,373	8,406
Total (1+2+3)	39,750	22,154	35,357	92,465

SOURCE: Production Costs of Table E.11 to 16:

(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.2.6 (2) Production Costs with Project(Cacao)

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	9,882	5,984	10,406	10,406
Herbicide	—	—	—	—
Insecticide	8,260	2,875	960	960
Fungicide	1,500	1,050	3,000	3,000
Adhesive	950	475	570	570
Shade Treo	750	—	—	—
Sub-Total	37,530	10,384	14,936	14,936
3 Others	1,064	600	1,035	1,035
Total (1+2+3)	63,938	22,352	40,556	40,556

Table E.2.6 (3) Production Costs with Project(Coconuts)

Item \ Year	1	2	3	4	5	6
1 Labors						
Labor	23,264	15,581	14,254	16,070	24,032	24,032
2 Materials						
Marking Post	270	—	—	—	—	—
Plant	11,360	—	—	—	—	—
Fertilizer	2,965	3,001	18,719	27,401	27,710	27,710
Insecide	2,867	3,365	3,365	663	829	829
Herbicide	5,692	3,795	3,795	3,795	3,795	3,795
Fungicide	857	1,286	1,286	1,715	1,715	1,715
Other	143	143	143	191	191	191
Sub-Total	24,154	11,590	27,308	33,765	34,240	34,240
3 Others	1,873	293	518	696	726	726
Total (1+2+3)	49,291	27,464	42,080	50,531	58,998	58,998

Table E.2.6 (4) Production Costs with Project(Banana)

Year / Items	1	2
1 Labor	102,000	102,979
2 Materials		
Plant	76,000	-
Fertilizer	145,200	158,920
Fungicida	136,300	140,020
Herbicida	54,450	58,170
Nematicida	65,000	68,741
Others	16,450	20,170
Sub-Total	493,400	446,021
3 Other	3,000	18,000
Total(1+2+3)	598,400	567,000

Table E.2.6 (5) Production Costs with Project(Plantain)

Year / Item	1	2	3
1 Labors			
Labor	32,720	31,851	31,851
Machinery	1,963	-	-
Sub-Total	34,683	31,851	31,851
2 Materials			
Seed	11,550	-	-
Fertilizer	10,397	15,479	15,479
Insecticide	17,112	34,224	34,224
Support Pole	-	5,400	5,400
Other	1,870	-	-
Sub-Total	40,129	55,103	55,103
3 Others	3,118	3,152	3,152
Total (1+2+3)	77,930	90,106	90,106

Table E.2.6 (6) Production Costs with Project(Black Pepper)

Item \ Year	1	2	3
1 Lobors			
Lobor	61,795	31,854	80,886
Machinery	13,862	—	—
Sub-Total	75,657	31,854	80,886
2 Materials			
Plant	178,750	—	—
Support Pole	68,750	—	—
Fertilizer	34,608	36,743	40,896
Herbicide	2,089	2,070	2,070
Insecticide	19,266	1,089	1,089
Fungicide	2,772	2,772	2,772
Other	191	706	706
Sub-Total	306,426	43,380	47,533
3 Others			
Freight	8,342	2,318	2,578
Transport	17,875	—	—
Sub-Total	26,217	2,318	2,578
Total (1+2+3)	408,300	77,552	130,997

Table E.2.7 Change of Producer's Price

Unit : ¢/t

crop / year	Banana	Cacao	Plantain	Rice	Maize	Kidney Bean	Beef
1980	2,514	19,370	1,771	2,619	3,000	7,492	10,202
1981	4,028	35,453	2,683	4,846	6,146	16,442	17,221
1982	9,017	50,690	5,564	10,374	10,763	26,718	29,108
1983	11,702	74,716	5,806	12,182	11,508	33,445	35,740
1984	12,182	98,200	5,713	11,725	11,508	33,445	37,181
1985	12,500	100,100	8,969	14,130	12,659	33,445	45,000
1986	13,000	100,100	9,005	14,180	13,880	42,315	50,000

Source : (1) CIFRAS DE PRODUCCION
AGROPECUARIA 1976-1985.
BANCO CENTRAL DE COSTA RICA
(2) EL SECTOR AGROPECUARIO 1986.
SEPSA.

E.3 Summary of Farm Management Survey

In order to understand the actual management of farm, farm management survey was done covering small scale farmers. Thirty farms were subject to the survey and the results can be summarized as Table E 3.1(1) to 3.1.(6).

The majority of small scale farmers cannot cover living expenses with only agricultural incomes and thus have become farmers with a side job. The main employers are the nearby banana plantation companies or large scale farmers. Although there are differences each year, the income from the side job amounts to approximately 60 - 70% of the total.

The average land holding by farmers in the area is approximately 11.0 ha. The farm management type differs according to farm size; the smaller farm, the more mixed cultivation of cacao and plantain is seen. For farms larger than 5.0 ha, single cropping of either cacao or rice prevails.

The average cropped area for rice farms is 4.0 to 5.0 ha which is equivalent to approximately 30 to 40% of the owned land. The planted area cacao farms is similar to that rice farms however the actual harvest is approximately 50 to 60% of that.

The reasons for low planting rate in comparison to plantain area are inundations, poor drainage and lack of funds. The cost for machinery rental for tillage, and sowing is 4,000 to 6,500 ₡ and for harvest is go to ₡/per bag.

Table E.3.1 (1) Summary of Farm Management Survey

1. Zone : A
2. No.of Farm Management Survey : 5

No.	General				Cropping System			
	District	No.of Family & Labor *1	Working Days (Day/Year)	Land Holding Type *2	Cropping Area(ha)	Farm Management Type & Area(ha)	Yield (t/ha)	Cropping Period J.F.M.A.M.J.J.A.S.O.N.D.
1	Matina Centro	4 persons Agr. 1 Non Agr.1	280	① 28.0 ② Owner ③ 1981(IDA)	3.0	Cacao 1.5 Rice 0.5 Tuber 0.5 Maize 0.5	0.3 2.2 6.5 0.5	
2	Matina Cuatro Millas	6 persons Agr. 2 Non AGR.2	300	① 12.0 ② Owner ③ 1967(IDA)	7.2	Rice 5.0 Pasture2.2	3.0 6 head	
3	Matina Centro	4 persons Agr.& Non Agr. 1	300	① 18.0 ② Owner ③ 1965 (1981 IDA)	1.6	Cacao 0.2 Pasture0.9	0.5 1 head	
4	Matina Centro	7 persons Agr. 1 Non Agr. 1	250	① 11.0 ② Tenant ③ -	4.0	Cacao 4.0	0.3	
5	Matina Cuatro Millasa	5 persons Agr. 1 Non Agr. 1	320	① 7.0 ② Tenant ③ -	4.0	Plantain 3.0 Coconut 1.0	5.0 2.0	

Production Materials				Technical Assistannce & Household Economy					
Seed (varaety	Fertilizer	Chemical	Machinery & Rental Fee	Technical Assistance	Credit	Agricultural Income(¢)	Non Agr. Income(¢)	Living Cost (¢/year)	Problem of Farm-Management
CR.1113 Xantosom Tico-V7	N. P. K. 60 30 10	Ditane M-45, Aldrin	Tractor : ¢ 6,000/ha	MAG	-	52,000	75,000 (Banana Farm)	120,000	•Drainage •Credit
CR.1113	N. P. K. 70 10 10	Ditane M-45	Tractor : ¢ 6,500/ha	-	-	75,000	180,000 (Banana)	220,000～ 24,000	•Drainage
UFseries	-	-	-	-	-	10,000	100,000 (Banana)	80,000～ 120,000	•Drainage •Credit
UFseries	-	Cobre-Sandoz, Daconil	-	IDA	-	52,800	72,600 (Banana Farm)	120,000～ 125,000	•Drainage •Credit
-	N. P. K. 50 30 30	-	-	-	-	33,000	96,000 (Banana Farm)	120,000	•Virus •Drainage

Remarks : ＊1」 Agr. : Agricultural Labor
Non Agr. : Non-Agricultural Labor

＊2」 ① Land Holding Area
② Types of Land Holding
③ Year of the Land Resister

Table E.3.1 (2) Summary of Farm Management Survey

1. Zone : B
2. No.of Farm Management Survey : 10

No.	General				Cropping System			
	District	No.of Family & Labor	Working Days (Day/Year)	Land Holding Type	Cropping Area(ha)	Farm Management Type & Area(ha)	Yield (t/ha)	Cropping Period J.F.M.A.M.J.J.A.S.O.N.D.
1	Bataan Sara	1 person Agr. 1	300	① 9.0 ② Owner ③ 1967(IDA)	6.5	Cacao 1.5 Maiz 2.0 Plantain 3.0	0.5 0.5 7.0	
2	Bataan Sara	1 person Agr. 1	320	① 16.0 ② Owner ③ 1977	12.0	Rice 10.0 Cacao 1.0	3.2 0.5	
3	Bataan Centro	8 persons Agr. 1 Non Agr. 1	150	① 8.0 ② Owner ③ 1980(IDA)	7.0	Rice 6.0 Cacao 1.0	3.0	
4	Bataan Leite	4 persons Agr. 1 Non Agr. 1	300	① 16.0 ② Owner ③ 1981(IDA)	2.0	Cacao 2.0	0.7	
5	Bataan Leite	6 persons Agr. 1 Non Agr. 1	300	① 8.8 ② Owner ③ 1980(IDA)	3.5	Rice 3.5	3.0	

Production Materiales				Technical Assistannce & Household Economy					
Seed (varaety	Fertilizer	Chemical	Machinery & Rental Fee	Technical Assistance	Credit	Agricultural Income(¢)	Non Agr. Income(¢)	Living Cost (¢/year)	Problem of Farm-Management
Maize tico-V7 Cacao UFSeries	N. P. K. 20 10 10	Cobre Sandoz	-	-	-	100,000	-	80,000 ～ 90,000	• Technical Assistance • Marketing
Rice C.R.1113 Cacao UFSeries	N. P. K. 100 70 40	-	Tractor 6,000 ～ 6,000/ha	IDA	-	130,000 ～ 150,000	-	800,000	• Technical Assistance • Drainage • Marketing
Rice C.R.1113	N. P. K. -	Pesticidos	Tractor 6,000 /ha	-	-	82,580	30,000 (Banana Farm)	110,000 ～ 120,000	• Drainage • Marketing
-	-	-	-	-	-	15,000	80,000(Banana Farm)	100,000	• Drainage • Credit
Rice C.R.1113	N. P. K.	Pesticidos	Tractor 60,000 ～ 65,000/ha	MAG	-	87,380	60,480 (Banana Farm)	130,000 ～ 140,000	• Drainage

Table E.3.1 (3) Summary of Farm Management Survey

1. Zone : B
2. No.of Farm Management Survey : 10

No.	General				Cropping System			
	District	No.of Family & Labor	Working Days (Day/Year)	Land Holding Type	Cropping Area(ha)	Farm Management Type & Area(ha)	Yield (t/ha)	Cropping Period J.F.M.A.M.J.J.A.S.O.N.D.
6	Bataan Luzon	10 persons Agr. 1 Non Agr. 1	330	① 7.5 ② Owner ③ 1965(IDA)	6.0	Cacao 6.0	0.3	
7	Bataan RAMAL 7	9 persons Agr. 2 Non Agr. 2	300	① 8.0 ② Owner ③ 1979	7.0	Rice 6.0 Cacao 1.0	3.5	———
8	Bataan Barbilla	3 persons Agr. 1 Non Agr. 1	300	① 6.0 ② Tenant ③ -	2.5	Plantain and Banana 2.5	Plantain 7.0 Banana 30.0	
9	Bataan Barbilla	7 persons Agr. 1 Non Agr. 1	280	① 5.0 ② Owner ③ 1980	3.0	Plantain 1.5 Coconut 1.5	7.5 2.0	
10	Bataan Centro	8 persons Agr. 1 Non Agr. 1	300	① 10.0 ② Owner ③ 1975	-	Pasture 10.0 (Catile) 5 head	0.25	

Production Materials				Technical Assistannce & Household Economy					
Seed (varaety	Fertilizer	Chemical	Machinery & Rental Fee	Technical Assistance	Credit	Agricultural Income(₡)	Non Agr. Income(₡)	Living Cost (₡/year)	Problem of Farm-Management
Cacao C.C. 18	-	Cobre Sandoz	-	-	-	51,000	50,000 (Rice Farm	100,000	• Credit • Techinical Assistance • Drainage
Rice C.R.1113 Cacao UFSeries	N. P. K. 100 50 30	Pestici-dos Cobre-sadz	Tractor ₡ 5,000/ha	MAG	-	100,000	100,000 (Banana Farm)	120,000 ～ 150,000	• Drainage • Credit
Banana (Grand Naie)	P. K. 30 10	—	—	—	—	30,000	80,000 (Banana Farm)	80,000 ～ 90,000	• Sigatoka-Negra • Drainage
—	N. P. K. 20 10 10	Pestici-dos	—	—	—	40,000	60,000 (Cattle Farm)	100,000	• Marketing • Drainage
—	—	—	—	—	—	16,000	80,000 (Rice Farm)	100,000	• Drainage

1. Zone : C

Table E.3.1 (4) Summary of Farm Management Survey

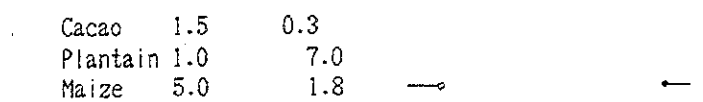
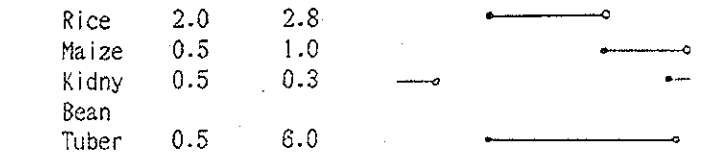
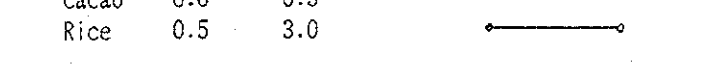
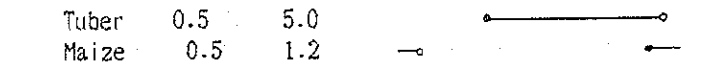
2. No.of Farm Management Survey : 5

No.	General				Cropping System			
	District	No.of Family & Labor	Working Days (Day/Year)	Land Holding Type	Cropping Area(ha)	Farm Management Type & Area(ha)	Yield (t/ha)	Cropping Period J.F.M.A.M.J.J.A.S.O.N.D.
1	Siquirres Indiana Tres	5 persons Agr. 1 Non Agr. 1	300	① 12 ② Owner ③ 1980(IDA)	3.0	Cacao 1.5 Plantain 1.5 Cattle 3 head	2.2 5.5 0.25	
2	Siquirres Indiana Doo y Tres	3 persons Agr. 1 Non Agr. 1	320	① 14 ② Owner ③ - (IDA)	10	Cacao 10	0.3	
3	Siquirres Indiana Tres	1 person Agr. 1 Non Agr. 1	320	① 3.5 ② Owner ③ 1982(IDA)	3.5	Cattle 5head	0.2	
4	Siquirres Indiana Dos	10 persons Agr. 1 Non Agr. 1	300	① 12 ② Owner ③ 1977(IDA)	0.7	Maize 0.2 Kiddny Bean 0.5	1.5 0.5	
5	Siquirres Pacuarito	7 persons Agr. 1 Non Agr. 1	300	① 10 ② Owners ③ 1982(IDA)	2.5	Rice 1.5 Kidny Bean 0.5 Tuber 0.5	3.5 0.3 6.0	

Production Materials				Technical Assistannce & Household Economy					
Seed (varaety	Fertilizer	Chemical	Machinery & Rental Fee	Technical Assistance	Credit	Agricultural Income(¢)	Non Agr. Income(¢)	Living Cost (¢/year)	Problem of Farm-Management
—	—		—	ASBANA	—	82,210	60,000 (Banana Farm)	142,210	• Drainage
UFSeries	N. P. K. 50 20 30			IDA	—	80,000	50,000 (Cacao Farm)	100,000	• Drainage • Credit • Pesticide
—	—	—	—	—	BNCR	13,000	50,000 (Cacao Farm)	50,000	• Drainage • Credit
Tico V7 Mexico80	N. P. K. 30 10 10			IDA	—	5,000	80,000 (Tips Factry)	80,000	• Drainage • Credit
C.R.I113 Mexico80	N. P. K. 50 30 30	Pesticides	Tractor 5,500/ha	IDA	—	38,000	60,000 (Banana Farm)	80,000	• Drainage • Marketing

Table E.3.1 (5) Summary of Farm Management Survey

1.Zone : D
2.No.of Farm Management Survey : 10

No.	General				Cropping System			
	District	No.of Family & Labor	Working Days (Day/Year)	Land Holding Type	Croping Area(ha)	Farm Management Type & Area(ha)	Yield (t/ha)	Cropping Period J.F.M.A.M.J.J.A.S.O.N.D.
1	Siquirres Rio Hurdo	6 persons Agr. 1	300	① 30.0 ② Owner ③ 1972(IDA)	20	Cacao 1.5 Plantain 1.0 Maize 5.0	0.3 7.0 1.8	
2	Siquirres Marry Land	10 persons Agr. 1 Non Agr. 1	310	① 10.0 ② Owner ③ 1986 (IDA)	3.5	Rice 2.0 Maize 0.5 Kidny Bean 0.5 Tuber 0.5	2.8 1.0 0.3 6.0	
3	Siquirres Marry Land	5 persons Agr. 1 Non Agr. 1	300	① 10.0 ② Owner ③ 1986 (IDA)	0.5	Kidny 0.1 Tuber 0.4 Cattle 3 head	 9.5 0.2	
4	Siquirres Marry Land	6 persons Agr. 1 Non Agr. 1	300	① 11.0 ② Owner ③ 1985(IDA)	6.5	Cacao 6.0 Rice 0.5	0.3 3.0	
5	Siquirres Marry Land	6 persons Agr. 1 Non Agr. 1	300	① 15.0 ② Owner ③ 1985(IDA)	1.0	Tuber 0.5 Maize 0.5 Cattle 5 head	5.0 1.2 0.3	

Production Materials				Technical Assistannce & Household Economy					
Seed (varaety	Fertilizer	Chemical	Machinery & Rental Fee	Technical Assistance	Credit	Agricultural Income(¢)	Non Agr. Income(¢)	Living Cost (¢/year)	Problem of Farm-Management
UFSeries Tico V-7	N. P. K. 100 20 10	Cobre Santoz	—	IDA	—	90,000 ～ 100,000	40,000 (Banana Farm)	100,000	•Drainage •Tecnical Assistance
C.R.1113 Tico V-7 Mexico80 Violanoo	N. P. K. 80 30 20	Pestici-de	Tractor 6,500/ha	IDA	—	41,300	43,000 (Cattle Farm)	80,000 ～ 85,000	• Drainage • Credit
Mexico80 Violanoo	N. P. K. 10 5 5	—	Tractor 4,000/ha	IDA	—	13,000	60,000 (Mata de C.R)	60,000	• Drainage • Credit
C.R.1113 UFSeries	N. P. K. 10 - -	Corre Santoz	Tractor 6,000/ha	IDA	—	60,000	60,000 (Banana Farm)	100,000	• Drainage
Violanoo Tico V-7	N. P. K. 20 - -	—	Tractor 4,000/ha	IDA	—	35,000	50,000 (Mata de C.R)	80,000 ～ 90,000	• Drainage

Table E.3.1 (6) Summary of Farm Management Survey

1. Zone : D
2.No.of Farm Management Survey : 10

No.	General				Cropping System			
	District	No.of Family & Labor	Working Days (Day/Year)	Land Holding Type	Croping Area(ha)	Farm Management Type & Area(ha)	Yield (t/ha)	Cropping Period J.F.M.A.M.J.J.A.S.O.N.D.
6	Siquirres Esperanza	6 persons Agr. 1 Non Agr. 1	300	① 10.0 ② Owner ③ 1986(IDA)	4.0	Tuber 1.5 Vegetable 3.0	6.0 —	
7	Siquirres Madre de Dios	4 persons Agr. 1 Non Agr. 1	300	① 6.0 ② Owner ③ 1986	—	Cattle 6.0 (2 head)	0.25	
8	Siquirres La Virginia	15 persons Agr. 1 Non Agr. 1	300	① 5.5 ② Owner ③ 1980	2.0	Cacao 2.0 Cattle 3.5 (1 head)	0.3	
9	Siquirres Islona	10 persons Agr. 1 Non Agr. 1	320	① 10.0 ② Owner ③ 1986(IDA)	4.0	Tuber 2.0 Fruits 2.0 Cattle 4.0 (2 head)	7.5 — 0.3	
10	Siquirres La Virgina	6 persons Agr. 1 Non Agr. 1	300	① 10.0 ② Tenant ③ —	6.0	Maize 4.0 Kidny Bean Plantain 2.0	1.2 0.3 7.0	

Production Materiales				Technical Assistannce & Household Economy					
Seed (varaety	Fertilizer	Chemical	Machinery & Rental Fee	Technical Assistance	Credit	Agricultural Income(¢)	Non Agr. Income(¢)	Living Cost (¢/year)	Problem of Farm-Management
Violan-ceo	N. P. K. 20 10 10	—	—	IDA	—	40,000	40,000 (Banana Farm)	80,000	·Drainage
—	—	—	—	—	—	10,000	60,000 (Cattle Farm)	60,000	·Drainage
UFSeries	—	Cobre Sandoz	—	—	—	15,000	200,000 (Banana Farm)	150,000	·Drainage ·Technic-al Assitance ·Credit
Xanto-soma	N. P. K. 50 20 10	Pestici-cide	Tractor 4,000/ha	IDA	BNCR	105,000	35,000 (Banana Farm)	100,000	·Drainage ·Credit ·Marketing
Tico V-7	N. P. K. 30 - -	Pestici-cide	—	—	—	35,000	45,000 (Cattle Farm)	80,000	·Drainage